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NUMERICAL MODELING OF QBO AND ENSO PHASE IMPACT ON THE EVOLVEMENT OF SUDDEN STRATOSPHERIC WARMING AND WAVES PROCESSES

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Overview:

- QBO phases: easterly QBO and westerly QBO.
- ENSO phases: El Niño and La Niña.
- atmospheric waves are periodic variations in hydrodynamic values.
- Zonal wavenumber (m) is one of the main wave parameter (an integer number of waves fitting along the latitude circle).
- Planetary waves propagate from their sources in the troposphere, transfer energy and momentum, form specific types of atmospheric circulation (for example, sudden stratospheric warming SSW), and transfer a signal from the quasi-biennial oscillation (QBO) and the El Niño Southern Oscillation (ENSO).

Purposes and tasks:

- to investigate the influence of various QBO and ENSO phases on wave processes of the winter stratosphere and the SSW evolution;
- to carry out a number of numerical experiments with the Middle and Upper Atmosphere Model (MUAM);
- to estimate the sensitivity of the zonal wind, temperature and geopotential fields with regard to a certain QBO and ENSO phases in the model.

The Middle and Upper Atmosphere Model (MUAM):

- is based on the standard system of primitive equations in a spherical coordinates.
- Radiation unit takes into account the atmosphere warming in the ultraviolet and visible regions of the spectrum, as well as cooling in the infrared radiation bands.
- Ion drag, molecular viscosity, thermal conductivity, turbulent diffusion and three-dimensional distribution of ozone are taken on.
- The main parameters calculated by the model are zonal, meridional, and vertical wind components, geopotential, and temperature.
- The horizontal grid is 36x64 grid-steps in latitude and longitude, respectively. Vertical grid – log-isobaric vertical coordinate, 56 nodes from the surface to 300-400 km. The time step is 2 hours.
- Weather changes and clouds in the troposphere are not modeled.

QBO and ENSO in MUAM

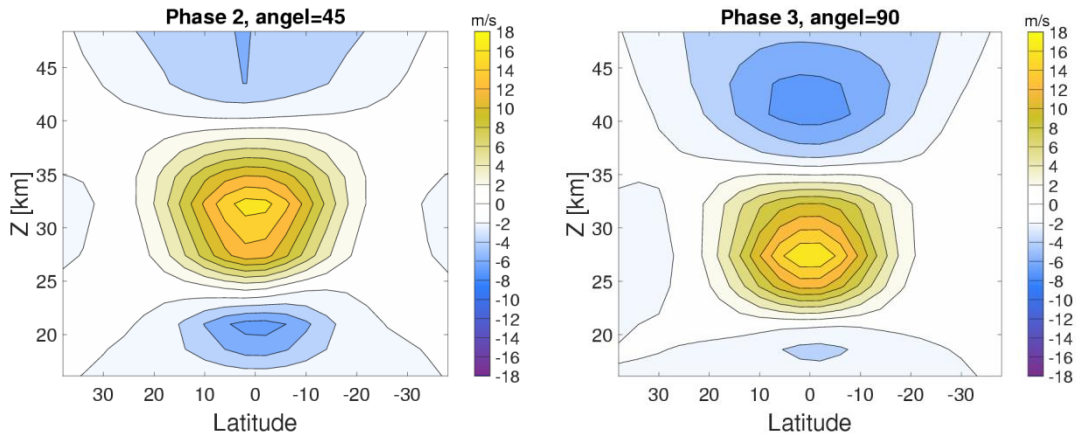


Figure 1. Zonally averaged zonal wind structures – 2 and 3 QBO phases (westerly QBO).

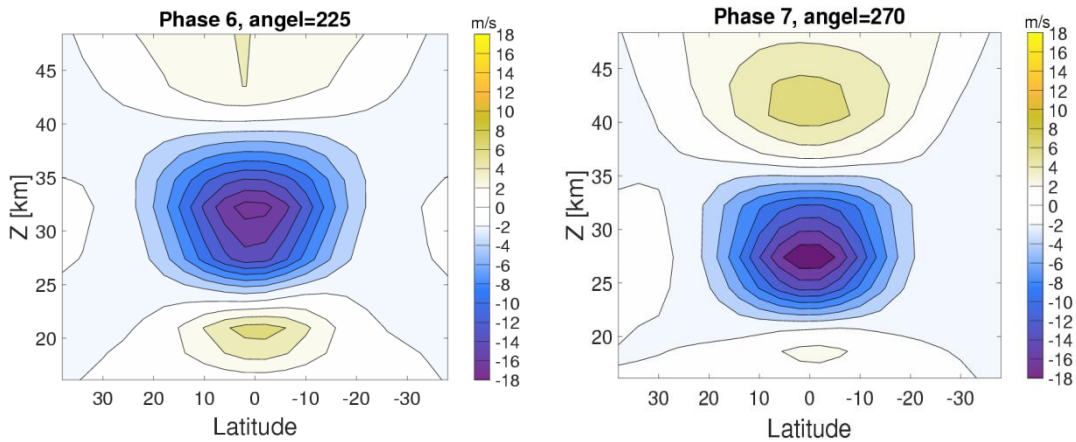


Figure 2. Zonally averaged zonal wind structures – 6 and 7 QBO phases (easterly QBO).

January	QBO phase, westerly	January	QBO phase, easterly
1983	3	1987	7
1985	2	1989	6
1993	3	1996	6
1995	3	1998	6
1997	2	2000	6
1999	2	2003	6
2002	2	2005	6
2004	2	2007	6
2008	2	2010	7
2013	2	2012	7

Table 1. Years with westerly and easterly phase of the QBO.

	Years (January)
El Niño	1983, 1992, 1998, 2003, 2010
La Niña	1989, 1999, 2000, 2008, 2011

Table 2. Years with El Niño and La Niña conditions.

Ensembles of solutions (10 runs each)

El Niño and easterly QBO

El Niño and westerly QBO

La Niña and easterly QBO

La Niña and westerly QBO

Simulated SSW

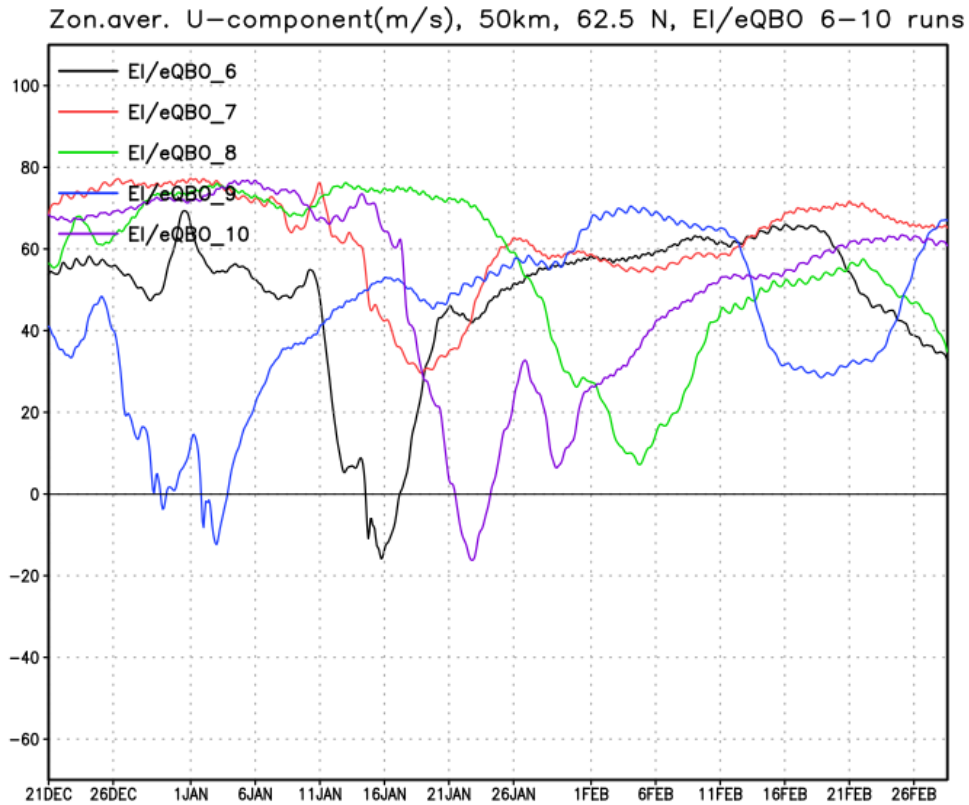


Figure 3.

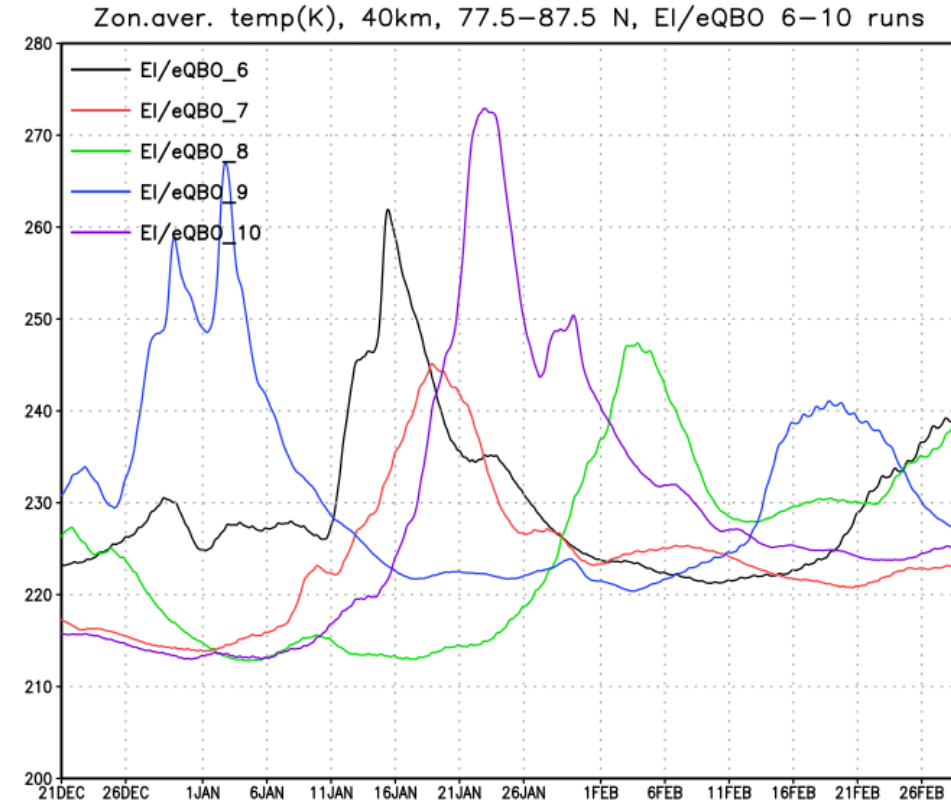


Figure 4.

Simulated zonal wind and temperature (La Niña and westerly QBO conditions)

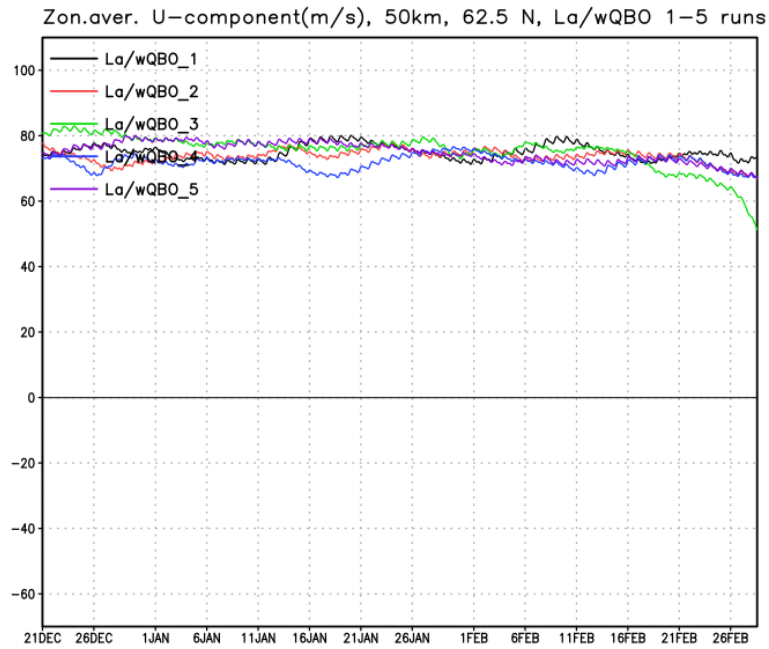


Figure 5.

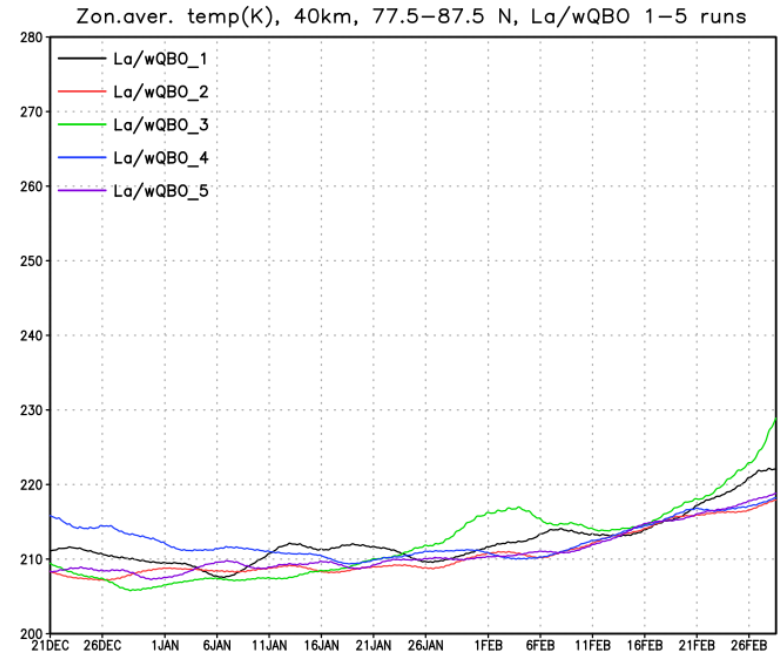


Figure 6.

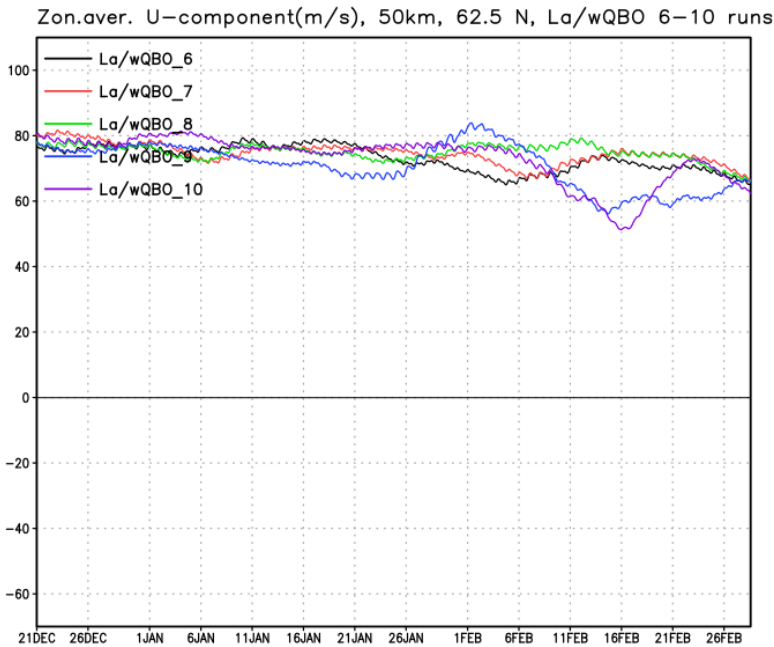


Figure 7.

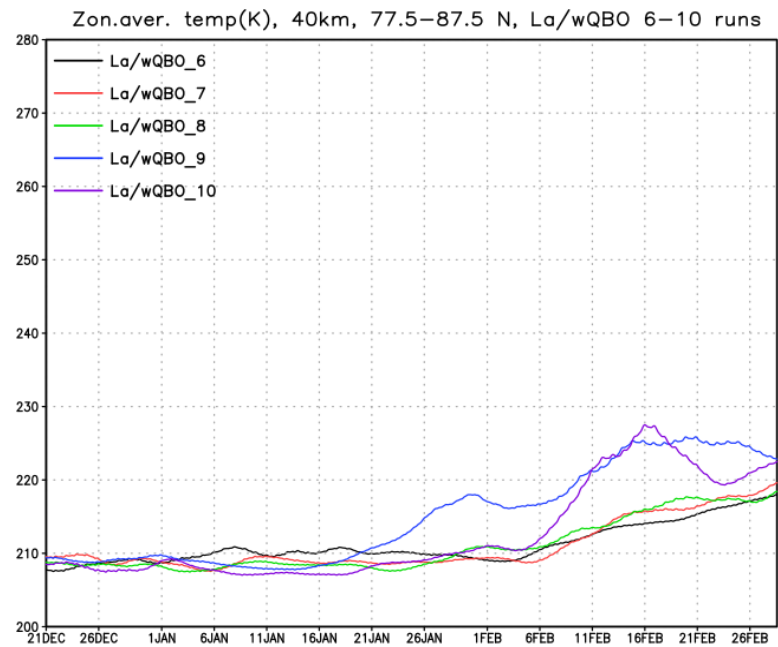


Figure 8.

Time intervals for averaging hydrometeorological fields over six runs in each ensemble

Table 3. El Niño and easterly QBO

Run No	Days during the SSW
1	January 5-14
3	January 14-23
6	January 12-21
7	January 12-21
8	January 29-February 7
9	December 27-January 5

Table 4. El Niño and westerly QBO

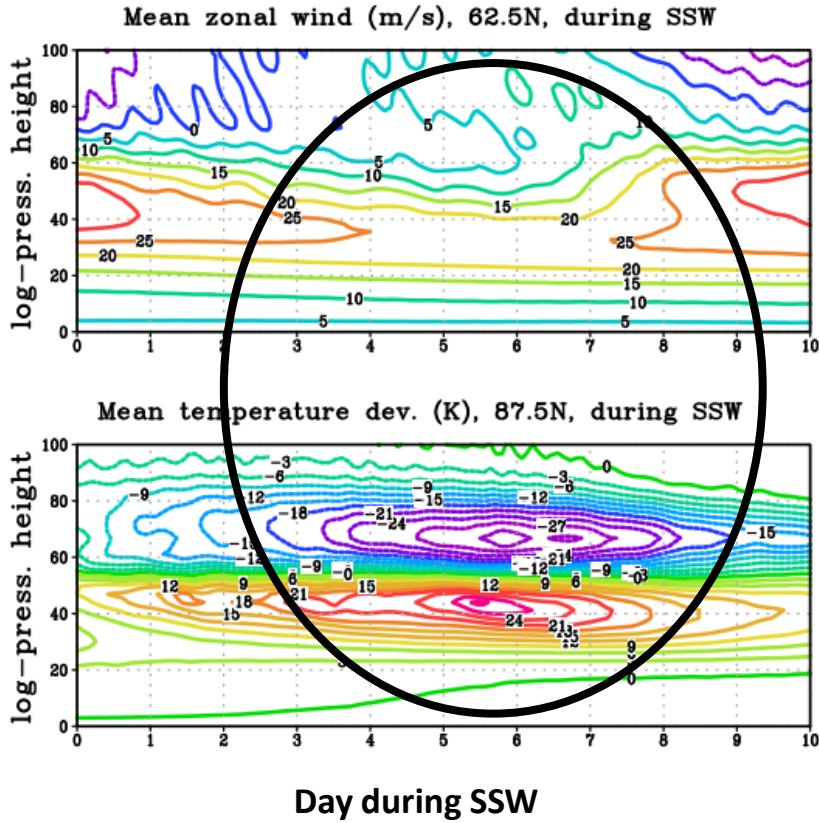
Run No	Days during the SSW
2	January 31-February 9
5	January 21-30
6	February 16-25
7	February 16-25
8	February 2-11
9	February 8-17

Table 5. La Niña and easterly QBO

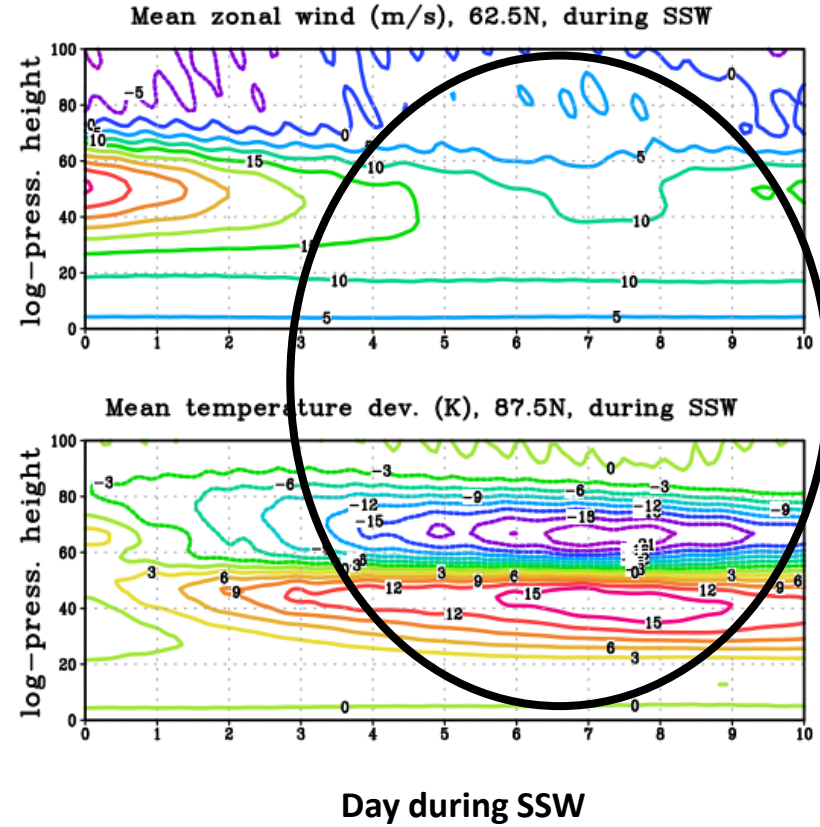
Run No	Days during the SSW
1	January 28-February 6
4	January 5-14
5	January 23-February 1
5	February 7-16
6	February 6-15
9	February 11-20

Simulated mean climatic SSW

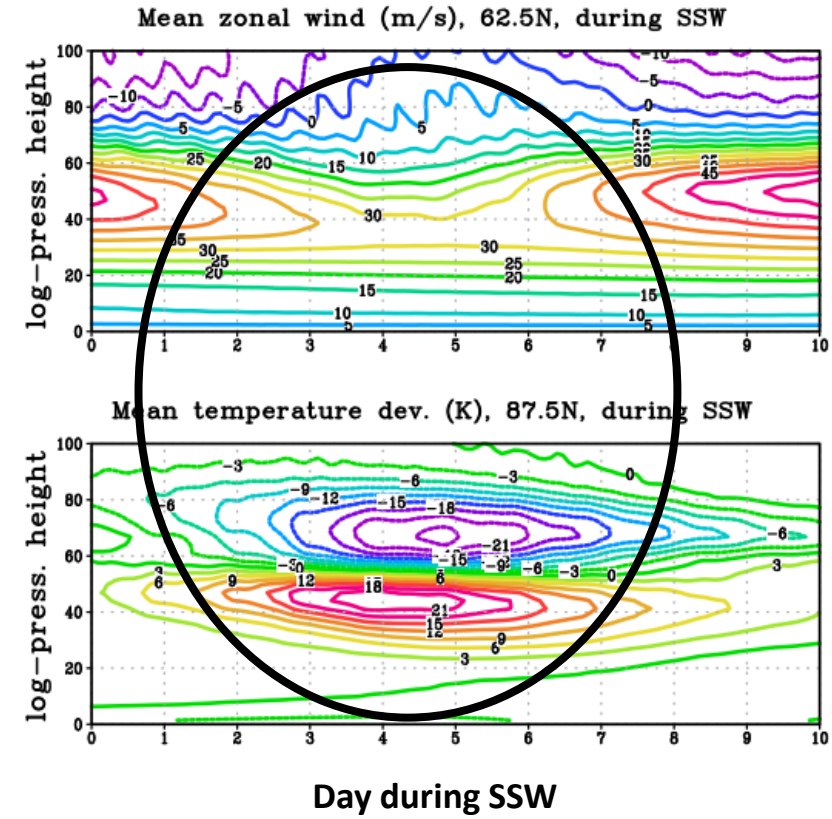
El Niño/easterly QBO



El Niño/westerly QBO

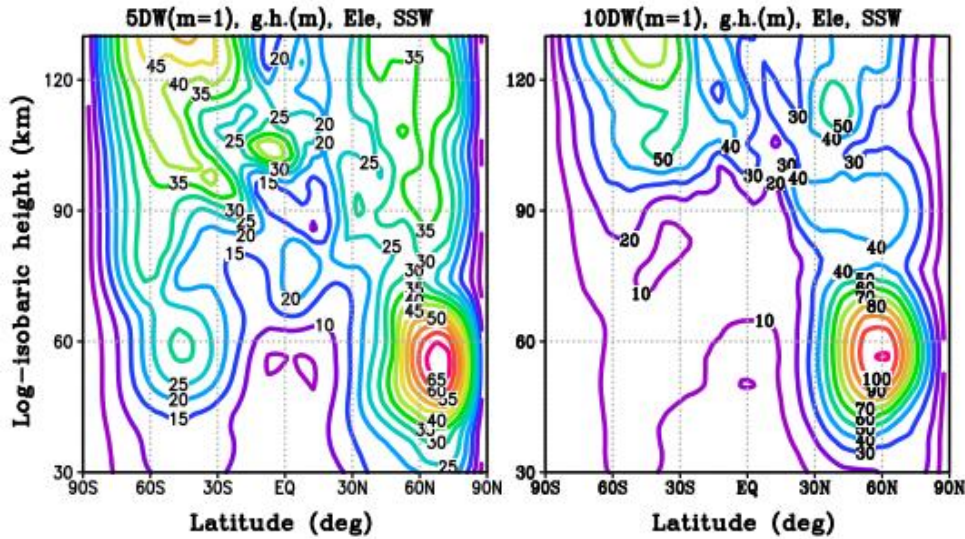


La Niña/easterly QBO

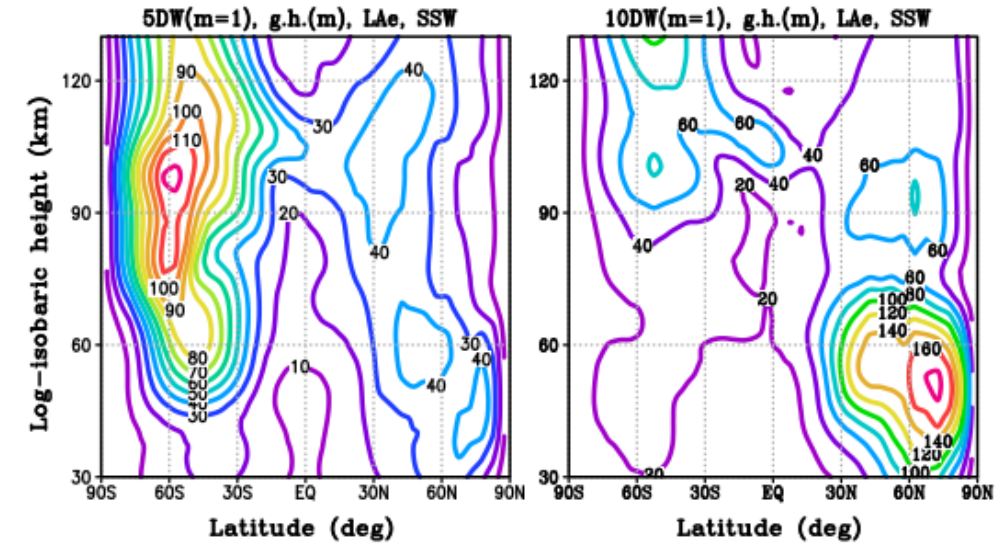


Simulated amplitudes of planetary waves with $m=1$, periods 5 and 10 days

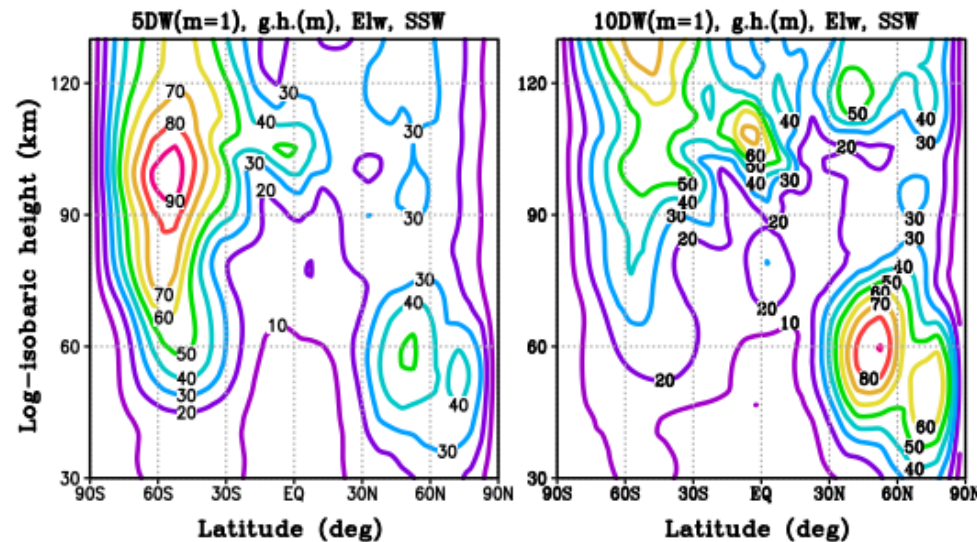
El Niño/easterly QBO



La Niña/easterly QBO



El Niño/westerly QBO



Conclusion and further tasks:

- the results of model simulation with the MUAM, taking into account the different phases of ENSO and QBO, for January-February are presented;
- the SSW in the MUAM was not simulated under the conditions of La Niña and westerly QBO;
- the maximal warming in the stratosphere and cooling in the mesosphere are modeled under the El Niño, easterly QBO conditions;
- the maximal mean zonal wind decreasing is modeled under the El Niño, westerly QBO conditions;
- the maximum amplitudes of propagating PWs are observed during the SSW under La Niña, easterly QBO conditions. These amplitudes decrease rapidly after SSW. Wave amplitudes continue to increase after SSW under El Niño conditions, regardless of the QBO phase;
- a hydrodynamic parameters of the atmosphere database for the winter months of the Northern hemisphere has been prepared with MUAM. It can be used to analyze wave motions and various dynamic processes in the middle atmosphere.



**Thank you for your attention!
Waiting for your questions
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