DELIBERA DEL DIRETTORE GENERALE

14 / 2026 del 29/01/2026

Oggetto: **PROGETTO ESA CLIMATE-SPACE: CLIMATE CHANGE AND HEALTH ACTIVITY - PRESA D'ATTO E APPROVAZIONE ACCORDO DI COLLABORAZIONE**

OGGETTO: PROGETTO ESA CLIMATE-SPACE: CLIMATE CHANGE AND HEALTH ACTIVITY - PRESA D'ATTO E APPROVAZIONE ACCORDO DI COLLABORAZIONE

vista la seguente proposta di deliberazione avanzata dal Direttore della Struttura Complessa Affari Generali e Legali

IL DIRETTORE GENERALE

PREMESSO che l'Agenzia Regionale Emergenza Urgenza (AREU) è un Ente del S.S.R. disciplinato dall'art. 16 L.R. 30.12.2009 n. 33 e s.m.i. e attivato dalla DGR n. 2701/2019 e dalla DGR n. 4078/2020;

VISTA la deliberazione dell'Agenzia n. 1/2024 "PRESA D'ATTO DELLA D.G.R. N. XII/1650 DEL 21/12/2023 DETERMINAZIONI IN ORDINE ALLA DIREZIONE DELL'AGENZIA REGIONALE EMERGENZA URGENZA (AREU) – (DI CONCERTO CON L'ASSESSORE BERTOLASO)" di nomina del Dott. Massimo Lombardo a Direttore Generale dell'Agenzia Regionale Emergenza Urgenza (AREU);

DATO ATTO che l'Agenzia, ai sensi dell'art. 16, comma 1, della citata L.R. n. 33 del 2009 garantisce il coordinamento intraregionale e interregionale, l'indirizzo, la gestione, lo svolgimento, il monitoraggio della rete dell'emergenza urgenza extra ospedaliera e del Servizio NUE 112. Assicura inoltre il coordinamento delle attività trasfusionali dei flussi di scambio e compensazione di sangue, emocomponenti ed emoderivati, il coordinamento logistico delle attività di prelievo e di trapianto di organi e tessuti, il coordinamento dei trasporti sanitari e sanitari semplici disciplinati dalla Regione, il coordinamento delle centrali operative integrate per la continuità assistenziale;

RESO ATTO che, con nota prot. n. 33998 del 12/11/2025 l'International Health Office di AREU ha Comunicato l'adesione di AREU al bando ESA ITT AO/1-12639/24/I-LR "Climate Change & Health – Re-issue" promosso dall'Agenzia Spaziale Europea (ESA), con il progetto ESA CLIMATE-SPACE: Climate Change and Health Activity, in coordinamento con dal Deutsches Zentrum für Luft- und Raumfahrt e.V. (DLR) German Aerospace Center;

DATO ATTO che l'obiettivo generale del progetto è quello di integrare i dati di Osservazione della Terra (Earth Observation), in particolare le Essential Climate Variables (ECV) fornite dall'Agenzia Spaziale Europea, con i dati sanitari regionali provenienti dalle chiamate di emergenza al 118, al fine di mappare e quantificare i rischi clima-salute nella regione Lombardia. Questa integrazione consentirà di analizzare gli effetti dei principali fattori climatici e ambientali — come le ondate di calore, l'inquinamento atmosferico e le variazioni della qualità dell'aria — sulla salute della popolazione e, in particolare, sulla domanda di servizi di emergenza sanitaria.

RILEVATO che il progetto ha durata di 36 mesi e dallo stesso derivano proventi, fino ad un massimo di € 70.000,00 a titolo di rimborso degli oneri sostenuti da AREU per il personale impiegato nella attività ivi previste;

PRESO ATTO che con nota prot. AREU n. 37113 del 12/12/2025 è pervenuto dal Deutsches Zentrum für Luft-und Raumfahrt e.V. (DLR) German Aerospace Center l'accordo oggetto la collaborazione di AREU in qualità di subcontractor nell'ambito del progetto CLIMATE-SPACE: CLIMATE CHANGE AND HEALTH ACTIVITY CLIMATE CHANGE AND HEALTH EMERGENCY CARE (CLIMA-CARE), allegato quale parte integrante e sostanziale del presente provvedimento, e già sottoscritto digitalmente dal main contractor;

RILEVATO che l'accordo prevede una partecipazione di AREU nel progetto in qualità di subcontrctor secondo il seguente impegno:

- messa a disposizione dei dati inerenti la propria attività istituzionale attraverso i Sistemi Informativi, rispettando le norme privacy;
- validazione epidemiologica dei dati;
- supporto nella creazione di protocolli condivisi per far fronte alle maxiemergenze;

RITENUTO, pertanto, opportuno prendere atto del progetto dal titolo CLIMATE-SPACE: CLIMATE CHANGE AND HEALTH ACTIVITY CLIMAte change and health emergency CARE (CLIMA-CARE), approvato da ESA, l'accordo di collaborazione con Deutsches Zentrum für Luft- und Raumfahrt e.V. (DLR) German Aerospace Center, comprensivo di allegati (technical proposal e statement of work) allegati quale parte integrante e sostanziale del presente provvedimento;

RITENUTO, inoltre, di designare quale responsabile del procedimento e coordinatore dell'attività da svolgersi nell'ambito dell'accordo, il dott. Giuseppe Stirparo, Dirigente della S.C: Direzione Medico Organizzativa di AREU;

PRESO ATTO che il Proponente del procedimento attesta la completezza, la regolarità tecnica e la legittimità del presente provvedimento;

ACQUISITI i pareri favorevoli del Direttore Amministrativo e del Direttore Sanitario, resi per quanto di specifica competenza ai sensi dell'art. 3 del D.Lgs. n. 502/1992 e s.m.i.;

DELIBERA

Per tutti i motivi in premessa indicati e integralmente richiamati:

1. di prendere atto della partecipazione di AREU al bando con la presentazione del progetto, unitamente ad altri enti interessati, CLIMATE-SPACE: CLIMATE CHANGE AND HEALTH ACTIVITY CLIMAte change and health emergency CARE (CLIMA-CARE);
2. di approvare, autorizzandone la sottoscrizione, l'accordo di collaborazione, comprensivo di allegati (technical proposal e statement of work) tra Deutsches Zentrum für Luft- und Raumfahrt e.V. (DLR) German Aerospace Center e AREU ad oggetto la collaborazione in qualità di subcontractor nell'ambito del progetto CLIMATE-SPACE: CLIMATE CHANGE AND HEALTH ACTIVITY CLIMAte change and health emergency CARE (CLIMA-CARE), allegati quale parte integrante e sostanziale del presente provvedimento;
3. di dare atto che l'accordo prevede una partecipazione di AREU nel progetto in qualità di subcontractor con il seguente impegno:

- messa a disposizione dei dati inerenti la propria attività istituzionale attraverso i Sistemi Informativi, rispettando le norme privacy;
- validazione epidemiologica dei dati;

AREU
Sistema Socio Sanitario
Regione Lombardia

- supporto nella creazione di protocolli condivisi per far fronte alle maxiemergenze;

4. di precisare che l'accordo di collaborazione decorre dalla data di sottoscrizione, fatti salvi i pregressi rapporti a decorrere dal 13.11.2025, e ha durata di 36 mesi e sino a, presumibilmente il 11/12/2028;
5. di designare quale referente del progetto è il dott. Giuseppe Stirparo, Dirigente della S.C. Direzione Medico Organizzativa;
6. di dare atto che dall'adozione del presente provvedimento derivano proventi per la conduzione del progetto fino ad un massimo di € 70.000,00 da imputare nella contabilità dell'Agenzia al conto di n. 30101240 "Contributi in c/esercizio da altri enti pubblici (extra FSR) – altro" – progetto ESA CLIMA-CARE;
7. di dare atto che, ai sensi della L. n. 241/1990, responsabile del presente procedimento è il dott. Giuseppe Stirparo, Dirigente della S.C. Direzione Medico Organizzativa;
8. di disporre che vengano rispettate tutte le prescrizioni inerenti alla pubblicazione sul portale web dell'Agenzia di tutte le informazioni e i documenti richiesti e necessari ai sensi del D.Lgs. n. 33/2013 e s.m.i., c.d. Amministrazione Trasparente;
9. di disporre la pubblicazione del presente provvedimento all'Albo Pretorio on line dell'Agenzia, dando atto che lo stesso è immediatamente esecutivo (ex art. 32 comma 5 L. n. 69/2009 s.m.i. e art. 17 comma 6 L.R. n. 33/2009).

La presente delibera è sottoscritta digitalmente, ai sensi dell'art. 21 D.Lgs. n. 82/2005 e s.m.i., da:

Il Direttore Amministrativo Andrea Albonico

Il Direttore Sanitario Gabriele Mario Perotti

Il Direttore Generale Massimo Lombardo

Subcontract No. D/565/67365947
To ESA Contract No. 4000150182/25/I-LR

with

Agenzia Regionale Emergenza Urgenza
ESA Entity Code: 1 000 047 743

CLIMATE-SPACE: CLIMATE CHANGE AND HEALTH ACTIVITY
CLIMAte change and health emergency CARE (CLIMA-CARE)

SUBCONTRACT

Between:

DEUTSCHES ZENTRUM FÜR LUFT- UND RAUMFAHRT e.V.
(hereinafter called "the Prime Contractor" or "DLR"),

whose Registered Office is at:
Linder Höhe
D-51147 Cologne
Germany

represented by its Executive Board,

Acting through its Institute Earth Observation and Aeronautics,

Located at: Münchener Str. 20, 82234 Weßling, Germany

of the one part,

and:

Agenzia Regionale Emergenza Urgenza
(hereinafter called "the Subcontractor" or "AREU"),

whose Registered Office is at:
Viale Monza 223
20126 Milano (MI)
Italy

represented by its Executive Board,

of the other part,

the following has been agreed between the Prime Contractor and the Subcontractor hereinafter also referred to individually as "Party" and collectively as the "Parties":

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APPENDIX 1: PAYMENT PLAN AND KICK-OFF PAYMENT(S) AND OTHER FINANCIAL CONDITIONS
APPENDIX 2: STATEMENT OF WORK
APPENDIX 3: CONTRACT CHANGE NOTICE
APPENDIX 4: INVENTORY/FIXED ASSET RECORD

ARTICLE 1 - SUBJECT OF THE SUBCONTRACT – APPLICABLE DOCUMENTS

1.1. Subject of the Subcontract

The Subcontractor, as further described in the Statement of Work in Appendix 2, undertakes to participate in the "CLIMA-CARE" project, to contribute to the delivery of the expected documentation as described herein, and take part if necessary in an oral presentation of the results to the ESA.

The Subcontractor undertakes to perform its work in accordance with the tasks assigned to him (all hereafter referred to as "the Work").

The work shall be performed in three Phases (hereafter "Phase" or "Phases") as defined in APPENDIX 2 hereto.
The Agency, and consequently the Prime Contractor, reserves the right not to proceed further with the work at the end of any Phase.
A decision by the Agency, and consequently the Prime Contractor, not to continue further with the work at the end of a Phase does not lead to the application of Clause 31 of the GCC.

The decision whether to proceed further or not shall be taken after completion of the preceding Phase and after acceptance, by the Agency, of the deliverables due under such preceding Phase in writing.

The Subcontractor shall start Phases 1, 2 and 3 only upon receipt of a written Authorisation to Proceed from the Prime Contractor's representatives nominated in ARTICLE 5, Clause 5, Sub-Clause 5.1.

Such Authorisation to Proceed with each specific Phase shall be given within two (2) weeks of the completion of the preceding Phase.

The Subcontractor's contribution consists of performing the defined tasks under the following Work Packages:

- WP 1: DEVELOPMENT OF AN ASSESSMENT REPORT ON CLIMATE AND HEALTH (as Contributor)
- WP 2: FULL DESCRIPTION OF THE SELECTED CLIMATE AND HEALTH CASE STUDY AND DEVELOPMENT OF THE RISK ASSESSMENT (as Contributor)
- WP 3: QUANTIFY THE HEALTH BURDEN ATTRIBUTABLE TO CLIMATE CHANGE AND EXACERBATED BY SOCIAL DETERMINANTS (as Contributor)
- WP 4: CLIMATE AND HEALTH ROADMAP TO INFORM ADAPTATION AND MITIGATION STRATEGIES (as Contributor)
- WP 5: MANAGEMENT, OUTREACH AND COMMUNICATION (as Contributor)

1.2. Applicable Documents

The Work shall be performed in accordance with the following documents, listed in order of precedence, in case of conflict:

a) The Articles of this Subcontract and its Appendix 1 (Payment Plan and Kick-Off Payment(s) and other Financial Conditions);

b) The General Clauses and Conditions for ESA Contracts (herein referred to as GCC), reference ESA/REG/002, rev. 4 not attached hereto but known to both Parties and available on https://esastar-publication.sso.esa.int/supportingDocumentation, under "Reference Documentation" – "Administrative Documents", as amended by this Subcontract;

c) Appendix 2 hereto: The Statement of Work, reference ESA-EOP-SC-RS-2024-53, issue 0.5, dated 02/11/2024, not attached hereto but known to both Parties;

d) The Subcontractor's Proposal consisting of the provided PSS Forms and the "Input for Proposal Submission" document, not attached hereto but known to both Parties.

1.3. This Subcontract shall enter into force upon its signature by both Parties.

The Kick-Off Meeting is expected to be held on 13 November 2025.

ARTICLE 2 - DELIVERY

2.1. Place and Dates of Delivery

2.1.1 Documents

The Subcontractor shall, during the performance of this Subcontract, contribute to the delivery of all documentation and reports as agreed with the Prime Contractor and specified in Appendix 2, in an electronic file. These contributions shall be sent to the Prime Contractor's Technical Officer mentioned in Article 5, Clause 5, Sub-Clause 5.1 a) of the Subcontract, unless otherwise specified, in accordance with the following specific provisions:

2.1.1.1 The Subcontractor is informed that the draft Phases 1 and 2 Reports shall be submitted by the DLR to the ESA for approval, by email in electronic searchable, indexed and not encrypted PDF and native (WORD) format, not later than two weeks before it is to be presented.

As a result, the Subcontractor shall, during the performance of this Subcontract, submit its contributions to the Reports to be delivered to the ESA, to the Prime Contractor's Technical Officer according to the schedule agreed with him and in advance prior to the respective submission to the ESA.

The Subcontractor is informed that the final version of the Phase 1 and 2 Reports shall be issued by the DLR in electronic searchable, indexed and not encrypted PDF and native (WORD) format, not later than four (4) weeks after the Agency's approval of the draft version.

As a result, the Subcontractor shall submit its contributions in electronic format, to the Prime Contractor's Technical Officer according to the schedule agreed with him and in advance prior to the respective submission to the ESA.

2.1.1.2 The Subcontractor is informed that the draft versions of the final documents as defined in Appendix 2 shall be submitted by the DLR to the ESA for approval, in electronic searchable, indexed and not encrypted PDF and native (WORD) format, not later than two (2) weeks before the documentation is to be presented.

As a result, the Subcontractor shall submit its contributions in electronic format, to the Prime Contractor's Technical Officer according to the schedule agreed with him and in advance prior to the respective submission to the ESA.

2.1.1.3 The Subcontractor is informed that the finalised versions thereof shall be issued by the DLR to the ESA, in electronic searchable, indexed and not encrypted PDF and native (WORD) format not later than four (4) weeks after the approval of the draft versions.

As a result, if revisions are expected and needed from the Subcontractor, it shall submit all the necessary information in an appropriate timing to the Prime Contractor's Technical Officer in order to allow the DLR to incorporate the necessary modifications into the finalised versions to be sent to the ESA.

2.1.1.4 The Subcontractor is informed that the draft versions of the Final Report and the Executive Summary Report as specified in Appendix 2 shall be submitted by the DLR to the ESA for approval, in electronic searchable, indexed and not encrypted PDF and native (WORD) format, not later than two (2) weeks before the documentation is to be presented.

As a result, the Subcontractor shall submit its contributions in electronic format, to the Prime Contractor's Technical Officer according to the schedule agreed with him and in advance prior to the respective submission to the ESA.

2.1.1.5 The Subcontractor is informed that the finalised versions thereof shall be issued by the DLR to the ESA, in electronic searchable, indexed and not encrypted PDF and native (WORD) format not later than four (4) weeks after the approval of the draft versions.

As a result, if revisions are expected and needed from the Subcontractor, it shall submit all the necessary information in an appropriate timing to the Prime Contractor's Technical Officer in order to allow the DLR to incorporate the necessary modifications into the finalised versions to be sent to the ESA.

ARTICLE 3 - PRICE & PAYMENT

3.1. Price

The price of this Subcontract amounts to:

70.000 EUR
(Seventy Thousand Euro),
Plus statutory VAT, if applicable

Broken down per Phase as follows:

Phase 1	Phase 2	Phase 3	Total Amount in EUR
9.294 €	19.350 €	41.356 €	70.000

The Agency may decide that certain items produced or purchased under the ESA Contract, and consequently the Subcontract, during its implementation (see Article 4 below) shall become ESA Fixed Assets. Such items shall be identified as becoming ESA Fixed Assets by means of a Contract Change Notice.

3.1.1 The type of price is the following:

A Firm Fixed Price as defined in Section 2.1 of Annex II to the GCC for Phases 1, 2 and 3.

3.1.2 The above-mentioned price does not include any taxes or duties in the Member States of the Agency.

3.1.3 The price is Delivered Duty Paid for all deliverables, exclusive of import duties and VAT in accordance with the INCOTERMS® 2020, to the addressee(s) specified in Article 5, Clause 5, Sub-Clause 5.1 a) of the Subcontract. Reference to INCOTERMS® 2020 in this provision is exclusively for the purpose of price definition.

3.2. Payment and Invoicing

3.2.1 General provisions

The Payment Plan and Kick-Off Payment(s) off-setting conditions applicable to this Subcontract are specified in Appendix 1 hereto.

The Kick-Off Payment constitutes a debt of the Subcontractor to the Prime Contractor until it has been set-off against subsequent milestone(s) as shown in Appendix 1 hereto.

In the event that the achievement of a milestone is delayed but the milestone is partially met at the milestone planning date foreseen, the Prime Contractor may, as an exception, effect a payment against an approved confirmation of the partially achieved milestone, not exceeding the value of the work performed at the date of payment.

When releasing the payment for a given milestone, if applicable, the Prime Contractor's payment shall be made after due deduction of the corresponding off-set of the Kick-Off Payment(s) as per the conditions of Appendix 1 to the Subcontract (Payment Plan and Kick-Off Payment(s) and other Financial Conditions).

In case of partial payment, the Prime Contractor shall deduct from the corresponding invoice(s) relative to the same milestone any outstanding amount of the Kick-Off Payment(s) still to be off-set.

Payments shall be made within thirty (30) calendar days of receipt of the required documents and fulfilment of the requirements as specified in 3.2.2 below.

Payment shall only be regarded as due if the invoice is issued and transferred in accordance with the following requirements. It is the Parties' understanding that invoices which do not correspond to these requirements do not constitute delay of payment:

E-Invoicing Portal:

Due to Regulation on Electronic Invoicing in Public Procurement (E-Rechnungsverordnung, ERechV) the DLR accepts, from 27th November 2020 on, only electronically issued and via the Federal E-Invoicing-Portal submitted invoices (E-Invoices). E-Invoices must be submitted with the following information via the E-Invoicing-Portal:

https://xrechnung-bdr.de

Routing-ID:	992–03005–81
Subcontract Number:	D/565/67365947

Payments shall be made by the Prime Contractor in EURO to the account specified by the Subcontractor. Such account information shall clearly indicate the IBAN (International Bank Account Number) and BIC/SWIFT (Bank Identification Code). The Parties agree that payments shall be considered as effected by the Prime Contractor on time if the Prime Contractor's orders of payment reach the Prime Contractor's bank within the payment period stipulated in the paragraph above.

Any special charges related to the execution of payments will be borne by the Subcontractor.

If applicable, invoices shall separately show all due taxes or duties.

3.2.2 Requirements for Kick-Off Payment Requests and invoices being regarded as due:

Kick-Off Payment (if any):
Kick-Off Payment Request: to be submitted after signature of this Subcontract by both Parties and the holding of the Kick-Off Meeting.

Kick-Off Payment Request: to be submitted after receipt of the Prime Contractor's written Authorisation to Proceed with a Phase.

Progress Payment(s):

- Milestone Achievement Confirmation (MAC), hereinafter referred to as "confirmation", with supporting documentation as necessary, submitted by the Subcontractor. The supporting documentation shall justify the actual achievement of the milestone(s) as defined in the Payment Plan specified in Appendix 1 hereto.

and

- Invoice(s);

Final Settlement:

- Confirmation, submitted by the Subcontractor with supporting documentation as necessary. The supporting documentation shall justify the actual achievement of the milestones as defined in the Payment Plan Specified in Appendix 1 hereto.

and

- Invoice(s);

and

- Receipt and/or acceptance, by the Prime Contractor and finally the Agency, of all deliverable items, of the services to be rendered and other obligations to be fulfilled, in accordance with the terms of this Subcontract;

In case of non-authorisation by ESA at the end of a Phase to proceed with the subsequent Phase, the last payment milestone of the last authorised Phase shall be deemed to constitute the Final Settlement of the Subcontract and all conditions associated to the Final Settlement shall be fulfilled for payment of such milestone.

3.2.3 Implementation of Payments conditions

The Subcontractor shall ensure that all Kick-Off Payment Request, invoices and confirmations, are submitted for payment exclusively through the process described above in 3.2.1.

The Prime Contractor shall credit the account of the Subcontractor to the Subcontractor's benefit.

The Prime Contractor shall be responsible for approving or rejecting, within ten (10) calendar days of receipt, the relevant Subcontractor's invoices and related supporting documents (e.g. MACs, Cost Reports).

The Prime Contractor shall be responsible for paying the accounts of the Subcontractor for this Subcontract in accordance with the applicable law and normal commercial practices.

The Agency and/or the DLR reserve the right to visit the Subcontractor's premises and ascertain the progress of the work being performed under the Subcontract, prior to making the progress payment concerned.

3.2.4 N/A

3.2.5 N/A

3.2.6 N/A

ARTICLE 4 - MANAGEMENT AND CONTROL OF INVENTORY ITEMS/FIXED ASSETS UNDER THE ESA CONTRACT

The following provisions apply to any items other than those items which fall within the scope of Article 2 of the Subcontract.

The Subcontractor shall specify, record, manage and control any and all customer items and ESA Fixed Assets under Construction (reference is made to Article 3.1 above) that are subject to this Subcontract. Such items are:

i. items produced or purchased under this Subcontract, including electronic components, special jigs, tools, test equipment, and which are paid for under the Subcontract with an individual or batch value (value of group of items) in the national currency equivalent to, or above Five Thousand (5,000) Euro;

ii. if any, items identified as becoming ESA Fixed Assets in Article 3 above or in a subsequent Contract Change Notice (CCN);

iii. if any, Customer Furnished Items (see Article 5 Clause 11 of the Subcontract) and/or Items Made Available by the Agency (see Article 5 Clause 12 of the Subcontract).

The Subcontractor shall operate an inventory control system ("Inventory Control System") of all the above-mentioned items and shall mark them as falling under this Article.

The Inventory Control System shall:

- record the existence, location, operational status and condition of all inventory items, and
- record the value and estimated life duration of all inventory items, and
- record changes in inventory value, and
- enable financial reconciliation to be made and status reports to be prepared for incorporation of the relevant data into the Agency's annual financial accounts.

The Subcontractor shall, as part of the Inventory Control System, maintain an Inventory/Fixed Asset Record (in an electronic tool of his choice) which shall, as a minimum, contain the information as shown in Appendix 4 to this Subcontract.

The Inventory/Fixed Asset Record shall be kept updated by the Subcontractor. It shall be made available to the Agency upon request but as a minimum yearly during the execution of the Subcontract (and at completion of each Project Phase as per ECSS-M-ST-10 if applicable). A final consolidated record shall be submitted with the final contractual deliverables as foreseen in Appendix 4 to this Subcontract.

If the Inventory/Fixed Asset Record also includes any of those items which fall within the scope of Article 2 of the Subcontract, these items are to be clearly set apart.

Items, for which no place of delivery has been identified in Article 2 of this Subcontract, are subject to the following provisions:

Upon completion of the work specified in the Subcontract, the Agency shall take decisions regarding the final destination and final ownership of each item listed in the Inventory/Fixed Asset Record. The Agency shall be free to choose amongst the following options with respect to the final destination and final ownership of such items:

a) the right to claim delivery to the Agency and transfer of ownership (the latter if applicable) with issue of appropriate instructions concerning packing and shipment (at the Subcontractor's expenses);

b) the right to claim or retain ownership and to negotiate with the Subcontractor a Loan Agreement if the Subcontractor is interested in keeping and using an item, with loan conditions making the Subcontractor responsible for the custody, the delayed delivery and the risks involved (at the Subcontractor's expenses);

c) the right to extend the custody of an item to the Subcontractor and to postpone its delivery to the Agency and the associated transfer of ownership – on conditions to be negotiated;

d) the renunciation of any rights to claim delivery and to claim transfer of ownership, leaving the item definitively in the possession and in the ownership of the Subcontractor, with or without financial compensation for the Agency (e.g. repurchase by the Subcontractor) and with or without special instruction;

e) the right to request the Subcontractor to dispose of an item on conditions to be negotiated.

Should the Agency decide to transfer an ESA Fixed Asset to a Third Party(ies) or to dispose of the Fixed Asset, the Subcontractor shall provide the full inventory information of the Fixed Asset to the Agency and complete the transfer or disposal forms to be provided by the Agency upon request by the Subcontractor through the Prime Contractor. The information to be given by the Subcontractor in the forms shall be agreed with the Agency.

The decisions taken by the Agency shall lead to instructions or negotiations, as the case may be and the results shall be recorded in the minutes of meeting.

ARTICLE 5 - COMPLEMENTS AND AMENDMENTS TO THE GCC

The General Clauses and Conditions for ESA Contracts, ref. ESA/REG/002, rev. 4 (GCC), apply to this Subcontract with the following complements and amendments. Provisions of the GCC not mentioned in this Subcontract shall apply unchanged.

Unless differently explicitly stated in the present Article 5, although the text of the General Conditions refers to the roles and the responsibilities between Agency and the Contractor, in the scope of the present Subcontract wherever you read the "Agency" it has to be considered as replaced by "the Prime Contractor", with the exception of:

- Clauses 6, 8.3, 8.4, 24, 27.4, 29, Part II and Annex I where the “Agency” shall mean the “European Space Agency”.

- Clauses 8.2, 8.5, 10.4, 11.8, 18, 26 and 38 where "Agency" means "the European Space Agency, through the Prime Contractor, and the Prime Contractor "; and the relevant clauses shall be interpreted accordingly,

- Where submission to and approval from the Agency is required, this will be done through the Prime Contractor for the purpose of the Subcontract.

and the references to the "Contract" shall be considered to refer to the "Subcontract"; and the "Contractor" to the "Subcontractor".

PART I: CONDITIONS APPLICABLE TO ESA CONTRACTS

CLAUSE 2: APPROVAL AND ENTRY INTO FORCE

For the purpose of this Subcontract the authorised representative of the Prime Contractor are Ms. Lorenza Gilardi (“Technical Officer”) and Mr. Thierry Renard (“Contract Officer”).

CLAUSE 4: ORIGINALS OF THE CONTRACTS

The following provision is added to Clause 4 of the GCC:

The Parties agree that electronic signature of this Subcontract shall have the same force and effect as hand-signed originals and shall be binding on both Parties to this Subcontract.

CLAUSE 5: THE PARTIES’ REPRESENTATIVES

Sub-Clause 5.1: The Prime Contractor’s Representatives

The Prime Contractor’s representatives are:

a) Ms. Lorenza Gilardi for technical matters or a person duly authorised by her (“Technical Officer”).

   All correspondence for technical matters will be addressed as follows:

	To:	With copy to:
Name	Lorenza Gilardi	
Telephone No.	+49 8153 28 1067	
e-mail address	lorenza.gilardi@dlr.de	
Mail Address	DLR e.V., Münchener Str. 20, 82234 Wessling, Germany	

b) Mr. Thierry Renard for contractual and administrative matters or a person duly authorised by him (“Contracts Officer”).

All correspondence for contractual and administrative matters (with exception of invoices as mentioned in Article 3.2) will be addressed as follows:

	To:	With copy to:
Name	Thierry Renard	Lorenza Gilardi +49 8153 28 1067 lorenza.gilardi@dlr.de
Telephone No.	+49 8153 28 1383	
e-mail address	thierry.renard@dlr.de	
Mail Address	DLR e.V. Münchener Str. 20 82234 Wessling, Germany	

c) Personal Data Protection matters shall be addressed to the Data Protection contact point as follows:

	To	With copy to
Name	Uwe Gorschuetz	
Telephone	+49 2203 601 4015	
Email	datenschutz@dlr.de	
Address	DLR e.V. Linder Hoehe 55147 Cologne, Germany	

Sub-Clause 5.2: The Subcontractor’s Representatives

The Subcontractor’s representatives are:

a) Mr. Andrea Pagliosa for technical matters or a person duly authorised by him (“Technical Officer”).

All correspondence for technical matters will be addressed as follows:

	To:	With copy to:
Name	Andrea Pagliosa	
Telephone No.	+39 3386911589	
e-mail address	a.pagliosa@areu.lombardia.it	
Mail Address	Viale Monza 223 20126 Milano (MI)	

b) Mr. Mirko Pugliara for contractual and administrative matters or a person duly authorised by him ("Contracts Officer").

All correspondence for contractual and administrative matters will be addressed as follows:

	To:	With copy to:
Name	Mirko Pugliara	
Telephone No.	+39 3394250828	
e-mail address	m.pugliara@areu.lombardia.it ufficio.progetti@areu.lombardia.it	
Mail Address	Viale Monza 223 20126 Milano (MI)	

c) Personal Data Protection matters shall be addressed to the Data Protection contact point as follows:

	To	With copy to
Name	Sara Moliterni	
Telephone	+39 0267129110	
Email	affari.generalilegali@areu.lombardia.it	
Address	Viale Monza 223 20126 Milano (MI)	

CLAUSE 6: PUBLICITY RELATING TO CONTRACTS

The link to the ESA logo in this clause is replaced with the following link: https://brand.esa.int/logo.

CLAUSE 8: GENERAL CONDITIONS OF EXECUTION

The following provision is added to Clause 8 of the GCC:

8.8 The Subcontractor shall, in accordance with the Agency’s Policy on the Prevention, Detection and Investigation of Fraud, to the extent allowed by applicable national law, cooperate with the Agency’s investigation team in any investigation of fraud initiated by the Agency and inform its personnel of their obligation to cooperate accordingly.

CLAUSE 9: KEY PERSONNEL

9.1 The Subcontractor’s Key Personnel is listed in the Subcontractor’s Proposal referred to in Article 1.2 above.

9.2 The procedure described in this Clause 9.2 shall be implemented through an exchange of letters. The letter may be sent electronically by email to the responsible Prime Contractor’s representatives identified in Sub-Clause 5.1 hereabove. The comprehensive qualification description and professional profile of the new key personnel shall be included in the email, in an encrypted file.

CLAUSE 10: SUBCONTRACTS

Part of the work on this ESA project, as described in the DLR's proposal, is to be subcontracted.

In relation to Article 3.2.3 above, the following provisions are added to Clause 10 of the GCC:

It is explicitly understood that the communication channel described below shall not replace the normal communication lines within the consortium nor the overall responsibility of the Prime Contractor to ensure proper and timely contractualisation and payments throughout the consortium:

A) With a view to optimise Subcontractors' time to payment and financial coverage, and to facilitate, when needed, the resolution of such issues, the Agency has established a dedicated centralised email address.

   Should the Subcontractor encounter serious difficulties in the process leading to:
   (i) timely payment of due invoices (i.e. related to a milestone already achieved) to be made by the Subcontractor's direct customer,
   (ii) contractual coverage of activities already kicked-off, the Subcontractor may directly contact the Agency at: indirectpayments@esa.int

B) The Subcontractor contacting the Agency through the above email shall document the steps already taken towards its direct customer in the consortium in order to resolve the issue and shall document that the Prime Contractor has been informed of the issue.

   In doing so, the Subcontractor shall attach the Standard Contact Form available at: https://esastar-publication.sso.esa.int/supportingDocumentation properly filled in or provide the same information in the body of the email.

CLAUSE 11: CUSTOMER FURNISHED ITEMS (CFI)

It is not foreseen that the Agency nor the Prime Contractor will provide any Items in accordance with Clause 11 of the GCC to the Subcontractor.

CLAUSE 12: ITEMS MADE AVAILABLE BY THE AGENCY

It is not foreseen that the Agency nor the Prime Contractor will make any Items available to the Subcontractor in accordance with Clause 12 of the GCC.

CLAUSE 13: CHANGES

The following provisions are added to Sub-Clause 13.4.1:

Only changes agreed in accordance with this procedure are deemed valid changes of the Subcontract.

Any changes that may impact the contractual baseline shall be implemented through a CCN.

The Subcontractor is informed that, during the course of the ESA Contract, the Prime Contractor shall always submit a CCN proposal to the ESA for the changes in the non-exhaustive list below:
- cancellation or changes to any work package included in the contractual baseline;
- subcontractors' replacements or ceasing their involvement in the activity;
- changes in the breakdown of the ESA Contract price between the Prime and the Subcontractor(s);

The template of a Contract Change Notice (CCN) is attached hereto as Appendix 3.

CLAUSE 14: TIME-LIMITS FOR THE PROVISION OF DELIVERABLES AND SERVICES

The Subcontractor may mark the deliverables documents with the following:

"© [COMPANY NAME] [YEAR OF PUBLICATION]
The copyright in this document is vested in [COMPANY NAME],
This document may only be reproduced in whole or in part, or stored in a retrieval system, or transmitted in any form, or by any means electronic, mechanical, photocopying or otherwise, either with the prior permission of [COMPANY NAME] or in accordance with the terms of ESA Contract No. 4000xxxxxx/XX/XX/xx."

CLAUSE 17: PENALTIES/INCENTIVES

Penalties for late delivery do not apply.

CLAUSE 27: PRICING

Sub-Clauses 27.3 and 27.4 do not apply, unless in case of termination as per Clause 30 of the GCC.

CLAUSE 34: APPLICABLE LAW

The substantive law referred to in Clause 34 of the GCC is the law of Germany. The scope of its applicability is as laid down in the said Clause of the GCC.

CLAUSE 35: DISPUTE RESOLUTION

The arbitration proceedings referred to in Clause 35 of the GCC shall take place in Cologne, Germany.

PART II: CONDITIONS CONCERNING INTELLECTUAL PROPERTY RIGHTS FOR ESA STUDY, RESEARCH AND DEVELOPMENT CONTRACTS

For the purpose of this Subcontract:

- Part II, Option A of the GCC shall apply, as modified by the special provisions below.
- The free licences provided for the benefit of ESA, and DLR to the extent necessary in order to monitor and verify the performance of the Work under the Subcontract and, more generally, as necessary for the fulfilment of DLR's obligations towards the Agency in the frame of the ESA project, in the present Subcontract and in Part II of the GCC, shall be deemed granted through signature of the present Subcontract and without the need to implement a separate licence.

The following provisions are added:

CLAUSE 36: GENERAL

The following provision is added to Sub-Clause 36.2 of the GCC:

The term "documentation" as defined in Annex IV to the GCC shall be interpreted to also include data files, CAD files, EXCEL® files and similar electronic files, which shall not be considered as "software" in the sense of Clause 42 of the GCC.

The Subcontractor's contributions to the electronic files containing these items shall be delivered to the Prime Contractor in the format agreed with the DLR Technical Officer specified in Article 5, Clause 5, Sub-Clause 5.1 a) of the Subcontract.

CLAUSE 37: INFORMATION TO BE PROVIDED

The following provision is added to Sub-Clause 37.2 of the GCC:

The Subcontractor shall not mark any documents as "Proprietary Information" unless agreed in advance with the Agency through the Prime Contractor. Any request from the Subcontractor shall be submitted accompanied by an appropriate justification.

CLAUSE 38: DISCLOSURE

The following provision is added to Sub-Clause 38.2 of the GCC:

The access rights granted to the Agency's employees under Sub-Clause 38.2 of the GCC are hereby extended to Prime Contractor and Subcontractor personnel providing technical, management, legal or administrative support to ESA as long as they have signed an engagement of confidentiality.

CLAUSE 43: BACKGROUND INTELLECTUAL PROPERTY RIGHTS

In pursuance of the requirements of Sub-Clause 43.1 of the GCC, the following is recorded:

At signature of this Subcontract, the Subcontractor has not identified Background Intellectual Property to be used for the purposes of the present Subcontract.

a) Notwithstanding the above, the following is agreed:
• if the Subcontractor, after the signature of the Subcontract, invokes the existence of Background Intellectual Property to be used and/or delivered for the purposes of the present Subcontract, the Subcontractor shall provide conclusive evidence to the Prime Contractor of the existence of this Background Intellectual Property and shall justify the reasons for which the existence of this Background Intellectual Property was not invoked before the Subcontract signature.

• If conclusive evidence and appropriate justification are provided by the Subcontractor for such additional Background Intellectual Property, the Parties shall formalise a Contract Change Notice to specify in detail which Information has been recognised as Background Intellectual Property.

• Conversely, if such evidence and justification are not provided, such additional information shall be deemed as having been generated in the frame of the Subcontract.

Sub-Clauses 43.4 and 43.7:

For the purpose of Sub-Clauses 43.4 and 43.7 of the GCC, the term “Agency Project” shall refer to the activities under the ESA Contract.

ARTICLE 6 – PERSONAL DATA PROTECTION

6.1 The Agency and the Prime Contractor shall be separate Data Controllers of the personal data of the Subcontractor specified in Clause 5.2 and referred to in Clause 9 above.

6.2 The Agency processes Personal Data subject to the ESA PDP Framework, i.e. the Personal Data Protection Framework applicable to ESA and available at http://www.esa.int/About_Us/Law_at_ESA/Highlights_of_ESA_rules_and_regulations.

6.3 A Privacy Notice regarding the processing of the Personal Data by the Agency for this processing operation is available at https://esastar-publication.sso.esa.int/supportingDocumentation/details/39.

6.4 The Subcontractor shall share the above-mentioned ESA Privacy Notice, with all Key Personnel whose Curricula Vitae were submitted to ESA.

6.5 The Subcontractor shall be a separate Data Controller of the contact details of DLR's Representatives as specified in Clause 5.1.

6.6 The Subcontractor and the Prime Contractor shall process the above-mentioned contact details of the other Party's Representatives subject to the Personal Data protection laws and regulations applicable to them (e.g EU Regulations in the field of personal data protection, including but not limited to the General Data Protection Regulation (Regulation (EU) nr. 2016/679) (hereinafter "GDPR").

6.7 The Personal Data exchanged by the Parties and ESA in the frame of this Subcontract will only be processed for:
a) the performance of the ESA Contract, including implementation, management, monitoring, audits and the fulfilment of the obligations set out herein;
b) the management of the relationship of the Parties in relation to the Subcontract, notably for administrative, financial, audit or for communication purposes;
c) the compliance with any legal or regulatory obligation to which a Party is subject.

Electronically/Digitally signed by the Parties to this Subcontract,

In: Cologne

On: 10.12.2025

For: Deutsches Zentrum für Luft- und Raumfahrt (DLR)

______________________________ i.A. Marion Lenz-Wendt Head of Department Procurement for Third-Party Funding (Projects)	______________________________ i.A. Thierry Renard Contract Officer Procurement for Third-Party Funding (Projects)

In: Milano

On:

For: Agenzia Regionale Emergenza Urgenza

______________________________	______________________________

APPENDIX 1: PAYMENT PLAN AND KICK-OFF PAYMENT(S) AND OTHER FINANCIAL CONDITIONS

Milestone Payment Plan:

Milestone (MS) Description	**Schedule Date**	**Payments from DLR to Subcontractor (In Euro)**
Progress (MS 1): Upon successful completion of all related tasks as defined in the SoW, including: • the preparation of the D1.1 Assessment Report (Table of Contents and draft version) • the delivery of the initial D5.1 Project Management Plan • the creation of the open-access repository (D2.3 v1), as reviewed and accepted by ESA.	05.06.2026	4.444
Progress (MS 2): Upon acceptance by ESA of : • the final D1.1 *Assessment Report on Climate and Health;* • the updated D5.1 *Project Management Plan*, • the initialization of *D2.1 Risk Identification and Assessment Document* and of *D2.2 Uncertainty and Validation Analysis* • the updated version of the open-access repository (D2.3 v2) and • the successful completion of the First Annual Review.	05.12.2026	4.850
TOTAL Phase 1		**9.294**
Payment Plan for Phase 2 (following release by the Agency and consequently the Prime Contractor of an Authorisation to Proceed with this Phase)		
Progress (MS 3): Upon acceptance by ESA of: • the D2.1 *Risk Identification and Assessment Document* • the D2.2 *Uncertainty and Validation Analysis* • the updated open-access repository (D2.3 v3) • the submission of the first scientific publication (D2.4 – PUB1) • the initialization of *D4.1 – Climate and Health Adaptation Roadmap*	05.06.2027	13.316
Progress (MS 4): Upon completion and ESA validation of: • the draft D3.1 *Health Burden Characterisation* • and the draft D3.2 *Uncertainty and Validation Analysis* • and the successful completion of the Second Annual Review	05.12.2027	6.034
TOTAL Phase 2		**19.350**
Payment Plan for Phase 3 (following release by the Agency and consequently the Prime Contractor of an Authorisation to Proceed with this Phase)		
Progress (MS 5): Upon ESA acceptance of: • the final D2.3 – Open-access and Public Repository; • the final D3.1 – Health Burden Characterisation; • and the final D4.1 – Climate and Health Adaptation Roadmap.	05.06.2028	19.424

Final Settlement (MS 6): Upon ESA acceptance of: • the final D3.3 – Update of the Open-access and Public Repository; • the submission of D3.4 – Scientific Publication (PUB2); • the final D5.2 – Executive Summary of the Project; • the final D5.3 – Final Report of the Project; • and the final D5.4 – Outreach and Communication Material Document. • and the successful completion of the Final Review Meeting	05.12.2028	21.932
TOTAL Phase 3		**41.356**
TOTAL SUBCONTRACT		**70.000**

<u>Kick-Off Payments and other Financial Conditions</u>:

Kick-Off Payment (in Euro)	Offset against	Offset by Euro	Condition for release of this Payment
3.253	MS 2	3.253	Upon signature of the Subcontract by both Parties and the holding of the Kick-Off Meeting.
6.772	MS 3 MS 4	2.772 4.000	Upon ESA, and consequently DLR, authorisation to proceed with Phase 2.
14.475	MS 5	14.475	Upon ESA, and consequently DLR, authorisation to proceed with Phase 3.

APPENDIX 2: STATEMENT OF WORK

Reference ESA-EOP-SC-RS-2024-53, issue 0.5, dated 02/11/2024.

not attached hereto but known to both Parties.

APPENDIX 3: CONTRACT CHANGE NOTICE

For submission of a change as per Clause 13 of the General Conditions, the Contractor shall submit his proposal in the format of a CCN using the cover page included below. The form shall be filled with the following information as a minimum:

- The Contractor's name and the Contract number
- The title of the area affected by the change (Work Package reference, new work, etc.)
- The name of the initiator of the change (Contractor or ESA)
- The description of the change (including Work Package Descriptions, WBS, etc.)
- The reason for the change
- The price breakdown in €, if any (breakdown by company, Phase, etc., including PSS-A2 and PSS-A8 forms)
- The Milestone Payment Plan for the CCN if any
- Effect on other Contract provisions
- Start of work - end of work (including contractual delivery dates and overall planning, milestones, etc.)
- A CCN Form, as per the format below, signed by the Contractor's representatives

The Contractor shall, on request of the Agency, provide additional documentary evidence. At the request of either Party, the proposed change may be discussed at a Change Review Board, consisting of both the Contracts Officer and the Technical Officer of each Party.

<table>
<tr><td rowspan="2">esa</td><td rowspan="2" colspan="2">DIRECTORATE:</td><td colspan="3">Contractor:</td></tr>
<tr><td colspan="3">Contract No.:</td></tr>
<tr><td rowspan="2">CONTRACT CHANGE NOTICE No.</td><td colspan="2">ISSUE:</td><td rowspan="2">DATE:</td><td rowspan="2" colspan="2">PAGE:</td></tr>
<tr><td colspan="2">DOC. No.:</td></tr>
<tr><td colspan="3">TITLE OF AREA AFFECTED (WORK PACKAGE ETC):</td><td colspan="3">WP REF:</td></tr>
<tr><td colspan="3">RECOMMENDED CLASS (A or B):</td><td colspan="3">INITIATOR OF CHANGE:</td></tr>
<tr><td colspan="6">DESCRIPTION OF CHANGE</td></tr>
<tr><td colspan="6">REASON FOR CHANGE</td></tr>
<tr><td colspan="6">PRICE BREAKDOWN (Currency)/PRICE-LEVEL</td></tr>
<tr><td colspan="5" rowspan="2">EFFECT ON OTHER CONTRACT PROVISIONS</td><td>START OF WORK</td></tr>
<tr><td>END OF WORK</td></tr>
<tr><td colspan="2">CONTRACTOR’S PROJECT MANAGER:

DATE:</td><td colspan="4">CONTRACTOR’S CONTRACTS OFFICER:

DATE:</td></tr>
<tr><td colspan="6">[DISPOSITION RECORD OR OTHER AGREED CONDITION RECORDED WITH THE CCN APPROVAL]</td></tr>
<tr><td colspan="2">ESA TECHNICAL OFFICER:

DATE:</td><td colspan="4">ESA CONTRACTS OFFICER:

DATE:</td></tr>
</table>

APPENDIX 4: INVENTORY/FIXED ASSET RECORD

1.1. Content of Electronic Inventory/Fixed Asset Record

The Contractor shall establish an electronic Inventory/Fixed Asset Record with, as a minimum, the following information:

For all items:
- contract number / Subcontract number if applicable
- unique item number
- confirmation that the item has been marked with the unique item number
- description of item
- part number/serial number/type code
- quantity
- system/subsystem
- property owner
- manufacturer
- classification (category – see section 1.2 below)
- acquisition value (i.e. original purchase price or price at contract signature as applicable)
- date of purchase or production ("in service date" if not corresponding with date of purchase/production)
- in-service date
- foreseen useful life (to be agreed with ESA)
- physical location (e.g. facility, building, room)
- entity responsible for care and custody
- related WBS code or other identifier to be coordinated with the Agency)
- description and date of any change to the property item
- planned method of disposal (if applicable)

In addition to the above, the following information shall be added to those items that are identified as becoming ESA Fixed Assets in Article 3 of the Contract, as applicable.

- Acquisition value
  - revision of this value as a result of change(s) to the asset
- Impairment report of each ESA Fixed Asset remaining in the custody of the Contractor after its acceptance by ESA (using the template that will be provided by the Agency upon announcement by the Contractor that the item has been impaired)
- date of acceptance by ESA (planned date of acceptance)
- foreseen handling after ESA acceptance (e.g. transfer to ESA, continuing in custody of the Contractor)

1.2. Classification of Inventory/ Fixed Assets items

For the purpose of Inventory/Fixed Asset Control, items shall be classified into five categories, according to the source and intended use of the items, as follows:

Source / Purpose	Supplier-acquired Items	Customer-furnished Items
Consumable items (e.g. parts, materials, supplies)	Class 1	Class 2
Capital items/production support equipment and tools (e.g. instruments, jigs, fixtures)	Class 3	Class 4
Items purchased by the Supplier or his lower tier suppliers on their own account but amortised under the Contract.	Class 5	

Note 1: Consumable items are parts, materials, supplies, components, modules, minor expendable tools, assemblies, units and subsystems which through the production process lose their identity and are absorbed directly or indirectly by the system/product to be provided under the Contract.

Note 2 Consumable items in principle are not capitalised per item, however, before consumption they are identified as assets of the Agency under the collective term "Consumable".

Note 3: Capital items/production support equipment and tools are jigs, fixtures, devises, apparatus, instruments, machines, installations, technical facilities, buildings, computer programmes, documentation, models, samples or any other item which, after their use in or in conjunction with the production process under the Contract, are expected to have a residual utility or other value for the Agency.

Note 4: Capital items have a useful life of more than one year and are identified as individual items in the Supplier and his lower tier suppliers list of Agency's assets

CLIMAte change and health emergency CARE (CLIMA-CARE)

Technical Proposal

Presented by the German Aerospace Center (DLR e. V.)
in response to ESA ITT AO/1-12639/24/I-LR
CLIMATE SPACE: CLIMATE CHANGE AND HEALTH ACTIVITY – RE-ISSUED

Contents

DETAILED PROPOSAL

1. BACKGROUND AND FACILITIES

1.1. Background of the company(ies)

1.1.1 Deutsches Zentrum für Luft- und Raumfahrt (DLR)

The German Aerospace Center (DLR) is the national research institution for aeronautics and space in Germany. It works in aeronautics, space, energy, transport, digitalization, and security, collaborating with national and international partners. Besides its own research, DLR manages Germany's space program for the federal government and oversees one of the country's largest project management agencies.

DLR has about 11,000 employees in 30 locations across Germany and offices in Brussels, Paris, Tokyo, and Washington D.C. In this project, the Trace Gases team from the Atmosphere department will contribute. The department is part of the German Remote Sensing Data Center (DFD), which is based in Oberpfaffenhofen (Bavaria) and Neustrelitz (Mecklenburg-Western Pomerania). Together with the Remote Sensing Technology Institute (IMF), DFD forms the Earth Observation Center (EOC), Germany's key center for Earth observation.

DFD provides data and services for science, industry, and public institutions. It operates national and international ground stations, giving direct access to Earth observation satellite data. DFD processes this data, distributes it to users, and stores it long-term in the German Satellite Data Archive (D-SDA). Its research focuses on the atmosphere, climate, global change, and civil security, helping to apply remote sensing in science and business. DFD also develops customized applications for crisis management at the Center for Satellite-Based Crisis Information (ZKI). The German Remote Sensing Data Center is ISO 9001 certified.

The Trace Gases team of the Atmosphere department at DFD, DFD-ATM, specializes in developing, validating, and applying atmospheric climate and air pollution data products from diverse sources, with a strong focus on high-resolution datasets. These products enhance exposure and health risk assessments. With extensive experience in time series and trend analysis, as well as evaluating health risks associated with air pollution and climate stressors, the team collaborates closely with leading medical research institutions (e.g., Barcelona Institute for Global Health, Heidelberg Institute of Global Health, Helmholtz Munich, and DLR Institute of Aerospace Medicine) and health insurance companies (e.g., AOK Baden-Württemberg, Barmer) to advance the integration of Earth Observation data in health-related research.

Their expertise spans chemical transport model development and optimization (e.g., POLYPHEMUS/DLR), satellite data retrieval, and statistical/machine learning-based downscaling techniques. They integrate emission data, ground-based measurements, and complementary datasets to refine air quality assessments. A key research focus is the impact of environmental stressors on health and well-being in urban environments. The team applies models such as PALM4U to simulate scenarios assessing air pollution and thermal stress effects on public health. Furthermore, they develop user-friendly platforms (e.g., AlpAirEO and

BioCliS) to disseminate health risk information, making exposure data on air pollution and thermal stress accessible to stakeholders.

Beyond research, the team actively contributes to evidence-based decision-making and policy development for urban health challenges. Collaborating with health insurers, governmental environmental and health authorities (e.g., Bavarian Health and Food Safety Authority (LGL), Bavarian State Ministry of Health and Care), medical research institutions, and global research initiatives (e.g., EuroGEO), they support the development of sustainable, resilient cities that prioritize public health. Their work informs health and environmental policies at city and regional levels, including in the Free and Hanseatic City of Hamburg and the Free State of Bavaria.

Related Experience and Projects

Earth Observation for Climate Change Adaptation and Mitigation (EO4CAM)

- **Funding Organization:** Bavarian Ministry of Economic Affairs, Regional Development and Energy
- **Lead Institution:** DLR
- **Duration:** 09/2024 – 08/2028
EO4CAM (Earth Observation Laboratory for Climate Adaptation and Mitigation) provides decision-makers with Earth Observation data to support climate adaptation and mitigation strategies. Satellite data enables the detection of gradual environmental changes over past decades and high-resolution monitoring of ongoing developments. These observations are used to develop predictive models, estimating future trends and guiding climate adaptation measures.

The project targets policymakers, offering objective and reliable insights through the EO4CAM data portal. The focus areas include urban environments, agriculture, forestry, geohazards, biodiversity, and health. EO4CAM brings together a dedicated expert group to explore how Earth Observation can support policy, public administration, and society in addressing climate change impacts. Initially focusing on Bavaria, the project involves the German Remote Sensing Data Center (DFD) of DLR, along with the Earth Observation Research Cluster (EORC) at Julius-Maximilians-Universität Würzburg (JMU), including the Chair of Remote Sensing and the Chair of Global Urbanization and Remote Sensing.

Environmental Stressors and Health Costs

- **Funding Organization:** German Aerospace Center (DLR)
- **Lead Institution:** DLR
- **Duration:** 01/2023 – 12/2026

The Environmental Stressors and Health Costs project investigates the health and economic consequences of air pollution and climate-related stressors. By integrating Earth observation data, health insurance records, and economic models, it aims to quantify population exposure, healthcare costs, and life quality losses (measured in DALYs and QALYs).

As the successor to the Environmental Stressors and Health project (2018 - 2022), this initiative builds on the existing collaboration with Institute for Aerospace Medicine (DLR ME-MKW), expanding its scope and methodologies. It develops a harmonized database to analyze dose-response relationships between pollution, temperature extremes, and health outcomes such as hospitalizations, mortality, and sick leaves due to illness. Economic modelling assesses both direct medical costs and indirect productivity losses linked to environmental stressors.

A key outcome will be a Policy Summary Report, translating scientific findings into actionable recommendations for policymakers and stakeholders. The project supports evidence-based decision-making for health and environmental policies, contributing to urban resilience and public health strategies.

Led by DLR DFD-ATM, with contributions from DLR ME-MKW) and the health insurance company AOK Baden-Württemberg, the project strengthens the role of Earth observation in health risk assessment and environmental justice.

Bioclimatic Information System for Bavaria

- **Funding Organisation:** Ministry of Health and Health Care, Ministry of Environment and Consumer Protection
- **Lead Institution:** DLR
- **Duration:** 01/2019 - 12/2022

The project was embedded in the "Climate Change and Health" reseach initiative and aimed to assess the impact of atmospheric environmental stressors on the health of Bavarian citizens. A key outcome of this project was the development of the BioClis (Bioclimatic Information System) prototype, which quantifies the health risks from heat and cold stress, as well as air pollutants. Integrated into the AlpEnDAC platform of the Virtual Alpine Observatory (VAO), BioClis provides real-time, spatially detailed, and color-coded analyses and predictions via a web-based interface.

BioClis simplifies complex environmental data into two main indices: the Aggregated Risk Index (ARI) and the Universal Thermal Climate Index (UTCI), which are presented in an easily understandable format. These indices are available on a county level for Bavaria, making the information accessible and actionable, especially for vulnerable groups such as the elderly. BioClis also allowed for a detailed statistical analysis of long-term health risks from heat stress and air pollution.

The system supports proactive health behavior and climate adaptation measures, contributing to the Bavarian Climate Adaptation Strategy (BayKLAS) by reducing the negative health impacts of climate stressors through preventative actions. BioClis serves as an innovative tool for public health prevention, diagnostics, and therapy, ultimately improving quality of life in the context of climate change.

e-shape : EuroGeo Showcases - Applications powered by Europe

- **Funding Organisation:** EU H2020
- **Lead Institution:** Armines
  Duration: 05/2018 - 04/2022

Supporting eight of the 17 Sustainable Development Goals (SDGs) from the United Nations (UN), the e-shape initiative aimed at moving away from a data-driven to a user-focused approach by gathering the knowledge of decades of public investment in the field of Earth Observation (EO) and cloud capabilities. With 32 project pilots spread out into seven thematic areas and keeping onboarding new ones, e-shape strived to provide EO services to decision-makers, citizens, industry and researchers.

e-shape's seven thematic activities, called showcases, are: *agriculture, health, energy, ecosystem, water, disasters* and *climate*. They all addressed societal challenges, foster entrepreneurship and support sustainable development, in alignment to the three main priorities of GEO (SDGs, Paris Agreement and Sendaï Framework). Their main goal was to strengthen EuroGEO as Europe's contribution to the Global Earth Observation System of Systems (GEOSS), aiming at bringing together Earth Observation resources in Europe.

In the frame of the health showcase were DLR was involved, the project pilot 2.3 "EO-based health risk profiling in the urban environment" aimed to improve air quality and health information in cities. The objectives of this pilot were:

- To improve health information, from air pollution data and land use/health/socio-economic features of cities, for use in public health assessment and urban planning.
- To evaluate and exploit citizen science data towards their integration with the official measurements.
- To strengthen decision making by allowing for pollution mitigation scenarios and provision of alerts.
- To raise awareness on AQ implications on public health, enhancing the citizen participation

ELK : Emissions, Air Quality and Climate Change in Hamburg

- **Funding Organisation:** DLR
- **Lead Institution:** DLR
  Duration: 05/2018 - 04/2022

As part of the DLR ELK project, a multimodel system was developed to conduct detailed analyses of air pollutant emissions and immissions as well as climate change interactions in the Hamburg metropolitan area. The goal of the project was to quantify the influence of various transport modes and environmental factors both on emissions and pollution sides, and to compare different modeling approaches in terms of their representativeness – comprising global coupled chemistry climate models down to urban climate models that resolve turbulence and buildings on street-scales for whole city regions.

A full simulation for the year 2019 was carried out using the EPISODE-CityChem model with a horizontal grid resolution of approximately 100 x 100 meters for the entire Hamburg region. Additionally, selected episodes were simulated with up to 5-meter spatial resolution in downtown Hamburg using PALM-4U. Initial results highlight the potential of high-resolution chemistry-transport models for comprehensive city-wide analysis and air quality assessment.

To investigate the effects of the mobility transition on air quality, scenarios for 2019 and 2030 were simulated based on agent-based traffic demand models and macroscopic traffic flow models TAPAS and SUMO. The coupling of PALM-4U with the climate-chemistry model

MECO(n) also enabled the analysis of the impacts of climate change on air quality and other urban climatological variables using climate projections.

The high-resolution emission inventories and air pollution maps were made available to user groups and stakeholders from the fields of politics, research, and society through various interfaces and media.

1.1.2 Politecnico di Milano (POLIMI)

Founded in 1863, the Politecnico di Milano is a public scientific-technological university that trains engineers, architects and designers. Many prominent scientists and architects have studied and taught here, including Achille Castiglioni, Gio Ponti, Gae Aulenti, Renzo Piano and Aldo Rossi, both Pritzker Prize winners in 1990 and 1998, respectively, and Giulio Natta, Nobel Prize winner for Chemistry in 1963. The Politecnico has always focused on quality and innovation in teaching and research, developing a fruitful relationship with the economic and productive reality through experimental research and technology transfer. Research is linked to teaching and is a priority commitment that enables the Politecnico di Milano to achieve high-level international results and to realize the meeting between the university and the business world. According to the QS World University Rankings 2025, Politecnico di Milano is ranked 1st in Italy and 111th in the world.

The Department of Electronics, Information and Bioengineering (DEIB) is one of the largest Information and Communication Technology (ICT) departments in Europe. With nearly 1,500 employees, the Department is a vital entity capable of supporting education, basic research, applied research, and technology transfer activities to companies. Research is DEIB’s main goal and it is pursued according to the highest international standards of quality. The Department's six sections bring together established competencies in the research areas of control systems, computer science, electronics, telecommunications, bioengineering and electrical engineering, but they also contribute, each with the peculiarities of their disciplines, to the methodological, technological and applicative development of five cross-cutting research areas: Artificial Intelligence (AI) Technologies; High Performance Computing, Smart Sensors and Big Data; Health Sciences and Technologies; Smart and Sustainable Eco-systems: Cities, Energy and Mobility; and ICT for Industry 4.0. The quality of the research work is evidenced by the extensive network of collaborations with top international institutions, which makes the Department a major player in the global scientific and technological innovation scenario. The DEIB has always shared with the Politecnico di Milano a strong vocation to cooperate with industry and society to bring real-world problems closer to academia. DEIB researchers are constantly engaged in long-term activities and application projects that have an immediate impact on companies. To this day the DEIB has registered a large number of patents and gave birth to many incubated and spin-off companies. The DEIB has always shown a constant ability to attract projects and investments, both from public agencies and private companies, national and international wise: it has participated in 129 H2020 projects, with a total value of about 51M€, and currently participates in about 45 Horizon Europe projects, with a total value of 24.3M€.

In particular, the resource that will participate to the project belongs to the D-Hygea Lab, within the Bioengineering section of DEIB. It is an open multidisciplinary environment devoted towards the development of innovative and practical solutions to reach the demand of different stakeholders, in terms of health promotion and disease prevention. In particular, the person involved in the project is the leader of the research group dedicated to Health-Geomatics, i.e. the application of geomatics theories and methods to health and healthcare-related issues. The goal is the development of data driven solutions to support decision-making in public health, based on the analysis of geo-localized data relevant to specific geographical territories and populations, with different goals including:

- Optimization of healthcare resources, with particular focus on emergency services
- Monitoring and prediction tools for the prevention of pandemic phenomena
- Exploring the spatial-temporal relation between non communicable diseases (cardiovascular and respiratory) and environmental features, with a specific focus on pollutants and heat-waves, towards the planning of smart health cities.

Related Experience and Projects

Data-driven moDelling of particUlate with Satellite Technology aid (D-DUST)

- **Funding Organization:** Cariplo Foundation
- **Lead Institution:** Politecnico di Milano – Department of Civil and Environmental Engineering
- **Duration:** 2021-2023

The project was devoted to investigate the impact of agricultural and zootechnic activities on the concentration of particulate matter in the air, exploiting satellite data for a continuous mapping. The specific role of the D-Hygea Lab team was to carry on the final work package, oriented at modelling the relation between agricultural land (and other land-use classes) and PM concentration with the support of Artificial Intelligence algorithm specifically developed for geospatial analysis. A full project repository is available at https://github.com/gisgeolab/D-DUST. This project allowed to acquire significant competences in terms of processing of EO data, and in particular in their use within explainable AI applications, along with the management of open access web-based repositories.

URBan ANAlytics (URBANA)

- **Funding Organization:** European Space Agency
- **Lead Institution:** GMATICS srl
- **Duration:** 2024-2025 (ongoing)

The project has the objective of developing various innovative analytics for enhancing the urban planning and analysis of urban environmental parameters and their impacts on people and infrastructures in urban areas. The project's primary goals include: I) Analysing the background, current activities, information needs and objectives of the involved stakeholders; II) Developing innovative analytical capabilities by combining Earth Observation (EO) data with non-EO data to provide insights that can transform urban planning and management; III) Testing and validating analytical procedures through demonstrative pilot projects agreed upon in collaboration with key stakeholders, and the generation and provision of test products to the

end-users to ensure their effectiveness and accuracy; IV) Defining a roadmap for future operational services, tailored to meet the needs of various users, enhancing the quality and efficiency of current services available.
As a subcontractor, the specific role of the D-Hygea Lab team is to develop one project pilot in collaboration with AREU (also part of the tender group) to assess the potential impact of heatwaves on the provision of Emergency Medical Services at intra-urban scale, considering the city of Milan (IT) as study case. The URBANA project is serving as an excellent ground for refining the modelling competences of exposure-response relationship to evaluate climate impact on human health, also considering population- and geography-related factors.

AdvaNced Technologies for Human-centrEd Medicine (ANTHEM)

- **Funding Organization:** Cariplo Foundation
- **Lead Institution:** National Plan for NRRP Complementary Investments
- **Duration:** 2023-2026 (ongoing)

The project aims to bridge the existing gap in healthcare for frail and chronically ill patients within specific areas affected by diseases lacking therapeutic options, through the use of technologies and innovative, multidisciplinary approaches. Research areas include smart monitoring: (development of new sensors and technologies or improvement of existing ones), prevention and diagnosis (development of new technologies and Artificial Intelligence (AI) methodologies to enhance diagnostics), personalized treatment (enhancement and expansion of personalized medicine pathways), and technological improvement and transferability. The D-Hygea Lab is involved in Spoke 3 “Risk factors monitoring, diagnostic tools and therapies in chronic disease”, whose goal is to design and develop innovative solutions for the assessment of chronic patients, the impact of environmental factors and lifestyle on health, and the identification of risk factors. Specifically, the role of the D-Hygea Lab team is to develop descriptive models to assess the short-term impact of environmental variables, in particular heatwaves and air pollution, on public health.

1.1.3 Group on Earth Observations (GEO)

The Group on Earth Observations (GEO), an established intergovernmental partnership of 115 member countries and over 140 participating organizations, brings exceptional expertise to this climate change and health activity through its proven record in coordinating global Earth observation initiatives at the intersection of urban environments, health, and climate change. Hosted by and enjoying a close working relationship with the World Meteorological Organization (WMO)—the UN's Specialized Weather/Climate agency—GEO leverages this strategic alliance to strengthen its global impact. GEO's Resilient Cities and Human Settlements Working Group (RCHS-WG) develops comprehensive approaches to integrating Earth observations into urban resilience frameworks worldwide, supporting cities in making evidence-based decisions that enhance climate resilience.

Additionally, GEO's Climate Change & Disaster Risk Reduction Working Group and the EO4Health Community of Practice (including its Heat-Health study group) provide specialized expertise that will be leveraged for scoping and reviewing project outputs, ensuring scientific rigor and practical relevance across climate and health domains. Through its unique position at the nexus of international cooperation, Earth science, and sustainable development, GEO delivers Earth intelligence solutions that address pressing global challenges.

Related Experience and Projects

The Global Heat Resilience Service

GEO is currently designing the Global Heat Resilience Service (GHRS), its flagship response to the UN Secretary-General's Call to Action on Extreme Heat (June 2024). This initiative addresses the escalating health risks posed by extreme heat events through standardized heat risk assessment methodologies, high-resolution urban heat modelling, and vulnerability assessment frameworks. Working with key partners including the World Meteorological Organization (WMO), the Global Climate Observing System (GCOS), DLR, C40 Cities Climate Leadership Group, and IBM, GEO is developing a co-designed service that translates complex climate and health data into actionable intelligence for cities worldwide. The GHRS provide actionable-insight of urban "hot spots" and vulnerable populations, accounting for factors like healthcare access, infrastructure quality, and socioeconomic status, then translates these insights into practical heat resilience strategies through user-friendly digital decision support tools. Co-design of this service is being taken forward with partner cities in Europe, Brazil, India, and Africa. Early conceptual design of the GHRS platform was scoped and explored through ESA’s Space & Global Heatlh Hackathon held in Geneva in May 2024.The GHRS is being supported through Horizon Europe with initial funding specifically allocated to GEO's collaboration with WMO and GCOS to scope and develop standardized heat risk assessment methodologies that can be implemented at the urban scale.

1.1.4 Agenzia Regionale Emergenza Urgenza (AREU)

The Regional Agency for Emergencies and Urgencies (Agenzia Regionale Emergenza Urgenza - AREU) is the regional public emergency healthcare system in the Lombardy region in Italy. It’s an agency with the goal of standardizing responses and performance, and it is closely integrated with the healthcare and social healthcare facilities throughout the region to ensure continuity of care for citizens. AREU’s work extends across the entire regional serving a population of approximately 10 million inhabitants.

In accordance with our regional guidelines, AREU guarantees the following services across the region:

- Intra-regional and inter-regional coordination, direction, management, implementation, and monitoring of the pre-hospital Emergency Urgency System (Service 118);
- Operation of the Single Emergency Number (NUE) 112;
- Operation of the European Harmonized Number 116117 (NEA), providing non-urgent medical care with a social;
- Logistical coordination for the collection, transport, and transplantation of organs and tissues;
- Coordination of transfusion activities, blood exchange flows, and compensation of blood, blood components, and blood products.

Also, AREU collaborates with the Civil Protection system to handle major emergencies and promotes scientific research activities. We offer specific training and refresher courses for professionals involved in the Agency's activities. AREU collects ambulance data of the entire Lombardy region (about 10 million of users) with his own software "EMMA". It collects events data about the performance of the ambulance (in the past ten years it has been collected over 8million events). Furthermore, it collects time of the performance and patients' health data (about 8 million in the past ten years).

Related Experience and Projects

Valkyries H2020

- **Funding Organization:** European Commission - Horizon 2020 programme
- **Lead Institution:** Indra Sistemas S.A.
- **Duration:** 2021-2023

The project seeks to develop, integrate, and demonstrate the ability to provide an immediate and coordinated response to emergencies related to search and rescue, health, and safety in scenarios involving natural or man-made disasters with numerous victims.

Iprocure - PS-PCP, iProcureSecurity Pre-Commercial Procurement

- **Funding Organization:** European Commission - Horizon 2020 programme
- **Lead Institution:** SYNYO GmbH
- **Duration:** 2021-2024
  The project is one of the Horizon 2020 projects funded by the European Union. Its goal is to develop innovative solutions for triage in the context of mass emergencies, providing a quick and accurate overview of victims and their conditions.

The utility of this information is to support decision-making for better resource allocation and rapid treatment of the injured, improving interoperability among responders and reducing the time related to information exchange.

NextGeneration eCall

- **Funding Organization:** European Commission - Horizon 2020 programme
- **Lead Institution:** ITS Mobility Gmbh
- **Duration:** 2024-2027 (ongoing)

The project, involving the participation of 11 countries and lasting for 36 months, prepares the EU Public Safety Answering Points (PSAPs) for the new eCall system based on the number 112. The objectives of the eCall NG project include updating infrastructures and procedures with technologies that, in addition to the current circuit-switched network, also encompass packet-switched networks (VoIP), as required by the new European regulations

URBan ANAlytics (URBANA)

- **Funding Organization:** European Space Agency
- **Lead Institution:** GMATICS srl
- **Duration:** 2024-2025 (ongoing)
-

As detailed for Polimi, the project has the objective of developing various innovative analytics for enhancing the urban planning and analysis of urban environmental parameters and their impacts on people and infrastructures in urban areas. AREU is participating as the reference stakeholder for the D-Hygea Lab team, in the development of a pilot to assess the potential impact of heatwaves on the provision of Emergency Medical Services at intra-urban scale in the city of Milan. AREU role is to provide insights about stakeholder's needs and priorities, and to test the developed pilot to generate an assessment report, identifying potential application, evaluating usability and pinpointing critical issues.

1.2. Overall Team composition, Proposed Key Personnel

The CLIMA-CARE project calls for a diverse team of specialists in Earth Observation, epidemiology, climate science, and cloud computing. As the lead organization, DLR has strategically brought together a group of experts with complementary competencies, forming a well-rounded team that meets the project's technical demands and drives its innovative objectives. The project benefits from a strong foundation of **previous collaborations** among the key partners, for example:

- **DLR** and **PoliMi** have an ongoing collaboration in health risk assessment related to air pollution. A PhD student from Polimi is currently spending six months at the DLR facility, where she is developing a health risk model to support the "Environmental Stressors and Health Costs" project. This work provides the methodological foundation that will be further adapted and developed during the course of the CLIMA-CARE project.

- **DLR and GEO** have established a productive, multi-faceted partnership spanning several joint initiatives focused on Earth observation applications for societal benefit. As a Participating Organization of GEO, DLR has been strategically involved in multiple GEO flagship initiatives. The collaboration began formally through the e-shape project (EuroGEO Showcases: Applications Powered by Europe), where DLR contributed its expertise in atmospheric monitoring and air quality data processing to develop services aligned with GEO's vision of accessible Earth observation data. DLR has also been actively engaged in the Human Planet Initiative, contributing valuable Earth observation expertise and datasets for monitoring human settlements and urbanization patterns that form critical baseline information for climate-health risk assessments. More recently, DLR and GEO have significantly deepened their collaboration on urban heat resilience initiatives, with DLR being a key technical contributor to the development of GEO's Global Heat Resilience Service (GHRS). Dr. Erbertseder (DLR) participated centrally in the initial "HeatSprint" co-design workshop in February 2024, bringing DLR's thermal remote sensing capabilities and climate science expertise to help shape the early conceptualization of the service. This early engagement has been instrumental in defining standardized methodologies for urban heat risk assessment and identifying appropriate Earth observation data sources for the GHRS platform.

- **PoliMI and AREU** can rely on almost ten years of collaboration on research activities, exploiting PoliMI analytical capabilities to process the large dataset systematically collected by AREU since 2015, relevant to multiple aspects of the provision of Emergency Medical Services. The overarching goal of this conjunct effort is to provide data-driven evidence for supporting decision-making, leveraging on state-of-art methodologies in data science and geospatial modelling. In particular, the D-Hygea Lab team was involved in several projects, covering both the optimization of resources allocation and the development of new knowledge about environmental, socio-demographic, socio-economic, and geographical factors impacting public health. Specifically, the main projects are:

    - Allocation of Ambulance Fleet: the D-Hygea Lab team developed a simulation model to optimize ambulance resource allocation. This model simulates emergency call patterns and intervention logistics, allowing for the identification of inefficiencies such as under- or over-resourced stations and areas with unmet demand. Initially implemented in Lombardy, the model is now being tested in Sardinia and Calabria, with ongoing improvements through the integration of predictive tools.
    - Environmental Epidemiology: the D-Hygea Lab team is advancing the study of how environmental factors impact population health through health-geomatics, shifting from individual health studies to territorial monitoring. Currently, we are developing novel frameworks to study the impact of environmental stressors on medical emergencies like cardiac arrest, myocardial infarction, and stroke.
    - Urban Heatwaves: the D-Hygea Lab team is addressing he anlysis of the impact of heatwaves on public health in Milan, using retrospective geo-localized ambulance dispatch data. This data is correlated with socio-urban features from open data sources across the city's 88 territorial units, with a focus on cardiovascular and respiratory conditions.
    - Pandemic Monitoring: during the 2020 COVID-19 outbreak in Lombardy, the D-Hygea Lab collaborated with AREU to analyze ambulance data, offering a more accurate view of the pandemic’s spread. Using spatial modeling and machine learning, we developed early-alert systems and predictive models for emergency services, demonstrating the value of data science in supporting pandemic response.
    - Public Access Defibrillation: given the sub-optimality of current PAD guidelines, the D-Hygea Lab team applied spatial modeling to assess and optimize the

distribution of Automated External Defibrillators, showing how data-driven management can enhance deployment efficiency.

These previous collaborations underscore our established track record in working with leading institutions and demonstrate our ability to deliver high-impact results. By leveraging this successful partnership network, we ensure that the expertise, resources, and lessons learned from past projects will be directly applied to this new project, maximizing its potential for success. Follows a short description of the Key Personnel:

- **Lorenza Gilardi (DLR-Project Manager)** has a background in environmental engineering and several years of experience at DLR researching the health effects of air pollution and thermal stress using Earth Observation (EO) and modeling data. Her research has focused on optimizing the exposure component in health risk assessments by incorporating population mobility patterns. Lorenza leads the DLR project Environmental Stressors and Health Costs and has contributed to the ESA AlpAirEO project as part of the EO4Society initiative. Additionally, she has provided valuable inputs for the ESA GTIF **|** Green Transition Information Factory.

- **Thilo Erbertseder (DLR-Science Lead)** is an atmospheric scientist and project manager at DLR and lecturer at the University of Würzburg. He has 27 years of experience in air quality, urban climate and health research. He was a member of the ESA mission advisory group for Sentinel-4 and Sentinel-5 and coordinated several Copernicus projects, including PASODOBLE and PROMOTE. In recent years he was the DLR principal investigator of research initiatives like "Urban Climate Under Change" (German Ministry of Education and Research), e-shape (H2020), NextGEOSS (H2020) and "Bioclimatic Information System for Bavaria" (Ministry of Health and Health Care, Ministry of Environment and Consumer Protection" focusing on Earth Observation, urban climate, environmental stressors and health risk assessments. By combining Earth Observation, urban climate modelling, data science and health research he is striving to make cities healthy, climate resilient and sustainable. His contributions span numerous national and international projects, scientific publications and patents. He recently co-authored a "The Lancet Planetary Health" data science study on urban heat islands, air pollution, CO2 emissions and mortality in 919 cities in Europe.

- **Jana Handschuh (DLR-WP manager)** is a PhD Meteorologist with 6 years of experience in air quality and atmospheric science. She contributed to more than six scientific projects addressing the monitoring of air pollution and atmospheric processes on different scales. She is specialist in the processing and application of remote sensing data on atmospheric composition (including Copernicus data from Sentinel-3 and -5p missions) and has extensive experience urban-scale climate and air quality modelling. She is furthermore familiar with the configuration and maintenance of web-services for atmospheric information products. Relevant projects she contributed to include European projects such as AlpAirEO (air quality, heat and health) and S-VELD (remote sensing of air pollution) and national to city-scale German Projects such as KLIPS (remote sensing and modelling of urban heat) or ELK (modelling of urban pollution).

- **Lorenzo Gianquintieri (POLIMI - WP manager)** obtained his MSC degree (2017) in Biomedical Engineering and a Ph.D. (2022) with an interdepartmental scholarship between the Electronics, Information and Bioengineering dpt. and the Civil and Environmental Engineering dpt. at Politecnico di Milano. As a fellow researcher in the same institution, his line of research is focused on Health-Geomatics, which is the application of geomatics technologies to health and healthcare-related data, with an orientation towards data science methods (in particular Machine Learning and GeoAI models). The intended outcome is the development of analysis frameworks and processing platforms to serve as decision-making support in the management of healthcare related resources, territorial monitoring, and prevention, specifically regarding environmental analysis and out-of-hospital emergency medicine. He is currently in charge of the Health-Geomatics research group within the D-Hygea Lab (Bioengineering section).

- **Andrea Pagliosa (AREU)** serves as the IT & Business Intelligence Specialist at the Regional Emergency and Urgency Agency (AREU) of Lombardy, Italy, where he has been contributing since 2009. He is responsible for managing the Business Intelligence and Analytics systems that support the regional emergency medical services. His work involves developing data-driven tools to optimize emergency response and resource allocation. Notably, he has co-authored research on the impact of heatwaves on cardiovascular emergencies, providing valuable insights into how extreme temperatures affect public health.

  Giuseppe Stirparo (AREU) Dr. Giuseppe Stirparo is a Medical Doctor at AREU's Epidemiological Observatory. He collaborates with the Regional Directorate of Welfare of REgione Lombardia, focusing on data flows for national health outcome programs and monitoring Essential Levels of Care (LEA). His research includes studies on emergency department waiting times in the post-pandemic era and the management of possible stroke cases by laypeople in pre-hospital settings.

  Roberto Faccincani (AREU) is the Director of the Mass Casualty Incidents (MCI) Unit at AREU and leads the Department for Mass Gatherings and Disaster Preparedness. He has extensive experience in planning and managing responses to large-scale emergencies and mass gatherings. His work includes developing disaster plans for mass casualty incidents and evaluating the interaction between emergency medical systems and hospital networks during train derailments.

- **Martyn Clark (GEO)** has extensive global experience supporting urban climate-resilience efforts across Europe, Asia, and Africa, collaborating with multilateral development banks, international NGOs, development agencies, and national and local governments. Currently serving as Urban Resilience Coordinator at the Group on Earth Observations, he leads the Global Heat Resilience Service (GHRS), pioneering the use of Earth Observations for urban heat risk mapping and modelling powered by EO-data. His experience spans technical assistance to governments at multiple levels, advisory work with development finance institutions, and research and innovation partnerships with UN agencies, including recent collaboration with ESA through the Space & Global Health Hackathon in May 2024. Martyn's work investigates the complex drivers of climate risks in urban settings, employing sophisticated remote sensing and geospatial analysis techniques to develop evidence-based adaptation strategies that connect climate change impacts to health outcomes across diverse urban contexts.

Table 1: roles of the project partners within the project CLIMA-CARE

Partner	**Role**	**Expertise and Contribution**
DLR (Project Lead)	Project management, Science Lead & EO science	Environmental data processing, EO data application, Exposure modelling
PoliMi	Sub-contractor	Engineering: ML- modelling and cloud computing
AREU	Sub-contractor	Certification of data with epidemiologist, supervisor for creation of protocols, provision ambulance data
GEO	Consultant	Climate Resilience & Partnerships Advisor

A detailed **Organizational Breakdown Structure (OBS)** is provided in [X], defining clear responsibilities and reporting structures.

1.1 Curricula Vitae of Key Personnel

The CVs for all key personnel are submitted in esa-star. The following list provides the names of CVs uploaded in esa-star: Gilardi, Handschuh, Erbertseder, Gianquintieri, Faccincani, Stirparo, Pagliosa and Clark.

Name	Role in the Project	Company	Manager of WPs
Lorenza Gilardi	Project Manager & WP leader	DLR	WP5 & WP4
Jana Handschuh	Climate scientist & WP leader	DLR	WP3
Thilo Erbertseder	Project Science Lead & EO expert	DLR	WP1
Lorenzo Gianquintieri	WP leader & cloud computing developer	PoliMI - DEIB	WP2
Roberto Faccincani	Medical Director for Mass Casuality Incidents	AREU	
Giuseppe Stirparo	Epidemiologist	AREU	
Andrea Pagliosa	Professional Tecnical collaborator	AREU	
Martyn Clark	Consultant	GEO	

1.3. Relevant scientific records

The working group already gathers several years of experience in the field of application of EO products for the health risk assessment due to climatological stressors and air pollution, as well as experience in the field of health geomatics and health risk modelling. Follow a non-exhaustive list of the latest relevant scientific publications:

· Erbertseder, T., Taubenböck, H., Esch, T., Gilardi, L., Paeth, H., & Dech, S. (2024). NO_2 pollution trends and settlement growth in megacities. *Journal of Selected Topics in Applied Earth Observations and Remote Sensing, 17*. https://doi.org/10.1109/JSTARS.2024.3419573

· Müller, I., Erbertseder, T., & Taubenböck, H. (2022). Tropospheric NO2: Explorative analyses of spatial variability and impact factors. Remote Sensing of Environment, 270, 112839. https://doi.org/10.1016/j.rse.2021.112839

· Handschuh, J., Erbertseder, T., & Baier, F. (2022). Estimating surface PM2.5 concentrations from AOD: A combination of SLSTR and MODIS. Remote Sensing Applications: Society and Environment, 26, 100716. https://doi.org/10.1016/j.rsase.2022.100716

· Voigt, C., Lelieveld, J., Schlager, H., Schneider, J., Curtius, J., Meerkötter, R., Sauer, D., Bugliaro, L., Bohn, B., Crowley, J. N., Erbertseder, T., Groß, S., Hahn, V., Li, Q., Mertens, M., Pöhlker, M. L., Pozzer, A., Schumann, U., Tomsche, L., Williams, J., Zahn, A., Andreae, M., Borrmann, S., Bräuer, T., Dörich, R., Dörnbrack, A., Edtbauer, A., Ernle, L., Fischer, H., Giez, A., Granzin, M., Grewe, V., Harder, H., Heinritzi, M., Holanda, B. A., Jöckel, P., Kaiser, K., Krüger, O. O., Lucke, J., Marsing, A., Martin, A., Matthes, S., Pöhlker, C., Pöschl, U., Reifenberg, S., Ringsdorf, A., Scheibe, M., Tadic, I., Zauner-Wieczorek, M., Henke, R., & Rapp, M. (2022). Cleaner skies during the COVID-19 lockdown. Bulletin of the American Meteorological Society. https://doi.org/10.1175/BAMS-D-21-0012.1

· Rittweger, J., Gilardi, L., Baltruweit, M., Dally, S., Erbertseder, T., Mittag, U., Naeem, M., Schmid, M., Schmitz, M.-T., Wüst, S., Dech, S., Jordan, J., Antoni, T., Bittner, M. (2022). Temperature and particulate matter as environmental factors associated with seasonality of influenza incidence: An approach using Earth observation-based modeling in a health insurance cohort study from Baden-Württemberg (Germany). Environmental Health, 21, 131. https://doi.org/10.1186/s12940-022-00927-y

· Handschuh, J., Erbertseder, T., & Baier, F. (2023). Systematic evaluation of four satellite AOD datasets for estimating PM2.5 using a random forest approach. Remote Sensing, 15, 2064. https://doi.org/10.3390/rs15082064

· Gilardi, L., Marconcini, M., Metz-Marconcini, A., Esch, T., Erbertseder, T. (2023). Long-term exposure and health risk assessment from air pollution: Impact of regional scale mobility. International Journal of Health Geographics, 22(1), 11. https://doi.org/10.1186/s12942-023-00333-8

· Samad, A., Kiseleva, O., Holst, C., Wegener, R., Kossmann, M., Meusel, G., Fiehn, A., Erbertseder, T., Becker, R., Roiger, A., Stanislawsky, P., Klemp, D., Emeis, S., Kalthoff, N., Vogt, U. (2023). Meteorological and air quality measurements in a city region with complex terrain: Influence of meteorological phenomena on urban climate. Meteorologische Zeitschrift. https://doi.org/10.1127/metz/2023/1124

· Hoffmann, L., Gilardi, L., Schmitz, M.-T., Erbertseder, T., Bittner, M., Wüst, S., Schmid, M., Rittweger, J. (2024). Investigating the spatiotemporal associations between meteorological conditions and air pollution in the federal state Baden-Württemberg (Germany). Scientific Reports, 14, 5997. https://doi.org/10.1038/s41598-024-56513-4

· Handschuh, J., Erbertseder, T., & Baier, F. (2024). On the added value of satellite AOD for the investigation of ground-level PM2.5 variability. Atmospheric Environment, 331, 120601. https://doi.org/10.1016/j.atmosenv.2024.120601

· Gilardi, L., Marconcini, M., Metz-Marconcini, A., Esch, T., Erbertseder, T. (2024). The influence of commuting on population exposure to air pollution: Toward global application with a proxy on the degree of urbanization. Journal of Selected Topics in Applied Earth Observations and Remote Sensing, 17. https://doi.org/10.1109/JSTARS.2024.3420155

· Iungman, T., Khomenko, S., Pereira Barboza, E., Cirach, M., Gonçalves, K., Petrone, P., Erbertseder, T., Taubenböck, H., Chakraborty, T., Nieuwenhuijsen, M. (2024). The impact of urban configuration types on urban heat islands, air pollution, CO2 emissions, and mortality in Europe: A data science approach. The Lancet Planetary Health, 8(7). https://doi.org/10.1016/S2542-5196(24)00120-7

· Gianquintieri, L., Brovelli, M.A., Pagliosa, A., Dassi, G., Brambilla, P.M., Bonora, R., Sechi, G..M, Caiani, EG. (2020) Mapping spatiotemporal diffusion of COVID-19 in Lombardy (Italy) on the base of Emergency Medical Services activities. ISPRS Int. Journal of Geo information; 9:639 https://doi.org/10.3390/ijgi9110639

· Gianquintieri, L., Brovelli, M.A., Pagliosa, A., Bonora, R., Sechi, G.M., Caiani, E.G. (2021) Geospatial correlation analysis between air pollution indicators and estimated speed of COVID-19 diffusion in the Lombardy region (Italy). Int. J. Environ. Res. Public Health; 18(22):12154. https://doi.org/10.3390/ijerph182212154

· Nawaro, J.A., Gianquintieri, L., Pagliosa, A., Sechi, G., Caiani, E.G. (2023). Heatwaves and their impact on cardiovascular health mortality and morbidity: a systematic review. Public health Review; 44:1606266 https://doi.org/10.3389/phrs.2023.1606266

· Gianquintieri, L., Oxoli, D., Caiani, E.G., Brovelli, M.A. (2024) Implementation of a GEOAI model to assess the impact of agricultural land on the spatial distribution of PM2.5 concentration. Chemosphere; 352:141438 https://doi.org10.1016/j.chemosphere.2024.141438

· Mahakalkar, A.U., Gianquintieri, L., Amici, L., Brovelli, M.A., Caiani, E.G. (2024) Geospatial analysis of short-term exposure to air pollution and risk of cardiovascular diseases and mortality–A systematic review. Chemosphere; 352:141495 https://doi.org10.1016/j.chemosphere.2024.141495

· Gianquintieri, L., Mahakalkar, A.U., Caiani, E.G. Exploring Spatial–Temporal Patterns of Air Pollution Concentration and Their Relationship with Land Use. Atmosphere; 15(6):699. https://doi.org/10.3390/atmos15060699

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1.4. Tenderer’s facilities for the execution of the work

DLR-DFD operates across multiple computing environments, including:

- **DLR Geofarm**, a virtualized computing cluster designed for flexible and scalable data processing. It consists of Blade centers with 96 servers, providing a total of 4,300 Opteron cores, 33 TB of RAM, and a multi-tiered storage system (1.9 PB SATA, 100 TB SAS, and 8 TB SSD). The infrastructure is interconnected via a 10 Gb/s Ethernet network, allowing dynamic allocation of virtual machines based on processing requirements, ranging from 4-core instances to the full system capacity.
- **DLR Terrabyte**, a strategic initiative ensuring independence from third-party constraints while integrating high-performance data analytics (HPDA) with rapid access to Earth Observation (EO) data. Developed in collaboration with the Leibniz Computing Centre (LRZ) of the Bavarian Academy of Sciences and Humanities (BAdW), Terrabyte leverages LRZ’s world-class supercomputing resources and expertise in energy-efficient operations. By embedding HPDA capabilities within LRZ’s ecosystem, it supports computationally and data-intensive EO applications while ensuring full control over the scientific and economic exploitation of DLR’s research. This collaboration enhances scalability, fosters synergy in EO data analytics, and secures robust computing resources for future research initiatives.

POLIMI

The D-Hygea Lab has a physical space within the DEIB (building 21, Via Camillo Golgi, 39, 20133 Milano MI, Italy) with use of six workstations: 2x Alienware Aurora R7 (256 GB + 1 TB storage, Intel i7-8700 @ 3.20GHz, 16 GB, GeForce GTX 1080 8GB, Windows 10), 1x HP Elite Desktop 800 G6 (512 GB + 1 TB storage, intel i7-10700 @ 2.90GHz, 16 GB, Intel UHD Graphics 630, Windows 10), 1x Alienware Aurora R16 (2 TB storage , intel i9-14900kf @ up to 6GHz, 64 GB, Nvidia RTX 4090 24 GB, Windows 11), 1x Dell Precision.

2. TECHNICAL PART

2.1. Understanding of the requirements and main objectives of the ITT

Climate change is increasingly exacerbating the impact of environmental stressors on human health, disproportionately affecting various regions worldwide, continuously worsening due to anthropogenic temperature raise [1], and intensifying existing health inequalities [2]. While human pathophysiology is well understood [3, 4, 5, 6], addressing these challenges requires a public health and ecological approach to deliver population-level insights and inform an effective policy-making [7, 8, 9], accounting for the impact on health services delivery and related direct and indirect costs [2] and thus fostering the goal of global adaptation [10].

Rising temperatures and more frequent heatwaves, as primary manifestations of climate change, trigger a cascade of environmental processes that can compromise air quality, too. High temperatures enhance the photochemical reactions that lead to surface ozone formation, particularly in the presence of sunlight and precursors like nitrogen oxides (NO_x) and volatile organic compounds (VOCs) [11]. Changes in precipitation patterns driven by climate change can lead to prolonged periods without rainfall in certain regions, contributing to the degradation of air quality. Reduced precipitation limits the natural removal of air pollutants through wet deposition and increases the resuspension of dust and particulate matter, especially in urbanized and industrial areas. These dry conditions also favour the formation and accumulation of secondary pollutants such as ozone and $PM_{2.5}$, further exacerbating air pollution episodes [12, 13]. Moreover, prolonged dry periods increase the risk of wildfires, which emit particulate matter ($PM_{2.5}$) and nitrogen oxides (NO_x), worsening air quality and presenting additional health risks [14]. In regions like the Po Valley in northern Italy, where precipitation decline is coupled with stagnant atmospheric conditions, the impact is particularly severe, resulting in persistent air pollution episodes during extended dry spells [15, 16].

Traditional exposure assessments based on in-situ ground stations are limited in spatial coverage and fail to capture population dynamics across heterogeneous territories [17]. EO-based and model reanalysis datasets [18, 19] allow a more comprehensive and spatially explicit estimation of environmental stressors, which is essential for ecological, population-level health modelling. This technology and the generated meteorological data are considered a promising enabler in the field, as witnessed by WHO itself [20]. To address the growing health burden of climate-related events, a robust and ecologically grounded framework is needed, that operationalises the IPCC risk paradigm (risk = hazard × exposure × vulnerability) [21, 22] through the integration of Essential Climate Variables (ECVs) and population health outcomes, embracing the cross-disciplinary perspective of the European Space Agency Climate Change Initiative (CCI) [23].

Despite advances in climate-health research [24, 9], major gaps remain in the definition of exposure and vulnerability. Exposure is often simplified as residence-based proximity, overlooking daily mobility and micro-environmental factors. Vulnerability, on the other hand, is multi-dimensional and shaped by socio-economic, health, and environmental conditions, which vary over space and time.

An ecological model of health enables the integration of environmental exposures, individual and contextual vulnerabilities, and behavioural factors, such as mobility or commuting patterns, to better reflect real-world health risks. This multilevel perspective supports the identification of population groups at higher risk and the development of targeted mitigation strategies [7, 8, 25], an increasingly urgent need in response to the observable evolutionary trends in the human society, such as progressive urbanization and population aging [26]. Integrating commuting patterns and time-activity behaviour into exposure modelling improves the accuracy of exposure assessment by accounting for time-activity behaviour beyond residential location. This dynamic exposure estimation reflects the actual time people spend in polluted environments (such as urban centers or industrial zones) and allows to capture the misalignment between residence and true exposure [27].

The Lombardy region, located in northern Italy with a population of more than 10 million residents (thus comparable to a medium-sized European country), represents a critical area for assessing the health impacts of climate change due to its combination of dense urban areas, significant industrial activity, and highly variable environmental conditions. Located in the Mediterranean area, recognized as a hotspot of climate change [28], the region is particularly vulnerable to extreme heat events [29], air pollution [30], and droughts, with both chronic and acute effects on public health. This makes Lombardy an ideal case study for examining the relationship between climate-induced environmental stressors and health outcomes at the regional scale. The region's extensive population exposure to both urban [29] and rural [30, 31] environmental stressors, coupled with its well-established healthcare data, provides a unique opportunity to model and quantify health risks using a combination of Earth Observation (EO) data and health outcomes.

By leveraging EO-derived indicators alongside census and health datasets, we aim to build an ecologically valid and scalable exposure-vulnerability model that captures gradients of susceptibility and adaptive capacity across different areas of the same region [32] and population groups. Within this framework, hazards will be characterised through ECVs, such as land surface temperature, air pollutants (e.g., ozone and $PM_{2.5}$), and precipitation anomalies, allowing for a consistent and traceable description of these events. Following the latest research direction in the field [33], the combination of EO data and advanced data-driven, Machine Learning-informed modelling (elaborating on existing model-based analytical tools [25, 34]) will enable us to quantify the health risks associated with climate-driven hazards, with a focus on cardiovascular and respiratory events requiring emergency care, embracing IPCC's advocate for a direct involvement of policymakers towards adaptation and mitigation [32].

To address these challenges and translate the analytical framework into operational tools for health risk assessment, the project will be guided by the following key research questions: How do heatwaves and air pollution, characterised through Essential Climate Variables (ECVs), influence emergency medical demand in Lombardy?

- How can remote sensing and AI-driven modelling approaches enhance the identification and quantification of climate-related health risks using ECVs?

- Which environmental drivers (derived from ECVs) are most strongly associated with increases in ambulance calls during climate-related events?

- How these increases impact the overall performance of Emergency Medical Services?

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2.2. Proposed approach to reach the main technical objectives of the ITT

The proposed approach aims at integrating multiple climate-change related events and focuses on enhancing Emergency Medical Services (EMS) to provide actionable insights into climate-related health risks. Central to the approach is a unified analytical framework that combines both knowledge-based and data-driven methodologies for comprehensive risk assessment.

The knowledge-based approach (WP2 Task 2) shall integrate EO-derived Essential Climate Variables (ECVs) with health-related and socio-demographic/socio-economic data to create GIS-based risk maps of climate-related health risks. This method utilizes an index-based approach aligned with the IPCC framework [RD-01, RD-02] (and received by WHO [RD-03]), incorporating PCA and expert weighting to calculate risk indices across hazard, exposure, vulnerability, and adaptive capacity dimensions. Uncertainty is addressed through expert elicitation, sensitivity analyses, and validation, while back-tuning from the data-driven approach further refines the models.

The proposed methodology will include the followings:

- Assessment of the current State of the Art: review the existing knowledge and use of EO data and Essential Climate Variables (ECVs) for assessing health risks from climate change events, focusing on increasing heatwave episodes and the deterioration of air quality due to changing precipitation patterns.
- Selection of ECV datasets: identify and select the most relevant ECV datasets, coupled with re-elaborated EO-based datasets, that provide key metrics for the selected environmental stressors (heatwaves, O_3, PM, and NO_2). These datasets will be integrated into both traditional and AI-based epidemiological models, leveraging EO data for an ecological approach to health risk assessment.
- Regional analysis: conduct a regional analysis on Lombardy, Italy, to detect observable trends in the selected ECVs and identify potential sub-regional patterns using spatial clustering techniques.
- An analysis of the need for downscaling at finer spatial and/or temporal resolutions the selected ECV and coupling with re-elaborated dataset for the application in the following steps.
- Downscaling analysis: assess the need for downscaling the selected ECVs to finer spatial and/or temporal resolutions, coupled with re-elaborated EO-based datasets, to enhance model accuracy in future analyses.
- Novel indexing: develop an Environment-Related Health Risk Index (EHRI), quantifying the interconnections between climate events and health outcomes across the region. This stage will also incorporate uncertainty analysis and optimization procedures to refine exposure thresholds and spatial granularity, enhancing the ecological understanding of health risks.

- ML-based features relevance assessment: Machine Learning models will assess the influence of EO-derived data, selected ECVs, and additional selected socio-economic features on health risk indexes. This process will identify spatial clusters exhibiting similar dynamics, refining risk maps by comparing knowledge-based and data-driven approaches to enhance the accuracy of the health risk assessment.

- Coupling with traditional epidemiological models: well-established modelling methods will be included in the project for refinement, benchmarking, and validation. Specifically, the implementation of risk mapping according to IPCC's definition will be conducted throughout all the development phases (WP2, WP3, WP4); the Distributed Lag Non-Linear Model (DLNM) will be considered as the gold standard for validating the novel proposed data-driven framework.

- Identification of ambulance calls attributable to environmental stressors: identify and quantify ambulances calls attributable to selected environmental stressors, such as heatwaves, O_3, PM, and NO_2. This will be used to understand the health burden associated with these stressors and inform EMS planning. By observing geographical disparities and the spatial variations in climate change impact, it will be also possible to speculate about the role of adaptation-related mechanisms across communities (e.g. urban vs rural).

- EMS simulation (EMS-DT): this module improves Emergency Medical Services (EMS) demand prediction under the available climate scenarios for the region of interest. The EMS model forecasts resource allocation (i.e. ambulances number and station location) and healthcare system performance under projected environmental stressors, helping to optimize EMS operations and plan for future climate-induced health impacts.

A non-exhaustive list of the ECV that will be examined for inclusion into the project model is:

- **Aerosols (CCI)**: Crucial for assessing particulate matter (PM) concentrations, especially $PM_{2.5}$ and PM_{10}. Aerosol data provide insights into the distribution and transport of fine particles that affect air quality and human health.
- **Tropospheric Ozone (CCI)**: Essential for monitoring ground-level ozone (O_3) concentrations. Elevated O_3 levels are linked to respiratory issues and are influenced by sunlight and precursor pollutants like NO_x and VOCs.
- **Nitrogen Dioxide (NO_2) (Sentinel-5P/TROPOMI)**: While not classified as an ECV, satellite instruments like TROPOMI provide high-resolution data on NO_2 concentrations, a key pollutant from vehicular and industrial emissions.
- **Surface Temperature (CCI)**: Influences the formation of ozone and the dispersion of pollutants. Higher temperatures can accelerate photochemical reactions leading to increased O_3 levels.
- **Surface Wind Speed and Direction (CCI)**: Affects the dispersion and transport of air pollutants. Wind patterns can carry pollutants over long distances or lead to their accumulation in certain areas.

- **Surface Pressure (CCI)**: Impacts atmospheric stability and the vertical mixing of pollutants. High-pressure systems can lead to stagnant air conditions, exacerbating pollution levels.
- **Relative Humidity (CCI)**: Influences the chemical reactions in the atmosphere and the formation of secondary pollutants. Humidity levels can affect the concentration and deposition of PM.
- **Precipitation (CCI)**: Rainfall can remove pollutants from the atmosphere through wet deposition, thereby affecting air quality.

2.3. First iteration if Sow Task(s) 1-5

WP1 – DEVELOPMENT OF AN ASSESSMENT REPORT ON CLIMATE AND HEALTH

OBJECTIVE

Led by DLR, this work package aims to develop a comprehensive assessment report that evaluates the impacts and projected future risks of climate change on health systems and facilities, human health, and well-being. While the assessment will provide a systematic overview of climate-health relationships, it will place particular emphasis on heat stress and air quality degradation as primary focus areas that directly relate to the case study to be developed in WP2. This targeted approach allows for more efficient resource utilization and ensures that the project's core investigation areas receive appropriate depth of analysis, while still maintaining awareness of the broader climate-health landscape. This report will be built in subsequent phases, including: first, to conduct a systematic literature review (WP1T1) following PRISMA guidelines to establish a state-of-the-art baseline; then, a literature-based assessment of the investigation focus (WP1T2) will be performed, by selecting 10 key climate-related health risks and identifying critical research topics and methodological gaps; next, stakeholder feedback will be integrated through a dedicated assessment (WP1T3) to ensure that the project’s theoretical and methodological directions will align with real-world needs; and finally, the overall project structure will be assessed (WP1T4) by comparing the initial hypotheses with the emergent knowledge gaps and refining the analytical framework accordingly. Collectively, these tasks will allow the project to identify critical knowledge gaps and define a clear set of science and technical requirements that will guide subsequent project activities.

WP1T1 – LITERATURE REVIEW

This task will be conducted following systematic review methods in accordance with PRISMA guidelines.
Necessary inputs are:

- The initial project documentation and hypotheses on EO applications in climate and health
- Definitions and scope of health, climate, and vulnerability parameters (RD-20)
- PRISMA protocols

The task will be performed in the following phases:

- WP1T1.1 Query definition:
  A set of relevant topics will be defined to guide the literature review, with particular focus on heat impacts and air quality degradation as key climate-related health concerns. The review will include the use of EO data to assess projected future risks of climate change for health, and for investigating the determinants of vulnerability, accounting for the dynamicity of human communities. On the base of the identified relevant topic, a specific search query will be defined (keywords and logical operators), along with inclusion and exclusion criteria.

- WP1T1.2 Manuscripts selection:
  A comprehensive search will be performed across multiple scientific and policy databases to retrieve high-impact publications, policy documents, and major climate and health reports, including the most recent IPCC Assessment Reports (RD-19, RD-20). The selection process will follow PRISMA guidelines by applying predefined inclusion and exclusion criteria, ensuring that the identified manuscripts are relevant and of high quality.

- WP1T1.3 Literature analysis:
  The retrieved literature will be systematically analyzed and synthesized. This phase will also follow PRISMA guidelines by documenting the screening process, assessing the quality of the studies, and extracting key data. The analysis will focus on how climate change factors impact various health domains.

  The generated output will be:

  - Query framework and PRISMA flow diagram
  - Selection of high-impact publications
  - A comprehensive synthesis of the literature highlighting key findings to form the SOTA section of the assessment report.

W1T2 – LITERATURE-BASED ASSESSMENT OF INVESTIGATION FOCUS

This task will build on the literature review by narrowing the focus of investigation and identifying the critical topics and research gaps. The project team will select 10 key climate-related health risks from the reviewed literature and pinpoint areas where evidence is scarce or inconclusive. In addition, a methodological assessment will be carried out to evaluate the strengths and weaknesses of current approaches, from GIS-based and expert-driven indices to novel data-driven techniques using EO datasets. Necessary inputs are the syntheses and findings from WP1T1.
The task will be performed in the following phases:

- WP1T2.1 Selection of 10 main climate-related health risks:
  Based on the outcomes of the systematic literature review, 10 key climate-related health risks will be selected for investigation, with priority given to those related to heat stress and air quality degradation.

- WP1T2.2 Identification of topics to investigate:
  Topics and aspects within the field where the current evidence is scarce or inconclusive, advocating for further research, will be pinpointed. Emphasis will be put on areas where the potential of EO data in addressing climate-related health impacts has not yet been fully explored.

- WP1T2.3 Methodological Assessment:
  The main methodological approaches used in the field will be investigated, ranging from GIS-based, expert-driven indices to novel data-driven approaches leveraging high-resolution EO datasets, examining their strengths and weaknesses. The findings will contribute to a better understanding of the current landscape and inform the development of improved methodologies in subsequent tasks.

  The generated output will be:

  - A documented selection and rationale for 10 primary climate-related health risks
  - An outline of research topics and questions where further investigation is needed
  - A critical assessment of existing methodologies, identifying both strengths and limitations, which will be integrated into the overall assessment report

WP1T3 – STAKEHOLDER-BASED VALIDATION OF INVESTIGATION FOCUS

DLR will lead stakeholder engagement activities, leveraging its established relationships with GEO's working groups and other international organizations. This task aims to complement the literature-based investigation focus by engaging relevant stakeholders to ensure that the project’s theoretical and methodological directions align with real-world needs. By involving international organizations (e.g., WHO, CDC, EO4Health Community of Practice) and other experts, the task will gather critical feedback, evaluate the degree of alignment between project’s focus and stakeholder perspectives, eventually informing necessary adjustments. Necessary inputs are:

- Preliminary investigation focus and methodologies derived from the literature review (WP1T1 and WP1T2)
- A list of potential stakeholders and their expertise areas to include and leverage:

The task will be performed in the following phases:

- WP1T3.1 Identification of relevant stakeholders:
  The project team will select suitable stakeholders based on the identified topics and methodologies. The focus will be on identifying experts from international organizations such as WHO, CDC, and GeoHealth, who have the capacity to provide insights into real-world needs. Criteria for selection will be defined, ensuring a diverse representation of expertise across health, climate, and EO applications. The selection process will leverage existing relationships established through the GEO Community, including but not limited to:
  - Contact points within GEO's Climate Change & DRR Working Group, Resilient Cities Working Group, and EO4Health Community of Practice; GEO’s Global Heat Resilience Service stakeholder engagement frameworks and initial findings from the GHRS project engagement with stakeholders around the subject of heat-health impacts

  - Participating experts of the EURO GEO Action Groups - specifically Climate, Disaster Resilience & Health;
  - Established relationships with Expert Teams from the World Meteorological Organization (WMO) and the Global Climate Observing System (GCOS) through the Horizon Europe funded iClimateAction project

- WP1T3.2 Planning of focus group:
  The project team will plan and organize a focused stakeholder consultation session to ensure efficient use of resources while still capturing diverse stakeholder perspectives. This will include scheduling, logistics, and defining the meeting modalities. Specific dates and times will be set to ensure maximum participation and effective collection of stakeholder feedback. An agenda will be prepared to guide discussions around the investigation focus and methodological approaches. Where possible, focus group sessions will be coordinated with GEO's Global Heat Resilience Service initiative activities to maximize efficiency and ensure consistent messaging across both initiatives. The GEO thematic working groups will be engaged to contribute to these sessions and ensure appropriate representation from their respective communities.

- WP1T3.3 Compliance check:
  During and after the focus group sessions, stakeholder feedback will be systematically analyzed to assess the alignment between the literature-based investigation focus and the practical indications provided by stakeholders.

- WP1T3.4 Focus adjustments:
  The initial assumptions regarding knowledge gaps in climate-related health impacts will be compared with the gaps identified through the systematic literature review and adjusted through investigation focus tasks. This comparison will help to validate or adjust the initial project hypotheses.

  The generated output will be:

  - A stakeholder feedback report summarizing the insights gathered, including documented alignments and divergences between the literature-based focus and stakeholder input, and a structured synthesis of feedback from GEO working groups and Communities of Practice.
  - A revised investigation focus and methodology document that incorporates stakeholders' suggestions and reflects the refined project direction.

WP1T4 – ASSESSMENT OF PROJECT STRUCTURE

The project's planned analytical framework, integrating both knowledge-based and data-driven approaches, will be evaluated to determine its capacity to address the identified gaps, with specific reference to the technical implementation. If needed, recommendations for refining the project structure will be developed, resulting in a clear set of science and technical requirements that will guide subsequent tasks (WP2, WP3, and WP4). The assessment will be strengthened through validation by GEO working groups, ensuring that the refined project structure aligns with international best practices and initiatives in climate-health monitoring and response. Necessary inputs are:

- Findings and documented research gaps from WP1T1 and WP1T2
- Insights and feedback from stakeholder-based assessment (WP1T3)
- Detailed descriptions of the current analytical framework

The task will be performed in the following phases:

- WP1T4.1 Compliance assessment of the project's analytical framework:
  The project's analytical framework, designed to integrate both knowledge-based and data-driven approaches, will be assessed for its ability to address the identified gaps. This will include evaluating whether the current framework meets the necessary features required to effectively incorporate EO data and capture the complex interactions between climate change and health outcomes, as reflected in both literature findings and stakeholder feedback.

- WP1T4.2 Refinement of the project structure:
  Based on the comparison and compliance assessment, the project structure may be refined and tuned to ensure alignment with the newly defined scientific background. This process will result in a refined set of science and technical requirements that will inform subsequent tasks and enhance the overall robustness and effectiveness of the project's approach.

The generated output will be:

- An assessment of the current project structure's compliance with the identified requirements
- A refined set of science and technical requirements along with recommendations for any necessary adjustments to the project structure, to be incorporated into the final assessment report
- A framework for climate-health assessment validated by GEO experts and working groups focusing specifically on heat impacts and air quality degradation, which will guide subsequent project activities

WP2 - FULL DESCRIPTION OF THE SELECTED CLIMATE AND HEALTH CASE STUDY AND DEVELOPMENT OF THE RISK ASSESSMENT

OBJECTIVE

The overall objective of this work package is to comprehensively characterize the selected climate and health case study/ies and to develop robust methodologies for monitoring and quantifying climate-related health risk. This will be achieved by integrating diverse datasets (from ESA's EO and climate reanalysis products to socio-demographic, socio-economic, and health data) into a unified analysis-ready data structure (WP2T1). A dual approach will be employed: a knowledge-based analytical framework (WP2T2) and a data-driven approach (WP2T3, WP2T4, WP2T5). The knowledge-based approach will focus on developing GIS-based maps of climate-related health risk across the target territory using an index-based approach aligned with the IPCC framework. The data-driven method is based on three modules. The first one (WP2T3) computes a novel index (Environment-

Related Health Risk Index, EHRI + Weighted Meta-Analytical Relevance Score, WMARM) to capture the exposure-response dynamics; it also includes iterative optimization procedures to refine exposure thresholds, lag periods, and geographical granularity. While the initial project focus is on heat and air pollution, the opportunity of exploring additional climate-events will be assessed, given the full flexibility of the proposed methodology. The second module (WP2T4: 3-Stage Geospatial explainable Artificial Intelligence, 3S-GeoXAI) aims to develop new knowledge about impactful features (e.g. socio-economic and socio-demographic). The third module (WP2T5) focuses on health systems and facilities by leveraging the developed risk mapping to enhance the existing EMS Digital Twin, thereby supporting targeted interventions to reduce morbidity and mortality linked to climate-related health impacts. Population exposure will also be assessed using open-source commuting data to better capture daily mobility patterns, and a trend analysis of environmental and climatic variables will be performed to identify territorial clusters. Finally, all outputs will be systematically documented and maintained in an open-access repository (WP2T6) to support transparency, reproducibility, and long-term community engagement.

WP2.T1 – EXPERIMENTAL SET-UP PREPARATION

Goal of this task is to prepare and pre-process the necessary data sources, to obtain the analysis-ready data structure necessary for the implementation of the risk assessment framework.
Necessary inputs are the relevant data as identified in WP1:

- EO data from the ECV datasets, developed within the ESA CCI programme.
- Relevant socio-demographic, socio-economic and territorial features.

The task will be performed in the following phases:

- WP2T1.1 environmental data:
  EO data shall be relevant to temperature, humidity, and air quality, over a regular grid covering the target territory (Lombardy region, Italy). It will be necessary to scale all data to daily values, and to consider multiple derived measures including max, min, and daily average (possibly more), building time-series of single-day measures but also accounting for extended windows. The opportunity of investigating additional environmental data will be assessed.
- WP2T1.2 Health data:
  EMS data will be provided by AREU, collecting all calls to the 118 emergency number, all ambulances dispatches, and all rescued patients, from 2015. All records are geo-referenced through geographic coordinates and include information about time of intervention (in all different phases), characteristics of the place where the event occurred, classification of event reason, event severity code, and patients' information (age, gender). Thanks to the available information, it will also be possible to stratify the events according to knowledge inferred in WP1, focusing the analysis on specific sub-groups.
- WP2T1.3 Relevant features:
  Coherently with results of WP1, the relevant socio-demographic, socio-economic, behavioural (in particular mobility or commuting patterns), and territorial features, characterizing the target population and area (Lombardy region, Italy), will be fetched, mainly exploiting open-source data repositories (such as Lombardy's open-data portal and geoportal, along with Italy's national institute of statistics ISTAT). Relevant data will

include (but will not be limited to) population's age distribution, ethnicity, employment level, education, and behavioural information, and territorial land-use distinguishing urban areas, urban green, agricultural lands, industrial sites, and natural areas. Up-scale and down-scale techniques will be applied where necessary. Further attempts will be carried out with competent bodies to obtain all features identified as highly relevant in WP1 which are not available in open format; proxy measures will be alternatively considered. Furthermore, to account for the dynamicity of the population and better assess the population exposure, the daily commuting flows will be integrated into the model.

- WP2T1.4 Geographical subdivisions:
  A comprehensive trend analysis of the selected environmental climate variables will be performed, to identify visible trends in the historical data and to allow a cauterization of the sub-regional area by means of spatial autocorrelation techniques.
  Environmental, health-related, and relevant features data will all be referred to multiple spatial subdivisions of the target territory. Such subdivisions will be based on administrative limits, extended to custom aggregated districts with the highest possible uniformity of resident population. Single areas resulting from geographical subdivisions are referred to as 'Base Statistical Areas' (BSA).

The generated output will be the analysis-ready data structure.

WP2.T2 – KNOWLEDGE-BASED RISK MAPPING

Goal of this task is to develop a map of risk according to IPCC's definition, computing its distribution across the target territory, considering all relevant combinations of environmental hazards and health-related outcomes identified in WP1, based on consolidated knowledge and modelling frameworks.

Necessary inputs are pre-processed data from WP2T1:
- EO data
- Health data
- Relevant socio-demographic, socio-economic and territorial features
- Geographical subdivisions

The task will be performed in the following phases:

- WP2T2.1 Risk computation:
  To perform the risk computation, the following steps will be applied:
  - WP2T2.1.1 The pre-processed data (WP2T1) will be reviewed and categorized into four dimensions, according to IPCC's framework: hazard, exposure, vulnerability, and adaptive capacity, following IPCC's definitions.
  - WP2T2.1.2 Variables will be grouped into relevant subcategories (e.g., socio-demographic, socio-economic, territorial for vulnerability).
  - WP2T2.1.3 Principal Components Analysis (PCA) will be applied separately to each subgroup of features, according to widely adopted methodology in literature; composite indices will be generated for each subgroup based on the PCA results.
  - WP2T2.1.4 Based on output from WP1, the initial weight for each subgroup index will be assigned.

- WP2T2.1.5 Clinical experts within the team will review and validate the proposed weighting scheme to ensure its alignment with empirical and clinical evidence; the validated weights will then be applied to the PCA-derived indices.
- WP2T2.1.6 The weighted indices for hazard, exposure, vulnerability, and adaptive capacity will be integrated to calculate a comprehensive risk index for each spatial unit within the territory.

This procedure for risk computation will be replicated on the different climate events and at different levels of geographical granularity. For each iteration, a geographic information system (GIS) will be utilized to visualize the spatial distribution of the composite risk index; such map will provide a clear and accessible representation of areas with varying levels of climate-related health risk. According to the results of WP1, the opportunity of analysis stratification for different subgroups will be explored.

- WP2T2.2 Uncertainty analysis:
  Uncertainty will be dealt with through structured expert elicitation, sensitivity analysis, and validation against historical data. This will allow to compute confidence intervals and robustness metrics.

- WP2T2.3 Data-driven back-tuning:
  Based on the results of WP2T4, the data-driven relevance of the included features on the risk will be considered to back-tune the weights of risk index, assessing and quantifying the difference with the initial knowledge-based arrangement.

Generated outputs will be:

- For each climate event, detailed GIS-based maps showing the distribution of climate-related health risk across the territory, at different levels of granularity.
- Reviewed maps with dimensions weights back-tuned from results of WP2T4
- Comparative analysis between knowledge-based and data-driven approaches

WP2.T3 – DATA-DRIVEN RISK MAPPING

Goal of this task is to develop a map of risk distribution for the target territory, considering all relevant combinations of environmental hazards and health-related outcomes identified in WP1, based on a novel and completely data-driven approach. The formulation of this methodology allows to better investigate into the interlinkages of exposure and vulnerability, both accounted for. The strongly flexible structure of the analytical framework allows to investigate (according to available data) all climate events, including heatwaves, heavy rainfall, droughts, as well as cascading conditions such as heatwaves + droughts (typically in summer) and droughts + deteriorated air quality (typically in winter).
Necessary inputs are the pre-processed data from WP2T1:

- EO data
- Health data
- Geographical subdivisions

The task will be performed in the following phases:

- WP2T3.1 Computation of environment-related health risk index (EHRI):
  The computation of the proposed index (EHRI) will be based on the following procedure:

- WP2T3.1.1 ‘Exposed’ and ‘non-exposed’ days are identified based on daily measures for the target event across the whole study area, defining as ‘exposed days’ those where the measure is above a certain percentile of yearly distribution.
- WP2T3.1.2 The daily incidence of the target health-related adverse outcome (HAO) in each BSA is computed, encompassing N days of temporal lag; a baseline of average HAO incidence during non-exposed days is computed within a sliding window of 15 days (extendible if necessary) before and after target day, thus accounting for seasonality and other temporal trends; the difference between each day incidence and its baseline value is computed, separately for each BSA, constituting the target variable.
- WP2T3.1.3 The final index is obtained as the weighted (through p-value) average of the effect size values of a Wilcoxon Mann-Whitney U test, performed between target values in year-specific heat and non-heat days, across N bootstrap iterations, thus also allowing to infer 95% confidence intervals.

- WP2T3.2 computation of weighted meta-analytical relevance score (WMARM):
  To quantify with a unique metric the impact of the considered climate event on the target HAO, the WMARM value will be computed as follows:
  - WP2T3.2.1 The ‘standardized effect’ value (‘error units’ away from minimal significance value, 0) is computed for each observation (each BSA in each year) as the ratio between the absolute value of EHRI and the standard deviation of effect size values.
  - WP2T3.2.2 The BSA-specific weighted average of standardized effect values is computed using as weight the inverse of the absolute value of the confidence interval, and the yearly threshold distinguishing exposed and non-exposed days.
  - WP2T3.2.3 WMARM is computed as the final weighted average of absolute values across all BSAs, using the resident population (averaged across years) as weight.

- WP2T3.3 Iterative procedure for parameters optimization:
  - WP2T3.3.1 Optimization of exposure threshold and lag period: the computation of EHRI and WMARM will be iteratively repeated using different values for the definition of the exposure threshold and for the lag period; the parameters combination resulting in the max WMARM value can be considered that which maximizes the exposure-response effect.
  - WP2T3.3.1 Optimization of climate event measure definition and geographical granularity: comparing maximal WMARM values resulting from different setups, it is possible to compare different climate measures (e.g. daily average VS daily max) and different geographical granularities, identifying those maximizing the exposure-response effect.

- WP2T3.4 Uncertainty analysis:
  The proposed methodology embeds uncertainty handling by formulation. In particular: EHRI is obtained from bootstrap iterations, allowing the computation of 95% confidence intervals, and the p-values of the statistical tests are accounted for as weights; data for statistical testing are added a small (e.g. 1%) random noise to increase robustness and generalization capability; WMARM metric is inferred from standardized effect values, which are inversely proportional to standard deviation across bootstrap iterations; furthermore, WMARM is averaged across multiple years, using the confidence intervals as weights. Additionally, three ad-hoc steps will be included: uncertainty assessment

(replication of WMARM computation of highest values), sensitivity analysis (replication of WMARM computation for ranging values of HAO incidence during exposed days, e.g. from -60% to +200%), and validation against a gold standard (DLNM)

Generated outputs will be:

- For each experimental setup (type of climate event, eventual subgroups stratification), detailed GIS-based maps showing the distribution of climate-related health risk across the territory, at different levels of granularity.
- For each experimental setup (type of climate event, eventual subgroups stratification), optimized parameters including climate event measure definition, temporal lag, and geographical granularity.

WP2.T4 – DATA-DRIVEN FEATURES RELEVANCE ASSESSMENT

Goal of this task is to leverage on Machine Learning capabilities to assess the impact of selected features on the data-driven risk index (EHRI) as computed in WP2T3, allowing to identify territorial clusters with similar exposure-response drivers and to inform back-tuning of weights for knowledge-based risk mapping. Through this process, new knowledge can be developed about the dynamic components and multi-dimensionality of vulnerability.
Necessary inputs are:

- Pre-processed data from WP2T1: relevant socio-demographic, socio-economic and territorial features
- EHRI values resulting from WP2T3
- Baseline architecture (currently implemented on a different purpose)

The task will be performed in the following phases:

- WP2T4.1 Implementation of a three-Stage Geospatial eXplainable Artificial Intelligence (3S-GeoXAI) model:
  - WP2T4.1.1 Target variable computation: due to the variability in risk values despite small variations of explicative features, three indicators are derived to model frequency (f, % of years with significant risk recorded), intensity (I, magnitude of risk), and cumulated effect (CE, product between f and I). Furthermore, the regression task is transformed into a classification task, commuting continuous targets into binary ones based on median values, and using the distance from median for data enhancement (i.e. multiplying records proportionally to their distance from the median and adding some random noise).
  - WP2T4.1.2 Stage I – Rank-sum-based features selection: for attributes selection, a threshold equal to 0.5 on the uni-variate Spearman's correlation coefficient between each feature and the target variable will be applied; additionally, it is necessary (for the following stage) to consider a threshold of 0.8 on the collinearity matrix among features and to progressively remove collinear ones.
  - WP2T4.1.3 Stage II – Geospatial (Geo) enhancement through Multiscale Geographical Weighted Regression (MGWR): from MGWR are inferred the bandwidth (number of areas around each record in the dataset to be considered to maximize the correlation) and the weights (numerical value assigned for each feature on each cell, for each record in the dataset), subsequently used to re-map the whole spatially transformed dataset, thus enhancing the local spatial relationship.

- WP2T4.1.4 Stage III – eXplainable AI (XAI) module through SHapely Additive exPlanations (SHAP): the dataset obtained with previous processing is used to train a Machine Learning (ML) algorithm, specifically a Random Forest (RF), which will only be used to infer knowledge about the complex and non-linear interactions among features and targets through the SHAP algorithm.

- WP2T4.2 Results analysis and clusters identification:
  - WP2T4.2.1 Cumulated features relevance: to provide a quantitative comparison of the previous results, the rank of attributes in the SHAP evaluation on the different targets will be compared by dividing the sum of ranks by the maximal possible value, thus inferring a unique metric scaled in the 0-1 range.
  - WP2T4.2.2 Clusters identification: SHAP algorithm provides a point-by-point evaluation of each feature's relevance, allowing to model features' relevance across the territory through unsupervised learning methods (e.g. Support Vector Clustering SVC), thus resulting in a subdivision of the territory with similar dynamics in terms of climate events-induced health risk.

- WP2T4.3 Uncertainty analysis:
  Subsequently to results interpretation, the RF models will be validated on each identified territorial cluster, including only relevant features (without the geo-based re-projection performed in WP2T4.1.3) for that cluster, by mean of the ROC AUC in a 10-fold cross-validation protocol. Additionally, 95% CIs will be estimated with the Clopper-Pearson method, considering the median values across five cycles of 10-fold cross-validation.

Generated outputs will be:

- Analysis of features (as identified in WP1) relevance on climate-related health risk (as modelled in WP2T3)
- Identification of territorial clusters with similar dynamics in terms of climate-related health risk

WP2.T5 – ENHANCEMENT OF EMERGENCY MEDICAL SERVICES DIGITAL TWIN (EMS-DT) THROUGH RISK-INFORMED DEMAND PREDICTION

Goal of this task is to leverage on the knowledge developed through WP2T4 to enhance the performance of the existing Digital Twin for Lombardy's Emergency Medical Services (EMS-DT), specifically increasing the accuracy of the demand prediction module by including environmental and climate-related information. The target is therefore the impact on a specific healthcare system and its facilities, looking directly at morbidity, whereas the analysis stratification on high-severity events can be considered a good proxy for mortality. The proposed approach can contribute to understanding of the climate-related health risks and directly inform the support on adaptation.
Necessary inputs are:

- Territorial clusters with similar dynamics in terms of climate-related health risk identified in WP2T4
- Existing EMS-DT with related data structures

The task will be performed in the following phases:

- WP2T5.1 implementation of enhanced demand prediction module:
  For each territorial cluster identified in WP2T4, a ML-based module will be implemented for the prediction of the demand (EMS calls), separately for urgent and non-urgent interventions, relying on the inclusion of time-variant variables, i.e. date-time, day of the week, and environmental variables (as identified in WP1). The implementation is addressed as a multi-class classification task through supervised learning, where the target is the number of EMS class in each area with three pre-defined labels: 0, 1, >1. To inform the following modules of the digital twin, extremely high geospatial (1km-diameter hexagonal cells) and temporal (1h) granularity will be applied. EMS data from 2015 to 2019 will be used for training, data from 2023 will be used for validation, and data from 2024-2025 for testing. A Correlation-based Filter method will be used for feature selection, and the Principal Component Analysis (PCA) algorithm will be employed for feature reduction separately on groups of cross-correlated variables. The choice of the specific ML algorithm will be based on multiple evaluation metrics obtained in testing phase, including (but not limited to): balanced accuracy on single records, root-mean square error (RMSE) on wider spatial-temporal aggregations.

- WP2T5.2 EMS-DT results interpretation:
  Leveraging on the following modules of the EMS-DT, which simulate interventions (accounting for the inherent randomness of the system) and estimate the required number of ambulances to be dispatched on the territory, it will be possible to quantify the impact of extreme weather events (as defined in WP2T3) on the EMS system, providing a comparison between model-based assessment (generalizable) and historical data. This allows to address the impact of climate not only on the demand for EMS, but also on the provision of the systems and the implications in terms of resources allocation, with a punctual spatial-temporal perspective.

- WP2T5.3 Uncertainty analysis:
  Uncertainty management is the core rationale for the implementation of a Digital Twin: while historical analysis may be biased by random components, a replicated simulation accounting for randomness allows to distinguish systematic issues for extemporary events. Each computed metric (e.g. number of ambulances to be allocated in a specific area) is therefore represented by a distribution of values rather than a single measure, thus allowing to straightforwardly compute 95% confidence intervals. With specific relevance to ML models, the validation process is inherent to the framework, as it serves the selection of the best performing algorithm; additionally, a ROC-AUC analysis with 95% CIs estimated with the Clopper-Pearson method, considering the median values across five cycles of 10-fold cross-validation, will be included.

Generated outputs will be:

- Comparison between historical and simulation-based EMS resources use during extreme weather events
- EMS-DT-based resources requirements for efficient system management

WP2.T6 – OPEN-ACCESS PROJECT REPOSITORY (OA-PR) MANAGEMENT AND MAINTENANCE

Goal of this task is to establish and sustain a comprehensive open-access repository that ensures transparency and long-term accessibility of all project outputs. This aims to support collaborative research and foster reproducibility by providing a centralized platform for code, data, and detailed documentation that remains publicly available beyond the project's duration. A cloud-based repository will be implemented using GitHub as the main platform for hosting the project code and version control. Complementing this, Zenodo will serve as the overarching repository for all project data, results, and methodological documentation. Throughout the project, the repository will be continuously updated. A comprehensive README document will be included to provide a full description of the methodology and clear instructions on how to utilize the repository's contents. Upon project completion, the repository will be maintained as an open-access resource to support ongoing community engagement and ensure the longevity of the project outputs.

WP3 - QUANTIFY THE HEALTH BURDEN ATTRIBUTABLE TO CLIMATE CHANGE AND EXACERBATED BY SOCIAL DETERMINANTS

OBJECTIVE

The primary objective of WP3 is to quantify the future health burden attributable to climate change by comparing current (factual) conditions with carefully designed counterfactual scenarios. This will be achieved by integrating high-resolution climate projections—such as 2-meter temperature and precipitation data from the best available datasets at the start of the WP (e.g., Destination Earth Digital Twin, CMIP6)—with projections of socio-economic, demographic, mobility, and adaptation-related variables. Demographic trends will be based on projections from the Italian National Institute of Statistics (ISTAT), while commuting dynamics in Lombardy will be derived from the Matrice Origine Destinazione 2030 dataset. The analysis will rely on the risk estimates and modeling outputs produced in WP2 (including D2.1, D2.2, WP2T2, and WP2T4), ensuring continuity in exposure-response relationships and spatial risk mapping. Additionally, the feature inventory developed in WP3T1 will support data integration and scenario development. A key element of this WP will also be the evaluation of new data available at the start of the WP to ensure the incorporation of the most up-to-date information. The results will include the simulation of the health burden on healthcare infrastructure, particularly ambulance stations. Multiple scenarios will investigate various combinations of social, climatic, and adaptation factors at three different levels: worst-case, most-likely, and best-case.

The activities of the WP can be unpacked as follow:

WP3.T1 – DATA EXPLORATION

This task aims to identify, retrieve, and harmonize datasets necessary for scenario-based simulations to estimate the health burden attributable to climate change. By aligning future climate projections, social determinants, and adaptation-related data with previous risk modelling, this task supports the evaluation of differences between current and counterfactual scenarios. The task will be performed in the following phases:

- WP3T1.1 - Database search for exploratory analysis and inventory start:
  An initial survey of available datasets will be performed, starting from Digital Twin for

Climate Change Adaptation data from Destination Earth Initiative and CMIP 6. This step involves searching for future projections of climate, social determinants, and adaptation-related data. The objective is to identify potential sources that align with the inputs and outputs defined in WP1 and WP2, ensuring consistency with previous risk modelling. After downloading candidate datasets, a systematic inventory will be compiled. Only data that can be successfully retrieved and validated will be considered for further analysis.

- WP3T1.2 - Integration and downscaling operations:
  Given that the project operates at a regional scale, spatial and temporal resolution adjustments will be applied as needed. These operations will harmonize the resolution of climate, social, and adaptation data with the EMS Digital Twin (EMS-DT) input requirements, ensuring consistency across datasets. To answer the requirement of the intracity/intercity comparability analysis, simulations with the Parallelized Large-Eddy Simulation Model for Urban Climates PALM4U developed by the German Weather Service (DWD) will be carried out for selected cities in Lombardy.

- WP3T1.3 - Uncertainty analysis:
  The ISO/TS 21564:2019 standard will be applied to quantify the level of matching between the relevant features identified in WP2 and the information retrieved in WP3T1: each feature will be therefore scored from 3 (no correspondence found) to 0 (perfect match). This will be applied for both the knowledge-based relevant features (output of WP2T2) and features selected through the 3S-GeoXAI model (WP2T4); a final metric will be computed as the weighted average, using as weight the inverse of the respective relevance (weights from WP2T2 and rank-sum index for WP2T4).

  The generated outputs will be:

  - A validated inventory of available datasets with confirmed data quality
  - Harmonized datasets with adjusted spatial and temporal resolutions for regional analysis
  - Uncertainty metric scores for each feature, based on ISO/TS 21564:2019 guidelines
  - A structured data repository to support subsequent simulation tasks in WP3

WP3T2 – DEFINITION OF FUTURE SCENARIOS

The objective of this task is to develop a comprehensive set of future scenarios by matching relevant features from WP3T1 to three key dimensions: climatic conditions, social determinants, and adaptation strategies. Also, it aims at defining a best-case, most likely, and worst-case level scenario to each dimension. This process will generate up to 27 distinct scenarios, which will be formatted into structured datasets compatible with the EMS Digital Twin (EMS-DT, as developed in WP2T5) framework. This approach will enable a detailed counterfactual analysis to quantify the health burden attributable to climate change.

Necessary inputs are:

- Feature inventory from WP3T1 (including climate, social, and adaptation-related data)
- Risk mapping outputs from WP2
- Data from global/regional climate projection models (e.g., Destination Earth's Digital

Twin and/or CMIP6)
- Projections on social determinants and adaptation factors, such as population aging, demographic changes, climate policies: (e.g. ISTAT - "Statistiche Sperimentali: Previsioni comunali della popolazione LINK, Regione Lombardia RCP 8.5 LINK, ISPRA – SCIA LINK)

The task will be performed in the following phases:

- WP3T2.1 DATA MATCHING TO SCENARIOS DIMENSIONS
  Different future scenarios will be constructed across three dimensions: climatic conditions, social determinants, and adaptation strategies. It will therefore be necessary to assign each relevant feature identified in WP3T1 to one (or more) of such dimensions.

- WP3T2.2 IDENTIFICATION OF LEVELS
  Each dimension will be modelled at three levels: best-case, most likely, worst-case. These levels will be obtained by a synchronous tuning of all features included in the dimensions; however, it must be noticed that mixed cases (different levels on different dimensions) might be hard to obtain, depending on features' impact on multiple dimensions. Ideally, $3^3 = 27$ distinct scenarios will be obtained.

- WP3T2.3 IMPLEMENTATION OF STRUCTURED DATASETS FOR EMS-DT
  The defined scenarios will be formatted into structured datasets that conform to the EMS-DT's input requirements. This step ensures that the modelled scenarios can be seamlessly integrated into the EMS-DT simulation framework for subsequent impact evaluation.

- WP3T2.4 UNCERTAINTY ANALYSIS
  Future projections inherently come with a certain degree of uncertainty. However, the identification of the multi-level scenarios (best-case, most likely, worst-case) across three different dimensions (for a total of $3^3 = 27$ combinations) is considered sufficient to properly account for projections-related uncertainty. Features' impact on multiple dimensions will be addressed through experts' feedback, carefully evaluating each scenario's coherence.

  The generated output will be:

  - Matched datasets aligning each feature with the scenario dimensions (climatic, social, adaptation)
  - A set of up to 27 distinct scenario combinations (best-case, most likely, worst-case for each dimension)
  - Structured datasets formatted for integration with the EMS-DT simulation framework

WP3T3 – KNOWLEDGE-BASED IMPACT ESTIMATION

This task aims to generate risk outputs for each scenario defined in WP3T2 by applying both the original, literature-based weighting scheme (WP3T3.1) and a back-tuned, data-driven weighting scheme (WP3T3.2). GIS-based maps will be produced (WP3T3.3) to visualize the spatial distribution of climate-related health risk, and a rigorous uncertainty analysis (WP3T3.4) will be conducted. This dual approach enables a critical comparison between knowledge-based and empirical risk assessments, thereby quantifying the health burden attributable to climate change while considering social inequality and geographical variability.

Necessary inputs are:

- Structured scenario datasets from WP3T2 (climatic, social, and adaptation dimensions)
- Original risk outputs and weights from WP2T2.1 (knowledge-based approach)
- Back-tuned weights and corresponding data-driven insights from WP2T2.3 and WP2T4

The task will be performed in the following phases:

- WP3T3.1 EXPECTED OUTPUT BASED ON ORIGINAL WEIGHTING
  Considering the scenarios defined in WP3T2, the risk outputs will first be generated using the original, literature-based weighting scheme as established in WP2T2.1. This will serve as a baseline for assessing the health impact under the current knowledge framework.

- WP3T3.2 EXPECTED OUTPUT BASED ON BACK-TUNED WEIGHTING
  Subsequently, again considering the scenarios defined in WP3T2, outputs will be re-calculated using the weights applied in WP2T2.3, back-tuned from data-driven insights from WP2T4. This dual evaluation allows for a critical comparison between purely knowledge-based and empirically adjusted risk assessments.

- WP3T3.3 MAPS GENERATION
  GIS-based maps will be produced for each scenario, visualizing the spatial distribution of climate-related health risk across the region, replicating the structure proposed in WP2T2.

- WP3T3.4 UNCERTAINTY ANALYSIS
  Uncertainty will be rigorously integrated into this evaluation by replicating the uncertainty analyses from WP2T2.2.1 (structured expert elicitation) and further quantifying error propagation from sensitivity analysis performed in WP2T2.2.2 This ensures that confidence intervals and uncertainty bounds accompany all risk outputs and maps.

  The generated output will be:

- Risk outputs for each scenario using both original and back-tuned weighting schemes
- GIS-based maps displaying the spatial distribution of climate-related health risks
- Detailed uncertainty analysis reports, including confidence intervals and error propagation metrics

WP3T4 – SIMULATION THROUGH EMERGENCY MEDICAL SERVICES DIGITAL TWIN (EMS-DT)

This task aims to simulate emergency service demand and operational impacts across the 27 defined scenarios using the EMS Digital Twin (EMS-DT, as developed in WP2T5). By integrating structured scenario datasets with the EMS-DT, this task quantifies how future climatic and socio-economic conditions may alter emergency service calls, resource allocations, and other performance indicators. Repeated iterations will capture the inherent randomness of system performance, providing robust uncertainty estimates to support a comprehensive assessment of the health burden attributable to climate change. The outcome will allow the comparison of the health burden within and between different cities in Lombardy.

Necessary inputs are:
- Structured scenario datasets from WP3T2.3 (including climatic, social, and adaptation dimensions)
- EMS-DT demand prediction module and associated input parameters (e.g. territorial clusters) from WP2T5.1

The task will be performed in the following phases:

- WP3T4.1 DEMAND GENERATION FOR EACH SCENARIO
  The demand prediction module of EMS-DT (developed in WP2T5.1) will be used to simulate demand (i.e., emergency service calls) under each of the 27 defined scenarios. This step leverages the structured scenario datasets (WP3T2.3) to forecast how future conditions may alter emergency service demands regionally.

- WP3T4.2 EMS IMPACT SIMULATION FOR EACH SCENARIO
  Building on the demand forecasts, the EMS-DT will simulate operational impacts for each scenario. This includes resource allocation (e.g., number of ambulances) and other key performance indicators relevant to emergency response, directly linking climate and social determinants to health system performance.

- WP3T4.3 RESULTS COLLECTION
  All simulation outputs, including demand forecasts, resource allocations, and associated uncertainty measures, will be systematically collected. This consolidated dataset forms the basis for comparative analysis and further evaluation of the health burden attributable to climate change.

- WP3T4.4 UNCERTAINTY ANALYSIS
  The simulation-based approach allows to compute multiple iterations to capture the inherent randomness in system performance (as also addressed in WP2T5.3.2). Repeated runs will provide distributions for each output metric, enabling robust uncertainty estimation through statistical analysis (e.g., confidence intervals).

  The generated output will be:
  - Demand forecasts for emergency service calls for each scenario
  - Simulation outputs detailing resource allocation (e.g., number of ambulances) and key performance indicators
  - Comprehensive report linking scenario-based simulation outcomes to the quantified health burden attributable to climate change

WP3T5 – RESULTS ANALYSIS

This task aims to conduct a comprehensive comparison between the knowledge-based risk mapping outputs (WP3T3) and the simulation-based EMS-DT outputs (WP3T4) to assess the health burden attributable to climate change. This task employs data normalization, spatial correlation metrics, and Multi-Criteria Decision Analysis (MCDA) to quantitatively evaluate how variations in weighting schemes, social determinants, and geographical variability influence risk estimates, thus supporting robust health impact assessments and informing climate adaptation strategies.

Necessary inputs are:
- Risk outputs from WP3T3 (original and back-tuned weightings)
- Simulation outputs from WP3T4 (demand forecasts, resource allocation metrics, and uncertainty measures)

The task will be performed in the following phases:

- WP3T5.1 COMPARISON BETWEEN KNOWLEDGE-BASED AND DATA-DRIVEN APPROACHES
  A detailed comparative analysis will be conducted between the outputs obtained via the risk mapping approach (WP3T3) and the simulation-based approach (WP3T4). The comparison will assess the consistency and divergence between these two approaches, identifying how variations in weighting schemes and simulation dynamics influence the overall health burden estimates, with particular attention to the role of social determinants and geographical variability.

  To achieve this, the following procedure will be applied:

  - WP3T5.1.1 Data normalization, aligning spatial and temporal resolutions for the risk indices (from WP3T3) and the simulation outputs (from WP3T4) through methods such as z-scores or min–max normalization.

  - WP3T5.1.2 Spatial correlation metric: Moran's I will be computed to quantify the similarity in spatial patterns between the two approaches.

  - WP3T5.1.3 Multi-Criteria Decision Analysis (MCDA): key performance indicators (KPIs) derived from both methodologies will be identified, normalized, weighted, and aggregated; such composite scores are used to rank the scenarios, with the highest values indicating the most favourable condition, providing a clear and quantitative basis for comparing the different approaches, and revealing convergence or divergence between the knowledge-based risk mapping and EMS-DT simulation outputs.

  - WP3T5.2 COMMENTARY ON RESULTS

    A comprehensive commentary will be developed to interpret the integrated findings from both the knowledge-based and simulation-based approaches, targeting in particular:

    - Quantitative comparison: interpretation of spatial correlation (Moran's I) and MCDA rankings, highlighting convergence or divergence between approaches

    - Impact of weighting schemes: evaluation of differences between literature-based and data-driven weightings on risk estimates.

    - Social determinants and geographical variability: assessment of how these factors influence emergency service demand and health burden estimates.

- Uncertainty and robustness: discussion of confidence intervals and sensitivity analyses to validate the reliability of results.
- Policy and adaptation implications: insights for health system planning and climate adaptation based on the comparative findings.

The generated output will be spatial correlation metrics (Moran's I), MCDA composite scores and scenario rankings based on key performance indicators, commentary on weighting impacts, social determinants, geographical variability, and policy/adaptation implications

WP3T6 – OPEN-ACCESS PROJECT REPOSITORY (OA-PR) MANAGEMENT AND MAINTENANCE

Goal of this task is to establish and sustain a comprehensive open-access repository that ensures transparency and long-term accessibility of all project outputs. This aims to support collaborative research and foster reproducibility by providing a centralized platform for code, data, and detailed documentation that remains publicly available beyond the project's duration. A cloud-based repository will be implemented using GitHub as the main platform for hosting the project code and version control. Complementing this, Zenodo will serve as the overarching repository for all project data, results, and methodological documentation. Throughout the project, the repository will be continuously updated with new findings, datasets, and algorithms, all of which will be thoroughly commented to enhance usability. A comprehensive README document will be included to provide a full description of the methodology and clear instructions on how to utilize the repository's contents. Upon project completion, the repository will be maintained as an open-access resource to support ongoing community engagement and ensure the longevity of the project outputs.

WP4 – CLIMATE AND HEALTH ROADMAP TO INFORM ADAPTATION AND MITIGATION STRATEGIES

OBJECTIVE

This work package aims to develop a comprehensive Climate and Health Adaptation Roadmap that leverages Essential Climate Variables (ECVs) derived from Earth Observation (EO) to support evidence-based adaptation and mitigation strategies in the health sector.
To achieve this, WP4 will first establish a robust baseline of current climate adaptation options (Task 1), with a focus on how ECVs contribute to monitoring, risk assessment, and decision support for health and well-being. It will then assess the opportunities and limitations of current ECVs (Task 2), based on project-specific insights from GIS-based and data-driven approaches, and produce a technical matrix identifying key factors affecting adaptation strategies.
Based on this assessment, WP4 will formulate forward-looking recommendations for the improvement, integration, and application of ECVs in health-focused climate services (Task 3). These recommendations will also inform AREU (the regional emergency medical service provider) on how Emergency Medical Services (EMS) need to be adapted to remain effective

under projected future climate and health stress conditions—particularly in relation to heatwaves, air quality degradation, and associated increases in service demand.
In parallel, an initial five-step implementation framework will be evaluated and refined (Task 4), defining the operational structure needed to integrate ECVs into computational modeling, risk analysis, and adaptive decision-making processes. The final deliverable (Task 5) will be a consolidated Climate and Health Adaptation Roadmap that synthesizes all findings and provides practical guidance for using ECVs in climate-resilient health planning and EMS preparedness.

WP4T1 – STATE-OF-THE-ART (SOTA) ANALYSIS OF CLIMATE ADAPTATION OPTIONS

Goal: Establish a robust baseline of current climate adaptation strategies with a specific focus on the role of Essential Climate Variables (ECVs) in supporting health system resilience and human well-being.
Phases:

- **WP4T1.1** Conduct a comprehensive review of key adaptation reports (e.g., RD-16, RD-19, RD-20, RD-30), analyzing how ECVs are currently used to monitor, assess, and manage climate-related health risks.
- **WP4T1.2** Integrate insights from our dual analytical approach:
  • *Knowledge-based:* Examine how ECVs are applied in GIS mapping and expert-driven indicators.
  • *Data-driven:* Assess how ECVs are processed in our data-driven models using high-resolution EO data.
- **WP4T1.3** Identify gaps where the project's unified framework (as developed in WP2 and WP3) can enhance current practices.

Output: A detailed SOTA report summarizing the role of ECVs in existing adaptation strategies and highlighting research and implementation gaps addressed by our project.

WP4T2 – ANALYSIS OF SATELLITE-BASED OPPORTUNITIES AND CONSTRAINTS

Goal: Evaluate the potential and limitations of current ECVs in supporting health-related adaptation strategies, based on project-specific methodologies and findings.
Phases:

- **WP4T2.1** Catalogue current ECVs relevant to health (e.g., air quality, temperature extremes, drought indicators), assessing their spatial/temporal resolution, continuity, latency, and accessibility in relation to emergency planning and health risk modelling.
- **WP4T2.2** Integrate findings from WP2 and WP3:
  - From WP2: Spatial risk information from GIS-based mapping and indicator development.
  - From WP2 and WP3: Risk quantification and projections using the EMS-DT simulation module.
- **WP4T2.3** Develop a technical matrix mapping opportunities and constraints of ECVs and their implications for health adaptation planning.

Output: A technical matrix outlining key ECV characteristics, limitations, and their strategic relevance for climate-health applications.

WP4T3 – SATELLITE- BASED OPPORTUNITIES- RECCOMENDATIONS ON THE ECVs

Goal: Formulate recommendations to improve the relevance, accessibility, and integration of ECVs for future climate-health adaptation and long-term planning.

Phases:

- **WP4T3.1** Identify current limitations in ECV usage for health applications, including gaps in resolution, thematic coverage, and temporal continuity.
- **WP4T3.2** Provide strategic recommendations on: • Which ECVs are most relevant for assessing and anticipating climate-related health risks;
  • How to enhance their integration into monitoring systems and decision-making processes;
  • What data attributes are critical for their operational use.
- **WP4T3.3** In collaboration with AREU, translate scenario-based results into actionable recommendations for Emergency Medical Services (EMS), including projected service demand, resource planning, and location-specific vulnerabilities.

Output: A set of recommendations on ECV prioritization and EMS adaptation needs, contributing directly to the Climate and Health Adaptation Roadmap.

WP4T4 – DESIGN OF A FIVE-STEP FRAMEWORK FOR CLIMATE AND HEALTH ADAPTATION FOCUSED ON SATELLITE-BASED SOLUTIONS

Goal: Design a five-step framework to integrate satellite-based ECVs into climate and health adaptation, specifically for EMS preparedness and response.
Approach:
We will identify five key steps based on the following criteria:

- Relevance to health system adaptation (e.g., EMS response to climate risks).
- Effective use of satellite-based ECVs.
- Feasibility in terms of data availability and implementation.

Output: A five-step framework that incorporates ECVs into climate-health adaptation planning, focusing on enhancing EMS capabilities.

WP4 TASK 5 – PRODUCTION OF THE CLIMATE AND HEALTH ADAPTATION ROADMAP

Goal: Synthesize all WP4 findings into a clear and actionable Climate and Health Adaptation Roadmap, supporting the integration of ECVs into real-world planning and decision-making.
Phases:

- **WP4T5.1** Consolidate findings from WP4T1 through WP4T4 into a structured and coherent roadmap.
- **WP4T5.2** Develop integrated graphical representations to: • Illustrate the five-step implementation framework;

• Visualize key ECV-related dimensions (e.g., exposure, vulnerability, adaptability);
• Showcase how our project's methods (WP2 and WP3) translate into actionable adaptation measures.

- **WP4T5.3** Validate the roadmap to ensure alignment with project outcomes, stakeholder needs, and best practices in climate-health adaptation.

Output: The final Climate and Health Adaptation Roadmap, featuring a narrative, graphics, and evidence-based guidelines for leveraging ECVs in climate-resilient health systems.

WP5 – MANAGEMENT OUTREACH AND COMUNICATION

This Work Package ensures the effective coordination, communication, and visibility of the CLIMA-CARE project. It supports smooth project execution, timely delivery of outputs, stakeholder engagement, and the dissemination of project results to the scientific community, stakeholders, and the public.

WP5T1 – PROJECT MANAGEMENT AND REPORTING

Led by DLR, this task ensures both scientific and administrative coordination of the project. It includes day-to-day management of project activities, internal coordination among partners, and quality assurance to guarantee timely and high-quality delivery. Regular progress is monitored through structured internal reporting, and project meetings are organized to align the work across the consortium and maintain ongoing communication with ESA. The task also covers the preparation of key project documentation and final reporting.

WP5T2 – SCIENTIFIC HIGHLIGHTING AND REPORTING

This task focuses on effectively communicating the scientific progress of the project. It includes the preparation of concise scientific updates and highlights for ESA (see monthly and quarterly reports), as well as dissemination through participation in major scientific conferences. The team will submit abstracts, present results, and contribute to increasing the scientific visibility and impact of the project through final presentations and other tailored materials for the research community.

WP5T3 – INTERACTION WITH ESA CLIMATE AND CCI COMMUNITIES

To ensure alignment with ESA's overarching climate and health agenda, this task facilitates active engagement with the Actionable Climate Information section and the Climate Change Initiative (CCI) community. The project team will regularly share results, visuals, and key messages with ESA to support institutional communication and policy dialogue. Participation in ESA events and contributions to international initiatives will also be ensured when relevant and requested.

WP5T4 – OUTREACH AND PUBLIC ENGAGEMENT

This task focuses on building the project's public presence. A dedicated website will be created to showcase scientific results, updates, and key materials in an accessible format.

The website will serve as a central platform for engaging researchers, policymakers, and the general public. The project will also maintain an active LinkedIn presence, complemented by blog posts and contributions to external media. All partners will support content creation to ensure broad and inclusive communication of CLIMA-CARE's objectives and findings.

2.4. Reservations –Compliance

REQUIREMENT		COMPLIANT (Y/N/P)	REMARKS
REQ- 1	Projects ***shall*** select only one Stream from the possible two Streams (i.e., Global or regional/local). This activity encourages that the studies use locations outside ESA's Member States (RD-25).	Y	Regional Stream
REQ- 2	Projects ***shall*** focus on the climate change impact on health systems and facilities (RD-03), and the climate-related health impacts directly affected by three high-impact climate events: (i) heatwaves, (ii) heavy rainfall and floods, or (iii) droughts.	Y	The focus on health systems and facilities is set by studying Emergency Medical Services; insights on climate-related health impacts are the main output of WP2
REQ- 3	Projects ***shall*** address priority knowledge gaps on climate change impacts for health system and facilities, human health and well-being, and migration, as identified in peer reviewed papers by the international scientific community, by undertaking novel scientific analyses.	Y	The proposed modelling methodology is novel; project's focus and implementation will be assessed including insights from literature review and experts' elicitation
REQ- 4	Projects ***shall*** exploit, to the fullest extent possible, the ECV datasets developed within the ESA CCI programme, ESA's EO data archive and, if required, other satellite products: the use of these space data ***shall*** be a major component of the research efforts but is not limited to these.	Y	EO data are one primary input for the technical implementation
REQ- 5	Projects ***shall*** exploit global or regional climate projections dataset in TASK 4. For example, projects ***should*** consider the usage of the new (global) Digital Twin for Climate Change Adaptation dataset (RD-26), developed by Destination Earth Initiative (RD-27, RD-28). Alternatively, projects ***should*** consider the sixth phase of the Coupled Model Intercomparison Project (CMIP6) in case of the use of either historical or scenario (i.e., Shared Socioeconomic Pathways (SSPs)) simulations (RD-29).	Y	Climate projection data are the core input of WP3, whose output will be the foundation for WP4
REQ- 6	Projects ***shall*** include at least one of the three high-impact climate events described in Section 2.1. Compound or cascading events are welcome if it includes at least one the high-impact climate events.	Y	Main focus on heat and air pollution (cascading event), with possible extension of modelling to any additional climate event.

REQ- 7	Projects ***shall*** take full advantage of new and existing science results, models, research tools, and ongoing projects from national, European and international research, when planning, implementing and reviewing the progress of the project. There ***shall*** be no duplication of any work covered by other projects and programmes.	Y	Modelling methodology is novel, yet built upon existing background knowledge
REQ- 8	Projects ***shall*** consider carefully the role of uncertainty, including consideration of all significant sources of uncertainty (including observational, model internal variability, etc), mapping (i.e. documentation of each source and its relevance in the processing chain), and their impact. Where possible, projects ***shall*** include quantification and formal propagation of uncertainties	Y	In all computational tasks, uncertainty is dealt with through dedicated analyses
REQ- 9	Projects ***shall*** carry out a verification and validation study of the results of the main analysis work, documenting findings and quantifying uncertainty estimates.	Y	Validation against historical data is performed when possible, while robustness analyses are embedded in other cases
REQ- 10	REQ-10.1 Projects ***shall*** produce at least 2 publications that are submitted to peer-reviewed journals within the project duration, focusing on the intersection of climate change and its impact on public health, epidemiology, and health policy.	Y	
	REQ-10.2 Projects ***shall*** discuss with the TO about the intended journal for publication. The TO ***shall*** approve the final selection.	Y	
	REQ-10.3 Projects ***shall*** send to the TO the final publication draft to be reviewed and approved before the submission.	Y	
REQ- 11	REQ-11.1 Projects ***shall*** submit at least 2 conference abstracts (or 2 conference papers) and attend in person the respective conference (if the abstract/paper accepted) within the project duration. The conferences must be focused on the intersection of climate change and its impact on public health. *Note to the tenderer*: Projects should consider submitting an abstract or organize a session in the following conferences: • International Society for Environmental Epidemiology (ISEE) • European Geoscience Union (EGU) • ESA's Living Planet Symposium 2028 (LPS28)	Y	
	REQ-11.2 Projects ***shall*** send to the TO the final conference abstract or paper to be reviewed and approved before the submission.	Y	
REQ- 12	Projects ***shall*** coordinate with and maintain a relationship to ESA CCI ECV projects and other international projects to take advantage of ongoing studies and networks outside the project. This will ensure datasets and tools are applied correctly and that any inconsistencies are fed back to the CCI teams; a mutual exchange to discuss methods and results ***shall*** be facilitated.	Y	Activity included in WP1, to be carried on along the whole project implementation

REQ- 13	Projects ***shall*** conform with the applicable documents relating to data use and publication (AD-1, AD-2) to ensure accessibility, traceability and repeatability of results.	Y	
REQ- 14	Projects ***shall*** design graphic representations that easily demonstrate the role of satellite-based information: As a component for adaptation and mitigation strategies (e.g., figures in RD-20 and RD-30), To support climate responses and adaptation options for health system and facilities, human health and well-being, and migration (e.g., figure SPM4 (a) and (b) from RD-16).	Y	Included in the outputs of WP4
REQ-15	Projects ***shall*** create, maintain updated and running, during the whole duration of the project, an open-access and public project repository in a cloud-based platform (e.g., GitHub (RD-31) and ESA's DestinE platform (RD-28) and/or ESA's Network of Resources (NoR) (RD-32)). This repository will contain all data, results, "How to use" (README) document with the full description of the methodology, and all project related commented-algorithms. After the end of the project, the repository shall remain open-access and public, and should have an in-kind maintenance.	Y	Open-access repositories will be activated and maintained along the project (dedicated tasks described in WPD)
REQ-16	Projects ***shall*** have an active digital presence on LinkedIn and post at least every 3-months.	Y	
REQ-17	The tenderer ***shall*** complete the mandatory Digital Responsibility Survey (Annex A) and attach it as Annex into the proposal.	Y	
REQ-18	Projects ***shall*** bring a multidisciplinary team containing EO experts, epidemiologists, climate scientists, and cloud computing developers/engineers.	Y	

2.5. Existing own concepts/products to be used (Prime and Subcontractors)

AREU will provide the ambulance data of the entire Lombardy Region that has 10 million citizens. AREU has the ownership of the data that will be shared with the partners for these projects. We will continue to have the copyright of the data that shall not be used from other entity without previous approve from AREU. We will provide our Epidemiologist to certify the data and out Medical Director of Mass Casuality Incident to supervise the creation of protocols.

DLR has much experience in the processing of satellite data and generates many data products related to atmospheric composition and air pollution. For example, it developed an AI-based method to derive ground-level pollutant concentrations from satellite column data. Based on this approach, relevant datasets and products can be generated to support the proposed project.

2.6. Third Party's concepts/products (outside of the consortium which is composed by the Prime Contractor and Subcontractor/s) intended to be used

- Commuting data: (https://www.dati.lombardia.it/Mobilit-e-trasporti/Matrice-OD2016-Passeggeri-Scenario-2030/sht7-5jd5)
- Land use (https://geoservice.dlr.de/web/maps/de:lcc)
- Demographic information: Italian National Institute of Statistics (ISTAT https://www.istat.it/)
- Socio-economic and beahvioral data: Italian National Institute of Statistics (ISTAT https://www.istat.it/)
- Socio-economic and socio-demographic data: Lombardy regional open-data portal (https://www.dati.lombardia.it/)
- Geographical and territorial data: Lombardy region geoportal (https://www.geoportale.regione.lombardia.it/)
- Infrastructures: OpenStreetMap (https://www.openstreetmap.org/)

2.7. Potential Problem Areas

2.7.1. Identification of the main problem(s) or problem area(s) likely to be encountered in performing the activity

PROBLEM AREA 1 - PROJECT STREAMLINING

- **Coordination**: delays in initial phases (e.g., literature review, methodology evaluation) could create bottlenecks in subsequent tasks (e.g., framework development). Timely engagement of high-level stakeholders (e.g., WHO, CDC) is challenging. Example tasks affected include WP1T1 (literature review), WP1T2 (methodology evaluation), and WP1T3 (stakeholder-informed framework development). If WP1T1 and WP1T2 are delayed or poorly integrated, WP1T3 may lack the necessary inputs to develop a robust and relevant framework, thus compromising the overall coherence and impact of WP1.

- **Expertise Alignment and Uncertainty: d**ifferences between expert judgment and data-driven analysis could lead to inconsistent uncertainty estimates.
  Example tasks affected include WP2T2 (structured expert elicitation) and WP3T3 (uncertainty integration). In WP2T2, inadequate training or methodological support could result in biased or unreliable expert-derived uncertainty estimates. In WP3T3, reconciling divergent uncertainty formats and sources may complicate the construction of robust confidence intervals and undermine the interpretability of model results.

PROBLEM AREA 2 - DATA ISSUES

- **Availability, Completeness, and Usability**: The project may face significant challenges related to the availability, completeness, and quality of key datasets, particularly in health and socio-demographic domains. Emergency Medical Services (EMS) data may suffer from inconsistent entries or data sensitivity-related concerns, while socio-demographic and adaptation-related datasets can be outdated, overly aggregated, or inaccessible due to institutional or licensing barriers. Furthermore, essential variables identified through prior analysis may be missing in future datasets, compromising the continuity and depth of analysis. These limitations can constrain data integration efforts, reduce analytical robustness, and introduce delays due to the need for negotiations or additional anonymization processes.
  Tasks particularly affected include WP2T1 (data processing and integration) and WP3T1 (scenario alignment and data mapping). In WP2T1, poor-quality or incomplete EMS and demographic data may hinder stratified analyses and risk modelling. In WP3T1, restricted or outdated datasets could delay future projections or reduce the relevance of integrated variables, weakening the consistency of forward-looking assessments.

- **Harmonization and Compatibility**: Differences in formats, resolutions, and standards between datasets could reduce analysis reliability.
  Affected tasks include WP2T1 (data harmonization) and WP2T2 (modelling and validation). WP2T1 may face delays in preparing harmonized datasets ready for modelling. WP2T2 may suffer from low-quality validation due to weak alignment between historical records and modelled inputs.

- **Processing**: Managing high-resolution EO data, detailed health records, and complex spatial features imposes significant data processing demands, especially for scenario-building, where limited or uncertain quantitative projections hinder the creation of well-contrasted future scenarios.
  Affected tasks include WP2T1 (data preparation and preprocessing) and WP3T2 (scenario development). WP2T1 may experience delays or reduced efficiency without scalable data infrastructure. WP3T2 could struggle to define robust and distinct scenario pathways due to data scarcity or lack of quantitative projections, limiting the quality and informativeness of scenario simulations.

PROBLEM AREA 3 - TECHNICAL ISSUES

- **Cross-Model Coherence**: The project entails integrating multiple methodological outputs, including GIS-based mapping, expert-defined indices, and data-driven simulation tools like EMS-DT, into a unified decision-support framework. This presents substantial challenges in terms of technical streamlining, as datasets may differ in spatial resolution, temporal frequency, or scope. Successful integration will depend on careful data harmonization and consistent modelling conventions, to ensure that outputs from distinct components can be meaningfully aligned for use in the subsequent modules. Misalignment or incompatibility at any stage may compromise the overall coherence of the project’s technical deliverables.
  Particularly affected tasks include WP3T4 (integration of scenarios with EMS-DT) and WP4 (cross-cutting synthesis and system-level integration). WP3T4 may encounter

delays or inaccuracies in simulations if data input standards are not harmonized. WP4 could struggle to combine outputs from different work packages into a coherent framework, potentially weakening the utility of the final risk assessment and prioritization outputs.

- **Computational Requirements**: The project's computationally intensive tasks (e.g., MGWR modeling, multi-dimensional bootstrapping) may lead to performance bottlenecks and delays if there is insufficient high-performance computing infrastructure. Affected tasks include WP2T3 (multi-dimensional bootstrapping), WP2T4 (MGWR modeling), WP3T2 (scenario data preparation), and WP3T4 (simulation in EMS-DT). WP2T3 and WP2T4 could face long runtimes and reduced reproducibility due to computational demands. WP3T2 and WP3T4 may encounter scalability and integration issues when processing and running multiple simulation scenarios, requiring advanced infrastructure and careful coordination within working team.

- **Correctness and Statistical Robustness**: Advanced models (e.g., WMARM, MGWR) may suffer from overfitting or distortions due to spatial clustering issues or model assumptions, reducing the reliability of outputs
  Affected tasks include WP2T3 (threshold optimization), and WP2T4 (MGWR-based transformations and SHAP-driven clustering). WP2T3 risks produ.cing models that perform well only under specific configurations, while WP2T4 may generate spatial mappings and clusters that are unreliable or misleading if assumptions of spatial or feature homogeneity are violated. This could reduce the trustworthiness and practical usability of model outputs in territorial health adaptation planning.

- **Design-related Issues**: Difficulty in establishing a ground truth for climate-health risks may lead to ambiguous comparisons between knowledge-based and data-driven models, while high spatial granularity could cause biased predictions in low-density areas.
  Tasks affected include WP2T2 (comparison of approaches, weight assignment), WP2T5 (spatial-temporal granularity, class imbalance), and WP3T2 (dimensional overlap, scenario redundancy). These tasks may lead to unreliable or biased outputs due to data sparsity, poor model calibration, or oversimplified assumptions. WP3T5 also faces challenges in explaining model divergences, which could make it difficult to provide actionable recommendations based on the varying results. WP4 is affected by the challenge of ensuring scalability of the implementation framework across diverse regions, which may limit its practical applicability without local adaptations.

PROBLEM AREA 4 - RESULTS USABILITY

- **Information Overload**: The project’s complexity may result in too many outputs, making it difficult for stakeholders to draw meaningful conclusions without clear structure.
  Tasks affected include WP2T3 (stratification complexity, potential for information overload), WP3T2 (scenario explosion, risk of diluting insights), WP3T4 (challenges in managing large volumes of simulation data), and WP4 (difficulty in synthesizing diverse insights into a clear, actionable roadmap). These challenges could make it difficult for stakeholders to effectively interpret and apply results, potentially reducing the impact of the project’s recommendations.

- **Interpretation Challenges and Communication Strategies**: Decision-makers may struggle to interpret probabilistic outputs and confidence intervals, potentially leading to misinterpretations and inefficient policy recommendations.
  Tasks affected include WP2T5 (uncertainty interpretation and decision-maker understanding), WP3T4 (interpretation of results, balancing competing goals), WP3T5 (complexity in contextualizing divergent or convergent results), WP3T5 (misleading conclusions about health burden), WP3T5 (ineffective policy recommendations), and WP4 (inconsistent or unclear roadmap). If results are not properly structured, these tasks may lead to confusion or a lack of actionable outcomes.

- **Maps:** Results interpretability could be particularly troublesome in relation to the generation and interpretation of GIS-based maps. This project output could arise several challenges related to spatial resolution and scale mismatches. For instance, overlaying datasets with varying resolutions may lead to inconsistent visualizations, complicating the accurate representation of multi-dimensional risk data. Furthermore, interpreting these maps could oversimplify complex interactions between variables, potentially leading to misinterpretations by decision-makers. Additionally, visualizing uncertainty, such as confidence intervals, may confuse stakeholders if it is not clearly communicated or if it varies significantly across regions, limiting the effectiveness of these visual tools.

2.7.2. Proposed solutions to the problems identified

PROBLEM AREA 1 - PROJECT STREAMLINING

The project should adopt a flexible approach that reduces cascading delays. This includes producing early prototypes of key outputs (e.g., draft literature reviews, provisional methodologies) to inform subsequent tasks before full completion. Internal checkpoints should be introduced to identify integration issues early, while regular synchronization meetings could help manage inter-task dependencies. Stakeholder engagement risks can be reduced by including an early, well-planned engagement strategy with backup participants and incentives. This could be fostered by preparing a reserve pool of alternative participants and using low-effort engagement tools (e.g., short surveys). Also, partially decoupling task dependencies (e.g., allowing WP1T2 to begin using external references) will further enhance adaptability. This strategy would allow WP1T3 to proceed even under uncertainty, supporting project streamlining. For personnel turnover, a similar strategy of anticipative identification of back-up resource can be implemented.

The project should establish clear protocols for integrating uncertainty from both expert judgement and model-based analysis. This includes using standardized methods for uncertainty expression, and implementing methodological harmonization of inputs. Pilot tests in WP2T2 can improve the consistency of expert contributions, while structured uncertainty assessment frameworks in WP3T3 will support coherent integration across sources, enhancing the reliability and interpretability of final outputs.

The project should base its recommendations on a dual approach distinguishing between near-term enhancements, implementable with current capabilities, and long-term innovations, envisioned as potential. WP4T2 should include consultations with EO experts, tentative cost-benefit analysis, and comparison with existing satellite mission roadmaps.

PROBLEM AREA 2 - DATA ISSUES

- The project should map available datasets early and identify alternative sources when needed, while clearly documenting any data limitations. WP2T1 and WP3T1 must build flexible workflows that adjust to differences in data quality and resolution. When data gaps occur, proxy measures or imputation methods should be evaluated for potential use, while any uncertainty in the results should be clearly explained.

- To address the challenges of integrating different data sources, the project should develop standardized preprocessing procedures for harmonizing formats, structures, and resolutions across EO, health, socio-demographic, and geospatial data. This includes defining clear rules for upscaling, downscaling, and validation to minimize errors. Also, pilot tests should be run early in WP2T1 to refine the process and coordinate with data providers.
- The project should develop a scalable data structure that supports storage, cleaning, and integration of high-resolution EO data, health records, and spatial features. In addition, the project should explore alternative quantitative sources or proxy measures to fill gaps in projections features, ensuring that scenario development is as informative as possible.

PROBLEM AREA 3 - TECHNICAL ISSUES

- The project should define in advance well-structured data standards, conventions, and integration processes. This includes setting specific formats for spatial and temporal data. Also, coordination between research teams is essential to identify and resolve inconsistencies, to intervene before integration issues arise. Also, a high level of automation in the implementation of processing algorithms will help minimizing incoherencies, as data format mismatches would result in execution breaks.

- The project should plan access to high-performance computing resources and adopt efficient and well-documented code and data workflow. This includes optimizing processing pipelines, using parallel computing where possible, and applying version control to support internal interoperability and reproducibility. Regular technical coordination among team members will be essential to help identify infrastructure needs and avoid bottlenecks during processing phases.

- To reduce the risk of overfitting and unstable results, the project should use strong cross-validation strategies and minimize the number of parameters to be tuned. Results should be compared, to the possible extent, across alternative modeling approaches to assess consistency and improve reliability through validation protocols. On top of mitigation measures, robustness assessment will be thoroughly conducted by carefully evaluating uncertainty and its propagation across processing modules.
  Although major changes to design could be unfeasible, the project should involve evaluating each computational step individually, to determine if small modifications

could improve performance. When possible, different approaches should be tested on smaller sections of the model or data, and their outcomes should be compared. The feasibility of this approach must be assessed according to the project schedule and the available time, ensuring that tests can be run without excessive delay in development.

PROBLEM AREA 4 - RESULTS USABILITY

- Outputs should be progressively filtered, grouped, and prioritized, based on their relevance to key decision points. Summaries and visual supports should be designed to highlight contrasts across setups (scenarios and subgroups), reducing the overall informative content to be transmitted to stakeholders. Where possible, structured templates and modular outputs should be used to support clarity and reduce the burden, in a step-by-step simplification process, to keep results usable and aligned with decision-making needs.

- To support interpretability, an approach of progressive outputs structuring should be applied, similarly to the suggested strategy to reduce information overload. Different layers of explanation should be provided, tested for clarity and usefulness depending on stakeholder needs. Probabilistic and comparative results should be translated into practical implications, using visual supports and synthetic key messages. When conflicting or ambiguous patterns arise, multiple interpretations should be presented and contrasted, carefully evaluating the trade-off between transparency and oversimplification. Compatibly with the project's time and resource constraints, the opportunity of refining communication formats through small iterations of feedback shall be evaluated.

- Spatial resolution mismatches should be addressed step-by-step by testing different aggregation or harmonization strategies and assessing their effects on visual clarity. Uncertainty should be visualized using standardized symbols, tested in small iterations to ensure stakeholder understanding. When possible, maps should be accompanied by brief explanatory notes or comparative views to prevent oversimplification and help interpret variable interactions, all within the project's available time and resources.

2.7.3. Proposed trade-off analyses and identification of possible limitations or non-compliances

Here we identify possible trade-offs, limitations and non-compliances related to the problem areas identified above:

- The availability of health data is highly influenced by the geographical location considered. This might imply the exclusion of certain areas. The validation and uncertainty analysis can still be performed for better covered areas. Therefore, a major impact on the overall outcome on the project remains reasonably low.

- WP1 involves a trade-off related to the narrowing of the project's focus: concentrating on a limited set of events allows for deeper analysis and better alignment with the partners' expertise, potentially supporting smoother project execution. In contrast, a

broader assessment covering multiple climate events would enhance generalizability and reduce the risk of bias, ensuring that important but less prominent topics are not overlooked. A similar trade-off applies to stakeholder engagement: involving a broader and more diverse group may provide a more holistic perspective, while a smaller, more targeted group could improve efficiency and reduce execution time.
The expected impact on the project is low: the planned WP1 activities are designed to carefully balance existing expertise, evidence from the literature, and input from stakeholders to ensure both relevance and feasibility. The final composition of the stakeholder group will largely depend on availability and the outcomes of engagement efforts.

- WP2 is inherently affected by a multi-dimensional trade-off due to the numerosity of:
  - experimental set ups (combination of climate event, health output, geographic granularity, patients' stratification)
  - tested configurations (exposure thresholds and lag periods)
  - iteration parameters (N of bootstrap iterations, of configuration tested for uncertainty, of sensitivity analysis iterations, of sensitivity analysis data range)
  - territorial clusters
  - years of EMS-DT simulation

  Increasing the numerosity of the abovementioned model parameters would result in a more significant identification of local (in space and time) dynamics, and a more accurate robustness assessment. A decrease would instead favour statistical relevance and can exponentially reduce processing time.
  The expected impact on the project is medium: batched testing on limited data subsets can help quantify in advance the effects of parameters tuning, thus helping to estimate in advance the opportune 'working point'; nevertheless, this preventive phase shall be addressed carefully and inevitably require the allocation of development time. Due to the data dimension, the risk of time-consuming iterations failing, or resulting unusable, is still to be accounted for regardless any mitigation measure.

CLIMAte change and health emergency CARE (CLIMA-CARE)

KO meeting – November 13th, 2025

Agenda of the meeting

Meeting agenda	
10:00 – 10:10	Welcome and quick round of presentation (DLR)
10:10 – 10:20	ESA presentation of the CCI Climate Change and Health Activity (ESA)
10:20 – 10:30	Team presentations (DLR,POLIMI,GEO, AREU)
10:30 – 10:45	Project overview (DLR, all)
10:45 – 11:15	Description of Work Packages (Part 1) • WP1: Development of an Assessment Report on Climate and Health (DLR) • WP2: Full Description of the Selected Climate and Health Case Study and Development of the Risk Assessment (POLIMI)
11:15 – 11:25	Coffee break
11:25 – 12:10	Description of Work Packages (Part 2) • WP3: Quantify the Health Burden Attributable to Climate Change and Exacerbated by Social Determinants (DLR) • WP4: Climate and Health Roadmap to Inform Adaptation and Mitigation Strategies (DLR) • WP5: Management, outreach and communication (DLR)
12:10 – 12:20	ESA comments, inputs
12:20 – 12:30	Review of the list of actions decided during the meeting

CLIMA-CARE Team

CLIMA-CARE Partners - DLR

German Aerospace Center (DLR) – German Remote Sensing Data Center (DFD)

- In charge of project lead and project scientific developments
- Ongoing collaborations with ESA in various projects.

Lorenza Gilardi (PM)
DLR Scientist

Dr. Thilo Erbertseder (SL)
DLR Senior Scientist
Lecturer

Dr. Jana Handschuh
DLR Scientist

Role in project

Prime contractor (PM)
Science Lead (SL)

WP1 – WP lead, ECV selection
WP2 – Env. data (EO +other) validation
WP3 – Lead, Future health impact quantification (support)
WP4 – Lead, Climate–health strategy design- support
WP5 – Management, Outreach and Communication

CLIMA-CARE Partners
POLIMI

D-Hygea Laboratory – Bioengineering section of Electronics, Information and Bioengineering department

- In charge of Work Package 2 – models development for risk assessment and impact on healthcare services

Lorenzo Gianquintieri
PhD, assistant Professor in Bioengineering

Role in project

WP1 – Co-design

WP2 – WP lead: implementation of risk assessment model and EMS digital twin for impact analysis on healthcare services

WP3 – Support: execution of climate projections impact assessment

WP4 – Support: results exploitation from WP2 and WP3

CLIMA-CARE Partners

Agenzia Regionale Emergenza Urgenza of Lombardy Region (AREU)

Sub-affiliation

- In charge of the data certification process with our epidemiologist
- Contribution in the creation of protocols
- Provision of data related to pre-hospital rescue operations

Dr. Roberto Faccincani
Director - Major Emergencies and Mass Gatherings Dept

Dr. Giuseppe Stirparo
Medical Director and Public Health Specialist

Dr. Andrea Pagliosa
Business Intelligence and Analytics, IT Dept.

Role in project

- IT & Business Intelligence
- Epidemiological Observations
- Mass Gatherings and Disaster Preparedness user-perspective

WP1 support the project coordinator in managing the consortium

WP2 prepare and pre-process the pre-hospital data

WP3 quantify the future health burden related to climate change

WP4 Contribute to develop a Climate and Health Adaptation Roadmap

CLIMA-CARE Partners

Group on Earth Observations (GEO)

Sub-affiliation

- Intergovernmental partnership of 115 member countries and 140+ participating organizations promoting EO as a global, public good
- Urban resilience as a key engagement priority through dedicated working groups
- Coordinator of Global Heat Resilience Service (GHRS)

Martyn Clark
Urban Resilience Coordinator,
GEO Secretariat

Role in project

- Urban Resilience Advisor
- Urban Network Engagement
- EO Integration for Health Applications

WP1 Lead urban resilience literature review and stakeholder requirements framework

WP2/3 Quality assurance for urban transferability and methodology validation

WP4 Scalability assessment and five-step framework evaluation

WP5 Urban network engagement and knowledge dissemination

CLIMA-CARE Background

esa

High-impact climate hazards

- Heatwaves
- Heavy rainfall and floods
- PM.25 Droughts and deterioration of air quality

→ Increased frequency and intensity
→ Trigger of direct and indirect health effects

Health Impacts & Gaps

- Rising emergency demand, mortality peaks, system stress
- Lack of integrated evidence on *how* health systems respond

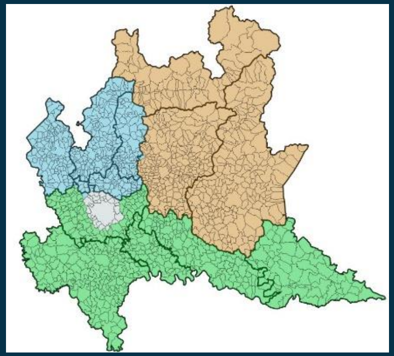
→ Understanding system response is key to climate-resilient health planning.
→ Strengthening the role of EO applications for health care emegency planning

CLIMA-CARE Background

HEALTH EMERGENCY DATA:

- **AREU Ambulance mission records** (EMMA database) from Lombardy's emergency medical services **(EMS-118** or **112**).
- Each record includes: event type, location, time, response unit, outcome, and **anonymized patient** information.
- Data are **operational, near real-time**, and geo-localized.
- **Access restricted** to project partners under AREU data governance agreement.

4 EMERGENCY RESPONSE CENTER



12 LOCAL ORGANIZATIONS

SRA SRL SRM SRP

Daily etl

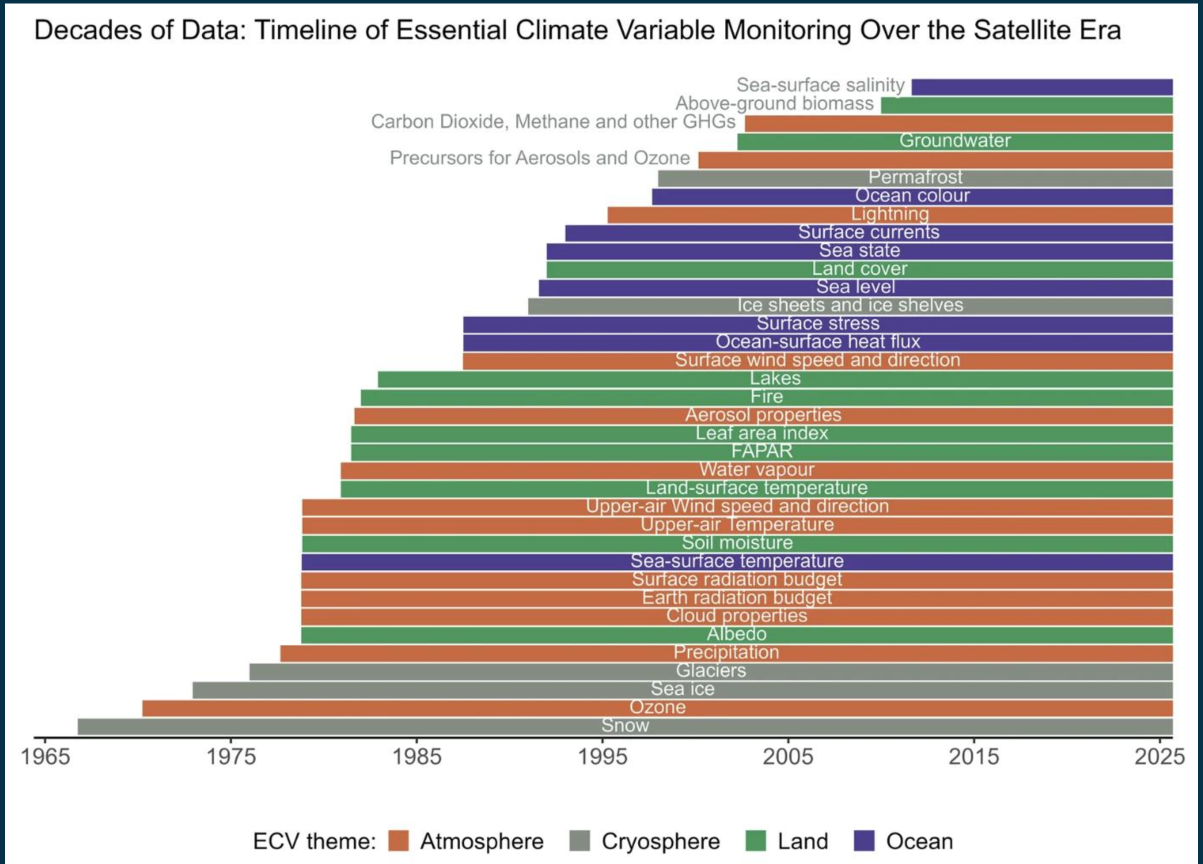
AREU DWH

CLIMA-CARE Background

ENVIRONMENTAL DATA:

- Availability of satellite derived Essential Climate Variables (ECVs)
- EO subproducts (land cover, settlement layers, etc..)
- Modelling data

→ **quantify exposure, vulnerability and health system burden** under current and projected scenarios



Sarah, C., Rochelle, S., Johanna, N. *et al.* Earth observations for climate adaptation: tracking progress towards the Global Goal on Adaptation through satellite-derived indicators. *npj Clim Atmos Sci* **8**, 359 (2025). https://doi.org/10.1038/s41612-025-01251-1

Scientific questions

1.

How do **heatwaves** and **air pollution**, characterized through Essential Climate Variables (**ECVs**), **influence emergency medical demand** in Lombardy?

2.

Which **environmental drivers** (derived from ECVs) are most strongly associated with increases in ambulance calls during climate-related events?

3.

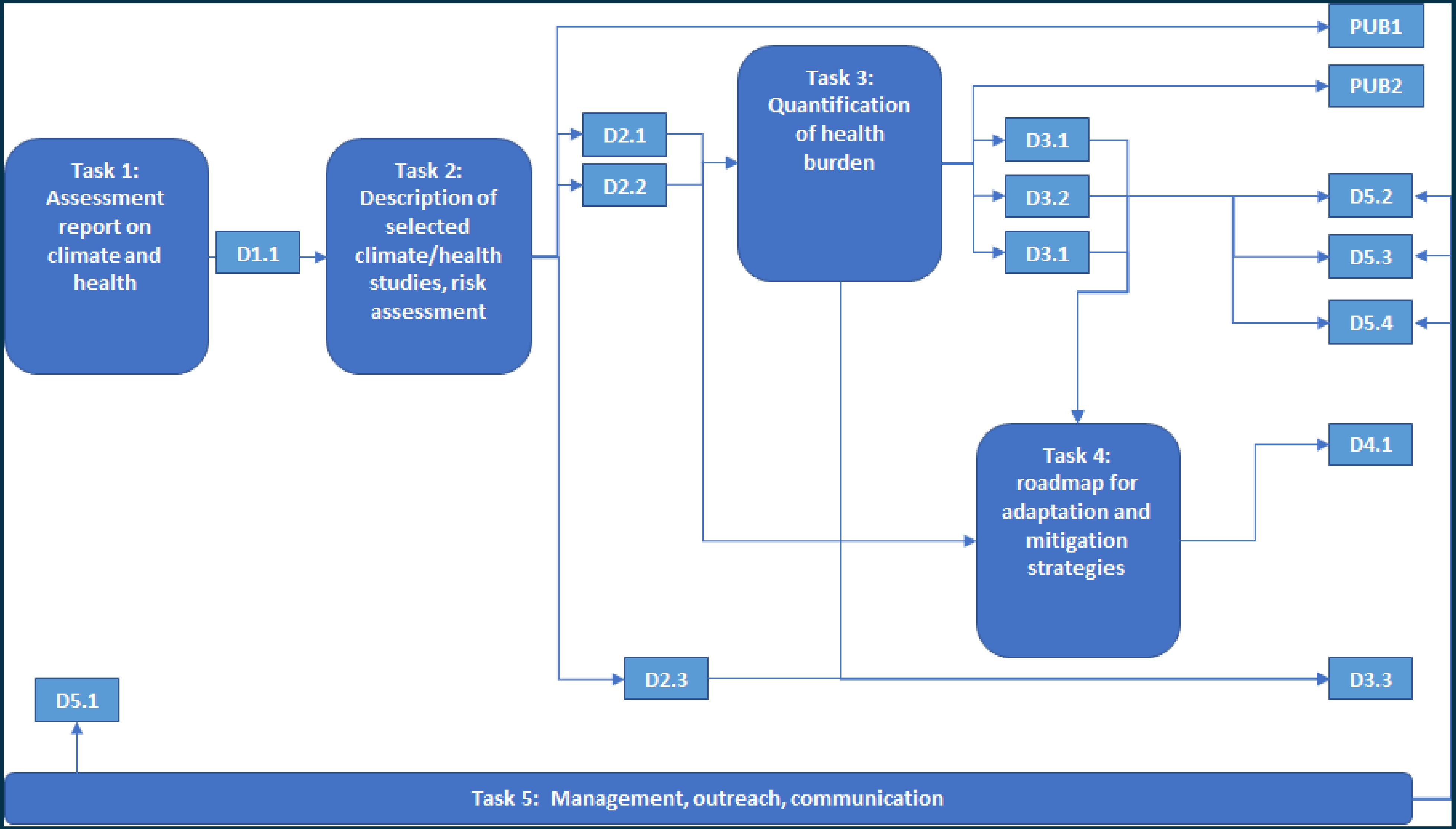
How can **remote sensing** and **AI-driven modelling** approaches enhance the **identification** and **quantification** of climate-related health risks using ECVs?

4.

How these increases **impact** the overall **performance** of **Emergency Medical Services**?

Work Logic

esa



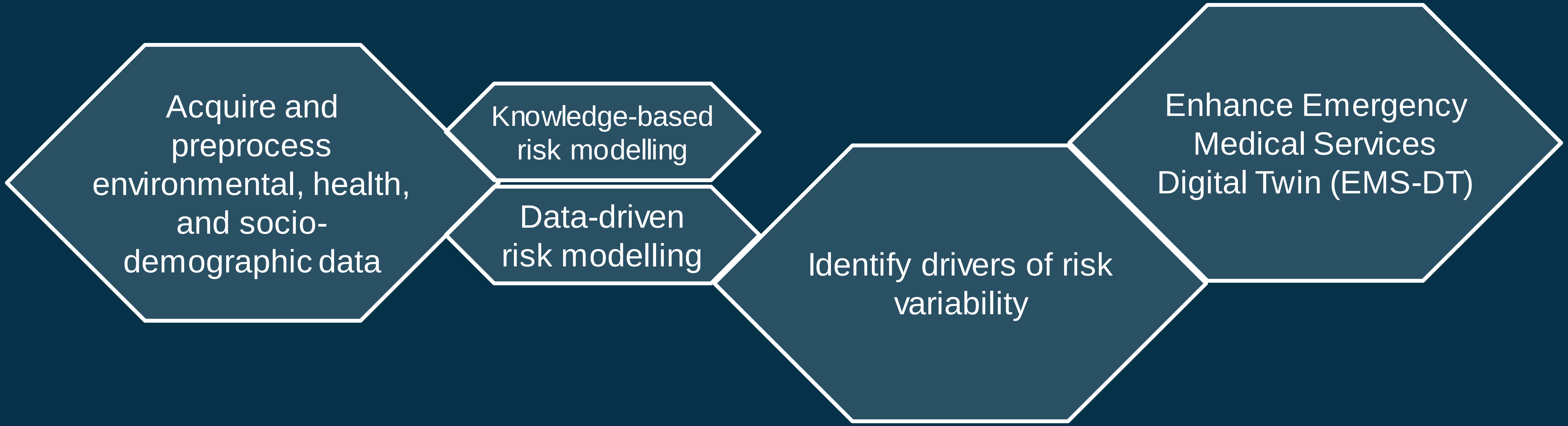
WP1 Assessment Report on Climate and Health

GOALS

- Compile an Assessment Report on Climate and Health with a focus on EO applications
- Align the project framework according to a rigorous literature- and stakeholder-based review on knowledge gaps, requirements and priorities.

WP2 Full Description of the Selected Climate and Health Case Study and Development of the Risk Assessment

Goal: Implement a two-fold risk assessment framework (knowledge-based and data-driven), identify main drivers of risk variability, and apply risk modelling to estimate the impact of environmental hazards on Emergency Medical Services.



WP2 Full Description of the Selected Climate and Health Case Study and Development of the Risk Assessment

Goal: Implement a two-fold risk assessment framework (knowledge-based and data-driven), identify main drivers of risk variability, and apply risk modelling to estimate the impact of environmental hazards on Emergency Medical Services.

GOALS

- Develop a method to **quantify** the **health-related risk** induced by an **environmental hazard**, and map it on the target territory
- Identify the **most relevant factors** increasing health-related risk induced by an environmental hazard
- Assess the **impact** of environmental hazards **on** the demand and delivery of **Emergency Medical Services**
- Framework coordination, storage, and replicability-oriented organization

INPUTS

- Framework for climate-health assessment (WP1 output), including:
  - documented selection and rationale for 10 primary climate-related health risks
  - outline of research topics and questions
  - critical assessment of existing methodologies
  - stakeholder feedback report

OUTPUTS

- Risk models (GIS-based maps)
- Enhanced EMS-DT

CONTRIBUTIONS

DLR

Climate and data science, scenario design, risk asessment

POLIMI

Scenario design, risk assessment, modelling

AREU

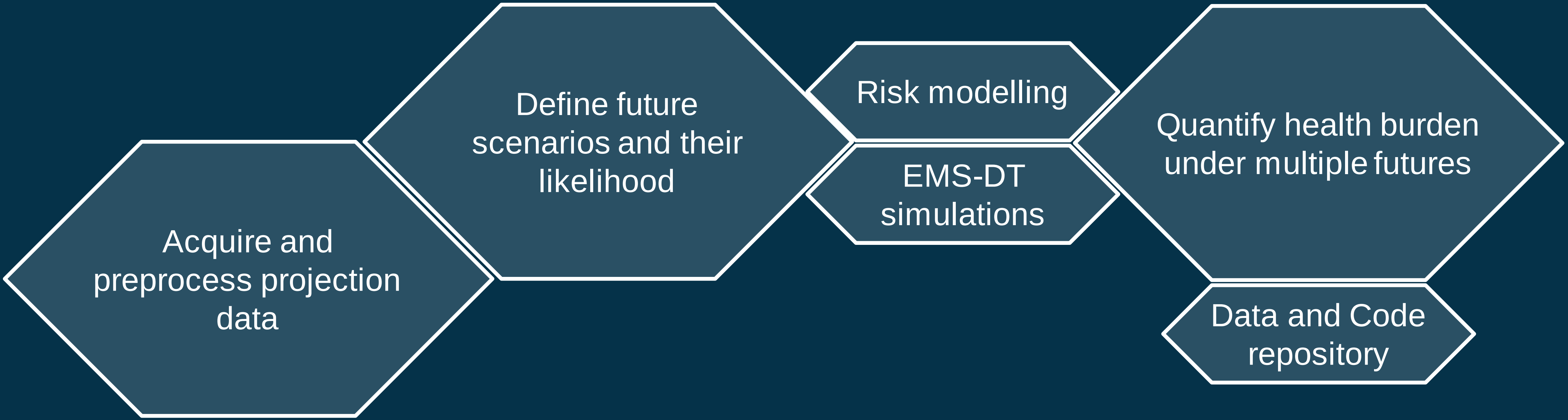
EMS data, DT implementation

GEO

Advisory

WP3 Quantification of Health Burden Attributable to Climate Change and Exacerbated by Social Determinants

Goal: Integrate climate projections, socio-economic trends and adaption pathways to simulate and evaluate future health impacts.



WP3 Quantification of Health Burden Attributable to Climate Change and Exacerbated by Social Determinants

Goal: Integrate climate projections, socio-economic trends and adaption pathways to simulate and evaluate future health impacts.

Acquire and preprocess projection data

Define future scenarios and their likelyhood

Risk modelling

EMS-DT simulations

Quantify health burden under multiple futures

Data and Code repository

CONTRIBUTIONS

DLR Lead, data acquisition and preprocessing, scenario design, results analysis

POLIMI Scenario design, risk assessment, modelling

AREAU EMS data and DT implementation, advisory

GEO Advisory

WP3 Quantification the Health Burden Attributable to Climate Change and Exacerbated by Social Determinants

GOALS

- Integrate climate projections, socio-economic trends and adaption pathways to simulate and evaluate future health impacts
- Support health system preparedness and adaption planning using advanced modelling and EMS-DT
- Combine risk modelling and scenario-based simulations

INPUT

- Risk maps and exposure-response models (WP2)
- Climate projections (CMIP6, DestinE)
- Socio-demographic projections (ISTAT)

OUPUT

- Risk maps and EMS-DT simulations
- Quantified health burden under multiple futures
- Data and code repository

CONTRIBUTIONS

DLR

Climate and data science, scenario design, risk asessment

POLIMI

Scenario design, risk assessment, modelling

AREU

EMS data, DT implementation

GEO

Advisory

WP4 Climate and Health Roadmap to Inform Adaptation and Mitigation Strategies

Goal: Produce a Climate & Health Adaptation Roadmap that shows how Earth Observation (EO) can help monitor and plan health adaptation strategies at different geographical scales.

- Review existing climate–health adaptation frameworks and best practices.
- Analyse how EO and ESA CCI data can support adaptation planning
- Provide user-driven recommendations for ESA
- Develop a structured framework describing how EO data supports every step of health adaptation
- Combine all results into the final Climate & Health Adaptation Roadmap

WP Lead: DLR (Lorenza Gilardi)
Start: May 2027 End: October 2028
Duration: ~18 months

D4.1 Climate and Health Adaptation

MS3 (Annual Review 2): Nov 2027 — review of framework draft
MS4 (Final Review): Nov 2028 — acceptance of D4.1

WP5 Management, Outreach and Communication

Objectives:

- Ensure scientific and administrative coordination of the project.
- Communicate results effectively to ESA, the scientific community, and the public.
- Strengthen project visibility through publications, conferences, and digital outreach.
- Manage reporting activities (MPR, QSR, reviews) and maintain alignment with ESA requirements.

WP Lead: DLR (Lorenza Gilardi)
Start: Nov 2025 End: October 2028 Duration: 36 months

- **D5.1** – Project Management Plan (PMP)
- **D5.2** – Executive Summary of the Project
- **D5.3** – Final Report
- **D5.4** – Final Outreach and Communication Material
- **D5.5** – Final Presentation
- **MPR / QSR** – Monthly Progress Reports & Quarterly Status Reports
- **Conference materials** – Abstracts, presentations, posters
- **Promotional materials** – Website, social media posts, etc

- **KO (3 Nov 2025)** – Project start & PMP submission (D5.1)
- **MS2 (Nov 2026)** – PMP update & publication of project webpage (D5.2)
- **MS3 (Nov 2027)** – Interim communication and dissemination outputs
- **MS4 (Sep 2028)** – Executive Summary, Final Report, and Outreach Material (D5.2–D5.4)

Implementation