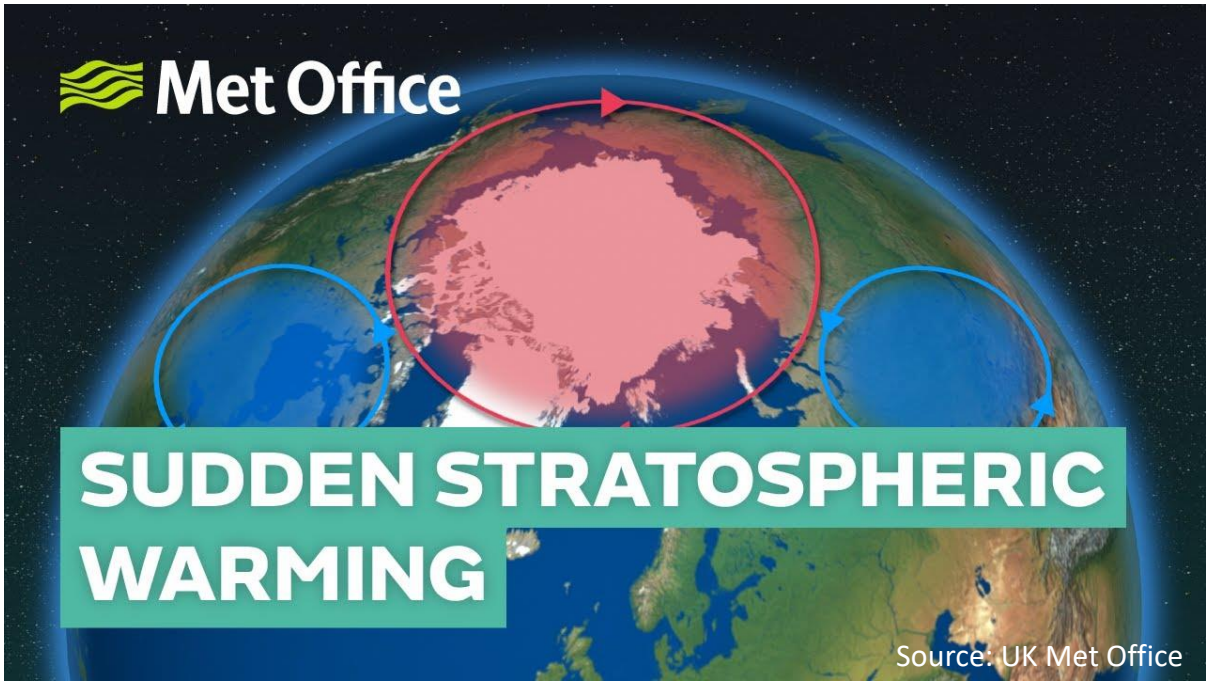
Meteorological conditions in the Mesosphere during SSW events



Benedikt Gast

Seminar Upper Atmosphere

Leipzig, August 14th, 2020

Contents

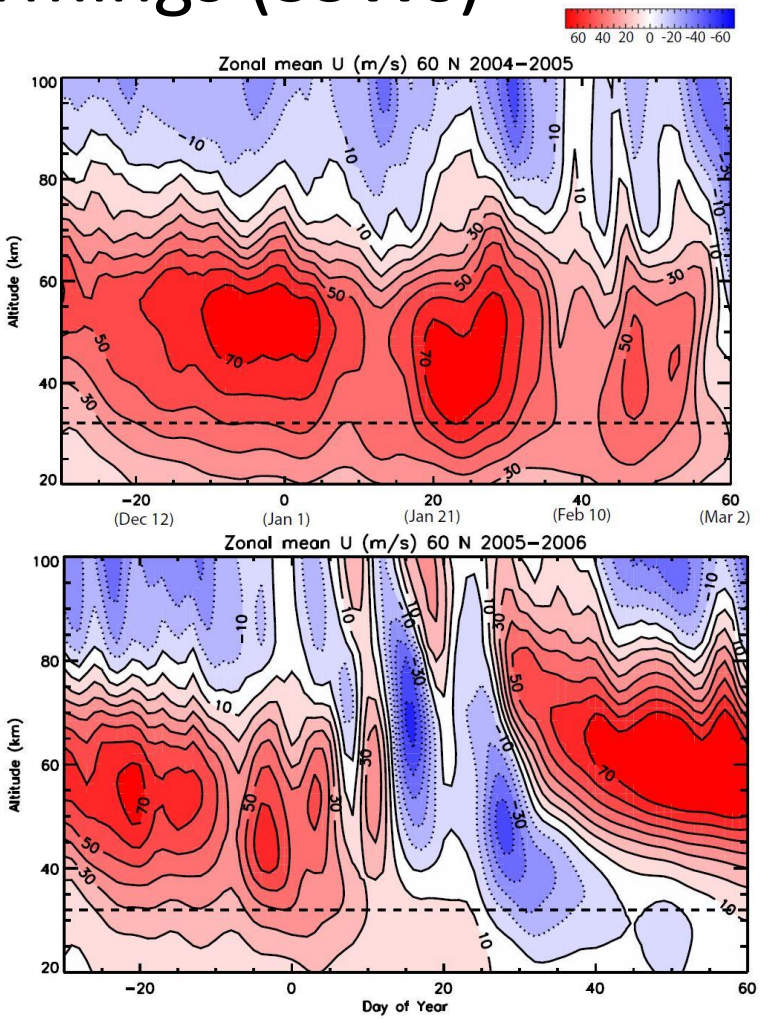
Sudden Stratospheric Warmings (SSWs)

undisturbed conditions:

- eastward stratospheric jet
- westward mesospheric jet
- zero wind line near 75 km

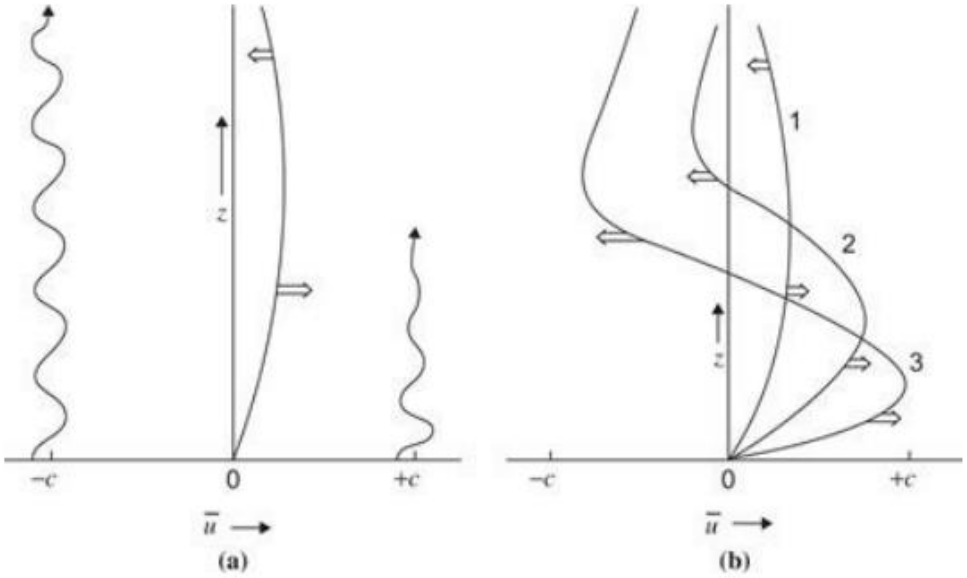
SSW event:

- planetary waves initiate the SSWs
- westward flow in the stratosphere
- sometimes elevated stratopause



Wind profiles during an undisturbed winter (upper panel) and during a winter with SSW event and elevated stratopause (lower panel).

Gravity wave filtering in the atmosphere



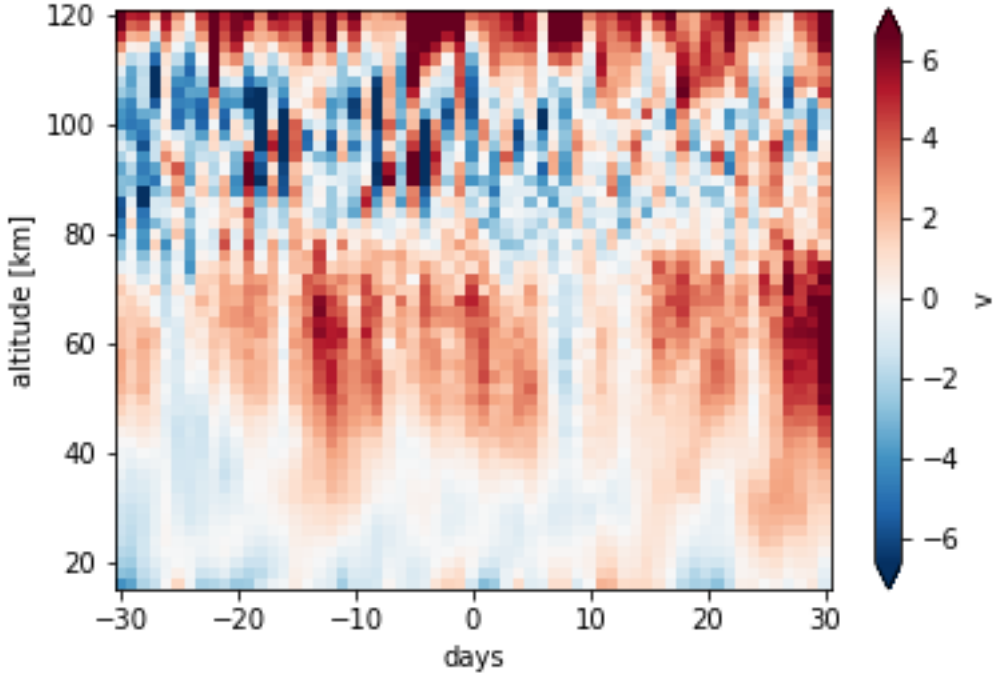
Wind profile and gravity wave propagation for normal winter conditions (a) and during SSW events (b)

$$m^2 = \frac{N^2}{(c - \overline{u})^2}$$

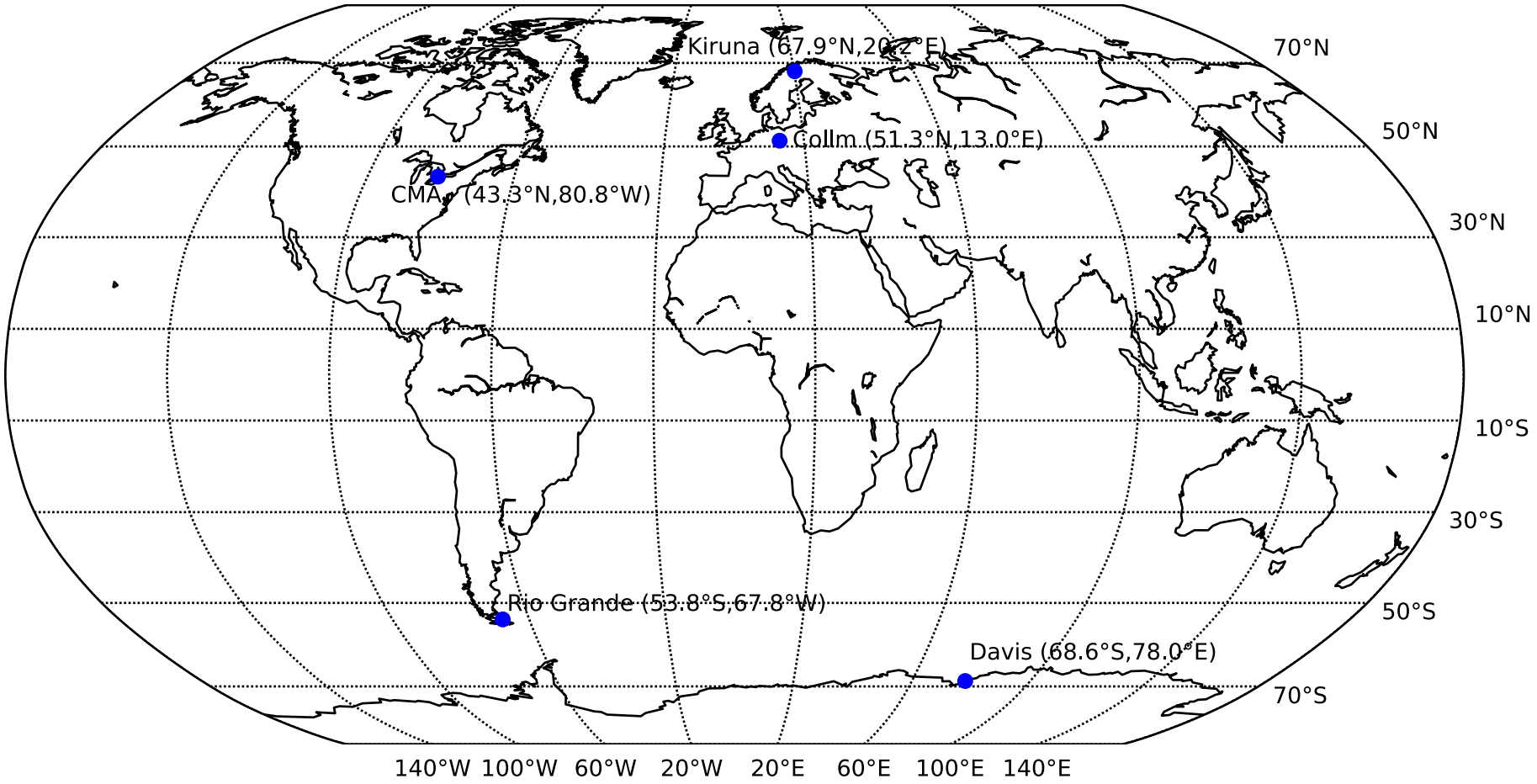
m – vertical wave number
N – buoyancy frequency
c – phase speed
ū – background wind

Superposed epoch analysis

- goal: characterize the meteorological conditions during an „average“ SSW event
- data from each event are ordered with reference to the SSW onset
- average parameters for all SSW events are determined with reference to the epoch time

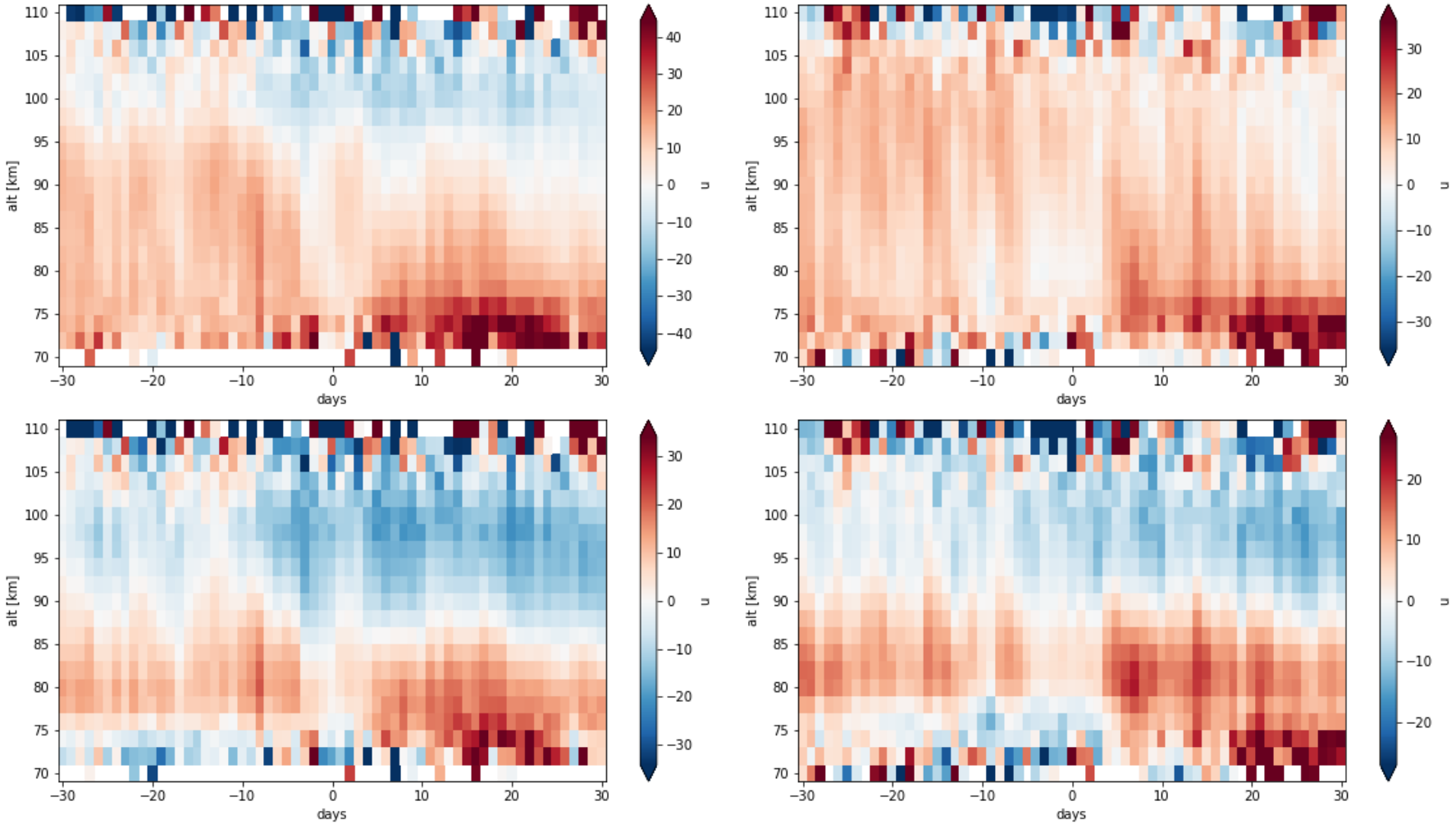


Locations of the meteor radar stations



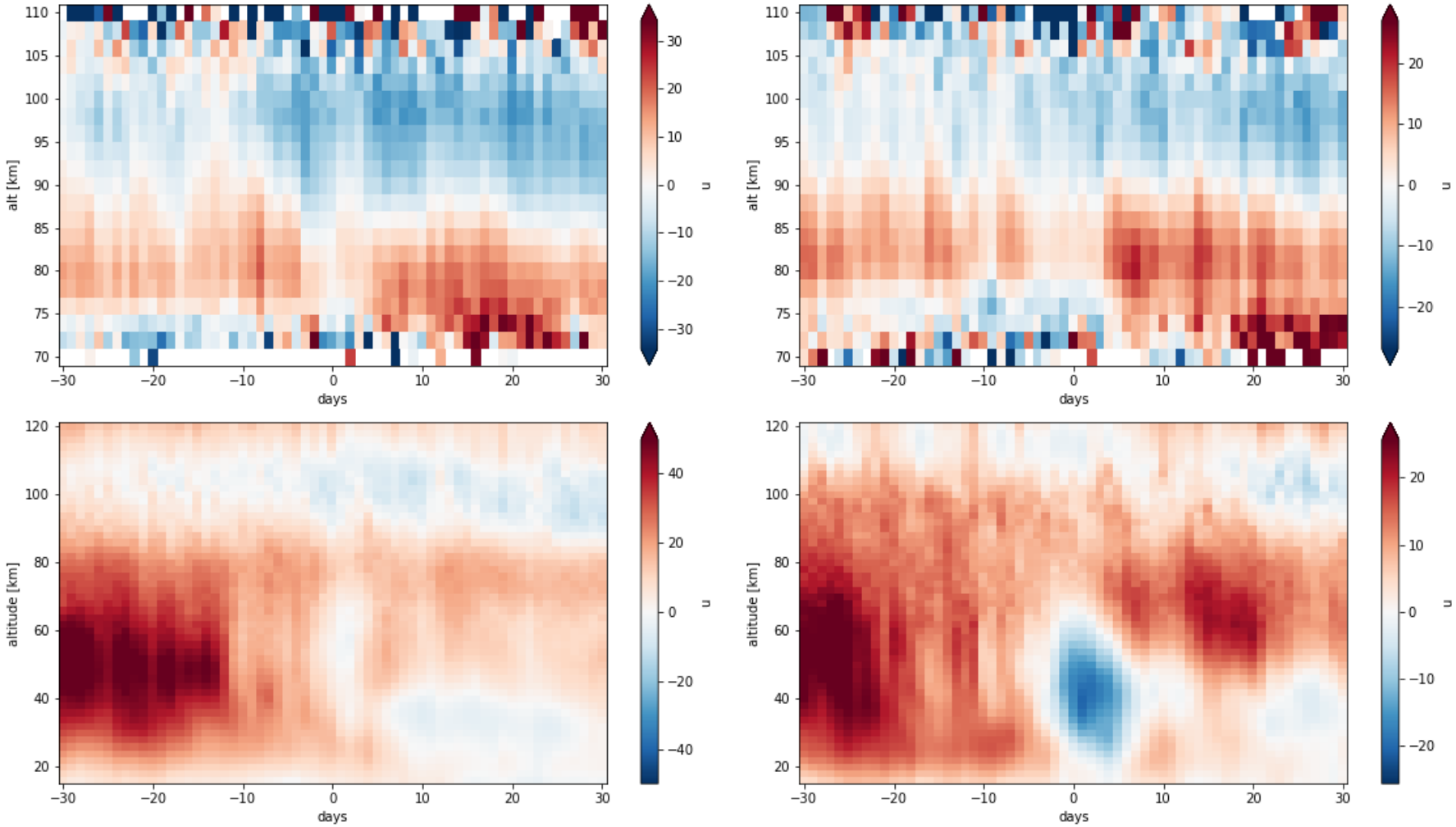
Winds

Measurements of u at Collm and Kiruna



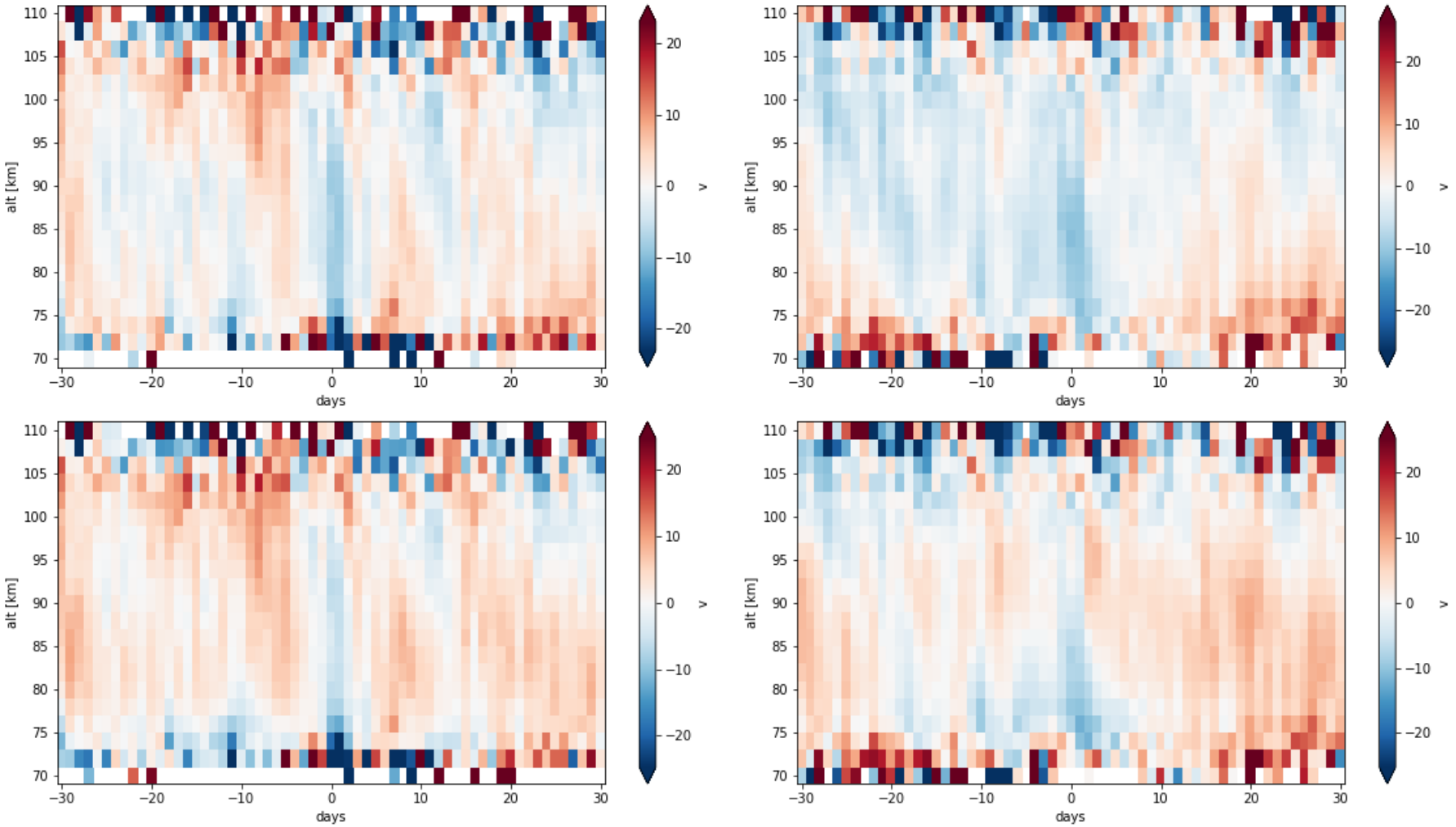
Measurements of meteor radars at Collm Observatory (left) and Kiruna (right): climatology (upper panels) and anomalies (lower panels) of the zonal wind component.

Measurements and GAIA data of u at Collm and Kiruna



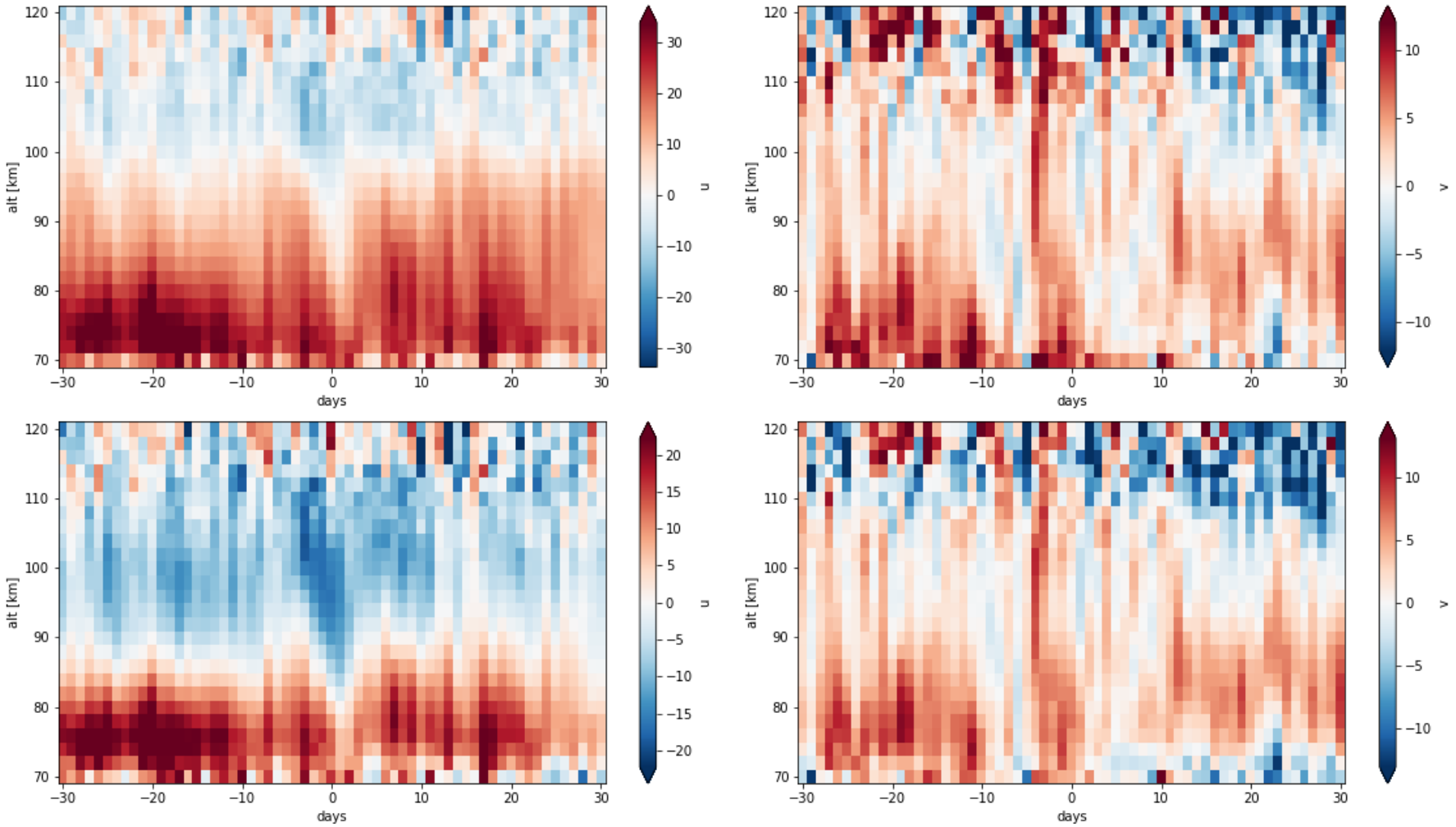
Measurements of meteor radars (upper panels) and GAIA data (lower panels) of the anomalies of the zonal wind component at Collm Observatory (left) and Kiruna (right).

Measurements of v at Collm and Kiruna



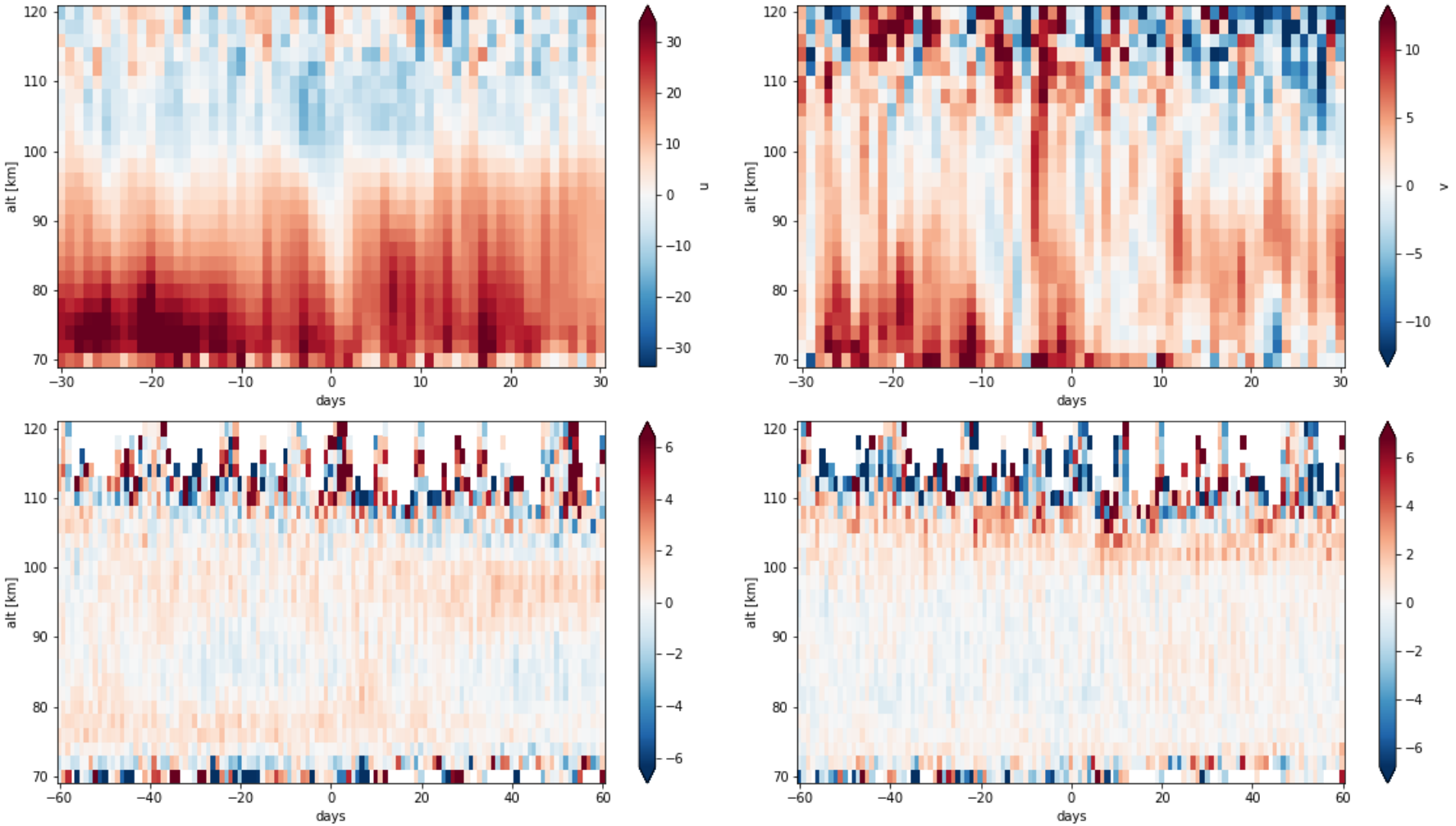
Measurements of meteor radars at Collm Observatory (left) and Kiruna (right): climatology (upper panels) and anomalies (lower panels) of the meridional wind component.

Wind measurements at CMA station



Measurements of the CMOR meteor radar at London, Ontario (Canada): zonal wind component (left) and meridional wind component (right): climatologies (upper panels) and anomalies (lower panels).

Wind and gravity wave measurements at CMA station



Measurements of the CMOR meteor radar at London, Ontario (Canada): climatologies of the zonal components (left) and meridional components (right) of wind (upper panels) and gravity waves (lower panels).

Inter – hemispheric coupling

- weaker northward meridional wind on the NH around the SSW onset

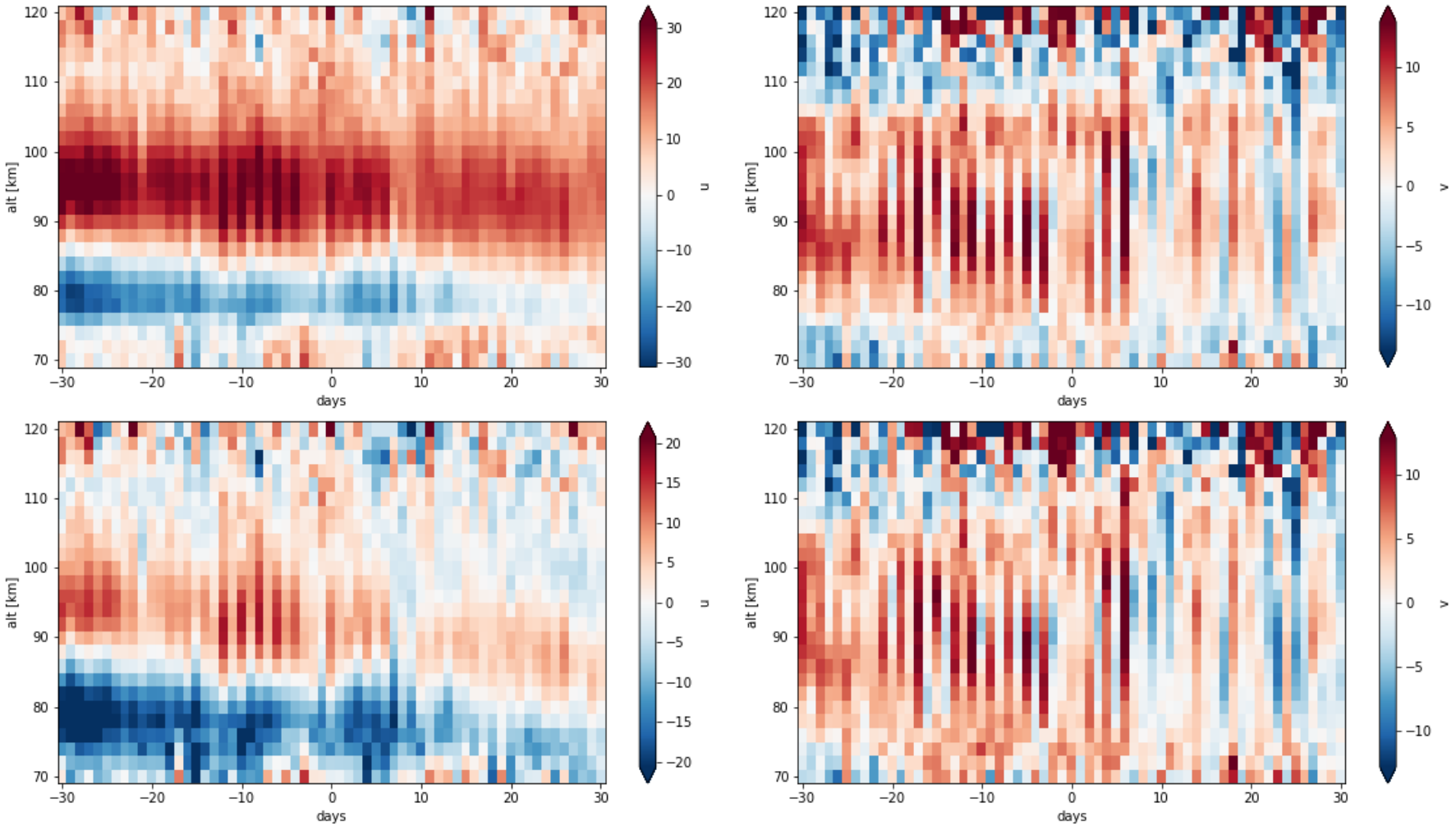
→ Cooling at the polar and warming at the tropical mesosphere

→ weaker latitudinal gradient on the SH

Effects on the Southern Hemisphere:

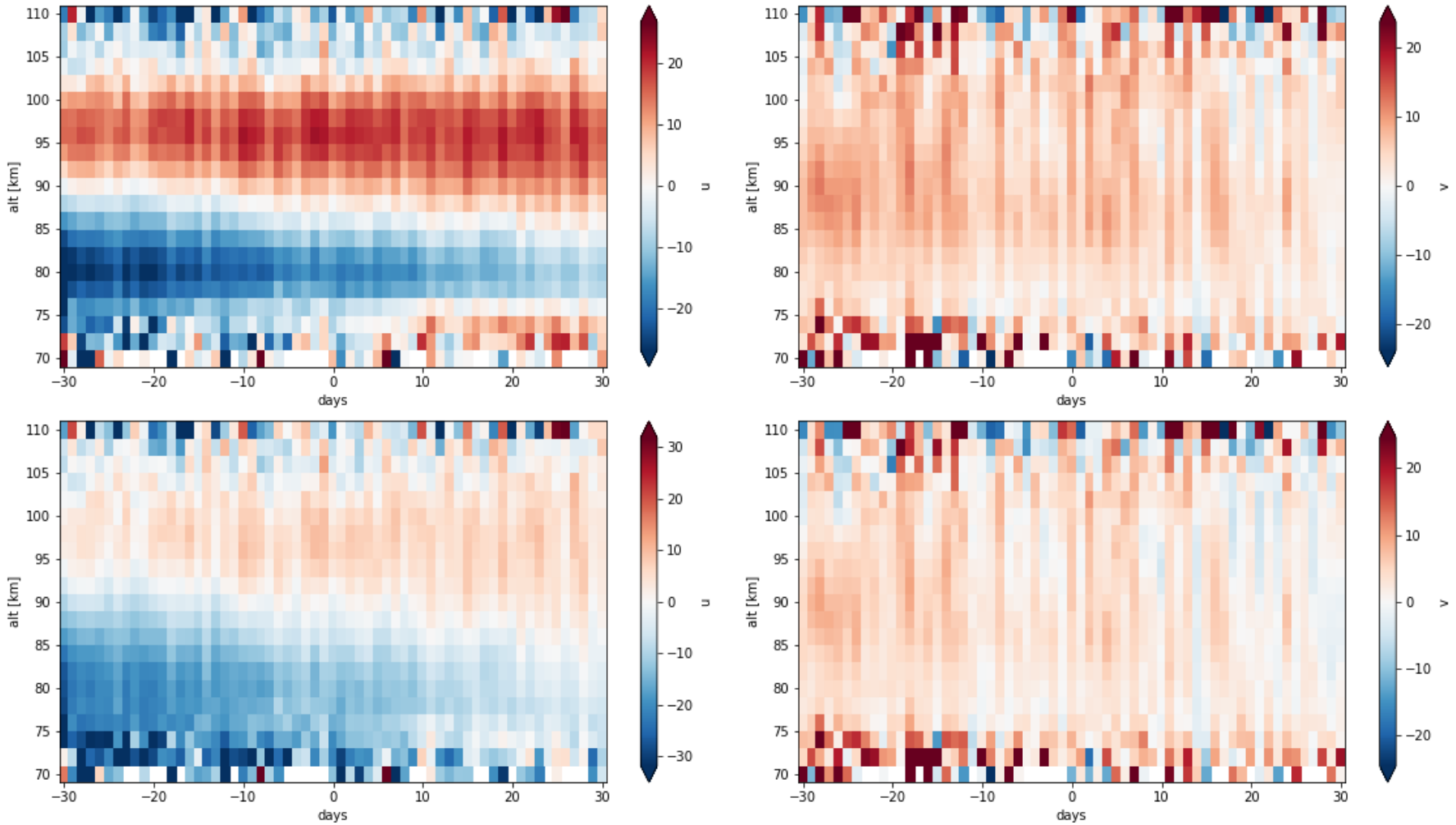
- occur with 4 – 10 days time shift
- weakening of the westward zonal wind
- reduced gravity wave activity in the upper mesosphere, below increased
- negative anomaly of the mean meridional wind

Wind measurements at Rio Grande (Argentina)



Measurements of the meteor radar at Rio Grande (Argentina): zonal wind component (left) and meridional wind component (right): climatologies (upper panels) and anomalies (lower panels).

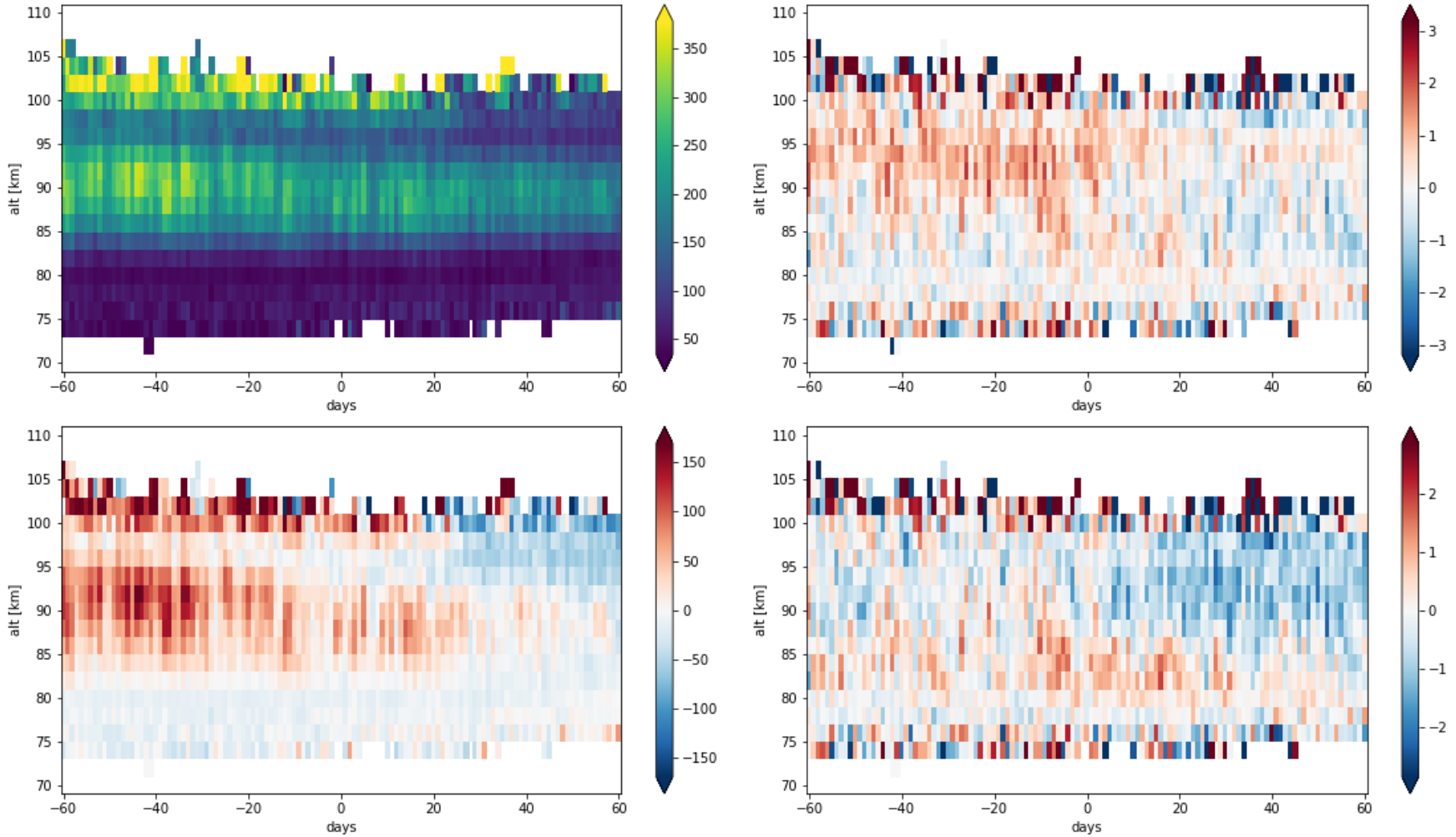
Wind measurements at Davis (Antarctic)



Measurements of the meteor radar at Davis (Antarctic): zonal wind component (left) and meridional wind component (right): climatologies (upper panels) and anomalies (lower panels).

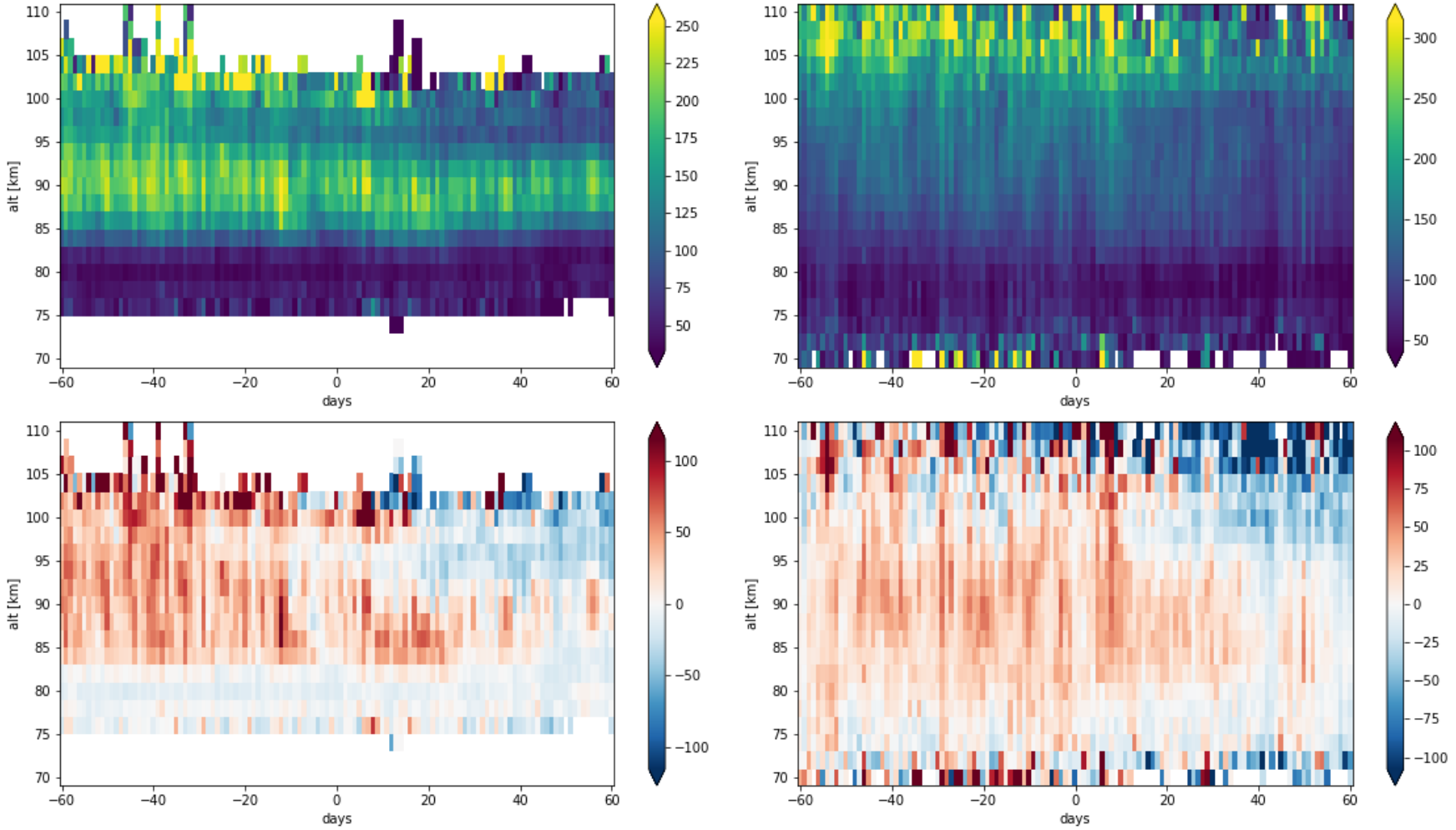
Gravity waves

Gravity wave measurements at Collm Observatory



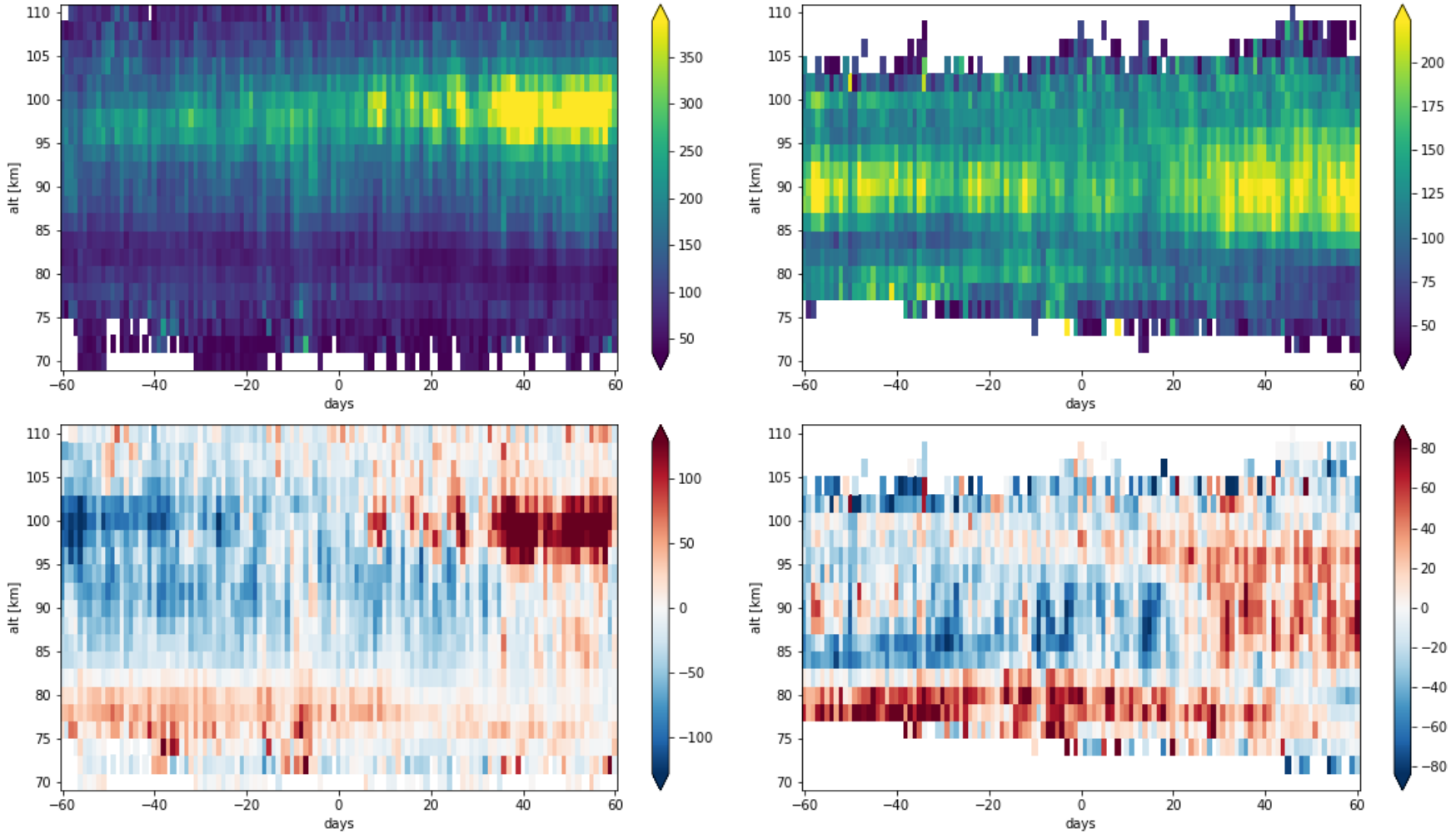
Measurements of the meteor radar at Collm Observatory: total kinetic energy (left) and zonal component (right) of gravity waves: climatologies (upper panels) and anomalies (lower panels).

Gravity wave measurements at Kiruna and CMA



Measurements of the meteor radars at Kiruna (left) and CMA (right): climatologies (upper panels) and anomalies (lower panels) of the total kinetic energy of gravity waves.

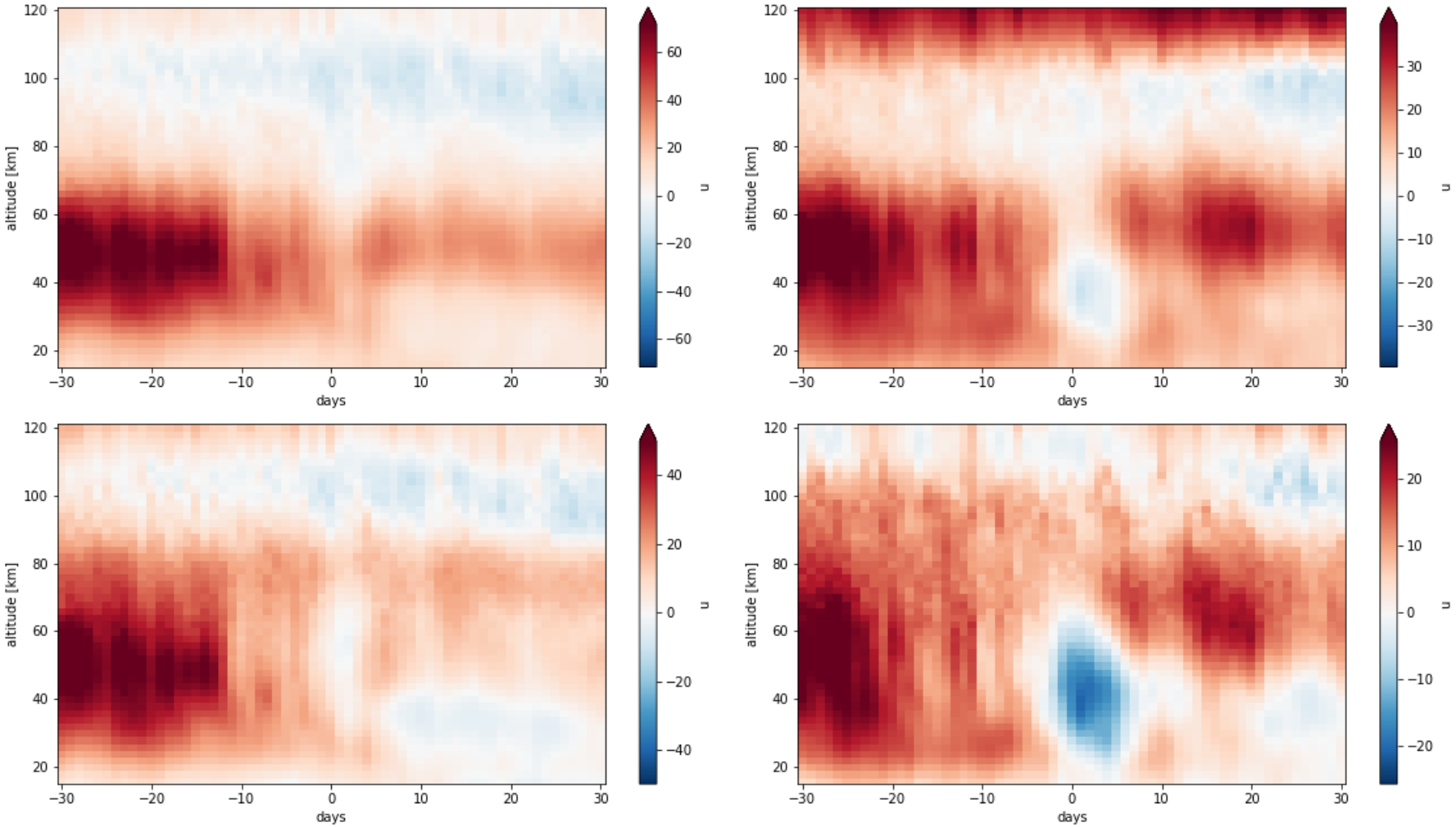
Gravity wave measurements at Rio Grande and Davis



Measurements of the meteor radars at Rio Grande (left) and Davis (right): climatologies (upper panels) and anomalies (lower panels) of the total kinetic energy of gravity waves.

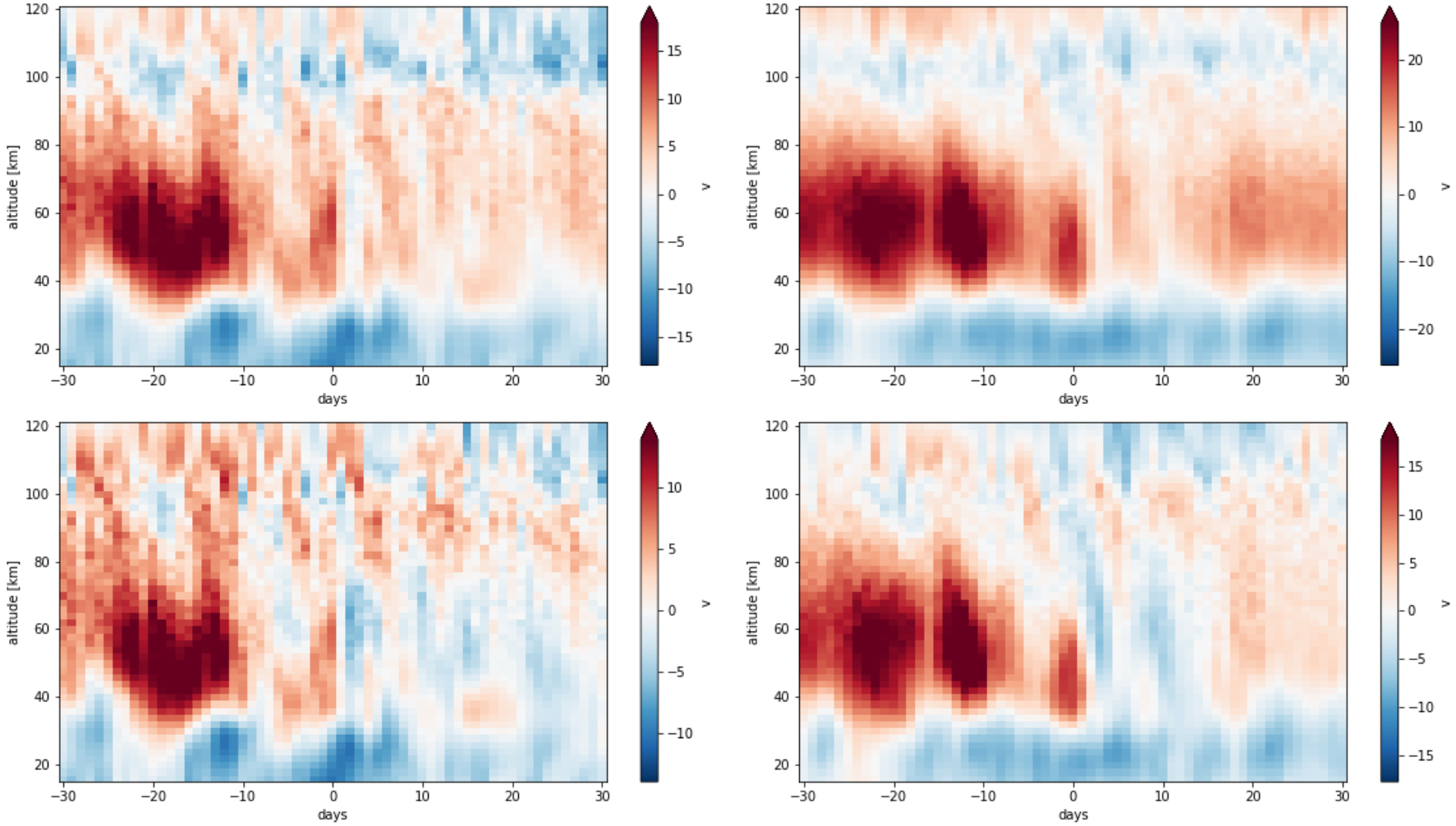
GAIA model data

GAIA model data of u at Collm and Kiruna



GAIA model data of the zonal wind component at Collm Observatory (left) and Kiruna (right): climatology (upper panels) and anomalies (lower panels).

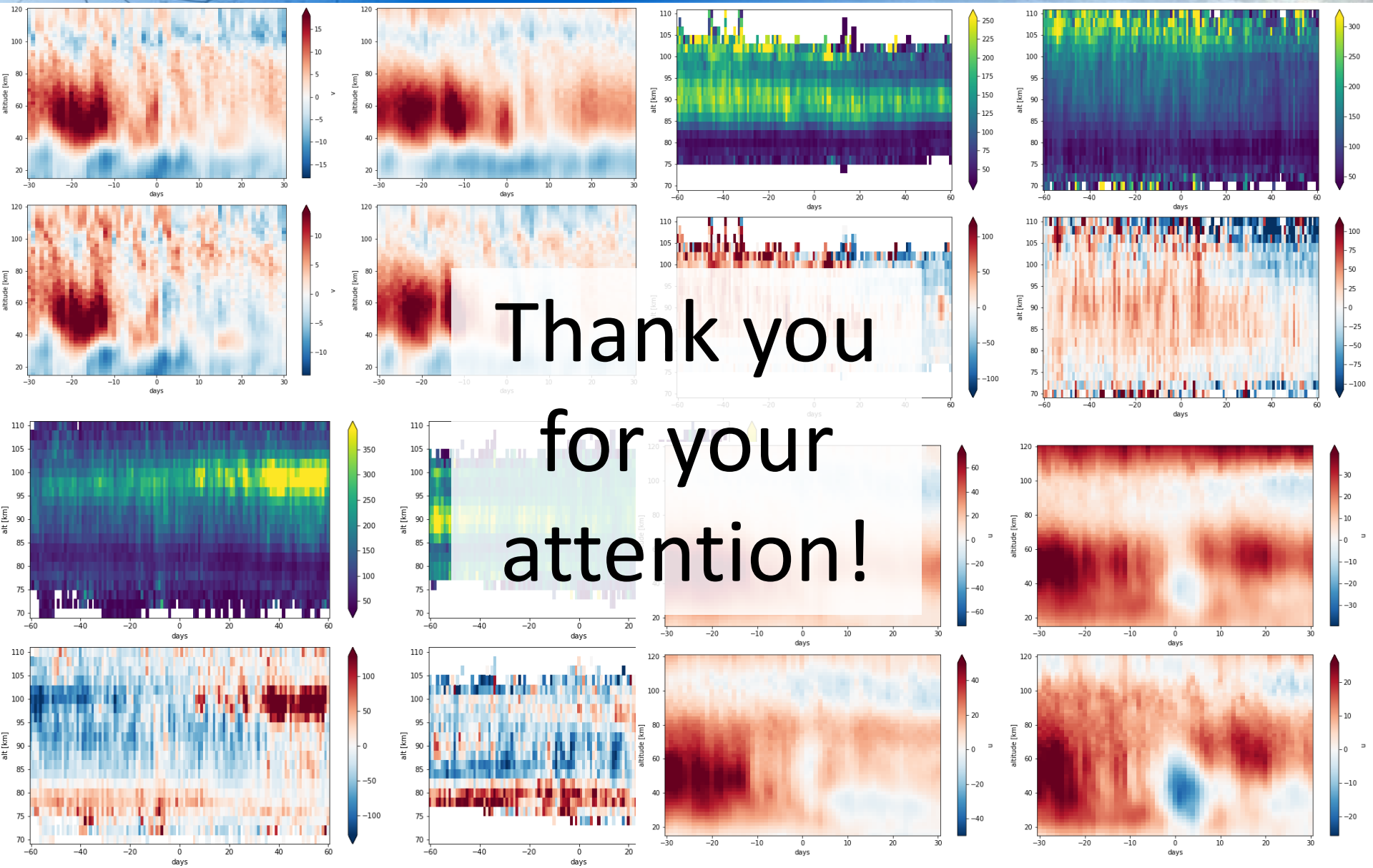
GAIA model data of v at Collm and Kiruna



GAIA model data of the meridional wind component at Collm Observatory (left) and Kiruna (right): climatology (upper panels) and anomalies (lower panels).

5. Summary

- strong latitudinal dependence of the effects of a sudden stratospheric warming
- on the northern hemisphere: enhanced gravity wave activity in the upper mesosphere before the SSW events
- results for the southern hemisphere are consistent with the inter-hemispheric coupling theory
- elevated stratopause seems to be a common phenomenon after SSWs
- gravity waves are an important driver for the mesospheric circulation
- to understand all effects, planetary waves must be investigated, too



Thank you for your attention!

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