Environment and Climate Change Canada / GPC Montreal

Assessment, research and development

Bill Merryfield

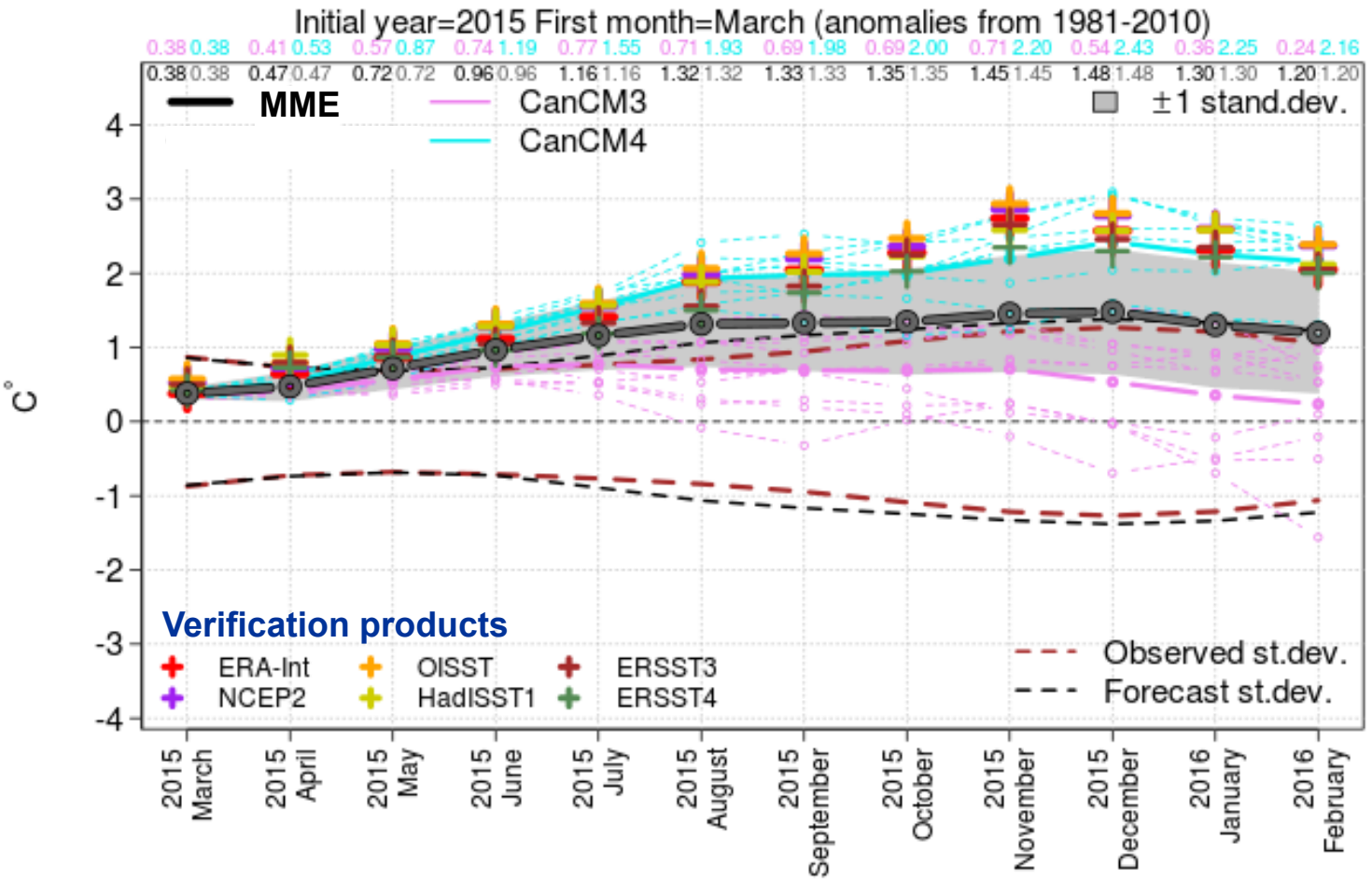
Canadian Centre for Climate Modelling and Analysis (CCCma)

with contributions from colleagues at CCCma and CMC

2015-17 ENSO forecasts

2015-16 El Niño Predictions

Nino3.4 from 28 Feb 2015

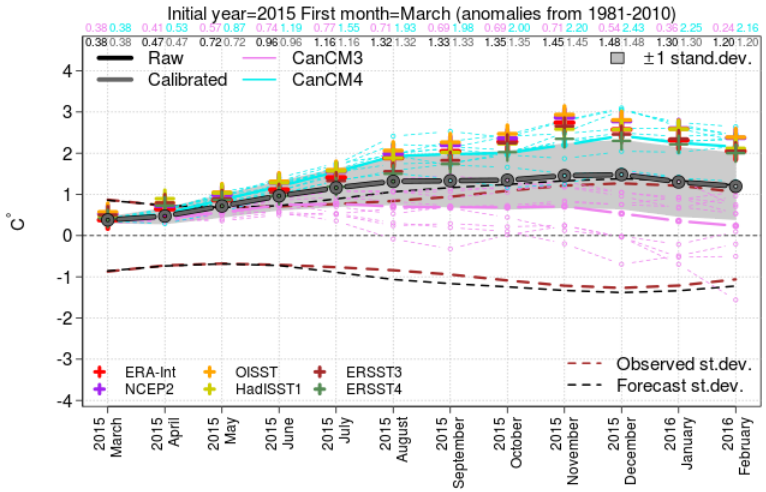


CanCM3: No large El Niño
CanCM4: Accurate through 12 months!

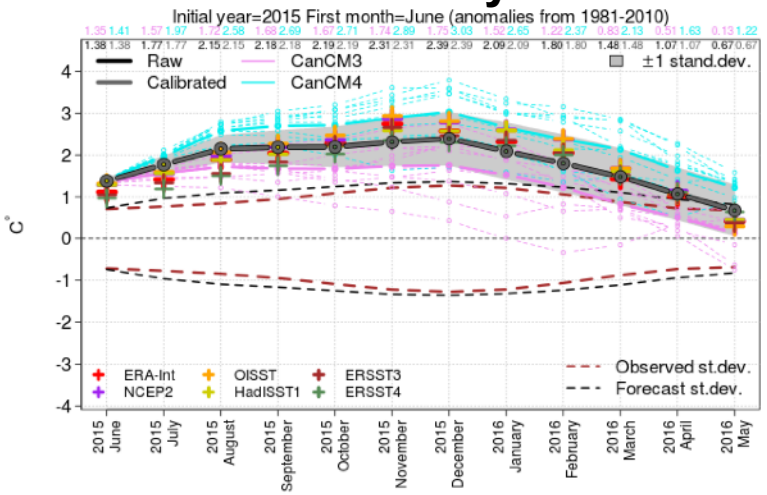
→ ***CanCM4 provides "early warning" at long range***

2015-16 El Niño Predictions

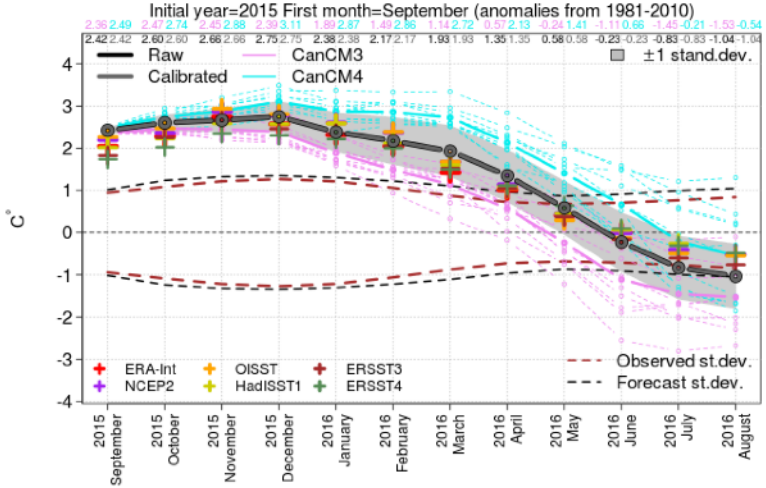
From 28 Feb 2015



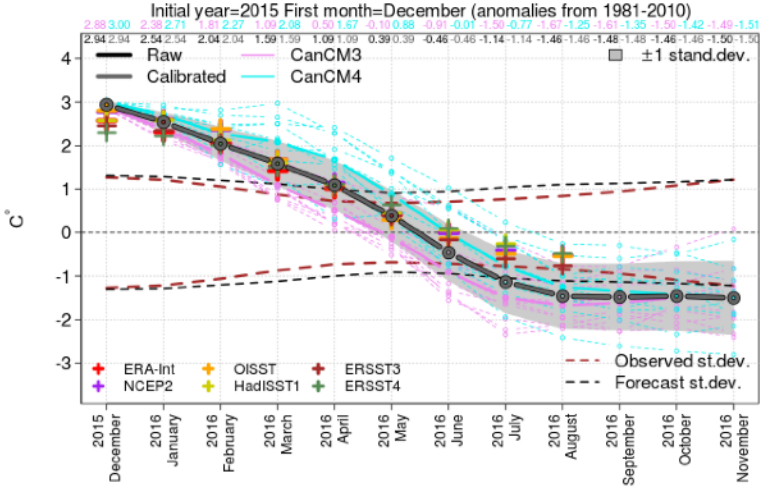
From 31 May 2015



From 31 Aug 2015



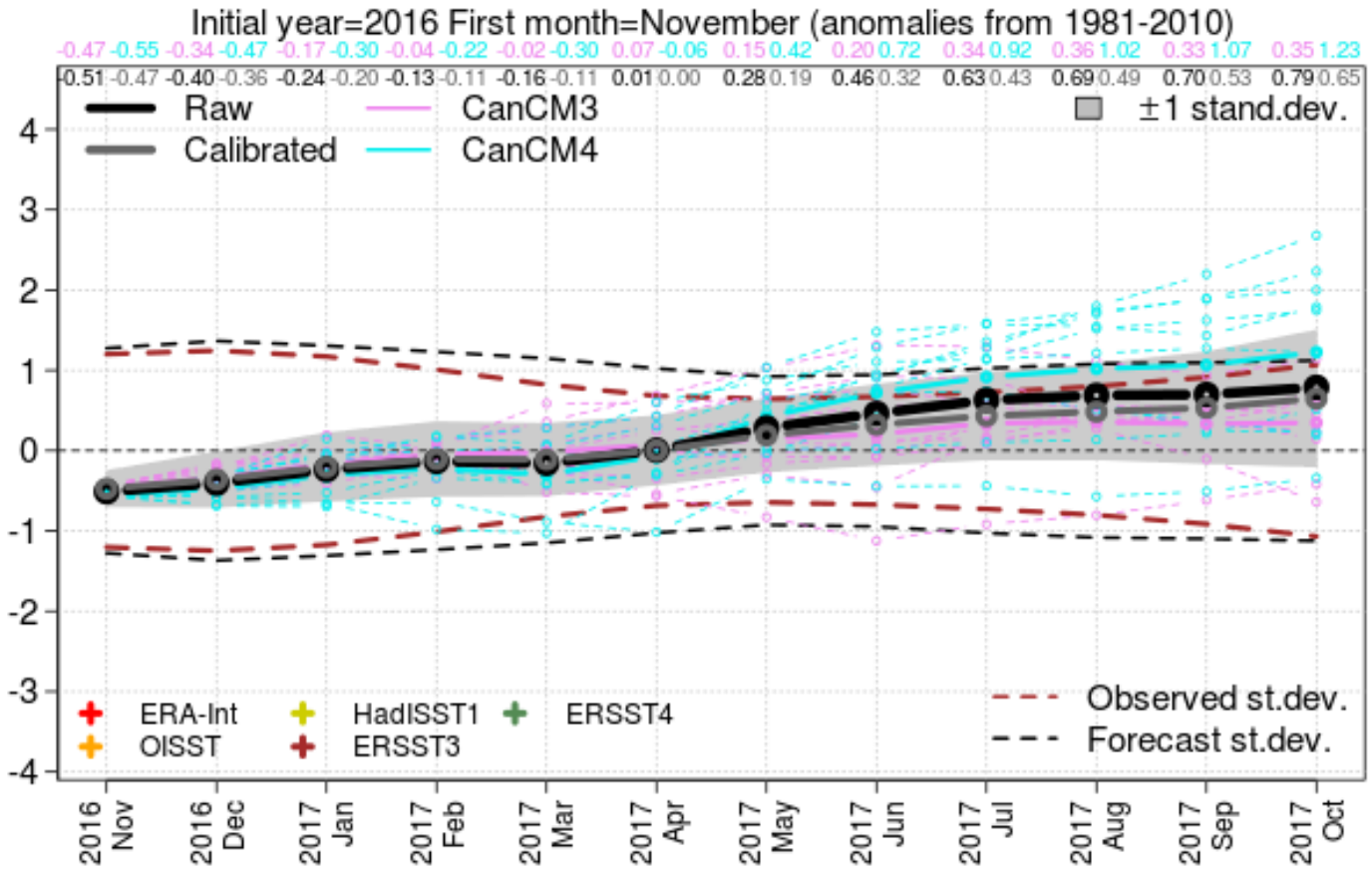
From 30 Nov 2015



- After CanCM4 “early detection” in late winter, **combined forecast better represents amplitude and timing of phase reversal**
- **CanCM3** reverses too soon, **CanCM4** too late, **combined CanSIPS** “just right”

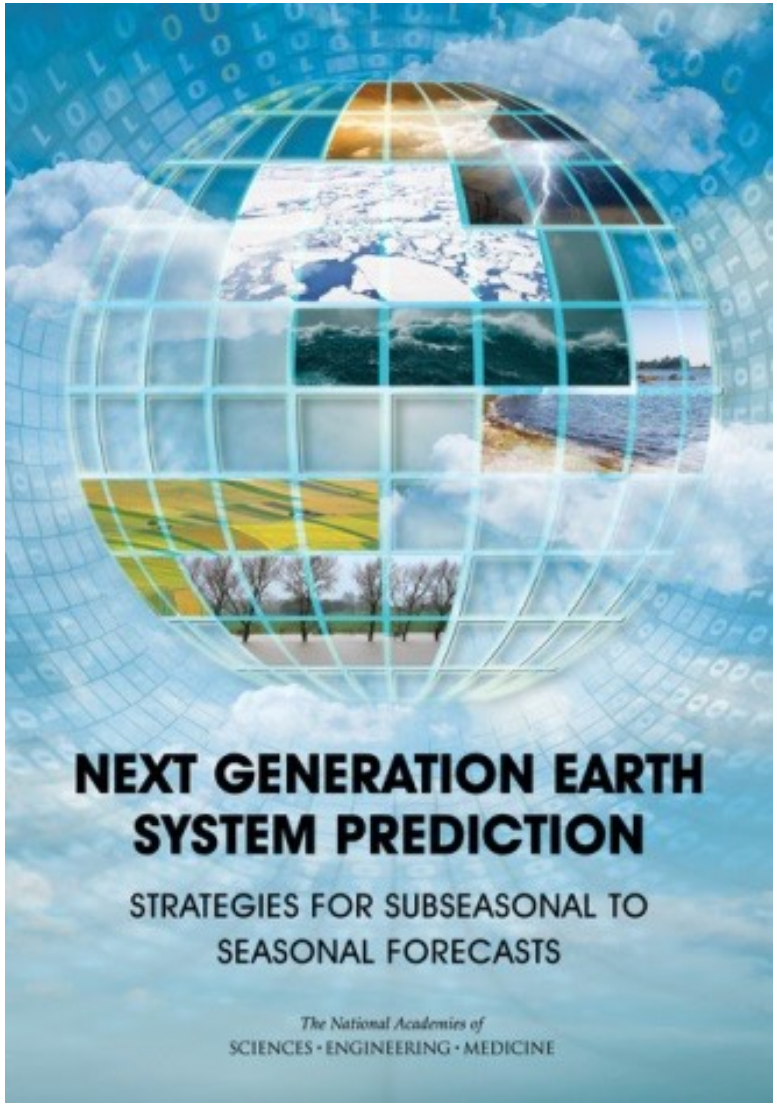
Current Nino3.4 forecast

From 31 Oct 2016



→ ***Possible return to El Niño in 2017-18?***

Experimental products



National Academy of Sciences (2016)

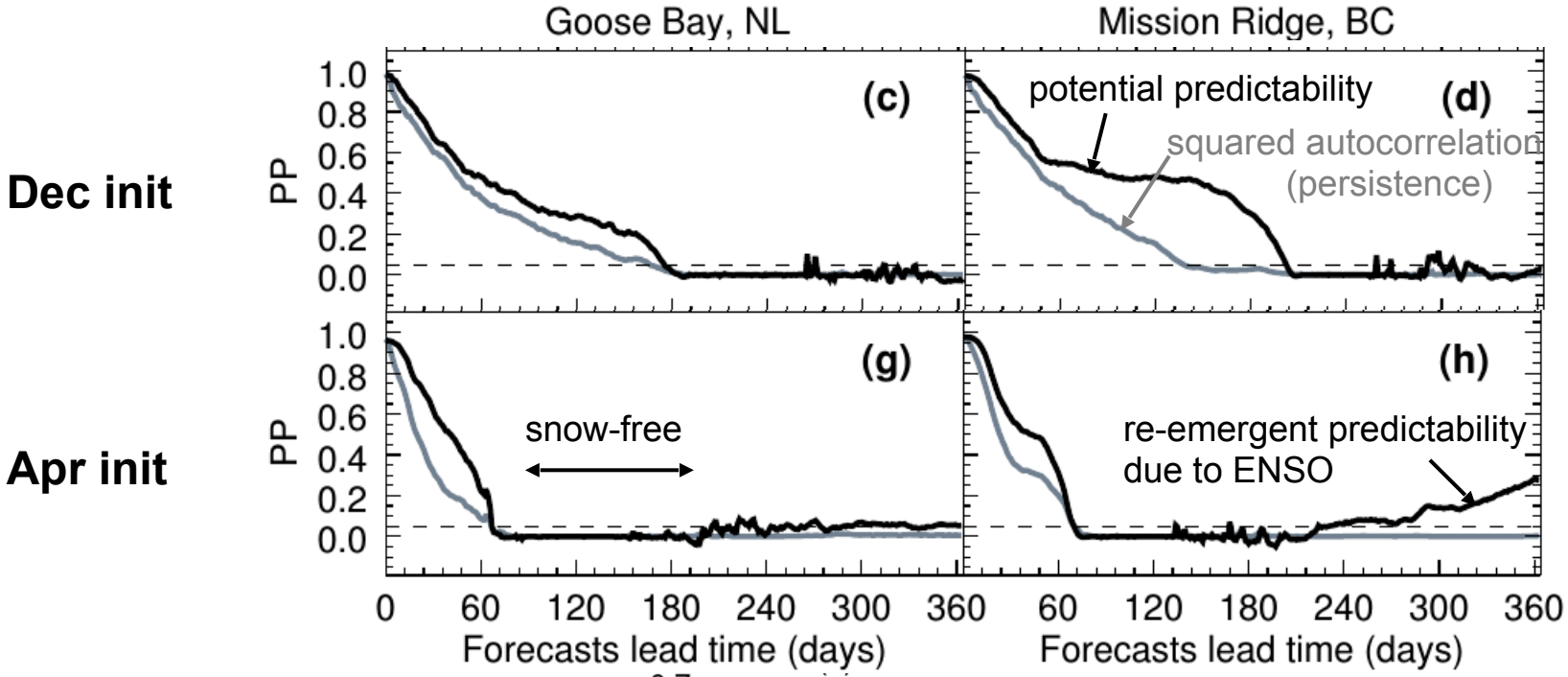
"As the availability and skill of seasonal climate forecasts—and more recently subseasonal predictions—has improved, S2S forecasts are increasingly being used in sectors such as agriculture, energy, and water resources management. However, there is ***enormous potential to further increase the benefits*** *of S2S predictions.* ***Many sectors have yet to exploit even the S2S information that is currently available****.*

The user base could expand dramatically if the skill of S2S forecasts improves, ***more variables of the Earth system are explicitly forecast*** *(e.g., a* ***wider range of conditions of the ocean, cryosphere, and land surface****), and users' awareness of and ability to apply S2S information to important decisions and actions increases."*

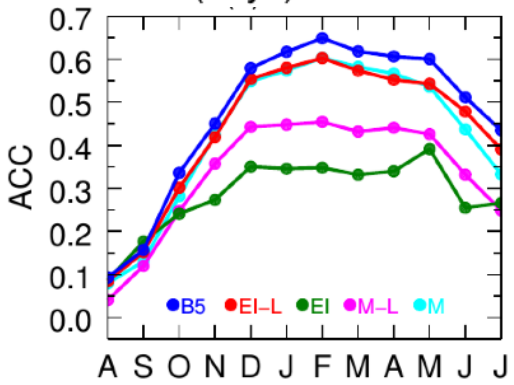
CanSIPS prediction of snow

Sospedra-Alfonso et al., J. Hydromet. (2016a,b)

- High potential predictability and verification skill found for snow water equivalent (SWE) due to anomaly persistence & climate prediction skill



- Skill depends strongly on verification product used, reflecting observational uncertainty →



Anomaly correlation skill averaged over the Northern Hemisphere, according to 5 verification products: ERA-Interim, MERRA Land, MERRA, ERA-Interim Land, "Blended5" (Mudryk et al., J Clim 2015)

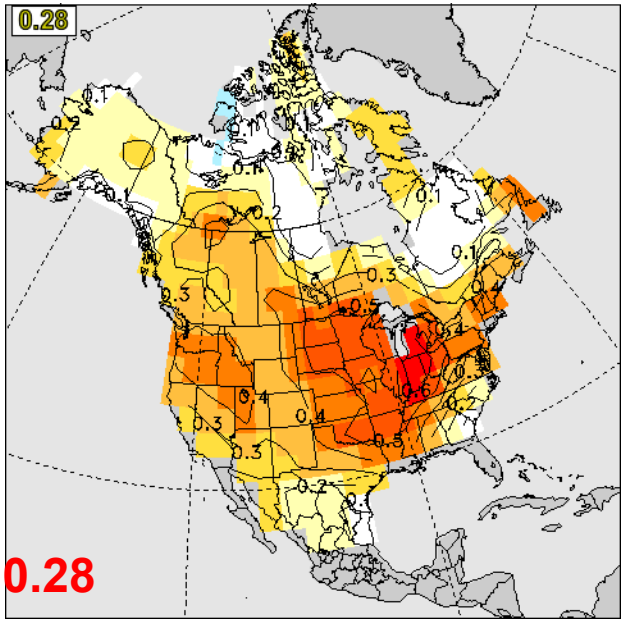
Dependence of SWE skill on verification dataset

FMA lead 0 anomaly correlation

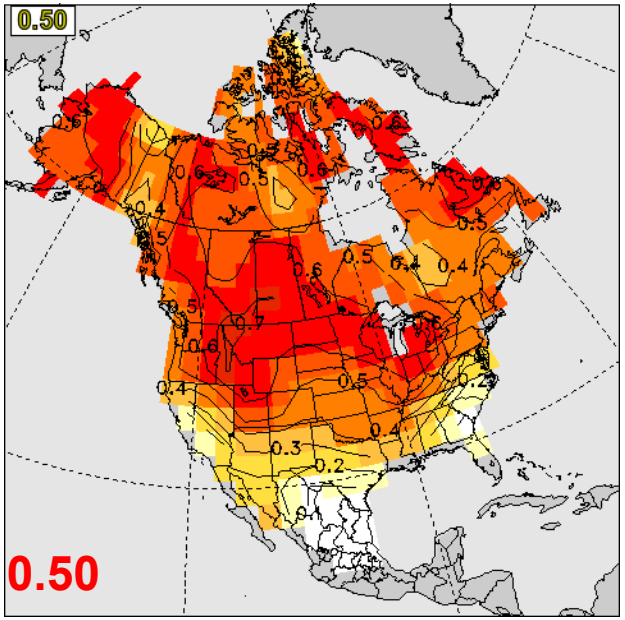
Single-product verifications

Multi-product verification

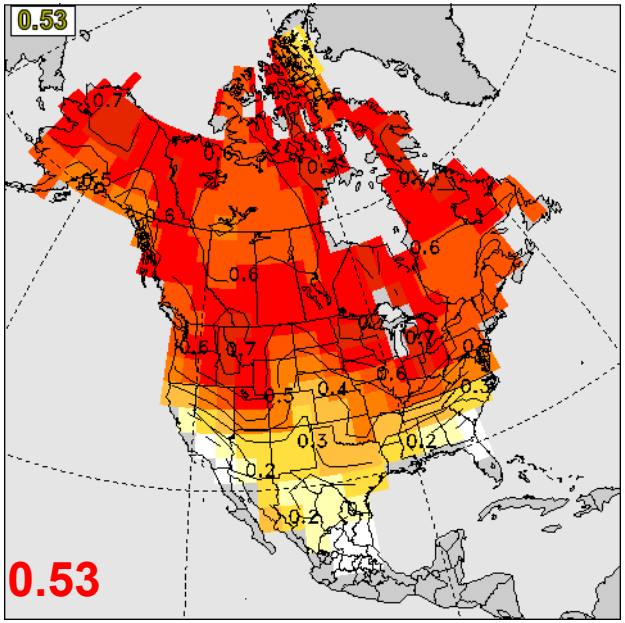
ERA-Int



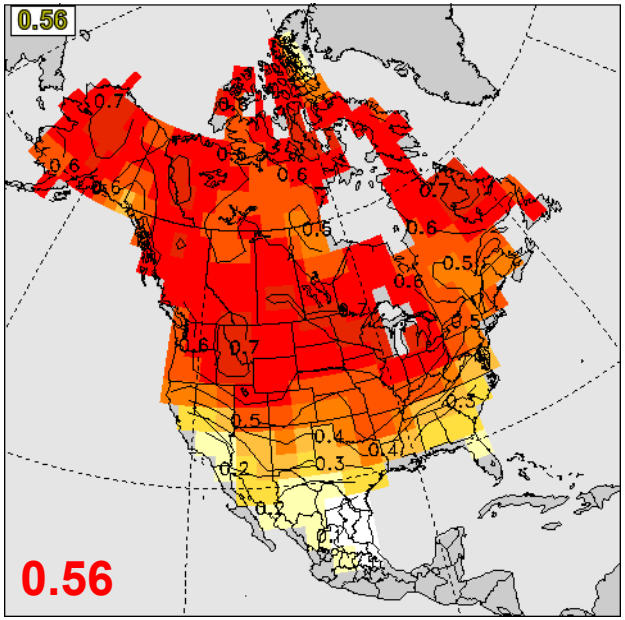
ERA-Int Land



MERRA



Blended5



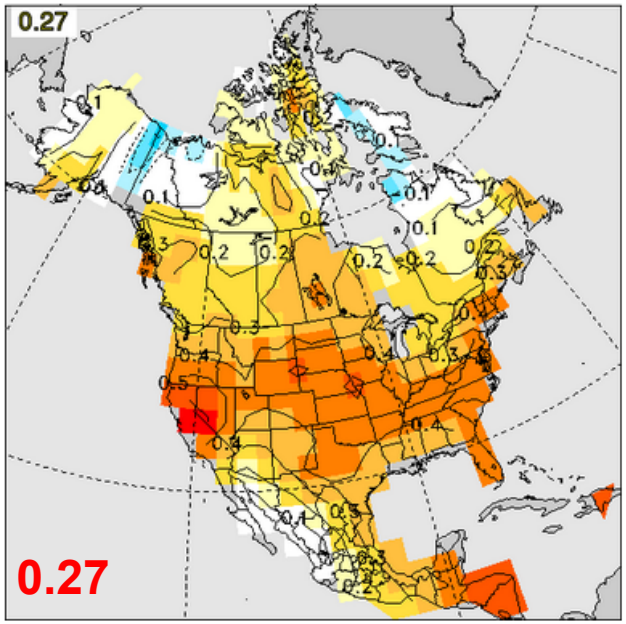
Dependence of soil moisture skill on verification dataset

JJA lead 0 anomaly correlation

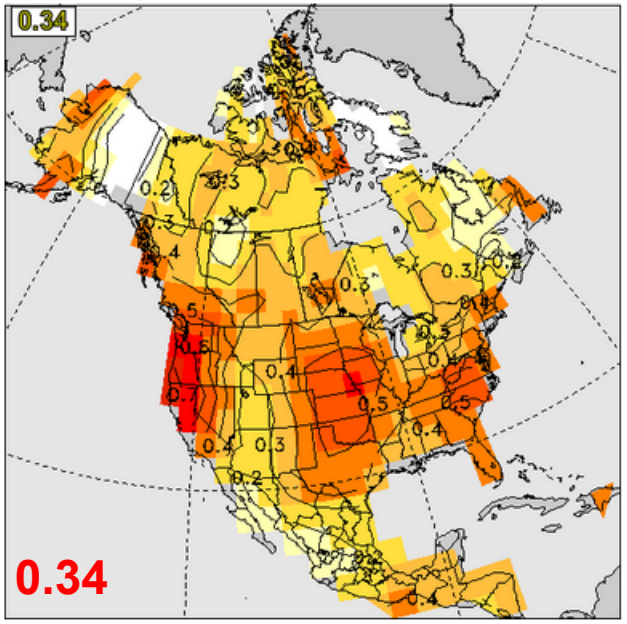
Single-product verifications

Multi-product verification

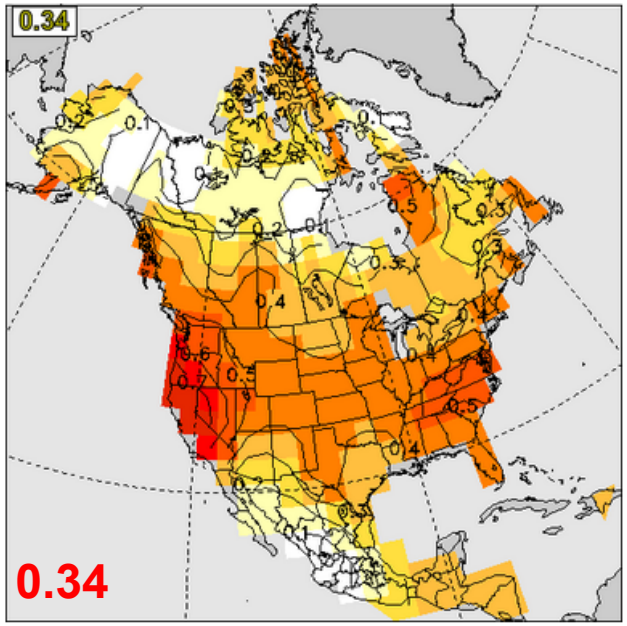
ERA-Int



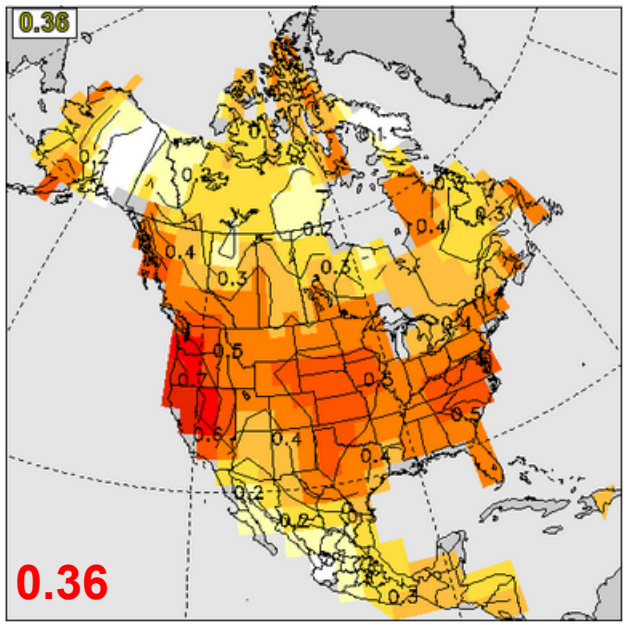
ERA-Int Land



MERRA2



ERA-Int Land – MERRA2



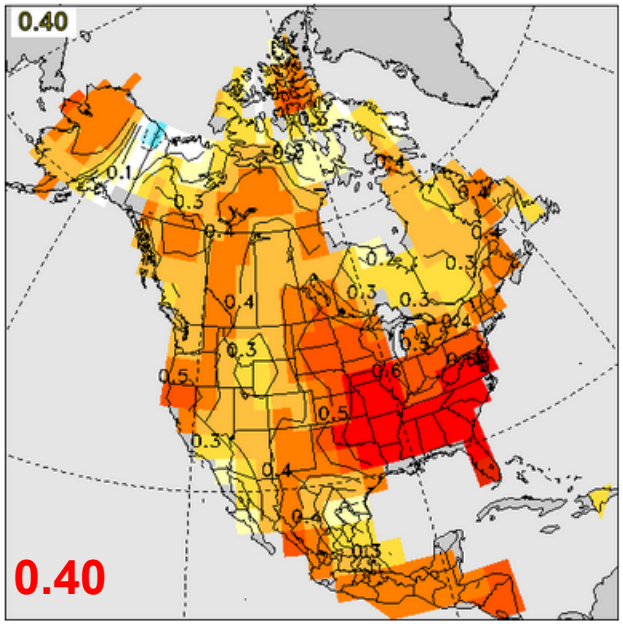
Dependence of soil moisture skill on verification dataset

DJF lead 0 anomaly correlation

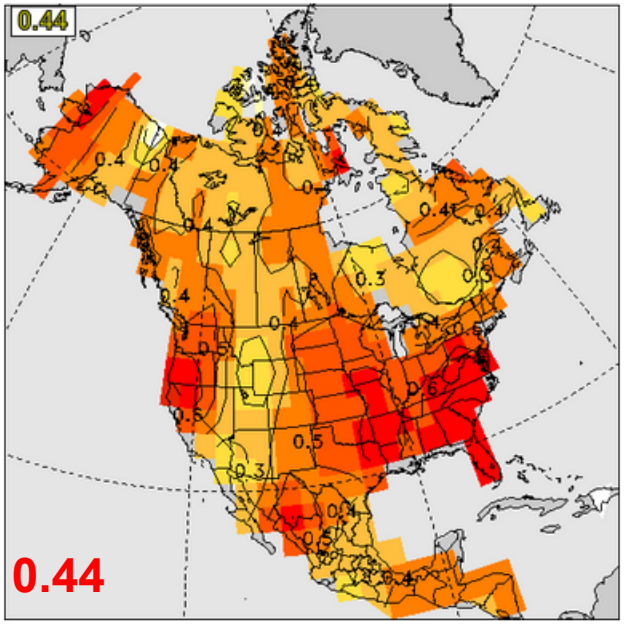
Single-product verifications

Multi-product verification

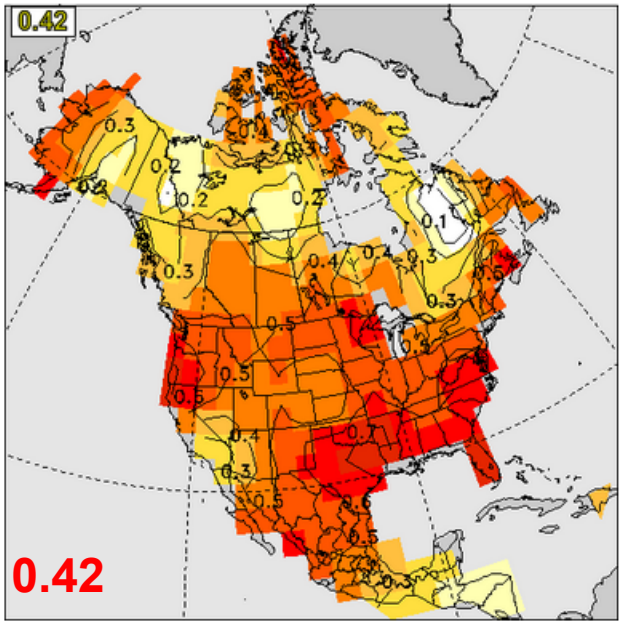
ERA-Int



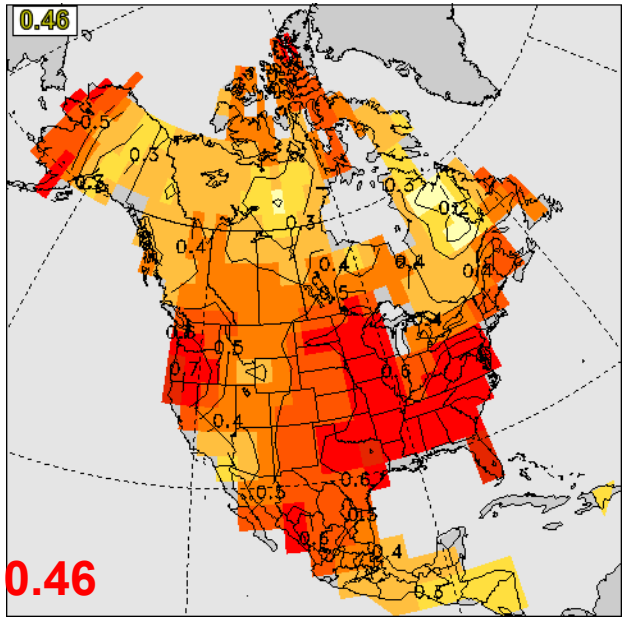
ERA-Int Land



MERRA2



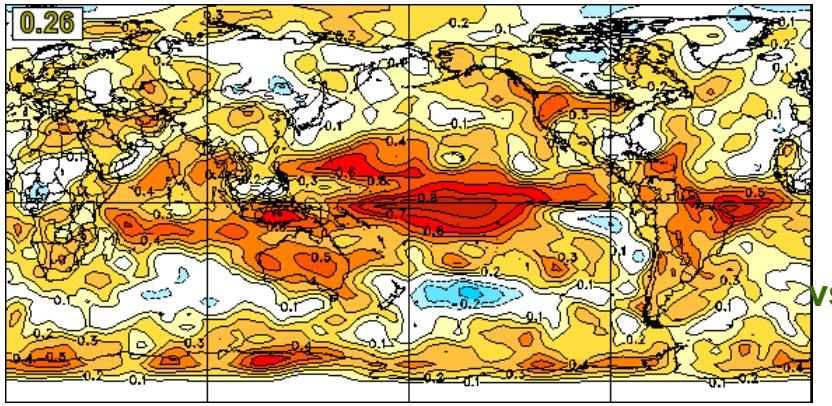
ERA-Int Land – MERRA2



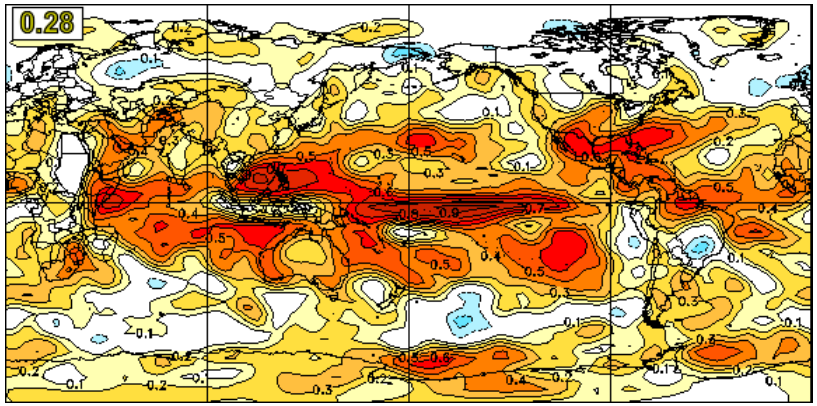
Products of relevance to solar energy

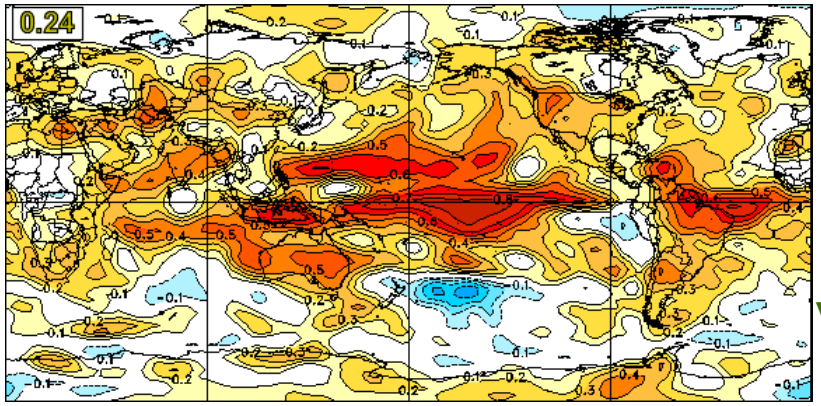
MJJ

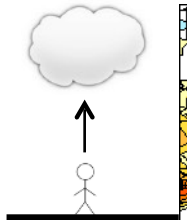
DJF



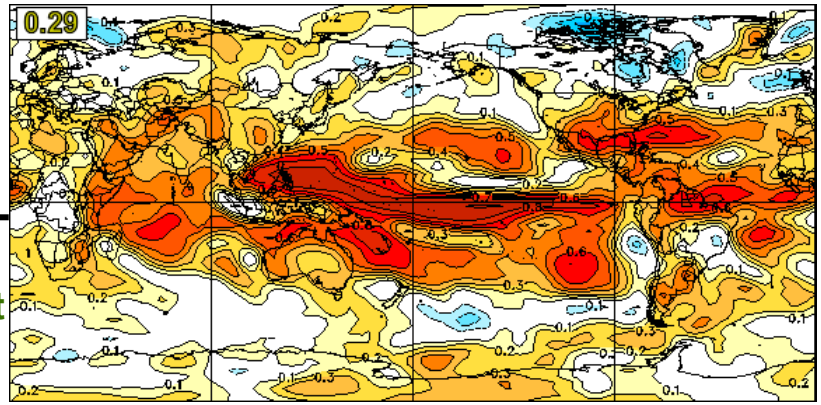
vs ERA Int

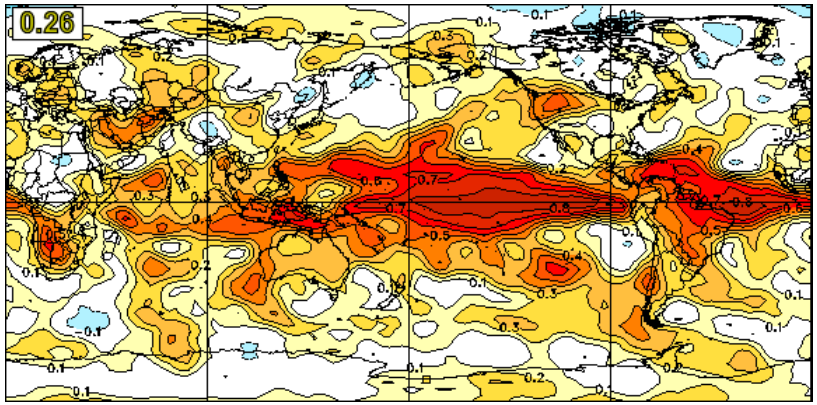




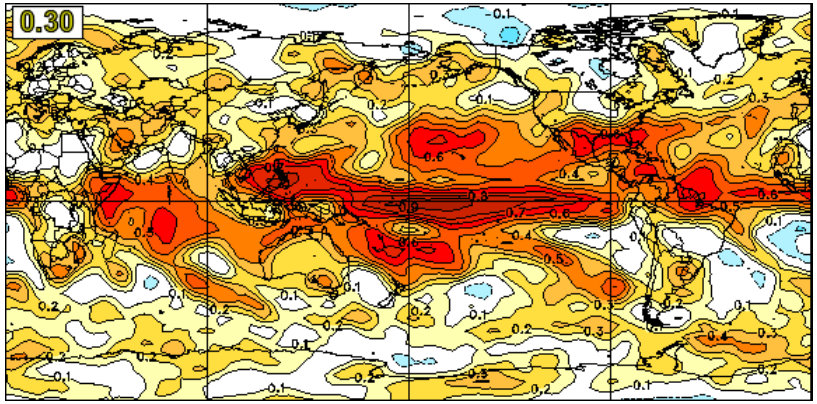


vs ERA Int



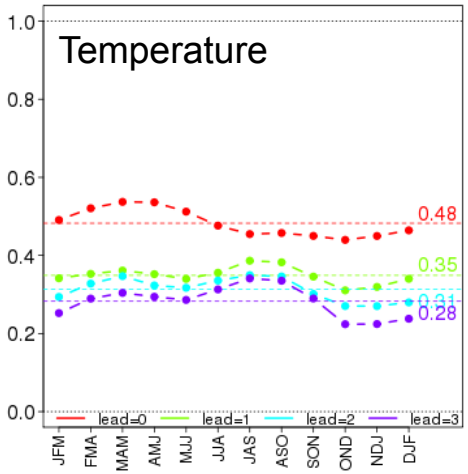


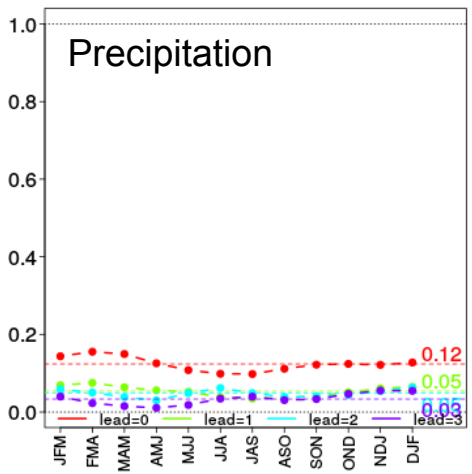
vs GPCP2.2

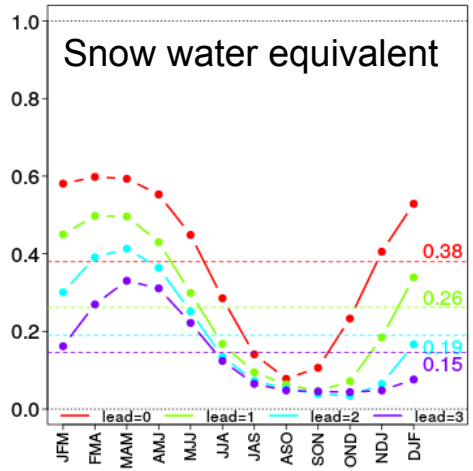


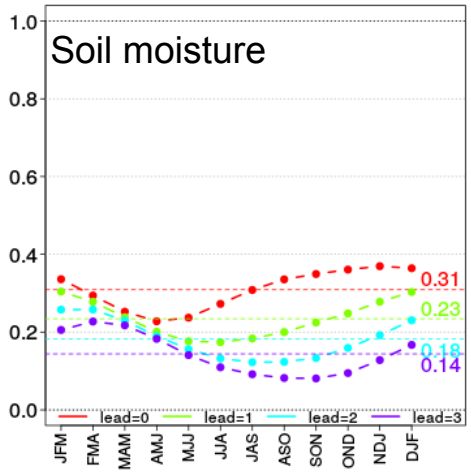
Season and lead time dependence

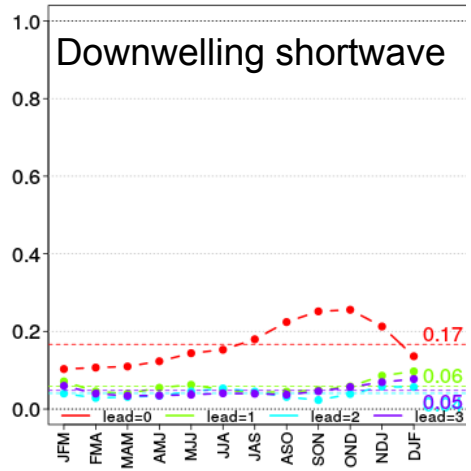
Canada-averaged anomaly correlation

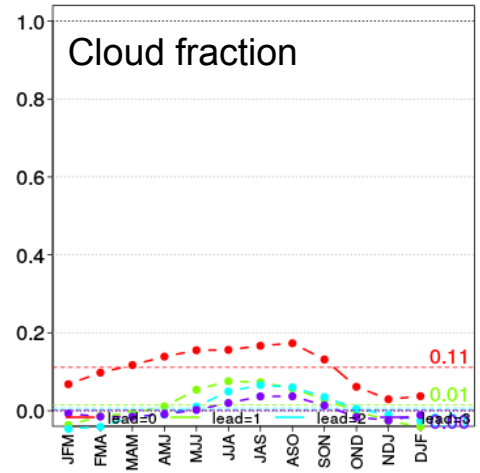


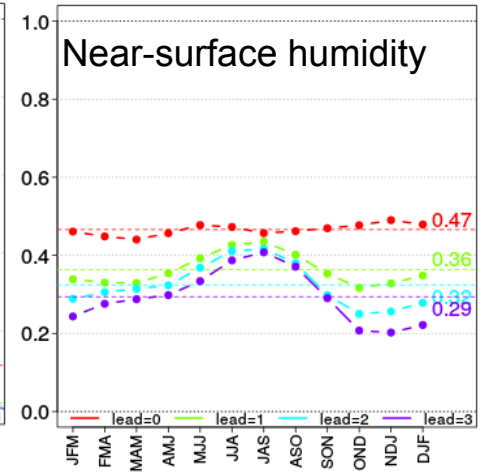












Coming soon: Standardized Precipitation Evapotranspiration Index (SPEI)

Experimental dynamical downscaling

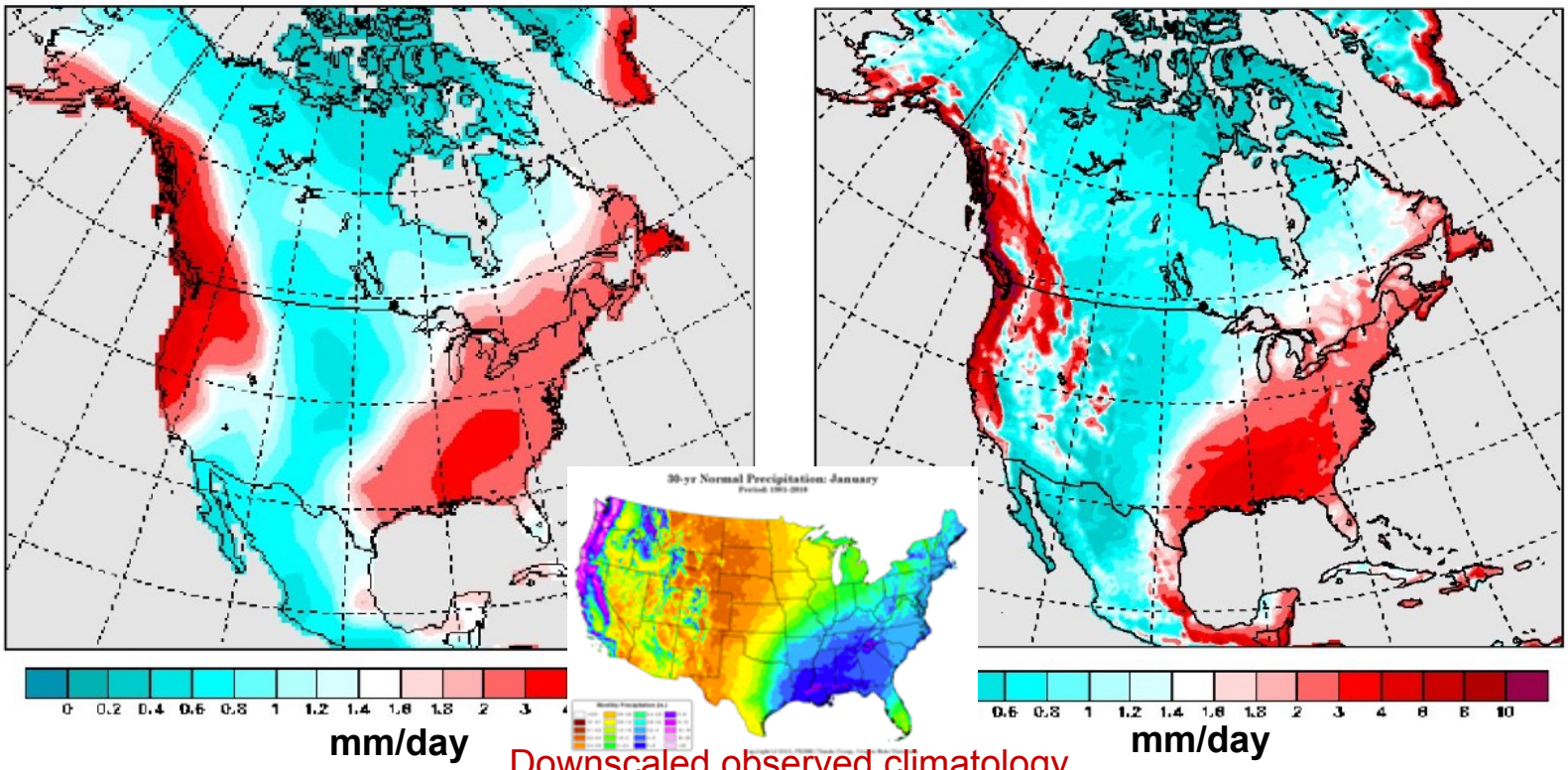
Experimental downscaling of CanSIPS forecasts

- CORDEX North America grid (0.44°/50 km or 0.22°/25 km resolution)
- Could be run concurrently with global forecasts
- Potential to become operational if value demonstrated
- Since last time: hindcasts run & analysed

January climatological precipitation

CanCM4 global Δx≈300km

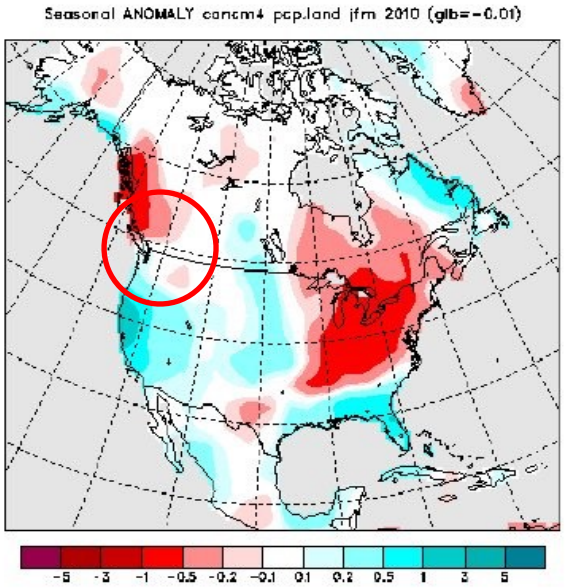
CanRCM4 regional Δx≈25km



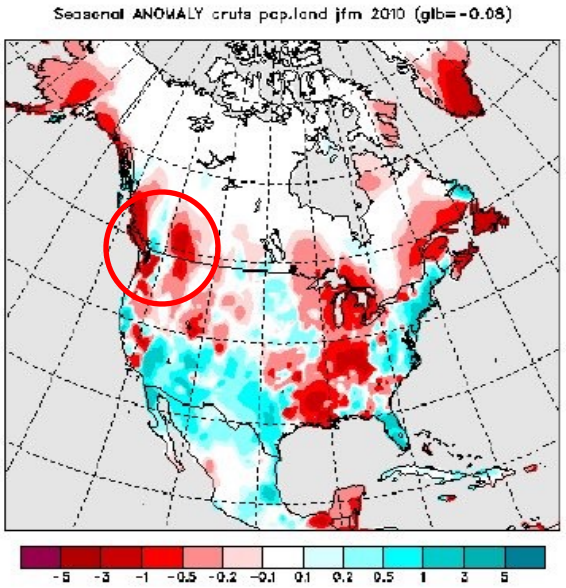
Downscaled observed climatology

Precip
JFM 2010
lead 0

CanCM4 **Forecast ~300km**

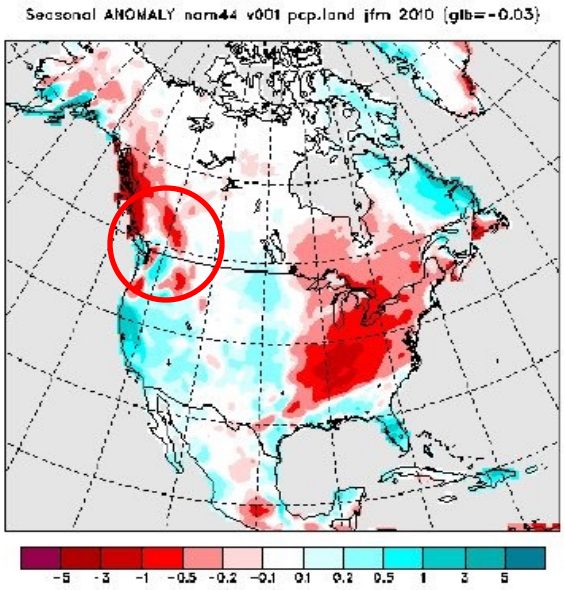


CRUTS **Obs ~50km**

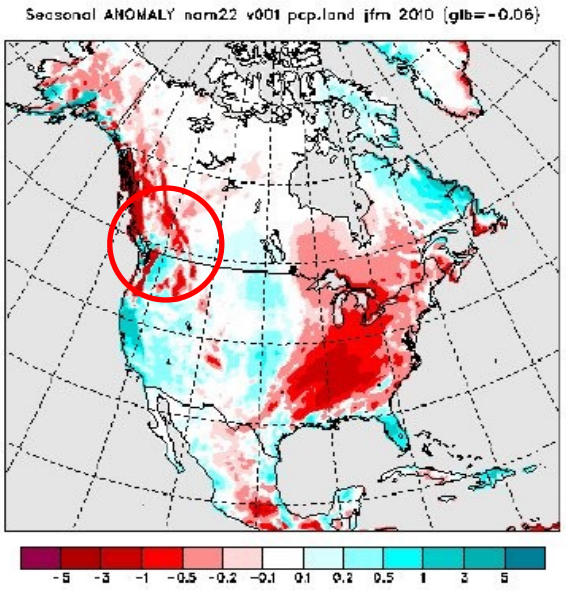


Added value?

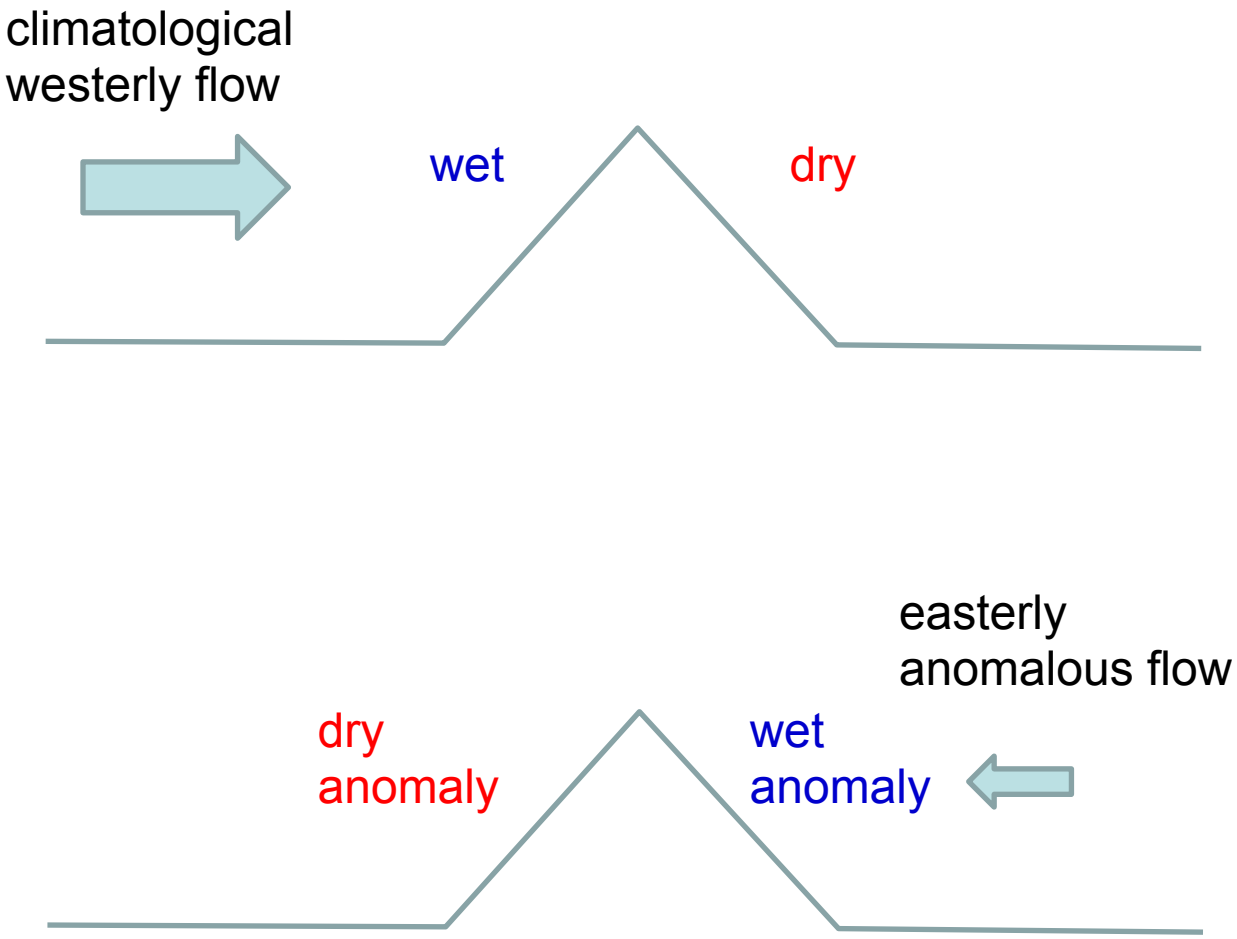
NAM44 **Forecast 50km**



NAM22 **Forecast 25km**



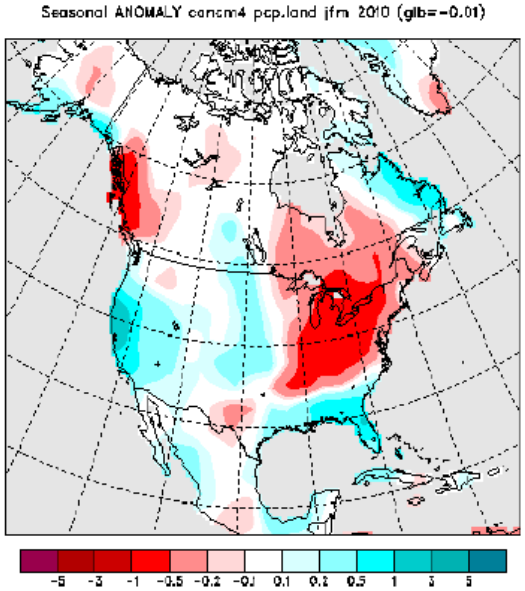
Circulation effects on precipitation in rain shadow



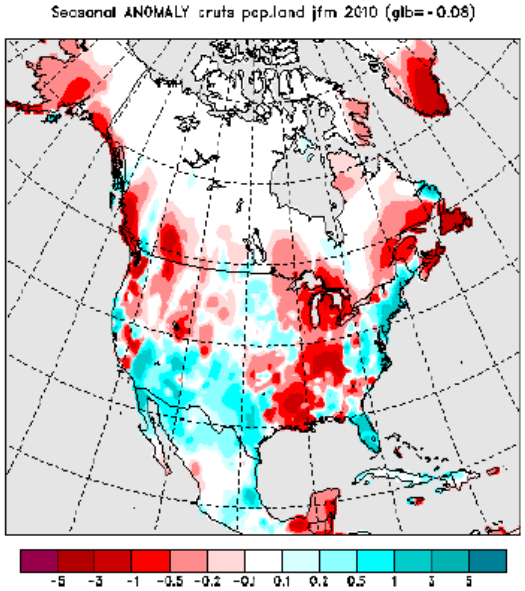
→ Hypothesis: *expect anomalous easterly flow in forecasts having adjacent oppositely-signed anomalies*

PCP anomalies 2010JFM

CanCM4



CRUTS



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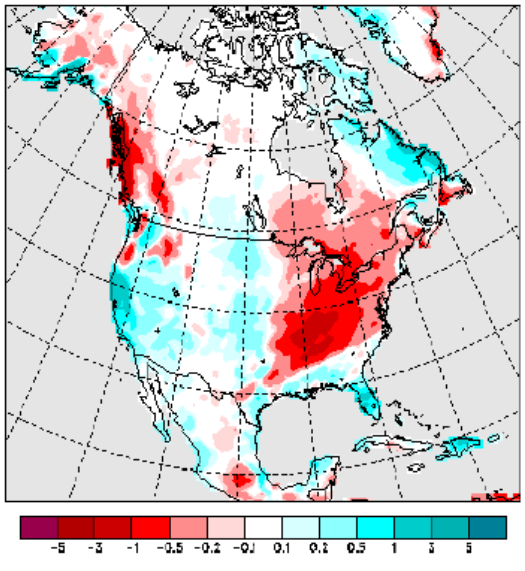

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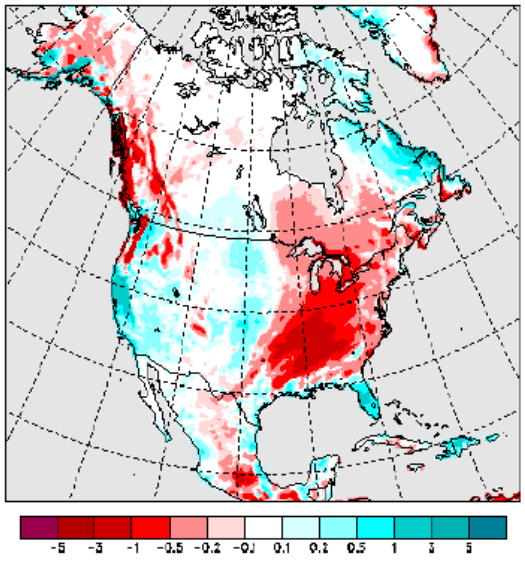
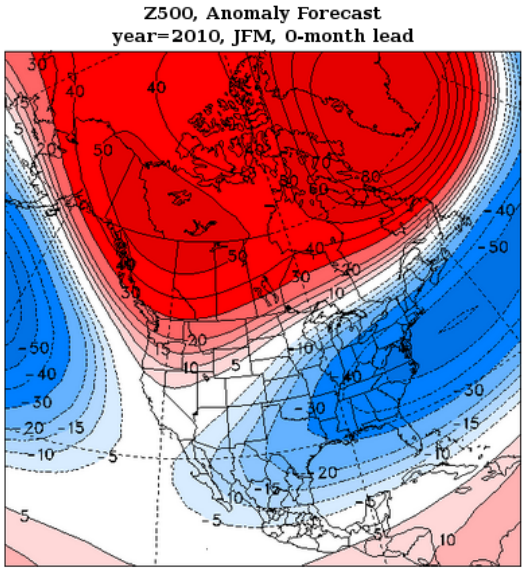
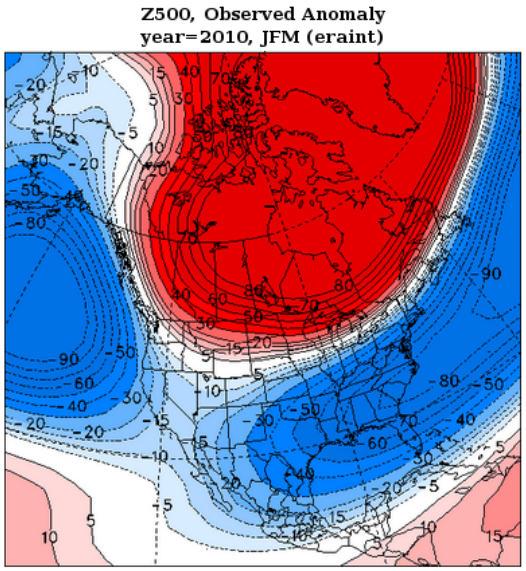


Z500 CanSIPS forecast



Uncalibrated ensemble mean anomaly forecast.

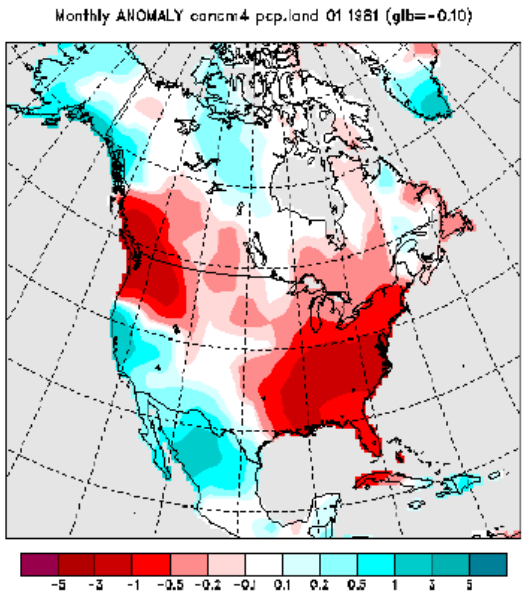
Z500 Era-Interim



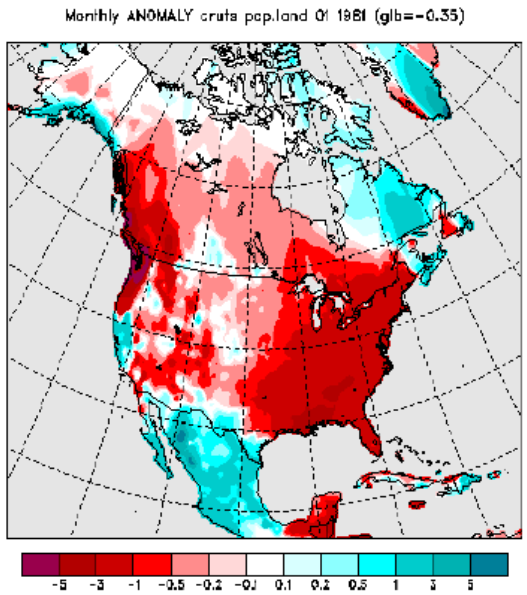
Observed anomaly.

PCP anomalies 1981 01

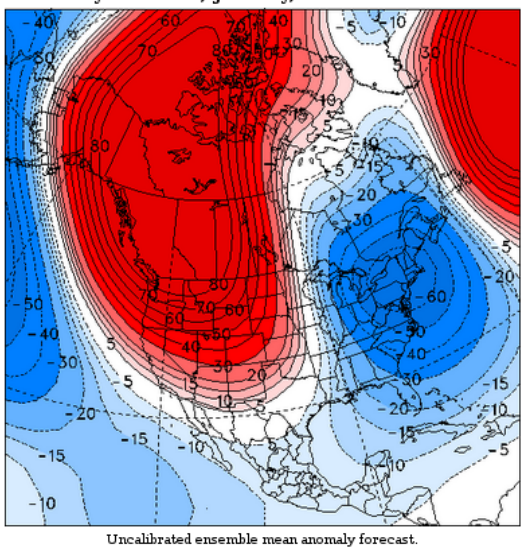
CanCM4



CRUTS



Z500 CanSIPS forecast



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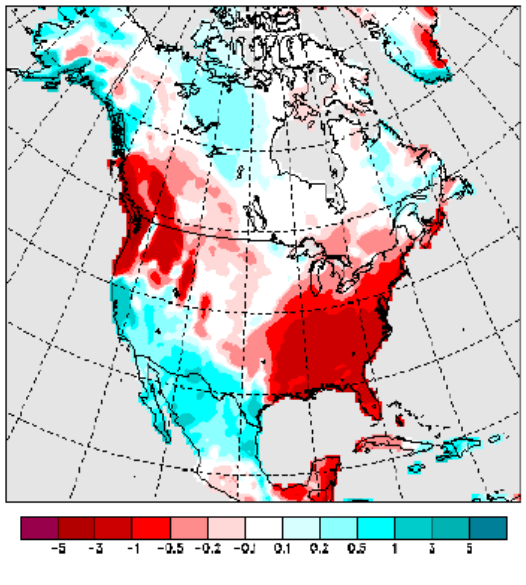
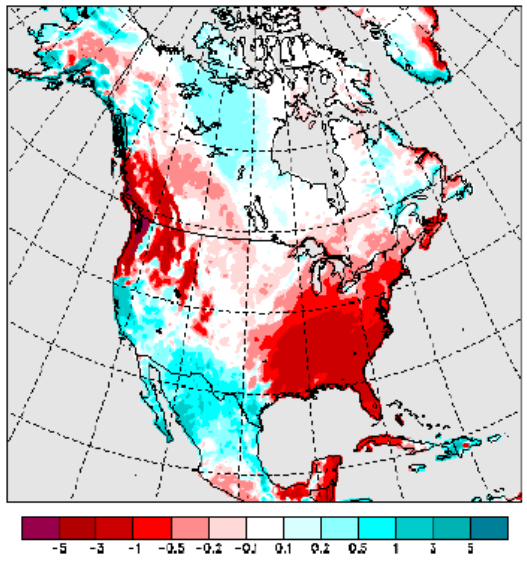
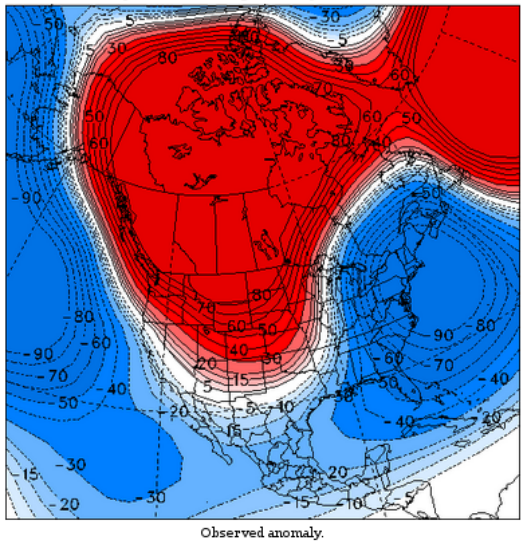


NAM22



Z500 Era-Interim

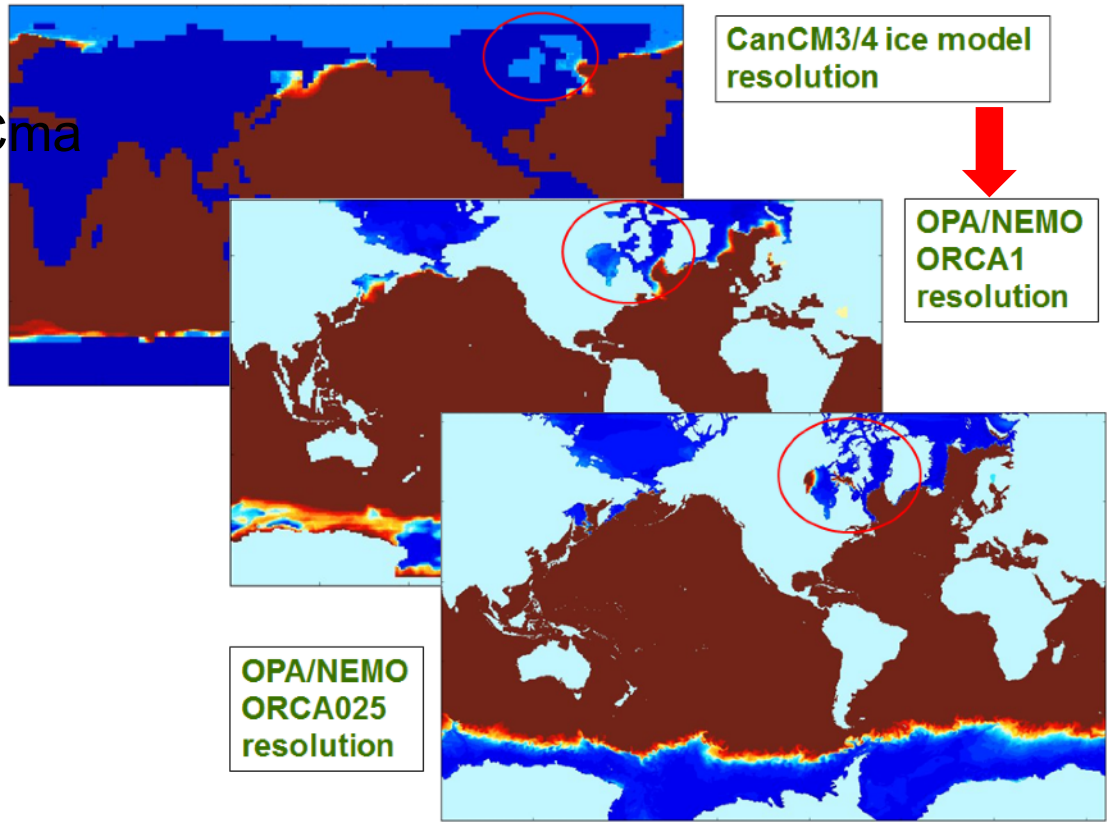


Model development

Prospective new CanSIPS models

- **GEM-NEMO** developed at CMC
  - GEM4 atmospheric component, 1.4° resolution, semi-Lagrangian
  - NEMO/ORCA1 ocean (~30-40 km resolution in Arctic)
  - CICE sea ice model

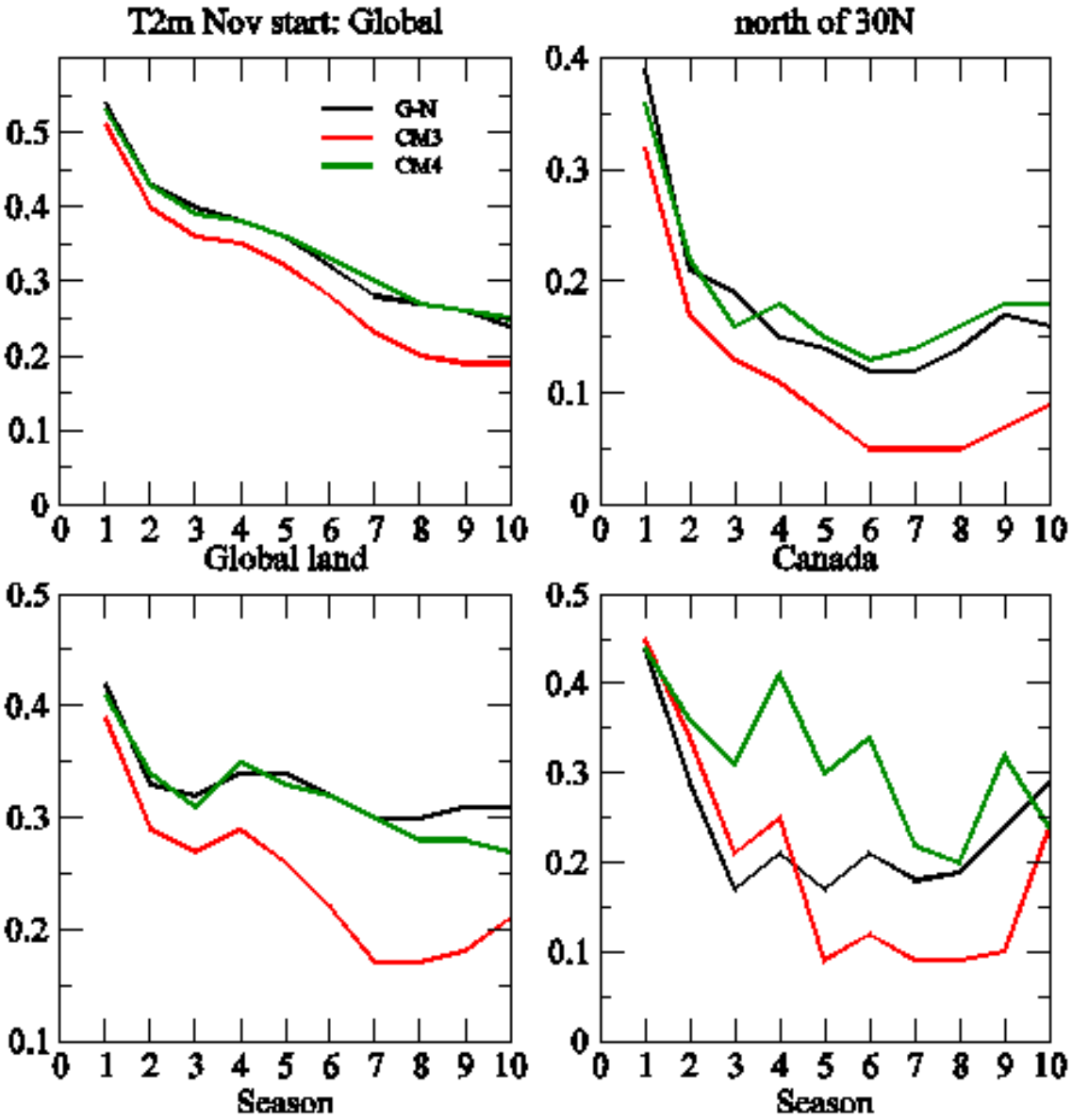
- **CanESM5** developed at CCCma
  - CanAM5 atmospheric component, 2.8° resolution, spectral
  - NEMO/ORCA1
  - LIM2 sea ice model



Initial assessment of GEM-NEMO hindcasts

Area averaged anomaly correlation in indicated regions for Nov initialization

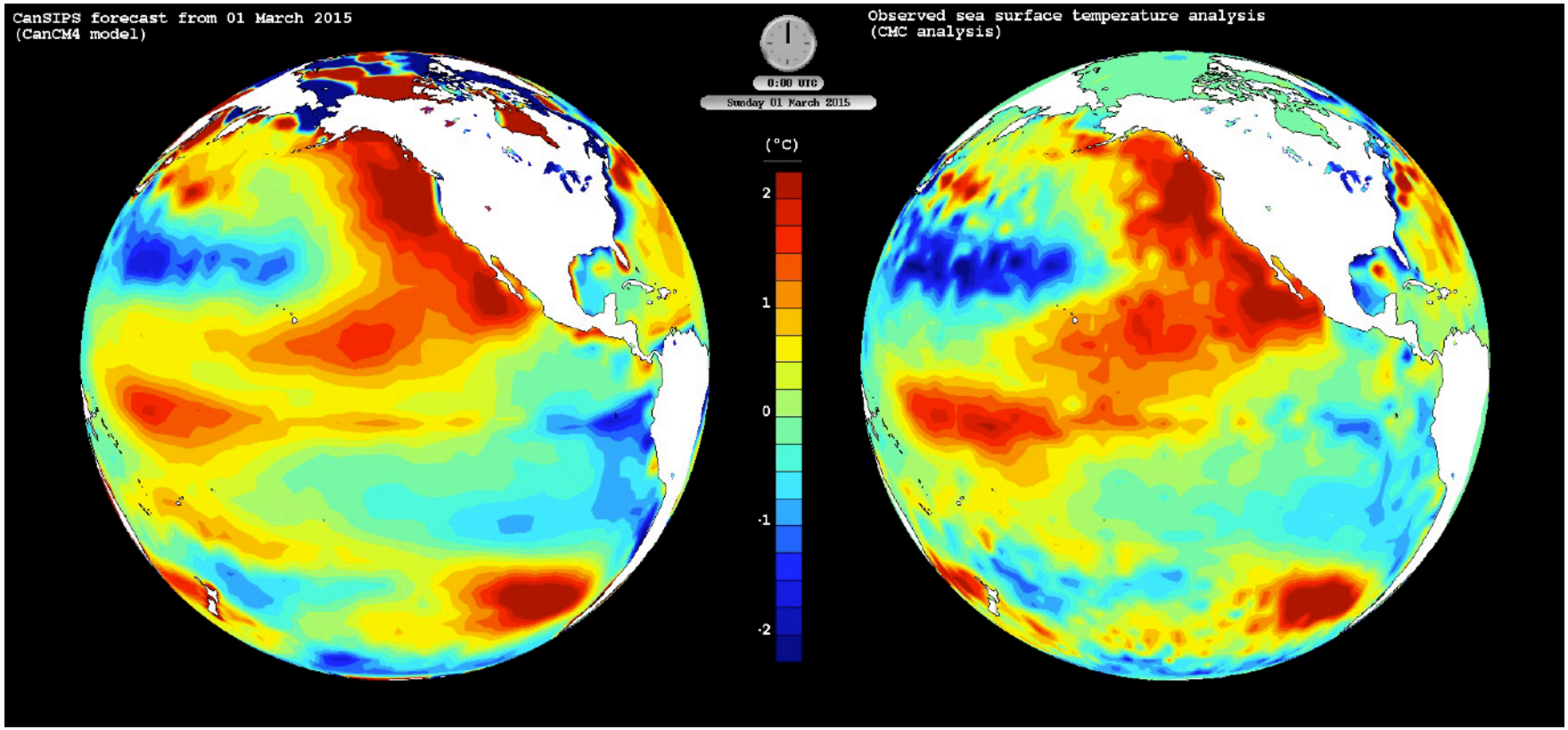
GEM-NEMO
CanCM4
CanCM3



Verification of CanCM4 El Niño forecast from 28 Feb 2016

Daily SST anomalies 1 Mar 2015 - 28 Feb 2016

Predicted (CanCM4 model)	Observed (CMC analysis)



Animation by Jean-Philippe Gauthier and Juan-Sebastian Fontecilla (CCMEP)

CanSIPS snow water equivalent (SWE) forecasts & skill

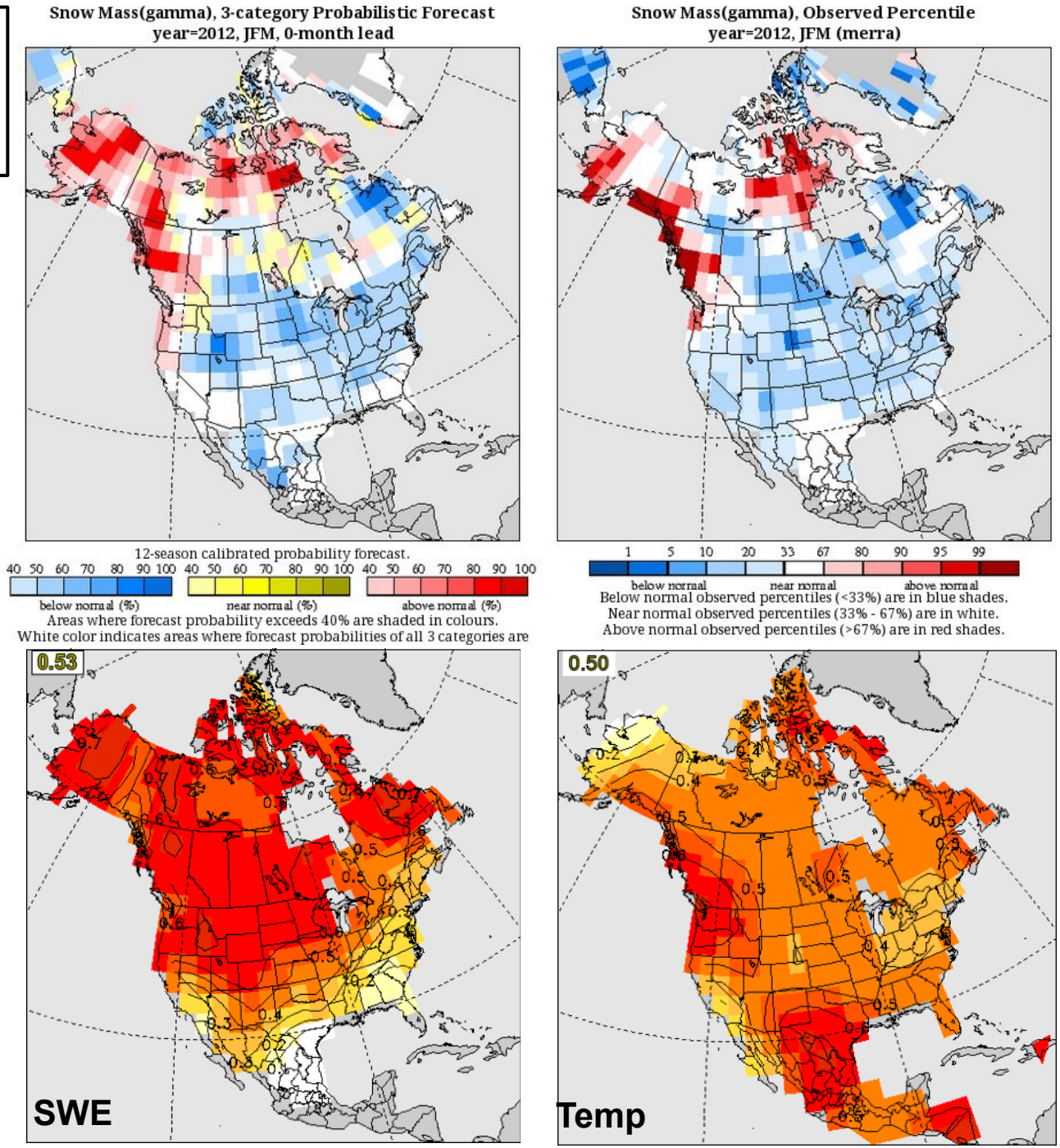
JFM 2012 (lead 0)

- 3-category probabilistic forecast (left)
- MERRA verification (right)

Anomaly correlation

JFM (lead 0)

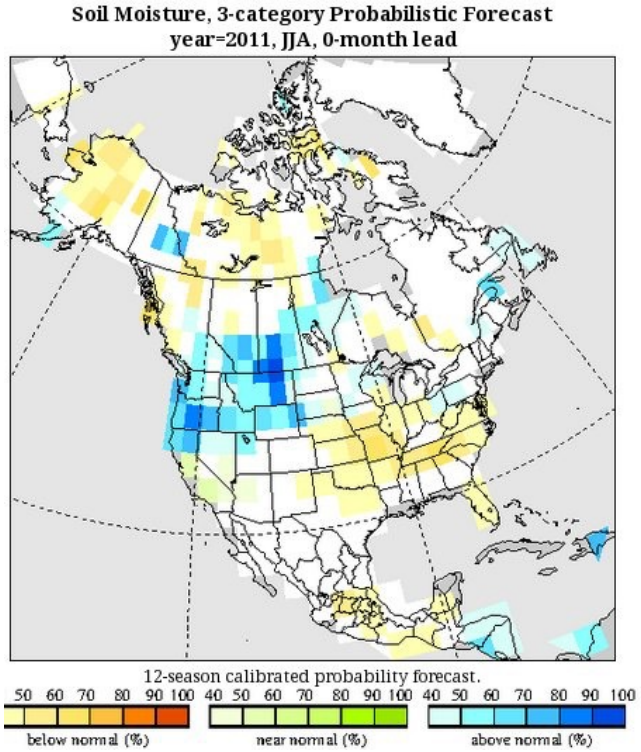
- SWE (left)
- Temperature (right)
- SWE skill attributable to
  - Accurate SWE initialization
  - Tendency for initial snowpack anomalies to persist
  - Ability to predict future climate

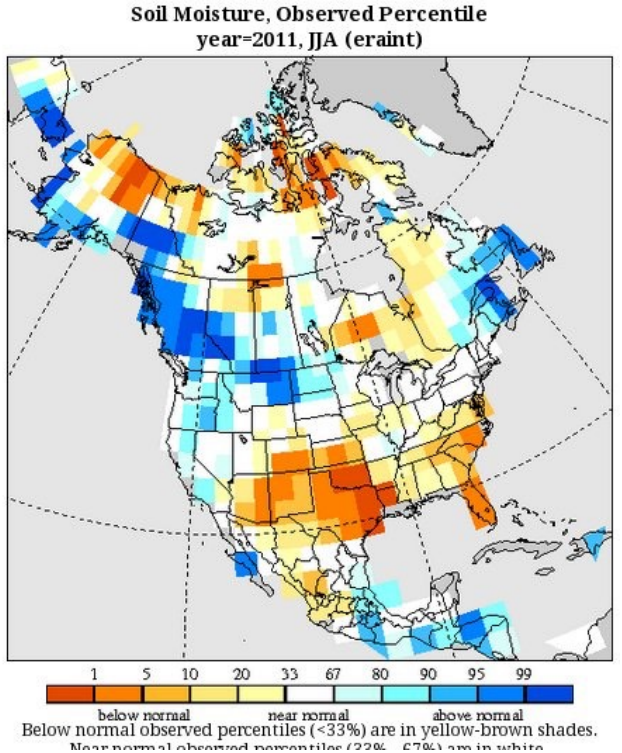


CanSIPS soil moisture forecasts & skill

JJA 2011 (lead 0)

- 3-category probabilistic forecast (left)
- ERA-interim verification (right)

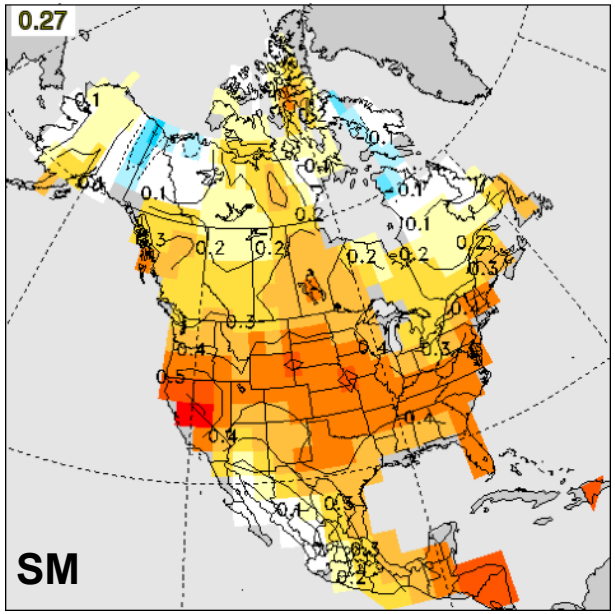


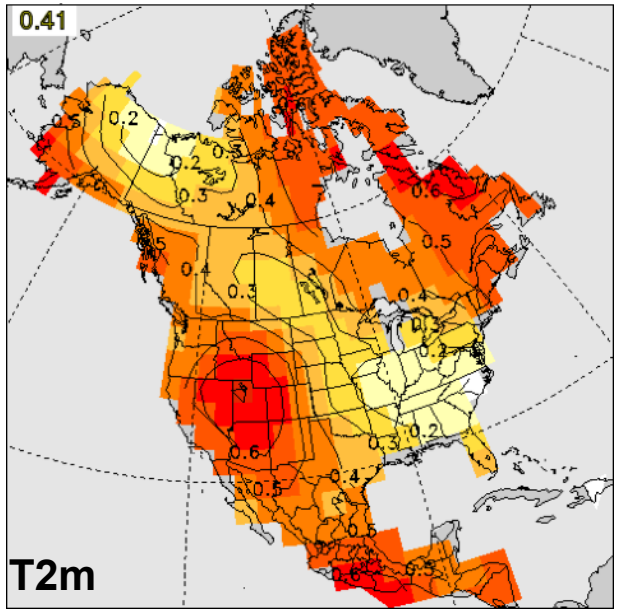


Anomaly correlation*

JJA (lead 0)

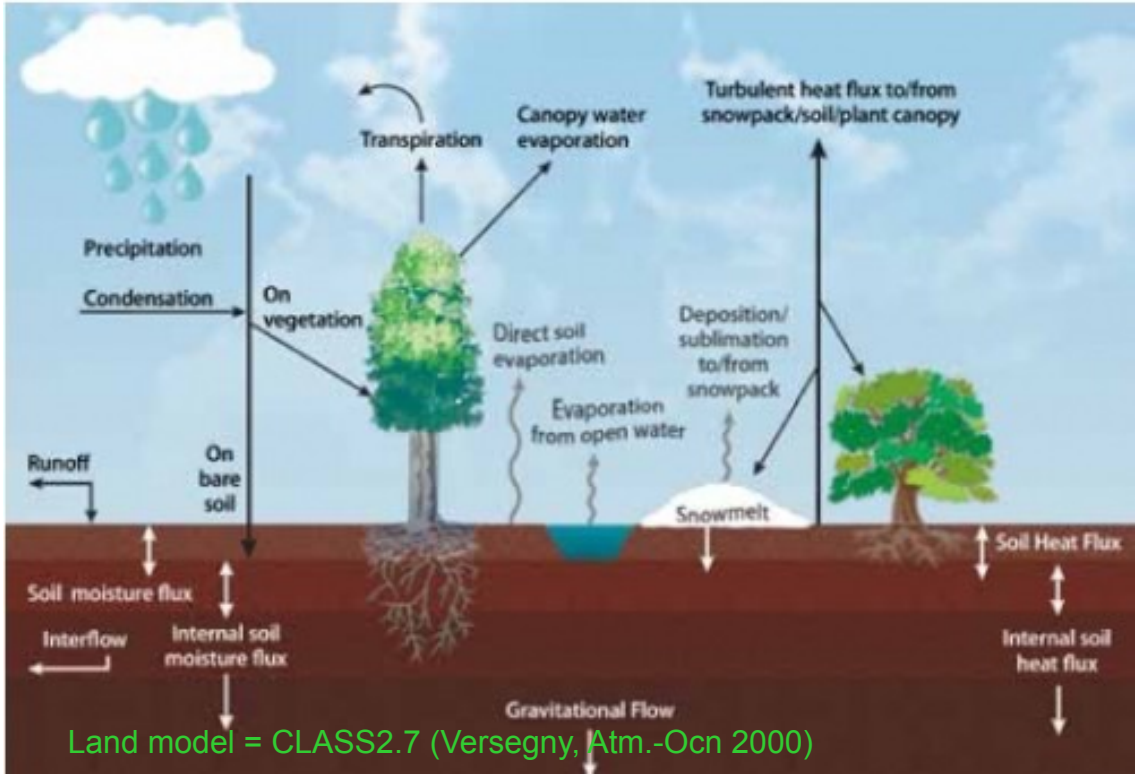
- Soil moisture (left)
- 2m temperature (right)





*ERA-interim verification

CanSIPS Land initialization

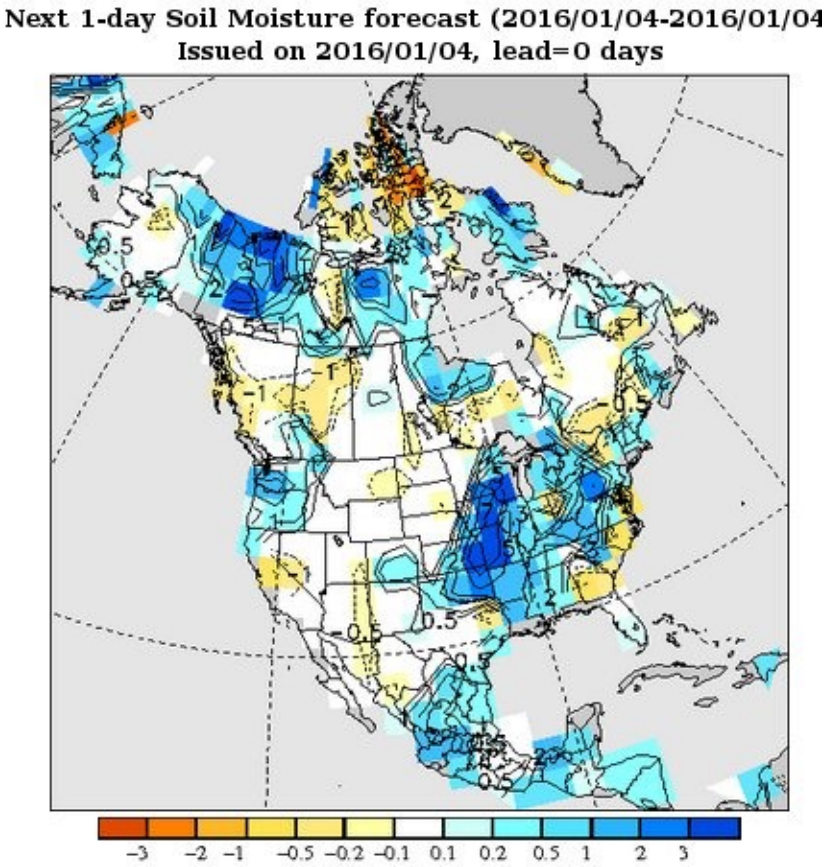


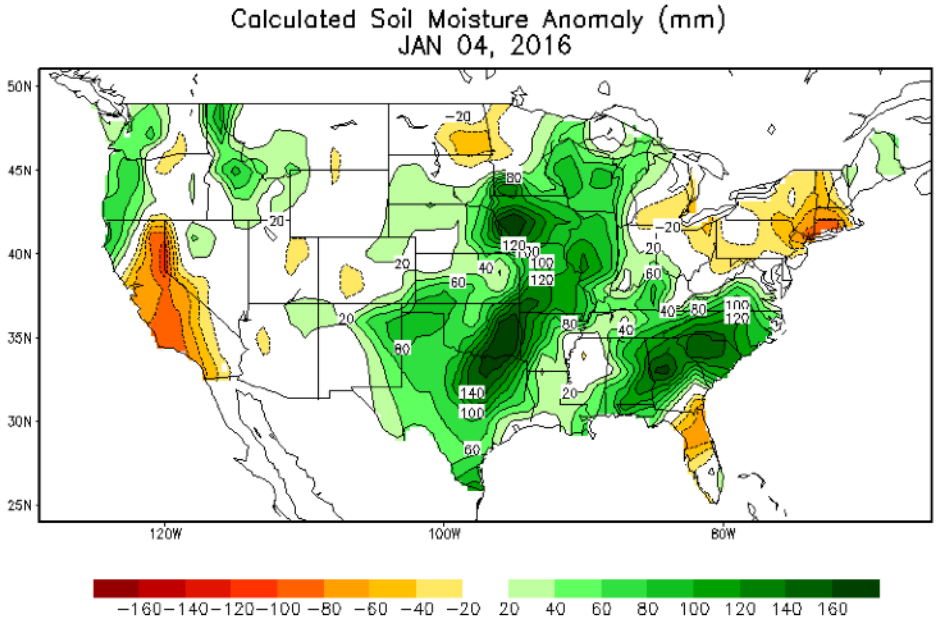
www.eoearth.org/view/article/152990

Direct atmospheric initialization through 4D assimilation of 6-hourly T, q, u, v using incremental analysis update (~nudging)

Indirect land initialization through response to model atmosphere

Efficacy of CanSIPS soil moisture initialization: 1st-day forecast vs NCEP daily analysis

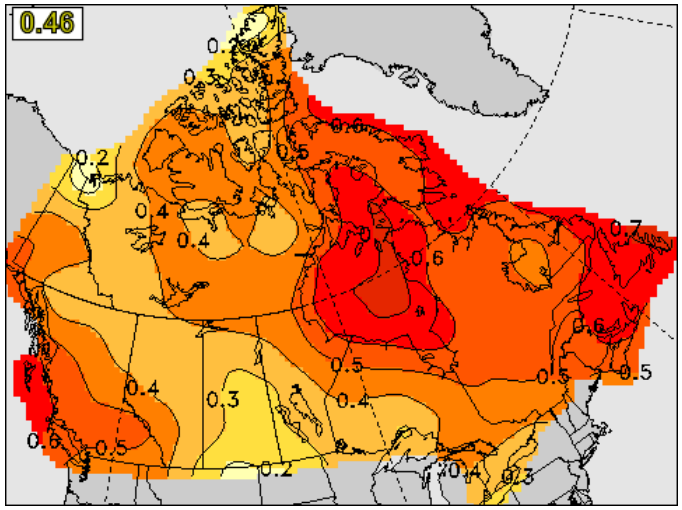




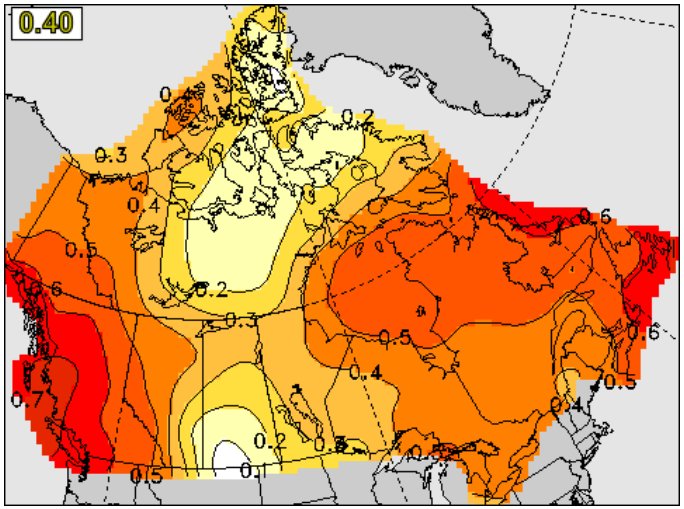
http://www.cpc.ncep.noaa.gov/soilmst/index_jh.html

Near-surface specific humidity

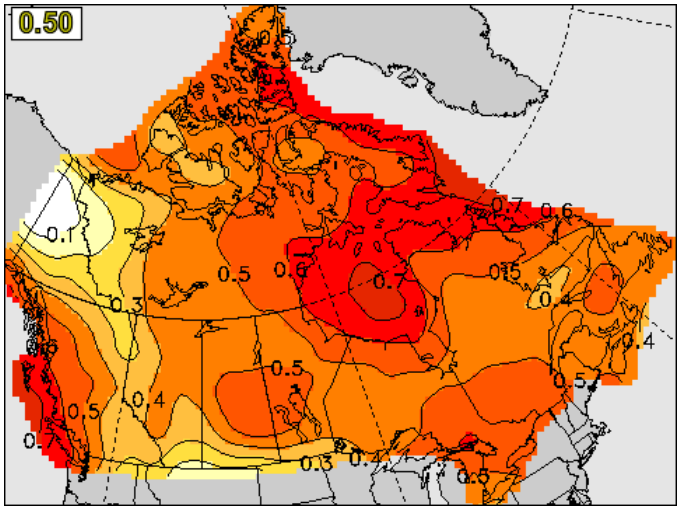
DJF (Lead 0 months)



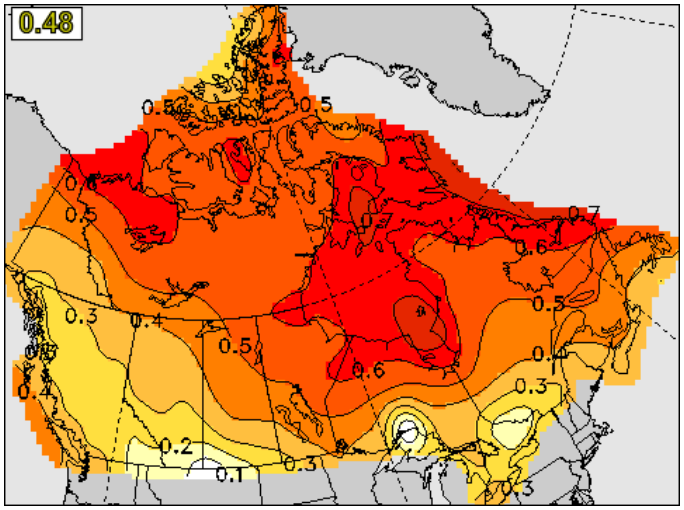
MAM (Lead 0 months)



JJA (Lead 0 months)



SON (Lead 0 months)



ERA-interim verification

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
- Forecasts from January extended to decadal (CanCM4 only)