Helmholtz Climate Initiative

Regional Climate Change

Topic1: Evaluation of Arctic Land Snow Cover Characteristics, Surface Albedo, and Temperature for Spring from RCM simulations and Satellite Data

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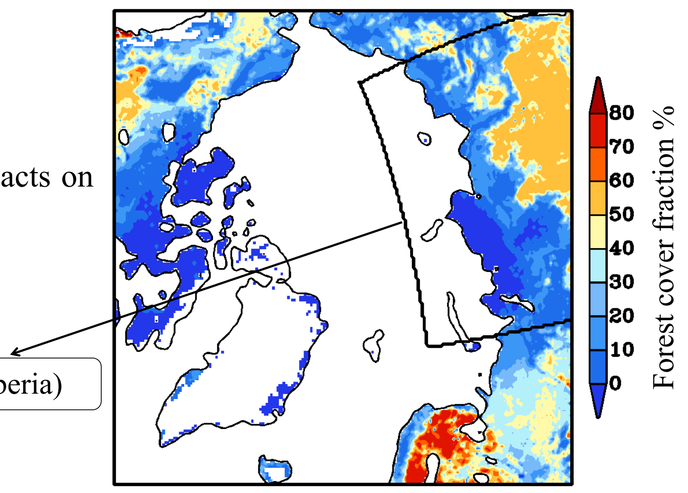
Introduction

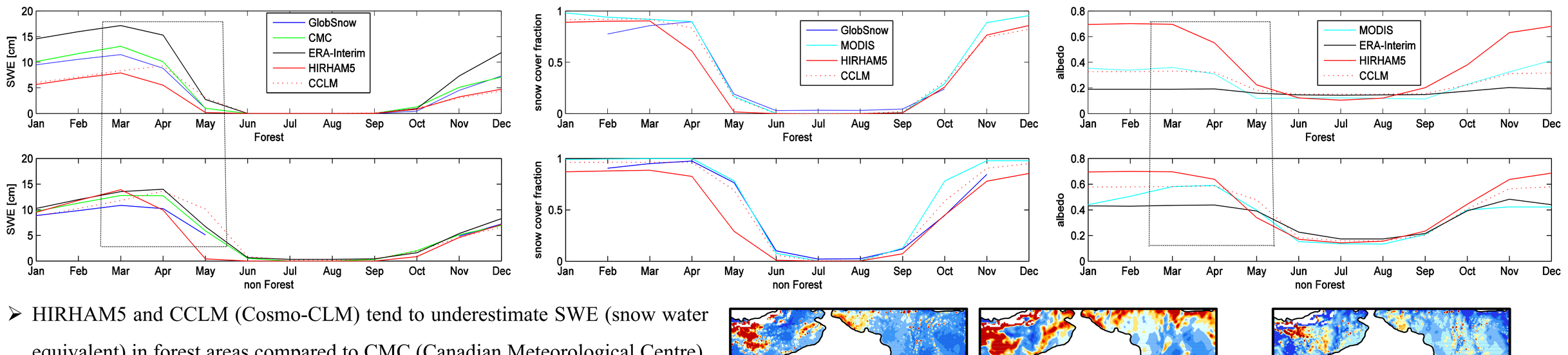
- Study [1] area: Arctic. The key regions in the global climate system, evidenced by many rapid environmental changes (e.g. [2,3]).
- Simulation time period: 2008-2010.
- Background: Land surface temperature (LST) reflects the surface energy budget. Snow cover characteristics have significant impacts on the LST (e.g. [4]). E.g. isolating snow effect, snow phase change, snow-albedo feedback mechanism.

Motivation

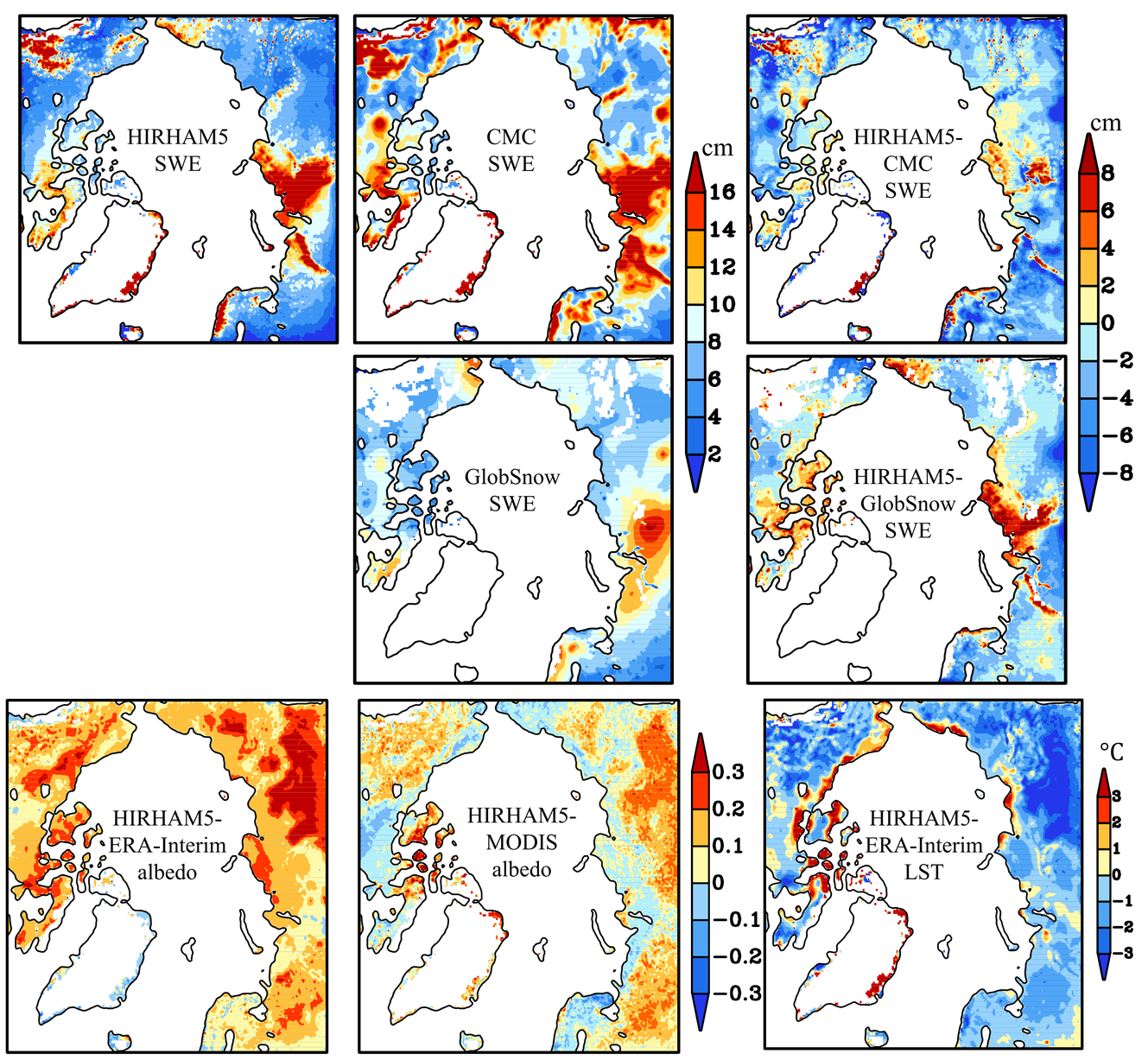
- Is the HIRHAM5 model able to reproduce LSTs correctly?
- Does the influence of albedo on LST play a key role?
- How does the influence of snow on LST differ between forest and bare ground?
- Can biases in the modeled LST be explained with biases in snow cover characteristics?



Results and discussion



- HIRHAM5 and CCLM (Cosmo-CLM) tend to underestimate SWE (snow water equivalent) in forest areas compared to CMC (Canadian Meteorological Centre), GlobSnow and ERA-Interim.
- Both models are better in reproducing SWE over non-forest areas than over forest areas. *Possible reason: the complexity of forest vegetation snow feedback.*
- Over forest and non-forest areas, HIRHAM5 strongly underestimates SCF (snow cover fraction) by 0.2-0.5 in April and May compared to MODIS and GlobSnow. In October and November, HIRHAM5 agrees with GlobSnow, while MODIS shows higher SCF especially over non-forest areas.
- HIRHAM5 has a positive albedo bias over forest in spring compared to ERA-Interim and MODIS, i.e. over the West Russian Arctic, Lena River basin and parts of river basins in Alaska and Canada.
- Largest overestimation occurs in spring in Siberia (by more than 0.2: ca 60%-70%) compared to MODIS. *Possible explanation: fallen leaves and branches on snow coverage, which are not considered in the albedo parameterization in HIRHAM5, and would cause a much darker albedo despite snow coverage.*
- Over non-forest regions, the HIRHAM5 albedo shows better agreement with MODIS than over forest regions.
- CCLM shows a better performance for SCF and albedo. *Separate consideration of deciduous and evergreen forest => influence on the snow and albedo over forests.*



Conclusion

>>HIRHAM5 can generally capture the main characteristics of the spatial patterns and the annual cycle of SWE, SCF, albedo and LST, although significant biases are detected.

>>The albedo and temperature bias in spring for Siberian deciduous tree forest could be caused by neglecting the snow-masking effect of fallen leaves and branches for deciduous tree forest in the SCF parameterization [5].

>>Suggestions: Consider different forest types (e.g. as done in CCLM) for the albedo parameterization and implement the effect of fallen leaves and branches on snow.

References

>>[1], Zhou et al., "Evaluation of Arctic land snow cover characteristics, surface albedo and temperature during the transition seasons from regional climate model simulations and satellite data". Advance in Meteorology, Volume 2014 (2014), Article ID 604157.

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>>[4], Lawrence D. , and A. Slater. "The contribution of snow condition trends to future ground Climate." Climate Dynamics, 34:969–981, 2010.

>>[5], Roesch et al., "Assessment of snow cover and surface albedo in the ECHAM5 general circulation model". Journal of Climate, 19, p. 3828-3843, 2005.