ECOPOTENTIAL:
Improving future ecosystem benefits through Earth Observations

Starting date: 1st June 2015, Duration: 4 years, 47 partners

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www.ecopotential-project.eu

This project has received funding from the *European Union's Horizon 2020 research and innovation programme* under grant agreement No 641762

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ECOPOTENTIAL: “back to the future”

Ecosystems are seen as “one physical system” with their environment, with strong geosphere-biosphere-hydrosphere interactions

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ECOPOTENTIAL in a nutshell

- Focus on a **network of Protected Areas**
- Identify relevant **ecosystem services** and focus on supporting **ecosystem functions/processes**
- Build **EO data products** to characterize ecosystems state and changes
- Collect existing **in-situ** data and identify data gaps
- Quantify **changes** in the ecosystems
- Build **models** capable of assimilating EO and in-situ data, capable to include uncertainty estimates
- Estimate the **future state** of ecosystems

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ECOPOTENTIAL in a nutshell

- Build knowledge with relevant stakeholders: PA staff, environmental managers, etc
- Define policy options and the requirements of future protected areas
- Make all results available to the community, contributing to GEO/GEOSS (GEO ECO, GNOME) through a Virtual Laboratory Platform
- Produce dissemination material at multiple levels
- Develop a pan-European view starting from the information gained at PA level

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ECOPOTENTIAL

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Working in partnership with 23 Protected Areas in Europe and beyond

Ecosystem types:
Mountains
Arid/semi-arid
Coastal/marine

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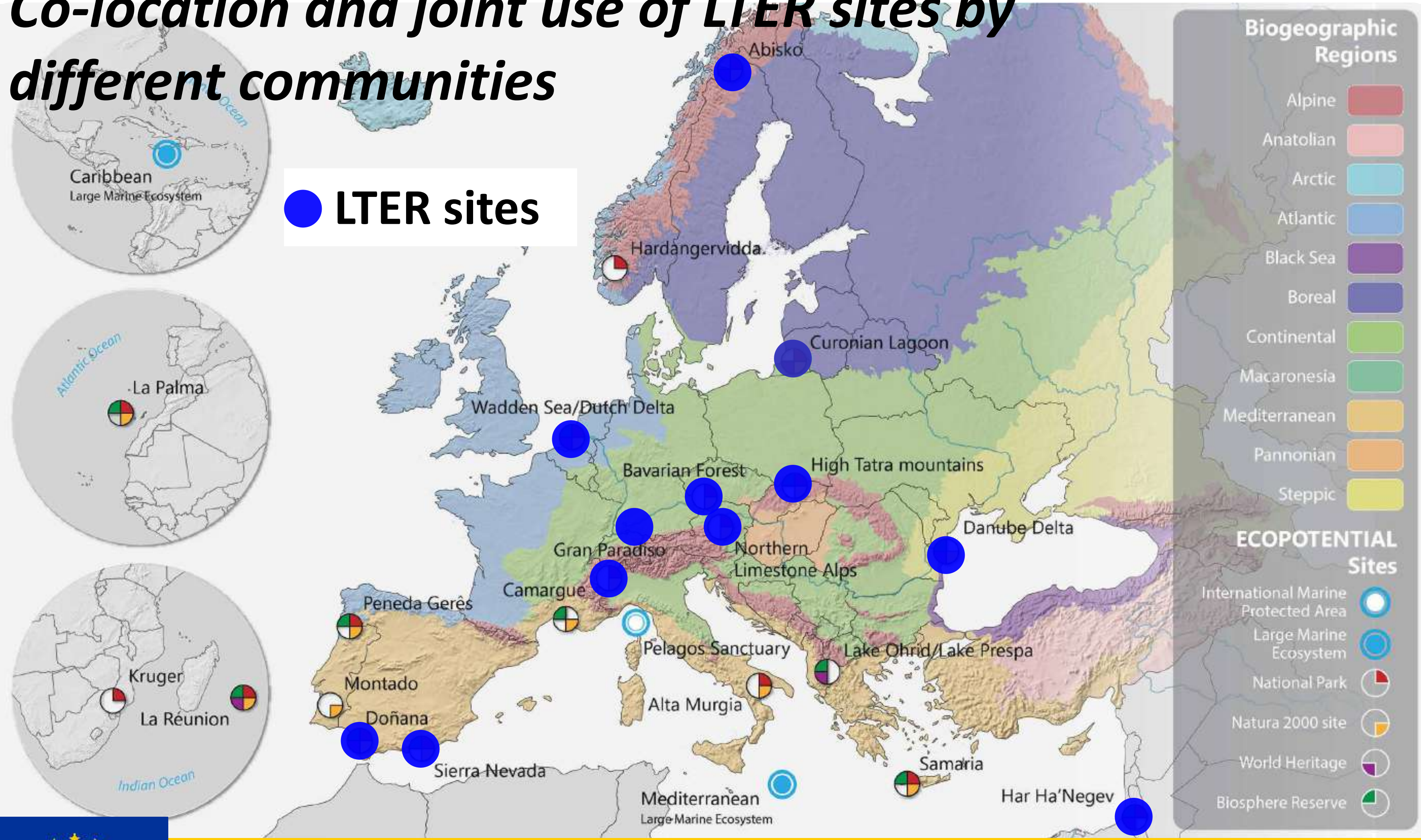
Working in partnership with 23 Protected Areas in Europe and beyond

Co-location and joint use of LTER sites by different communities



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Representativeness of ECOPOTENTIAL PAs

Spatial analysis is foused on:

- Terrestrial and Coastal Ecosystems (no „marine only“ ecosystems)
- European Continent (without Greenland)
- National Parks (NP)
- UNESCO Man and Biosphere Reserves (MAB)
- Natural UNESCO World Heritage Sites (WHS natural)

Data Sources are:

- World Database on Protected Areas (IUCN and UNEP-WCMC 2016)
- Database on National Designated Areas (EEA 2016)
- Additional literature and web search

Hofmann, Beierkuhnlein et al, 2016, in prep 2017

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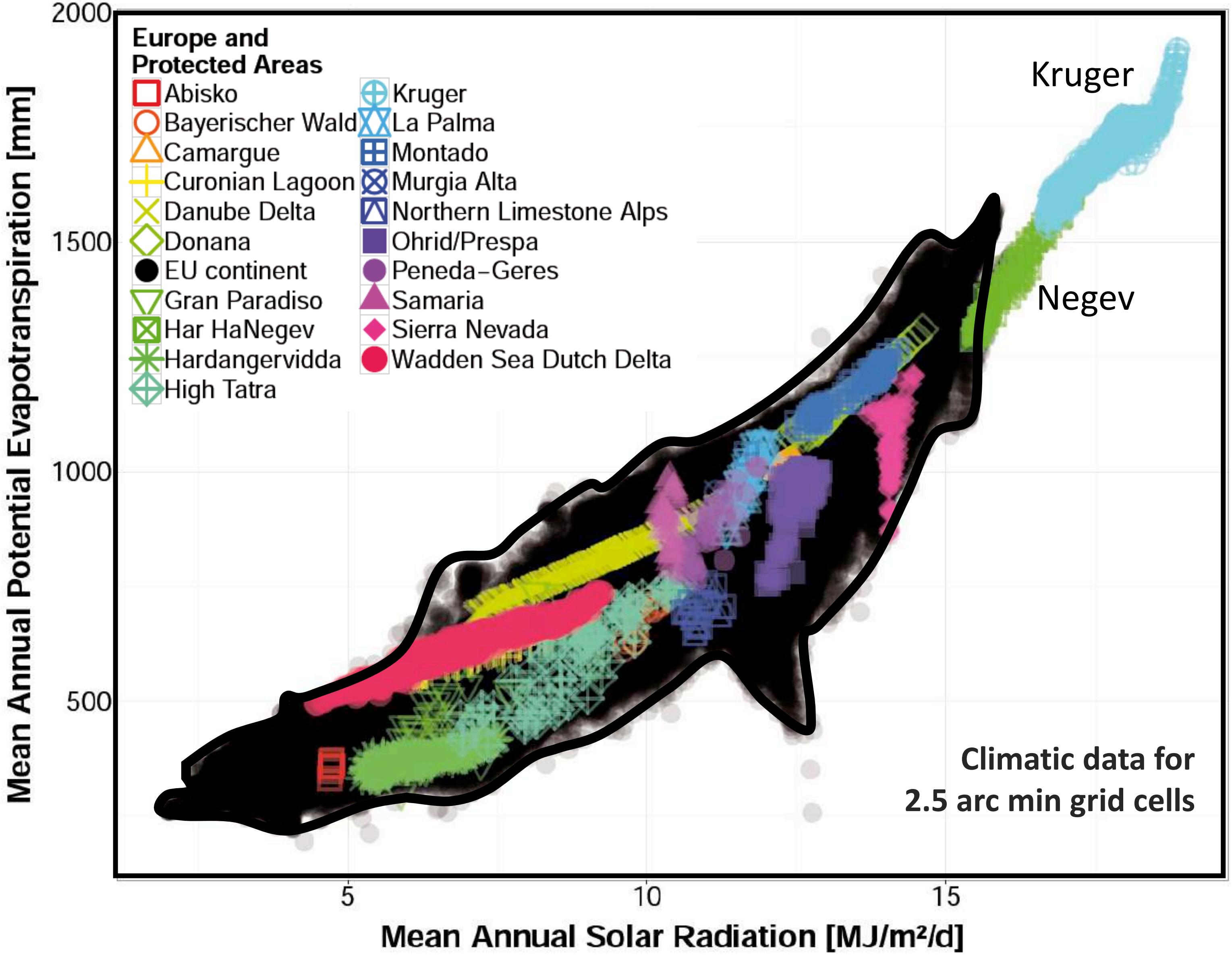
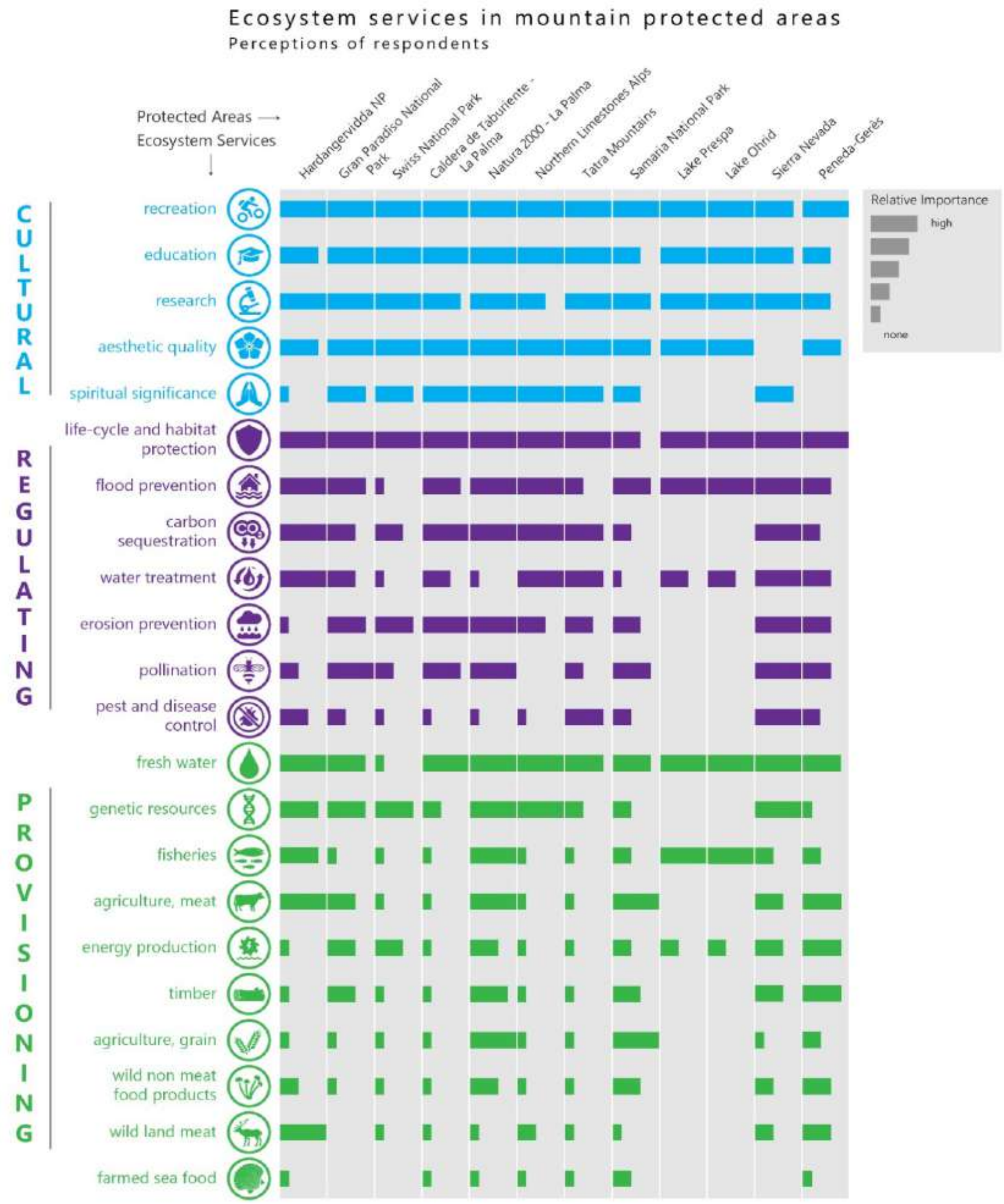
ECOPOTENTIAL and climate



Results of the questionnaire sent to PA managers/staff with the collaboration of ECOPOTENTIAL partners working in each PA



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Synthesis report based on results from questionaires to PA staff

Main findings:

- The Ecosystem Service (ES) approach **is used little in PA management**.
  - Lack of knowledge
  - Lack of ES included in formal goals and policy frameworks relevant for PAs

    (Ecosystem preservation and tourism/recreation are the main formal goals of PAs)
  - Respondents were positive to the ES approach and identified a range of important ES provided by their PAs
- The use of EO tools in the management of PAs **is overall low** but has (eco)potential to be enhanced.
- There are **good cases of use of EO tools** in particular PAs and a **strong willingness to share experiences**.
- A range of **training resources**, as well as software and hardware tools, are required for the PAs to be able to effectively apply the technical tools provided by ECOPOTENTIAL: access to data is often good, but lack of capacity to analyse and use the data.
- PAs requested **more knowledge on how to use of EO tools and Remote Sensing** data for management in particular, in relation to their formal goals.

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What do we study in the Protected Areas:

Current state of Protected Areas from Remote Sensing

Ongoing changes in the ecosystems and environment of the ECOPOTENTIAL Protected Areas

Future projections on the state of the ecosystem in the ECOPOTENTIAL Protected Areas

Narratives related to stakeholder needs: The Storylines

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Narratives for an integrated approach with stakeholders: The ECOPOTENTIAL storylines

- Focus on given Protected Area(s) and identify the main Ecosystem Services of interest and the functions/processes supporting them
- Identify indicators for the state of the ecosystem and of ecosystem processes (DPSIR SoE), for the most important control factors on the ecosystem, for the main (human-induced) pressures (DPSIR Pressures)
- Identify the most critical/endangered/fragile ecosystem components and identify indicators of the impacts/response of ecosystem structure, functions and services (DPSIR Impacts)
- Identify, retrieve, collect and possibly extend the data base (in situ and Remote Sensing) for the above indicators and the relevant Essential Variables
- Identify societal and management responses (DPSIR Responses) and develop conservation and management policy options

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An arid/semi-arid storyline: Spatial-temporal dynamics of savanna ecosystems as a life support system to wildlife and livestock production in and around Kruger National Park (A. Ramoelo, CSIR, SA)

Ecosystem service	Ecosystem property needed to keep / improve the service	Supporting ecosystem characteristics
Ecotourism	Species abundance and diversity e.g. presence of wild animals (Elephants, Rhino, Buffalo, Lion, Leopards etc),	healthy state of open grasslands and woodland habitats and vegetation diversity
Grazing and Browsing resources (wild and domesticated animals)	Grass and tree foliage or cover	Quality and quantity grass and leaves for grazing and browsing respectively.
Woody resources (energy and timber)	Woodland components (trees)	Quantity and species of trees
Water	Vegetation productivity, soil quality	Vegetation cover, low alien species cover

Driver of change	Indicator	Method [reference] (type)*
Fire	Burnt area – frequency of fires	http://www.afis.co.za/
Grazing activities	Biomass and quality	Ramoelo et al. (2012; 2015) (R)
Elephant tree pushovers	Tree cover (%)	Wessels et al. (2011), Mathieu et al. (2013), Naidoo et al. (2014) (R,M)
Fuel wood collection	Tree cover (%) or woody biomass (tons/ha)	Mathieu et al. (2013), Naidoo et al. (2014), Mograbi et al. (2015) (M)
Bush encroachment	Tree cover (%)	Naidoo et al. (2014) (R)
Land use – settlement and agriculture	Land cover or use	National Land Project – SA (R)

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An arid/semi-arid storyline: Spatial-temporal dynamics of savanna ecosystems as a life support system to wildlife and livestock production in and around Kruger National Park (A. Ramoelo)

DPSIR Type	Indicator Variable	Nearest Essential Variable (and originating typology)
State	Herbaceous biomass (g/m^2)	Above ground biomass (ECV)
	Leaf nitrogen (%)	Ecosystem function (EBV)
	Tree biomass (ton/ha)	Above ground biomass (ECV)
	Tree cover (%)	Habitat structure (EBV)
	Habitat structure/type	Habitat structure (ECV)
	Vegetation productivity – LAI	LAI (ECV)
	Precipitation dynamics - Drought	Precipitation (ECV)
	Landscape diversity index	Land cover (ECV)
	Water and carbon fluxes	Evapotranspiration, soil moisture, carbon fluxes (ECV)

Link with Essential Variables

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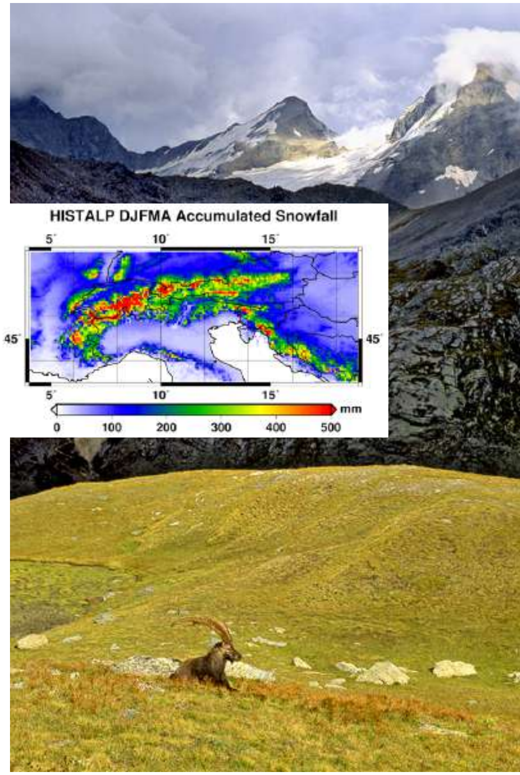
A mountain storyline: high-altitude environments as a life-support system to wild herbivores (S. Imperio, T. Bargmann)



Ecosystem service	Ecosystem property needed to keep / improve the service	Supporting ecosystem characteristics
Sustainable tourism (GPNP, HNP) / hunting (HNP)	• Traditional landscape • Biodiversity • Presence of flagship species (Alpine ibex, chamois, wild reindeer)	• Floristic, arthropod and avian diversity • Wild ungulates distribution and abundance • Disturbance regimes
Habitat for rare and/or endemic species and/or of cultural value	• Micro-habitat diversity • Low human disturbance rates (tourism, pollution, land management)	• Species and community population dynamics • Phenology • Precipitation and temperature regimes • Disturbance regimes
Food production	• Cattle (GPNP), sheep (HNP) • Wild meat production (reindeer, grouse, fish)	• Gross primary production • Plant forage value
Water provision	• Soil moisture • Water budget	• Precipitation and temperature regime • Soil water content • Evapotraspiration
Carbon balance/storage	• Carbon cycling between soil, vegetation and atmosphere	• CO_2/CH_4 exchanges • Soil organic carbon • Resilience to extreme events and to soil freeze–thaw cycles

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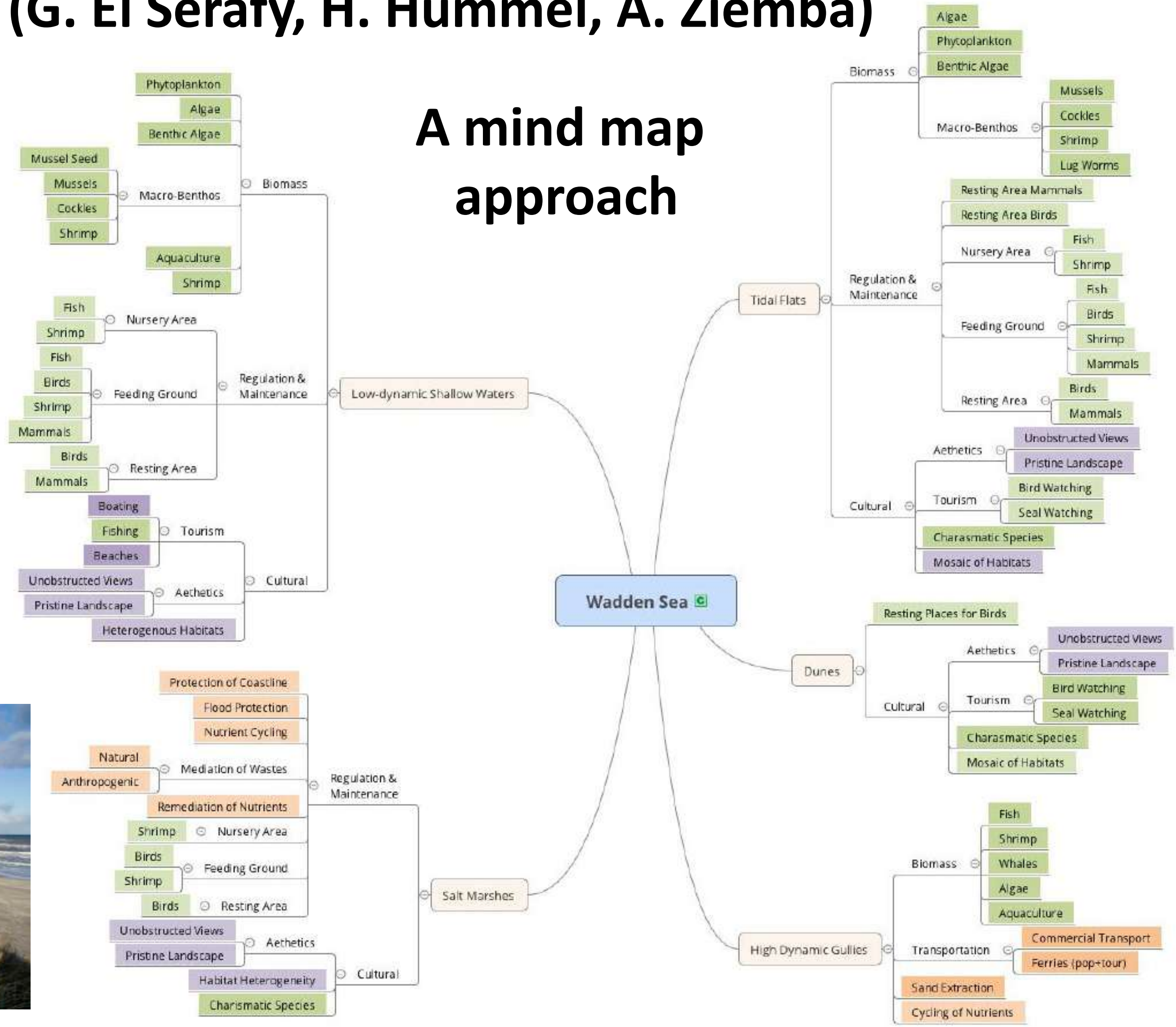
A coastal storyline: the Wadden Sea improving coastal lagoon benefits under multiple pressures

(G. El Serafy, H. Hummel, A. Ziemba)

A mind map approach



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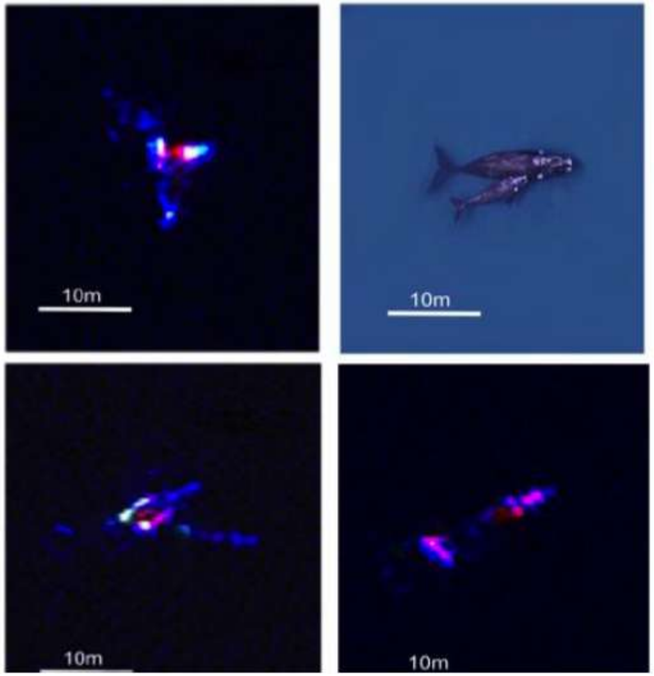
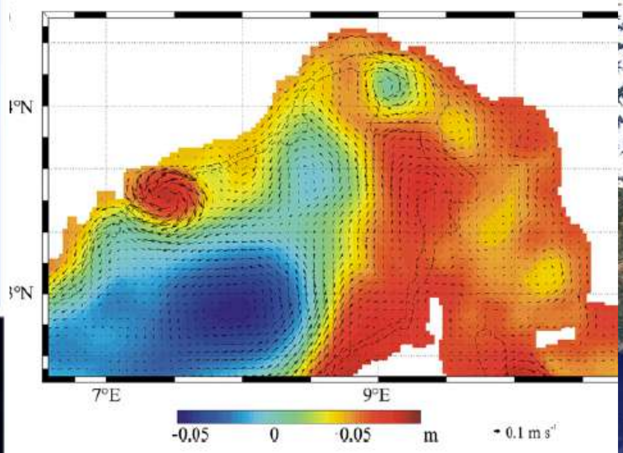
A marine storyline: the Pelagos sanctuary (V. Drakou, L. Pendleton, W. Appeltans)



Southern Right Whales in Valdes Peninsula, captured with WorldView3 images from Digital Globe – © British Antarctic Survey/Digital Globe



Fin Whale observed in the Pelagos Sanctuary – Photo ©: F. Bendinoni – Thetis Research Institute

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A freshwater storyline:
ESS approach for the sustainable management of Lake Ohrid
(S. Giamberini, O. Tasevska, I. Baneschi)

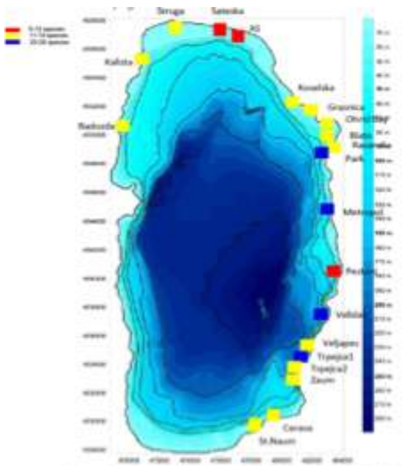
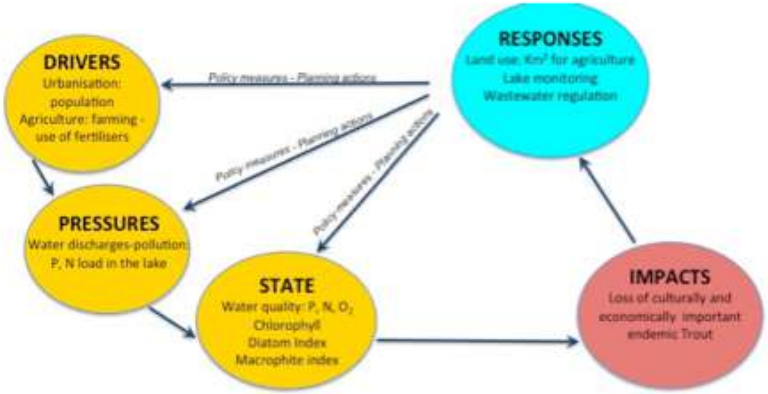
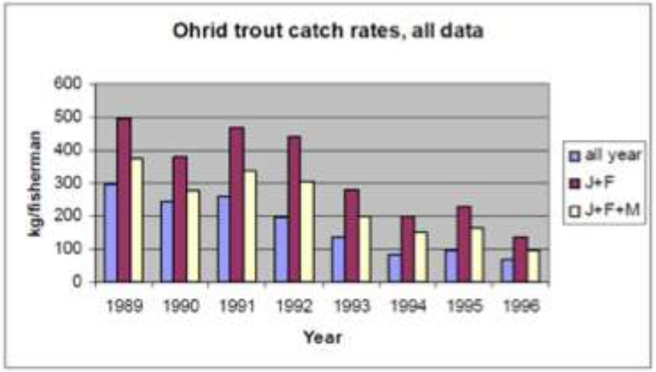
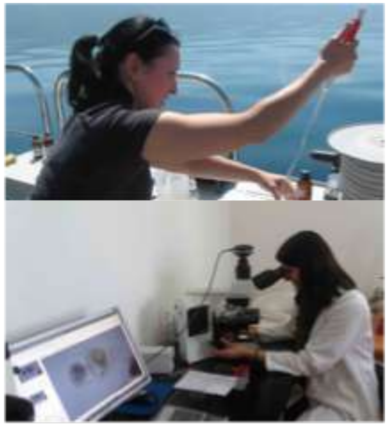
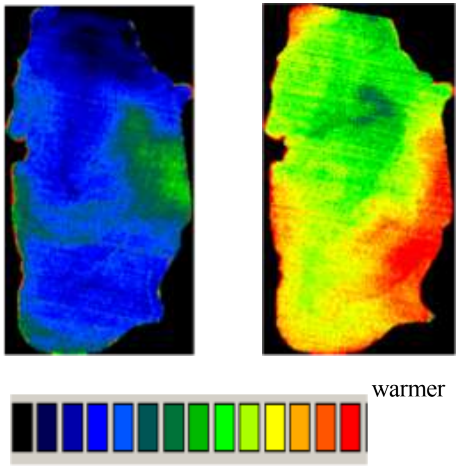


Figure 7. Distribution of the endemism of the macroinvertebrates in Lake Ohrid









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An emerging thread: ongoing changes in PAs

**Meteo-climatic drivers
from gridded and local data**

**LC/LU, vegetation, turbidity, chlorophyll-a
and other info from Remote Sensing**

**In situ data on
ecology/biology/pop.dyn./geomorphology/hydrolog
y/water**

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Example of PA changes: the Gran Paradiso National Park

Gridded meteo-climatic datasets

E-OBS: 0.25°, EURO4M: 0.05° (only prec)

HISTALP, OI (Piedmont): 0125°

Model outputs and reanalyses

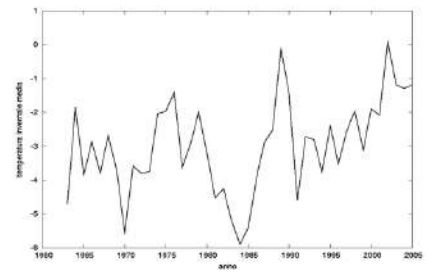
CMIP5, EURO-CORDEX,

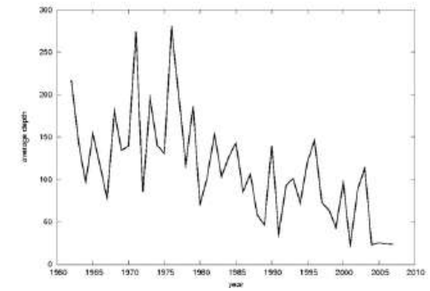
ERA-Interim/Land and 20CRv2, MERRA, NCEP

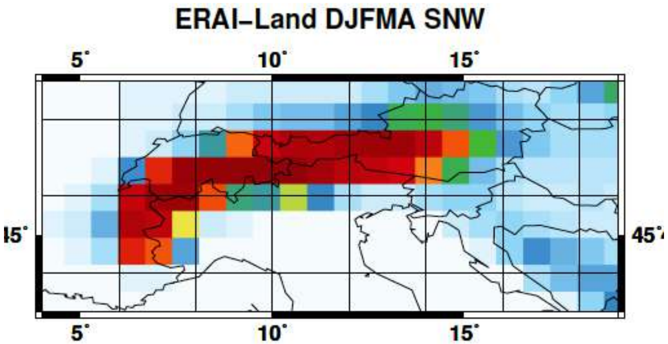
Local meteo-climatic datasets

about 30 temperature sensors

2 meteo stations







Water/carbon fluxes and phenology

eddy covariance

flux chambers

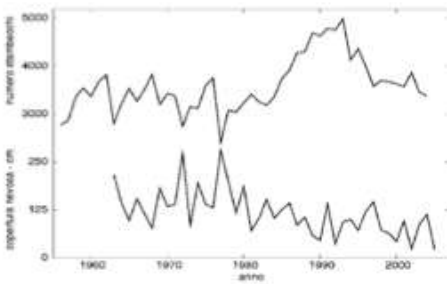
Ecosystem and population dynamics

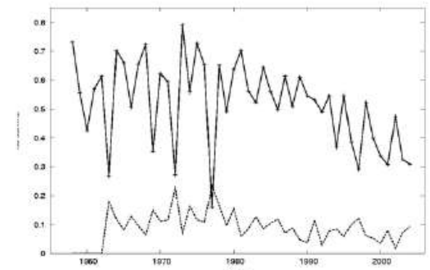
ibex, chamois, vegetation, biodiversity

Satellite products

e.g. snow: Global SWE, AMSR-E

vegetation, NDVI, LC/LU





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Spatial-temporal dynamics of savanna ecosystems a life support system to wildlife and livestock production in and around Kruger National Park (A. Ramoelo, CSIR)

SoE	Indicator	Method [reference] (type)*
Distribution of grazing and browsing resources in the semi-arid environments	amount of grass per unit area (biomass)	empirical techniques [Ramoelo et al. 2015] (M)
	percentage of nutrients in dry matter (leaf N (%))	empirical techniques [Ramoelo et al. 2012; 2015] (M)
	percentage of tree cover per unit area (%)	field, LiDAR and SAR empirical techniques [Mathieu et al. 2013, Naidoo et al. 2014, Urbazaev et al. 2015] (M)
	above ground woody biomass per unit area (ha) & woody volume as biomass proxy	field, LiDAR and SAR empirical techniques [Mathieu et al. 2013, Naidoo et al. 2014] (M)

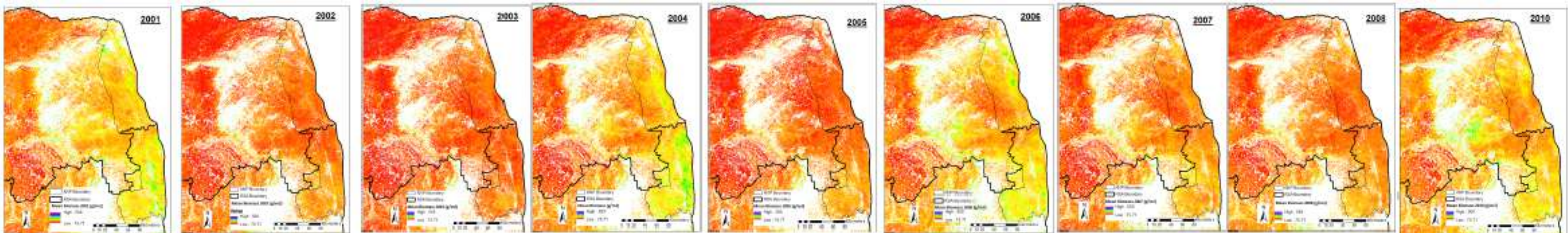
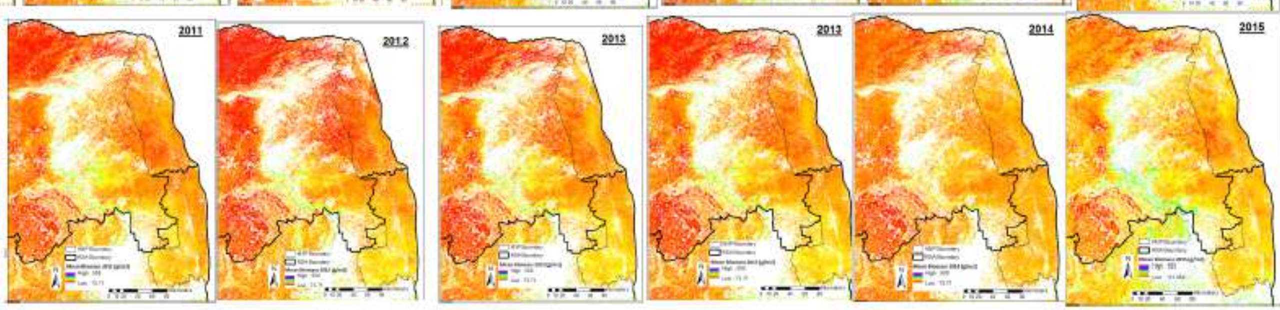


Figure 2: Time series of mean annual biomass data based on 500m spatial resolution MODIS data (2001 – 2015).



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PA changes:
Selected RS variables

Type of ecosystem	RS variable
Mountains	NDVI
	Snow cover (duration)
	Gross primary production
Coastal/marine	Chlorophyll a concentration
	Sea Surface Temperature
	Total suspended solids
Arid ecosystems	NDVI
	Soil moisture
	Tree cover density (%)

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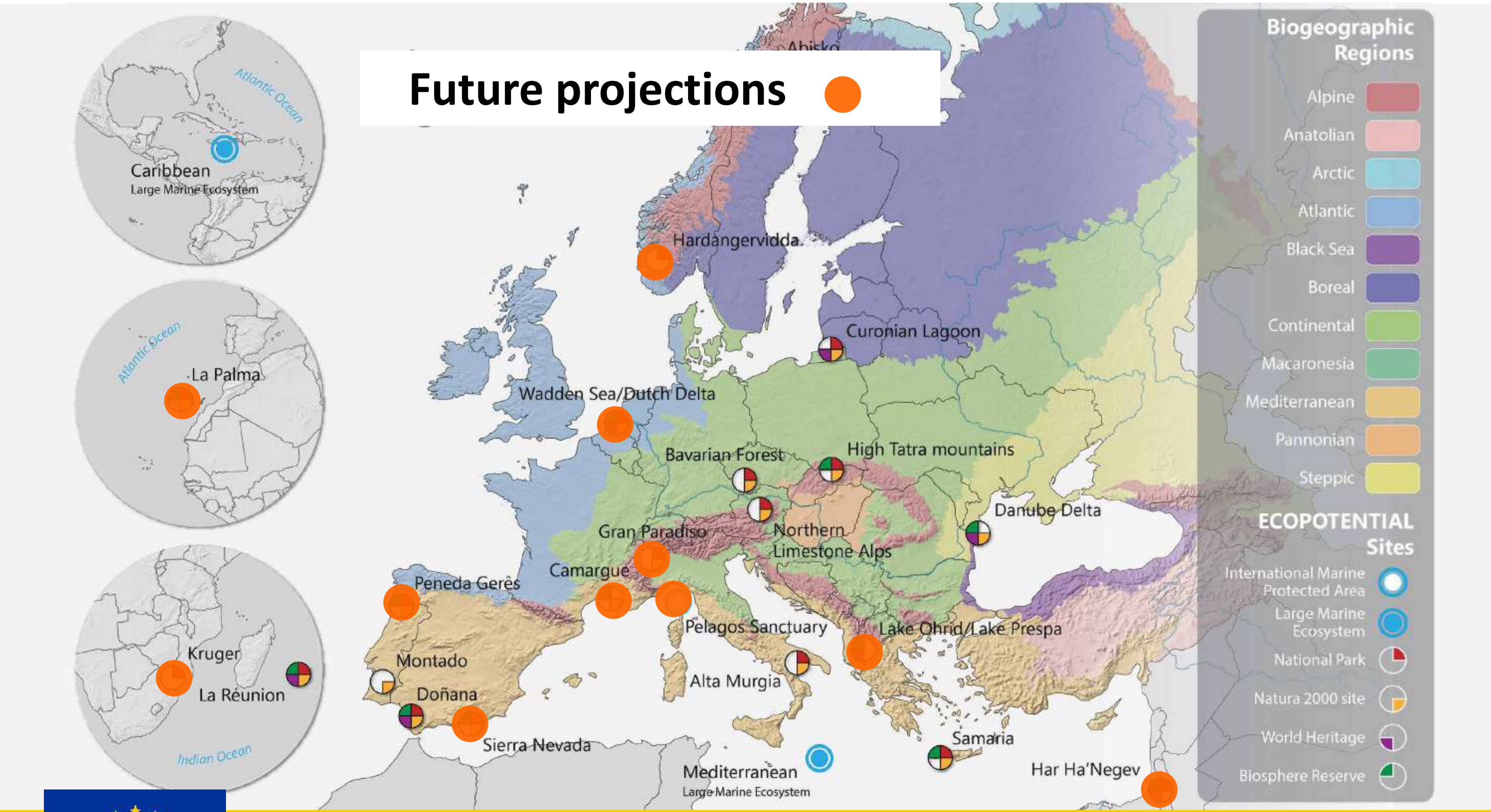
Working in partnership with 23 Protected Areas in Europe and beyond



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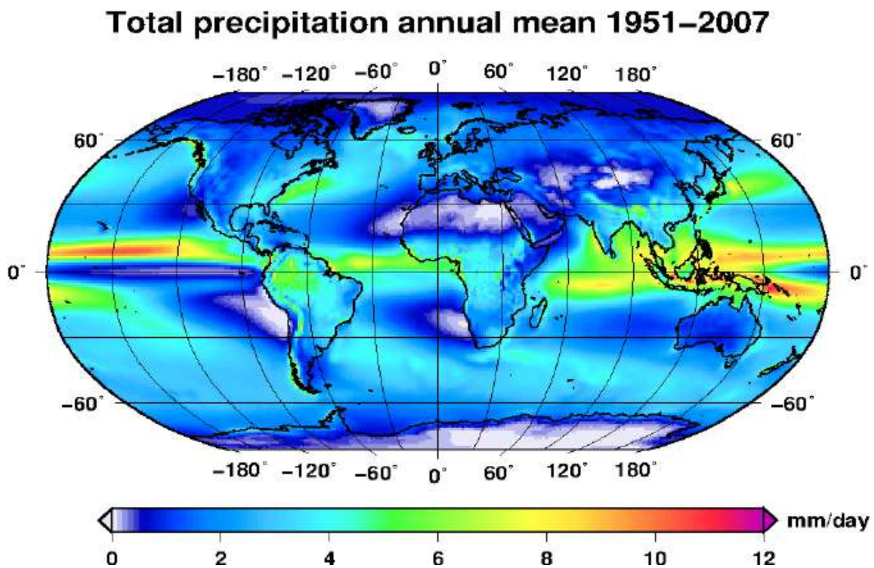
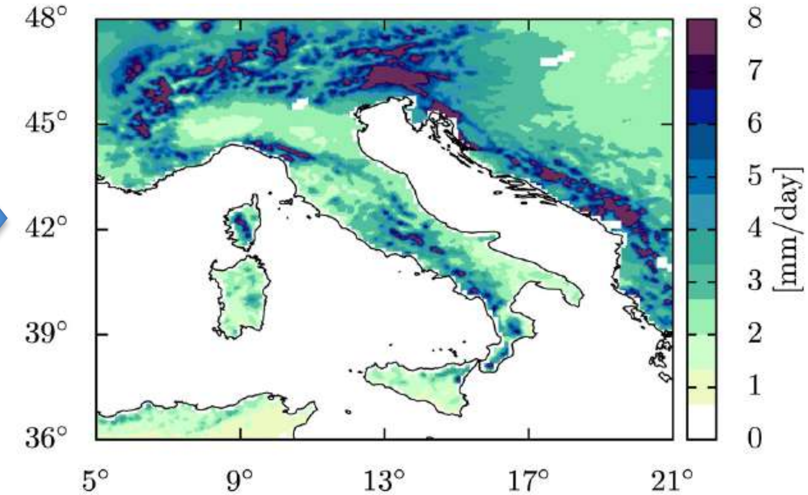
Scale mismatch: the downscaling-impact chain

5 CMIP5 GCMs, RCP4.5, RCP8.5



Euro-CORDEX – 11 km – 5 members



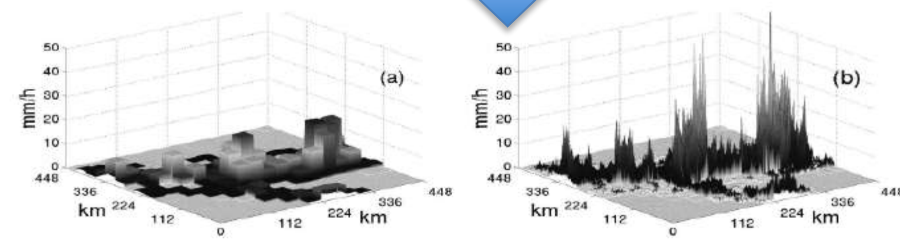


FIG. 10. (a) A snapshot of the forecasted rain field obtained from the LAM forecast and (b) one example of a downscaled field obtained by application of the RainFARM. The vertical scale indicates precipitation intensity (mm h^{-1}) and it is the same for the two fields.

Stochastic downscaling for prec
Interpolation with orography correction for temp

Specific eco models for each PA

PA	Ecosystem function	Model	Variables	Spatial resolution	Temp. resolution
Camargue	marsh hydrology	locally developed hydro model	Precipitation Evapo-transpiration	1 degree obtained by aggregating CORDEX runs at 0.11°	Monthly
Wadden Sea	state of the lower trophic levels of the marine ecosystem	DELFT3D including NPZD	Wind Radiation Precipitation Temperature (air) boundary conditions for the local ocean model	0.11° nominal from CORDEX runs	3 hours
Curonian Lagoon	state of the main trophic levels in the lagoon ecosystem	hydro + NPZD locally developed + ECOSIM	Temperature Precipitation boundary conditions for the local ocean model	0.11° nominal from CORDEX runs	3 hours
Hardanger vidda	reindeer population dynamics; vegetation dynamics	locally developed models	Precipitation Temperature Snow cover	1 km obtained by different downscaling methods 0.11°	daily
Gran Paradiso	Alpine grassland dynamics, ungulate population dynamics	locally developed models + soil models	Precipitation Temperature Snow cover	250 meters from downscaling temperature and precipitation	daily
Gran Paradiso	State of the alpine lake ecosystems	locally developed NPZD models	Precipitation Temperature Snow cover	250 meters from downscaling temperature and precipitation	daily
Gran Paradiso	spatial biodiversity distribution	locally developed model	Temperature	90 meters obtained by downscaling e-Obs from 2006 and/or future scenarios from WorldClim	daily and/or climatology
Kruger	biomass distribution; animal distribution; fires	correlation models	Temperature Precipitation Wind	0.11°	daily
Negev	small-scale dynamics and interaction between geomorph. and vegetation	LPJmL EcoHyd	Temperature Precipitation	5 meters downscaling with the meteo version, active only when it rains	hourly

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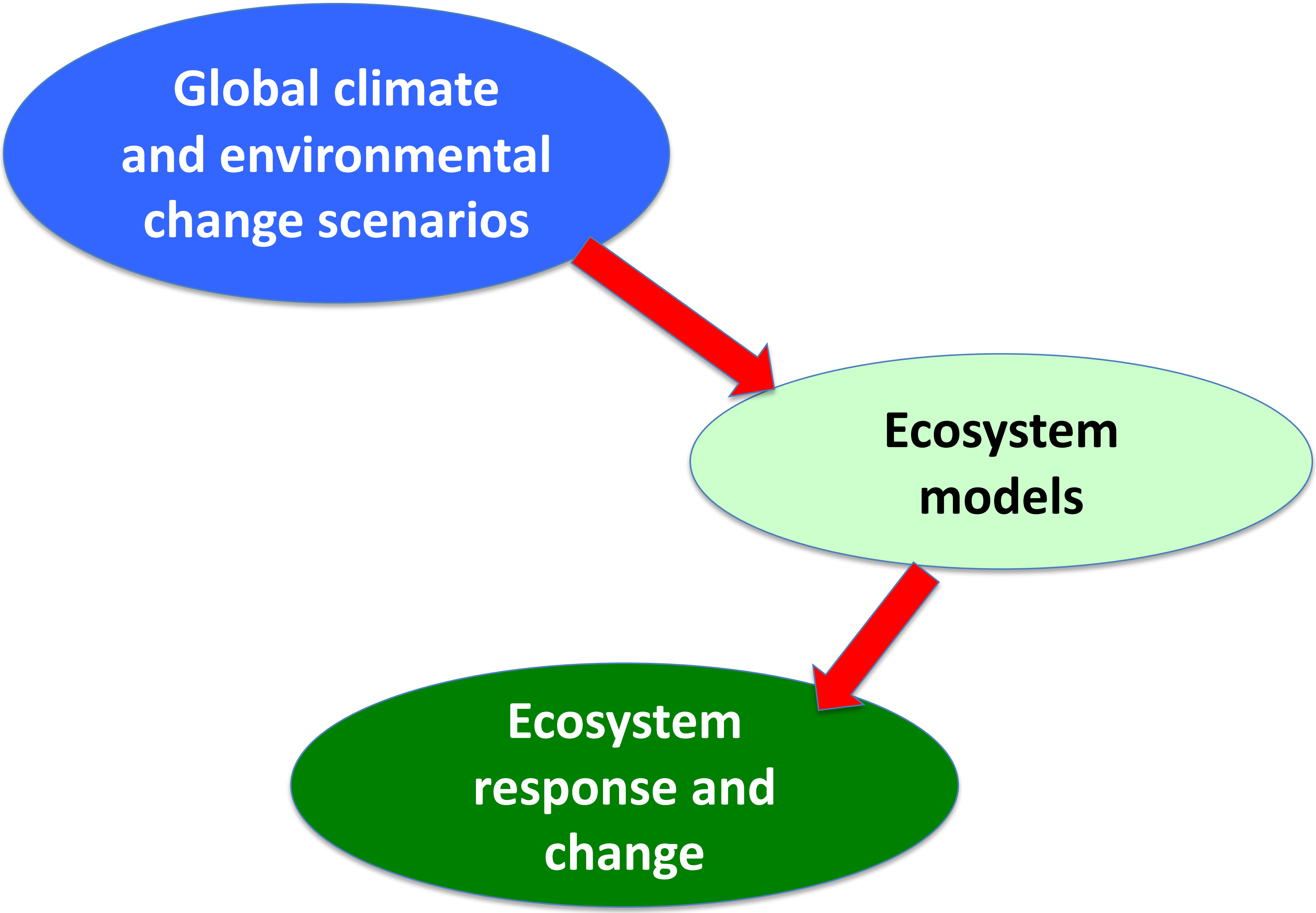
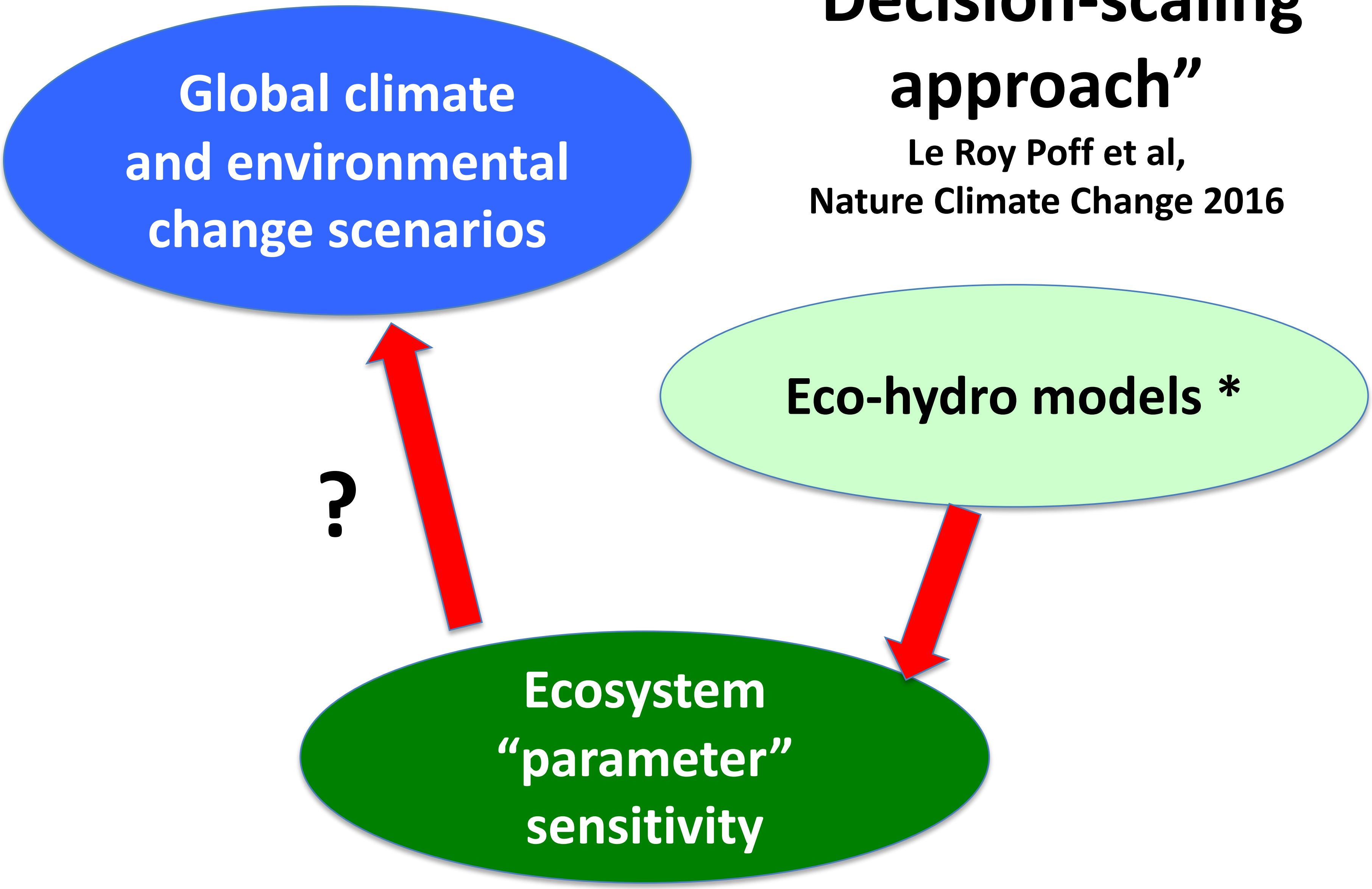

Global climate and environmental change scenarios
Ecosystem models
Ecosystem response and change

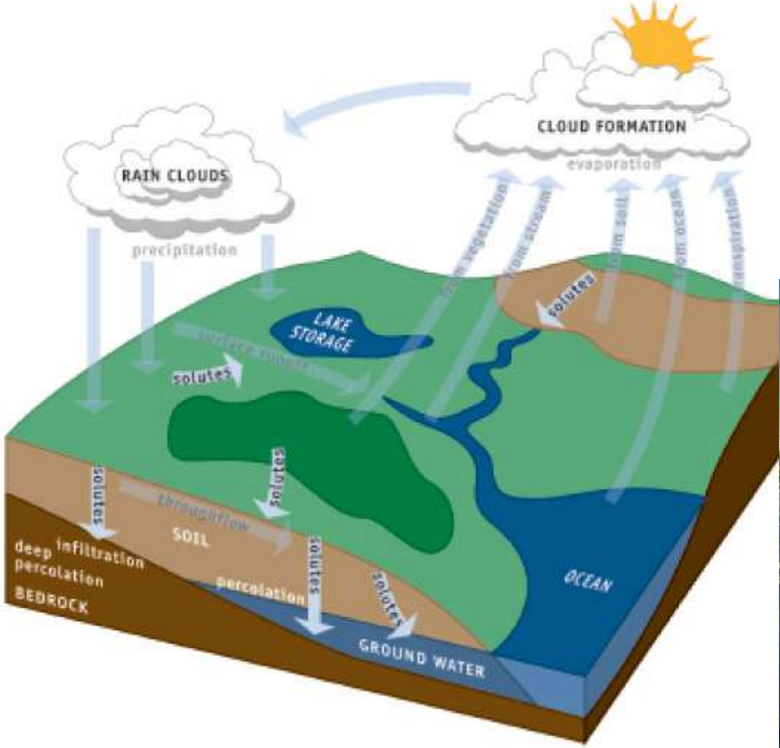
"Decision-scaling approach"

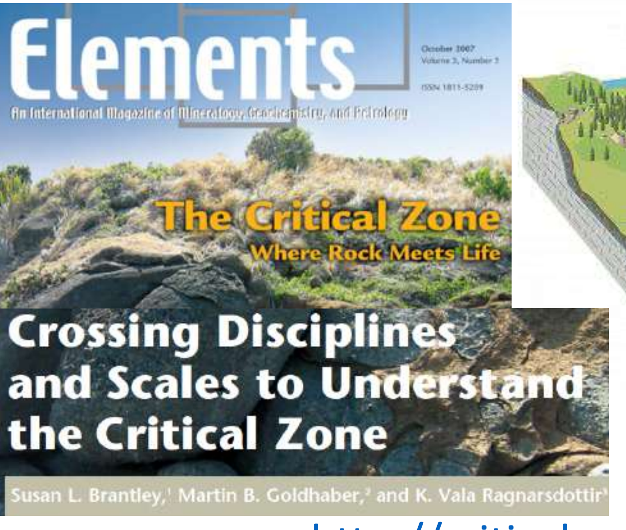
Le Roy Poff et al,
Nature Climate Change 2016

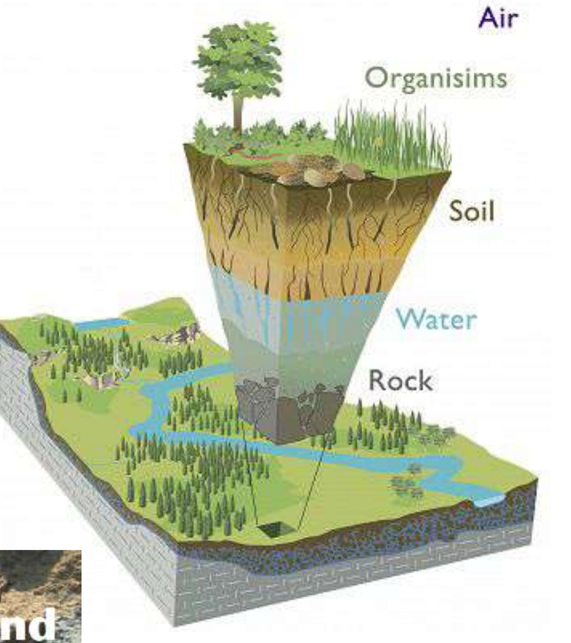


* How to test a eco-hydro model?...

The Earth Living Skin (aka the Earth Critical Zone)



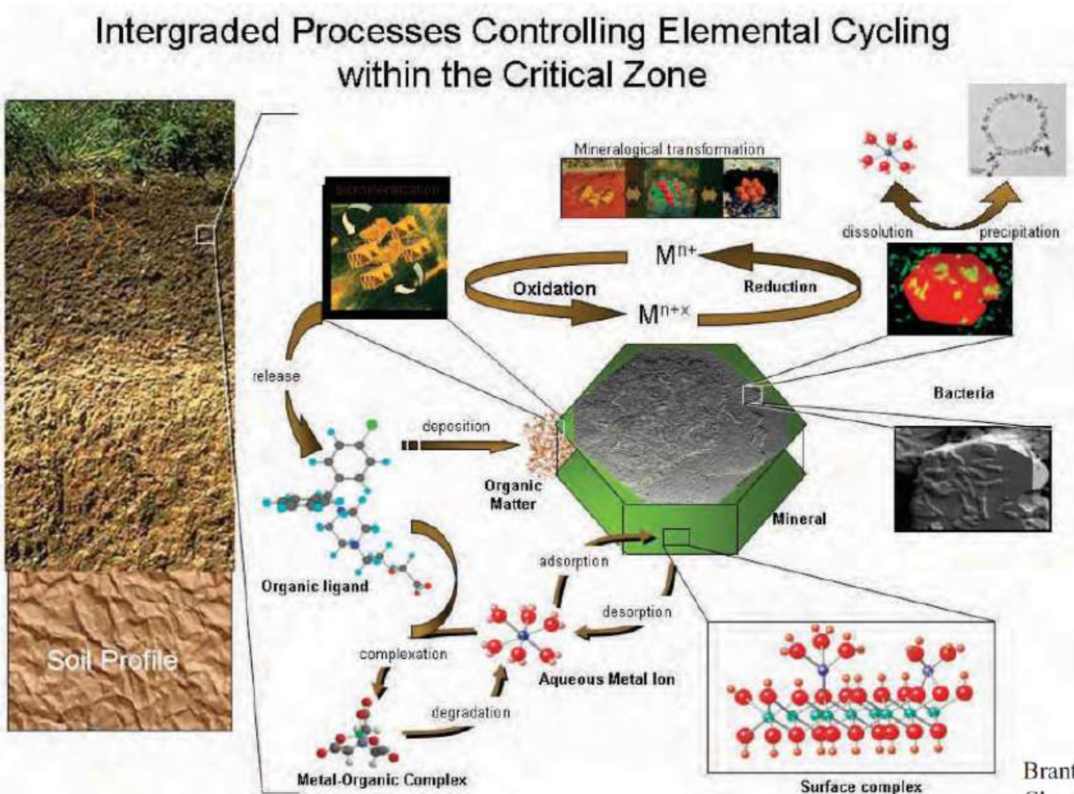




www.czen.org , http://criticalzone.org/national/

The layer between the top of vegetation canopy and the "rocky matrix", where physics, chemistry, hydrology, eco-hydrology, geology and biology closely interact

The Earth Living Skin
(aka the Earth Critical Zone)



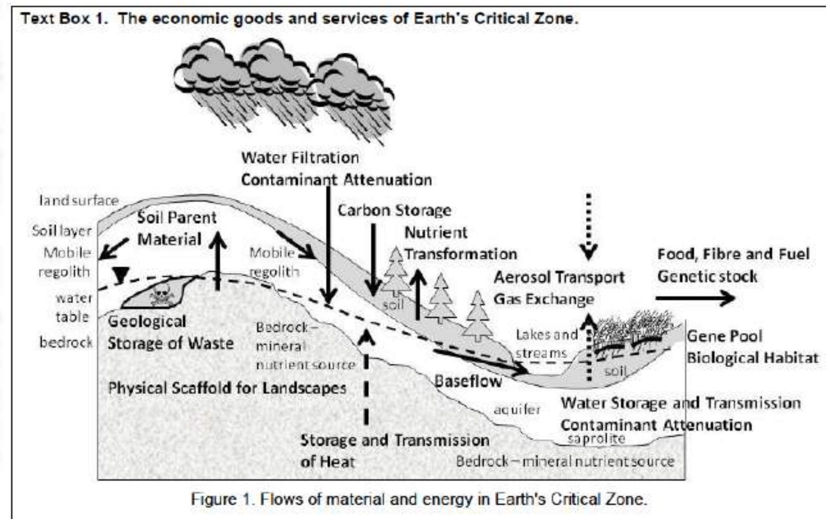


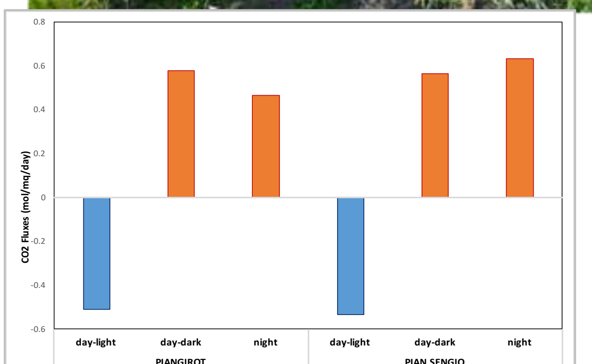
Figure 1. Flows of material and energy in Earth's Critical Zone.

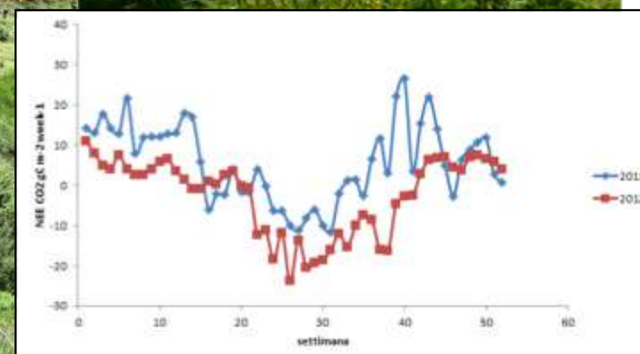
Sustaining Earth's Critical Zone

Brantley, S.L., White, T.S. , White, A.F., Sparks, D., Richter, D., Pregitzer, K., Derry, L., Chorover, J., Chadwick, O., April, R., Anderson, S., Amundson, R., 2006, Frontiers in Exploration of the Critical Zone: Report of a workshop sponsored by the National Science Foundation (NSF), October 24-26, 2005, Newark, DE, 30p.

Biogeochemical cycling
Hydrological cycle
Weathering

Studies of the ECZ at GPNP





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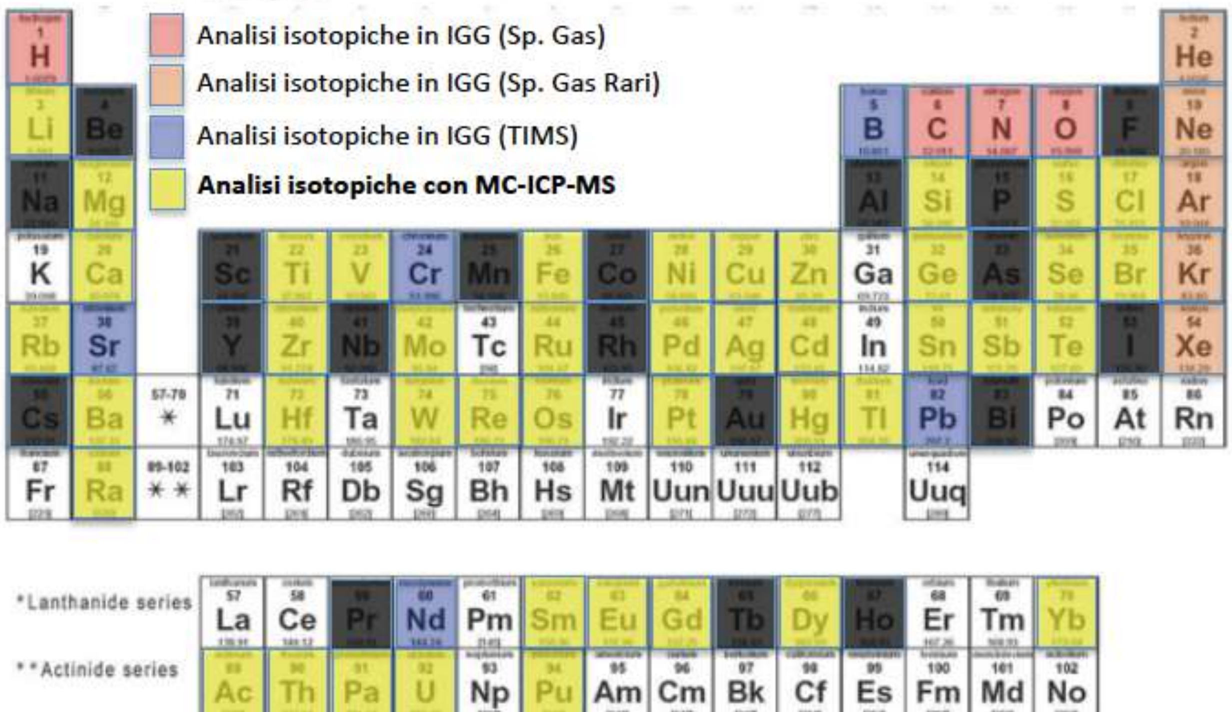
ECRA General Assembly,
7-8 March 2017, Bruxelles, Belgium

MC-ICP-MS


Analisi isotopiche in IGG (Sp. Gas)
Analisi isotopiche in IGG (Sp. Gas Rari)
Analisi isotopiche in IGG (TIMS)
Analisi isotopiche con MC-ICP-MS
*Lanthanide series
**Actinide series

ECOPOTENTIAL contribution to GEO/GEOSS:

GEO ECO – the GEO Global Ecosystem Initiative:

Extend the ECOPOTENTIAL approach at global level

(in particular: long-term changes in Pas)

Telecon on 21 April 2017

Creation of a

GEO Ecosystem Community of Practice:

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Thanks for your attention

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