

Coupled Seasonal Forecasting at CCCma

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Canadian Centre for Climate Modelling and Analysis

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Atmospheric Sciences



Dynamical Seasonal Forecasting in Canada

Canadian Clivar Network 2001-2007

- Historical Forecast Project (HFP)
 - 6-run ensembles, 2 models (GCM2, SEF)
 - persisted SSTs
 - *Current operational system* (SEF → GEM in 2004)
- HFP2
 - 10-run ensembles, 4 models (GCM2, GCM3, SEF, GEM)
 - persisted SSTs
 - *Operational Fall 2007*
- Begin development of *coupled* forecast capability at CCCma
 - *prognostic SSTs*, enabling *longer leads*

GOAPP

- Coupled Historical Forecast Project (**CHFP**)

CCCma



Dynamical Seasonal Forecasting in Canada

Canadian Clivar Network 2001-2007

- Historical Forecast Project (HFP)
 - 6-run ensembles, 2 models (GCM2, SEF)
 - persisted SSTs
 - *Current operational system* (SEF → GEM in 2004) ← **3 month outlook lead 0 mo**
- HFP2
 - 10-run ensembles, 4 models (GCM2, GCM3, SEF, GEM)
 - persisted SSTs
 - *Operational Fall 2007* ← **3 month outlook lead 0, 1 mo**
- Initial development of *coupled* forecast capability at CCCma
 - *prognostic SSTs*, enabling *longer leads*

GOAPP

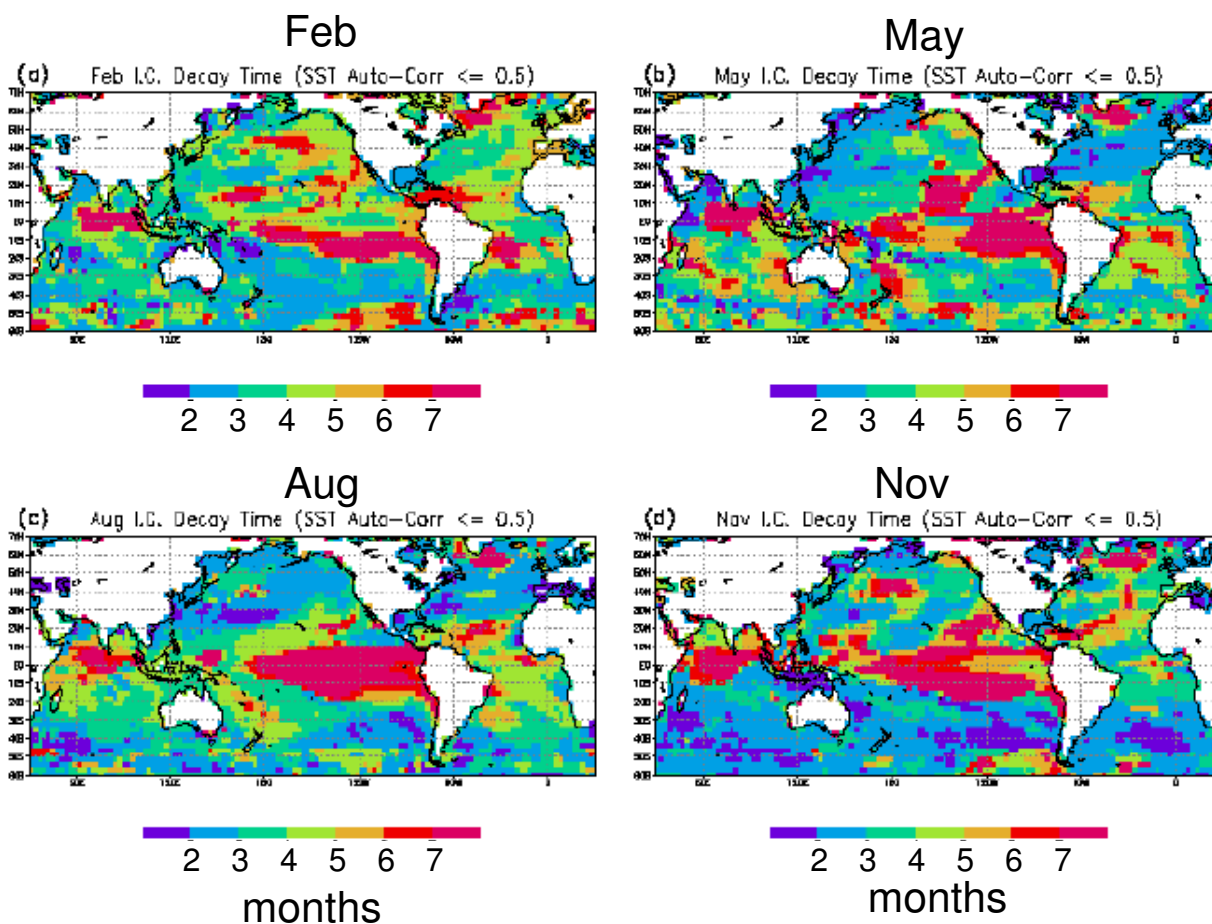
- Coupled Historical Forecast Project (**CHFP**)

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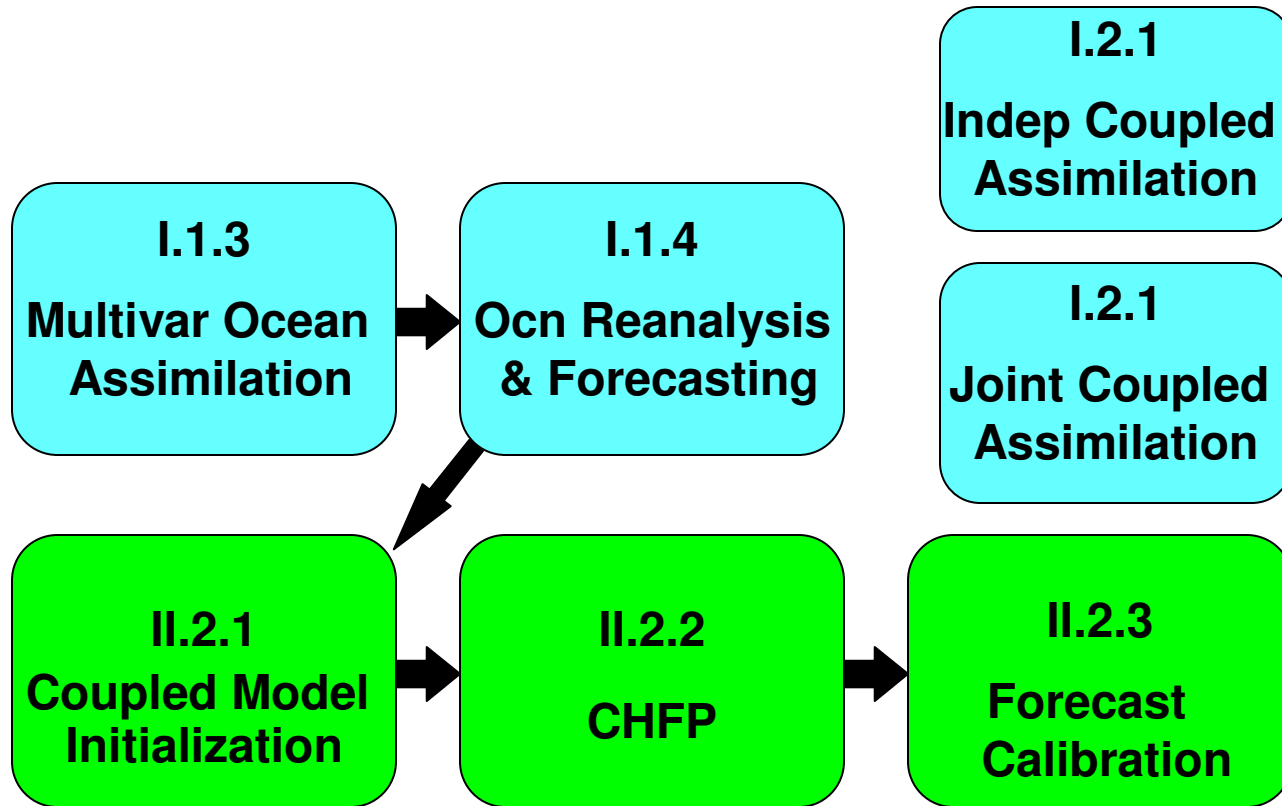
Observed SST autocorrelation time scale

Months before autocorrelation < 0.5 :

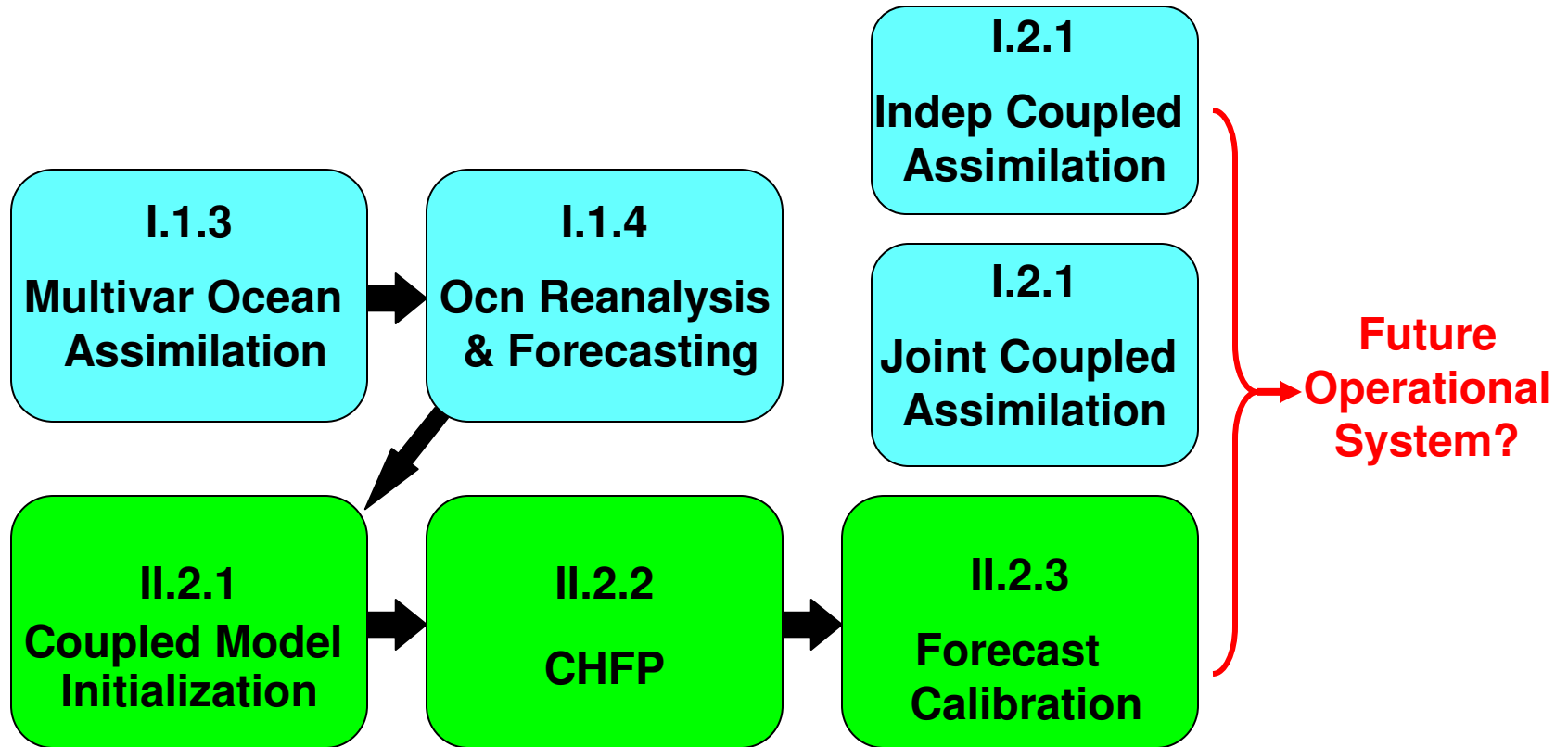


Goddard & Mason (*Clim Dyn* 2002)

CHFP Role within GOAPP

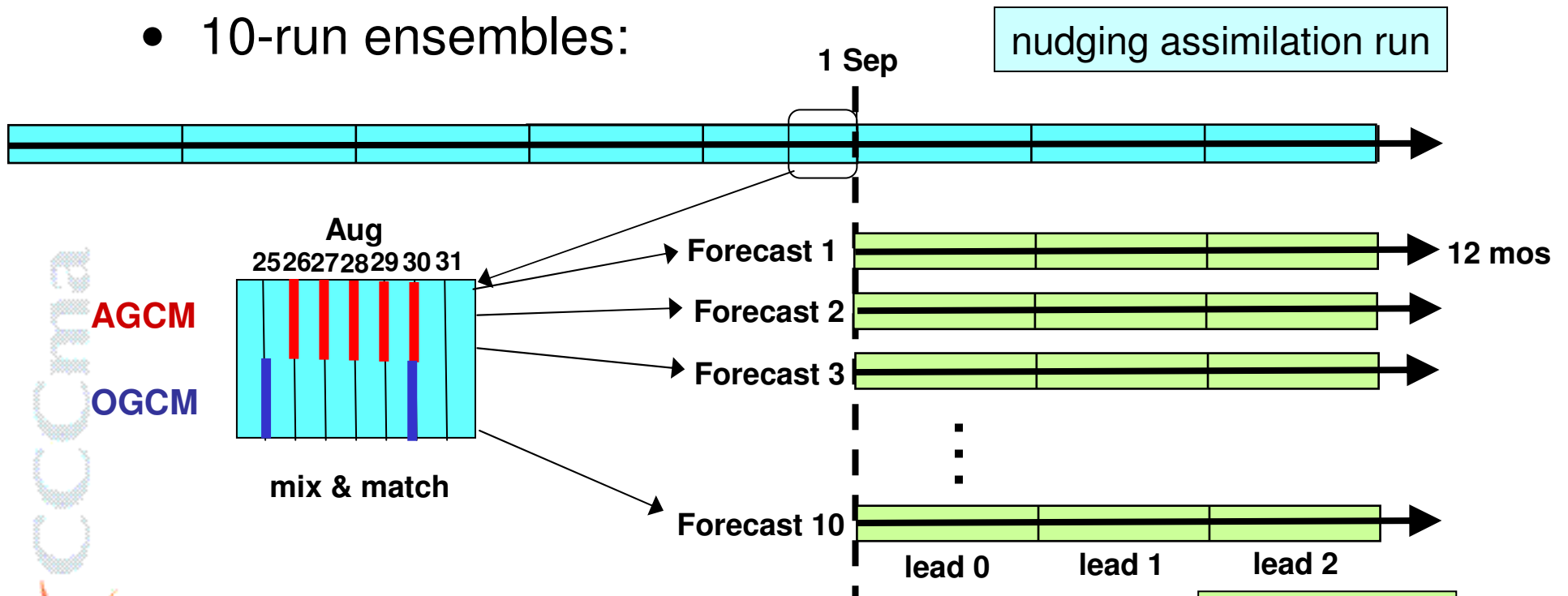


CHFP Role within GOAPP



CHFP Prototype

- CGCM3.1 (T63)
- Ocean initialization via SST “nudging” to obs $\tau=10d$
- Initialize 1 Sep, 1 Dec, 1 Mar, 1 Jun 1972/3-2001/2
- 10-run ensembles:



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Forecast methodology/verification

- Bias correction from 30y forecast climatology
- Verify by computing
 - anomaly correlation
 - mean-square skill score: **MSSS** = $1 - \frac{\sigma_{fcst}^2}{\sigma_{clim}^2}$
 - > 0 if more skillful than climatological forecast
 - % correct of categorical forecasts
 - Brier skill score, etc.

Mean sq fcst error

$$1 - \frac{\sigma_{fcst}^2}{\sigma_{clim}^2}$$

Mean sq error of climatological fcst



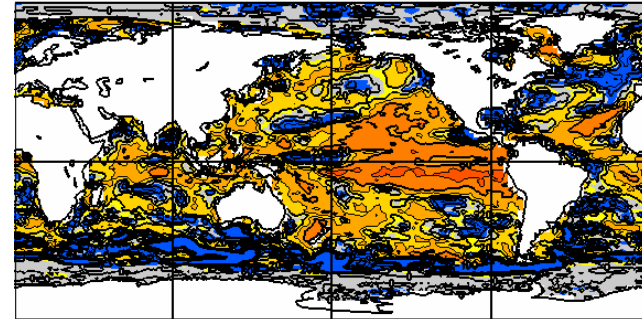
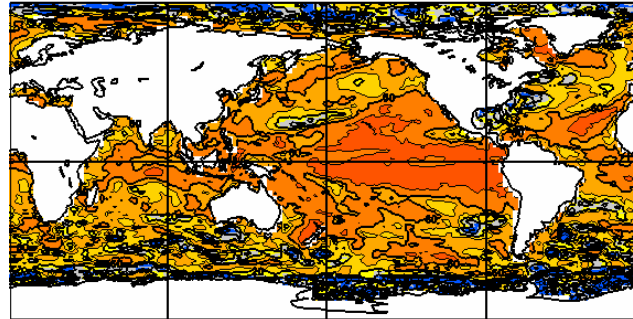
August
Initialization

Prototype forecast results

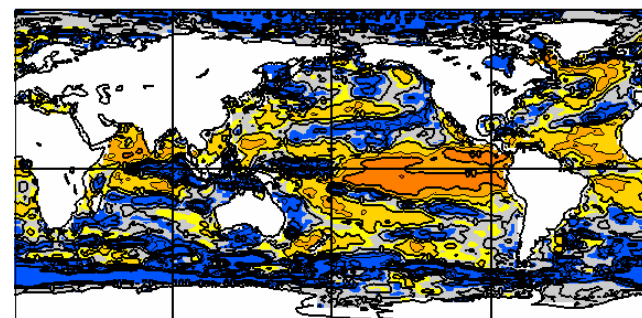
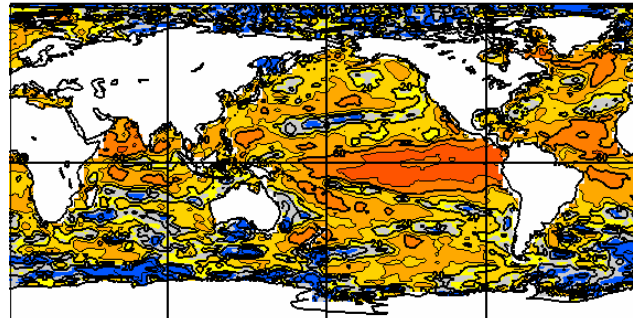
Anomaly correlation

MSSS

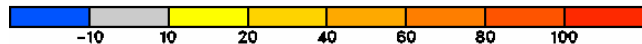
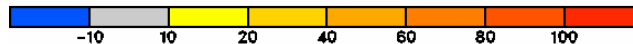
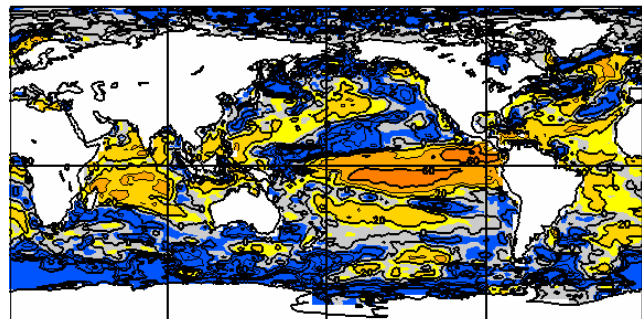
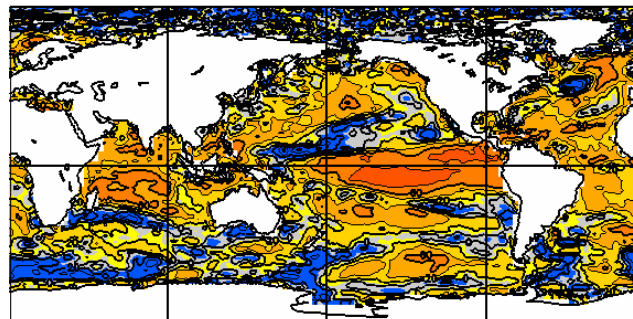
October
Lead 1



December
Lead 3



February
Lead 5



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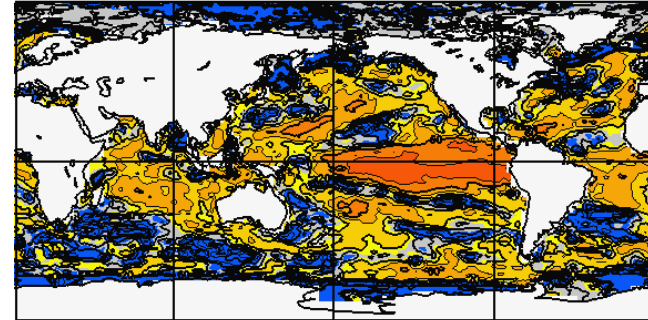
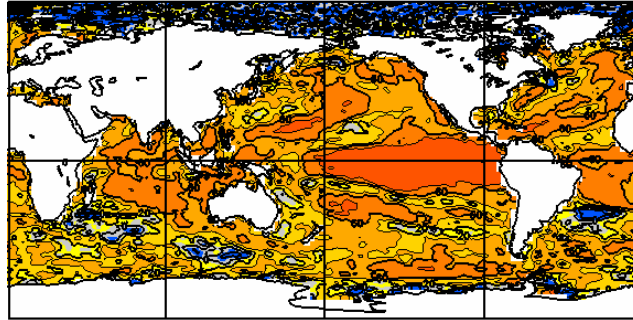
November
Initialization

Prototype forecast results

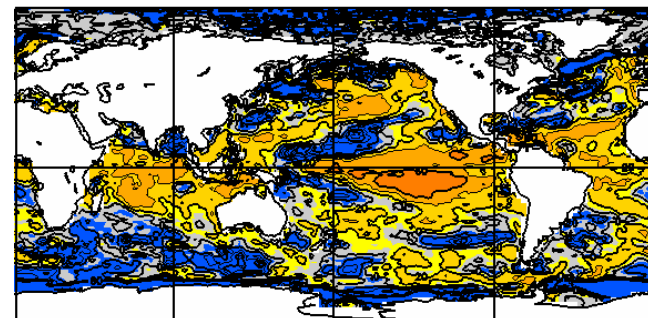
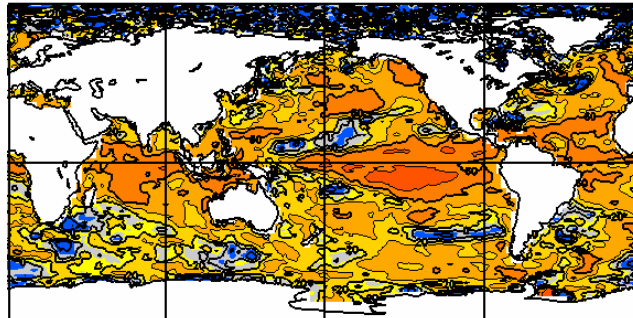
Anomaly correlation

MSSS

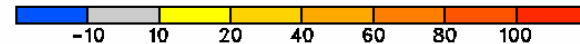
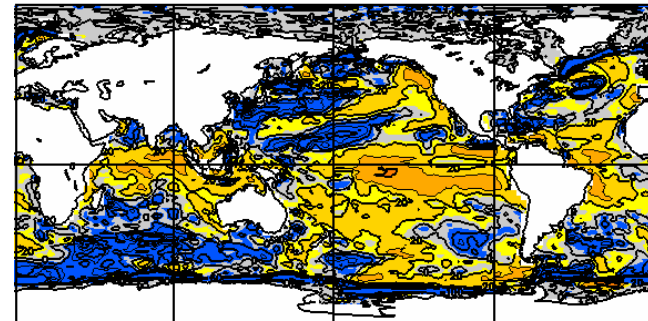
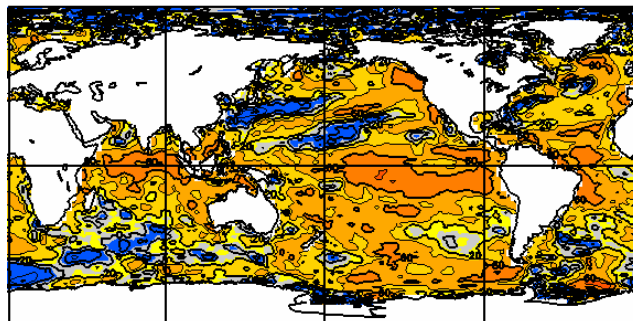
January
Lead 1



March
Lead 3



May
Lead 5



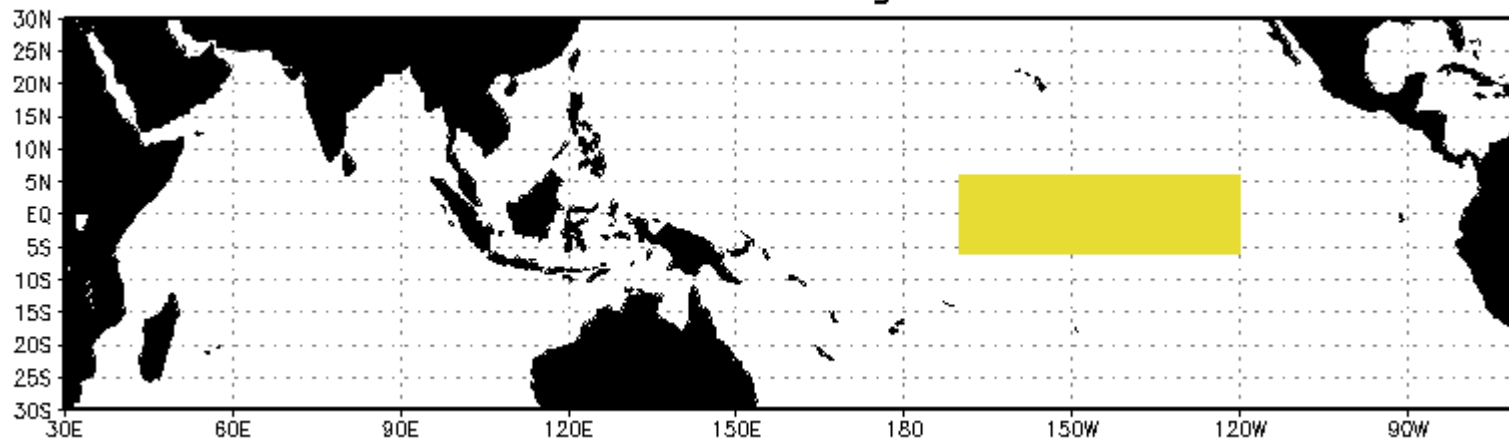
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Prototype forecast results

NINO3.4 “plume”

Nino3.4 region



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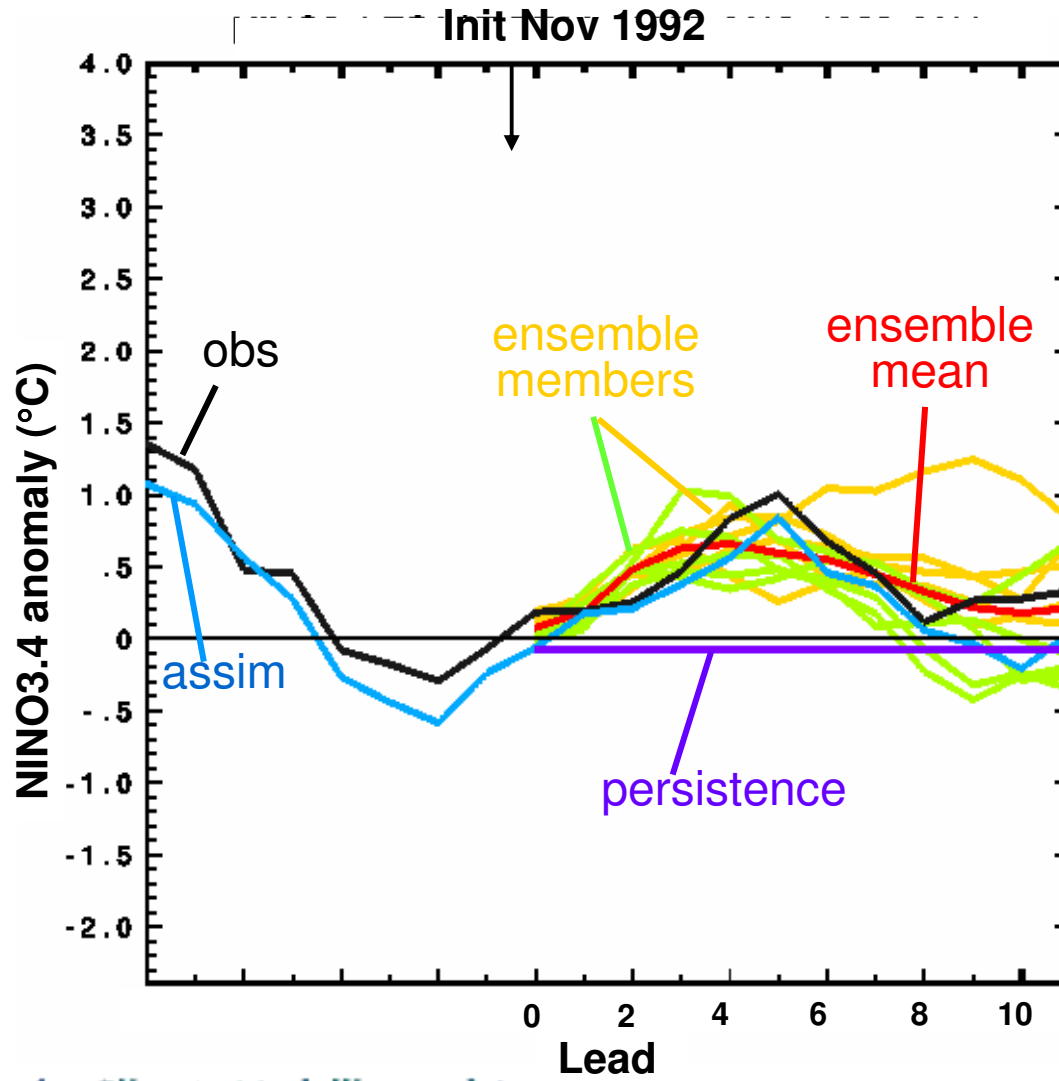


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Canada

Prototype forecast results

NINO3.4 "plume"



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Surface temperature forecast for Canada

Lead 1

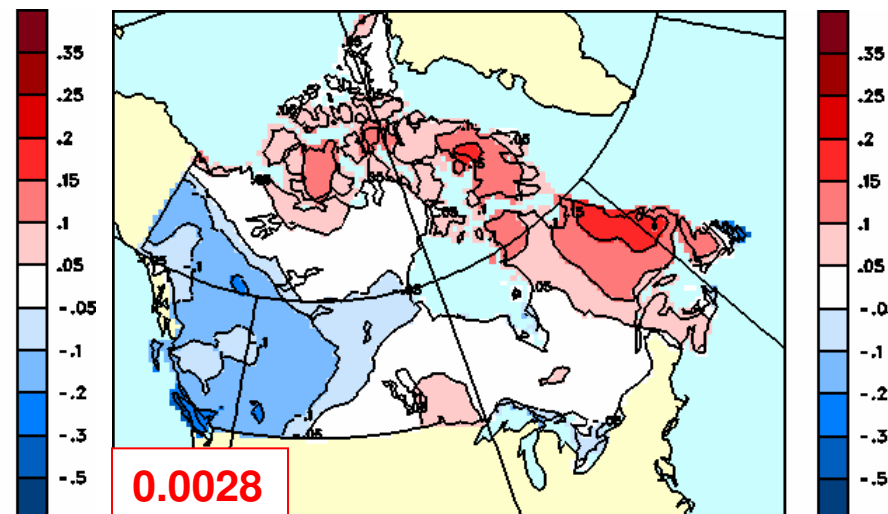
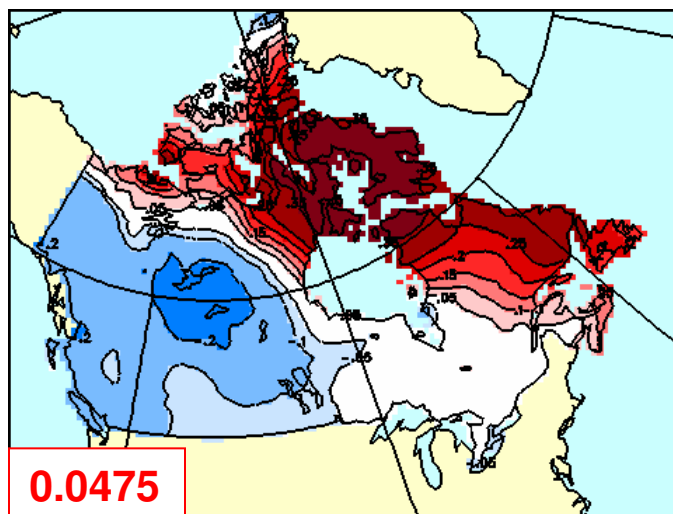
OND
forecast

Proto-CHFP

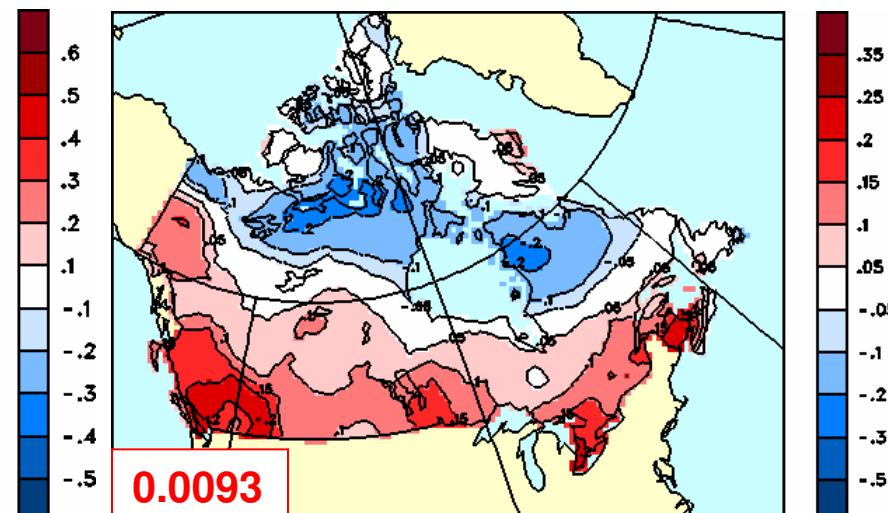
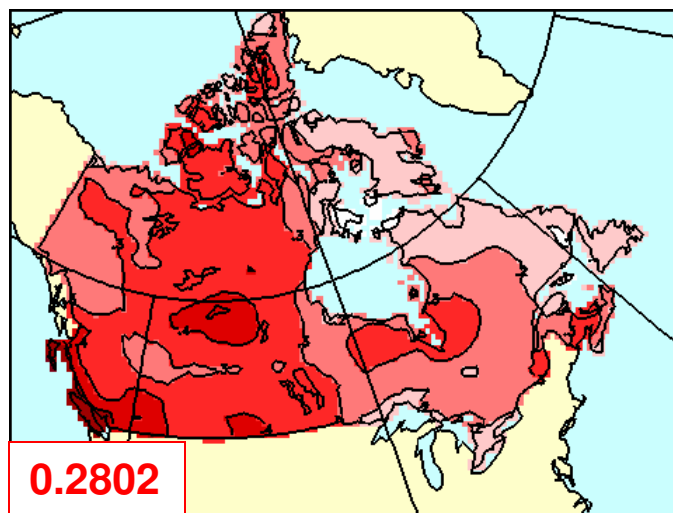
MSSS

HFP2

MSSS



JFM
forecast



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Surface temperature forecast for Canada

Lead 1

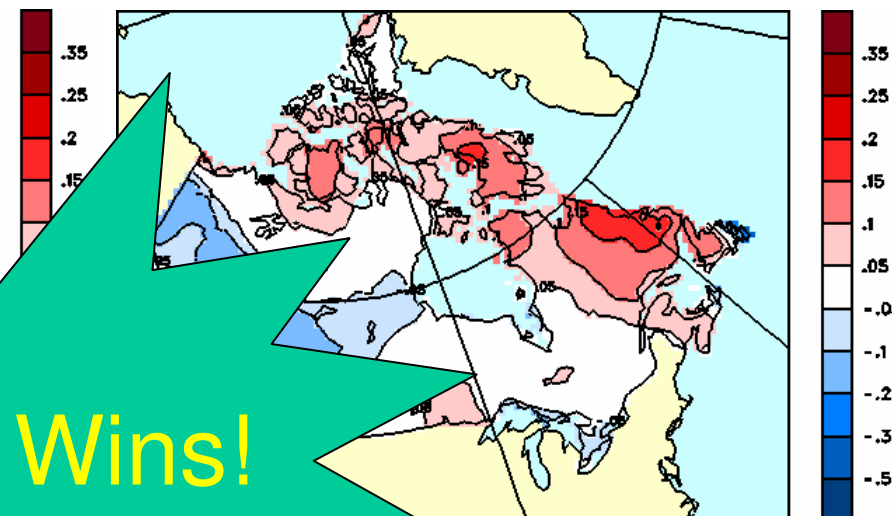
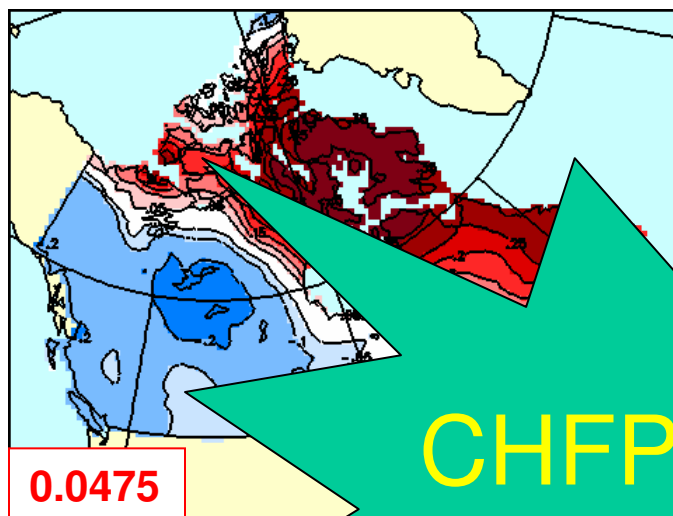
Proto-CHFP

MSSS

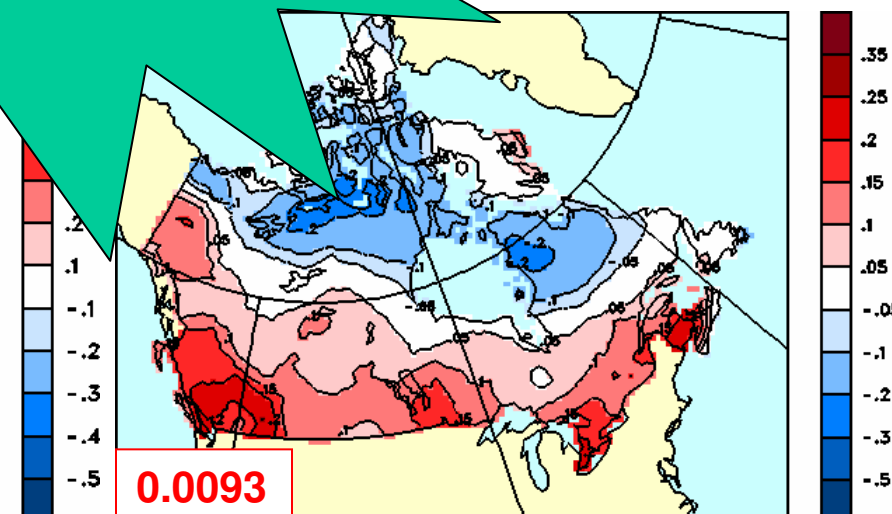
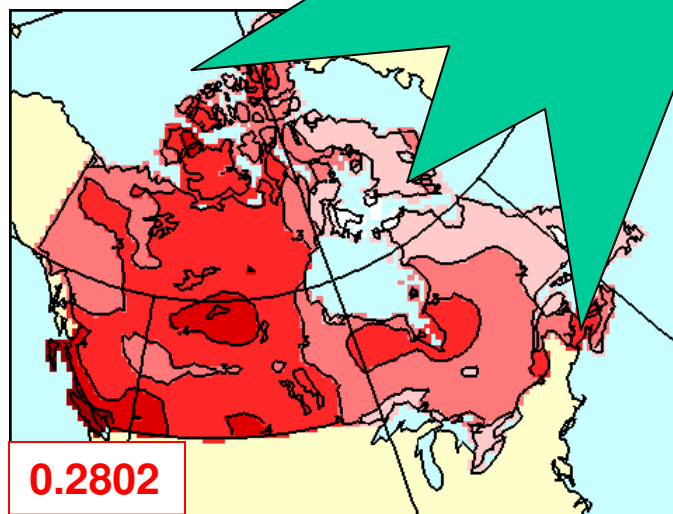
HFP2

MSSS

OND
forecast



JFM
forecast



CHFP Wins!

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Surface temperature forecast for Canada

Lead 0

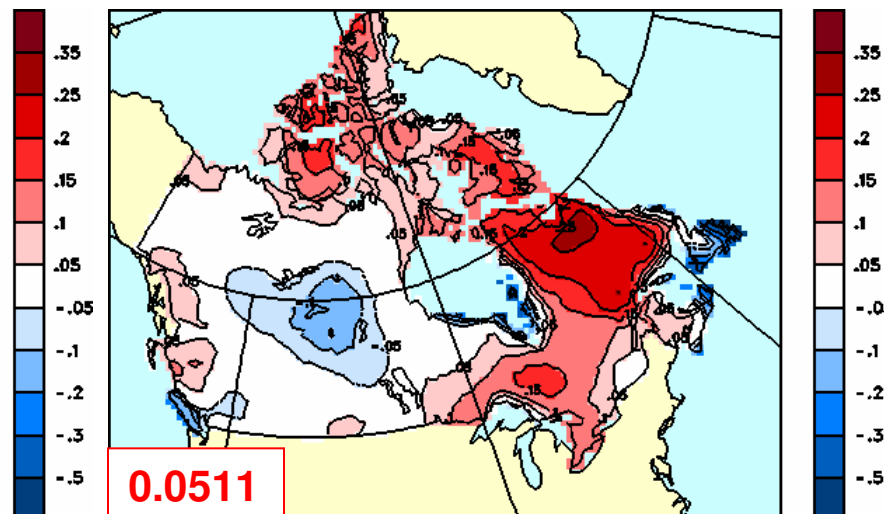
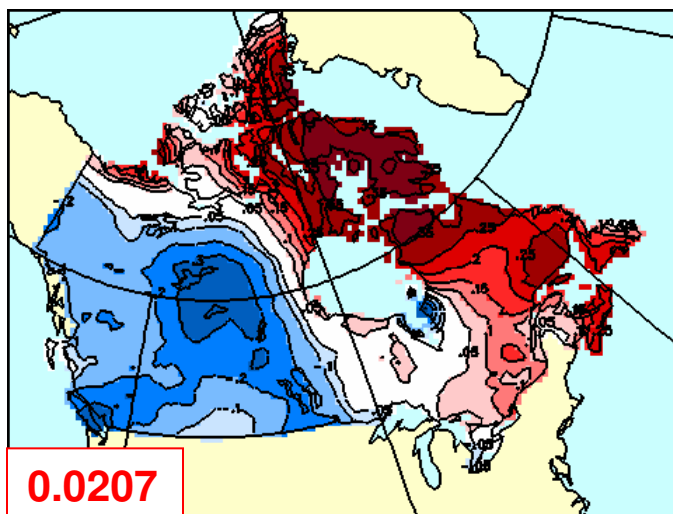
Proto-CHFP

MSSS

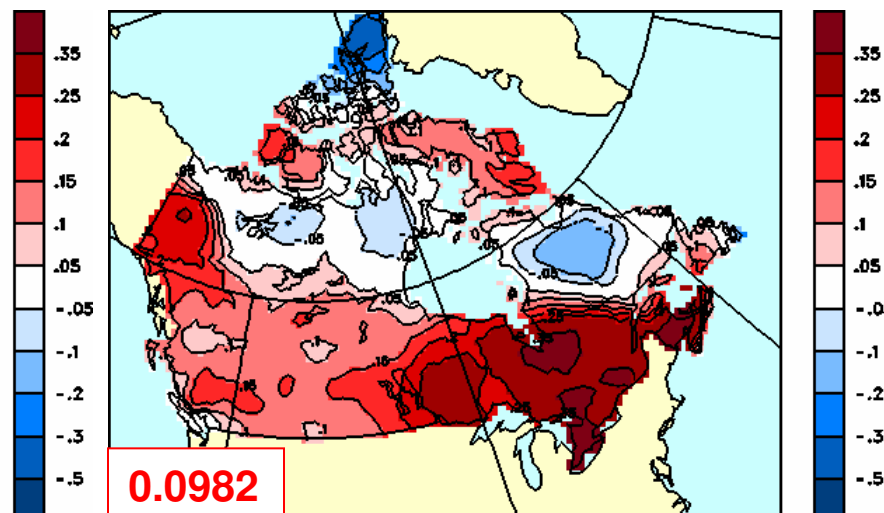
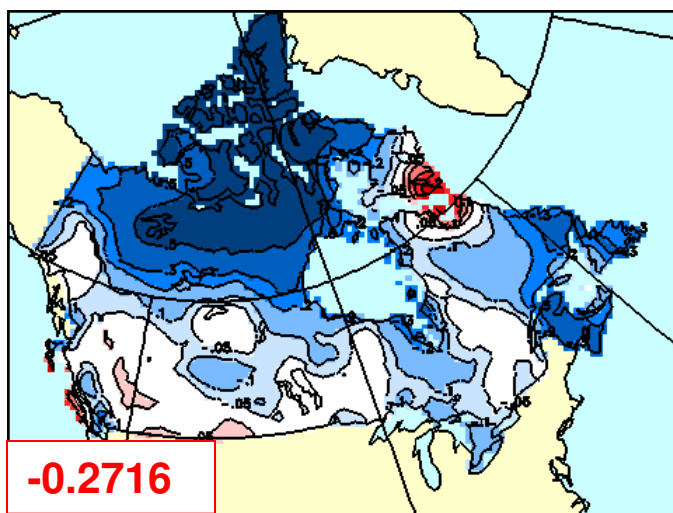
HFP2

MSSS

SON
forecast



DJF
forecast



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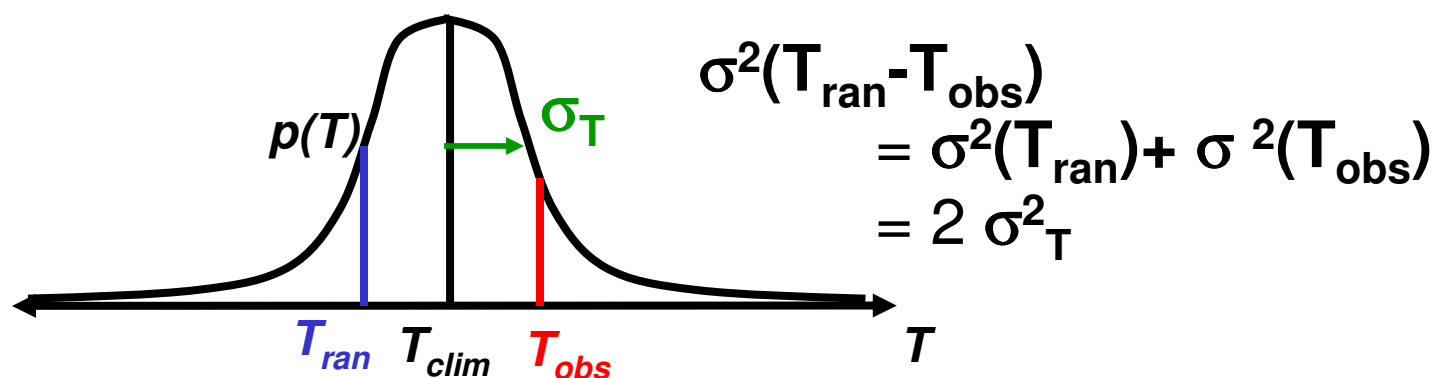


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Environnement
Canada

Why proto-CHFP loses to HFP2 at lead 0

- HFP2 initialized by atmospheric reanalysis → close to “truth”
- Proto-CHFP atmospheric IC have incorrect “weather”



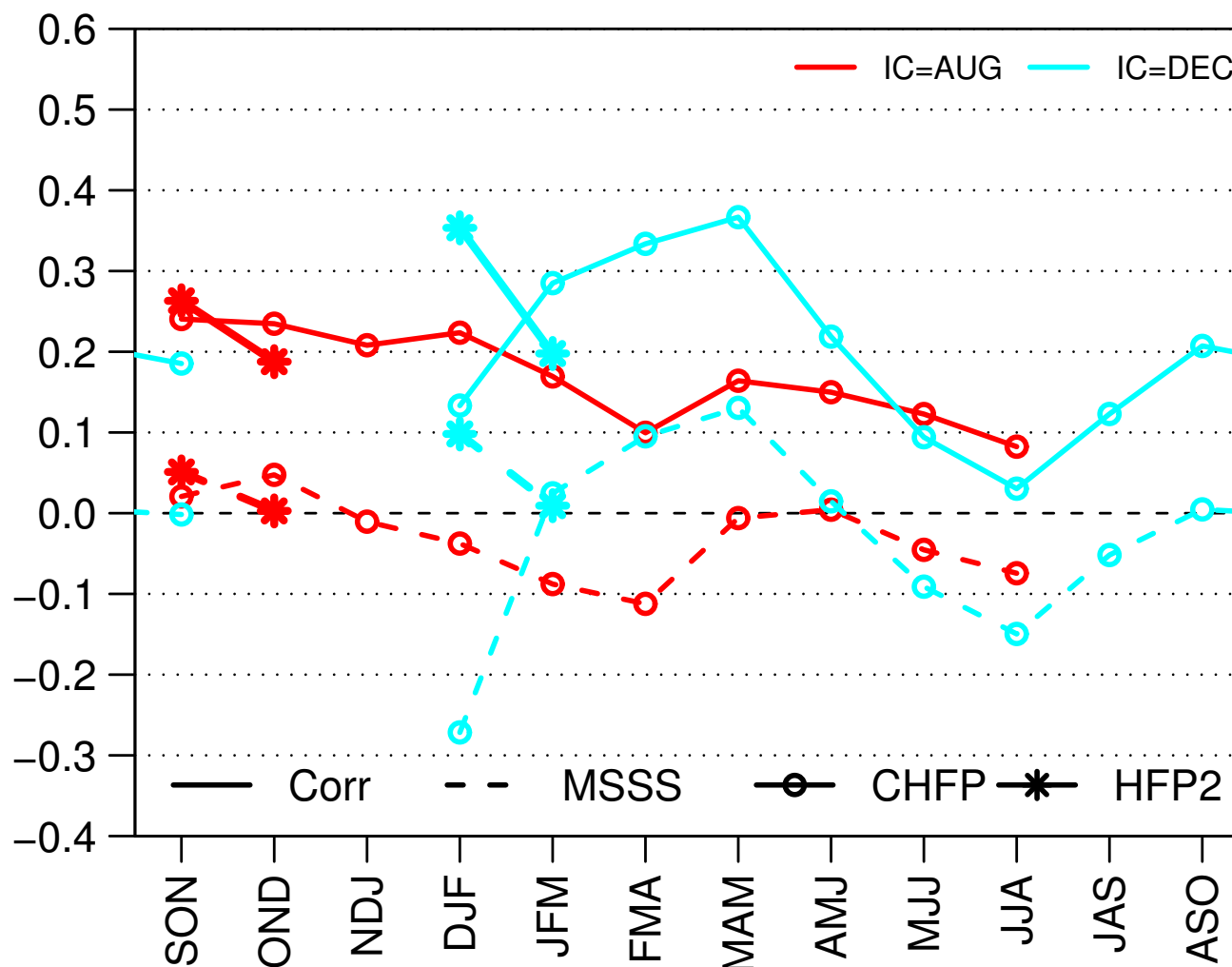
$$\text{MSSS}_{\text{clim}} = 1 - \frac{\sigma_T^2}{\sigma_T^2} = 0$$

$$\text{MSSS}_{\text{ran}} = 1 - \frac{2\sigma_T^2}{\sigma_T^2} = -1$$



Surface temperature forecast for Canada

TAS Canada, cangrd, 1972–2001



CCCma

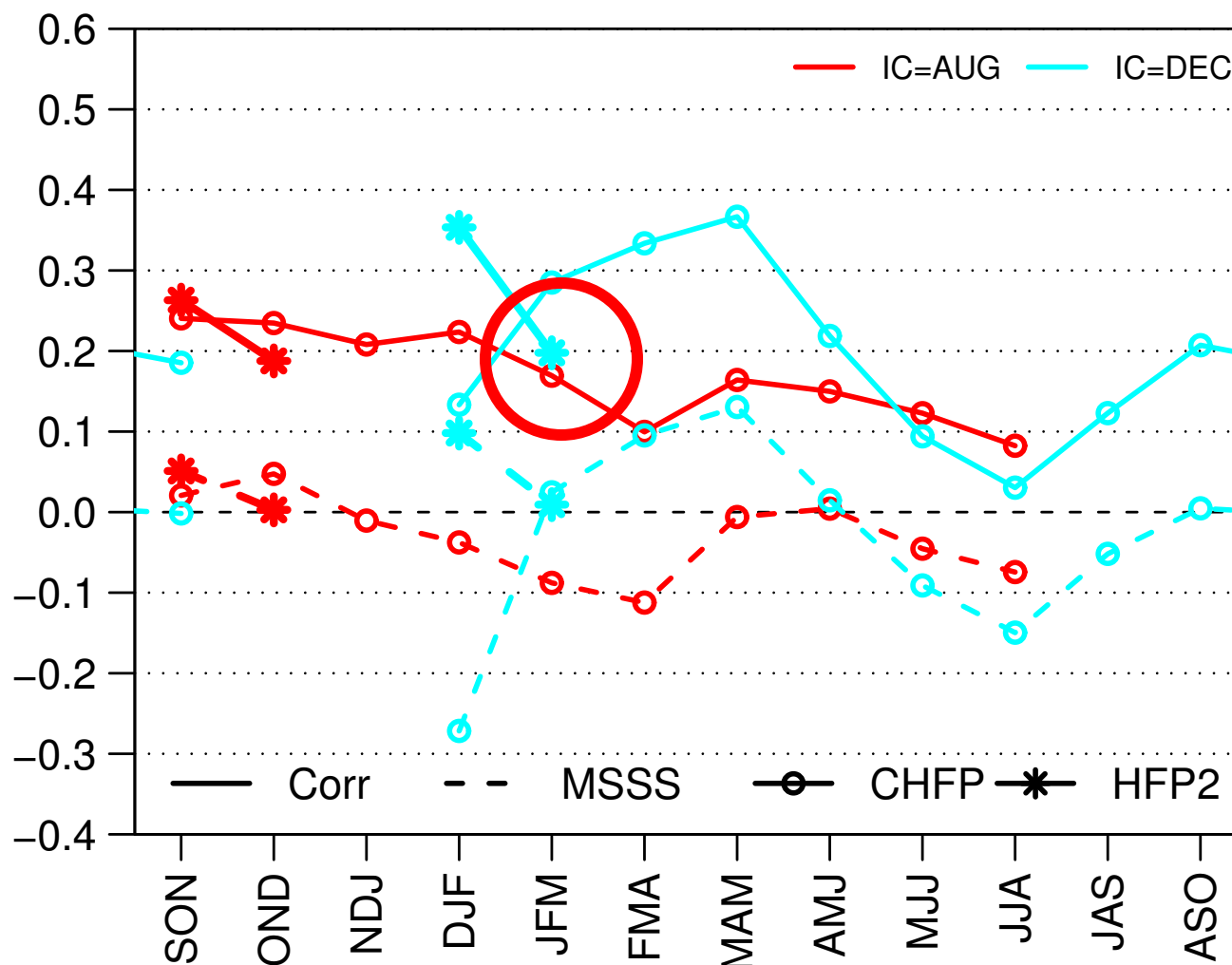


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Environment Canada / Environnement Canada

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Environnement
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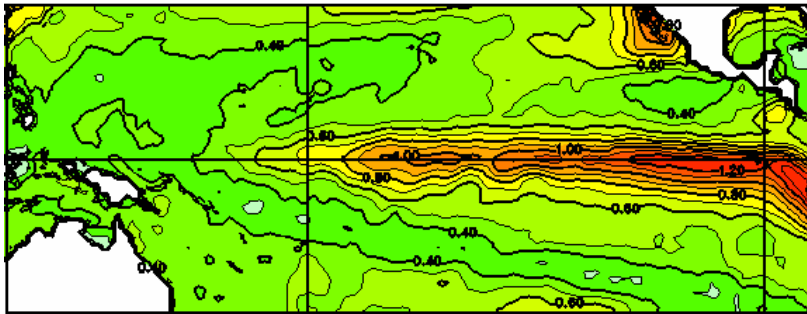
Proto-CHFP vs HFP2

- Proto-CHFP outperforms HFP2 @ lead 1, even though
 - 10 run × 1 model ensemble, vs 10 run × 4 models
 - simple ocean initialization
 - forecast NINO3.4 beaten by persistence until lead ≈ 7
 - CGCM3.1 ENSO SST variability weak, concentrated in central rather than E Pacific

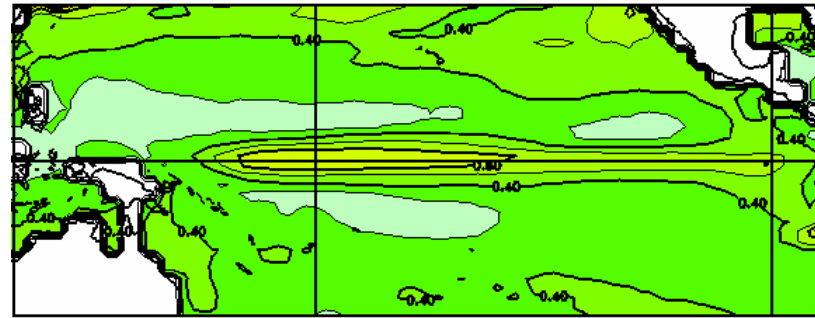


Standard deviation of anomalous monthly SST

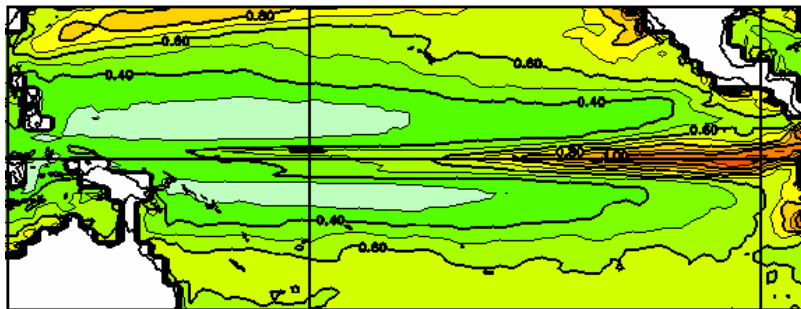
Observations 1950-99



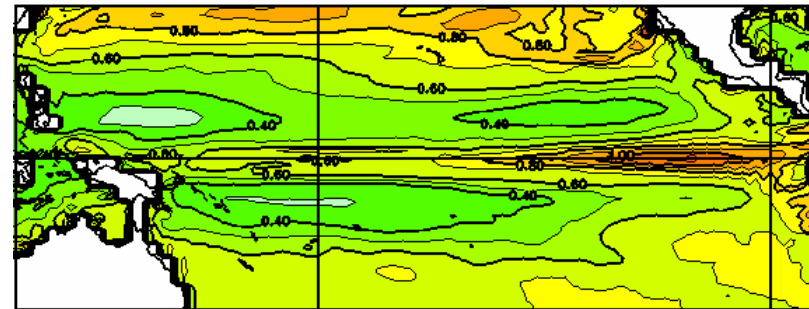
CGCM3.1



AGCM3 + OGCM4

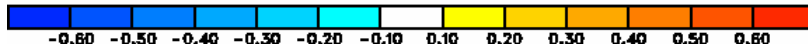
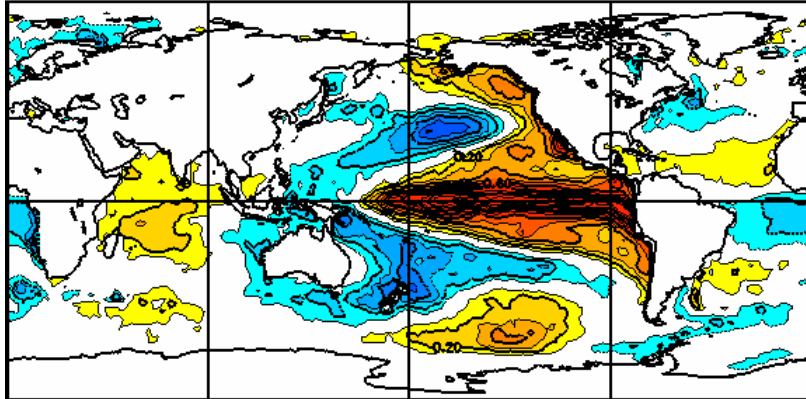


CGCM4

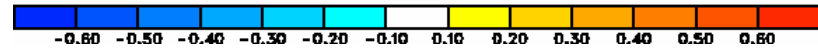
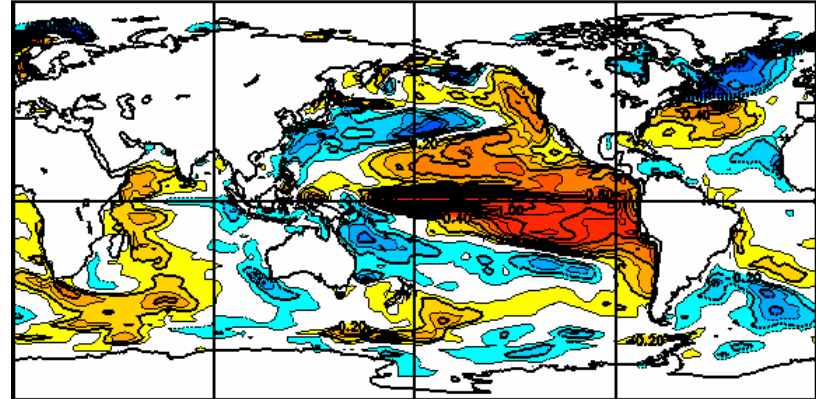


Regression of annual mean SST vs NINO3.4

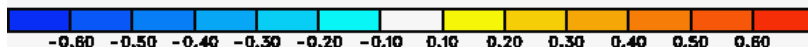
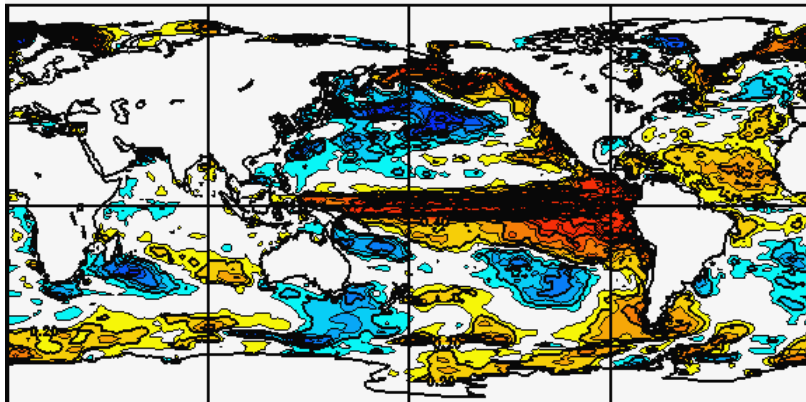
Observations 1950-99



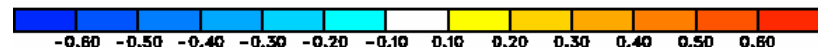
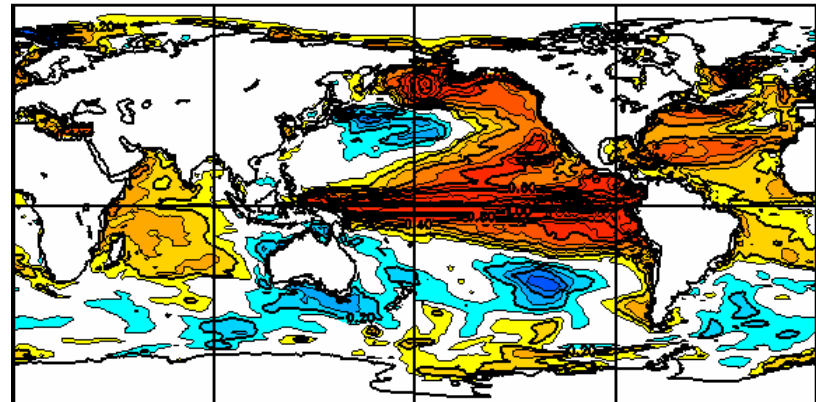
CGCM3.1



AGCM3 + OGCM4



CGCM4



What's next

- Newer CGCM version
- Initialize AGCM with obs as in HFP, HFP2
- Ocean data assimilation
 - 2D Var (Tang et al. *JGR* 2004)
 - Semi-prognostic method (Greatbatch et al. *Ocean Modelling* 2006)
 - Spectral nudging (Thompson et al. *Ocean Modelling* 2006)
- Multiple input reanalyses: NCEP SODA GFDL +Theme I?



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- Task Force of Seasonal Prediction → **TFSP Experiment**: multi-model ensemble of retrospective coupled forecasts

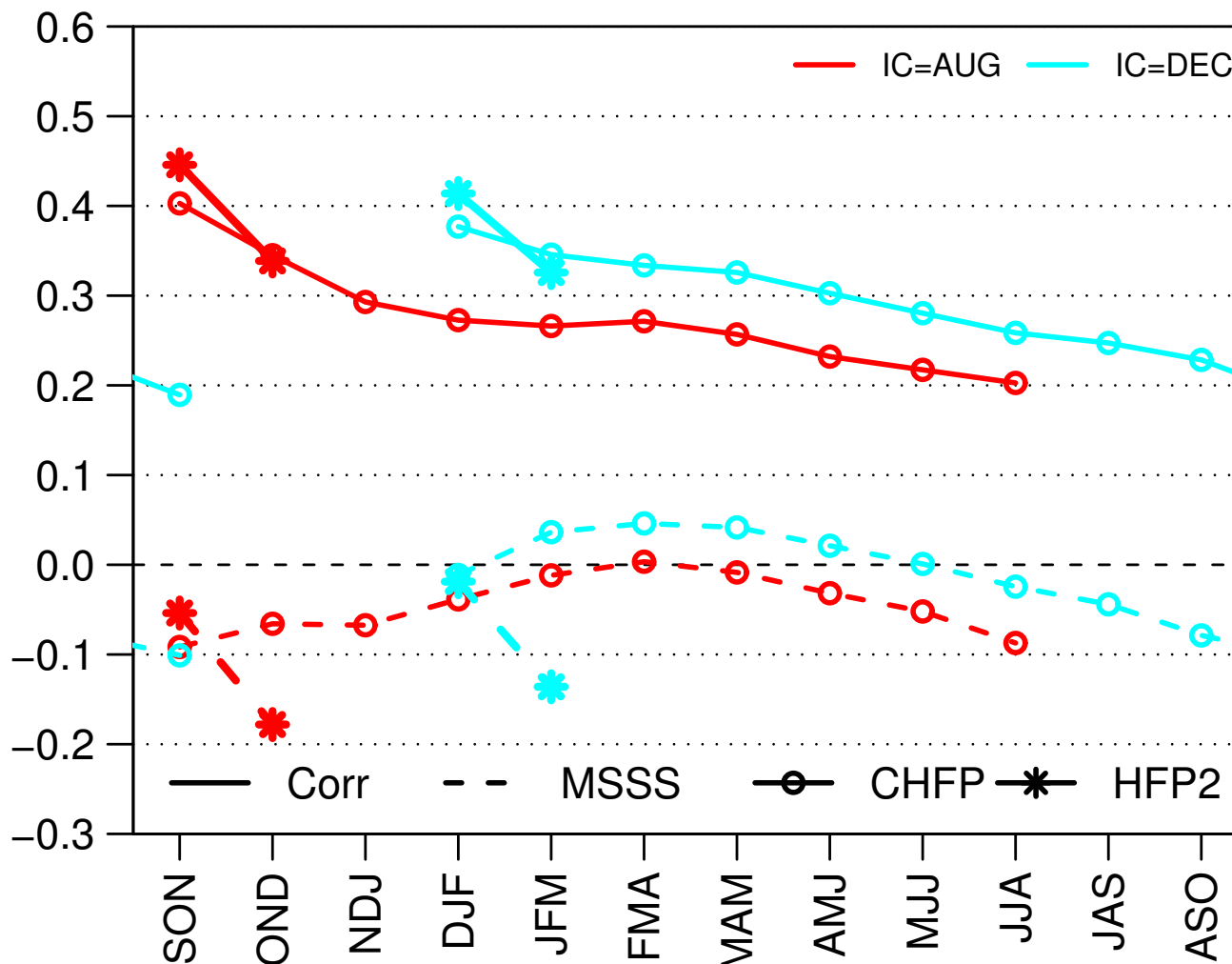


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TAS glb, era40, 1972–2001



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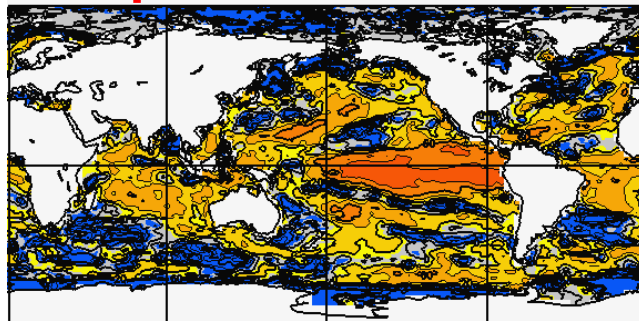


Prototype SST forecast vs persistence

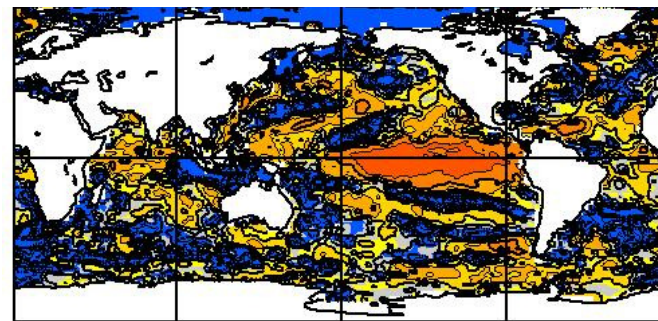
November
Initialization

January
Lead 1

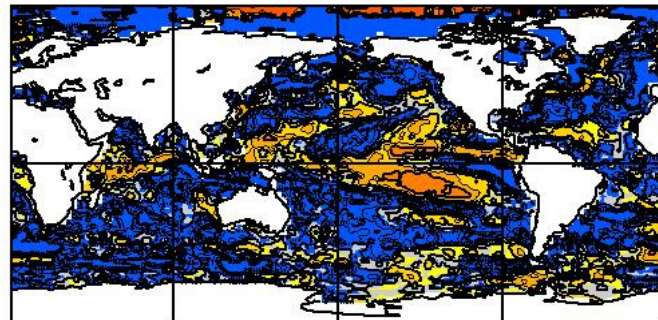
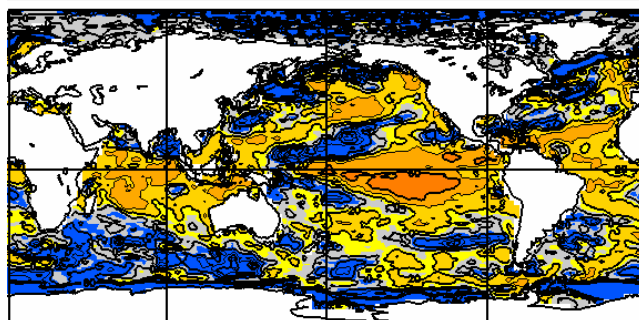
Coupled forecast MSSS



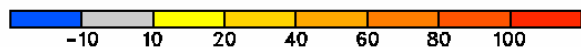
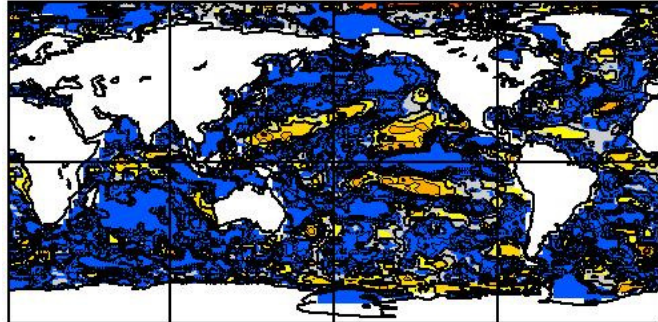
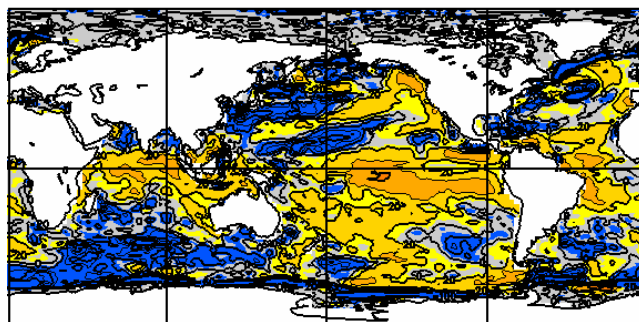
Persistence MSSS



March
Lead 3



May
Lead 5



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