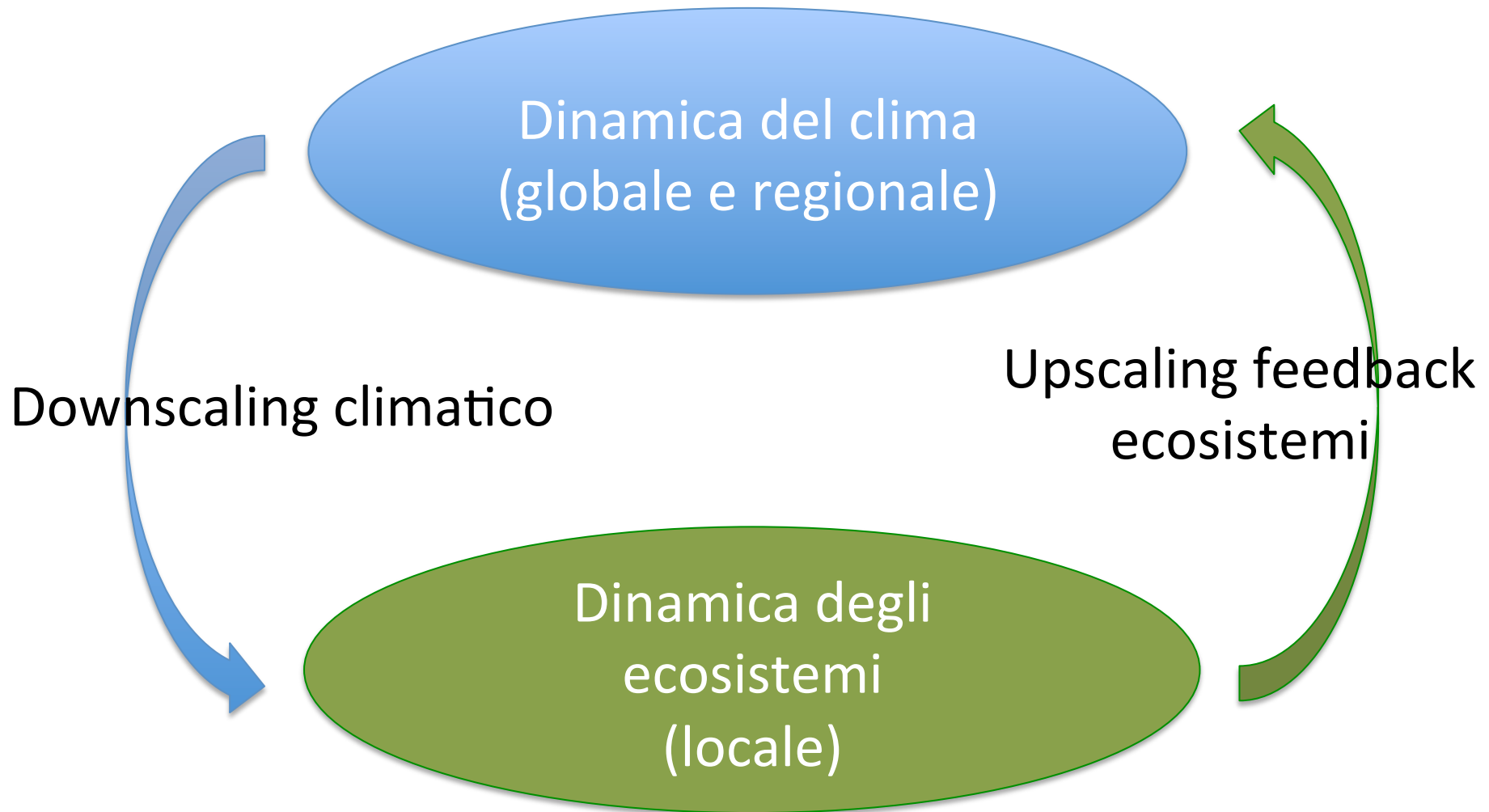


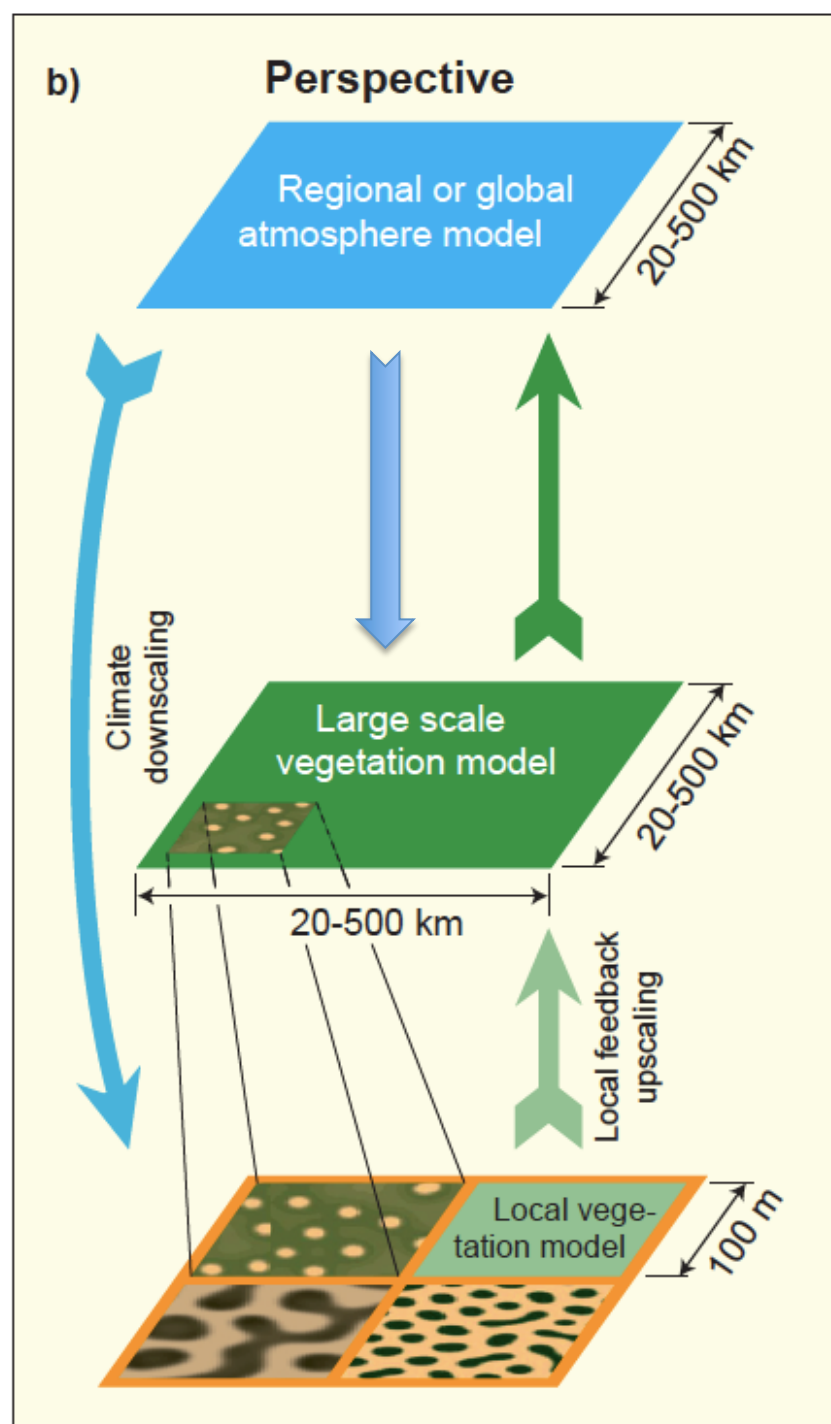
Modellistica interazioni ecosistemi-clima

A. Provenzale, CNR-ISAC, Torino



Interazioni su molte scale

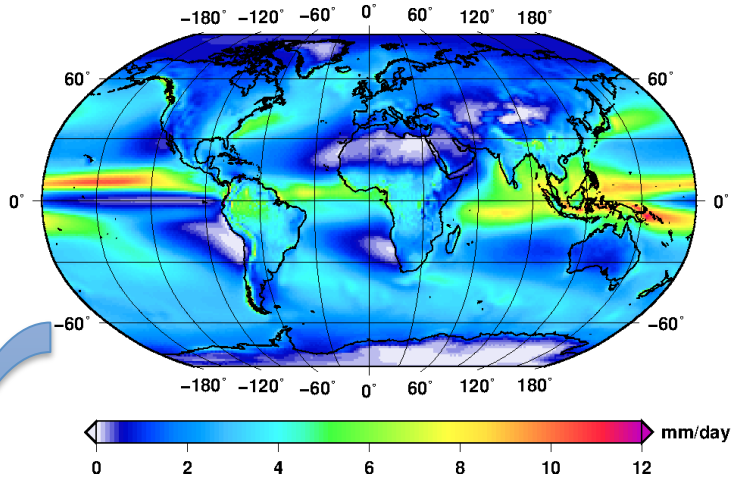
Rietkerk et al.
Ecological complexity 2011



Propagazione dell'incertezza

EC-Earth GCM

Total precipitation annual mean 1951–2007



Risposta dell'ecosistema

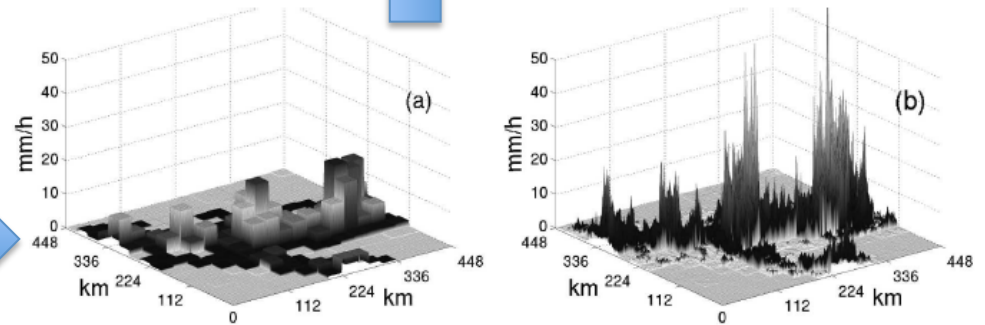
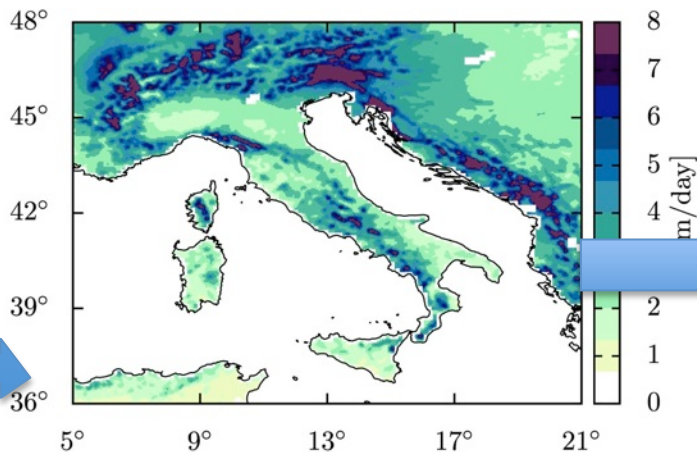


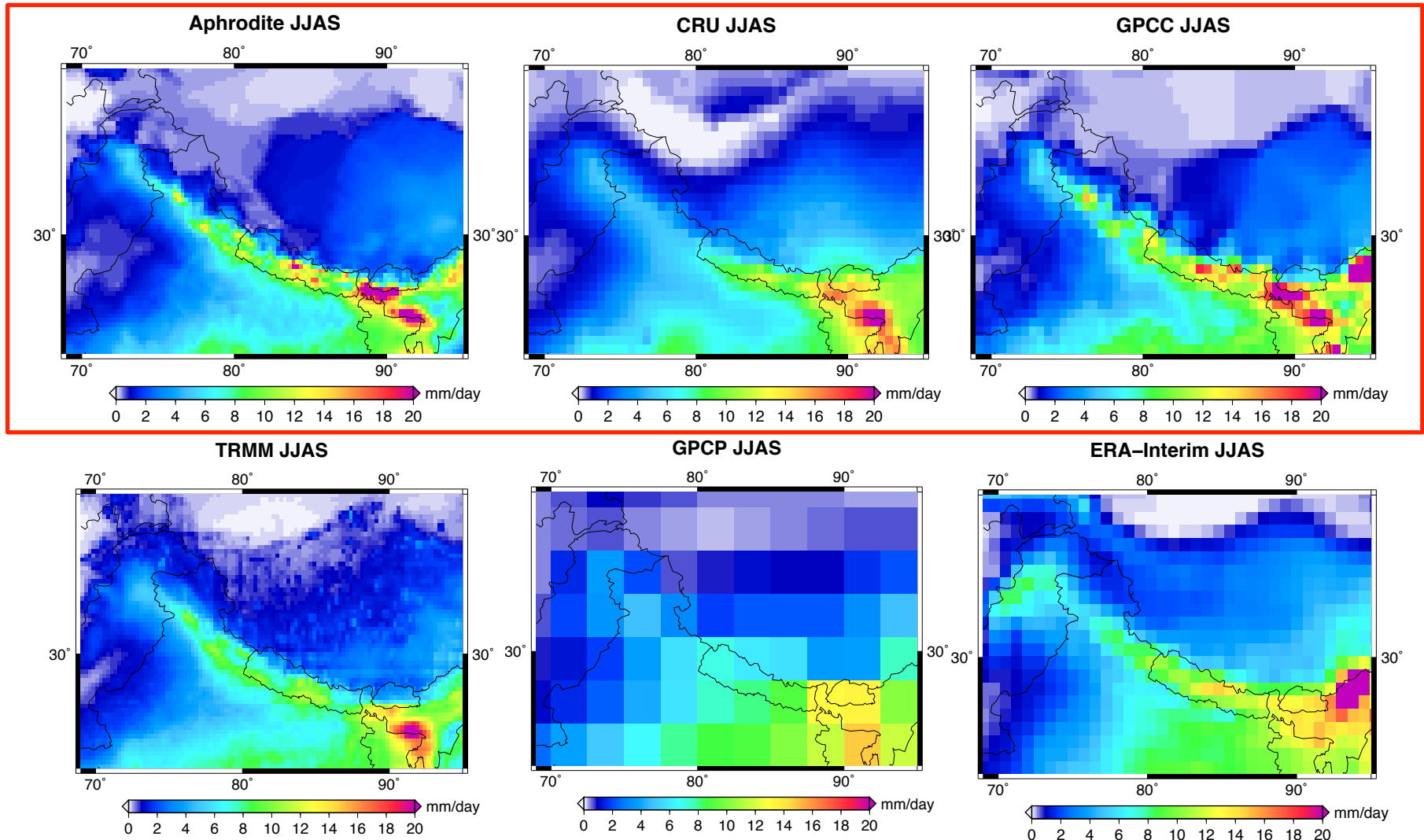
FIG. 10. (a) A snapshot of the forecasted rain field obtained from the LAM forecast and (b) one example of a downscaled field obtained by application of the RainFARM. The vertical scale indicates precipitation intensity (mm h⁻¹) and it is the same for the two fields.

WRF RCM

Downscaling statistico/stocastico

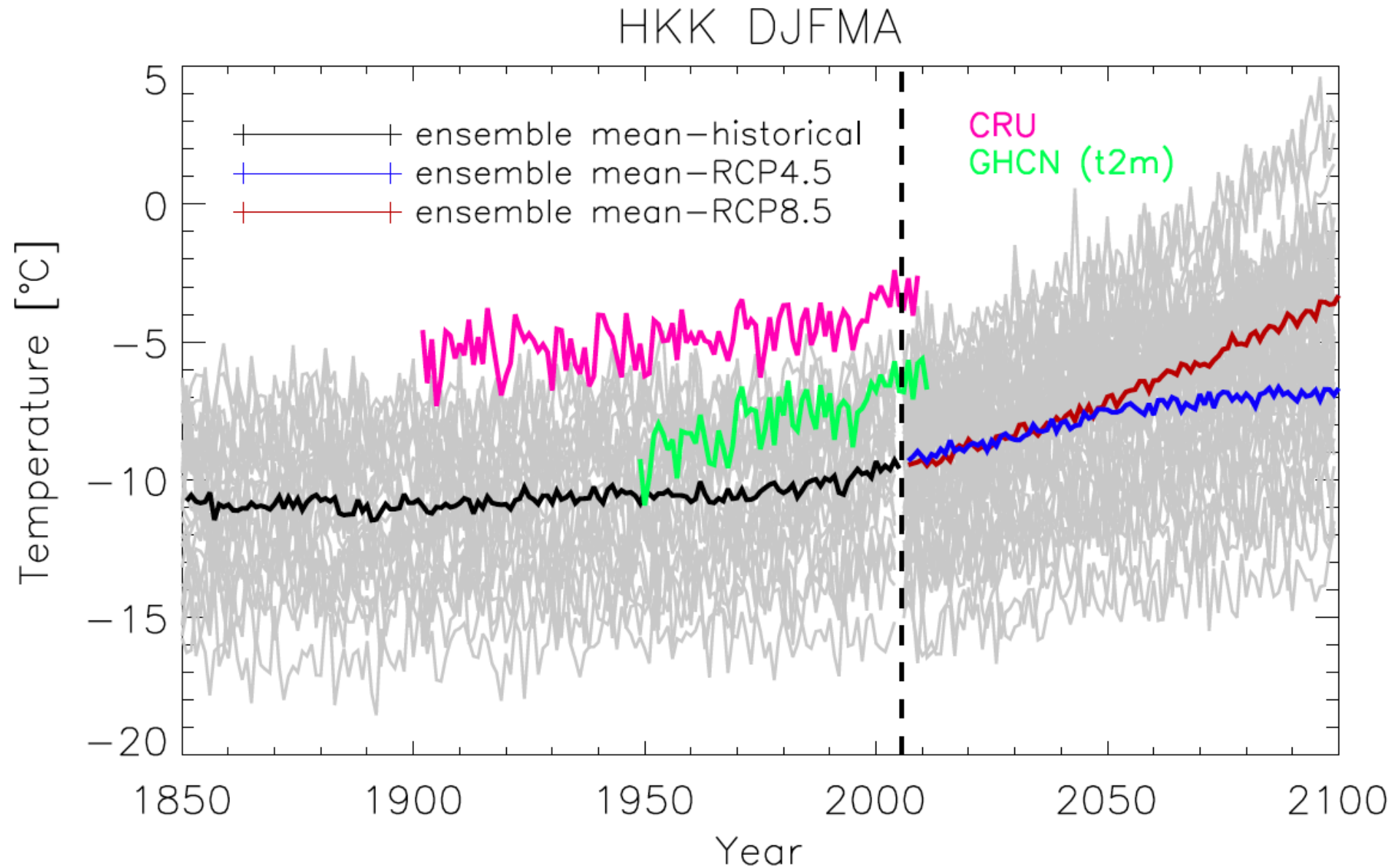
Incertezza nei dati climatici

Precipitazione estiva in HKKH, Media 1998-2007



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

Incertezza degli scenari climatici



Attività di modellistica ecologica (1)

CNR-ISAC Torino

1. Analisi dati e modelli statistici/empirici della dinamica di popolazione di specie individuali: **stambecco e camoscio al PNGP, fagiano di monte, pernice bianca**, ungulati a Castelporziano.
2. Analisi dati e modelli statistici/empirici della **biodiversità montana** (PNGP, Orsiera, Veglia-Devero).
3. Analisi dati e modelli deterministici degli **ecosistemi lacustri d'alta quota** (PNGP).
4. Modellistica empirica della relazione fra migrazioni dell'avifauna (Mediterraneo, sub-artico) e parametri biologici e climatici.

Attività di modellistica ecologica (2)

CNR-ISAC Torino

5. Interazione fra plankton e turbolenza oceanica a mesoscala (vortici) con modelli deterministici bio-fluidodinamici.
6. Modelli deterministici di interazione suolo-vegetazione-atmosfera in zone aride e semi-aride (spazio implicito).
7. Modelli deterministici a spazio esplicito della dinamica della vegetazione e di *pattern formation* in zone aride.

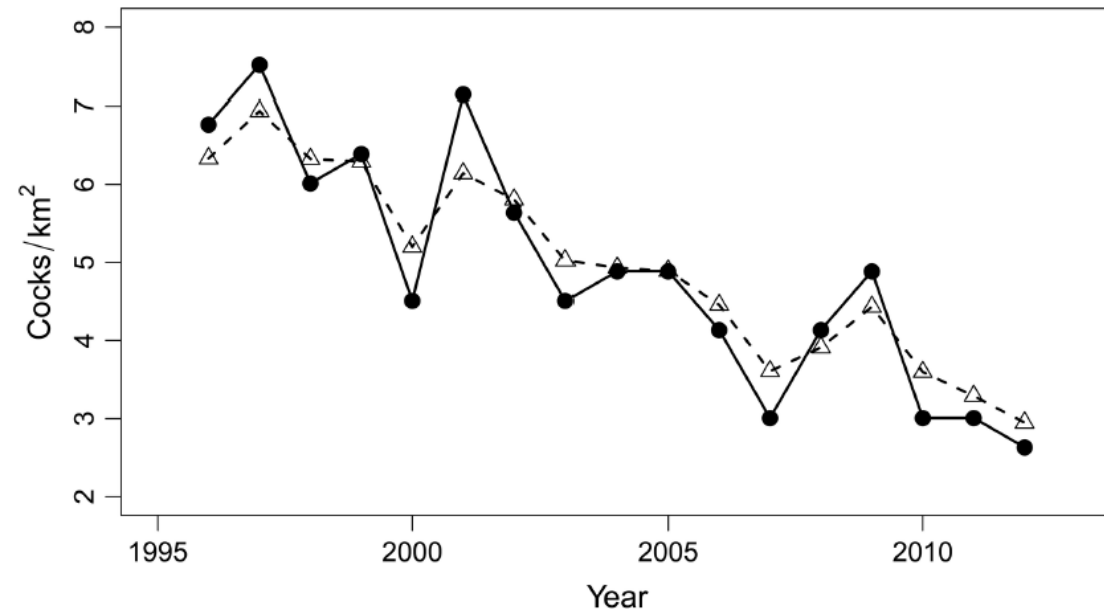
Attività di modellistica ecologica (3)

CNR-ISAC Torino

8. Modelli deterministici semplificati (EBM) dell'interazione clima-vegetazione e abitabilità planetaria.
9. Interazione vegetazione-clima in modelli climatici globali a complessità intermedia (PlaSim) e state-of-the-art (EC-Earth).
10. Effetto della vegetazione sulla circolazione locale/regionale (modello atmosferico WRF).

Pernici bianche al Veglia Devero

Imperio et al. PLOS ONE 2013

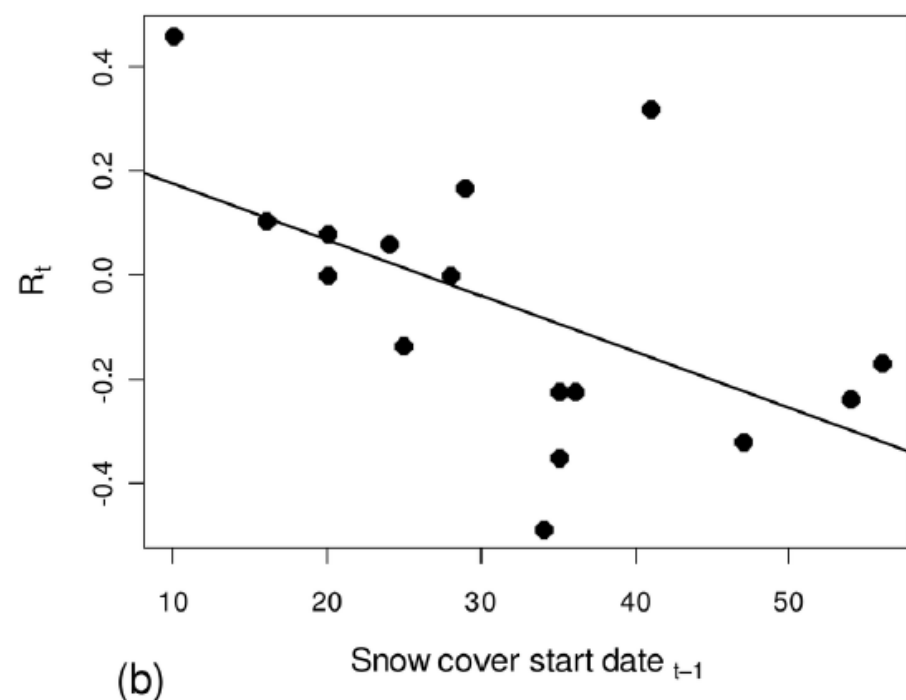
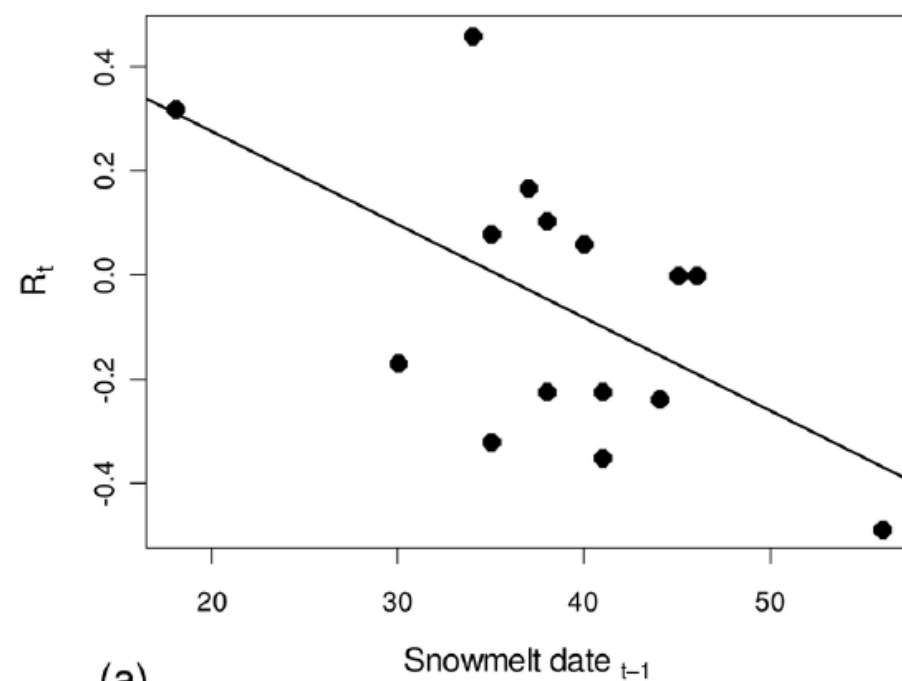


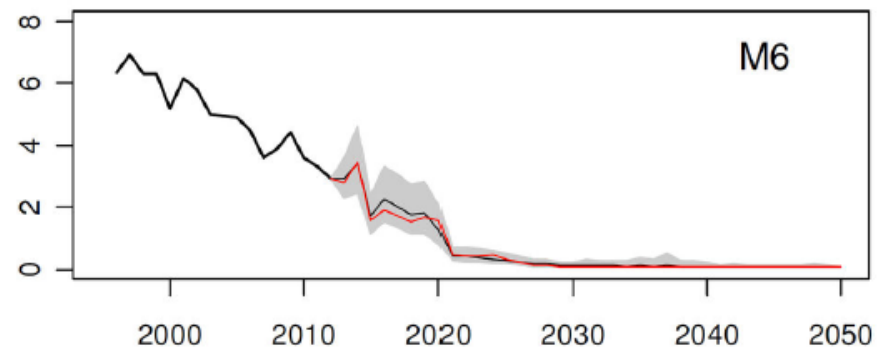
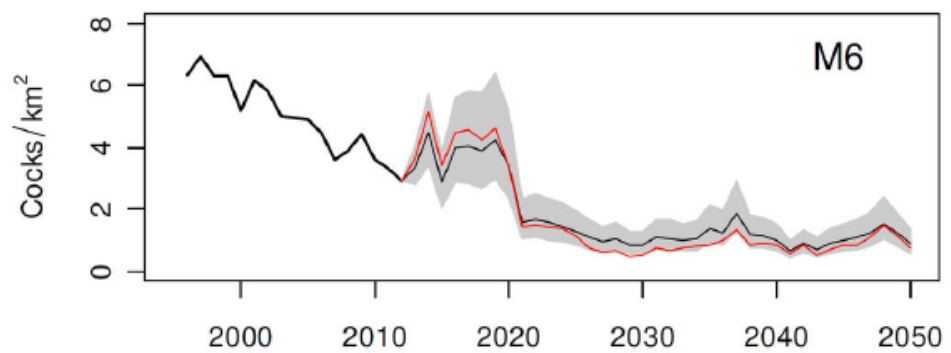
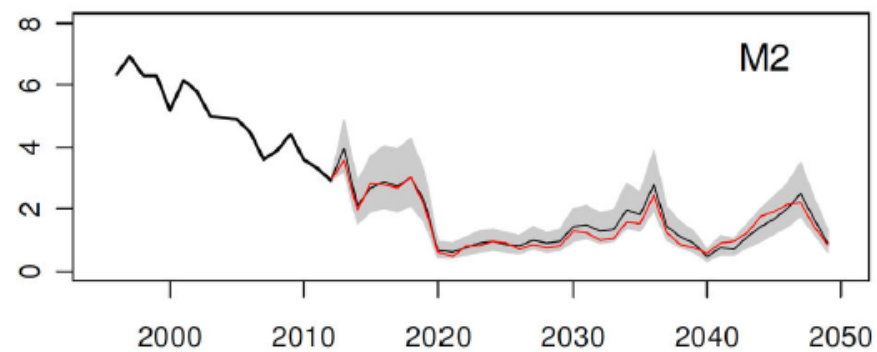
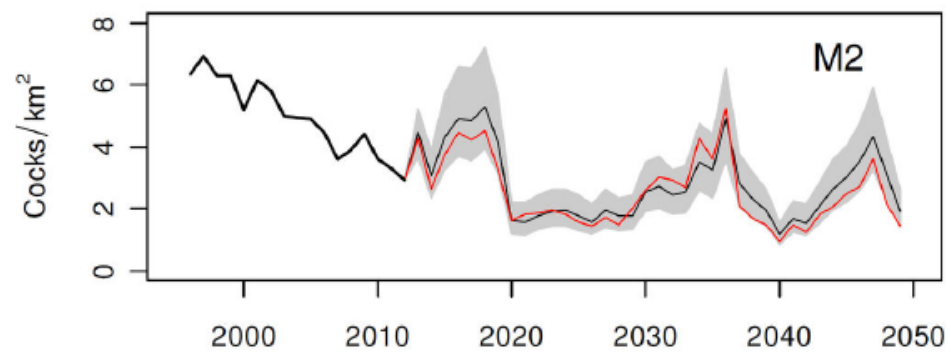
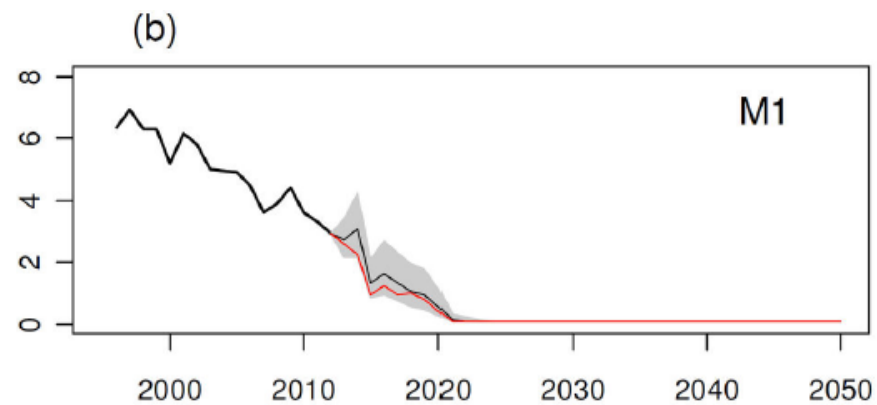
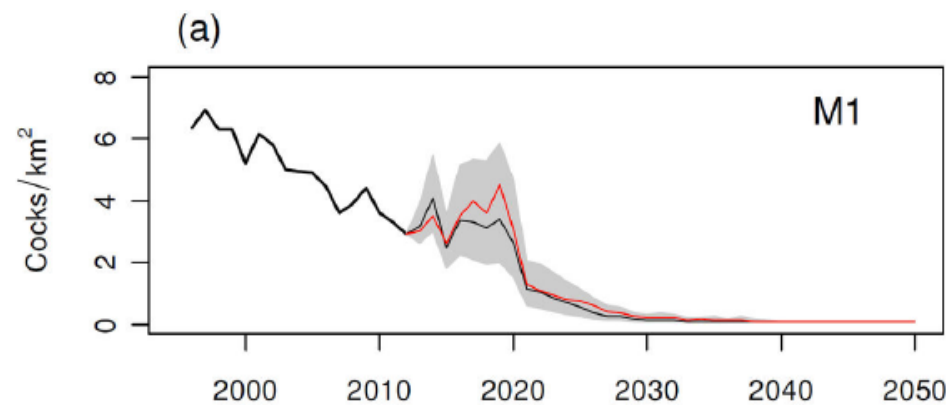
$$R_t = a + b \ln N_{t-1} + \sum_{i=1}^v c_i V_i + \varepsilon$$



Model	Intercept	$\ln N_{t-1}$	$\ln N_{t-2}$	SE_{t-1}	SS_{t-1}	SP_t	$T(\text{July})_{t-1}$	$P(\text{July})_{t-1}$	$T(\text{Jan-Mar})_t$	$T(\text{Apr-May})_t$	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
M7	-0.07 ± 0.04			-0.19 ± 0.04	-0.18 ± 0.04					-0.01 ± 0.04	3	0.78	-46.51
M8	0.42 ± 0.25	-0.30 ± 0.15		-0.14 ± 0.04		0.16 ± 0.04					3	0.77	-46.34
M9	-0.07 ± 0.04			-0.17 ± 0.05		0.16 ± 0.05					2	0.69	-45.79
M10	-0.08 ± 0.04			-0.18 ± 0.04		0.19 ± 0.05				0.08 ± 0.05	3	0.75	-45.02

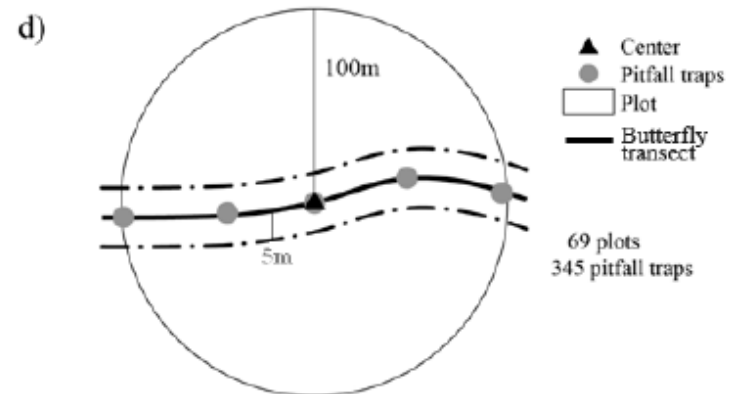
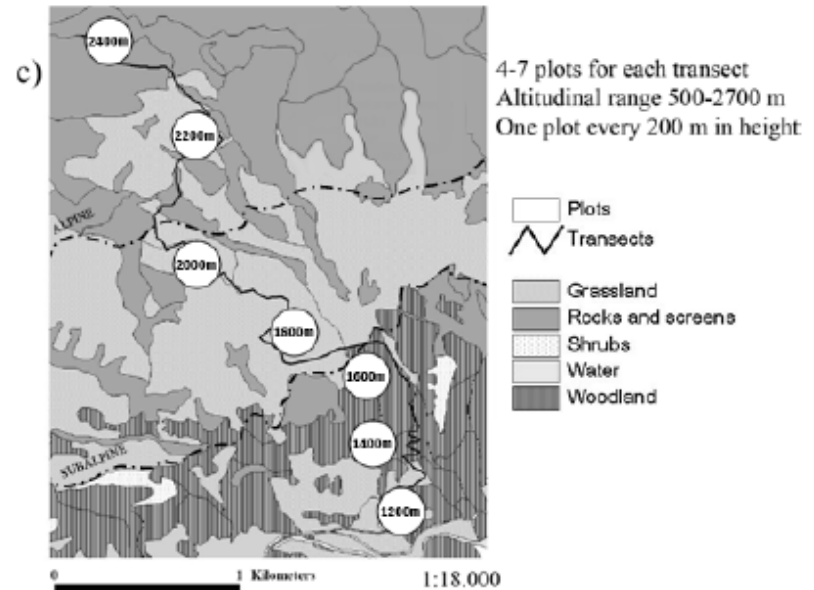
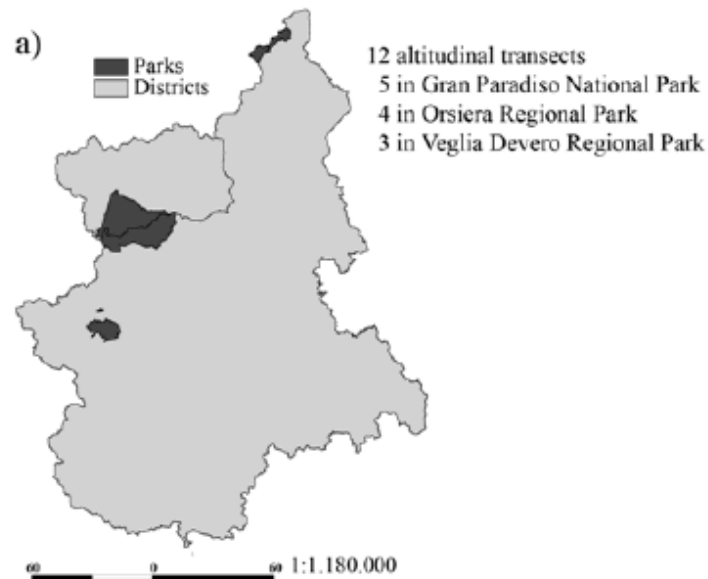
Model ID, parameter estimates $\pm$ standard error for intercept and selected variables ($\ln N_{t-1}$: log-normal density at time $t-1$; $\ln N_{t-2}$: log-normal density at time $t-2$; SE: snow cover end date; SS: snow cover start date; SP: length of snow cover period; T: mean temperature; P: precipitation), number of variables included in the model, coefficient of determination (R^2), and AICc are given for each model. Significant factors are in bold.





Biodiversità animale montana

Viterbi et al. Community Ecology 2013



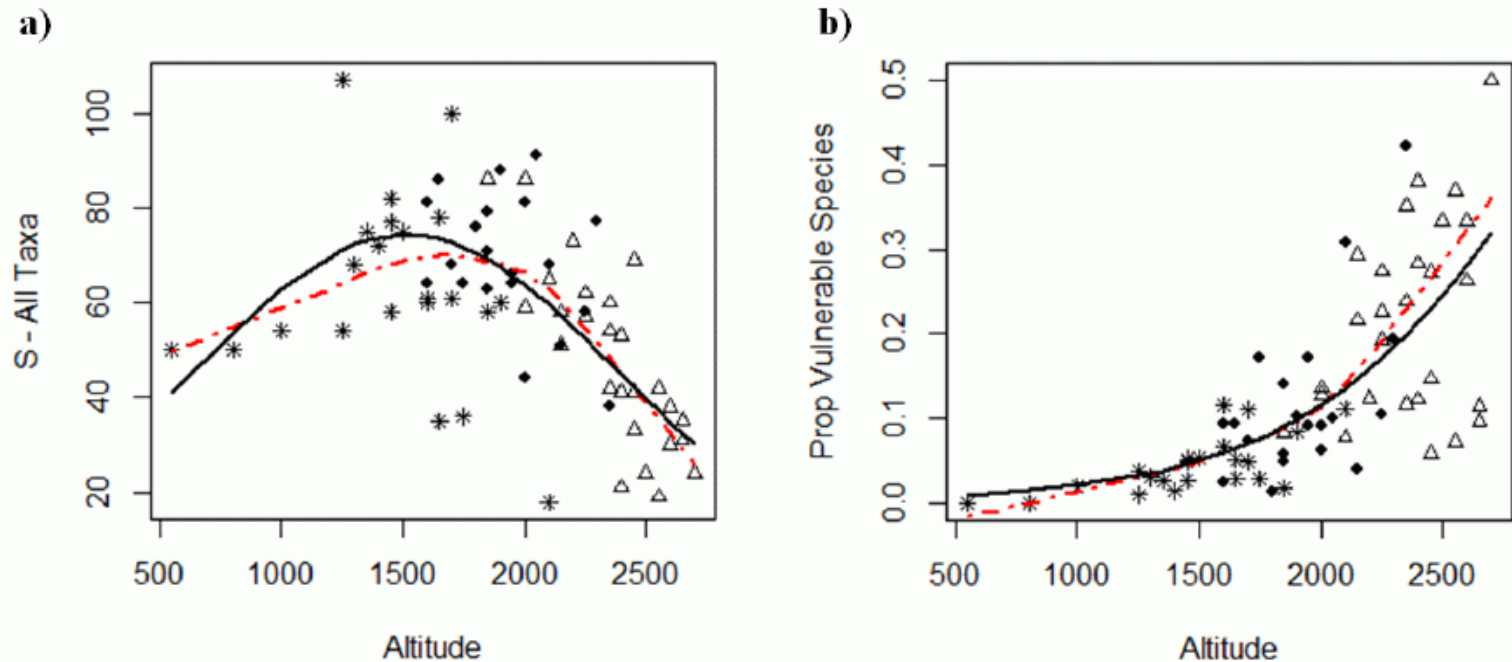


Figure 2. Scatterplots of the total species richness per site for all taxa pooled together (a) and of the proportion of vulnerable species (b) along the altitudinal gradient. The LOWESS regression curve is represented as a dashed line, while the significant regression curve is represented as a solid line. Montane belt (*), Subalpine belt (●), Alpine belt (△).

Environmental variables: temperature,
altitude, belt, geography

Biodiversity Monitoring Project



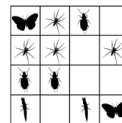
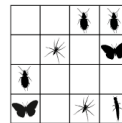
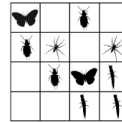
Environmental Predictors

Temp
Temperature
Altitude

Tempark
Temperature
Altitude
Geography

All
Temperature
Altitude
Geography
VegetationCover

Species data



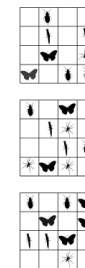
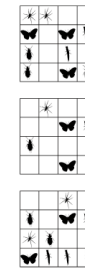
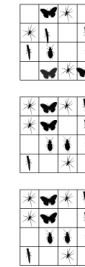
Current situation

Climate change scenarios

1.5 Min
1 Degree
1.5 Max

1.5 Min
1 Degree
1.5 Max

1.5 Min
1 Degree
1.5 Max

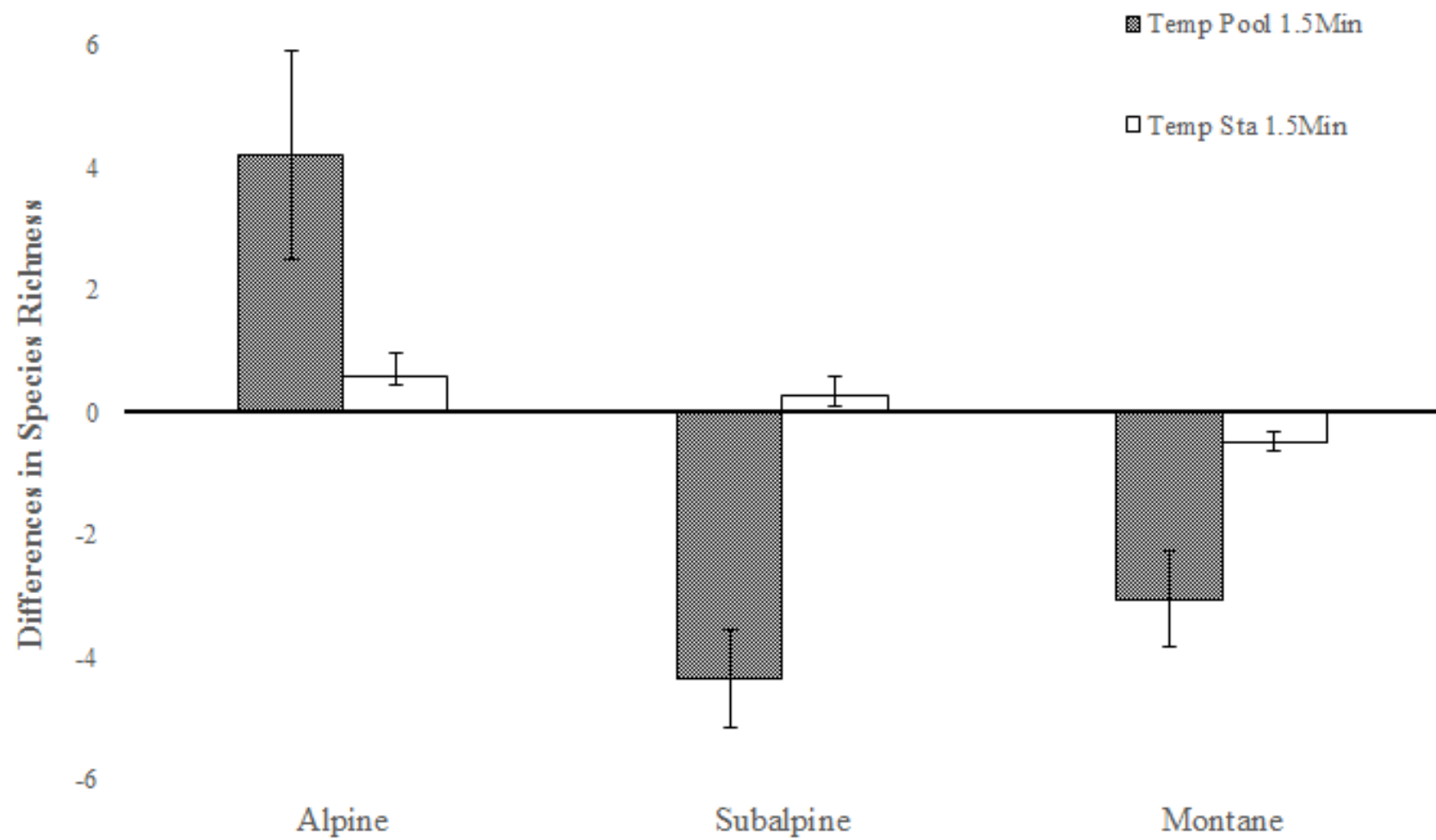


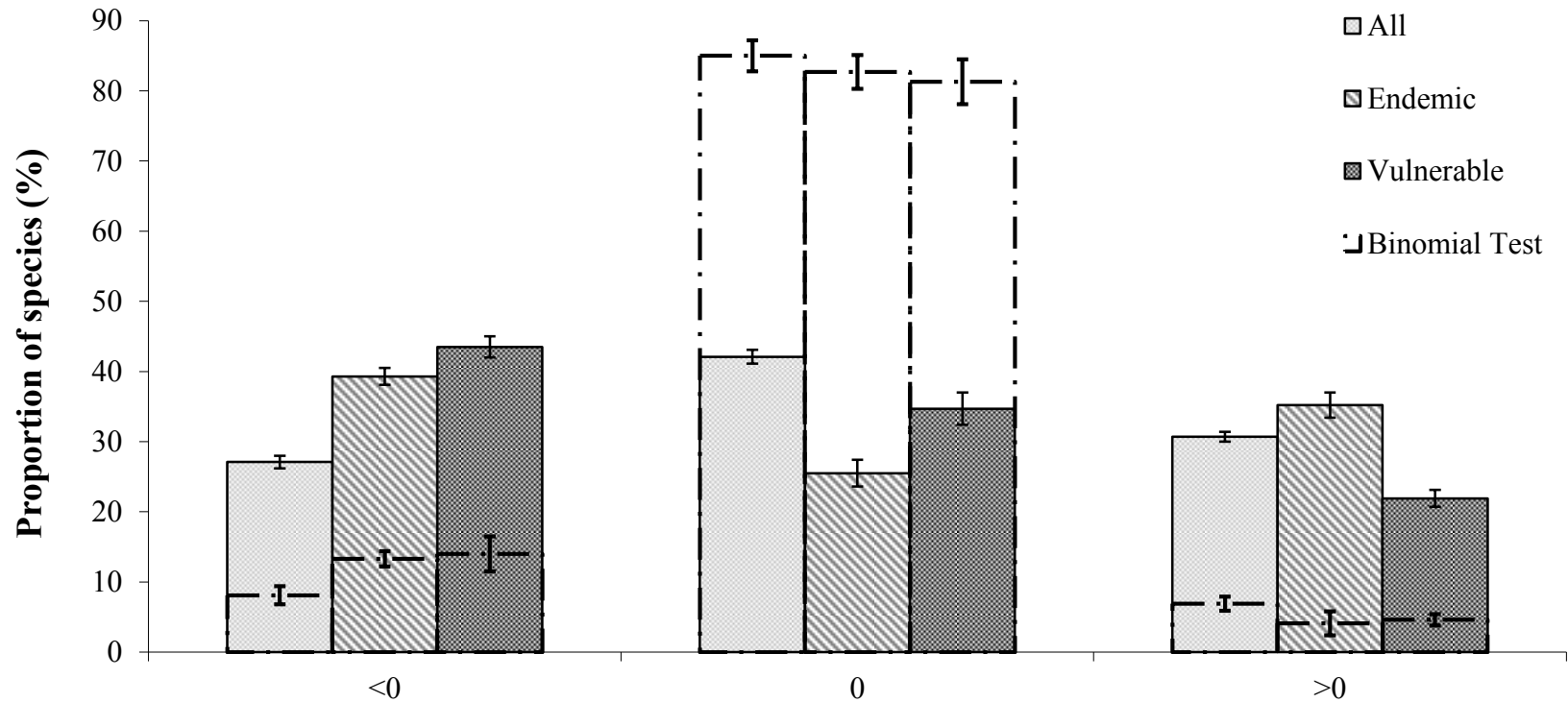
Predictions

Output

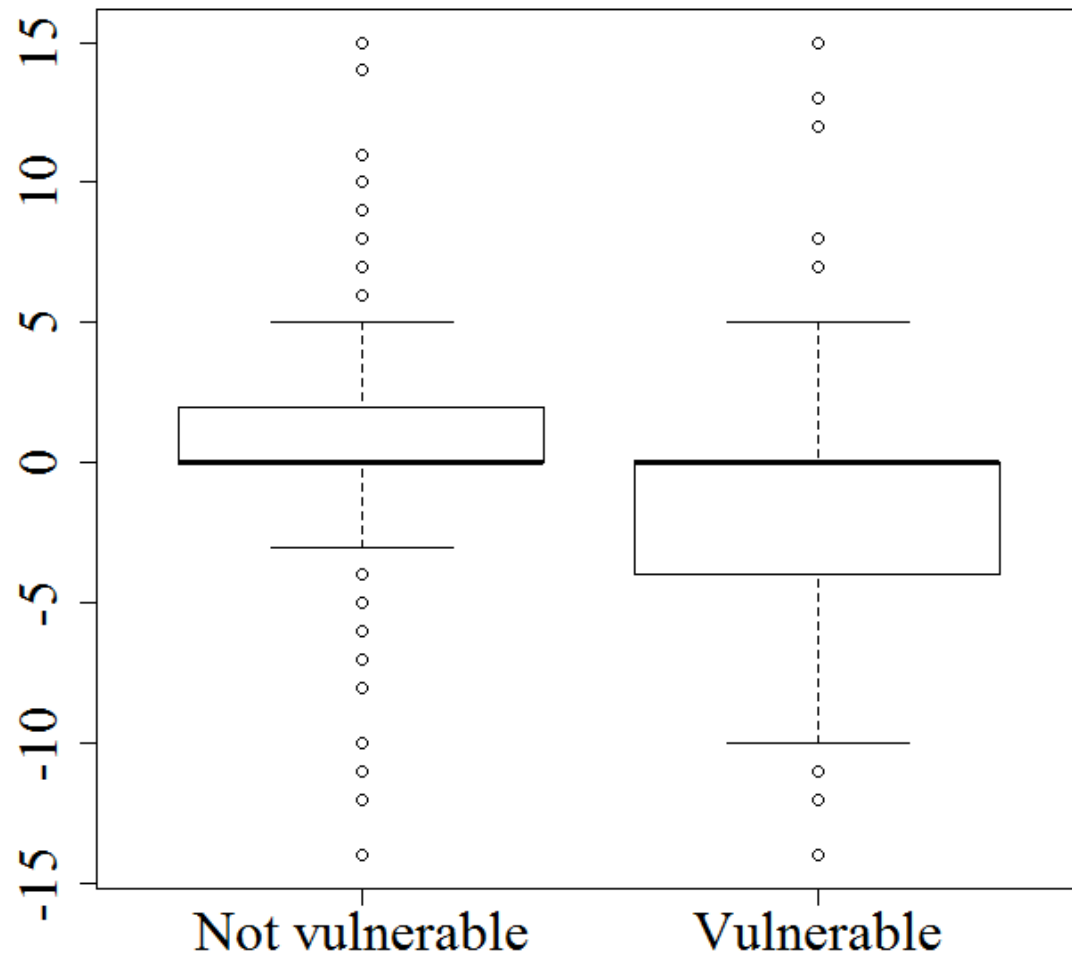
1. Species
2. Plot
3. Community
4. Belts

Viterbi et al, *sub judice*





Percentage of species that showed a decrease (<0), an increase (>0) and no variation (0), in the number of occupied plots. Dotted lines represent *varying* (>0 and <0) and *not varying* (0) *species* after binomial test. Bar charts represent mean value and error bars the standard error among model classes and scenarios.



Box plots of the number of plots gained or lost for vulnerable species in the Tempark model class, 1.5Min scenario. The box shows the median, the first and the third quartile of the distribution, whiskers represent minimum and maximum values and outliers are plotted as circles.



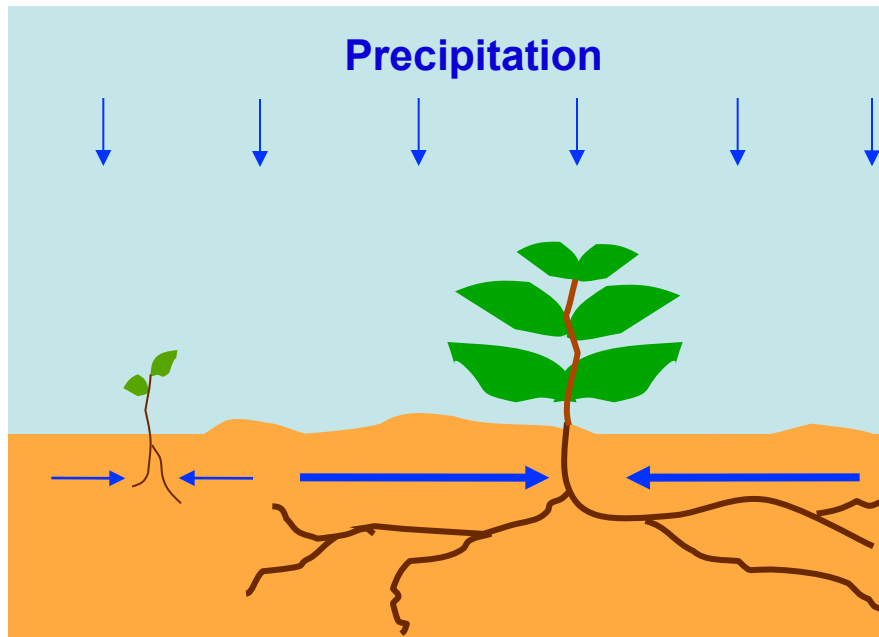
Rietkerk et al., *The American Naturalist* **160** (4), 2002

Pattern di vegetazione in zone aride

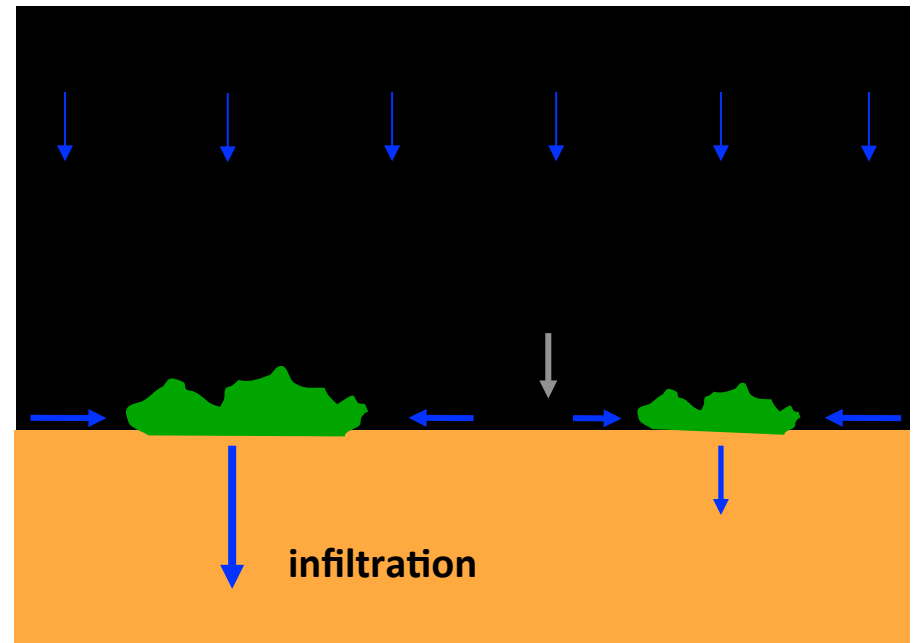
Meccanismi di *vegetation patterning*

Feedback positivo fra biomassa e acqua + competizione

Ruolo delle radici



Infiltrazione



von Hardenberg et al, PRL 2001, Gilad et al PRL 2004, JTB 2007,
Kletter et al JTB 2009, Baudena et al AWR 2013

Modello vegetazione – umidità del suolo - runoff

Biomassa vegetale

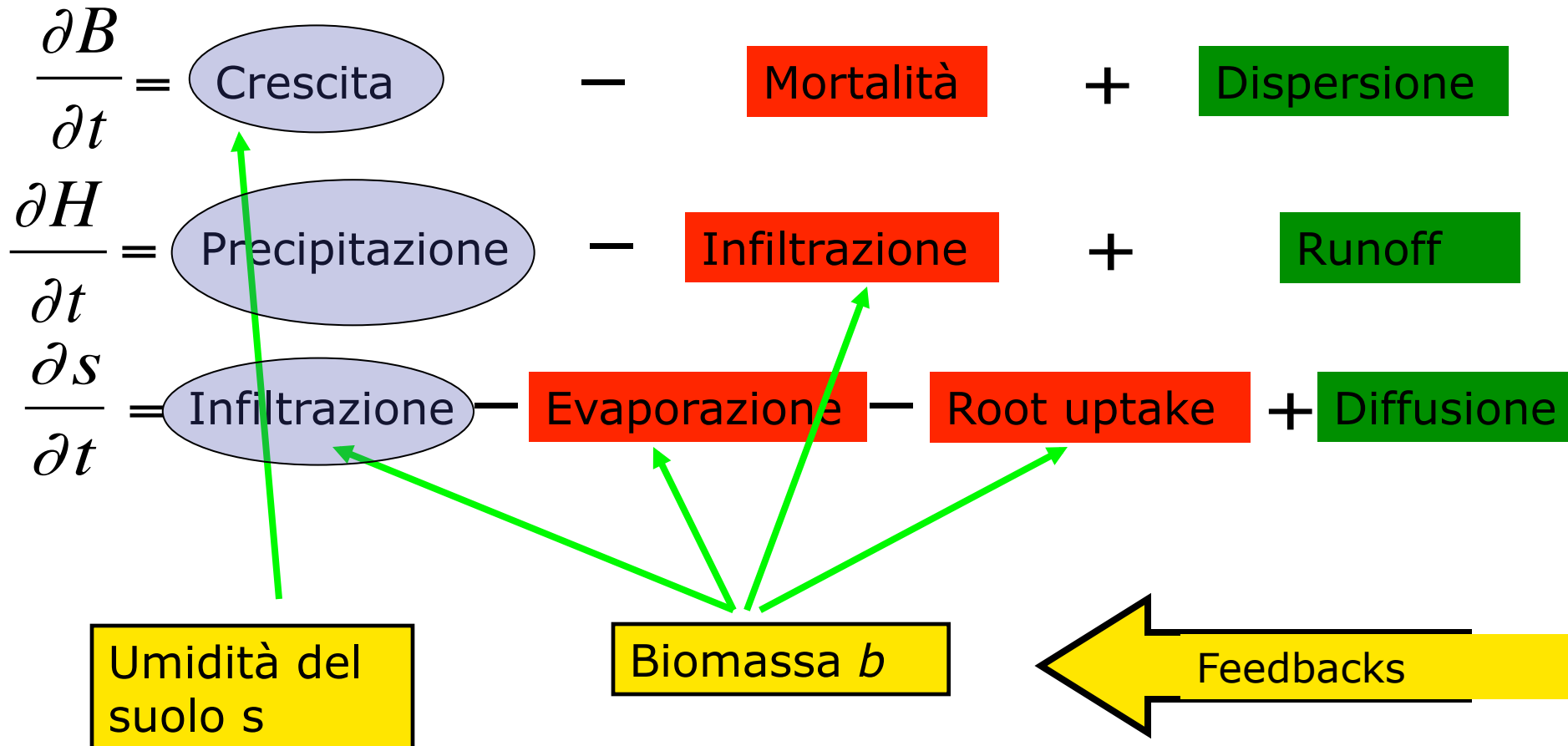
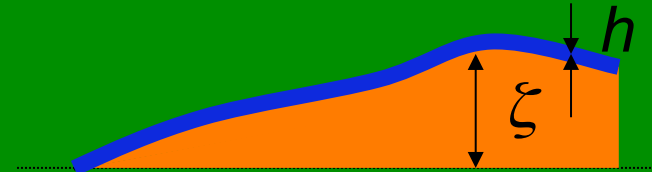
$b(x,t)$ [Kg/m²]

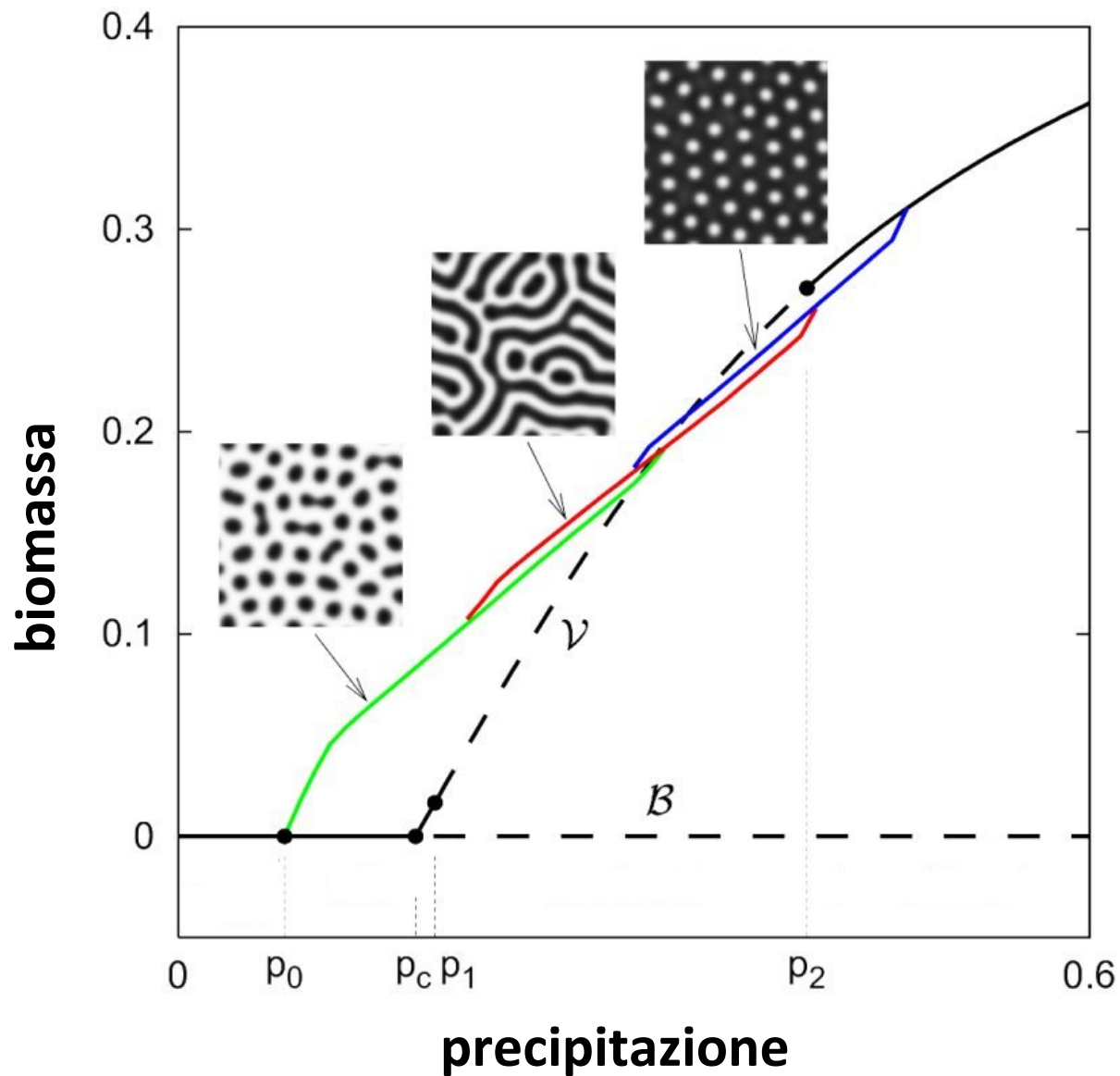
Umidità relativa del suolo

$s(x,t)$

Altezza acqua superficie

$h(x,t)$ [mm] o [Kg/m²]





Equilibri multipli
con distribuzione non omogenea di vegetazione

Tutti i modelli sono sbagliati

...e non vanno mai confusi con la realtà.

Ma anche i dati, spesso, sono imprecisi

e il “dato” ha (più) valore se è inserito
in uno schema interpretativo.

L’uso consapevole e “informato”
di modelli permette di sviluppare schemi
interpretativi e quantificare le domande,
se le domande sono ben poste.