Geosphere-biosphere-hydrosphere interactions in the earth critical zone

lessons from European Protected Areas and the H2020 ECOPOTENTIAL project

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

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

GBH interactions: “back to the future”

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

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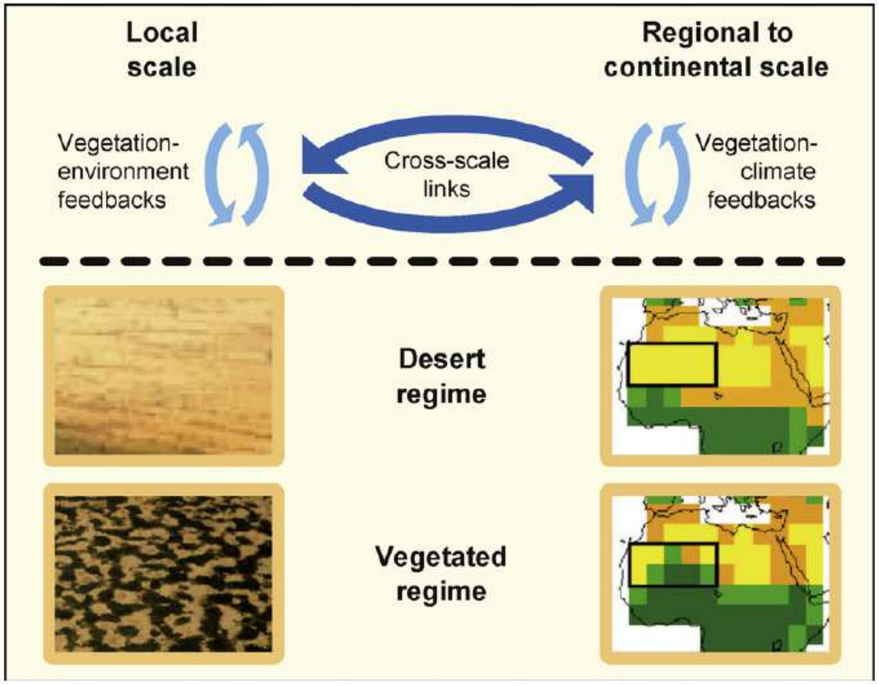
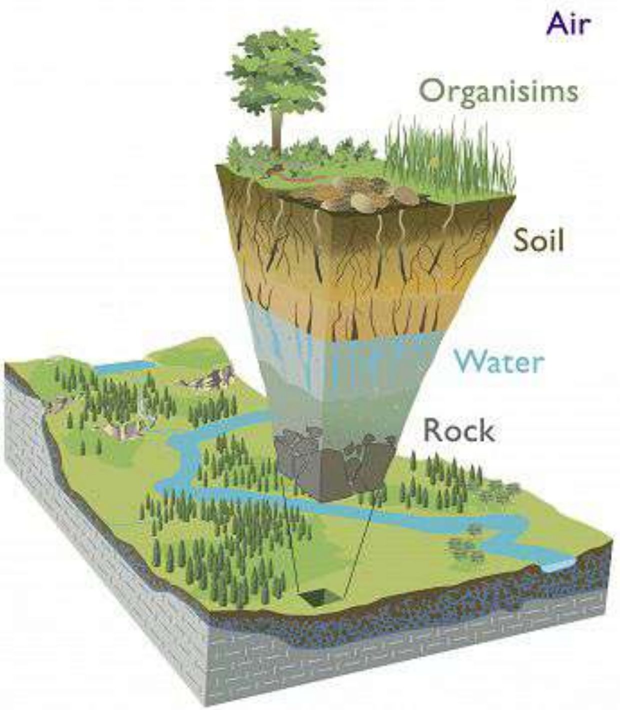
The Earth Living Skin (aka the Earth Critical Zone)





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

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ECOPOTENTIAL: Improving future ecosystem benefits through Earth Observations

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

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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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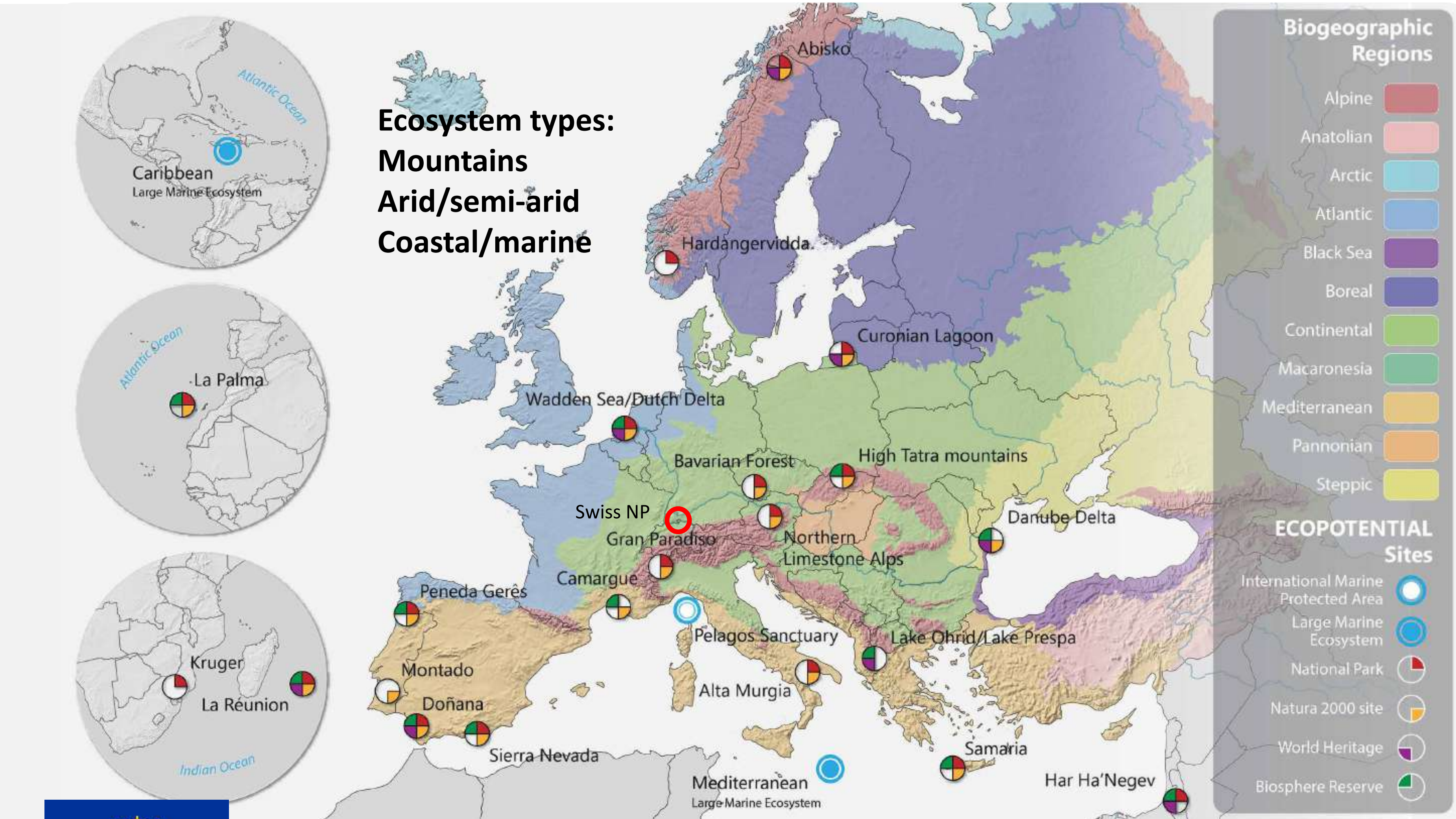
Working in partnership with 23 Protected Areas in Europe and beyond

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



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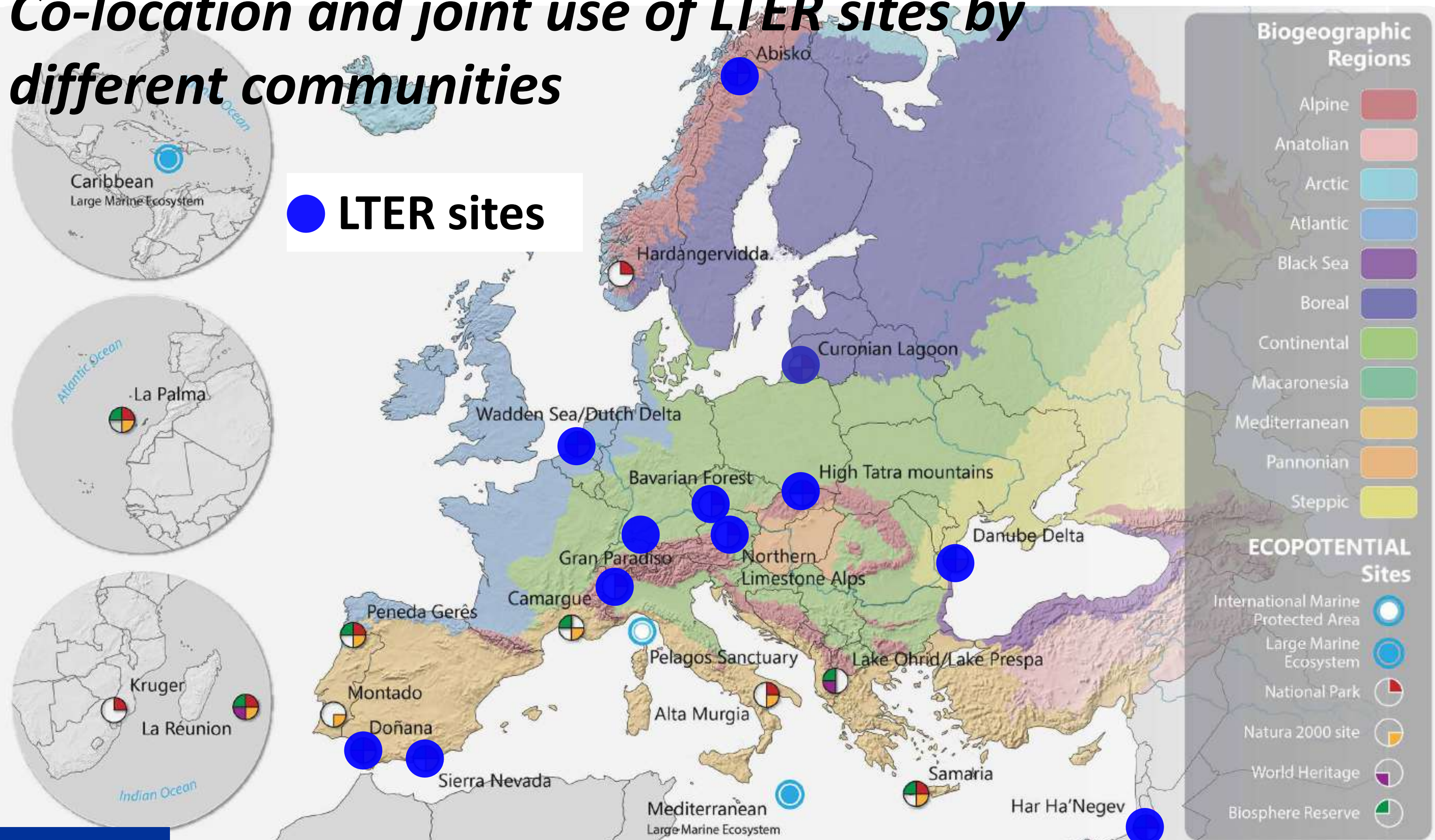
Co-location and joint use of LTER sites by different communities



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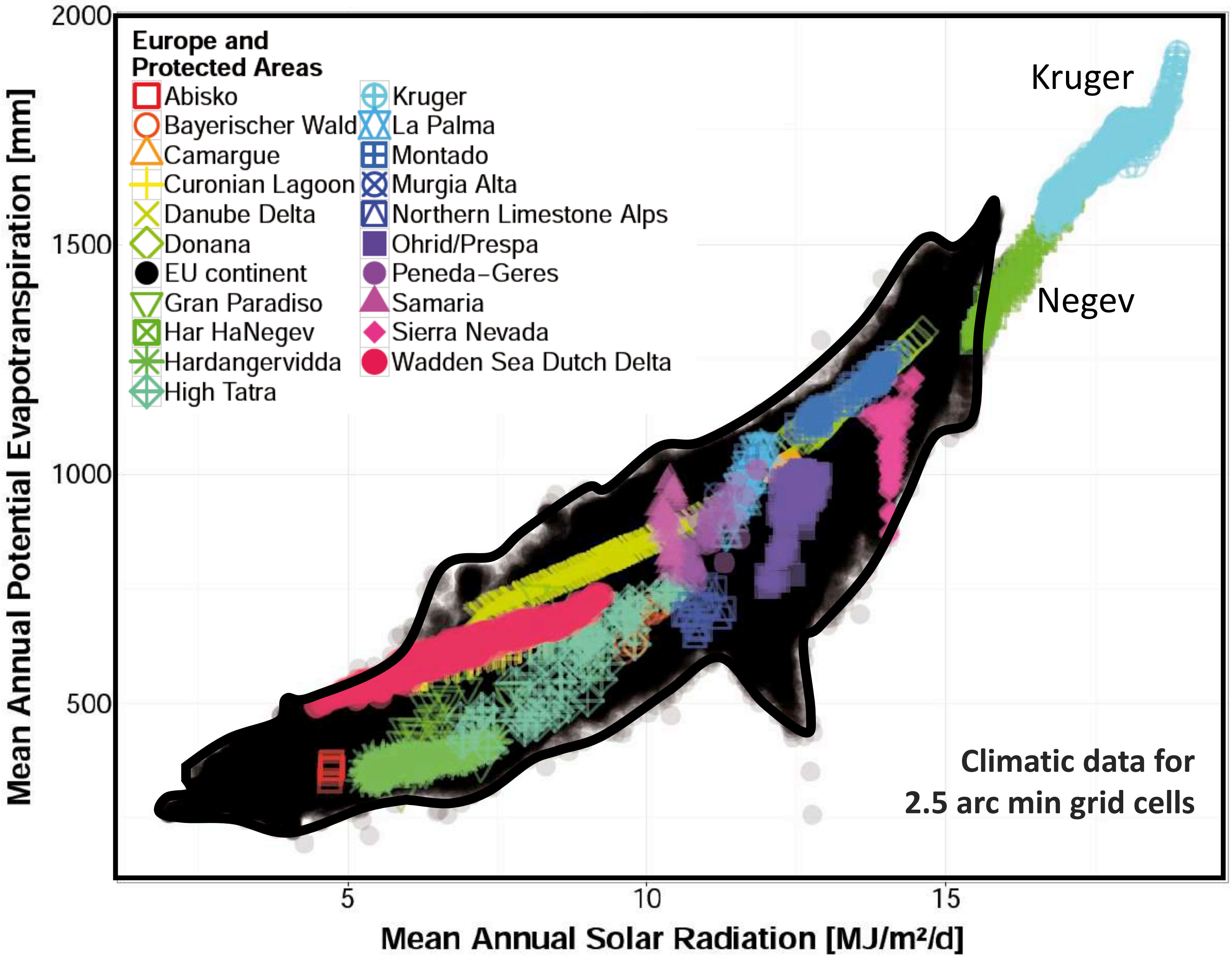
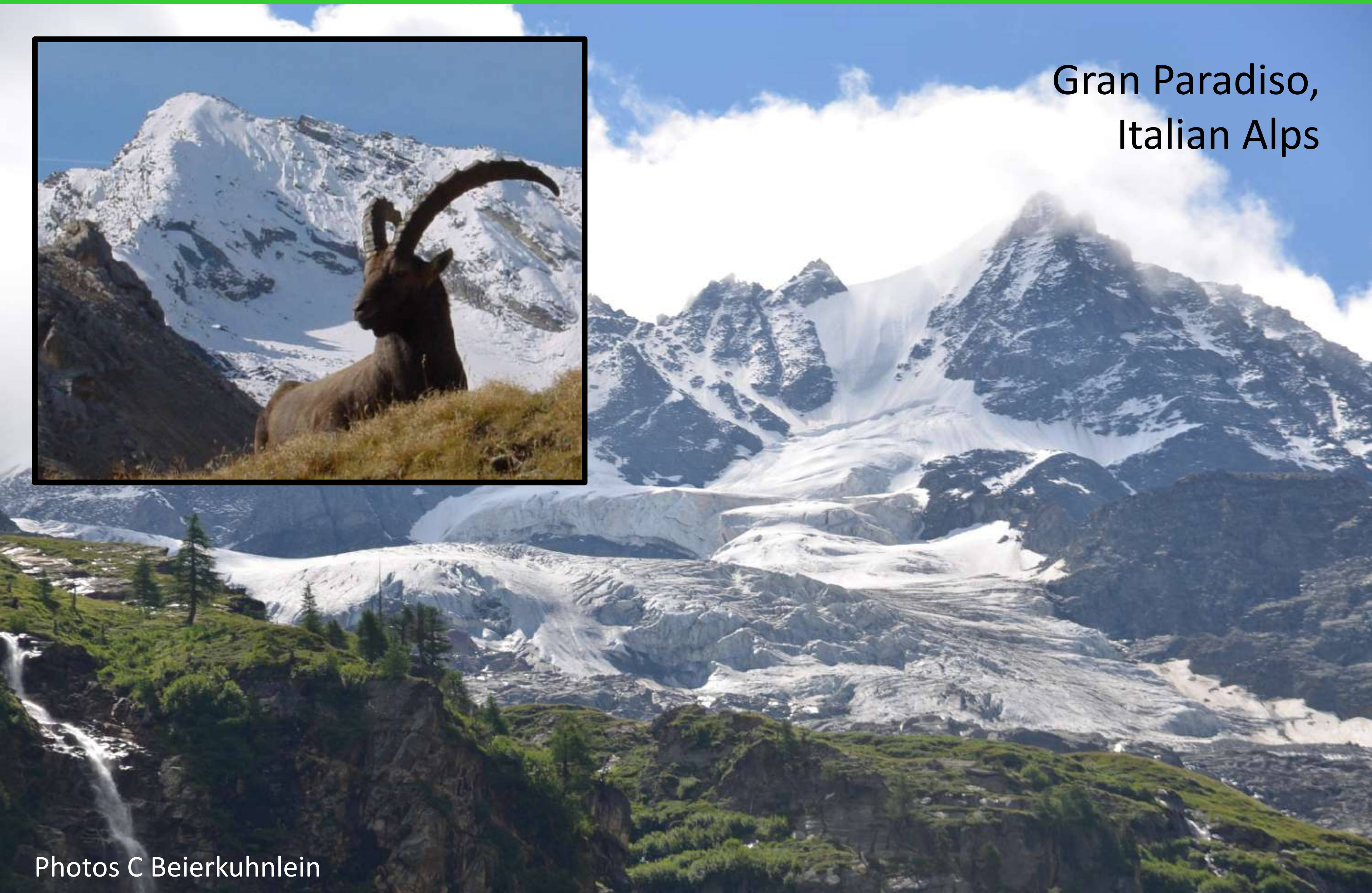
ECOPOTENTIAL and climate



Geo-bio-hydro interactions in PAs



Gran Paradiso,
Italian Alps

Photos C Beierkuhnlein

Geo-bio-hydro interactions in PAs

Geo-bio-hydro interactions in PAs

Negev Desert, Israel

Photos C Beierkuhnlein, A Provenzale

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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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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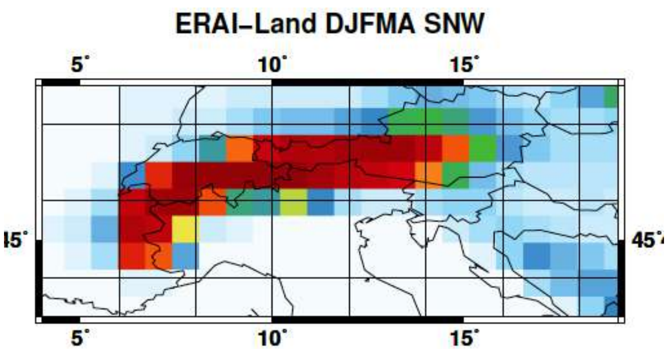
Example of PA changes: the Gran Paradiso National Park

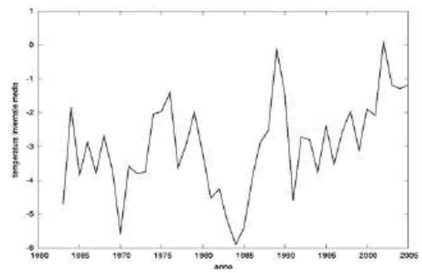
Gridded meteo-climatic datasets
E-OBS: 0.25°, EURO4M: 0.05° (only prec)
HISTALP, OI (Piedmont): 0125°

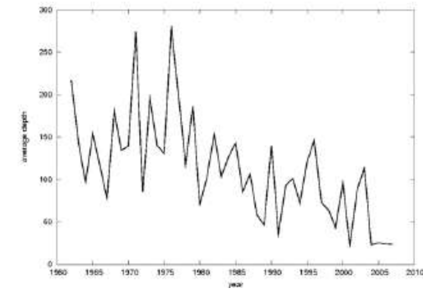
Model outputs and reanalyses
CMIP5, EURO-CORDEX,
ERA-Interim/Land and 20CRv2, MERRA, NCEP



Satellite products
e.g. snow: Global SWE, AMSR-E
vegetation, NDVI, LC/LU

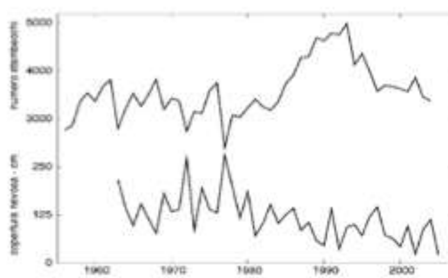
Local meteo-climatic datasets
about 30 temperature sensors
2 meteo stations

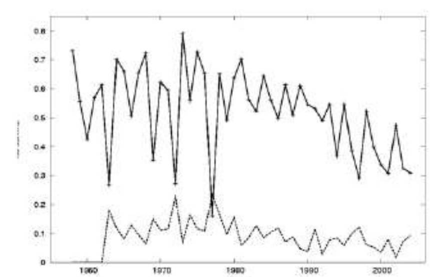




Water/carbon fluxes and phenology
eddy covariance
flux chambers

Ecosystem and population dynamics
ibex, chamois, vegetation, biodiversity





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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)

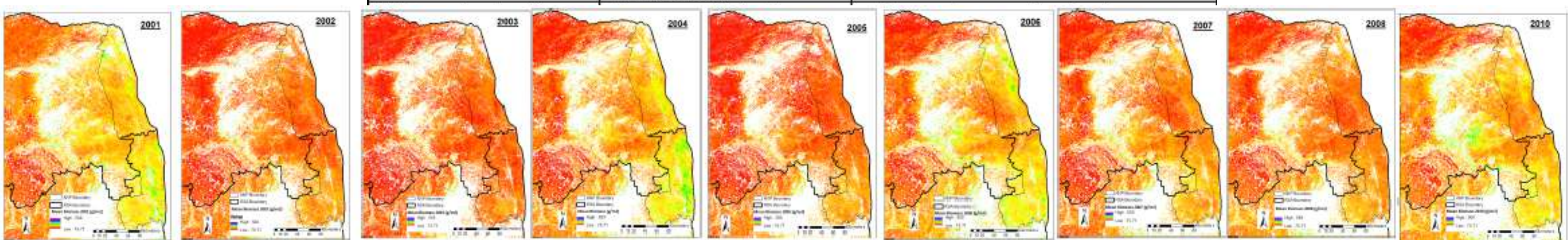
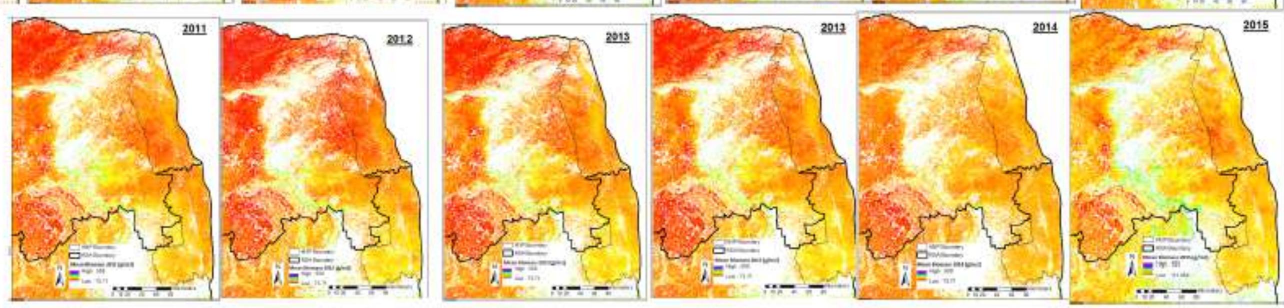


Figure 2: Time series of mean annual biomass data based on 500m spatial resolution MODIS data (2001 – 2015).



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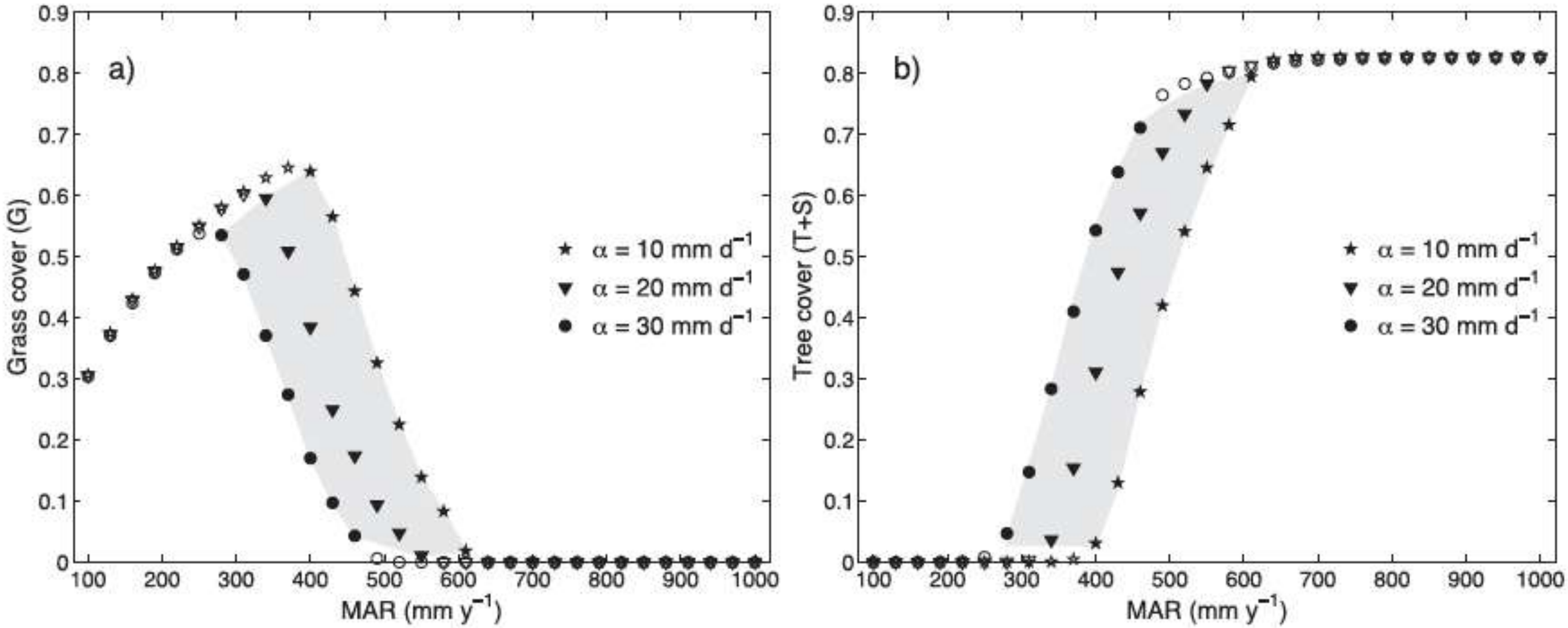

Effects of rainfall intermittency on model savanna dynamics

Tree-grass competition for soil water in arid and semiarid savannas: The role of rainfall intermittency

Donatella D'Onofrio[1,2], Mara Baudena[3], Fabio D'Andrea[4], Max Rietkerk[3], and Antonello Provenzale[2]

Water Resources Research

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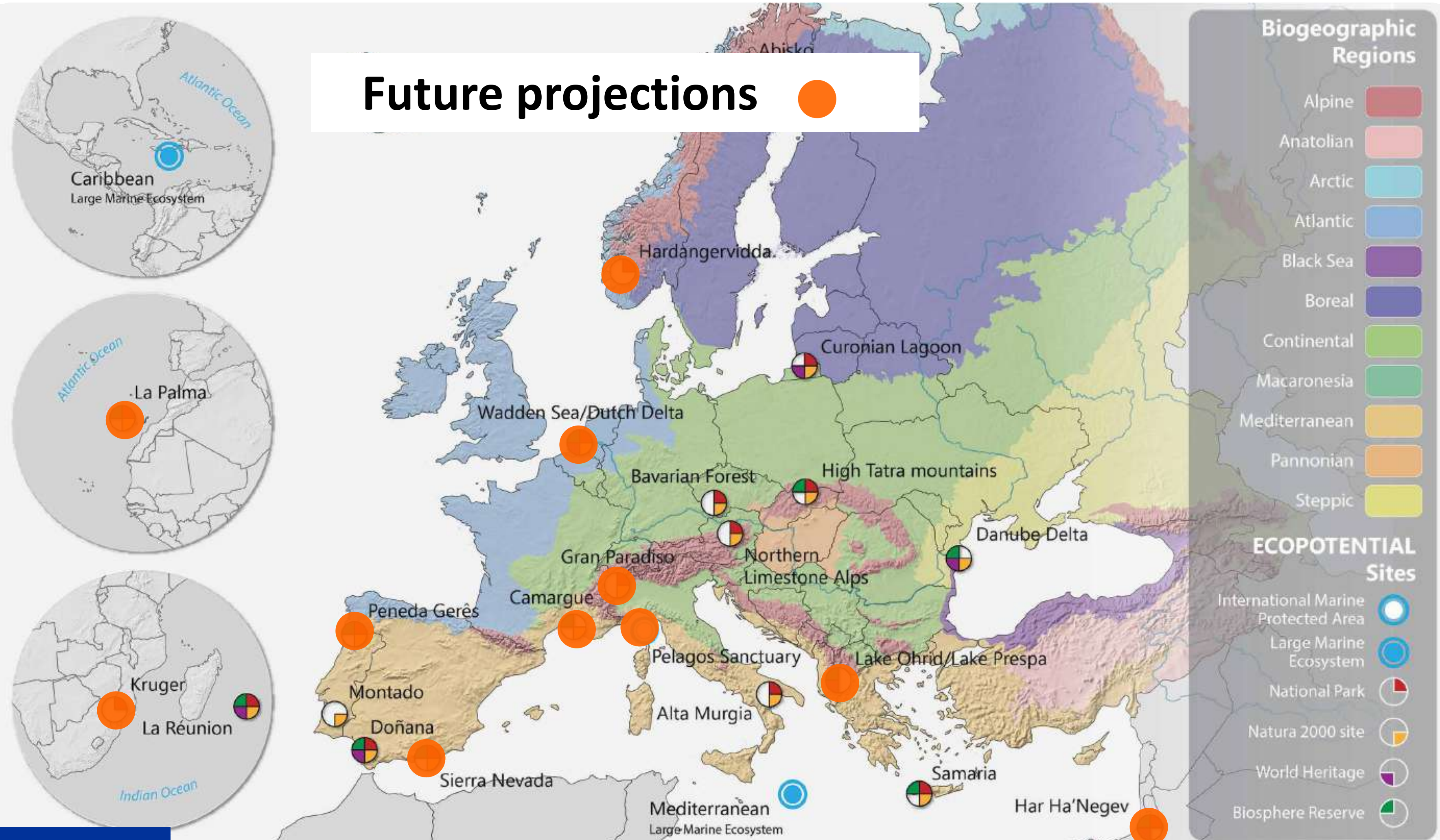

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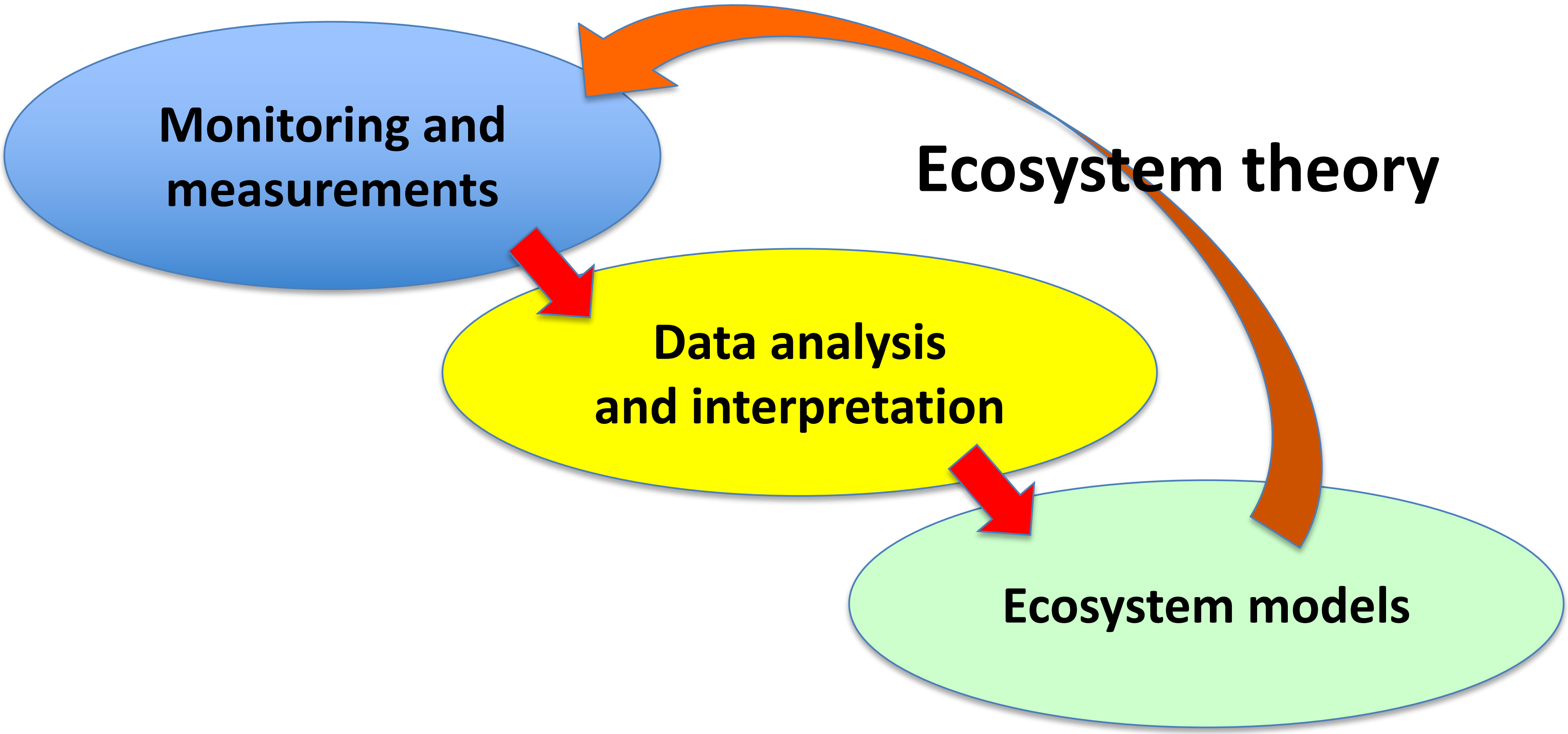
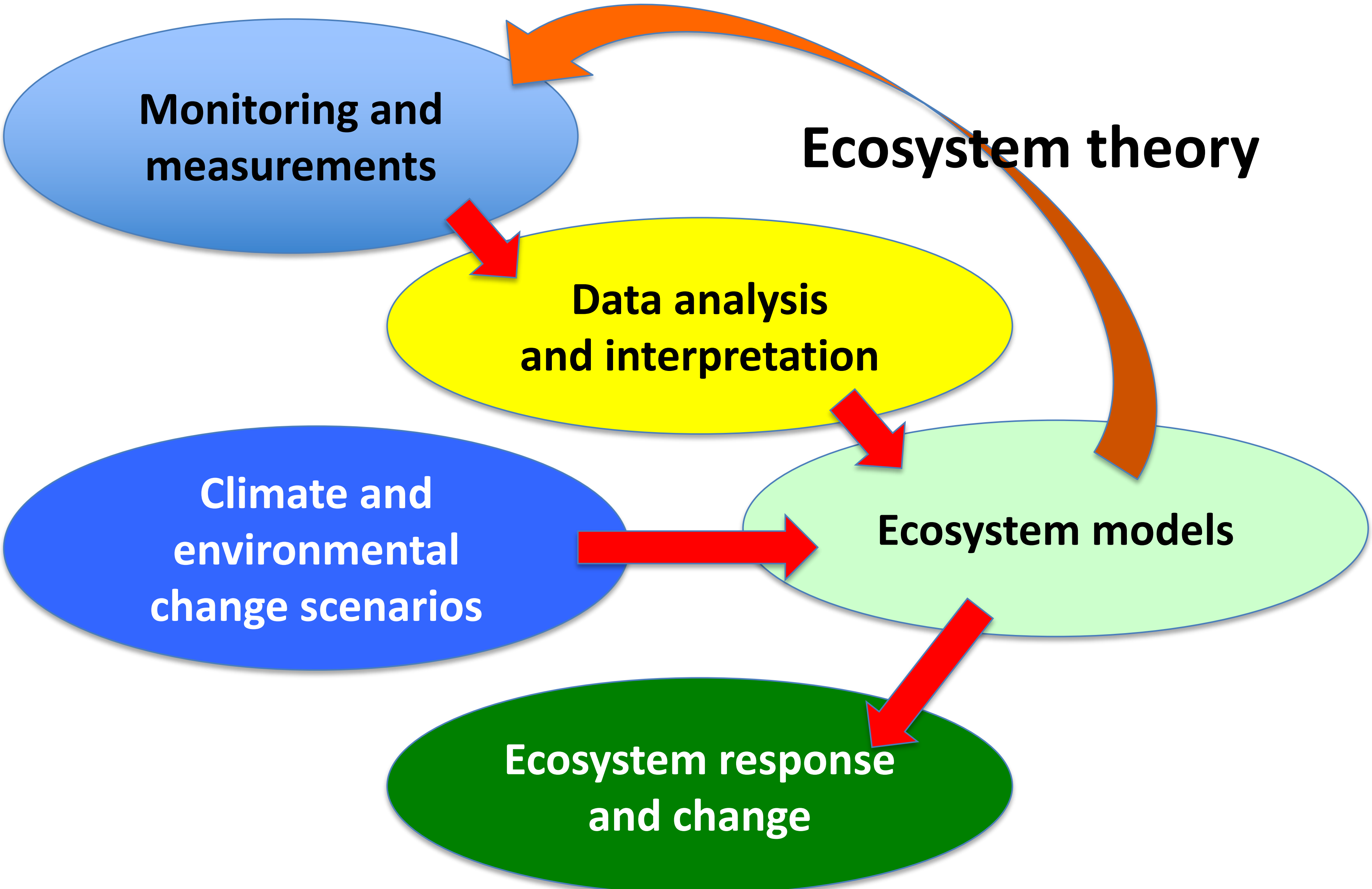
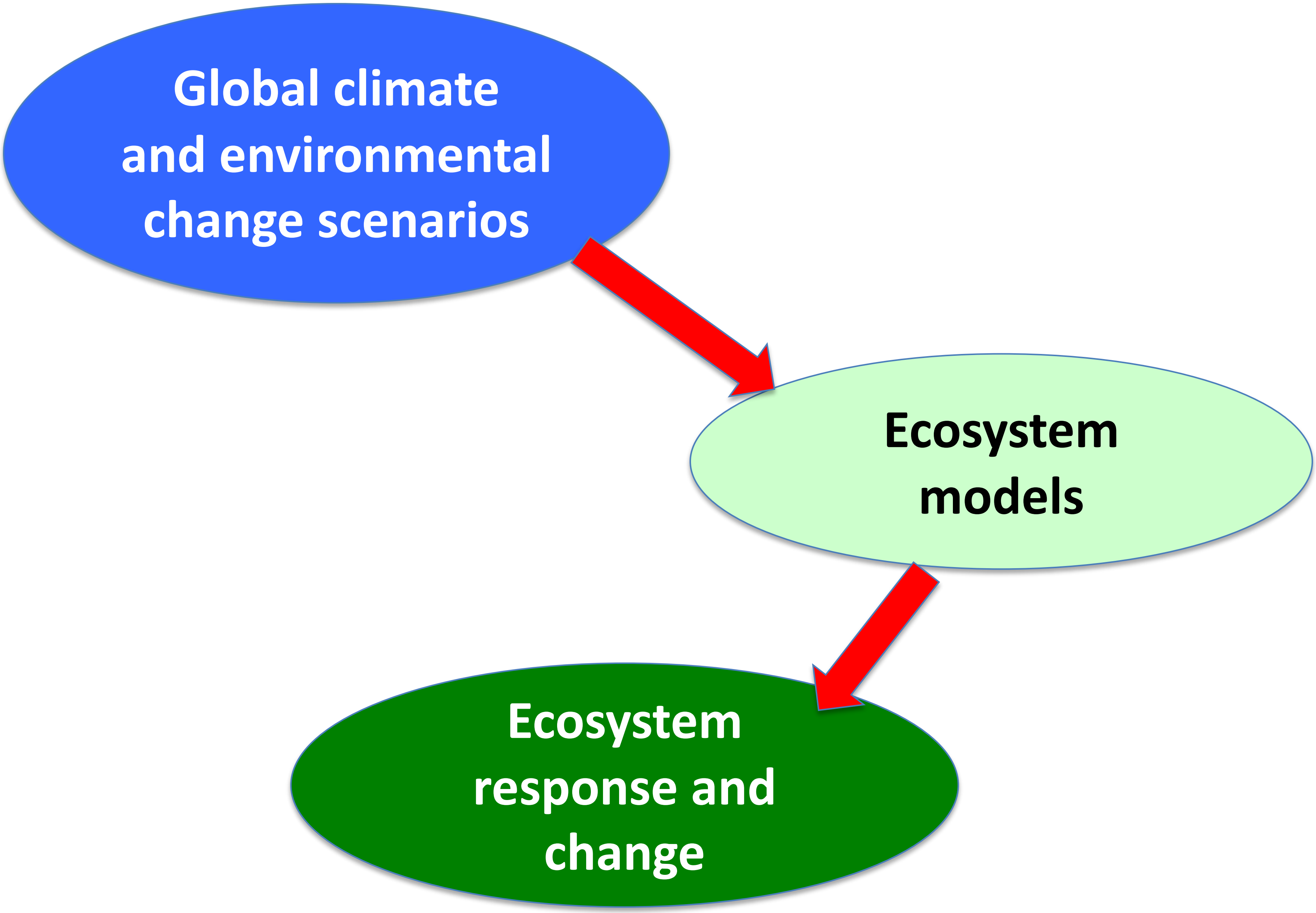


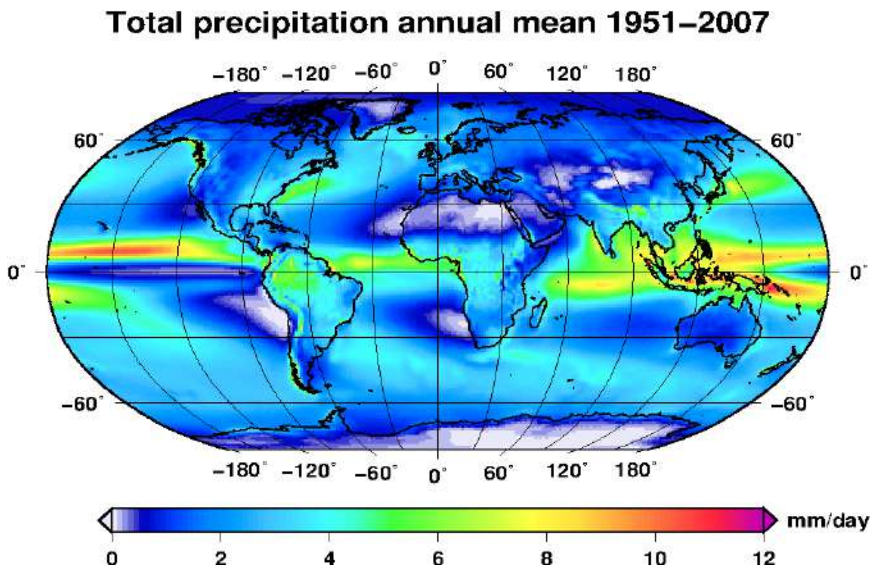
How do we address prediction of ecosystem response to global change?


Monitoring and measurements
Ecosystem theory
Data analysis and interpretation
Climate and environmental change scenarios
Ecosystem models
Ecosystem response and change

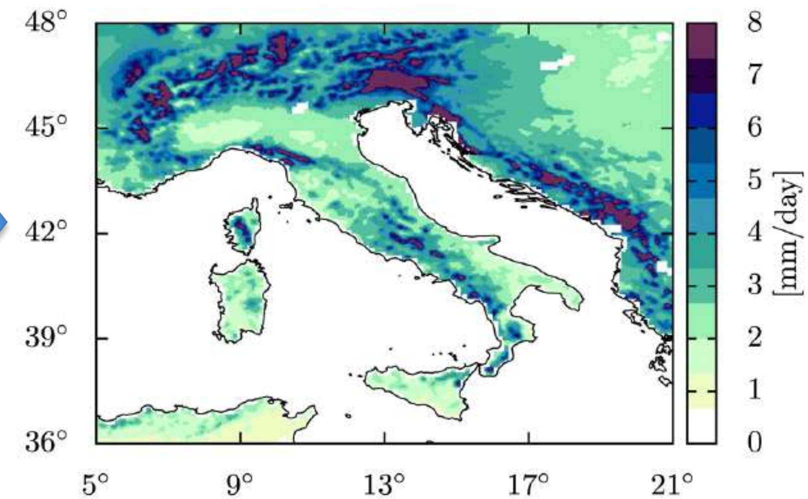

Global climate and environmental change scenarios
Ecosystem models
Ecosystem response and change

Scale mismatch: the downscaling-impact chain

GLOBAL CLIMATE MODEL



REGIONAL CLIMATE MODELS



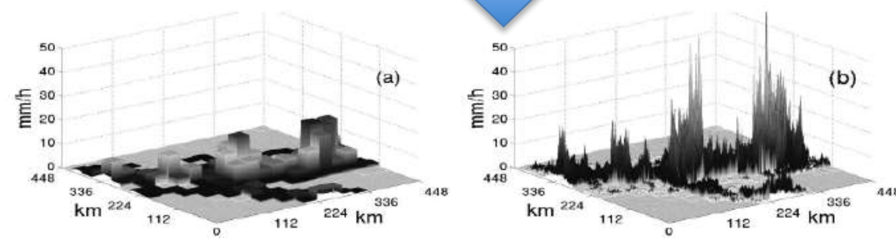


FIG. 10. (a) A snapshot of the forecasted rain field obtained from the LAM forecast and (b) one example of a downscaled field obtained by application of the RainFARM. The vertical scale indicates precipitation intensity (mm h^{-1}) and it is the same for the two fields.

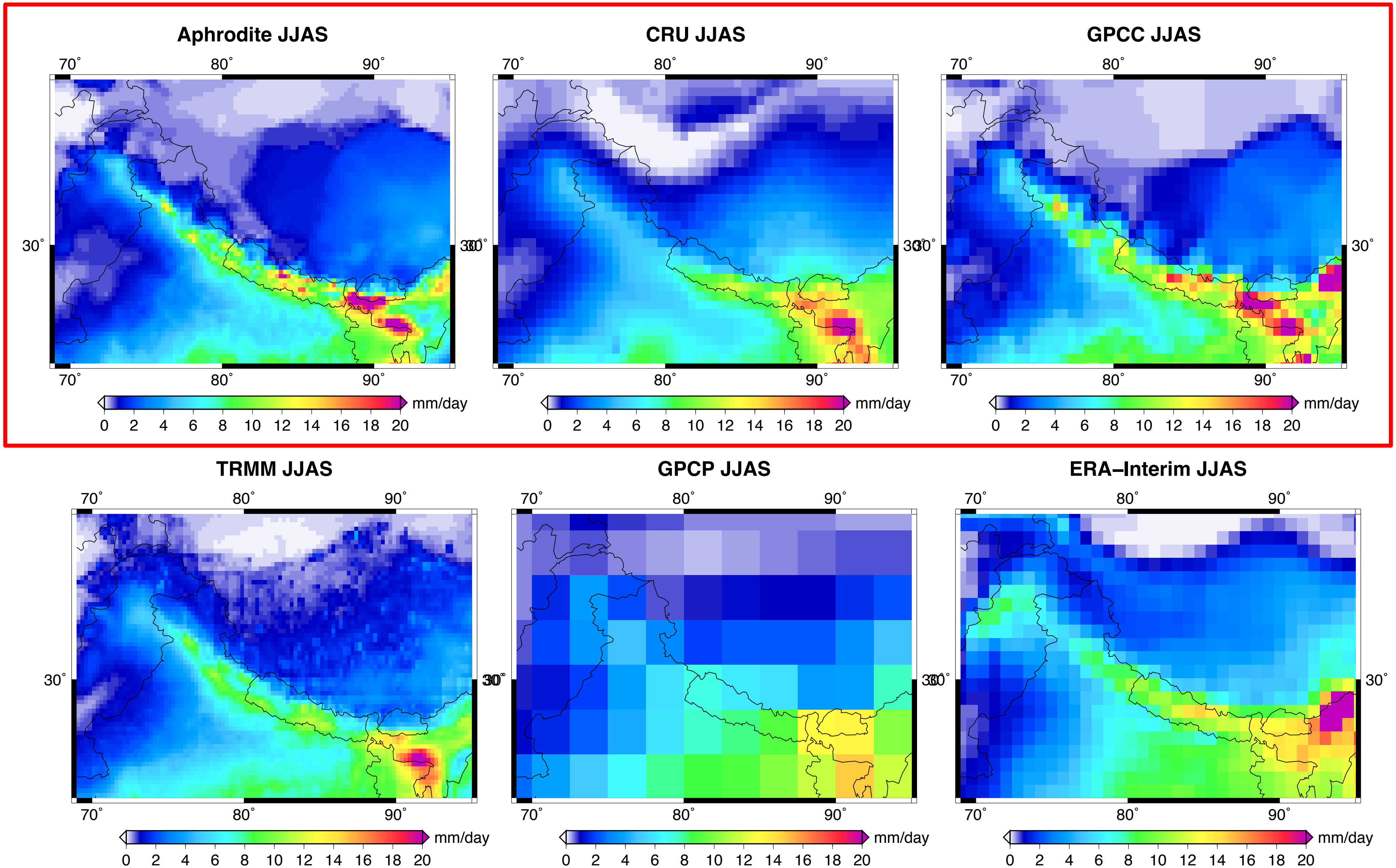
STOCHASTIC / STATISTICAL DOWNSCALING

ECO-HYDROLOGICAL MODELS


Troubles, oh troubles

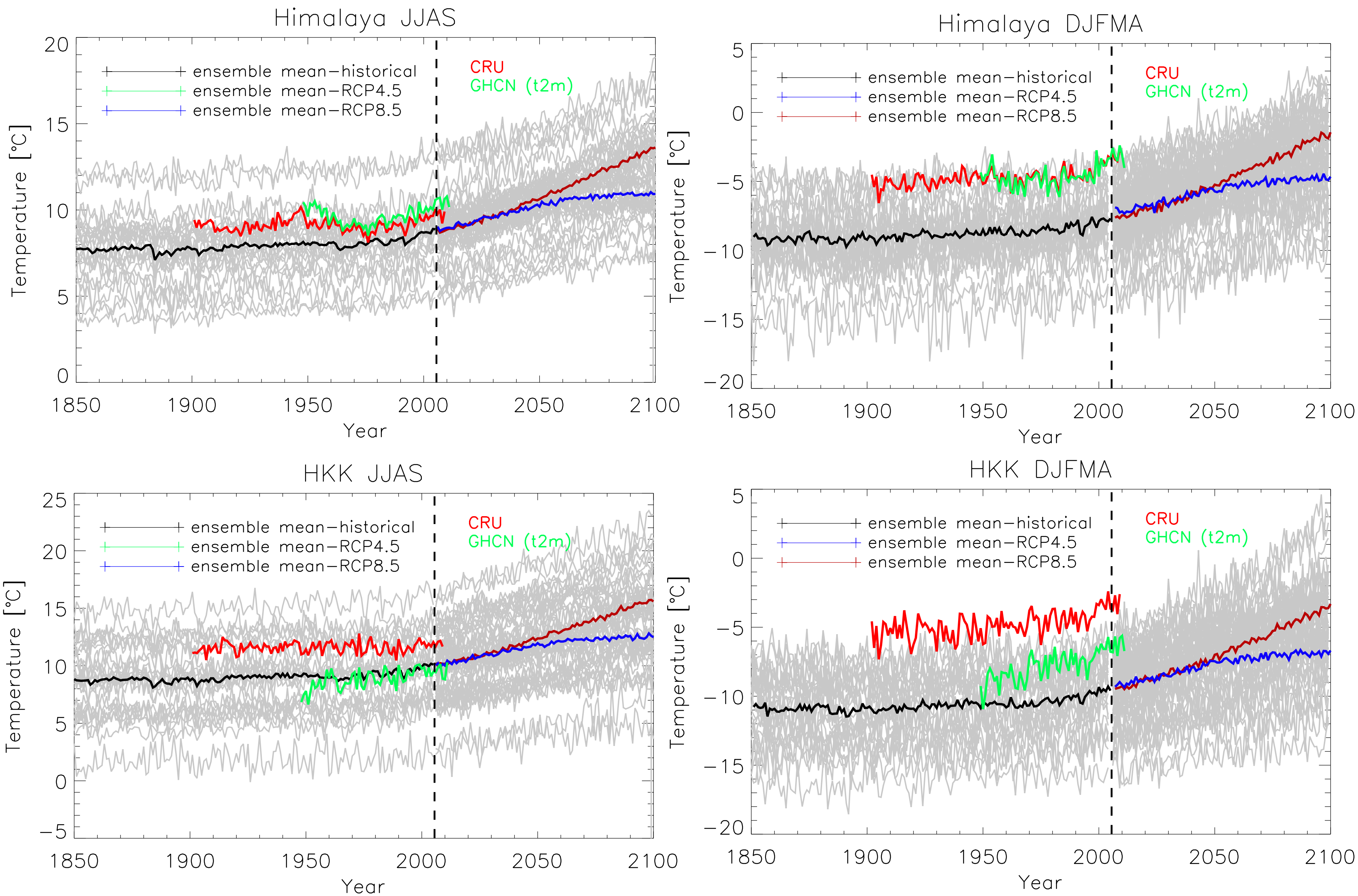
The chain of uncertainties: data for model validation

Summer precipitation (JJAS), Multiannual average 1998-2007

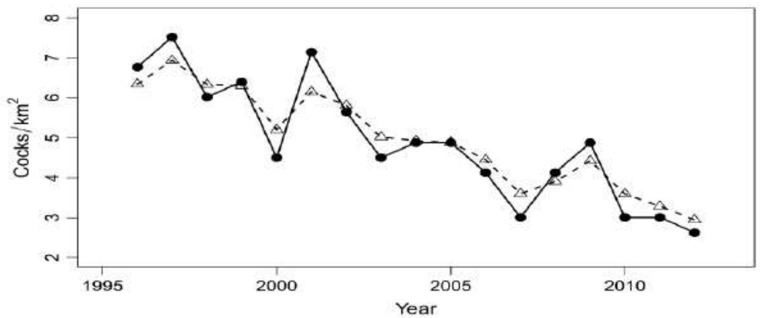


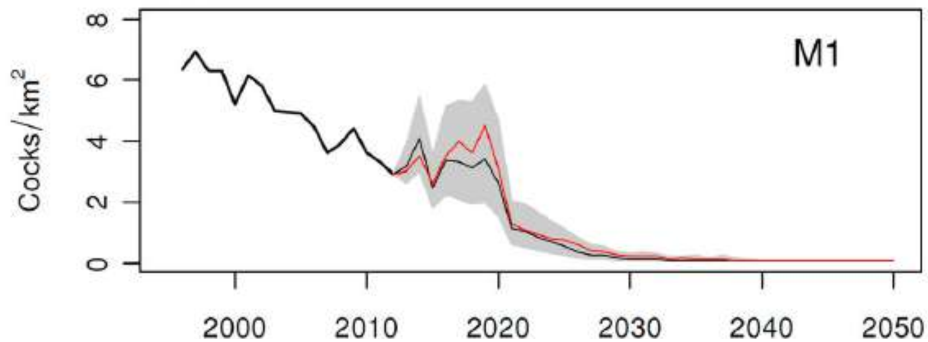
Palazzi E., von Hardenberg J., Provenzale A.: Precipitation in the Hindu-Kush Karakoram Himalaya: Observations and future scenarios, JGR 2013

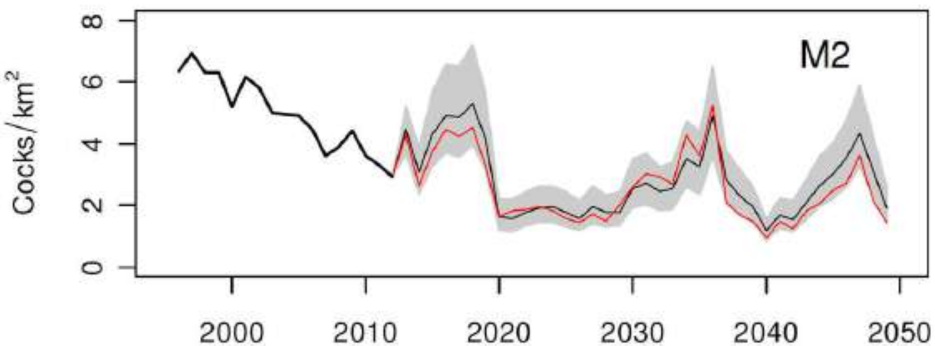
Sources of uncertainty: the spread of CMIP5 temperatures

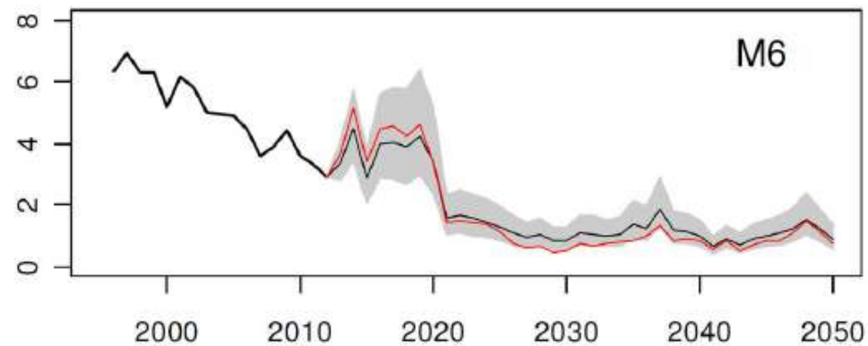


Statistical uncertainties in ecological models







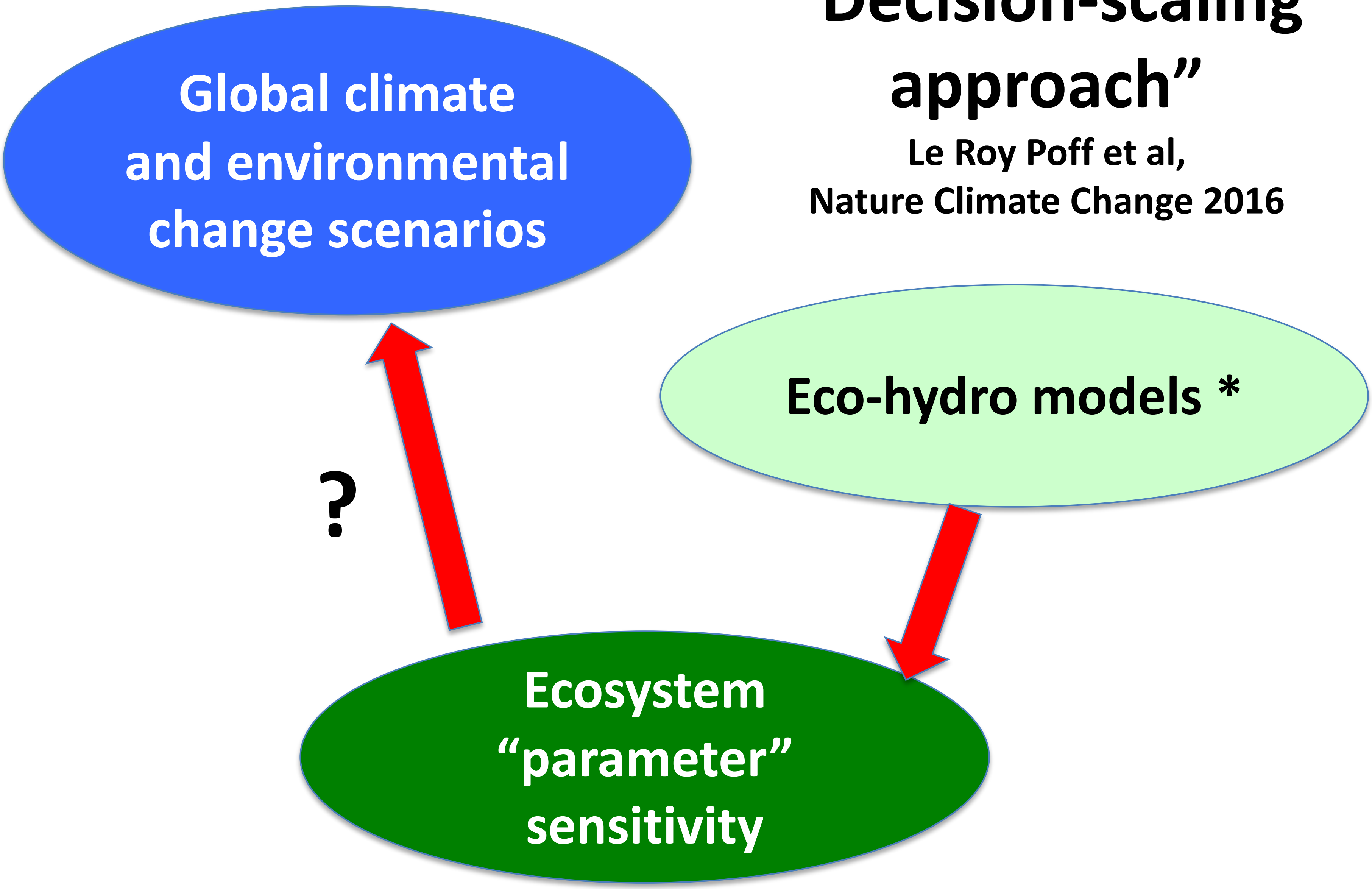


Model	Intercept	lnN_{t-1}	lnN_{t-2}	SE_{t-1}	SS_{t-1}	SP_t	$T(July)_{t-1}$	$P(July)_{t-1}$	$T(Jan-Mar)_t$	$T(Apr-May)_t$	var.	R^2	AICc
M1	-0.07±0.04			**-0.19±0.04**	**-0.18±0.04**						2	0.78	-50.53
M2	0.34±0.24		-0.25±0.14	**-0.19±0.04**	**-0.19±0.04**						3	0.83	-50.20
M3	-0.07±0.04			**-0.19±0.04**	**-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

"Decision-scaling approach"

Le Roy Poff et al,
Nature Climate Change 2016



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

Thanks for your attention

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