Helmholtz Climate Initiative

Regional Climate Change

Topic1: Atmosphere Land coupling in the Arctic: HIRHAM5-CLM4.0

X. Zhou, H. Matthes, A. Rinke, K. Dethloff
Alfred Wegener Institute for Polar and Marine Research (AWI)
Email: xzhou@awi.de

Motivation of the coupling

•Understand and represent land surface processes in Arctic region.

•Improve land and atmosphere interactions in the modeling.

•Land model CLM4.0 (Community land model) has more sophisticated bio-geophysical and hydrological processes with improved vegetation dynamics.

Model setup

•Run time interval: 1979-2011.

•Horizontal resolution: 25 km.

•Vertical resolution: of 40pressure levels from land surface up to 10hPa (~30km height).

•Boundary forcing (Era-Interim): Surface pressure, Wind, Temperature, Specific humidity, Cloud water, Cloud ice, Sea surface temperature, Sea ice fraction.

•Surface data (for Hirham-CLM): Plant functional types (Pfts), Soil color, Organic matter, Percentage of lake and wetland, Percentage of sand and clay, Percentage of glacier.....

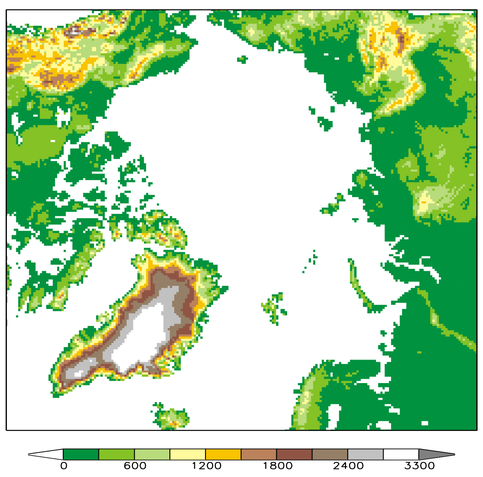


Figure 1. Integration area and orography [m]

Surface input data improvement

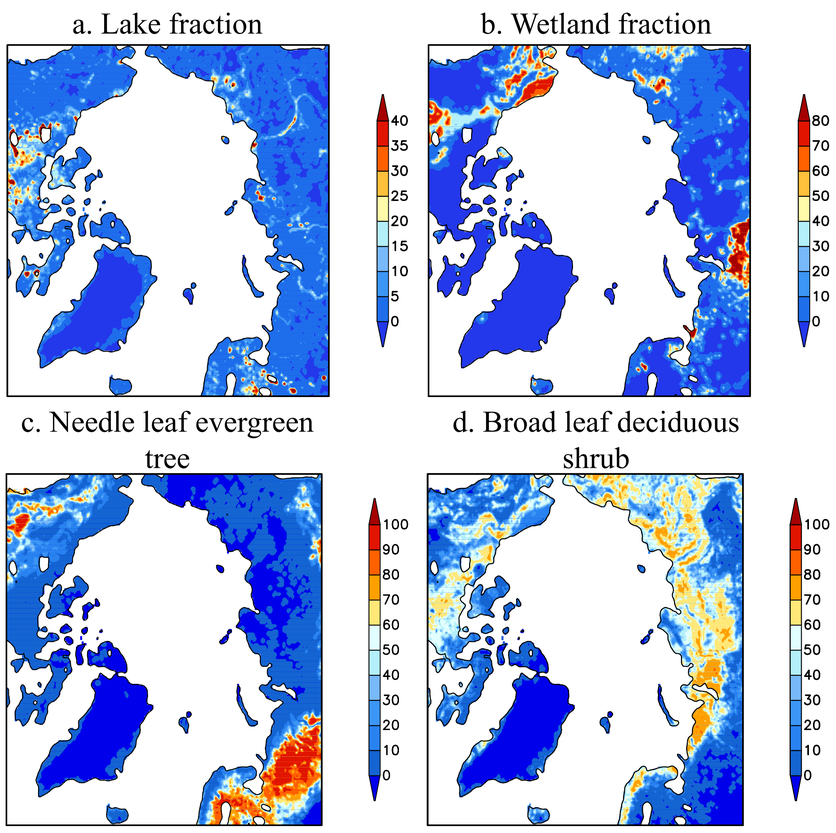


Figure 2. Spatial distribution of selected land surface input data of CLM4.0

•New surface input data are created from the following different sources:

>>Pfts, leaf area index, stem area index and Soil color from MODIS (Moderate Resolution Imaging Spectroradio-meter, Lawrence and Chase, 2007).

>>Soil organic matter from WISE (Wide-field Infrared Survey Explorer, Wright et al. 2010) and HWSD (Harmonized World Soil Database, Freddy Nachtergaele et al. 2012).

>>Lake and wetland fraction from GLWD (Global Lake and Wetland Database, Cogley J.G. 1991).

>>Soil sand and clay fraction are derived from IGBP (The International Geosphere-Biosphere programme) soil data.

>>Canopy top and bottom heights are from Bonan (1996) as described in Bonan et al. (2002b).

Coupling Structure

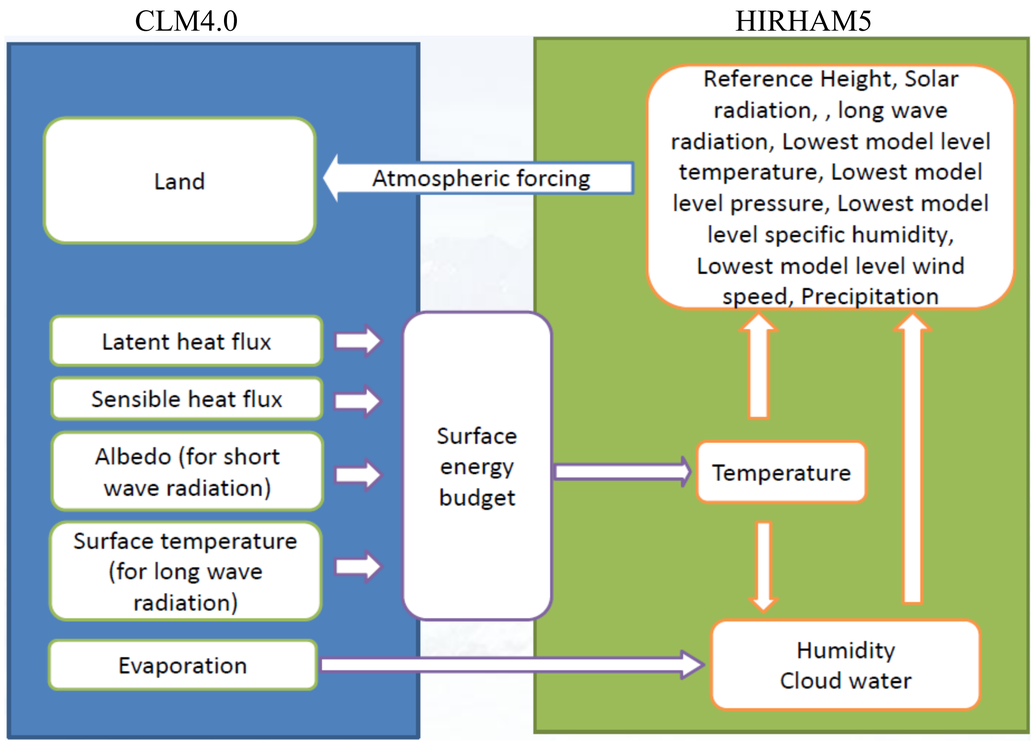


Figure 3. HIRHAM5 CLM4.0 coupling scheme

Validation of HIRHAM5

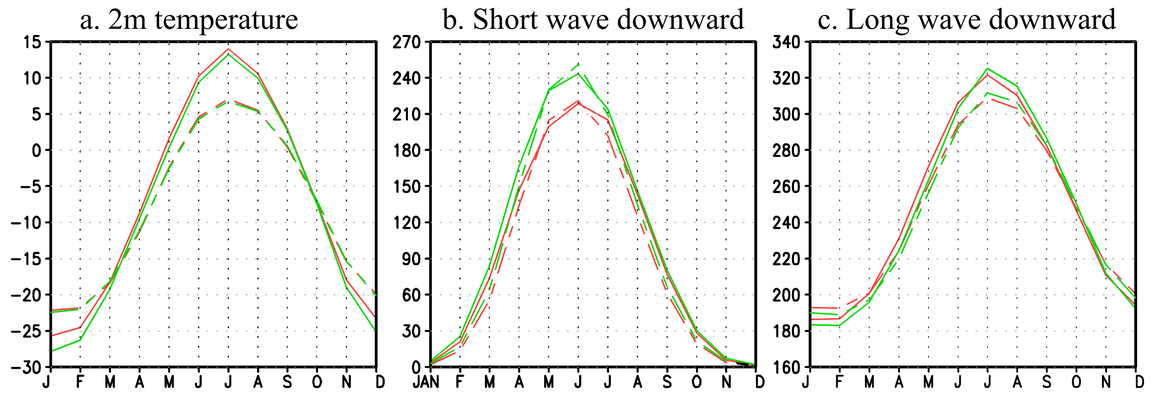


Figure 4. Annual cycle of atmospheric fields: mean 2m temperature (a, unit: °C), short wave radiation (b, unit: W/m^2) and long wave radiation (c, unit: W/m^2) from HIRHAM5 (red line) in comparison with Era-interim (green line) for the whole domain (dashed line) and only land domain (straight line) for year 1979-2011.

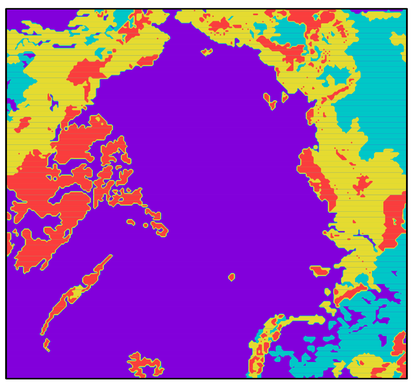
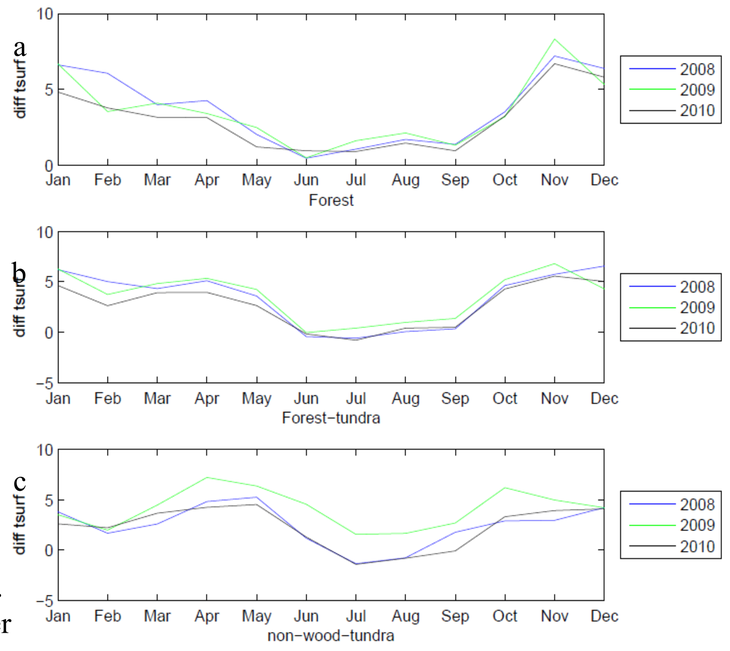


Figure 5. Vegetation distribution

>> Forest

>> Forest tundra

>> Non wood tundra



•LST small differences in summer.

•LST large differences in winter and transition seasons.

•Possible reasons:

>>Too few detection of clouds by MODIS over snow and ice (Torbjørn et al. 2013)

>>Affection of snow on albedos and surface energy budget.

Figure 6. Annual cycle of differences in mean LST (land surface temperature, units: °C) from HIRHAM5 in comparison with MODIS satellite observation for different Pfts land cover (HIRHAM5 minus MODIS: a, Forest; b, Forest-tundra; c, Non-wood-tundra) during different years from 2008 to 2010.

HIRHAM5-CLM4.0 coupling results without feedback

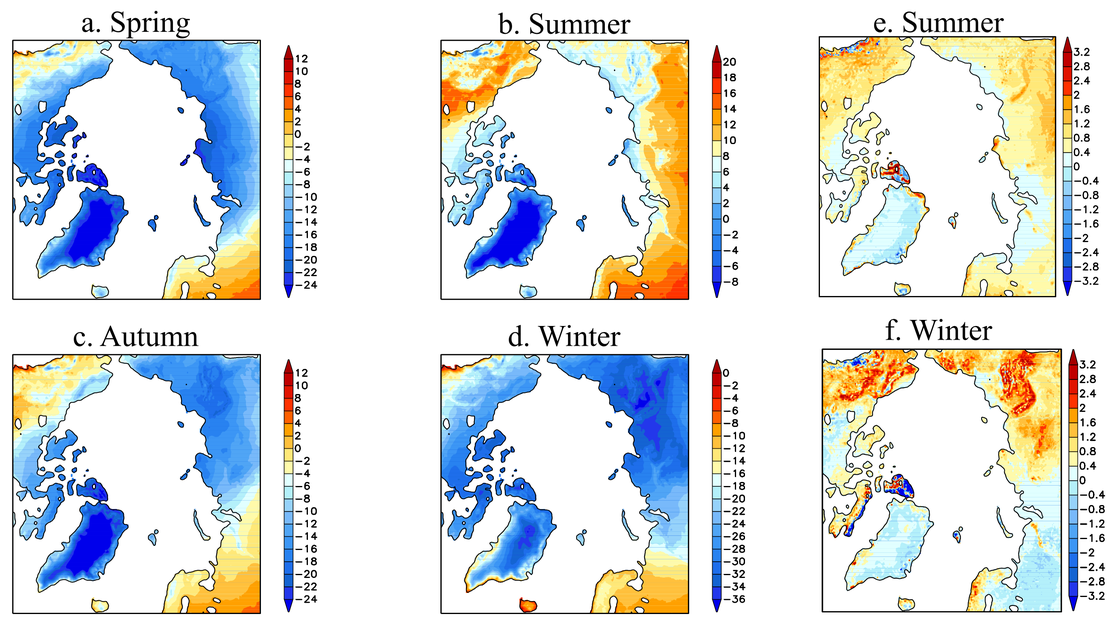


Figure 7. Seasonal mean of 2m temperature (unit: °C) for 1979 (a, b, c, d) and differences of HIRHAM5 minus CLM4.0 (e, f).

Summary

>>Creation of new land surface data for new coupled version is technically running.

>>Latent and sensible heat flux feed back, albedo (short wave radiation) feed back.

•Current focus & next steps

>>Validation of HIRHAM5 simulation.

>>Carrying on and validation of simulation from CLM4.0 driven by HIRHAM5.

>>Processing available dataset for simulation validation.

>>Incorporation of long wave coupling in the model setup.

Reference:

Bonan, G.B. 2002. Ecological Climatology: Concepts and Applications. Cambridge University Press.

Cogley, J.G. (1991): GGHYDRO-Global Hydrographic Data Release 2.0. Trend Climate Note 91-1, Dept. Geography, Trend University, Peterborough, Ontario.

Freddy Nachtergaele et al. (2012): Harmonized World Soil Database (version 1.2).

Lawrence, P.J., and Chase, T.N. (2010): Representing a MODIS consistent land surface in the community Land Model (CLM 3.0). J. Geophys. Res. 112: G01023. doi: 10.1029/2007JF00883.

Torbjørn et al. Quality assessment of MODIS land surface temperatures over an Arctic ice cap, Vol. 15, EGU2013-6957, 2013.

Wright et al. (2010): The Wide-field Infrared Survey Explorer (WISE): Mission Description and Initial On-orbit Performance. The Astronomical Journal 140 1868 doi:10.1088/0004-6256/140/6/1868.