Centro Euro-Mediterraneo per i Cambiamenti Climatici

Decadal Predictions at CMCC

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1.1 The Consortium Members

Centro Italiano Ricerche Aerospaziali

Istituto Nazionale di Geofisica e Vulcanologia

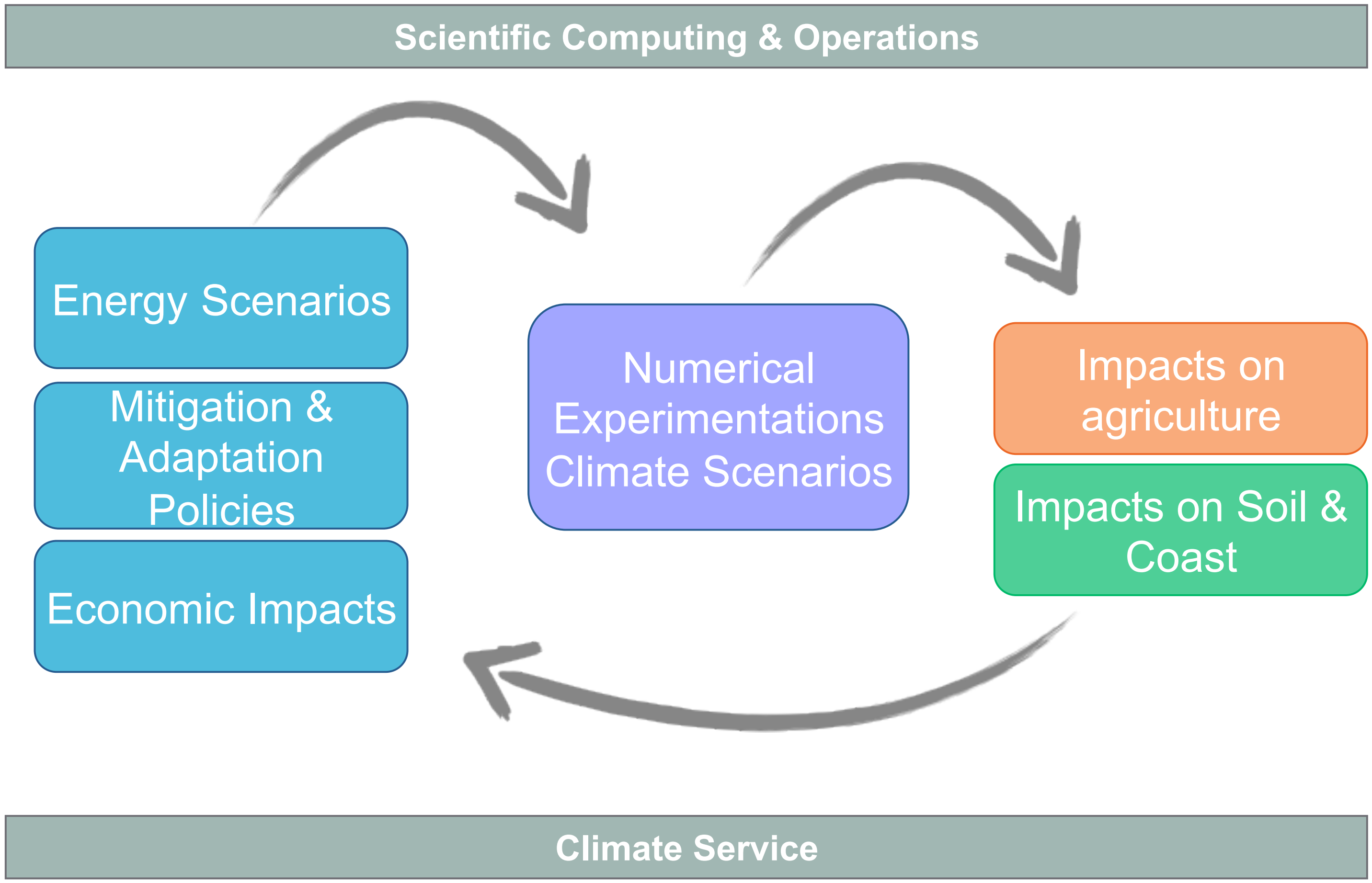
Università degli Studi del Salento

Consorzio Venezia Ricerche

Fondazione Eni Enrico Mattei

Università degli Studi del Sannio

3. Six Integrated Divisions



2.3 Training Activities

- **Doctorate School in Global Change Science and Policy – ChangeS**
  In partnership with: University of Venice, University of Salento, University of Sassari

- Aim: promoting and coordinating advanced studies on climate change impacts and policy

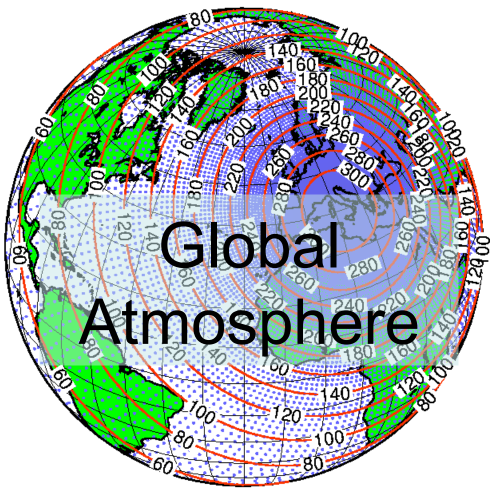
- Activities: advanced training and research activities with emphasis on the development of innovative management strategies for both physical and socio-economic climate related phenomena.

  4 Ph.D. programs currently active on:
  - **Science and Management of Climate Change** – Venice, Bologna
  - **Environmental and Energy Systems** – Lecce
  - **Climate Change Sciences** - Lecce
  - **Agriculture and Forestry Systems** – Sassari

- A structured **Winter and Summer Schools Programme**

Decadal Predictions at CMCC

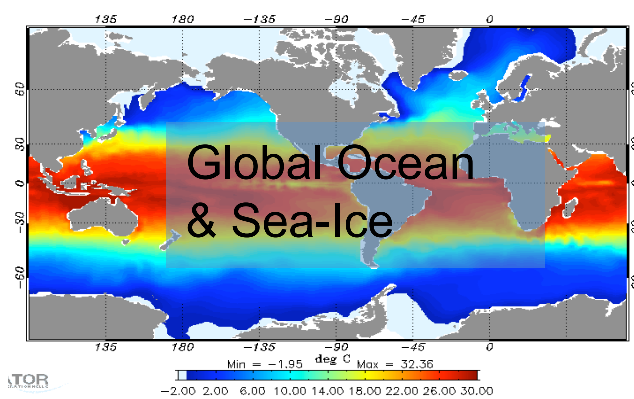
The CMCC-CM model



ATMOSPHERE

ECHAM5 T159L39 (~ 80 Km)

COUPLER Oasis 3



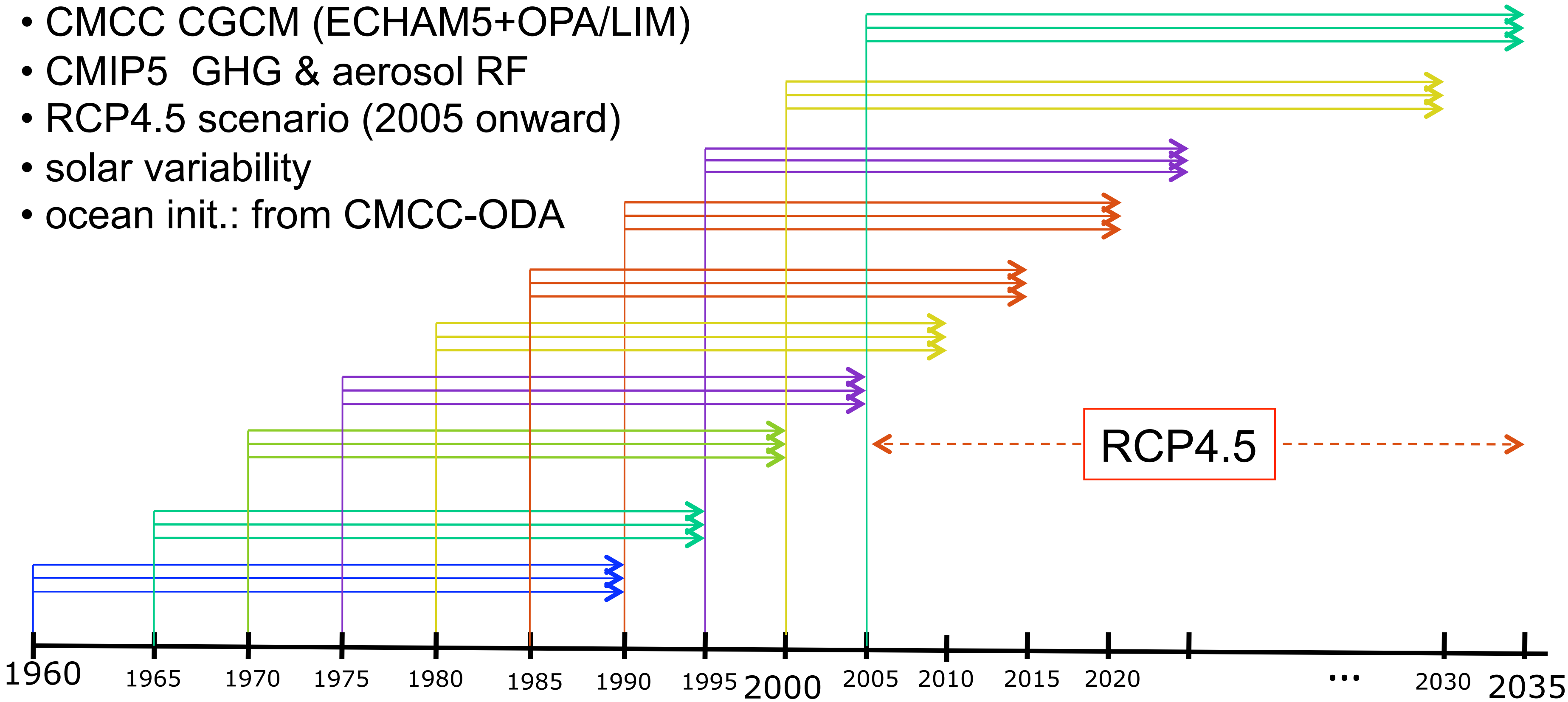
OCEAN:
OPA 8.2/ORCA2 (2º-1/2°)

SEA-ICE: LIM

Decadal Predictions: experiment setup

◆ 30-year hindcast/forecast simulations grouped into 3-members ensembles, for different start dates.

- CMCC CGCM (ECHAM5+OPA/LIM)
- CMIP5 GHG & aerosol RF
- RCP4.5 scenario (2005 onward)
- solar variability
- ocean init.: from CMCC-ODA



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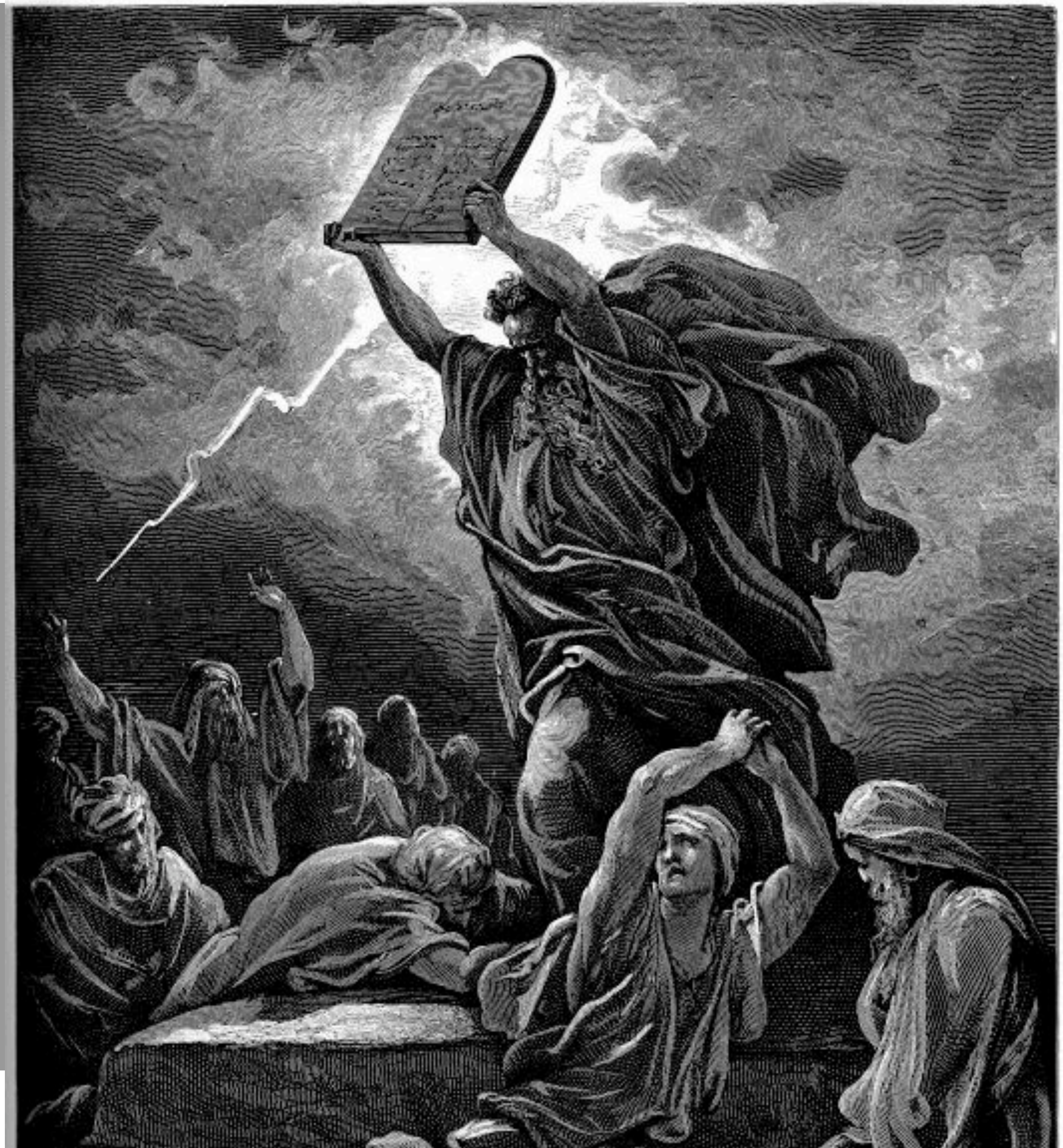
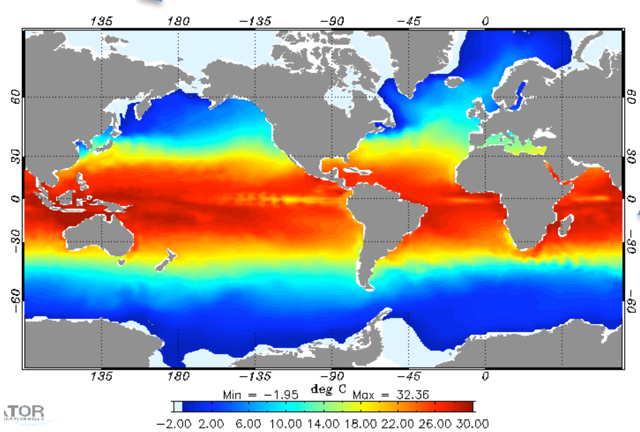


Initialization

- Ocean Initialization: Full fields from CMCC ocean analyses (OI and 3DVAR)
- Sea-ice: model climatology

Sea-Ice & Snow thickness
init.: model climatology



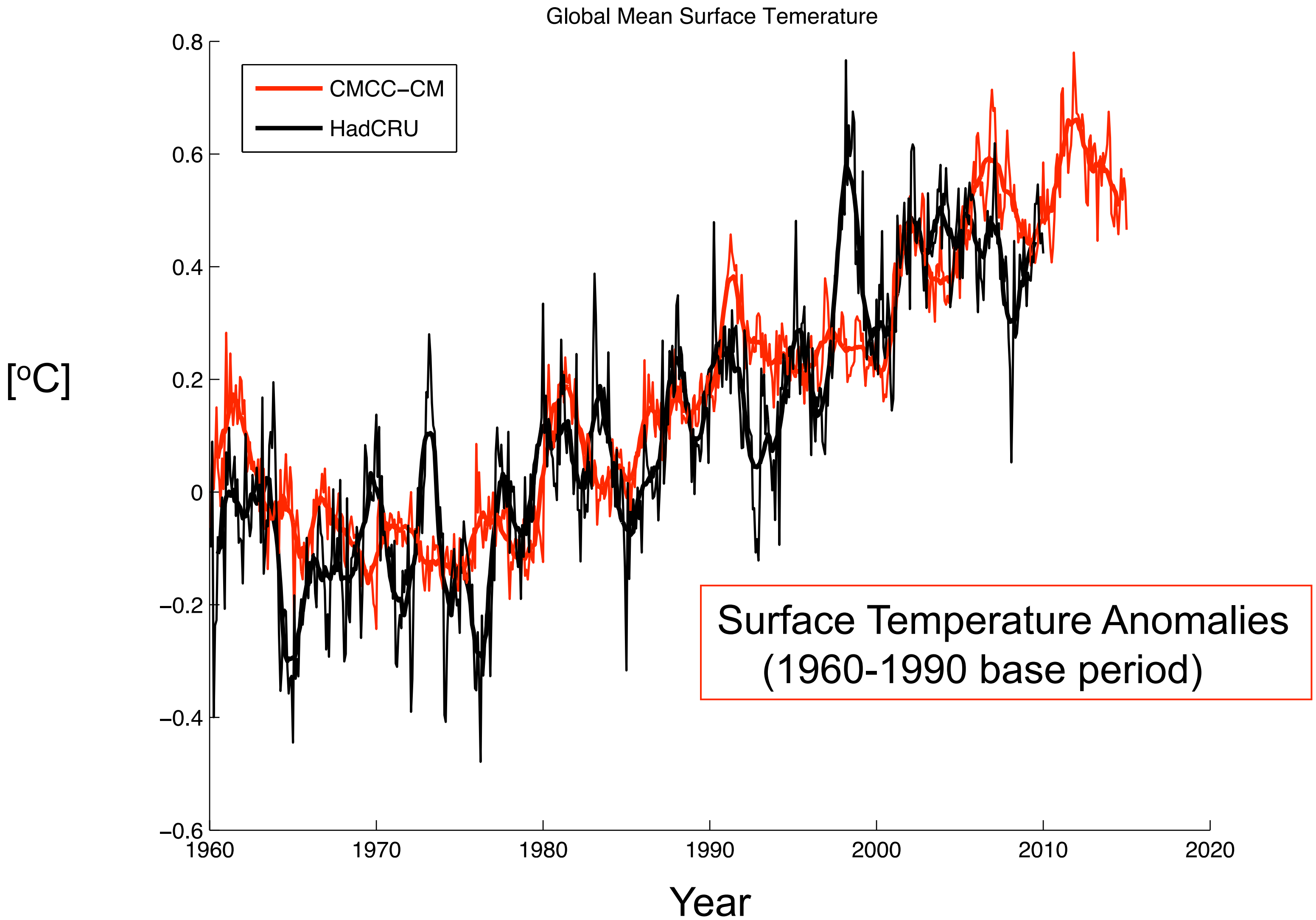
OCEAN: different analyses (strategy adopted to generate the ensemble spread)

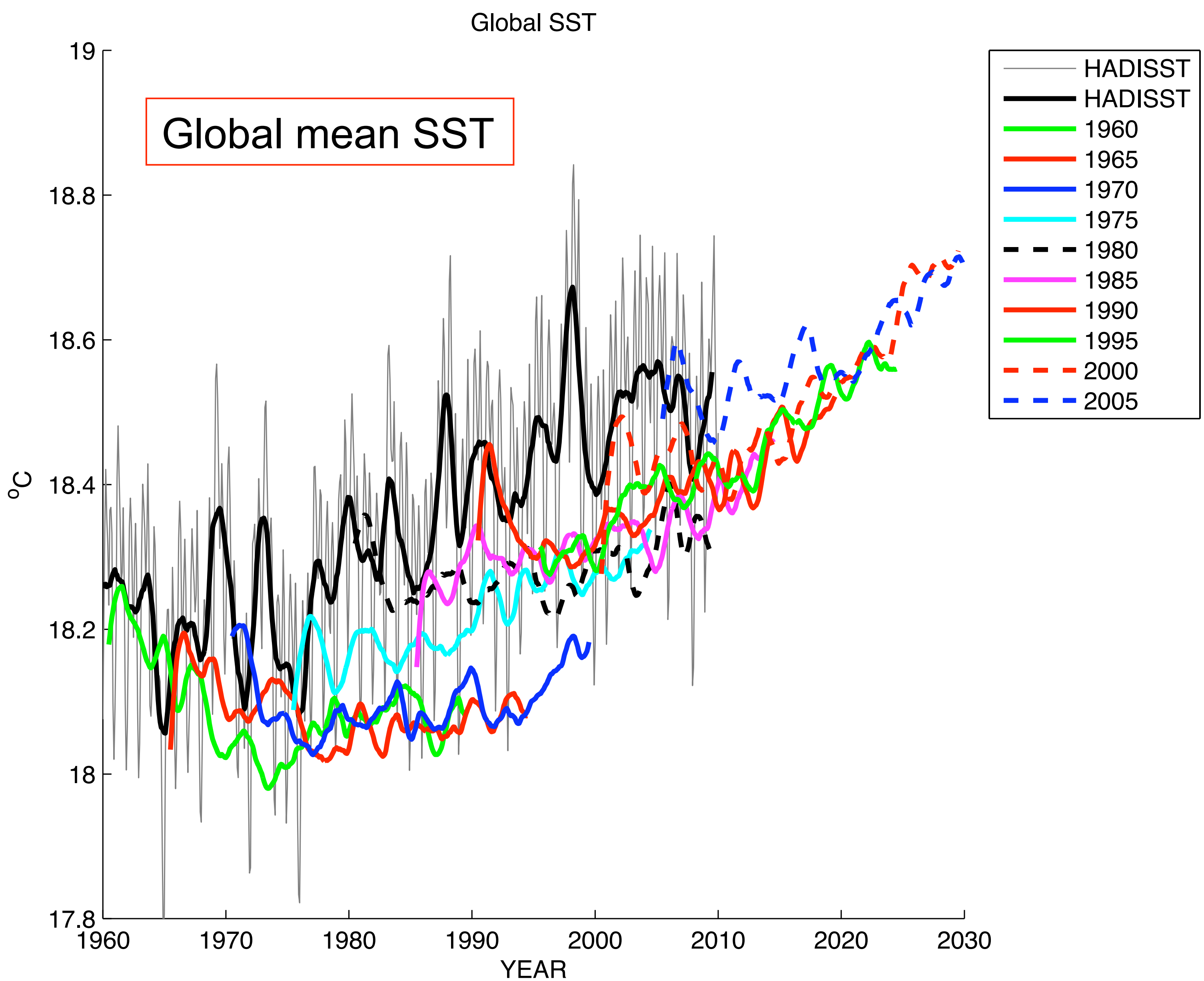
CMCC - OI

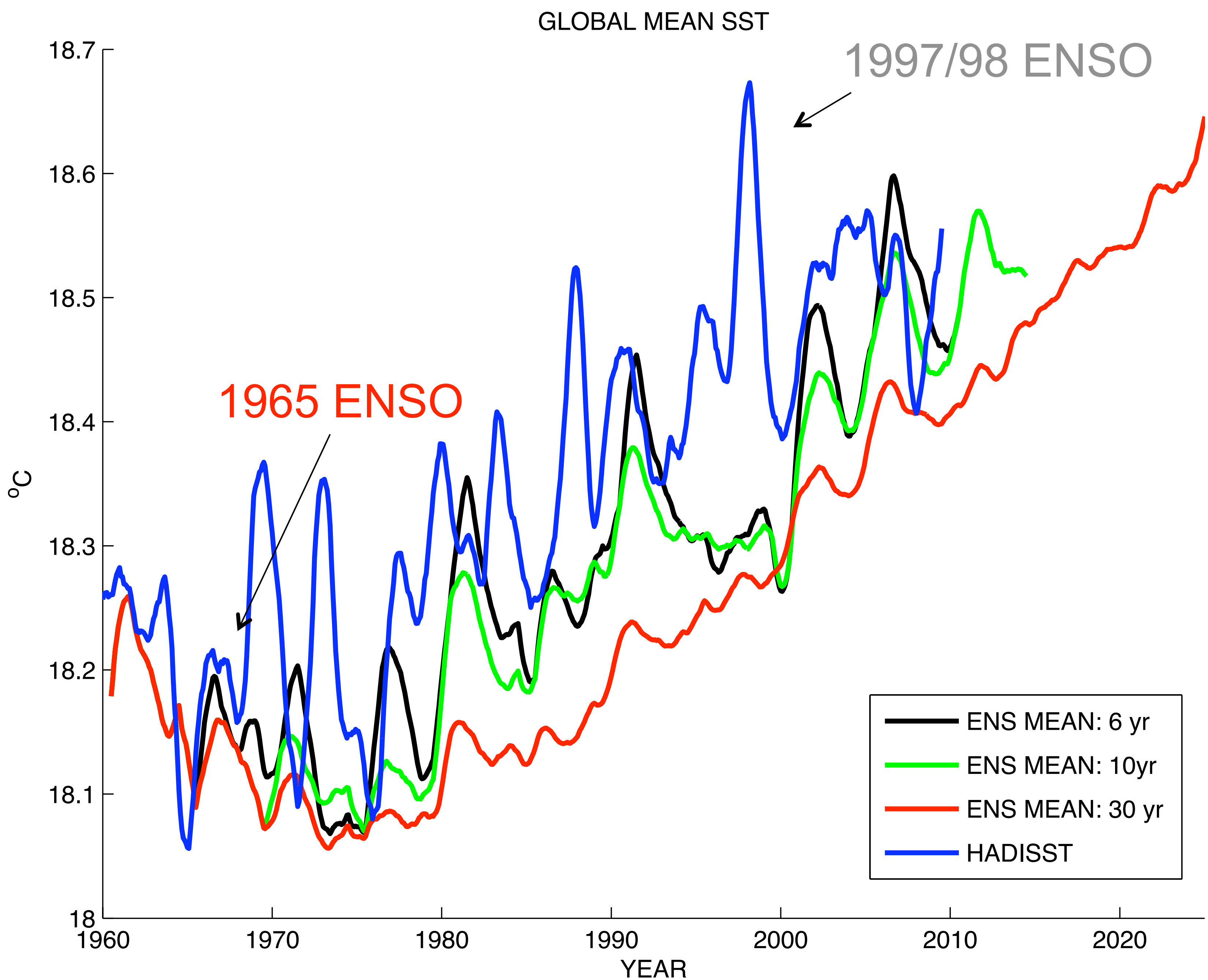
CMCC – 3DVAR1

CMCC – 3DVAR2

• Decadal Predictions : Stream1 completed

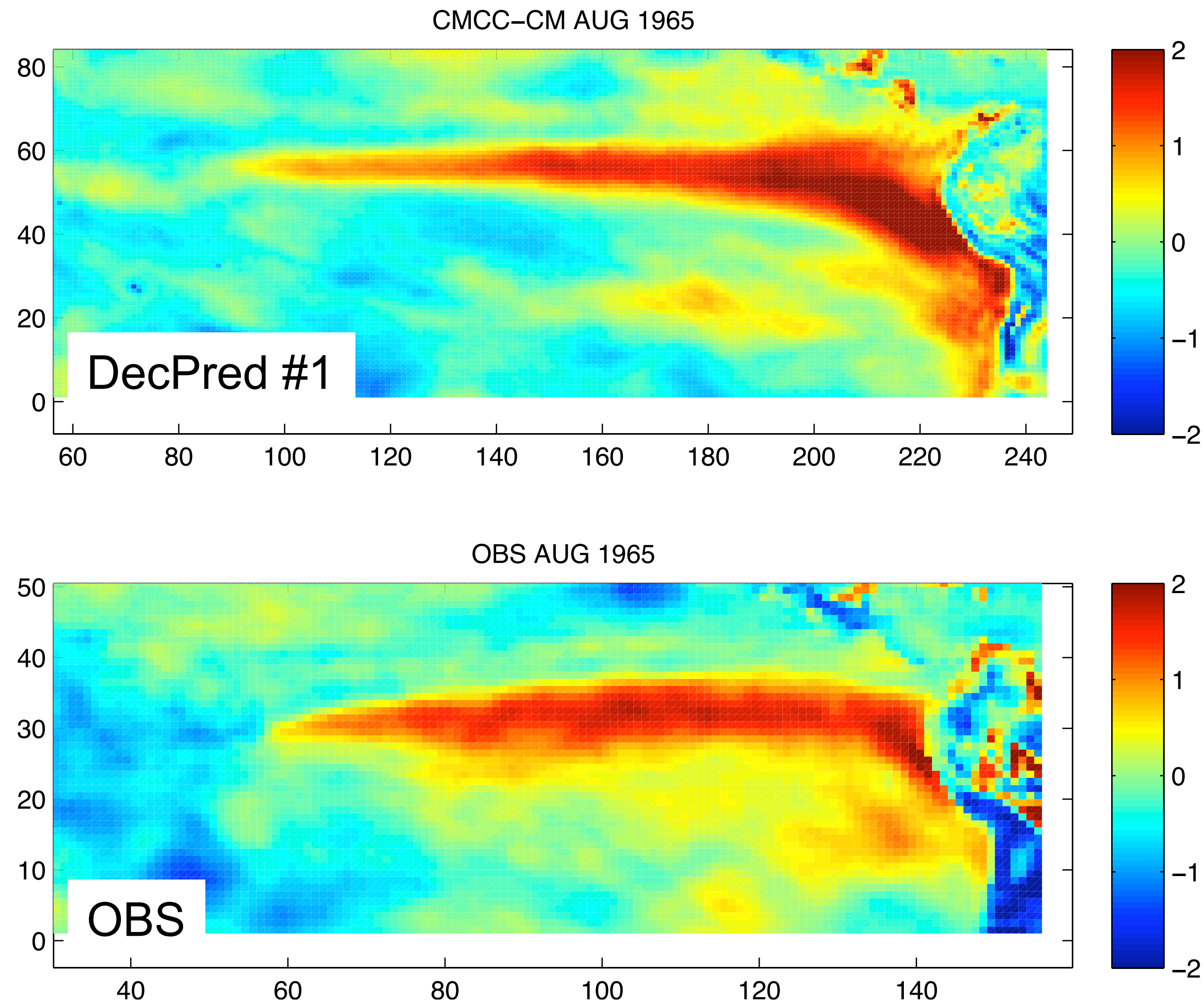



Global SST
Global mean SST
HADISST
HADISST
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
19
18.8
18.6
18.4
18.2
18
17.8
°C
1960
1970
1980
1990
2000
2010
2020
2030
YEAR

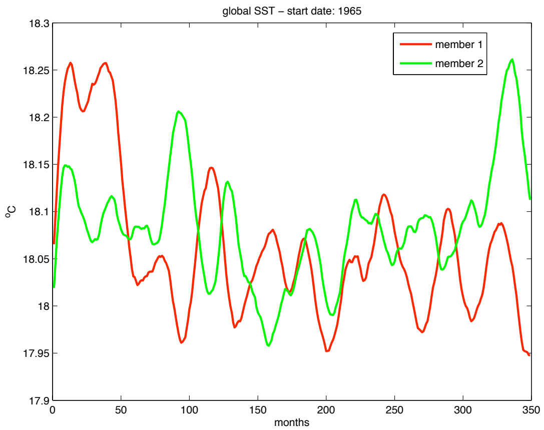


GLOBAL MEAN SST
1997/98 ENSO
1965 ENSO
18.7
18.6
18.5
18.4
18.3
18.2
18.1
18
oC
1960
1970
1980
1990
2000
2010
2020
YEAR
ENS MEAN: 6 yr
ENS MEAN: 10yr
ENS MEAN: 30 yr
HADISST

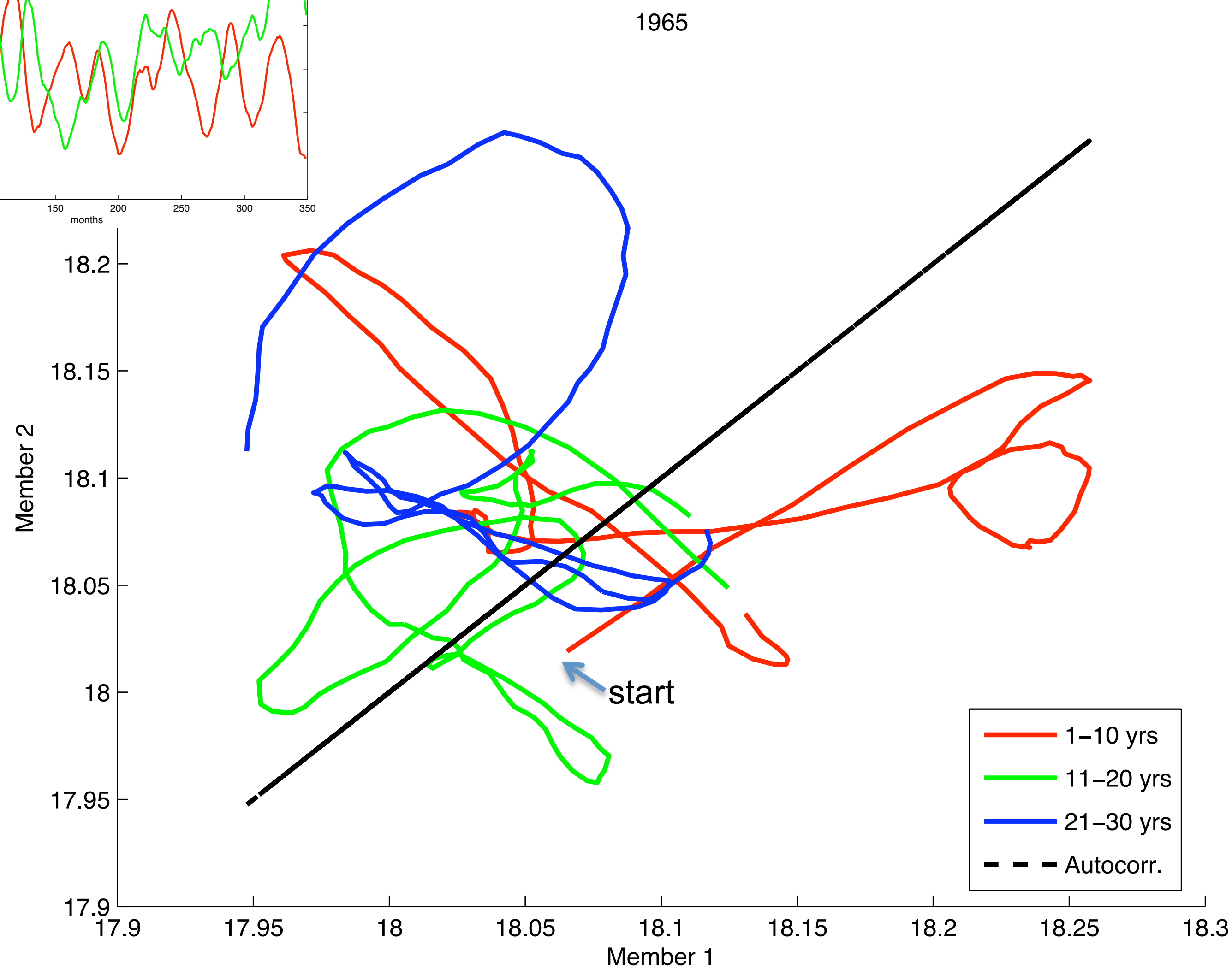
ENSO 1965 Prediction



Surface Temperature Anomaly



Global mean SST : member 1 & 2 scatterplot



Predictability limits: loss of consensus between ensemble members

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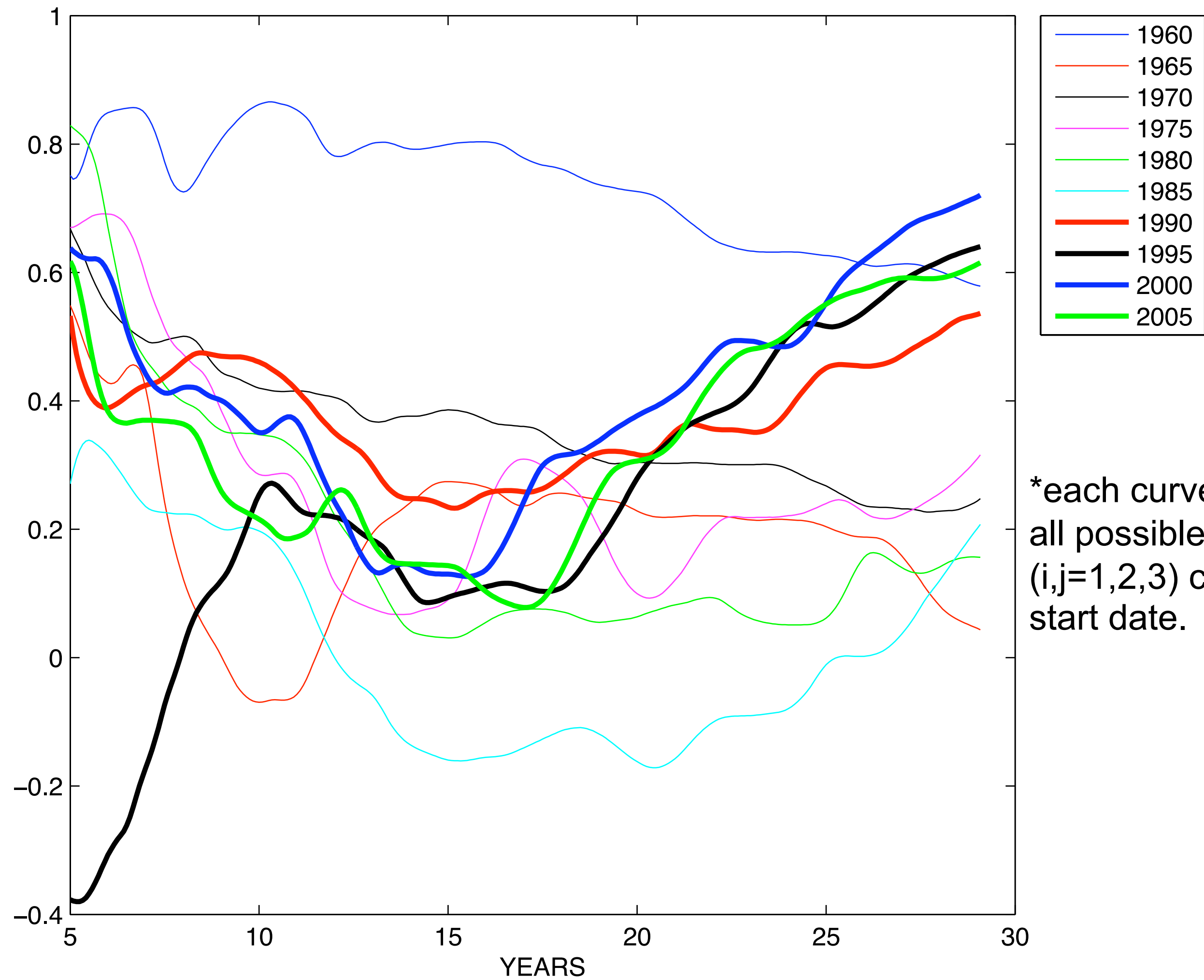
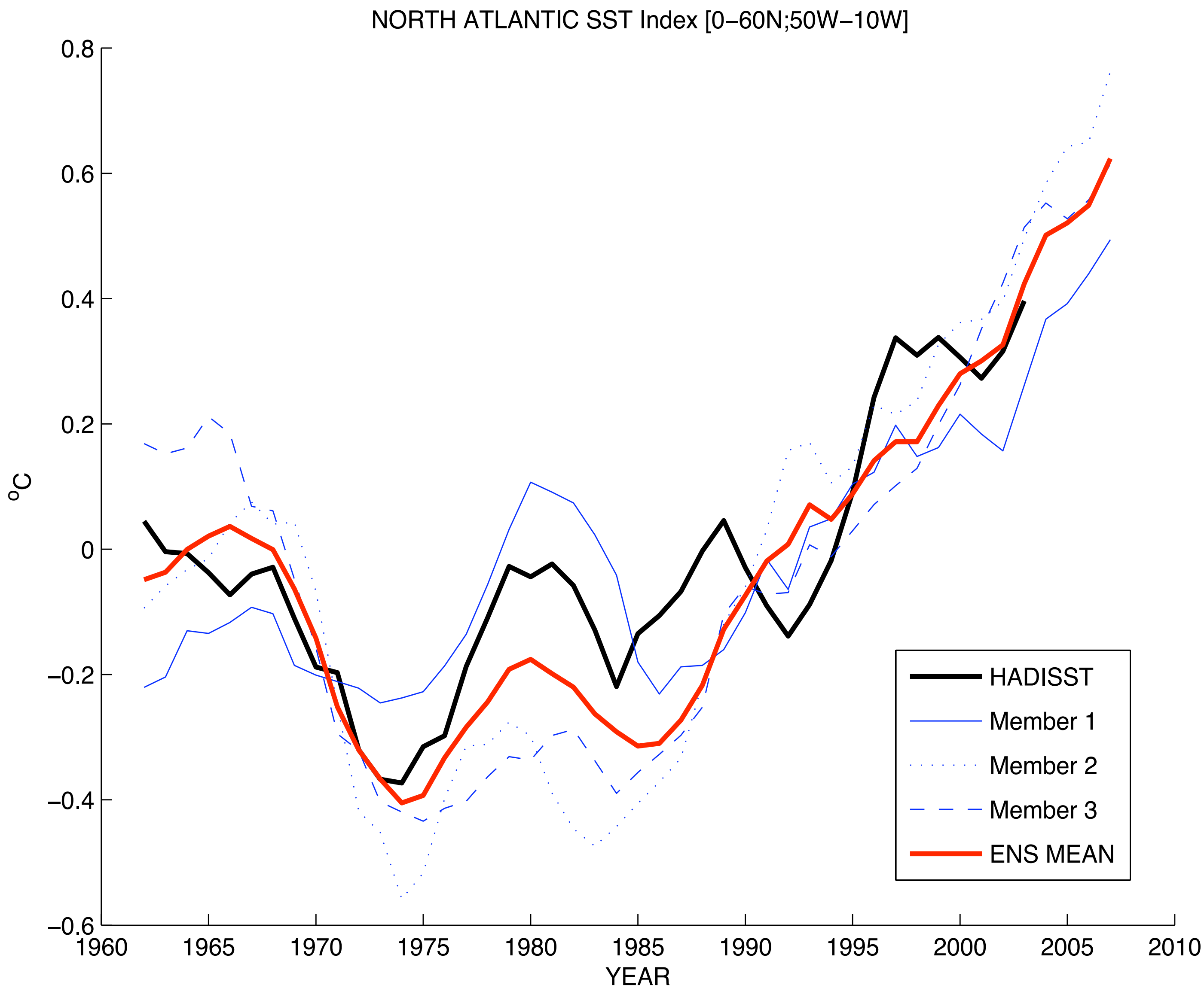


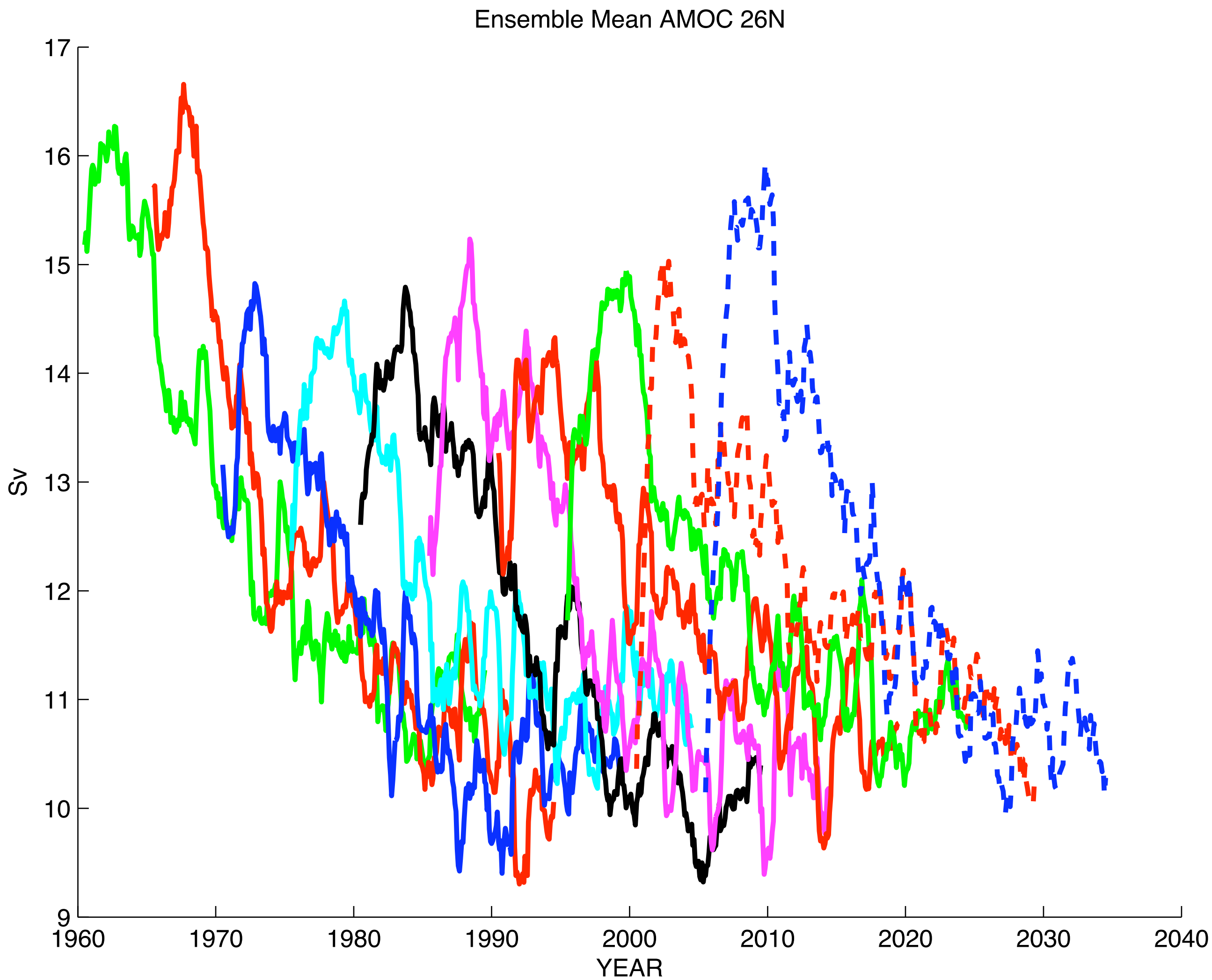
*each curve is an average over all possible C_{ij} couplets (i,j=1,2,3) computed for each start date.

evolutive cross-correlation : $C_{i,j}(t) = \int_0^{T+t} m_i(t')m_j(t')dt'$ i,j=1,2,3

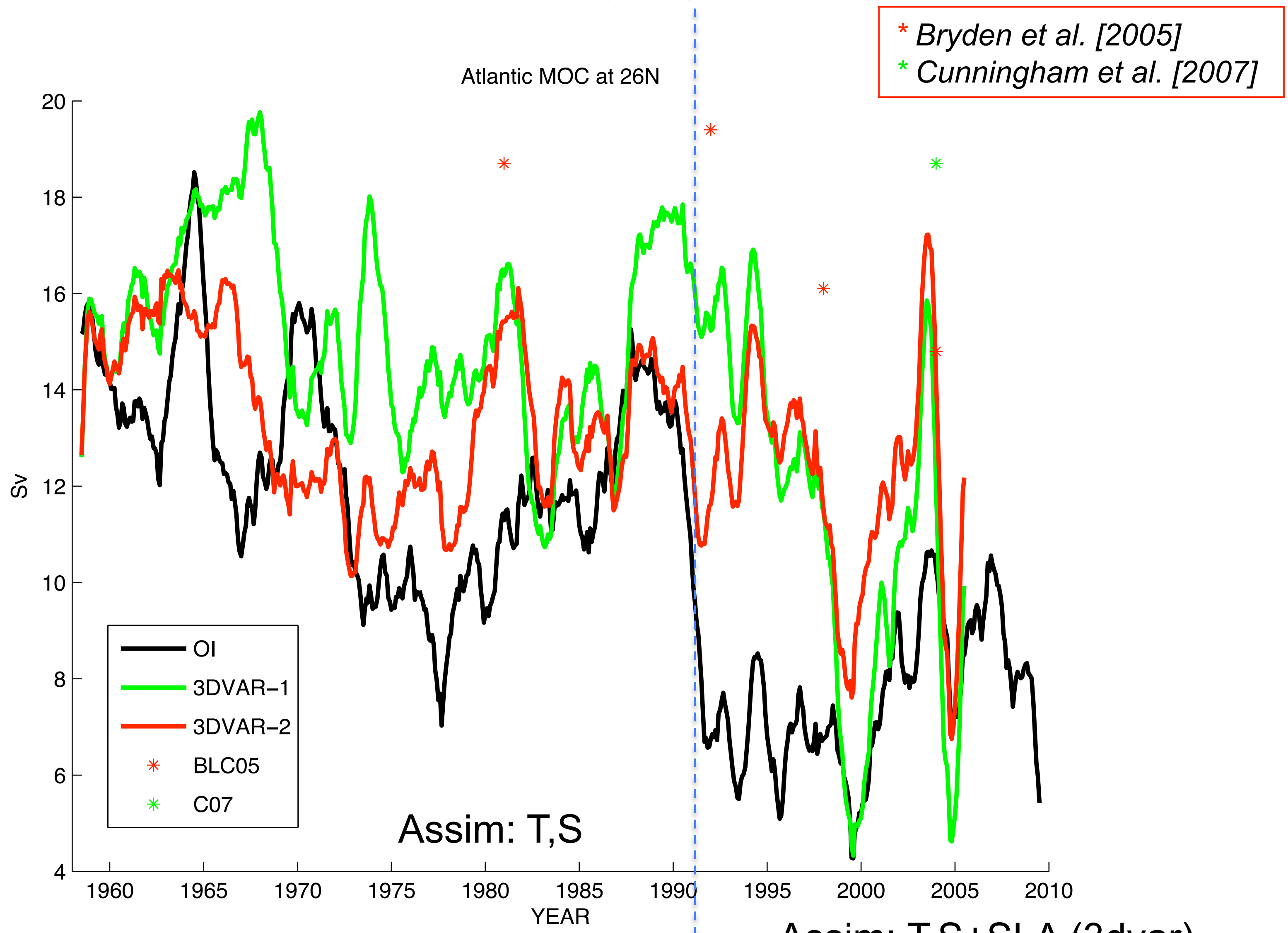


NORTH ATLANTIC SST Index [0−60N;50W−10W]
0.8
0.6
0.4
0.2
0
−0.2
−0.4
−0.6
oC
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
YEAR
HADISST
Member 1
Member 2
Member 3
ENS MEAN

MOC is affected by drift, although with a slower adjustment, wrt to SST.
Adjustment towards model attractor occurs in a ~20 yrs time scale

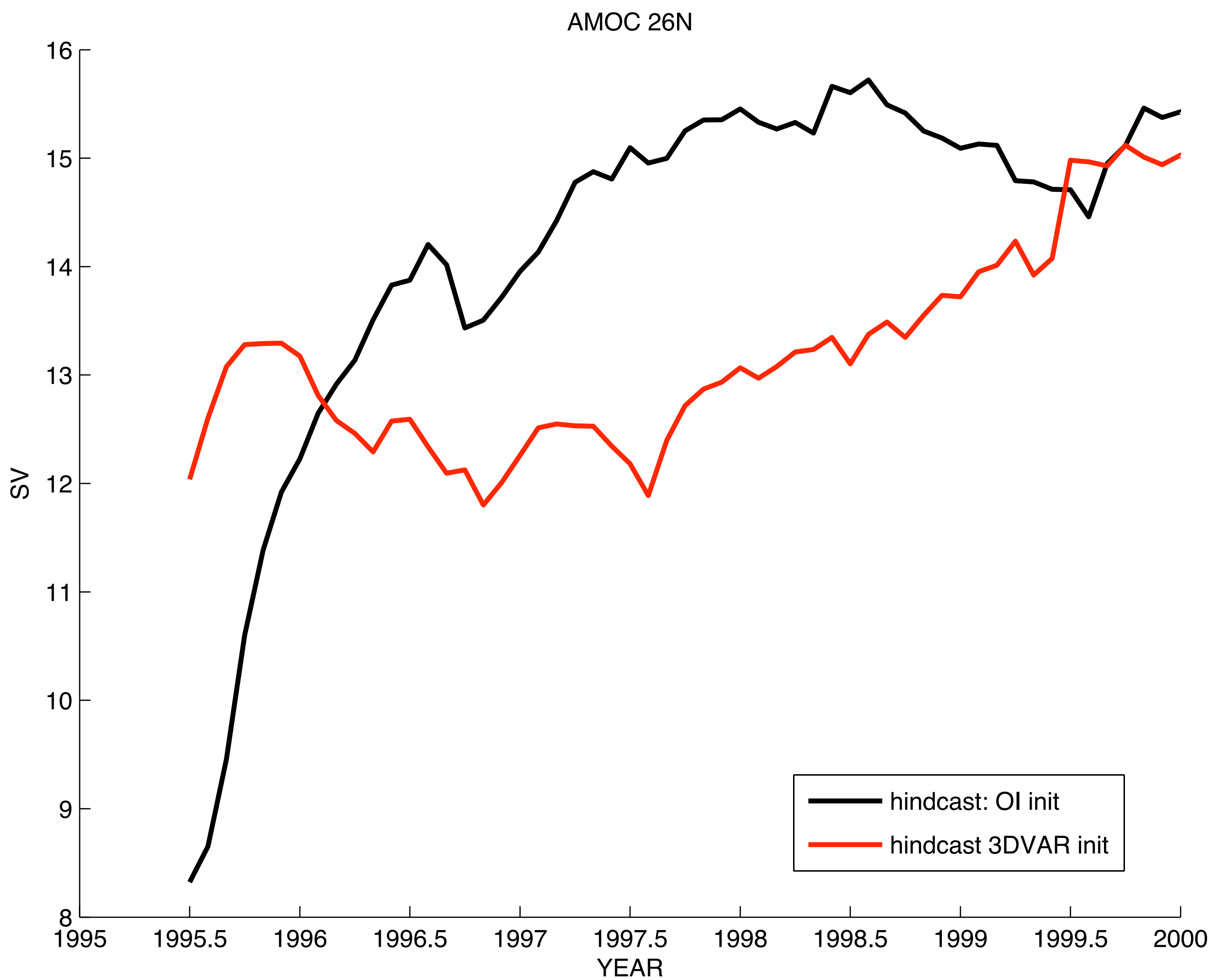


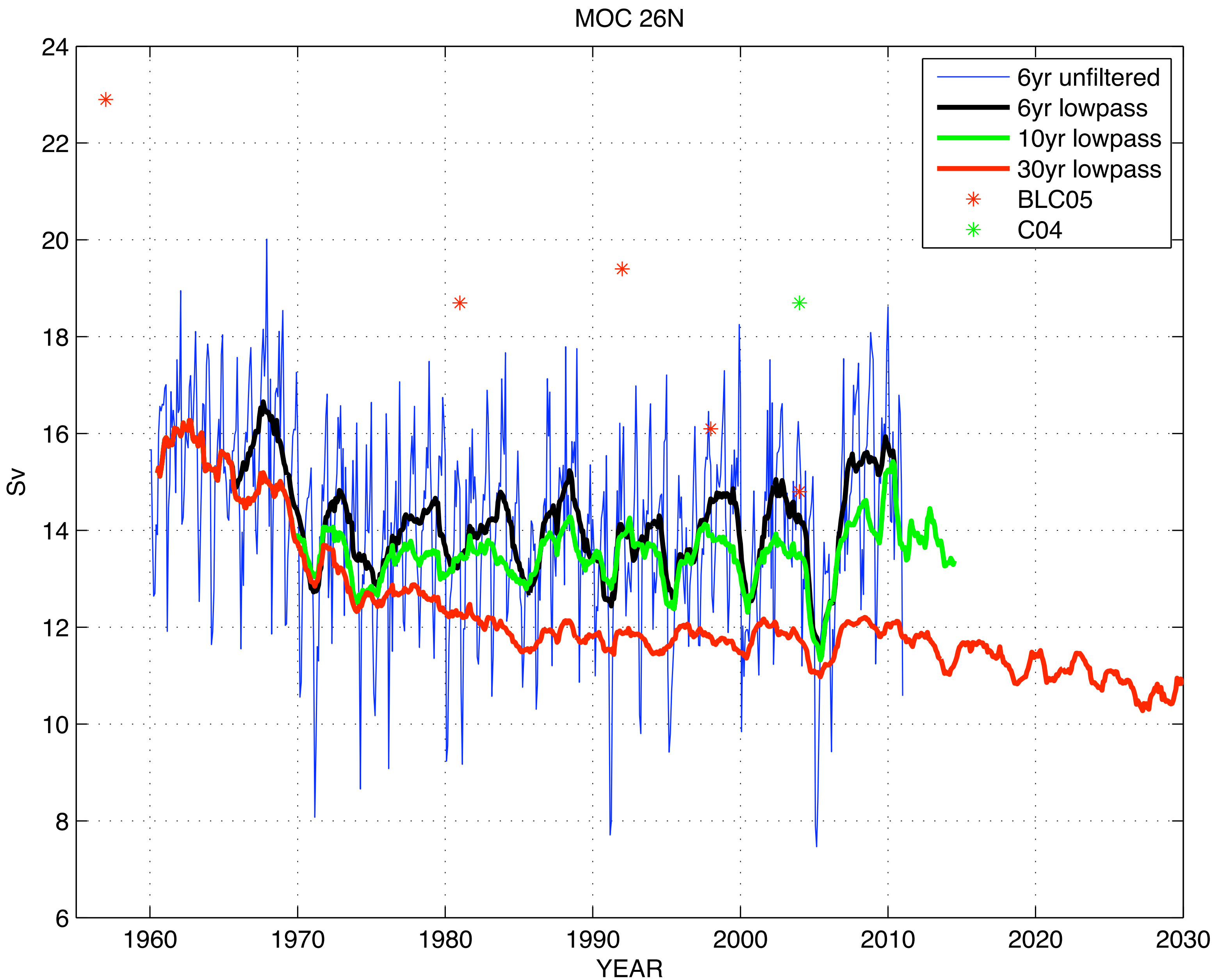
AMOC in CMCC ODA affected by large uncertainties



OI: T,S (1960-2005)
3DVAR: T,S (1960-2005) & SLA (1992 onward)

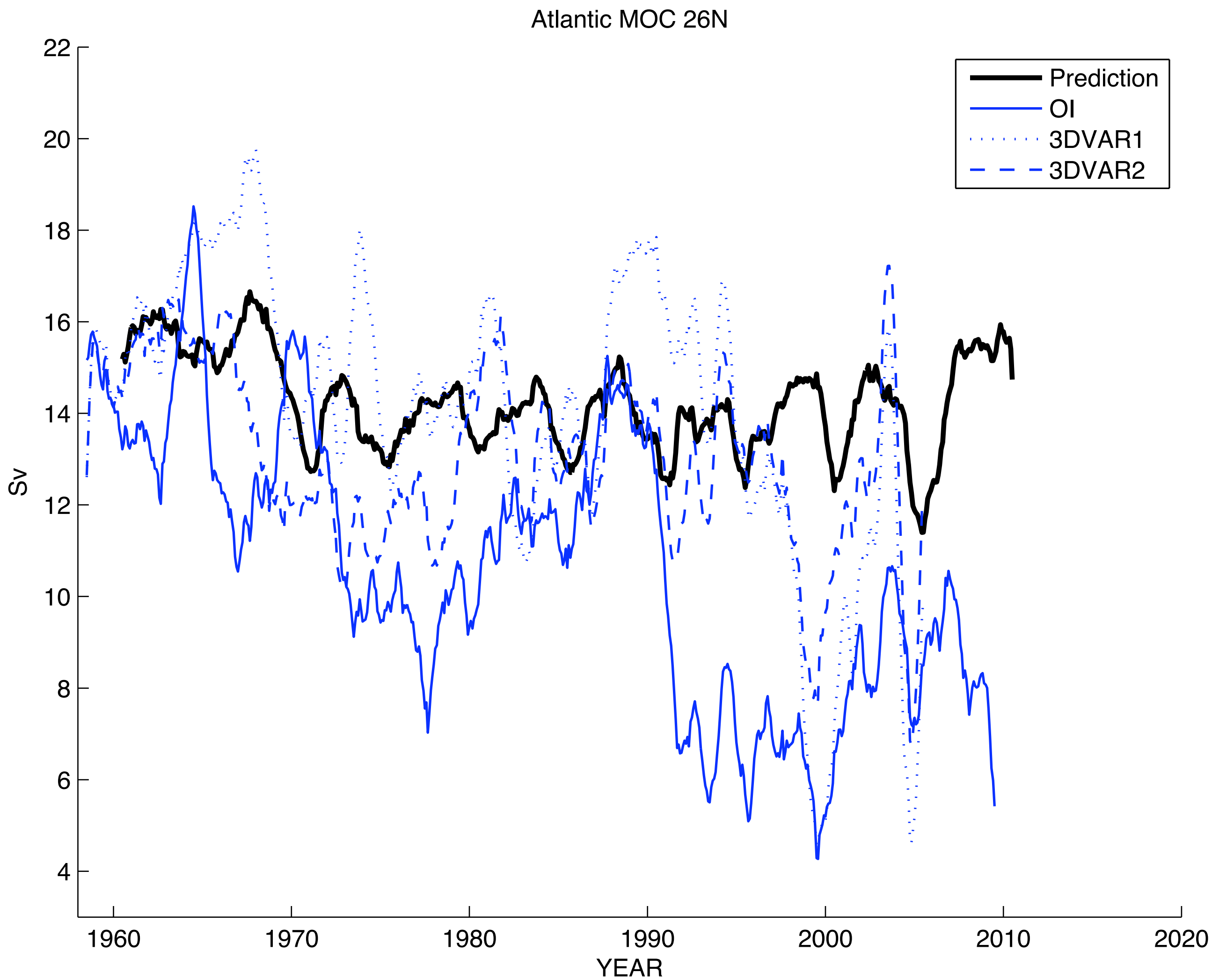
MOC initialized with two different ocean analyses follow very different trajectories





MOC 26N
Sv
YEAR
24
22
20
18
16
14
12
10
8
6
1960
1970
1980
1990
2000
2010
2020
2030
6yr unfiltered
6yr lowpass
10yr lowpass
30yr lowpass
BLC05
C04

MOC Prediction vs Analysis: hindcast show a much weaker variability wrt analyses



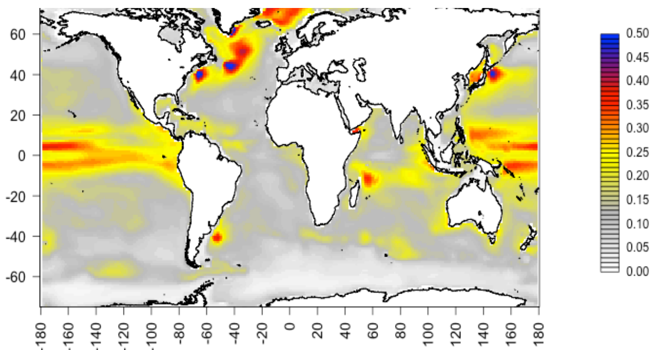
Conclusions (?)

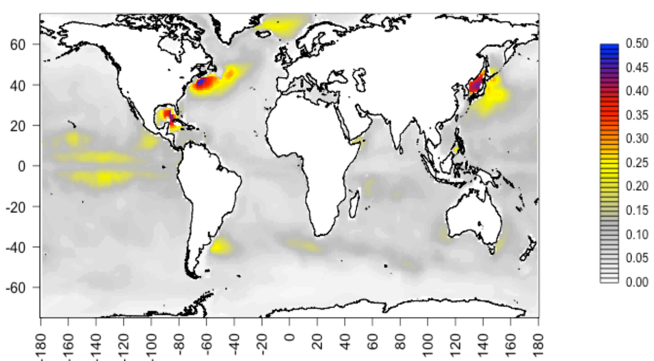
- The use of ocean analyses to initialize DP differing by both assimilation technique (OI & 3DVAR) and assimilated data (T,S profiles & SLA) yields a sufficiently large spread.
- Influence of IC 1-5 years
- Some predictability in some fields
- Predictability in interesting parameters still to be investigated

- Future model … T255/321 -- 0.25 ocean
- Coupled assimilation

The three Global Ocean analysis systems at CMCC

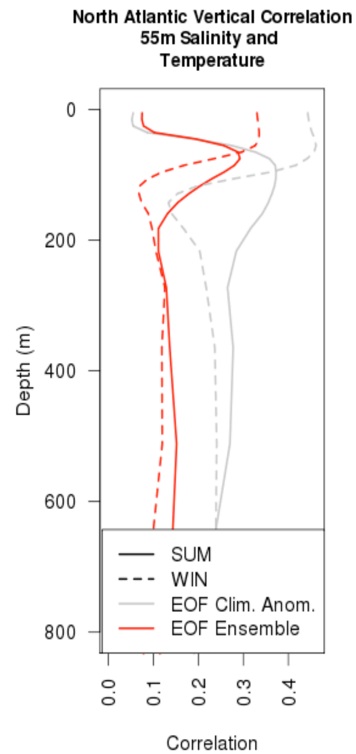
1) **Optimal Interpolation (OI)** analysis system assimilating hydrographic data of (T, S) from EN3 dataset and using bivariate EOFs computed from model climatological anomalies for representing model-error vertical covariances (Bellucci et al., 2007, Masina et al., 2011);
2) **3DVAR** data assimilation system assimilating hydrographic data of (T, S) from EN3 dataset and along-track altimetric observations (1992-onward). The same set of EOFs as in the OI is used (Storto et al., 2011);
3) **3DVAR** data assimilation system as the previous but with a different set of vertical EOFs, derived from the differences between 6 ensemble members and the ensemble mean within an **ensemble variational assimilation experiment (1993-2005) with perturbed observations, surface forcing and model parameterization tendencies**.

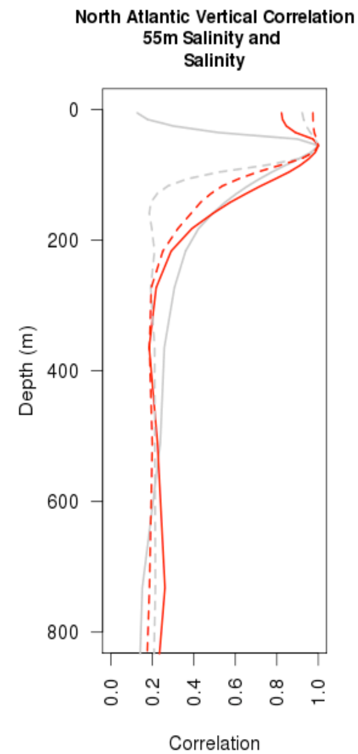




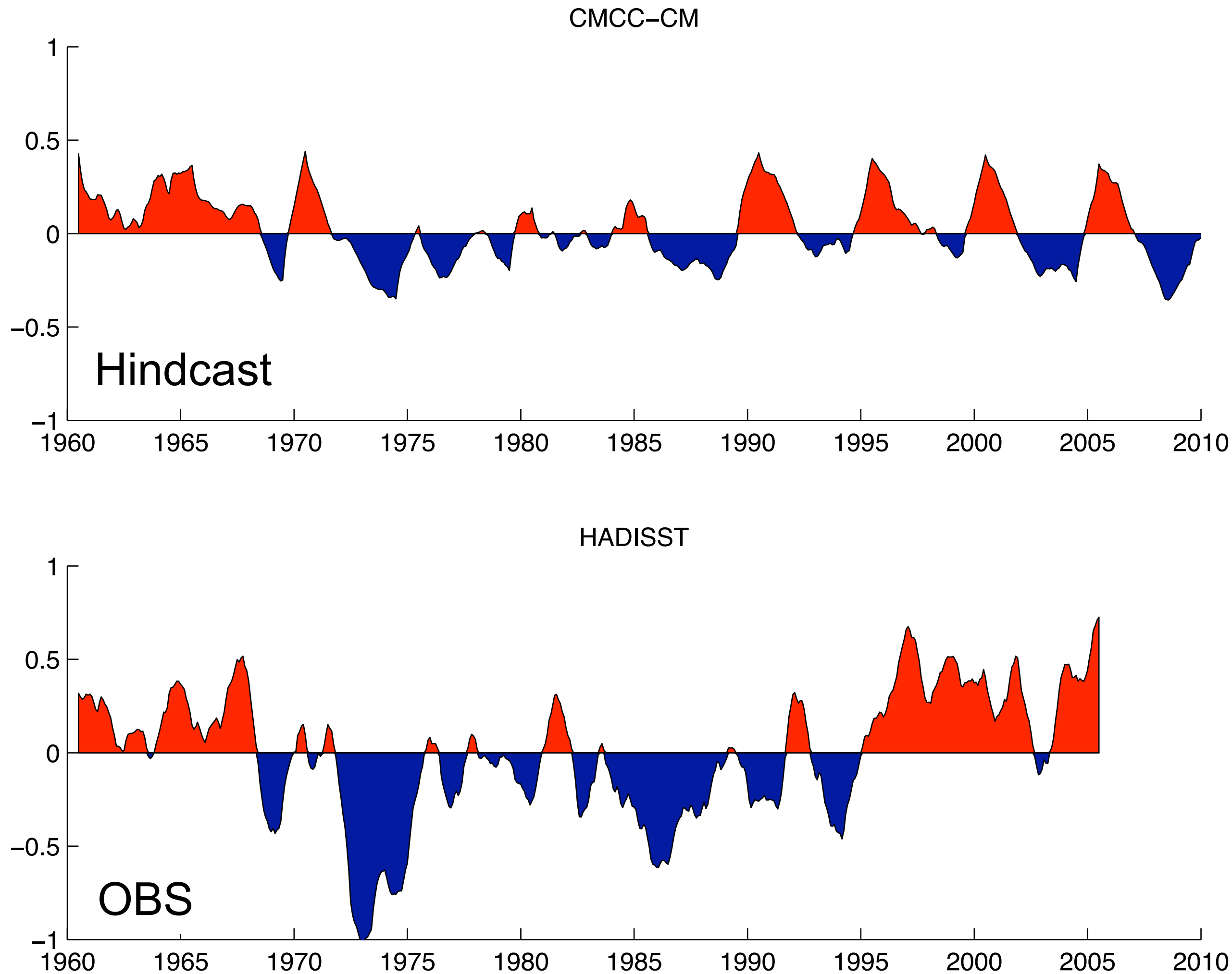
On the left: 0-100 m summertime temperature st. dev. for EOF first set (top) and EOF second set (bottom). The latter shows a smaller error signal and peaks only in mesoscale areas.

On the right: North-Atl. averaged profiles of summer and winter model-error vertical (cross-)correlations between 55 m salinity and the other model levels for the two EOF sets. The ensemble derived set exhibits a stronger salinity upper ocean auto-correlation in Summer, but generally a smaller cross-correlation.





AMO Index


CMCC–CM
1
0.5
0
–0.5
–1
Hindcast
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
HADISST
1
0.5
0
–0.5
–1
OBS
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010