

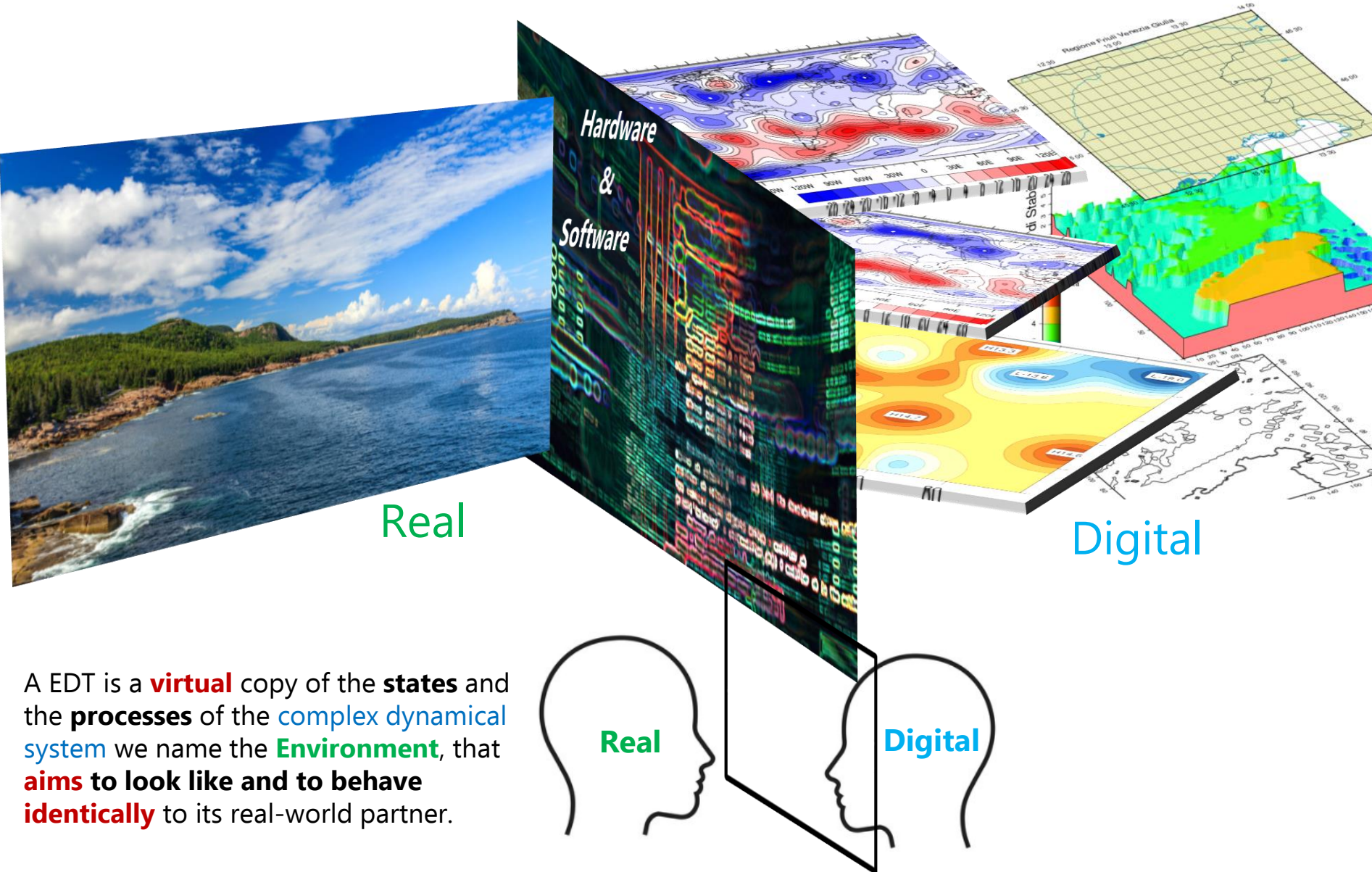
Developing and implementing a Digital Twin of the environment, at local scale

6th Workshop on Water Resources in Developing
Countries: Hydroclimate Modeling, Information Tools
and Simulation Techniques

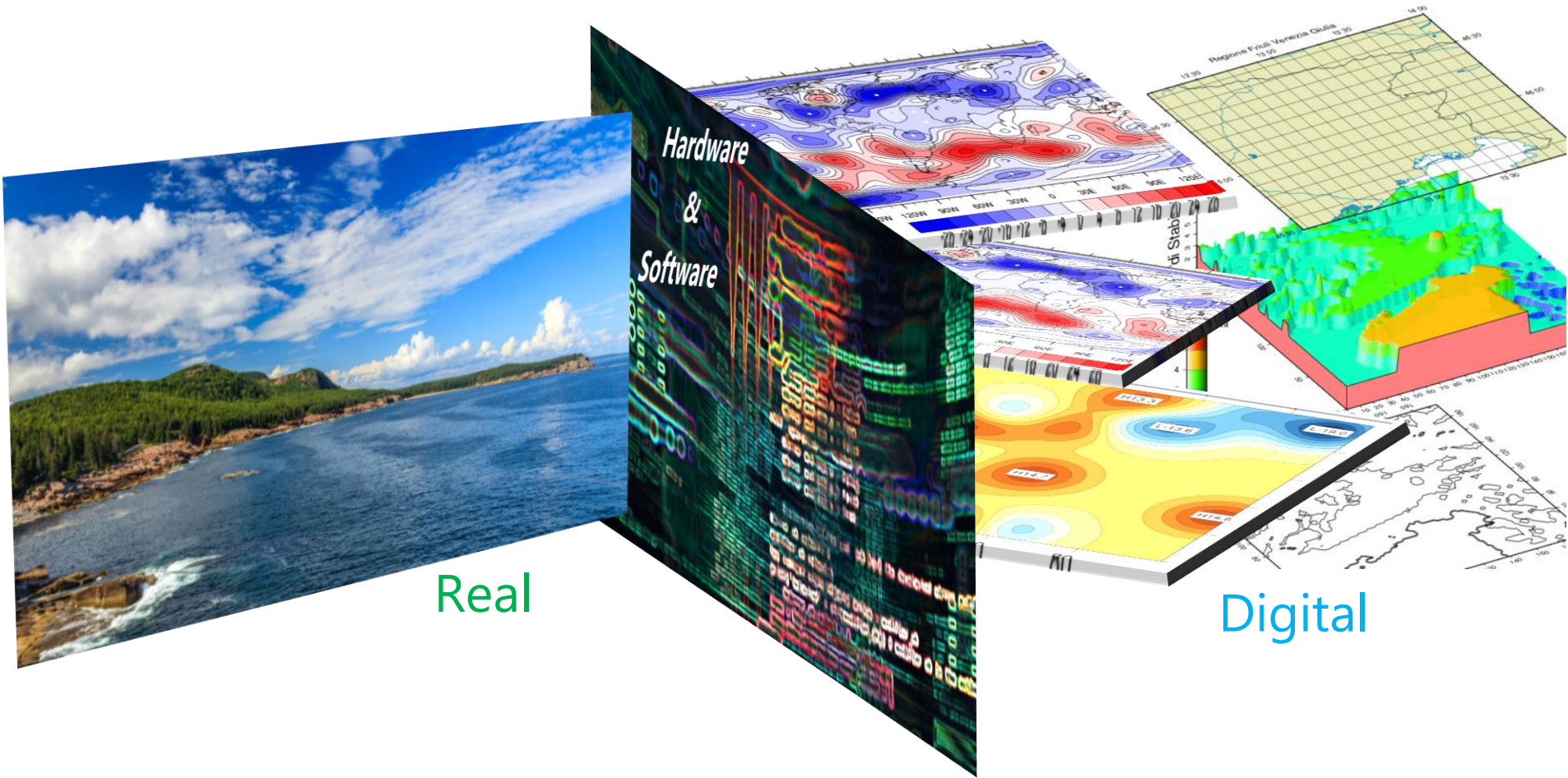
Dario B. Gaiotti,

Regional Center for Environmental Modelling, ARPA FVG

- ❑ Why do we need a digital twin of the environment (EDT)?
- ❑ General features of a EDT at local scale
- ❑ Key point for the implementation of a EDT
- ❑ The EDT implemented by ARPA FVG



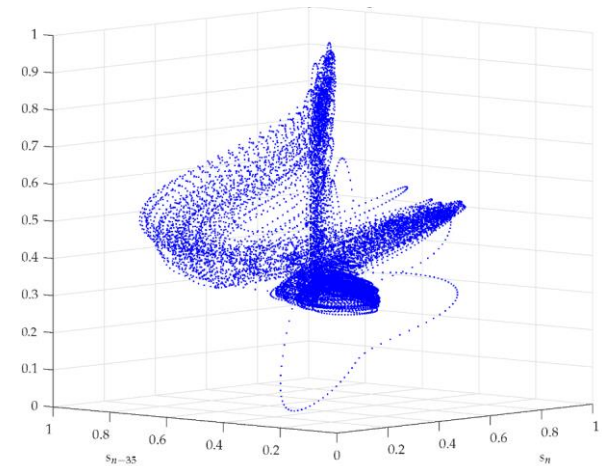
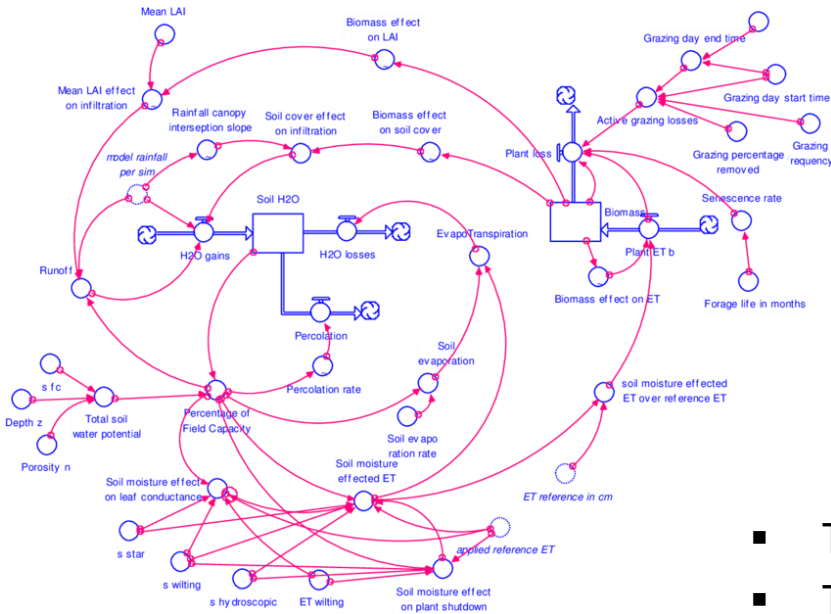
A EDT is a **virtual** copy of the **states** and the **processes** of the **complex dynamical system** we name the **Environment**, that **aims to look like and to behave identically** to its real-world partner.



Diagnostic purposes: to fill in information where there are no measurements available

Prognostic purposes: to see in advance environment evolution and possible scenarios

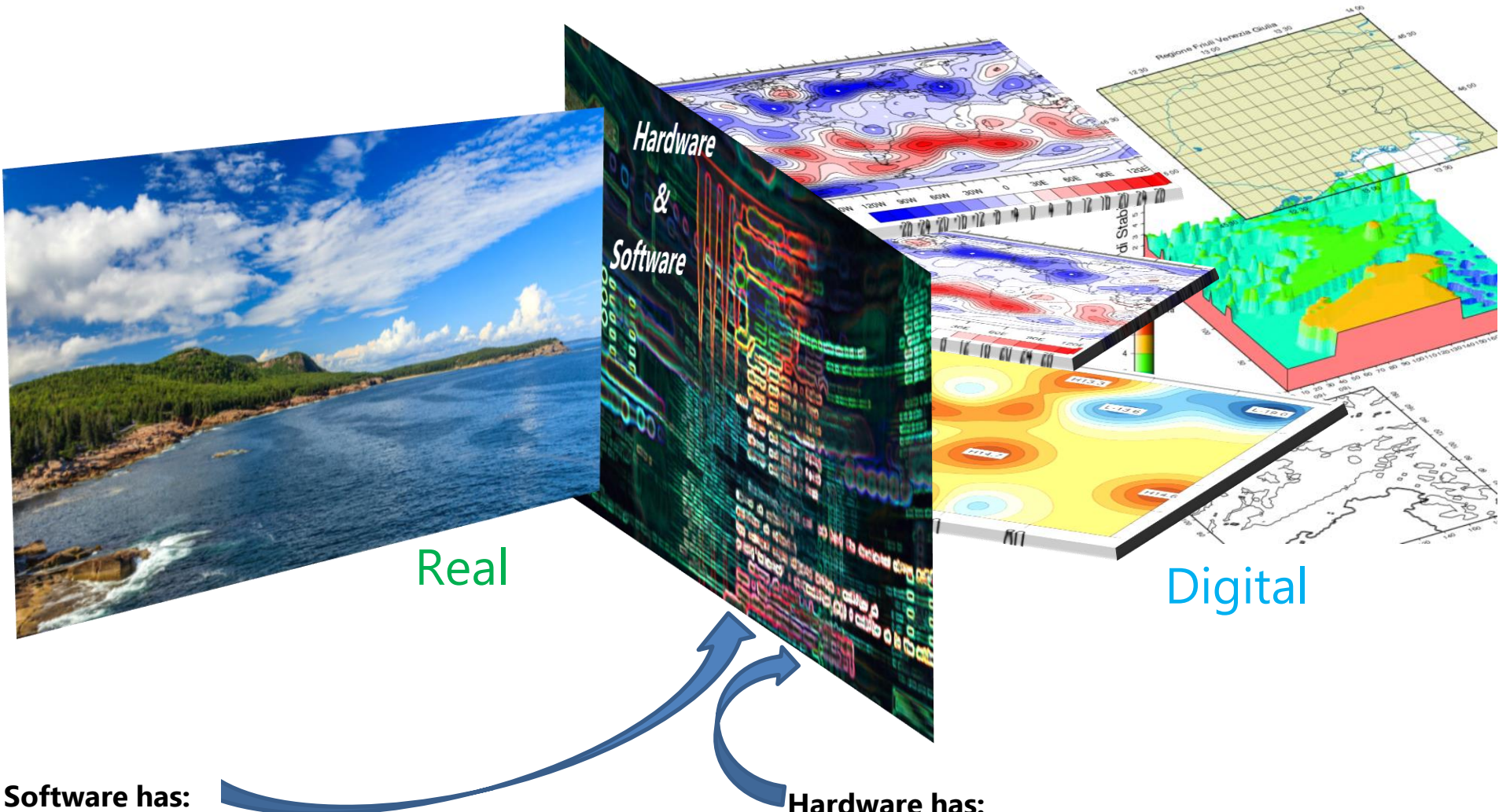
The Environment is a **complex dynamic system**



It has a **structure** and a **behavior**

- The **structure**, is composed by elements (sub systems)
- There are **interactions** between the elements
- **It cannot be** considered an **isolated system**
- Its objective is to **reach an overall** (dynamic) **equilibrium**

The behavior of the Environment is a consequence of its structure, the interactions among its elements, and the overall objective



Real

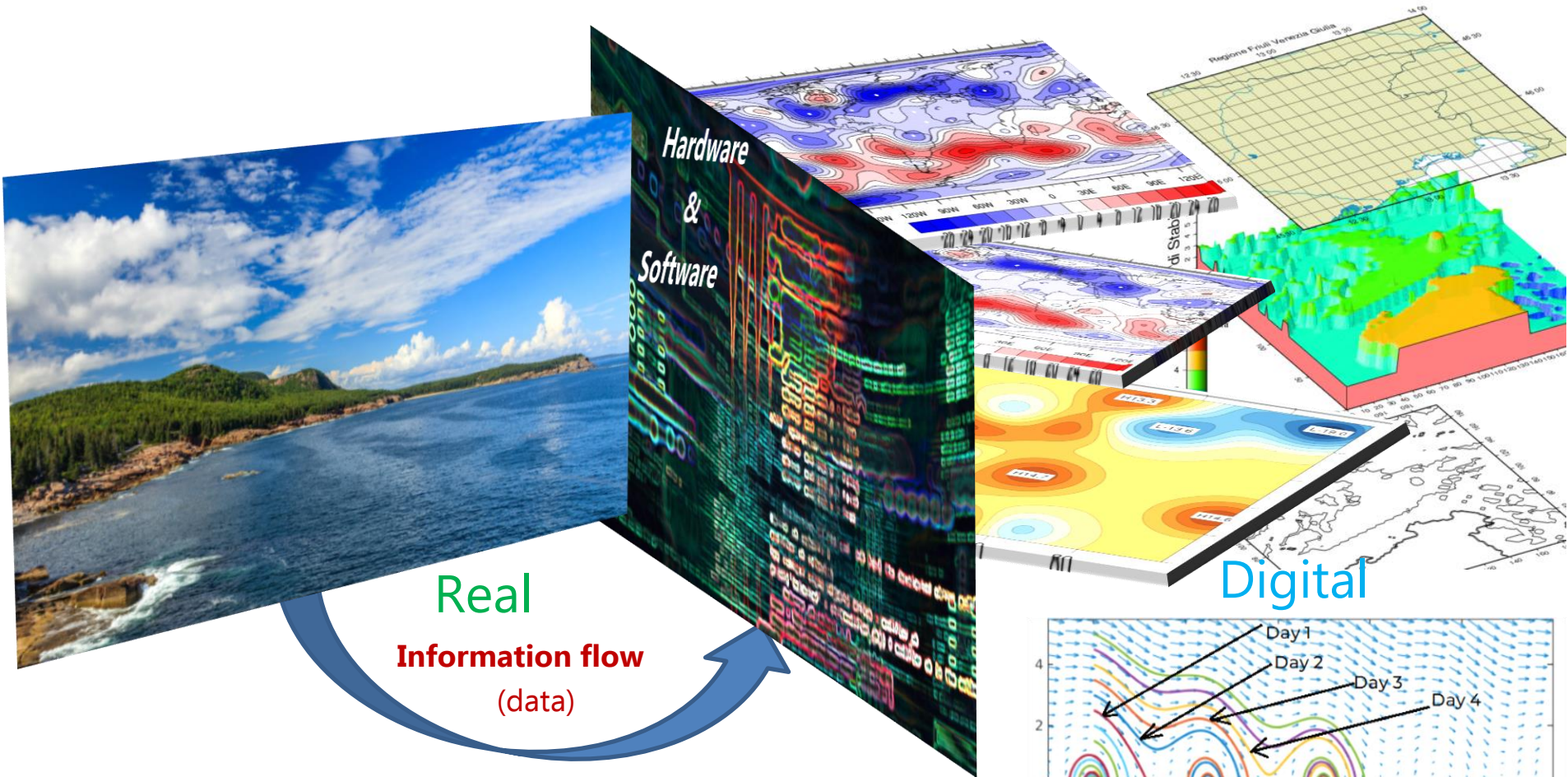
Digital

Software has:

- to describe the elements composing the environment
- to include the objective (function) of each element
- to reproduce the interactions among the elements

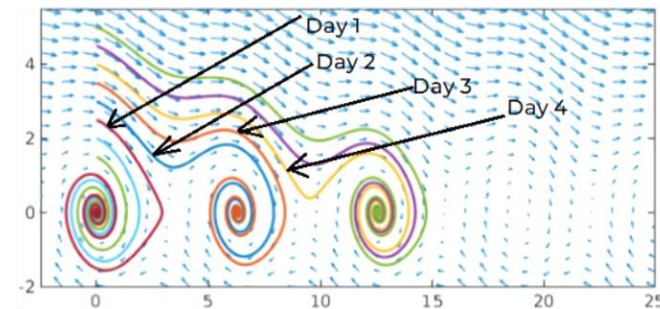
Hardware has:

- to execute the software as fast as possible
- to store all the generated simulation of the reality
- to be fast in recovering the stored information

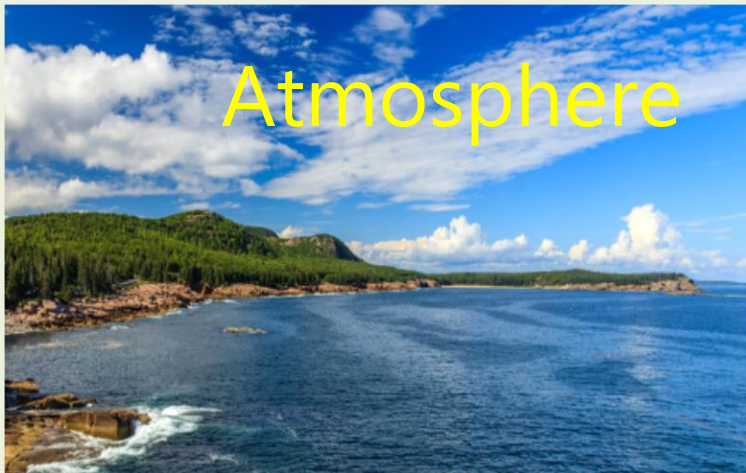


Continuous information flow from the reality into the software:

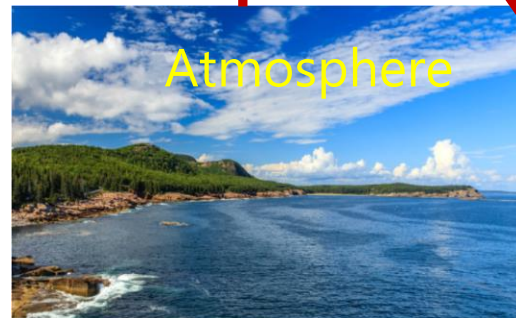
- to correct the trajectory of the system on the phase space continuously
- to let the software to learn and to improve the virtual copy of the reality
 - Software Upgrade (SU) + Machine Learning (ML) + Artificial Intelligence (AI)



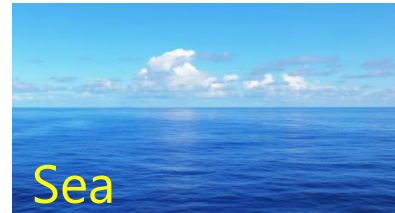
Environment



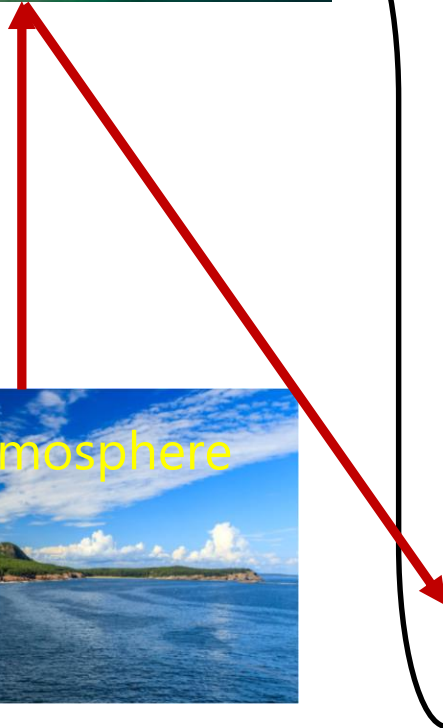
Two way interaction - input and feedback



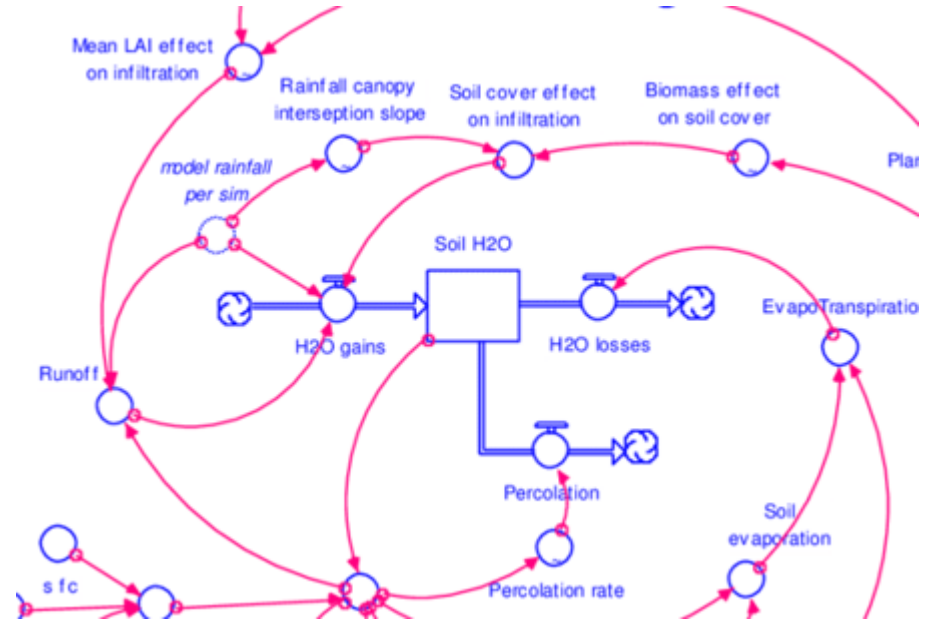
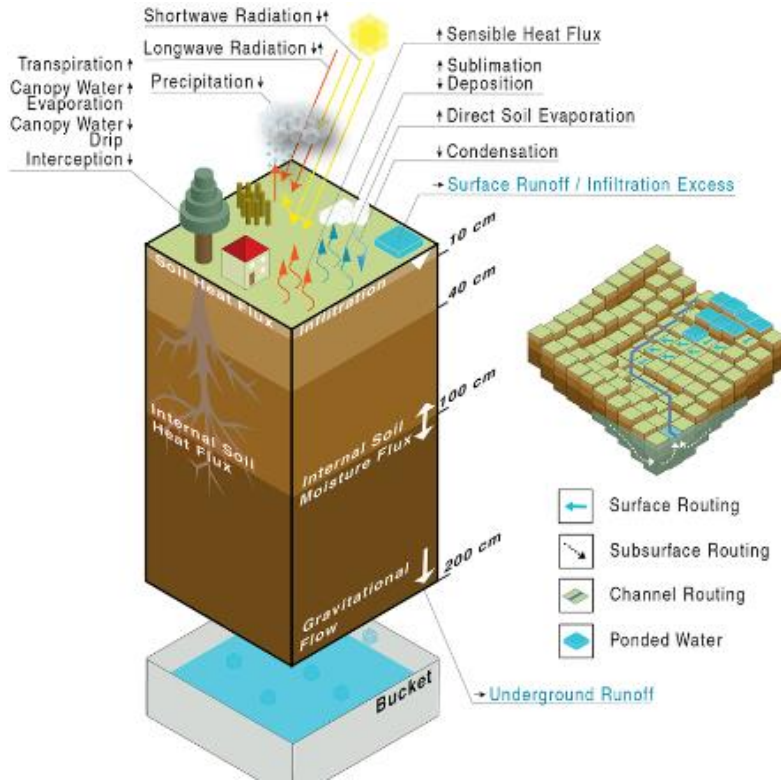
Aggregation **Level 1**



Aggregation **Level 2**



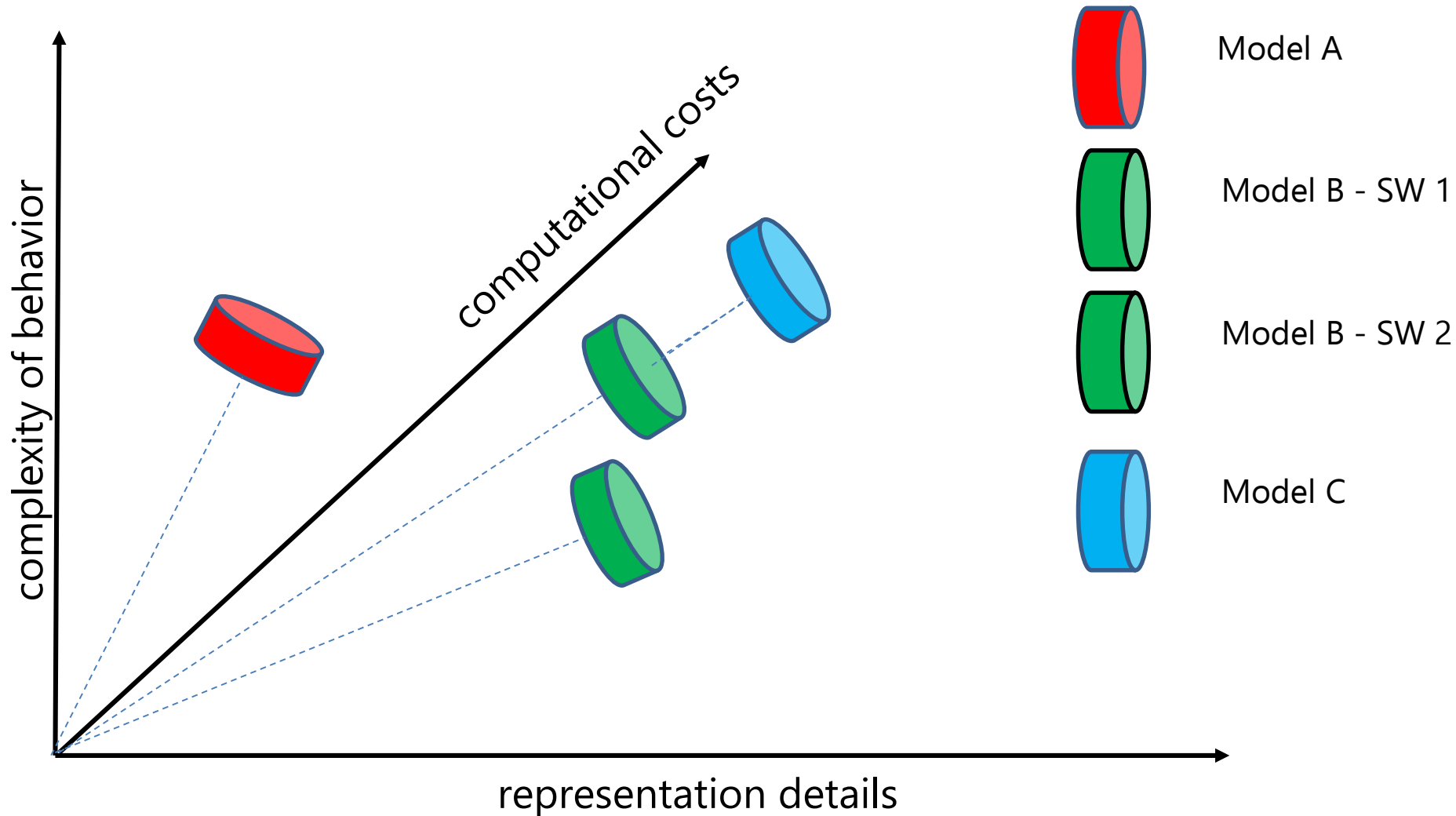
In a Digital Twin, interactions among the system components have to be described as representative of reality as possible.



What does it mean as representative of reality as possible?

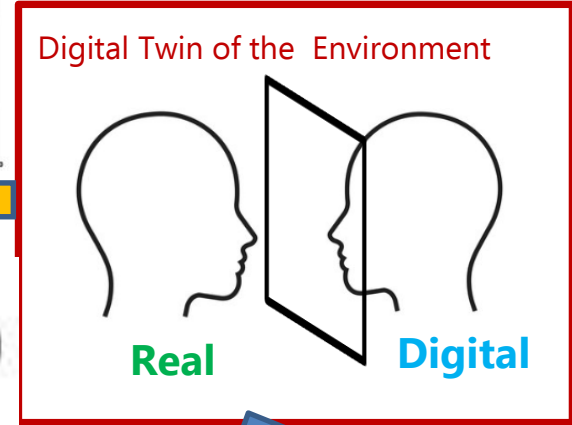
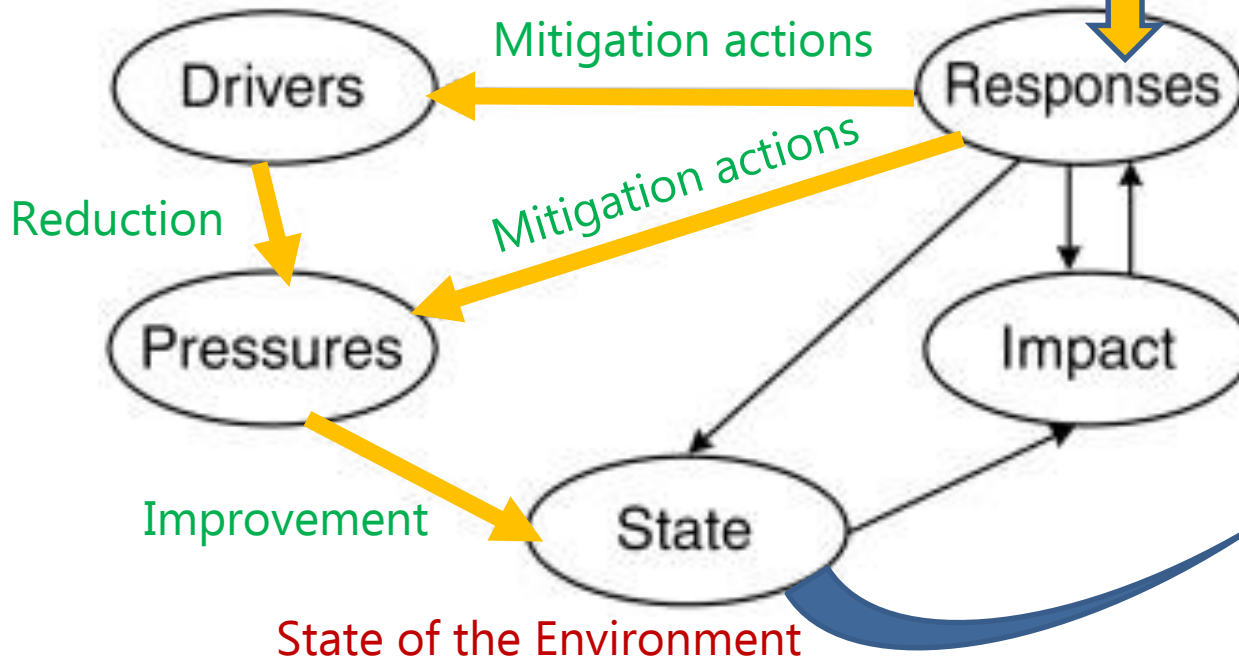
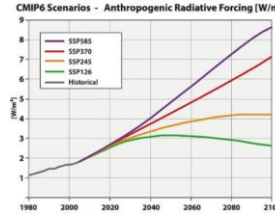
It depends on the **accuracy** and the **detail** requested to the Digital Twin. Be aware of the **feedback and non linearity** response of the components. In the Digital Twin, software implements the component behavior and its interaction with the other components and the boundary

No. Usually there are more than one according to **representation details**, **complexity of behavior**, **computational costs**, implementation **software**, etc.



Yes, when the information from digital twin are used to act on environment

Example: Mitigation to Climate Change



DPSIR logical framework. Smets E., Weterings R., Environmental indicators: typology and overview, Technical report No. 25, European Environment Agency, Copenhagen (1999) 19 pp.



Global



Local



Boundary conditions



Initial conditions



Spatial (time) resolution



Description complexity



Behavior complexity

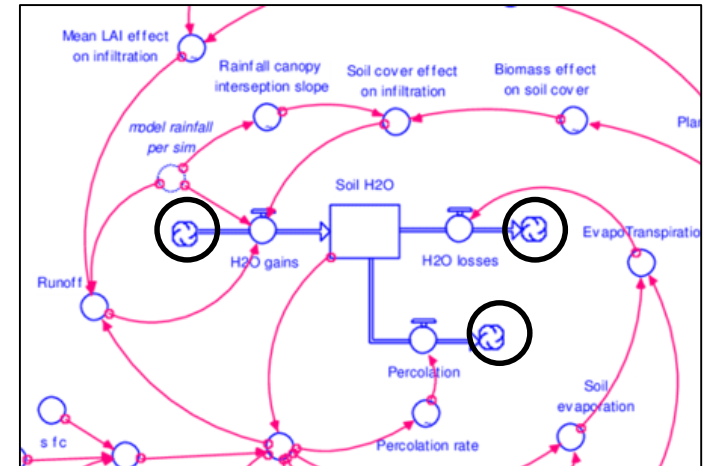
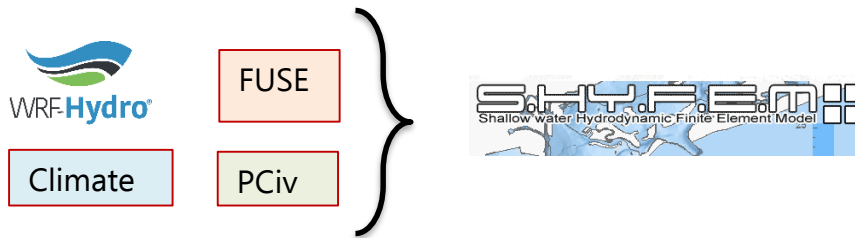


Computation costs



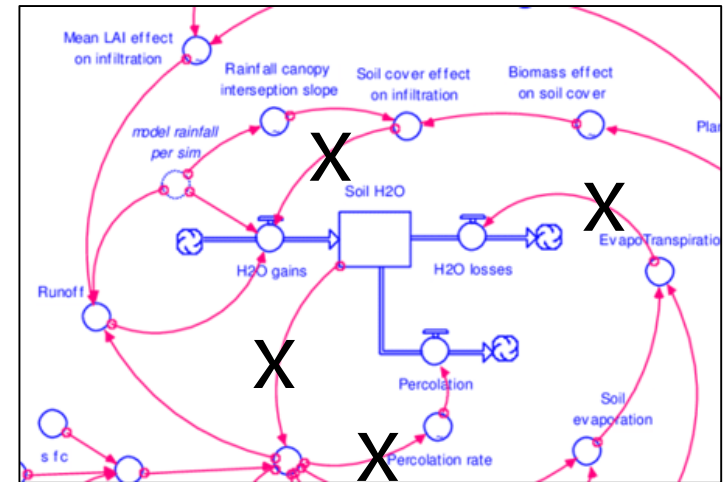
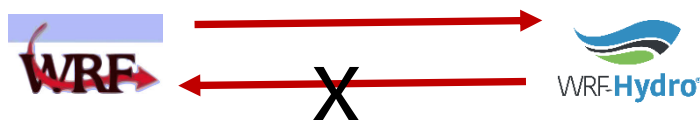
❑ Boundary conditions essential and often characterizing the evolution (**disadvantage**)

- Dependence from **external sources** of information
- Sources **redundancy required**
- Quality **sensitivity from outer quality**



❑ Some feedbacks are negligible for several applications (**advantage**)

- **No** need to **couple models**
- Simplified **workflows**
- Reduced **computational costs**



Regional Environmental Modelling Centre



- Conceptual models
- Analytical models
- Numerical models
- High Performance Computing
- Big Data analysis and handling
- Data and metadata archival



Permanent staff
7 people (3 women + 4 men)

+

Temporary employees (for project purposes)

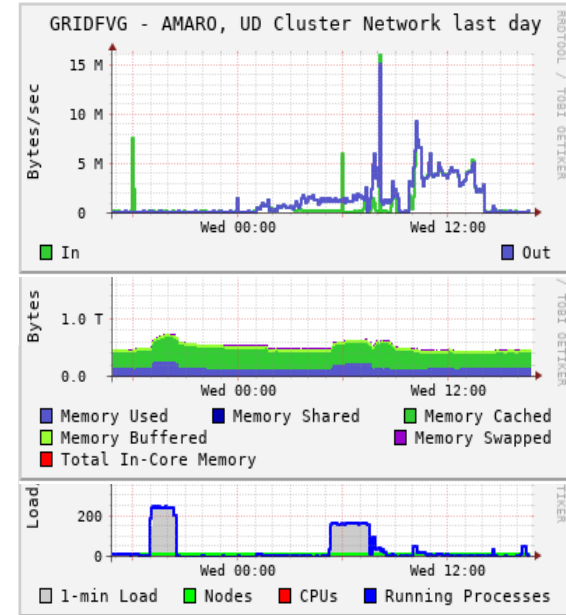
High Performance Computing: operational and on demand + Workflow manager



CPU's Total: 780
 Hosts up: 18
 Hosts down: 0

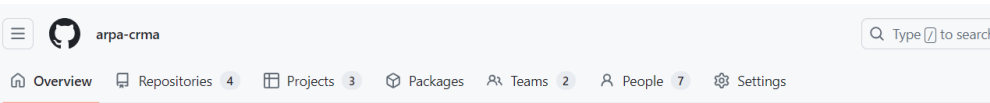
14 computational nodes
 4 service nodes

> 25 operational suites
 > 1000 operational tasks
 Tens of pre-operational suites



About 84 TB of data
 About 200 TB capacity

- Project monitoring
- Code documentation
- Code versioning
- Continuous integration
- Resources monitoring



ARPA FVG **trac**
Integrated SCM & Project Management

connesso come **giaiotti**

Wiki Cronologia Obiettivi **Sperimenti** Segnalazio

Indice dei repository

Nome	Dimensione	Rev	Età	Autore	Ultima modifica
operative_workflows		aa181e	8 settimane	CRMA operative user <[omitted]>	Replaced the bulletin date with the v
development		1441845	2 mesi	CRMA operative user <[omitted]>	SHYFEM forecast: vertical reference
operative		aa181e	8 settimane	CRMA operative user <[omitted]>	Replaced the bulletin date with the v
AIR_LOCAL_TRA1_oper		o51a7af	3 mesi	CRMA operative user <[omitted]>	Bug fix in cleaning tasks. ...
BKups		7f17c25	6 anni	operative	Updated the BKups suite to include t
BRONX		45b3295	3 anni	CRMA operative user <[omitted]>	Added possibility to run the BRONX
CMEMS_download		aa181e	8 settimane	CRMA operative user <[omitted]>	Replaced the bulletin date with the v
DATAIN_oper		e1cca6c	4 mesi	CRMA operative user <[omitted]>	Bug fix. ...
F_Air		0008074	6 anni	operative	The spy node tspp_fair had a proble
F_Air_SG		3438cb9	14 mesi	CRMA operative user <[omitted]>	Aggiunta la funzionalità al filtro di k
FARM_diagn		8691c19	2 mesi	CRMA operative user <[omitted]>	Added new transfer procedure for fu
FARM_diss		67006e4	3 mesi	CRMA operative user <[omitted]>	Added automatization of alert proces
FARM_oper		57f9de9	6 anni	operative	Updated the FARM_oper suite to m
FARM_panel		i56e0de	16 mesi	CRMA operative user <[omitted]>	Moved FARM_panel, MANAGE_ARCH
GNOME_in		f541923	8 settimane	CRMA operative user <[omitted]>	Update due to the release of new C
GNOME_inputs		59c3e0b	3 anni	CRMA operative user <[omitted]>	Fixed a bug in the diagnostic of wind
HYP4SHY		c106d0b	13 mesi	CRMA operative user <[omitted]>	The "ecFlow" suite named "HYP4SHY
ISPRA_download		o51a7af	3 mesi	CRMA operative user <[omitted]>	Bug fix in cleaning tasks. ...
MANAGE_ARCH		4b6133a	14 mesi	CRMA operative user <[omitted]>	Messa in operatività lo scaricamento
METEO_plots		7dc2f05	6 anni	operative	Updated all the operative and the de
OMNIA_extract		d36385f	8 mesi	CRMA operative user <[omitted]>	Necessary changes for new OMNIA d
Panoptes		e637056	15 mesi	CRMA operative user <[omitted]>	Bug fix: if the path of temporary dir
PYGNOME_run		e680333	11 mesi	CRMA operative user <[omitted]>	The "ecFlow" suites "GNOME_in" in
SHYFEM_oper		f541923	8 settimane	CRMA operative user <[omitted]>	Update due to the release of new C
SMHI_download		o51a7af	3 mesi	CRMA operative user <[omitted]>	Bug fix in cleaning tasks. ...
STZ_data_display		c96a907	8 mesi	CRMA operative user <[omitted]>	Added OMNIA extraction INSERT S
WRF_2_DIA		8916c08	21 mesi	CRMA operative user <[omitted]>	Added a new family in WRF_2_DIA e
WRF_dis		9604264	8 mesi	CRMA operative user <[omitted]>	Minor change, added directory exist



Cronologia compilazioni andamento

trova

#18	6-nov-2023 9.35
#17	4-set-2023 16.42
#15	28-lug-2023 16.14
#14	17-lug-2023 8.52
#13	17-lug-2023 8.43
#12	3-lug-2023 10.24
#11	20-giu-2023 15.08
#10	
#9	
#8	
#7	
#6	
#5	
#4	
#3	
#2	
#1	

AdriaClimPlus_4_PP2

Panoramica dello stato

Otteni un'istantanea dello stato degli elementi. [Visualizza tutti gli elementi](#)

56% Da completare

Stato	Conteggio
Da completare	5
In corso	2
Permanente	2
Completata	0
Totale	9

Attività recente

Rimani aggiornato su cosa accade nel corso del progetto.

VENERDÌ 3 MAGGIO 2024

- Giaiotti D. ha modificato lo stato a Permanente su **FIRST-9 - Interazione tra progetti** 18 giorni fa
- Giaiotti D. ha aggiornato Rank di **FIRST-9 - Interazione tra progetti** 18 giorni fa
- Giaiotti D. ha modificato lo stato a Permanente su **FIRST-6 - Contributo alla comunicazione aeropettuale** 18 giorni fa
- Giaiotti D. ha modificato Priorità in 'Low' su **FIRST-9 - Interazione tra progetti**

Tipi di lavoro

Otteni una suddivisione degli elementi in base al loro tipo. [Visualizza tutti gli elementi](#)

Tipologia	Distribuzione	Conteggio
Sottotask	56%	5
Task	44%	4

ATLASSIAN Jira

- ❑ Fast response of the hardware
- ❑ Metadata for search and archival
- ❑ Data formats supported by community software and apps
- ❑ Intelligent system to help you in answer search

- Data file format**
- netCDF
 - GRIB1/GRIB2
 - Binary
 - ASCII
 - CSV
 - Binary
 - XML
 - BUFR



Catalogo CRMA - Centro Regionale di Modellistica Ambientale

Q Search Map

Search ...

Search **242** data sets, services and maps, ...

Topografia globale ad alta risoluzione (SRTM, 3 arc-sec)

Browse by

INSPIRE themes Topic

Type of resources

Dataset

122

Collection session

3

Service

3

Maps and graphics

1

Data identification

Citation

Date (Publication) Mar 2024

Purpose
Il formato del data set (cioè in file binari con file "index" descrittivo) è quello richiesto dal programma geogrid di WRF-WPS per creare la topografia sul grigliato del modello.

Status
Completed

User
ARPA FVG - CRMA
ARPA FVG CRMA Centro Regionale di Modellistica Ambientale - Palmanova - UD , Friuli Venezia Giulia , 33057 , Italy

Maintenance and update frequency
As needed

Keywords

- Topografia
- 3 arc-sec
- Modelli
- WRF

Overviews

Spatial extent

Keywords

Provided by

Share on social sites

Twitter Facebook LinkedIn Email

Access to the portal

Read here the full details and access to the data.

Associated resources

Latest news Most popular Comments

What we simulate (forecasts, analyses, events and impacts)

Accidental events and impacts
 Fires, Oil spill, Environmental impacts assessment

Weather

- Forecast
- Analyses

Physical Sea

- Forecast
- Analyses



Air quality

- Forecast
- Analyses

Hydrology

- Forecast
- Analyses

Local scale climate scenarios

- Atmosphere, Lagoon, Sea and impacts

Weather (forecasts and analyses)

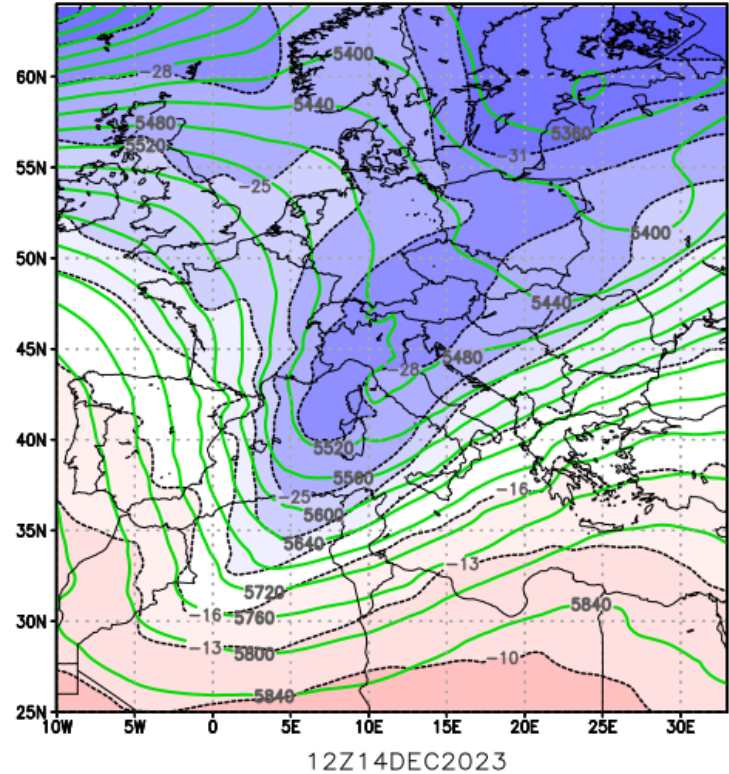
3 domains

- ❑ from 50 km to 2 km resolution
- ❑ 1 run/day 00UTC
- ❑ up to +120h

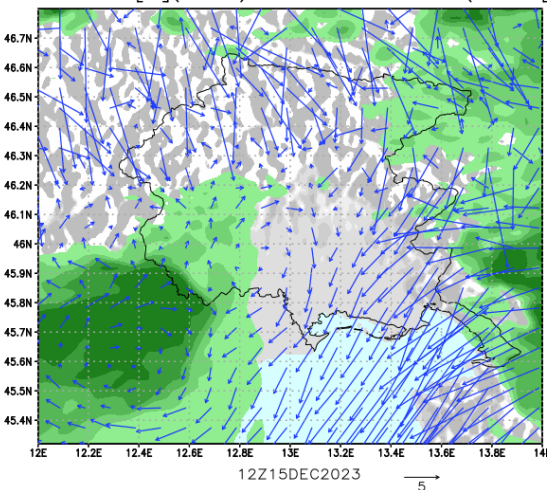
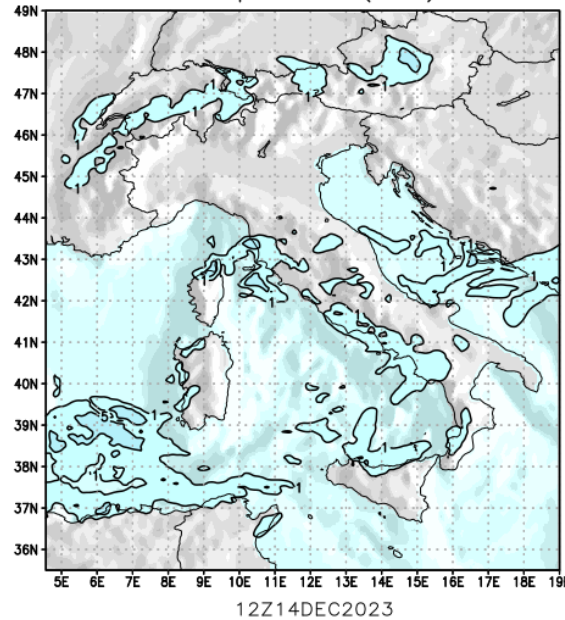
Certified quality EN ISO 9001



Altezza geopotenziale[m] (contorni)
temperatura[C] a 500hPa (colori)

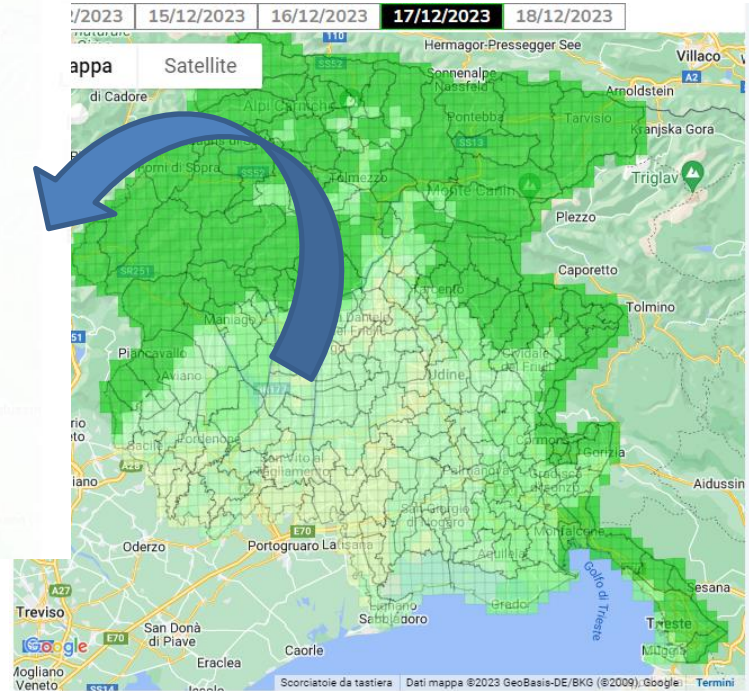
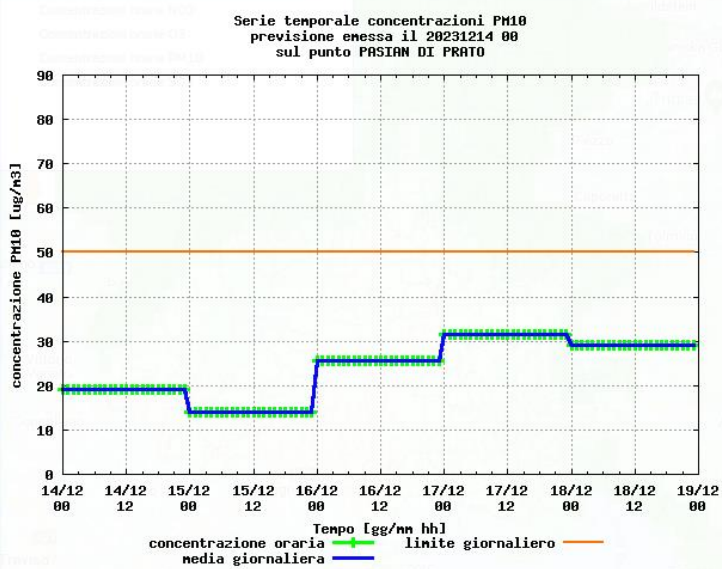


Precipitazione(mm)



Air quality (forecasts and analyses)

Pasian di Prato - Previsione delle concentrazioni particolato sottile con diametro inferiore a 10µm



Cerca comune

chiudi tutte le box reset

Legenda e controllo visualizzazione

Indicat.
PM10 - concentr. media giornaliera

Griglia griglia80x80_2x2

Elab. del 14/12/2023 avvertenze per la consultazione

- TUTTI
- fino a 0 µg/Nm³
- 0 ÷ 10 µg/Nm³
- 10 ÷ 20 µg/Nm³
- 20 ÷ 30 µg/Nm³
- 30 ÷ 40 µg/Nm³
- 40 ÷ 50 µg/Nm³
- 50 ÷ 60 µg/Nm³
- 60 ÷ 70 µg/Nm³
- 70 ÷ 80 µg/Nm³
- 80 ÷ 90 µg/Nm³
- > 90 µg/Nm³
- DATO NON RILEVABILE

1 domains

- 2 km resolution
- 1 run/day 00UTC
- up to +120h

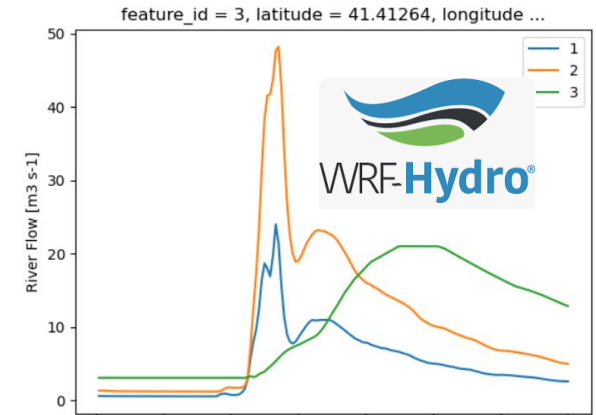
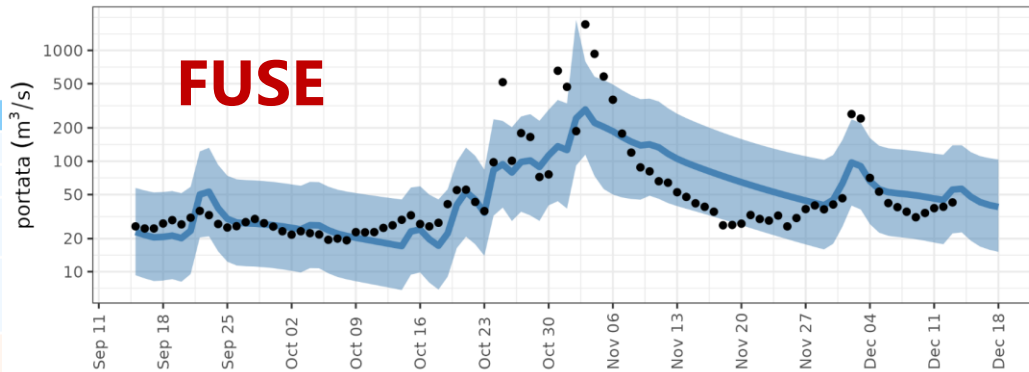
Certified quality EN ISO 9001



Forecasts for each Municipality and services for the activation acute air pollution prevention plans

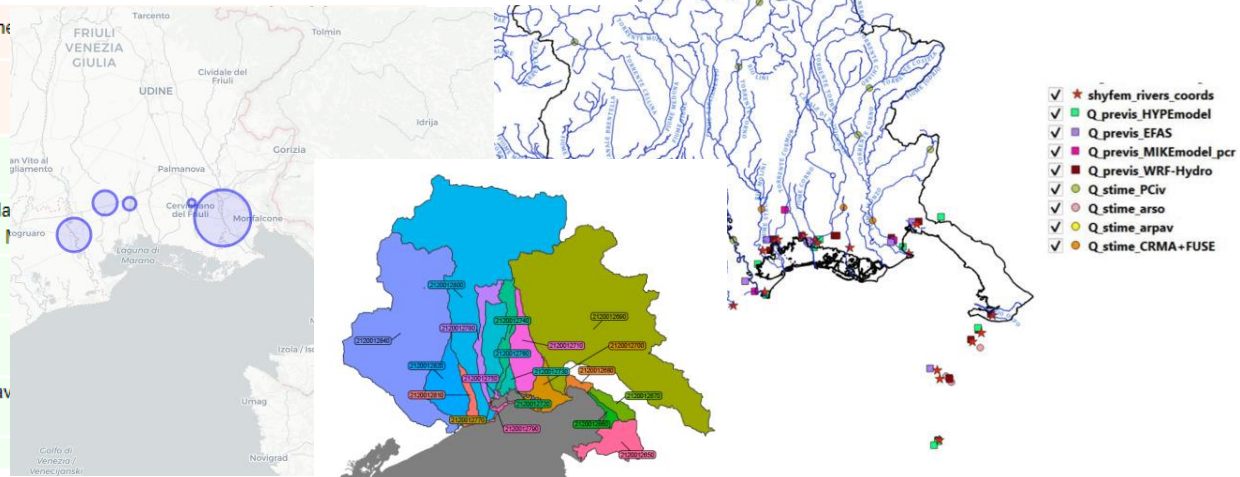
Hydrology (forecasts, estimates and measures)

Tagliamento (C800)
stime di portata dal 15/09/2023 al 13/12/2023, previsioni fino al 18/12/2023

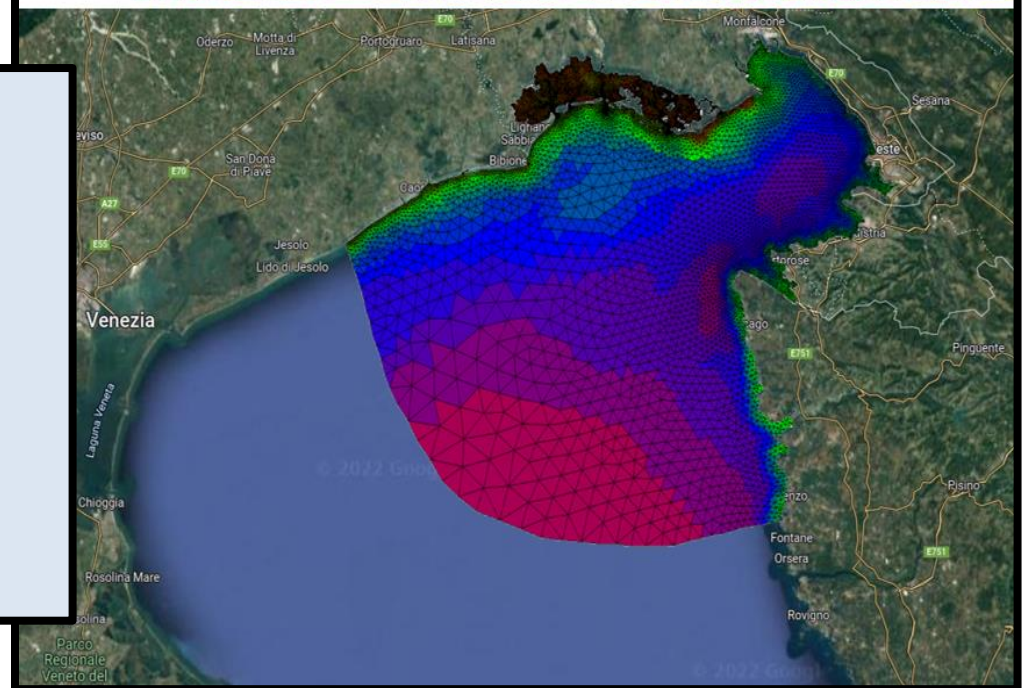
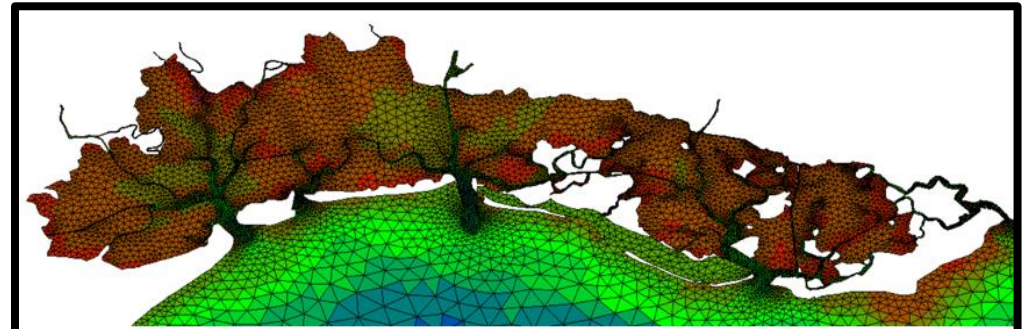
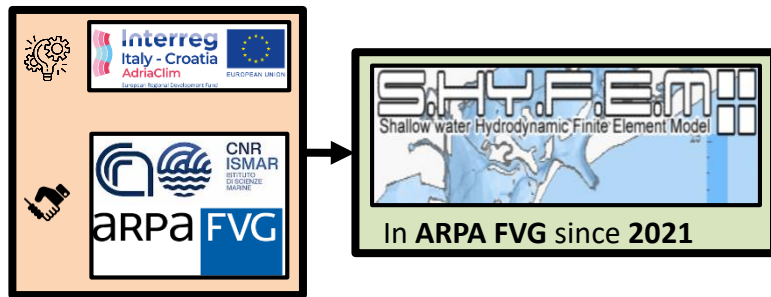


pallini neri: stime da livelli idrometrici misurati
linea blu: 'ensemble mixture' delle previsioni 'fuse'
fascia azzurra: intervallo di confidenza al 90% della previsione

Tipo	Fonte
Misura	SGRI
	OGS
	PCiv
	ARPAV
ARSO	
ARPAV	
Stime	PCiv
	CRMA
	CRMA (FUSE)
Previsioni	CRMA (WRFHydro)
	SMHI (HYPE)
	PCiv (MIKE)
	EFAS
	AbDAO (SWAT)

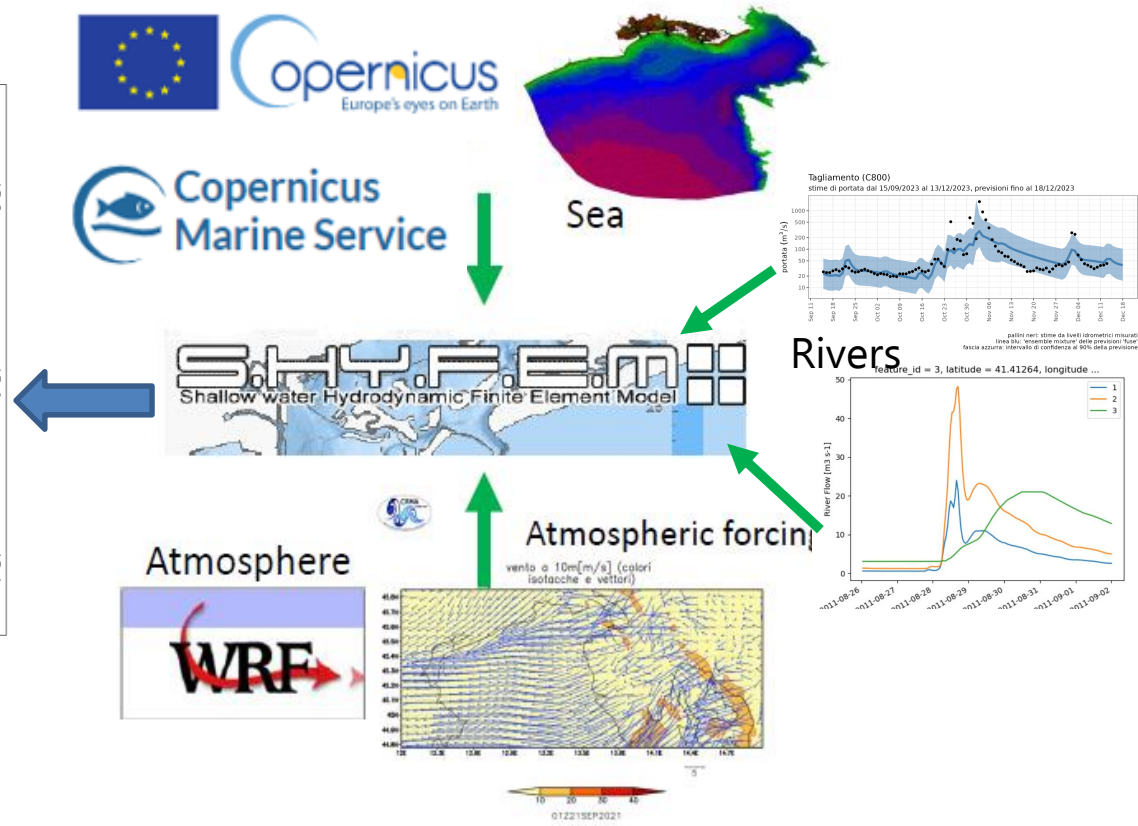
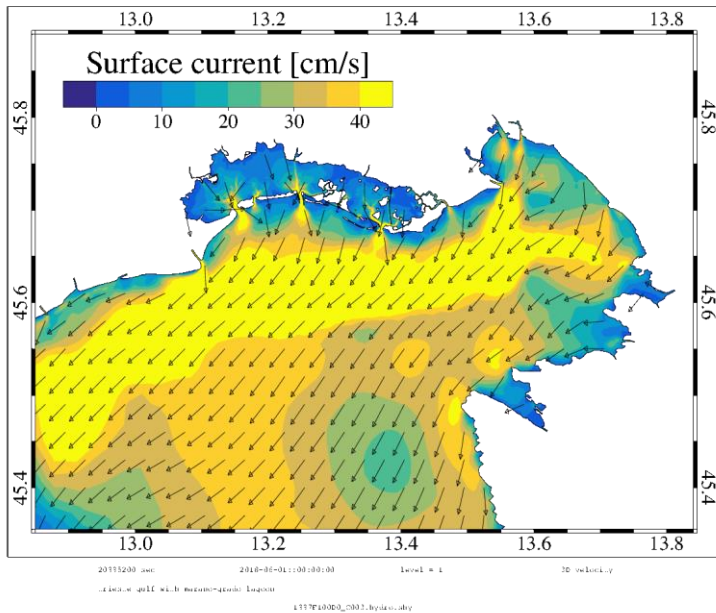


Physical Sea (model)



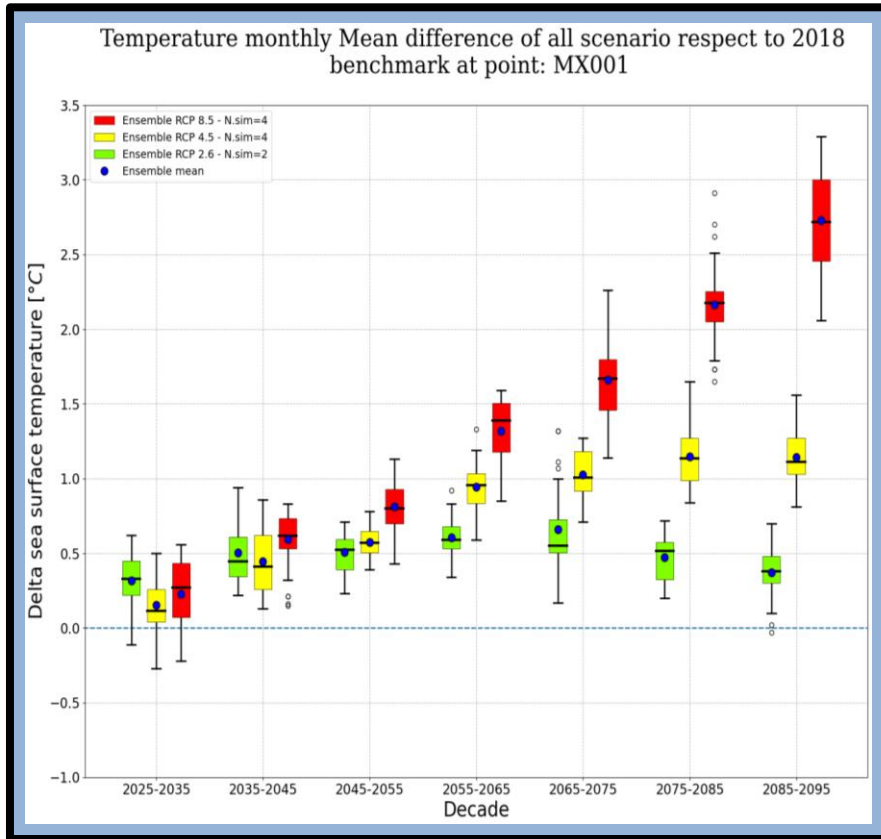
- Lon. [°E]: 12.75119 ÷ 13.81224
- Lat. [°N]: 45.15940 ÷ 45.80302
- Prof. media [m]: 21.5
- Prof. max. [m]: 34.7
- N° nodi: 18311
- N° elementi: 33100
- N° livelli verticali: 22
- Ris. spaziale: da pochi km (mare aperto) a circa 10 metri (canali lagunari)

Physical Sea forecasts

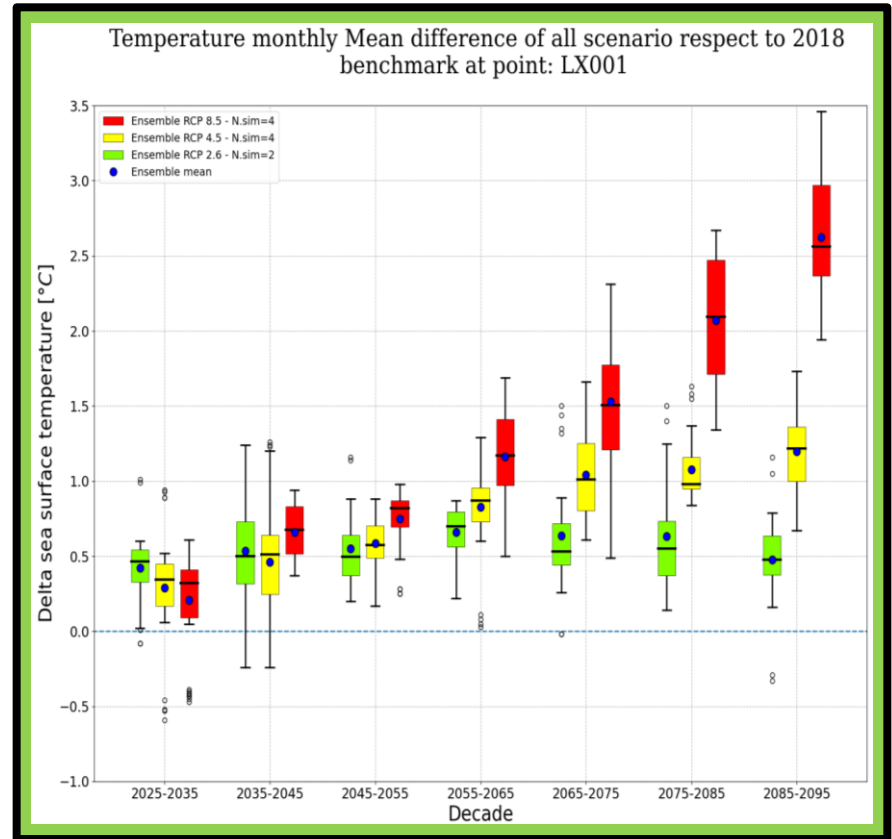


Local scale climate scenarios

Open sea

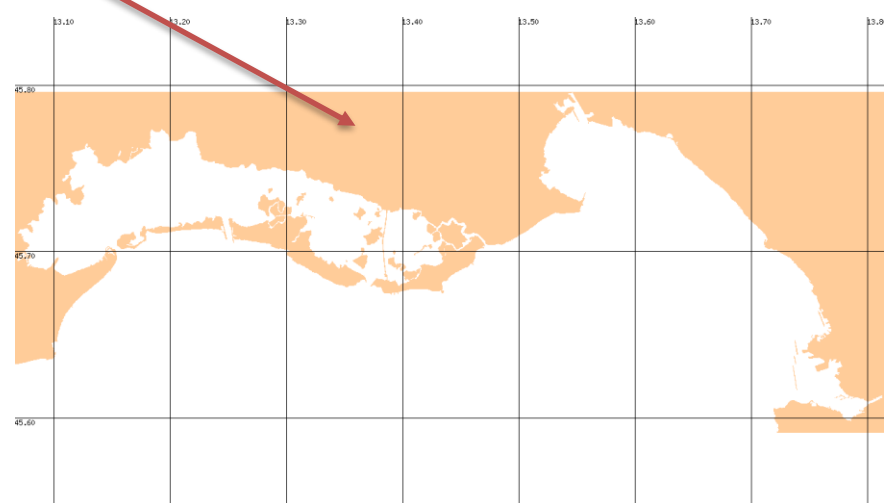
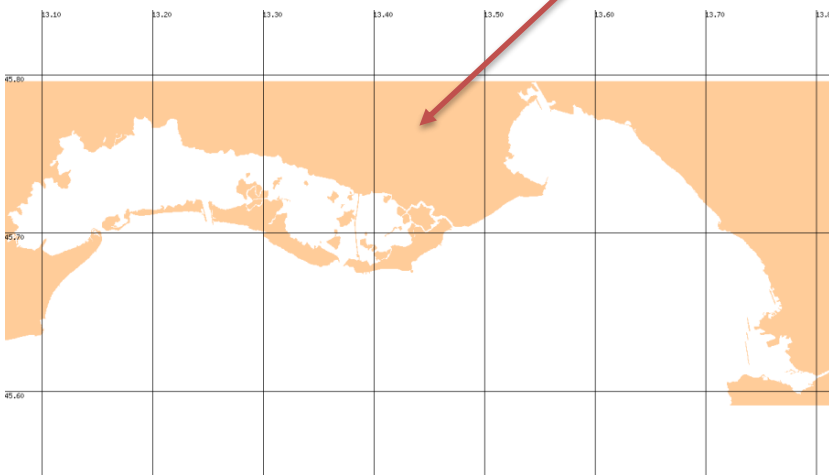
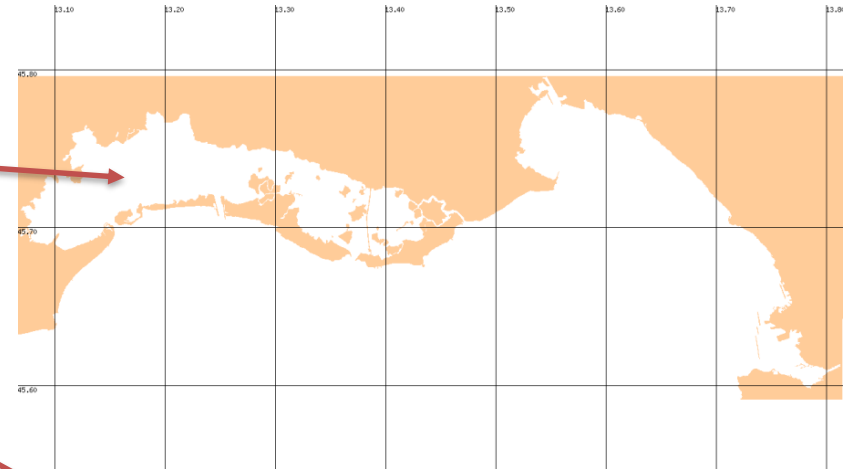


Lagoon



Accidental events and impacts (oil spill operational + on demand)

ID	Spill location	Spill start hour							Last update
		00	01	02	03	04	05		
18E0F10248_0000		06	07	08	09	10	11	2023-12-14	
		12	13	14	15	16	17		
		18	19	20	21	22	23		
		00	01	02	03	04	05		
18E0F10248_0001		06	07	08	09	10	11	2023-12-14	
		12	13	14	15	16	17		
		18	19	20	21	22	23		
		00	01	02	03	04	05		
18E1F10348_0002		06	07	08	09	10	11	2023-12-14	
		12	13	14	15	16	17		
		18	19	20	21	22	23		
		00	01	02	03	04	05		



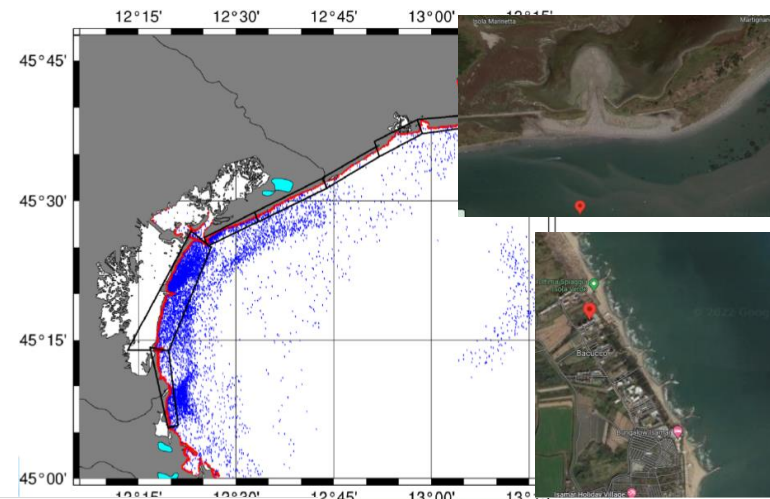
- 16 sources:**
- Trieste
 - Monfalcone
 - Isonzo
 - Grado
 - Laguna di Marano
 - Tagliamento
 - Livenza
 - Piave
 - Laguna di Venezia
 - Brenta-Adige
 - Po
 - Reno
 - Koper
 - Piran
 - Rovinj
 - Pula



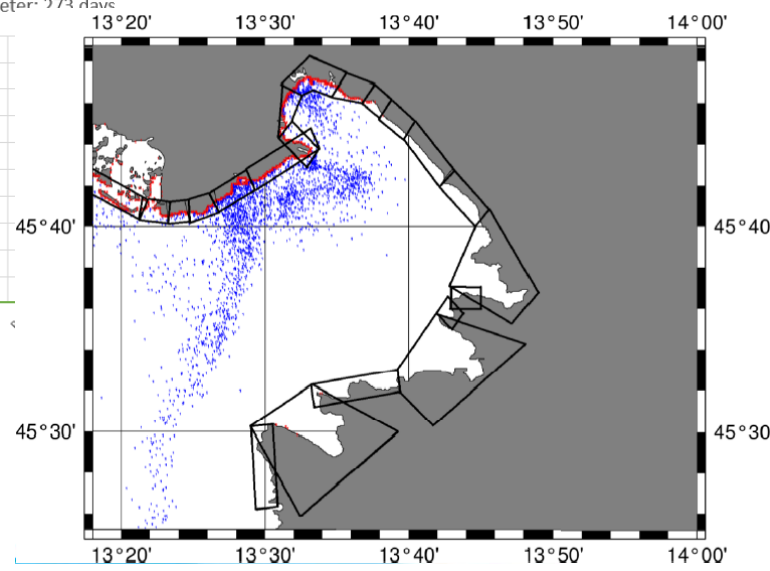
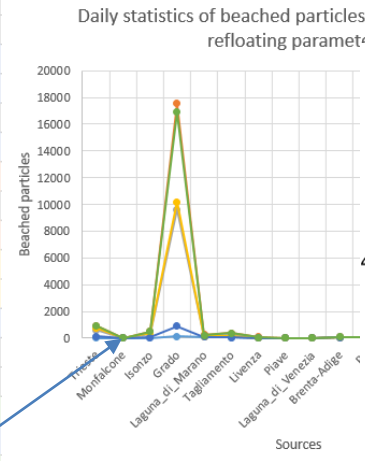
- 3 refloating parameters:**
- 76 days
 - 150 days
 - 273 days

The same beach type

- ❑ Simulate the LE transport
- ❑ Compute the LE reaching the beach polygon
- ❑ Compute the beached LE
- ❑ Identify the source of LE



lon	lat	count	place
13,5617	45,5328	31238	Piran
13,0979	45,6395	25813	near Tagliamento mouth
13,0979	45,6379	23145	east faro punta Tagliamento
13,6147	45,0895	17300	Fogarolica in front of Rovigno
13,0979	45,6411	15001	near Tagliamento mouth
13,1509	45,6913	11464	Lignano beach
13,1663	45,701	11248	Isola Marinetta
13,1531	45,6945	10295	Lignano near the source of Marano Lagoon
12,2785	44,63	10222	Beach in porximity of the Reno mouth
12,2763	44,6316	10206	Beach in porximity of the Reno mouth
13,0957	45,6347	10032	west faro punta Tagliamento
12,3204	45,1752	8863	Bacucco
13,3717	45,68	8440	east faro Grado
13,5219	45,7641	8440	Lido di Staranzano
13,0979	45,6428	8096	near Tagliamento mouth
13,5197	45,7609	7931	south Lido di Staranzano
13,3607	45,68	7917	Banco d'Orio near source
13,5197	45,7592	7764	south Lido di Staranzano
13,1001	45,646	7674	Lignano just near the Tagliamento mouth



Accidental events and impacts (Fires and pollutants dispersion)

The screenshot displays a web-based simulation interface for fire and pollutant dispersion. The main window is titled "SIMULAZIONE INCENDI" and includes a navigation menu with options like "Main", "coord. da click", "coord. da indir.", "limite region.", "limiti ammin.", "mis. distanze", "reset mappa", and "logout".

Map Interface: The left side shows a "Carta Territoriale" map of the Friuli-Venezia Giulia region, with a red boundary indicating the simulation area. A zoomed-in view of the Gorizia area is shown in a black-bordered inset at the bottom left, highlighting a grid of blue squares representing the simulation domain.

Simulation Parameters: The right side contains a "Simulazione" panel with the following settings:

- Descrizione:** [Empty text field]
- Coord. del centro:** Lat. [Empty], Long. [Empty]
- Data/ora (locale) di inizio dell'incendio:** 14/12/2023 12:38
- Tipologia della sorgente:** SVERSAMENTO DI IDROCARBURI - 20 mq [OK]

Domain Settings: A "dominio" panel allows for configuring the simulation area:

- estensione (km):** Lat. [6], Long. [6], **risoluzione (m):** [100]
- risoluzione meteo (m):** [500] [visualizza]
- spostamento (km):** verso ovest [1], verso sud [1] [nascondi]

Simulation Duration: A "simulazione" panel sets the "Durata di ciascun passo" to 10 min, 20 min, 30 min, or 40 min.

Profile and Source Parameters: A "profilo" panel shows a vertical profile with values: #1 [0.25], #2 [0.5], #3 [1], #4 [0.5], #5 [0]. A "parametri tipo sorgente" panel includes: "Densità di potenza max (kw/m2)" [1900], "Superficie massima" [20], and "Altezza del fuoco" [0].

Visualization: The background features a 3D visualization of a fire plume rising from a building. A black-bordered inset at the bottom right shows a 2D map of the same area with a dense grid of blue squares, representing the spatial distribution of the simulation results. The map also labels "Parco naturale regionale delle Prealpi Giulie" and "Triglavski narodni park".

Accidental events and impacts

Fires, Oil spill, Environmental impacts assessment

Weather

- Forecast
- Analyses



Physical Sea

- Forecast
- Analyses

- monitor and simulate the local environment system developments (land, marine, atmosphere, **biosphere**);
- anticipate environmental hazardous events and resultant anthropic and ecosystem impacts;
- enable the development and testing of scenarios for ever more sustainable development and to adapt to climate change.

Air quality

- Forecast
- Analyses



at local scale

Hydrology

- Forecast
- Analyses

Local scale climate scenarios

- Atmosphere, Lagoon, Sea and impacts