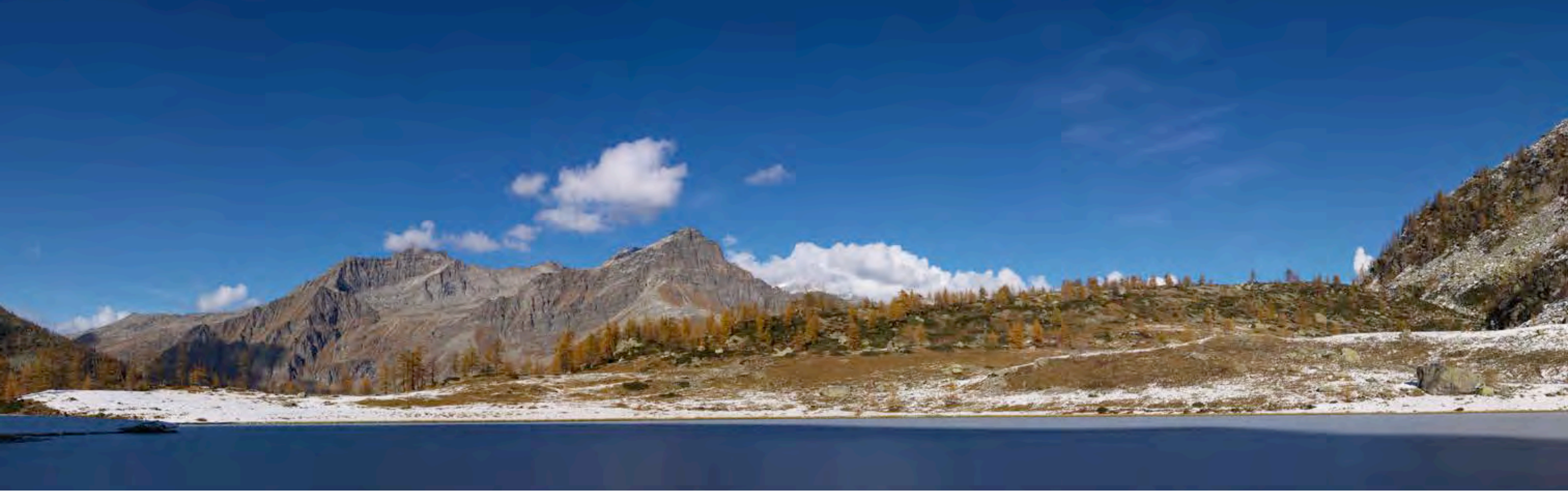
Modelling climate impacts on ecosystems and biodiversity: light and dark sides

A. Provenzale, CNR IGG, Pisa



ECOPOTENTIAL

Improving future ecosystem benefits through Earth Observations

This project is funded by the European Union (Grant agreement No. 641762)

GROUP ON EARTH OBSERVATIONS

ECOPOTENTIAL: Regional scale and Protected Areas

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

ECOPOTENTIAL in a nutshell:

Make best use of Earth Observations to characterize the state and changes of ecosystems and improve their conservation and management

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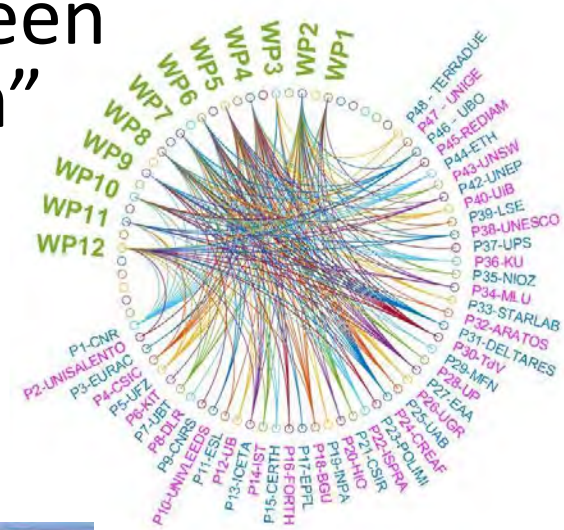
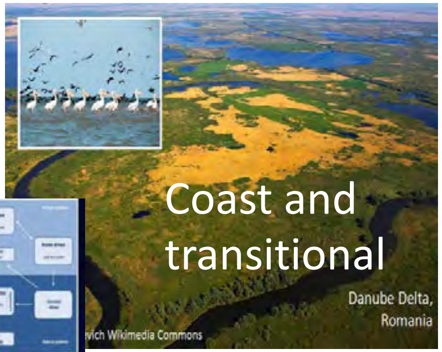
ECOPOTENTIAL in a nutshell (2015-2019)

In ECOPOTENTIAL, ecosystems are seen as "**one (complex) physical system**" with their environment, with cross-scale geosphere-hydrosphere-climate-biosphere interactions





48 partners
12 WPs

4 ecosystem types

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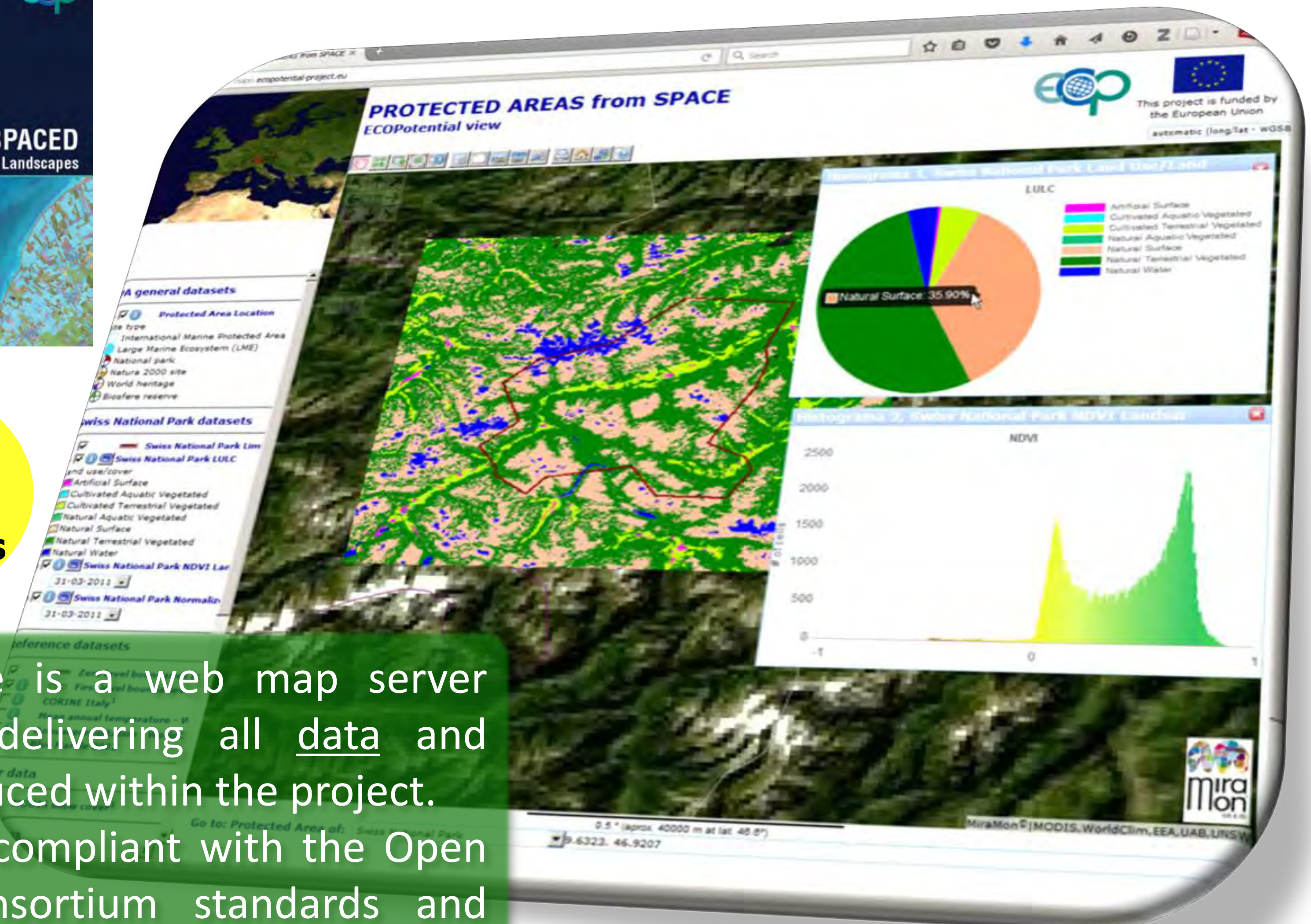
PROTECTED AREAS from SPACE

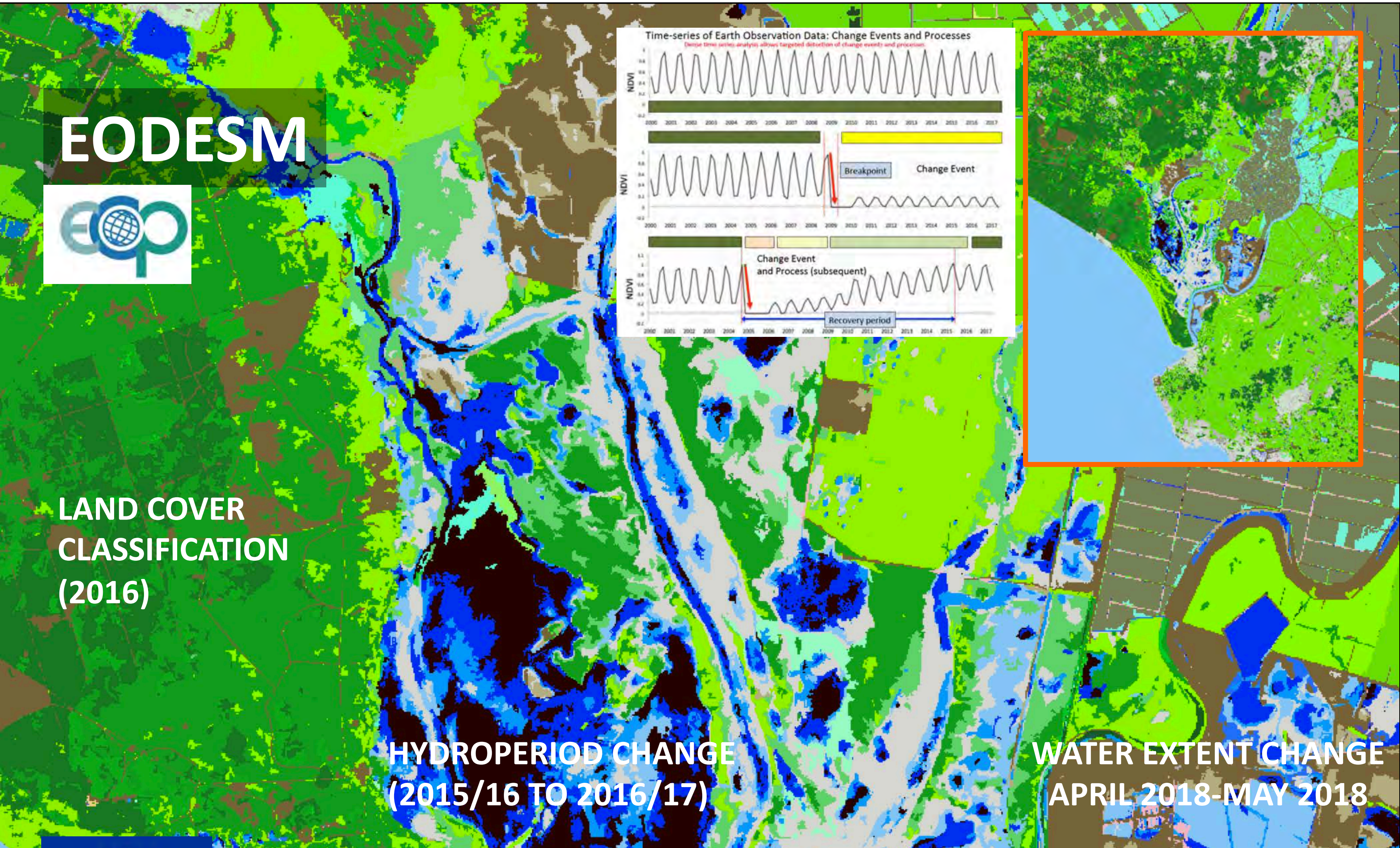
Remote sensing data and products



PA from space is a web map server showing and delivering all <u>data</u> and <u>metadata</u> produced within the project.
This service is compliant with the Open Geospatial Consortium standards and allows visual analysis.

http://maps.ecopotential-project.eu/

COMPREHENSIVE DETECTION OF CHANGE OVER MULTIPLE TIME SERIES: EXAMPLE FROM DONANA NATIONAL PARK, SPAIN, USING SENTINEL-2



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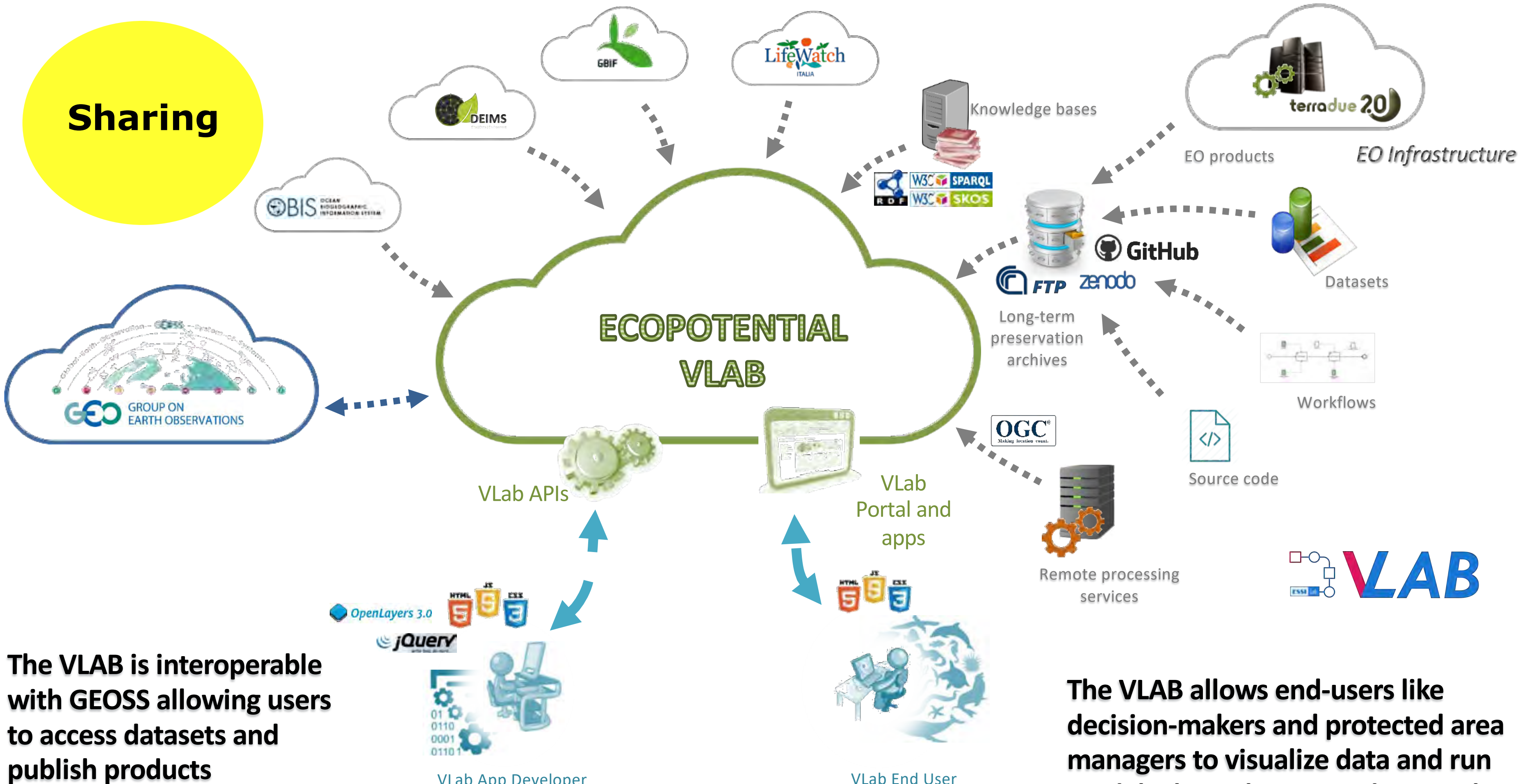
Virtual Laboratory Platform

Consiglio Nazionale delle Ricerche

All data, images, products and models are made available through the VLAB

Sharing



The VLAB is interoperable with GEOSS allowing users to access datasets and publish products

The VLAB allows end-users like decision-makers and protected area managers to visualize data and run models through apps and a portal.

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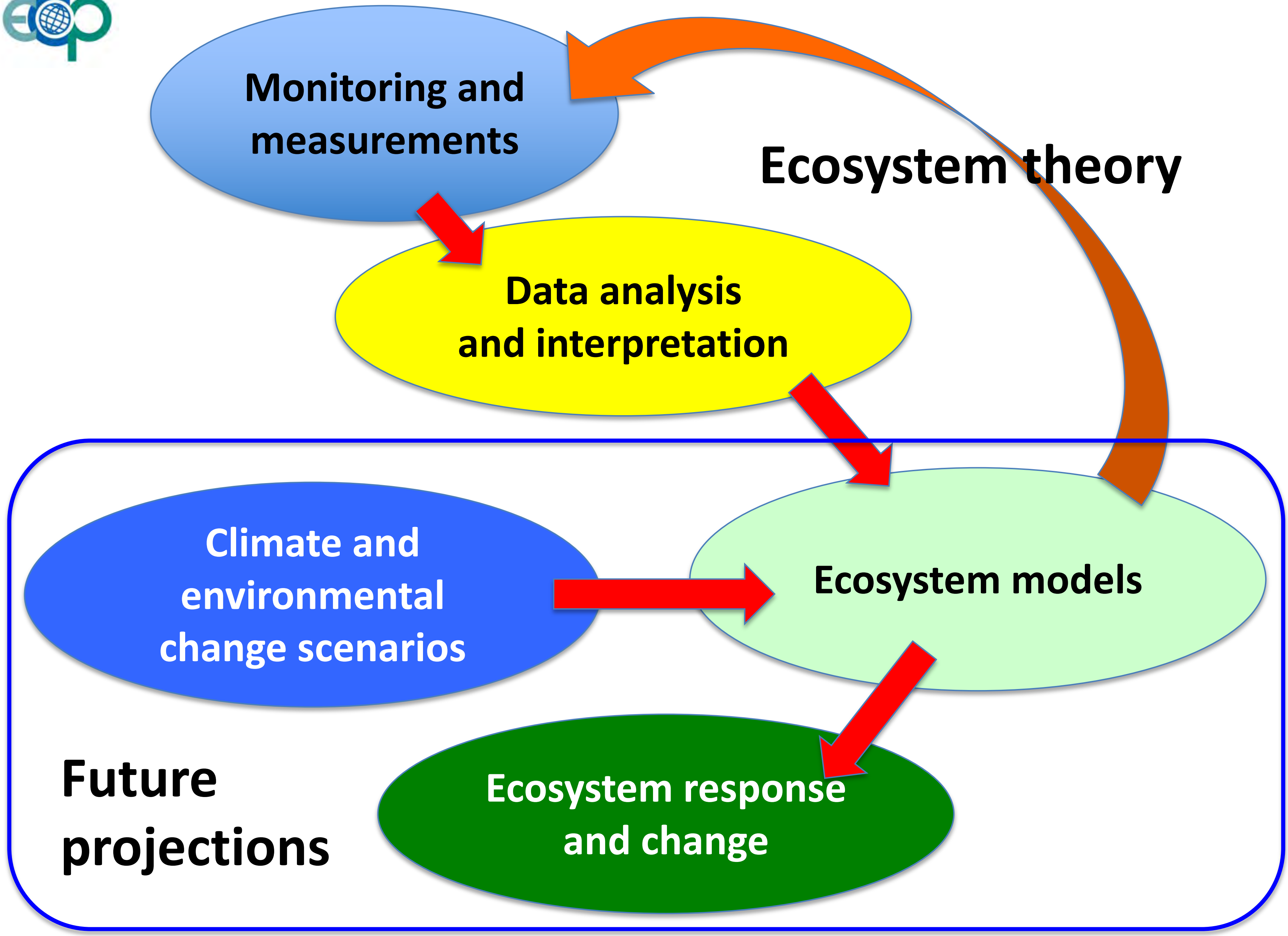
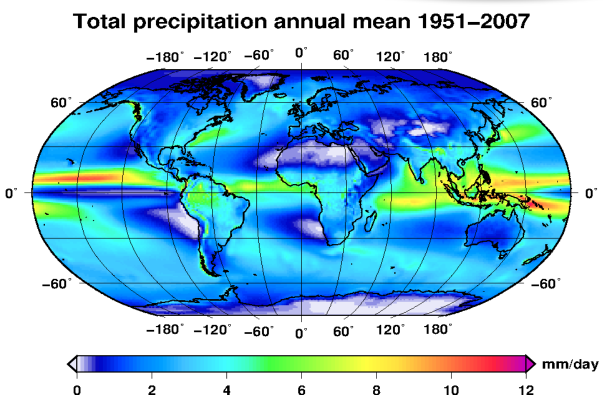
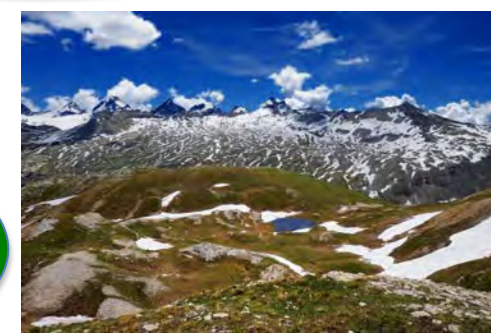

Monitoring and measurements
Ecosystem theory
Data analysis and interpretation
Climate and environmental change scenarios
Ecosystem models
Future projections
Ecosystem response and change

Impact of climate change on ecosystems and the environment

Global climate and land-use change scenarios



Environmental (eco-hydro-carbon) models



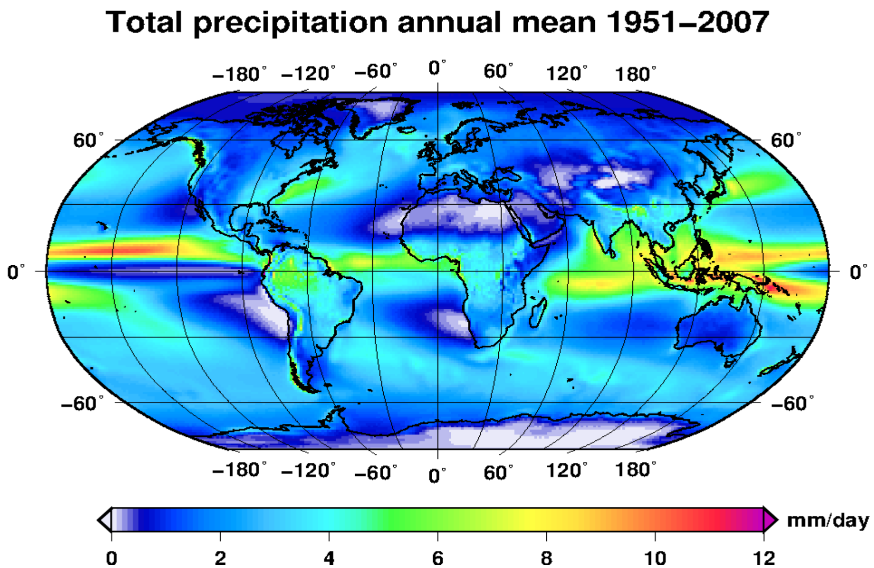
Ecosystem response and change

A known unknown:

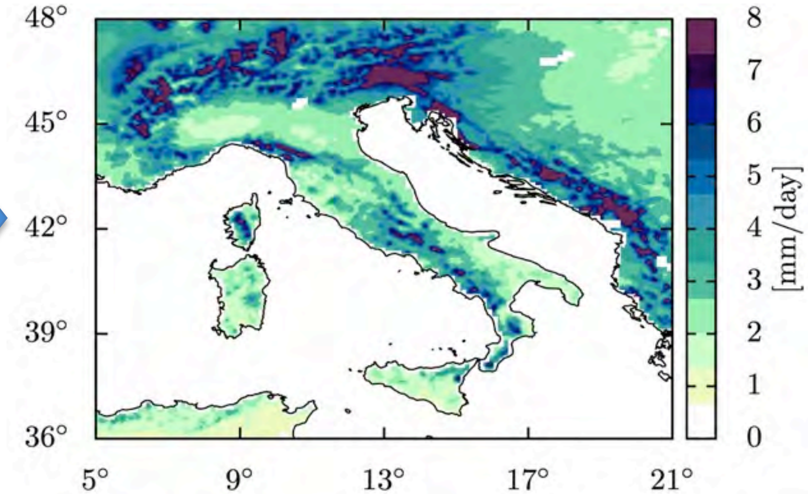
Scale mismatch between
climate change (and its modelling)
and local ecosystem response

Scale mismatch: the downscaling-impact chain

GLOBAL CLIMATE MODEL



REGIONAL CLIMATE MODELS



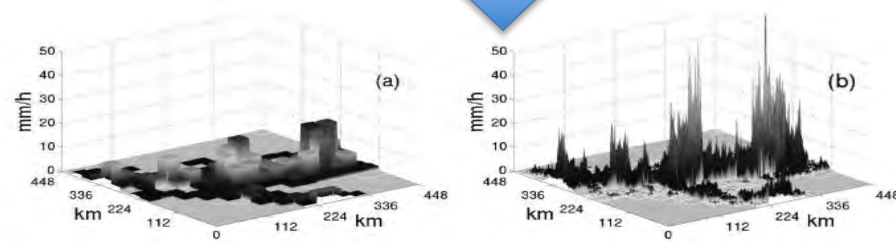


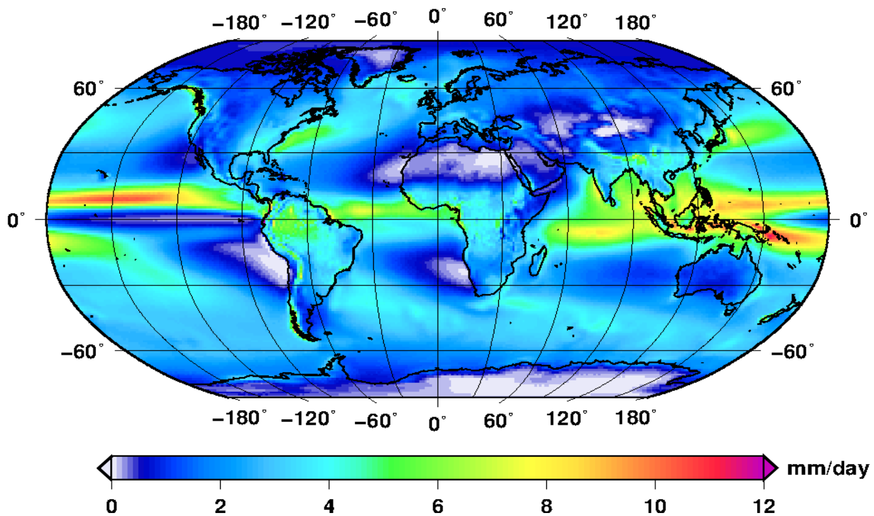
FIG. 10. (a) A snapshot of the forecasted rain field obtained from the LAM forecast and (b) one example of a downscaled field obtained by application of the RainFARM. The vertical scale indicates precipitation intensity (mm h^{-1}) and it is the same for the two fields.

STOCHASTIC / STATISTICAL DOWNSCALING

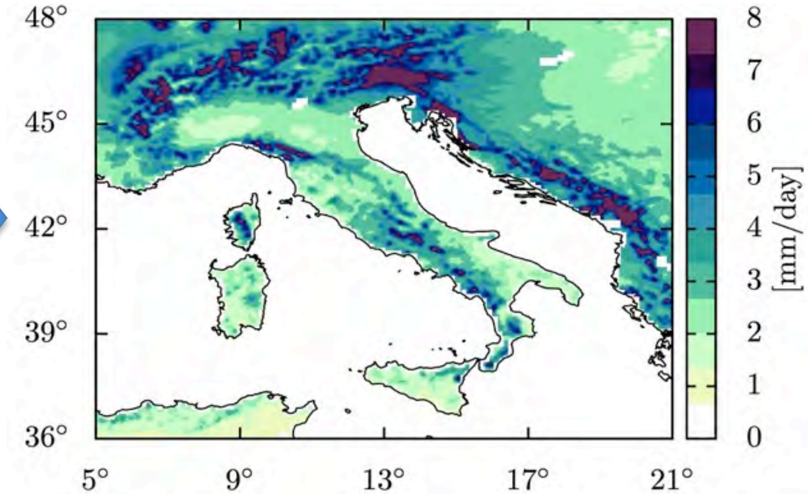
ECO-HYDROLOGICAL MODELS

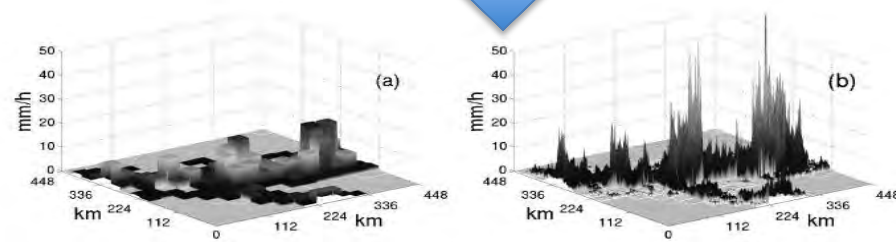
Scale mismatch: the downscaling-impact chain

5 CMIP5 GCMs, RCP4.5, RCP8.5



Euro-CORDEX – 11 km – 5 members





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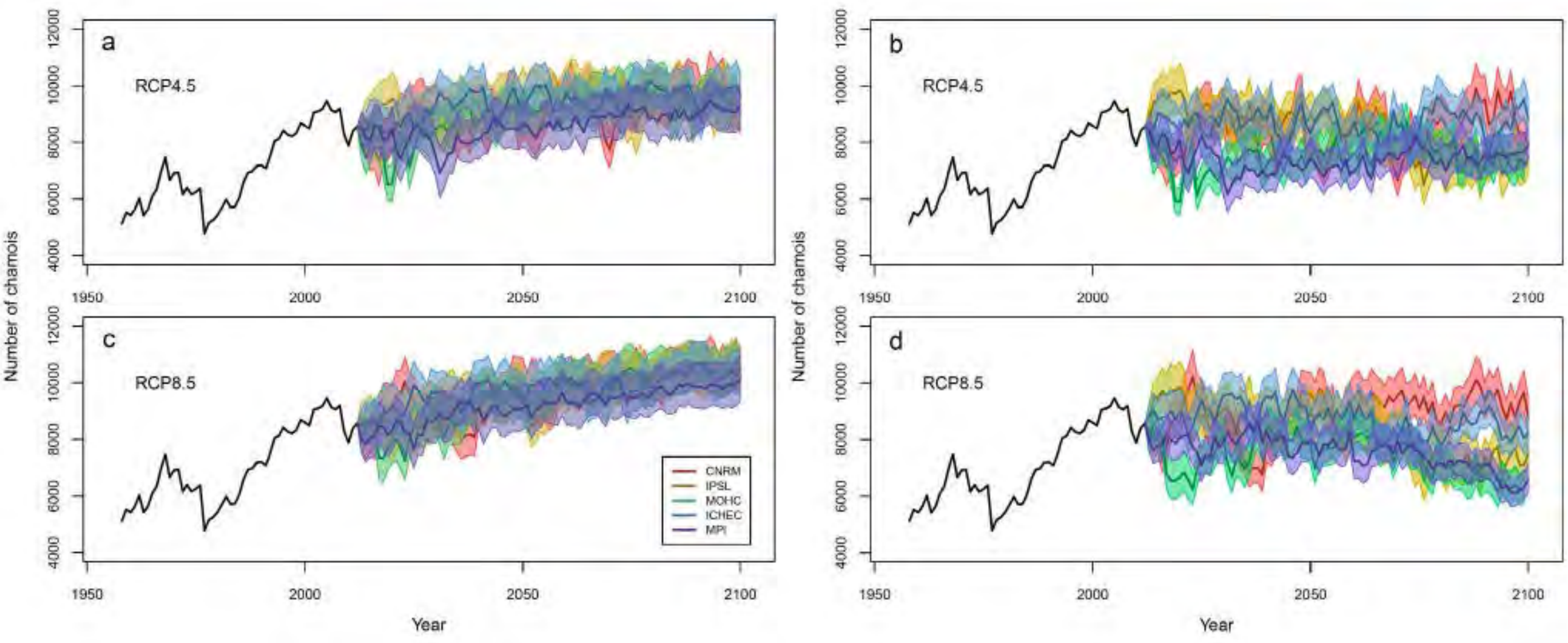
Stochastic downscaling for prec
Interpolation with orography correction for temp

Specific eco models for each PA

Projections of chamois population density in Gran Paradiso National Park

Unstructured model

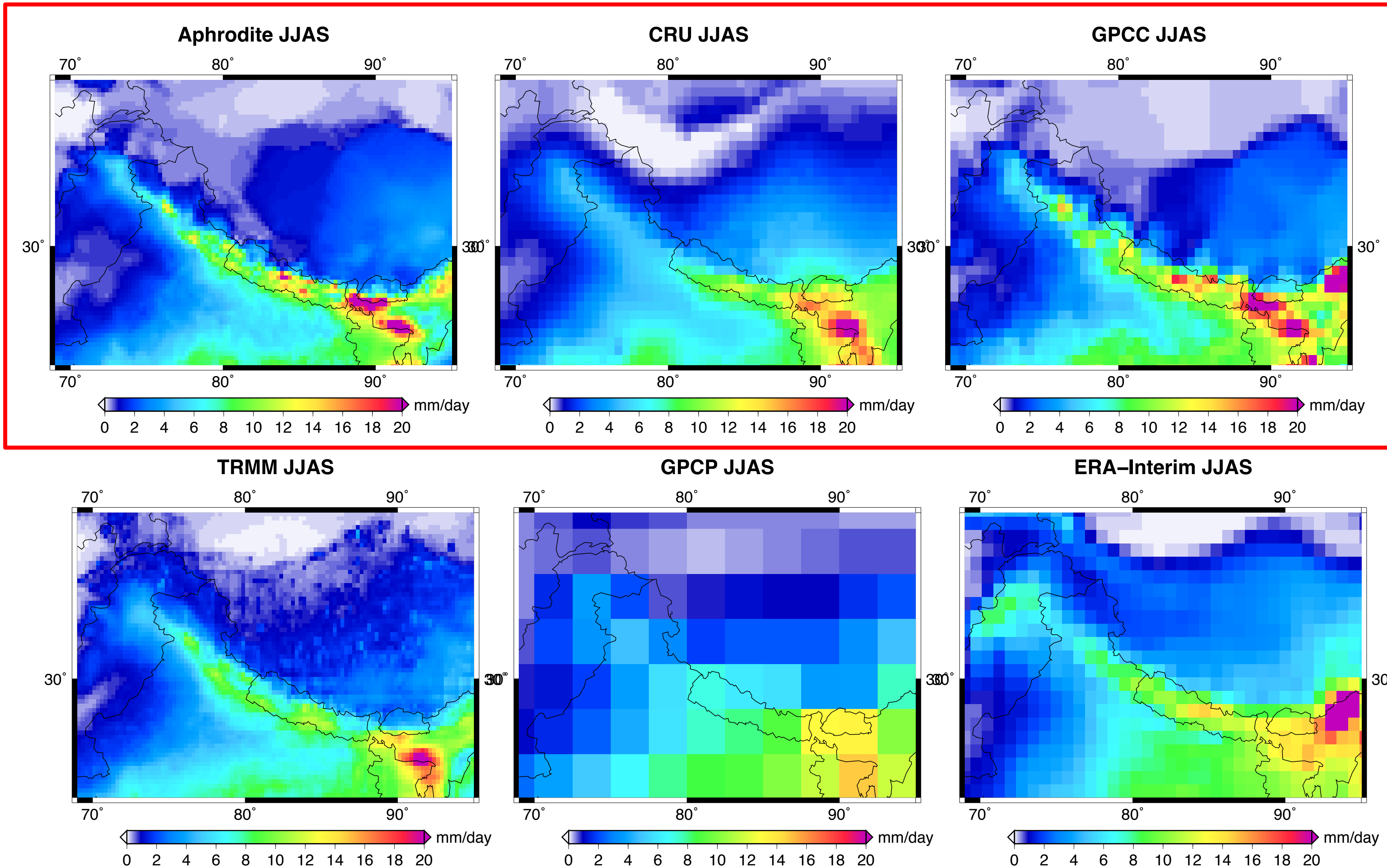
Structured model




Troubles along the way…

The chain of uncertainties: data for model validation

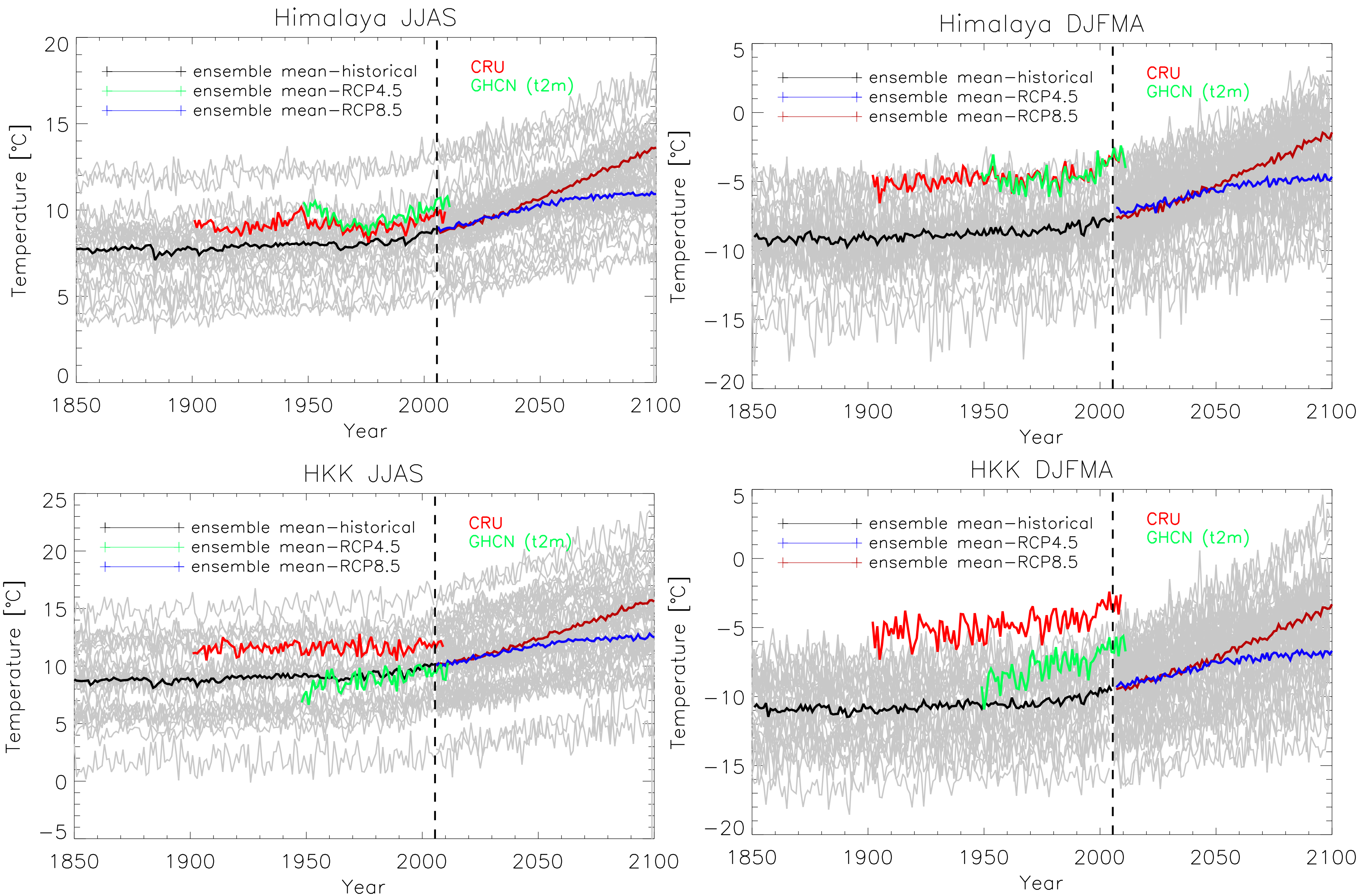
Summer precipitation (JJAS), Multiannual average 1998-2007



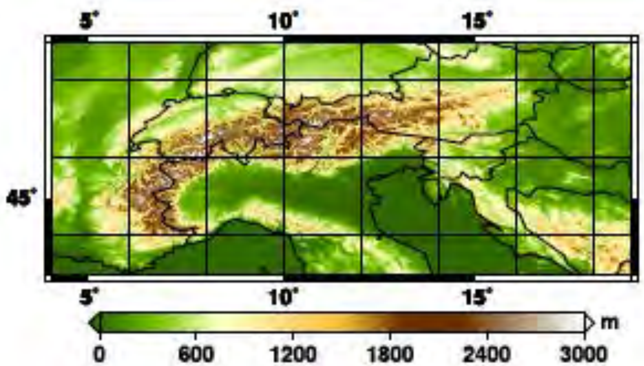
Palazzi E., von Hardenberg J., Provenzale A.:

Precipitation in the Hindu-Kush Karakoram Himalaya: Observations and future scenarios, JGR 2013

the spread of CMIP5 temperatures

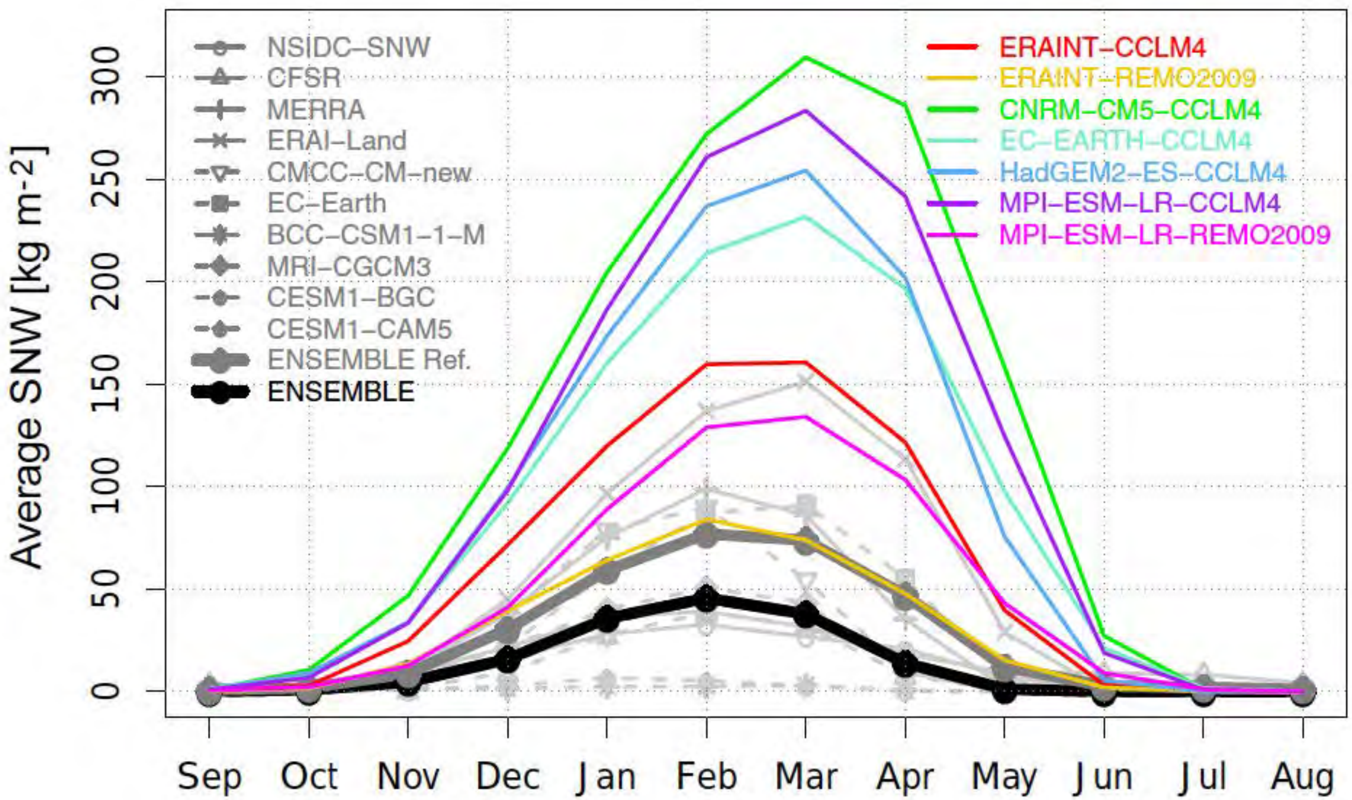


Using Regional models: Snow on the Greater Alpine Region



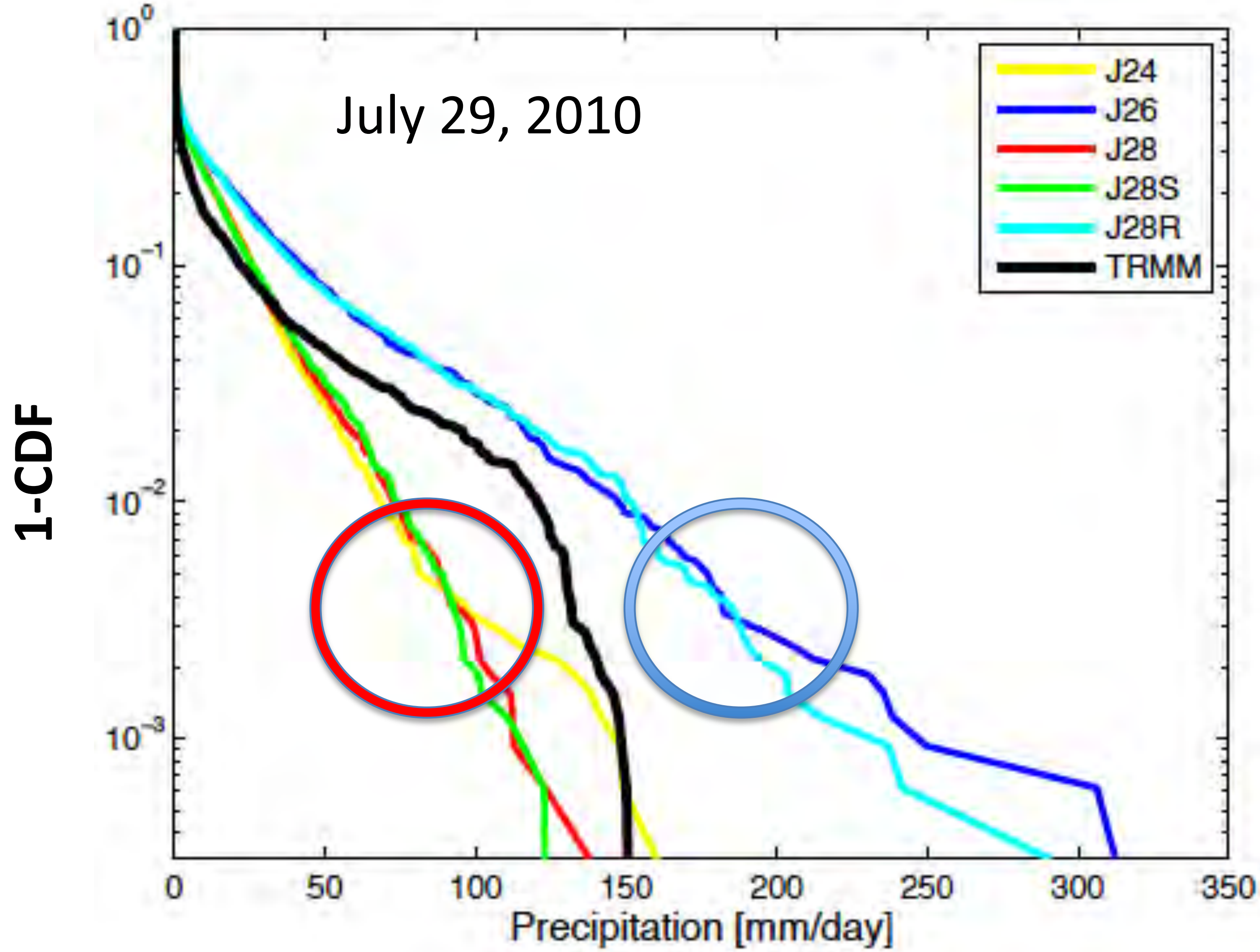
Terzago, von Hardenberg, Palazzi, Provenzale, The Cryosphere 2017

SNW annual cycle – CORDEX RCMs



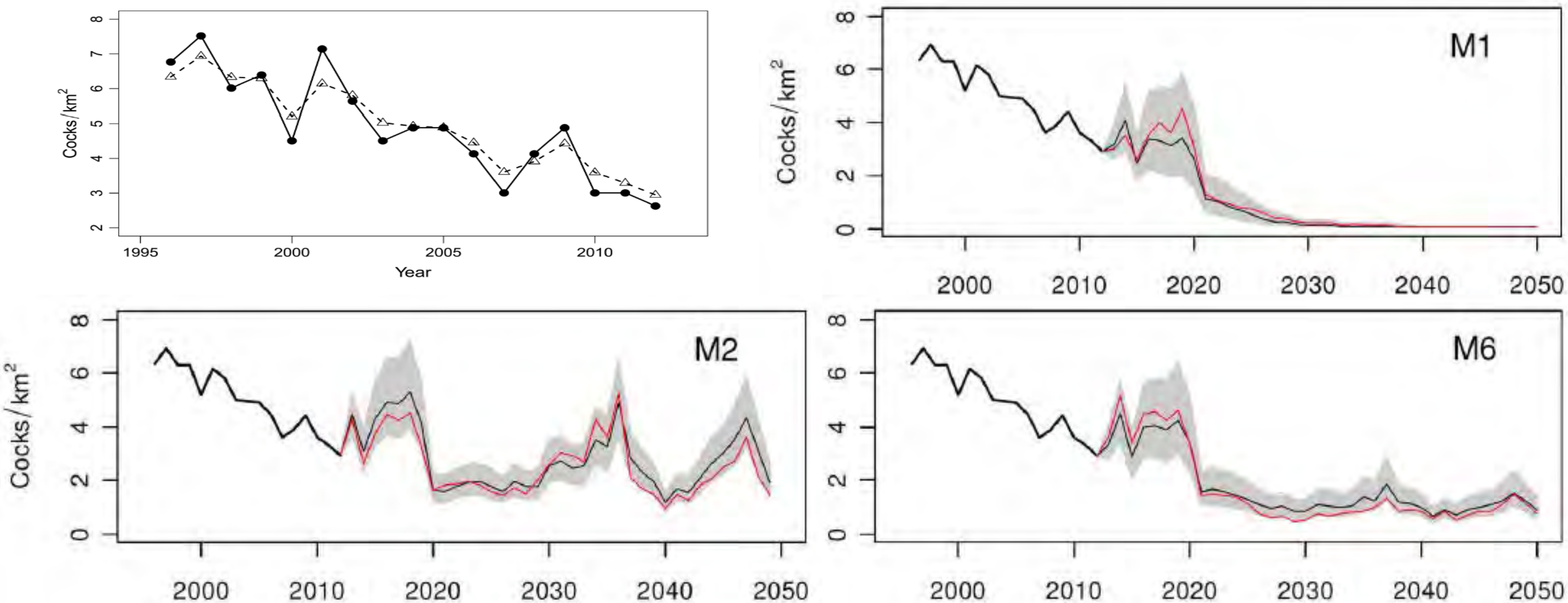
1990 - 2005

Precipitation statistics from WRF (Pakistan Flood 2010)



Viterbo et al., JHM 2016

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

Comments

Huge uncertainties in data, climate models, downscaling procedures, impact models: need for **ensemble approaches**, need for **uncertainty estimates**, need for **caution** in providing and interpreting results.

Need for **new approaches** to estimating future ecosystem responses

What-if scenarios:
what if temperature grows above 1.5 (or 2, or 3) °C with respect to pre-industrial?

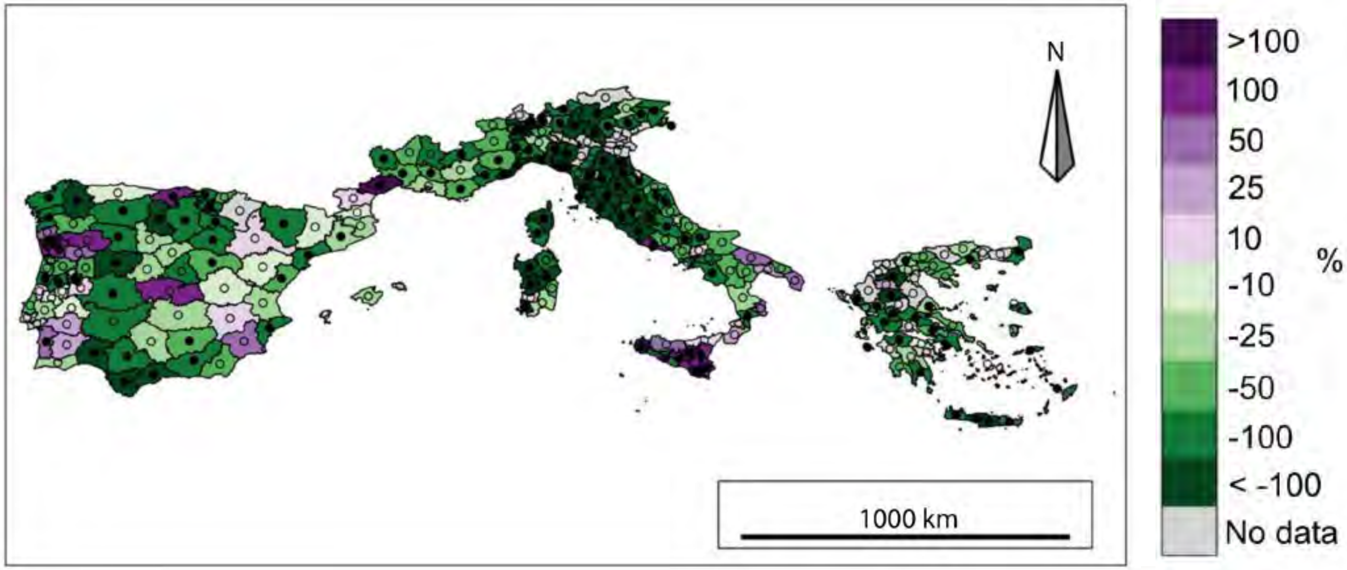
Fires in Mediterranean Europe

Use of European datasets:
EFFIS, CRU TS for SPEI
National inventories
Remote Sensing products

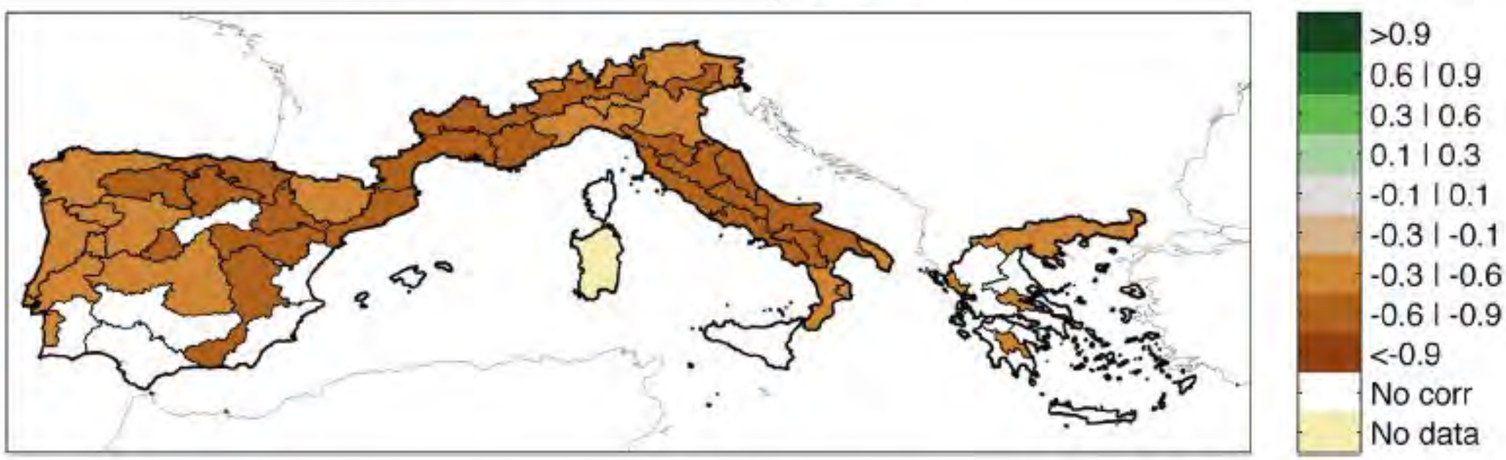
Marco Turco et al., PLOS ONE 2016
Scientific Reports 2017
Nature Communications 2018a, 2018b
Int. J. Applied Earth Observation and Geoinformation 2019

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

Recent changes in Fire Occurrence in the Mediterranean: Burned Area



Turco et al, PLOS ONE 2016



Turco et al, Sci. Reports 2017

Figure 1. Correlations between detrended log(*BA*) and $SPEI_3(0, 8)$, the SPEI for an accumulation time scale of 3 months and calculated in August (8) of the coincident summer (i.e. with the time lag of 0 year). Only correlations that are collectively significant from an FDR test[45] are shown. This figure is created with Matlab version R2012a (http://www.mathworks.com/).

With a global temperature rise > 1.5 °C above pre-industrial, the estimated summer burned area in the Mediterranean can double

1.5 °C

2 °C

3 °C

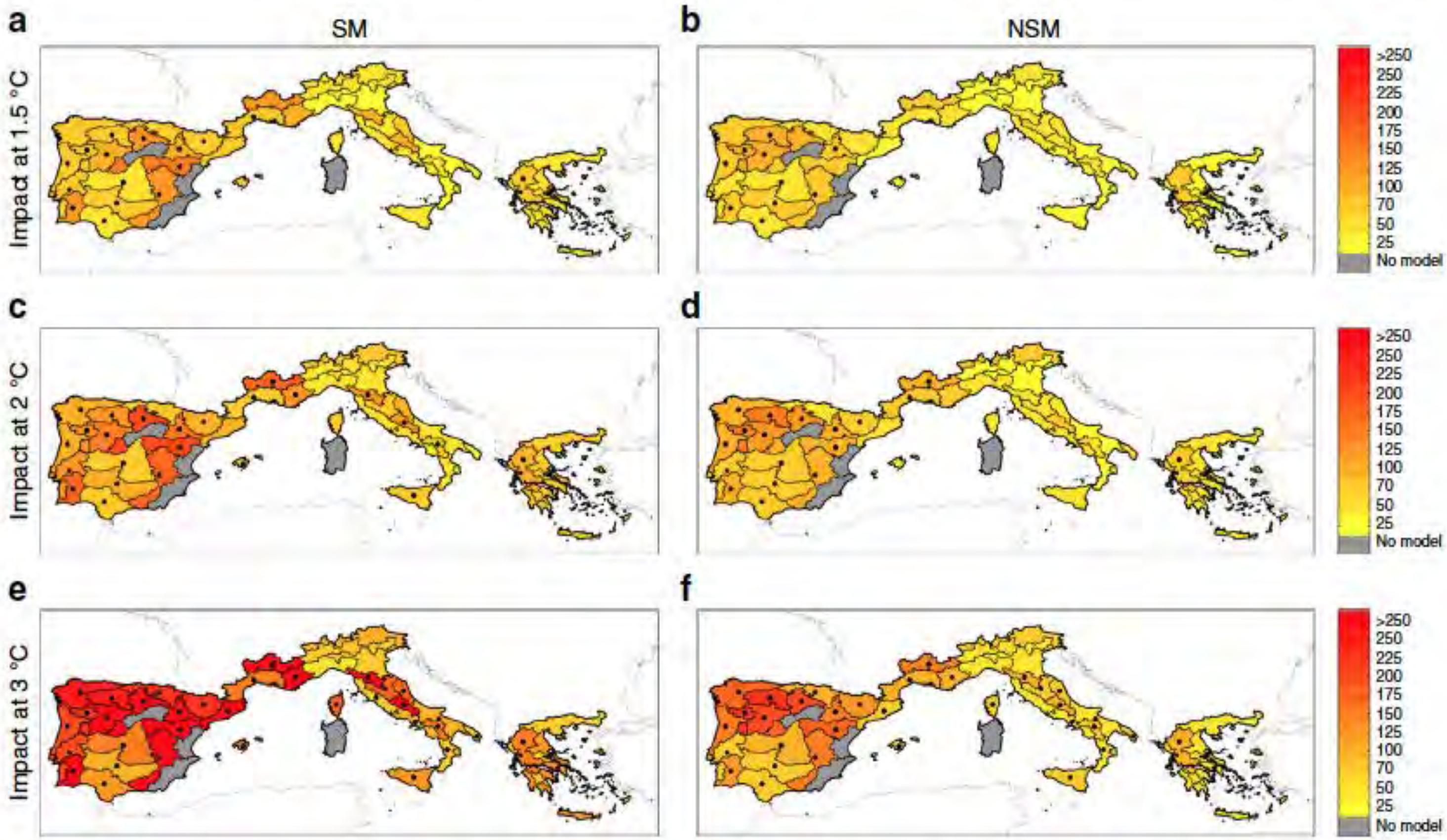
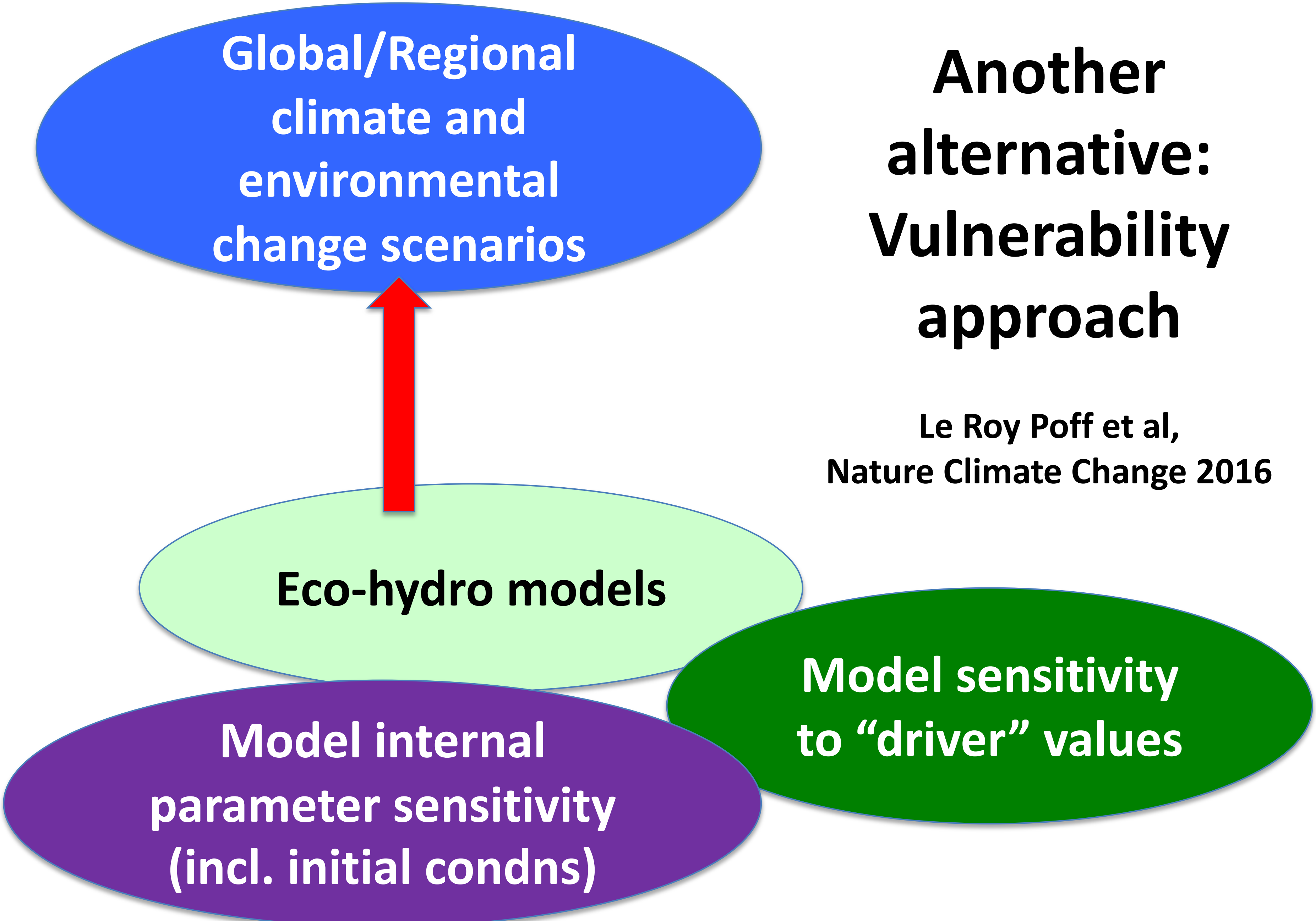


Fig. 4 Ensemble mean burned area changes. Burned area changes (%) for **a** the +1.5 °C case with the stationary model SM (i.e., using Eq. 3), (**b**) the +1.5 °C case with non-stationary model NSM (i.e., NSM). using Eq. (4), (**c**) the +2 °C case with SM, (**d**) the +2 °C case with NSM, (**e**) the +3 °C case with SM, and **f** the +3 °C case with NSM. Dots indicate areas where at least 50% of the simulations (1000 bootstrap replications × the ensemble of RCMs) show a statistically significant change and more than 66% agree on the direction of the change. Coloured areas (without dots) indicate that changes are small compared to natural variations, and white regions (if any) indicate that no agreement between the simulations is found (similar to ref.[70])

Turco et al, Nature Communications, 2018

Another alternative: Vulnerability approach

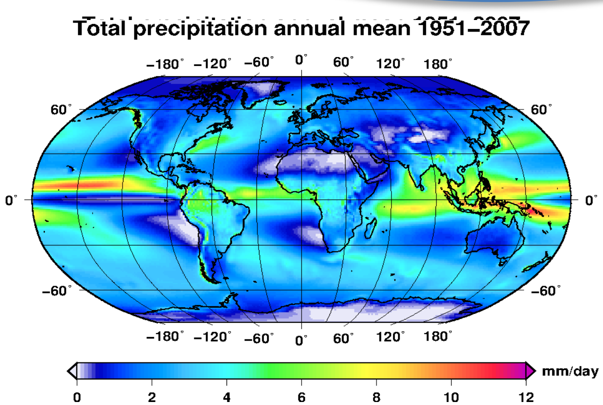
Le Roy Poff et al, Nature Climate Change 2016



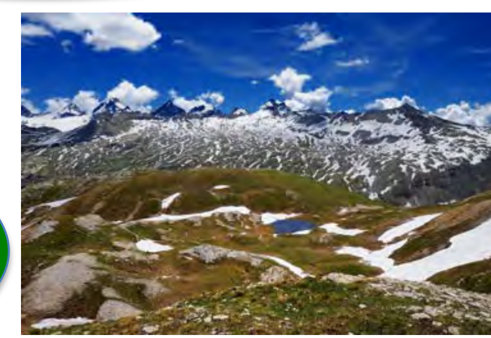
Feedbacks of ecosystems on climate change

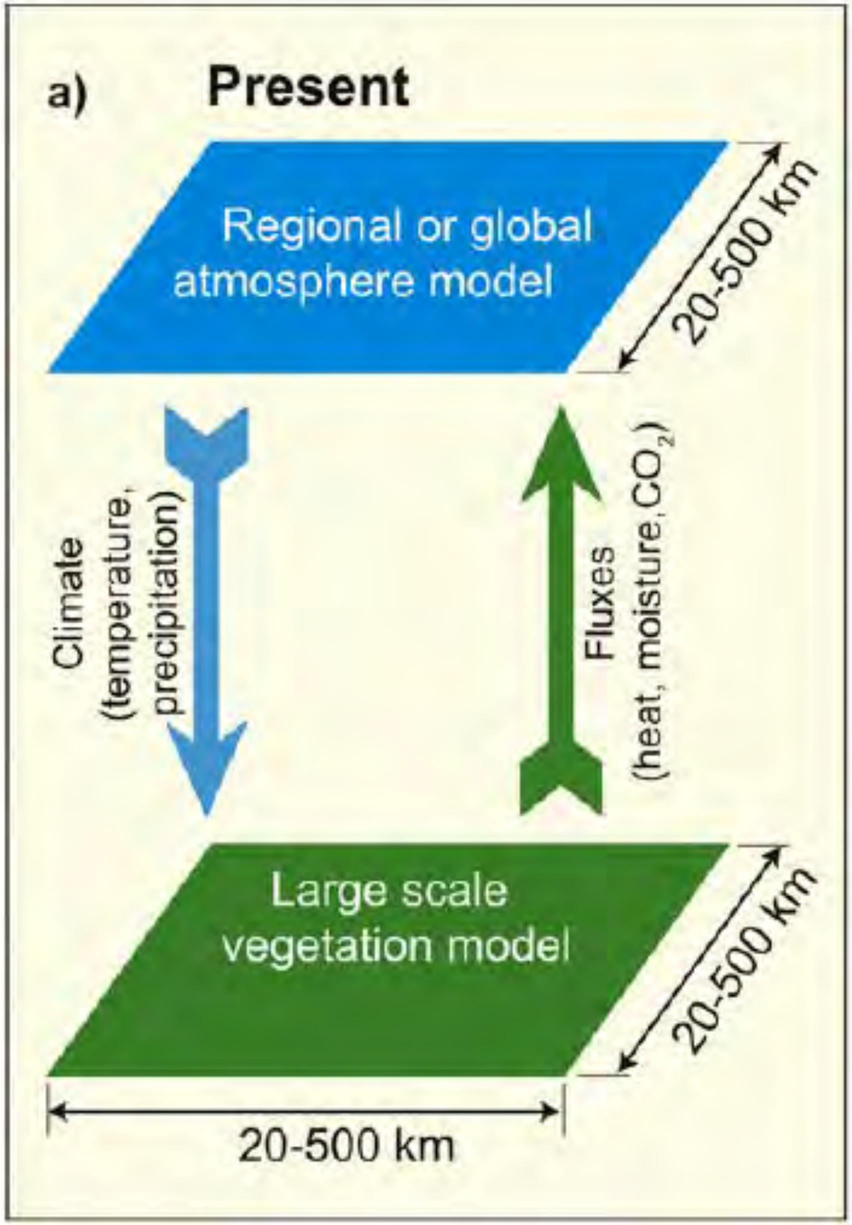
Global climate and land-use change scenarios

Environmental (eco-hydro-carbon) models

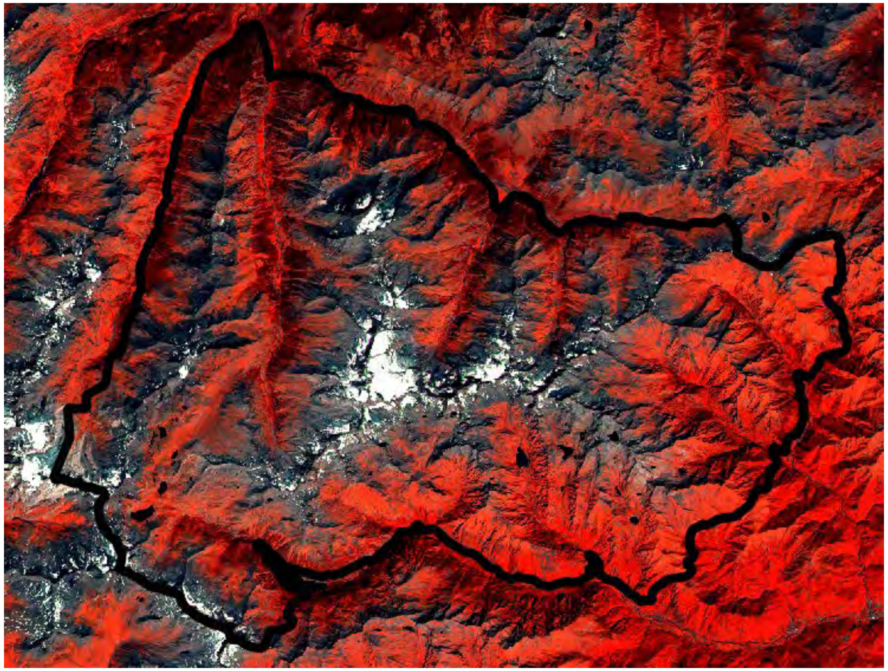


Ecosystem response and change



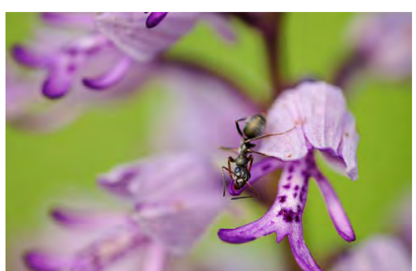


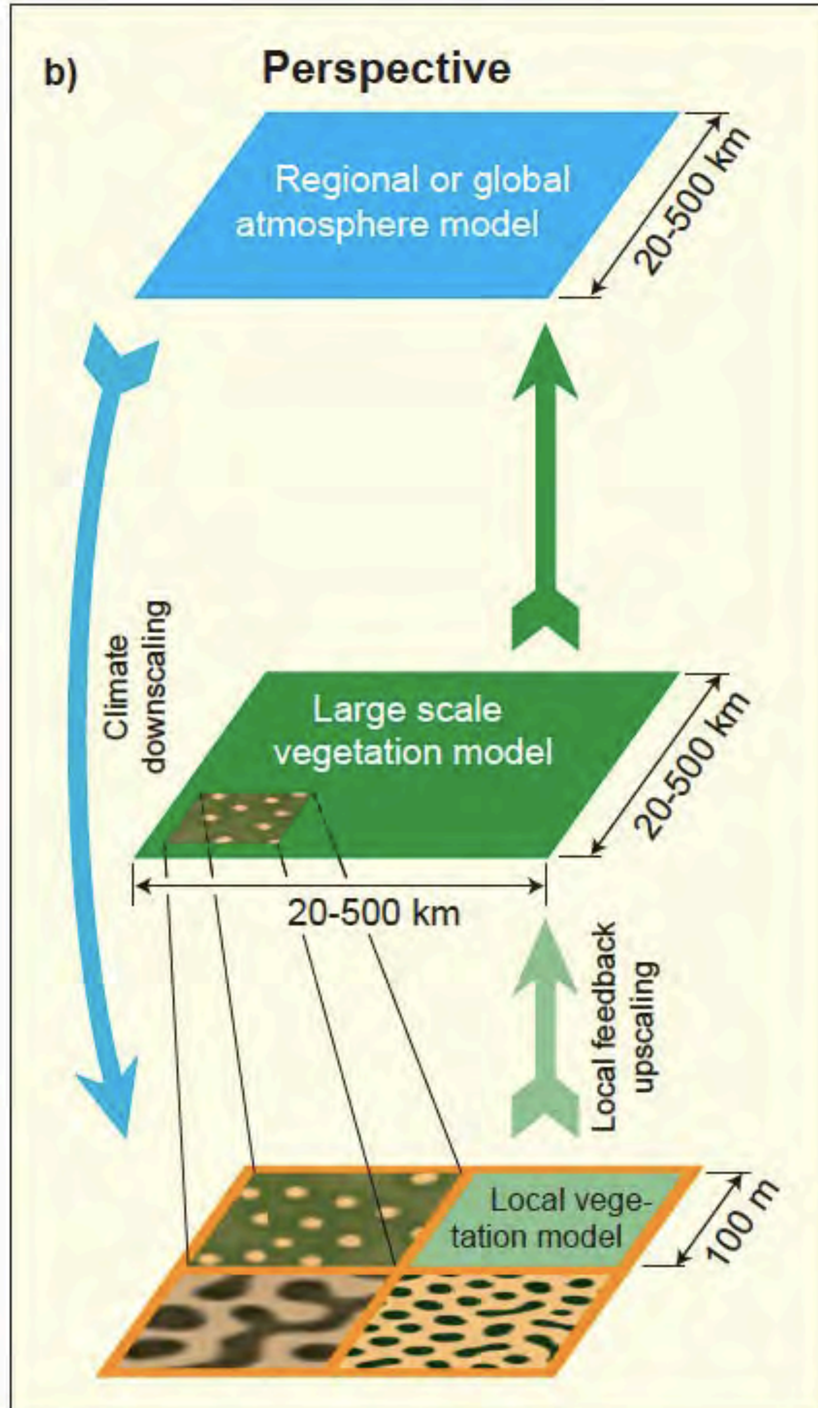
Climate models use smoothed versions of ecosystem dynamics (mainly vegetation)



Cross-scale feedbacks
(Rietkerk et al 2011)
(Soranno et al 2014)

Do changes in small-scales affect large-scale behavior?





The ECOPOTENTIAL Legacy

LifeWatch ERIC

eLTER RI

GEO ECO

The GEO Global Ecosystem Initiative

GEOSS

EuroGEOSS

A EUROPEAN APPROACH TO GEOSS

GEO GNOME

GEO BON

GEOESSENTIAL

ERA-PLANET

H2020 e-shape

Horizon Europe

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Thank you for your attention