Changes in Southern Ocean sea ice thickness and volume

reconstructed with data assimilation

François Massonnet

P. Mathiot • T. Fichefet

H. Goosse • C. König Beatty

M. Vancoppenolle • T. Lavergne

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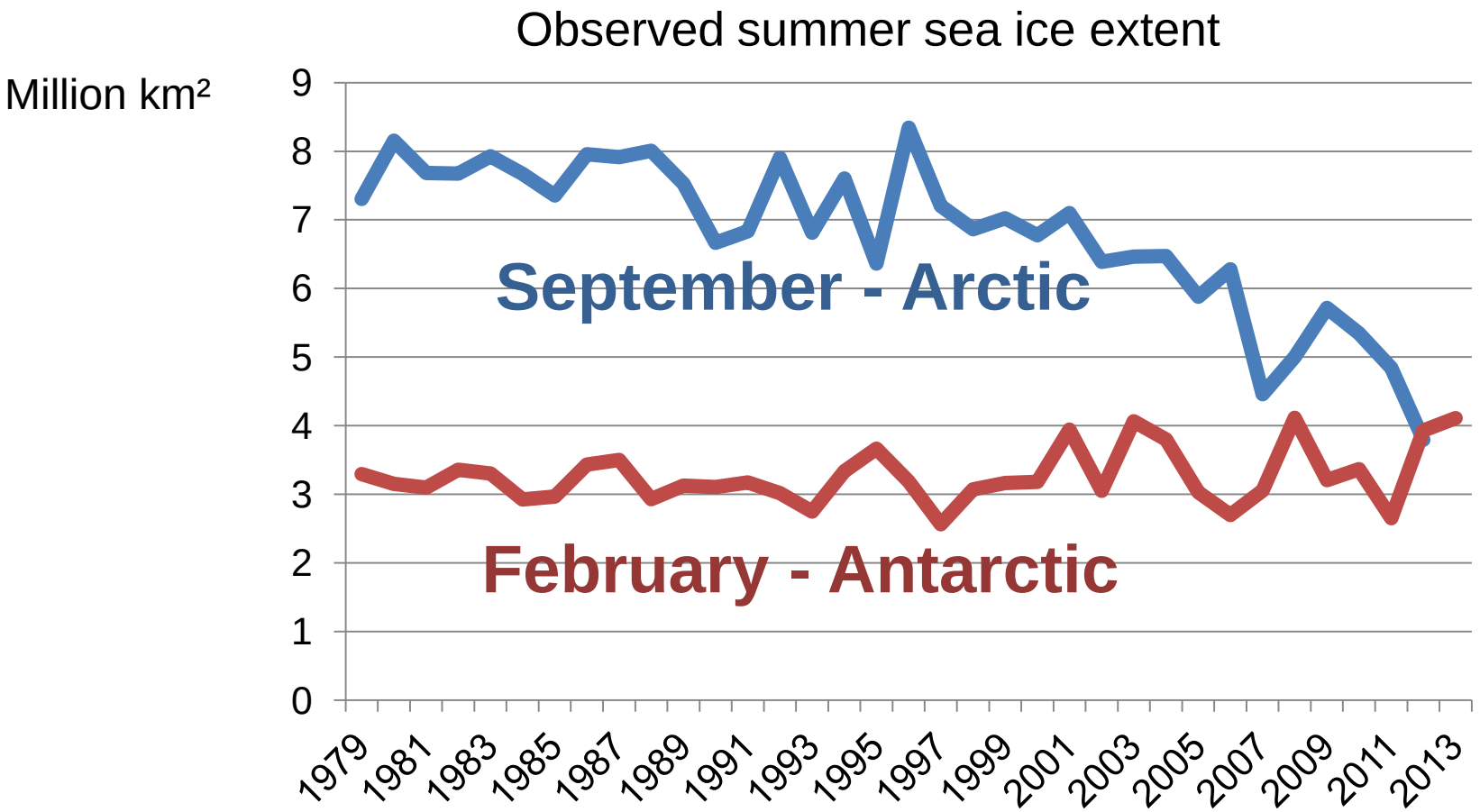
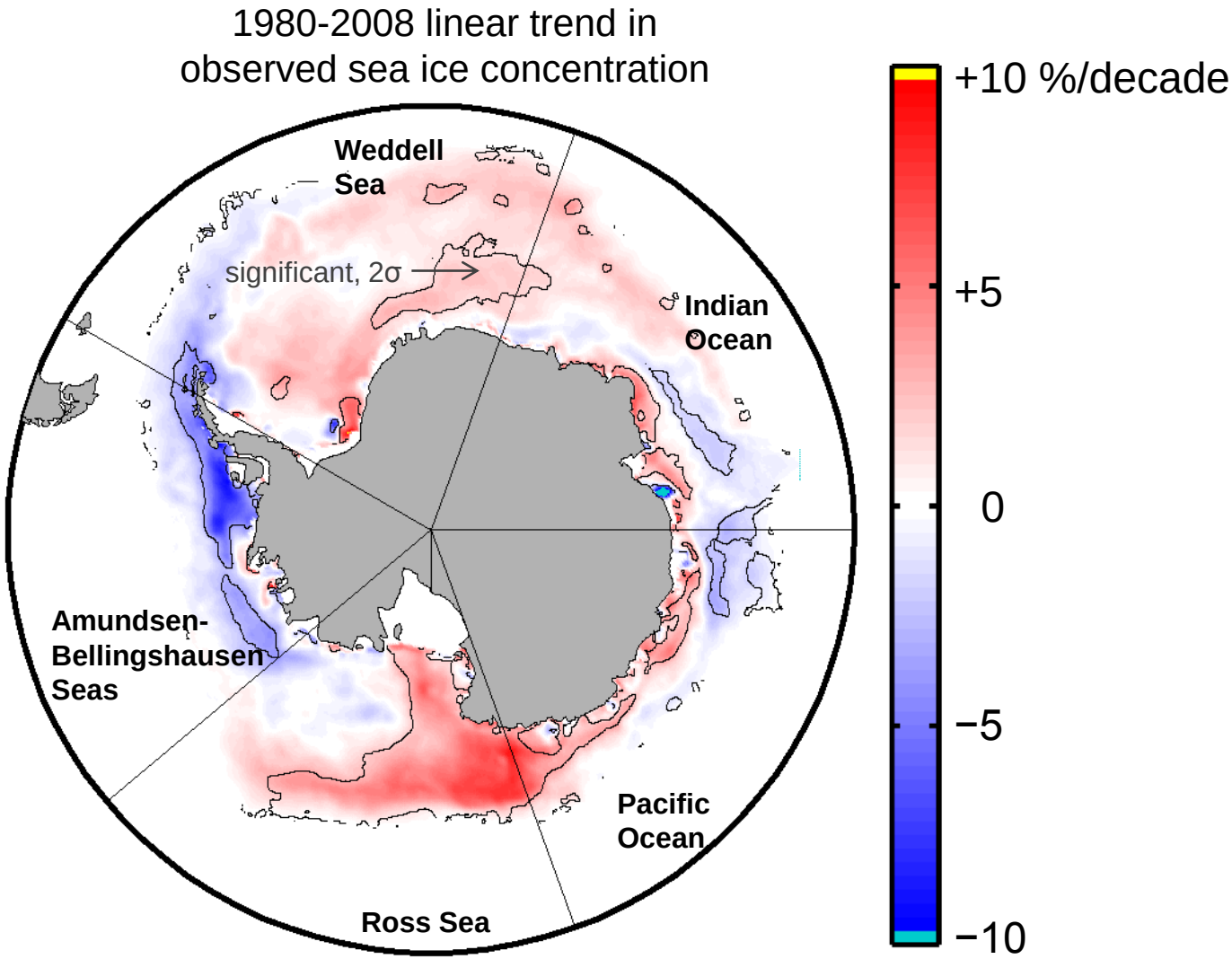
The 2012 sea ice kiss

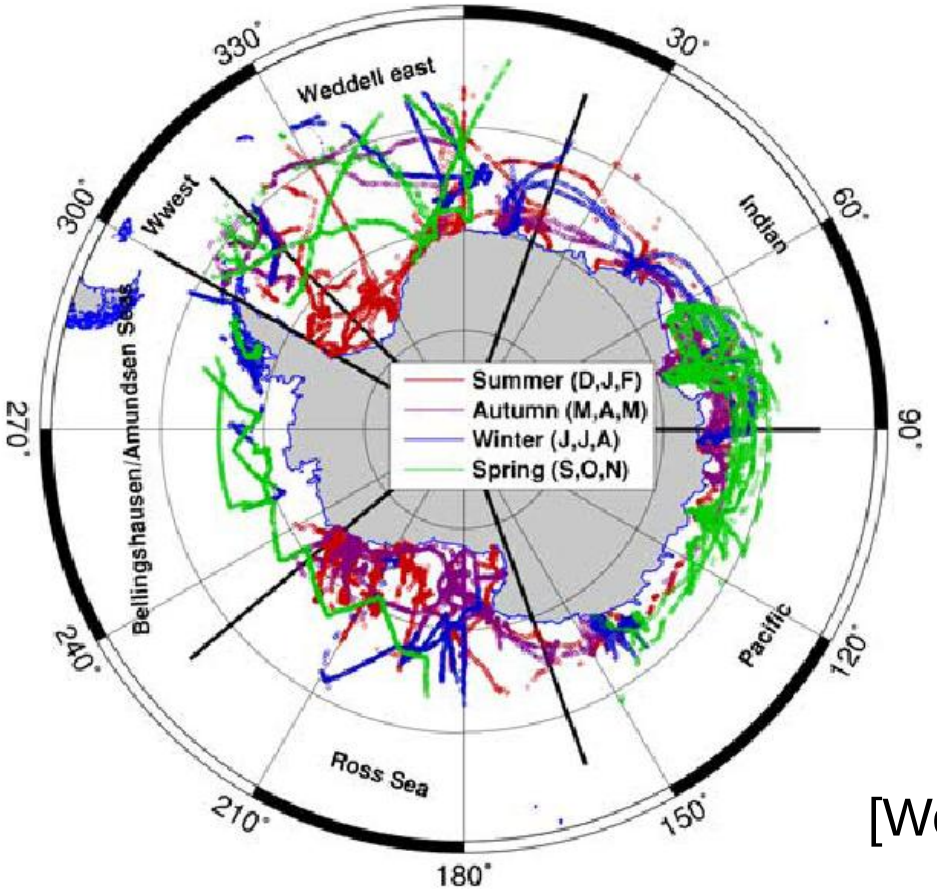


Complex sea ice changes



Complex sea ice changes incomplete understanding

About 80 field campaigns provided ice thickness measurements over 1981-2005



[Worby et al., 2008]

-Data assimilation as an optimal solution

-Increased sea ice volume in a warming world

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The ensemble Kalman filter is a forecast-analysis method

$\mathbf{x}^f$

Forecast
(NEMO-LIM2)

$\mathbf{d}$

Observations
Global, daily sea-ice **concentrations**
(OSI-SAF)

The ensemble Kalman filter is a forecast-analysis method

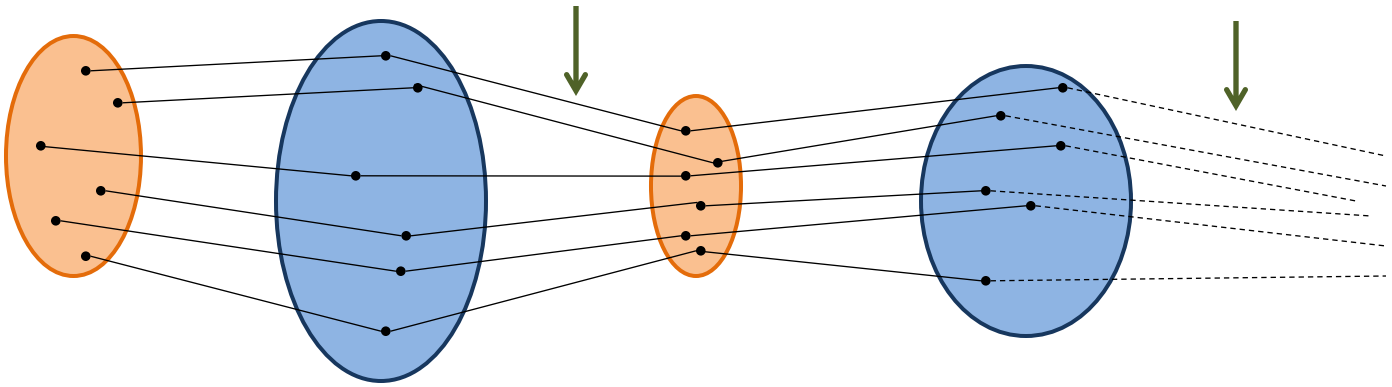
$$\mathbf{x}^a = \mathbf{x}^f + \mathbf{K}\,(\mathbf{d} - \mathbf{H}\,\mathbf{x}^f)$$

Analysis

Forecast (NEMO-LIM2)

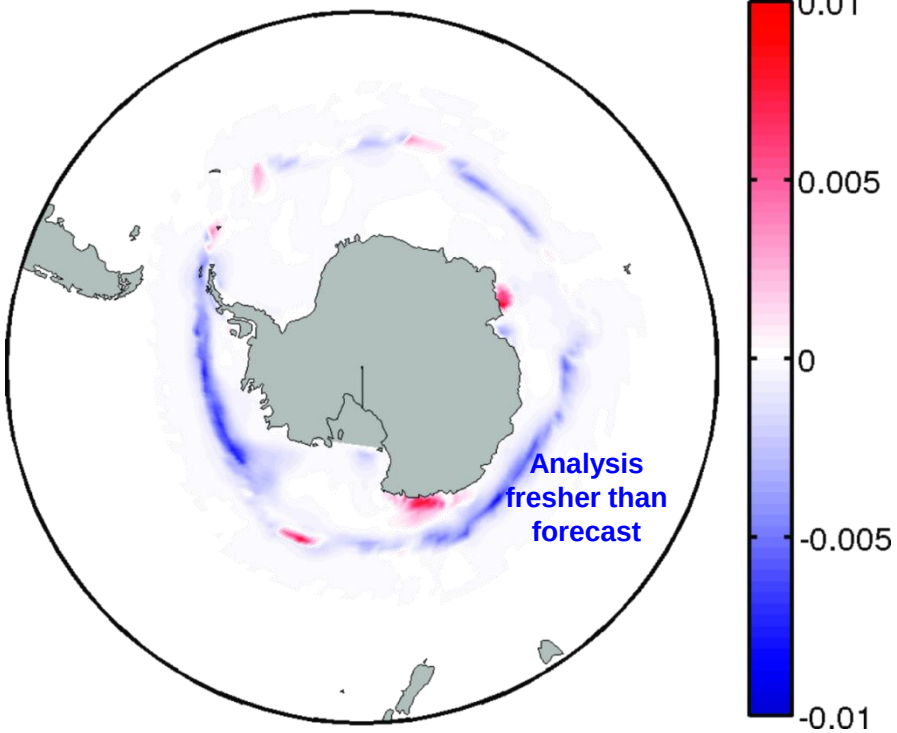
Kalman gain

Observations Global, daily sea-ice **concentrations** (OSI-SAF)



The ensemble Kalman filter is a forecast-analysis method

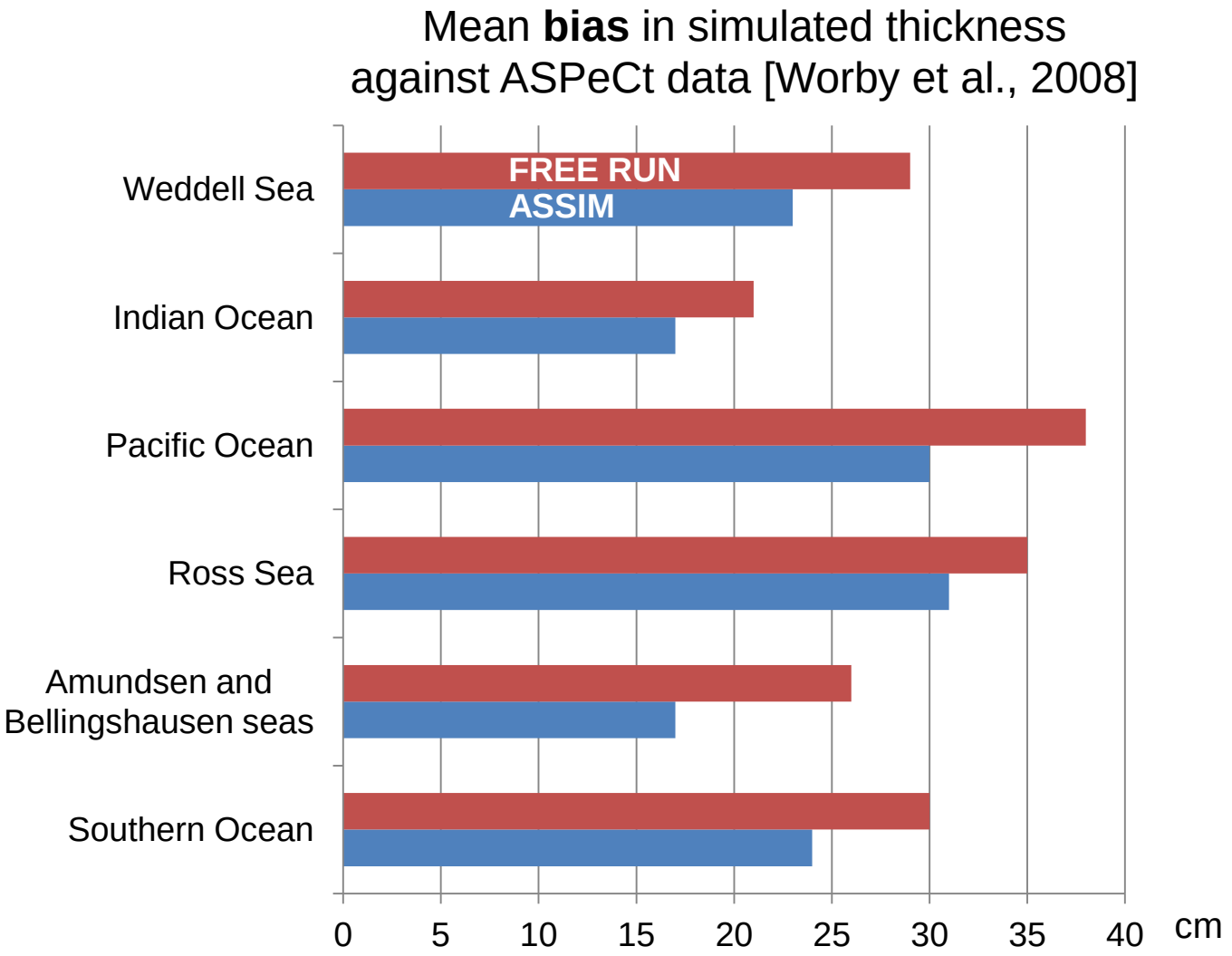
Example of an update in sea surface salinity



A practical solution to the full-state estimation problem

A good tradeoff for the estimation of model error covariance matrix in a nonlinear system

Improved simulated sea ice thickness



-Data assimilation as an optimal solution

> Solves the full state estimation problem

> Effective improvements in simulated ice thickness

-Increased sea ice volume in a warming world

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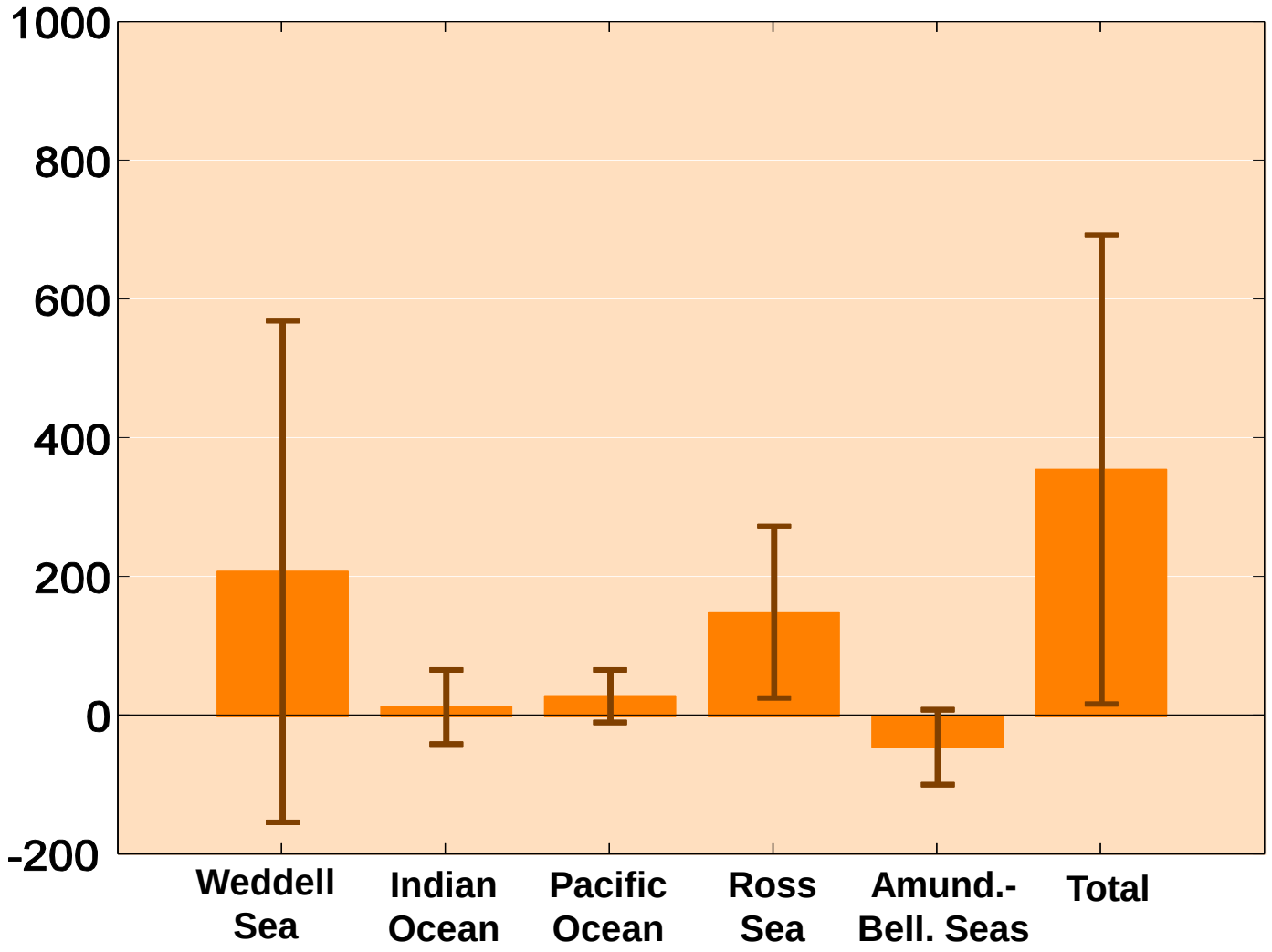
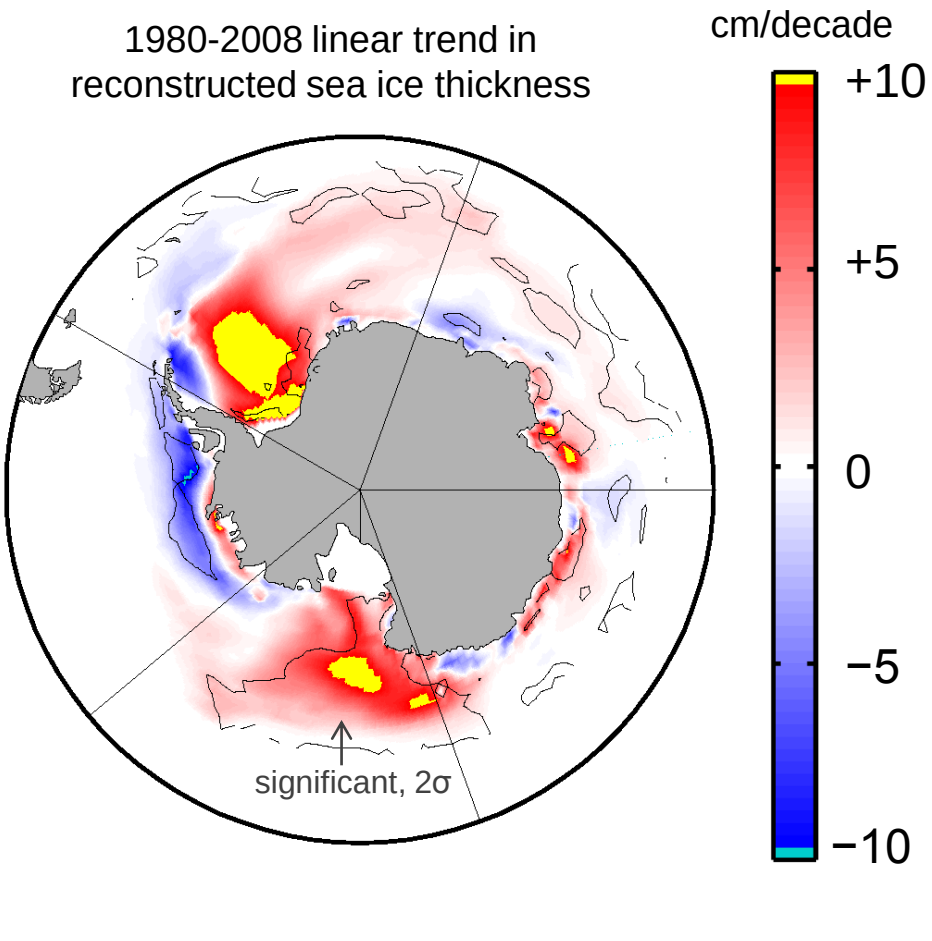
Weak, regionalized and noisy increase in Antarctic sea ice volume

1980-2008 trend in sea ice volume [km³/decade]



Mechanisms for Southern Ocean sea ice variability



The global increase in volume
should be analyzed
at the regional scale first

Regional signed responses
are a result of regional dynamical
and thermodynamical processes

[Holland et al., 2012; Bromwich et al., 2012;
Liu et al., 2004; Lefebvre and Goosse, 2008]

-Data assimilation as an optimal solution

> Solves the full state estimation problem

> Effective improvements in simulated ice thickness

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> The signal-to-noise ratio is low!

> Sea ice volume/thickness interannual trends follow area/concentration trends

Take home messages

-Data assimilation is a promising tool to estimate past changes

for which we cannot have more measurements

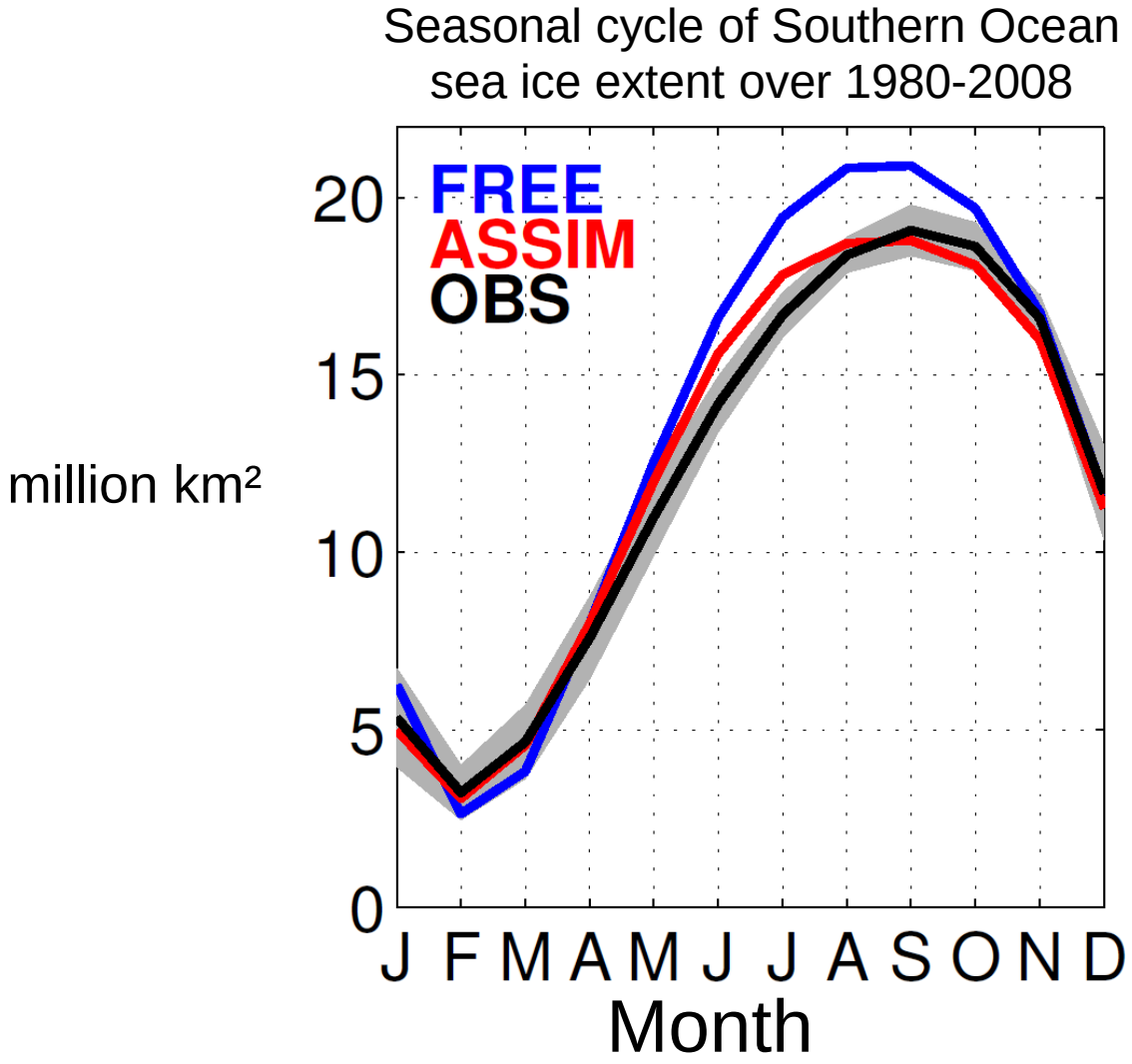
-The reconstruction is available on request

if you know what you are using!

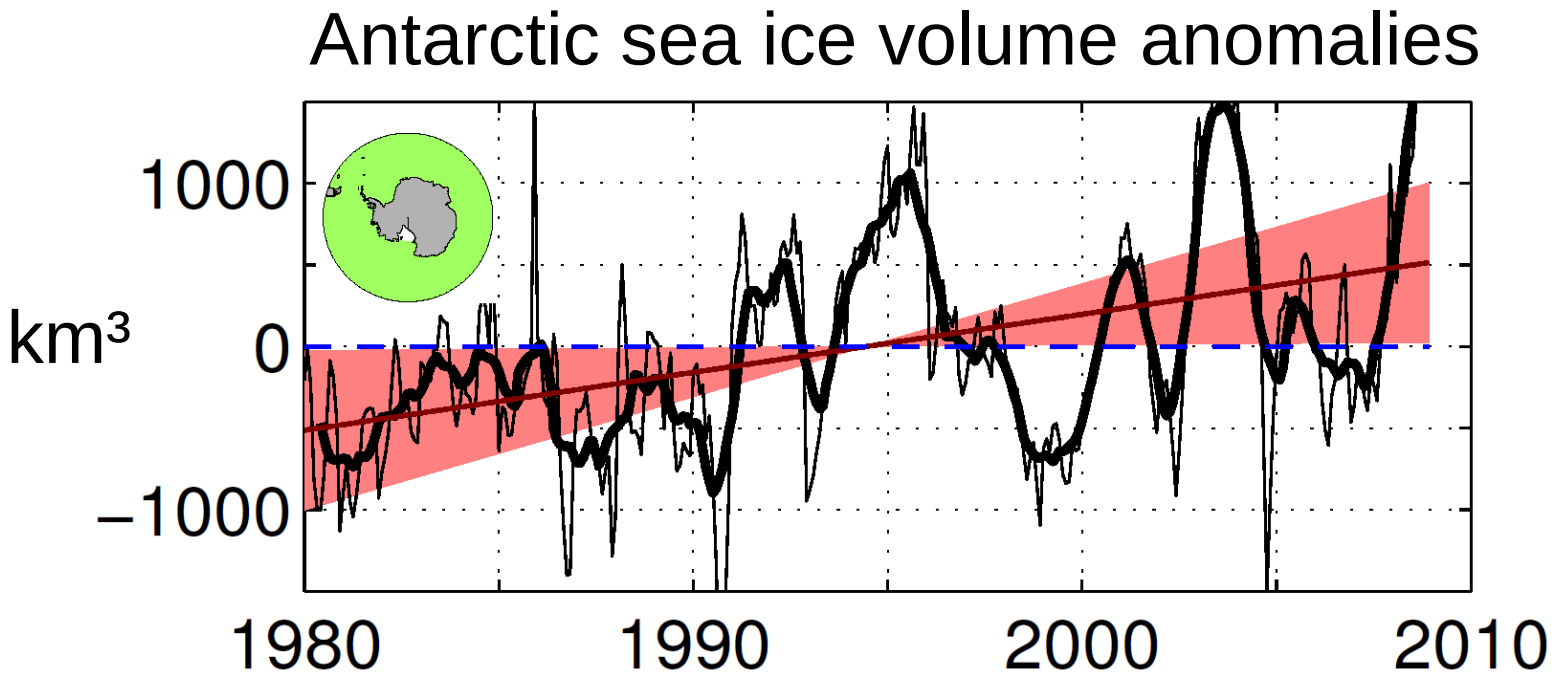
francois.massonnet@uclouvain.be

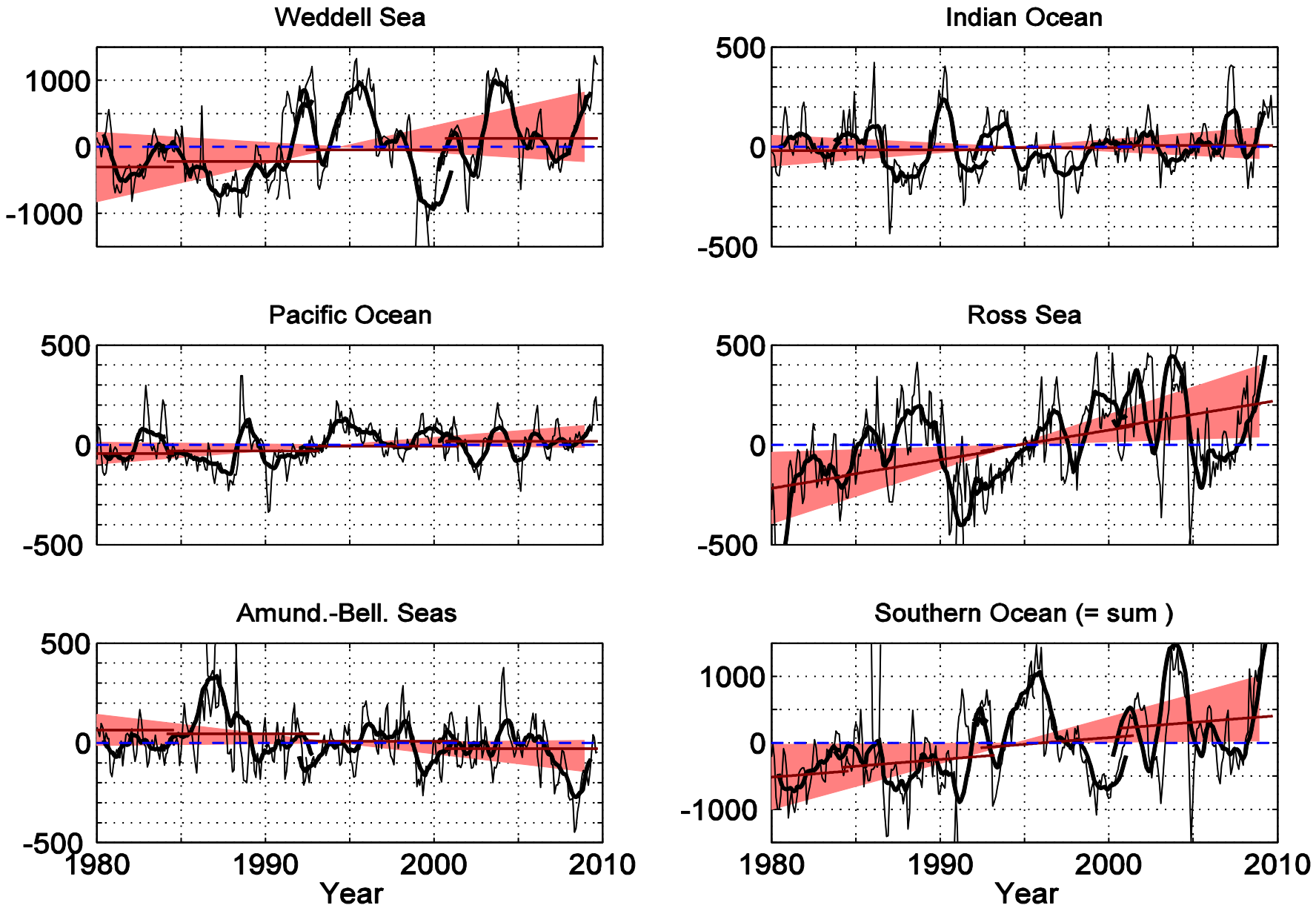
www.climate.be/u/fmasson

Improved simulated sea ice extent (« of course »)



Weak, regionalized and noisy increase in Antarctic sea ice volume




Weddell Sea
1000
0
-1000
Indian Ocean
500
0
-500
Pacific Ocean
500
0
-500
Ross Sea
500
0
-500
Amund.-Bell. Seas
500
0
-500
Southern Ocean (= sum)
1000
0
-1000
1980
1990
2000
2010
Year
1980
1990
2000
2010
Year