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The role of global mean temperature and low-level clouds for Arctic temperature inversions

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Temperature inversions are a characteristic feature of the Arctic wintertime boundary layer. They play an important role for the surface energy budget, air-sea ice momentum coupling and are one factor contributing to the Arctic Amplification of climate change. Understanding the mechanisms that control temperature inversions and their representation in GCMs is therefore an important challenge in advancing our understanding of Arctic climate.

Comparing the CMIP3 models to reanalysis data, Medeiros et al. (2011) found that

- Most models overestimate mean wintertime inversion strength.
- The spatial distribution of inversion strength over the Arctic ocean is bimodal, with a dominant mode at strong inversions and a less stable secondary mode.
- About half of the models simulate excessively strong inversions, the others overestimate the weight of the strongly stable mode.

Applying this framework to the climate change experiments in CMIP3, we find that both the distribution between the modes and the typical value of the stable mode change with global mean temperatures. As sea ice cover decreases, the less stable mode representative of open ocean conditions becomes dominant, while the weakening of the stable mode inversion strength is a consequence of amplified surface warming in the Arctic.

Therefore, part of the biases found by Medeiros et al. (2011) can be explained by the model biases in sea ice extent and global mean temperatures. These biases are exacerbated by the comparison of model data from the entire historical runs beginning in the 19th century to reanalysis data restricted to the late 20th century.

After accounting for the global mean temperature biases, models still simulate considerably different inversion strengths. Inversion strength is anticorrelated to low-level cloud cover across different models, but not to the surface cloud radiative effect. What causes those remaining across-model differences in inversion strength and how they relate to the simulated clouds yet remains to be understood.

Medeiros, B., C.Deser, R.Tomas and J. Kay, 2011: Arctic inversion strength in climate models. J.Climate, 24, 4733-4740