A data assimilation approach for reconstructing sea ice volume in the Southern Hemisphere

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1. Puzzling Antarctic sea ice

In a global warming context,

Arctic sea ice…

-extent is rapidly **shrinking**

-concentration trends distribution is **relatively homogeneous** (see below).

-is **thinning** almost everywhere

-simulated by models follows the same negative trends

-changes are **significant**

Antarctic sea ice…

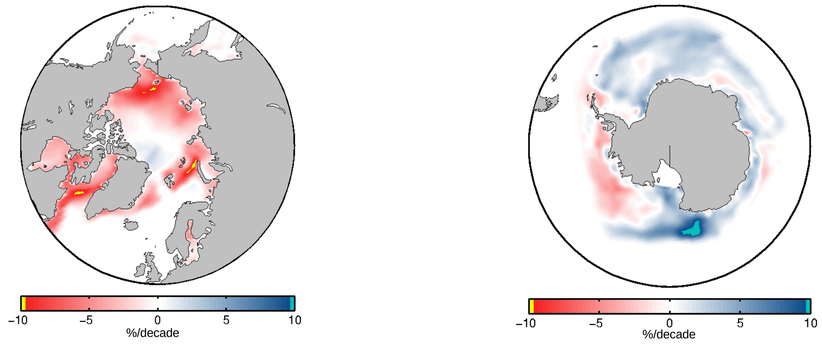
-extent is slightly **expanding**

-concentration trends distribution is **heterogeneous** (see below).

-is not sufficiently sampled to derive robust trends of sea ice thickness

-simulated by coupled climate models shows contradictory trends

-changes are **not systematically significant**



Observed trends of Arctic (left) and Antarctic (right) sea ice concentration, 1983-2007. *Sea ice concentration data: OSISAF, 2010.*

Objective

Attempt to reconstruct the recent **decadal variability of the Antarctic sea ice volume** by statistical-based combinations of **observations** and **model hindcasts**, emphasizing the **regional contributions** of the different sectors in the Southern Ocean.

3. Collateral benefits

By the nature of the EnKF, the assimilation of a variable *i* has an impact on any other variable *j* as long as *i* and *j* are correlated.

*Mean absolute difference of **sea ice thickness** with respect to the ASPeCT data set (Worby et al., 2008), in different ocean sectors of Antarctica. «* FREE RUN *», resp. «* ASSIM RUN *» denotes the run without and with **assimilation of sea ice concentration**.*

	mean $\|\Delta h\|$ (m)	
	FREE RUN	ASSIM RUN
Weddell	0.29	0.22
Ind. Ocean	0.21	0.17
West Pacific	0.38	0.30
Ross	0.35	0.32
Amund. –Bel.	0.26	0.18
Whole Antarctica	0.30	0.23

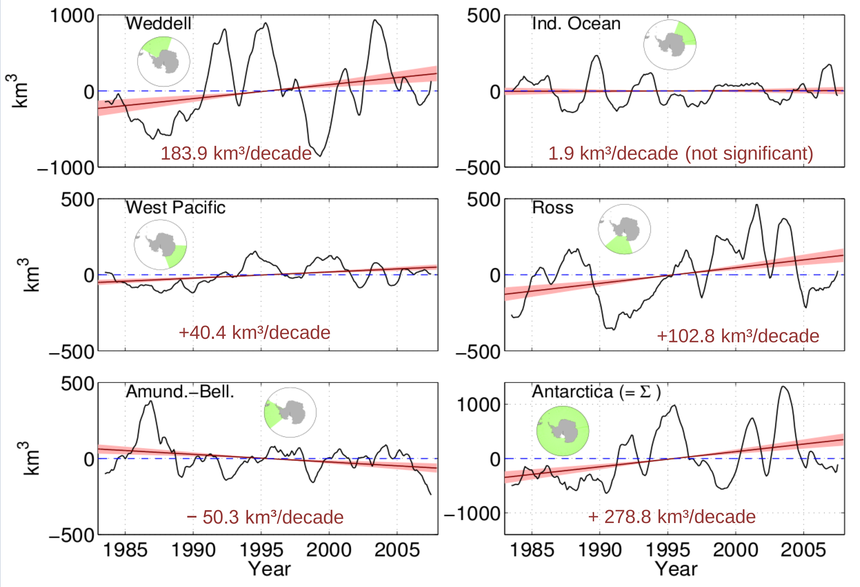
Conclusions

-Unlike its Arctic counterpart, Antarctic sea ice variability cannot be analyzed as a whole but rather as a **sum of contributing sectors**.

- Antarctic sea ice thickness/volume trends patterns resemble those of sea ice concentration/extent.

-This is a **first attempt**. Only the ice concentration is assimilated, and the freshwater budget is not corrected after assimilation

4. SH volume changes



Regional variability of the 1983-2007 SH sea ice volume as reconstructed by the NEMO-LIM2 ocean-sea ice model constrained by the EnKF. ***Black*** *lines: 1-yr running mean of sea ice volume monthly anomalies;* ***Red*** *lines: linear fit of the anomalies with the ±2σ envelope of the fit.*

2. EnKF data assimilation

The **En**semble **K**alman **F**ilter (*Evensen, 2003*)

$$\mathbf{x}^a = \mathbf{x}^f + \mathbf{K}\,(\mathbf{d} - \mathbf{H}\,\mathbf{x}^f)$$

Analysis $\mathbf{x}^a$

Forecast $\mathbf{x}^f$ (daily, LIM2 (*Fichefet and Morales Maqueda, 1997*), ORCA2)

Kalman gain $\mathbf{K}$ Includes obs. error and model forecast error covariance matrices

Observations $\mathbf{d}$ Global, daily sea-ice **concentrations** 1979-2005 (*OSISAF, 2010*)

Projection $\mathbf{H}\,\mathbf{x}^f$ Interpolation model-observation grids

➞ EnKF is statistically consistent

➞ Multivariate data assimilation

Possibility for cross-variable improvements (e.g. sea ice thickness through concentration)

Note that…

-ice concentration only is assimilated

-no correction (yet) on the freshwater budget after assimilation time step

References

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