The role of soil moisture on Southern Africa climate

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MONASH South Africa
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START/PACOM Centre of Excellence
Regional node for climate modeling

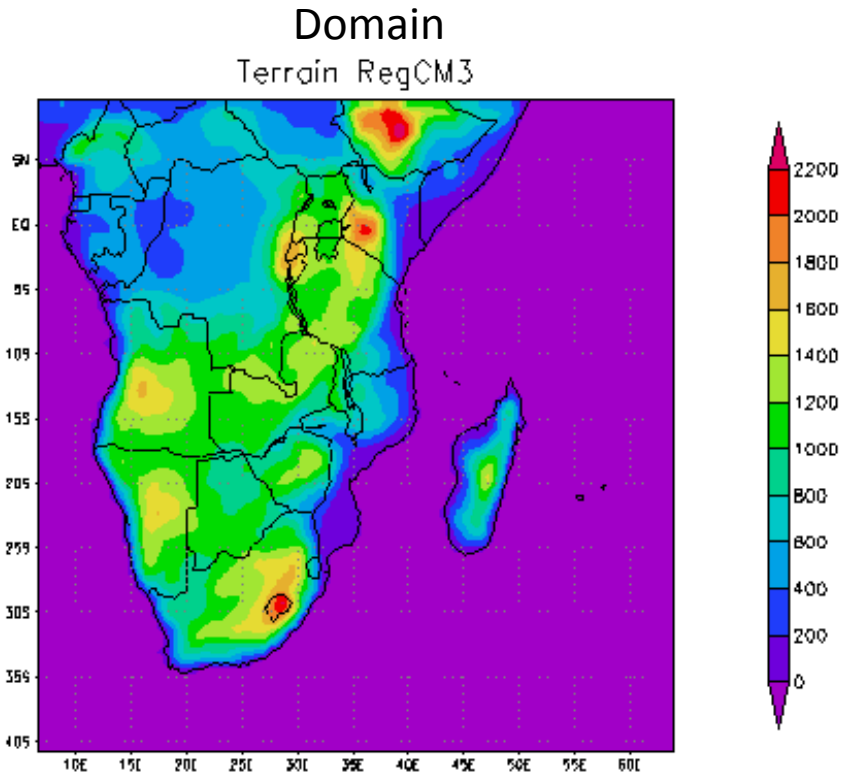
Synopsis

- Concern - **The role of factors of climate variability over southern Africa**:
  - ➢ *Land surface-Atmosphere Interactions project.*
- The role of soil moisture conditions on climate variability over the region.
  - Feedbacks mechanisms.
  - Synoptic analysis
  - Sub-regional analysis

Experimental set-up

Control run

- RegCM3,
- 50 km Resolution ,
- MIT- Emanuel Scheme,
- NCAR-NCEP reanalysis, NOAA OISST and GLCC Land Cover.
- Summer simulations – 7 months run for Sep to Mar 1991/92 (dry) and 1995/96 (wet) with 1 month spin-up.

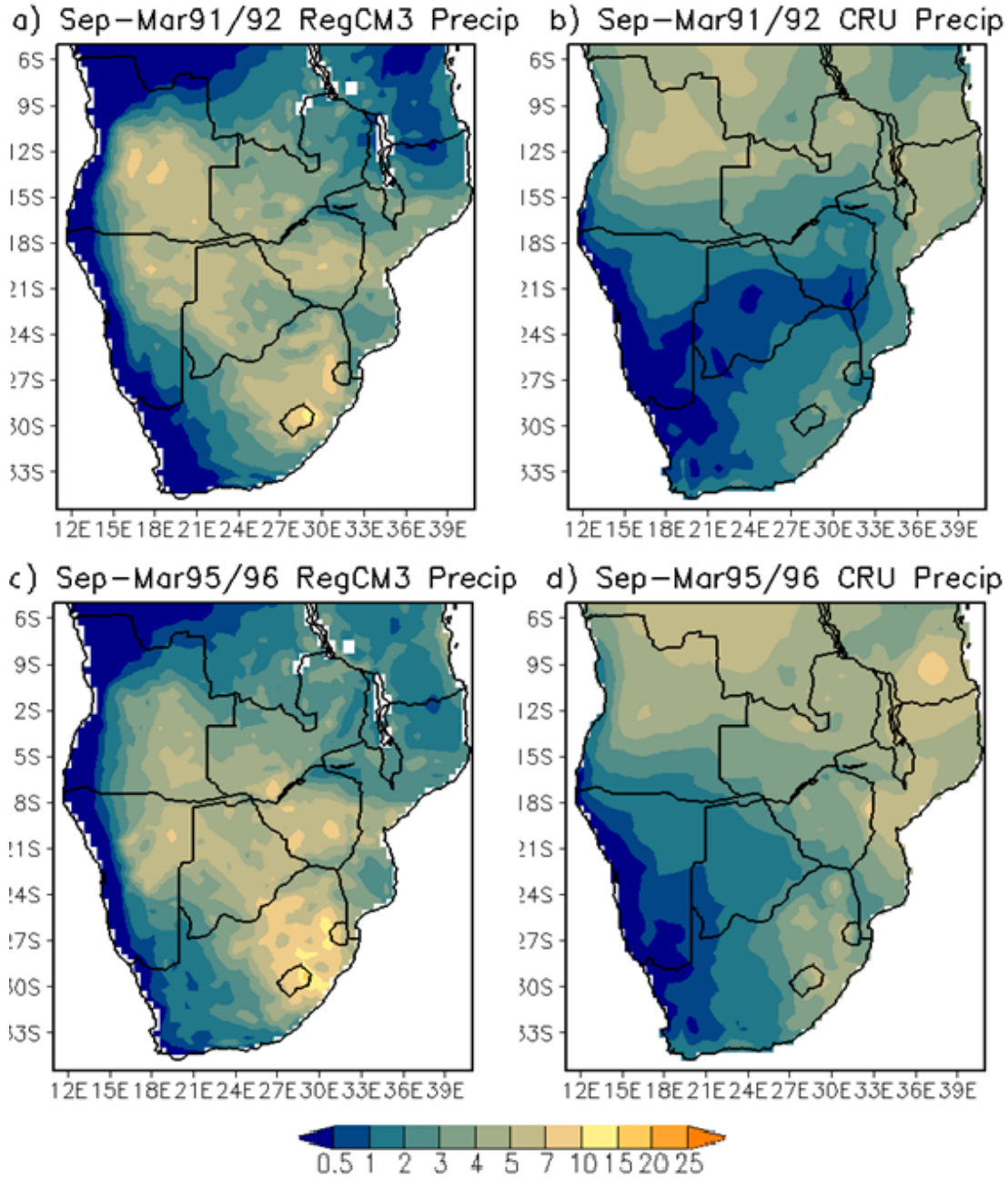


Interactive moisture runs

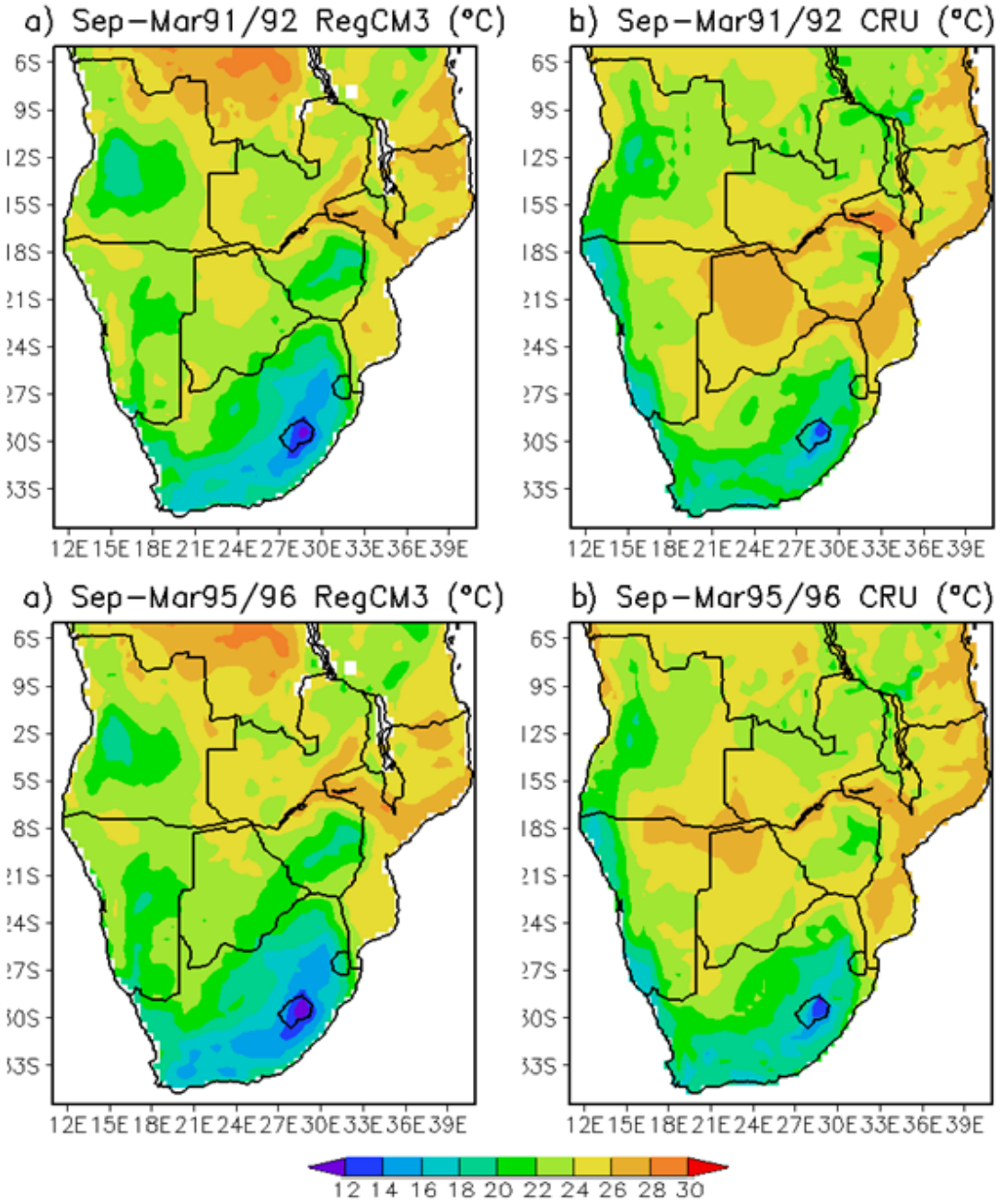
- As in control run but soil moisture being initialized at:
  - 25% (wilting point) and
  - 75%(saturation point),

    field capacities in the BATS scheme.

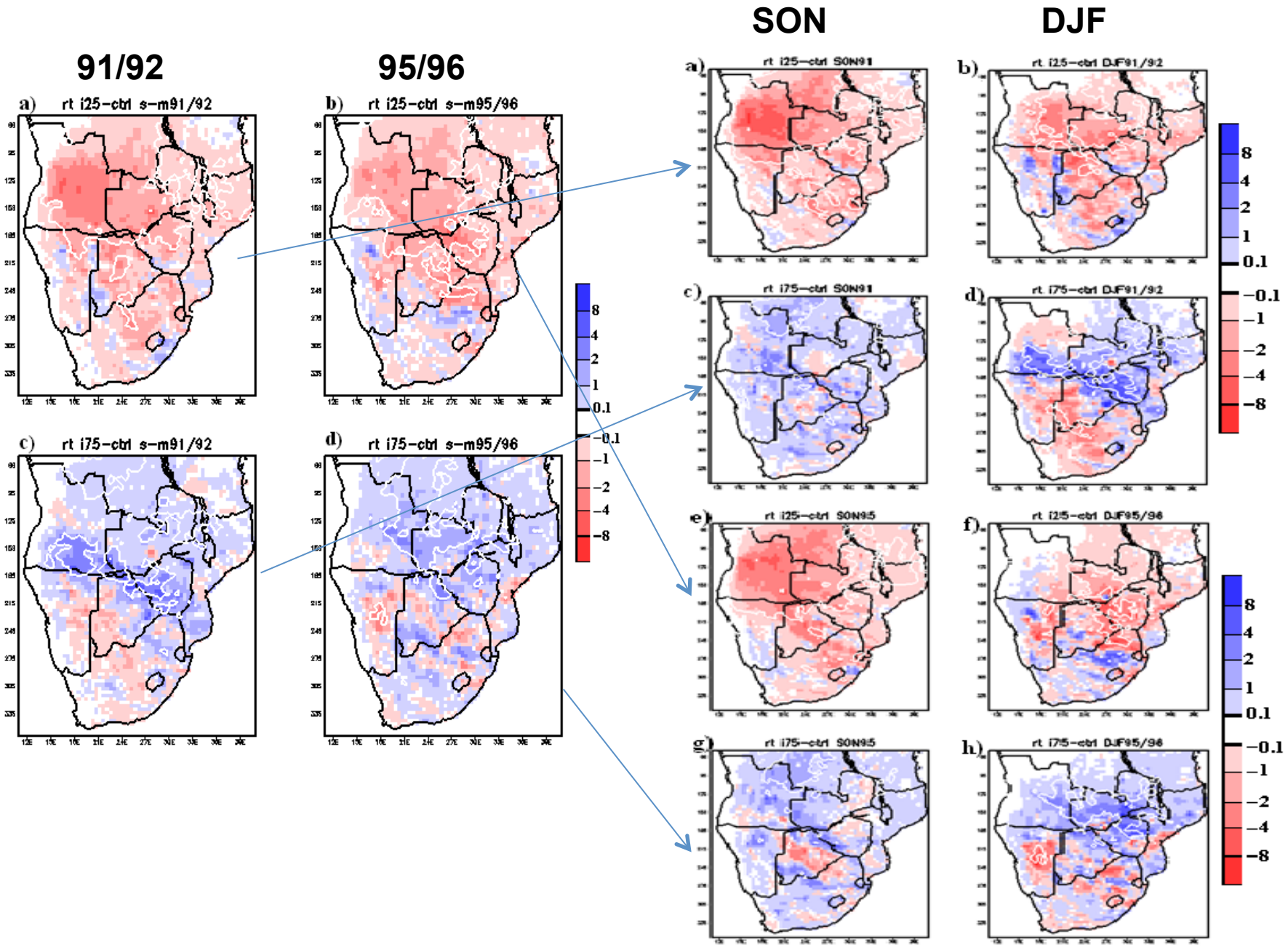
Total Precipitation



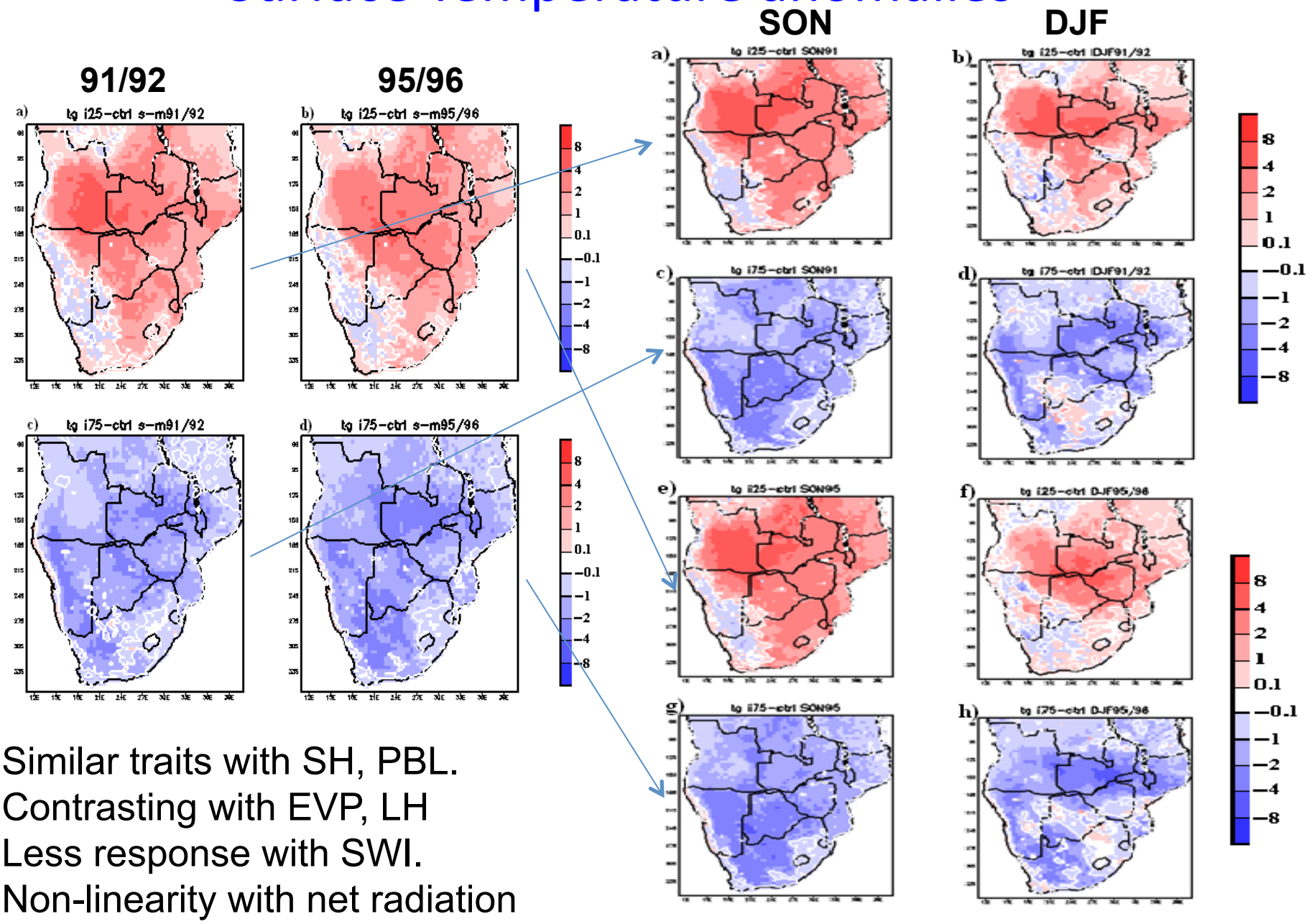
Air Temperature



Total precipitation anomalies

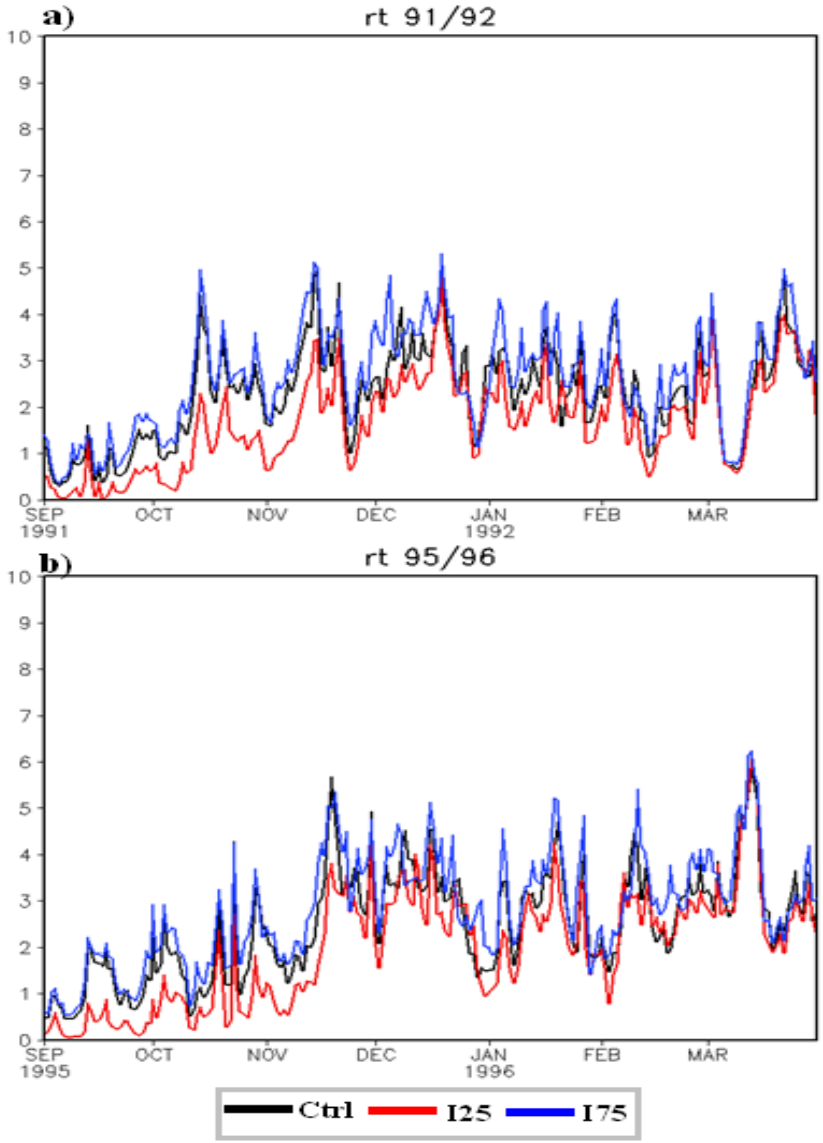


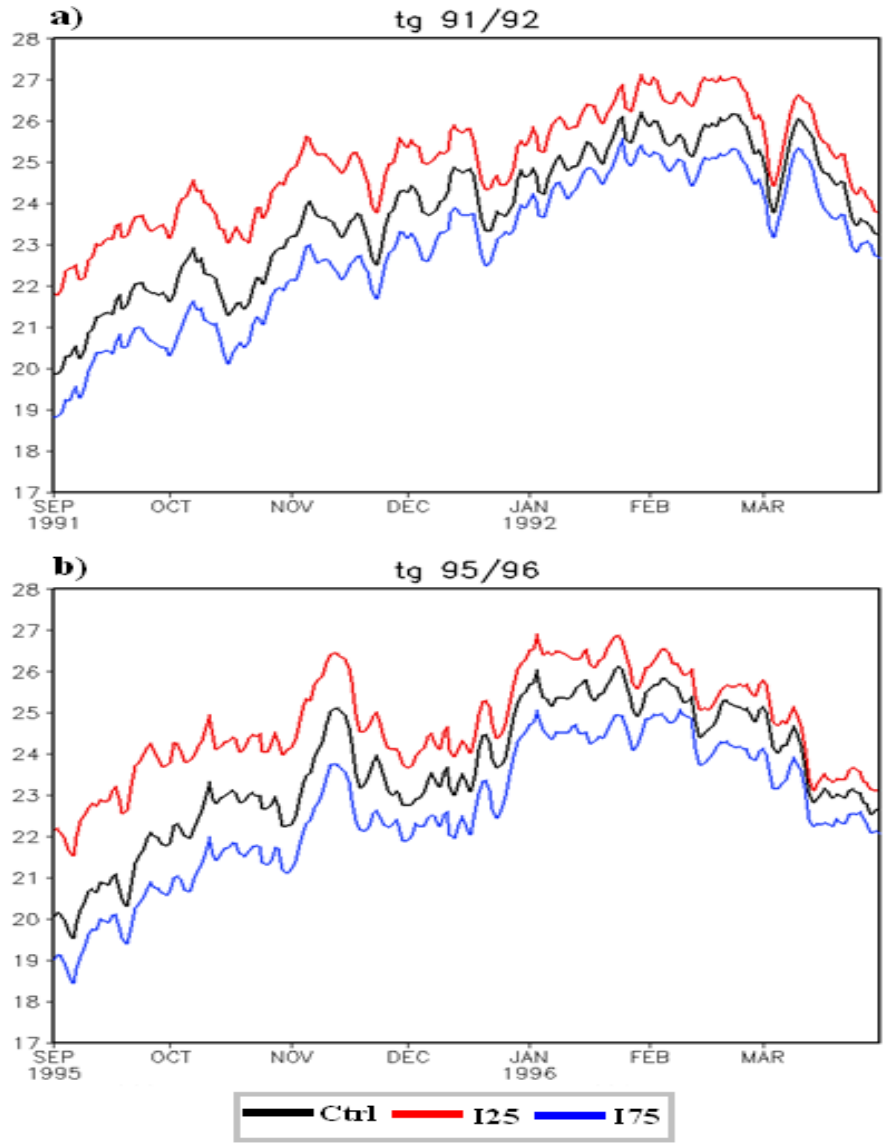
Surface Temperature anomalies



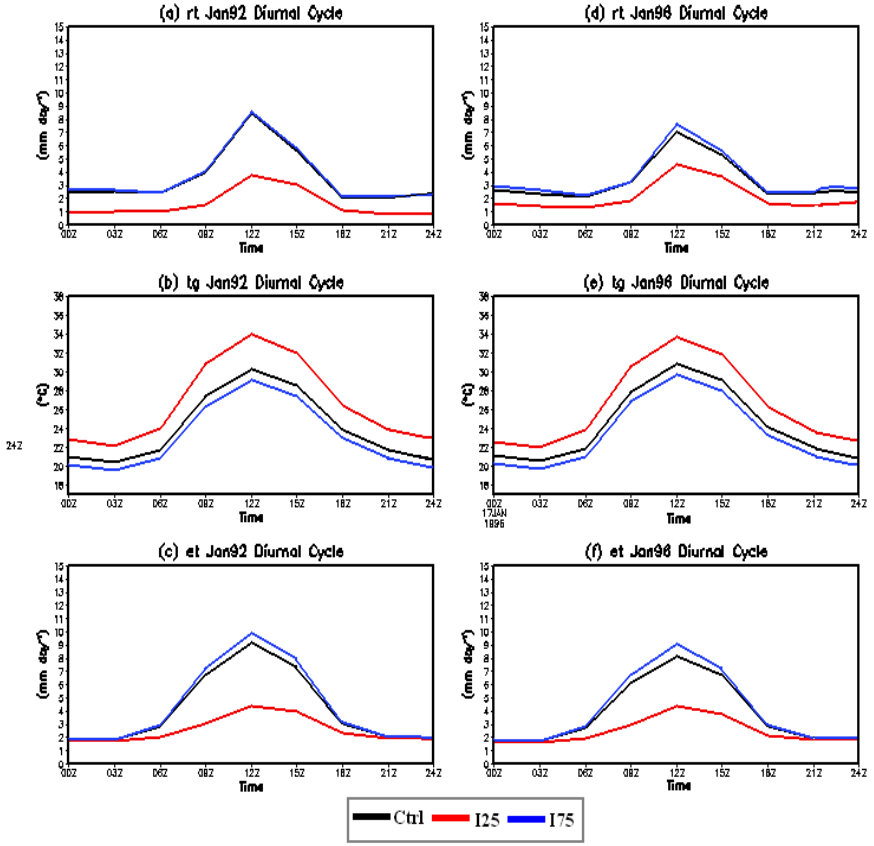
- Similar traits with SH, PBL.
- Contrasting with EVP, LH
- Less response with SWI.
- Non-linearity with net radiation

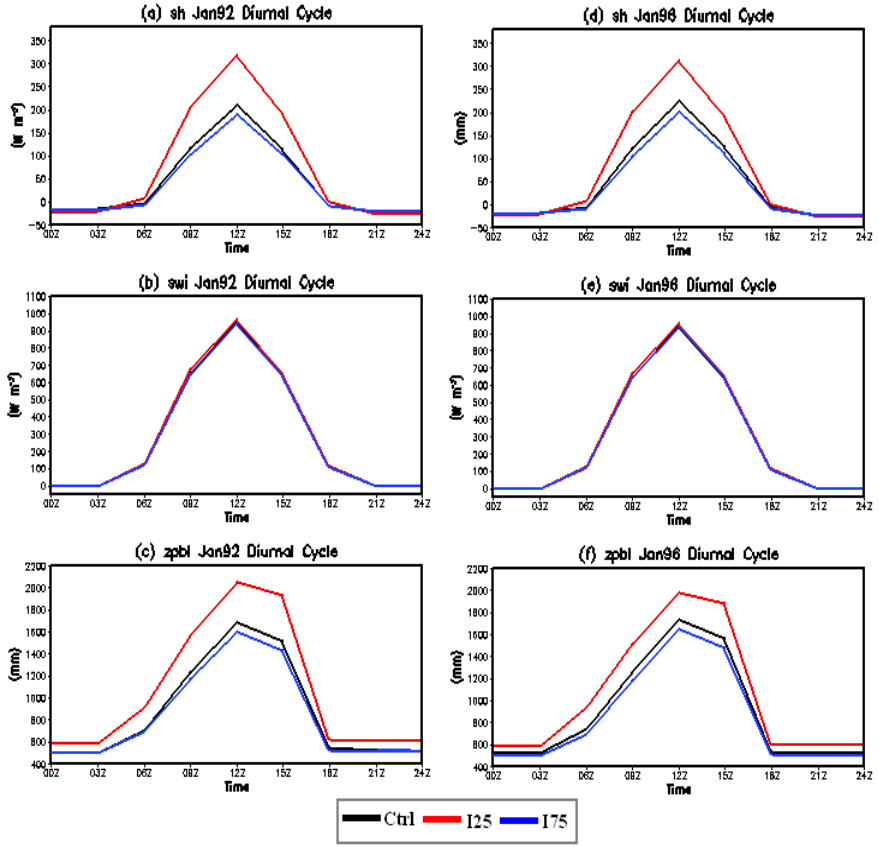
Temporal analysis



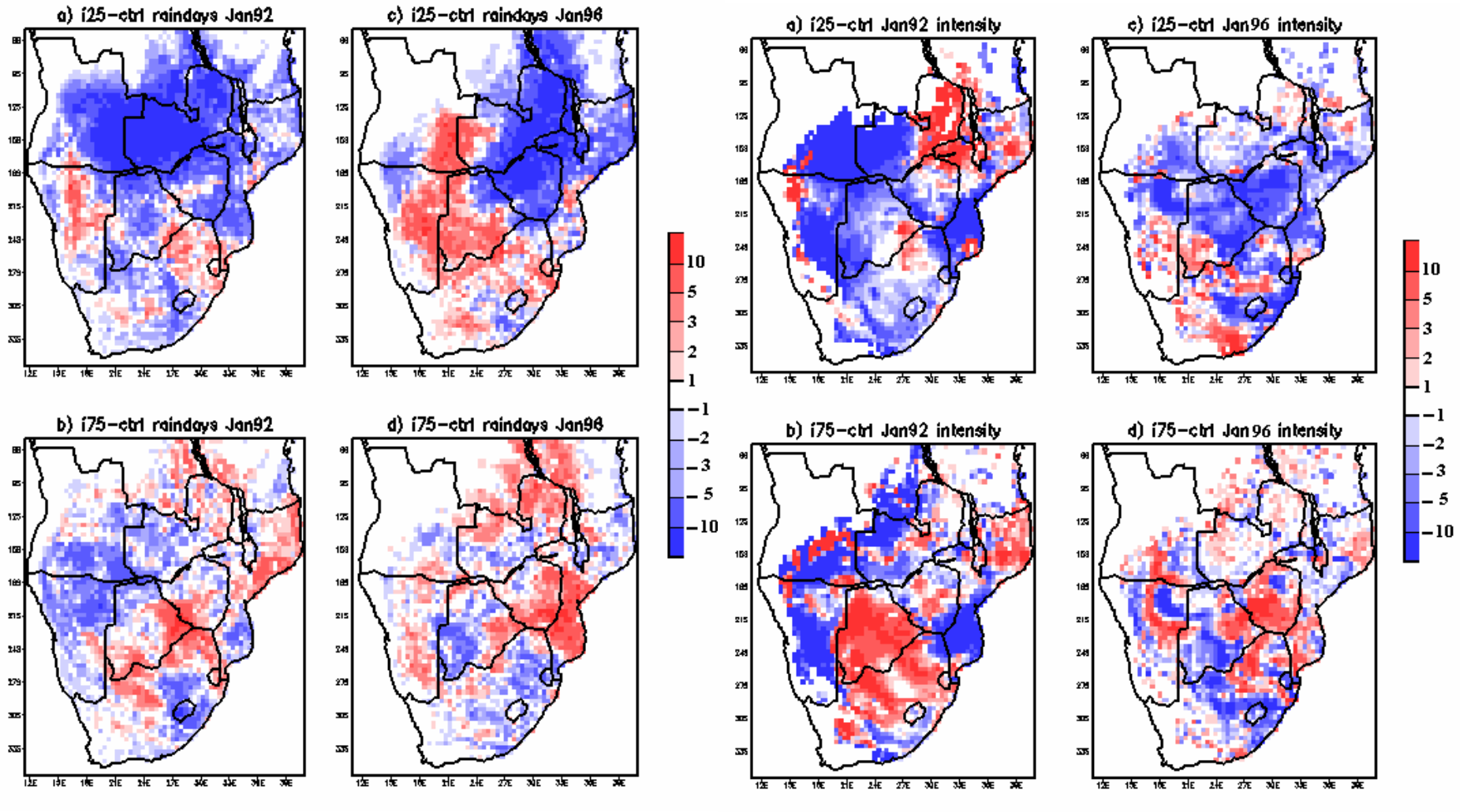


Diurnal Cycles of surface variables on effect of soil moisture perturbation

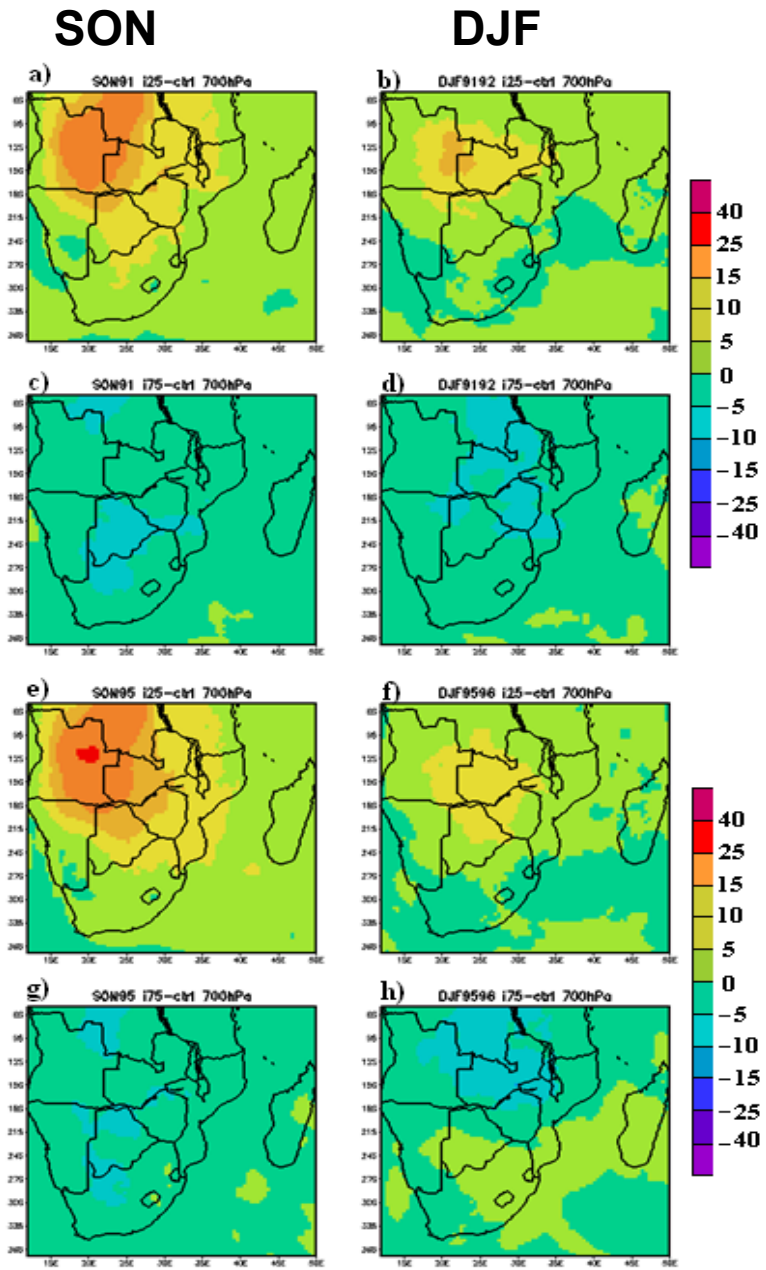




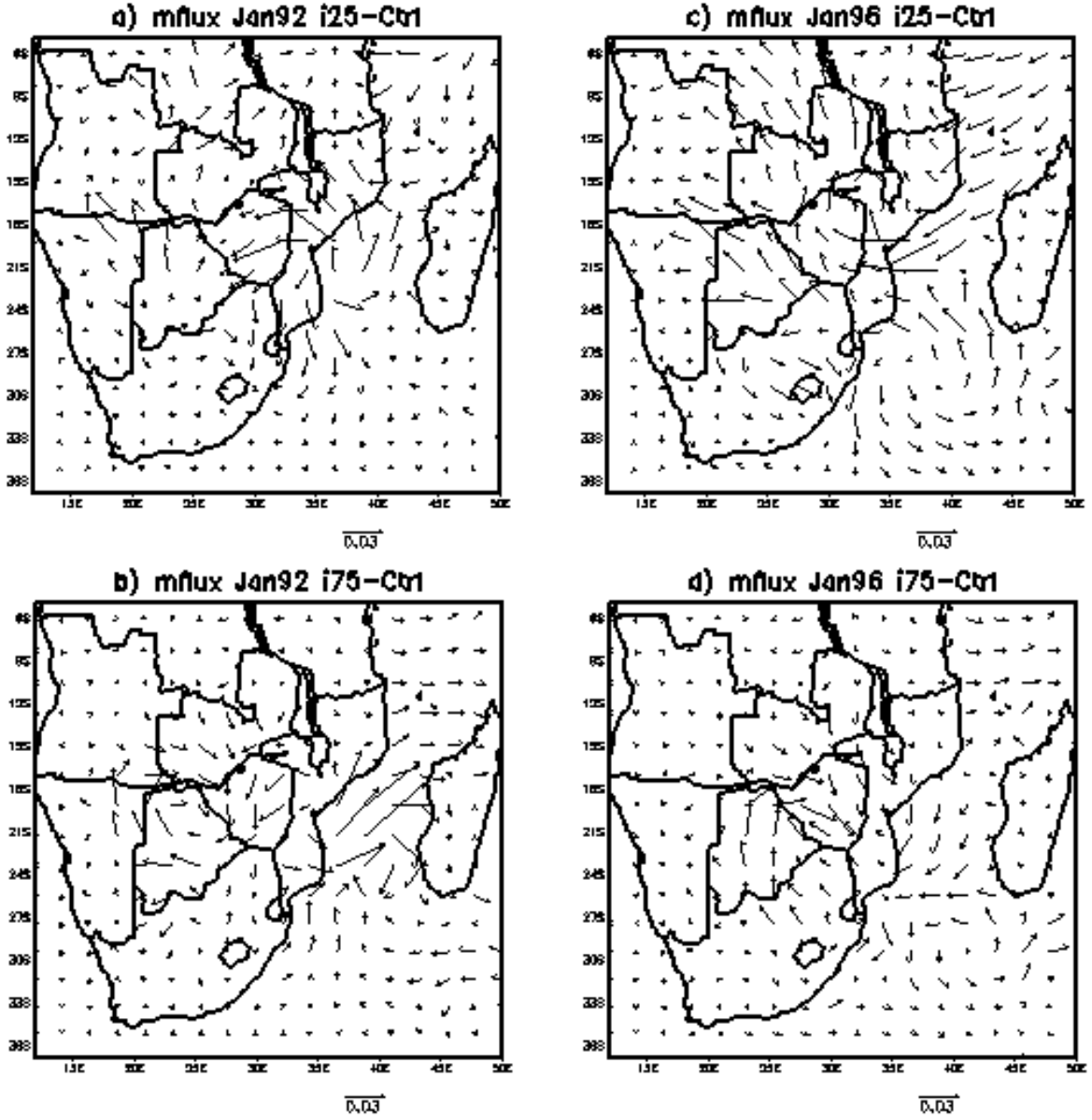
Rain Days and intensity



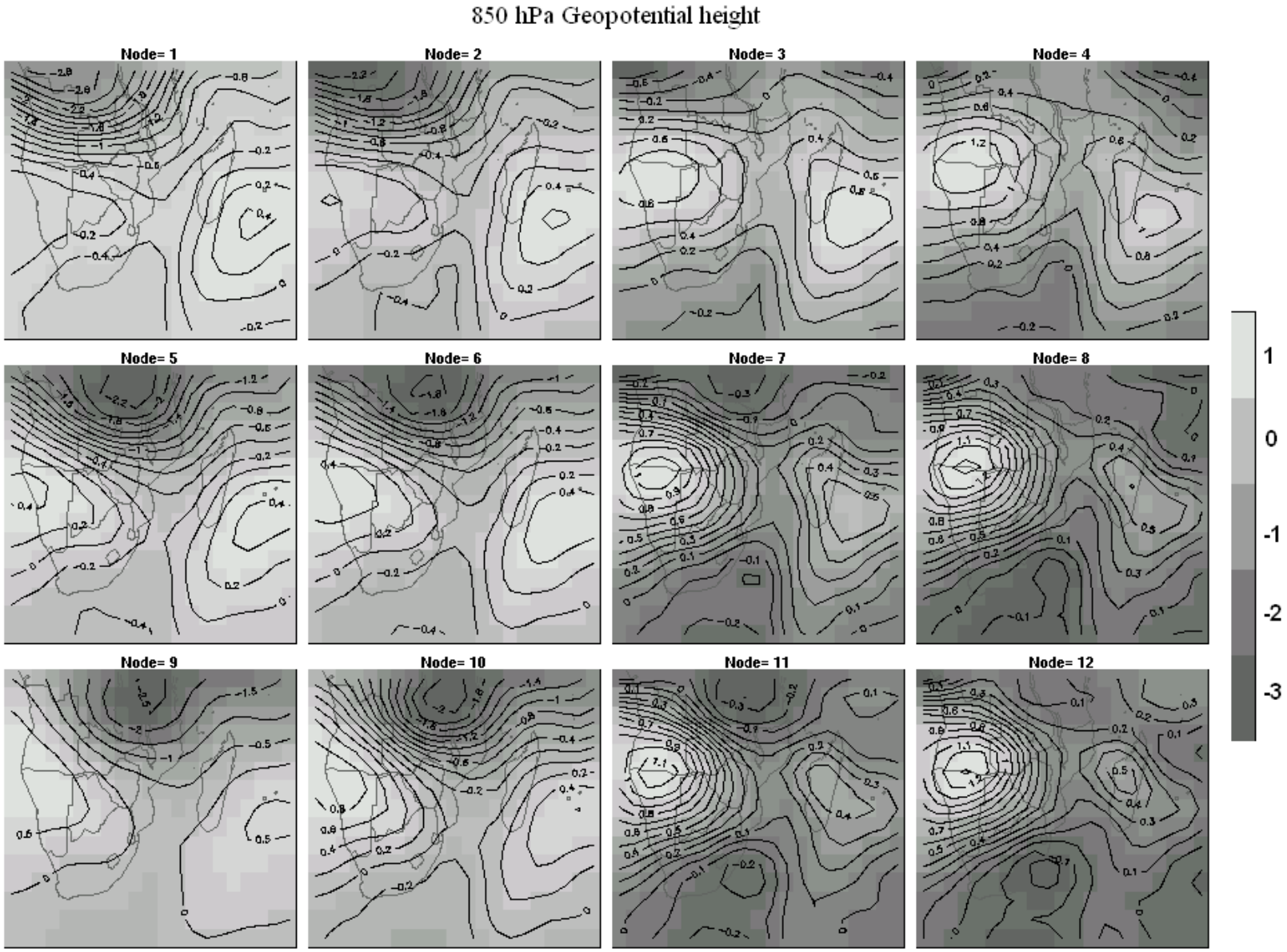
700hPa Geo-Potential Height



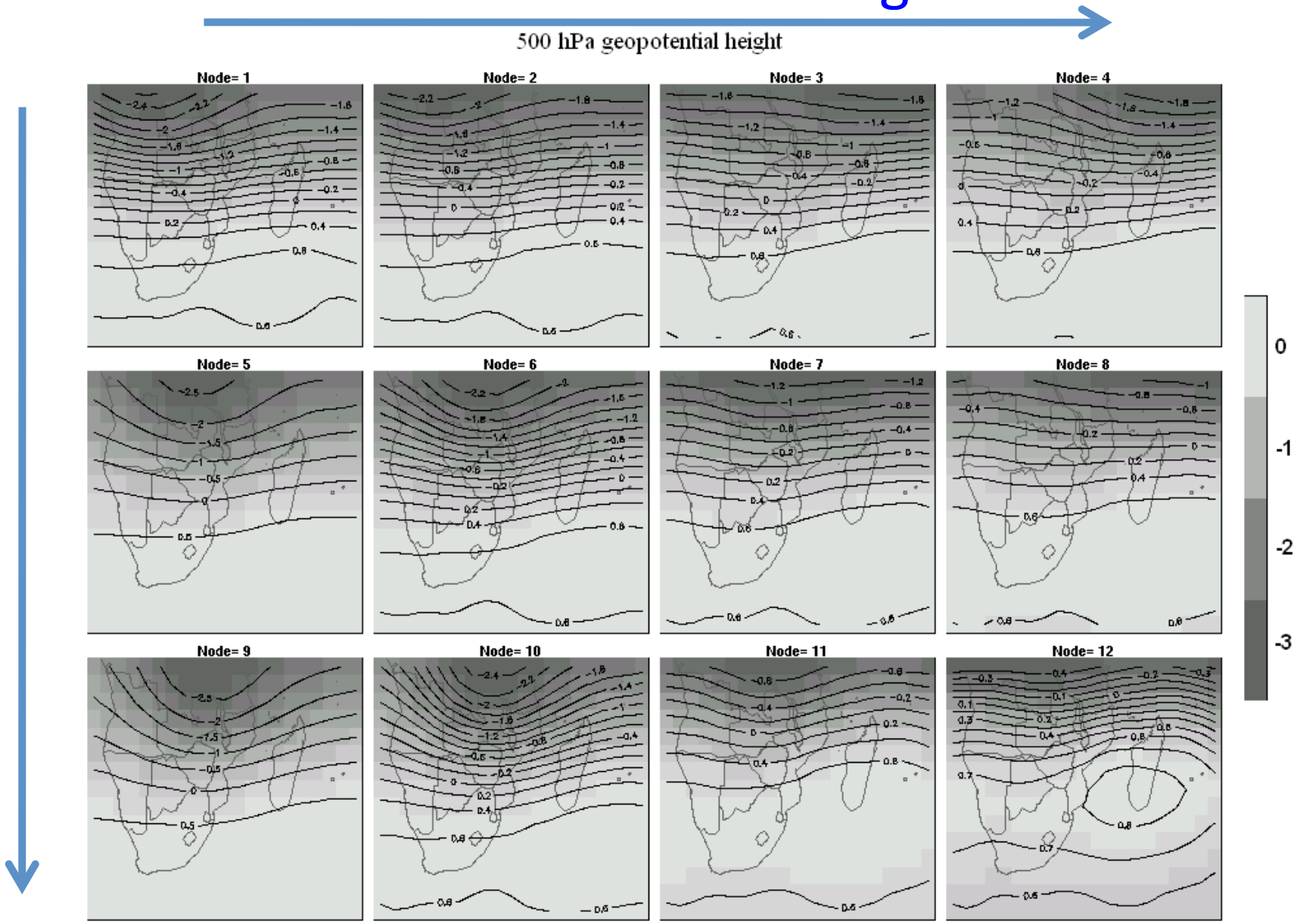
Moisture flux



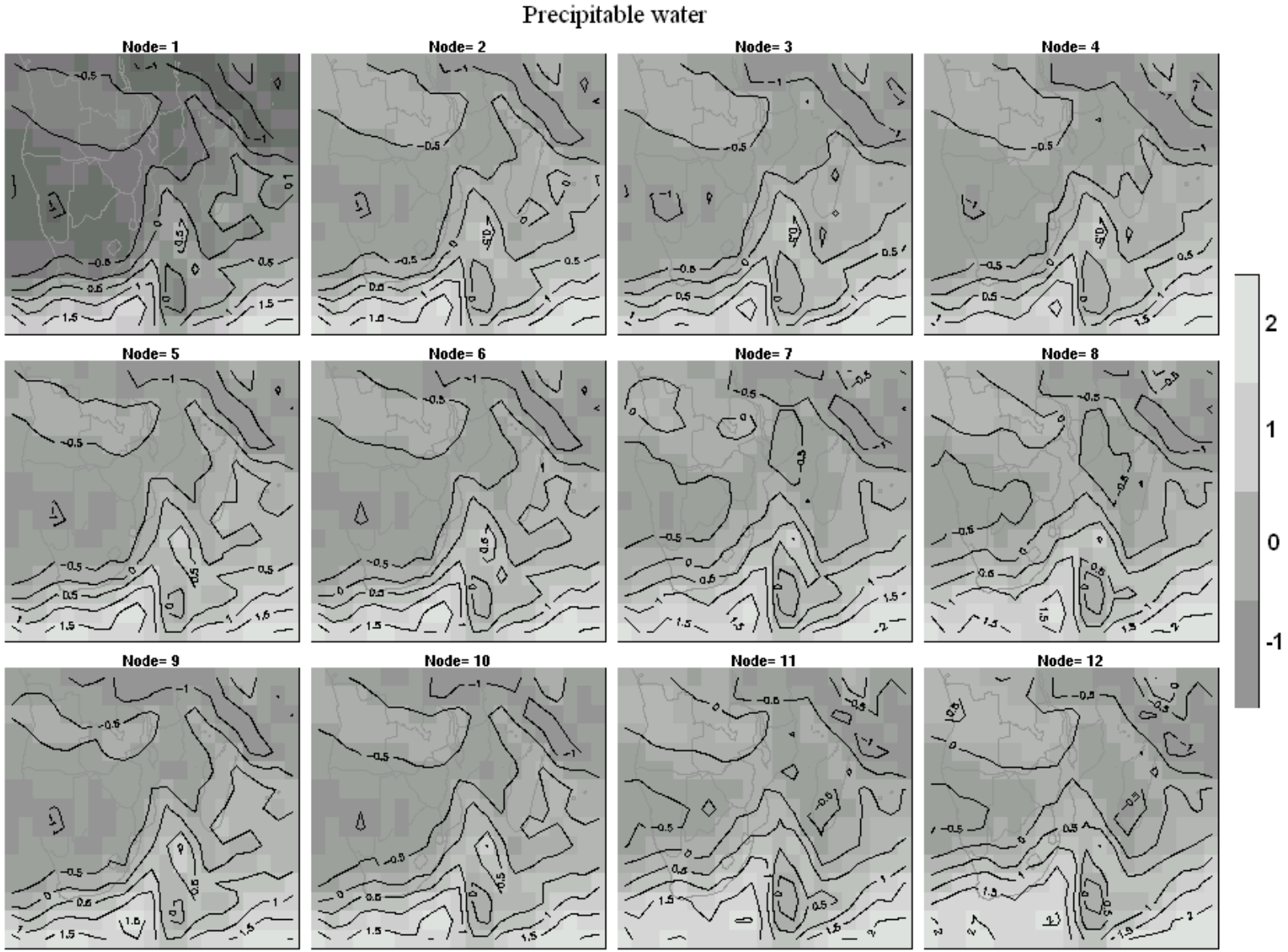
Self-organized mapping of NCEP 850hPa Geo-Potential Height



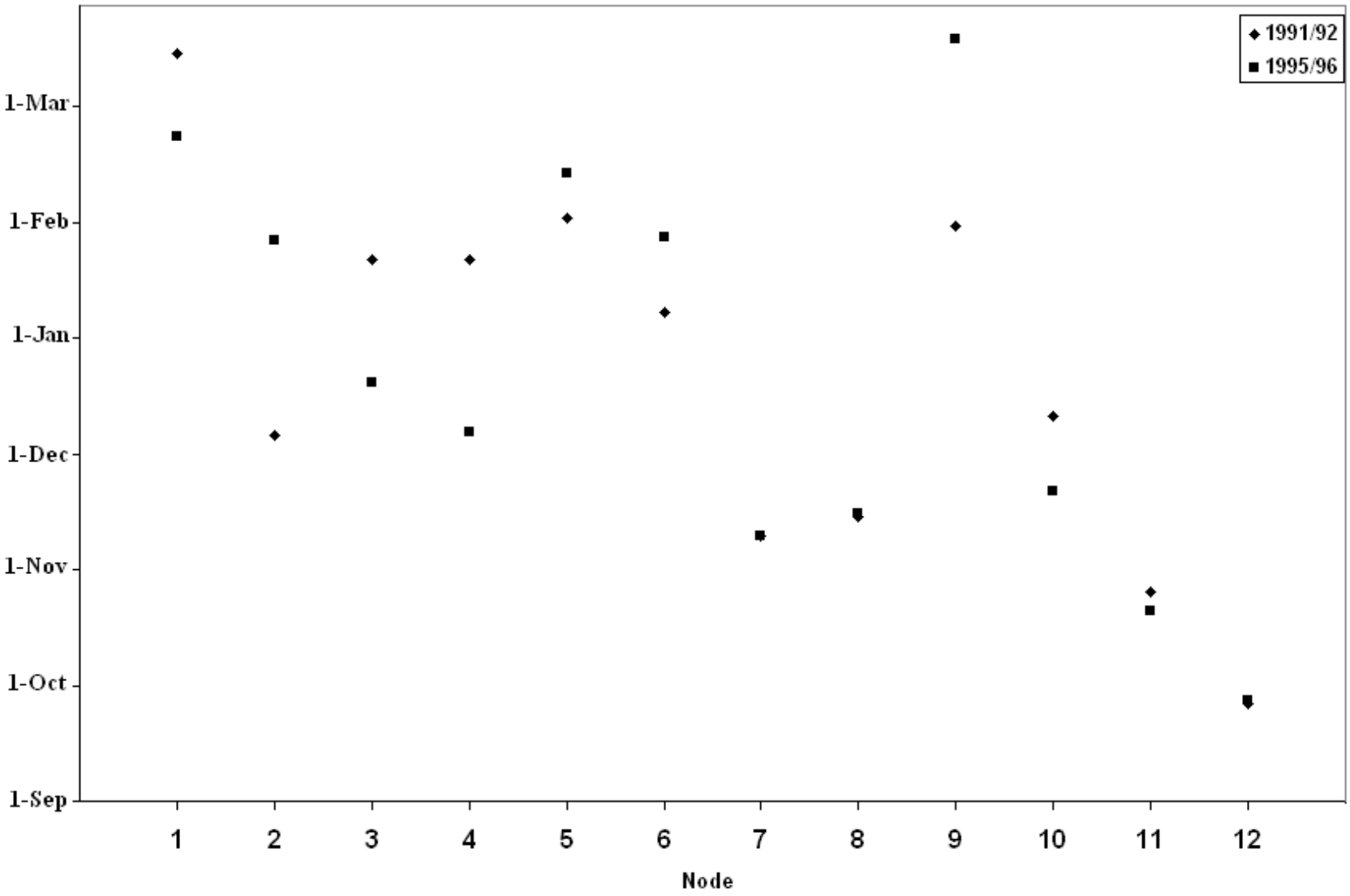
Self-organized mapping of NCEP 500hPa Geo-Potential Height



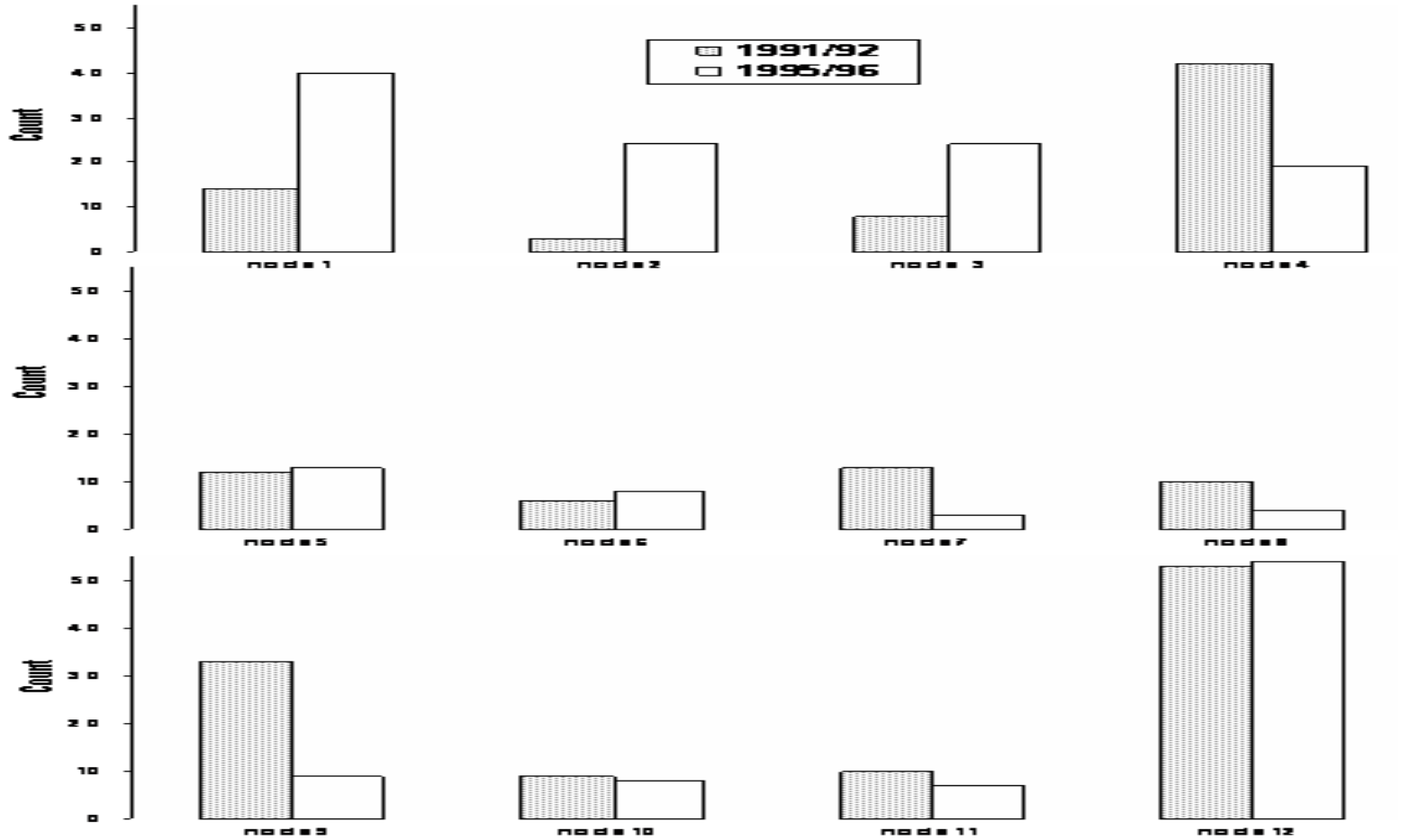
Self-organized mapping of NCEP 700hPa Precipitable Water



Median date of occurrence

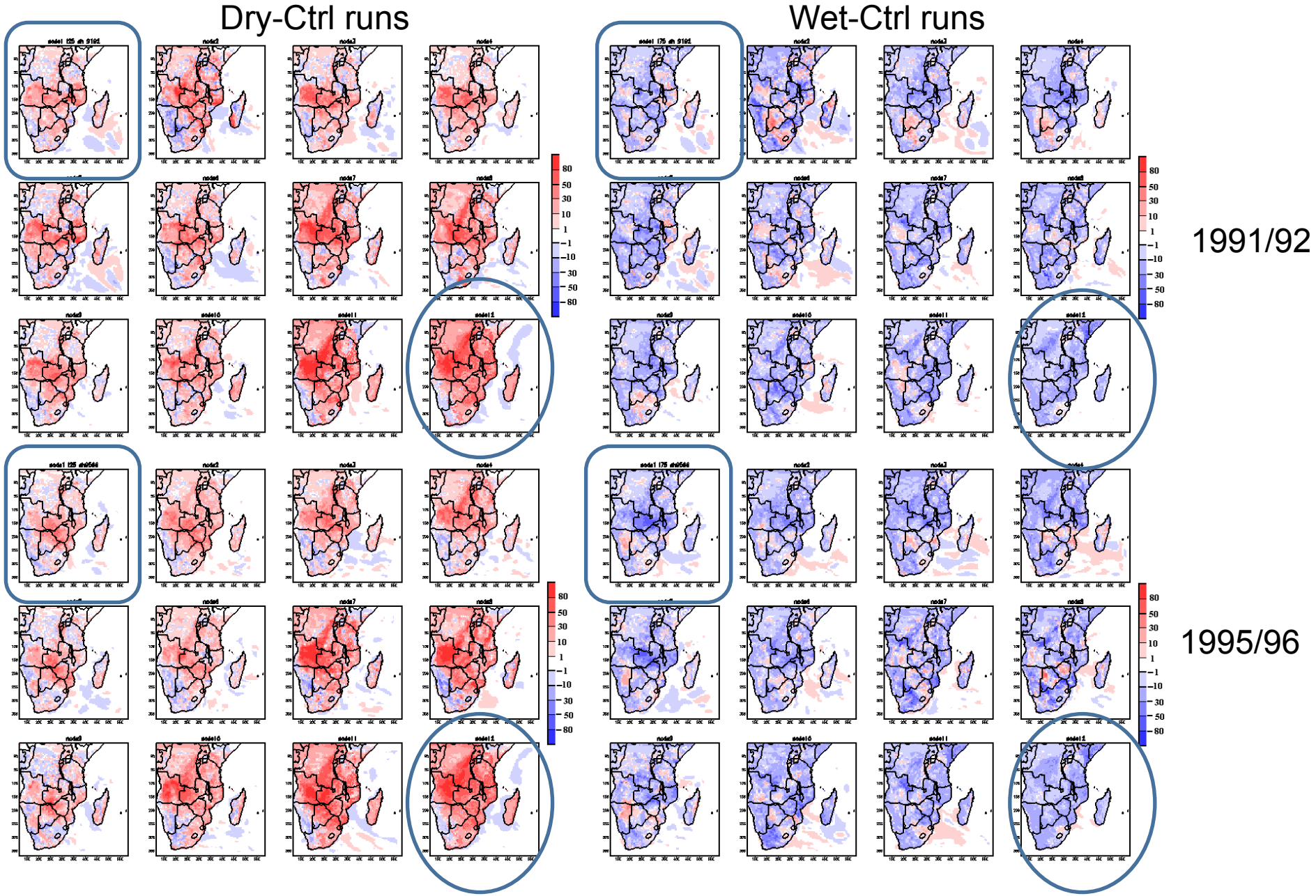


Frequency of occurrence

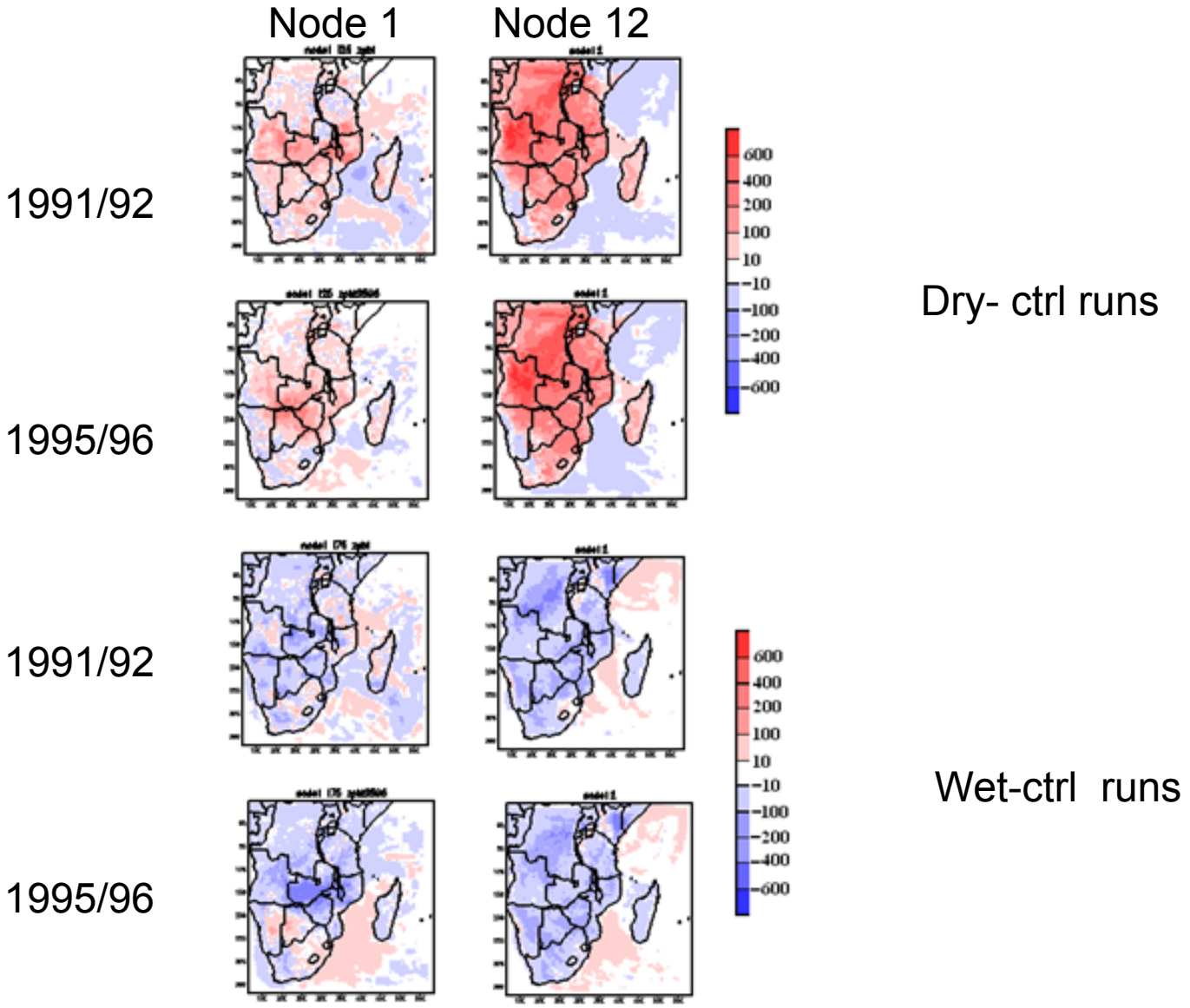


Synoptic patterns classification

Sensible heat flux



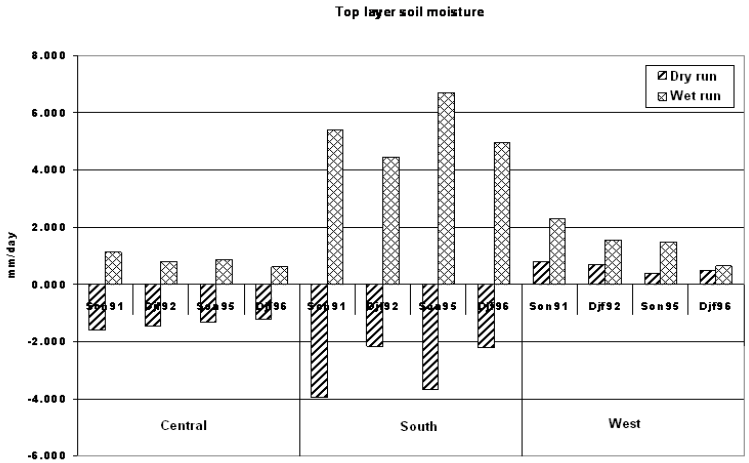
Spatial distribution within the synoptic – Planetary Boundary Layer

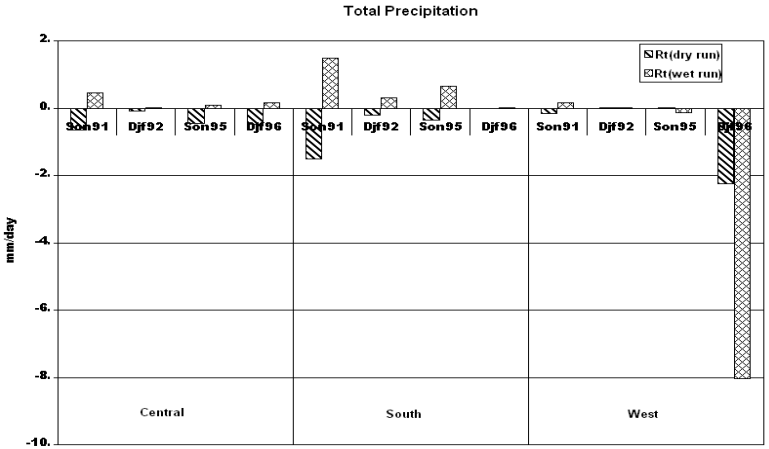


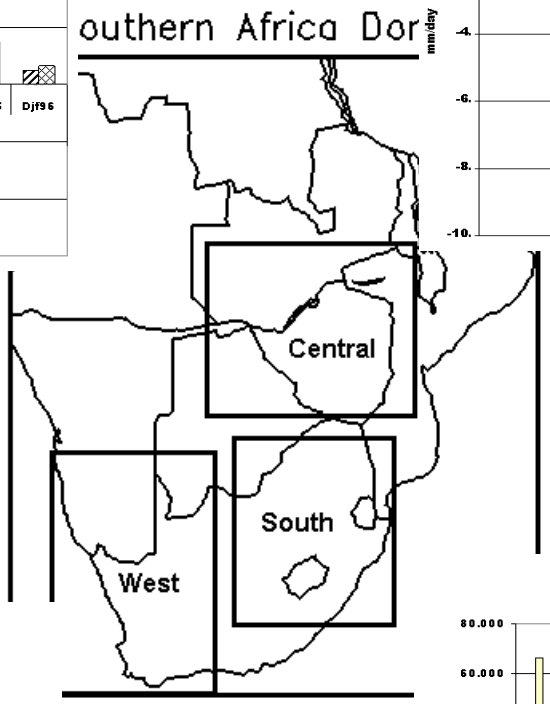
Dry- ctrl runs

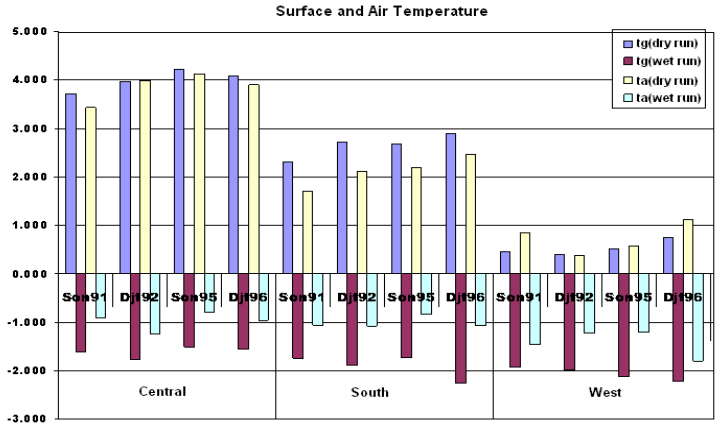
Wet-ctrl runs

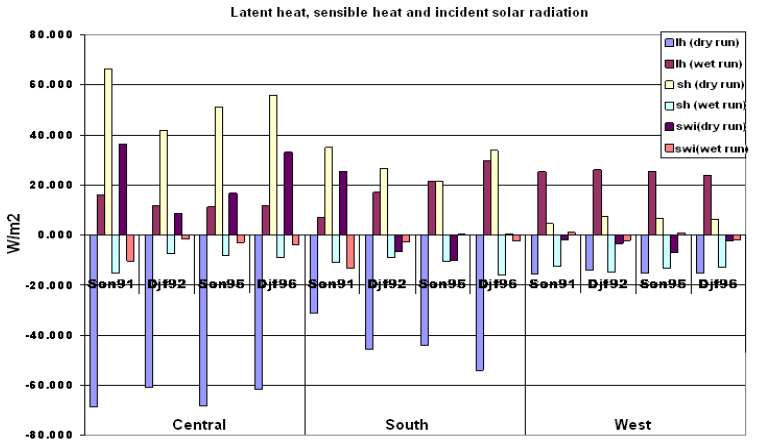
Sub-regional Analysis



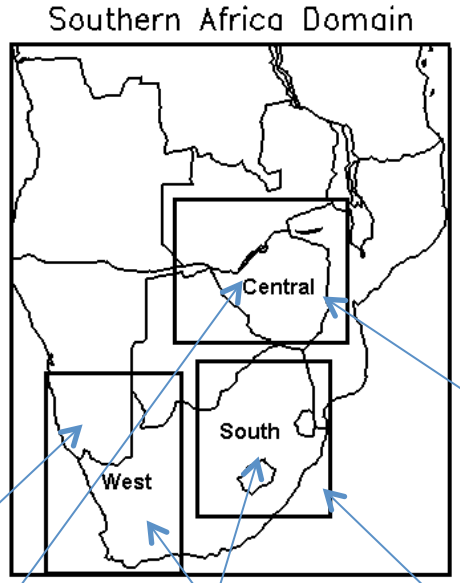






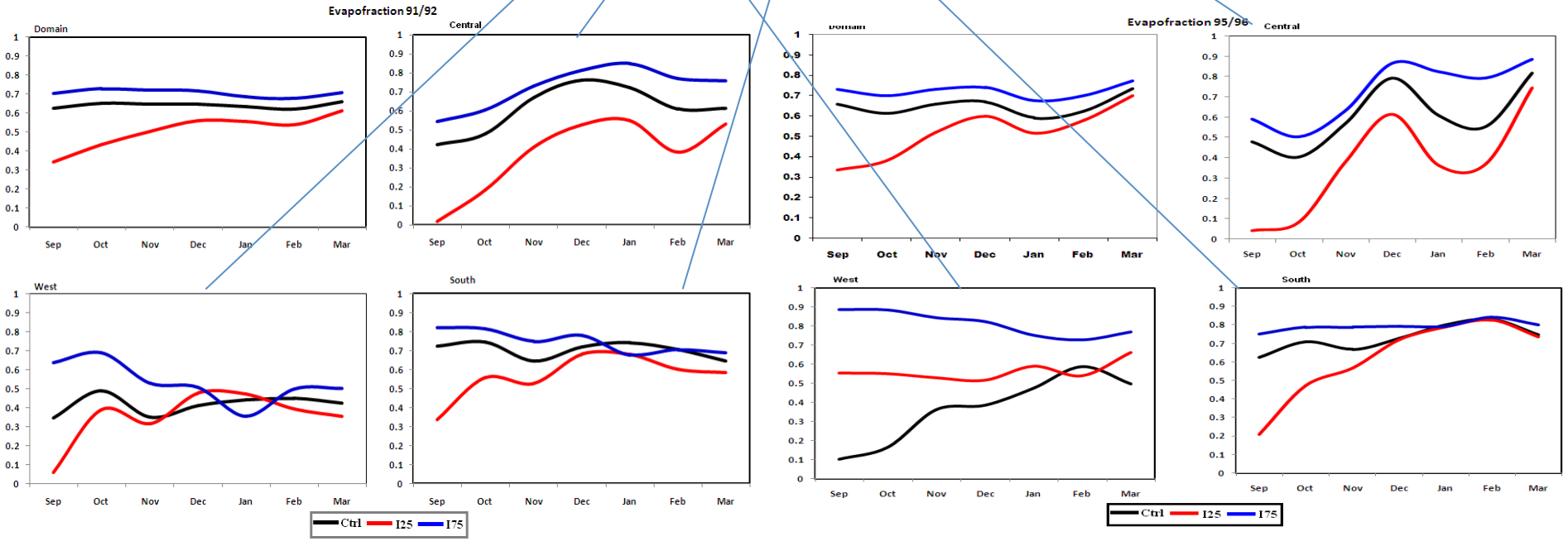


Evaporative Fraction



1991/92

1995/96



Summary

- The dry soil moisture perturbations result in stronger geopotential responses as compared to the wet soil moisture perturbations.
- This aids in explaining the stronger and persistent positive (negative) responses for surface temperature, sensible heat and PBL (latent heat) observed for dry soil moisture perturbation of the analysed variables during early summer.
- Southwestern parts of the region are consistently showing slight geopotential decreases for all the perturbations of late summer.
- This is consistent with unresponsive characteristics noted over southwestern areas of the region which are typically dry during this season rendering any dry/wet perturbation a forcing that would increase moisture levels.

Summary

- Dominant synoptic state (node 12) shows a surface tropical ridge of HP with a LP system to the SE of the region and mid-level anticyclonic circulation over Indian Ocean but also having low level moisture to the south of the domain.
- These synoptic characteristics are observed to occur during early summer in the seasonal evolution analysis of the SOM array.
- The left side of SOM generally represents the wet synoptic states which occur during mid into late summer for both 1991/92 and 1995/96.
- The SOM does somewhat show the transition to the model's equilibrium state with responses to soil moisture initialisation showing stronger responses during early summer and favouring dry synoptic states or being influenced by the late winter/spring synoptic characteristics.
- SH and PBL anomalies have spatial consistent positive responses to surface temperature.
- Over the southwestern area, there are no distinctive responses to dry/ wet soil moisture perturbations across the synoptic states for the all the surface variables.

Summary

- In general, dry (wet) conditions have positive feedbacks with similar dry (wet) synoptic forcings of the regional climate.
- Anomalous dry forcing persists for longer and exacerbates the changes in the regional circulation especially during a drought or dry period.
- Dry soil induces an anticyclonic anomaly whilst wet soils enhance weak anticyclonic or cyclonic circulation especially over the northern parts of southern Africa.
- There are contrasting responses to soil moisture perturbations over southern parts of the region.
- Aspects of geography and terrain are also influential.

Future

- Comparison of different land surface schemes.
- Longer time-scale simulations.
- Ensemble of RCMs.
- Taking on-board some of the proposed CORDEX metrics!
- Mixed convection schemes.
- Increase resolution depending on the end-user requirements.

Grazie
Thank You
Danke
Tatenda
Obrigado
Merci
Siyabonga
etc