Sensitivity of Present Day Arctic Climate Simulations to Snow

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photo: Thomas Opel

Motivation - Why do we care?

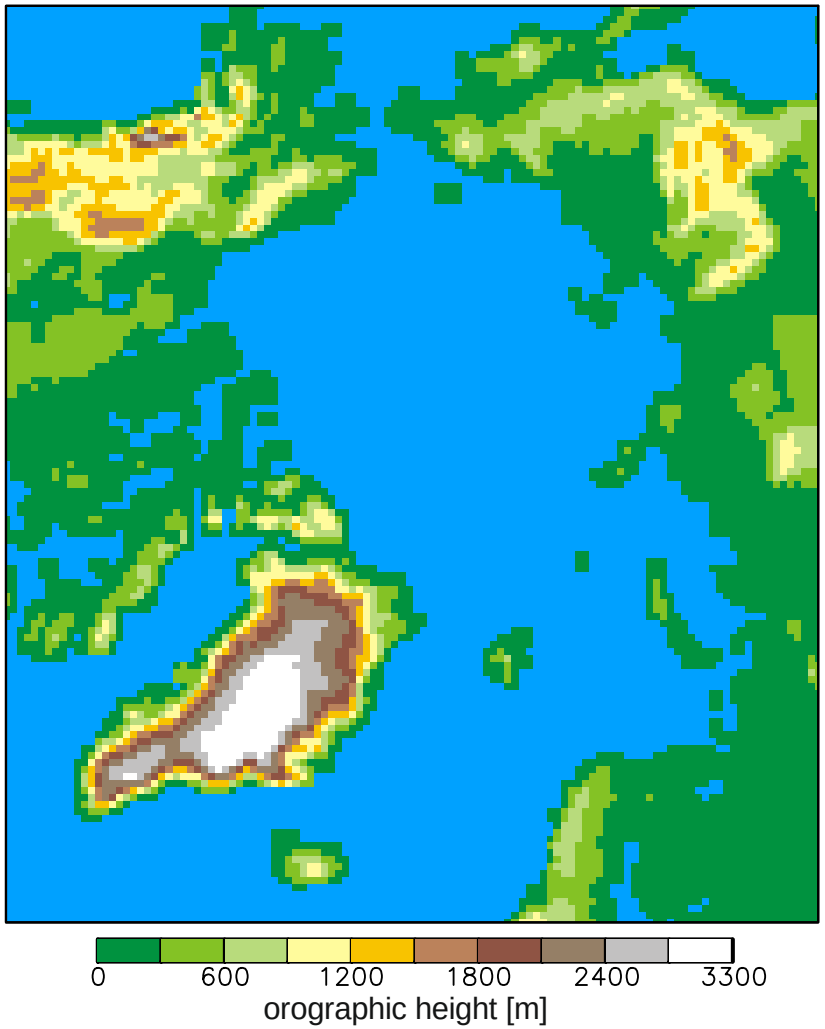
- Snow covers Arctic land between 6 and 9 months of the year
- Snow acts a mediator between atmospheric and ground and impacts both through its thermal and optical properties (albedo, insulation)
- snow melt impacts hydrology (availability of water, summer temperatures) which leads to memory effects
- surface conditions interact via feedback mechanisms with the atmosphere

1. To what snow properties are the simulations of atmosphere and ground sensitive?
2. Are there remote impacts on the atmosphere, or are all effects only local?

- global climate models come with a wide variety in the complexity of their snow schemes – can we estimate the impact on simulated present day climate?

Framework

- model: regional Arctic climate model HIRHAM5-CLM4SP
- model was run with different complexities of the CLM4 snow scheme



model setup:

- the model is run with 25km horizontal resolution, the domain roughly covers the area north of 60°N
- the atmosphere runs with 60 vertical levels (1012hPa to 0.1 hPa)
- all experiments were run with identical initial conditions for January 2005 from a spin up run
- lower and lateral boundary conditions are identical for all runs (ERAInterim data)

Experiment Setup

- **ctrl**: standard CLM4 snow scheme
- **allsnow_srad**: if there is snow, the canopy is always completely covered by snow (approximation of no snow masking by vegetation)

➢ higher albedo

- **nosnow_srad**: there never is snow on the canopy (approximation of maximum possible snow masking by vegetation)

➢ lower albedo

- **noaerosol**: aerosol deposition on the snow was switched off

➢ higher albedo

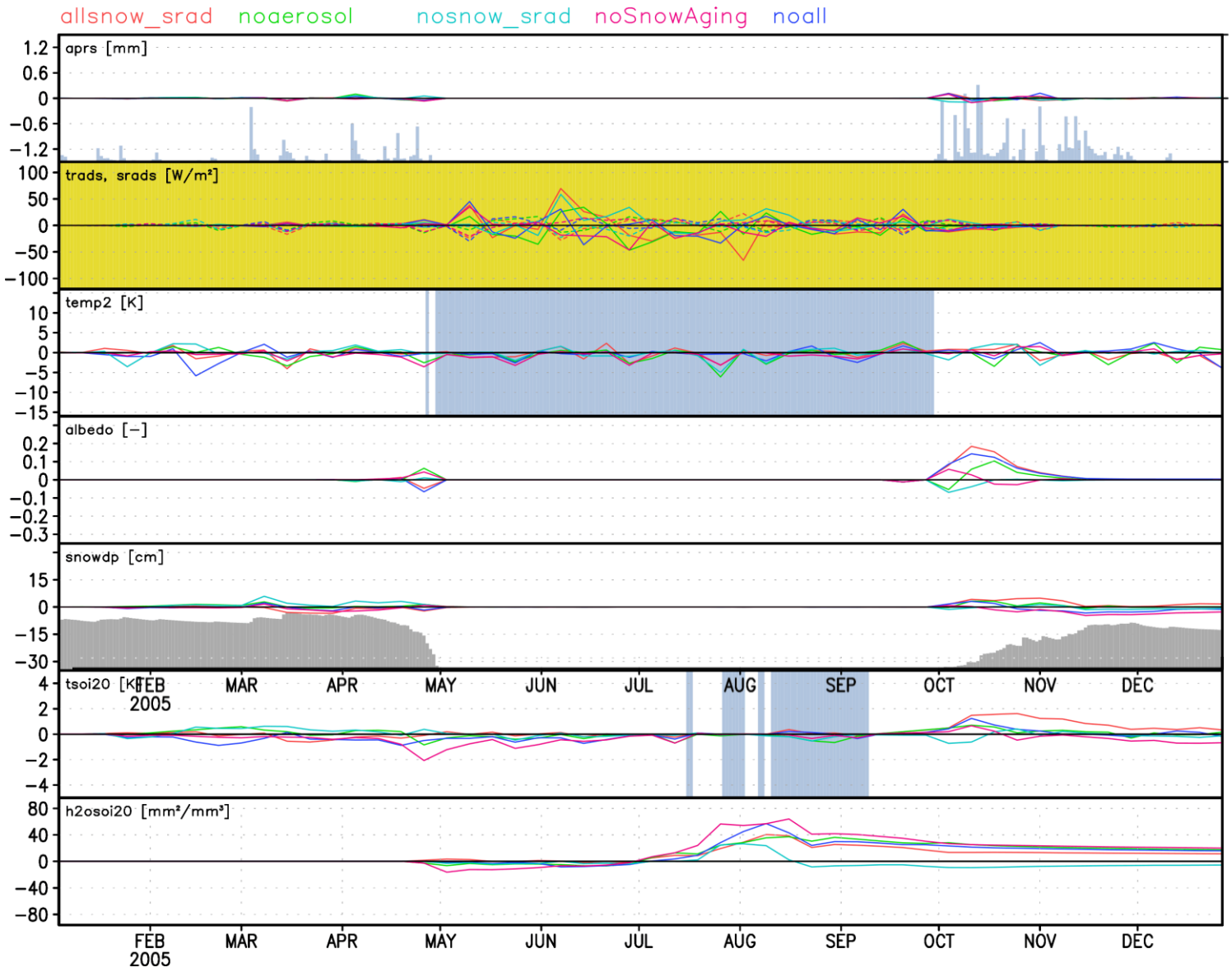
- **noSnowAging**: changes of albedo and thermal conductivity of the snow pack during melt (due to the infusion with melt water) as well as snow compaction were switched off

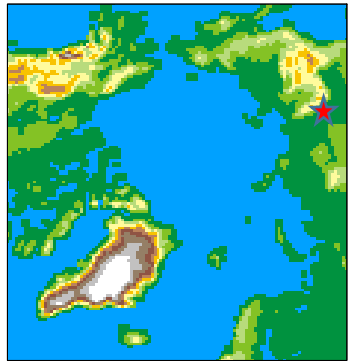
➢ higher albedo, lower thermal conductivity, higher heat capacity

- **noall**: maximization of snow dependent albedo, combination of allsnow_srad, noaerosol and noSnowAging

➢ highest albedo, lower thermal conductivity, higher heat capacity

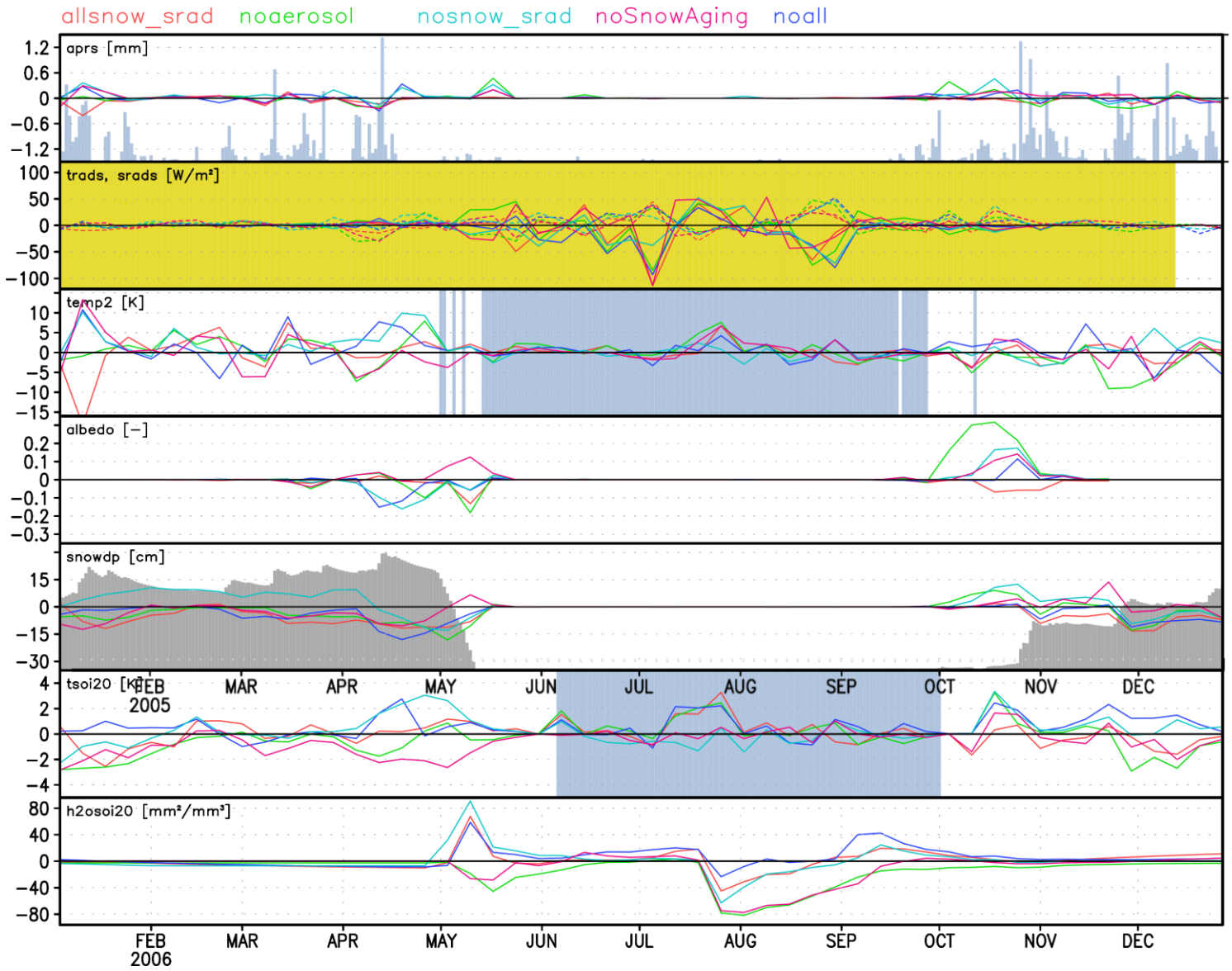
changes at a single point

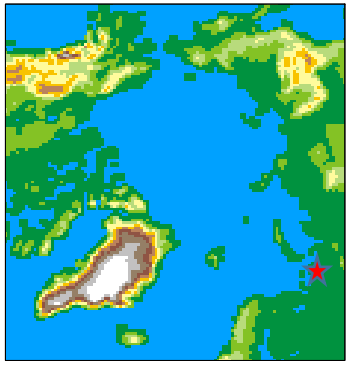




98% boreal deciduous needleleaf trees

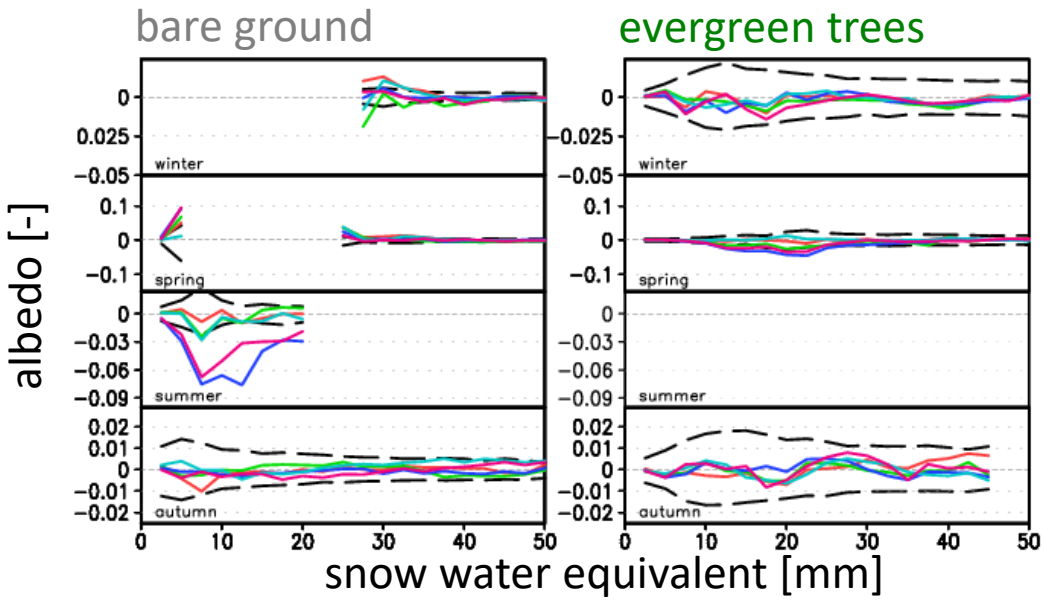
changes at a single point

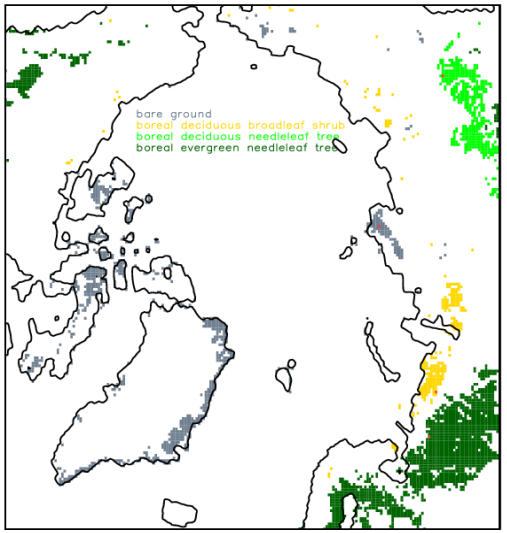




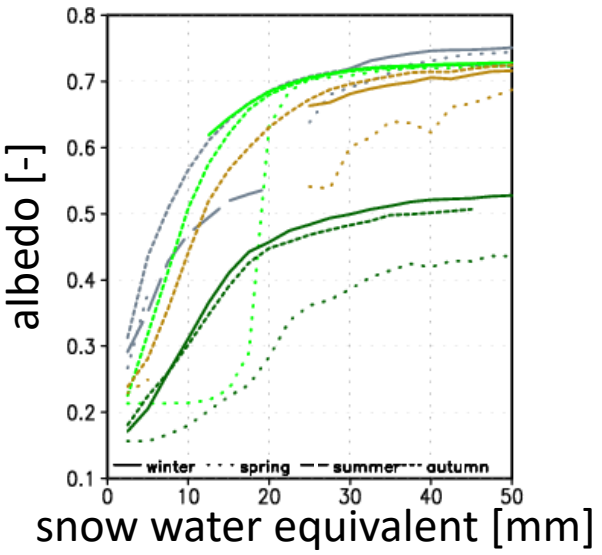
81% boreal deciduous broadleaf shrubs

functional relationships

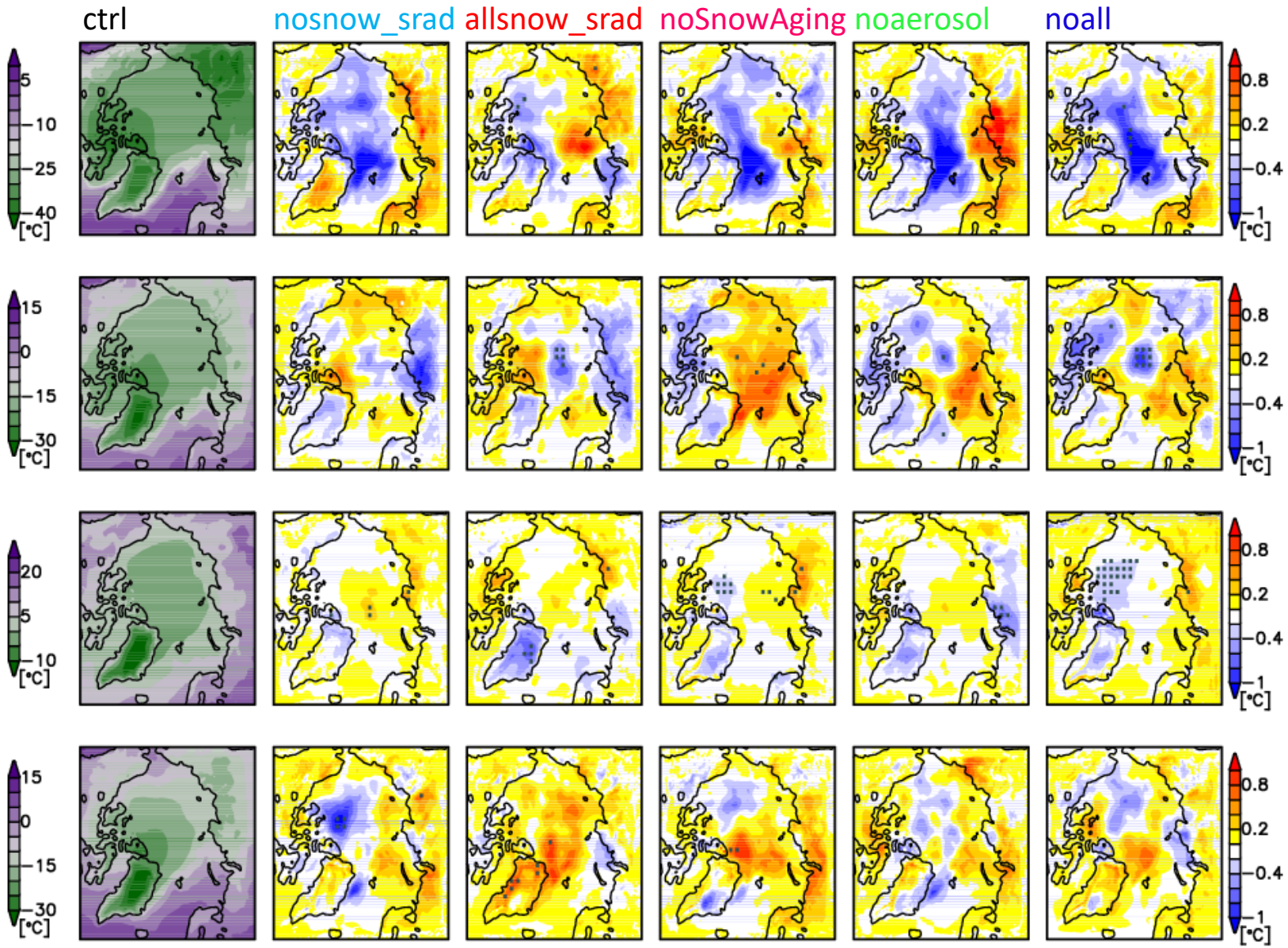




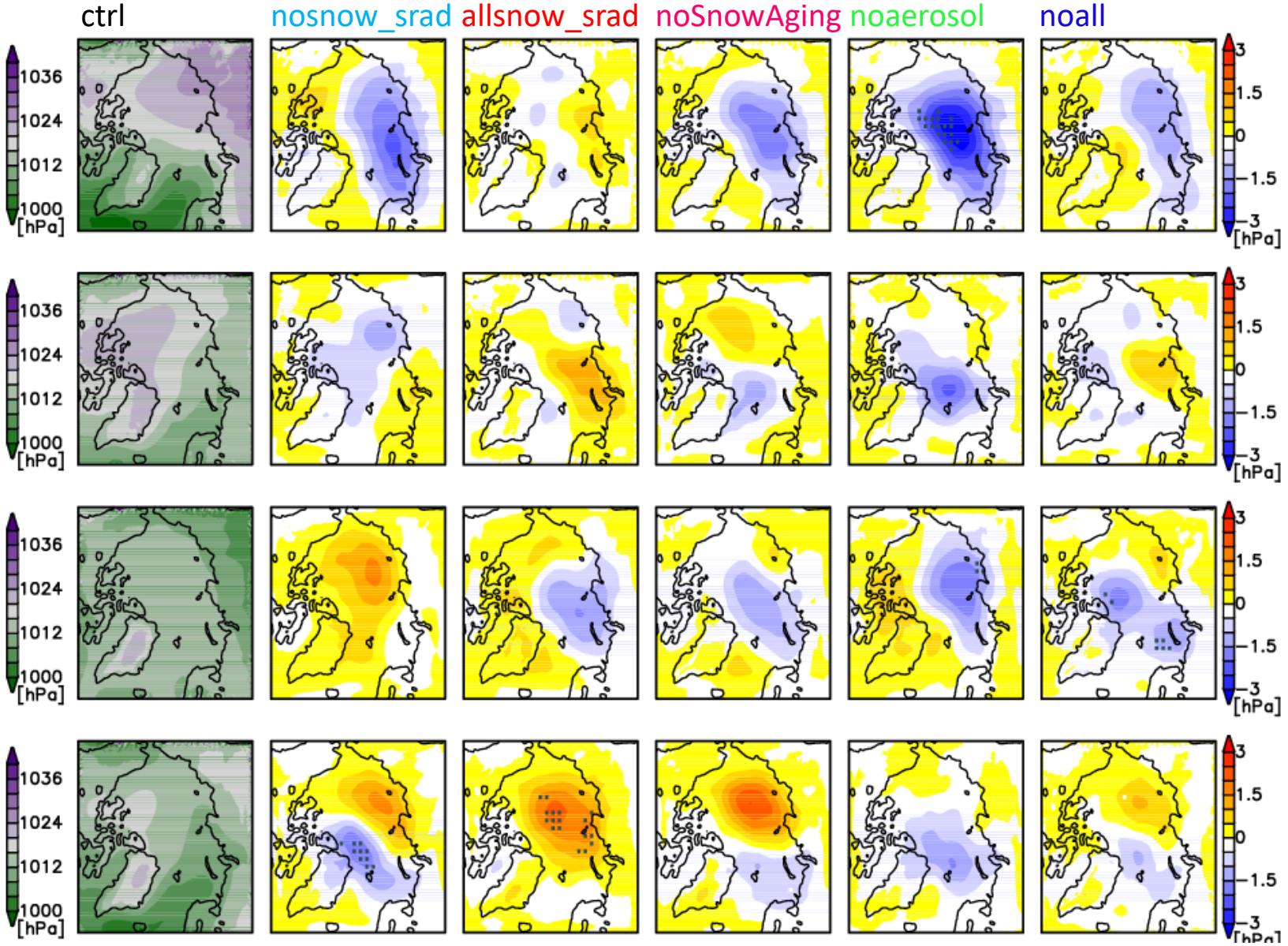
allsnow_srad nosnow_srad
noaerosol noSnowAging noall



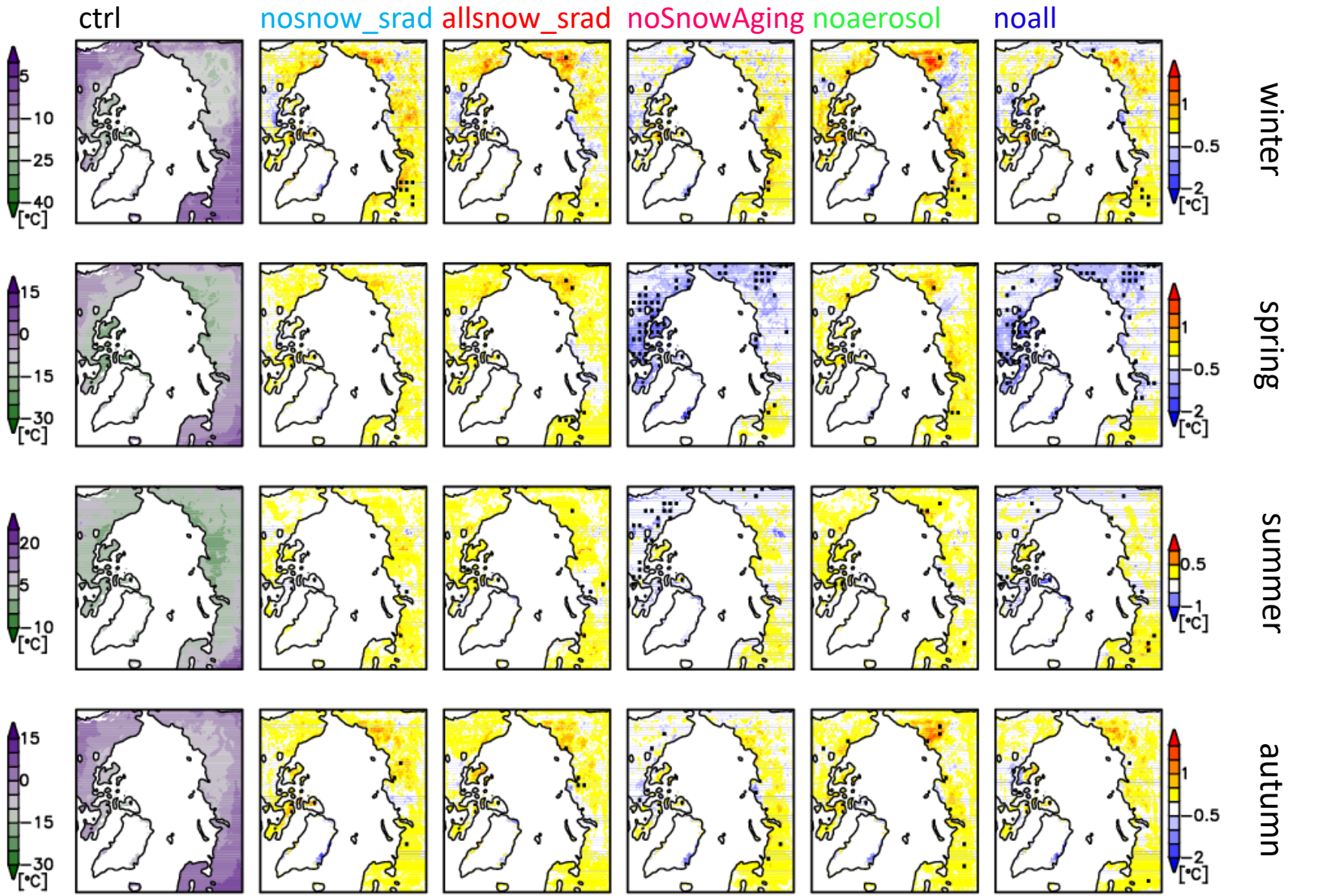
Impact: 2m air temperature



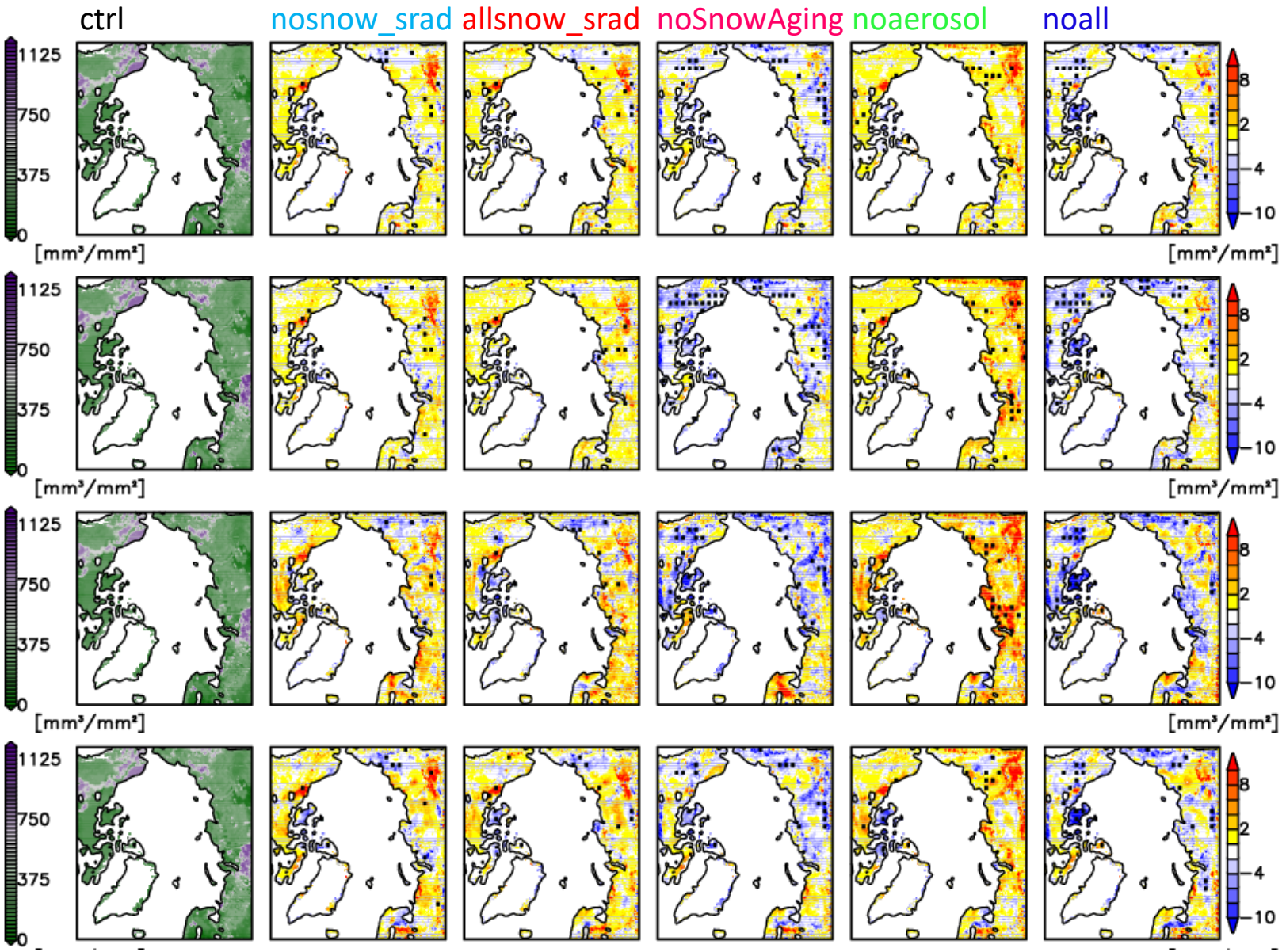
Impact: mean sea level pressure



Impact: soil temperature (20cm)



Impact: soil moisture (20cm)

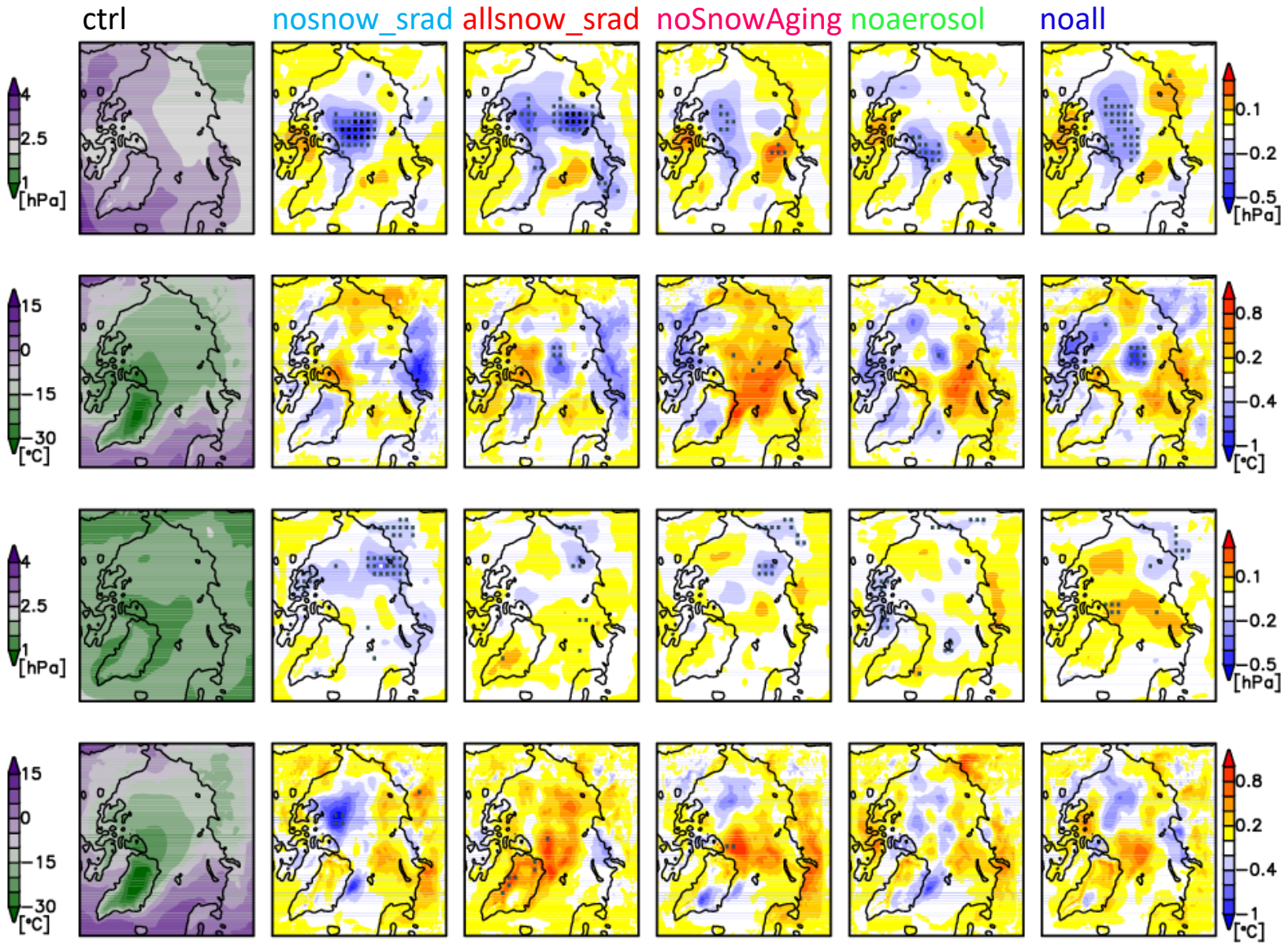


Conclusions

1. To what snow properties are the simulations of atmosphere and ground sensitive?
   - ➢ impact of changing optical properties of snow or grid cell are relatively small and mostly no statistically significant
   - ➢ changing thermal properties changes the ground significantly
2. Are there remote impacts on the atmosphere, or are all effects only local?
   - ➢ impacts on the atmosphere are most prominently remote
   - ➢ changes are however not statistically significant

- This may indicate that climate models' representations of present-day Arctic climate are relatively insensitive to the complexity of the used snow model as long as there is no focus on specific processes like snow melt and ground temperature which may be less well represented.
- Memory effects in soil temperature and soil moisture might lead to larger differences on longer timescales.

Impact: cyclone tracks & air temperature




Thank you for your attention!
photo: Heiko Gerricke