In-situ measurements of ozone and gravity waves during the Concordiasi 2010 long-duration balloon campaign in the Antarctic lower stratosphere

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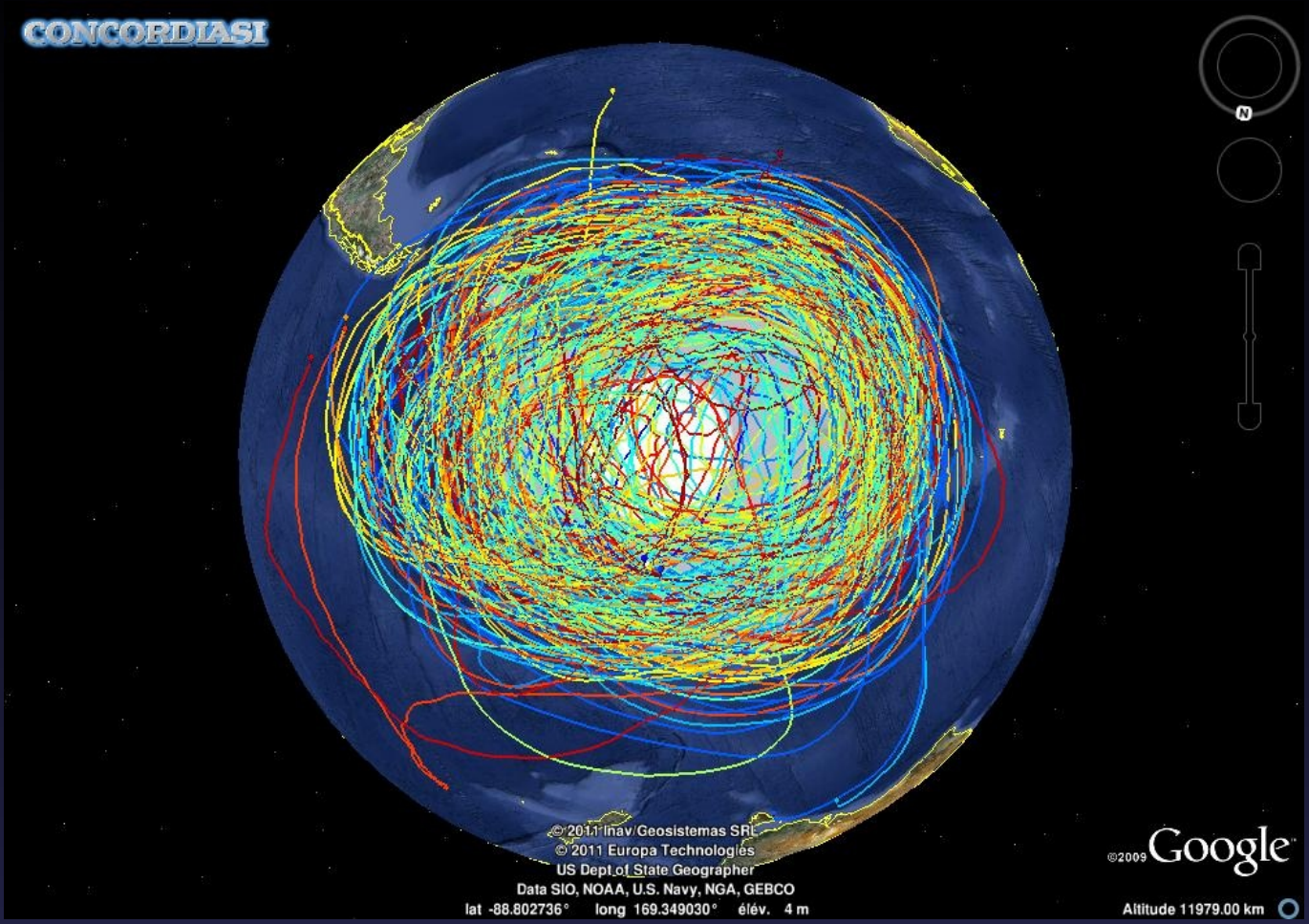
AWI team and sounding stations in Antarctica

Concordiaisi Workshop, Boulder, Oct. 2011

Concordiasi

19 long-duration, superpressure-balloon flights

Sept. 2010- Jan. 2011
Mean duration : 69 days



Flight-level measurements

- Meteorological obs. every 30 s (> 2.3 Gobs)
  TSEN (LMD) + GPS (ISBA/CNES)
  u, v (0.02 m/s), P (0.1 Pa), T (<0.1/0.3 K)
  → assimilated by operational NWPs
- Ozone obs. every 15 min (6 flights)
  B-Bop (LMD) + UCOz (UCAR)
  lightweight ozone UV photometer
  precision: 20 ppb

Tsen dataset

- A final version of the Tsen dataset has been produced in May 2011
  - Merge of Isba positions w/ Tsen met. Observations
  - Interpolation in small data gaps (< 15 min)
  - Correction for daytime heating of temperature sensors

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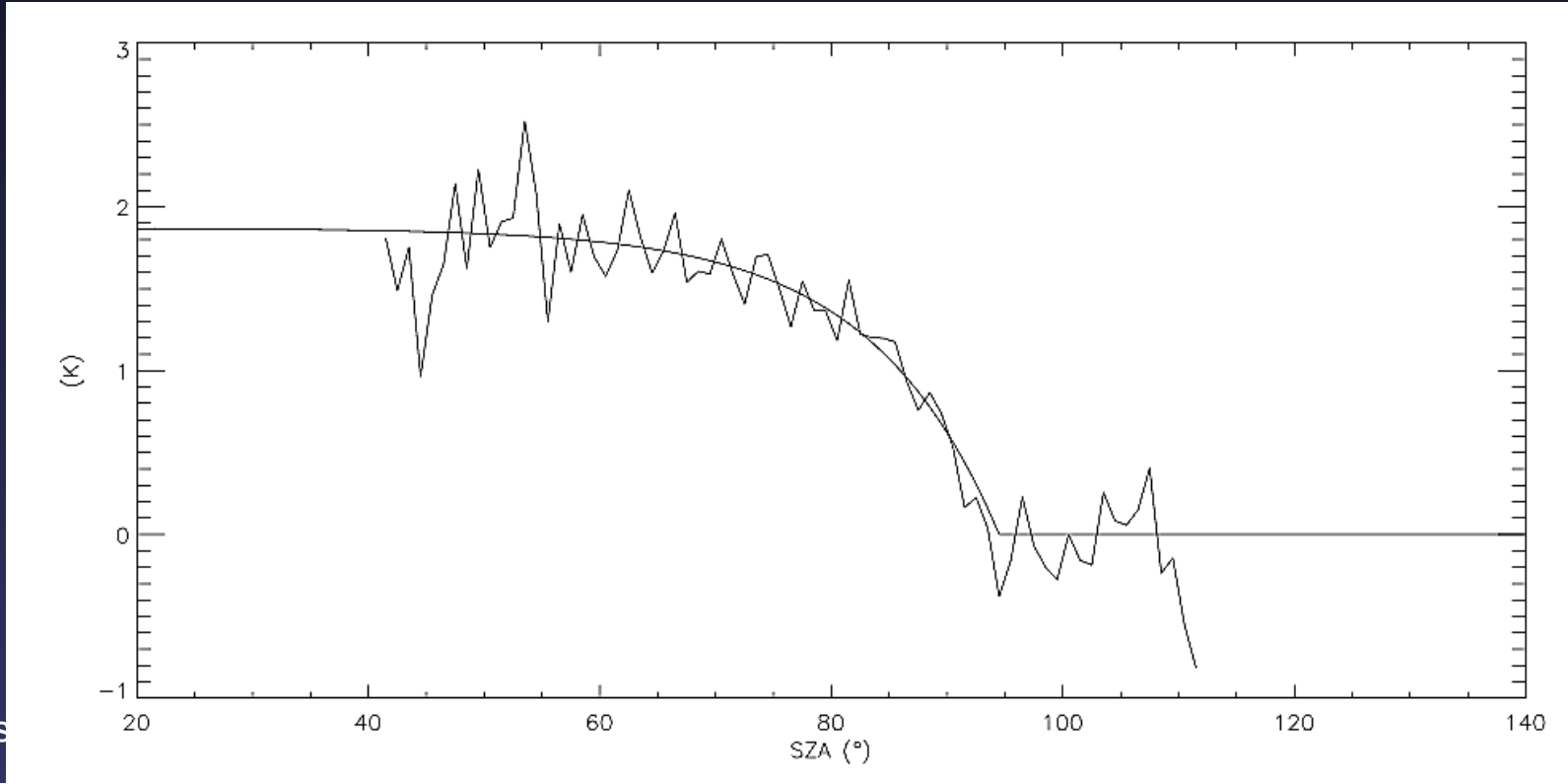

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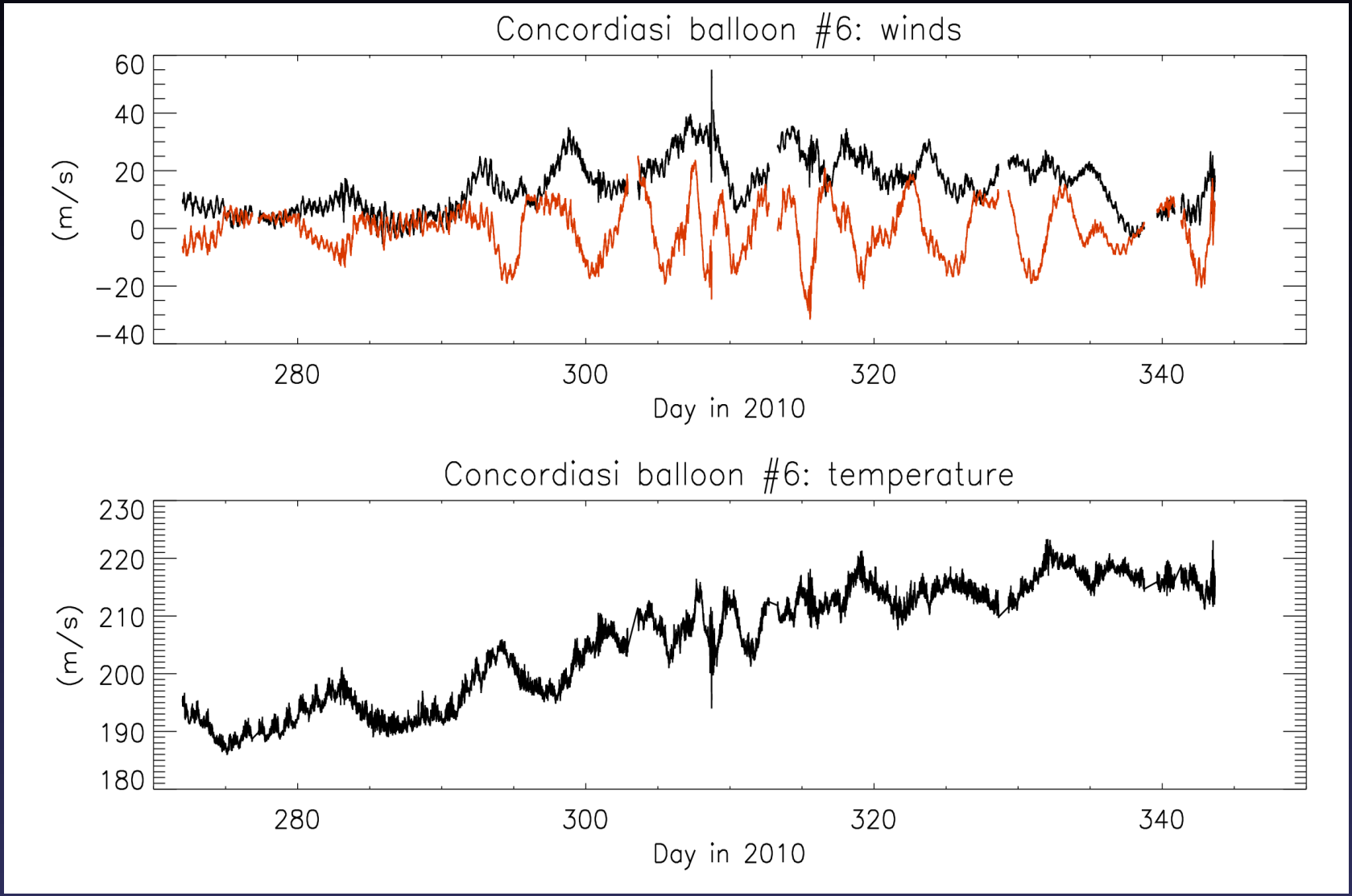
  - Merge of Isba positions w/ Tsen met. Observations
  - Interpolation in small data gaps (< 15 min)
  - Correction for daytime heating of temperature sensors
- Archived in the Concordiasi database and LMD ftp repository

Some observations



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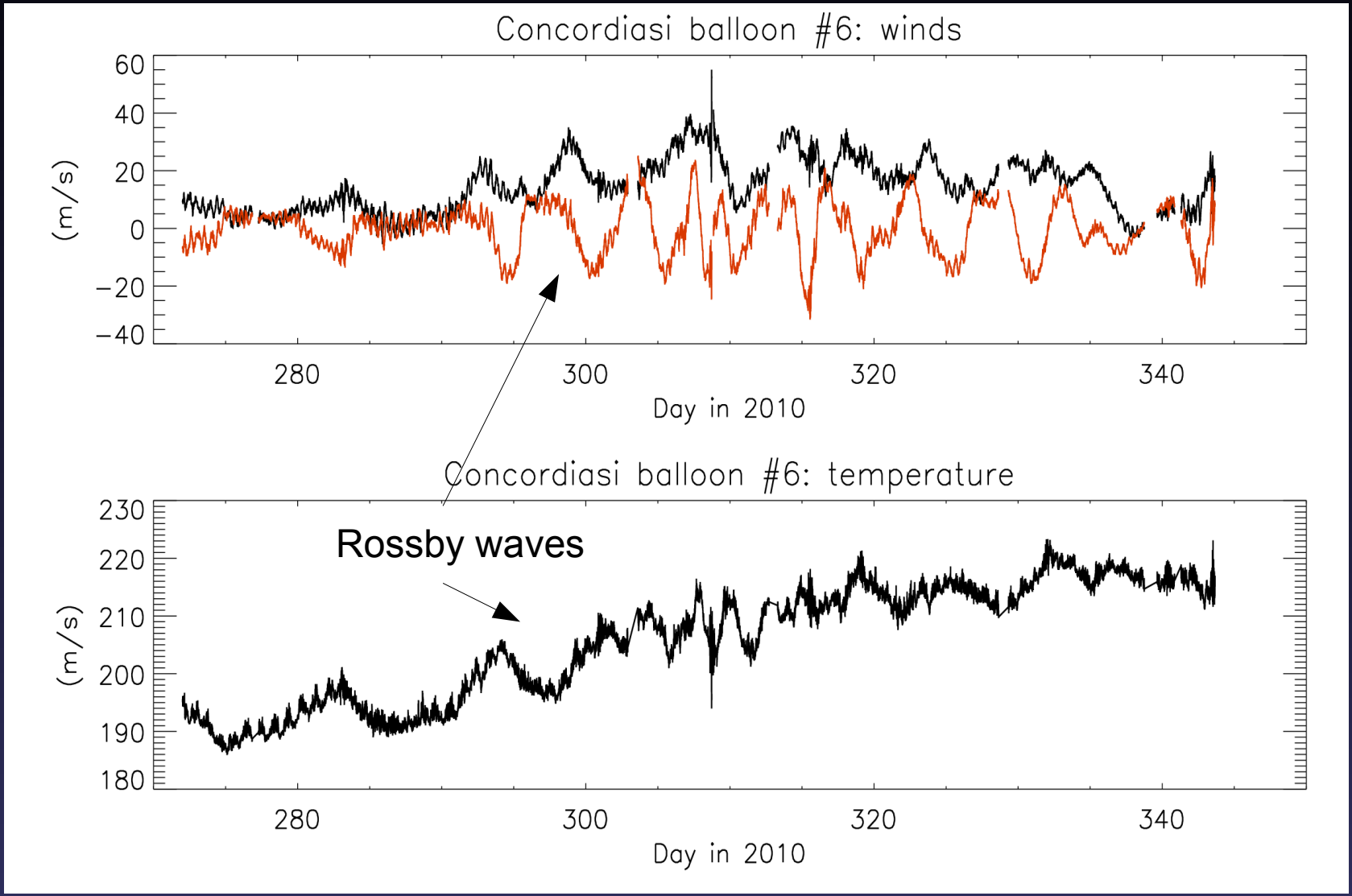

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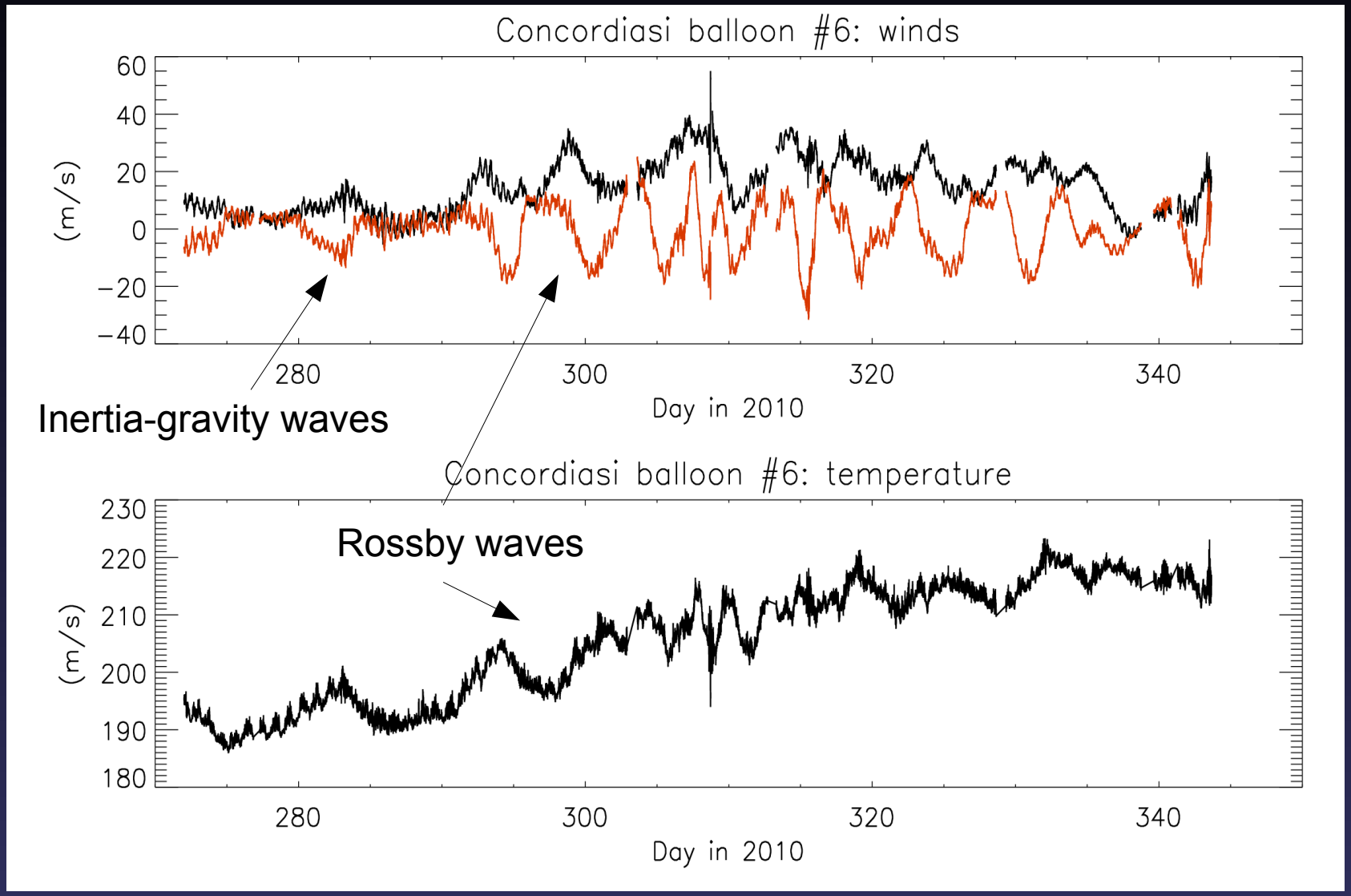

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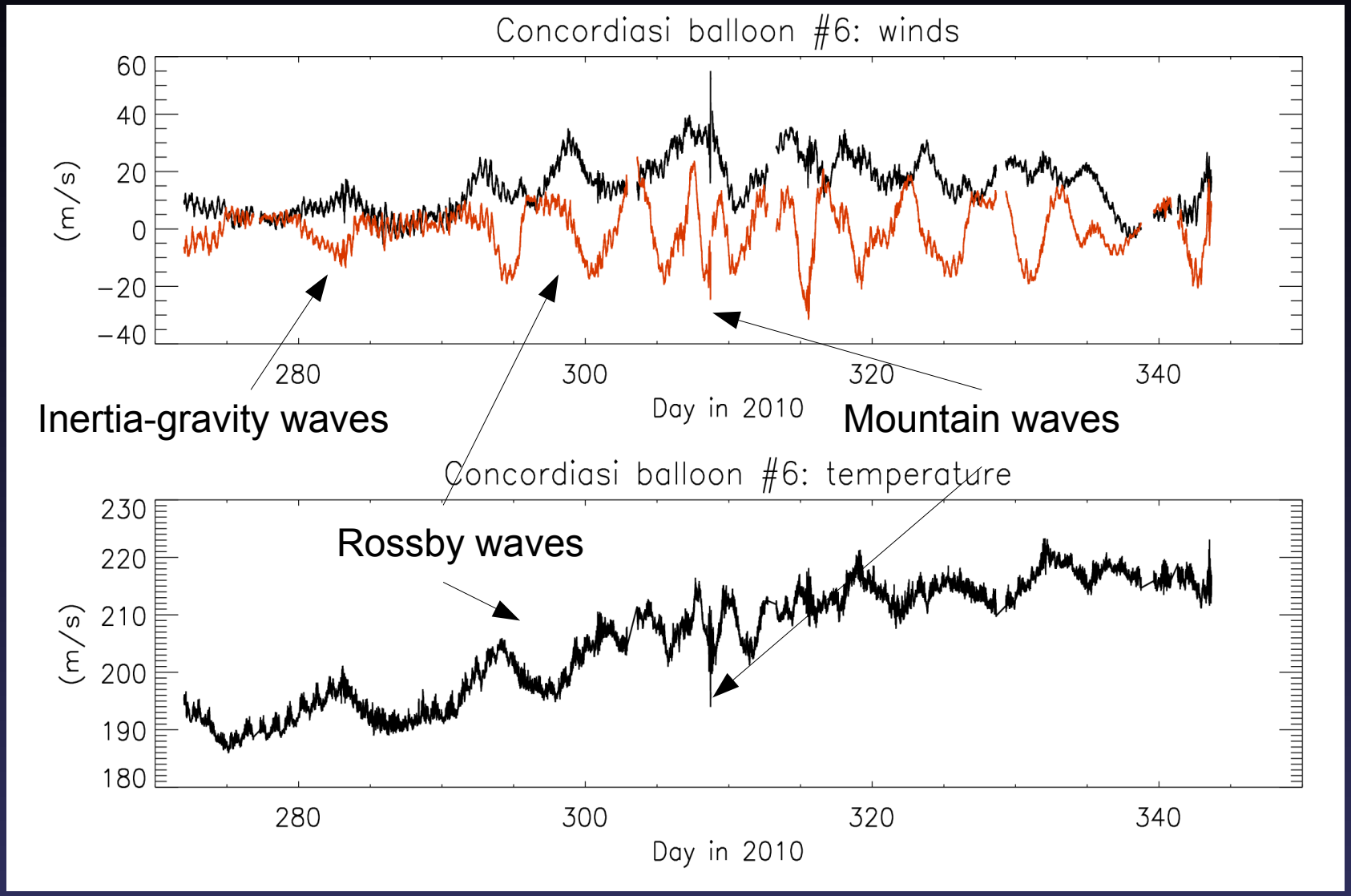

Gravity waves

- Gravity waves play a major role in driving the global Brewer-Dobson circulation in the middle atmosphere, as well as in warming the winter polar stratosphere
  - Parameterized in GCMs → need observations to constrain parameters
  - Observations at global scales are difficult, as well as diagnosing momentum flux

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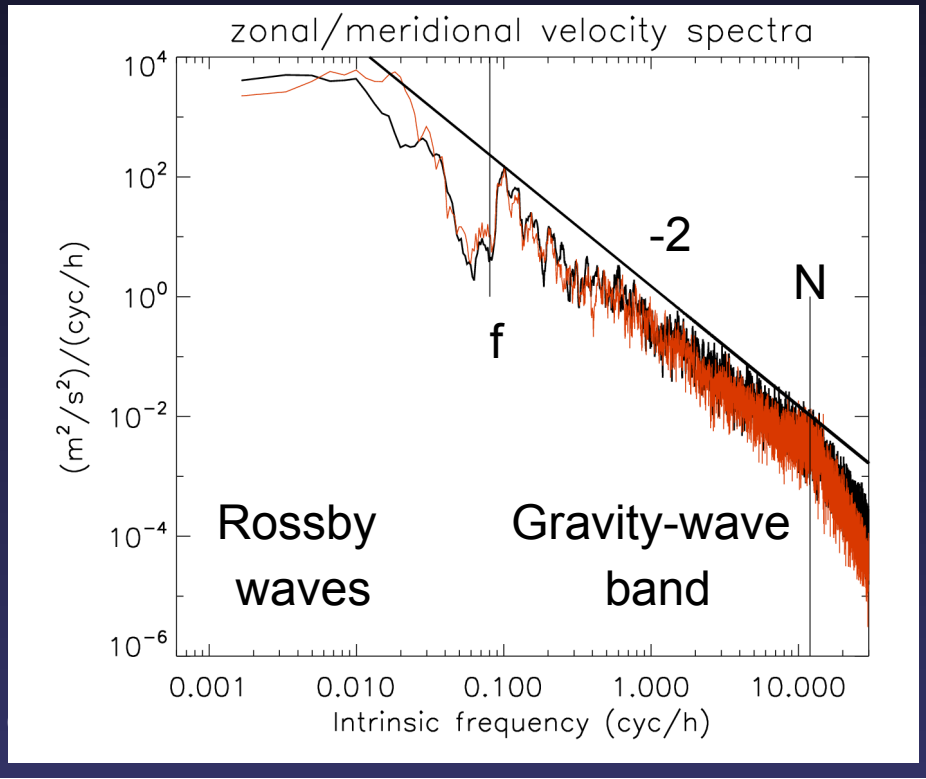

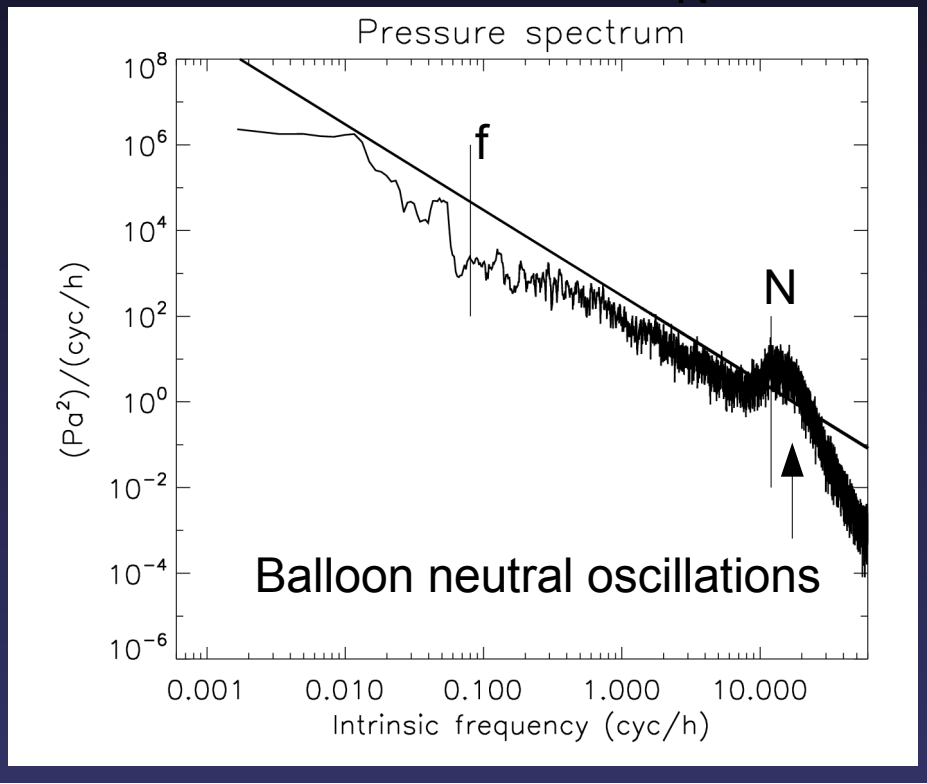

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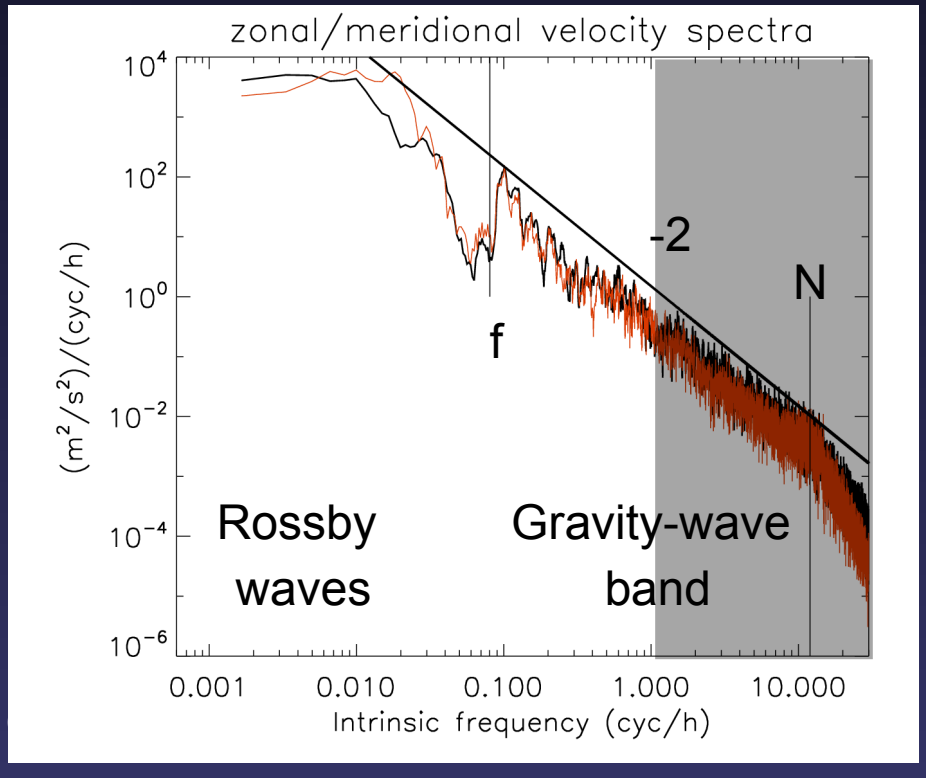
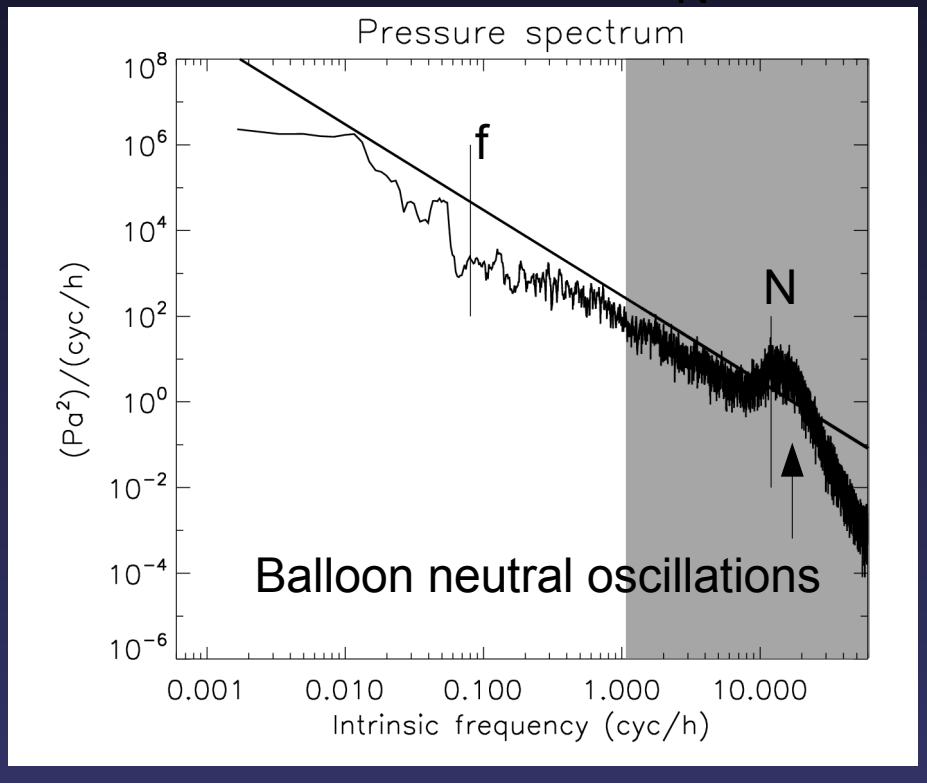
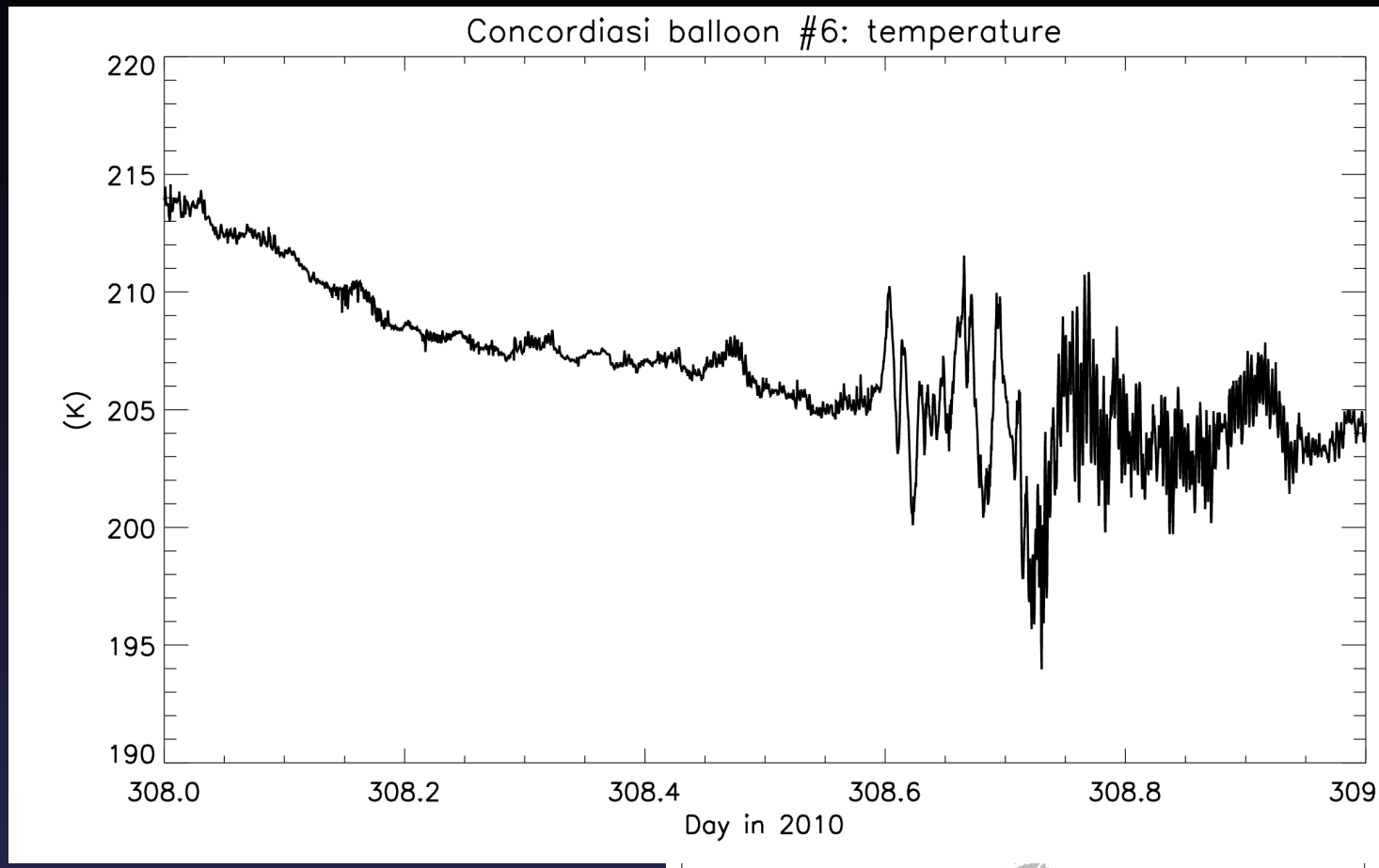




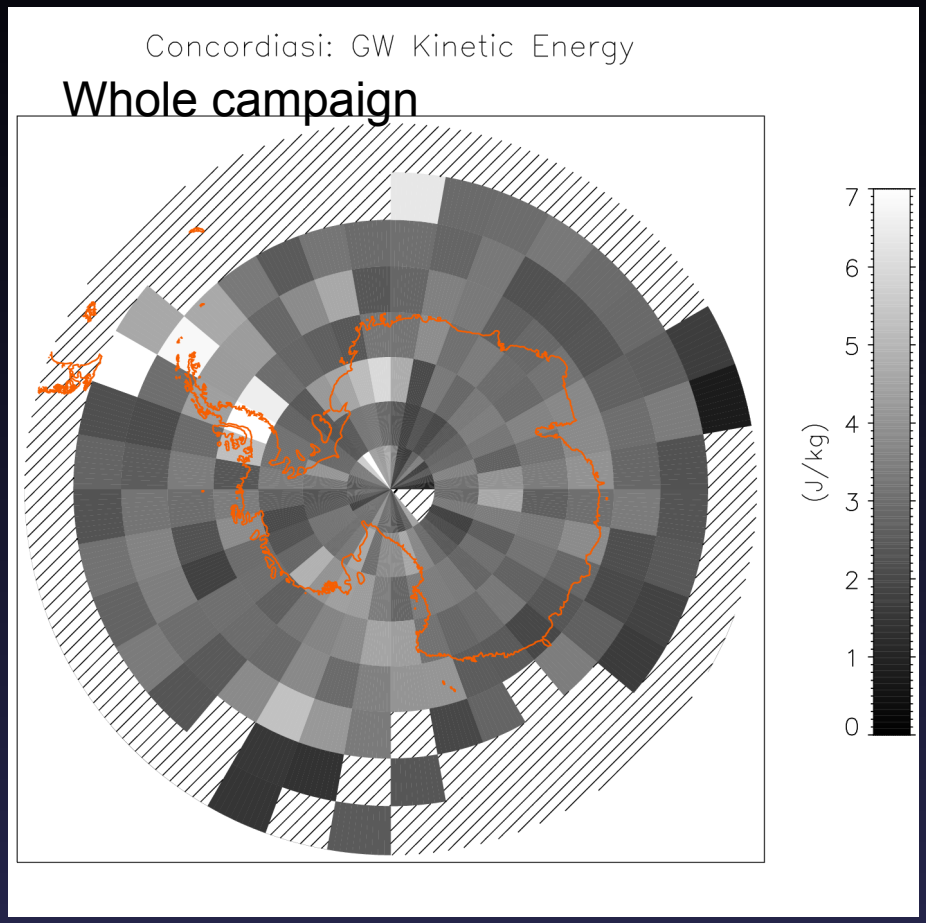
Orographic gravity waves

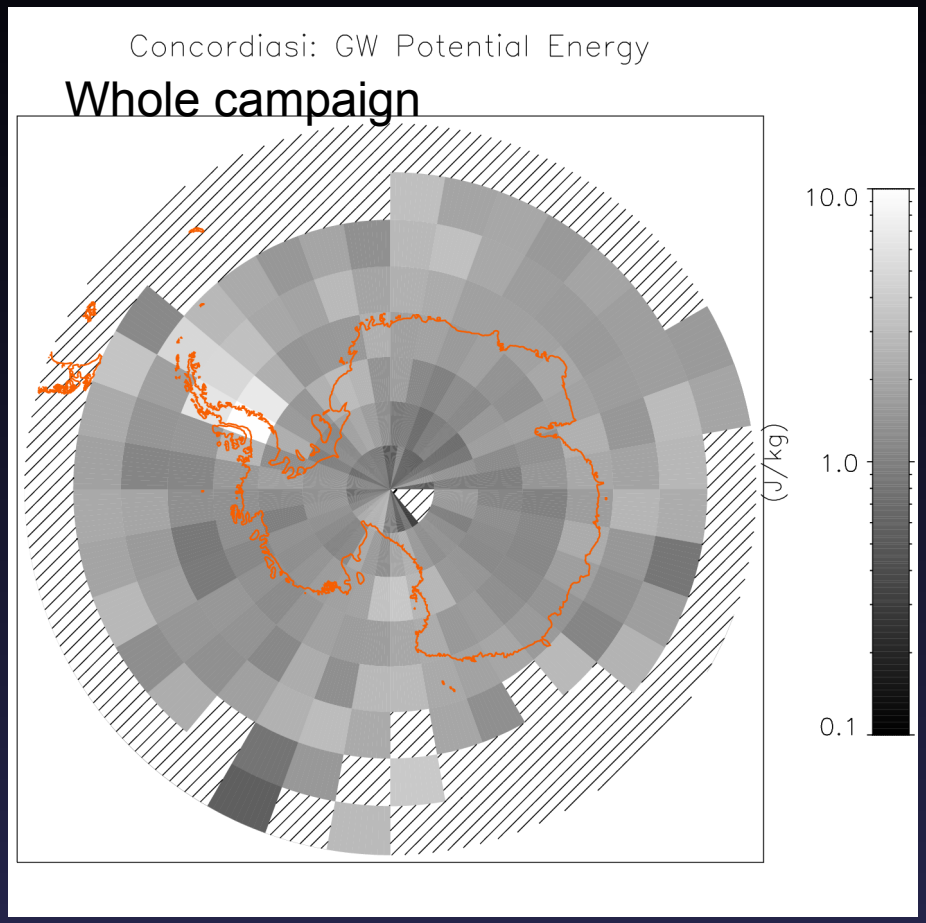


T' ~ 15 K, u' ~ 35 m/s
Vertical displ. 1.5 km
Period of 10 min – 1 hr
→ fully resolved by obs.

Such mountain waves are not only important for dynamics but can also trigger the formation of PSC particles

Gravity waves

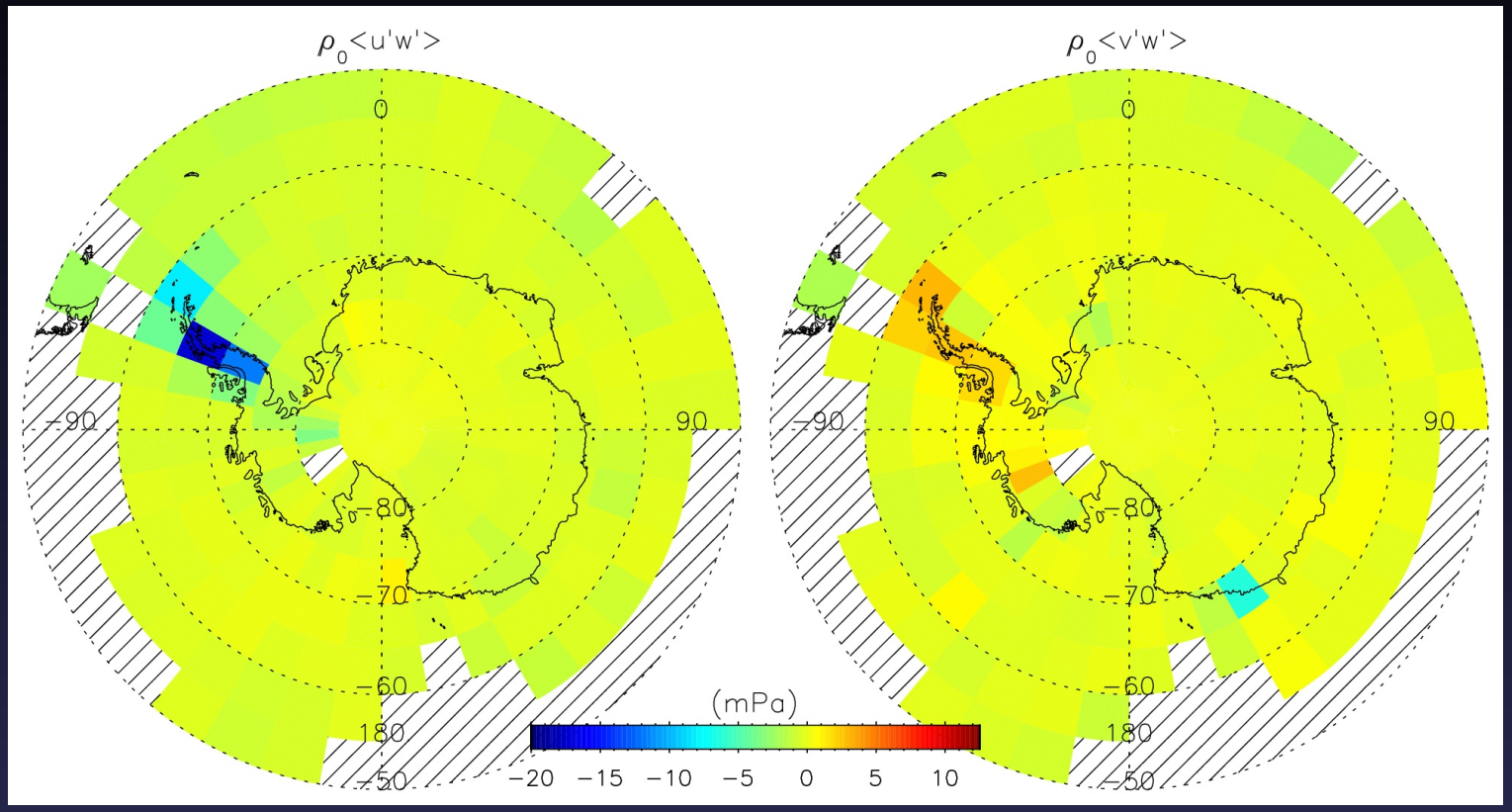




Antartica Peninsula and Drake Passage are hotspots of gravity-wave activity in Antarctica
Potential energy (higher frequency waves) increases from the Pole toward mid-latitudes
→ GW source above the oceans (storm tracks, front, convection)

Directional momentum fluxes

Zonal Meridional



Extend Vorcore 2005 results to higher-frequencies in terms of momentum fluxes

Directional momentum fluxes

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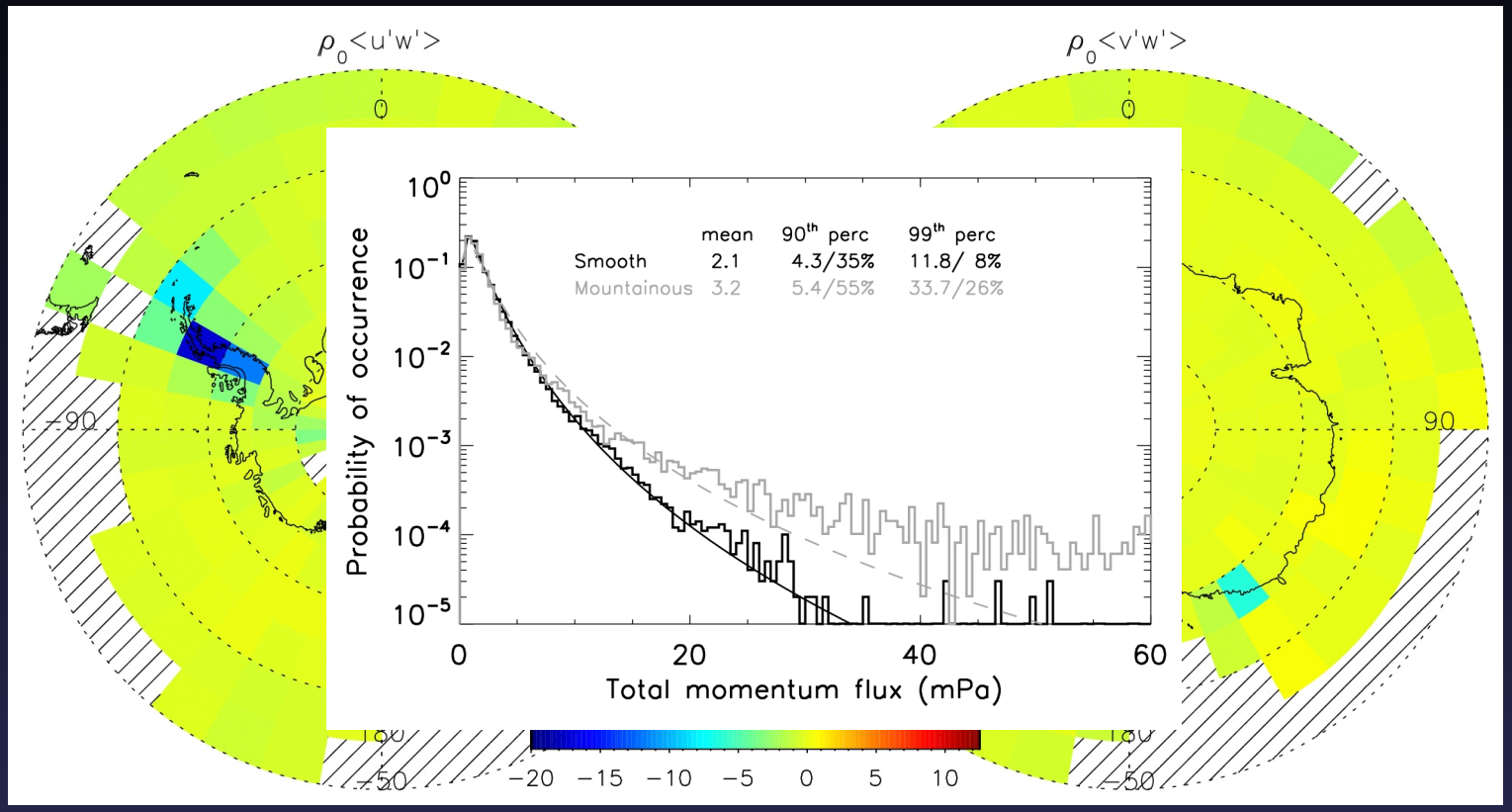
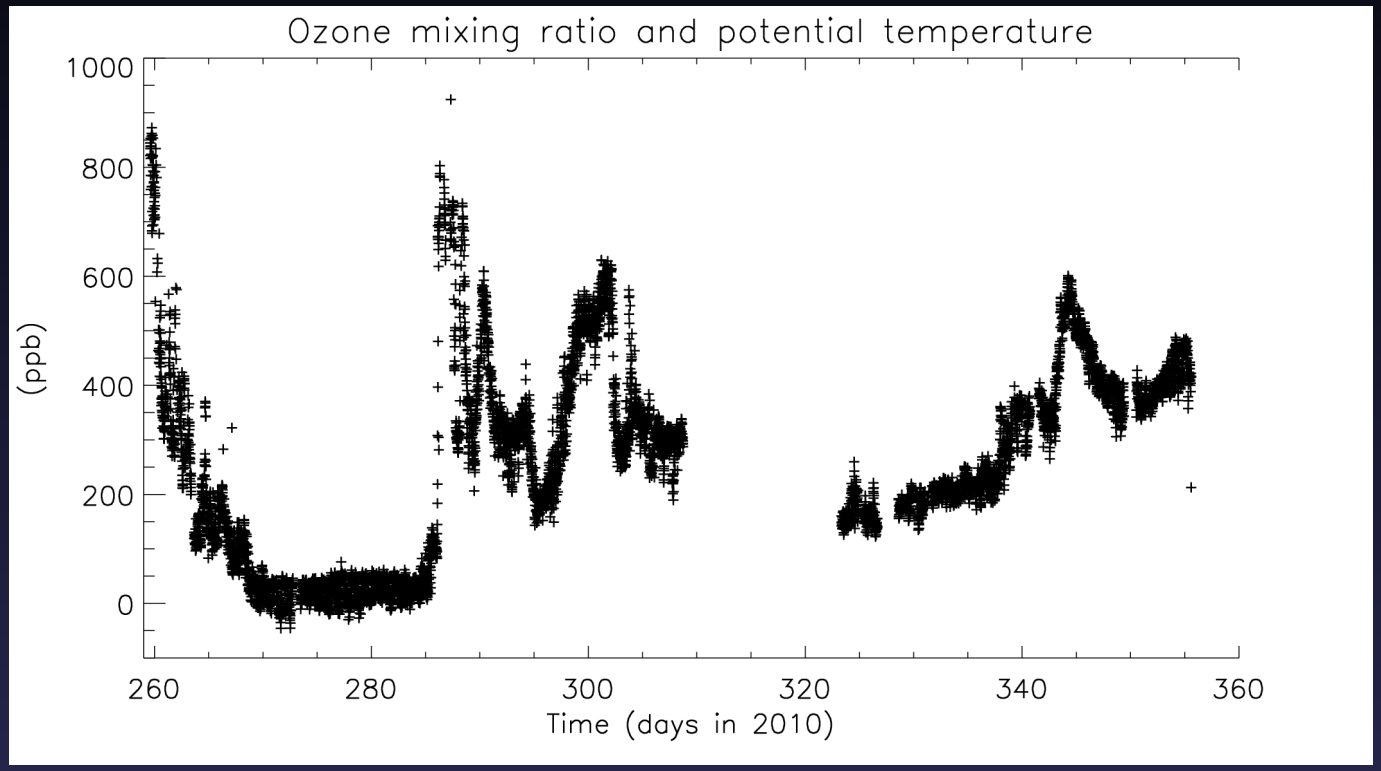


Extend Vorcore 2005 results to higher-frequencies in terms of momentum fluxes and wave intermittency

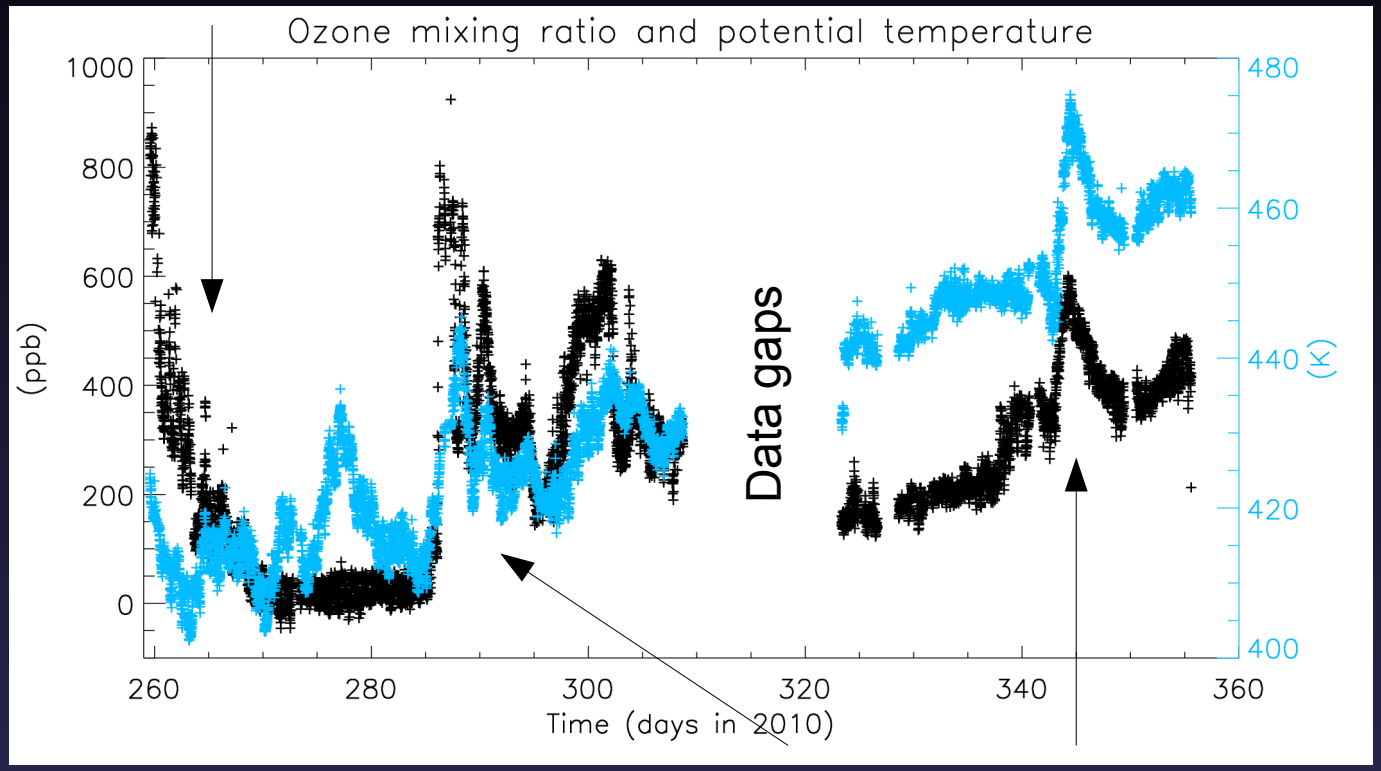
Ozone observations – PSC 14



Super-pressure balloons behave as quasi-Lagrangian tracers
→ could track ozone evolution in an 'air mass'

Ozone observations - PSC14

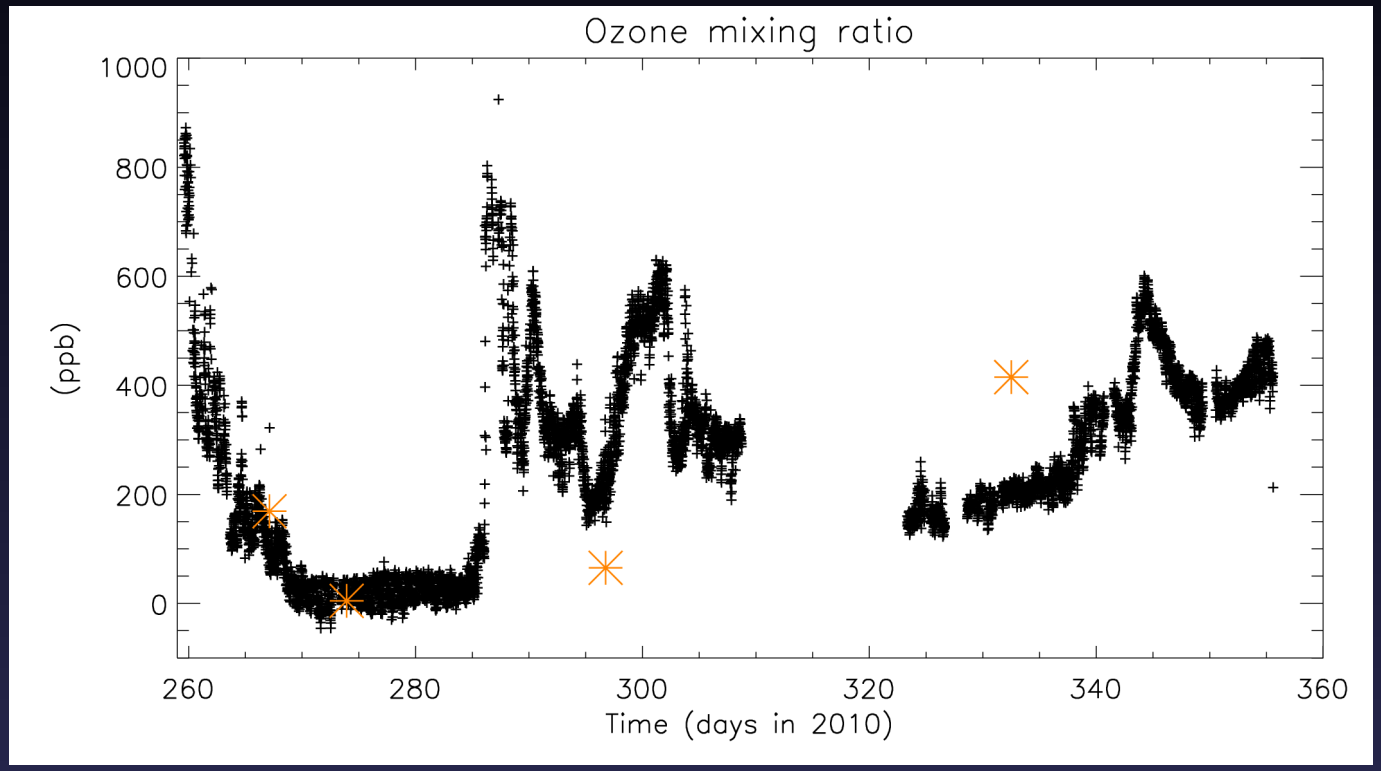
Chemical depletion



Transport-dominated variations

Ozone observations - PSC14

Coordinated match campaign



McMurdo	McMurdo	Belgrano	South Pole
24 Sept.	1st Oct.	23 Oct.	28 Nov.

Ozone loss estimates

- Explain the ozone variations due to balloon motions :
  - Project ozone variations on potential temperature (1 day window)

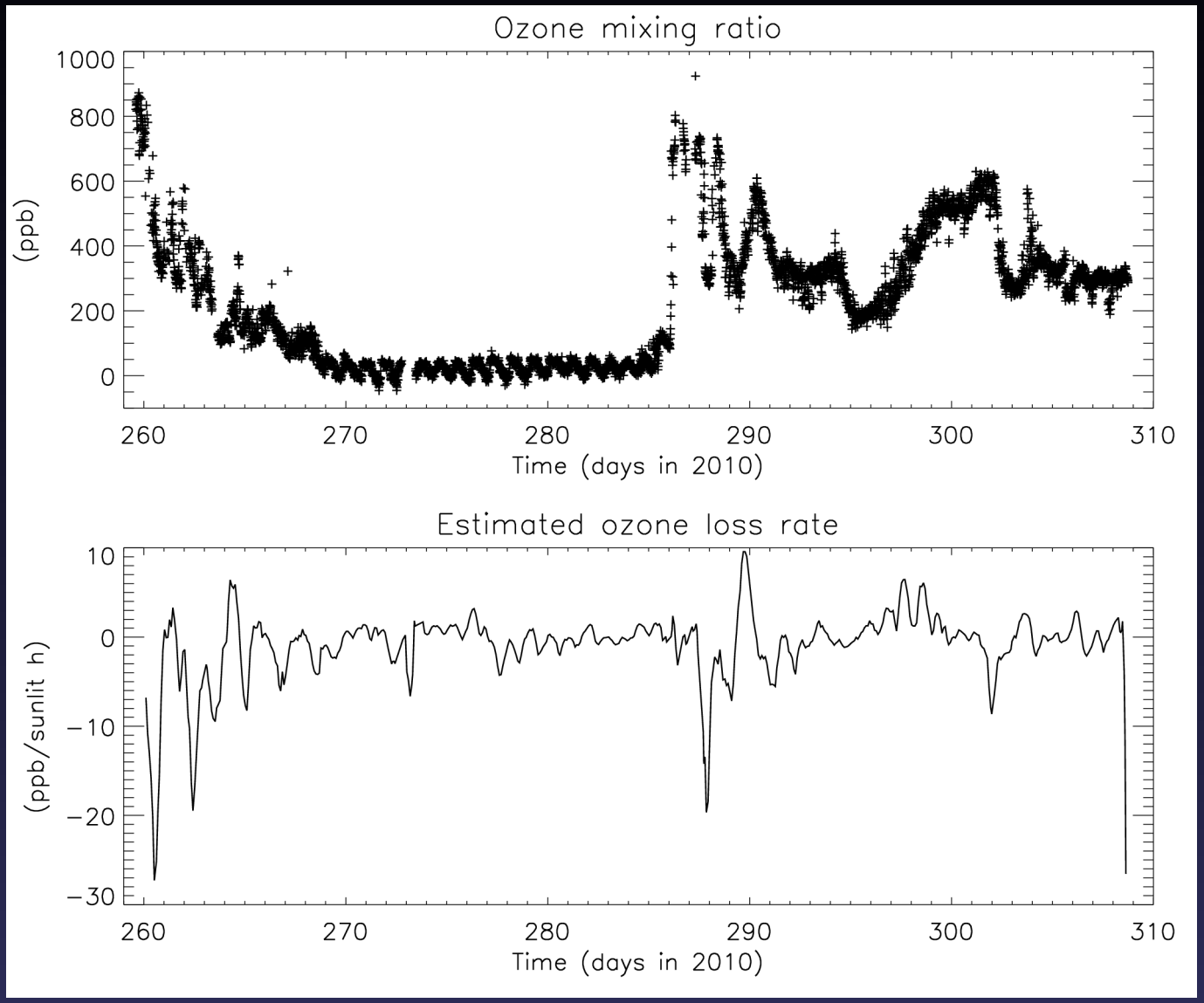
    $X_{O3}(t) = a\ \theta(t) + \varepsilon(t)$

- Explain the residual in terms of ozone loss :

  $\varepsilon(t) = \text{loss} \,.\, t + c(t)$

  express loss in ppb/sunlit hour

Ozone loss estimates



Ozone loss generally < 10 ppb/sunlit hour but can reach up to 25 ppb/sunlit hour

Conclusions

- Concordiasi dataset shows promising dynamics studies
  - Almost whole gravity-wave range resolved
  - Ability to compute momentum fluxes, study wave intermittency
- Ozone measurement have been sucessfully performed
  - Diagnose ozone loss on a quasi-Lagrangian vector
  - Compare PSC 14 w/ other flights (including Ucoz)
- … obviously lot of work to do in the coming years

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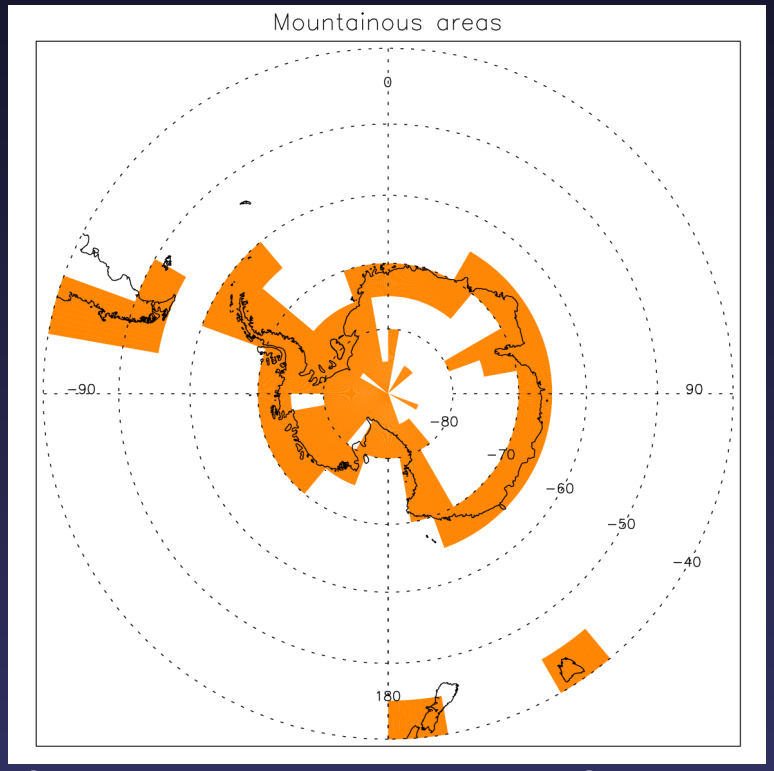
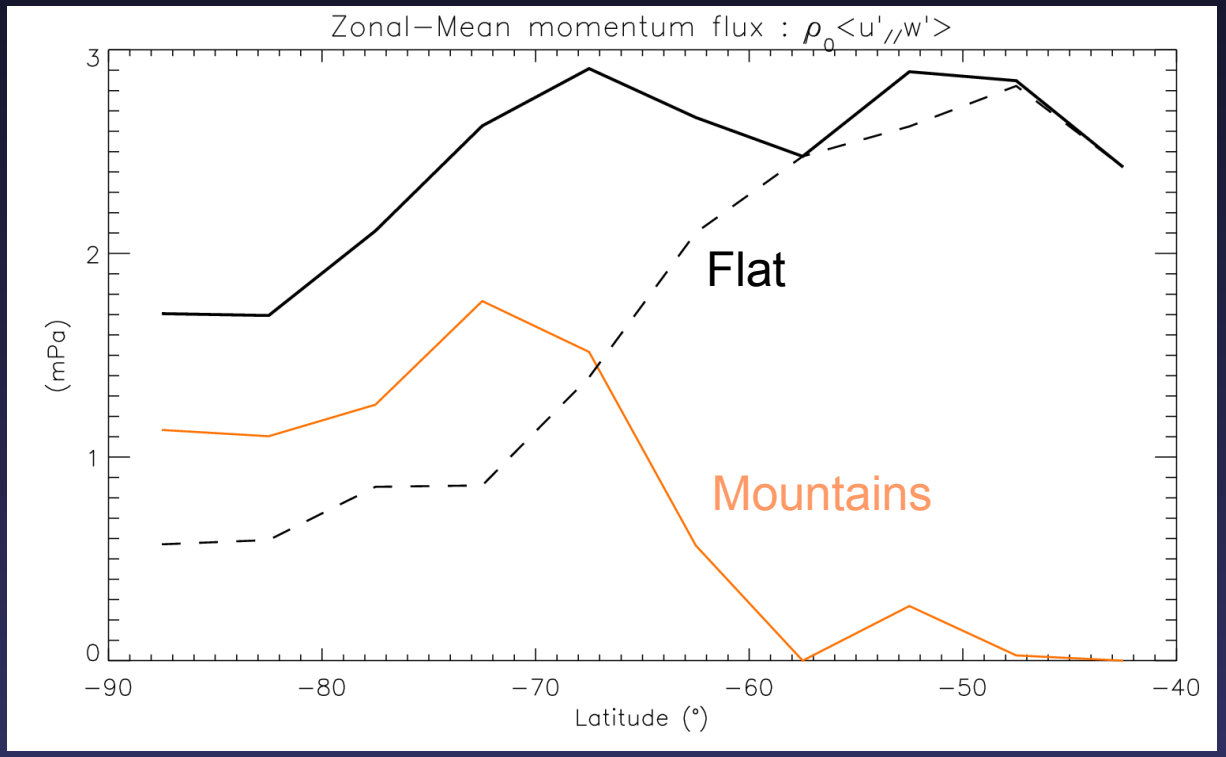
- … obviously lot of work to do in the coming years
- Willing to make a 'similar' campaign at low latitudes: Strateole Phase 2
  - Waves dynamics, transport (dehydration), clouds, NWP accuracy

Thank you for your attention!

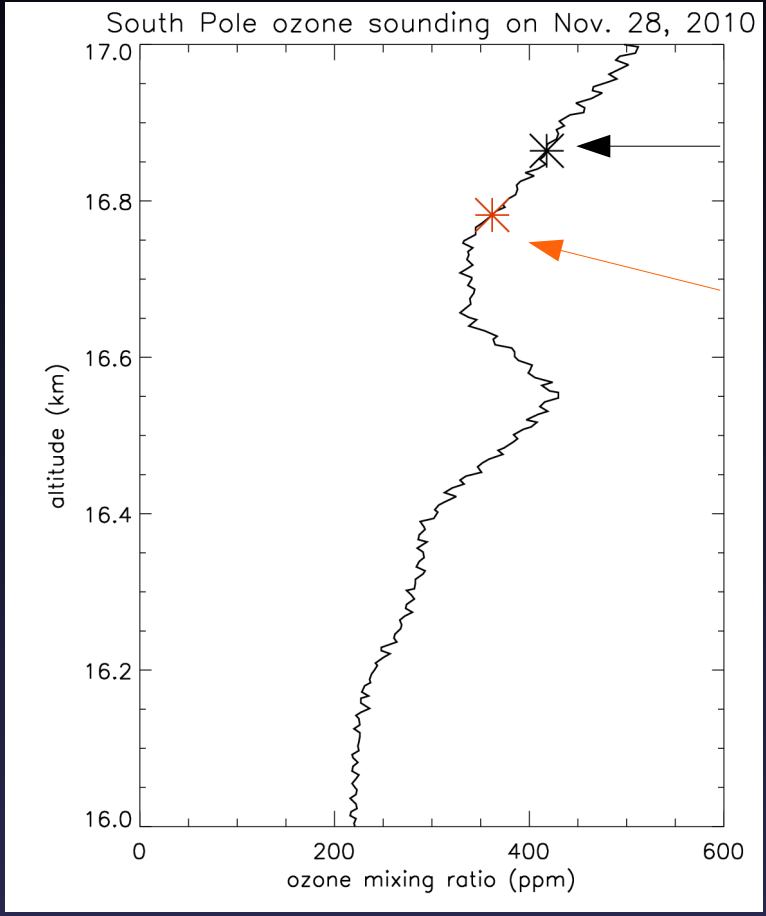
Orographic/Non-orographic waves

- Geographical criterion (based on topography gradients) to flag boxes as mountainous or non-mountainous
- Compute zonal-mean absolute fluxes and the contribution of both types of areas





South Pole Ozone Sounding



Value used for
the comparison =
Same potential temperature

LD Balloon Altitude

Long-duration balloon flew in a strong ozone gradient
that may explain part of the difference