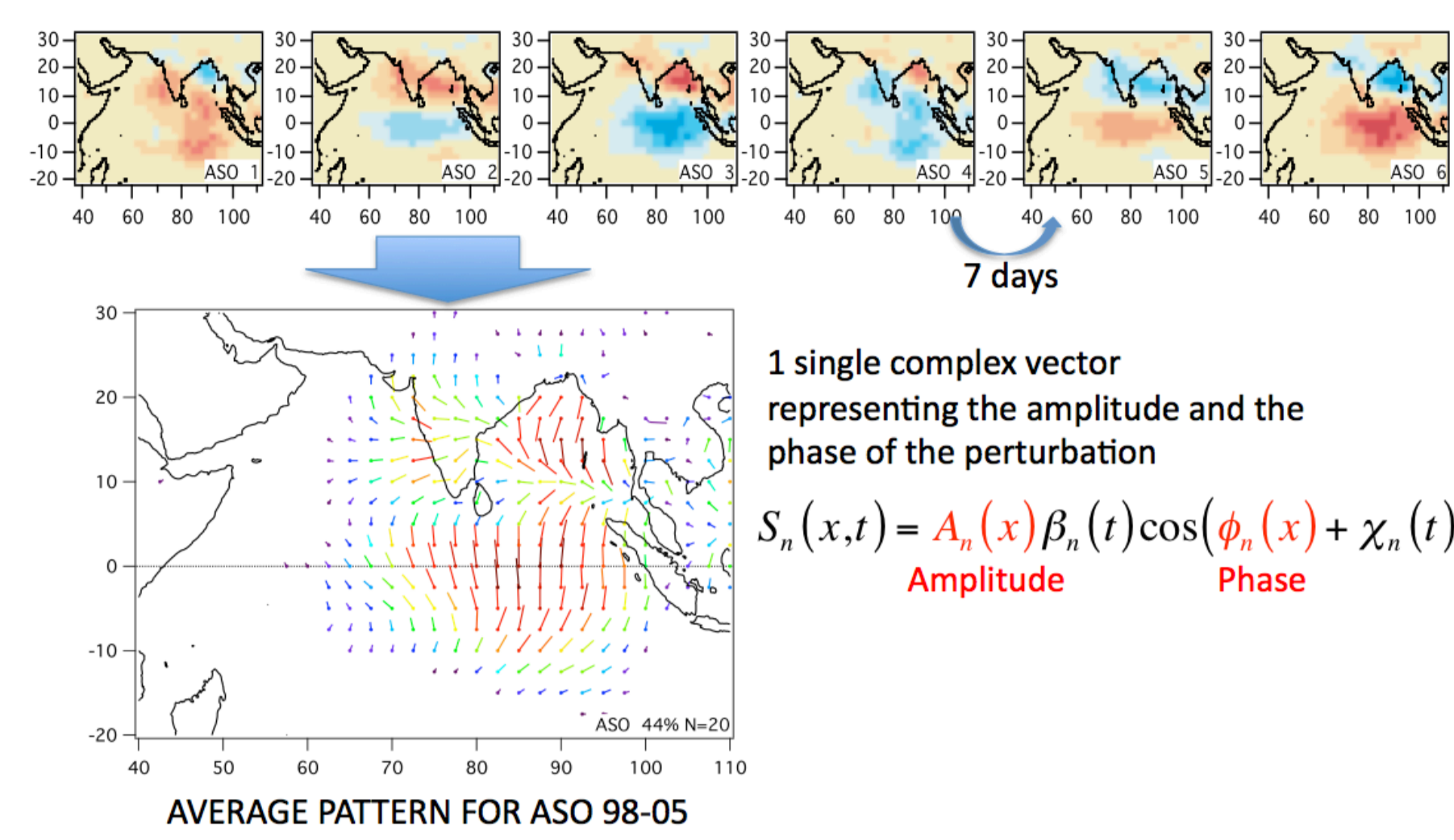# Tropical Intraseasonal Variability in Seasonal Hindcasts

J.P. Duvel (LMD), P.K. Xavier (UKMO), F. Doblas Reyes (ECMWF), B. Oueslati (CNRM) and P. Braconnot (LSCE)
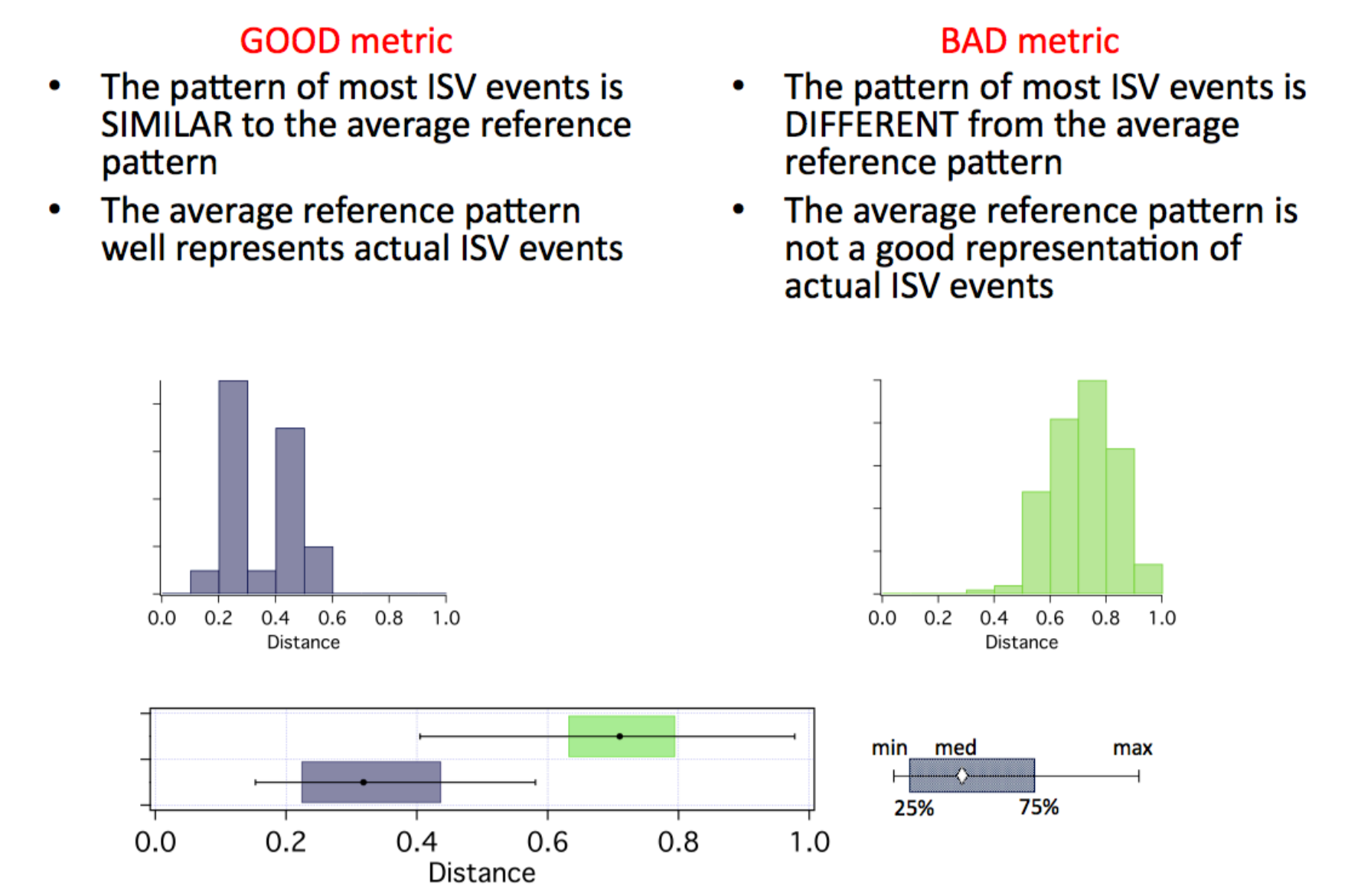
How to evaluate the simulated ISV?

- Average pattern not sufficient:
  - What is the meaning of the average perturbation pattern?
  - Are there (at least) some realistic ISV events simulated?

- Inspect the ENSEMBLE of ISV events:
  - What is the reproducibility of the simulated perturbation patterns among the different ISV events.
  - What is the realism of the simulated perturbation patterns for the different ISV events.

Representation of the rain perturbation pattern of an event

7 days

1 single complex vector representing the amplitude and the phase of the perturbation

$$S_n(x,t) = A_n(x)\beta_n(t)\cos(\phi_n(x) + \chi_n(t))$$

Amplitude   Phase

AVERAGE PATTERN FOR ASO 98-05

The metric

GOOD metric
- The pattern of most ISV events is SIMILAR to the average reference pattern
- The average reference pattern well represents actual ISV events

BAD metric
- The pattern of most ISV events is DIFFERENT from the average reference pattern
- The average reference pattern is not a good representation of actual ISV events
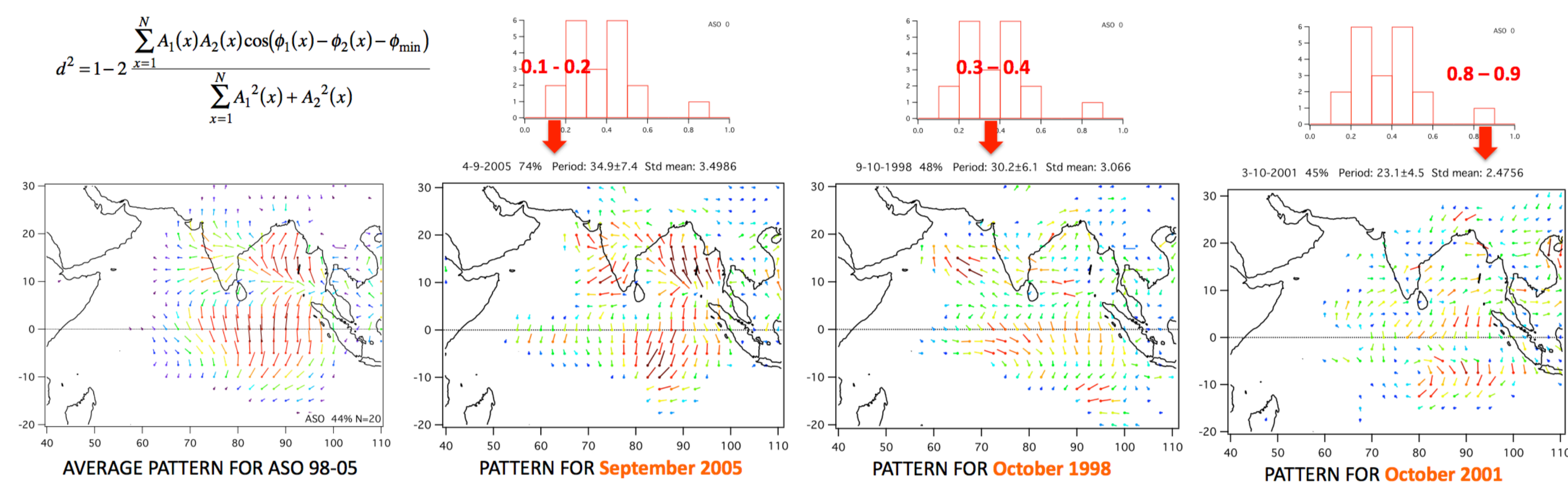
min med max
25% 75%

Approach

The Local Mode Analysis

- Based on windowed Complex EOF analyses.
- The LMA detects **each ISV event** and gives its perturbation pattern with a simple mathematical form.
- An average pattern may be computed and compared to the pattern of each event:
  - Assess the reproducibility of the perturbation pattern.
  - Assess the realism of the simulated ISV by comparing each pattern to the average OBSERVED pattern.
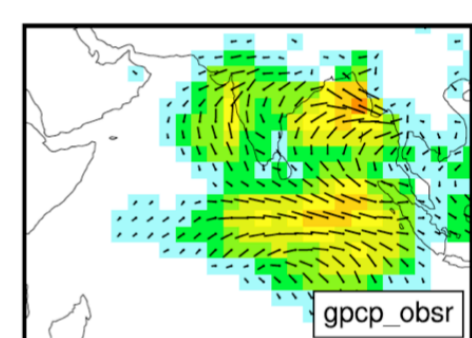
The distance between two patterns

$$d^2 = 1 - 2\frac{\sum_{x=1}^{N} A_1(x)A_2(x)\cos(\phi_1(x) - \phi_2(x) - \phi_{min})}{\sum_{x=1}^{N} A_1^2(x) + A_2^2(x)}$$

0.1 - 0.2   4-9-2005 74% Period: 34.9±7.4 Std mean: 3.4986

0.3 - 0.4   9-10-1998 48% Period: 30.2±6.1 Std mean: 3.066

0.8 - 0.9   3-10-2001 45% Period: 23.1±4.5 Std mean: 2.4756

AVERAGE PATTERN FOR ASO 98-05

PATTERN FOR September 2005

PATTERN FOR October 1998

PATTERN FOR October 2001

Climate simulations

- GPCP observations 1997-2006
  - ~24 ISV events
- 19 IPCC AR4 Models 20th century climate
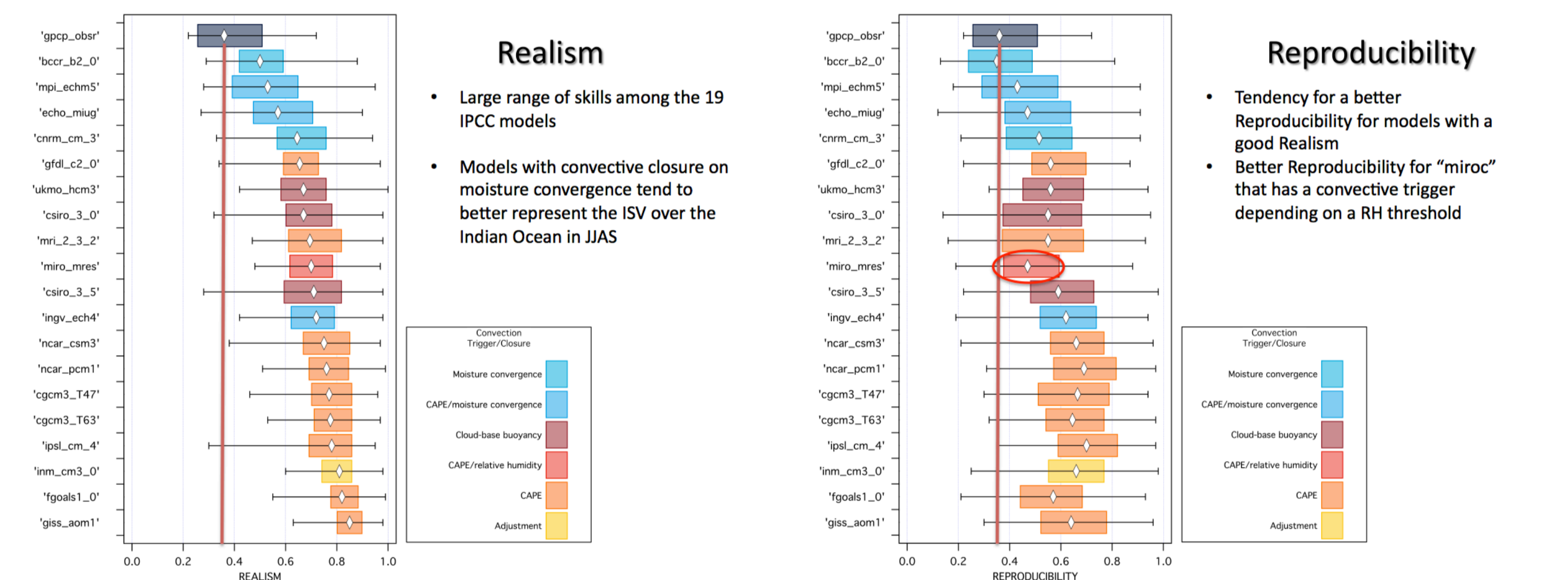 - 40 years
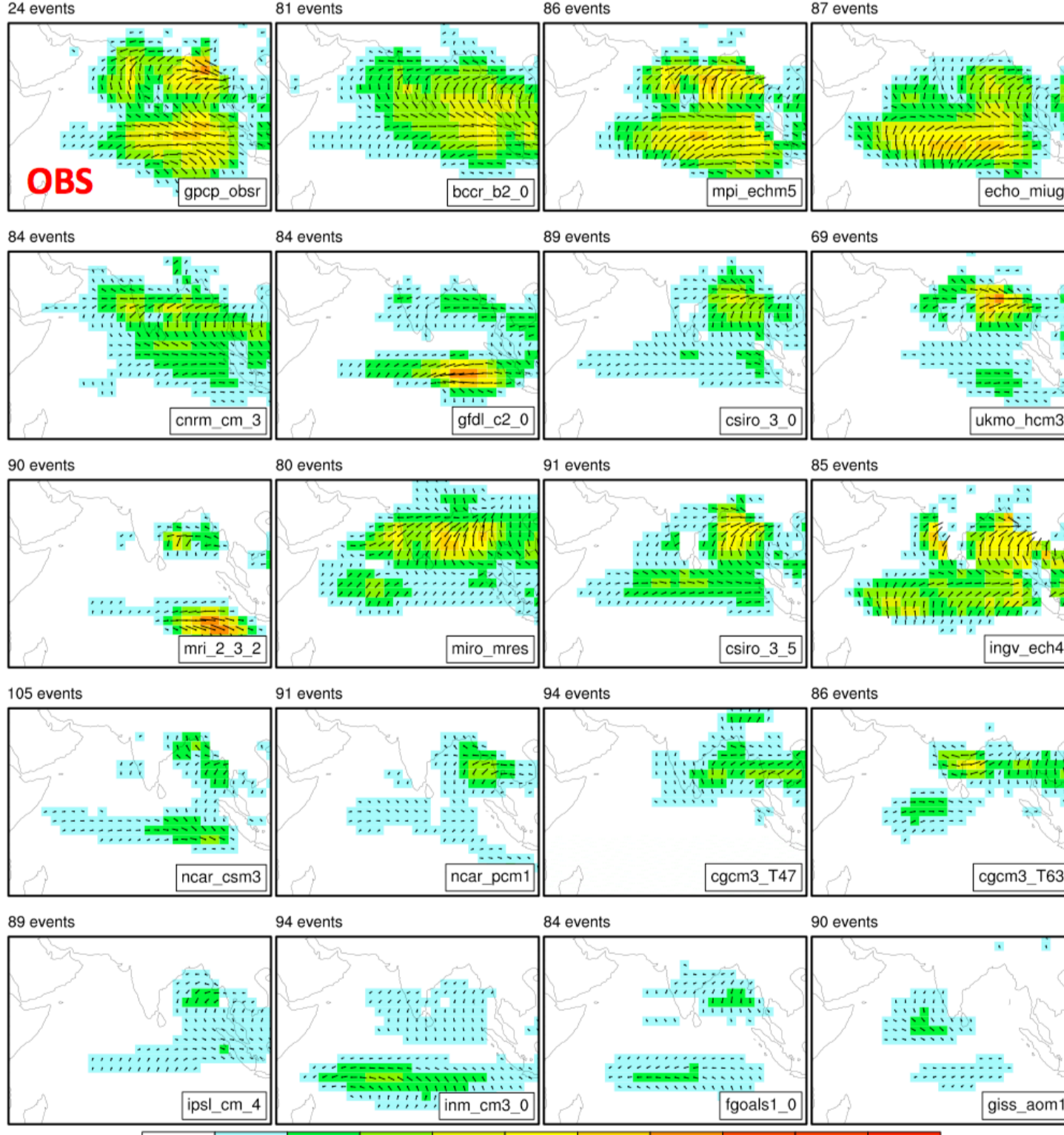 - ~100 events/model

gpcp_obsr

Realism

- Large range of skills among the 19 IPCC models
- Models with convective closure on moisture convergence tend to better represent the ISV over the Indian Ocean in JJAS

Convection Trigger/Closure:
Moisture convergence
CAPE/moisture convergence
Cloud-base buoyancy
CAPE/relative humidity
CAPE
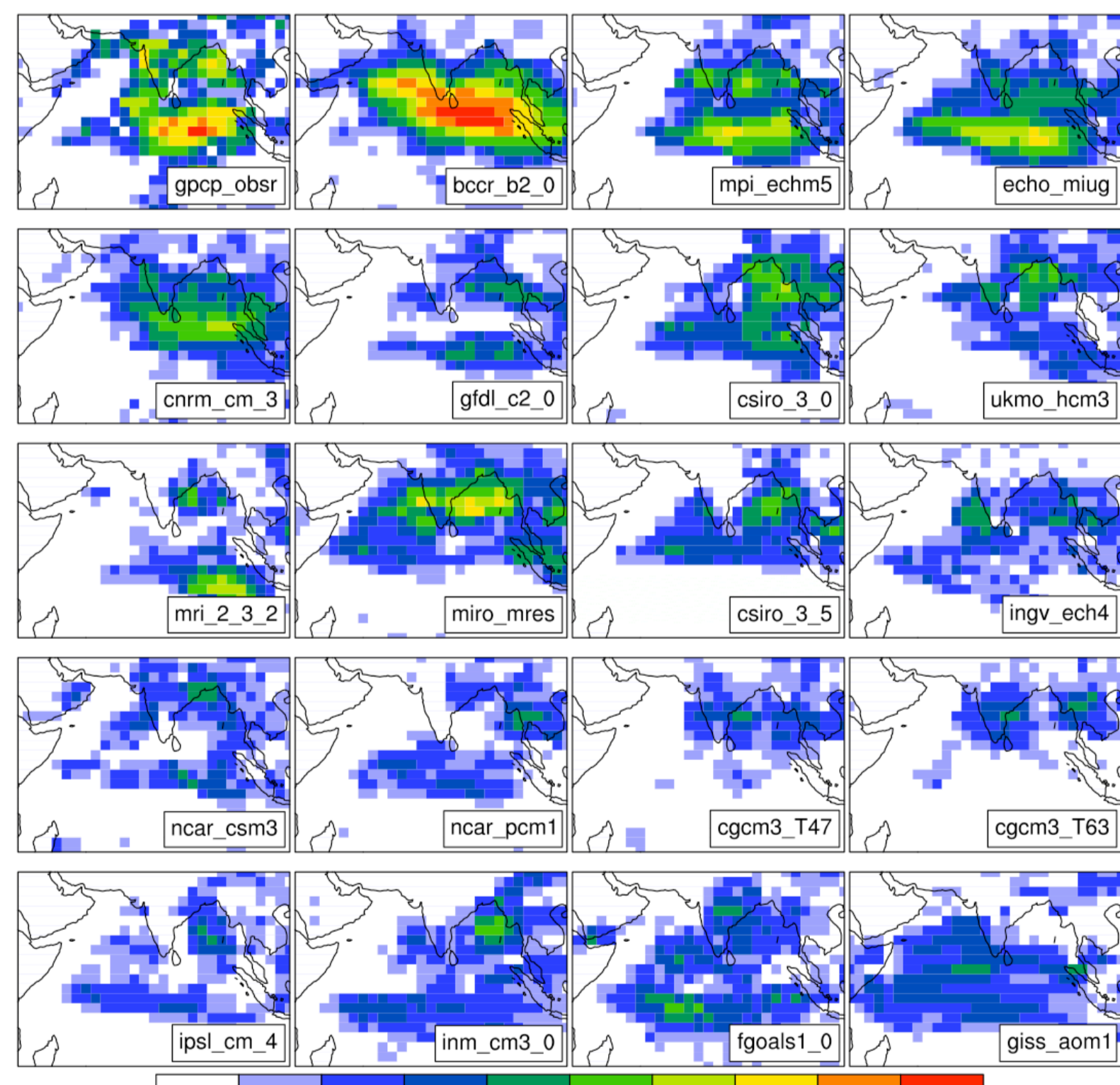Adjustment

Reproducibility

- Tendency for a better Reproducibility for models with a good Realism
- Better Reproducibility for "miroc" that has a convective trigger depending on a RH threshold

Corresponding average patterns

OBS

24 events 86 events 86 events 87 events
gpcp_obsr bccr_b2_0 mpi_echm5 echo_miug
84 events 84 events 86 events 89 events
cnrm_cm_3 gfdl_c2_0 csiro_3_0 ukmo_hcm3
90 events 80 events 91 events 85 events
mri_2_3_2 miro_mres csiro_3_5 ingv_ech4
105 events 94 events 91 events
ncar_csm3 ncar_pcm1 cgcm3_T47 cgcm3_T63
89 events 94 events
ipsl_cm4 inm_cm3_0 fgoals1_0 giss_aom1

Ratio of the large-scale organized ISV

bccr_b2_0 mpi_echm5 echo_miug
cnrm_cm_3 gfdl_c2_0 csiro_3_0 ukmo_hcm3
mri_2_3_2 miro_mres csiro_3_5 ingv_ech4
ipsl_cm_4 inm_cm3_0 fgoals1_0 giss_aom1

Precipitation spectra - BoB

(a) Power spectra over Bay of Bengal
gpcp_obs / models

(b) Redness vs ISV metric
r=0.58
White — Red

(c) 2-60 days variance vs ISV metric
r=-0.59

1.gpcp_obsr   11.csiro_3_5
2.bccr_b2_0   12.ingv_ech4
3.mpi_echm5   13.ncar_csm3
4.echo_miug   14.ncar_pcm1
5.cnrm_cm_3   15.cgcm3_T47
6.gfdl_c2_0   16.cgcm3_T63
7.csiro_3_0   17.ipsl_cm_4
8.inm_hcm3   18.inm_cm3_0
9.mri_2_3_2   19.fgoals1_0
10.miro_mres   20.giss_aom1

Conclusions

- Development of an event-by-event diagnostic of the ISV
- Good Reproducibility of the Monsoon ISV pattern in observations

- Weak Reproducibility for most coupled GCMs
- Large range of skills among the different coupled models
- For models with a poor Realism in the ISV patterns:
  - Poor Reproducibility of the ISV pattern
  - Too local ISV of the precipitation
    - ISV not governed by large-scale organized events
  - More redness of the time power spectrum
  - Weak day-to-day variability

Xavier, P.K., J.P. Duvel, P. Braconnot and F.J. Doblas-Reyes, 2010: An evaluation metric for intraseasonal variability in climate models. *J. Climate*. In press.

Xavier et al. 2010

Hindcasts

The analysis procedure

- November hindcasts (**LONG**)
  - give the representation of the summer ISV by the coupled models
  - effect of the November initialization supposed to be null

Indian Summer Monsoon
Model 4 / Model 3 / Model 2 / Model 1
4 models / 9 members
Nov 00 Feb 01 May 01 Aug 01 Nov 01 Feb 02
Initialization   Lead time = 6 months

- May hindcasts (**INIT**)
  - give the impact of the initialization procedure on:
    - The representation of the ISV
    - The seasonal march of the monsoon

Indian Summer Monsoon
OBSERVATIONS
4 models / 9 members
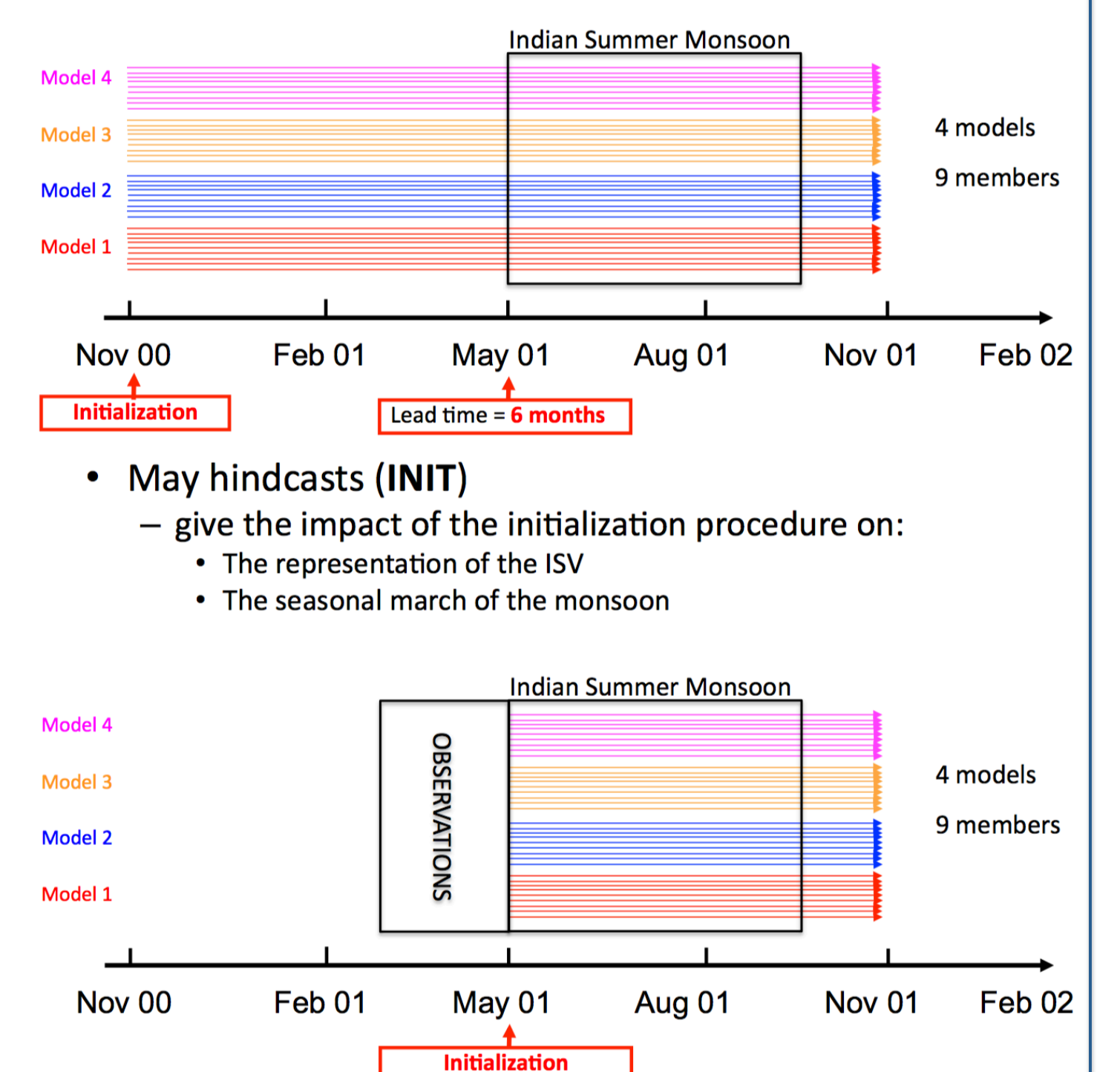Nov 00 Feb 01 May 01 Aug 01 Nov 01 Feb 02
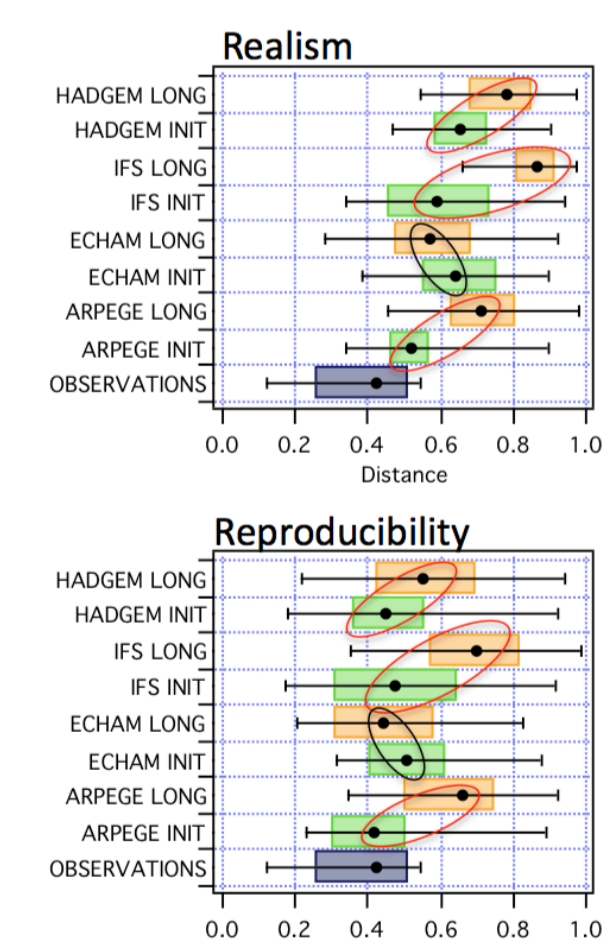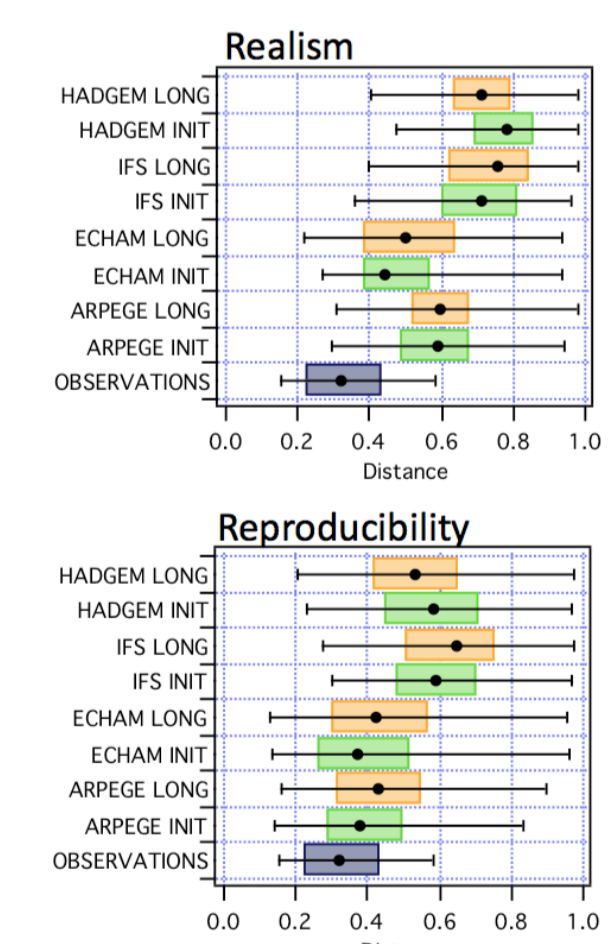Initialization

ENSEMBLES hindcasts

- We use part of the seasonal hindcasts performed in the framework of the ENSEMBLES project
- multi-model
  - IFS/HOPE, ARPEGE/OPA, HadGEM2, ECHAM/OM1
- Different initialization procedures
  - Initial conditions from ocean analyses forced by ERA-40 surface fluxes with different perturbations in surface stress and SST (IFS, ARPEGE, HadGEM2).
  - Initial conditions from three-member ensemble coupled simulation where the model SST is restored to observed SST values (ECHAM)

ISV in May for ENSEMBLES

Realism
Reproducibility

HADGEM INIT / HADGEM LONG / IFS LONG / IFS INIT / ECHAM LONG / ECHAM INIT / ARPEGE LONG / ARPEGE INIT / OBSERVATIONS

- Improvement of the Realism and of the Reproducibility of the ISV patterns for INIT for IFS, ARPEGE and HADGEM
- Slight negative impact of the initialization procedure for ECHAM:
  - from coupled simulation with restored SST
  - May be due also to the larger gap between observation and simulation around the 1st of May.

ISV in JAS for ENSEMBLES

Realism
Reproducibility

HADGEM INIT / HADGEM LONG / IFS LONG / IFS INIT / ECHAM LONG / ECHAM INIT / ARPEGE LONG / ARPEGE INIT / OBSERVATIONS

- Marginal impact of the initialization on both the Realism and the Reproducibility
- Better Realism and Reproducibility for ECHAM and Arpege

ISV triggered by an initialization shock

- Large rain perturbation triggered by the convective scheme in the western IO
- An eastward perturbation is generated due to a Gill-type dynamical response
- Generate ISV-type events and the monsoon onset

Effect of the SST initialization

- Warm SST anomaly in the western equatorial IO
- Growth of the rain anomaly reinforced by the low frequency of the coupling (1 day)
  - The SST anomaly is maintained 24 hours, whatever the convective activity

OBSERVATION ARPEGE INIT ARPEGE LONG   OBSERVATION ARPEGE INIT ARPEGE LONG
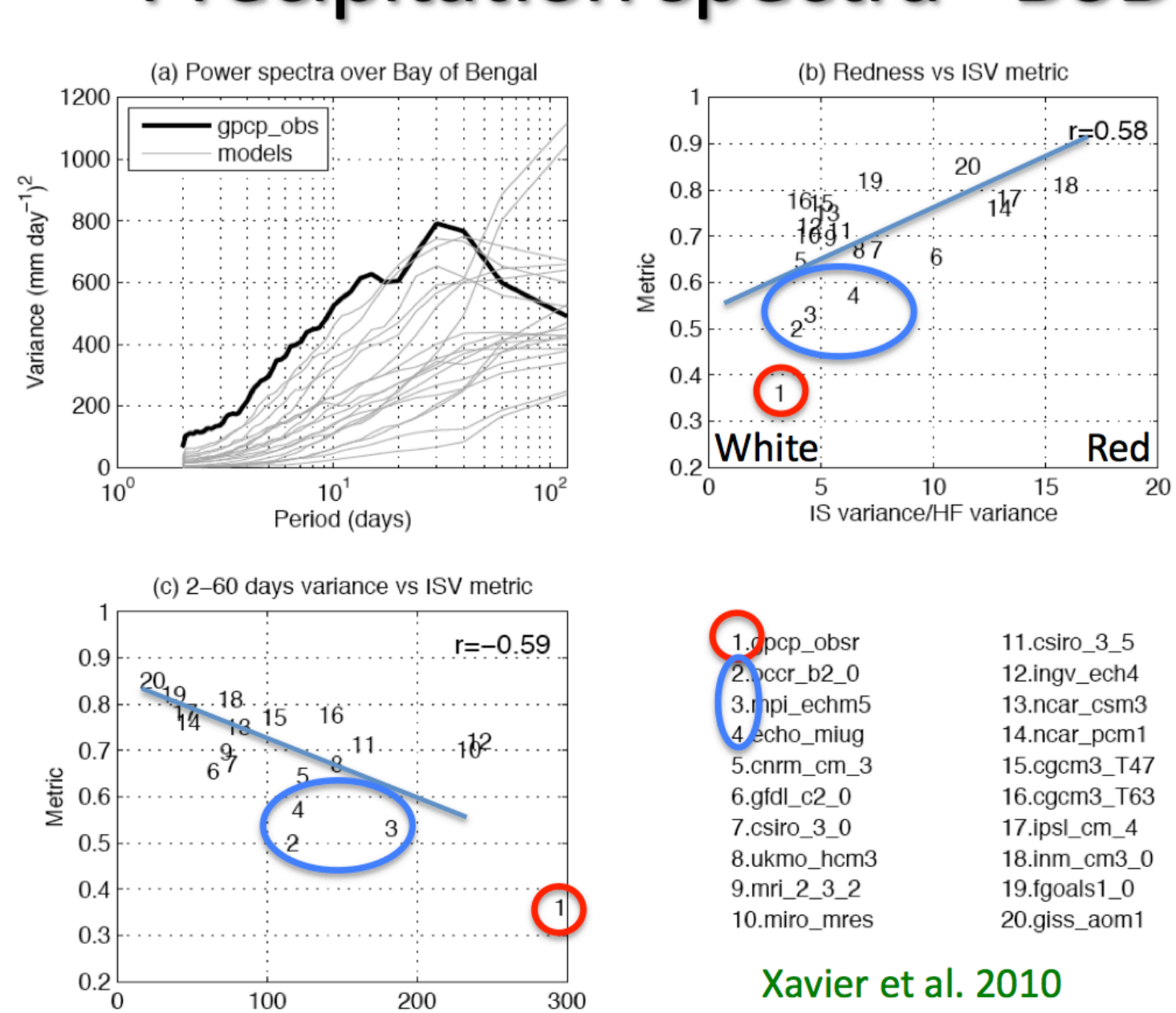MAY JUNE
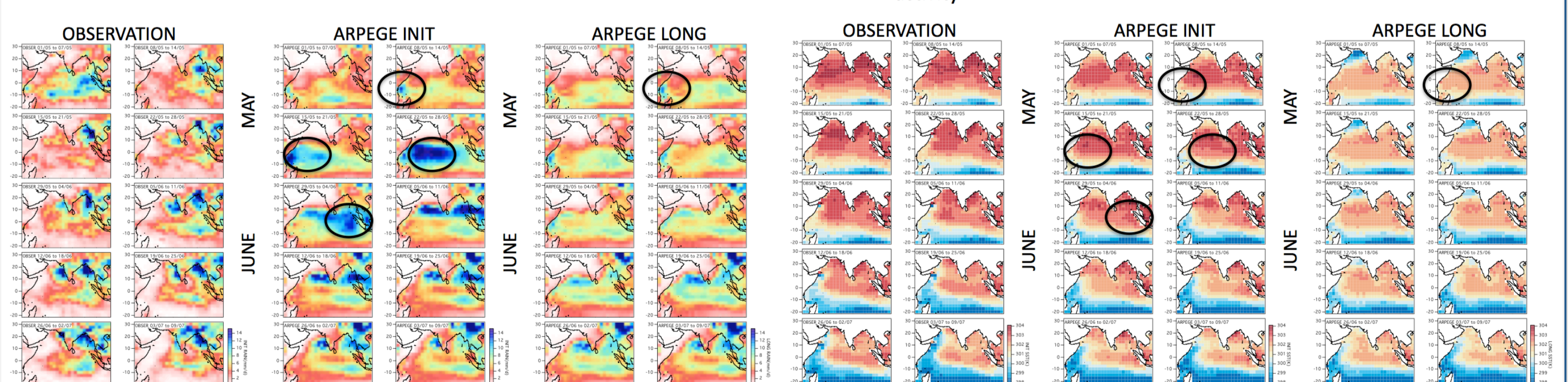
Conclusions

- The realism and the reproducibility of the ISV patterns are slightly improved by the initialization process for the first two months (May and June here)

- This does not mean that the predictability at 10-30 days is improved by these ISV...

Tentative diagnostic for ARPEGE

- The better Reproducibility and Realism of the ISV patterns in May-June for INIT is related to the triggering of ISV events generated by a response of the convective scheme to the initialized SST field.

- These "forced" ISV events are quite realistic (Gill response to organized rain perturbations) but may hide or perturb a real ISV event for a particular year.