U-CLIMAT: LEVERAGING SATELLITE DATA AND ARTIFICIAL INTELLIGENCE FOR CLIMATE RISK AND IMPACT ASSESSMENT

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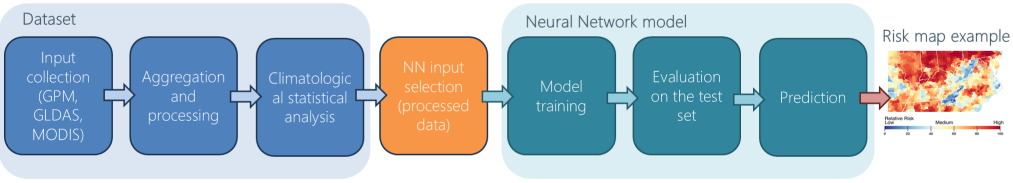
INTRODUCTION

The increase in the frequency and intensity of **extreme weather events** due to **climate change** poses significant environmental, economic and social challenges, and prevention is one of the key actions to counter the growing effects of climate change. Today, Remote Sensing (RS) data can be used for a wide variety of Earth Observation (EO) purposes and often represent a better alternative to traditional survey methods. Established EO programs, such as the European Copernicus program, ensure a combination of reliable, freely available and systematic data. These characteristics make RS an extremely valuable source in mitigating the effects of climate change and is increasing used in emergency situations [1]. In this work we **propose U-Climat (Urban-CLimat Impact Mitigation Adaptation Tool)**: a new service that **combines satellite EO data with Artificial Intelligence (AI)** to develop advanced climate risk and impact mapping tools. In the field of EO, AI represents a powerful driver of knowledge: Deep Learning (DL) algorithms are often used in the analysis of geospatial data throughout the processing chains.





METHODOLOGY



U-Climat's objective is to furnish a **risk assessment** through a dynamic evaluation of exposure to damage from extreme events, and the quantification of damage caused by such events. First results were obtained in the context of **flood extreme events, employing a multi-parametric approach using multi-source EO data**. The key parameters include precipitation, soil moisture, and Land Surface Temperature (LST) which were obtained from different satellite missions for selected areas of interest. Global Precipitation Measurement (GPM) mission was considered for precipitation [2]; Global Land Data Assimilation System (GLDAS) was considered for soil moisture [3]; finally, data from Moderate Resolution Imaging Spectroradiometer (MODIS) was used for LST [4]. Data were processed and analysed using Google Earth Engine and Python environments, enabling efficient handling of large datasets across different temporal scales. The methodology includes data collection, processing, and harmonization in terms of spatial and temporal resolution. Then, climatological anomalies were calculated by determining long-term averages of monthly values over periods of 20 years, and extreme values were obtained focusing on peak values near event occurrences.



MAIN INNOVATIONS to bring in the insurance world:
- Use of satellite data & AI for dynamic risk mapping
- Qualitative/Quantitative damage assessment

Future service integration:
NRT post-event damage assessment using drone and VHR imagery

MOTIVATION AND ENGAGEMENT

~30 billion losses due to extreme weather events in Italy over the last 10 years
(source: European Environment Agency, 2024)

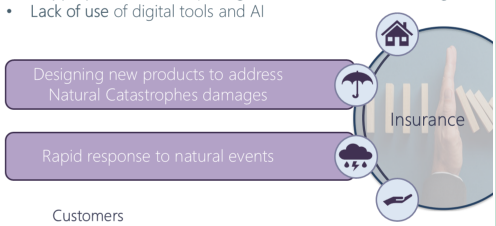


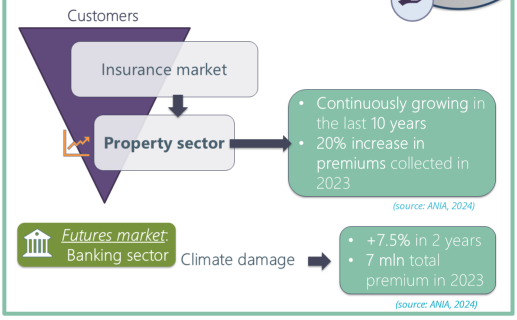
Losses covered by insurance and insured companies are 5%[1, 2]
(source: BCE, 2022), (source: ANIA, 2024)

Law of 2024 → Obligation for Italian companies to take out Natural-Catastrophes damage insurance

Managing **impacts** of extreme weather events for:
Companies → Complying with regulations
Insurance → Providing products to cover climate risks

Challenges:
- Inappropriate standard pricing models for NAT-CAT damages
- Lack of use of digital tools and AI





DATASET

	Satellite	Sensor	Data availability	Spatial Resolution
Temperature	Sentinel-3	SLSTR (Sea and Land Surface Temperature Radiometer)	2016 (3A) - present	1km (thermal infrared bands)
Soil moisture	Sentinel-1	C-band	2014 (1A) - present	5m x 20m (Interferometric Wide (IW) swath mode)
Land Cover	Sentinel-2	MSI (MultiSpectral Instrument)	2015 (2A) - present	10m, 20m, 60m
	Landsat 1-5	MSS (MultiSpectral Scanner)	1972-1992	80m (data processed to 60m)
	Landsat 4-5	TM (Thematic Mapper)	1982-2012	30m
	Landsat 7	ETM+ (Enhanced Thematic Mapper Plus)	1999-present	30m (15m panchromatic band)
Temperature + Land Cover	Landsat 8-9	OLI (Operational Land Imager), TIRS (Thermal Infrared Sensor)	2013-present	OLI: 30 m (15m pan band) TIRS: 100 m (resampled to 30m)
Precipitation	MSG	SEVIRI (Spinning Enhanced Visible and InfraRed Imager)	Multi	Multi
	GPM	Multi	Multi	Multi

Soil analysis
- Temperature — Satellite remote sensing data with thermal sensors
- Soil Moisture — SAR data or other satellite-derived SM products
- Land Cover — Multispectral data. Possible additions with ground/auxiliary data

Precipitation — Meteorological satellite data. Possible additions with ground/auxiliary data

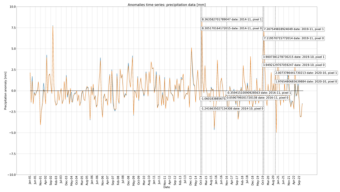
RESULTS

Use case on flood vulnerability: Integrate data from soil analysis with rainfall data to estimate flood risk

- Climatological averages: mean of monthly values of a climate variable over a specified period (typically 2-20 years)
- Calculation of the monthly anomaly values for a specific variable (e.g., precipitation) for a given pixel

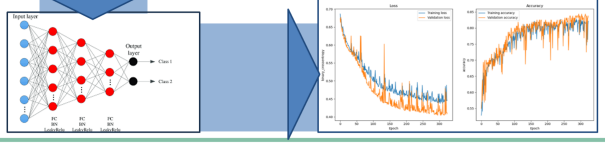
$$Anomaly = x - x_{norm}$$

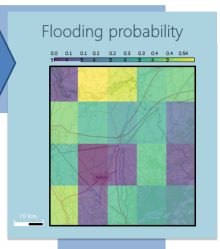
- x = actual value of average precipitation in a specific month
- x_{norm} = value of long-term average precipitation over several years for the same month



- Variables: precipitation, soil moisture, LST, LC
- Input: selection of the processed data (e.g., 3-days before the flood event values)

- Output: flood/non-flood
- Best test accuracy: 0.87





Recently launched the startup
Blue Dot Observation

Won awards in national startup competitions





References

[1] H. S. Munawar, A. W. Hammad and S. T. Waller, "Remote sensing methods for flood prediction: A review," Sensors, vol. 22, no. 3, p. 960, 2022.

[2] R. K. Pradhan, Y. Markonis, M. R. Vargas Godoy, A. Villalba-Pradas, K. M. Andreadis, E. I. Nikolopoulos, S. M. Papalexiou, A. Rahim, F. J. Tapiador and M. Hanel, "Review of GPM IMERG performance: A global perspective," Remote Sensing of Environment, vol. 268, p. 112754, 2022.

[3] H. Bi, J. Ma, W. Zheng and J. Zeng, "Comparison of soil moisture in GLDAS model simulations and in situ observations over the Tibetan Plateau," Journal of Geophysical Research: Atmospheres, vol. 121, no. 16, pp. 2658-2678, 2016.

[4] T. N. Phan and M. Kappas, "Application of MODIS land surface temperature data: a systematic literature review and analysis," Journal of Applied Remote Sensing, vol. 12, no. 4, pp. 041501-041501, 2018.

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