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Fourth ICTP Workshop on the Theory and Use of Regional Climate Models: Applying RCMs to Developing Nations in Support of Climate Change Assessment and Extended-Range Prediction

3 - 14 March 2008

Climate Risk Management and the use of Regional Climate Model simulations in developing nations

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Climate Risk Management and the use of Regional Climate Model simulations in developing nations

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New York, USA

outline

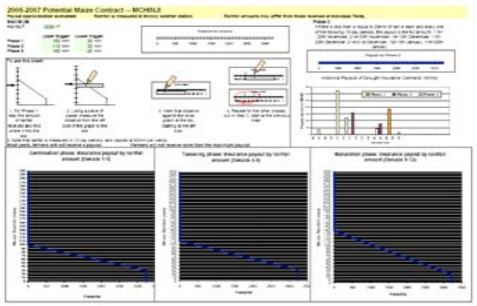
- what is Climate Risk Management? – some examples
- statistical tailoring methods for seasonal forecasts
- role of Regional Climate Models – examples from SE Asia

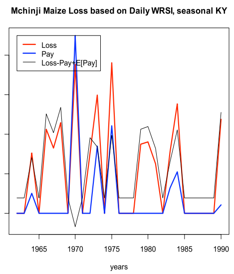
Climate Risk Management examples

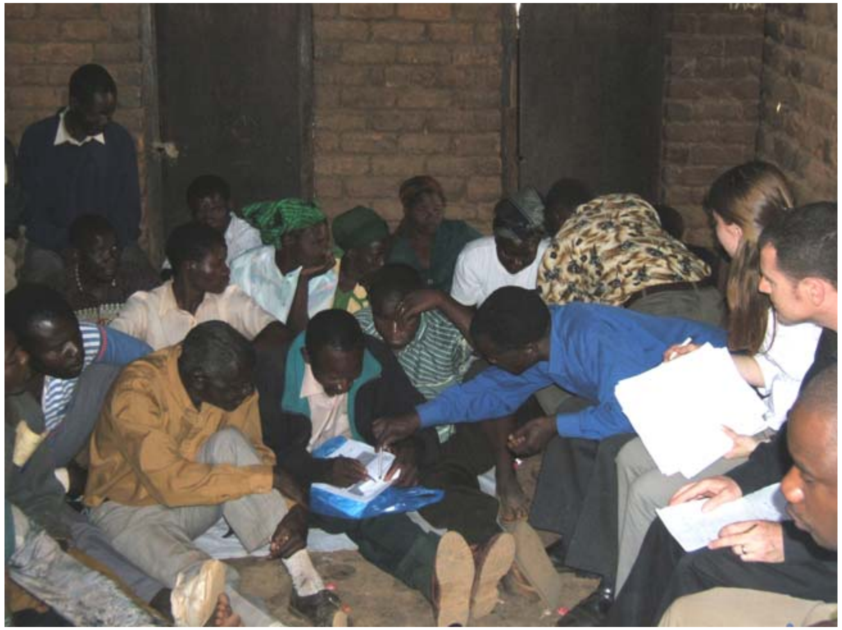
- index insurance in Malawi
- reservoir management in Manila
- malaria mapping and early warning in Africa

Index Insurance and Climate Risk Management

- **In Malawi, smallholder farmers report they cannot obtain inputs necessary to address climate variability**
  - High yielding seeds require cash the farmers do not have
  - Drought risk prevents farmers from being eligible for loans
  - Malawi farmers **report they want to adjust practices to take advantage of seasonal forecasts but are unable to obtain appropriate fertilizer and seed**







- **Index insurance risk management package**
  - **We have designed the contracts for a drought insurance system that provides the backbone for a package of loans, groundnut, and maize inputs for smallholder farmers**
  - Drought insurance solves traditional crop insurance pitfalls
  - Partners include Malawi farmers and financing associations (NASFAM, OIBM MRFC, Malawi Insurance Association), the World Bank CRMG, Malawi Met Service, CUCRED
  - Project is in its second year of implementation, scaling up from about 900 farmers last year to several thousand, due to overwhelming demand
  - Additional pilots underway (e.g. Kenya, Tanzania, South Africa . . .)
  - We are cooperatively developing packages that provide **price incentives, risk protection, and strategic input availability so farmers can take advantage of forecasts**
  - Farmers report that this program is **how they adapt to climate variability and change**

IRI The International Research Institute for Climate and Society

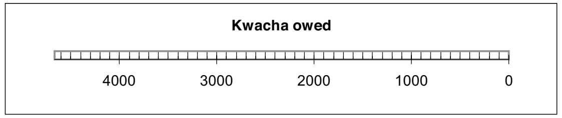
Contact: Daniel Osgood, deo@iri.columbia.edu

2006-2007 Potential Groundnut Contract -- CHITEDZE

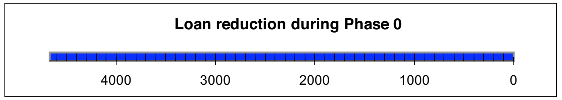
Loan approximation worksheet **Rainfall is measured at Chitedze Research Station.** **Rainfall amounts may differ from those received at individual fields.**

TOTAL LOAN 4667.35

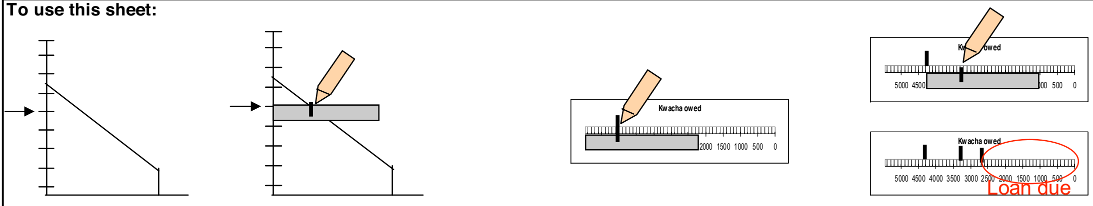
	Upper trigger	Lower trigger
Phase 1	35 mm	30 mm
Phase 2	35 mm	30 mm
Phase 3	220 mm	20 mm



Phase 0:
If there is less than 25mm of rain in each and every one of the following 10-day periods, the loan is reduced to zero: 11th-20th November, 21st-30th November; 1st-10th December; 11th-20th December; 21st-31st December, 1st-10th January, 11th-20th January



To use this sheet:



1. For Phase 1, read the amount of rainfall received and find where it hits the line.

2. Using a piece of paper, measure the distance from the left side of the graph to the line.

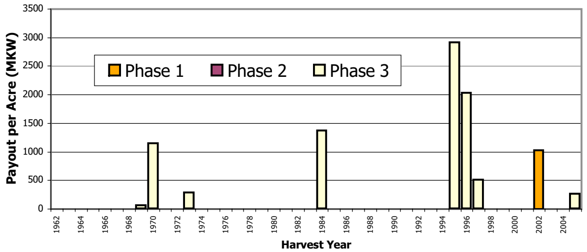
3. Mark that distance against the small graph at the top, starting at the left side.

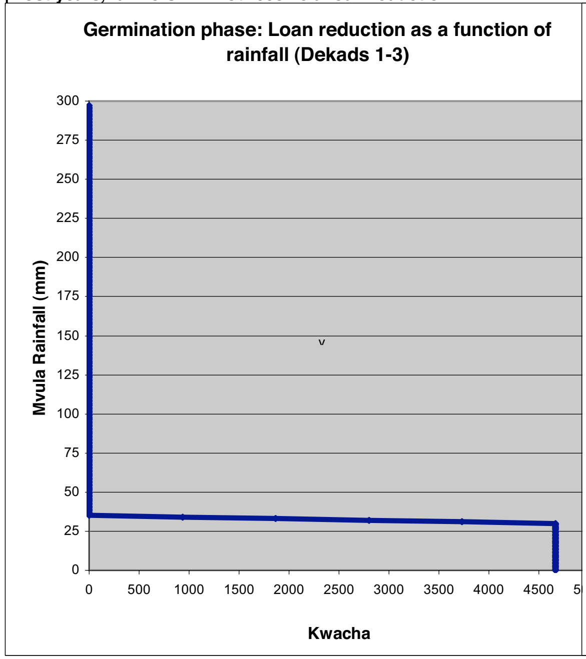
4. Repeat for the other phases, but in Step 3, start at the previous mark.

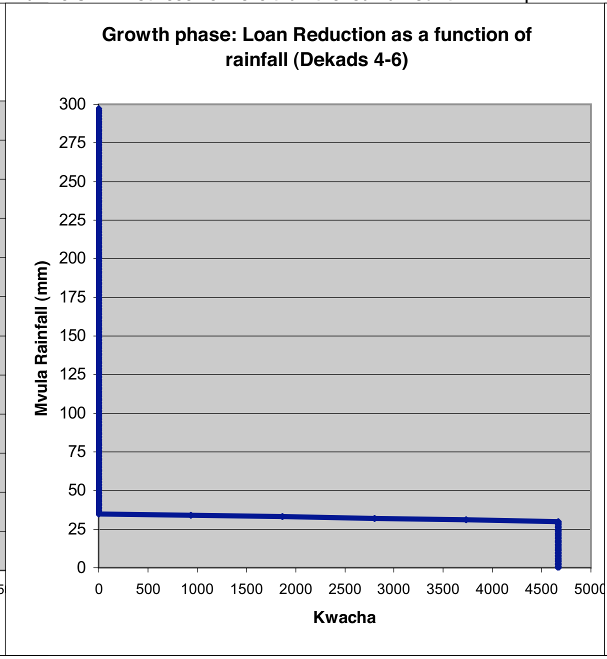
5. Note that rainfall is measured in 10 day periods, and capped at 60mm per period.

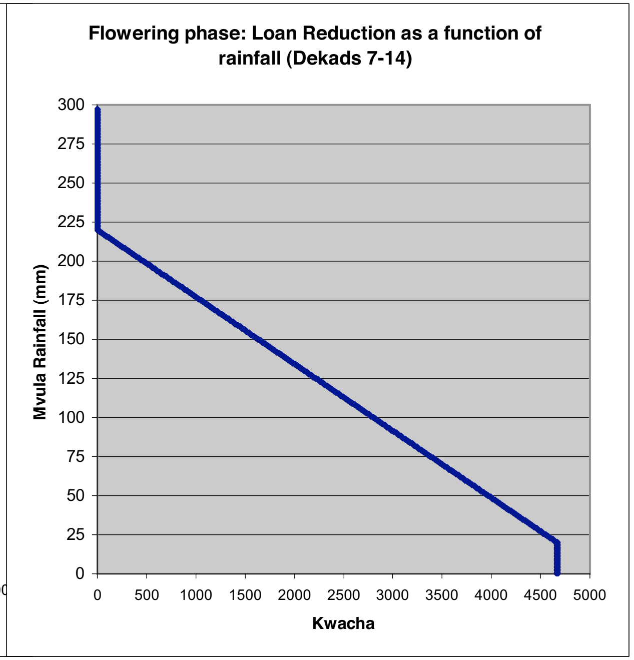
Most years, farmers will not receive a loan reduction. **Farmers will not receive more than the loan amount.**

Historical Payouts of Drought Insurance Contracts, Chitedze







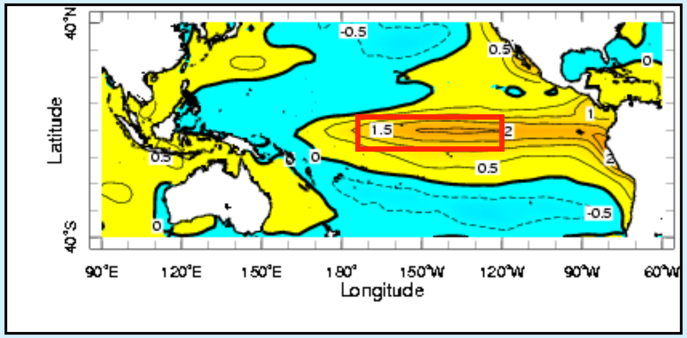


D. Osgood (IRI)

Downscaling for Philippines Reservoir Inflow

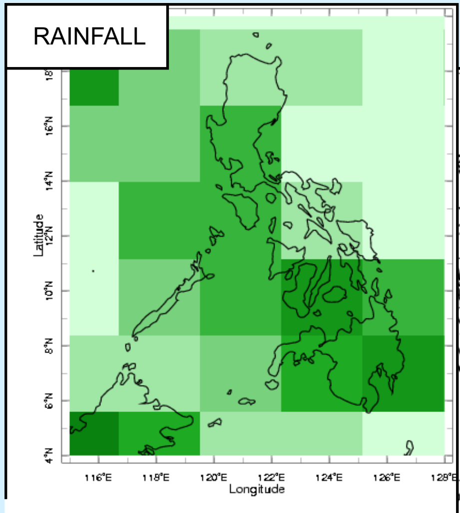
B. Lyon (IRI)
A. Lucero (PAGASA)

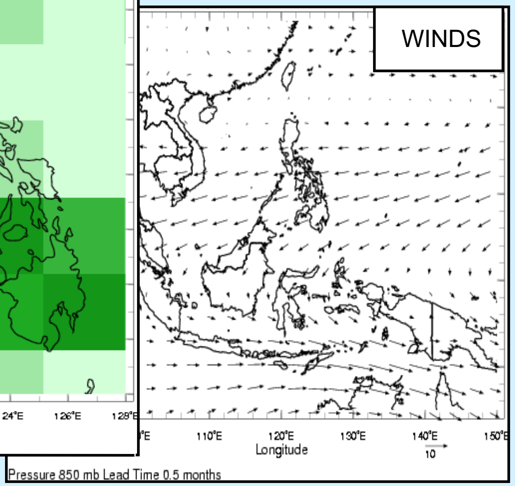
Sea Surface Temperatures



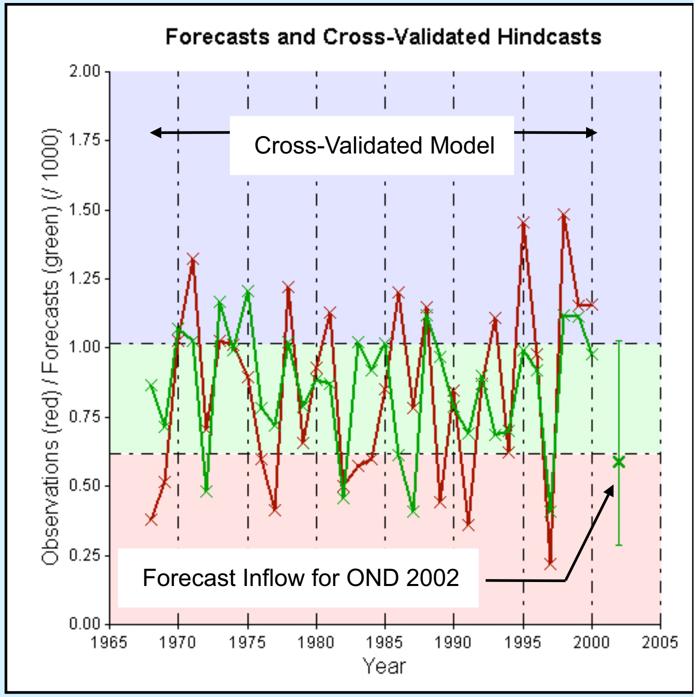
Historical Angat Inflow Observations

Global Climate Model



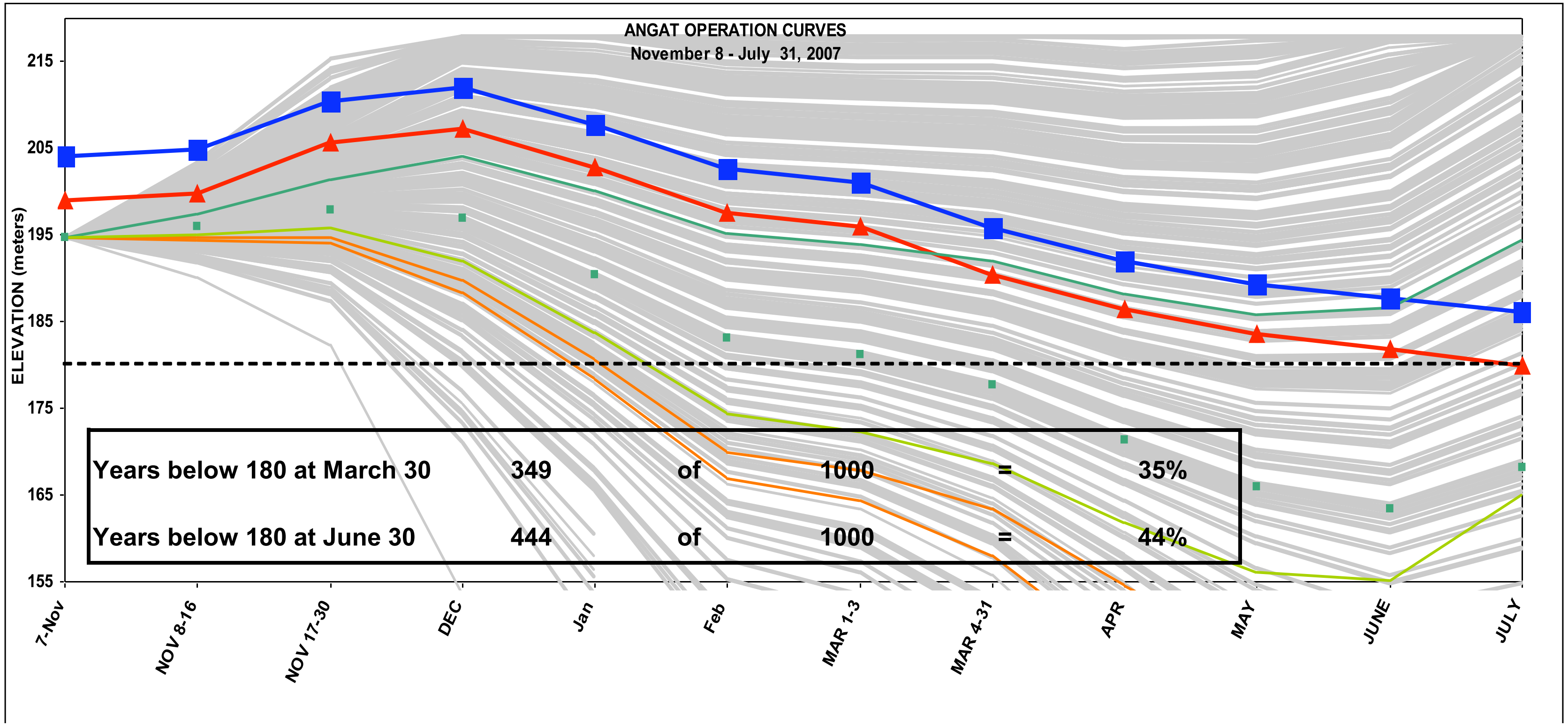


Statistical Model

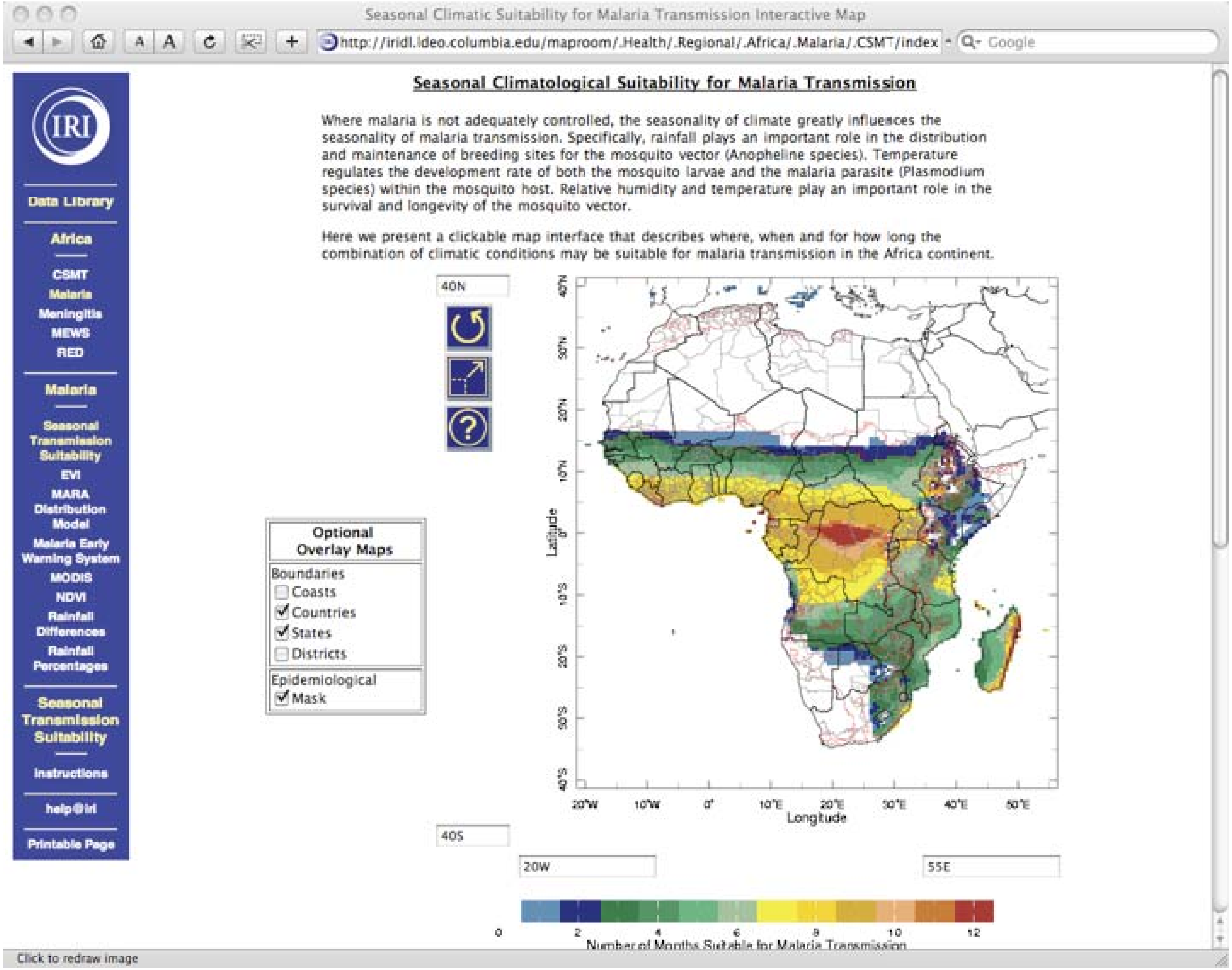


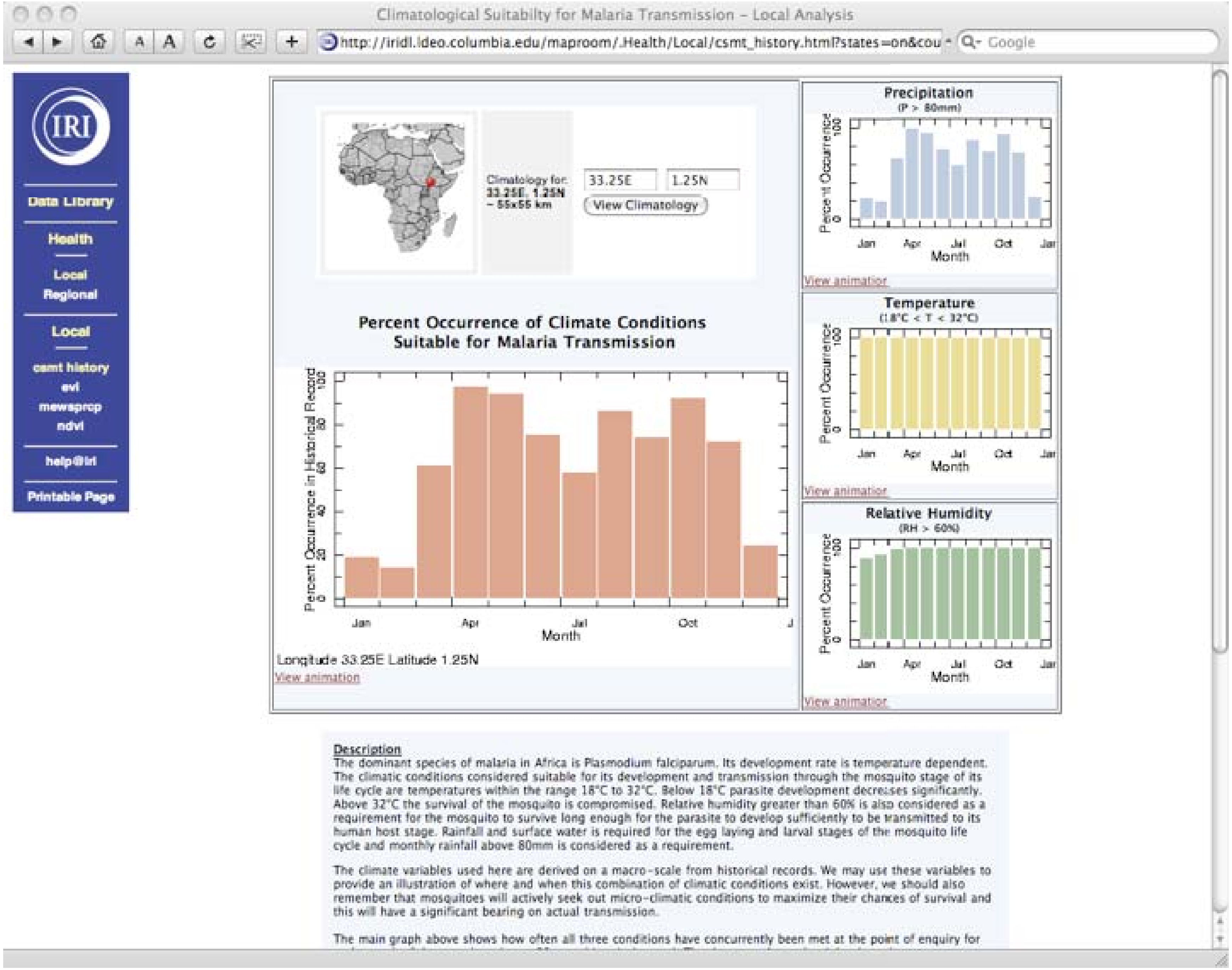
Forecasted Reservoir Inflows

C. Brown (IRI)



1. Reservoirs operated without forecasts in risk averse mode
   – Anticipating drought of record in every year
2. Forecasts provide enhanced estimate of drought risk
   – Identifying opportunities in years when drought risk is low
3. Decision Support System communicates forecast in relevant terms
   – Reservoir levels, reliability, water deliveries
4. Risks of forecast use must also be managed
   – Evaluating options for managing the low probability event


Seasonal Climatic Suitability for Malaria Transmission Interactive Map
http://iridl.ldeo.columbia.edu/maproom/.Health/.Regional/.Africa/.Malaria/.CSMT/index
Google
Data Library
Africa
CSMT
Malaria
Meningitis
MEWS
RED
Malaria
Seasonal Transmission Suitability
EVI
MARA Distribution Model
Malaria Early Warning System
MODIS
NDVI
Rainfall Differences
Rainfall Percentages
Seasonal Transmission Suitability
Instructions
help@iri
Printable Page
Seasonal Climatological Suitability for Malaria Transmission
Where malaria is not adequately controlled, the seasonality of climate greatly influences the seasonality of malaria transmission. Specifically, rainfall plays an important role in the distribution and maintenance of breeding sites for the mosquito vector (Anopheline species). Temperature regulates the development rate of both the mosquito larvae and the malaria parasite (Plasmodium species) within the mosquito host. Relative humidity and temperature play an important role in the survival and longevity of the mosquito vector.
Here we present a clickable map interface that describes where, when and for how long the combination of climatic conditions may be suitable for malaria transmission in the Africa continent.
40N
40S
20W
55E
Optional Overlay Maps
Boundaries
Coasts
Countries
States
Districts
Epidemiological
Mask
Latitude
Longitude
Number of Months Suitable for Malaria Transmission
Click to redraw image

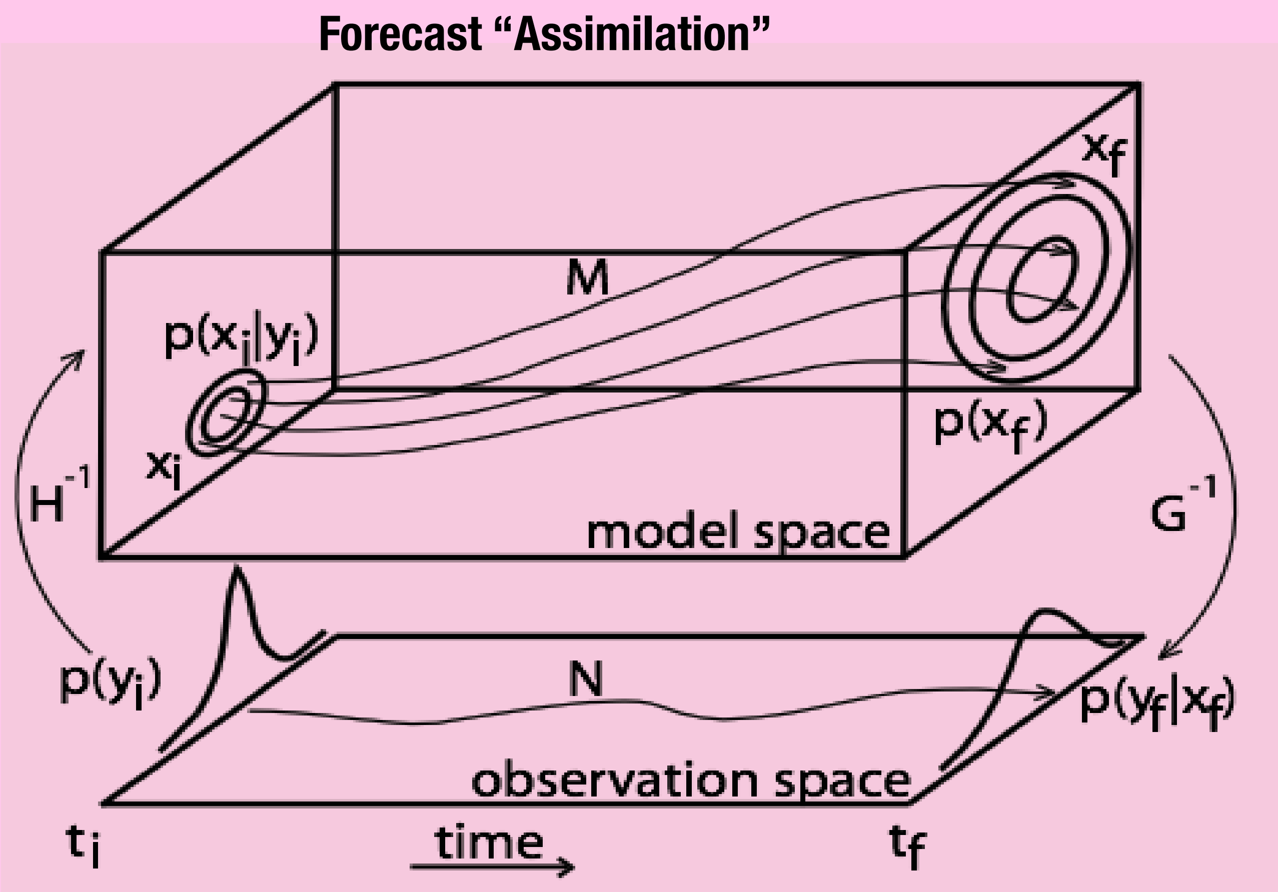


Climatological Suitabilty for Malaria Transmission - Local Analysis
http://iridl.ldeo.columbia.edu/maproom/.Health/Local/csmt_history.html?states=on&cou
Google
IRI
Data Library
Health
Local
Regional
Local
csmt history
evi
mewsprop
ndvi
help@iri
Printable Page
Climatology for:
33.25E, 1.25N
~ 55x55 km
33.25E
1.25N
View Climatology
Percent Occurrence of Climate Conditions
Suitable for Malaria Transmission
Percent Occurrence in Historical Record
0
20
40
60
80
100
Jan
Apr
Jul
Oct
Month
Longitude 33.25E Latitude 1.25N
View animation
Precipitation
(P > 80mm)
Percent Occurrence
Month
View animation
Temperature
(18°C < T < 32°C)
Percent Occurrence
Month
View animation
Relative Humidity
(RH > 60%)
Percent Occurrence
Month
View animation
Description
The dominant species of malaria in Africa is Plasmodium falciparum. Its development rate is temperature dependent. The climatic conditions considered suitable for its development and transmission through the mosquito stage of its life cycle are temperatures within the range 18°C to 32°C. Below 18°C parasite development decreases significantly. Above 32°C the survival of the mosquito is compromised. Relative humidity greater than 60% is also considered as a requirement for the mosquito to survive long enough for the parasite to develop sufficiently to be transmitted to its human host stage. Rainfall and surface water is required for the egg laying and larval stages of the mosquito life cycle and monthly rainfall above 80mm is considered as a requirement.
The climate variables used here are derived on a macro-scale from historical records. We may use these variables to provide an illustration of where and when this combination of climatic conditions exist. However, we should also remember that mosquitoes will actively seek out micro-climatic conditions to maximize their chances of survival and this will have a significant bearing on actual transmission.
The main graph above shows how often all three conditions have concurrently been met at the point of enquiry for

“tailoring” of seasonal forecasts

- correction of various biases (aka calibration, fcst assimilation)
- spatial “downscaling” of seasonal averages
  - local stations
  - administrative units, e.g. districts, to match user needs & ag. data
- user-relevant meteorological “events” (eg dry-spell probability)
- coupling to a sectoral (e.g. crop) model
- probability format: want a “CDF” conditioned reliably on fcst

A probabilistic motivation

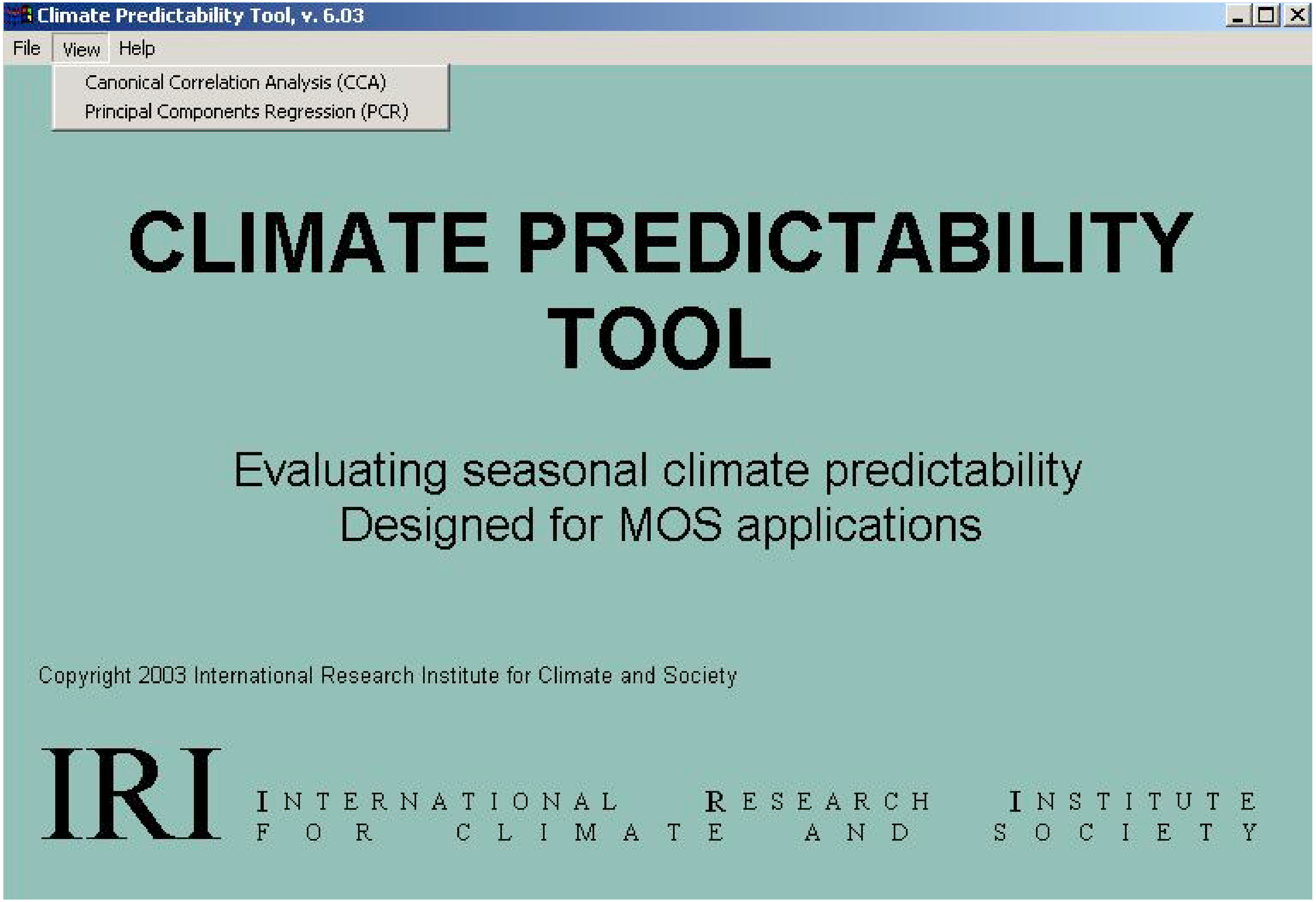


Stephenson et al (2005)

statistical approaches

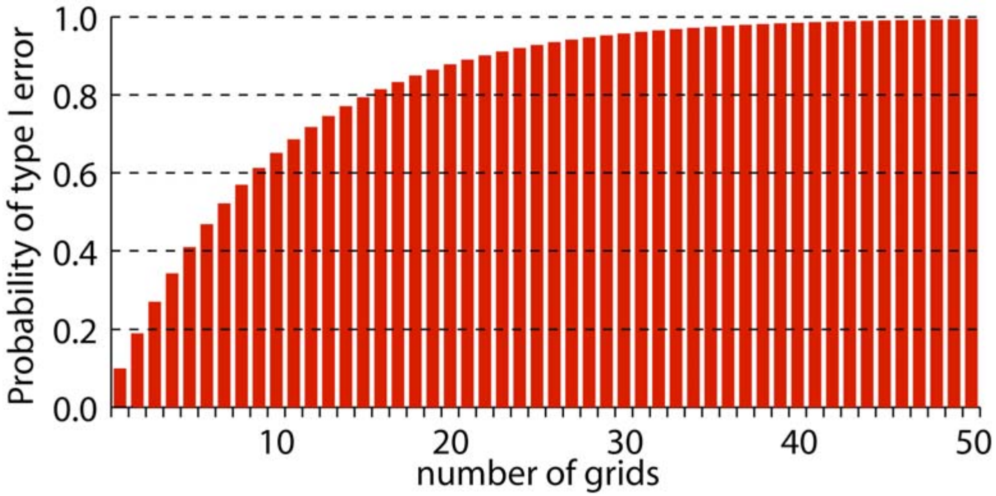
- distinguish methods applied to seasonal or monthly averages (“spatial downscaling”) versus methods that attempt to construct stochastic daily weather sequences conditioned on GCM seasonal forecasts
- seasonal averages: regression methods
- daily sequences: analog (resampling) methods and stochastic weather generators

seasonal averages: “CPT”



Why not multiple Regression?

Multiplicity - Too many grids from which to choose.



Multicolinearity - Grids are strongly correlated.

$$\text{Nino3.4}_{\text{Mar}} = \beta_0 + 0.761 \times \text{Nino3.4}_{\text{Feb}} + \varepsilon$$

$$\text{Nino3.4}_{\text{Mar}} = \beta_0 + 0.628 \times \text{Nino3.4}_{\text{Jan}} + \varepsilon$$

$$\text{Nino3.4}_{\text{Mar}} = \beta_0 + 1.216 \times \text{Nino3.4}_{\text{Feb}} - 0.395 \times \text{Nino3.4}_{\text{Jan}} + \varepsilon$$

cross-validation is essential

1951	Predict 1951	Omit 1952	Omit 1953	Training period			
1952	Omit 1951	Predict 1952	Omit 1953	Omit 1954	Training period		
1953	Omit 1951	Omit 1952	Predict 1953	Omit 1954	Omit 1955	Training period	
1954	Training period	Omit 1952	Omit 1953	Predict 1954	Omit 1955	Omit 1956	Training period
1955	Training period		Omit 1953	Omit 1954	Predict 1955	Omit 1956	Omit 1957

Ensure that cross-validation window length is at least twice the decorrelation time

.. or use retroactive forecasting

1981	Training period (1951-1980)	Predict 1981	Omit 1982+			
1982	Training period (1951-1981)		Predict 1982	Omit 1983+		
1983	Training period (1951-1982)			Predict 1983	Omit 1984+	
1984	Training period (1951-1983)				Predict 1984	Omit 1985+
1985	Training period (1951-1984)					Predict 1985

forecast verification

.. an example from CPT

Cross-validated scores

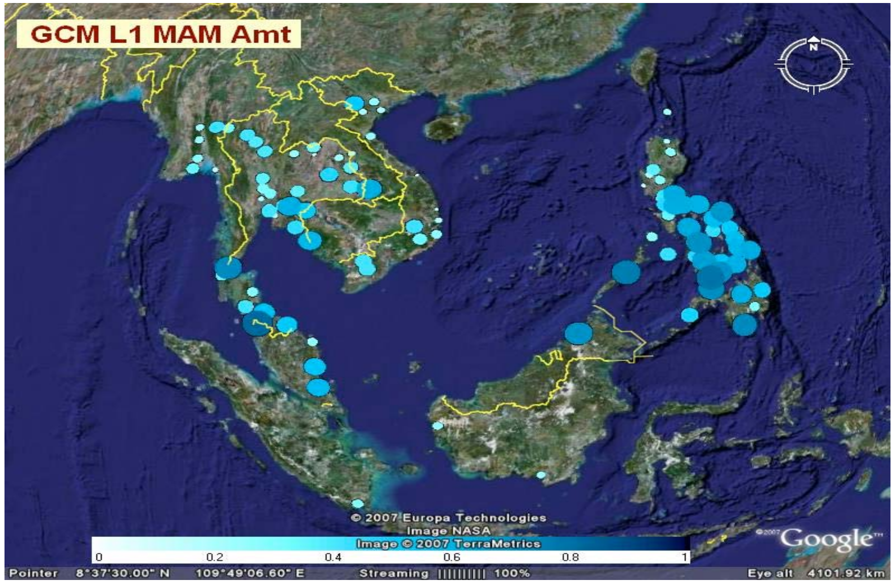
Station 2

WAING 9.62S, 120.22E

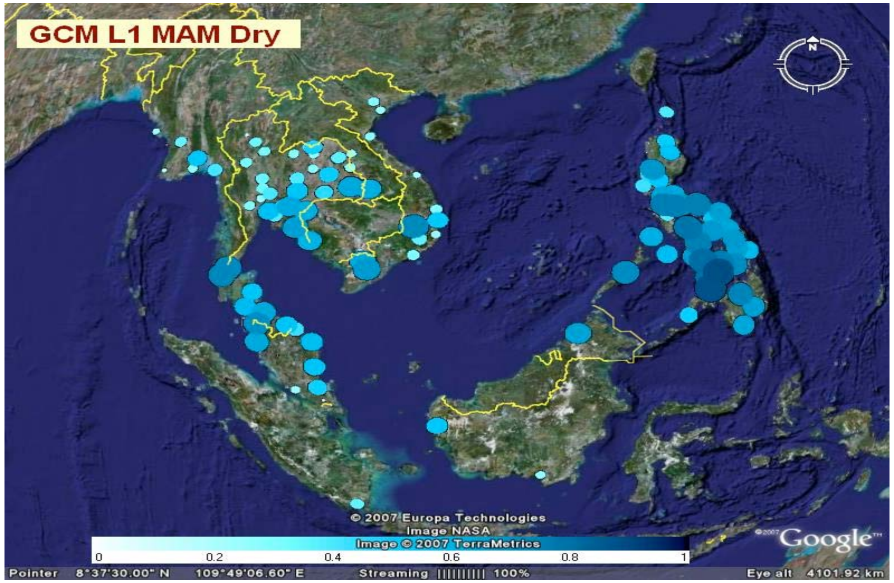
Score:	Sample:	Confidence limits:	P-value:
Continuous measures:		Confidence level: 95.000%	
Pearson's correlation	0.6840	0.5262 to 0.8338	0.0000
Spearman's correlation	0.7175	0.5212 to 0.8378	0.0000
Mean squared error	684.12	350.13 to 1071.87	0.0000
Root mean squared error	26.16	18.71 to 32.74	0.0000
Mean absolute error	20.43	14.46 to 25.91	0.0020
Bias	-1.40	-10.75 to 7.13	N/A
Categorical measures:			
Hit score	63.33	46.67% to 80.00%	0.0020
Hit skill score	45.00	20.00% to 70.00%	0.0020
LEPS score	55.00	31.63% to 79.54%	0.0020
Gerrity score	52.50	29.02% to 77.34%	0.0020
ROC area (below-normal)	0.8550	0.7036 to 0.9839	0.0020
ROC area (above-normal)	0.8800	0.7095 to 0.9877	0.0020

Example from recent ASEAN-IRI training workshop - anomaly correlation skill

seasonal rainfall total

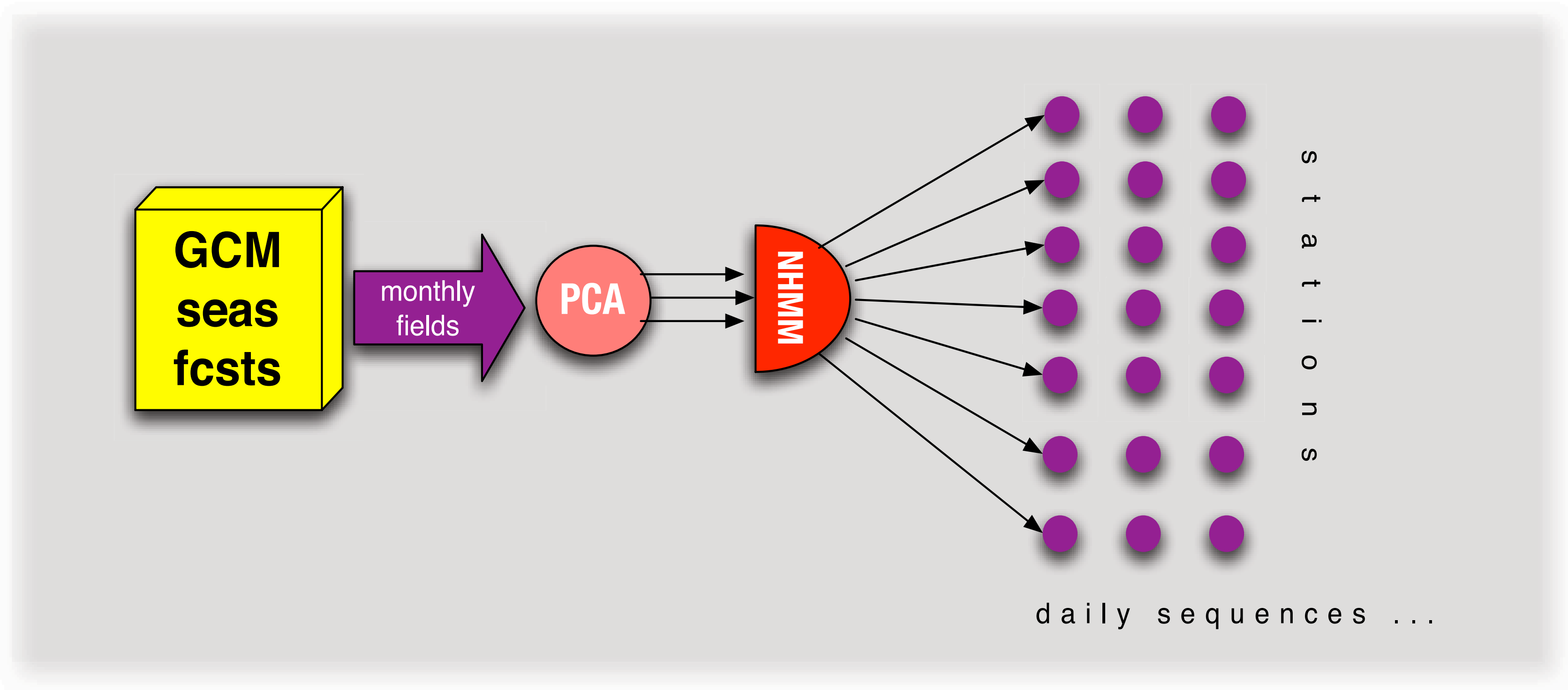


number of dry days per season

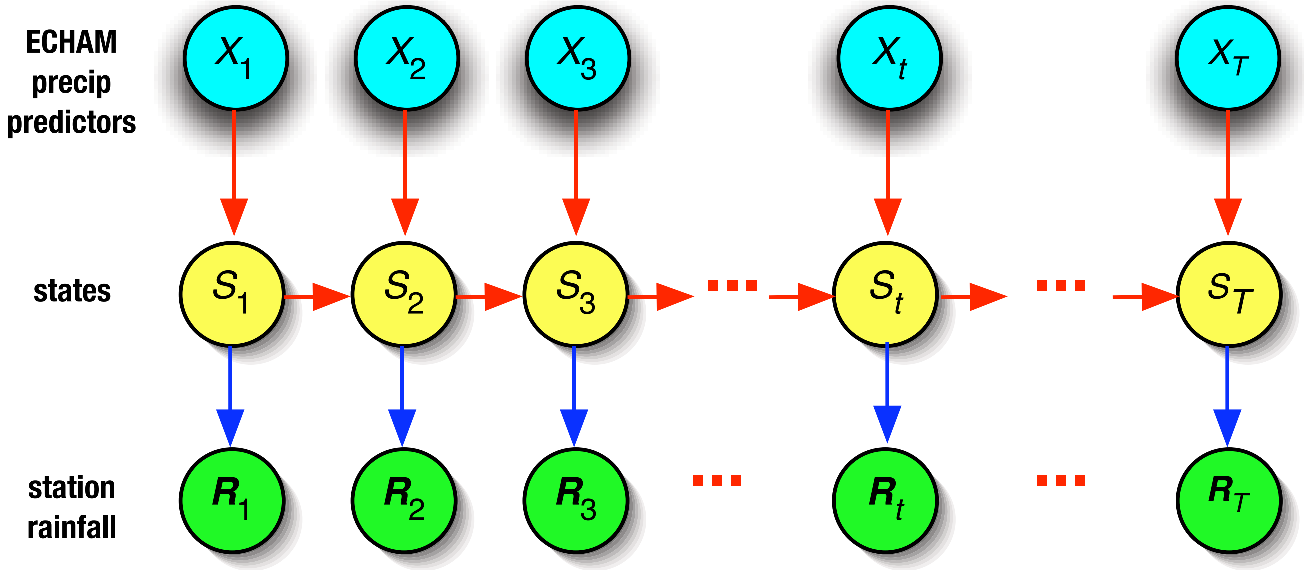


MAM rainfall from ECHAM-CA March 1st hindcasts

conditioning stochastic daily weather sequences on seasonal forecasts

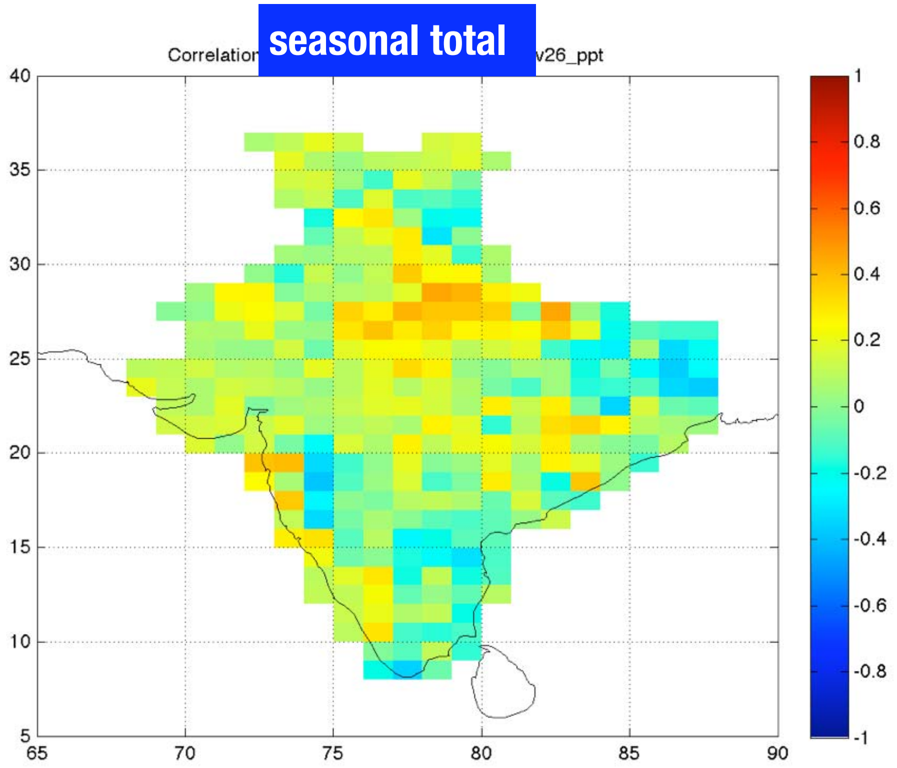


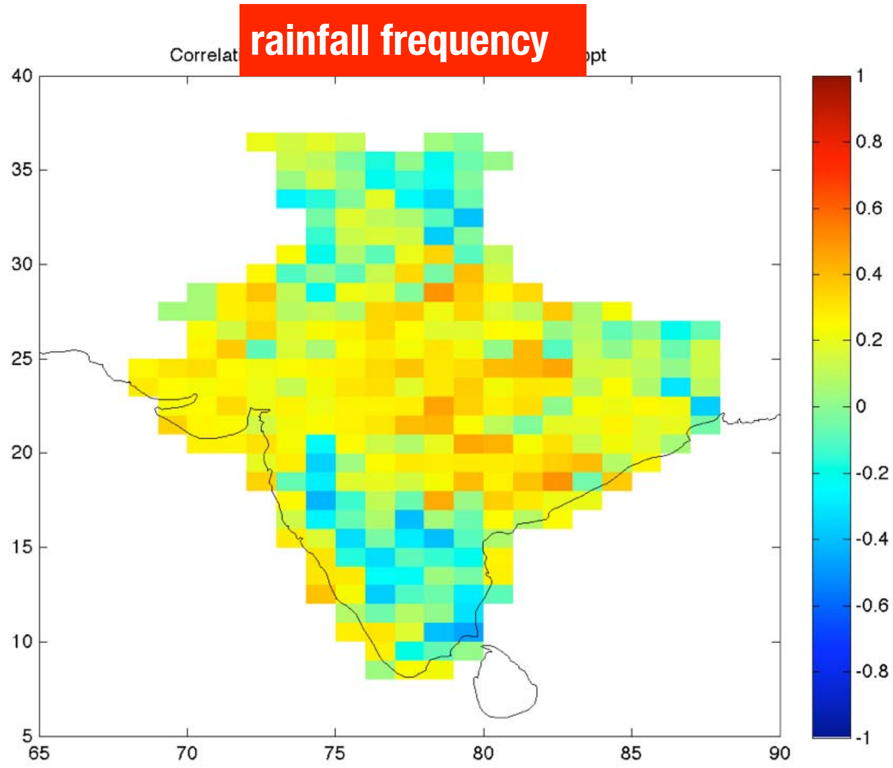
hidden Markov model (HMM)



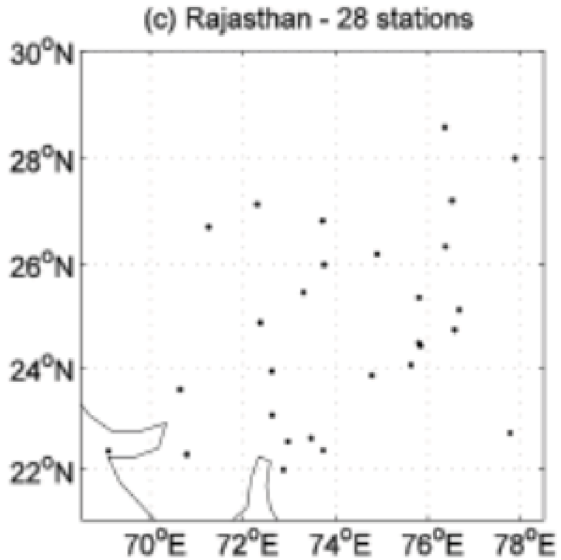
Jun–Sep anomaly correlation skill:

NHMM[ECHAM4 precip (65E-200E, 5N-35N) , IMD]





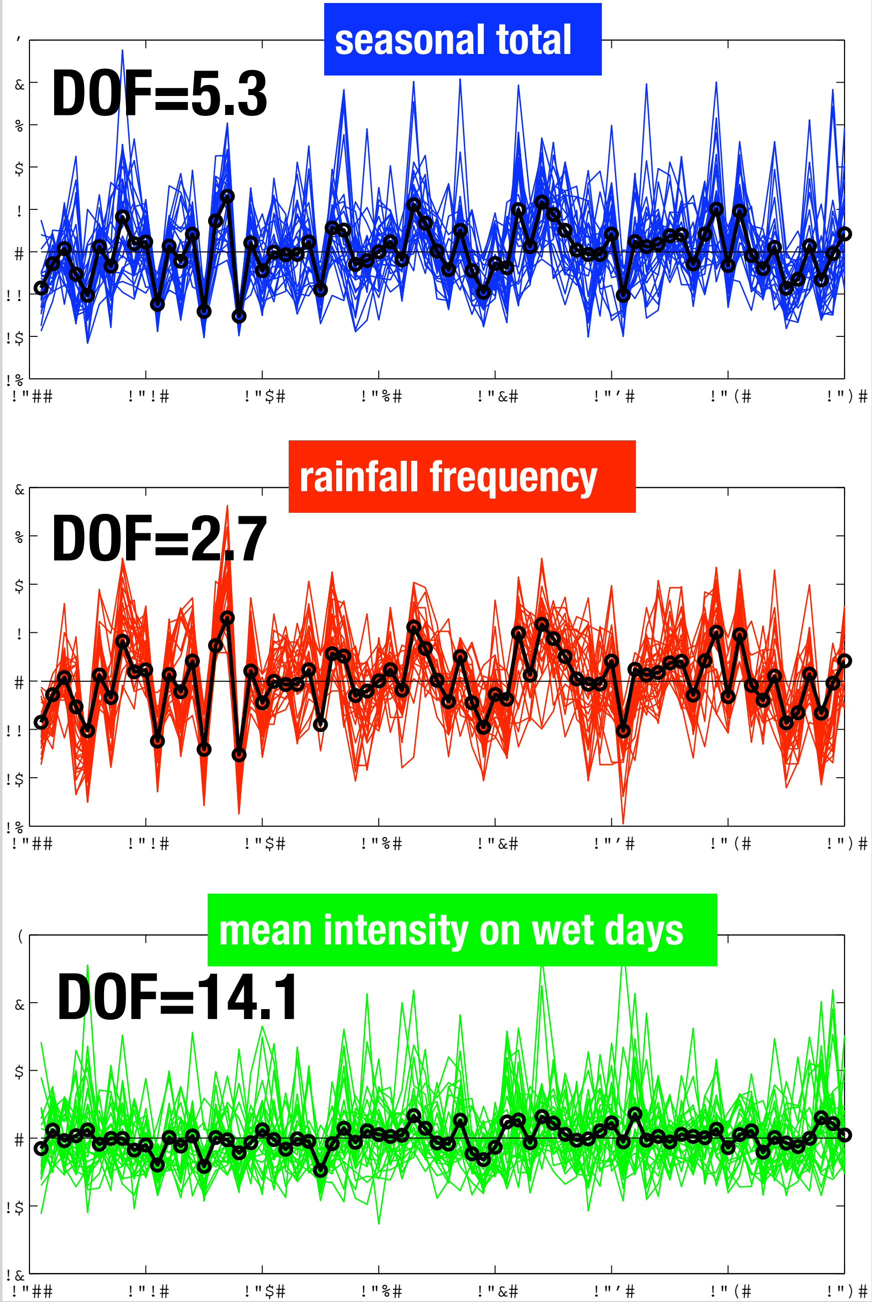
seasonal anomalies at individual stations



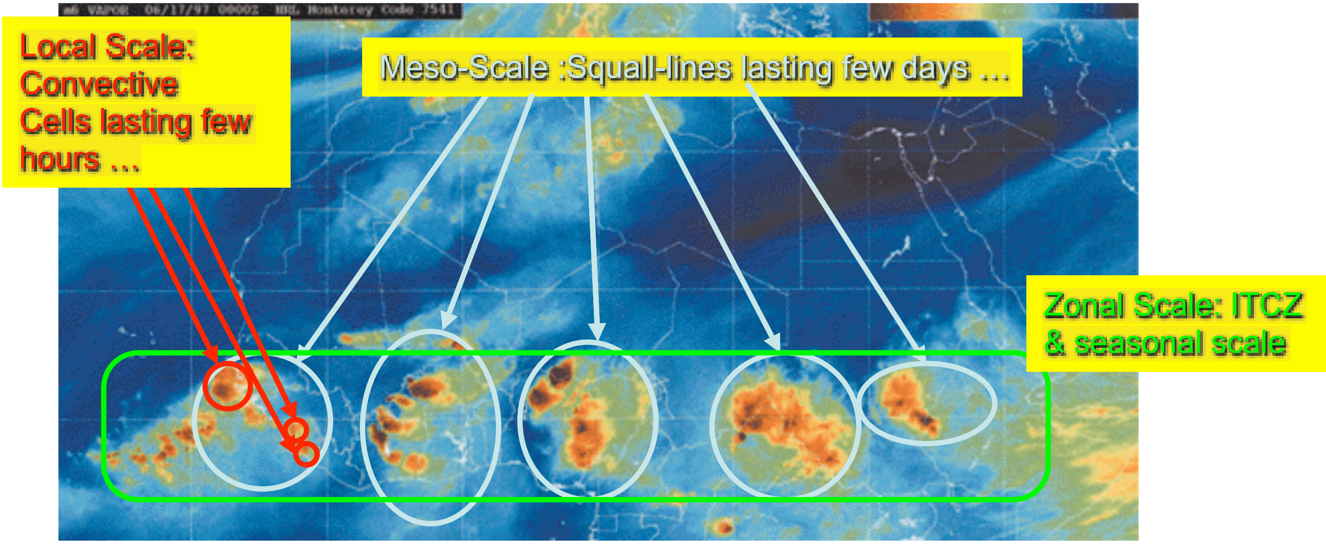
Jun–Sep 1900–70

seas. amount =
(no. of wet days) x (mean intensity on wet days)

Rainfall at individual stations and station-average



why are seasonal anomalies of rainfall frequency more coherent than intensity?



Water vapor image Canal June 17, 1997 at 00h (C.D. Thorncroft)

- intense convection is very fine scale: may hit or miss a raingauge
- organization of rainfall is larger scale
- climate forcings integrate across a season, preferentially acting on occurrence

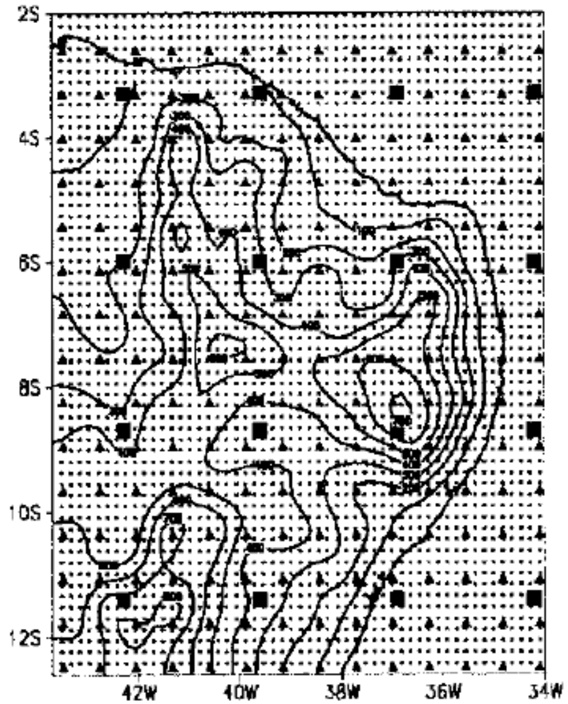
V. Moron

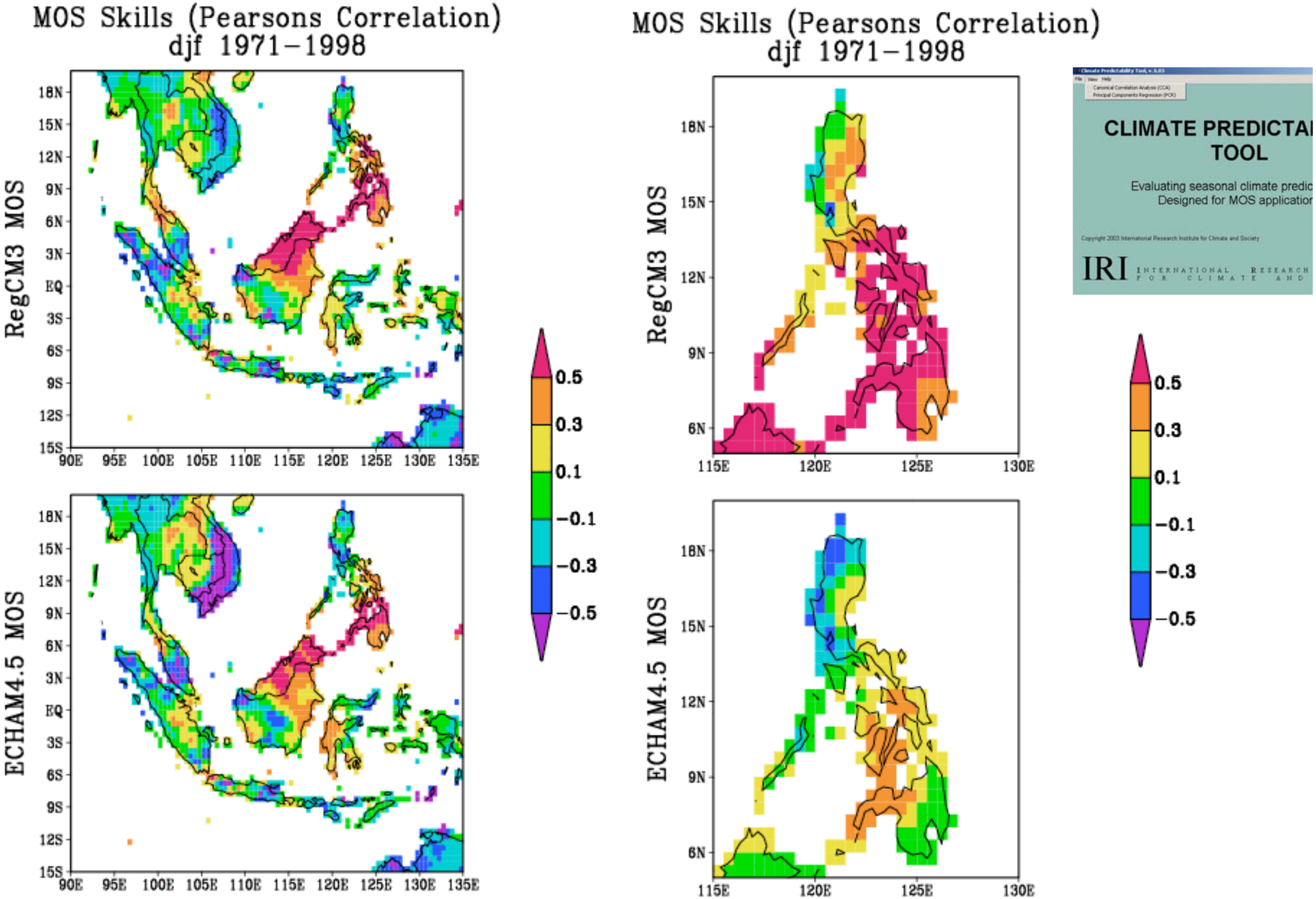
role of Regional Climate Models

examples from SE Asia

regional climate models

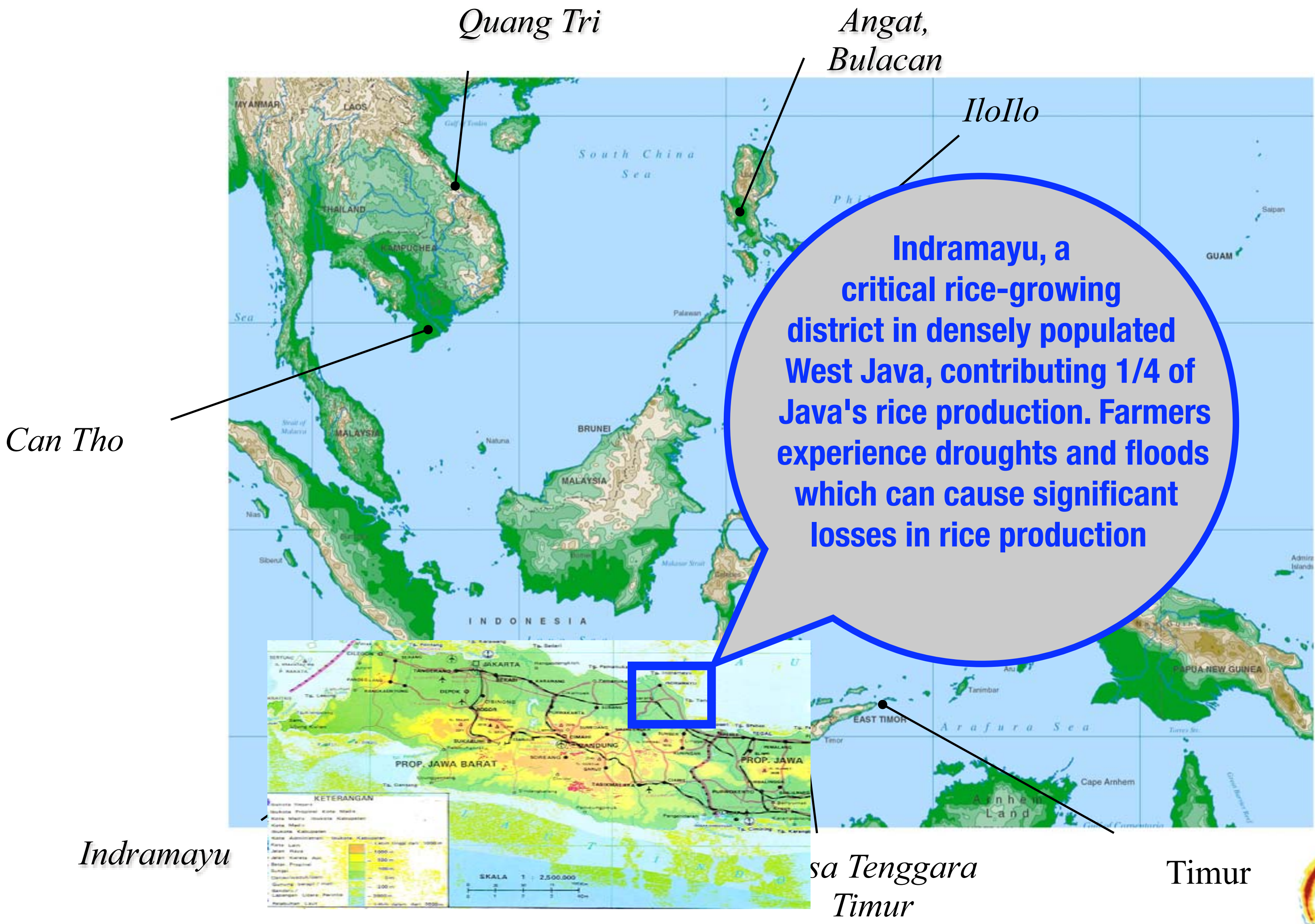
- "dynamical downscaling" requires 6-hourly archived 3-dimensional dynamical fields at the lateral boundaries: - very costly in storage!
- multi-model GCM ensembles (~100 members) present problems for RCMs in terms of both CPU and storage costs
- RCMs have their own model biases, so some statistical calibration may still be required
- may play a growing role in the future (although GCMs are themselves increasing in resolution)
- powerful tool to aid understanding of small-scale climate processes
- important capacity building role in developing countries



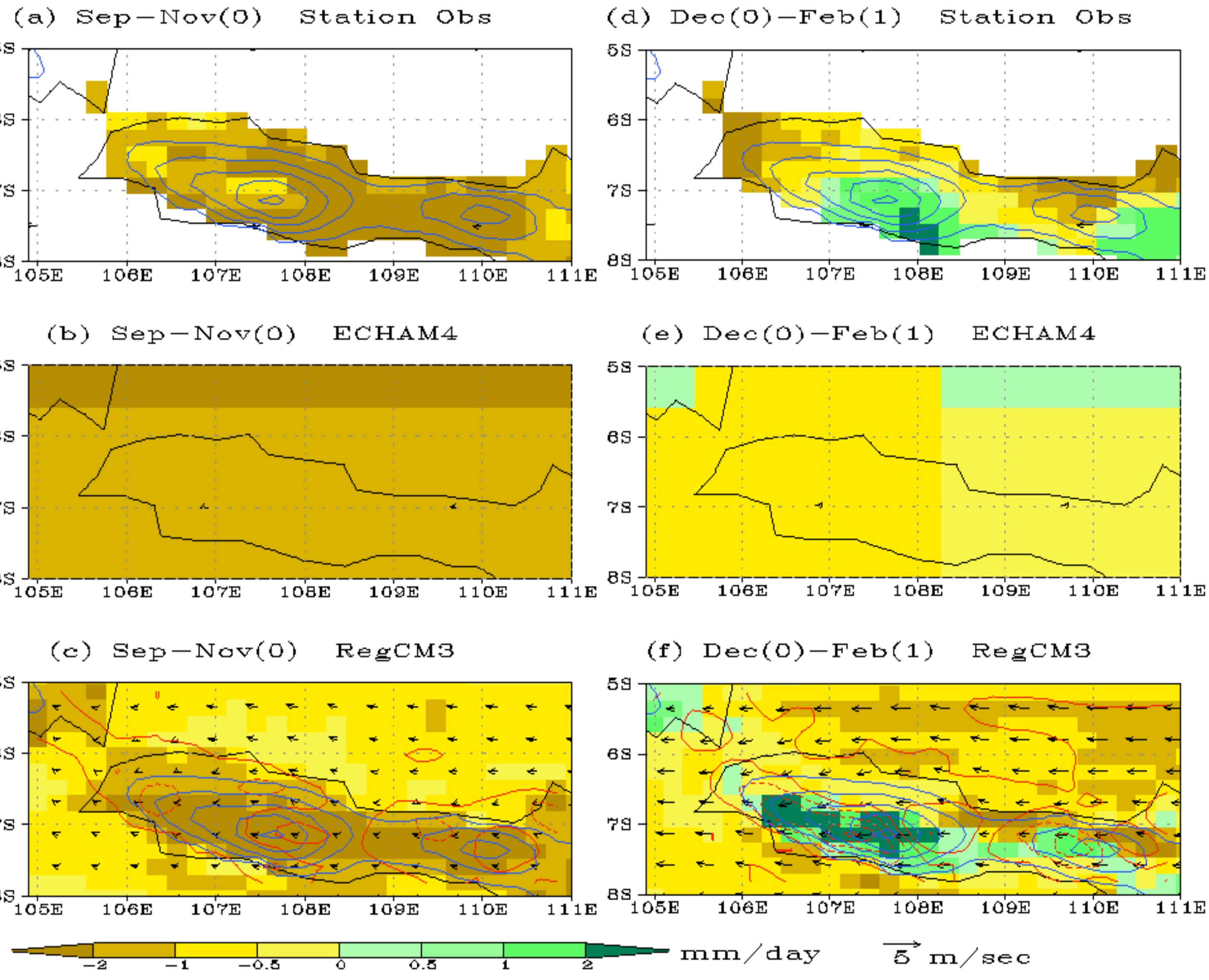

MOS Skills (Pearsons Correlation)
djf 1971-1998
RegCM3 MOS
ECHAM4.5 MOS
18N
15N
12N
9N
6N
3N
EQ
3S
6S
9S
12S
15S
90E 95E 100E 105E 110E 115E 120E 125E 130E 135E
0.5
0.3
0.1
-0.1
-0.3
-0.5
MOS Skills (Pearsons Correlation)
djf 1971-1998
RegCM3 MOS
ECHAM4.5 MOS
18N
15N
12N
9N
6N
115E 120E 125E 130E
CLIMATE PREDICTA
TOOL
Evaluating seasonal climate predic
Designed for MOS applicatio
IRI
INTERNATIONAL RESEARCH
FOR CLIMATE AND

Climate risk management: Demonstration sites in SE Asia

Diversity of climate hazards + socio-economic systems
Multi-scale partnerships



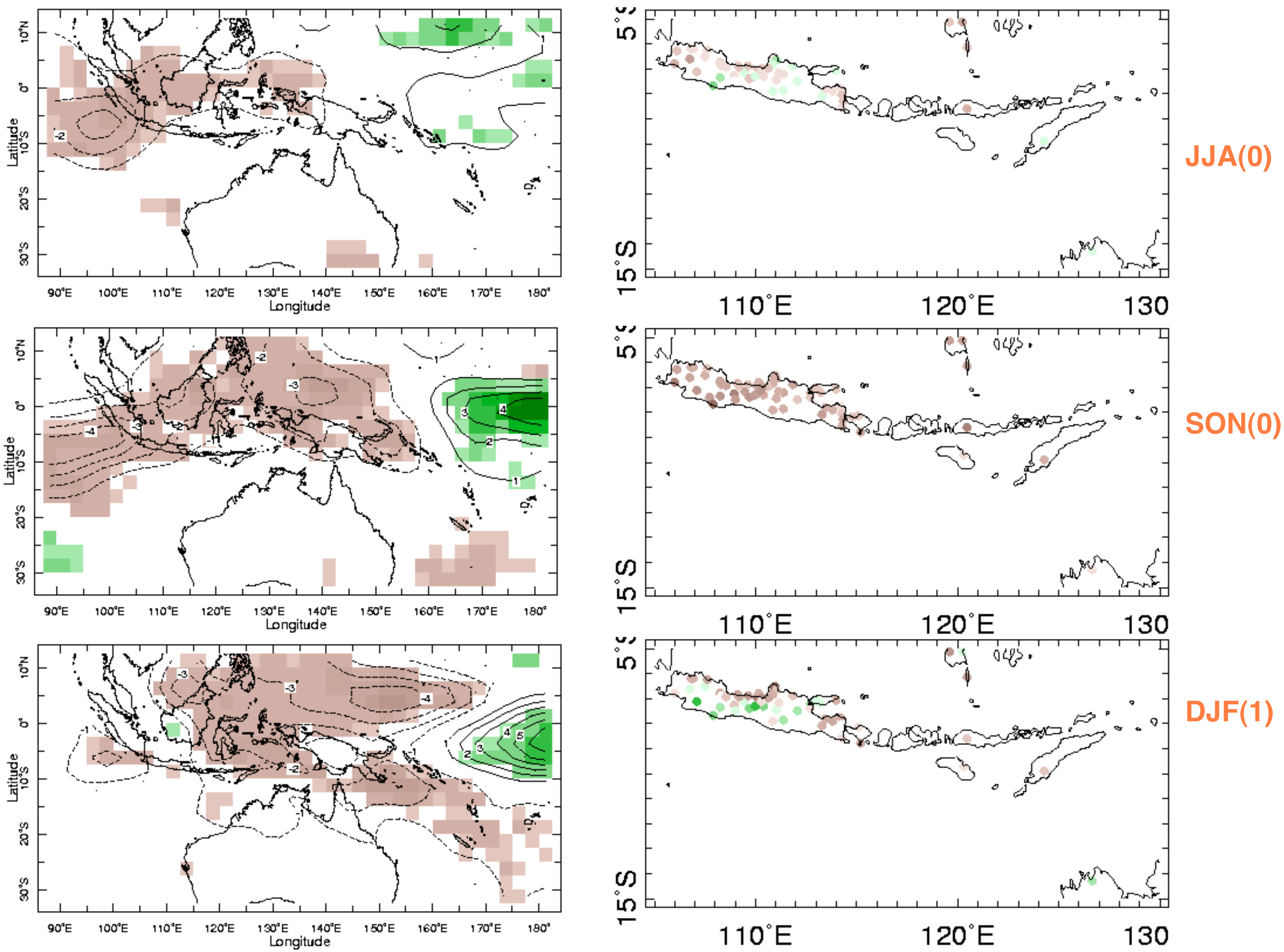
An example of RCM use : recovering subgrid scale teleconnections in Java



(El Nino – Climatology) composite of seasonal precipitation (mm/day; shaded), low–level winds (m/s, vector) and divergence (red contour interval is 1e–5 in c&f). Top panels: observation, middle: ECHAM4, bottom: RegCM3. Terrain heights are shown by blue contours (interval 200 m)
El Nino years: 72/73, 82/83, 86/87, 91/92, 94/95, 97/98; Java Indonesia

(Qian et al., GRL, in press)

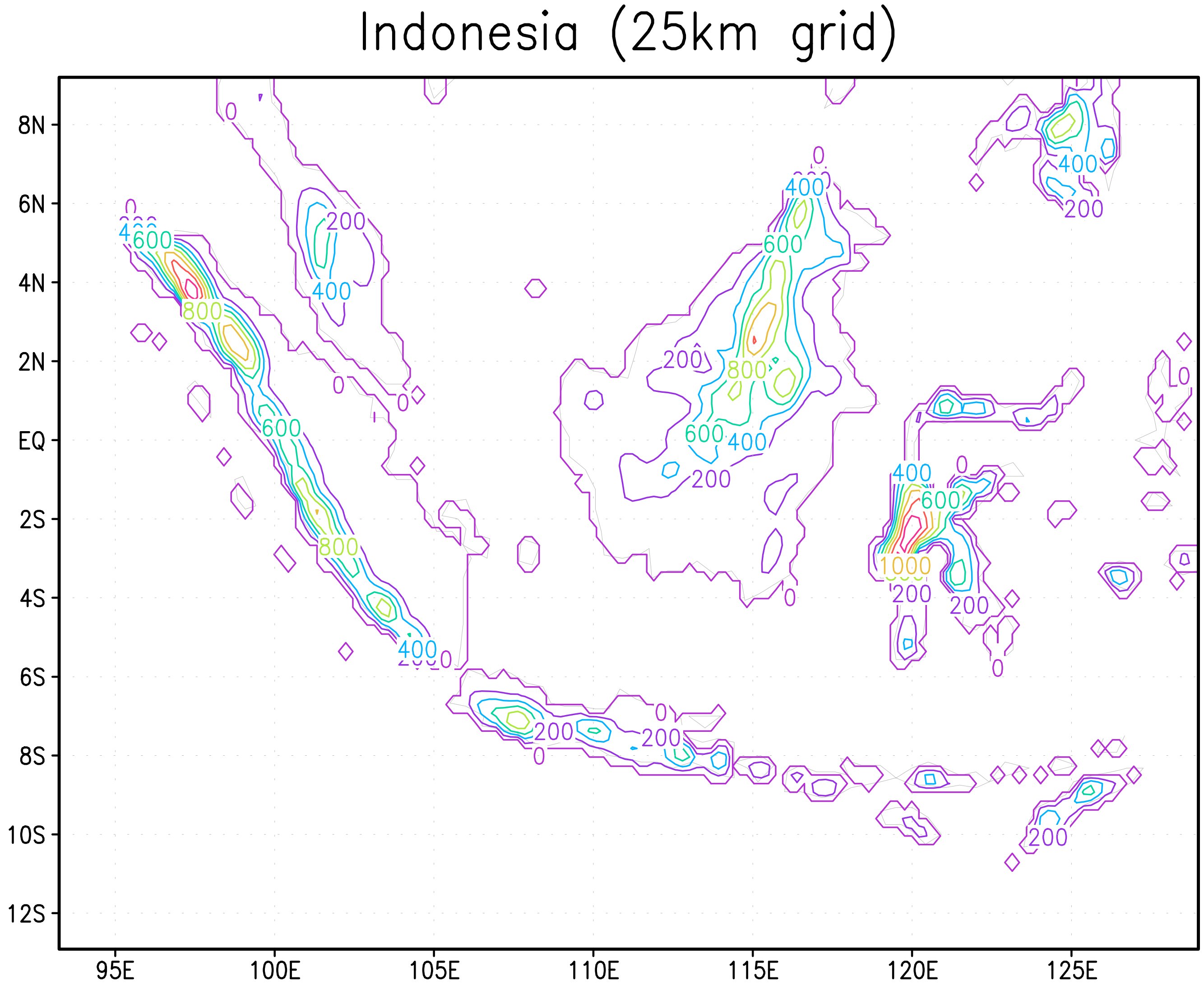
From the large-scale context to a regional setting



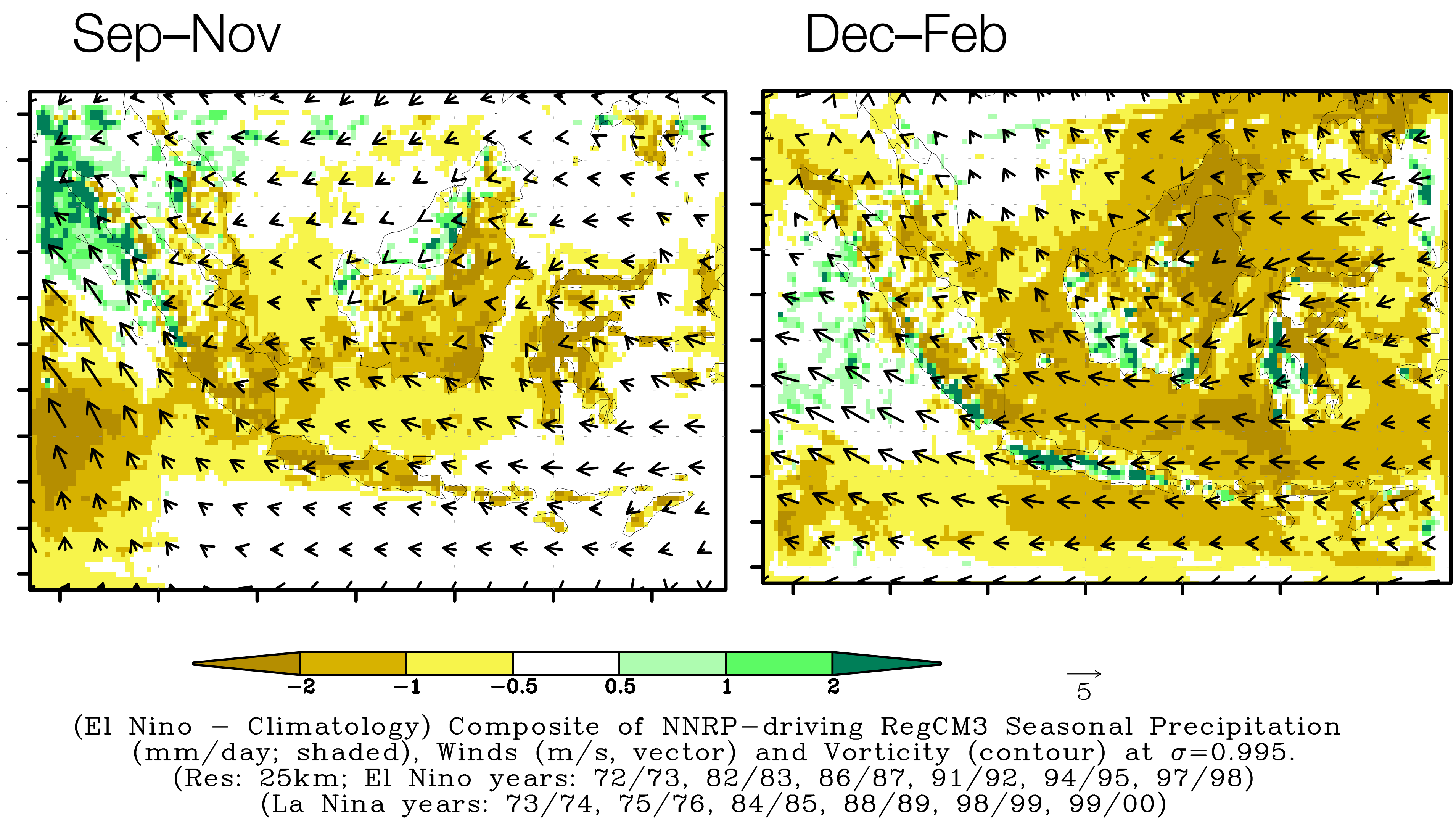
NASA/GPCP prcp

NOAA/NCDC/GHCN prcp

reanalysis forced RegCM3 simulations

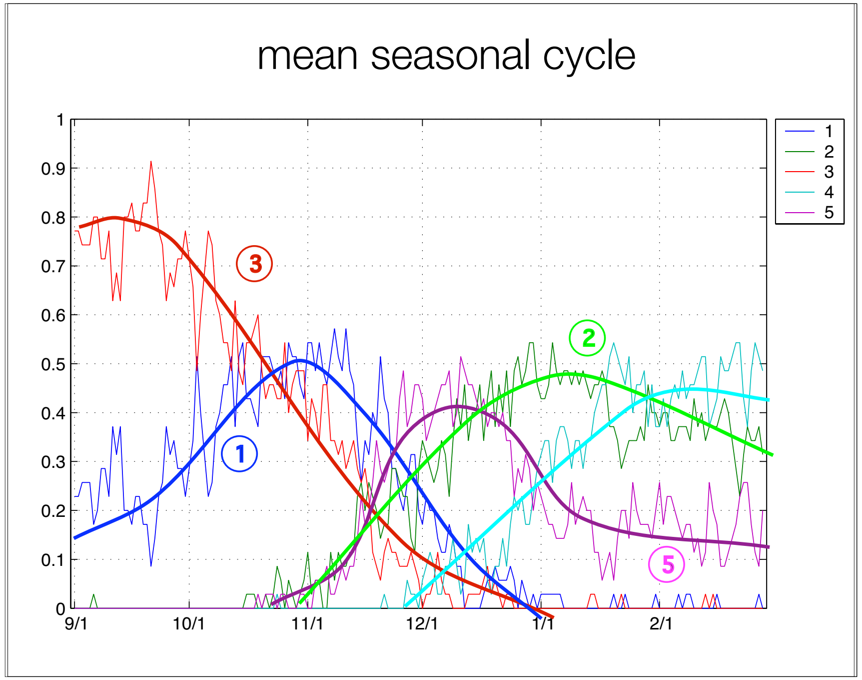


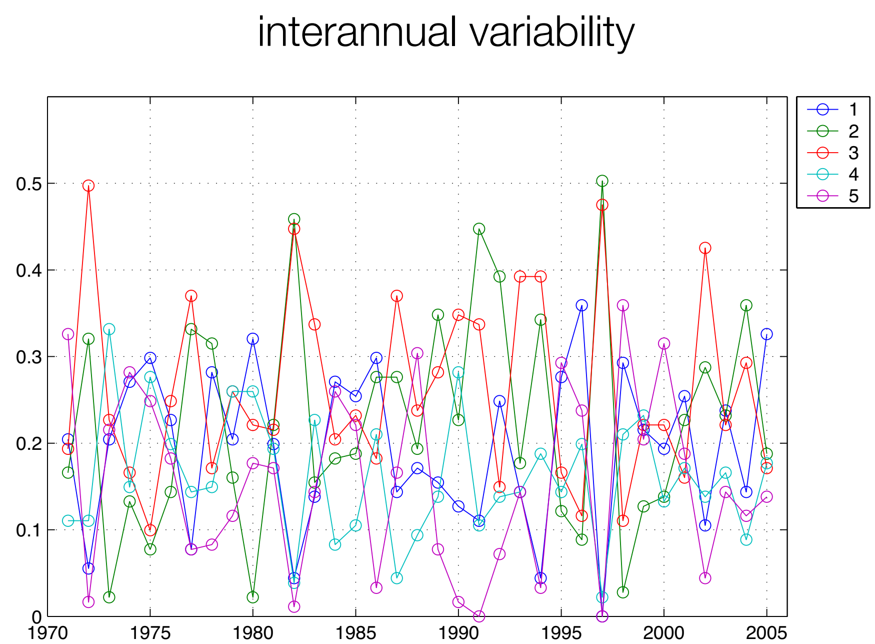
RegCM3 precip & sfc wind anomalies: El Niño minus climatology (6 yrs)



weather types

- k-means, 5-cluster solution in PC subspace of 850hPa standardized NCEP reanalysis daily winds



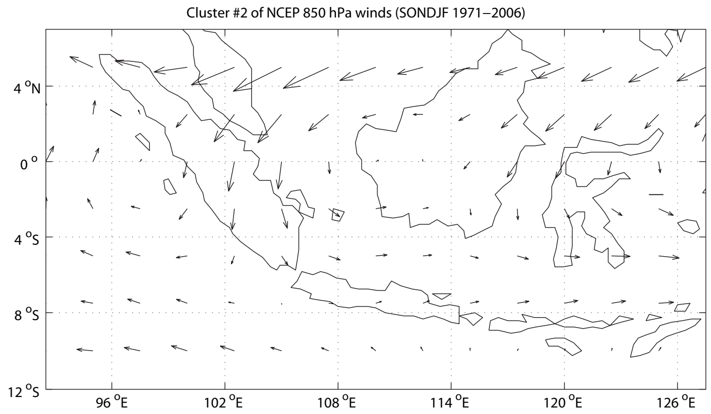


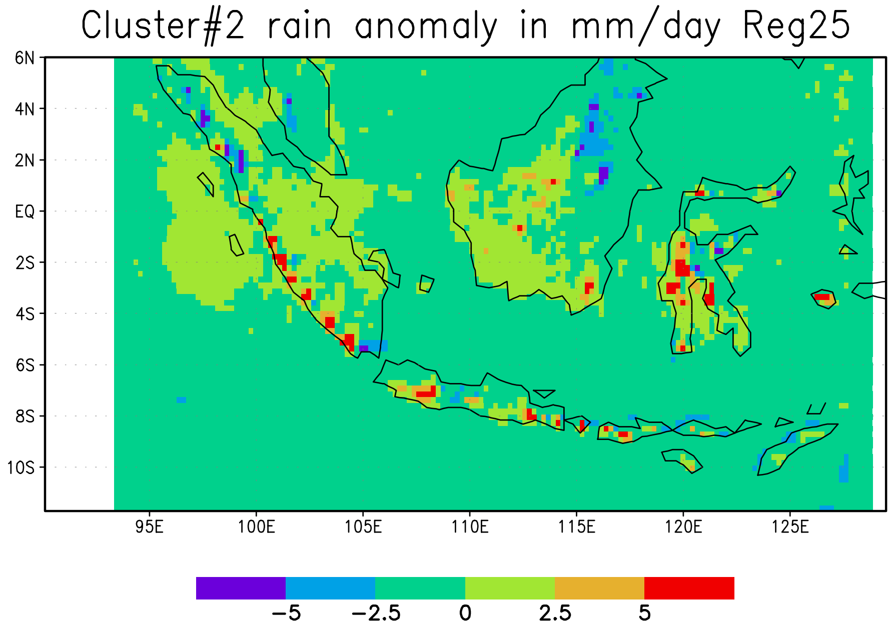
EN: more of 3 (early) & 2 (late)

LN: more of 1 (early) & 5 (mid)

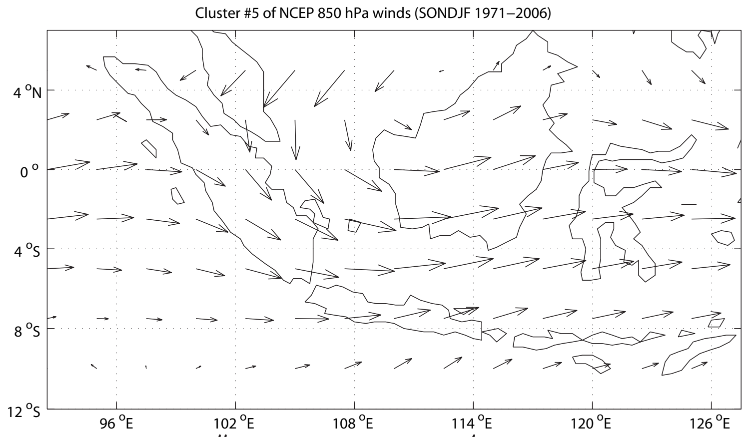
wet-season weather types

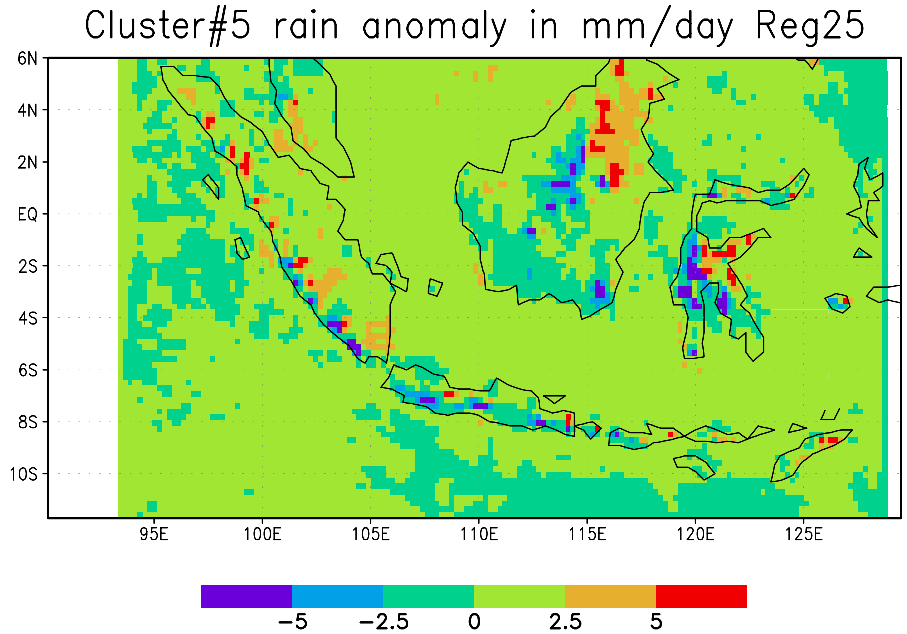
“El Niño”





“La Nina”

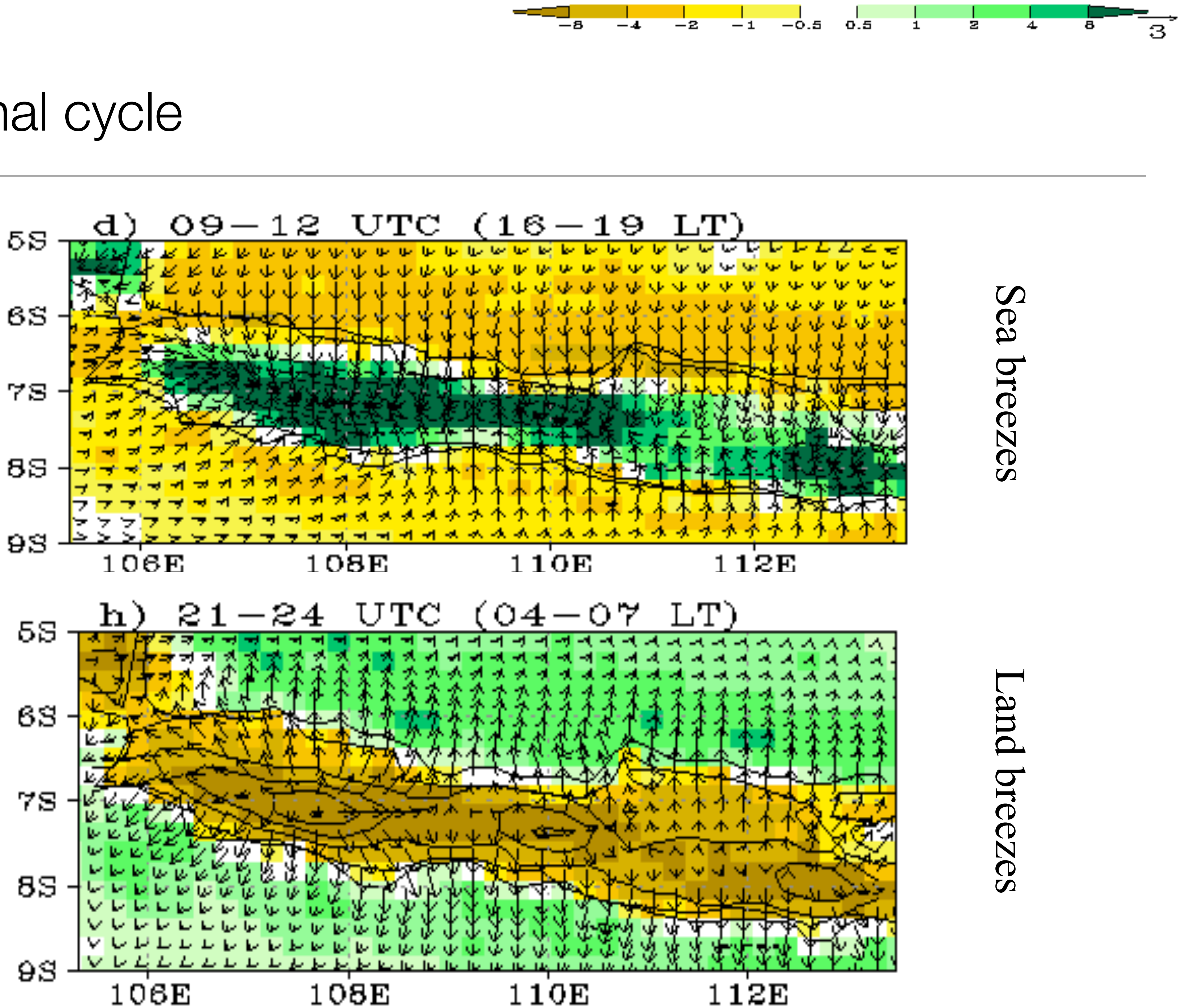




hypothesis

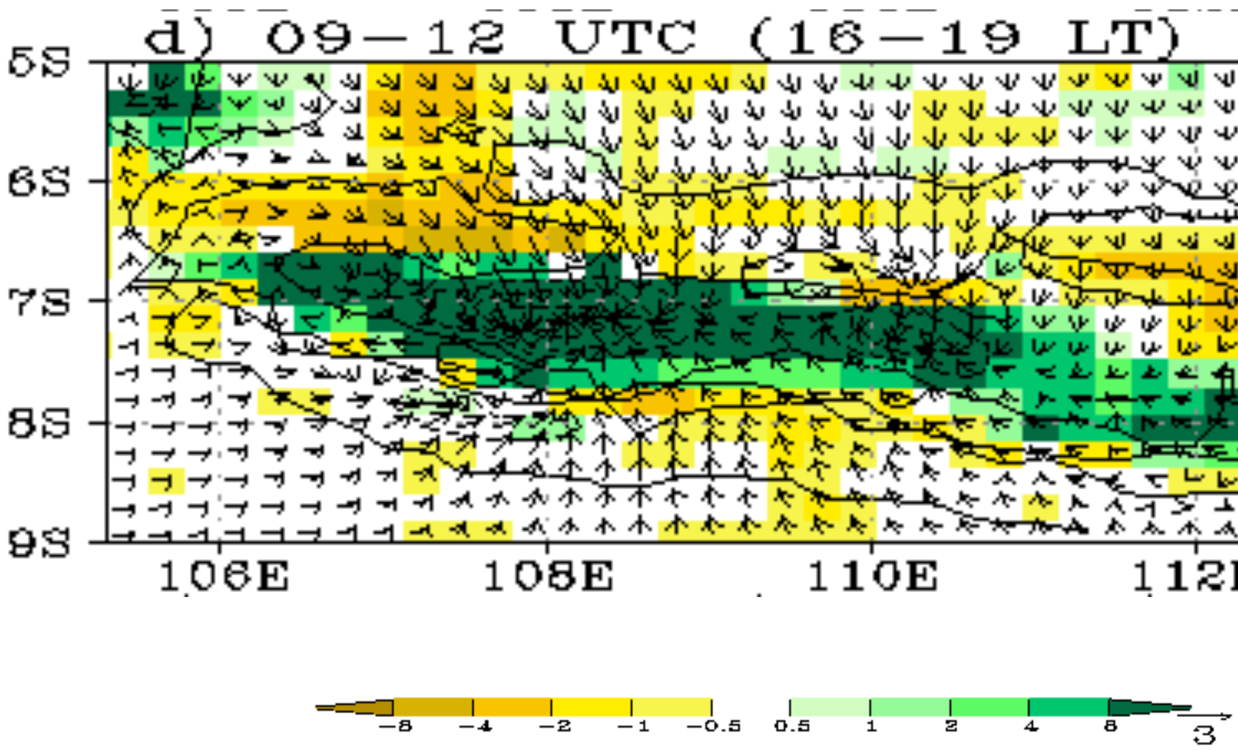
- the “dipolar” rainfall anomalies seen during the wet season (DJF) El Niño years are due to weak large-scale monsoon flow
- this favors a pronounced diurnal cycle with wet anomalies over the mountains

diurnal cycle



Effect of mountain-valley breezes on the diurnal cycle of rainfall over Java

(Control run – flat island run)



summary

- climate risk management framework: synthesis of historical, monitored and forecast information, optimized for identified sectoral decision points
- statistical tailoring methods for climate forecasts to local quantities (weather, sectoral) of relevance
- seek quantities that are both relevant *and* predictable, e.g. number of dry days, or monsoon onset
- important roles for RCMs in furthering understanding of local-scale variations in historical risks and forecasts, and in capacity building in developing countries