Environment Canada Environnement Canada

Canada

Review and Discussion of Theme II

Bill Merryfield
Canadian Centre for Climate Modelling and Analysis
Environment Canada

GOAPP Workshop 31 May 2010 *Ottawa*

Theme II: Seasons to Decades

- **Sub-Theme II.1 Analysis and Mechanisms**

  What are the origins of predictability?

- **Sub-Theme II.2 Predictability of the Coupled System**

  What are the limits of predictability?

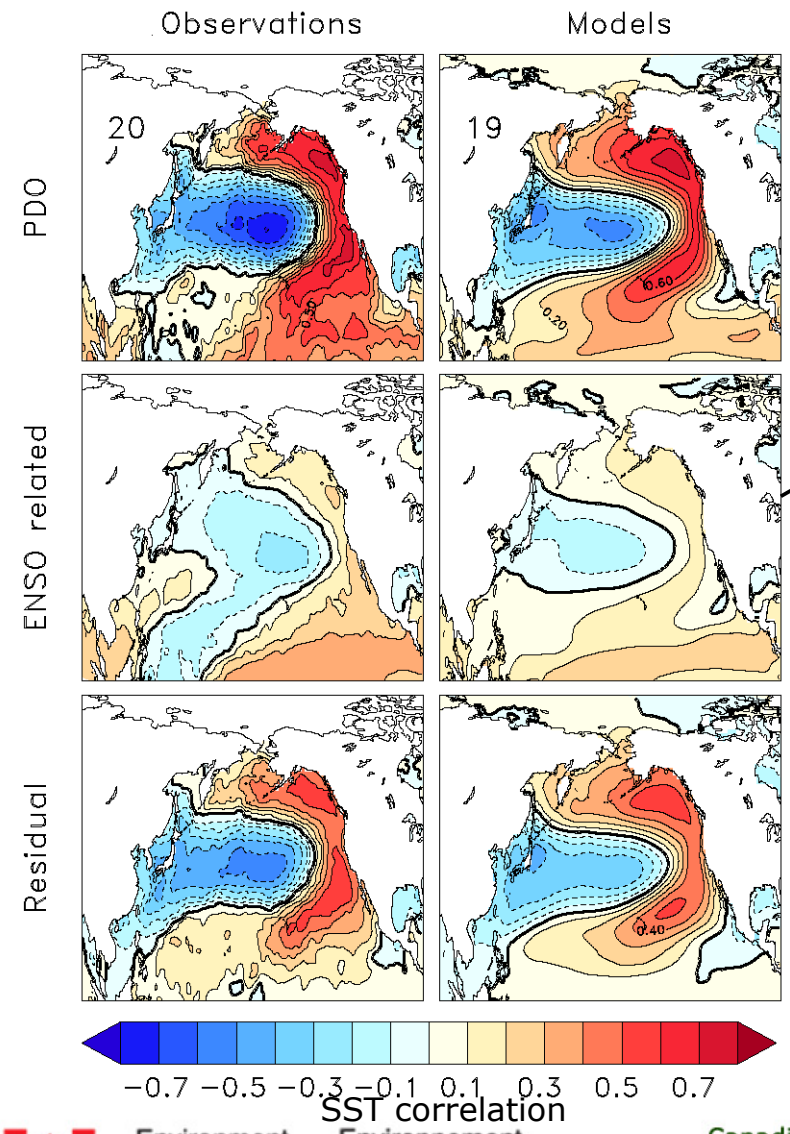
- **Sub-Theme II.3 Prediction**

  How well can we predict in practice?

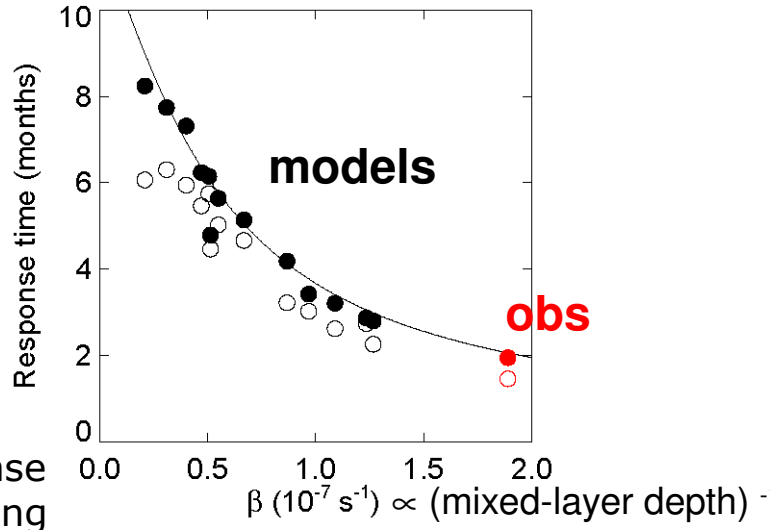
Sub-Theme II.1 Analysis and Mechanisms

Do models capture the tropical influences on North Pacific temperature variability?

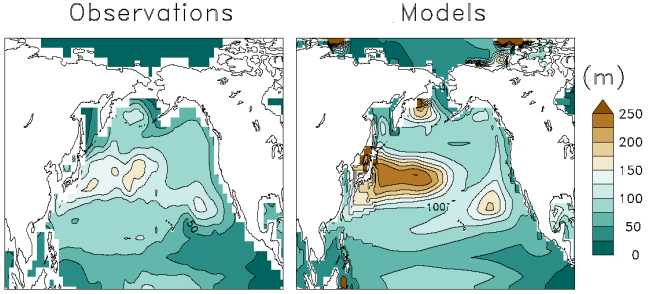
Lienert et al. J. Clim (in preparation)



Lag of response to ENSO forcing



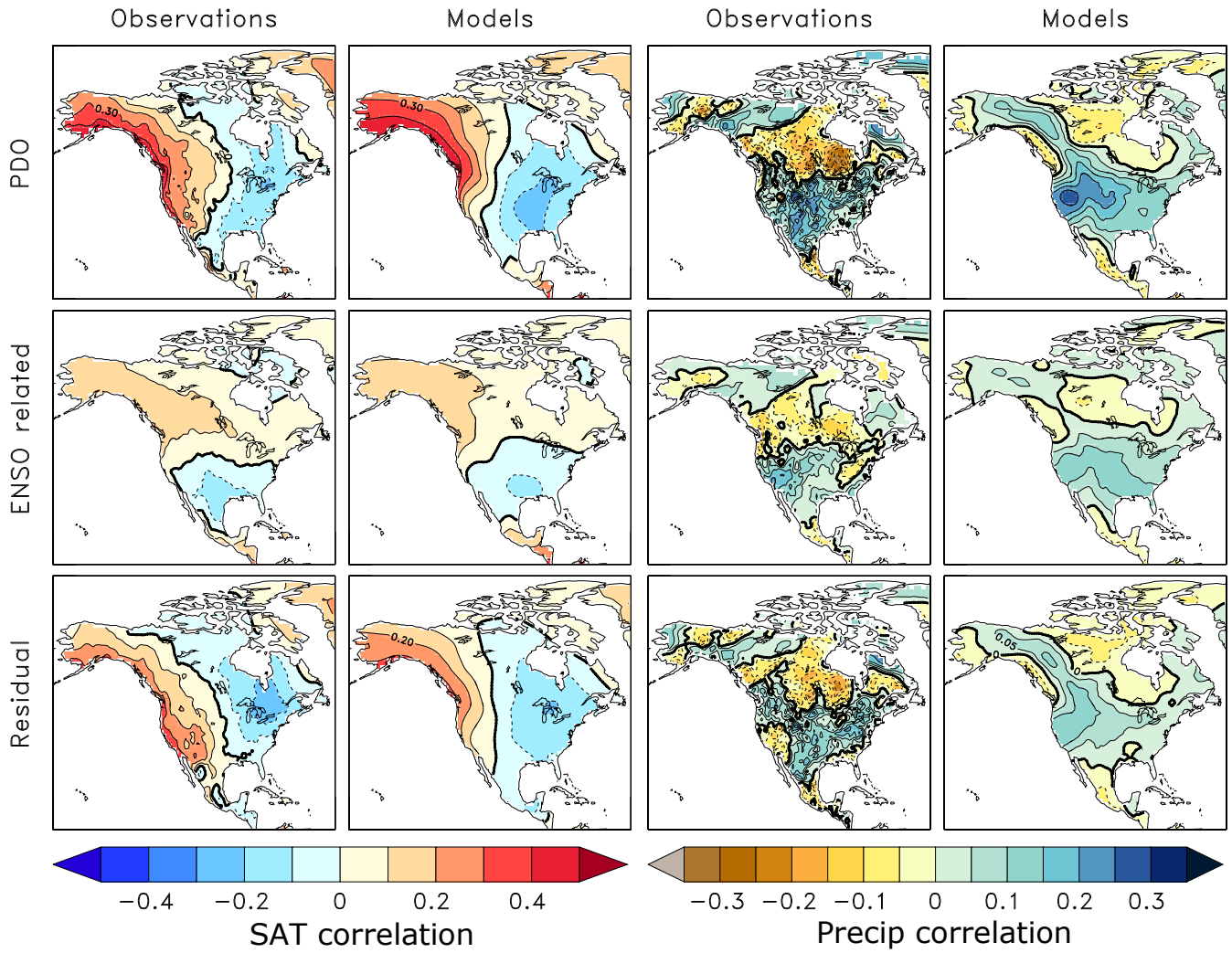
Winter mixed-layer depth



F. Lienert Wed 11:15

PDO-related patterns of North American Climate Variability

F. Lienert (UVic) and J. Fyfe (CCCma)



Sub-Theme II.2 Predictability of the Coupled System

21st Century decadal potential predictability

Boer 2010 (submitted)

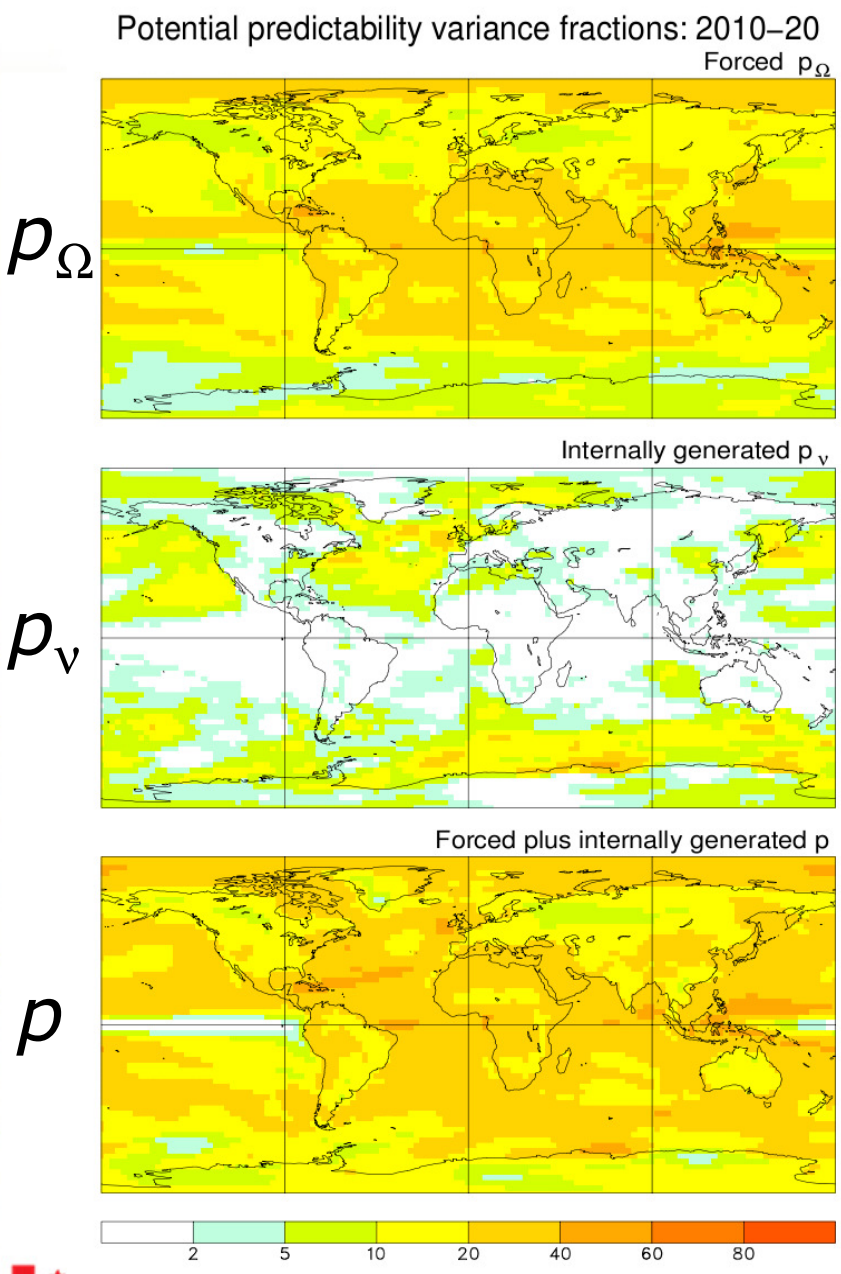
- Climate variables with *forced component* have associated variances

$$\sigma^2 = \sigma^2_\Omega + \sigma^2_\nu + \sigma^2_\varepsilon$$

– Ω is long timescale *externally forced* variability
  - obtained by fitting 2nd order orthogonal polynomial
– ν is long timescale *internally generated* variability
– ε is short timescale *unpredictable "noise"* variability
- statistics pooled across models
- Potential predictability variance fraction has two components

$$p = (\sigma^2_\Omega + \sigma^2_\nu)/\sigma^2 = p_\Omega + p_\nu$$

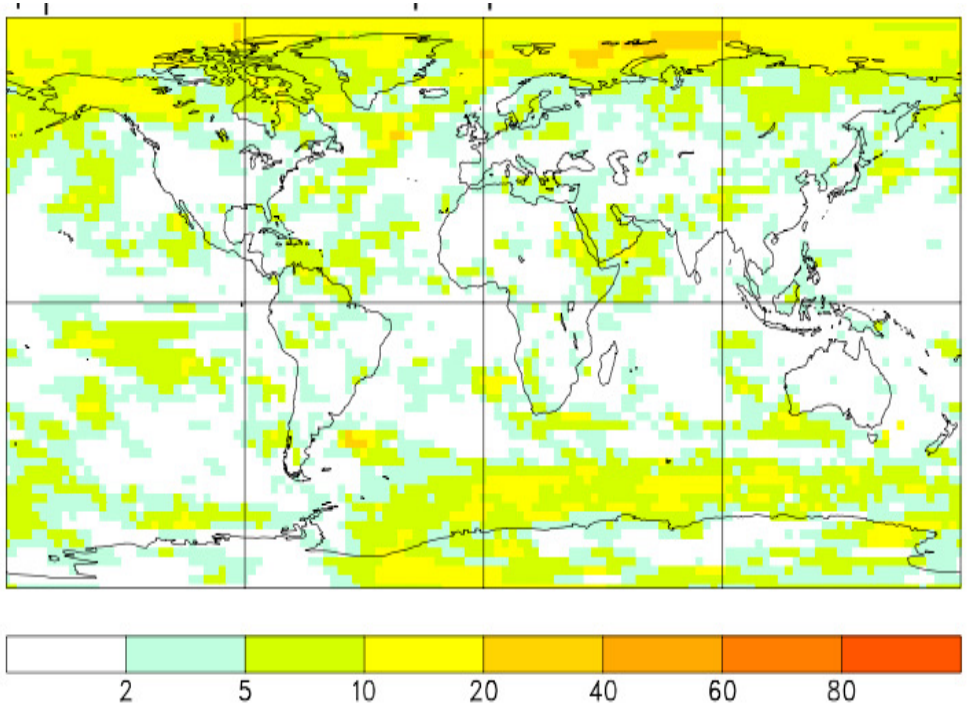
Potential predictability of temperature for *2010-20* *("next decade")*



- percentage of total variance over decade
  - associated with forced component
  - associated with internal variability
- p_Ω and p_ν tend to be inverses of one another so $p = p_\Omega + p_\nu$ is more uniform than either

Potential predictability of precipitation

Potential predictability of precipitation: 2020-30 (i.e. for *second* decade)



- *due to forced component*
- noise variance for precipitation is large
- internally generated p_{ν} is small as a result
- only *multi-decade* $p_{\Omega 1}$ contributes and then only modestly

G. Boer Tue 11:45

"Decadal potential predictability of forced and internally generated variability in the 21st century"

G. Boer Thu 11:30

"Characterizing the long timescale variability of the climate system"

Potential seasonal predictability of Summer Asian-Australian Monsoon at NCEP Coupled Model (Yang and Tang, CMOS talk)

Tue 12:15

$$MI = -\frac{1}{2}\left\langle \ln\left(\frac{\sigma_p^2}{\sigma_q^2}\right)\right\rangle$$

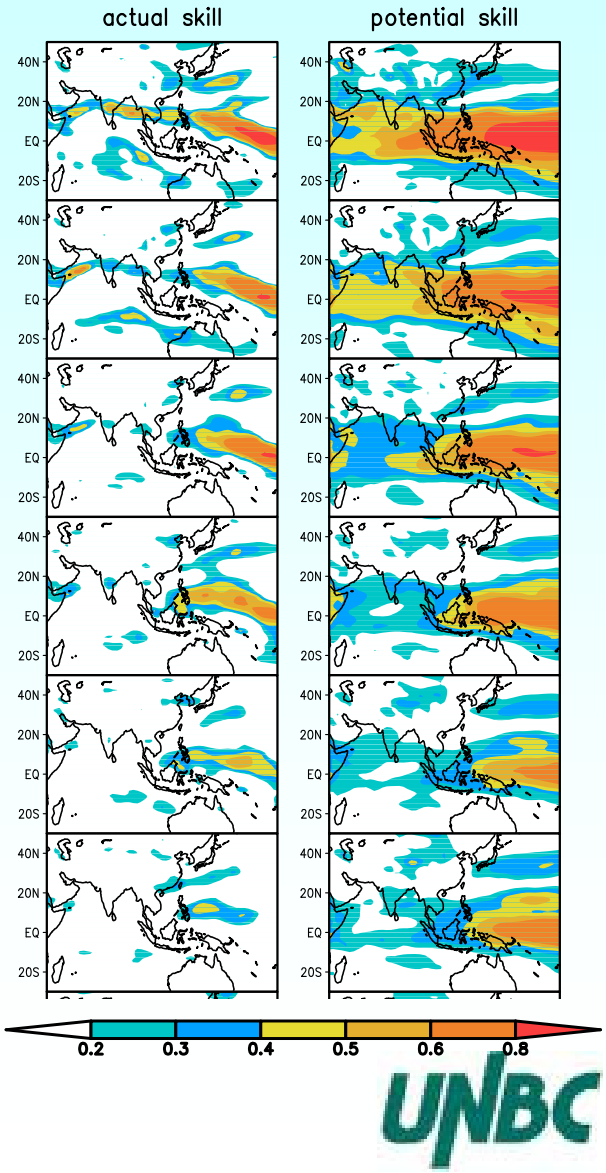
"Mutual information"

Potential skill

$$MSESS = 1 - \frac{MSE}{MSE_{c\,\mathrm{lim}}} = 1 - \frac{\left\langle (f-o)^2 \right\rangle}{\mathrm{var}(o)}$$

Actual skill

U850 prediction skill at lead times from 1 month (top) to 6 months (bottom)



Conclusions

(1) The **potential skill is larger than actual skill**, indicating the possibility of skill improvement after model development.

(2) Potential skill has a better relationship with actual skill for correlation than for MSESS.

(3) Potential predictability is dominated by normalized ensemble mean shift.

UNBC

Sub-Theme II.3 Prediction

II.3.1 Coupled Model Initialization

Estimating Model Errors in an EnKF Assimilation System of Argo profiles (Deng and Tang, CMOS talk).

Wed 11:00

Ocean Model:OPA/NEMO 0.5°

Exps	Model error	inflator	bias	Bias Correction
E1	0	0	0	no
E2	1	0	0	no
E3	0	Adaptive	0	no
E4	1	Adaptive	0	0
E5	1	Adaptive	1	Dee's
E6	1	Adaptive	1	Persistent

0: without consideration in EnKF;

1: consideration in EnKF

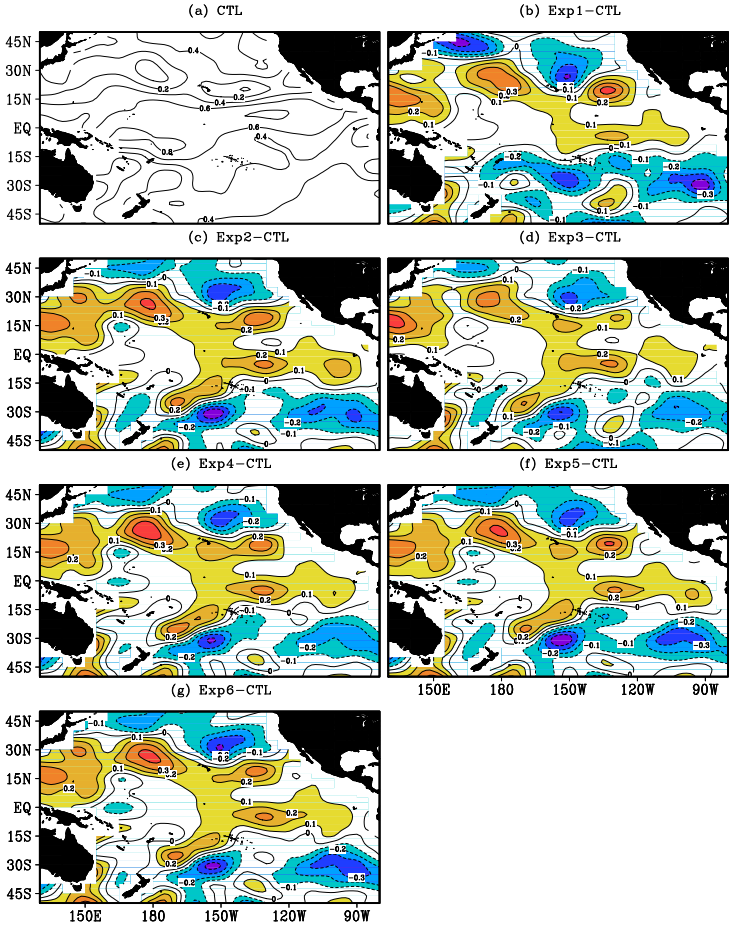
UNBC

Surface Zonal Current

All experiments increase correlation and reduce RMSE of surface zonal current in the tropical Pacific Ocean (30S-30N), especially in the central equatorial Pacific Ocean.

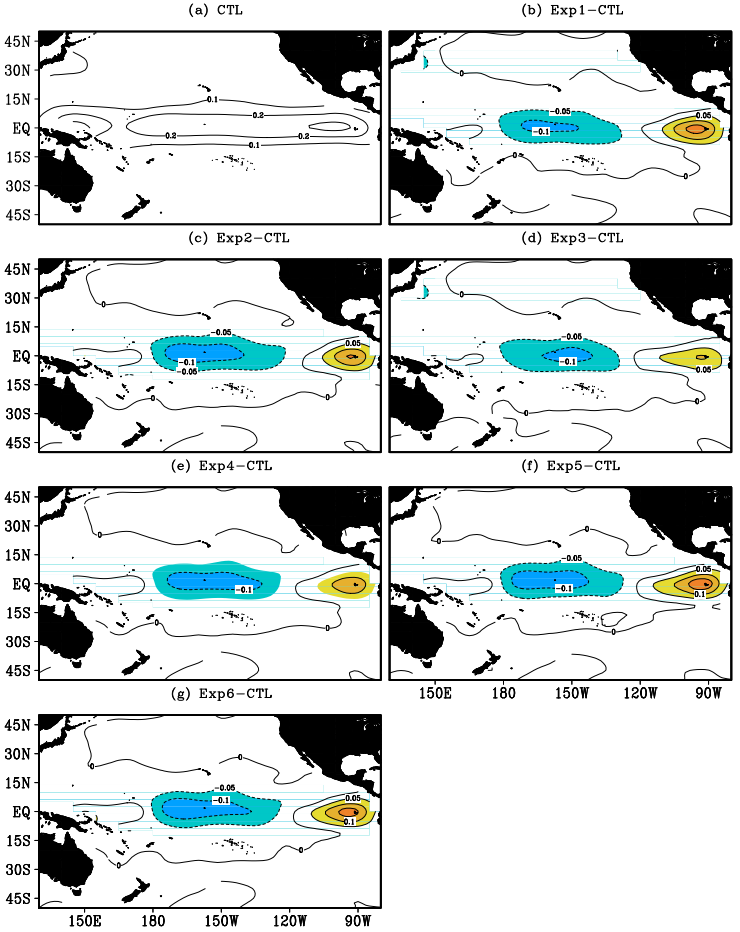
Correlation

No Assim **E1 to E6 - No Assim**



RMSE

No Assim **E1 to E6 - No Assim**



E2,E4-E6 are superior to E1 and E3, so additive error method is superior to the covariance inflation in EnKF. However the differences between the 6 experiments are not significant

UNBC

II.3.2 The Coupled Model Historical Forecasting Project

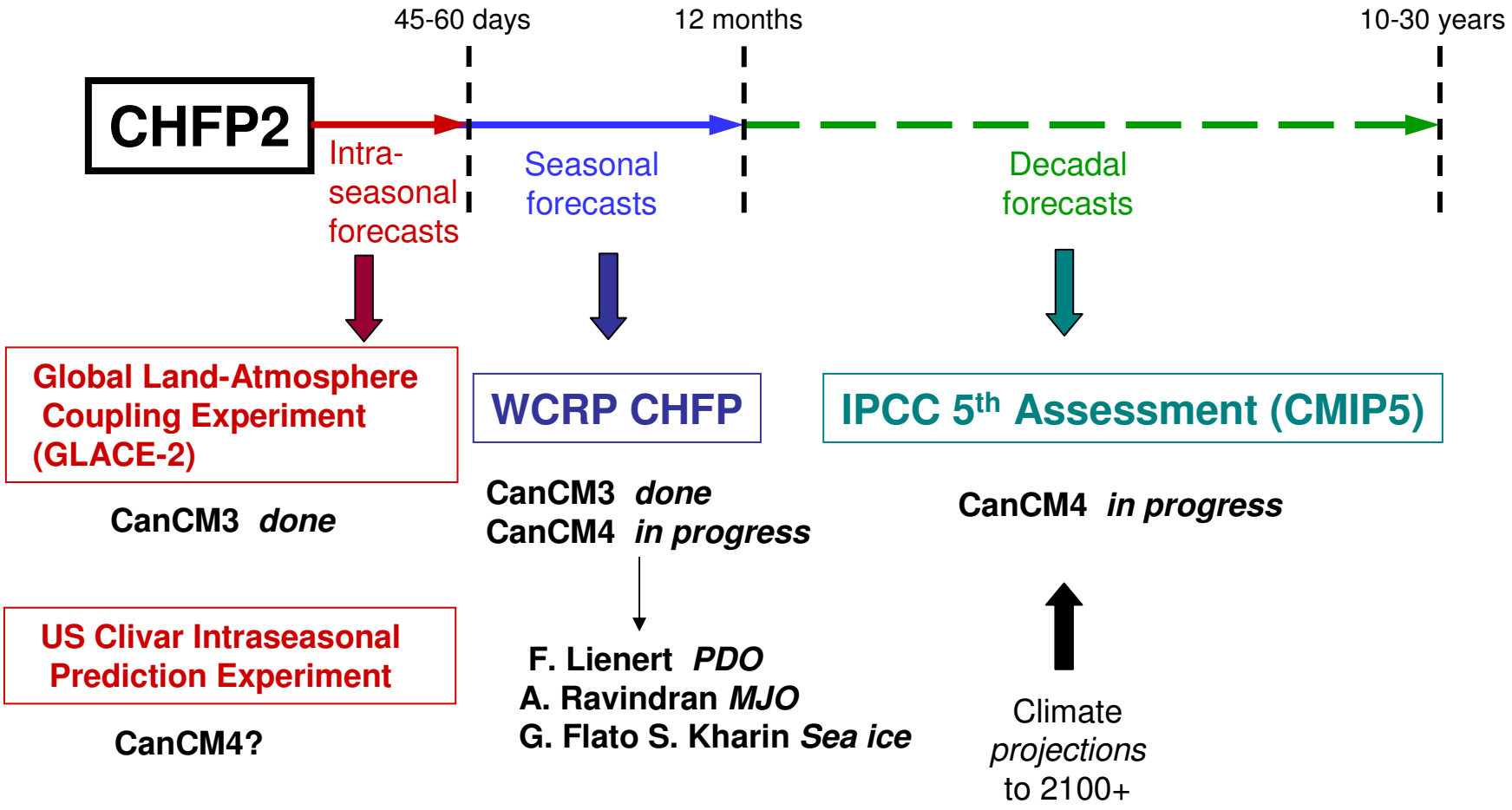
		Two-tier	One-tier		
		HFP2 [1)]	CHFP1	CHFP2	
				CHFP2A	CHFP2B
Model		GCM2, GCM3 SEF, GEM	CGCM3.1(T63) (AGCM3+OGCM3)	CanCM3 (AGCM3+OGCM4)	CanCM4 (AGCM4+OGCM4)
Initialization	atm	NCEP	-	IRU/CIN assim	IRU/CIN assim
	ocean	Previous month SSTA	Nudged SST	+2Dvar assim with S-correction	+2Dvar assim with S-correction
	sea ice	clim	-	Nudge to obs.	Nudge to obs.
Ensemble member		40 (4 model X 10)	10	10	10
Commencing dates		1st for all 12 months	1st for MAR, JUN, SEP, DEC	1st for all 12 months	1st for all 12 months*
Forecast duration		4 months	12 months	12 months	12months
Retrospective period		34 years (1969-2002)	30 years (1972-2001)	30 years (1979-2008)	30 years (1979-2008)

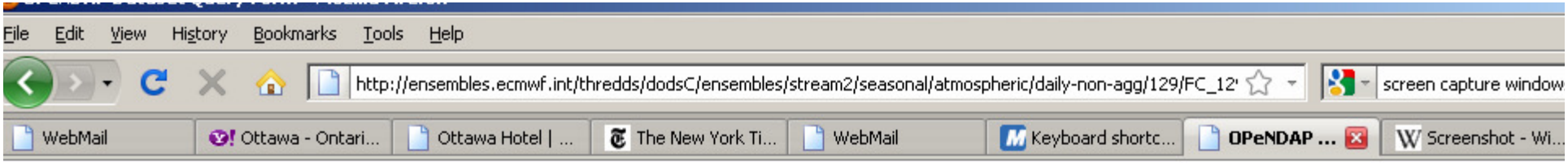
*in progress

W. Merryfield *Tue 11:30*

W.-S. Lee *Tue 12:00*

CHFP2 contributions to international activities





OPeNDAP Dataset Access Form

Tested on Netscape 4.61 and Internet Explorer 5.00.

Action: Get ASCII | Get Binary | Show Help

Data URL: http://ensembles.ecmwf.int/thredds/dodsC/ensembles/stream2/seasonal/e

Global Attributes:

```
/index.html, http://www.ecmwf.int/research/EU_projects/ENSEMBLES
/experiments/index.html"
Comment: "Data interpolated from original model grid into a regular
grid. Data restrictions: none"
Unlimited_Dimension: time
```

Variables:

☐ **longitude**: Array of 32 bit Reals [longitude = 0..143]

longitude:

```
data_type: "float"
units: "degrees_east"
axis: "X"
standard_name: "longitude"
topology: "circular"
modulo: 360
```

☐ **latitude**: Array of 32 bit Reals [latitude = 0..72]

latitude:

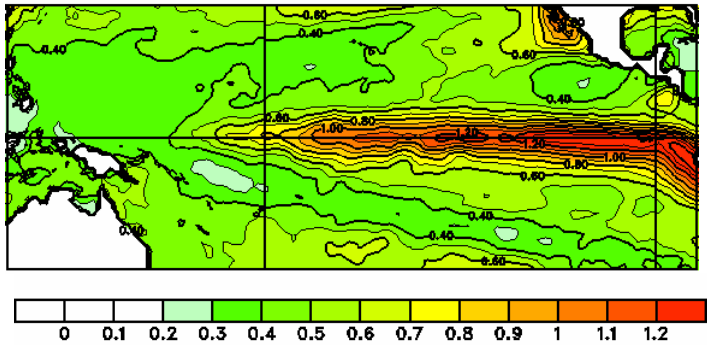
```
data_type: "float"
units: "degrees_north"
axis: "Y"
```

Done

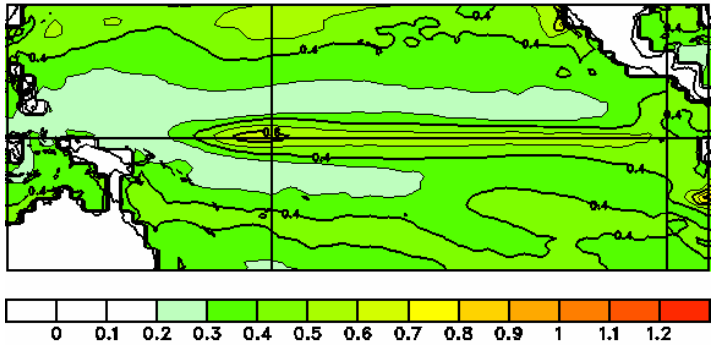
ENSO in Forecast Models

Monthly SSTA standard deviation

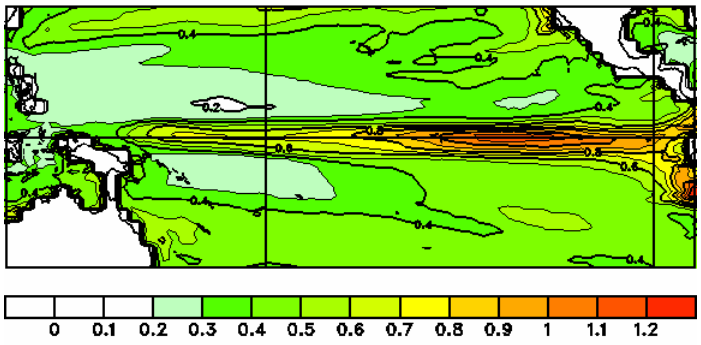
Observations:
HadISST 1970-99



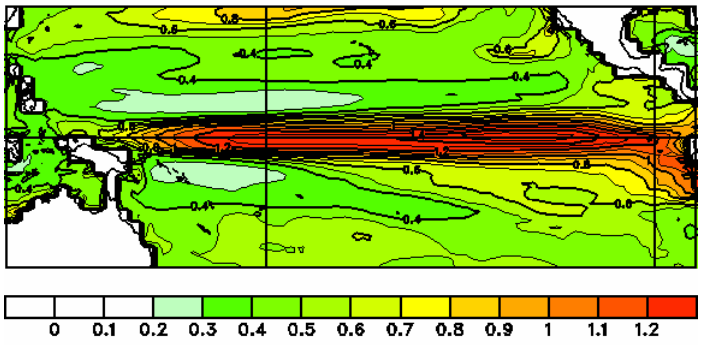
AGCM3+OGCM3 (CGCM3.1/IPCC AR4)
CHFP1



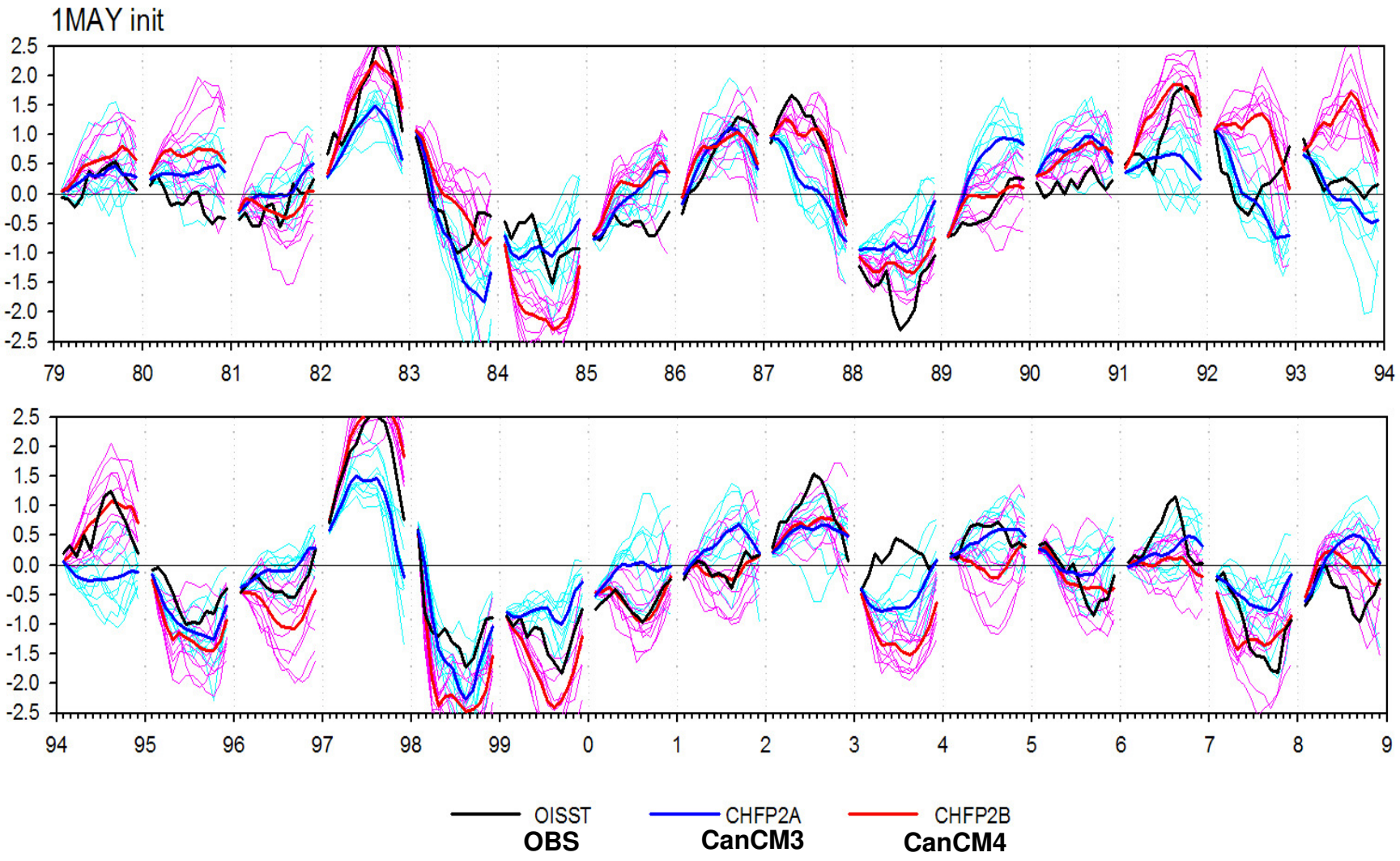
AGCM3+OGCM4 (CanCM3)
CHFP2A



AGCM4+OGCM4 (CanCM4)
CHFP2B

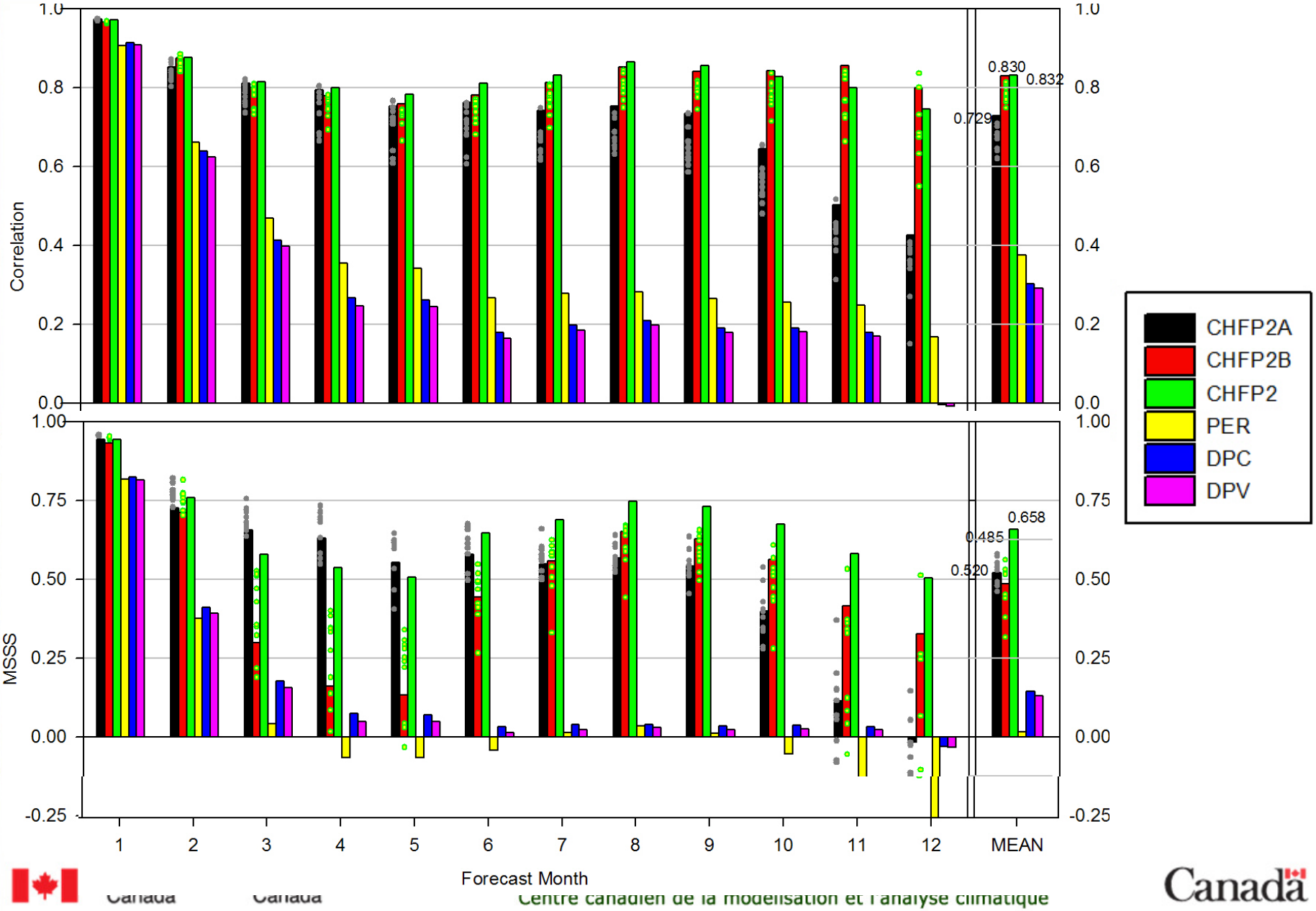


CHFP2 Nino3.4 forecasts from 1 May



Ensemble forecasts from1MAY: CHFP2A vs CHFP2B

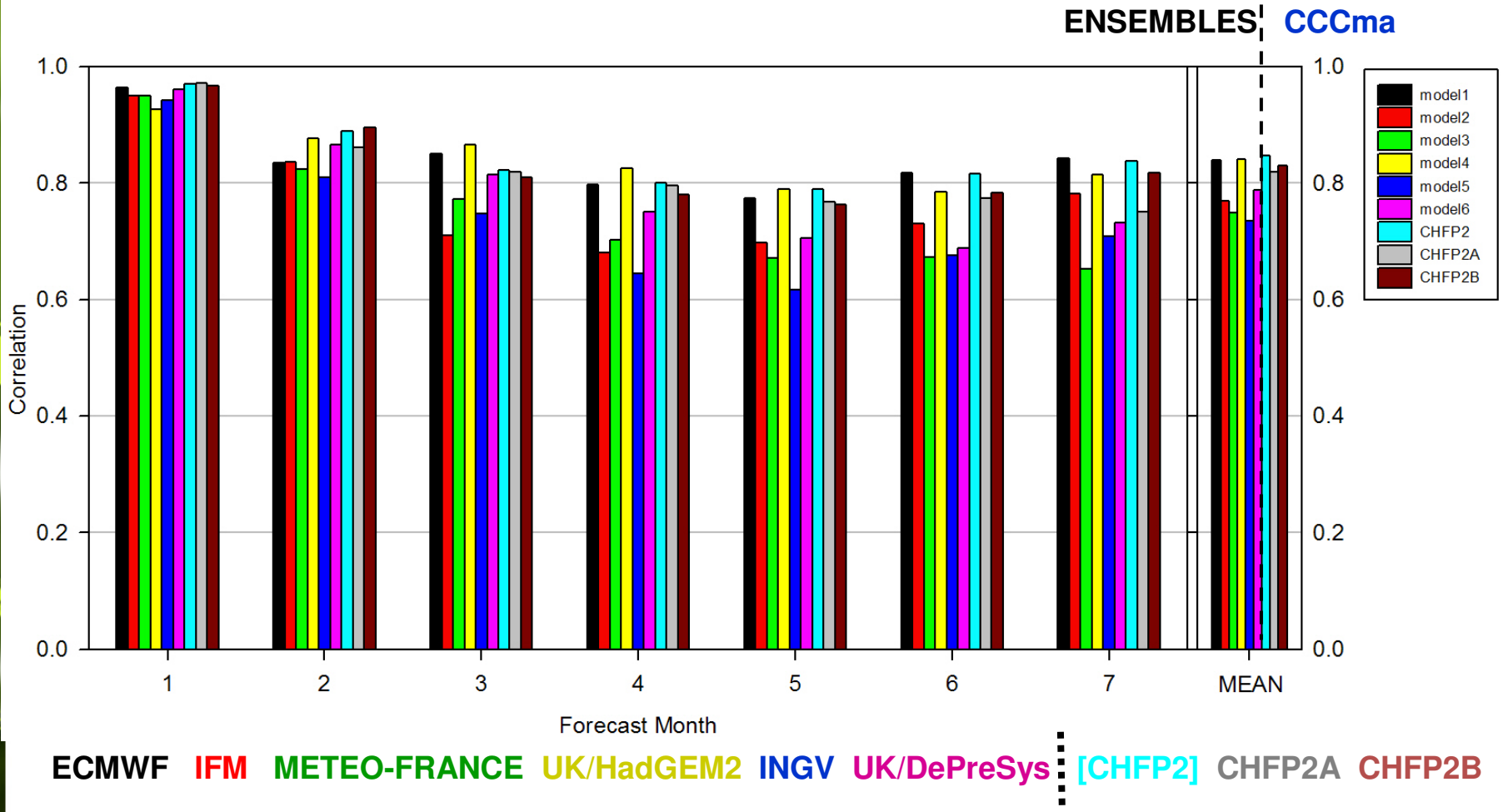
Nino3.4 CORR and MSSS 1979-2008



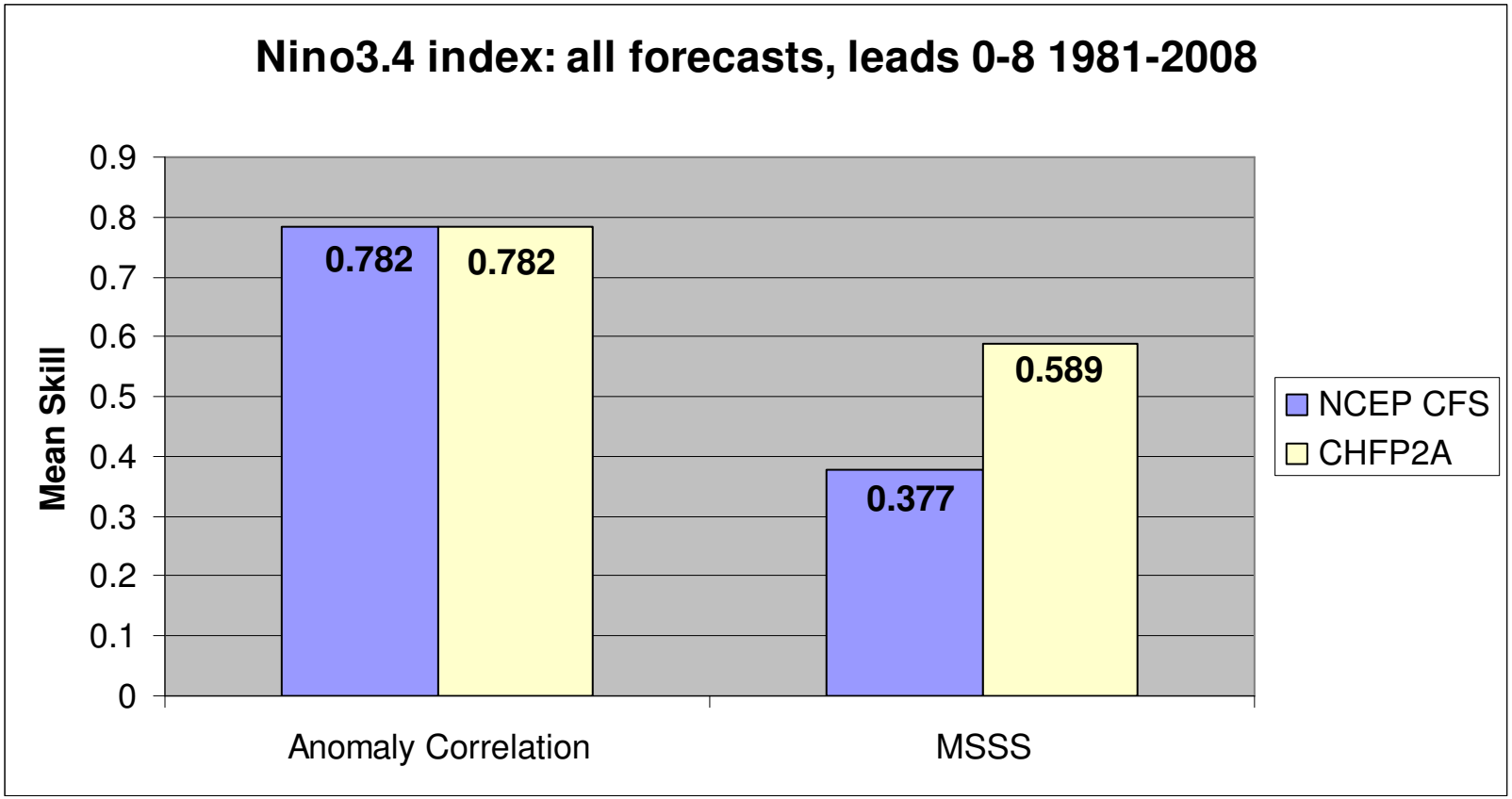
CHFP2 vs EU "ENSEMBLES"

Nino3.4 CORR from 1 MAY 1979-2005 (vs OISST)

ENSEMBLES : 9-ensemble CHFP2A/B : 10-ensemble

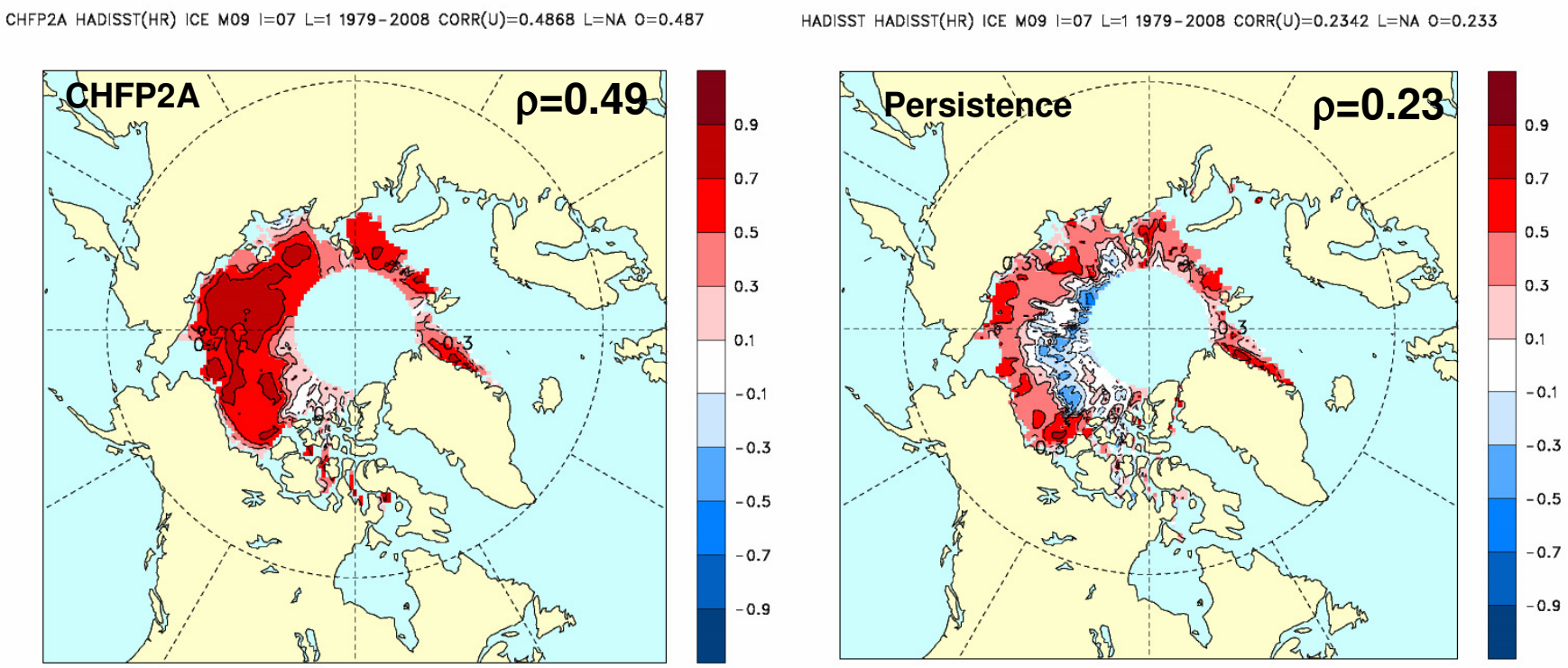


CHFP2A vs NCEP CFS



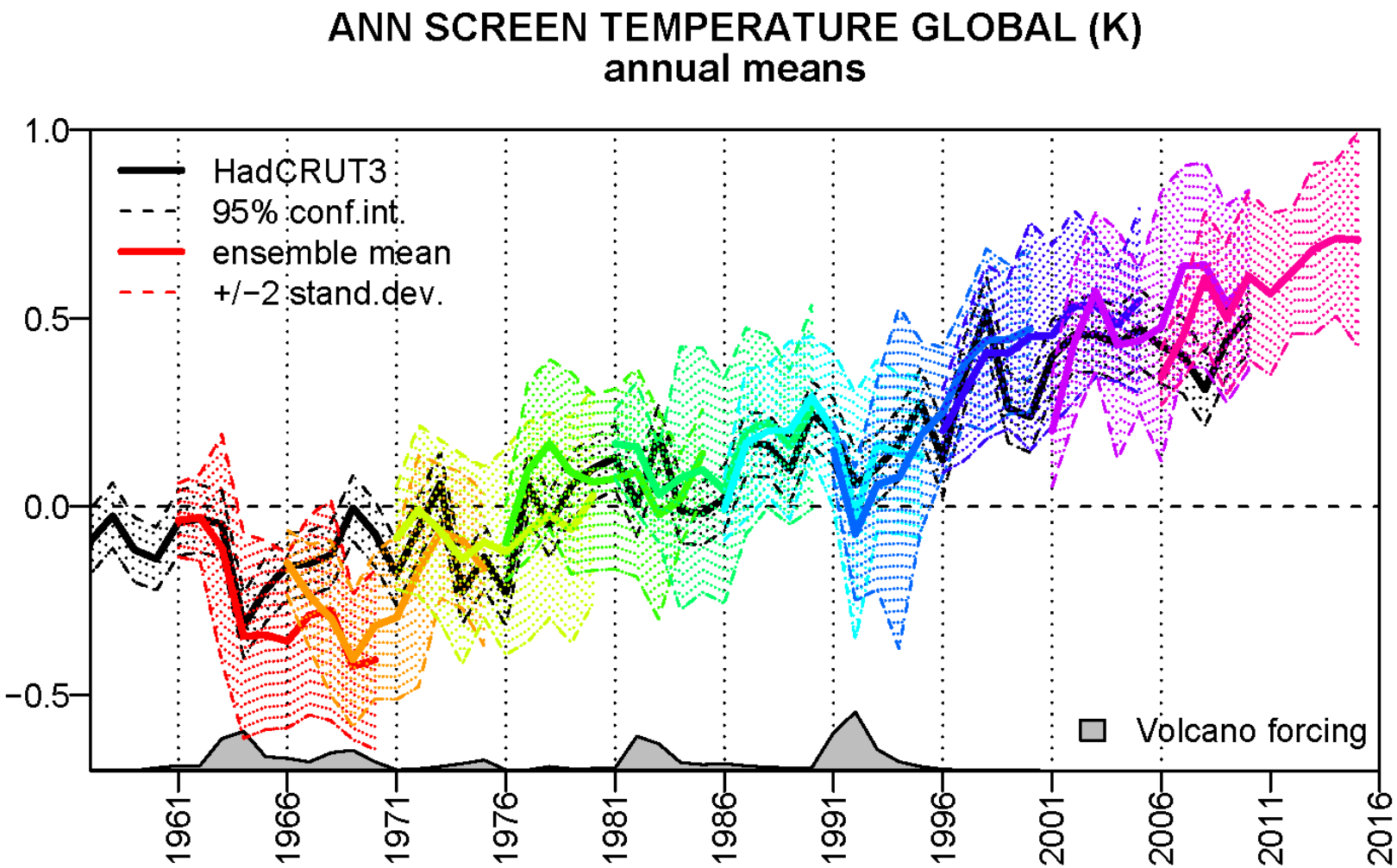
CHFP2A forecasts of sea ice

Loead-1 September Forecast (from1 Aug)



G. Flato ***Fri 15:30***

Initial decadal forecasts



II.3.4 Sensitivity of Seasonal Climate Forecasts in the CCCma GCM to the Initialization of Land Surface Hydrological States

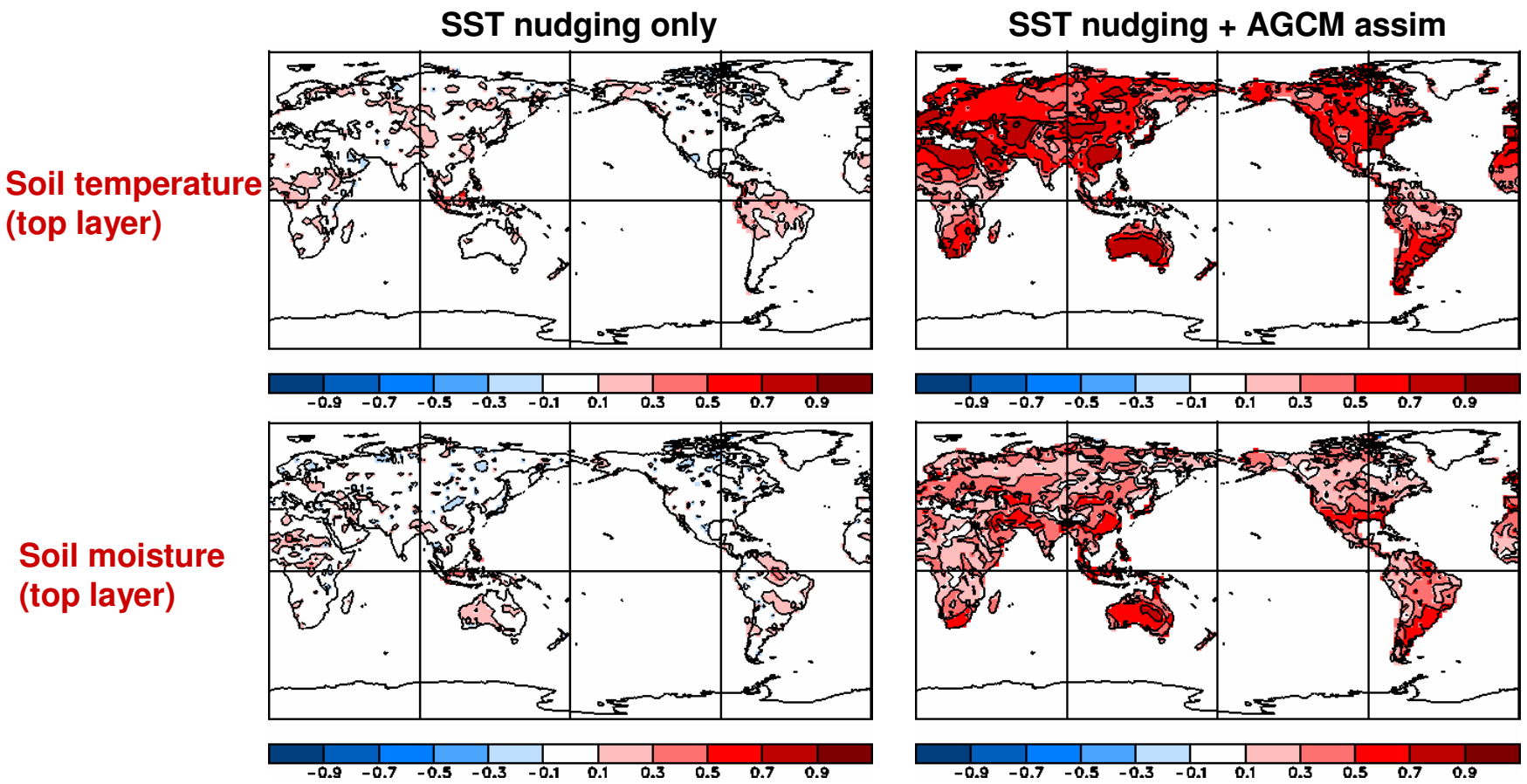
- CanCM3/4 CLASS land surface model forced off-line with bias-corrected reanalysis fields
- This land surface *analysis* (not realizable in real time) provides

  - I.C. for sensitivity experiments to assess the role of land-surface initialization (including soil moisture) in forecast skill
    → ***GLACE-2***

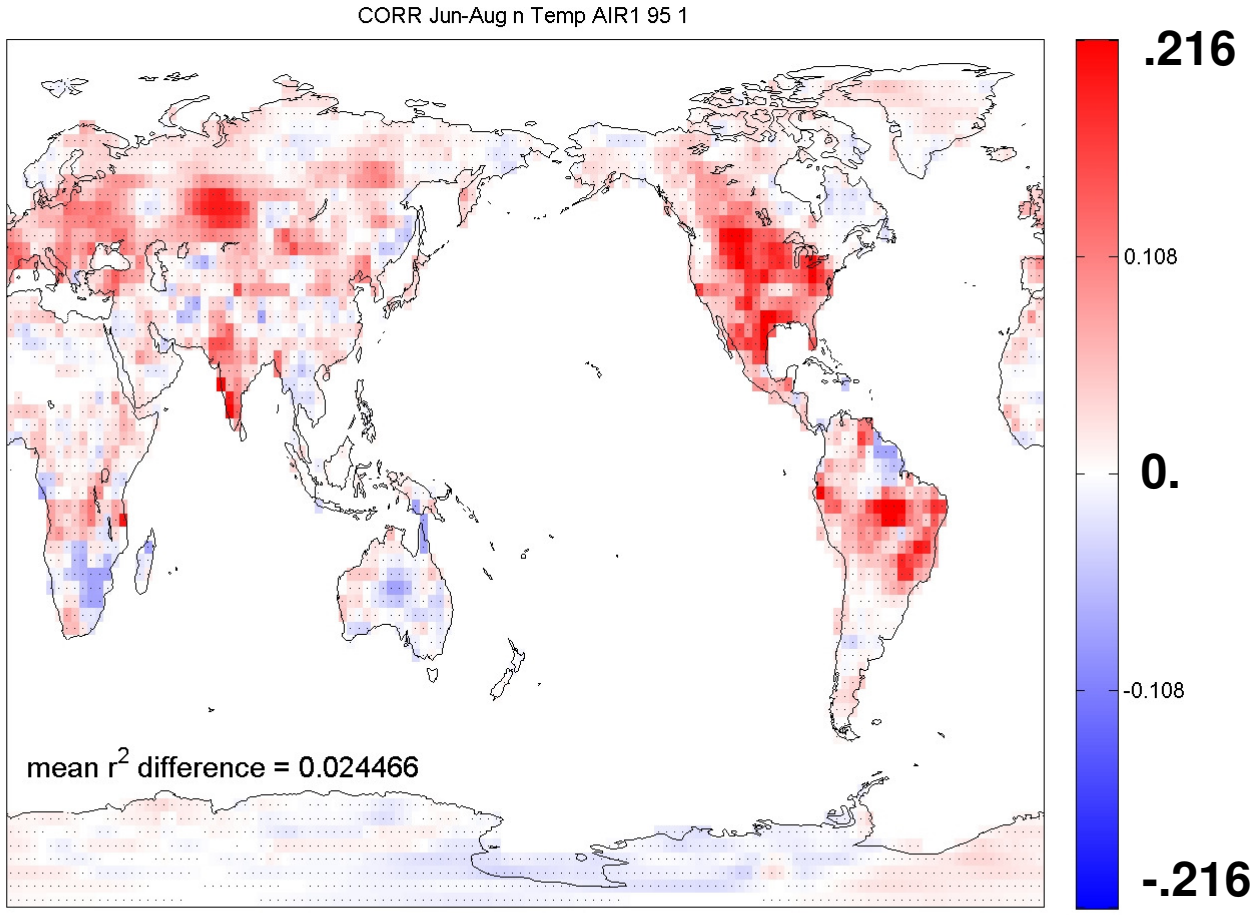
  - benchmark for assessing quality of operational forecast IC

Impacts of AGCM assimilation: Improved land initialization

Correlation of assimilation run vs Guelph offline analysis



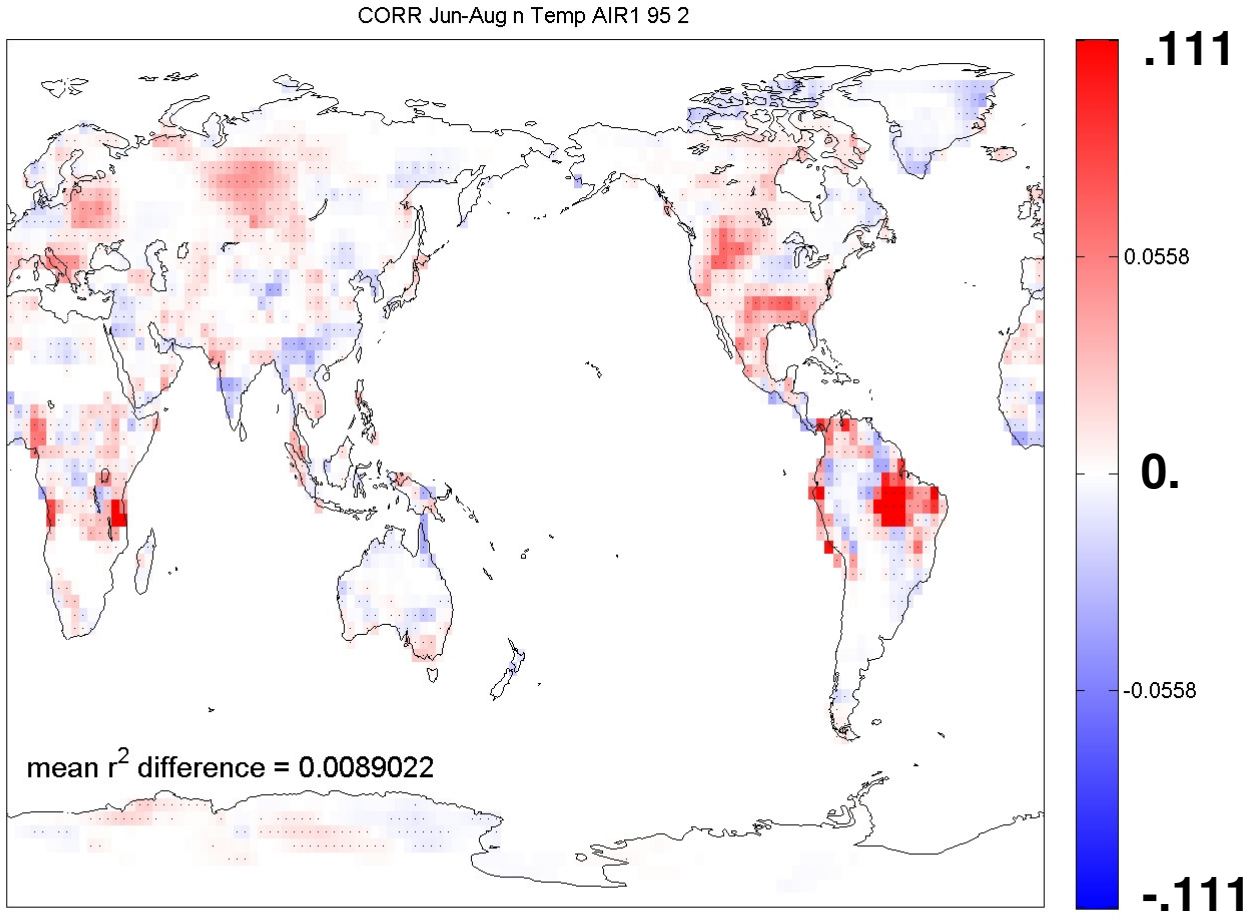
Anomaly correlation skill enhancement: realistic – unrealistic land initial conditions



• = statistically significant

1-15 days

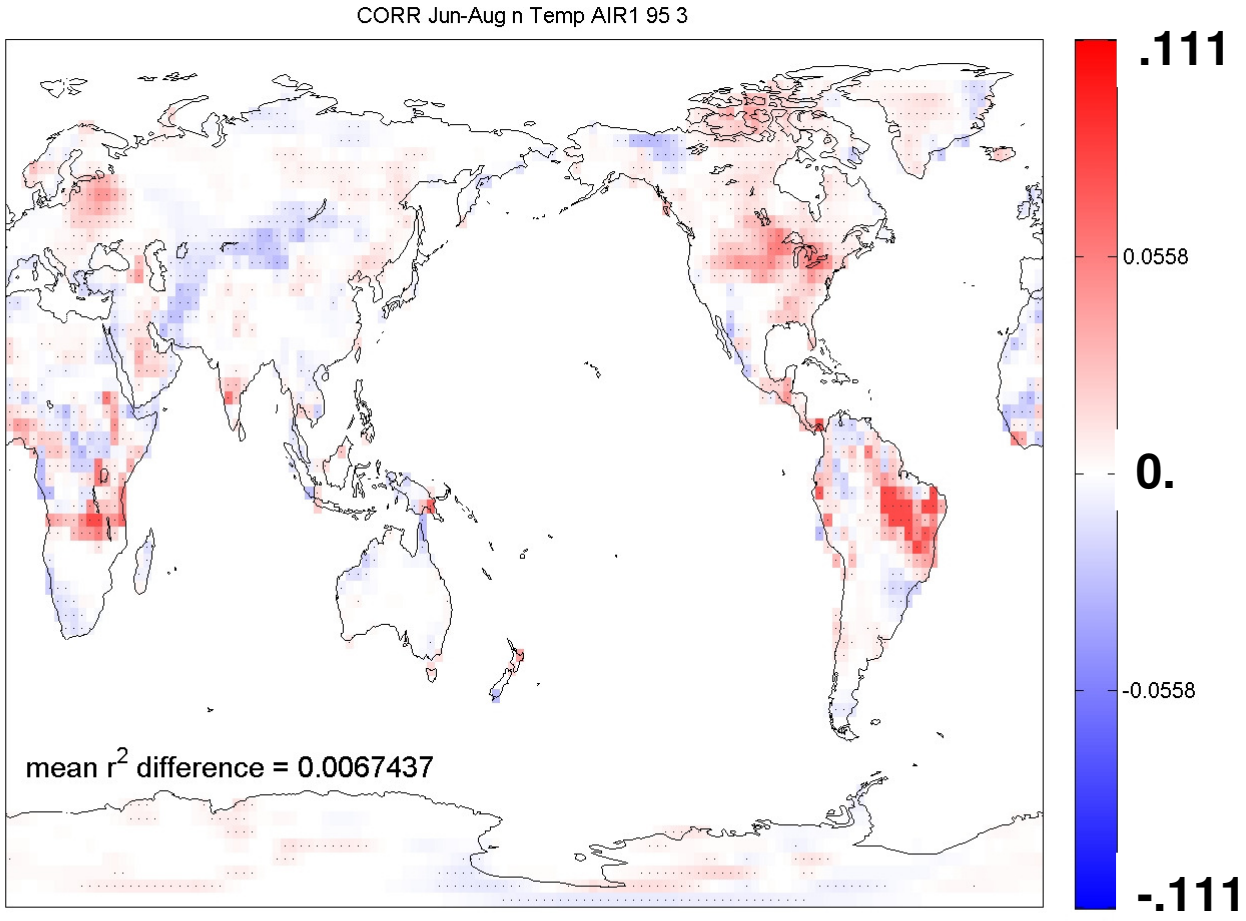
Anomaly correlation skill enhancement: realistic – unrealistic land initial conditions



• = statistically significant

16-30 days

Anomaly correlation skill enhancement: realistic – unrealistic land initial conditions



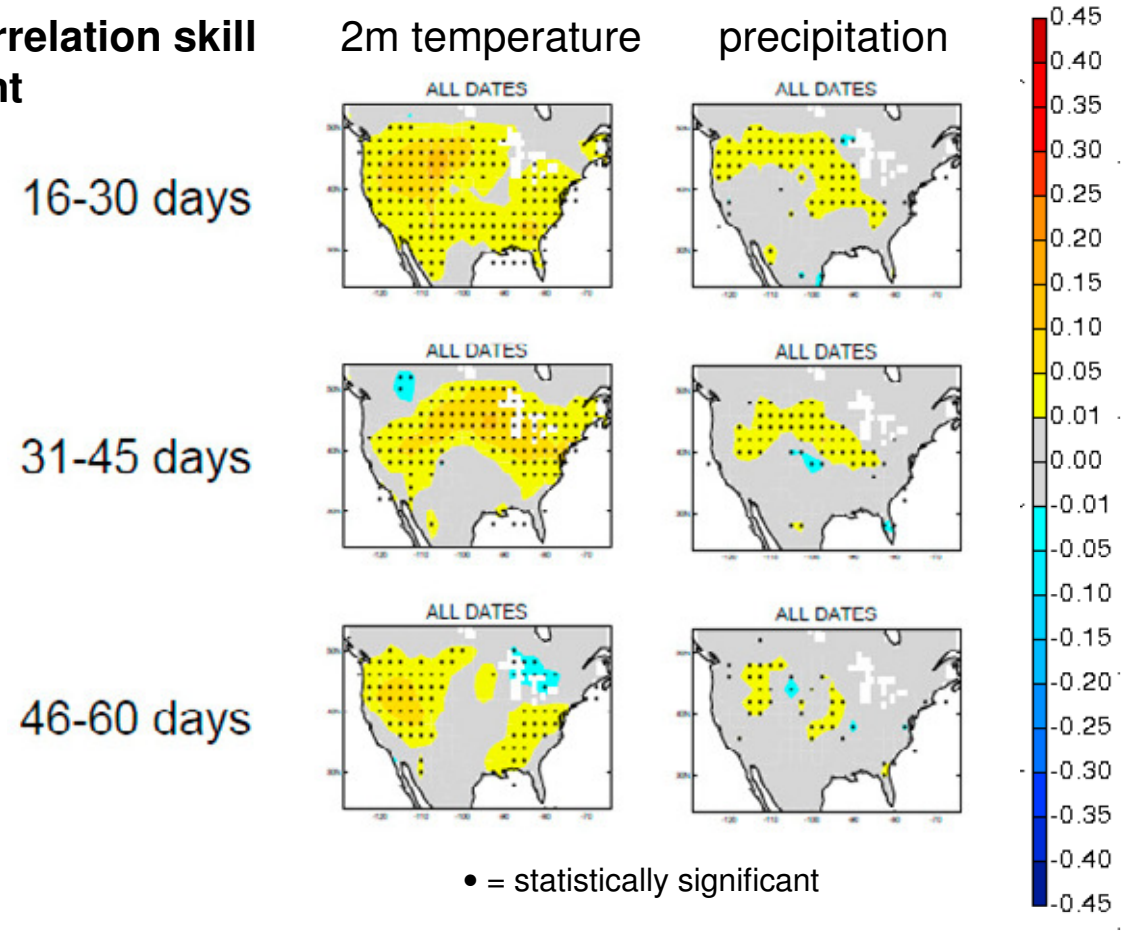
• = statistically significant

31-45 days

GLACE-2 initial results

Ensemble of 10 seasonal forecast models (including CCCma)

Anomaly correlation skill enhancement



• = statistically significant

Koster et al. *GRL* 2010

N. Alavi ***Tue 14:00*** ***"Relationship of seasonal climate forecast error to uncertainty in soil moisture initializations"***

"The role of soil moisture initialization in forecasting drought occurrence" **G. Drewitt** ***Tue 14:15***

Sub-Theme II.3 Prediction

II.3.3 Forecast Combination, Calibration and Verification

Carlos Gaitan (Ph.D. student under **W. Hsieh**, UBC):

Statistical Downscaling:

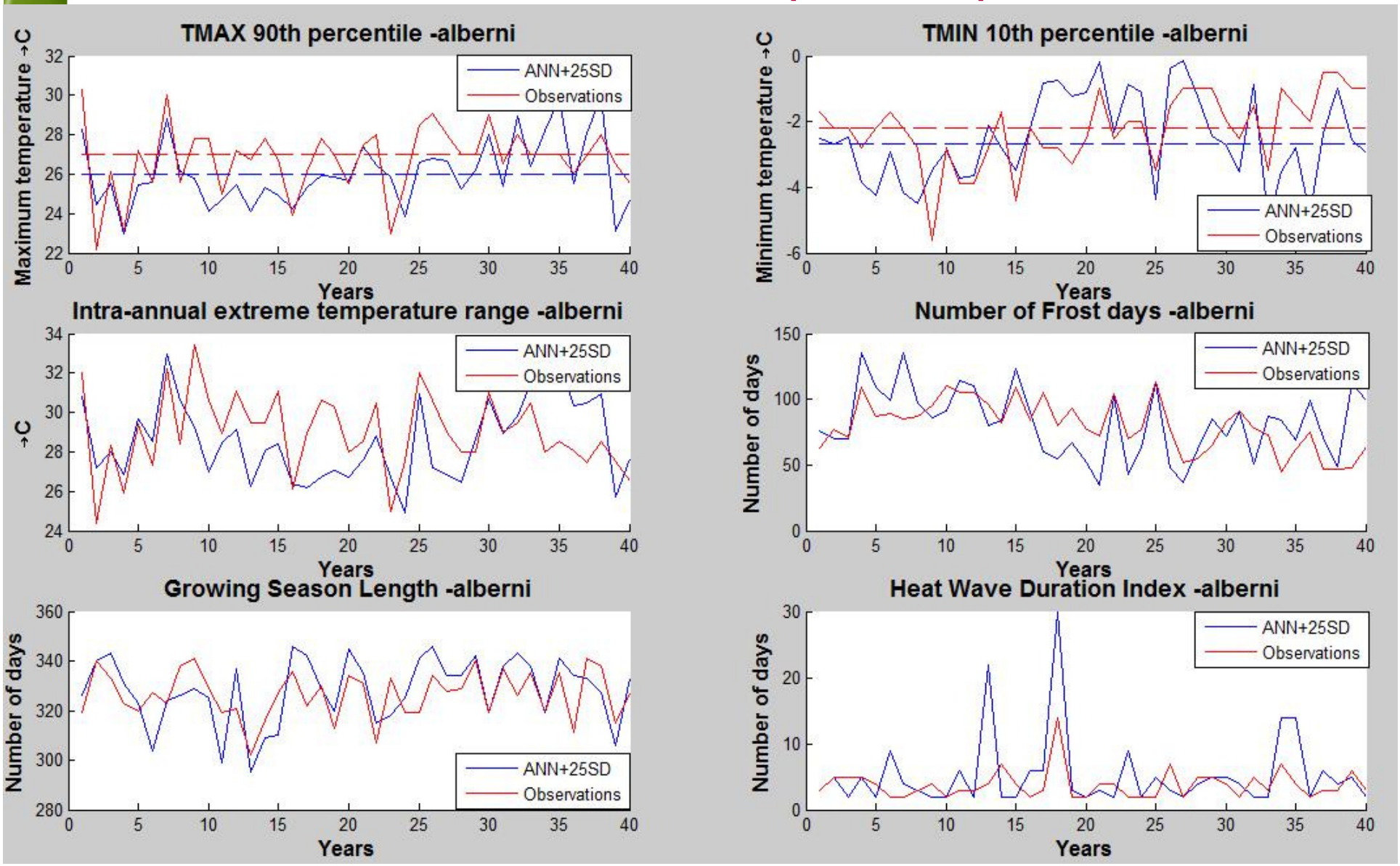
Predictors

- Canadian Global Climate Model version 3 (CGCM 3.1)
  - 21st century emission Scenarios
    - A2
    - A1B
- NCEP/NCAR Reanalysis (1961-2000)

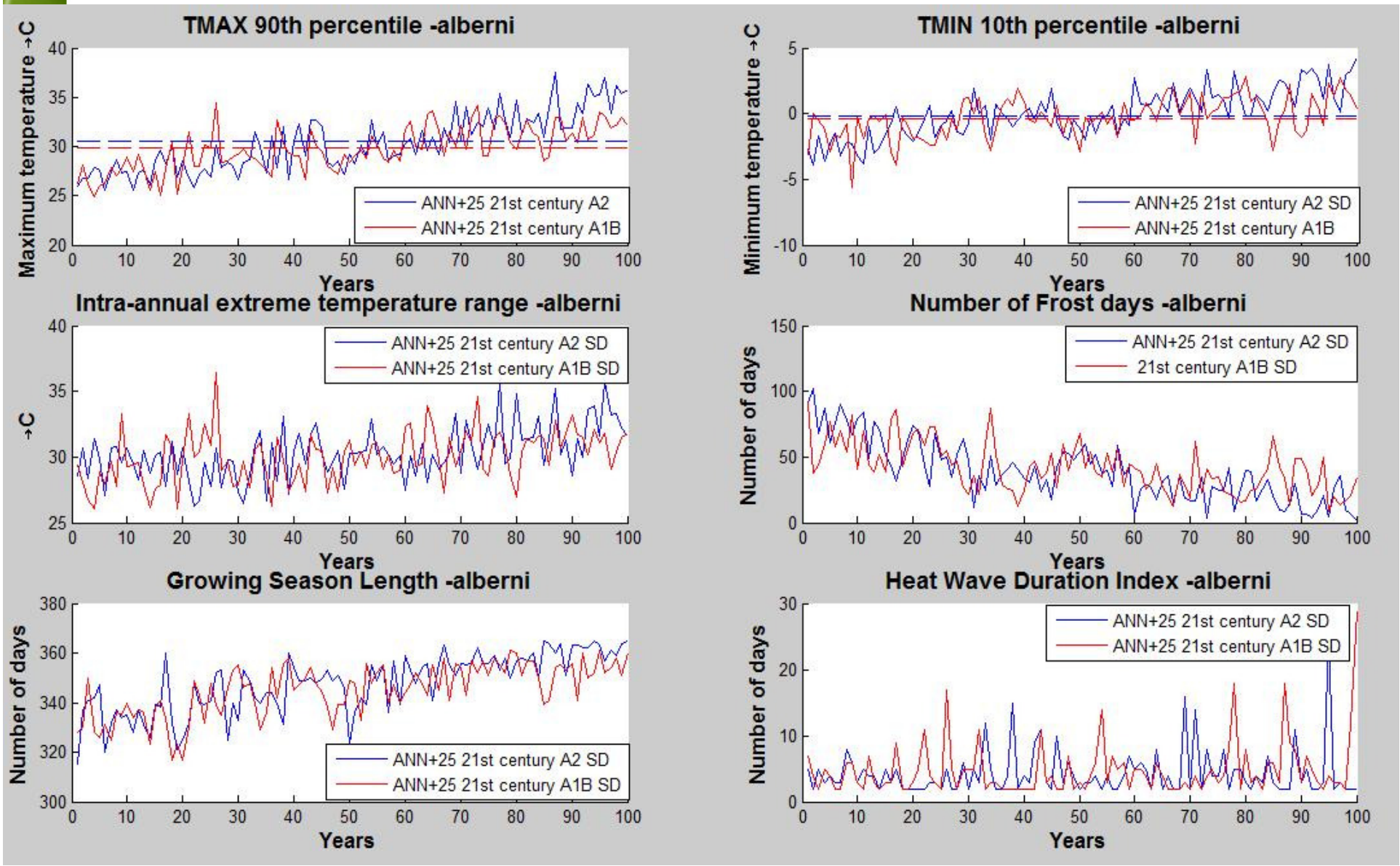
Predictands

- Daily station values of:
  - Maximum temperature (TMAX)
  - Minimum temperature (TMIN)

STARDEX INDICES (1961-2000): DOWNSCALE USING ARTIFICIAL NEURAL NETWORK MODEL WITH 25 PREDICTORS (ANN+25)



PROJECTION TO 2001-2100 BY "ANN+25" MODEL: STARDEX INDICES



Conclusions

Since October 2006, Theme II research has

- Clarified the relation between intrinsic and tropically forced North Pacific variability in climate models
- Quantified potential predictability in stationary, warmer, and warming climates
- Developed an effective and operation-ready coupled seasonal-to-interannual prediction system for Canada
- Explored the application of this forecast system to decadal-multidecadal prediction