Final Report for Project **1246**

Project title: **ROMIC II – Joint project: The Quasi-Biennial Oscillation in a Changing Climate (QUBICC)**

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The project aims to understand how the quasi-biennial oscillation modulates tropical deep organised convection. This may happen through different mechanisms: (i) horizontal wind and its vertical shear; (ii) adiabatic temperature changes in the upper troposphere / lower stratosphere; (iii) diabatic temperature changes; or possibly (iv) a combination of (i) to (iii). While the mechanisms (i) to (iii) cannot be separated in realistic experiments, this is possible in idealized experiments. Specifically we use an aqua-planet setup in ICON-A with further modifications as necessary for testing each of the mechanisms.

Results

The experimental design is focused on tropical conditions. The lower boundary conditions of the aqua-planet were modified to these conditions by scaling the sea surface temperature (SST). This allows an aqua planet simulation with SST and meridional SST gradients adapted to the tropics which are reflected in a weak meridional SST gradient of less than 0.5 K between equator and the poles. The first experiments of the first computational phase had to be repeated because a change of the icon version was necessary for working on the Levante computer.

The control run shows an aggregation of convection in a zonal band around the equator at about day 50, assuming that convection is relatively balanced around the equator at this time. This demonstrates a distinct difference to the previous experiments performed with an older icon version. In order to verify the influence of the QBO-associated wind on the aggregation, the experiments for mechanism (i) were repeated with a weak and a strong wind shear (Fig. 1). Additionally, a first experiment for mechanism (ii) of the meridional wind nudging scheme, was initiated on day 50 as well, with a convergence in the upper stratosphere (Fig.1). This second implemented nudging scheme based on the assumption that the introduced divergence or convergence initiates a secondary circulation that changes the temperature profile in the lower stratosphere / upper troposphere. The onset of aggregation starts during day 74 of the control simulation, whereas the aggregation in the weak and strong u-wind nudging experiments is

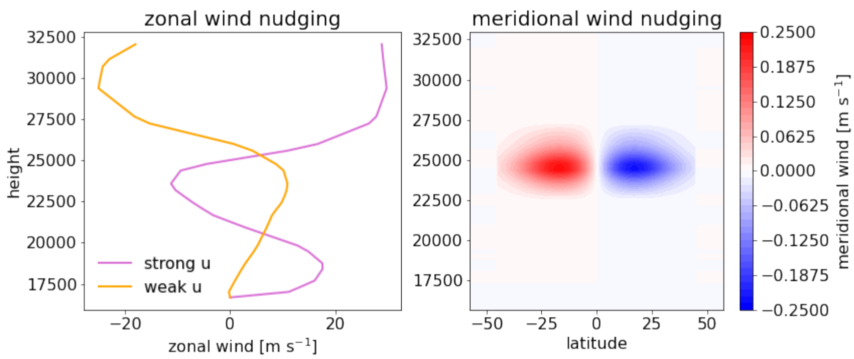

Figure 1: (left) Idealised vertical wind profiles for the zonal wind component in the nudging region and (right) idealised meridional wind distribution.

delayed by approximately one day (Fig.2). In order to gain more insight into the starting phase of the aggregation, mean profiles are determined considering only grid points with exceeding cloud water and cloud ice content of 0.1 g/kg, assuming that these grid points are inside the convective area.

The analysis of the region of the incipient aggregation process demonstrates that the depth of the simulated convection seems not deep enough, showing highest altitude reach 13.5 km. Although the nudged region starts roughly 4 km on top, there are changes in the mean state. Mean vertical profiles of the temperature for grid points above the selected threshold for cloud water and cloud ice, demonstrate stronger changes in mean temperature for weak zonal wind experiments (Fig.3). The cloud water and cloud ice content are also increased (not shown) in the mean vertical profiles of the weak zonal wind experiments, which hints to stronger vertical velocities in weak wind experiments. Thus the zonal wind nudging experiments show that the condition of the stratosphere has an impact on the aggregation of convection although not as strong as expected. One reason could be the thermodynamic state in the tropopause region. Mean temperature profiles of the entire nudging region indicate a strong decrease in the tropopause height and an increase in the thickness of the tropopause. The experiments for meridional wind nudging started at the beginning of last year. This meridional QBO nudging scheme was developed on the basis of a simplified functional Ansatz. Unfortunately, the project suffered due to the change of model version and the end of the project by the employee, so that the experiments could not be fully completed.

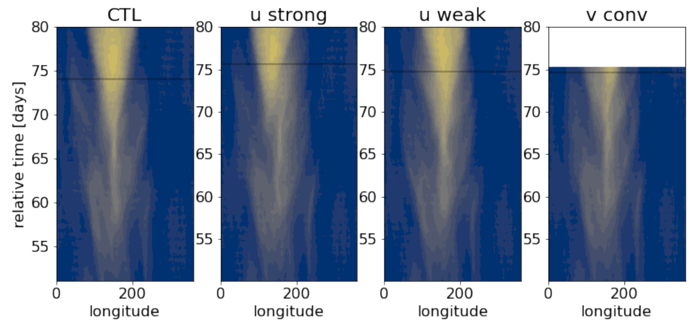

Figure 2: Hovmöller diagram of the meridional mean of the vertically integrated water vapour between 40°S-40°N.

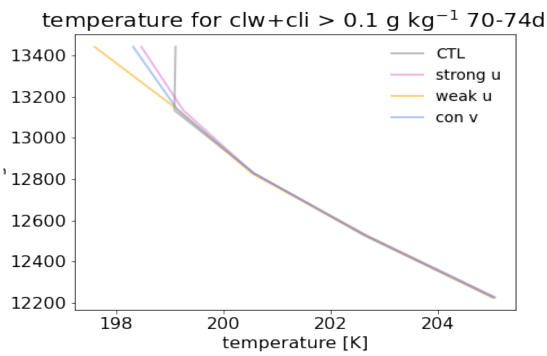

Figure 3: Mean temperature profiles for the aggregation region.

In summary, it was shown that the zonal wind of the QBO has an influence, albeit only a small one, which did not lead to a publication. Still the idealized experiments developed here are expected to be useful in future works on mechanisms of the influence of the QBO on tropical convection.

The transition required a change of the code. In order to be consistent, the first experiments were repeated. While in principle the experiments behave similarly, this also showed that the underlying aggregation process is sensitive to the details in the physics, as introduced with the changed model code. For instance, the time scale of the aggregation was increased from 30 days in the older version to 50 days in the newer version.