ECOPOTENTIAL:
Improving future ecosystem benefits through Earth Observations

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

Coordinator: **Antonello Provenzale**
Institute of Geosciences and Earth Resources, National Research Council of Italy

Co-Coordinator: **Carl Beierkuhnlein**
Biogeography, BayCEER, University of Bayreuth, Germany

Project Manager: **Carmela Marangi**
Institute of Applied Mathematics, National Research Council of Italy

External Communication Officer: **Mariasilvia Giamberini**
Institute of Geosciences and Earth Resources, National Research Council of Italy

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SWOS-ECOPOTENTIAL meeting,
16-20 January 2017, Arles+Camargue, France

Università del Salento

EURAC research

CSIC

Helmholtz Zentrum für Umweltforschung UFZ

KIT Karlsruhe Institute of Technology

Universität Bayreuth

DLR

marbec marine biodiversity exploitation & conservation

University of Leeds

Environment Systems

InBIO Research Network Biodiversity and Evolutionary Biology

Técnico Lisboa

FORTH Foundation for Research & Technology - Hellas

EPFL École Polytechnique Fédérale de Lausanne

אוניברסיטת בן-גוריון בנגב Ben-Gurion University of the Negev

CSIR our future through science

ISPRA

Politecnico di Milano

CREAF

UAB Universitat Autònoma de Barcelona

ugr Universidad de Granada

NIOZ

umweltbundesamt

Starlab Living Science

museum für naturkunde berlin

Tour du Valat

Deltares

Aratos Technologies

iDiv German Centre for Integrative Biodiversity Research (iDiv) Halle-Jena-Leipzig

CESBIO

UNESCO

LSE The London School of Economics and Political Science

Universitas Bergensis

terradue 2.0

UNEP

UNSW Australia | Science

ETH zürich

Environmental and Water Agency of Andalusia

Regional Ministry of Environment and Spatial Planning

UBO université de bretagne occidentale

Université de Genève

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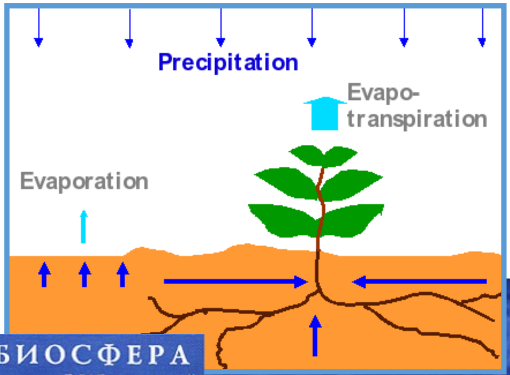
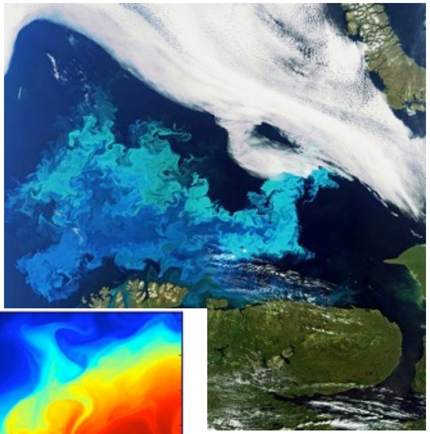
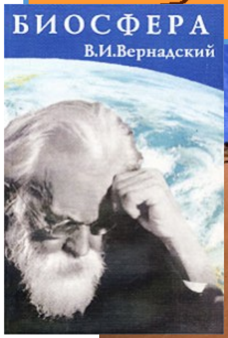
ECOPOTENTIAL

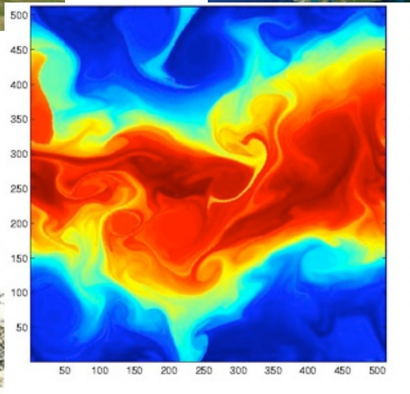
ECOPOTENTIAL: “back to the future”

In ECOPOTENTIAL, ecosystems are seen as “one physical system” with their environment, with strong geosphere-biosphere interactions









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*SWOS-ECOPOTENTIAL meeting,
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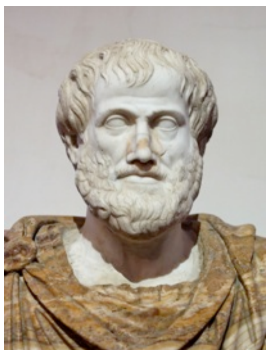
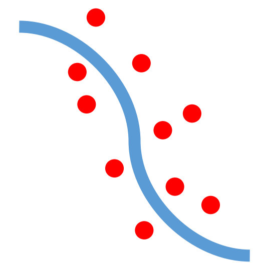
ECOPOTENTIAL: role of Essential Variables

A critical analysis of the meaning and role of Essential Variables for Ecosystems:



Hypokeimenon
Symbebekòs

Essential Biodiversity Variables
Essential Climate Variables
Essential Ocean Variables
...



dimensional reduction
slow manifold

Which ones can be used, how can be extended
What EVs are "more common" than others

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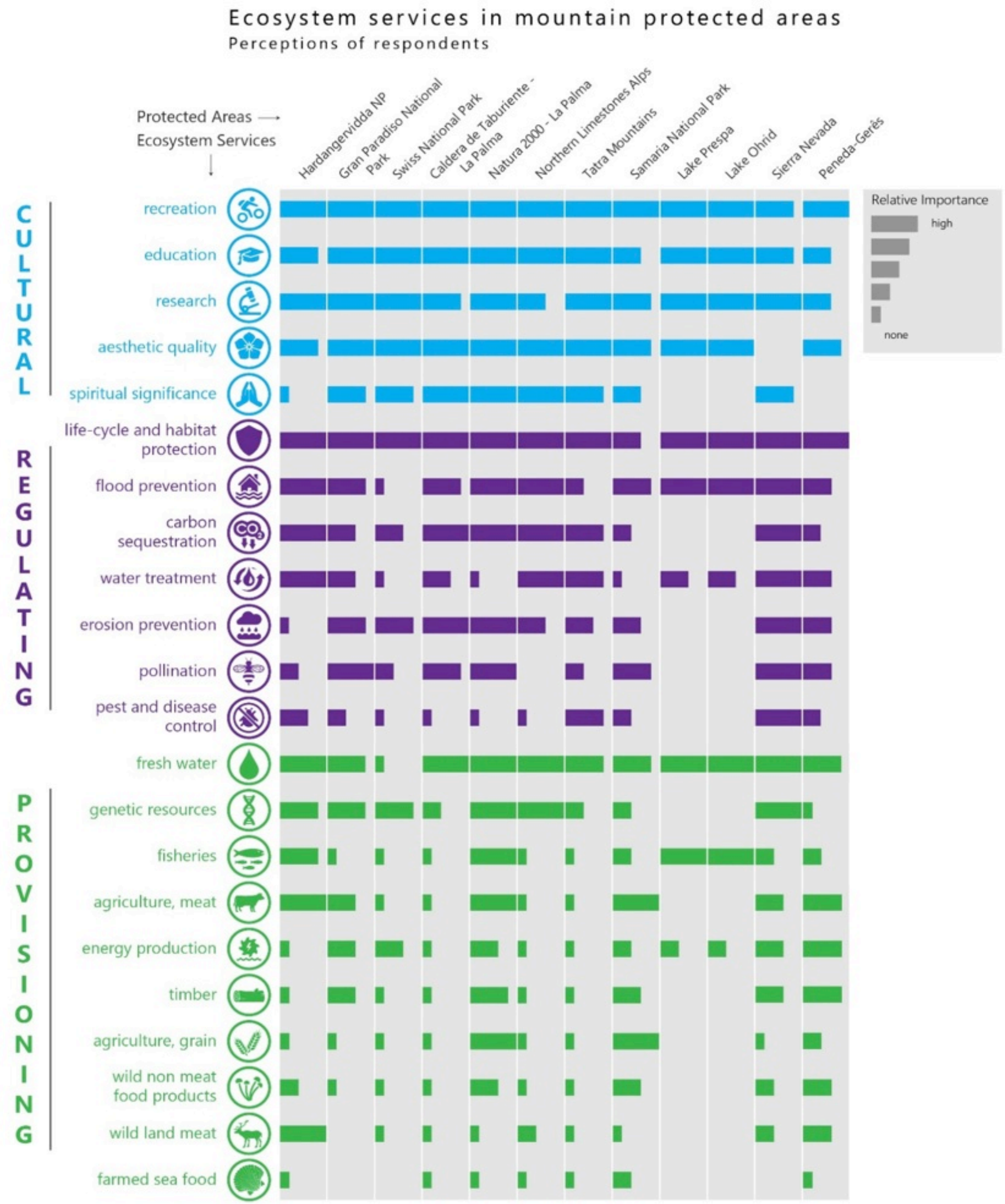
Results of the questionnaire sent to PA managers/staff with the collaboration of ECOPOTENTIAL partners working in each PA



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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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ECOPOTENTIAL workshop
with researchers and PA staff
San Rossore Natural Park (Pisa), 2-5 May 2017

- **Main goals:**
  - Inform PA participants about the tools in development in ECOPOTENTIAL
  - Collect information about how to tailor tools and capacity building to suit PA needs
  - Develop a Community of Practice across Europe and beyond on the use of EO tools and the ES approach for PAs
- **Main topics covered by workshops:**
  - Analysis and application of in-situ monitoring data
  - Use and interpretation of Remote Sensing products
  - Modelling ecosystems, ecosystem functions and services
  - Citizen science activities in PAs
  - Virtual Lab Platform

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ECOPOTENTIAL

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Working in partnership with 23 Protected Areas in Europe and beyond

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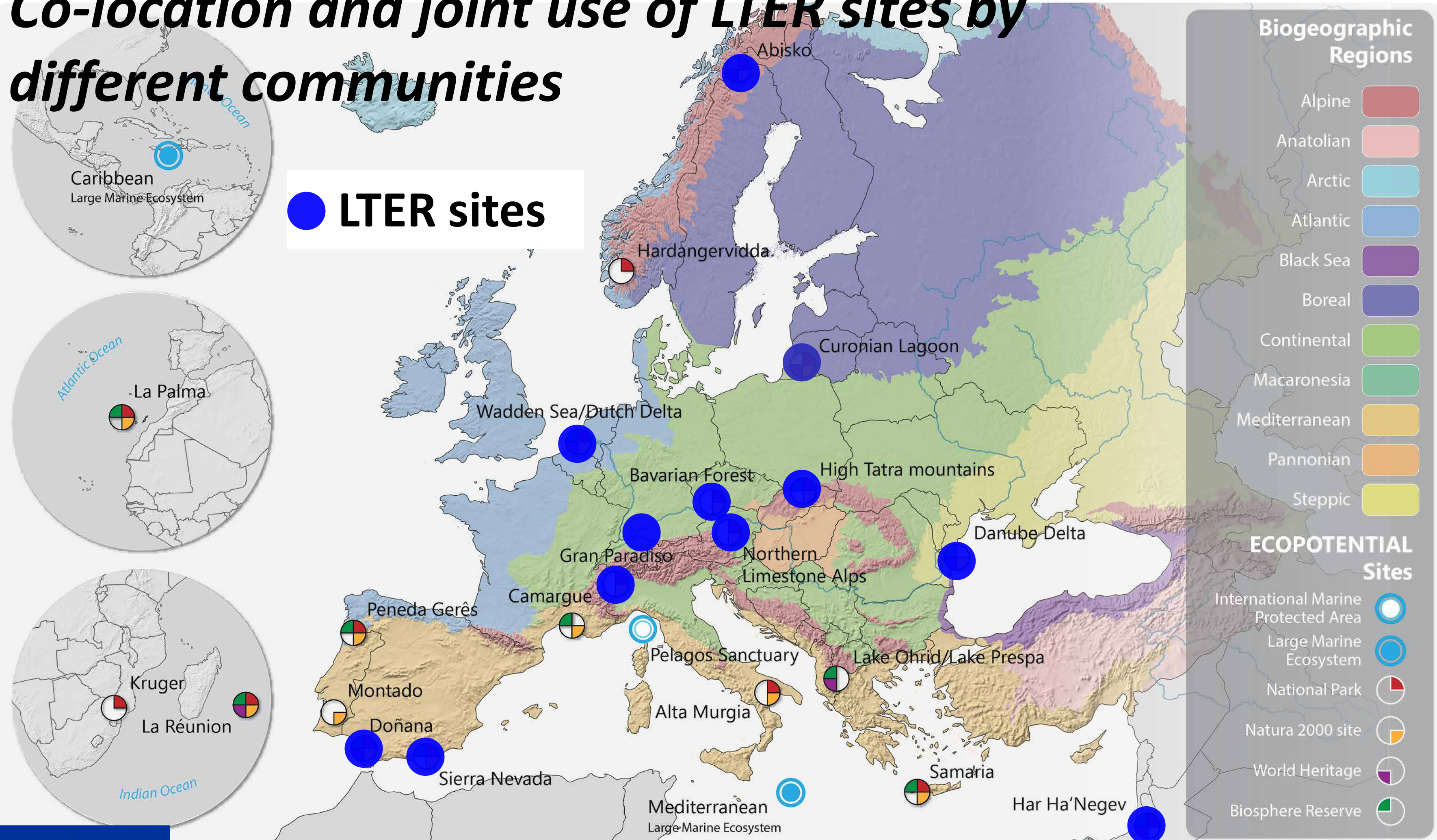
Working in partnership with 23 Protected Areas in Europe and beyond

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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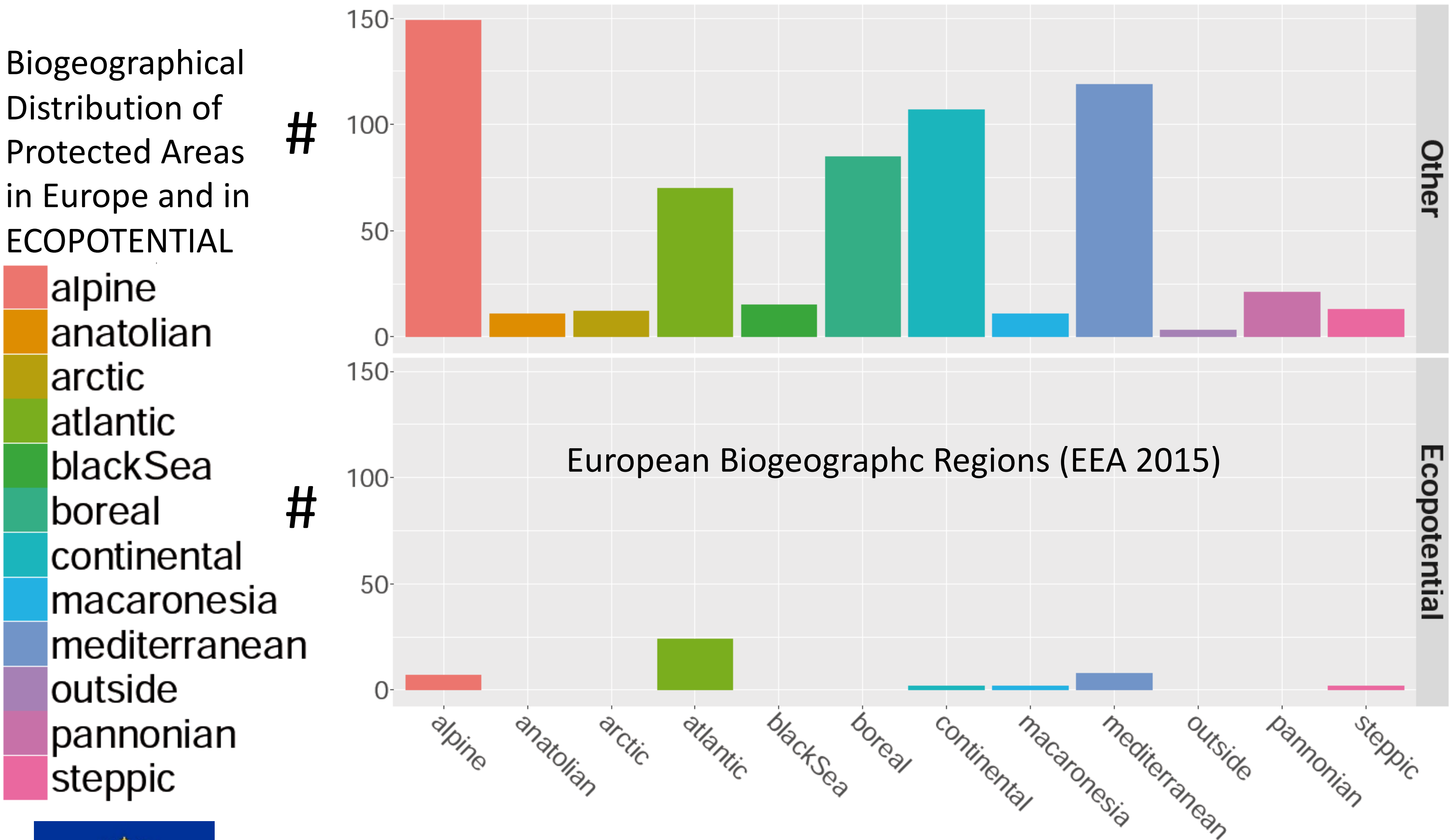
PAs and Biogeography

Biogeographical Distribution of Protected Areas in Europe and in ECOPOTENTIAL



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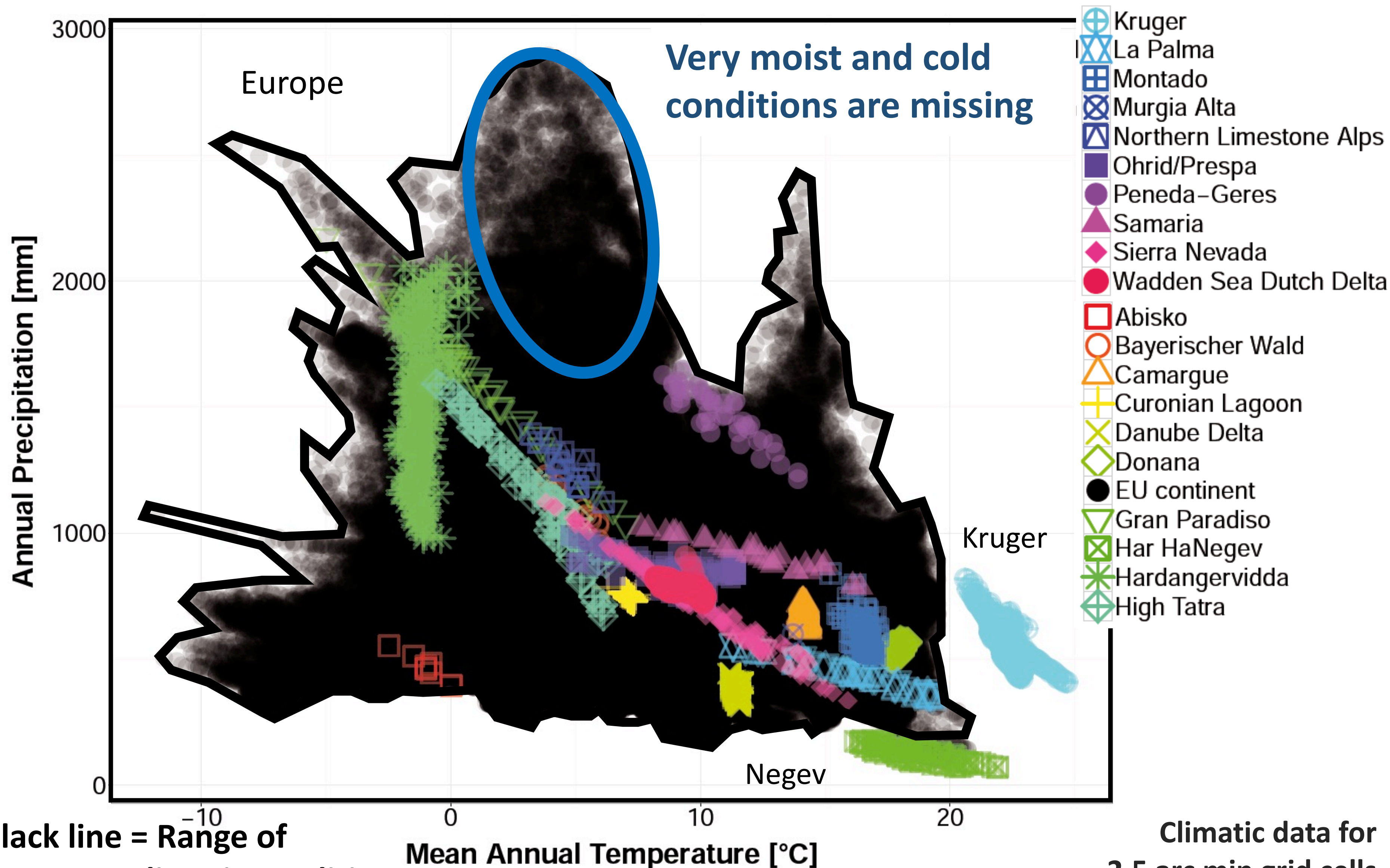
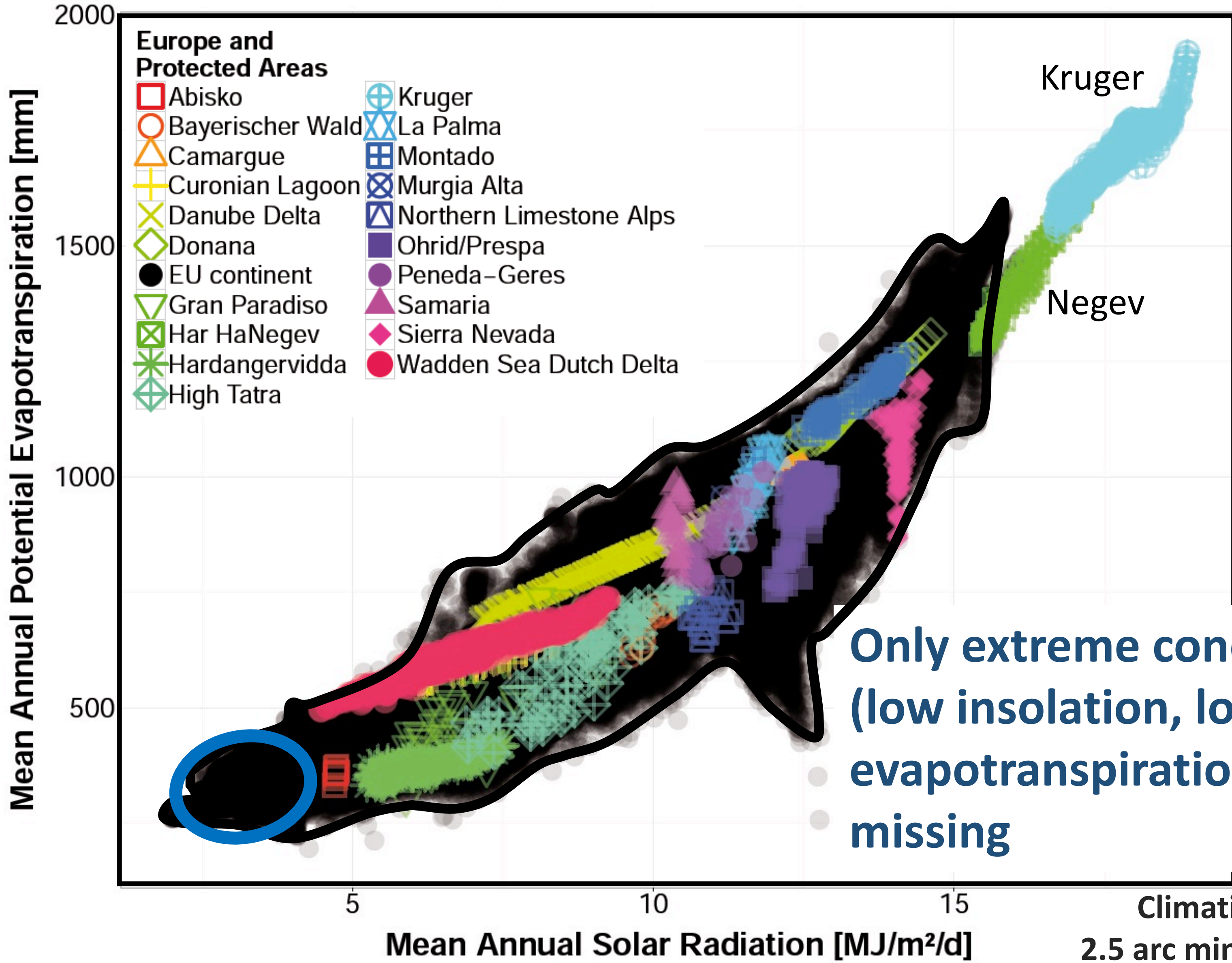
ECOPOTENTIAL and climate



Black line = Range of European climatic conditions

Climatic data for 2.5 arc min grid cells

ECOPOTENTIAL and climate



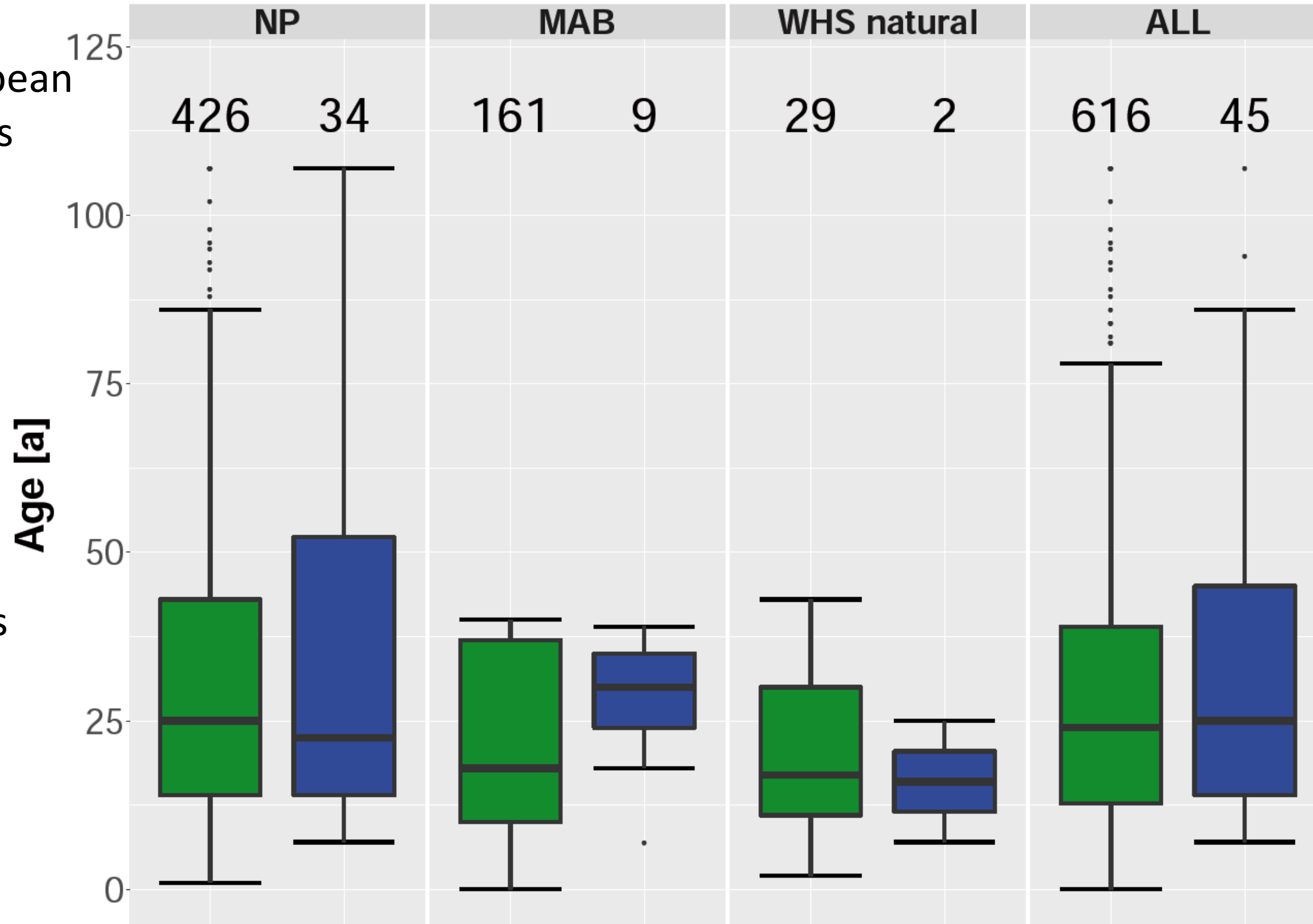
Only extreme conditions (low insolation, low evapotranspiration) missing

Climatic data for 2.5 arc min grid cells

Time since Establishment

All Large European Protected Areas

ECOPOTENTIAL sites



Age distribution of Pas in Europe and within ECOPOTENTIAL.
Note that some sites include several PAs.

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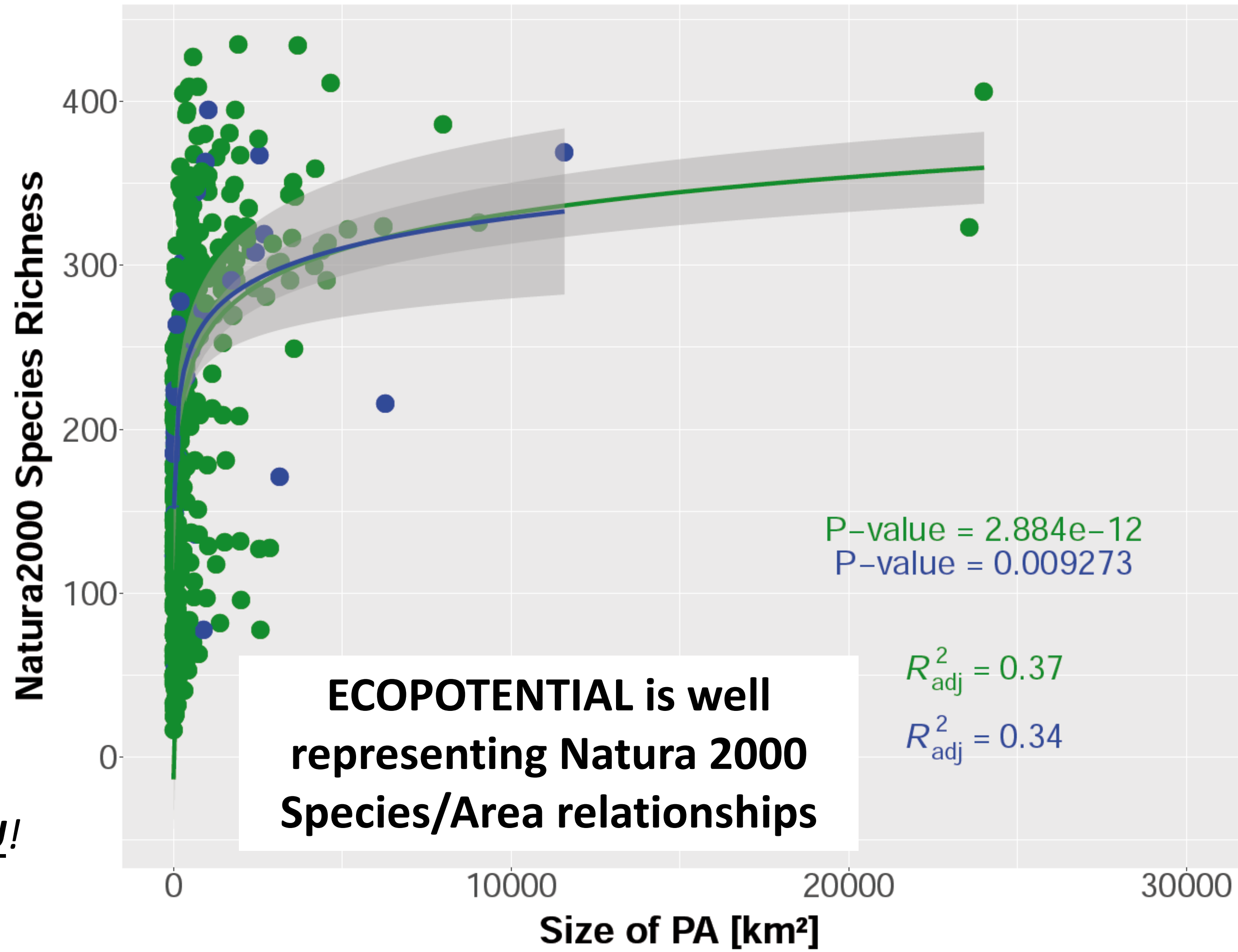
Protected Areas and diversity

All Large European Protected Areas

ECOPOTENTIAL sites



Only species with a legal status that need to be reported to the <u>EU</u>!

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ECOPOTENTIAL PAs:

- European Protected Areas form a dense network!
- Priority Areas can be identified!
- **ECOPOTENTIAL establishes a representative selection of sites in terms of diversity, climate, age etc.**
- **ECOPOTENTIAL sites serve as future observatories with intense implementation of Earth Observation in face of environmental changes**

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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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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	field, LiDAR and SAR empirical techniques [Mathieu et al. 2013, Naidoo et al. 2014] (M)

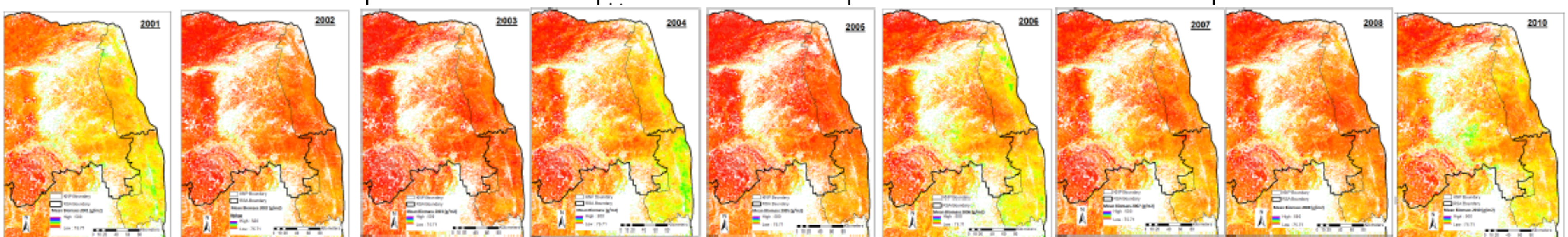
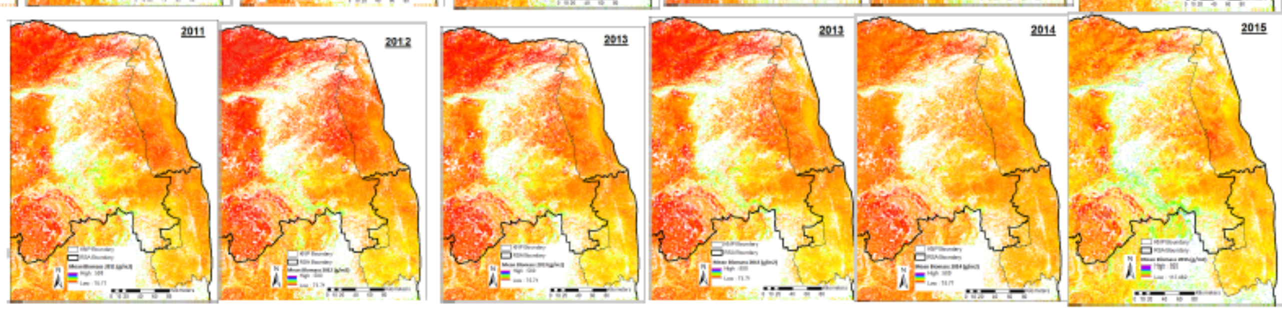


Figure 2: Time series of mean annual biomass data based on 500m spatial resolution MODIS data (2001 – 2015).



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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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Remote Sensing products developed in ECOPOTENTIAL: first 18 months

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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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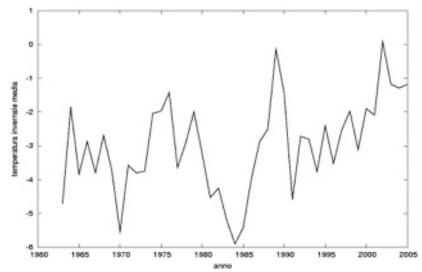
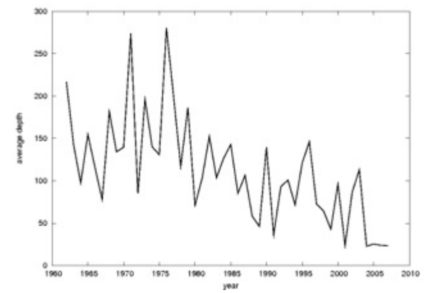
Example of PA changes: the Gran Paradiso National Park

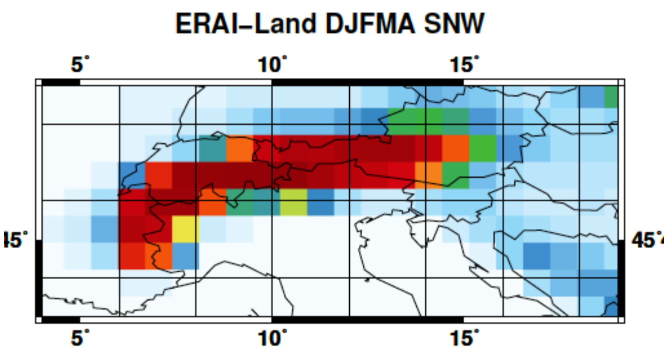
Gridded meteo-climatic datasets
E-OBS: 0.25°, EURO4M: 0.05° (only prec)
HISTALP, OI (Piedmont): 0125°

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



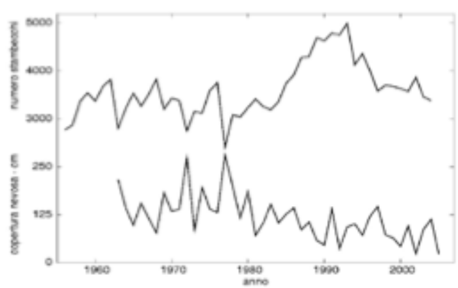


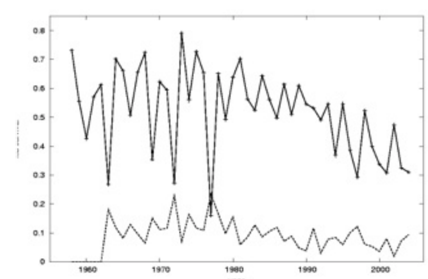


Water/carbon fluxes and phenology
eddy covariance
flux chambers

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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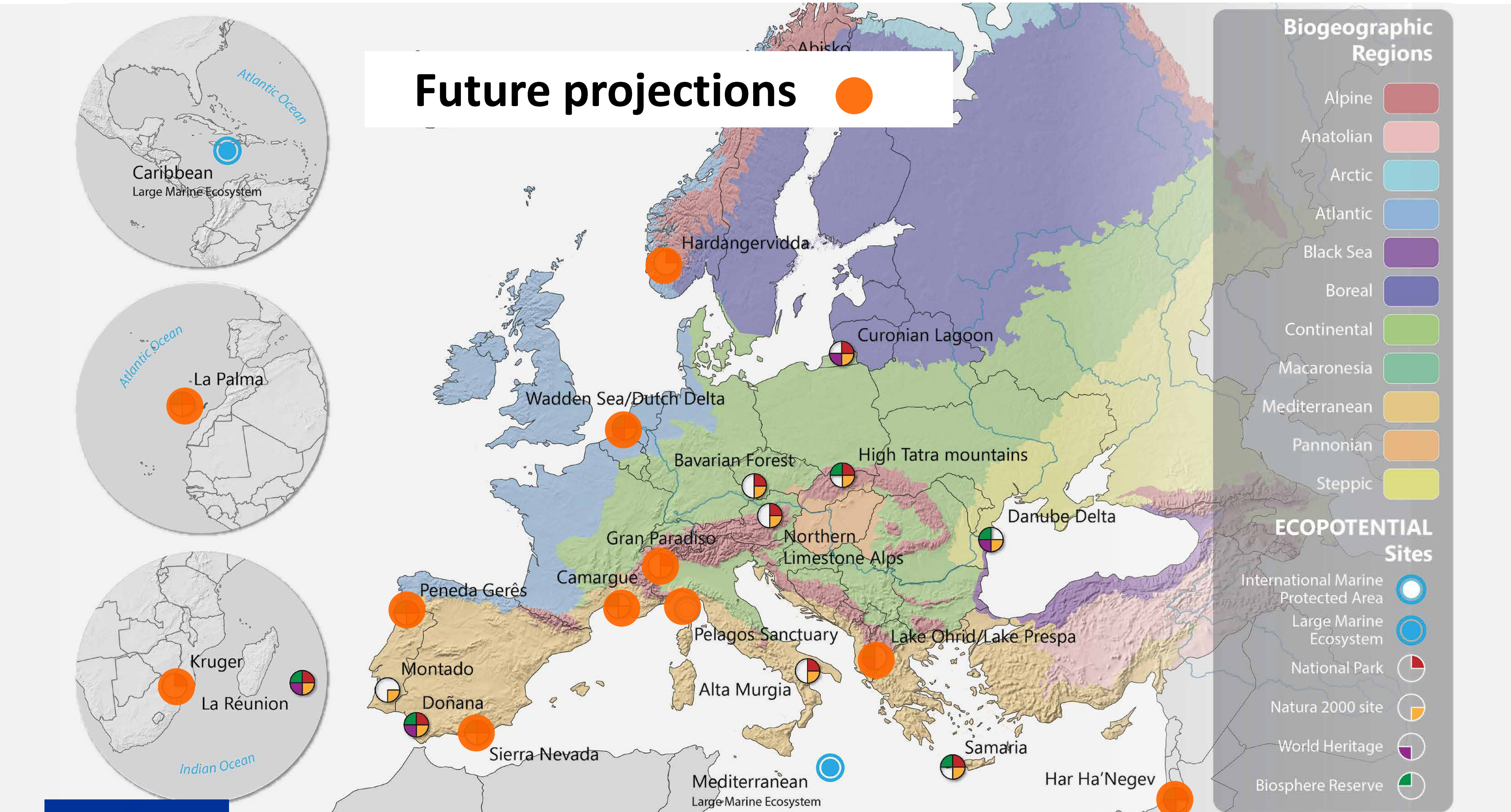
Working in partnership with 23 Protected Areas in Europe and beyond



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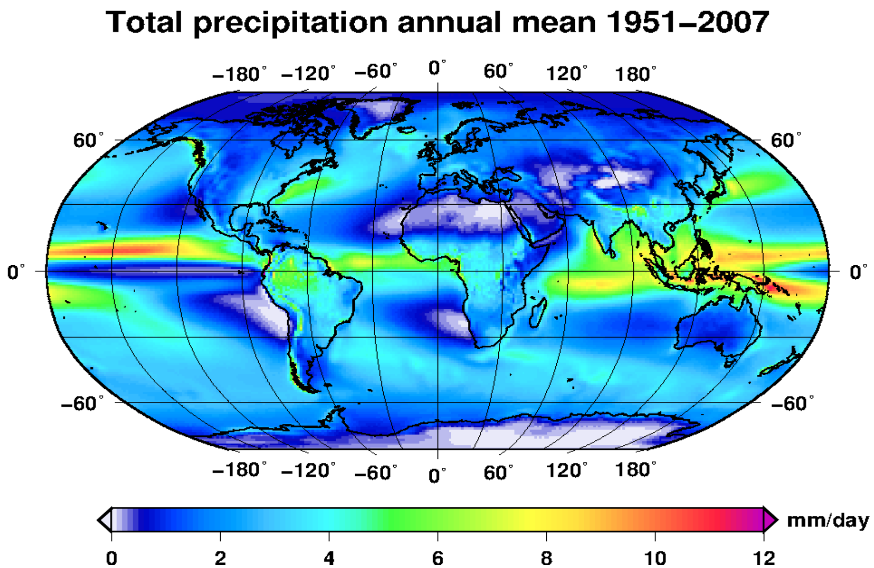
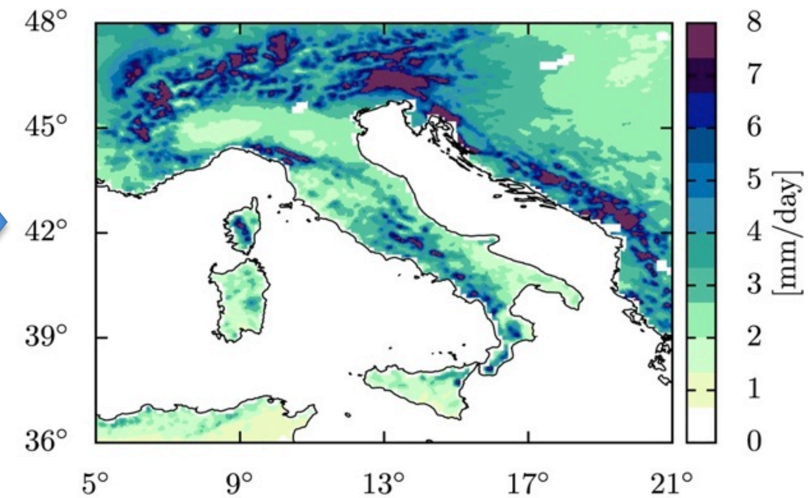
Scale mismatch: the downscaling-impact chain

GLOBAL CLIMATE MODEL



REGIONAL CLIMATE MODELS



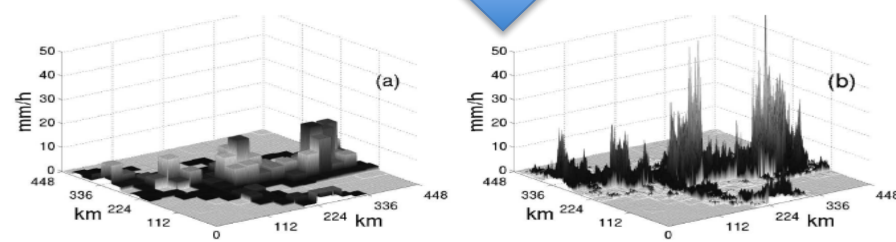


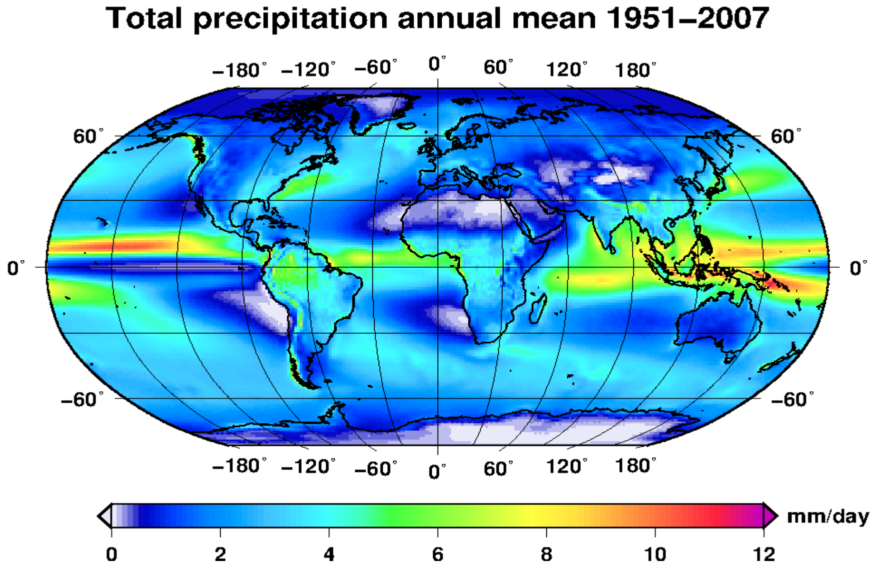
FIG. 10. (a) A snapshot of the forecasted rain field obtained from the LAM forecast and (b) one example of a downscaled field obtained by application of the RainFARM. The vertical scale indicates precipitation intensity (mm h^{-1}) and it is the same for the two fields.

STOCHASTIC / STATISTICAL DOWNSCALING

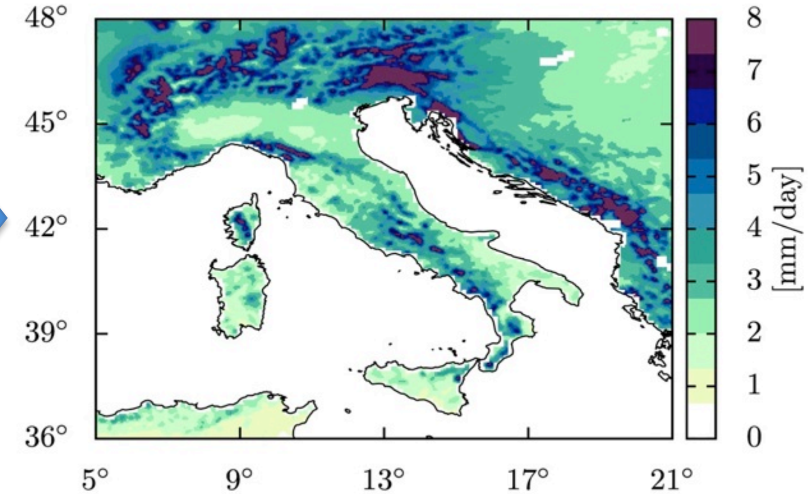
ECO-HYDROLOGICAL MODELS

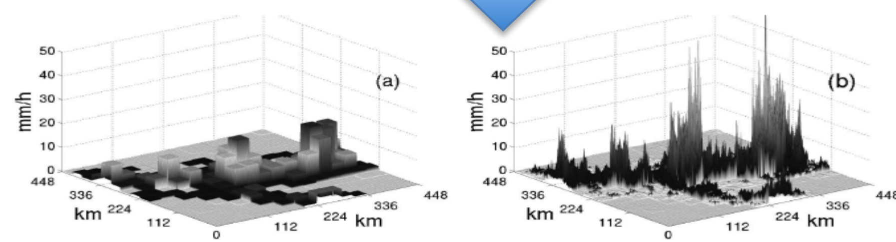
Scale mismatch: the downscaling-impact chain

5 CMIP5 GCMs, RCP4.5, RCP8.5



Euro-CORDEX – 11 km – 5 members





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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 (Precipitation, Temperature) 0.11° (Snow cover)	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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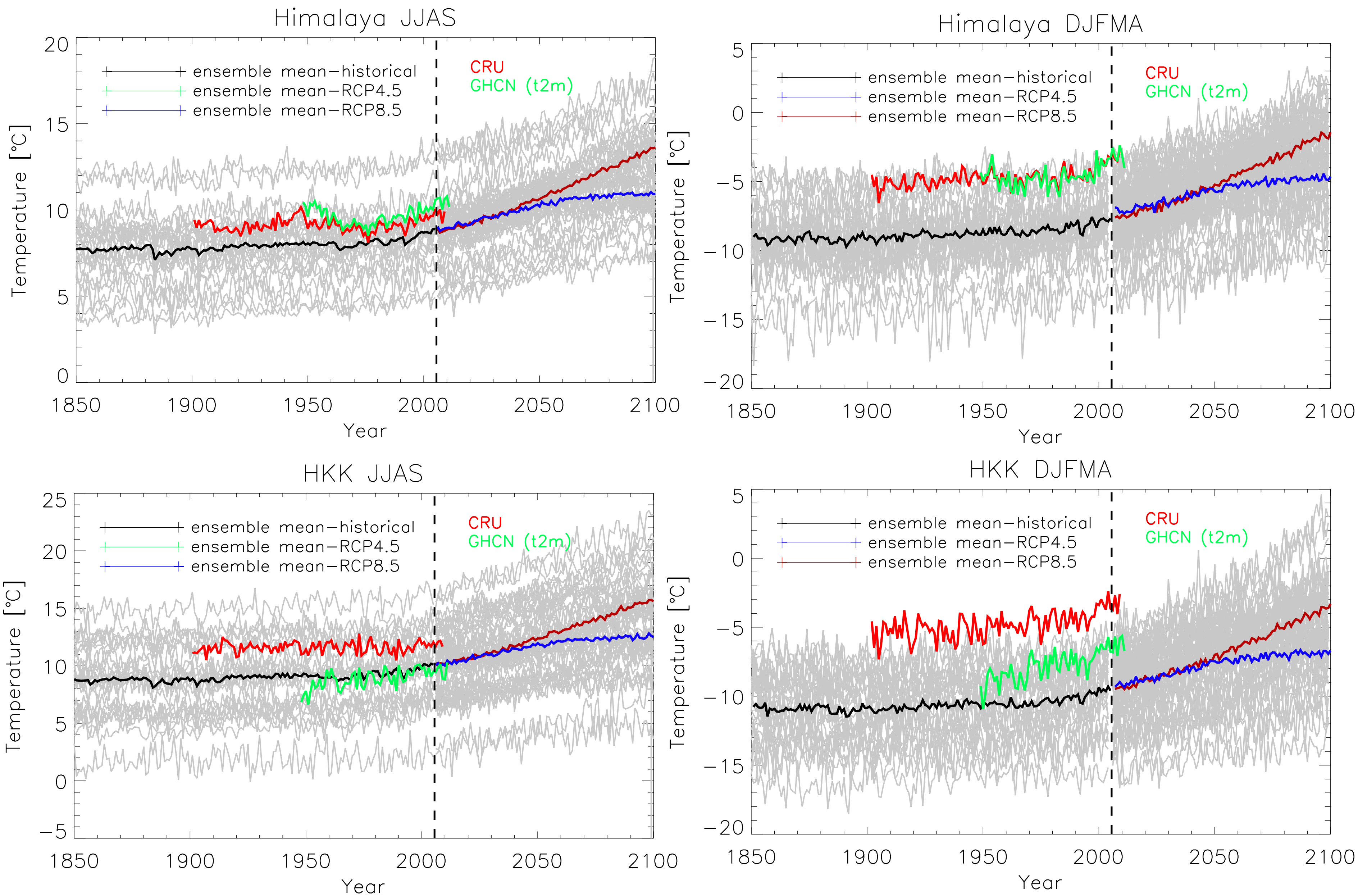
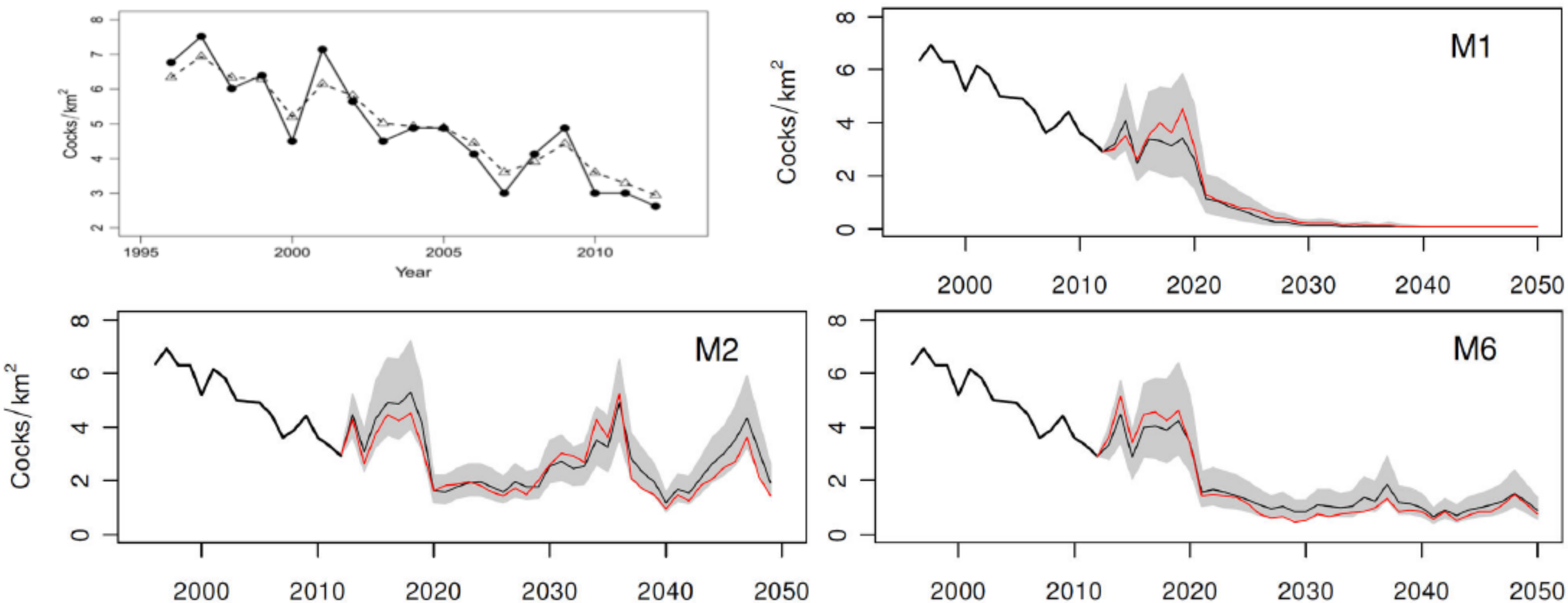
Sources of uncertainty: the spread of CMIP5 temperatures



Statistical uncertainties in ecological models



Model	Intercept	lnN_{t-1}	lnN_{t-2}	SE_{t-1}	SS_{t-1}	SP_t	$T(July)_{t-1}$	$P(July)_{t-1}$	$T(Jan\text{-}Mar)_t$	$T(Apr\text{-}May)_t$	var.	R^2	AICc
M1	-0.07±0.04			**-0.19±0.04**	**-0.18±0.04**						2	0.78	-50.53
M2	0.34±0.24		-0.25±0.14	**-0.19±0.04**	**-0.19±0.04**						3	0.83	-50.20
M3	-0.07±0.04			**-0.19±0.04**	**-0.18±0.04**			0.05±0.03			3	0.82	-49.28
M4	-0.07±0.04			**-0.19±0.04**	**-0.17±0.04**		-0.05±0.04				3	0.81	-48.51
M5	-0.07±0.04			**-0.20±0.04**	**-0.18±0.04**				-0.03±0.04		3	0.79	-47.28
M6	0.08±0.26	-0.10±0.16		**-0.18±0.04**	**-0.17±0.04**						3	0.78	-46.98

Simona Imperio, Radames Bionda, Ramona Viterbi, Antonello Provenzale,
Alpine Rock Ptarmigan, PLOS One, 2013

ECOPOTENTIAL conceptual threads

- Addressing the **scale mismatch** between climate projections and ecosystem response (downscaling and upscaling)
- Propagation and estimate of **uncertainties** in ecosystem projections
- **Data assimilation** in ecological models
- Role of changing **climate extremes** and driver intermittency
- The interplay of **geomorphology and ecosystem dynamics**
- How are PAs **identified and selected**

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

Uncertainty and data assimilation

Requirements of future protected areas

Dissemination activities

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Links with other projects

and perspectives

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GEO
GROUP ON
EARTH OBSERVATIONS

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)

- GEO-GNOME: the GEO Network on Observations and information in Mountain Environments

- GEO BON: the GEO Biodiversity Observation Network

- Creation of a GEO Ecosystem Community of Practice

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The ECOPOTENTIAL Virtual Laboratory Platform

a significant contribution to GEOSS

as an interoperable system of virtual laboratories

and data/products/results/information portal

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Links with other EU projects/infrastructures:

- SWOS
- EU-BON
- LifeWatch
- European LTER
- Volcanic Supersites (GEO/GEOSS and EU)

ECRA: European Climate Research Alliance

Belmont Forum: CRA “Mountains as sentinels of change”

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Interaction with the US Community:

ECOPOTENTIAL – LIFE meeting

(LIFE: Linked Institutions for Future Earth)

UCI Irvine, November 2016:

- **Upscaling of local information**
- **Future projections based on a bottom-up approach**

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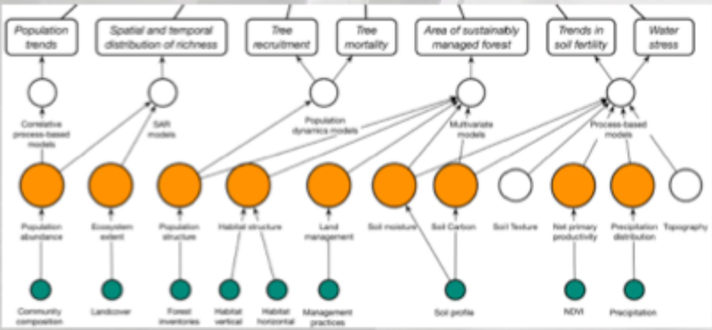
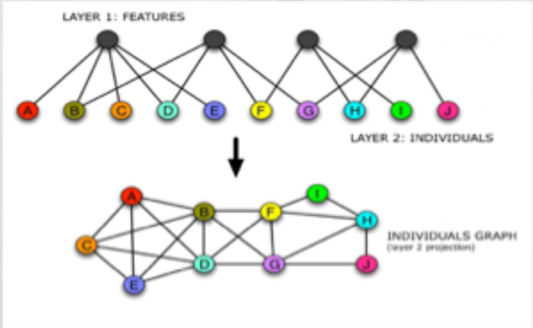
Perspectives on cross-scale analysis (beyond individual PAs)

- **Continental-scale Vegetation / Land Cover models**
- **Similarities and dissimilarities between PAs**

- EBVs

- Complex Network Analysis for PA changes





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Perspectives on cross-scale analysis (beyond individual PAs)

Connectivity in the Ocean

- **LME Mediterranean**

(transport barriers, fish larvae)

- **LME Caribbean – Gulf of Mexico**

(diversity and conservation of deep-water corals)

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Perspectives on cross-scale analysis (beyond individual PAs)

The Earth Critical Zone:

Cross-scale from sub-mm to global

Start a network of CZ sites in Europe:

GPNP, Sierra Nevada, Negev, …

(volcanic supersites: Etna)

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SWOS-ECOPOTENTIAL meeting,
16-20 January 2017, Arles+Camargue, France