# Connecting Prediction Information and Products to Applications

Lisa Goddard

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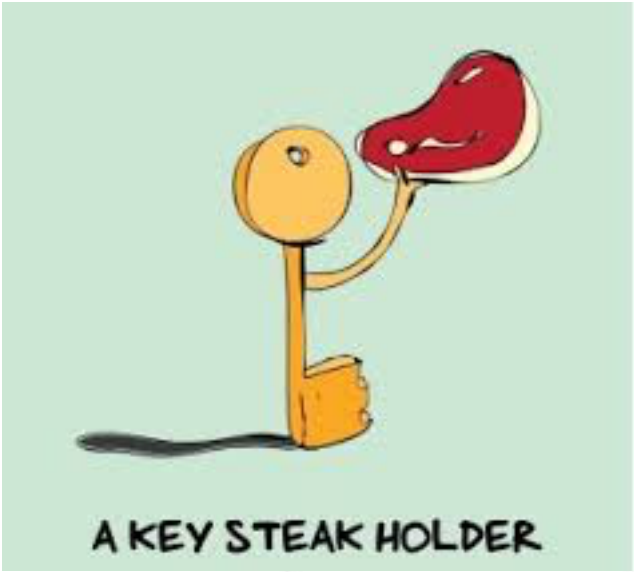
for Climate and Society
EARTH INSTITUTE | COLUMBIA UNIVERSITY

Thanks to Nachiketa Acharya, Angel Munoz, Andy Robertson, and Nicolas Vigaud

# Not all steakholders are the same

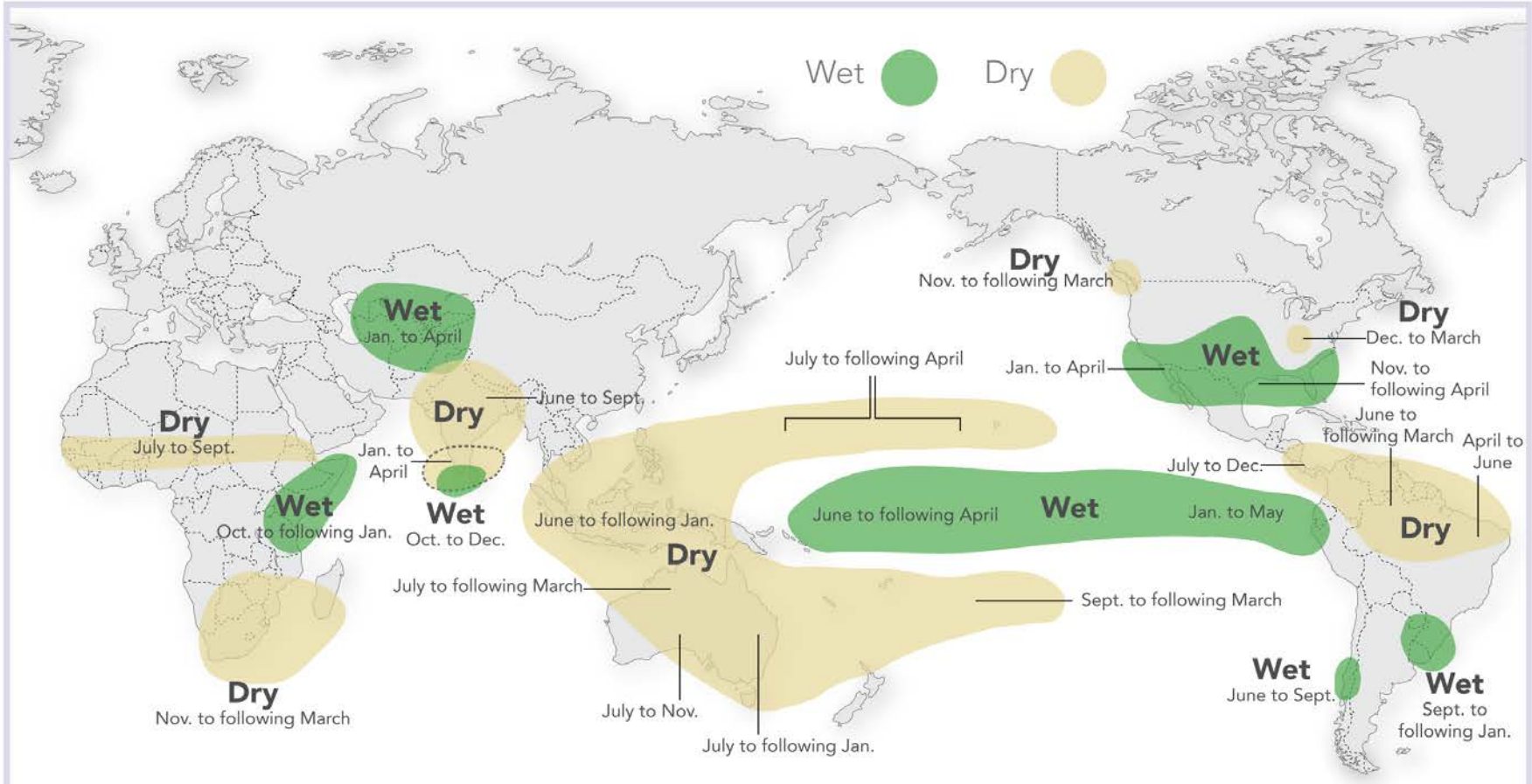



(Courtesy of Jim Buizer, UA)

# "Expected" Climate Impacts During El Niño

## El Niño and Rainfall

El Niño conditions in the tropical Pacific are known to shift rainfall patterns in many different parts of the world. Although they vary somewhat from one El Niño to the next, the strongest shifts remain fairly consistent in the regions and seasons shown on the map below.




For more information on El Niño and La Niña, go to: http://iri.columbia.edu/enso

http://iri.columbia.edu/ENSO/


Sources:
1. Ropelewski, C. F., and M. S. Halpert, 1987: Global and regional scale precipitation patterns associated with the El Nino Southern Oscillation. Mon. Wea. Rev., 115, 1606-1626;
2. Mason and Goddard, 2001. Probabilistic precipitation anomalies associated with ENSO. Bull. Am. Meteorol. Soc. 82, 619-638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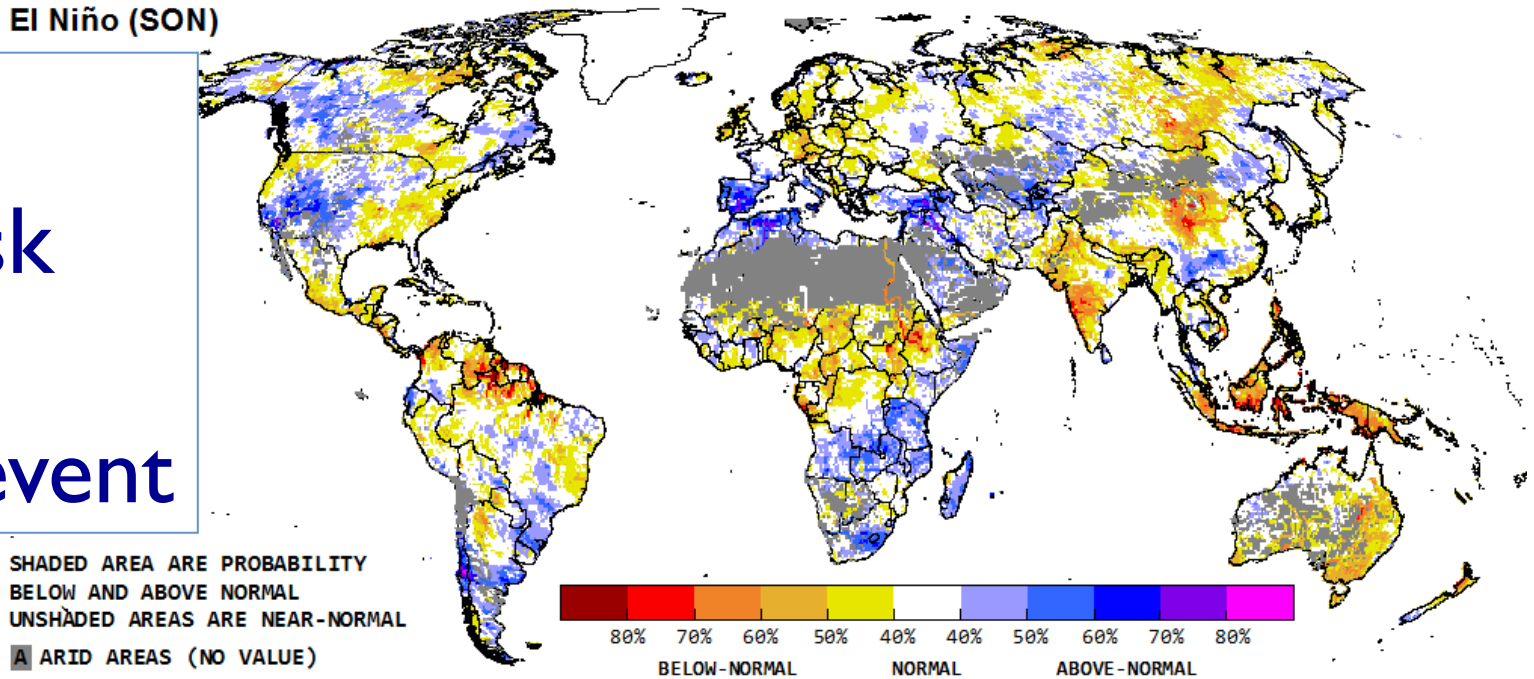
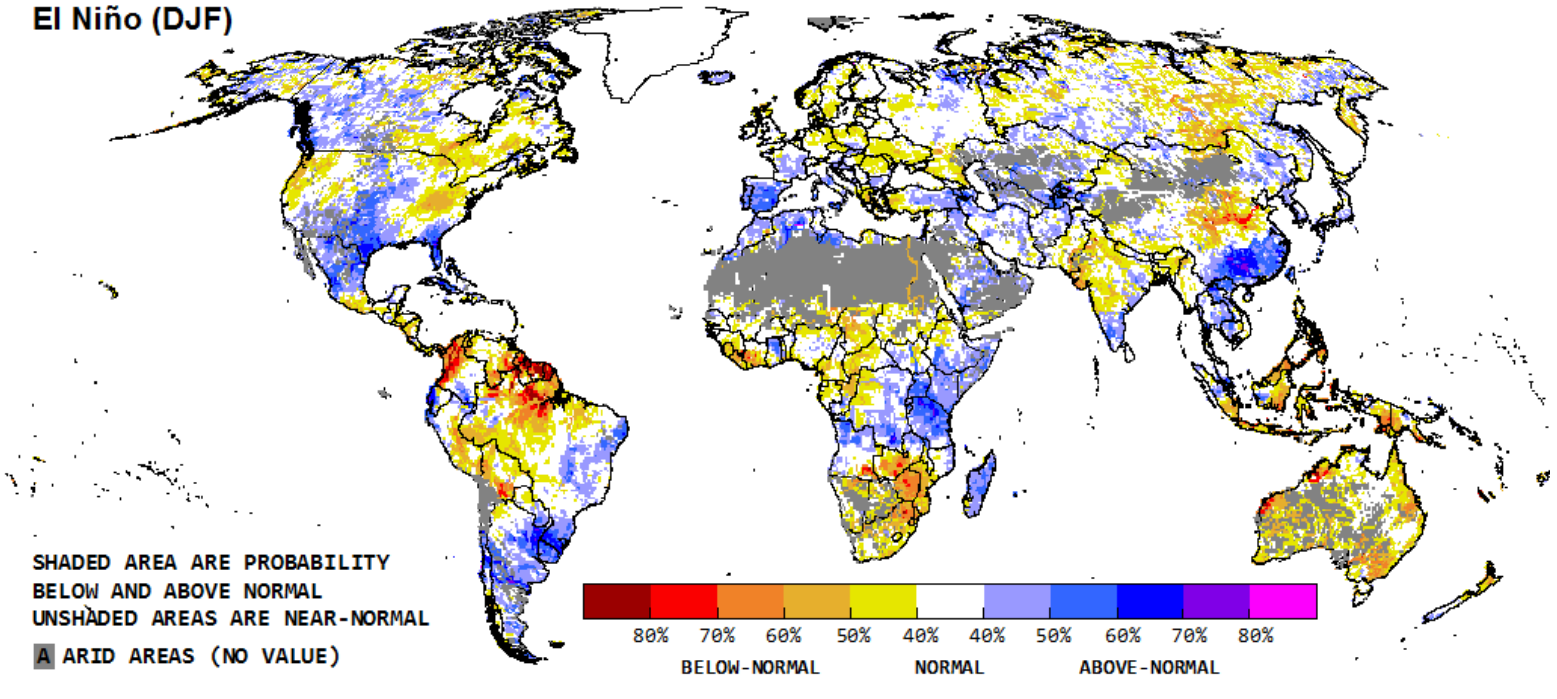
# Expected Flood Risk during an El Niño event



# FAO: Early Warning – Early Action

## SOMALIA EXAMPLE: RESULTS

### Situation Analysis

- El Niño 2015: Risk of floods affecting more than 90 000 people and 9100 ha of farmland along the Shebelle and Juba Rivers.

### Example FAO Actions:

- strengthen riverbanks
- build flood barriers

### Return on Investment

- Investment: 1.7m USD
- approx. 6.7m USD in maize production saved, 4 x the investment

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World Health Organization

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## Humanitarian Health Action

- Humanitarian Health Action
- Crises
- Technical guidelines
- Key policy documents
- Donor centre
- Global network
- Global Health Cluster

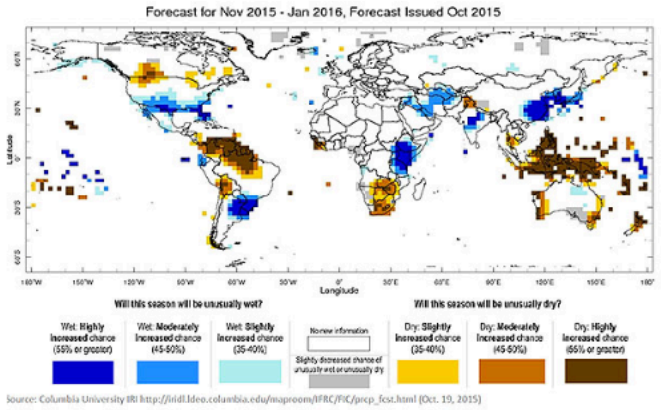
# Health preparedness for El Nino event 2015 - 2016

### Global Situation Assessment of El Niño-related Health Risks

WMO has confirmed reports that a mature and strong El Niño is present in the tropical Pacific Ocean. International climate models suggest that the 2015/2016 El Niño will strengthen further before the end of 2015 and become one of the strongest El Niño events in the past twenty years.

The El Niño phenomenon is a major concern to global public health as it has the potential to exacerbate health risks associated with extreme weather in different parts of the world. The last major event of similar magnitude in 1997-1998 resulted in significant health impacts across multiple WHO Regions [WHO Factsheet : El WHO Fact sheet on the El Niño Southern Oscillation (ENSO) and health UPDATE OF NO.192 (2000)], for example:

- in Eastern Africa, extensive flooding led to food insecurity associated with widespread economic losses in agriculture and livestock, as well significant destruction of health infrastructure throughout the region;
- in Djibouti, Kenya, Mozambique, Somalia, Uganda and the United Republic of Tanzania unusually high rainfall triggered major outbreaks of cholera in, as well as unexpectedly large outbreaks of Rift Valley Fever (RVF) in Kenya, Somalia and Tanzania, for example, in Garissa District, Kenya (population 231,022) alone, there were 170 deaths from haemorrhagic fever and an estimated 27,500 infections;
- in Latin America, Peru and central Ecuador experienced rainfall more than 10 times the usual levels, with consequential flooding and extensive landslides that resulted in widespread destruction of homes and infrastructure;
- the Pacific Island region was hit by a drought so severe that 50% of Fiji's population required government water delivery, and the sugarcane harvest was slashed by 50% with widespread economic impacts.

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IGAD Climate Prediction and Applications Centre Monthly Bulletin, May 2015 October 2015

Estado actual de las condiciones del Océano Pacífico Y su posible evolución durante el año 2015-2016.

Rift Valley Fever factsheet

WHO pre-positions emergency supplies in Somalia in preparation for El Niño

World Health Organization Reports
http://www.who.int/hac/crises/el-nino/en/

# EL NIÑO EFFECTS AND HEALTH CONSEQUENCES


**What Ministries of Health and WHO are doing for country and regional preparedness for El Niño**

WHO is acutely aware of the high risk conditions of 2015 and providing support to WHO Member States and partners to enhance preparedness measures for the current El Niño event. The health sector should prepare for the specific risks associated with the El Niño event. This event also provides the opportunity to reinforce all-hazards preparedness of communities and countries, and the readiness of WHO, the Global Health Cluster and other national, regional and global actors for health emergencies.

# EXAMPLES

## Seasonal-to-Interannual (Seas):

1. Philippines (World Food Program): Food Security preparedness
2. Ethiopia: Water resource management & hydro-power

## Sub-Seasonal (SS):

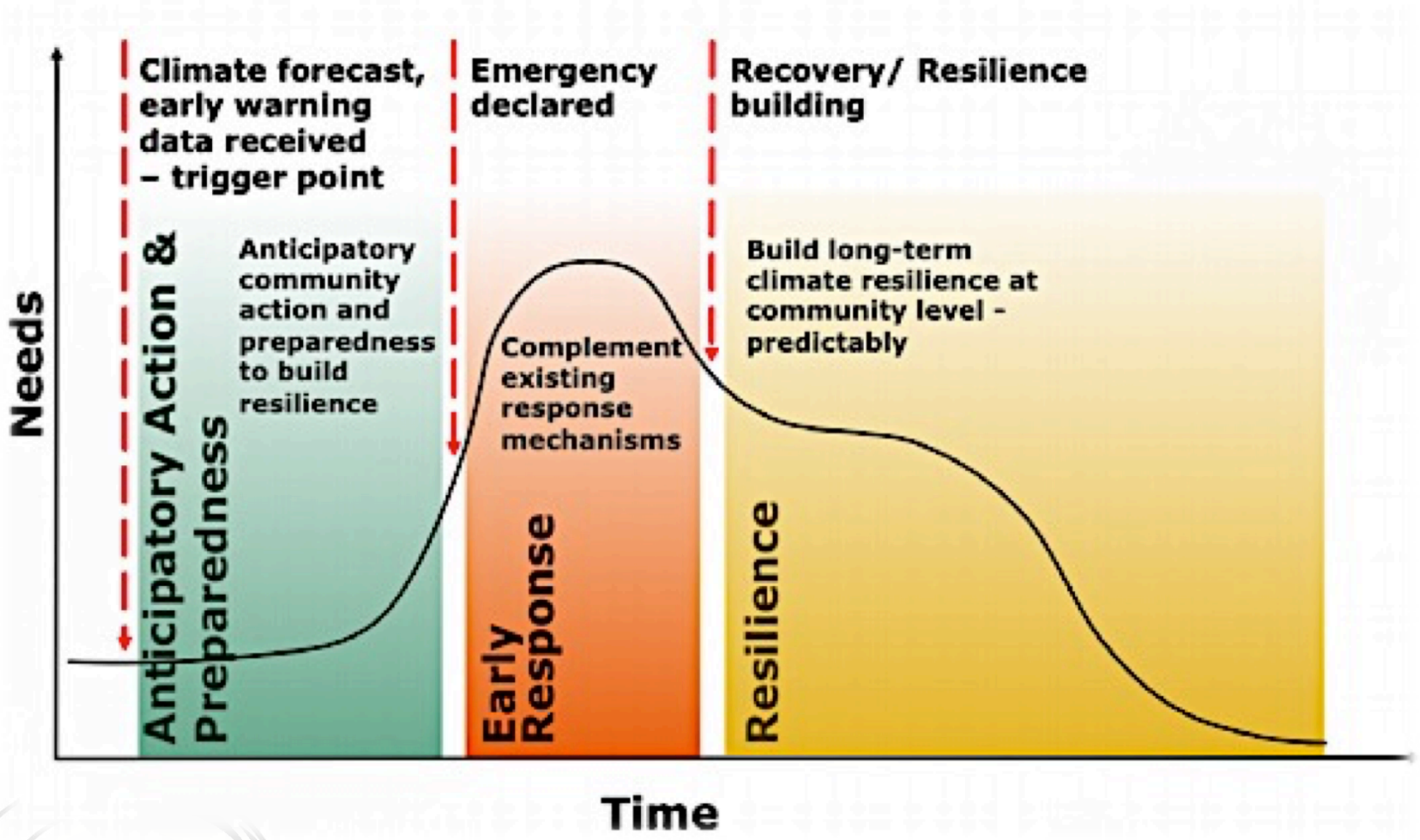
1. Colombia: Water resource management & hydro-power
2. Bihar, India: Agriculture

## Seasonal-to-Decadal (Dec):

1. South Africa (western Cape) Water Mgmt: System resilience

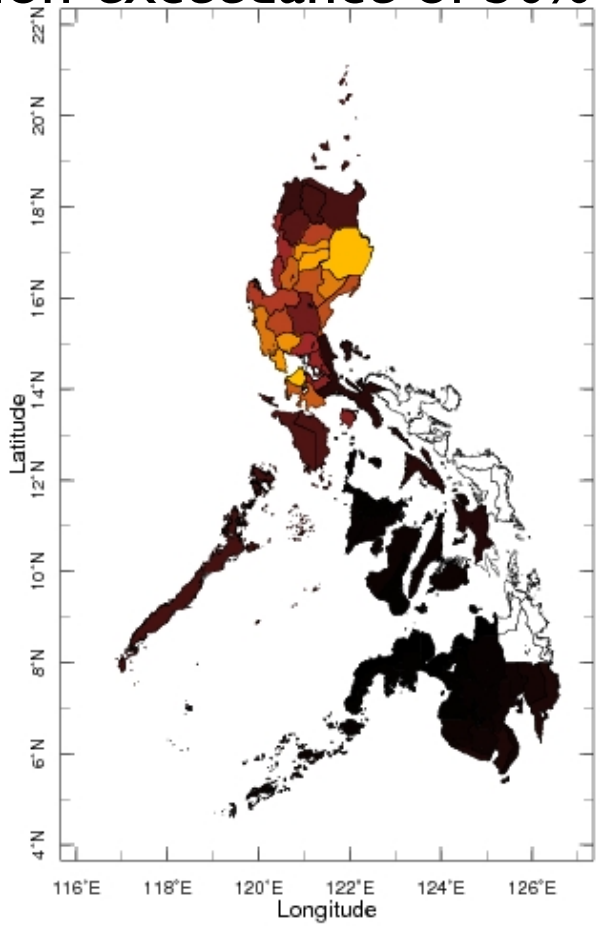
# WFP's Food SECuRE

## Pioneering Example of Forecast-based Financing



# WFP's Food SECuRE – Drought Triggers

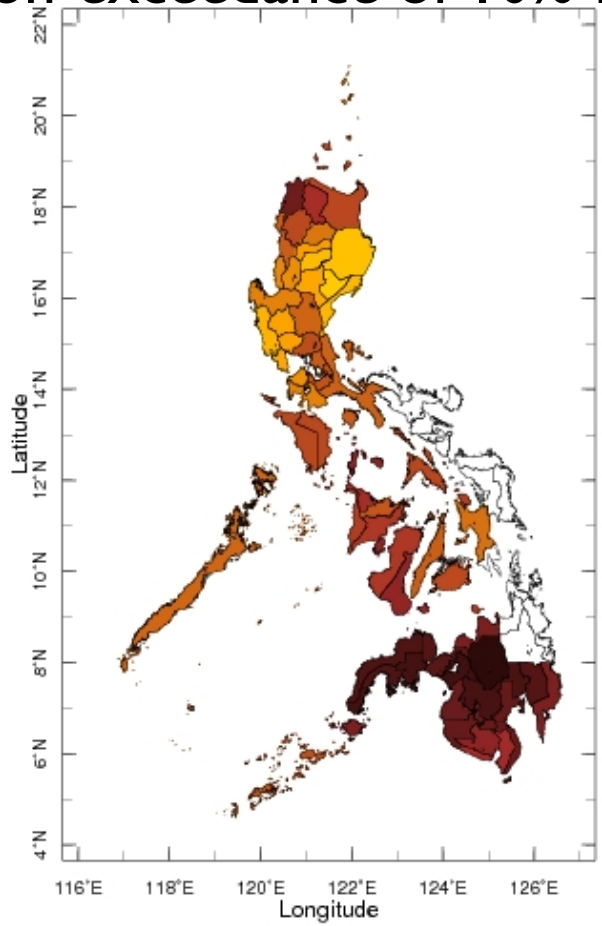
## Non-exceedance of 50%-ile



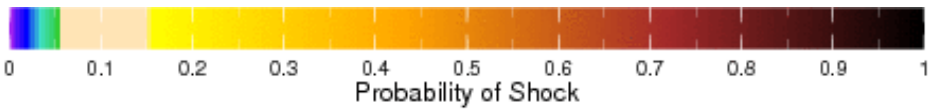

Jan-Apr 2016 Forecast issued September 2015


*Made Sept. 2015*

## Non-exceedance of 10%-ile




Jan-Apr 2016 Forecast issued September 2015



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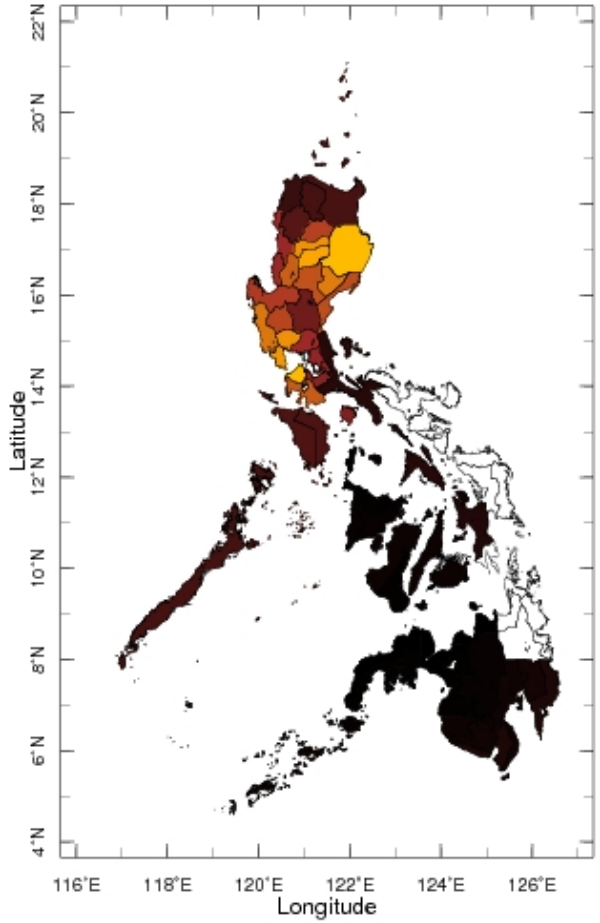
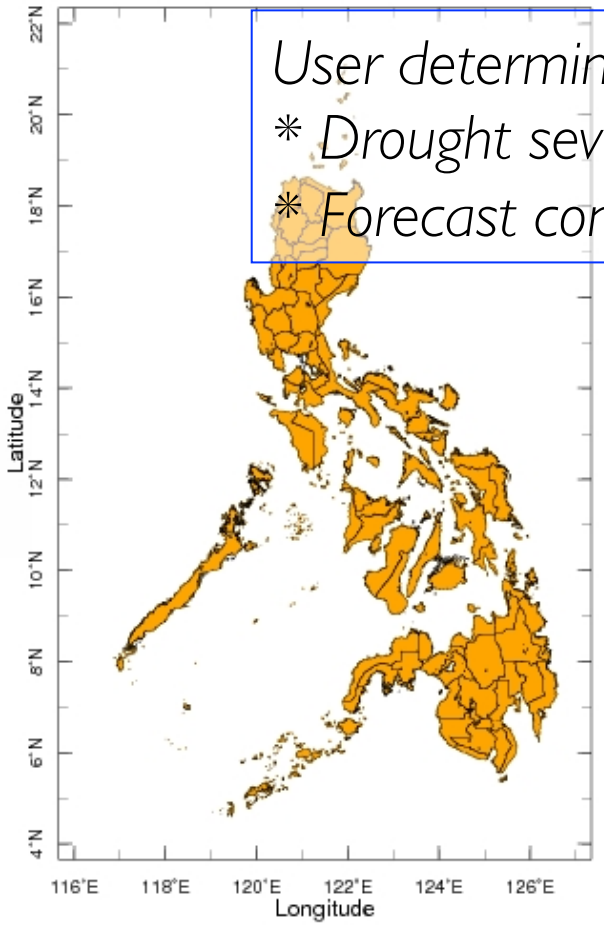



*Made Sept. 2015*

## "ACTIVE TRIGGERS"




*User determines:*
* *Drought severity*
* *Forecast confidence*

Jan-Apr 2016 Forecast issued September 2015





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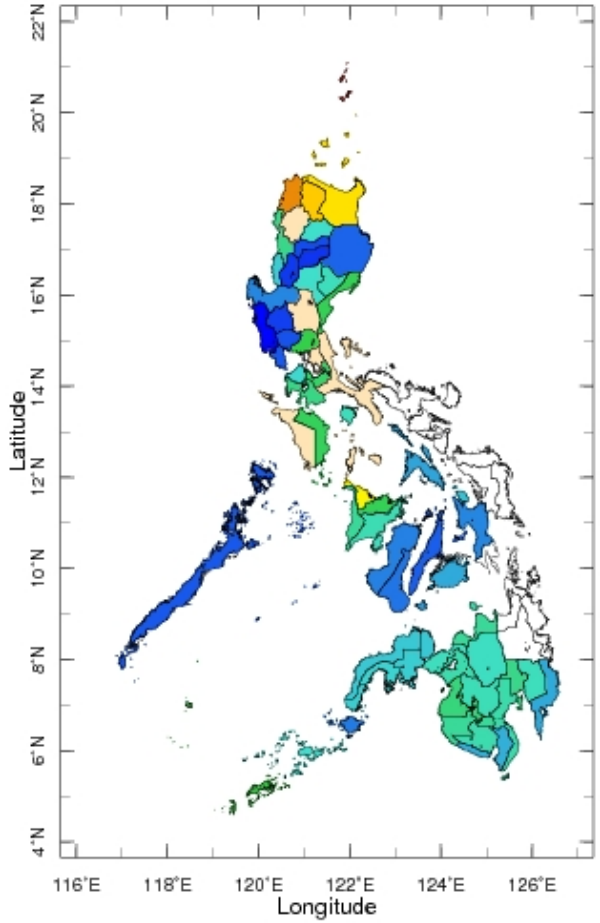
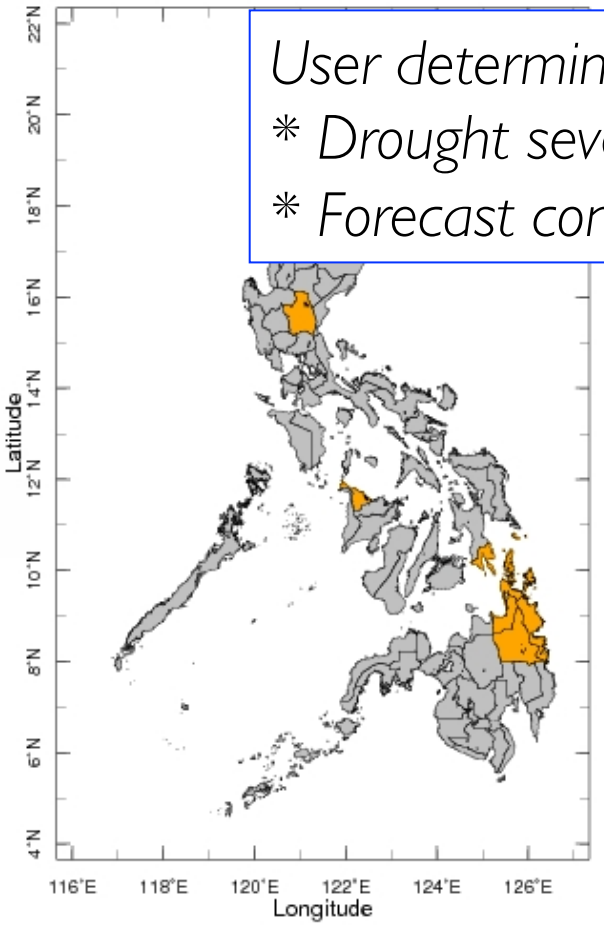
# WFP's Food SECuRE – Drought Triggers

## Non-exceedance of 50%-ile




*Made Sept. 2016*

## "ACTIVE TRIGGERS"



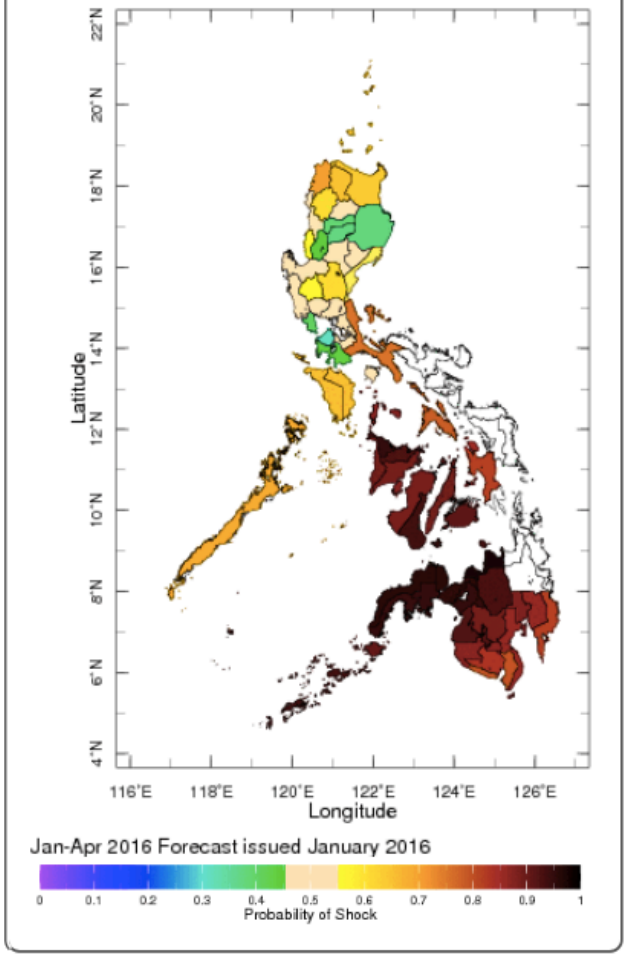

*User determines:*
* *Drought severity*
* *Forecast confidence*

Jan-Apr 2017 Forecast issued September 2016


# WFP's Food SECuRE – District Dashboard

FooDSECuRE Philippines | Trigger Tools: Philippines Drought Shock in Climate Types 1, 2 and 4 | Drought Shock: non-exceeding, Percentile, 50.0 %-ile | Trigger Threshold: 50 % likelihood of shock to occur

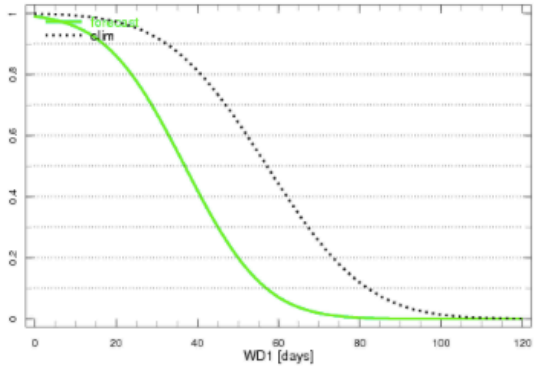
Description | Dataset Documentation | Contact Us




| Target Date | Issue Date |
|---|---|
| Jan-Apr 2016 | Jan 2016 |

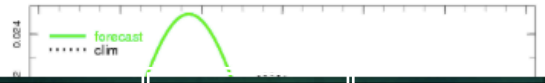
Forecasts for **BOHOL, 7**

**Probability of Exceedance**



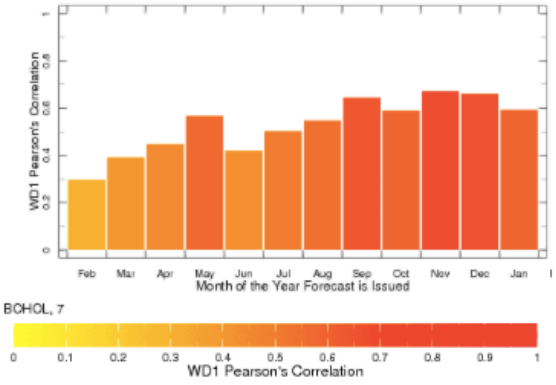

Jan-Apr 2016 Forecast issued January 2016

**Probability Distribution**




Skill and History of Triggers for **BOHOL, 7**

**Skill**




**History of Trigger Forecasts**

For all forecasts

| Targeting | Issued in |
|---|---|
| Jan-Apr | Jan |

Seas-I

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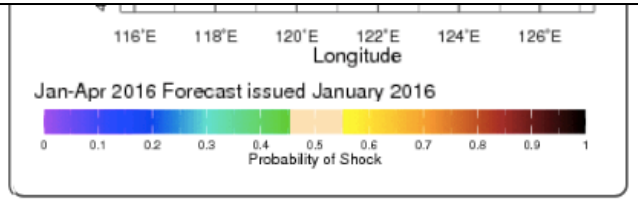
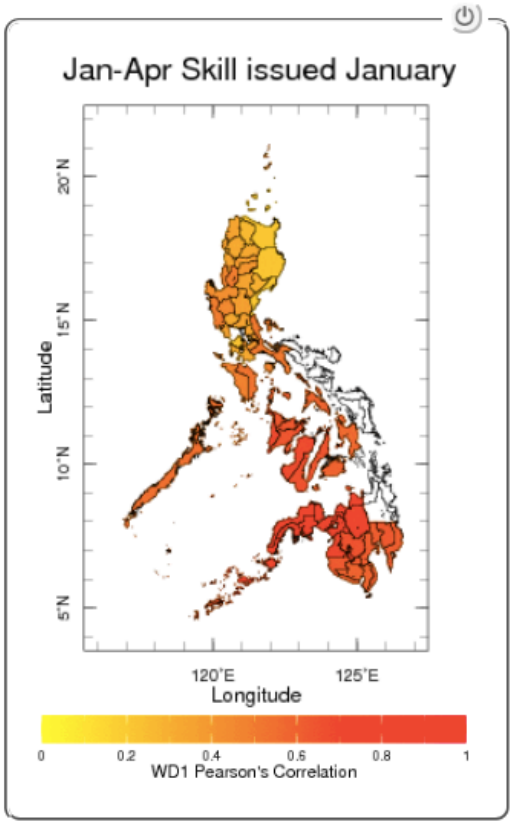
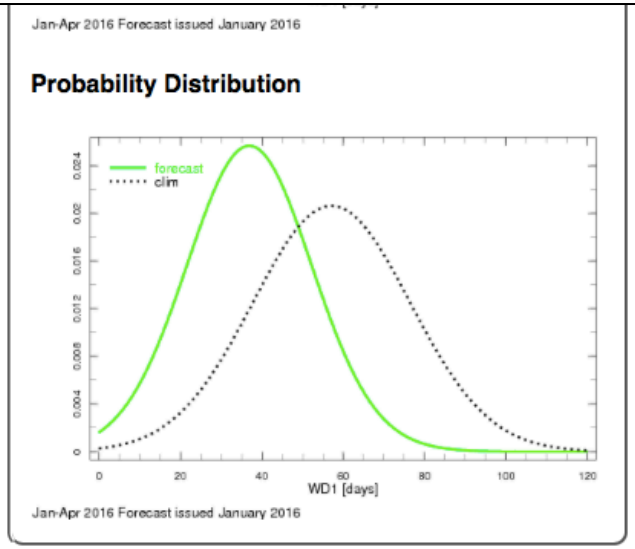
# WFP's Food SECuRE – District Dashboard




**Philippines Drought Shock in Climate Types 1, 2 and 4**

Forecast of droughts in January-April season.

**History of Trigger Forecasts**

| For all forecasts | Targeting | Issued in |
|---|---|---|
| | **Jan-Apr** | **Jan** |
| Worthy-Action | 22.0 | |
| Act-in-Vain | 8.0 | |
| Fail-to-Act | 7.0 | |
| Worthy-Inaction | 20.0 | |

For all forecasts made, by Issue Date:

| | |
|---|---|
| Jan 2007 | Worthy-Action |
| Dec 2006 | Worthy-Action |
| Nov 2006 | Worthy-Action |
| Oct 2006 | Worthy-Action |
| Sep 2006 | Worthy-Action |
| Aug 2006 | Worthy-Action |
| Jul 2006 | Worthy-Action |
| Jun 2006 | Fail-to-Act |
| May 2006 | Worthy-Action |
| Apr 2006 | Worthy-Action |
| Mar 2006 | Fail-to-Act |
| Feb 2006 | Worthy-Action |
| Jan 2006 | Worthy-Inaction |
| Dec 2005 | Worthy-Inaction |
| Nov 2005 | Worthy-Inaction |
| Oct 2005 | Worthy-Inaction |
| Sep 2005 | Act-in-Vain |
| Aug 2005 | Act-in-Vain |
| Jul 2005 | Act-in-Vain |
| Jun 2005 | Act-in-Vain |



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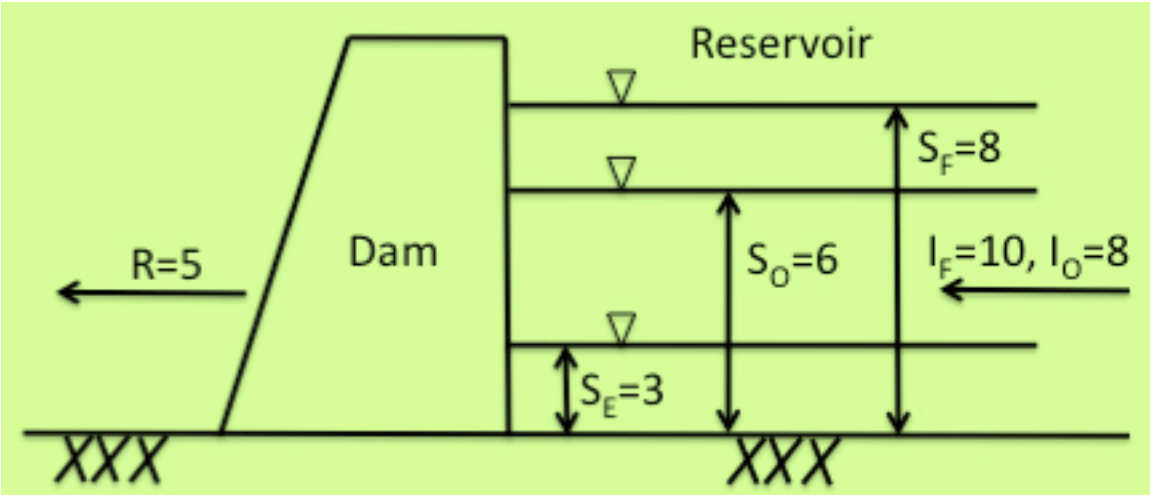
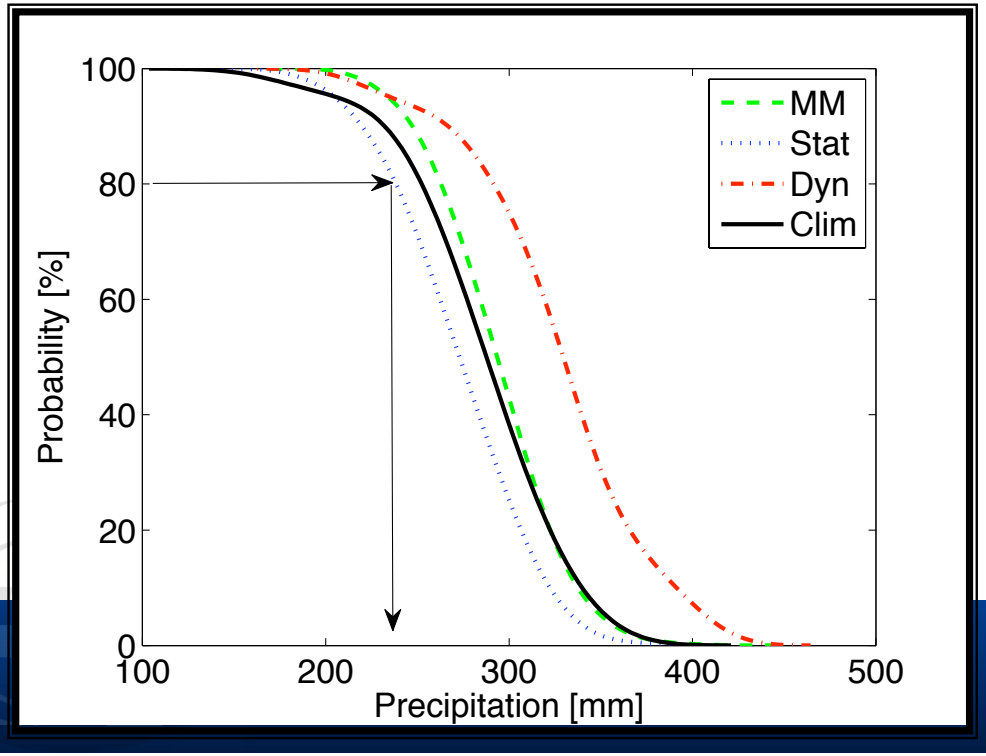
# ETHIOPIA – Water resource management & hydro-power

# Reservoir Management: Linked Model System

Monthly reservoir update based on forecast and observations




Select precipitation exceedance probability, apply to prediction ensemble

(Block and Goddard, 2012, WRR)

# Hydropower Benefits w/ different forecasts

## Using probabilities of exceedance; threshold reliability = 200 GW hrs/mo

| Forecast Technique | Mean Benefits [$M/dec] | Mean Losses [$M/dec (*f*)] | Dependability [%] | Superior Benefit Cases Decadal [%] | Annual [%] |
|---|---|---|---|---|---|
| Perfect Forecast | 3350 | - | 100% | | |
| *prob = 80%* | | | | | |
| Statistical | 2740 | 25 (10%) | 100% | 18 | 23 |
| Dynamical | 2610 | 100 (66%) | 100% | 0 | 15 |
| Multi-model | 2780 | 5 (2%) | 100% | 82 | 35 |
| No Forecast | 2610 | - | >99% | 0 | 27 |
| *prob = 95%* | | | | | |
| Statistical | 2500 | 35 (23%) | 100% | 8 | 20 |
| Dynamical | 2200 | 237 (100%) | 100% | 0 | 0 |
| Multi-model | 2550 | 48 (5%) | 100% | 88 | 44 |
| No Forecast | 2440 | - | 100% | 4 | 36 |

For prob=50%: benefits and reliability drop



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# Hydropower Benefits w/ different forecasts

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| Forecast Technique | Mean Benefits [$M/dec] | Mean Losses [$M/dec (*f*)] | Dependability [%] | Superior Benefit Cases Decadal [%] | Annual [%] |
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For prob=50%: benefits and reliability drop



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# Sub-Seasonal: weeks 1-4

# COLOMBIA – Rainfall forecasts for hydro-power



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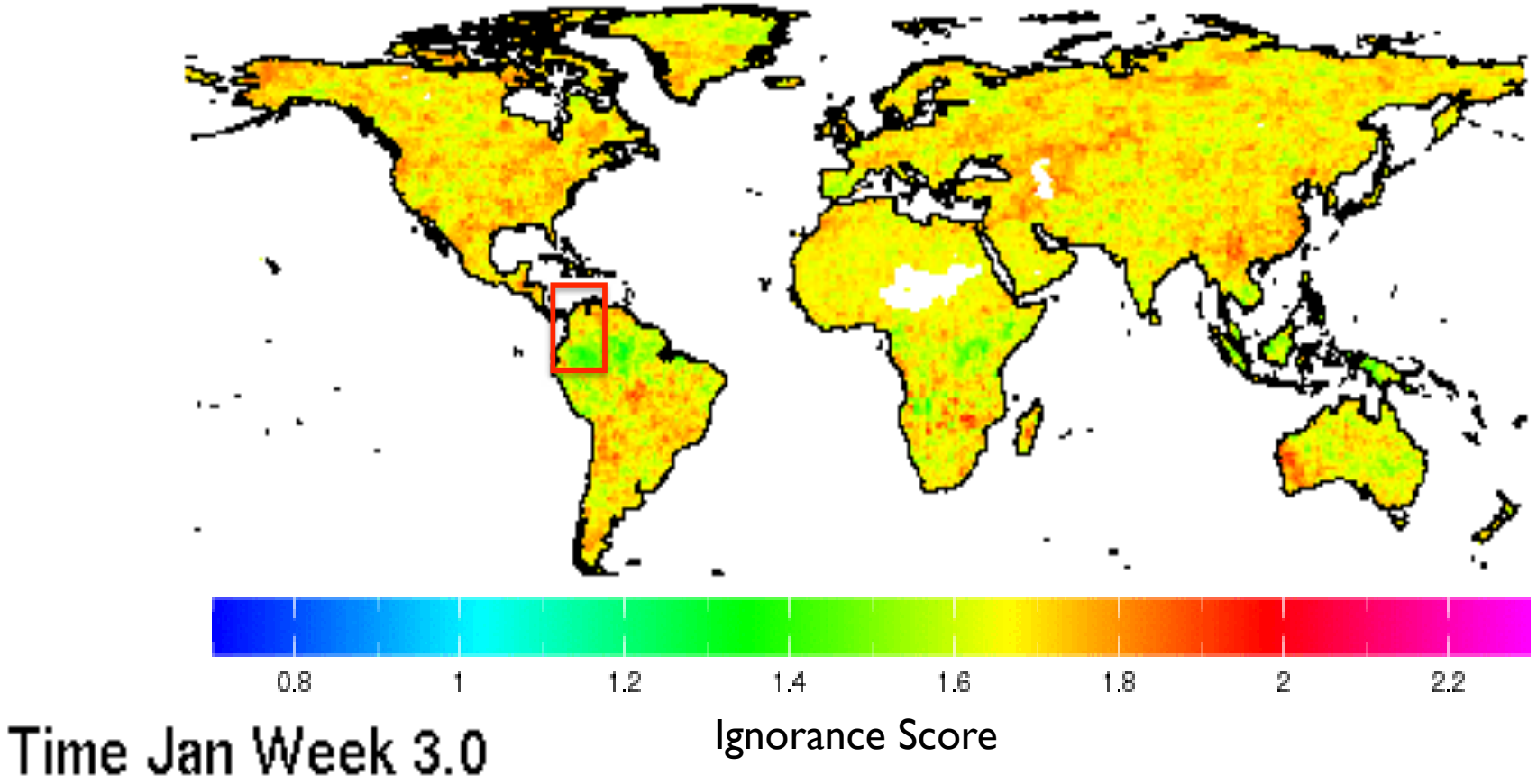
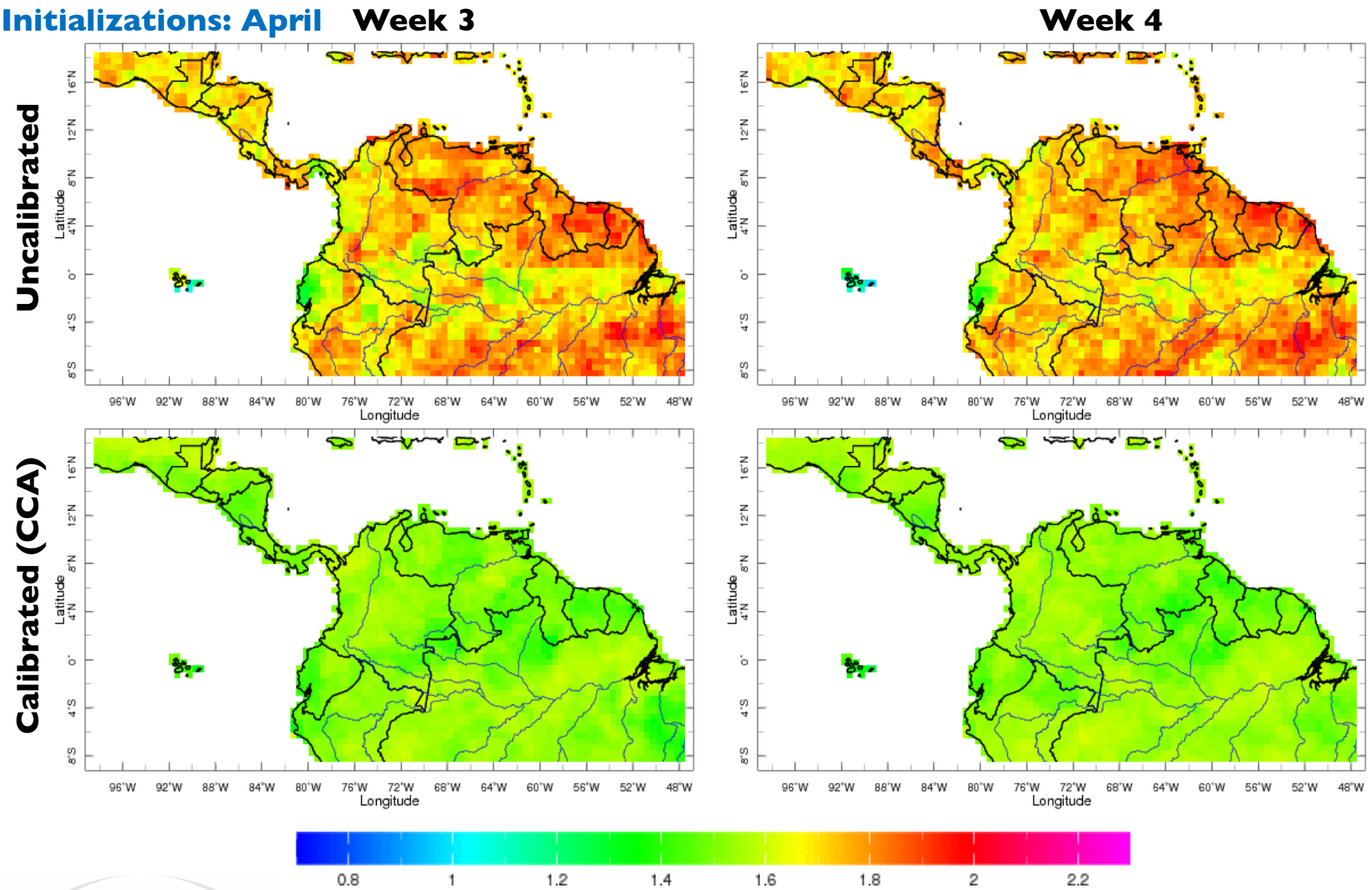
# Seasonality of Sub-seasonal Skill




**S2S, A3:** *Ángel Muñoz:* "How Much Can M.O.S. Improve Sub-seasonal Prediction Skill"

## Initializations: April




Muñoz et al (in prep)



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# Proto-type Forecast Map Room: *in Spanish*

Cuarto de Mapas: Sub-Estacional

Contexto Histórico: ¿Cuál es el comportamiento típico de las variables climáticas?

Región

Semana 1
Semana 2
Semana 3
✓ Semana 4
Semana 5
Semana 6

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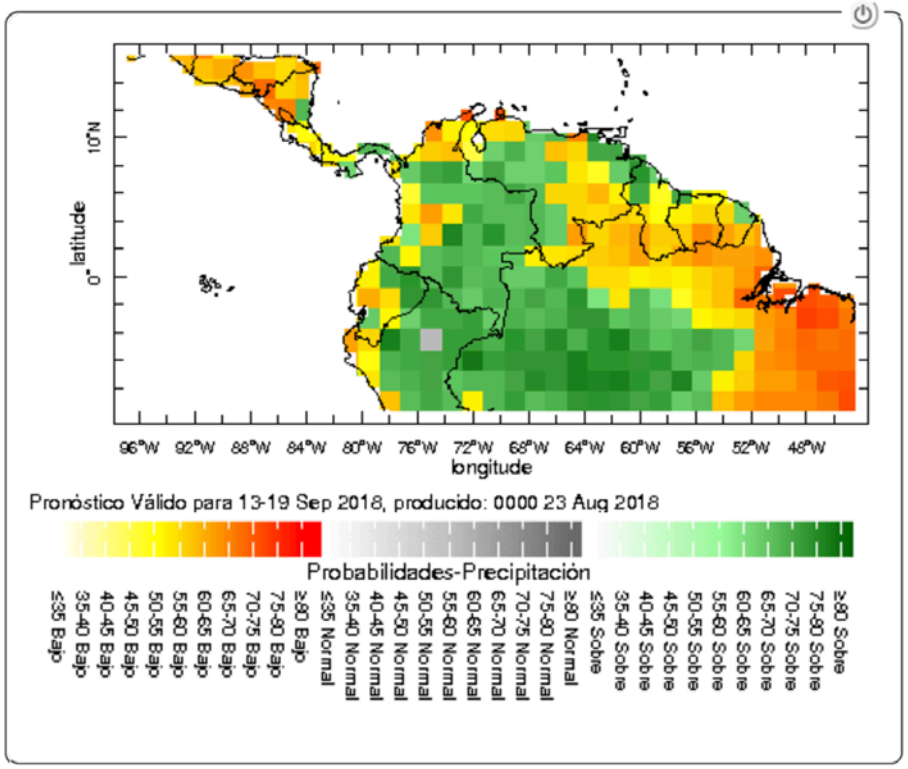
## Pronóstico Probabilístico Sub-Estacional

Este mapa muestra las probabilidades de cantidad de lluvia, asociadas a cada categoría (bajo la normal, normal, sobre la normal), para un período semanal, desde la semana 1 a la semana 6 a partir de la fecha de prodcucción del modelo.

Las fechas de validez del producto experimental se muestran en la parte inferior de la figura, así como la fecha en que fué producido. La Coordinación del Proyecto Internacional de Pronósticos Subestacionalesi ha provisto al Observatorio Latinoamericano estos pronósticos experimentales para permitir a sus usuarios verificar su confiablidad. Varios investigadores están realizando en este momento estudios formales para verificar este producto. Manéjese como experimental y no como un producto final.

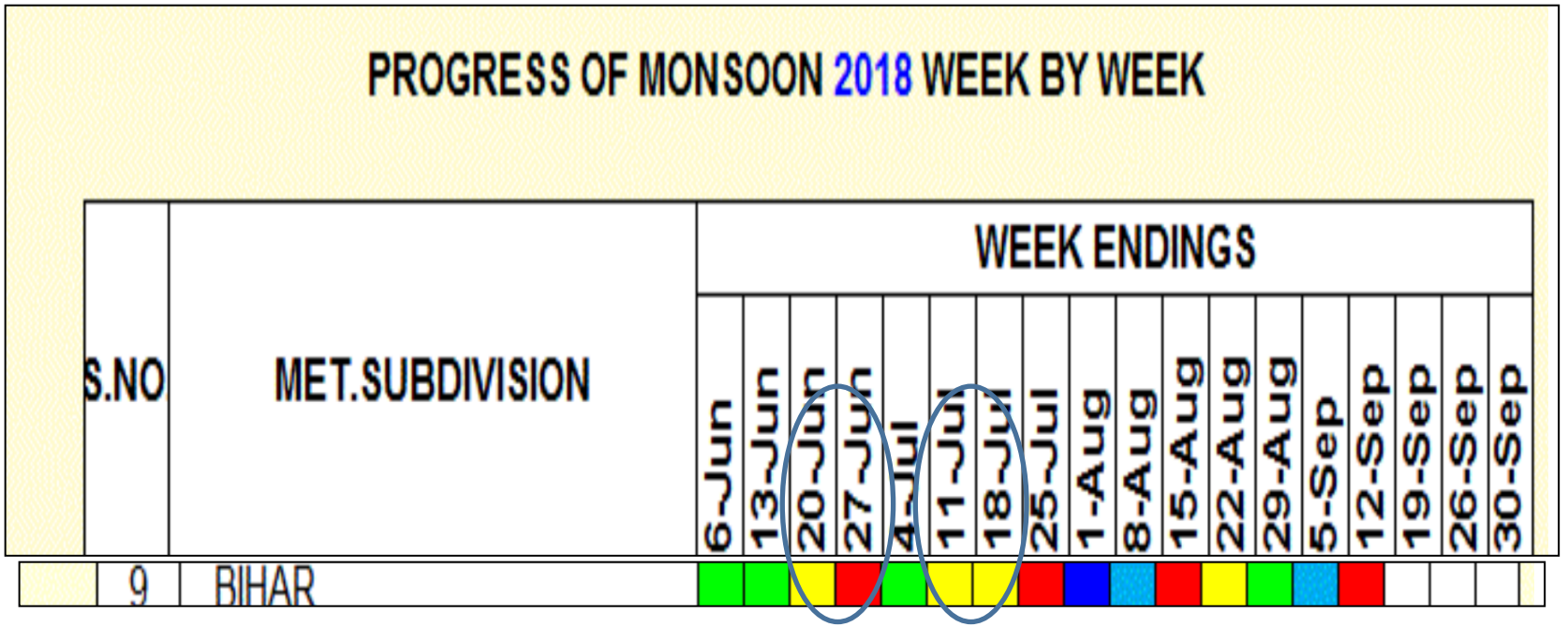
Los distintos colores indican las señales o categorías de la variable en cuestión: sobre la normal (verde), normal (gris) y bajo la normal (rojo). La intensidad de cada color indica las probabilidades (y no cantidad o magnitud), que deben interpretarse como una medida de qué tan seguros estamos de que lo mostrado es lo que va a ocurrir. Regiones en blanco corresponden a regiones en las que no hay una señal clara, no hay datos o los modelos no pasaron las pruebas de control de calidad, y por ende es preferible no dar información. Los rangos de probabilidades se listan debajo de los mapas.

Las probabilidades deben siempre compararse con las asociadas a un pronóstico por adivinación (esto es, uno dado al azar): 33%. Valores superiores a 35% se consideran acá distintos a este umbral de 33% o umbral "climatológico". Valores inferiores a 33% implican que adivinar el pronóstico es mejor que el resultado del modelo. Valores superiores a 70-80% son extremadamente raros, e indican altas certezas.



# Bihar, INDIA – Rainfall forecasts for agriculture

# Observed progress of monsoon, Bihar




Source: http://www.imd.gov.in

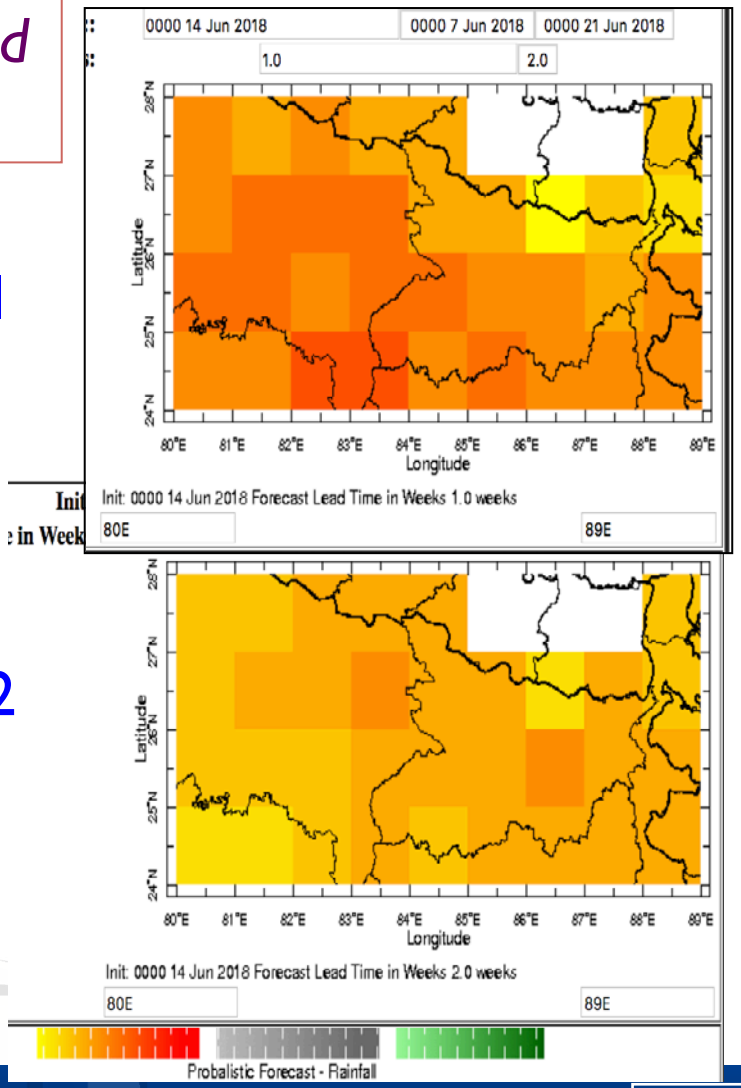
# Forecast progress of monsoon, Bihar

## Forecast issued on June 14th

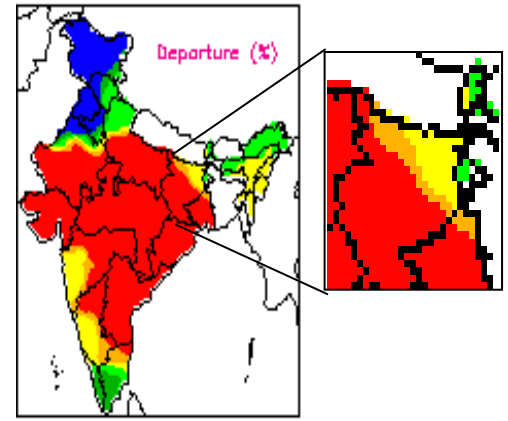
*Calibrated NMME*

Week 1

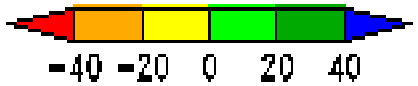
Week 2

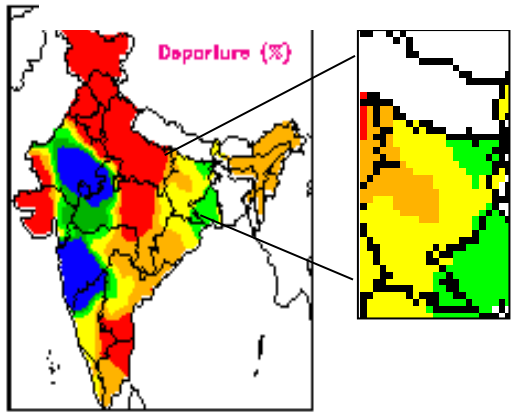



## Observed weekly rainfall




Week ending June 20




Week ending June 27

Source:http://mol.tropmet.res.in

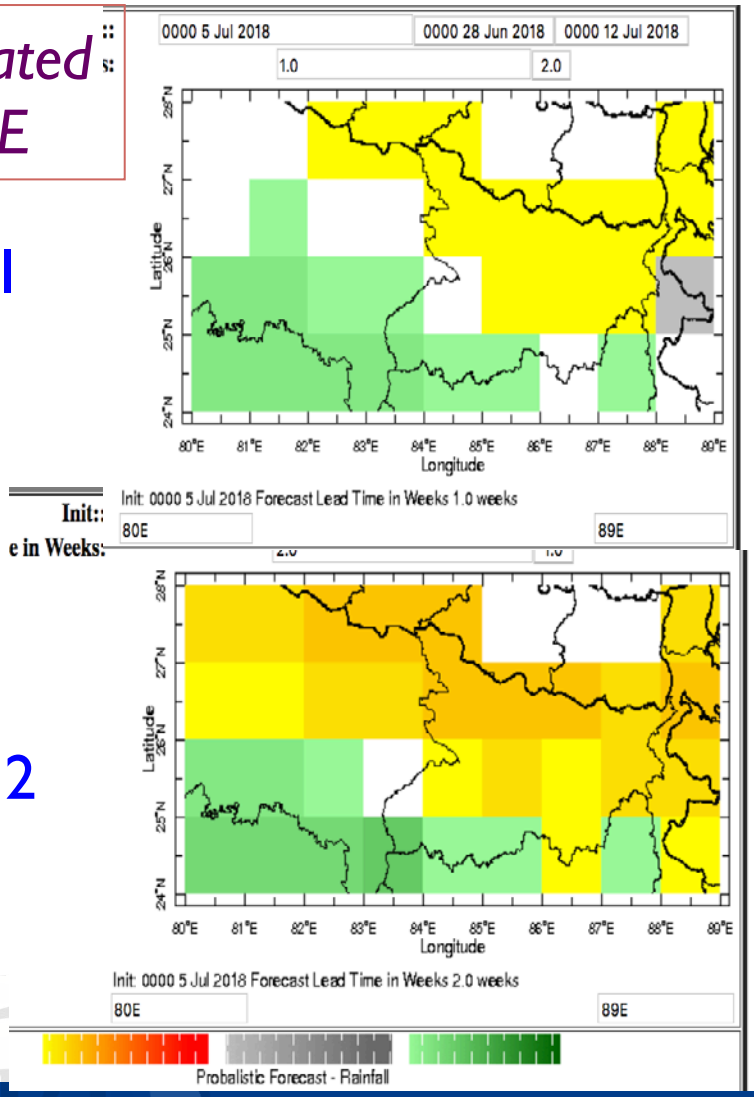
# Forecast progress of monsoon, Bihar

## Forecast issued on July 5th

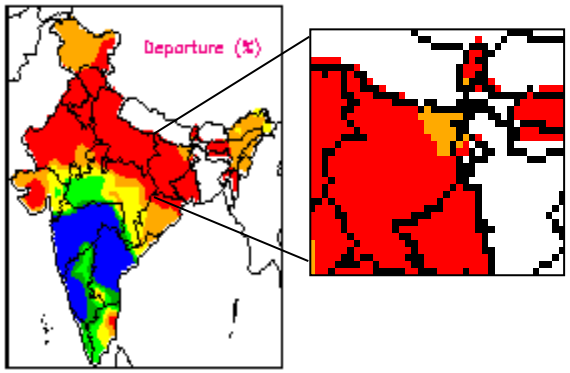
*Calibrated NMME*

Week 1

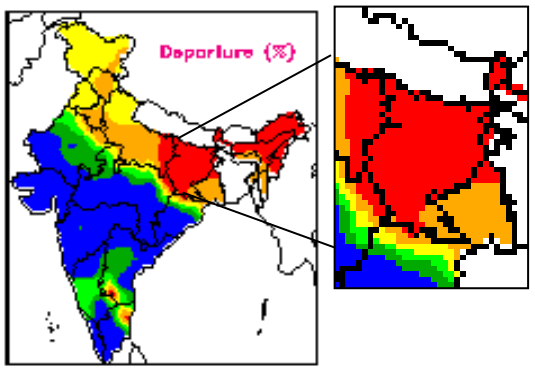
Week 2




## Observed weekly rainfall




Week ending July 11


Week ending July 18

Source:http://mol.tropmet.res.in

# Translation of forecasts into local language

## Example: July 6, 2018

For East Champapran and Darbhanga by SAU-Pusha

डा० राजेन्द्र प्रसाद केन्द्रीय कृषि विश्वविद्यालय
पूसा,समस्तीपुर (बिहार)

सब-सीजनल मौसम पूर्वानुमान
(IRAP-IMD-RPCAU Collaborative Effort)

दरभंगा एवं पूर्वी चम्पारण जिलों के लिए

उप-मौसमीय (सब-सीजनल) पूर्वानुमान

*सप्ताह संख्या-१ (६-१२ जुलाई)* में थोड़ा अधिक संभावना के साथ (३३ प्रतिशत की तुलना में ४० प्रतिशत) सामान्य से कम वर्षा हो सकती है।

*सप्ताह संख्या-२ (१३-१६ जुलाई)* में भी थोड़ा अधिक संभावना के साथ (३३ प्रतिशत की तुलना में ४० प्रतिशत) सामान्य से कम वर्षा हो सकती है।

(ए. सत्तार)
नोडल पदाधिकारी, कृषि मौसम
आर०पी०सी०ए०यू०, पूसा, समस्तीपुर

For Nawada and Jehanabad District, prepared by SAU-Sabour

बिहार कृषि विश्वविद्यालय, सबौर, भागलपुर

सीजनल मौसम पूर्वानुमान
(IRAP-IMD- BAU Collaborative Effort)
नवादा एवं जहानाबाद जिलों के लिए

मौसमीय (सीजनल) पूर्वानुमान

12 जूलाई से 30 सितम्बर 2018 तक (बचे हुए मॉनसून सीजन में ) थोड़ा अधिक संभावना के साथ ( 33 प्रतिशत की तुलना में 40 प्रतिशत ) सामान्य से अधिक वर्षा होने की संभावना है।

(बीरेन्द्र कुमार)
नोडल पदाधिकारी,
कृषि मौसम सेवा
बिहार कृषि विश्वविद्यालय, सबौर, भागलपुर

**S2S, A1:** "Sub-seasonal prediction of the Indian monsoon: Case study over Bihar", A. Robertson
**S2D,B3:** "Evaluating a new calibration method for Seasonal Probabilistic Prediction for Indian Summer Monsoon"- Nachiketa Acharya

# Seasonal-to-Decadal: 2-20 yrs out

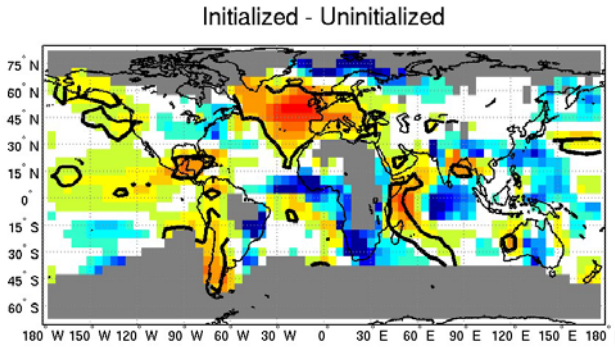
# Decadal Predictions: Temperature

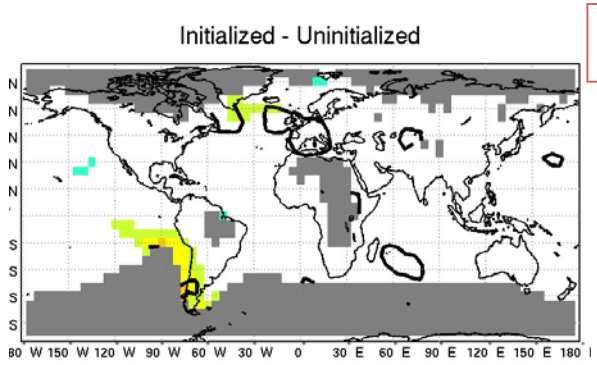
## Multi-model Ensemble (12 models: Equal Weighting ) – Decadal Average

Mean Error Skill Score

Correlation

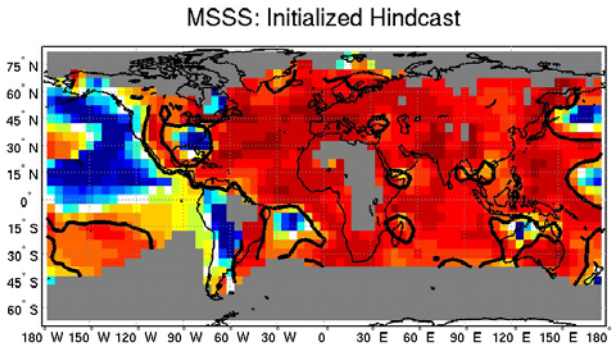
*DIFFERENCE*

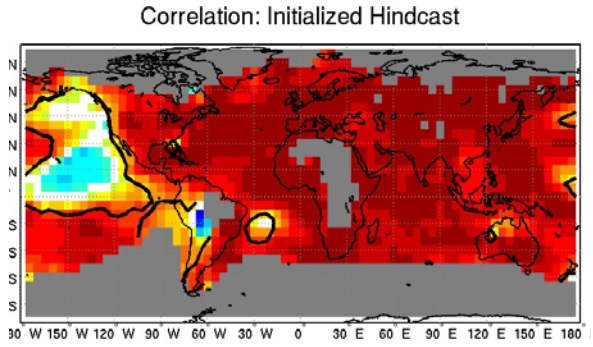



*DIFFERENCE*

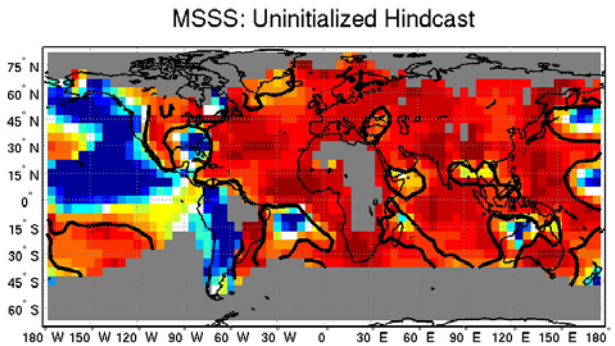
Decadal Prediction

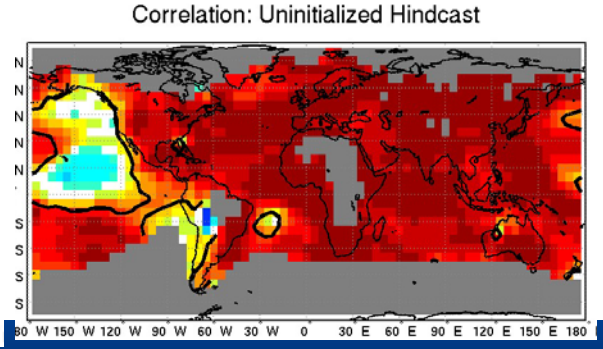



Decadal Prediction

Climate Change Projection



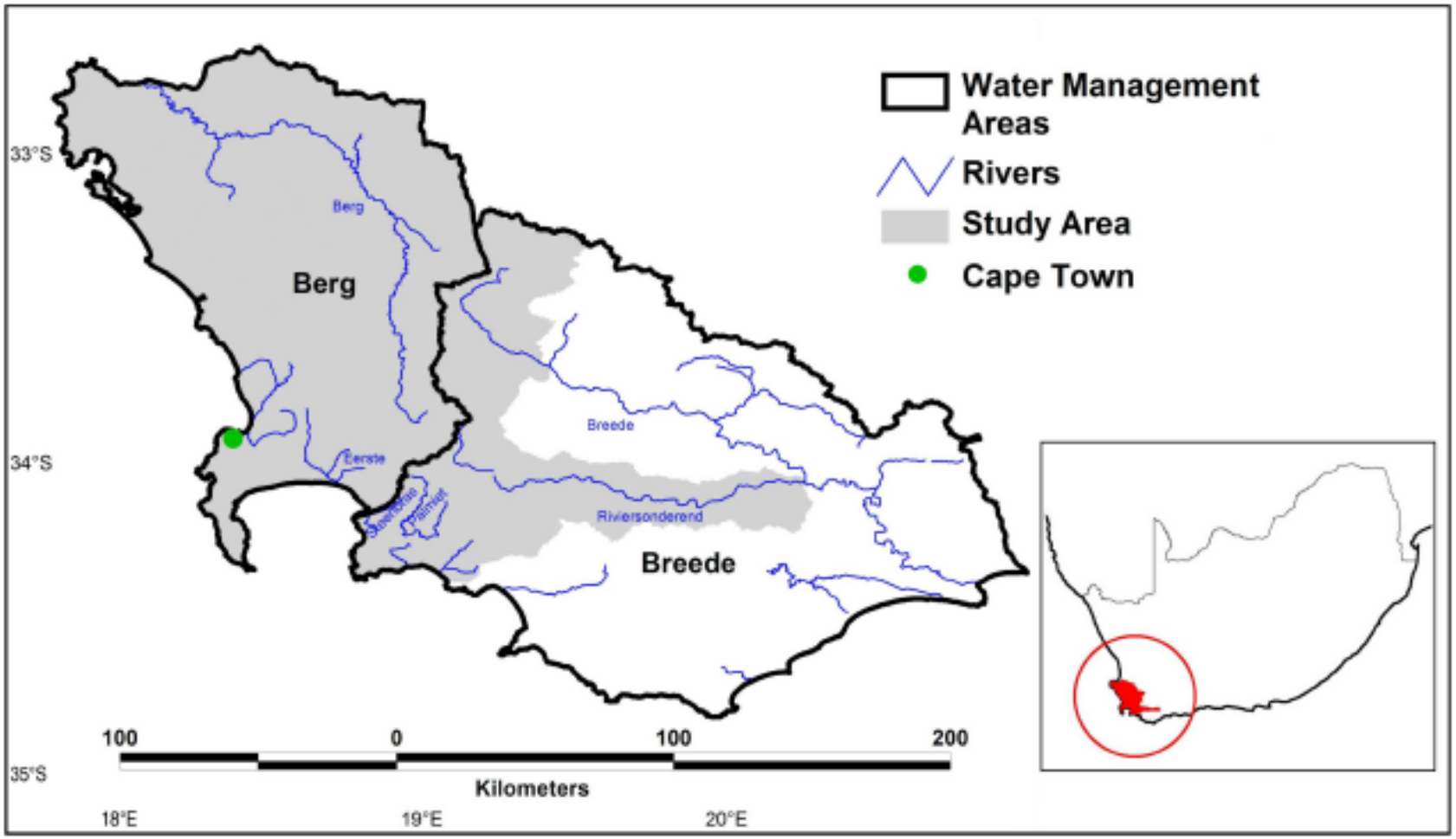

Climate Change Projection

(Blue = Bad; Red = Good):


What information can be provided in places where there is no signal from decadal phenomena, or where the models have poor performance??

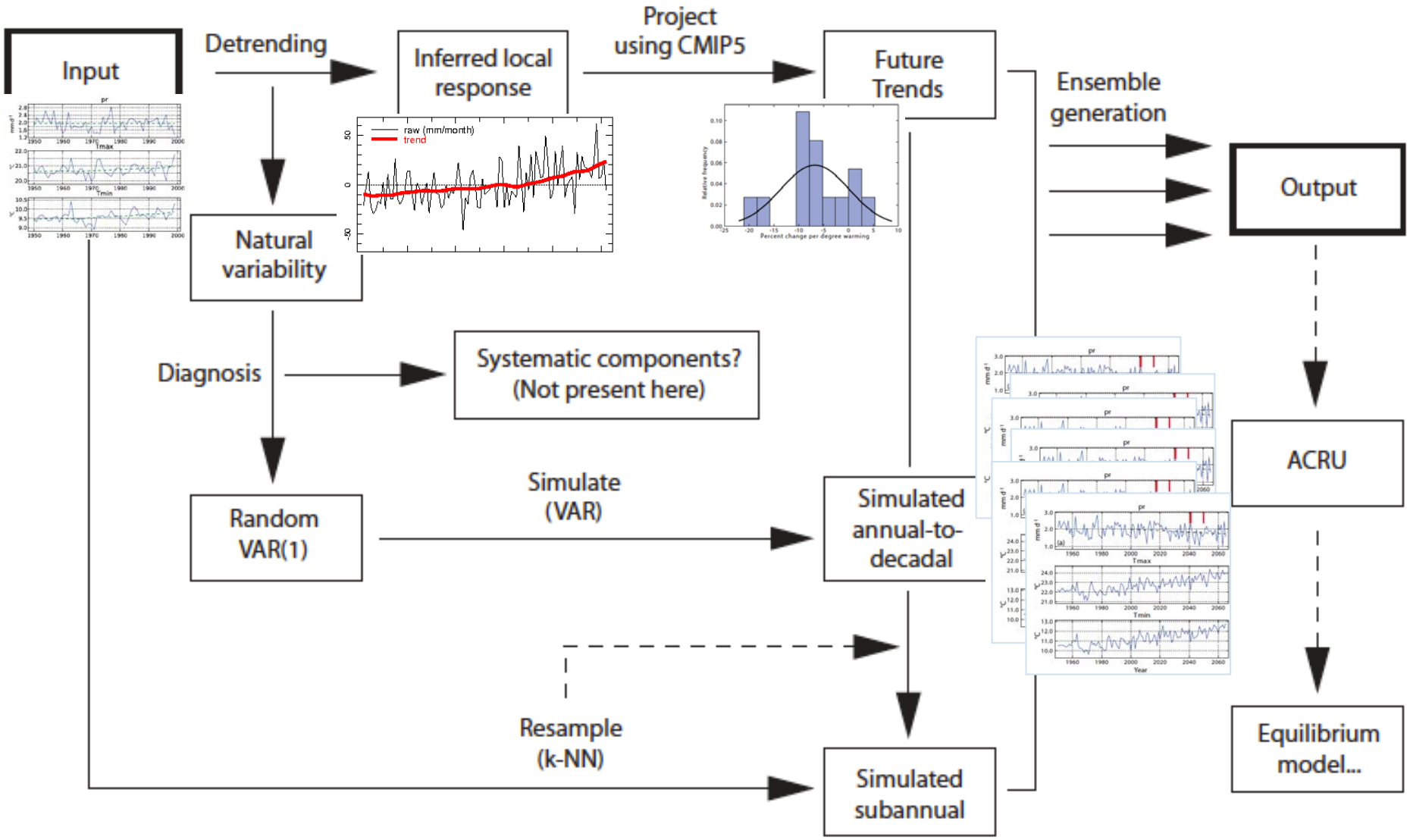
# Resiliency of Water Resources and Mgmt

## Berg and Breede Water Mgmt Areas

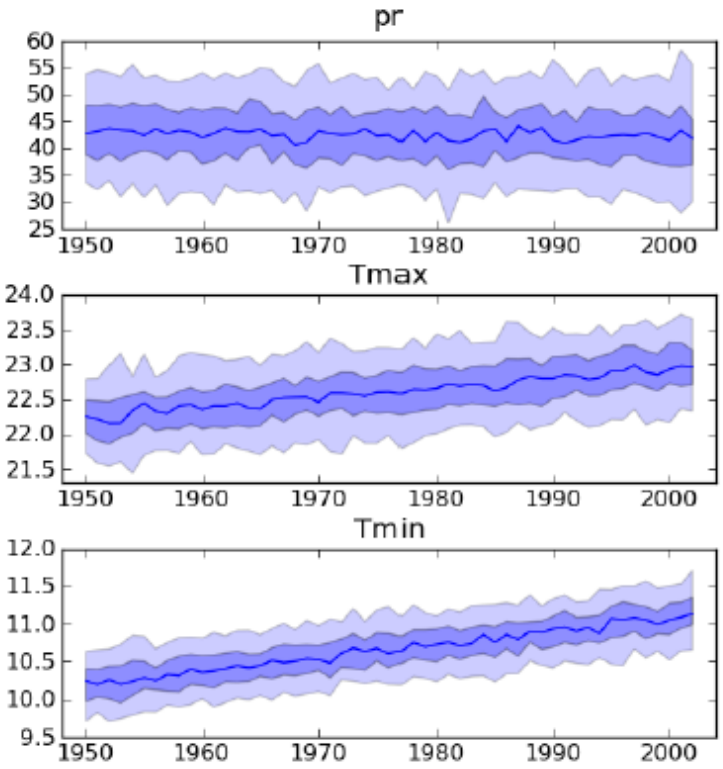


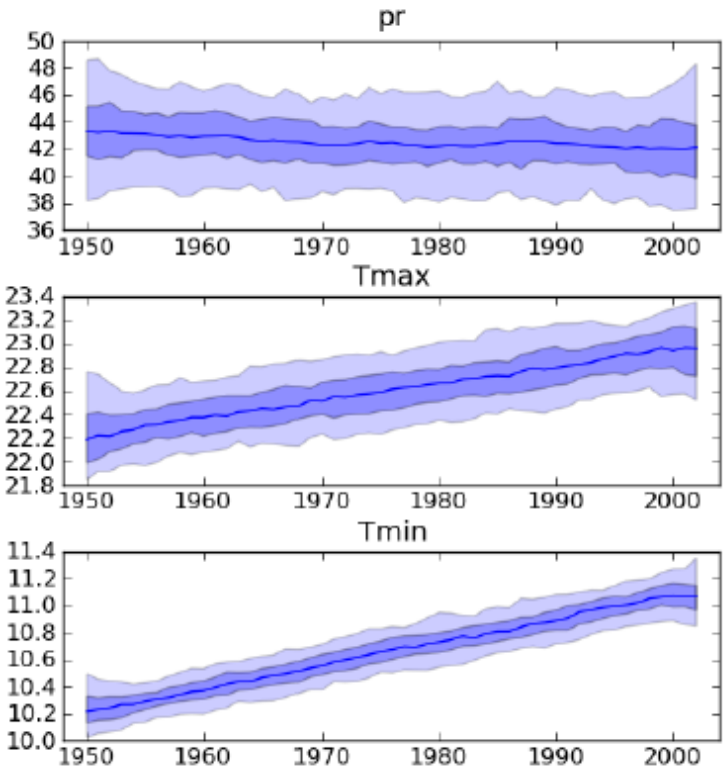
# STOCHASTIC SIMULATIONS:

(Greene, et al. 2012)



# STOCHASTIC SIMULATIONS: ... the envelope please




- Left: Unsmoothed simulations
- IQR and 0.05-0.95 quantile shown, 100 simulations.
- Right: Similar, but for smoothed simulations (9-year unweighted running mean)



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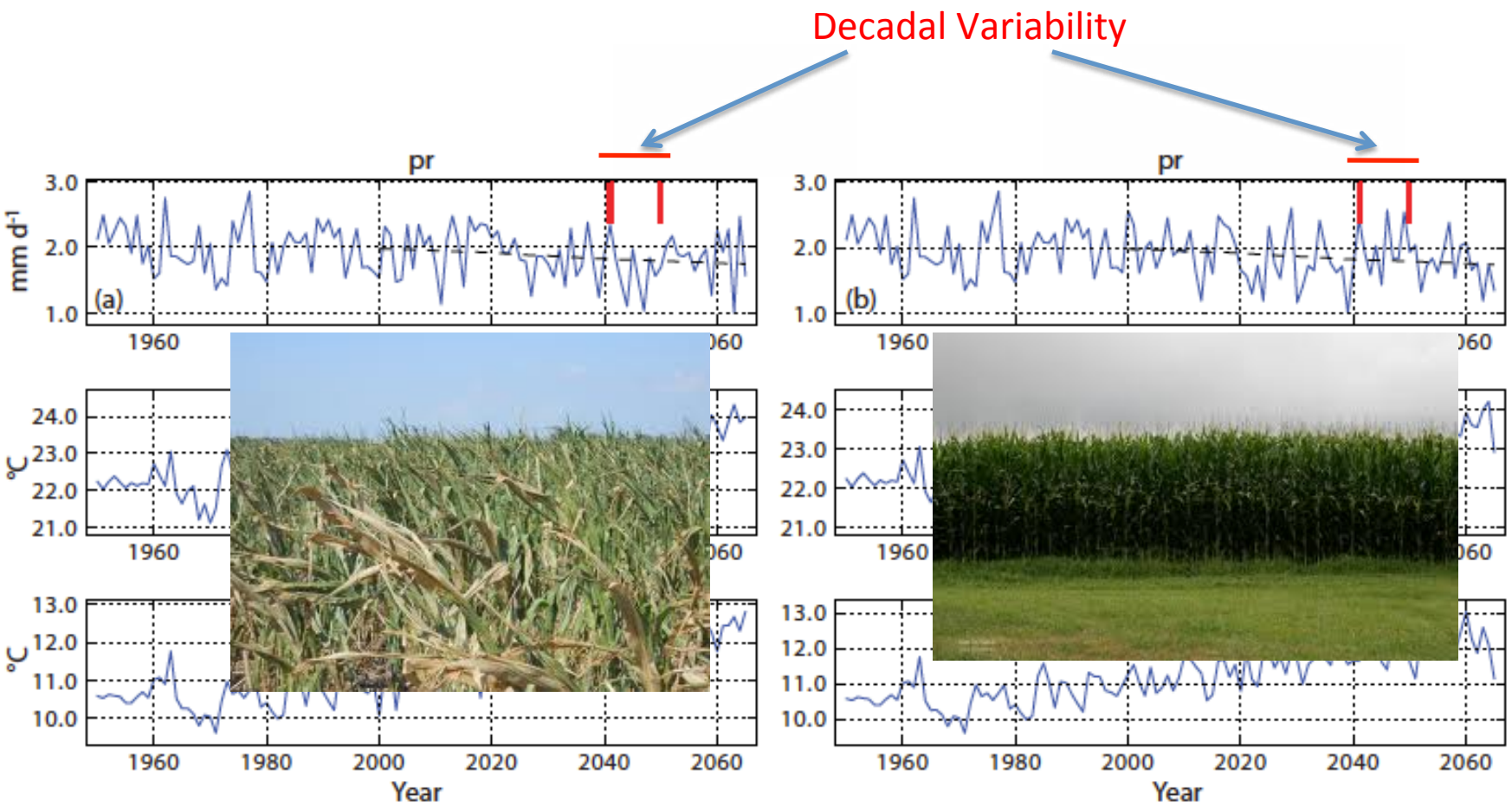
for Climate and Society
Earth Institute | Columbia University

# STOCHASTIC SIMULATIONS: *2 Ensemble Members*



There are no answers, only choices.

*Stanislaw Lem/Steven Soderbergh (Solaris)*

# Thank You


goddard@iri.columbia.edu info@iri.columbia.edu

# IRI Prediction Talks

**S2S, P-A1:** *Andrew Robertson*: "Sub-seasonal prediction of the Indian monsoon: Case study over Bihar"

**S2S, A3:** *Ángel Muñoz*: "How Much Can M.O.S. Improve Sub-seasonal Prediction Skill"

**S2S, P-A3:** *Nicolas Vigaud*: "Wintertime Weather Regimes over North America and Their Predictability from Sub-Monthly Reforecasts"

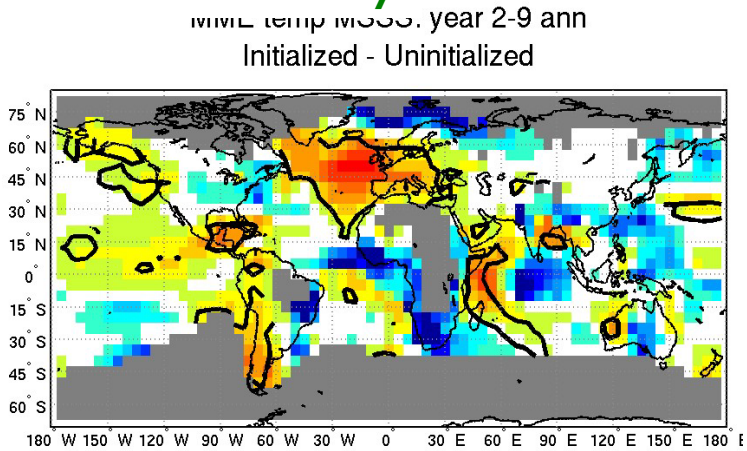
**S2S, P-B3:** *Nicolas Vigaud*: "North American Summer Heat Waves and Modulation from North Atlantic Simulated by an AGCM"

**S2S, P-A4:** *Colin Kelley*: "Differences in Timescales of Rainfall Predictability for Six Countries, within Agricultural Context"

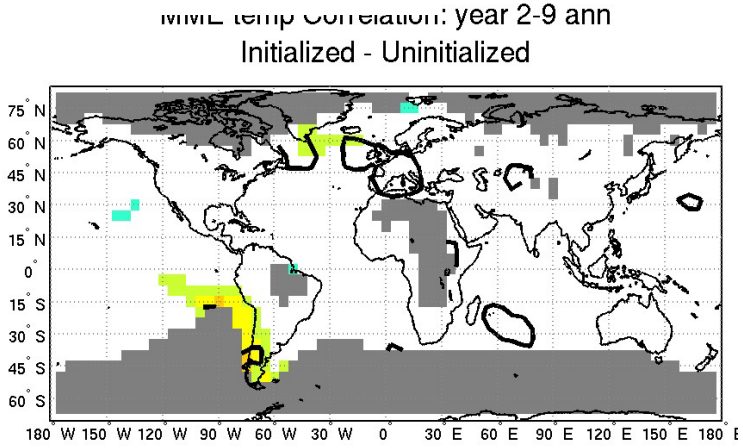
**S2D, B3:** *Nachiketa Acharya*: "Evaluating a new calibration method for Seasonal Probabilistic Prediction for Indian Summer Monsoon"

# Decadal Predictions: *Skill still to be demonstrated*

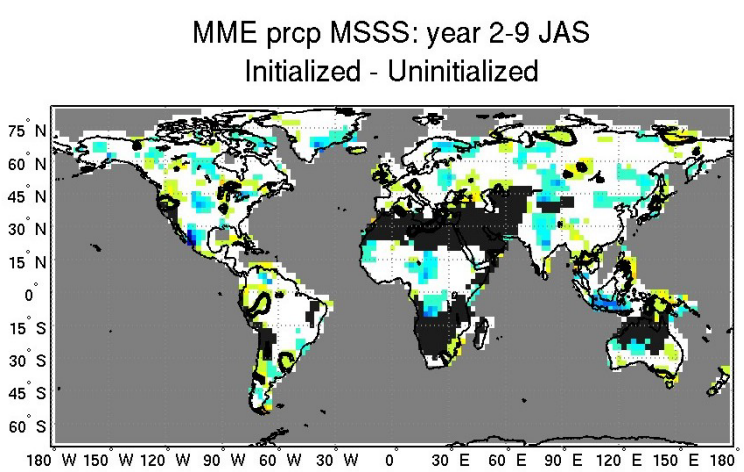
## Relative Accuracy

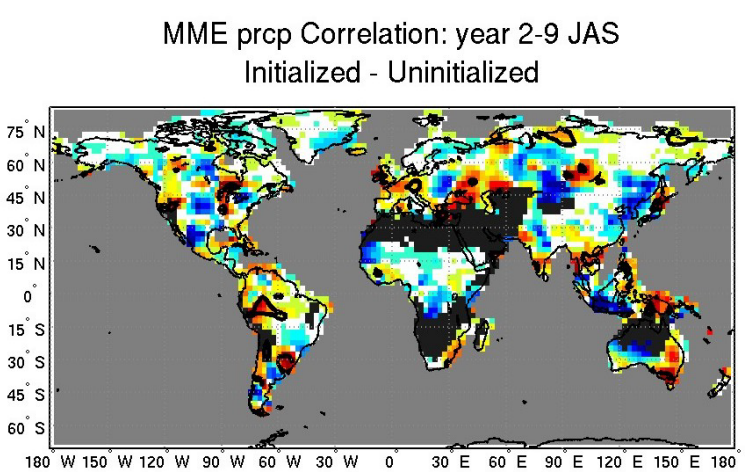



## Correlation




Annual Temp.




Jul-Aug-Sep Rainfall

*(based on Goddard et al. 2012, Climate Dynamics)*