Use of dynamical seasonal forecasts in the consensus outlooks of African Regional Climate Outlook Forums (RCOFs)

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ECMWF Seminar, 3-7 September 2012, Reading, UK

Content

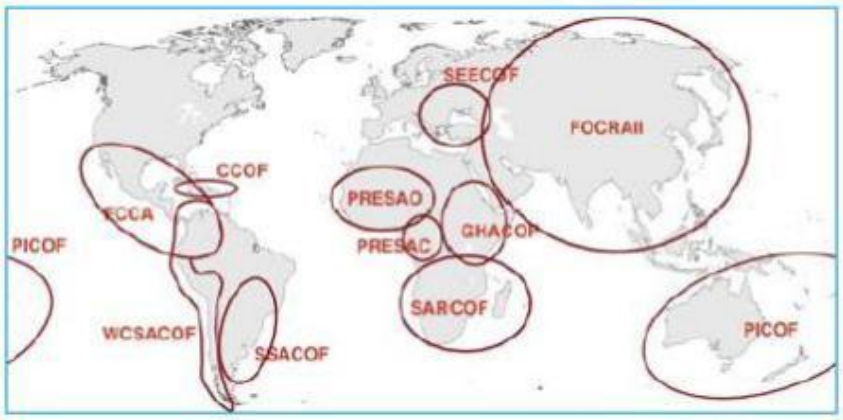
- Introduction to Regional Climate Outlook Forums (RCOFs) in Africa
  - Key product: consensus seasonal rainfall forecasts (>90% of African agriculture is rain-fed)
  - impacts, successes, skill…
- Construction of regional consensus seasonal outlooks (focus on Greater Horn of Africa)
  - Contribution of statistical & dynamical systems
- Developments in using dynamical seasonal forecasts in the consensus
- Met Office work with DFID and future challenges

Regional Climate Outlook Forums (RCOFs)

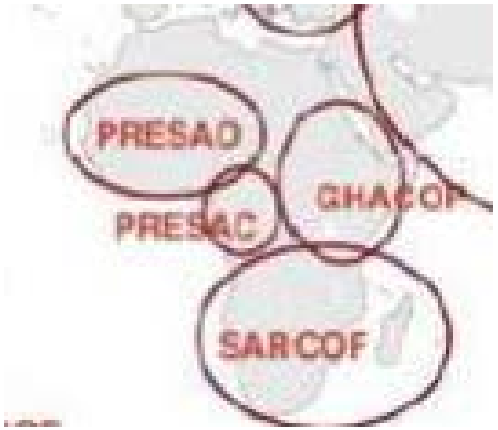
- RCOFs are a key mechanism for developing and disseminating consensus in regional seasonal forecasts;
- First one took place for southern Africa in 1997;
- Endorsed as a key activity in the WMO developing Global Framework for Climate Services (GFCS);

Typically:

- ‘pre-COF’ workshop (1-2 weeks) for training of NMS staff from the region and preparation of **consensus seasonal outlook**
- 2-3 day Forum for release and discussion of the forecast and general forecaster/user interaction



RCOFs in Africa



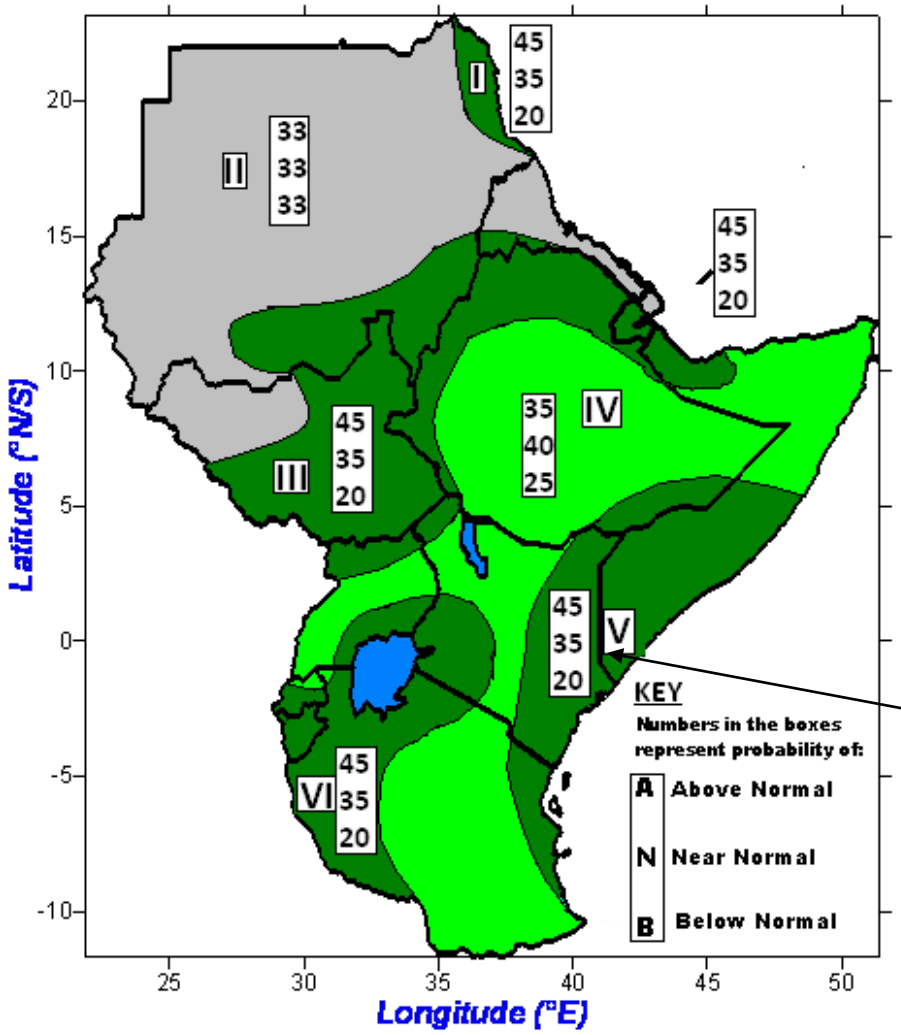
Four RCOF activities in sub-Saharan Africa coordinated by:

- ACMAD (African Centre for Meteorological Applications for Development), Niamey, Niger: **PRESAO and PRESAC**
- ICPAC (IGAD Climate Prediction and Applications Centre), Nairobi, Kenya: **GHACOF**
- SADC-CSC (Southern African Development Community Climate Services Centre), Gabarone, Botswana: **SARCOF**

Timing and ‘target periods’ of African RCOFs

- PRESAO: held end of May for the JAS season (peak of the West African Monsoon)
- PRESAC: held early October for the OND season (Central Africa main rains)
- GHACOF: 3 Forums held annually:
  - **February:** March-May ‘long rains’ season (ITCZ moves north)
  - **May:** June-September season in north of region
  - **August:** September to December ‘short-rains’ season (ITCZ move south)
- SARCOF: held late August for the OND & JFM season
- Note: many forecasts are <1 month lead (heritage of basis in statistical prediction)

Format of the consensus outlook: GHACOF example for SOND 2012

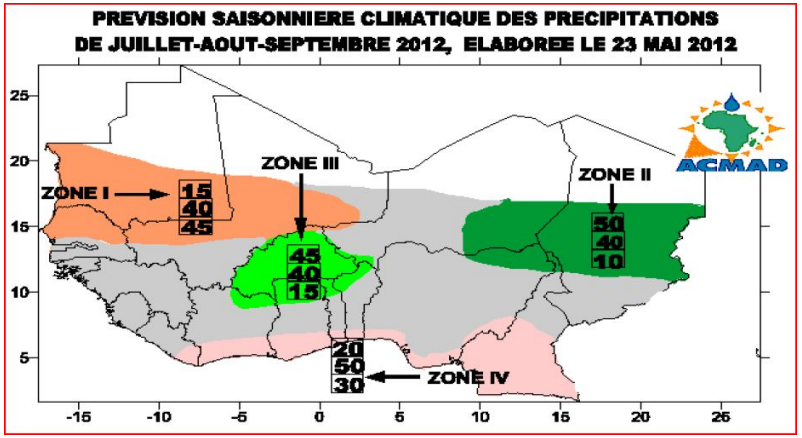


Tercile category probabilities

P(abv)	45
P(avg)	35
P(blw)	20

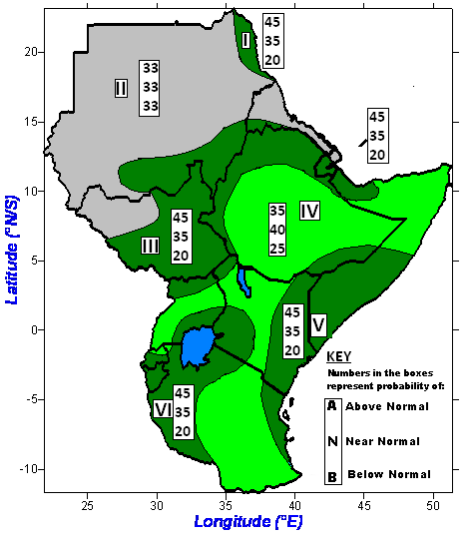
African RCOF consensus forecasts

West Africa: PRESAO: JAS



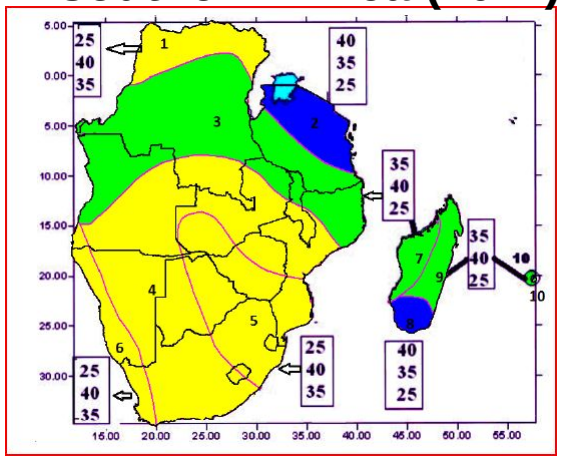
http://www.acmad.org/

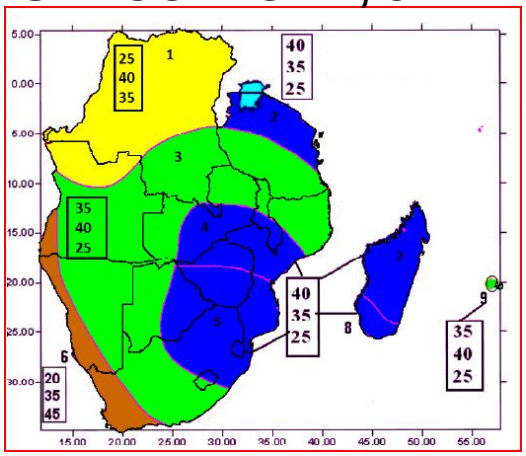
Greater Horn of Africa: GHACOF: MAM, JJAS, SOND



http://www.icpac.net/

southern Africa (2011): SARCOF: OND, JFM



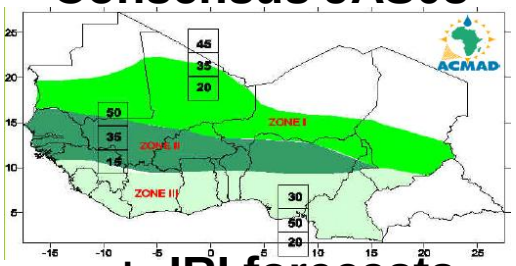


http://www.sadc.int/

PRESAO: Flood preparedness, JAS 2008

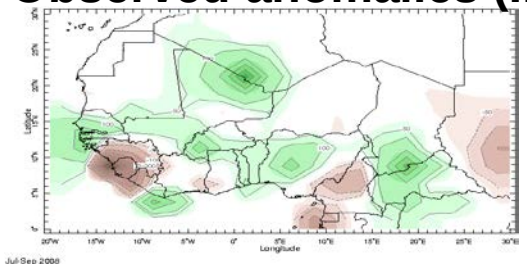
- 2008 West Africa floods (Tall et al., 2012)
- First pre-emptive appeal in IFRC history based on a seasonal forecast.
- Pre-positioning of disaster relief items (e.g. sanitation kits, tents, mosquito nets)
- ‘No regrets’ strategies

Consensus JAS08



+ IRI forecasts

Observed anomalies (IRI)



Flood affected regions

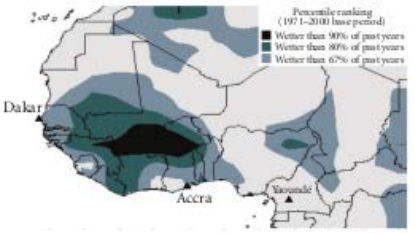


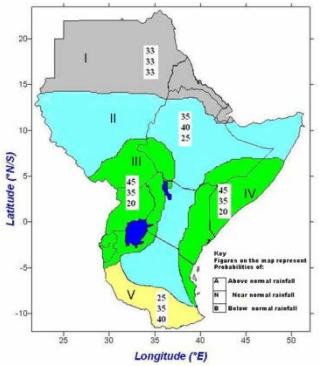
FIGURE 4: Observed rains and location of stocks prepositioned by IFRC in June–August 2008, represented by triangles (source: authors).

Int. Jour. Geophys, 2012
http://www.hindawi.com/journals/ijgp/2012/986016/

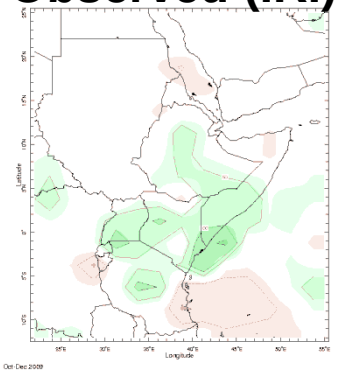
GHACOF: ‘bumper’ harvest Kenya 2009

- Pers comm. Abdishakur Othowai (Kenya Red Cross/ICPAC)
- Kenya Red Cross distributed $ 0.5M of seed to 70,000 farmers
- Sufficient to plant 1 additional acre each
- Bumper harvest valued at $2.5M
- Storage delayed onset of shortages in 2010/11 drought (securing 2 years of food security in Ukambani region)

consensus SOND 2009



Observed (IRI)



A Dangerous Delay

The cost of late response to early warnings in the 2011 drought in the Horn of Africa

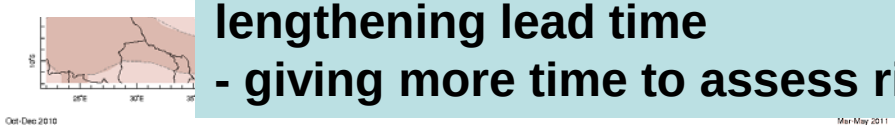
11

Save the Children

Oxfam

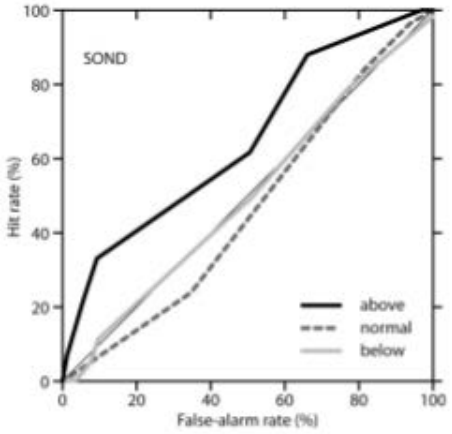
‘Governments, donors, the UN and NGOs need to:
• focus on managing the risks, not the crisis
• act on early warning systems, not wait for certainty’

Role for dynamical seasonal forecasts, including in lengthening lead time
- giving more time to assess risk and develop response

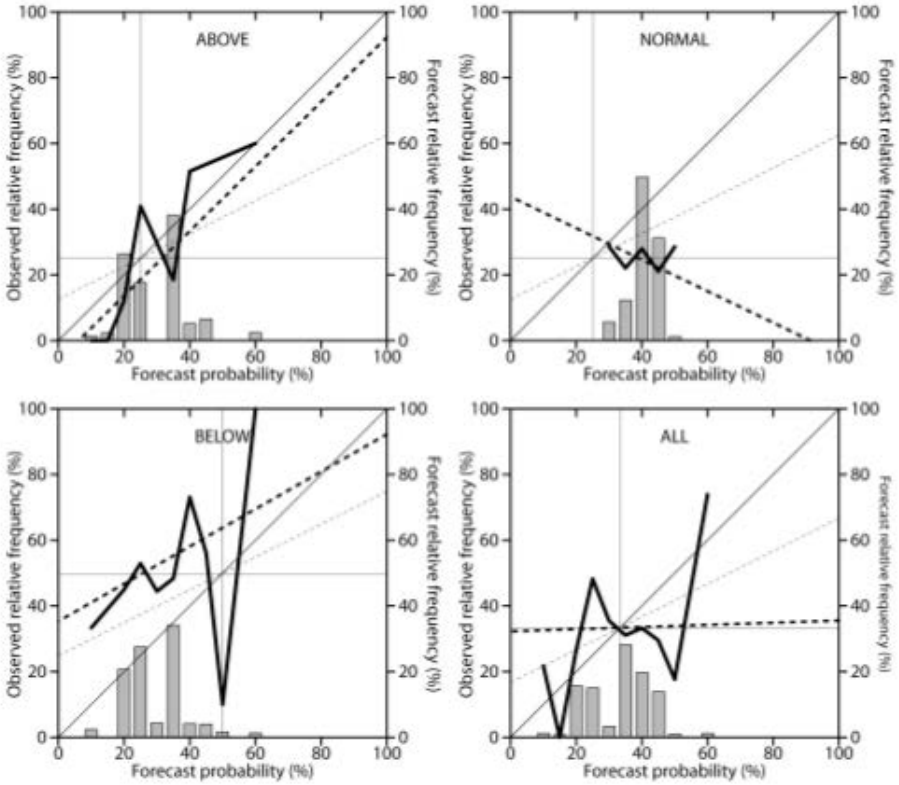


Verification of GHACOF SOND forecasts 1998 – 2007 Mason and Chidzambwa 2008

ROC



Reliability



	Obs freq.	Avg fcst prob
abv	25%	30%
avg	25%	40%
blw	50%	30%

http://academiccommons.columbia.edu/catalog/ac:126389

Summary: the RCOF process

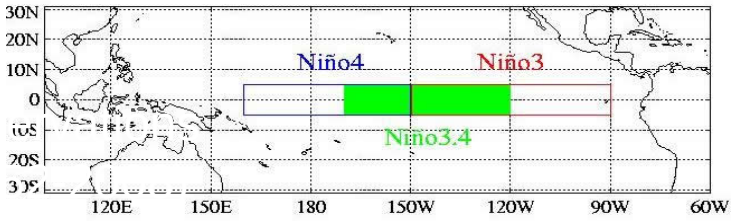
- Main mechanism for developing regional/international consensus on seasonal prospects (also forecast dissemination, training)
- Forecasts are used by regional stakeholders – good examples of effective interventions (e.g. International and National Red Cross, FEWS-NET)
- Sets the framework for national outlooks prepared by NMSs in the region (in most cases)
- 10-year assessment indicates forecasts have skill – but some limitations (e.g. hedging)
- Most have short lead time (limiting response)

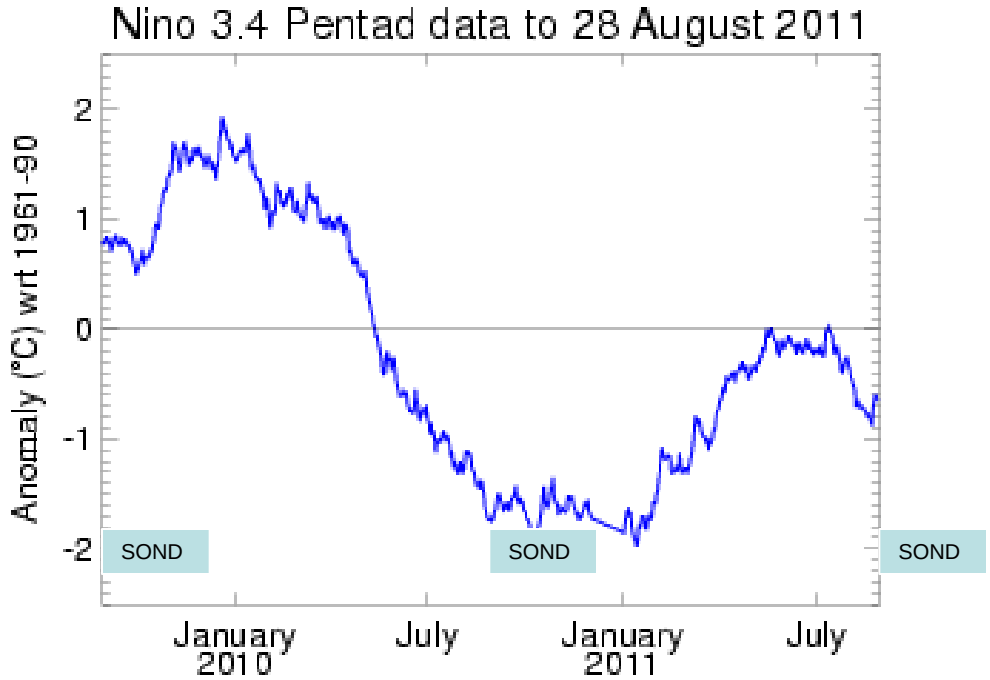
Consensus generation: GHACOF ‘short rains’ example

Statistical forecast methods

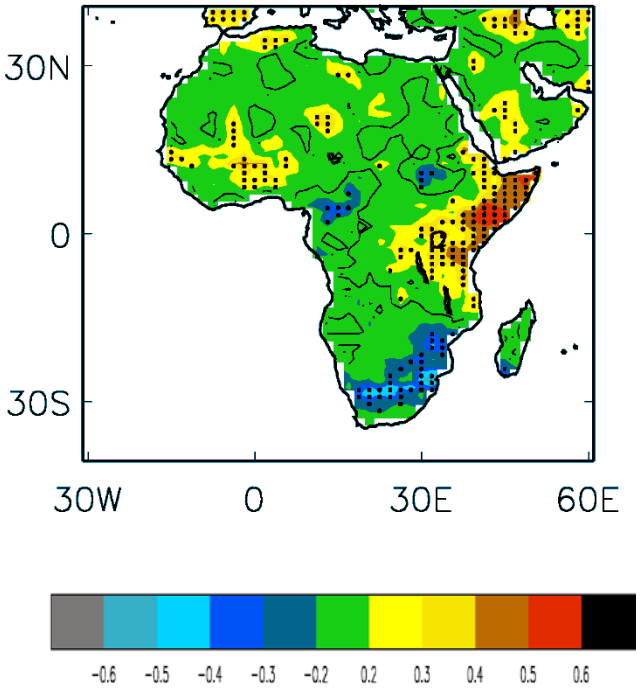
- Statistical forecast methods form the basis of RCOF consensus outlooks in Africa
- In common with many rainy seasons in Africa, inter-annual variability of the GHA short rains is relatively strongly driven by key SST modes (e.g. ENSO and Indian Ocean Dipole)
  - Tropical Atlantic, Mediterranean also important for some regions
- Statistical/empirical forecasting based on historical associations of rainfall with SST modes generally competitive with dynamical methods
- Use of dynamical models is currently largely subjective – key challenge to develop more objective use with aim to:
  - improve the skill of the consensus
  - increase lead time

ENSO influence on GHA short rains (OND)

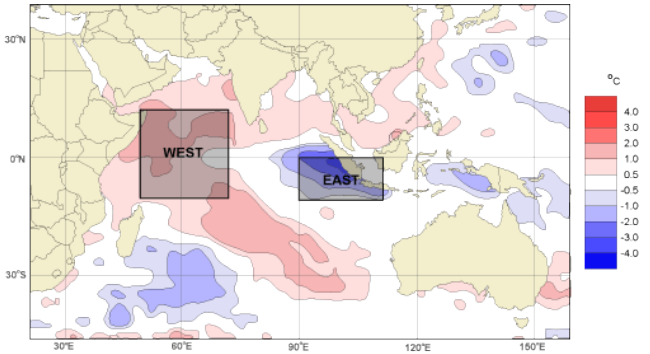


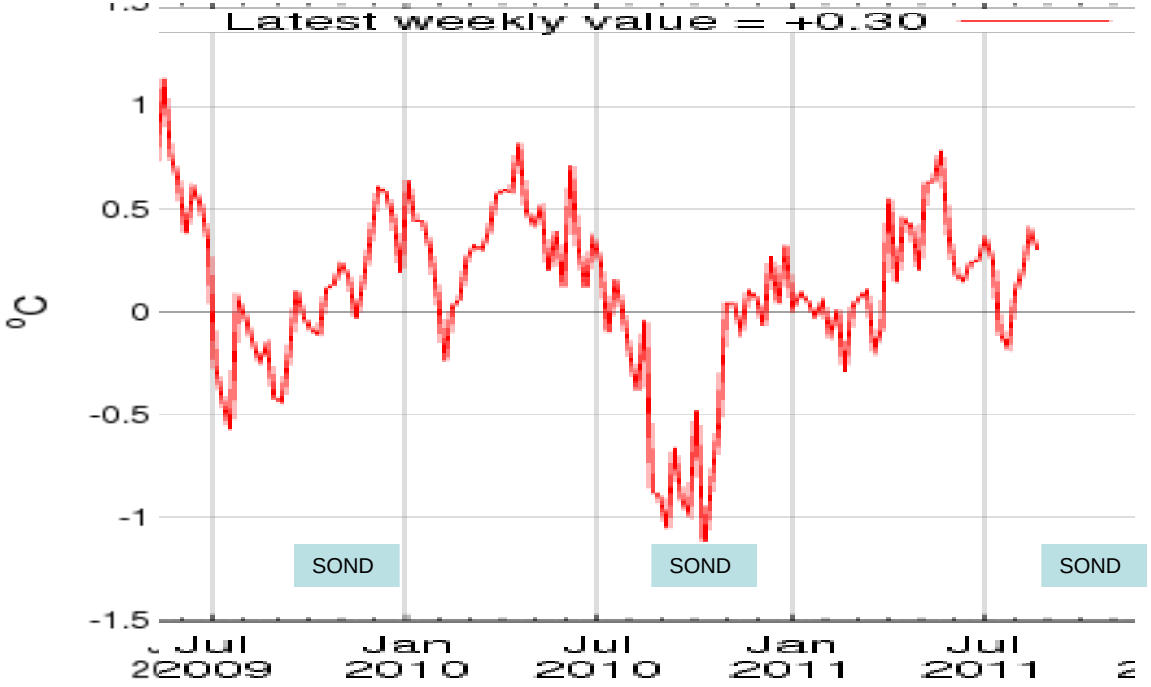


Observed correlation of OND rainfall and Nino3.4 index (1952-2008)

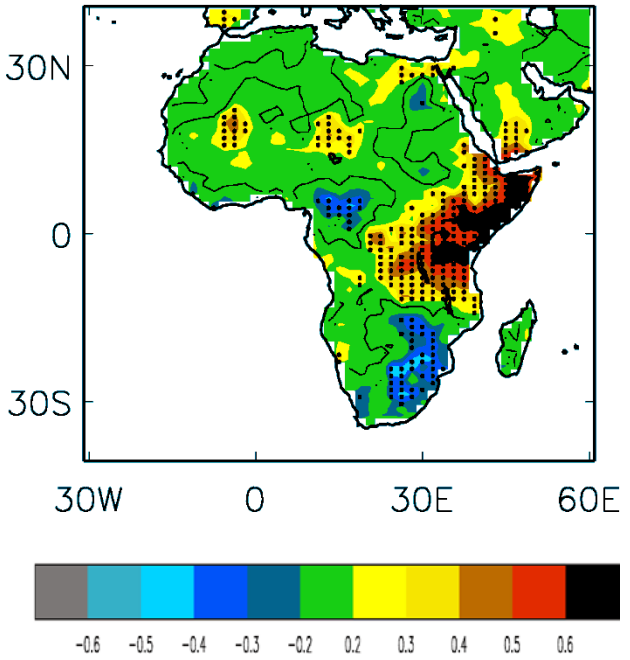


Indian Ocean Dipole influence on GHA short rains (OND)





Observed correlation of OND rainfall and IOD index (1952-2008)



Flow chart summarising GHACOF seasonal precipitation consensus forecast production process

Representatives from NMSs of the region

Regional Centre (ICPAC) team

Global Centres (GPCs) e.g. Met Office

Station data timeseries for their country; national climate knowledge

Predictor timeseries: pre-season SST and atmos parameters; regional knowledge

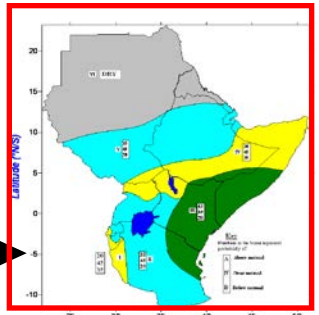
Dynamical model forecasts, incl ENSO plus skill information etc

Statistical models/forecasts for individual countries

Calibrate and combine forecasts

Compare statistical and dynamical – adjust/blend; expert judgement

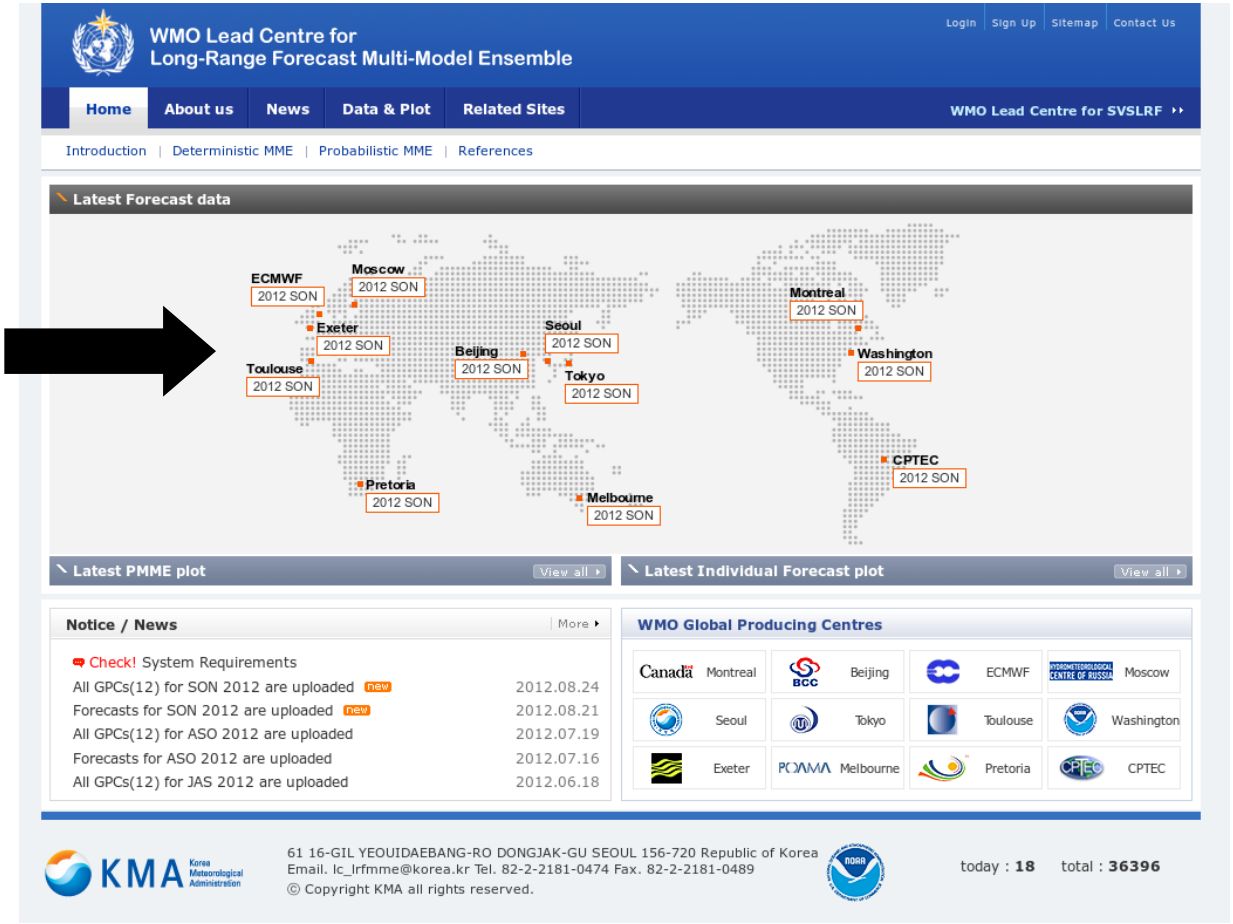
First draft of regional forecast map – built up country by country



Final consensus

WMO Lead Centre for Long-Range Forecast Multi-Model Ensembles

12 WMO Global Producing Centres for Long-range forecasts (GPCs)



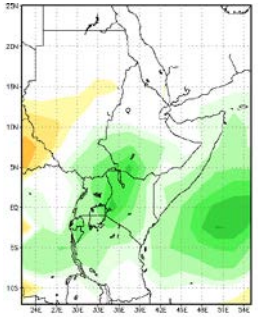
Jointly operated by Korean Meteorological Administration (KMA) and NOAA NCEP Climate Prediction Centre (CPC)

www.wmolc.org

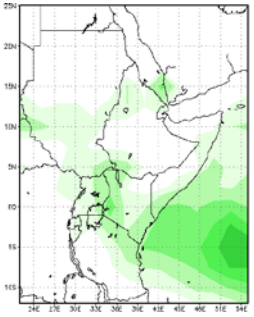
Forecasts for SON 2011 from 12 WMO GPCs: ensemble mean rainfall anomaly

Coupled systems (interactive ocean-atmosphere; evolving ocean)

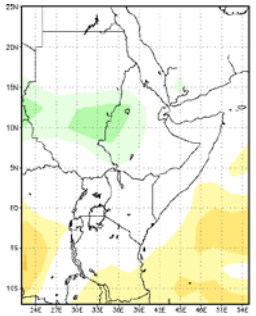
Exeter



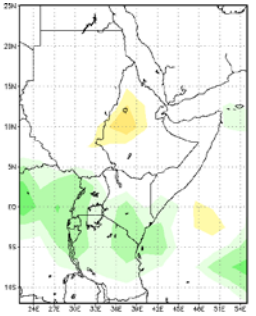
ECMWF



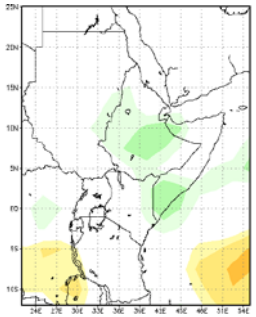
Toulouse



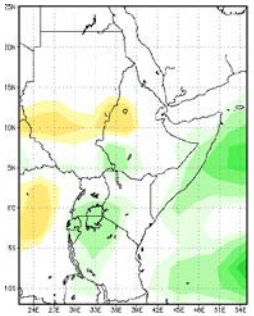
Washington



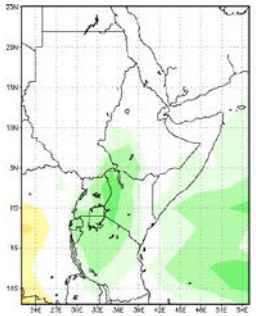
Beijing



Melbourne

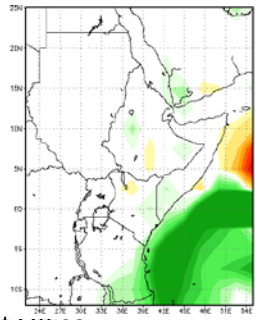


Tokyo

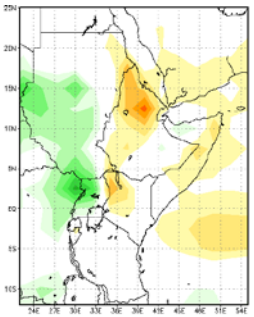


Un-coupled systems (non-interactive ocean-atmosphere; 'static' ocean)

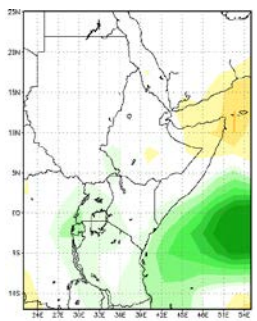
Moscow



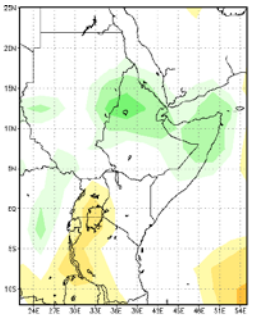
Seoul



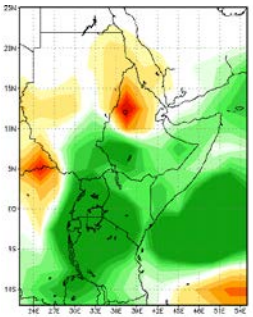
Montreal

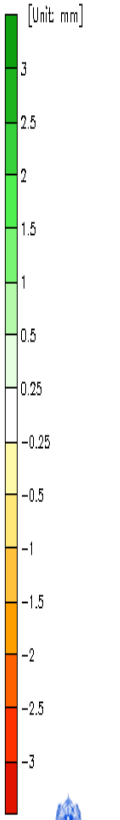


Pretoria



CPTEC





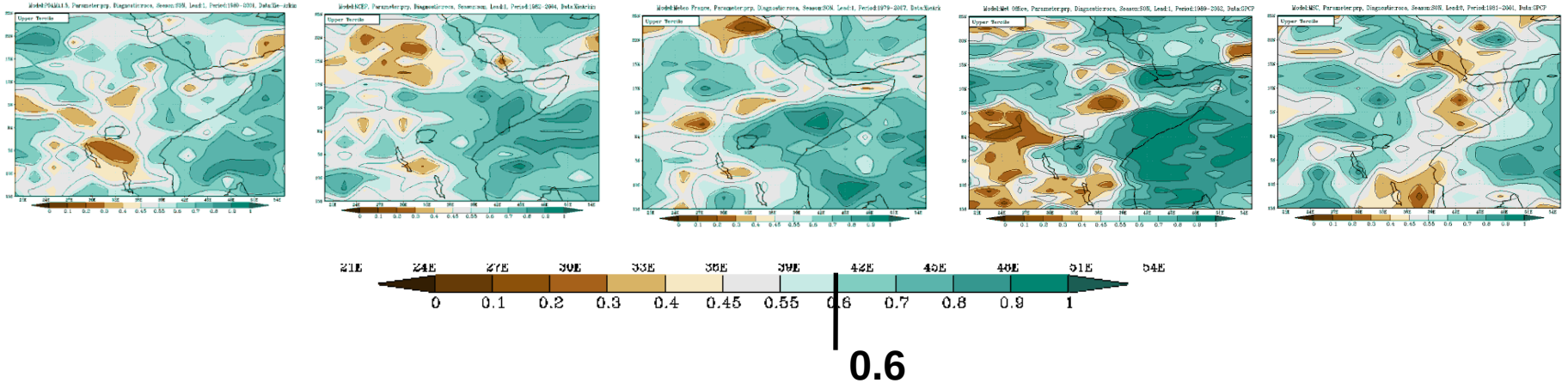
Lead Centre for LRFMME

2010-08-24-02:10

WMO Lead Centre for Standard Verification System for Long-range Forecasts (SVSLRF)

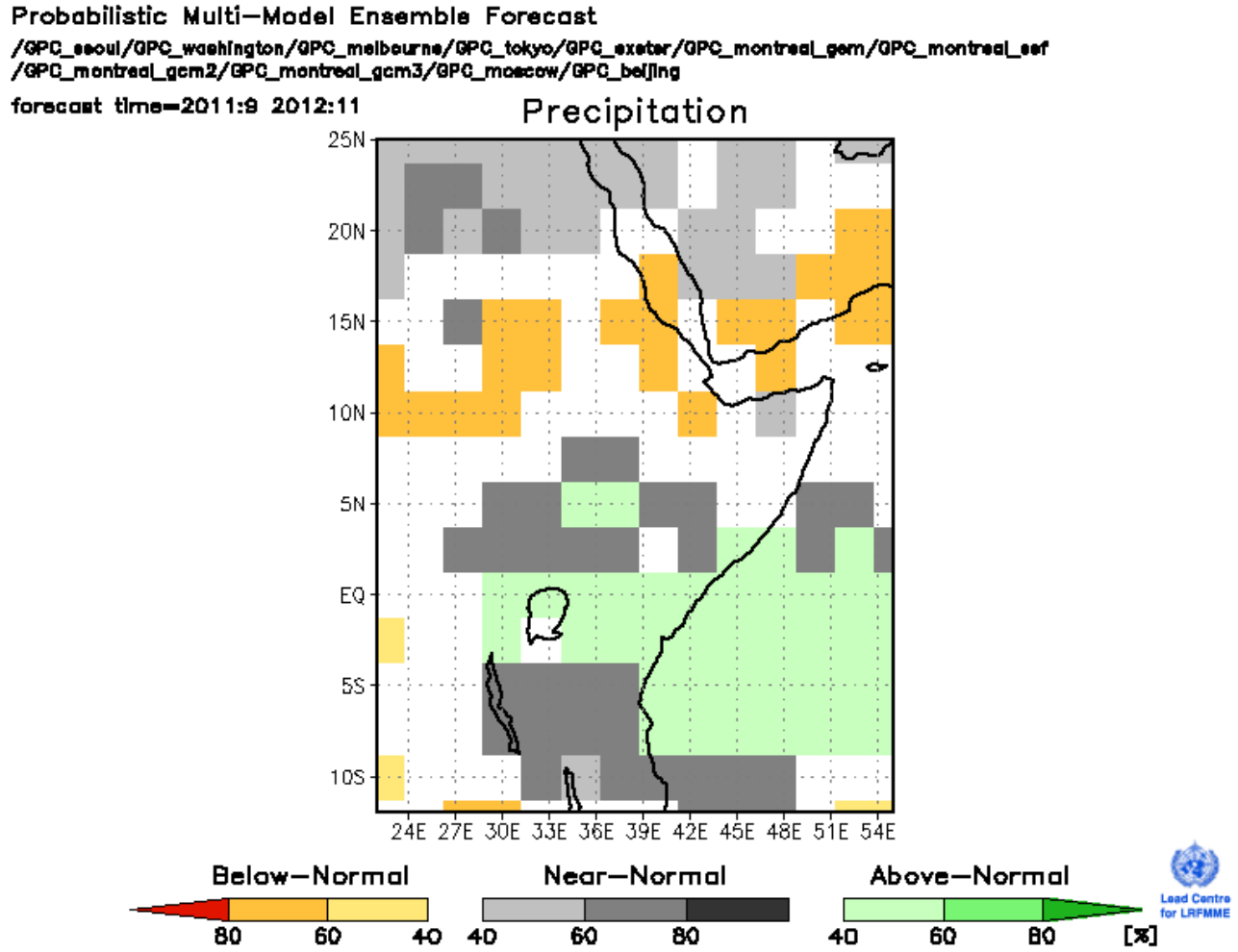
www.bom.gov.au/wmo/lrfvs

Melbourne **Washington** **Toulouse** **Exeter** **Montreal**



ROC scores for above normal category

Probabilistic MME (WMO LC-LRFMME): SON 2011

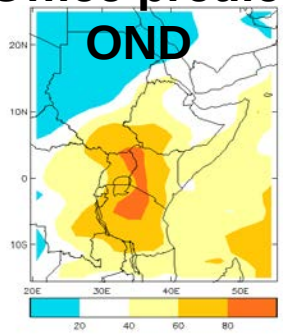


DFID-Met Office Climate Science Research Partnership (CSRP): Contribution to consensus process

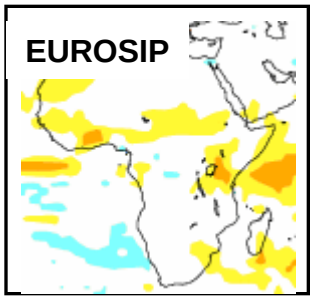
Met Office
Hadley Centre

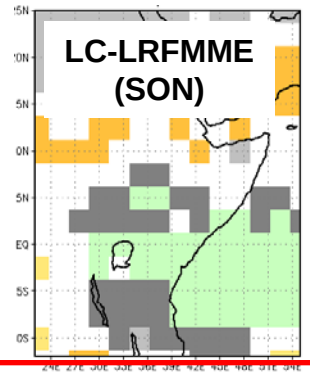
Greater Horn of Africa (GHACOF29) consensus forecast for Sept-Dec 2011 – forecast made at peak of drought crisis

Met Office prediction:



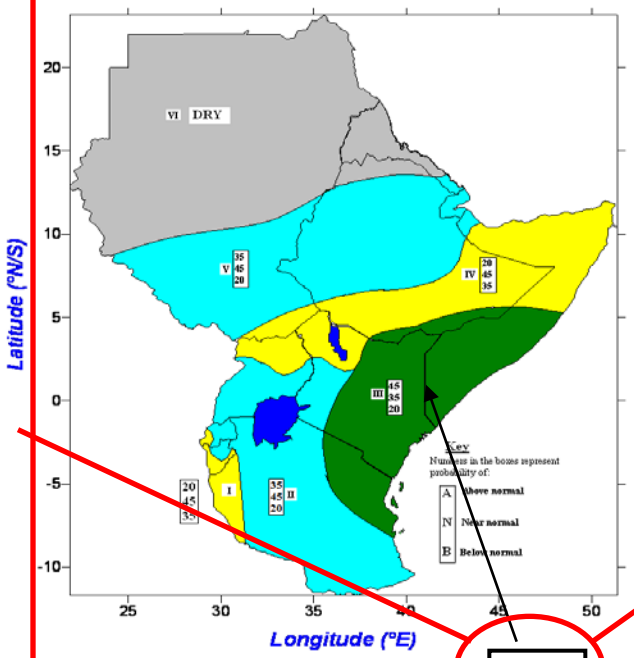
P(abv)





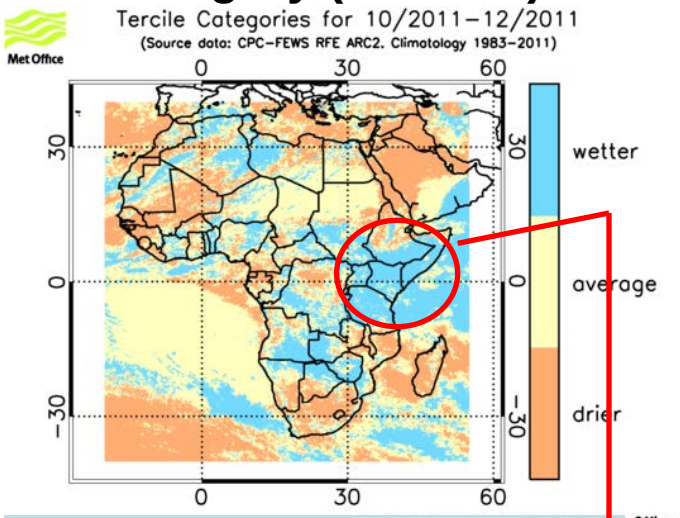
P(abv)
P(avg)
P(blw)

GHACOF consensus forecast



P(abv)	45
P(avg)	35
P(blw)	20

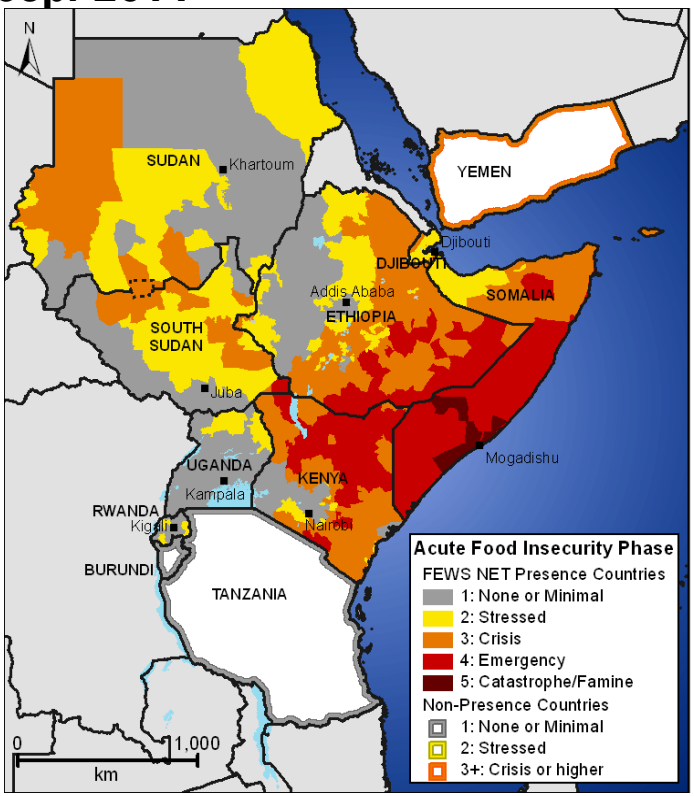
Observed rainfall category (Oct-Dec)



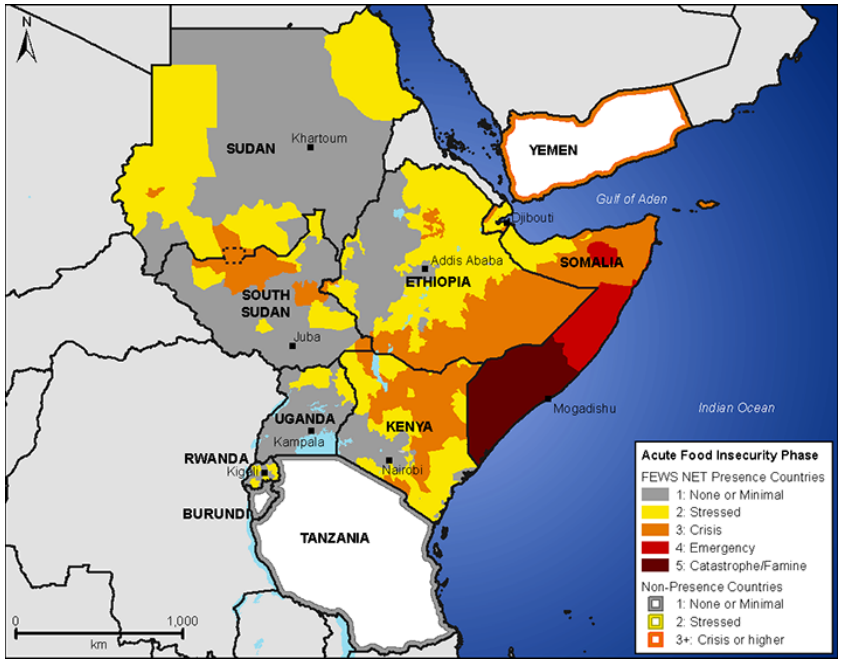
- **Above average rainfall predicted most likely**
- **Above average occurred**
- **Some alleviation from drought**

FEWS-NET Food Security Outlook for Oct-Dec 2011 used the forecast and gave generally improving outlook

Estimated Food Security Outcomes: Aug-Sept 2011



Estimated Food Security Outcomes: Oct-Dec 2011



- Improvements in food security dependent on:
  - i. Large-scale multi-sectoral interventions
  - ii. Decline in food prices
  - iii. Performance of the Oct-Dec short rains
  - iv. Conflict resolution

Flood reports in media: 4 Nov 2011

‘The UN refugee agency reports heavy rains and flooding in parts of Somalia, Kenya and Ethiopia are causing havoc among thousands of displaced Somalis in the region. The UNHCR says flood-damaged roads are hampering relief efforts to thousands affected by the heavy rains….’

‘The heavy rains in parts of the region are bringing some welcome relief to drought-hit areas. At the same time, they are creating a disaster of another sort.’

Met Office
Hadley Centre

Towards a more objective approach: Calibration of GPC forecasts – using Canonical Correlation Analysis (CCA)

Experiments with CCA calibration using 5 GPC models

Systems calibrated over 1982-2009 period – subset of GPCs:

- ECMWF system 4
- Meteo-France
- CFS1 & 2
- (un-calibrated probabilities from GloSea4 shorter hindcast)

CCA software:

- CCA utility of the Climate Predictability Tool (CPT) developed at IRI is used
- Following similar approach introduced by JP Ceron at PRESAO

Principles

- Find pattern covariance of the hindcast ensemble mean (rainfall, U&V, SST) over a large-scale domain – typically 60°W – 100°E; 40°S – 40°N with…
- …observed rainfall over the domain of interest (GHA)
- Purpose: correct systematic errors including typical pattern/positional errors
- Forecast probabilities reconstructed using normal distribution of standard (calibrated) forecast error.

Example: CFS prediction of MAM GHA Rainfall

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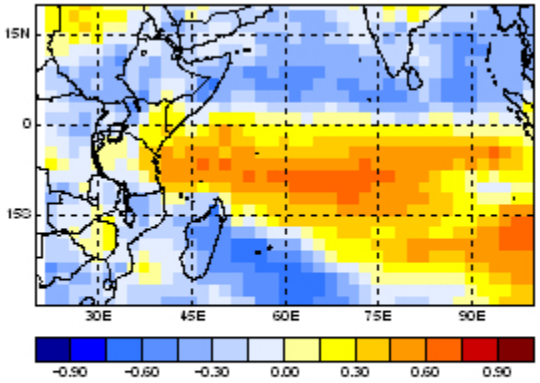
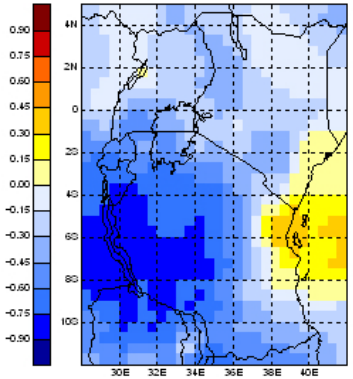
HINDCAST: 1st mode of variability in hindcast (1982-2009)

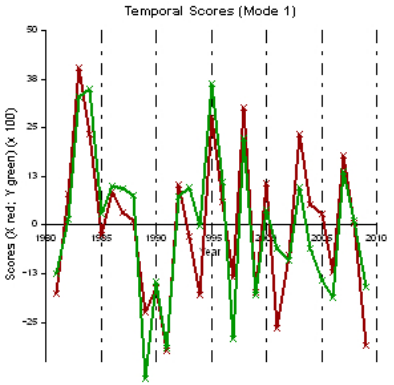
CFS ensemble mean large-scale MAM rainfall



Observed MAM regional rainfall

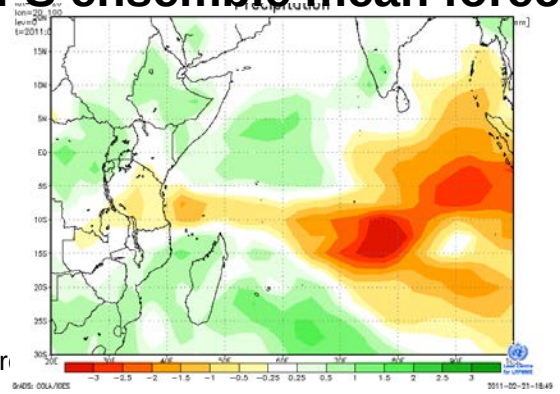


Timeseries (EM – red; Obs – green)

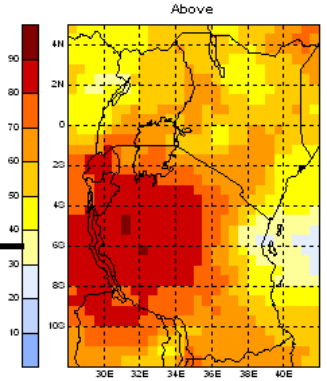


FORECAST: MAM 2011

CFS ensemble mean forecast



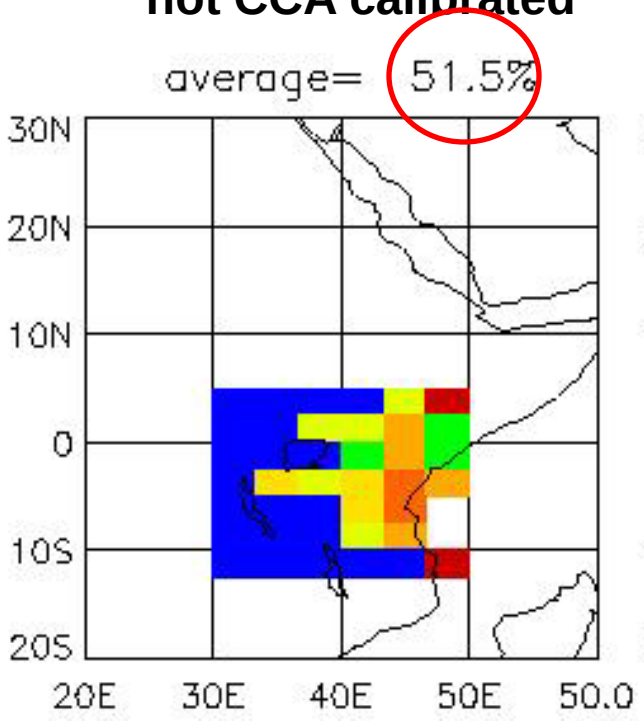
33%



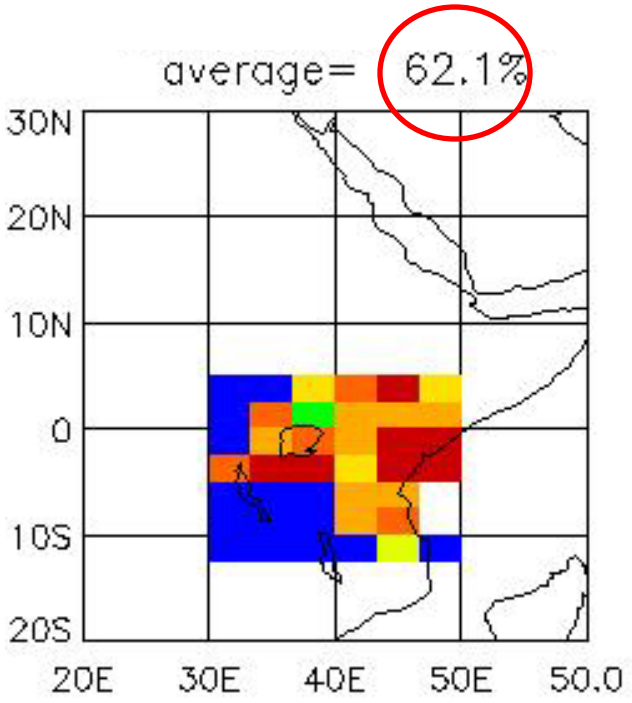
Calibrated probability for above normal category
(Probs from normal dist, 1 sd)

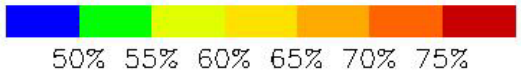
ROC skill of multi-model hindcasts of SOND precipitation 1996-2009

ECMWF/Meteo-France/CFS1/CFS2/GloSea4 not CCA calibrated

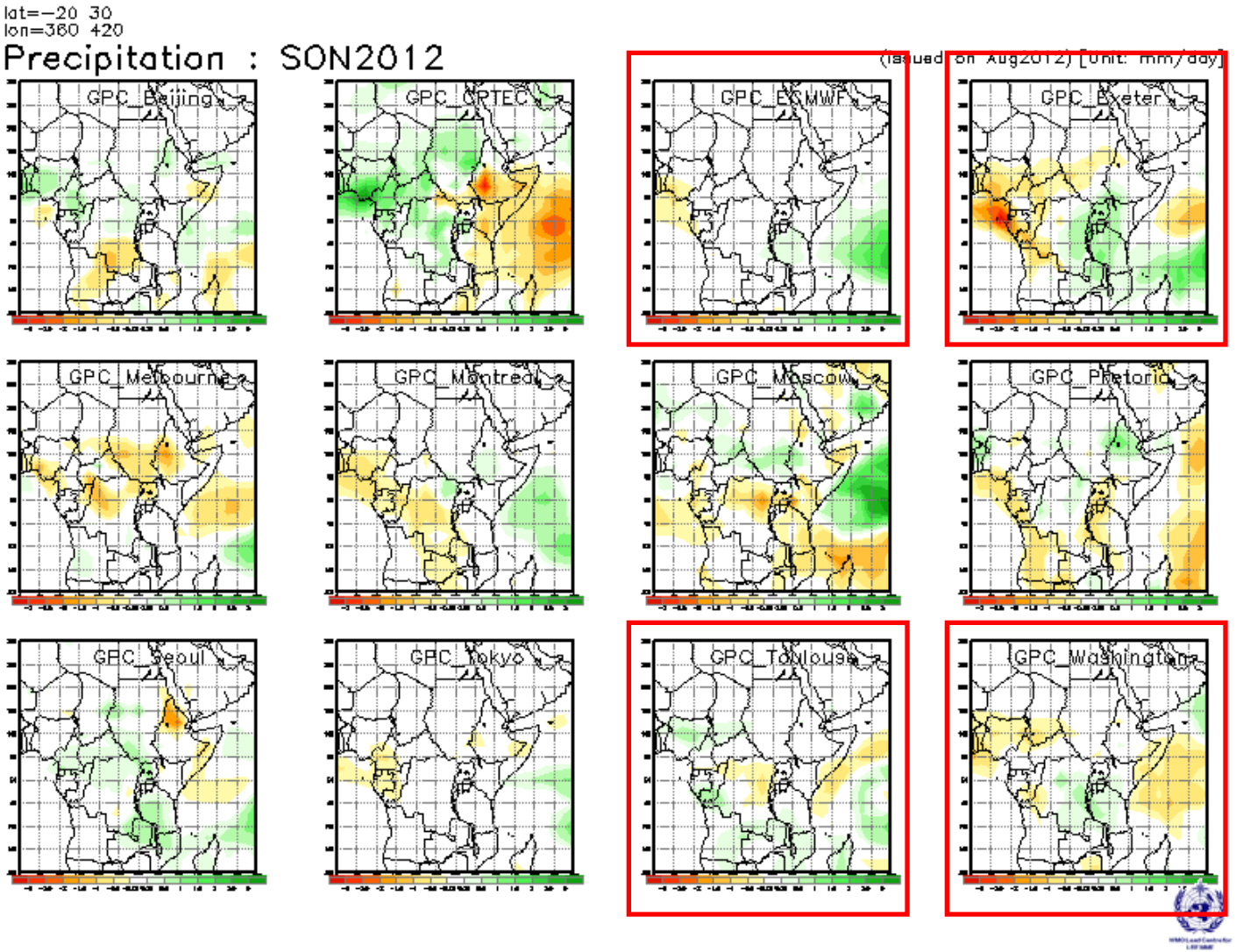


ECMWF/Meteo-France/CFS1/CFS2 CCA calibrated





Ensemble mean precip SON 2012: 12 WMO GPCs



CCA Calibrated probabilities: SOND 2012 most skilful of a range tested

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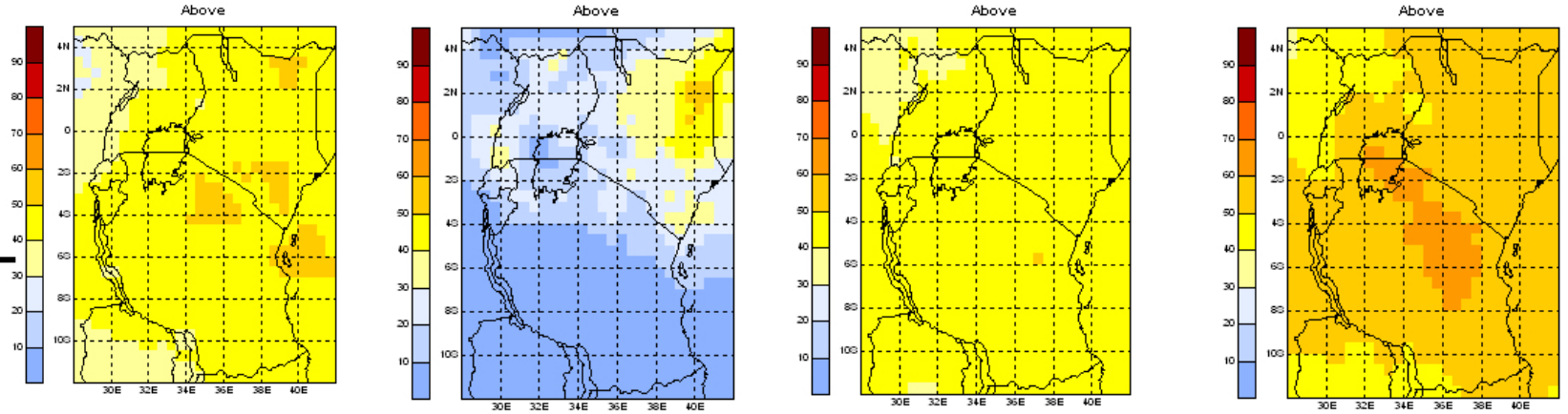
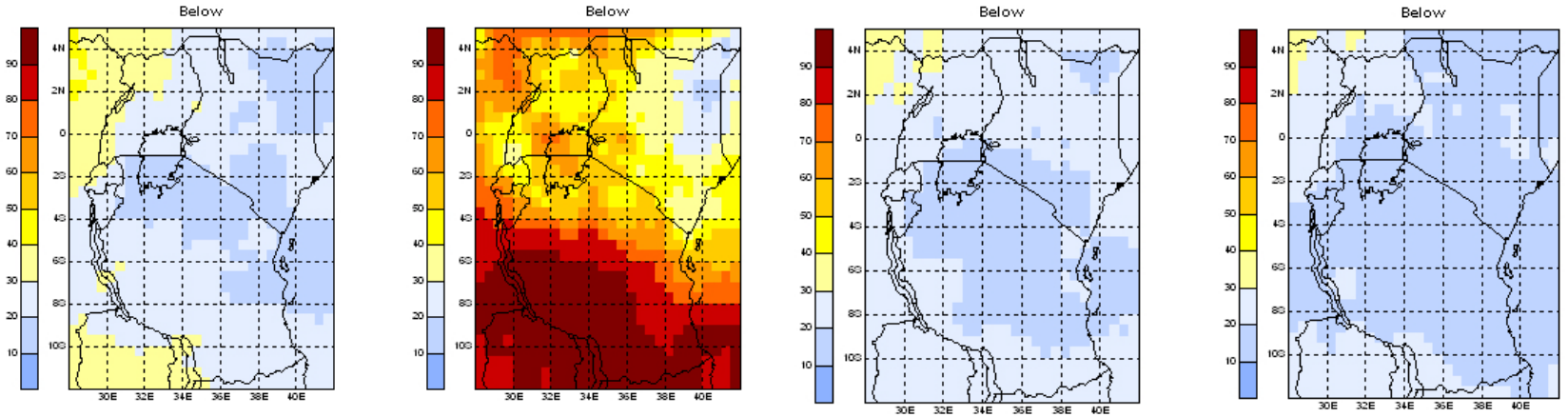
ECMWF (Pr) | **Meteo-Fr (Pr)** | **CFS1 (Pr)** | **CFS2 (SST)**

33%

P(abv)

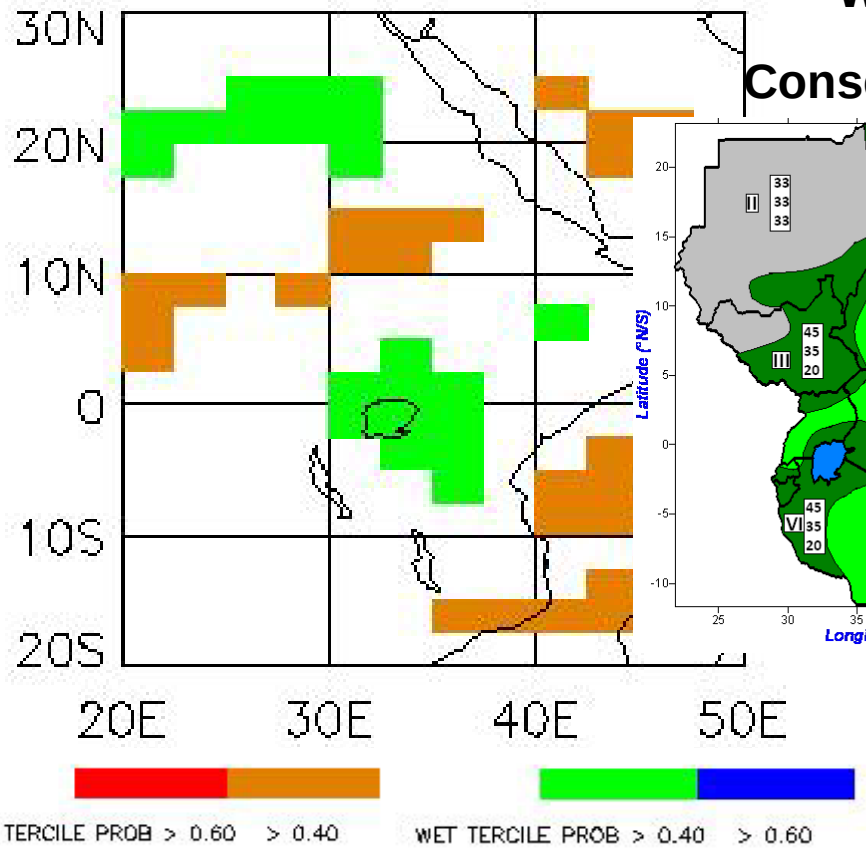


P(blw)



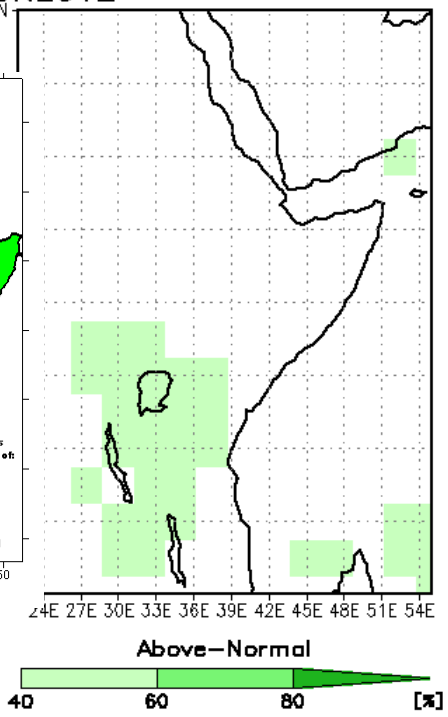
Multi-model average calibrated probabilities: SOND 2012

CCA skill calibrated (hybrid)



P(abv): LC-LRFMME (SON)
Weights inv. prop. to ensemble size
: SON2012

Consensus



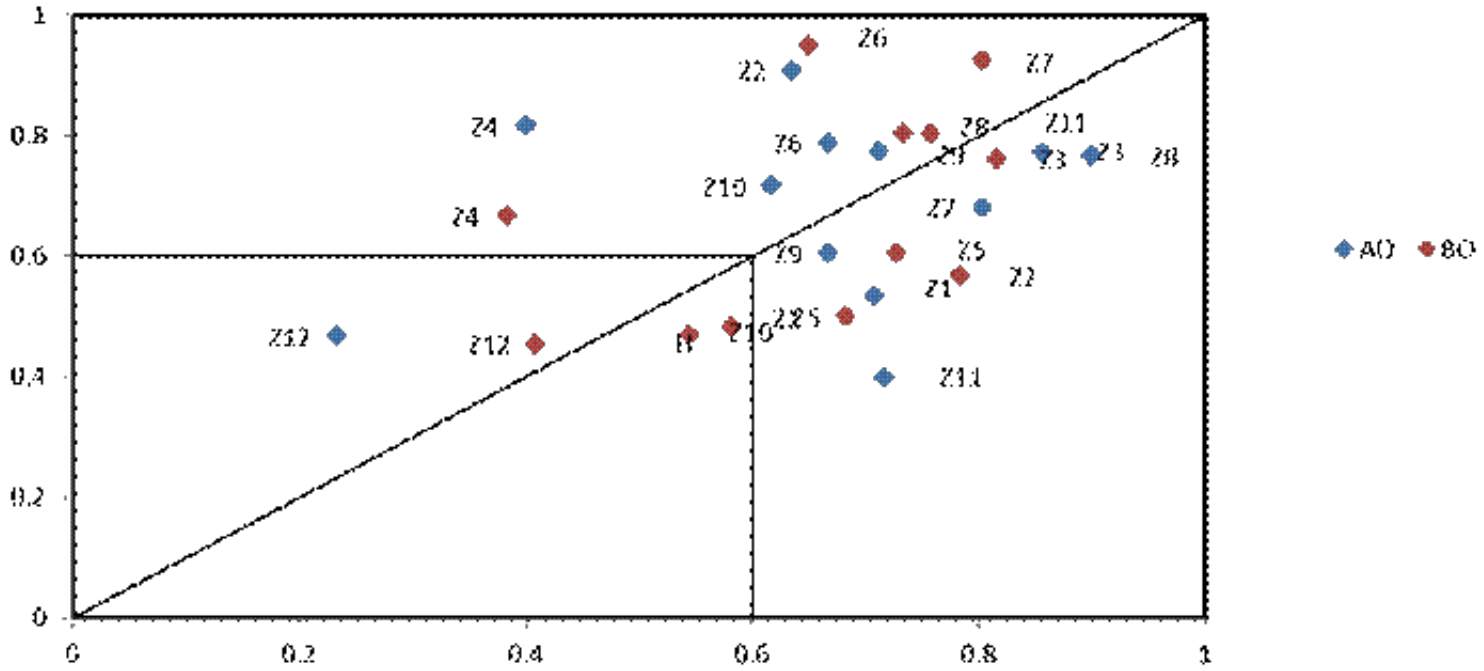
70% CCA calibrated (ECMWF; MF; CFS1&2)
30% Uncalibrated (ECMWF; MF; CFS1&2; GloSea4)

Seoul; CFS1; Melbourne; Tokyo; GloSea4; Montreal; Moscow; Beijing

Next…objectively combine statistical predictors and dynamical predictors in National forecasts – Mary Kilavi (KMD)

Forecasts for 12 climate zones of Kenya: EOFs of large-scale dynamical forecast output used in regression with 'conventional' statistical predictors

ROC scores: statistical +dynamical predictors



ROC scores: statistical predictors only

Flow chart summarising GHACOF seasonal precipitation consensus forecast production process

Met Office Hadley Centre

Representatives from NMSs of the region

Regional Centre (ICPAC) team

Global Centres (GPCs) e.g. Met Office

Station data timeseries for their country; national climate knowledge

Predictor timeseries: pre-season SST and atmos parameters; regional knowledge

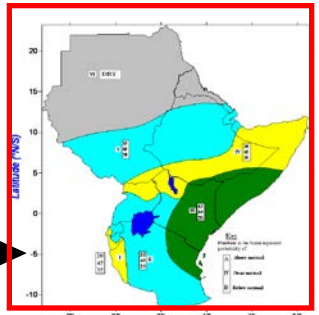
Dynamical model forecasts, incl ENSO plus skill information etc

Statistical forecasts for individual countries

Calibrate and combine forecasts

Compare statistical and dynamical – adjust/blend; expert judgement

First draft of regional forecast map – built up country by country



Final consensus

Flow chart summarising GHACOF seasonal precipitation consensus forecast production process

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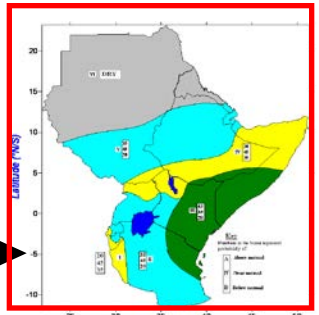


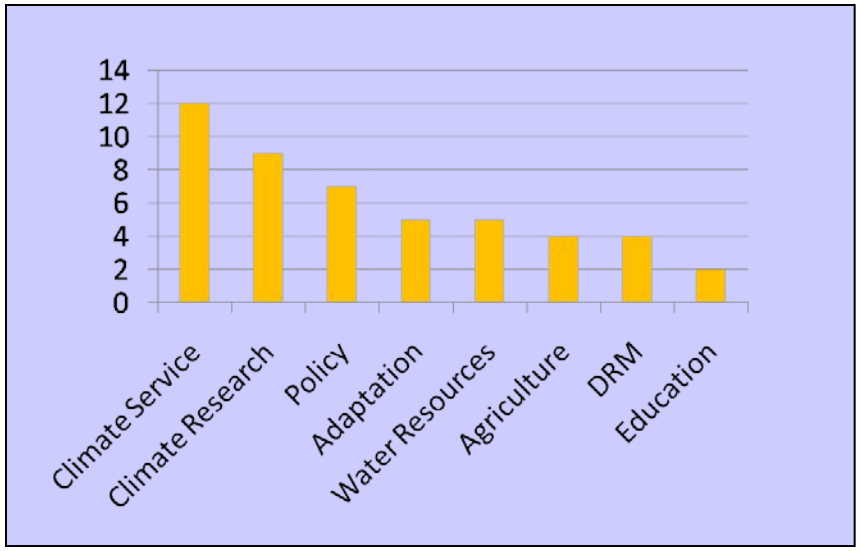
Final consensus

DFID-Met Office Climate Science Research Partnership (CSRP)

Initial consultation

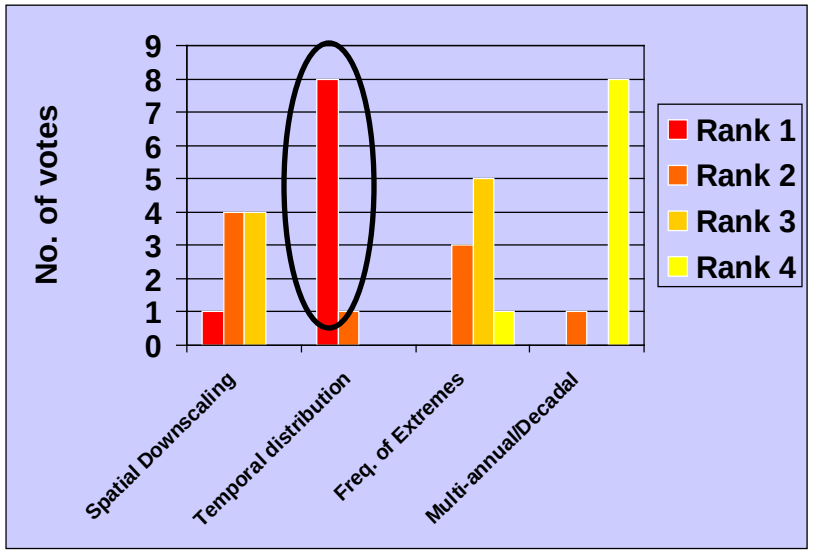
Total of 52 interviews across 8 African countries

Type and number of organisations interviewed



Questionnaire fielded to 9 climate service providers

Ranking of priorities

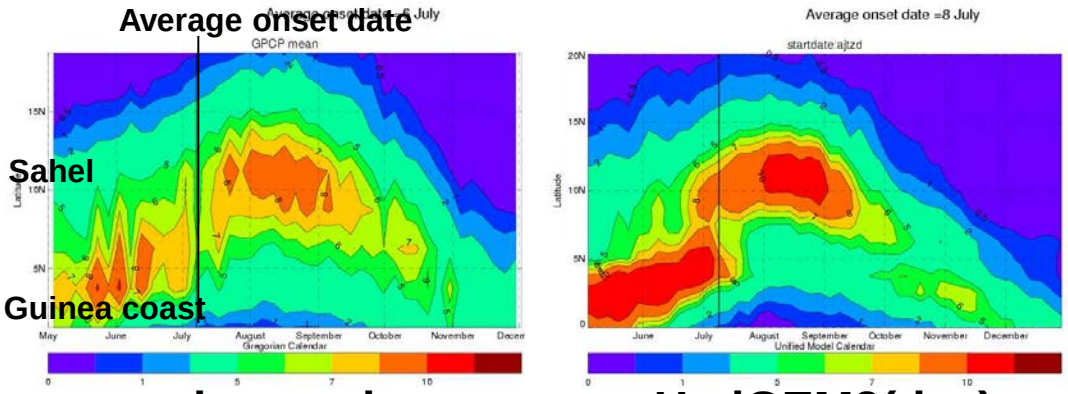


Key conclusion: There is a high priority need for predictions of the temporal distribution of seasonal rainfall: onset, cessation, in-season dry spells

Rainy season onset – focus on West Africa

How well do models used in IPCC's AR4 represent WAM season onset?

West African Monsoon (latitude Vs time)

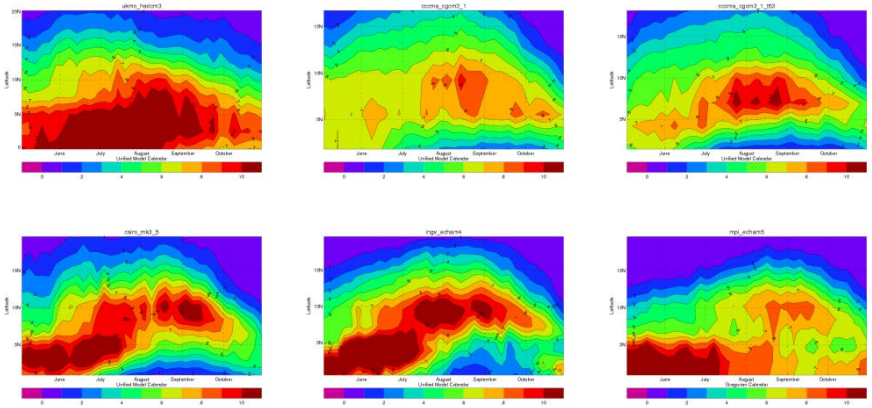


observed

HadGEM3(dev)

- Good representation in HadGEM3 provides opportunity to improve understanding of mechanisms driving onset;

Sample of CMIP3 models from AR4

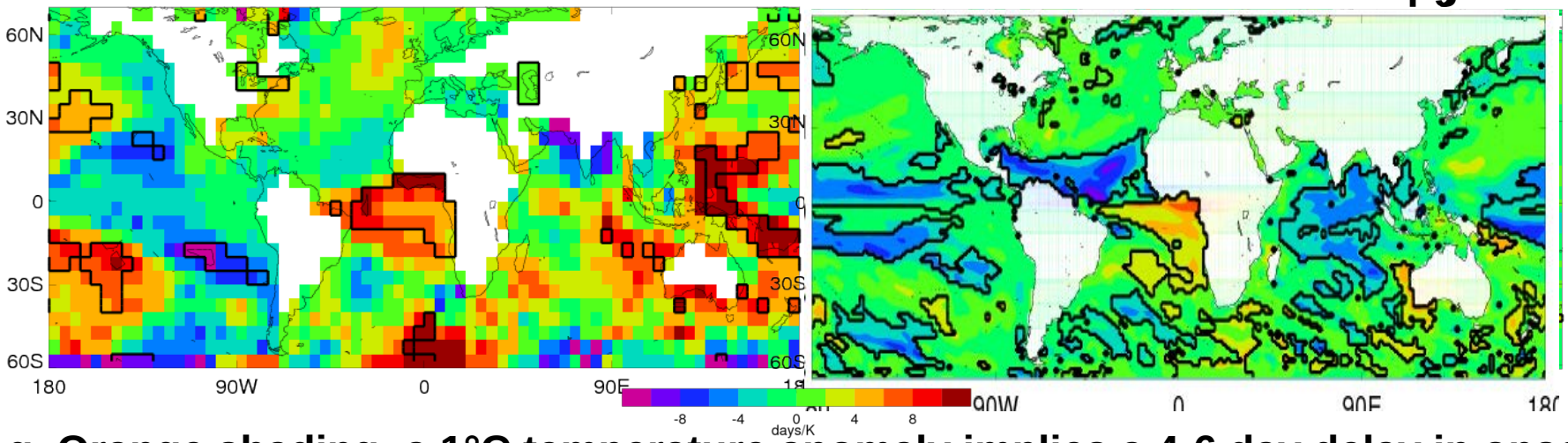


Understanding drivers of the WAM onset timing

Link between global sea surface temperature (SST) anomalies in June and onset timing

Michael Vellinga

Observed **Modelled – GloSea4 seasonal system**

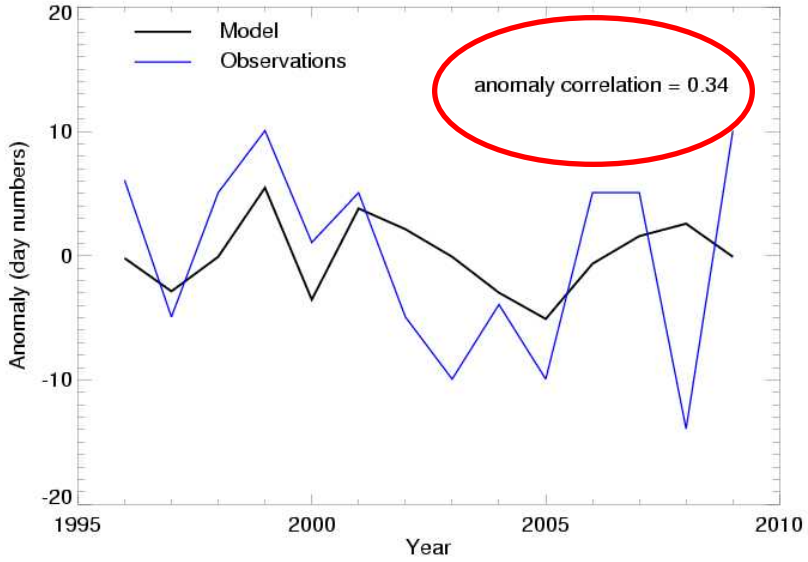


e.g. Orange shading: a 1°C temperature anomaly implies a 4-6 day delay in onset (Onset definition: pentad when maximum rainfall moves and stays north of 10°N)

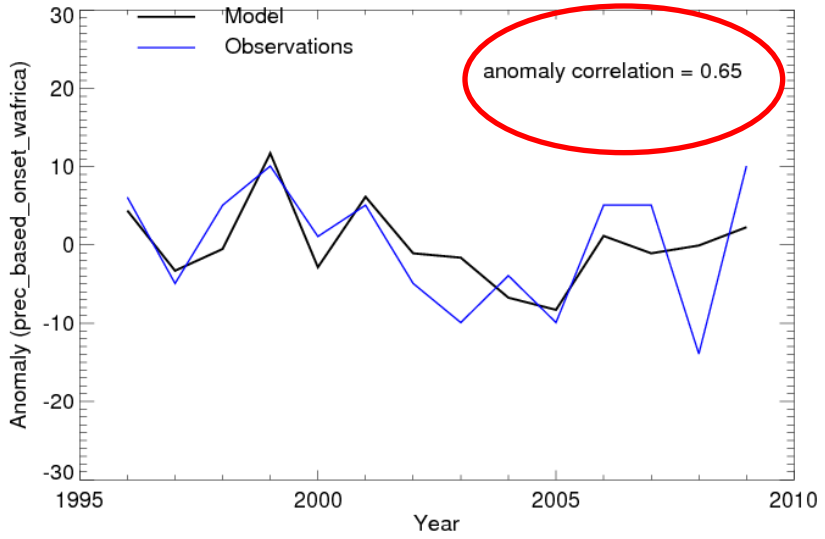
- **The Atlantic influence is modelled, to a degree, by the Met Office GloSea4 system (and other systems). Vellinga et al. 2012: Clim. Dyn. (accepted)**
- **This leads to some predictability of inter-annual variability in WAM onset (despite relatively large errors in average WAM rainfall in some models)**

Improved seasonal prediction of West African Monsoon onset timing in latest seasonal system

Observed and predicted onset dates for the West African Monsoon (1996-2009)



GA2.0 version of GloSea4 seasonal prediction system



Latest (GA3.0) version of GloSea4 – including upgraded soil moisture initialisation

Predicting onset timing GHA

based on local time of arrival of 20% of long-term seasonal average

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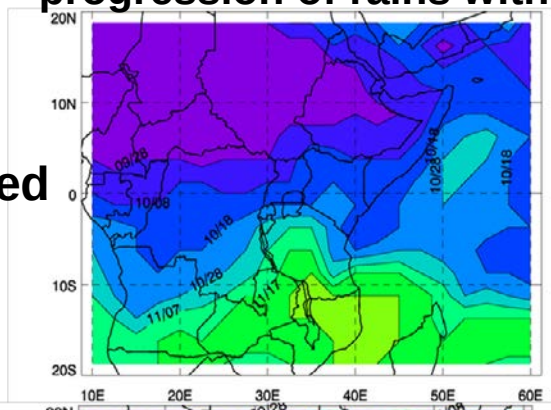
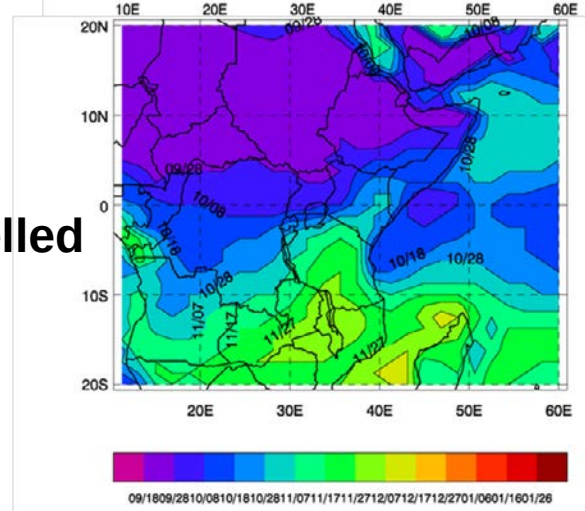
Average southward progression of rains with ITZC

observed

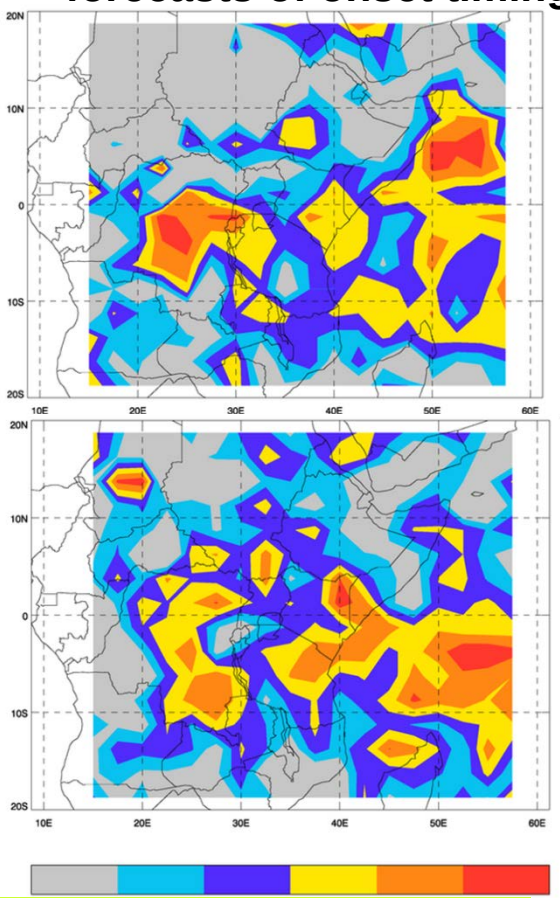


modelled



Example: East Africa short-rains (OND)

Skill of Met Office seasonal forecasts of onset timing



early onset

orange/red = 'good' skill

late onset

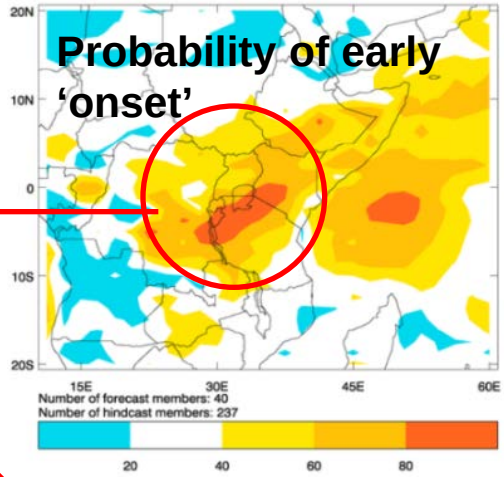
Encouraging first results: trial onset forecasts have been provided to Regional Climate Outlook Forums ICPAC, ACMAD and SADC-DMC

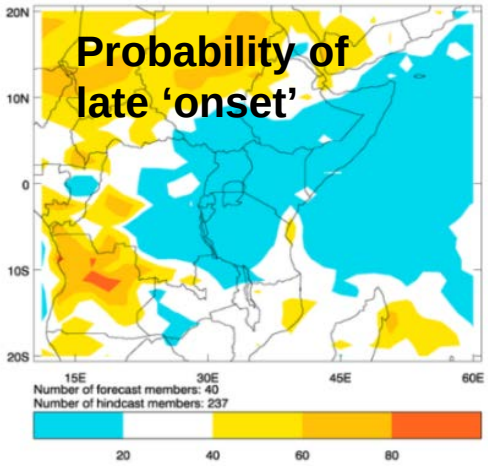
New trial products for RCOFs: onset prediction and monitoring

Example: Greater Horn of Africa, short-rains season 2011– predicted with one month lead

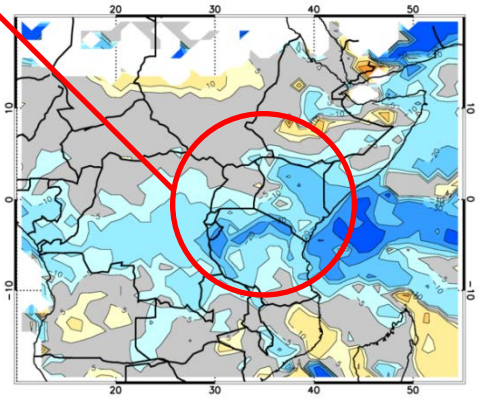
Early onset predicted most likely

Early onset occurred

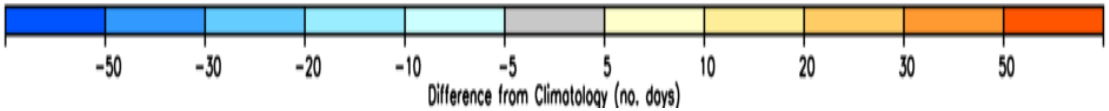




Prediction is based on local time of arrival of 20% of long-term seasonal average



CSRP monitoring product: Observed time of 'onset' (in days difference from long-term average



- **Assessment over retrospective cases indicates forecast can discriminate early/late onset in ~70% of cases (Tanzania/Kenya)**
- **Onset forecasts being trial at regional centres in East, West and southern Africa**

Longer-lead prediction

Correlation of Nino3.4 and IOD predictions at 1 and 4 month lead: 1989-2005

	Aug starts			May starts		
	GloSea4	**ECMWF S3**	**Persist**	**GloSea4**	**ECMWF S3**	**Persist**
Nino3.4	0.91	0.90	0.98	0.78	0.79	0.4
IOD	0.77	0.79	0.87	0.25	0.31	0.36

For GHA short-rains:

- **Hard to beat ENSO persistence from August starts**
- **More potential for dynamical systems to contribute GHA forecasts (i.e. to statistical methods) at long-lead**

Pledge from Entebbe 2011: Investigate longer-lead outlooks – short rains 2012

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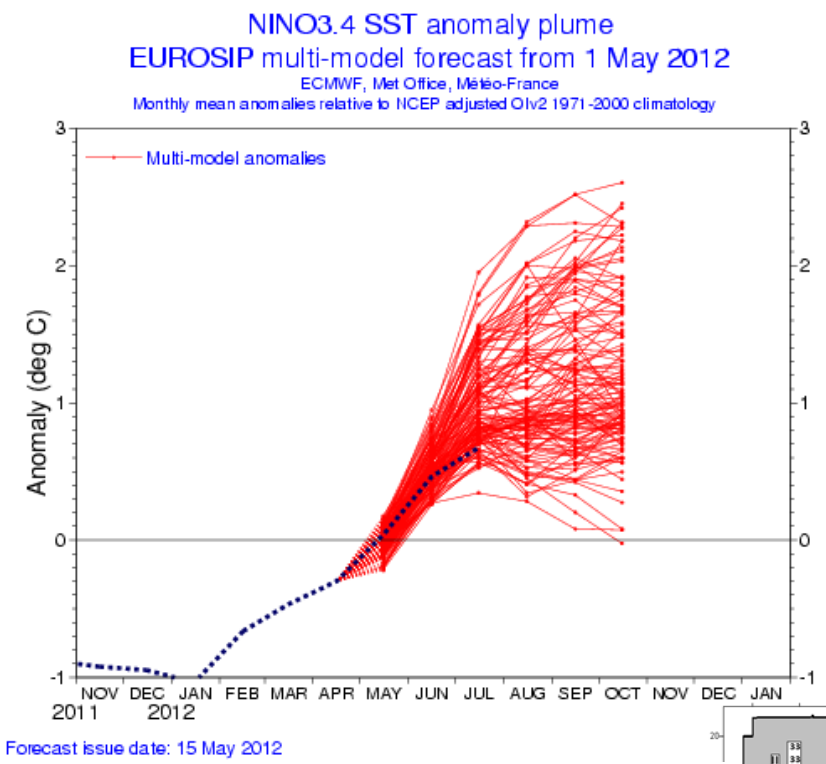
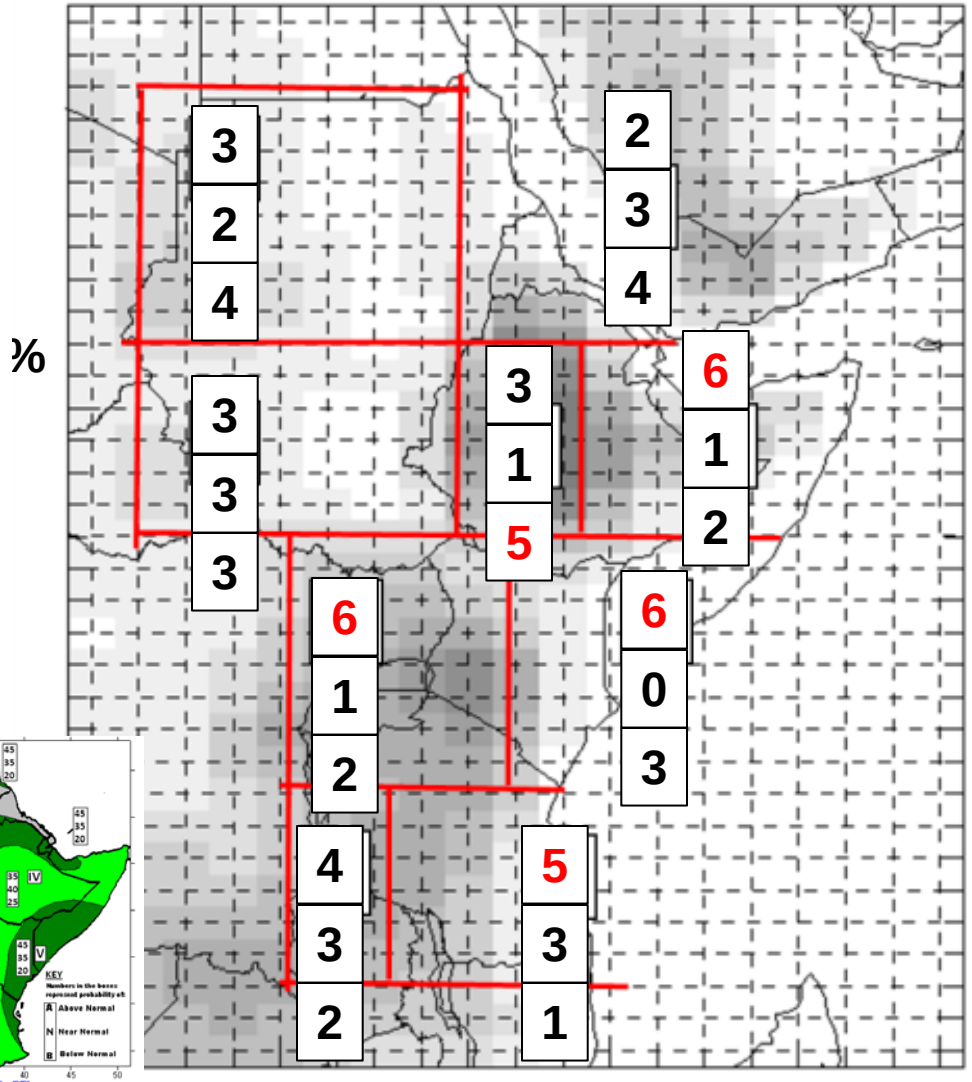
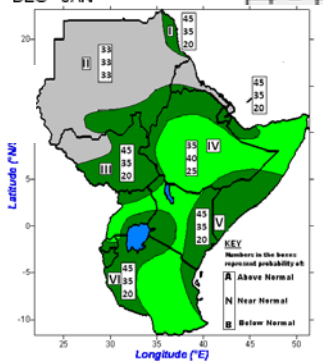


Consensus Aug 2012

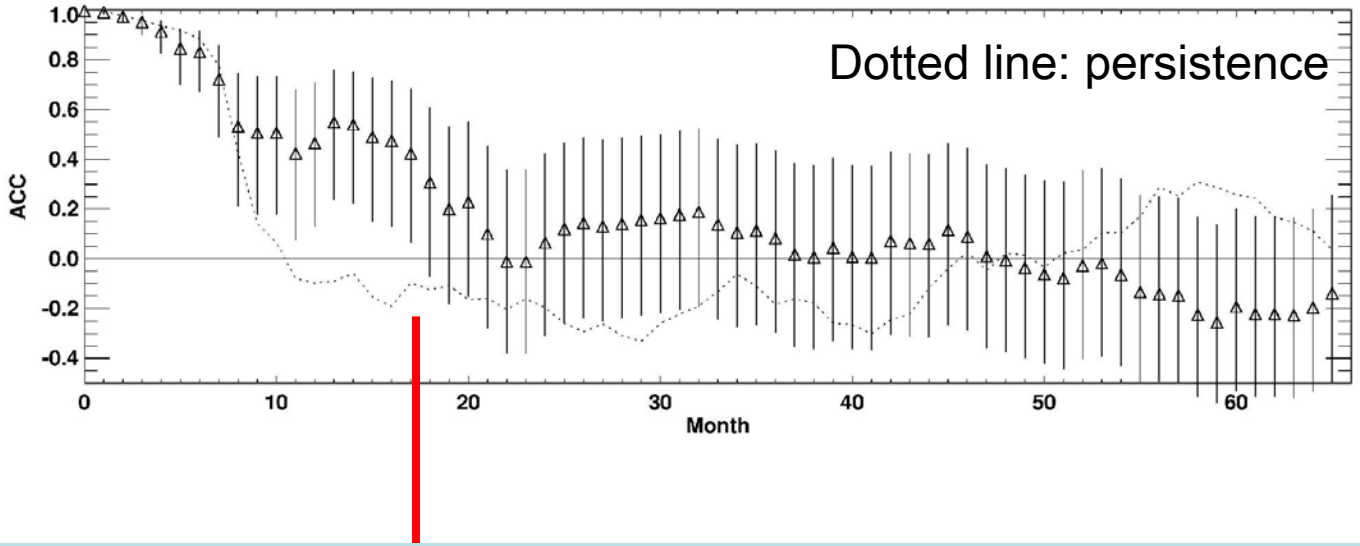
Frequency of short-rains rainfall categories in last 9 El Niño years





‘Seamless’ monthly-to-decadal prediction:
Skill for El Nino/La Nina prediction to 18 months ahead

correlation skill for monthly Niño3.4 index to 5 years ahead; from 22 retrospective forecasts from 1st November – 95% confidence limits



- **Positive skill for El Niño/La Niña prediction retained to ~18 months.**
- **Showing potential for longer-lead rainfall outlooks in regions strongly influenced by ENSO – allowing more time to prepare responses to potential drought/flood.**

Summary

- RCOFs in Africa: effective activities for regional climate risk management – important for GPCs to strengthen engagement (as planned in the GFCS);
- Consensus forecast production – predominantly statistically based (reasons of skill, familiarity, 'ownership');
- Role of dynamical forecasts has increased following WMO (CBS/CCl) establishment of infrastructure (designation of GPCs, LCs LRFMME & SVSLRF);
- More objective use of dynamical forecasts (together with statistics) is a key challenge;
- Longer-lead provision is needed and may be a key opportunity for dynamical systems to make 'step change';
- Temporal distribution of rains (including onset) a key requirement – CSRP research shows promising potential.

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Thank you!