WP 2.6
Pilot studies, dissemination and coordination

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Pilot studies, dissemination and coordination

- **Water resources in the HKKH**
- **Changes in snow resources in mountain areas**
- **Terrestrial biodiversity in the Alps**
- Effect of aerosols in high-altitude areas
- Multi-secular climate simulation for the Med area
- Precipitation in high-elevation regions
- Response of Alpine glaciers to climate change
- High-res climatological information for a 30 y reference period
- Effect of climate change on Alpine plant germination

The CMIP5 picture of current and future precipitation and snow resources in the Karakoram-Himalaya

Palazzi, von Hardenberg, Provenzale, in prep 2013

Filippi, Palazzi, von hardenberg, Provenzale, in prep 2013

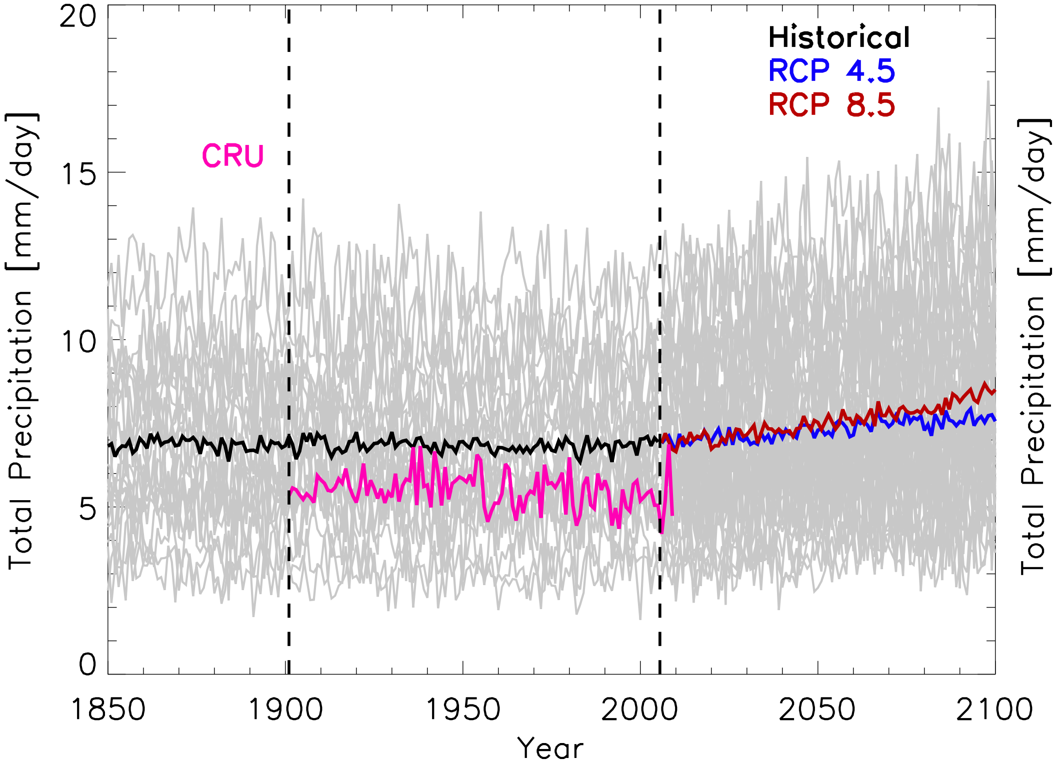
Terzago, von Hardenberg, Palazzi, Provenzale, in prep 2013

List of the CMIP5 models employed in this study. Bold entries indicate the models with a representation of the indirect sulfate aerosol forcing. Starred entries are Earth System Models (ESM).

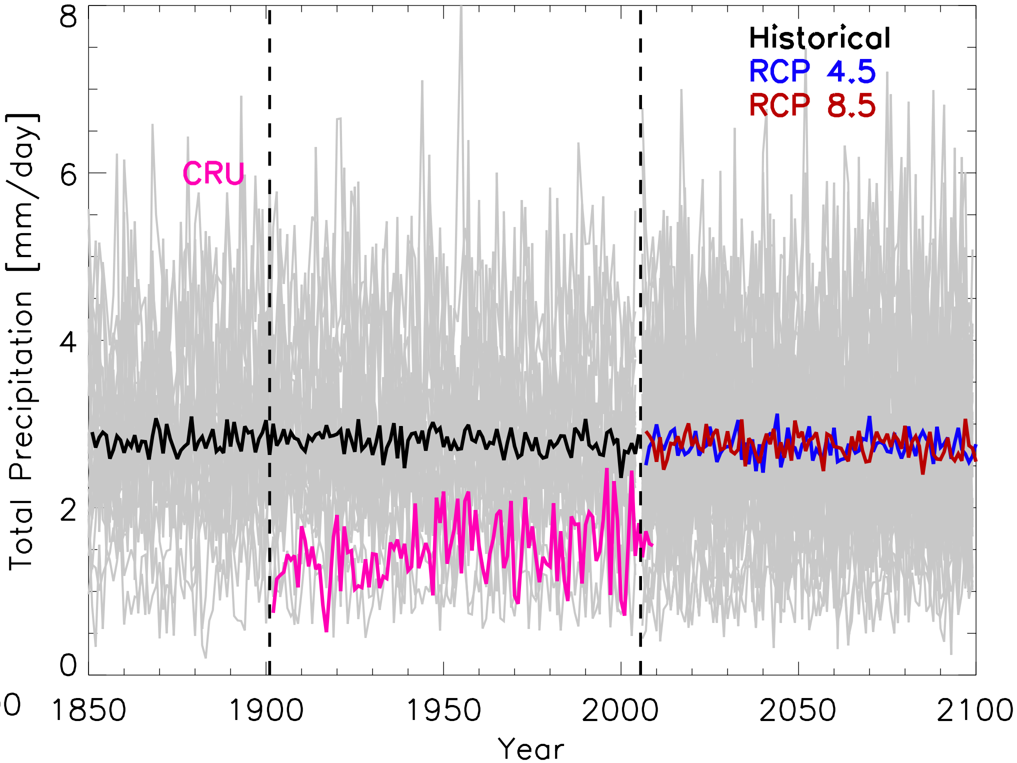
Name	Horizontal resolution (°)	Institute ID	First indirect	Second indirect	Key reference
bcc-csm1-1-m	1.125×1.125	BCC	No	No	
bcc-csm1-1	2.8125×2.8125	BCC	No	No	Wu et al. (2013)
CCSM4	1.25×0.9375	NCAR	No	No	Meehl et al. (2012)
CESM1-BGC	1.25×0.9375	NSF-DOE-NCAR	No	No	
CESM1-CAM5	1.25×0.9375	NSF-DOE-NCAR	No	No	
CMCC-CM	0.75×0.75	CMCC	N/A	N/A	Scoccimarro et al. (2011)
EC-Earth	1.125×1.125	EC-EARTH	No	No	Hazeleger et al. (2012)
FGOALS-g2	2.8125×3	LASG-CESS	N/A	N/A	Li et al. (2013)
*FIO-ESM	2.8125×2.8125	FIO	No	No	Song et al. (2012)
*MPI-ESM-LR	1.875×1.875	MPI-M	No	No	Giorgetta et al. (2013)
***CanESM2**	2.8125×2.8125	CCCMA	Yes	No	Arora et al. (2011)
CMCC-CMS	1.875×1.875	CMCC	Yes	No	Davini et al. (2013)
CNRM-CM5	1.40625×1.40625	CNRM-CERFACS	Yes	No	Voldoire et al. (2013)
CSIRO-Mk3-6-0	1.875×1.875	CSIRO-QCCCE	Yes	No	Rotstayn et al. (2012)
INM-CM4	2.000×1.500	INM	Yes	No	Volodin et al. (2010)
***IPSL-CM5A-LR**	3.750×1.8947	IPSL	Yes	No	Hourdin et al. (2013)
***IPSL-CM5A-MR**	2.500×1.25874	IPSL	Yes	No	Hourdin et al. (2013)
MRI-CGCM3	1.125×1.125	MRI	Yes	No	Yukimoto et al. (2012)
ACCESS1-0	1.875×1.25	CSIRO-BOM	Yes	Yes	Bi et al. (2013)
ACCESS1-3	1.875×1.25	CSIRO-BOM	Yes	Yes	Bi et al. (2013)
HadGEM2-CC	1.875×1.25	MOHC	Yes	Yes	Martin et al. (2011)
***HadGEM2-ES**	1.875×1.25	MOHC	Yes	Yes	Bellouin et al. (2011)
MIROC5	1.40625×1.40625	MIROC	Yes	Yes	Watanabe et al. (2010)
***MIROC-ESM**	2.8125×2.8125	MIROC	Yes	Yes	Watanabe et al. (2011)
***NorESM1-M**	2.500×1.875	NCC	Yes	Yes	Bentsen et al. (2013)

Precipitation time series CMIP5 models and CRU obs.

Himalaya Summer (JJAS)



HKK Winter (DJFMA)

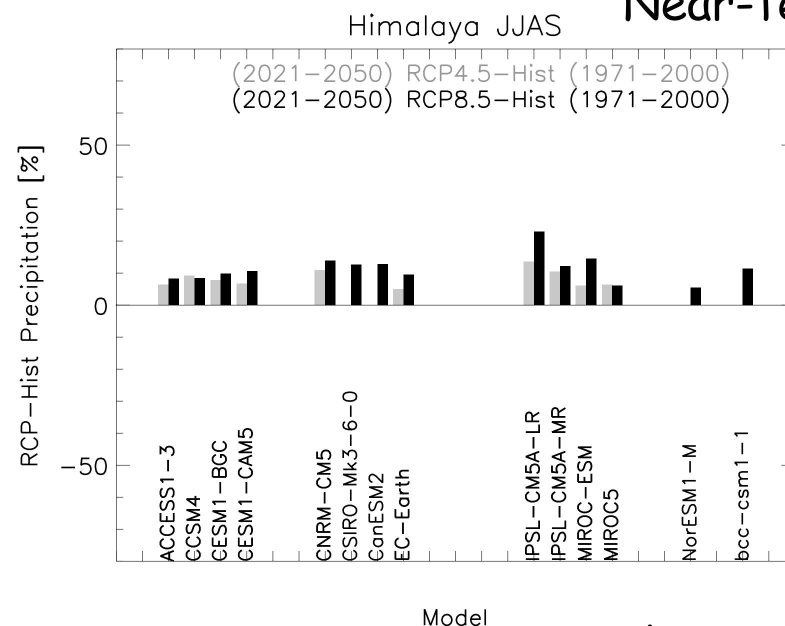


Only five GCMs (ACCESS-0-1, ACCESS-0-3, HadGEM-CC, HadGEM-ES, and CanESM2) simulate, in agreement with the CRU observations, a statistically significant decreasing trend in **summer precipitation in the Himalayan region** over the years 1901-2005, but for all of them the trends are higher than the one inferred from CRU. All these models do account for the indirect effect of sufate aerosols; 2 of them are Earth System Models.

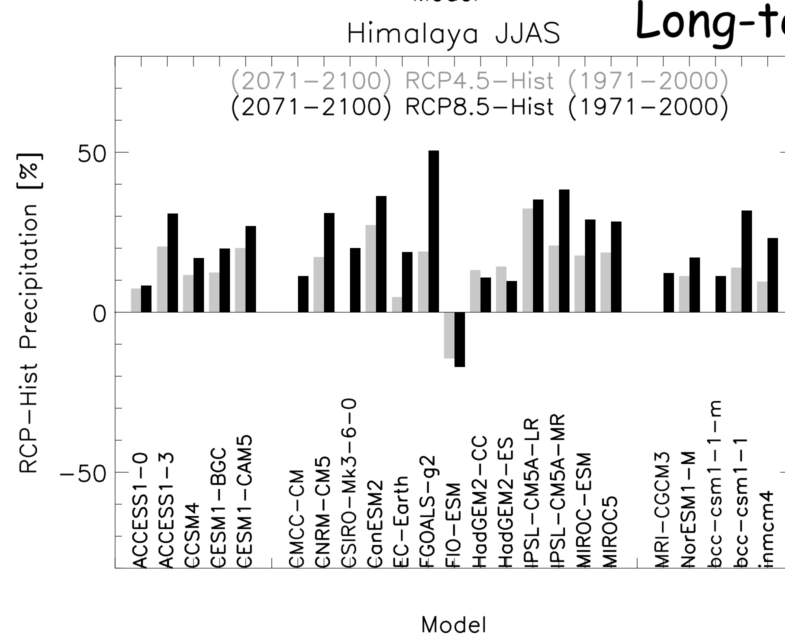
Himalaya JJAS
Significant Precipitation trends and changes

	Historical 1901-2005	JJAS RCP4.5 2006-2100	RCP8.5 2006-2100
Observations			
CRU	**-0.366**		
CMIP5 models			
bcc-csm1-1-m	0.017	0.167	**0.828**
bcc-csm1-1	0.024	0.834	**2.076**
CCSM4	0.276	0.518	**1.740**
CESM1-BGC	-0.108	**0.824**	**1.851**
CESM1-CAM5	-0.391	**2.578**	**3.790**
CMCC-CM	-0.149	0.236	**0.981**
EC-Earth	**0.517**	0.003	**1.061**
FGOALS-g2	0.309	**0.924**	**2.235**
FIO-ESM	0.044	**-1.543**	-0.822
MPI-ESM-LR	-0.121	-0.351	0.150
CanESM2	**-1.000**	**1.561**	**2.225**
CMCC-CMS	0.145	0.606	-0.026
CNRM-CM5	0.191	**0.584**	**1.763**
CSIRO-Mk3-6-0	-0.079	0.160	**0.773**
INM-CM4	0.084	**0.769**	**1.877**
IPSL-CM5A-LR	-0.076	**0.870**	**1.025**
IPSL-CM5A-MR	0.032	**1.463**	**2.533**
MRI-CGCM3	0.066	-0.260	0.326
ACCESS1-0	**-0.490**	**0.745**	**1.211**
ACCESS1-3	**-0.529**	**1.957**	**2.967**
HadGEM2-CC	**-0.771**	**1.718**	**1.600**
HadGEM2-ES	**-0.454**	**1.394**	**1.356**
MIROC5	**0.575**	**2.173**	**3.678**
MIROC-ESM	0.331	**1.598**	**2.389**
NorESM1-M	-0.038	**1.788**	**2.419**

Near-term



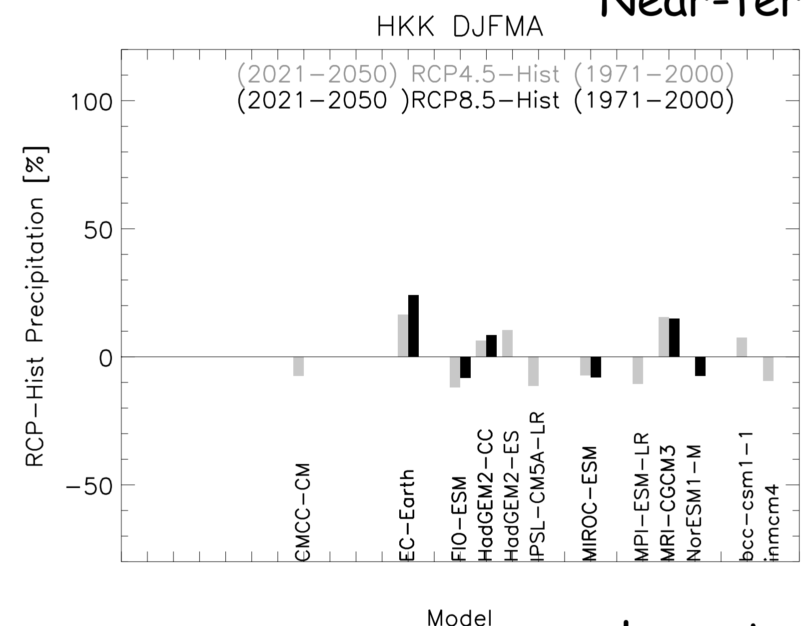
Long-term



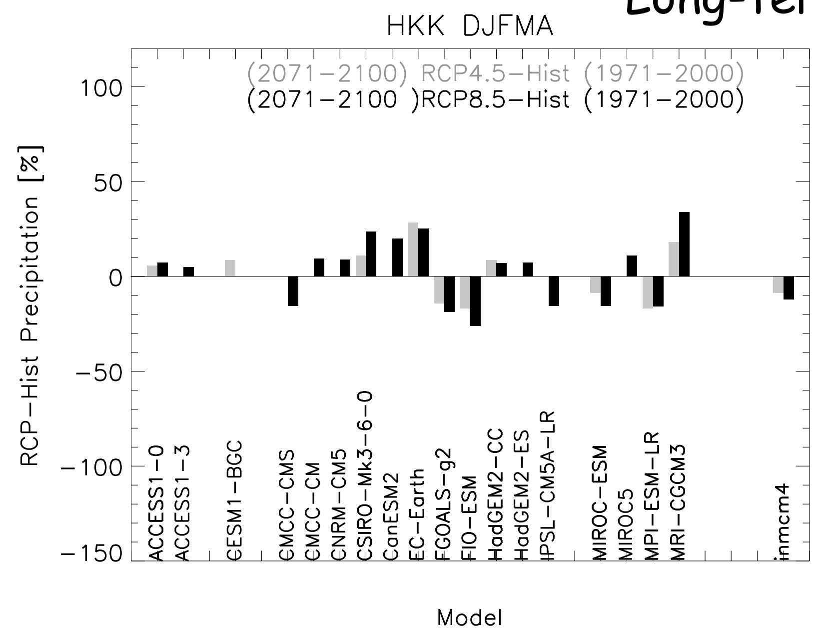
HKK DJFMA
Significant Precipitation trends and changes

	Historical 1901-2005	DJFMA RCP4.5 2006-2100	RCP8.5 2006-2100
Observations			
CRU	**0.396**		
CMIP5 models			
bcc-csm1-1-m	-0.087	0.128	-0.069
bcc-csm1-1	-0.227	-0.189	0.024
CCSM4	-0.254	-0.090	-0.279
CESM1-BGC	-0.263	-0.112	-0.514
CESM1-CAM5	-0.045	-0.055	0.219
CMCC-CM	-0.162	0.331	0.307
EC-Earth	-0.010	**0.458**	0.333
FGOALS-g2	0.185	**-0.553**	**-0.573**
FIO-ESM	-0.215	-0.483	**-1.090**
MPI-ESM-LR	-0.486	-0.502	**-1.090**
CanESM2	0.006	-0.100	0.187
CMCC-CMS	-0.183	**-0.830**	**-0.794**
CNRM-CM5	0.326	0.159	**0.956**
CSIRO-Mk3-6-0	-0.233	**0.370**	**0.537**
INM-CM4	-0.173	-0.093	**-0.578**
IPSL-CM5A-LR	-0.242	0.418	-0.580
IPSL-CM5A-MR	-0.365	0.453	-0.240
MRI-CGCM3	0.015	0.267	**1.092**
ACCESS1-0	0.178	0.009	0.170
ACCESS1-3	0.128	0.096	**0.320**
HadGEM2-CC	-0.104	**0.336**	0.195
HadGEM2-ES	-0.030	-0.008	0.307
MIROC5	-0.045	-0.018	-0.253
MIROC-ESM	0.025	-0.159	**-0.567**
NorESM1-M	0.021	-0.128	-0.103

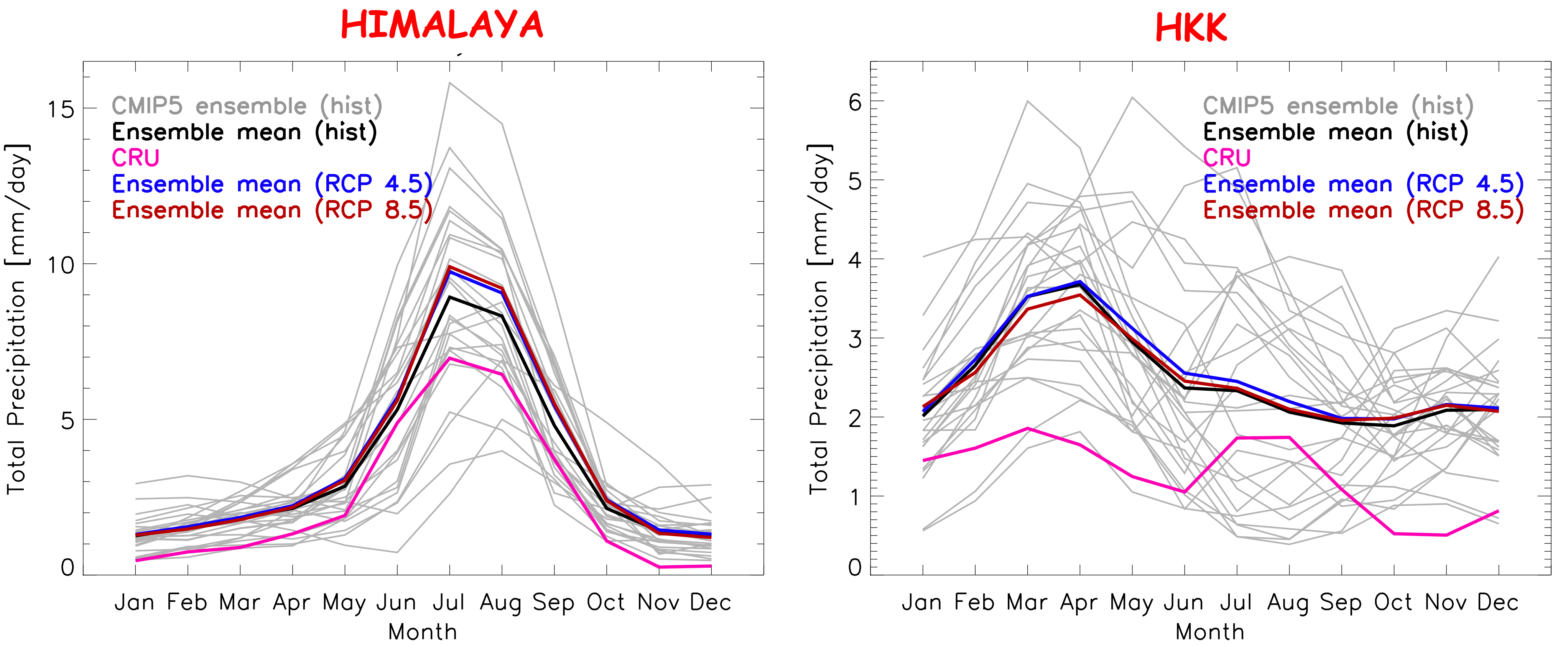
Near-term



Long-term



Precipitation Annual Cycle (1901-2005) CMIP5 and CRU obs.

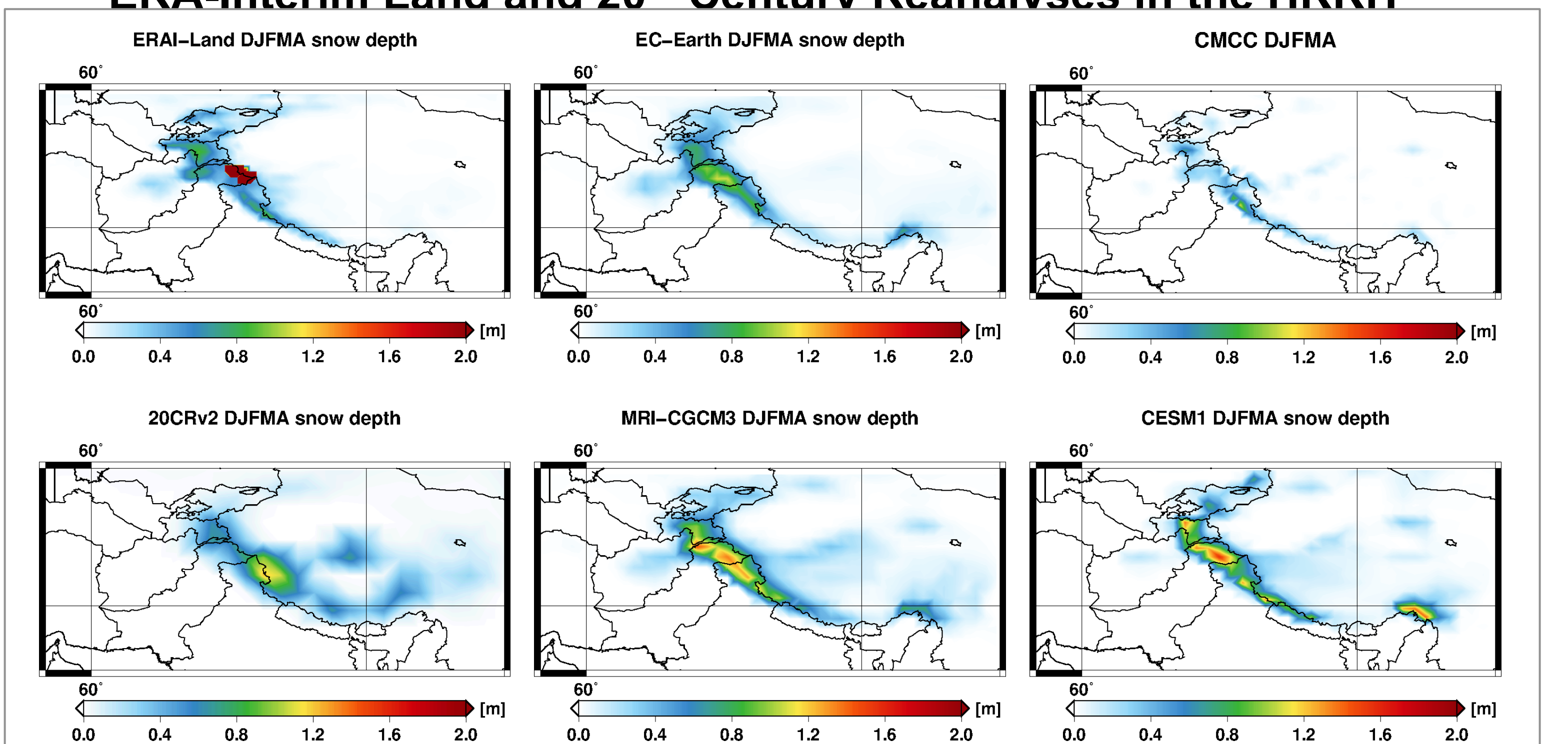


Large **model spread** relative to the model mean (black solid line).
Himalaya: the annual cycle of precipitation is coherently reproduced by the models giving rise to one-modal precipitation distributions during the year (maximum in summer, for most models in July, in very few cases in August).
HKK: The models reproduce precipitation annual cycles with different characteristics.

The multi-model mean indicates an overestimation of the simulated precipitation all over the year (with respect to CRU).

Current snow depth and expected changes in the HKKH mountains from CMIP5 Global Climate Models

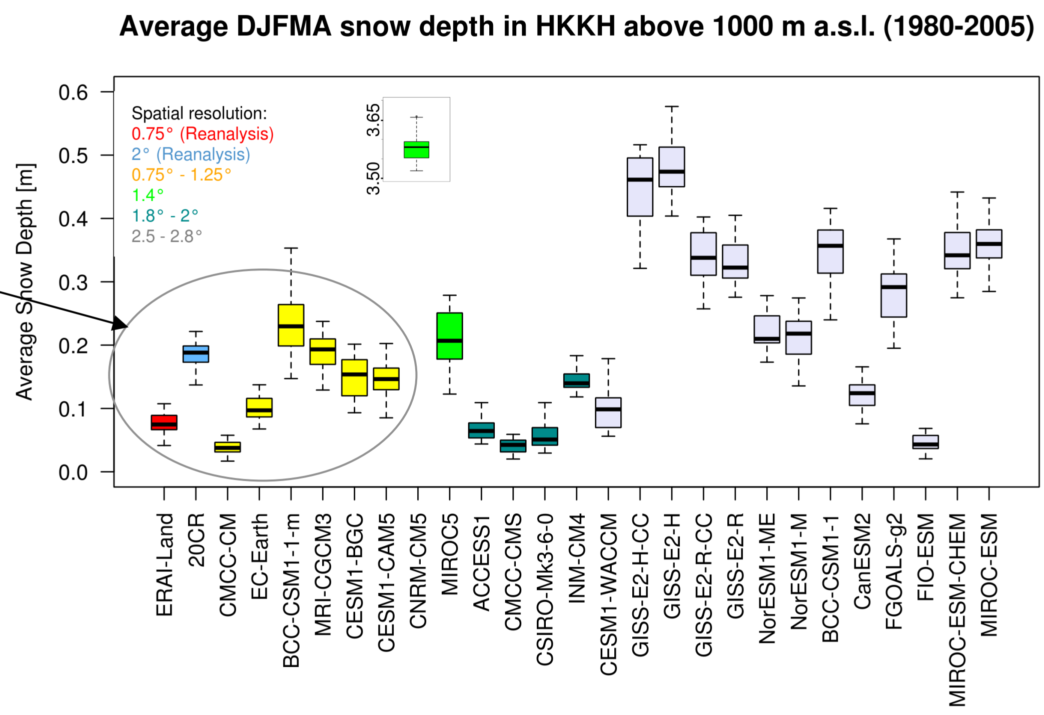
- **For all CMIP5 GCMs including snow depth variable we considered:**
  - **Historical runs (1850-2005)**
  - **Future simulations (RCP4.5 RCP8.5, period 2006-2100)**
- **Insufficient surface snow depth observations, GCMs compared to ERA-Interim Land and 20th Century Reanalyses in the HKKH**



Model	Spatial Resolution [°]
CMCC-CM	0.75
BCC-CSM1.1m	**1.125**
MRI-CGCM3	**1.125**
EC-Earth	**1.125**
CCSM4	**1.25**
CESM1-CAM5	**1.25**
CESM1-FASTCHEM	1.25
CNRM-CM5	1.40625
MIROC5	1.40625
ACCESS1-0	1.875
CMCC-CMS	1.875
CSIRO-Mk3-6-0	1.875
inmcm4	2
CESM1-WACCM	2.5
GISS-E2-H-CC	2.5
GISS-E2-H	2.5
GISS-E2-R-CC	2.5
GISS-E2-R	2.5
NorESM1-ME	2.5
NorESM1-M	2.5
bcc-csm1-1	2.8125
CanESM2	2.8125
FGOALS-g2	2.8125
FIO-ESM	2.8125
MIROC-ESM-CHEM	2.8125
MIROC-ESM-CHEM	2.8125

<u>DJFMA snow depth</u> spatially averaged over HKKH (1980-2005):

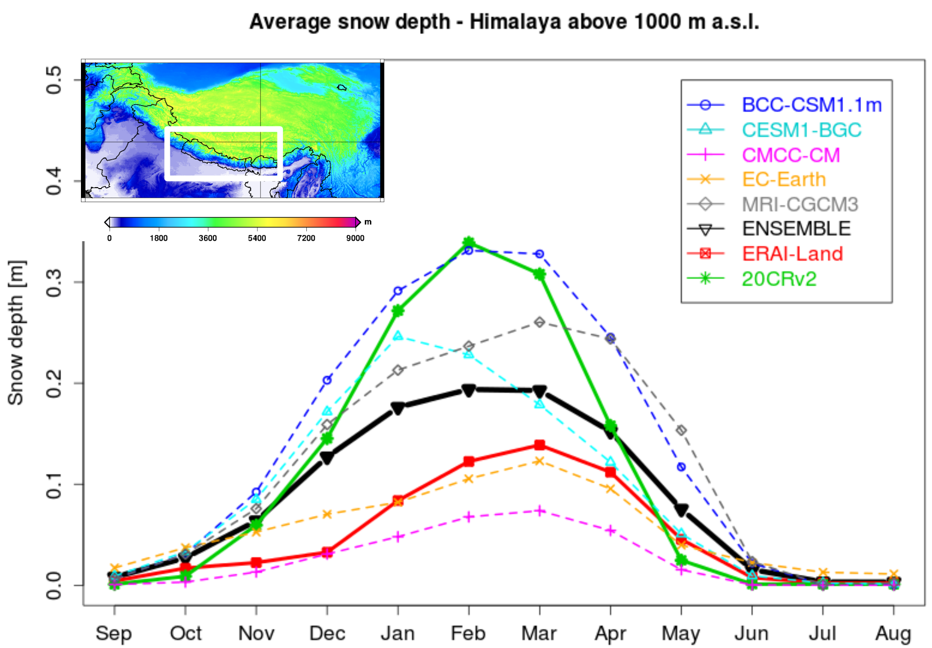
- GCMs with spatial resolution > 1.25° are closer to Reanalyses than the low resolution models

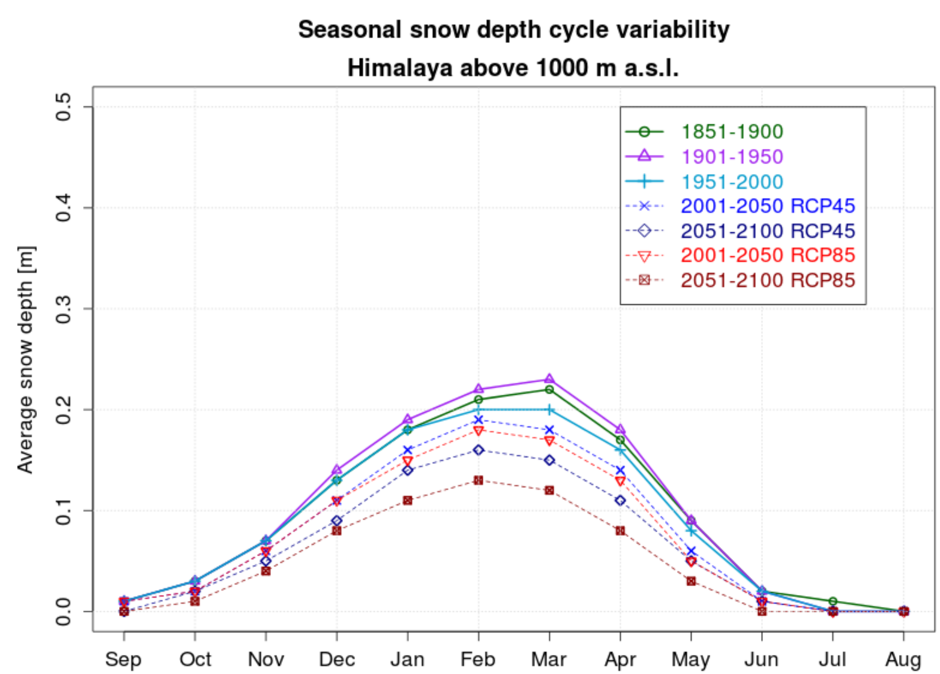


We explored the seasonal cycle and its expected variations in the 21st century

- GCM ensemble mean compares well to the reanalyses in 1980-2005

- snow depth is expected to decrease in both HKK and Himalaya regions





Snow projections 2006-2100

Karakoram

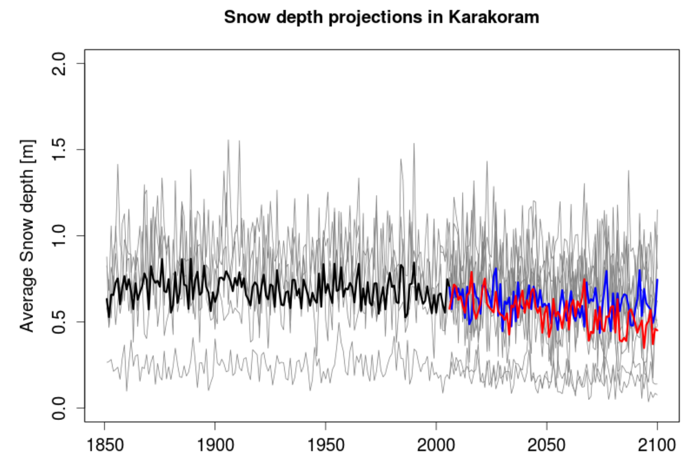
	Snow depth trend [cm/100y]	
1850-2005	-3*	
1961-1990	8	
2006-2100 RCP45	-5*	- 8%
2006-2100 RCP85	-19**	- 28%

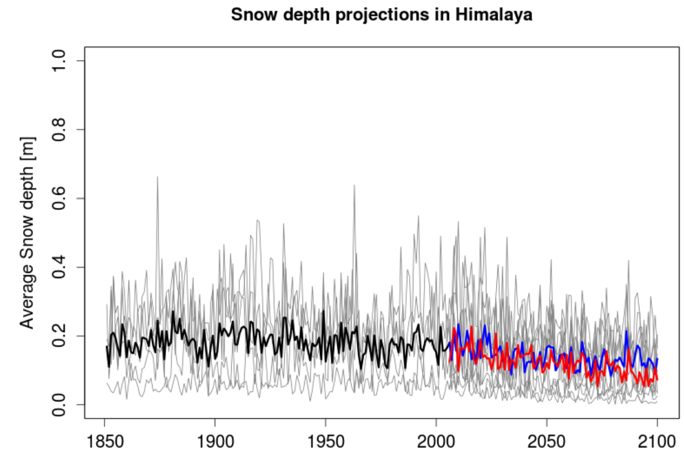
Himalaya

	Snow depth trend [cm/100y]	
1850-2005	-1.2	
1961-1990	-1.2	
2006-2100 RCP45	-5**	- 30%
2006-2100 RCP85	-9**	- 50%

* significant at α=0.05, ** significant at α=0.001

Stronger decrease in Himalaya than HKK





Conclusions

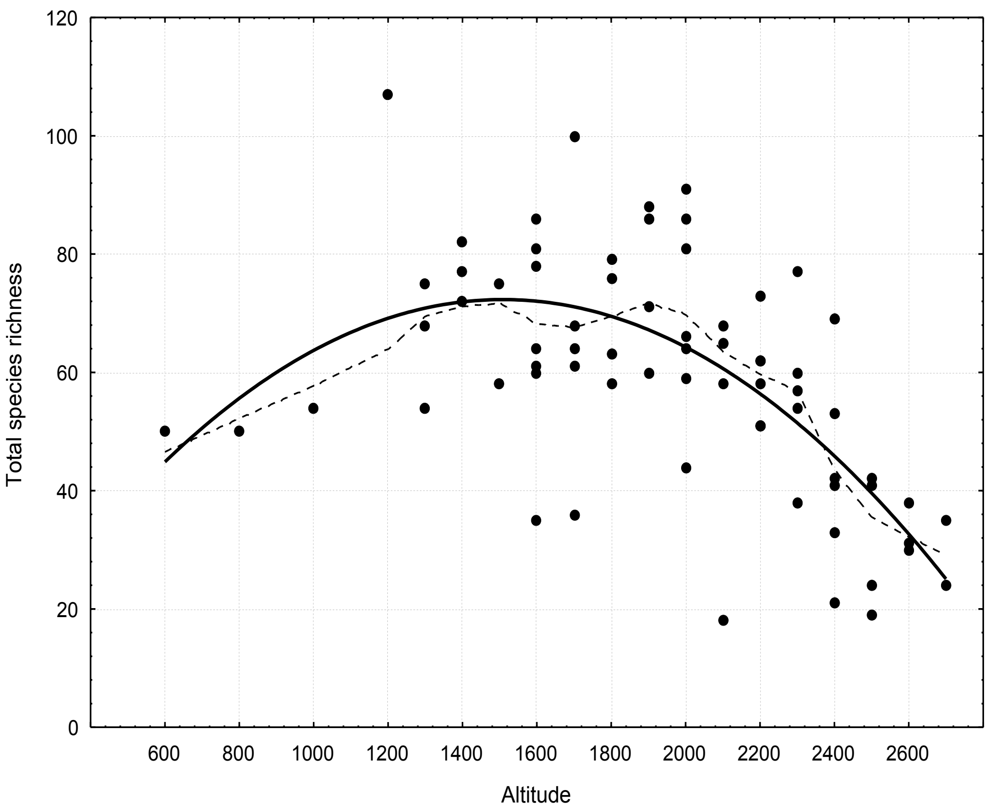
- High spatial resolution (>1.25°) GCMs' snow depth average fields in HKKH are in good agreement with reanalyses
- GCM ensemble mean compares well with reanalyses, it is reasonable to use it for future simulations.
- GCMs projections indicate strong snow depth reduction in all HKK region, expecially in Himalaya mountains

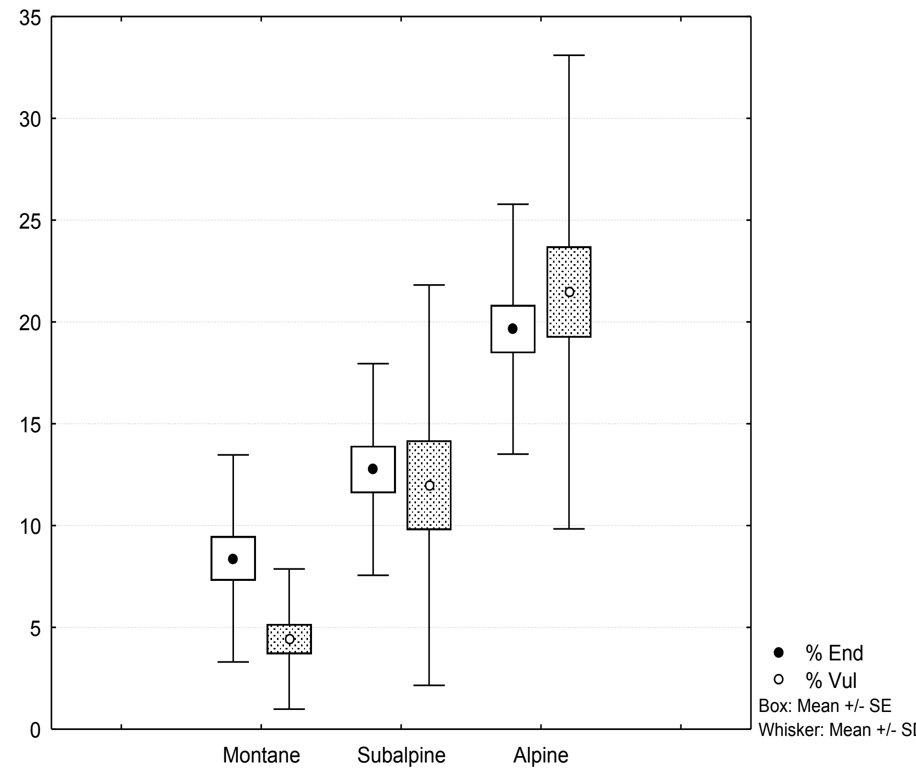
Mountain biodiversity and its changes

A long-term project in different protected areas, started in 2006





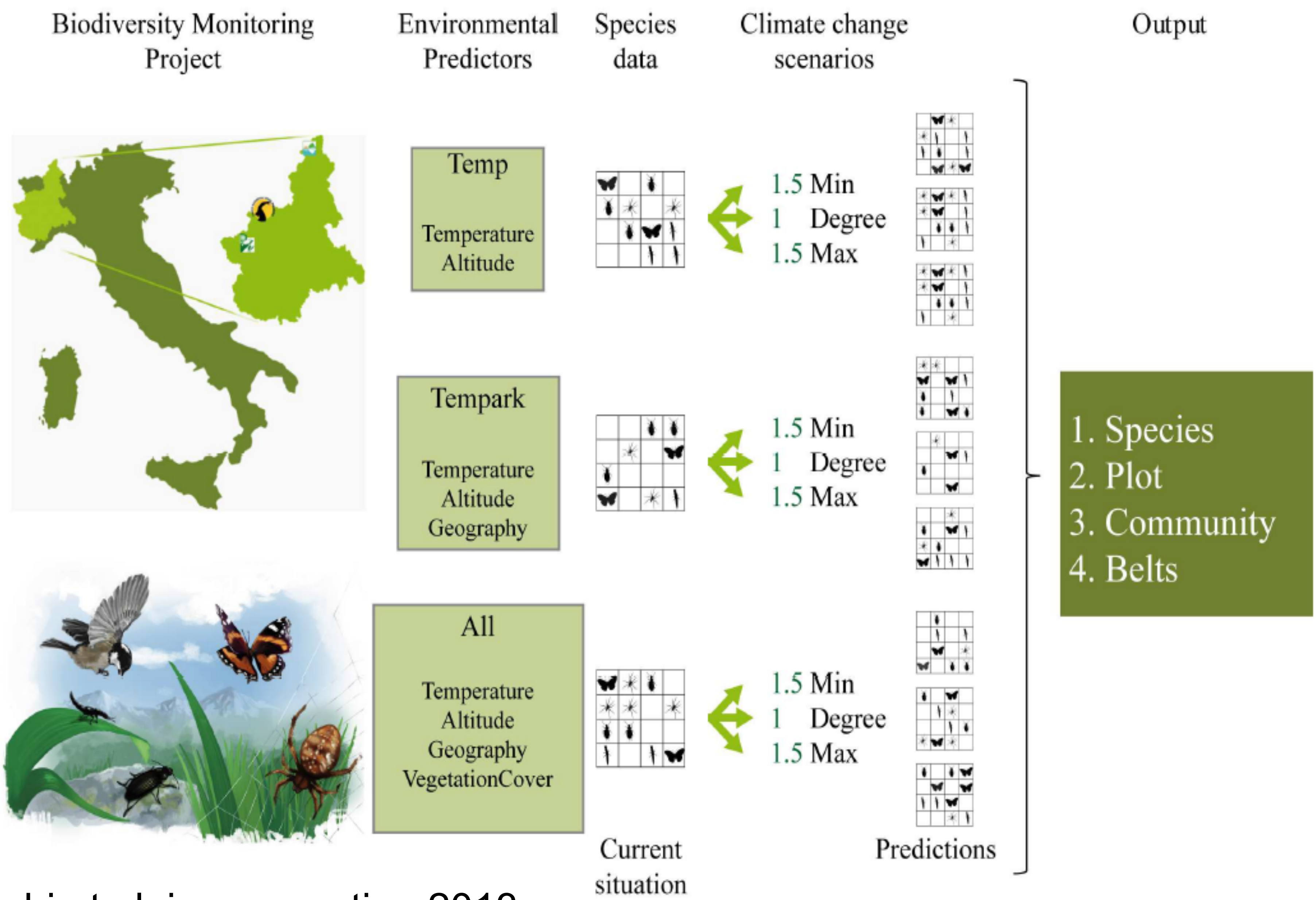




Viterbi et al, Community Ecology 2013

Mountain biodiversity and its changes

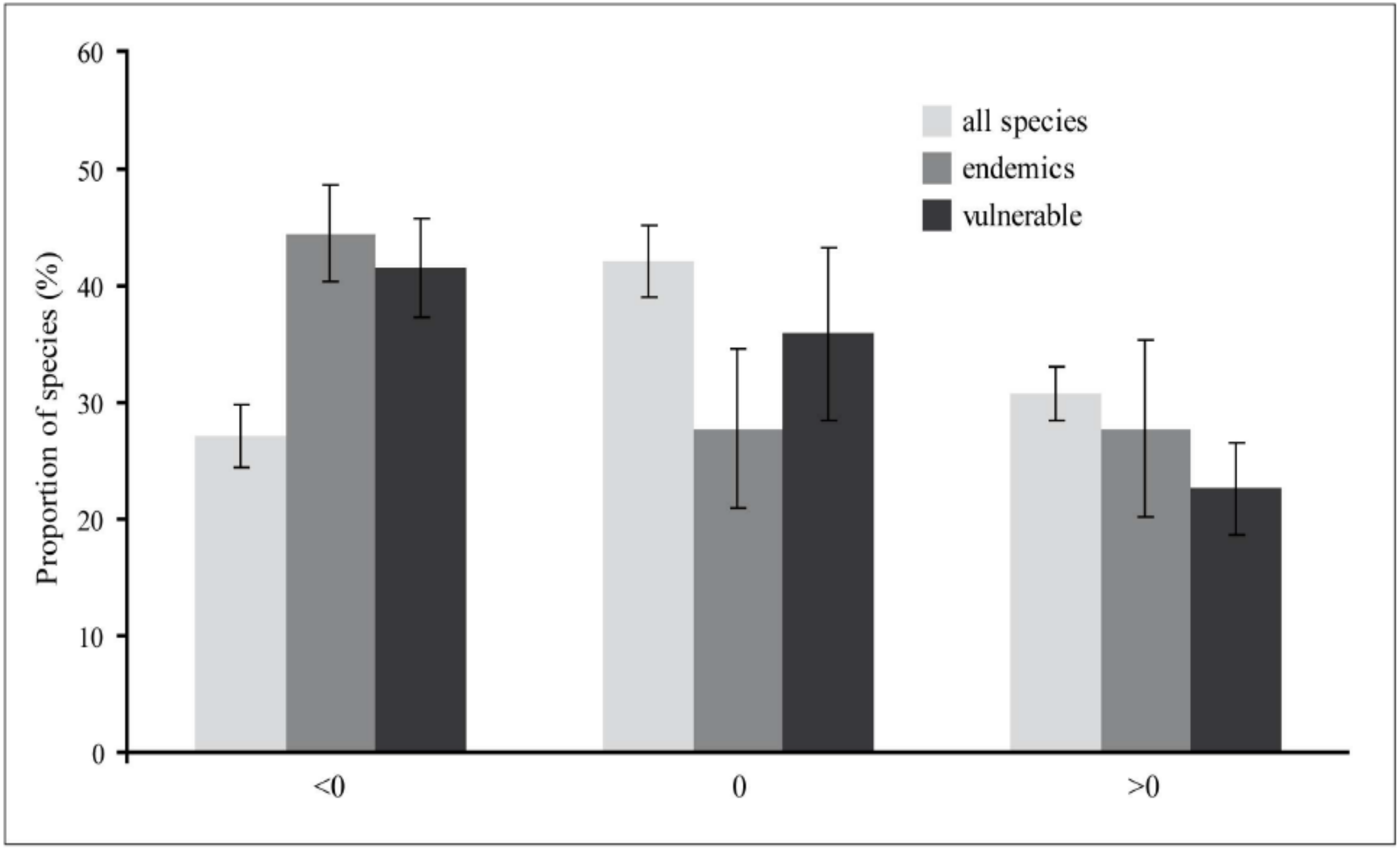
Projections of biodiversity changes



Viterbi et al, in preparation 2013

Mountain biodiversity and its changes

Projections of biodiversity changes



Percentage of contracting, stable and expanding species

Viterbi et al, in preparation 2013

WP 2.6
Pilot studies, dissemination and coordination

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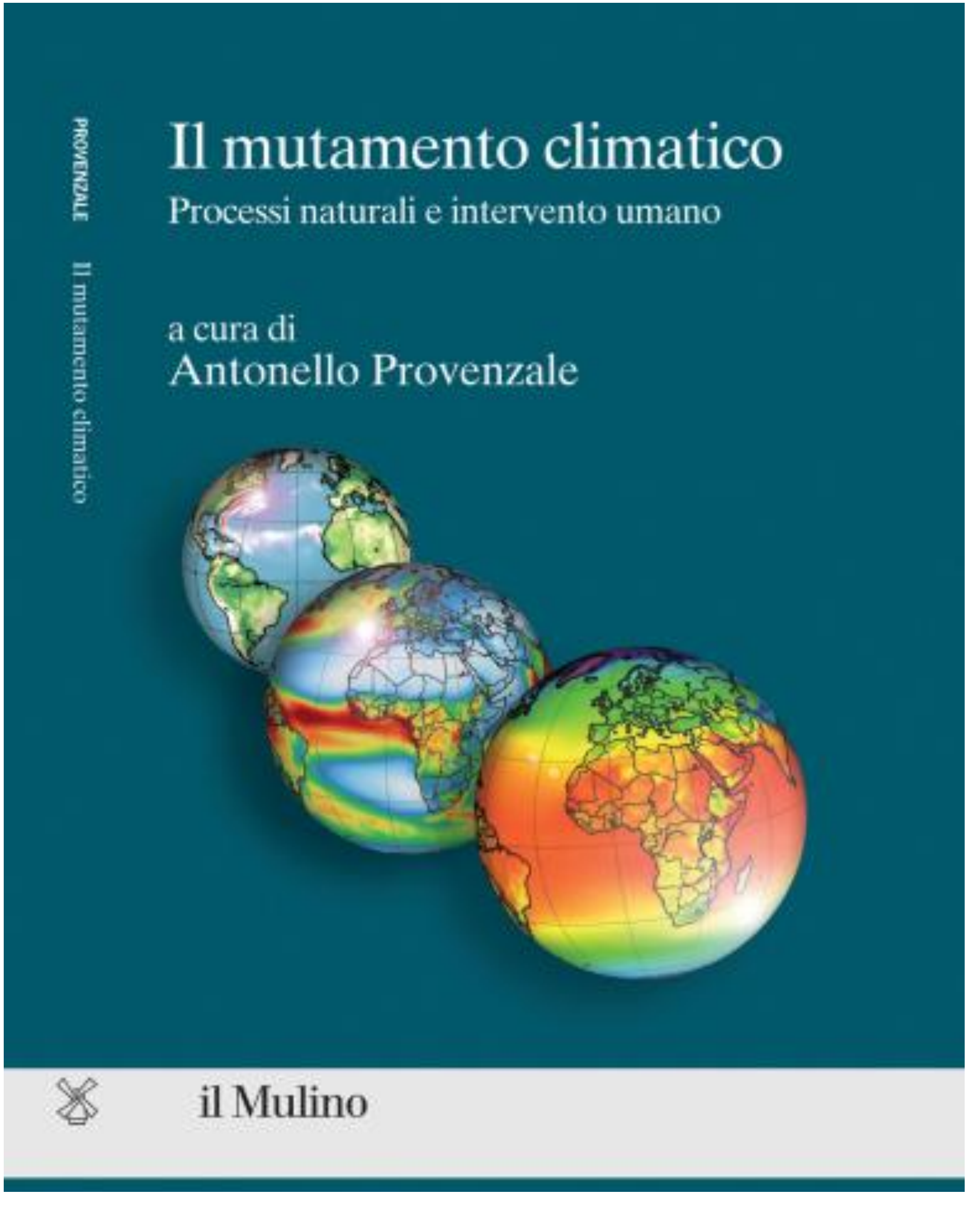
- Multi-secular climate simulation for the Med area
- Precipitation in high-elevation regions
- Effect of climate change on Alpine plant germination

Accademia delle Scienze di Torino, maggio 2012
Volume pubblicato da Il Mulino



Filmato “Ecosistemi d’alta quota” di M. Andreini e P. Fioratti

Progetto Alcotra
Galliformi Alpini