On downscaling methodologies for seasonal forecast applications

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Interfacing seasonal forecasts with applications ...

- goal of reducing climate-related risks in diverse sectors, often in developing country settings
- while the skill of climate models may have plateaued, there is an important opportunity to increase the *usable* skill of seasonal forecasts
- evidence that tailored quantities like dry-day frequency is generally more predictable than the seasonal total at the station scale
- ultimately need to recast the downscaling problem in terms of sectoral variables, such as reservoir inflow, crop planting decisions (sowing date, crop variety ..) by interfacing climate forecasts with sectoral models for reservoir management, crops, index insurance etc
- important implications for downscaling methodologies

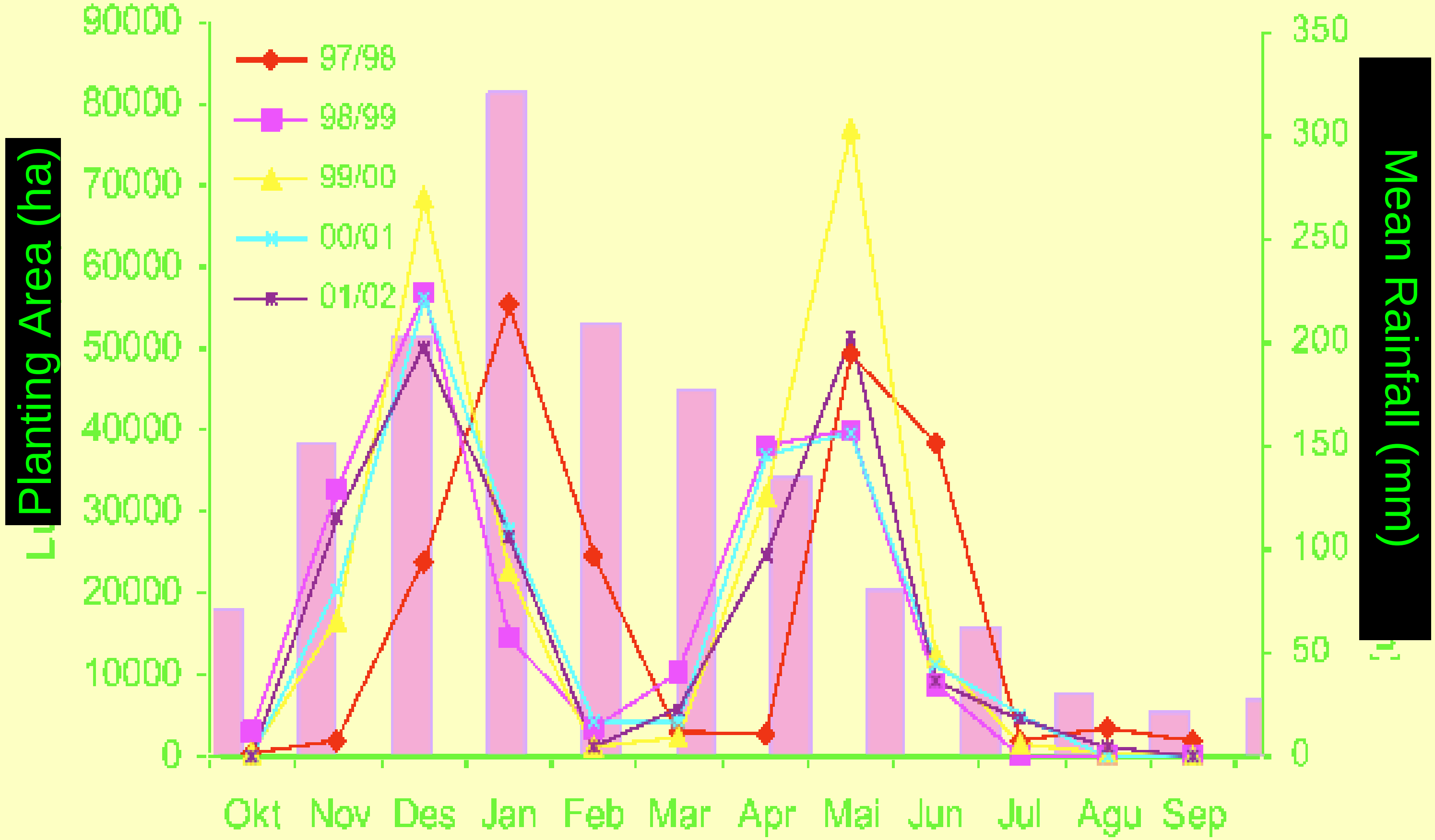
Outline

1. Examples from agriculture, reservoir management and health sectors
2. A possible way of translation from seasonal predictability toward intra-seasonal time scales : example of frequency of dry days vs. seasonal total
3. Methodologies for downscaling to daily weather sequences
4. Role of regional climate models
5. Conclusions

AGRICULTURE …

Indramayu is a small area lying on the northern coast of Java near 107°E and 6.5°S

Kab. Indramayu



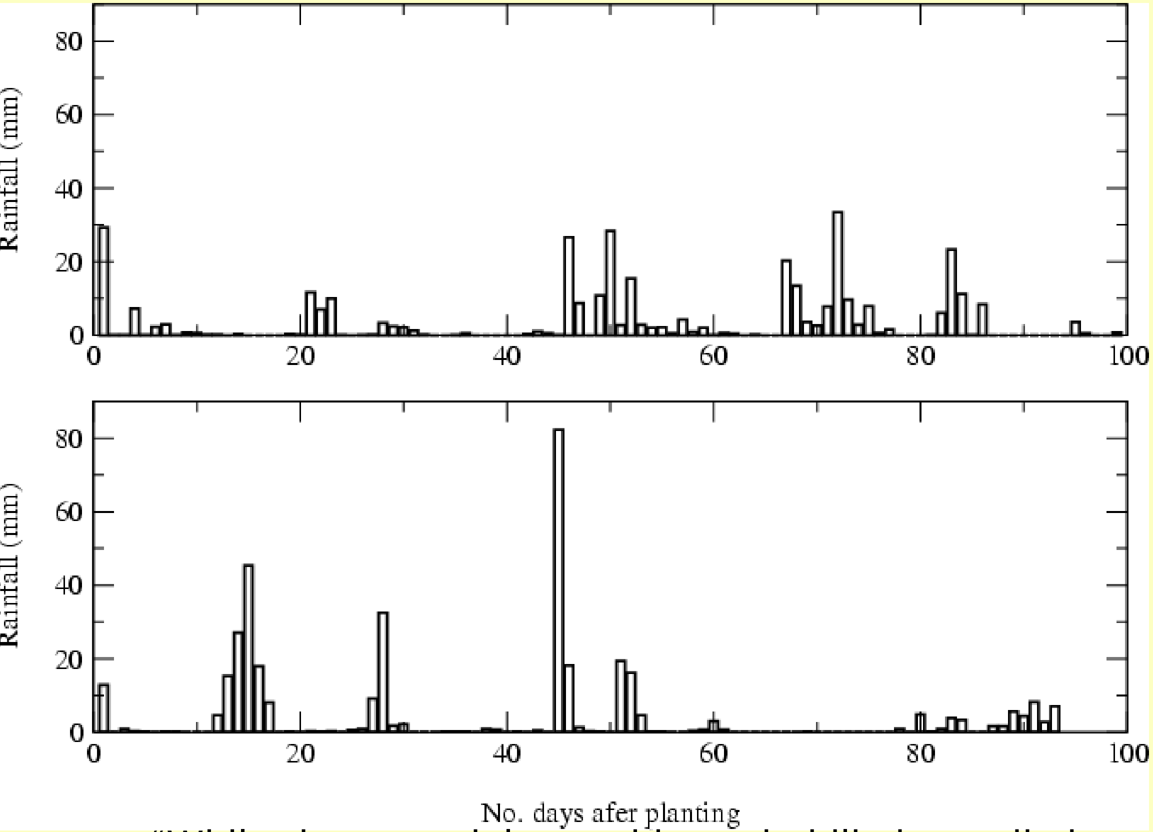
- critical end-users needed information : onset and retreat of rainy season ~ planting dates

- more generally : **phase, frequency of occurrence, persistence and intensity of daily rainfall** are crucial for the amount of yields

- climatic key-variable = daily sequence of rainfall at local-scale

(courtesy of Pr. Rizaldi Boer, Bogor Agricultural University, Indonesia)

EFFECT OF FREQUENCY & SHAPE OF WET SPELLS VS SEASONAL AMOUNTS …



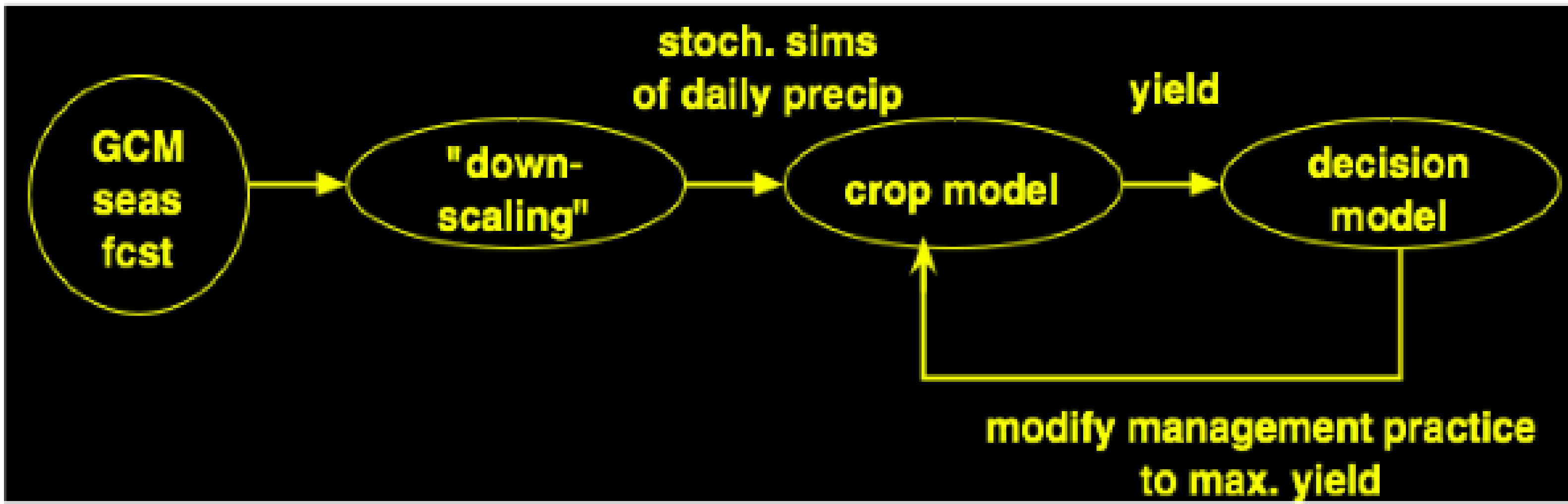
1975
Total rainfall: 394mm
Model: 1059 kg/ha
Obs: 1360 kg/ha

1981
Total rainfall 389mm
Model: 844 kg/ha
Obs: 901 kg/ha

"While these models provide probabilistic predictions of the seasonal mean climate they also produce daily time series of the evolution of the weather and therefore provide information on the statistics of the weather during the crop growing season. Of prime importance is that these daily time series can be used to drive crop simulation models" (Challinor et al. 2003).

(source: Roger Stone)

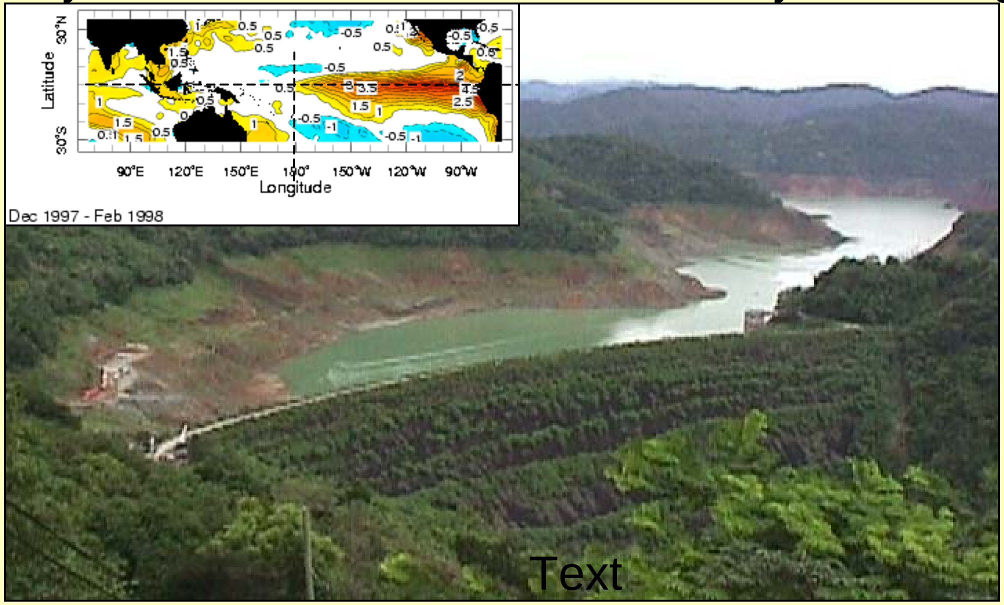
bridging **C**limate into **R**isk **M**anagement



.. crop model can act as a non-linear temporal integrator

HYDROLOGY …

Interannual Variability of Seasonal Rainfall in Luzon is Closely Tied to Large Scale Changes in SST…



1998
Philippines Drought

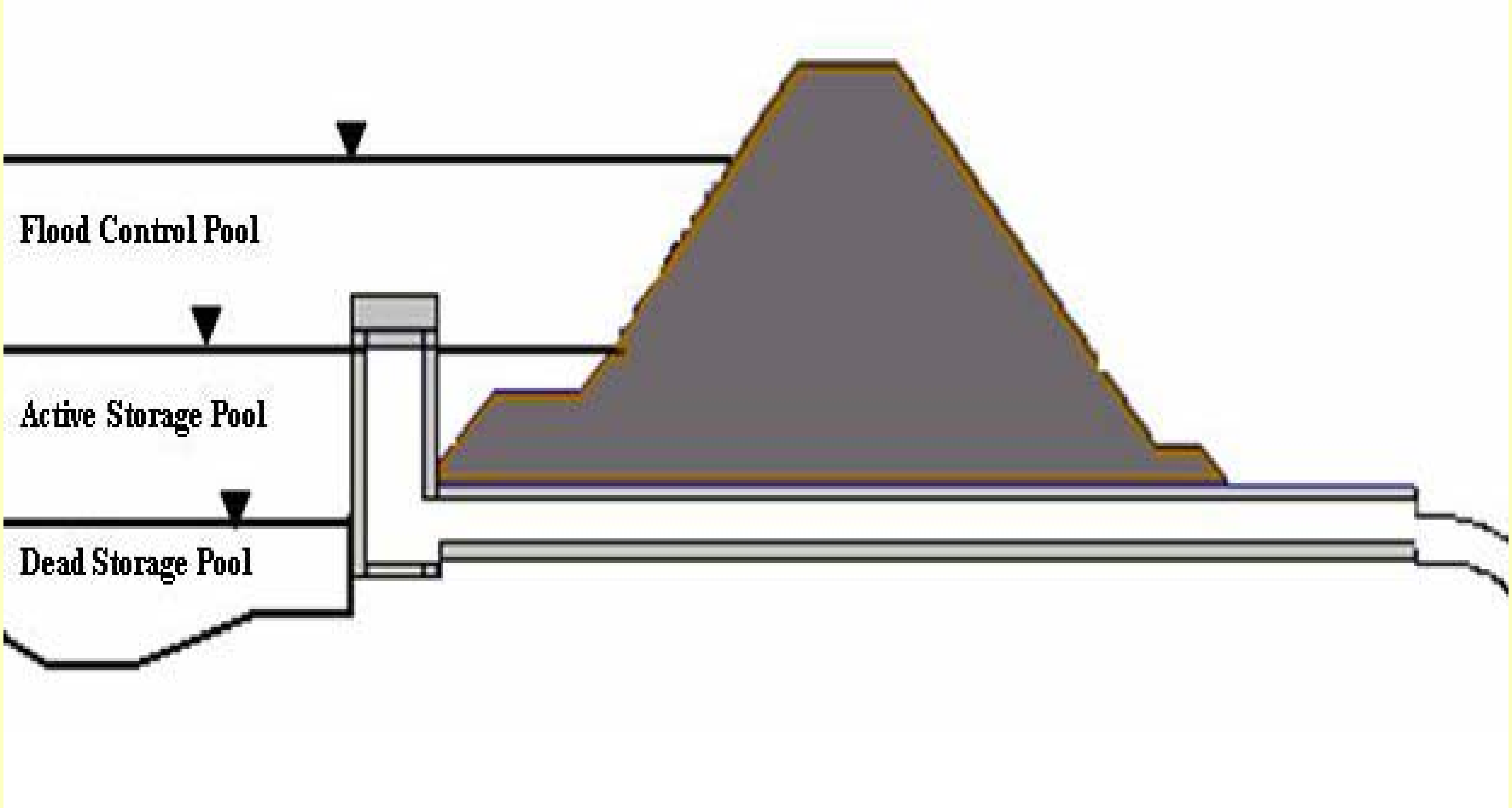
Drought during the 1997-98 El Niño affects the Angat Reservoir, Philippines

Photo credit: MWSS

1999
Flooding in the Philippines

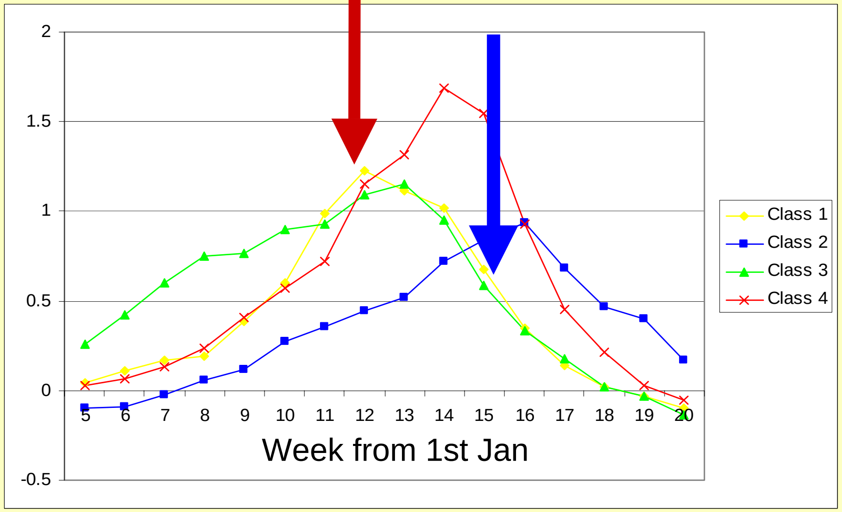
Photo credit: Reuters

Typical Reservoir Storage Allocation

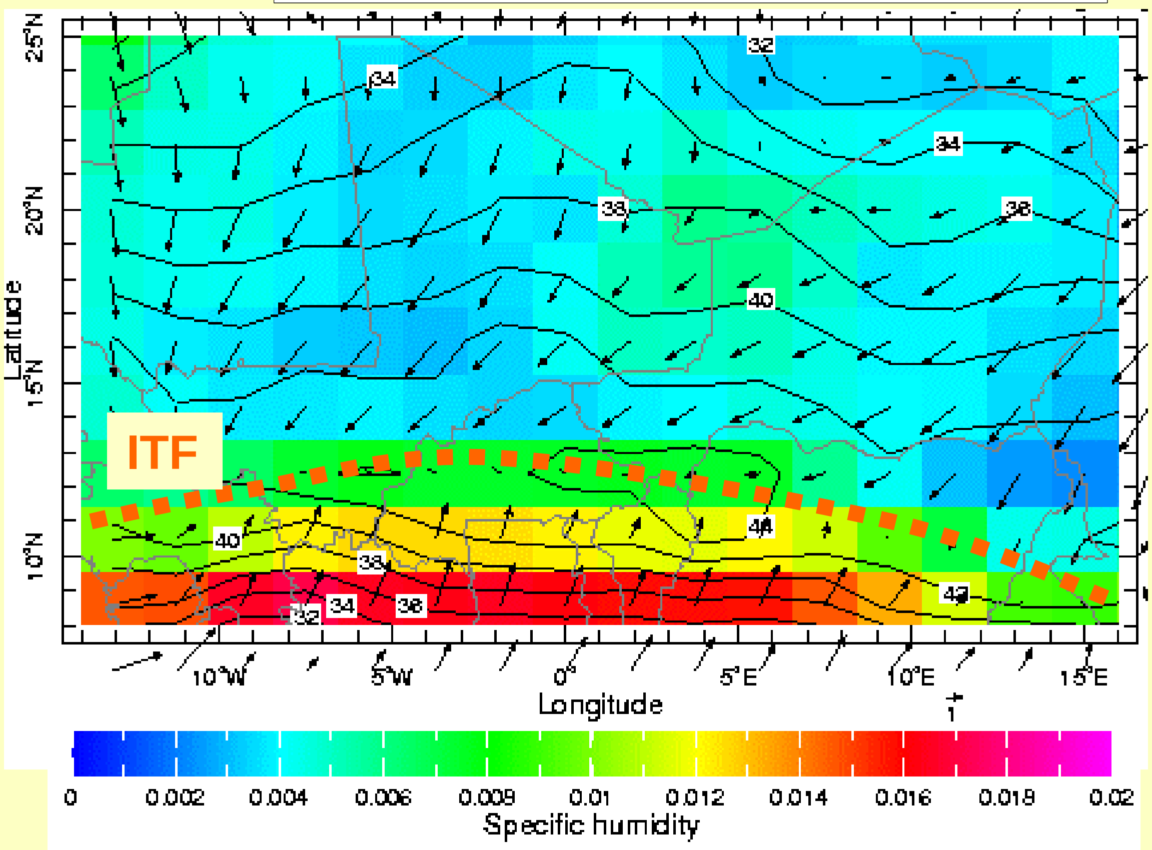


- climatic key-variable = **daily-to-weekly sequences of rainfall on the basin-scale through the whole rainy season**

HEALTH …



Example of weekly incidence of meningitis in central Sahel (4 belts)



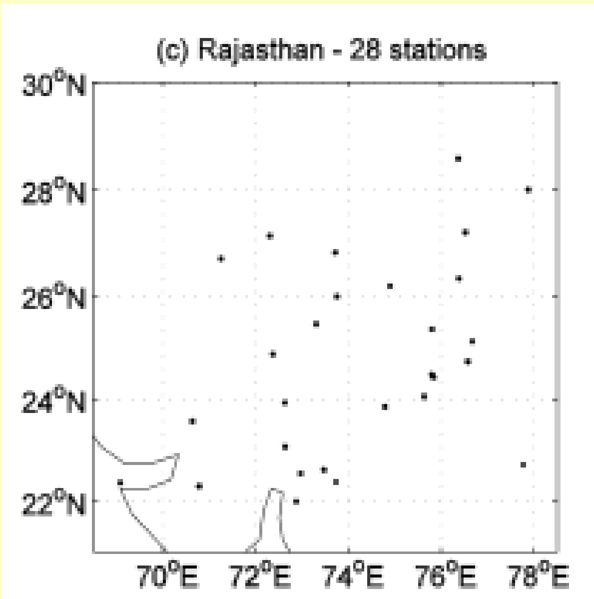
= peak in central Sahel (class 1) associated with highest temperatures, in the region of convergence between Harmattan and southwesterlies and termination linked to arrival of moister, cooler and cleaner air

-critical end-users information : phase & speed of the advance of ITF

- climatic key-variable here : **weekly sequence of temperature, specific humidity and wind**

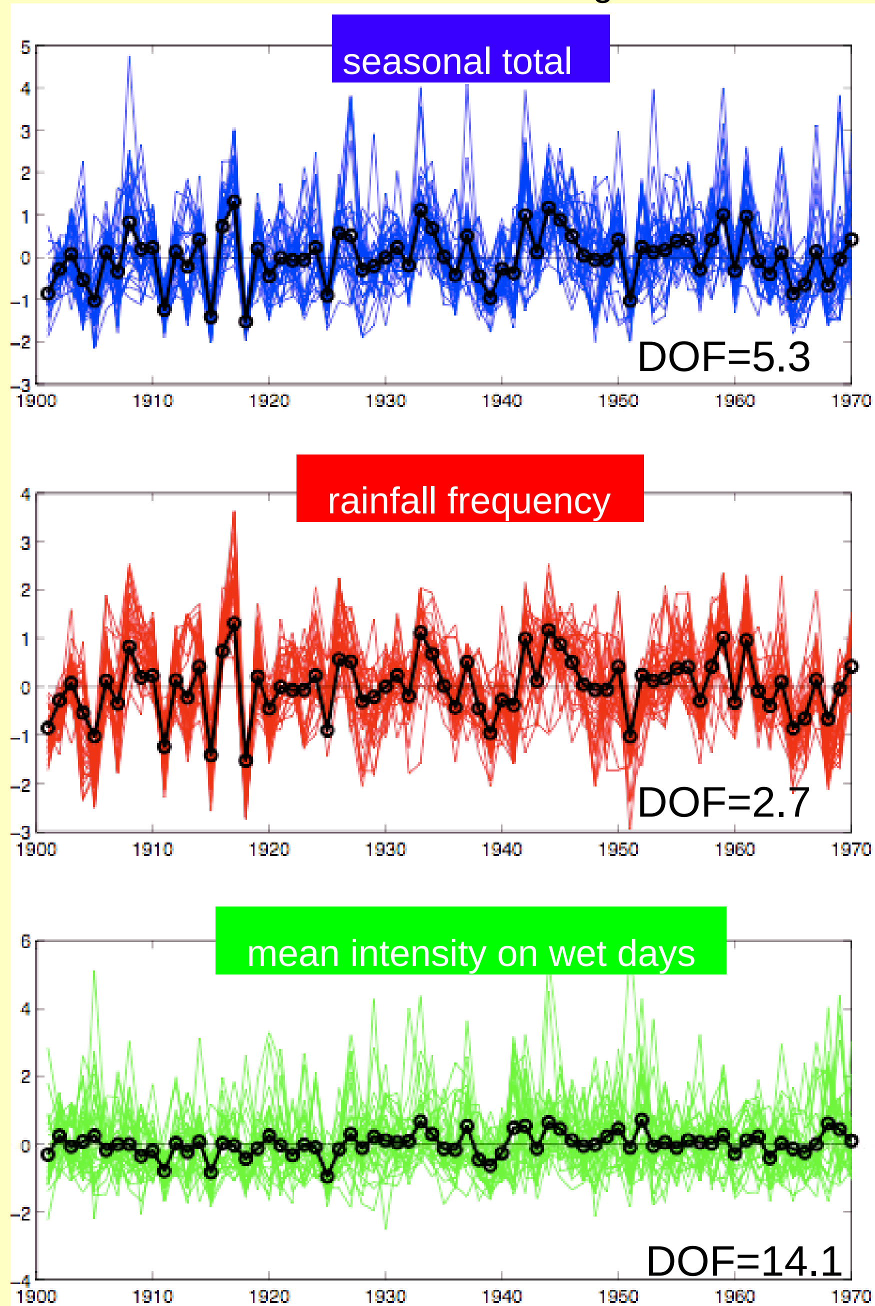
(courtesy : S. Trzaska)

PREDICTABILITY OF INTRA-SEASONAL PROPERTIES …



Jun–Sep
1901–70

Rainfall at individual stations
and station-average

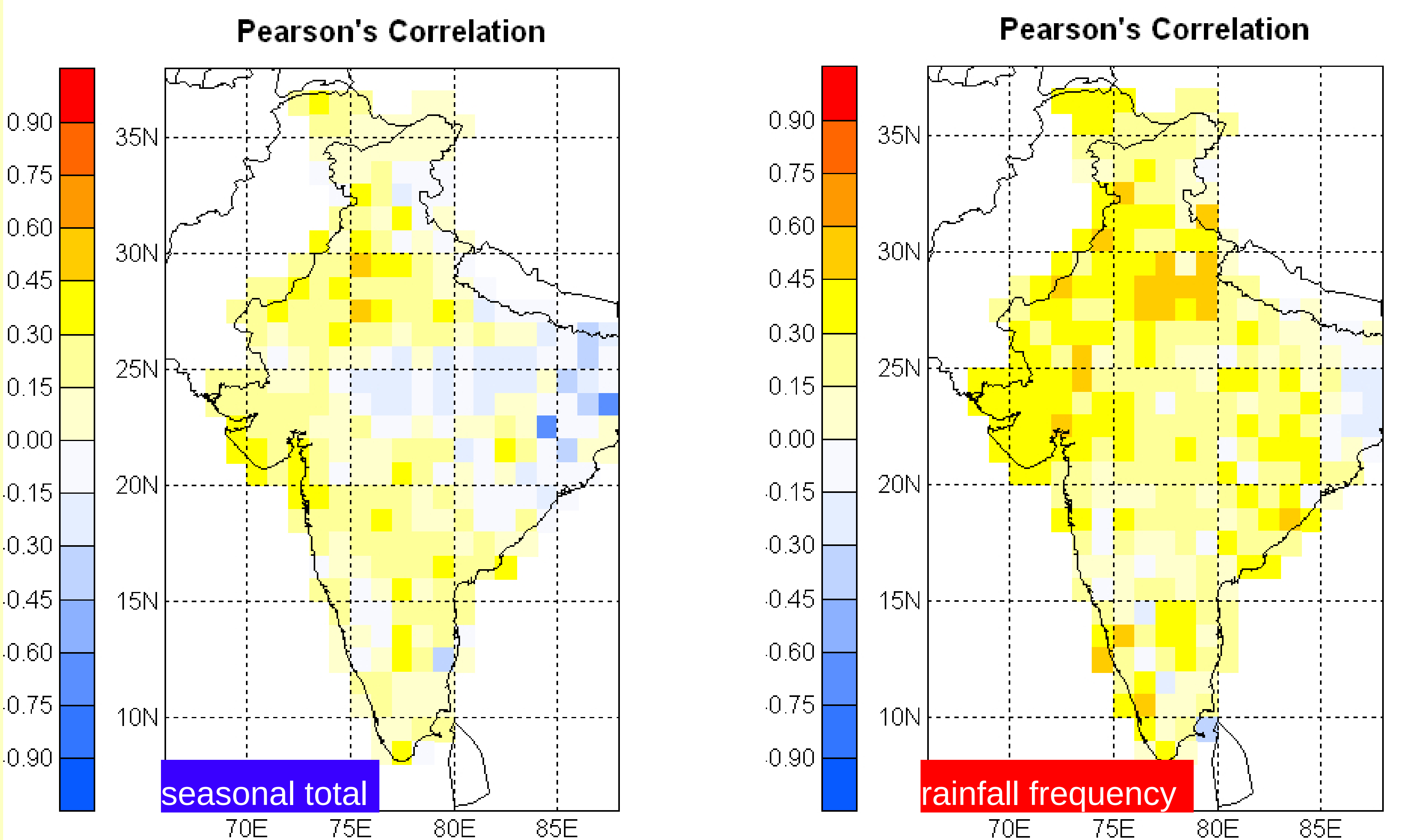


seas. amount =
(no. of wet days) x (mean intensity on wet days)

details in poster (# 8, session III)

(Moron et al., J. Clim, in press)

Jul–Sep anomaly correlation skill from July 1:
CCA [ECHAM4-constructed analogs precip (60E-180E, 10S-30N) , IMD]



rainfall frequency = $N_{wet}/N = (N - N_{dry})/N$

two basic ways to make seasonal predictions of weather statistics

1. any transfer function, linear or nonlinear using the statistic of interest as the predictand:

   $\mathbf{y} = \mathbf{A}\mathbf{x} + e$

   where **y** is a seasonal-average quantity:

   i. number of dry days at a station

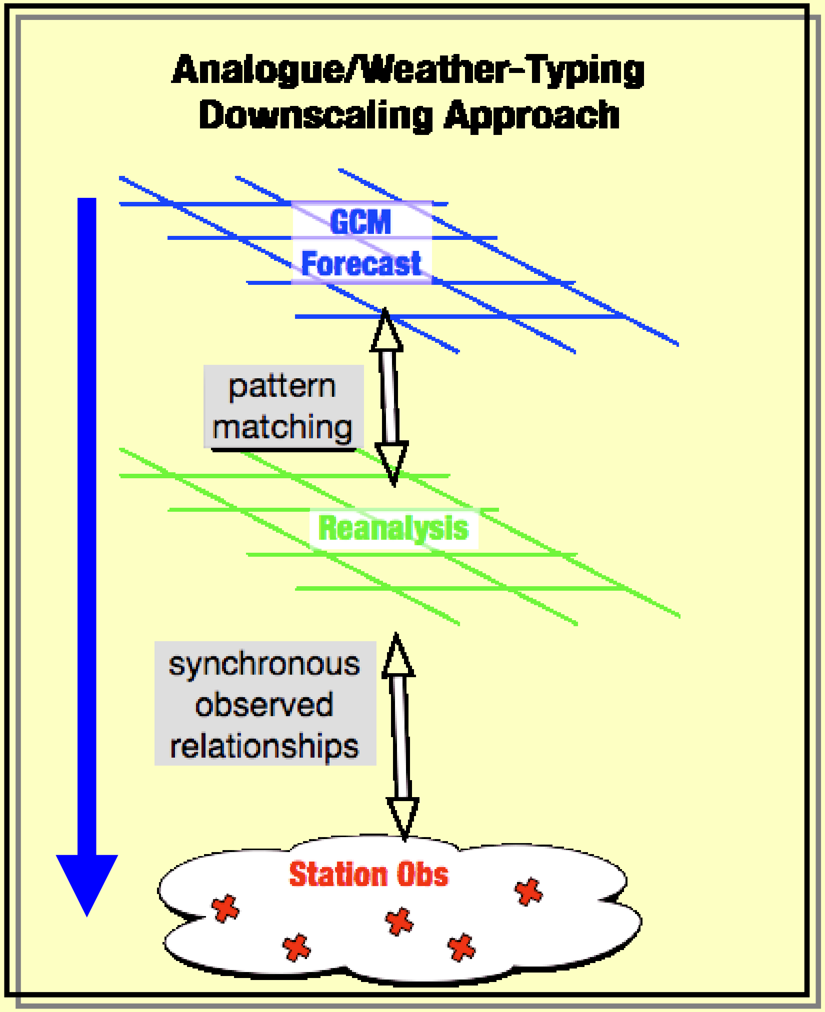
   ii. number of dry spells of 10 days or longer (or anything else as onset date etc.)

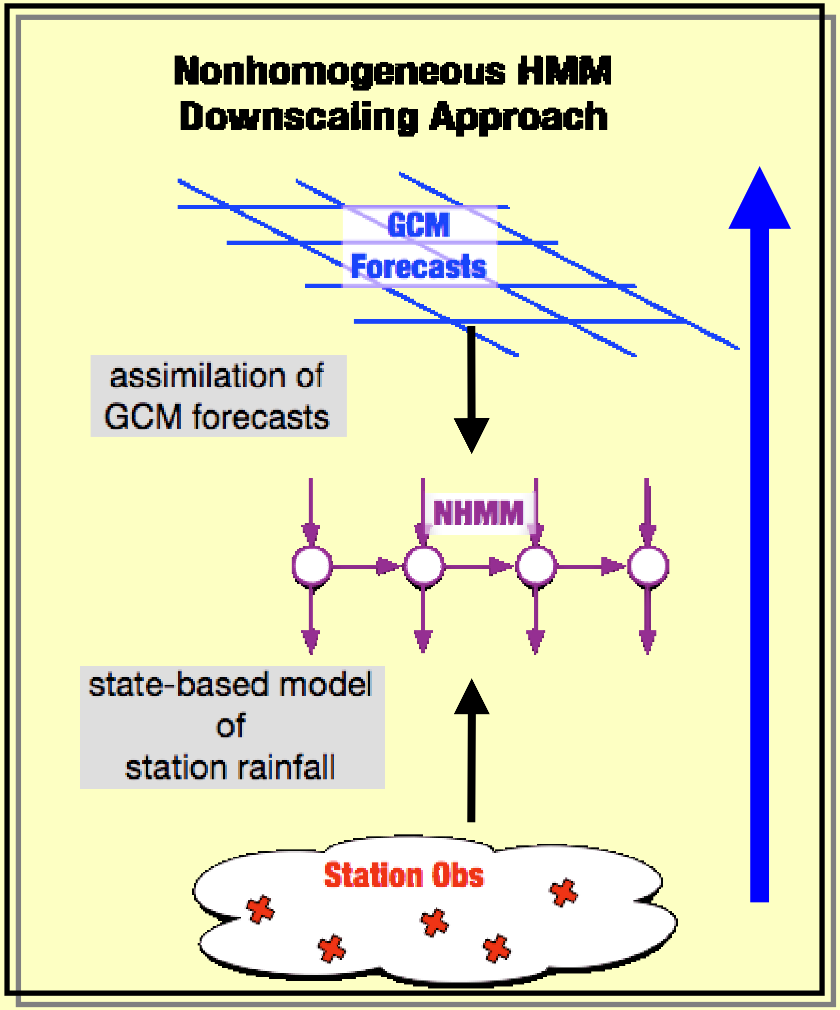
   - the regression model is trained using observed estimates of **y**, and GCM hindcasts **x**. Then, given a GCM forecast $\mathbf{x_f}$, we can predict $\mathbf{y_f} = \mathbf{A}\mathbf{x_f}$ directly.

2. Use a method to obtain daily rainfall sequences from the GCM forecast. Then simply construct the needed statistic from the predicted daily sequences. The advantage is that daily sequence can be used in crop or hydrological models but the statistical model is a little bit more complicated to optimize

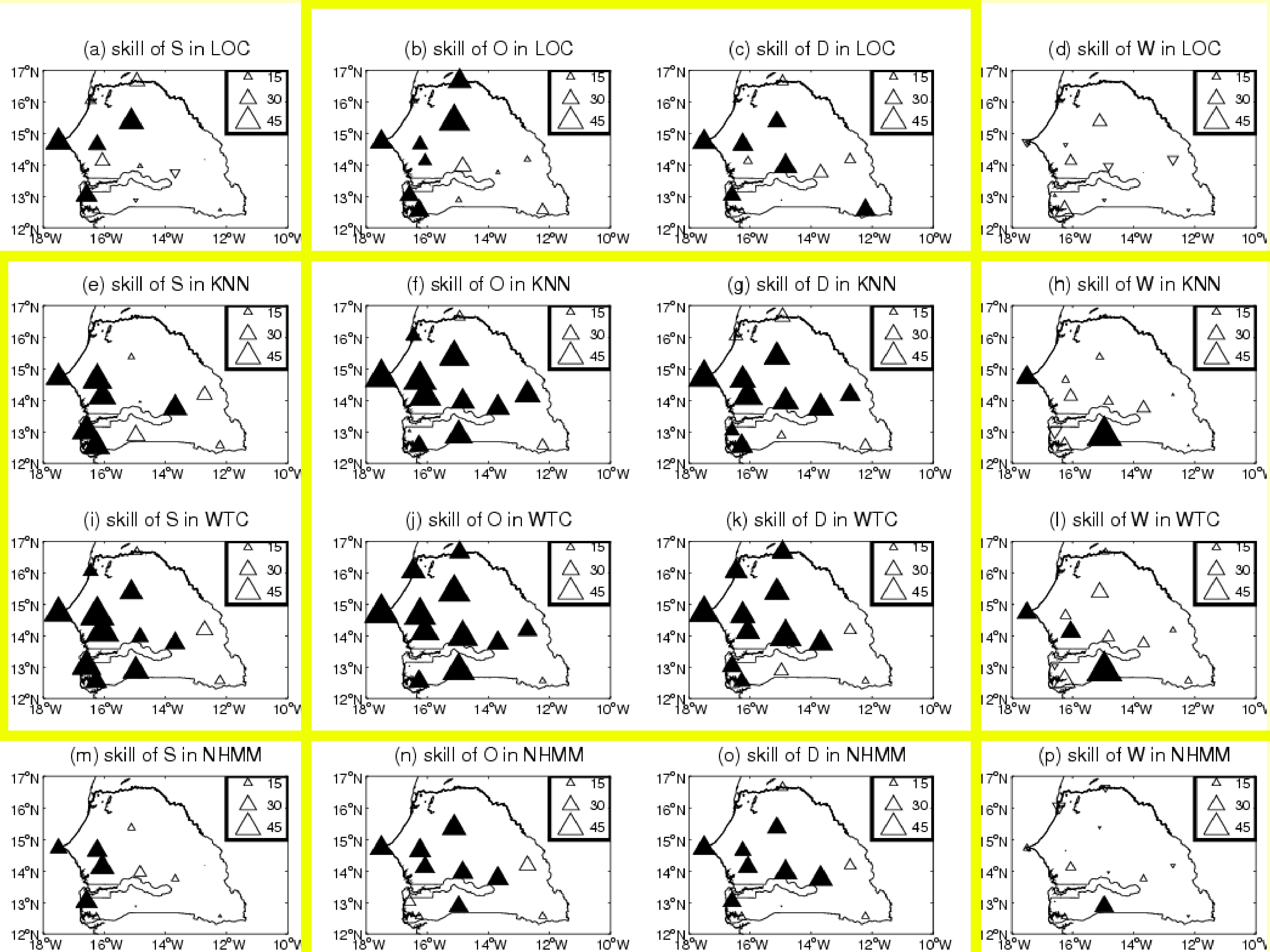
Example of methodologies for downscaling to daily weather sequences (method 2)

- analog techniques (KNN, WT)
- weather generators (e.g. NHMM)





An example of intercomparison of *4 methods* for statistical downscaling of ISV characteristics in Senegal from hindcast SST-forced AGCM (method 2)



Local scaling

K nearest neighbor

Weather type

Non-homogeneous HMM

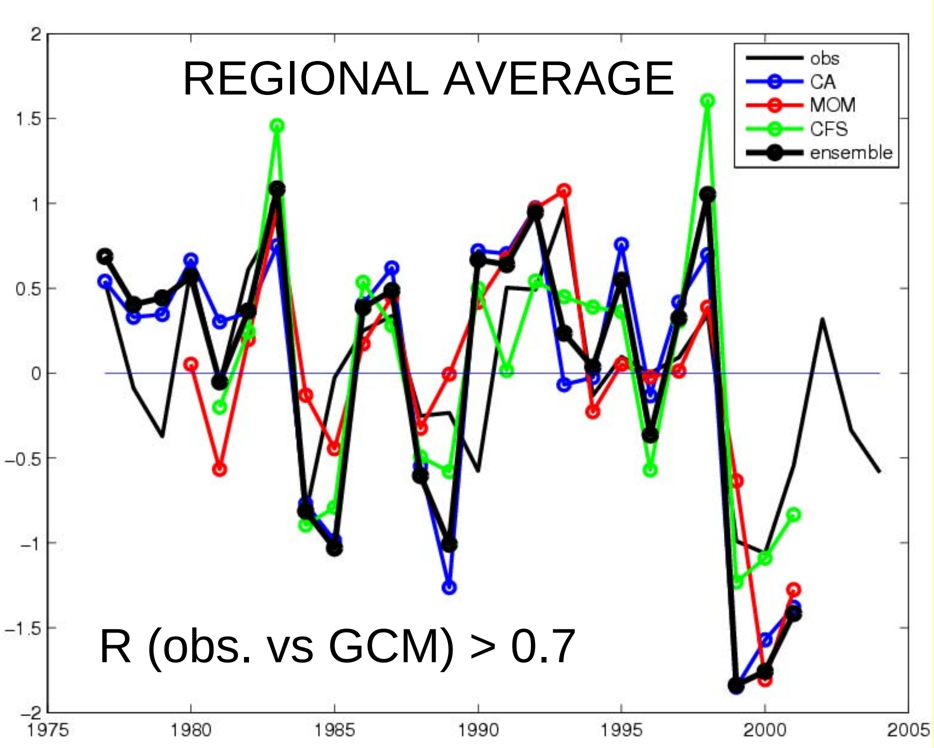
seasonal amount **nb of wet days** **mean length of dry spells** **mean length of wet spells**

Skill = correlation (x 100) between observed and simulated ISV (from a 24 runs ensemble)

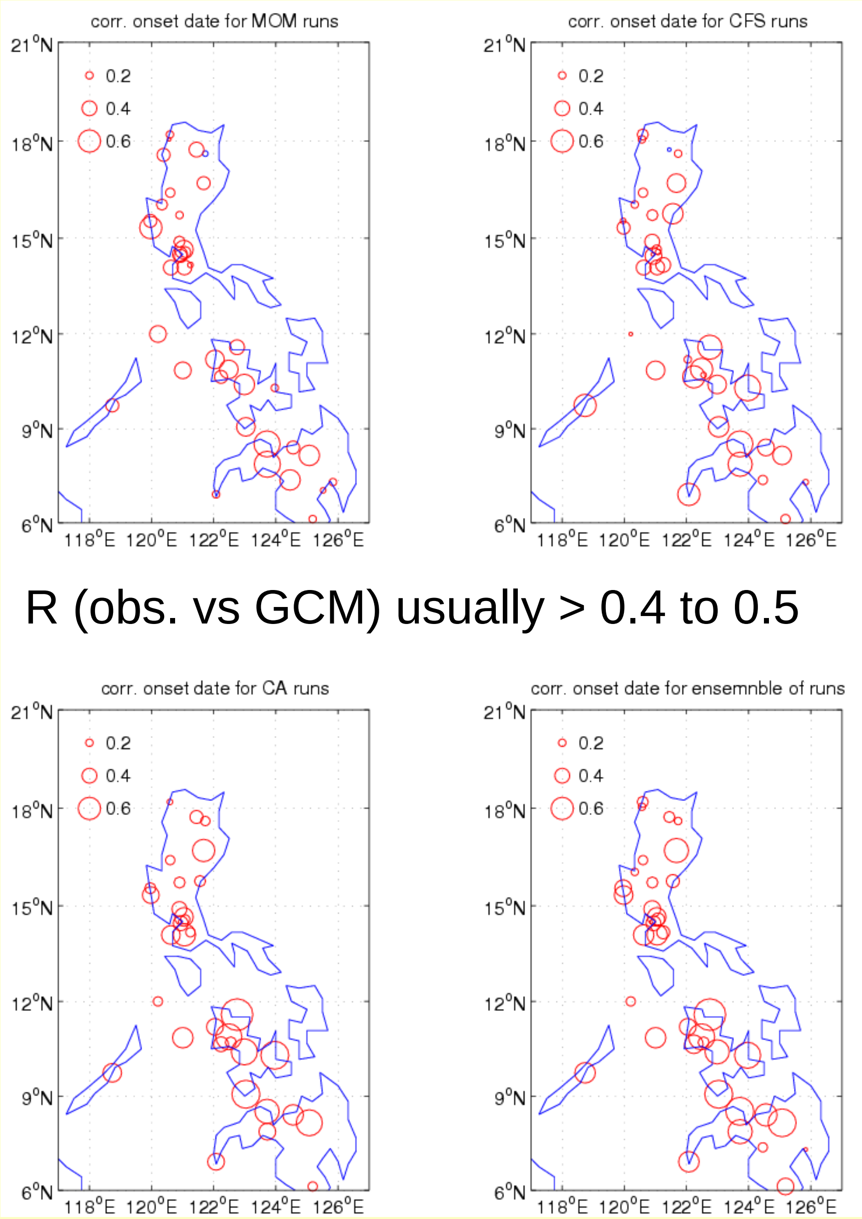
(Moron et al., J. Clim, in press)

An example of forecast of a specific ISV : the onset of boreal summer monsoon in western Philippines (around mid-May) by real-time forecast SST…
(with A. Lucero and F. Hilario, PAGASA, Philippines)

- observations from PAGASA (40 stations)
- CA = AGCM forced by forecast SST using constructed analogs (24 runs)
- CFS = Coupled GCM of NCEP (15 runs)
- MOM = Coupled GCM of IRI (7 runs)
- all runs are initialized from the 1st April for 6 months (varying available period in 1977-2001)
- daily sequences of rainfall are simulated using a KNN scheme using regional-scale winds at 850 and 200 hPa as predictors



STATION-SCALE SKILL

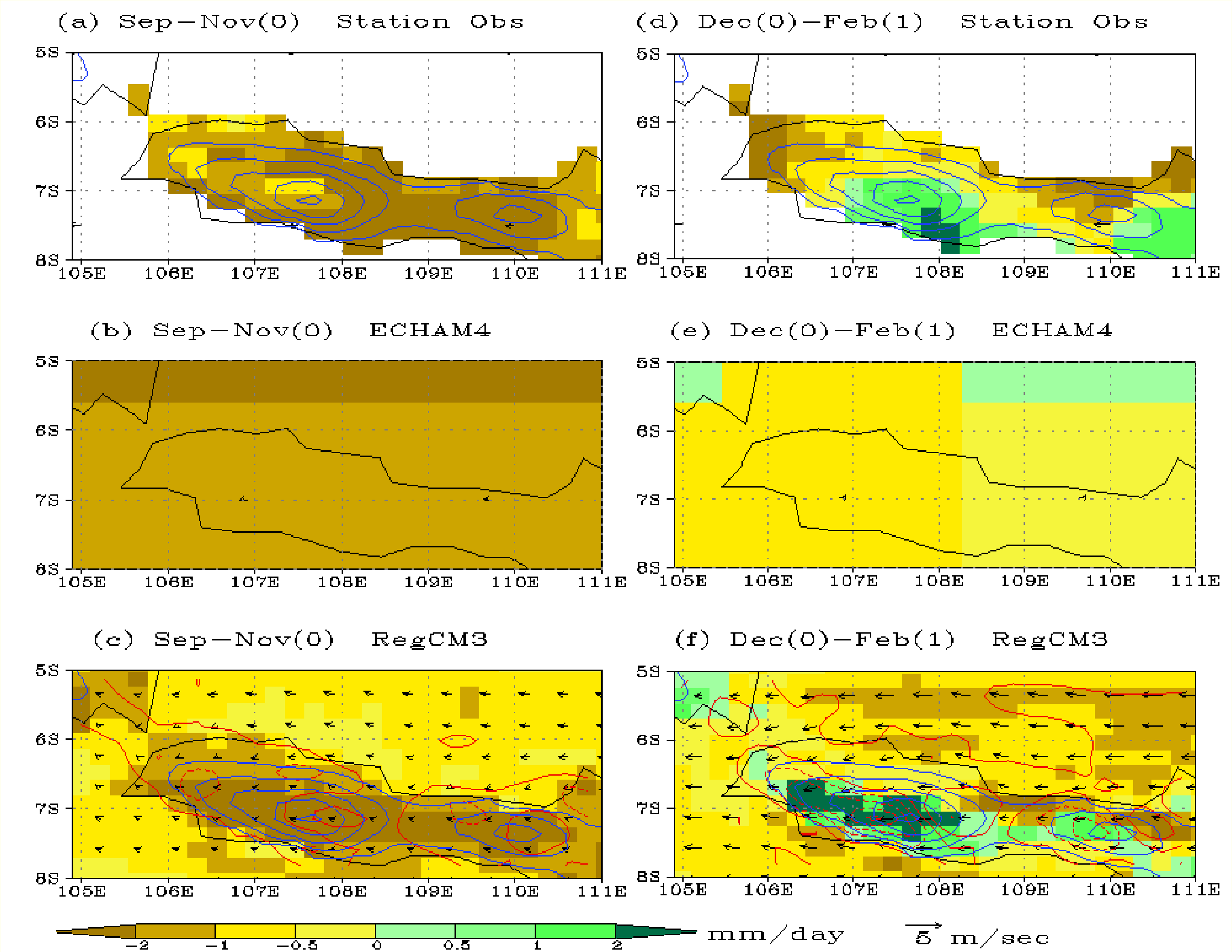


(collaboration IRI-PAGASA in progress)

role of regional climate models

- improves the realism of topography & land surface
- various approaches of dynamical downscaling (stretched GCM, nested RCM etc.)
- specific issues with RCMs
- - nesting and boundaries of the RCM
- - RCM results may still need statistical post-processing
- it is not obvious that dynamical models (GCMs, RCMs) will be able to deliver more useful information than purely statistical transformations in every case
- but dynamical models have a key role to play in understanding the physical processes involved and making the forecasts credible
- importance of assessing competing statistical and dynamical methods on an equal rigorously cross-validated footing

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)

Conclusion : specific climate-science issues ...

- Importance of predictability of sub-seasonal characteristics
  - often closer to the “tailored” climate variables that are relevant to potential users
  - recent results indicate that the frequency of dry days (or rainfall frequency) in the tropics is often considerably more predictable at the local scale than seasonal rainfall total
  - may extend to dry spells and even monsoon onset, for example over SE Asia

- Suggests that a merging of seasonal predictions with intraseasonal predictions may be particularly fruitful

Conclusion : upstream and downstream issues ...

- Urgent and critical need for validated (and complete) observed local-scale data at daily time scale (not only for rainfall but also any variables related to any end uses in agriculture, hydrology, health and food security)
- Need for satellite estimates of such variables
- Going beyond the seasonal amounts : including systematically intra-seasonal properties (as frequency of wet days) in GCM studies
- Studying how is translated the seasonal predictable component toward intra-seasonal time scales
- Climate risk management of key importance to developing countries where it cannot be done in isolation but critically needs to engage regional institutions and a careful mapping of institutions and policy
- Critical education-training-outreach and capacity-building components
- Need for user-friendly but statistically rigorous tools (eg CPT) and open codes and software
- Need for intercomparison exercises for statistical and dynamical downscaling