Influence of Process Interactions on MJO-Like Convective Structures in the IFS model

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With Thanks to

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Conclusions

One month ago…

<u>Original Talk Plan</u>

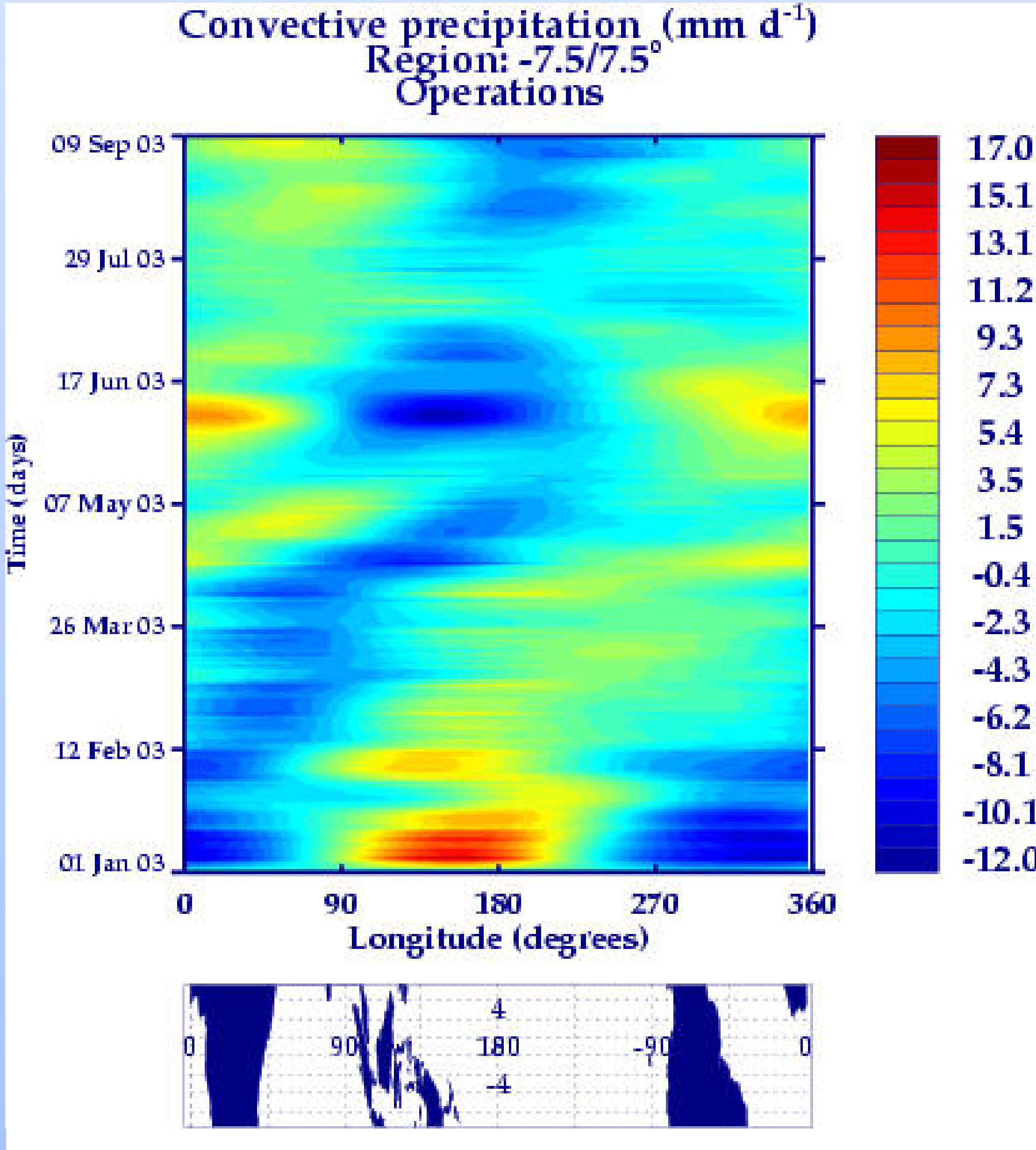
- **Show strengths & inadequacies of MJO in IFS**
- **Conduct sensitivities tests to obtain perfect MJO**
- **Go home happy and have a cup of tea**

Outline

ECMWF products:

- 10 day forecasts at T511 L60 resolution
- 6 month seasonal forecasts at T95 L60 resolution (coupled)
- 1 month coupled forecasts

1. **MJO in default model**
2. **Possible Thermodynamic Feedbacks**
3. **Aqua Planet Sensitivity Tests**



T511 Operations
Year 2003
10 day forecasts
“pasted” together

Obvious Westward and Eastward propagating modes

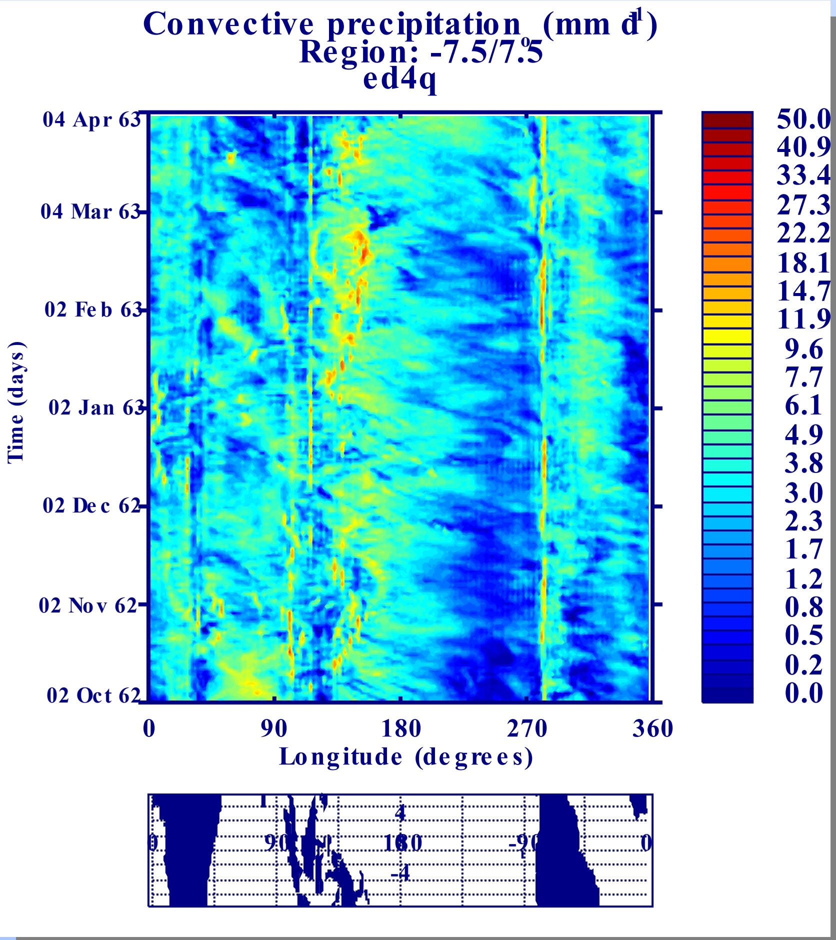
Signs of slow eastward propagation of large wave numbers

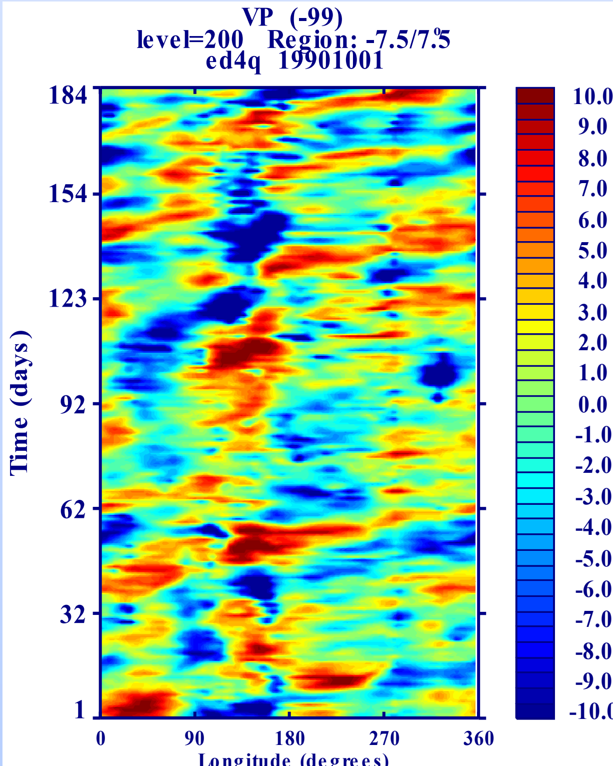
Approach

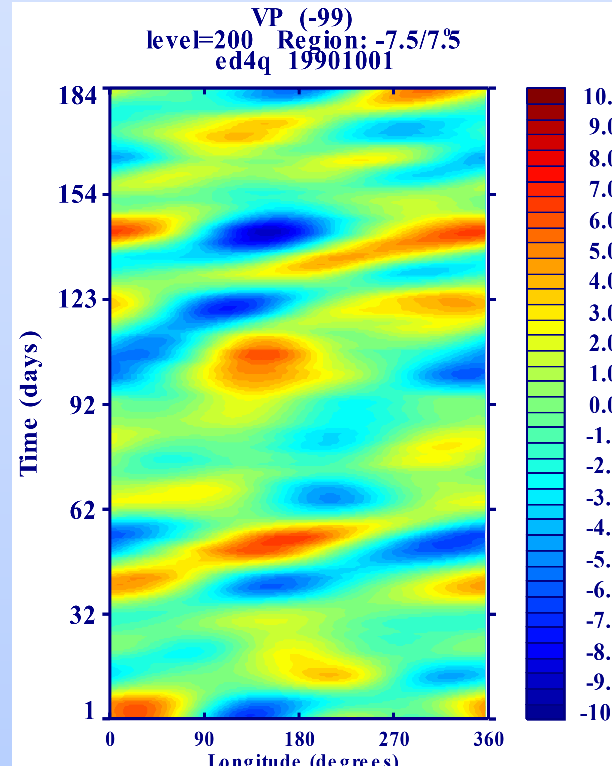
- **Problem with T511:**
  - "Short" forecasts
  - Expensive to conduct sensitivity Experiments
  - Influenced by initial conditions
- **Thus this study will use T95 (L60) resolution**
  - As used by seasonal forecast

- **A series of 6 month forecasts conducted**
- **1962-2000 April and October starts**
  - Can examine interannual variability
  - ERA40 period

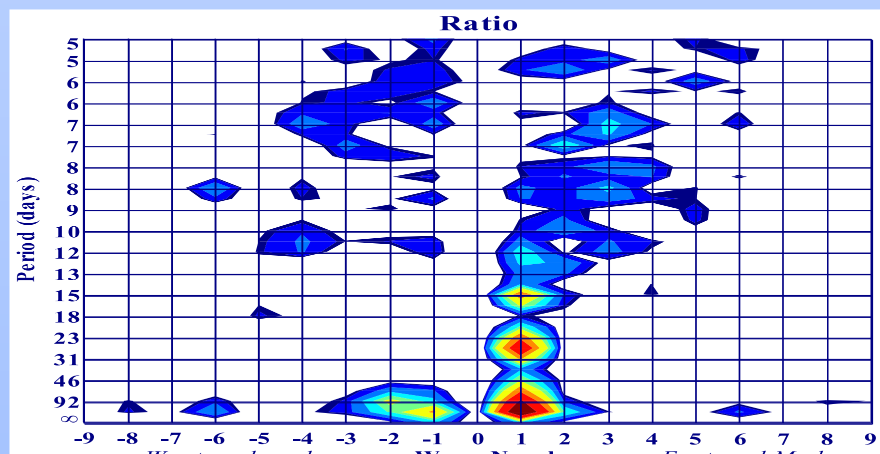
Convective rainfall Shows similar organisation to T511 operational model





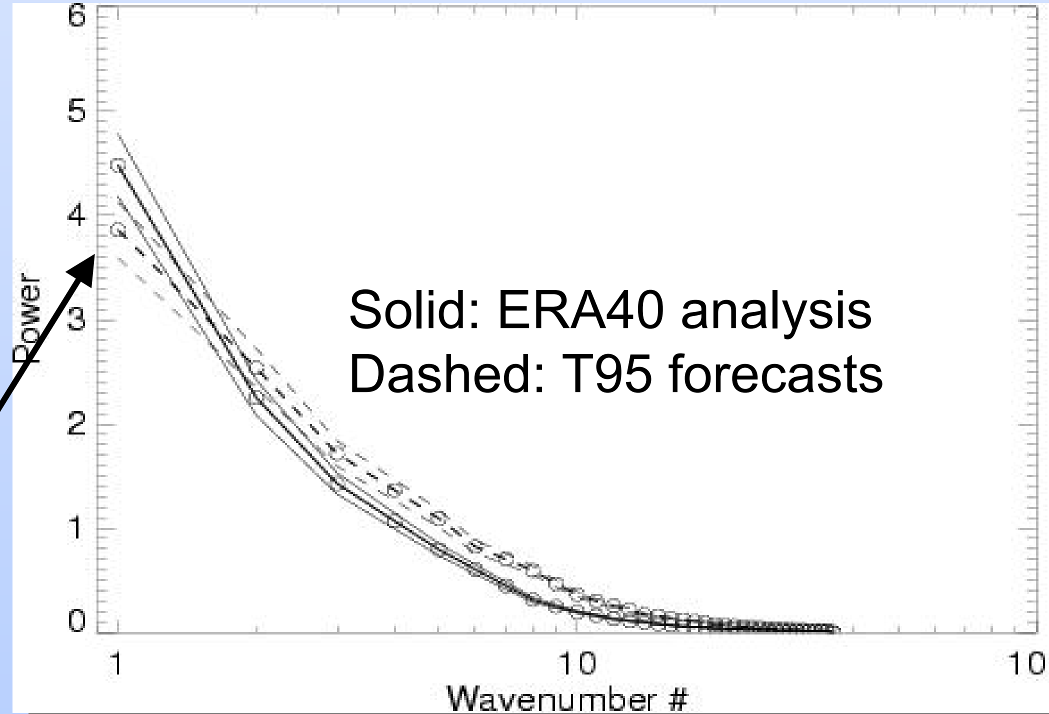


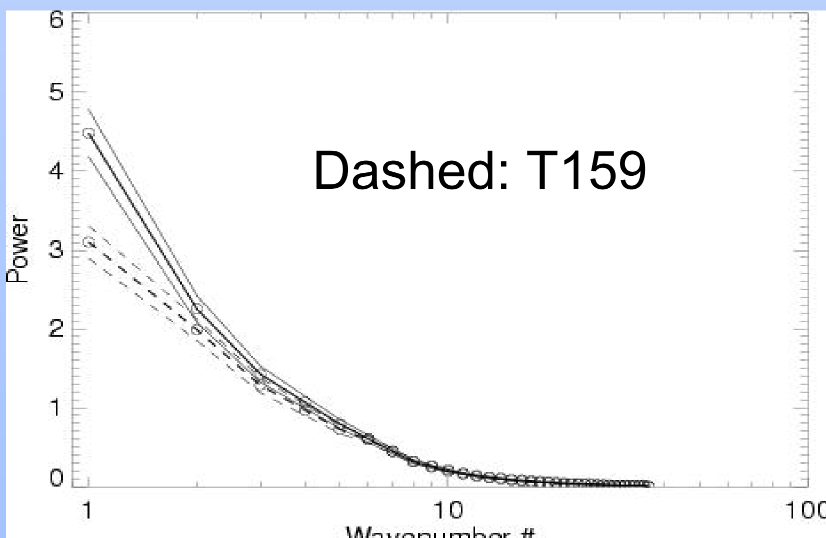
200hPa Velocity Potential

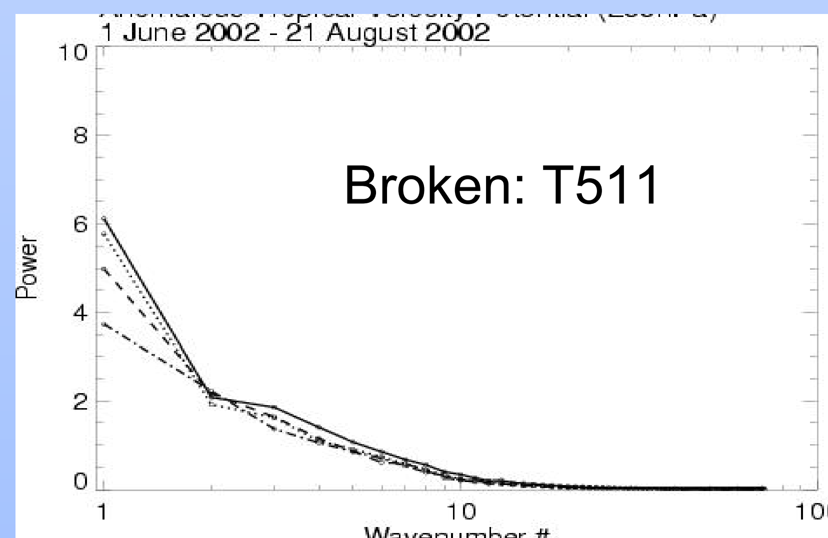


Spectral Power of 200hPa VP as a function of wavenumber

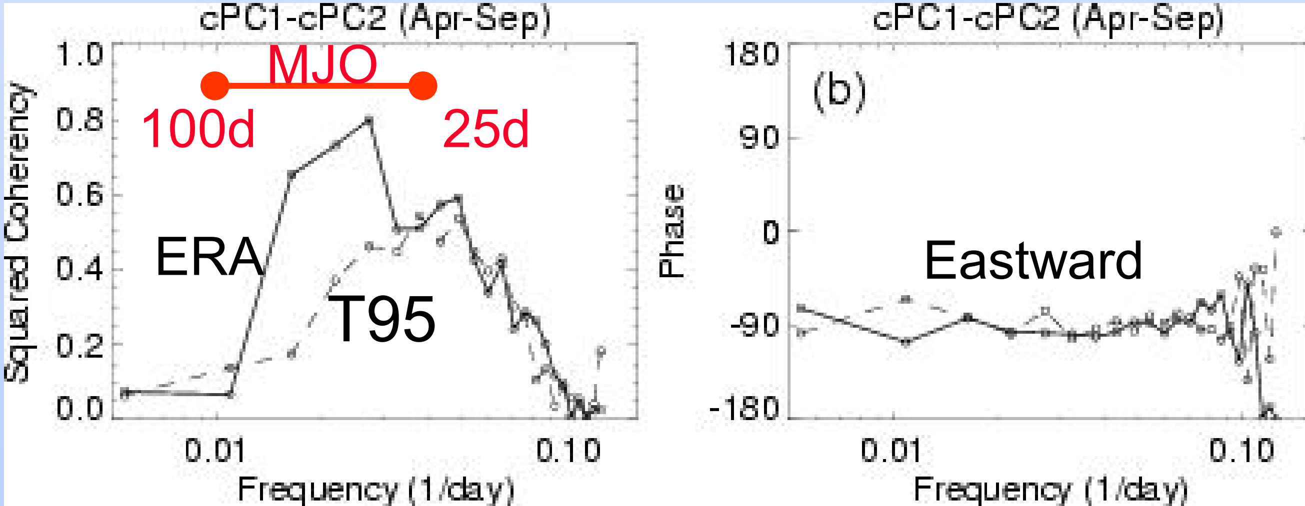
Small Loss of power at wavenumber 1



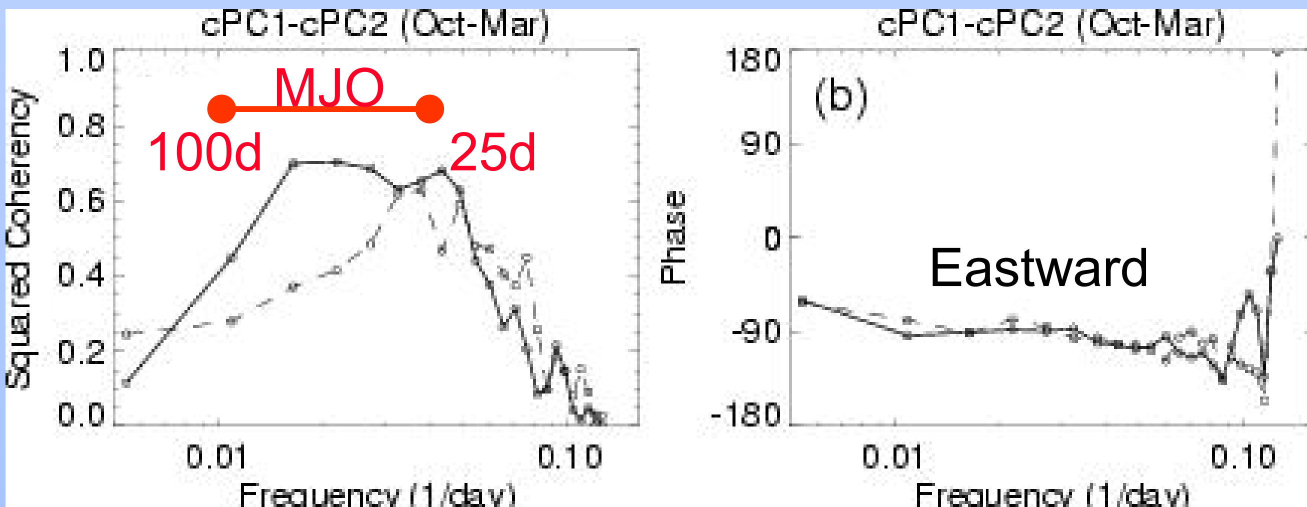




EOF Analysis of T95 and ERA40



Summer



Winter

Solid:ERA

Dashed: T95

High frequencies well reproduced

Low Frequency in main MJO-"band" under represented – Less coherent propagation of signal

Convective Organisation

Thermodynamic mechanisms have been suggested:

- Cloud-radiation feedback
- Role of SST perturbations (coupling)
- **Convective-water vapour feedback**

Water Vapour Feedback

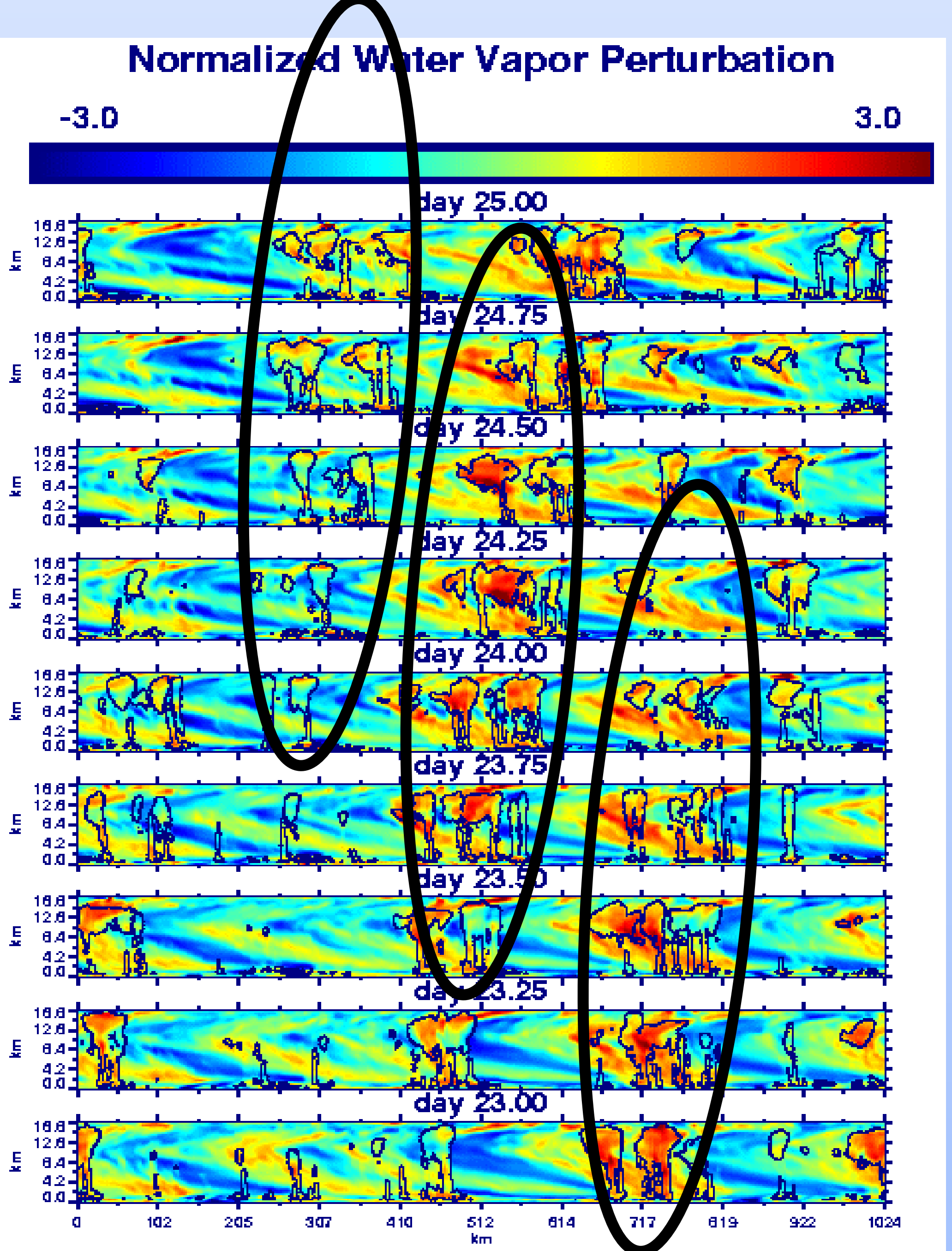
- Precipitating convection dries the atmosphere:
- In a Eulerian view, drying is associated with subsidence, while local environment is moistened through convective detrainment
- This local moistening can “precondition” the atmosphere, making it favourable for future convection

How does water vapour favour preconditioning?

Entrainment into Updraughts

Boundary Layer Theta_e

Complication of downdraughts and organisation!

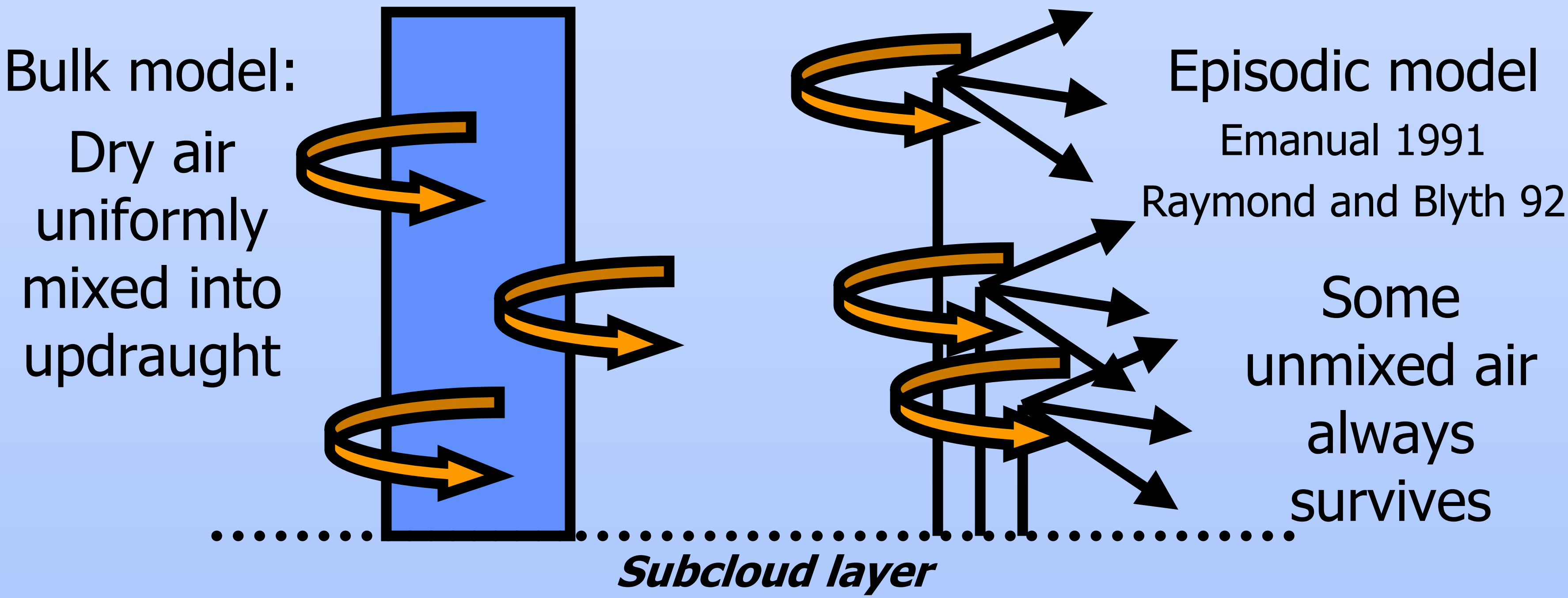


Water Vapour feedback

This cloud resolving model integration showed a strong "water vapour" mode

Packets of convection were modulated by the phasing of boundary layer theta_e and free tropospheric moisture structure

Reminder: The IFS Tiedtke scheme is a bulk mass flux model

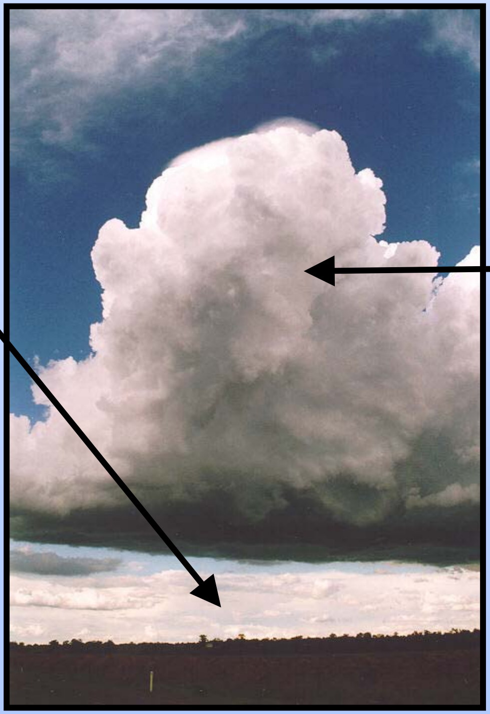


Which is closest to a CRM with a 2km horizontal resolution?

Two Examples of Targeted Sensitivity Tests

Boundary Layer Theta_e

ENHANCE/INHIBIT RAINFALL EVAPORATION



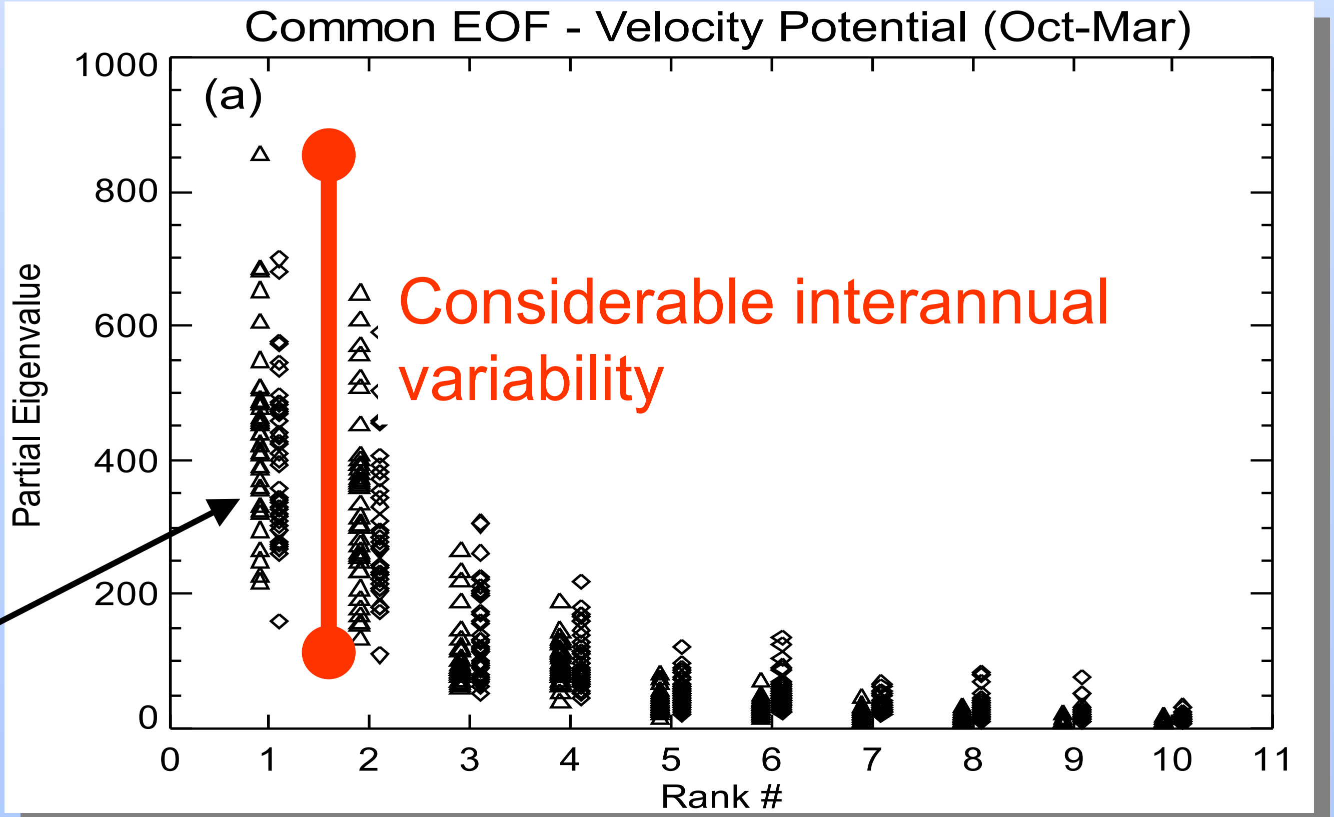
Entrainment into Updraughts

ENHANCE ENTRAINMENT FACTOR

Enhance:
Coverage from 5% to 30%
Double evaporation rate
Increase RH limit from 80% to 100%

Enhance:
Entrainment increase by factor of 5

Interannual Variability and the Aqua Planet

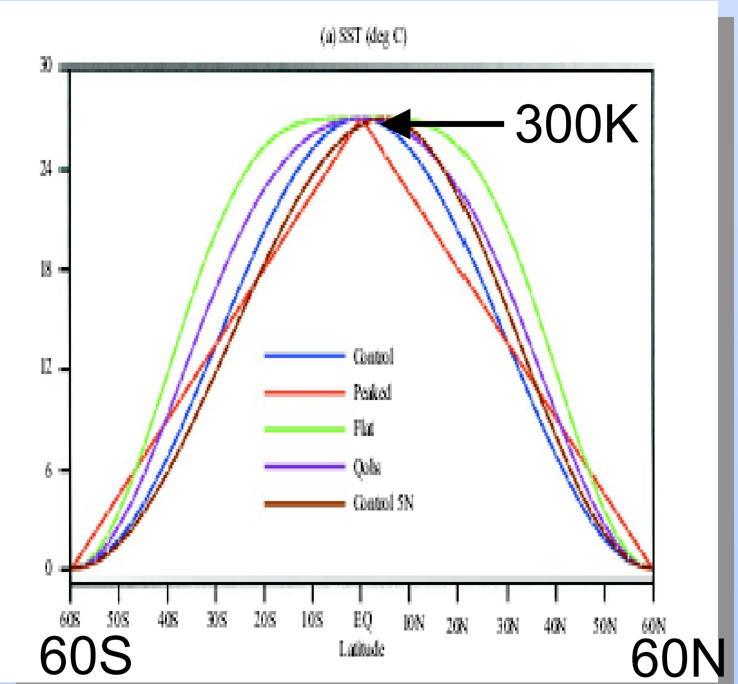


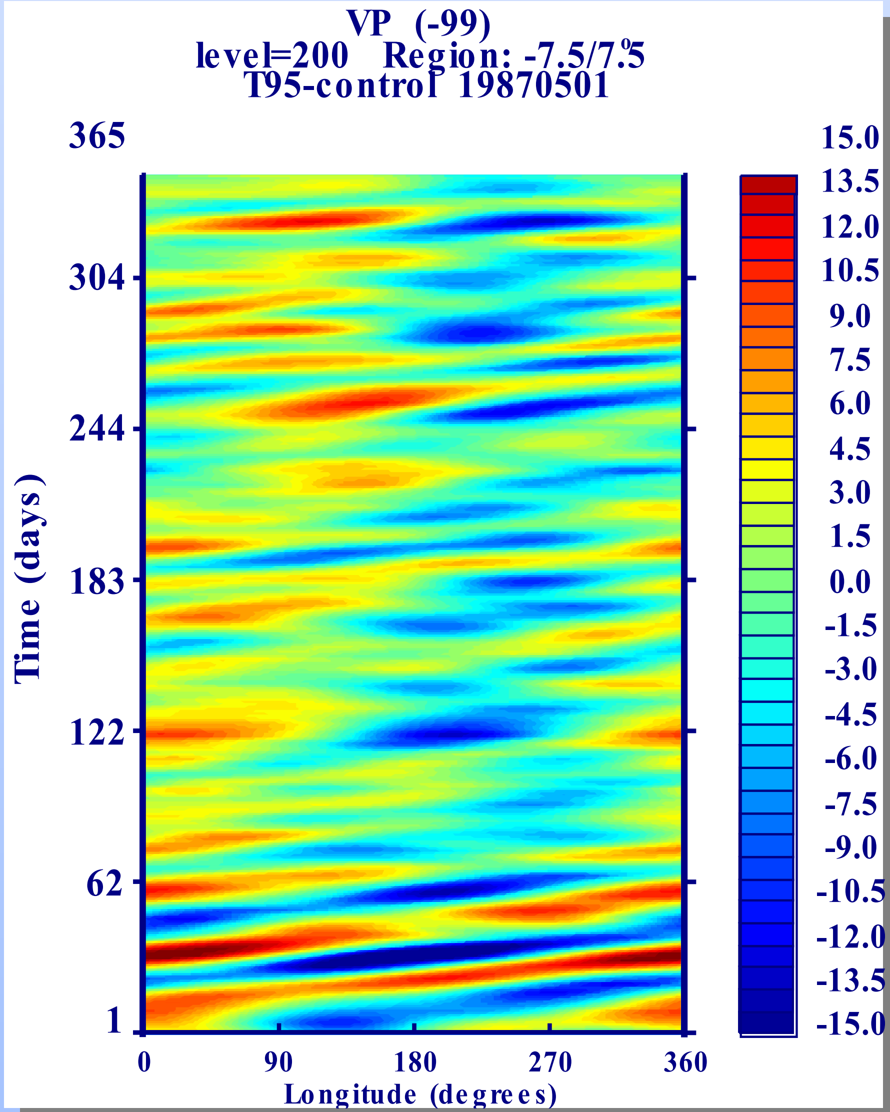
T95 and ERA40

Interannual variability considerable in standard setup

Use Aqua Planet investigation to allow phase space investigation

Aqua Planet Investigation

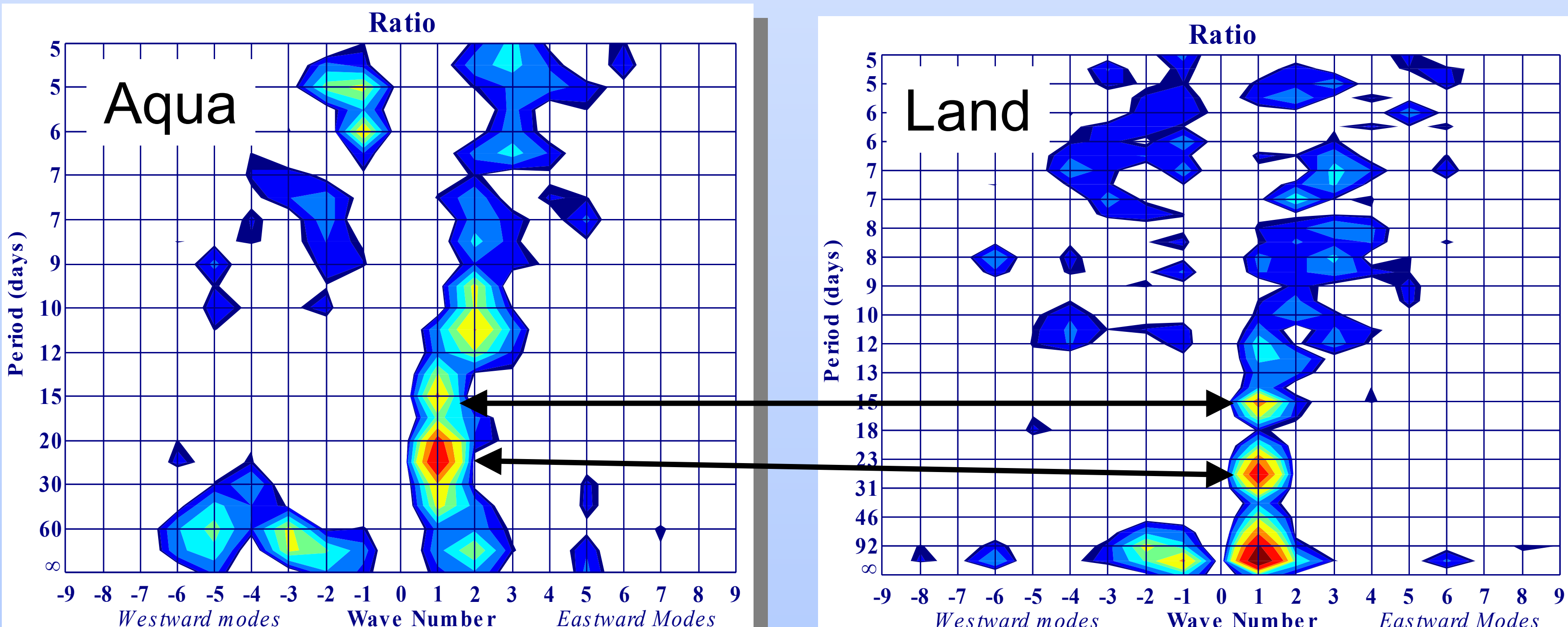


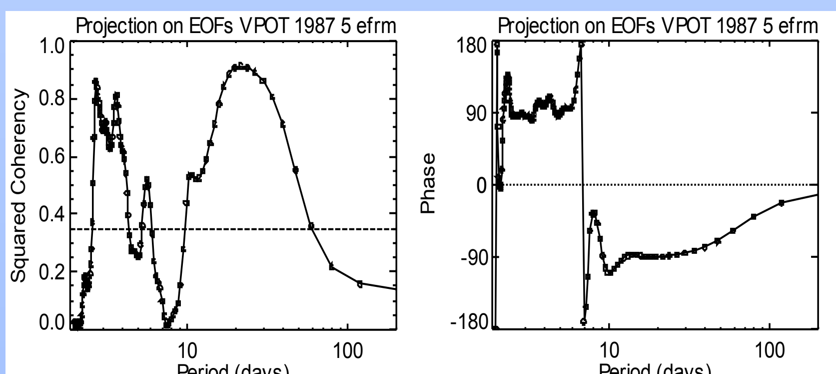


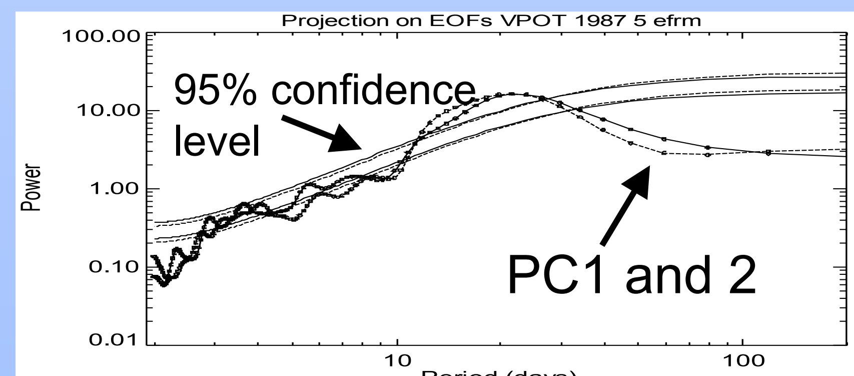
To reduce variability: Test in aqua planet mode

Zonally symmetric SSTs, peaking on the equator

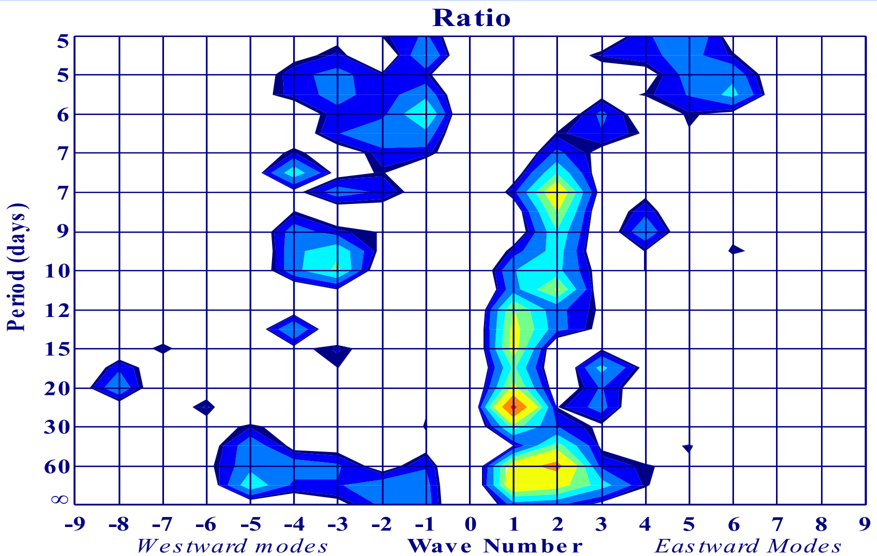
Wave-number frequency Spectra – Control Run

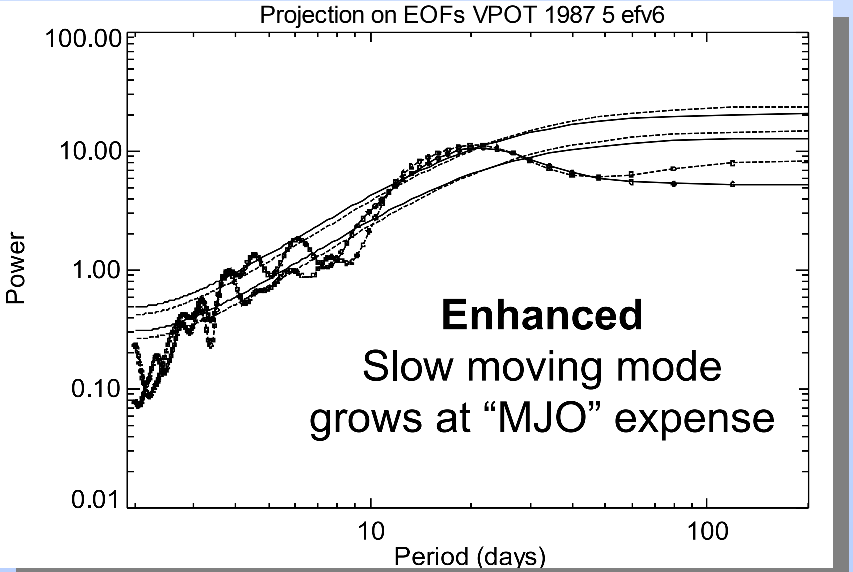


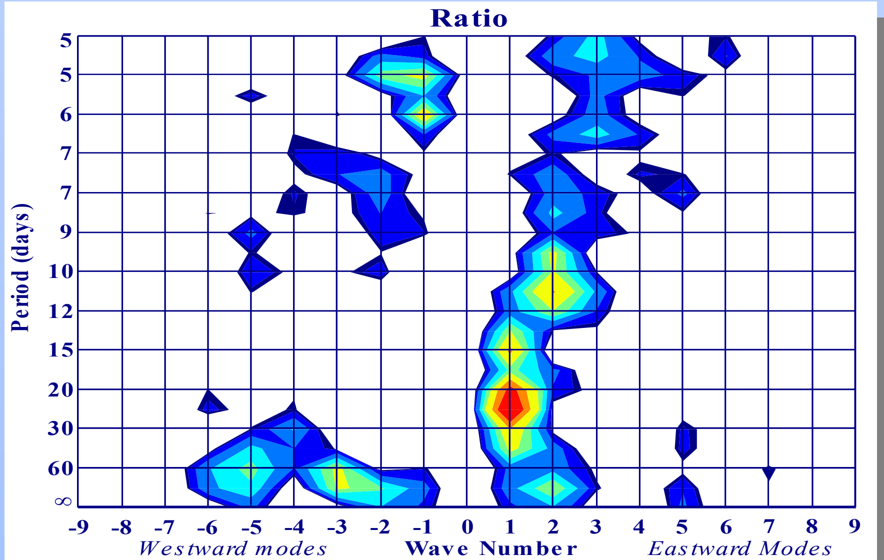


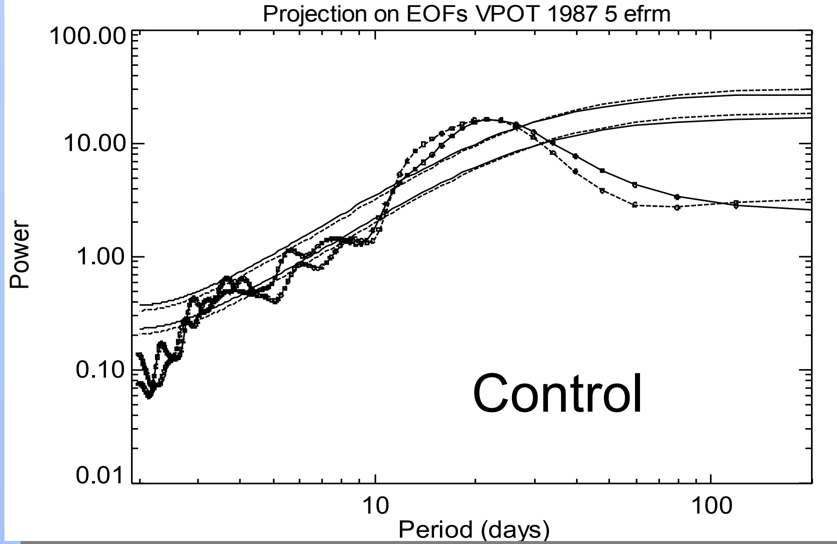


Enhanced Rainfall Evaporation

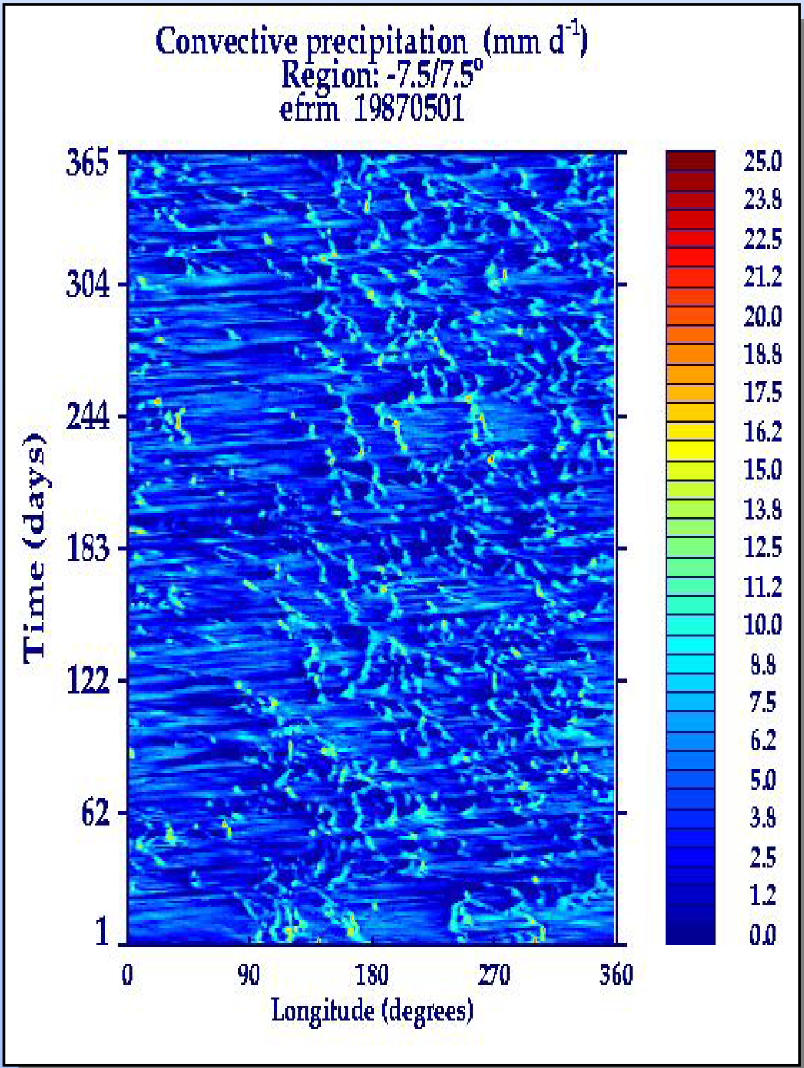


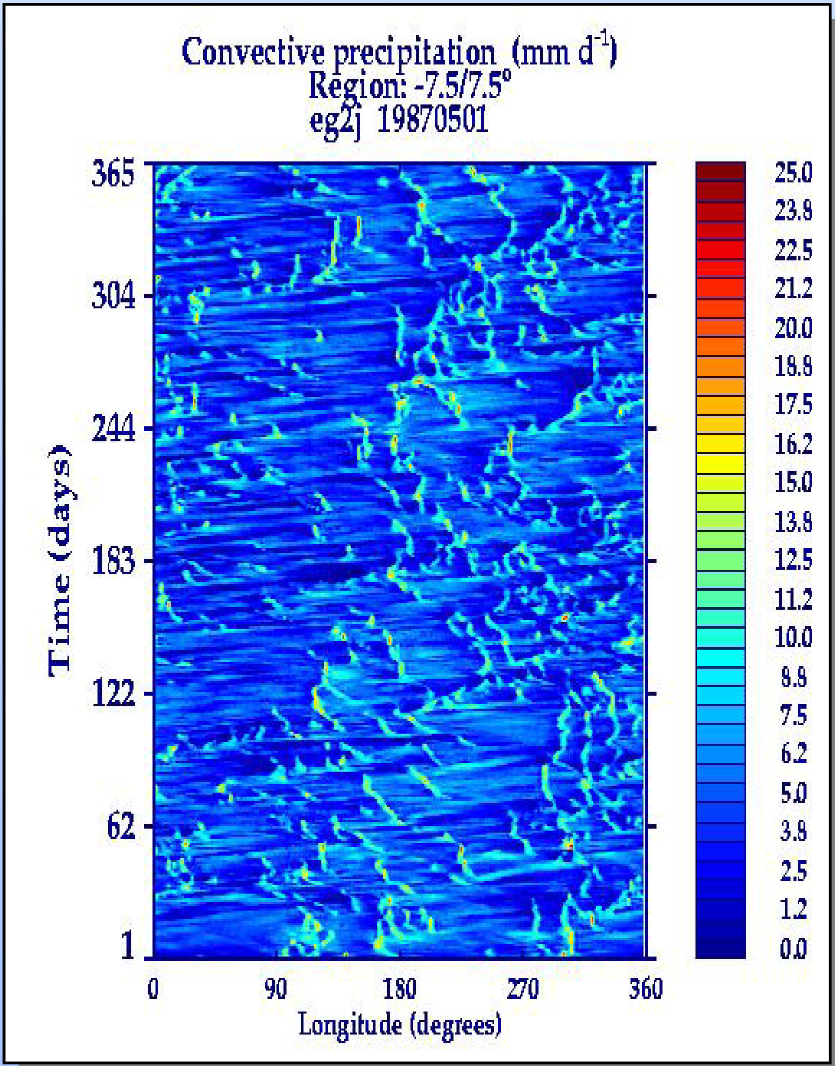




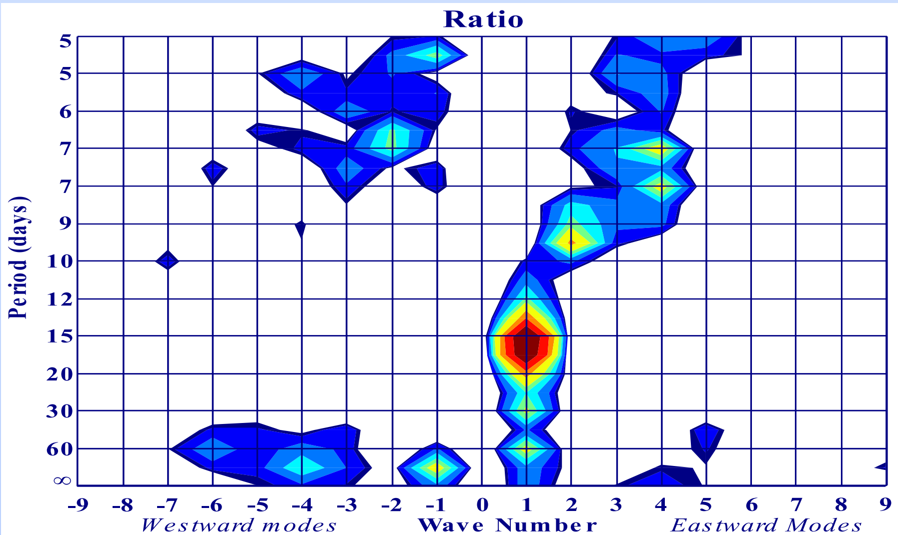


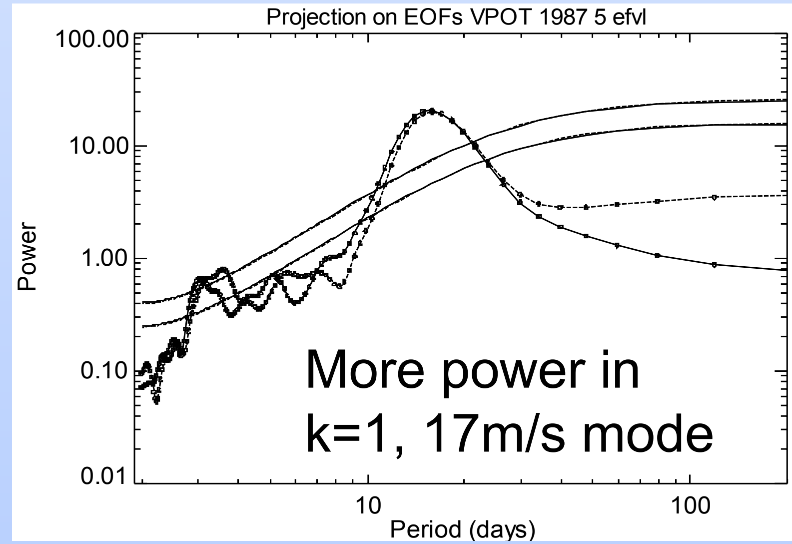
Convective systems do not appear altered

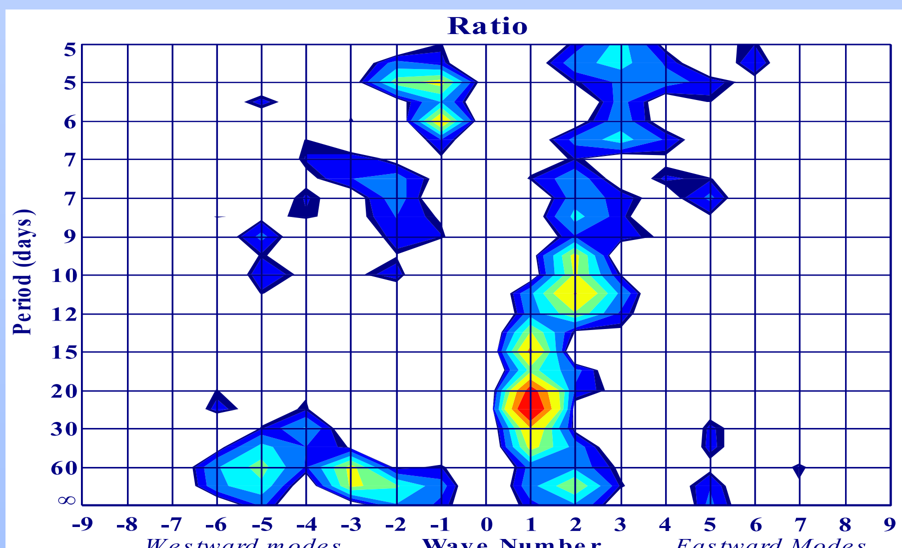


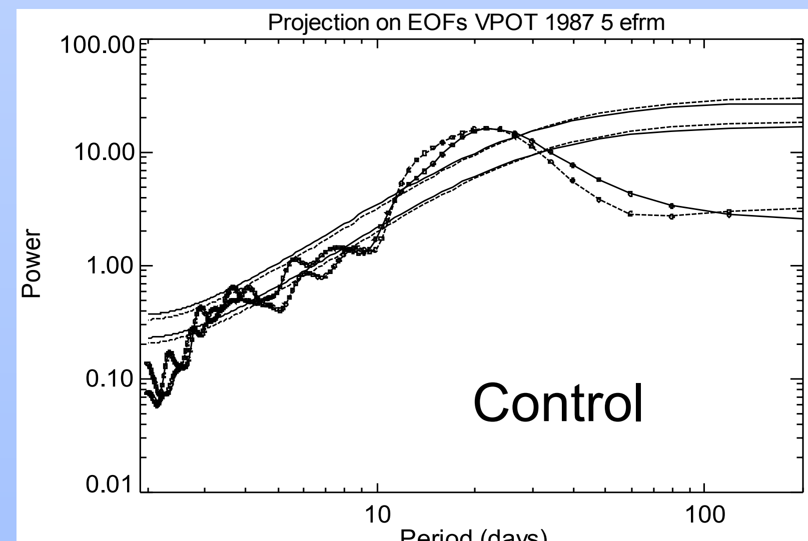


5 x Entrainment



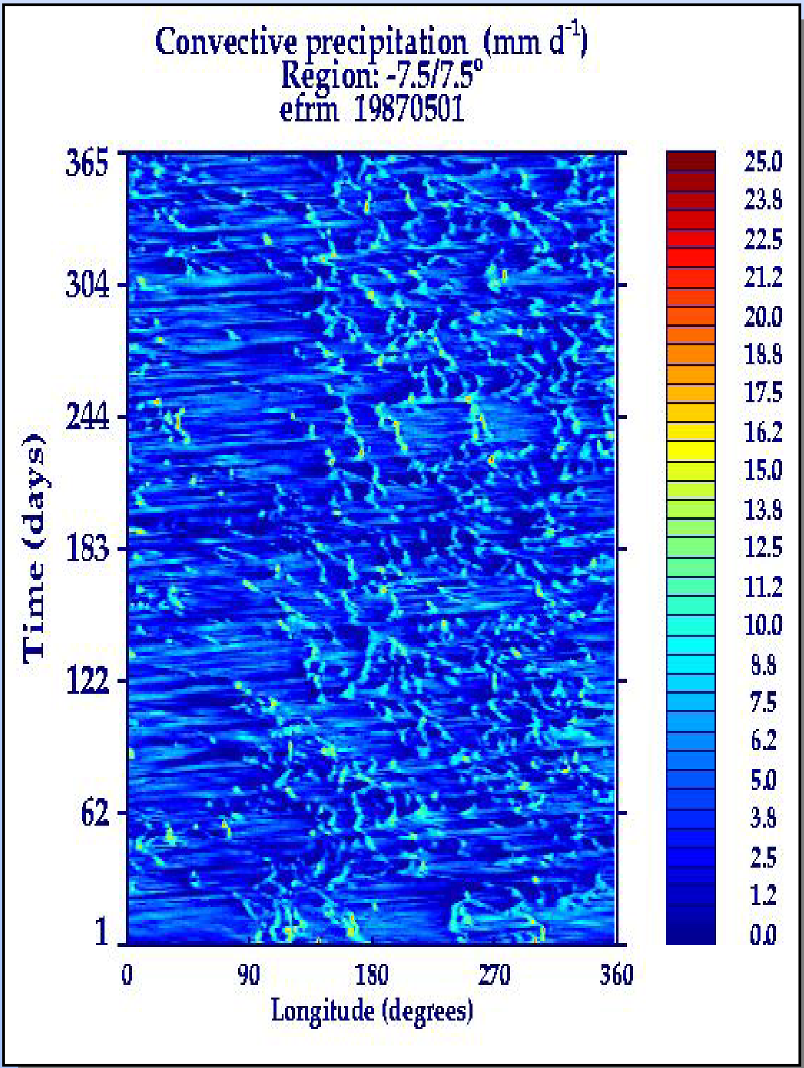






Effect on LSP/CP balance

Control



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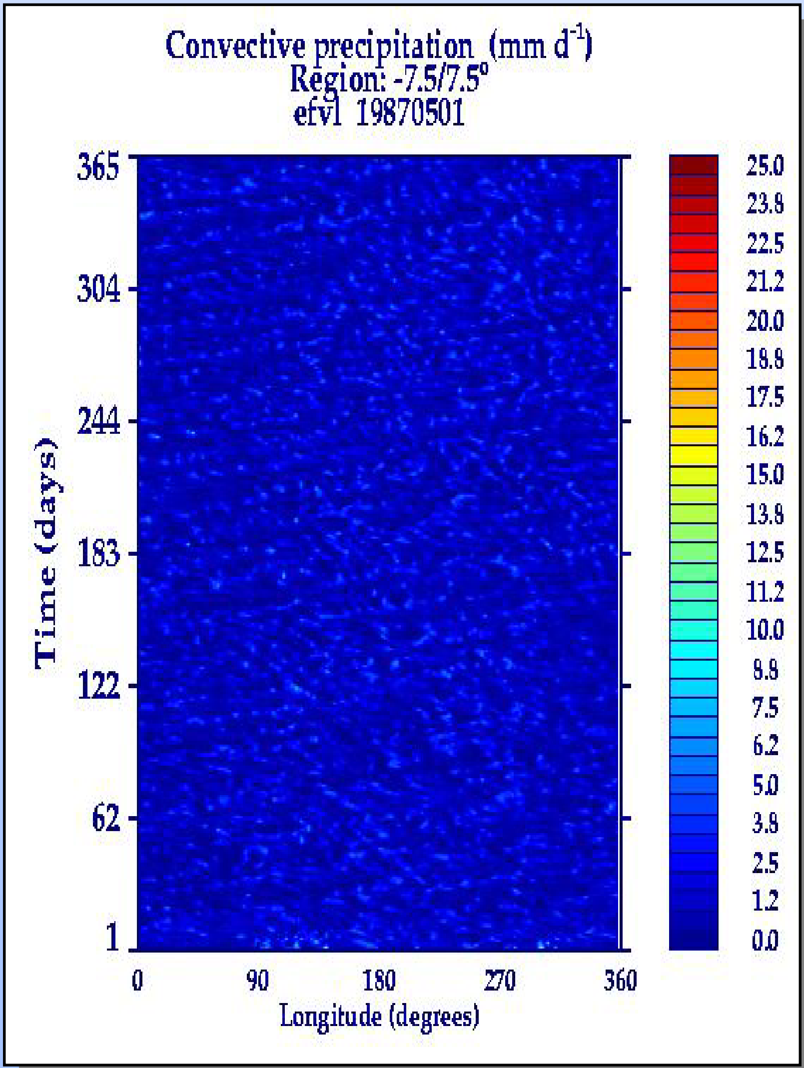
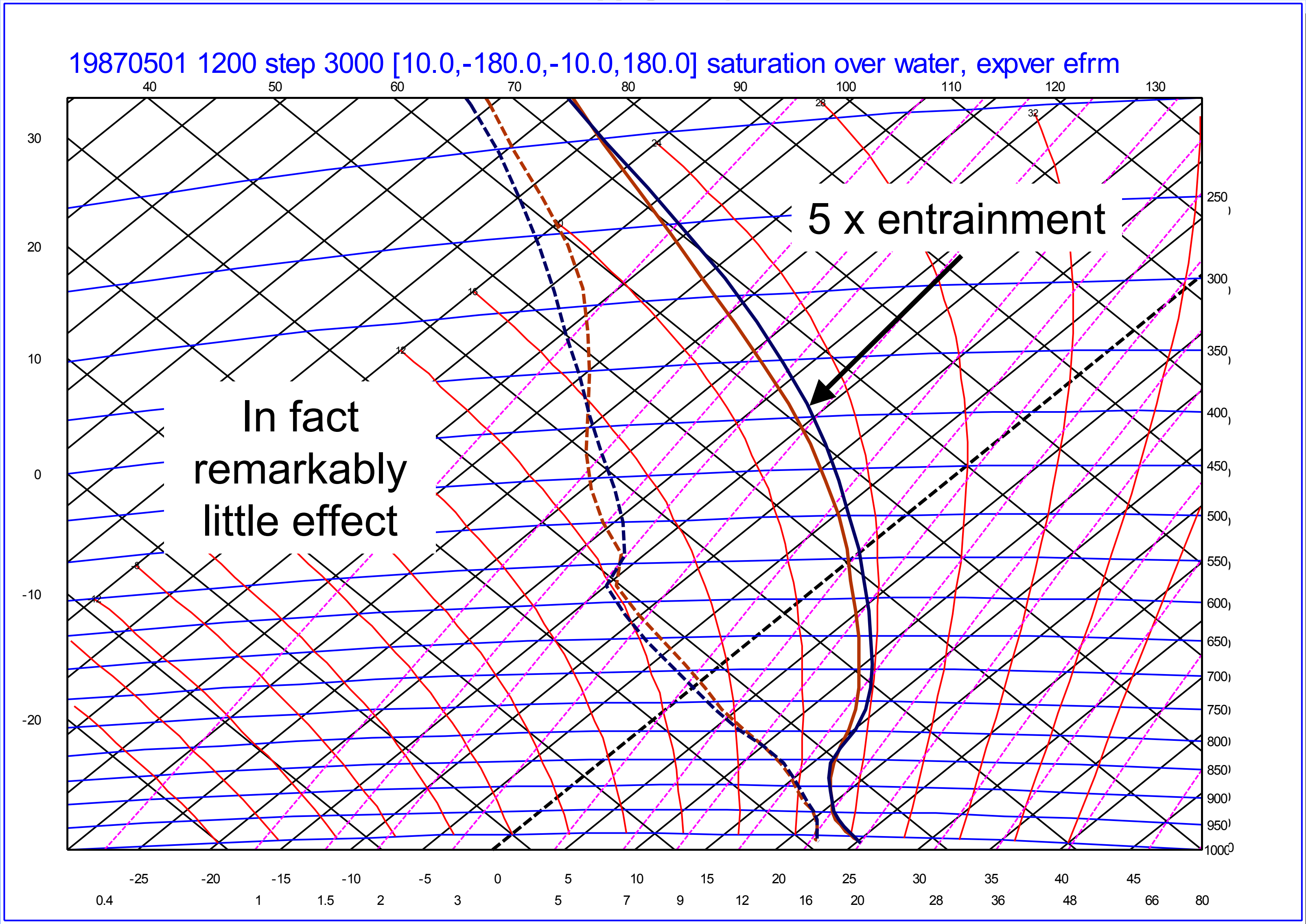
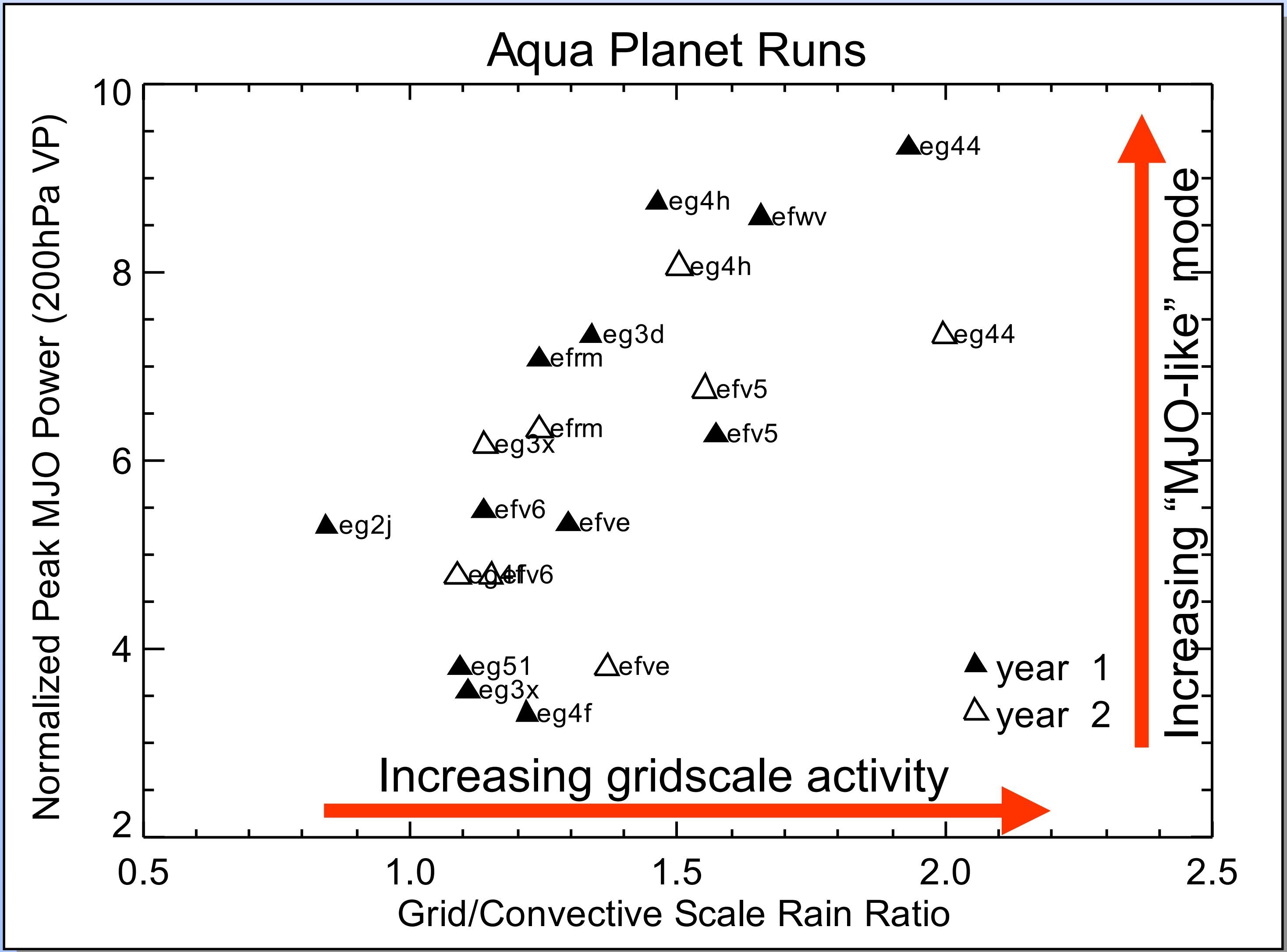


Expected effect in "Cloud Resolving Model" world

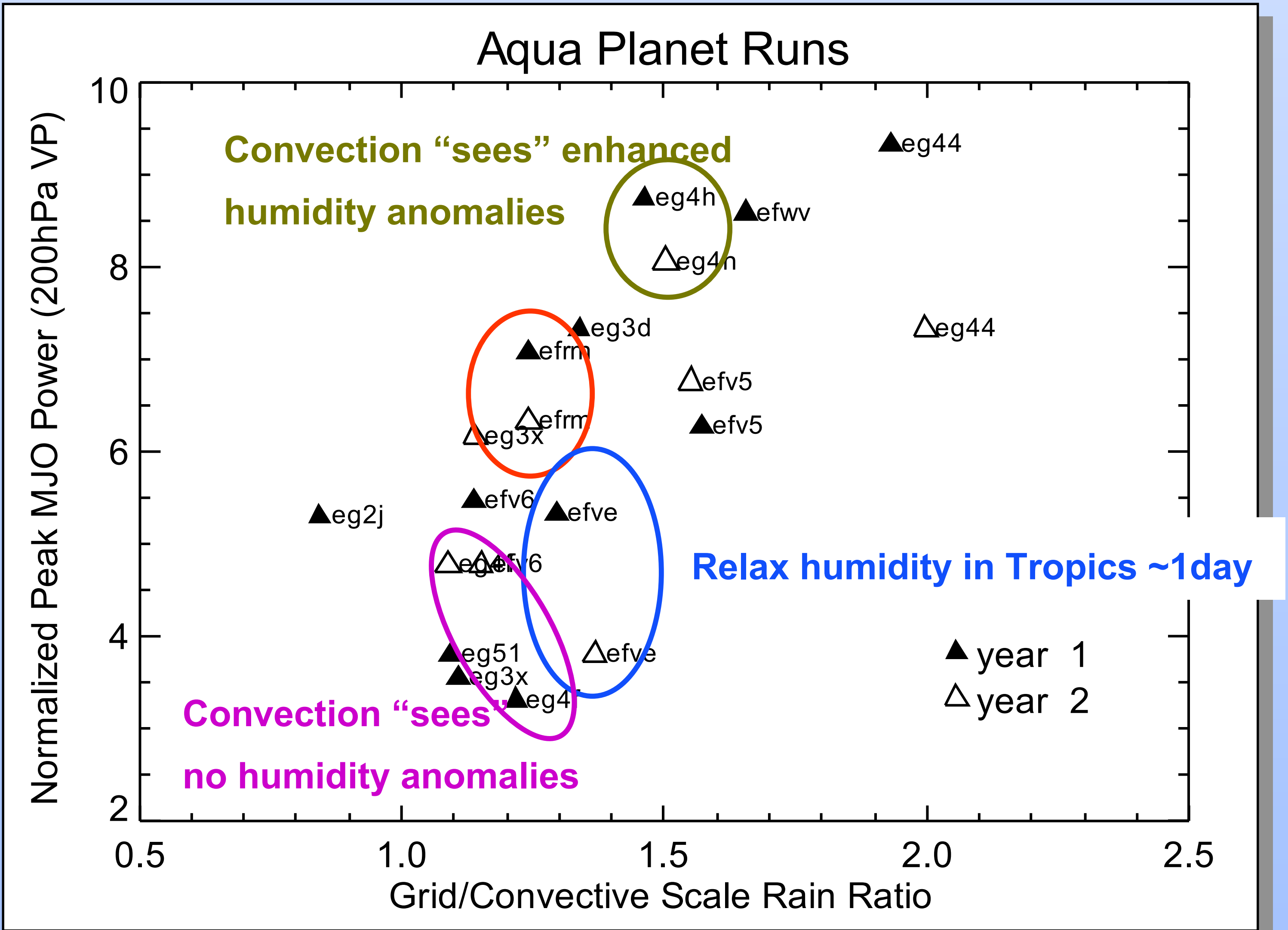


So is the change in “MJO- “MJO-like” peak power associated with the gridscale/convective-scale latent heating balance?

Increasing Large-scale activity increases MJO-like peak power (K=1,2,3 15days<p<120days)



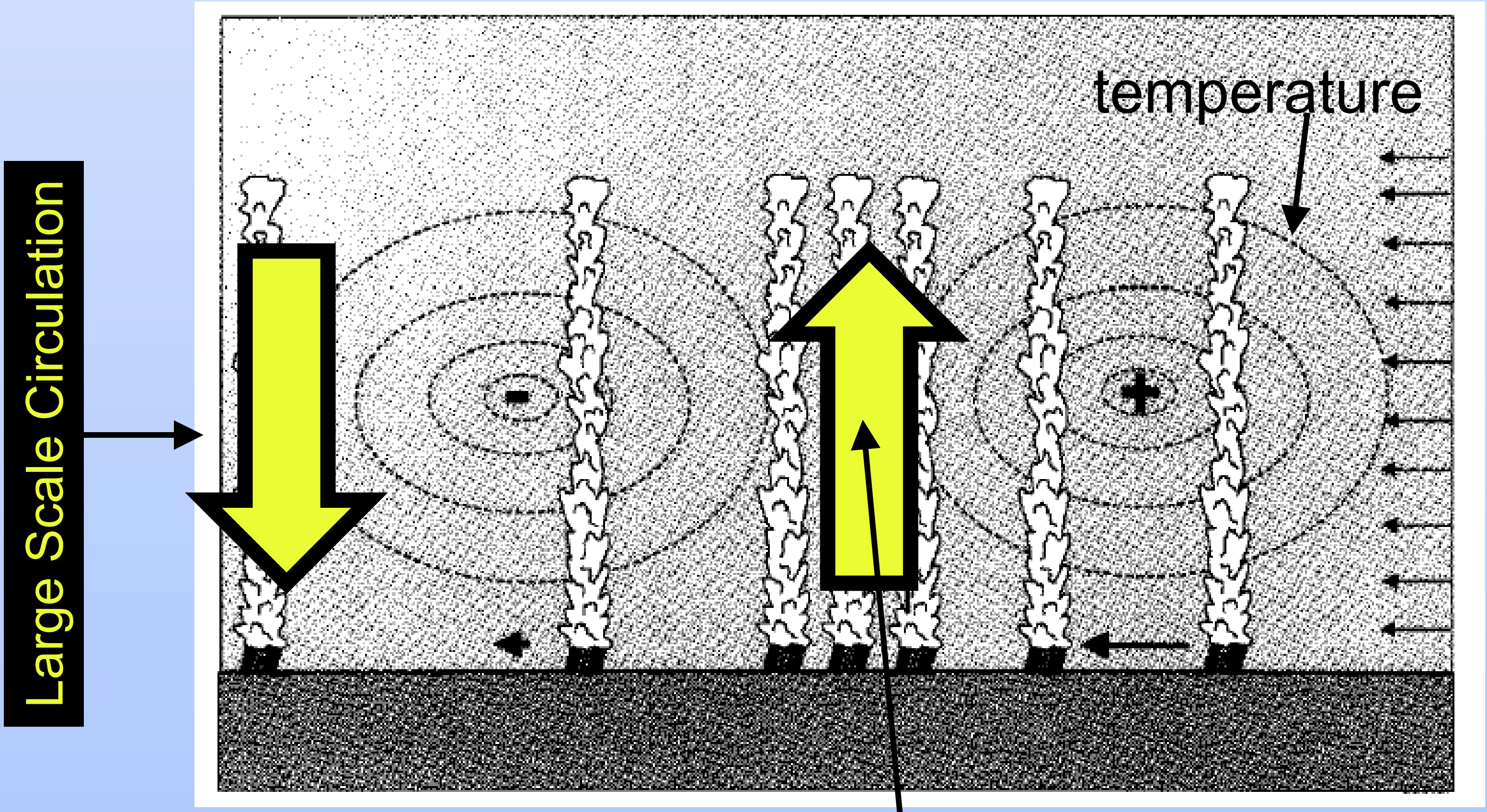
This is not to say water vapour does not have an influence



Large-Scale Latent Heating, and the ENB Paradigm

- **Unlike ENB model, gross moist stability for large scales not always positive in IFS**
- **A significant proportion of the large-scale rainfall is *not* associated with the stratiform mode**
- **Rather it is expressed in gridscale convective motions**
- **Moreover the cloud scheme permits negative effective moist stability to occur before the gridpoint attains saturation**

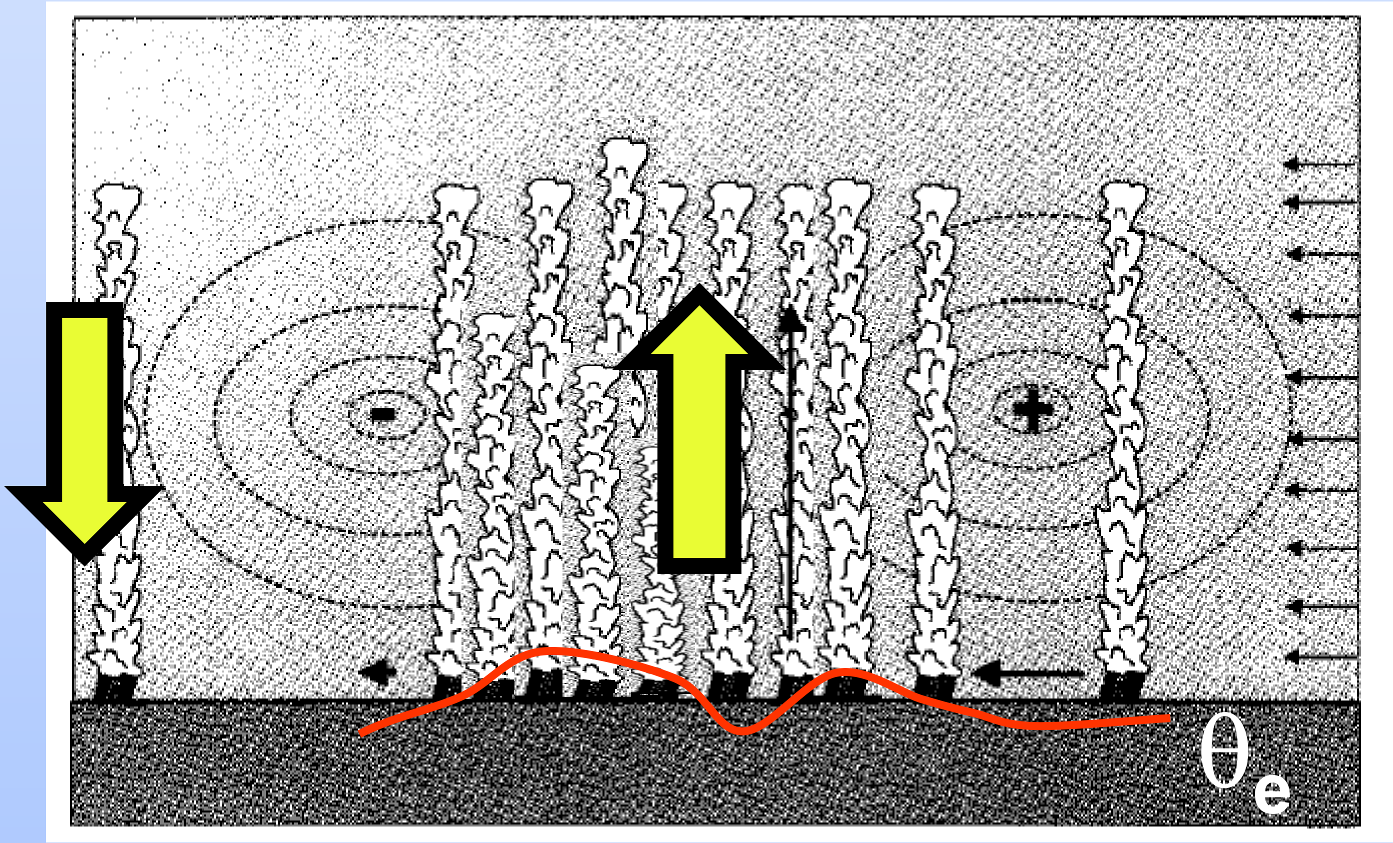
Large-scale precipitation in Kelvin Wave



Latent heating (from cloud scheme) directly in phase with upward motion by construction. Changes in cloud scheme have large influence on incidence of grid-scale convection

Convective-scale precipitation in Kelvin Wave

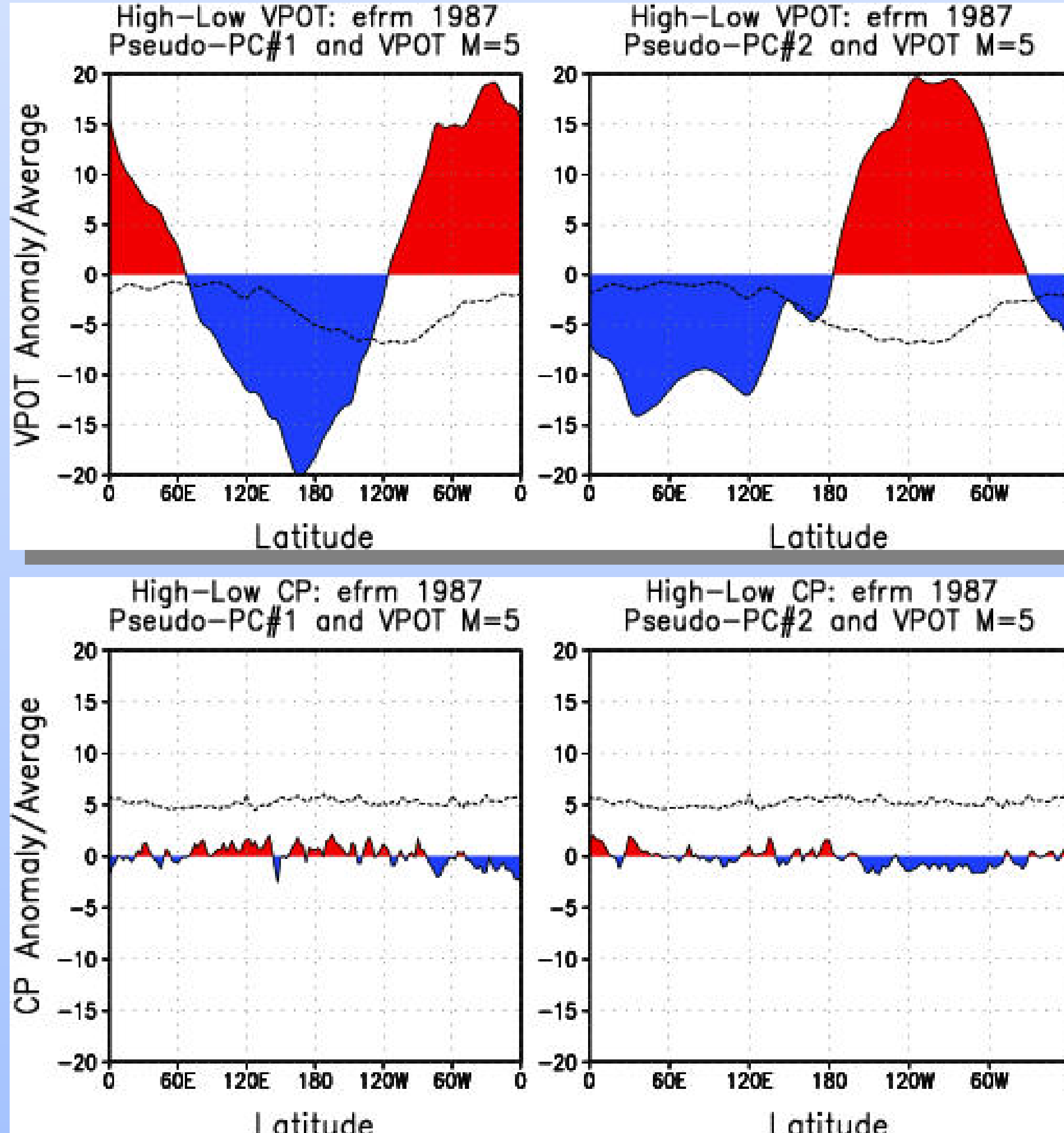
Large Scale Circulation



The convection parameterization is not so constrained, and responds to *PBL* theta_e, CAPE, (humidity). Can provide heating out of phase, possibly damping the wave.

<u>T95 Default</u>

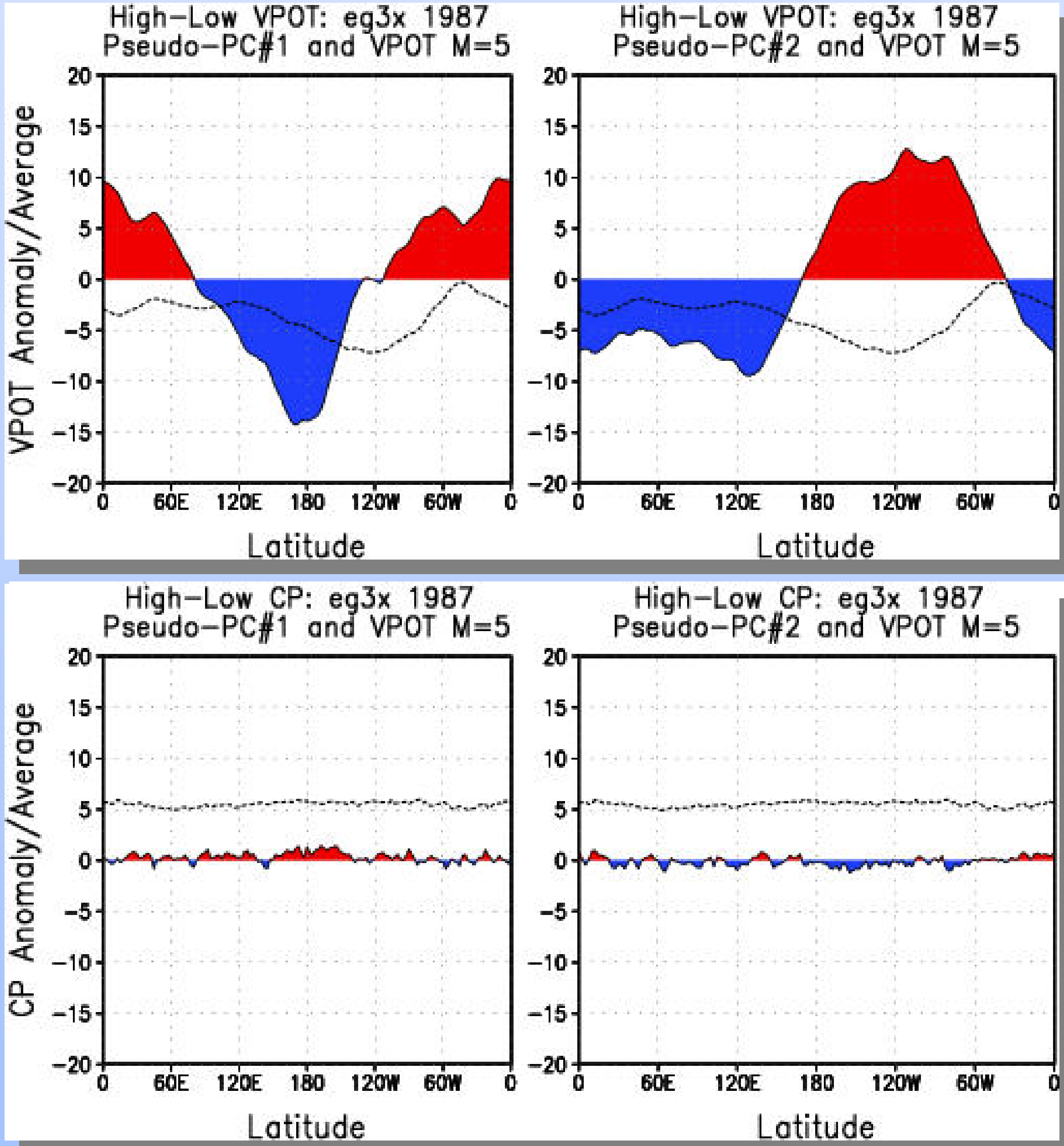
Strong positive positive precipitation anomaly coinciding with with upward motion



Perturbation for convective precipitation much smaller

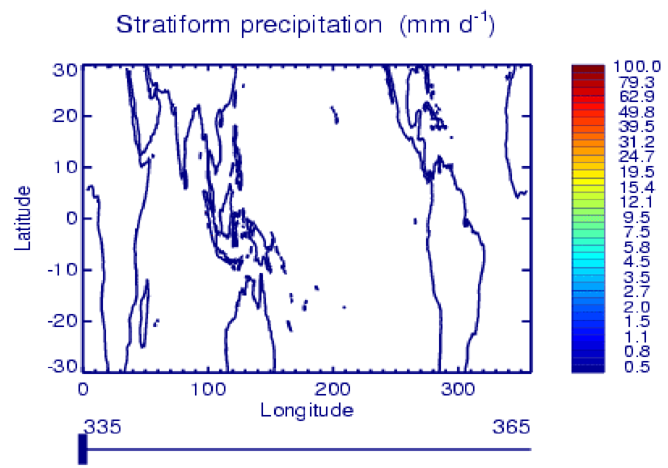
T159 Default

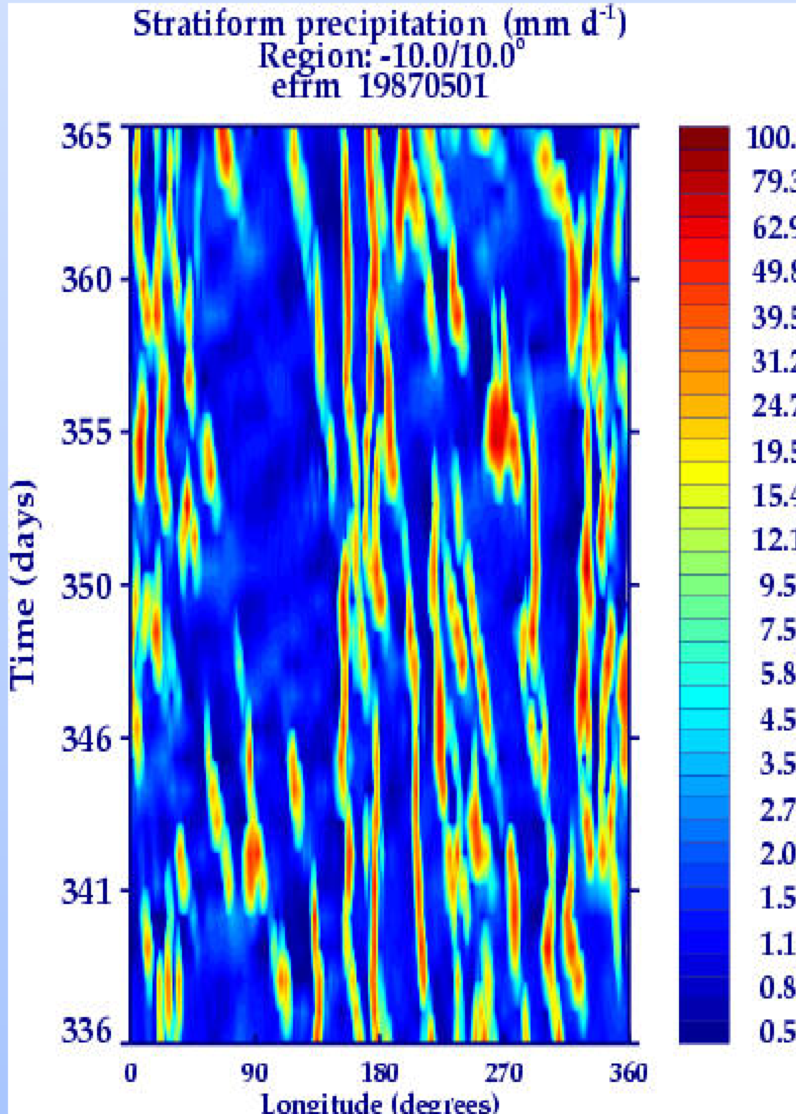
Large-scale precipitation anomaly coinciding with with upward motion



No convective signal

However, strongest precipitation appears to be associated with advection of low level humidity anomalies





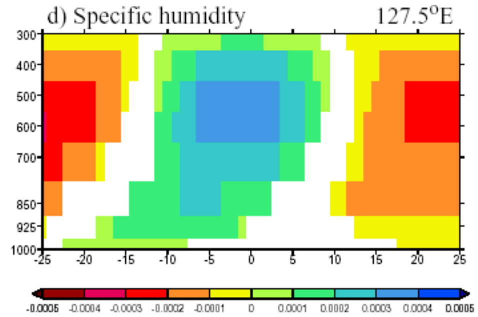
Conclusions I

- **The MJO-like eastward propagating signal in the the ECMWF appears to independent of resolution resolution and coupling**
  - T95,T159,T255,T95-coupled, T511
  - T159 and higher resolutions show weaker signal
- **The phase speed is approx. 20 m/s, peak at wavenumber 1**
- **In these faster phase speeds (>20m/s) models produces interannual variability well**

Conclusions II

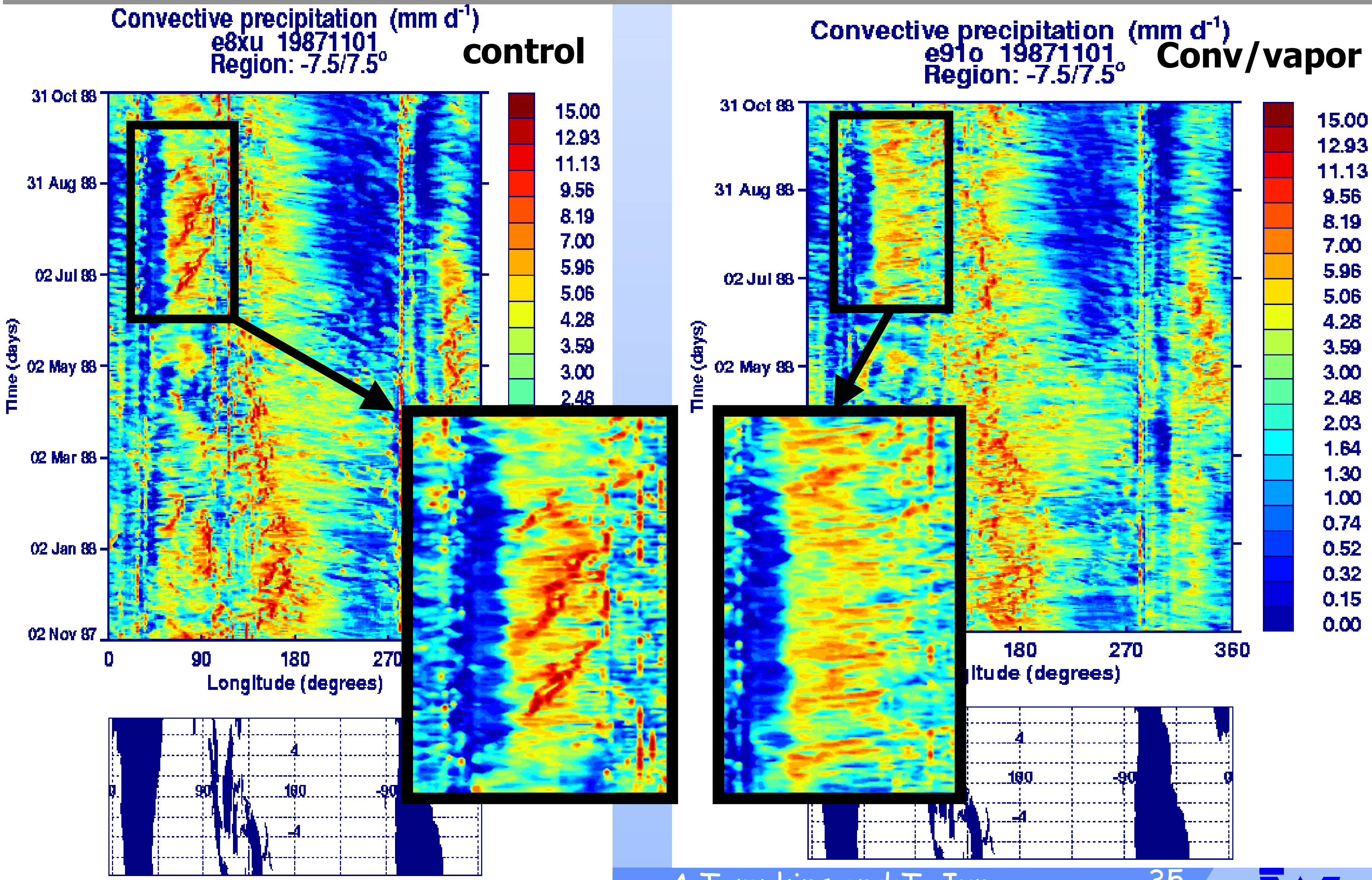
- Sensitivity tests showed little evidence of “water vapour-convection” feedback mode *in the model*
- Is there a fundamental physical process missing from the model?

Stolen from Kenneth Sperber

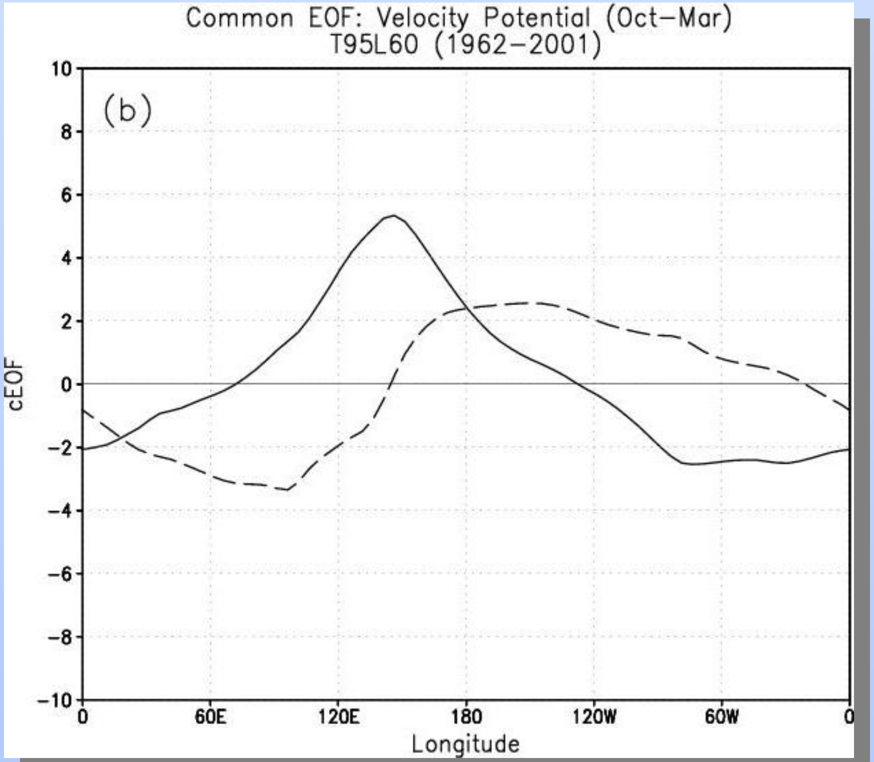


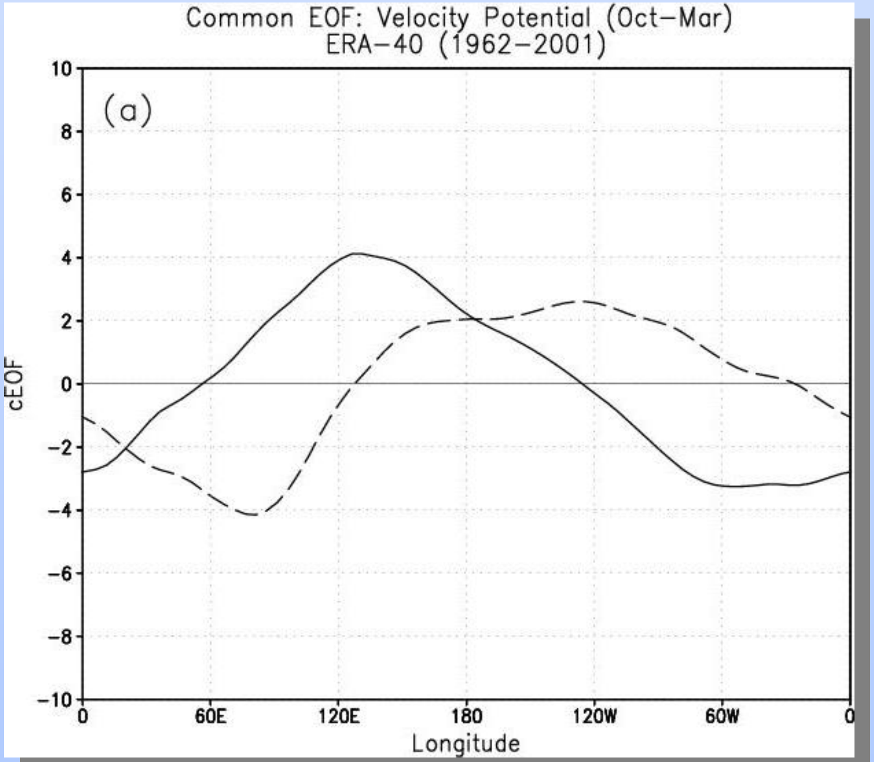
- The 20 m/s mode appears to be a consequence of coupling between large-scale dynamics and GRIDSCALE latent heating
  - The convective parameterization scheme damps this mode
  - But does not affect the propagation velocity
- What should the LSP/CP balance be?

Previous "old" (25r1) model cycle produced slow water vapour mode: Role of shallow convection?



EOF Analysis of T95 and ERA40





First two (independent) EOFs in quadrature signifying propagating signal at wavenumber 1.