CLIMA-CARE – Climate Change and Health Emergency CARE

Deutsches Zentrum für Luft- und Raumfahrt
German Aerospace Center

POLITECNICO MILANO 1863

GEO GROUP ON EARTH OBSERVATIONS

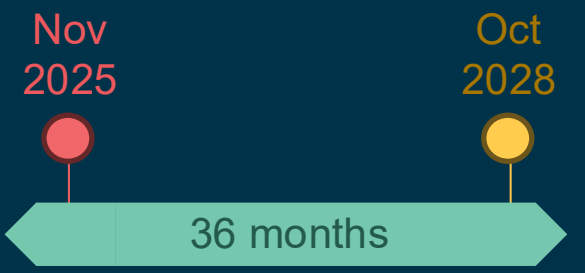
AREU

CCI Colocation Meeting – Lorenza Gilardi

24/03/2026

Project Objectives

ESA ITT: *AO/1-12639/24/I-LR – Climate-Space: Climate Change and Health Activity*

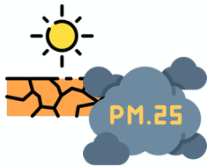


How are climate-related health hazards influencing emergency medical service demands?

Connections with wider community and policy activities

- GEO Health Community of Practice
- GEO Global Heat Resilience Service
- ESA Climate-Space programme and CCI datasets

Thermal stress

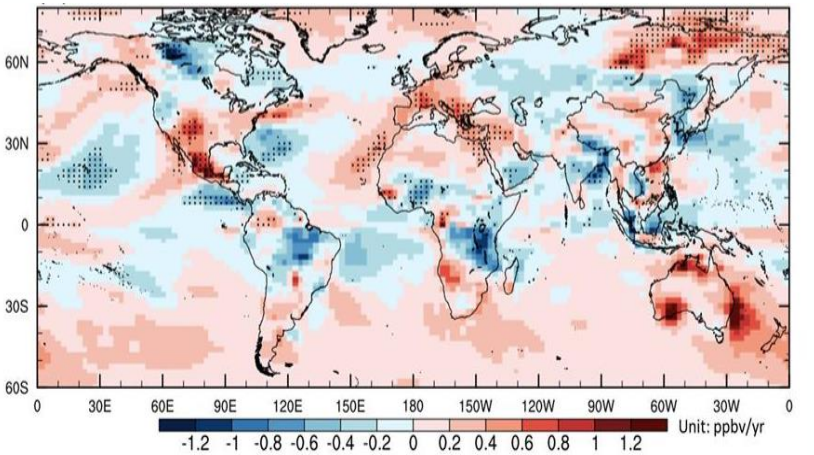


Droughts and air quality

Scientific Background

Climate change-driven air pollution and health risk

- **Climate change can worsen air-pollution mortality ("climate penalty"):** higher O_3 and $PM_{2.5}$–related deaths projected under high-warming scenarios (e.g., RCP8.5) (CVD, RD). Silva et al., Nat Clim Change, 2017
- **Paris-aligned mitigation delivers major near-term health co-benefits from cleaner air**; globally, benefits can exceed mitigation costs (ratio ~1.4–2.45). Markandya et al., Lancet Planet Health, 2018
- **Internalizing air-pollution mortality in policy optimization can avert mortality** (~1.62 Mio fewer premature deaths annually in welfare-maximizing scenarios). Reis et al., Lancet Planet Health, 2022
- Modeling suggests **broadly increasing surface O_3** with warming over land, **while $PM_{2.5}$ responses vary regionally**. Murray et al., PNAS, 2024, Lyu et al., One Earth, 2023
- **The combined burden from air pollution and temperature may rise sharply**; end-of-century mortality could approach ~30 million/year in one assessment, with temperature risks increasing faster than pollution risks. Pozzer et al., Nat Commun, 2024



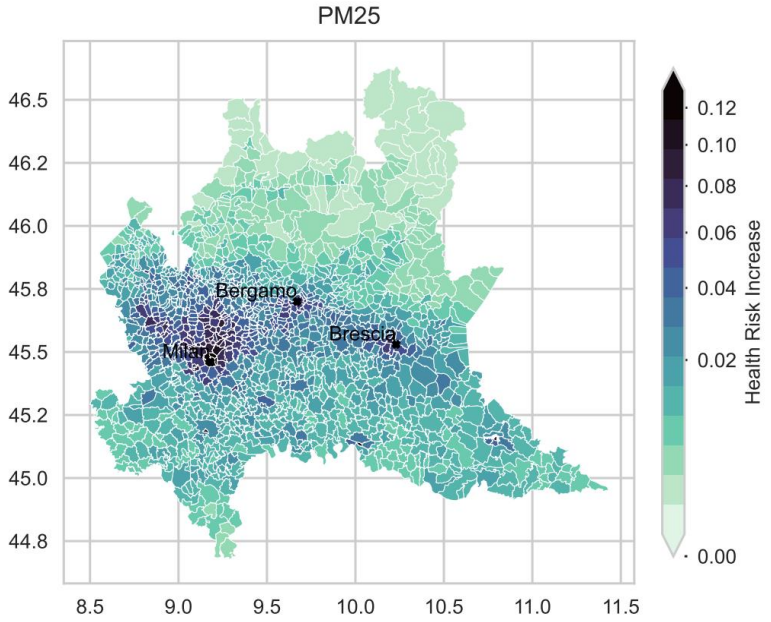
Changes in surface O_3 (2014–2019) due to climate change only. Lyu et al., 2023

Project Objectives

- **Integrate ESA CCI ECVs and EO data** to support indicators of **human exposure to heat and air pollution**
- **Link EO-derived environmental conditions with emergency medical service (EMS) call records** to identify climate-driven health risk patterns
- **Develop spatial risk maps and predictive models** of climate-related emergency demand using EO and health data
- **Support health system preparedness and adaptation planning** through EO-based climate-health indicators

Skeleton overview of the approach

Pilot region: Lombardy, Italy



Health risk increase due to long-term exposure to $PM_{2.5}$ in Lombardy, Italy. Source: Gilardi et al., 2023.

DATA

ESA CCI Essential Climate Variables (ECVs)

EO/EO-derived datasets

Reanalysis Data

Climate Projections

Anonymized emergency medical service (EMS) call records

METHOD

DATA DRIVEN APPROACH	• Environmental data resampling and re-gridding • Risk curves with DLNMs • Hazard-based spatial clustering • XAI
KOWLEDGE BASED APPROACH	• Qualitative risk evaluation with IPPC-framework • Strong stakeholder and expert engagement

From climate hazards to health system preparedness

1. Climate & Exposure Indicators

- Selection of climate-health relevant indicators
- Heat and pollution exposure metrics
- Urban exposure indicators

- EO datasets (CCI / Copernicus)
- Land Surface Temperature(LST)
- AOD, NO_2, O_3 trop. columns
- Land cover / albedo
- Meteorological reanalysis (ERA5)

2. Climate–Health Modelling

- Statistical linkage: environment–EMS
- Spatio-temporal EMS analysis
- Environmental risk driver identification

- EMS emergency calls
- Environmental indicators (from Step 1)
- Population distribution
- Commuting patterns (O/D matrix)

3. Risk Mapping & Forecasting

- Spatial risk maps
- Prediction and scenarios of emergency service demand
- Identification of high-risk hotspots

- Model outputs (from Step 2)
- Environmental indicators
- Scenario-based climate projections (CMIP6, DestinE)

4. Health System Applications

- Early warning indicators
- Decision support for EMS preparedness and response
- Climate adaptation guidance

- Forecasts of environmental indicators
- Risk prediction outputs
- Health system operational data

ECVs being used – preliminary selection

- ECVs with highest score

ECV	CLIMA-CARE Score	CLIMA-CARE Notes
Land Surface Temperature	●●●●●	Core exposure variable for heat-health analysis
Albedo*	●●●●●	Good temporal and spatial resolution for heat modelling
Atmospheric Aerosols	●●●●●	Key exposure proxy for air pollution ($PM_{2.5}$)
Land Cover	●●●●	Good high-resolution land cover context
Leaf Area Index	●●●●	Useful vegetation exposure modifier
Vegetation Index (NDVI)	●●●●	Vegetation exposure proxy
…	….	…

* CCI xECV

Scoring system

●●●●● = core dataset meeting ≤1 km and high temporal resolution;
●●●● = very useful modifier;
●●● = supportive dataset;
●● = limited relevance due to spatial/temporal constraints;
● = marginal;
0 = not suitable.

ECVs being used

Strengths

- Global coverage and long-term consistency
- Strong basis for **exposure assessment**
- Availability within ESA CCI framework (open and standardized datasets)

Weaknesses

- Lack of **direct health-relevant metrics**
- Inconsistent spatial resolution across ECVs
- Column vs surface mismatch (AOD, O_3 but also NO_2)
- Limited temporal resolution for **extreme events**

ECVs being used

Wish list

- Harmonized **multi-ECV datasets** at common resolution (<1 km / urban-ready)
- Pre-computed **health-relevant indicators**
  - heat stress indices
  - pollution exposure metrics
- Operational **compound hazard variables** (heat + pollution)
- High temporal resolution (sub-daily / heatwave-ready)
- Urban-scale products (<100 m where possible)

Results & relevance to the CCI community

Preliminary results from WP1 (ongoing)

- **Limited integration** of EO-derived hazards with health outcomes
- Lack of **combined exposure metrics** (heat + air pollution)
- Strong **spatial scale mismatch** between EO, models and health data
- Heavy reliance on **proxy variables** (e.g. LST, AOD)
- **Multi-hazard analysis** still underdeveloped

Key implications for CCI

- Need for **integrated / compound multi-ECV products**
- Need to move from variables → **health-relevant indicators**
- Requirement for **harmonized spatial resolution**
- Critical need for **EO–health data integration frameworks**

Key gap

- **Spatially explicit climate–health risk models** for EMS integrating CCI ECVs, EO-indicators, health data and vulnerability.