The Cryosphere

Supplement of

Snow depth in high-resolution regional climate model simulations over southern Germany – suitable for extremes and impact-related research?

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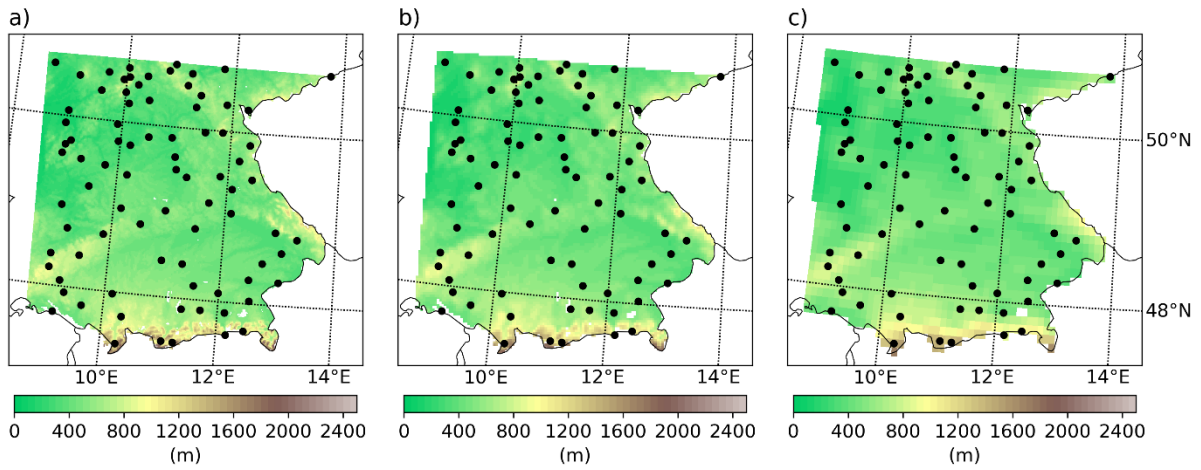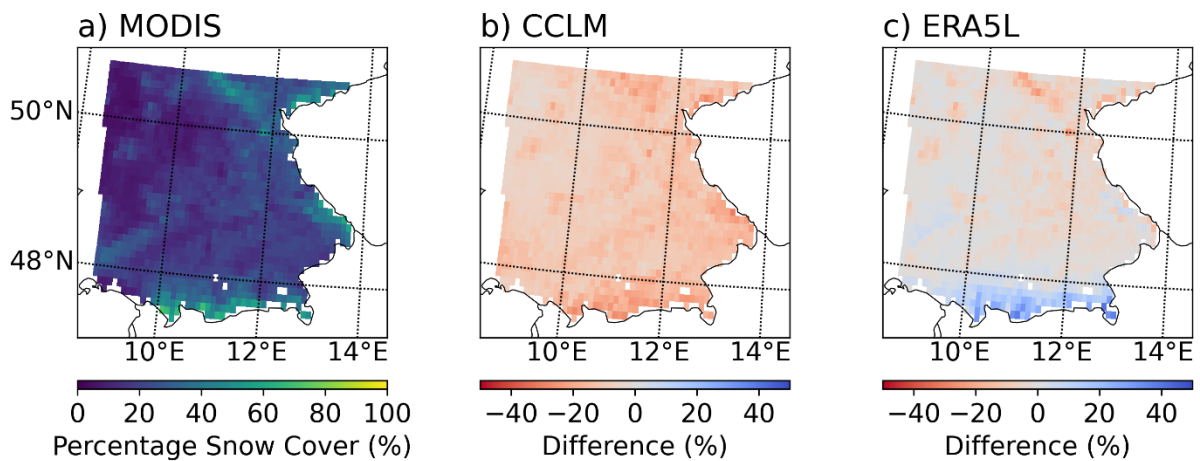**Figure S1: Representation of elevation in WRF (a), CCLM (b), and ERA5L (c).**

Figure S2: Mean snow cover fraction during November to April averaged over the period 2000-2018. For the remote sensing product (a, MODIS MOD10C1.061), only data with at least "okay" quality are considered. The differences (b,c) are calculated as model minus remote sensing product, where red (blue) colour refers to an under-(over)estimation of the model. The mean snow cover fraction amounts to 20% (MODIS), 9% (CCLM), and 19% (ERA5L).
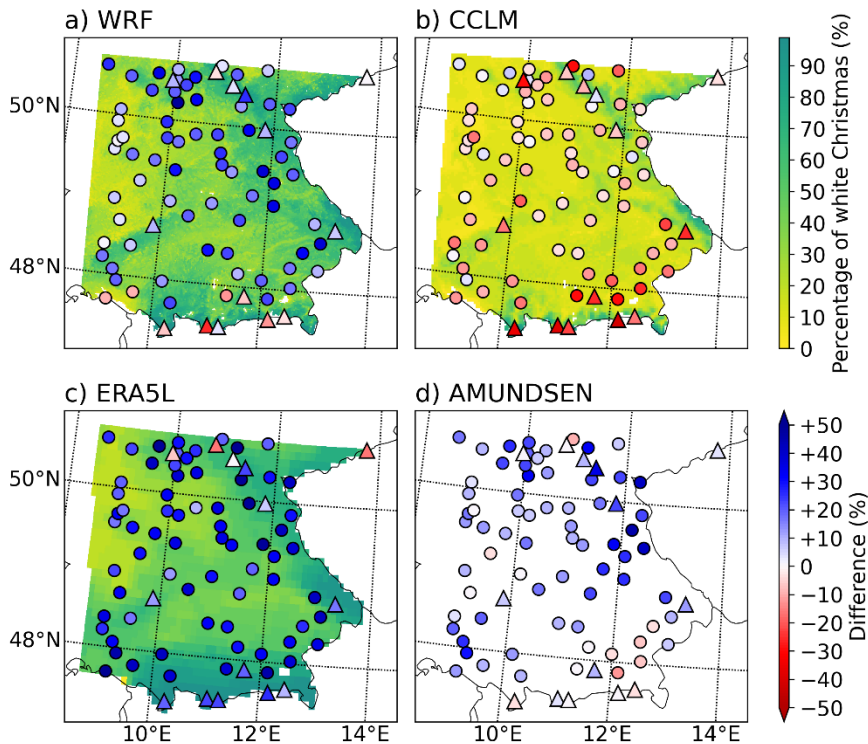
Figure S3: Percentage of white Christmas during 1987 – 2018 simulated by the WRF model (a), CCLM (b), ERA5L (c), and AMUNDSEN (d). White Christmas is defined as more than 0.01 m snow depth on either the 24th, 25th, or 26th of December. The percentage point differences at the stations (coloured dots) are calculated as model minus observation. Red (blue) colour refers to an under- (over)estimation of the model.

Table S1: Pearson rank correlation for biases of extreme snow dynamics over all 83 localities. Significant correlations at the 95 % (99 %) level are marked with one (two) asterisks. For AMUNDSEN, the elevation, temperature, and precipitation of the driving CCLM climate are shown.

Rank correlation between…	WRF	CCLM	ERA5L	AMUNDSEN
Mean annual maximum snow depth bias and model elevation	-0.67**	-0.77**	0.51**	0.06
Mean annual maximum snow depth bias and elevation bias	-0.05	-0.01	0.91**	-0.15
Mean annual maximum snow depth bias and temperature bias	-0.78**	-0.66**	-0.90**	-0.48**
Mean annual maximum snow depth bias and precipitation bias	0.33**	0.02	0.64**	0.43**
Mean annual maximum snow accumulation bias and model elevation	-0.55**	-0.80**	-0.61**	-0.66**
Mean annual maximum snow accumulation bias and elevation bias	-0.22*	-0.21	0.19	-0.28**
Mean annual maximum snow accumulation bias and temperature bias	-0.76**	-0.73**	-0.08	-0.73**
Mean annual maximum snow accumulation bias and precipitation bias	-0.01	0.02	0.71**	0.10
Mean annual maximum snow melt bias and model elevation	0.59*	0.55**	0.67**	0.30**
Mean annual maximum snow melt bias and elevation bias	0.01	0.14	-0.13	0.33**
Mean annual maximum snow melt bias and temperature bias	0.53**	0.61**	-0.02	0.64**
Mean annual maximum snow melt bias and precipitation bias	0.08	-0.18	-0.61**	-0.28**
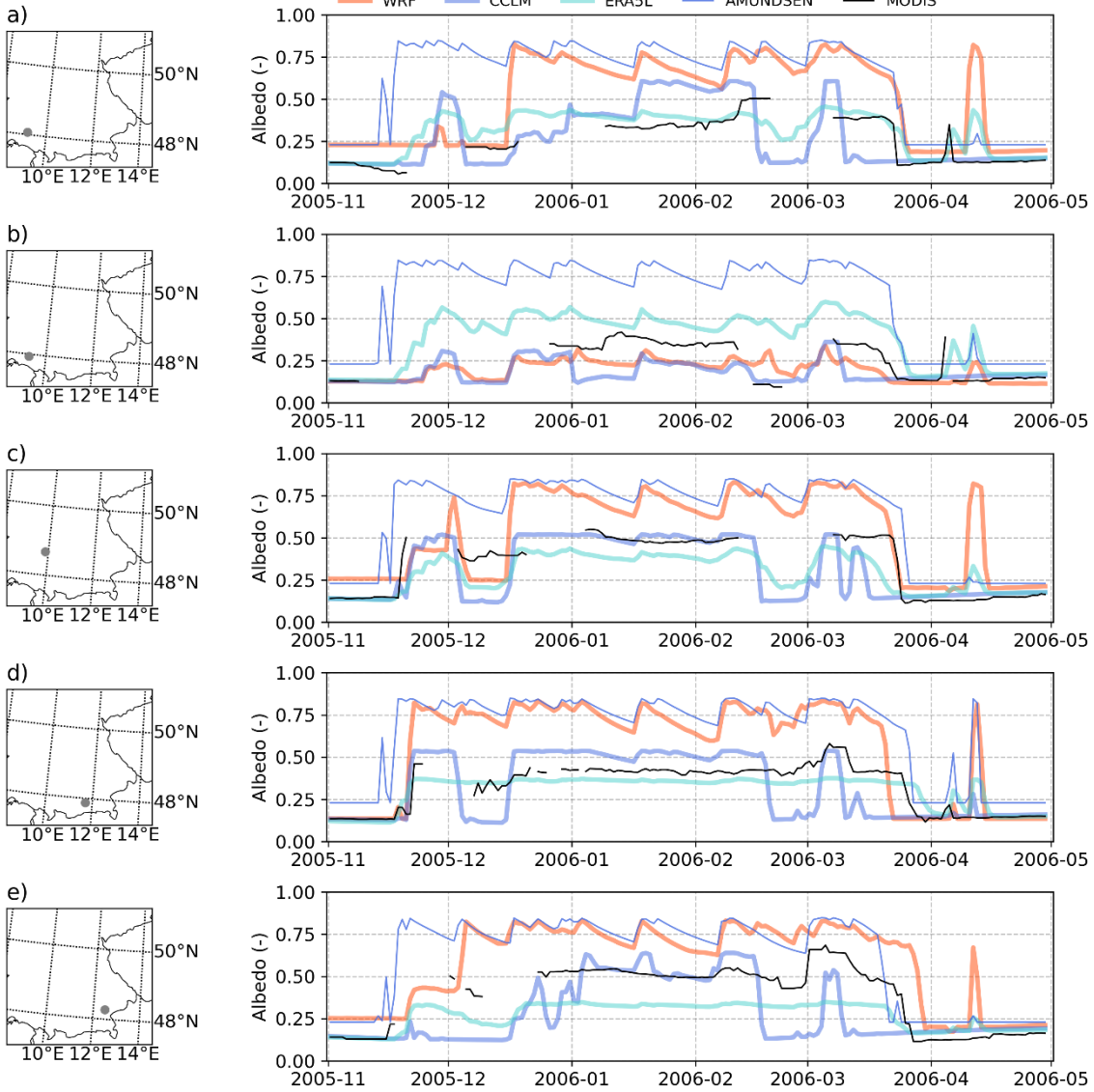
Figure S4: Daily albedo based on remote sensing (MODIS MCD43C3), the WRF, CCLM, and AMUNDSEN simulations over the winter season 2005/2006 at five locations. For the MODIS time series, only data with at least "mixed" or good quality are shown. The second y-axis shows the temperature bias of WRF compared to the weather stations. For the evolution of snow depth during this season, the reader is referred to Figure 5. Land cover information is provided in Table S2.

Table S2: Land cover information for the sites in Figure 17. The vegetation fraction of the WRF simulation refers to its extent during the vegetation period.

Location (Fig. S4)	WRF	CCLM	ERA5L	AMUNDSEN
a)	grassland with 62% vegetation fraction	9% deciduous forest and 10% evergreen forest	87% deciduous broadleaf trees and 10% crops / mixed farming	grassland (point scale)
b)	evergreen needleleaf forest with 90% vegetation fraction	55% deciduous forest and 12% evergreen forest	41% interrupted forest and 59% crops / mixed farming	grassland (point scale)
c)	grassland with 80% vegetation fraction	36% deciduous forest	81% Interrupted forest and 17% crops / mixed farming	grassland (point scale)
d)	urban and built-up land with 0% vegetation fraction	6% deciduous forest and 27% evergreen forest	100% deciduous broadleaf trees	grassland (point scale)
e)	grassland with 78% vegetation fraction	12% deciduous forest	100% interrupted forest	grassland (point scale)
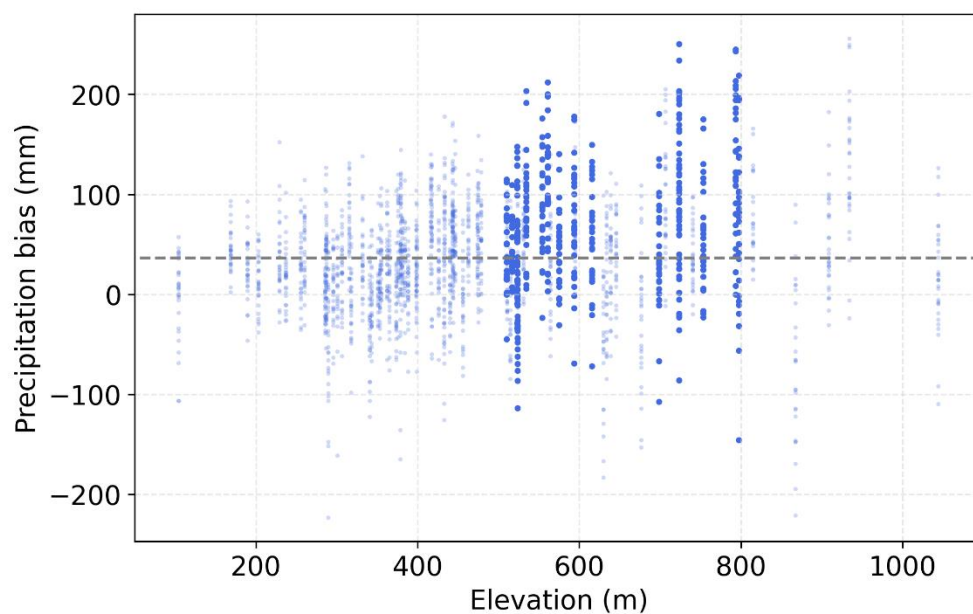
Figure S5: Annual winter precipitation biases of the CCLM minus observations is plotted against the model elevation. Locations north of 48.5° N and above 500 m are marked opaque. The grey dashed line shows the mean precipitation bias.