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Emergent constraints in climate projections: a case study of changes in high latitude temperature variability

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Climate model projections include large uncertainties particularly in characteristics beyond large-scale mean such as changes in regional temperature variability. Recently, there has been a lot of work aiming at reducing the uncertainty by means of emerging constraints. The idea is to search for strong correlations between present behaviour and the projected changes in certain variables across a range of models, in order to produce ensembles of models calibrated with present-day observation. The underlying assumption is that models with better present-day behaviour have a better representation of local feedbacks and processes and are thereby more reliable for projections. So far it is unclear how to combine the information gained from emerging constraints across timescales, metrics and spatial scales for highest reduction in spread. This work intends to investigate properties of emerging constraints in a representative case study.
CMIP5 models consistently project a reduction in temperature variability over the ocean associated with sea ice retreat. While models disagree on the magnitude of the variability reduction, where find a clear structure that models with high present-day variability show a strong reduction, and vice versa. At the grid-point level correlations between the magnitude of present day variability and its change are very high (-0.9 to -0.8). We use this relation to test how the selection of different metrics and timescales can reduce the spread across calibrated model projections. We show that a robust constraint can be obtained by combining relevant metrics across seasons which results in a strong reduction in spread of model projections. We also show that in some cases using individual metrics could be more effective than aggregating all the available information. We investigate the effectiveness of different types of constraints in the context of different target period (1^{o}C, 1.5^{o}C or 2^{o}C global warming), forcing (RCP8.5 and RCP4.5) and when saturation of the constraint occurs.