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Sub-seasonal and Seasonal Forecasting at Environment and Climate Change Canada

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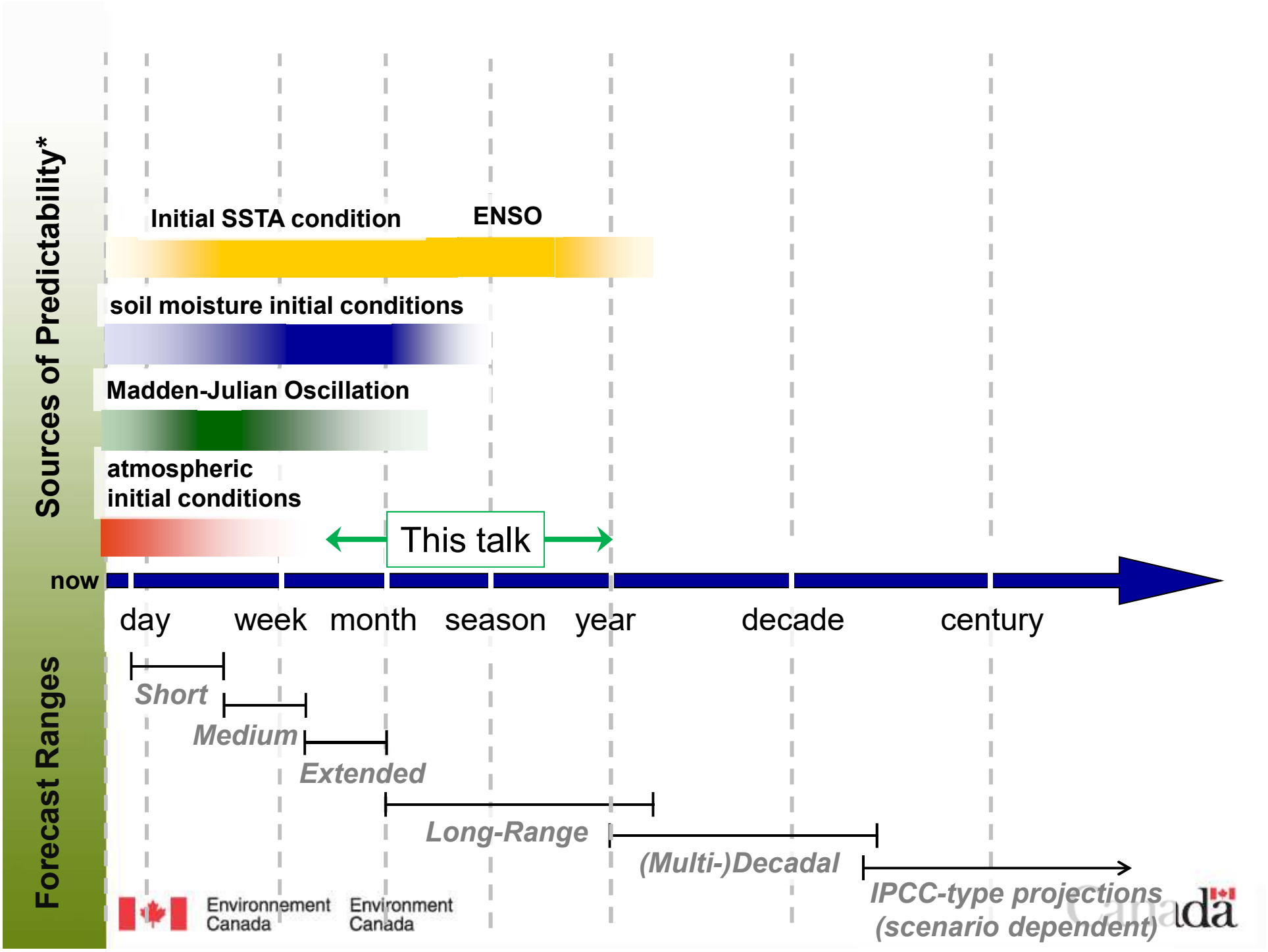
WMO RCC-Washington workshop, Sep.30-Oct.4 2019

Outline

- Background, timescales, sources of predictability
- Sub-seasonal to seasonal forecasting system: GEPS
  - Model
  - Initialisation
  - Forecasts, evaluation
  - Products
- Canadian Seasonal to Interannual Prediction System: CanSIPSv2
  - Models
  - Initialisation
  - Forecasts
  - Products
- Concluding remarks


Sources of Predictability*
Initial SSTA condition
ENSO
soil moisture initial conditions
Madden-Julian Oscillation
atmospheric
initial conditions
This talk
now
day
week
month
season
year
decade
century
Forecast Ranges
Short
Medium
Extended
Long-Range
(Multi-)Decadal
IPCC-type projections
(scenario dependent)
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Background – Sub Seasonal

- Current operational extended and sub-seasonal prediction systems GEPS (coupled since July 2019)

Atmosphere: GEM

- GEM4.8-LTS-13
- Horizontal resolution: ~39 km Yin-Yang grid
- 44 levels

Ocean: NEMO

- Horizontal resolution: 0.25° × 0.25°
- 50 levels
- coupled with sea ice --- CICE

GEM-NEMO Subeasonal System

- **Two components:**

  1) Hindcast (model statistics, verification)

  2) Real time forecast

Real time forecast

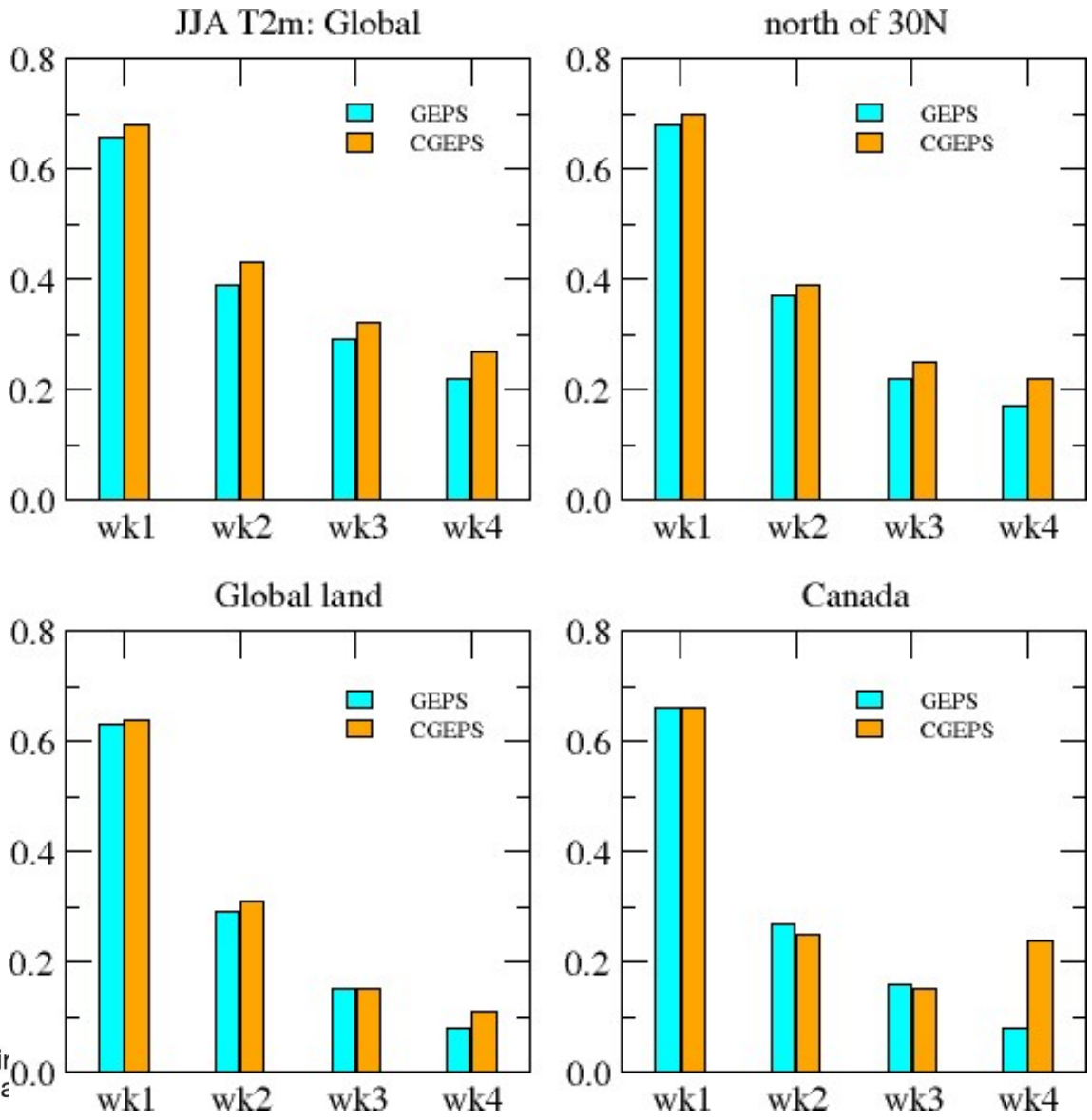
- Atmosphere IC:
  - Perturbed ensemble Kalman filter data assimilation.
- SST and sea ice IC: GEOPS analysis of CMC
- Land IC: CMC analysis
- 20 + 1 members
- Simulation of model uncertainties:
  - A multi-parameterization approach, each member having its own physics parameterization.
  - Stochastic perturbations added to tendencies from the parameterized physical processes.
  - Stochastic kinetic energy backscattering scheme.

Hindcast

- There is no assimilation with Kalman Filter.
- We start from the upper air re-analyses from ERA-interim reanalysis. Random isotropic perturbations added to create 4 different initial conditions.
- Land: off-line CMC SPS forced with ERA-interim atmosphere
- Ocean: ORAS5
- Sea ice concentration: HAD2CIS
- Sea ice thickness: ORAS5
- On the fly

Verification of the Sub-Seasonal Forecasting System

Verification: JJA T2m



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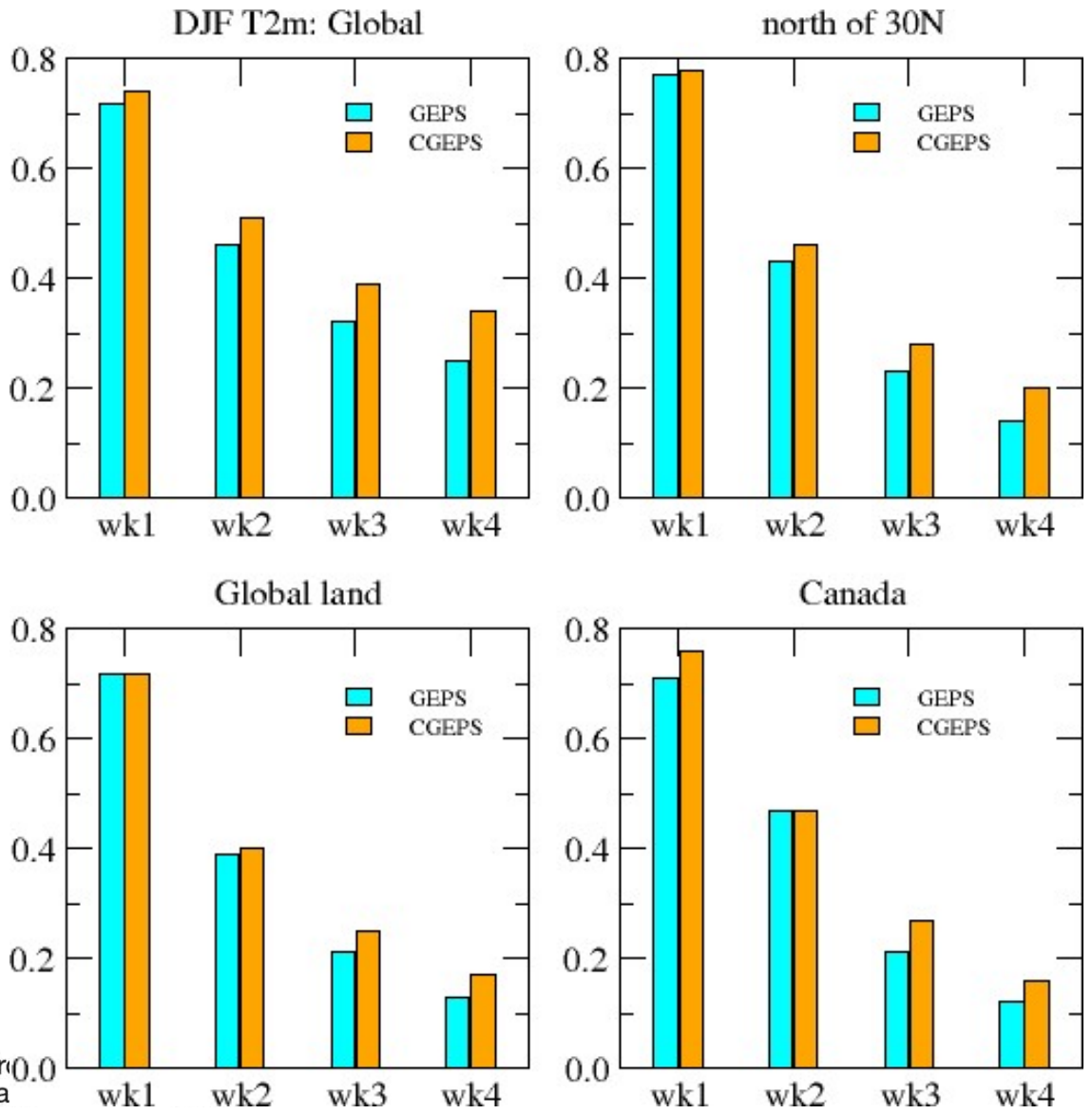
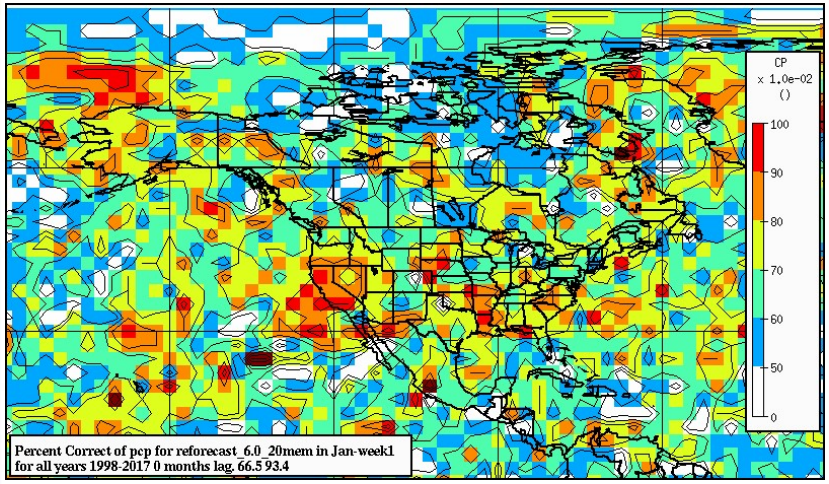
Verification: DJF T2m

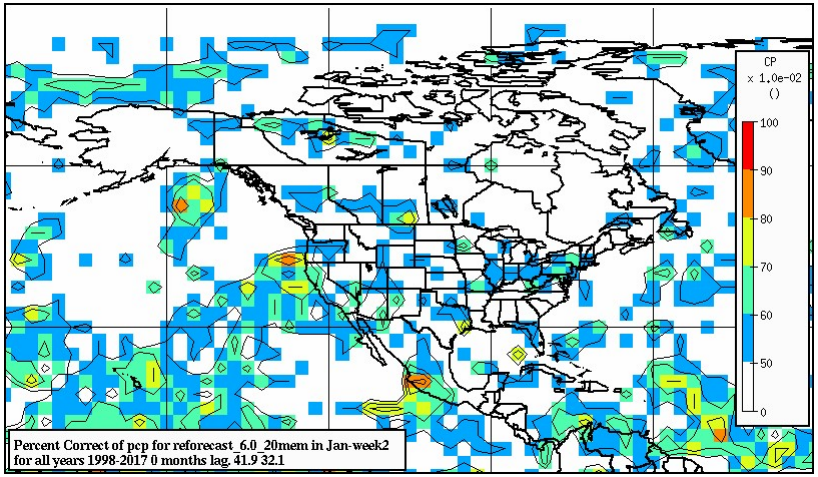


Verification: Precipitation
January initialisation, Percent Correct Skill Score

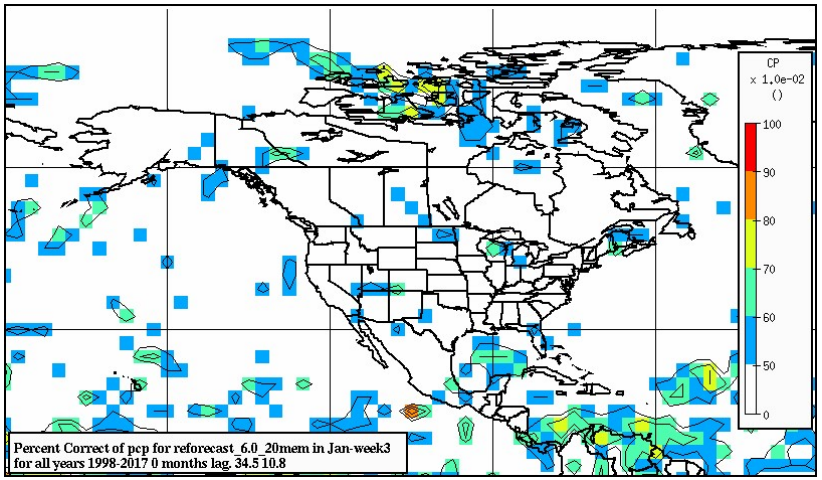
Week 1



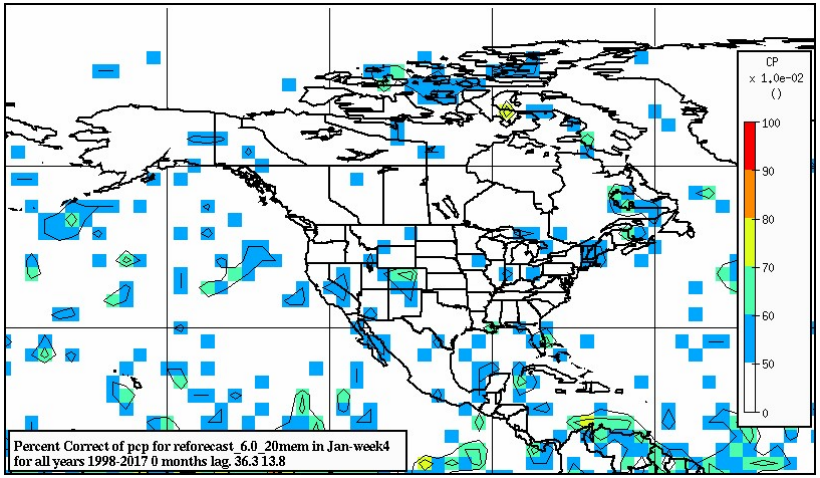
Week 2



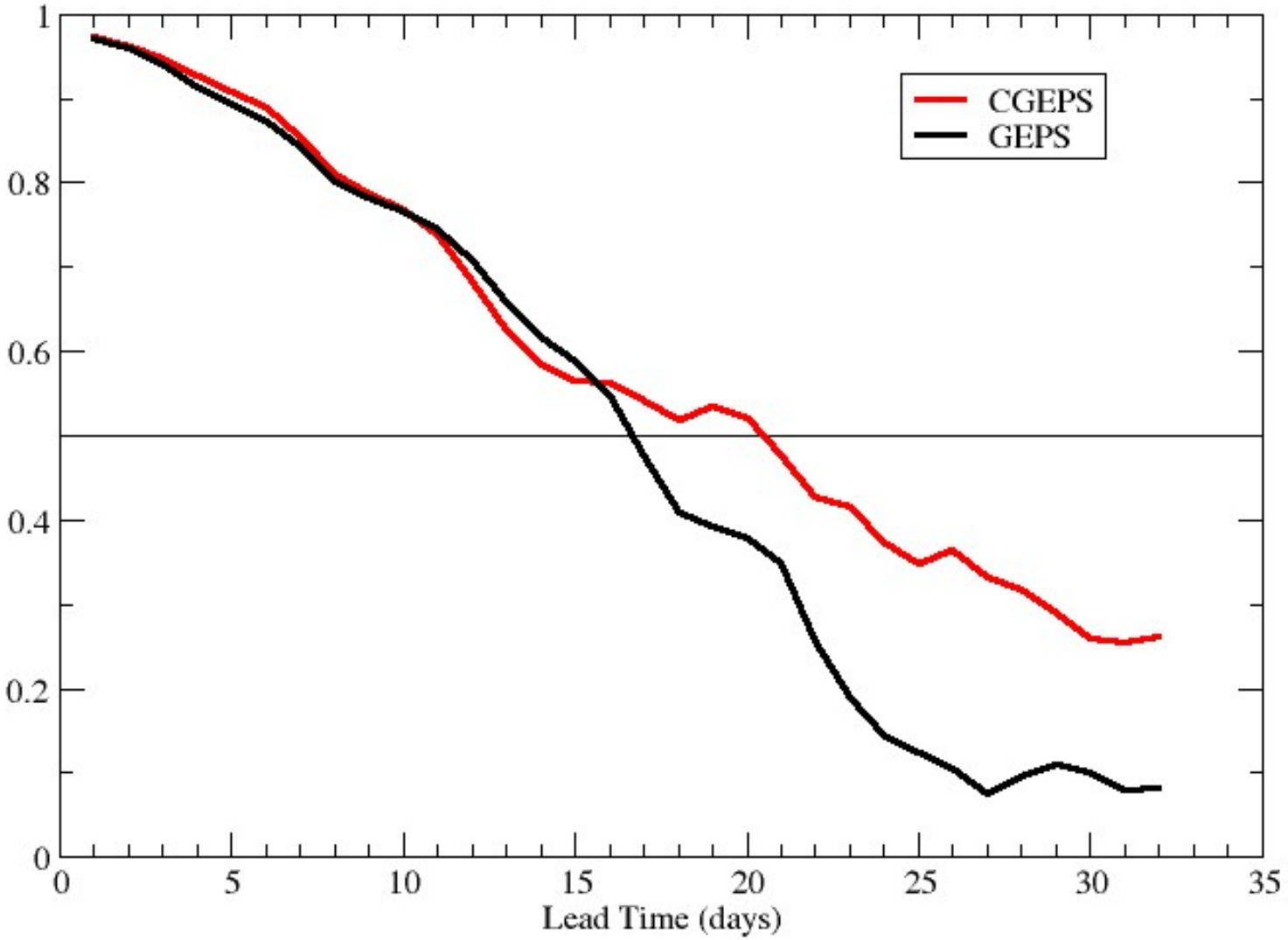
Week 3



Week 4



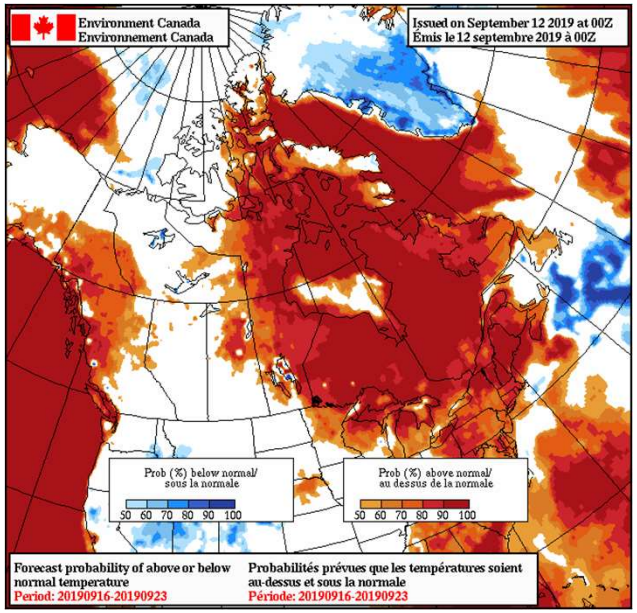
DJF MJO Correlation Skill



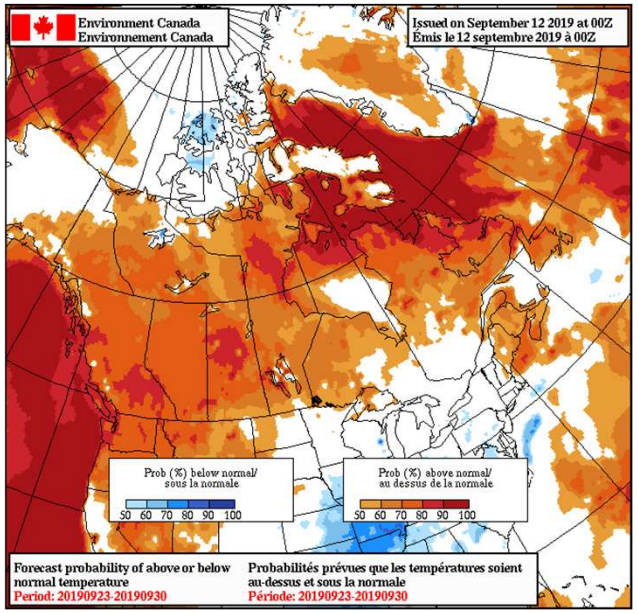
Sub-Seasonal Forecast Products

- Probabilistic Forecasts for w1, w2, w3, w4 and monthly. Temp and Precip

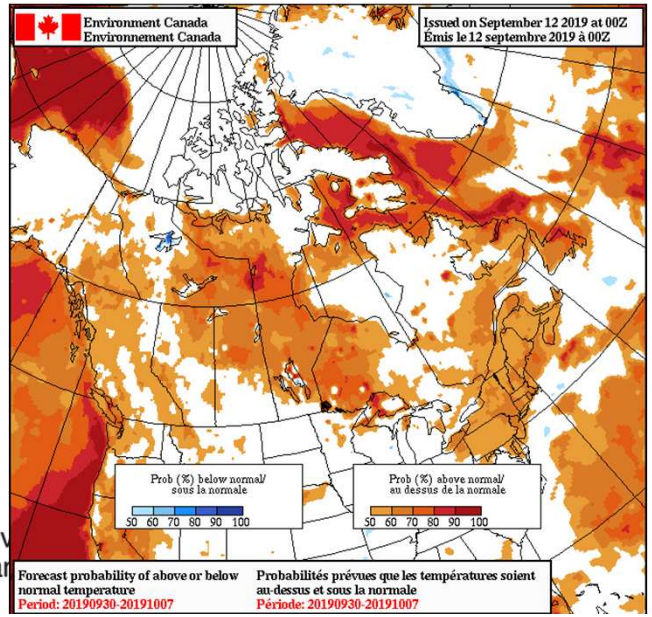
W1: 2019-09-16 -> 2019-09-23



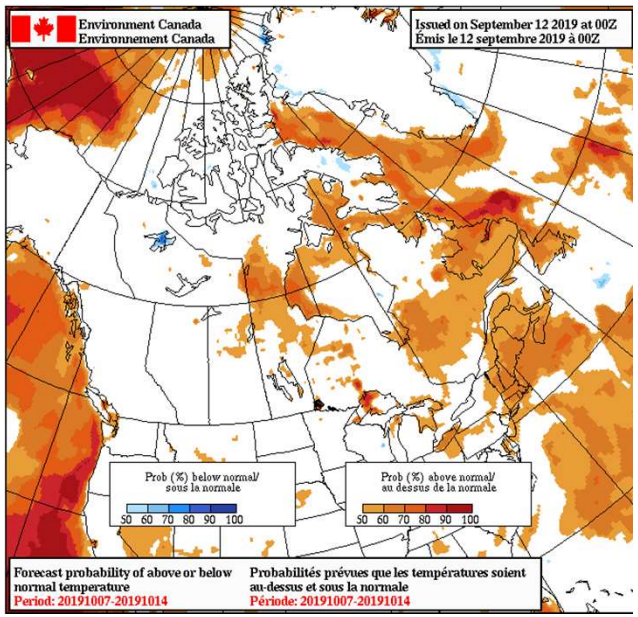
W2: 2019-09-23 -> 2019-09-30



W3: 2019-09-30 -> 2019-10-07



W4: 2019-10-07 -> 2019-10-14

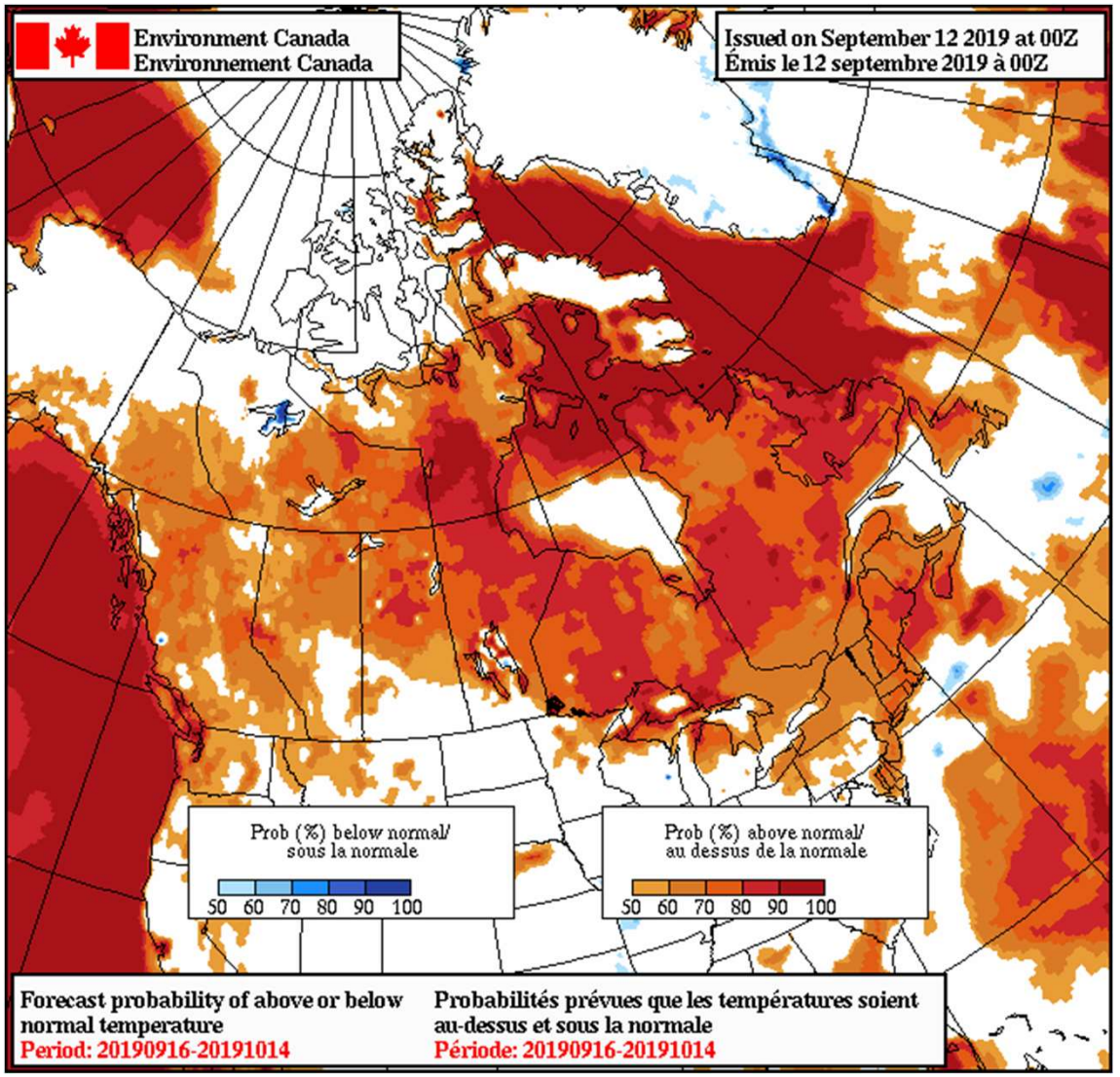


Sub-Seasonal Forecast Products

We contribute to:

1. WMO S2S data base
2. NMME SubX

Combined forecast: four weeks (monthly)



http://collaboration.cmc.ec.gc.ca/cmc/ensemble/monthly/prev_mens_geps.html

The Canadian Seasonal to Interannual Prediction System (CanSIPSv2)

- Developed at CCCma (BC) and RPN (QC)
- Operational at CMC-Montreal since August 2019
- 2 models CanCM4i and Gem-Nemo, 10 ensemble members each (new system)
- Forecasts initialized at the start of every month
- Hindcast verification period = 1981-2010
- Operational forecasts contribute to **NMME** and WMO/APCC/IRI ensembles
- Forecast range = 12 months

CanSIPSv2 Models

CanCM4i

CanAM4 Atmospheric model
- T63/L35 (≈2.8° spectral grid)
- Deep conv as in Zhang & McFarlane (1995)
- Shallow conv as per von Salzen & McFarlane (2002)
- Improved radiation, aerosols

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

Gem-Nemo

Gem Atmospheric model
- Resolution 256x128 ~1.4deg
- -79 levels, top at 0.075 hPa
- Time step: 1 hour
- Land surface scheme: ISBA
- Deep convection scheme: Kain-Fritsch
- Shallow convection scheme: Kuo transient scheme
- Surface flux scheme: implicit flux for members 1-5, explicit flux for members 6-10

Nemo: Ocean model
- -NEMO (3.6)
- ORCA1 grid: Horizontal resolution: 1° × 1° , 1/3 degree meridionally near the equator
- 50 vertical levels
- Time step: 30 minutes
- coupled with sea ice --- CICE (with five-category sea ice)
- GEM and NEMO are coupled once an hour through GOSSIP coupler

°C

CanSIPSv2 Initialisation

GEM-NEMO, **forecast mode:**

Atmosphere: 10 members from ENKF of GEPS

Land: offline SPS forced by CMC analysis

Ocean: CMC GIOPS

Sea ice concentration: CMC GIOPS

Sea ice thickness: CMC GIOPS

GEM-NEMO, **hindcast mode:**

Atmosphere: ERA-interim 10 members (random isotropic perturbations)

Ocean: ORAP5 from ECMWF - T, S, H, U, V

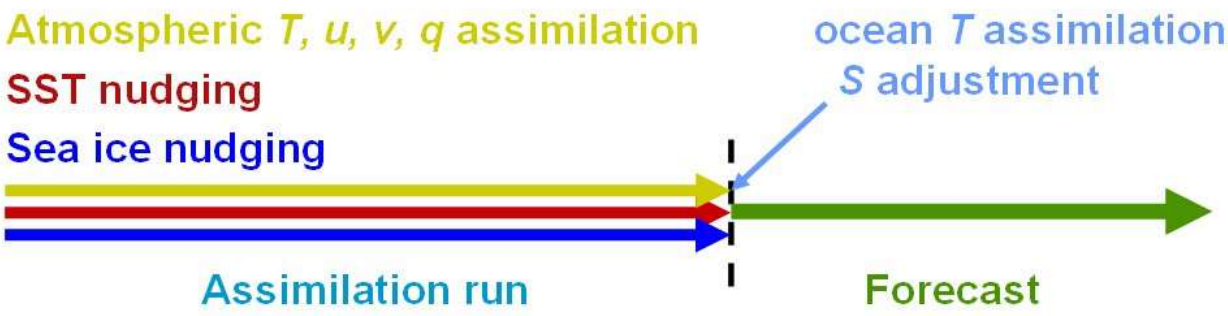
Land: off-line SPS forced by ERA-interim atmosphere

Sea ice concentration: Had2CIS

Sea ice thickness: ORAP5

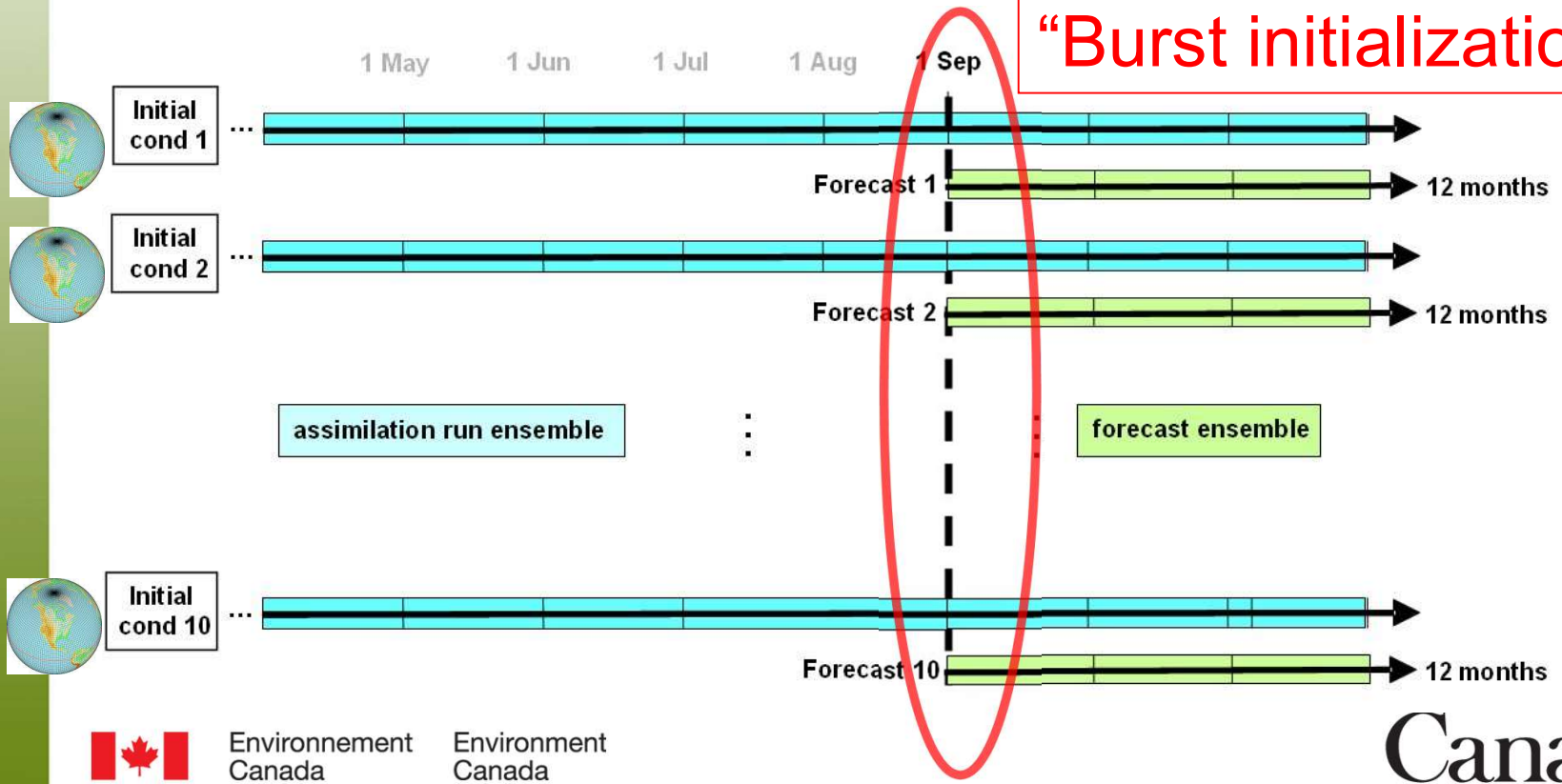
°C

CanCM4i initialization



Sea ice thickness from a statistical model of Dirkson et al (2017)

"Burst initialization"



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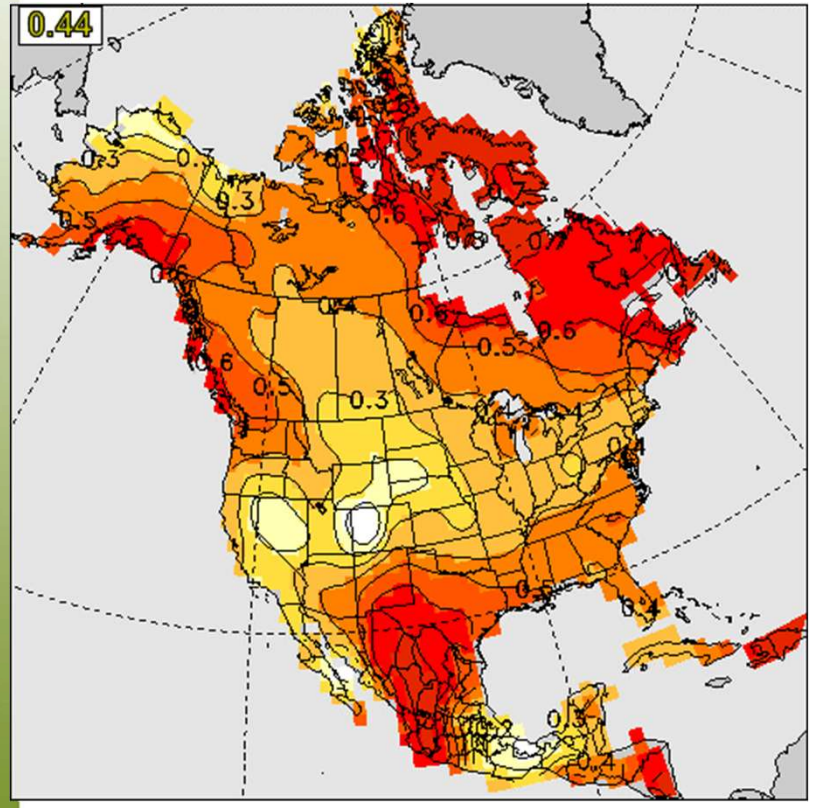
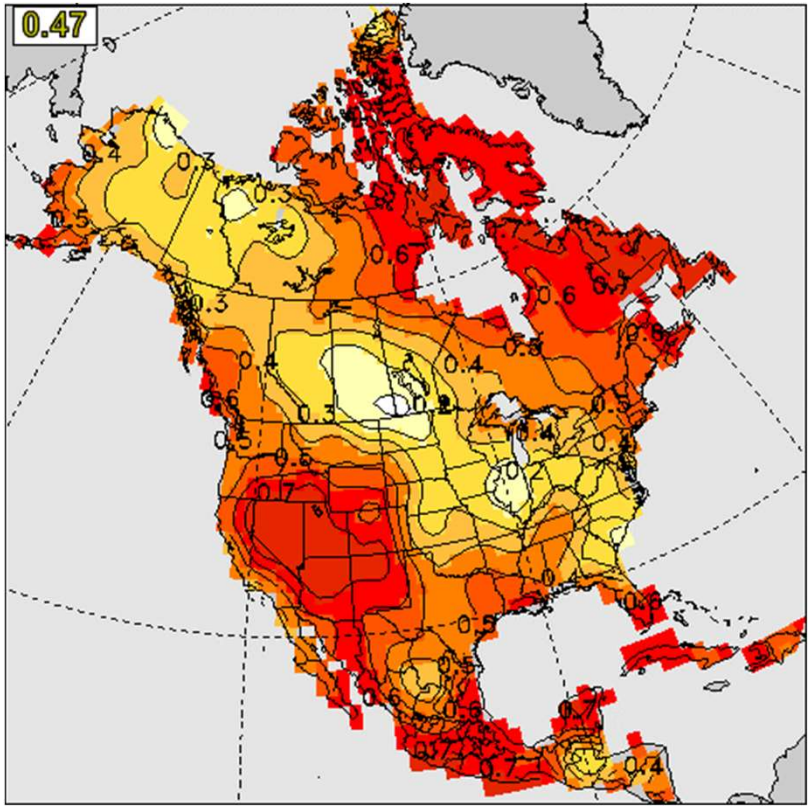
CanSIPSv2 scores

T2m Percent correct DJF



T2m Percent correct JJA



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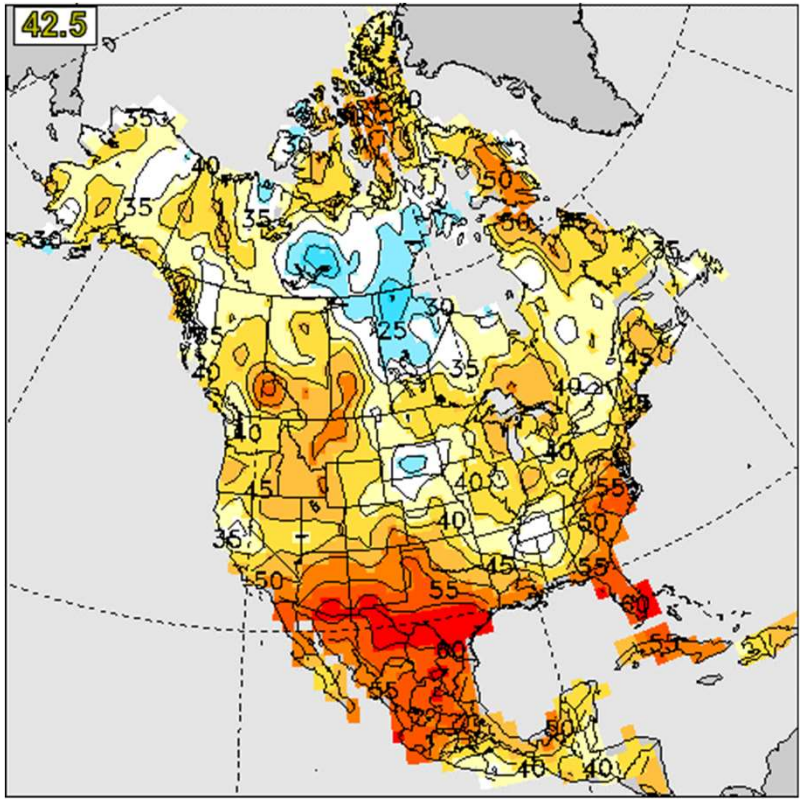
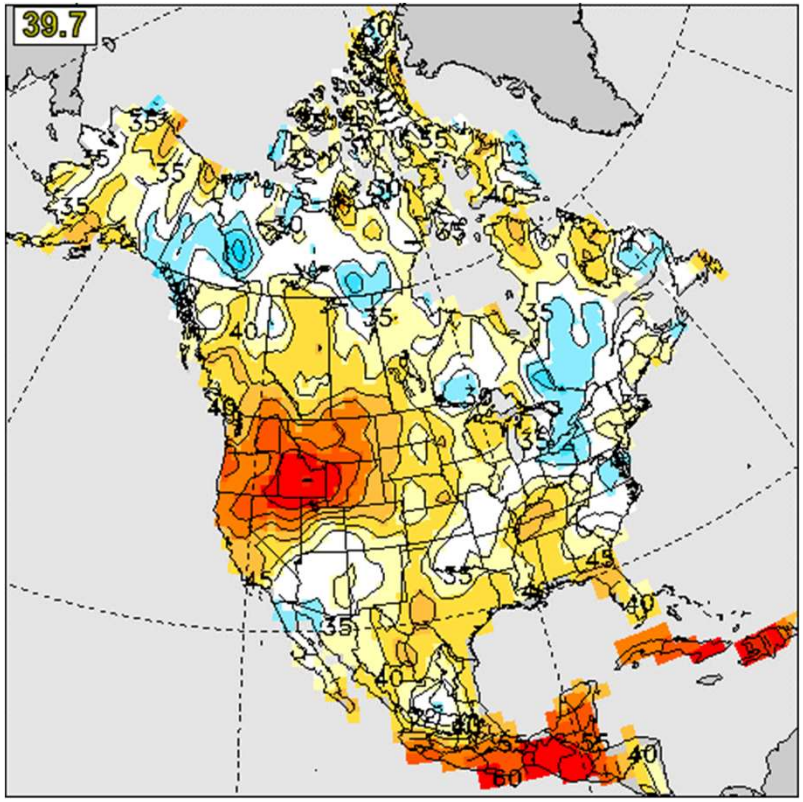
CanSIPSv2 scores

Precipitation Percent correct DJF



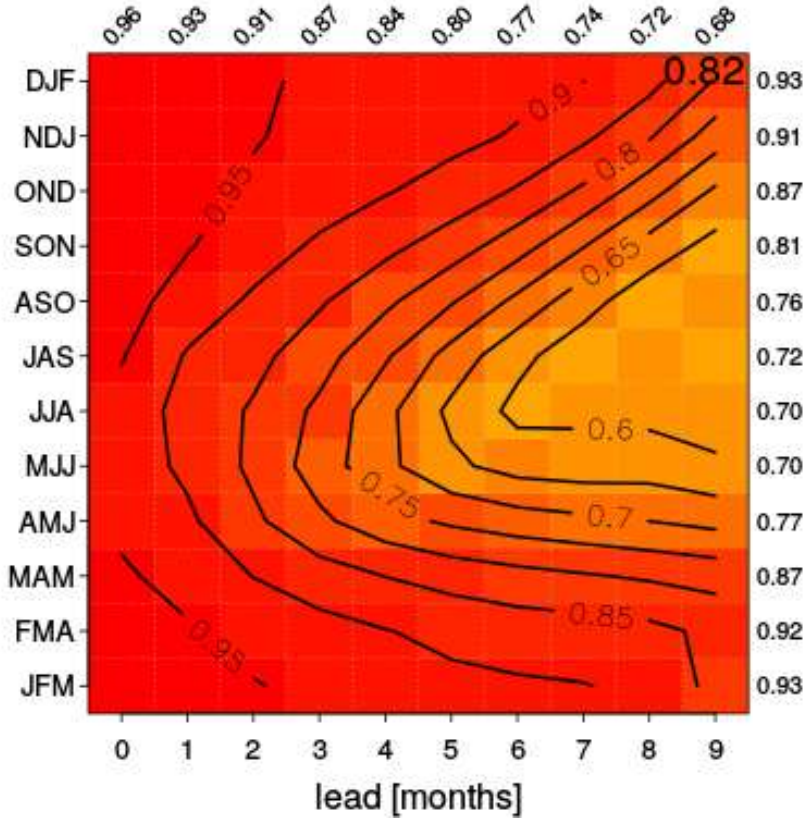
Precipitation Percent correct JJA



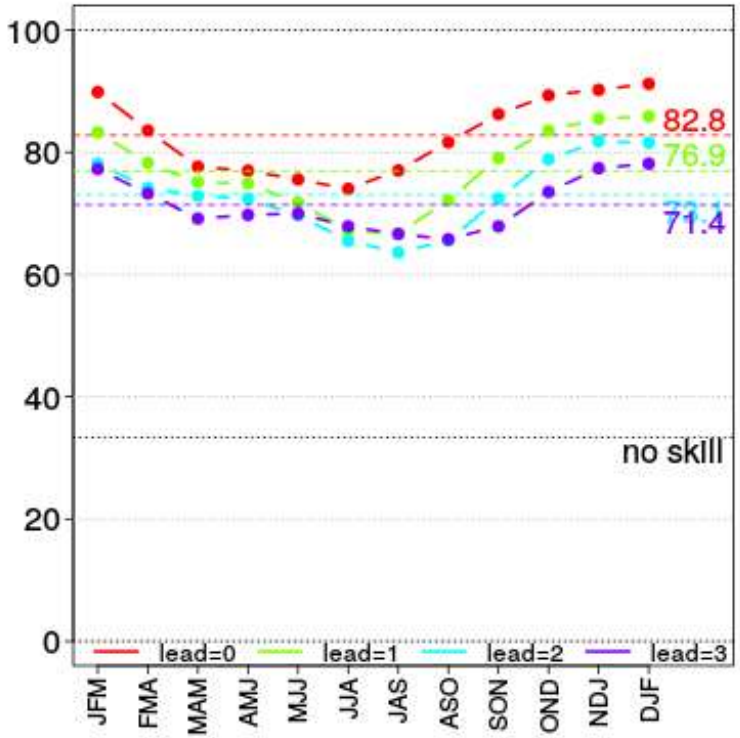
CanSIPSv2 ENSO scores

Nino 3.4 index versus OISST

correlation



Percent correct



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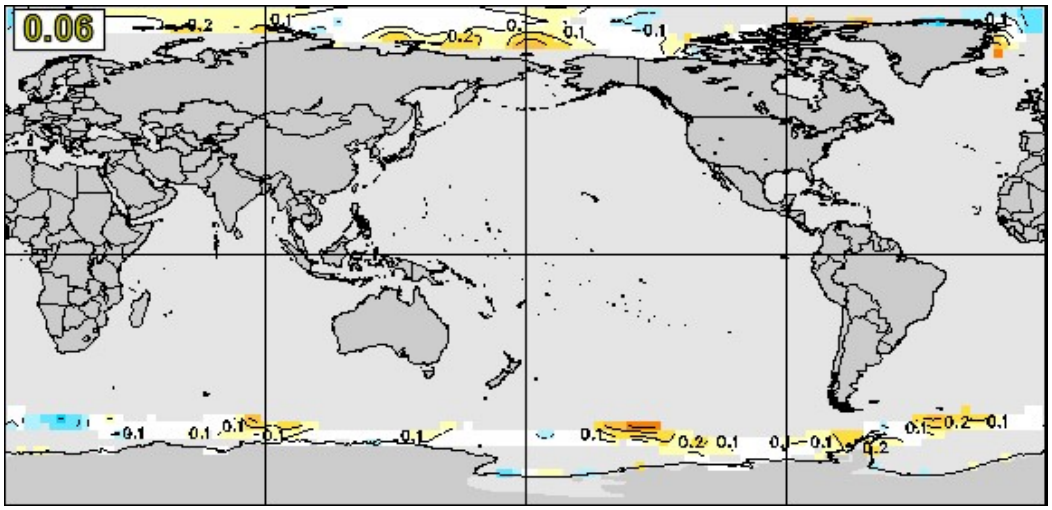
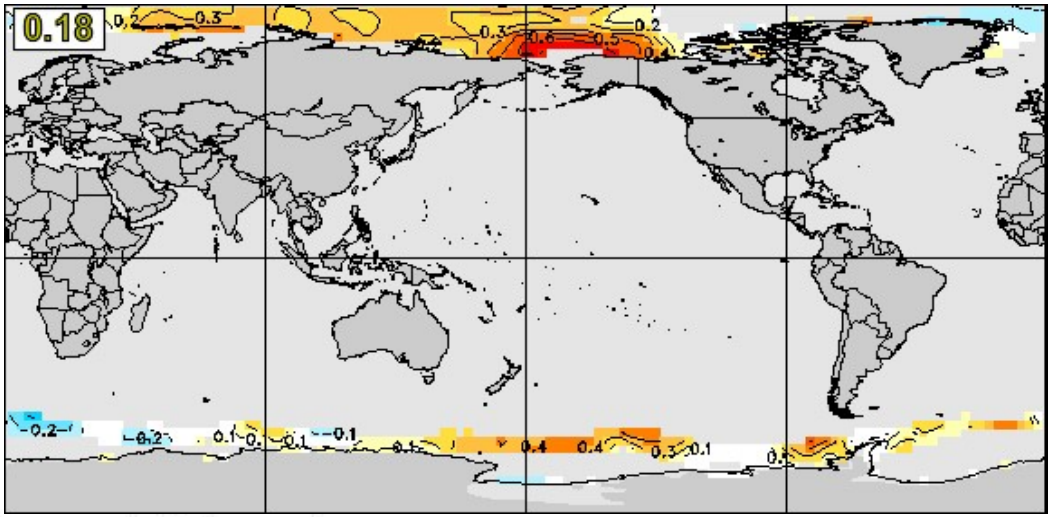
Anomaly correlation skill of SIC for September

Initialized on May 1, 4-month lead



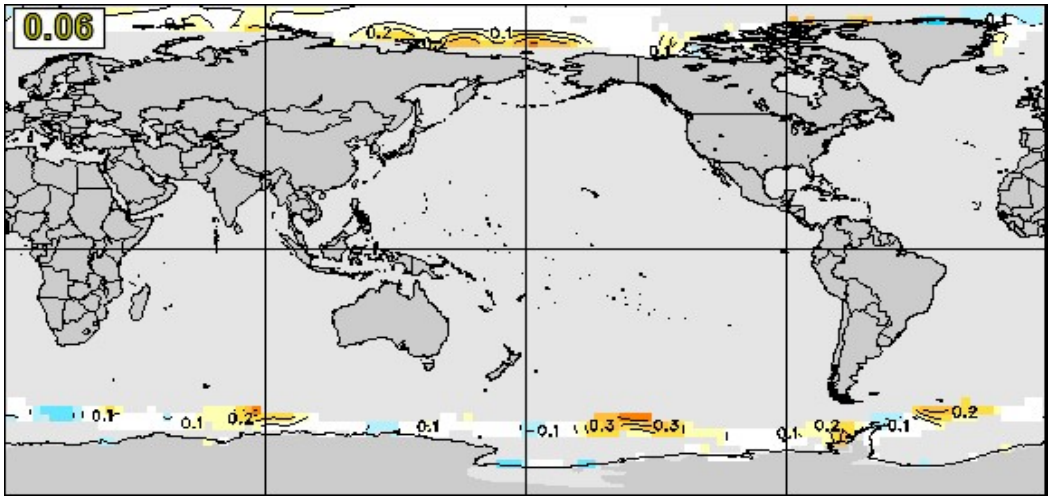
CanCM4



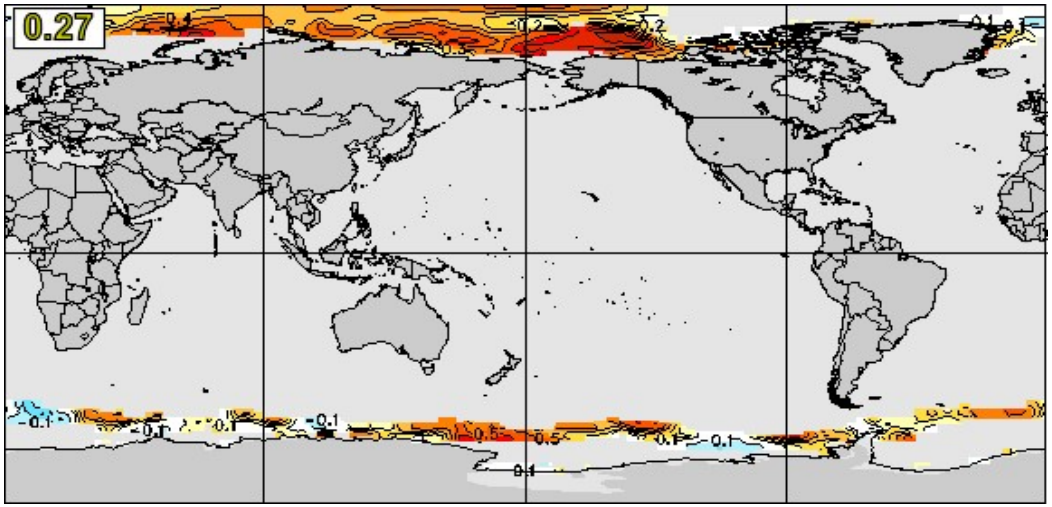
CanCM4i

Anomaly correlation skill of SIC for September

Initialized on May 1, 4-month lead



CanSIPS



CanSIPSv2

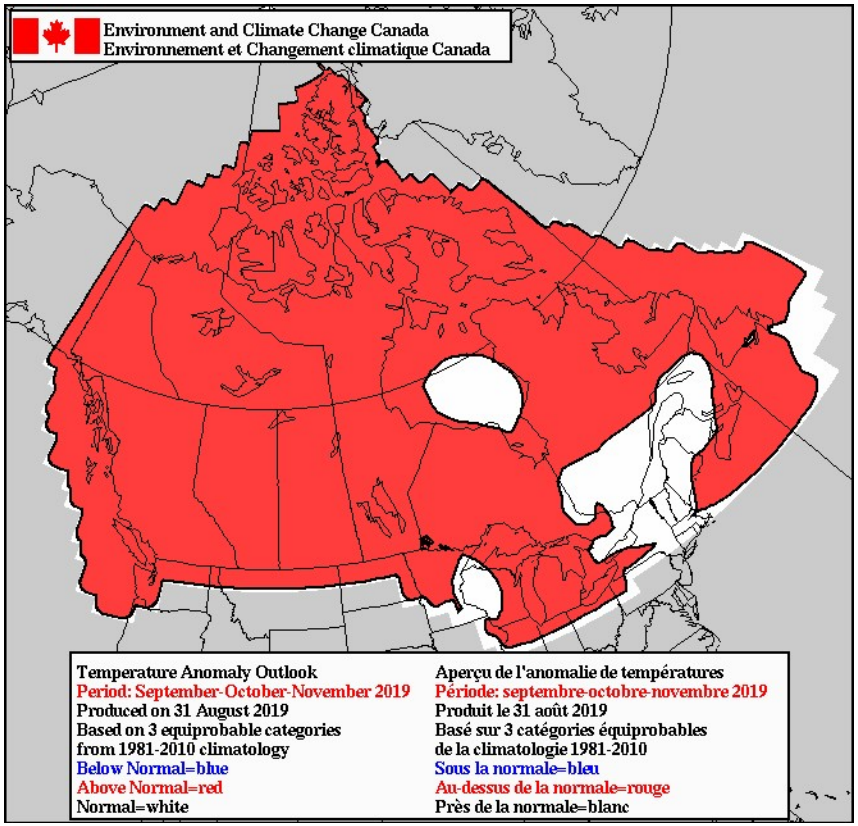
Seasonal Forecast Products

- Deterministic category forecasts
- Probabilistic category forecasts
- Near surface temperature and precipitation
- Officially: once a month we do one year forecast
- Unofficially: everyday forecast for the two following seasons.
- We contribute to: WMO (as a lead center), NMME, IRI, APECC.
- We provide seasonal forecast to the Regional Climate Outlook forums (e.g. South East Asia, Carribian,)

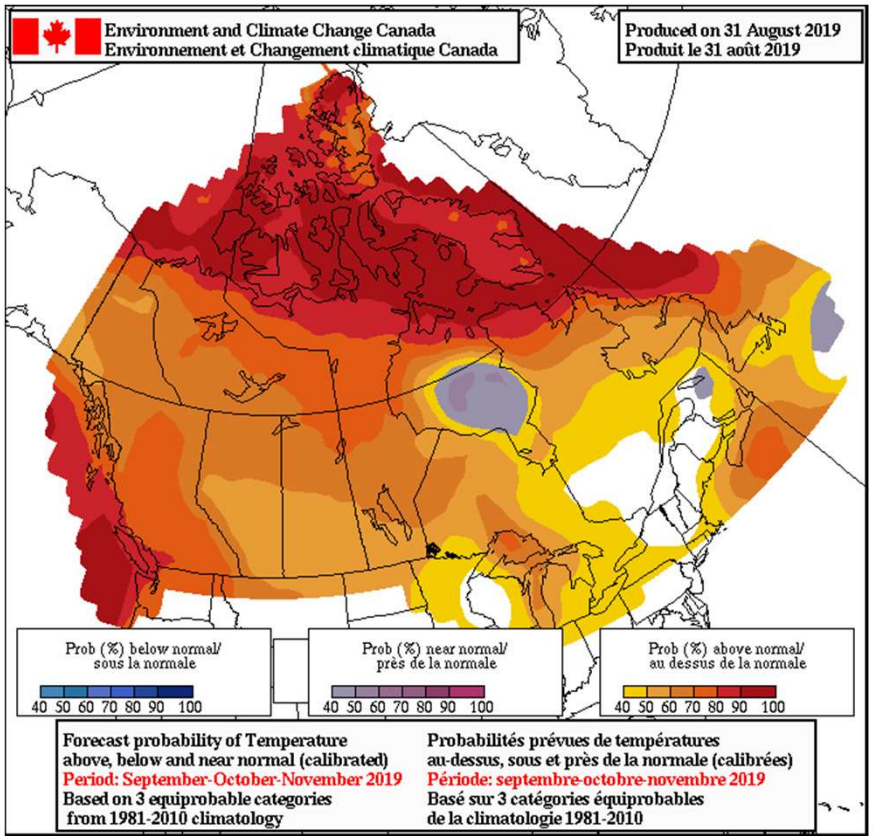
Seasonal Forecast Products

- Category forecasts: Above, below and near normal based on equiprobable categories. Sep-Oct-Nov 2019.

Deterministic, Temperature



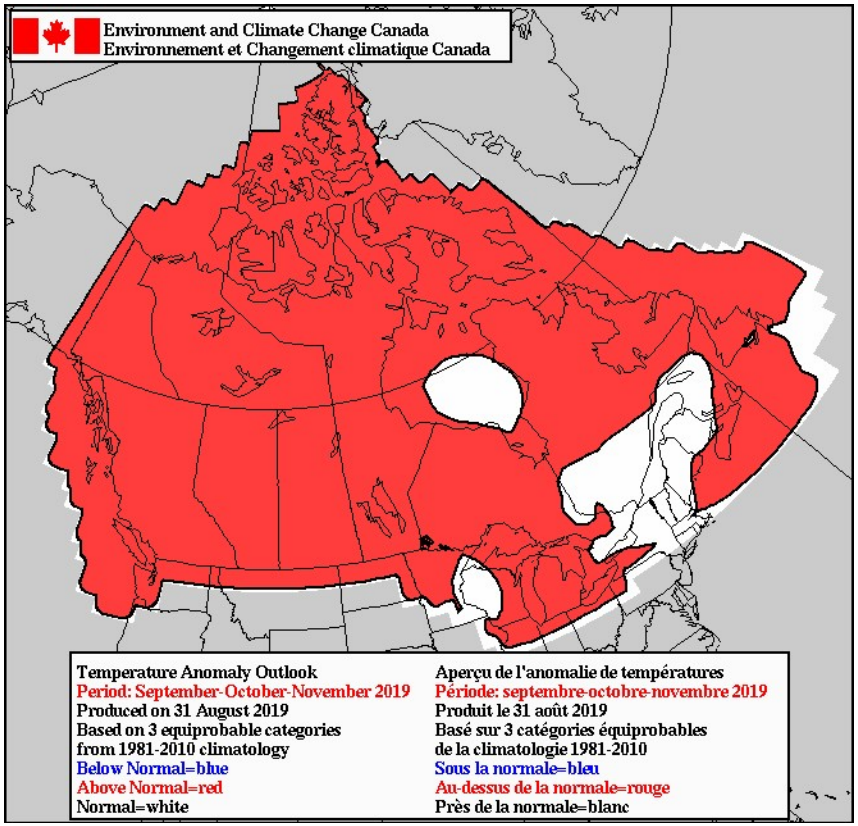
Probabilistic, Calibrated Temperature



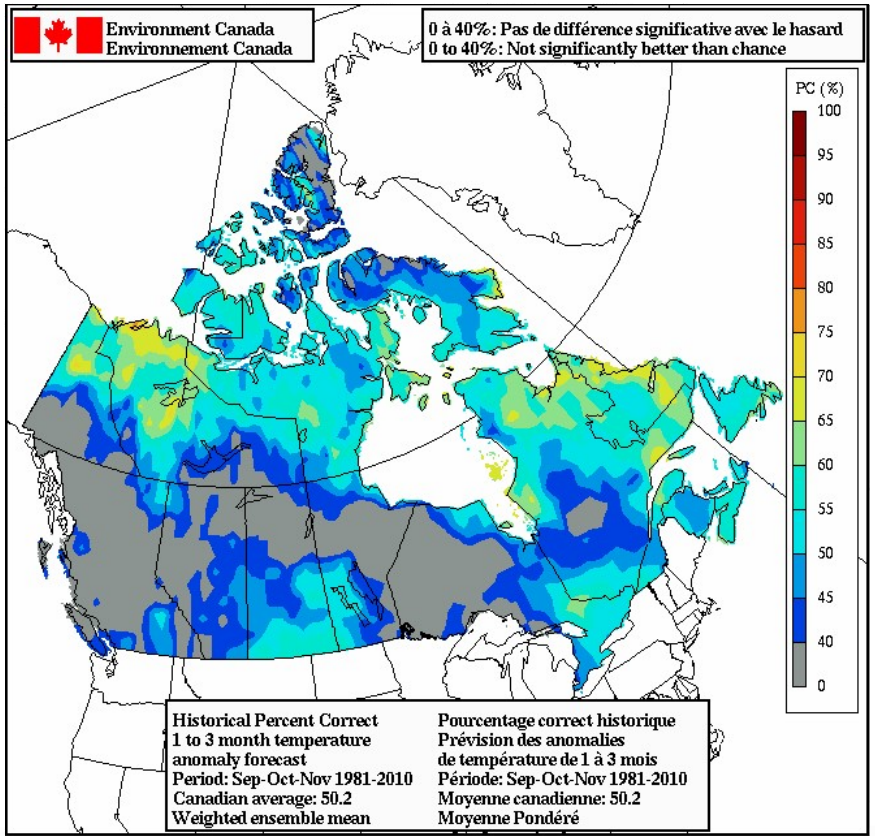
Seasonal Forecast Products

- Category forecasts: Above, below and near normal based on equiprobable categories. Sep-Oct-Nov 2019.

Deterministic, Temperature



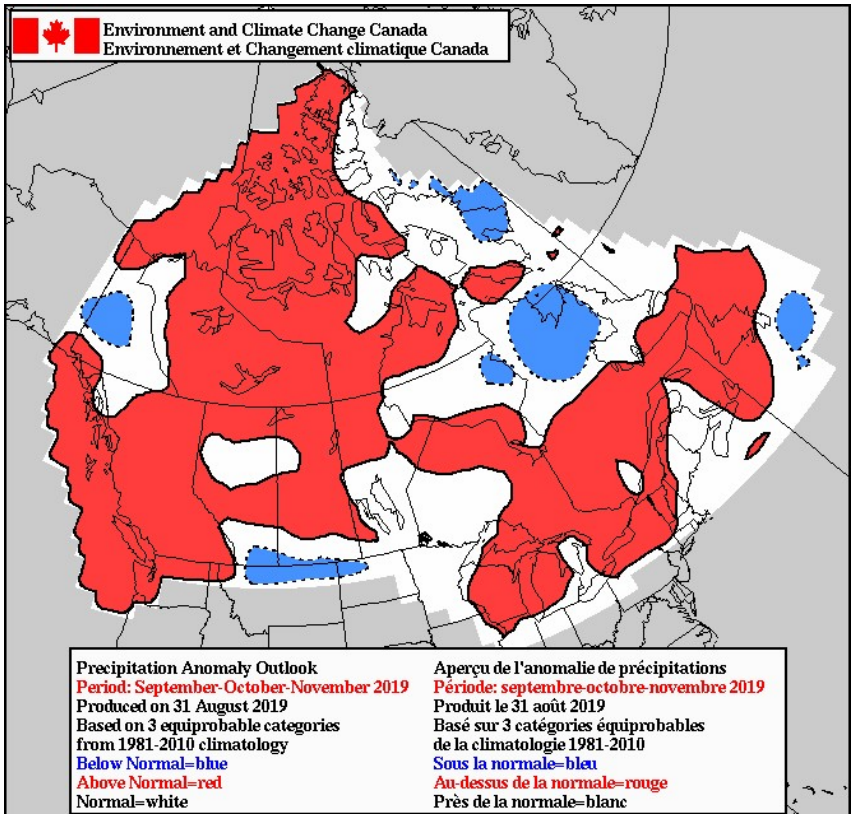
Skill, PC, Temperature SON



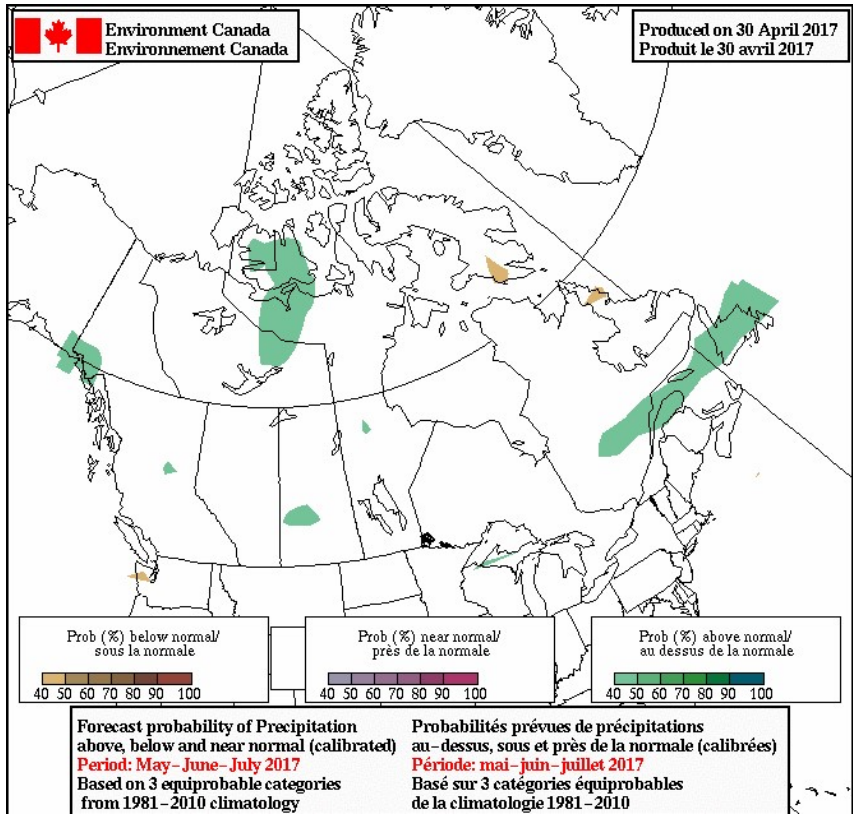
Seasonal Forecast Products

- Category forecasts: Above, below and near normal based on equiprobable categories. Sep-Oct-Nov 2019.

Deterministic, Precipitation



Probabilistic, Calibrated Precipitation



Seasonal Forecast Products

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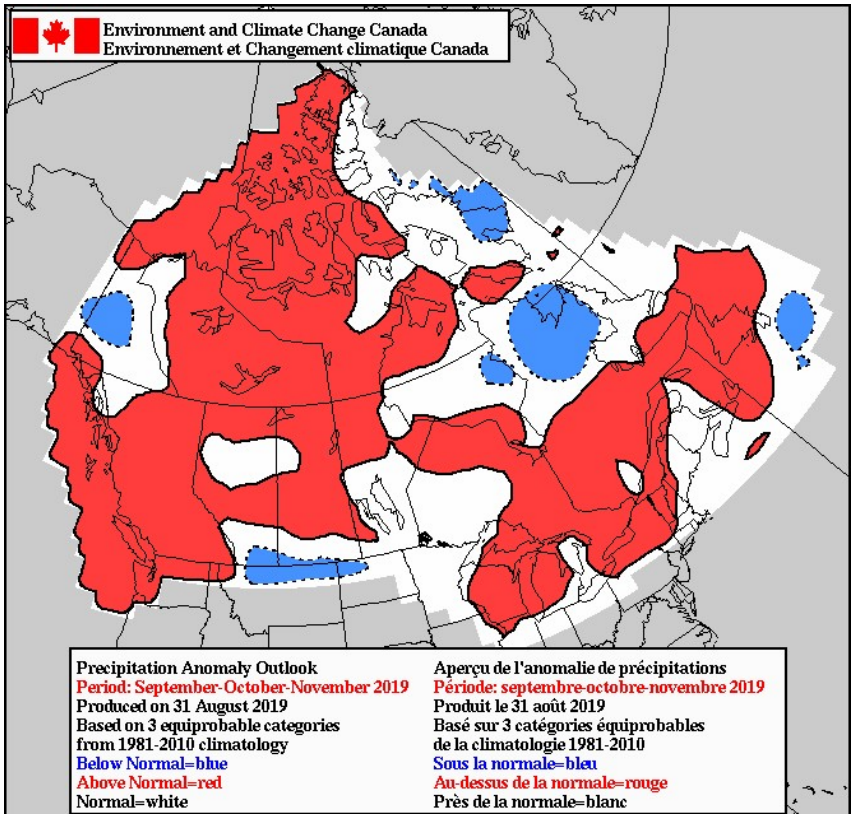
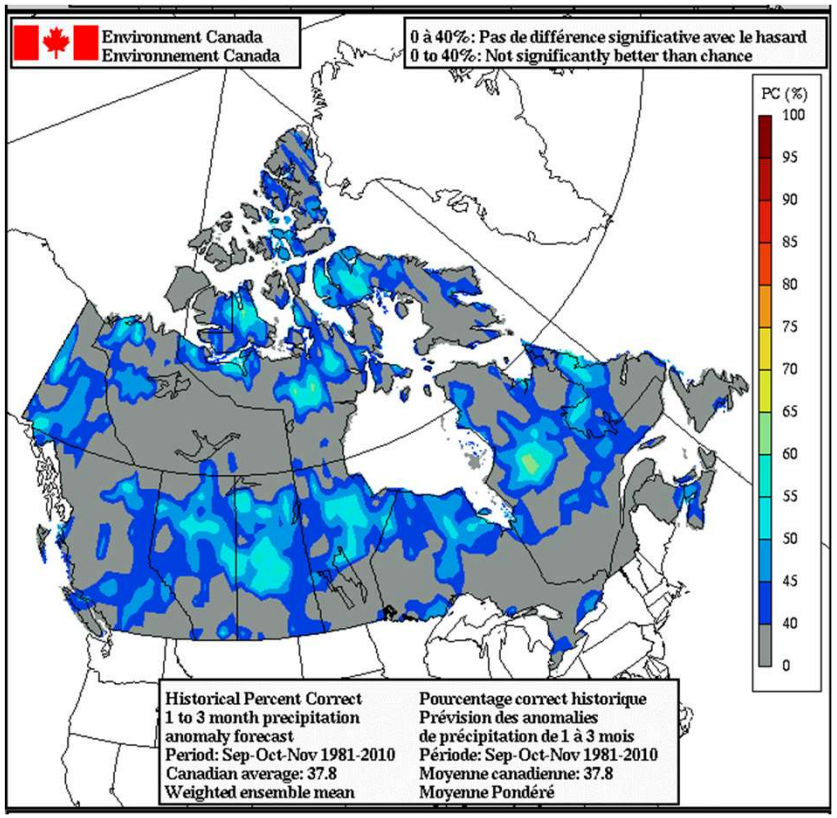
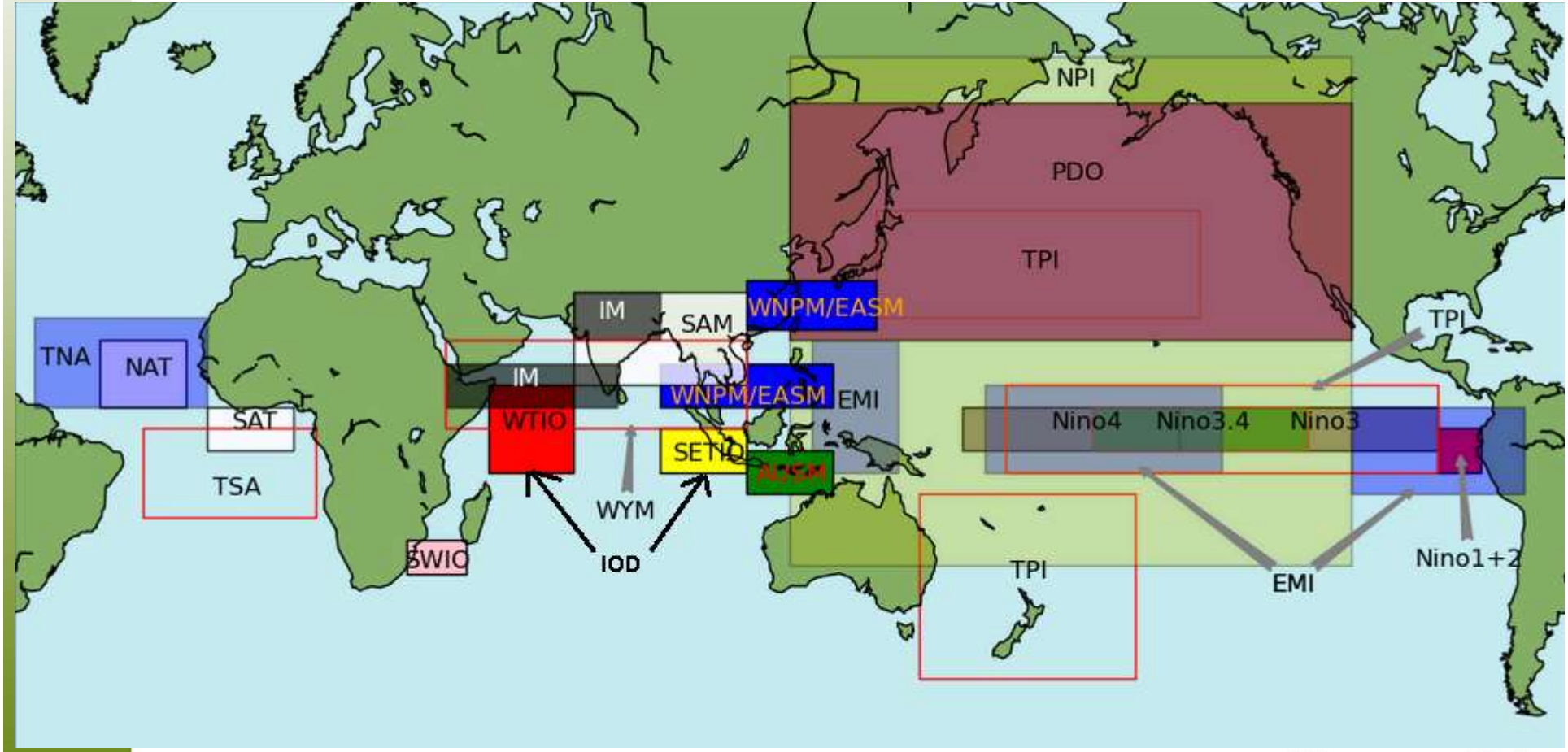
Deterministic, Precipitation



Skill, PC, Precipitation SON



Seasonal Forecast Products
Climate Indices



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Concluding remarks

CanSIPSv2 (operational since August 2019):

- Environment and Climate Change Canada has used MMEs for its seasonal predictions since 1995
- Current **CanSIPS** uses two coupled climate models, GEM-NEMO and CanCM4i, with different physics and model errors
- **MME has better ENSO amplitude** than either model alone due to offsetting biases
- Future MME planned to include CanESM5 in the far future

GEPS (sub-seasonal, coupled, operational since July 2019):

- Temperature: very good scores for week 1 and 2, usable scores for week 3. Improvements in week 4 comparing to the uncoupled system.
- Precipitation: good scores for week 1, usable skill in week 2 and 3 in lower latitudes.
- Improved MJO skill, up to 21 days lead.
- Probabilistic approach in forecasts.

Thank you!

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