Precession and obliquity forcing of the North-African summer monsoon

A sensitivity study with the high resolution GCM EC-Earth

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1. Research aims

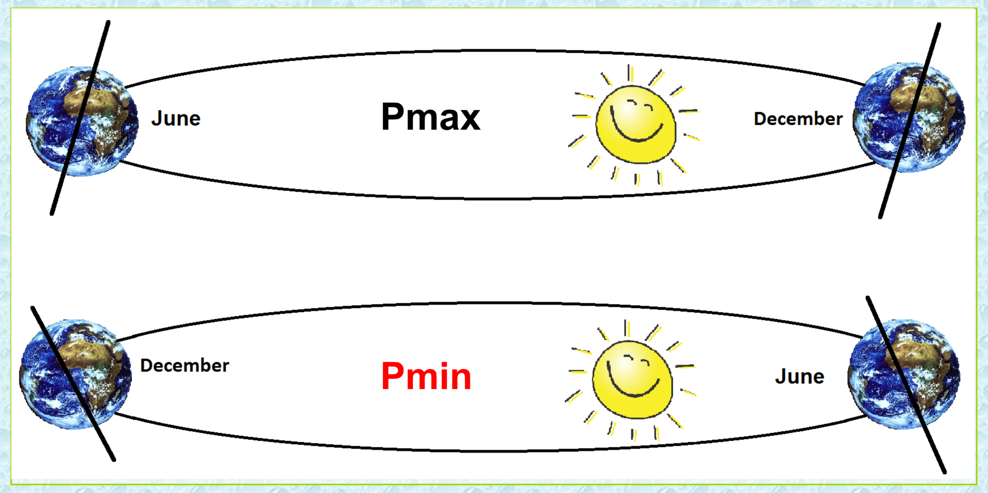
- Investigate how changes in the Earths orbit around the Sun affect the North-African summer monsoon.
- Specifically, examine the precession and obliquity forcing separately (see 2.2).
- This is the first study of the separate precession and obliquity forcing using a fully coupled high resolution GCM.

2.1 EC-Earth

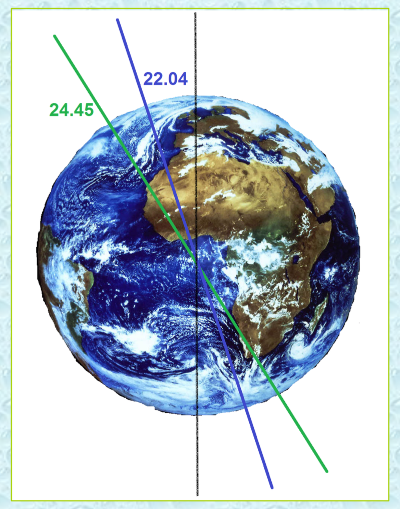
- EC-Earth 2.2: fully coupled ocean-atmosphere GCM (see for more details Hazeleger et al., 2011)
- Atmosphere: 1.1°x1.1° (T159), 62 vertical levels, ocean: 1°x1°, 42 vertical levels
- Atmosphere based on weather forecast model (IFS C31R1, ECMWF) → sophisticated parametrisations

2.2 Model Set-up

- Two extremes of the precession parameter, at high eccentricity, both with obliquity at 22.04°

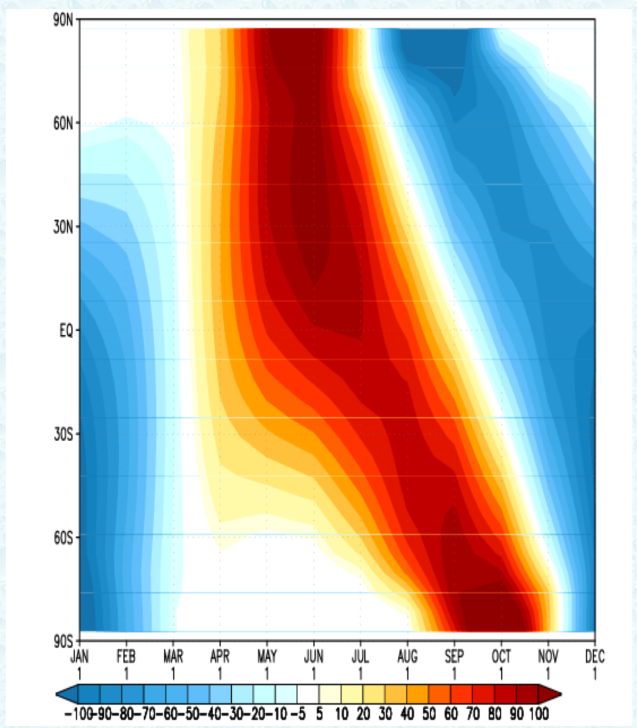


- Two extremes of obliquity, 22.04° (**Tmin**) and 24.45° (**Tmax**), both with circular orbit (eccentricity=0, i.e. no precession), as in Tuenter et al., 2003



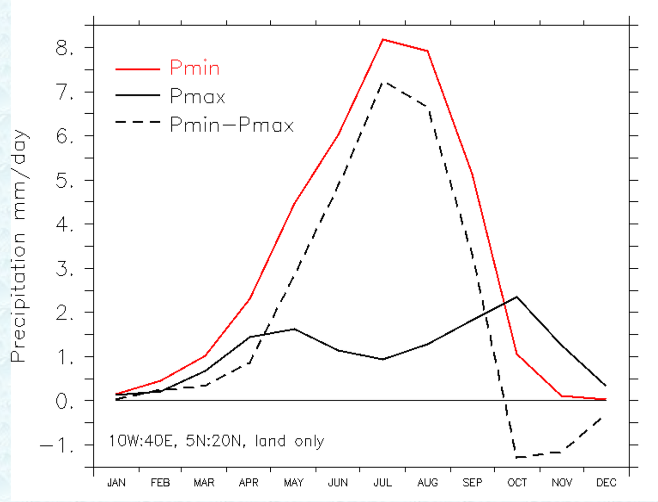
- All other boundary conditions set to pre-industrial values

3. Precession

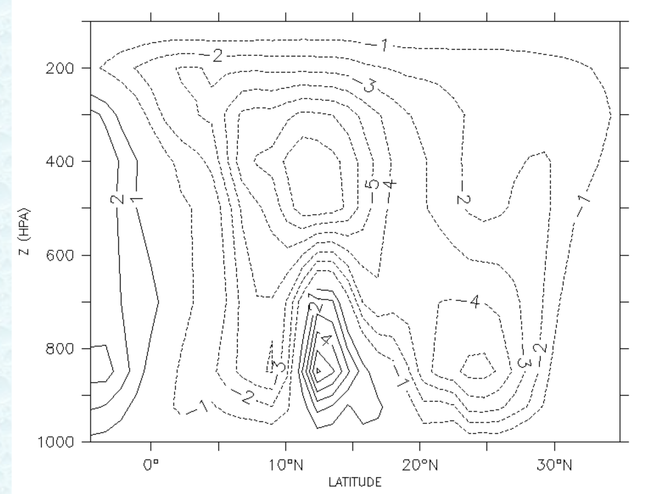


Insolation difference (Wm^{-2}), precession minimum – maximum (**Pmin** - **Pmax**)

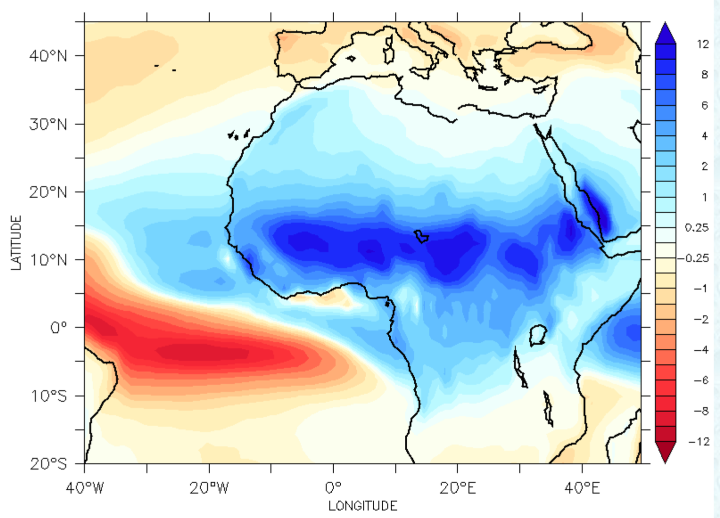
Pmin: stronger monsoon precipitation, winds and circulation



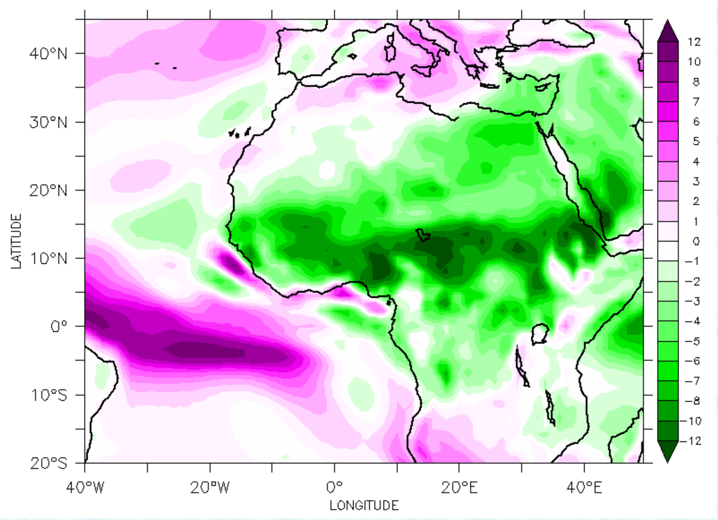
Precipitation over North-Africa in both precession experiments, mm/day



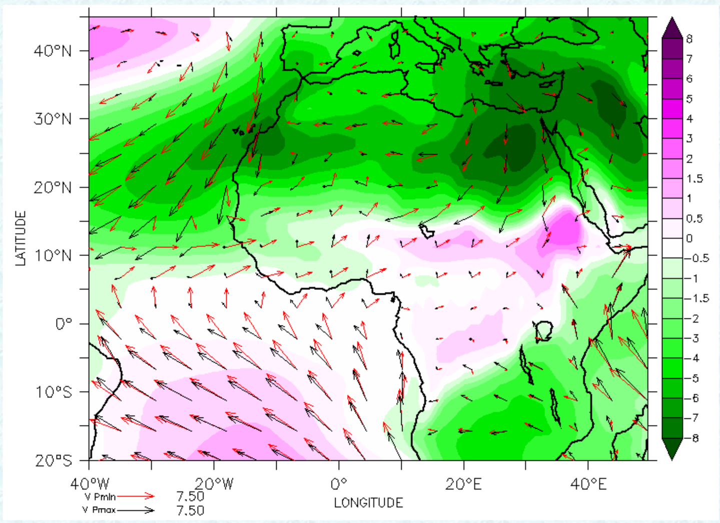
Vertical velocity 30°W:40°E, **Pmin** - **Pmax**, JJA, 10^{-2} Pa/s



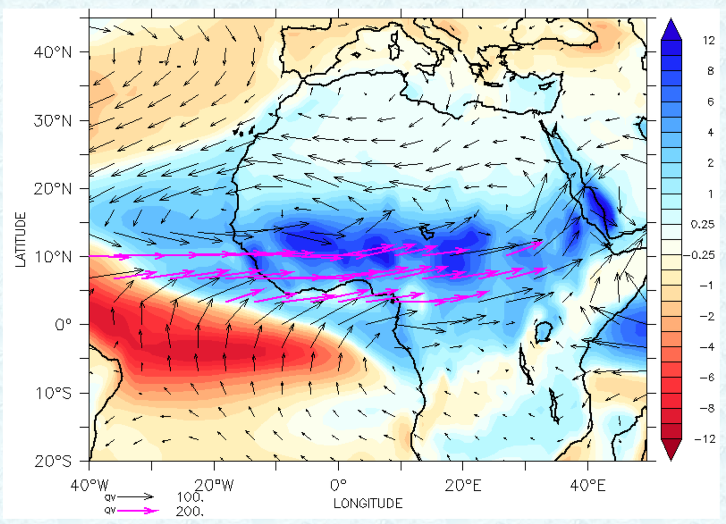
Precipitation **Pmin** - **Pmax**, JJA, mm/day



Vertical velocity 500 hPa, **Pmin** - **Pmax**, JJA , 10^{-2} Pa/s

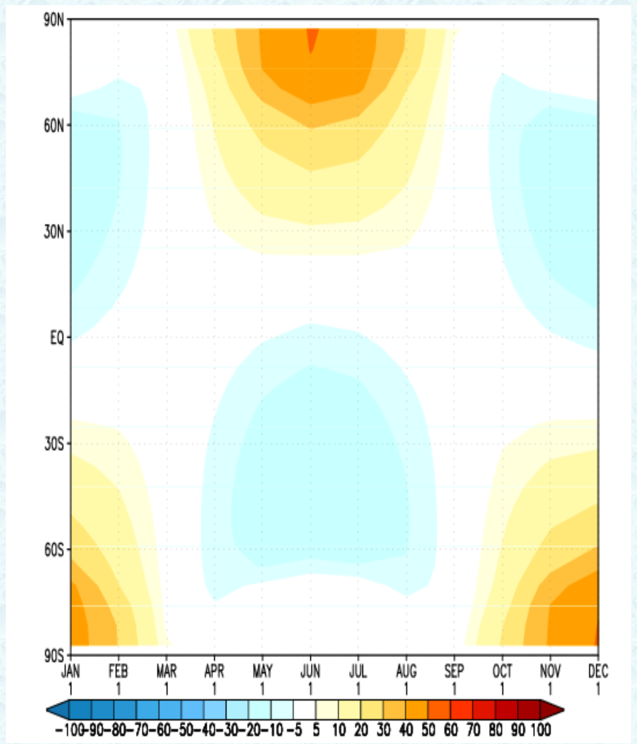


Surface pressure **Pmin** – **Pmax**, (hPa) and surface wind (m/s), JJA, **Pmin** = red, **Pmax** = black



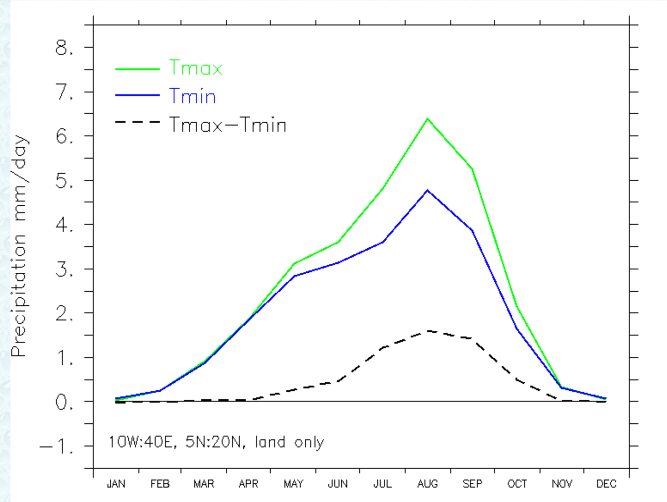
Net precipitation (mm/day) and moisture transport ***Q*** (kg/(ms)), **Pmin** – **Pmax**, JJA

4. Obliquity

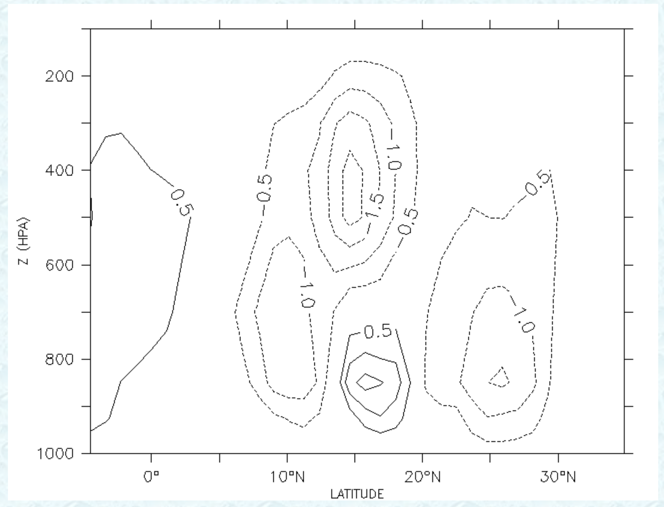


Insolation difference (Wm^{-2}), obliquity maximum – minimum (**Tmax**- **Tmin**)

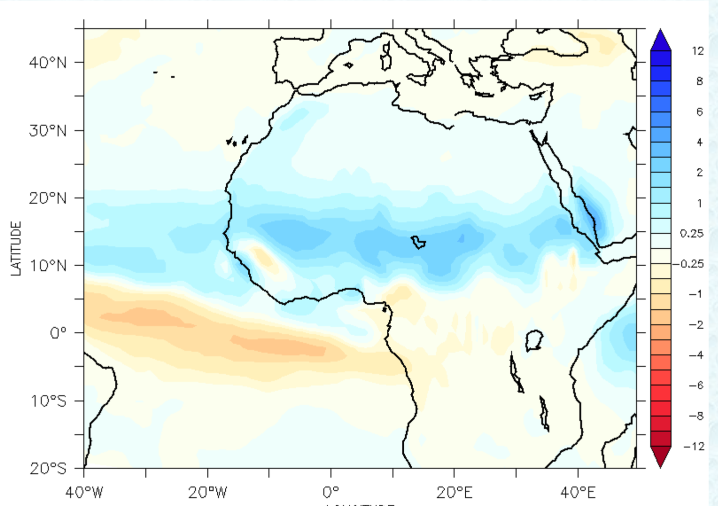
Tmax: stronger monsoon precipitation, winds and circulation



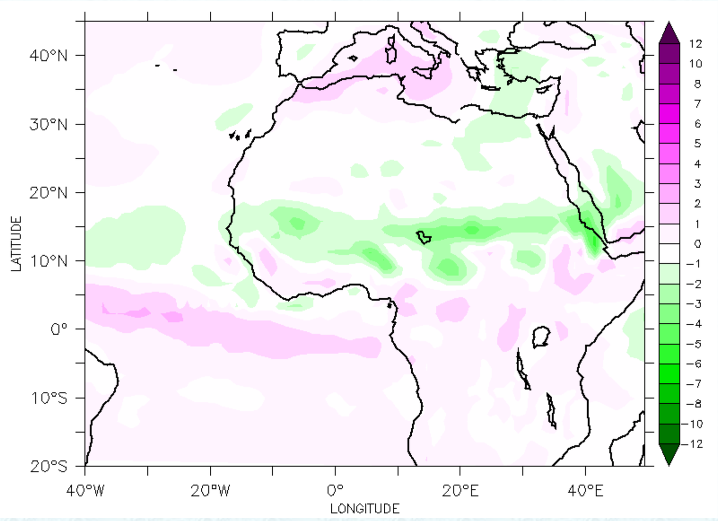
Precipitation over North-Africa in both obliquity experiments, mm/day



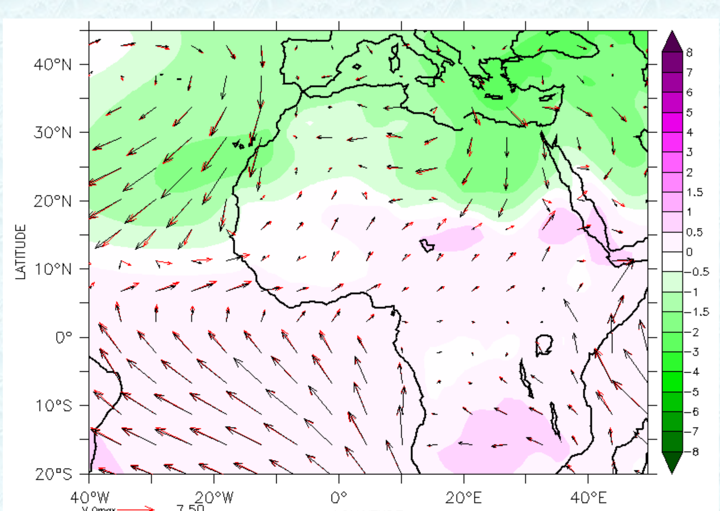
Vertical velocity 30°W:40°E, **Tmax** - **Tmin**, JJA, 10^{-2} Pa/s



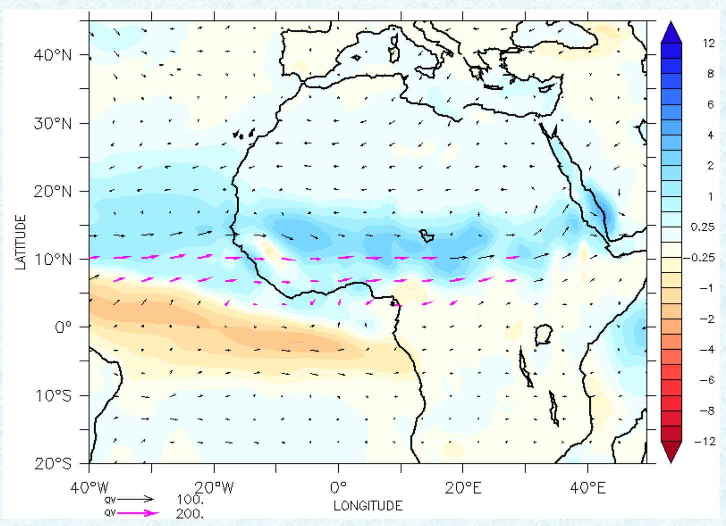
Precipitation **Tmax** - **Tmin**, JJA, mm/day



Vertical velocity 500 hPa, **Tmax** - **Tmin**, JJA , 10^{-2} Pa/s



Surface pressure **Tmax** - **Tmin**, (hPa) and surface wind (m/s), JJA, **Tmax** = red, **Tmin** = black



Net precipitation (mm/day) and moisture transport ***Q*** (kg/(ms)), **Tmax** - **Tmin**, JJA

References

Hazeleger et al. 2011, Climate Dynamics, Volume 39, Issue 11, pp 2611-2629, DOI 10.1007/s00382-011-1228-5
Tuenter et al. 2003, Global and Planetary Change, Volume 36, Issue 4, pp 219-235, DOI 10.1016/S0921-8181(02) 00196-0

5. Conclusions

- EC-Earth shows both the precession and obliquity signals in the North-African monsoon
- Monsoon is strengthened at times of high Northern Hemisphere summer insolation (Pmin and Tmax)
- Obliquity signal present despite low insolation changes over low latitudes
- Mechanisms of monsoon response to orbital forcing fundamentally different to Tuenter et al. (2003)

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