Project: **1097**

Project title: **Multiscale Dynamics of Atmospheric Gravity Waves**

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The goal of the project is to improve the representation of sub-grid scale gravity wave (GW) effects on the resolved flow in atmospheric models in a large altitude range from the troposphere to the lower thermosphere (~ 110km). Our ongoing efforts are focusing on 1) the implementation of a transient GW propagation model (MS-GWaM: Multi Scale Gravity Wave Model), which describes direct GW-mean-flow interactions without the steady-state approximation, in a high-top global model (UA-ICON) and 2) the implementation of a physically based scheme of convective GW sources and its coupling to MS-GWaM in UA-ICON, in addition to an existing, globally uniform non-orographic GW source. As a reference and a representative of GW parameterization schemes used in current operational models, a steady-state version of MS-GWaM (ST-MS-GWaM) has been implemented to UA-ICON as well, which shares the treatment of all possible components (wave sources and wave saturation scheme) with the transient MS-GWaM scheme but differs from it "only" in the treatment of propagation, i.e. excluding direct GW-mean-flow interactions and thus transience. Perpetual runs and simulations for 14 Decembers and Junes (1991-1998, 2010-2015) have been performed using each version of MS-GWaM, both of which are coupled to the convective and uniform sources. The results indicate that both MS-GWaM and ST-MS-GWaM produce circulations reasonably close to the observed climatology, e.g. to URAP data (see figure 1). The effect of transient propagation on the GW representation can be emphasized by diagnosing GW intermittency, i.e. the spatial and temporal variability of GW momentum fluxes. For GWs from the uniform and continuous non-orographic GW source, MS-GWaM produces more intermittent GW (pseudo-)momentum fluxes than ST-MS-GWaM (see figure 2), which is due to GW refraction and the corresponding transient changes of group velocity. On the other hand, in case of convective GWs, of which the source itself is highly intermittent, the transient propagation reduces the GW intermittency by spreading out in time the momentum fluxes emitted by the intermittent source, unless severe wave refraction occurs, e.g., near the polar night jet.

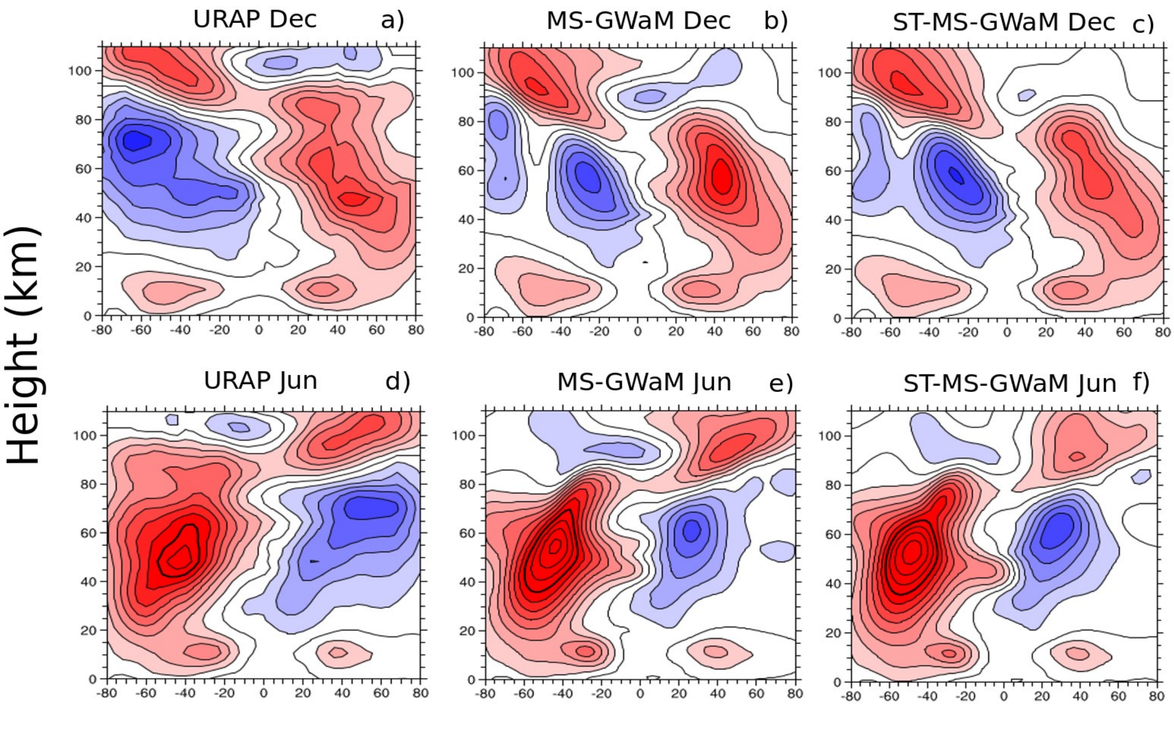

Figure 1: Latitude – height cross section of zonal mean zonal wind for December (a,b,c) and June (d,e,f) as observed within the URAP period 1992-1997 (a,d) and simulated by UA-ICON using MS-GWaM (b,e) and ST-MS-GWaM (c,f) within the period 1991-1998.

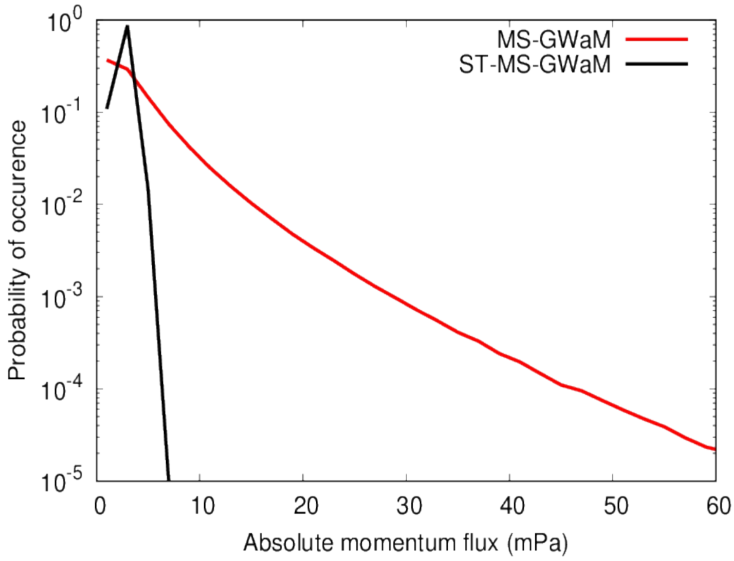

Figure 2: Probability of occurrence of (pseudo) momentum flux by GWs from the uniform source at mid-latitudes at 20 km height as parameterized by MS-GWaM (red line) and ST-MS-GWaM (black line) in UA-ICON simulations (period 1991-1998 December). Larger occurrence probabilities for large momentum flux values imply more intermittent GW fields.

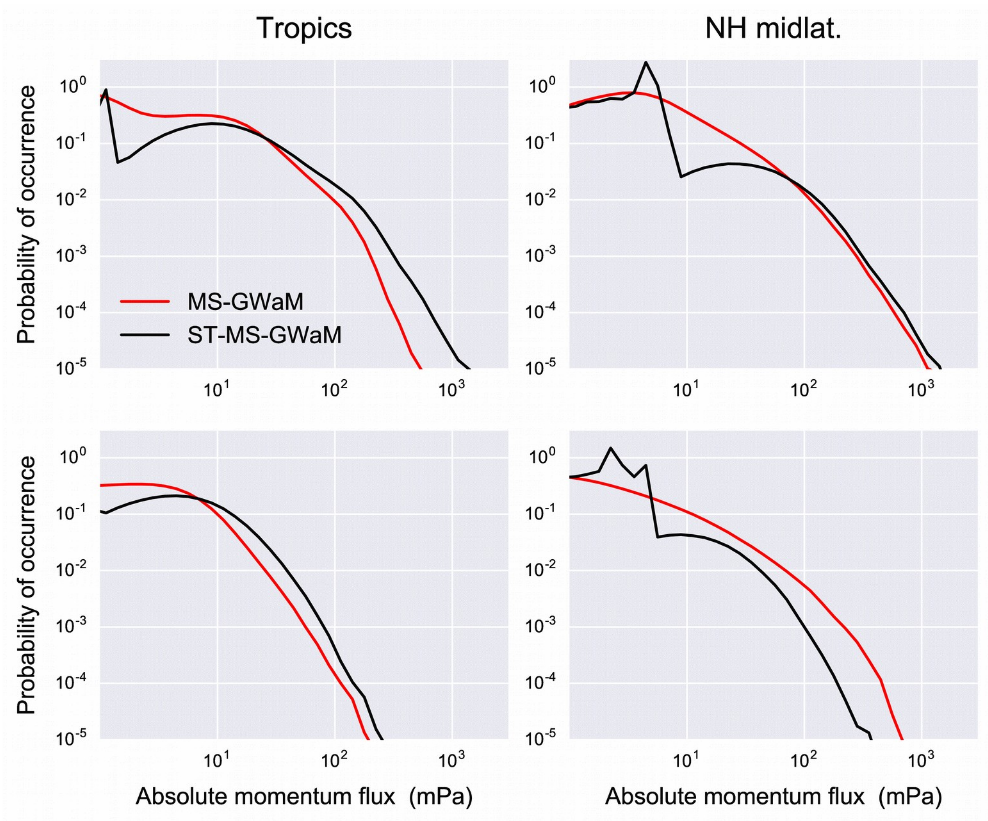

Figure 3: The same as in Fig. 2 except for the total GW field (from all sources) in the tropics (left) and northern mid-latitudes (right) at 20 km (upper) and 50 km (lower), as a function of base-10 logarithm of the flux.

As a result, the total GW field in the tropics (figure 3) is less intermittent in MS-GWaM than in ST-MS-GWaM owing to the dominance of convective GWs, whereas near the polar night jet in the upper stratosphere midlatitudes, it is more intermittent in MS-GWaM. Overall, the GW intermittency simulated by MS-GWaM is much closer to the observations than that by ST-MS-GWaM, reflecting an improvement of GW representation via the transient modeling of GWs. Two papers are in preparation to be submitted to the Journal of the Atmospheric Sciences very soon in order to summarize the implementation details and the impact of the above described developments.