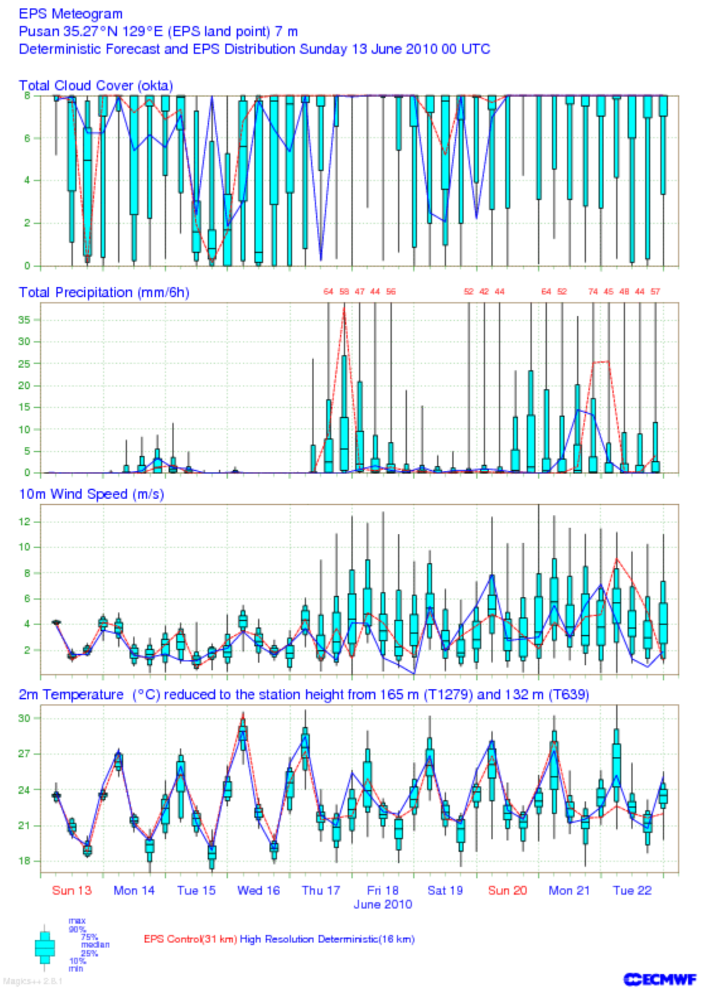
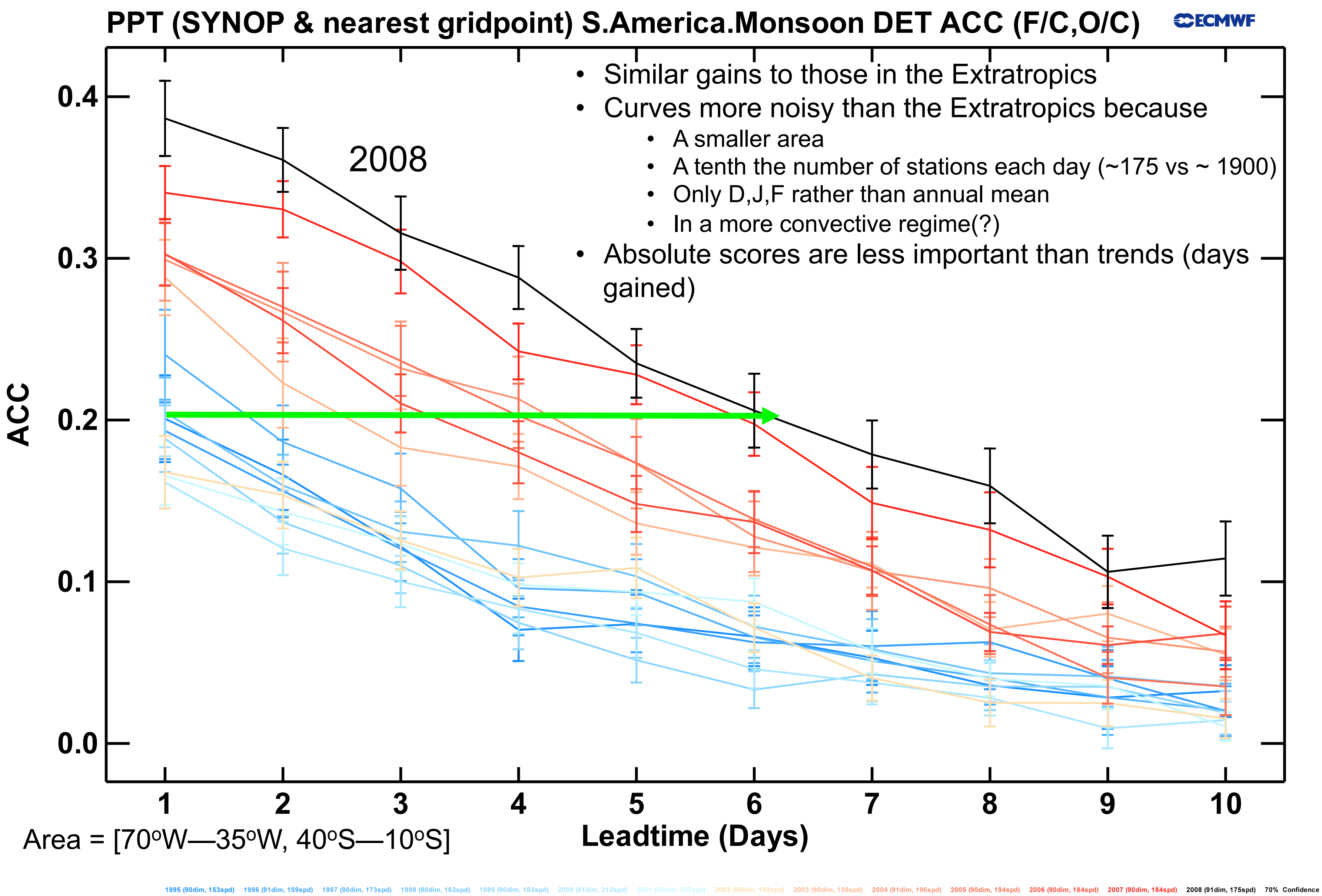
Where we are with Precip, Monsoon and MJO in the ECMWF IFS and what we are still trying/learning



Thank You Organizers

Peter Bechtold, Thomas Jung, Mark Rodwell,
Martin Steinheimer, Frederic Vitart

S. American Monsoon (DJF)
Evolution Det. Precip. Scores from 1995-2008

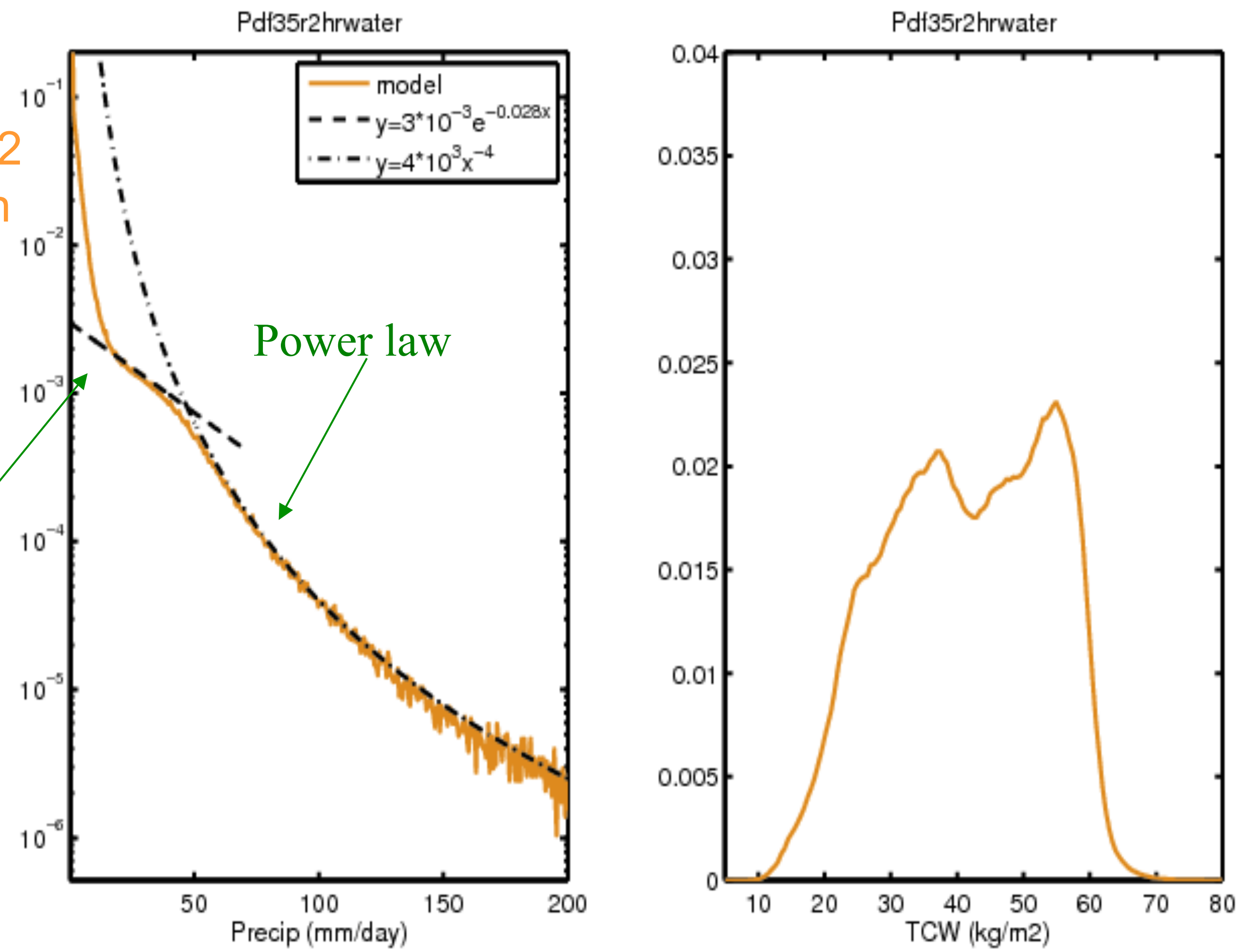


Pdfs of instantanous Precip fluxes and TCW in Tropics

together with A. Geer

from T799 33r1
during first 24h

from T1279 35r2
during first 24h



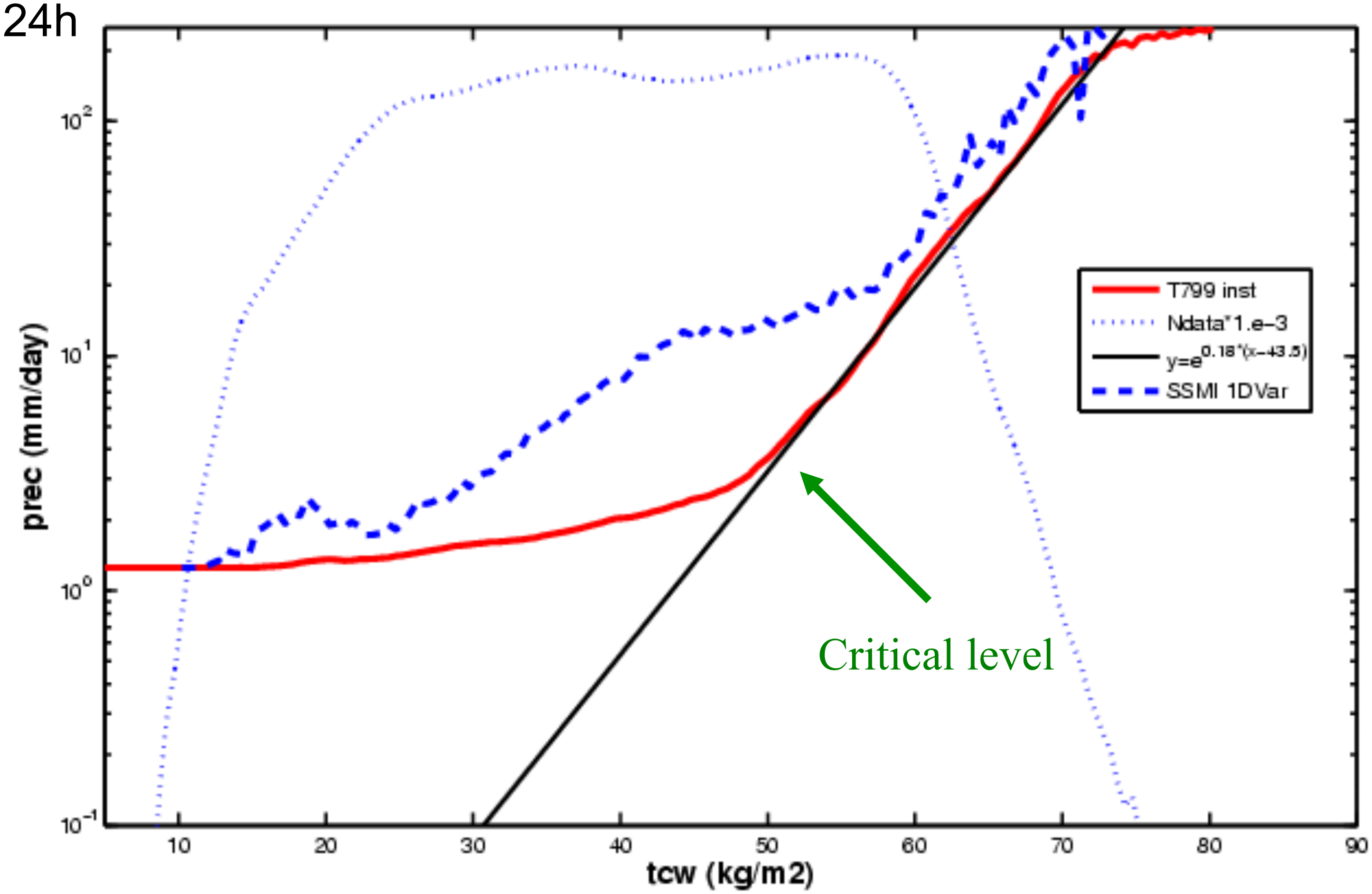
exponential

SSMI is from 1D-Var, but underestimates high rain rates (high TCW) as columns where more than 1/3 of precip is snow have been discarded

Mean Precip versus TCW from 2D Pdf

together with A. Geer

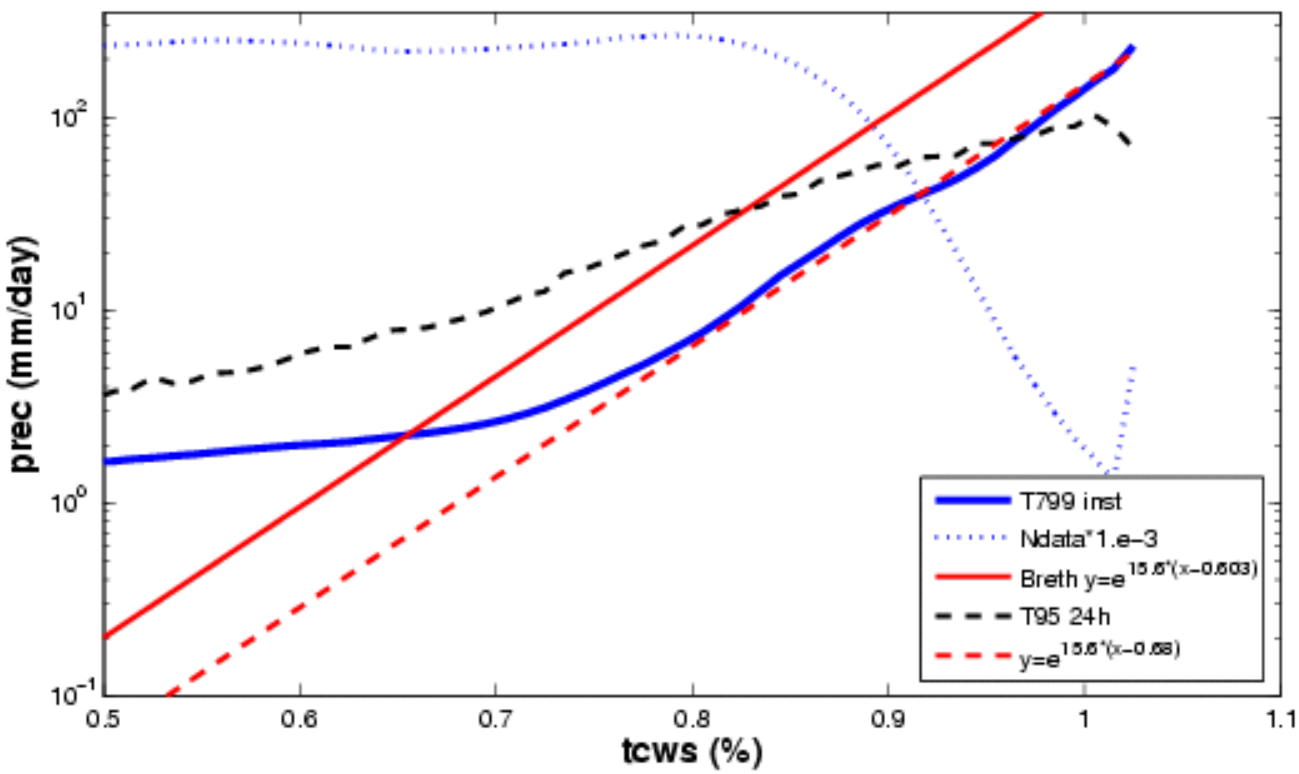
from T799 33r1
during first 24h



SSMI is from 1D-Var, but underestimates high rain rates (high TCW) as columns where more than 1/3 of precip is snow have been discarded

Precip vs total column water relative humidity

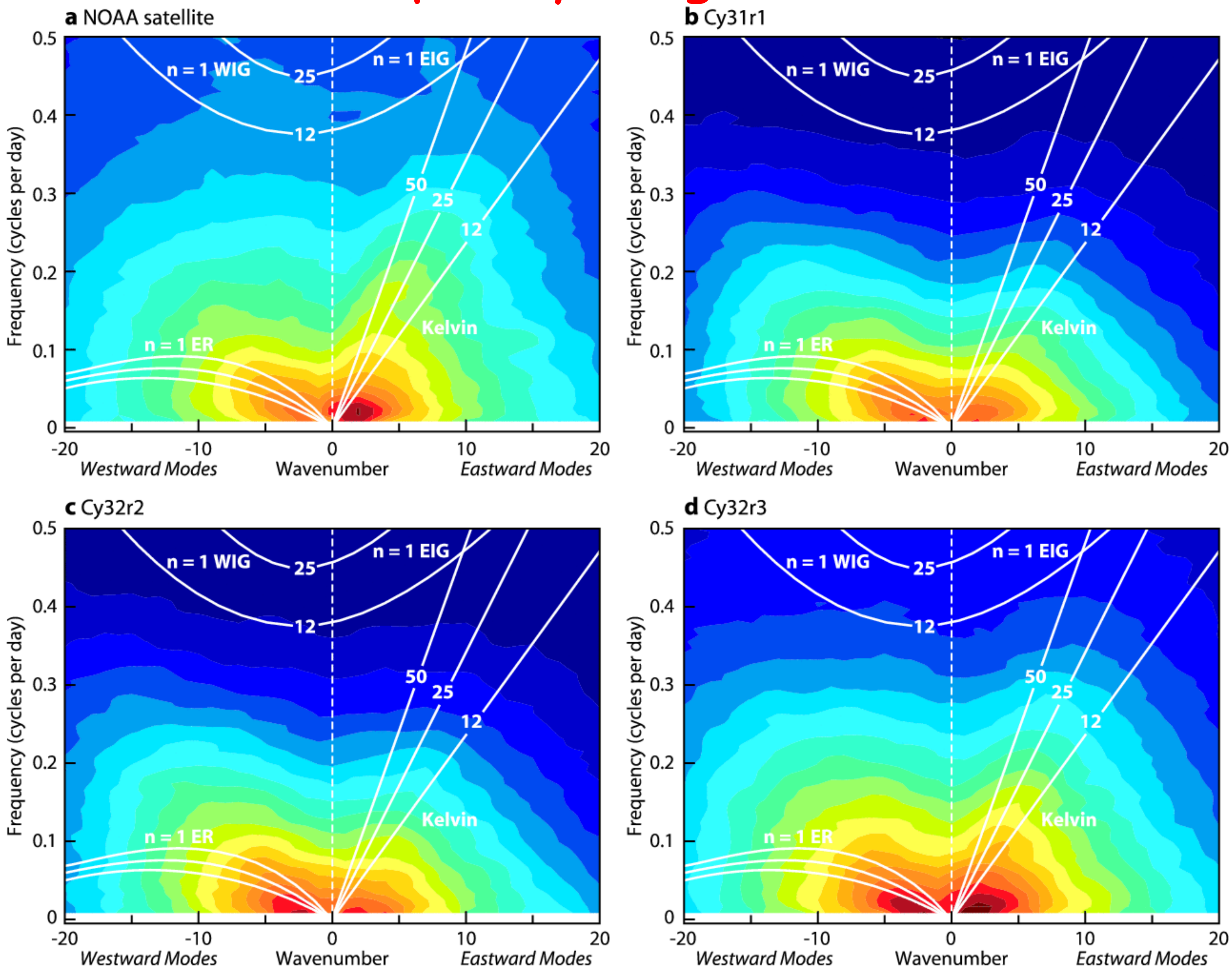
The atmosphere (model) a self-organized critical system ?



Or just more Precip when the entire column becomes saturated ?

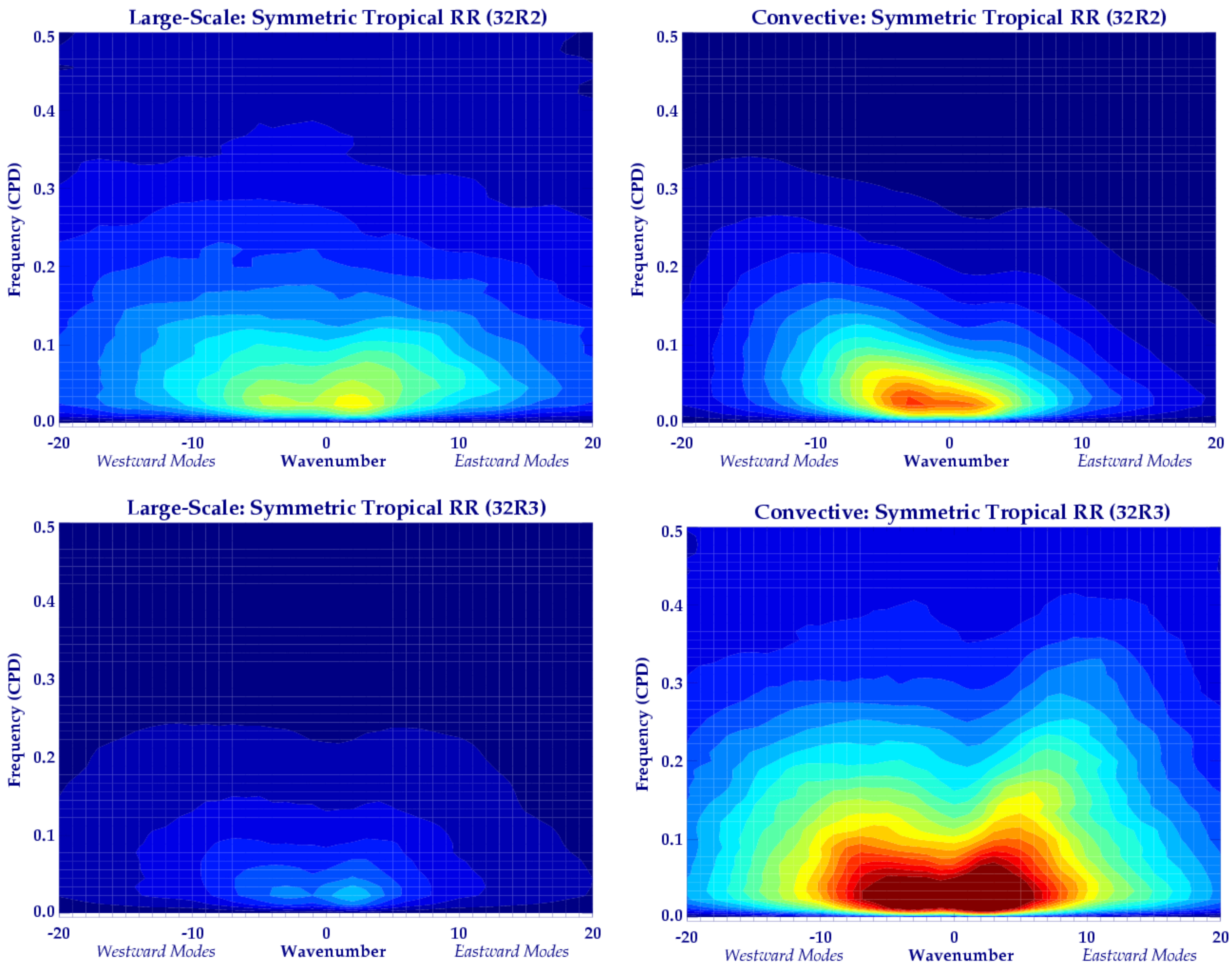
see also Bretherton et al. (J. Clim. 2004), or Fuchs and Raymond & Neelin papers

Wavenumber frequency Diagrams of OLR



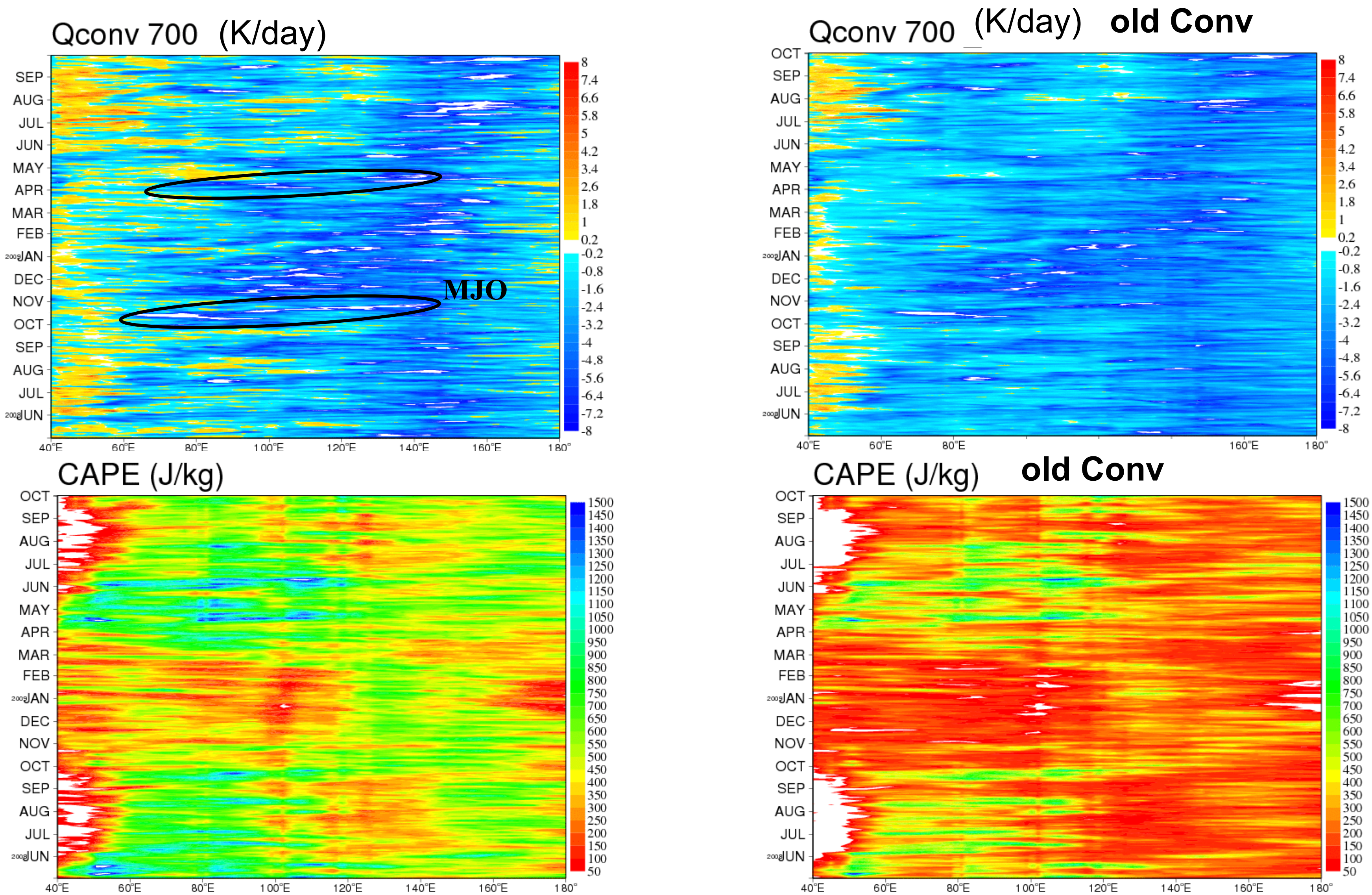
P. Bechtold et al. 2007, QJ

Wavenumber frequency Diagrams of CP & LSP



Better (Kelvin) wave activity, what has changed?

Use YOTC data set 24h forecasts, redo with pre Nov2007 conv



Lorenz Energy cycle

conversion rates of potential in kinetic energy

Generation Conversion

$$\frac{da}{dt} = NQ + \alpha\omega = N\overline{Q} + \overline{\alpha}\overline{\omega} + \overline{\alpha'\omega'}$$

Lorenz efficiency factor

Net heating

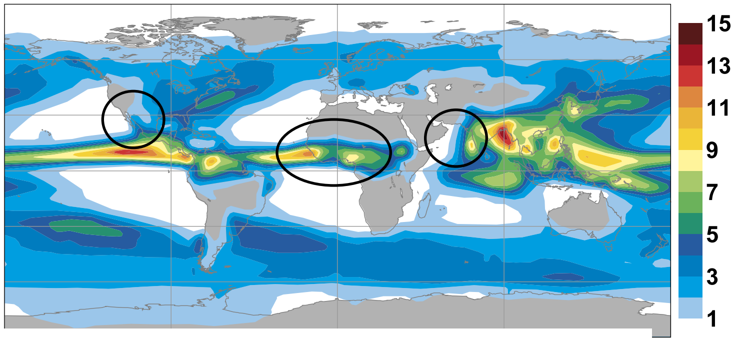
$$\overline{\alpha'\omega'} = \frac{R}{P}[1 + (\varepsilon^{-1} - 1)]\,\overline{T'\omega'} + (\varepsilon^{-1} - 1)\overline{\alpha}\,\overline{q'\omega'}$$

unfortunately locally not whole story as on would need to also consider $\nabla \bullet (V\phi)$

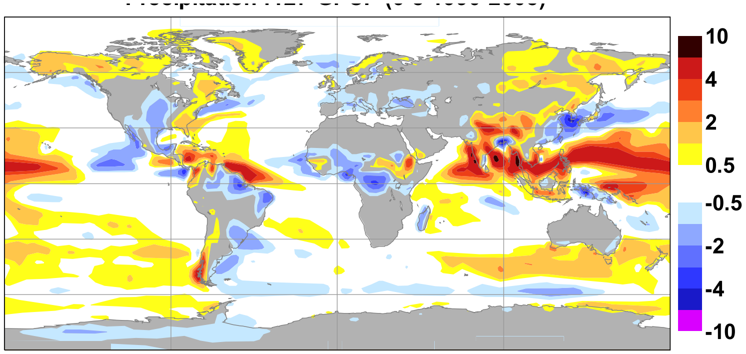
see also M Steinheimer, M Hantel, P Bechtold Tellus 2008

Precipitation JJA: Sensitivity to Model Formulation
Seasonal integrations

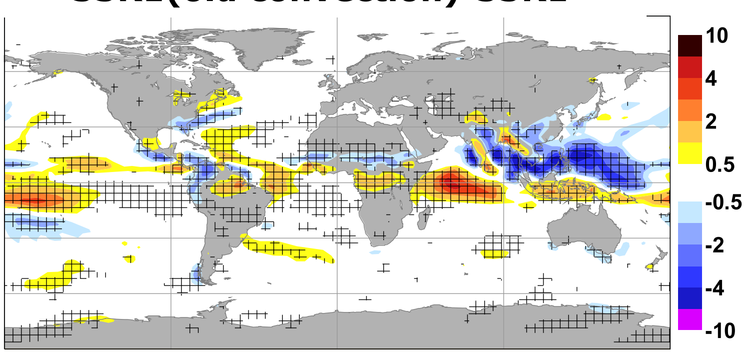
GPCP JJA 1990-2006



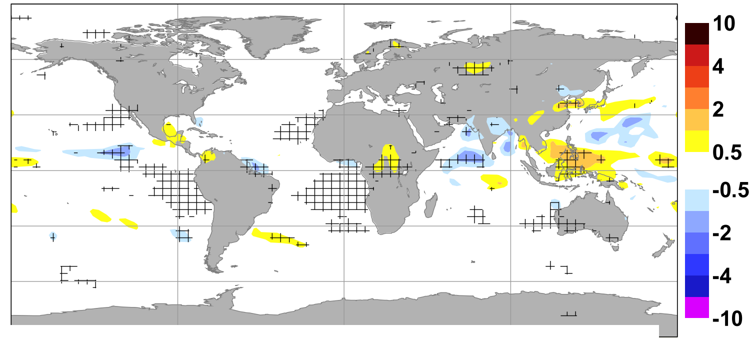
33R1-GPCP



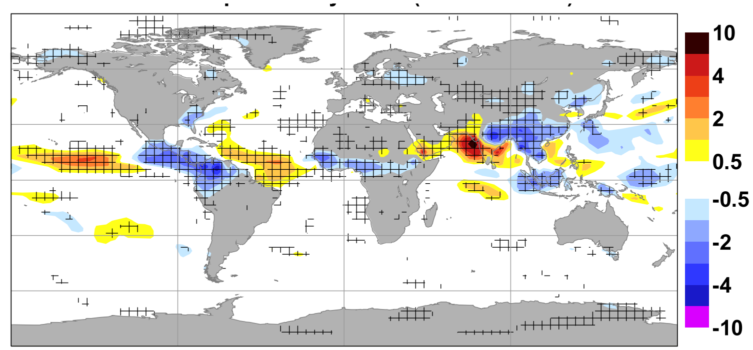
33R1(old convection)-33R1



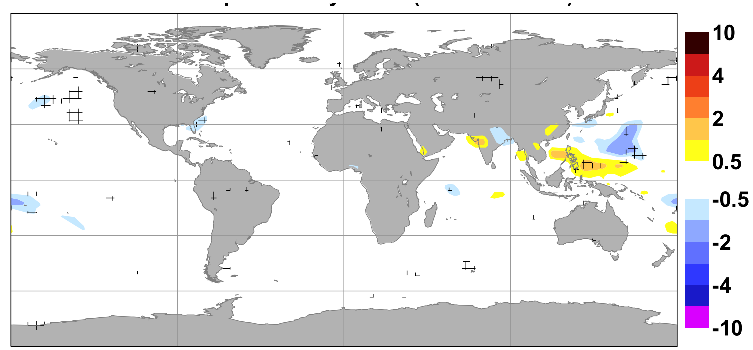
33R1(old vdiff)-33R1



33R1(old radiation)-33R1

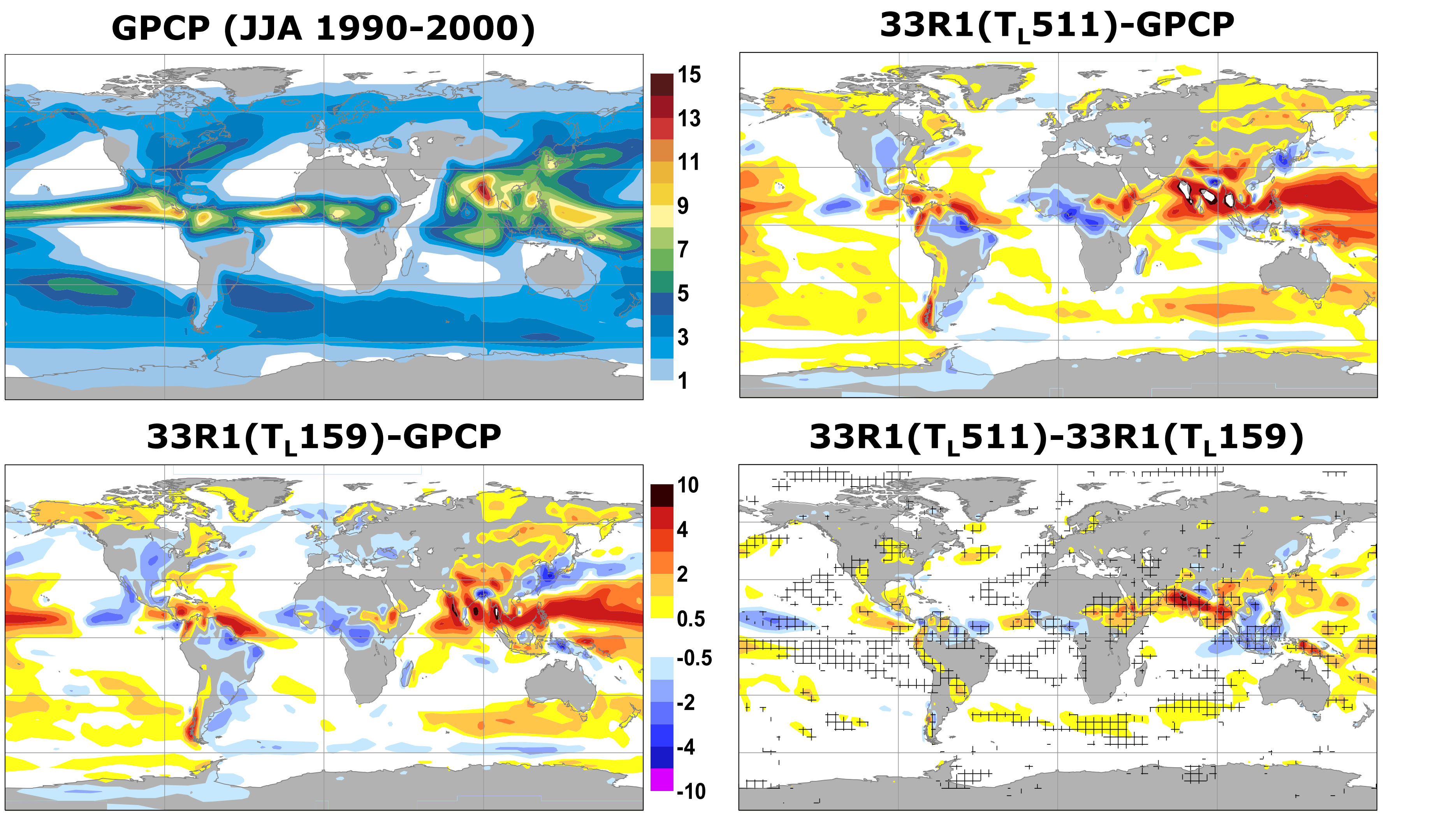


33R1(old soil hydrology)-33R1

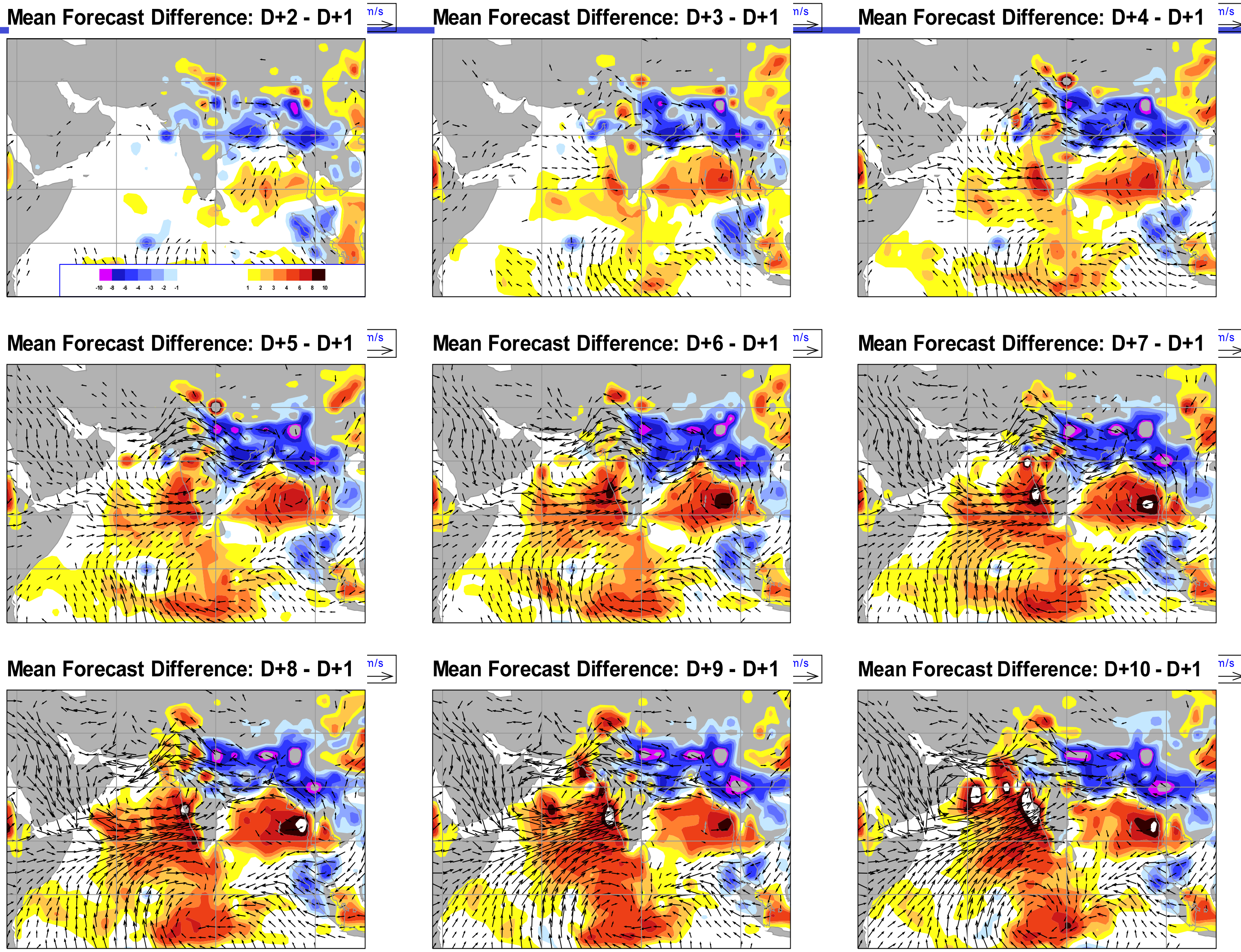


T. Jung, G. Balsamo, P. Bechtold et al. 2010, QJ

Precipitation JJA: Sensitivity to Resolution
Seasonal Integrations



Model Adjustment Day 1-10 : JJA 2008

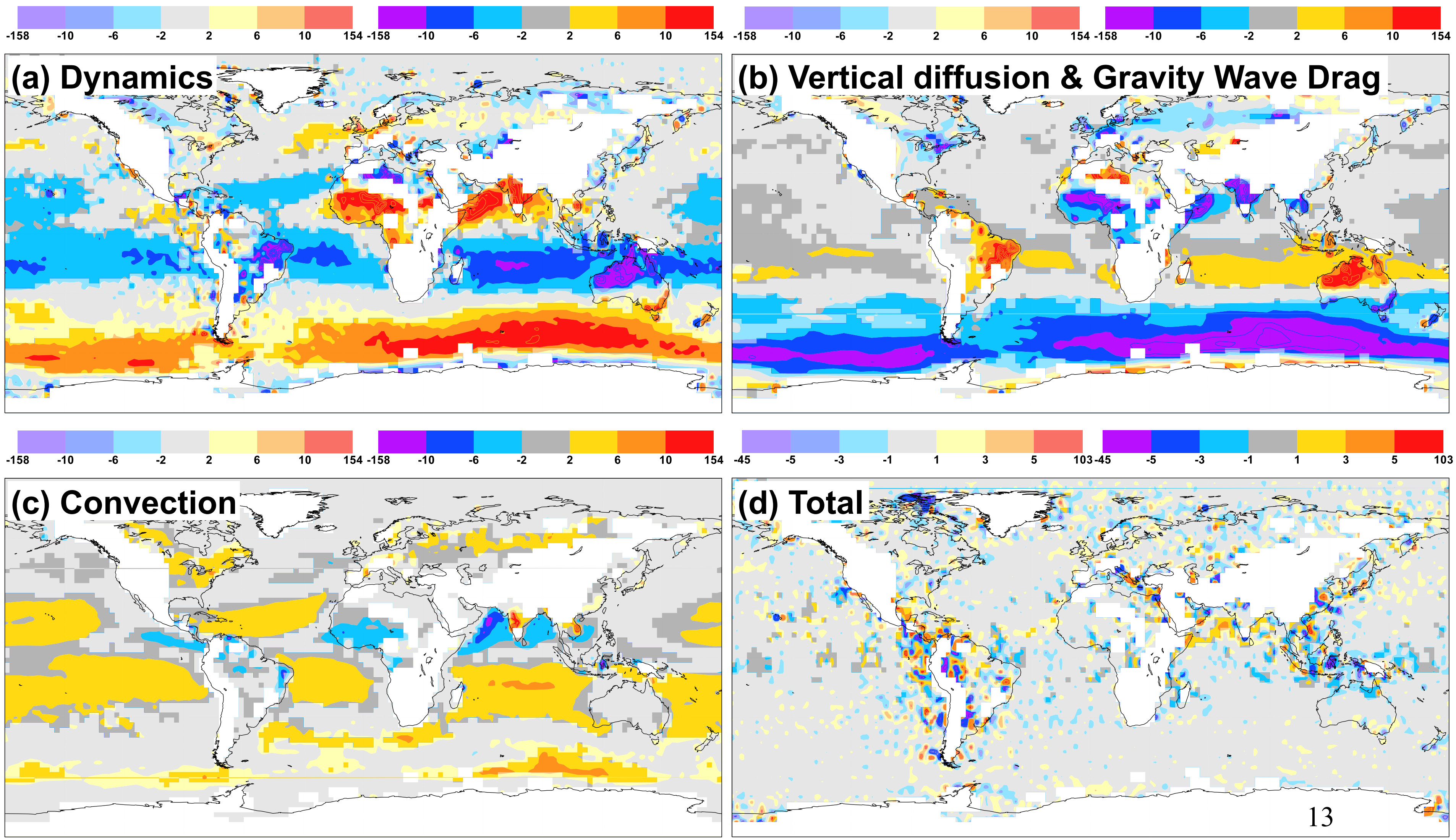


Initial Process Tendencies JJA 2008: U at 925 hPa

High resolution deterministic forecast

33R1

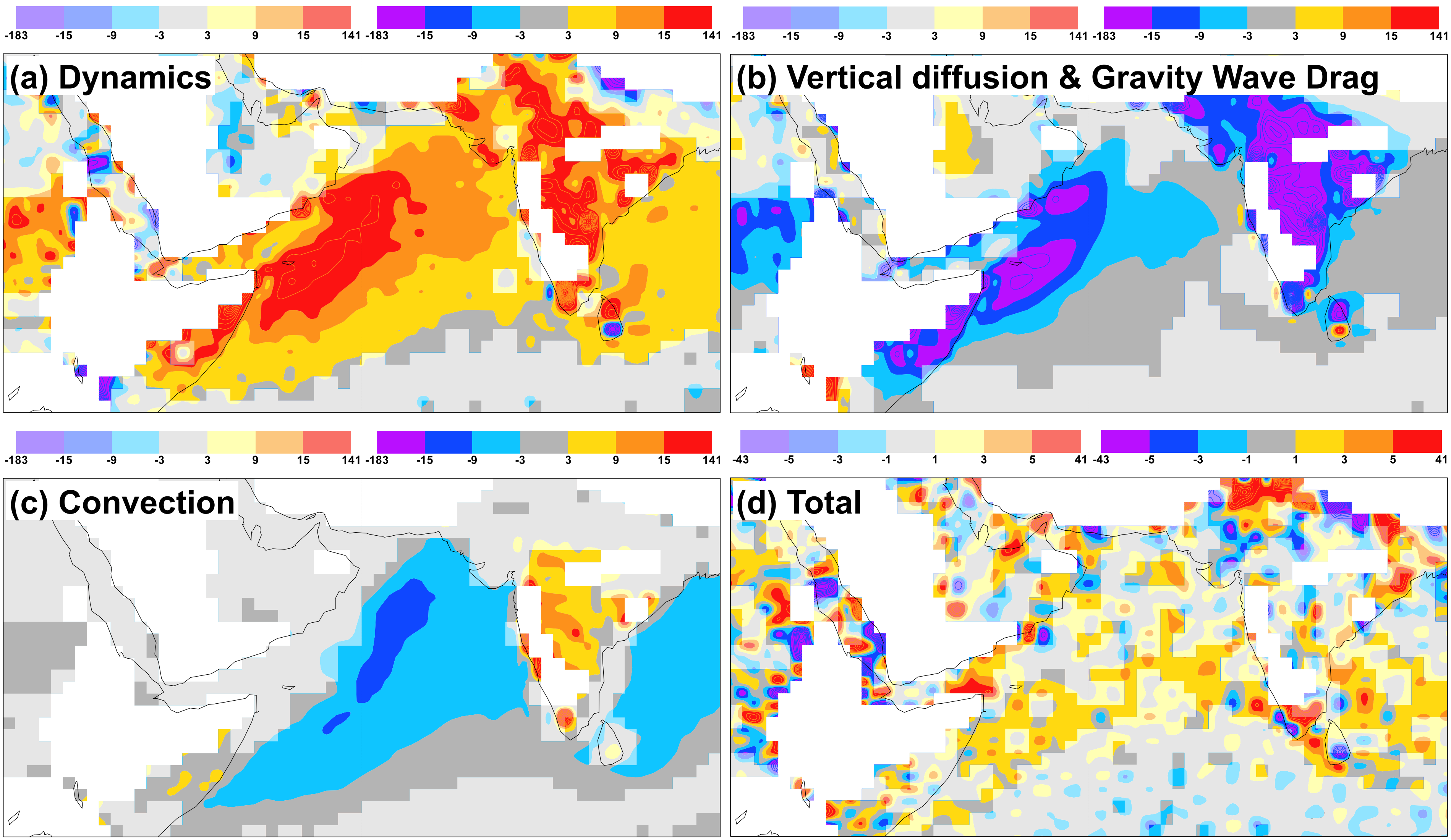
Unit = ms^{-1} over first 24h of forecast



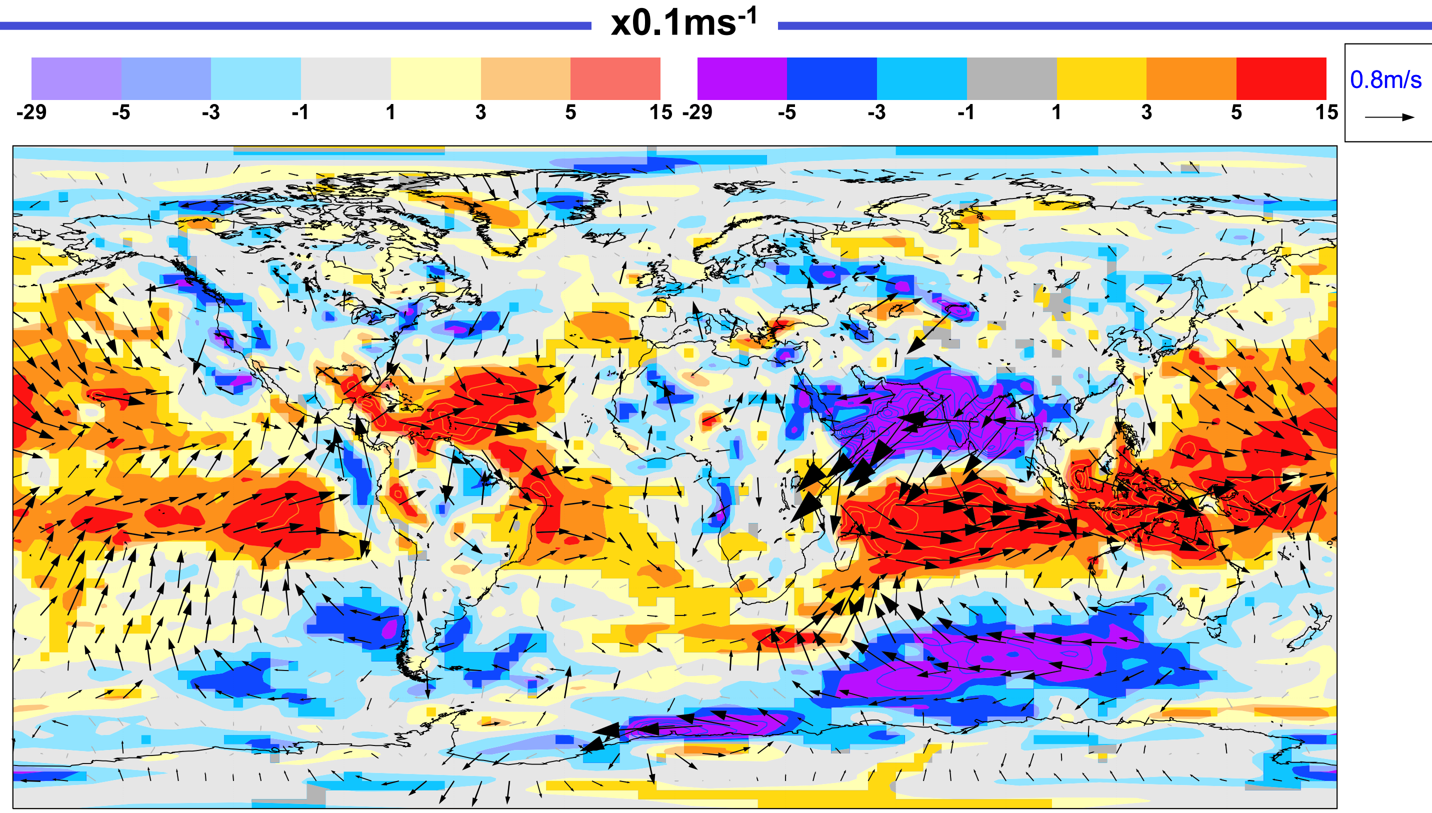
Initial Process Tendencies JJA 2008: U at 925 hPa

33R1

Unit = ms^{-1} over first 24h of forecast

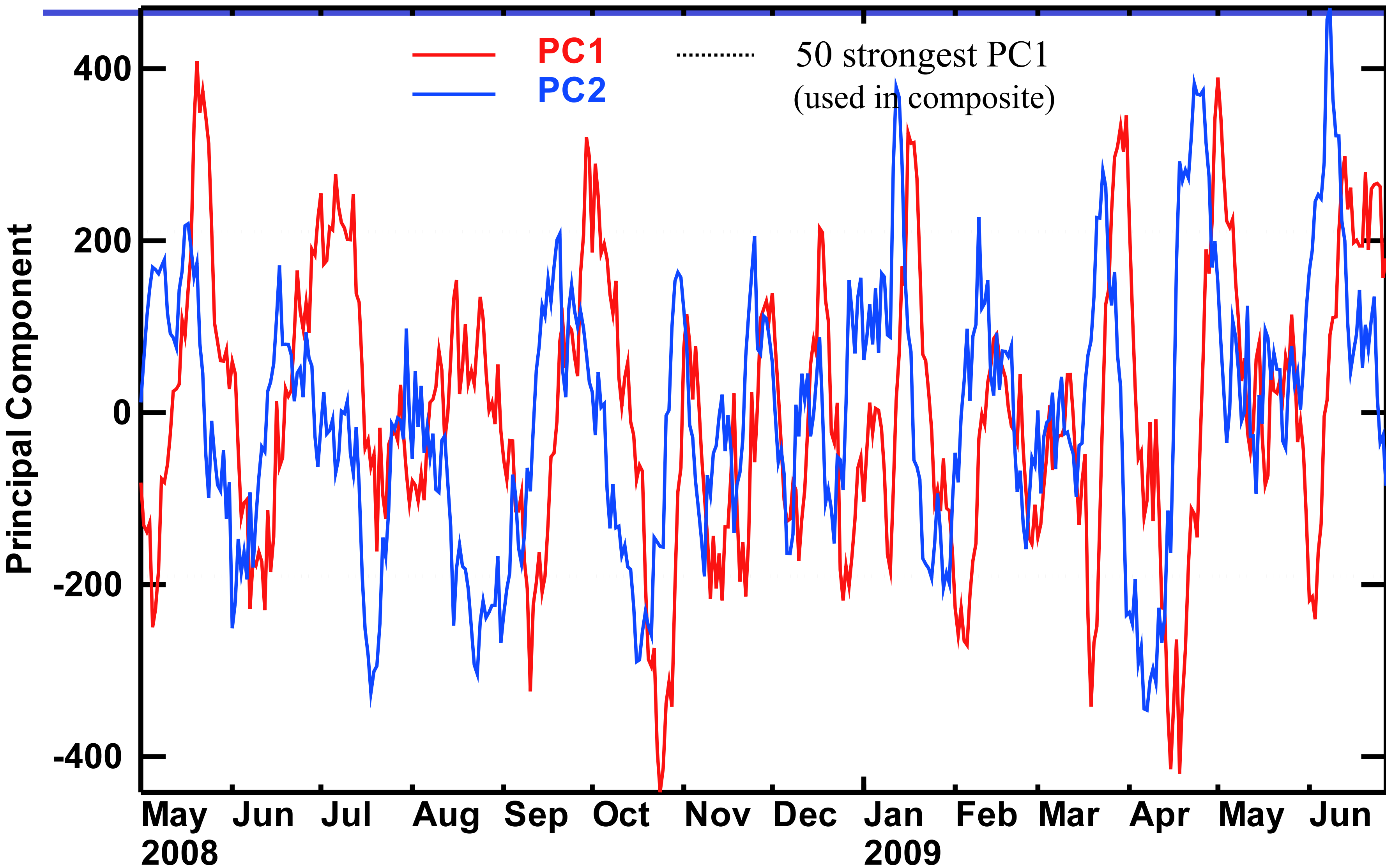


JJA 2008 u and v 925hPa Analysis Increments



- Analysis Increments indicate that the modelled low-level flow over the Indian Ocean and Arabian Sea (and thus moisture transport into the monsoon) is too strong.
- Are these increments pointing to the root-cause for the monsoon error?

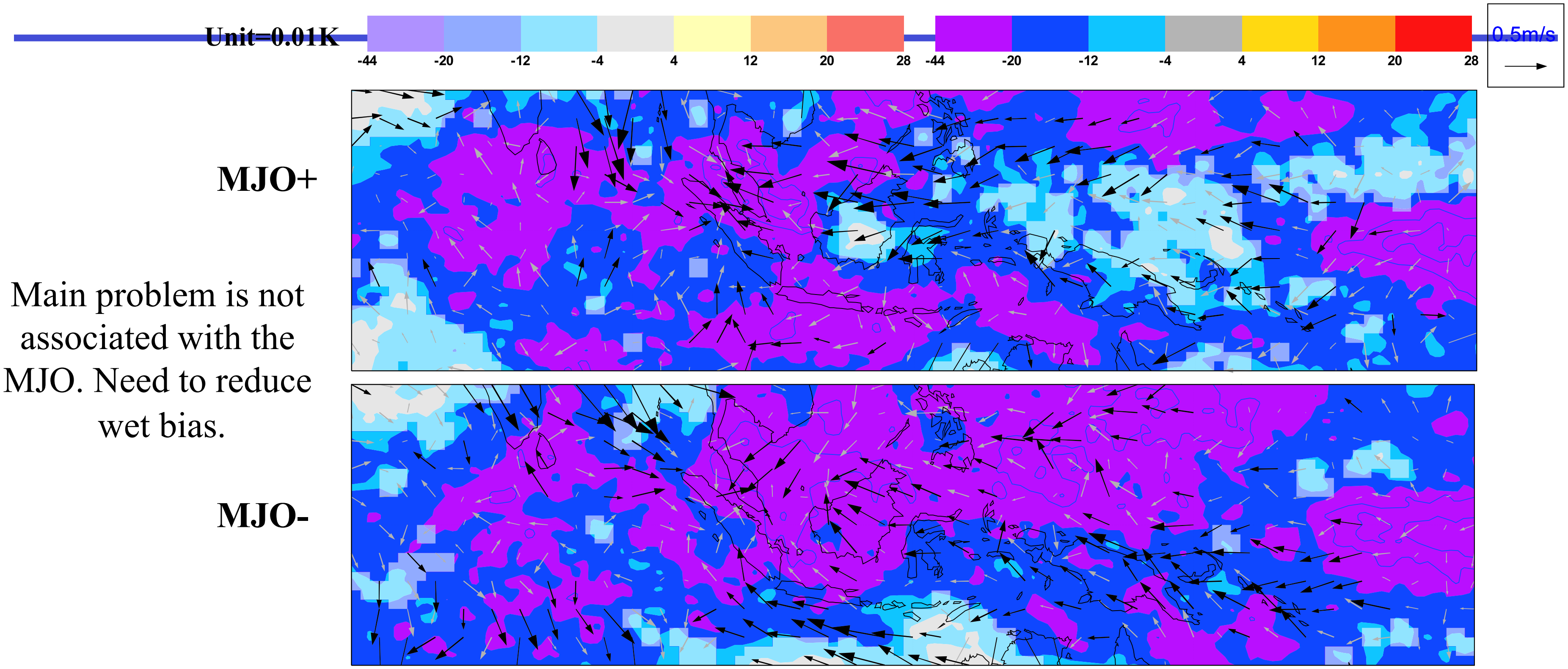
PC1&2 of Vel.Pot. Operational Analyses



EOF2 leads EOF1 by a quarter period: indicating eastward propagation

ECMWF

Analysis Increments (12hr window): T500

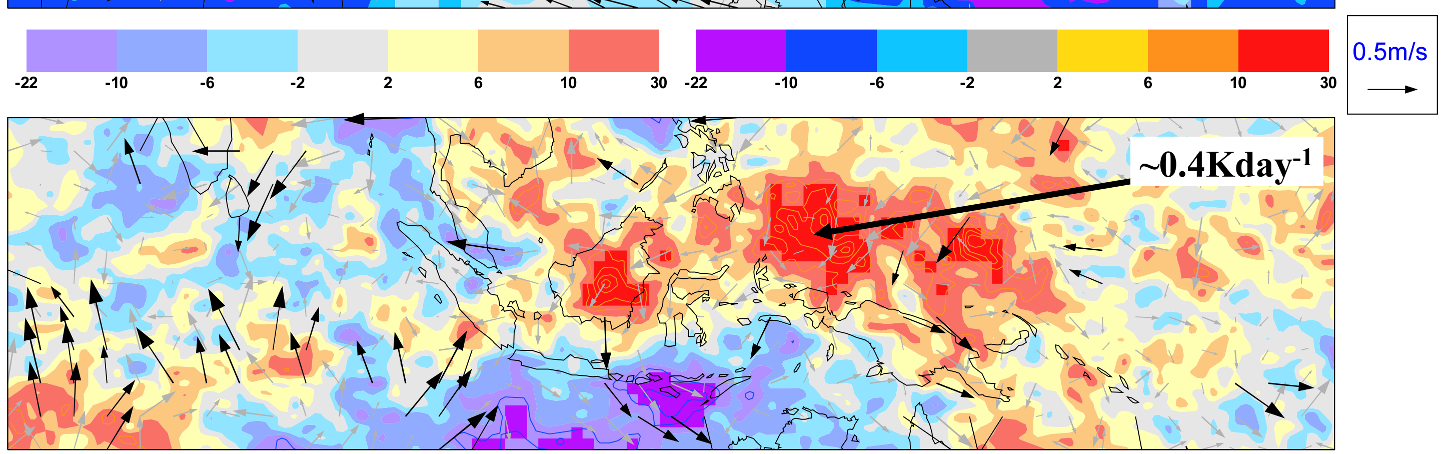


MJO+

Main problem is not associated with the MJO. Need to reduce wet bias.

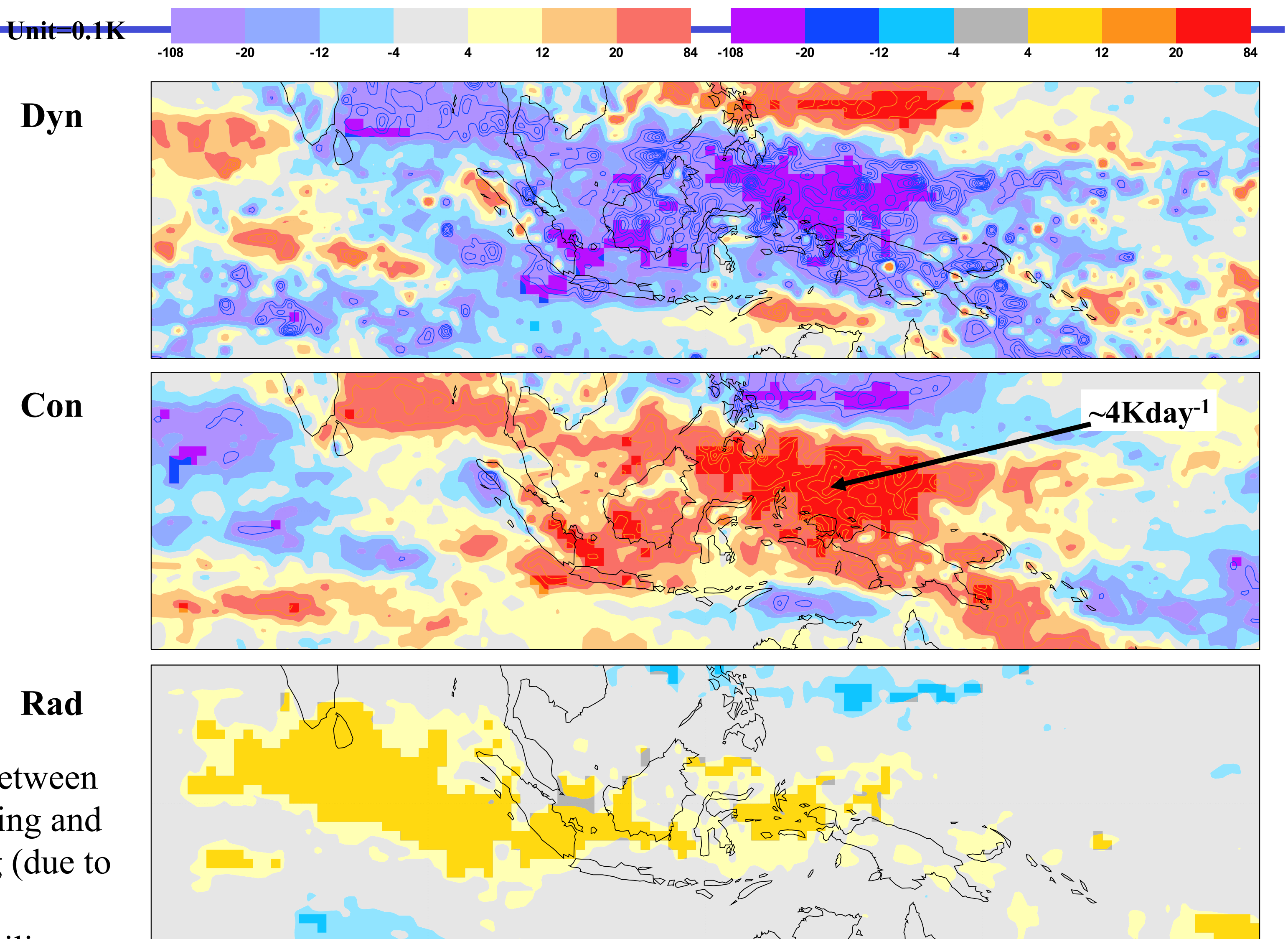
MJO-

δMJO



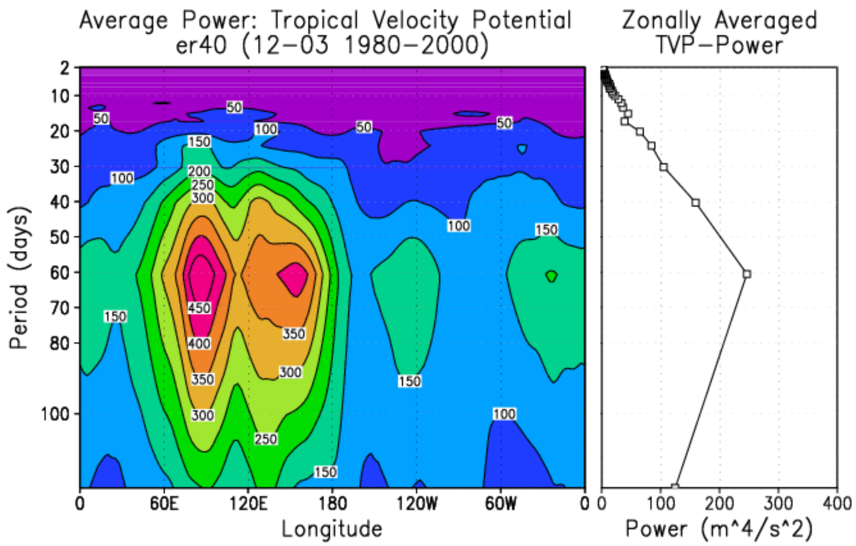
Model "MJO convection" ~90% of true signal?

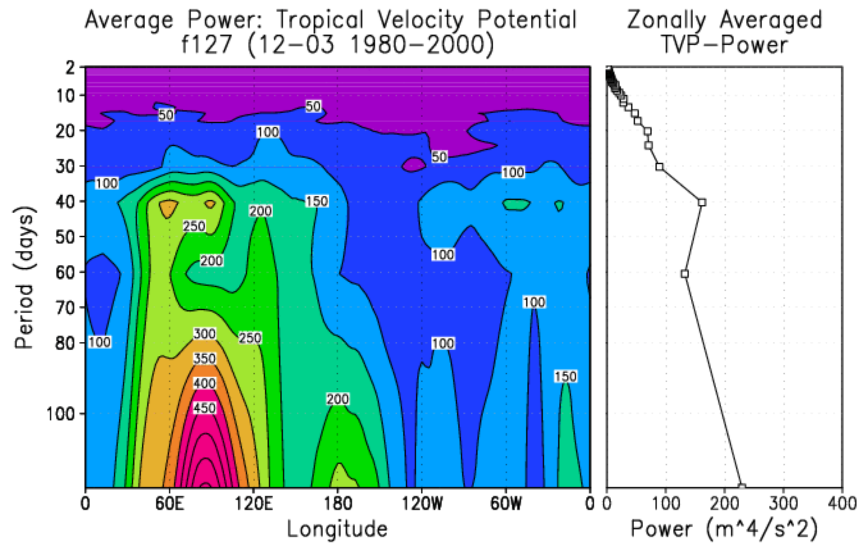
Initial Tendencies (First 24hr): T500, δMJO



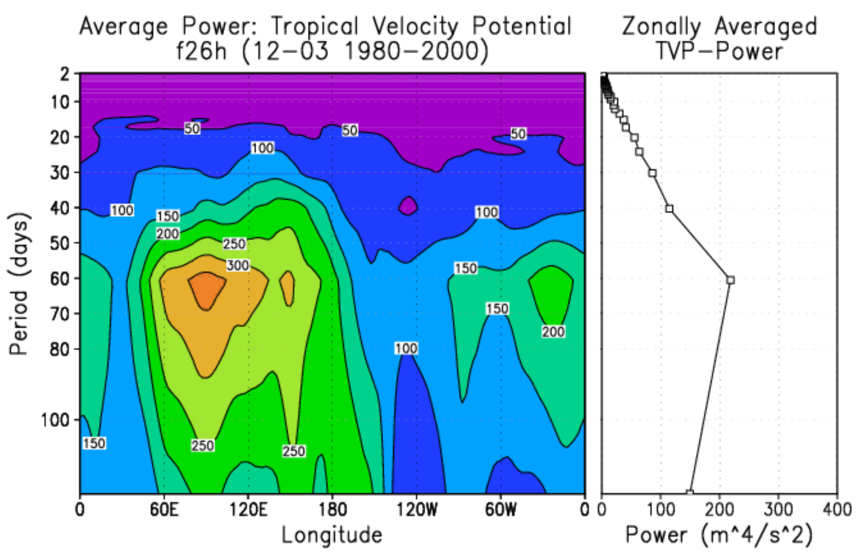
Main balance between convective heating and dynamic cooling (due to ascent).
Radiation stabilises atmosphere behind MJO

Convection sensitivity experiment winter



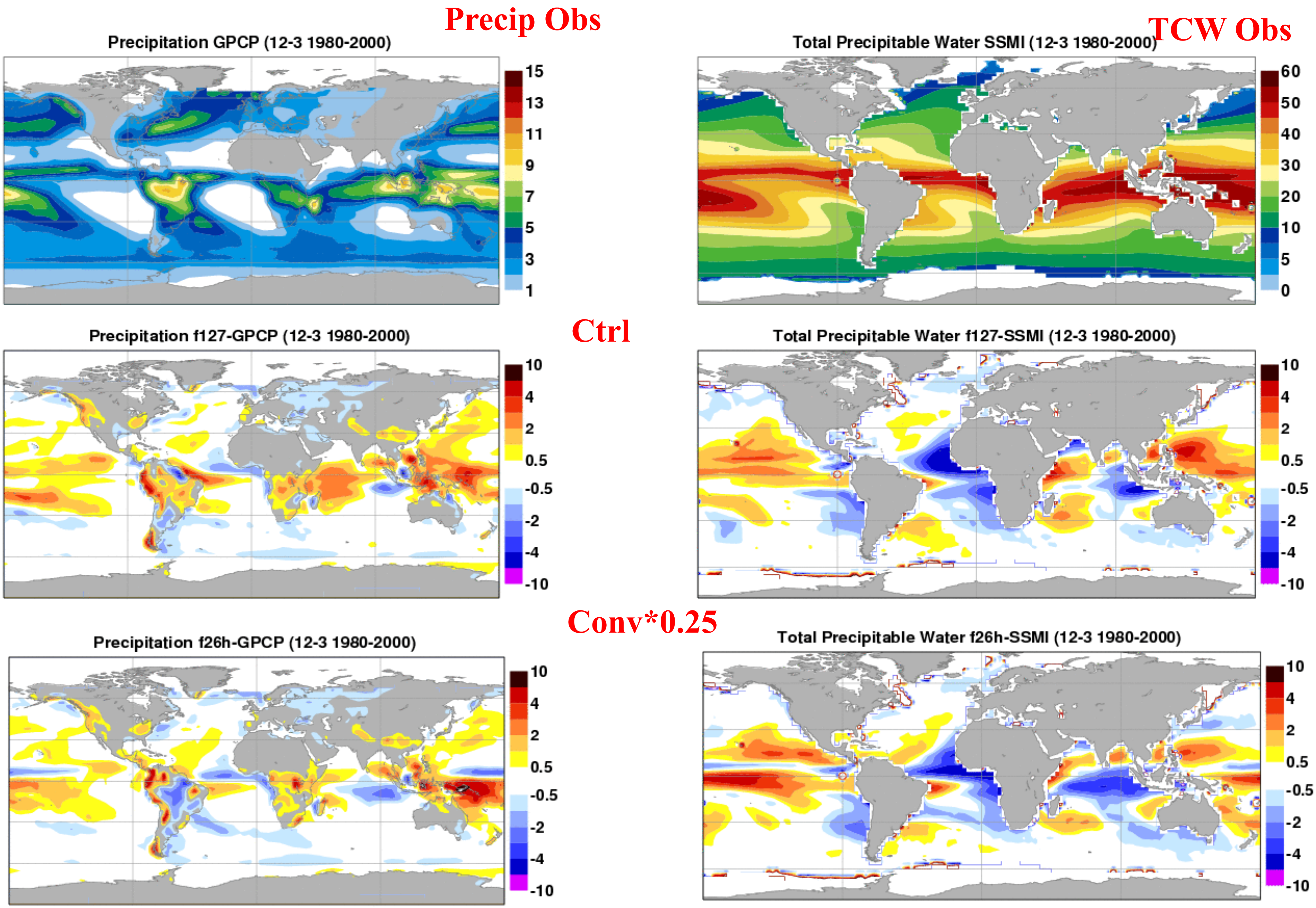


Ctrl



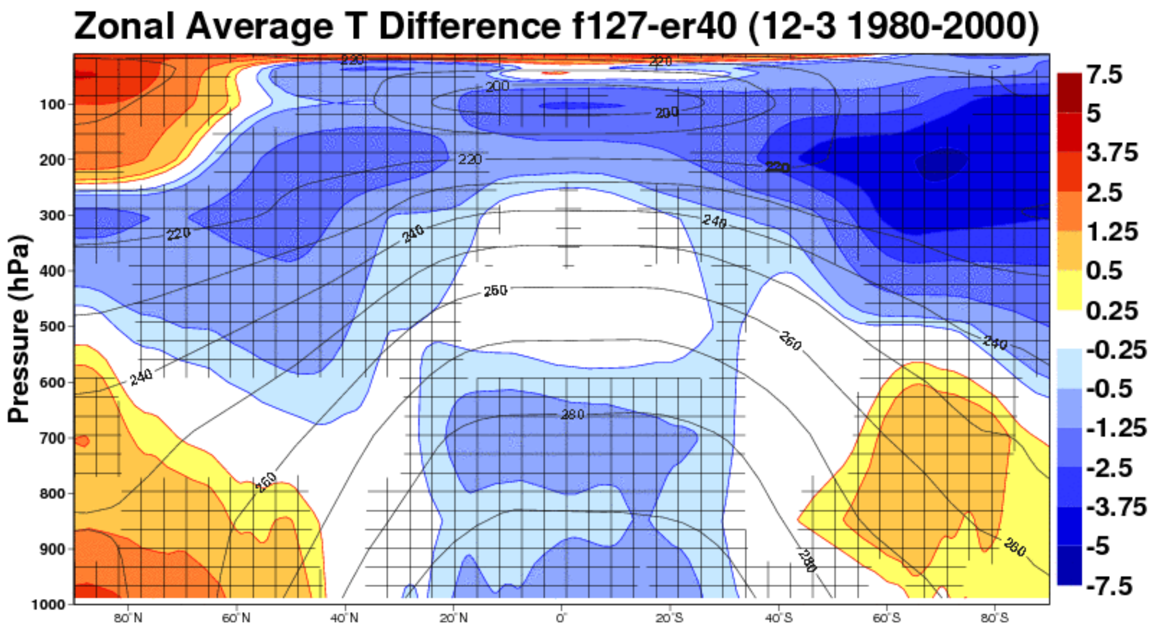
Conv*0.25

Convection sensitivity experiment winter: mean state

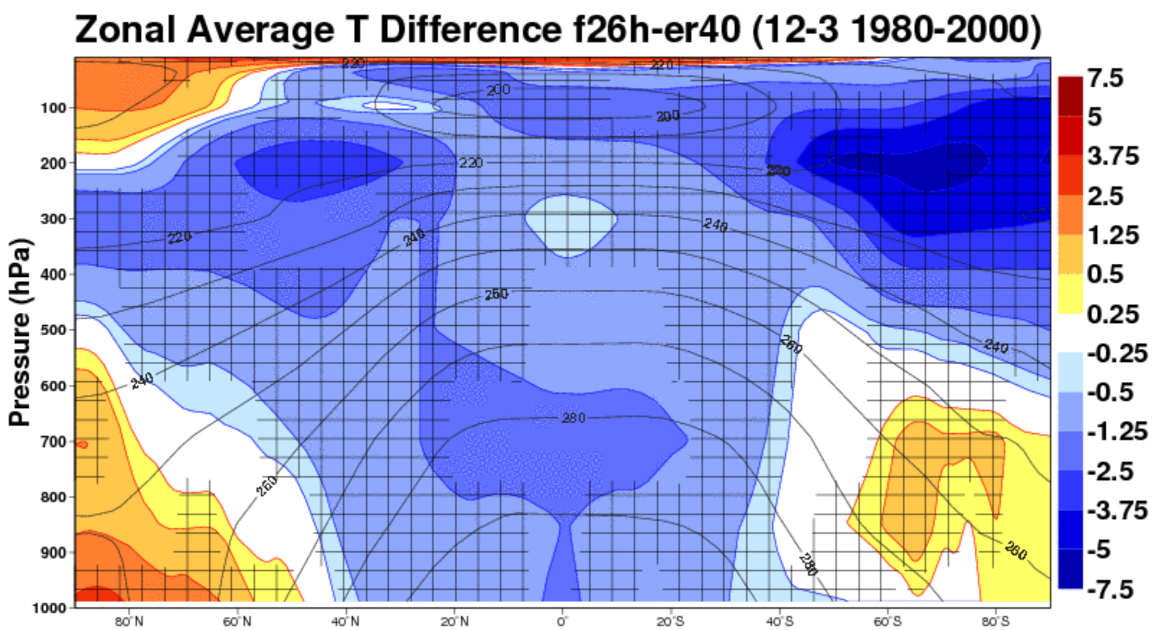


Convection sensitivity experiment winter: mean state

Ctrl

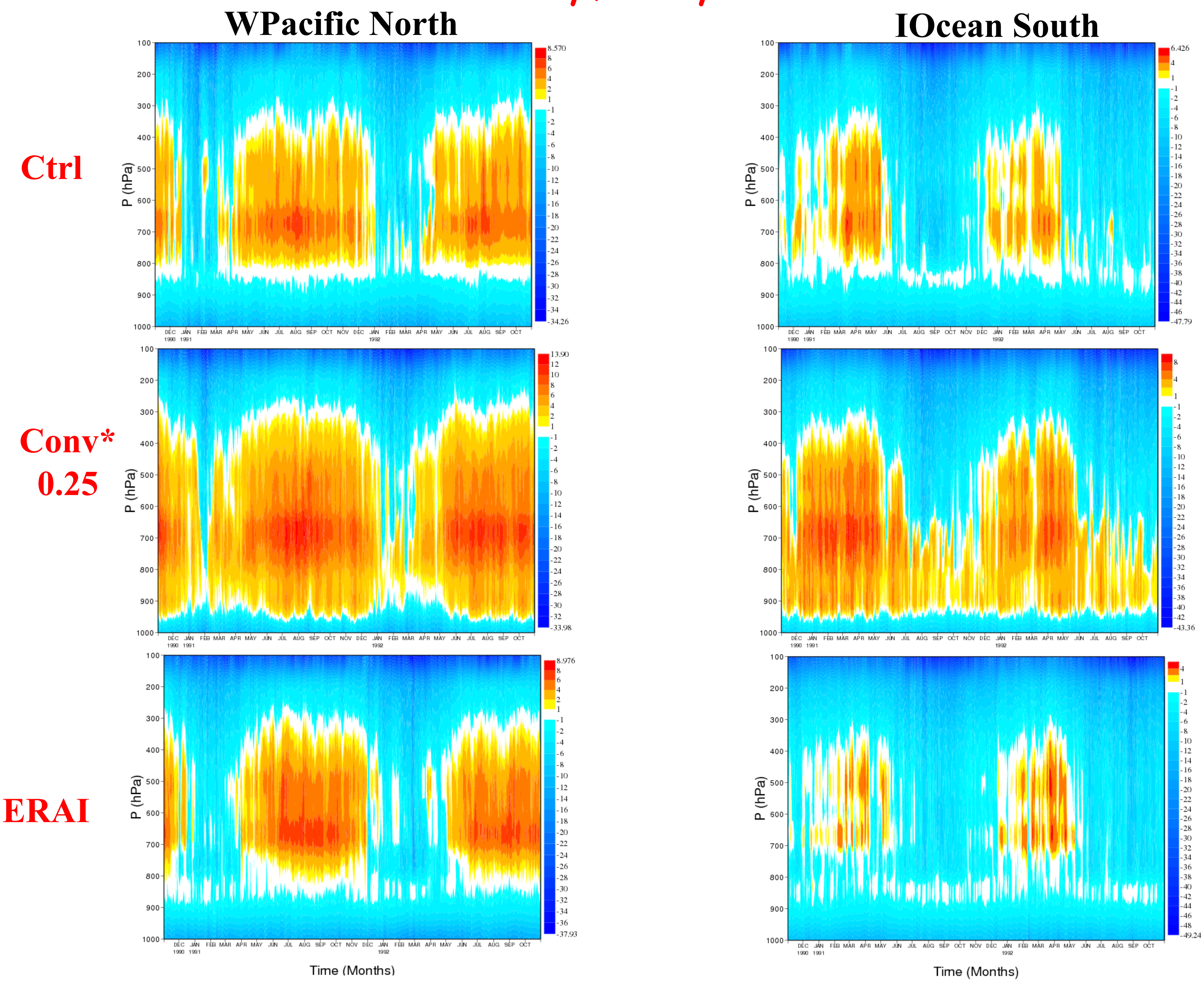


Conv*0.25



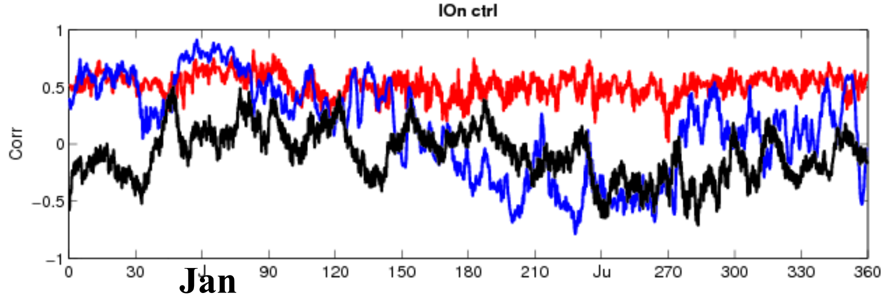
Check for vertical stability, daily

$$\theta_e(T, q, P = 1000) - \theta esat(T, P)$$

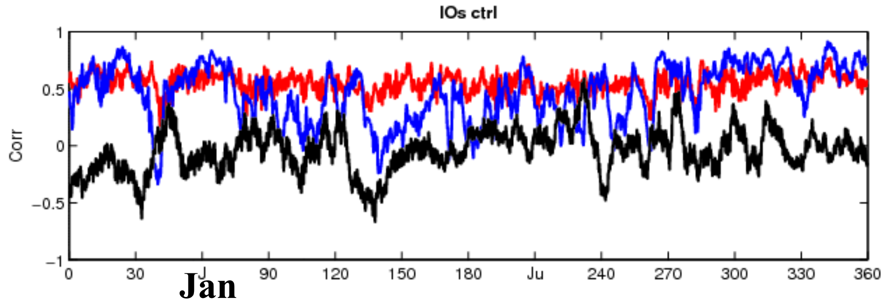


Correlations: 700-500RH-Precip CAPE-Precip 250hPaVelpot for Indian Ocean North & South from 6hly data

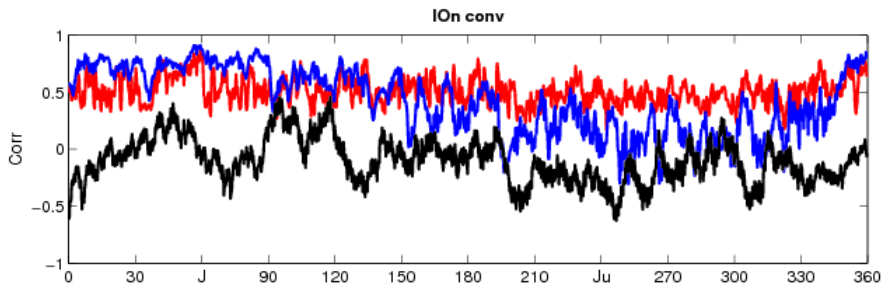
IO north Ctrl



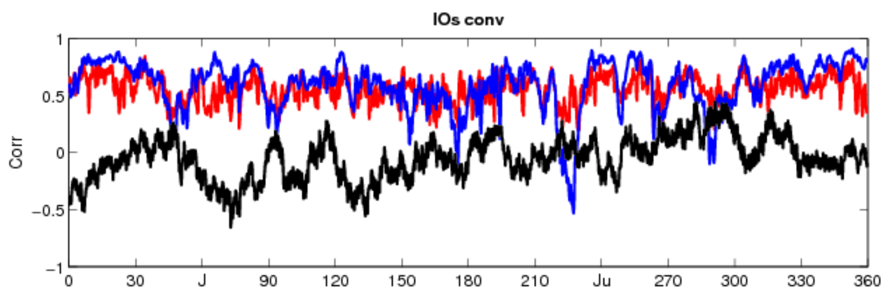
IO south Ctrl



IO north Conv*0.25



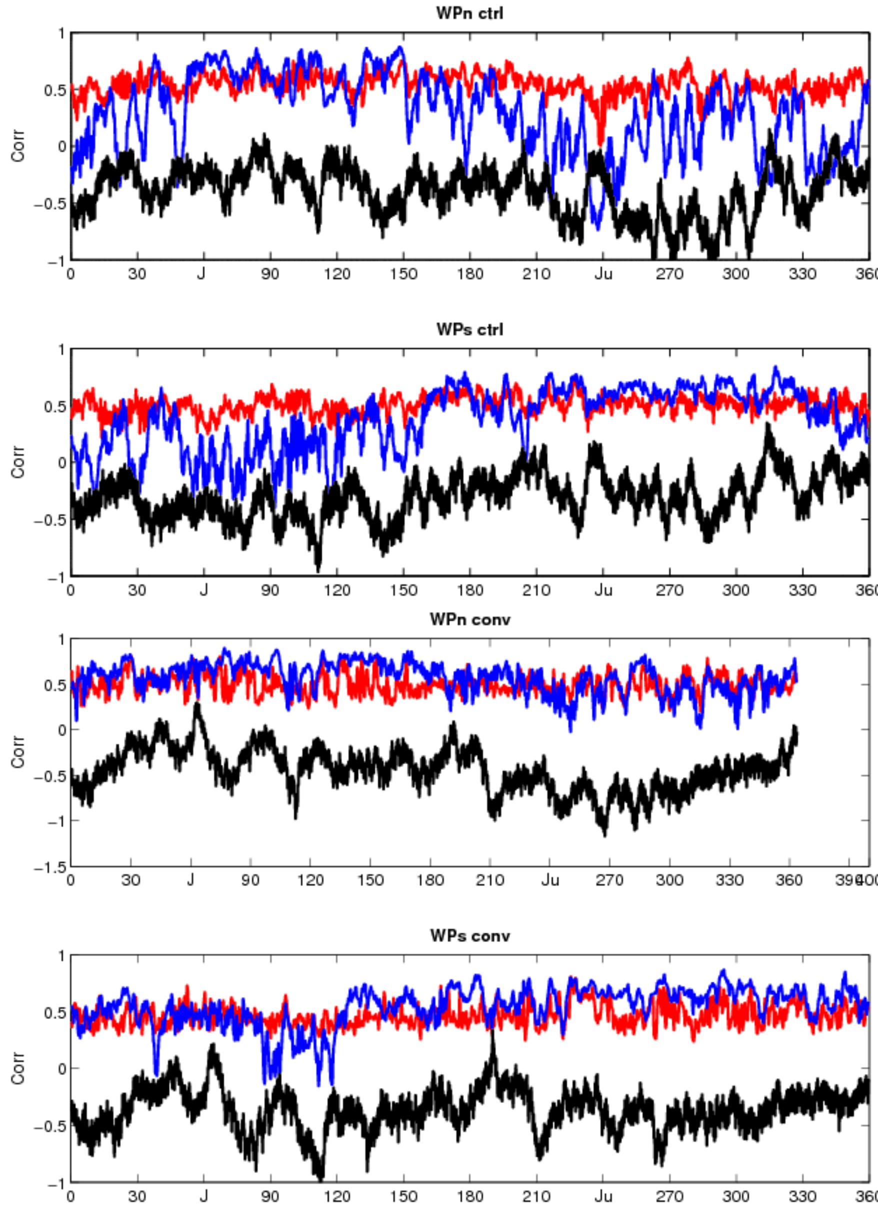
IO south Conv*0.25



Correlations 500 RH-Precip CAPE-Precip 250hPaVelpot for Pacific Ocean North & South from 6hly data

Ctrl

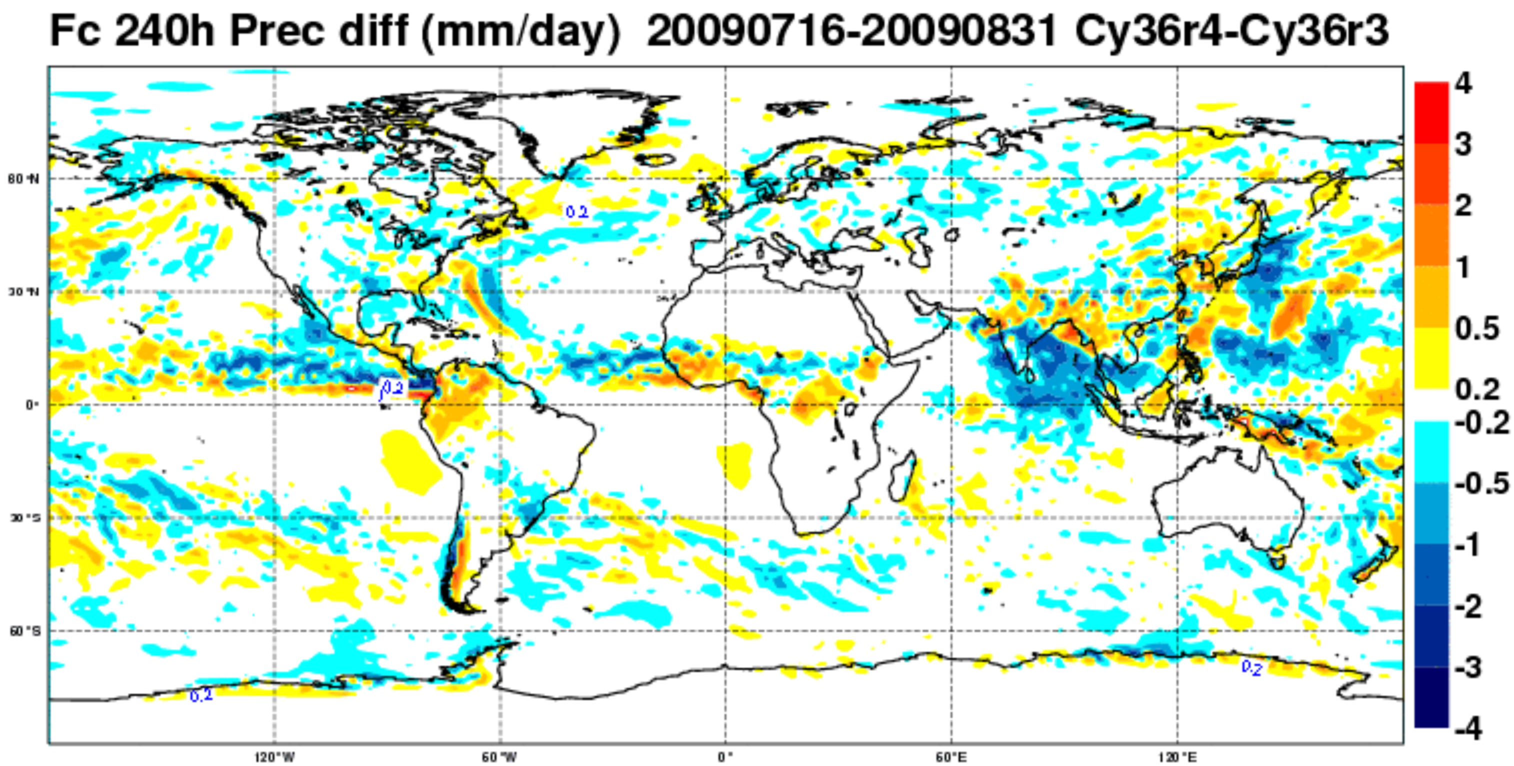
Conv*0.25



Remarks

- ATHENA project: run IFS for 40 years at T159 (125 km) - T2000 (10 km) resolution. Results barely resolution dependent but better variability/correlations and tropical storm activity at >40 km resolutions. See Poster by Emilia Jin and colleagues!
- MJO driven by extratropical Rossby wave activity (resonance effect) as in Wedi&Smolarkiewicz (JAS 2010)? *Difficult to proof even with extratropical relaxation experiments*
- Overestimation of convection –> supression of convection and slow build up of CAPE/moisture probably key factor
- Can get MJO for wrong reason= overly cold unstable troposphere?
- For detailed phase composites and predictability of MJO on monthly/seasonal time scale in IFS see talk by Frederic Vitart

Convection modifs for next cycle:



Improvements for next cycle due to Conv+Microphysics
Improvements also seen in upper tropical winds and MJO (see Frederic)

Due to decreased shallow convection-surface fluxes-> lesss precip, or due to improved entrainment/detrainment-> better upper tropospheric structure or change in stability?

For future my guess is radiation aerosol will be very important to improve Monsoon

Cellular Automaton

belongs to the family of self-critical systems, e.g. forest fires, sand pile, game of life etc.

ECMWF

Aim:

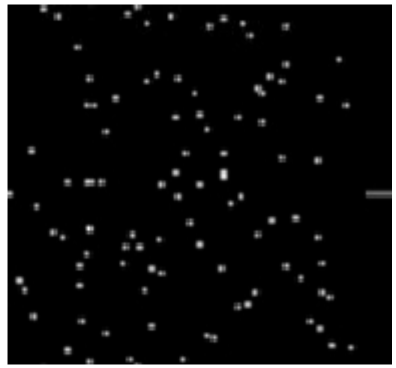
- Improve on the MJO
- Improve on the propagation of convection in general

Technique

- Use e.g regular lat/lon grid, play game of life
- Initialize living cells at convective points, propagate and create living cells as function of CAPE using certain rules – include wind speed through probability
- Couple 2D CA field (number of lives) to convection parametrization by perturbing T,q input profiles (+ [living cells] or – [no lives] vertical sine function, amplitude 0.2 K, 2% humidity)

Cellular Automaton (number of lifes) in IFS

Toy model



in IFS T159 coupled with convection scheme