The new modernized version of the regional model REMO

REMO2020: On the way to a regional earth system model

Joni-Pekka Pietikäinen, Kevin Sieck, Lars Buntemeyer, Thomas Frisius and Daniela Jacob

Climate Service Center Germany (GERICS)

REgional MOdel REMO:

- Regional climate model developed at Max-Planck Institute for Meteorology and currently maintained at the Climate Service Center Germany
- Previous versions used in PRUDENCE, ENSEMBLES and several CORDEX activities including CORDEX-CORE simulations

REMO2020 version:

- The main tool for CMIP6 downscaling (CORDEX)
- Dynamical core: rewritten, includes the non-hydrostatic extension (for kilometer scale simulation) and a new mass conserving wet-core approach for water species
- Physics module: rewritten and restructured to optimize performance and includes almost all previous development branched, such as FLake lake model and interactive MOsaic-based VEgetation iMOVE. Also new development steps, for example aerosol climatology approaches (MACv2-SP/MERRA-2), a 3-layer snow module and a prognostic precipitation approach
- The model has been re-tuned for different resolutions separately (horizontal and vertical)

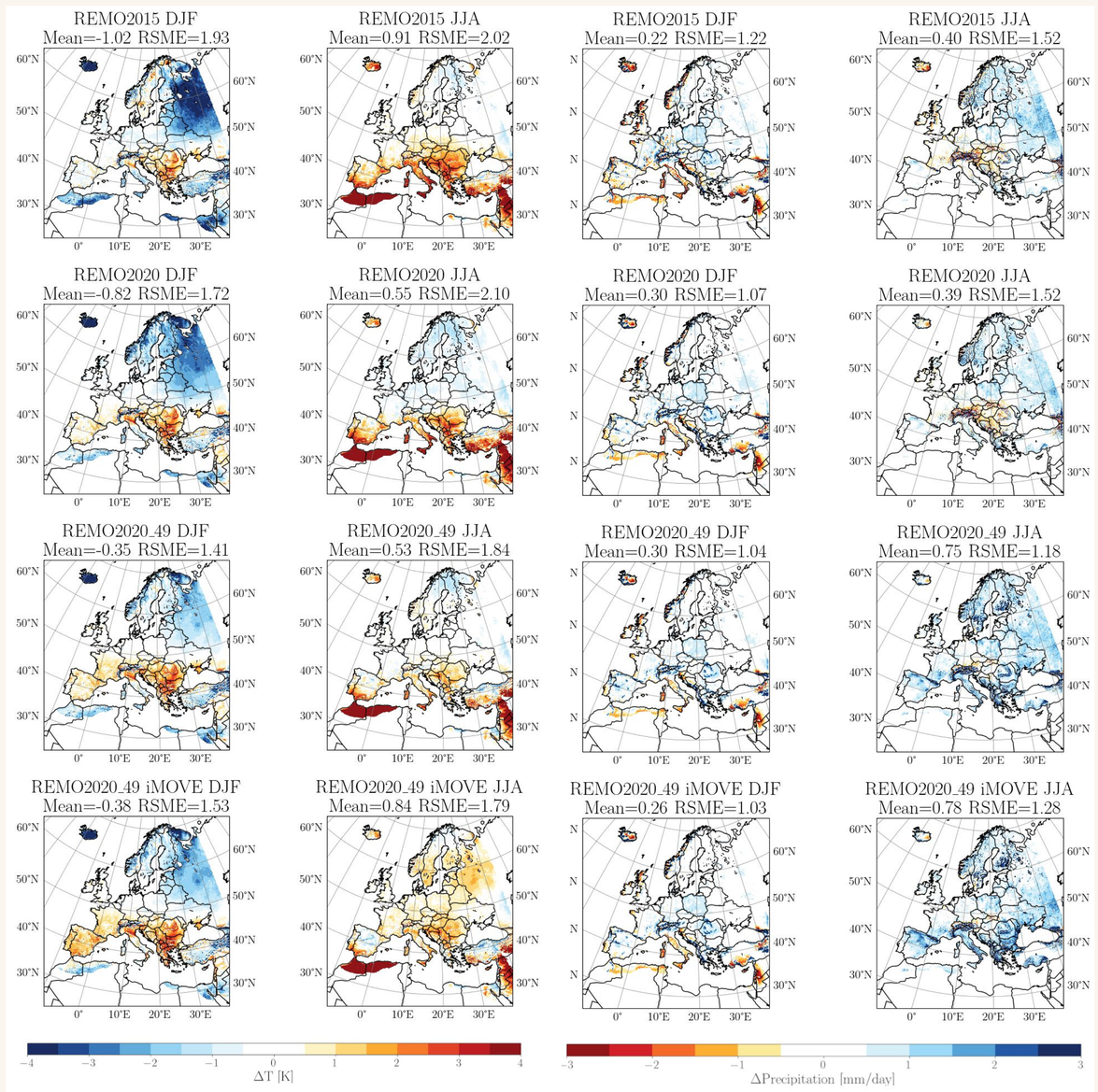

Figure 1: Temperature and precipitation biases from REMO2015, REMO2020 (both 27 levels) and from REMO2020_49 and REMO2020_49 iMOVE (both 49 levels) against E-OBS data for the time period of 2001-2010. The domain is the default EUR-11.

- **REMO2020 shows overall better agreement with E-OBS data than REMO2015 (both 27 vertical levels)**
- **With 49 levels the bias reduces further for temperature whereas the mean bias for precipitation is increased in summer**
- **REMO2020 iMOVE (with dynamical vegetation) shows an enhanced warm bias in summer and almost no differences in precipitation**
- **REMO2020_49 will be the main model for CMIP6 downscaling activities and iMOVE version will be used at least in LUCAS-FPS**

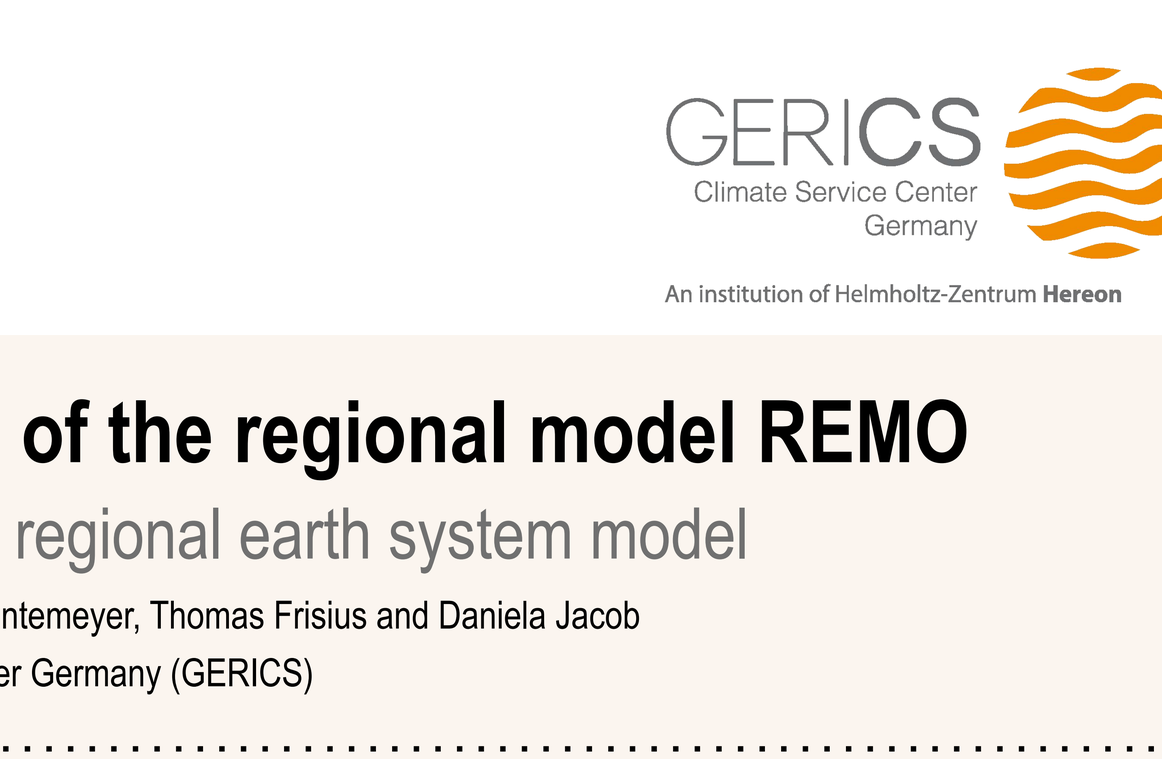

Figure 2: a) Time-averaged daily precipitation (mm) for the REMO-NH evaluation run (top), REGNIE (middle) and difference (bottom), b) time-averaged 2m temperature for the REMO-NH evaluation run (top), E-OBS (middle) and difference (bottom), c) probability density function of hourly precipitation for REMO-NH at 0.0725° resolution (violet), REMO at 0.11° resolution (green) and DWD radar data (black) for July 2005.

- **Figure 2 shows results of a 10 year ERA-5 driven evaluation run (2005-2014) by REMO2020 using the nonhydrostatic high resolution setup (REMO-NH, 0.0275°) in which the convective parameterization is switched off. The comparison of precipitation and 2m temperature with observations is reasonable (Fig. 2a,b). A precipitation bias is visible in mountainous regions where the REGNIE data set could also be inaccurate. The probability density function of hourly precipitation for July 2005 (Fig. 2c) reveals an added value of the nonhydrostatic setup in comparison with the hydrostatic REMO at 0.11° resolution when compared with DWD radar data.**

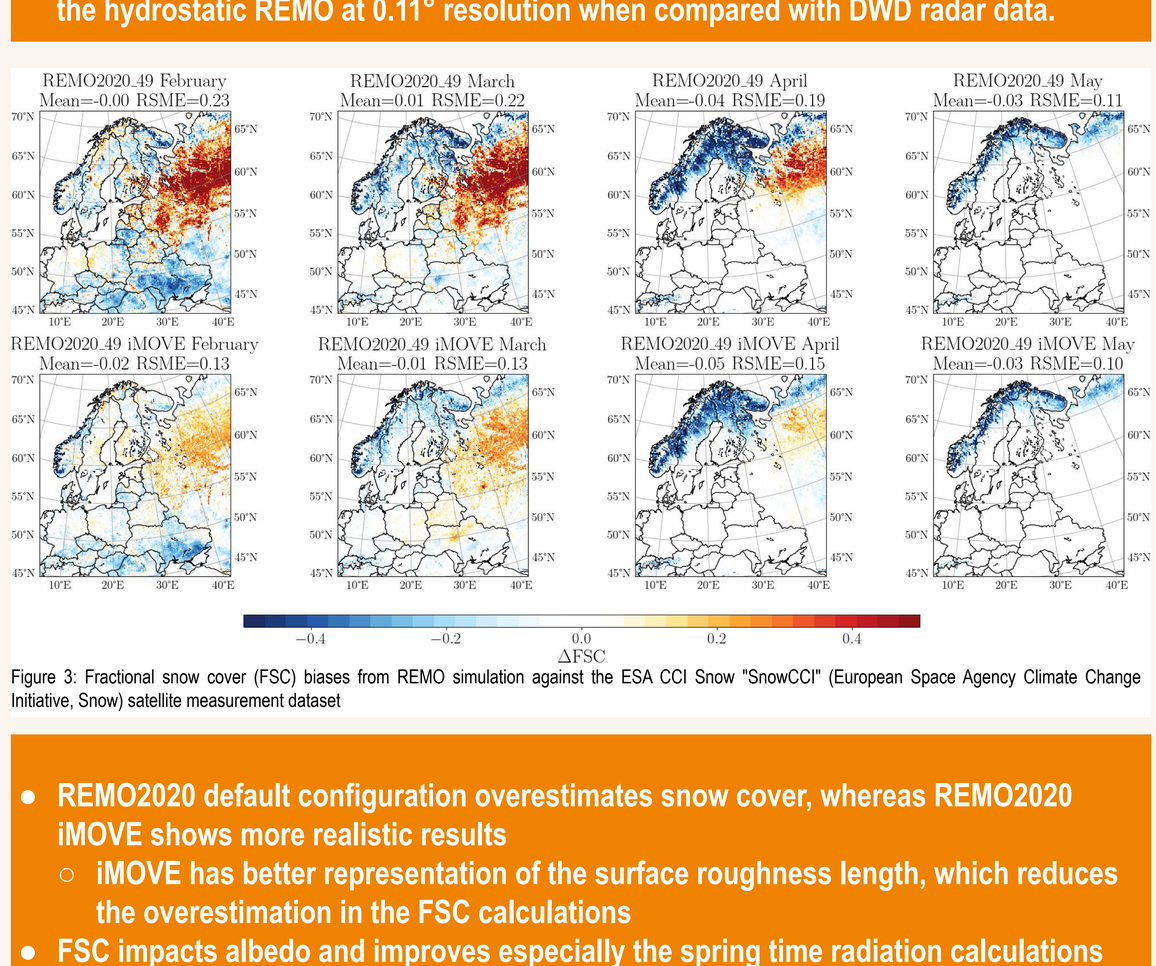

Figure 3: Fractional snow cover (FSC) biases from REMO simulation against the ESA CCI Snow "SnowCCI" (European Space Agency Climate Change Initiative, Snow) satellite measurement dataset

- **REMO2020 default configuration overestimates snow cover, whereas REMO2020 iMOVE shows more realistic results**
  - **iMOVE has better representation of the surface roughness length, which reduces the overestimation in the FSC calculations**
- **FSC impacts albedo and improves especially the spring time radiation calculations leading to better accord in terms of temperature (not shown here)**

Steps towards a regional earth system model RESM

- REMO2020 (atmosphere only) reproduces a realistic climate in Europe
- The new modular structure of REMO2020 makes coupling of other model components, such as regional ocean model, easier than in the earlier REMO versions
- Passive module approach supports the concept of including the necessary components of a RESM and makes their implementation more efficient (FLake and iMOVE as examples)
- Ongoing work:
  - Ocean coupling, better representation of urban fraction, irrigation scheme

Climate Service Center Germany (GERICS) • Helmholtz-Zentrum Hereon • Fischertwiete 1 • 20095 Hamburg • Germany

Joni-Pekka Pietikäinen • Email: Joni-Pekka.Pietikaeinen@hereon.de • www.climate-service-center.de