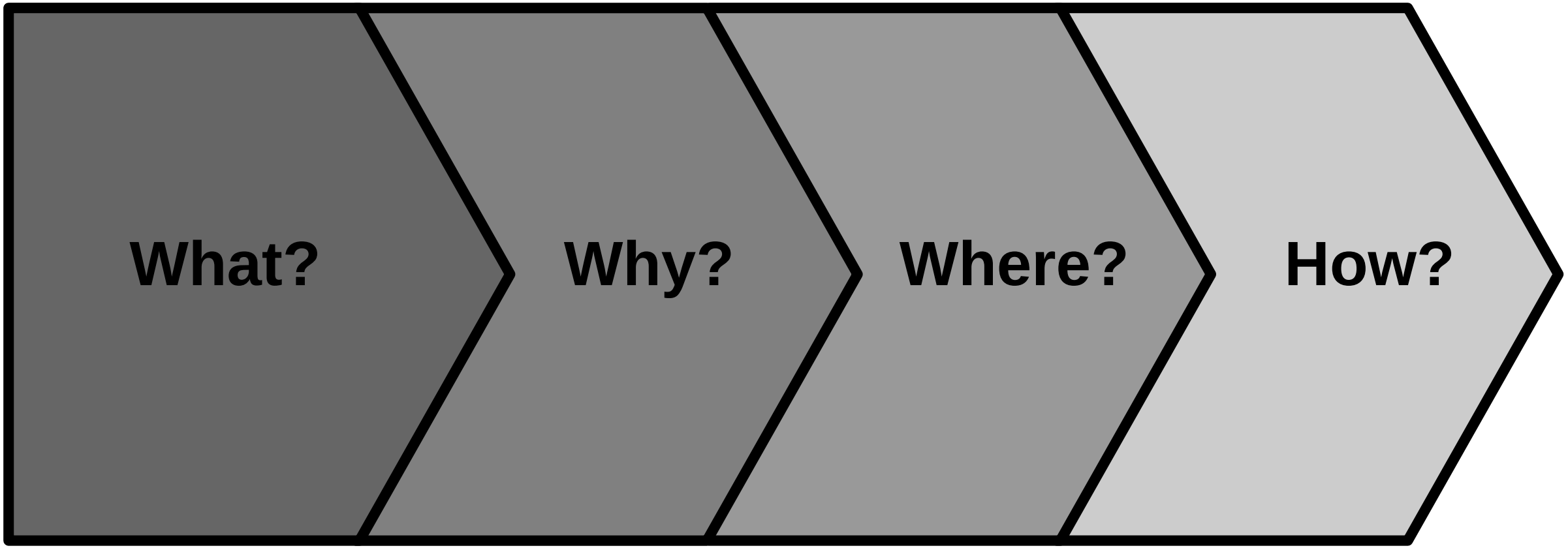
How do SSWs manifest in the upper mesosphere?

Ales Kuchar ales.kuchar@uni-leipzig.de @kuchaale

Benedikt Gast
Christoph Jacobi

Funded by VACILT (DFG) project
https://github.com/VACILT/SSW_project

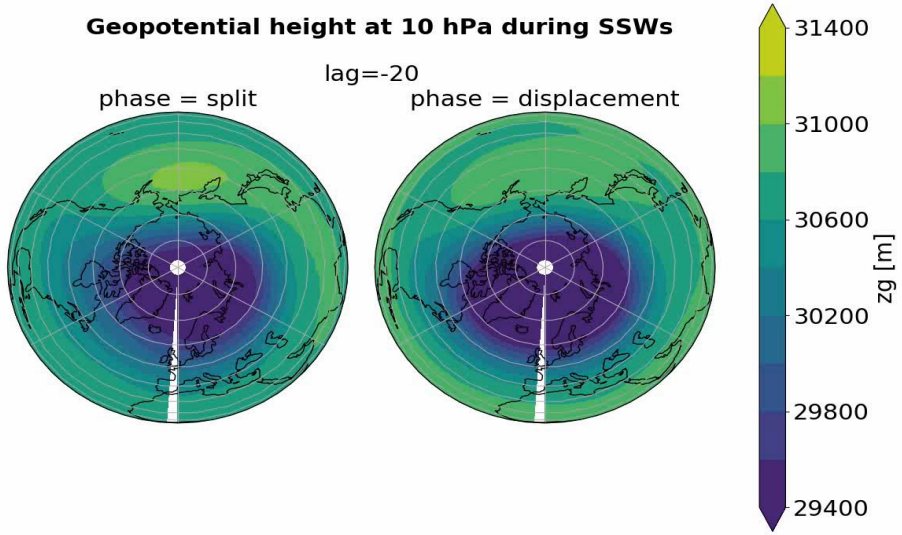
Flowchart of content



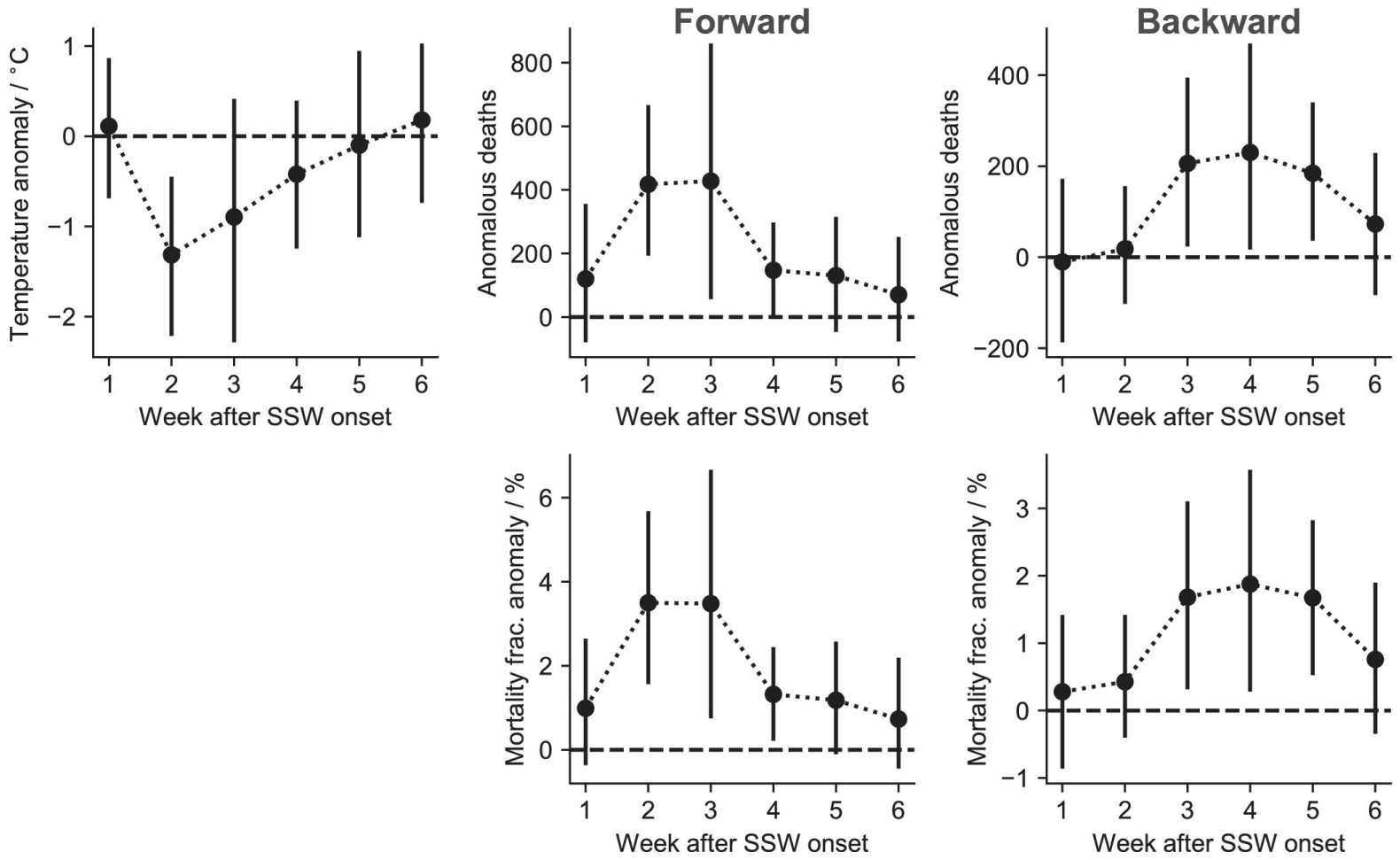
What SSWs are?

- **SSWs**: stratospheric temperatures can fluctuate by more than 50°C in days

- **Major SSW**: reversal of westerly winds at 60°N&10 hPa (WMO)

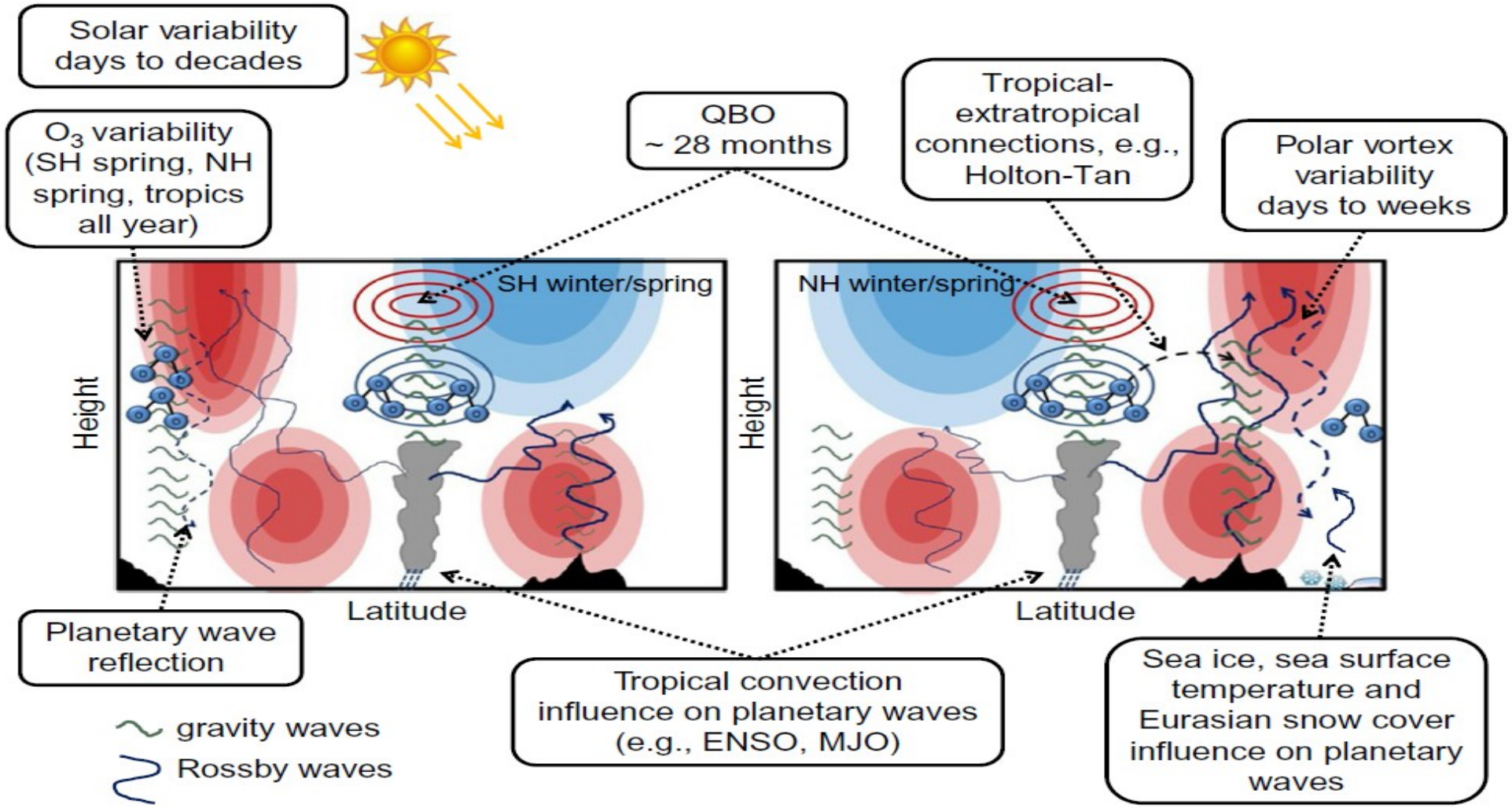


Why to study SSWs?



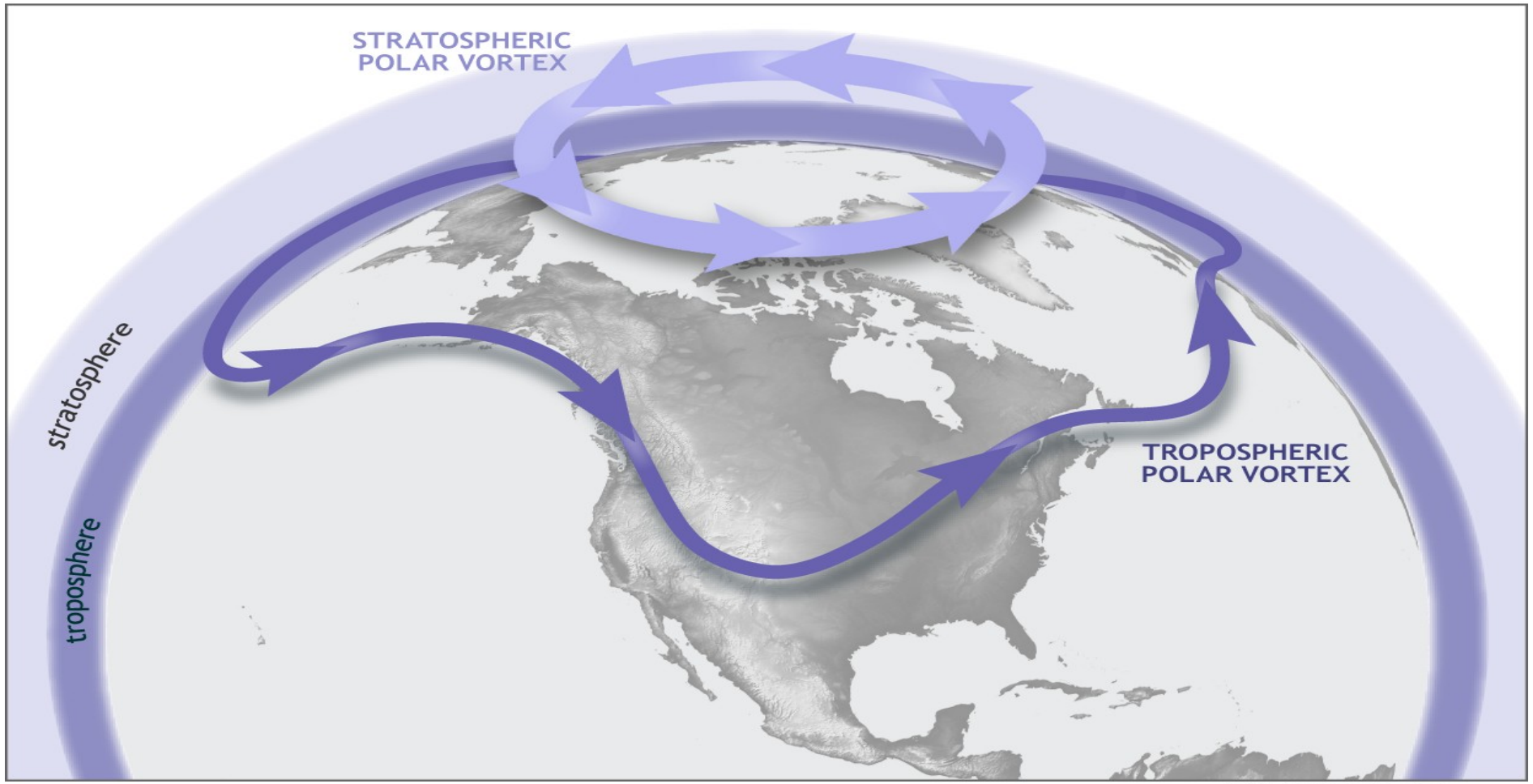
Charlton-Perez et al (2020)
doi: 10.1002/asl.1013

Coupling processes



Butler et al. (2019)
doi:10.1016/B978-0-12-811714-9.00011-5

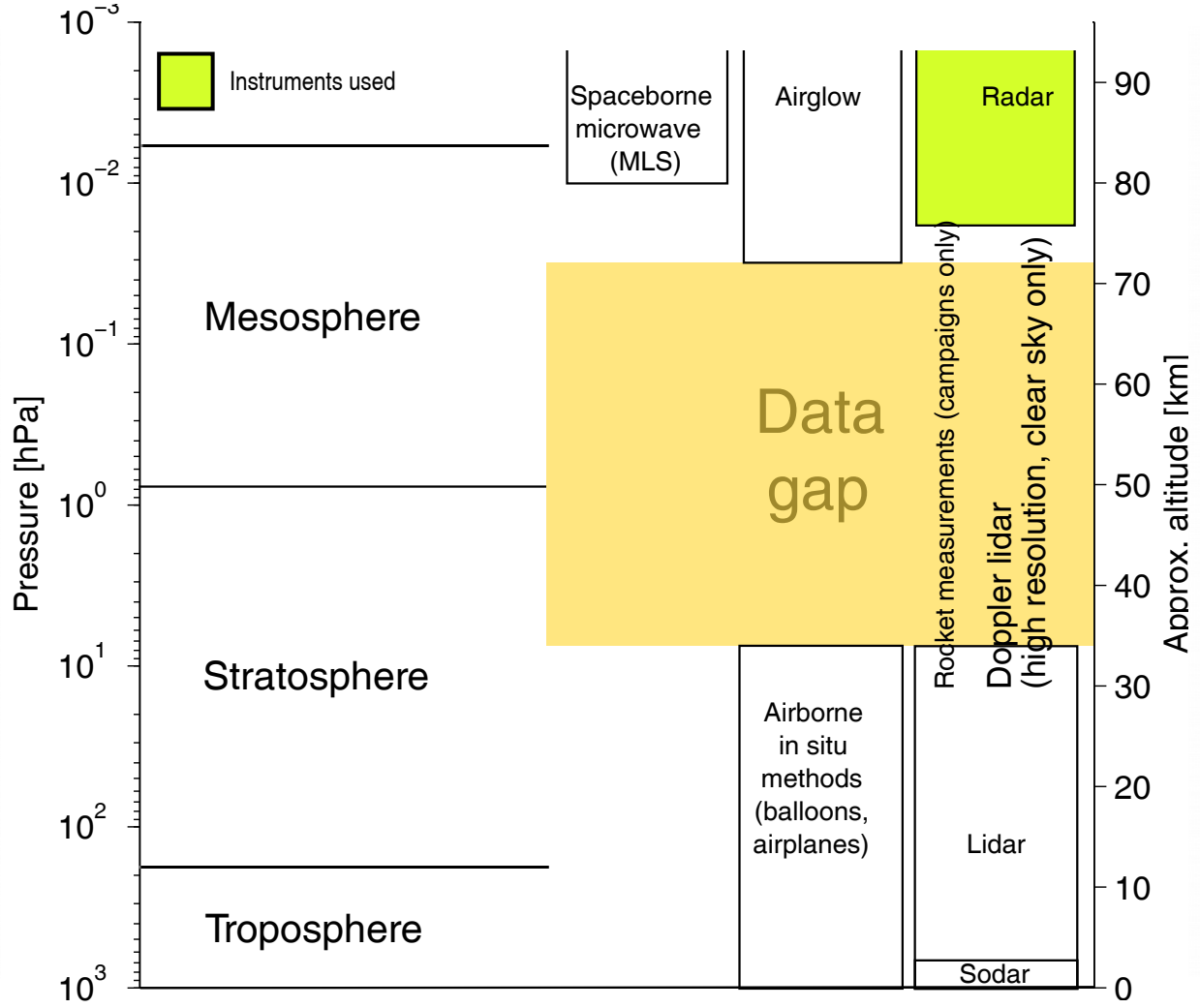
Tropospheric vs. stratospheric polar vortex



NOAA Climate.gov
Data: Waugh et al., 2017

Datasets

Meteor radar station	Time range	Number of events
Kiruna	1999-2019	27
Collm	2004-2019	19
CMA	2002-2018	22
Rio Grange	2008-2019	13
Davis	2005-2019	19



Methodology

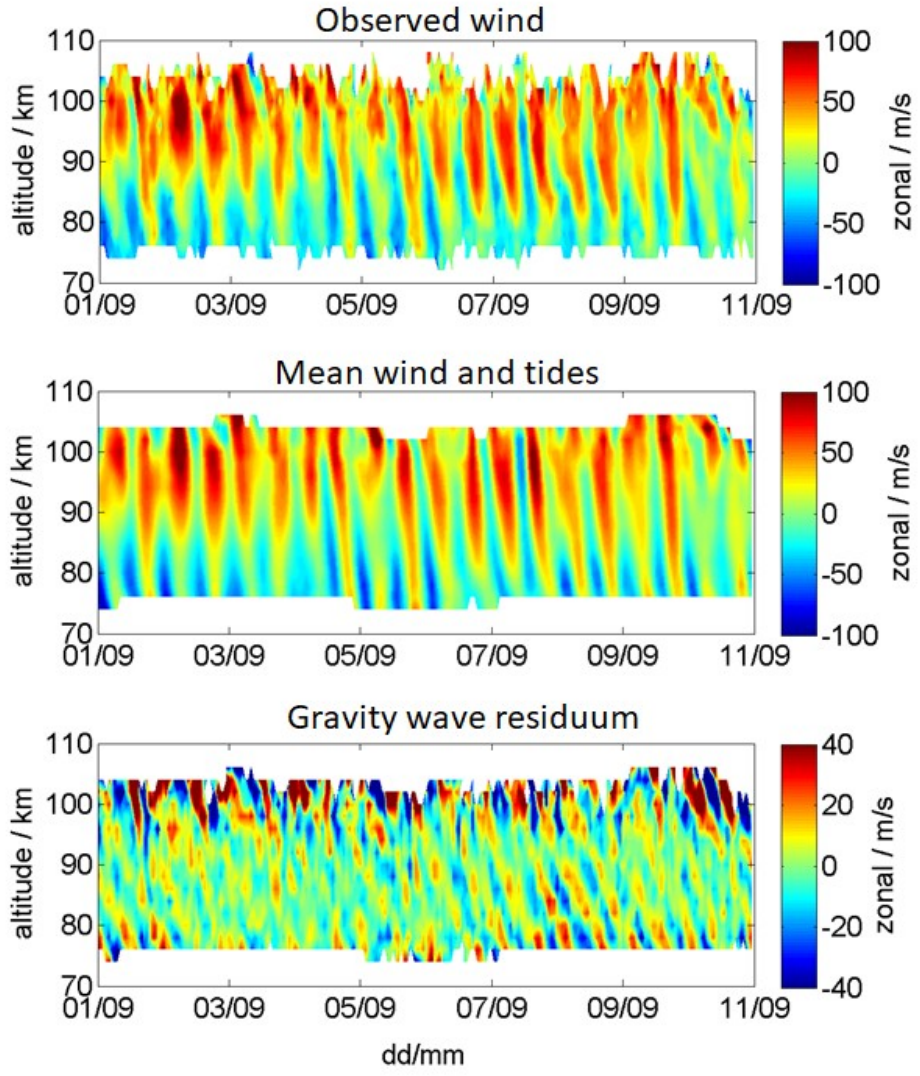
Adaptive spectral filtering:

Hourly observed data ⇨ Daily mean wind, tides, GW residuum

Sliding window length 24 hour

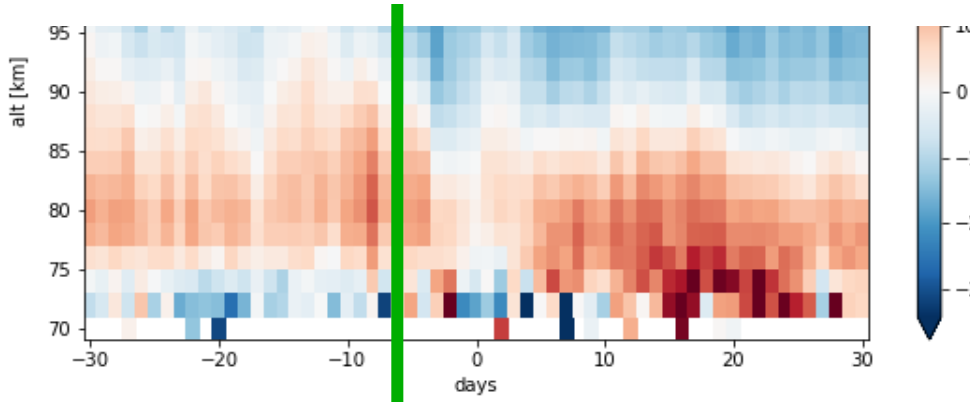
$$u,v = u_0, v_0 + \sum_{n=1}^{3} a_n \sin\left(\frac{2\pi}{T_n} * t\right) + b_n \cos\left(\frac{2\pi}{T_n} * t\right)$$

u,v	observed zonal meridional component
u_o, v_o	mean zonal and meridional component for the mean wind and each wave
a_n, b_n	coefficients to the amplitude
T_n	24 hours for diurnal tide 12 hours for semidiurnal tide GW = residuum

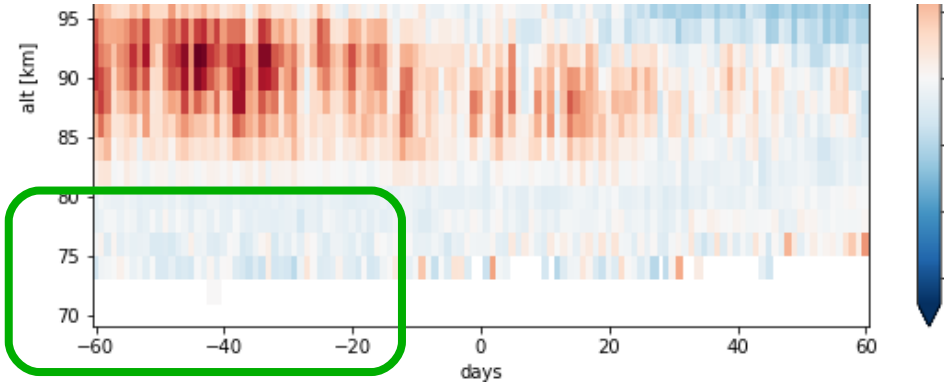


Decomposition of the observed wind (top) into the mean wind and tidal component (middle), and the gravity wave residuum (bottom) for Andenes 01/09/2017 - 11/09/2017. Note the different labels of the colorbar (Wilhel e al, 2019).

Averaged conditions above Collm (NH)

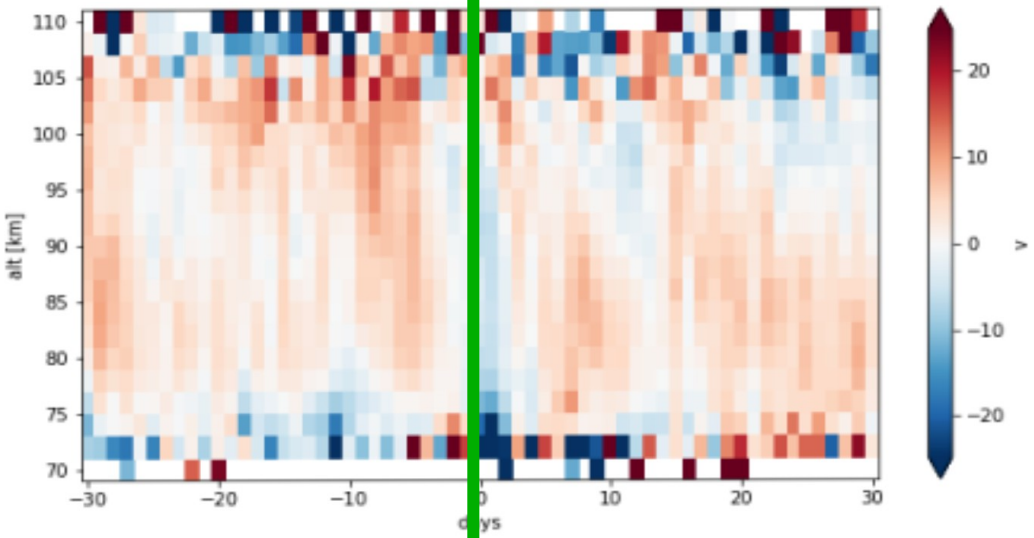


Measurements of meteor radars at Collm Observato
anomalies (lower panels) of the zonal wind compone



Measurements of the meteor radar at Collm Observa
(right) of gravity waves: climatologies (upper panels)

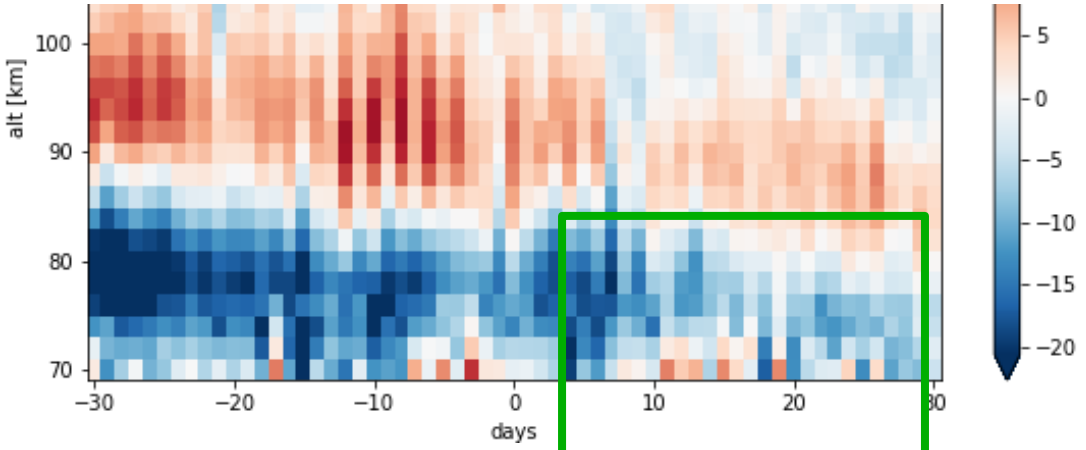
Results



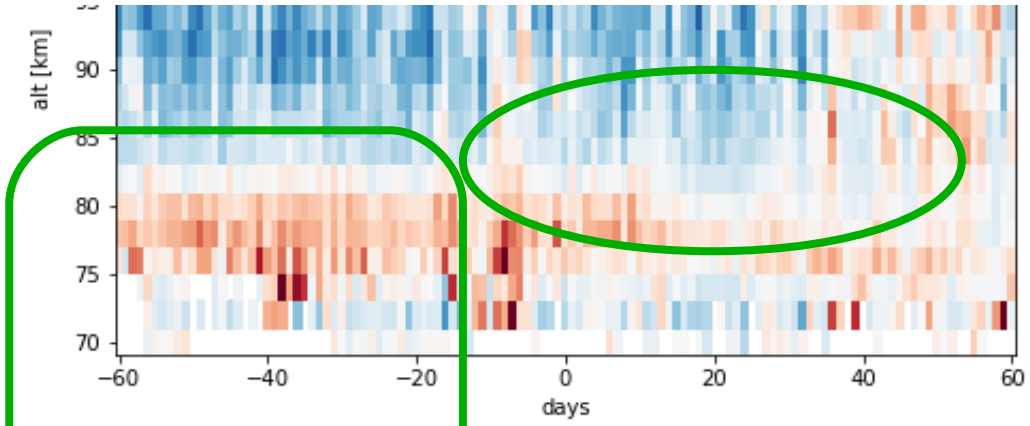
Results

- Westerly strengthening => wind drop
  => strengthening again
- Weaker northward meridional wind
  around the onset
- Enhanced GW activity before SSWs

Averaged conditions above Rio Grande (SH)



Measurements of the meteor radar at Rio Grande (Arg
wind component (right): climatologies (upper panels) a



Measurements of the meteor radars at Rio Grande
anomalies (lower panels) of the total kinetic energ

Results

Results

- Weakening of westward and eastward zonal wind
- More pronounced effects in GW activity
- Manifestations of inter-hemispheric coupling

Conclusions

- Strong latitudinal and longitudinal effects of SSWs
- Inter-hemispheric manifestations confirms theory (Körnich and Becker; 2010) in contrast to Yasui et al (2016)
- GWs as important driver in the mesosphere

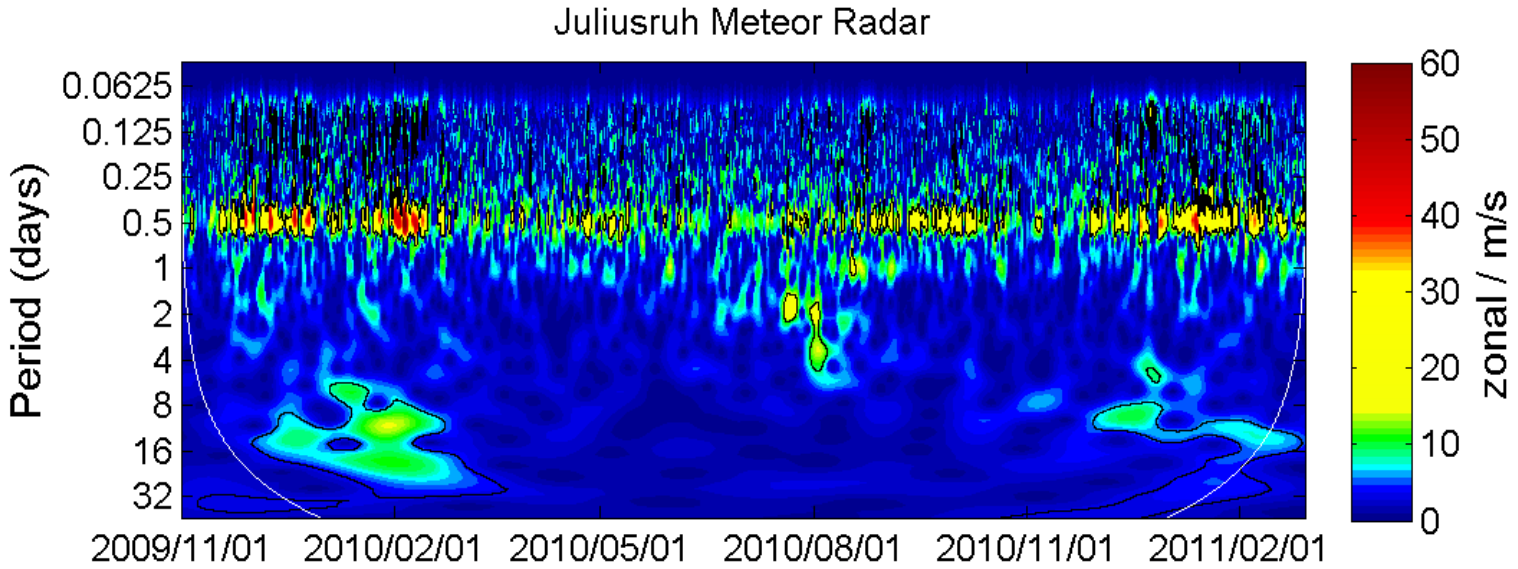
Future outlook

- PWs understanding needed
- Diffentiate between major and minor SSWs

Questions?

NOT ONLY THE TROPOSPHERIC ONE ;)

The seasonal pattern of atmospheric waves



radar observations are nearly continuous (up to 99% of time) at MLT altitudes (74-106 km)

resulting time series contains all types of waves (gravity waves, tides, planetary waves)

decomposition of time series for the different wave types (observed wave properties, not intrinsic properties !!!)