NCAR Models and NMME

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Some Relevant Discussion Points

- Why MME? Diversity/Correction
- NCAR’s possible role(s)
- New Opportunities at NCAR
- Current status and results

NCAR Role

- Zeroth order- supply modeling capability to the community and hand off the forecast responsibility
- Has led to a good collaborative/synergistic relationship with COLA/GMU
- Fine for slow evolution of capabilities but will miss opportunity to capitalize on model advances and opportunities; ie MME could be more diverse

Model advances

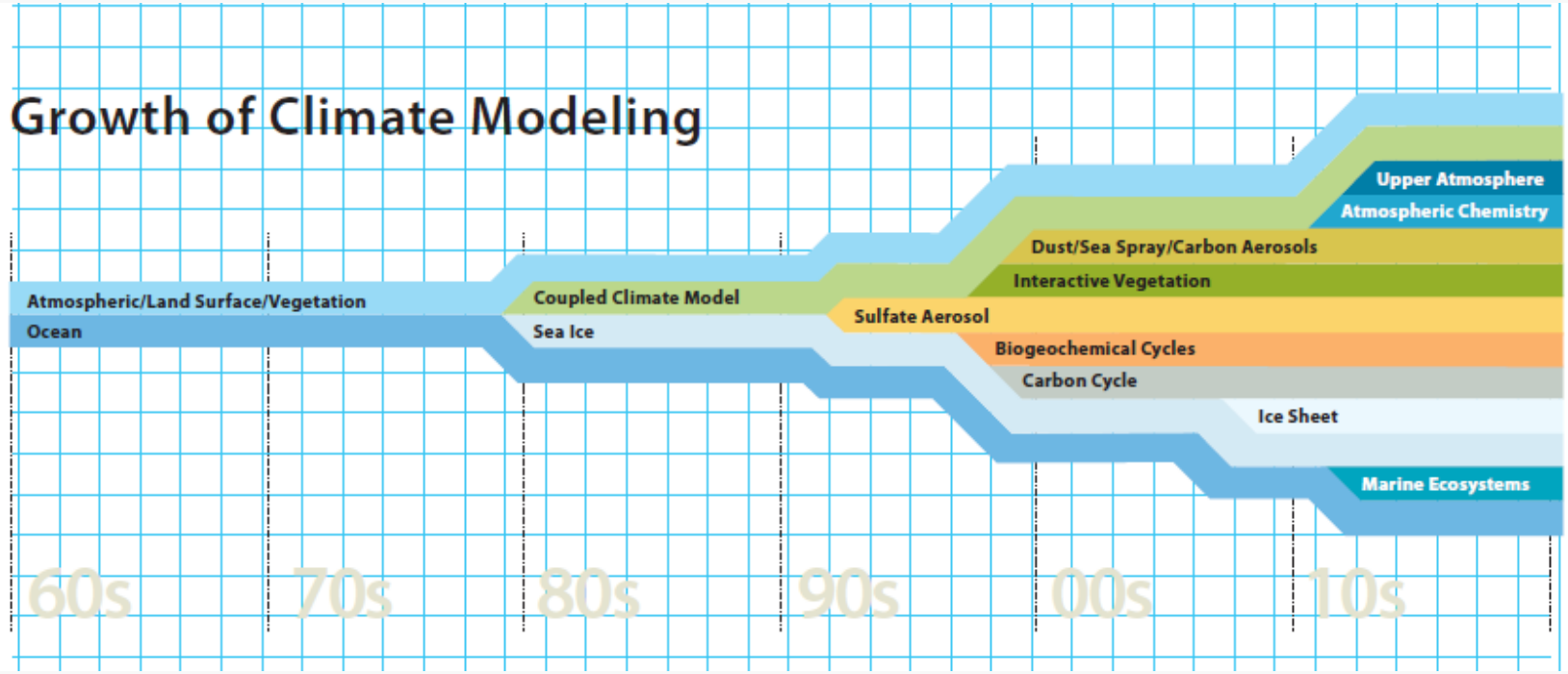
Slow evolution: CCSM4

- CAM4 (improved version of CAM3
- New versions of POP,CLM and new Sea ice component models
- Clouds radiation very sensitive/difficult at high resolution
- Some components (to be) tested by COLA

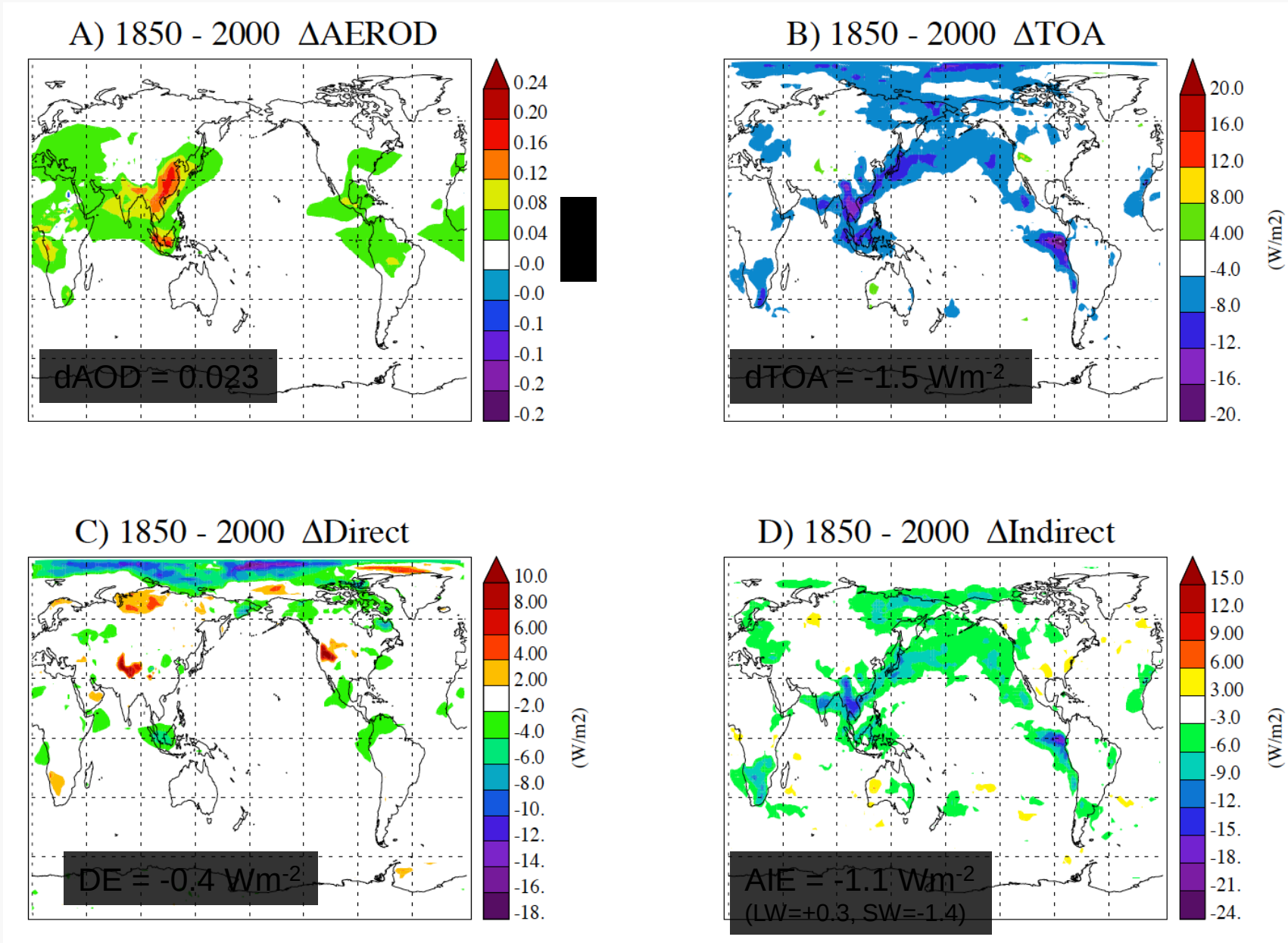
Rapid revolution: CESM1

- CAM5 new PBL, Clouds microphysics and radiation
- Aerosols and Chemistry
- Carbon –Nitrogen cycles
- More consistent clouds and radiation at high resolution
- Improved climate not yet being tested in prediction
- Cutting (ragged) edge science

The cutting edge



Aerosol Indirect Effect: Maps



High resolution (1/4° CAM5) tropical cyclones frequency

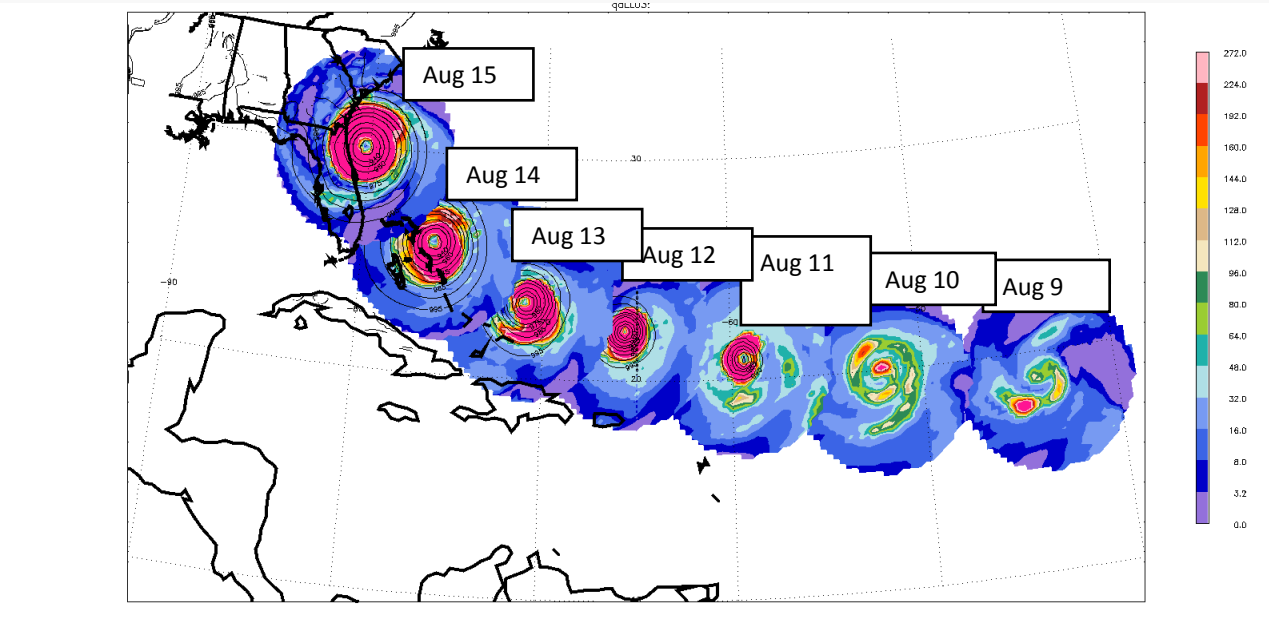


Figure 1 Powerful Atlantic hurricane which formed in a 0.23°x0.31° CAM5 run forced with observed SSTs. The figure shows instantaneous precipitation rates (colored shading) and surface pressure (contours) every 24 hours at 00Z beginning on Aug 9 2005. Fileds are shown within a radius of 500 km of the diagnosed storm center. The storm is remarkably intense, attaining a minimum central pressure below 910 hPa, with maximum winds of over 140 kts (~70 ms^{-1}) at 50 m. Note the relatively dry eye at center of the storm in its mature phase.

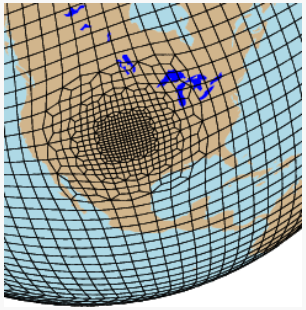
Preparing CESM for Petascale Computing

Real Planet: 1/8º Simulations

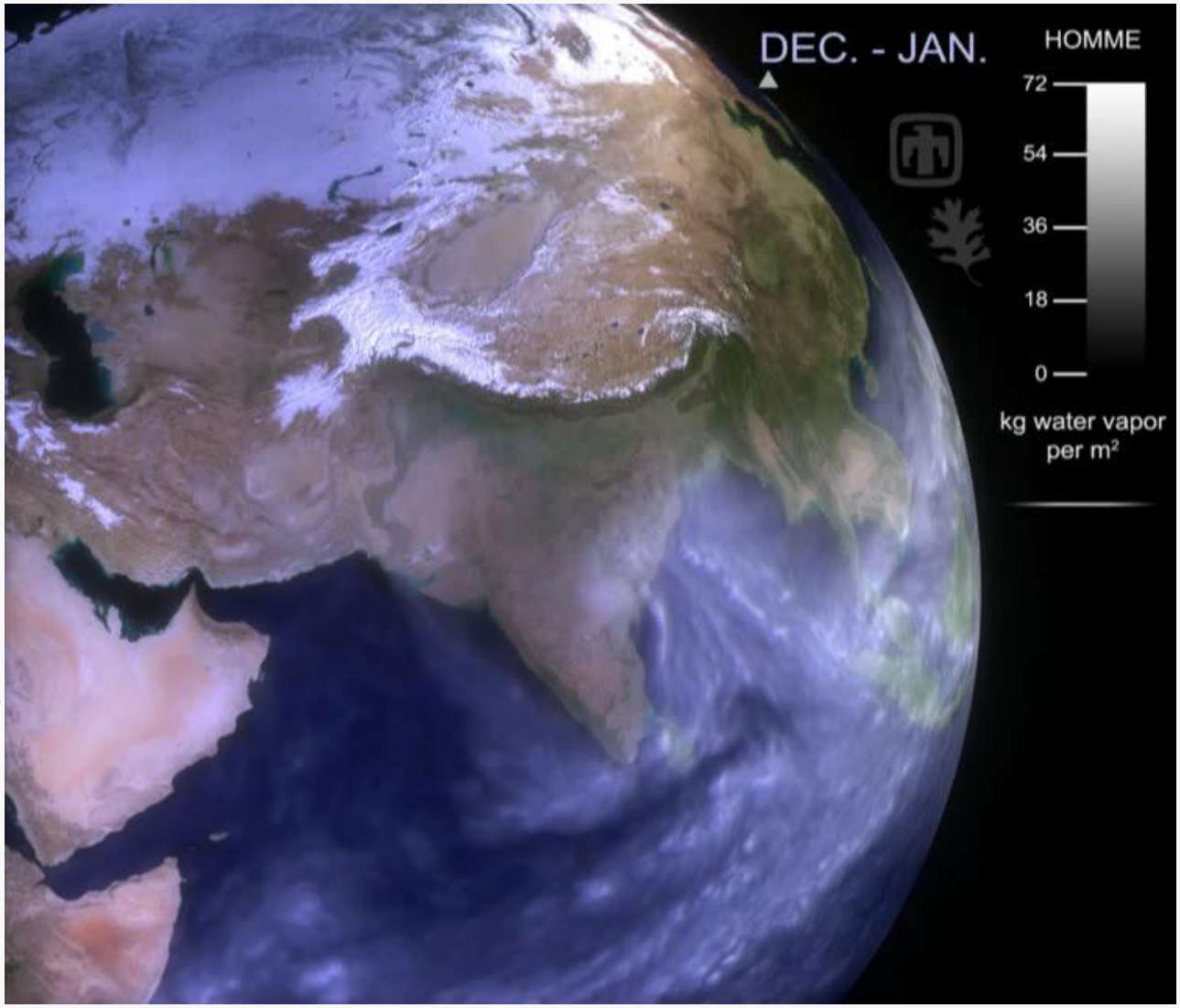
Lat-lon grid based CAM dycore is largest bottle-neck to parallel scalability

Improved scalability by introduction of cubed-sphere based dycores (from HOMME) into CAM in CESM1.0

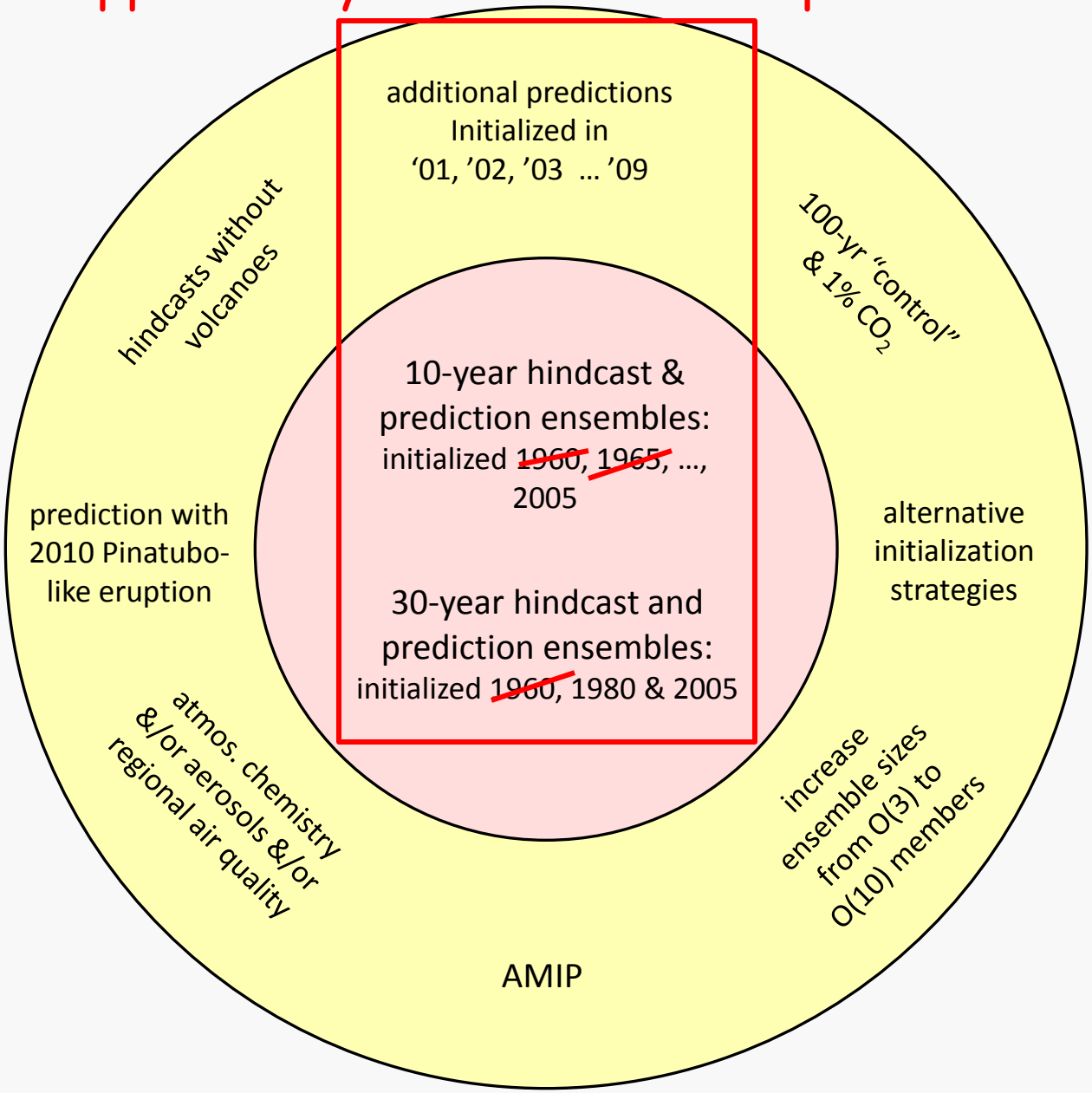
Capability for ultra-high resolution simulations and Regional mesh refinement



Courtesy Mark Taylor



CMIP5 Decadal Prediction Experiments
Opportunity due to CLIVAR protocol

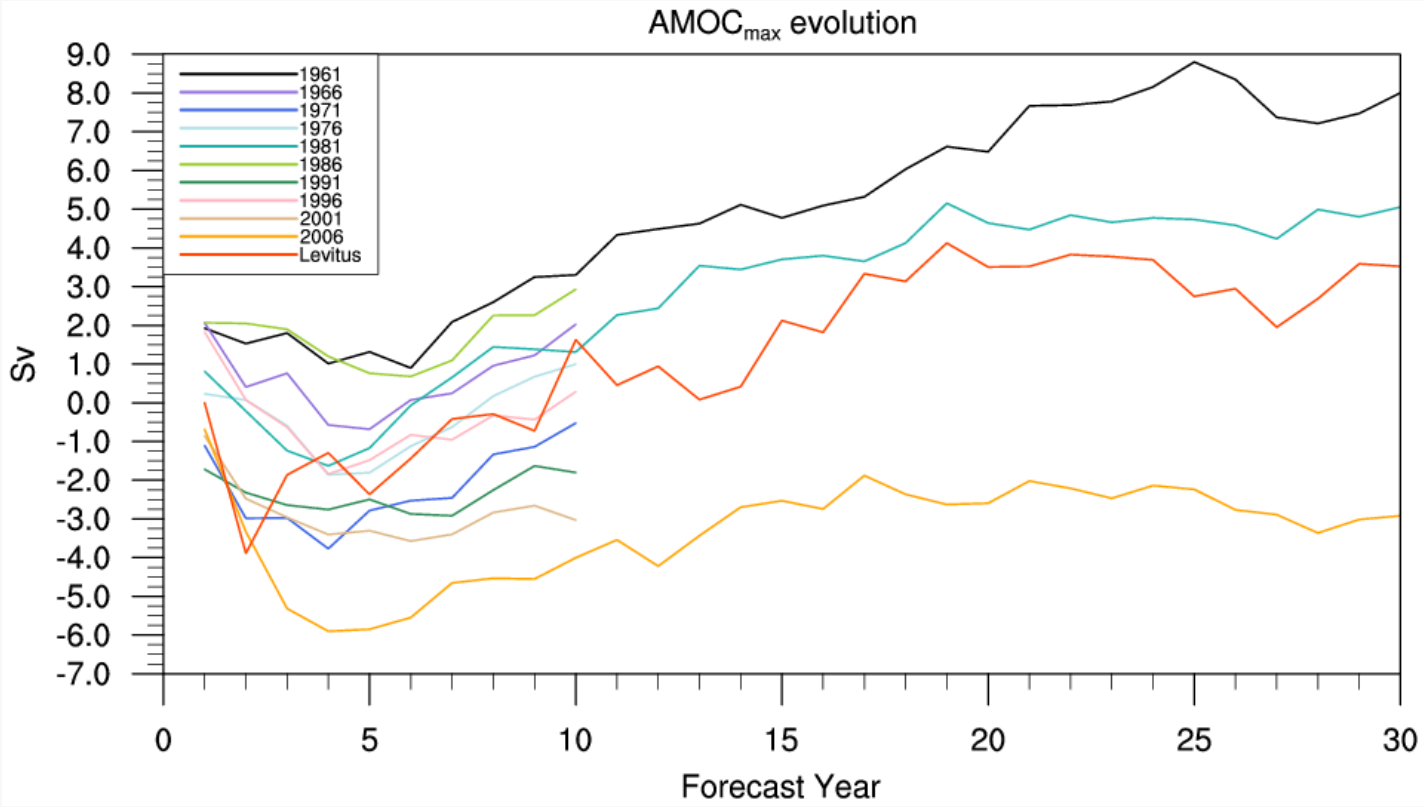


Two sets of decadal predictions

- First initialization: Ocean ‘hindcast’ using observed SST and Large-Yeager forcing (referred to hindcast initialized) [1970-present completed]
- Weakly coupled ensemble Kalman Filter initialization using DART (referrred to as DART intialized) [2000-present, in progress]

Hindcast results: systematic bias/model drift

$AMOC_{max}$ change from HD state, in DP experiments

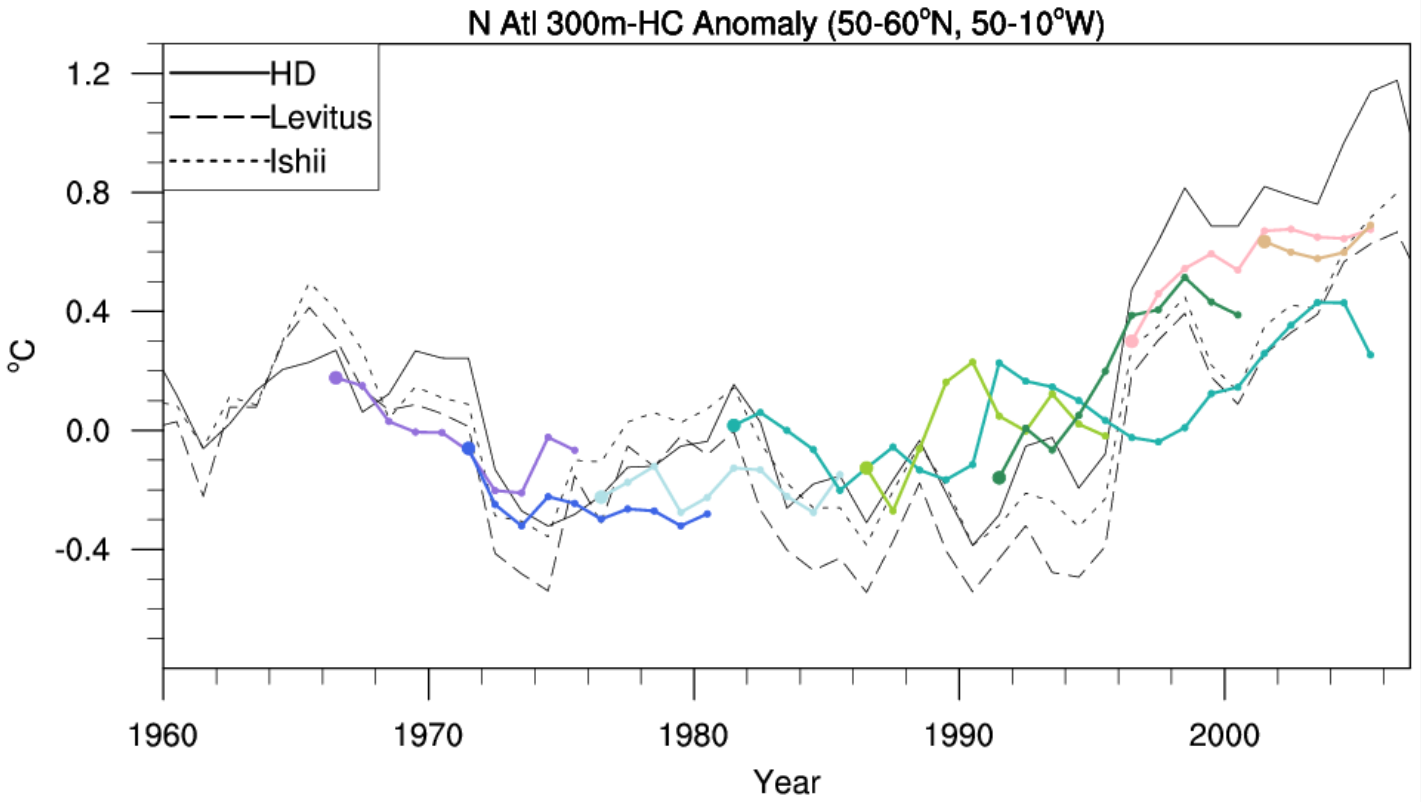


- AMOC in DP runs consistently exhibits ~5yr decrease followed multidecadal upward trend

- Same behavior as in a ‘cold start’ from Levitus climatology (red)

Results: bias corrected predictions

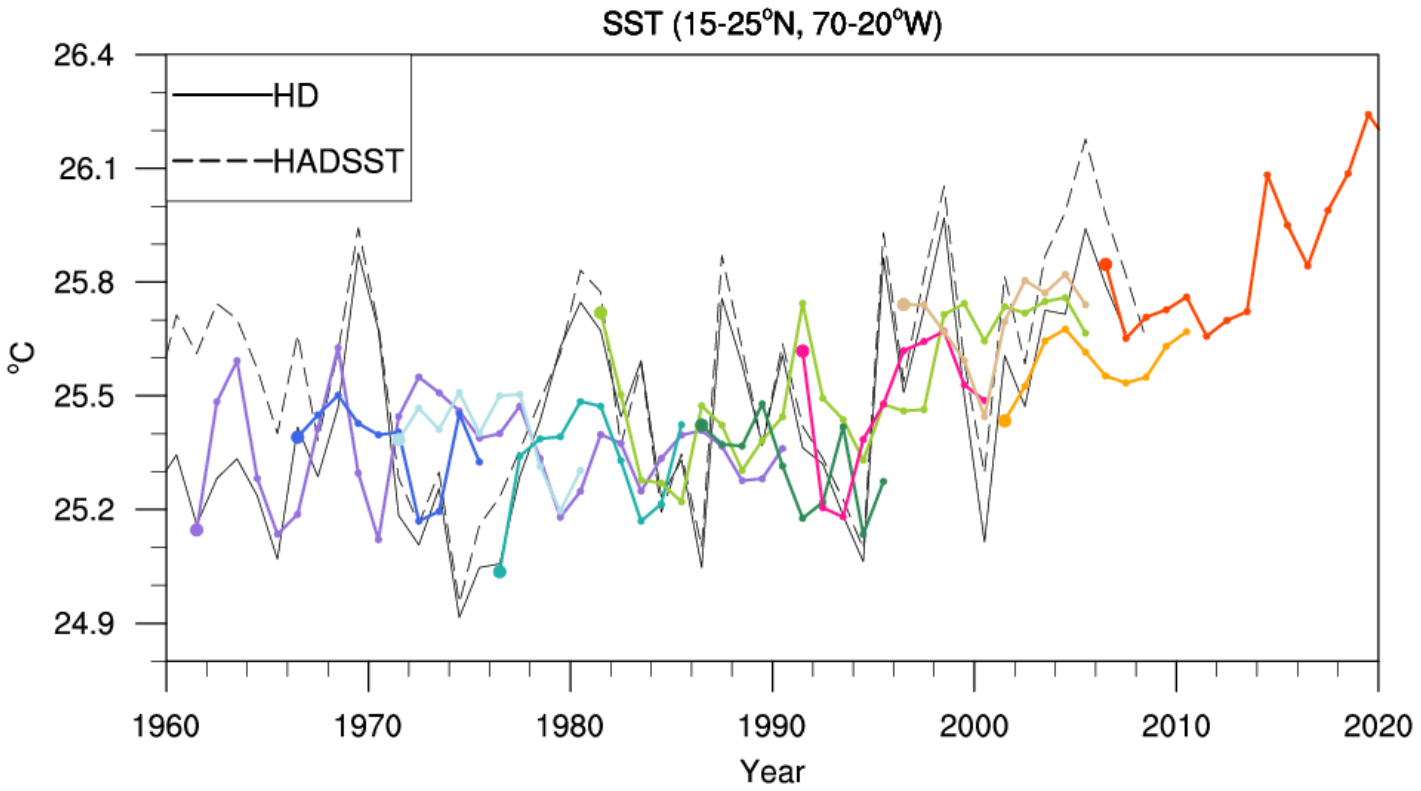
North Atlantic Subpolar Gyre Heat Content



• After subtracting mean HC drift, predictive skill is discernible (eg, 1991ic, 1966ic, 1996ic)

Results: bias corrected predictions

Subtropical Atlantic SST



- Note DP's from 1976ic, 1981ic, 1996ic

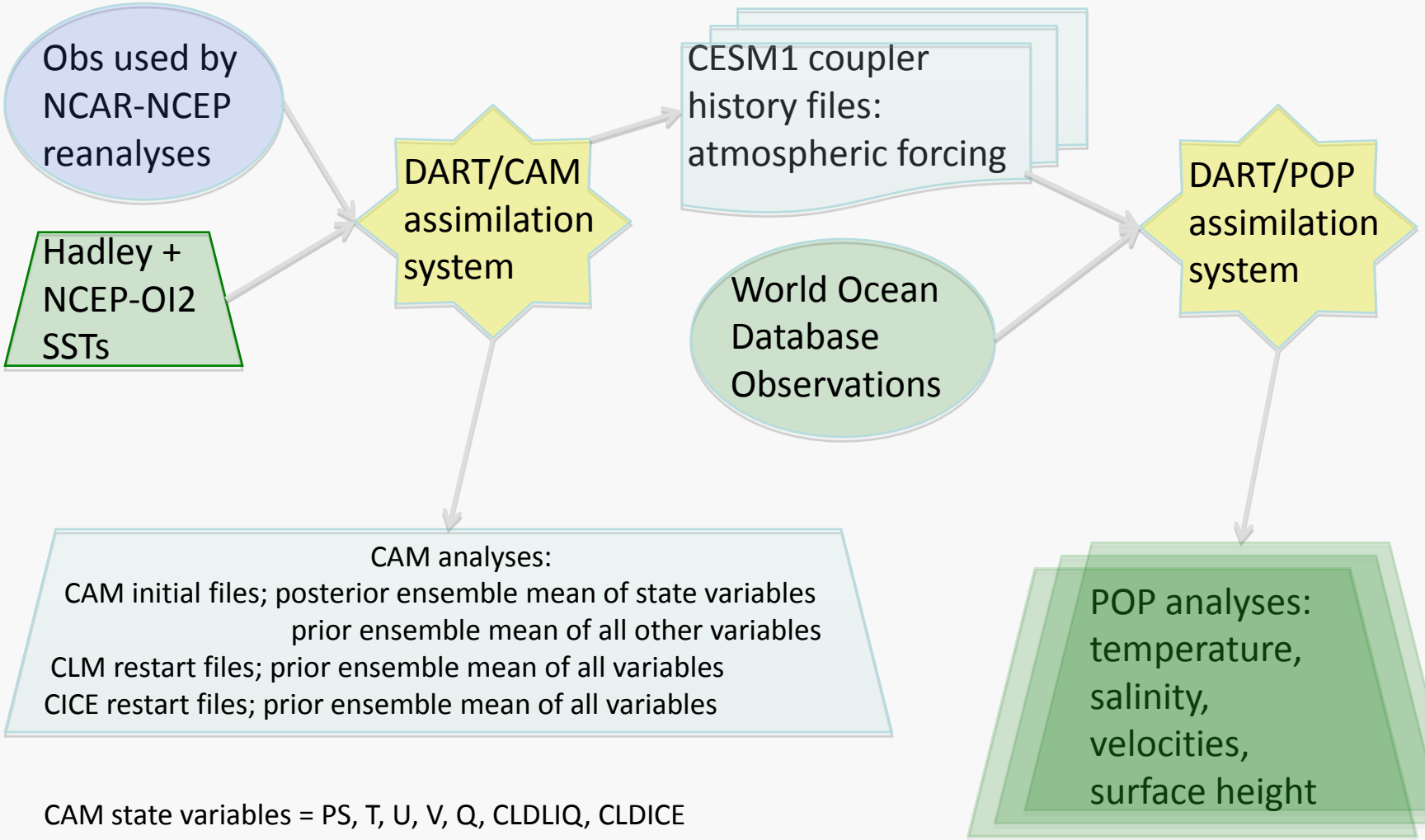
Because there is no operational decadal prediction in US, NSF is willing to let NCAR explore these challenges
For experiments after 2000 we are using
"WEAKLY" COUPLED EnKF DATA ASSIMILATION

Force each ocean ensemble member with a different member from an atmospheric ensemble reanalysis:

- Run an 80-member ensemble of CAM assimilation with 6-hourly coupler output files from each member,
- Run a 46-member ensemble of POP assimilation forced with output from 46 of the CAM assimilation runs.

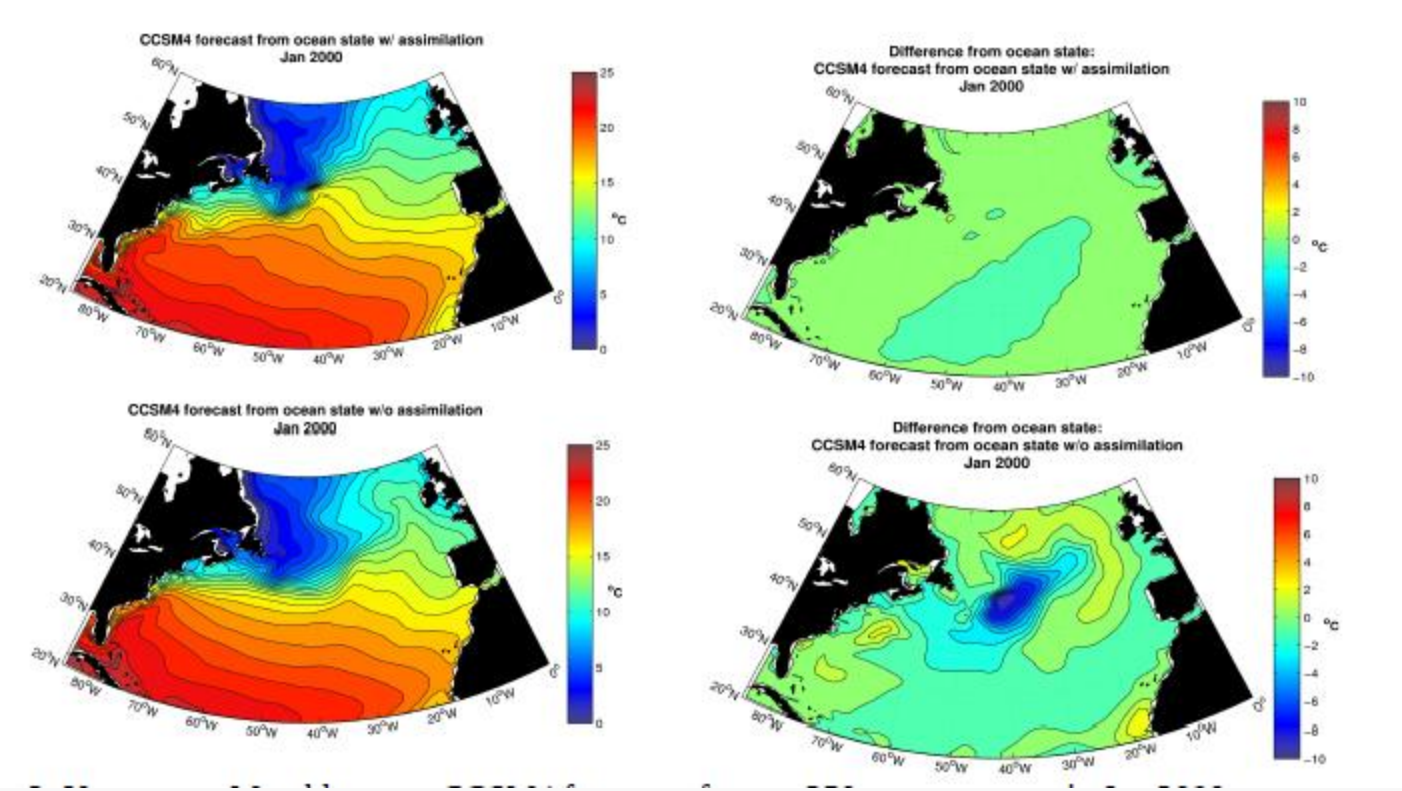
This technique is already in operation (starting from 1 January 1998) and preliminary analyses indicates much increased ensemble spread compared to uncoupled assimilation.

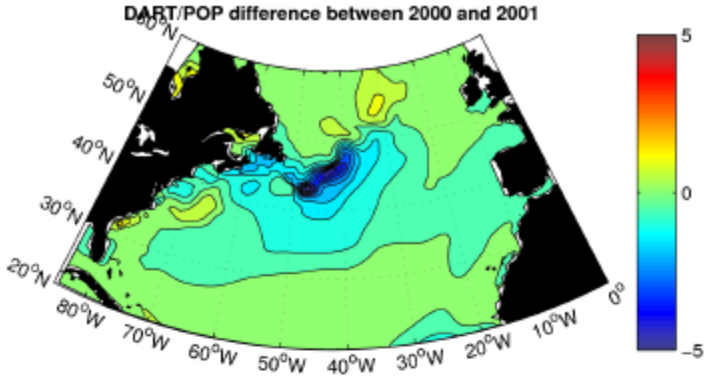
Coupled Ocean-Atmosphere Schematic

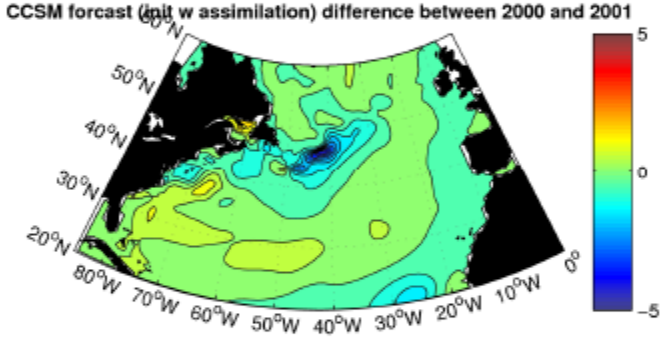


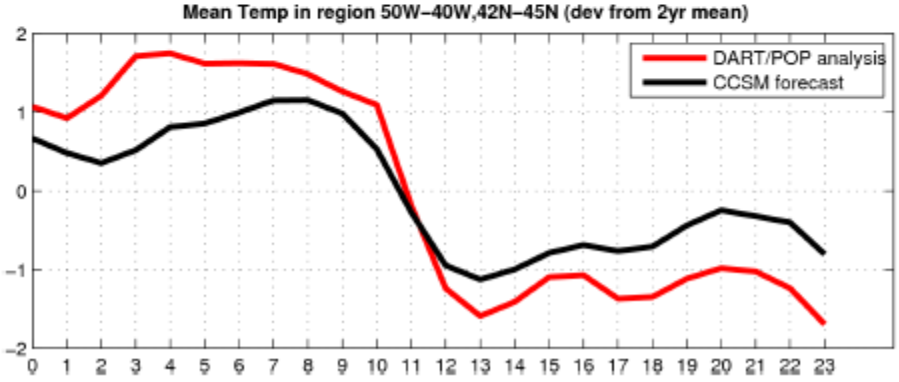
CAM state variables = PS, T, U, V, Q, CLDLIQ, CLDICE
Prior = values before assimilation (but after a short forecast)
Posterior = values after the assimilation of observations at that time

DART Results
Less Bias




DART/POP difference between 2000 and 2001
60°N
50°N
40°N
30°N
20°N
80°W
70°W
60°W
50°W
40°W
30°W
20°W
10°W
0°
5
0
−5


CCSM forcast (init w assimilation) difference between 2000 and 2001
60°N
50°N
40°N
30°N
20°N
80°W
70°W
60°W
50°W
40°W
30°W
20°W
10°W
0°
5
0
−5


Mean Temp in region 50W–40W,42N–45N (dev from 2yr mean)
DART/POP analysis
CCSM forecast
2
1
0
−1
−2
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23

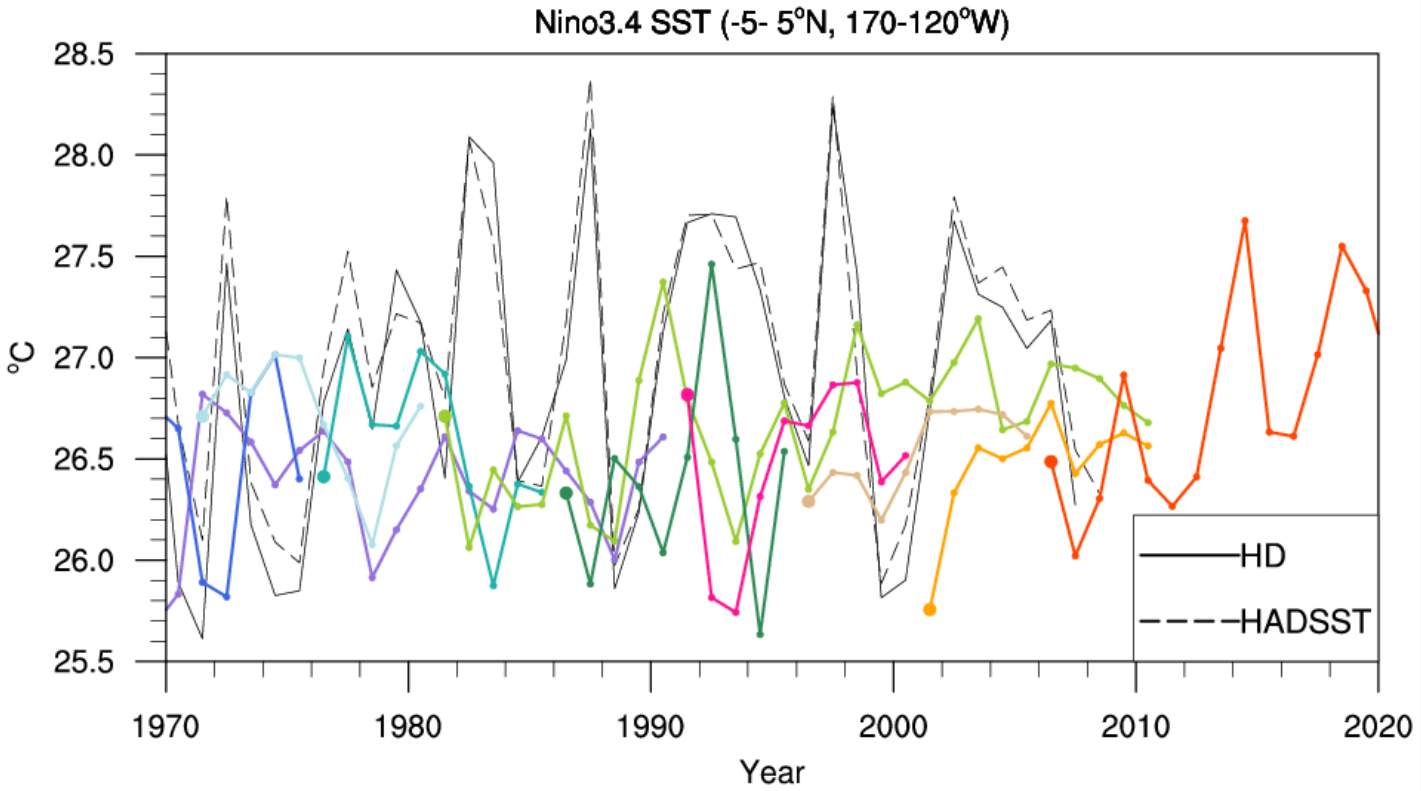
Summary

- MME gives better chance at forecast improvement
- Can take advantage of the current CMIP5 to jumpstart effort
- NCAR could play an active (or passive) role in the NMME effort : predictions with coupled DA or supply community tools

The End

III. Results: de-drifted predictions

Nino3.4 SST



- Little apparent skill from this annual mean analysis

- Hindcast-initialized DP ensembles initialized between 1961-2006 have been integrated and are being analyzed

- DA-initialized DP ensembles will soon be available

- Drift correction will be key to DP analysis; preliminary results in this regard are promising

Thank you