International Max Planck Research School on
EARTH SYSTEM MODELLING

# Decadal Variability: Internal Variability and Sensitivity to Subtropics

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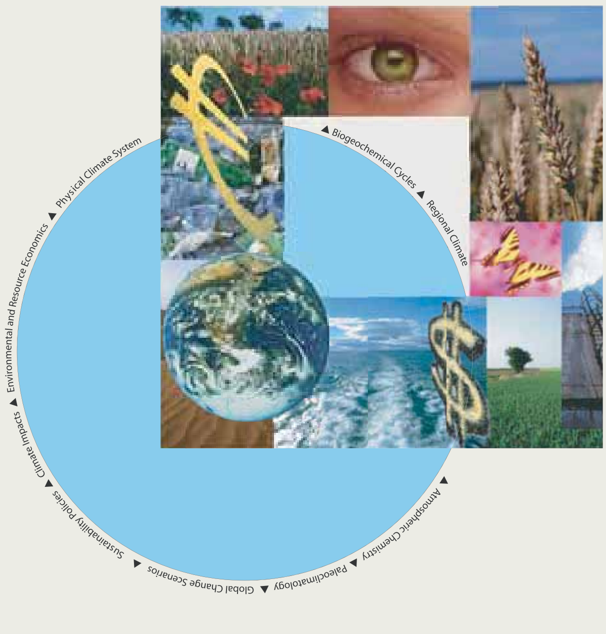

# Abstract

Additional to the interannual variability, the Pacific region experiences climate fluctuations on decadal and longer time scales. It is not clear whether Tropical Pacific decadal variability is internal to Tropical Pacific, or whether the midlatitudes exhibit independent decadal variability that affects the tropics or ENSO variability. Available observational data are insufficient to determine the true causes of Tropical Pacific decadal variability. Internal and remote forcing from subtropics are investigated in this study. This is done with state of the art global circulation models (coupled and uncoupled).

The leading mode of Tropical Pacific decadal variability in the ECHAM5-MPIOM model, isolated in the tropical cells (TC) index by means of SSA, has a period of about 17 years. The associated SST spatial structure is characterized by a horseshoe-like pattern with maximum explained variance in the central-western equatorial Pacific and off the equator, therefore resembling the signature of the observed decadal climate variability in the tropical Pacific. The mechanism for decadal variability in the model involves coupled ocean-atmosphere processes over the western tropical South Pacific, in the region of the SPCZ. Strong positive TCs are associated with periods of increased ENSO variability and vice versa, contributing to the decadal modulation of ENSO activity.

The influence of the remote subtropical forcing was studied in more detail with tailored experiments performed with the ocean-atmosphere-sea ice coupled model ECHAM5/MPI-OM. In these sensitivity experiments, the coupled model is forced with idealized sea surface temperature anomalies (SSTA) and sea surface salinity anomalies (SSSA) in the subtropics of both hemispheres. Thus, the relative impact of the subtropical North and South Pacific Oceans on the tropical climate mean state and variability can be estimated.

The largest impact on tropical mean climate and variability was simulated in the SSTA experiments. Subtropical South Pacific thermal forcing had more impact on equatorial ocean sea surface temperature than the subtropical North Pacific. In response to a 2°C warming in the subtropical South Pacific, the equatorial Pacific SST increases by +0.58°C, being about 65% larger than the change in the North Pacific experiment. The results show that the subtropics affect equatorial SST mainly through the „atmospheric bridge“ for the South Pacific experiments and through the„oceanic bridge“ for the North Pacific experiments. This explains the different timescale of the response in the two experiments. Although the tropical

Pacific surface response to an enhanced warming/cooling in the subtropics is to first order linear, we found that the negative thermal forcing has a stronger impact on the equatorial thermocline.

Similar sensitivity experiments conducted with the AGCM ECHAM5 showed that both air-sea interactions and ocean dynamics are crucial for the generation of simulated tropical climate response to the subtropical surface warming/cooling.

We found that the statistics of ENSO exhibit significant changes in amplitude and frequency in response to a warming/cooling in the subtropical South Pacific: a 2°C subtropical South Pacific SST warming can reduce the mean ENSO standard deviation by 28%, while a 2°C subtropical South Pacific SST cooling can increase the mean ENSO standard deviation by 21%. The simulated changes in the equatorial zonal SST contrast between the eastern equatorial Pacific and the warm pool region are the main contributor to the modulation of ENSO variability in our South Pacific sensitivity experiments. The simulated intensification/weakening of the annual cycle in response to an enhanced warming/cooling in subtropical South Pacific may also lead to a weaker/stronger ENSO. The subtropical North Pacific thermal forcing did not change the statistical properties of ENSO.

The main results of this study suggest that subtropical South Pacific climate variations play a dominant role in tropical Pacific decadal variability and in the decadal modulation of ENSO activity.