H2020 E-SHAPE

Geoss for Disasters in UrBan Environment Pilot 2

Martina Lagasio, CIMA Research Foundation

A. N. Meroni, L .Pulvirenti, G. Squicciarino, A. Parodi, CIMA Research Foundation

H. Kontoes, A. Tsouni, N. Bartsotas, National Observatory of Athens (NOA)

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Introduction

The story

Mediterranean region frequently struck by very intense hardly predictable weather events causing significant amount of fatalities and socio-economic damages every year.

IPCC: The frequency of heavy rainfall events and droughts will intensify in the 21st century.

Current available tools for weather prediction and main lacks:

- Numerical Weather Prediction (NWP) models able to produce forecasts at very high resolution (km scale).
- Inaccurate representation of the initial and boundary conditions is a major source of uncertainty for weather forecasts.
- Assimilation of conventional observations cannot provide km scale description of the atmosphere.

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The Pilot goals

Objectives

Use of in-situ **Personal Weather Stations (PWS)**, existing **citizen weather observatories**, **satellite observations** (Sentinel), and **low-cost sensors**, for the **enhanced hydro-meteorological** forecasting, addressing the prediction of high-impact weather events in cities, such as flash-flood, wind storms, hail storms, lightning storms, and peri urban fires.

Core Co-designers: Italian Civil Protection Department, ARPAL – Agenzia Regionale per la Protezione dell'Ambiente Ligure, Italy

Identified key users: EU decision makers, GEO Space and Security Community Activity, International organisations such as the UN

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What the Pilot can do

e-shape

disaster
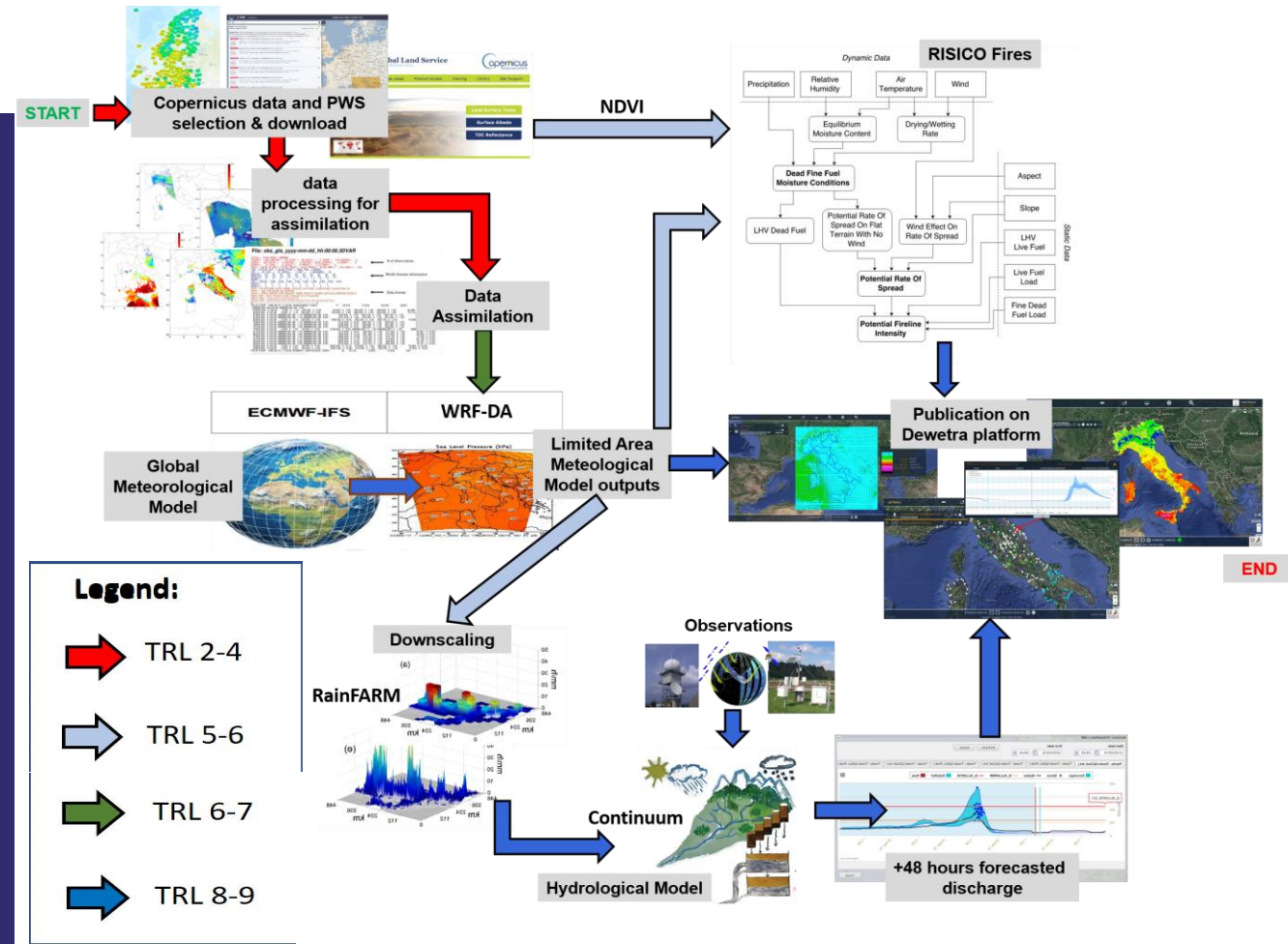
Making ideas happen...

What Pilot 2 can do:

Copernicus Sentinel and PWS data assimilated in an hydro/fire-meteorological forecasting chain can provide additional information for high-resolution NWP models allowing to **improve forecast of such high impact weather events**.

Current status

Current status

The current status is based on the results achieved in the framework of the STEAM project (funded by the European Space Agency), the existing **hydro-meteorological chains built up in cooperation with the Italian Civil Protection Department and the ARPAL - Agenzia Regionale per la Protezione dell'Ambiente Ligure** having different TRL for each of the chain components ranging between 3 and 9.

Forecast chain composition

Selection and download of Sentinel data, possibly Copernicus services products and in-situ observations (PWS) -> WRF-Data Assimilation -> RISICO (Fire forecast) & RainFARM-Continuum (Flood forecast) -> publication on MyDewetra platform.

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# Automatic Procurement of Sentinel Data

A script to automatically search and download Sentinel-1/-2/-3 products from the Copernicus Open Access Hub is presently operational (**Italian territory**).

Currently S-1 GRD products and S-2 level 2A products are downloaded, but the procurement of S-1 OCN data (in particular Ocean Wind Fields –OWI) and S-3 LST and SST data is foreseen

The possibility to use data coming from the Copernicus land service will be explored (timeliness requirement for NWP applications may be critical)

Variables like Surface Soil Moisture will be automatically generated from GRD data if necessary
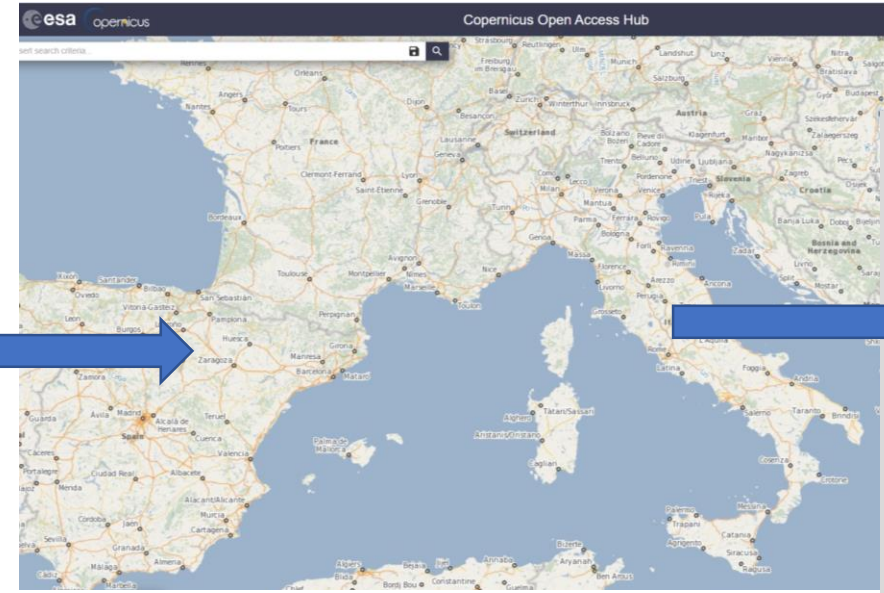
Products are resampled and reprojected to a reference grid (geographic latlon – WGS84). 0.0135x0.0135 degrees

Rel. orbit 15 (ascending)
Sep. 8, 2017, h. 17:15 UTC

Example: SSM map derived from the S-1 acquisition performed on Sep. 8, 2017 (GRD product)
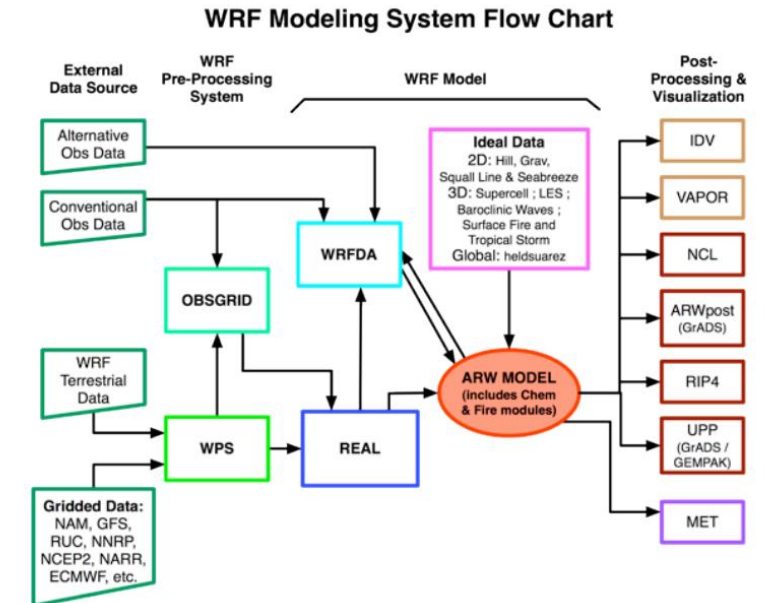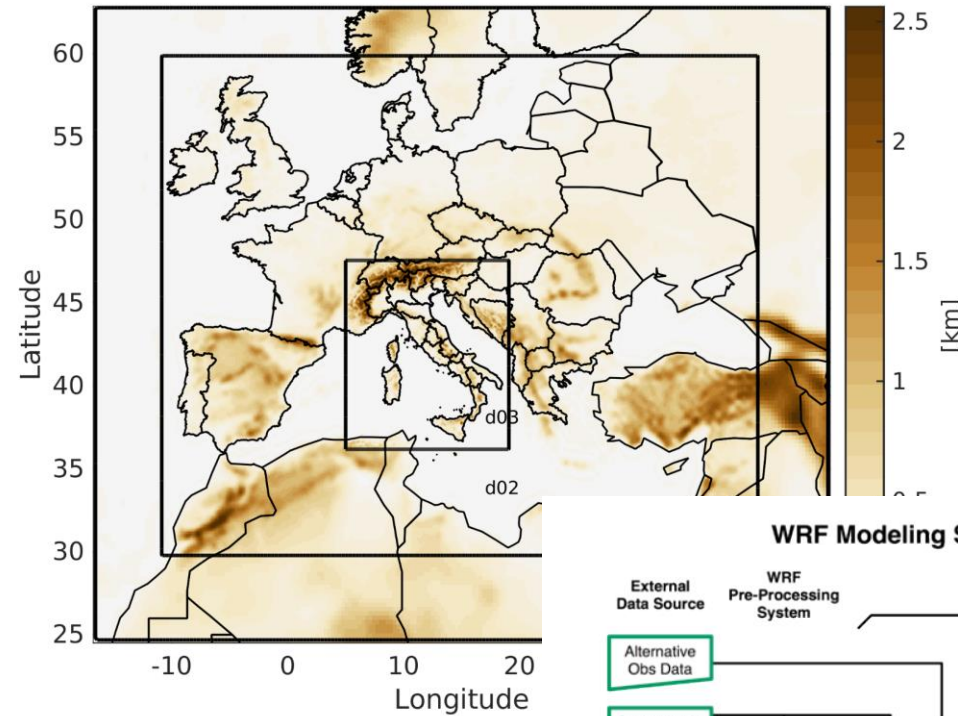
Soil moisture [m³/m³]
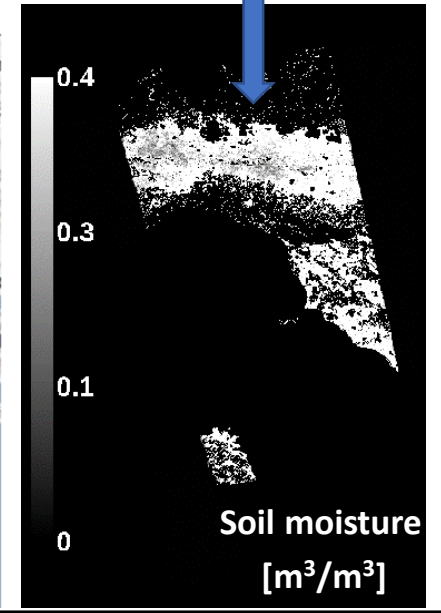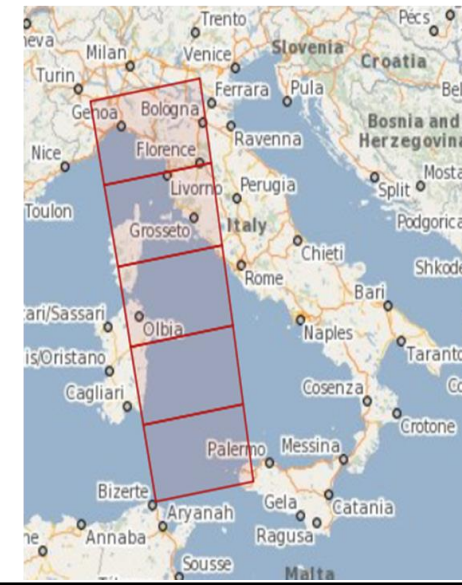
The hydro/fire-meteorological chain: WRF

The Advanced Research WRF (ARW) model is a fully compressible and non-hydrostatic model. Its vertical coordinate is a terrain-following hydrostatic pressure coordinate.
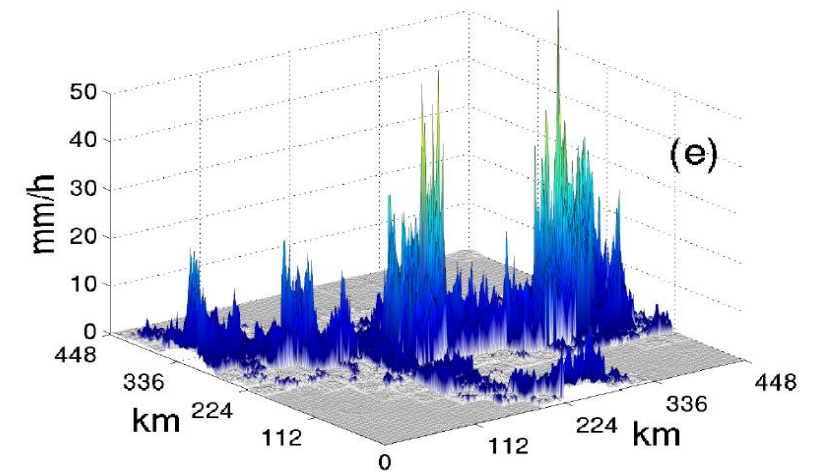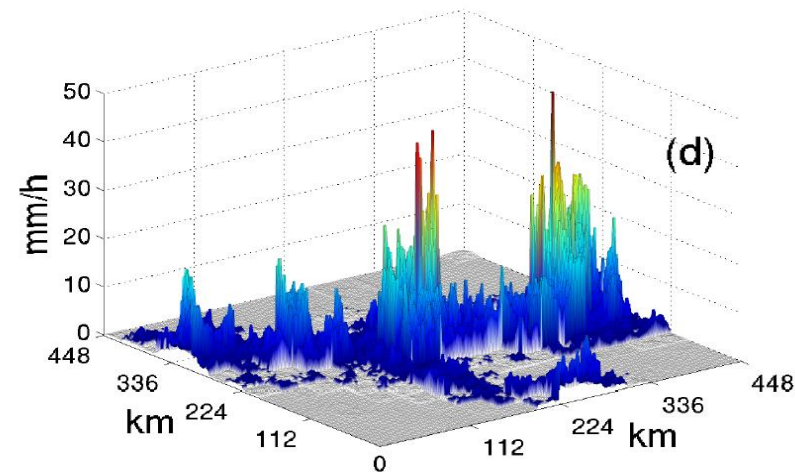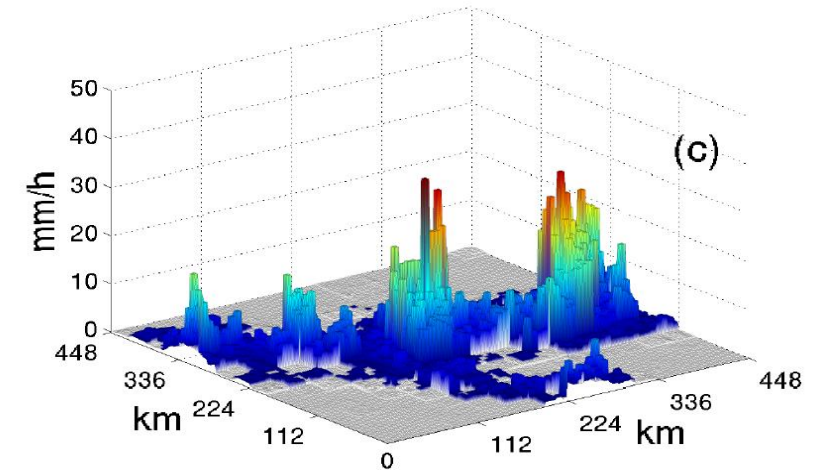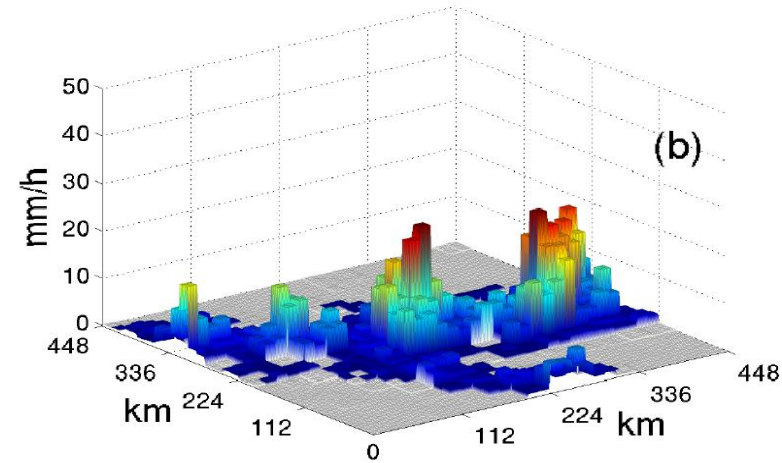
3 nested domains:

22.5, 7.5 e 2.5 km

50 vertical levels

The hydro/fire-meteorological chain: RainFARM

It is a stochastic downscaling algorithm that generate an ensemble of rainfall fields with high resolution. It preserves the total volume and the spatial structure above a certain scale

Rebora, N., Ferraris, L., von Hardenberg, J., & Provenzale, A. (2006). RainFARM: Rainfall downscaling by a filtered autoregressive model. *Journal of Hydrometeorology*, *7*(4), 724-738.

The hydro/fire-meteorological chain: Continuum

MAIN CHARACTERISTICS:

- Simple but complete description of Hydrological Cycle
  - Schematization of vegetation interception and water table
  - Tank schematization of overland and channel flows

- Mass Balance and Energy Balance completely solved

- Fully Distributed

- River network derived from a DEM

- Spatial-temporal evolution of:
  - Streamflow
  - Evapotranspiration
  - Vegetation retention
  - Land Surface Temperature
  - Soil Moisture
  - Water table

- It can be **calibrated using only satellite data** (e.g. surface temperature or soil moisture). Model suitable for application in data scarce environments

The model code is open
http://continuum.cimafoundation.org

https://github.com/c-hydro/hmc-dev
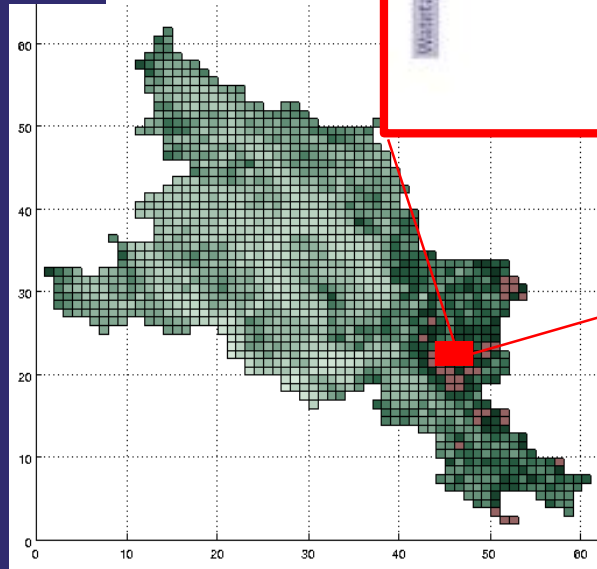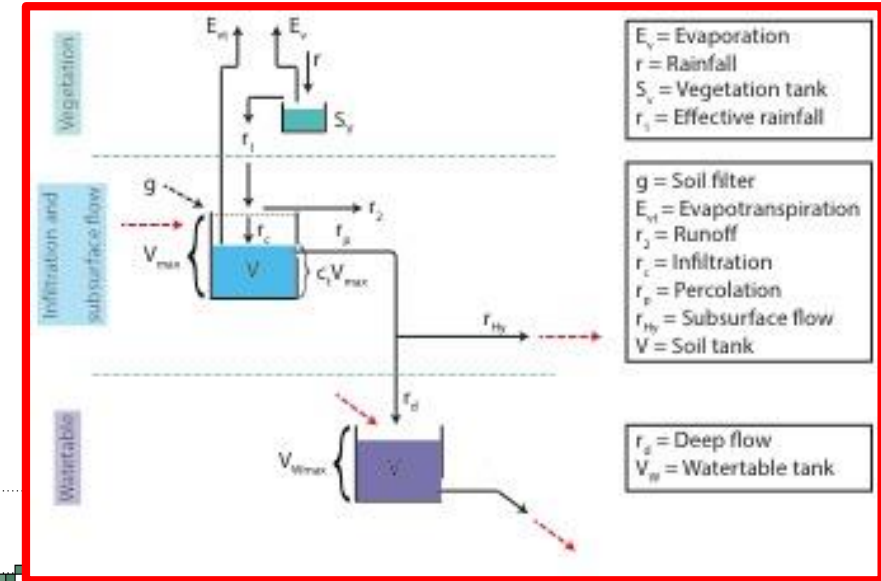
Silvestro, F., Gabellani, S., Delogu, F., Rudari, R., & Boni, G. (2013). Exploiting remote sensing land surface temperature in distributed hydrological modelling: the example of the Continuum model. *Hydrology and Earth System Sciences*, *17*(1), 39.

The hydro/fire-meteorological chain: RISICO

Weather forecast

SENTINEL2

MAIN CHARACTERISTICS:

Simple assessment of dead fine fuel moisture directly correlated with the probability of fire ignition.

Use of satellite data for the assessment of dead fine fuel load.
Evaluation of the main characteristic of fire propagation in case of ignition in terms of potential rate of spread and fireline intensity.

Hourly evolution of fire propagation based on the impact of weather on the potential fire front
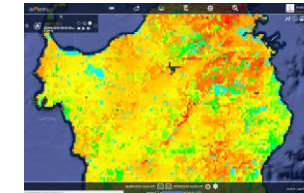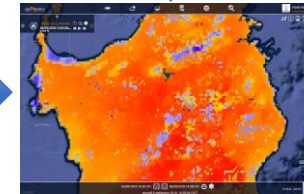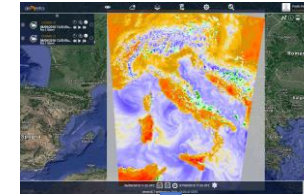
Early warning

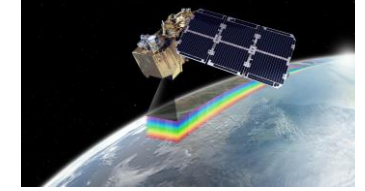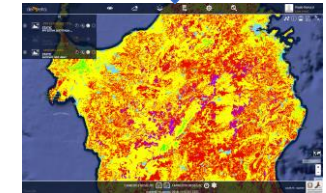**Metop**
ASCAT
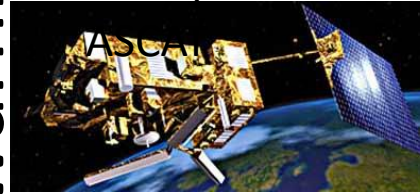
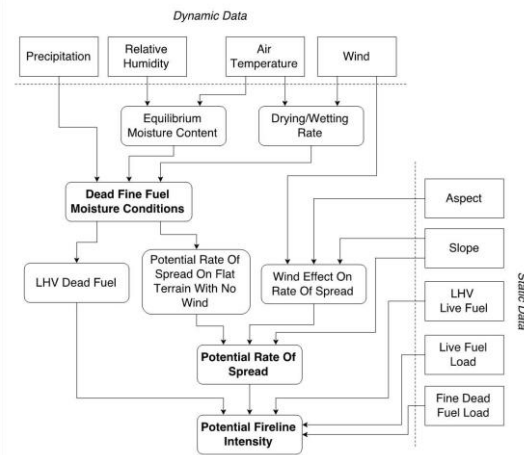**Soil Moisture**

Continuum

NDVI Dead fine fuel load

Rate of spread

FDI RISICO

Probability of fire ignition and fire propagation

Fiorucci, P., Gaetani, F., & Minciardi, R. (2008). Development and application of a system for dynamic wildfire risk assessment in Italy. *Environmental Modelling & Software*, *23*(6), 690-702.

Preliminary results

Example from STEAM project results

Preliminary results example of services for stakeholders

The assimilation of satellite observations and in-situ sensors has been tested in some use cases in the framework of the STEAM project and the ARPAL agreement respectively.

The full hydro-meteorological and fire-meteorological chains are already operational at CIMA Foundation fed by WRF outputs without assimilation and nearly operational with radar data assimilation in WRF model.

Wind field (Sentinel-1 OCN product) assimilation result for the 2017 Livorno flood

Improvement of convective field forecast

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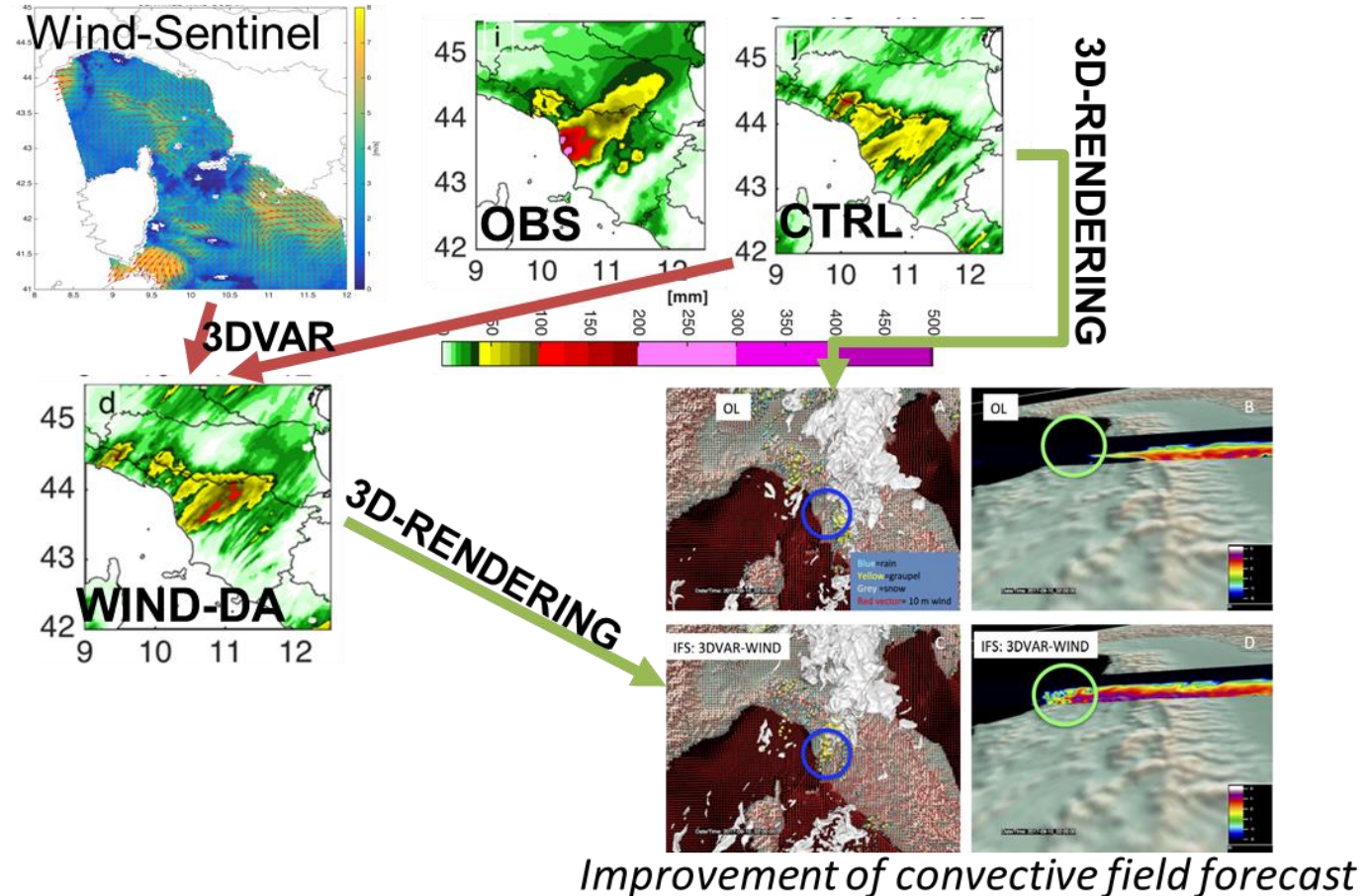
EO variables assimilated

Land & Sea Surface Temperatures derived from the Sea and Land Surface Temperature Radiometer (SLSTR) Sentinel-3 level 2 products

Products generated on a 1x1 km2 grid

Surface soil moisture derived from Sentinel-1 GRD IW products by applying a multi-temporal retrieval algorithm (maximum likelihood)

Algorithm implemented in a software package designed to set up a surface soil moisture mapping service at national (Italian) scale, [Pulvirenti et al., Environ. Model. Softw., 2018]

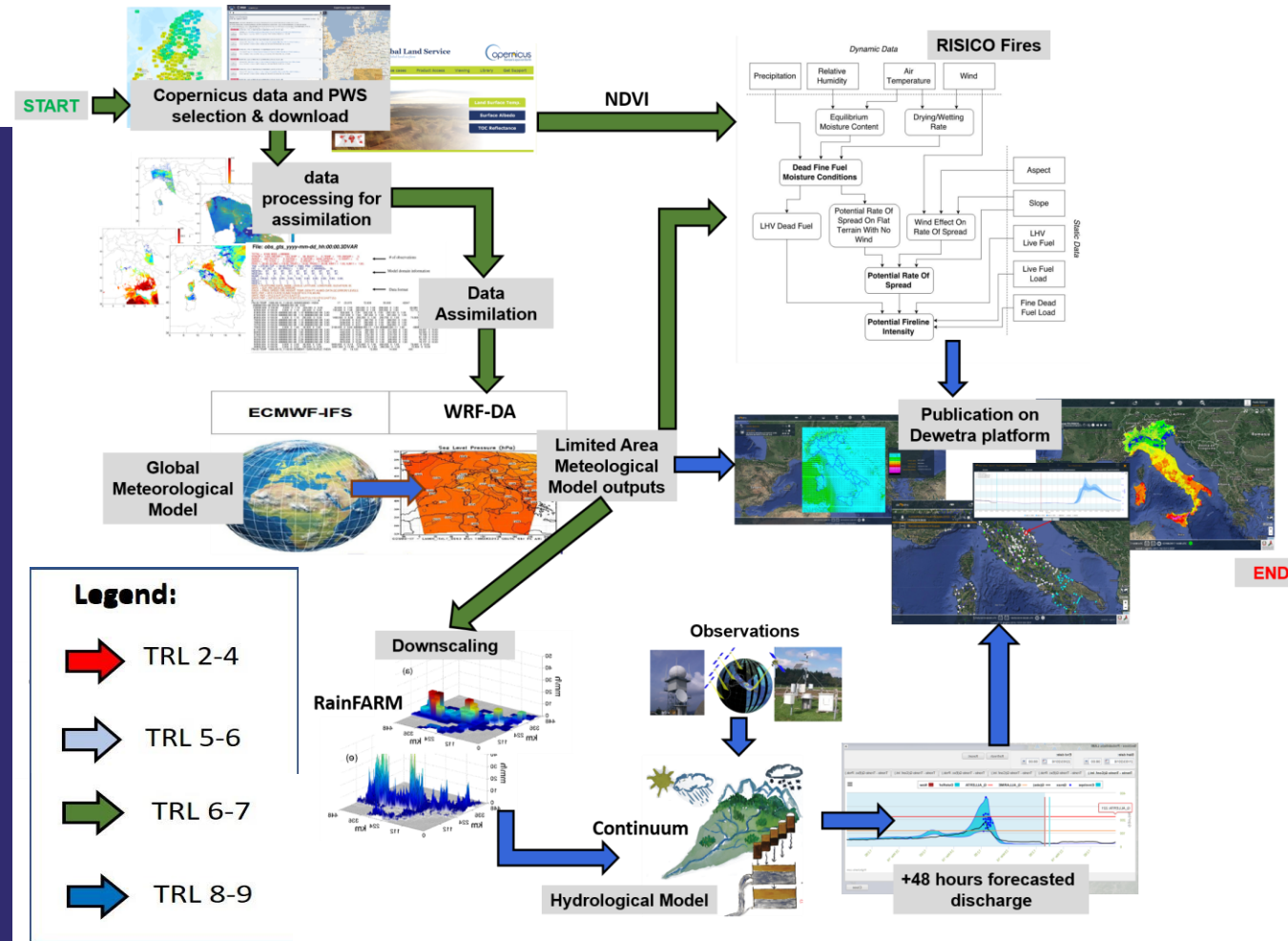**Wind field** derived from the OCN OWI level 2 Sentinel-1 product

Ground range gridded estimate of the surface wind speed and direction at 10 m asl, derived from SM, IW or EW modes

Spatial resolution 1x1 km2
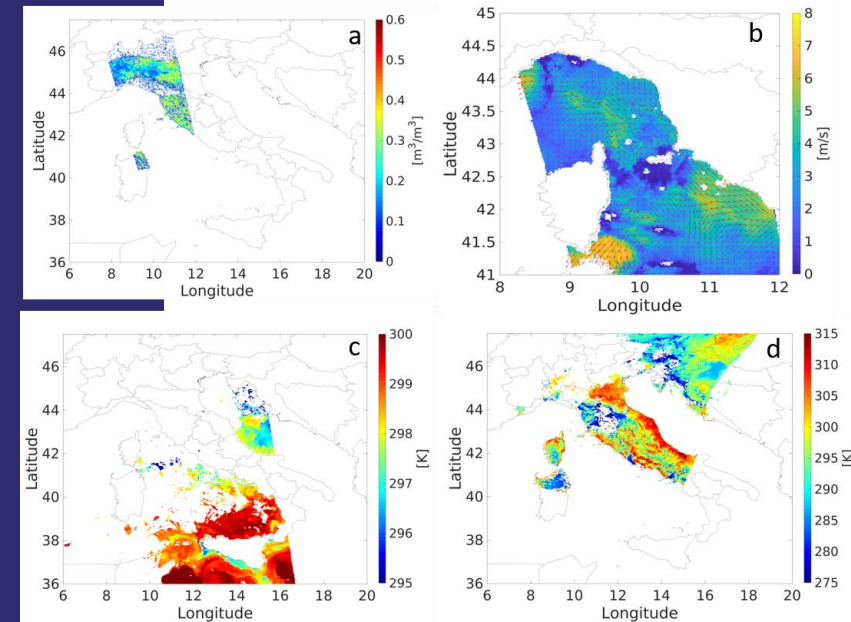
Targeted status

Targeted status

The **existing chain will be consolidated and innovated up to a minimum TRL of 7** for all the chain components.

The Approach

Most of the work will be devoted to the improvement of **Sentinel data and personal weather stations data selection, download and assimilation automatization**.

Such **observations assimilated into the WRF model will feed the hydro/fire-meteorological chains** already operational for the Italian Civil Protection Department.

All model outputs produced will be published on MyDewetra platform to make them available for stakeholders.

Targeted forecast chain workflow

Legend:

- TRL 2-4
- TRL 5-6
- TRL 6-7
- TRL 8-9

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