Middle atmosphere sources of non-migrating tides, and non-linear interaction of tidal components.

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Summary

Based on simulations with the Middle and Upper Atmosphere Model (MUAM) the relative role of those sources of tides that are situated in the middle atmosphere is considered: non-linear interaction between stationary planetary waves and migrating tides, heating due to absorption of solar radiation by ozone distributed in longitude.

The vertical propagation of tides is controlled by the background wind. Due to interactions between the tidal components and the zonal mean wind, they are able to influence the background circulation as well. To investigate the generation of secondary tides due to non-linear interaction between the primary thermal tides and to estimate the contribution of the migrating tides into the formation of the zonally averaged circulation the heating parameterisation in the MUAM was modified to allow filtering of the thermal sources of different tidal components.

Middle and Upper Atmosphere Model

(MUAM, *Pogoreltsev et al., 2007*)

• 3D nonlinear mechanistic model of the atmospheric circulation extended from the 1000 hPa surface up to heights ionospheric F2-layer, based on the Cologne Model of the Middle Atmosphere-Leipzig Institute for Meteorology (COMMA-LIM, *Fröhlich et al., 2003*).

• Up to 60 levels in log-pressure heights z=x*7 km, where x=-ln(p/1000) with a step-size of about 0.4. In the present study a 48 level version of the MUAM is used (upper boundary is around 135 km). Horizontal resolution is 5°*5.625°(latitude/longitude) .

• Marchuk-Strang splitting of the initial Cauchy problem according to the physical processes and Matsuno time-integration scheme with a time steps of 450s have been used. The prognostic equation for geopotential height at the lower boundary has been used to simulate the global resonant properties of the atmosphere.

Middle atmosphere sources of non-migrating tides

When planetary waves are strong in the stratosphere (for instance, during sudden stratospheric warming events), the main middle atmosphere contribution to the generation of non-migrating tides is a non-linear interaction between primary migrating tides and the stationary planetary wave with zonal wave number m=1 (SPW1). Large-scale longitudinal ozone inhomogeneities lead to additional sources of non-migrating semidiurnal (m=1) and diurnal (m=2) tides (SDT1 and DT2).

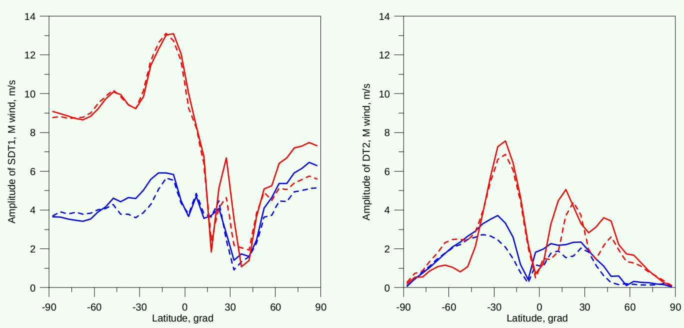

Fig. 1: Amplitudes of SDT1 and DT2 in meridional wind at 120 km during strong and weak SPW1 amplitudes in January (red and blue lines) with taking into account the 3d and 2d ozone field (solid and dashed lines) (*Suvorova and Pogoreltsev, 2010*)

• Fröhlich K. et al., 2003. Numerical simulation of tides, Rossby and Kelvin waves with the COMMA-LIM model // Adv. Space Res., V. 32, P. 863-868.

• Pogoreltsev A.I. et al., 2007. Planetary waves in coupling the lower and upper atmosphere. // J. Atmos. Solar-Terr. Phys., doi:10.1016/j.jastp.2007.05.014.

• Suvorova E., Pogoreltsev A. The simulation of non-migrating tides in the middle atmosphere // Geomagnetizm and Aeronomy, 2010, in press.

Non-linear interaction of tidal components

The *3 different Runs* were calculated with MUAM for March:

F0 run: without filtering of any harmonics in total heating (control run).

F1 run: with filtering of the 1st harmonic;

results: the amplitude of migrating diurnal tide (DT1) is negligible (Fig.2), and the amplitudes of DT2, TDT3, QDT4 are a bit smaller than in the F0 run. SDT2 has approximately the same amplitudes as in the F0 run.

F2 run: with filtering of the 2nd harmonic;

results: the amplitude of migrating semidiurnal tide (SDT2) is smaller (this tide is generated by self-interaction of DT1, Fig.3) and amplitudes of SDT4, SDT3, QDT4 are smaller.

Both DT1 and SDT2 tides generate circulation cells in the meridional and vertical winds from 40S to 40N that result from accelerations due to tidal dissipation. The filtering of thermal harmonics changes the zonally averaged temperature by about 1-4 K above 100 km, and the mean flow by up to 8 m/s above 60 km (Fig.4), and the circulation cells in the meridional and vertical wind components (Fig.5).

There are daily variations of accelerations due to disspation of gravity waves distributed through the tidal structure of wind. In the case of filtering of the thermal tidal sources these variations disappear (24h in the F1 run and 12h in the F2 run, not shown).

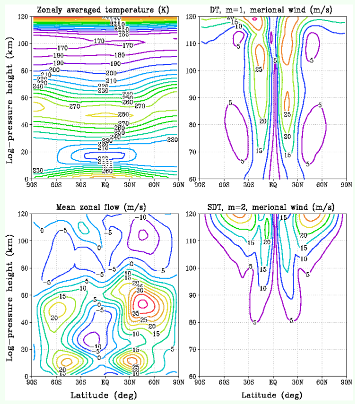

Fig. 2: Mean zonal flow and zonally averaged temperature, migrating diurnal (DT1) and semidiurnal (SDT2) tides in meridional wind (F0 run).

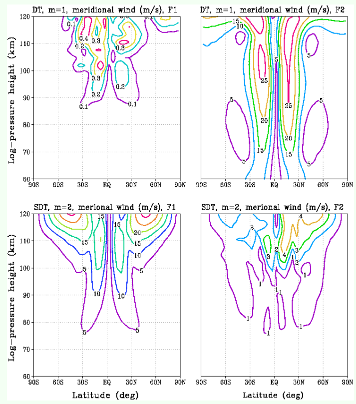

Fig. 3: Migrating diurnal (DT1) and semidiurnal (SDT2) tides in meridional wind (F1 and F2 runs).

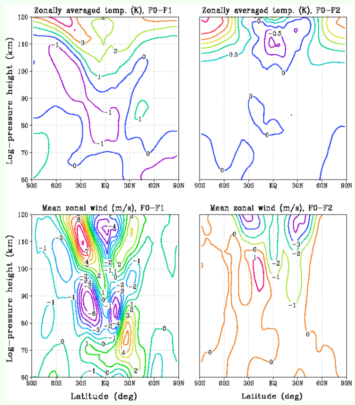

Fig. 4: Difference between runs (F0-F1 and F0-F2) for mean zonal flow and zonally averaged temperature.

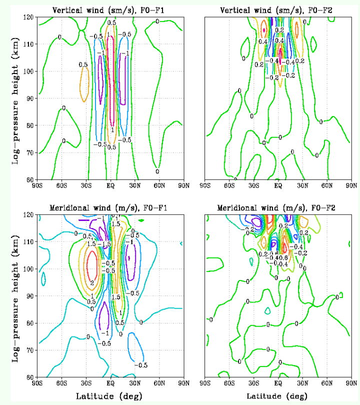

Fig. 5: Difference between runs (F0-F1 and F0-F2) for zonally averaged meridional and vertical wind components.

The simulations of the migrating and non-migrating tides with the MUAM show that the model is capable the observed tides in the MLT region as well as the large-scale features meridional circulation to reproduce.

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