Bjerknes Centre for Climate Research

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Climate Prediction at the Bjerknes Centre

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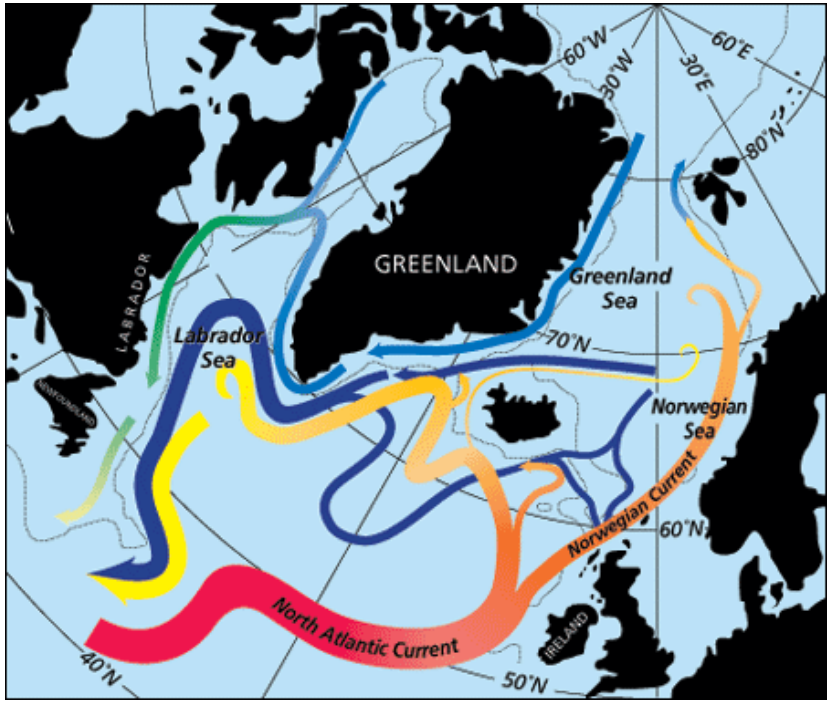
PREFACE EPOCASA 1961 1997 GREENICE PRACTICE

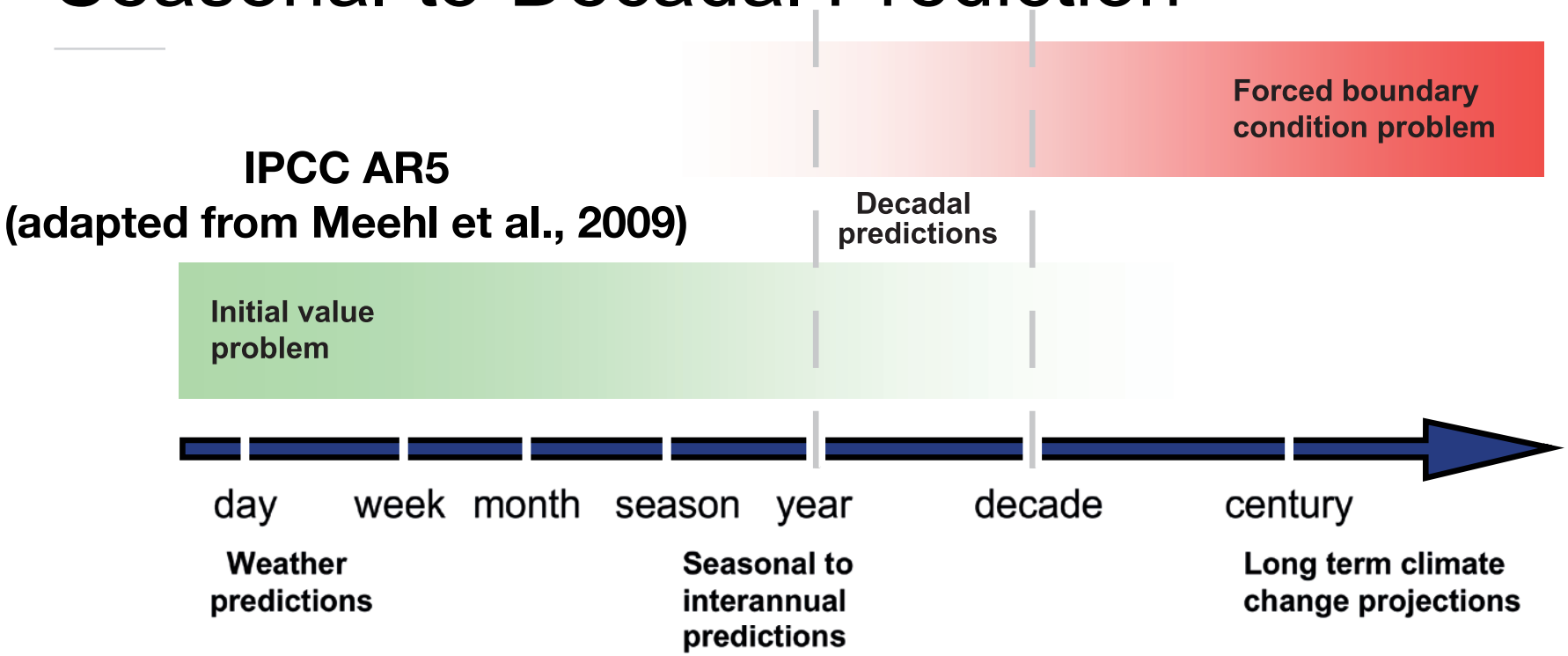
UNIVERSITY OF BERGEN uni Research NERSC Nansen Center, Bergen HAVFORSKNINGSINSTITUTTET INSTITUTE OF MARINE RESEARCH

To improve our understanding of seasonal-to-decadal predictability in the Atlantic Sector

- Development of a Climate prediction system
- Predictability of Subpolar Gyre
- What mechanisms support the predictability?
- How to enhance the predictability base on our understanding?
- Tool: Norwegian Climate Prediction model (NorCPM)



Seasonal-to-Decadal Prediction

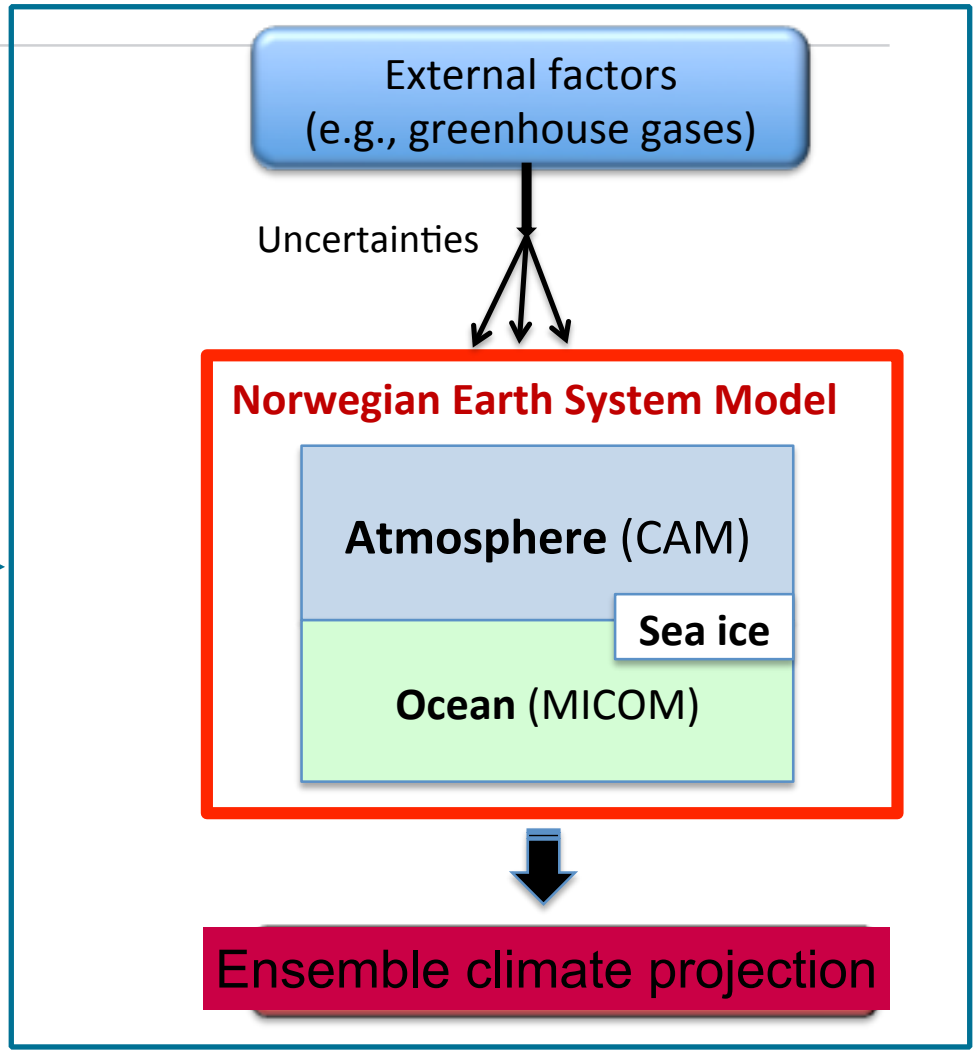


- Seasonal-to-decadal prediction depends on initial condition and forcing
- Most of the predictability is in the ocean (larger inertia and heat capacity)
- Prior attempt shows potential using simple initialization method: Keenlyside 08, Smith 08, Pohlman 09…

Climate Projection

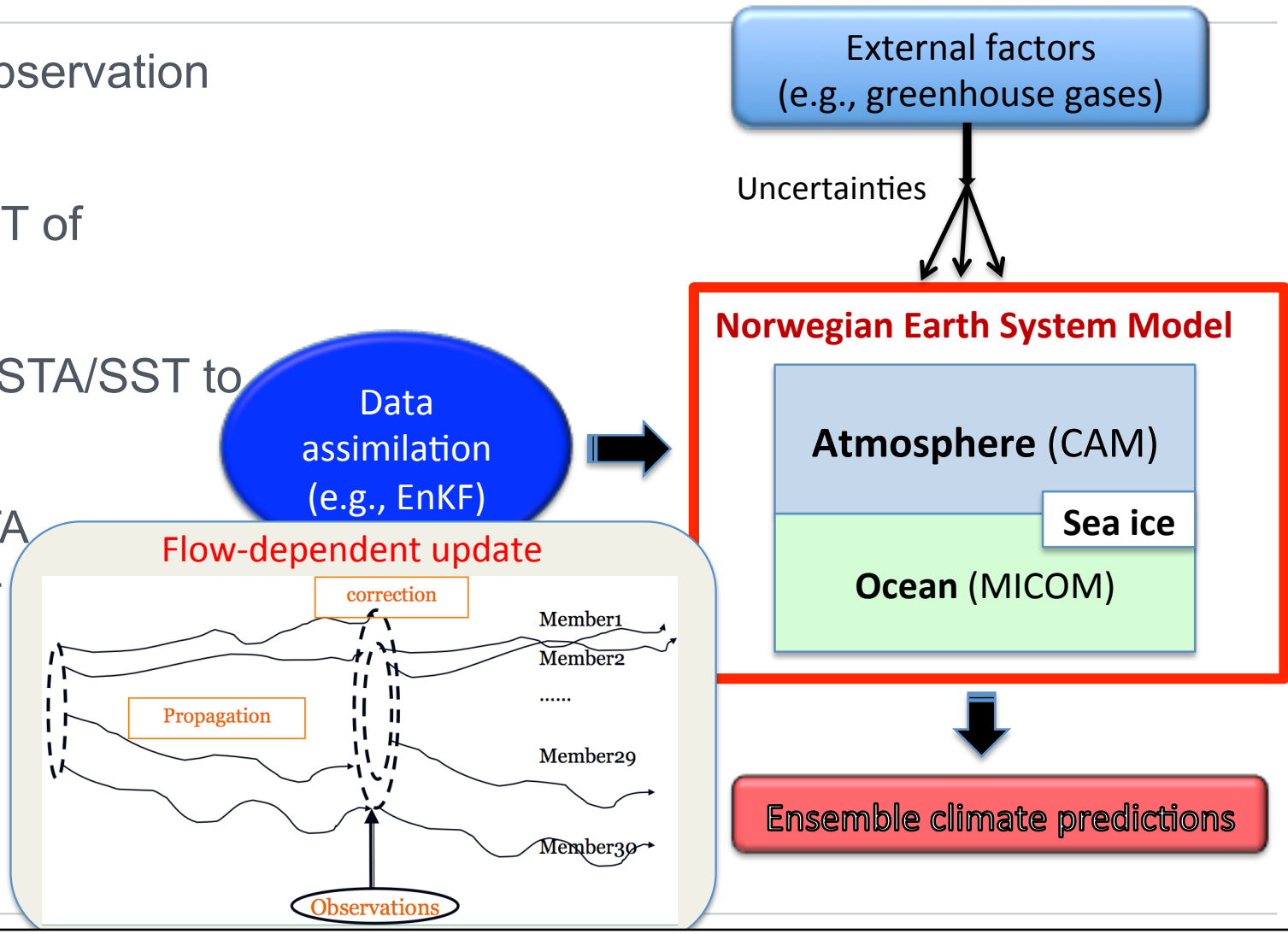
- Considering only external forcing.

Climate projection →



Norwegian Climate Prediction Model

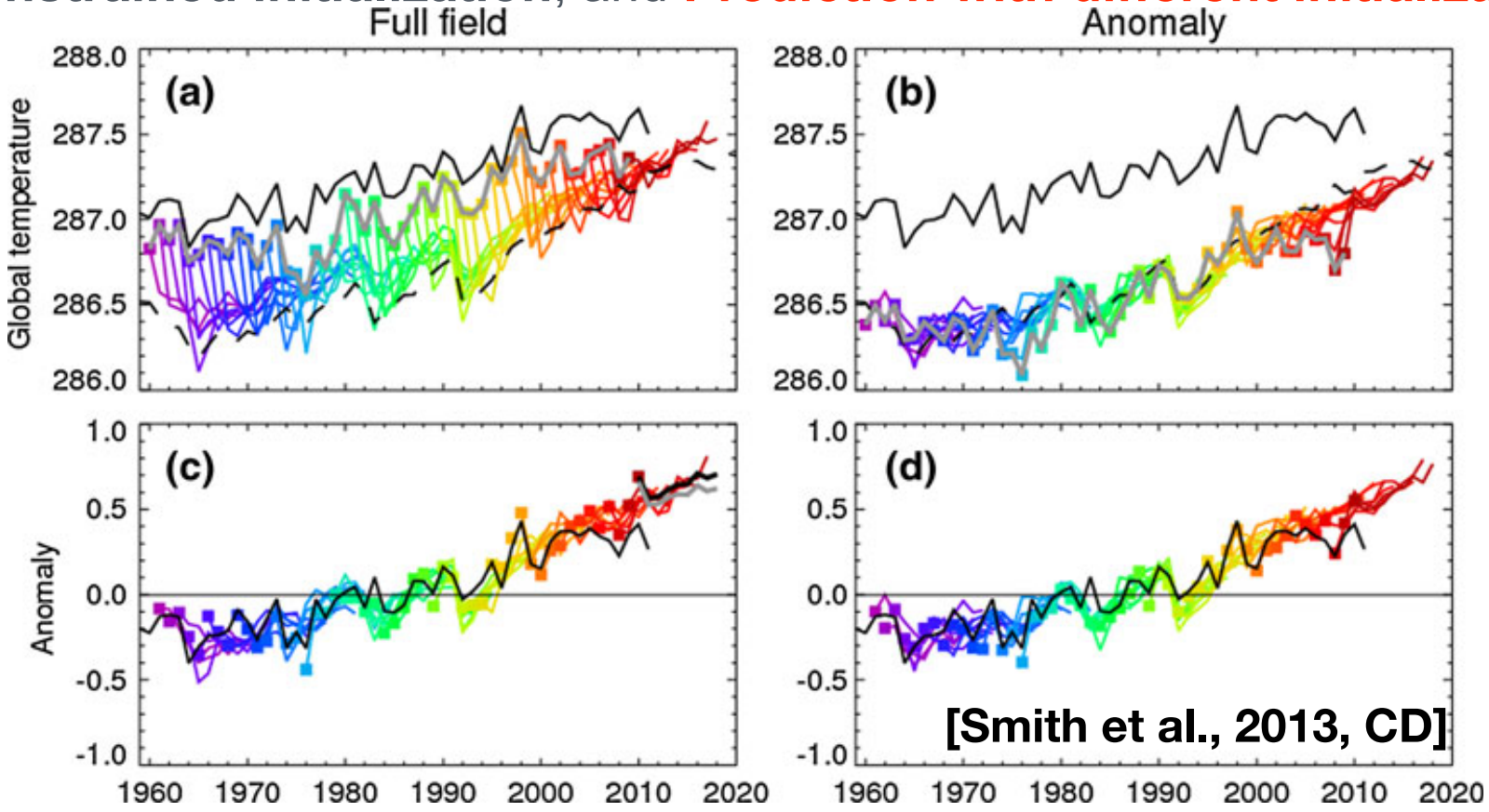
- Assimilate observation to NorESM.
- Nudge U, V, T of atmosphere
- Assimilate SSTA/SST to ocean
  - EnKF-SSTA
  - EnKF-SST



"Developed novel scheme to reduce drift of EnKF assimilation in isopycnal ocean model, Wang et al."

Initialization of Earth System Model

- **Observed global temperature**, **Modeled global temperature**, **Constrained initialization**, and **Prediction with different initialization**



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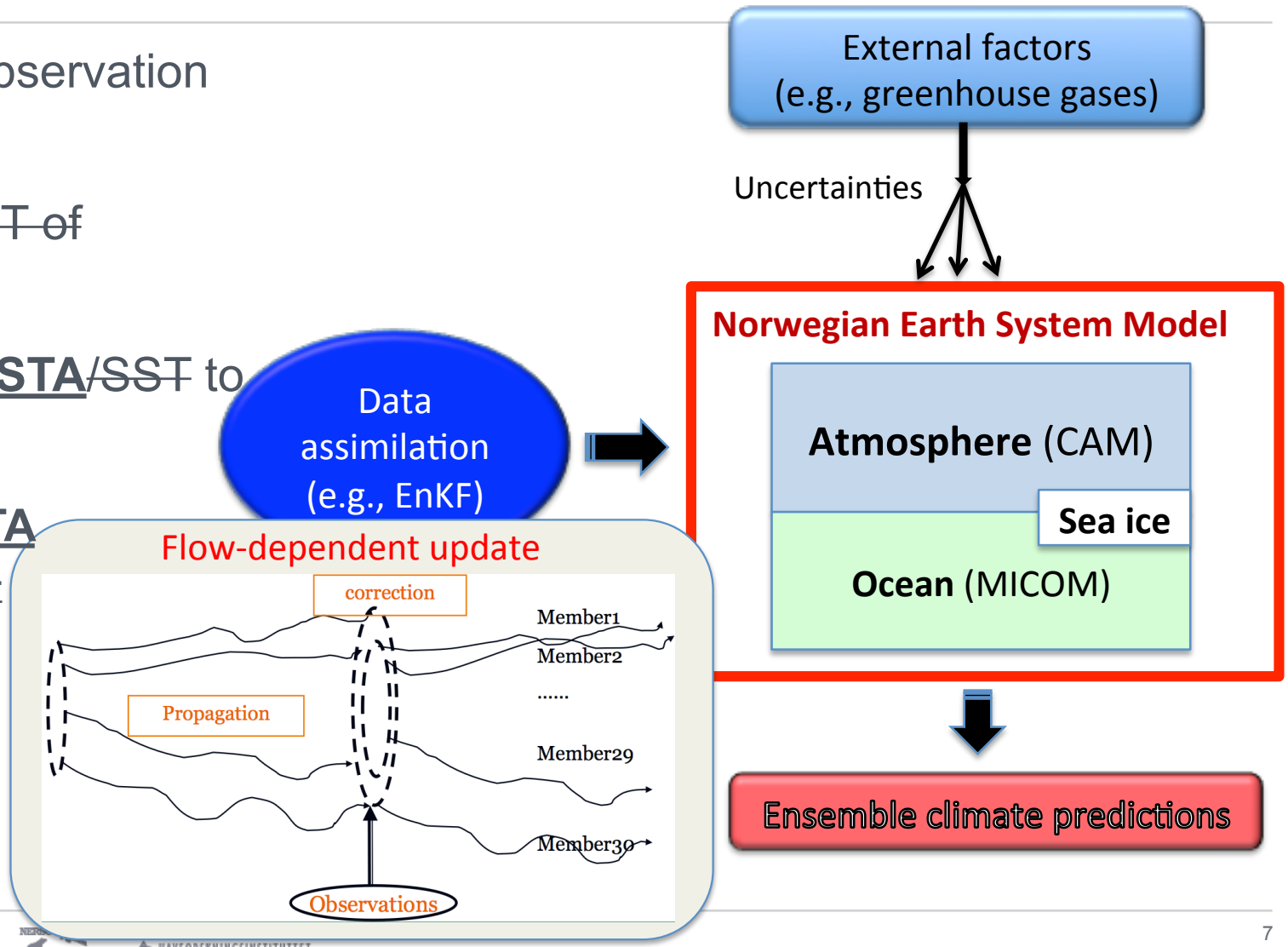
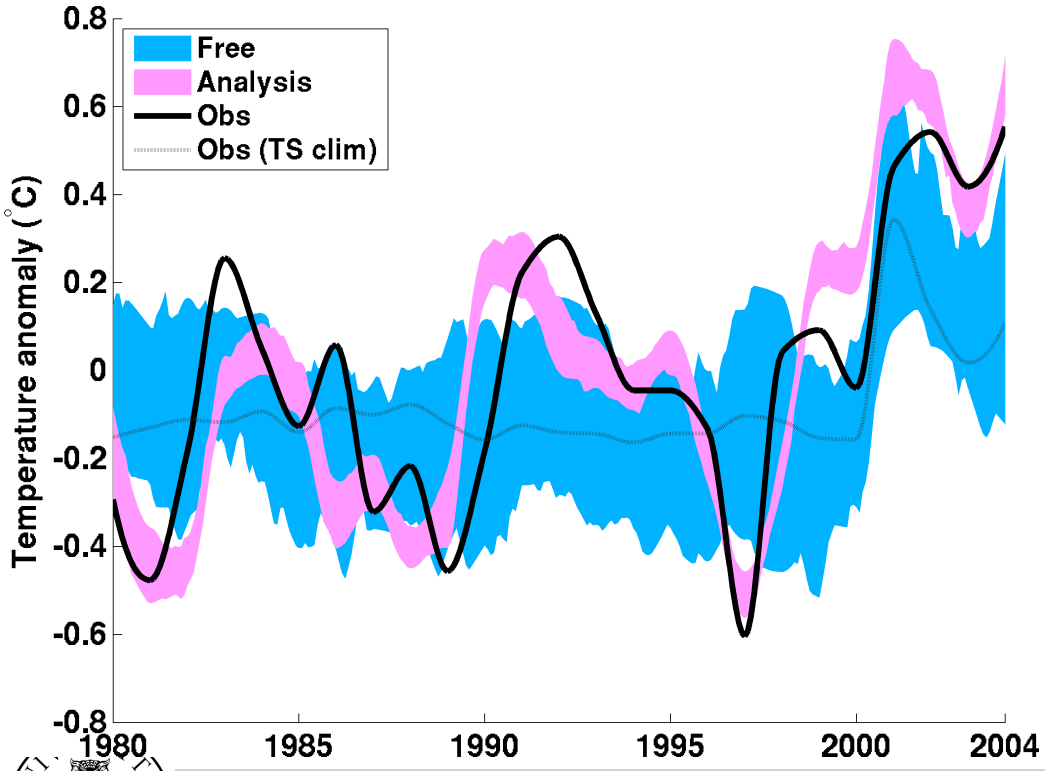


Observed SST data can constrain Nordic Sea Atlantic Layer

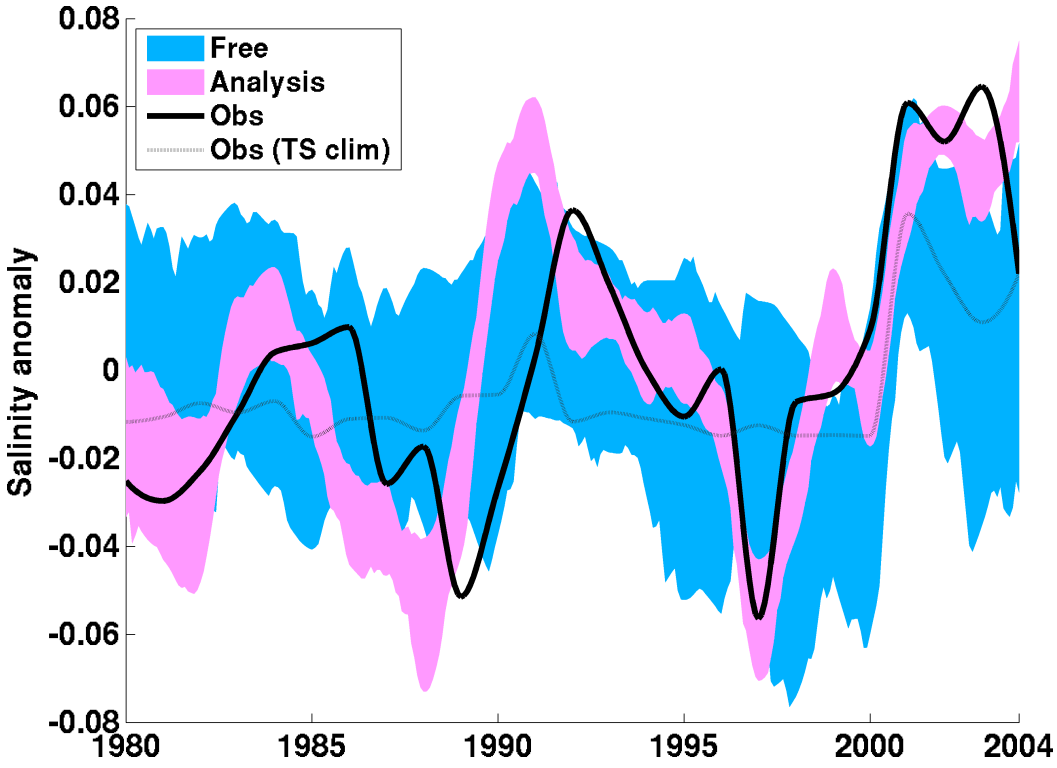
- **Free**, **EnKF-SSTA analysis**, **Observation**

~ 2º Ocean

Temperature anomaly

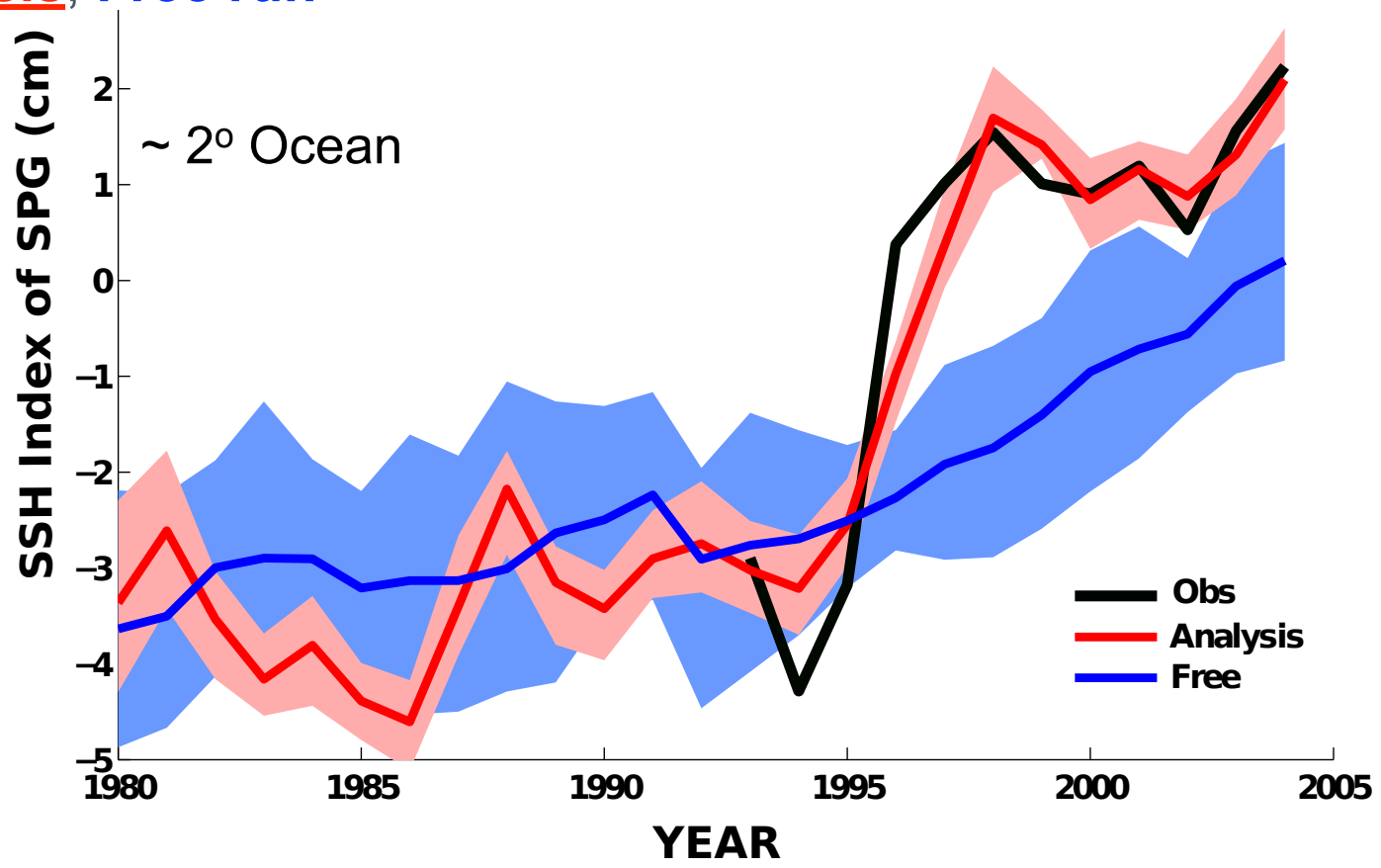


Salinity anomaly



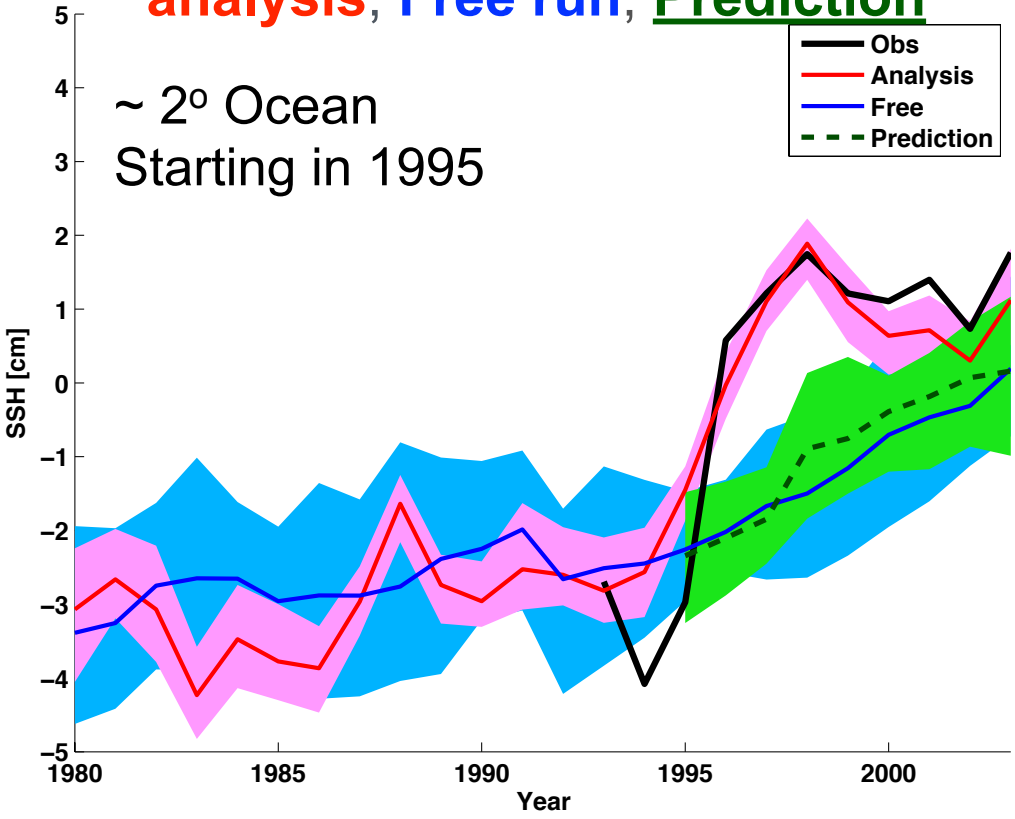
Observed SST data captures the weakening of the North Atlantic Subpolar Gyre (SPG) in the mid-90's

- North Atlantic Subpolar Gyre Strength: **Observed**, **EnKF-SSTA analysis**, **Free run**



Prediction with Anomaly Initialization

- No skill found in predicting SPG index.
- North Atlantic Subpolar Gyre Strength: **Observed**, **EnKF-SSTA analysis**, **Free run**, **Prediction**



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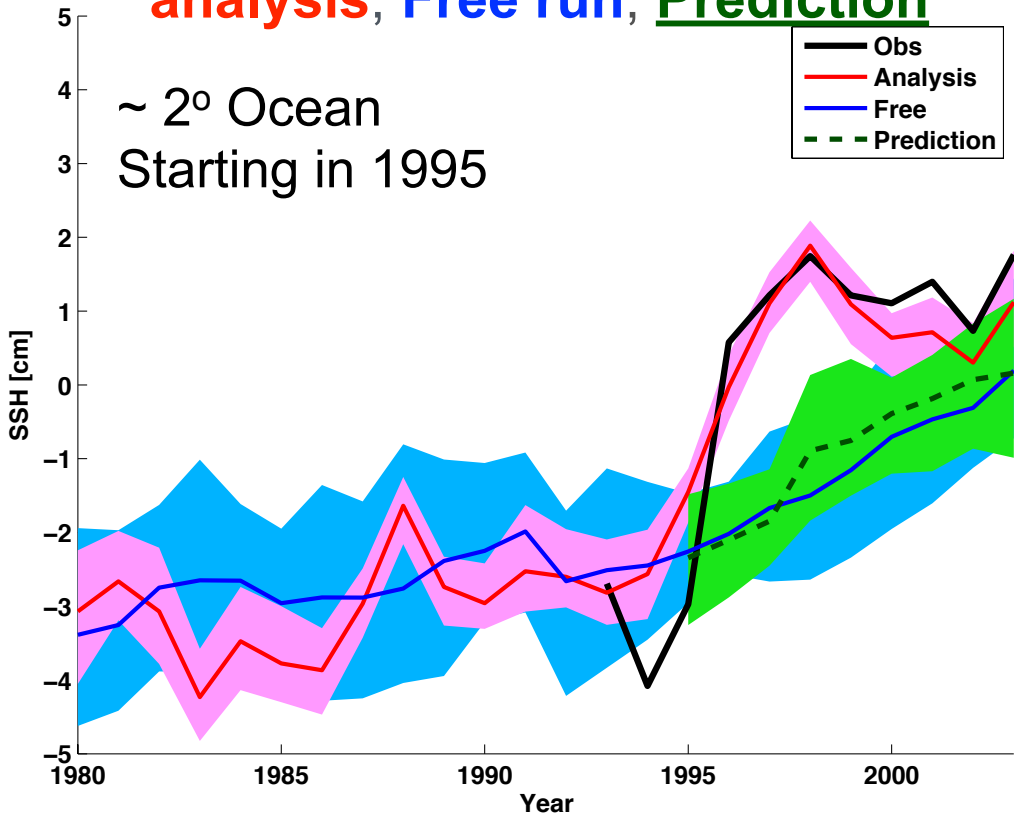
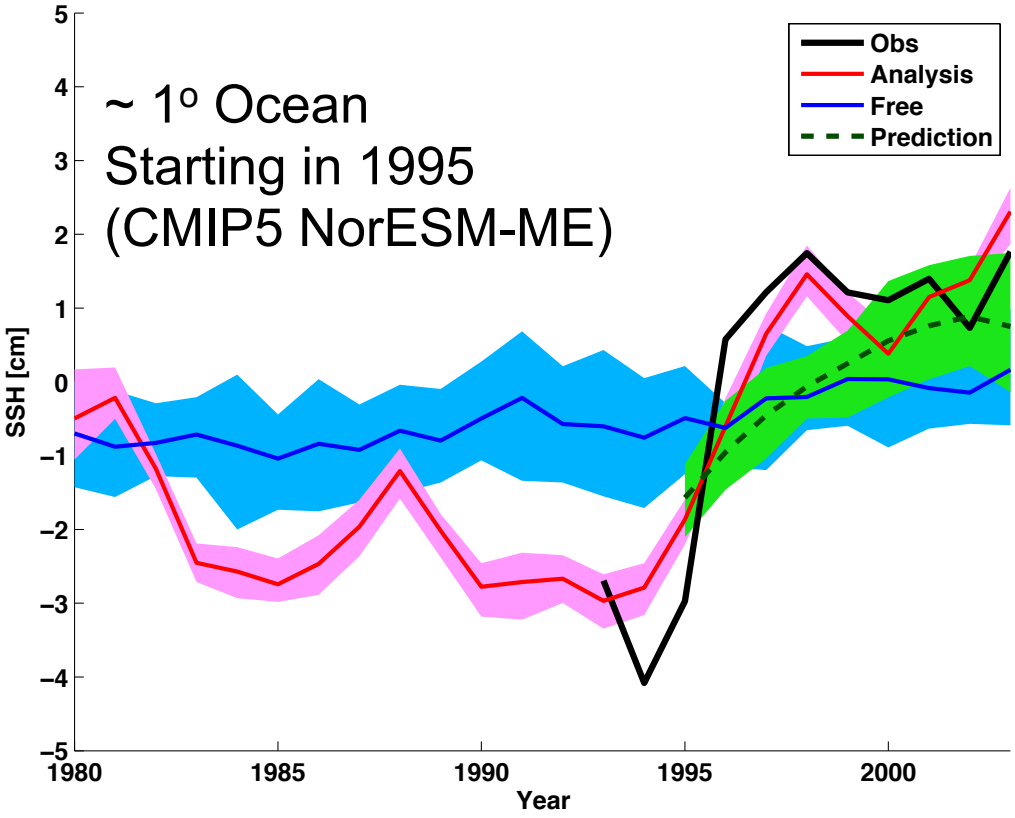
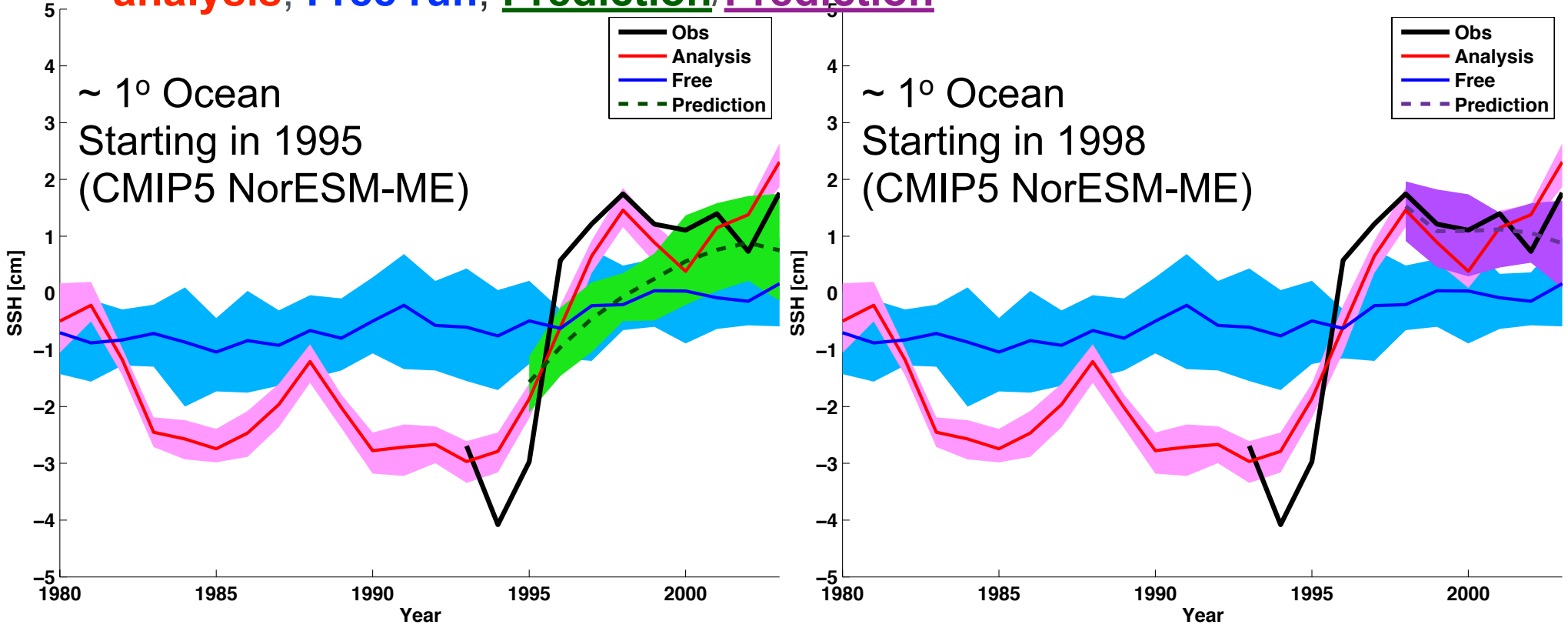




Skill Change due to Different Ocean Resolution

- SPG index is box-averaged SSH [60W-15W,48N-65N]
- North Atlantic Subpolar Gyre Strength: **Observed**, **EnKF-SSTA analysis**, **Free run**, **Prediction**/**Prediction**



Norwegian Climate Prediction Model

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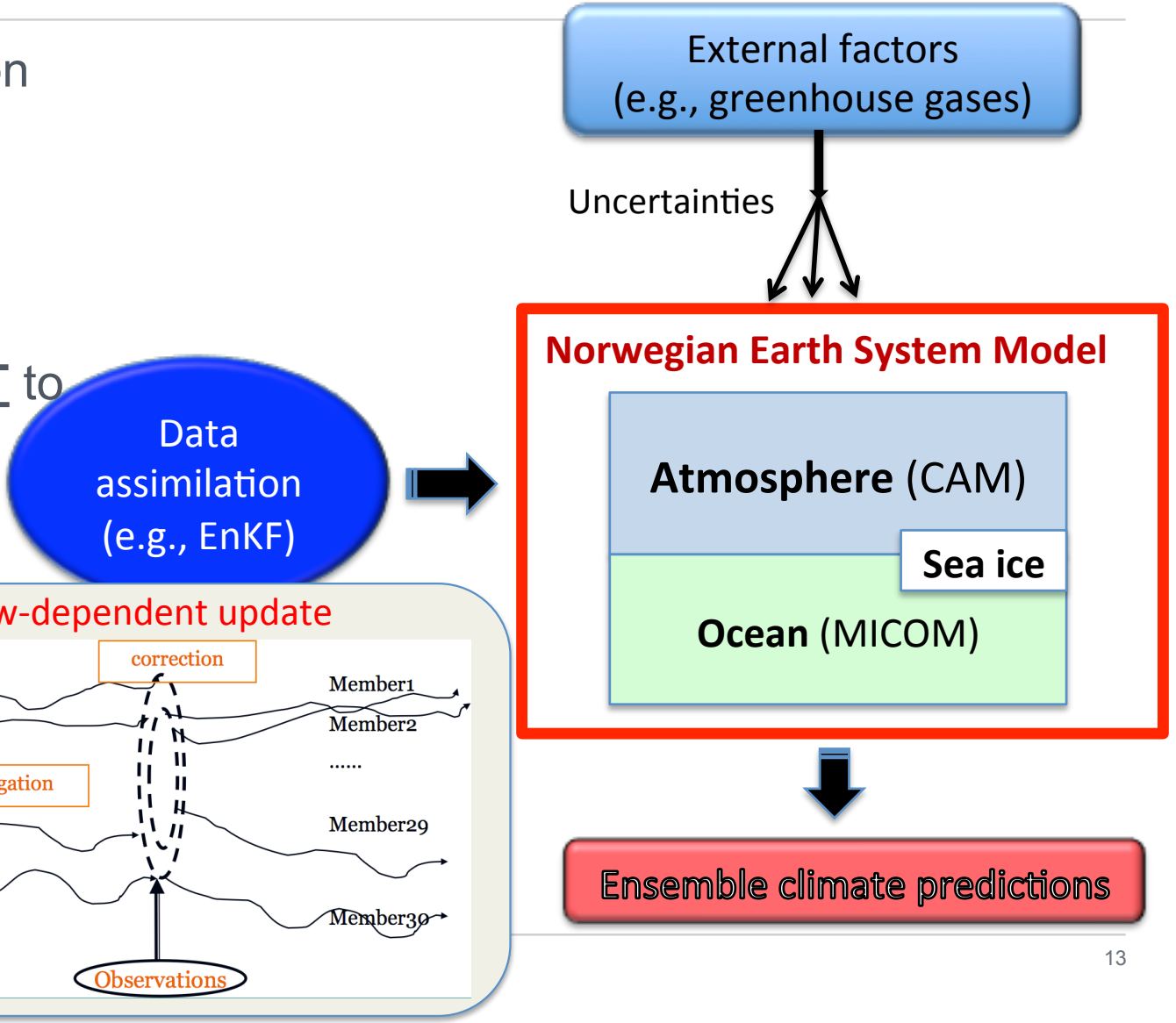
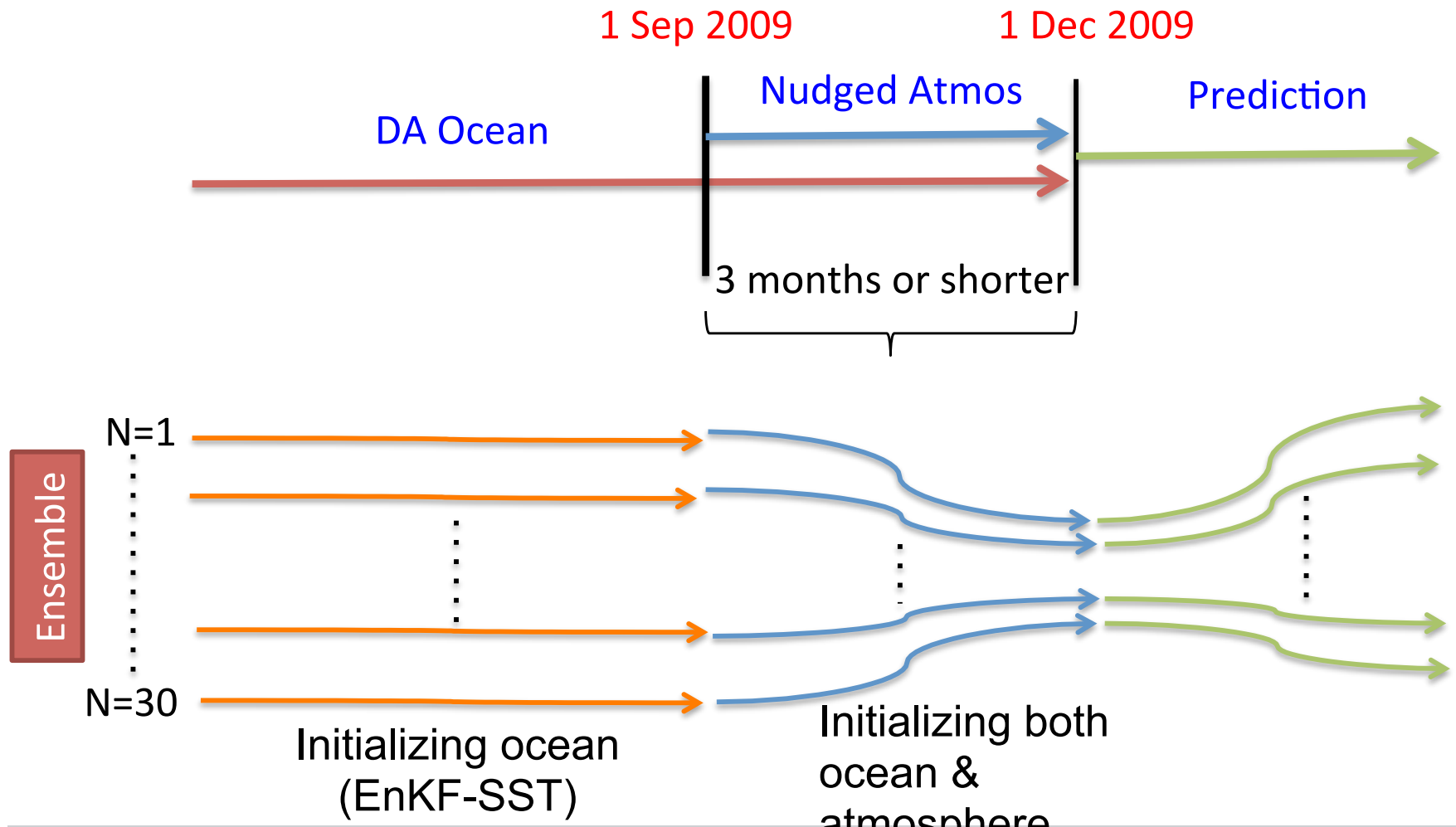
  - ~~EnKF-SSTA~~
  - **EnKF-SST**

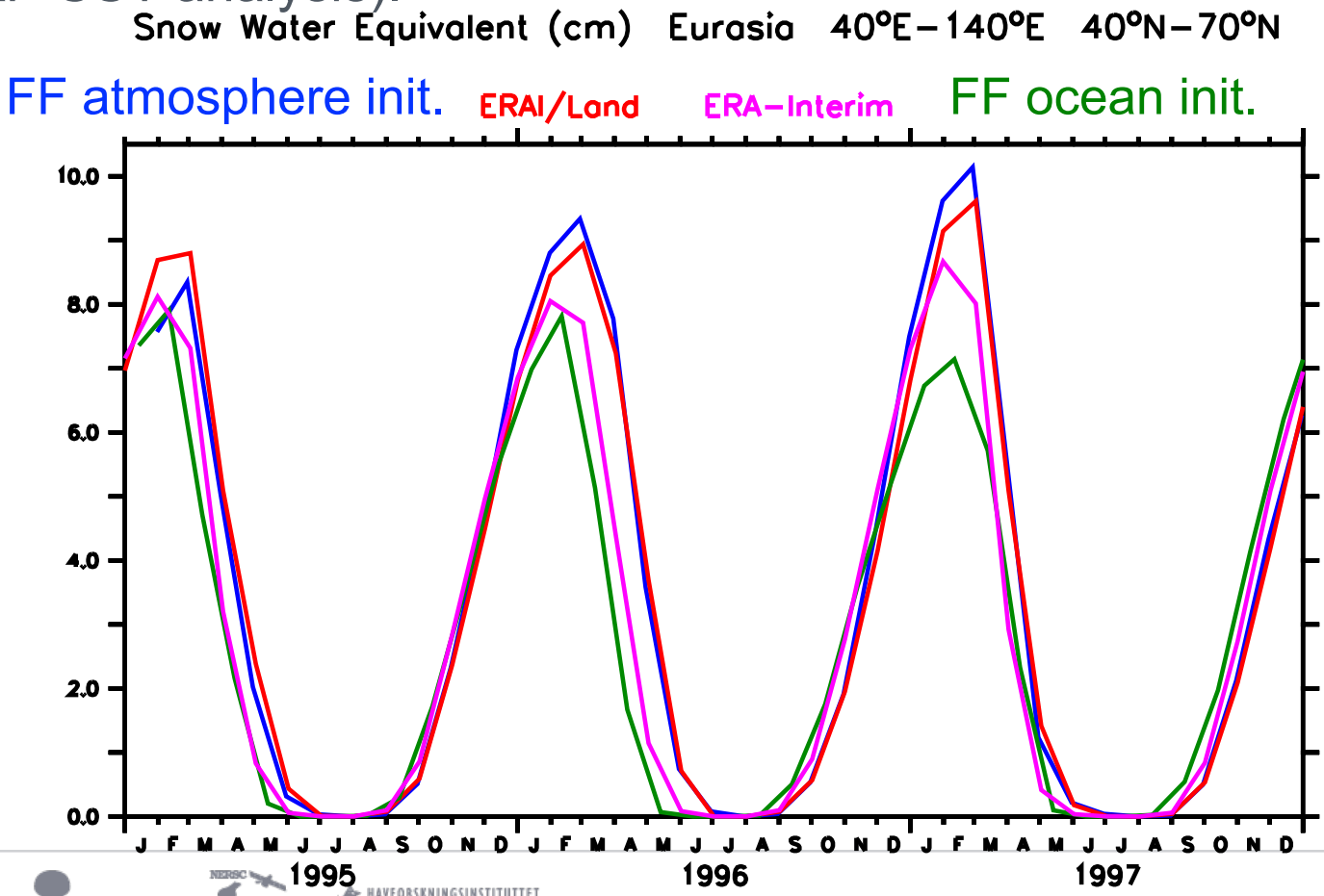


Predication Approach with Full Field Initialization



Snow Initialization

- Snow cannot be properly initialized with full-field ocean initialization (EnKF-SST analysis).



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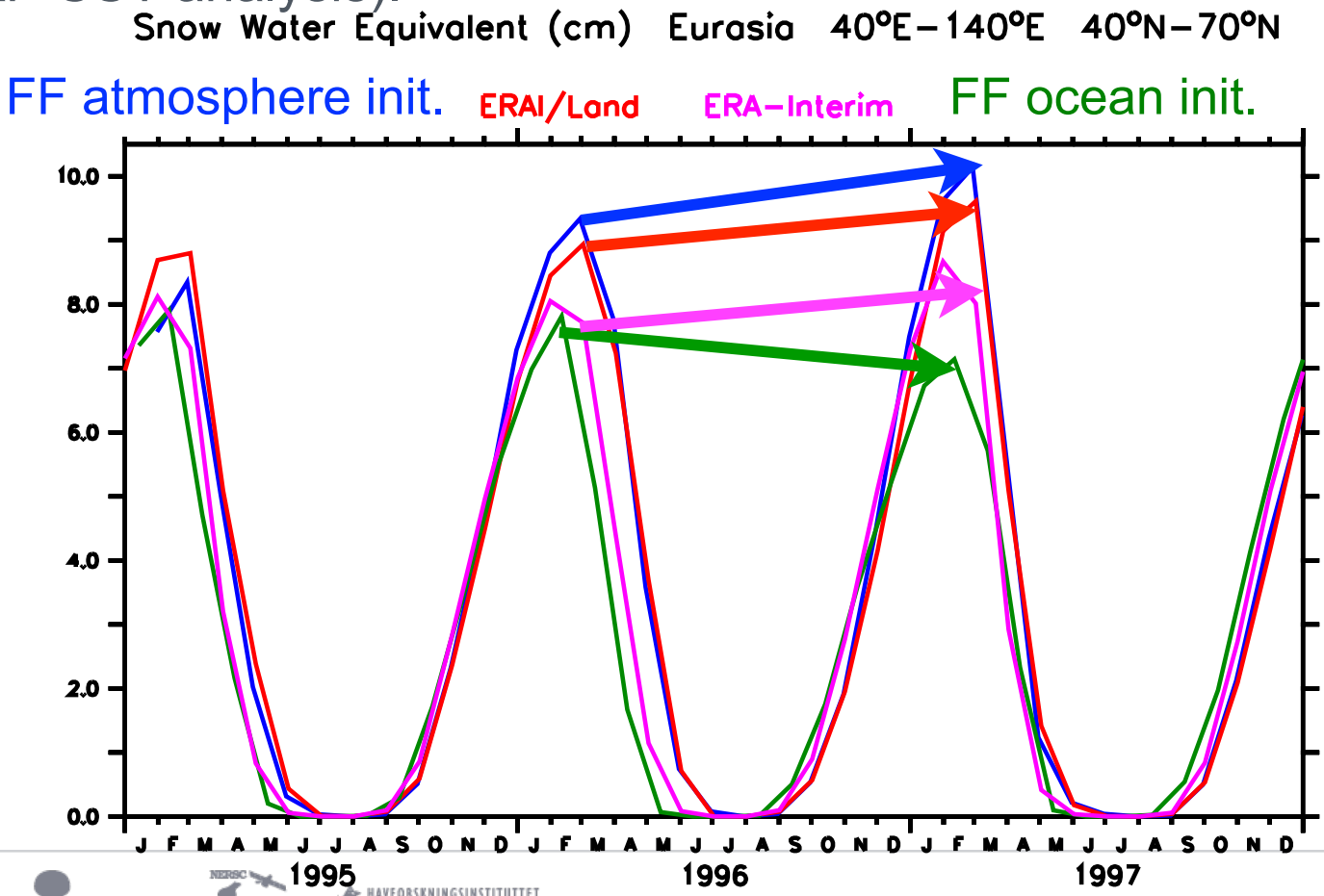


To improve our understanding of seasonal-to-decadal predictability in the Atlantic Sector

- Ongoing work
  - Development of a Climate prediction system
    - To prepare full-field (atm & ocean) initialization (NorESM-ME, CMIP5)
    - To test the skill of atmosphere nudging in initializing land surface
    - (For seasonale-to-decadal prediction towards CMIP6)
  - Mechanisms of the predictability
    - To compare with dataset
      - World Ocean Atlas 2013 (decadal periods: 84-94, 95-04)
    - To evaluate the impacts of ocean heat content and subsurface hydraulic features

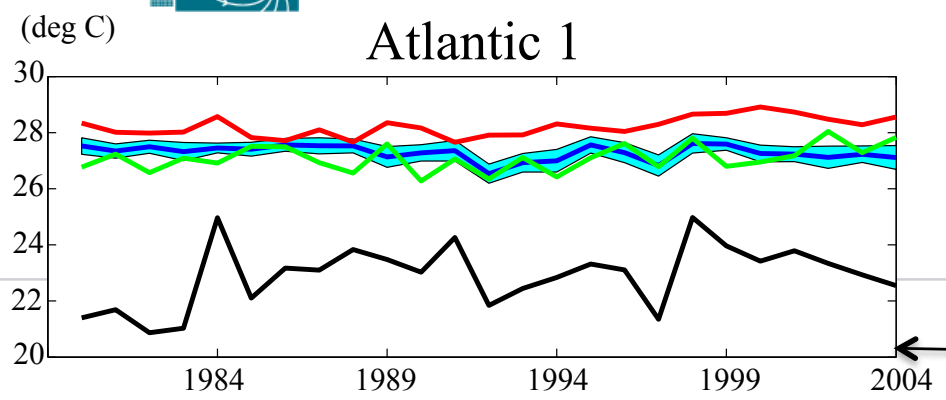
NorCPM Wiki

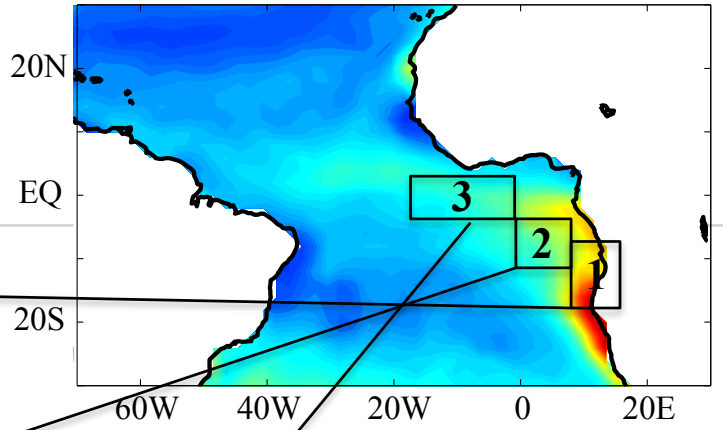
- NorCPM wiki first draft started:
- Presentation page:
- https://wiki.uib.no/norcpm/index.php/Main_Page

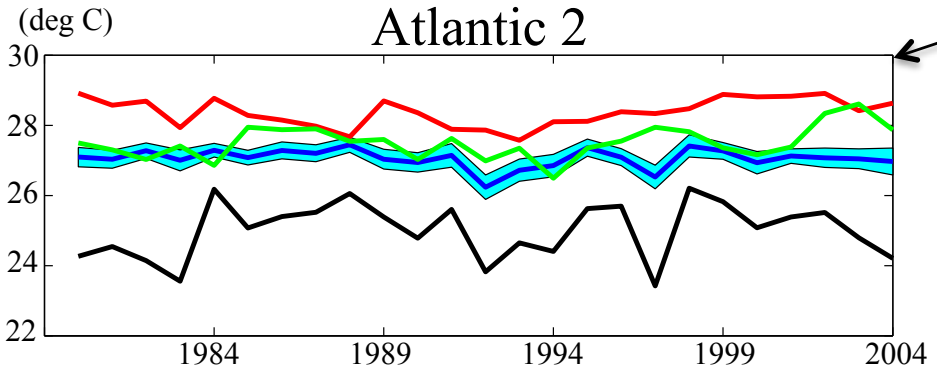
Name on Norstore	NorESM version	observation	ens size	Finished/Ongoing	Remark
First_Try	F19_tn21	SST	30	Finished	minor bug in EnKF, small drift in MSL, good SPG
Second_Try	F19_tn21	SST	30	Finished	small drift in MSL, good SPG
Third_Try	F19_tn21	SST	30	Finished	weak SPG in reanalysis
Fourth_Try	F19_tn21	SST	30	Finished	unrealistic
Fifth_Try	F19_tn21	SST	30	Finished	very mild improvement compare to second
ME	F19_G16	SST	30	ongoing	??
Yiguo_try	F19_tn21	SST	30	ongoing	??
FF_ini_try	F19_tn21	SST	30	Finished	??

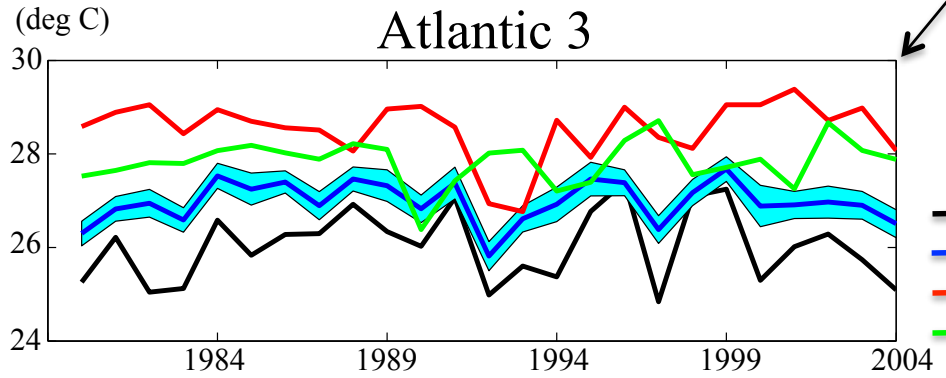
- User Manual:
- https://wiki.uib.no/norcpm/index.php/NorCPM_User_Manual

Thanks for your attention.



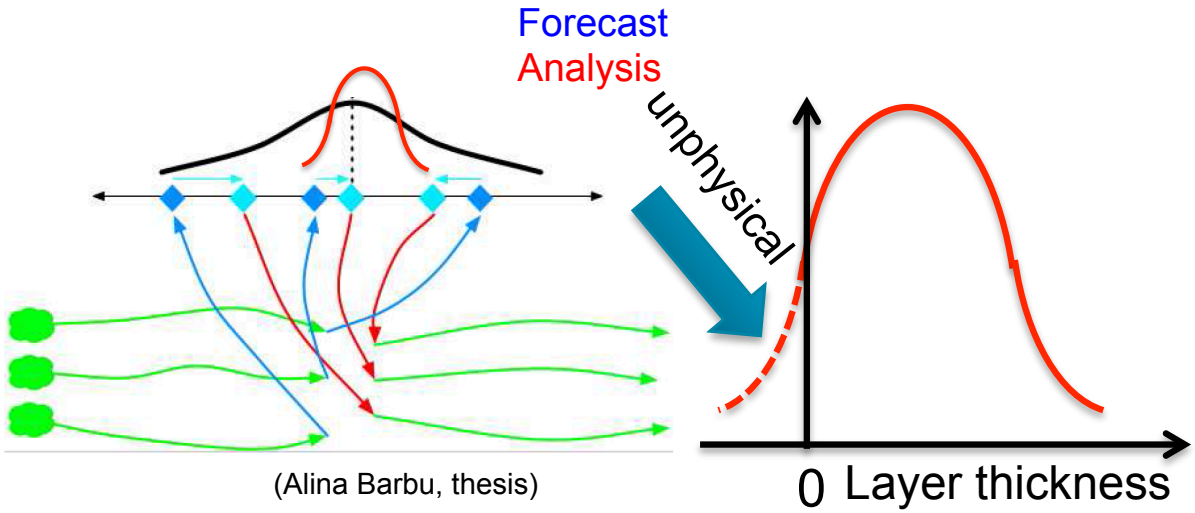






HADISST2
NorCPM(Full)
NorESM
NorESM (intermediate resolution for ocean)

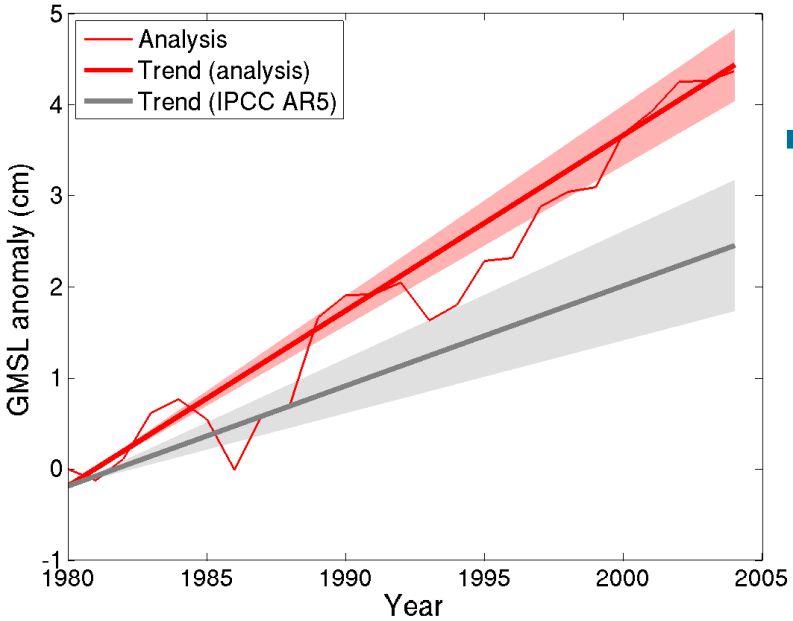
Fixing assimilation drift



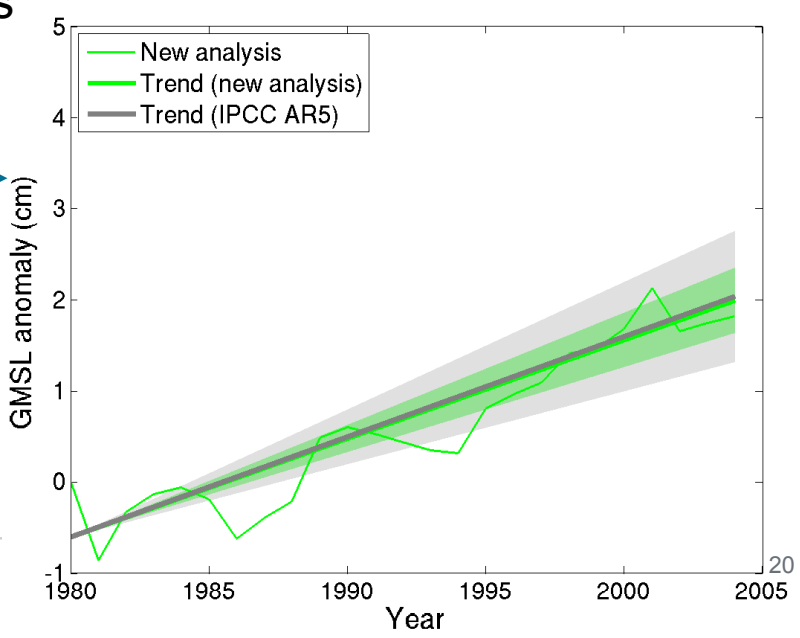
(Alina Barbu, thesis)

- Post-processing of negative value of DP by taking water from neighboring layers.

(Figure courtesy of Y. Wang)

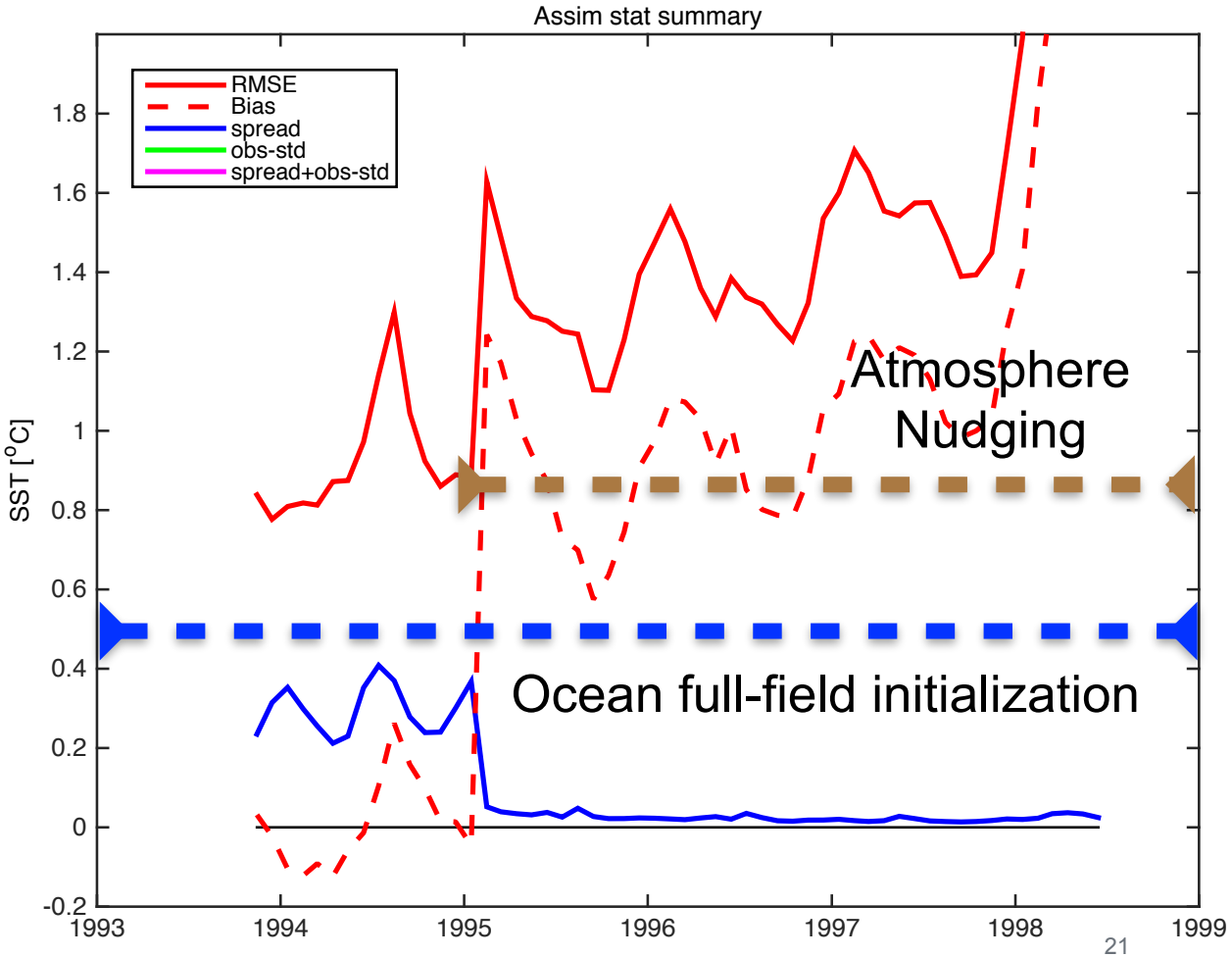


group problematic layers until no unphysical values obtained



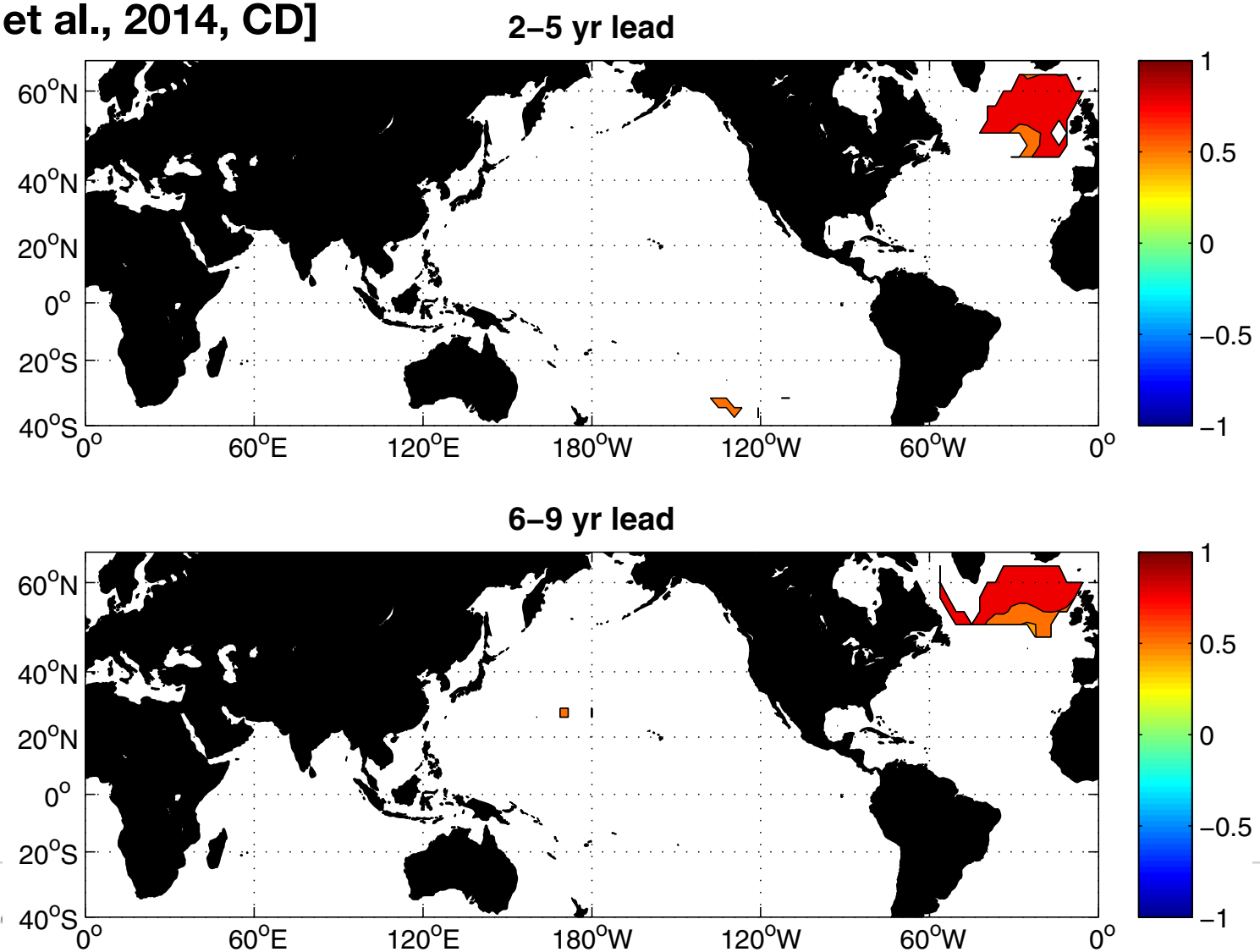
Ready for Prediction?

- Ocean initialization
  - Base on **HadISST**
- Atmosphere nudging
  - 26 level 100% relaxed to met data
  - Met data are interpolated from **ERA-Interim**



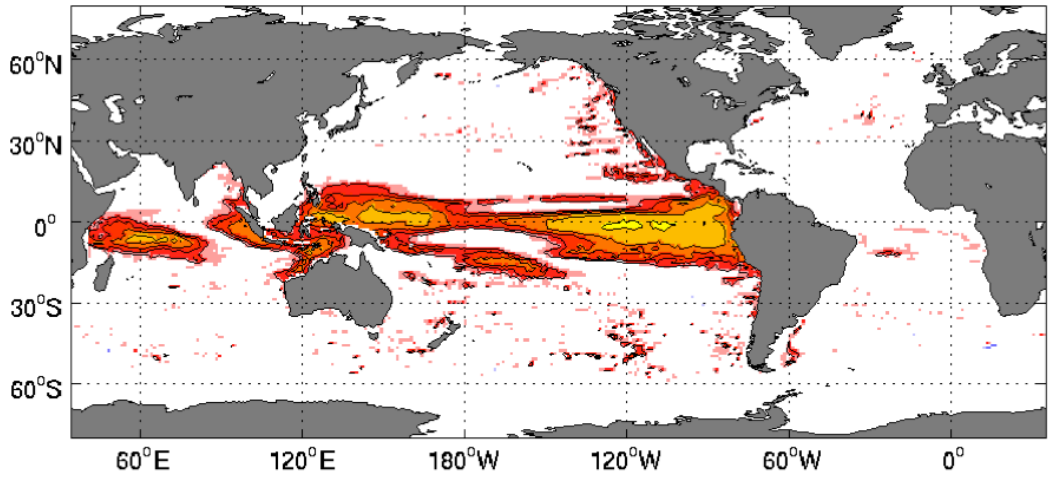
Skill due to Initialization

[Karspeck et al., 2014, CD]

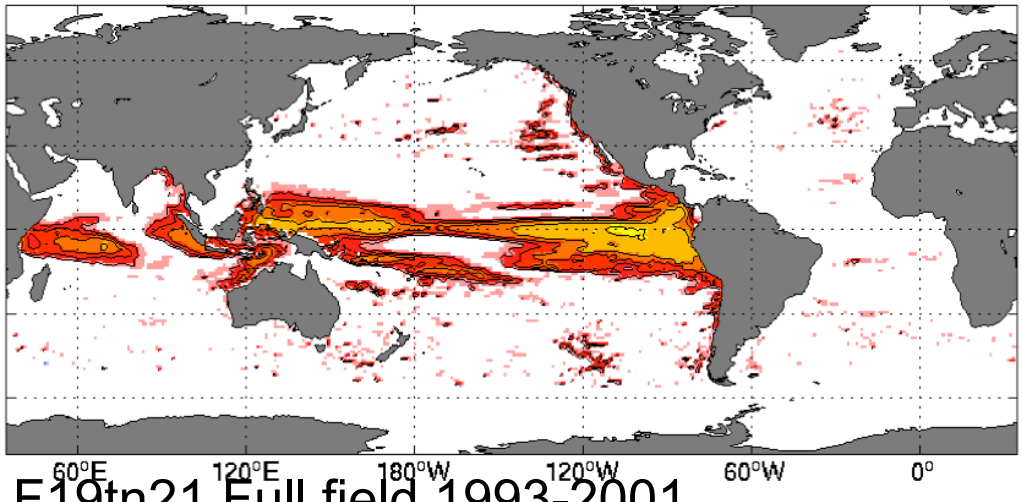


Sea surface height: Correlation between observed and assimilation system

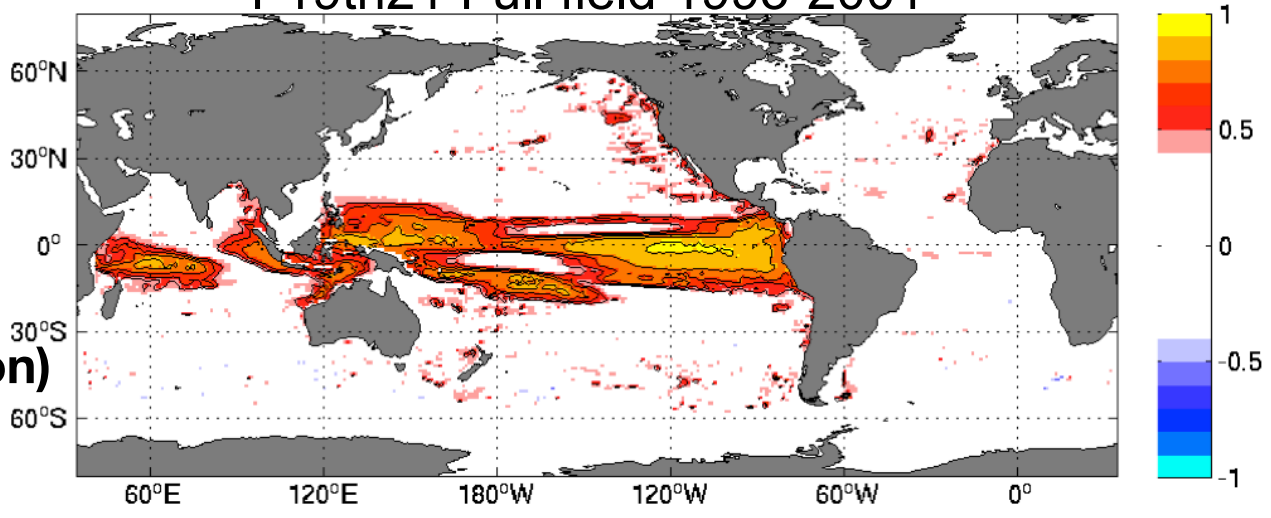
F19tn21 anom 1993-2001



ME anom 1993-2001



F19tn21 Full field 1993-2001



(Figure courtesy of F. Counillon)

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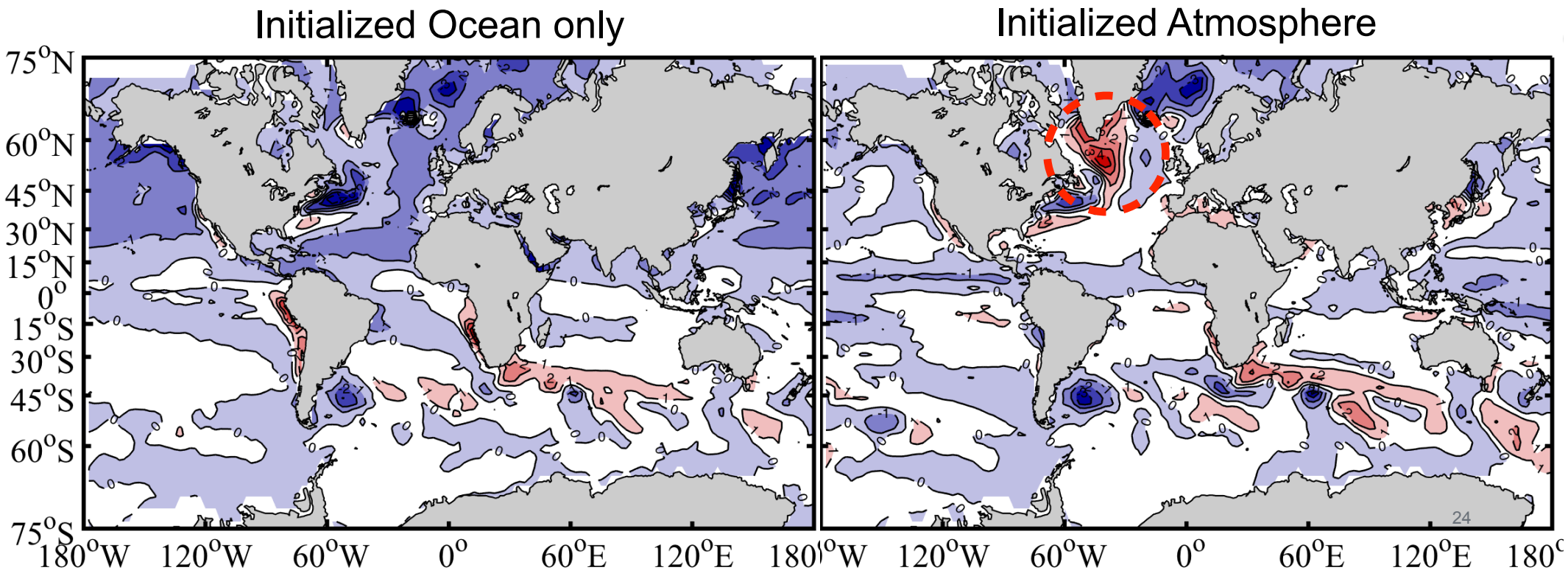
SST Bias of Two Different Experiments

- Annual average over 1996 to 1997
- Tropical bias is smaller.
- Increasing bias over Subpolar gyre.



ERA-Interim/Land

- ERA-Interim/Land is a global reanalysis of land-surface parameters from 1979-2010 at 80 km spatial resolution. It was produced with a recent version of the HTESSEL land-surface model.

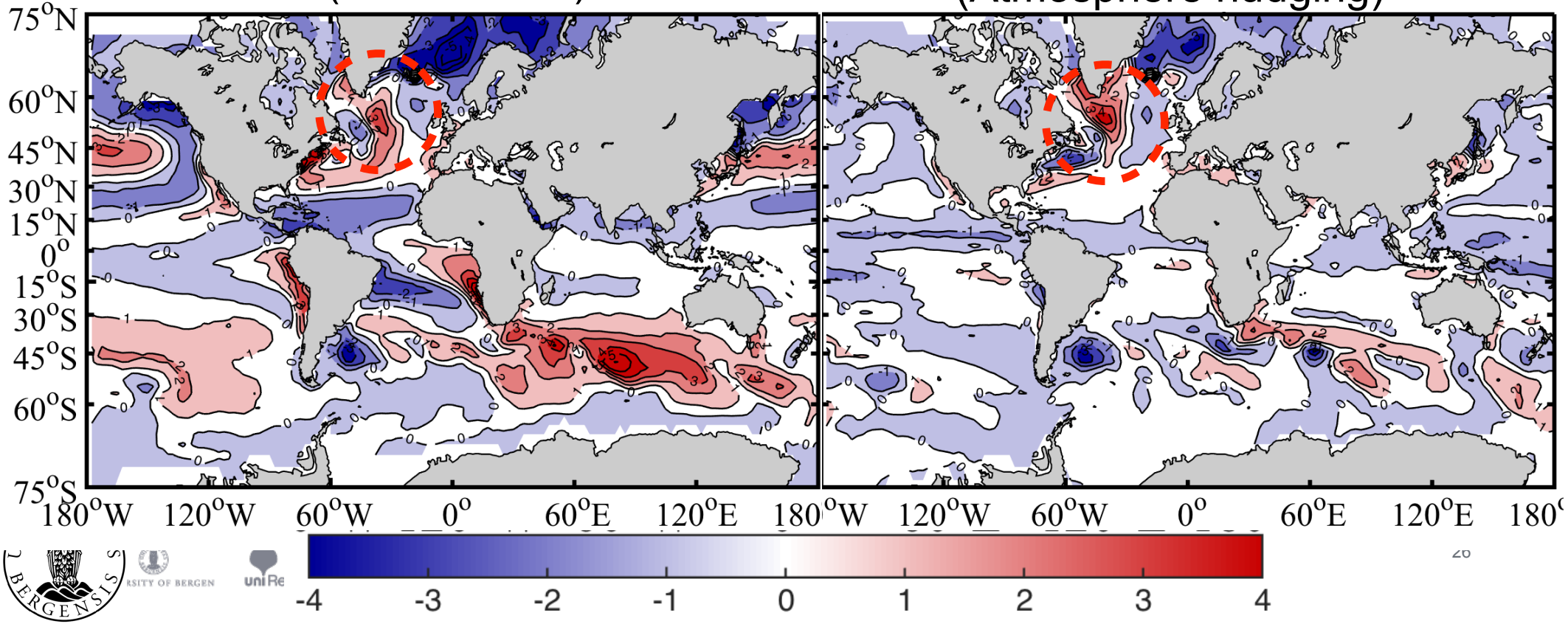
- Simulation with the latest ECMWF land surface model driven by meteorological forcing from the ERA-Interim atmospheric reanalysis and **precipitation adjustments based on Global Precipitation Climate Project**. ERA-Interim/Land preserves **closure of the water balance** and includes a number of parameterisations improvements in the land surface scheme with respect to the original ERA-Interim dataset, which makes it suitable for climate studies involving land water resources.

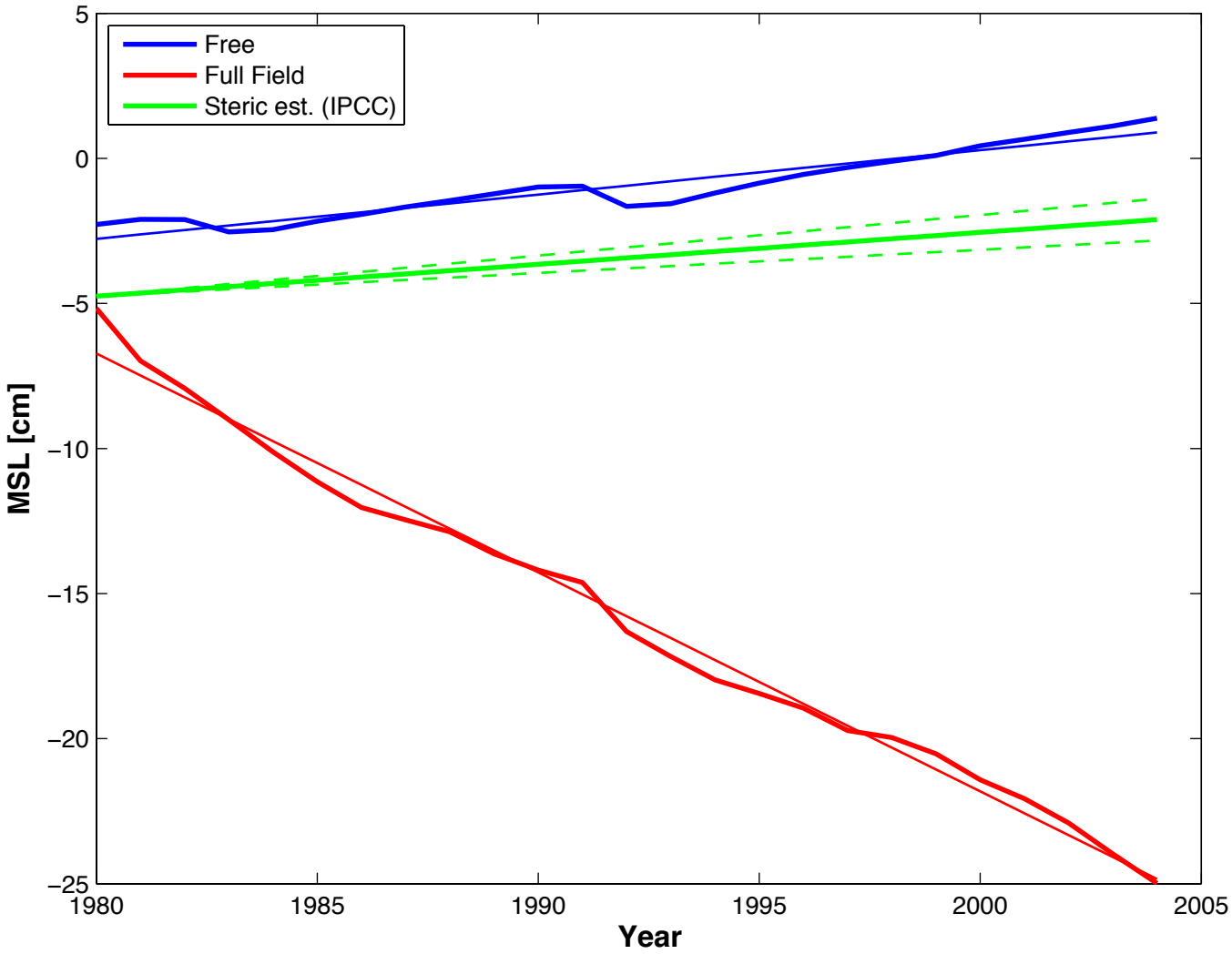
SST Bias of Two Different Experiments

- Annual average over 1996 to 1997
- Overall bias is smaller; Increasing warm bias over Subpolar gyre.

Anomaly initialization
(EnKF-SSTA)

Full-field Atmosphere initialization
(Atmosphere nudging)




Free
Full Field
Steric est. (IPCC)
MSL [cm]
Year
5
0
−5
−10
−15
−20
−25
1980
1985
1990
1995
2000
2005

Drift of SSH in FF-initialization Ocean