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Factors affecting atmospheric vertical motions as analyzed with a generalized omega equation and Open IFS model

Oleg Stepanyuk and Jouni Räisänen
University of Helsinki, Department of Physics, FI-00014, P.O. Box 48, Helsinki, Finland, oleg.stepanyuk@helsinki.fi

The ongoing greenhouse-gas induced climate change is generally expected to increase the intensity of heavy precipitation. In past decades, the relation between precipitation and vertical motion was shown in a few studies (Chen QS, et.al. 1997; Rose, Lin 2003; Van den Dool 1987). Main driving forces maintaining vertical motion are temperature and vorticity advection (adiabatic atmospheric dynamics) and diabatic heating, much of which is caused by condensation of water vapor. The distinction between these two factors is important, because condensation heating is both a consequence and cause of rising motion – in this sense vertical motion is maintaining itself, which makes the prediction of precipitation amounts more complex. Because of condensation heating, even relatively weak low pressure systems can be associated with heavy precipitation particularly in late summer, when the atmospheric moisture content is largest. In the future, warming of climate and the accompanying increase in water vapor is likely to make this type of synoptic situations more common.
Here we analyse the drivers of atmospheric vertical motion in different latitude zones, using a generalized omega equation (Räisänen 1995) that can separately diagnose the contributions of different physical processes to the vertical motion field. As the input data, we use a large data set obtained from atmospheric model simulations done with OpenIFS, a version of the Integrated Forecast System (IFS) used at ECMWF for operational weather forecasting that has been made available to academic and research institutions under license since early 2013.