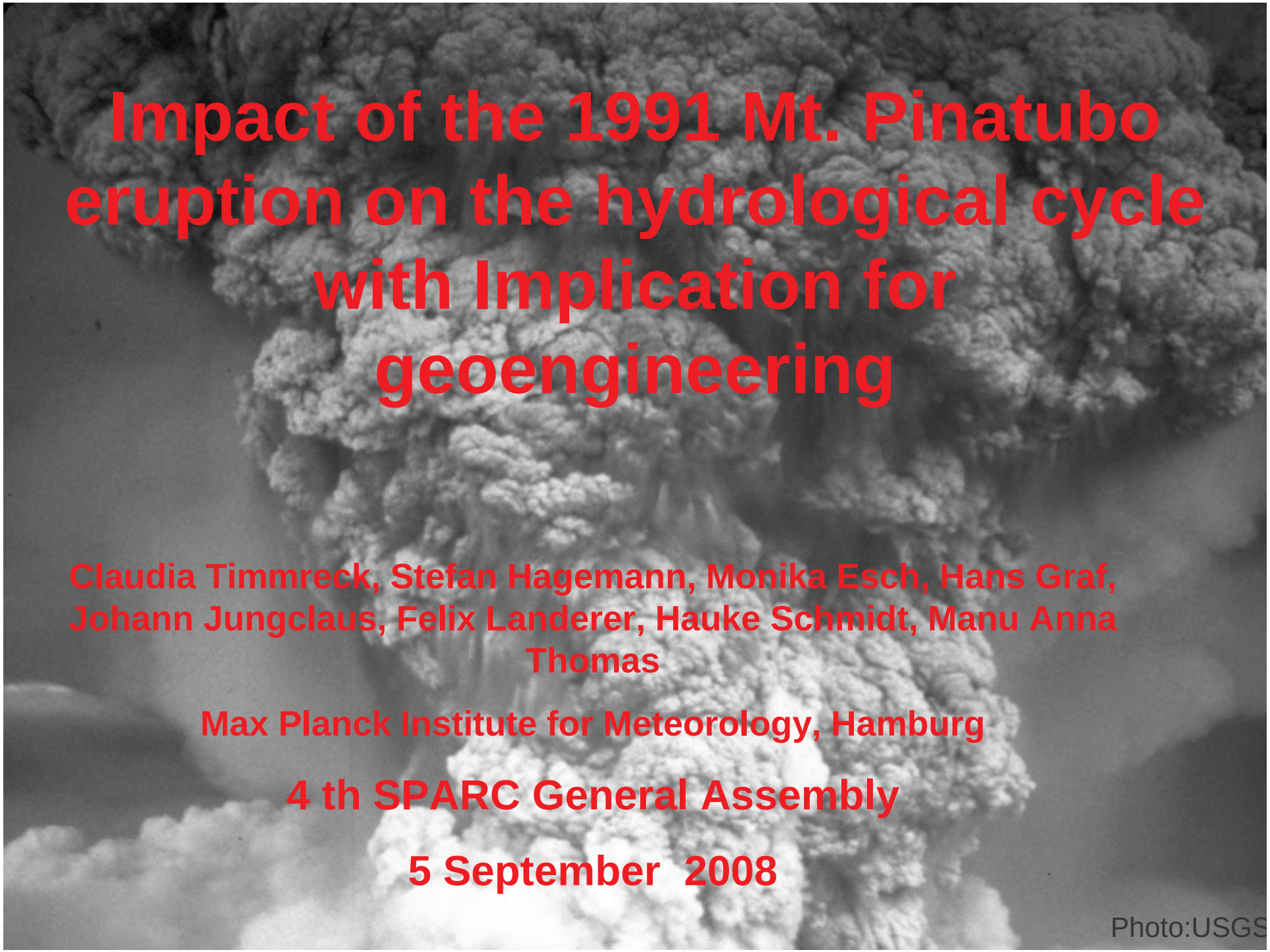


Impact of the 1991 Mt. Pinatubo eruption on the hydrological cycle with Implication for geoengineering

Claudia Timmreck, Stefan Hagemann, Monika Esch, Hans Graf, Johann Jungclaus, Felix Landerer, Hauke Schmidt, Manu Anna Thomas

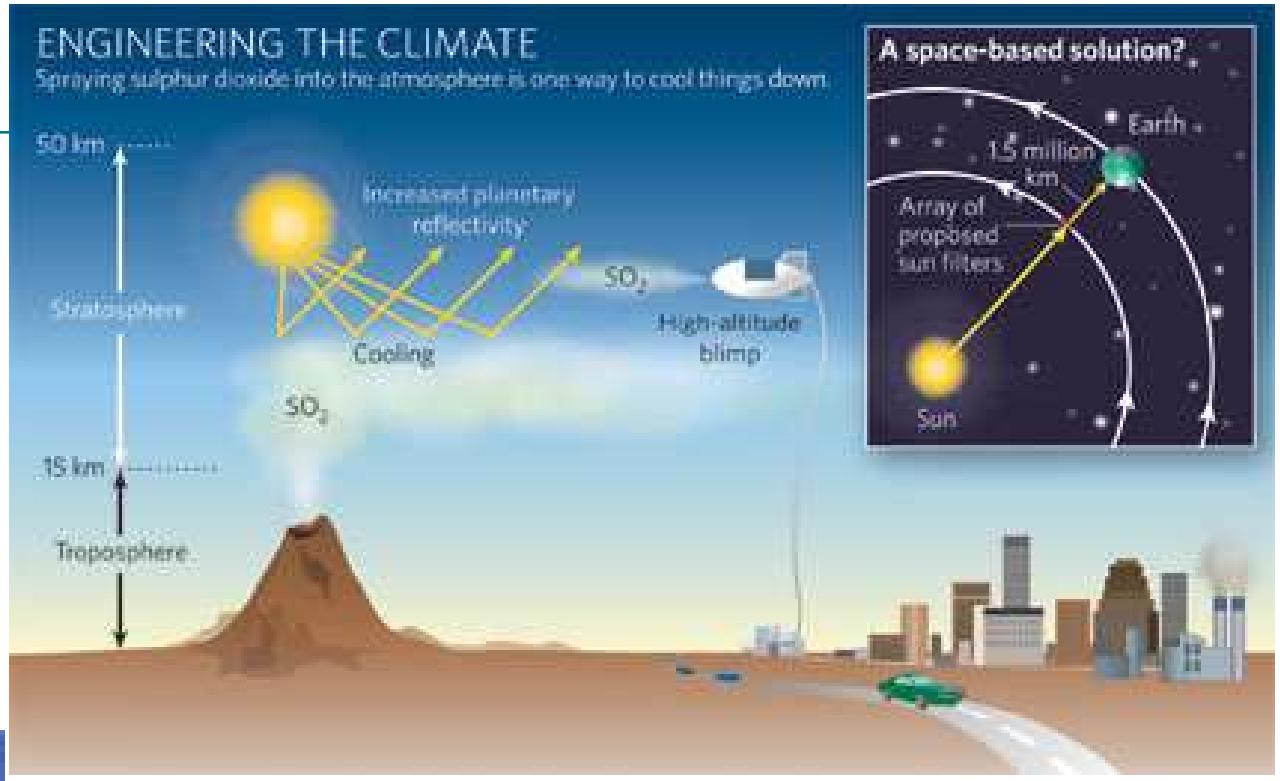
Max Planck Institute for Meteorology, Hamburg

4 th SPARC General Assembly

5 September 2008

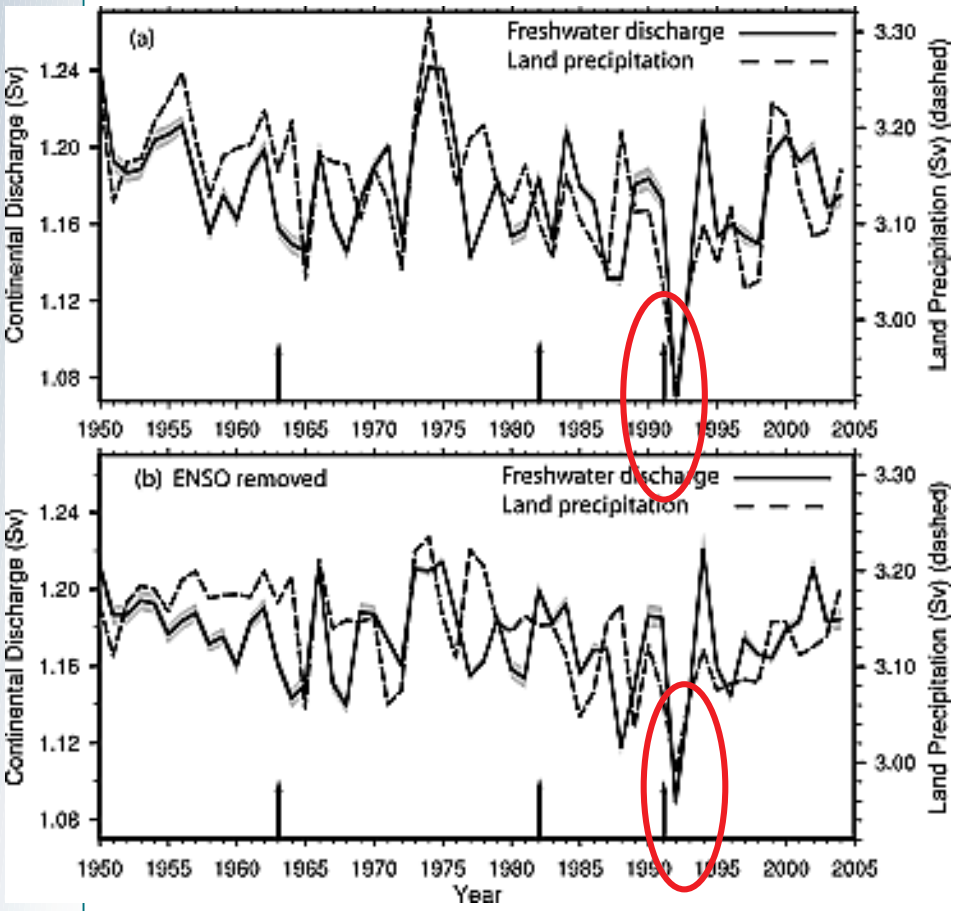
Photo:USGS

Changing climate due to increasing greenhouse gases has enforced the discussion of geoengineering actions



Nature 2007

- Large volcanic eruptions are a pretty good analogue for albedo enhancement experiments due to an enhanced loading of stratospheric aerosol.
- In particular the June 1991 eruption of Mt. Pinatubo serves as a good test bed to investigate possible side effects.

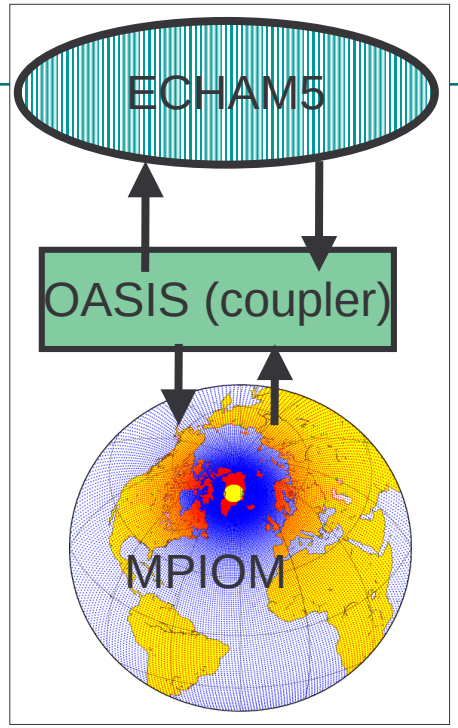


Trenberth and Dai, GRL 2007

§After the Pinatubo eruption a decrease in surface air temperature, atmospheric water vapor, sea level in runoff and in precipitation over land has been observed (e.g. Soden et al, 2002 Broccoli et al, 2003;Trenberth and Dai, 1997).

§During the winter following the Mt. Pinatubo eruption an El Niño took place. It is currently uncertain to what degree this has influenced the climatic response.

Volcanic AOGCM runs



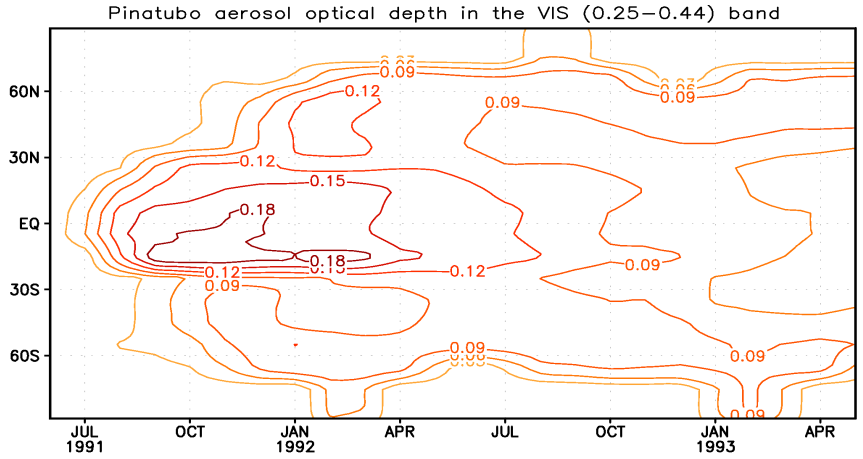
We have carried out a series of volcanic simulations with the coupled AOGCM **ECHAM5/MPIOM** (Jungclaus et al, 2006)

ECHAM5: T63L31, model top 10 hPa.

MPIOM : 1.5 horiz. 40 vertical levels

The volcanic radiative forcing is calculated online in the model. A realistic spatial-temporal distribution of aerosol optical parameters for the Pinatubo episode is used.

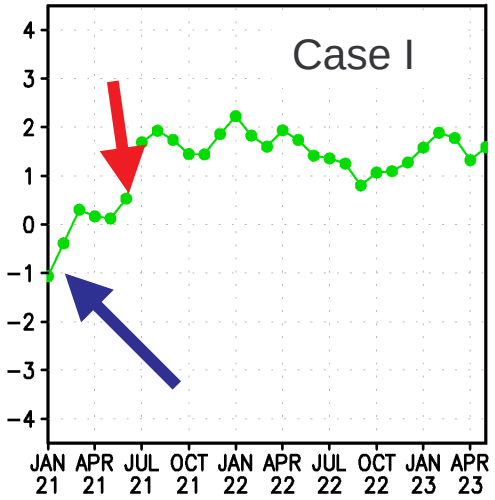
Optical depth in the visible



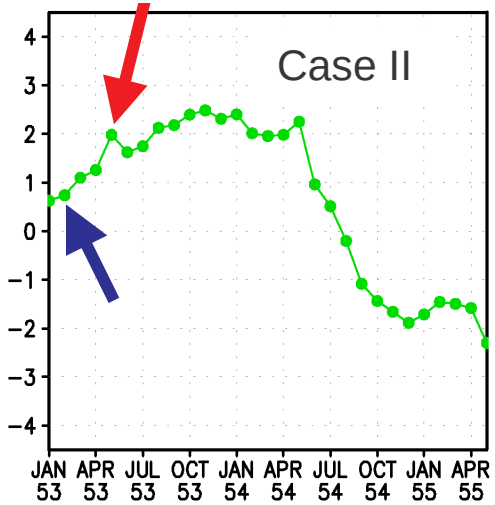
G. Stenchikov priv com.

Coupled El Niño Volcanic runs

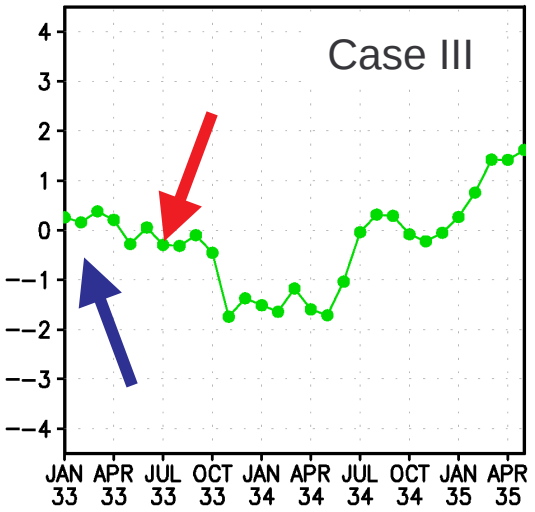
devloping El Niño



ongoing El Niño

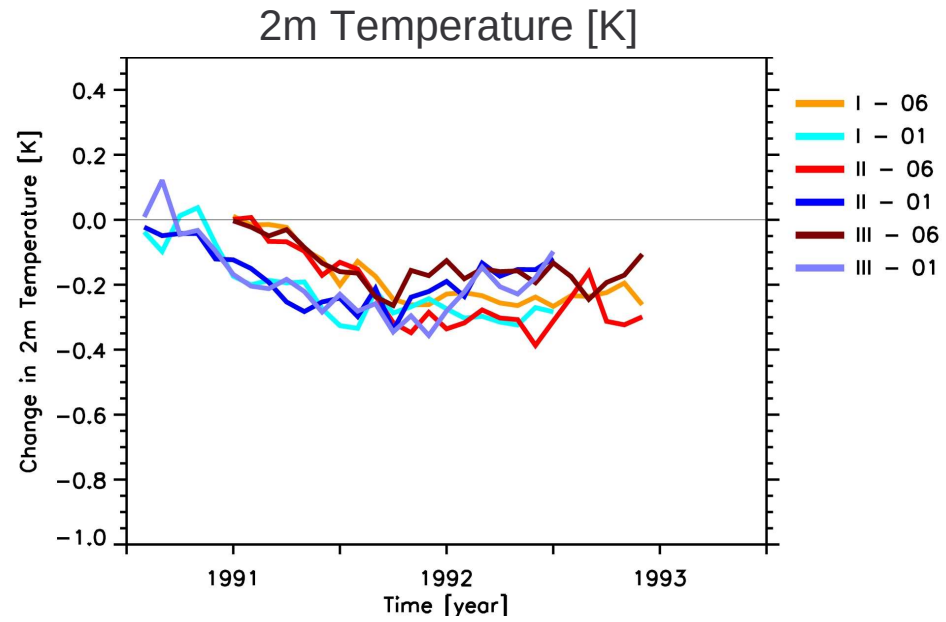


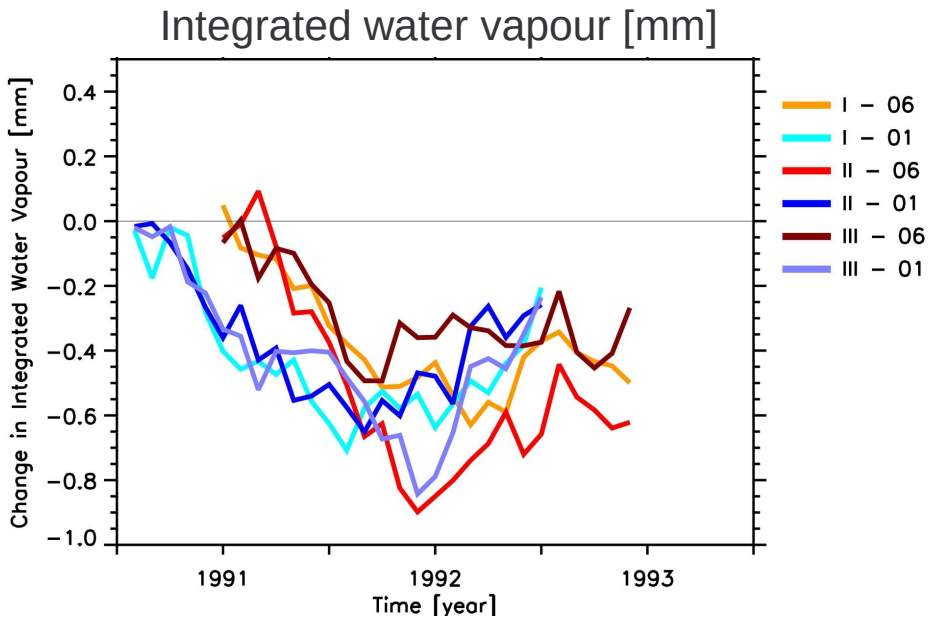
neutal conditions

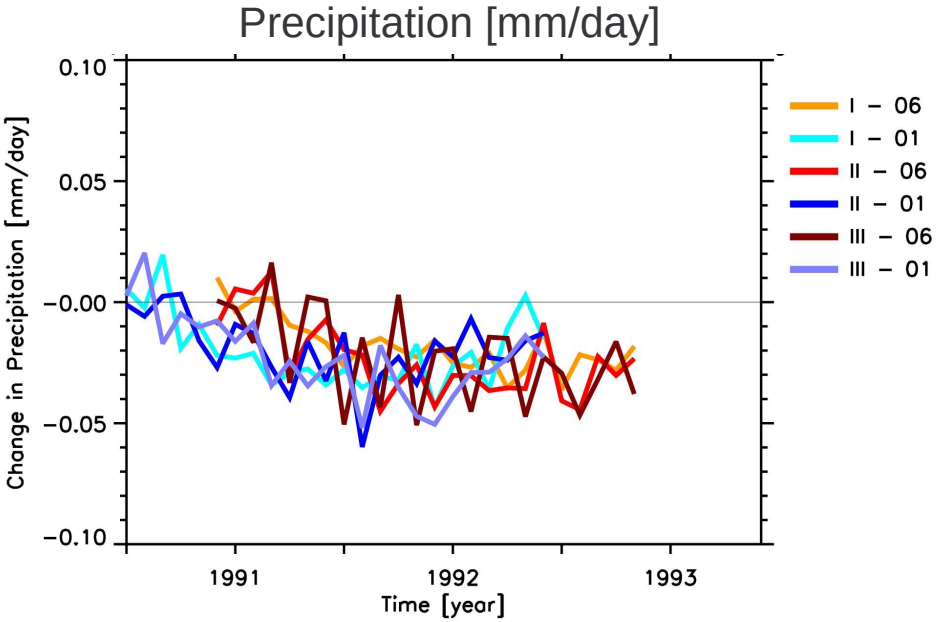


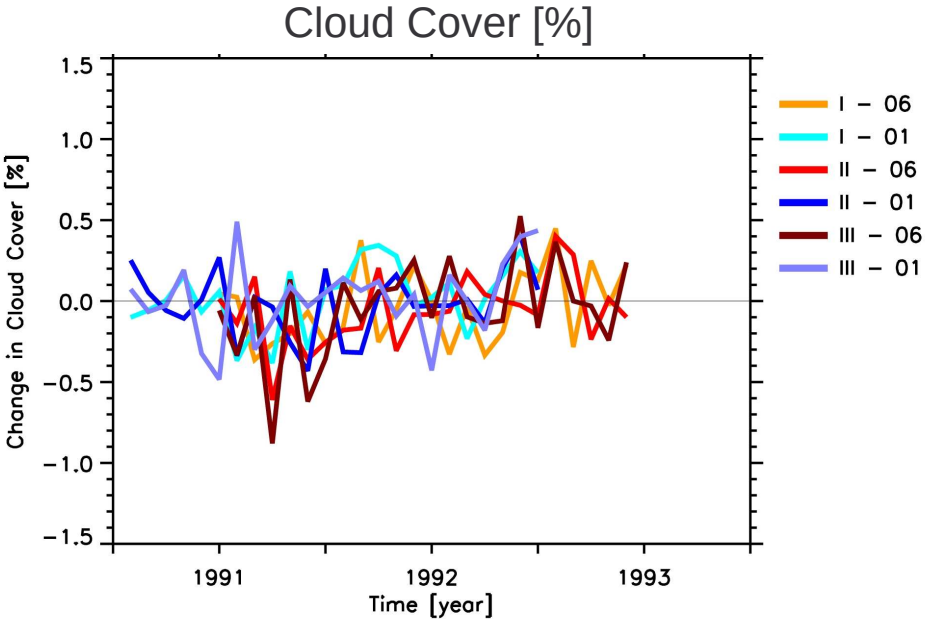
- Three different cases are selected from a 100 year control run.
- 10 ensembles for volcanically perturbed and unperturbed conditions starting in **January** and **June**
- Each ensemble run has been performed for two years.

Time series of global anomalies (perturbed –unperturbed)





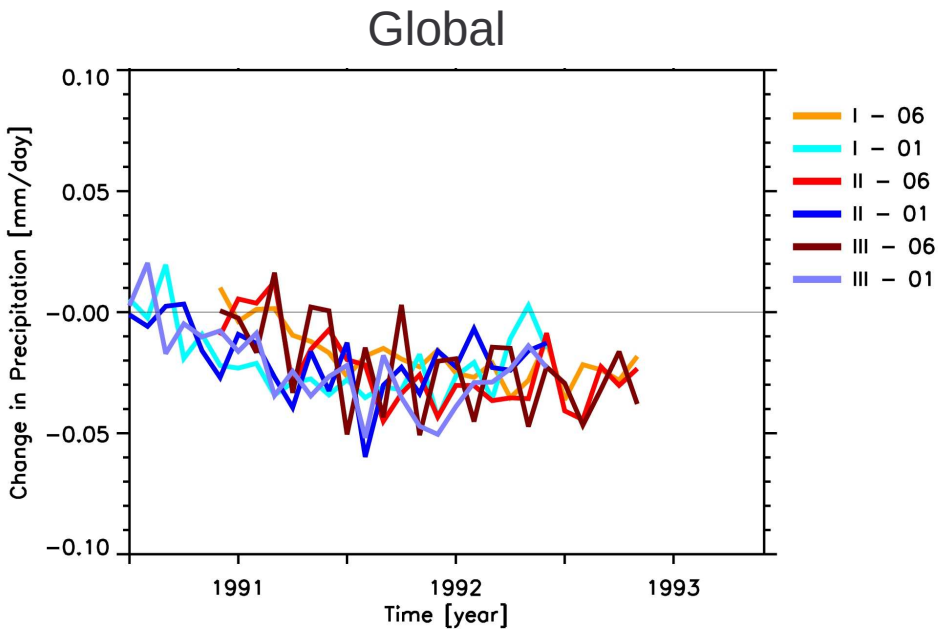


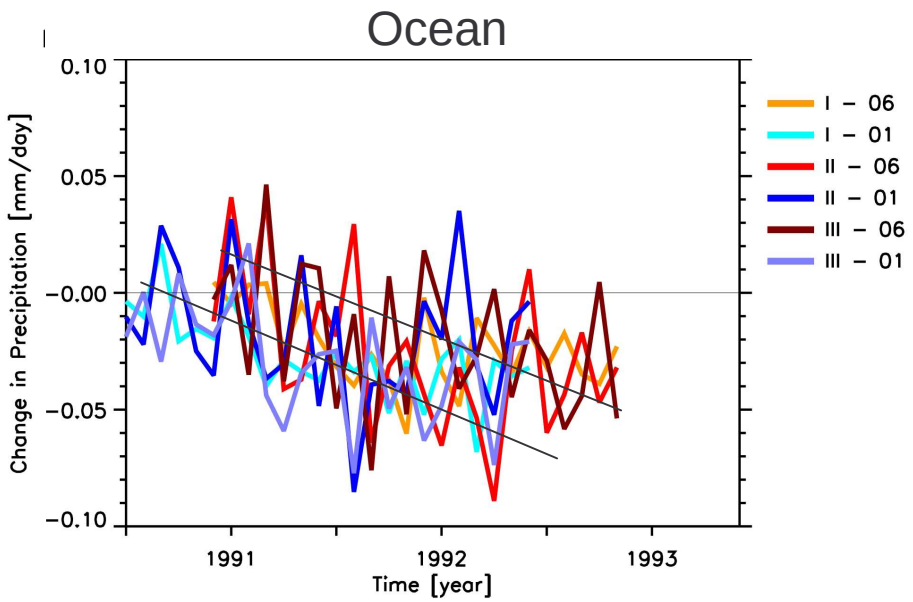


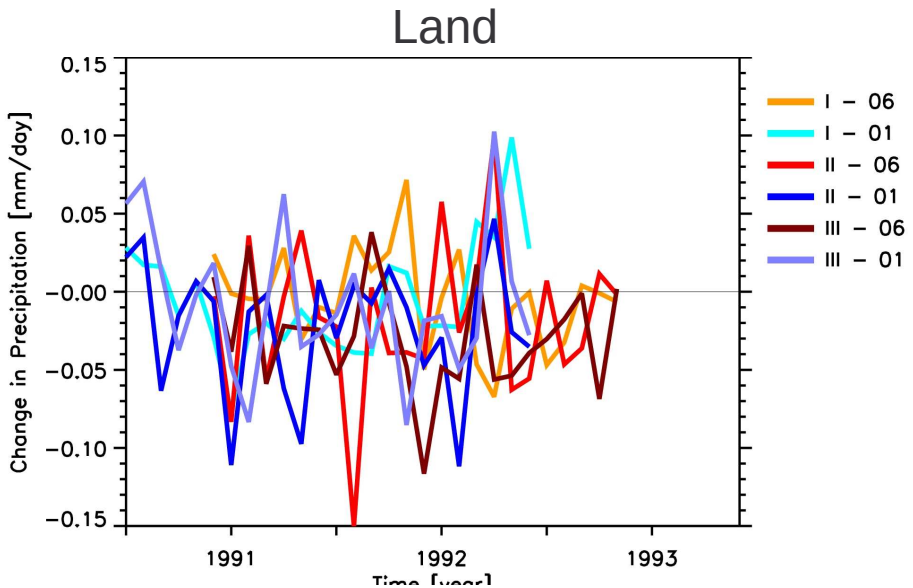
19. Aug. 2008, by Stefan Hagemann, MPI

19. Aug. 2008, by Stefan Hagemann, MPI

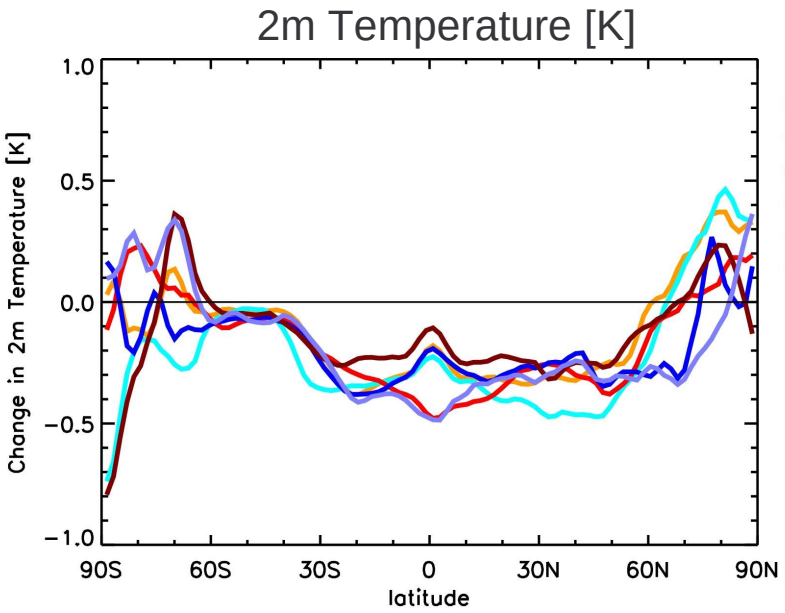
Precipitation Anomalies [mm/day]

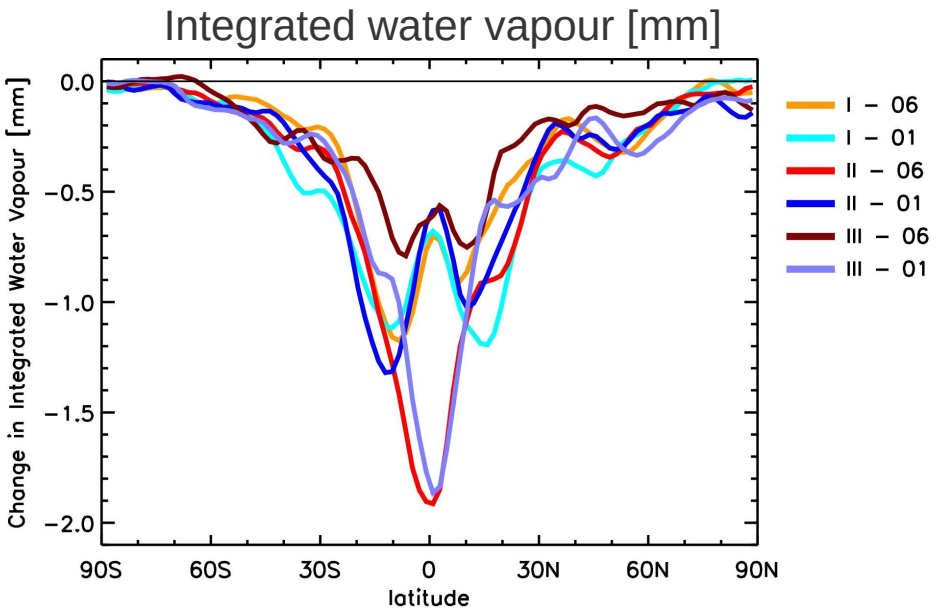


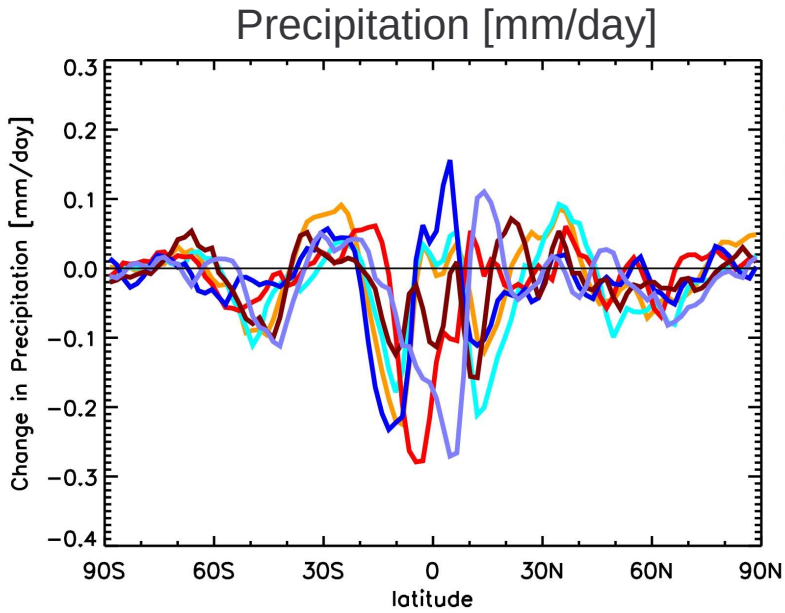


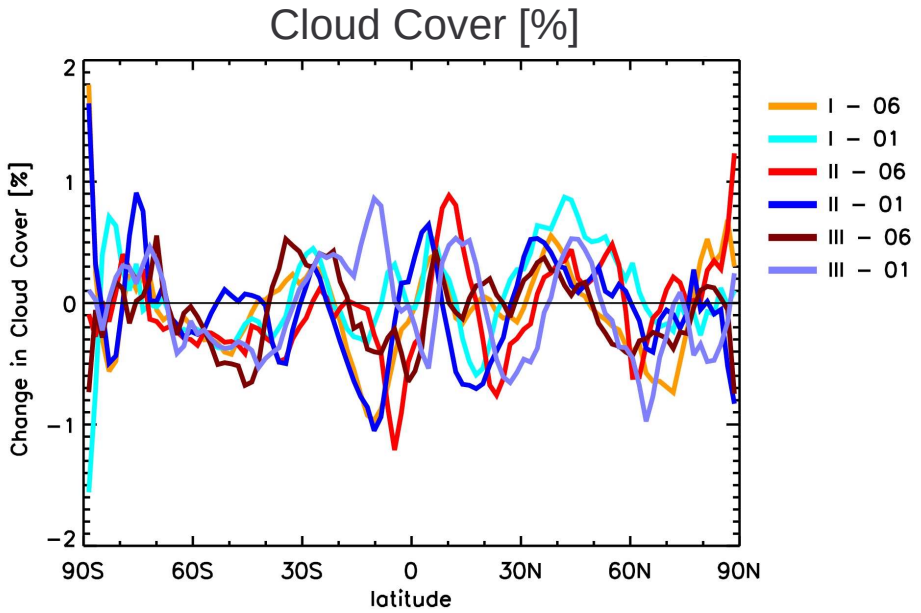


Annual mean (Oct. 91/Sep. 92) of global anomalies





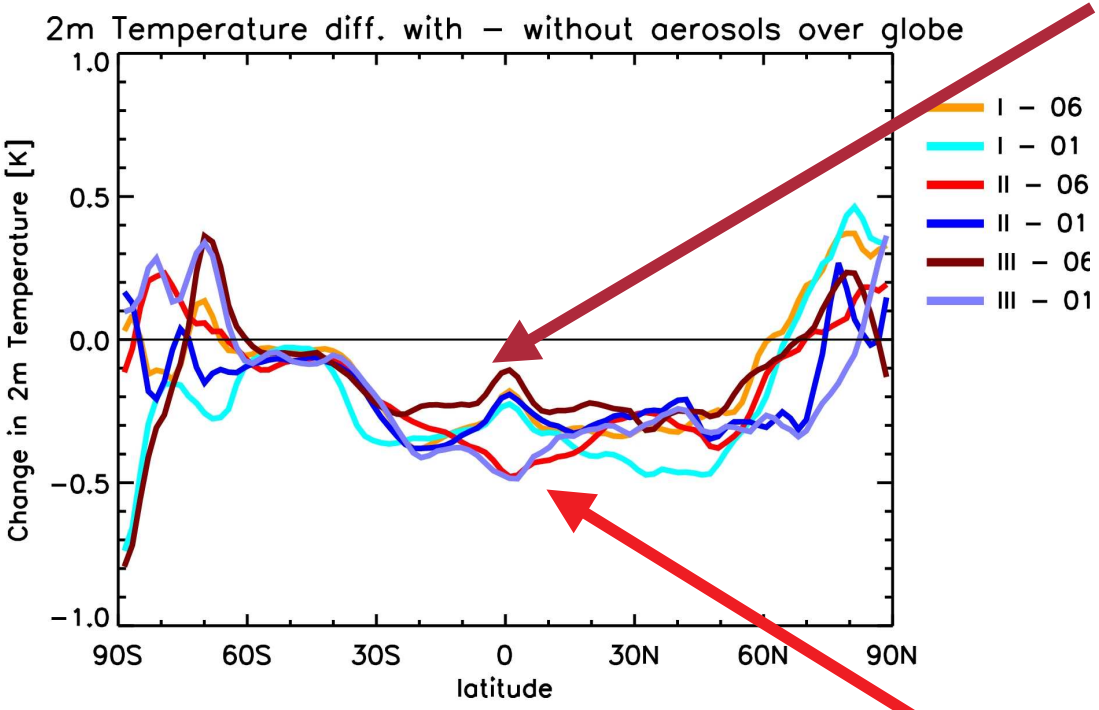


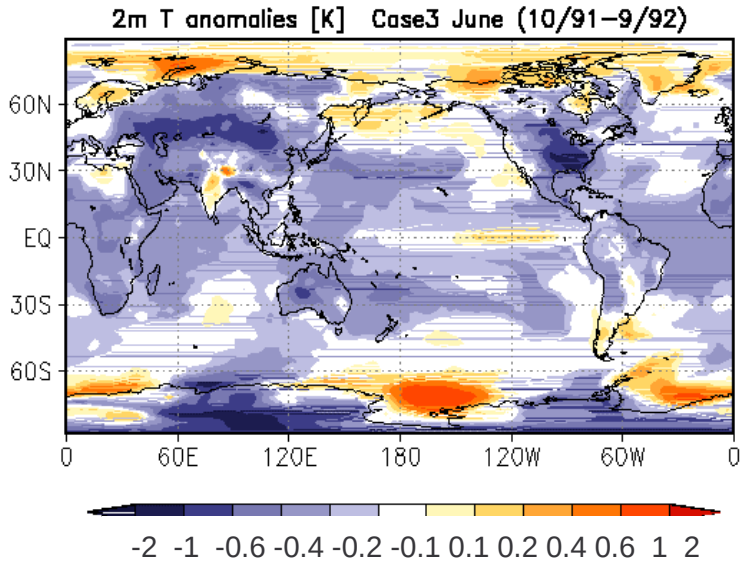


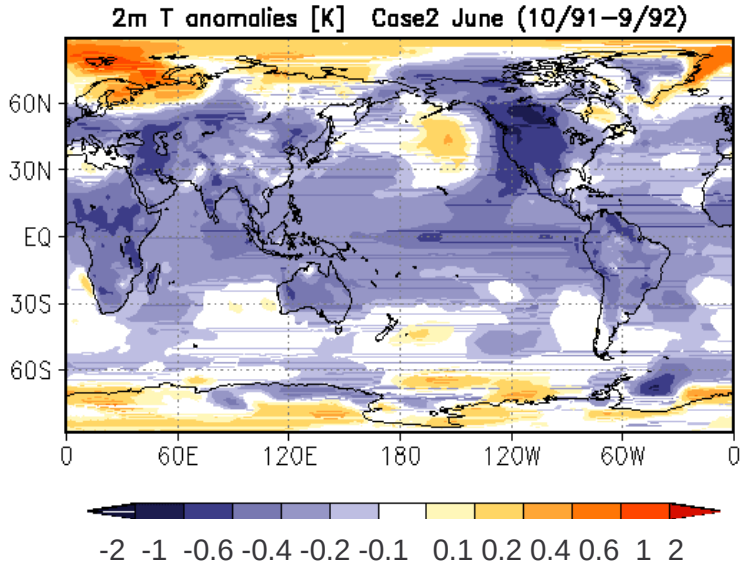
19. Aug. 2008. by Stefan Hagemann, MPI

19. Aug. 2008. by Stefan Hagemann, MPI

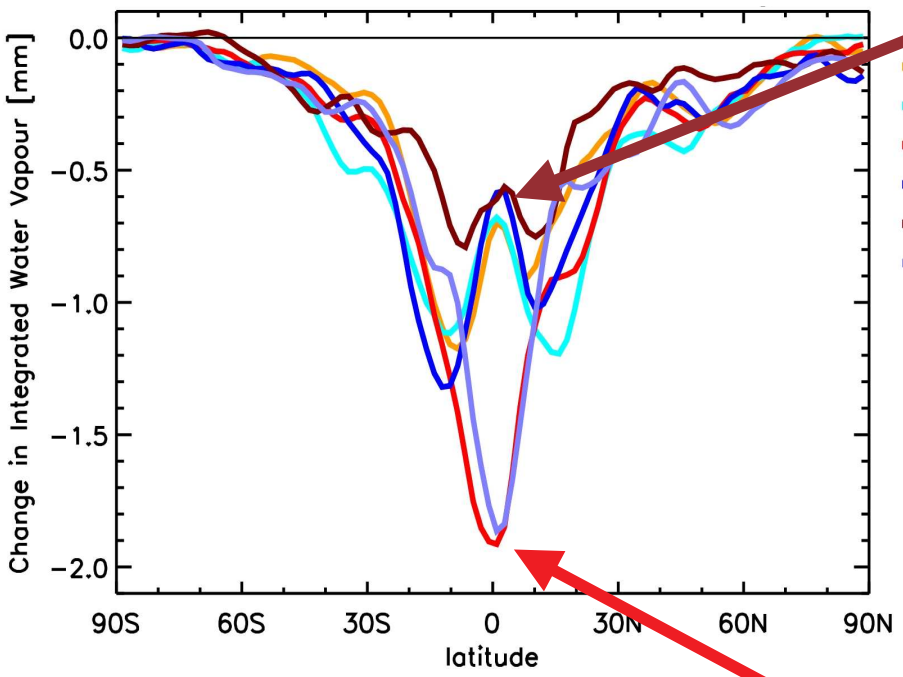
Annual mean (Oct. 91/ Sep. 92) of T anomalies [K]

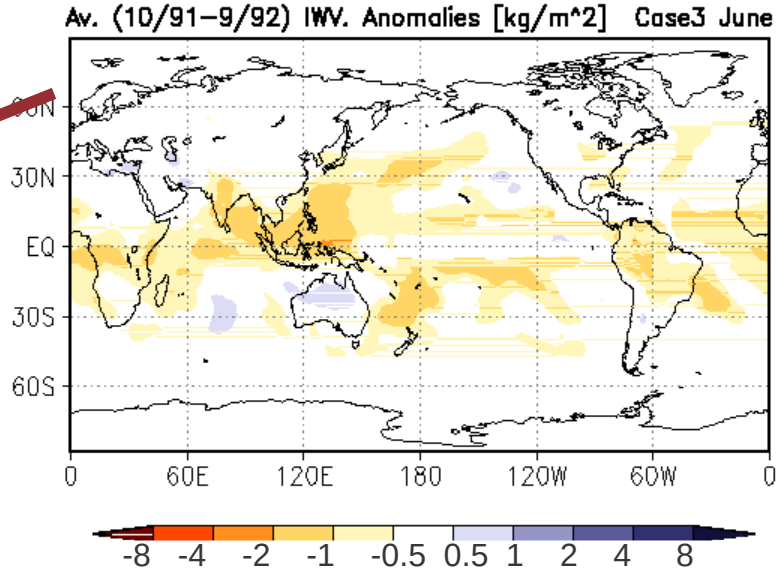


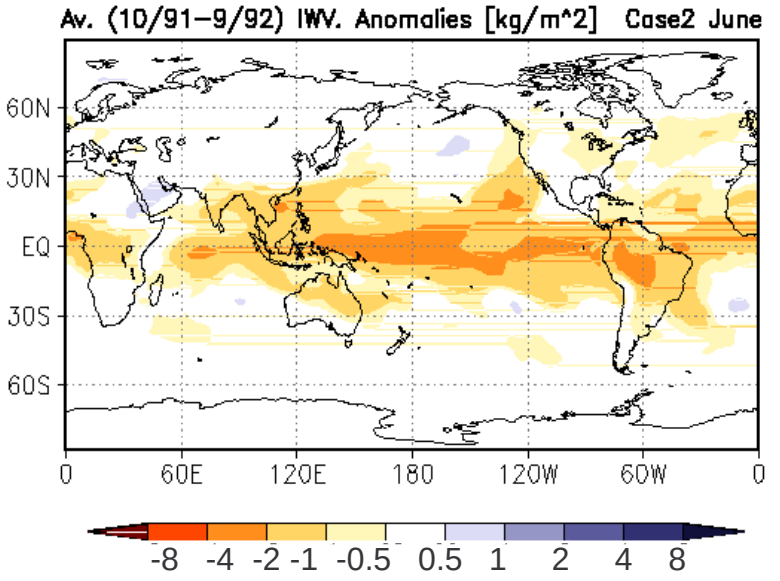




Annual mean (Oct.91/ Sep. 92) of integrated water vapor anomalies

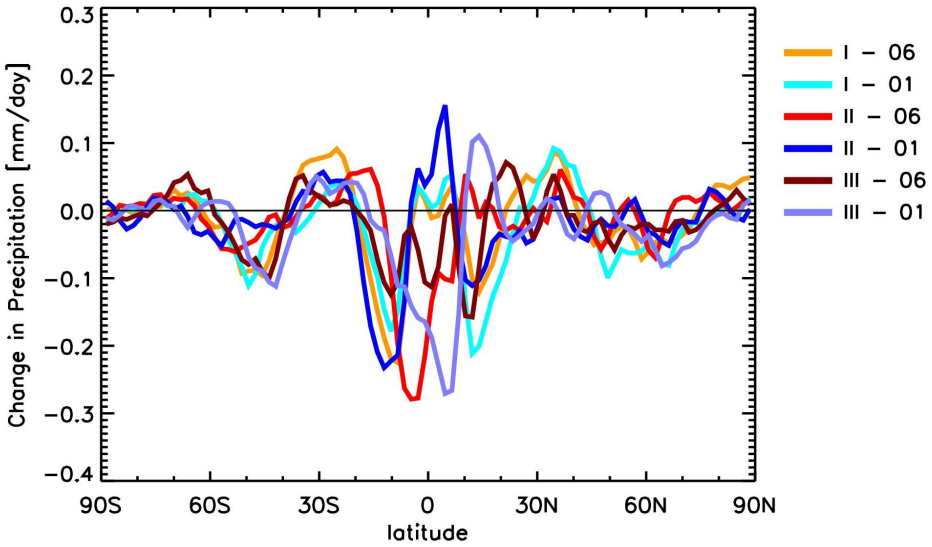




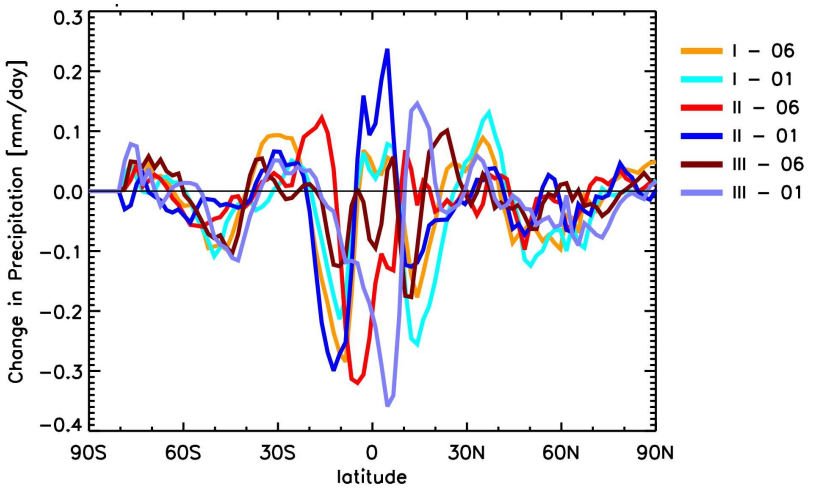


Precipitation Anomalies [mm/day]

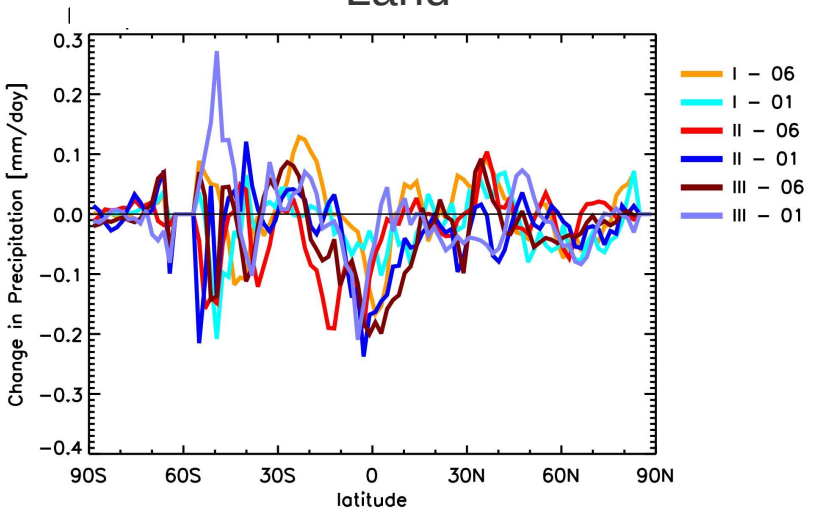
Global



Ocean

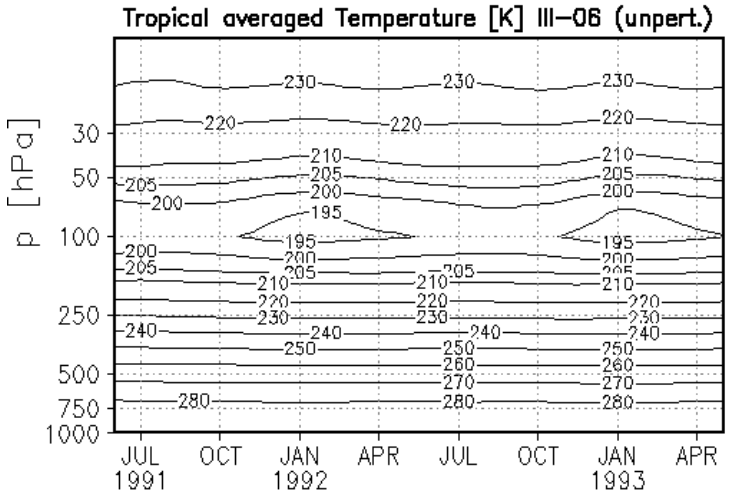


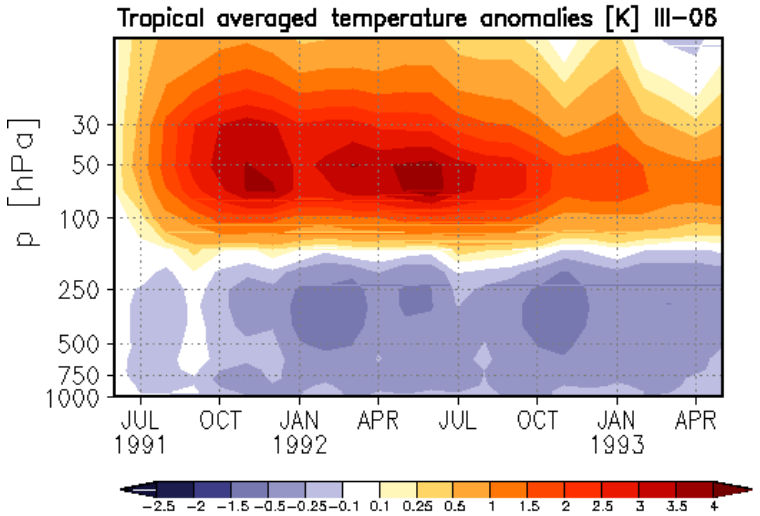
Land



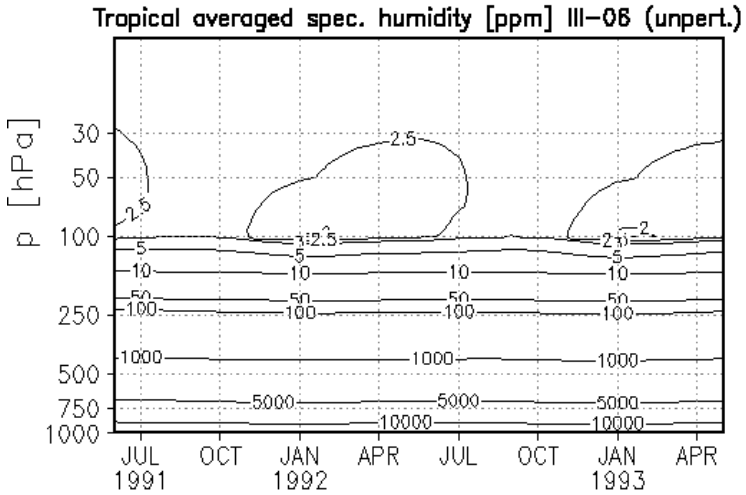
Tropical Anomalies (30N-30S)

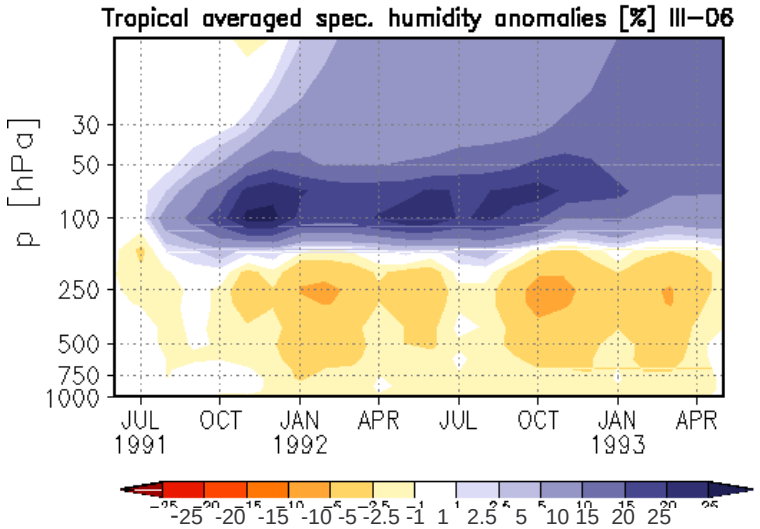
Temperature anomalies [K]





Specific humidity anomalies [%]

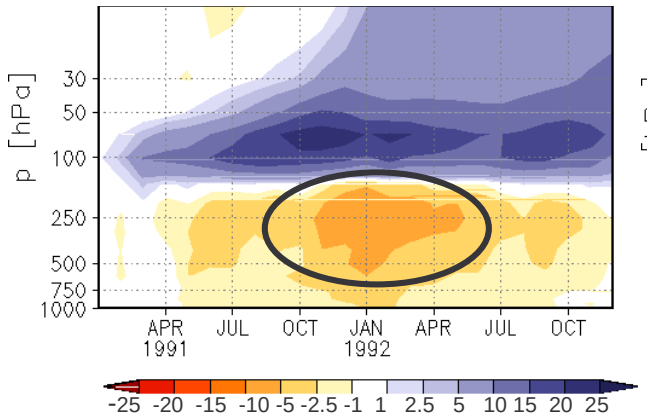




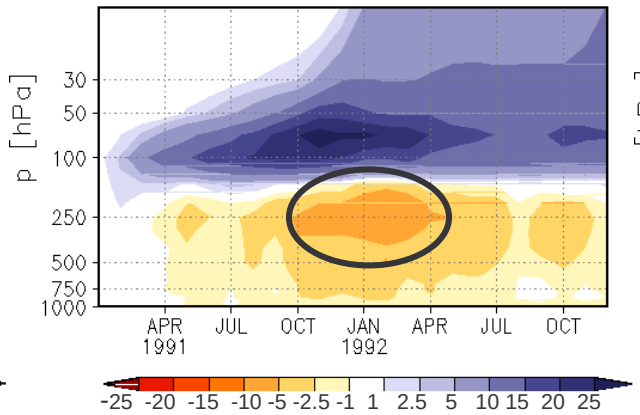
January cases

Tropical av. specific humidity anomalies [%]

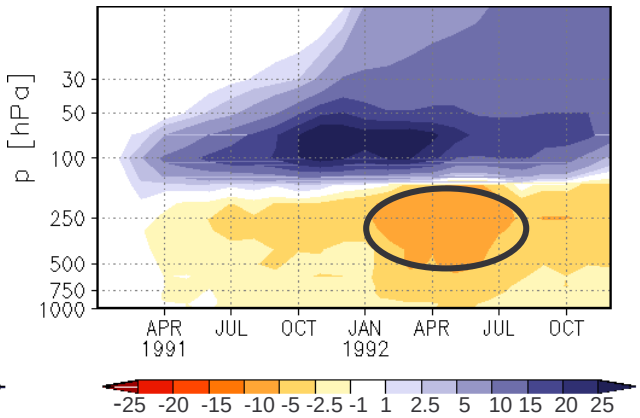
Case I January



Case II January

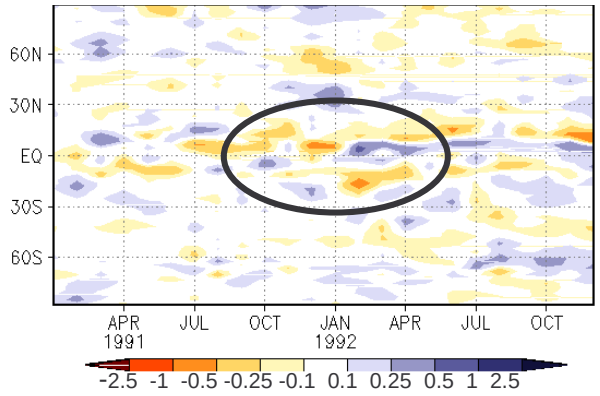


Case III January

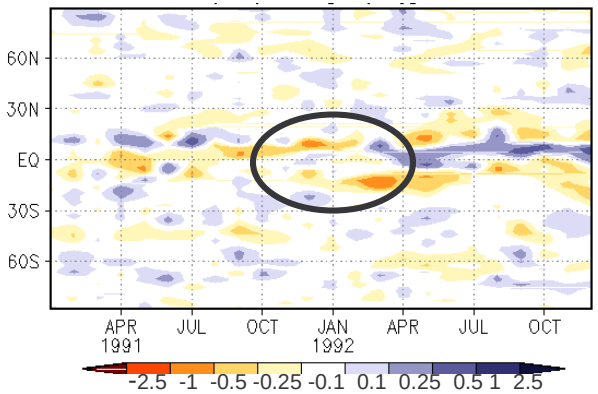


Convective precipitation anomalies [mm/day]

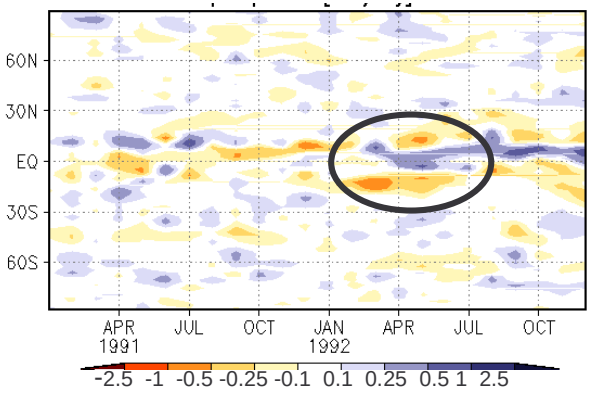
Case I January



Case II January



Case III January



Summary

- Global surface temperature anomalies are around 0.3 K
- Significant reduction in integrated water vapour in particular over the warm pool region.
- No clear picture in cloud cover anomalies although individual cases show significant changes.
- Clear reduction in precipitation over the ocean, over land the precipitation anomalies are more variable, changes result from changes in convective precipitation, shift of the ITCZ
- Initial ocean state is important for volcanic induced changes in the hydrological cycle
- Changes in the vertical water vapour distribution are related to the vertical temperature profile and modulated by aerosol induced changes in convective precipitation

Future activities

- **For volcanic simulations:**

  Simulation of large volcanic eruption with an Earth System model including interactive aerosol microphysics and chemistry (high top model) see poster 99

- **For geoengineeering implications:**

  Upcoming FP7 project IMPLICC (start approx. January 2009 → Ensemble of ESM experiments under climate change conditions