**Parametrization of the atmospheric heating due to latent heat release.**

The assumption that non-migrating atmospheric tides can be caused by large-scale longitudinal inhomogeneities of the latent heat release diurnal variation due to water vapor condensation in clouds under deep convection in the troposphere was made by Lindzen (1978). This assumption obtained the support in Hamilton (1981), where the precipitation data were used and numerical simulations were made. Then a series of works on migrating and non-migrating tides due to latent heat release using the satellite and/or the re-analysis precipitation data was published (Forbes et al., 1997; Forbes and Zhang, 2001; Hagan and Forbes, 2002; Zhang et al., 2010a, 2010b). In the latter paper the comparison of the relative role of the solar heating and the latent heat release emitted as a result of water vapor condensation in production of atmospheric tides was conducted and it was shown that these contributions are comparable. Unfortunately, little concern is given to the generation of stationary planetary waves (SPW). That is why the problem of the development of semi-empirical model of the atmospheric heating due to latent heat release as a result of water vapor condensation that takes into account diurnal and longitudinal variations was stated.

Lower boundary conditions and latent heating have been calculated as averaged over **La Nina (1989, 1999, 2000, 2008, 2011)** and **El Nino (1983, 1992, 1998, 2003, 2010)** years separately.

Based on the modern-era retrospective analysis MERRA data (Rienecker et al., 2011) a new parametrization of atmospheric heating due to latent heat release as a result of water vapor condensation was developed. The prevailing source of humidity in the tropical and subtropical troposphere is convective precipitation. The more humid areas emerge in the same place as convective areas: over the western part of the Pacific Ocean, over South America and Africa, over south-east Asia.

Latent heat can be a source of diurnal and semi-diurnal variations that become most apparent at the heights between 80 and 150 km (Forbes et al., 1997; Forbes and Zhang, 2001; Hagan and Forbes, 2002; Zhang et al., 2010a, 2010b). Longitudinal variations of this heating can in turn lead to additional generation of SPW. And so far we have developed a climate model of atmosphere hating due to latent heat release that takes into account longitudinal variations. It is supposed to take into account diurnal variations of heating and to assess their role in generation of atmospheric tides in future. To estimate the latent convection heat of condensation the parametrization proposed in Forbes et al., (1997) was used. As the basis the MERRA fields of convection precipitation amount were taken and interpolated on the MUAM grid. The latent heat of condensation value is calculated using the empirical formula that was suggested in the paper by Hong and Wang (1980). This formula was obtained on the basis of the measurements represented in Reed and Recker (1971):

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where  - is the observed distribution of precipitation rate by latitude and longitude,  - is empirical formula of latent heat vertical distribution depending on precipitation rate near the ground:

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where  - is a constant which depends on precipitation amount.

The latent heat of condensation was calculated for all the latitudes and longitudes of the model taking into account diurnal variations. Then in order to make the local (or universal) time change accounting in MUAM possible, the distribution of heating was approximated for each latitude at a time by a set of five zonal harmonic waves. Then every zonal harmonic wave was approximated by stationary wave and time harmonics with periods T=24 and 12 hours with the separation of the received fluctuations into waves going to the west and to the east. As a result at any time the heating taking into account mean zonal values, longitudinal variations (stationary waves) and diurnal variations of latent heat of condensations was calculated in MUAM.

The heat sources of waves going to the west and east that were obtained on the basis of heating data in January for the years with distinct El Nino (1983, 1992, 1998, 2003, 2010) and La Nina (1989, 1999, 2000, 2008, 2011) were analyzed by themselves. The results are shown in Figures 1.1 – 1.7.

In the Figure 1.1 the latitude-altitude distribution of mean zonal values of heating due to latent heat release as a result of water vapor condensation is shown. Maximum values are observed in equatorial area of the Southern Hemisphere. But in years with distinct La Nina the maximal area of heating is significantly broader and spreads into the Northern Hemisphere. The additional heating in the equatorial area will lead to the increase of latitudinal temperature gradient in middle latitudes which causes the intensification of jet streams in the troposphere.

In the Figure 1.2 the amplitudes of mean zonal variations in heating with periods of 24 and 12 hours are shown. In those years when the La Nina was observed the heating area is broader due to the additional heating source shift into the Northern Hemisphere, but heating terms for El Nino in January are characterized by the more powerful heating in equatorial area. The same situation is observed when analyzing the tidal components of the heating with zonal wavenumber m=1 for (Fig. 1.3, the upper panels). It is noteworthy that now the heating sources for the waves going to the east have appeared (Fig. 1.3, the lower panels). They are certainly weaker than the sources for the westward propogating waves.. These additional heating sources are approximately identical in cases of both La Nina and El Nina and equal in area and in heating capacity even more than the sources of migrating semi-diurnal tide (the upper right panel). On considering the amplitudes of tidal variations with zonal wave number 2, 3 and 4 the mentioned above features are preserved (Figures 1.4-1.6).

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| |  |  | | --- | --- | |  |  | | Pic. 1.1 Mean zonal heating released due to water vapor condensation in the troposphere averaged per day. El Nino is in the left part, La Nina is in the right part. Distance between isolines is 0.2 K/day. | | |
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| Pic. 1.2 Amplitudes of the tidal components during heating due to condensation latent heat release. Zonal wave number m=0. The upper part stands for El Nino, the lower part stands for La Nina. Distance between isolines is 0.04 K/day. |

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| |  |  | | --- | --- | |  |  | | Pic. 1.3 The amplitudes of tidal components during heating due to condensation latent heat release. Zonal wave number m=1. The left part stands for El Nino, the right part stands for La Nina. Distance between isolines is 0.004 K/day for the periods T=24 h (to the west); 0.02 K/day for T=12 h (to the west), 24 and 12 hours (to the east). | | |

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| Pic. 1.4 The amplitudes of tidal components during heating due to condensation latent heat release. Zonal wave number m=2. The left part stands for El Nino, the right part stands for La Nina. Distance between isolines is 0.004 K/day for the periods T=24 h and 12 h (to the west); 0.02 K/day for T=24 h and 12 h (to the east). | |

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| Pic. 1.5 The amplitudes of tidal components during heating due to condensation latent heat release. Zonal wave number m=3. The left part stands for El Nino, the right part stands for La Nina. Distance between isolines is 0.02 K/day for the periods T=24 h and 12 h (to the west) and 12 h (to the east); 0.04 K/day for T=24 h (to the east). | |

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| Pic. 1.6 The amplitudes of tidal components during heating due to condensation latent heat release. Zonal wave number m=4. The left part stands for El Nino, the right part stands for La Nina. Distance between isolines is 0.02 K/day. | |

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| Pic. 1.7 The amplitudes of stationary planetary waves with wave numbers 1 and 2 during heating due to latent heat release as a result of water vapor condensation. The left part stands for El Nino, the right part stands for La Nina. Distance between isolines is 0.2 K/day. | |

Since the interaction of the waves and the mean flow taking place during the intensification of planetary waves within several days leads to polar vortex disturbance and can cause SSW it is necessary to analyze the influence of heating sources due to latent heat release on the generation of SPW1 - SPW4 (Fig. 1.7). The SPW3 and SPW4 during heating are comparable and very similar to each other in years with La Nina and El Nino. The considerable amplitudes of SPW2 during heating in years with La Nino stand out. The heating values for SPW2 in these years are considerably higher and broader in comparison with the SPW2 during heating in years with El Nino. SPW1 amplitudes during heating in years with La Nina are slightly lower, but the area of heating is broader than in years with El Nino.