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Seasonal Forecast Development at CCCma: Toward the Second Coupled Historical Forecasting Project (CHFP2)

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Canadian Foundation for Climate
and Atmospheric Sciences (CFCAS)

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

ysis
climatique

GCAPP

The Coupled Model Historical Forecasting Project (CHFP)

- For forecast systems, sets of *retrospective forecasts* are essential for
 - *correcting forecast bias*
 - *assessing forecast skill from past performance*
 - *guiding optimal calibration*
- **Current EC operational system** based on **HFP2**:
 - 4 AGCMs (AGCM2, AGCM3, SEF, GEM)
 - ensemble size 4×10
 - persisted SSTA
 - 4 month forecasts

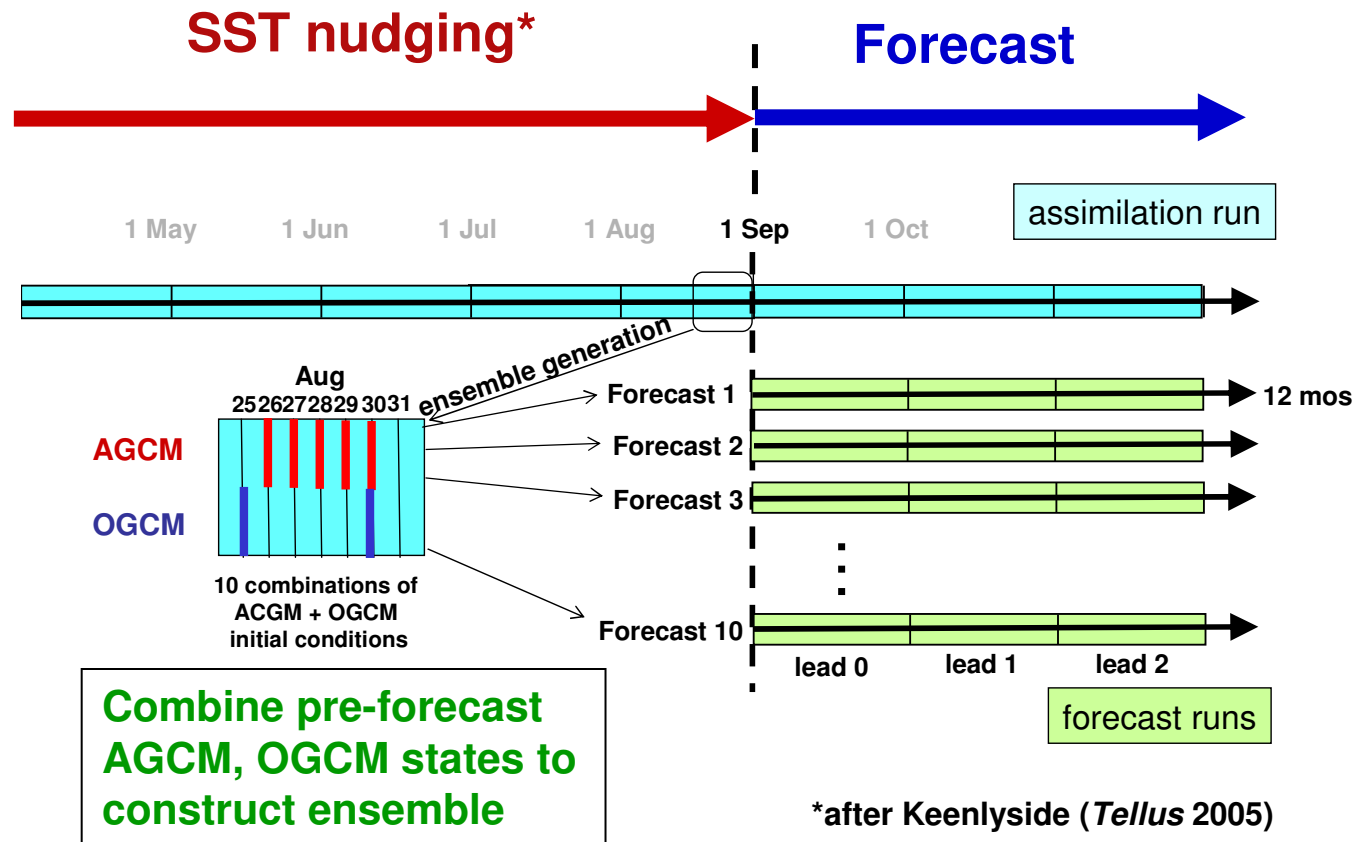


The Coupled Model Historical Forecasting Project (CHFP)

- Under GOAPP, develop *coupled* forecast system
→ *SSTA part of forecast*
- **CHFP1**: modest pilot project
- **CHFP2**: incorporate model + initialization + calibration improvements
- 12 month forecasts



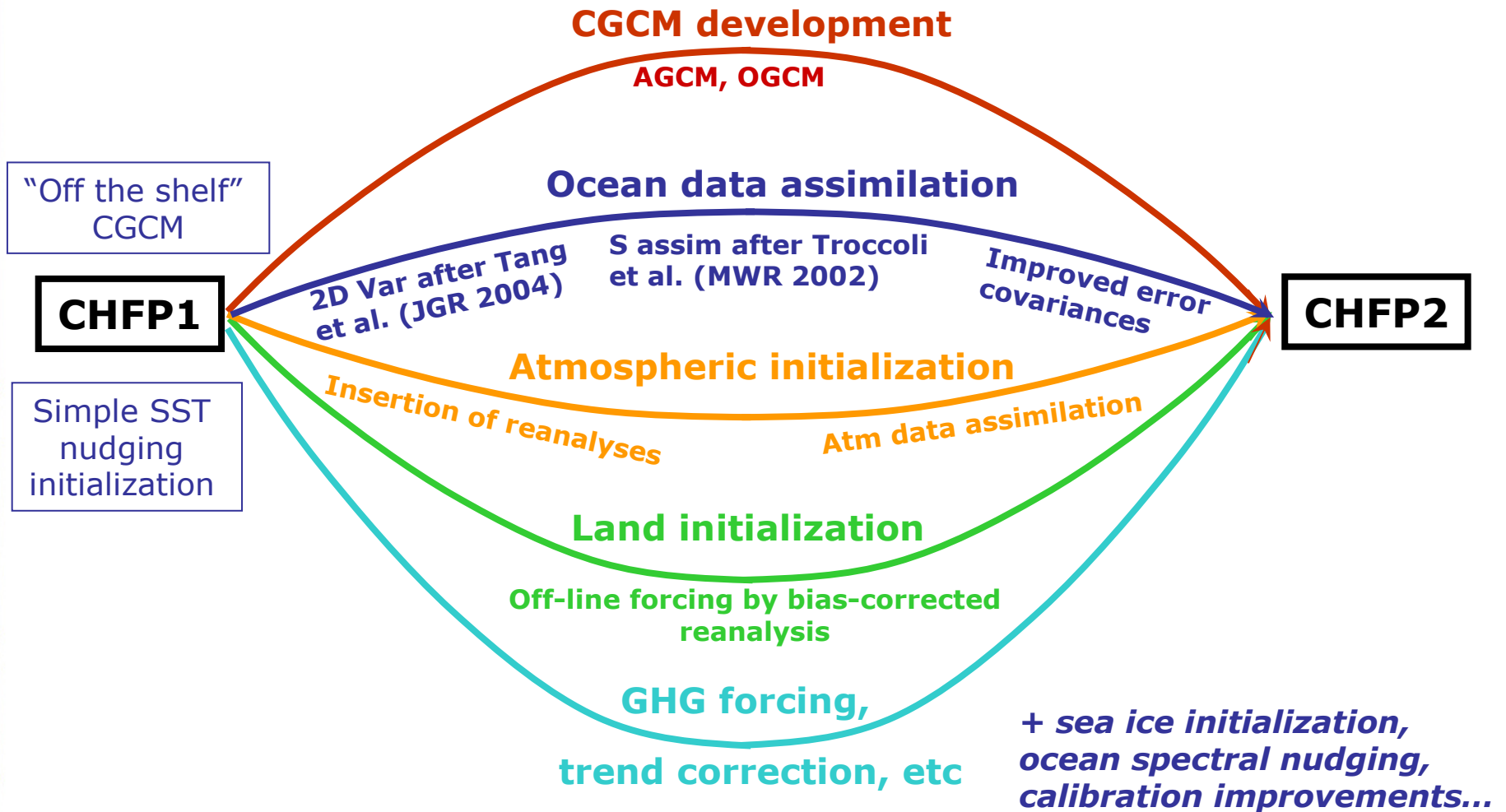
CHFP1 initialization



→ *simplest procedure likely to have much skill*



Coupled Forecast System Development Path



CHFP2 forecast model configurations

	AGCM3	AGCM4
OGCM3	CHFP1	—
OGCM4	CHFP2 ₁	CHFP2 ₂

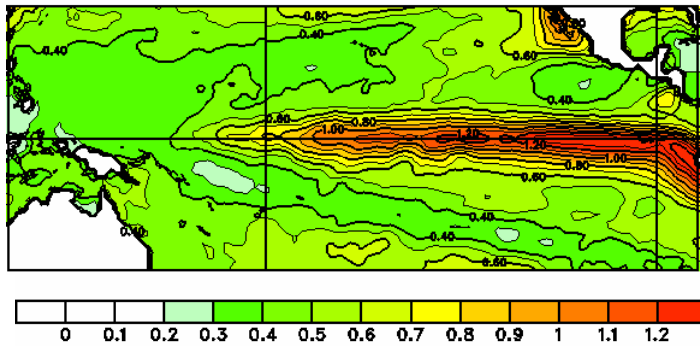
- **OGCM4**: higher vertical resolution (10m in upper ocean), new physics
- **AGCM4**: many new physical parameterizations, prognostic aerosols...
- Same horizontal resolution ($\approx 2.8^\circ \times 2.8^\circ$ AGCM, $1.4^\circ \text{lon} \times 0.9^\circ \text{lat}$ OGCM)



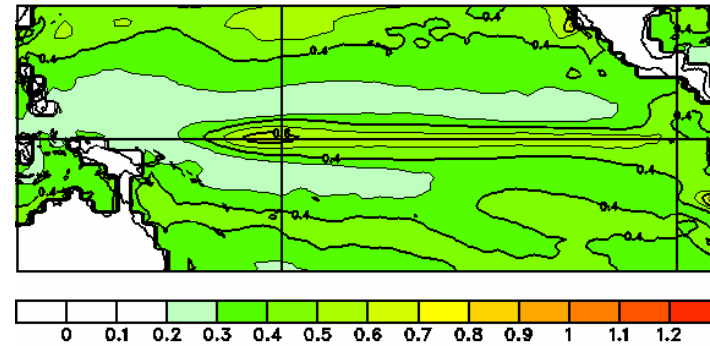
Model improvements: ENSO

Monthly SSTA standard deviation

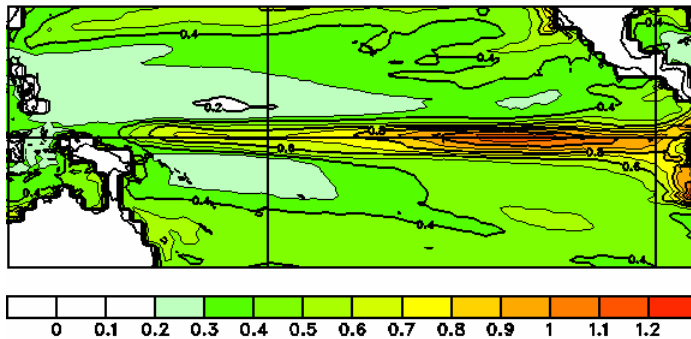
Observations:
HadISST 1970-99



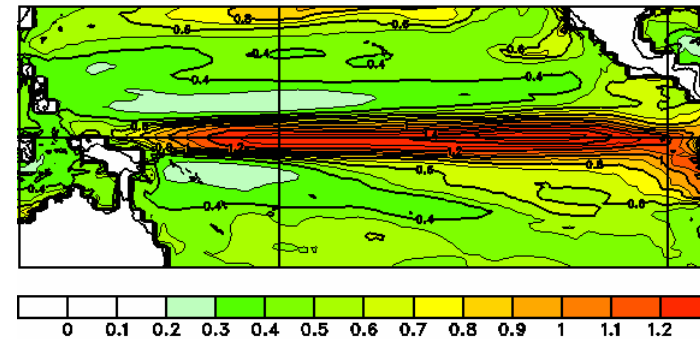
AGCM3+OGCM3
CHFP1



AGCM3+OGCM4
CHFP2₁



AGCM4+OGCM4
CHFP2₂



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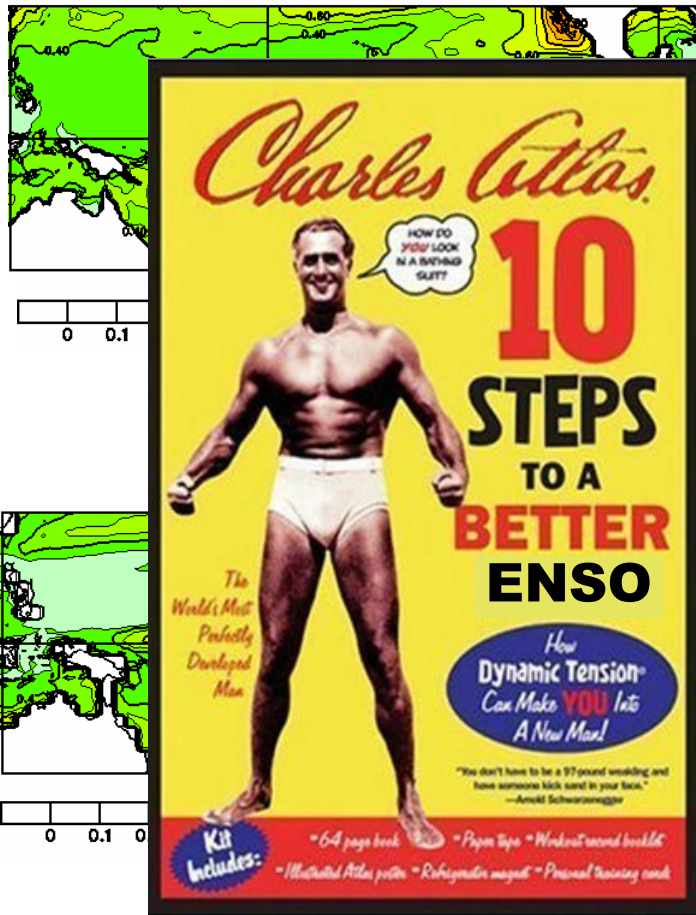
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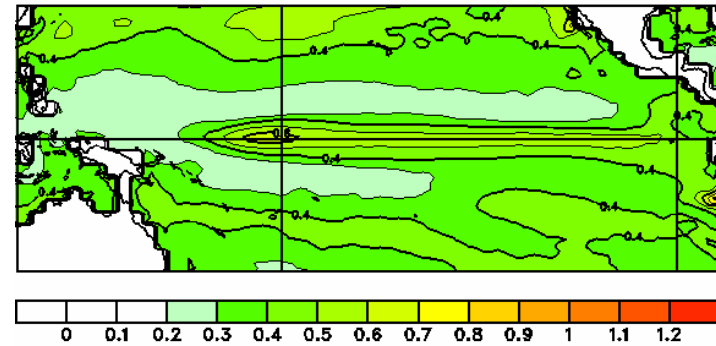
Model improvements: ENSO

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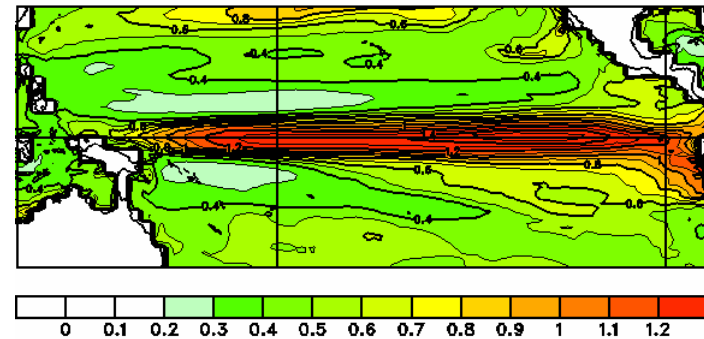
Observations:
HadISST 1970-99



AGCM3+OGCM3
CHFP1



AGCM4+OGCM4
CHFP2₂



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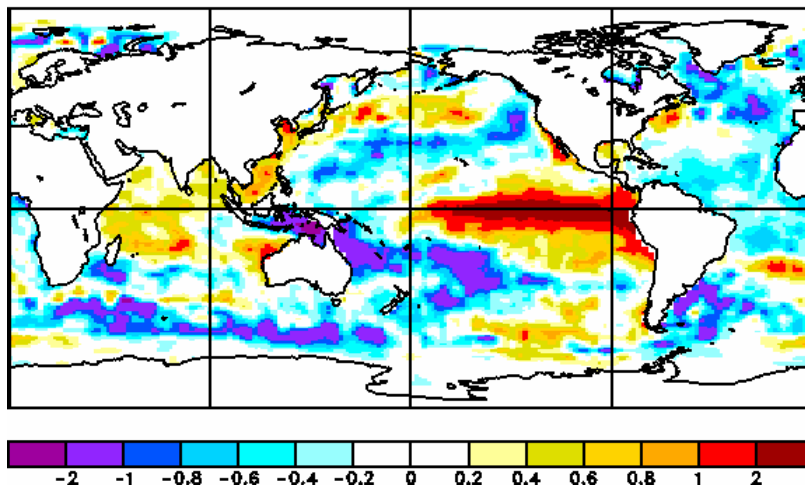
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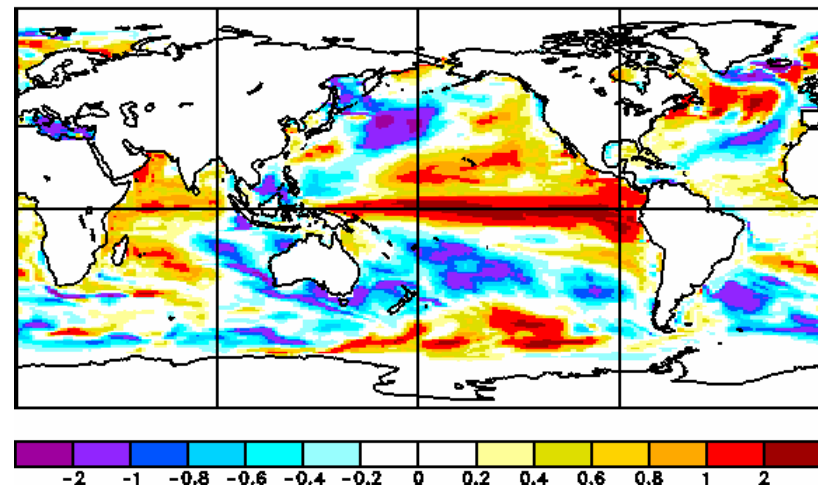
ENSO Forecast Example

Potential for improved prediction skill illustrated by 11-month lead prediction of 1982/83 El Nino:

Obs SSTA Nov 1982



Deterministic forecast SSTA Nov 1982
AGCM4 + OGCM4 Lead=11 mo



→ While such outcomes not always possible (even in theory), a *strong El Nino is now within the range of possibilities admitted by the model*



Impact of Model improvements on ENSO Prediction

	OGCM AGCM	Ens size	Avg skill
CHFP2	OGCM4 + AGCM3	1	0.55
	OGCM4 + AGCM4	1	0.64
CHFP1	OGCM3 + AGCM3	1	0.48
	OGCM3 + AGCM3	10	0.60

Mean NINO3.4 correlation skill of rolling 3-month forecasts
 Dec → Nov Mar → Feb Jun → May Sep → Aug
 SST nudging only 1972-2001



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N=1 CHFP2 skill exceeds N=10 CHFP1 skill

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N=1 CHFP2 skill exceeds N=10 CHFP1 skill

→ much room for further improvement through ensembles & better initialization

Mean NINO3.4 correlation skill of rolling 3-month forecasts

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SST nudging only 1972-2001



Ocean Initialization

- **Off-line assimilation of 3D gridded analyses**
 - variational assimilation as in Tang et al. *JGR* 2004
 - experimenting with different forms for error covariances
- **S assimilation through preservation of T-S relationship**
 - procedure of Troccoli et al. *MWR* 2002
 - prevents spurious convection, etc.
- Details, skill improvements to be described by W.-S. Lee



Atmosphere initialization

- **CHFP1**: atmosphere initialized by SST nudging alone
 - some skill initializing tropical Pacific winds
 - initial state has wrong “weather” → *poor 1st month skill*
- **CHFP2 option 1**: insert NCEP reanalysis as in HFP2
- **CHFP2 option 2**: *assimilation* of NCEP reanalysis via *incremental reanalysis updates (IRU)* → realistic weather throughout period preceding forecast



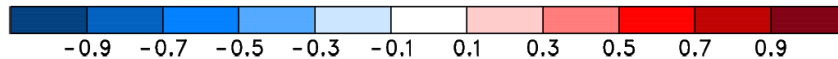
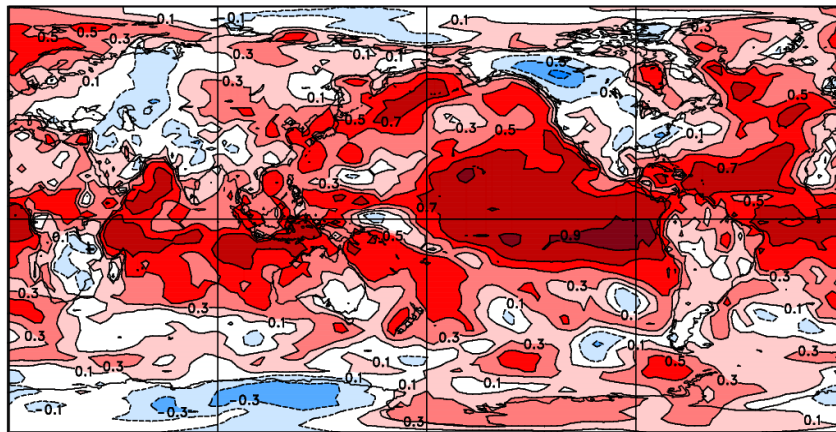
Impact of AGCM NCEP Initialization

Surface temperature correlation skill

First forecast month from 1 Sep

SST nudging only

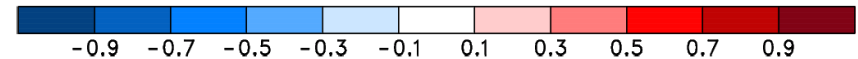
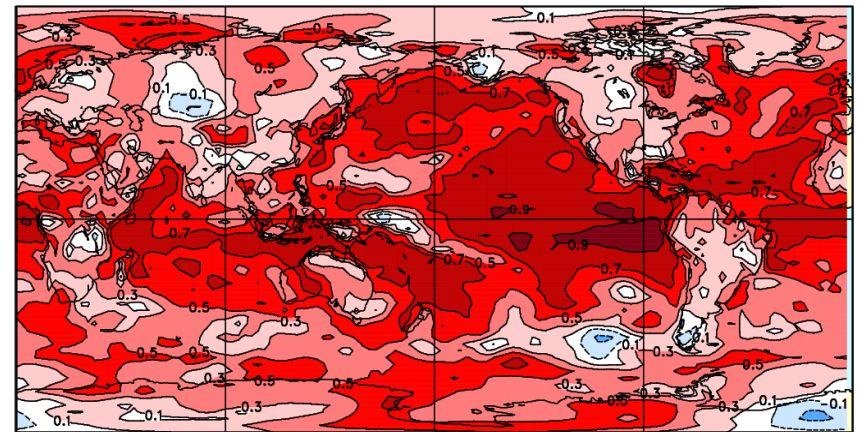
WS09 ERA40 ST M09 I=08 L=0 1972-2001 CORR(U)=0.3543 L=0.152 O=0.442



GLOBAL: 0.35
LAND: 0.15

SST nudging + NCEP insertion

WS09N ERA40 ST M09 I=08 L=0 1972-2001 CORR(U)=0.4920 L=0.318 O=0.568



GLOBAL: 0.49
LAND: 0.32



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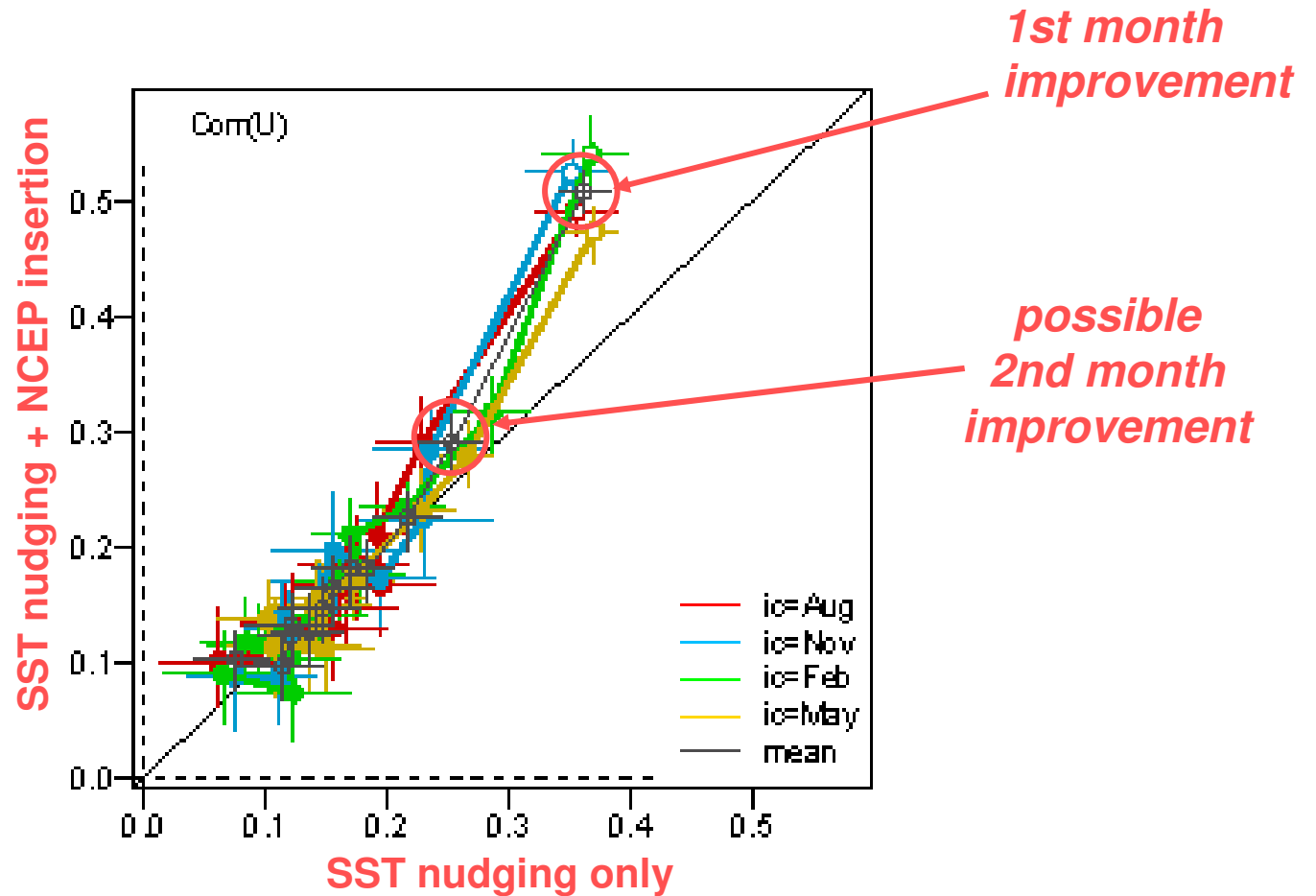
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Impact of AGCM NCEP Initialization

Surface temperature correlation skill: Global mean



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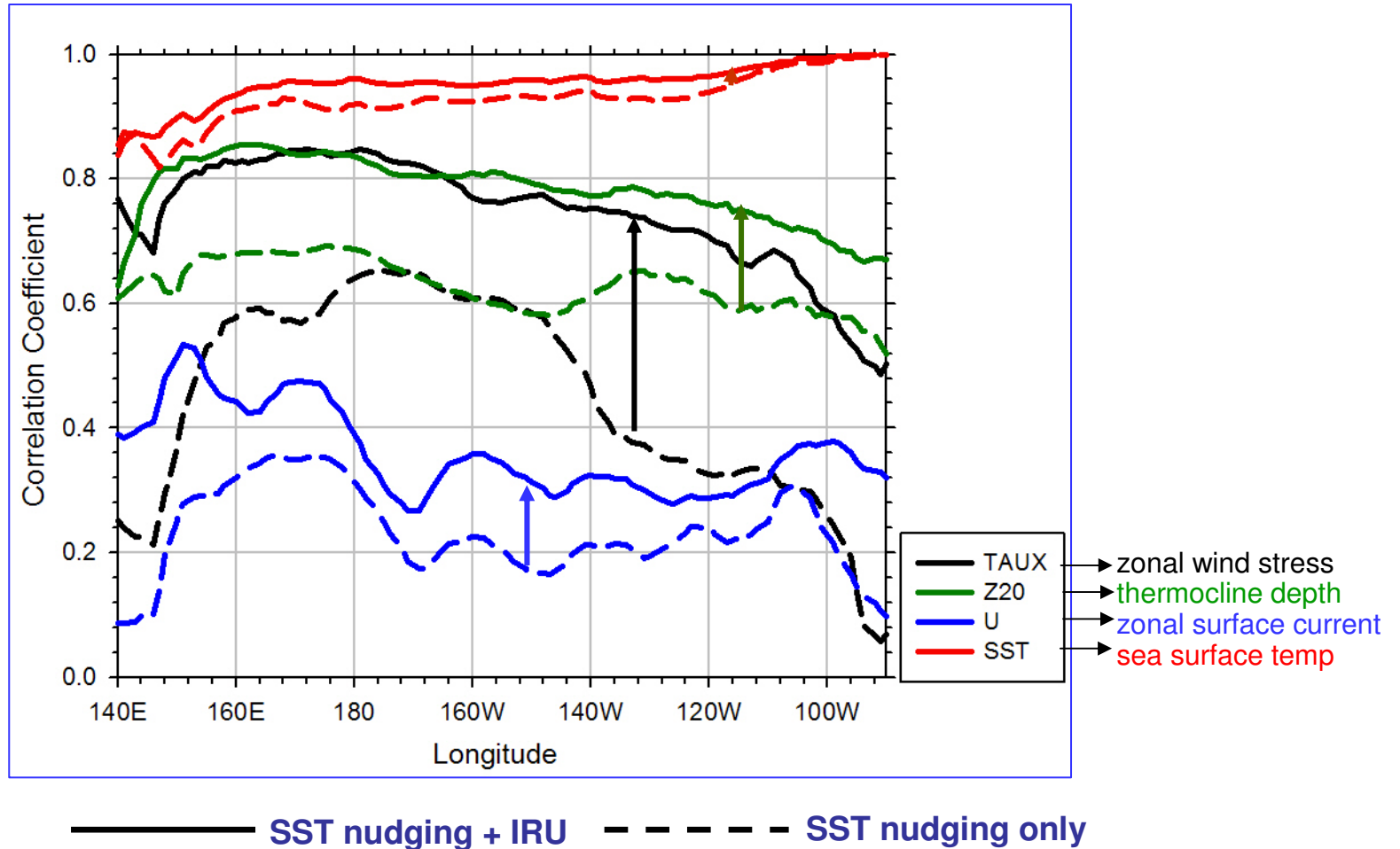
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Impact of AGCM IRU Initialization

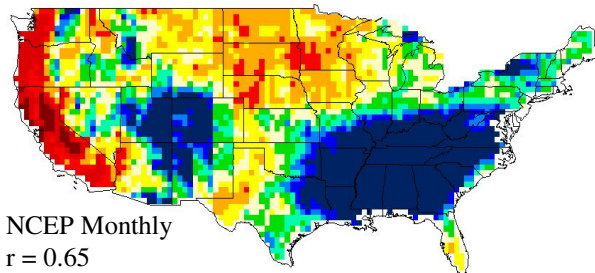
Correlations with obs in equatorial Pacific (5S→5N)



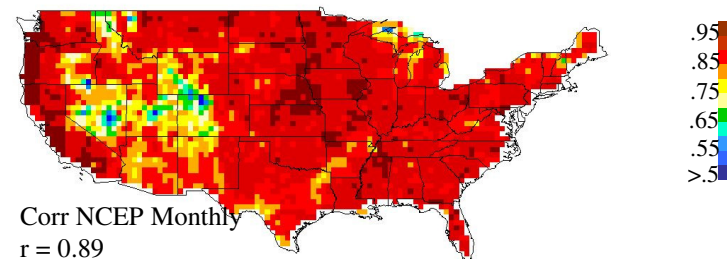
Land surface initialization

- CCCma collaboration with *Aaron Berg, Gordon Drewitt (U Guelph)*
- Strategy: drive CLASS land surface model used in CGCM off-line with *bias-corrected* NCEP reanalysis after Berg et al. (Int J Clim 2005)

before bias correction



after bias correction



- Provides soil moisture, temp, snow cover...



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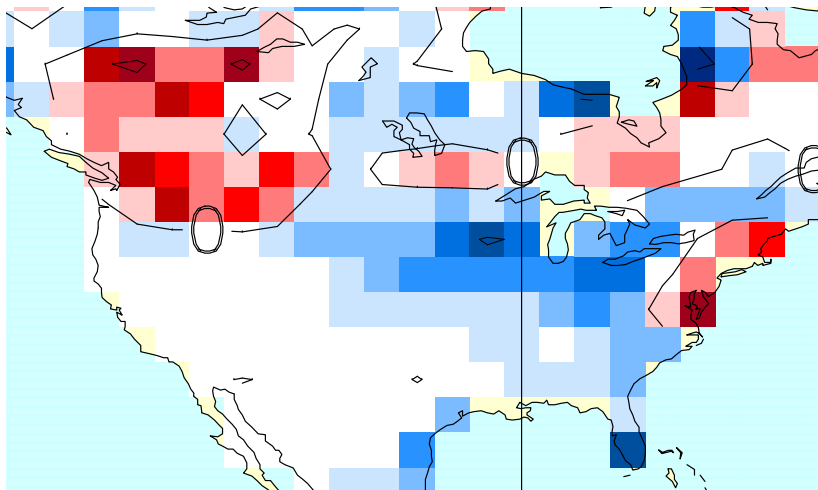
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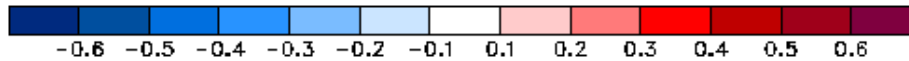
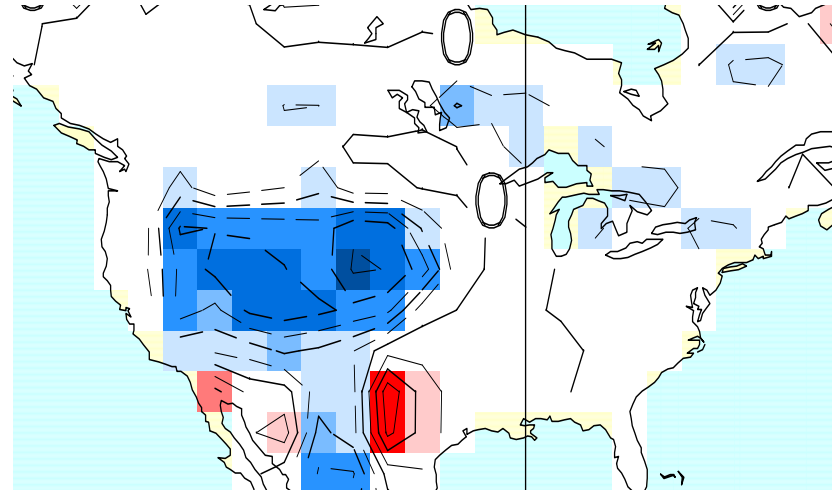
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Relative soil moisture anomaly (top layer) July 2002

Default initialization



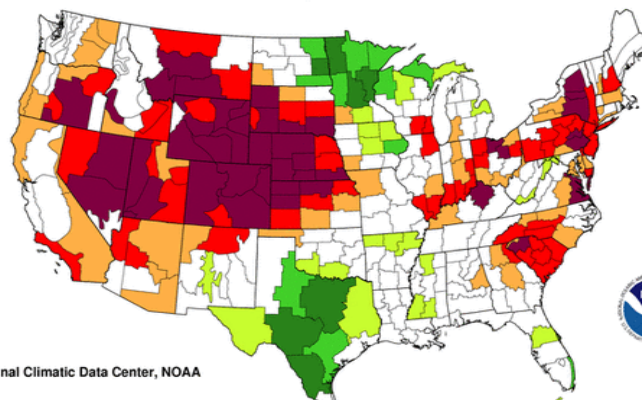
Off-line initialization



Palmer Z Index
Short-Term Conditions

July 2002

Observed
drought
index



National Climatic Data Center, NOAA



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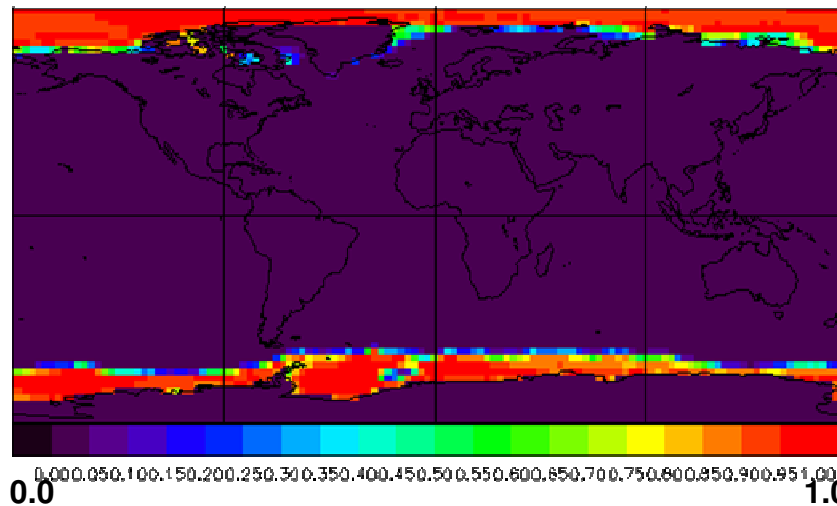
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Sea ice initialization

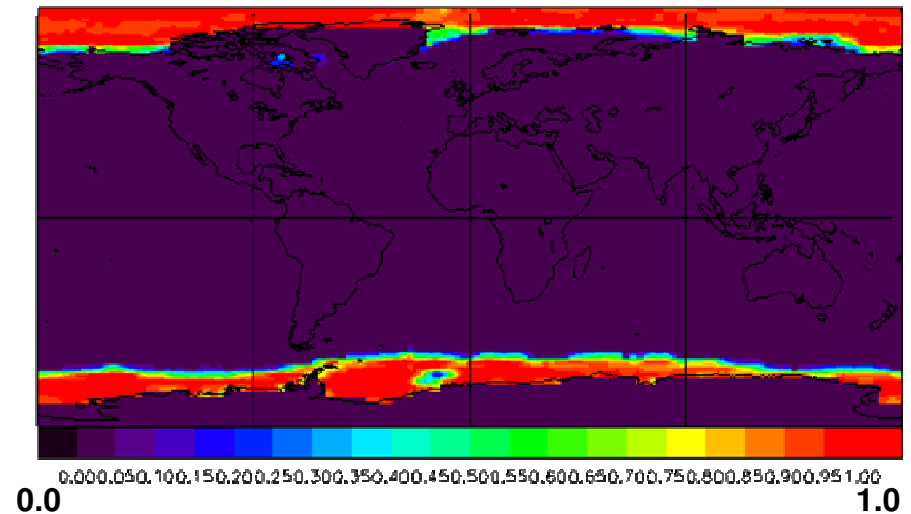
- Nudge to Hadisst observations

Sea ice concentration: August 1976

Hadisst



Forecast initial conditions

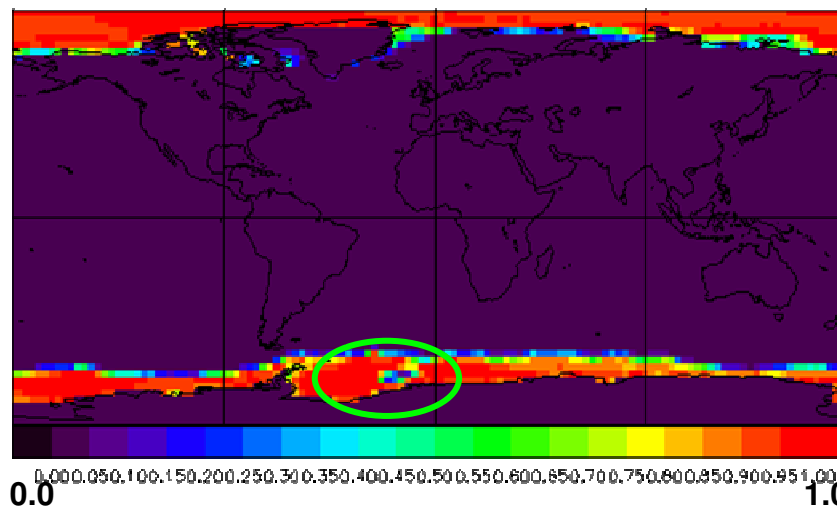


Sea ice initialization

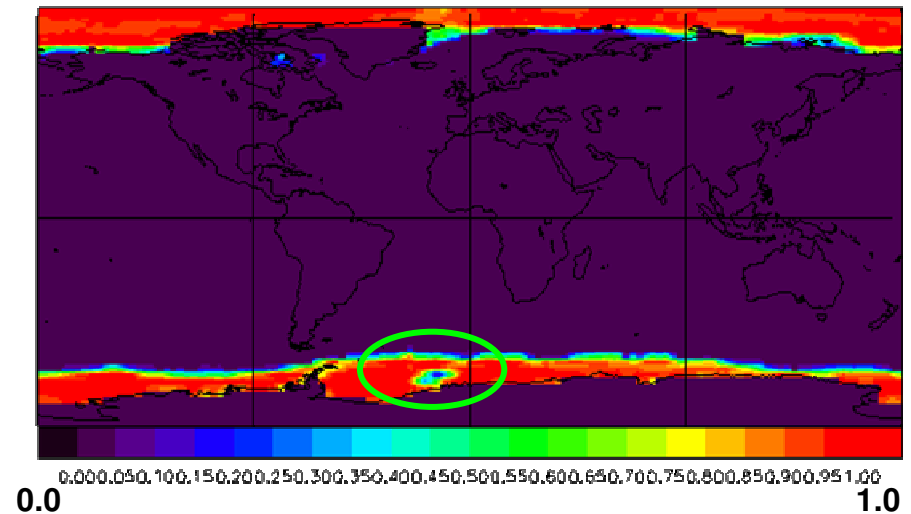
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Sea ice concentration: August 1976

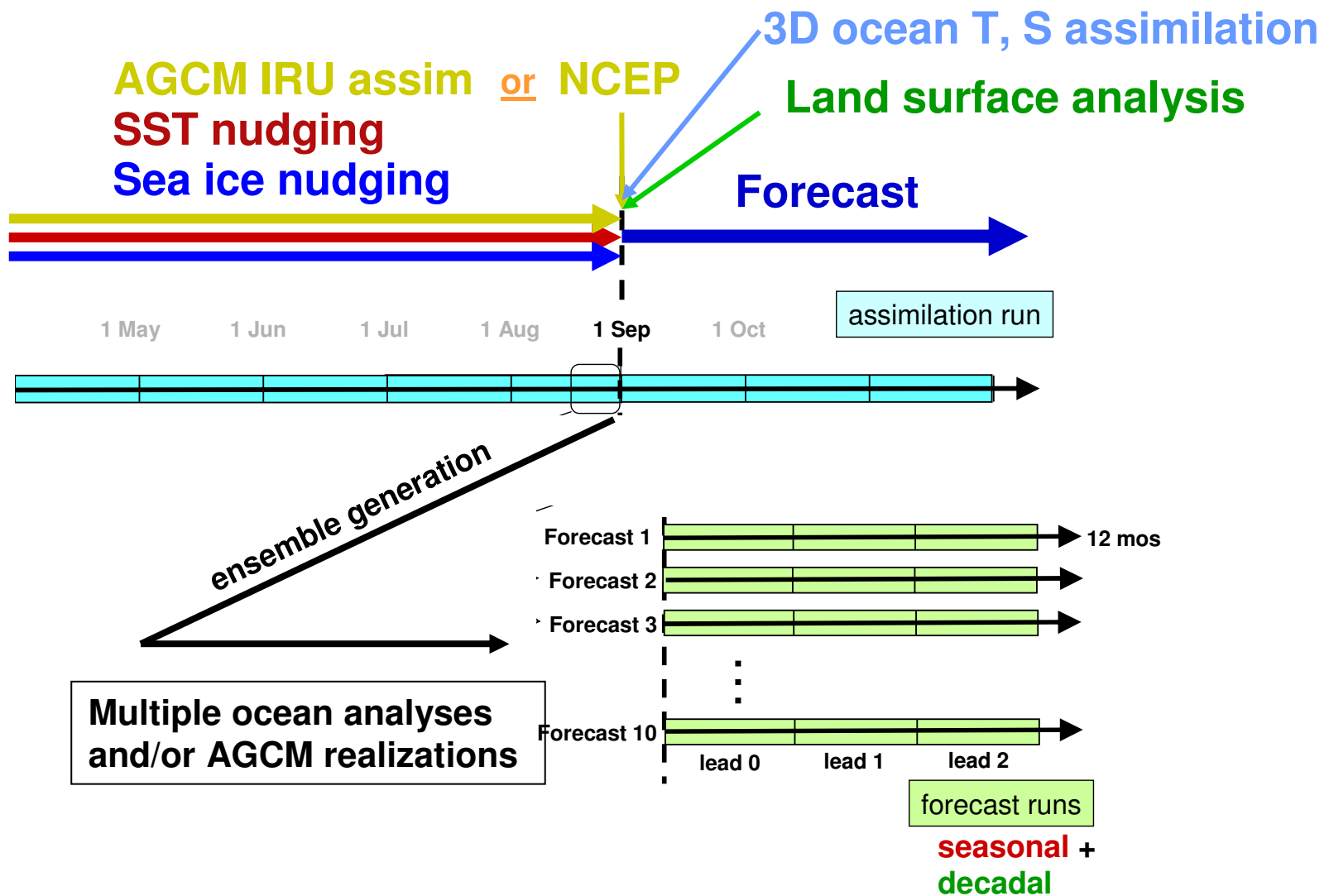
Hadisst



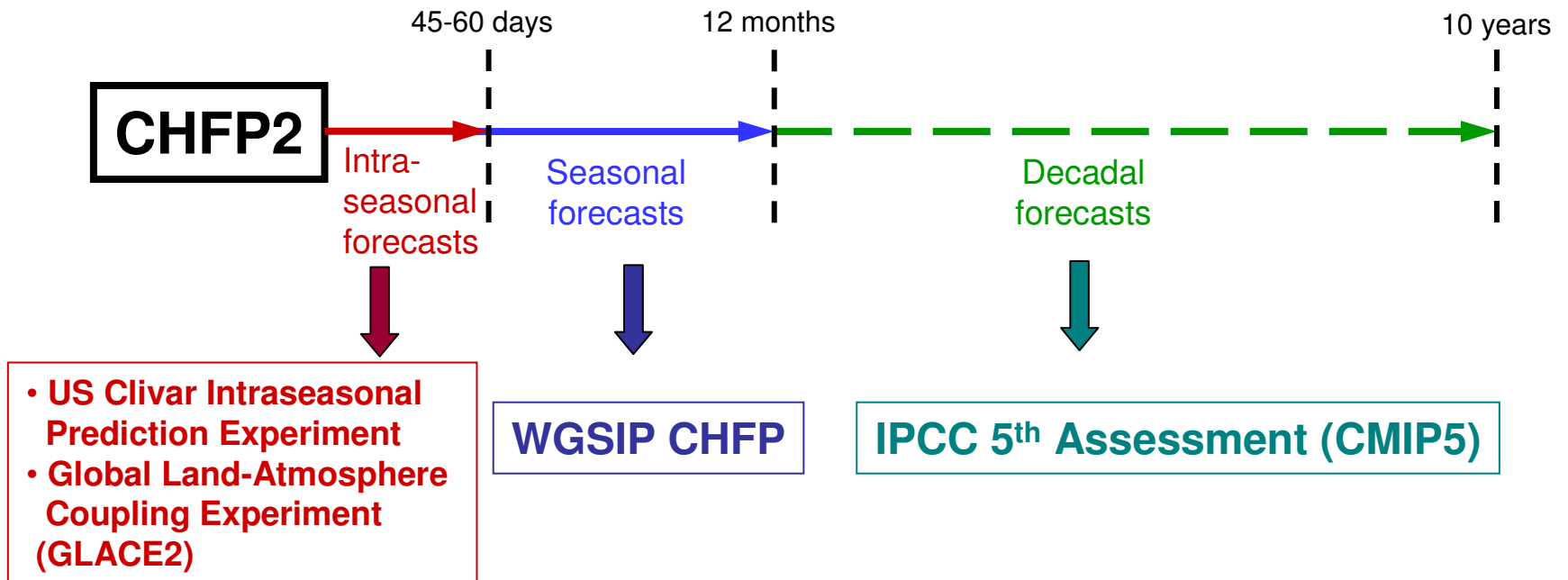
Forecast initial conditions



CHFP2 initialization



CHFP2 potential contributions



Conclusions

- **CHFP2** model components finalized
- Model improvements already point to big skill improvement over CHFP1
- Candidate initialization procedures undergoing final testing/evaluation
- CHFP2 will be a multimodel ensemble:
 - OGCM4 + AGCM3
 - OGCM4 + AGCM4
- CCCma contribution to international CHFP, IPCC...

