

Projections of meteorological and snow conditions at Col de Porte (French Alps)

using downscaled and adjusted EURO-CORDEX climate projections

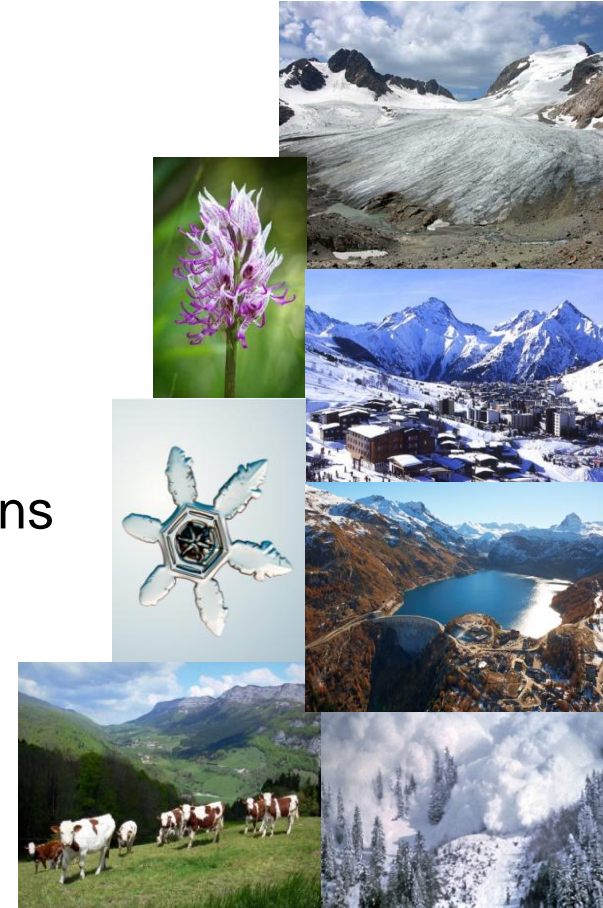
D. Verfaillie, M. Déqué, S. Morin, M. Lafaysse
Météo-France – CNRS, CNRM UMR 3589, France

The issue

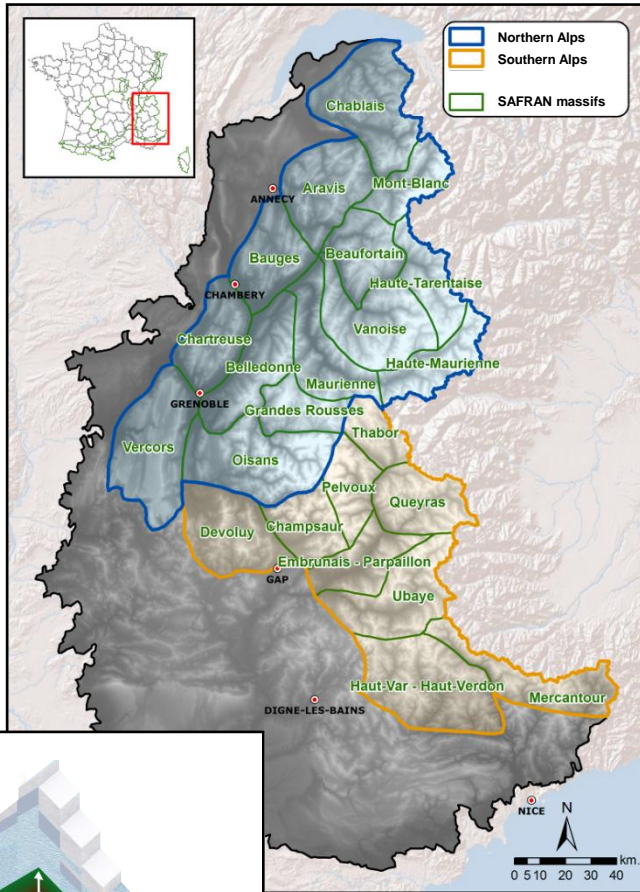
- Strong societal demand about **climate change** impacts and its **adaptation/mitigation**
 - Mountain regions :
 - snow availability
 - impacts on glaciers & water resources
 - ecosystem vulnerability
 - climate-related hazards
- **Impact models** sensitive to sub-diurnal variations

Downscaling and bias-adjustment method :

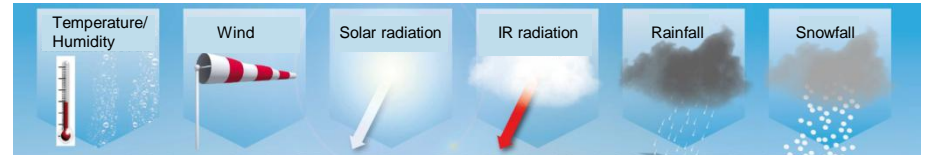
- quantile mapping & weather regimes
- vs. a meteorological reanalysis (SAFRAN)
- multi-variable and hourly



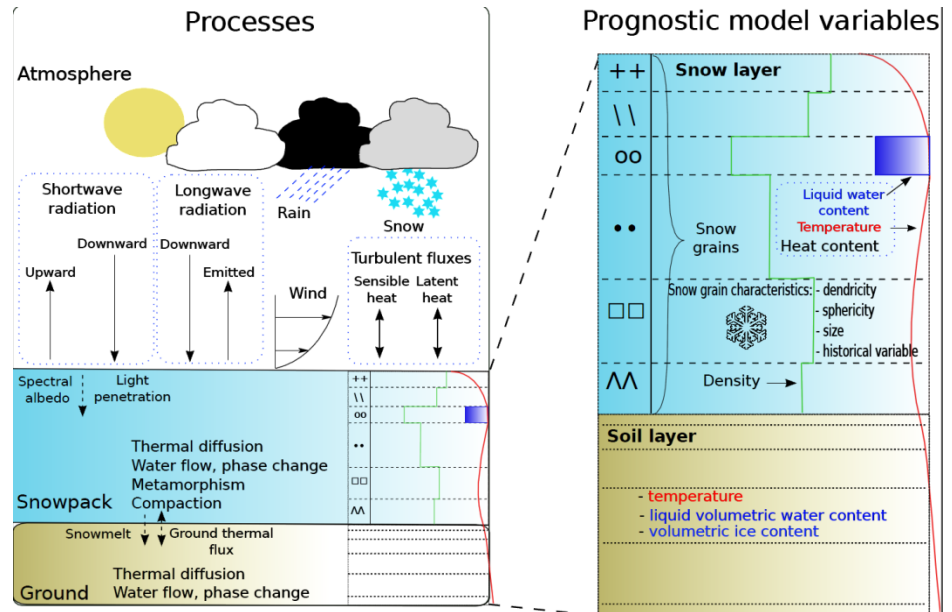
Reanalysis & snow modelling



Spatial subdivision by massifs & 300 m elevation bands

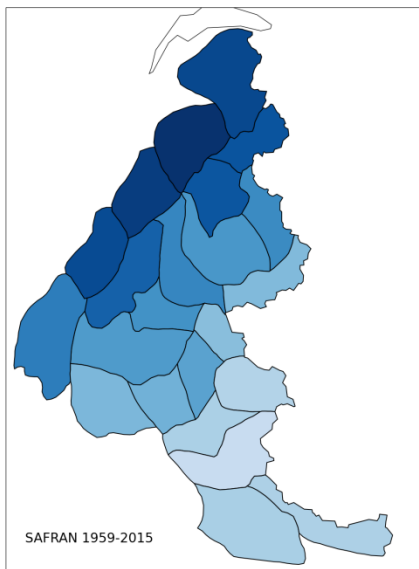


SAFRAN reanalysis used as « pseudo-observation »



Snow model ISBA-Crocus

Reanalysis & snow modelling



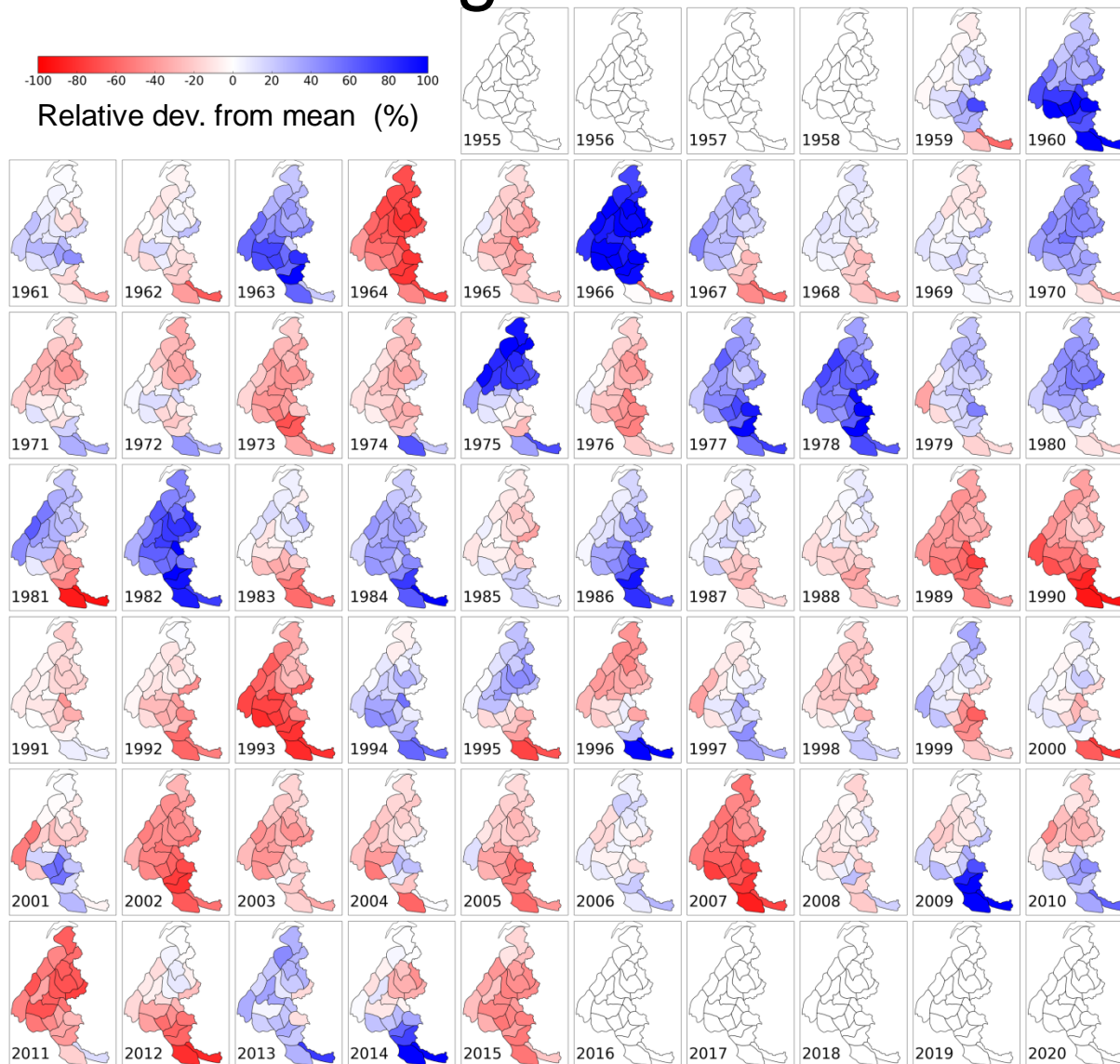
0 15 30 45 60 75 90 105 120

Mean snow height from Nov to Apr at 1800m (cm)

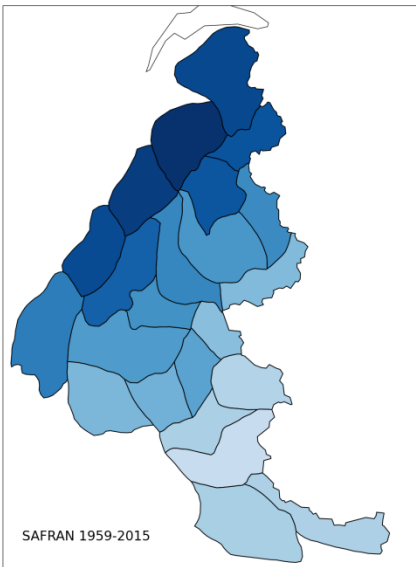
SAFRAN-Crocus

Strong interannual variability

-100 -80 -60 -40 -20 0 20 40 60 80 100
Relative dev. from mean (%)



Reanalysis & snow modelling



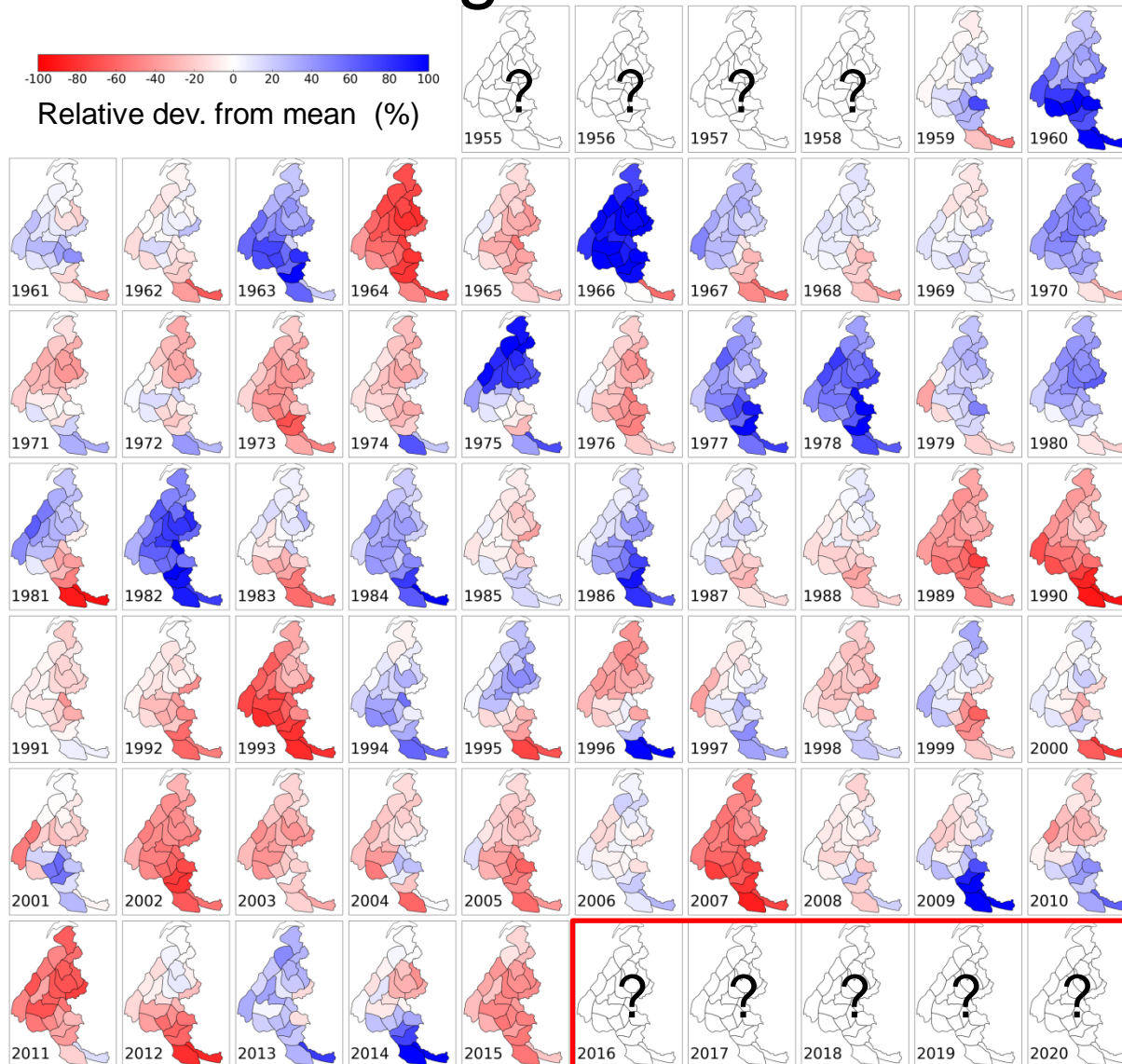
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Mean snow height from Nov to Apr at 1800m (cm)

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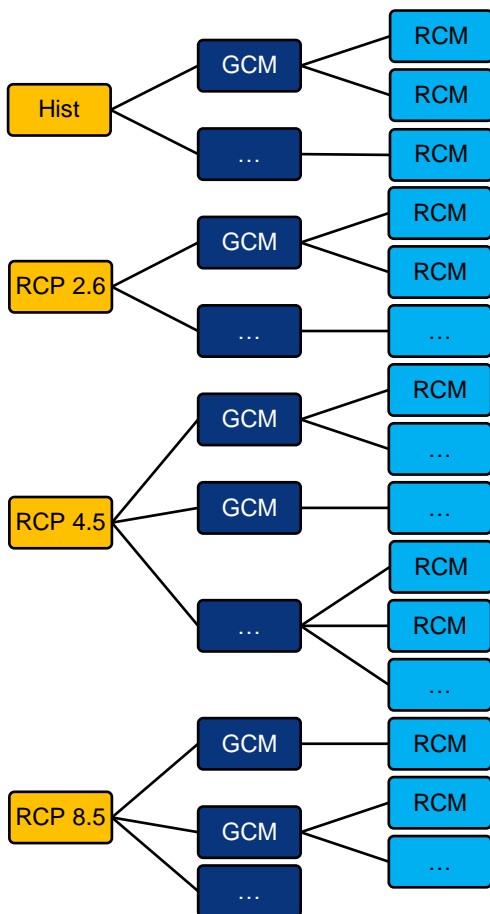


Downscaling & adjustment chain

Forcing/
Scenarios

EUROCORDEX
12 km simulations

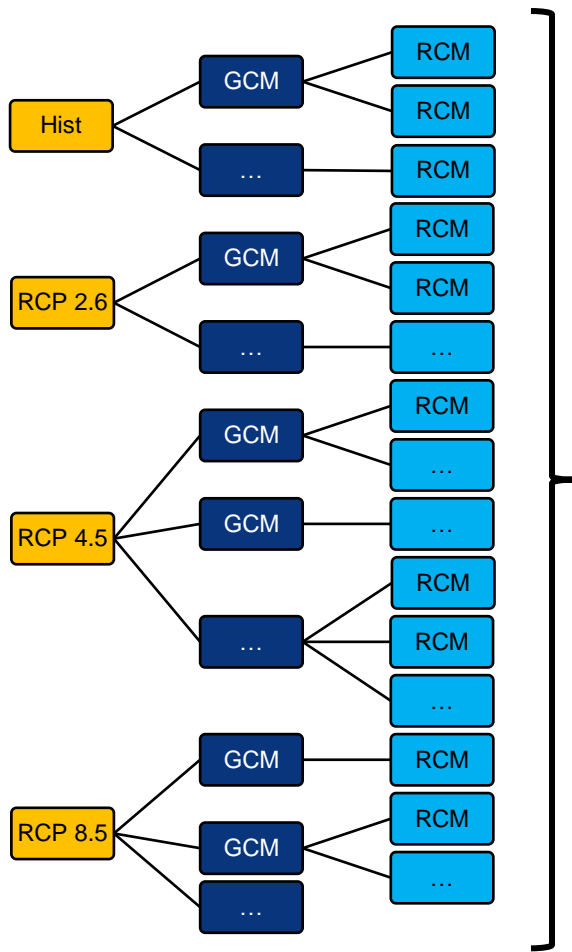
= 4 forcing/scenarios
13 GCMs
10 RCMs



	Histo	RCP2.6	RCP4.5	RCP8.5	Sum
planned	35	8	20	34	97
done	13	4	13	13	23

Downscaling & adjustment chain

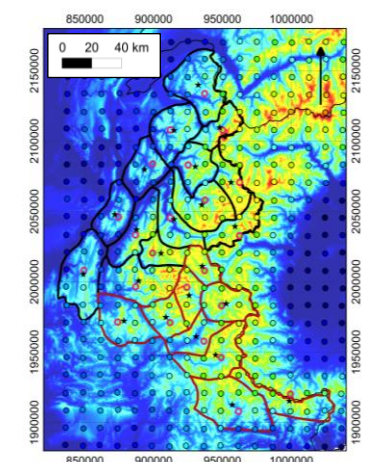
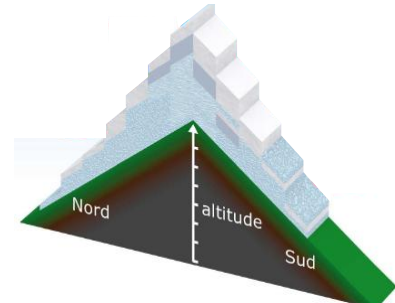
Forcing/
Scenarios EUROCORDEX
12 km simulations



Scenarios of
T, Q, Pr, Wind, Rad

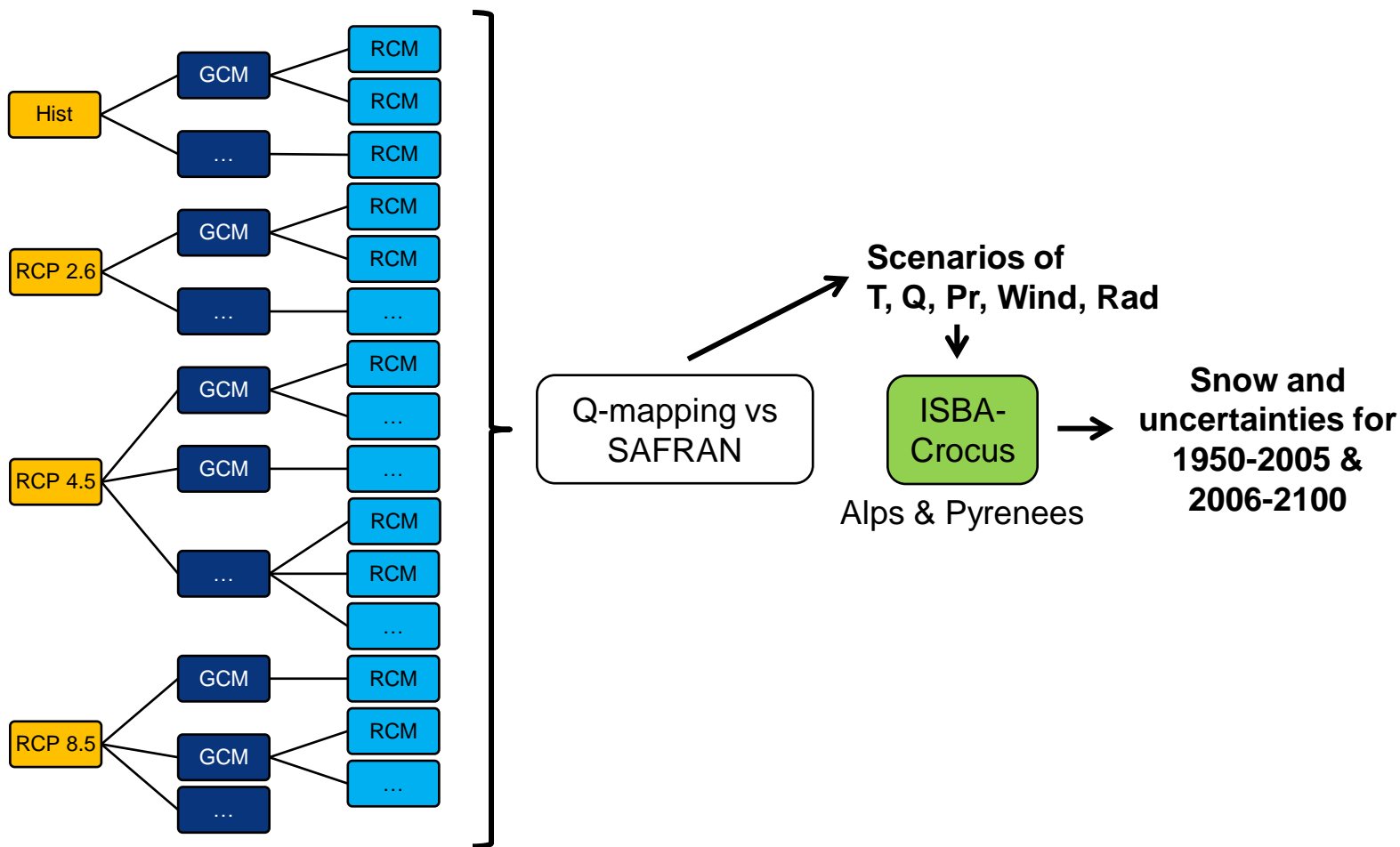
Q-mapping vs
SAFRAN

*Spatial subdivision by massifs
& 300 m elevation bands*



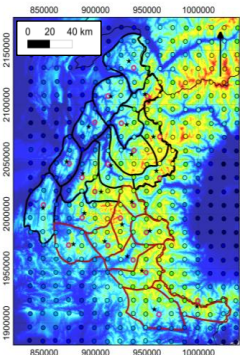
Downscaling & adjustment chain

Forcing/
Scenarios EUROCORDEX
12 km simulations

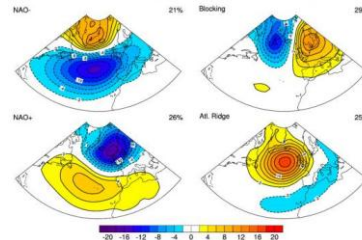


Downscaling & adjustment chain

1. Neighbouring RCM grid points

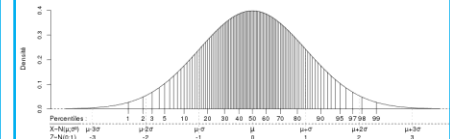


2. RCM & ERA-Interim regimes

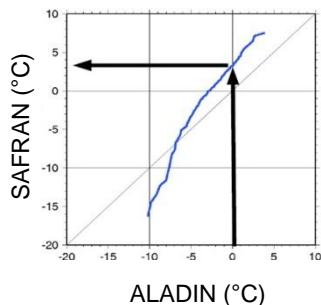


3. SAFRAN : 1h → daily

4. Percentiles of historical RCM & SAFRAN (variable, season, regime)



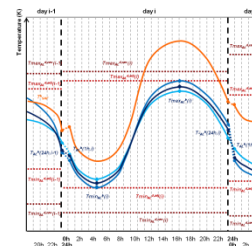
5. Quantile mapping (variable, season, regime)



6. SAFRAN analogous days, criteria:

- same month
- same regime
- coherent Pr.
- consecutive days (when possible)

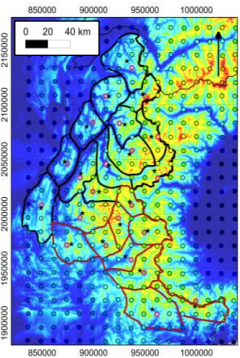
7. Adjusted RCM : daily → 1h (shape from SAFRAN analogues)



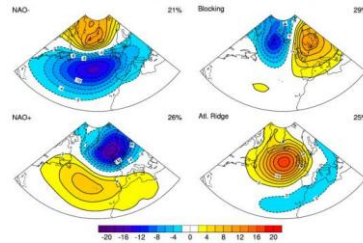
8. Total precipitation separation into rain and snow (1°C threshold) + additional quantile mapping of rain and snow separately

Downscaling & adjustment chain

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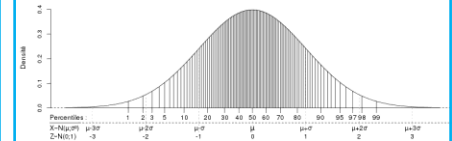


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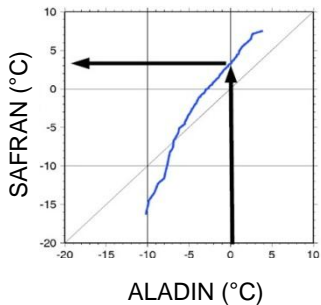


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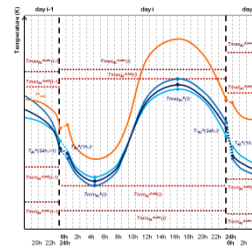
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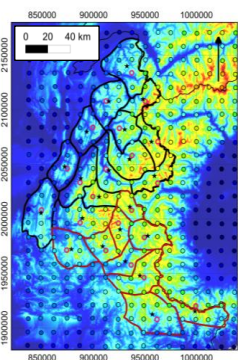
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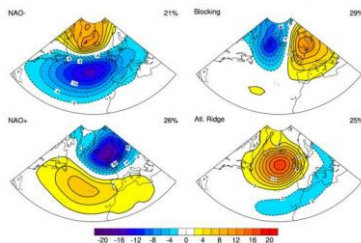
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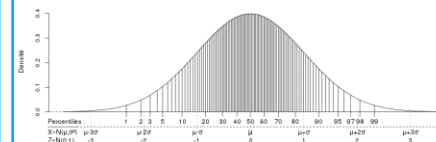


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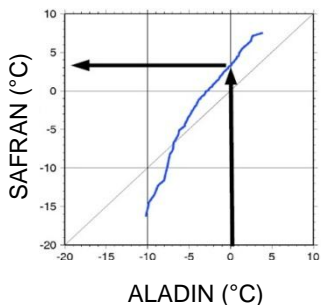


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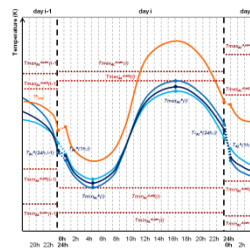
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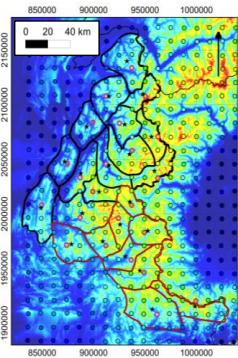
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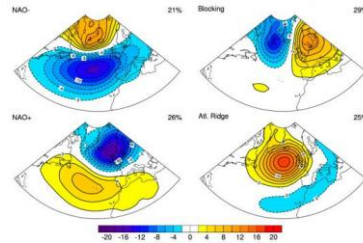
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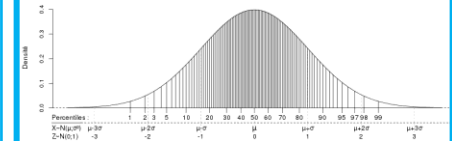


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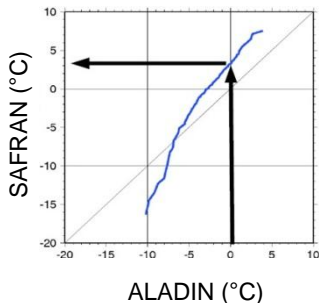


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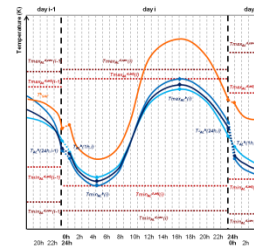
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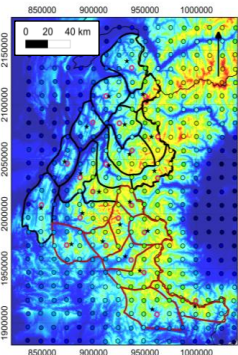
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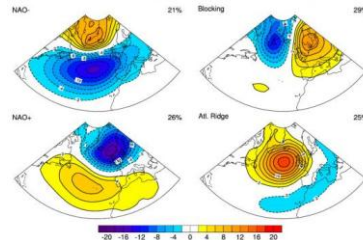
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Downscaling & adjustment chain

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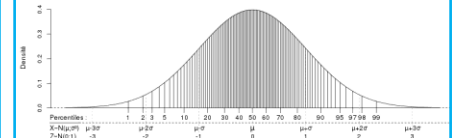


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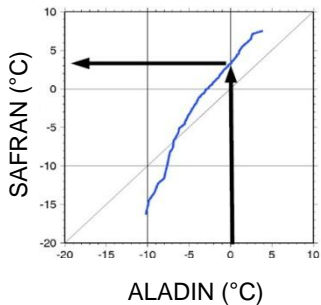


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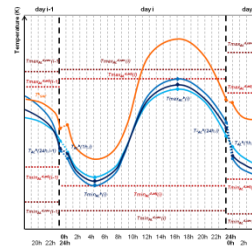
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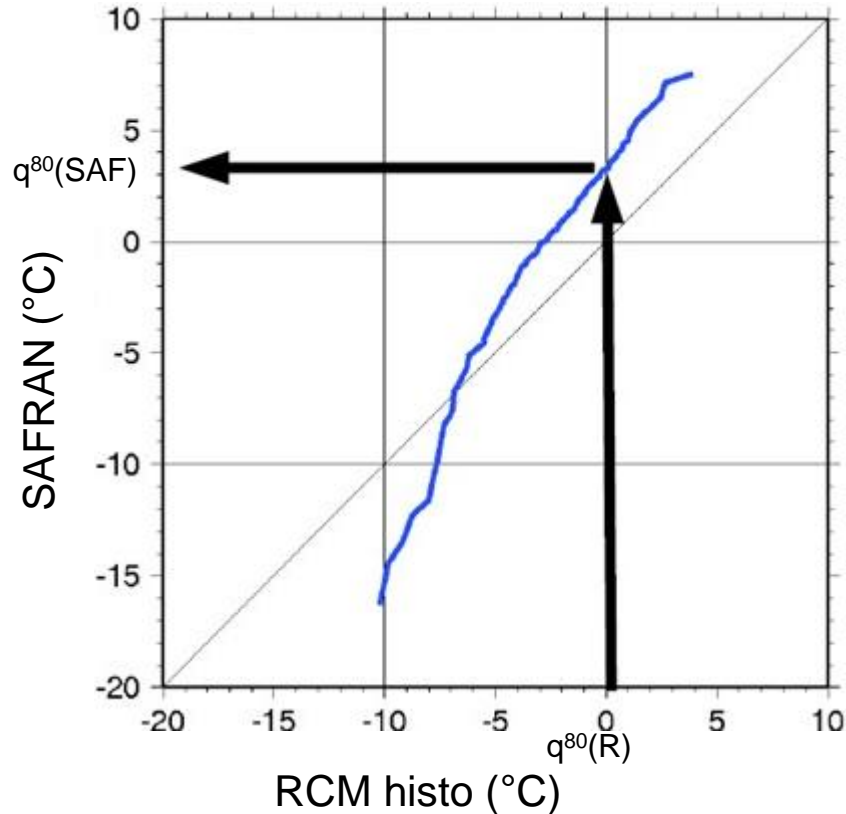
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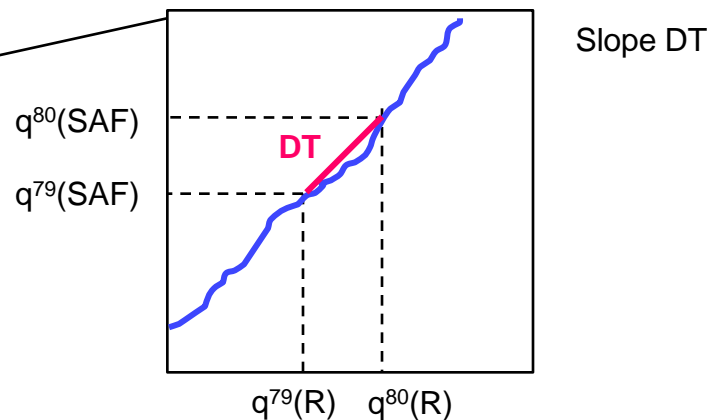
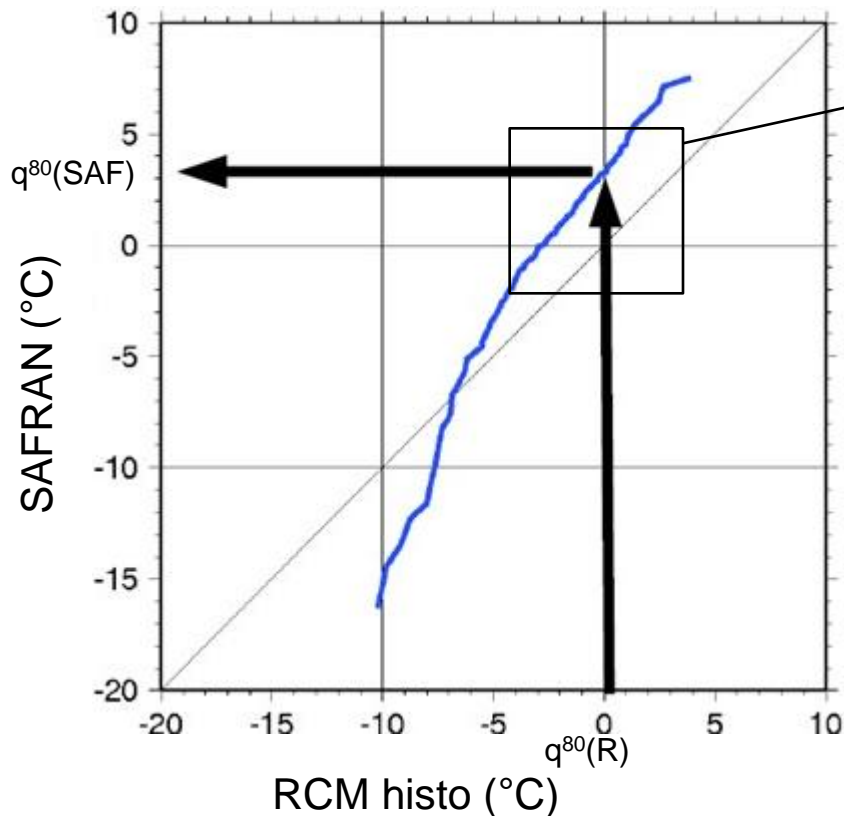
Downscaling & adjustment chain

- Quantile-quantile historical SAFRAN/RCM diagrams



Downscaling & adjustment chain

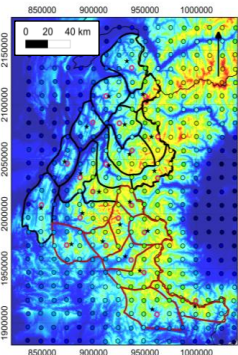
- Adjustment of RCM values (histo + scenarios) vs. SAFRAN



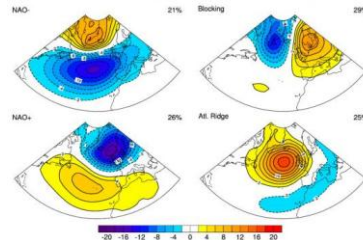
Adjustment :
 For a value $z(R)$,
 As soon as $q^x(R) \geq z(R)$:
 $z(R)_{\text{corr}} = q^{x-1}(\text{SAF}) + (z(R) - q^{x-1}(R)) \times DT^x$

Downscaling & adjustment chain

1. Neighbouring RCM grid points

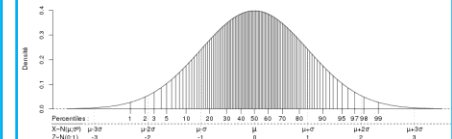


2. RCM & ERA-Interim regimes

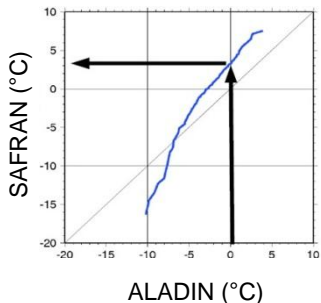


3. SAFRAN : 1h → daily

4. Percentiles of historical RCM & SAFRAN (variable, season, regime)



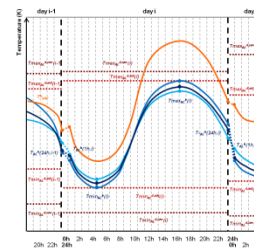
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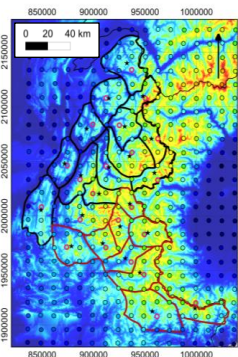
7. Adjusted RCM : daily → 1h (shape from SAFRAN analogues)



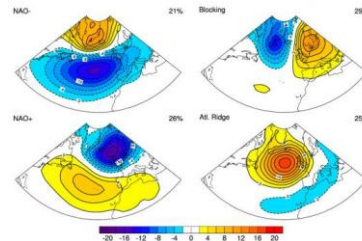
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Downscaling & adjustment chain

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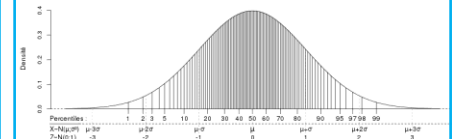


2. RCM & ERA-Interim regimes

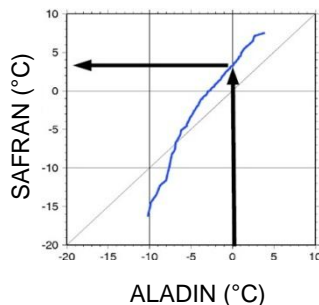


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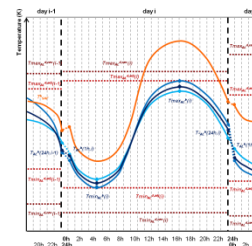
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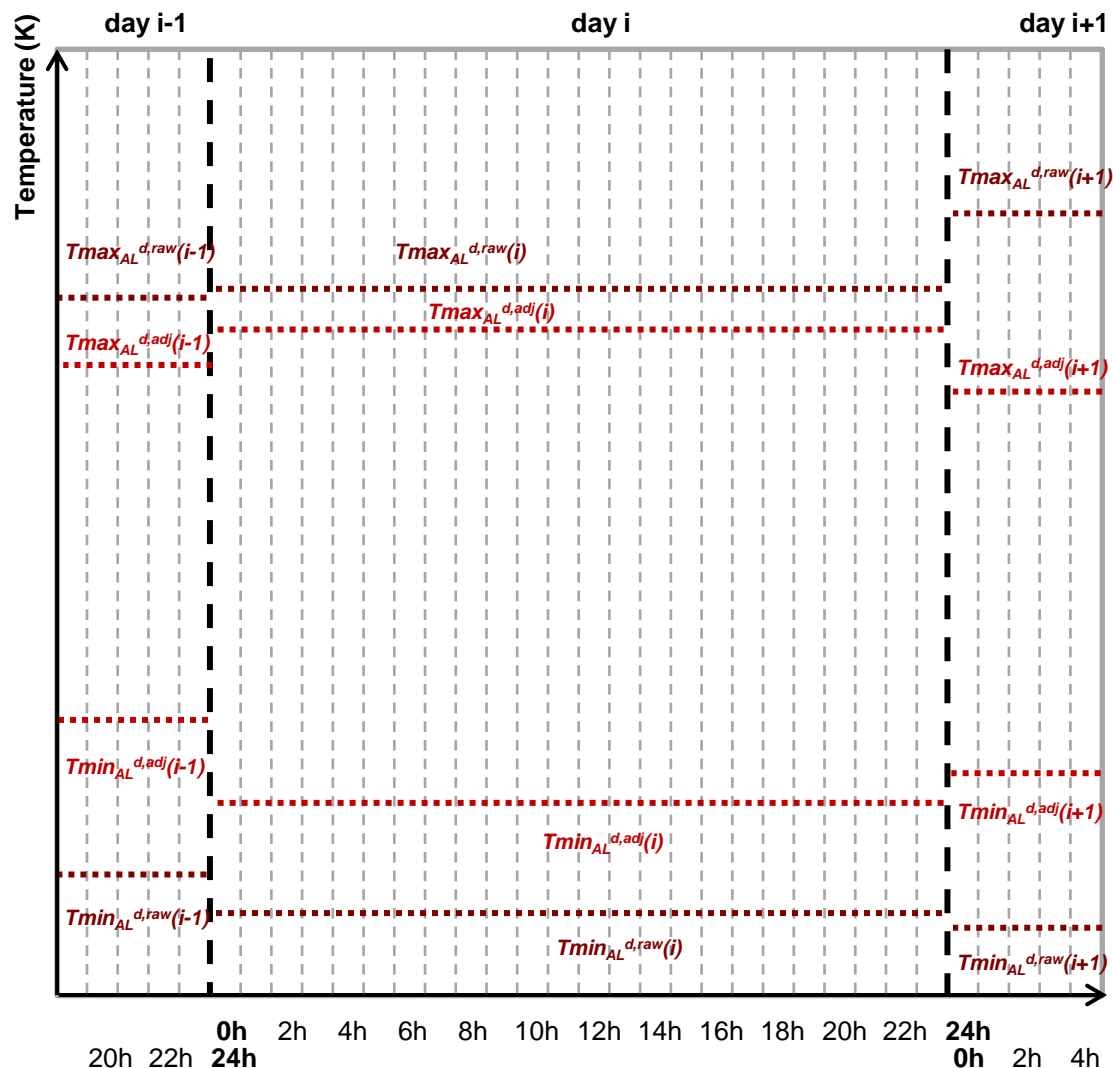
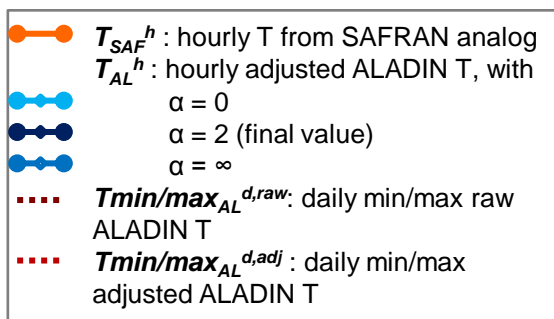
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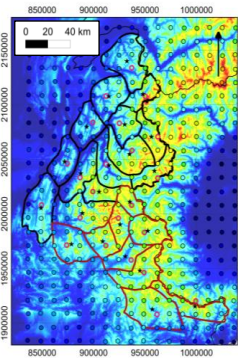
Downscaling & adjustment chain

- Disaggregation of adjusted RCM from daily to hourly : temperature

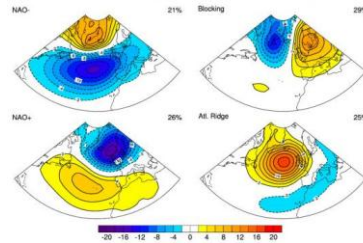


Downscaling & adjustment chain

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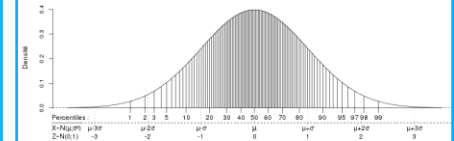


2. RCM & ERA-Interim regimes

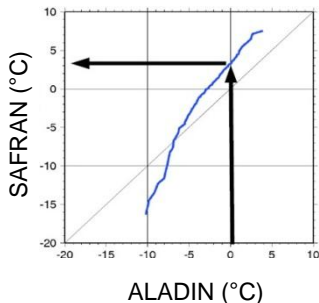


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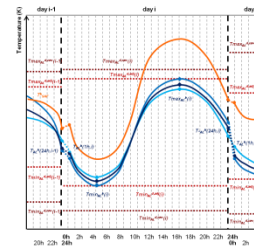
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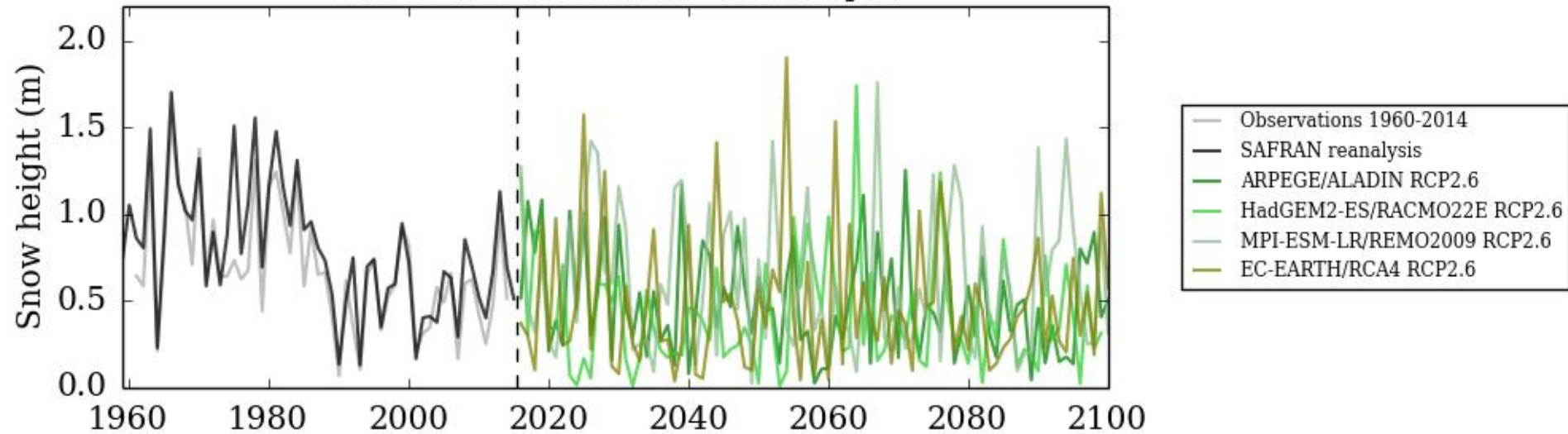


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Example of results

Snow height from Crocus at the INARCH/ GCW site Col de Porte

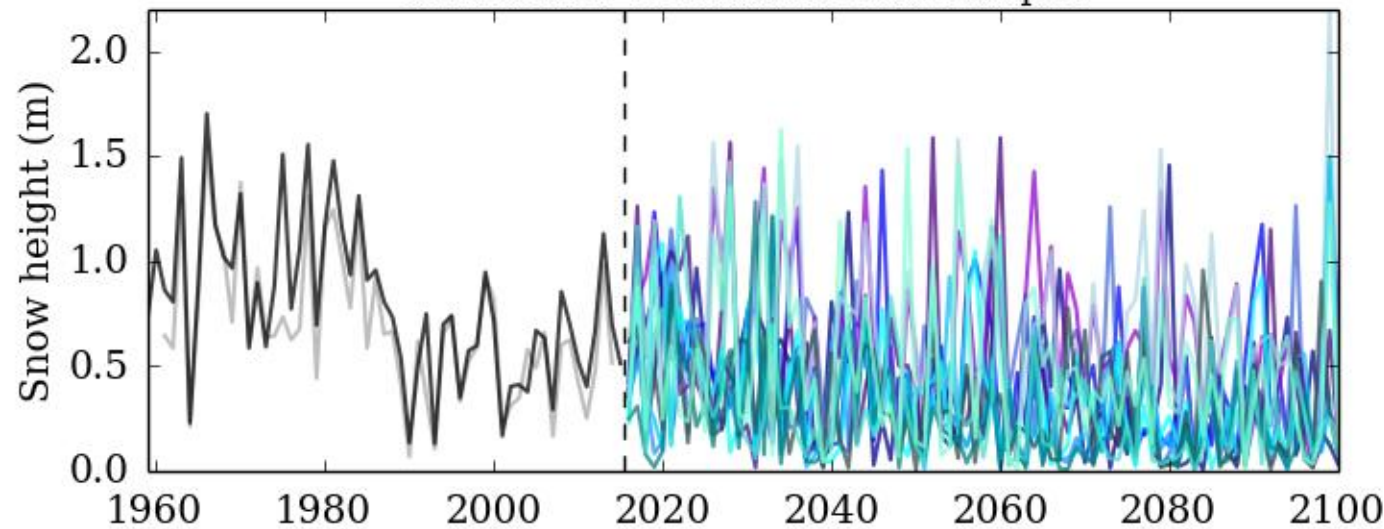
Chartreuse 1500m November-April



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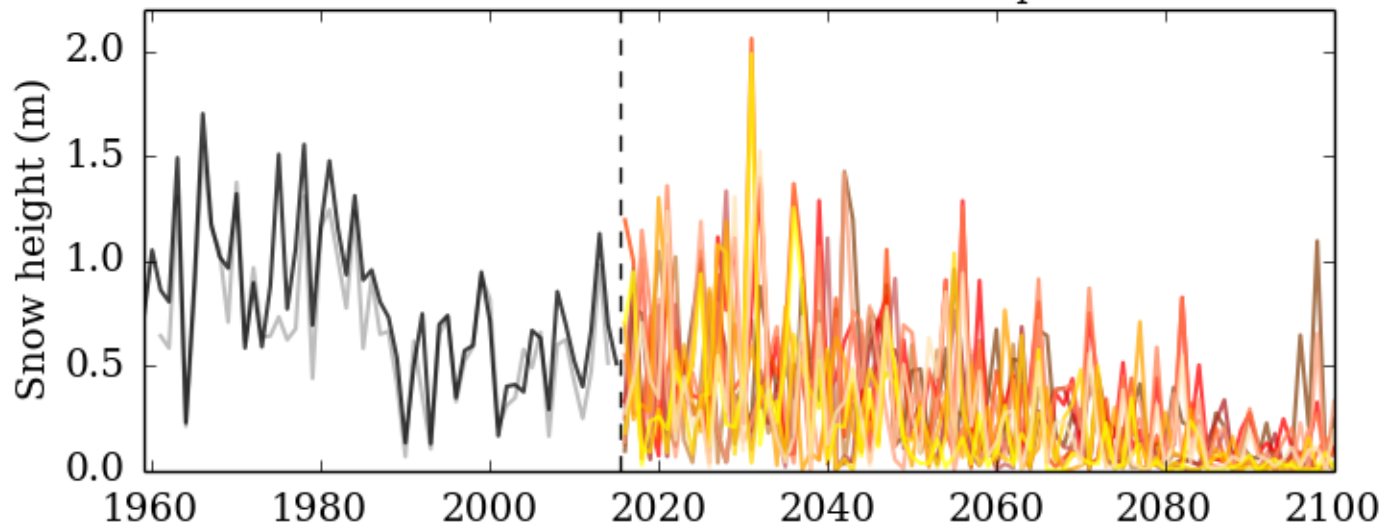


- Observations 1960-2014
- SAFRAN reanalysis
- ARPEGE/ALADIN RCP4.5
- ARPEGE/CCLM4-8-17 RCP4.5
- EC-EARTH/CCLM4-8-17 RCP4.5
- HadGEM2-ES/CCLM4-8-17 RCP4.5
- MPI-ESM-LR/CCLM4-8-17 RCP4.5
- IPSL-CM5A-MR/WRF331F RCP4.5
- HadGEM2-ES/RACMO22E RCP4.5
- MPI-ESM-LR/REMO2009 RCP4.5
- ARPEGE/RCA4 RCP4.5
- EC-EARTH/RCA4 RCP4.5
- HadGEM2-ES/RCA4 RCP4.5
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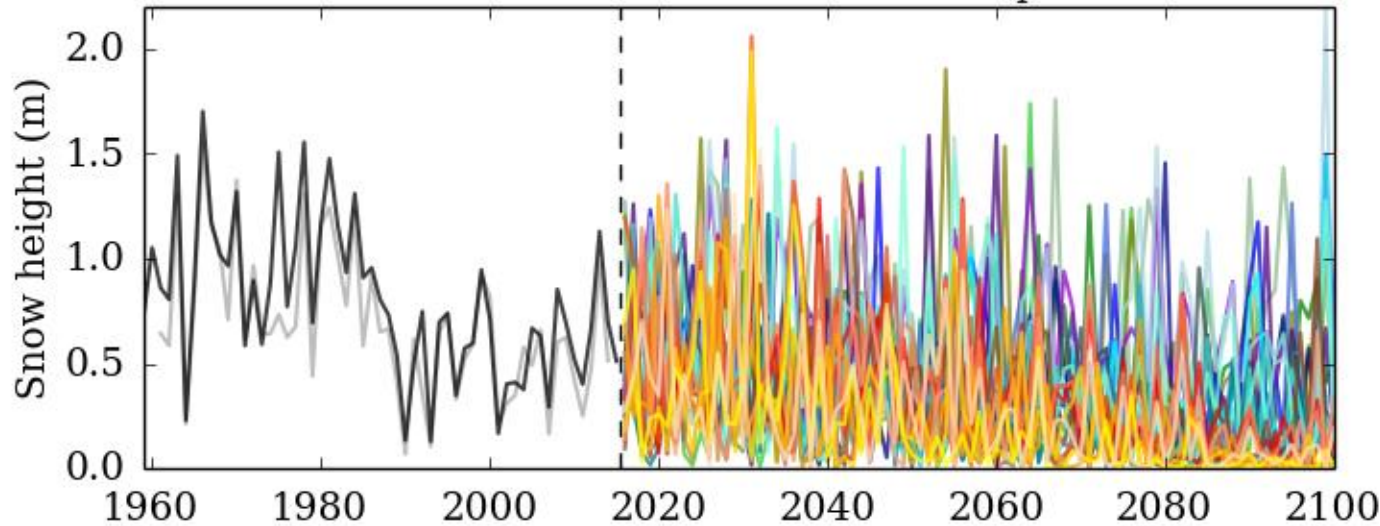


- Observations 1960-2014
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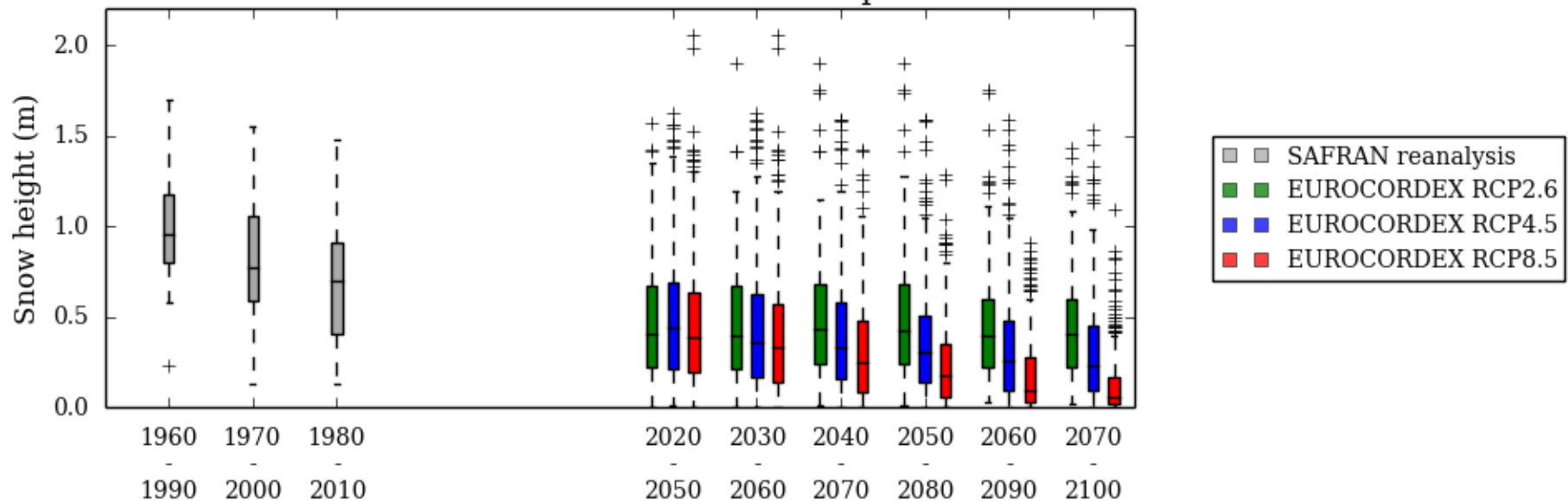


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- ARPEGE/ALADIN RCP4.5
- ARPEGE/CCLM4-8-17 RCP4.5
- EC-EARTH/CCLM4-8-17 RCP4.5
- HadGEM2-ES/CCLM4-8-17 RCP4.5
- MPI-ESM-LR/CCLM4-8-17 RCP4.5
- IPSL-CM5A-MR/WRF331F RCP4.5
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- ARPEGE/RCA4 RCP4.5
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- MPI-ESM-LR/CCLM4-8-17 RCP8.5
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- HadGEM2-ES/RACMO22E RCP8.5
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- HadGEM2-ES/RCA4 RCP8.5
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Example of results

Snow height from Crocus at the INARCH/ GCW site Col de Porte

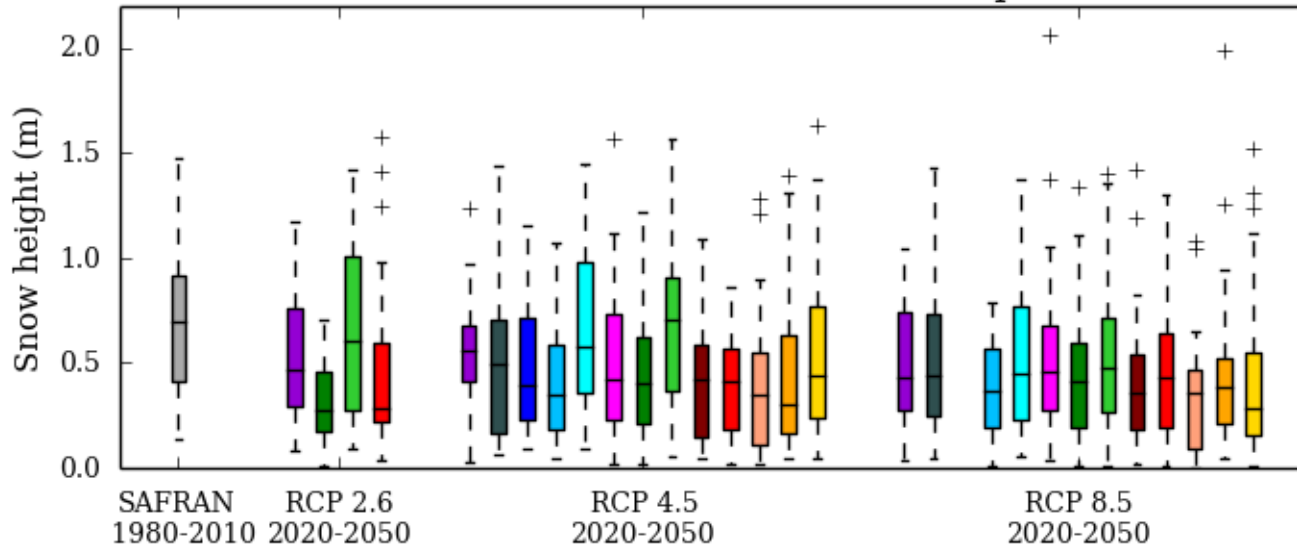
Chartreuse 1500m November-April



Example of results

Snow height from Crocus at the INARCH/ GCW site Col de Porte

Chartreuse 1500m November-April

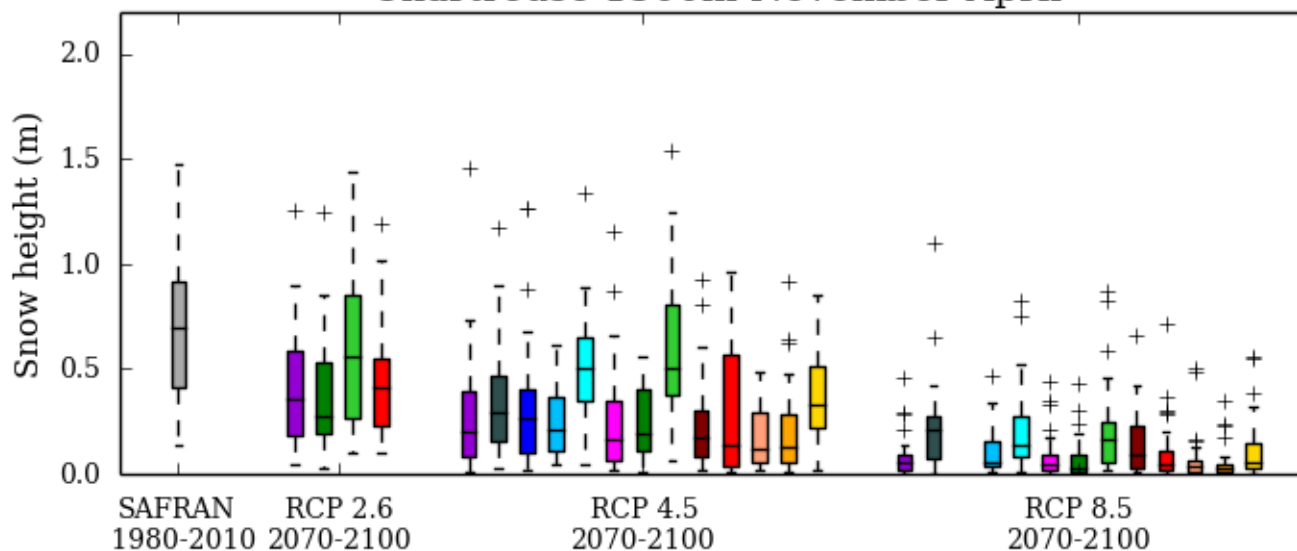


- SAFRAN reanalysis
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Example of results

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- EC-EARTH/RCA4
- HadGEM2-ES/RCA4
- IPSL-CM5A-MR/RCA4
- MPI-ESM-LR/RCA4

Conclusions & Perspectives

- Generic downscaling & adjustment method for climate projections
- Respects the RCM **chronology**
- Yields **continuous hourly** time series of adjusted meteorological variables (not only Pr & T) → energy balance land surface models
- Numerous possible applications: natural & artificial snow production, agricultural & forest management, mountain ecosystems, glaciology, glacial hydrology, ...
- **Article:**
Verfaillie et al., in review. The downscaling and adjustment method ADAMONT v1.0 for climate projections in mountainous regions applicable to energy balance land surface models, GMDD, in review. doi : 10.5194/gmd-2016-168
- Snow at Col de Porte : strong **interannual variability**, differences between RCP scenarios and between EUROCORDEX models
- **Future work:** application to all mountain ranges in France

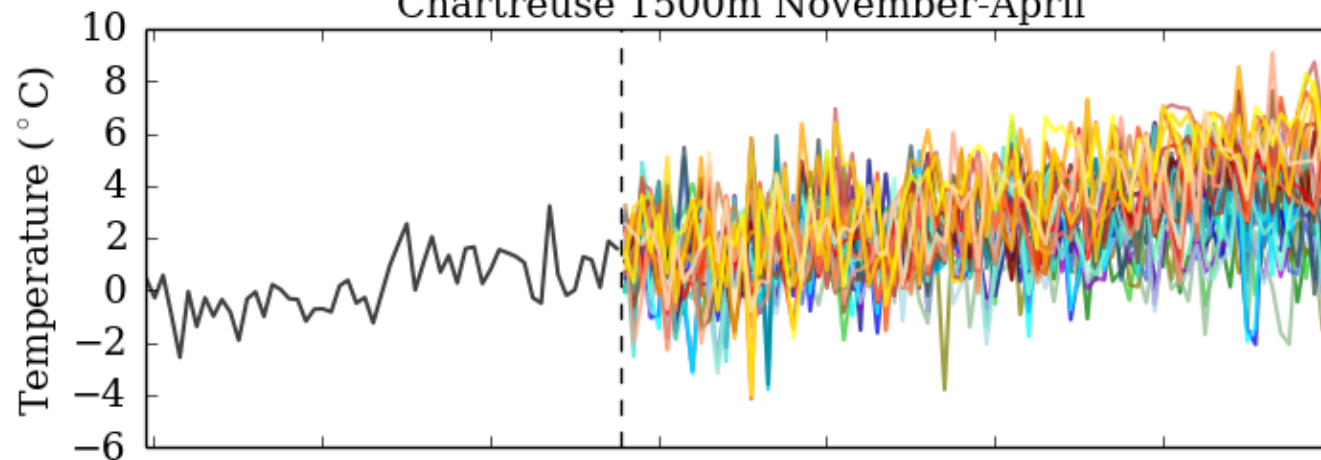


Thanks for your attention

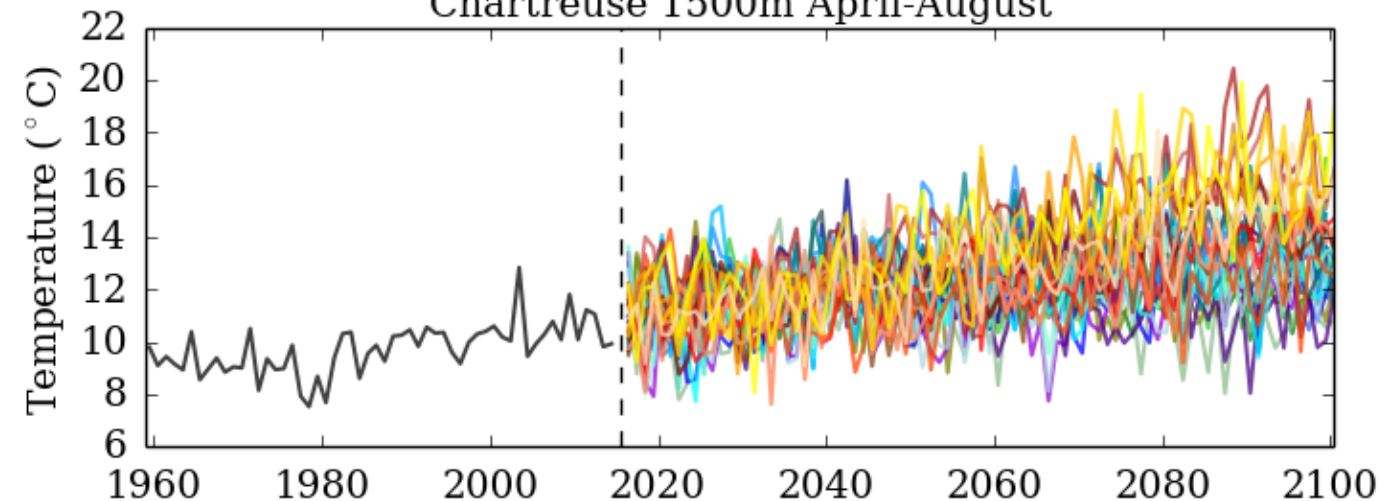
Any question?

First results – Meteorological variables

Chartreuse 1500m November-April



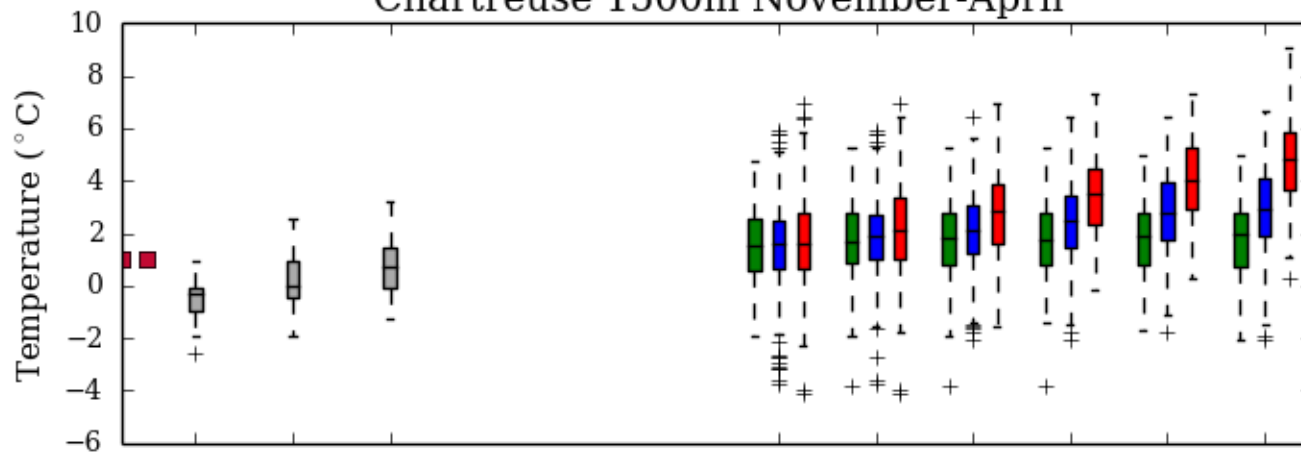
Chartreuse 1500m April-August



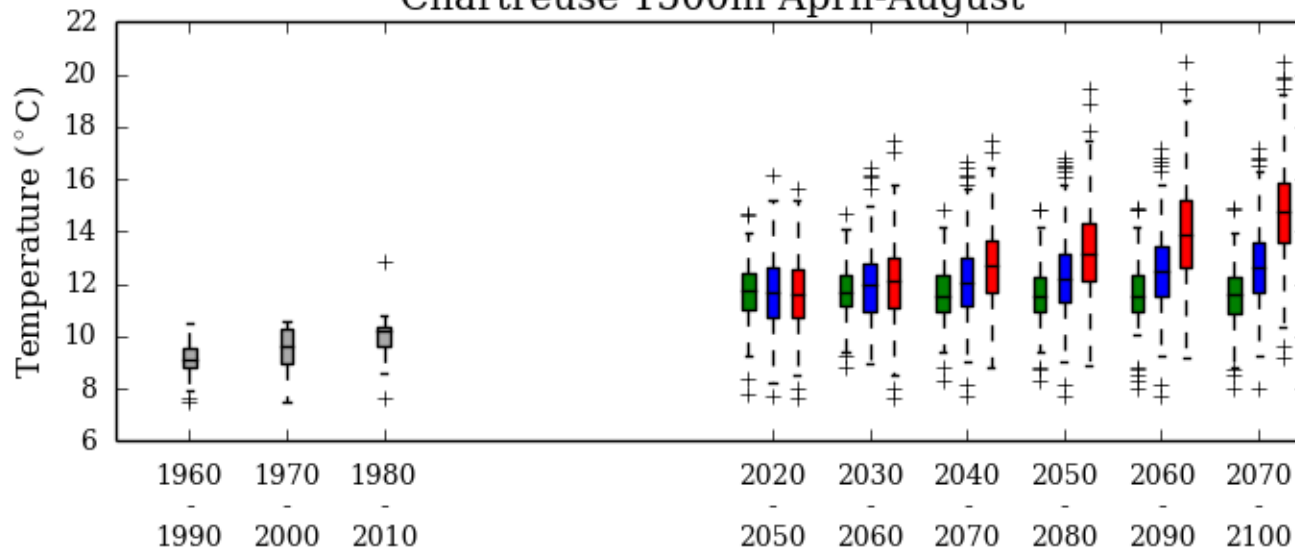
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First results – Meteorological variables

Chartreuse 1500m November-April



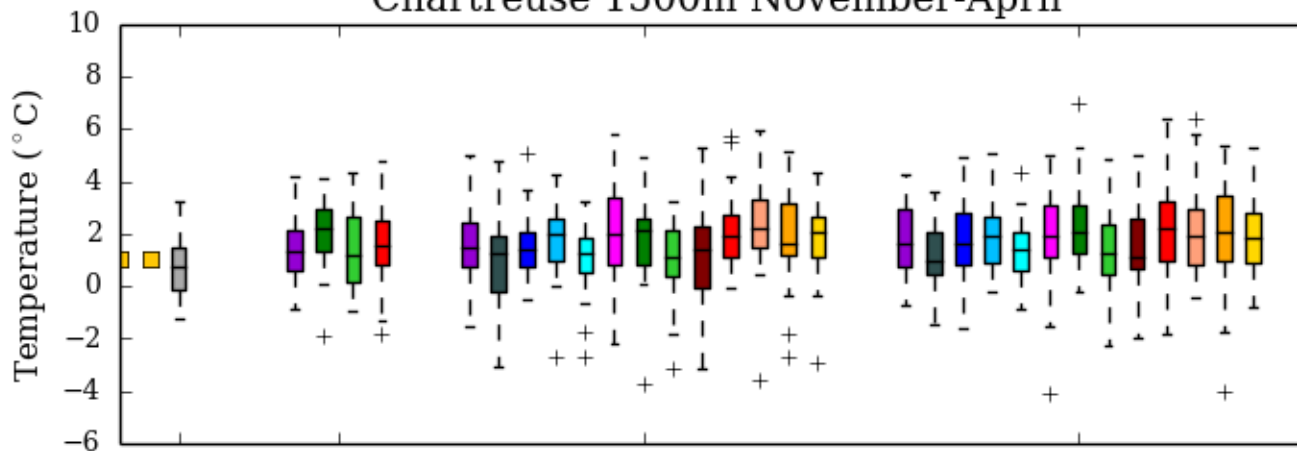
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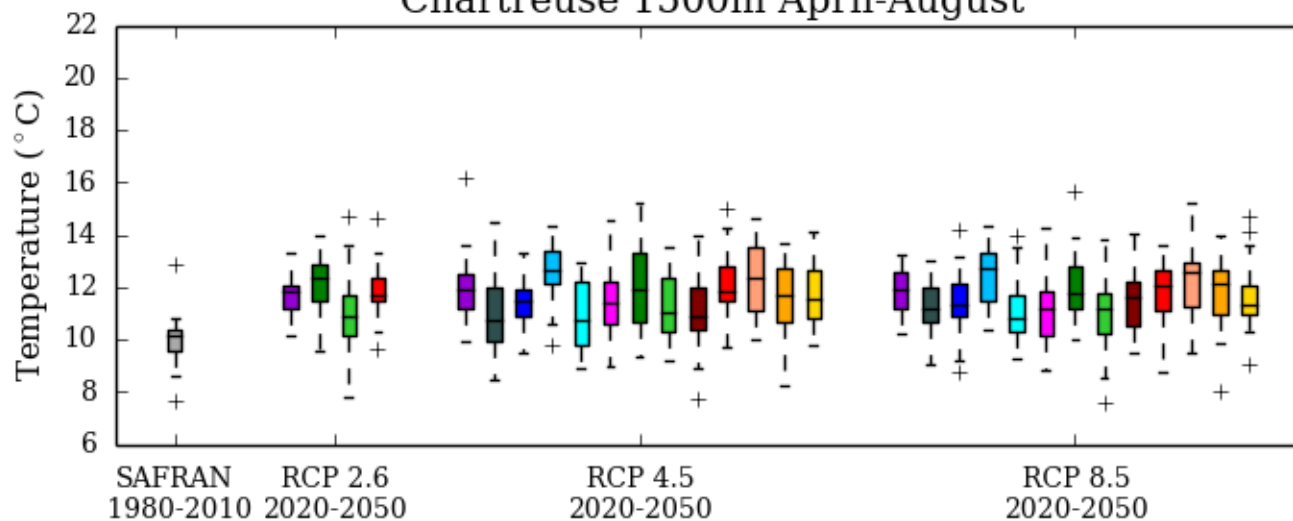
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First results – Meteorological variables

Chartreuse 1500m November-April



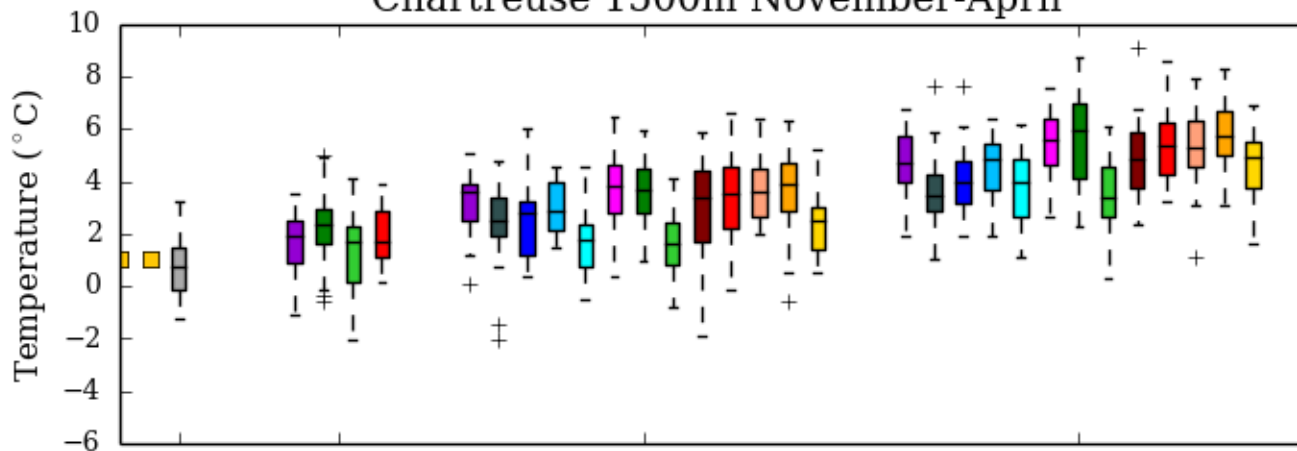
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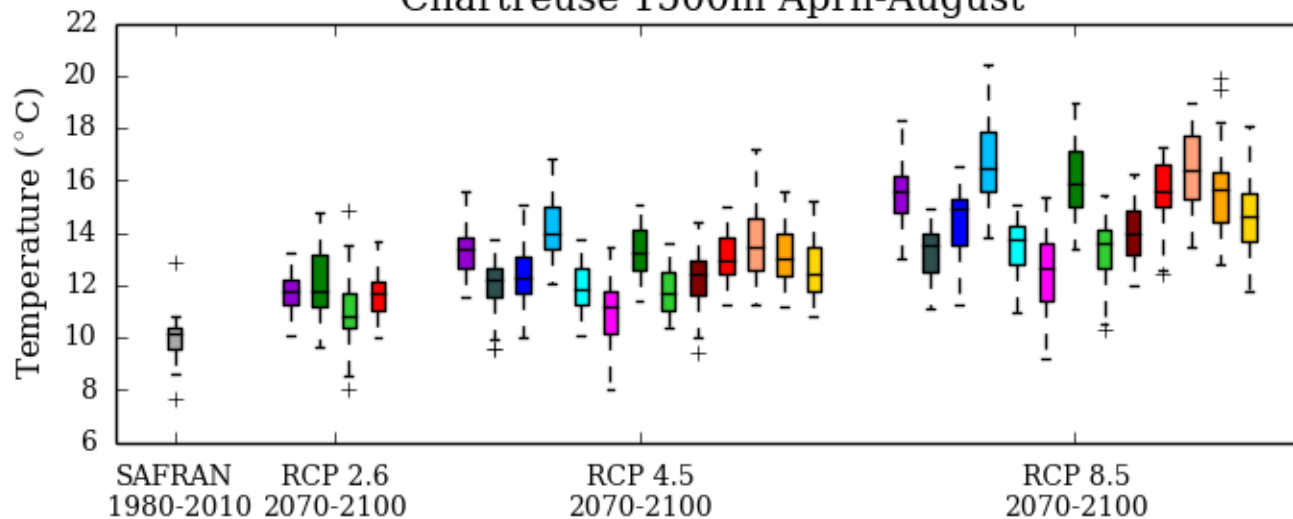
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First results – Meteorological variables

Chartreuse 1500m November-April



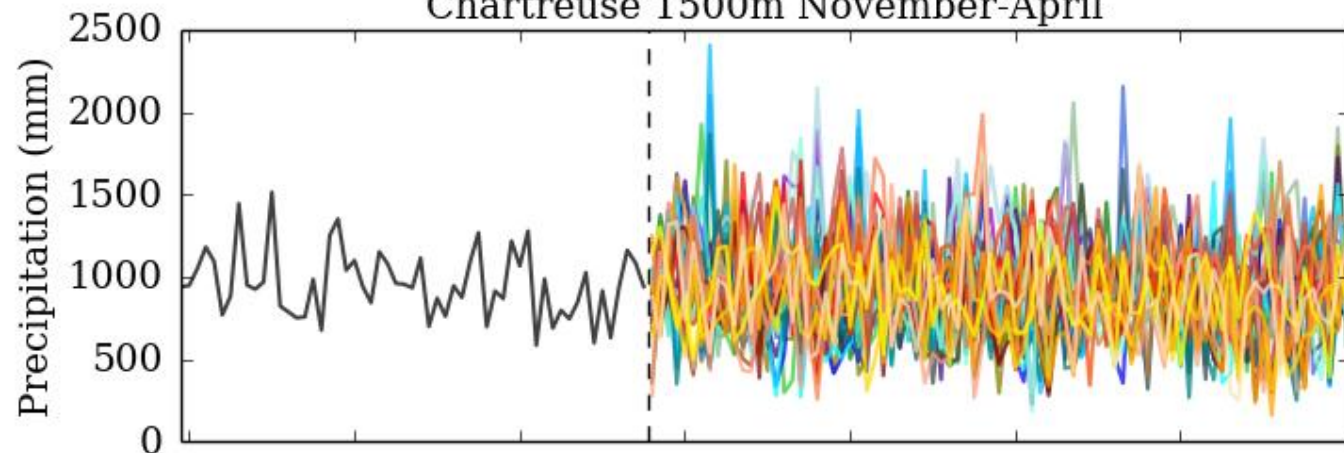
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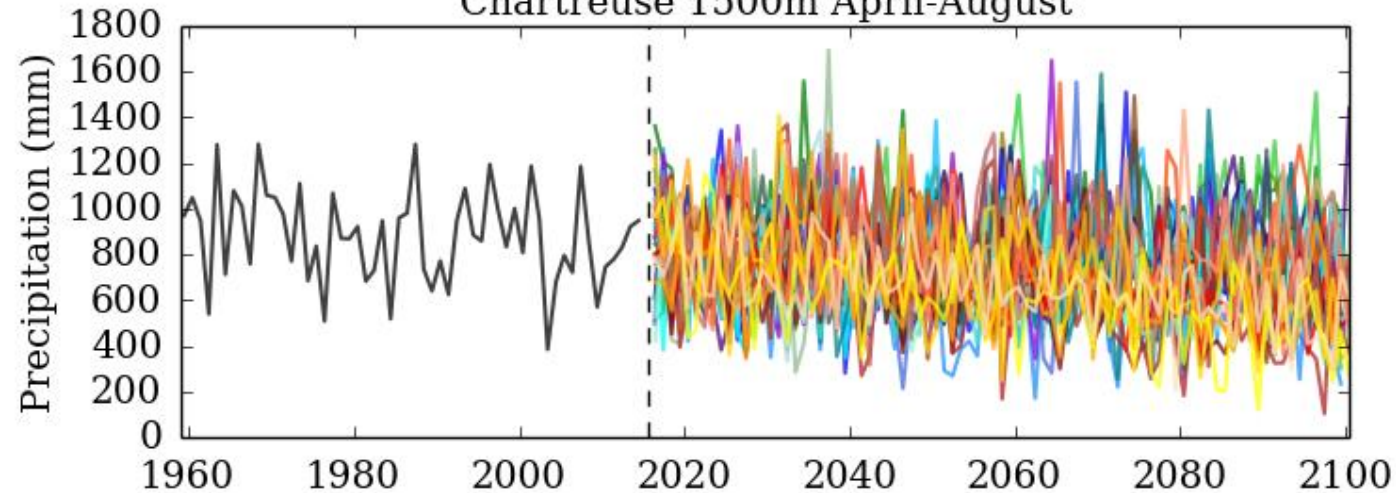
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First results – Meteorological variables

Chartreuse 1500m November-April



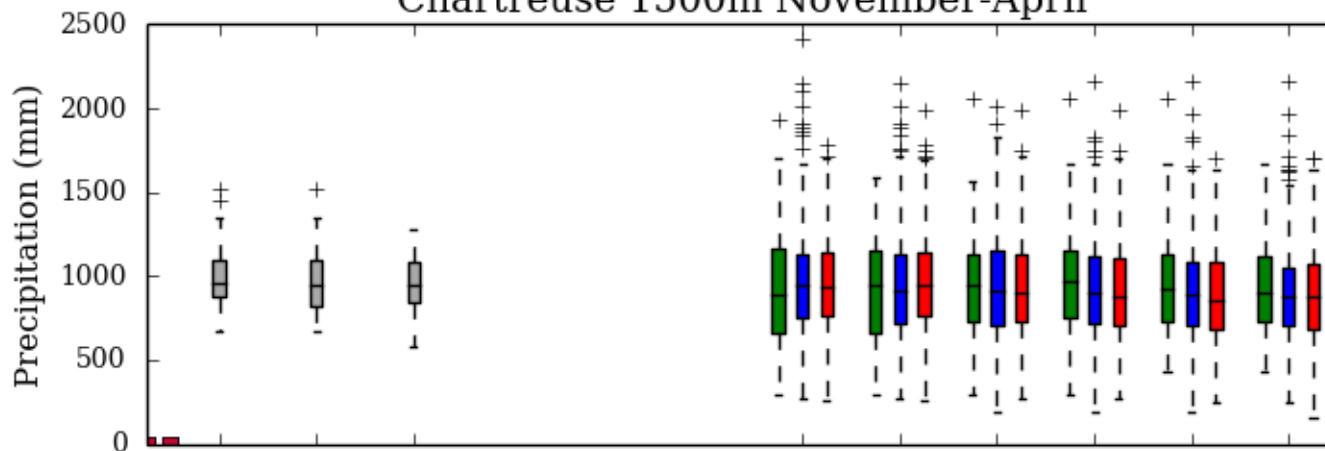
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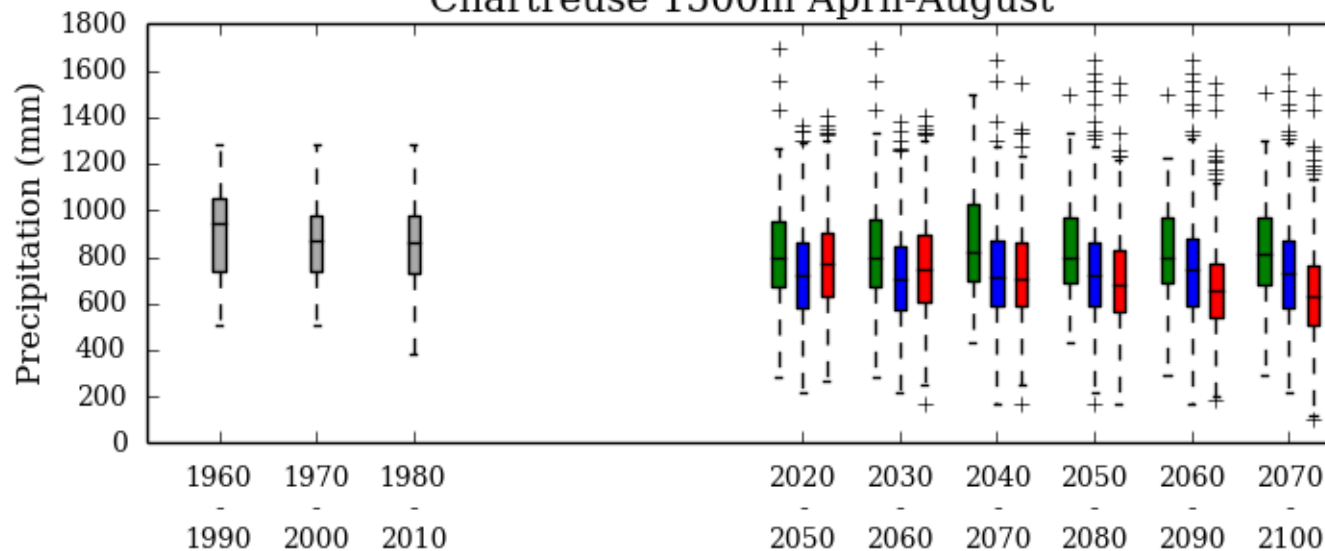
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First results – Meteorological variables

Chartreuse 1500m November-April



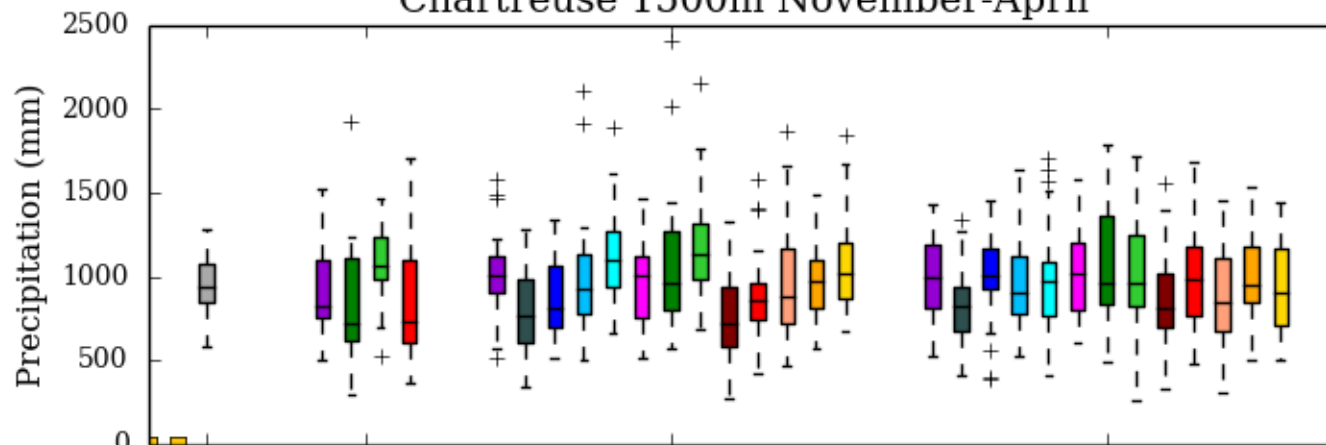
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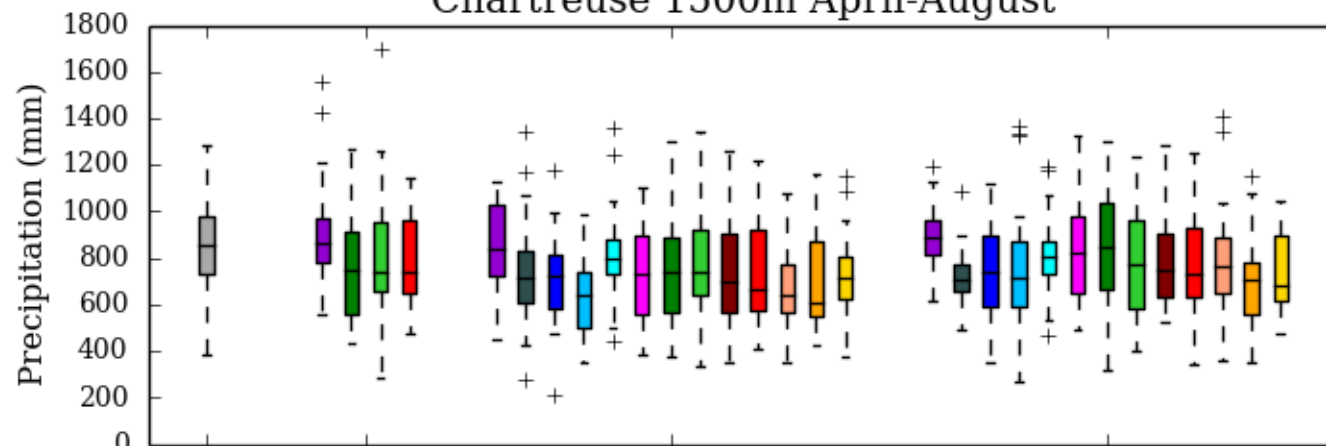
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- EUROCORDEX RCP2.6
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First results – Meteorological variables

Chartreuse 1500m November-April



Chartreuse 1500m April-August



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- HadGEM2-ES/RACMO22E
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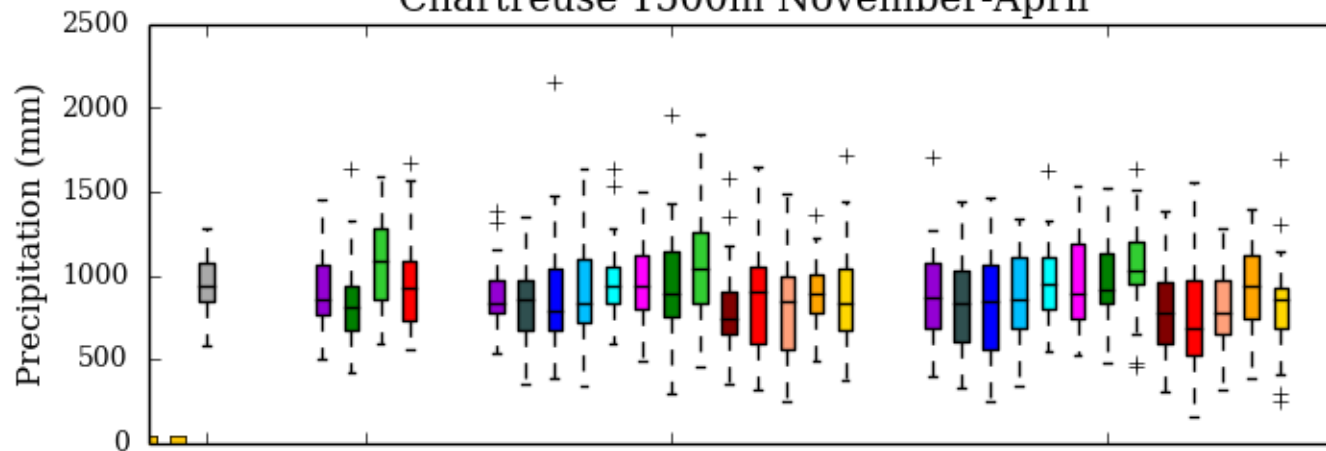
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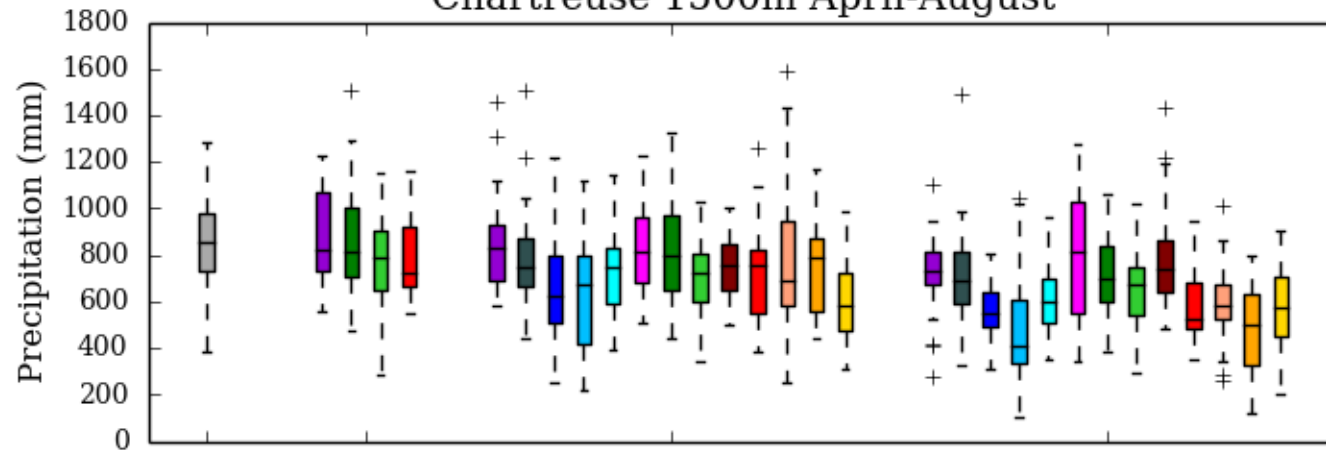
RCP 8.5 2020-2050

First results – Meteorological variables

Chartreuse 1500m November-April



Chartreuse 1500m April-August



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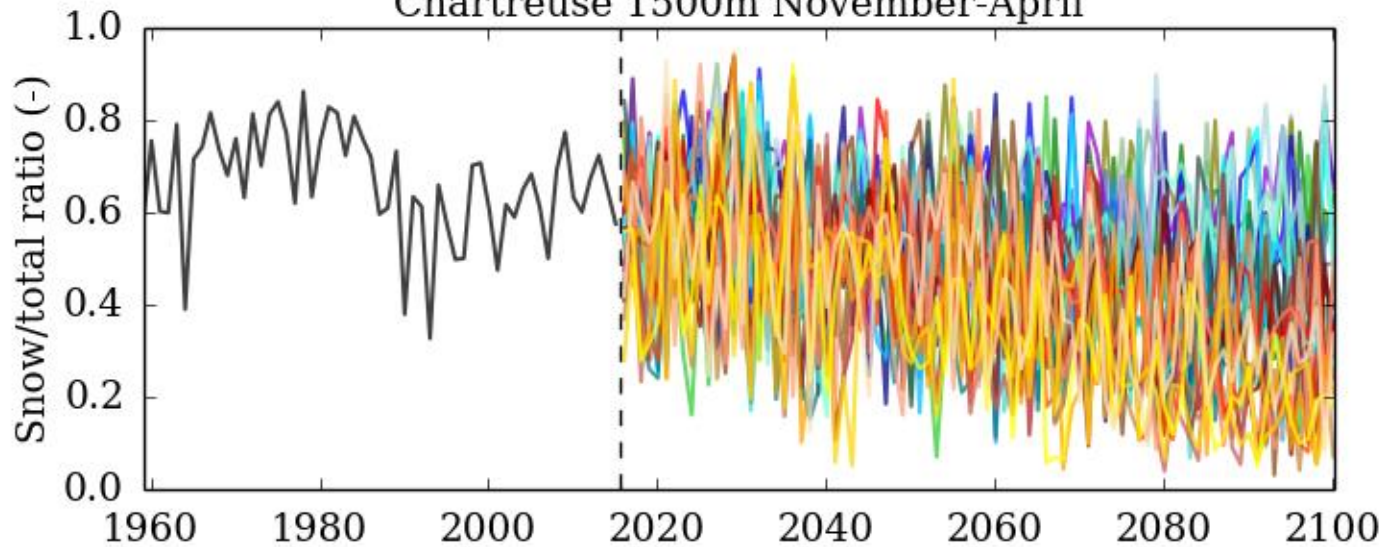
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RCP 4.5 2070-2100

RCP 8.5 2070-2100

First results – Meteorological variables

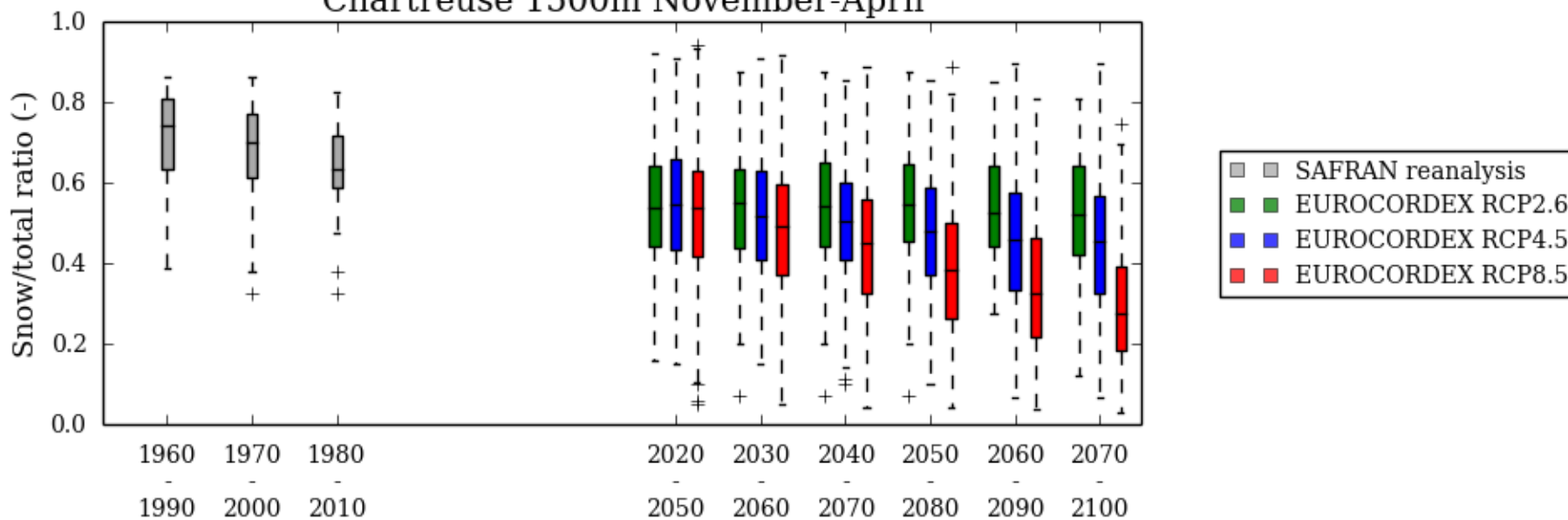
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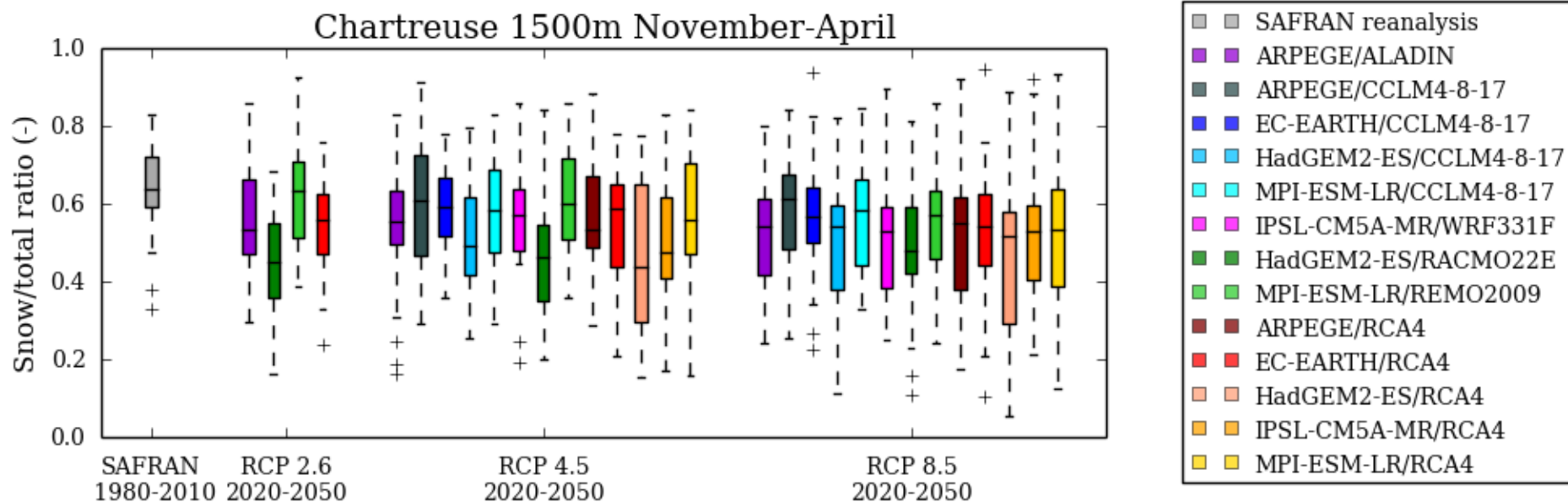
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- ARPEGE/ALADIN RCP8.5
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First results – Meteorological variables

Chartreuse 1500m November-April



First results – Meteorological variables



First results – Meteorological variables

