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The CCCma sub-seasonal to decadal forecasting system

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Fondation canadienne pour les sciences
du climat et de l'atmosphère (FCSCA)

GCAPP

CCCma seasonal to interannual forecasts

- **Current EC operational system “HFP2”** is *two-tier*
 - future SST's = persisted anomalies
 - cannot predict El Niño (or La Niña)
 - no dynamical forecast beyond 4 months
- **CCCma coupled forecasting system**
 - developed under CFCAS support
 - future SST's *predicted* as part of forecast
 - forecasts to 12 months (+ decadal)
 - designed to function in an operational environment
 - **Coupled Historical Forecasting Project v.2 (CHFP2)**



CCCma seasonal to interannual forecasts

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4 AGCMs: *GCM2, GCM3, SEF, GEM*

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2 CGCMs: *CanCM3, CanCM4*



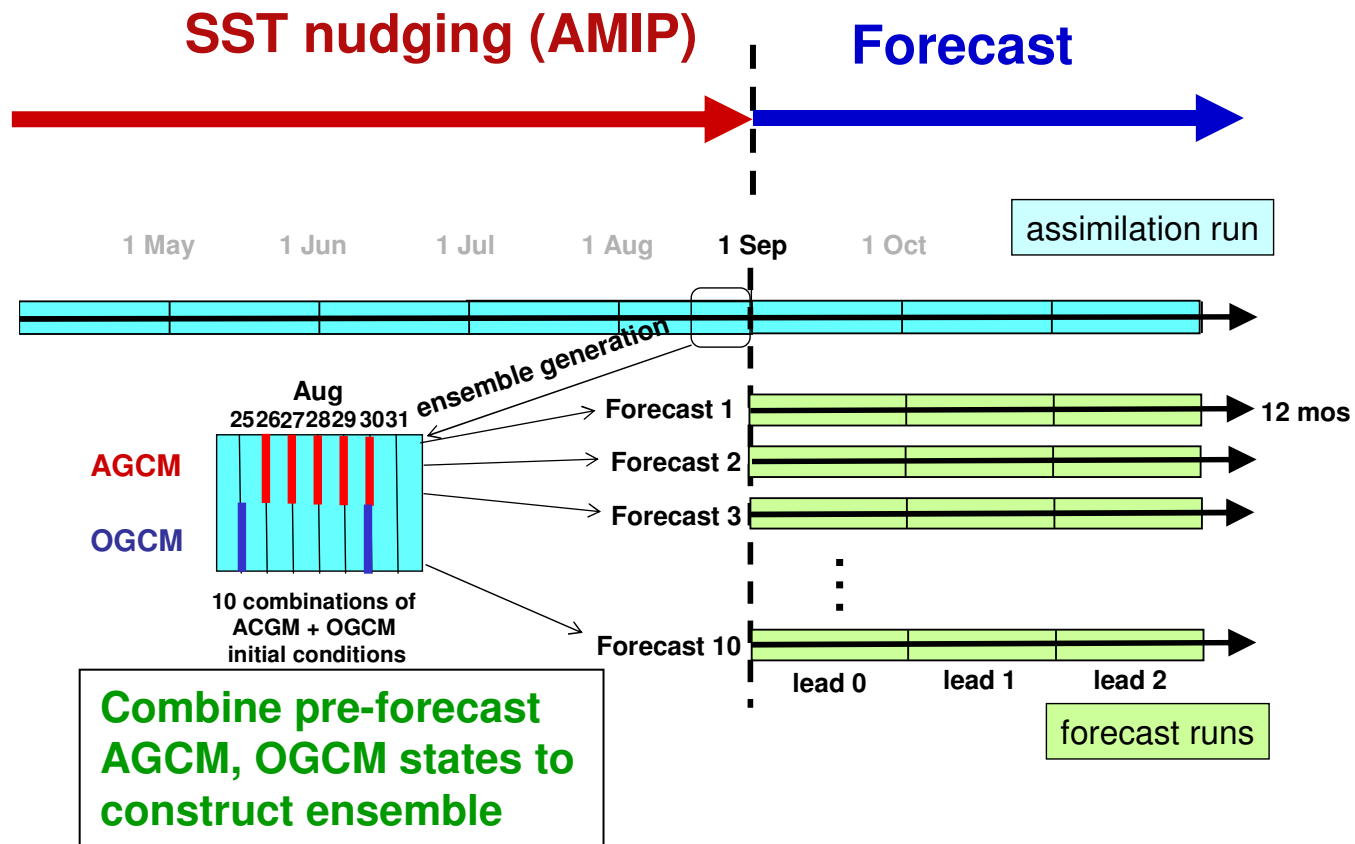
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CHFP1 initialization

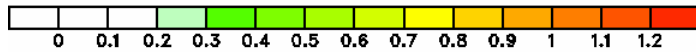
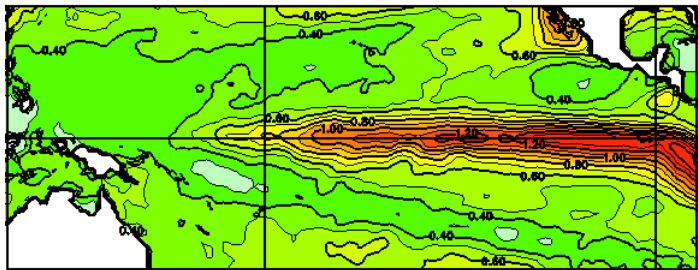


CGCM3.1(AR4)

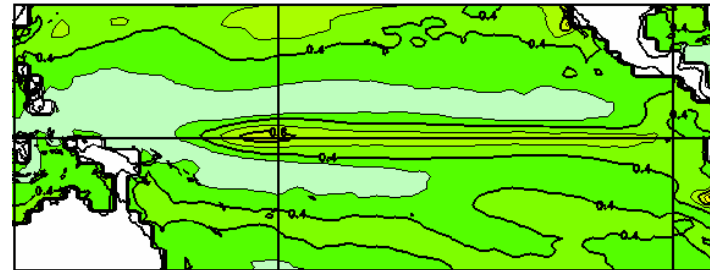


Model Improvement : ENSO

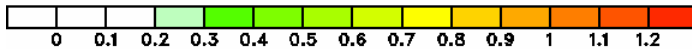
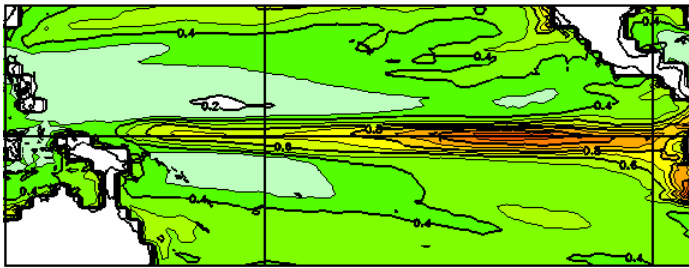
Observations:
HadISST 1970-99



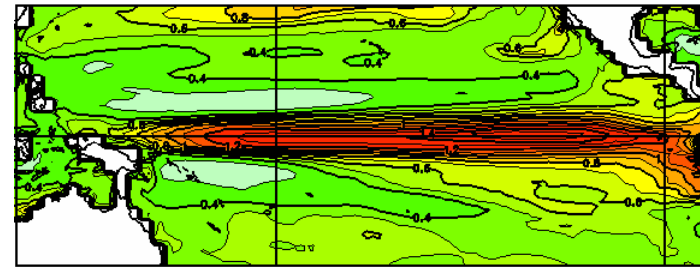
AGCM3+OGCM3 (CGCM3.1/IPCC AR4)
CHFP1



AGCM3+OGCM4 (CanCM3)
CHFP2A



AGCM4+OGCM4 (CanCM4)
CHFP2B



Monthly SSTA standard deviation



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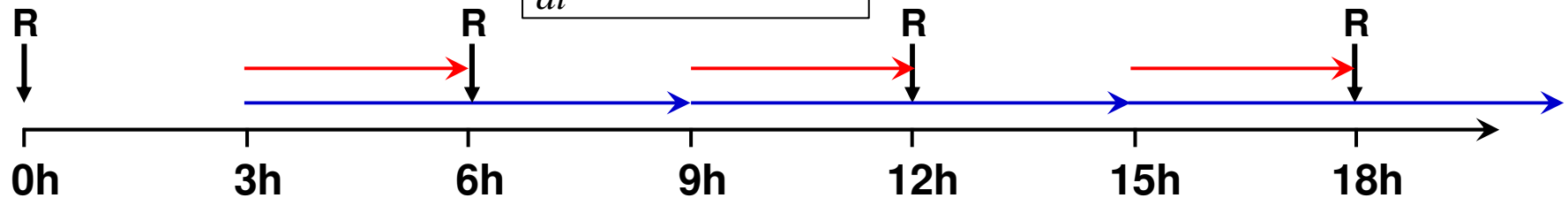
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CHFP2 Atmospheric Data Assimilation

Incremental Reanalysis Update (IRU) assimilation:

- run model freely for 3h (“forecast”)
- difference with reanalysis → “centered” increments $\Delta\mathbf{x}^a$
- rewind, rerun for 6h, adding analysis increments as forcing to model equations:

$$\frac{d\mathbf{x}}{dt} = M(\mathbf{x}) + h(t)\Delta\mathbf{x}^a$$

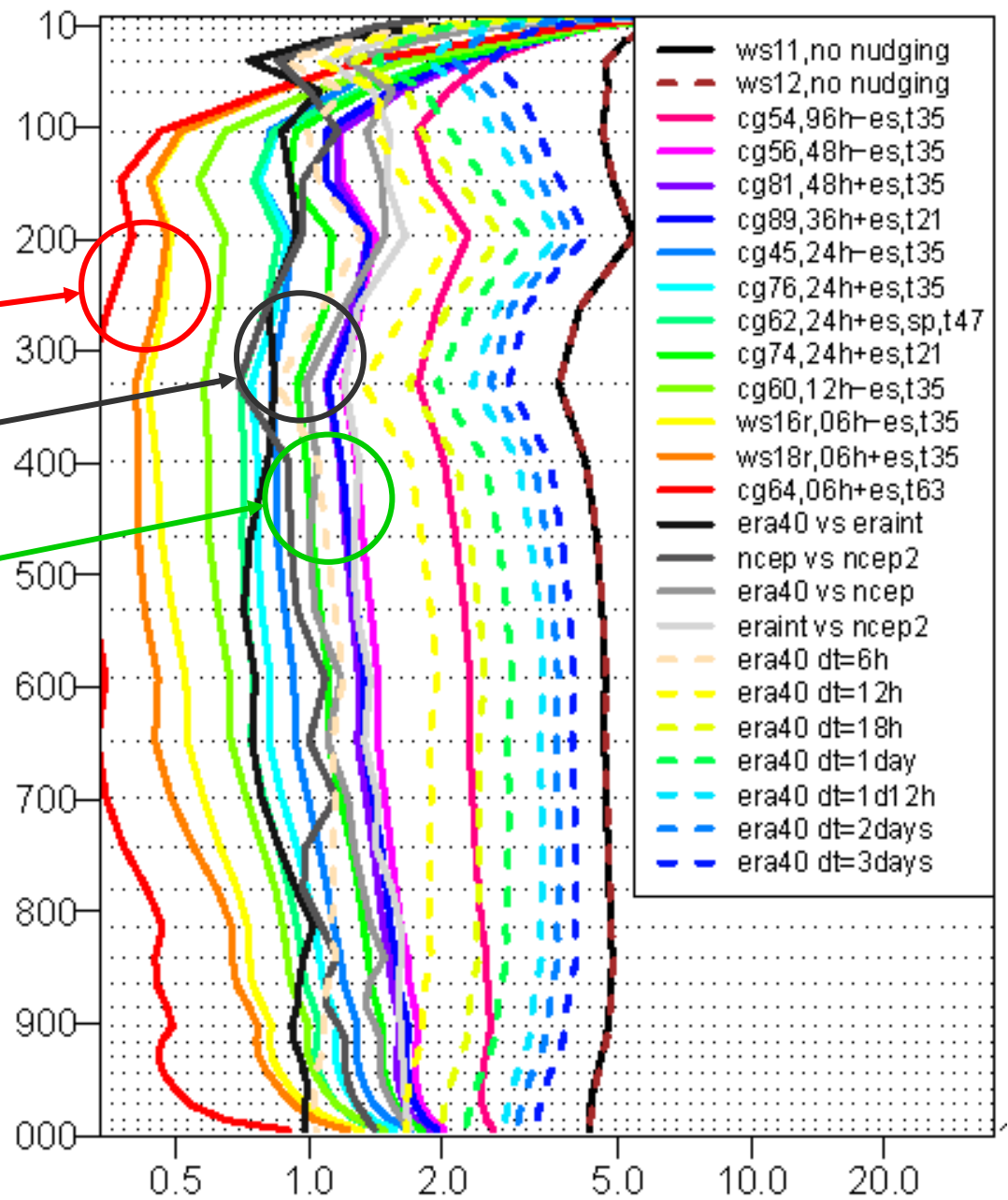


- * To better reflect observational uncertainties in ensemble, “dial back” assimilation \longrightarrow **constant incremental nudging (CIN)**



Pairwise standard deviations of air temperature vs height

temp-sd, 1979-1988, era40



IRU

Differences between reanalysis products

CIN

- Insert 1/4 of increment
- Truncate at T21

Benefits of IRU/CIN vs SST nudging

- accurate AGCM initialization
→ essential for 1st month skill
- ensemble generation
- better land initialization
- better ocean initialization

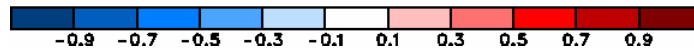
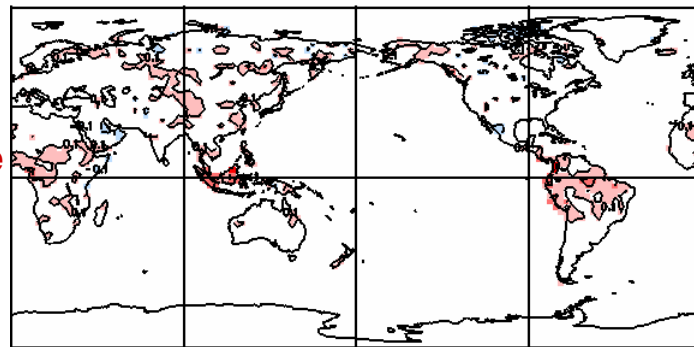


Impacts of AGCM assimilation on land initialization

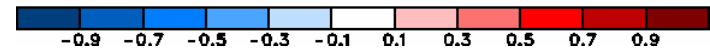
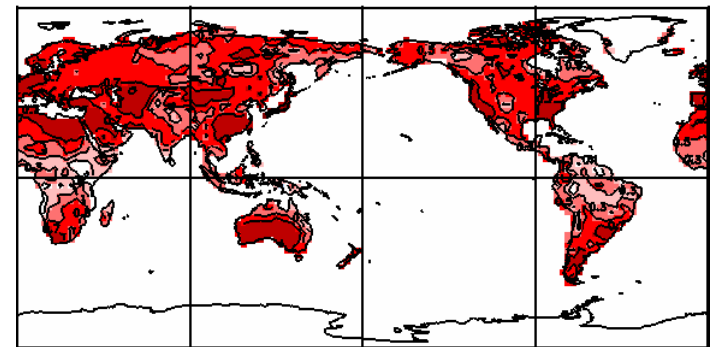
Correlation of assimilation run vs Guelph offline analysis

Soil temperature
(top layer)

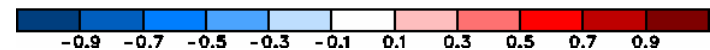
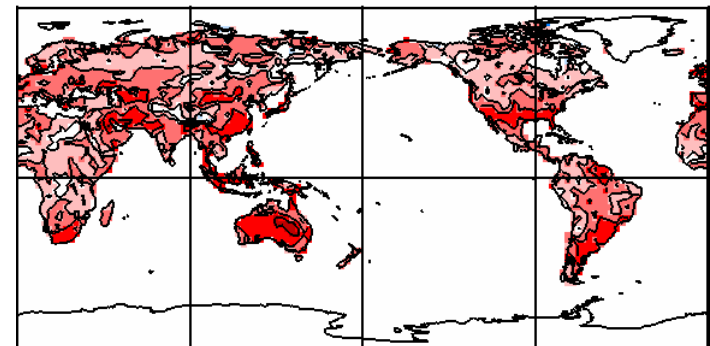
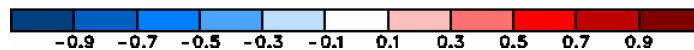
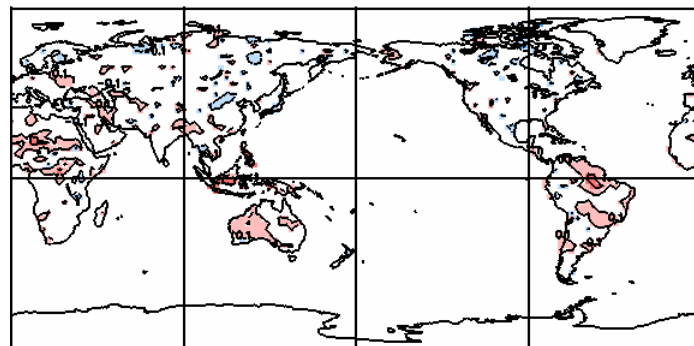
SST nudging only



SST nudging + AGCM assimim

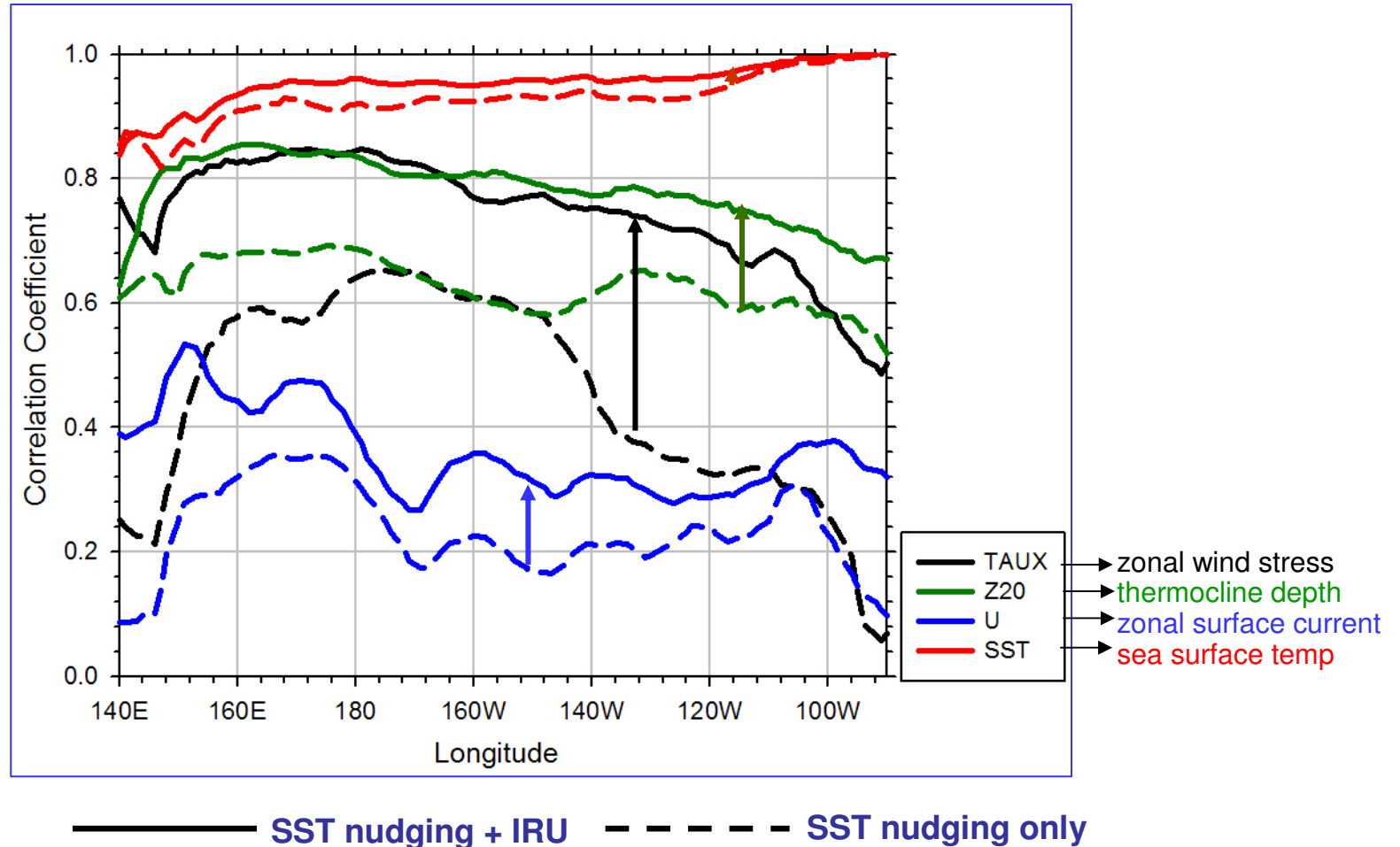


Soil moisture
(top layer)



Impacts of AGCM assimilation on ocean initialization

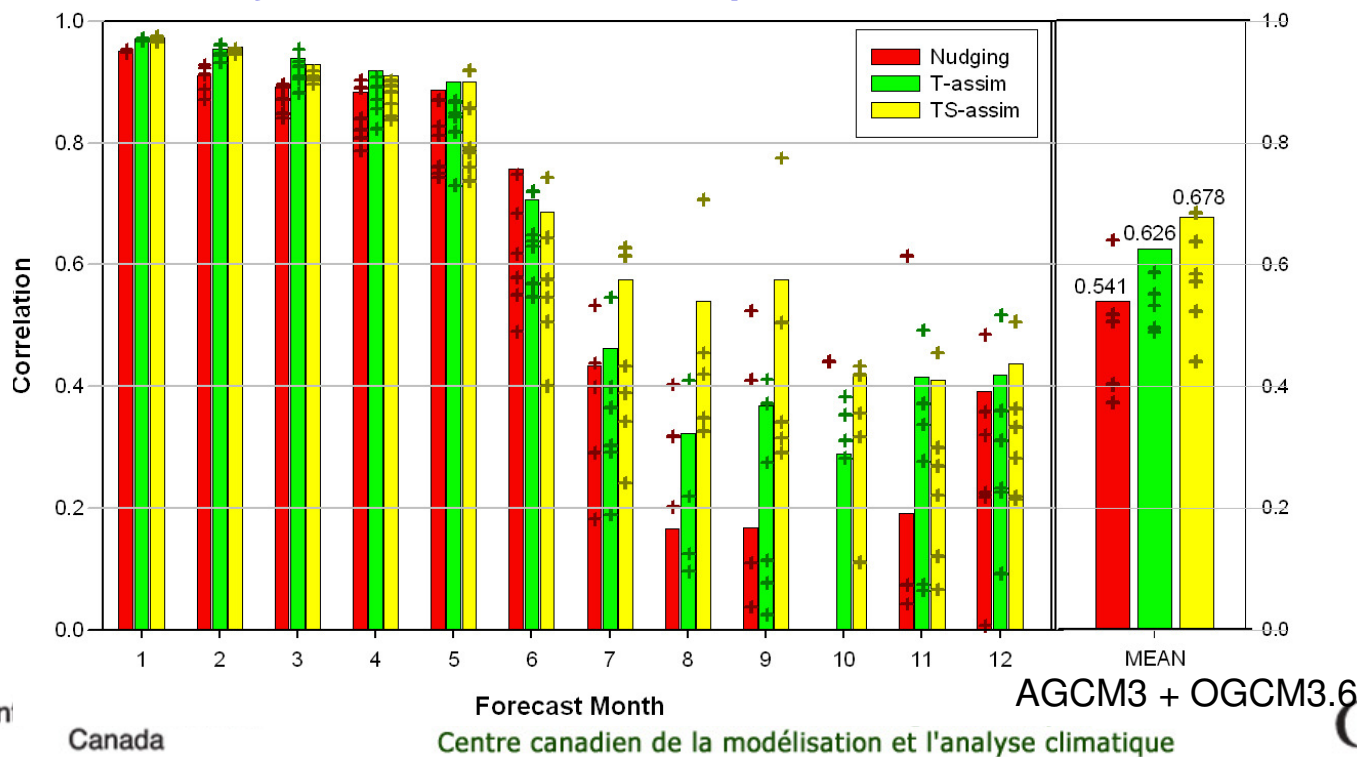
Correlations vs obs in equatorial Pacific (5S→5N)



CHFP2 Ocean Data Assimilation

- **T assimilation**
 - procedure of Tang et al. *JGR* 2004
 - off-line variational assimilation of 3D gridded analyses
- **S assimilation**
 - procedure of Troccoli et al. *MWR* 2002
 - preservation of T-S relationship: prevents spurious convection, etc.

Nino3.4 anomaly correlation: from 1 Sep 1980-2001 (6 ensemble members)

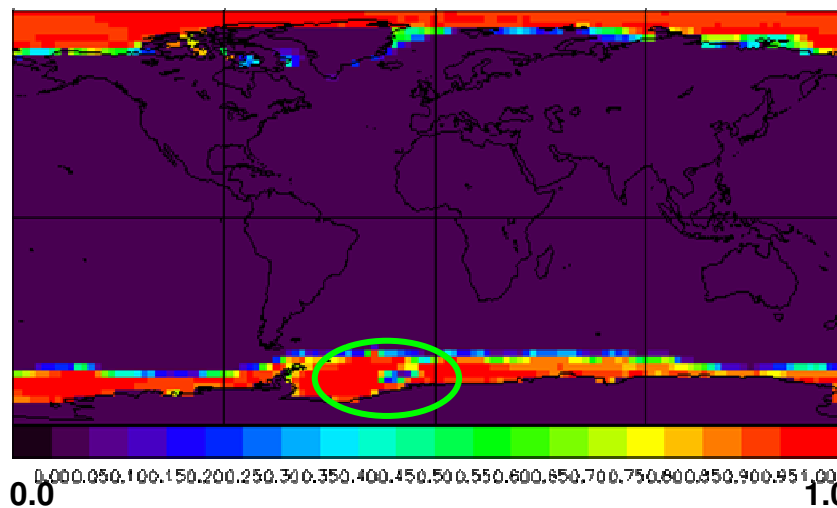


CHFP2 Sea ice initialization

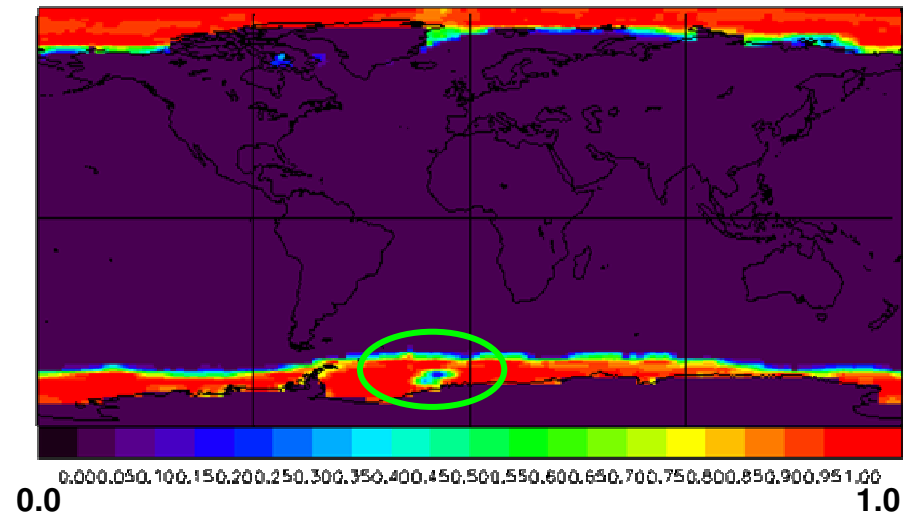
- Relax to Hadisst observations

Sea ice concentration: August 1976

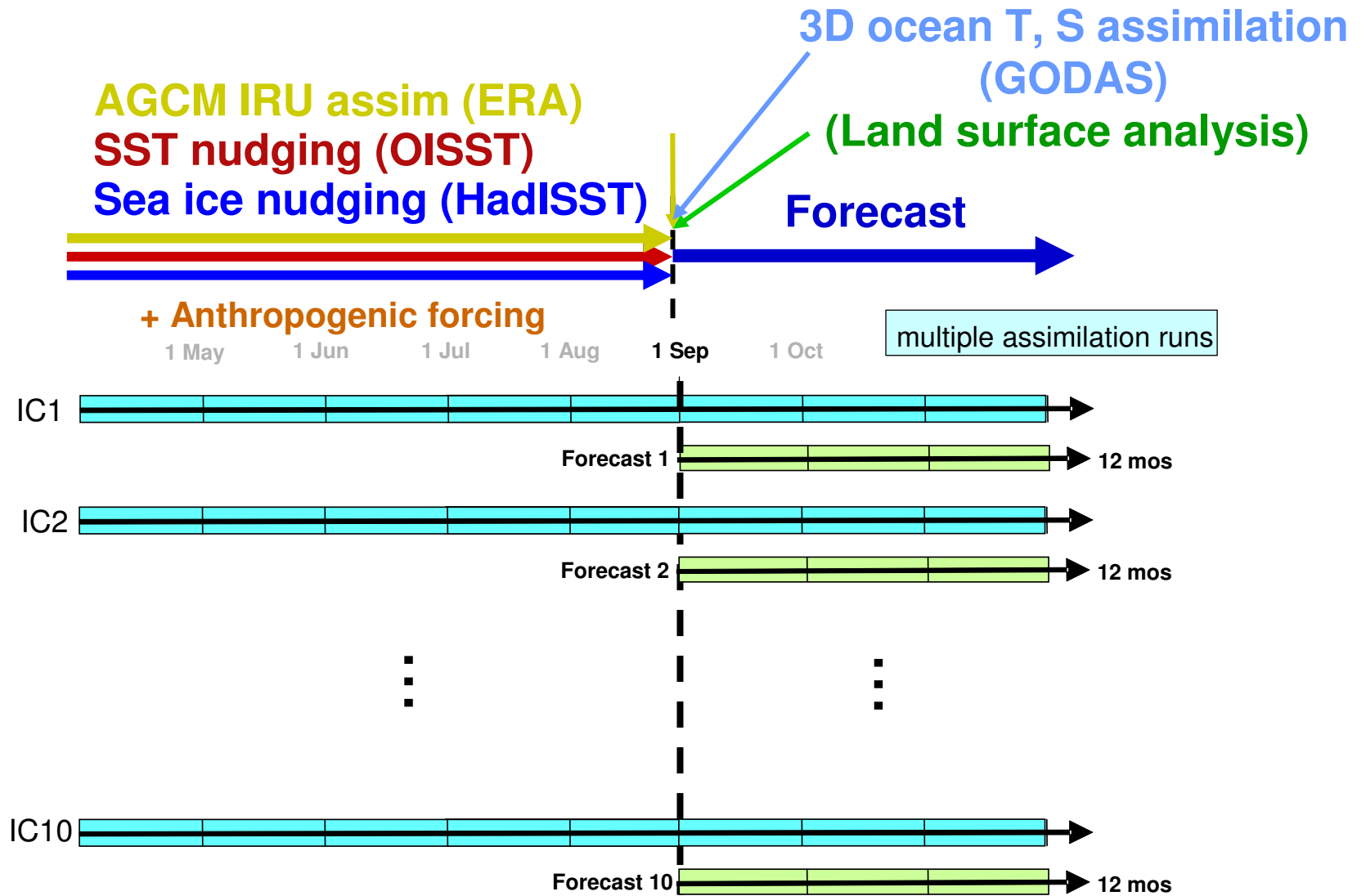
Hadisst



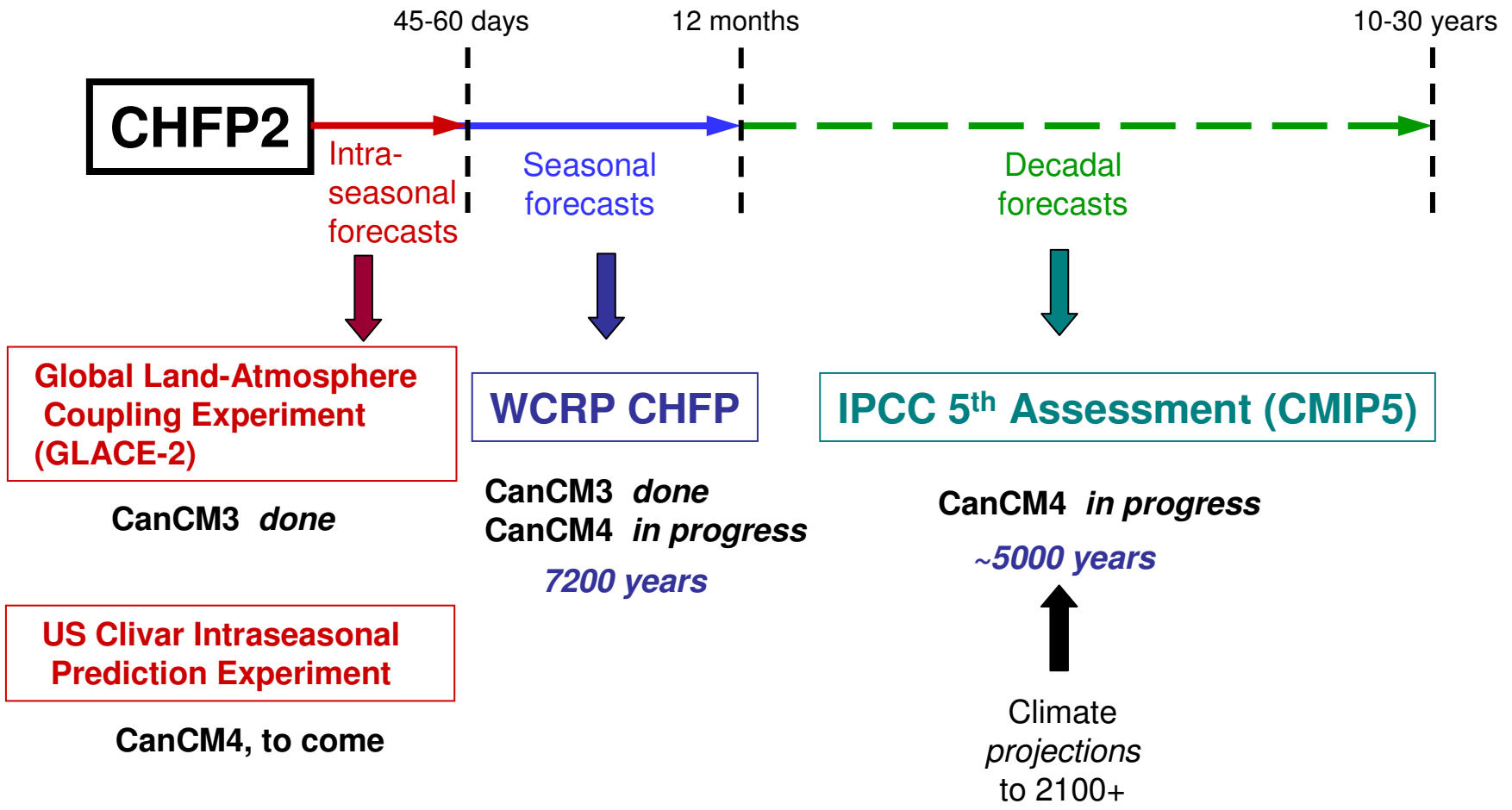
Forecast initial conditions



CHFP2 initialization



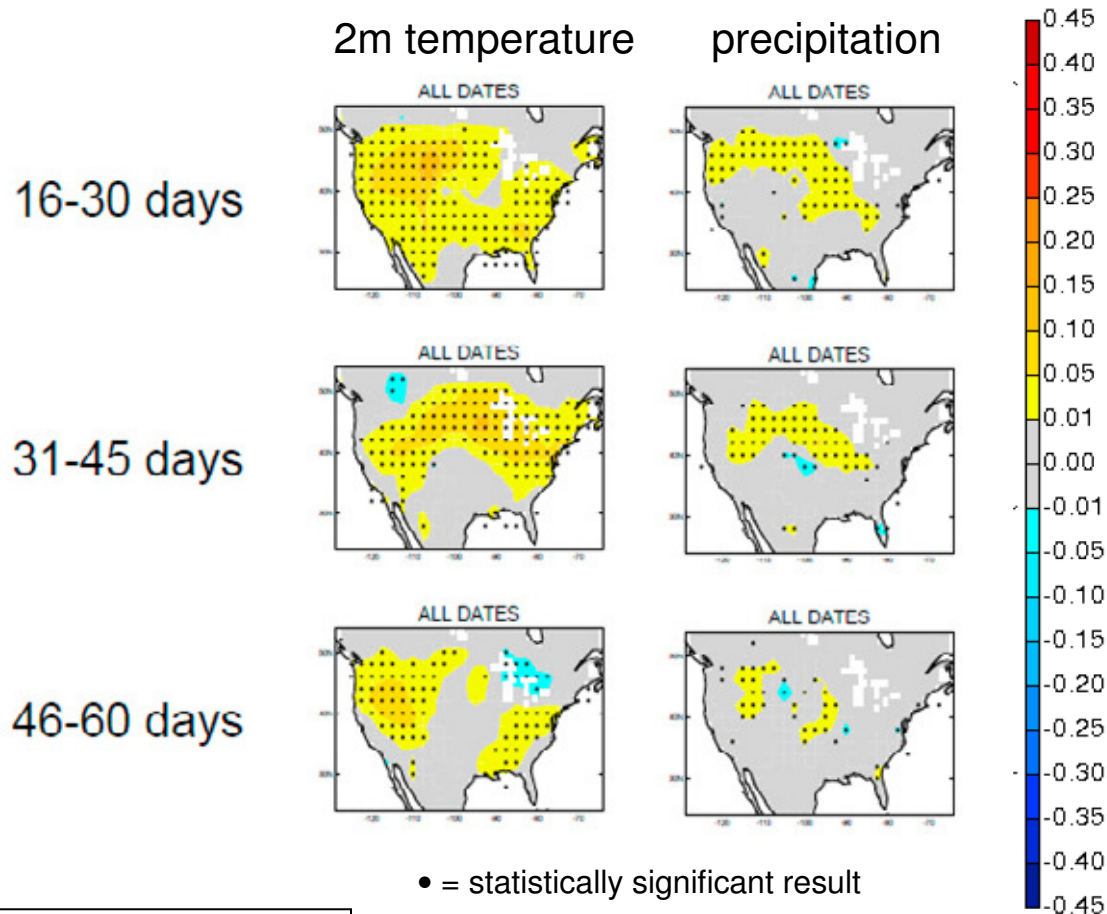
CHFP2 contributions to international activities



GLACE-2 initial results

A coordinated effort to assess the role of land-surface initialization (including soil moisture) in forecast skill. Plots show anomaly correlation skill enhancement attributable to realistic land initial conditions

Ensemble of 10 seasonal forecast models (including CCCma)



Koster et al. *GRL* 2010



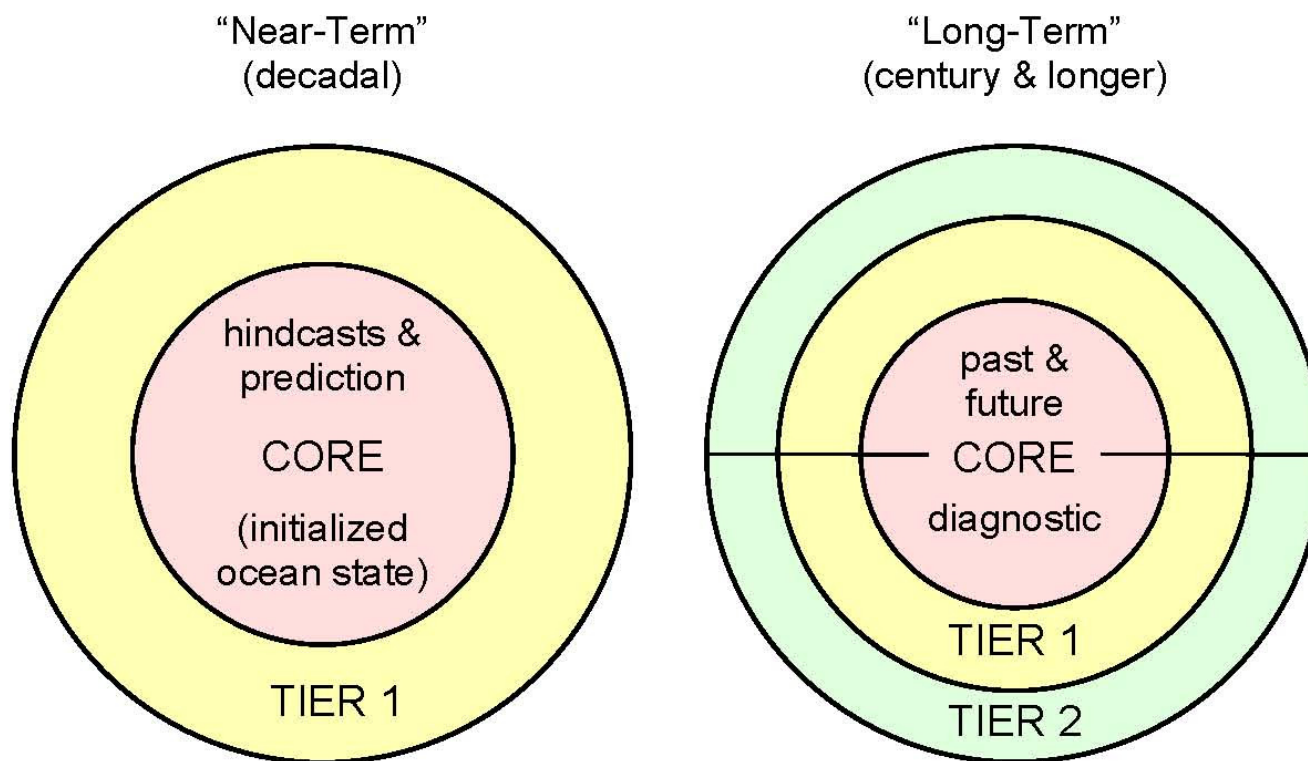
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IPCC AR5: From projection to prediction



Schematic of the two focus areas of CMIP5

Taylor et al.: CMIP5 Experiment Design



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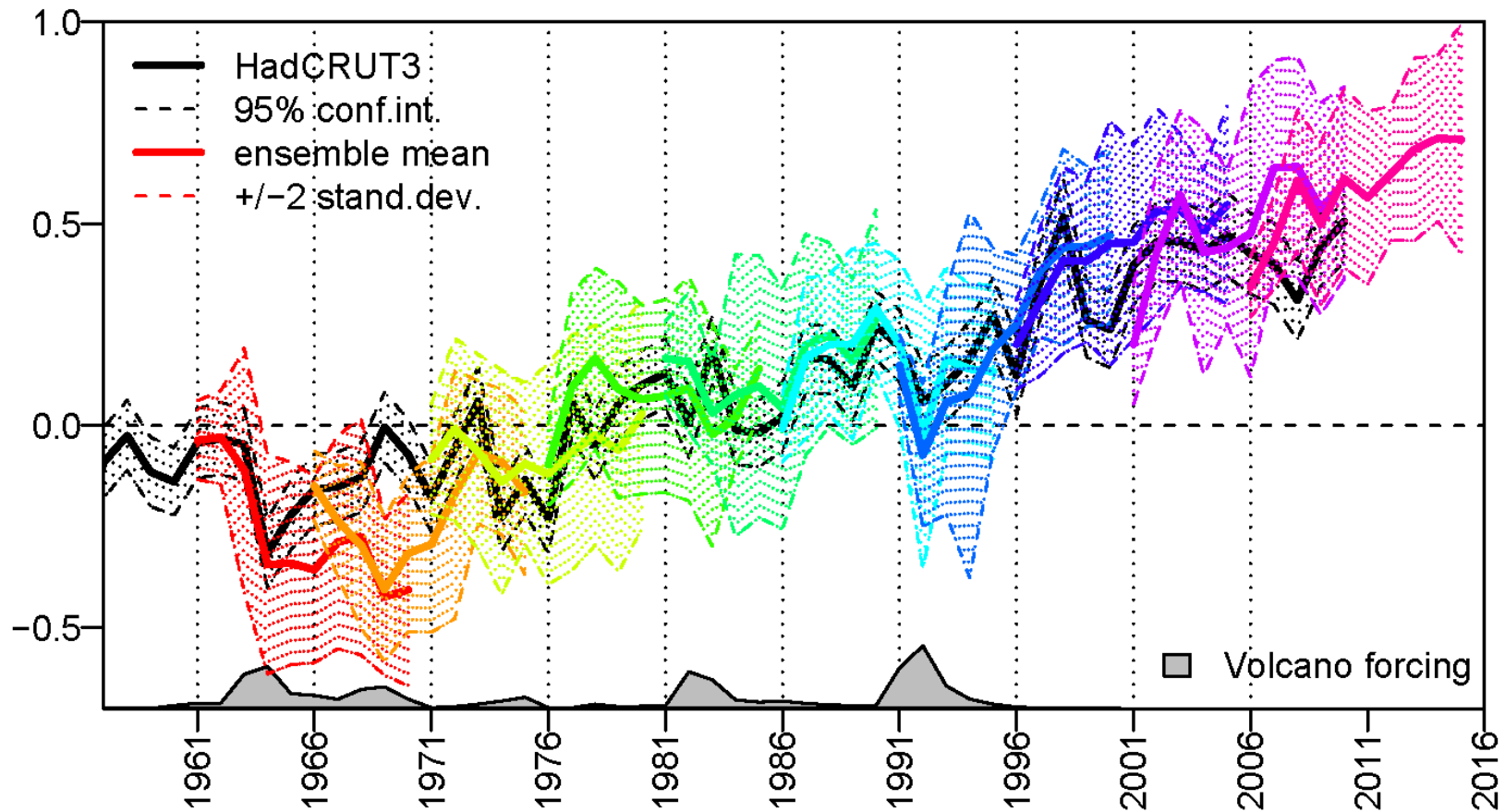
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Decadal forecast results to 2015

ANN SCREEN TEMPERATURE GLOBAL (K)
annual means



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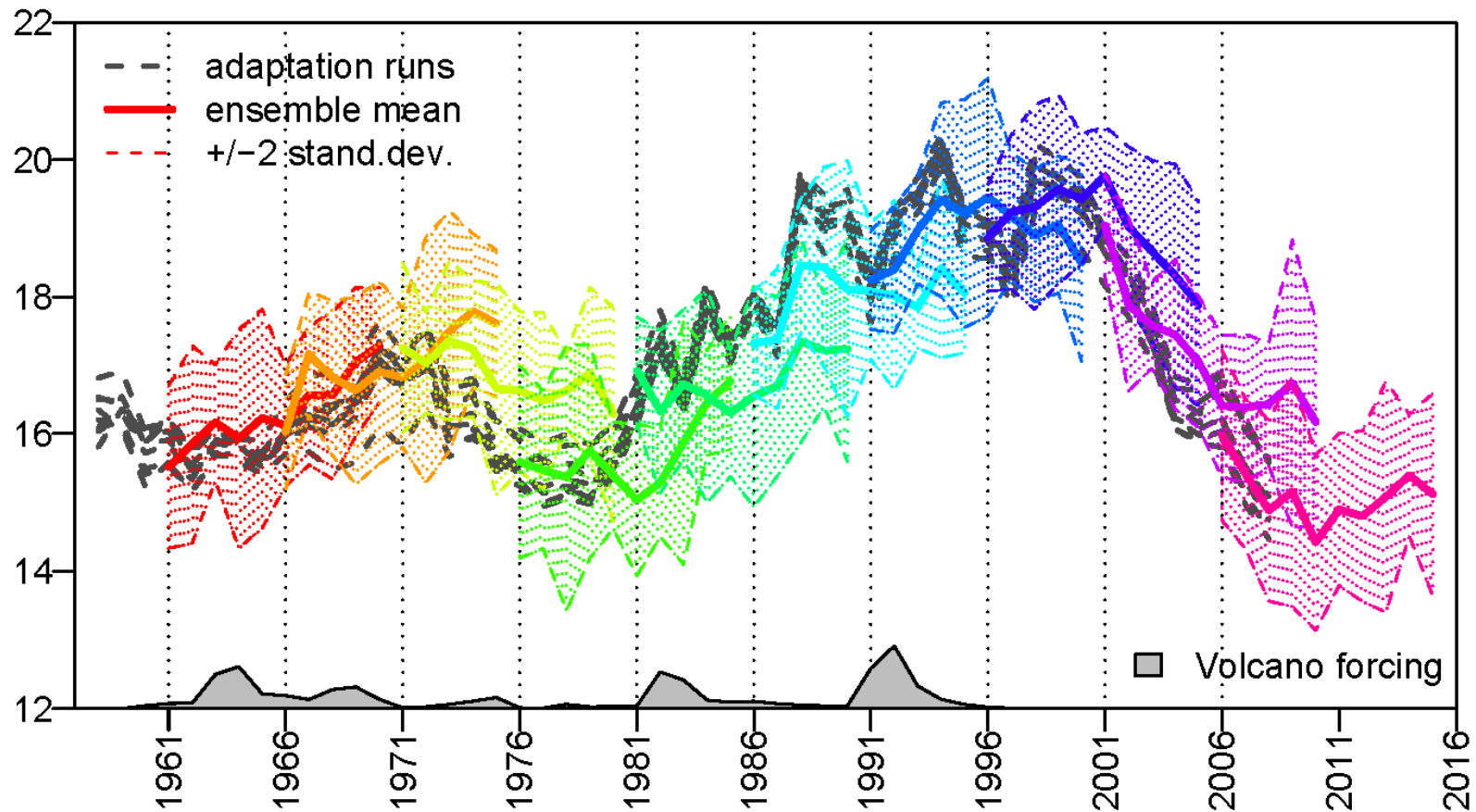
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Decadal forecast results to 2015

ANN MAX MERIDIONAL V PSI NATL 26N(SV)
annual means



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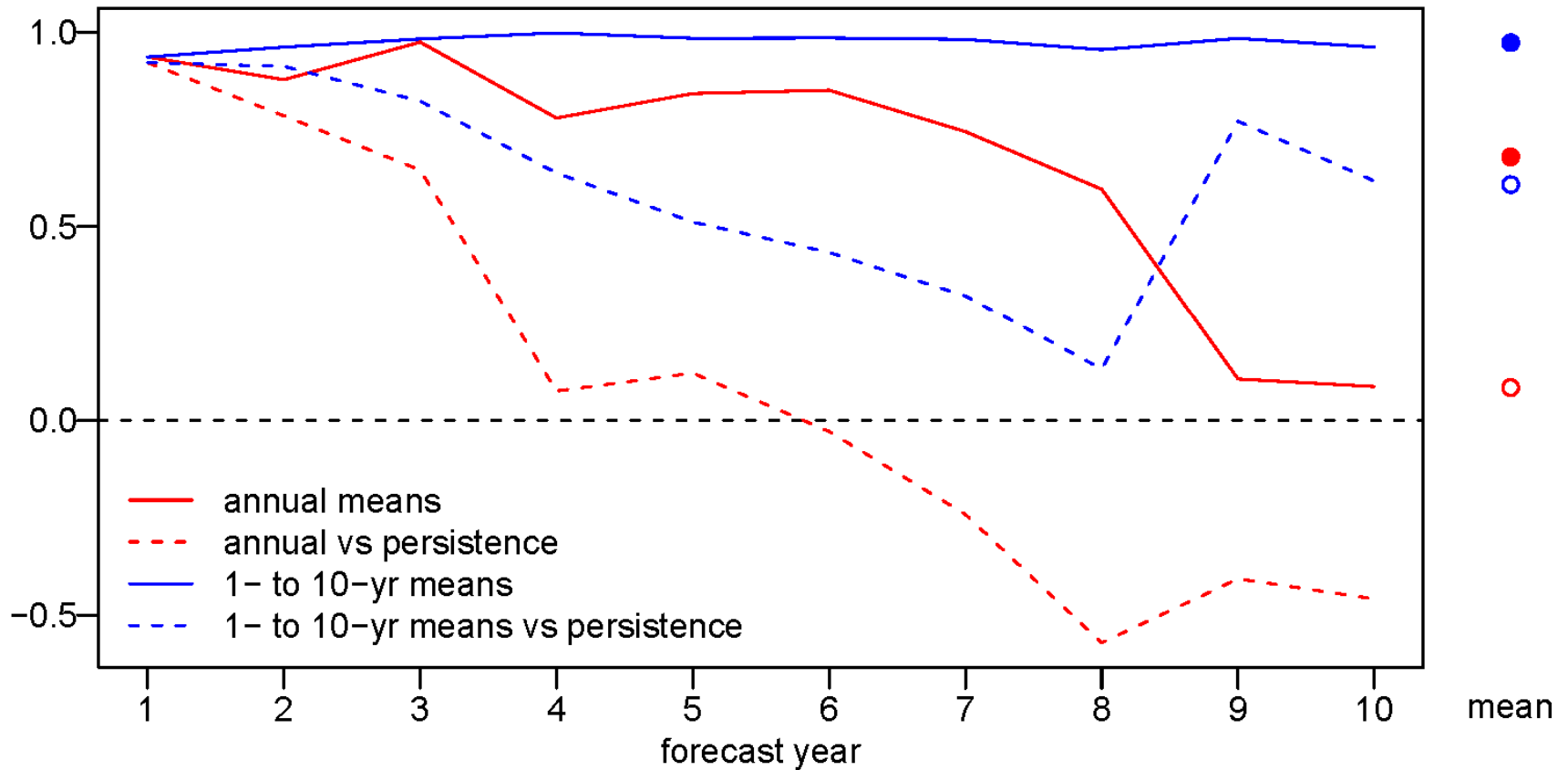
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Correlation of forecast and analysis MOC anomalies

ANN MAX MERIDIONAL V PSI NATL 26N(SV)
Correlation



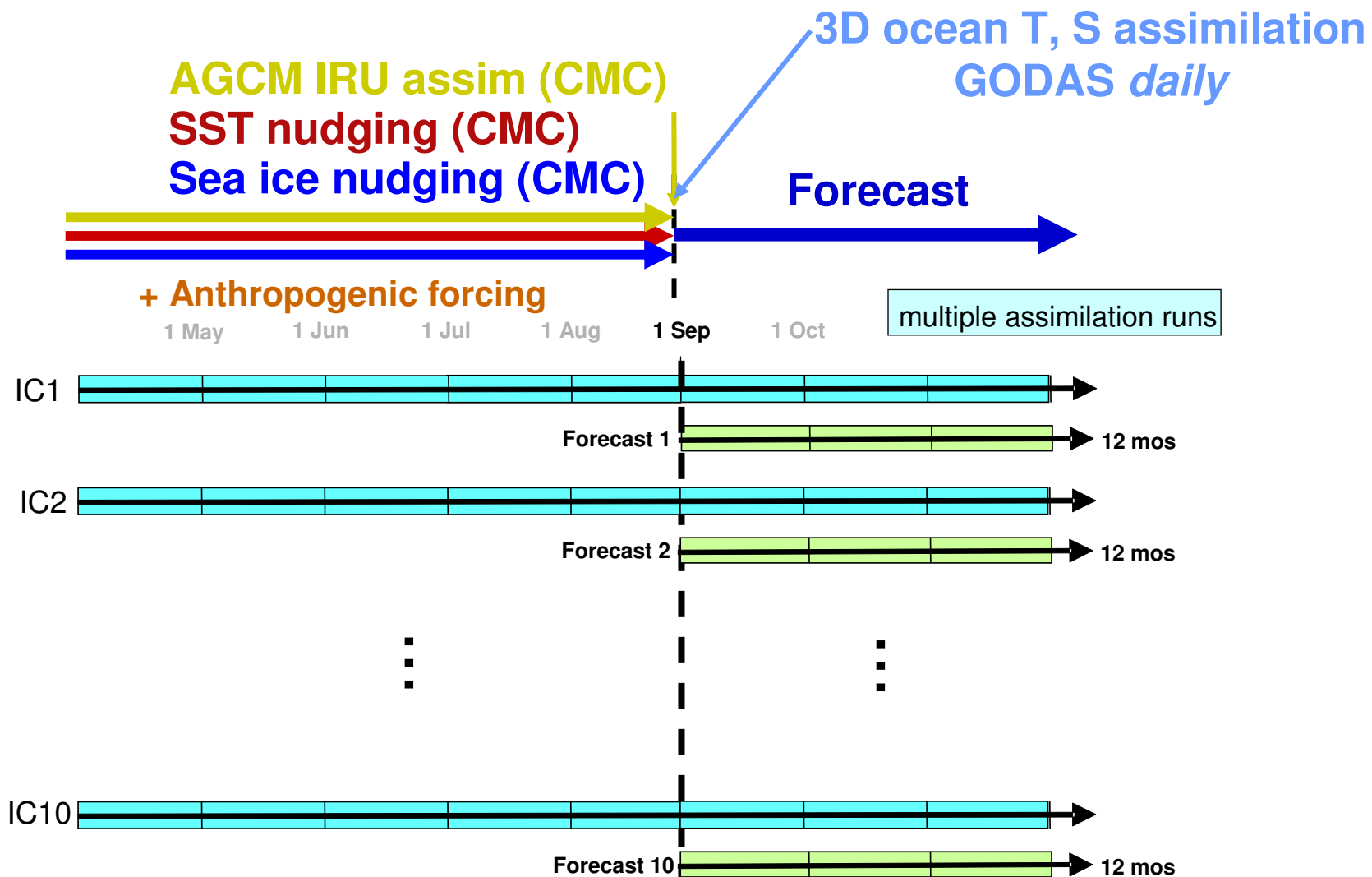
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CHFP2 operational setup



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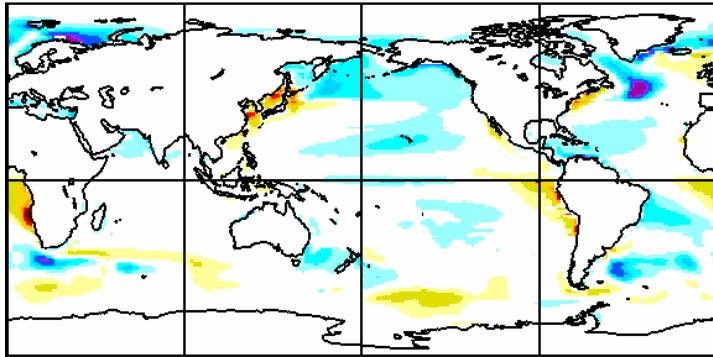
Further potential improvements (next generation)

- improved ocean data assimilation
- improved real-time land initialization
- bias removal through *spectral nudging*, which suppresses OGCM biases without damping interannual variability
- perhaps something similar for AGCM

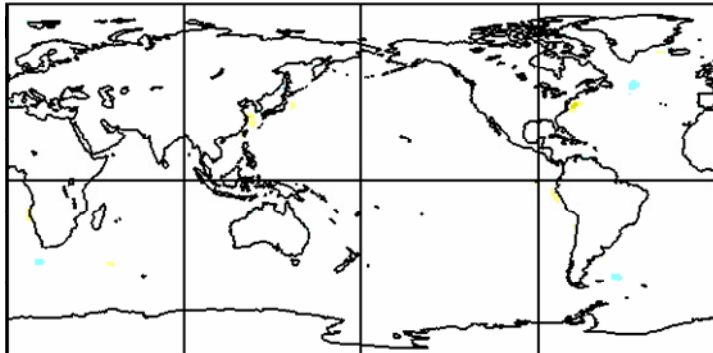


Benefits of spectral nudging

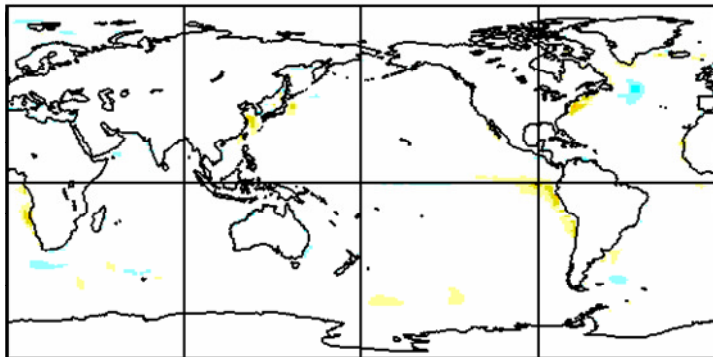
SST biases



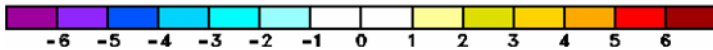
freely running



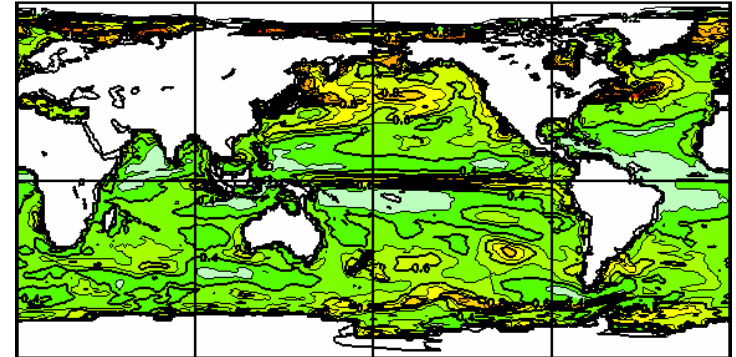
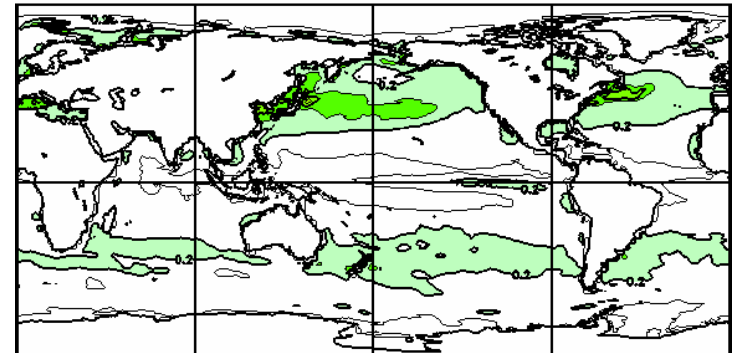
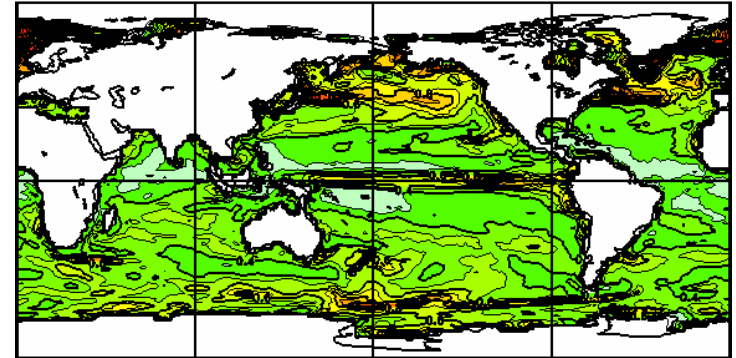
conventionally nudged



spectrally nudged



SST variability



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HFP2 initialization

