North American Multi-Model Ensemble (NMME): Development, products, and activities

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NMME

The North American Multi-Model Ensemble

- **NMME** (North American Multi-Model Ensemble) is an unprecedented MME system intended to improve intra-seasonal to interannual (ISI) operational predictions based on the leading US and Canada climate models.
- Seasonal forecasting guidance available monthly, following CPC operational forecasting schedule, since August, 2011.
- All participating models strictly follow the same protocol.

www.cpc.ncep.noaa.gov/products/NMME

Why MME? Why the NMME?

- Models are imperfect: biases and poor estimations of their own skill.
- Performance of multi-model ensembles is better than single models; skill increase comes from error cancellation and non-linearity of diagnostics.
- Several earlier projects (DEMETER, ENSEMBLES, etc.) have tested the theory of MME.
- Users require predictions with minimal uncertainty accompanied by reliable estimates of that uncertainty.
- NCEP was recommended by the National Research Council to implement an NMME system to improve ISI forecasting.

Palmer et al. (2004), BAMS

National Research Council (2010)

Developing the NMME

- Initial planning meetings in February and April of 2011 held by NOAA's Climate Test Bed (CTB) to bring together the participants.
- All major US global coupled atmosphere-ocean climate models were represented (Canadian models joined Year 2).
- First forecasts issued in August 2011.
- **NMME Phase-I**: An experimental system initiated as a Climate Test Bed (CTB) research project supported by CPO/MAPP in FY11. "NMME of opportunity."
- **NMME Phase-II**: An **improved** experimental system as a FY12-FY13 MAPP/CTB research project with additional support from NSF, DOE and NASA. Includes subseasonal timescales.

Kirtman et al. (2014), BAMS

Phase I protocol

- Monthly-mean forecasts
- Specifications:
  - 1° longitude x 1° latitude horizontal resolution
  - 3 primary variables (T2m, prate, SST)
  - Hindcasts from 1982-2010 (at least)
  - At least 9-month lead forecasts
  - Delivered by 1700h Eastern on the 6th of each month
- All data (hindcast and forecast) is archived and available to the public.

http://iridl.ldeo.columbia.edu/SOURCES/.Models/.NMME/

MODELS Aug 2011 - present

- Four models continue from year 1
  - **CFSv2, GFDL CM2.1, NASA GEOS5, NCAR CCSM3**
  - CFSv1, IRI's ECHAMa and ECHAMf retired Aug. 2012
- Two models continue from year 2
  - EC's **CanCM3, CanCM4**
- GFDL's **FLORa06 and b01** introduced in March
  - Combined into one for RT forecasts starting May 2014
- **NCAR CCSM4** introduced in May

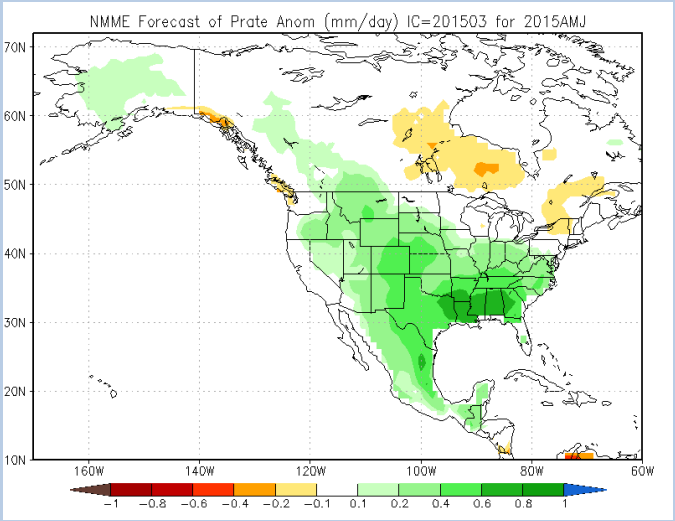
www.cpc.ncep.noaa.gov/products/NMME

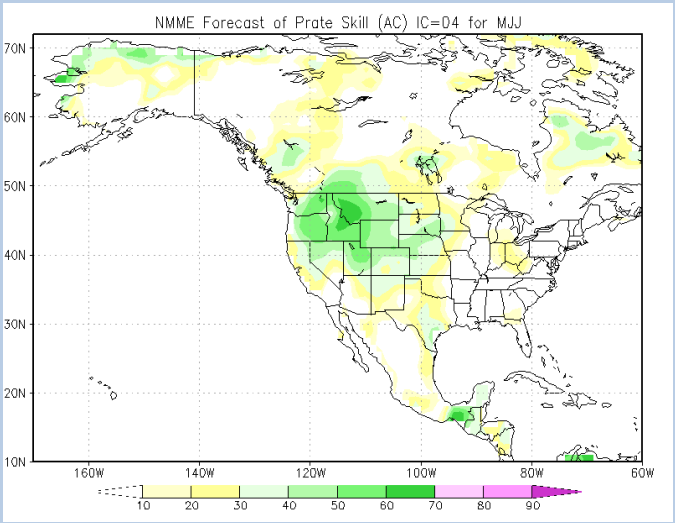
NMME

The North American Multi-Model Ensemble

Phase I products

- 2 m temperature, precip rate, SST
- Available forecasts and products, August 2011:
  - 1-month mean spatial anomalies
  - 3-month mean spatial anomalies
  - Niño3.4 plumes
  - Skill maps based on anomaly correlation from hindcasts



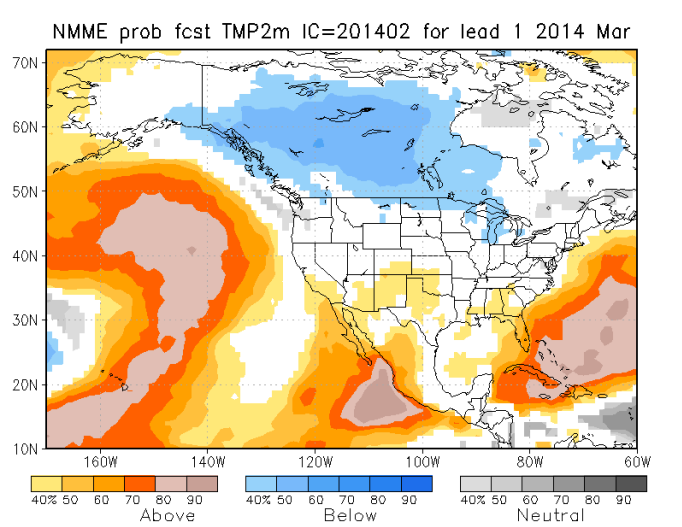


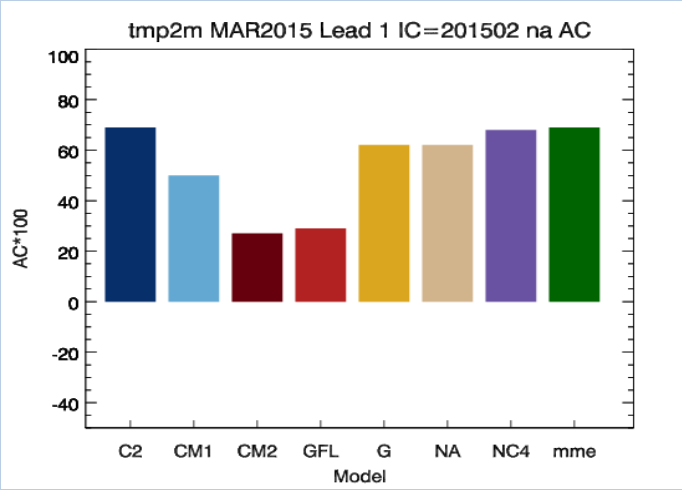
NMME

The North American Multi-Model Ensemble

Phase I products

- Experimental probability forecasts (Nov. 2012)
- Deterministic forecasts of additional variables: 200 hPa heights, Tmax, Tmin, soil moisture*, runoff* (May 2013)
- Real-time verif. (Nov. 2013)
- Probabilistic Tmax/Tmin forecasts (June 2015)





National Weather Service

Climate Prediction Center

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HOME > NMME Forecasts of Monthly Climate Anomalies

Welcome to the North American Multi-Model Ensemble home!

3-month mean spatial anomalies
1-month mean spatial anomalies

Niño3.4 Plumes
International MME
Experimental: Probability forecasts
Preview: additional variables
Real-time verification (preliminary)

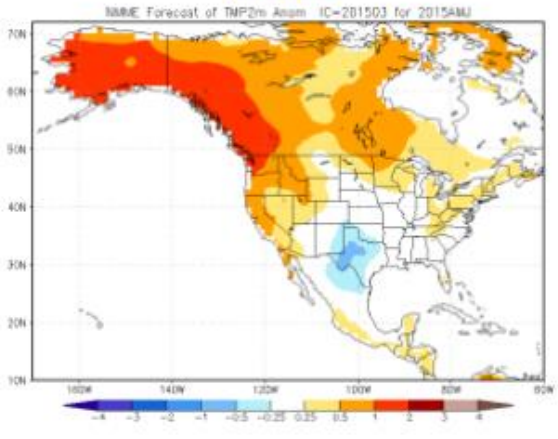
NMME Realtime Forecasts **Archive**
***** Data Access *****

About the NMME
Join the NMME mailing list

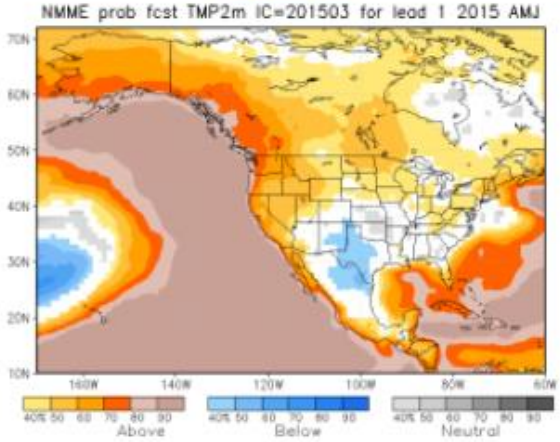
For additional information, contact Qin Zhang (**Qin.Zhang@noaa.gov**) or Emily Becker (**Emily.Becker@noaa.gov**)

Season 1 tmp2m forecast

NMME



Prob fcst



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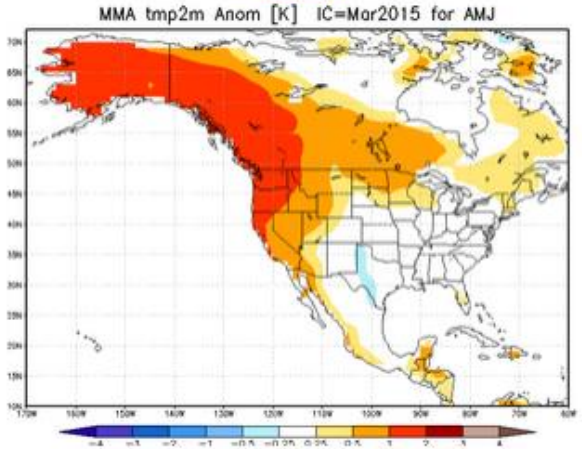
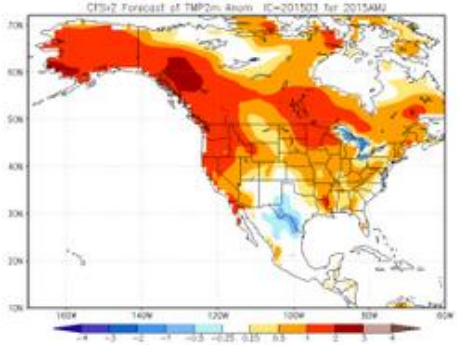
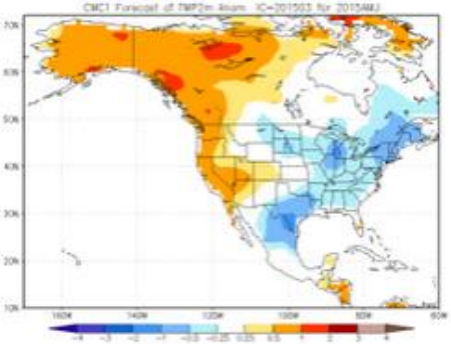


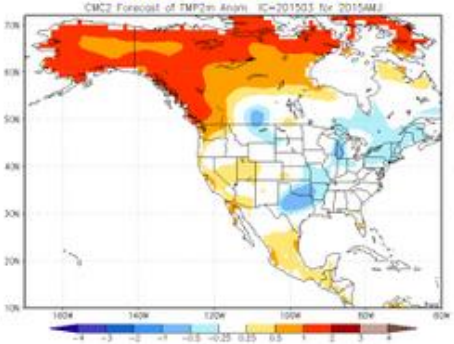
NCEP CFSv2



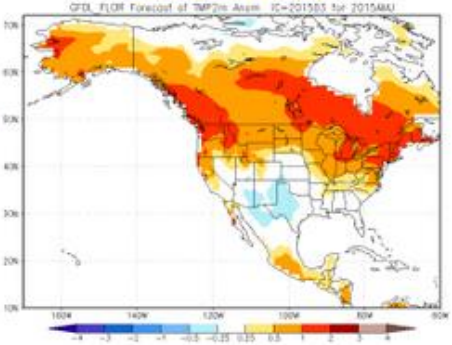
CMC1 CanCM3



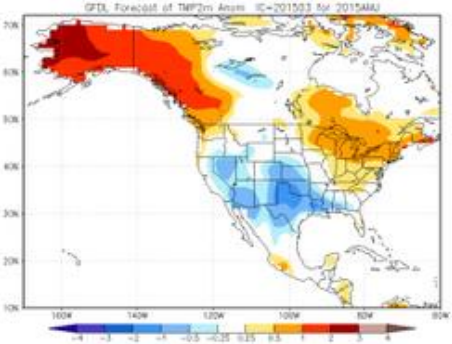
CMC2 CanCM4



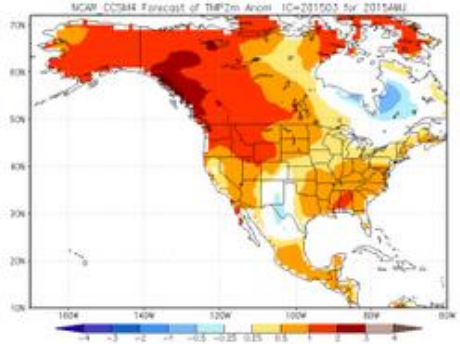
GFDL FLOR



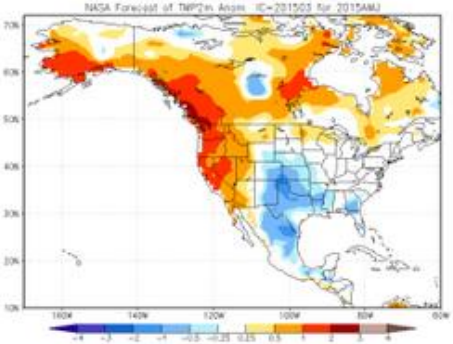
GFDL CM2.1



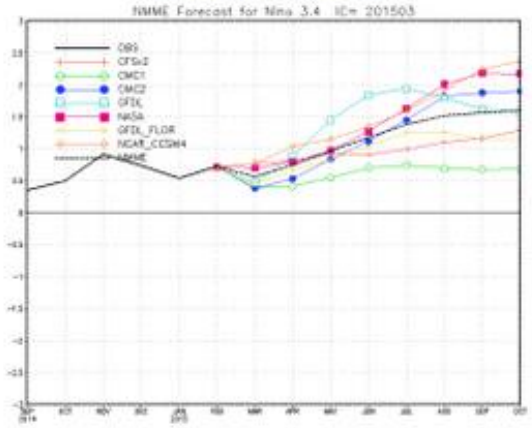
NCAR CCSM4



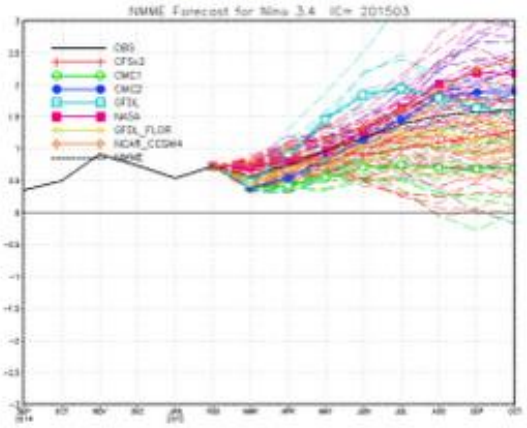
NASA GEOS5



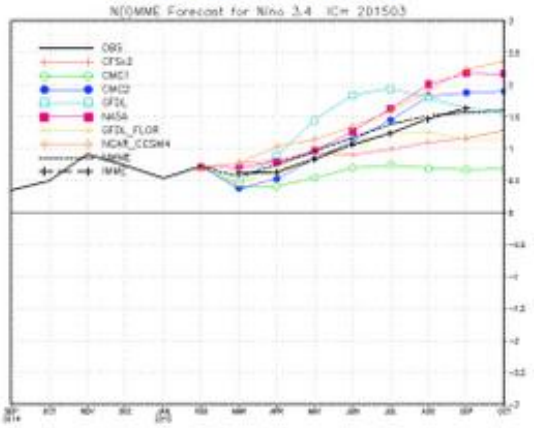
Ensemble Mean



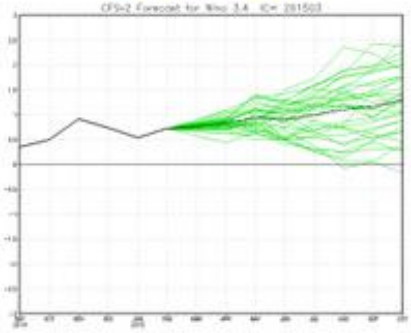
All Members



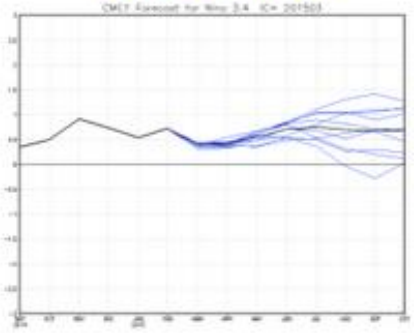
Ens Mean + IMME



CFSv2_CFSv2



CMC1_CanCM3



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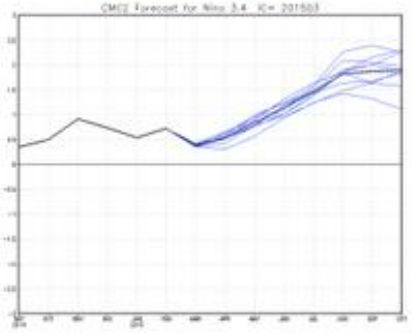
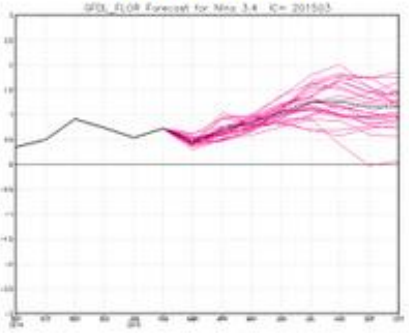
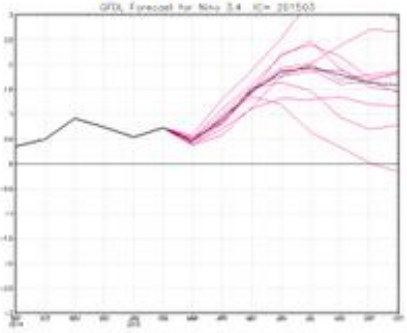


GFDL_FLOR



GFDL_CM2.1



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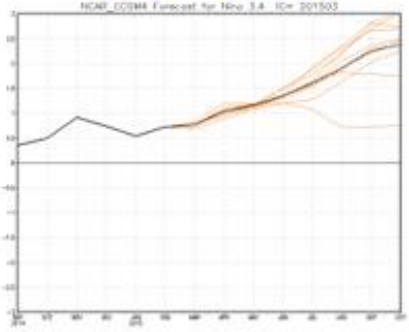

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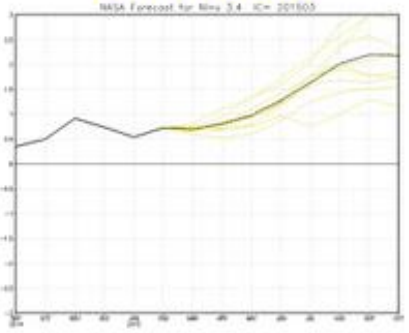
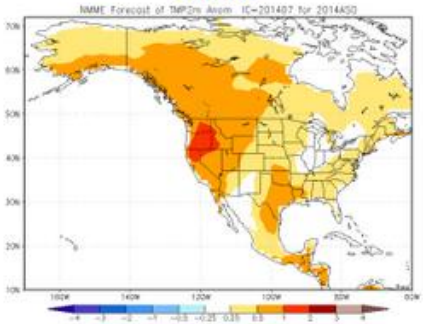
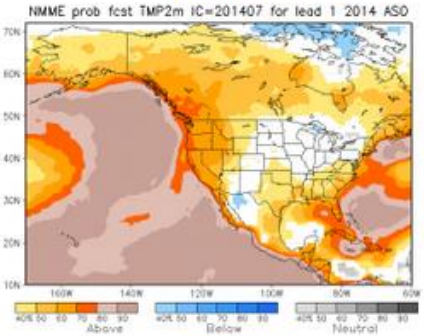


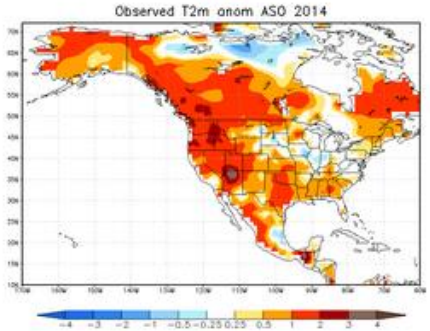
NMME



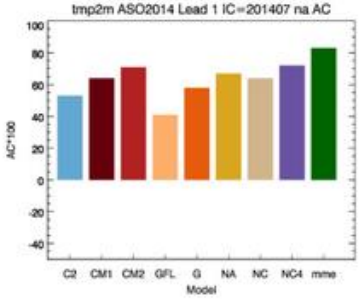
Prob fcst



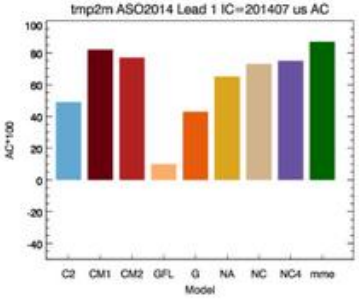
obs



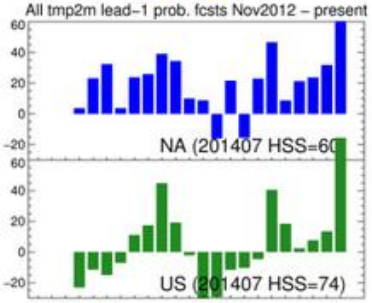
North Amer. AC



CONUS AC



Heidke SS



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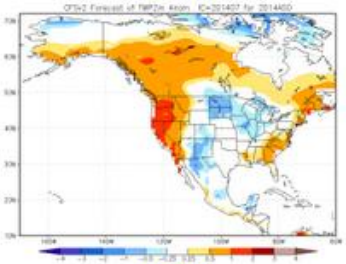

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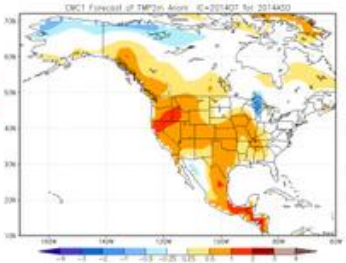

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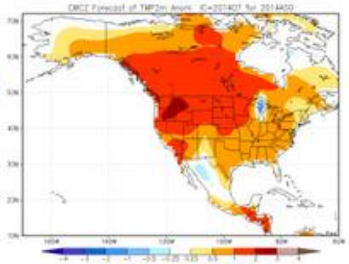
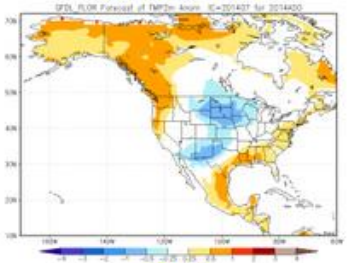


GFDL_FLOR



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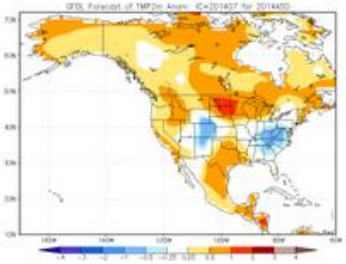

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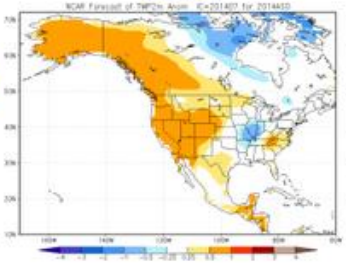

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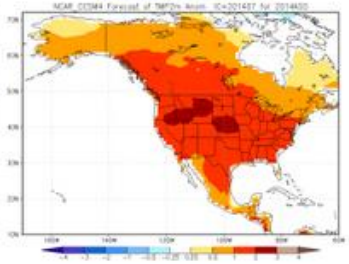
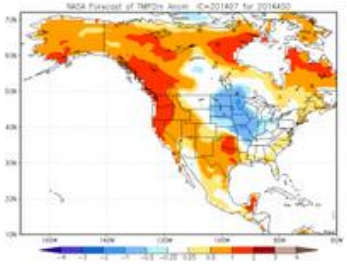


NASA

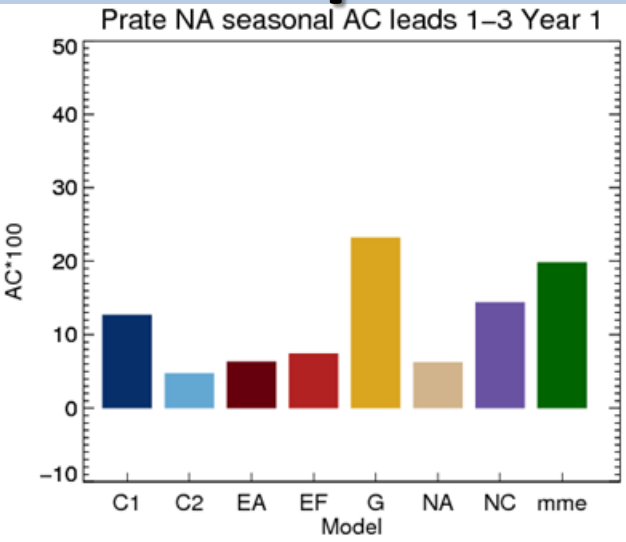


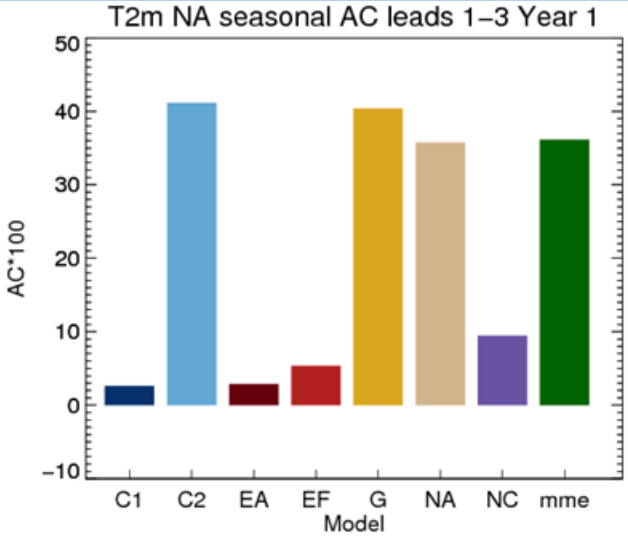
Real-time verification (Years 1 & 2)

Precip rate

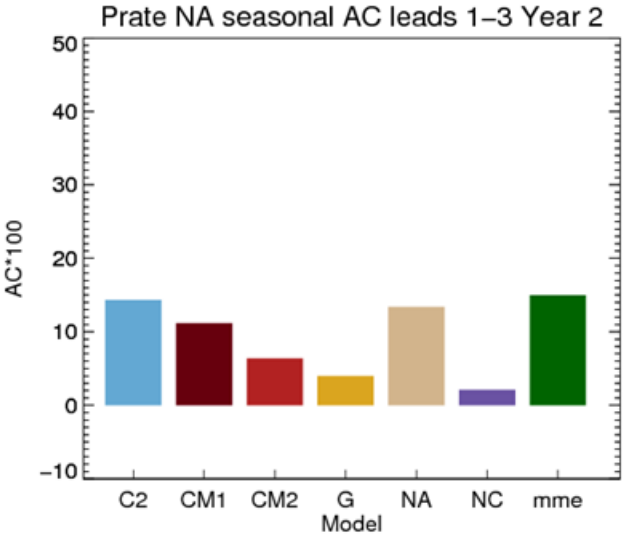
T2m

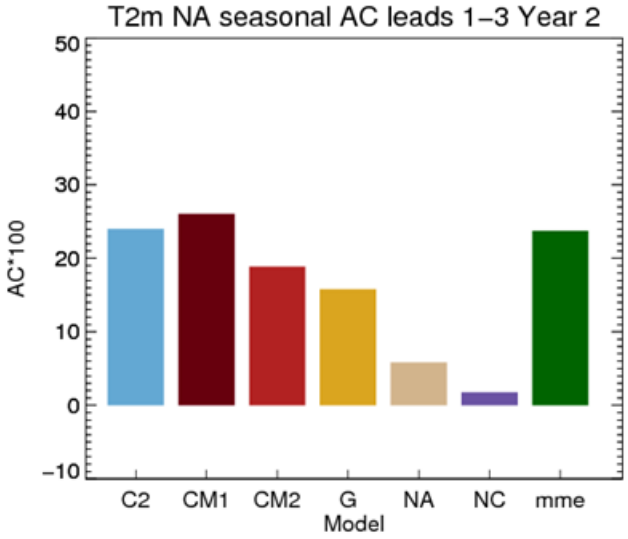
Yr 1



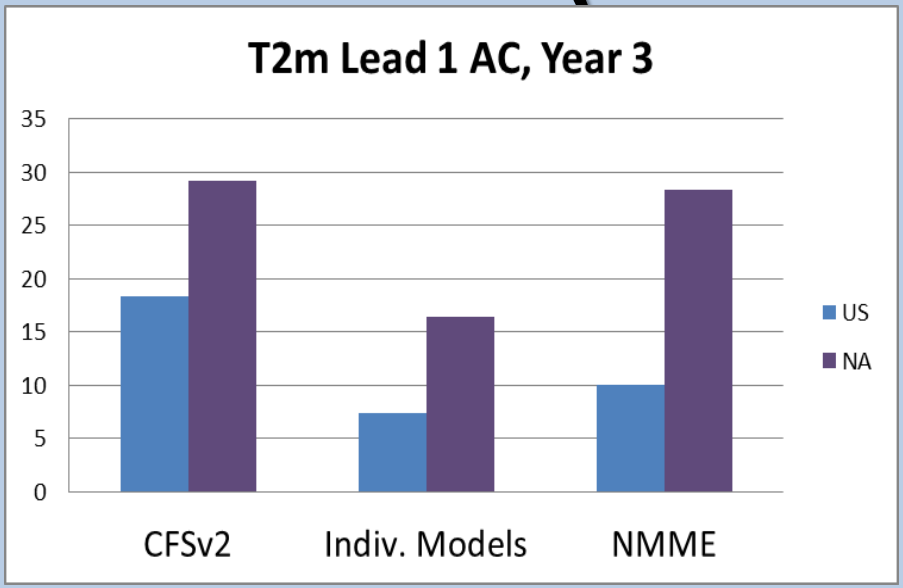


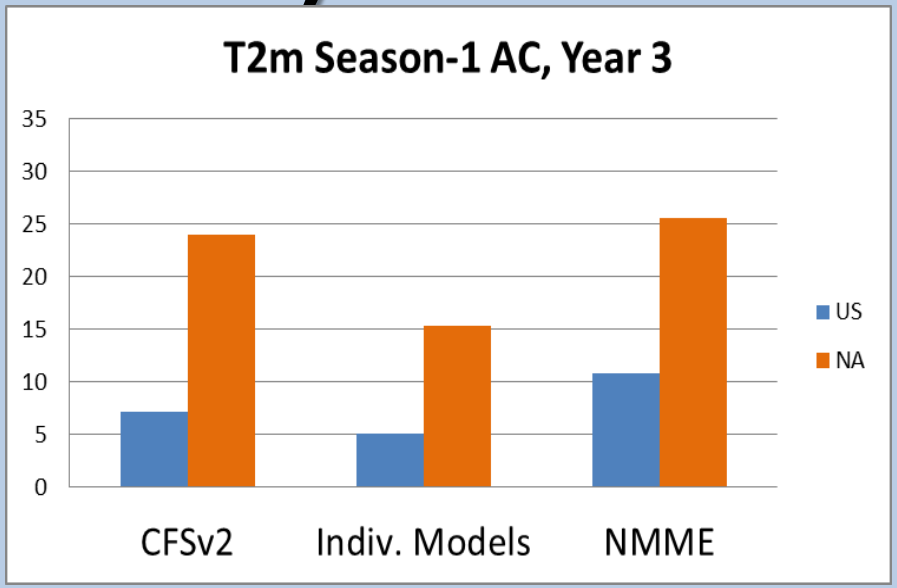
Yr 2

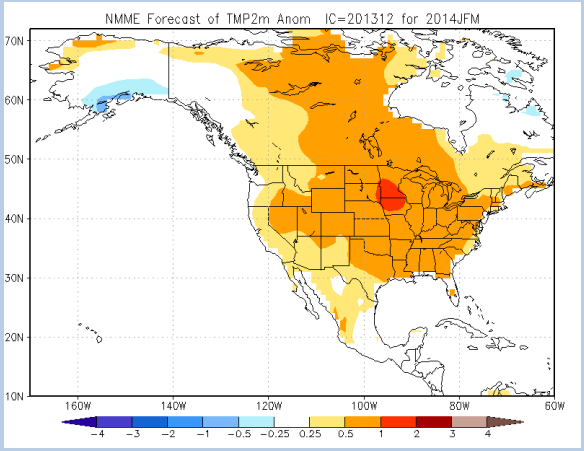


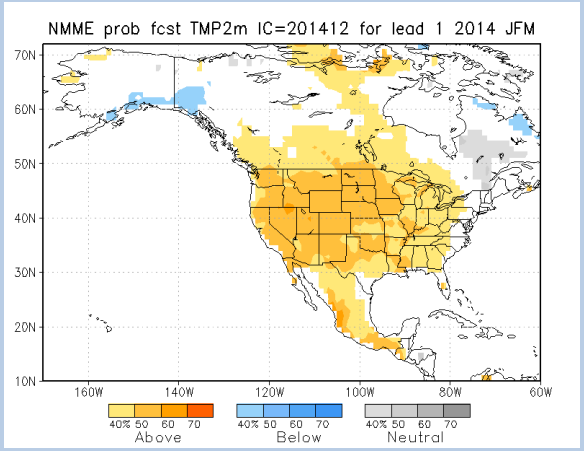


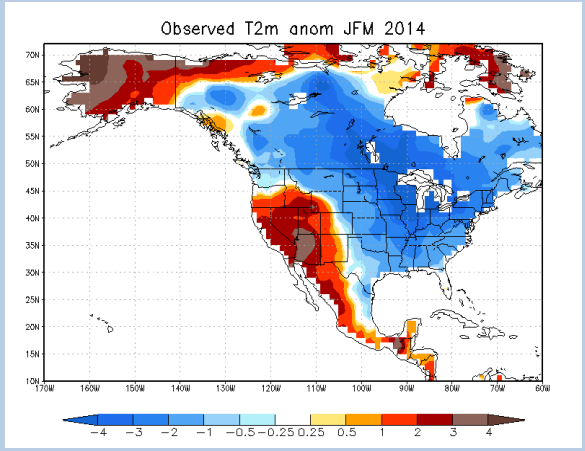
Year 3 verification – T2m anomalies (3-month mean)



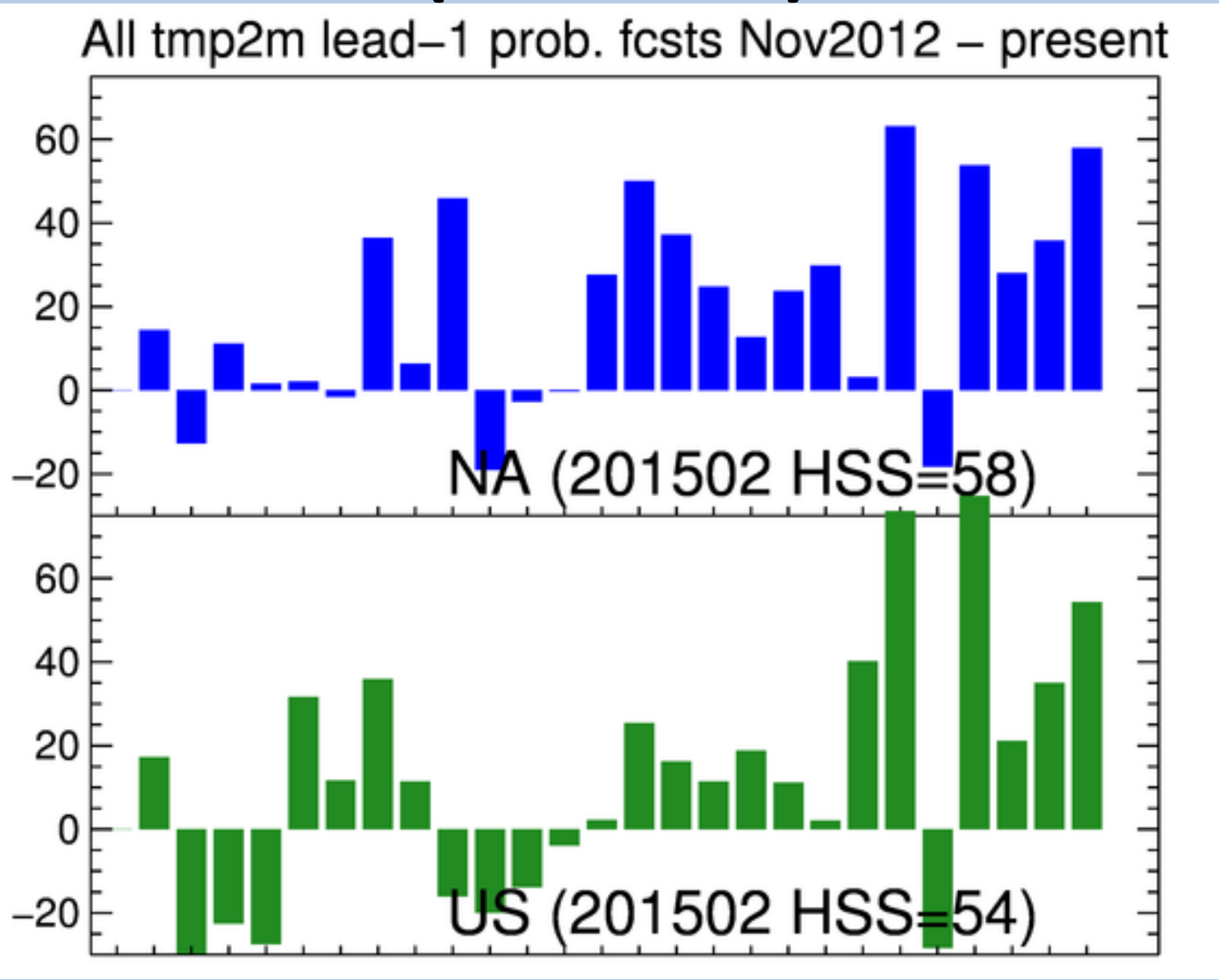




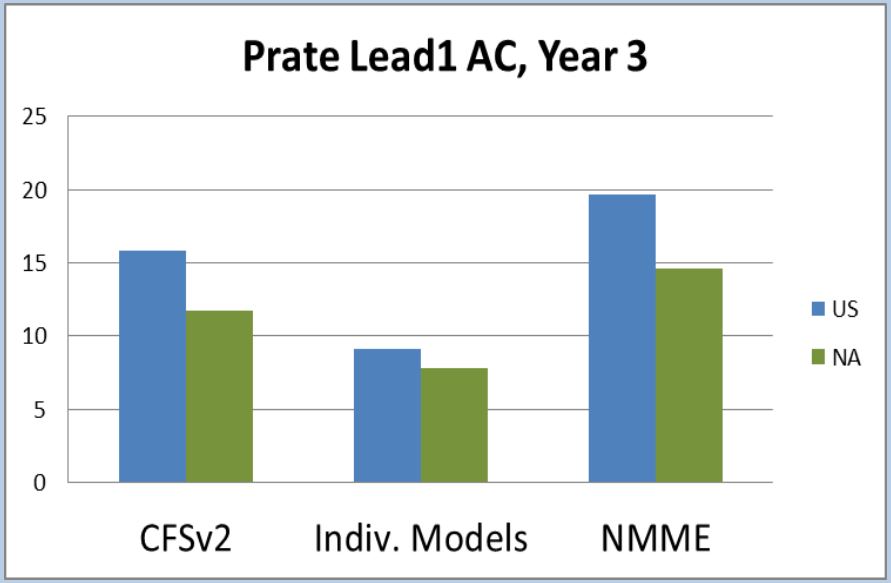


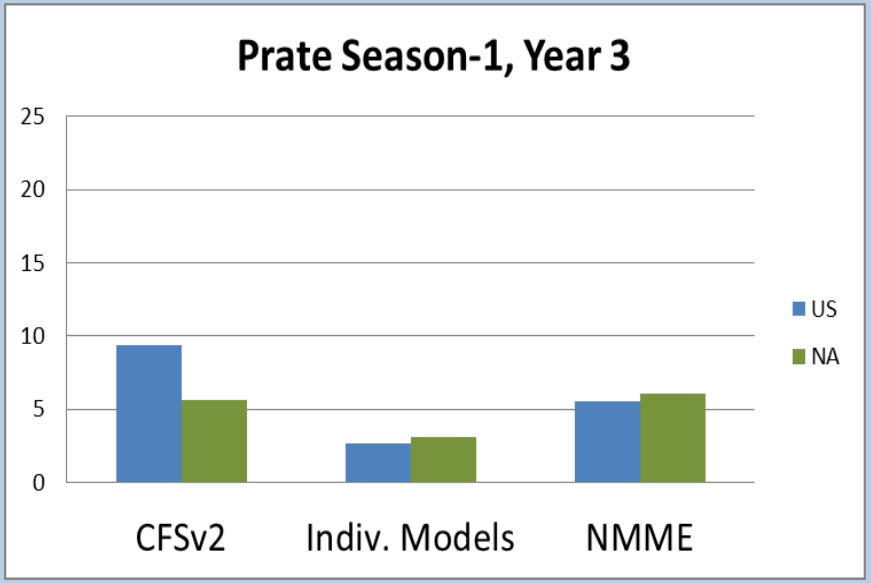


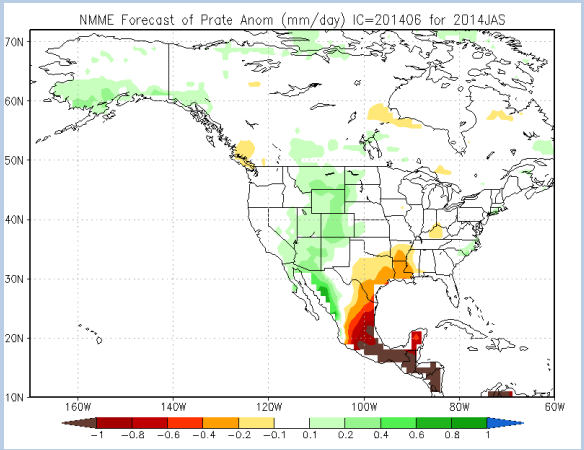
Realtime Verification – T2m prob fcsts (1-month)

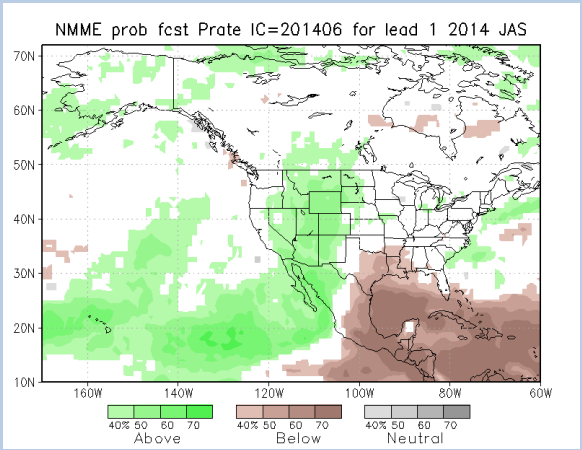


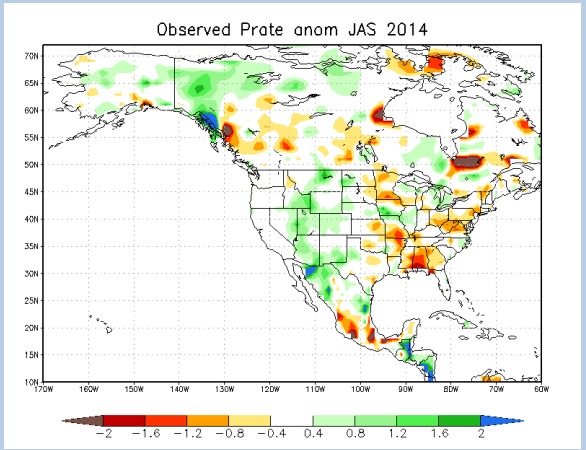
Year 3 verification – Prate anomalies (3-month mean)



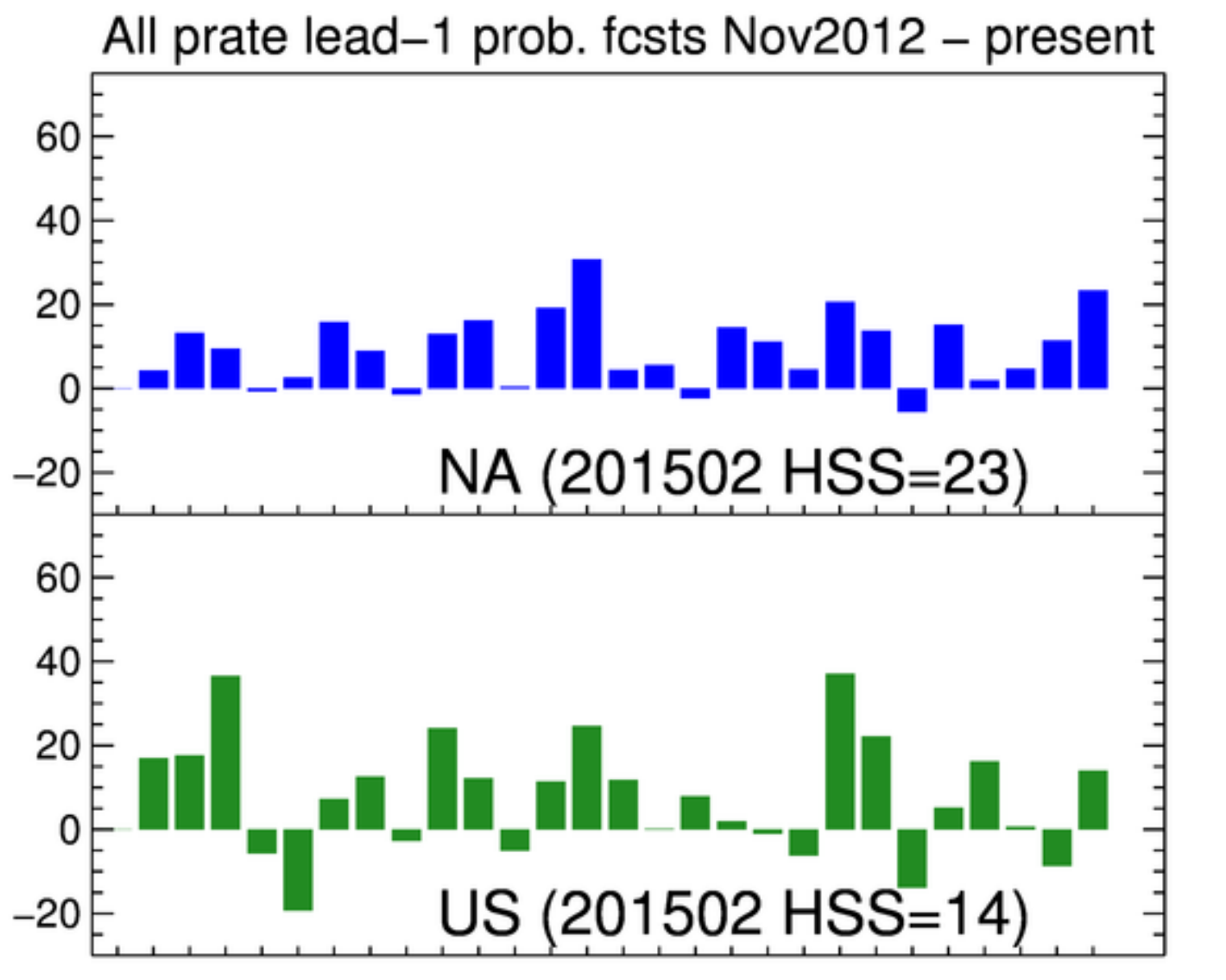




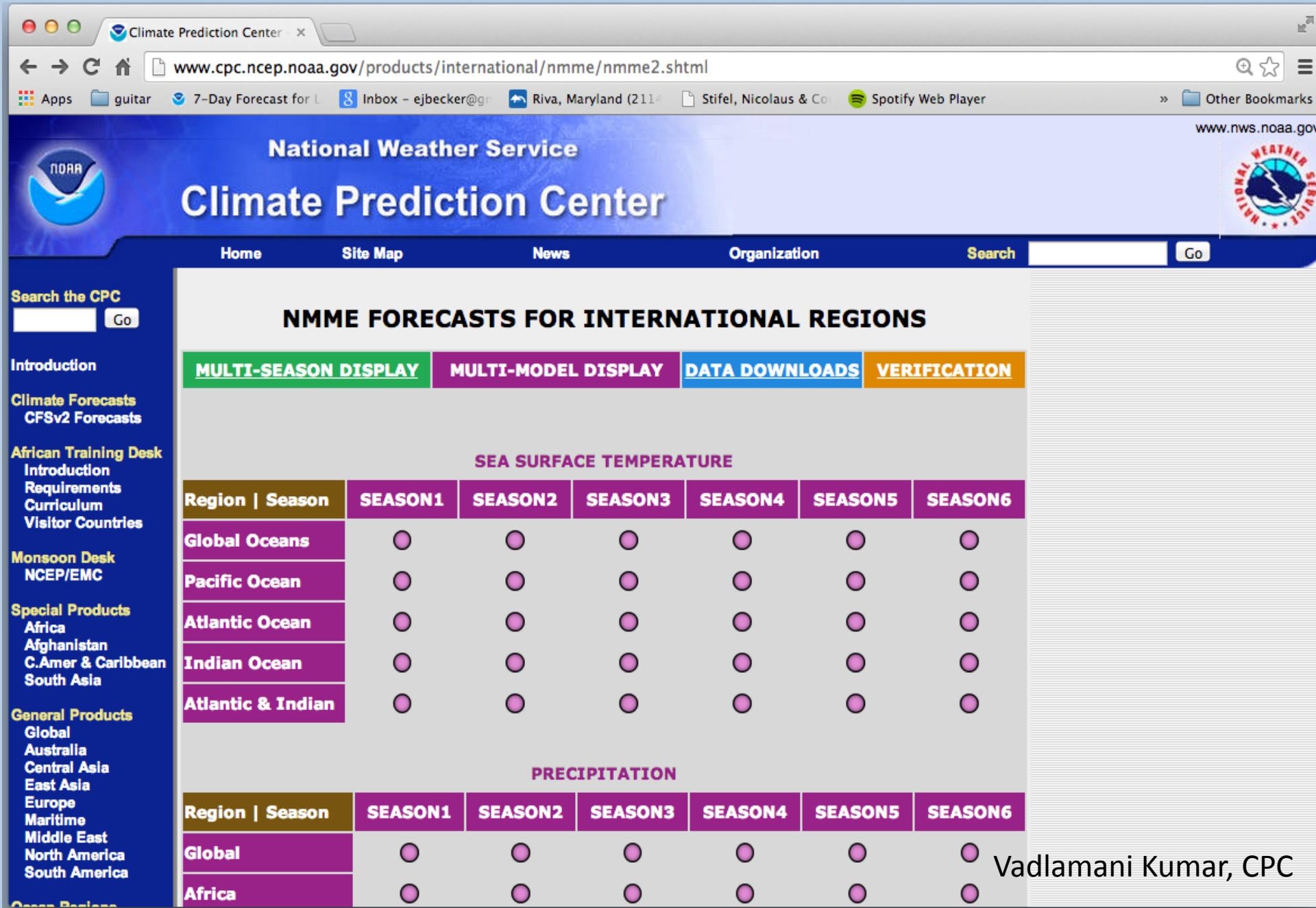




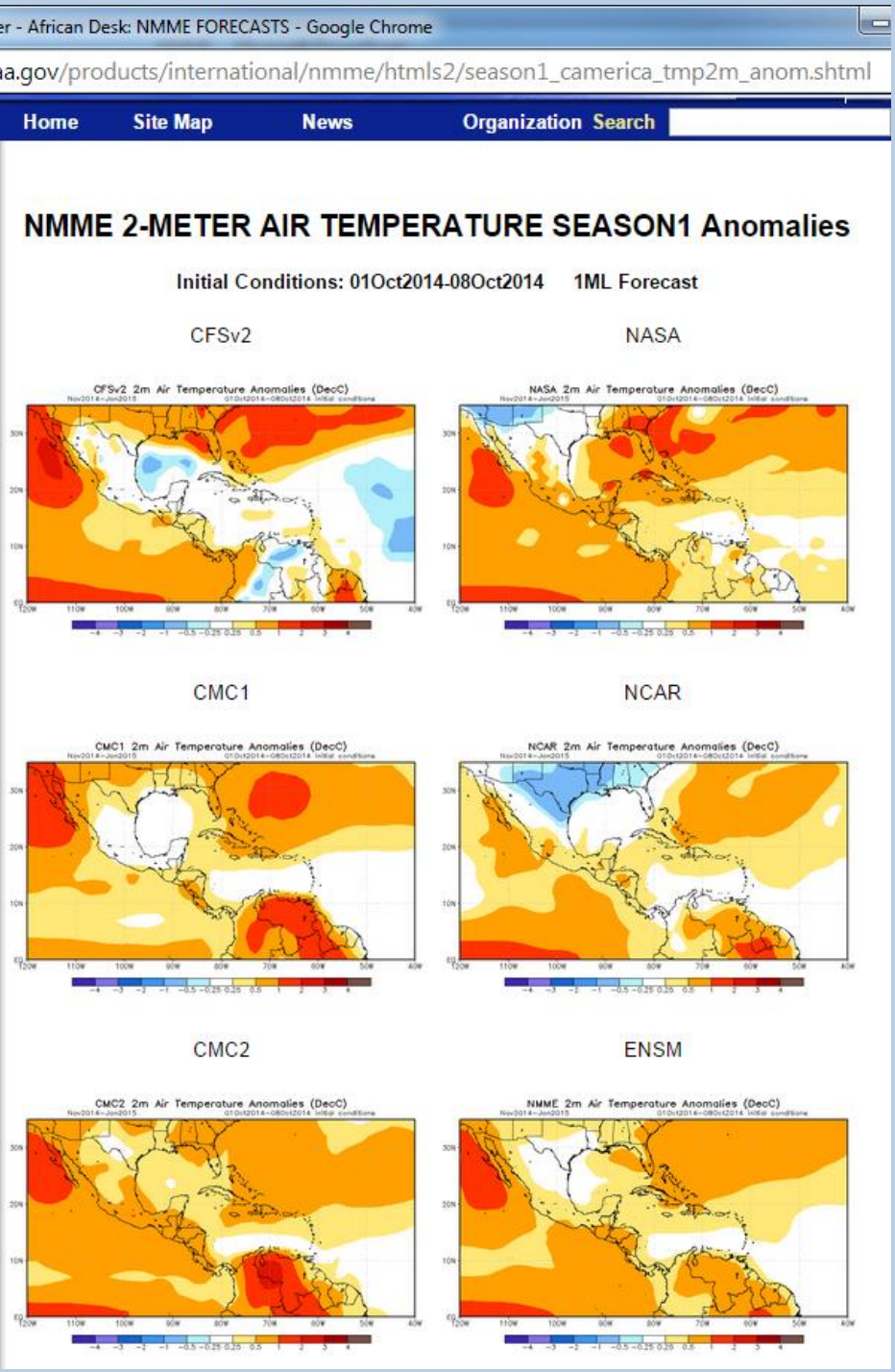
Realtime verification – prate prob fcsts (1-month)



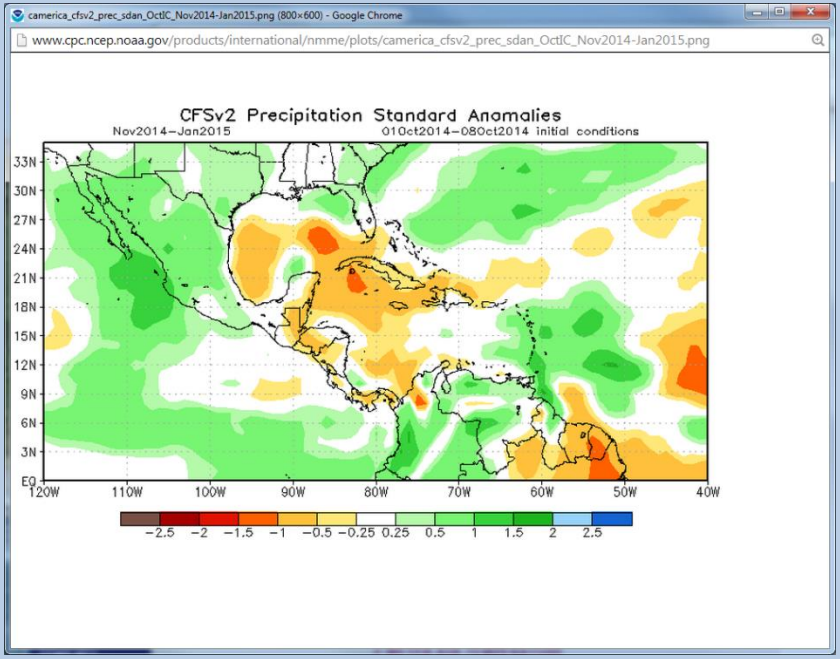
CPC International Desk



Vadlamani Kumar, CPC



- Anomalies
- Standardized anomalies
- Skill Masked standardized anomalies
- Skill maps
- Probability anomalies

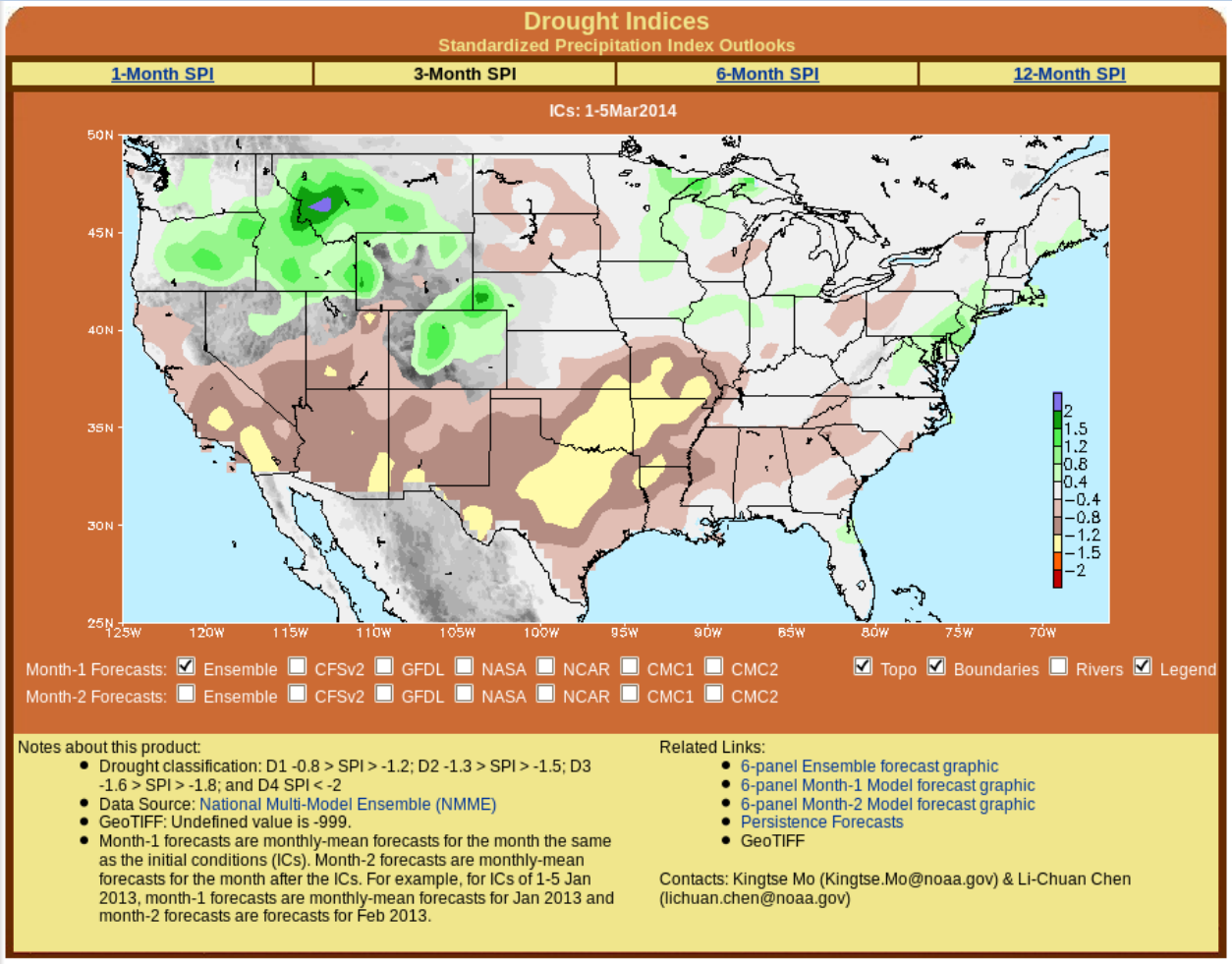


Vadlamani Kumar, CPC

CPC International Desk

- http://www.cpc.ncep.noaa.gov/products/international/nmme/nmme2.shtml
- Global, Africa, Carribbean, Maritime Continent, Central Asia, South Asia, East Asia, and South America regions
- Downloadable data in text format
- Only seasonal data is available

Real-Time NMME SPI Forecasts: bias correction and spatial downscaling



Available at http://www.cpc.ncep.noaa.gov/products/Drought/Monitoring/spi_outlooks_3.shtml

Kingtse Mo and LiChuan Chen, CPC

Peru Ministry of the Environment

Firefox

IGP - Pronóstico de El Niño

www.met.igp.gob.pe/variabclim/modelos.html

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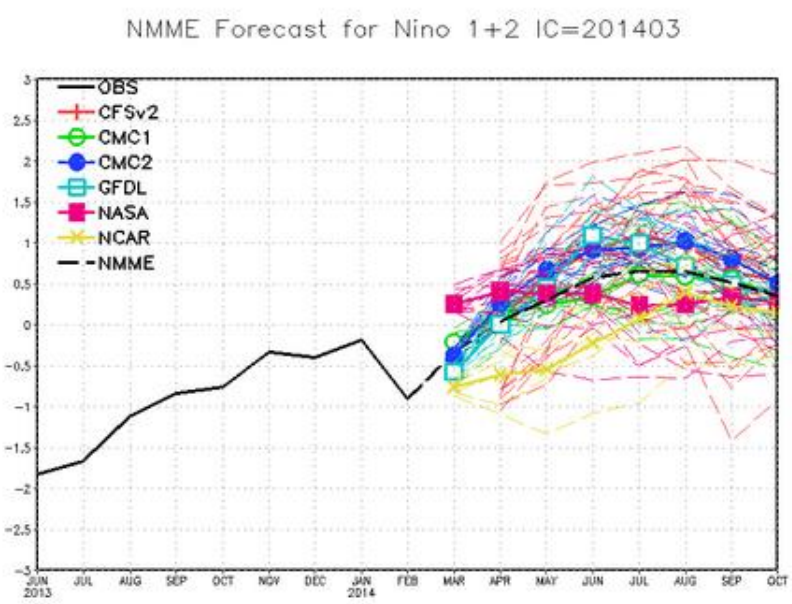
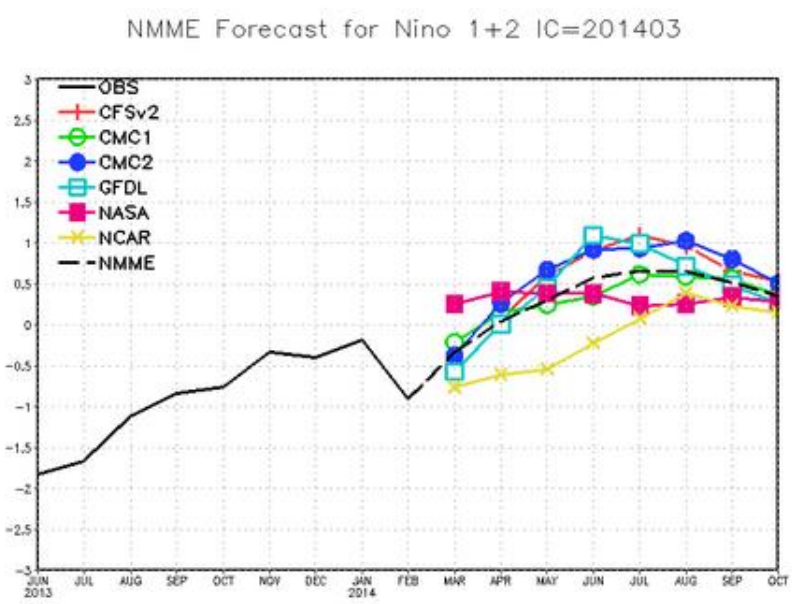
NMME Niño 1+2 plumes



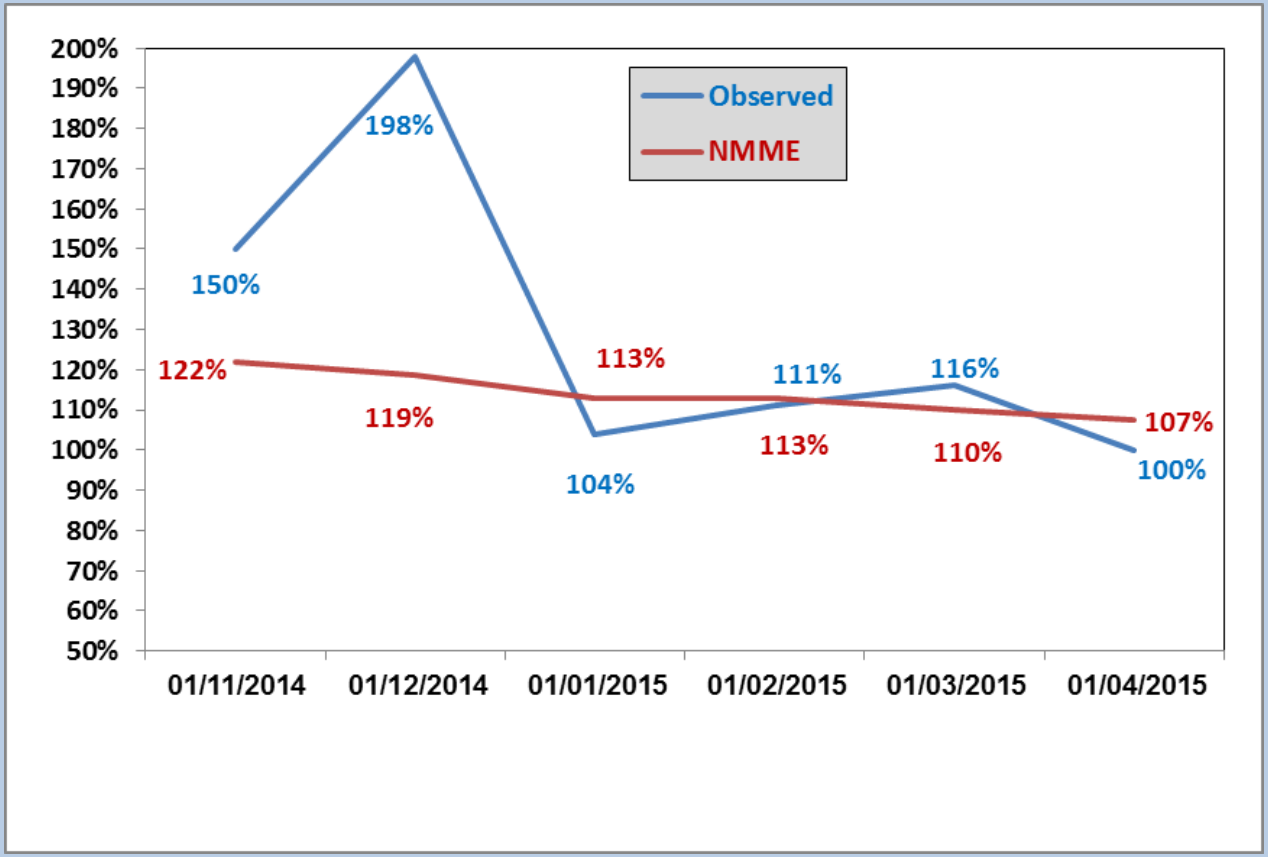
Preparation: IGP(Peru); Data NMME Project, sponsored by NOAA, DoE, NASA and NSF(USA)



Preparation: IGP(Peru); Data NMME Project, sponsored by NOAA, DoE, NASA and NSF(USA)

Israel Meteorological Service

Observed monthly precipitation (blue) vs. the forecast for Israel (in red) run by the IHS based on the NMME ensemble model for Israel



Phase II

- Subseasonal (45-day forecasts) and seasonal
- 22 atmospheric & land variables,
- 9 ocean and sea-ice fields
- 360x181 degree horizontal resolution
- NetCDF format
- http://www.cpc.ncep.noaa.gov/products/ctb/nmme/NMME_Data_Strategy.pdf
- Data is being loaded into the database right this minute

https://www.earthsystemgrid.org/search.html?Project=NMME

Thank you!

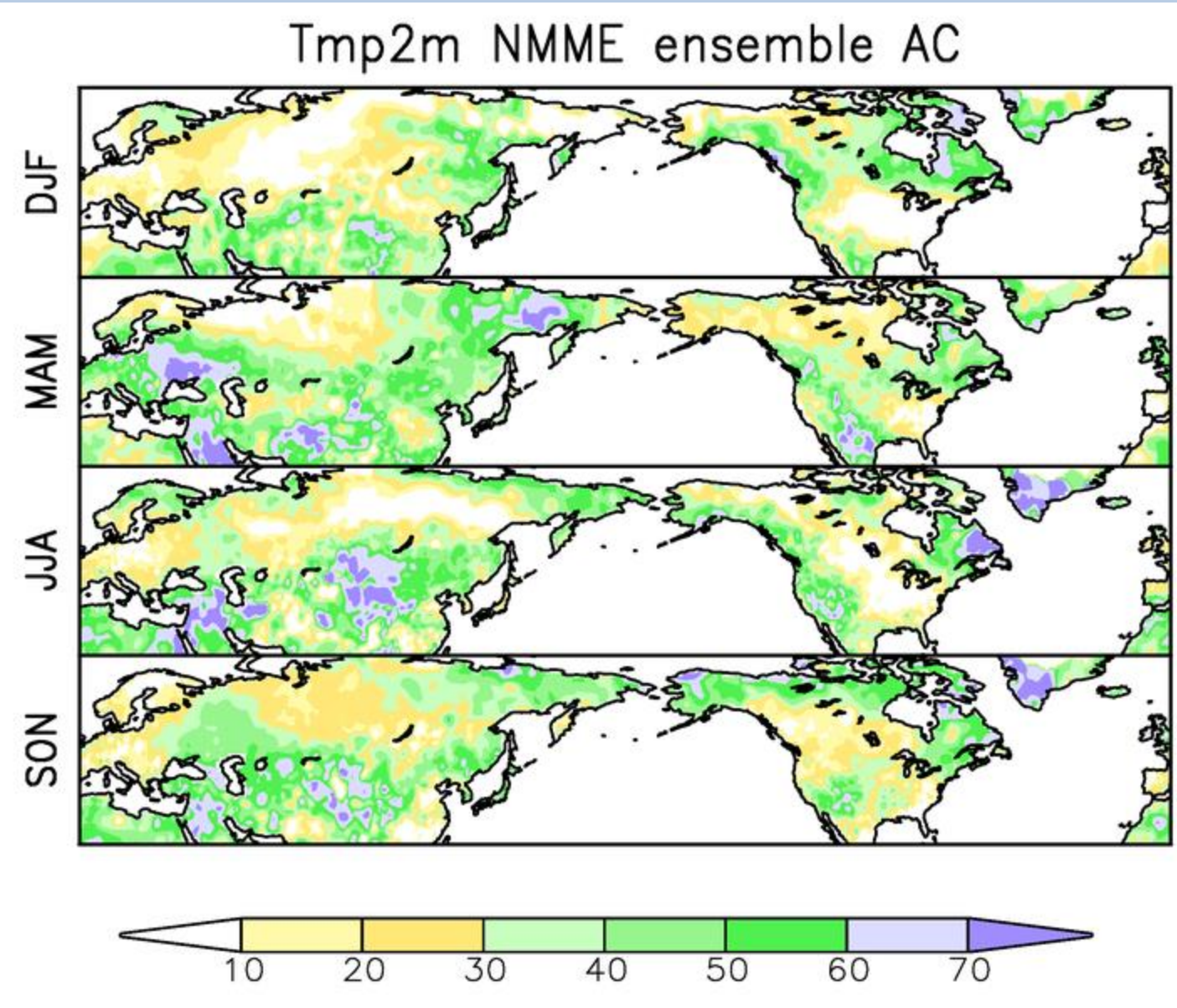
Information/data availability summary

- Reference article: Kirtman et al. 2014: The North American Multi-Model Ensemble (NMME): Phase-1 Seasonal to Interannual Prediction, Phase-2 Toward Developing Intra-Seasonal Prediction. http://journals.ametsoc.org/doi/abs/10.1175/BAMS-D-12-00050.1
- Currently available:
  - 1982-2010 hindcasts of monthly means, T2m, SST, prate:http://iridl.ldeo.columbia.edu/SOURCES/.Models/.NMME/
  - most forecasts, Aug 2011 – current, monthly means, bias-corrected anomalies, T2m, SST, prate: ftp://ftp.cpc.ncep.noaa.gov/NMME/realtime_anom/
- Available approximately August 2014:
  - all kinds of goodies, Phase II: https://www.earthsystemgrid.org/search.html?Project=NMME
- NMME web page at CPC: http://www.cpc.ncep.noaa.gov/products/NMME/
- CPC International Desk NMME page: http://www.cpc.ncep.noaa.gov/products/international/nmme/nmme2.shtml

Verification data

- Tmp2m: GHCN+CAMS, regridded to 1° x 1° (Fan and van den Dool 2008). Land only.
- Precipitation rate (deterministic assessments): CPC global Unified Rain-Gauge Database, regridded to 1° x 1° (P. Xie et al. 2010). Land only.
- Precipitation rate (probabilistic assessments): CPC Merged Analysis of Precipitation (CMAP), (Xie and Arkin 1997). Land & ocean, regridded from 2.5°x2.5° to 1° x 1° .
- Sea-surface temperature: OI-2 (Reynolds et al. 2002), native resolution is 1° x 1°.

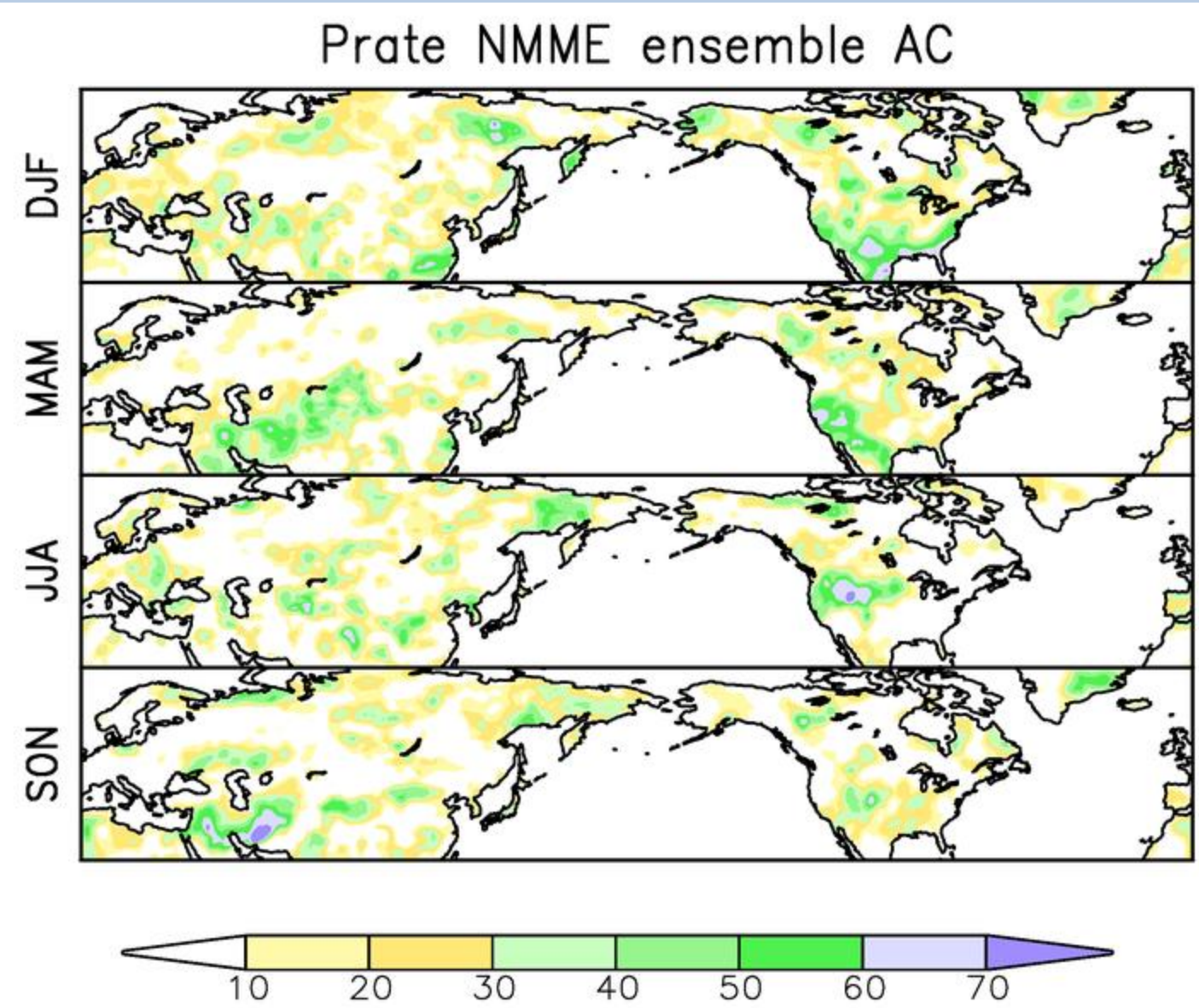
Hindcast skill: 2 m temperature



EM AC
CFSv1: 12
CFSv2: 29
CMC1: 17
CMC2: 27
GFDL: 25
NASA: 23
CCSM3: 0
NMME=29

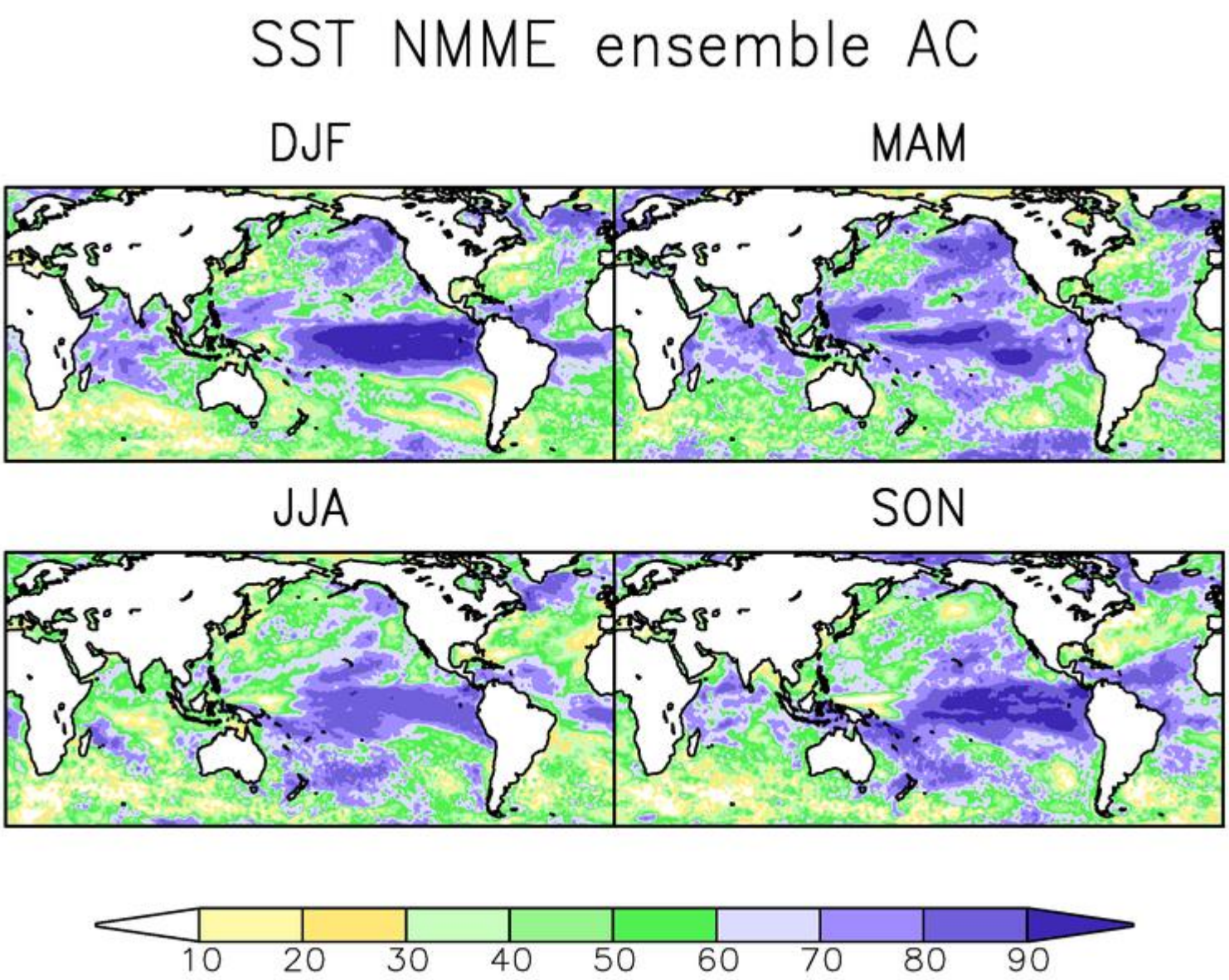
All lead-1 seasons

Hindcast skill: Precipitation rate



EM AC
CFSv1: 10
CFSv2: 12
CMC1: 9
CMC2: 11
GFDL: 12
NASA: 9
CCSM3: 4
NMME=16

Hindcast skill: SST



NH AC
CFSv1: 29
CFSv2: 41
CMC1: 44
CMC2: 46
GFDL: 42
NASA: 35
NCAR: 15
NMME=50

Niño3.4 reg.
CFSv1: 82
CFSv2: 82
CMC1: 87
CMC2: 85
GFDL: 80
NASA: 88
NCAR: 80
NMME=89

Sept. IC forecasts for OND Niño3.4