Geophysical Research Abstracts
Vol. 13, EGU2011-4518, 2011
EGU General Assembly 2011

Elevation Gradients of European Climate Change in the Regional Climate Model COSMO-CLM

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A transient climate scenario experiment carried out by the regional climate model COSMO-CLM within the ENSEMBLES project is analyzed to assess the elevation dependency of 21st century European climate change. A focus is put on near-surface conditions. Model evaluation reveals that COSMO-CLM is able to reproduce the observed altitudinal variation of 2m temperature and precipitation in most regions and most seasons. The analysis of climate change signals suggests that 21st century climate change might considerably depend on elevation. Over most parts of Europe and in most seasons, near-surface warming significantly increases with elevation. This is consistent with simulated changes of the free-tropospheric air temperature but can only be fully explained by taking into account regional-scale processes involving the land surface. In winter and spring, the anomalous high-elevation warming is typically connected to a decrease in the number of snow days and the snow-albedo feedback. Further factors are changes in cloud cover and soil moisture and the proximity of low-elevation regions to the sea. The amplified warming at high elevations becomes apparent during the first half of the 21st century and results in a general decrease of temperature lapse rates. It does not imply an early detection potential of large-scale temperature changes. For precipitation, only few consistent signals arise. In many regions precipitation changes show a pronounced elevation dependency but the details strongly depend on the season and the region under consideration. There is a tendency towards a larger relative decrease of summer precipitation at low elevations, but there are exceptions to this as well. An extension of the analysis to the entire ENSEMBLES RCM suite reveals a high model agreement concerning the amplification of the 21st century warming signal at high elevations.