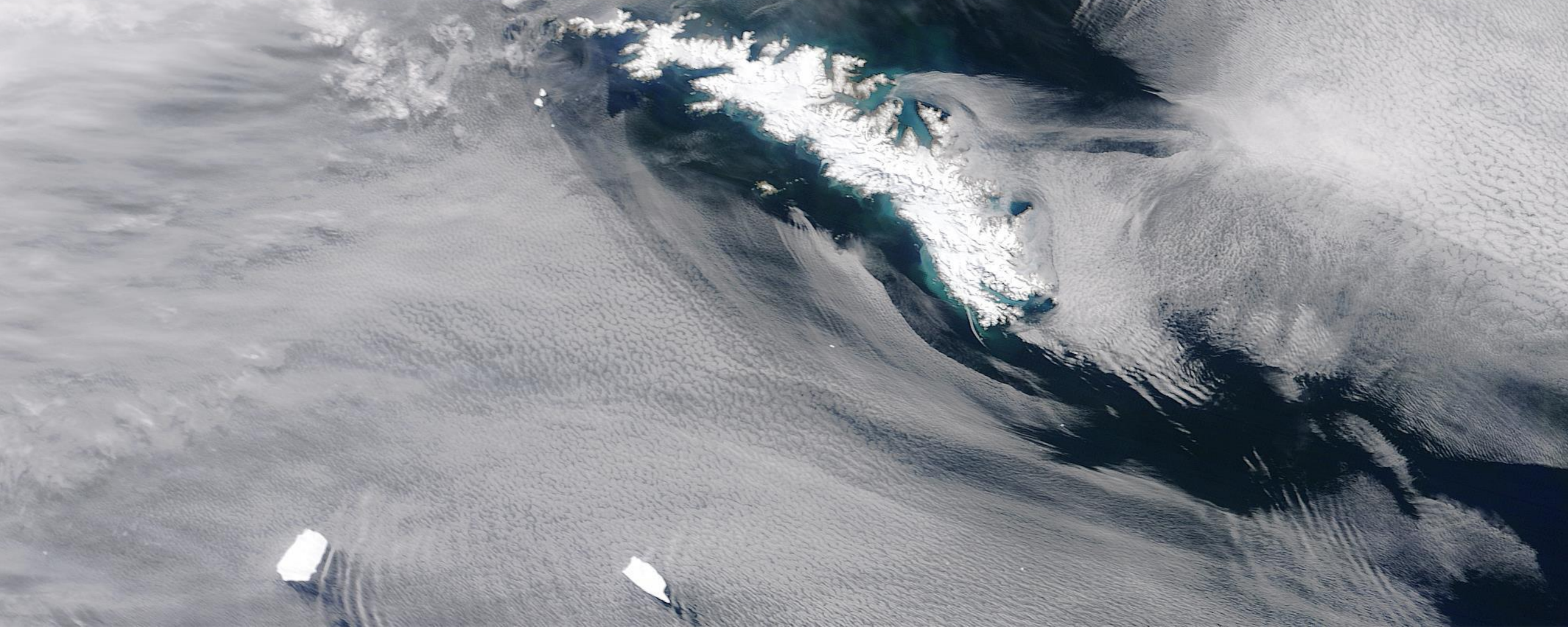

Knowing Meteors, Knowing u:
Using meteor radar to investigate winds, waves and tides in the mesosphere

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NERC SCIENCE OF THE ENVIRONMENT
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NATURAL ENVIRONMENT RESEARCH COUNCIL
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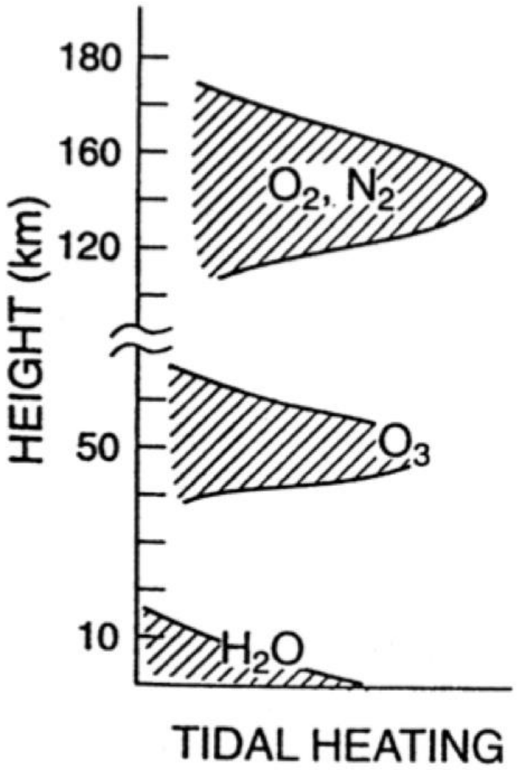
UNIVERSITY OF BATH

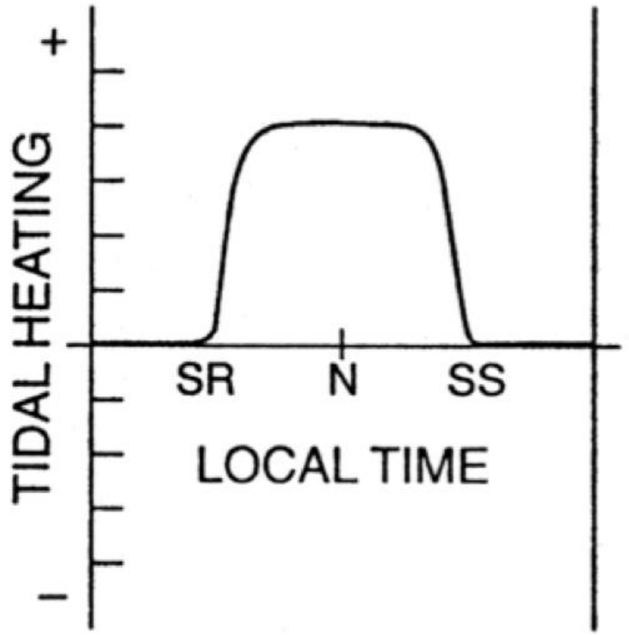
In this talk….

- What are atmosphere tides?
- Why do we care?
- How can we measure tides in the MLT?
- First results of tides over South Georgia.
- Possible causes of tidal variability.

What are atmospheric tides?

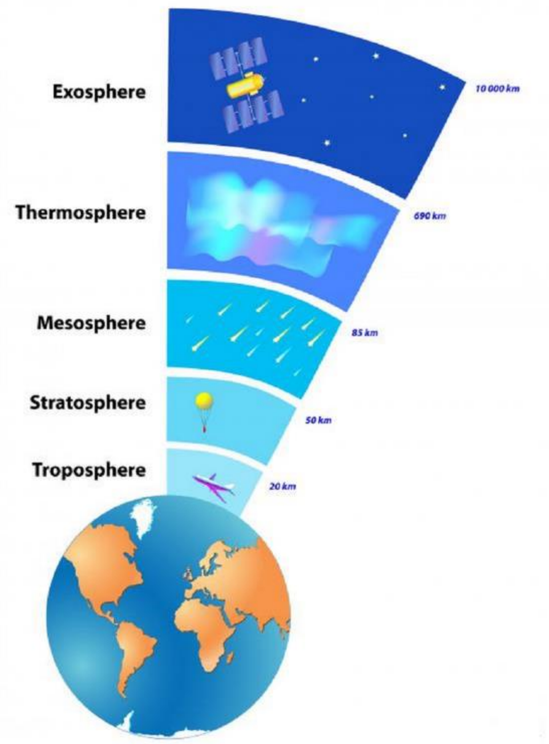
- Analogous to ocean tides but driven by solar heating - rather than the moon.
- Solar tides: produced by sun heating atmosphere.
- Tides appear in u, v, T, ρ etc.





Why do we care?

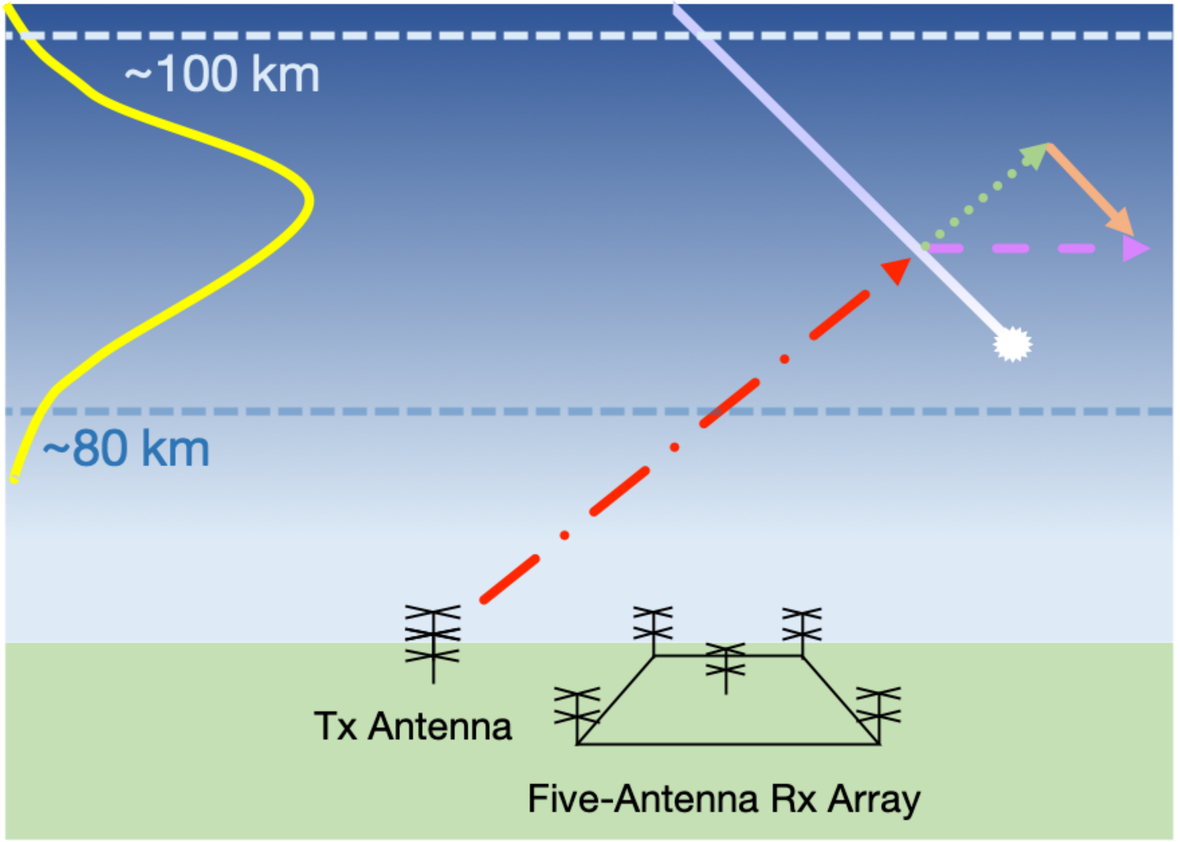
- They couple the whole atmosphere - from the surface to near-space.
- Next generation of GCMs will push into the thermosphere.
- Observations of tides are needed to constrain model development.
- However, MLT tides are notoriously difficult to measure…



How can we measure the tides in the MLT?

Measuring tidal winds in the MLT - Meteor Radar

- Meteor radar operate continuously to give hourly winds.
- Thousands of meteors used for wind calculation in the MLT region every day.
- Use a Doppler shift method from the ionised trail to measure winds.



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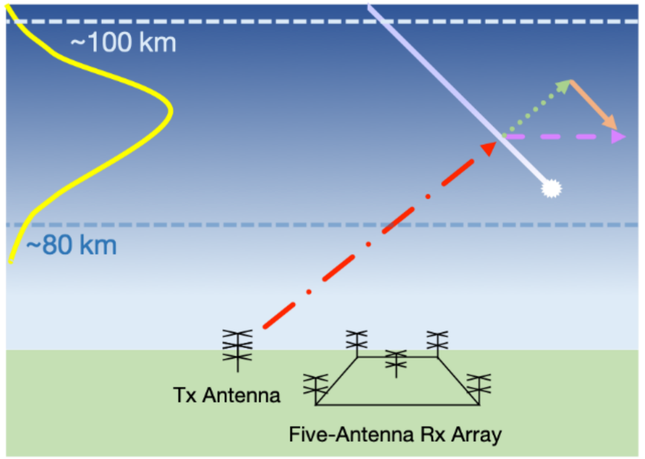
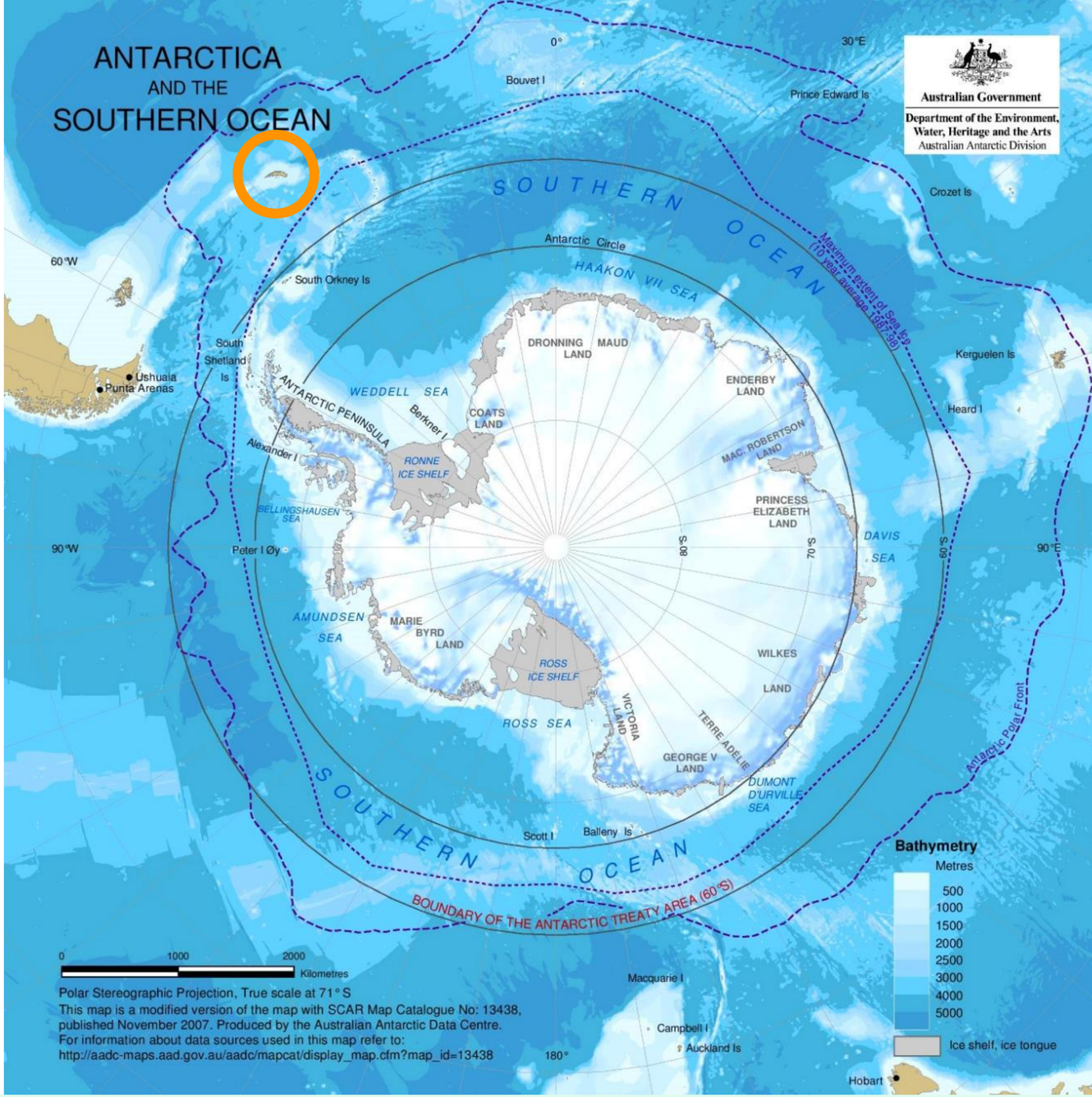
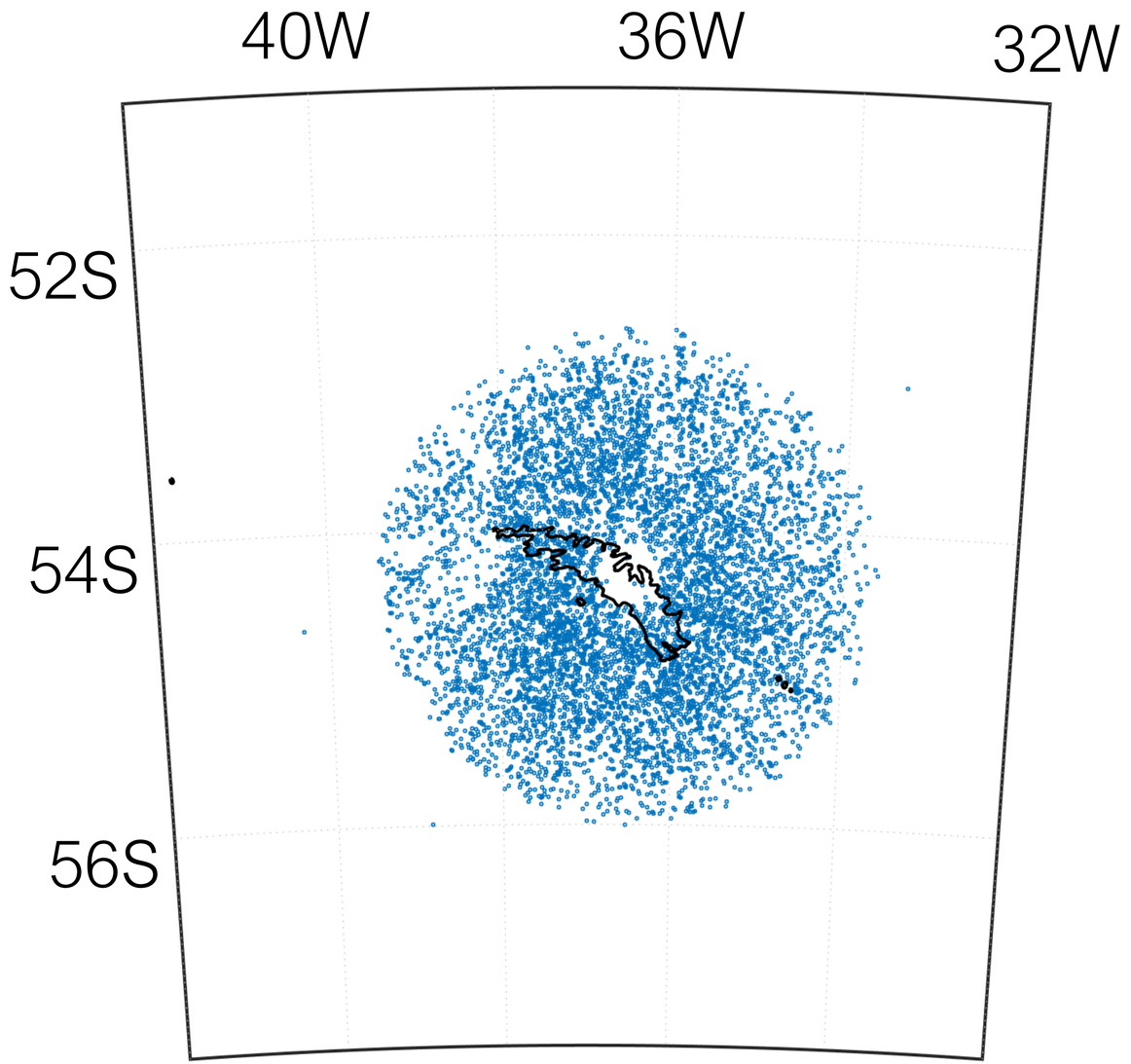
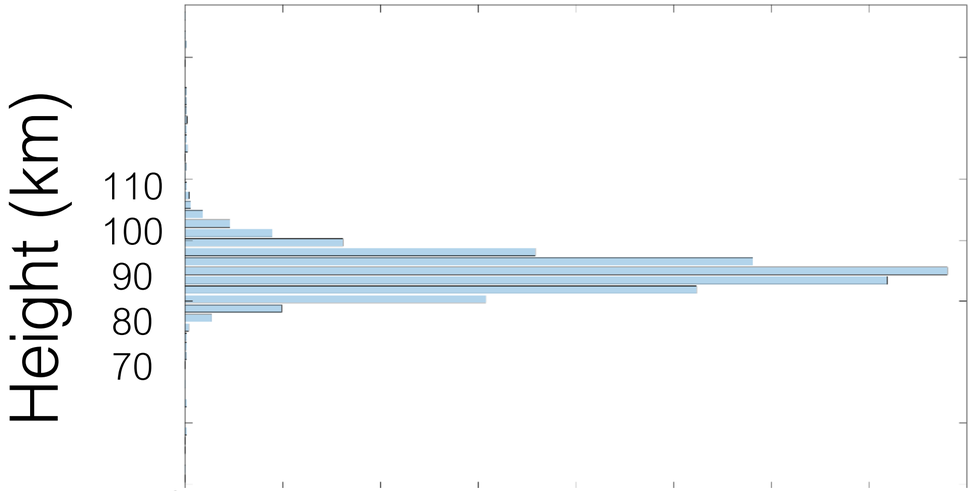


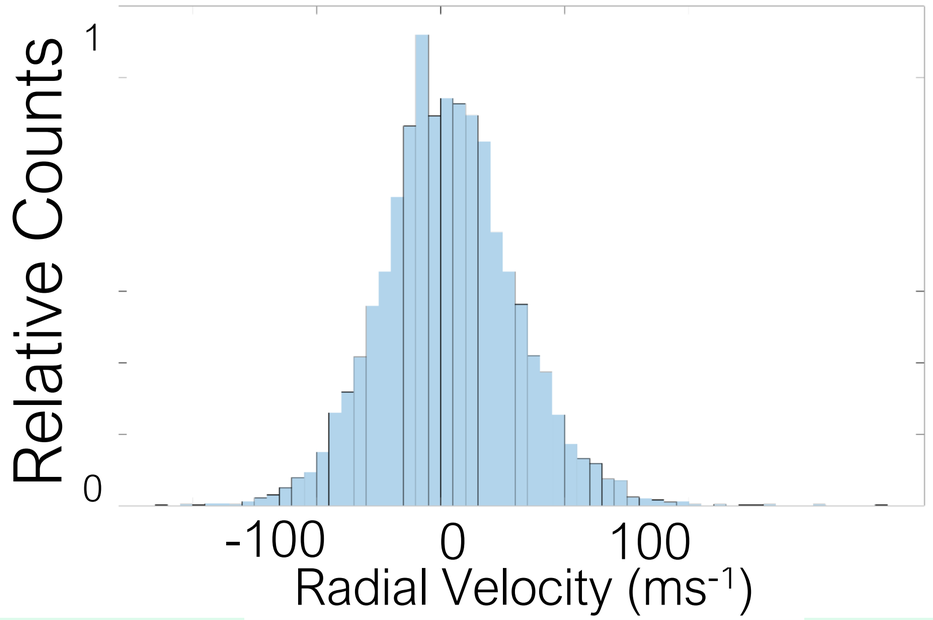
Where do we measure?

- Not much land at 50S to 60S!
- 12-hour tide maximises at this latitude.
- We have a meteor radar on South Georgia (orange).



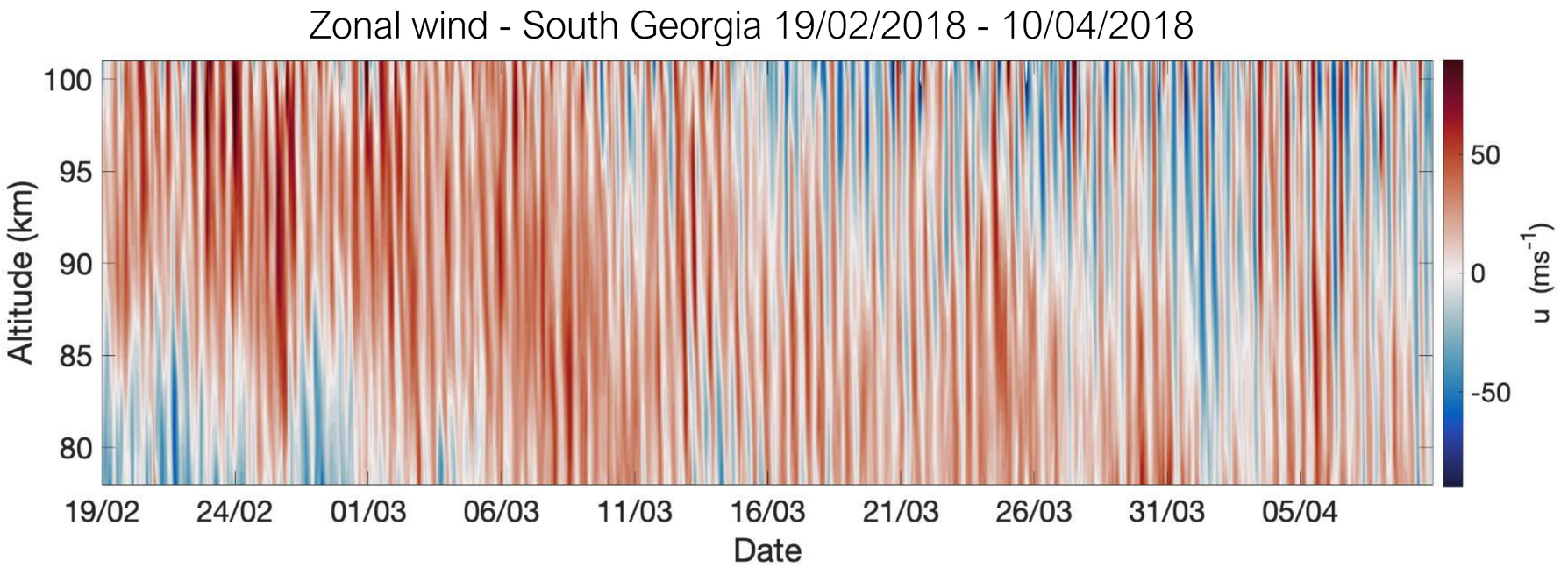

40W
36W
32W
52S
54S
56S


Height (km)
110
100
90
80
70
0
1
Relative Counts


Relative Counts
1
0
-100
0
100
Radial Velocity (ms-1)

First results of tides over South Georgia.

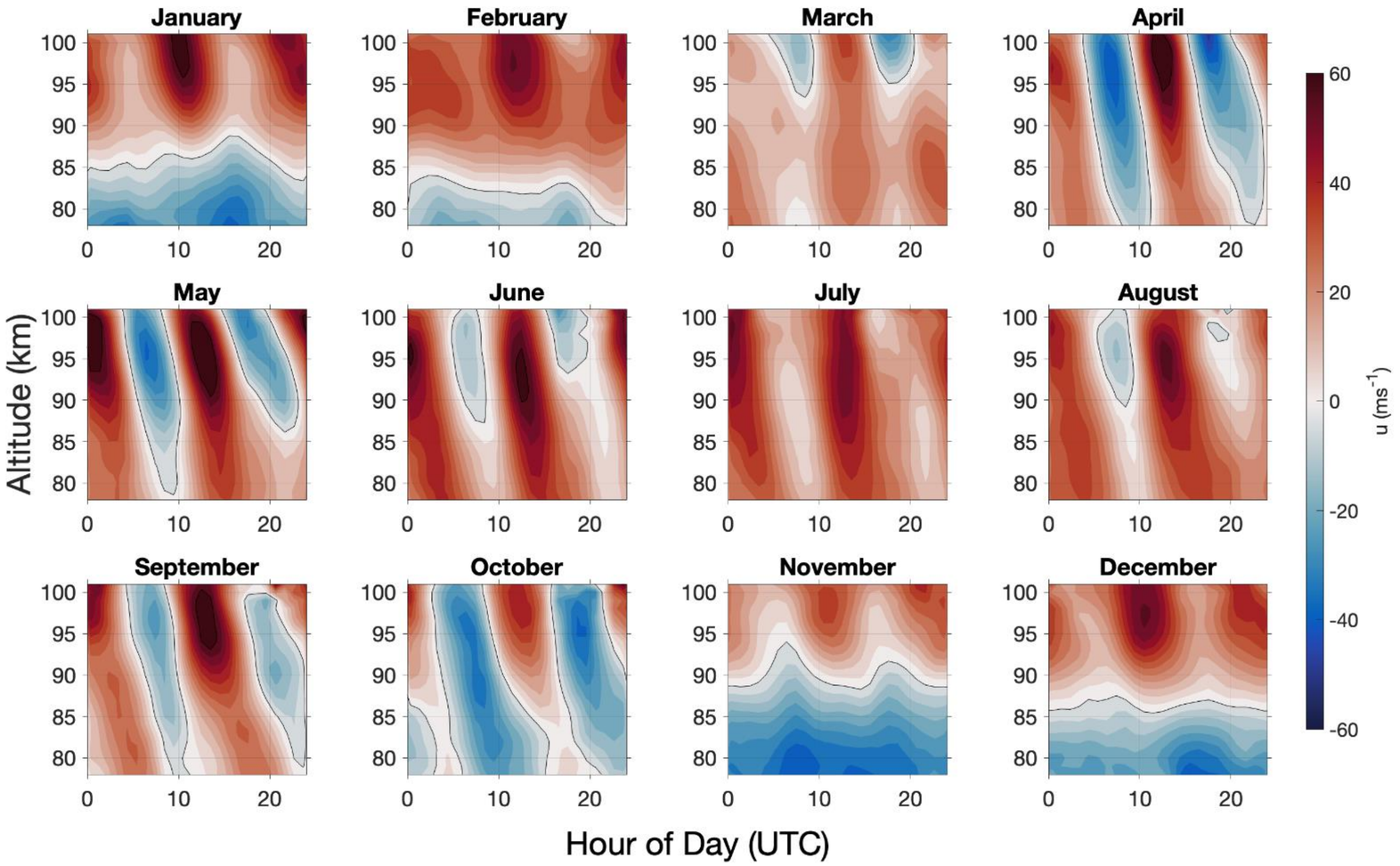
Meteor Radar MLT Winds



- Radar operates at all times.
- Hourly winds are a key strength of the radar.
- Continuous winds allows for spectral analysis.

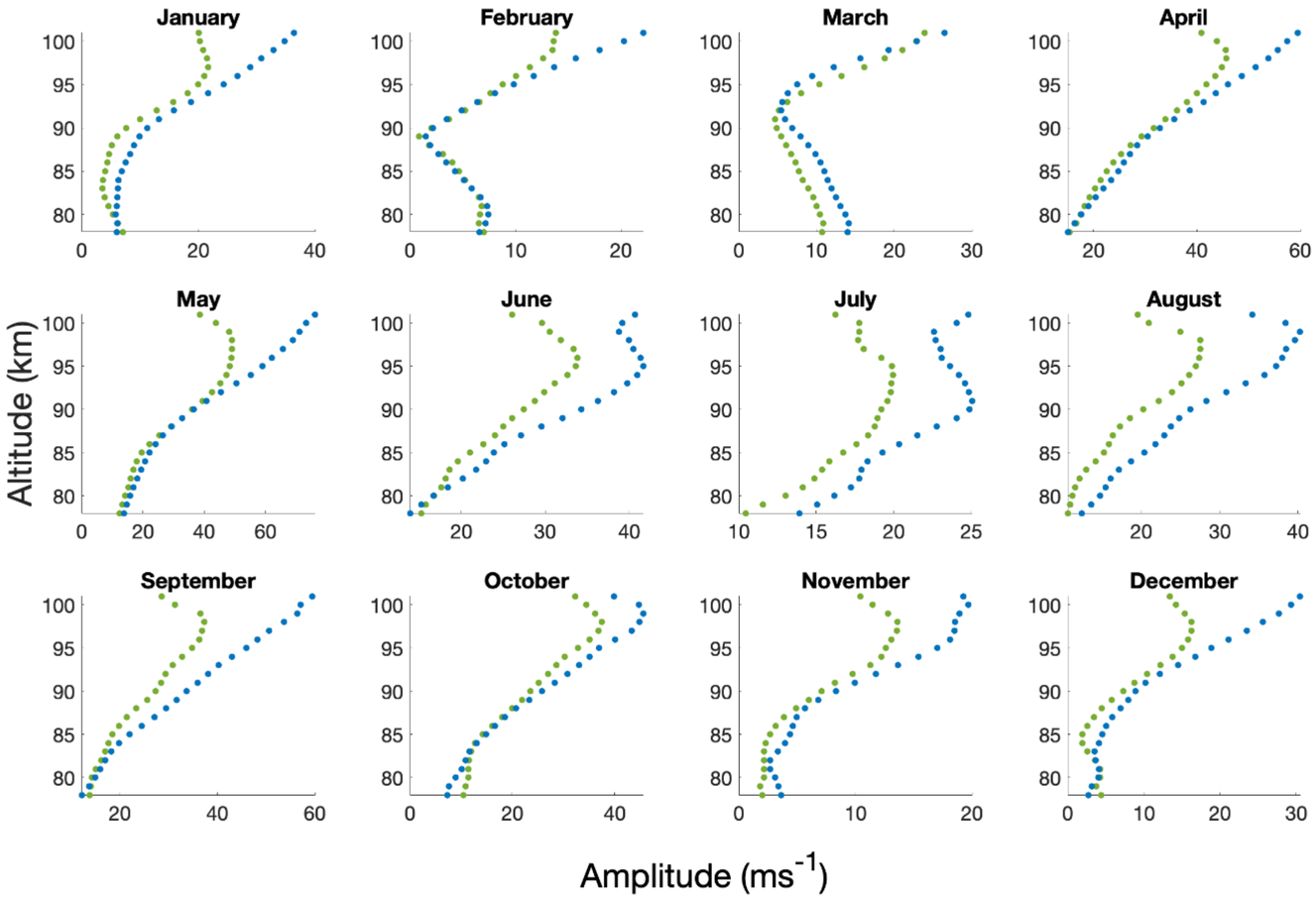
- Winds are from -60 ms^{-1} to +60 ms^{-1}.
- Strong changes at the daily scale.
- Huge 12-tide present.

Measuring the Tides



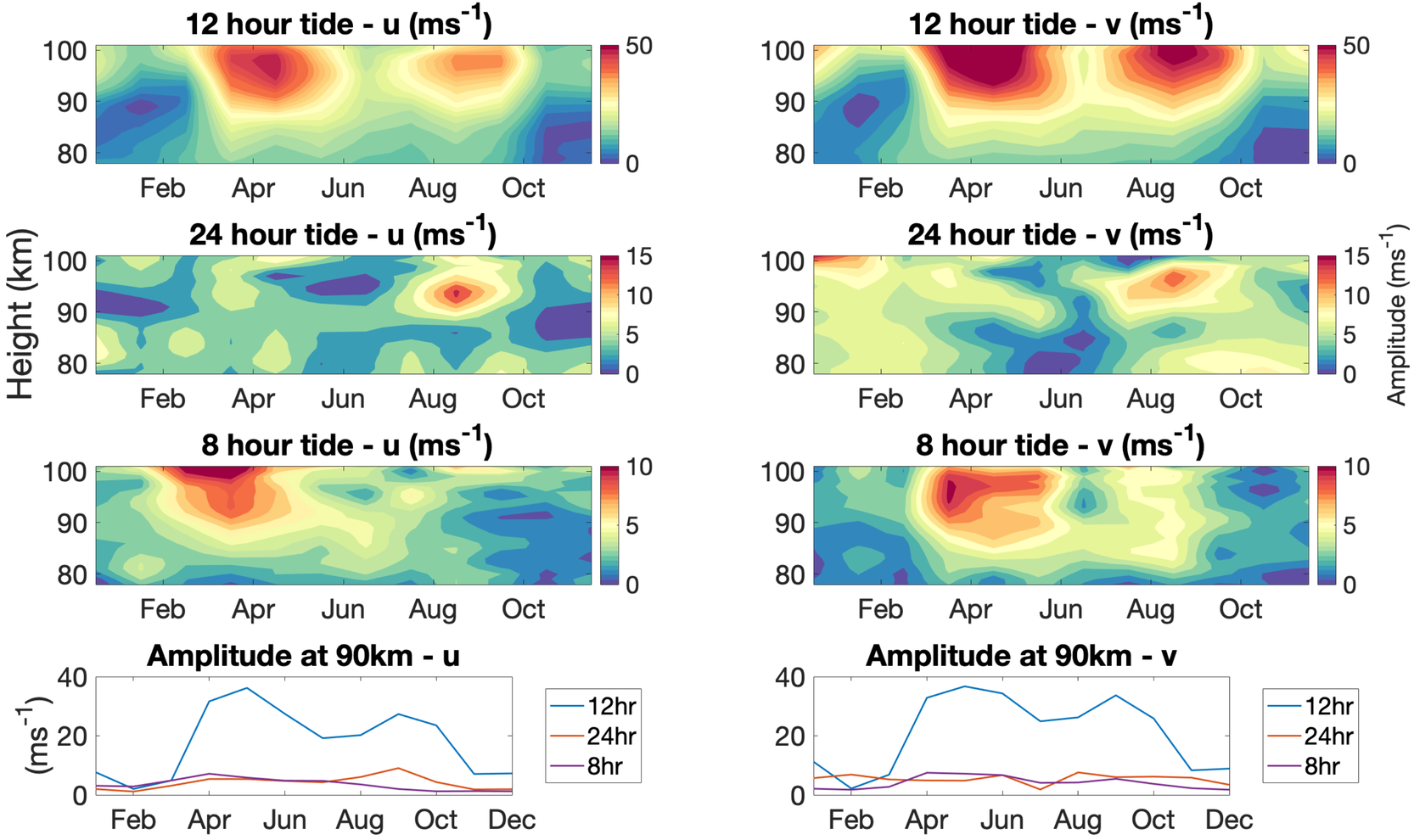
- Composite day (or mean day) highlights repeating features in the data.
- Black line indicates the 0 wind line.
- Very strong 12-hour tide during autumn into winter.

Tidal Amplitudes - 12-hour tide



- 12-hour tide amplitudes in zonal (green) and meridional (blue) directions.
- Tidal amplitudes usually larger at higher altitudes.
- Large month-to-month changes but zonal and meridional winds generally similar form.
- Amplitudes reach over 60 ms^{-1} in the MLT.

Seasonal Variability of the tides

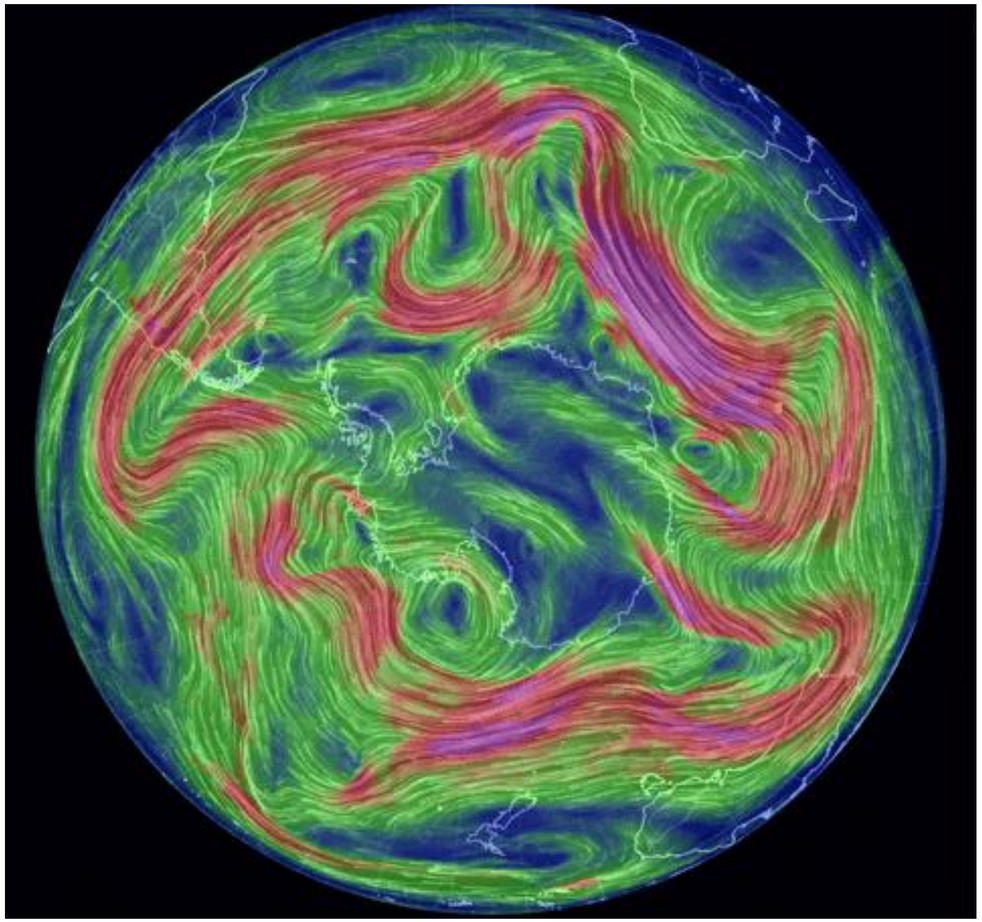


- 8- and 24- hour tide are weak in comparison to the 12- hour tide at this latitude.
- However, in v in February, the 12-hr tide is at a lower amplitude to the 24-hr tide and similar to the 8-hr.
- Strong seasonal variation in all tides.

Possible causes of tidal variability.

Proposed drivers of tidal variability.

- Heating changes related to solar variability.
- Changes to atmospheric background such as wind.
- Non-linear coupling with other tidal modes and planetary waves.



Conclusions

- Atmospheric tides dominate the dynamics of the MLT region
- Radar provides exceptional data set to investigate tides.
- Massive tidal variability at all time scales from hours to annually.
- Next step: investigate physical drivers of this variation with the eCMAM model.

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Spectral Analysis

- A Lomb-Scargle periodogram can show us what repeating features are present in our data
- Here is 2018 over South Georgia.
- Atmospheric tides are strong - particularly the 12-hour tide.
- Clear that atmospheric tides are dominating the spectral power.
- But how strong are they?