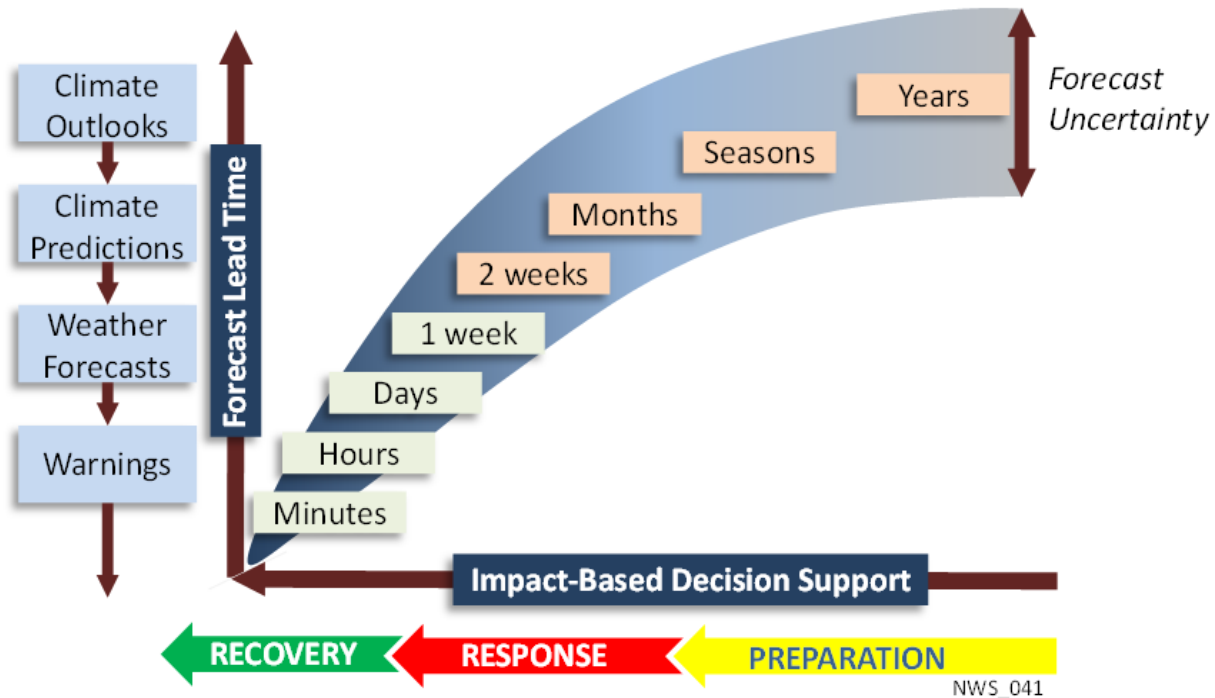# Sub-Seasonal to Seasonal Forecasting for Africa

Wassila Mamadou Thiaw

Climate Prediction Center
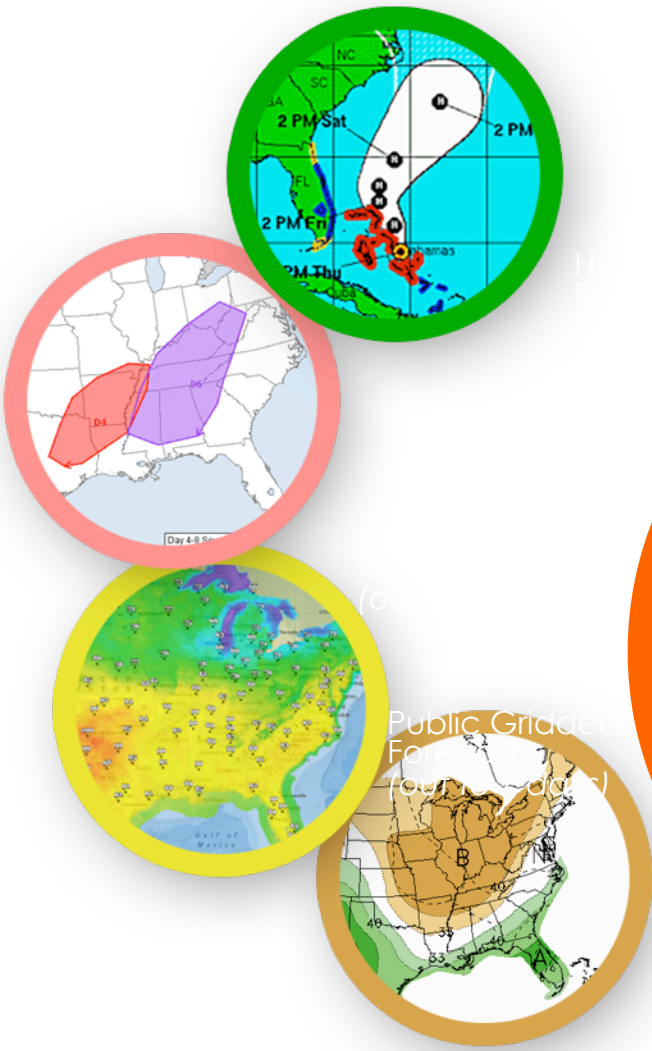
NOAA Forecast Continuum

e.g. Disaster management planning and response

e.g. Crop Selection, Water management
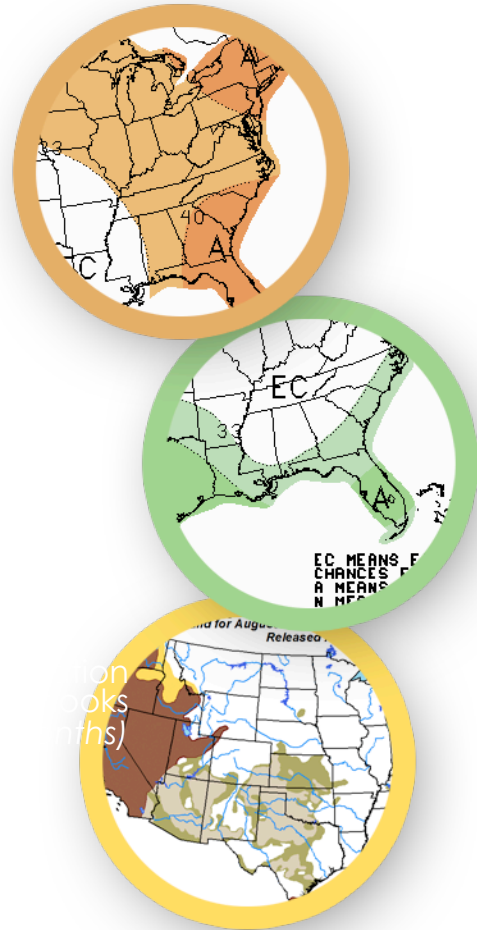
e.g. Infrastructure development

Scientific Challenge

?

Sub-Seasonal Forecasting

Temp/Precip Outlooks (6 -10, 8 -14 days)

Seasonal and monthly Outlooks (Temp/Precip, and drought)

3

International Training Desks

On-the-job training

- South American Desk (1988)

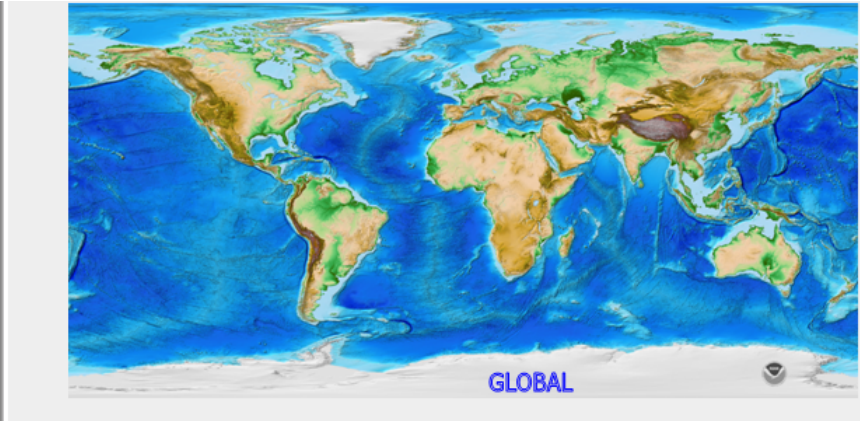- Caribbean Desk (1992)

- African Desk (1994)

- Monsoon Desk (2010)

CPC International Desks Website

www.cpc.ncep.noaa.gov; international desks

Provide access to real time global and regionalized weather and climate forecasts, enabling decision making in agriculture and water around the world.

Introduction

African Training Desk
Introduction
Requirements
Curriculum
Visitor Countries

Short&Medium-Range Forecasts
GFS GEFS & GDAS

Climate Forecasts
CFSv2 Forecasts
NMME

Special Products
Africa
Central Asia
C.Amer & Caribbean
South Asia

General Products

GLOBAL

Current Satellite IR Imagery

Global	Pacific & Atlantic	Indian & Pacific	Atlantic & Indian

NCEP GFS and GEFS

Forecasts for Regions other than Africa:

00Z Cycle	06Z Cycle	12Z Cycle	18Z Cycle

Forecasts for Africa Domains

AFRICA	00Z Cycle	06Z Cycle	12Z Cycle	18Z Cycle
EAST AFRICA	00Z Cycle	06Z Cycle	12Z Cycle	18Z Cycle
NORTH AFRICA	00Z Cycle	06Z Cycle	12Z Cycle	18Z Cycle
SOUTHERN AFRICA	00Z Cycle	06Z Cycle	12Z Cycle	18Z Cycle
WEST AFRICA	00Z Cycle	06Z Cycle	12Z Cycle	18Z Cycle

NCEP CFSv2 and NMME

SEASONAL FORECASTS	MONTHLY FORECASTS	DATA DOWNLOADS	VERIFICATION

SEA SURFACE TEMPERATURE

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

PRECIPITATION

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

Week-2 Rainfall Probability of Exceedance of 50 mm

NOAA GEFS 20160315 00zCYC FCST Probability of Week1 Precip > 50mm   VALID 20160322/0000V168

| | 5 | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 95 | |
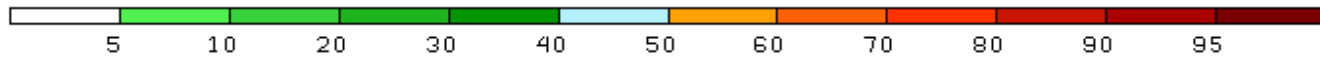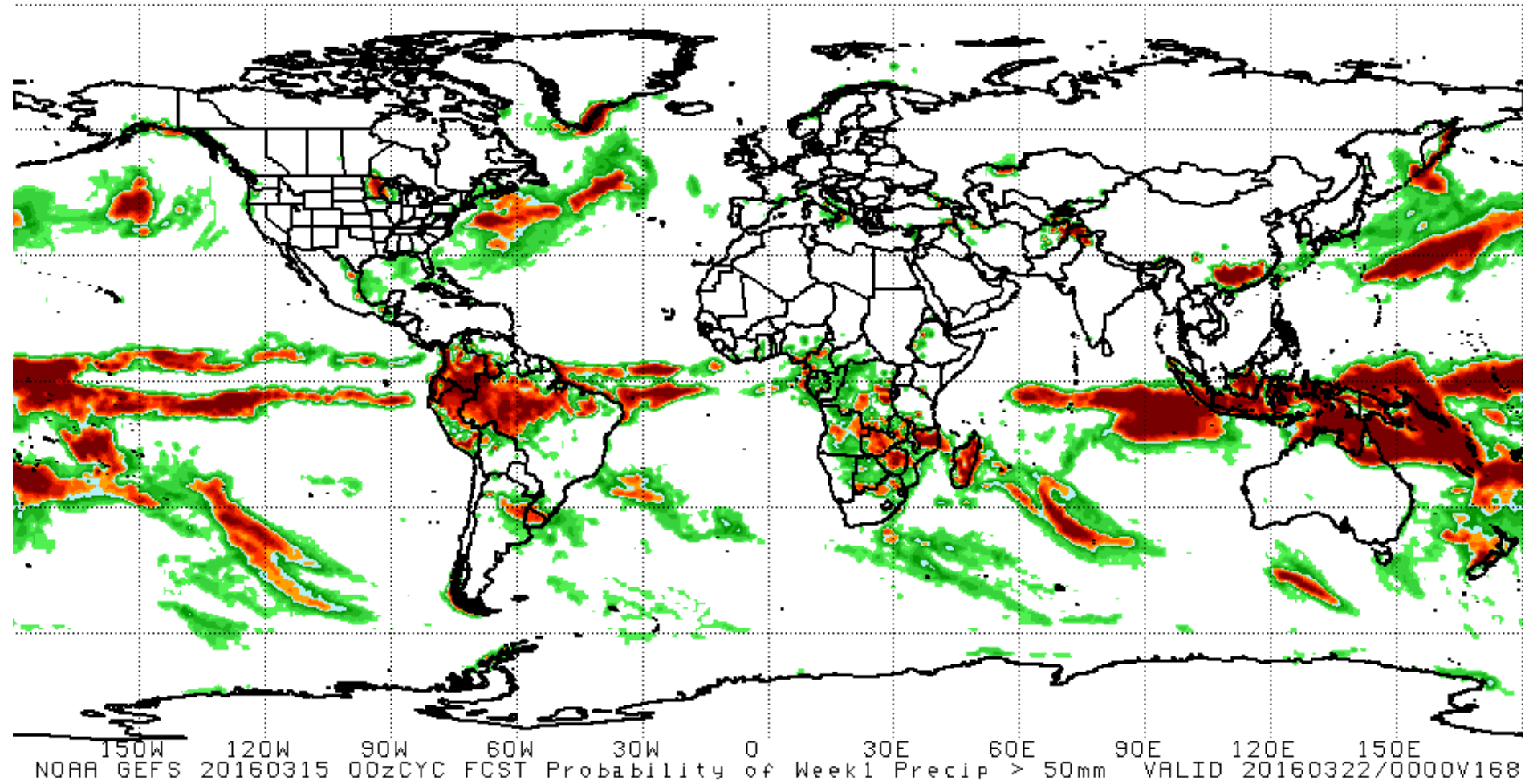
# NMME Categorical Probability Precipitation Seasonal Forecasts, Apr-June 2016, March IC
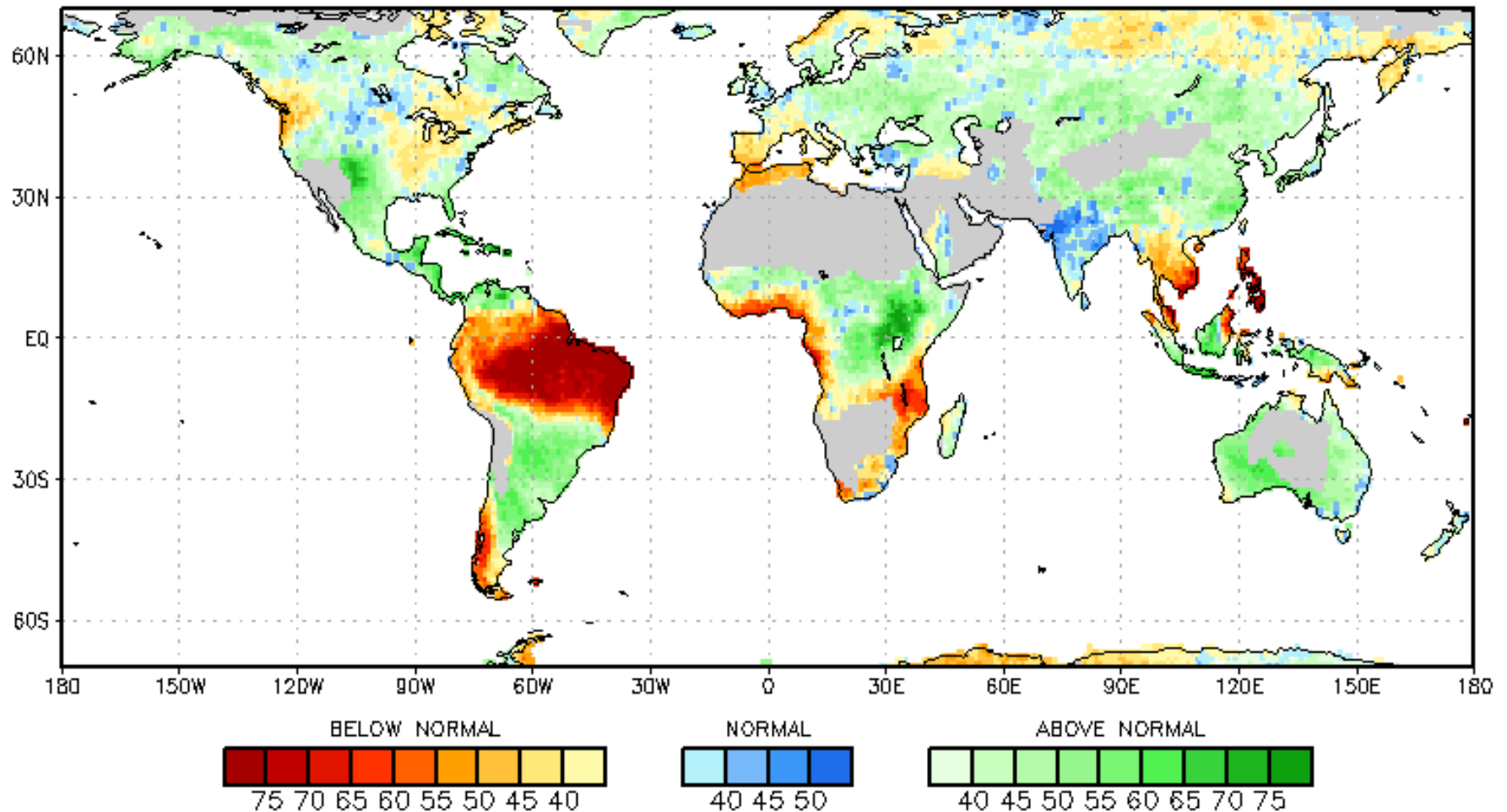
Addressing the gap in operational climate forecasting:

Week-3 to Week-4 Forecasts

Tools for Operational Sub-Seasonal Forecasting

- Madden Julian Oscillation

- Numerical Weather and climate models

- El Nino Southern Oscillation

Madden Julian Oscillation (MJO) Velocity Potential Maps (example)
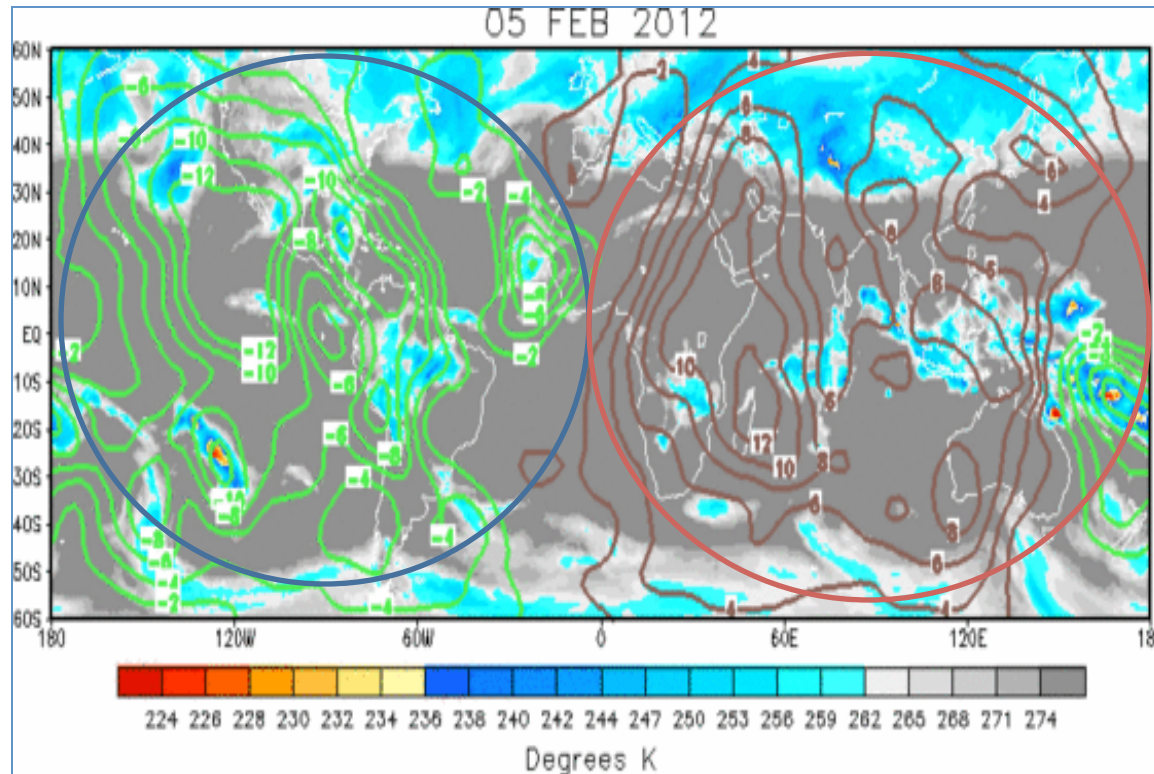
- The above map show 200 hPa Velocity Potential Anomaly on February 5, 2012.
- Green shade indicates areas of upper level divergence and convection or precipitation at surface. Brown contours indicate areas of upper level convergence or subsidence and suppressed precipitation at surface
- The map shows a wave number one pattern, with
  - the MJO related upper level convergence prevailed over eastern half of Africa, the Indian Ocean and the Maritime Continent, and
  - the MJO related the upper level divergence extending across the western hemisphere.
- Associated with this pattern, suppressed convective activity was observed over many places of Africa.
- **How will this pattern evolve in time and Space >> MJO Projections (Dynamical and Statistical)**
- **How will it impact rainfall over Africa>> MJO Rainfall composite maps for Africa**

Sub-Seasonal Forecasting

The Madden Julian Oscillation

Spring 2005 MJO Event

22 FEB 2005
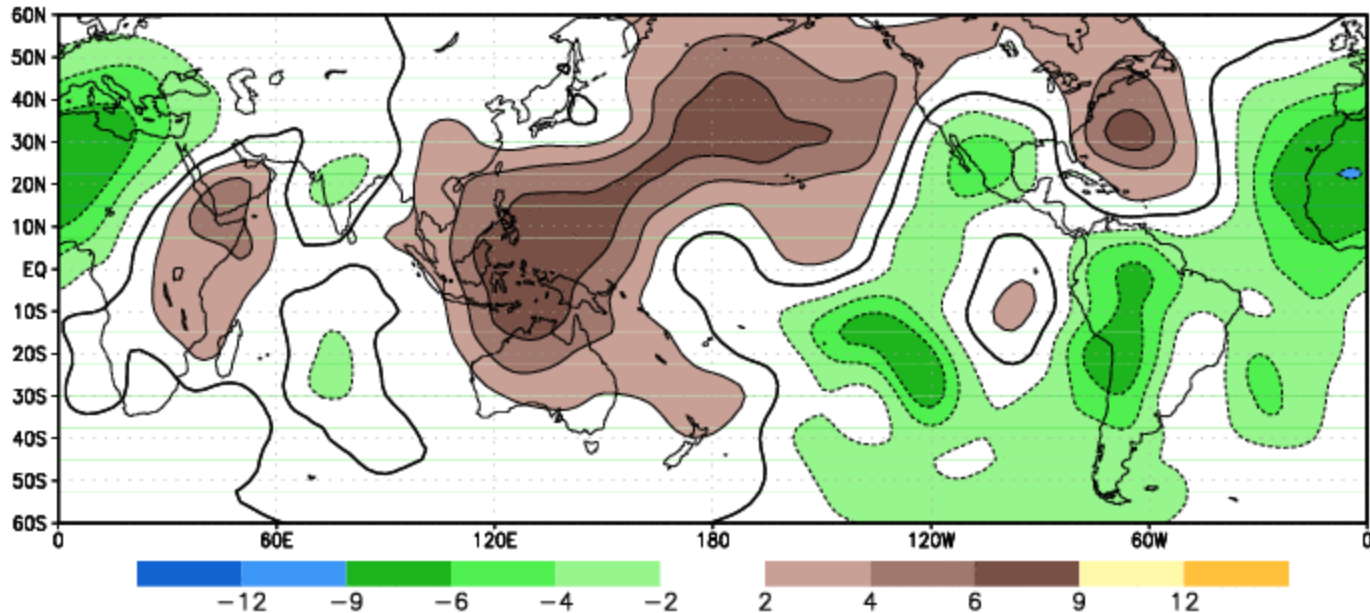
- The MJO is a global scale wave that occurs in the tropics and results in changes in important atmospheric and oceanic features: rainfall and Sea surface temperature (SST)

- Enhances predictability in parts of the tropics

Dynamical Model Forecasts – Verification

MJO Rainfall Anomaly Composite Oct-Dec, 1983-2012

The active phase of the MJO is located over Africa during phase 8 – 2 of the MJO in the Wheeler-Hendon diagram

For this season, rainfall surpluses are present over equatorial East Africa during phase 8 – 3 of the MJO, while suppression is observed during phase 5 – 7 of the MJO.
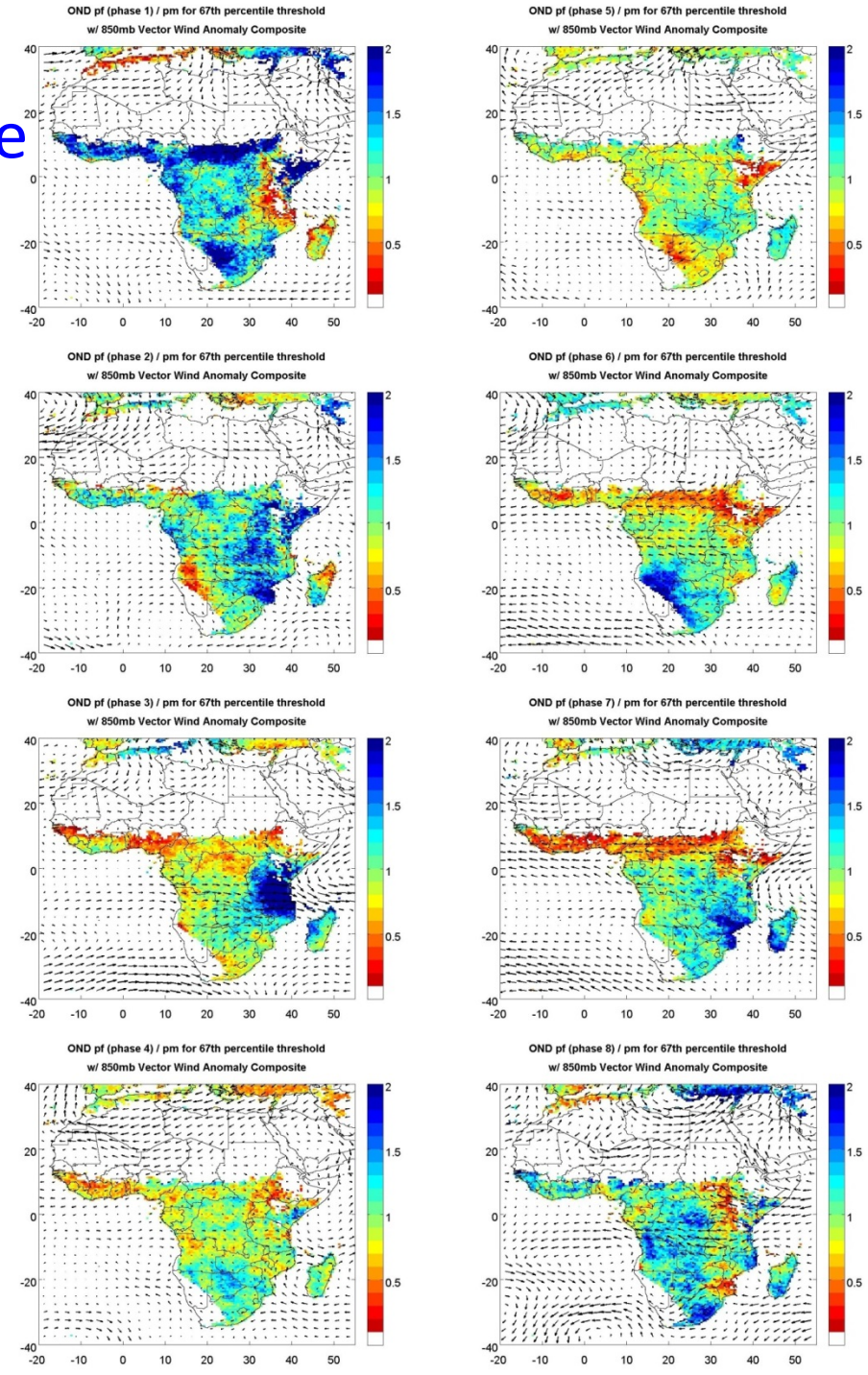
Scientific Challenge

NOAA's Climate Forecast System (CFSv2)
Precipitation forecast skill

Week-1

Week-2

Week-3

Week-4

20   30   40   50   60
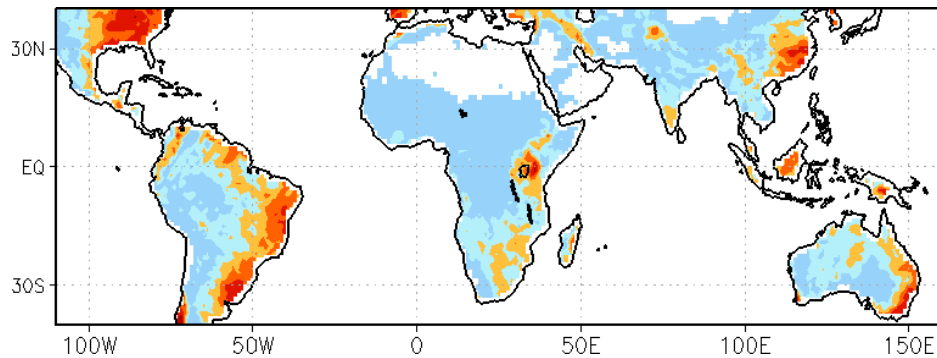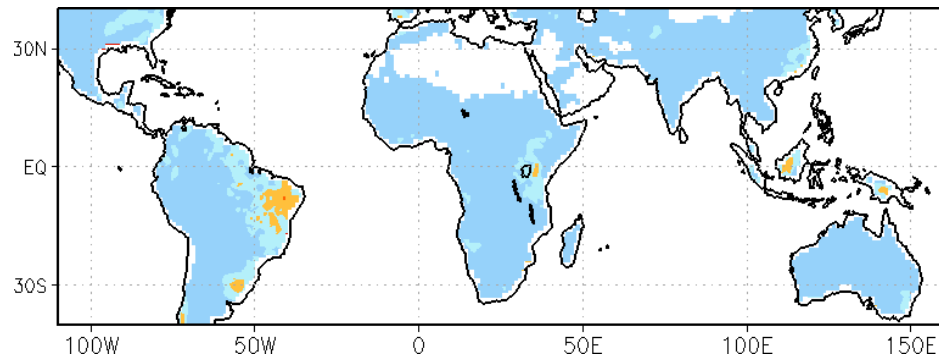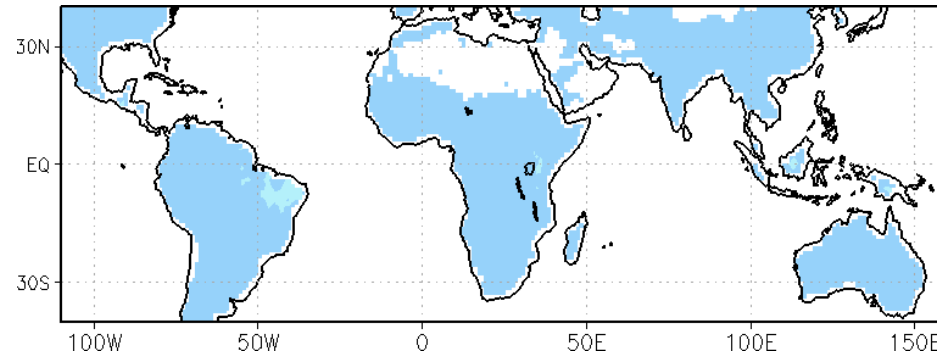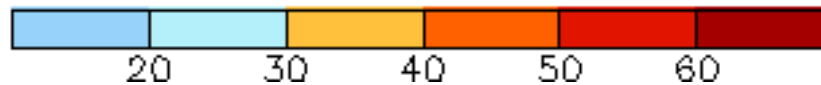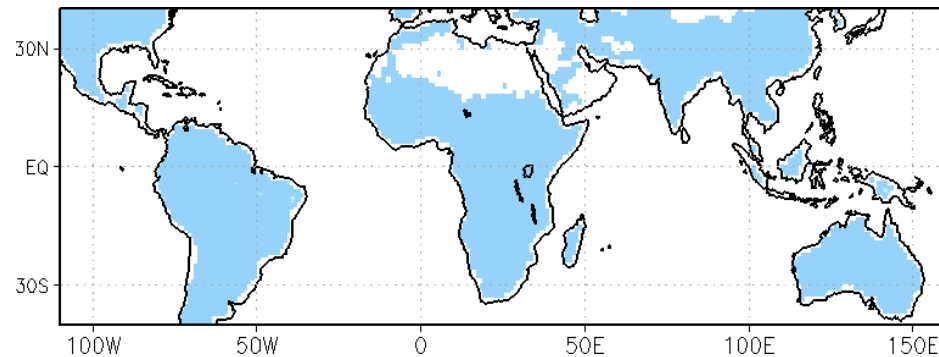
Scientific Challenge

NOAA's Climate Forecast System (CFSv2)
Bias Corrected precipitation forecast skill

Week-1, with BC
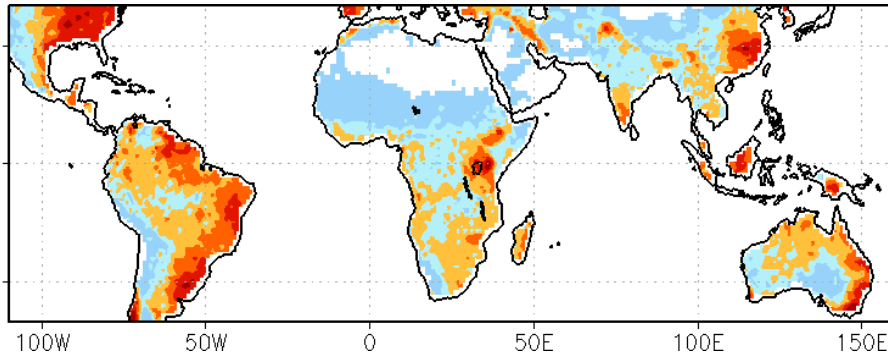
Week-2, with BC
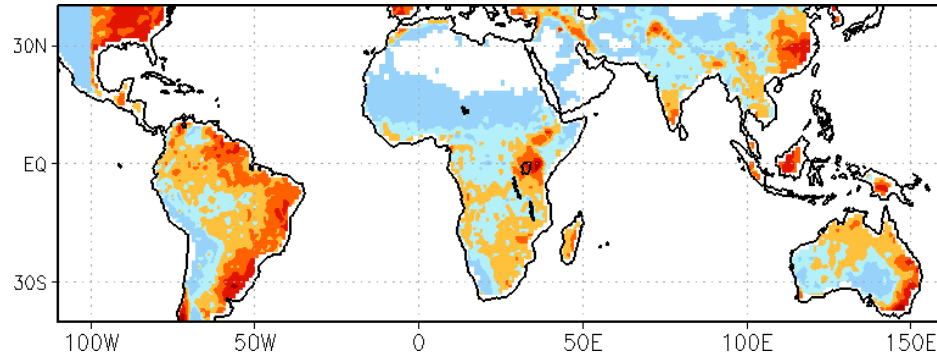
Week-3, with BC
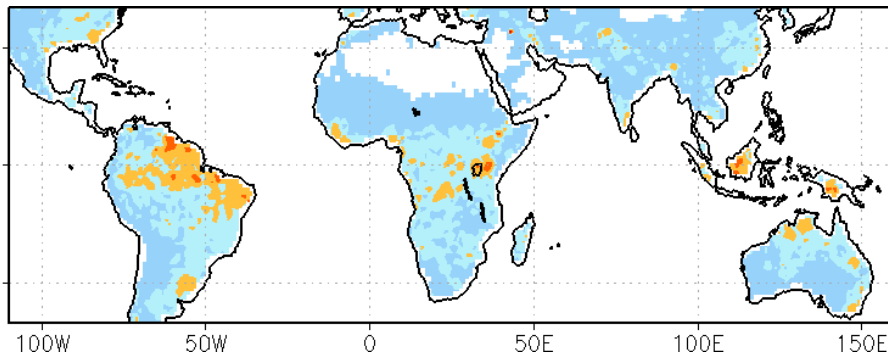
Week-4, with BC
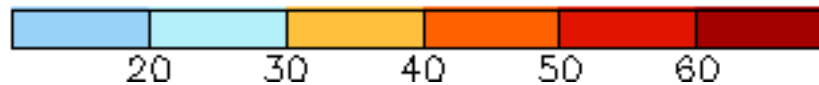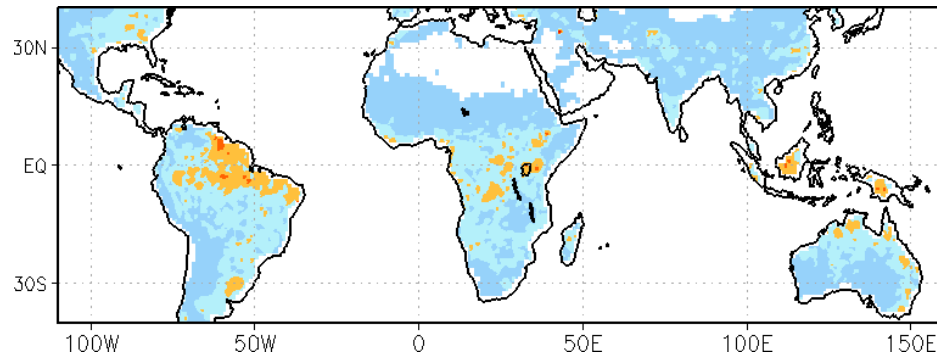
Plan for week3-4 Outlooks

- CPC Task Team to develop strategy for week-3/4 outlooks

- Approach

  – Use operational models from the U.S., Europe, and Japan

  – Evaluate model performance for precipitation and temperature forecasts

  – Calibrate model precipitation and temperature outlooks

  – Develop methods for forecast verifications

Real-time verification (bottom) of week 3/4 forecast (top): Bottom plots shows hits (green) and misses (red)
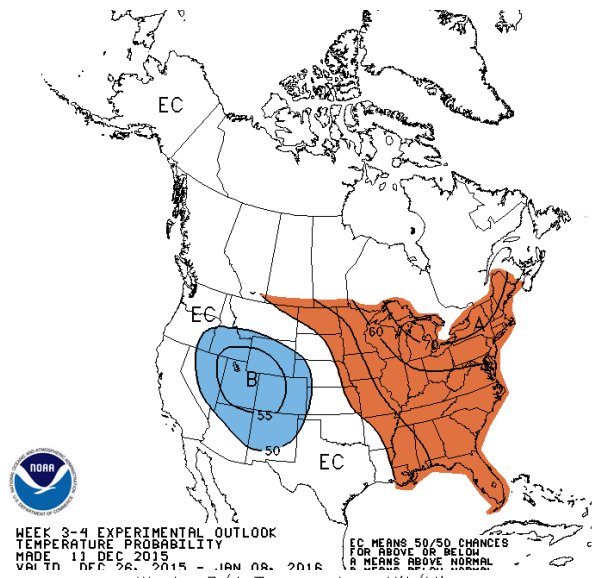
Source NOAA/CPC
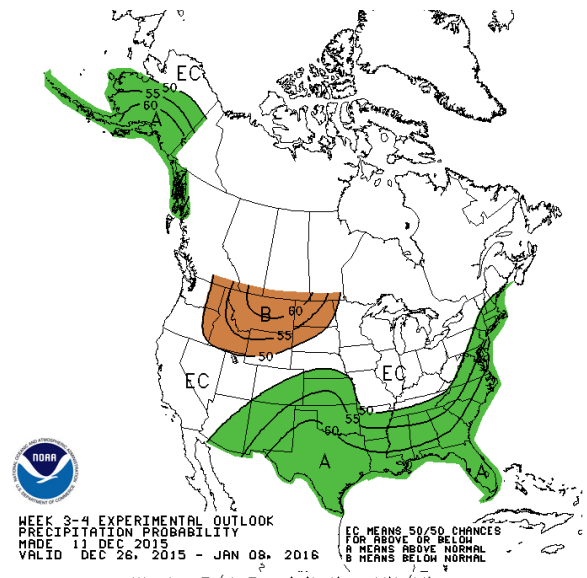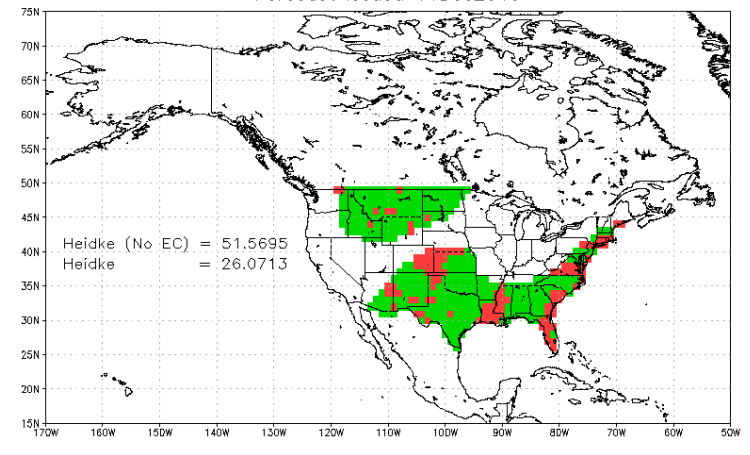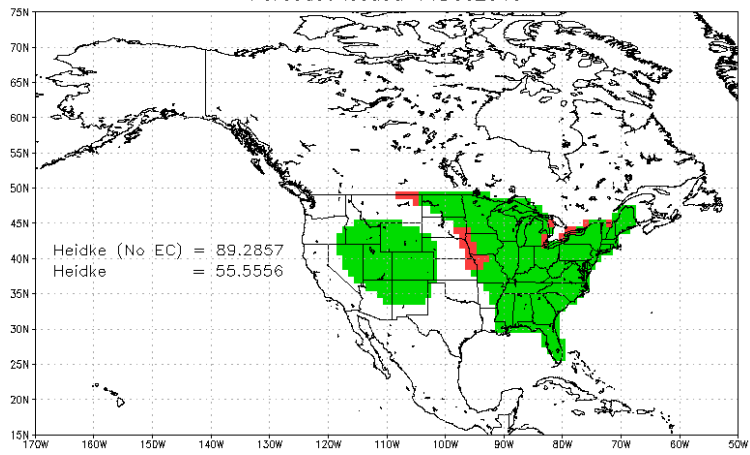
Sub-Seasonal Forecast Data

- S2S Website

http://apps.ecmwf.int/datasets/data/s2s-reforecasts-instantaneous-accum-ecmf/levtype=sfc/type=cf/

- ECMWF 10 members, 1996-2015
- NCEP 3 members 1999-2010
- UKMO 2 members 1998-2015
- JMA 4 members 1981-2010

T Model Anomaly (left) and Probability Forecasts (right)

Valid 1 – 14 July 2016

Weeks 3/4 ECMWF 2m Temp Anomalies

Valid 1 – 14 July 2016

ECMWF Week-3/4 Two Category T2m Probability
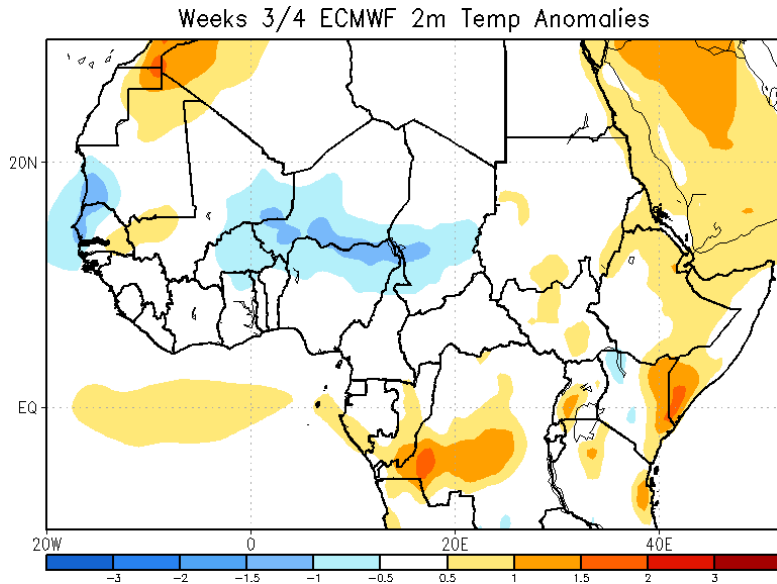
P Model Anomaly (left) and Probability Forecasts (right)

Valid 1 – 14 July 2016

Valid 1 – 14 July 2016

Weeks 3/4 ECMWF Prec Anomaly

ECMWF Week-3/4 Two Category Precipitation Probability
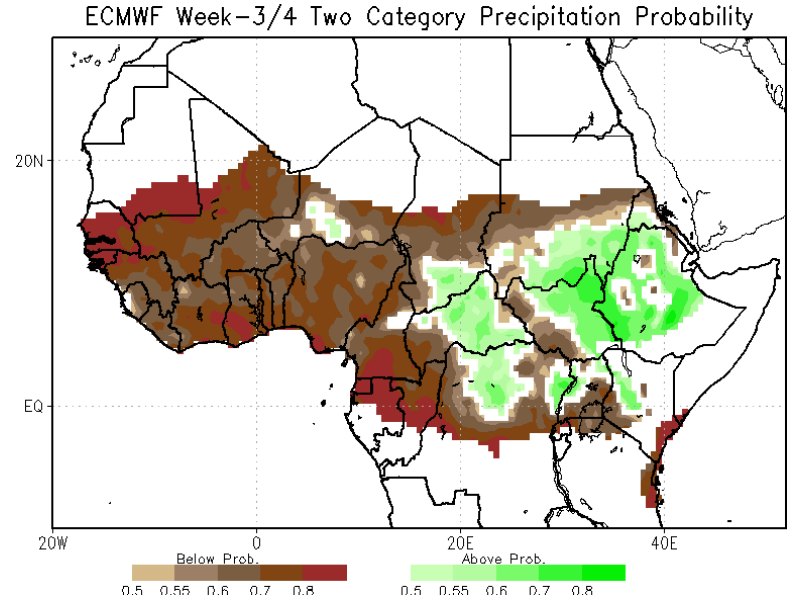
# ECMWF T2m Anomaly and 2-category Calibrated Week-3/4(valid 17-30 Jun 2016)

Weeks 3/4 ECMWF 2m Temp Anomalies
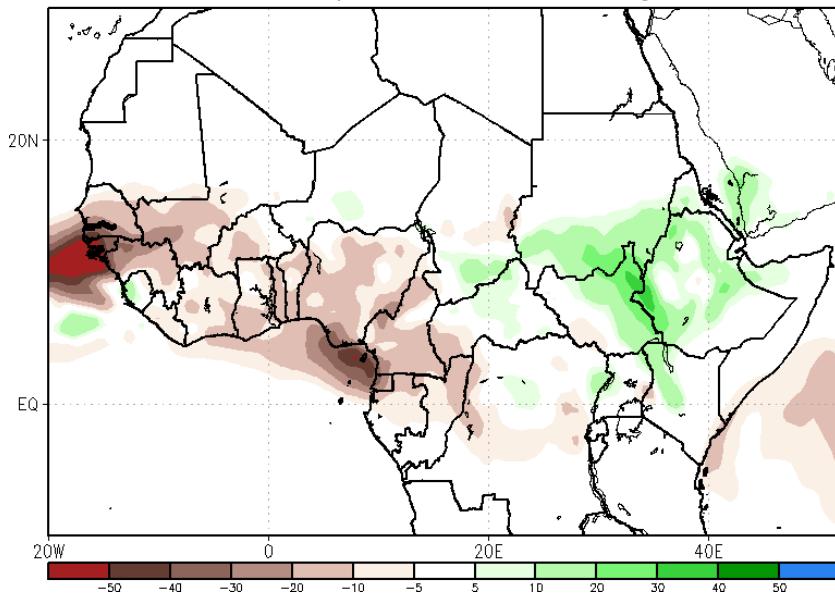
Week-3/4 Regress. Calib. two-Category T2m Fcst.

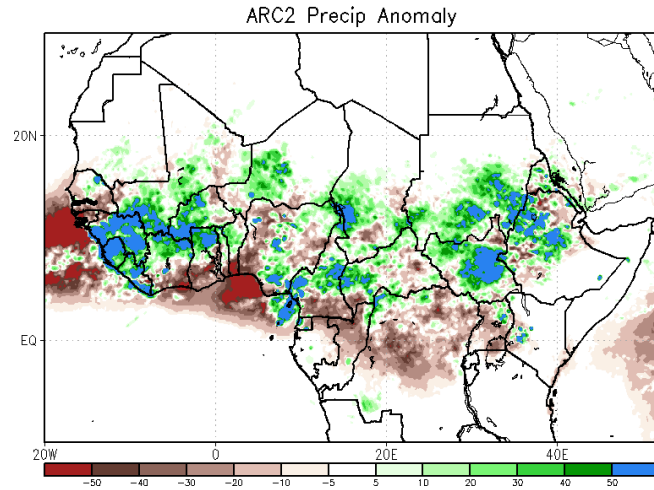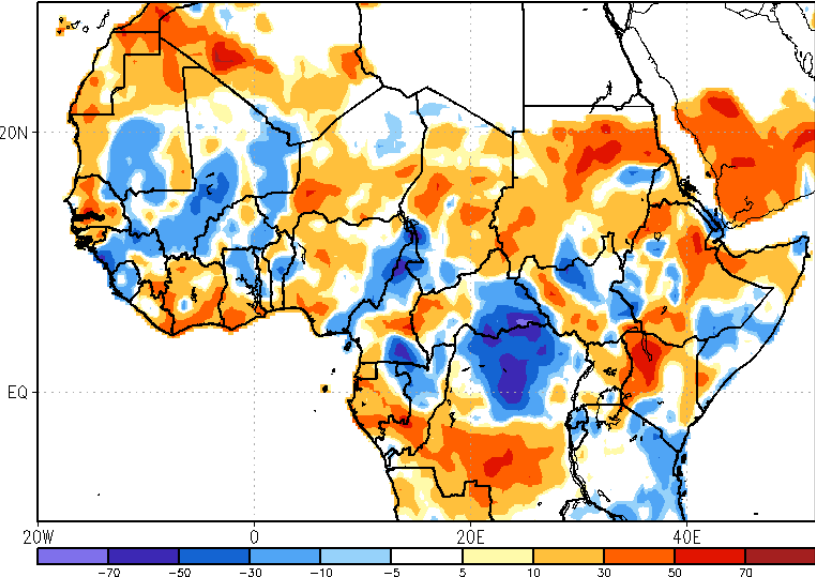# ECMWF T2m Anomaly and 2-category Calibrated Week-3/4(valid 17-30 Jun 2016)
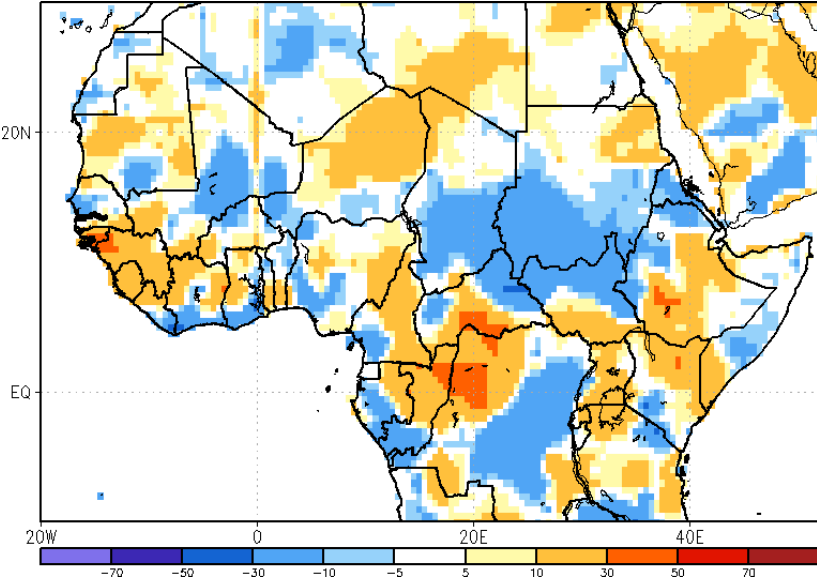
ECMWF Precip Anomaly and 2-category Calibrated Week-3/4(valid 17-30 Jun 2016)
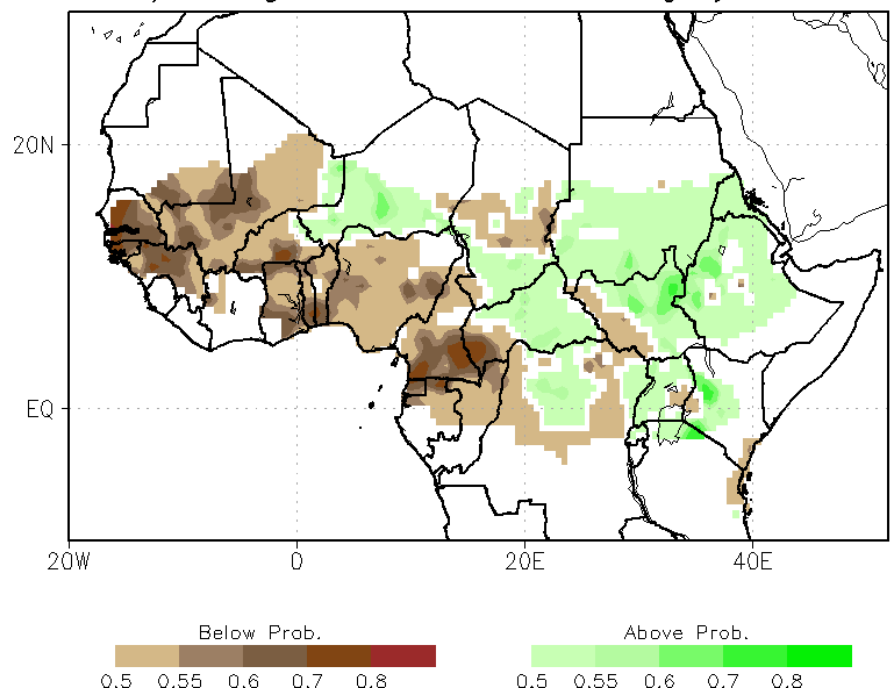
ECMWF Precip Anomaly and 2-category Calibrated Week-3/4(valid 17-30 Jun 2016)
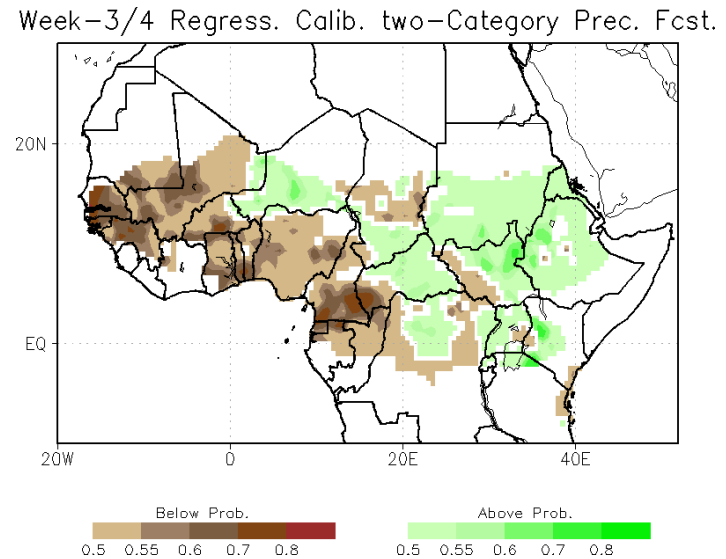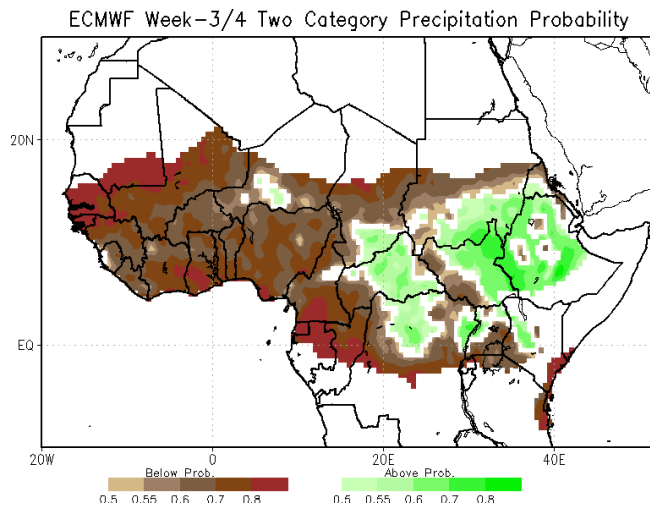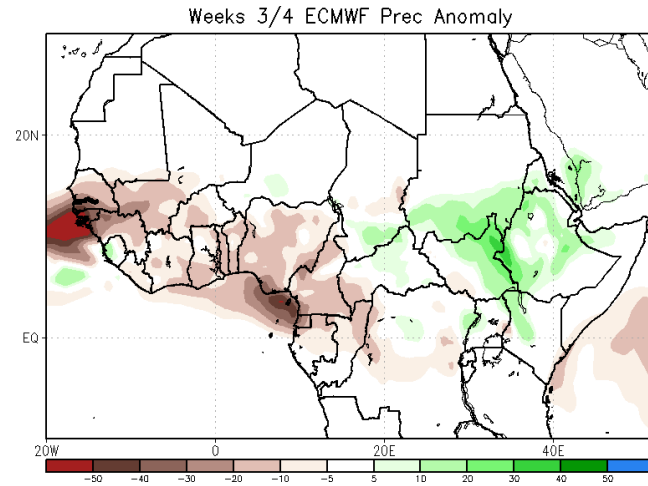
Heidke Skill Score based on 26 Forecasts in JJA
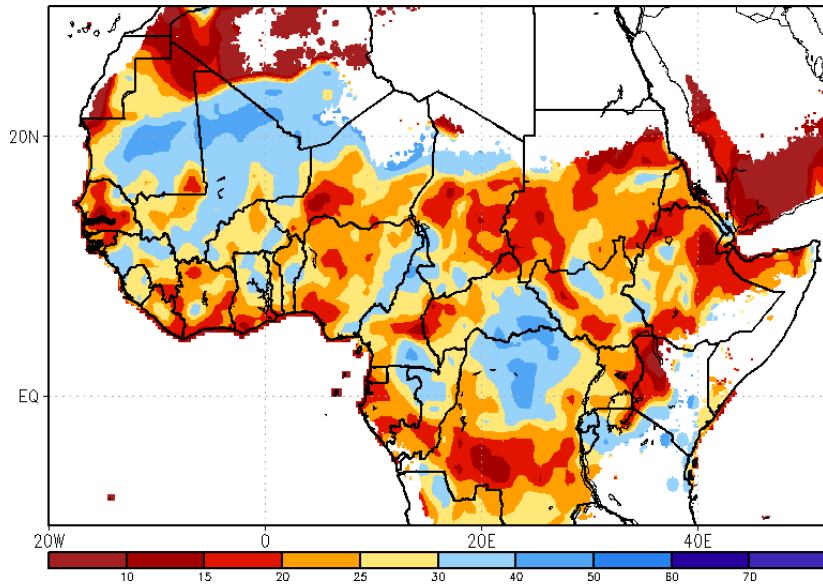
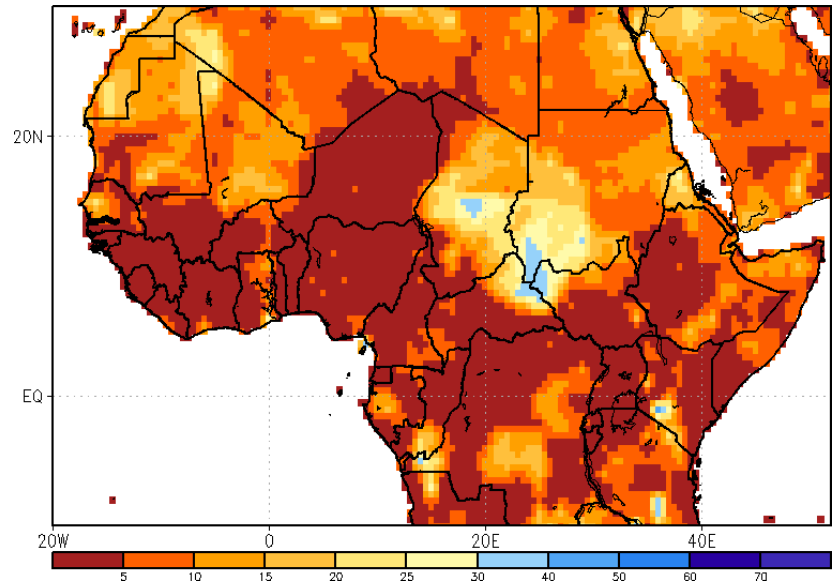## HSS, Precip (perfect score is 100%)

HSS, T2m(Perfect Score is 100%)

Brier Score based on 26 Forecasts in JJA
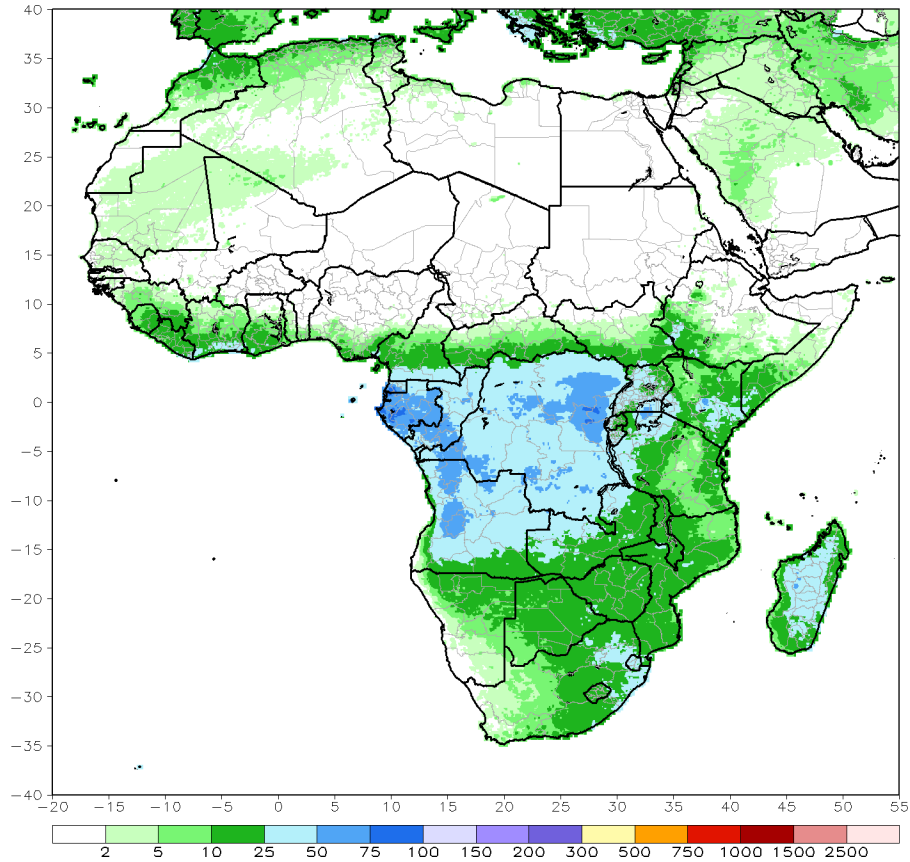
BS, Precip (Perfect Score is 0)
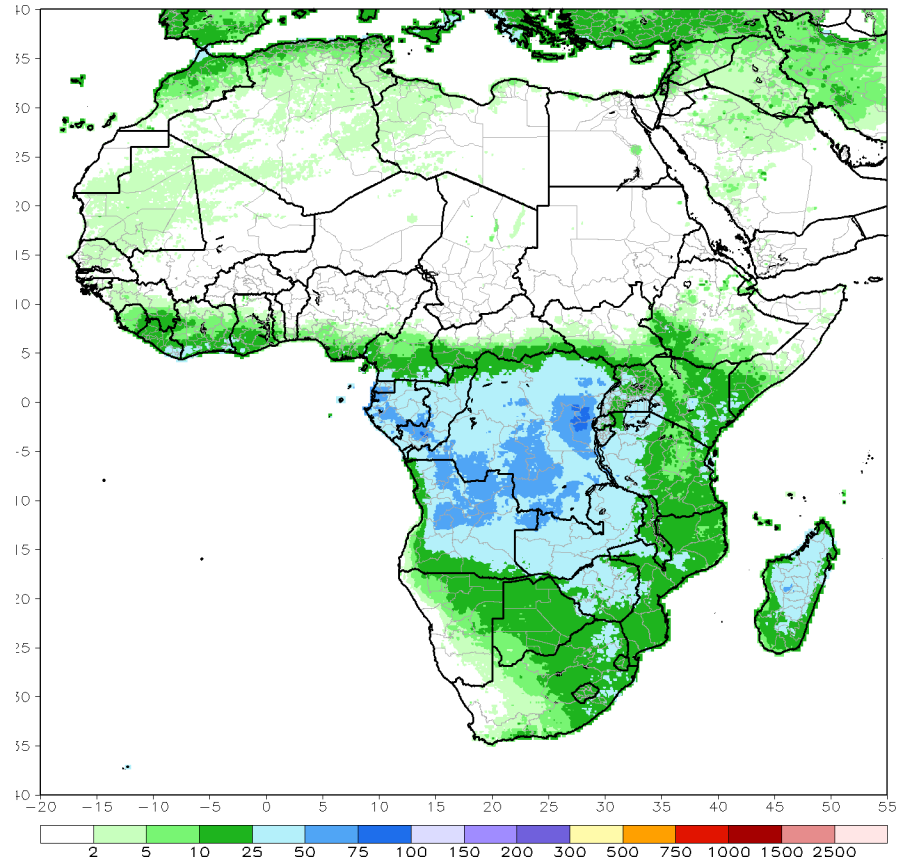
BS, T2m (Perfect Score is 0)

ARC2 Climatological Rainfall

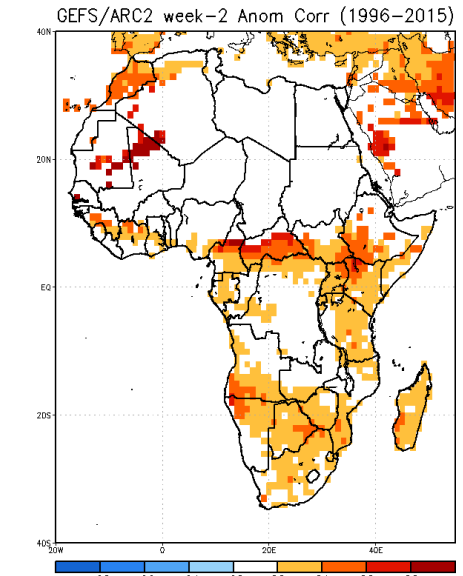ARC2 week1 Climatological Rainfall (mm)
Period: 14NOV – 20NOV

ARC2 week2 Climatological Rainfall (mm)
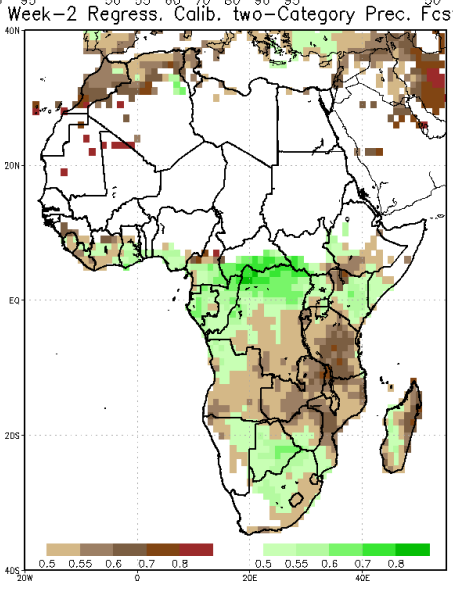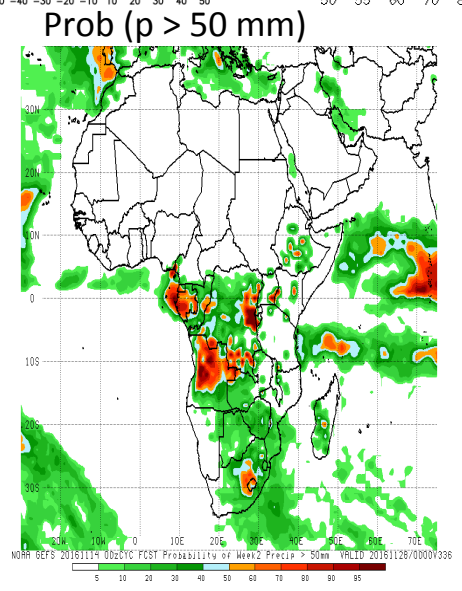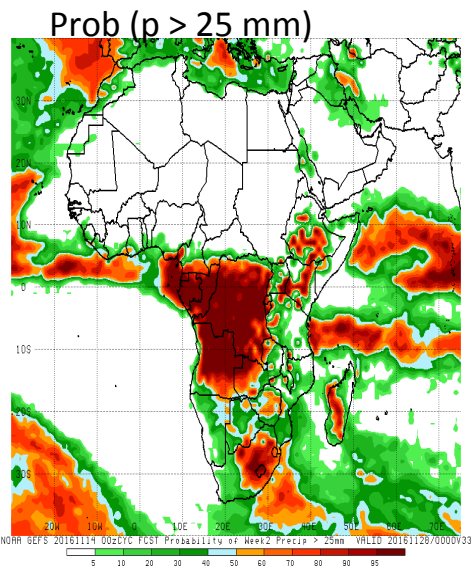Period: 21NOV – 27NOV

NCEP GFS/GEFS/ECMWF bias corrected forecasts for Week 2
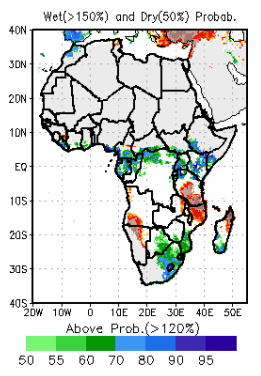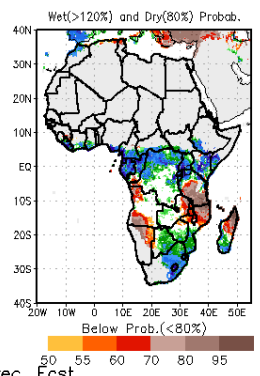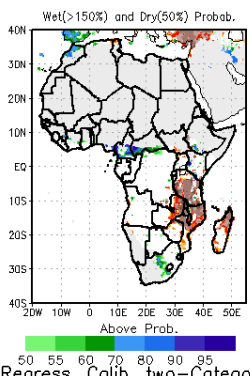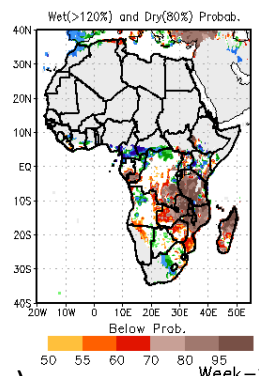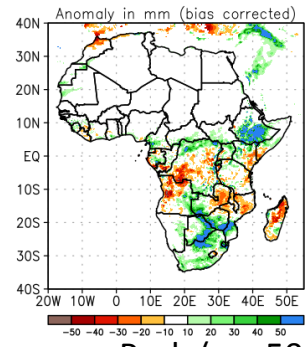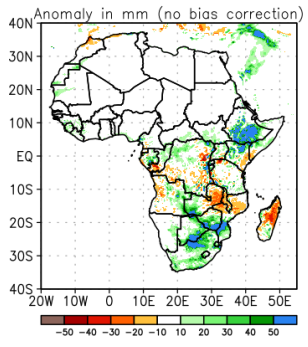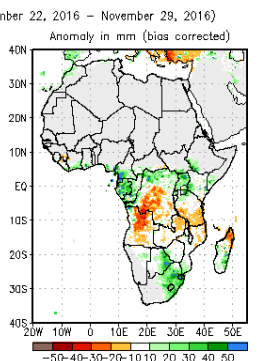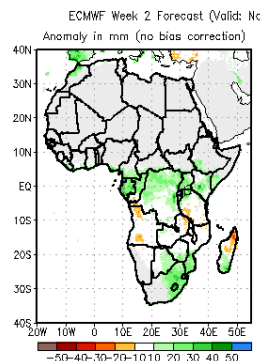
NCEP GFS 700 mb and 200mb Div 7-day forecast Week 2

GFS 700mb week2 Mean Divergence Anomaly (10e+5/s)
Ending: 06z28Nov2016

GFS 200mb week2 Mean Divergence Anomaly (10e+5/s)
Ending: 06z28Nov2016

Week1 and Week 2 Outlook

Issued: Nov 14, 2016

Week 1 Outlook for Africa
Valid: 15 November - 21 November, 2016

1. There is an increased chance for above-average rainfall over southern Cameroon, southwestern CAR, Equatorial Guinea, Gabon, Congo-Brazzaville, northwestern Angola and western DRC: The projected phase of the MJO, combined with an area of anomalous lower-level convergence and upper-level divergence is expected to enhance rainfall in the region. **Confidence: Moderate**
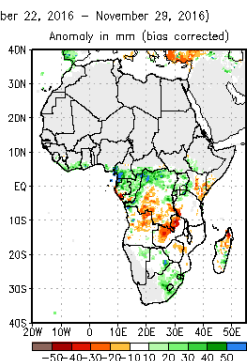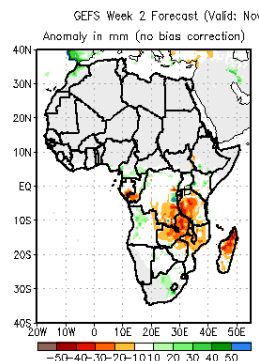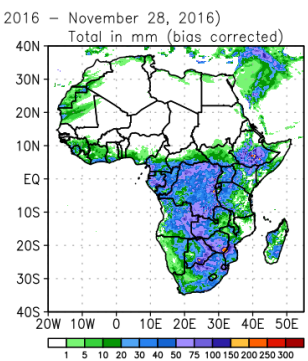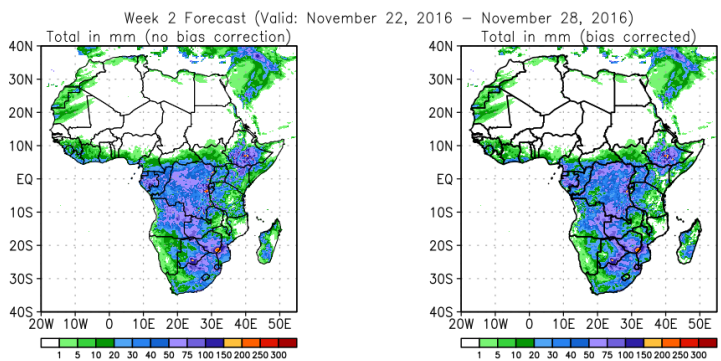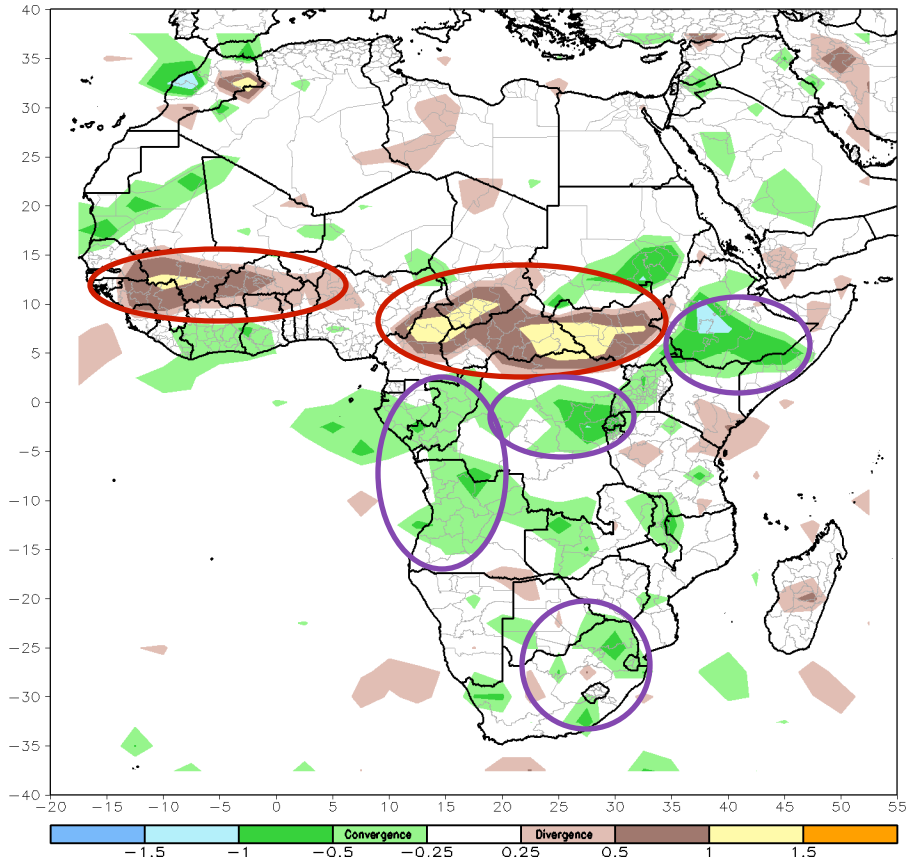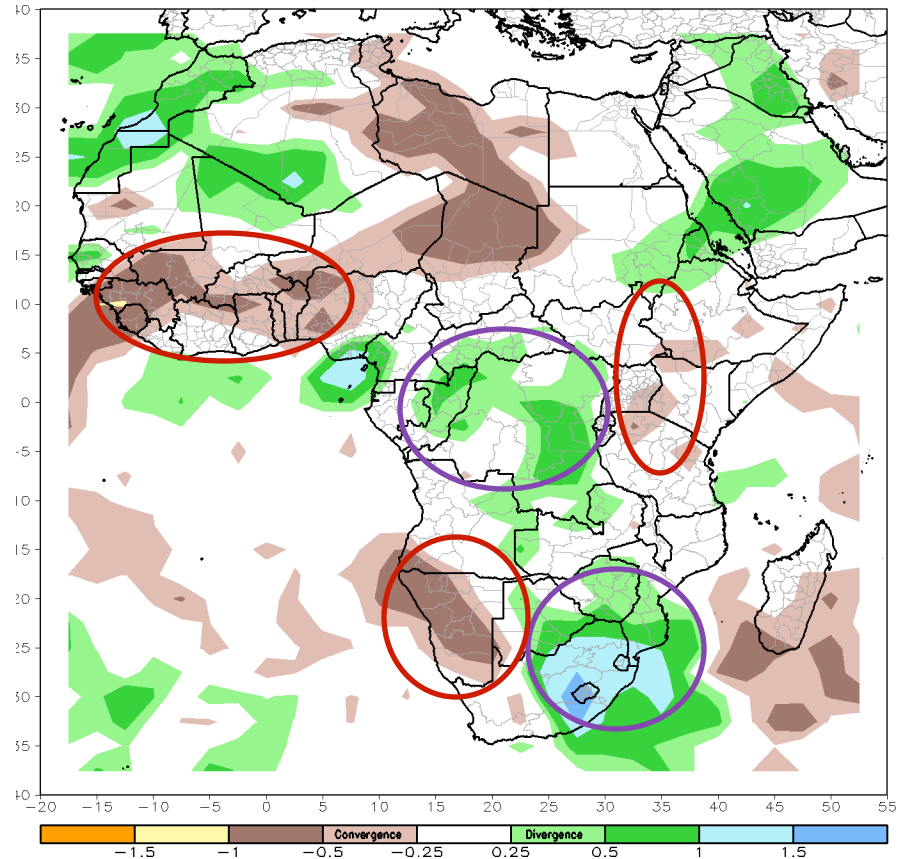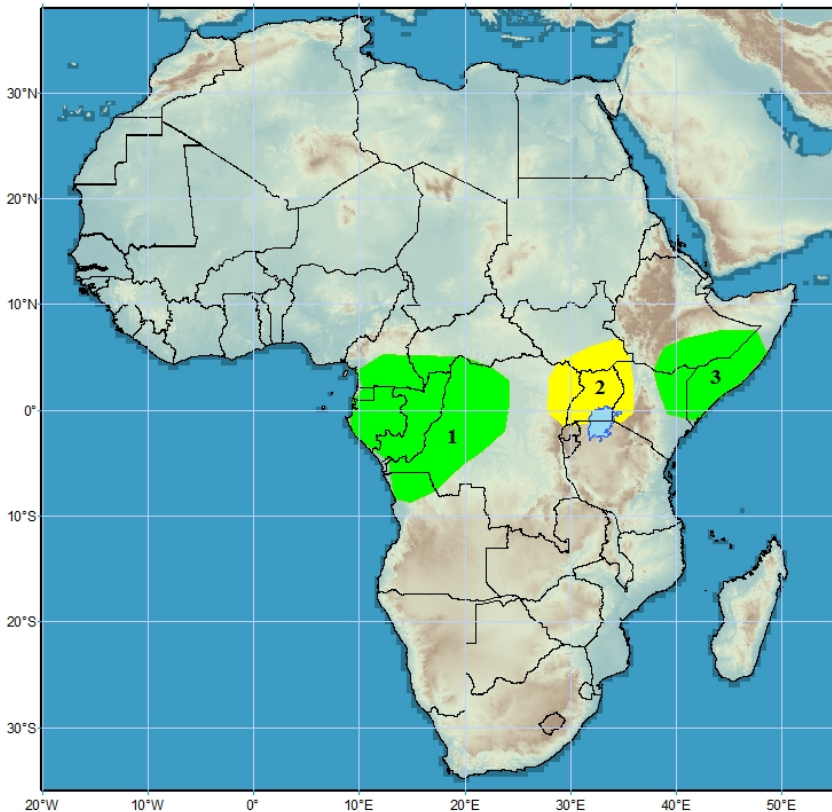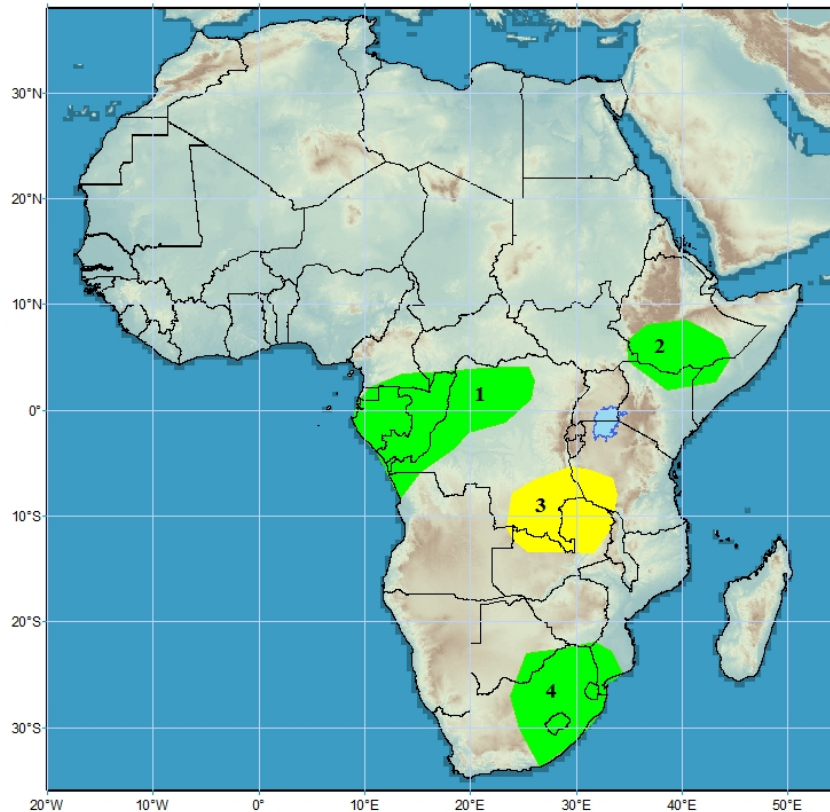
2. There is an increased chance for below-average rainfall over parts of northeastern DRC, southern South Sudan, and western Kenya: An area of lower-level divergence and upper-level convergence is expected to suppress rainfall in the region. **Confidence: Moderate**

3. There is an increased chance for above-average rainfall across southeastern Ethiopia, eastern Kenya and southern Somalia: An area of anomalous lower-level onshore flow from the Indian Ocean, combined with the projected phase of the MJO is expected to enhance rainfall in the region. **Confidence: Moderate**

Issued: Nov 14, 2016

Week 2 Outlook for Africa
Valid: 22 November - 28 November, 2016

1. There is an increased chance for above-average rainfall over Equatorial Guinea, Congo-Brazzaville, Gabon, and western DRC: **Confidence: Moderate**

2. There is an increased chance for above-average rainfall over southern Ethiopia and the neighboring areas of northern Kenya and Somalia: An area of anomalous lower-level convergence is expected to enhance rainfall in the region. **Confidence: Moderate**

3. There is an increased chance for below-average rainfall across southeastern DRC, northern Zambia and southwestern Tanzania: An area of anomalous lower-level divergence is expected to suppress rainfall in the region.

4. There is an increased chance for above-average rainfall over portions of South Africa, Lesotho, and Swaziland: An area of anomalous lower-level cyclonic circulation and upper-level divergence is expected to enhance rainfall. **Confidence: Moderate**

Seasonal Forecasts:
The Use of the North American Ensemble (NMME) Forecasts

NMME Real Time Forecasts

| Models	Initial Conditions	Members
CFSv2 (NCEP)	1st to the 8th of month	24
CCMs (Canada)	1st of each month	20
GFDL	1st of each month	34
NASA	5 days / 1 day	11
NCAR	1st of each month	6
MME	Combined	95

- **Forecasts released by the 10th of each month**
- **All models have the same horizontal resolution 1.0° X 1.0°**

NMME Regionalized Forecasts
www.cpc.ncep.noaa.gov; international desks; nmme

SEASONAL FORECASTS		MONTHLY FORECASTS		DATA DOWNLOADS		VERIFICATION

SEA SURFACE TEMPERATURE

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

PRECIPITATION

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

MME SST Forecast, DJF, Nov IC

NMME Forecast SST Skill
November initial conditions Season 1
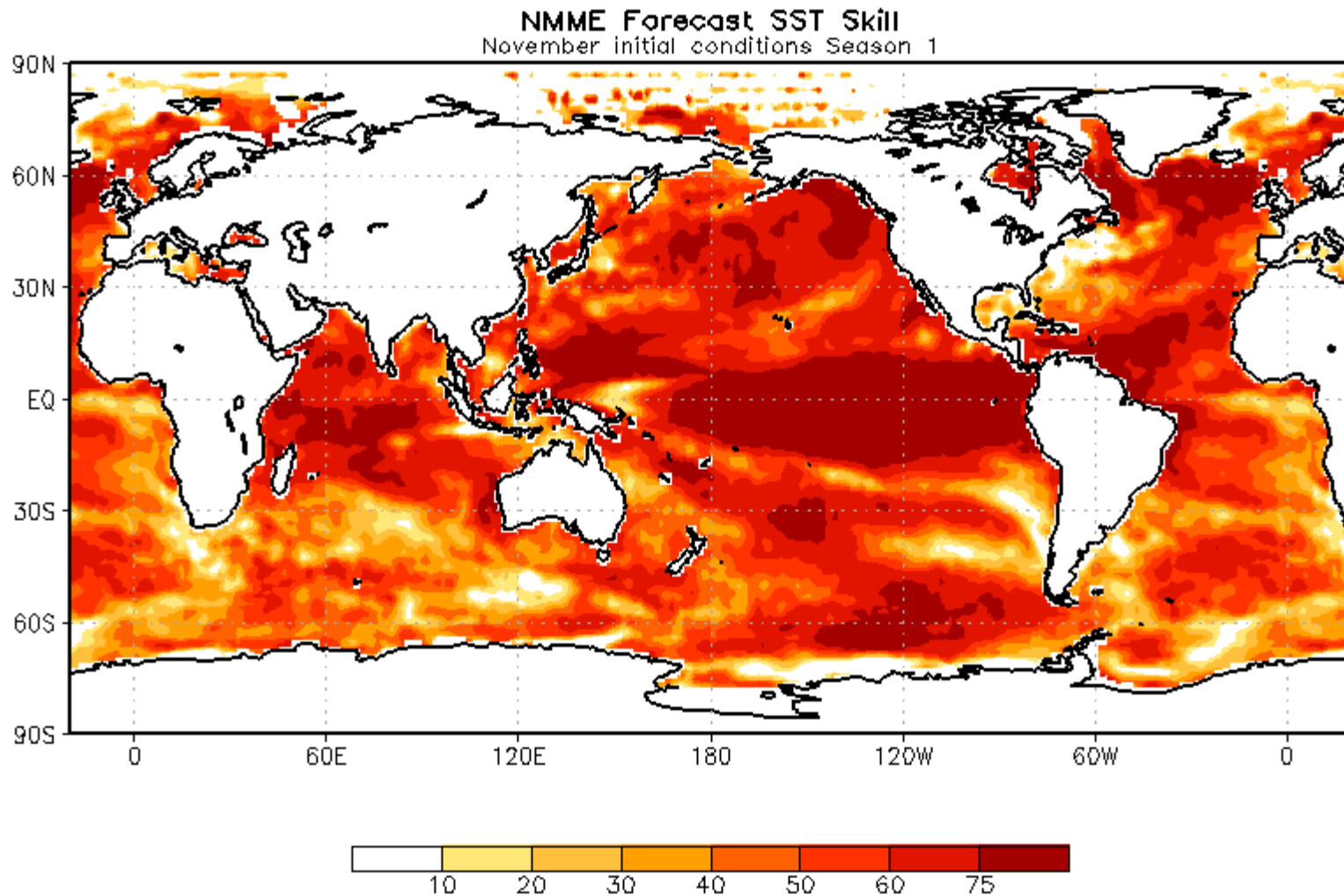
Seasonal Forecasts for Africa
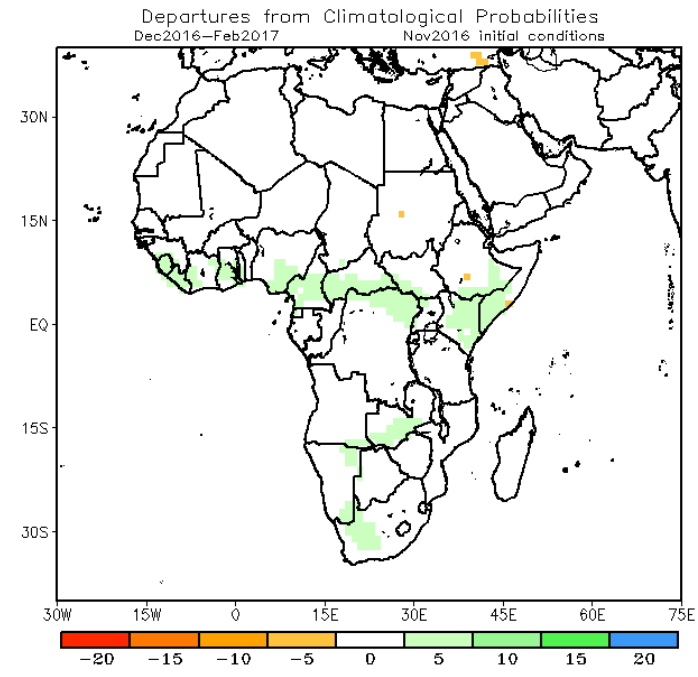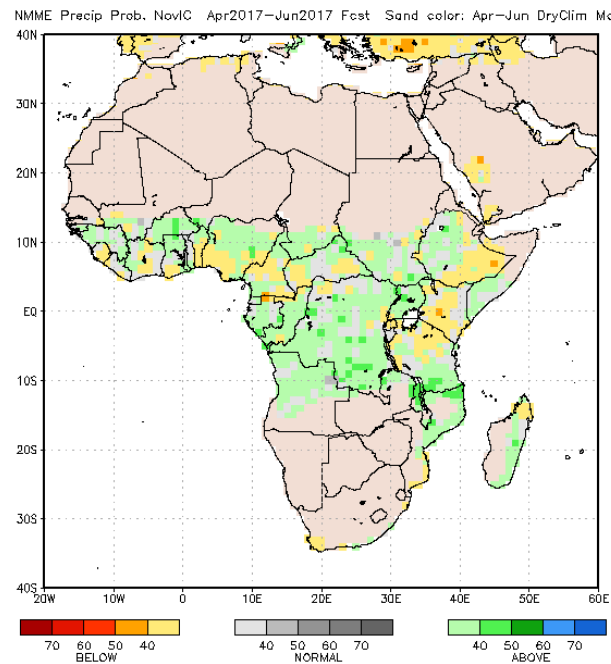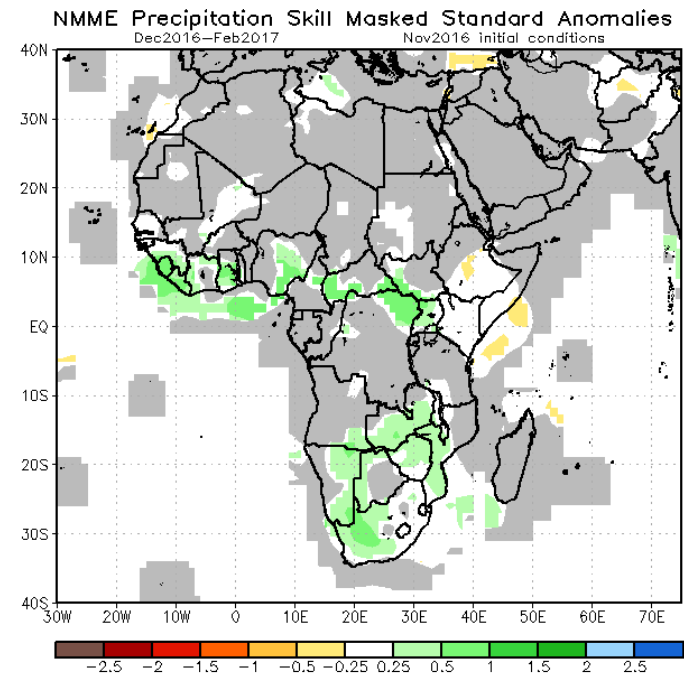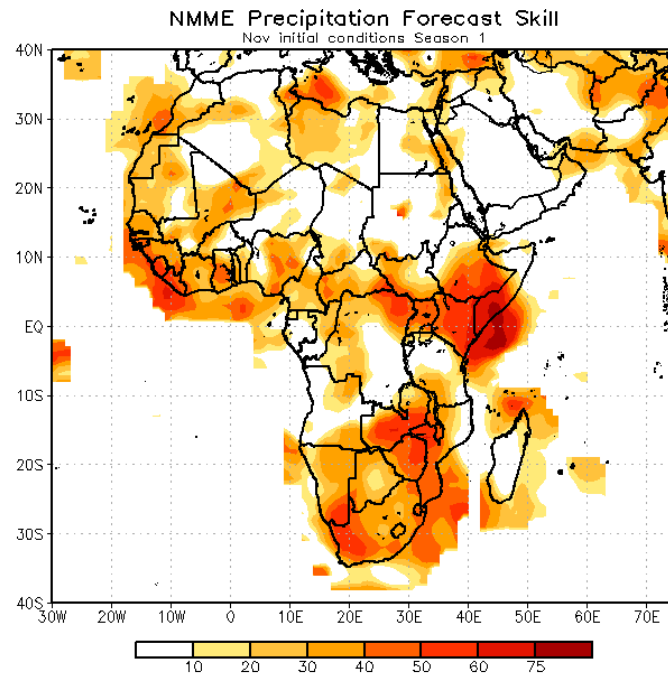
Seasonal Forecast Experiments for the Sahel

ERSST
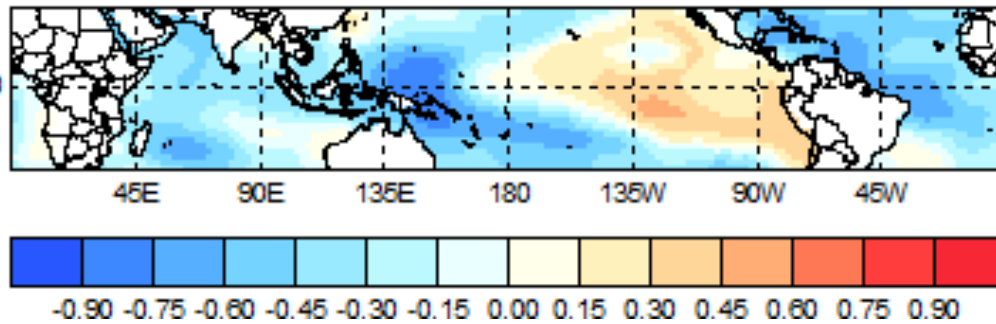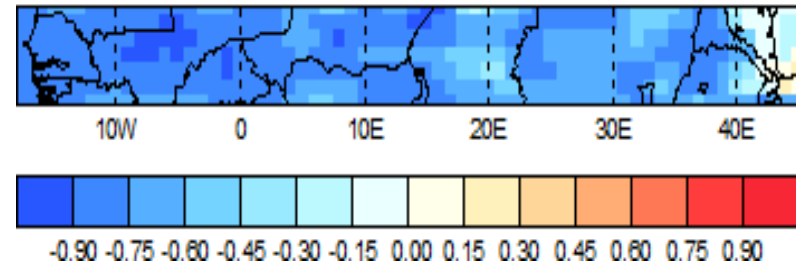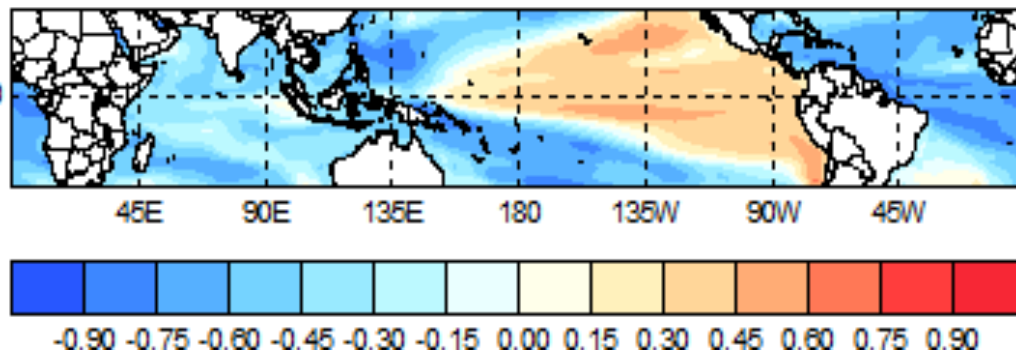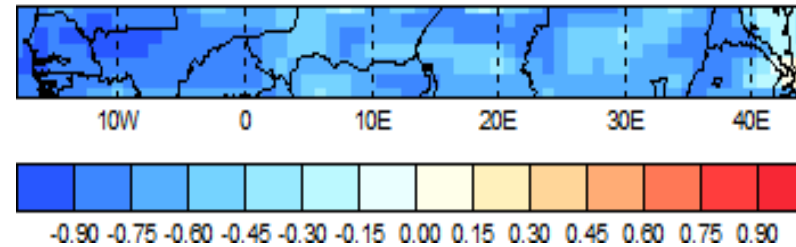
NMME

ERSST

Pearson's Correlation
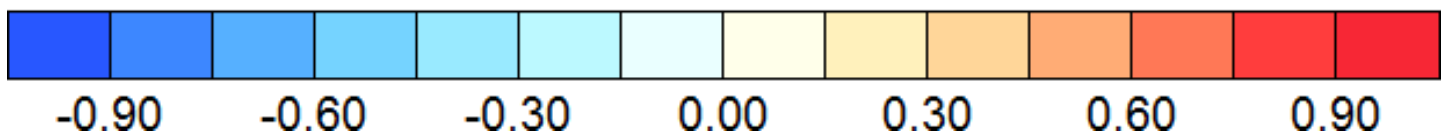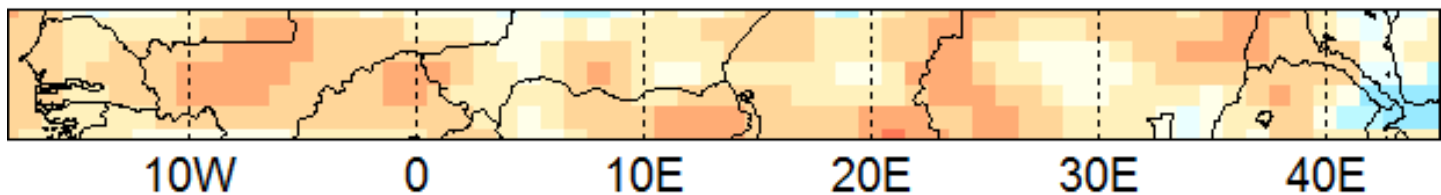
NMME

Pearson's Correlation
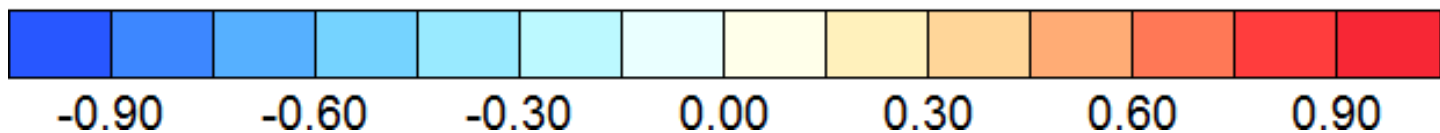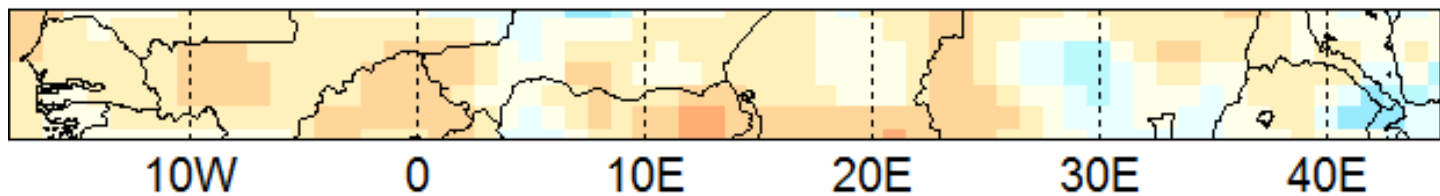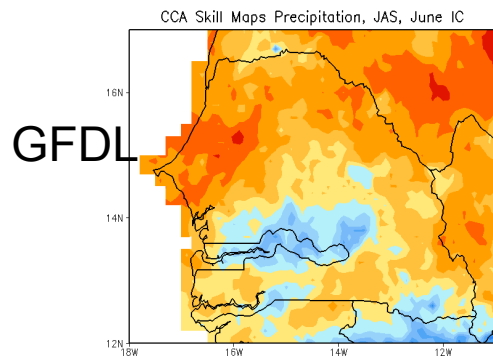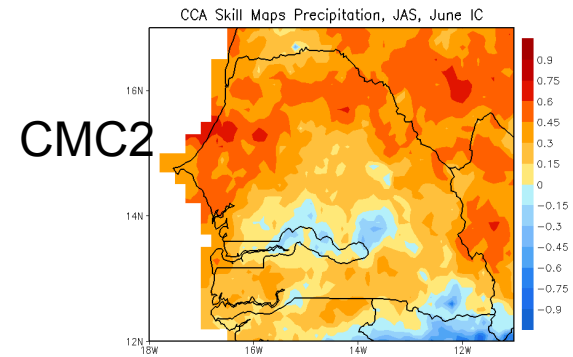
Seasonal Prediction Experiments for Senegal

- Predictand Data: NCEP Climate Forecast System
  - ReAnalysis 1 for Temp and ARC2 for Precip

- Predictor Data:

  - MME models
    - Global tropical SST
    - CCA Correction

  - ERSST

- Experiments are run for JAS, ASO, SON, OND, and NDJ with June IC

CCA Skill Maps Precipitation, JAS, June IC

CFS2

CMC1

CMC2

GFDL

NASA

NCAR
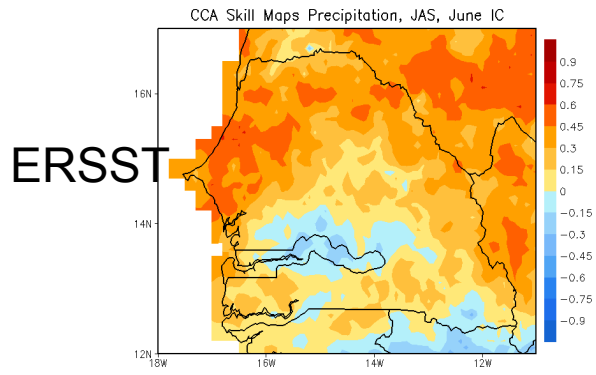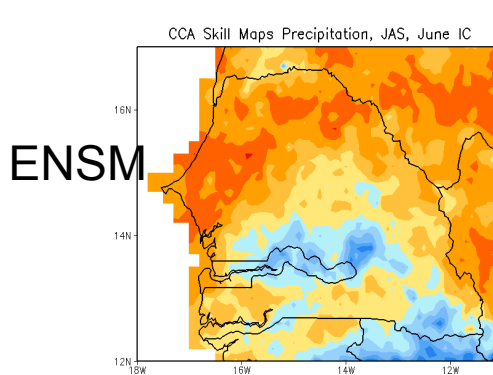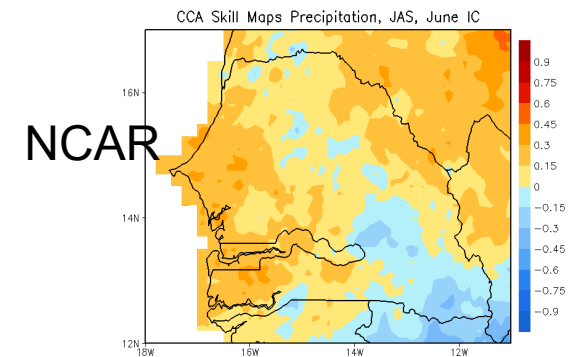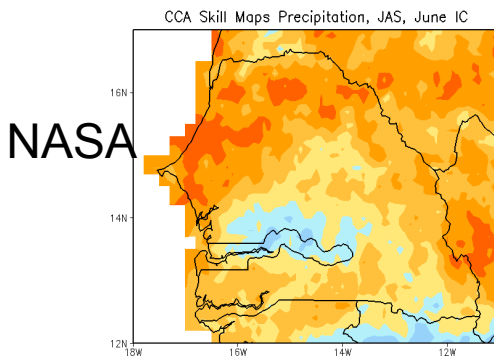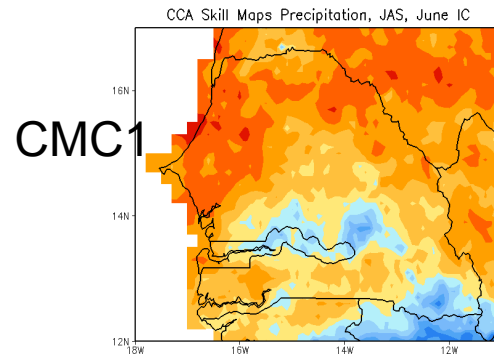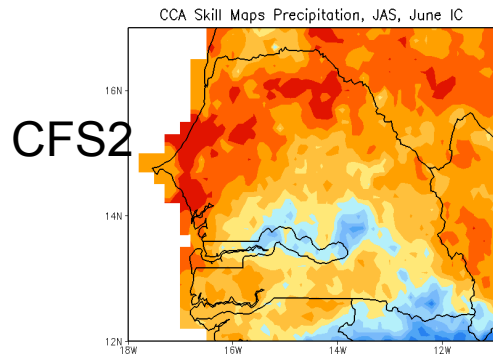
ENSM

ERSST

NMME ens mean has skill comparable to ERSST.

CFSv2 seems to exhibit highest Skill over western Senegal

CCA Skill Precipitation, June IC
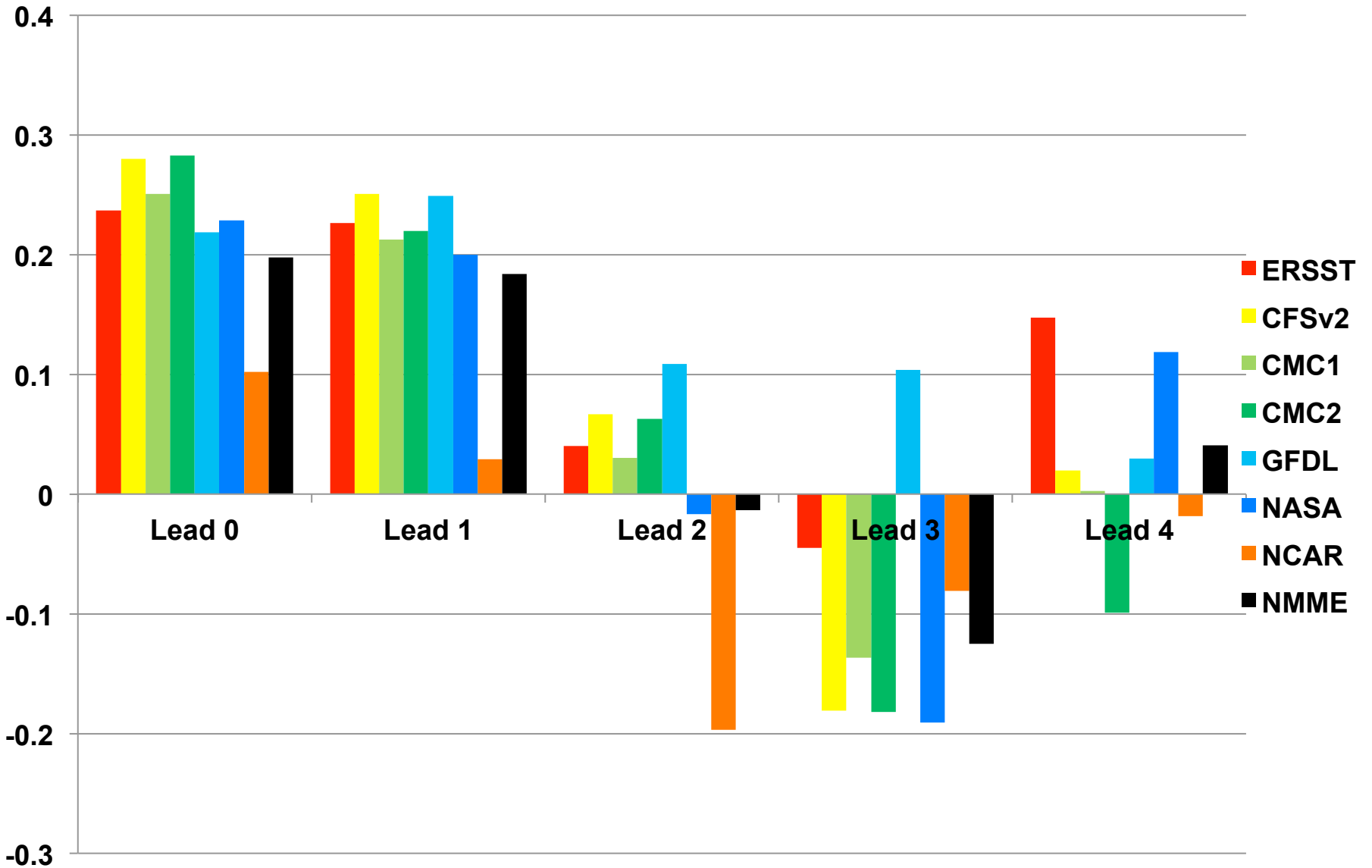
P Anomaly correlation before and after CCA corrections, June IC

| Experiments	CFSv2	CMC1	CMC2	GFDL	NASA	NCAR	NMME
Lead 0: Forecasts	0.28	0.25	0.28	0.22	0.23	0.10	0.20
CCA Corrections	0.14	-0.12	0.10	-0.06	0.16	0.09	0.05
Lead 1: Forecasts	0.25	0.21	0.22	0.25	0.20	0.03	0.18
CCA Corrections	-0.03	-0.10	0.18	-0.01	0.39	0.02	0.05
Lead 2: Forecasts	0.07	0.03	0.06	0.11	-0.02	-0.20	-0.01
CCA Corrections	-0.07	-0.03	0.05	-0.15	0.19	-0.10	0.00
Lead 3: Forecasts	-0.18	-0.14	-0.18	0.10	-0.19	-0.08	-0.12
CCA Corrections	-0.30	-0.18	-0.16	0.01	-0.10	-0.03	-0.02
Lead 4: Forecasts	0.02	0.00	-0.10	0.03	0.12	-0.02	0.04
CCA Corrections	-0.29	-0.03	-0.24	-0.04	0.04	0.00	0.01

CCA Skill Maps Temperature, JAS, June IC
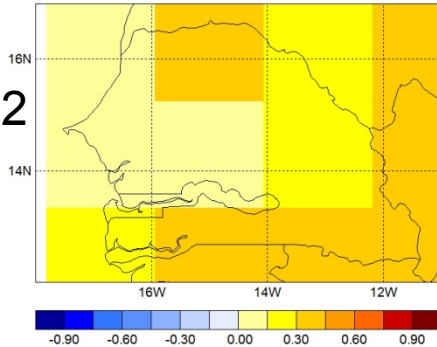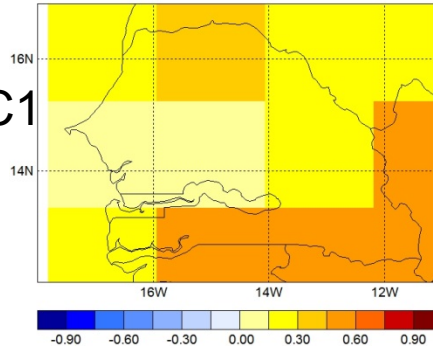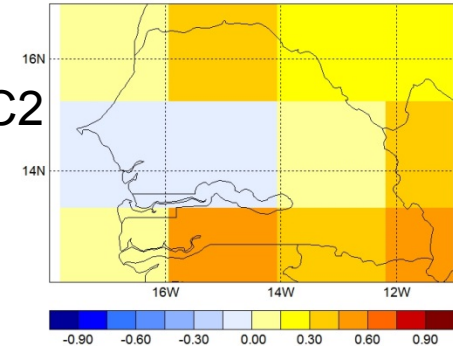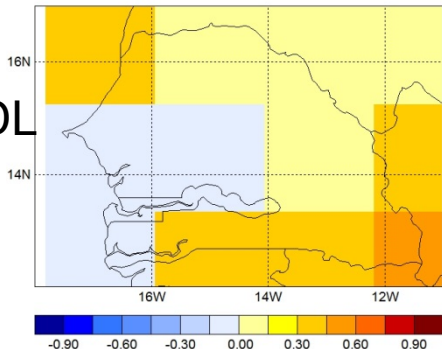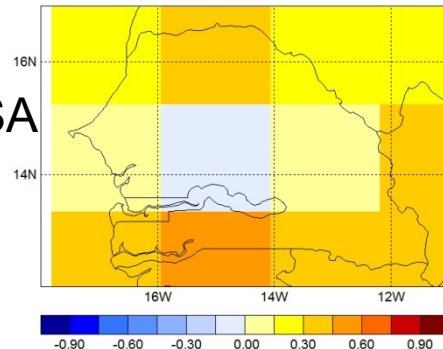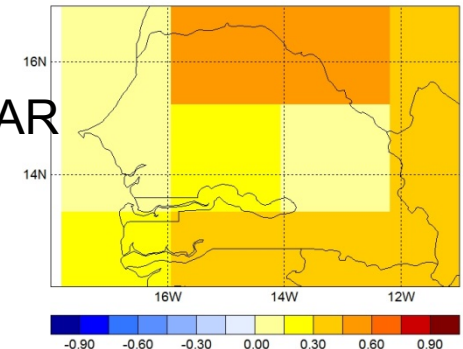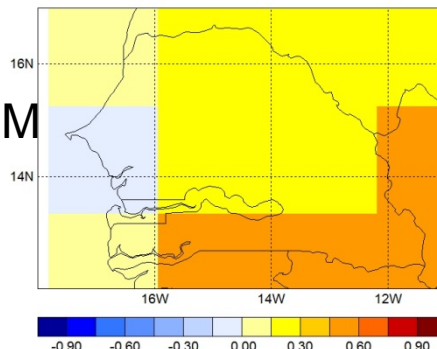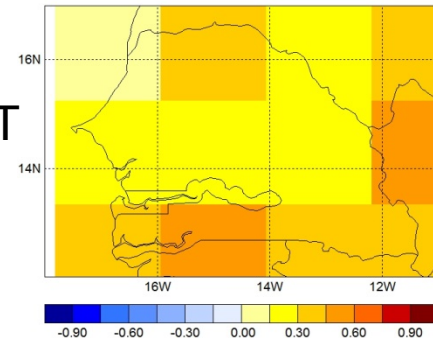
NMME ens mean seems to perform better than ERSST along the southern border of the domain, but less skillful over the western end of Senegal.

T Anomaly correlation before and after CCA corrections, June IC

| Experiments	CFSv2	CMC1	CMC2	GFDL	NASA	NCAR	NMME
Lead 0: Forecasts	0.26	0.28	0.23	0.19	0.27	0.29	0.23
CCA Corrections	0.43	0.45	0.43	0.43	0.41	0.26	0.46
Lead 1: Forecasts	0.43	0.40	0.40	0.24	0.37	0.52	0.41
CCA Corrections	0.42	0.42	0.42	0.55	0.45	0.20	0.50
Lead 2: Forecasts	0.44	0.39	0.46	0.33	0.46	0.54	0.48
CCA Corrections	0.50	0.38	0.46	0.40	0.42	0.10	0.57
Lead 3: Forecasts	0.58	0.48	0.51	0.49	0.57	0.43	0.60
CCA Corrections	0.55	0.37	0.46	0.35	0.59	-0.17	0.56
Lead 4: Forecasts	0.56	0.46	0.42	0.52	0.52	0.33	0.58
CCA Corrections	0.47	0.23	0.39	0.44	0.52	-0.03	0.47

CCA Skill 2m Temperature, June IC
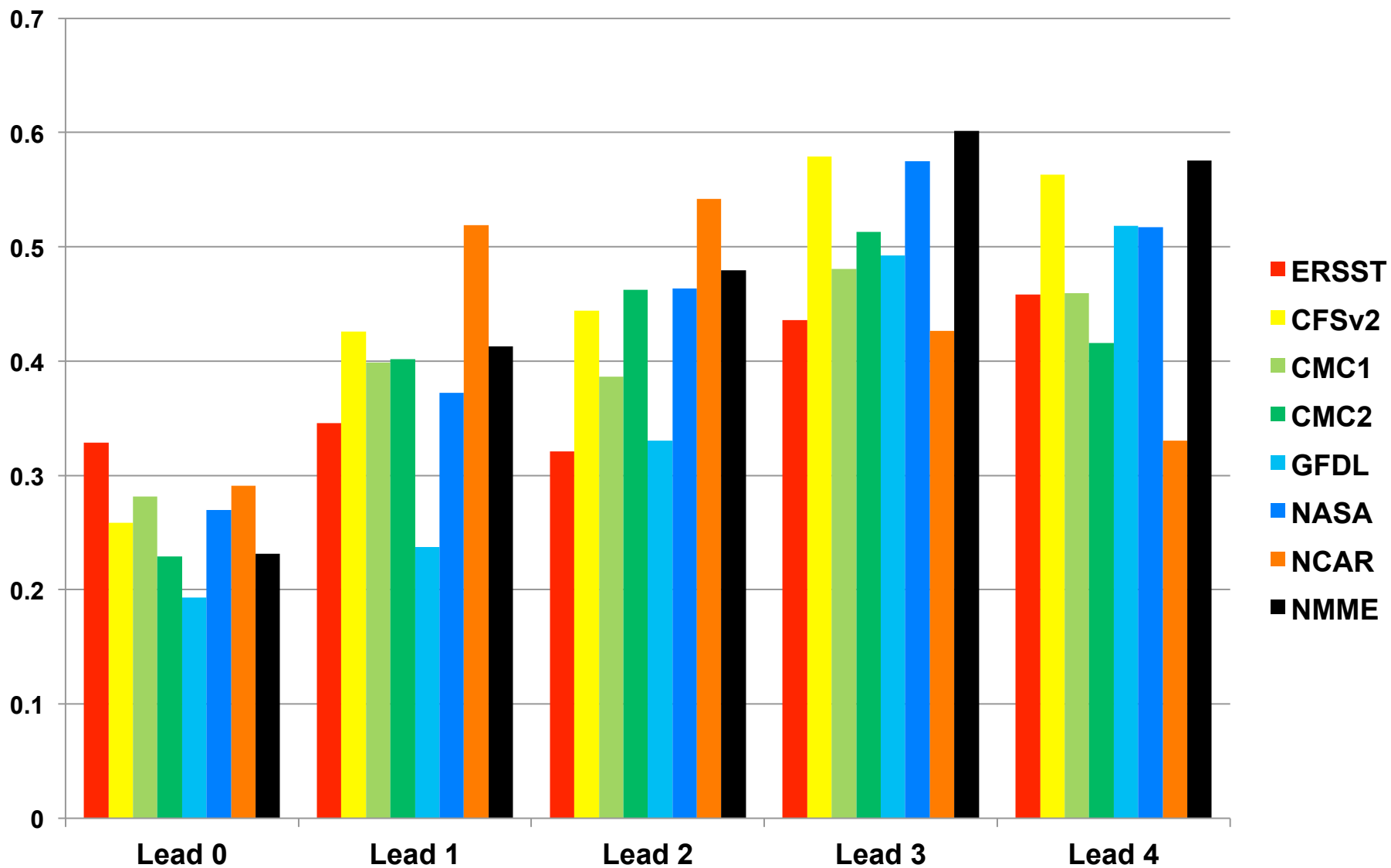
# Global observed SST correlation skill Maps of Mozgrid 2 and Arc2
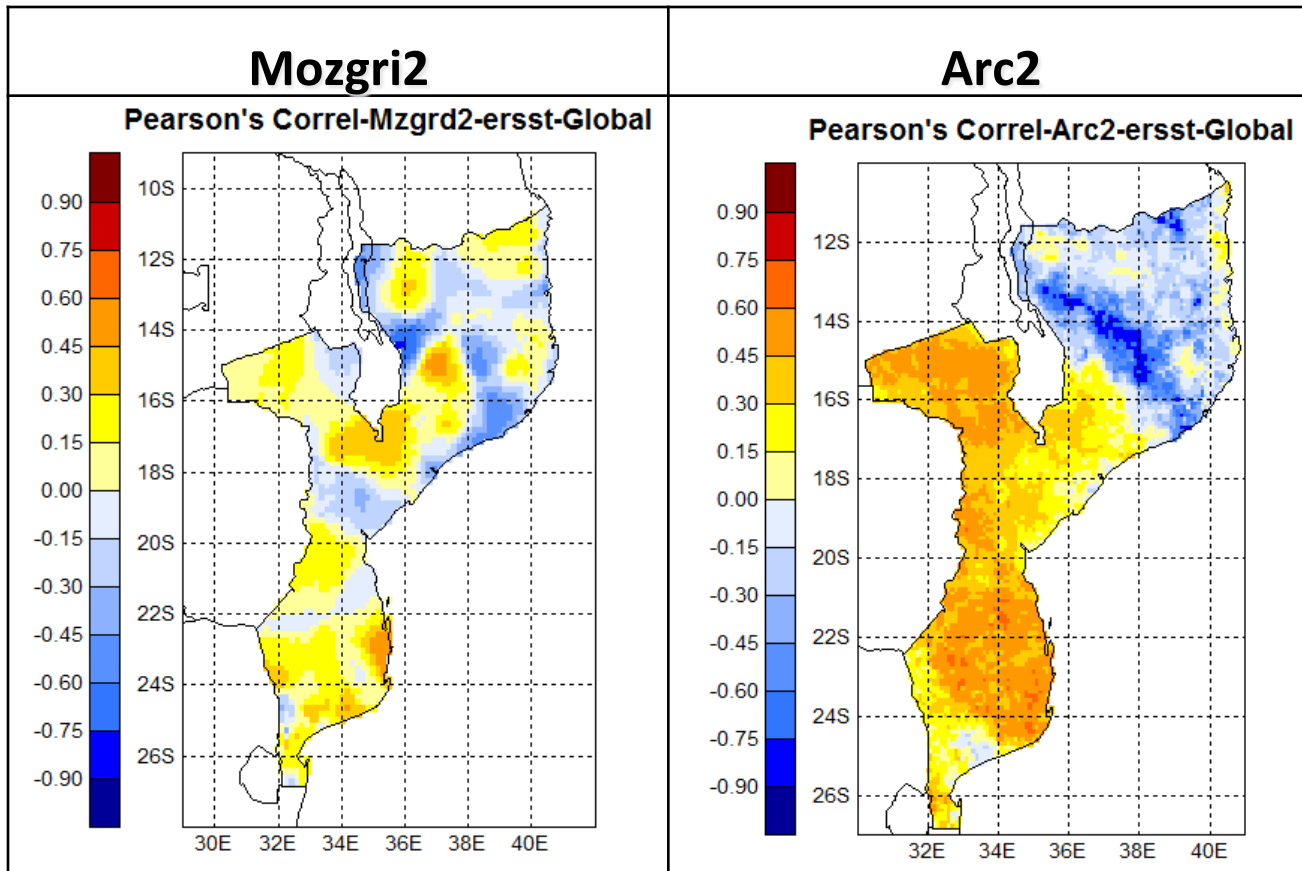
Arc2 exhibits a consistent homogenous correlation skill than Mozgrid2, where the two precipitation homogeneous zones have different skill signal:
i. A positive correlation to the Region2 and;
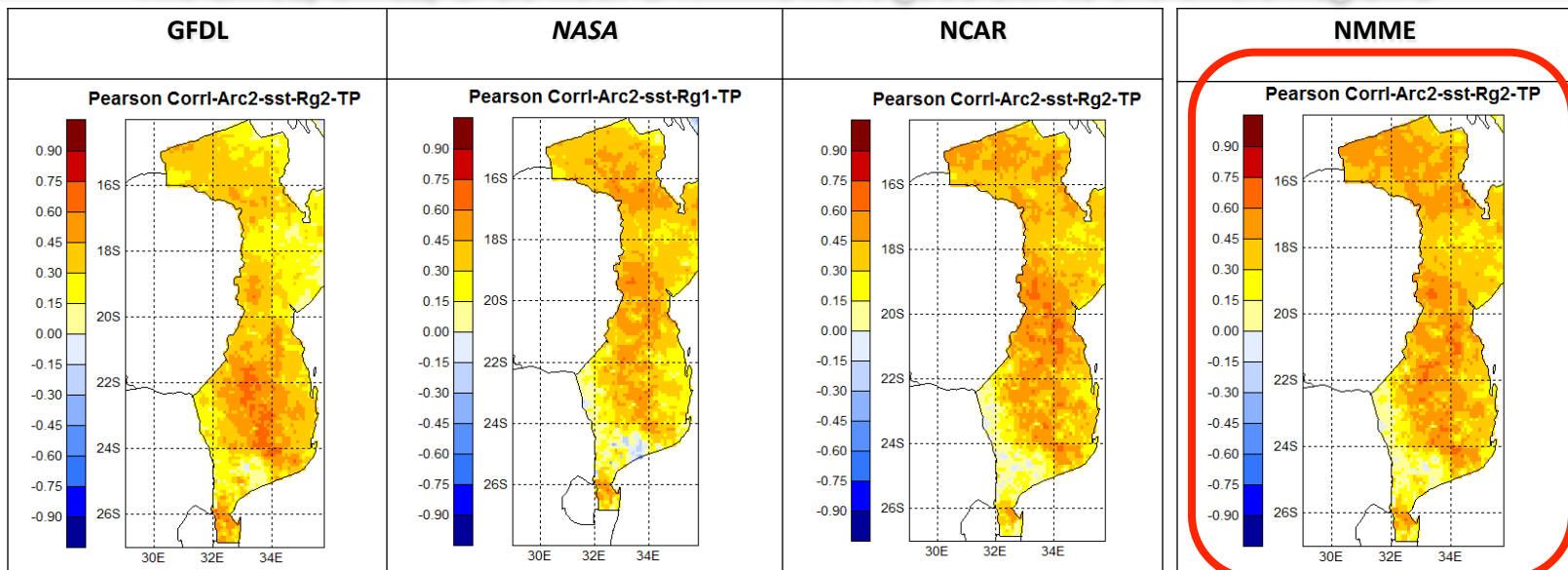ii. Negative correlation to the Region1.

Pearson's Correlation
Predictor: SST-Model output DJF_Nov_IC
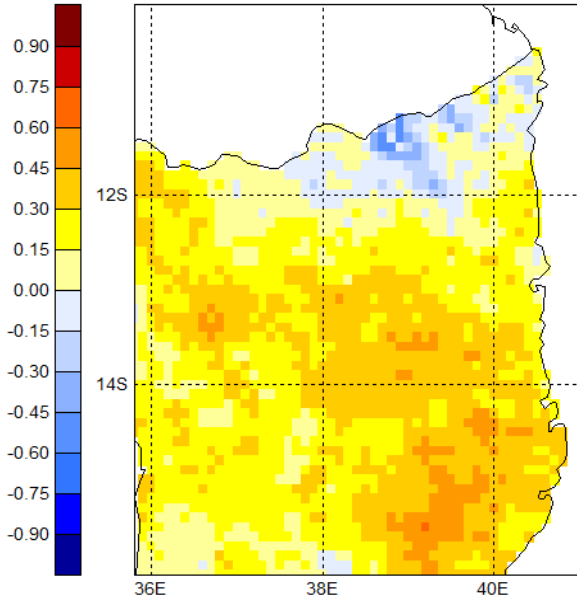## Predictand: Arc2 (DJF) Precipitation - Region 2; Domain: Tropical Pacific (10N, 10S, 160W, -80E)
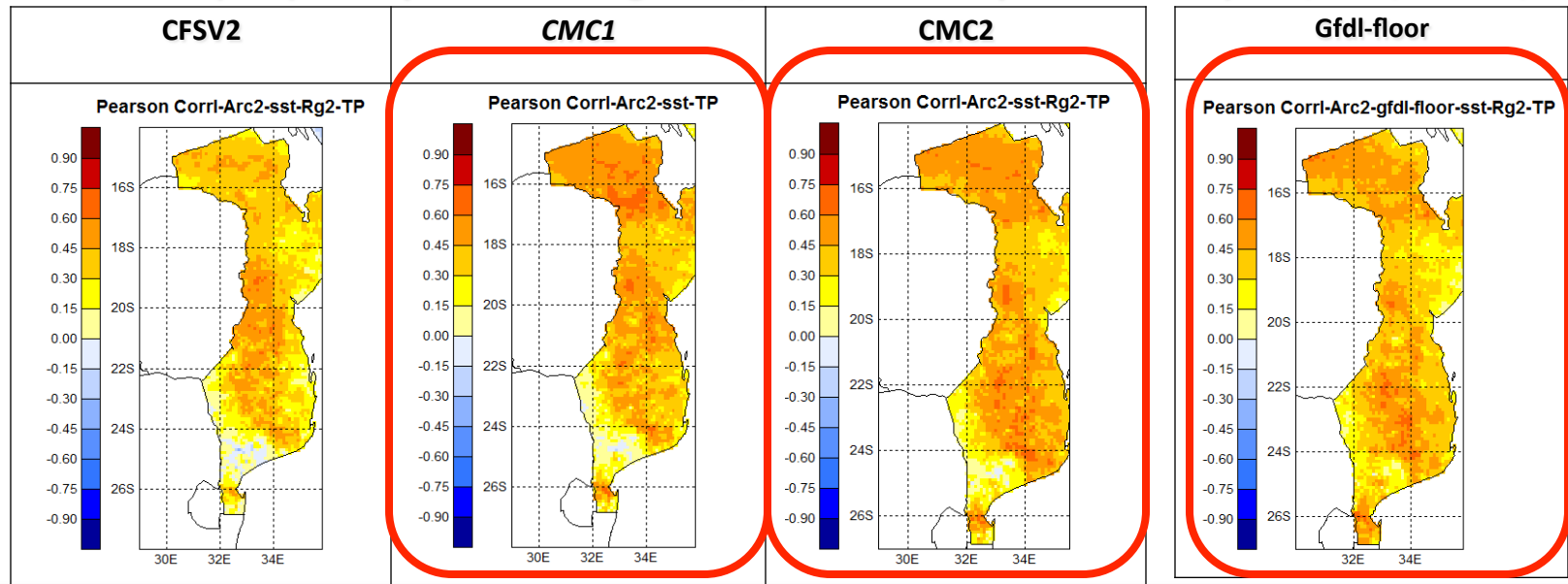
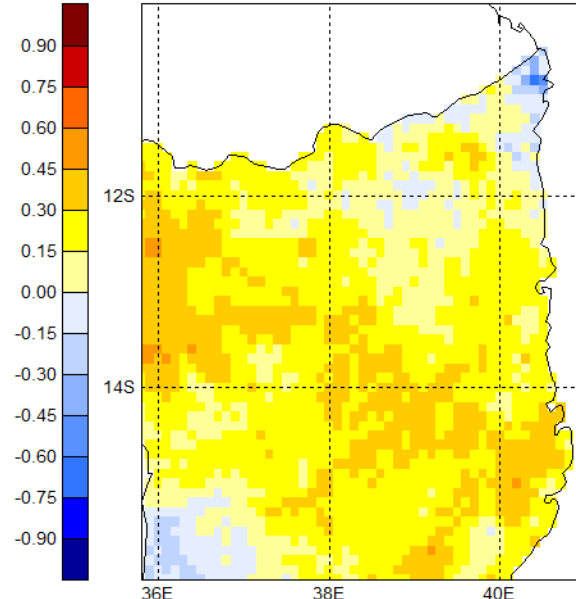The CMC1, CMC2, GFDL-floor & NMME have good skill to the whole Region 2

CCA correction for Region 1
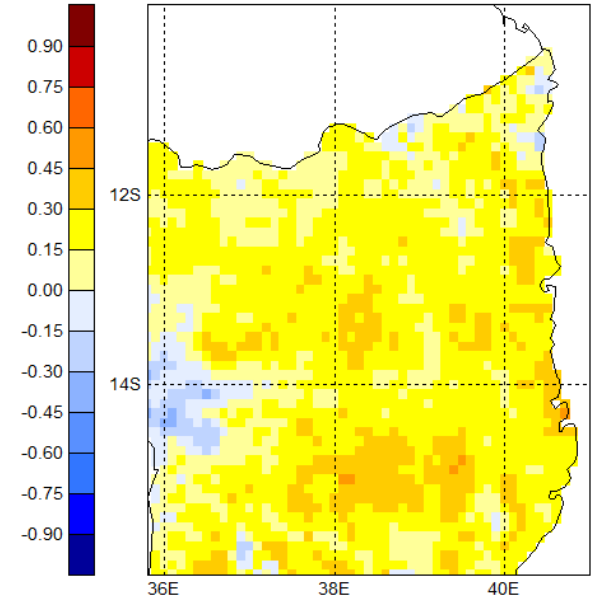
CFSv2 and NMME Data Access

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

cfsv2/

nmme/

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

- cpt
  - All NMME model hindcasts & forecasts are available in cpt format
    File name example: cfsv2_precip_octic_amj_1983-2014.txt

Summary

- U.S. NMME Forecasts provide additional guidance to NMHSs to improve seasonal forecasts

- Forecasts are complementary to LC-LRFMME

  - CFSv2, CM1, and CM2 already contribute to LC-LRFMME

  - NMME provides timely access to data

  - Allow for downscaling at a regional and national level

- Model temperature forecasts are highly skillful and comparable to CCA forced with observed SST

  - CCA Corrections using model predicted 2mT as predictor, improves skill

- Model precipitation forecasts are not that skillful, and CCA correction does not improve skill. CFSv2 tends to perform better at lead0 and lead1.