On the role of the Alps for Central European Climate

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1 Introduction

Orography has a strong influence on weather and climate. Large mountain ranges affect the global circulation and determine the distribution of different climate regimes. Being a smaller mountain range in Central Europe, the Alps might not have a strong influence on the global scale. However, for Central European weather and climate the orographic effects of the Alps are crucial. Different synoptic and mesoscale flow phenomena such as lee-cyclogenesis or Föhn are related to these mountains. Moreover Alpine orography is responsible for the distribution of temperature and precipitation both over the Alps as well as in the vicinity upstream and downstream of the Alps.

2 Method overview

The orographic effects of the Alps on the European climate are investigated and quantified using two simulations of the regional climate model COSMO-CLM (i.e. COSMO5.0_clm6) at a resolution of 12 km. Simulations are integrated over a 32 year period (1979-2010) with ERA-Interim data as initial data and boundary forcing.
A comparison of the resulting climates of the two experiments shows the response of the European climate to the presence of the Alps.

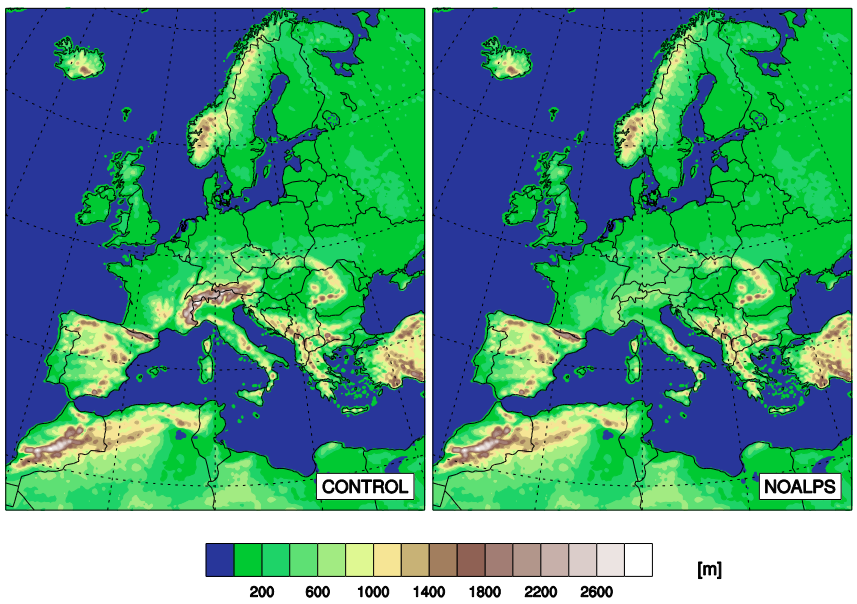

Fig. 1. COSMO-CLM domain with the topography of the CONTROL (left) and the NOALPS simulation (right). In the NOALPS experiment some additional parameters like soil texture, roughness length, root depth and leaf area index had to be adjusted accordingly to the new elevation.

3 Results I: 1981-2010 Climatology

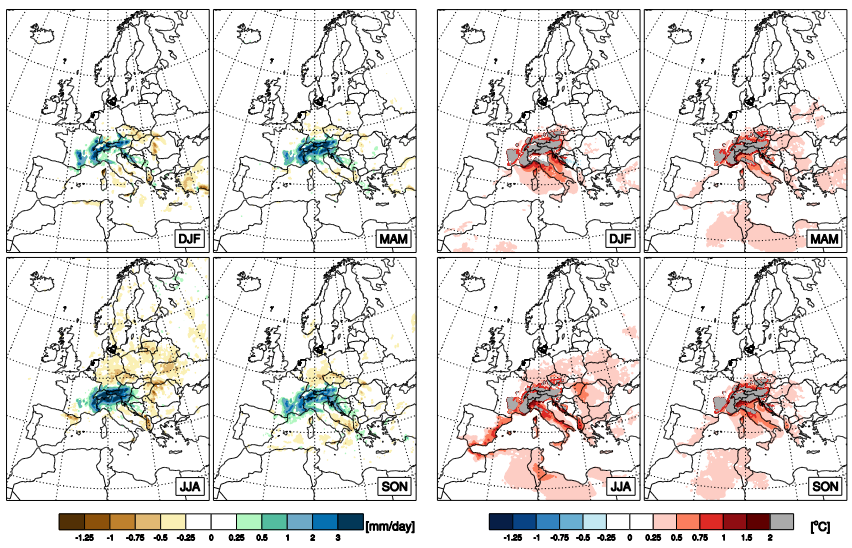

Fig. 2. Seasonal precipitation difference (CONTROL-NOALPS) for the period 1981-2010. The main effect is a substantial increase in the region where the orography is removed and a decrease in the surrounding areas. This distribution can be explained by different mechanisms of orographic precipitation.

Fig. 3. Same as Figure 2 but for temperature. Since it is difficult to compare temperatures at grid points with different heights, this area is colored in gray. The resulting pattern is showing a warming for large parts of Europe. Changes in heat fluxes and cloud cover but also the blocking of cold air by the Alps are reasons for the increase in temperature.

3 Results I: 1981-2010 Climatology

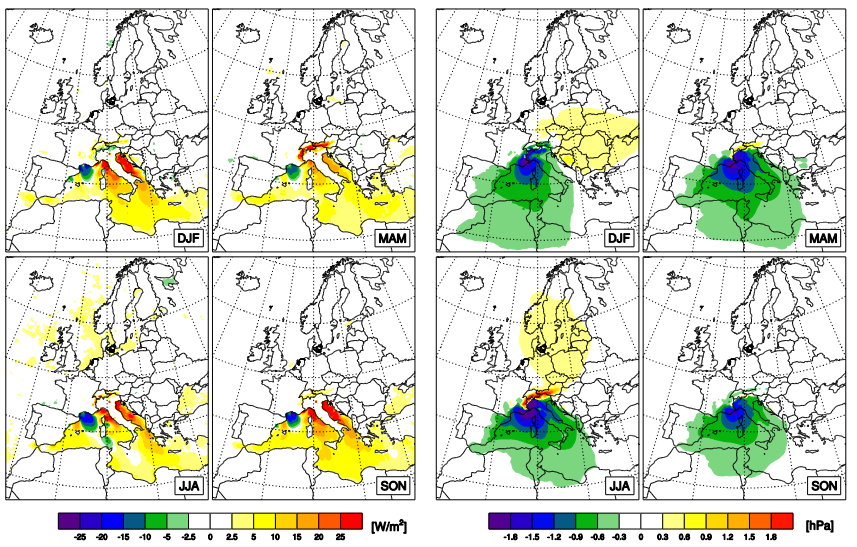

Fig. 4 . Same as Figure 2 but for surface energy balance. The negative values in the Gulf of Lyon and the positive values in the rest of the Mediterranean are caused by changes in the heat fluxes which in turn are due to changes in wind speed.

Fig. 5. Same as Figure 2 but for mean sea level pressure (MSLP). The main effect of the alpine orography is a lower pressure over large parts of the Mediterranean, especially in the Gulf on Genoa with a reduction in the MSLP up to -2 hPa. The most plausible explanation is an association with differences in the occurrence of lee cyclones.

4 Results II: Lee cyclone case study

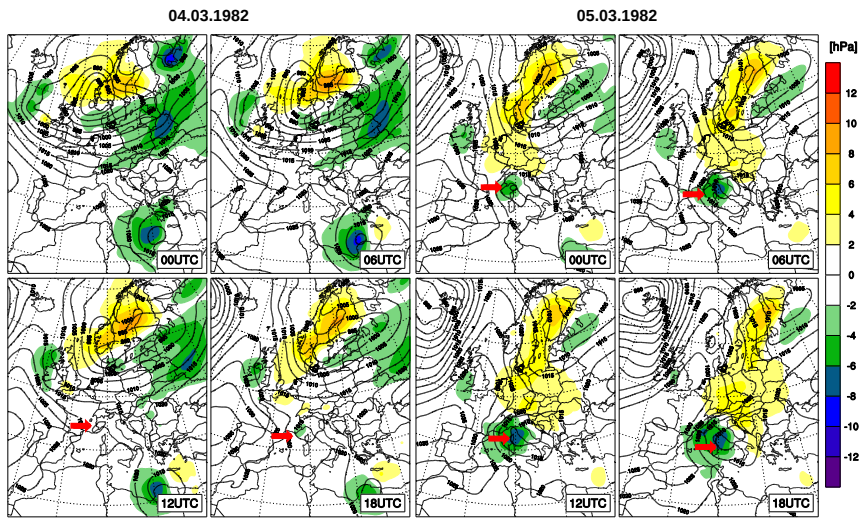

Fig. 6. Sea level pressure of the CONTROL simulation (contour every 5 hPa) and the differences of the simulations (CONTROL-NOALPS, colored) for 4 and 5 March 1982. The difference between the two simulations are very small in the beginning of the cyclogenesis and only become visible on March 4 at 18 UTC (the lee cyclone which developed March 2-3 is still visible in the Mediterranean Sea between Greece and Egypt). The further the progression of the cyclone on March 5, the greater the differences in sea level pressure. On one hand the lee cyclone in the NOALPS simulation has a higher central pressure, on the other hand it is shifted noticeably to the east. (Here is only shown one example, but for other lee cyclones the results are comparable.)

5 Conclusion

The main orographic effects of the Alps are:
- An increase in precipitation in the Alps and a decrease around.
- A warming for large parts of Central Europe.
- An evident negative pressure anomaly over the Gulf of Genoa.
- Lee cyclones are even occurring in absence of topography, although with pronounced differences in strength, location and time of development.

6 References & Contact

References
Spirig, C., 2016: On the role of the Alps for Central European Climate. Master thesis, Institute for Atmospheric and Climate Science, ETH Zürich, (in prep.).

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