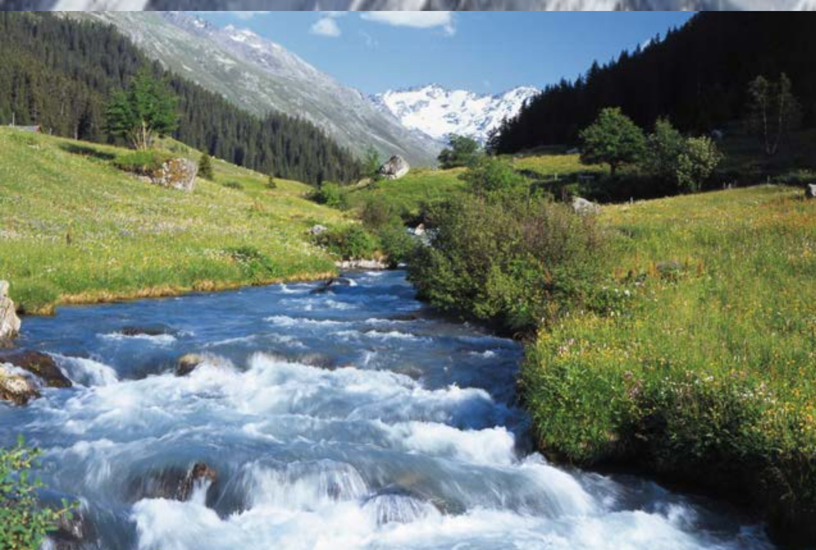
16th EMS Annual Meeting & 11th European Conference on Applied Climatology (ECAC) | 12–16 September 2016 | Trieste, Italy

Impact of climate change on runoff timing over the Alpine region

Erika Coppola, Francesca Raffaele, Filippo Giorgi



The Abdus Salam International Centre for Theoretical Physics

Outline

- Methodology and Snow Driven Runoff (SDR) definition
- Validation of the ensemble model output
- SDR change signal
- Discussion of the results
- Summary

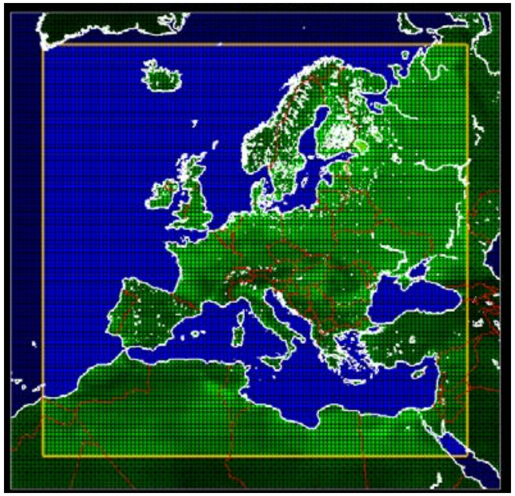
Methodology and SDR definition

- In analogy with Rauscher et al. [2008] study done for western US, we considered only regions that are dominated only by SDR. Those **regions** are selected as areas in **which 50% or more of the annual runoff occurs in the period April-July**.
- Following Moore et al. [2007], we calculated the Julian Day inside the **water year** (from October to September of the following year), on which each percentile of that year's annual flow occurred.
- To investigate on the early, middle and late seasonal flows **we calculated the 25th, 50th and 75th** DQFs (Date of Quarterly Flow). These calculations were performed only for regions in which 50% or more of the annual runoff occurs in April-July.

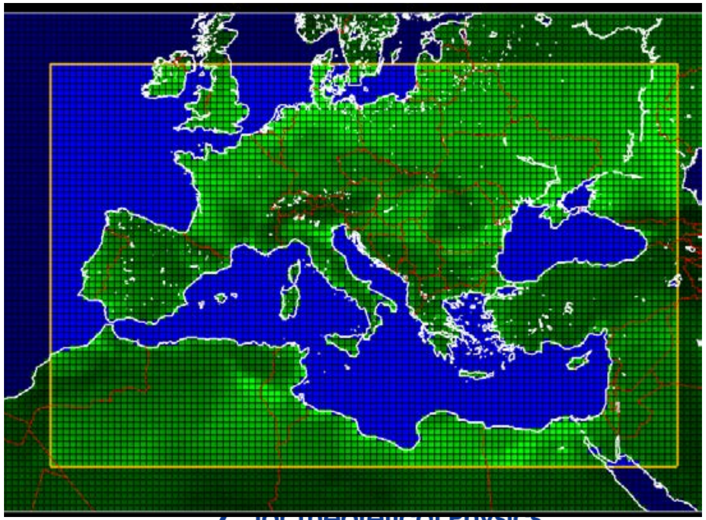
Methodology - Models

Model	Resolution	Driven-model	Domain
ALADIN	0.11 deg – 0.44 deg	CNRM-CM5	Med-CORDEX
RegCM	0.11 deg – 0.44 deg	HadGEM	Med-CORDEX
RACMO22E	0.11 deg – 0.44 deg	EC-EARTH	Euro-CORDEX
CCLM4-8-17	0.11 deg – 0.44 deg	MPI-ESM-LR	Euro-CORDEX

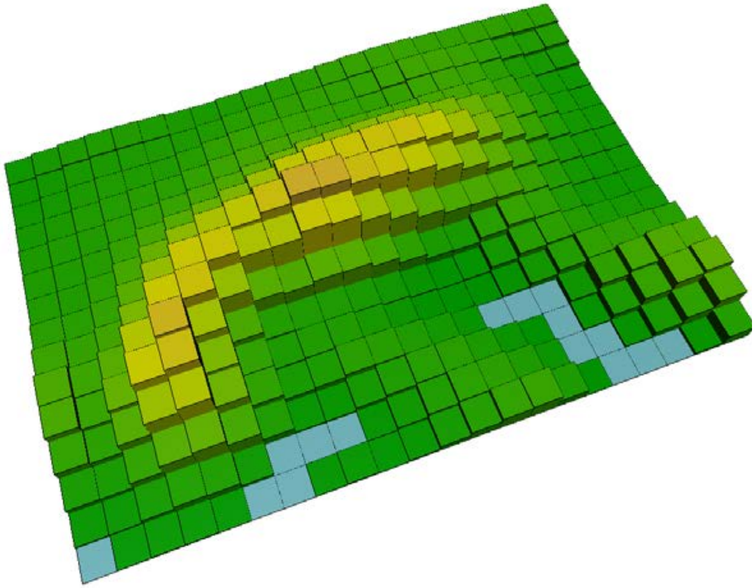
Euro-CORDEX



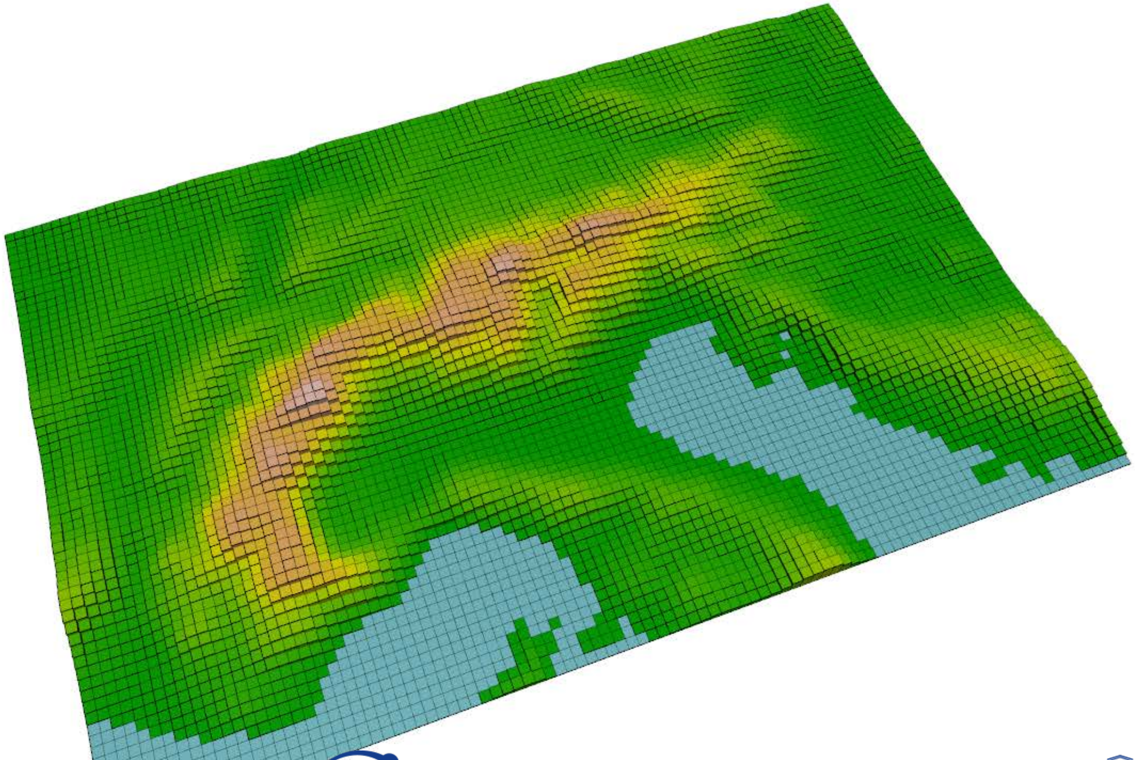
Med-CORDEX



Methodology - Grids



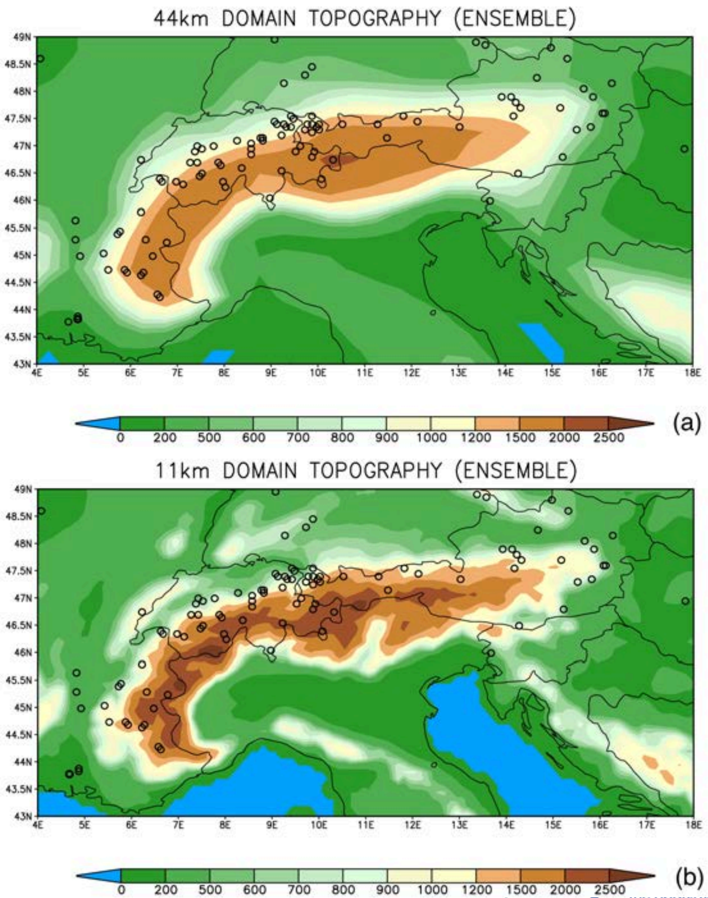
0.44



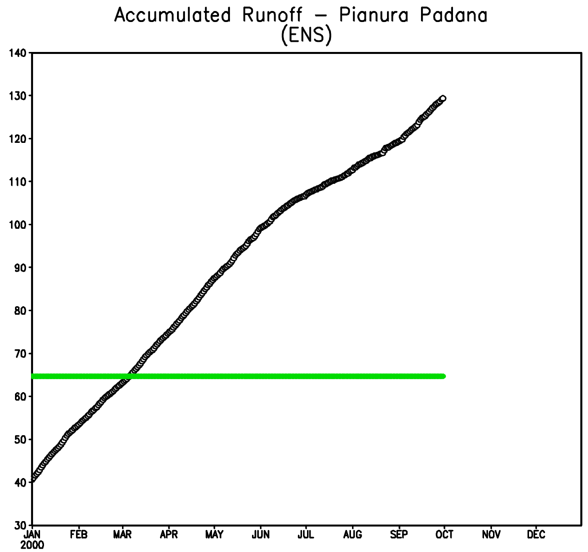
0.11

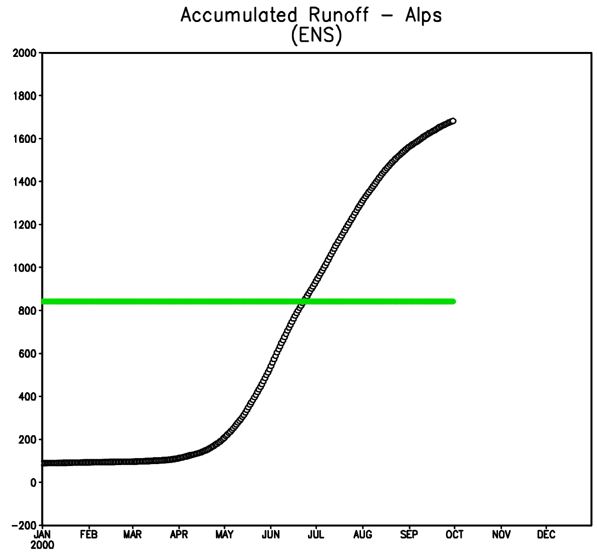
Methodology - OBS

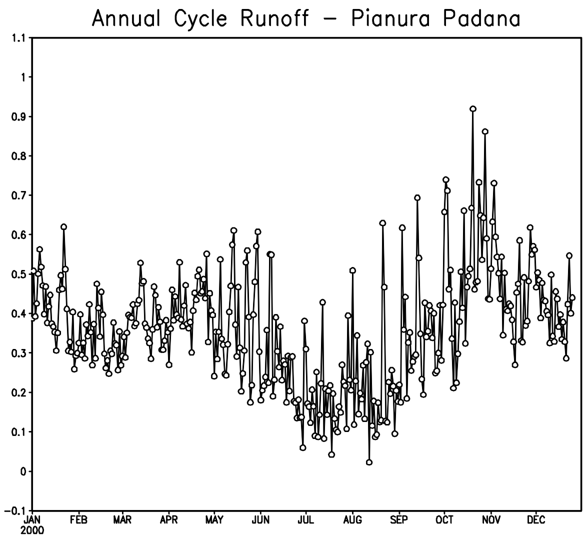
European Water Archive (EWA) observed runoff stations dataset over the Alps

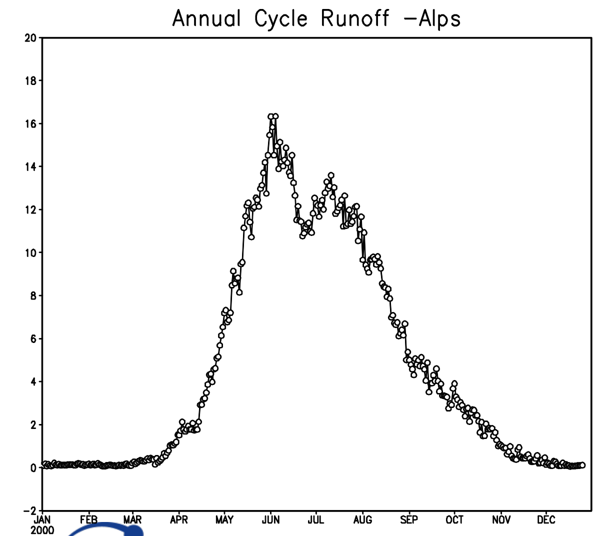


Methodology - MASK

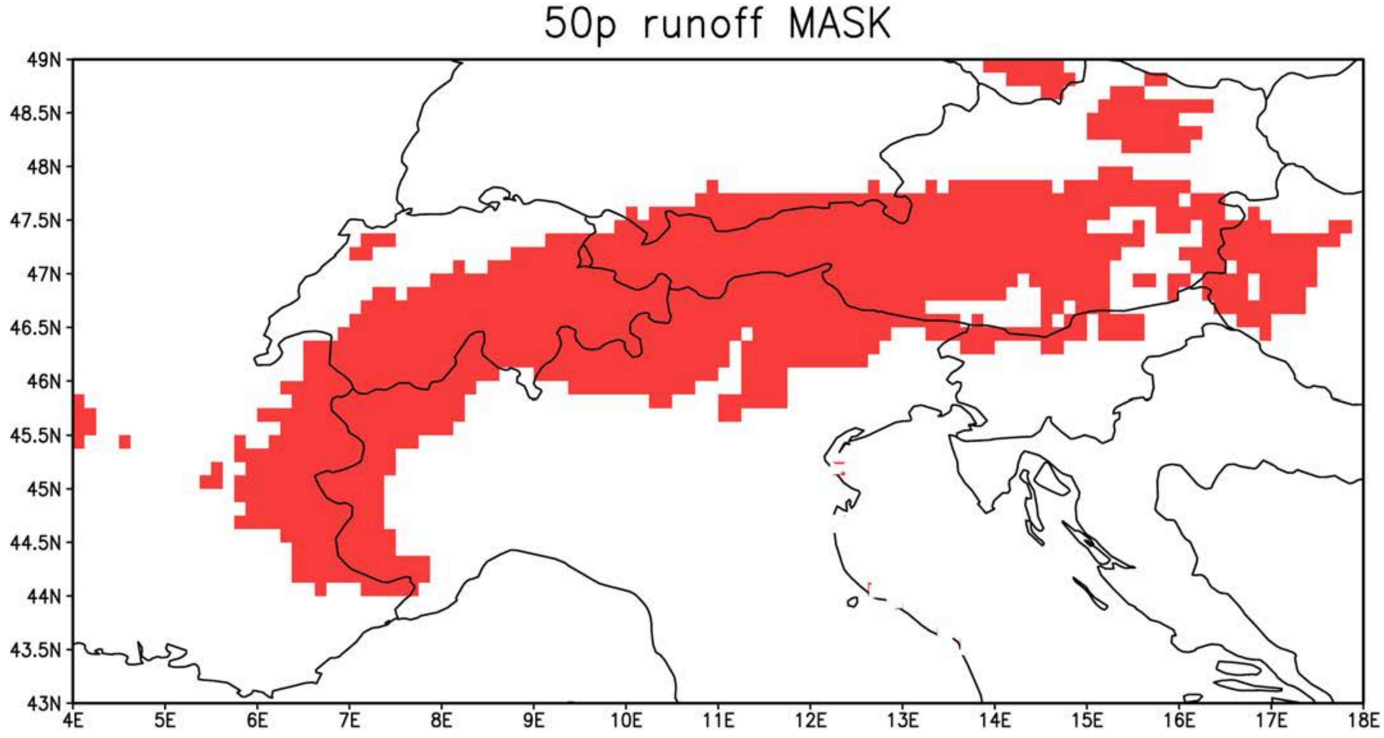








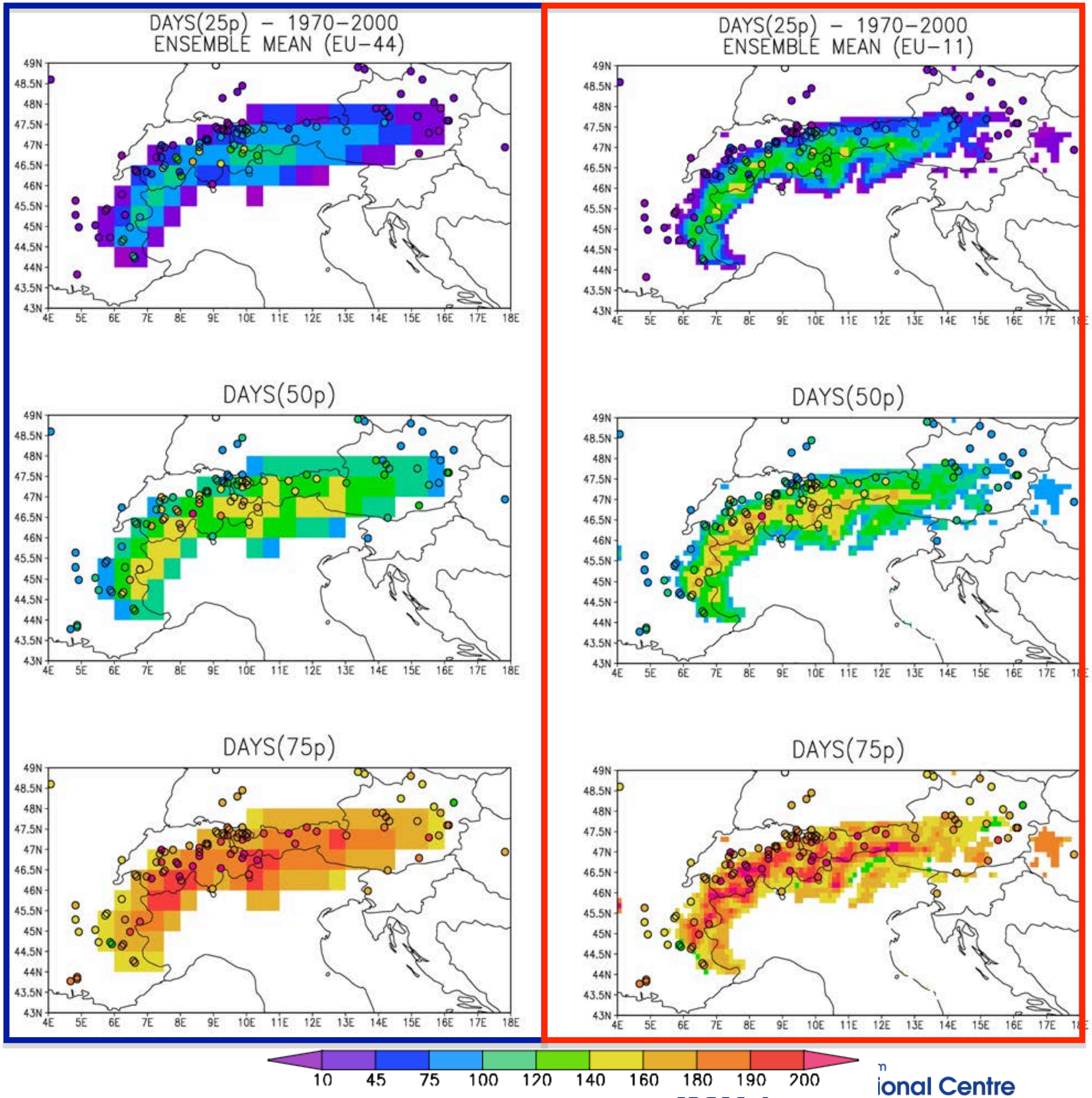
Methodology - MASK



The Abdus Salam International Centre for Theoretical Physics

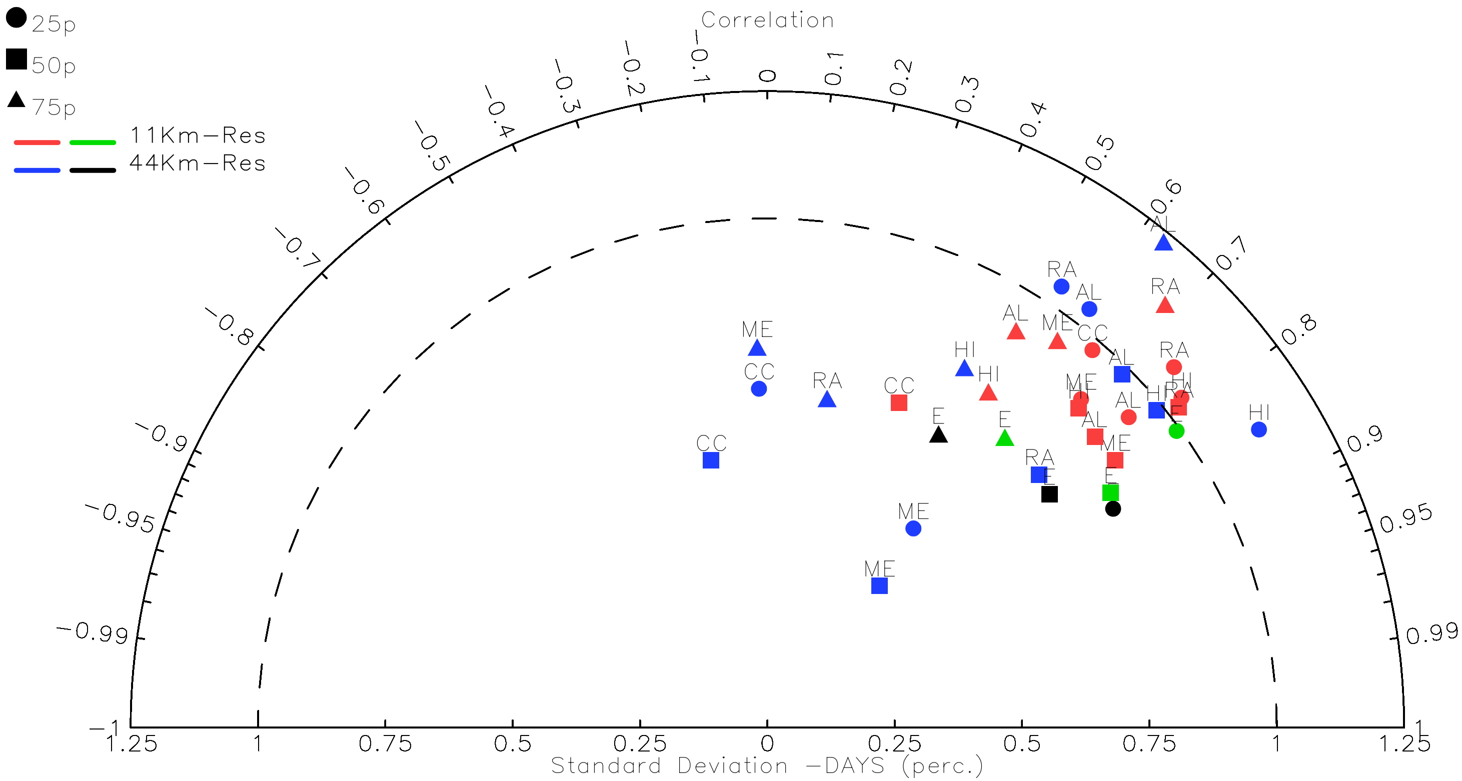
Validation

0.44



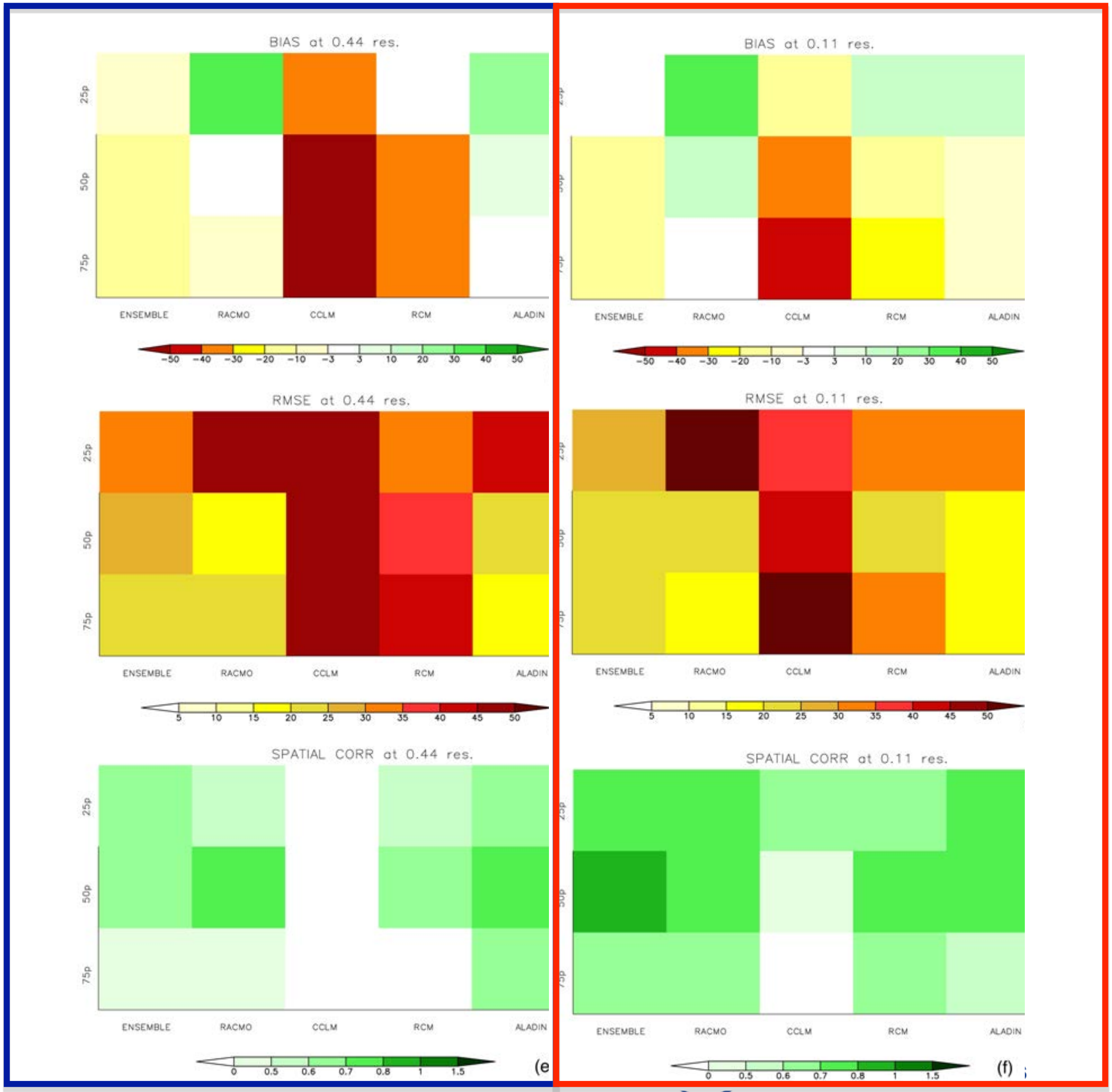
0.11

Validation of the ensemble model output



Validation of the ensemble model output

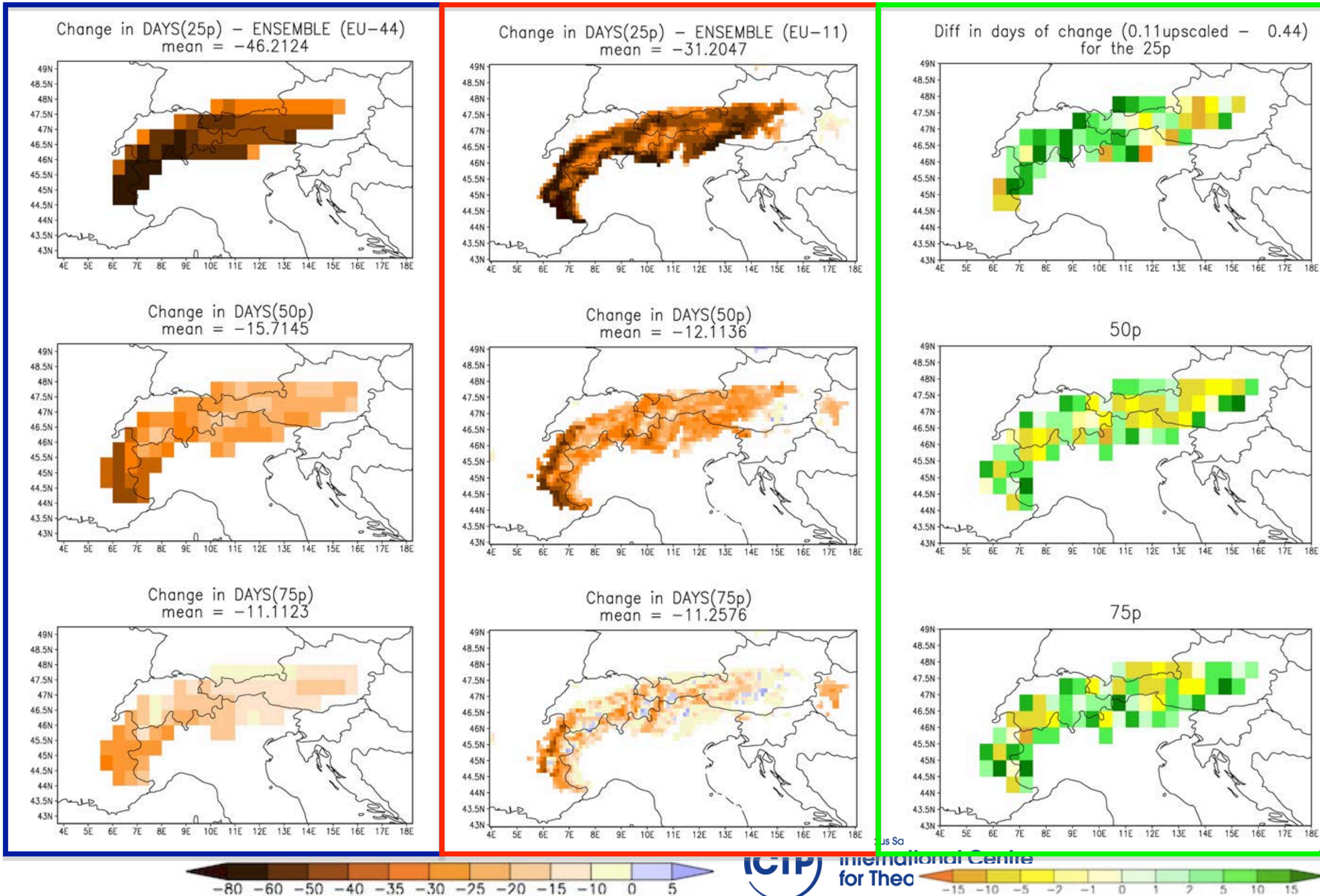
0.44



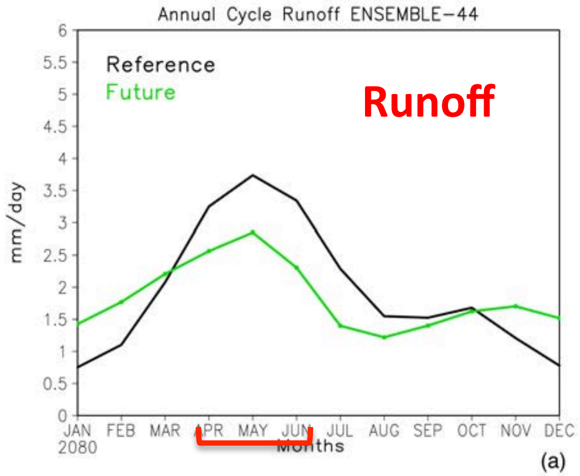
0.11

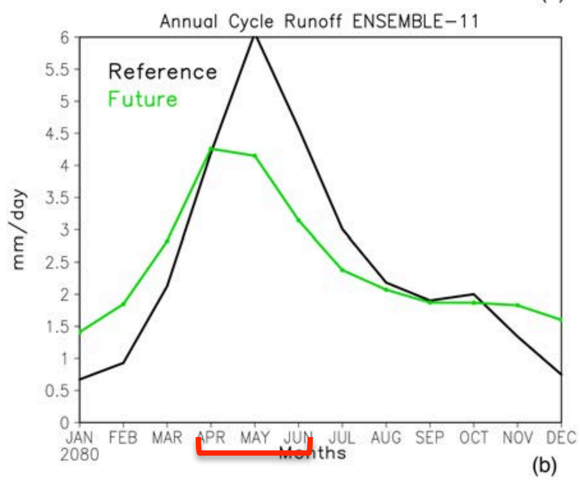
Results-Model ensemble change-days

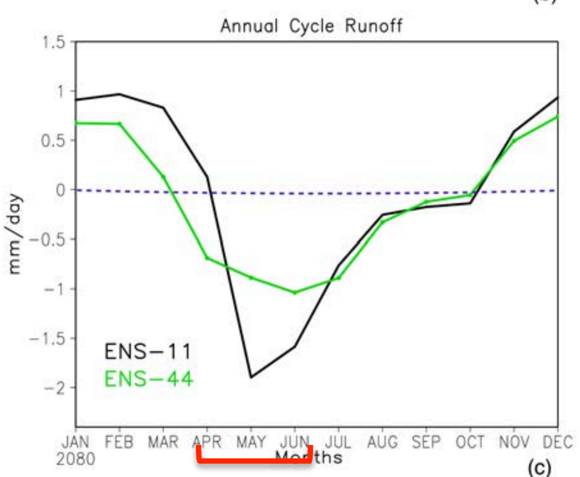
0.44 **0.11** **0.11-0.44**

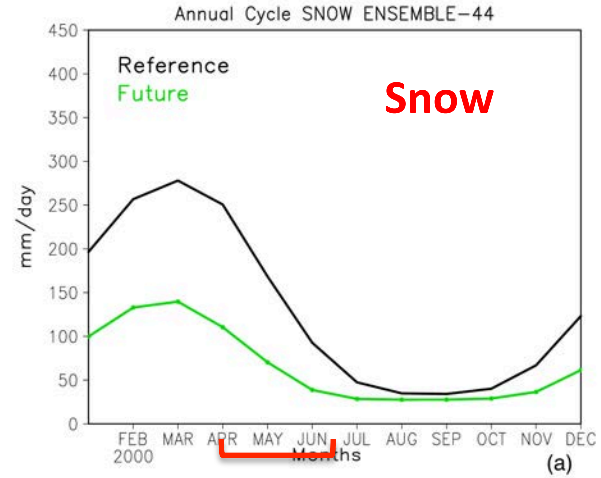


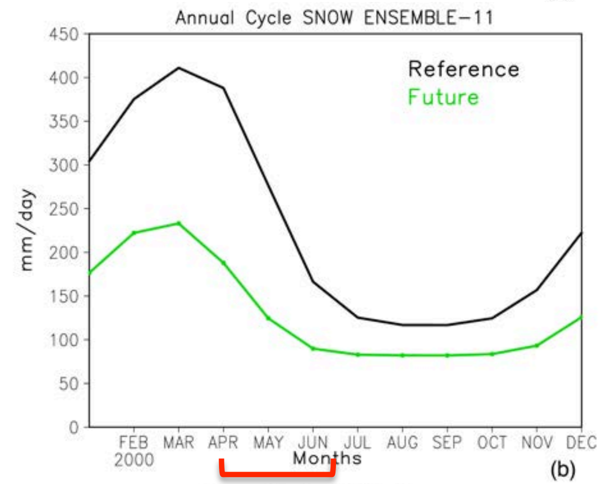
Discussion
runoff change
snow change

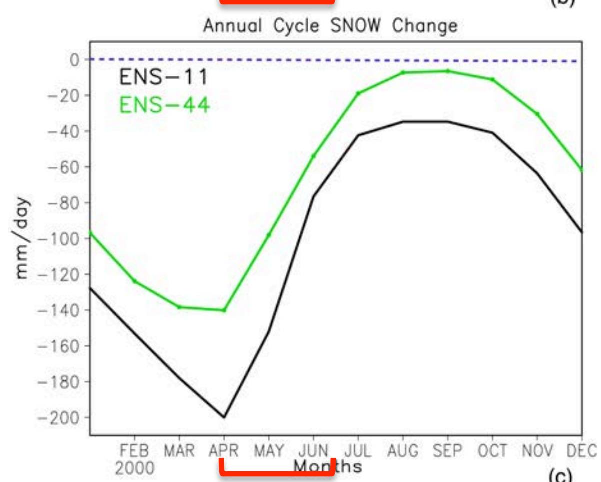






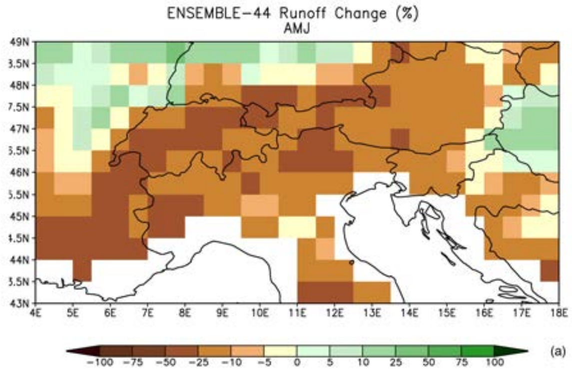


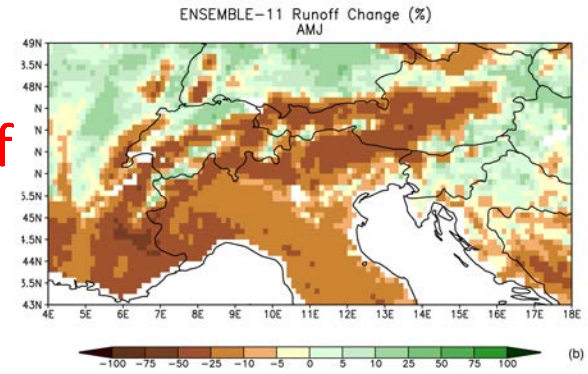




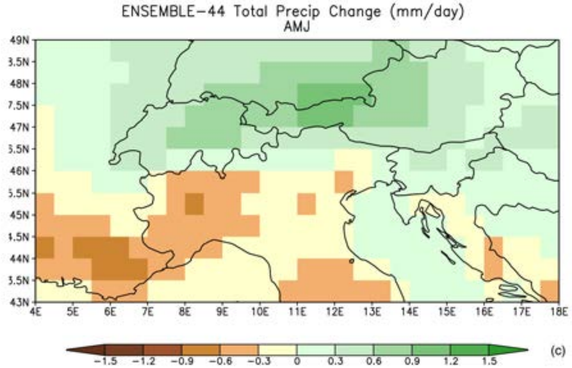
Discussion- runoff and precipitation change

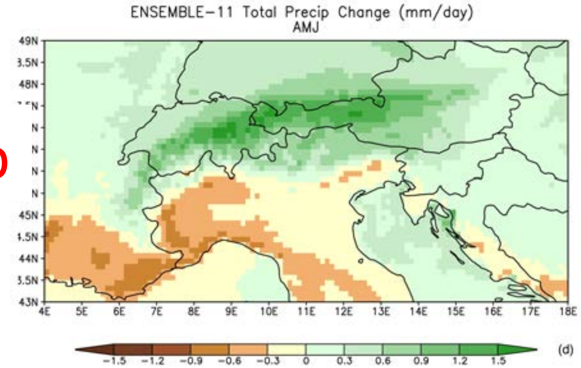
0.44 **0.11**





runoff

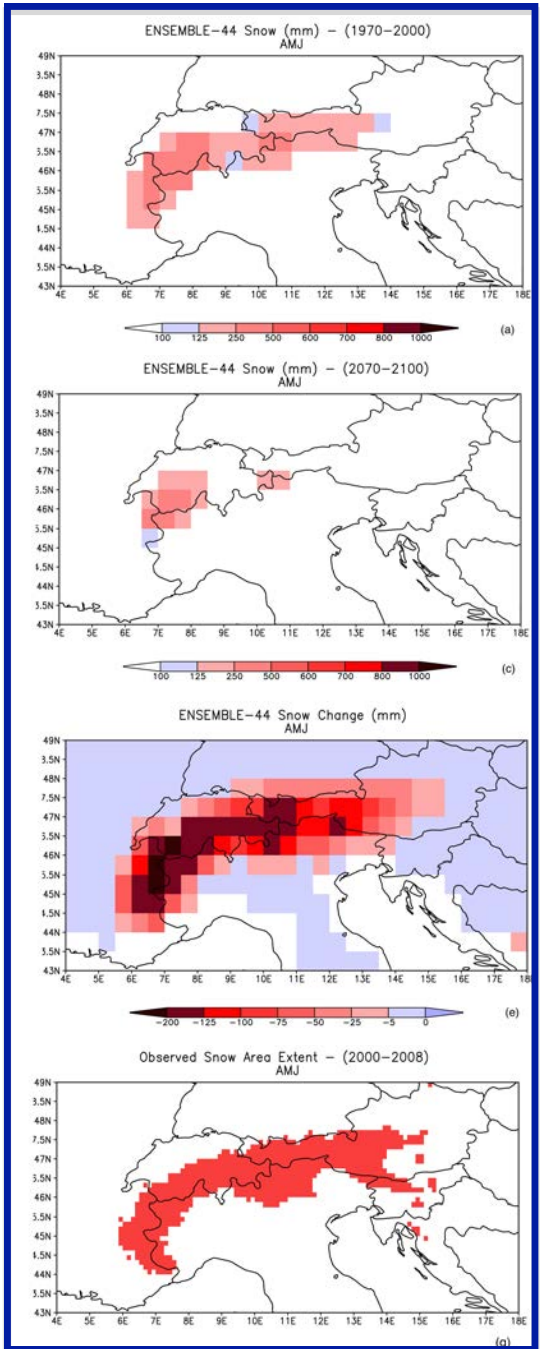


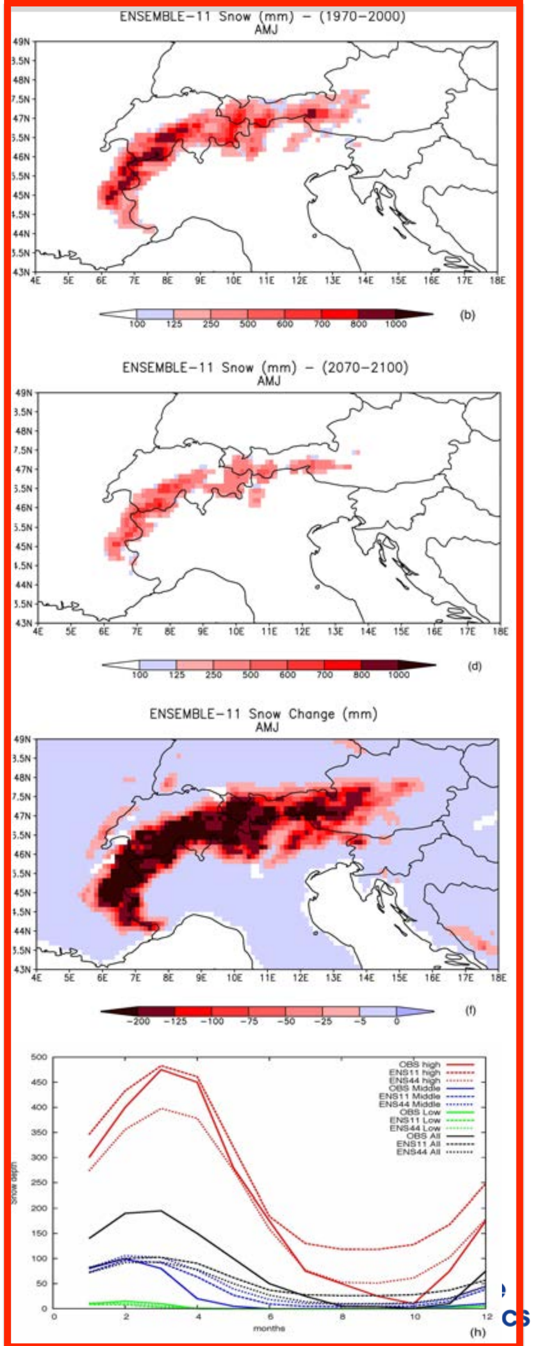


precip

Discussion-Snow change

0.44

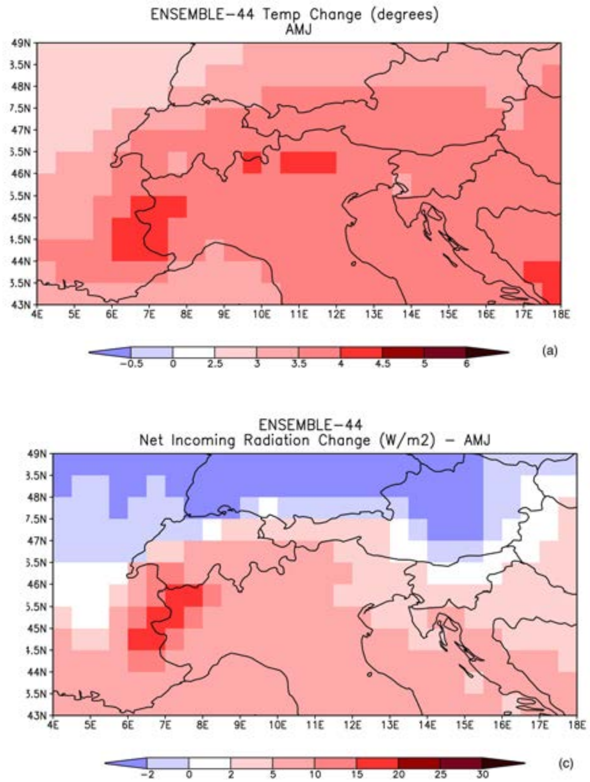




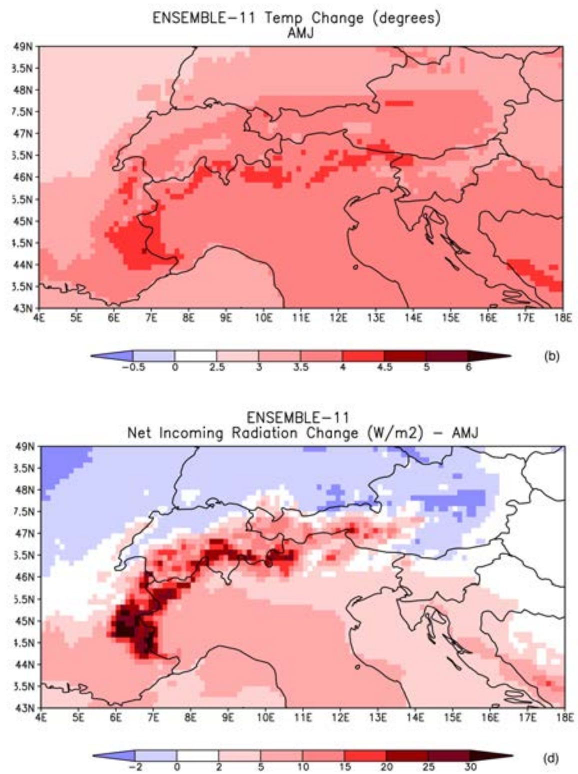
0.11

Discussion- Temperature and Net surface shortwave radiation change

0.44



0.11



Summary

- The 0.11 ensemble is able to capture the timing of the SDR in the Alpine change. The 0.44 has a worse performance when compared to the stations.
- The response of SDR to climate changes is dominated by increases in winter temperatures (up to 4 C) and associated reductions in snow cover.
- The response of the SDR to global warming is dominated by the effect of the related reduction in spring snow cover. The 25th, 50th and 75th percentiles of SDR are shifted earlier in the year during the end-of-century time slice, with this effect being especially pronounced for the 25th and 50th percentiles in response to spring snowmelt
- The temperature increases reduce the amount of land covered by snow and hence the surface albedo (reflectivity). This results in an increase in the amount of surface absorbed solar radiation and further amplifies the surface warming, resulting in additional melting and a positive feedback (known as the snow-albedo feedback).
- For both ensemble model resolutions, the 25^{th} DQF largest changes are up to 80 days and are distributed all around the perimeter of the Alpine chain for the 0.11 resolution and more concentrated on the west side for the 0.44 resolution. The 50^{th} and the 75^{th} show changes up to 50 and 35 days respectively, but a different spatial distribution tighten to the topography is evident.

Summary continued

- The change in SDR decrease from the 25th to the 75th and this means that the annual hydrograph is widening and the time is moving backward with all happening earlier then the present day (Coppola et al.,2014).
- The main difference between the 0.11 and 0.44 resolution is in the spatial distribution of the change signal with a reduced time shift on the highest elevation for the 0.11 resolution.
- the topographic signal found in the change of runoff and SDR quantiles simulated by the 0.11 models is related to the persistence of snow cover over the highest Alpine peaks in the future time slice and the local increase of precipitation (convective) (Giorgi et al,2016), which also affects the details of the spatial patterns of warming over the Alps.
- Accurate simulation of changes in runoff timing requires **high resolution representation of the Alpine topography**. Early SDR can have several **impacts** and **consequences** for the **society** and **ecosystem**. The change in the hydrological cycle can increase **flood** in winter and spring, change the water load in the stream and lakes and therefore **change** the **aquatic ecosystem**. The change in timing of the runoff pick can be relevant for the **water storage regulation** for **hydropower** production, **agriculture** and **domestic usage** and all this can impact the **economy** of the region.

Coppola E., Raffaele F., Giorgi F., Impact of climate change on runoff timing over the Alpine region. DOI 10.1007/s00382-016-3331-0. *Climate Dynamics.*