REMOLAND: New high-resolution surface boundary data for the regional climate model REMO and their impacts

Katrin Ziegler, Felix Pollinger, Daniel Abel and Heiko Paeth / Institute of Geography and Geology, University Wuerzburg

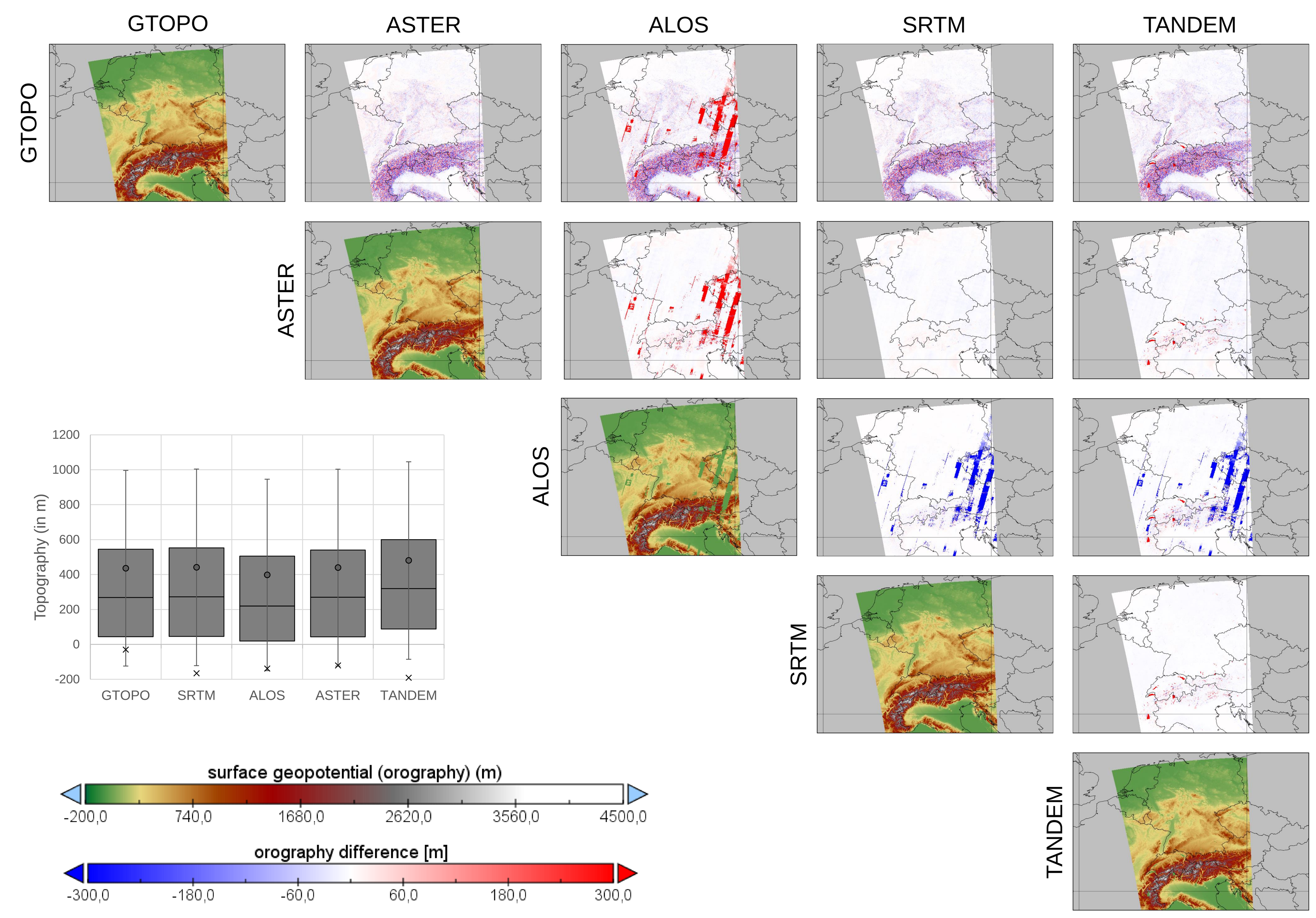
Abstract/ Introduction

In cooperation with the Climate Service Center Germany (GERICS) we want to improve the land surface module in the regional climate model REMO. High-resolution resolution climate models are essential to analyze the local impacts of the climate change. However, the surface boundary data in climate models are usually insufficient for highest-resolutions. Based on REMO2015 we included and compared five different high-resolution topographic data sets. We also tested three new soil data sets with a higher spatial resolution and with new parameters for a new soil parametrization. These boundary data can be used to improve the thermal and hydrological processes of soil in REMO which will be realized in the next project step.

Tab. 1: Comparison of the metadata of five topographic data sets

	GTOPO	ASTER	ALOS	SRTM	TANDEM
resolution	1km	30m	30m	90m	90-900m
coverage	90° N/S	83° N/S	83° N/S	60° N/ 56° S	90° N/S
date	1993-1996	2009/2011	2015/2017	2000	2018
organisation	USGS EROS	METI, NASA, USGS	EORC, JAXA	NASA, USGS	DLR

Fig. 1: Comparison of five topographic data sets (at 1km resolution) for Germany



Data introduction and comparison

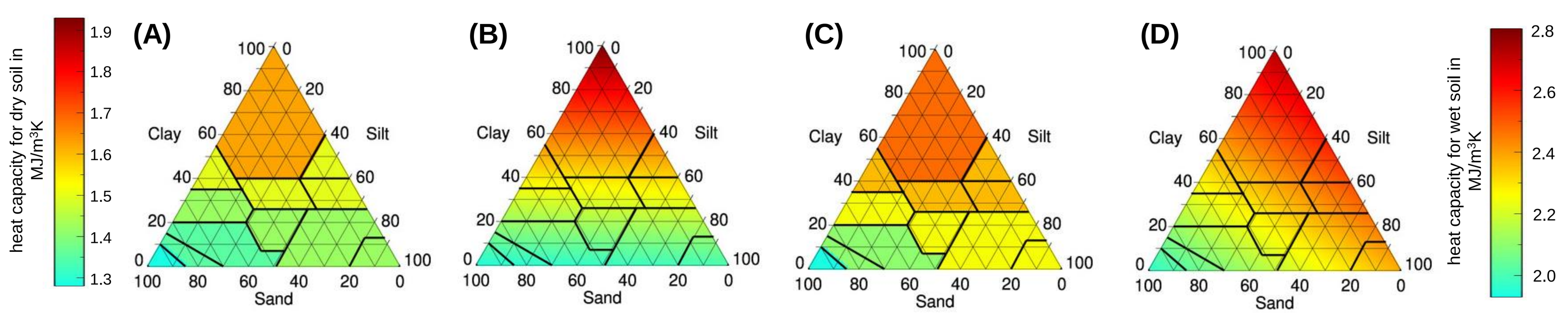
In REMO preprocessor the GTOPO topographic data set [1] with a resolution of 1km was used to get information about surface orography, variance of orography and roughness length. To face the requirements of regional model getting surface initial data in higher resolution four new topographical data sets were implemented and tested: SRTM (90m) [2, 3], ALOS (30m) [4], TANDEM (90-900m) [5,6] and ASTER (30m) [7].

Fig. 1 shows that these topographic data sets differ significantly. All new data sets have high differences in the Alps compared to the original data GTOPO. On the maps you can see that ALOS data have some issue with missing values over large areas. Consequently, this data set was excluded from further calculations.

For old and new soil variables in higher resolution we used SoilGrids [8] and Harmonized World Soil Database (HWSD) [9] and an updated version of the original FAO data set [10] . The original FAO data was a texture class card in 50km resolution. For each of the six texture classes a table contained the needed soil properties. Additionally, pore volume, thermal diffusivity and heat capacity can be calculated with PedoTransferFunctions (PTF) with the new variables sand and clay content as input in 1km resolution.

In Fig. 2 the different volumetric heat capacities for dry and saturated soil calculated with the old scheme (using a classification of texture) and the new scheme (using sand and clay content) is presented. It is expected that the new one is more realistic due to the smooth transitions.

Fig. 2: Vol. heat capacity for dry (A, B) and wet (C, D) soil with old (A, C) and new (B, D) parametrization



Model results

We run REMO with the original surface data as validation run and with ASTER as new topographical and SoilGrids as new soil data in 0.11° resolution for Germany from 2003-2006 and compared seasonal values of temperature and precipitation with E-OBS (V19).

Fig. 3A shows that the validation run is too cold in winter especially in the Alps, where it's too cold also in spring and too warm in most regions in autumn. Fig. 5A1 confirms temperature differences in winter are higher than in the other seasons when the explained variance is 97%.

In Fig. 3B you can see there is too much precipitation in the South Alps in winter and spring. In summer, this area and the most other parts of Germany are modelled too dry. Taking results of Fig. 5B1 into account, low precipitations are highly overestimated from REMO and there is a large spreading of the values which results in explained variance from only 28-36%.

Fig. 4 shows the seasonal difference between the validation and the new model run. The new topography and soil data set cool nearly the whole model area a little bit (Fig. 4A). The results in Fig. 5A2 show that there is no significant difference in temperature between the two models.

The difference of the precipitation shows that the South Alpine regions that were modelled too wet in validation run are simulated drier. However, the already too dry modelled summer also gets less precipitation with the new data (Fig. 4B). But there are no significant differences in the scatterplots that are shown in Fig. 5B2.

Overall, the new data sets do not change the seasonal bias from REMO run with the standard data compared to observations significantly.

Fig. 3: Seasonal Comparison of mean 2-m-Temperature (A) and sum of Precipitation (B) difference between REMO-Validation-Run (GTOPO/FAO) and E-OBS

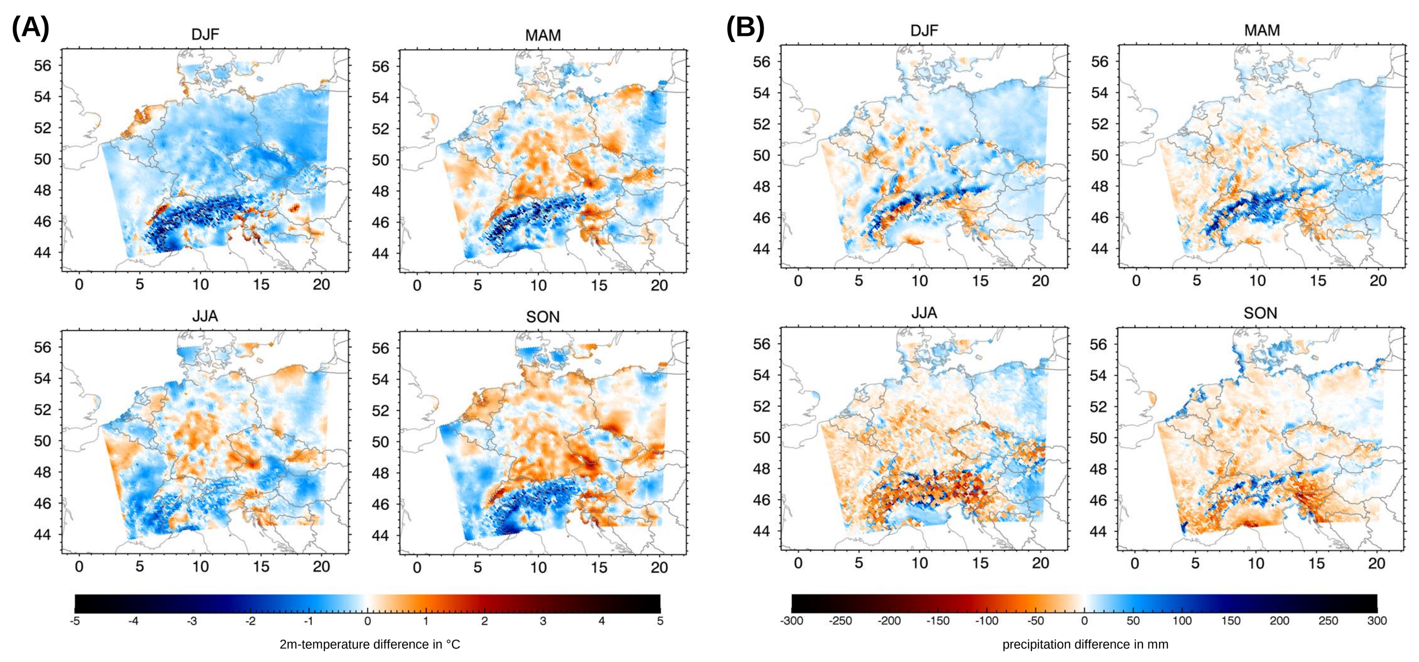


Fig. 4: Seasonal Difference of mean 2-m-Temperature (A) and sum of Precipitation (B) between REMO-Validation-Run (GTOPO/FAO) and new REMO-Run (ASTER/Soilgrid)

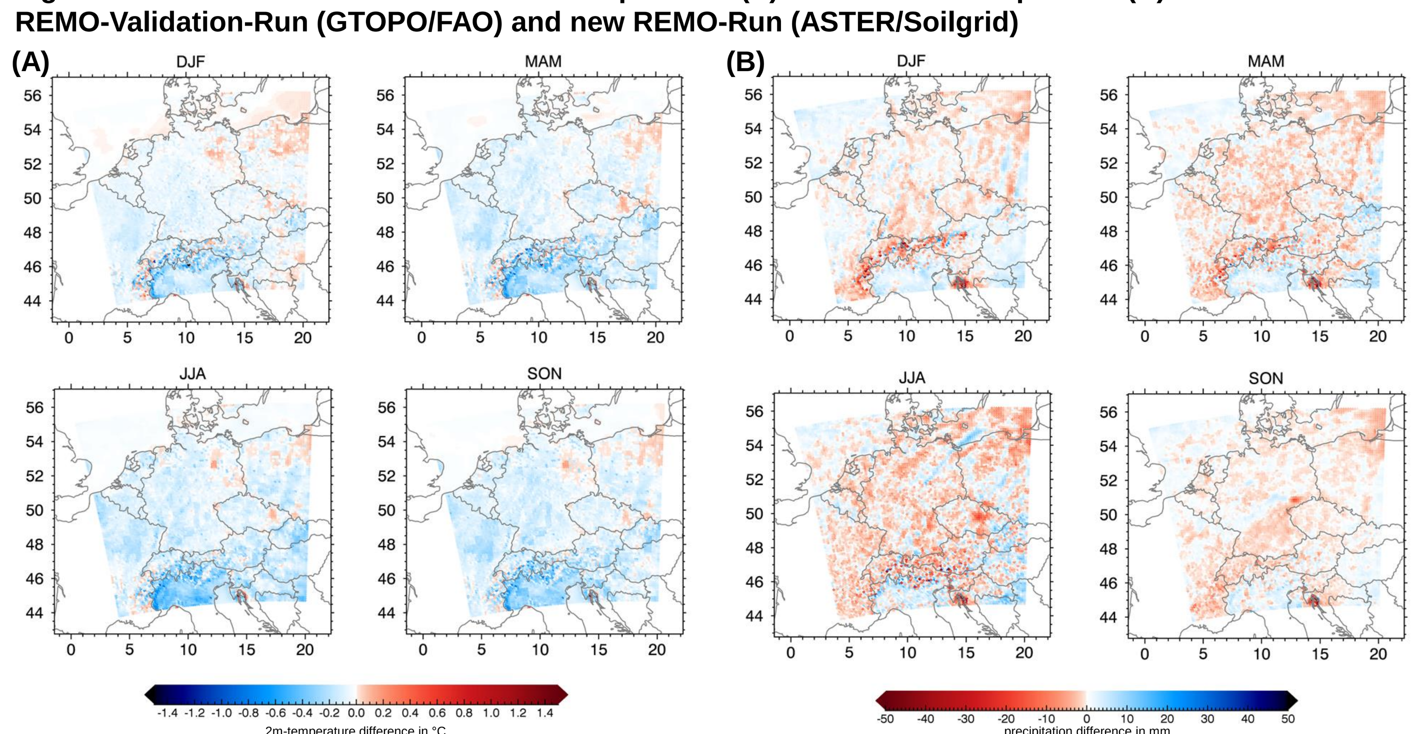
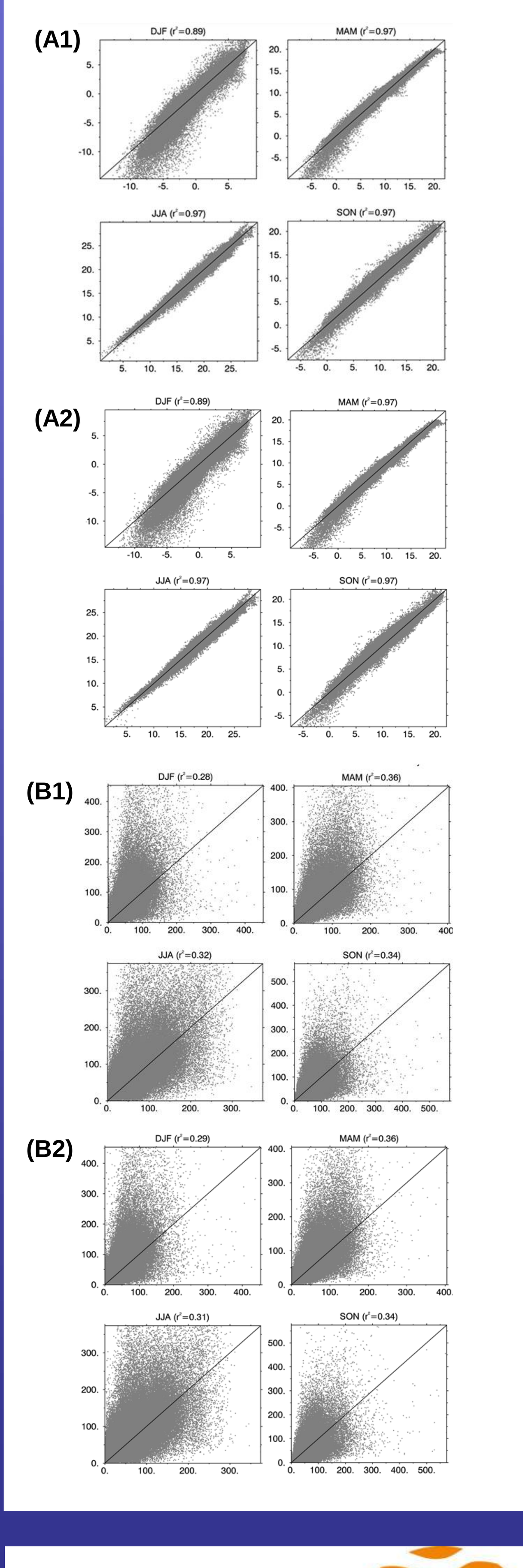


Fig. 5: Seasonal Scatterplot with explained variance; x: E-OBS and y: Model (A) 2m-Temperature, (B) Precipitation, (1) GTOPO/FAO, (2) ASTER/SoilGrids



Conclusion

The potential of new high-resolution surface data sets is huge. The shown differences in temperature and precipitation are very small in a resolution of 0.11° (~12km). But aiming for model resolutions around 3km the implementation of new surface data sets is essential.

Institut für GEOGRAPHIE & GEOLOGIE
Physische Geographie
Julius-Maximilians-UNIVERSITÄT WÜRZBURG

Literature

(1) Gesch, Dean B.; Verdin, Kristine L.; Greenlee, Susan K. (1999): New land surface digital elevation model covers the Earth. In: Eos Trans. AGU 80 (6), S. 69. DOI: 10.1029/99EO00050.
(2) Farr, Tom G.; Rosen, Paul A.; Caro, Edward et al. (2007): The Shuttle Radar Topography Mission. In: Rev. Geophys. 45 (2), S. 1485. DOI: 10.1029/2005RG000183.
(3) Rodriguez, Ernesto; Morris, Charles S.; Belz, J. Eric (2006): A global assessment of the SRTM performance. In: Photogrammetric Engineering & Remote Sensing 72 (3), S. 249–260.
(4) Takaku, J.; Tadono, T.; Tsutsui, K. (2014): Generation of High Resolution Global DSM from ALOS PRISM. In: Int. Arch. Photogramm. Remote Sens. Spatial Inf. Sci. XL-4, S. 243–248. DOI: 10.5194/isprsarchives-XL-4-243-2014.
(5) Wessel, Birgit; Huber, Martin; Wohlfart, Christian et al. (2018): Accuracy assessment of the global TanDEM-X Digital Elevation Model with GPS data. In: ISPRS Journal of Photogrammetry and Remote Sensing 139, S. 171–182.
(6) Rizzoli, Paola; Martone, Michele; Gonzalez, Carolina et al. (2017): Generation and performance assessment of the global TanDEM-X digital elevation model. In: ISPRS Journal of Photogrammetry and Remote Sensing 132, S. 119–139.
(7) Tachikawa, Tetushi; Kaku, Manabu; Iwasaki, Akira et al. (2011): ASTER global digital elevation model version 2-summary of validation results. NASA.
(8) Hengl, Tomislav; Jesus, Jorge Mendes de; MacMillan, Robert A. et al. (2014): SoilGrids1km--global soil information based on automated mapping. In: PloS one 9 (8), e105992. DOI: 10.1371/journal.pone.0105992.
(9) Nachtergaele, F., Velthuizen, H. V., Verelst, L., Wiberg, D. (2009). Harmonized World Soil Database (HWSD). Food and Agriculture Organization of the United Nations, Rome.
(10) FAO-UNESCO Soil Map of the World. Revised legend. World Soil Resoures Report No. 60 (1988). Rome.

GERICS Climate Service Center Germany
An institution of Helmholtz-Zentrum Geesthacht