El Niño influence on the mesosphere/lower thermosphere circulation seen by a VHF meteor radar at Collm (51.3°N, 13°E)

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1 Summary

Correlation of MLT winds and ENSO

- Connection of stratosphere with ENSO is well established.
- Observations show possible connection of tropospheric circulation and mesosphere/lower thermosphere (MLT).
- We performed numerical simulations to show this connection.
- Effect reverses at an altitude of about 90 km.

Main conclusion

Middle atmosphere circulation near the MLT is coupled to ENSO. The effect reverses near 90 km, and the signature is weak if the peak height of meteor flux is considered.

2 MLT wind observations at Collm

State of the Art

- The middle atmosphere during winter is connected with El Niño-Southern Oscillation (ENSO).
- The stratospheric polar vortex is weaker during El Niño.
- Sudden stratospheric warmings are more frequent during El Niño winters.
- Most analyses refer to the stratosphere, here we are interested in the MLT and its relation to the troposphere.

VHF meteor radar

- Horizontal winds from Doppler shifted VHF signal from meteor trails.
- Vertical wind profiles 80-100 km.
- Collm, 51.3°N, 13.0°E.

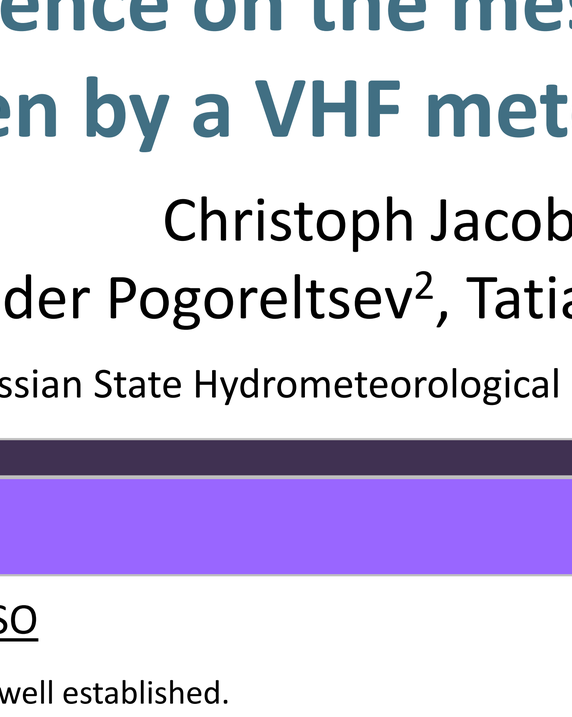

Fig. 1: 08/2004 – 04/2016 mean monthly mean zonal (black) and meridional (red) winds over Collm at 94 km (top) and 85 km (bottom). Error bars show the standard deviation. Winter 2015/16 values are highlighted as big circles.

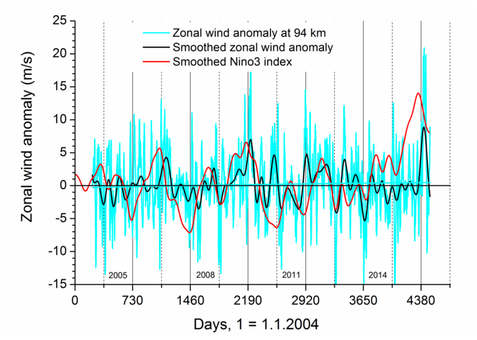

Fig. 2: Collm zonal mean winds at 94 km and Nino-3 index. Strong westerlies are observed after El Nino, especially during the late 2015/2016 winter, when an extreme El Niño event was registered.

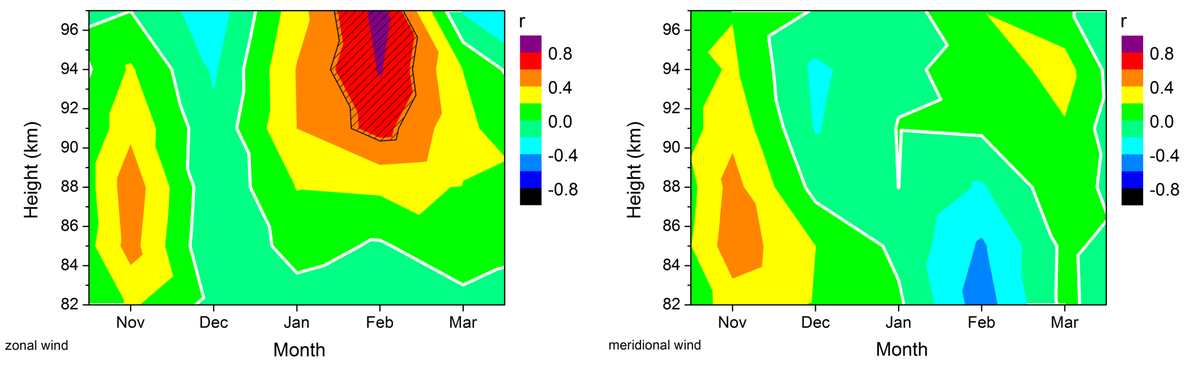

Fig. 3: Correlation coefficients of Collm zonal (left) and meridional (right) winds and Nino-3 index (Jacobi et al., 2017).

3 Numerical modeling

MUAM numerical model

- 3D grid point mechanistic model (Pogoreltsev et al., 2017).
- Surface to lower thermosphere.
- Primitive equations.
- Parameterized gravity waves, radiation, latent heat release.
- Lower boundary from MERRA temperatures and geopotential heights.
- 9 runs for El Niño and La Niña conditions, resp.

- Results confirm weaker zonal winds in the stratosphere and stronger winds in the upper mesosphere/lower thermosphere during El Niño.
- Stronger stationary planetary wave of wavenumber 1 (SPW1) but weaker SPW2 during El Niño than during La Niña.

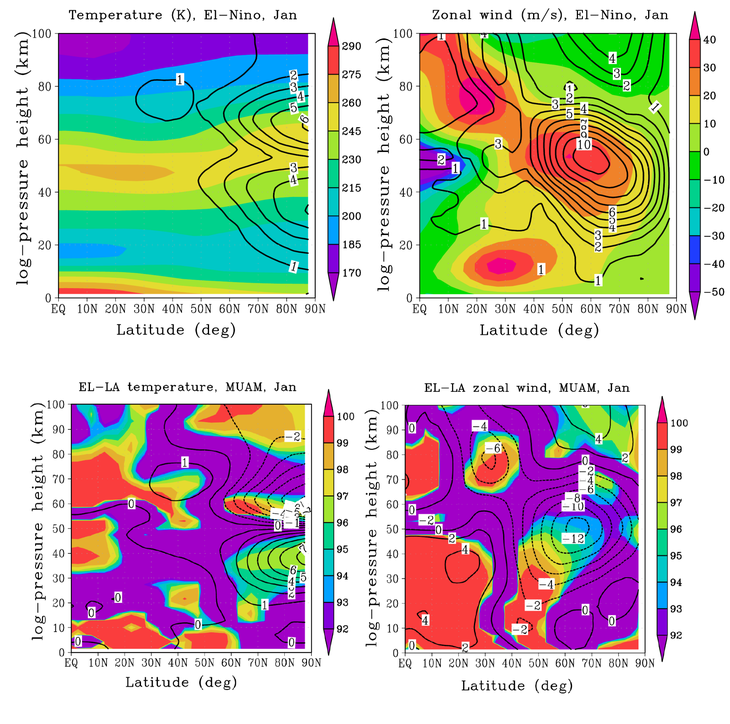

Fig. 4: Upper row: MUAM January mean temperatures (left) and zonal winds (right) and standard deviations. Lower row: Differences El Niño – La Niña and significance level (colors).

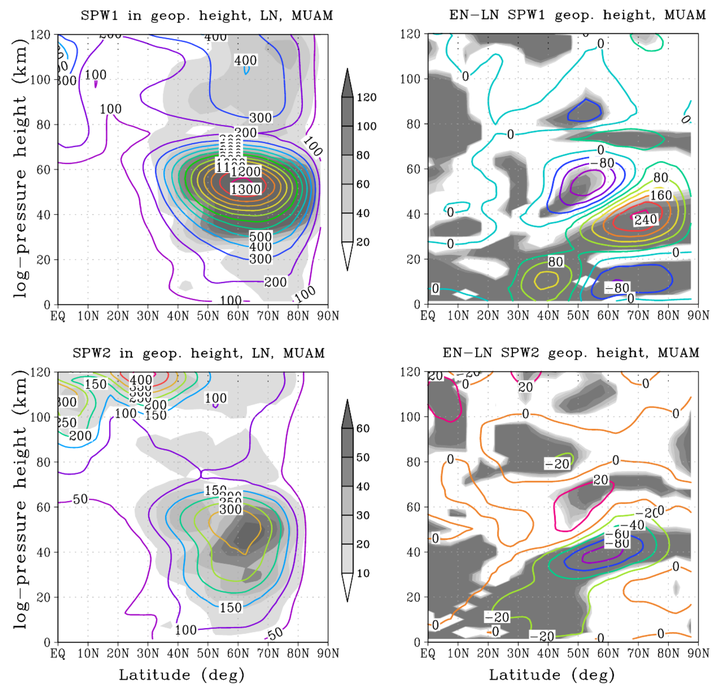

Fig. 5: Stationary planetary wave in geopotential height for La Niña conditions (left) and difference between El Niño and La Niña (right). Panels are for wavenumber 1 (top) and 2 (bottom).

4 Conclusions and final remarks

Conclusions

- ENSO signature is visible in the middle and high latitude middle atmosphere up to the MLT.
- Visible in radar observations and qualitatively confirmed by numerical modeling.
- Weak effect near 90 km.

Perspectives

- Analysis of vertical coupling processes including the mesosphere using MERRA-2 and ERA5 reanalyses.

References

- Jacobi, Ch., T. Ermakova, D. Mewes, and A.I. Pogoreltsev, 2017: El Niño influence on the mesosphere/lower thermosphere circulation at midlatitudes as seen by a VHF meteor radar at Collm (51.3°N, 13°E), Adv. Radio Sci., in press.
- Pogoreltsev, A.I., Vlasov, A.A., Fröhlich, K., Jacobi, Ch., 2007: Planetary waves in coupling the lower and upper atmosphere, J. Atmos. Sol.-Terr. Phys., 69, 2083–2101, doi:10.1016/j.jastp.2007.05.014.

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