OPERANDUM

International Summer School

ALMA MATER STUDIORUM
UNIVERSITÀ DI BOLOGNA

BOLOGNA, 29th August –1st September 2022

EU funded project
GA no. 776848

OUTLINE

BACKGROUND

NBS and its role in mitigating the effects of adverse climate change

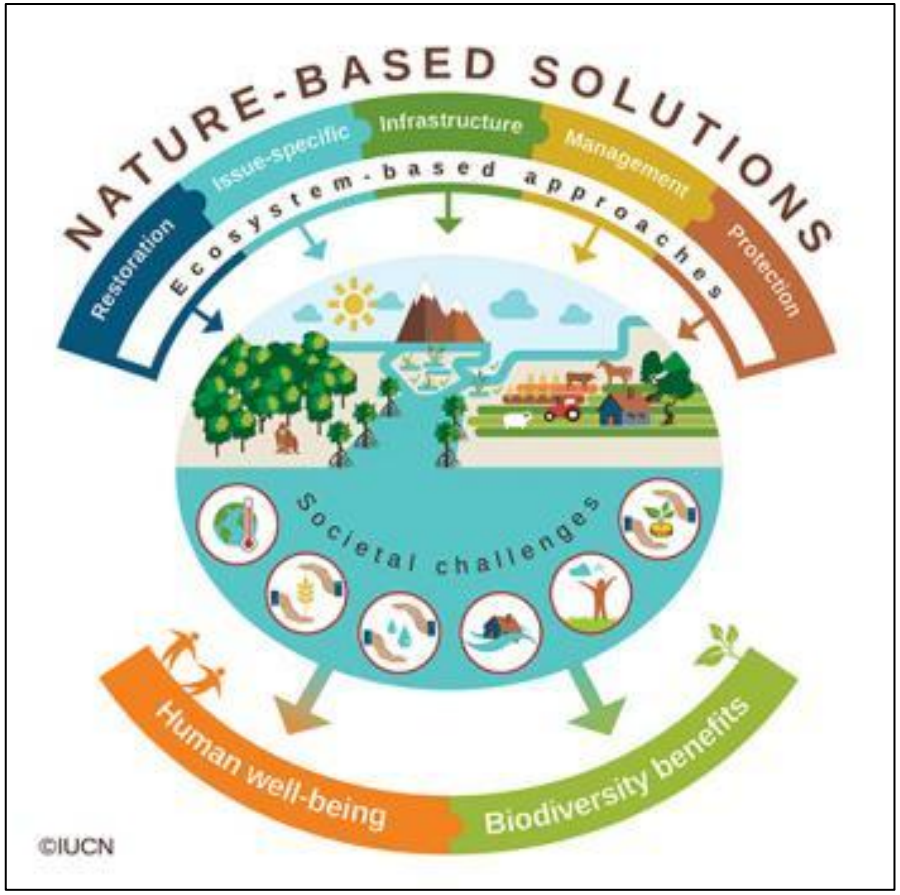
OPERANDUM AND ITS GOALS

OAL concepts

CHALLENGES & OPPORTUNITIES IN NBS IMPLEMENTATION

Nature-based Solutions: concept(s)

Conceptual framework



Nature-based Solutions as an umbrella term for ecosystem-related approaches

Nature-based Solutions (NBS) are defined by International Union for Conservation of nature (IUCN) as "**actions to *protect, sustainably manage, and restore* natural or modified *ecosystems*, that address *societal challenges* effectively and adaptively, simultaneously providing *human well-being* and *biodiversity benefits***".

Broad definition – valid across disciplines it requires declination according to the expertise

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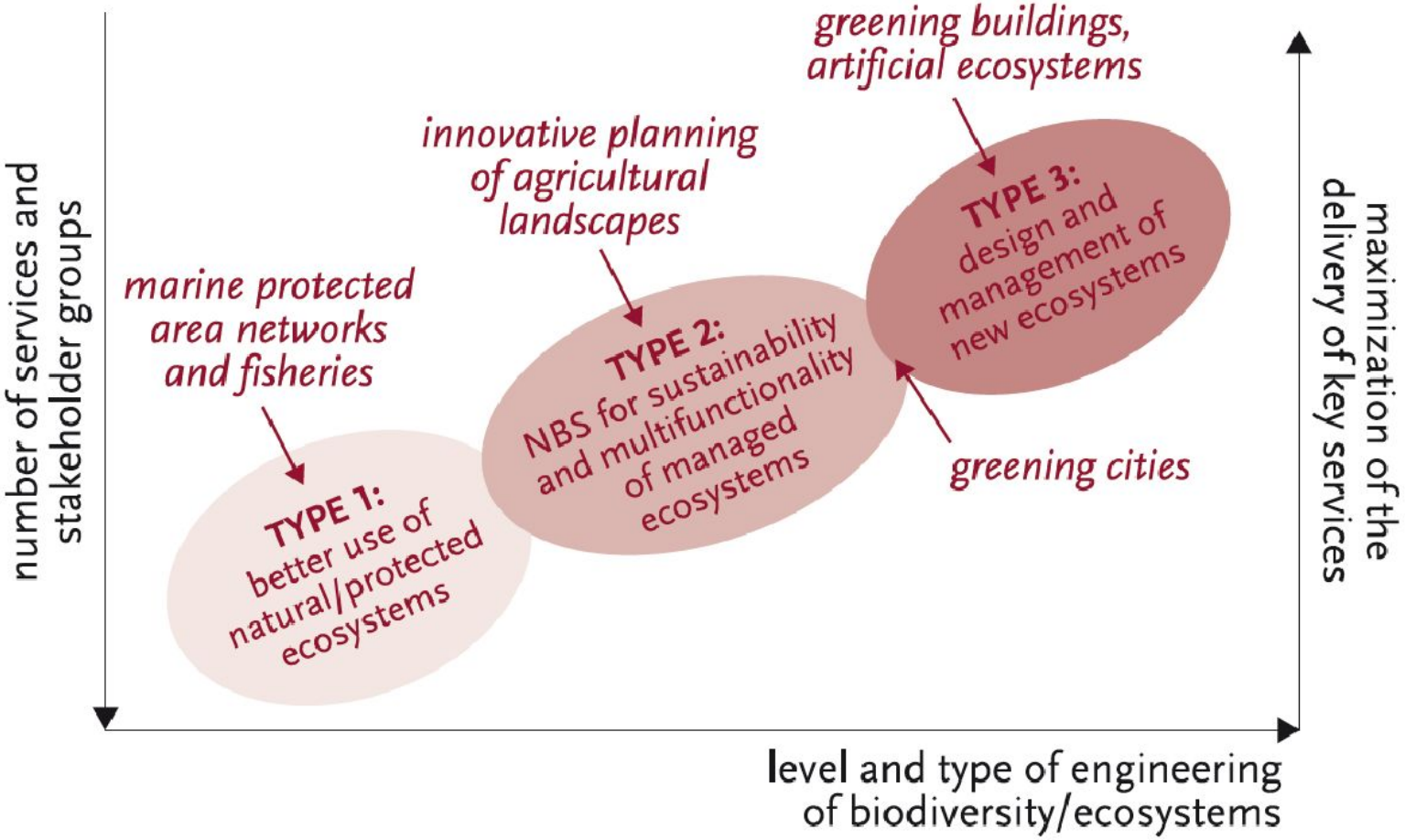
NbS Approaches



Eggermont et al. 2015 GAIA-Ecological Perspectives for Science and Society, 24(4), 243-248

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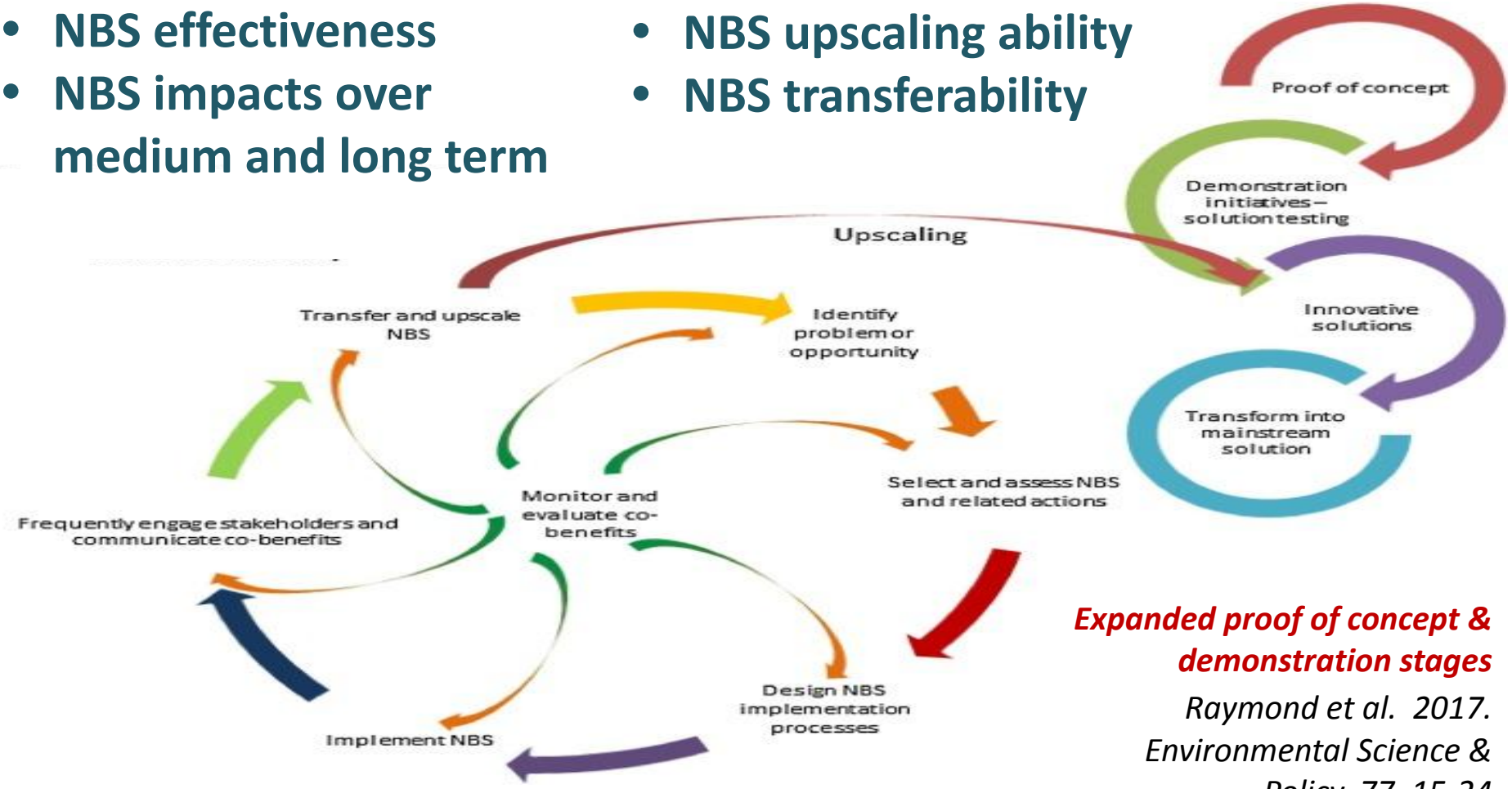
NbS Challenges

Lack of science-based evidence on:

- **NBS effectiveness**
- **NBS impacts over medium and long term**
- **NBS upscaling ability**
- **NBS transferability**



Expanded proof of concept & demonstration stages

Raymond et al. 2017. Environmental Science & Policy, 77, 15-24

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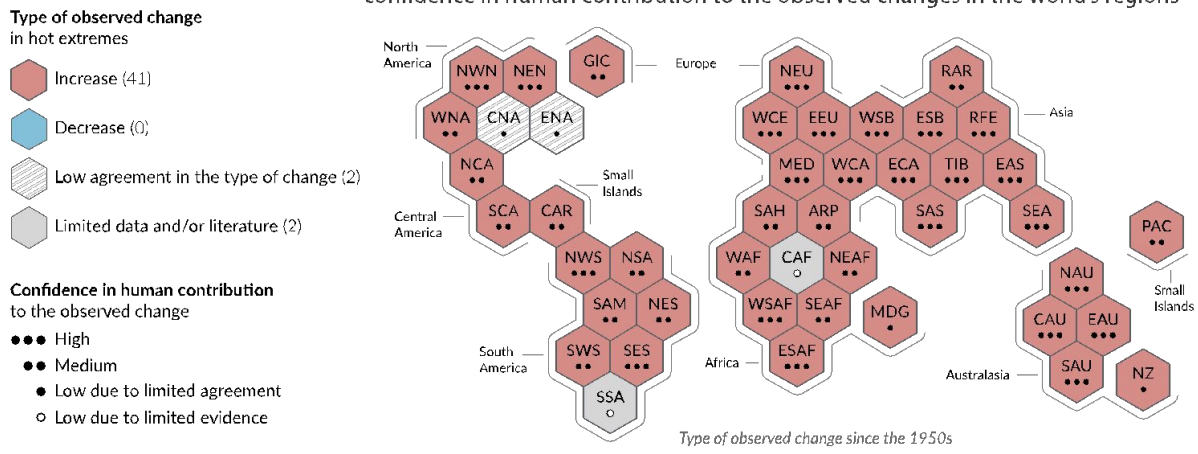
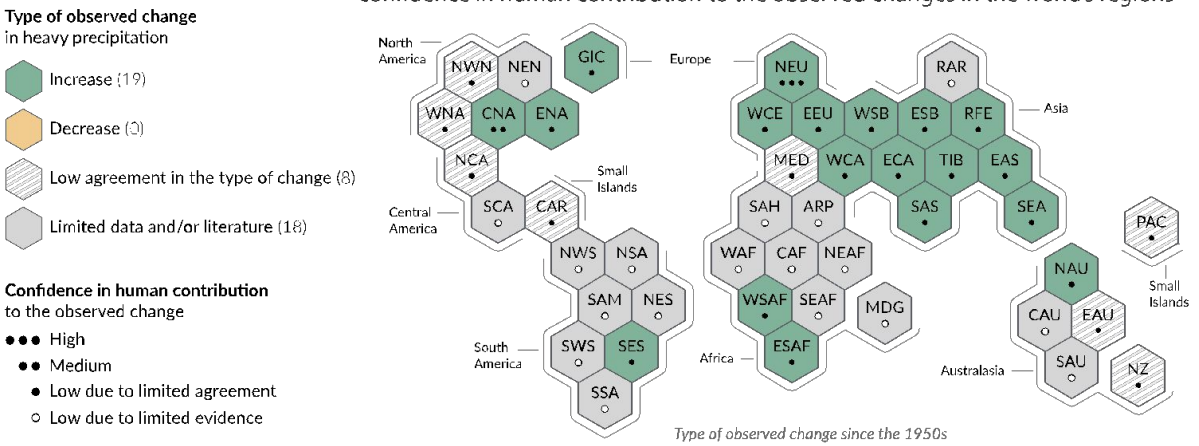
Climate change and extreme weather

OPERANDUM

a) Synthesis of assessment of observed change in **hot extremes** and confidence in human contribution to the observed changes in the world's regions

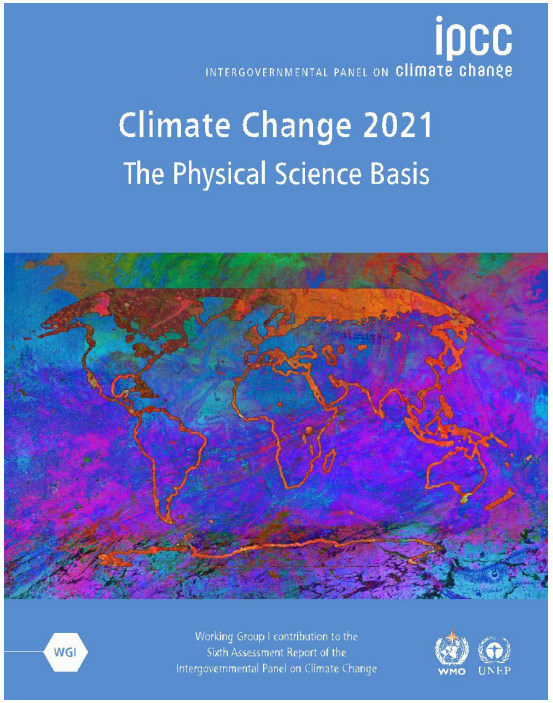


b) Synthesis of assessment of observed change in **heavy precipitation** and confidence in human contribution to the observed changes in the world's regions

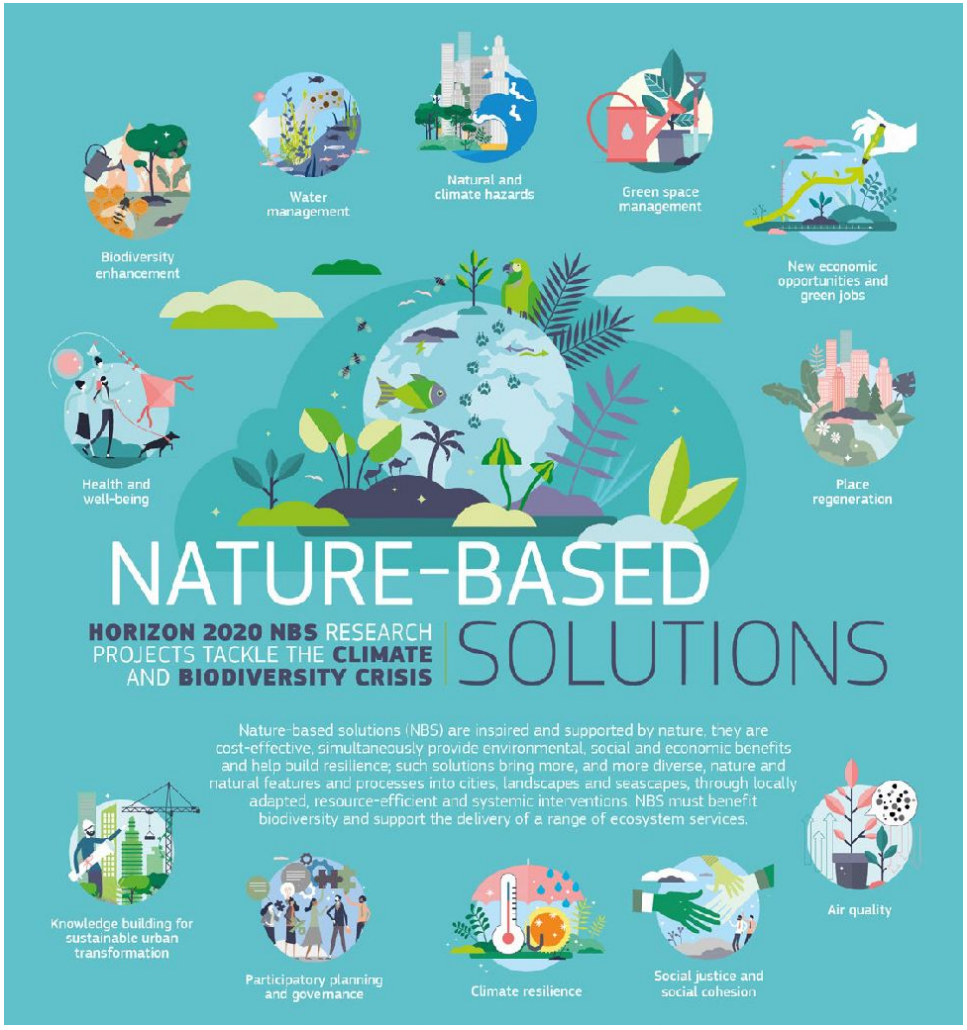


Figures from the summary for policymakers of the latest IPCC report

Climate Change can translate low-risk situations high risk situations and sharpen the impact of hydro-meteorological hazards.



EU – funded research



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EU – funded research

> 150 MEURO in 2018 for 18 projects

ThinkNature	CSA	SC5-10-2016	Establish science-policy-business-society interfaces to allow for continuous dialogue and interaction
NAIAD	RIA	SC5-9-2016	Promote the uptake of ecosystem-based approaches for disaster risk reduction and climate change and the exploration of the concept of the insurance value of ecosystems
Nature4Cities **Naturvation**	RIA	SCC-03-2016	Enable the systemic integration of NBS into a sustainable **urban** planning, new governance, business, financi models and partnerships
CONNECTING Nature **Urban GreenUp** **UNALAB** **GrowGreen**	IA	SCC-02a-2016	To provide a robust, EU-wide evidence base and develop a European reference framework for nature-based sol in **cities** (water and climate resilience)
CLEVER Cities **EdiCitNet** **URBiNAT** **proGIreg**	IA	SCC-02b-2017	To provide a robust, EU-wide evidence base and develop a European reference framework for nature-based solutions in **cities** (inclusive urban regeneration)
OPERANDUM **PHUSICOS** **RECONECT**	IA	SC5-08-2017	To provide evidence that NBS are flexible, multi-beneficial alternatives to traditional engineering to cope with extreme hydro meteorological events

OPERANDUM

OPERANDUM delivers the tools and methods for the validation of nature-based solutions in order to enhance resilience in European rural and natural territories by reducing hydro-meteorological risks.

OPERANDUM

OVERALL OBJECTIVE

To reduce hydro-meteorological risks in European territories

Co-design
Co-develop
Deploy
Test and demonstrate

Push NBS' Business exploitation

1. Provides **science-evidence** for the usability of **NBS, best practices** for their design based on **participatory** processes

2. Foresees multiple level of **stakeholders engagement** to leverage widest possible NBS **acceptance** and **diffusion** as a good practice.

3. Strengthens local framework of **NBS-based policies** and promotes **technology** and **innovation** in NBS to create a **European leadership**

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SPECIFIC OBJECTIVES

- **SO1** - Integrate knowledge about **NBS efficacy** against hydro-meteorological risks

- **SO2** - Strengthen technology **innovation** in the area of NBS

- **SO3** - Improvement of **acceptance** of NBS based implementation

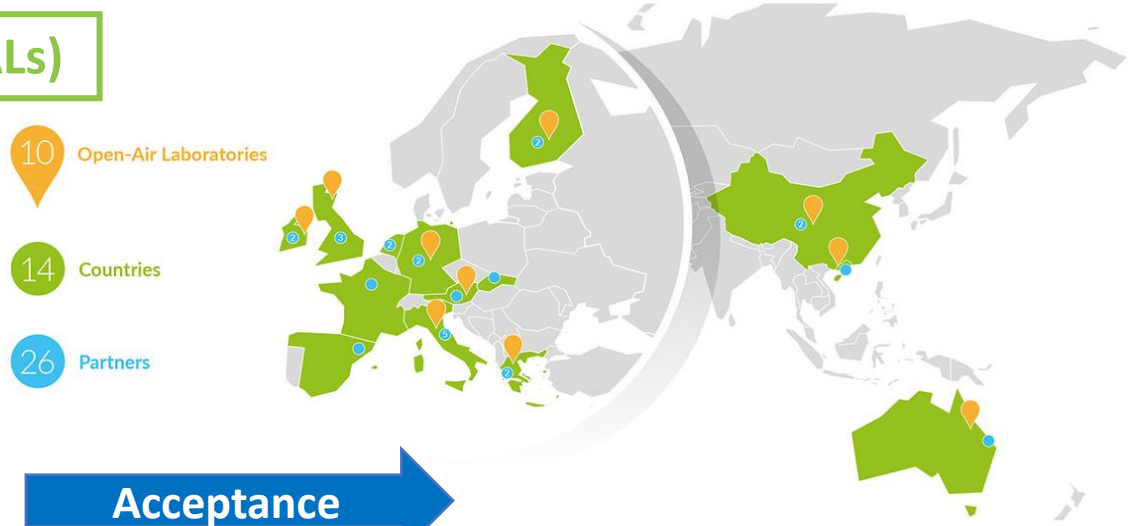
- **SO4** - Enhancement of market demand and **increase of competitiveness** of NBS

- **SO5** - **Strengthening** the adoption of NBS in **national policies** for **DRR** land planning, **EIP Water**

OVERVIEW & PROJECT CONCEPT

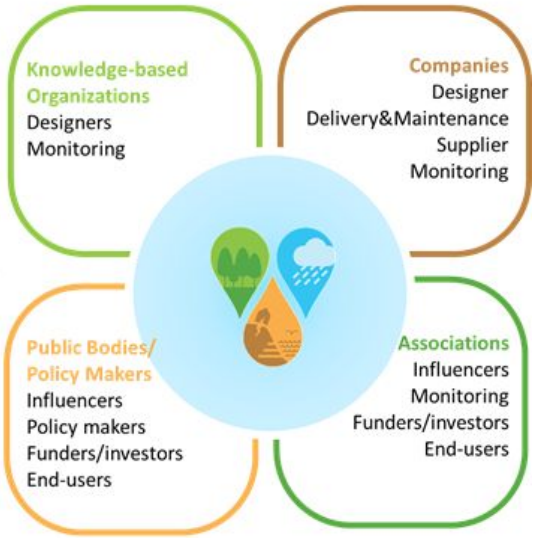
OPEN-AIR LABORATORIES (OALs)

- Start date of the project: **01/07/2018**
- Project duration: **54 months** (end date 31/12/2022)
- Overall budget:
  Total cost: **14.696.502** €
  Maximum EU grant amount: **€ 12,257,343.25**



- Co-design, co-develop, deploy of novel **blue/green/hybrid NBS**
- Technical and scientific evaluation for **NBS efficacy**
- Cutting-edge multiple **monitoring systems**
- Upscaling and replication through up-to-date **multi-scale numerical modelling** *evaluated using novel monitored data*

Acceptance



- ***Policy uptake***
- ***Innovation on NBS (CONVENTIONAL AND NOT CONVENTIONAL)***
- ***Business opportunity and exploitation***
- ***Novel and originally-designed ICT platform on NBS***

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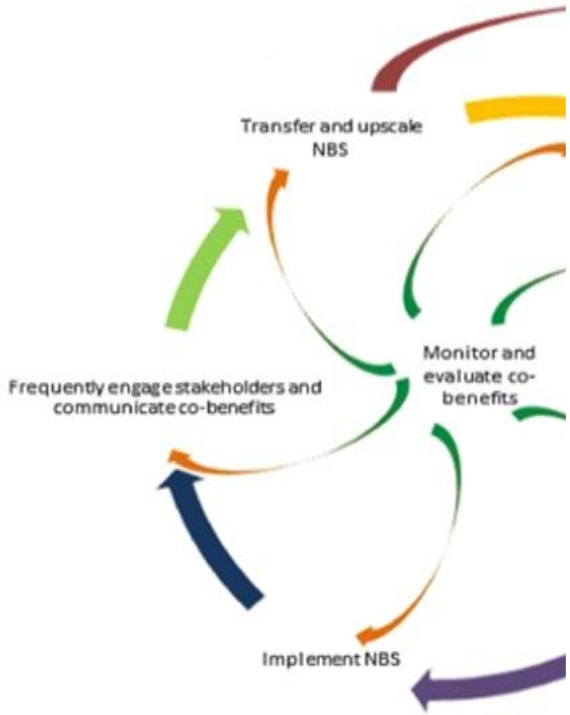
STRATEGY OF OPERANDUM

Lack of science-based evidence on:

- NBS upscaling ability
- NBS transferability

- NBS effectiveness
- NBS impacts over medium and long term



Expanded proof of concep demonstration stages

NBS-CHALLENGES

Acceptance
(holistic view on stakeholder engagement strategy, (WP8, WP3), building evidence)

Multi-scale modelling
able to capture short and long term – strong linkage with climate projections downscaled at OAL levels (WP5)

Careful strategy for design
of monitoring NBS using cutting-edge monitoring systems, and multiple investigation (e.g. Downscaled laboratory) (WP4)

Innovation in novel NBS or in novel applications
(WP2); novel NBS platform (OPERANDUM GeoIKP) based on latest developments on the field (from case studies (WP1), new cases and paved on detailed user profiles) (WP7)

Multi-level impacts
(local, national, EU, international) - WP8,WP9

A variety of hazards & risksbeing considered
(from river flooding to landslides, storm surge, coastal erosion, eutrophication, salt intrusion)

Emphasis on Indicators used at multi-level
(from monitoring the experiments, for the evaluation of dynamic indicators)
(WP1, WP2, WP3, WP6)

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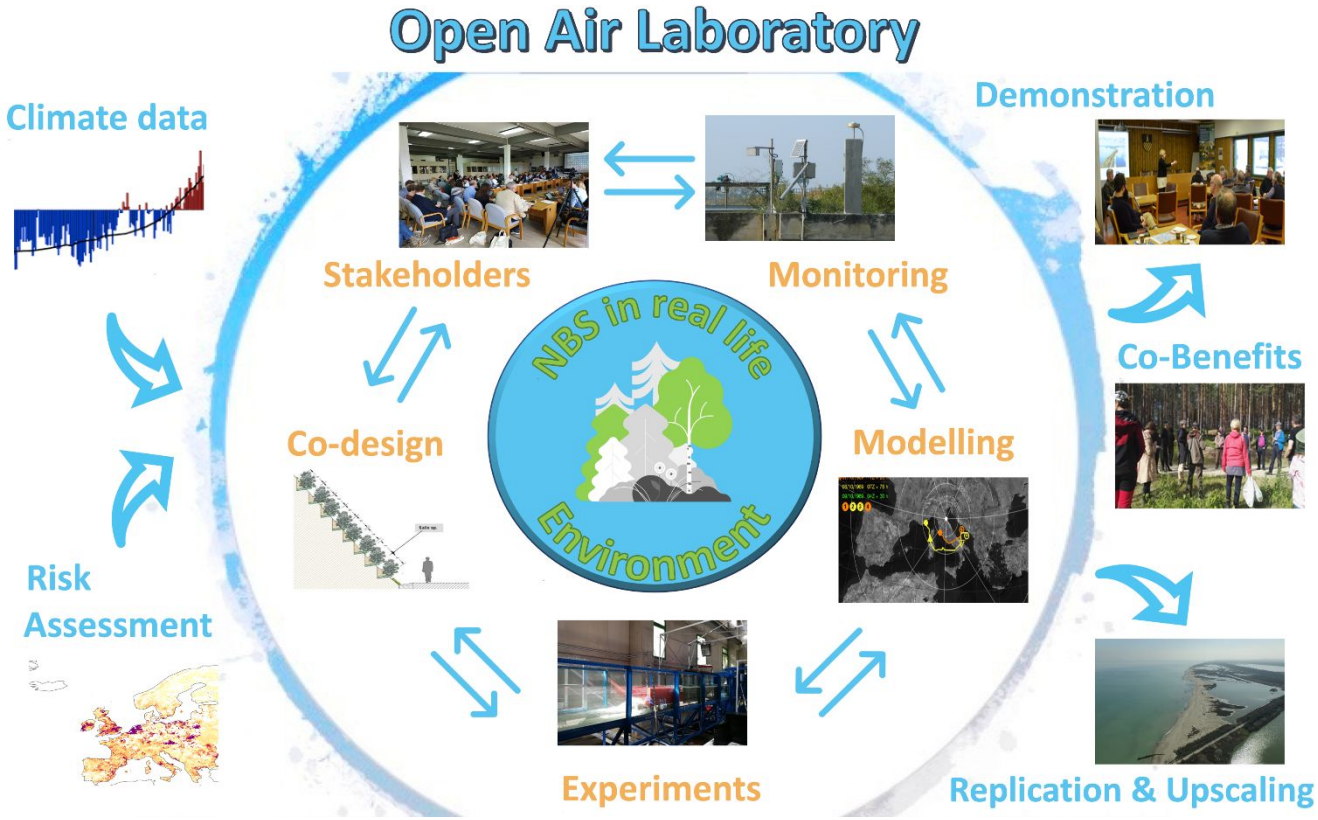
FOCUS on NBS implementation via OAL

OPERANDUM site-specific NBS are co-designed, co-developed and tested with local stakeholders in open-air laboratories (OALs).

The Open-Air Laboratory

A trademark of OPERANDUM, Open-Air Laboratories generalize the Living Lab approach to the co-creation and demonstration of NBS. It is the framework where scientists from different disciplines work together with enterprises, regional agencies and all stakeholders in a holistic approach towards climate change adaptation



The 'products' of the OAL

Demonstration of NBS effectiveness.

Assessment of **co-benefits**

Evidence basis and methodology for **replication and upscaling**

My Climate Risk

The OALs operationalise an ongoing transition in climate science and climate change adaptation, from a '**predict then act**' approach to a '**bottom-up approach**'.

As outlined by the research agenda of the World Climate Research Programme, this new approach is based on multi-disciplinary labs that work closely with **local stakeholders** to provide climate-related knowledge that is relevant at the **local scale**.

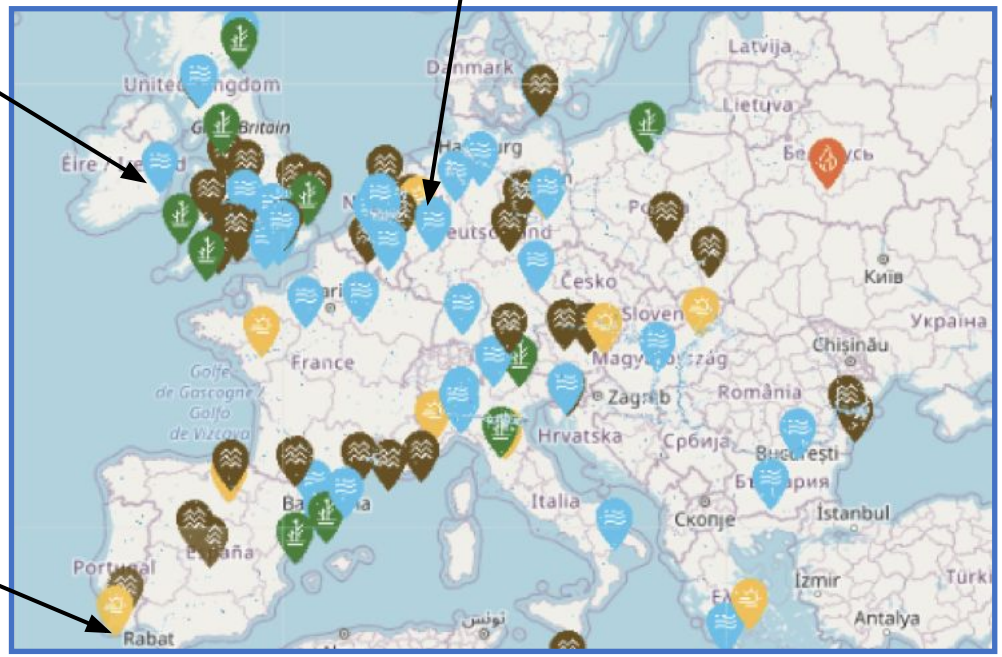
WCRP
World Climate Research Programme

NBS for hazards spreading in Europe

Green roofs/walls to reduce flood and heat wave risks in Dublin

River restoration for flood protection, Netherlands

Water retention landscape to reduce drought risk in Portugal



Sites of application of NBS to mitigate hydro-meteo hazards documented in the European **OPERANDUM GeoIKP platform**

NBS for coastal erosion & storm surge

Examples from OAL-ITALY

Marine Sea grasses

Zosteraceae

Posidoniaceae

Cymodoceaceae

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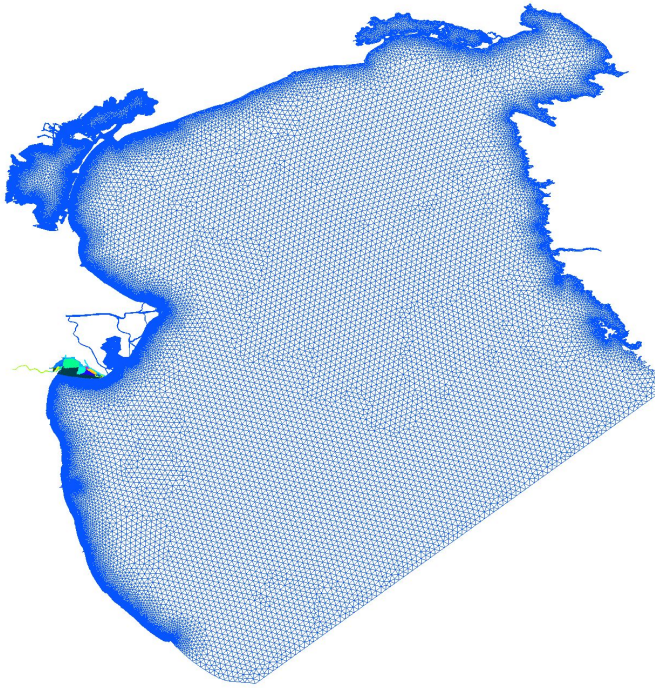
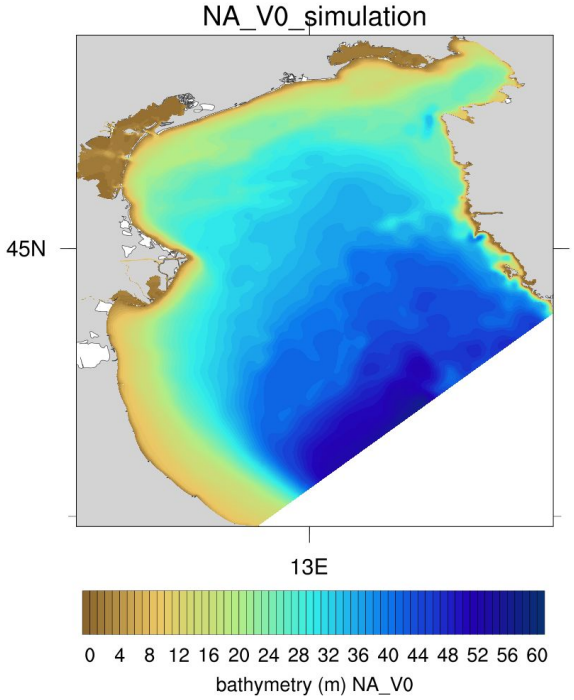
NBS for coastal erosion & storm surge

Tools to assess Sea Grasses Habitat





Full (3D) representation of coastal ocean Physical dynamics

VERY high resolution in the near-shore

WORKGROUP:
UNIBO (DIFA)
Arpae SIMC,
CMCC,
RINA-C

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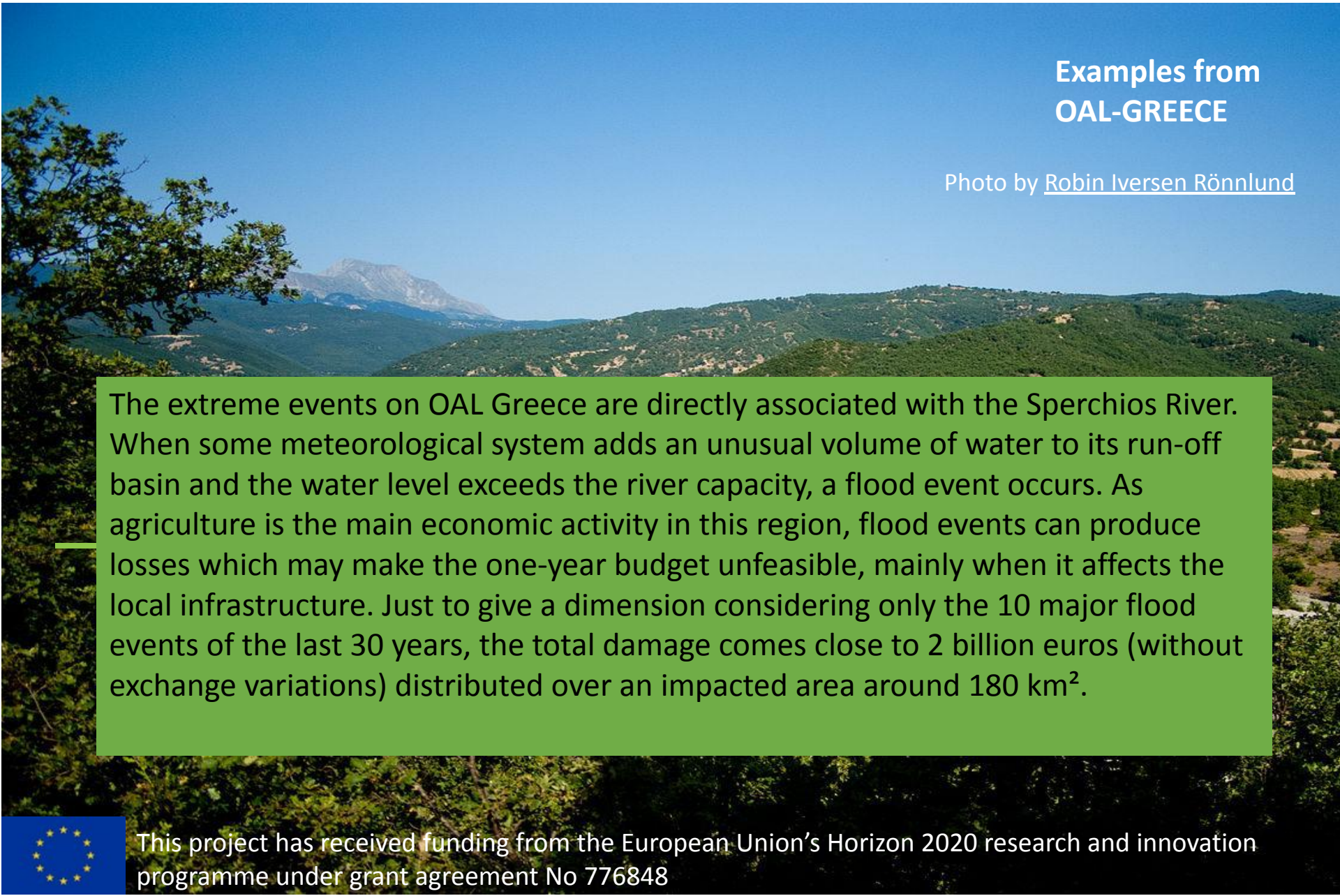
NBS for flooding



Examples from OAL-GREECE

Photo by Robin Iversen Rönnlund

The extreme events on OAL Greece are directly associated with the Sperchios River. When some meteorological system adds an unusual volume of water to its run-off basin and the water level exceeds the river capacity, a flood event occurs. As agriculture is the main economic activity in this region, flood events can produce losses which may make the one-year budget unfeasible, mainly when it affects the local infrastructure. Just to give a dimension considering only the 10 major flood events of the last 30 years, the total damage comes close to 2 billion euros (without exchange variations) distributed over an impacted area around 180 km².

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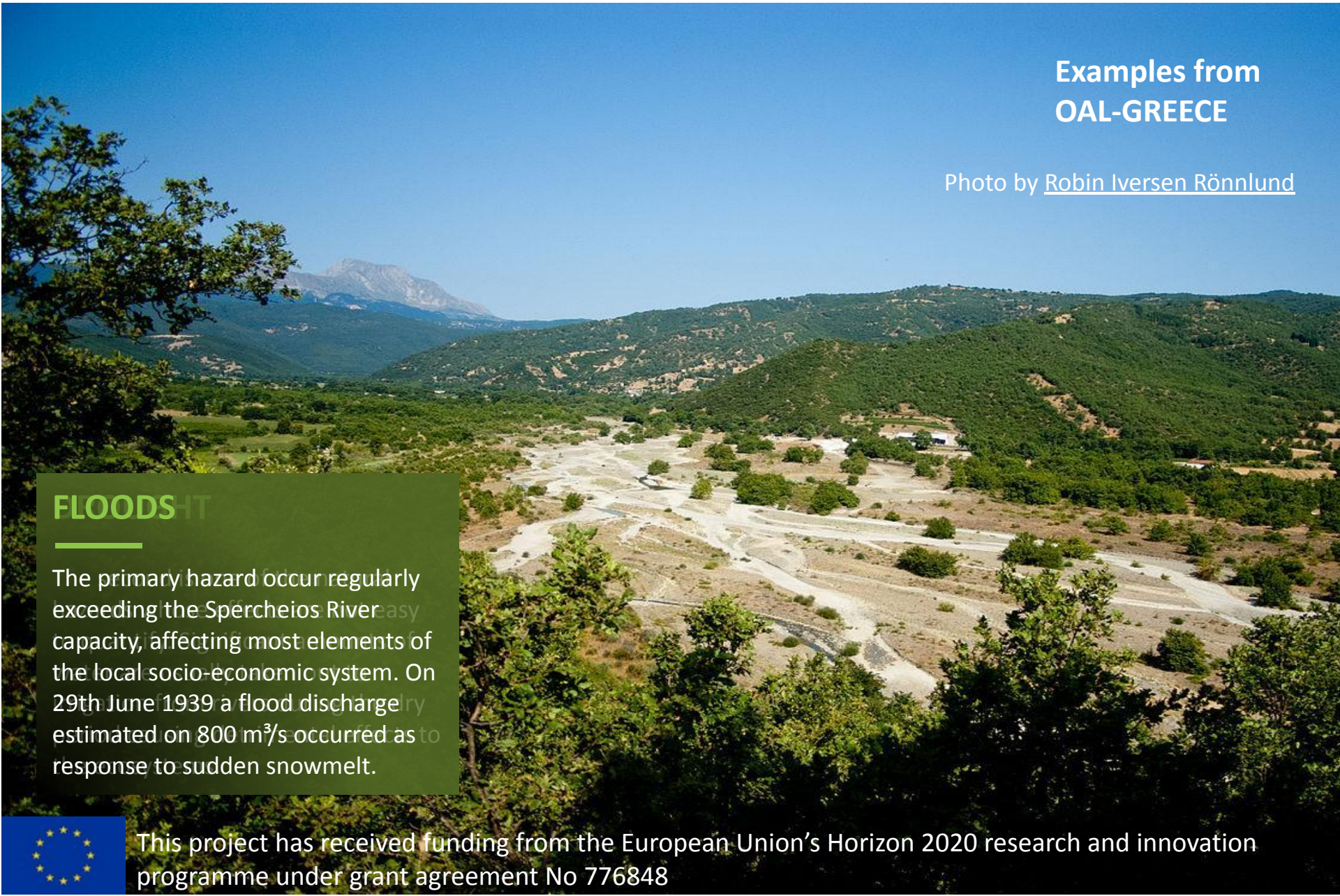
NBS for flooding



Examples from OAL-GREECE

Photo by Robin Iversen Rönnlund

FLOODS

The primary hazard occur regularly exceeding the Spercheios River capacity, affecting most elements of the local socio-economic system. On 29th June 1939 a flood discharge estimated on 800 m^3/s occurred as response to sudden snowmelt.

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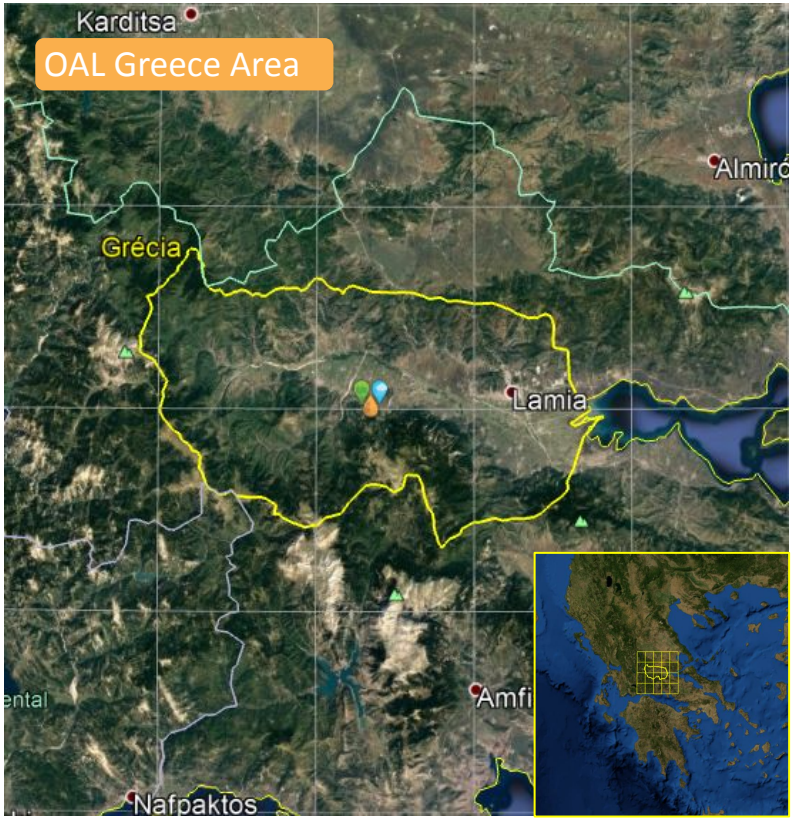
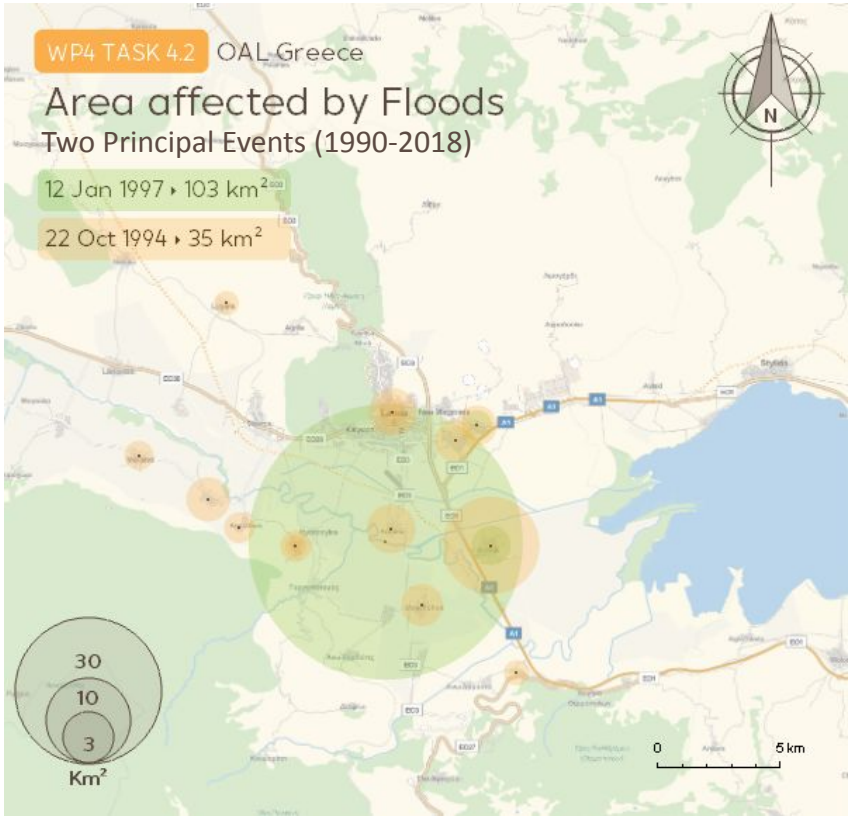
NBS for flooding

Examples from OAL-GREECE

FLOODS (local dataset)





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NBS for flooding

Examples from OAL-GREECE

TOP 10 EXTREME EVENTS

2 billion euros (without exchange variations) distributed over an impacted area around 180 km²

	Date	Event	Meteo System	Upper Air Structure	Max Rain Rate*	Total Precipitation*	Losses
01	31/12/1990	Flood	Single Cells	Mer. Trough[3]	0.7 mm/h	3.9 mm/120h	Agriculture
02	07/10/1994	Flood	Cold Front	Cut-off Low	4.5 mm/h	26.7 mm/48h	Agriculture
03	21/10/1994	Flood	Cold Front	Cut-off Low	9.5 mm/h	134 mm/72h	Agriculture
04	12/01/1997	Flood	Cold Front	Cut-off Low	5.0 mm/h	69.4 mm/24h	Agriculture
05	25/12/2001	Flood	Cold Front	Conf. trough[2]	5.2 mm/h	20.5 mm/24h	Agriculture
06	23/01/2003	Flood	Single Cells	Diff. trough[1]	1.7 mm/h	5.5 mm/24h	Agriculture
07	31/01/2003	Flood	Cold Front	Diff. Trough[3]	4.5 mm/h	36.6 mm/48h	Infrastructure
08	28/05/2004	Flood	Single Cells	Diff. trough[1]	0.5 mm/h	1.6 mm/120h	Agriculture
09	21/04/2006	Flood	Single Cells	Conf. trough[2]	4.8 mm/h	12.3 mm/24h	Economic
10	29/01-03/02 2015	Flood	Medicane	Cut-off Low	6.0 mm/h	191mm/120h	Infrastructure agriculture

*Mean over 6 gridpoints inside the OAL area using the ERA5 dataset. [1]Diffluent trough. [2]Confluent trough. [3]Meriodional trough.

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NBS for lanslides & floods

Examples from OAL-AUSTRIA

LANDSLIDES and FLOODS

Composed by several valleys and small tributaries distributed along 11.5 km of the Watten River, the OAL Austria is exposed to landslides and floods. In most cases, the identification of landslide events can be very long once the ground displacement occurs about cm/year.

According to historical records, extreme rainfall events in this region can simultaneously trigger both hazards.

The main event occurred in 1999, a 100-year flood around the Pentecost season that mostly affected Bavaria and Tirol. In this year, the flood was caused by heavy rainfall coinciding with the regular Alpine meltwater

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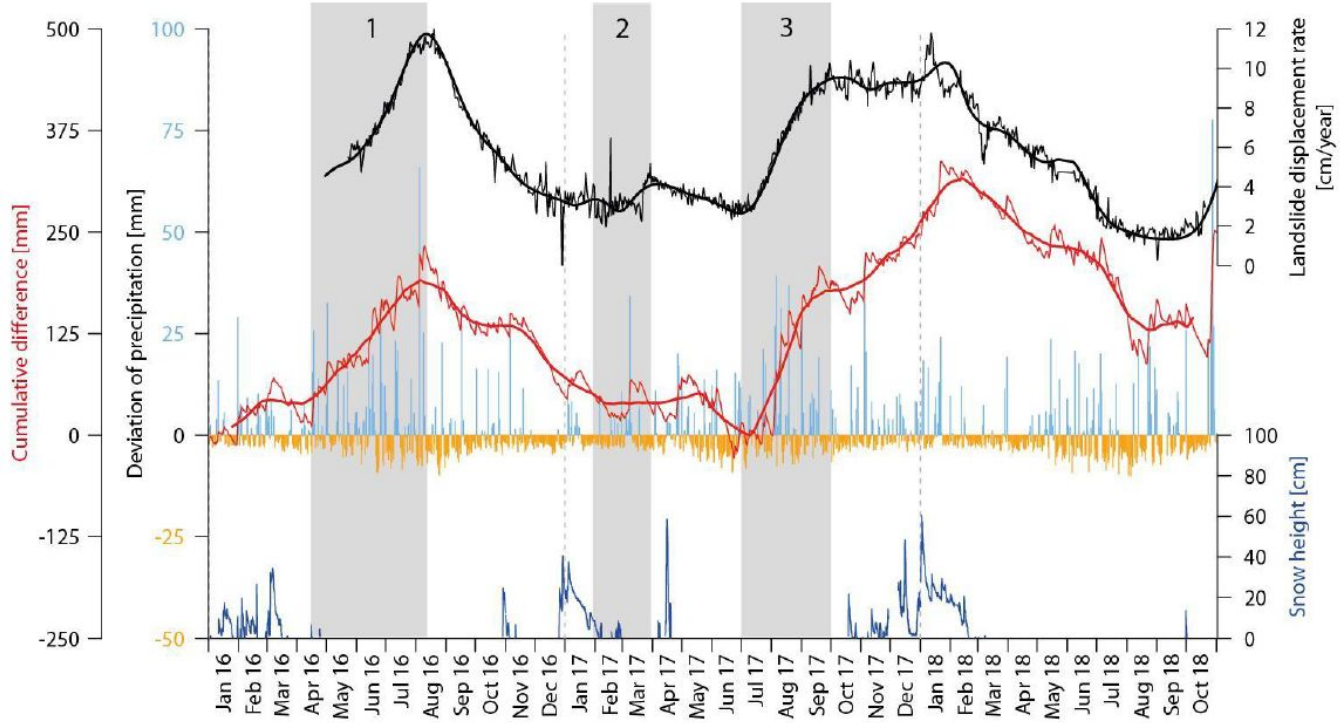
NBS for lanslides & floods

Examples from OAL-AUSTRIA

LANDSLIDE

Comparison of the **displacement rate derived from an** (Automatic Tracking Total Station) **ATTS** and time series of **snow height** and daily deviation of precipitation from the long-term mean (1989-2018; orange, runoff and light blue, precipitation) and its **cumulative sum**. The displacement rate and the deviation of precipitation are shown on a daily basis (thin lines) and as shifting central means with a window size of 50 days.



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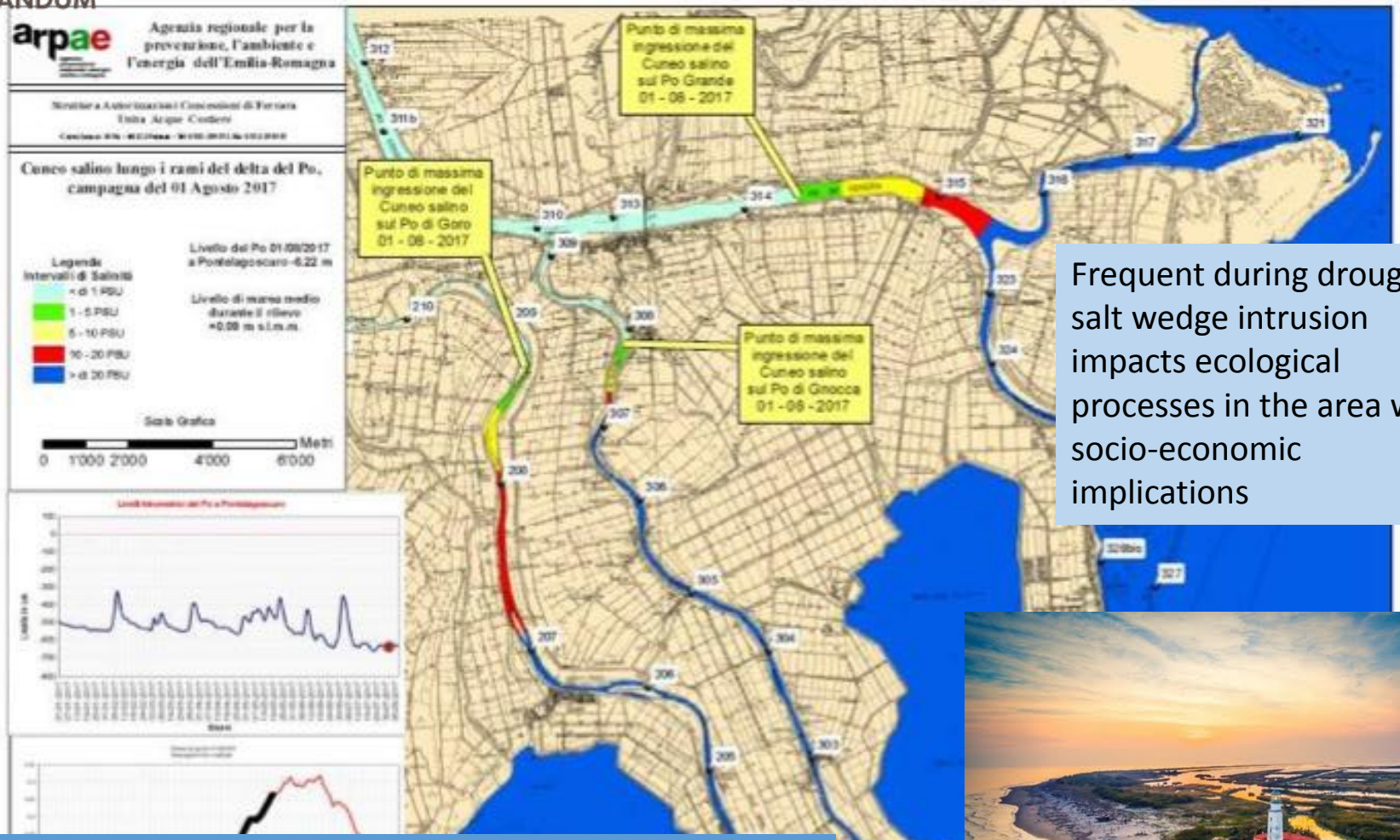
Drought & Salt intrusion

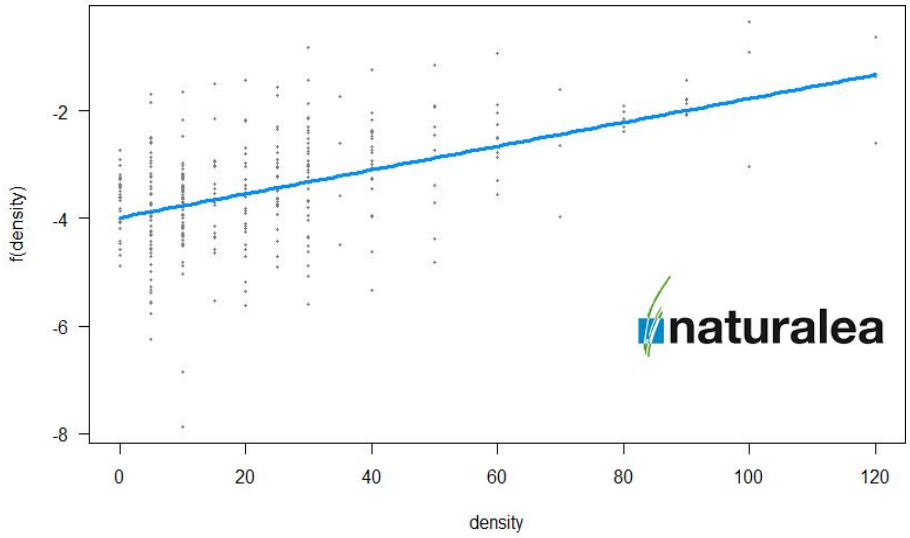
OPERANDUM



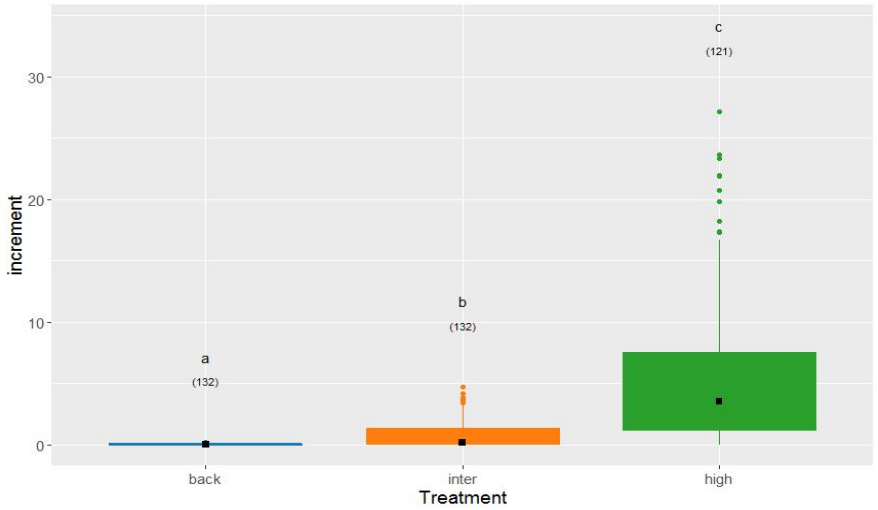
Frequent during droughts, salt wedge intrusion impacts ecological processes in the area with socio-economic implications

Planimetric view of the Po delta with highlighted sections of the river affected by the rising of the saline wedge, and the different degree of salinity for each stretch.

Drought & Salt intrusion



Atriplex portulacoides has absorbed part of the salt added to the chanel



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OPEn-air laboRAtories for Nature baseD solUtions to Manage hydro-meteo risks

HAZARDS – EXTREMES AND METHODS

A detailed description of the **extreme** hydro-meteorological events occurred in the OALs (1989-2018), with the aim to provide an **assessment** of the background in experimental sites, to properly set-up **observational** and **modeling** tools, and experimental campaigns.

The **wide spectrum** of hazards, combined with the variety of **OALs** characteristics, prevented any attempt of standardized approach across the OALs.

The **site-specific criteria** adopted for selection reflect, purposely, how differently hydro-meteorological risks are perceived by the Partners in charge of OALs.

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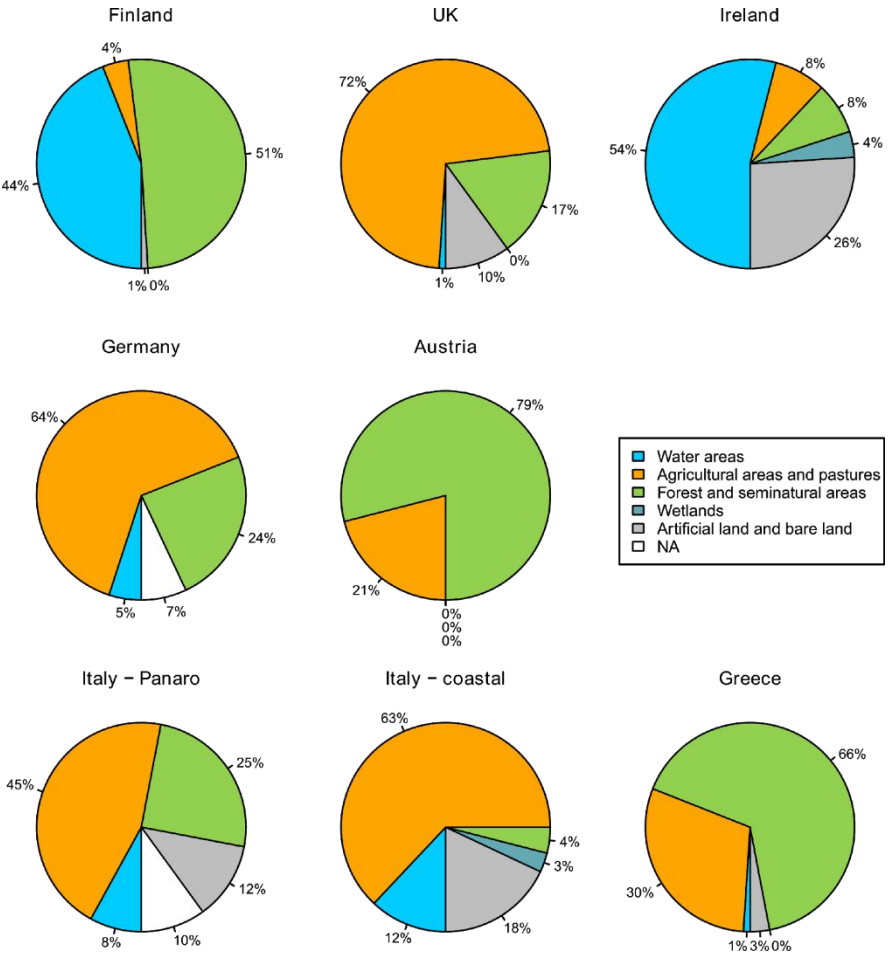
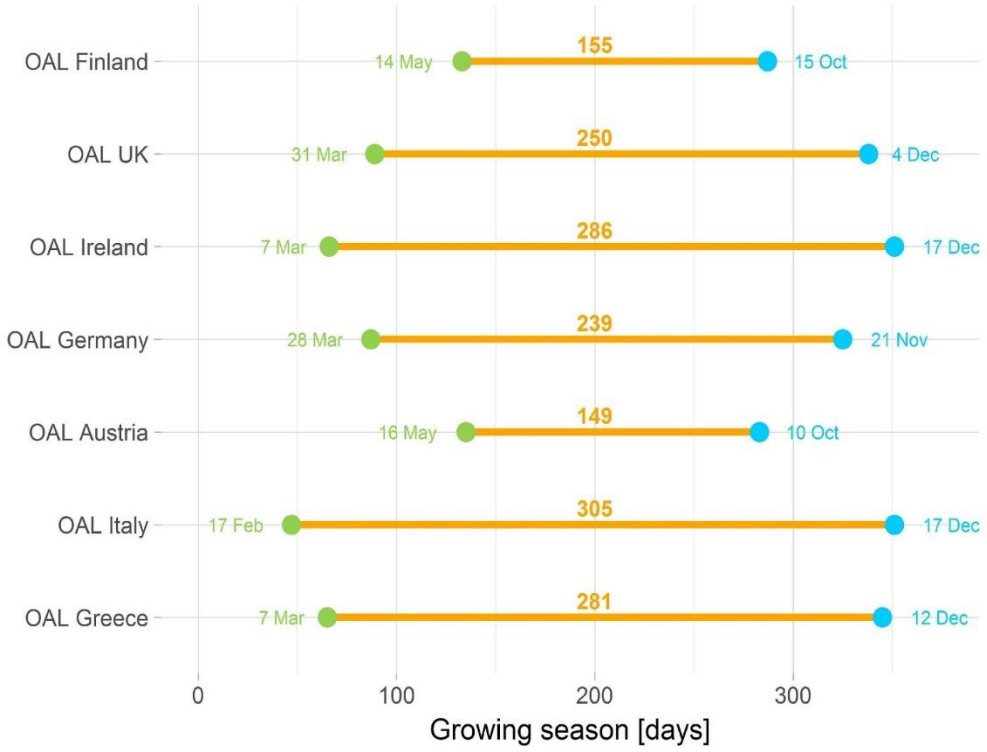
OPEn-air laboRAtories for Nature baseD solUtions to Manage hydro-meteo risks

OAL physical and climatological characterisation



Based on ERA5 reanalysis
1989-2018



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Extreme Events in OPREANDUM OALs

source of data for extreme event selection across the OALs

OAL	IT	FI	DE	GR	AT	UK	IE	CH	HK	AU
Newspaper records		X	X						X	
Scientific literature	X		X							
Local authorities	X		X	X	X		X	X	X	
Direct data analysis	X	X	X		X	X			X	X
Global repository										
Internal database	X				X				X	

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Extreme events in OALs

classification of the criteria used for events' selection in the OALs

Event	IT	FI	DE	GR	AT	UK	IE	CHK	CML	AUS
Flood	River Level	Impact	Impact	Area	Impact		Area			
Storm Surge	Wave Energy					Wave height		Impact		
Land slide					Landslide Speed	Rainfall Rate				Rainfall Rate
Drought	River Flow		Impact	Aridity Index					SPI	
Heat wave		Impact						Impact		

Quantitative, site specific, threshold values: numerical thresholds are used to classify the severity of events, after local climatology. Quantitative threshold values defined looking at OPERANDUM dataset. Qualitative assessment after direct analysis of multidimensional data (stakeholders' reports, impact on media)

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OAL Italy

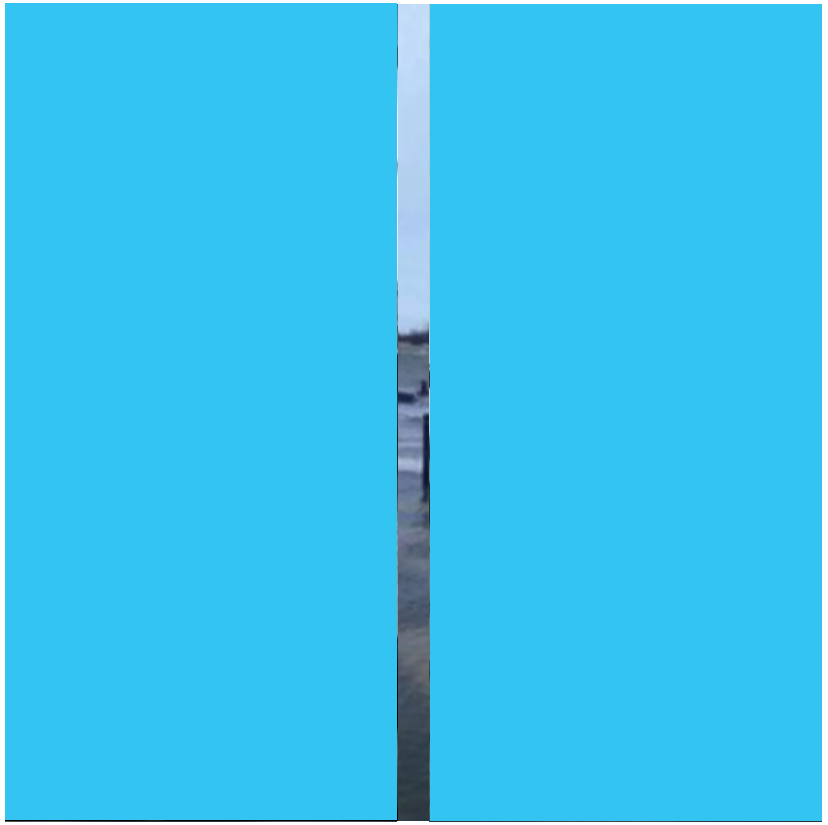
STORM-SURGE (5-7 Feb 2015)

Defined by local authorities as the main event within the North Adriatic in the last decade, responsible of several damages to infrastructures, defences structures and bathing establishments along the whole northern Italian Coast.

EXTREME RECORDS	
1.21 m	Sea Level Porto Corsini
4.31 m	Wave Height Nausicaa

OBSERVATION DATA	
44°(NE)	Wave Direction
516 m²h	Wave Energy
74 h	Duration
Severe	Energetic Storm

OTHER DAMAGES: Beach Erosion and Marine Flooding



Credits lanuovaferrara.gelocal.it

Dolan & Davis (1992– classification scheme - severe

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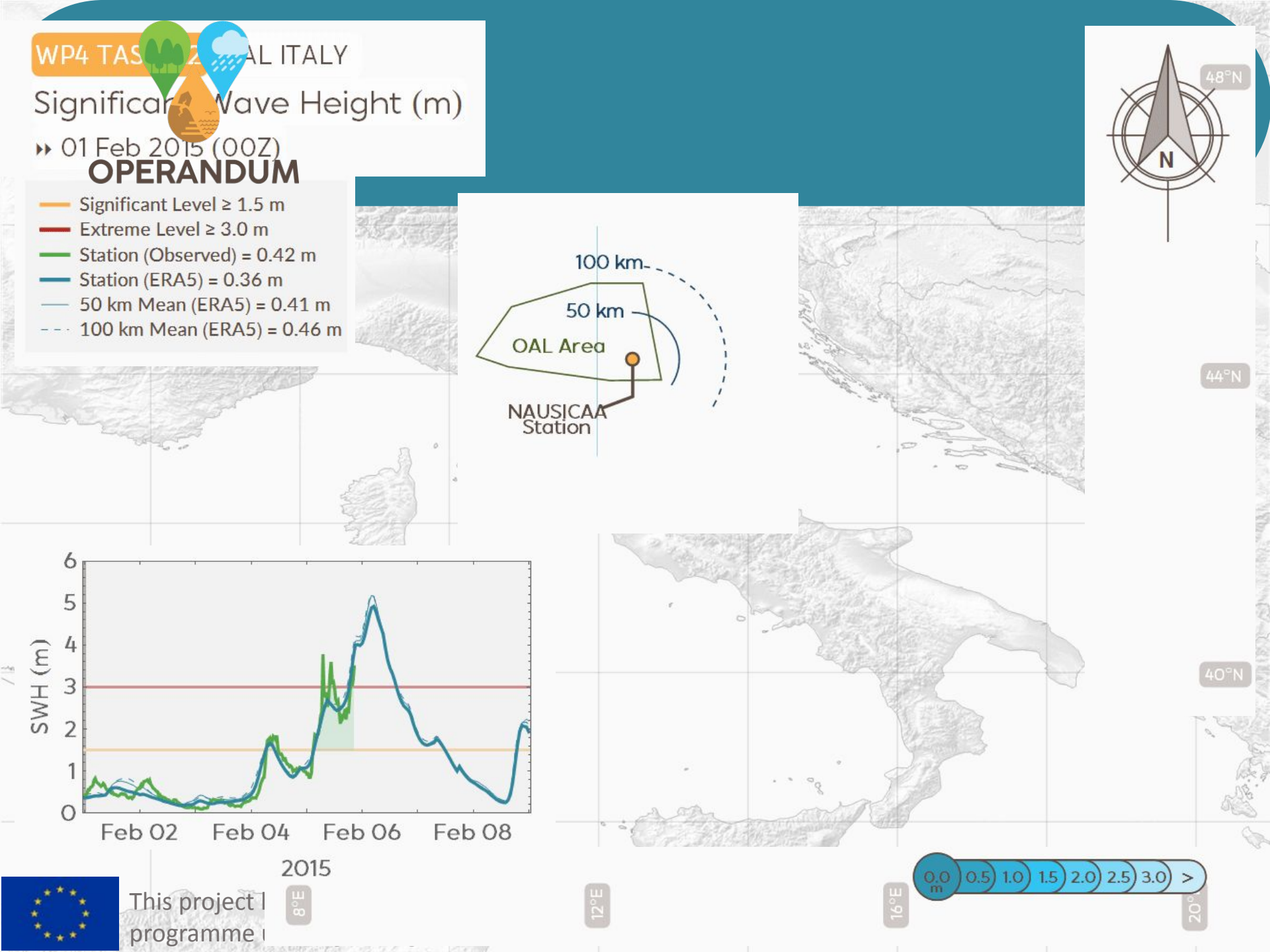

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programme

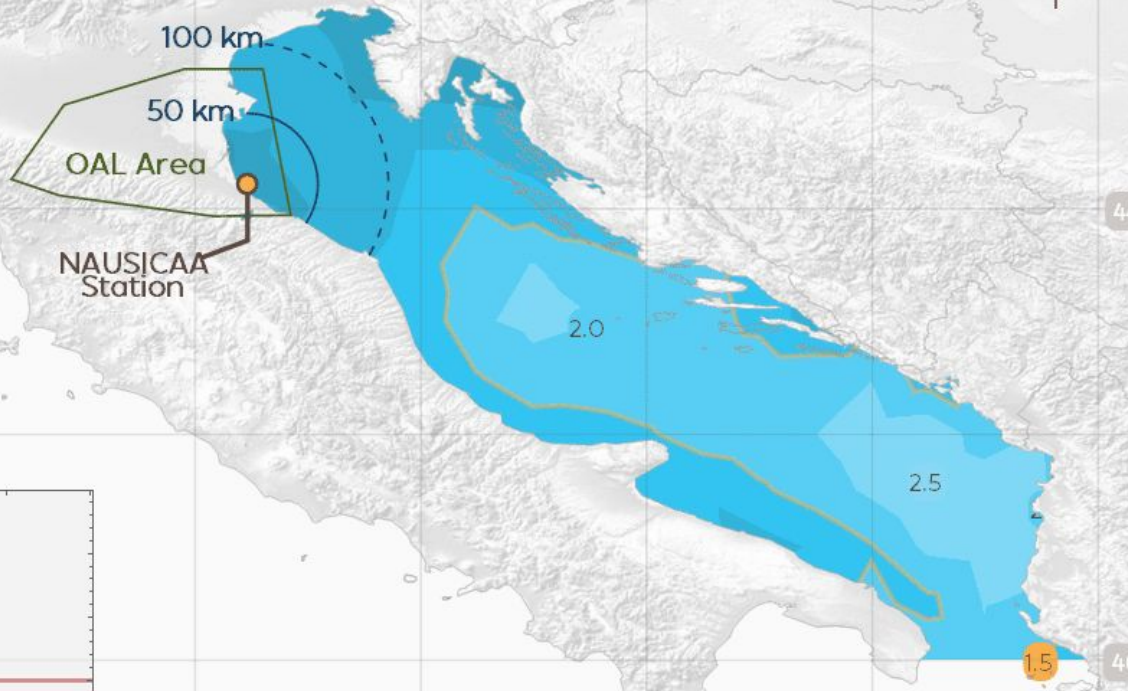
WP4 TASK 4.2 OAL ITALY

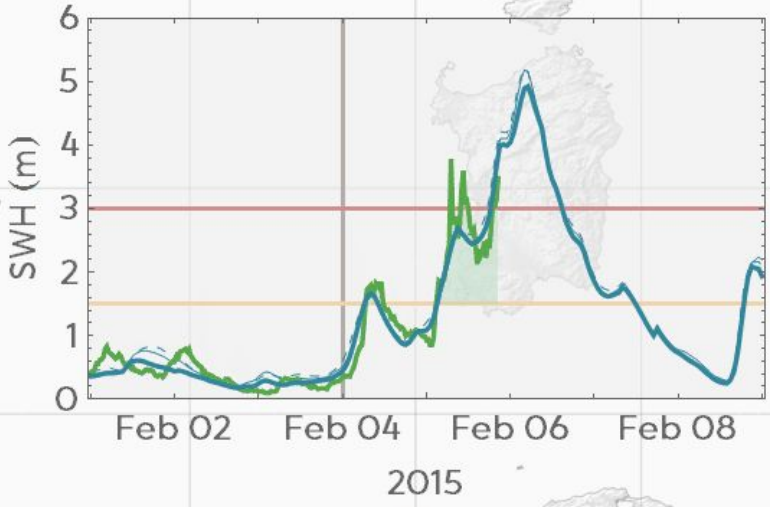
Significant Wave Height (m)

▸▸ 04 Feb 2015 (00Z)

OPERANDUM

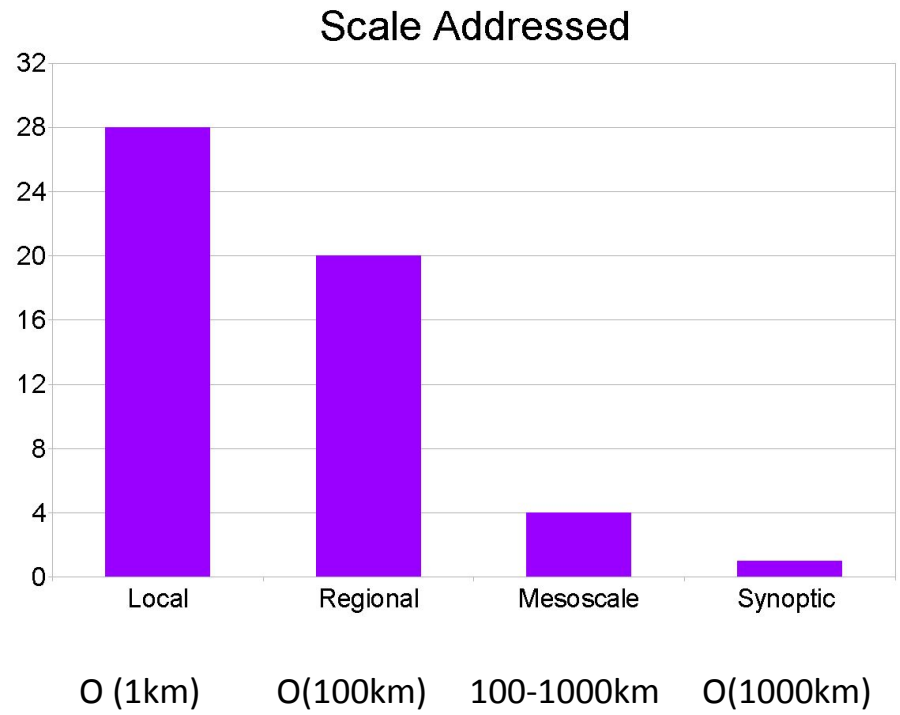
- Significant Level ≥ 1.5 m
- Extreme Level ≥ 3.0 m
- Station (Observed) = 0.35 m
- Station (ERA5) = 0.45 m
- 50 km Mean (ERA5) = 0.51 m
- 100 km Mean (ERA5) = 0.61 m

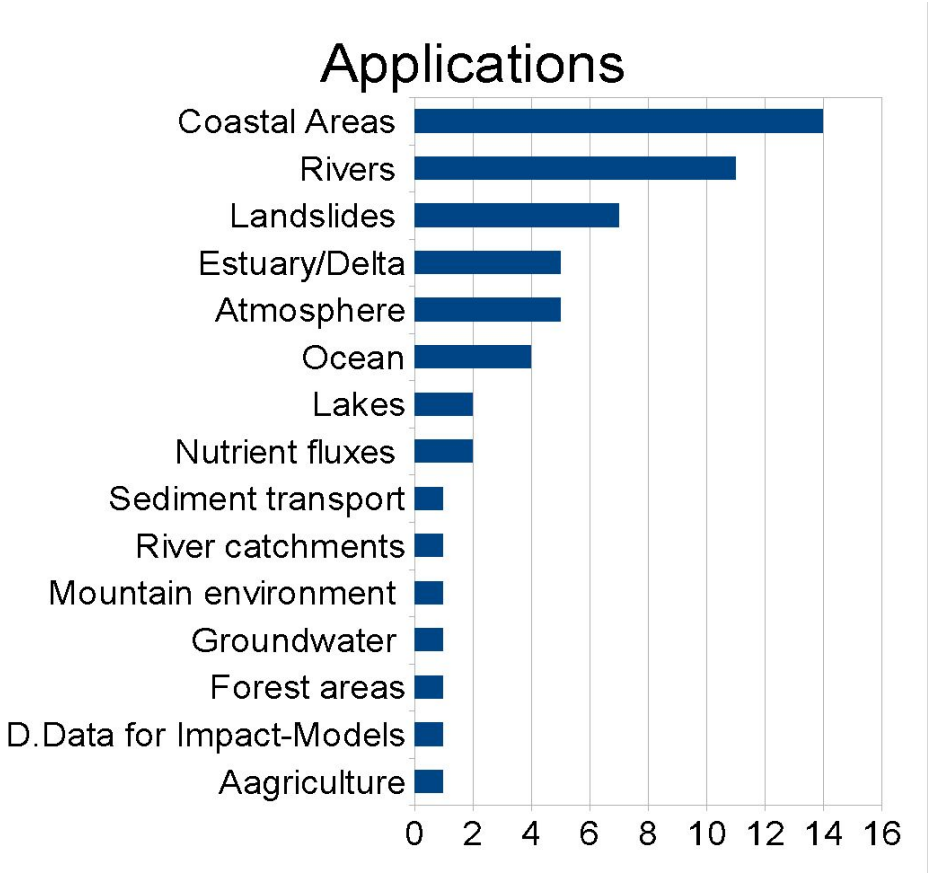




Type of models involved in OPERANDUM

Scale addressed and Ability of the numerical models of being applied at different scales.





EU funded project
GA no. 776848

OPERANDUM

OPEn-air laboRAtories for Nature baseD solUtions to Manage hydro-meteo risks

Operandum is a European project that researches **sustainable** solutions based on nature to **adapt** rural and natural territories to **extreme weather events**. The project focuses on **floods, droughts** and **storm surges** that are rising in frequency due to **climate change**. It delivers tools and methods to prove the efficacy of nature-based solutions. In the process, the team includes **multiple stakeholders** like researchers, policymakers and citizens. With its work, Operandum establishes the framework to strengthen **adaptation policies** while **boosting business opportunities** to build more **resilient** territories.

HAZARDS

THE PROJECT IN NUMBERS

- 10 Open-Air Laboratories
- 26 International partners
- 4+ Years (2018-2022)
- 14M€ Funding

10 OPEN AIR LABS

Austria, Finland, Germany, Greece, Ireland, Italy, Scotland (UK), Australia, China, China (Hong Kong).

Operandum **tests** several Nature-Based Solutions through a novel concept: **10 Open-Air Laboratories (OALs)**, international 'living labs' where the solutions are co-developed and demonstrated with **local stakeholders**, covering **different climate change scenarios**.

GeoIKP

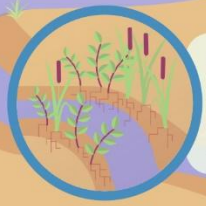
The **Geospatial Information Knowledge Platform** (GeoIKP) serves as an online open hub for **sharing knowledge** about Nature-Based Solutions. It includes information for **multiple stakeholders** and offers **assessment tools** to guide them through the implementation of the solutions.

NATURE-BASED SOLUTIONS

Nature-Based Solutions (NBS) are inspired and **supported by nature**, as opposed to traditional engineering adaptation measures that are built against it. They are **cost-effective** and **locally adapted**, and provide environmental, social and economic benefits.

To reduce **erosion** and **landslips** in the **coastal area**, in the **UK OAL** the team is building a **live crib wall** with timber logs instead of the conventional concrete. This allows vegetation to cover the wall, providing **stability** and **landscape regeneration** simultaneously.

Storm surges cause **coastal erosion** in seascapes. In Lido di Volanoz Beach, in the **Italy OAL**, the team is building **artificial dunes**, as they can protect them and also adapt to the changes in wind, climate and sea levels.



Eroded rivers' embankments are more vulnerable to **floods**. In the Panaro River, in the **Italy OAL**, Operandum is planting **herbaceous perennial deep rooting plants** to protect them.

Extreme weather events can increase the **nutrient load of lakes** and cause **eutrophication**, limiting the oxygen available in their waters. In the **Finland OAL**, Operandum is building **artificial wetlands**, as they have low water flow velocity and can **capture nutrients** before the river enters the lake.

To prevent **surface erosion** and **shallow landslides**, Operandum is constructing in the **UK OAL live ground anchors**, an engineered anchored grid, supplemented with natural sustainable materials. This temporary structure supports **vegetation growth** and provides **slope stability**.

Landslides can be frequent in **slopes** when there is **heavy rain**. In the **Austria OAL**, the team is **planting** the land with saplings of **local plant species** to stabilize the slope and reduce erosion.

In some slopes, **surface and groundwater accumulations** are common and they lead to **soil liquefaction** and **landslides**. In Scotland, in the **UK OAL**, Operandum is building a **live pole drain** with natural sustainable materials to promote the development of roots and retain eroded materials and debris.

To manage **droughts** and **heatwaves**, the **China OAL**'s team is **increasing afforestation**, as forests can serve as **heat sinks** and increase humidity.

www.operandum-project.eu +39 051 209 5215

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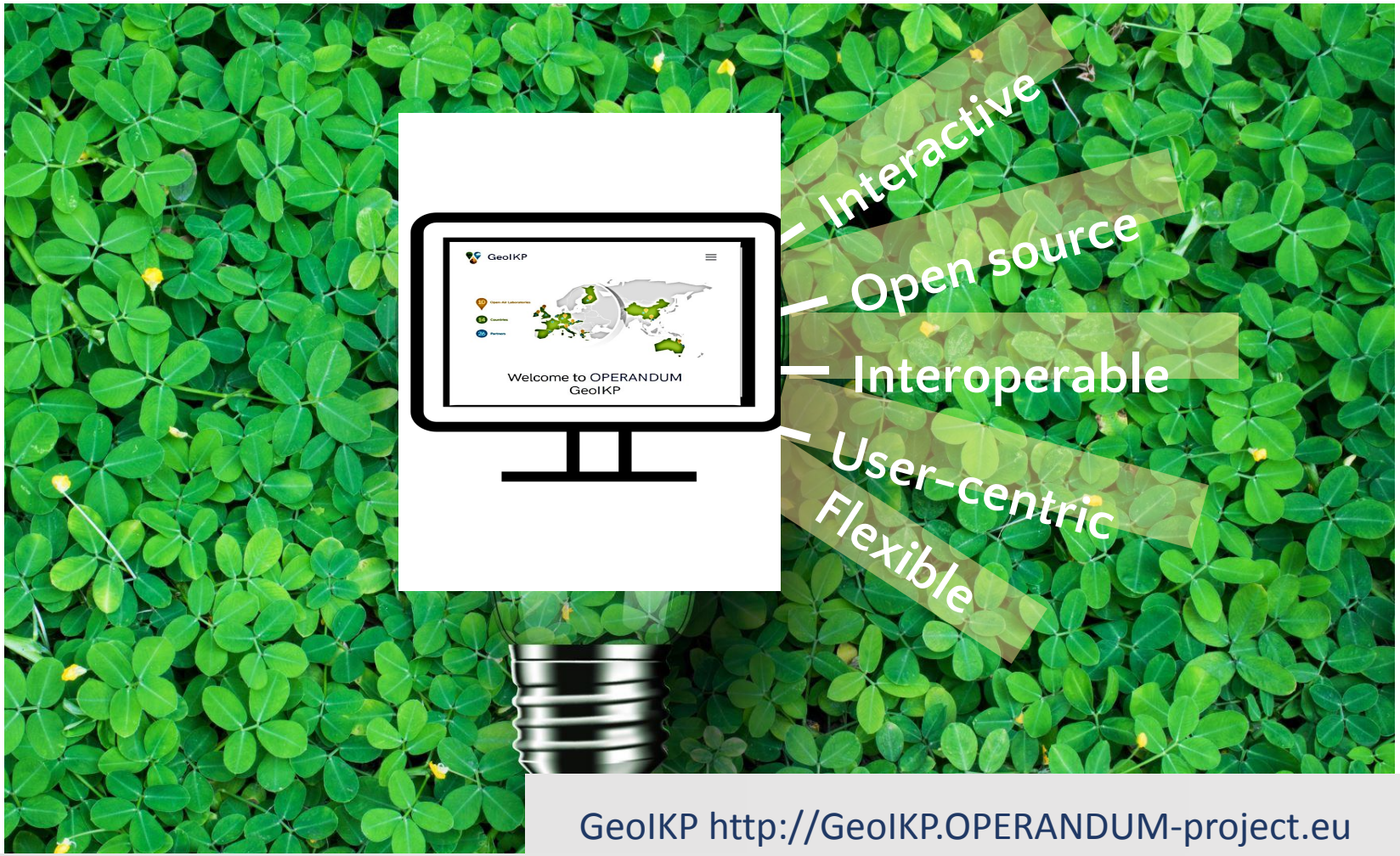
This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 776848.

OPERANDUM

OPERANDUM Web-Based Platform



GeoIKP

GeoIKP http://GeoIKP.OPERANDUM-project.eu

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OPERANDUM Open-Air Laboratories

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OPERANDUM VIDEO

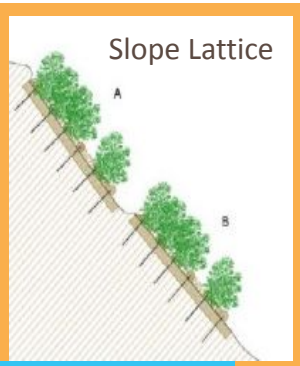
OPERANDUM NBS vs Hazards

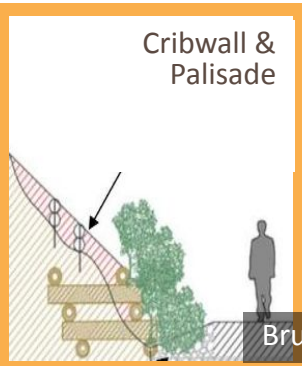
NUTRIENT LOAD

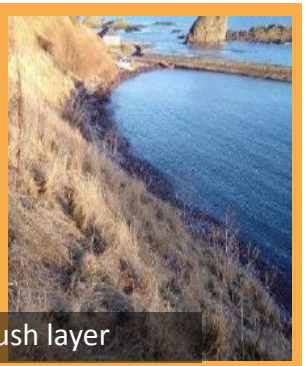

Constructed wetland


Peak flow control structures

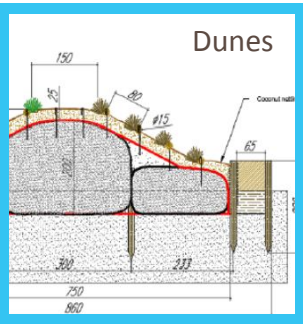
LANDSLIDE






Brush layer

COASTAL EROSION




Dunes


Marine plants

SALT INTRUSION


Zosteraceae


Salicornia

FLOOD


Green roofs


River embankment


Grazing animals


Natural water retention


Natural water retention

nded project GA no. 776848

Take home messages

- NBS are actions that can used to adapt to climate change by considering specific hazards, location, site characteristics
- NBS to be functional and effective needs to be monitored over time
- NBS implementation requires large resources and multi-disciplinary approaches – large projects such as OPERANDUM that includes a variety of expertise
- The scale is important
- Hazards and risks are interconnected in a non-obvious way – climatology and meteorology over the region and its projected change are key elements in designing and planning an NBS
- OAL is a concept that integrates all aspects required by an holostic approach in a systematic and reproducable manner
- NBS may be combined together to enhance their effectiveness
- Numerical modelling allows to verify that the NBS will be working in future climate

THANK YOU !

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