

# Use of S2S forecasts in applications

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IRI

International Research Institute  
for Climate and Society  
EARTH INSTITUTE | COLUMBIA UNIVERSITY

*ECMWF Workshop on sub-seasonal predictability, Nov 2–4, 2015*

# Outline

- Types of user and application, and entry points for obtaining S2S forecasts - developed and developing country users
- Tailored forecast information and verification
- Question of most user-relevant formats for forecasts on different time scales (weather-S2S-seasonal)

# Types of user and application

- Hazard early warning - enhancing preparedness to high-impact weather events
- Management decisions in weather-sensitive operations
- Large range of users from sophisticated to developing country

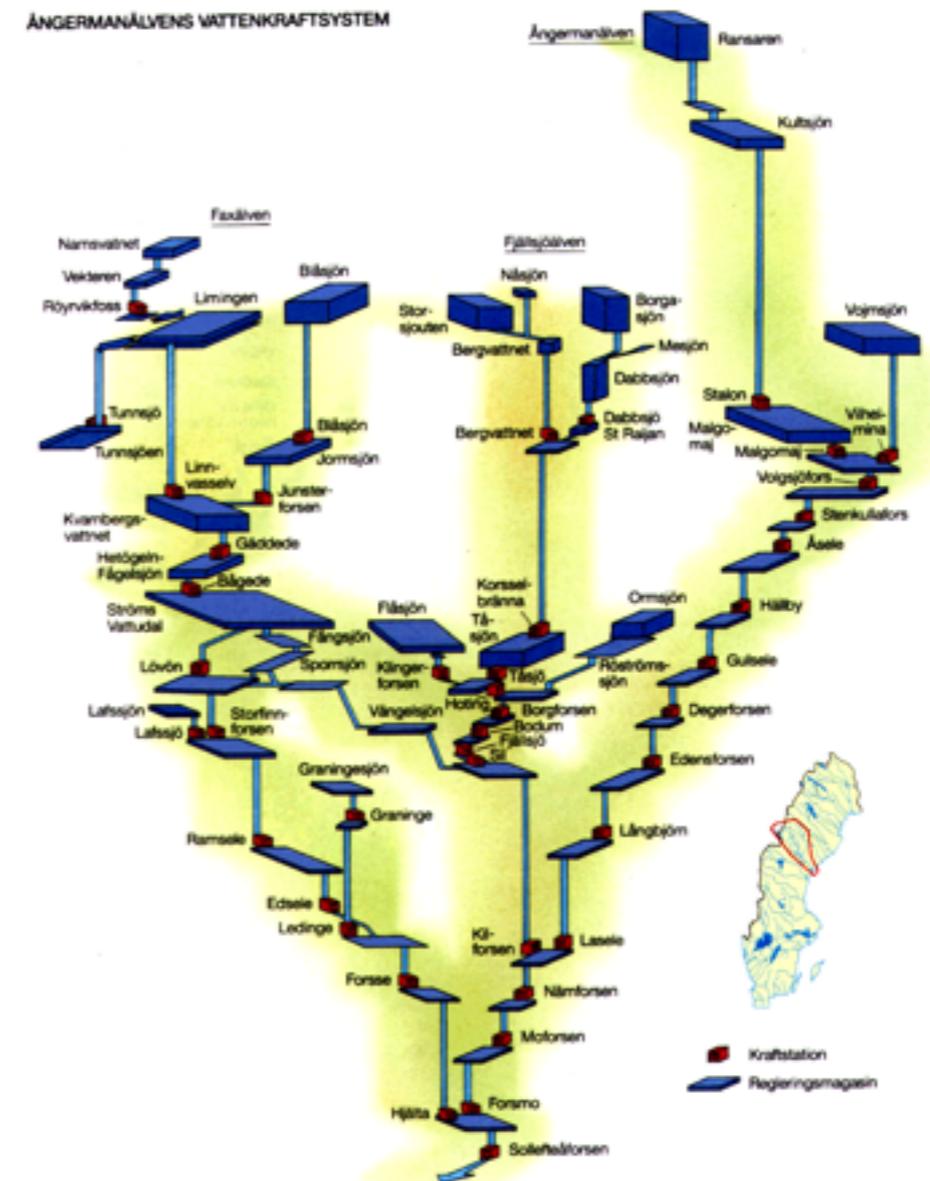
# Hydrologic Forecasts of spring flood volumes for Hydropower

## Short range forecasts, up to 10 days ahead

- Based on a meteorological forecast
- Most valuable at high flows (flood warnings), and for short term reservoir planning

## Long range forecasts, 1 to 6 months ahead

- Climatological forecast based on historical precipitation and temperature records
- Most valuable for water resources planning and operation of reservoirs



Kean Foster



**GFCS provides a worldwide mechanism for coordinated actions to enhance the quality, quantity and application of climate services.**

[Previous](#) [Resume](#) [Next](#)

### Priority areas



**Agriculture and food security**



**Disaster risk reduction**



**Health**



**Water**

### GFCS in action



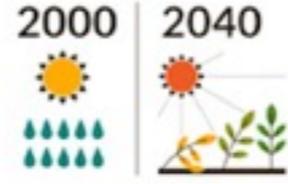
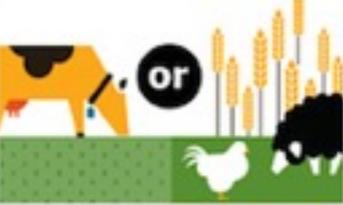
### Latest Contributions

**The International Climate Assessment and Dataset (ICA&D)**  
Submitted on: March 11, 2015

# How farmers around the world are making decisions based on weather and climate information

As climate change threatens food production, climate information services are helping farmers in Africa and South Asia make better decisions in the short and long-term to adapt to changing growing conditions.

	Type of information	Vehicles for delivering information	Farmer decisions affected
<b>WEATHER</b> Days to weeks	 <ul style="list-style-type: none"> <li>Observed rainfall and temperature</li> <li>Daily forecasts up to one week ahead of time</li> <li>Alerts on pests and diseases</li> <li>Early warning of extreme weather events</li> </ul>	 <ul style="list-style-type: none"> <li>Mobile phones</li> <li>Radio</li> <li>Television</li> </ul>	 <ul style="list-style-type: none"> <li>Timing of planting and harvest</li> <li>Timing of fertilizer, pesticide, and irrigation application</li> <li>Protecting lives and property from extreme events</li> </ul>
<b>CLIMATE VARIABILITY</b> Months to Years	 <ul style="list-style-type: none"> <li>Probabilities for seasonal rainfall and temperature conditions</li> <li>Seasonal climate variables targeted to particular agricultural risks (dry spells, rainy season start date, etc)</li> <li>Historical variability of climate variables</li> </ul>	 <ul style="list-style-type: none"> <li>Workshops with experts</li> <li>Conversations with agricultural extension agents (farm educators)</li> </ul>	 <ul style="list-style-type: none"> <li>Selecting crops and varieties</li> <li>Livestock stocking rates and feeding strategies</li> <li>Intensity of input use (fertilizer, pesticides)</li> <li>Labor or marketing contracts</li> <li>Intensifying and diversifying crops</li> <li>Diversifying sources of income</li> </ul>

<b>CLIMATE CHANGE</b> Decades or longer	 <ul style="list-style-type: none"> <li>Projections of future rainfall and temperature</li> <li>Historical trends in rainfall and temperature</li> <li>Historical changes in extreme events</li> </ul>	 <ul style="list-style-type: none"> <li>Workshops with researchers, agricultural extension agents, and meteorological services.</li> </ul>	 <ul style="list-style-type: none"> <li>Major capital investments (buying or expanding landholding, irrigation systems, farm equipment etc)</li> <li>Changing farming system or livelihood strategy</li> <li>Deciding whether or not to farm</li> </ul>
			

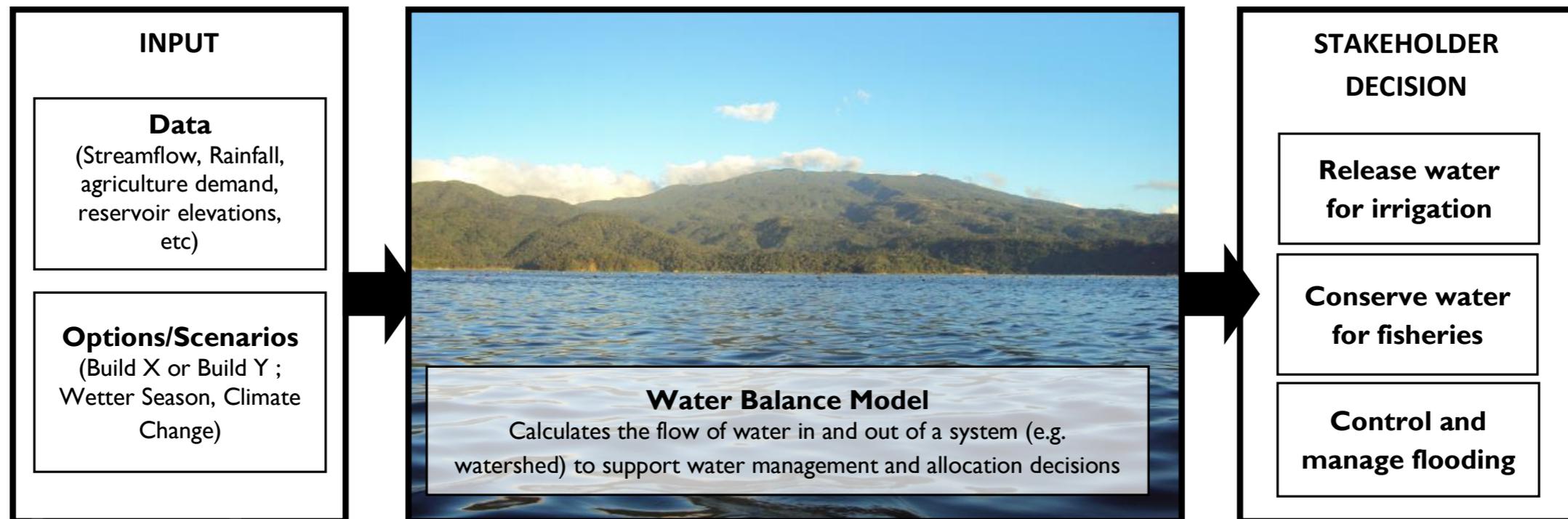
# Decision Support Tools for Climate Resilient Agriculture in the Philippines



Flooded rice paddies in Nabua, Camarines Sur after a typhoon

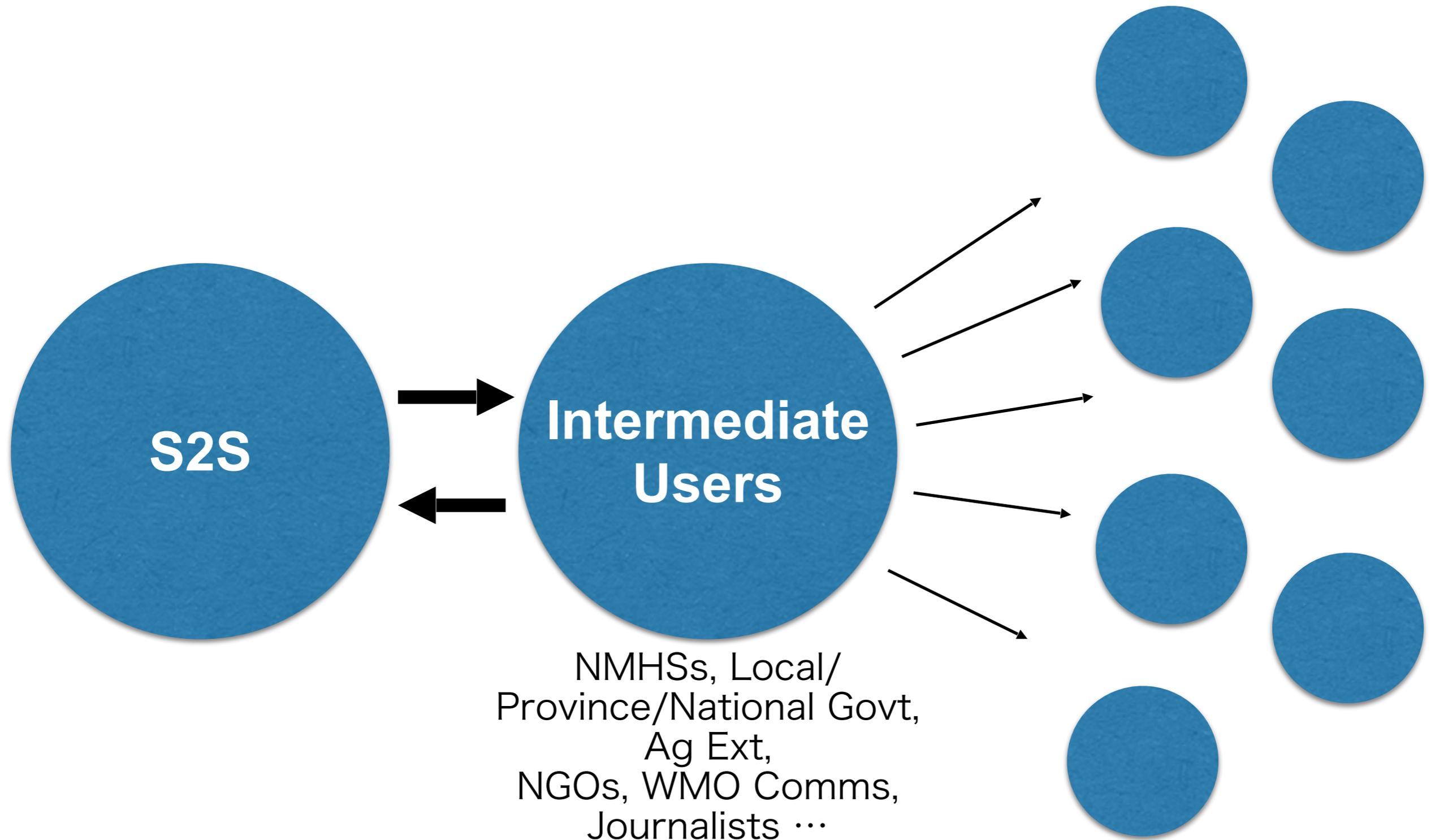
The Bicol Agri-Water Project - a USAID grant implemented by the **University of the Philippines Los Banos** Foundation, Inc. (UPLBFI), in partnership with the **IRI**, and the **Philippines Dept of Agriculture**, and Met Service (**PAGASA**) is working to develop, test, and apply **agro-climate tools to support decisions for managing climate risks at the farm level and water resources at the watershed level.**

Schematic diagram of WEAP Model



PI: A. Ines

# Important Entry Points with Users



Indirect Link with End Users via Intermediaries

# Scope defined by a set of hazards...



## Urban Flood:

Reducing mortality, morbidity, damage and disruption from flood inundation by intense rain, out-of-bank river flow, coastal wave & surge overtopping and from consequent urban landslides.

## Disruptive Winter Weather:

Reducing mortality, morbidity, damage and disruption from snow, ice and fog to transport, power & communications



## Wildfire:

Reducing mortality, morbidity, damage and disruption from wildfires & their smoke.

## Heat & Air Pollution in Megacities:

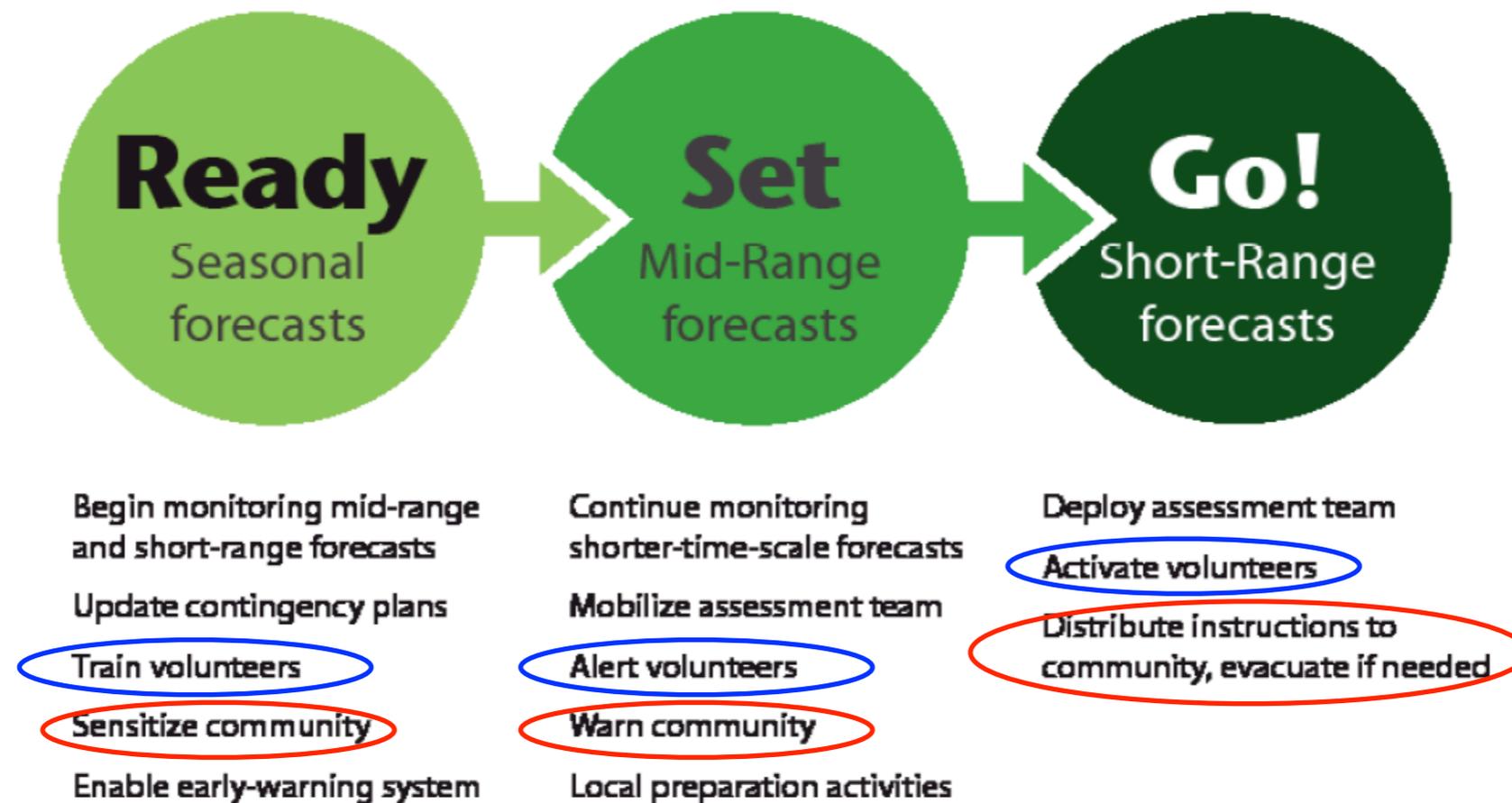
Reducing mortality, morbidity and disruption from extreme heat & pollution in the megacities of the developing and newly developed world.



## Extreme Local Wind:

Reducing mortality, morbidity, damage and disruption from wind & wind blown debris in tropical & extra-tropical cyclones, downslope windstorms & convective storms, including tornadoes

# Red Cross/IRI Example of using forecasts for Humanitarian aid Early Action



Source: M. Daly

# Maprooms for Humanitarian Aid

International Federation of Red Cross and Red Crescent Societies  
 IRI Forecasts in Context

Six-Day Forecasts  
 Where is exceptionally heavy rainfall expected?

Region  
 Global

Language  
 english

Description More Information Instructions Single-Day Precipitation Maps Dataset Documentation Contact Us

## Where is exceptionally heavy rainfall expected?

This map shows places in the world that are forecasted to receive exceptionally heavy rainfall in the next six days relative to what is normal for their location.

### What early action can I take to reduce possible disaster effects?

- Contact your local/regional meteorological department and monitor their forecasts for the next six days.
- Consider who may be most affected by heavy rainfall.
- Review your contingency plans and update as necessary.
- See pages 4 and 5 in this [Early Warning Early Action booklet](#) for examples of early action based on rainfall forecasts.

See the "More Information" tab for forecast details.

Forecast Start Time 0000 1 Jan 2008 ← 0000 30 May 2013 → 0000 16 Jun 2013  
 Forecast for 30 May 2013 - 4 Jun 2013 Issued 0000 30 May 2013

Latitude 60°N 30°N 0° 30°S 60°S  
 Longitude 180°W 150°W 120°W 90°W 60°W 30°W 0° 30°E 60°E 90°E 120°E 150°E

Heavy Rainfall Very Heavy Rainfall Extremely Heavy Rainfall

**Six-Day Forecasts**  
 Where is exceptionally heavy rainfall expected?  
 How does expected rainfall compare to normal rainfall for this month?  
 Where is it expected to be wetter than average?  
 How much rain is expected?

**Three-Month Forecasts**  
 Are the next 3 months likely to be unusually wet or dry?  
 Are the next 3 months likely to be exceptionally wet or dry?  
 Is it likely that unusually wet or dry conditions will end?  
 Is it likely that unusually wet or dry conditions will continue?  
 How Well Can We Predict Seasonal Climate?

**Past Conditions**  
 What Changes in Rainfall are Typical during El Niño?  
 What Changes in Rainfall are Typical during La Niña?  
 How much rain normally falls at this time of year?

**Recent Climate Trends**  
 How important have century-long shifts in climate been?  
 How important have decade-long shifts in climate been?  
 How important have year-to-year shifts in climate been?

**Vulnerability Indicators**

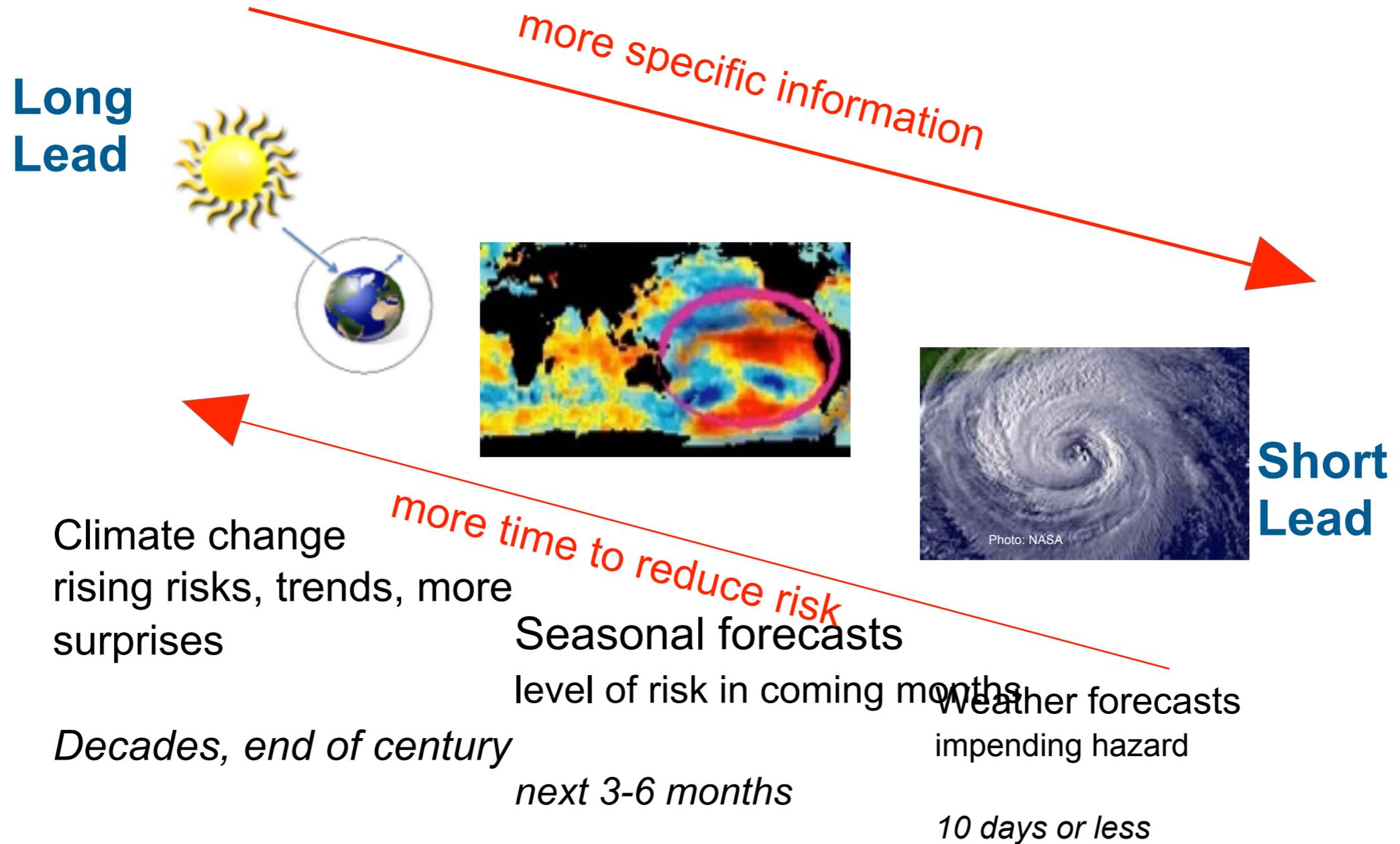
Share +1 Like 24

IRI

*developed in a partnership between IRI and IFRC*

Source:  
 IRI

# Using information across time-scales



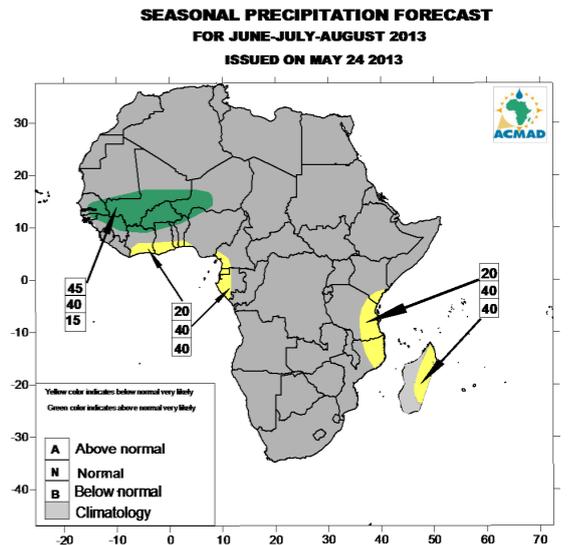
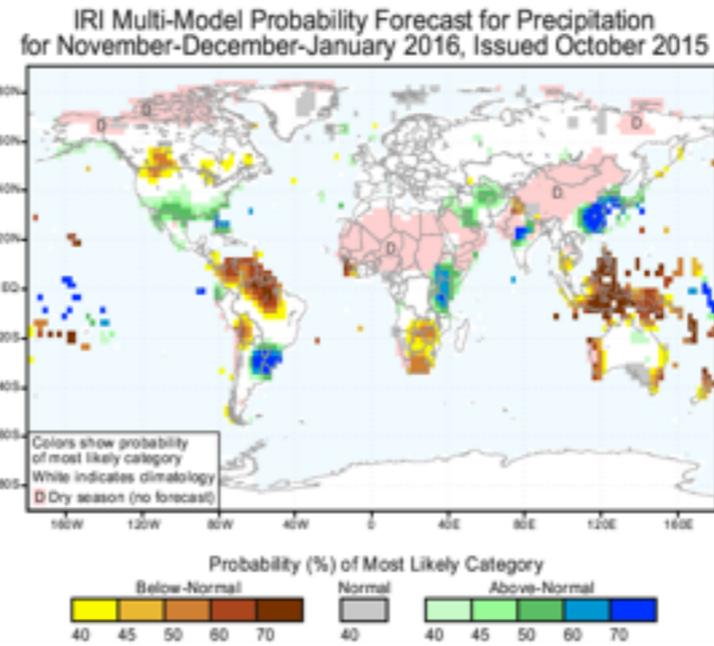
Source: Erin Coughlan

# Forecast access

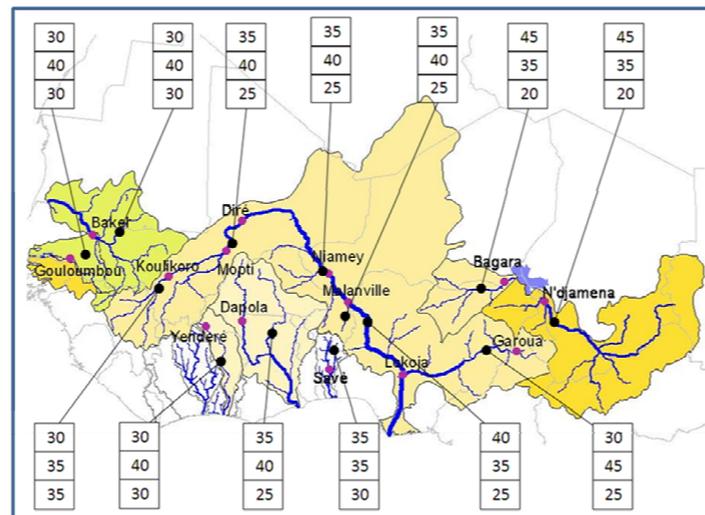
Press, TV, Radio

Online

Regional Climate Outlook Fora



Prévision hydrologique 2012



Graphics vs data to run sectoral models

# Enhancing National Climate Services (ENACTS) in Africa



## Improve Availability

- Build capacity of NMHS
- Quality Control station data
- Combine station data with proxies
- Improve seasonal forecast



## Enhance Access

- Install IRI Data Library
- Develop online tools for data analysis and visualization
- Create mechanisms for data sharing



## Promote Use

*Engage users:*

- *Raise awareness*
- Build capacity of users to understand and use climate info
- Involve users in product development

Tufa Dinku, IRI

# Tailored forecast information and verification

# Flexible Format Probabilistic Forecasts

Climate Forecasts  
Flexible Forecasts: Precipitation Flexible Seasonal Forecast  
Region: Global  
Model: Forecast  
Target Time: Sep-Nov 2015  
Climatology (1979 to 2011): 1981 to 2010  
Probability: non-exceeding  
Percentile: 20.0  
Precipitation Units: mm

Description Dataset Documentation More Information Instructions Contact Us

## Precipitation Flexible Seasonal Forecast

This seasonal forecasting system consists of probabilistic precipitation seasonal forecasts based on the full estimate of the probability distribution.

Probabilistic seasonal forecasts from multi-model ensembles through the use of *statistical recalibration*, based on the historical performance of those models, provide reliable information to a wide range of climate risk and decision making communities, as well as the forecast community. The flexibility of the full probability distributions allows to deliver interactive maps and point-wise distributions that become relevant to user-determined needs.

The default map shows globally the seasonal precipitation forecast probability (colors between 0 and 1) of exceeding the 50<sup>th</sup> percentile of the distribution from historical 1981-2010 climatology. The quantitative value (in mm/day) of that percentile is indicated by the contours. The forecast shown is the latest forecast made (e.g. Sep 2012) for the next season to come (e.g. Oct-Dec 2012). Five different seasons are forecasted and it is also possible to consult forecasts made previously. What makes the forecast flexible is that underlying the default map is the full probability distribution for the forecast and climatology. Therefore, the user can specify the historical percentile or a quantitative value (here precipitation in mm/day) for probability of exceedance or non-exceedance. The climatological reference on which the forecast probability of (non-)exceeding is computed can be tailored by defining its starting and ending years.

Clicking on a point on the map will show the local cumulative distribution and probability distribution functions of the forecast (green) together with the climatological distribution (black).

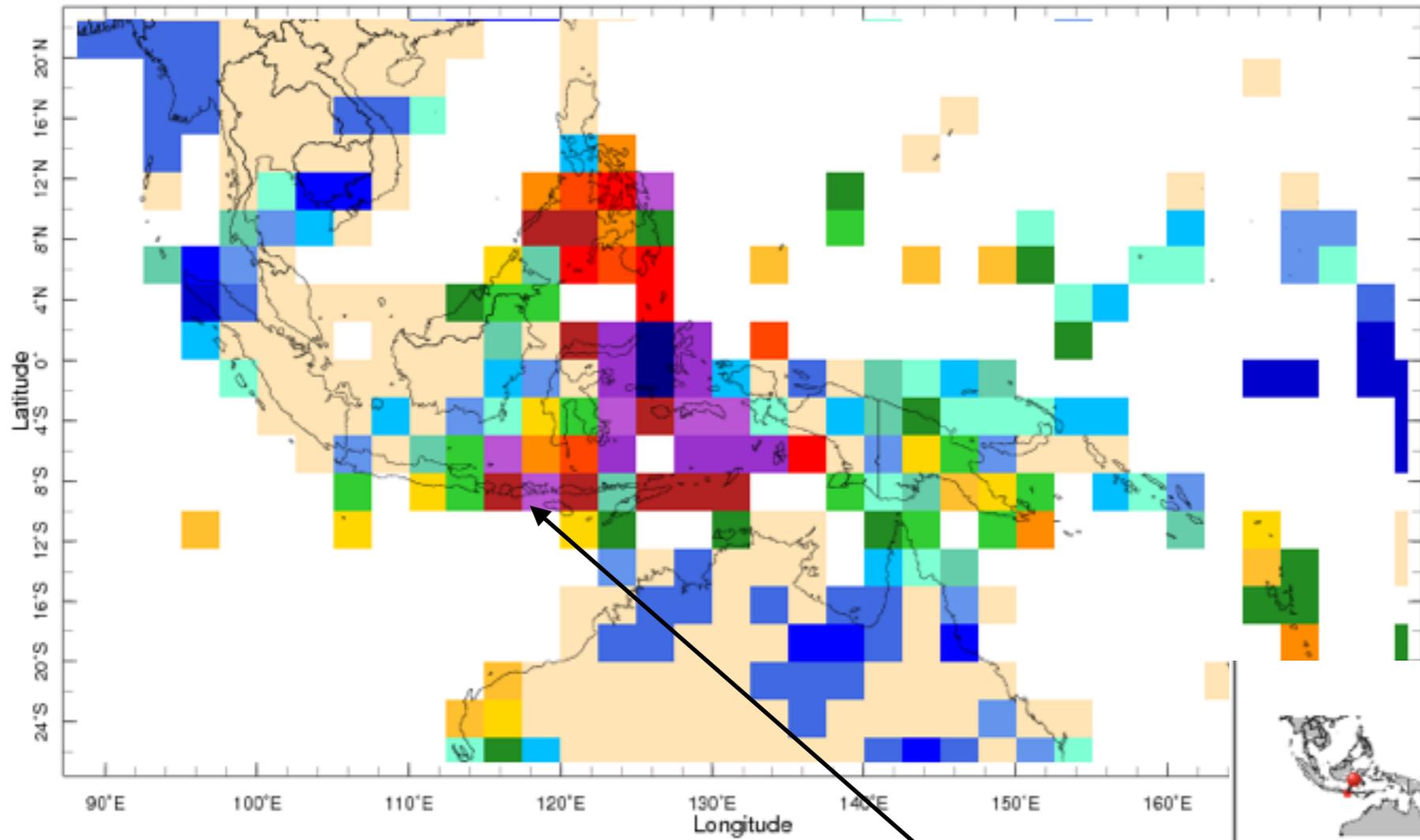
Sep-Nov 2015 Flexible seasonal Precipitation forecast issued 0000 1 Aug 2015

Probability of non-exceeding 20.0th %-ile

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# Non-exceedance probability of 20%-ile NDJ 2016 from Oct



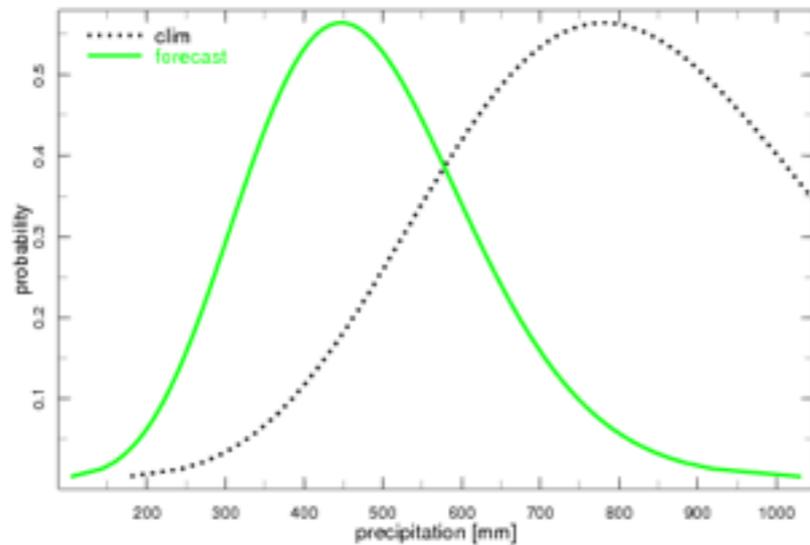
User Query  
of  
Forecast PDF  
- deciles  
- seas rainfall (mm)



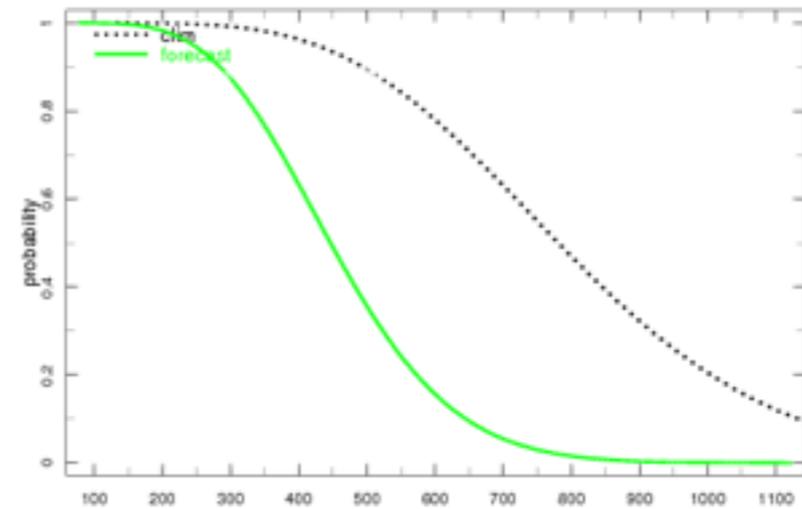
Target Date	Issue Date	Lead Time
Nov 2015 - Jan 2016	0000 1 Oct 2015	2.5

Nov 2015 - Jan 2016 Flexible seasonal Precipitation forecast issued 0000 1 Oct 2015

Forecast made for [115E-117.5E, 10S-7.5S]  
located in , Jawa Timur , Indonesia



lead 2.5 months S 0000 1 Oct 2015



Nov 2015 - Jan 2016 issued 0000 1 Oct 2015 at (116.25E,8.75S)

# Seasonal Climate Verifications

Download: [Descriptions of the IRI Climate Forecast Verification Scores](#)

## Verification of IRI's Seasonal Climate Forecast

Skill Category:

Score:

Variable:

Season:

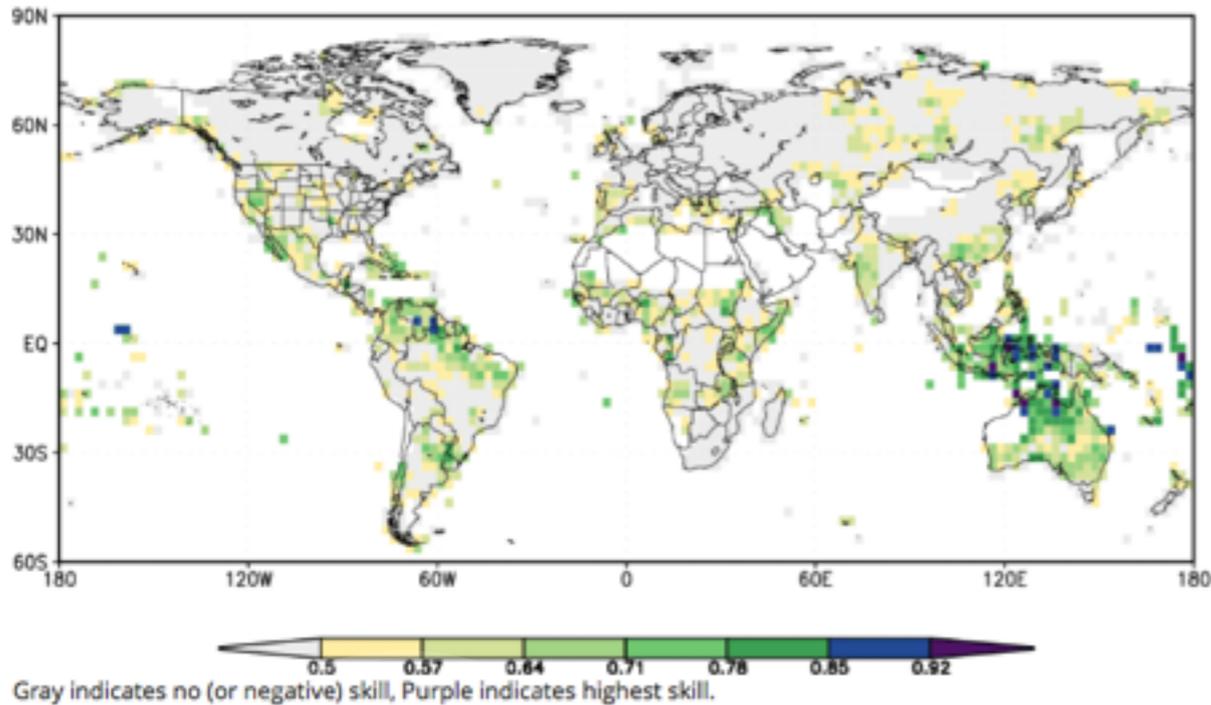
Lead:

- ✓ Measures of Discrimination
- Measures of Resolution and Reliability
- Measures of Unconditional Bias
- Measures of Number of Hits
- Measures of Value

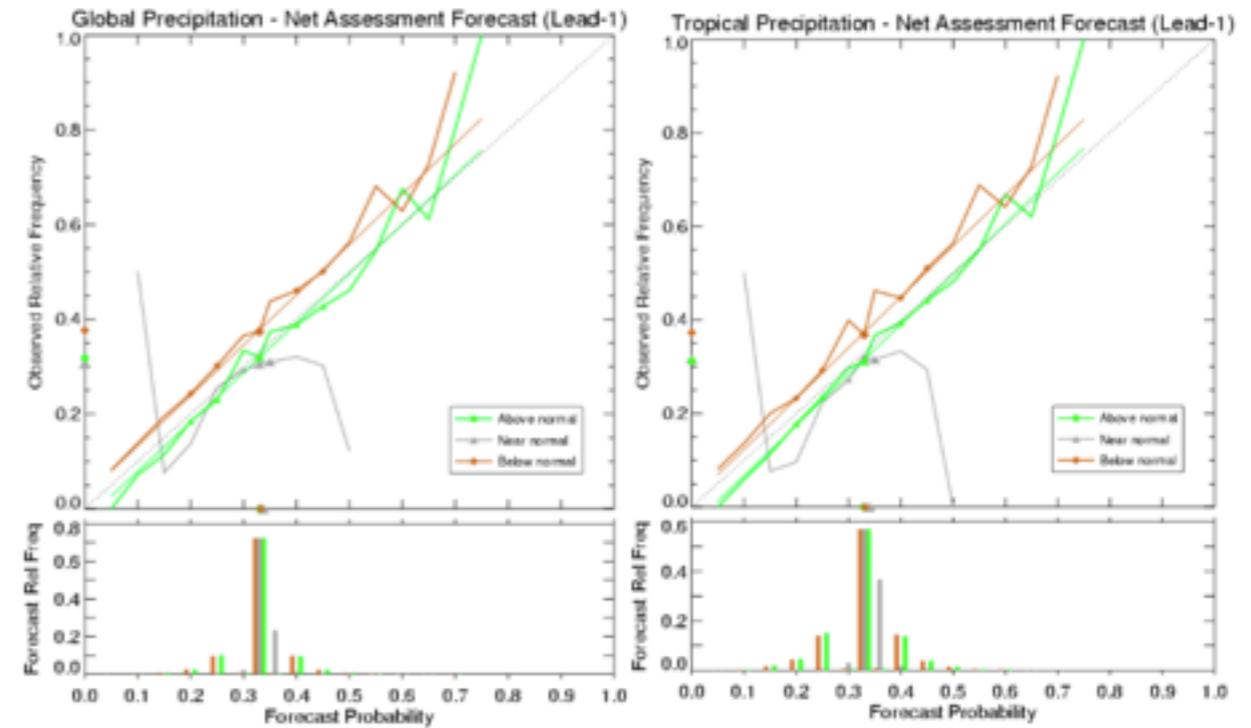
### Description of Score

The generalized ROC score (GROC), like the ROC, shows the degree of correct probabilistic forecast discrimination, even if the forecasts have biases or calibration problems. However, unlike ROC, GROC is generalized to encompass all forecast categories (below, near, and above collectively, rather than being specific to a single category).

### Generalized ROC (GROC): Lead 0.5 months, Precipitation Forecast Skill: SON



### Reliability Plots: Lead 0.5 months, Precipitation Forecast Skill: All Seasons

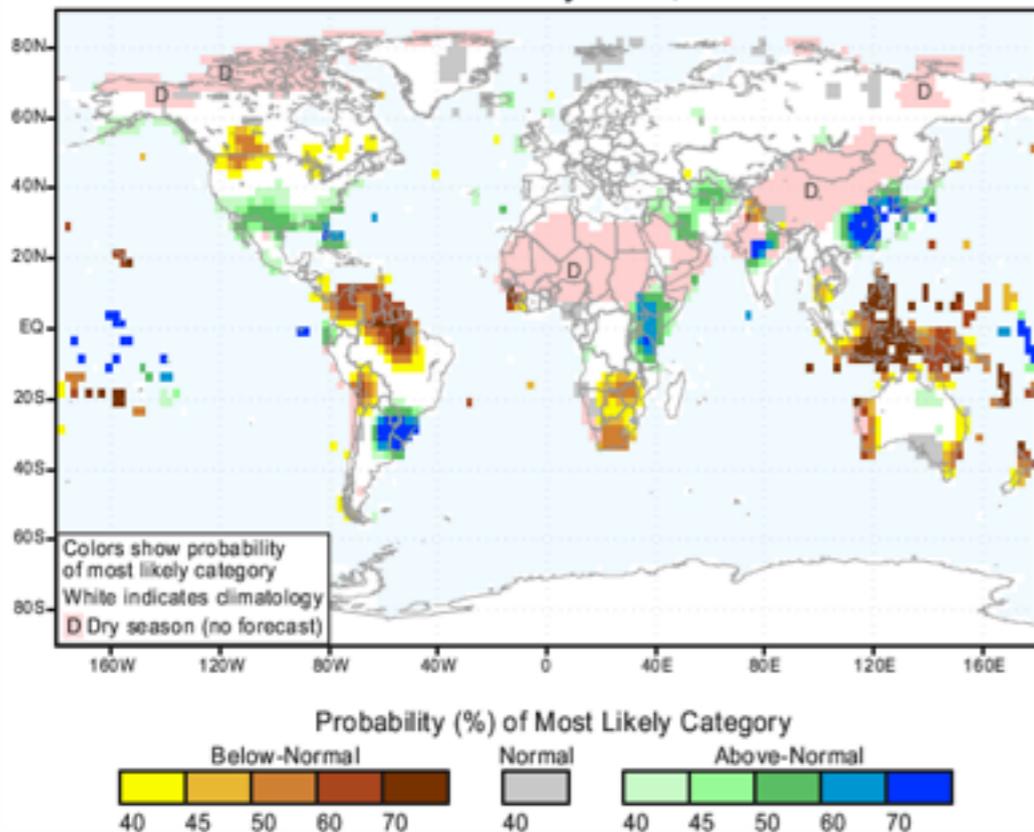


### Individual Forecast Score



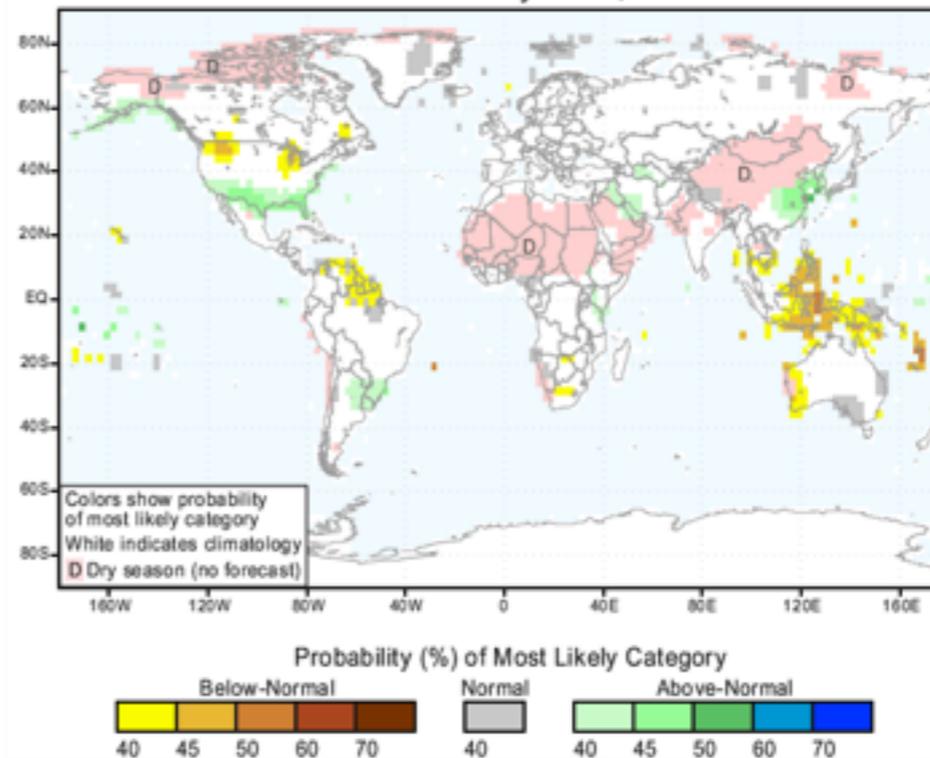
# NDJ 2016 Forecast

IRI Multi-Model Probability Forecast for Precipitation for November-December-January 2016, Issued October 2015

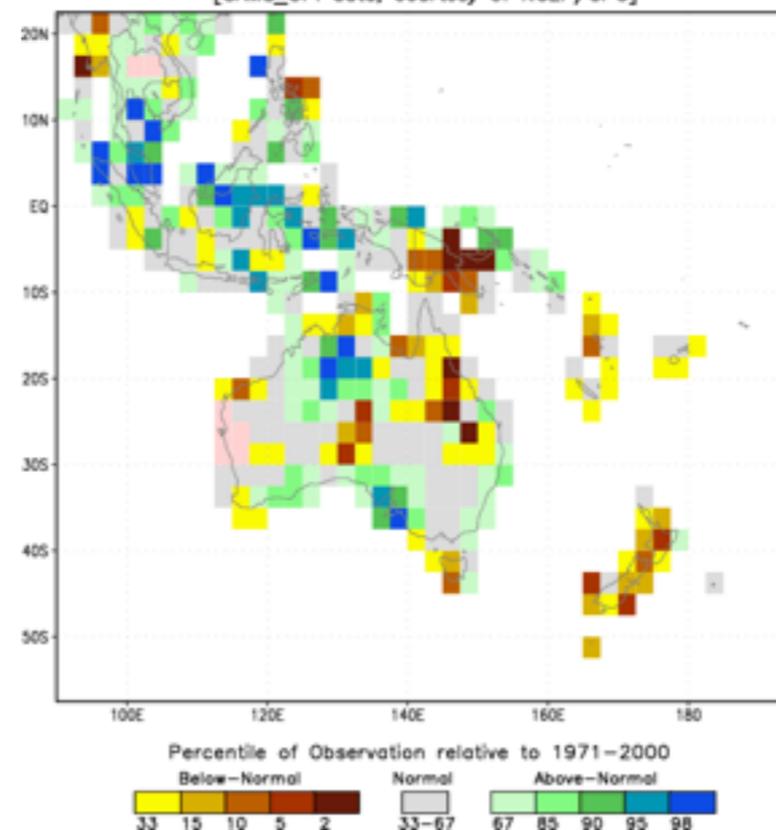


# NDJ 2015 Forecast

IRI Multi-Model Probability Forecast for Precipitation for November-December-January 2015, Issued October 2014



Observed Precipitation NDJ 2015  
[CAMS\_OPI data, courtesy of NCEP/CPC]

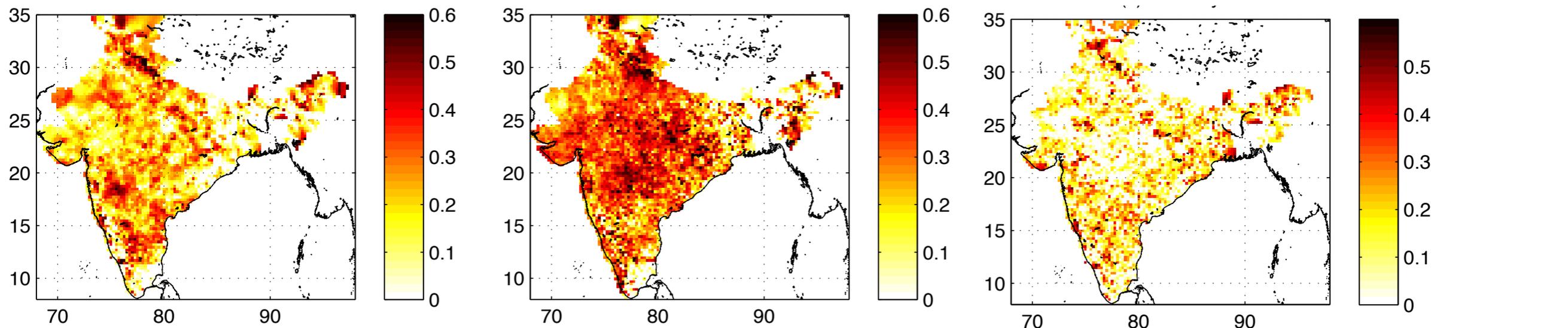


Forecast calibration... only when there is signal and skill should the forecast deviate from the climatological distribution

Verification of individual forecasts

# Certain User-relevant quantities may be *more* predictable

**Seasonal Total = Rain Day Frequency x Mean Intensity**



IMD 0.25-degree  
daily rainfall data

**Anomaly Correlation “Skill”**

**Cross-validated regression with observed tropical Indo-Pacific SST  
Jun–Sep 1901–2004**

# Downscaling and tailoring

Climate Predictability Tool, v. 6.03

File View Help

Canonical Correlation Analysis (CCA)  
Principal Components Regression (PCR)

## CLIMATE PREDICTABILITY TOOL

$$\hat{y} = Ax + b$$

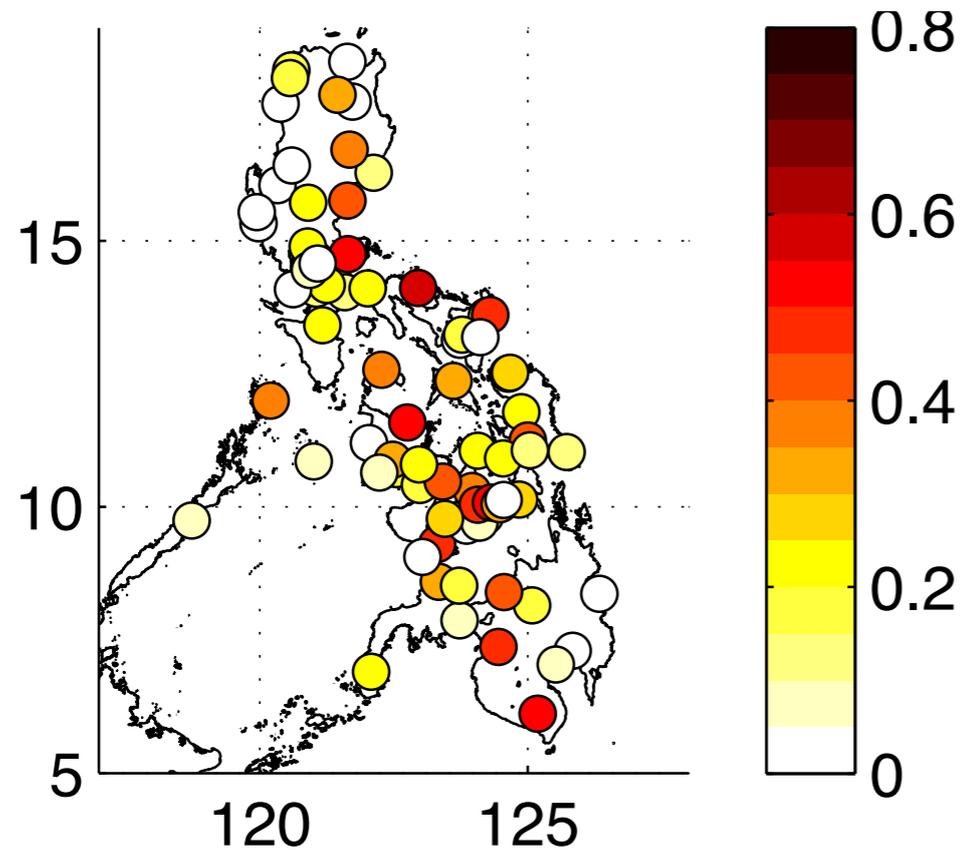
Copyright 2003

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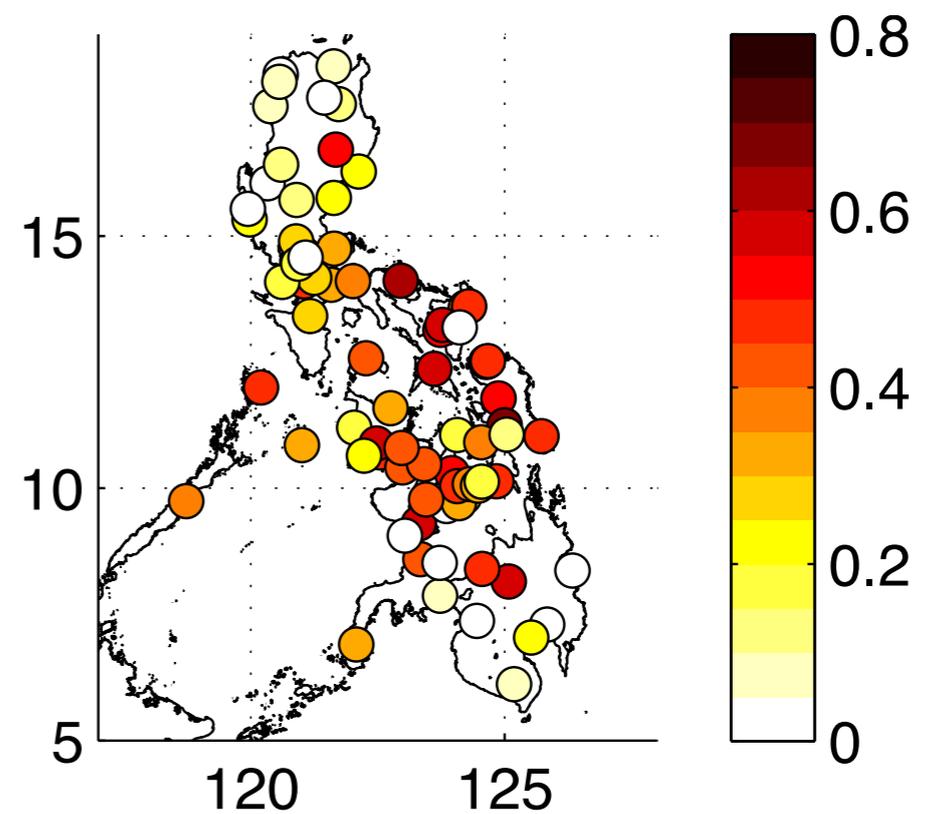
# Dynamical vs Statistical Downscaling of Seasonal Rainfall

## Anomaly Correlation Skill

25-km Nested Model



T42 GCM with PC Regression



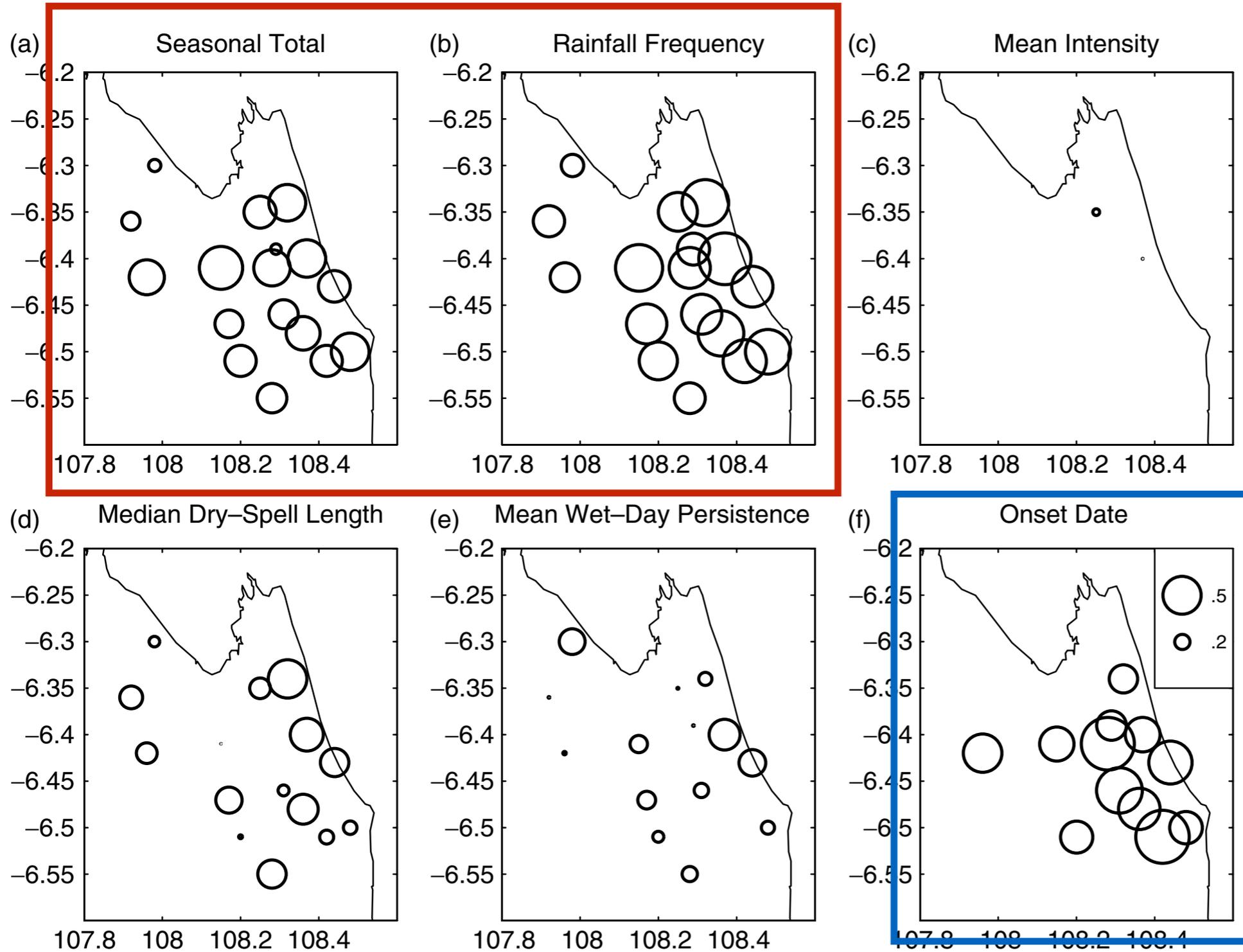
April–June, 1977–2004

Robertson et al. (2012, MWR)

# Skill of Downscaled Forecasts Indramayu, Java

**Station Rainfall  
Indramayu District,  
Indonesia**

**Forecasts for  
Sept–Dec  
from  
August 1**



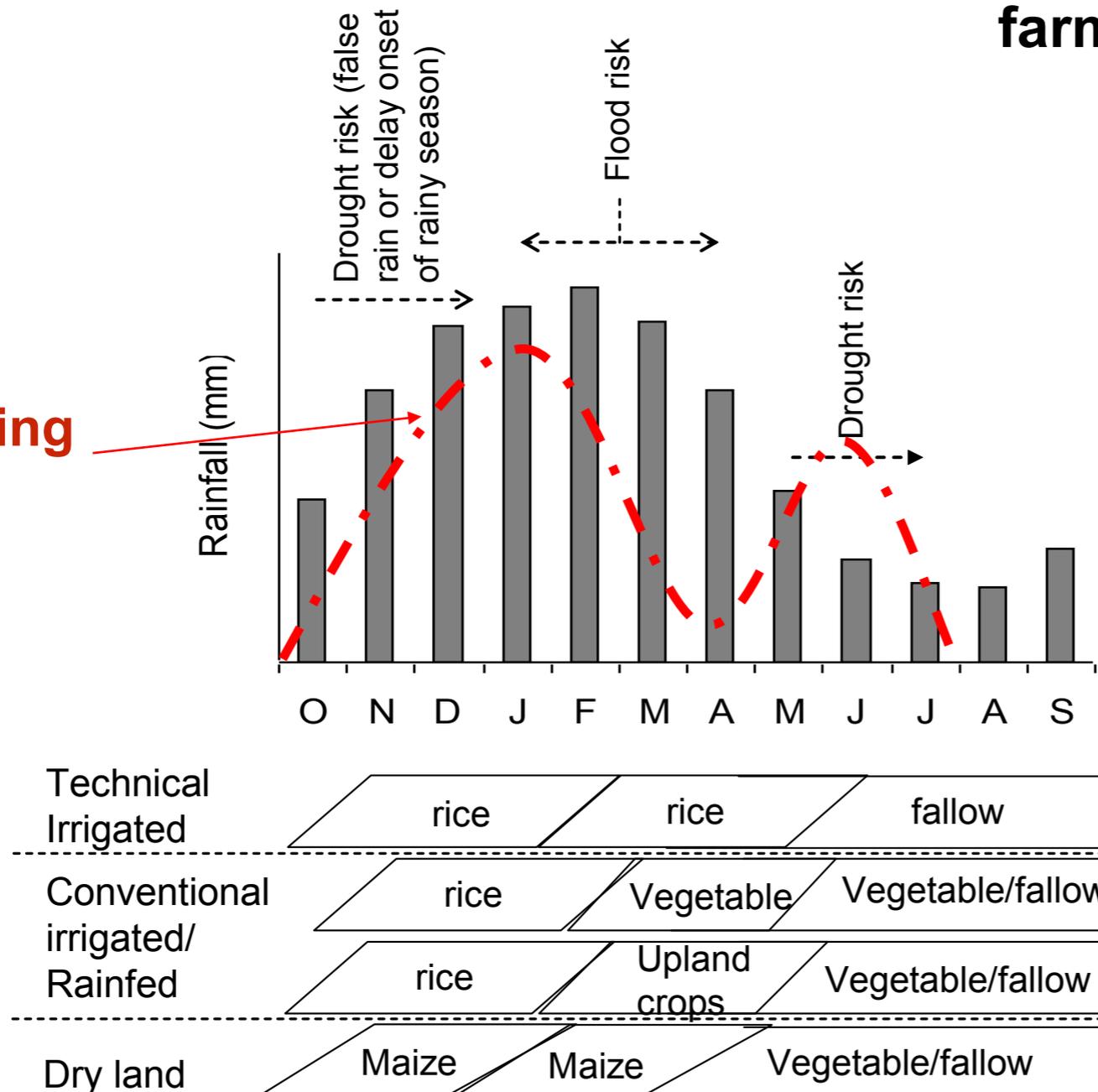
**Skill = Circle size**

Robertson et al. (2009)

# Typical climate risks for farming in Java

## Climate impact on farming system

rice planting area



Types of climate risks on lowland rice

- 1<sup>st</sup> Rice: flood risk in the period of between Jan and Feb
- 2<sup>nd</sup> Rice: drought risk due to early onset of dry season (rainy season ends earlier than normal)
- Maize: risk to be exposed to long dry spell at the start of rainy season (*false rain*)

Type of climate risks on dry-land farming

1. Maize/nuts: risk to be expose to drought risk (long dry spell or season break or rainy season ends earlier than normal)
2. Maize expose to high wind speed (Jan-Feb)

Source: Boer, 2005

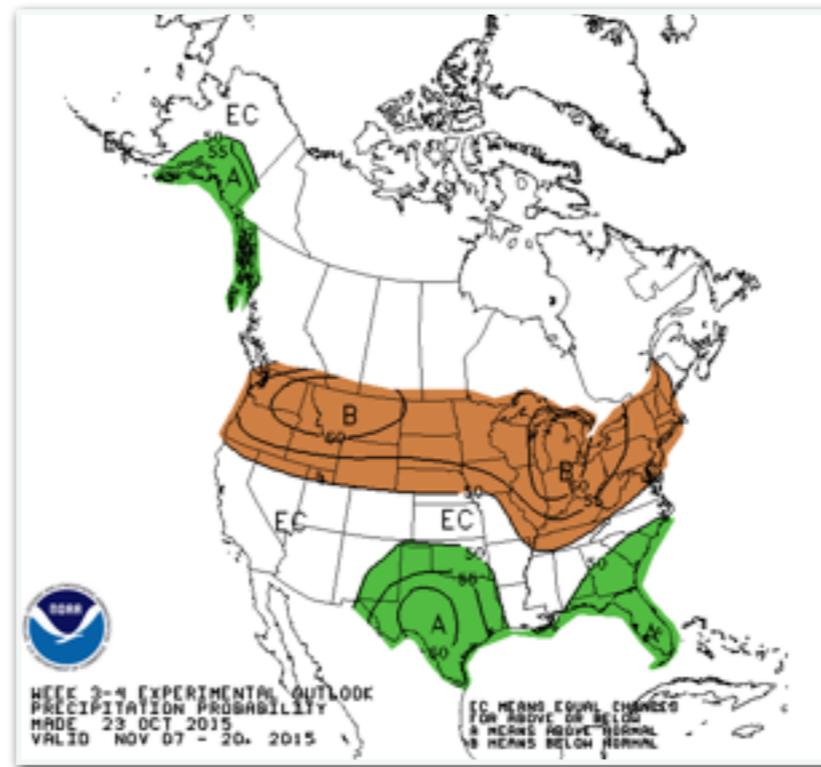
User-relevant formats for  
forecasts on different time  
scales (weather-S2S-seasonal)

# Forecast Formats

## Daily weather Fcst

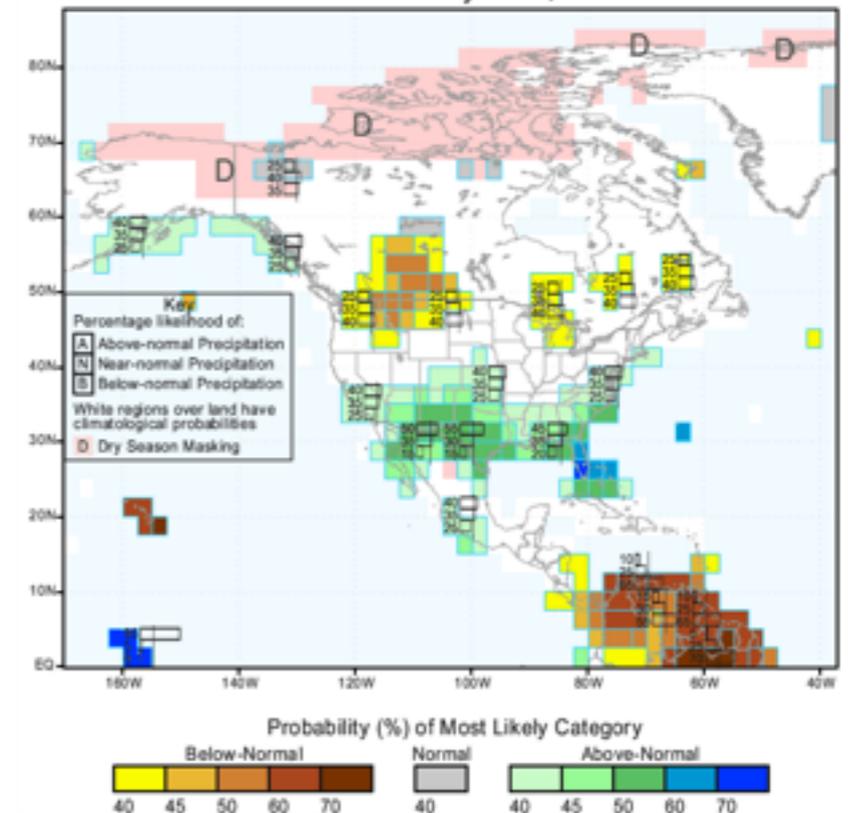


## Week 3-4 Outlook

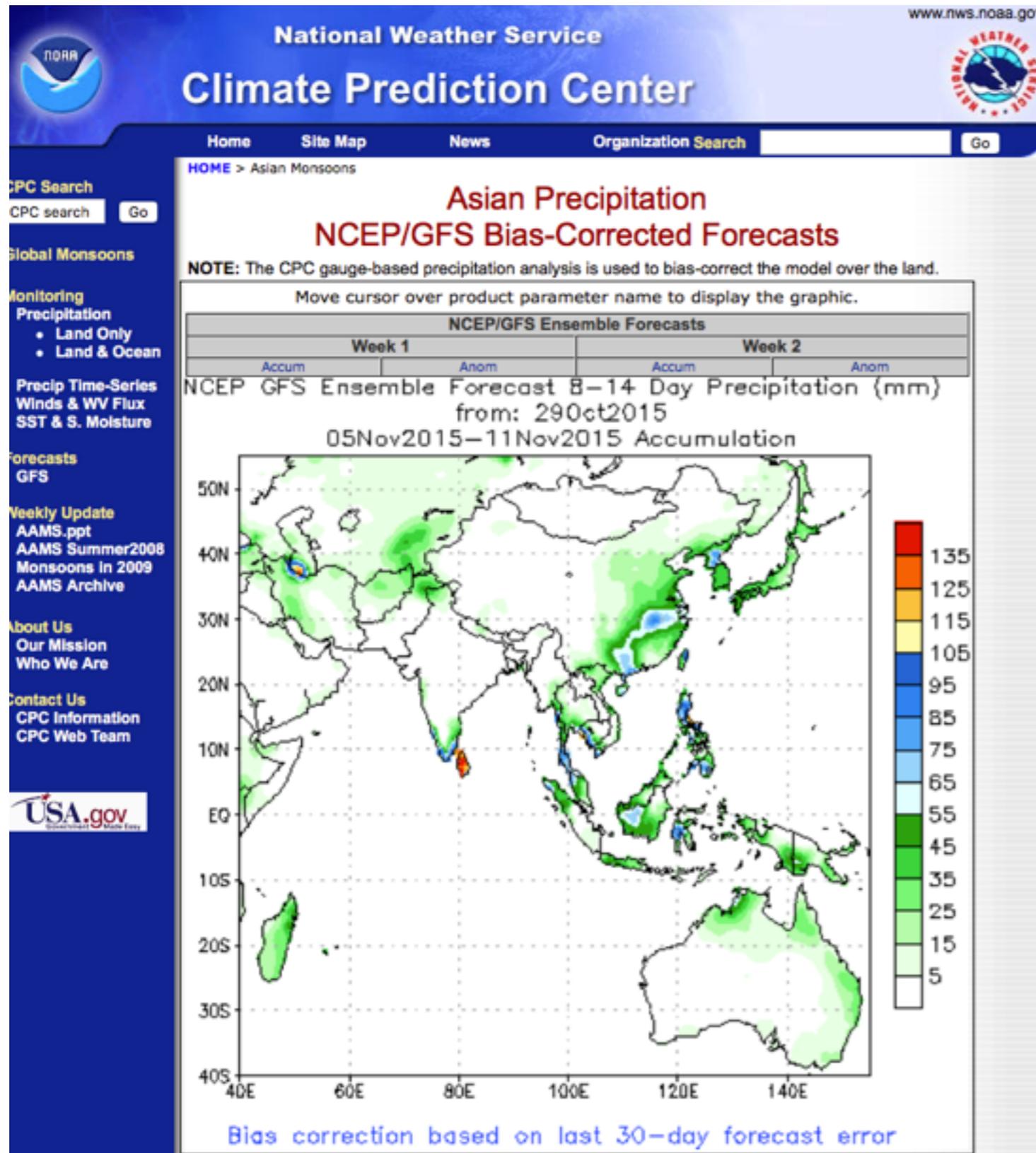


## Seasonal Fcst

IRI Multi-Model Probability Forecast for Precipitation for November-December-January 2016, Issued October 2015

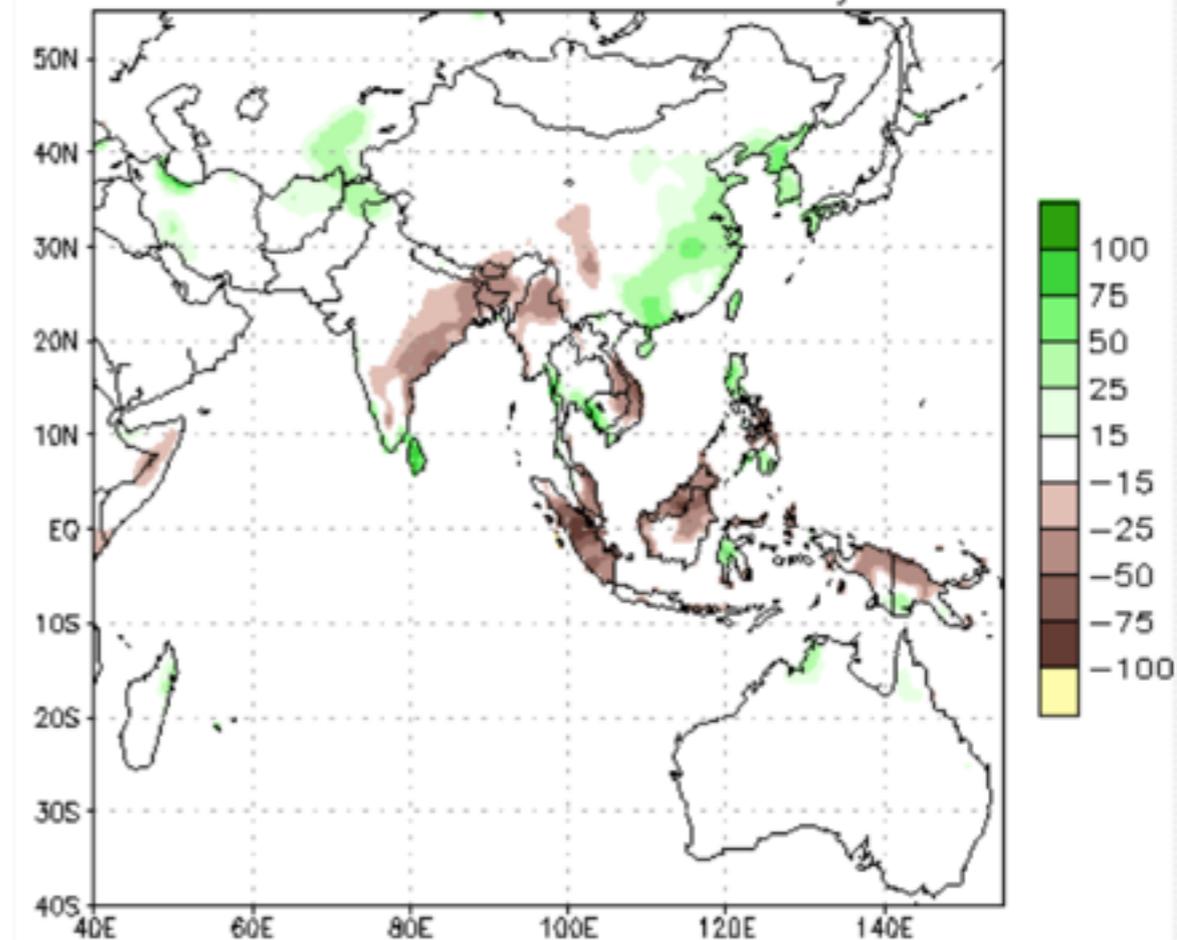


# Weekly Averages: Full Fields vs Anomalies



## Anomaly

NCEP GFS Ensemble Forecast 8-14 Day Precipitation (mm)  
from: 29Oct2015  
05Nov2015-11Nov2015 Anomaly



# Conclusions

- Need to consider S2S forecasts from perspective of user communities
  - Hazard early warning - enhancing preparedness to high-impact weather events
  - Management decisions in weather-sensitive operations [Crop management (e.g. fertilizer application, Reservoir system management, Climate sensitive diseases (e.g. malaria, flu), Energy generation/distribution (supply and demand mgmt), Transportation]
  - Large range of users from sophisticated to developing country
- Key attributes of Salience, Understandability, Legitimacy
  - Tailored products
  - Access by and from NMHSs
  - Proper verification

# Key user needs

- Access to forecast products by and from legitimate sources
- Ability to develop tailored products that are salient and understandable
  - Full forecast PDF
  - Long reforecast sets
  - Participatory research
  - Training



# Key Questions for S2S Applications

- **What are the key societal decisions** (low-hanging fruit) in agriculture food security, water management, public health, and DRR (i.e. the GFCS Priority areas) in monsoonal climates where sub-seasonal forecasts may have the most value?
- **What are the user requirements** for S2S monsoon forecasts to be useful to different these application communities? Are there specific needs for applications in terms of reforecasts, downscaling, and forecast verification?
- **How convenient is the S2S data portal** for applications community use? Which derived products would be most useful for applications?
- **What are important entry points** for connecting S2S forecast producers with users (e.g. governmental and non-governmental organizations that serve as intermediaries)?