Environment and Climate Change Canada
Environnement et Changement climatique Canada

Canada

Lab session on seasonal forecasting

Bill Merryfield

Canadian Centre for Climate Modelling and Analysis (CCCma)
Victoria, BC Canada

School on Climate System Prediction and Regional Climate Information
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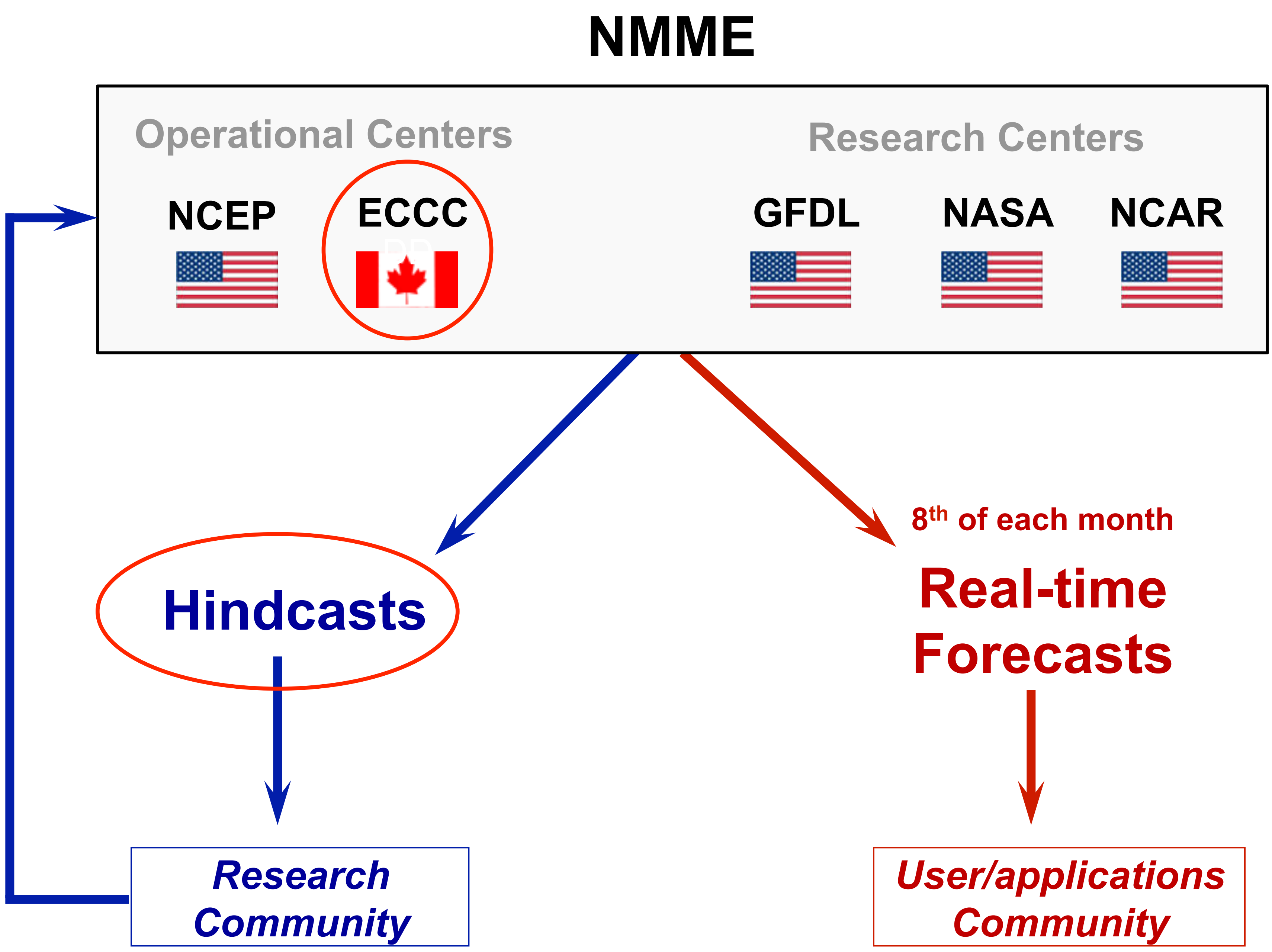
Overview

- This lab will consider ensemble hindcast data from a multi-model forecast system: the Canadian Seasonal to Interannual Prediction System (CanSIPS)

- CanSIPS combines forecasts from two models, CanCM3 and CanCM4, which contribute to the WMO, APCC and NMME ensembles

- Instead of working with 2-dimensional forecast fields, this lab will consider **indices** representing SST or precipitation averaged over various regions


NMME
Operational Centers
Research Centers
NCEP
ECCC
GFDL
NASA
NCAR
8th of each month
Hindcasts
Real-time Forecasts
Research Community
User/applications Community

The Canadian models

The Canadian Seasonal to Interannual Prediction System (CanSIPS)

- Developed at CCCma
- Operational at CMC since Dec 2011
- 2 models CanCM3/4, 10 ensemble members each
- Hindcast verification period = 1981-2010
- Forecast range = 12 months
- Forecasts initialized at the start of every month

CanSIPS Models

CanCM3

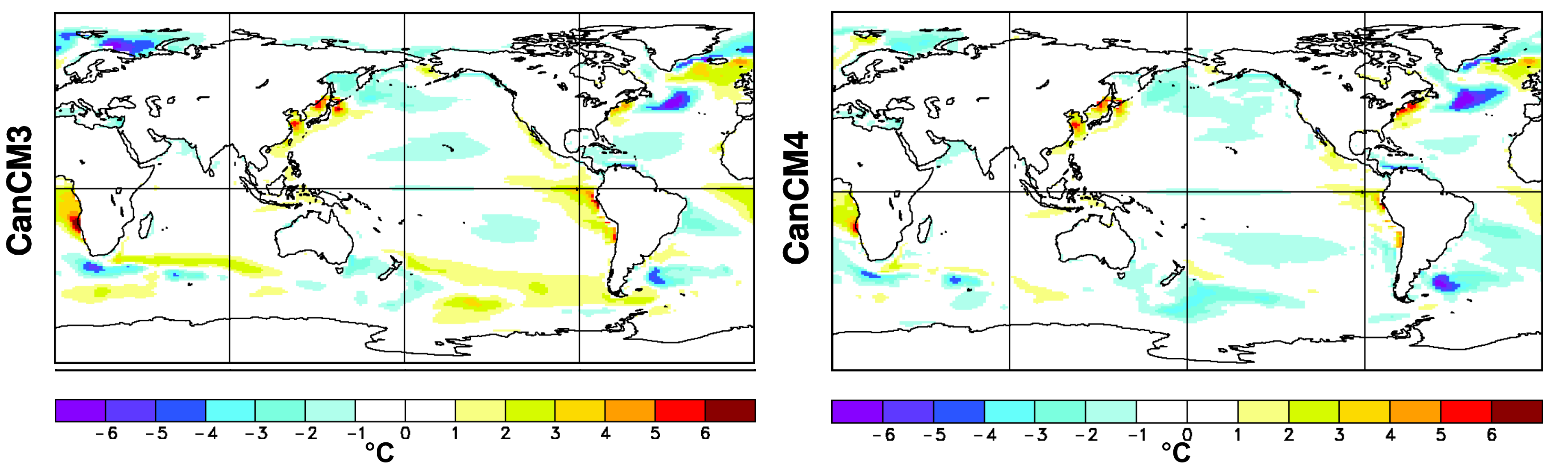
CanAM3 *Atmospheric model*
- T63/L31 (≈2.8° spectral grid)
- Deep convection scheme of Zhang & McFarlane (1995)
- No shallow conv scheme
- Also called AGCM3

CanOM4 *Ocean model*
- 1.41°×0.94°×L40
- GM stirring, aniso visc
- KPP+tidal mixing
- Subsurface solar heating climatological chlorophyll

CanCM4

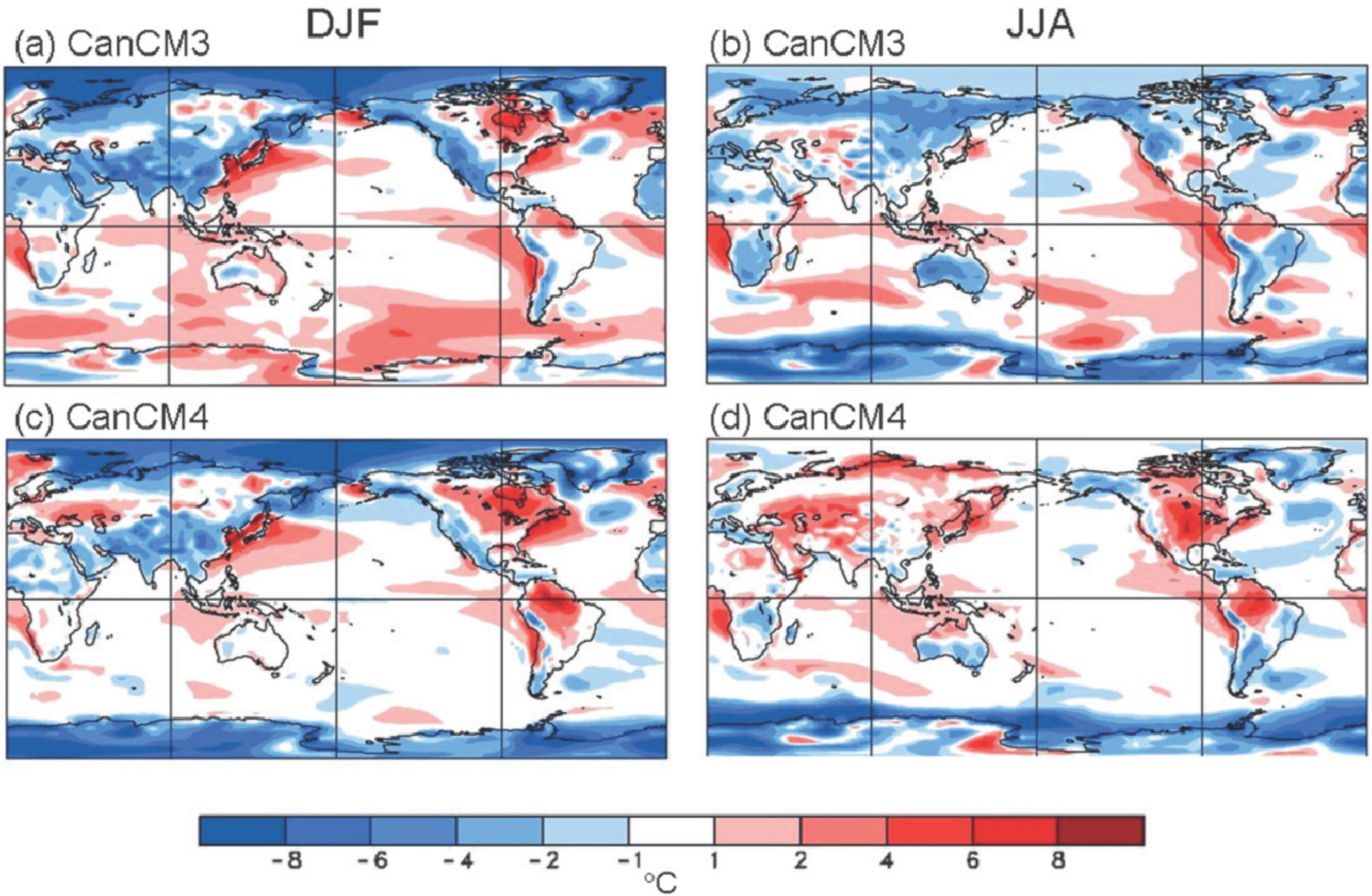
CanAM4 *Atmospheric model*
- T63/L35 (≈2.8° spectral grid)
- Deep conv as in CanCM3
- Shallow conv as per von Salzen & McFarlane (2002)
- Improved radiation, aerosols

SST bias vs obs (OISST 1982-2009)



CanSIPS model temperature biases

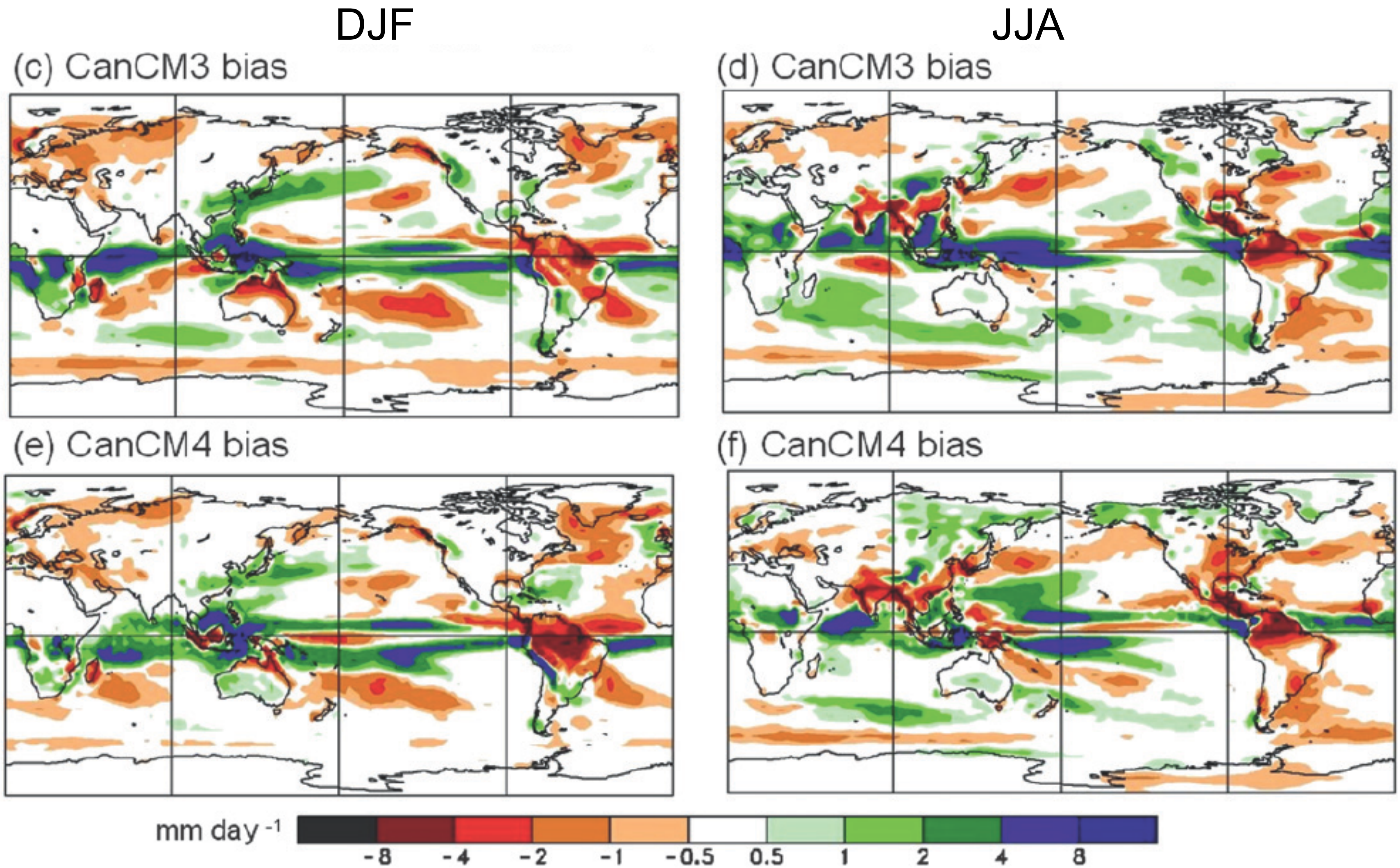
Biases of freely running models relative to ERA-Interim reanalysis 1981-2010



Merryfield et al. (MWR 2013)

CanSIPS model precipitation biases

Biases of freely running models relative to GPCP2.1 1981-2010



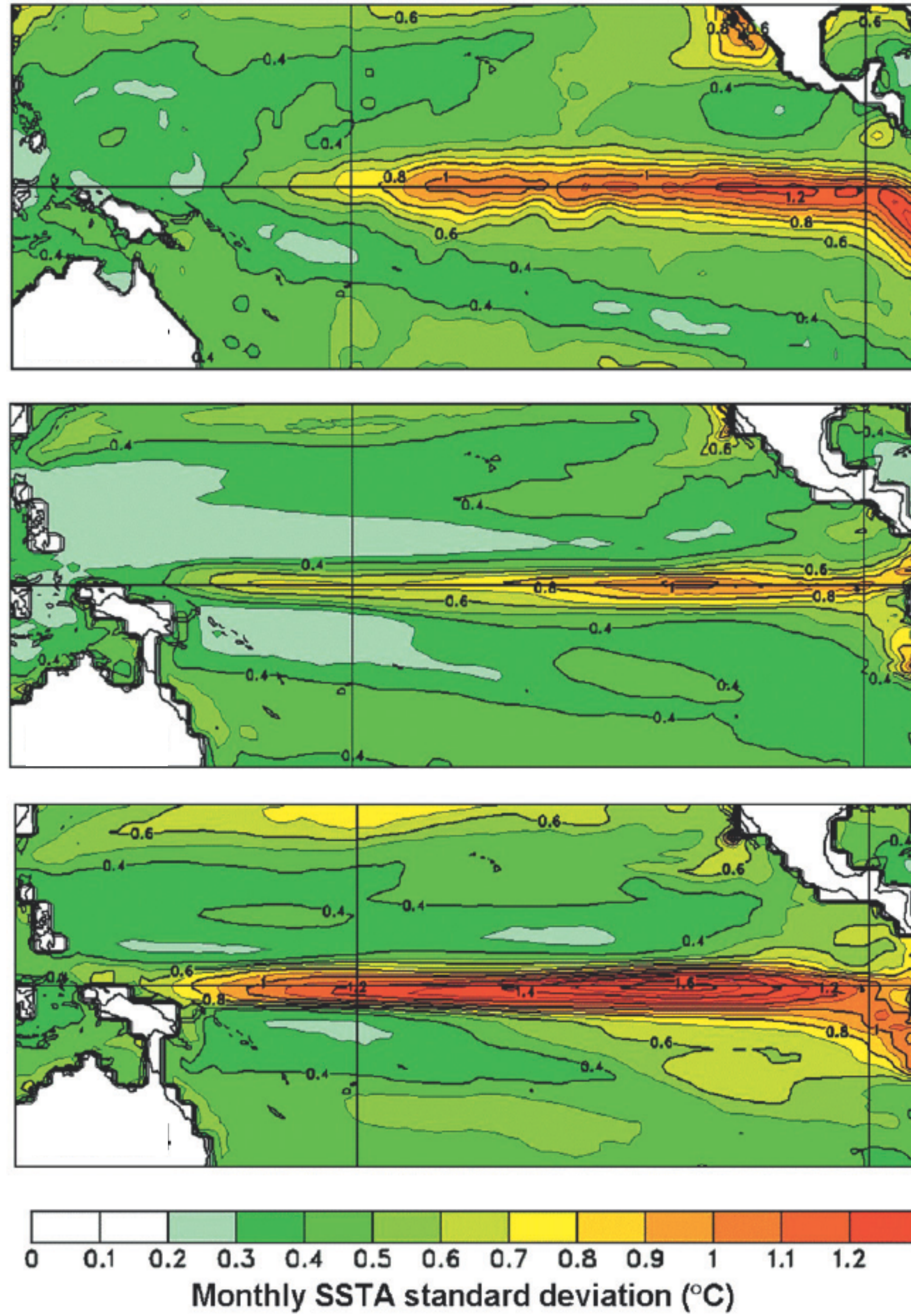
Merryfield et al. (MWR 2013)

ENSO variability in models

HadISST 1970-99 observed

CanSIPS / CanCM3
ENSO too weak

CanSIPS / CanCM4
ENSO too strong



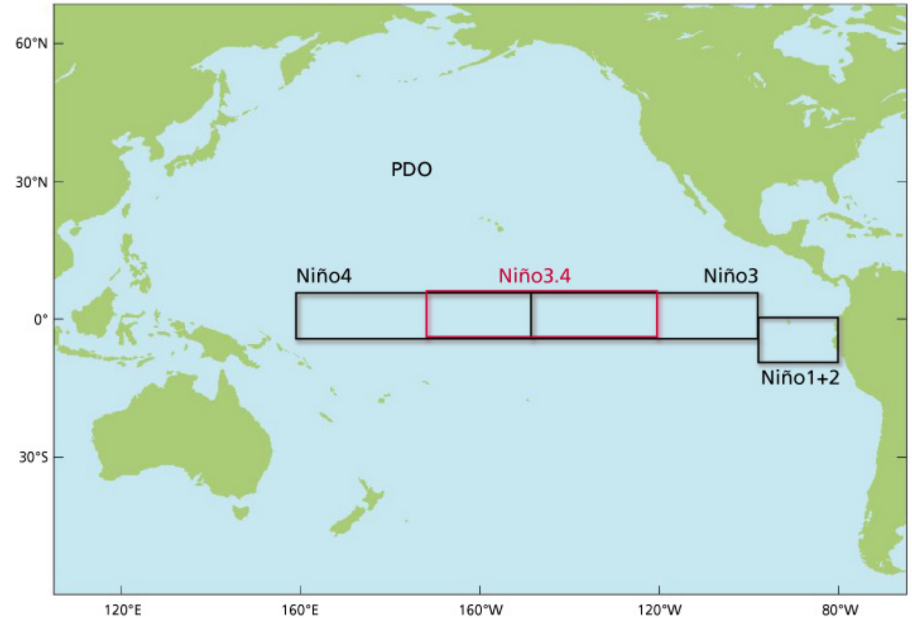
SST and precipitation indices

SST indices

http://ioc-goos-oopc.org/state_of_the_ocean/sur/

Pacific :

1.*Niño1+2* : SST Anomalies in the box 90°W - 80°W, 10°S - 0°.
2.*Niño3* : SST Anomalies in the box 150°W - 90°W, 5°S - 5°N.
3.*Niño4* : SST Anomalies in the box 160°E - 150°W, 5°S - 5°N
4.*Niño3.4* : SST Anomalies in the box 170°W - 120°W, 5°S - 5°N
5. *PDO* : Pacific Decadal Oscillation (EOF based)
6.*El Niño Modoki Index (EMI)*

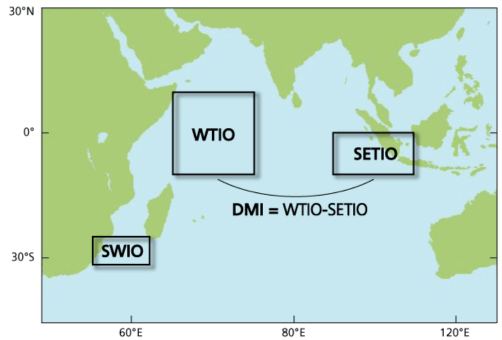


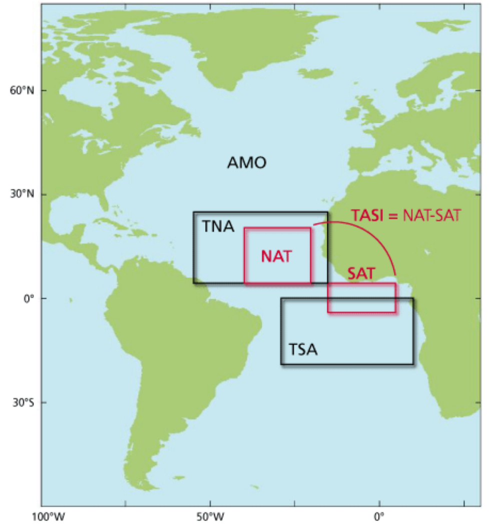
Atlantic :

1. *North Atlantic Tropical SST index(NAT)* ;
   SST anomalies in the box 40°W - 20°W, 5°N - 20°N.
2. *South Atlantic Tropical SST index(SAT)*
   SST anomalies in the box 15°W - 5°E, 5°S - 5°N.
3. *TASI = NAT – SAT*
4. *Tropical Northern Atlantic index(TNA)*
   SST anomalies in the box 55°W - 15°W, 5°N -25°N.
5. *Tropical Southern Atlantic index(TSA)*
   SST anomalies in the box 30°W - 10°E, 20°S - EQ.

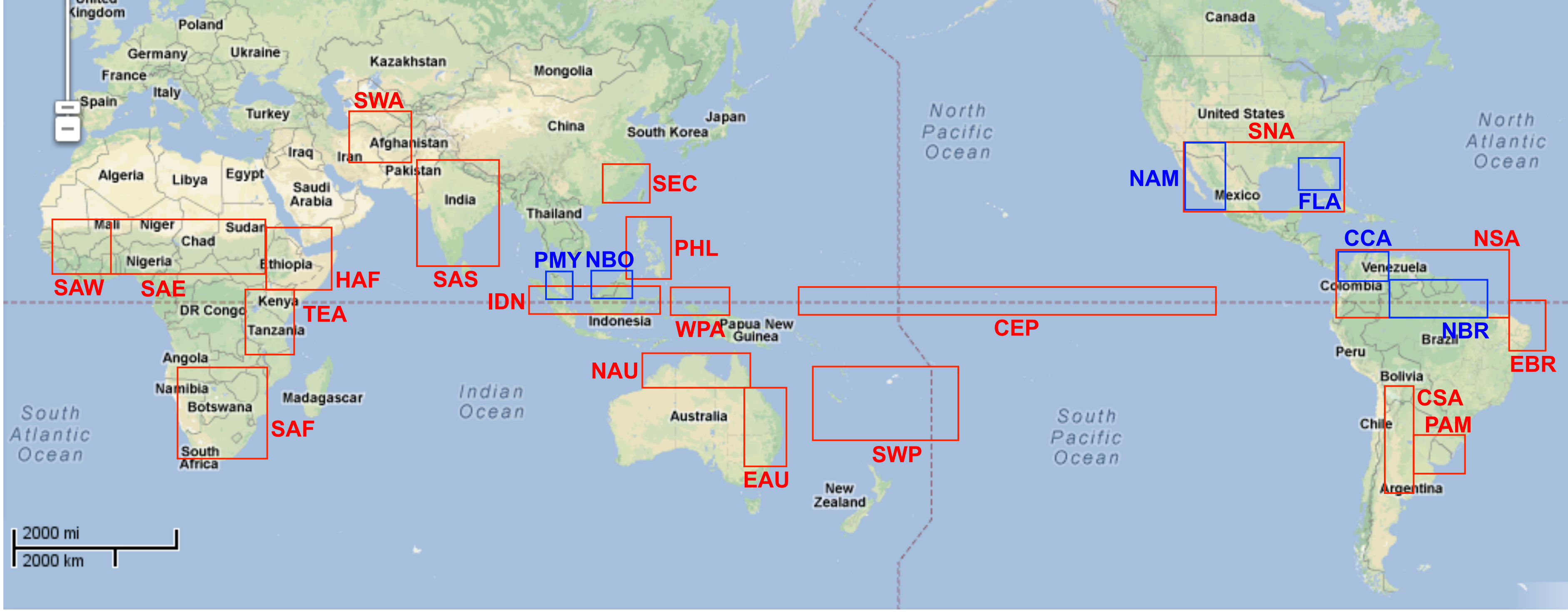
Indian Ocean :

1. *Western Tropical Indian Ocean SST index (WTIO)*
   : SST anomalies in the box 50°E - 70°E, 10°S - 10°N
2. *Southeastern Tropical Indian Ocean SST index(SETIO)*
   : SST anomalies in the box 90°E - 110°E, 10°S - 0°
3. *South Western Indian Ocean SST index(SWIO)*
   : SST anomalies in the box 31°E - 45°E, 32°S - 25°S
4. *Indian Ocean Dipole Mode Index (IOD)*
   : WTIO - SETIO

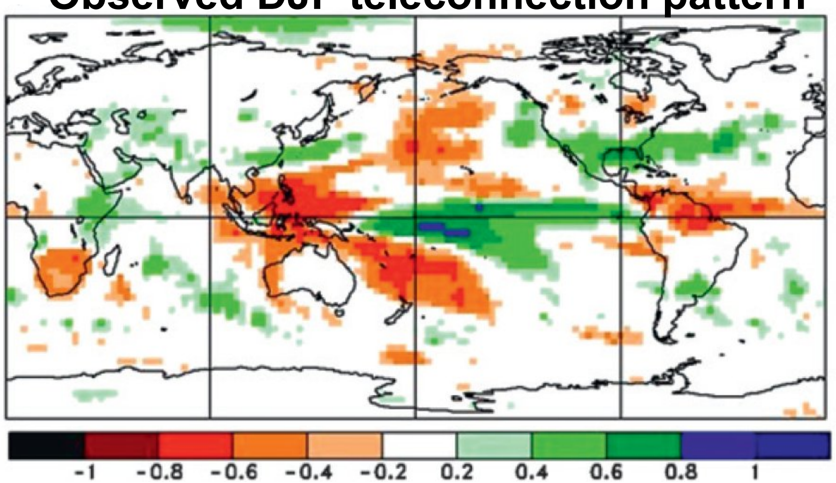




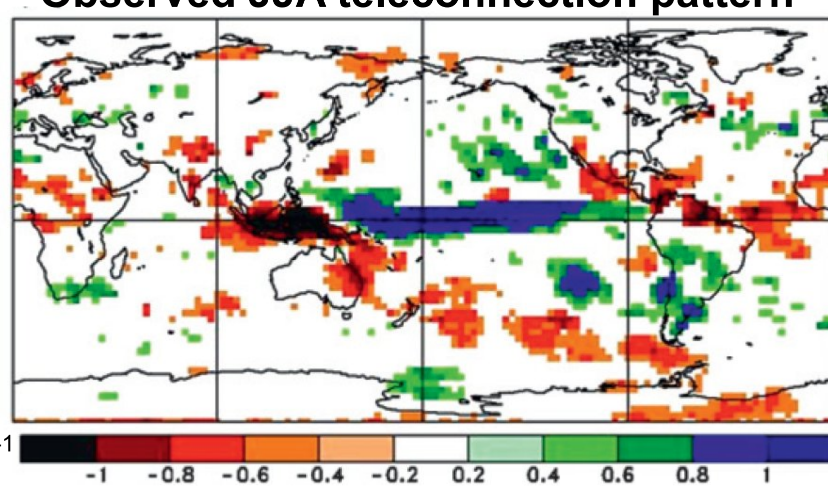
Precipitation indices based on ENSO teleconnections



Observed DJF teleconnection pattern



Observed JJA teleconnection pattern



Data structure

Overview of data

- Data for each of the 15 SST and 28 precipitation indices is available in four formats:
  - full values, ascii format
  - fill values, csv format
  - anomalies, ascii format
  - anomalies, csv format
- Observed values are also available, based on
  - NCEP OISSTv2 for SST
  - GPCP2.2 for precipitation
- Data is in the form of **seasonal means**: JFM, FMA, … DJF

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- Data is in the form of **seasonal means**: JFM, FMA, … DJF
- Data can be loaded from USB device of downloaded by ftp at

ftp://ftp.cccma.ec.gc.ca/pub/bmerryfield/ICTP_SCHOOL

File structure

- Each **forecast** file contains, for a particular index,
  - data for all seasons JFM…DJF
  - data for all lead times 0…9 months (months 1/2/3…10/11/12 of forecast)
  - for each lead time, data for all years 1981…2010
  - for each year, values for 10 ensemble members for each of the two models

- Each **observation** file contains, for a particular index,
  - data for all seasons JFM…DJF
  - for each season, observed values for all years 1981…2010

File names

- **SST forecast** files, for example for nino34 index, are named

  cancm3_cancm4_seas_full_1981_2010_sst_nino34.dat (full values & anomalies,
  cancm3_cancm4_seas_anom_1981_2010_sst_nino34.dat ascii)

  cancm3_cancm4_seas_full_1981_2010_sst_nino34.csv (full values & anomalies,
  cancm3_cancm4_seas_anom_1981_2010_sst_nino34.csv csv)

- **SST observation** files, again for nino3.4, are named

  oisst_seas_full_1981_2010_sst_nino34.dat
  oisst_seas_anom_1981_2010_sst_nino34.dat
  oisst_seas_full_1981_2010_sst_nino34.csv
  oisst_seas_anom_1981_2010_sst_nino34.csv

- **Precipitation forecast** files, for example for sae index, are named

  chfp2dc_seas_full_198101_201101_pcp_sae.dat
  chfp2dc_seas_anom_198101_201101_pcp_sae.dat

  chfp2dc_seas_full_198101_201101_pcp_sae.csv
  chfp2dc_seas_anom_198101_201101_pcp_sae.csv

- **Precipitation observation** files, again for sae index, are named

  gpcp2.2_seas_full_198101_201101_pcp_cca.dat
  gpcp2.2_seas_anom_198101_201101_pcp_cca.dat

  gpcp2.2_seas_full_198101_201101_pcp_cca.csv
  gpcp2.2_seas_anom_198101_201101_pcp_cca.csv

Forecast file contents

- **SST forecast** files

Season 1…12 (1=JFM, 2=FMA … 12=DJF)

Lead time 0…9 months

CanCM3 ensemble members 1-10

CanCM4 ensemble members 1-10

```
1 0
 1981   .20   .26   .23   .06   .15   .22   .25  -.01   .18   .05   .35   .12   .28   .15   .10   .05   .27   .01   .06   .07
 1982   .16   .17   .11   .04   .16   .00   .04   .13   .05   .09   .20   .50   .18   .36   .50   .26   .26   .29   .44   .18
 1983  1.95  1.80  1.94  1.78  1.78  2.02  1.85  1.87  1.76  1.82  2.39  2.62  2.31  2.48  2.49  2.32  2.44  2.60  2.48  2.41
 1984  -.81  -.74  -.72  -.70  -.84  -.96  -.84  -.49  -.72 -1.09 -1.66 -1.58 -1.75 -1.77 -1.61 -1.24 -1.22 -1.31 -1.21 -1.23
 :
 2009  -.34  -.30  -.37  -.73  -.55  -.52  -.53  -.49  -.52  -.81  -.65 -1.01  -.95  -.90 -1.05  -.91 -1.10  -.92  -.79  -.97
 2010  1.38  1.14  1.21  1.26  1.07  1.11  1.20  1.13  1.19  1.16  1.65  1.39  1.51  1.53  1.55  1.51  1.63  1.66  1.49   .86
2 0
 1981  -.01  -.16  -.08   .03  -.08  -.16  -.16   .01   .06  -.18   .05   .15   .13   .02   .06  -.15  -.02   .10  -.02  -.13
 1982   .17   .33   .15   .15   .26   .27   .22   .23   .23   .17   .58   .58   .55   .42   .45   .41   .64   .65   .45   .44
 1983  1.47  1.53  1.29  1.18  1.37  1.29  1.38  1.27  1.34  1.29  1.57  1.57  1.56  1.47  1.59  1.65  1.48  1.49  1.70  1.73
 :
 2009  1.31  1.34  1.44  1.33  1.31  1.37  1.26  1.35  1.45  1.46  1.92  1.94  2.03  1.82  1.96  1.68  1.99  1.89  1.83  1.81
 2010 -1.49 -1.91 -1.39 -1.18 -1.44 -1.82 -1.48 -1.66 -1.36 -1.62 -2.61 -2.16 -2.12 -2.31 -2.31 -2.09 -1.98 -2.28 -2.06 -2.49
1 1
 1981   .05   .33   .00   .27   .21   .30  -.03   .15   .30   .03  -.08   .00   .14  -.13  -.01  -.09   .16   .03   .20   .15
 1982  1.53  1.74  1.62  1.77  1.72  1.91  1.51  1.55  1.65  1.55  2.78  2.56  2.85  2.90  2.56  2.93  2.74  2.77  2.64  2.46
 1983  -.60  -.47  -.76  -.86  -.81  -.68  -.74  -.58  -.98  -.61 -1.33 -1.49 -1.81 -1.37 -1.75 -1.54 -1.38 -1.25 -1.80 -1.01
 :
 2009   .96  1.78   .98   .88  2.32  1.35  -.29  1.86  1.56  1.07   .54   .21  -.45   .61   .30  1.40  1.06   .03  1.52   .58
 2010  -.61 -2.14   .45  -.83 -1.01  -.74  -.74  -.36 -1.81 -1.65 -2.63 -3.11 -1.81 -2.07 -1.90 -2.15 -2.68 -2.40 -1.73 -2.31
12 9
 1981   .96   .76   .84   .25  -.67   .42  1.34  1.90   .20  -.09  -.67   .89  -.05   .77  -.87   .35  -.25  -.32  -.22  1.02
 1982  1.41  1.15  1.62   .97  2.46  1.45   .97   .75  1.58   .70  1.39  2.23  2.01  1.46  2.40  1.16  1.03  1.26  -.59   .39
 1983 -1.80 -1.64 -1.15 -1.85 -1.27  -.73 -2.30  -.95  -.99  -.40  -.69  -.06 -2.01  -.93 -1.04  -.92 -1.47   .18 -1.48 -2.32
 :
 2008  -.31  1.54   .98  1.09   .67   .67   .70   .26  1.64  1.51  -.57  -.23  -.77 -1.48  -.17   .34 -1.36  -.64  -.24  1.11
 2009  1.57   .56   .62  -.03   .14  -.50   .87  1.27   .69  1.01  1.02  1.16  1.10  1.21   .97   .15 -1.13   .07  -.24   .18
 2010 -1.67  -.51  -.07 -1.31 -1.23  -.71  -.50 -1.46  -.99 -1.17 -1.87 -2.26 -1.36 -2.17 -2.28 -2.88 -1.96 -2.79 -1.69 -3.18
```

- **Precipitation forecast** files have the same structure as above except values are formatted as floating point, for example 0.561784E+01. Values are in mm per day

Observation file contents

- **SST observation** files:

Season 1…12 (1=JFM, 2=FMA … 12=DJF)
(ignore)

```
1 0
  1981   -.46
  1982    .04
  1983   2.33
      :
  2009   -.76
  2010   1.26
2 0
  1981   -.48
  1982    .07
  1983   1.78
      :
  2009   1.60
  2010  -1.60
12 0
  1981   -.04
  1982   2.62
  1983   -.73
      :
  2008   -.82
  2009   1.50
  2010  -1.49
```

- **Precipitation observation** files:

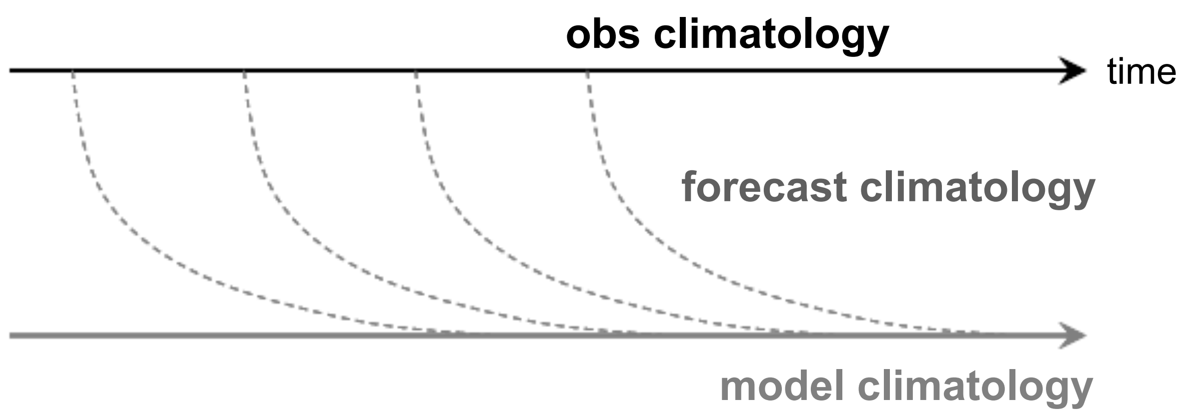
Season 1…12 (1=JFM, 2=FMA … 12=DJF)

```
1981        1   0.381642E+01
1982        1   0.285093E+01
1983        1   0.812642E+01
1984        1   0.137127E+01
           :
2009        1   0.161505E+01
2010        1   0.752517E+01
1981        2   0.446875E+01
1982        2   0.349676E+01
1983        2   0.670259E+01
           :
```

Correcting for model biases

1) Correction for model biases

- Because climate models are imperfect, each model has its own climate that differs from that of the real world
- Thus, models initialized near observed climate state will progressively *drift* towards biased model climate:



- These biases can be factored out by computing *anomalies* with respect to forecast climatology that is a function of forecast time and lead time, & comparing with observed anomalies

1) Correction for model biases

- Because climate models are imperfect, each model has its own climate that differs from that of the real world
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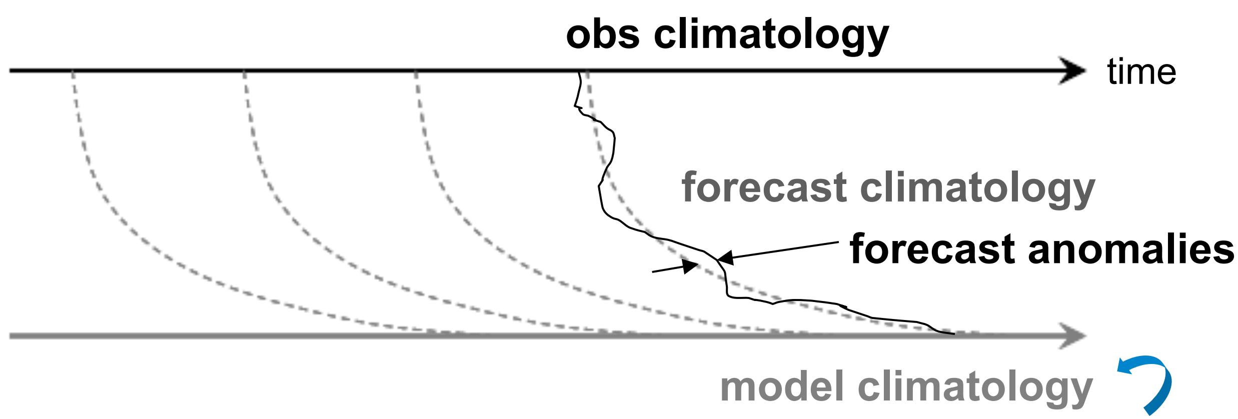
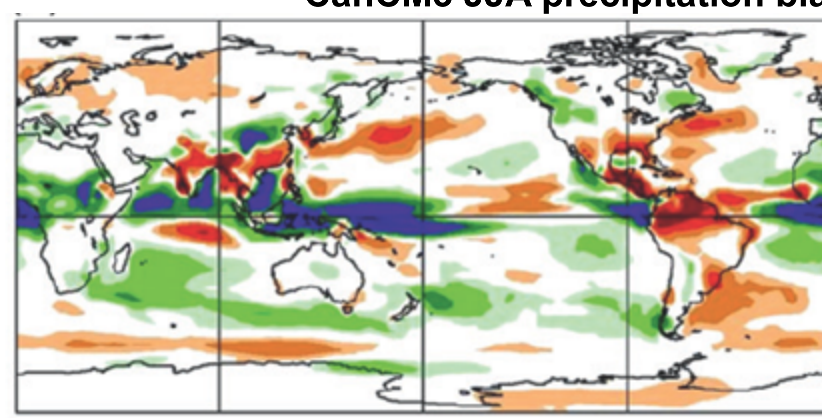


CanCM3 JJA precipitation bias



- These biases can be factorec
  anomalies with respect to for
  function of forecast time and
  with observed anomalies

Correction for model biases (cont.)

- Observed anomalies:

$$O'(t_{forecast},y_i) = O\,(t_{forecast},y_i) - \langle O\,(t_{forecast},y_i)\rangle$$

- Forecast anomalies:

$$F'(t_{forecast},t_{lead},y_i) = F\,(t_{forecast},\, t_{lead},y_i) - \langle F\,(t_{forecast},\, t_{lead},y_i)\rangle$$

  where < > indicates averaging over some standard set of years (e.g. 1981-2010)

  $t_{forecast}$ = target period for forecast, for example JFM
  t_{lead} = lead time

- This is the simplest and most frequently applied bias correction, although others are sometimes used

Suggested exercises

1) Calculate observed anomalies

a) Choose one or more precipitation and/or SST indices

b) Choose one or more target seasons, for example JFM

c) Using the full observed values $O(y_i)$, calculate the observed climatological mean

$$\langle O \rangle = \text{average over 30 values } y_i = 1981 \ldots 2010$$

d) Calculate the observed anomalies for each year 1981…2010:

$$O'(y_i) = O(y_i) - \langle O \rangle$$

2) Multi-model deterministic forecast

a) Choose one or more precipitation and/or SST indices

b) Choose one or more target seasons $t_{forecast}$ and lead times t_{lead}, for example JFM at lead 0 months

c) Using the full forecast values, calculate for each year y_i =1981…2010 the ensemble mean values *separately* for CanCM3 and CanCM4:

CanCM3 ensemble means $F3(y_i)$ = averages over forecast values 1…10

CanCM4 ensemble means $F4(y_i)$ = averages over forecast values 11…20

	CanCM3 ensemble members 1-10										CanCM4 ensemble members 1-10									
1 0																				
1981	.20	.26	.23	.06	.15	.22	.25	-.01	.18	.05	.35	.12	.28	.15	.10	.05	.27	.01	.06	.07
1982	.16	.17	.11	.04	.16	.00	.04	.13	.05	.09	.20	.50	.18	.36	.50	.26	.26	.29	.44	.18
1983	1.95	1.80	1.94	1.78	1.78	2.02	1.85	1.87	1.76	1.82	2.39	2.62	2.31	2.48	2.49	2.32	2.44	2.60	2.48	2.41
1984	-.81	-.74	-.72	-.70	-.84	-.96	-.84	-.49	-.72	-1.09	-1.66	-1.58	-1.75	-1.77	-1.61	-1.24	-1.22	-1.31	-1.21	-1.23

d) Calculate the forecast climatologies separately for each model:

CanCM3 forecast climatology <F3> = average of F3 over forecast years 1981-2010

CanCM4 forecast climatology <F4> = average of F4 over forecast years 1981-2010

2) Multi-model deterministic forecast (cont.)

e) Calculate the ensemble mean anomalies for each year 1981…2010 separately for each model:

CanCM3 anomalies $F3'(y_i) = F3(y_i) - \langle F3 \rangle$

CanCM4 anomalies $F4'(y_i) = F4(y_i) - \langle F4 \rangle$

f) Average the ensemble mean anomalies across the multi-model ensemble:

$$F'(y_i) = [F3'(y_i) + F4'(y_i)]/2$$

3) Calculate deterministic skill scores

Requires (1) and (2) to be done first

a) For one or more chosen indices, seasons, and lead times, consider the 30 years of observed anomalies $O'(y_i)$ from (1) and multi-model forecast anomalies $F'(y_i)$ from (2)

b) Compute the anomaly correlation (higher is better)

$$AC = \frac{<F' \; O'>}{\sigma(F') \; \sigma(O')}$$

average over 30 years 1981-2010

standard deviation of 30 forecast anomalies

standard deviation of 30 observed anomalies

c) Compute the root-mean square error (lower is better)

$$RMSE = [<(F' - O')^2>]^{1/2}$$

d) Repeat the above steps separately using the single-model forecast anomalies F3' and F4', compare to skills obtained for multi-model anomalies F'

4) Compare RMSE and ensemble spread

Requires (1), (2) and (3) to be done first

a) Consider the RMSE values for the multi-model forecast values F’ and the single-model forecast values F3’ and F4’ obtained from (2)

b) For the same variable, season and lead time, compute the multi-model ensemble variance $var(y_i)$ for each year based on the 20 anomaly values for the multi-model forecast

c) Compute its average over 30 forecast years $<var(y_i)>$

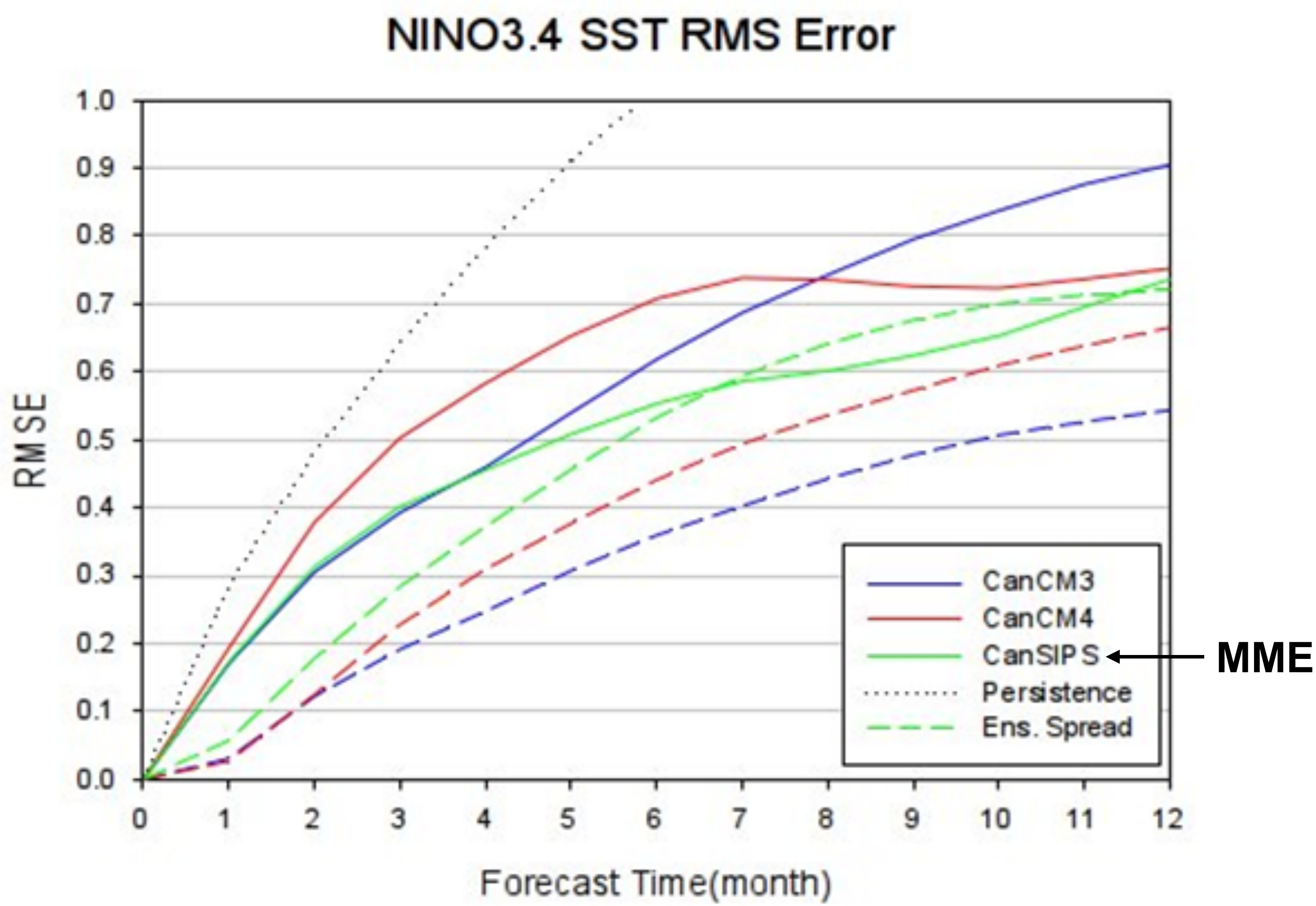
d) Compute the multi-model ensemble spread as $S = [<var(y_i)>]^{1/2}$

e) Repeat (b)-(d) for CanCM3 and CanCM4 only based on the 10 ensemble members for each model

f) Compare S to RMSE for the multi-model ensemble, and for CanCM3 and CanCM4 individually.

g) Overconfident forecasts tend to have $S < RMSE$. What do these results say about the level of overconfidence and hence reliability for CanCM3 and CanCM4 alone compared to the multi-model ensemble?

Results for the Nino3.4 SST index



5) Construct a simple probabilistic forecast

Requires (1) and (2) first

a) Consider the 20 multi-model ensemble forecast anomalies for one or more indices, target seasons, lead times and forecast years (one or more single forecasts)

b) Consider observed values for same index and season for 30 years 1981-2010, and sort these 30 values from lowest to highest O'_1, O'_2, … O'_{30} (labeling according to this order)

c) Calculate approximate tercile boundaries as

$X_B = (O'_{10} + O'_{11})/2$ between below normal and middle terciles

$X_A = (O'_{20} + O'_{21})/2$ between middle and above normal terciles

d) For a particular forecast, count how many of the 20 forecast anomalies fall in each climatological tercile category:

N_B = number of ensemble members $<X_B$

N_N = number of ensemble members $>X_B$ and $<X_A$

N_A = number of ensemble members $>X_A$

e) Convert to probabilities: $P_B = N_B/20$, $P_N = N_N/20$, $P_A = N_A/20$

6) Correlation and regression coefficients between SST-precipitation index pairs

Requires (1) and (2) first

a) Consider ensemble-mean anomalies for paired SST and precipitation indices, for one or more seasons and lead times

b) Based on 30 years of paired observed values $[O'_{SST}(y_i), O'_{Precip}(y_i)]$, compute correlation and regression coefficients as

$$AC = \frac{\langle O_{SST}' \, O_{Precip}' \rangle}{\sigma(O_{SST}') \, \sigma(O_{Precip}')}$$

average over 30 years 1981-2010

$$R = \frac{\langle O_{SST}' \, O_{Precip}' \rangle}{\sigma^2(O_{SST}')}$$

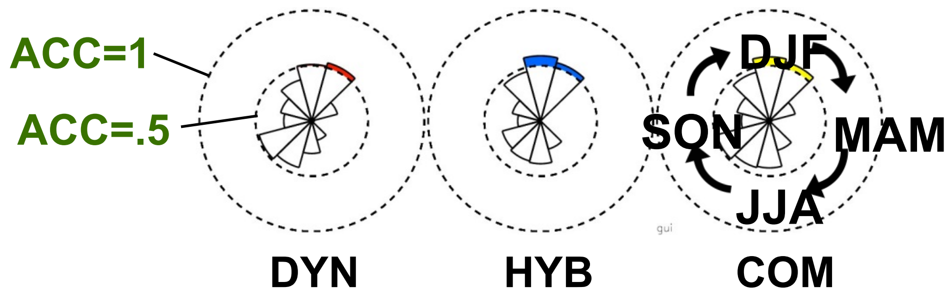
average over 30 years 1981-2010

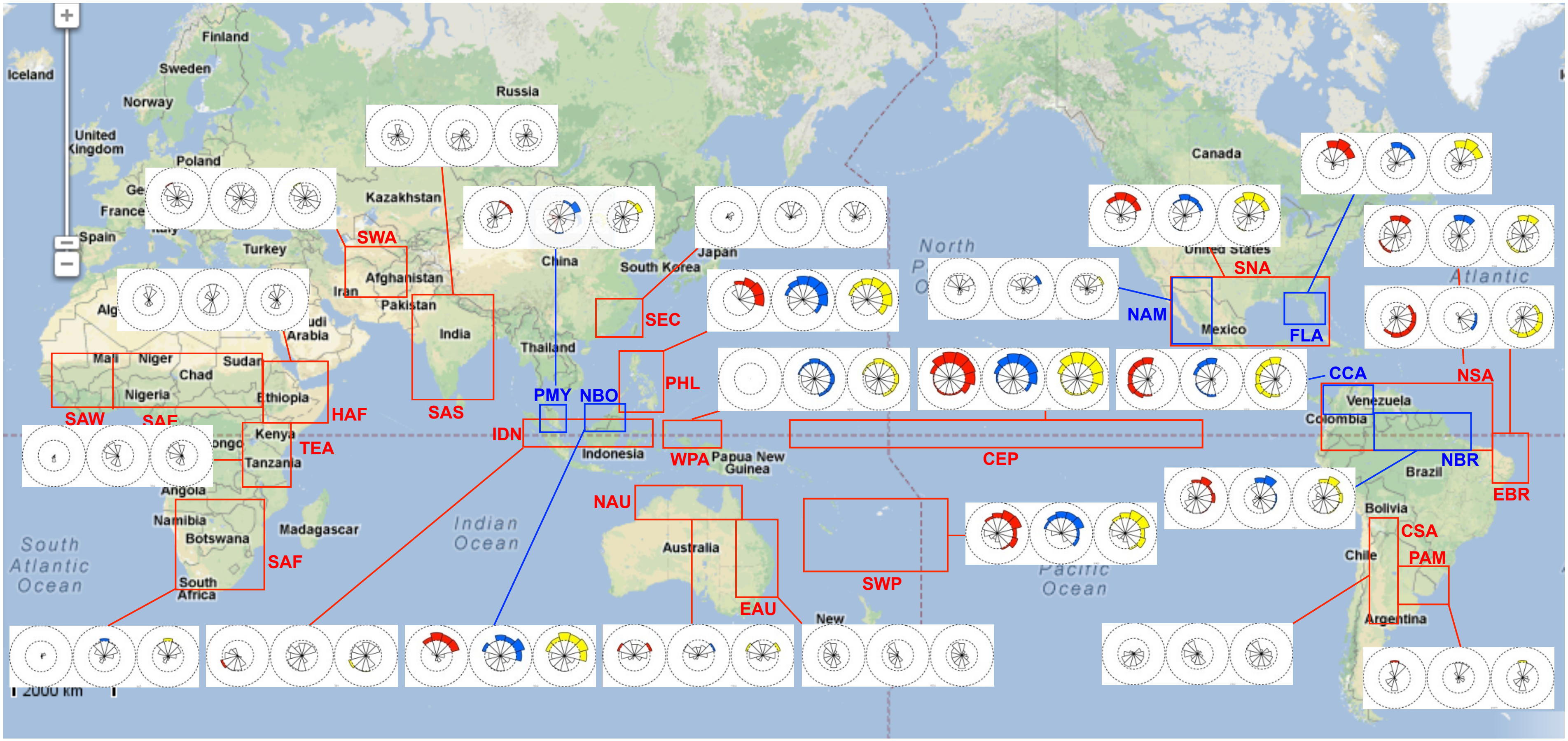
c) If AC is sufficiently high, forecast SST anomaly F_{SST}' could be used to make a hybric (dynamical + statistical) forecast of precipitation:

$$(F_{Precip}')_{hyb} = F_{SST}' \times R$$

d) Which is more skillful, $(F_{Precip}')_{hyb}$ or F_{Precip}' ?

Dynamical and hybrid skills for SST index=nino3.4





CanSIPS Explorer

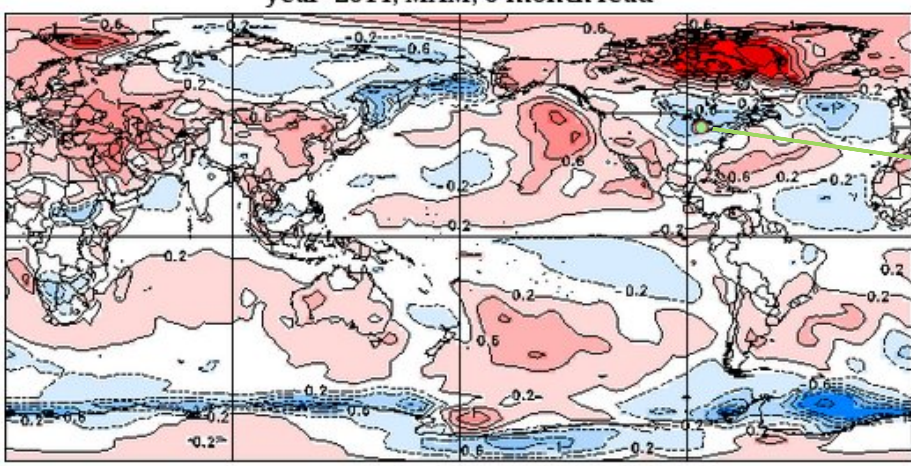
- Developed and maintained at CCCma by Slava Kharin
- Displays all monthly, seasonal hind/forecasts + verifications 1979-present + skills
- Probabilistic/deterministic forecasts (maps & local PDFs) for many variables, regions (**including Africa**), indices

CMC/CCCma (Environment Canada) CanSIPS Experimental 12-month Forecasts issued monthly
[related: CanSIPS 3-month forecasts issued daily] [contact: slava.kharin@ec.gc.ca]

Variable	Time avg.	Time lead	Prev./Next		First year/month		Version
Temperature	Seasonal	0-month	<<	>>	2014	Mar	cmc(d+e)

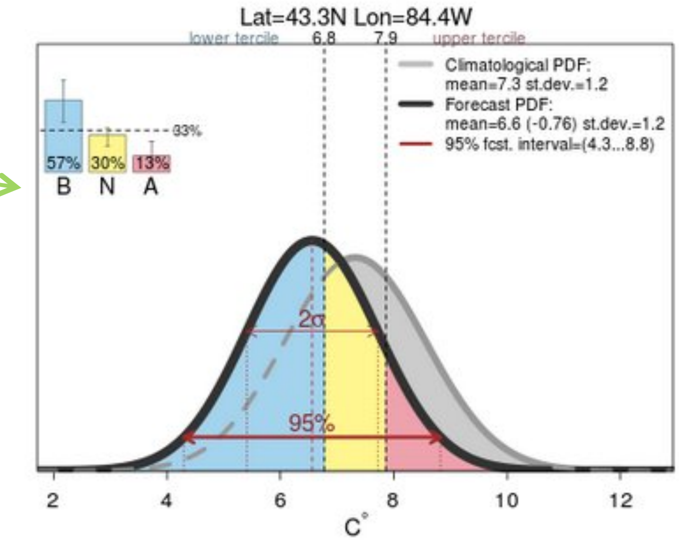
Region	Forecast Type	Observ. Type	Show PDF/Obs.	Calibration/Observations	
Globe(0..360)	Anomaly	N/A	Show PDF	Calibrated(constant)	eraint

Temperature, Anomaly Forecast
year=2014, MAM, 0-month lead



12-season calibrated ensemble mean anomaly forecast.

Local probability forecast



http://www.cccma.ec.gc.ca/cgi-bin/data/seasonal_forecast/sf2 ← *Monthly* to 12 mon

“ “ **sf2_daily**

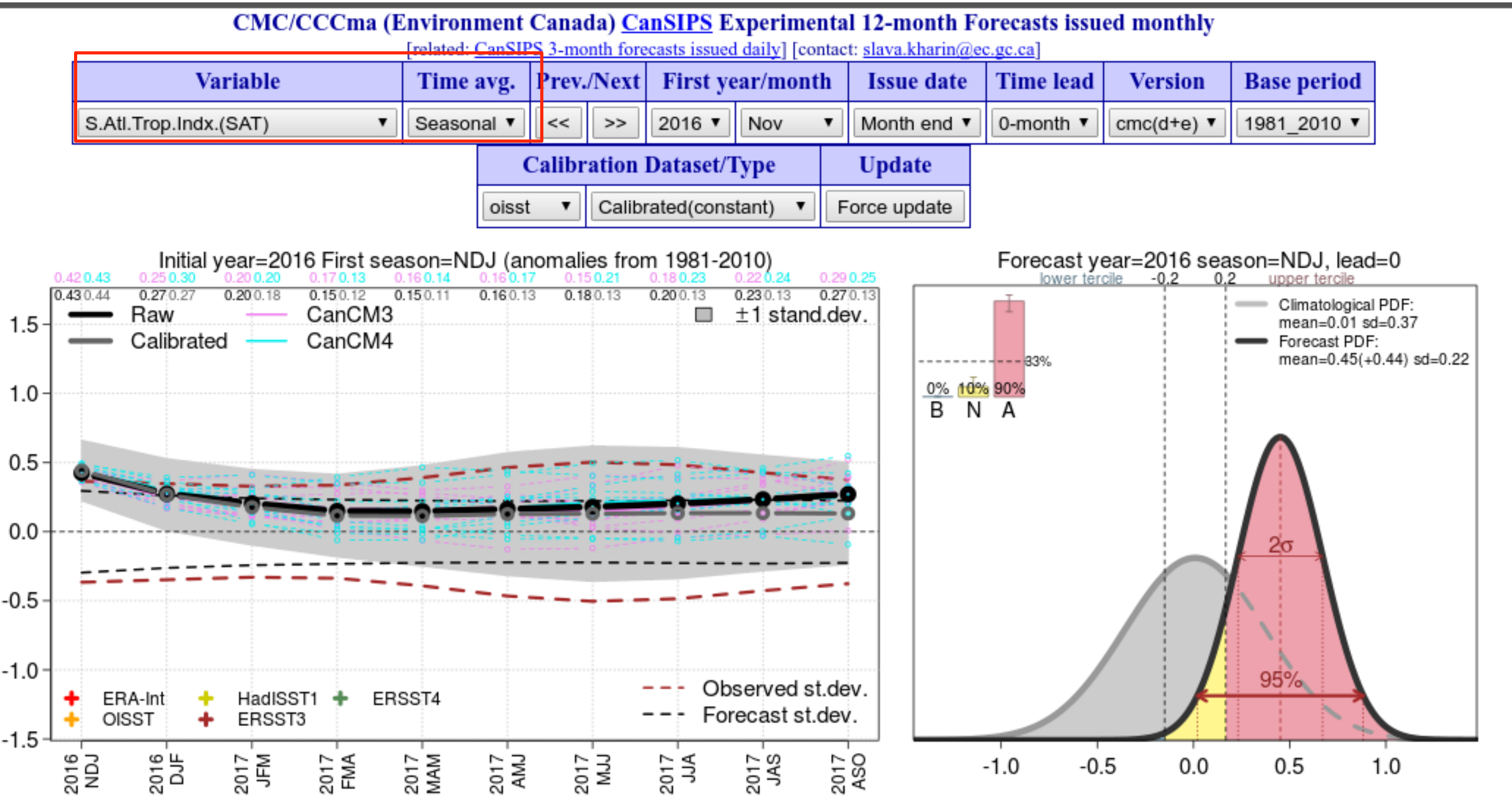
↑

Daily N-day, monthly & seasonal forecasts

username: cccmasf
password: seasforum

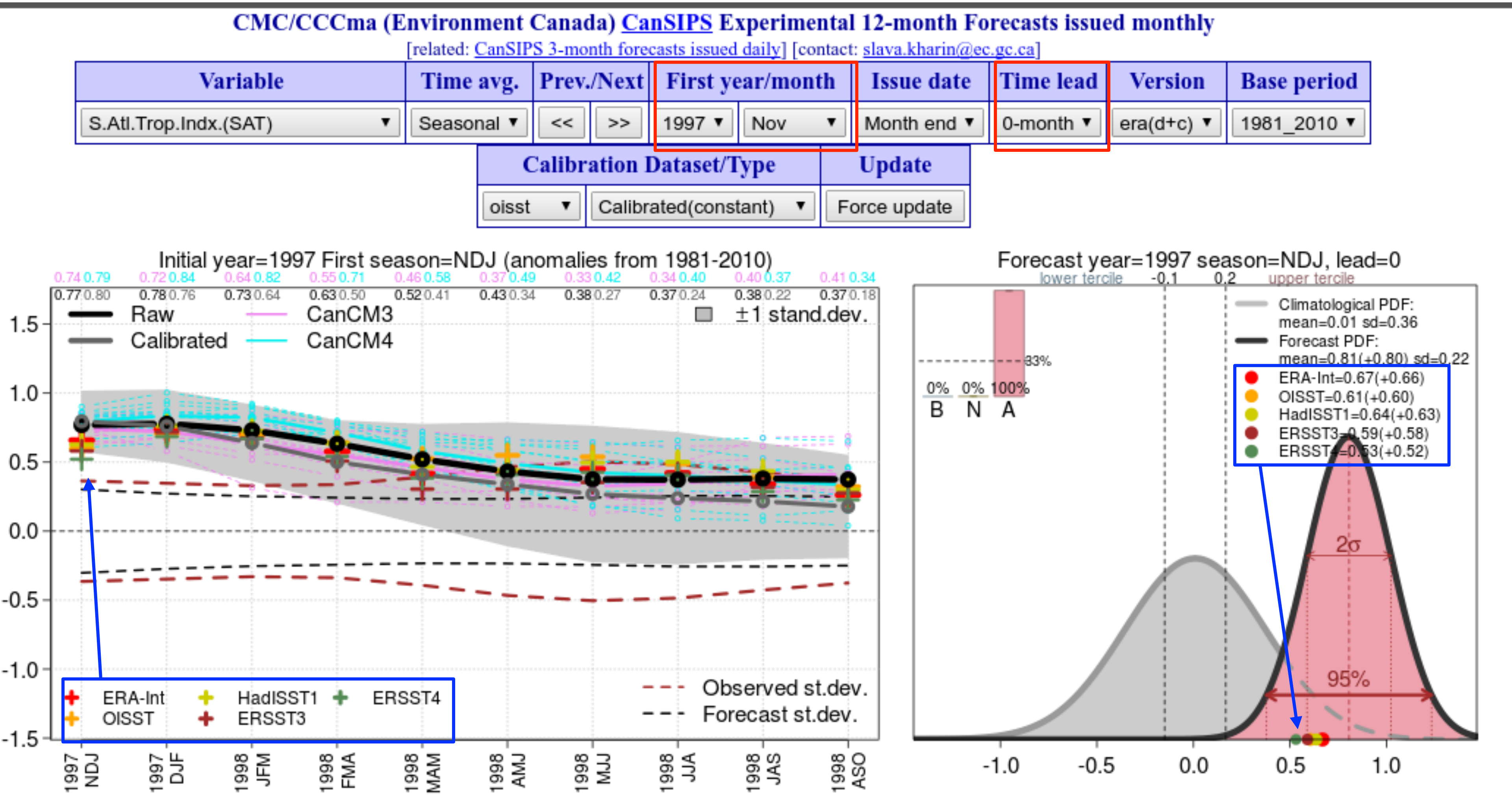
CanSIPS Explorer

Example: SAT SST index current forecast



CanSIPS Explorer

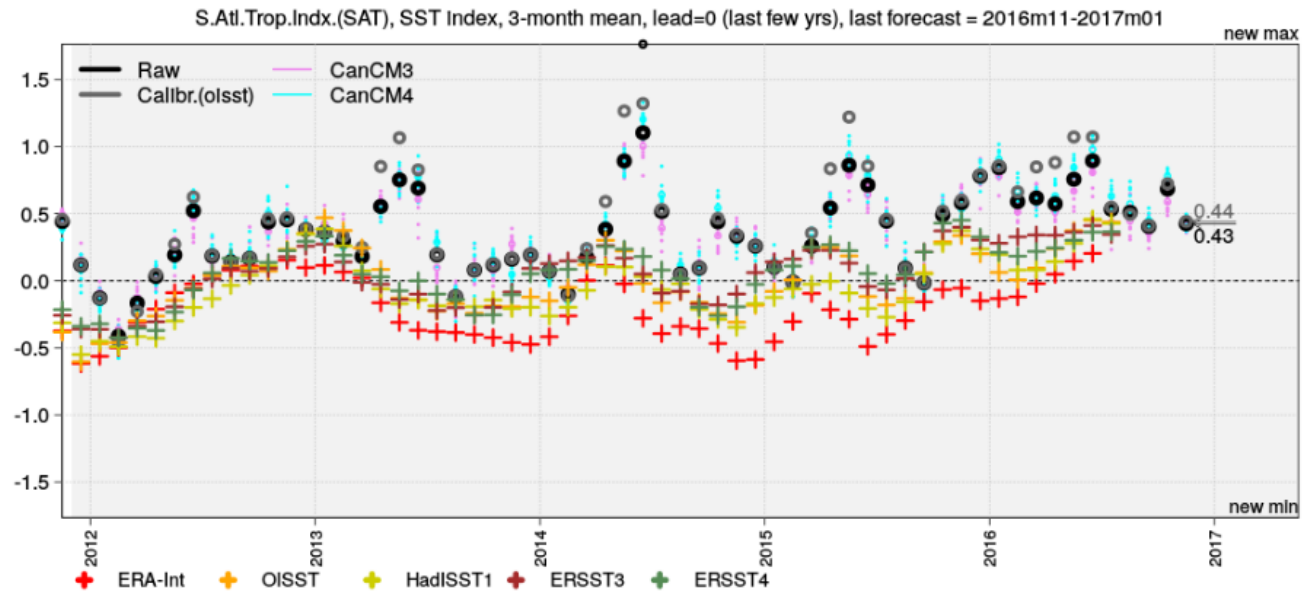
Example: SAT SST index hindcast from Nov 1997 + verification



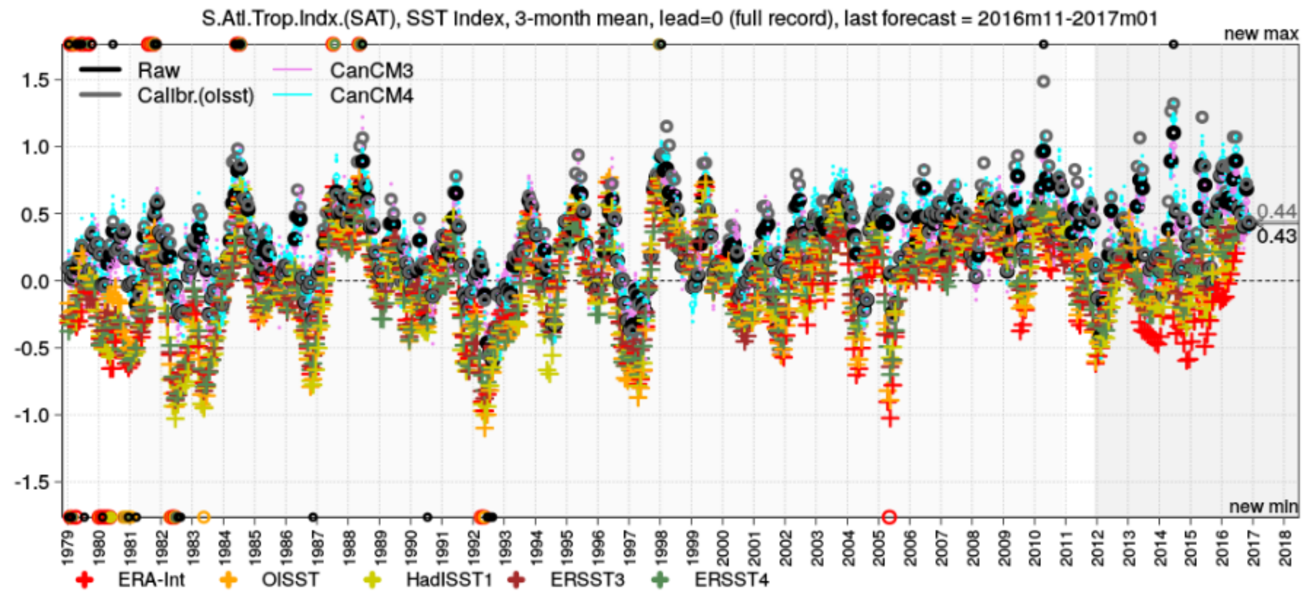
CanSIPS Explorer

Example: SAT SST index all hindcast + real time forecast verification

forecasts

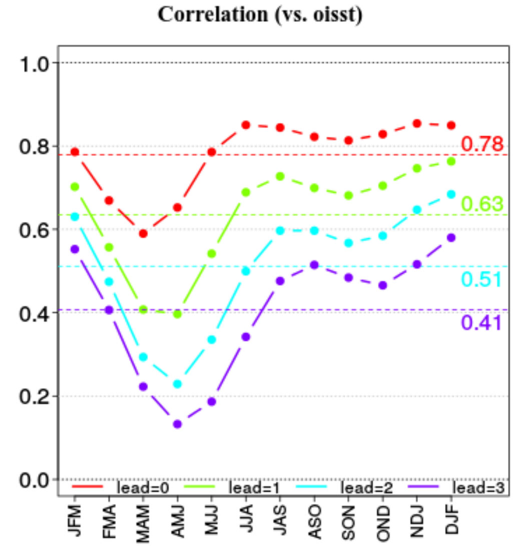


hindcasts

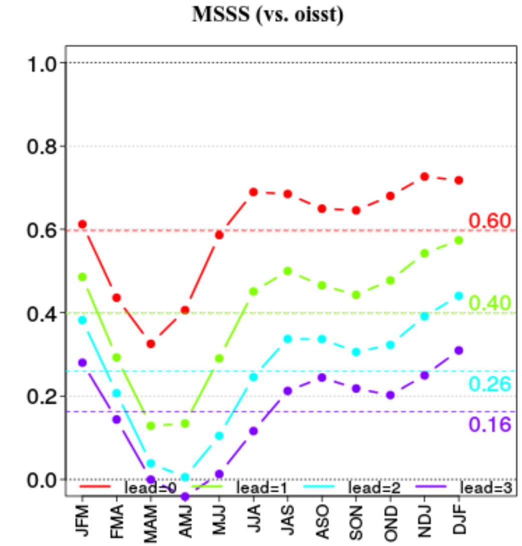


CanSIPS Explorer

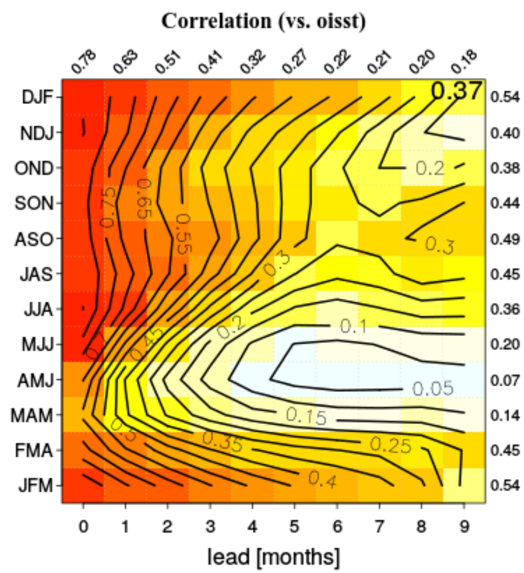
Example: SAT SST index hindcast verification skill scores



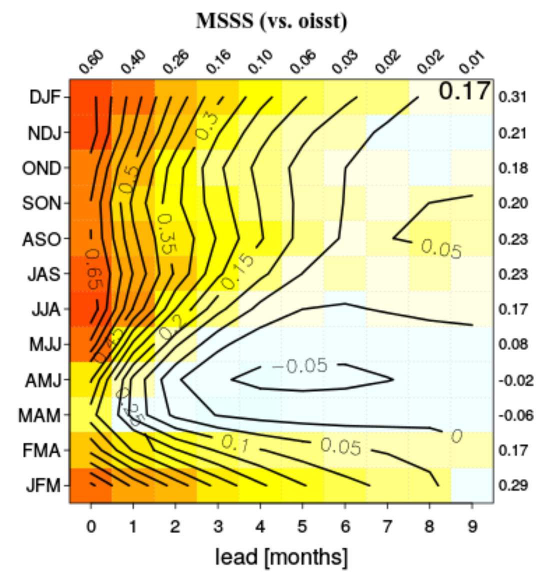
Correlation skill score of the multimodel mean forecast as function of lead and month/season.



Mean Square Skill Score of the linearly rescaled multimodel mean forecast as function of lead and month/season.



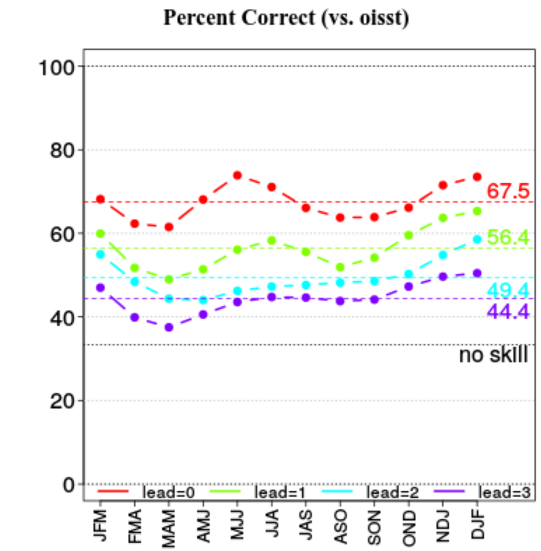
Correlation skill score of the multimodel mean forecast as function of lead and month/season.



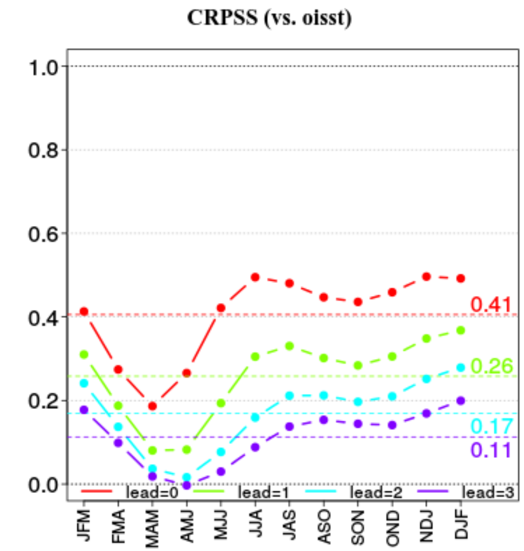
Mean Square Skill Score of the linearly rescaled multimodel mean forecast as function of lead and month/season.

CanSIPS Explorer

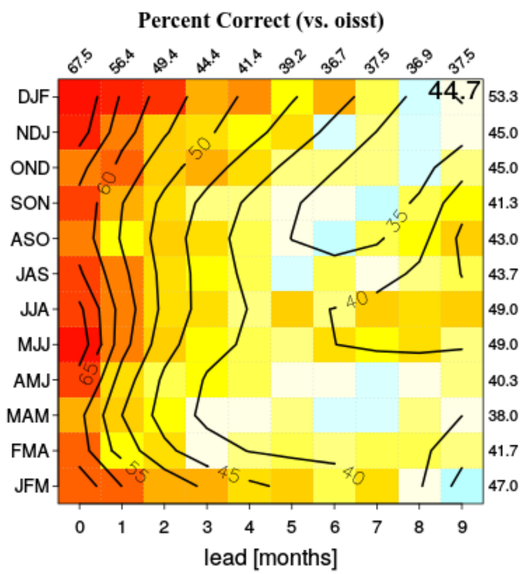
Example: SAT SST index hindcast verification skill scores



Percent correct is defined as the percentage of correctly predicted categories.
The percent correct of a random categorical forecast is 33.3%.



Continuous Ranked Probability Skill Score (oisst).



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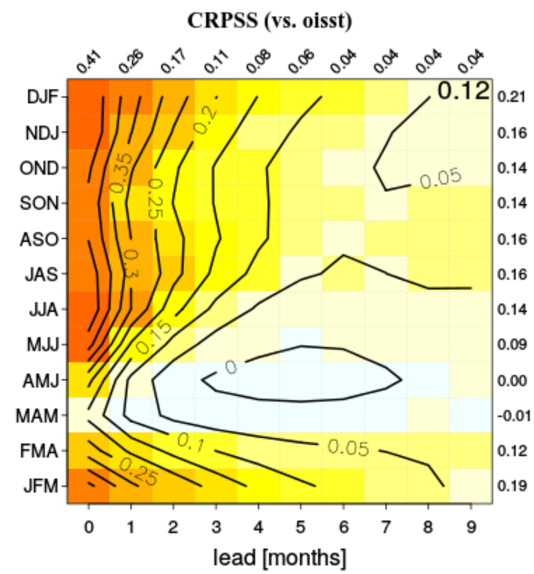
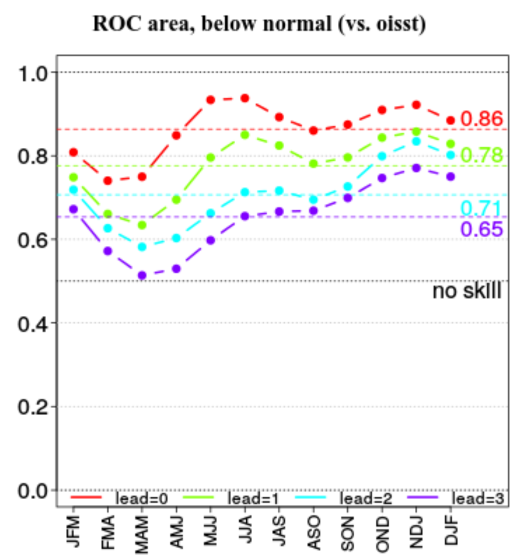


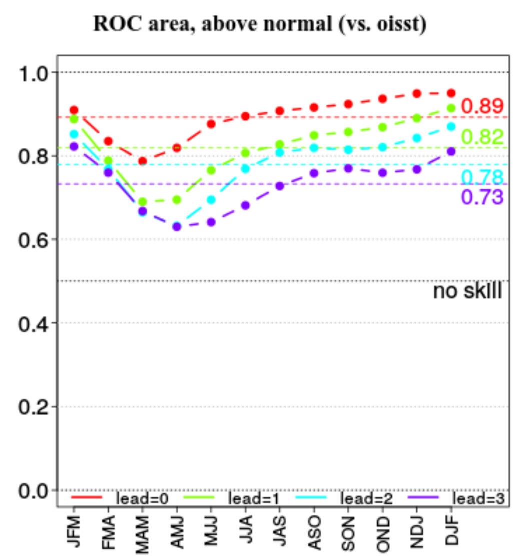
Continuous Ranked Probability Skill Score (oisst).

CanSIPS Explorer

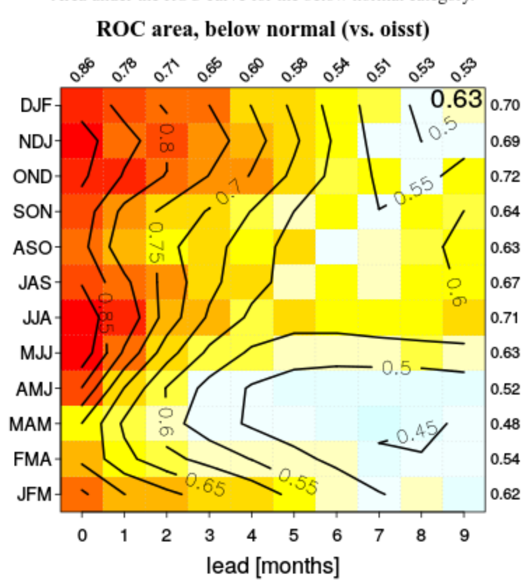
Example: SAT SST index hindcast verification skill scores



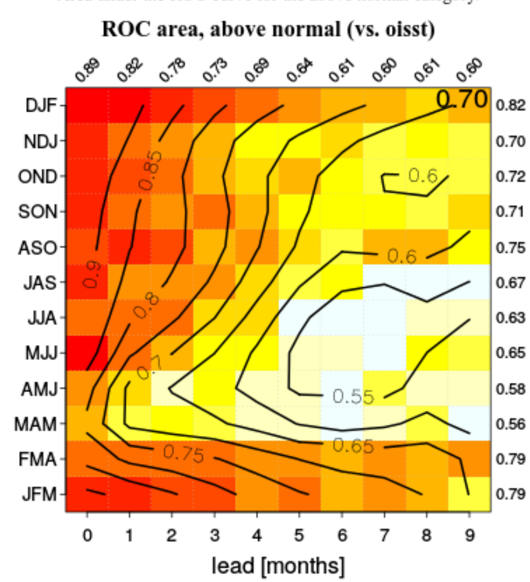
Area under the ROC curve for the below normal category.



Area under the ROC curve for the above normal category.



Area under the ROC curve for the below normal category.



Area under the ROC curve for the above normal category.

[related: CanSIPS 3-month forecasts issued daily] [contact: slava.kharin@ec.gc.ca]

Eumetcal course on forecast verification

http://www.eumetcal.org/resources/ukmeteocal/verification/www/english/courses/msgcrs/crsindex.htm

(web search "eumetcal verification")

Forecast Verification

Welcome to the modules on forecast verification. The modules are designed both for users of verification results, who wish to understand what the results really mean, and those who wish to dabble in verification methodology themselves.

There are 4 modules in this course. The introductory module covers general issues about reasons for verifying, and the different types of forecast and observation data used in verification. The other modules are organized by type of forecast. If you are new to the subject of verification, then it is highly recommended that you complete the introductory module, which will help put the other modules into better perspective. If, on the other hand, you already know what a "deterministic forecast of a continuous variable", or a "probability forecast of a categorical variable" is, then feel free to skip the generalities of the introduction and go directly to the modules on the various forecast types.

You can return to this index page at any point by clicking on the icon on the left hand side which looks like this:

Credits

Content	Laurence Wilson (Environment Canada) and Pertti Nurmi (Finnish Meteorological Institute)
Storyboards	Laurence Wilson (Environment Canada)
IT authoring	Sigbritt Näsman (Finnish Meteorological Institute)
Project Manager	Pertti Nurmi (Finnish Meteorological Institute)

Module Index

Index of /pub/bmerryfield/ICTP_SCHOOL/

Name	Size	Date Modified
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DATA_PRECIP/		
DATA_SST/		

Index of /pub/bmerryfield/ICTP_SCHOOL/DATA_PRECIP/

Name	Size	Date Modified
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ASCII_FULL/		
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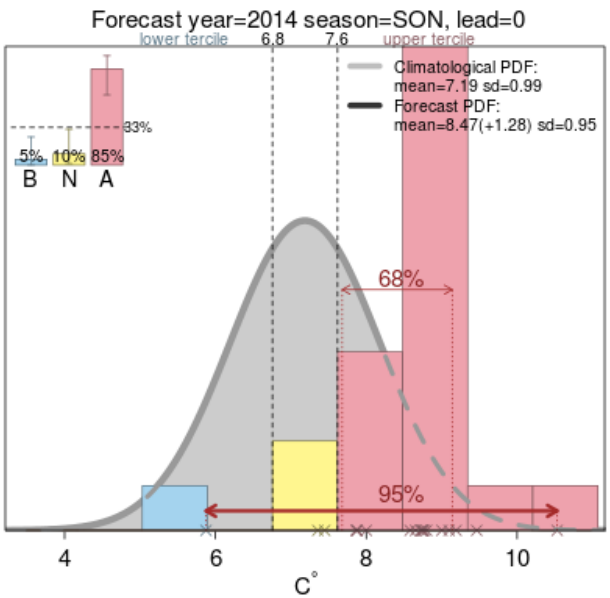
SST_CSV_FULL.tar	5.5 MB	

Construction of PDF

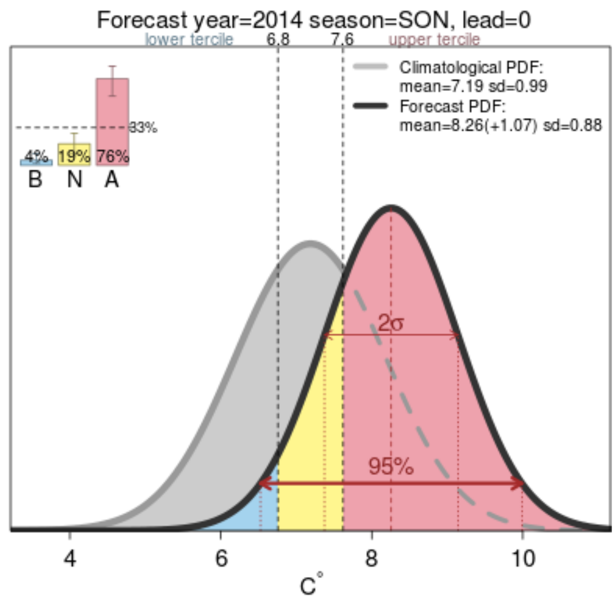
Example: lead 0 SON 2014 temperature forecast for Montreal

Anomalies for each ensemble member



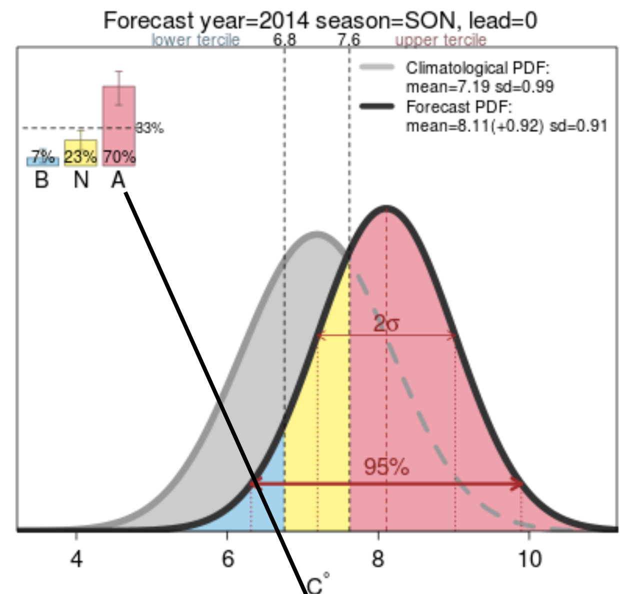
85% prob above normal

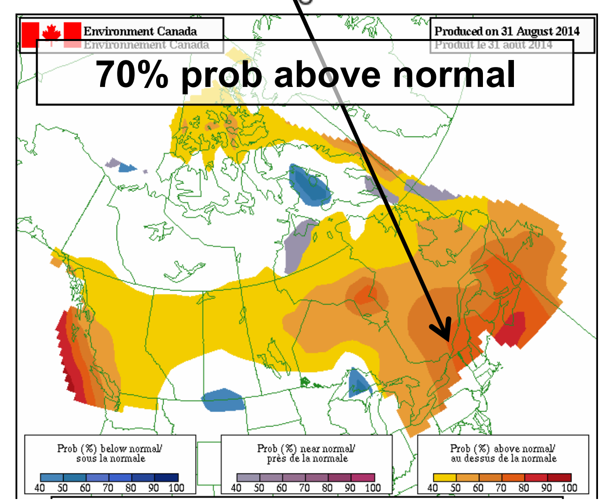
Gaussian fit



76% prob above normal

Calibrated PDF





70% prob above normal

Calibration: From hindcasts, find optimal rescaling of Gaussian mean and σ that maximizes probabilistic skill score

Details: Kharin et al. (A.-O., 2009)

Calculation of relative value score

Cost and loss for different outcomes

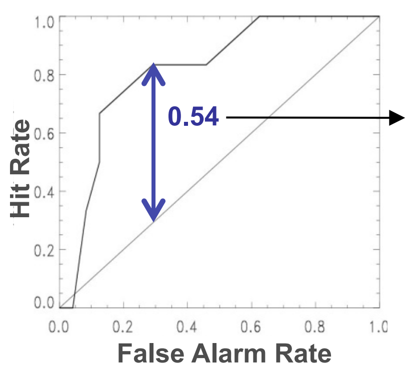
		Adverse event occurs: No	Adverse event occurs: Yes
Action taken	No	0	L
	Yes	C	C

Loss if event occurs and action not taken (L)

Cost of taking action (C)

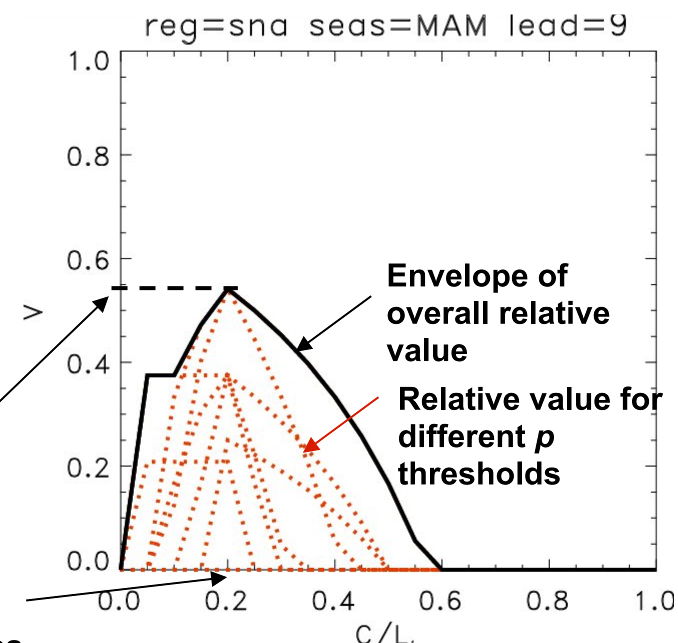
Example: prediction of extreme quintile

- Consider probability *p* of occurrence
- Hindcasts provide hit & false alarm rates for different *p* thresholds
- *V* is fraction of potential mitigation realized, vs *C*/*L* = cost/mitigation



Vmax=max(Hit Rate – False Alarm Rate)

Vmax occurs when *C*/*L* = climatological probability of occurrence (0.2 for quintiles,



"Cost-loss ratio"