North American Multi-Model Ensemble

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Acknowledgements:
NMME Team
CPC: Huug van den Dool; Emily Becker; Qin Zhang

Motivation

- The National Research Council (2010) recommended NCEP to implement an NMME system to improve ISI forecasting
- NMME Phase-I: Experimental system initiated as a Climate Test Bed (CTB) research project supported by NOAA in 2011
- NMME Phase-II: Improved experimental system as a 2012-2013 NOAA/CTB research project with additional support from NSF, DOE and NASA. Includes sub-seasonal timescales
- NMME and IMME are considered in the NCEP operational monthly and seasonal forecasting system

Model Overview

Models	Initial Conditions	Members
CFSv2 (NCEP)	1st to the 8th of month	32
CCMs (Canada)	1st of each month	20
GFDL	1st of each month	10
GFDL-FLOR	1st of each month	24
NASA	/5dy 4mb / lstdy 7mb	11
NCAR	1st of each month	10
NMME	Combined	107

- Forecasts released by the 8th of each month
- All models have the same horizontal resolution 1.0° X 1.0°
- Hindcasts are from 1982 - 2010

Regionalized NMME Forecasts

NMME SEASONAL FORECASTS FOR INTERNATIONAL REGIONS

SEASONAL FORECASTS | MONTHLY FORECASTS | DATA DOWNLOADS | VERIFICATION

SEA SURFACE TEMPERATURE

Region | Model	Anomalies	StdAnom	Masked StdAnom	SkillMaps	3Category Prob
Global	●	●	●	●	●
Pacific	●	●	●	●	●
Atlantic	●	●	●	●	●
Indian Ocean	●	●	●	●	●
Atlantic&Indian	●	●	●	●	●

PRECIPITATION

Region | Model	Anomalies	StdAnom	Masked StdAnom	SkillMaps	3Category Prob
Global	●	●	●	●	●
Africa	●	●	●	●	●
CAM&Caribbean	●	●	●	●	●
Maritime-CONT	●	●	●	●	●
Central Asia	●	●	●	●	●
East Asia	●	●	●	●	●
South Asia	●	●	●	●	●
South America	●	●	●	●	●

2-METER AIR TEMPERATURE

Region | Model	Anomalies	StdAnom	Masked StdAnom	SkillMaps	3Category Prob
Global	●	●	●	●	●
Africa	●	●	●	●	●
CAM&Caribbean	●	●	●	●	●
Maritime-CONT	●	●	●	●	●
Central Asia	●	●	●	●	●
East Asia	●	●	●	●	●
South Asia	●	●	●	●	●
South America	●	●	●	●	●

http://www.cpc.ncep.noaa.gov/products/international/nmme/ensm/index.shtml

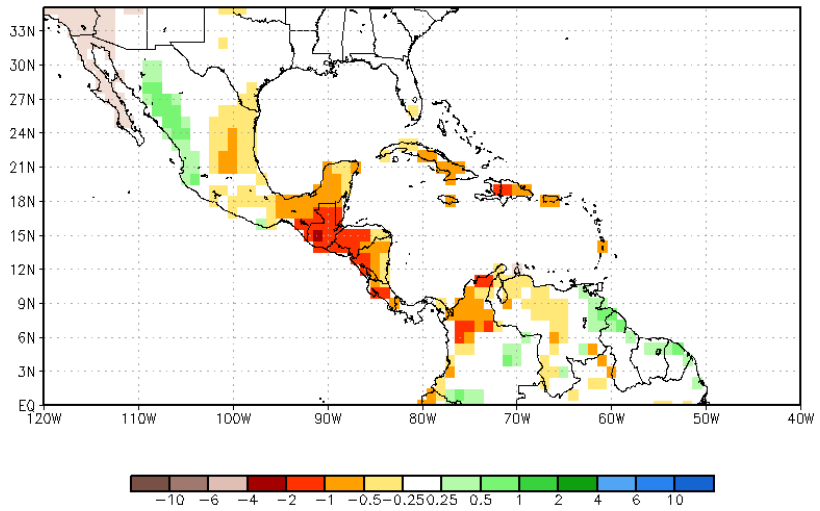
Deterministic and Probabilistic Forecasts

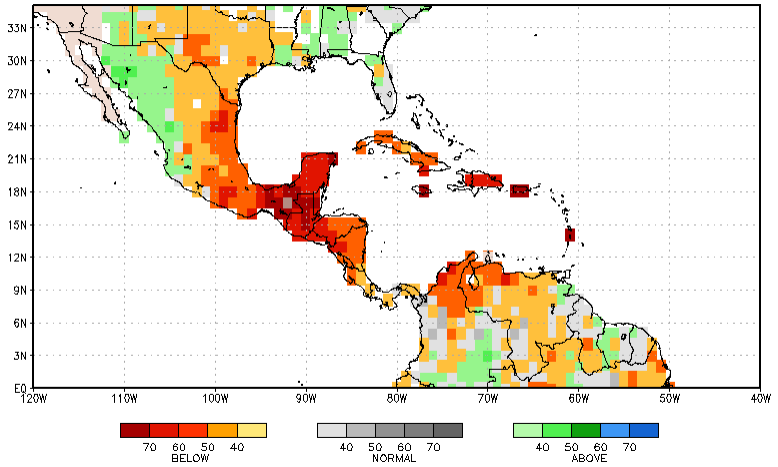
Deterministic

- Bias-corrected ensemble mean anomalies: anomalies are calculated using model's climatology
- MME uses **equal weighting** for each model
- Skill measures: AC; RMSE

Probabilistic

- For each year, tercile (A, N, B) thresholds determined from 28 years of the hindcasts of individual models
- Forecast mbers assigned to terciles; # of mbers in each class counted
- Historical skill used to calibrate probability forecasts.

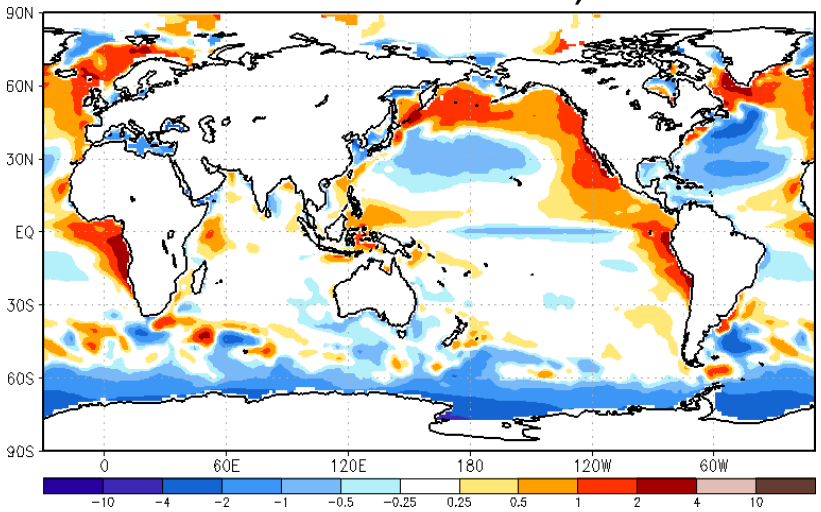




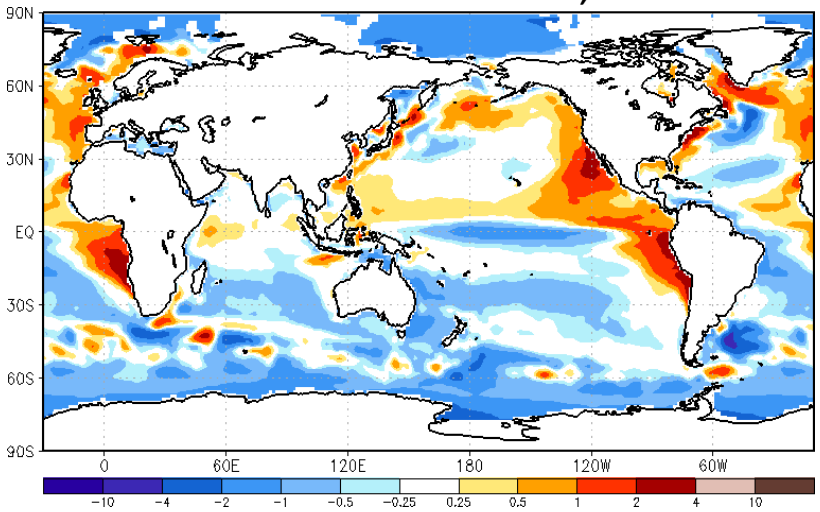
NMME SST Systematic Error, SST

Hindcast Period 1982-2010, May IC

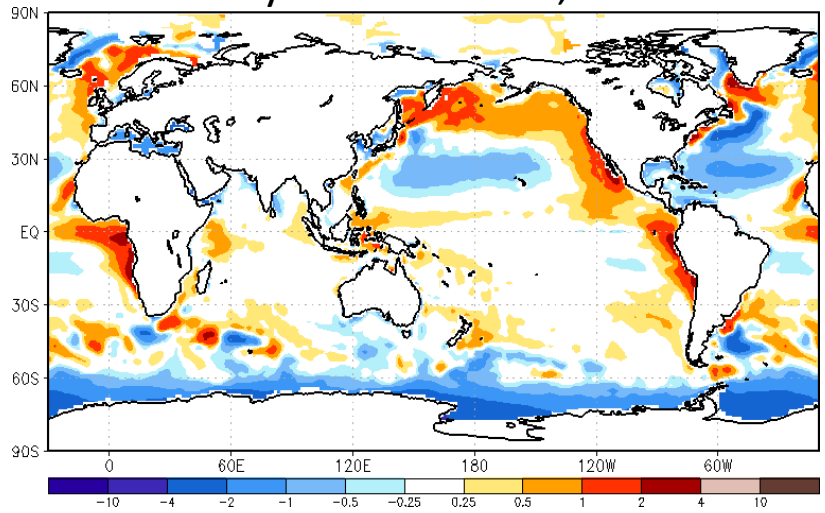
Seasonal 1-month lead, valid JJA



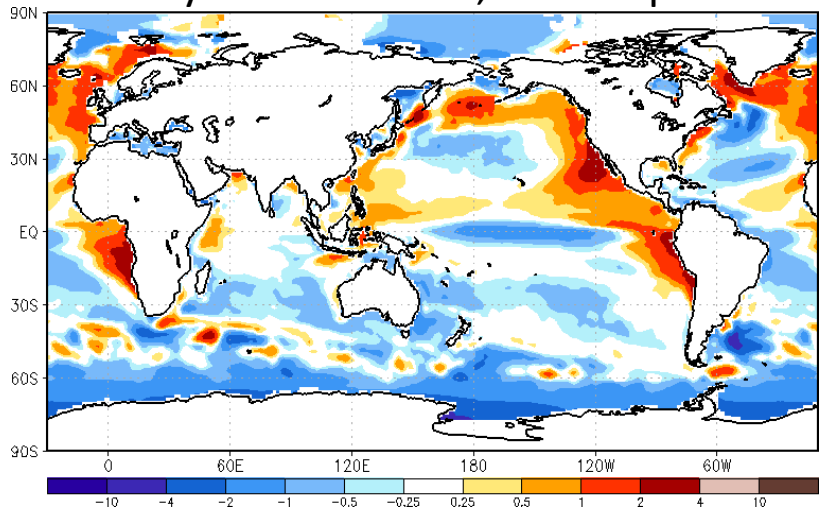
Seasonal 4-month lead, valid SON



Monthly 1-month lead, valid June

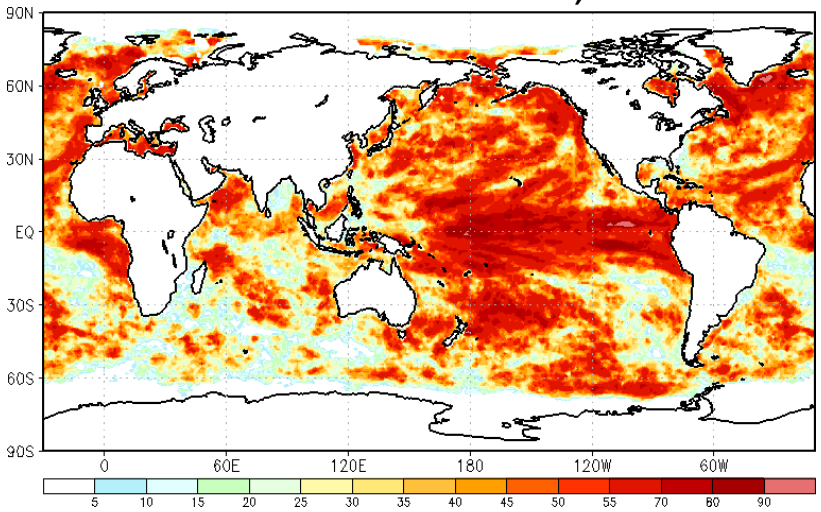


Monthly 4-month lead, valid September

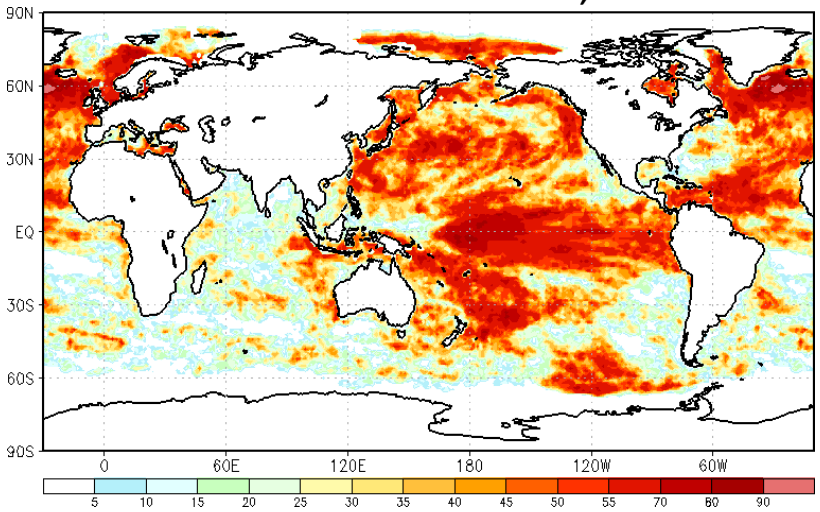


NMME HSS for SST Anomaly, Hindcast Period 1982-2009, May IC

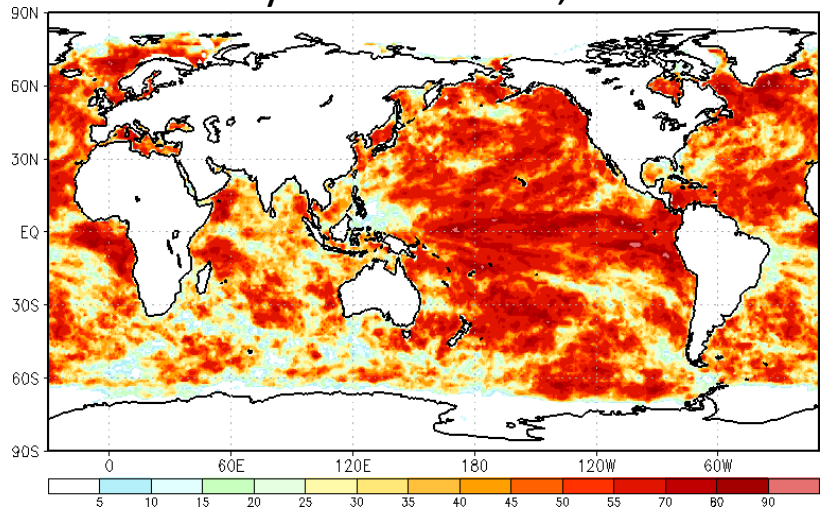
Seasonal 1-month lead, valid JJA



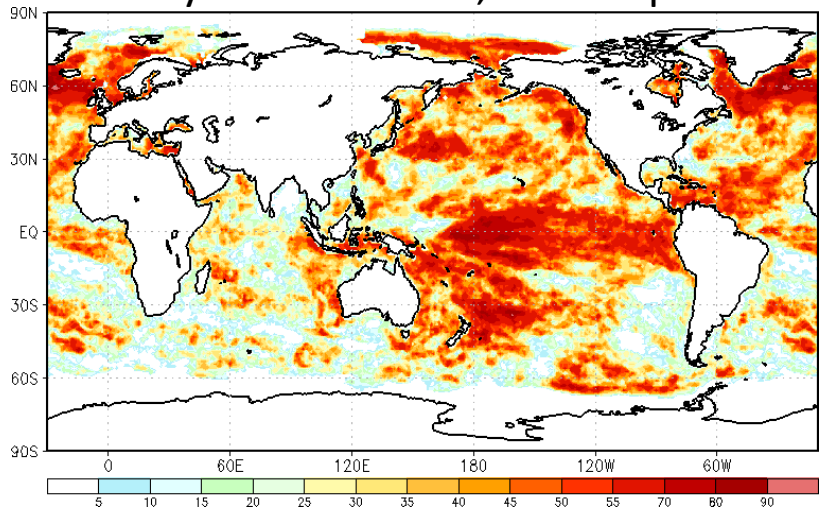
Seasonal 4-month lead, valid SON



Monthly 1-month lead, valid June



Monthly 4-month lead, valid September



NMME Data Access

ftp://ftp.cpc.ncep.noaa.gov/International/nmme/

- binary
  - Grads ctl file
  - Forecast data
    - SST
    - Precipitation
    - 2-meter temperature

Name	Last modified	Size
Parent Directory		-
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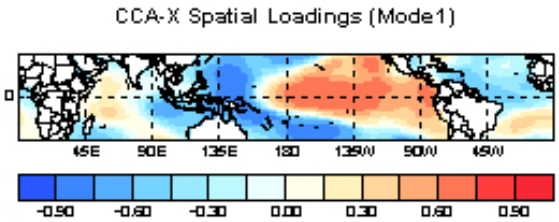
binary_monthly/	08-May-2018 14:05	-
binary_seasonal/	08-May-2018 14:07	-
monthly_nmme_forecast_in_cpt_format/	09-May-2018 12:56	-
monthly_nmme_hindcast_in_cpt_format/	09-May-2018 13:08	-
readme	16-Oct-2015 17:29	823
seasonal_nmme_forecast_in_cpt_format/	09-May-2018 14:07	-
seasonal_nmme_hindcast_in_cpt_format/	09-May-2018 14:16	-

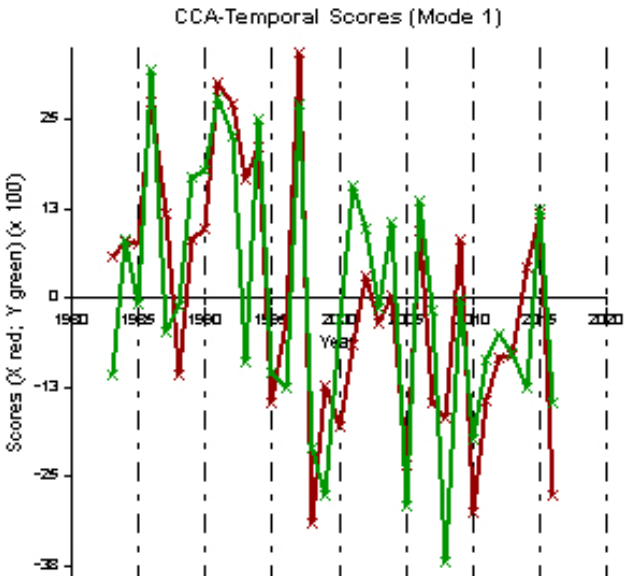
- cpt
  - All NMME model hindcasts & forecasts data are available in cpt format

Data and Statistical Downscaling - Malaysia

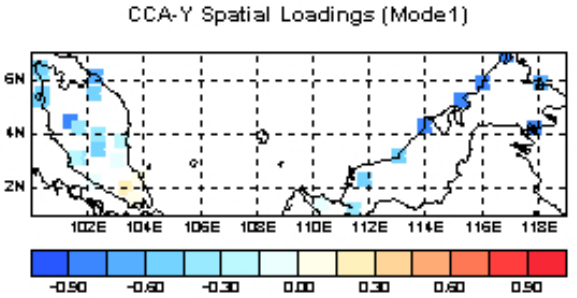
Predictand: station data

Predictor Loadings

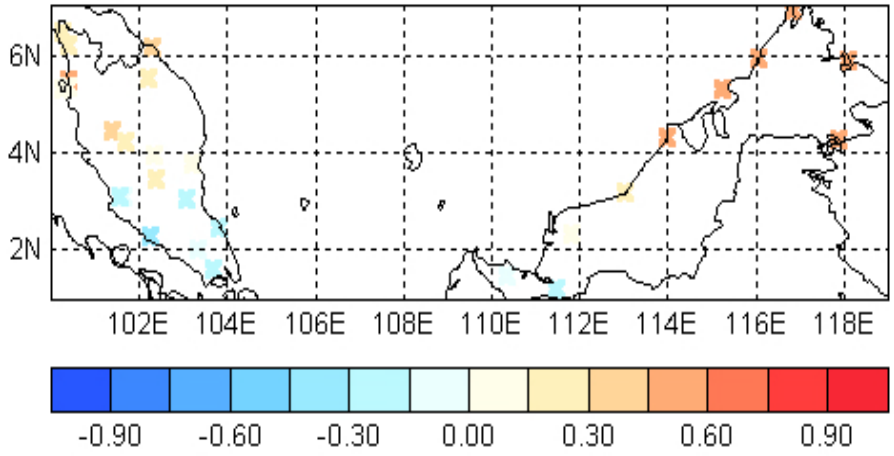




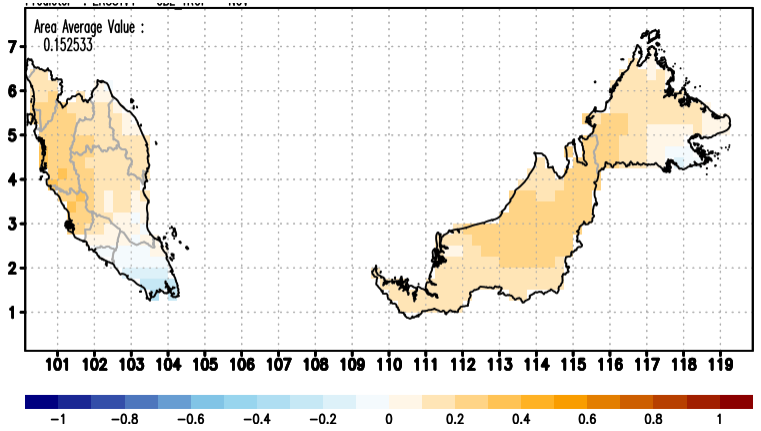
Predictand Loadings



Station Data Skill Map

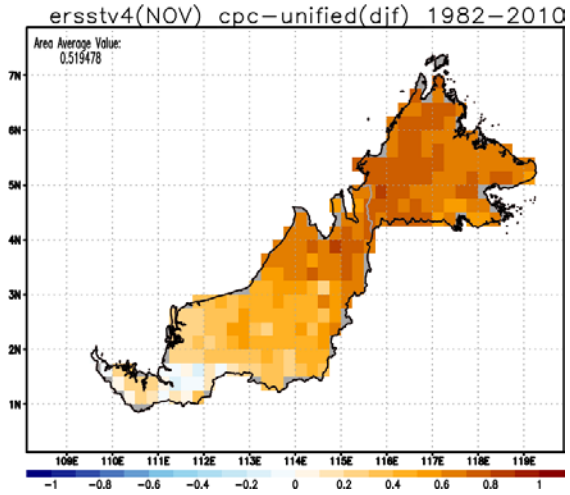


Gridded Data Skill Map

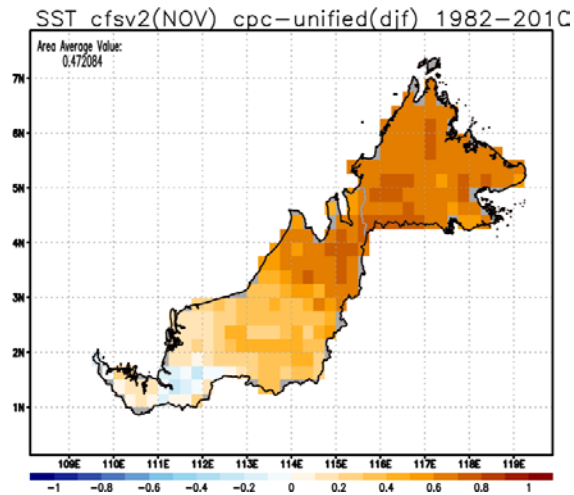


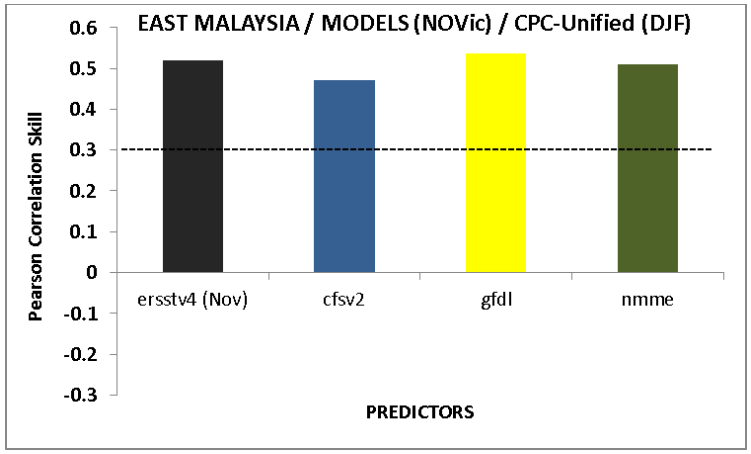
NMME Model Skill for East Malaysia

ERSSTv4 (NOV)

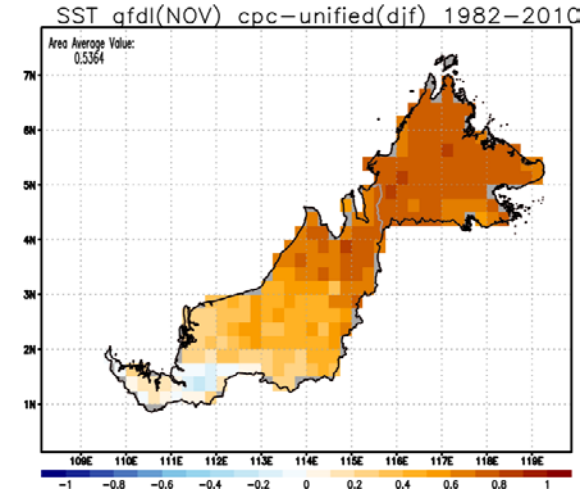


cfsv2

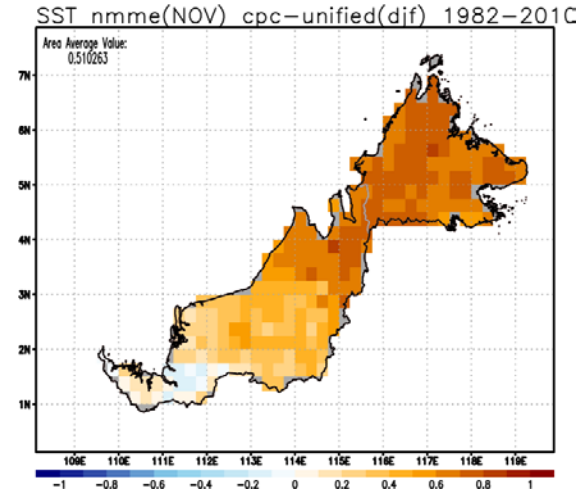




gfdl



nmme



CCA forced with NMME model predicted SST yields outcome comparable to CCA forced with observed SST.

Summary

- The NMME is an excellent tool for diagnostics studies and for enhancing forecast operations at NMHSs and RCCs
- Advantage: Model hindcast and forecast data readily accessible and in a user friendly format
- Inconvenience: Only three of the models, CFSv2, CCM-1 and CCM-2 are operational and from WMO GPCs
- NMME is used in operational monthly and seasonal forecasting at NCEP/CPC and contributes to predictability research
- Need to ensure data is of high quality for proper downscaling of NMME forecasts

Experimental Sub-Seasonal Forecasts

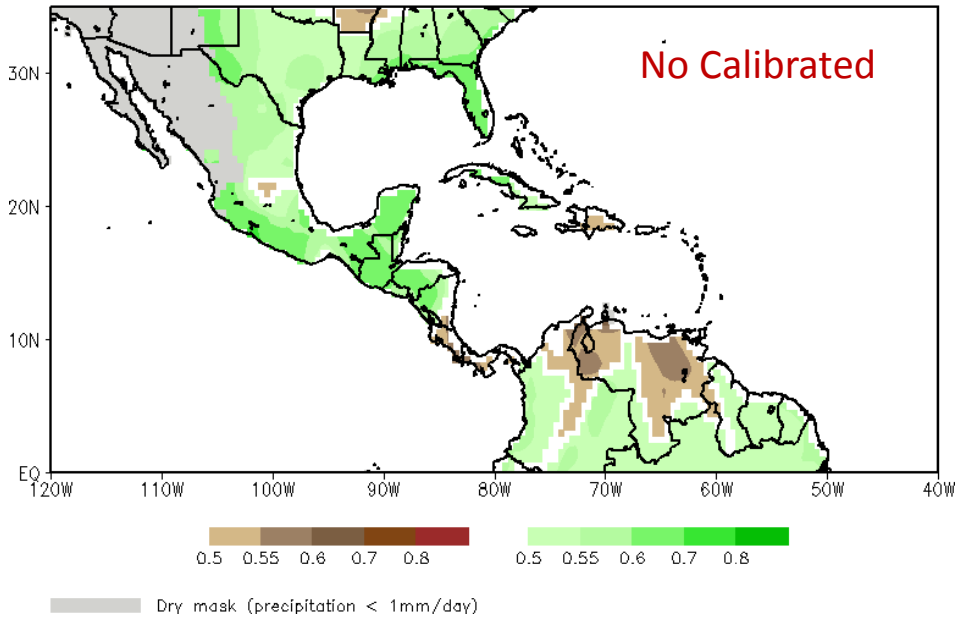
Week 3-4 Precipitaton Forecasts, RA-IV

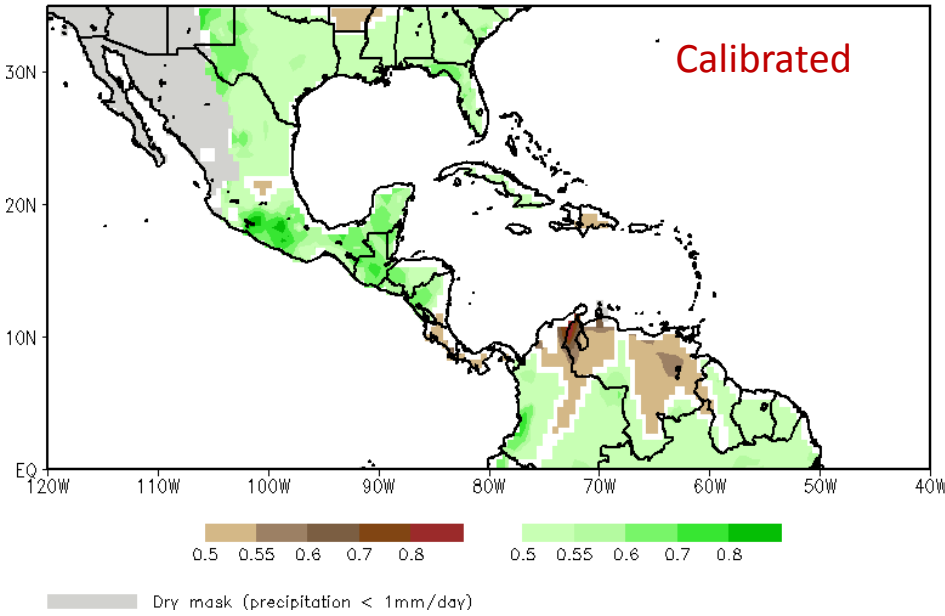
Two-category precipitation probabilistic forecasts

Model: NCEP CFSv2

Frequency: daily

Calibration:
- hindcast climatology (1996-2016)
- CPC unified gauge-based analysis of precipitation (1996-2016)





NCEP CFSv2 week 3-4 two-category precipitation probabilistic forecast,
Valid 17-30 May 2018 (IC: 1-2 May 2018)