Forcing of the middle atmosphere by thunderstorm activity

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(Times 10, Italic, centred)

The thunderstorm activity is one of the main mechanisms involved in the coupling between the troposphere and the middle atmosphere. Convective overshoots across the equatorial tropopause contribute to the transport and dehydration of air from the troposphere to the stratosphere. Gravity waves emitted at the top of convective clouds play an important role in the control of the general circulation up to the mesopause. Multi-technique observations preformed within the frame of the European project ARISE will help to better understand these phenomena and to improve their representation in numerical weather forecast models.

1. Role on troposphere to stratosphere transport

The thunderstorm activity plays an important role in the coupling between the troposphere and the middle atmosphere (stratosphere + mesosphere). Very high ascending winds are observed in the core of large convective clouds. Due to this strong vertical motion, the top of the clouds may reach altitudes higher than the tropopause and transport some air across the tropopause. This phenomenon, called overshooting, is one of the main mechanisms explaining the injection of air in the tropical lower stratosphere. Air is adiabatically cooled. In the ascending motion and temperatures lower than -85°C may be reached in equatorial convective regions. This cooling is associated with a strong dehydration, explaining the dryness of the stratosphere.

2. Gravity wave generation and forcing of the general circulation

Convective clouds are a source of gravity waves that can propagate up to the stratosphere and the mesosphere depending of the condition of their propagation (wind and temperature vertical profiles). The amplitude of these gravity waves increases with height due to the exponential decrease of atmospheric density until they reach a critical level, where the wind speed is equal to the phase speed, or a level of instability due to a too large amplitude, and break, transferring their momentum flux to the mean flow. The breaking of gravity waves is the main driver of the general circulation in the upper mesosphere. The land convection play also a role in the generation of thermal tides and in the diurnal cycle of temperature in the lower stratosphere [1]

3. Observations

Gravity waves are observed by different techniques, including ground-based lidars [2], radiosondes and satellite radio-occultation. A clear correlation is detected between the regions of deep convection and the energy of these waves in the middle atmosphere. These observations are essential to provide quantitative information for the parameterization of gravity waves in numerical weather forecast and climate models. These studies are made in the frame of the EU-FP7 Design Study project ARISE.

4. References

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[2] N. Mze N., A. Hauchecorne, P. Keckhut, Thetis M., Vertical distribution of gravity wave potential energy from long-term Rayleigh lidar data at a northern middle latitude site, J. Geophys. Res., 2014, in revision.