Project: **966**

Project title: **DynVar**

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Report period: **2017-01-01 to 2017-12-31**

Text: maximum of two pages incuding figures.

Resources have been used so far to evaluate the atmospheric momentum balance of the ICON model at ~40 km horizontal resolution and with 95 vertical levels, for the DRY MODEL configuration and the AQUA PLANET configuration. The experiments have been performed using the mh0925 and mh1010 resources, while the current project provided the storage resources. As in last year case, this is useful preparatory work previous to the CMIP6 analysis, not yet performed because the CMIP6 simulations are still in preparation.

ICON is the icosahedral non-hydrostatic atmosphere model, which we run experimentally at ~40 km of horizontal resolution. This is the first time that the stratospheric and mesospheric momentum balance is evaluated in ICON. An important result is that the momentum balance diagnostic is able to detect an imbalance in the mesosphere of ICON, in the AQUA PLANET configuration, related to a numerical mode we had previously discovered. The problem with ICON is that a numerical mode is present in the vertical velocity in the stratosphere and mesosphere, unless the time step is reduced significantly. The mode presents itself as a vertical standing wave in the vertical velocity, above convection. It is also affected by the intensity and intermittency of the convection (possibly). The fact that there is a vertical wave pattern in the mean vertical velocity suggests that there is a spurious (numerical instead of physical) source / sink of atmospheric momentum.

Figure 1 shows the atmospheric momentum balance at 0.1 hPa for the ICON-DRY model, for the tropics (area average 30S-30N). Figure 1 demonstrates that in this model there is a very good balance between the large scale meridional and vertical advection (blue curves), and the eddy induced zonal force per unit mass (green curves). The panel at right show the residual, clearly oscillating around zero. This indicates that there is some transience at the 30-day time scales, while the long time mean of the residual is very close to zero. Hence, there are no spurious sources / sinks of momentum in the model. Figure 2 demonstrates that this is not the case for the AQUA PLANET, given that a mean imbalance of ~1.9 m/s/d is detected. This is consistent with visual inspection of the mean vertical velocity. The ICON-DRY model has suppressed moist processes, its circulation forced by imposed mean heating rates in the troposphere, and it uses a time step of 40 sec, instead of the commonly used time step of 180 sec, given its horizontal and vertical resolution. As expected, the reduction of the time step has been successful in removing the (so far unexplained) spurious source / sink of momentum. The ICON AQUA PLANET model is run with the usual suits of moist convection and cloud parameterization, and also uses a time step of 40 sec. In this case, although the spurious mode is substantially reduced as well (in comparison with runs with a longer time step), a small impact is still noticeable in the mesosphere. Note that instead the atmospheric momentum balance is physically closed for both models in the stratosphere (not shown), pointing out to the localization of the bias to the mesosphere. Of interest for the CMIP6 exercise, is that the proposed method is well suited for diagnosing unphysical behaviour in a compact way.

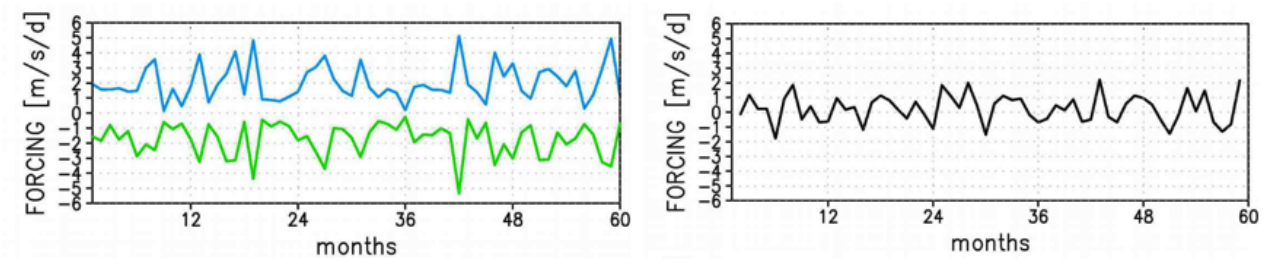

Figure 1. DynVarMIP diagnostics for 60 month of ICON-DRY model at 0.1 hPa (lower mesosphere). Shown are 30-day averages over 30°S-30°N of (left) the tendencies (m/s/d) due to meridional and vertical TEM advection (blue) and resolved waves (Eliassen-Palm divergence (green); (right) the residual (black, m/s/d).

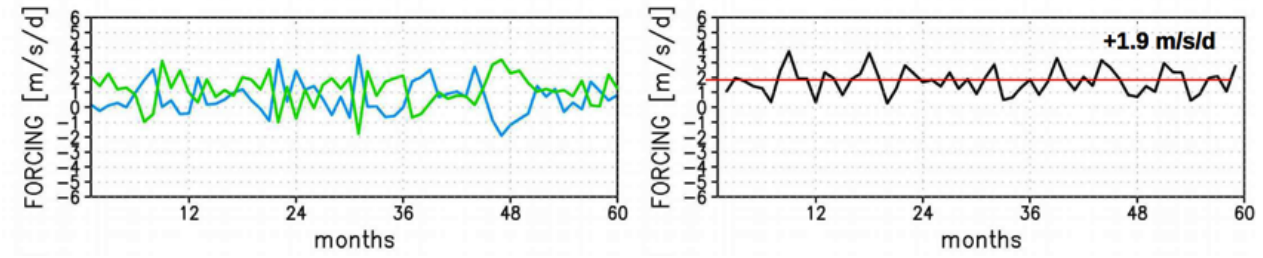

Figure 2. DynVarMIP diagnostics for 60 month of ICON AQUA PLANET model at 0.1 hPa (lower mesosphere). Shown are 30-day averages over 30°S-30°N of (left) the tendencies (m/s/d) due to meridional and vertical TEM advection (blue) and resolved waves (Eliassen-Palm divergence (green); (right) the residual (black, m/s/d).