On the anatomy of the NH sea ice extent and impacts of different bias correction methods in a set of CMIP5 coupled climate models

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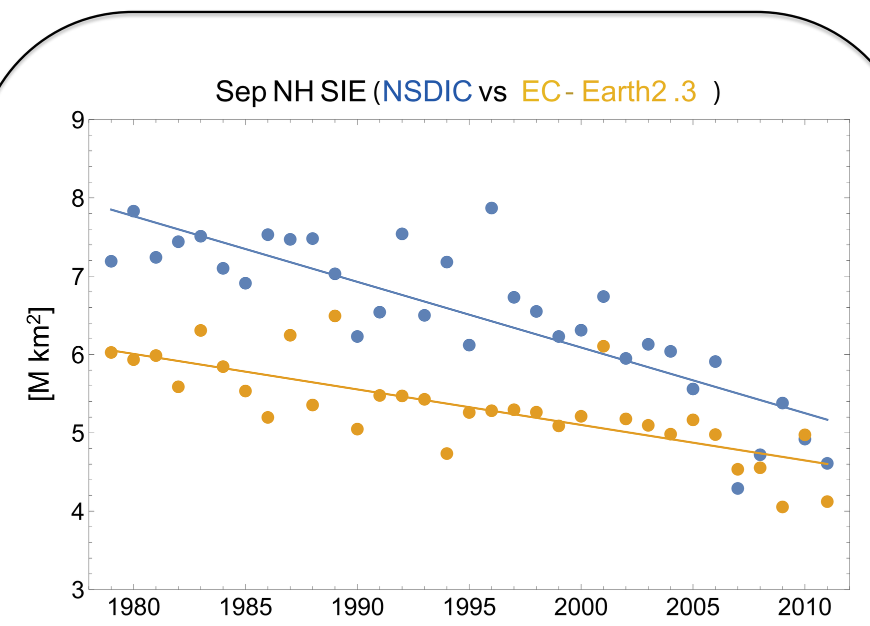
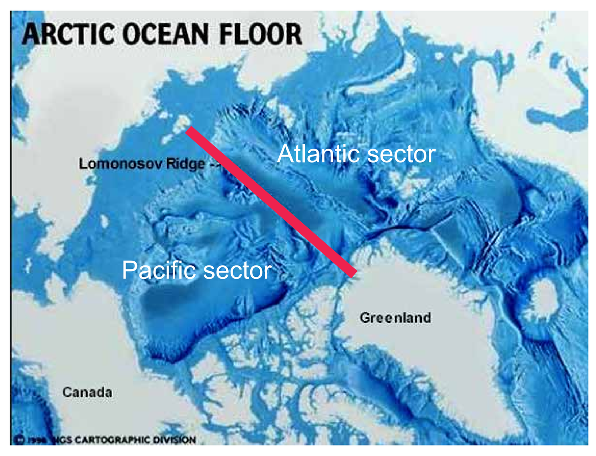
- We investigate the NH sea ice extent (SIE) in a set of CMIP5 models used for seasonal forecast with full-field initialization (1981-2010 period): EC-Earth2.3, CNRM-CM5, MPI-ESM-LR, MPI-ESM-MR, MPI-ESM-HR, CanCM3 and CanCM4
- Even with the best possible forcing, BC and IC model drift and bias can be > signal of interest → bias correction is necessary to asses skill
- Arctic sea ice cover in this set of models has typically different long-term mean, change and interannual variability than the observed one → can utilizing a hierarchy of bias correction methods yield better prediction skill?
- Is there a difference in prediction skill of the Atlantic and Pacific sector of the Arctic?



For example, observed negative trend in September NH SIE (from 1979) is about twice as strong as the one in EC-Eath2.3



We use Lomonosov ridge to separate the Arctic ocean into the Atlantic and Pacific sector with different circulation regimes.

- **The mean bias correction method** – can account for error in mean

$$m_{i,l} \equiv \overline{m_l} + m'_{i,l} \;\; and \;\; o_{i,l} \equiv \overline{o_l} + o'_{i,l},$$
$$m_{i,l} \longmapsto \hat{m}_{i,l} \equiv m_{i,l} - [\overline{m_l} - \overline{o_l}] = \overline{o_l} + m'_{i,l}.$$

- **The trend bias correction method** – can account for error in lin. trend

$$m_{i,l} \equiv [a_l^{(m)} + b_l^{(m)} i] + m''_{i,l} \;\; and \;\; o_{i,l} \equiv [a_l^{(o)} + b_l^{(o)} i] + o''_{i,l},$$
$$m_{i,l} \longmapsto \tilde{m}_{i,l} \equiv m_{i,l} - \{[a_l^{(m)} + b_l^{(m)} i] - [a_l^{(o)} + b_l^{(o)} i]\}$$
$$= \hat{m}_{i,l} - [b_l^{(m)} - b_l^{(o)}][i - \bar{i}].$$

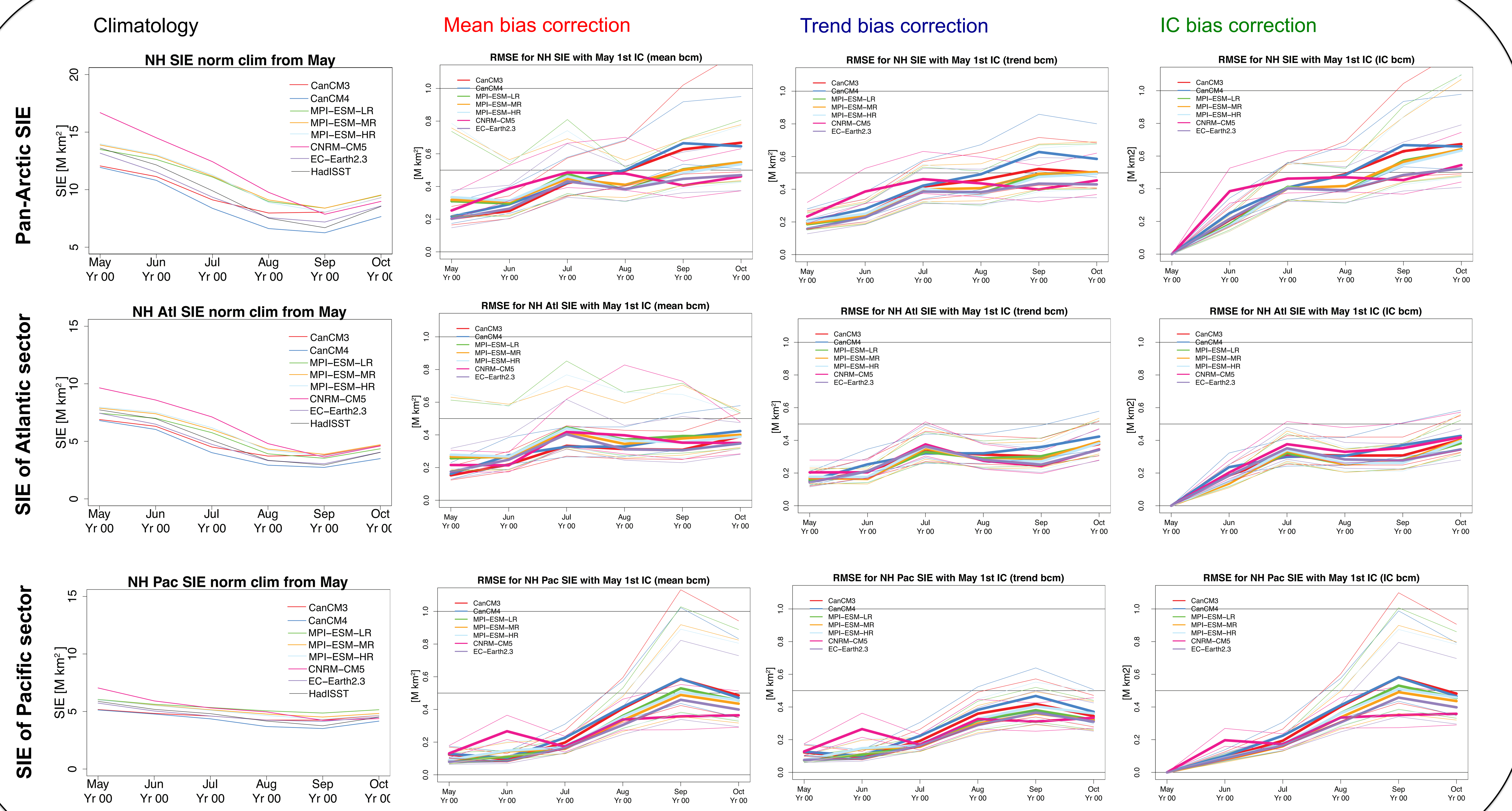
m - "raw" forecast, o - obs/analysis, i – start date (year), l - forecast time

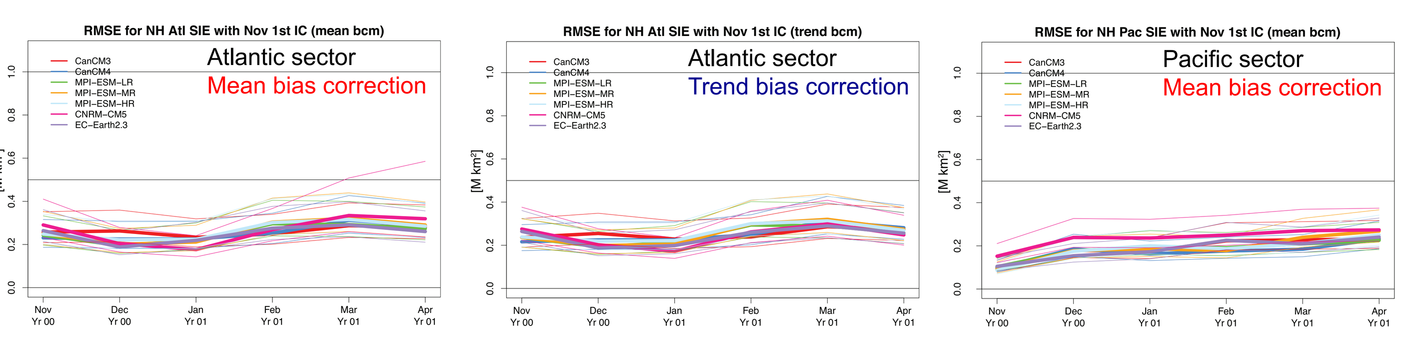
- **The IC bias correction method** - can take into account interannual variability in initial conditions

$$m_{i,l} \equiv [\alpha_l^{(m)} + \beta_l^{(m)} o_i^{(IC)}] + m'''_{i,l} \;\; and \;\; o_{i,l} \equiv [\alpha_l^{(o)} + \beta_l^{(o)} o_i^{(IC)}] + o'''_{i,l},$$
$$m_{i,l} \longmapsto \tilde{\tilde{m}}_{i,l} \equiv m_{i,l} - \{[\alpha_l^{(m)} + \beta_l^{(m)} o_i^{(IC)}] - [\alpha_l^{(o)} + \beta_l^{(o)} o_i^{(IC)}]\}$$
$$= \hat{m}_{i,l} - [\beta_l^{(m)} - \beta_l^{(o)}][o_i^{(IC)} - \overline{o_i^{(IC)}}].$$

Instantaneous IC is too noisy ⇒ smoothing OBS IC in time is critical for monthly and longer-term predictions

Implemented: $\mathbf{o^{(IC)}_i = o_{i,1}}$ (average over the first forecast month)





In boreal winter different bias correction methods offer no significant improvements in prediction skill, while Atlantic and Pacific sector of the Arctic are equally predictable

→ NH sea ice cover in winter is more predictable than in summer

→ Annual cycle of sea ice in the Pacific sector of the Arctic has smaller amplitude than in the Atlantic sector

→ IC (trend) bias correction method offers potential for an improvement of prediction skill in MJJ (JAS/ASO) initialized on May 1st

→ In summer sea ice in the Atlantic sector of the Arctic is more predictable than sea ice in the Pacific sector