



**MISTRAL**  
Meteo Italian Supercomputing Portal

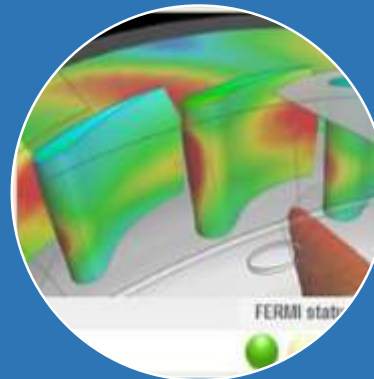
4 Marzo 2020

**Il Progetto Mistral - Il Supercalcolo a supporto di enti pubblici, ricerca e privati per la creazione di un Portale Nazionale degli Open Data Meteorologici.**

Gabriella Scipione (CINECA)



With the new Supercomputer MARCONI, Cineca ranks number 3 in Europe and 19 in the world in the TOP500.org list of the most powerful computing facilities.



## High Performance Computing

### Innovation and Research Support

High Performance Computing and Data Analytics

Tier 0 National and European

Scientific Visualization and Interactive Virtual Environments

Research and Development, education and training



Gabriella Scipione

Data Management & Analytics



# HPC can be used to solve scientific, industrial and societal challenges



## Health

- Development of personalised and precision medicine to make treatments more effective.
- Saving money and time in the development of new drugs, from the initial concept to the final phase of reaching the market.
- Saving lives and money, through early detection of diseases and quicker diagnoses.



## Climate change and weather forecasting

- 33% of the world's GDP is affected by the weather.
- Weather variations in Europe have an economic impact of around €400 billion annually.
- Severe weather resulted in high costs for Europe between 1970 and 2012:
  - 150,000 lives lost
  - €270 billion in economic damage.
- Using HPC technology, climate scientists can predict the size and paths of storms and floods more accurately, meaning that people can be alerted and evacuated faster, saving lives.



## Industry

- Reducing development time, minimising costs, optimising decision processes and producing higher quality goods and services.
- HPC has helped the car industry save more than €40 billion by, for example, reducing new vehicle development cycles from 60 months to 24 months.



## Cybersecurity

- It is estimated that between 2015 and 2021 the global costs of damage from cybercrime will double and reach \$6 trillion per year.
- Combined with artificial intelligence, HPC helps to detect:
  - strange systems behaviour
  - insider threats and electronic fraud
  - cyberattack patterns.
- This can shorten response times to hours instead of days, and even before a cyberattack happens.



## Energy

- HPC provides critical tools for:
  - designing renewable energy parks
  - designing high-performance photovoltaic materials
  - optimising turbines for electricity production.
- HPC expenditure in the energy sector is projected to grow by 5% in the next few years.

# Why meteo requires HPC?

■ To run WEATHER FORECAST

■ To improve the resolution: an increase in the resolution means an increase of the forecast quality

■ In post processing

■ For Meteo data visualisation

Improve forecast models (deterministic)  
Improve of the ensemble systems

From 2.2 to less than 1 km

For more useful and usable forecast .

To have multilayer representation on maps of complex data

# Connecting European Facilities - Telecom

Gabriella Scipione

- CINECA, HPC Dep.
- Data Management & Analytics

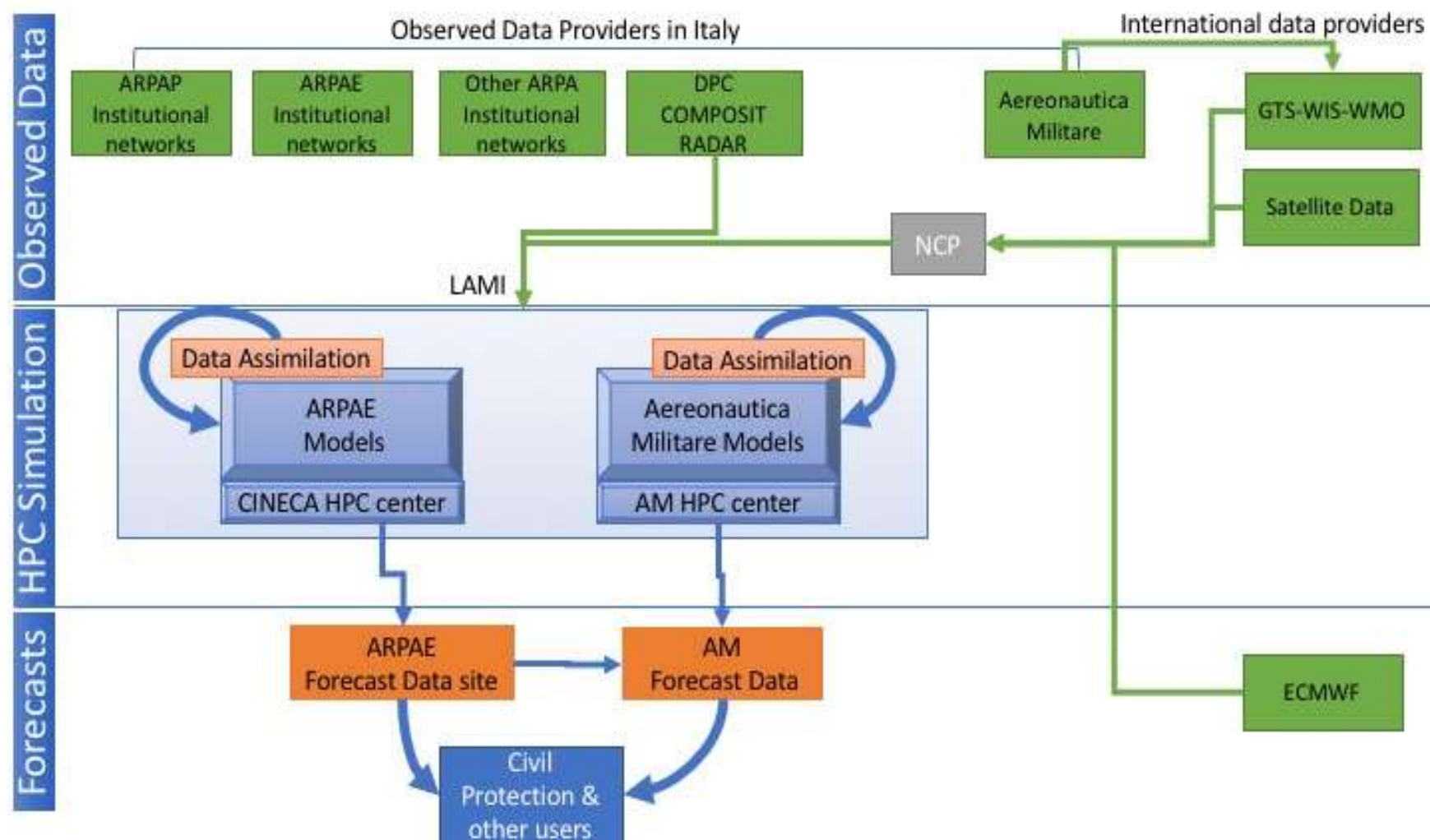
METEO

- **MISTRAL**
- **Meteo Italian Supercomputing portal**
- Start: 1st of October 2018
- Duration: 24 months
- **Partners:** Cineca, DPC, ARPAE, ARPAP, ECMWF, Dedagroup
- Total costs: € 2,342,242.5
- **Aim:** Weather Open data portal

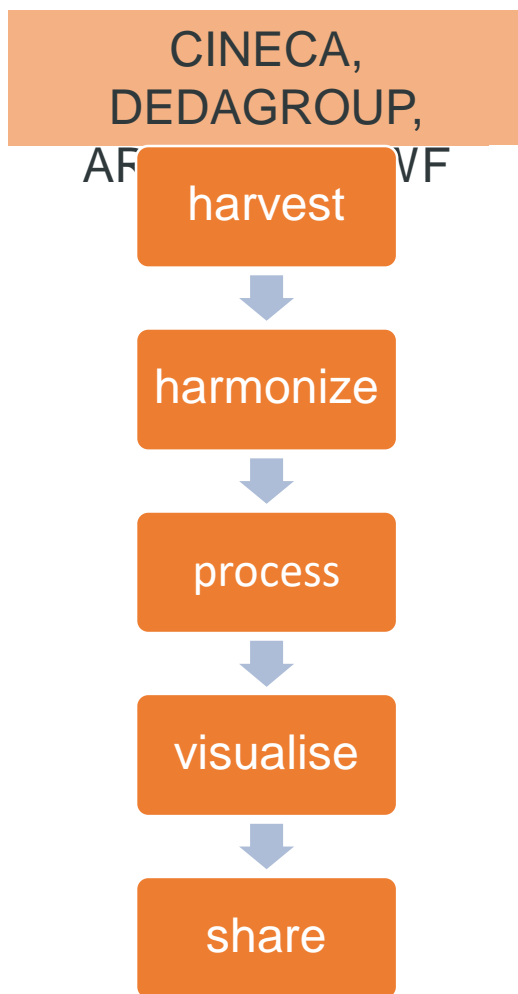
CLIMA-AGRICOLTURA

- **HIGHLANDER**
- **HIGH performance computing to support smart LAND sERvices**
- Start: 1st of October 2019
- Duration: 36 months
- Total costs: € 5,430,426.66
- **Partners:** Cineca, ArpaE, ArpaP, CMCC, U.Della Tuscia, FEM, ECMWF, CIA Agricoltori italiani, ART-ER

# Italy: State of the Art



# Mistral Data




 **Observations**

**Italian Regions network**

- deselect all
- Calabria
- Campania
- Emilia-Romagna
- Lazio
- Piemonte

**MeteoNetwork**

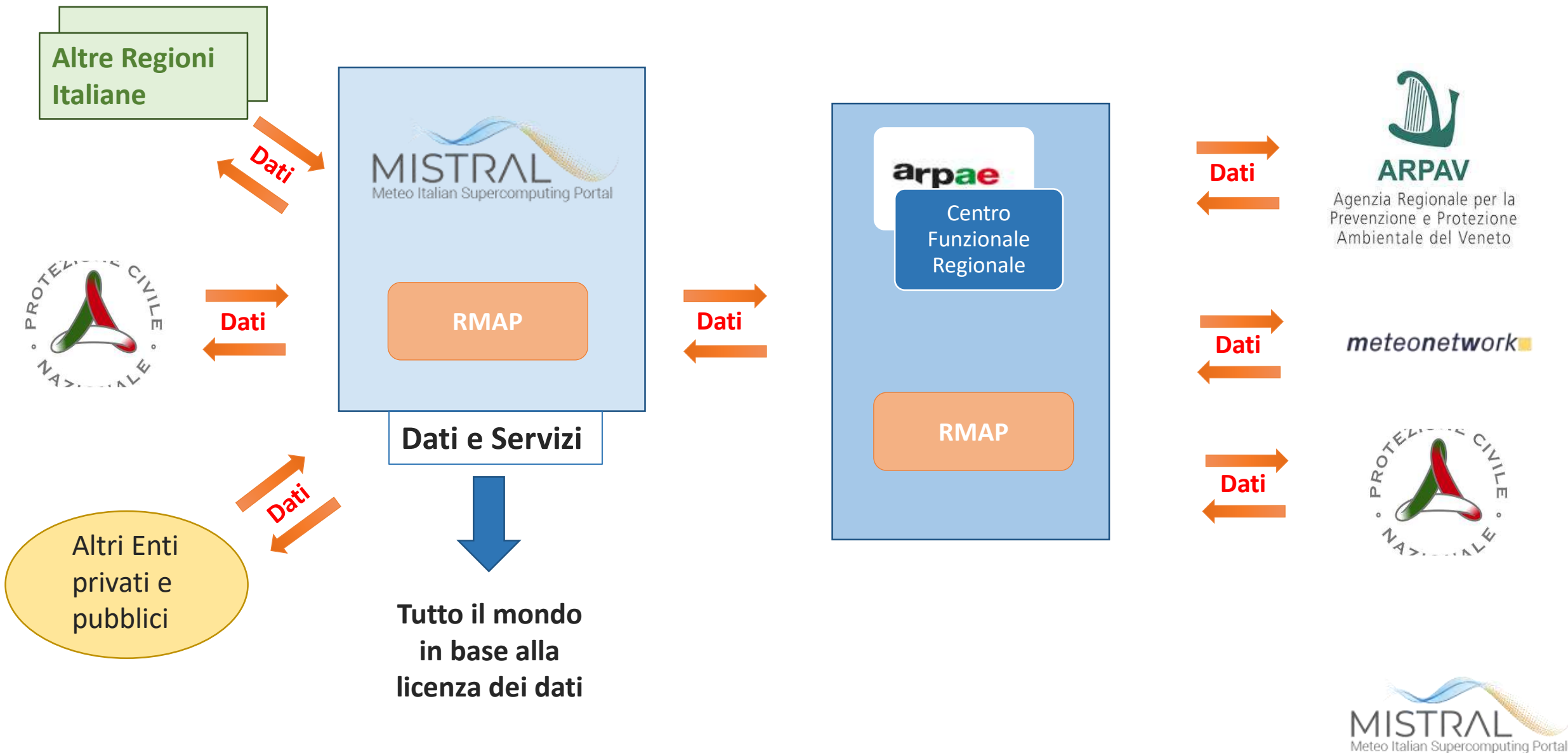
 **Forecasts**

- COSMO 5M**
- COSMO 2I**
- Flash flood**
- Multimodel**

 **Radar**

- DPC Radar network**

# Mistral Observational Data flow





## AUTORIZZAZIONE ALLA MESSA A DISPOSIZIONE DEI DATI OSSERVATIVI SULLA PIATTAFORMA MISTRAL

La Regione **<NOME REGIONE>** in qualità di titolare dei dati dei sensori delle stazioni al suolo della rete di monitoraggio meteo idro pluviometrica, allo scopo di rendere fruibili come “dati aperti” le informazioni in proprio possesso così come auspicato, in particolare per i dati ambientali, nel D.L. n. 195/2005<sup>(1)</sup> che stabilisce come principi generali che *“l’informazione ambientale sia sistematicamente e progressivamente messa a disposizione del pubblico e diffusa, anche attraverso i mezzi di telecomunicazione e gli strumenti informatici, in forme o formati facilmente consultabili, promuovendo a tale fine, in particolare, l’uso delle tecnologie dell’informazione e della comunicazione.”* e per i dati territoriali nella Direttiva 2007/2/CE<sup>(2)</sup> che istituisce un’infrastruttura per l’informazione territoriale nella Comunità europea (INSPIRE – Infrastructure for SPatial InfoRmation in Europe)

**ritiene**

di suo interesse la realizzazione del Portale web dei dati Meteorologici del progetto MISTRAL che si propone di raccogliere i dati meteorologici a livello nazionale e renderli accessibili secondo le policy concordate con i titolari dei dati.

Date queste premesse, la Regione **<NOME REGIONE>** autorizza il Consorzio del progetto MISTRAL, il cui coordinamento è affidato a Cineca, alla raccolta, archiviazione e messa a disposizione dei dati inizialmente in tempo reale e non validati, se disponibili eventualmente anche i dati storici, dei sensori delle stazioni al suolo della rete di monitoraggio meteo idro pluviometrica già condivisi con la rete dei centri funzionali e con DPC.

Il Consorzio MISTRAL provvederà senza oneri e costi per la Regione a raccogliere i dati direttamente da DPC partner di progetto.

I dati saranno messi a disposizione del Portale MISTRAL con licenza Creative Commons Attribution 4.0 International (CC-BY 4.0), senza costi a carico del Consorzio MISTRAL.

L'adozione di tale licenza viene indicata nelle Linee guida nazionali per la valorizzazione del patrimonio informativo pubblico (<https://docs.italia.it/italia/daf/ig-patrimonio-pubblico/it/bozza/index.html>).

La Regione Demanda a MISTRAL la predisposizione di tutti i meccanismi di interoperabilità necessari per:

- raccogliere i dati nella forma che sarà concordata dal team di progetto
- integrarli nell'Archivio centrale di MISTRAL
- renderli disponibili e riutilizzabili tramite la piattaforma MISTRAL come dati aperti secondo la Licenza Creative Commons Attribution 4.0 International (CC-BY 4.0)

data

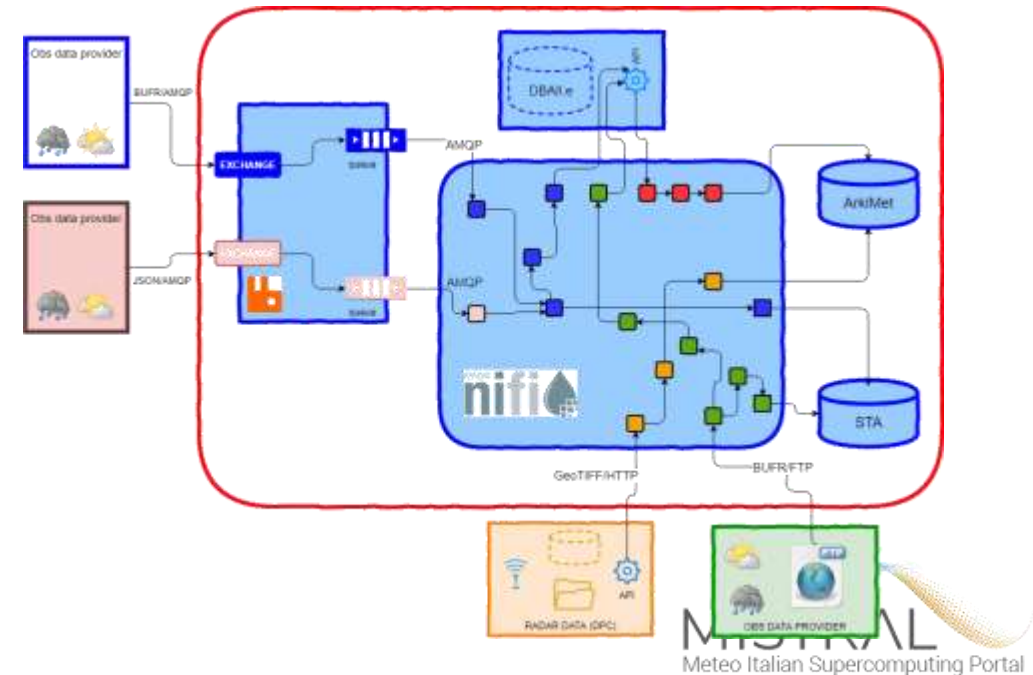
Il responsabile

Note

- 1 D.L. n. 195, 19 agosto 2005, "Attuazione della direttiva 2003/4/CE sull'accesso del pubblico all'informazione ambientale"
- 2 Direttiva 2007/2/CE del Parlamento Europeo e del Consiglio del 14 marzo 2007

# The Observational Data flows

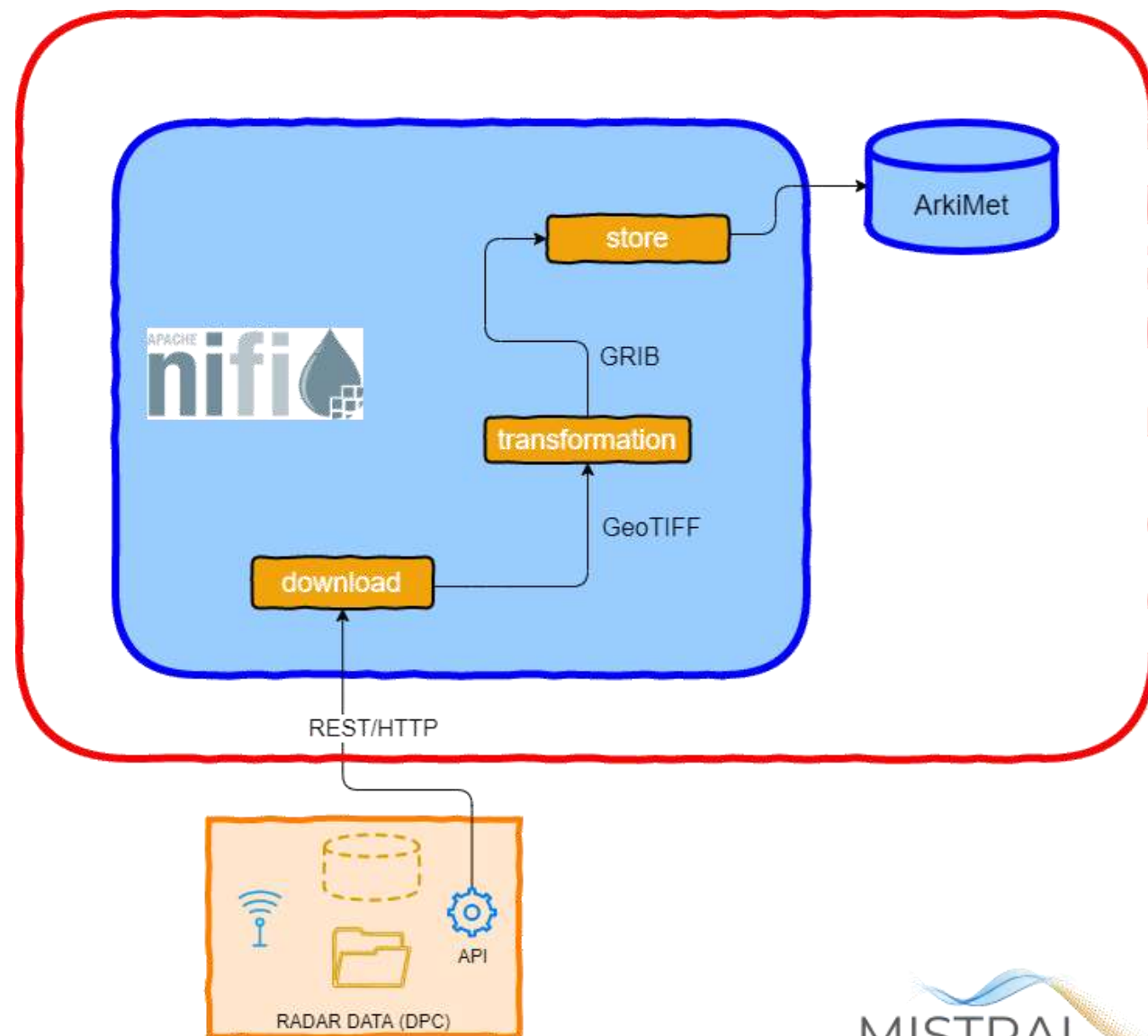
- Nation-wide **radar-derived products** coming from DPC
- **Ground station BUFR** data transmitted by Regions via **AMQP** channel
- **Ground station JSON** data transmitted by Regions and non-profit Weather Associations via **AMQP** channel
- **Ground station BUFR** data exposed by Regions on **FTP** server
- Internal short- to long-term repository data transfer





# Nation-wide radar-derived products from DPC

- 1. Download** – done by means of public DPC's WIDE APIS.  
Implemented with a polling process triggered on the base of each product nominal frequency and using a PostgreSQL DB to support retry and stop/restart events.
- 2. Transformation** – GDAL utilities and libraries to transform file format from GeoTIFF to GRIB. The setting of «no data value» and recalculation of the parameter value due to change of unit of measurement are also performed.
- 3. Storage** – the result GRIB file is stored into the Arkimet repository.





# Radar Data Products available from DPC

SRI	<ul style="list-style-type: none"><li>• Surface Rainfall Intensity [frequency: new data every 5min]</li></ul>
SRT1	<ul style="list-style-type: none"><li>• Surface Rain Total, representing the accumulated rainfall in the last 1 hour by integrating radar network data with data of the pluviometric stations on the ground [frequency: new data every 60min]</li></ul>
SRT3	<ul style="list-style-type: none"><li>• Surface Rain Total, representing the accumulated rainfall in the last 3 hours by integrating radar network data with data of the pluviometric stations on the ground [frequency: new data every 60min]</li></ul>
SRT6	<ul style="list-style-type: none"><li>• Surface Rain Total, representing the accumulated rainfall in the last 6 hours by integrating radar network data with data of the pluviometric stations on the ground [frequency: new data every 60min]</li></ul>
SRT12	<ul style="list-style-type: none"><li>• Surface Rain Total, representing the accumulated rainfall in the last 12 hours by integrating radar network data with data of the pluviometric stations on the ground [frequency: new data every 60min]</li></ul>
SRT24	<ul style="list-style-type: none"><li>• Surface Rain Total, representing the accumulated rainfall in the last 24 hours by integrating radar network data with data of the pluviometric stations on the ground [frequency: new data every 60min]</li></ul>
VMI	<ul style="list-style-type: none"><li>• Vertical Maximum Intensity [frequency: new data every 5min]</li></ul>
IR108	<ul style="list-style-type: none"><li>• Infrared satellite channel processed to obtain cloud cover [frequency: new data every 5min]</li></ul>
TEMP	<ul style="list-style-type: none"><li>• Surface temperature from ground stations [frequency: new data every 60min]</li></ul>
AMV	<ul style="list-style-type: none"><li>• Wind AMV Atmospheric Motion Vector. Vector data file representing wind intensity and direction at high altitude coming from satellite remote sensing [frequency: new data every 20min]</li></ul>
LTG	<ul style="list-style-type: none"><li>• Vector data file representing the location of lightnings calculated with triangulation of the signals received by dedicated ground antennas of the LAMPINET<sup>[1]</sup> network [frequency: new data every 10min]</li></ul>
HRD	<ul style="list-style-type: none"><li>• Heavy Rain Detection, map of important phenomena, classified according to a Severity Index; also displays their possible trajectory in the very short term [frequency: new data every 5min]</li></ul>

# Data post processing

## 1. Derived Variables

Forecast data

Observed data

- Calculate derived products not present in the original dataset
- (Wind direction, Wind Speed, Air Density, Dew point Temperature, Specific and Relative Humidity, Snowfall)

## 2. Statistic Elaborations

Forecast data

Observed data

- Calculate statistics processes (ex. accumulations or averages, Max and Min) for given products in a given time interval

## 3. Formt Conversion

Observed data

- Convert the output data file in JSON format

# Data post processing

## 4. Geographical Elaborations

- Interpolation on a different grid using an uploaded custom template file or writing the parameters of a custom new grid

Forecast data

- Grid cropping

Forecast data

- Interpolation on geo-referenced points defined by a

Forecast data   Observed data

# Weather Data Visualization

## Observed data: requirements

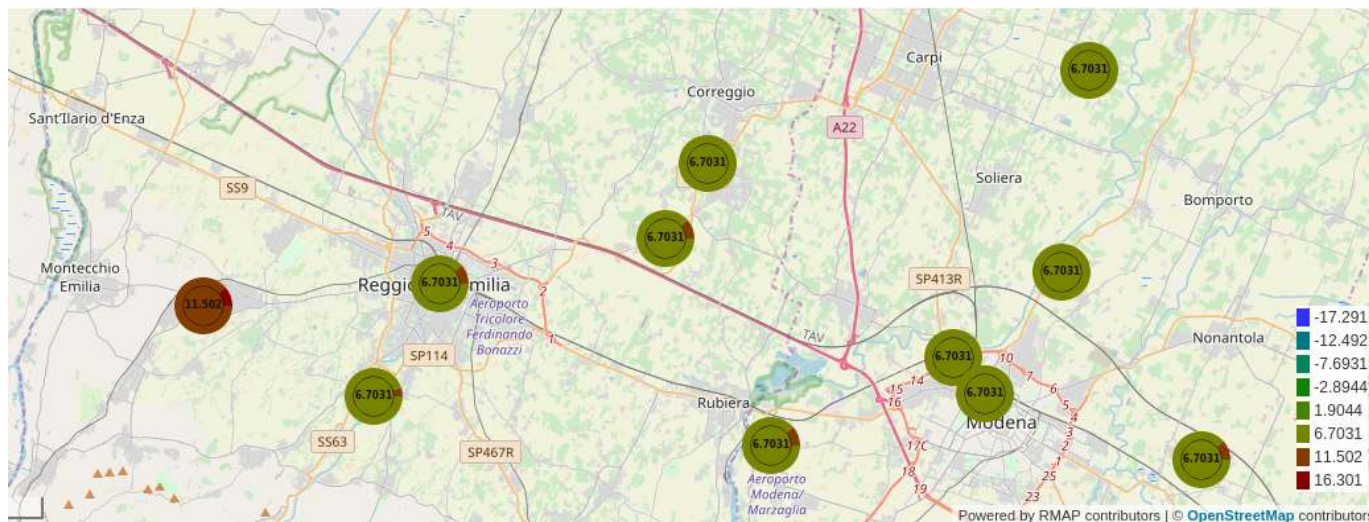
- Web service displaying observed data from all over Italy on a **map**
- **Interactive maps** with the possibility to **zoom** and **pan**
- **Filtering data** to display by reference **time** and **products**
- Filtering data by **networks** (es. Regional networks or MeteoNetwork)
- Map as interface to filter and **download** sets of observed data

## Forecast data: requirements

- Web service displaying observed data from all over Italy on a **map**
- **Interactive maps** with the possibility to **zoom** and **pan**
- Possibility to display vector images to have **high resolution while zooming**
- Overlap different meteorological variable layers (**multilayers**)



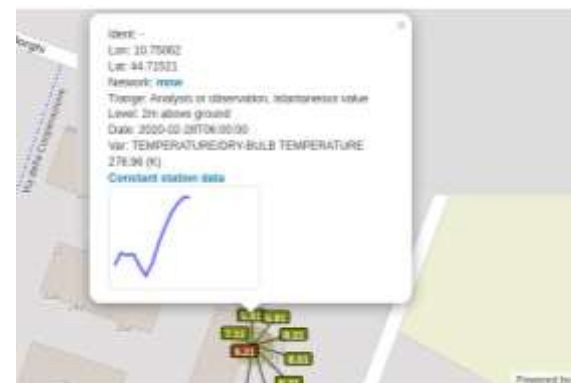
# Weather Observed Data Visualization (example taken from RMAP of ArpaE)



## Product values of a single station



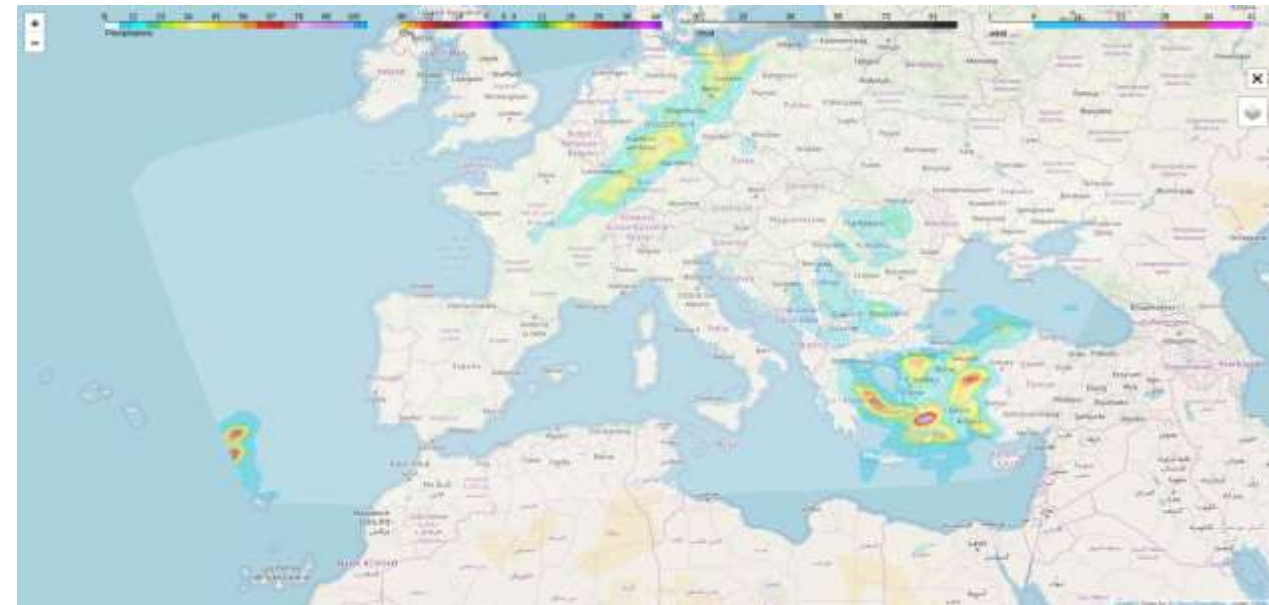
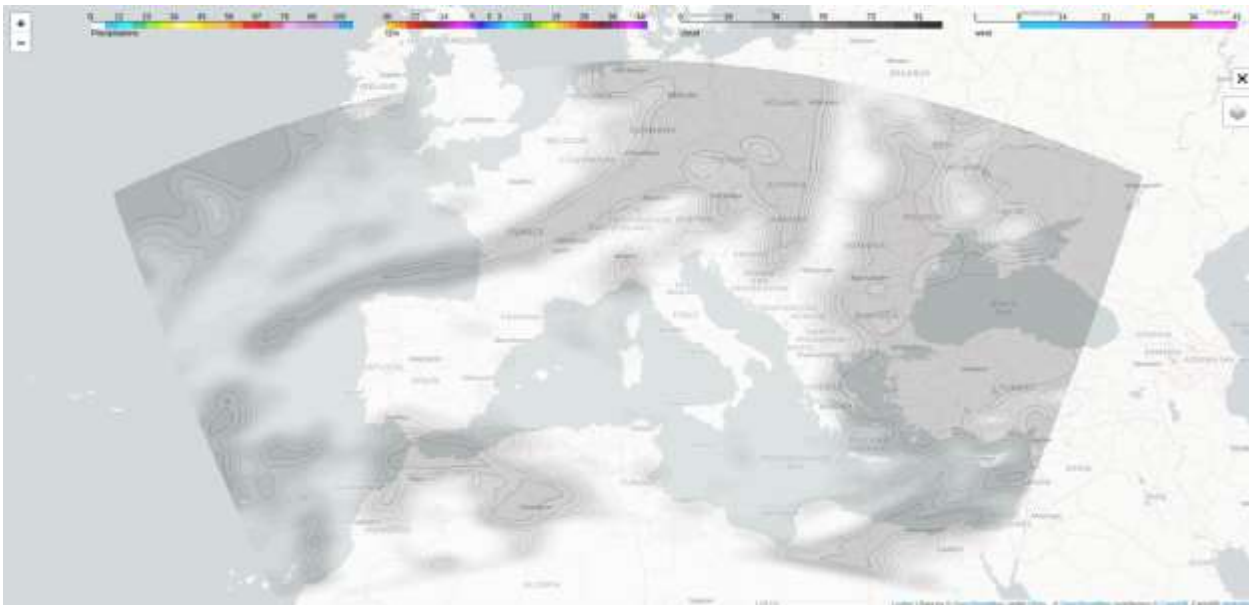
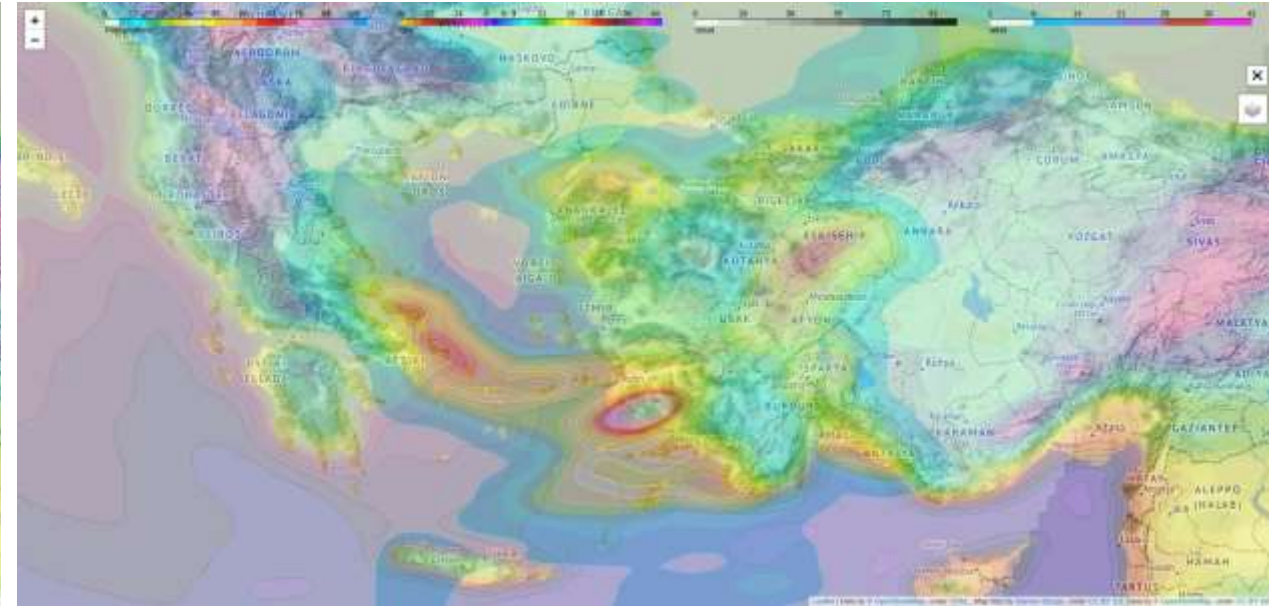
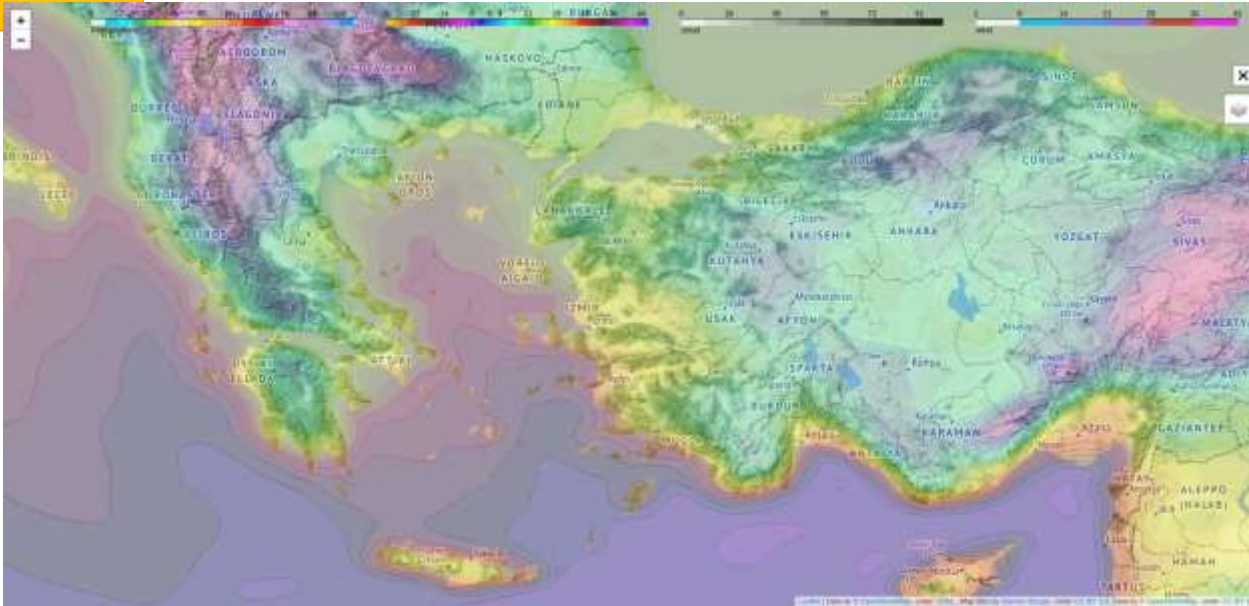
## Time series (Meteogram)



# Weather Forecast Data Visualization

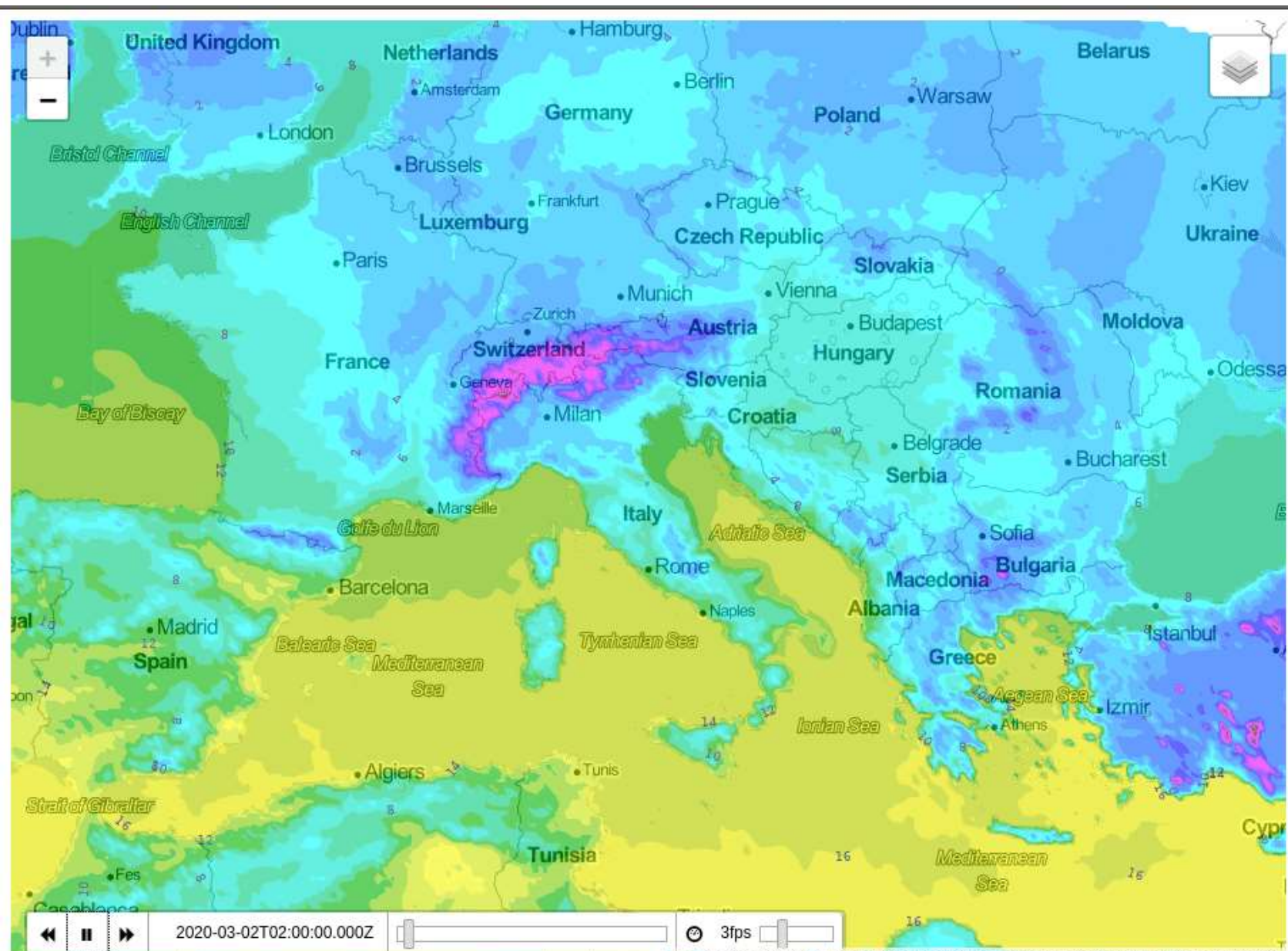
Requirements/ Tools	magics	matplotlib	plotly	folium	skinny
Temporal Slideshow	no	no	Yes	no	Yes
Interactive Pan	no	no	Yes	Yes	Yes
Multilayer	no	no	no	Yes	Yes
Zoom	no	no	Yes	Yes	Yes
File Size	<1Mb	<1Mb	~10Mb	1-10Mb	<1Mb
Images	Raster	Raster	Raster	Vettorial	Vettorial
Georeferential	Yes	Yes	no	Yes	Yes
Physical boundaries	Yes	Yes	no	Yes	Yes
Maps	magics	cartopy	-	openstreetmap	magics

# Vectorial graphs



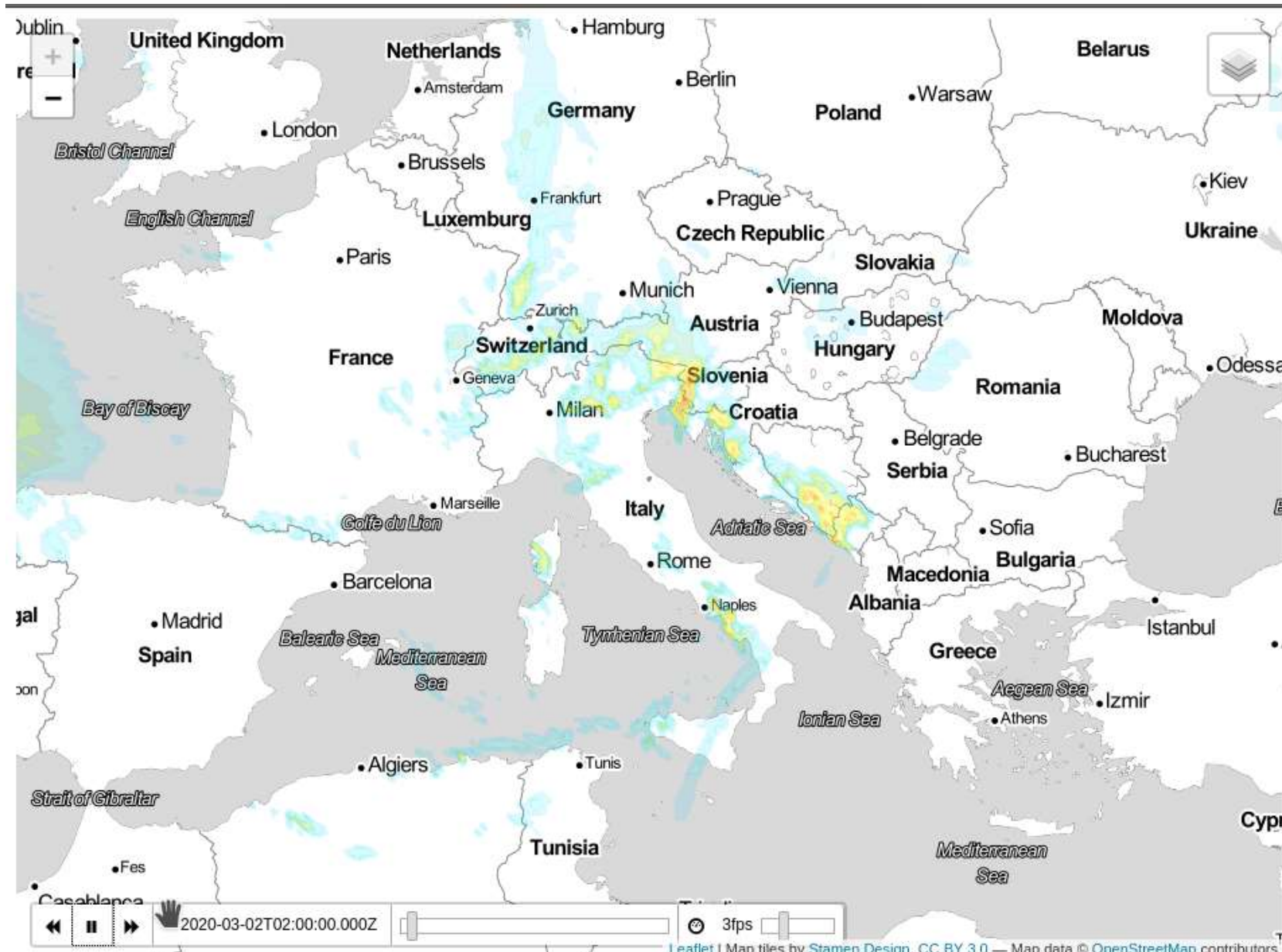


# Example Temp generated with Magics



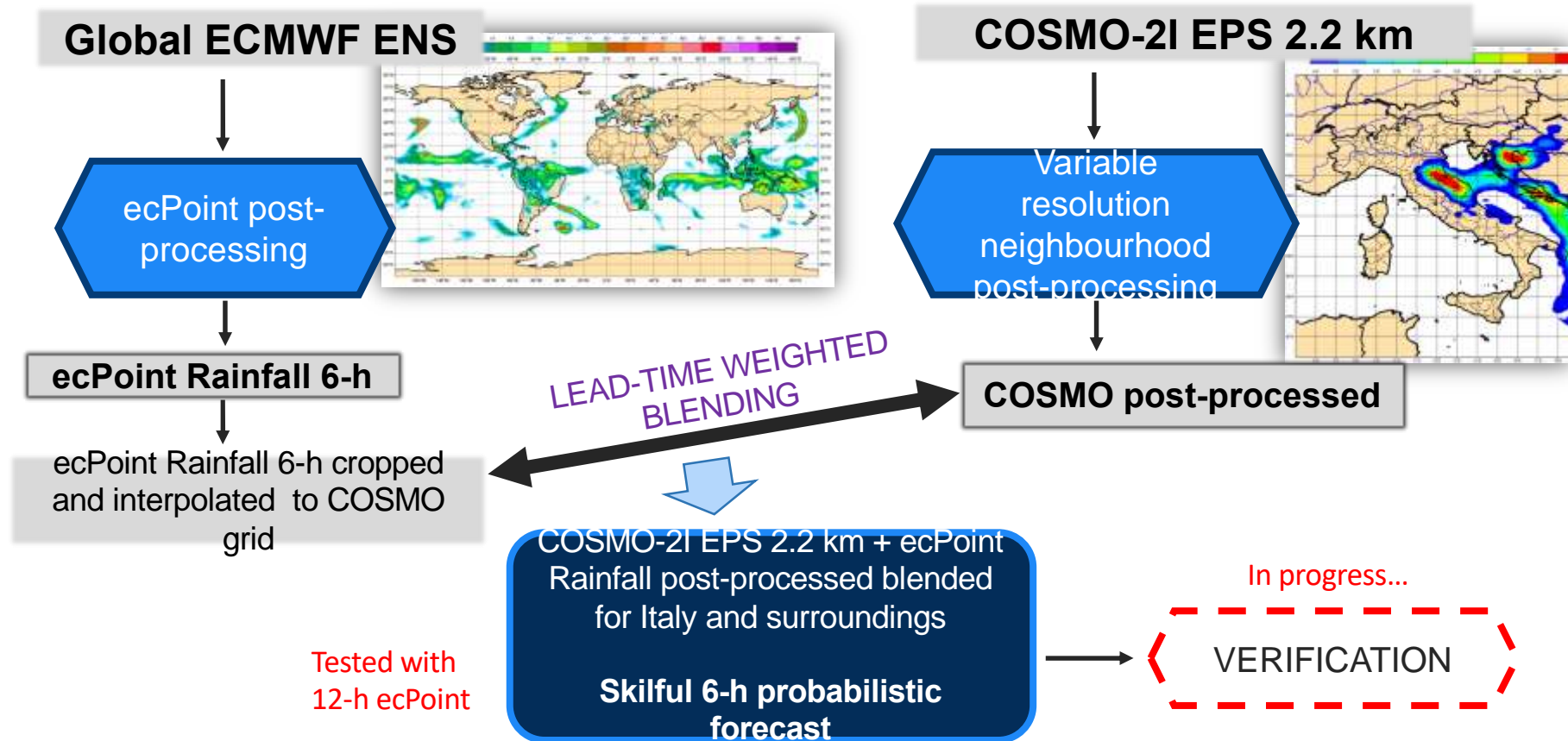


# Example Cumulated Precipitation with Magics

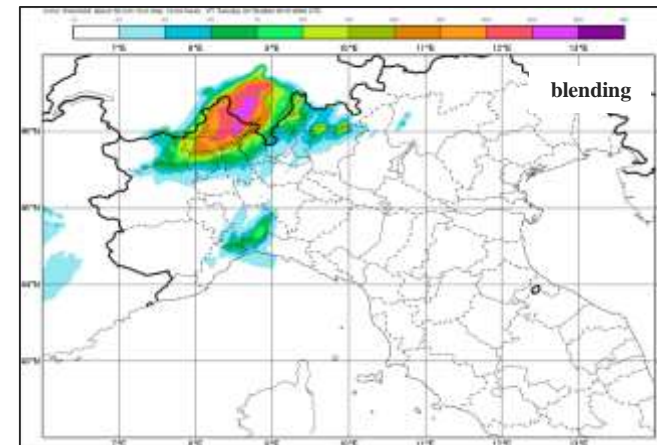
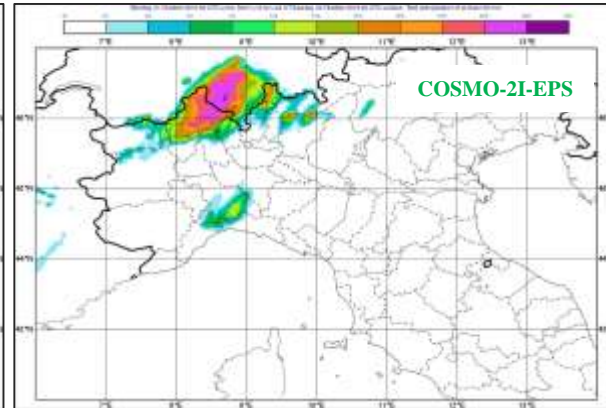
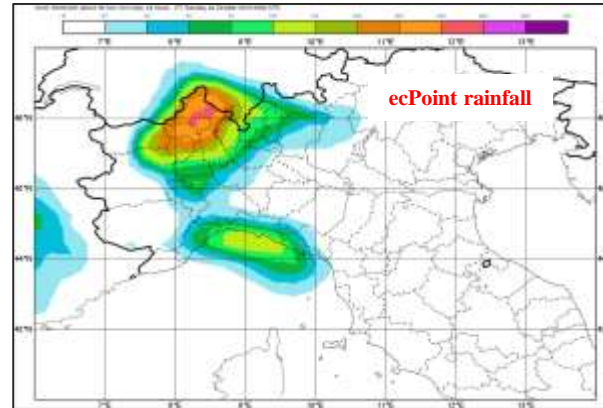
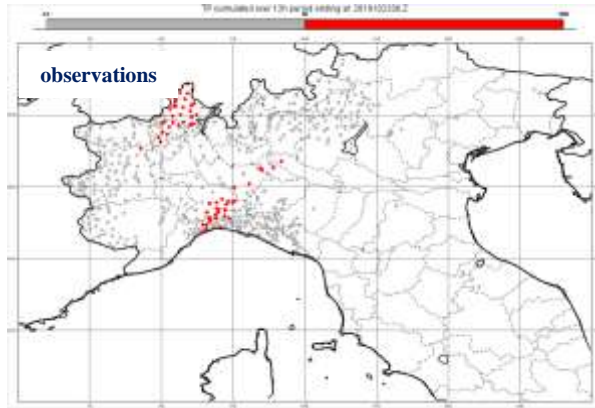


# Italy Flash Flood (ECMWF)

## Workflow for 6-h precipitation forecast



# Case study of 21 October 2019: heavy precipitation over Piedmont



- Both **ecPoint rainfall** and **COSMO-2I-EPS** struggle to predict properly the locations possibly affected by heavy precipitation.
- The best results are obtained by **blending** ecPoint rainfall and COSMO-2I-EPS.

European Centre for  
Medium-Range Weather  
Forecasts

Data  
Catalogue



**FILTER BY DATASET**

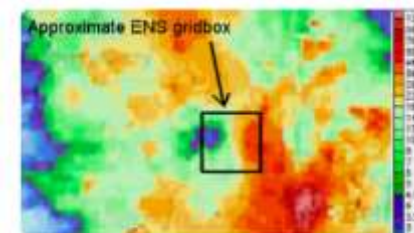
SEARCH BY FORECAST, OBSERVATION, REALTIME DATASET



**WEATHER DATA DOWNLOADER**

Meteo-Hub Application allow you to create and download your personal weather data collection. Choose from different forecast models, weather stations, parameters and time validity range. Download BUFR and GRIB format.

Italy Flash  
Flood



**ITALY FLASH FLOOD**

Application delivering probabilistic forecasts of 6-hour rainfall for Italy, created by blending together post-processed ensemble forecasts, from ECMWF ("ecPoint") and COSMO. Output shows pre-defined rainfall percentiles and probability thresholds for each COSMO grid point.

Multimodel  
Forecast



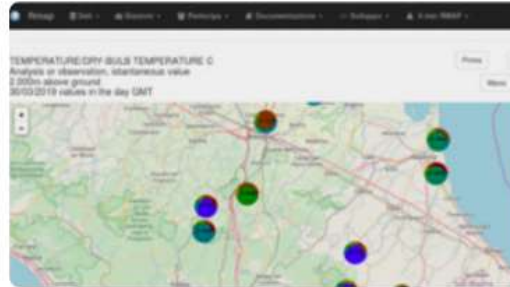
**MULTIMODEL FORECASTS**

Application based on the post-processing of different meteorological Models, for issuing temperature and relative humidity forecasts over Italian weather stations. The Multimodel



# Mistral Services: <http://www.mistralportal.it/opendata/>

## Data Visualisation



### ENVIRONMENTAL OBSERVATION

This Application provides observed meteorological data over italian locations obtained from public weather station. Real time and historical data is provided by using a geospatial information system or displayed in interactive graph.

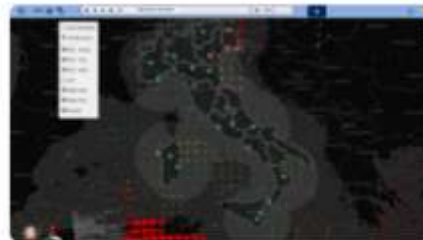


### FORECAST PRESENTATION

Application for forecast analysis, the user can choose parameters from a complete catalogue and move through the model time step. Creating a slideshow of information useful to make an accurate forecast overview on the italian and mediterranean area.

[Read more...](#)

## RADAR & REALTIME MAPS



### RADAR & REALTIME MAPS

Realtime applications for nowcasting weather alert, multilayer information system, allow the user to create an interactive picture of the italian and mediterranean area filled with radar, wind animation and more

[Read more...](#)

DEMO: Forecast Data Download



# Highlander

Da previsioni a breve termine a proiezioni a medio termine della variabilità climatica (eventi estremi e relativi rischi climatici) per supportare la pianificazione e il decision making su risorse e sistemi territoriali

Programmi di irrigazione

Servizio per previsione del fabbisogno idrico delle colture

Gestione integrata dei parassiti

Cambiamenti nell'idoneità del terreno per la vegetazione (foreste, colture)

Potenziale di incendio boschivo

Benessere degli animali e idoneità del terreno per l'agricoltura

Benessere umano

Ciclo dell'acqua e sostenibilità degli usi concorrenti

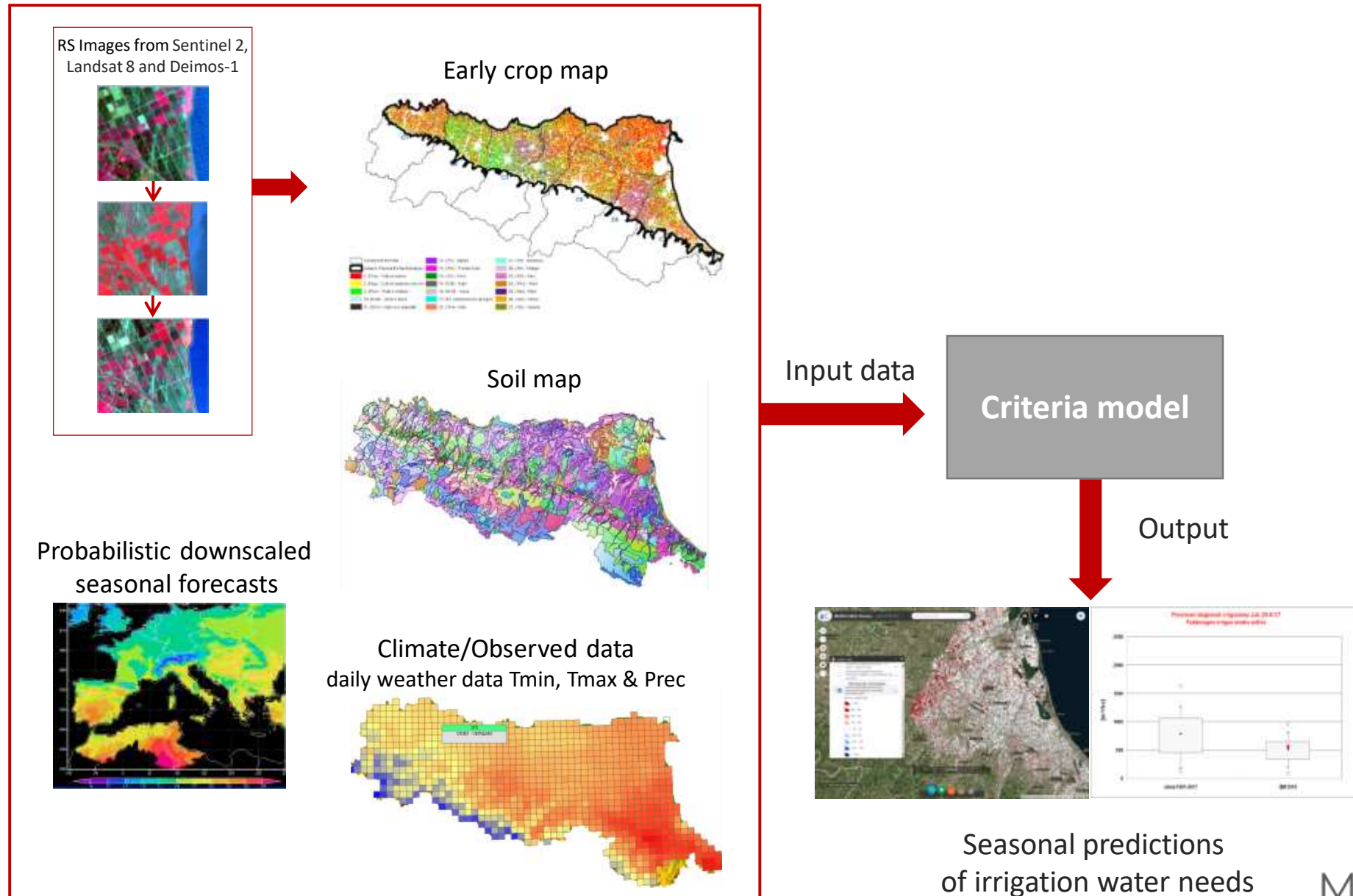
Integrazione di dati climatici, osservazioni satellitari e dati IoT a supporto della valutazione e gestione di ecosistemi

Previsioni e controlli sugli incendi boschivi

Gestione ambientale dei parchi naturali

Benessere degli animali

# Previsioni stagionali del fabbisogno idrico di irrigazione (ARPAE)



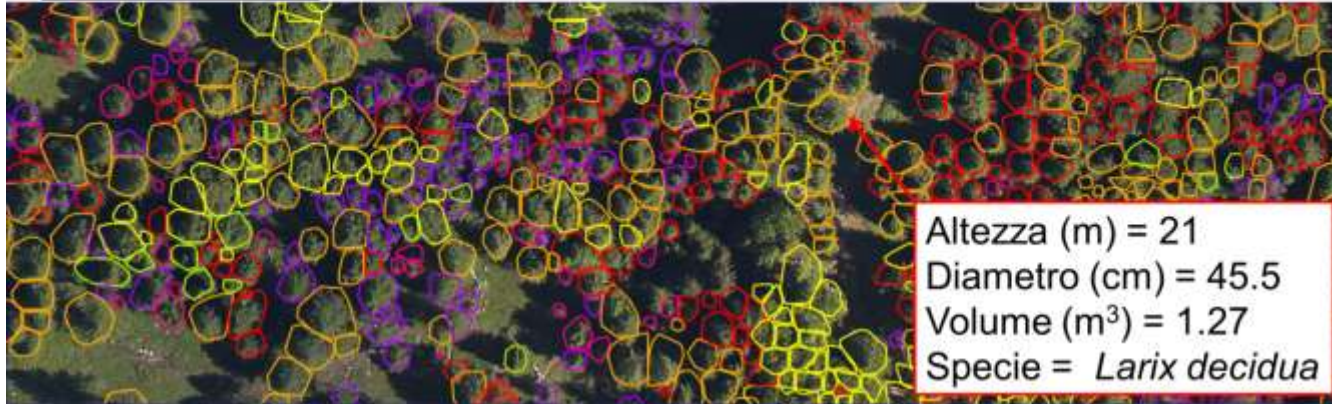
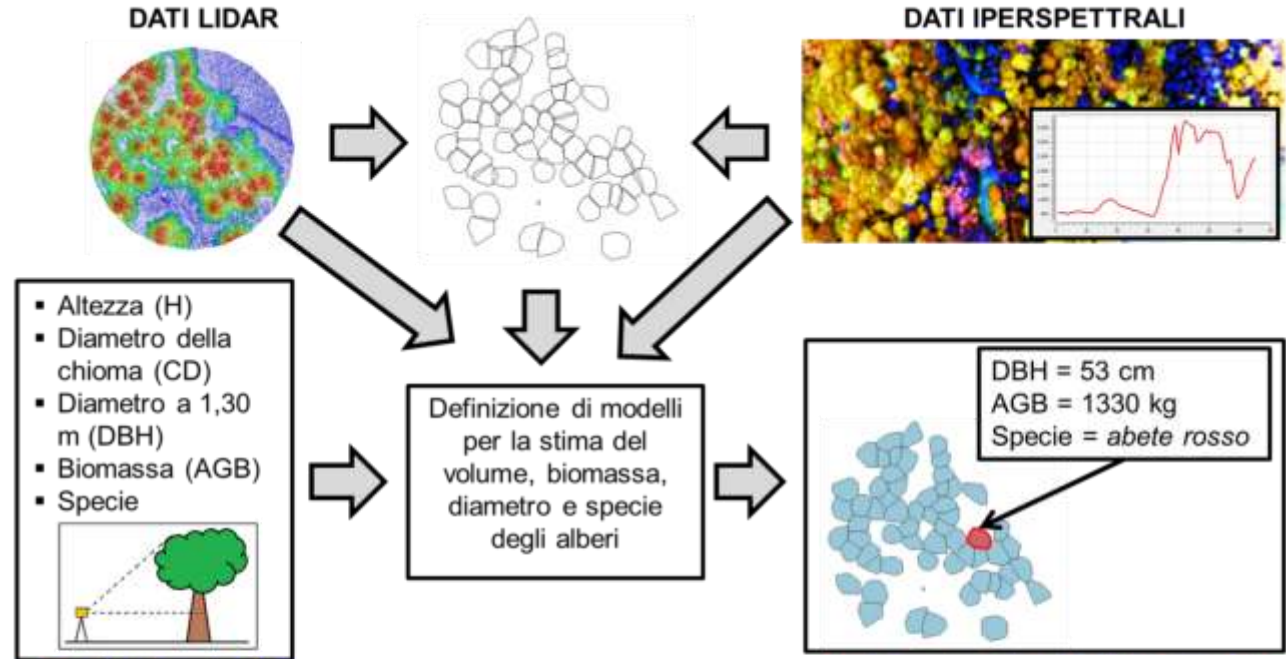


# Controllo e Gestione del Parco Naturale Paneveggio – Pale di San Martino

▪ Fondazione E. Mach



# Analisi delle foreste a livello di singoli alberi



Grazie!  
Come possiamo collaborare?