The Concordiasi Project

Additional observations over Antarctica for NWP

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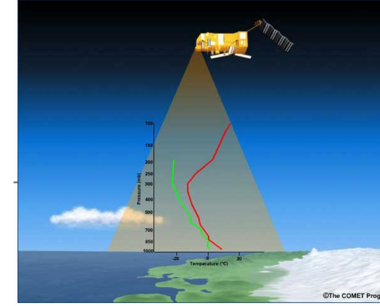
Concordiasi = CONCORDIA-IASI



A French-US initiative for climate / meteorology over Antarctica and at global scale

Improve the use of space-borne atmospheric sounders over polar regions, in particular “IASI” on board MetOp

Benefit from the continental French-Italian station “CONCORDIA”

Concordiasi: the international team

Participating Institutes:

- CNES, CNRS (LMD, LGGE, LA), Météo-France
- NSF, Purdue University, NCAR, University of Colorado, University of Wyoming
- Alfred Wegener Institute, UK Met Office
- Polar institutes: IPEV, PNRA, USAP, BAS
- ECMWF, BSRN

Collaborating institutes:

- NWP centres, NRL, NASA/GMAO, UCLA, ….

- **Overview of Concordiasi: “The Concordiasi project in Antarctica”**
  Rabier et al, Bulletin of the American Meteorological Society, January 2010.

- **Website www.cnrm.meteo.fr/concordiasi/**

Part of the THORPEX-IPY cluster

Antarctic area

Stratospheric super−pressure balloons

Flight level instruments

- meteorological sensors
- ozone sensors
- particle counter
- GPS receivers

Dropsondes

Concordia and Dumont d'Urville

Additional Regular radiosoundings

Concordia

Frequent radiosoundings and instrumented tower

2008	2009	2010	2011

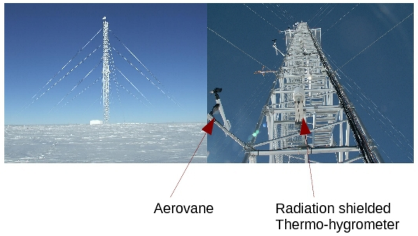
Preliminary Data Assimilation studies
Instrument preparation

IASI retrievals at Concordia
Boundary layer studies
Instrument preparation

Targeting dropsondes

IASI retrievals at dropsonde locations
Evaluation of chemical transport models

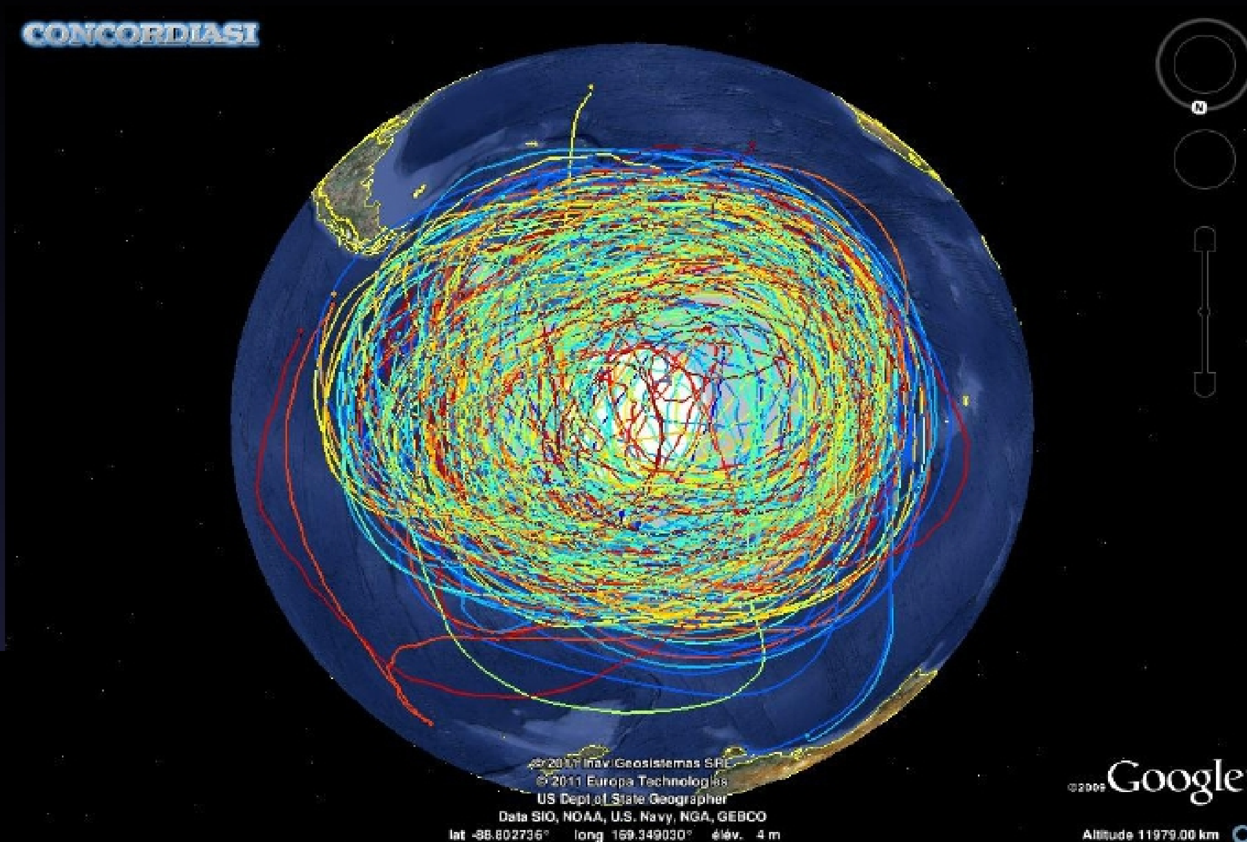
Scientific studies based on stratospheric data
Data Assimilation studies using balloon data
Validation of satellite data assimilation using dropsonde data



Concordiasi

19 long-duration, superpressure-balloon flights

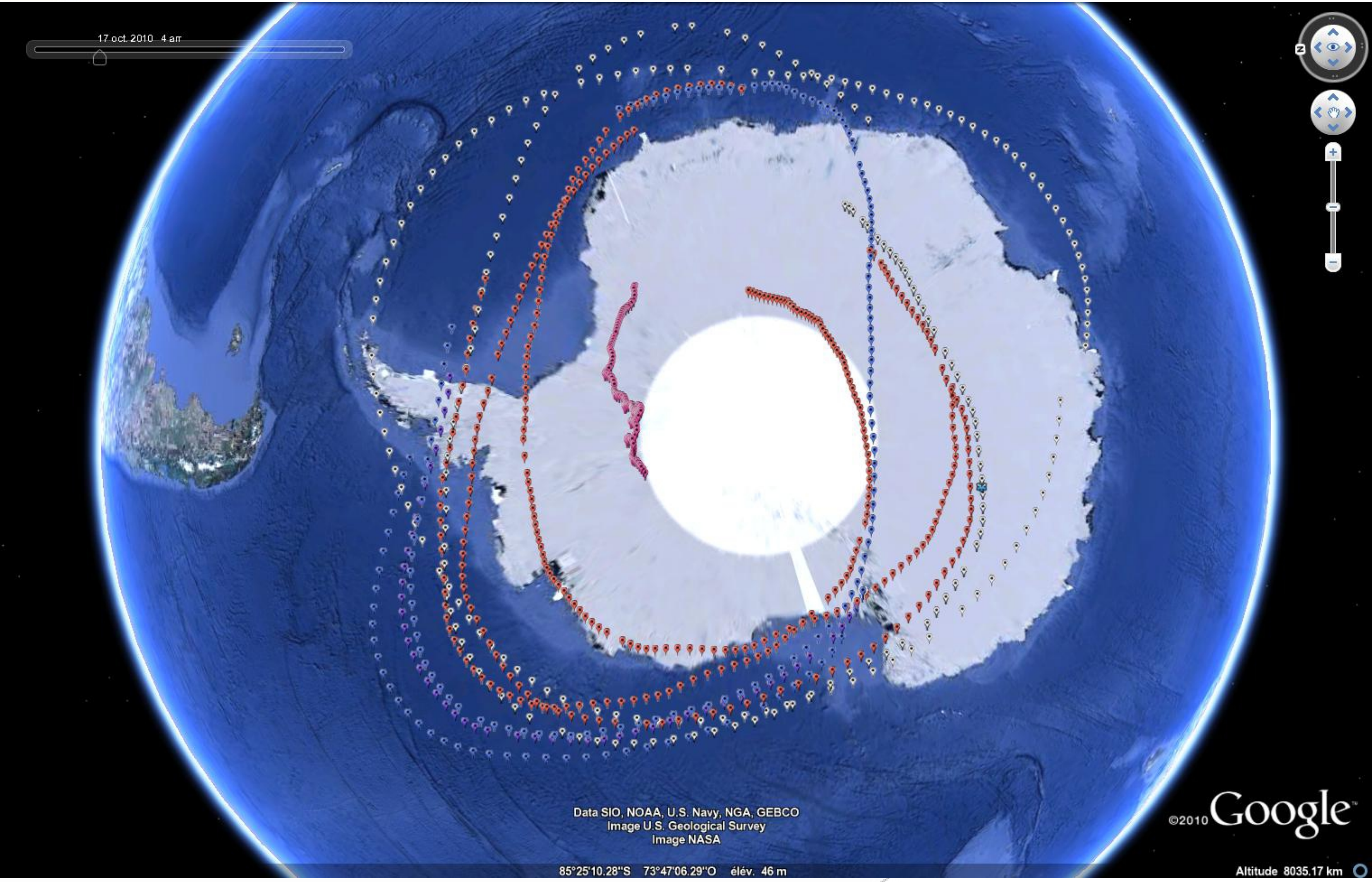
Sept. 2010- Jan. 2011
Mean duration : 69 days



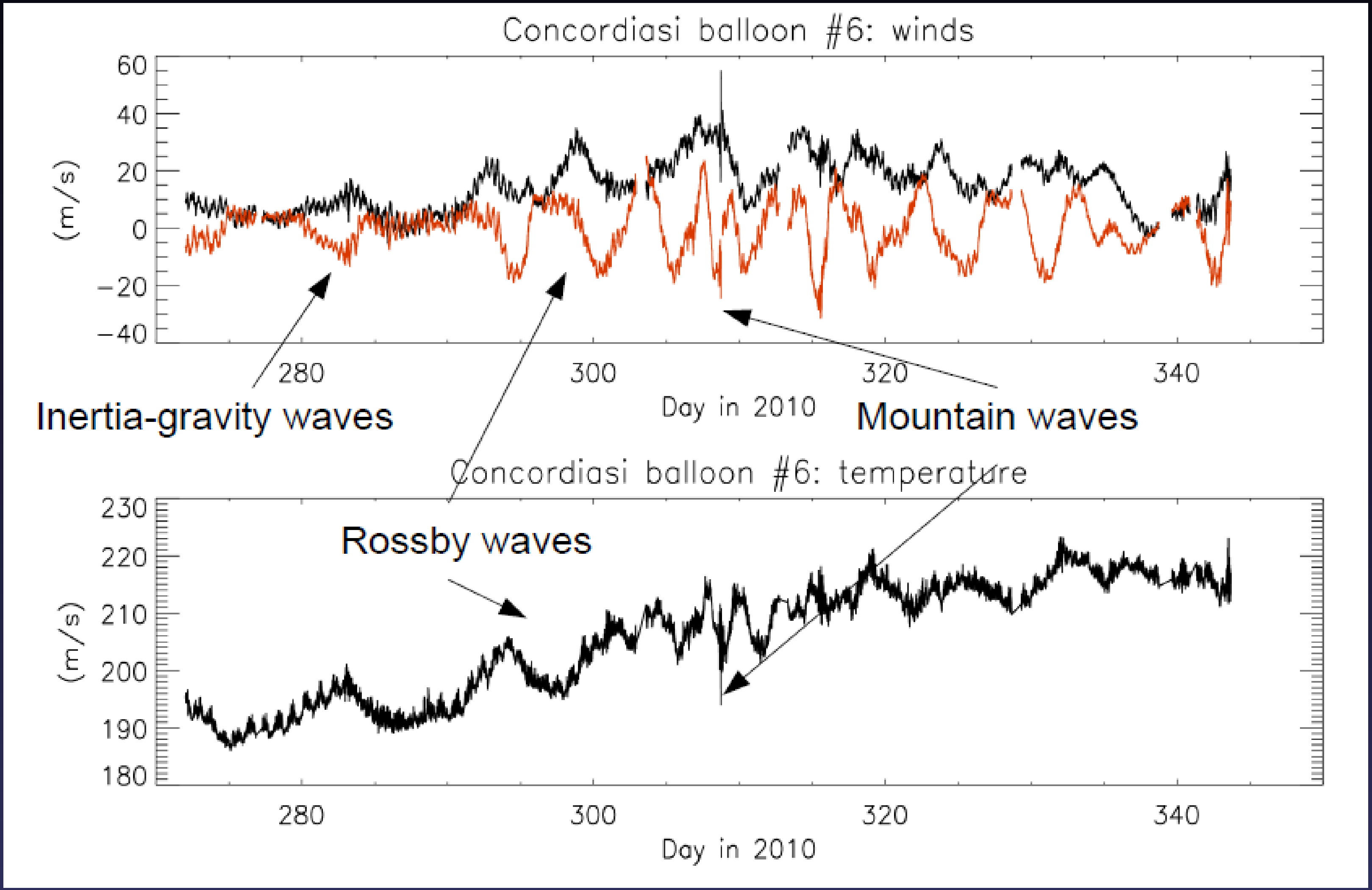
Flight level measurements

- 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

Driftworms 14-17 October 2010



Some observations



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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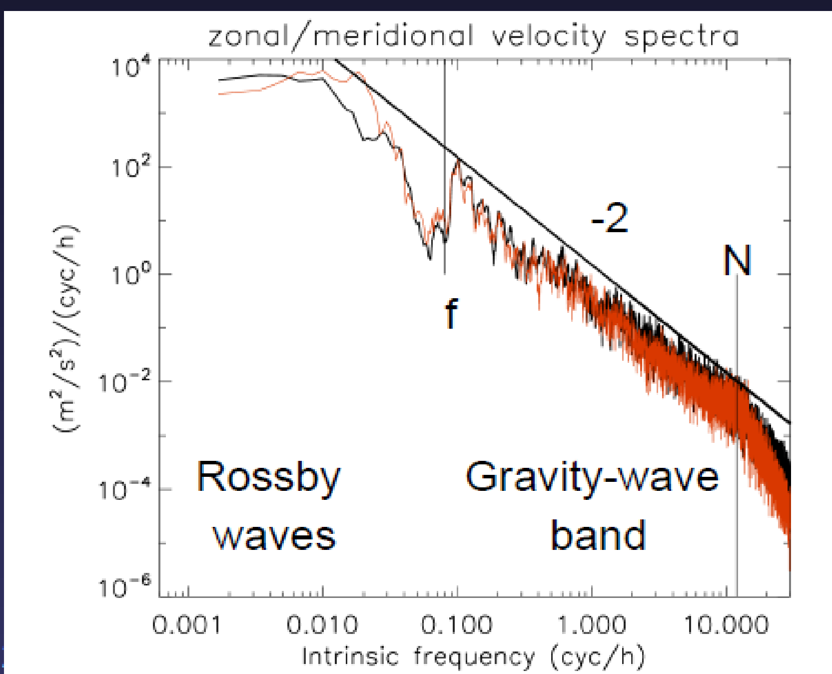
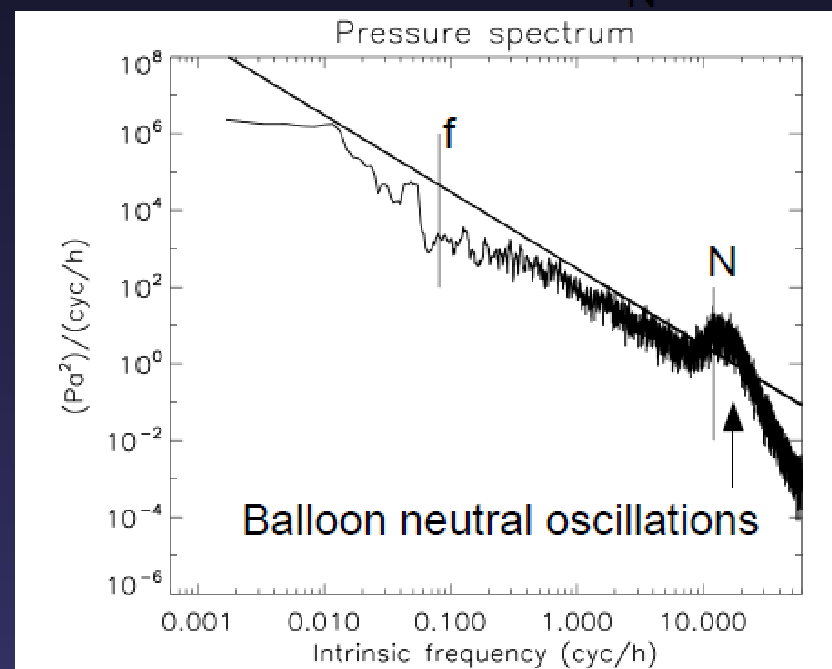
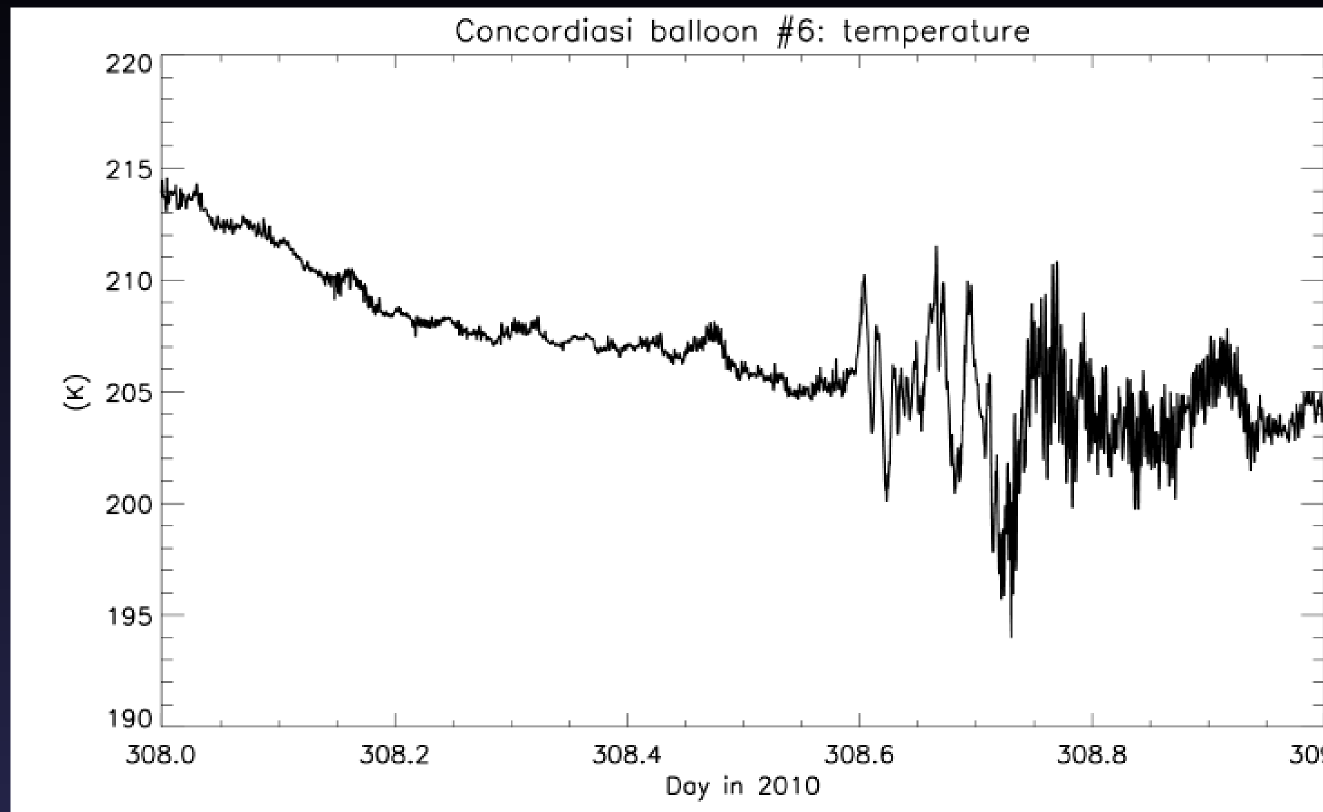




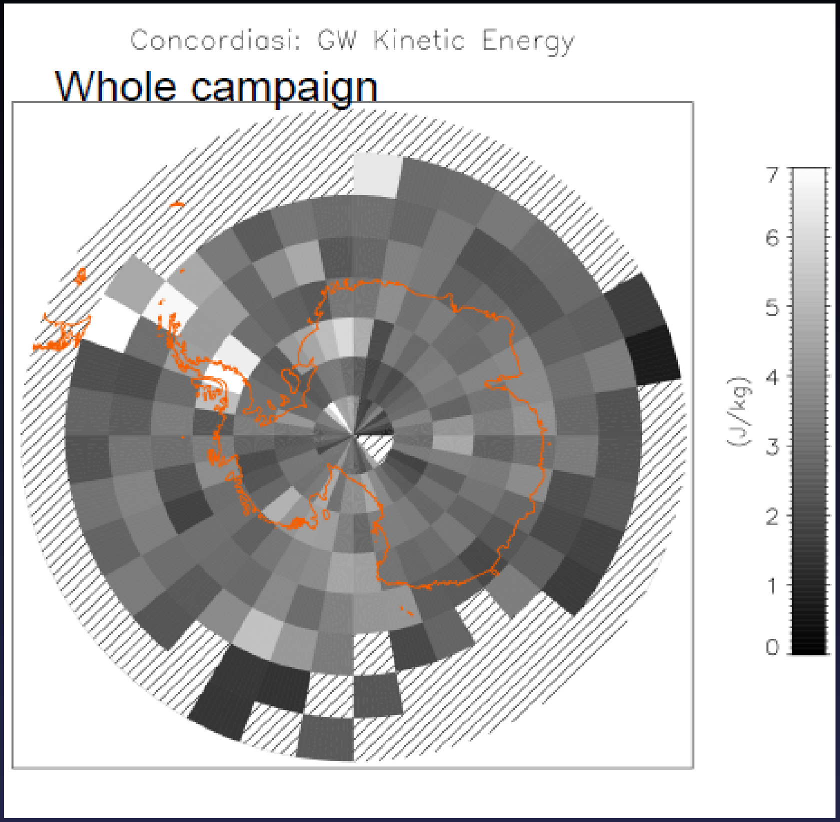
Orographic gravity waves

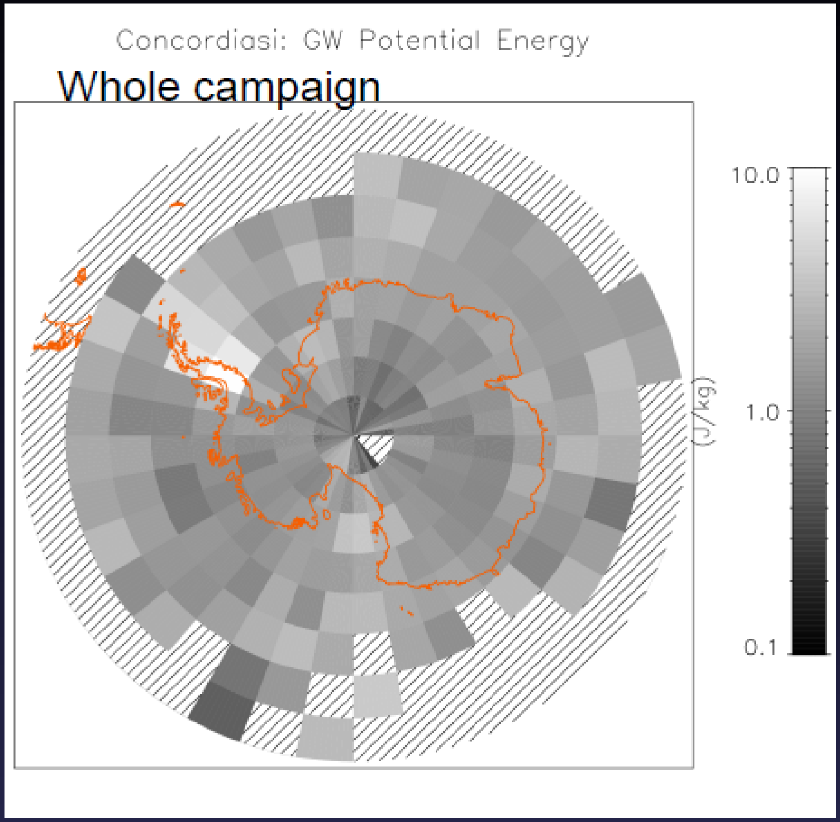


T' ~ 15 K, u' ~ 35 m/s
Vertical displ. 1.5 km
Period of 10 min – 1 hr
→ fully resolved by obs.

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

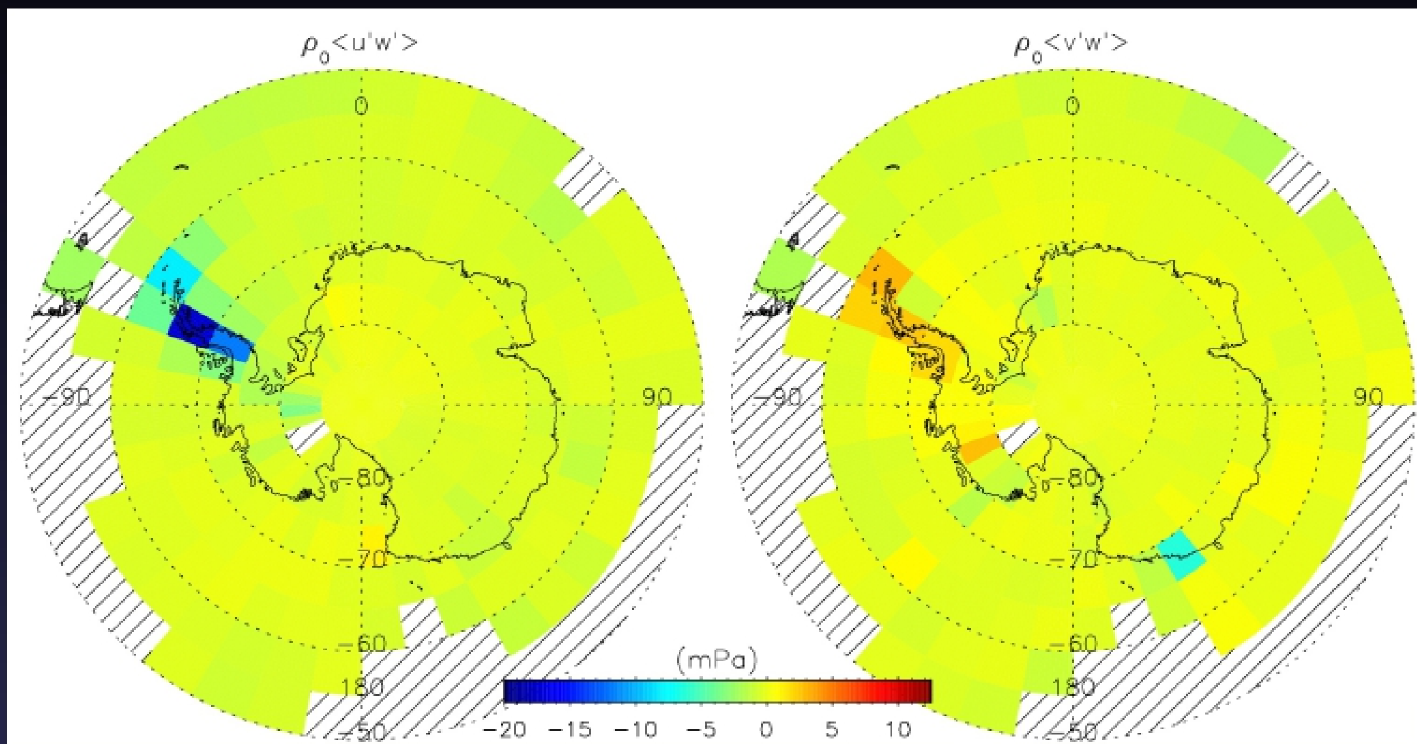
Potential energy (higher frequency waves) increases from the Pole toward mid-latitudes

→ GW source above the oceans (storm tracks, front, convection)

Goal : generalize Vorcore results (below)

Directional momentum fluxes

Zonal   Meridional

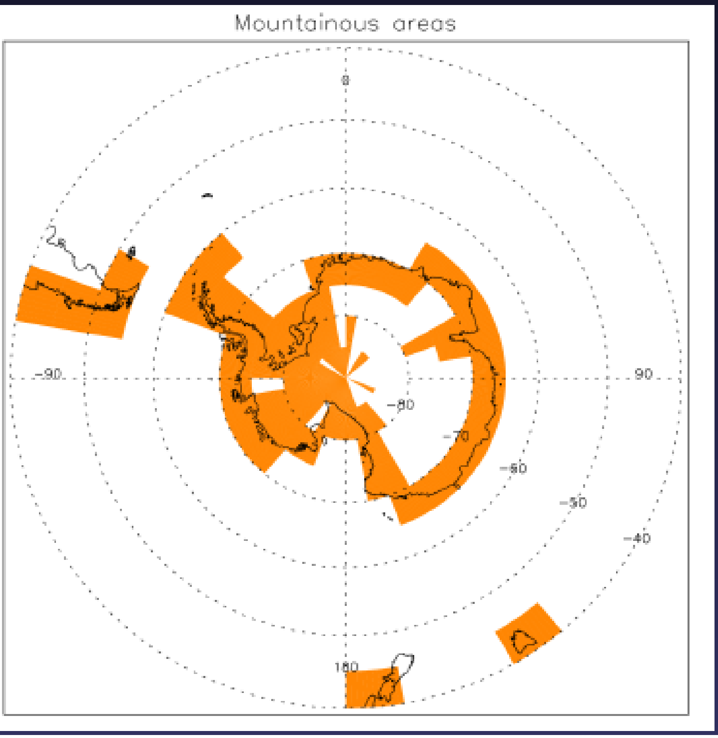


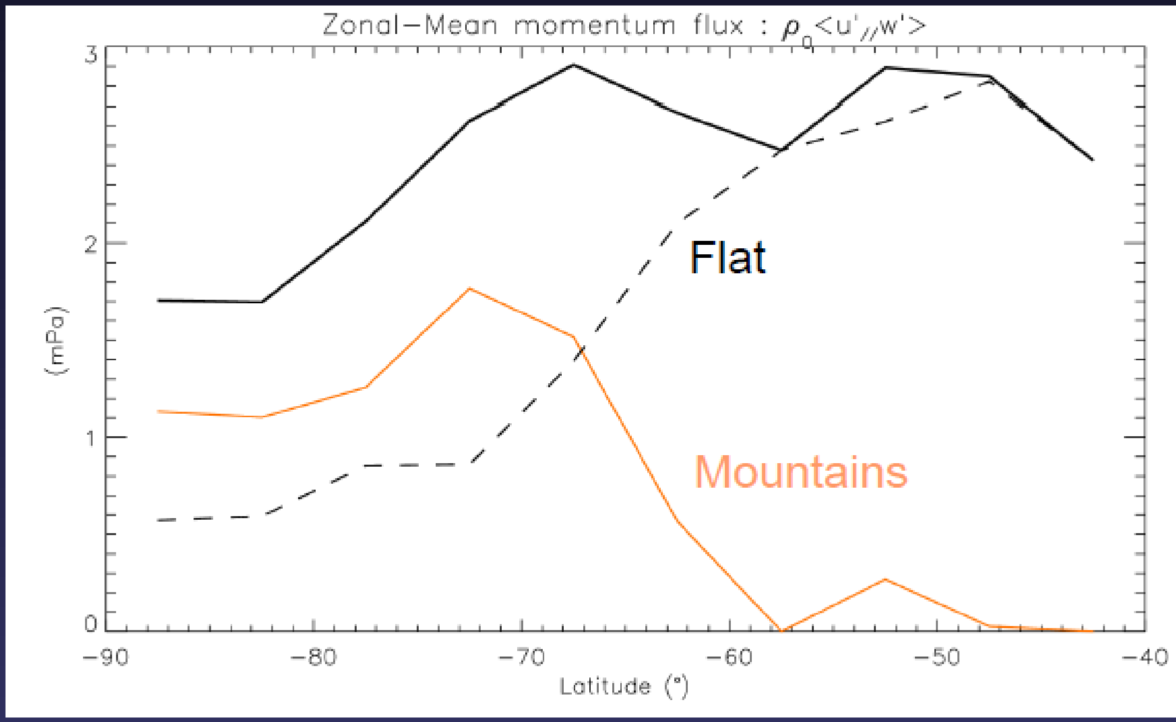
Extend Vorcore 2005 results to higher-frequencies

VORCORE, 2005

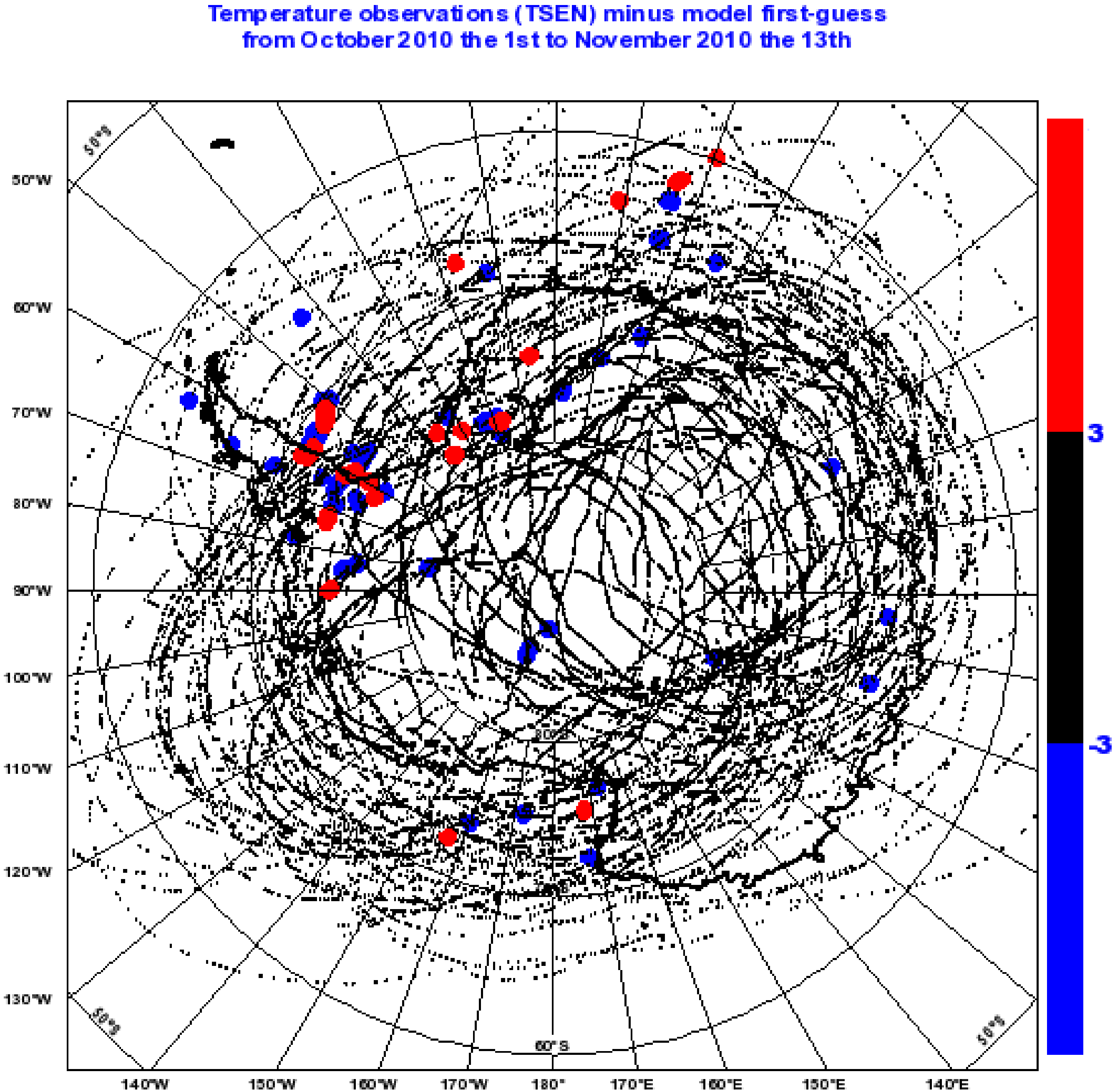
Orographic/Non-orographic waves

- 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





Monitoring of gondola temperature at 60-70 hPa



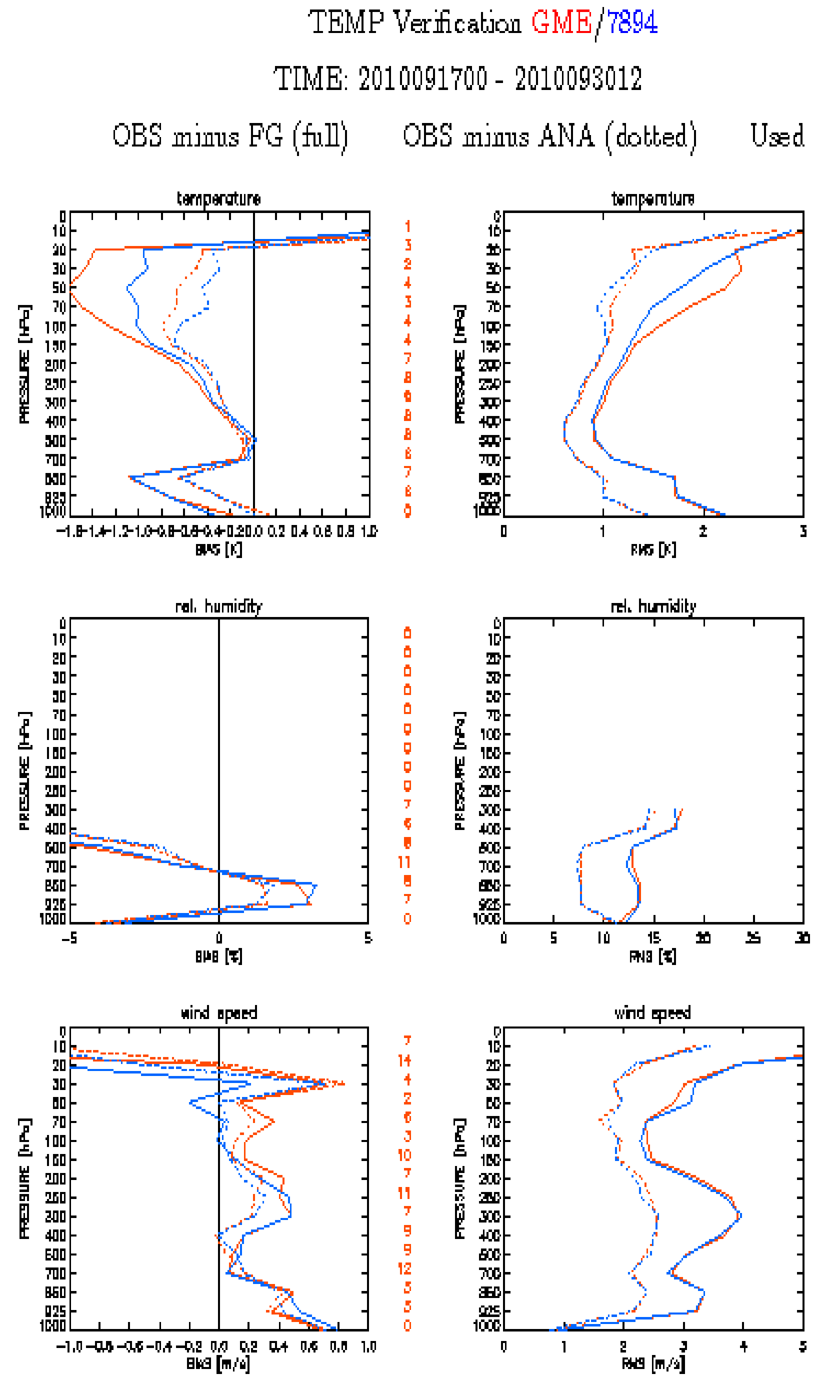
Large departures where gravity-wave activity

METEO FRANCE
Toujours un temps d'avance

Assimilation of gondola information at DWD

Radiosonde Verification

- Bias (left); RMS (right)
- Antarctic region
- Comparison of Routine (red) against Experiment using stratospheric balloon measurements (blue)



Results:

Temperature- and Windspeedbias is reduced over Antarctica in the lower stratosphere

RMS of temperature is reduced considerably for both, OBS minus FG and OBS minus Ana

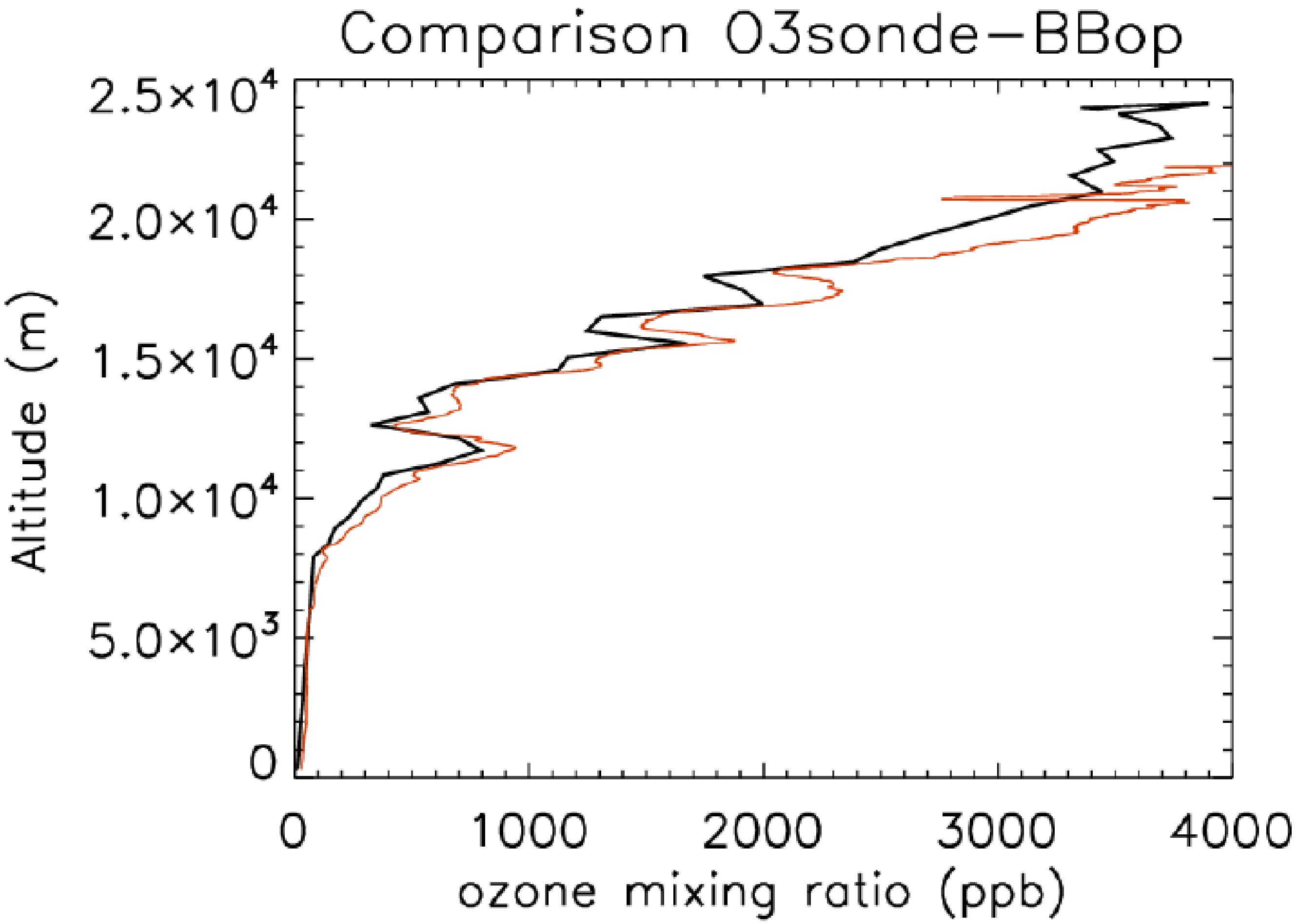
A. Cress DWD

B-Bop: Balloon-Borne Ozone Photometer

- UV dual beam ozone photometer
- developed for CONCORDIASI campaign
- precision ±20ppb, accuracy 3%
- 5 balloon flights so far

For Concordiasi, 3 flights with B-Bop, for a total of 168 days of data.

Test flight from Kiruna with an ozone sonde.

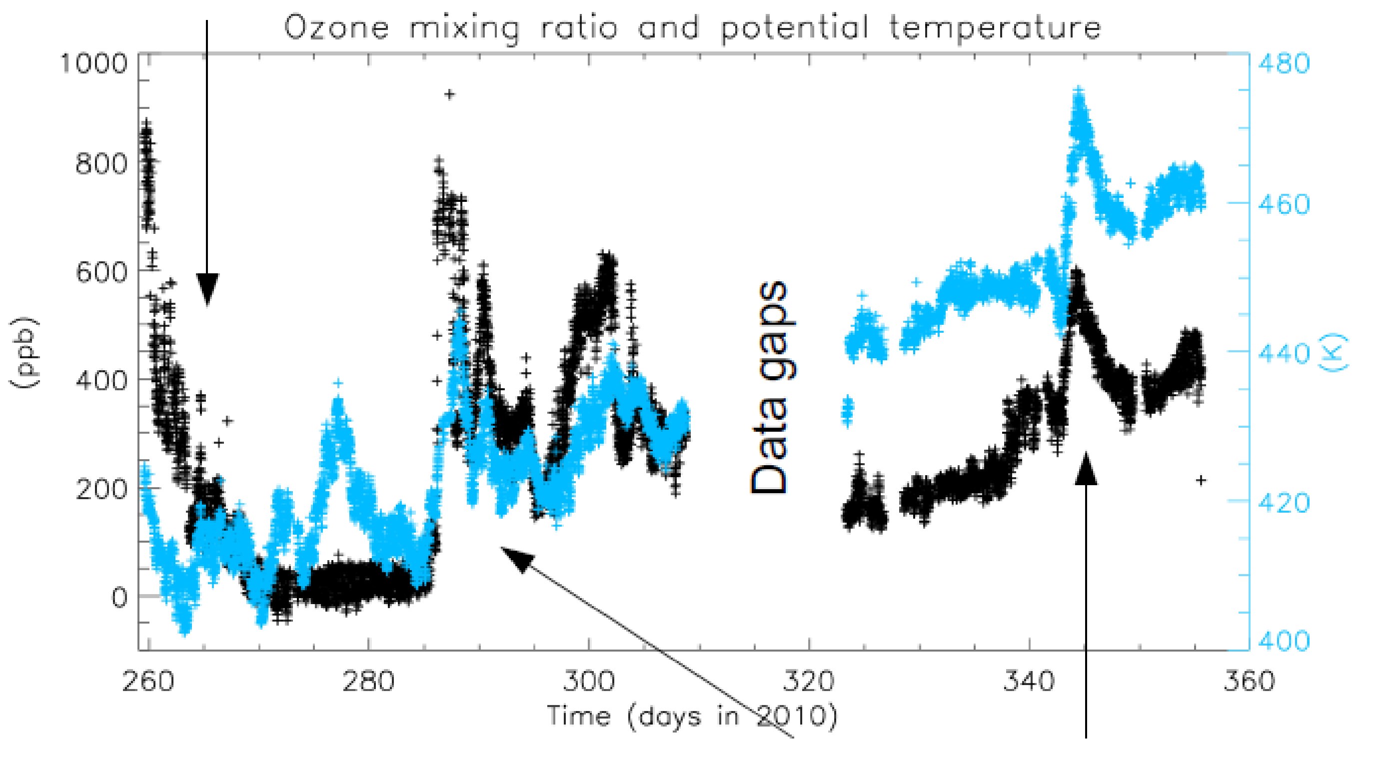


Red ozone sonde

Black B-Bop

Ozone observations - PSC14

Chemical depletion



Transport-dominated variations

Ozone loss estimates

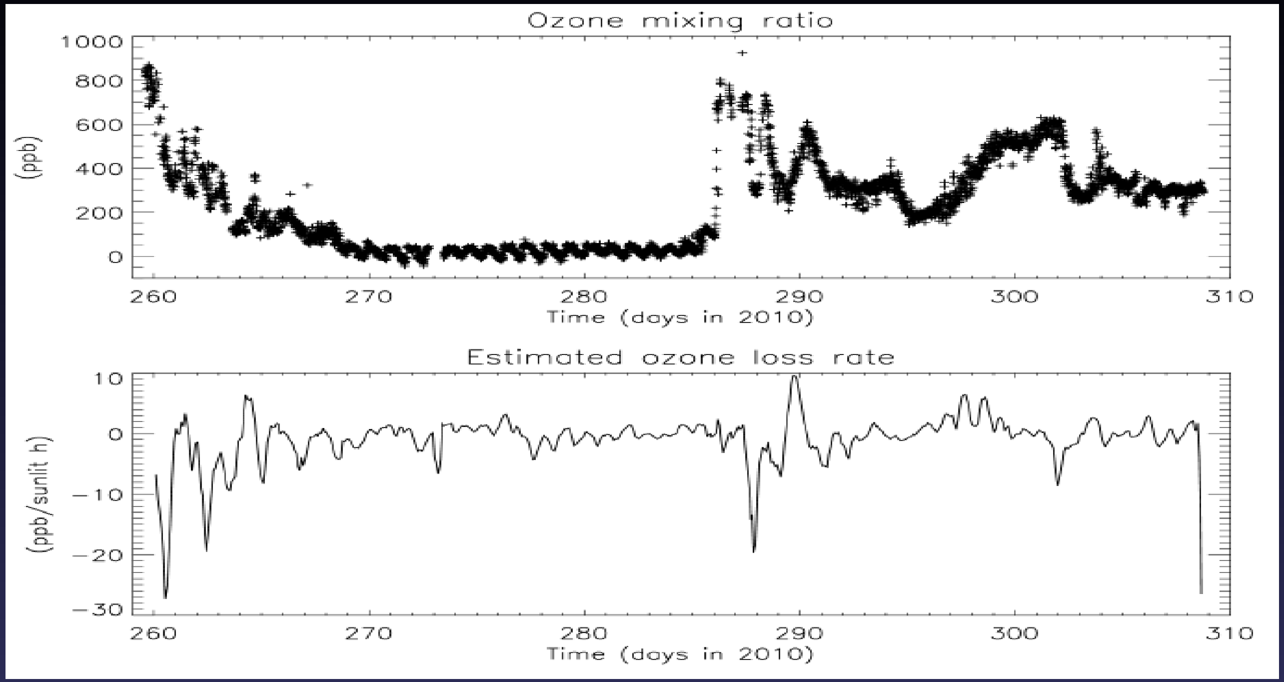
- Explain the ozone variations due to balloon motions :
  - Project ozone variations on potential temperature (1 day window)

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

- Explain the residual in terms of ozone loss :

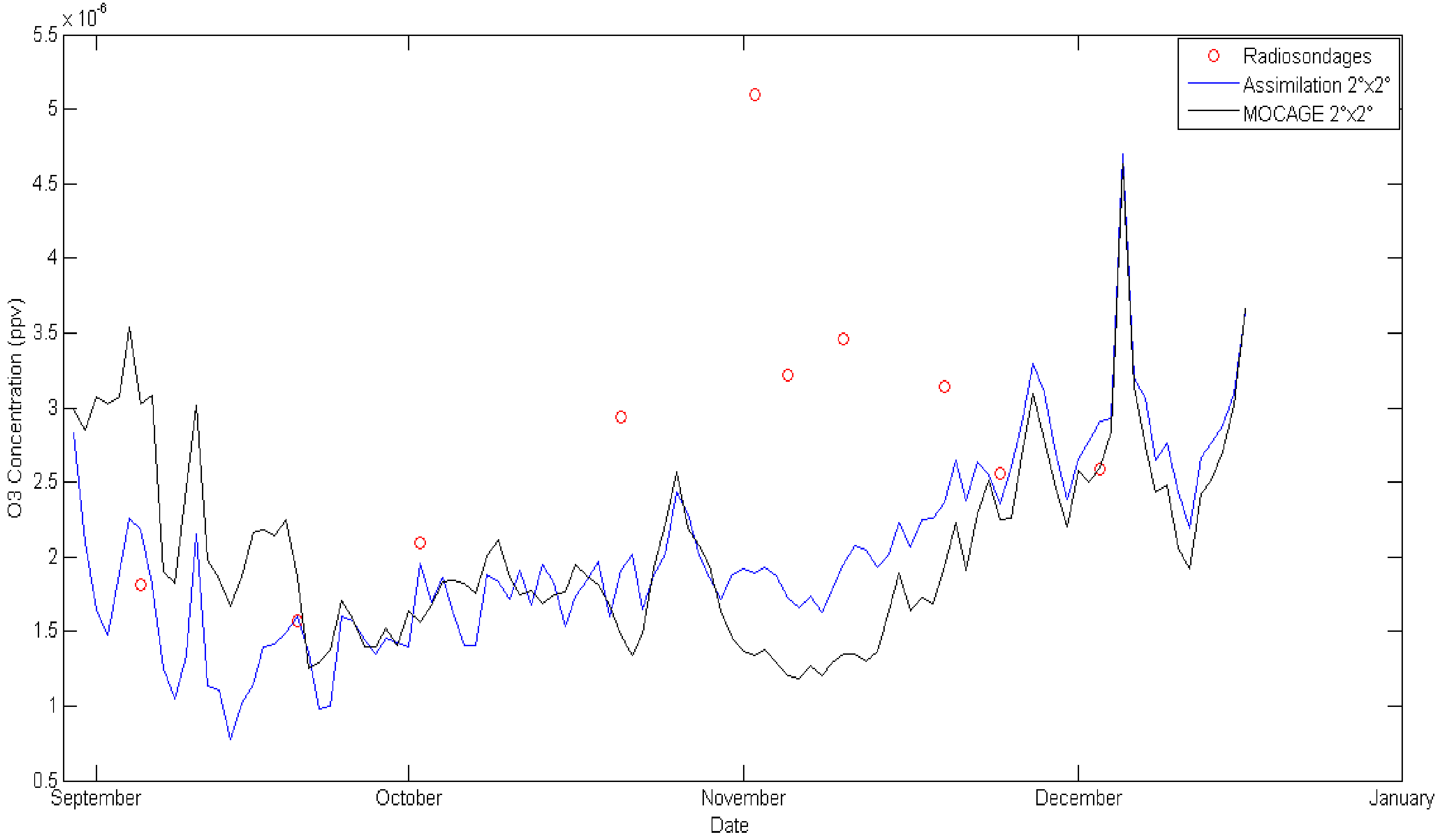
  $\varepsilon(t) = \text{loss}\,.\,t + c(t)$

  express loss in ppb/sunlit hour

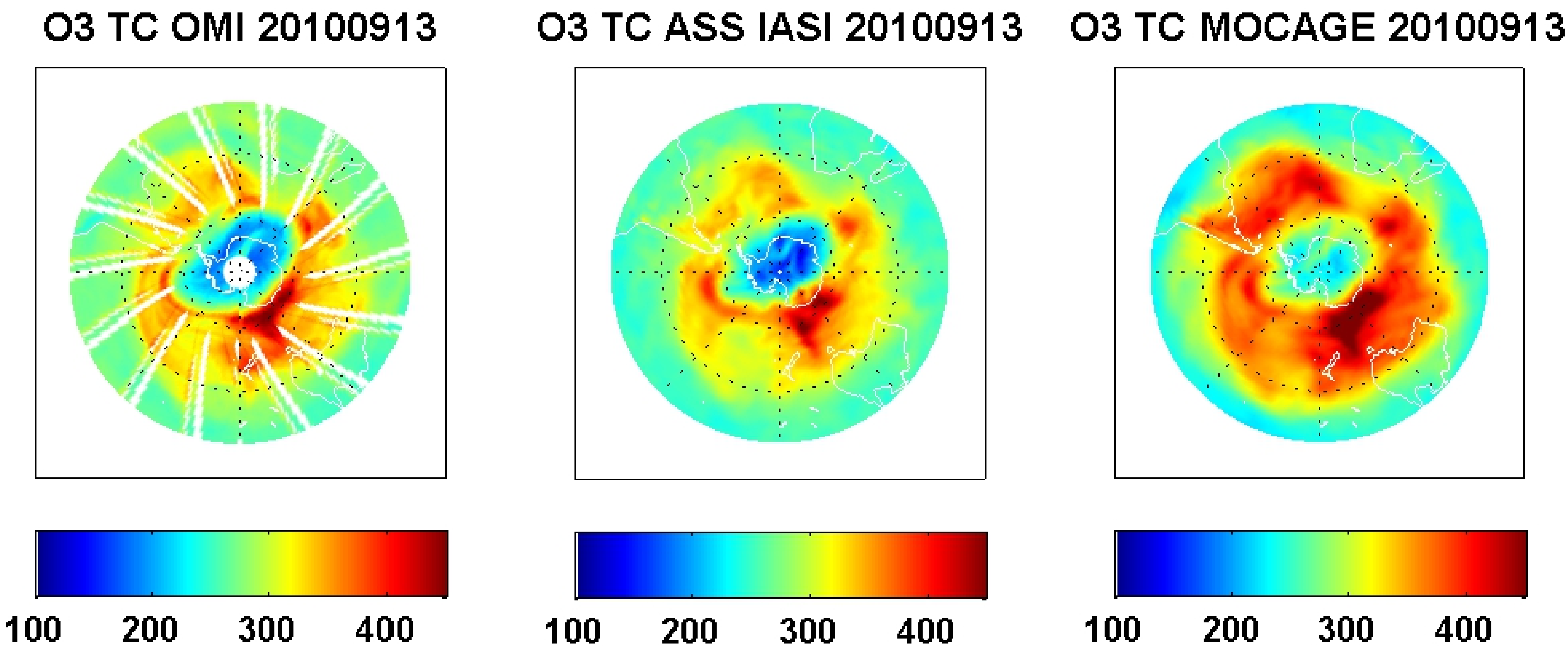


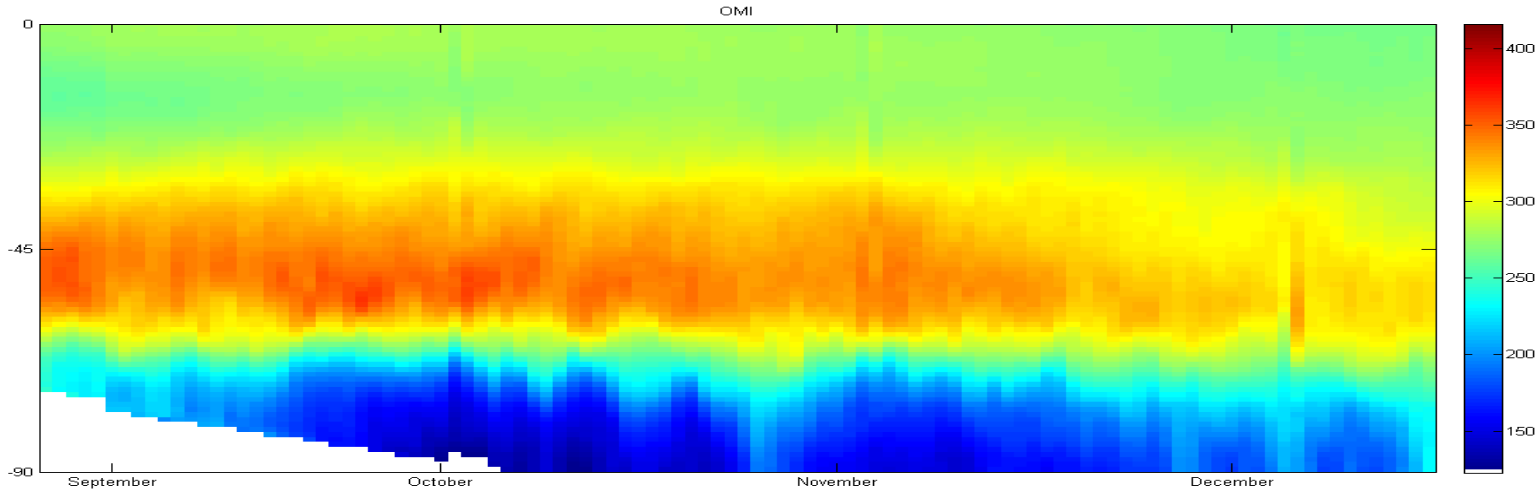
Ozone loss generally < 10 ppb/sunlit hour but can reach up to 25 ppb/sunlit hour

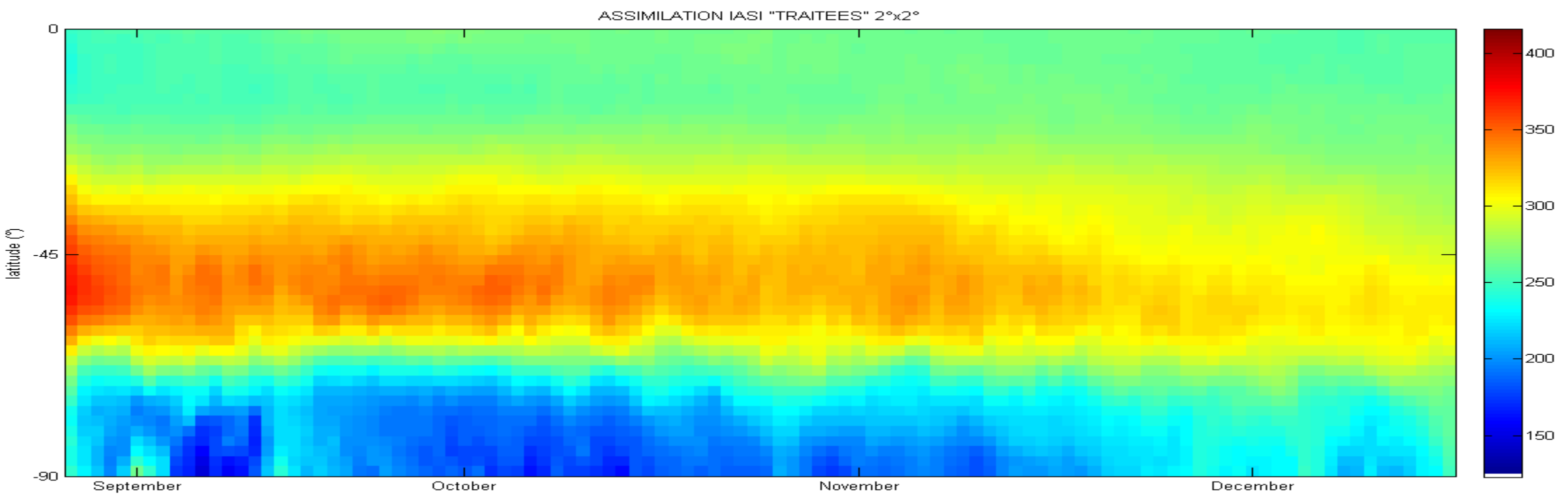
IASI Data assimilation experiments with MOCAGE



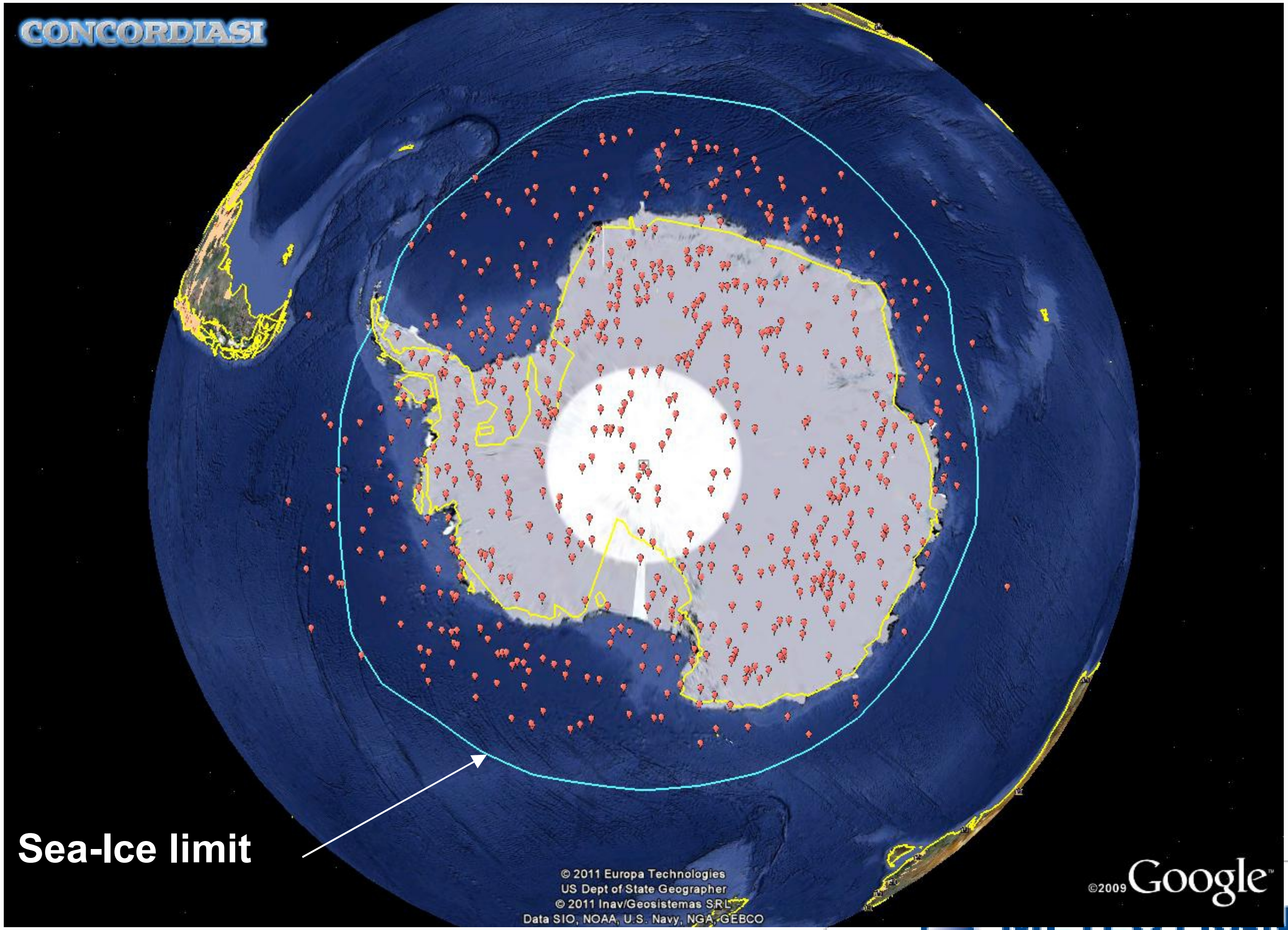
Validation with OMI data




OMI
0
-45
-90
September
October
November
December
400
350
300
250
200
150


ASSIMILATION IASI "TRAITEES" 2°x2°
0
-45
-90
latitude (°)
September
October
November
December
400
350
300
250
200
150

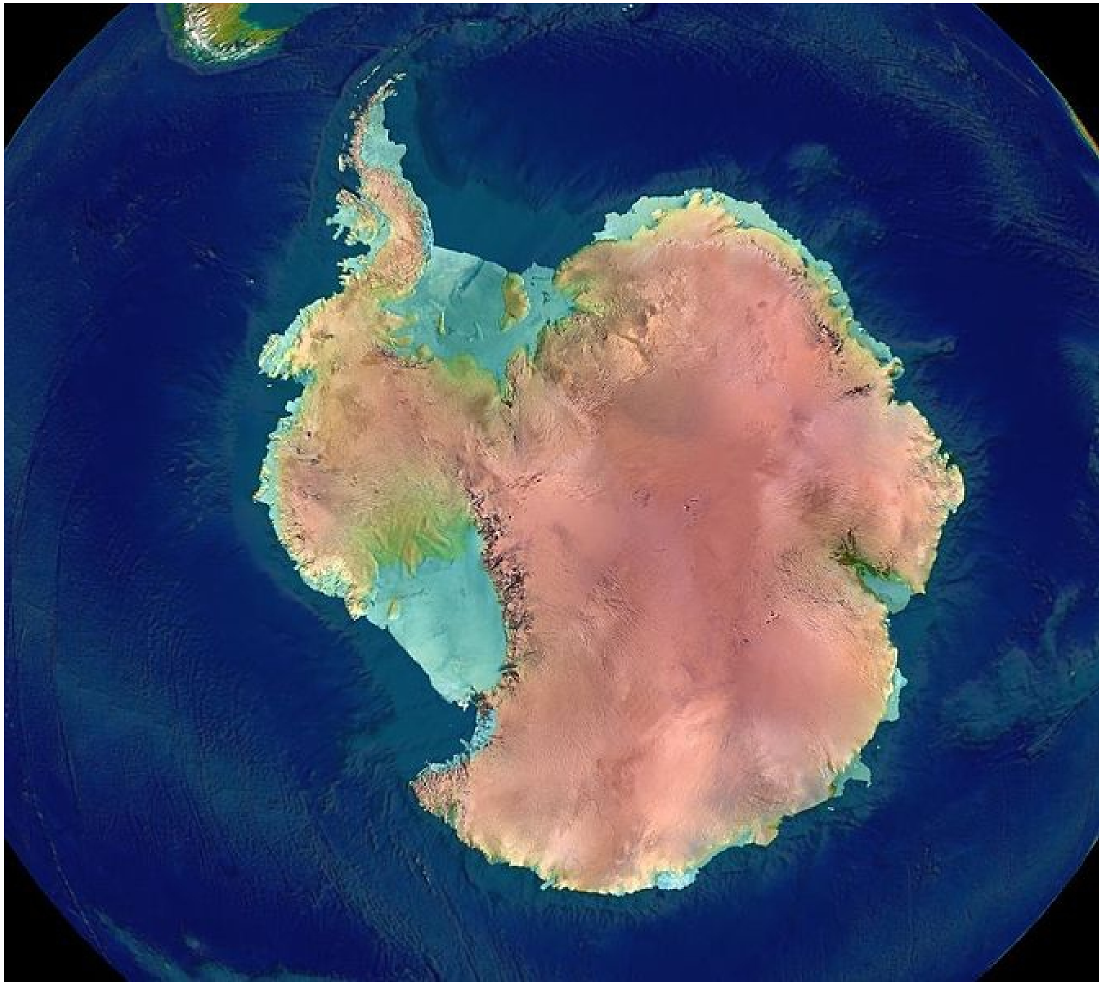
640 Dropsondes (20100923-20101201)



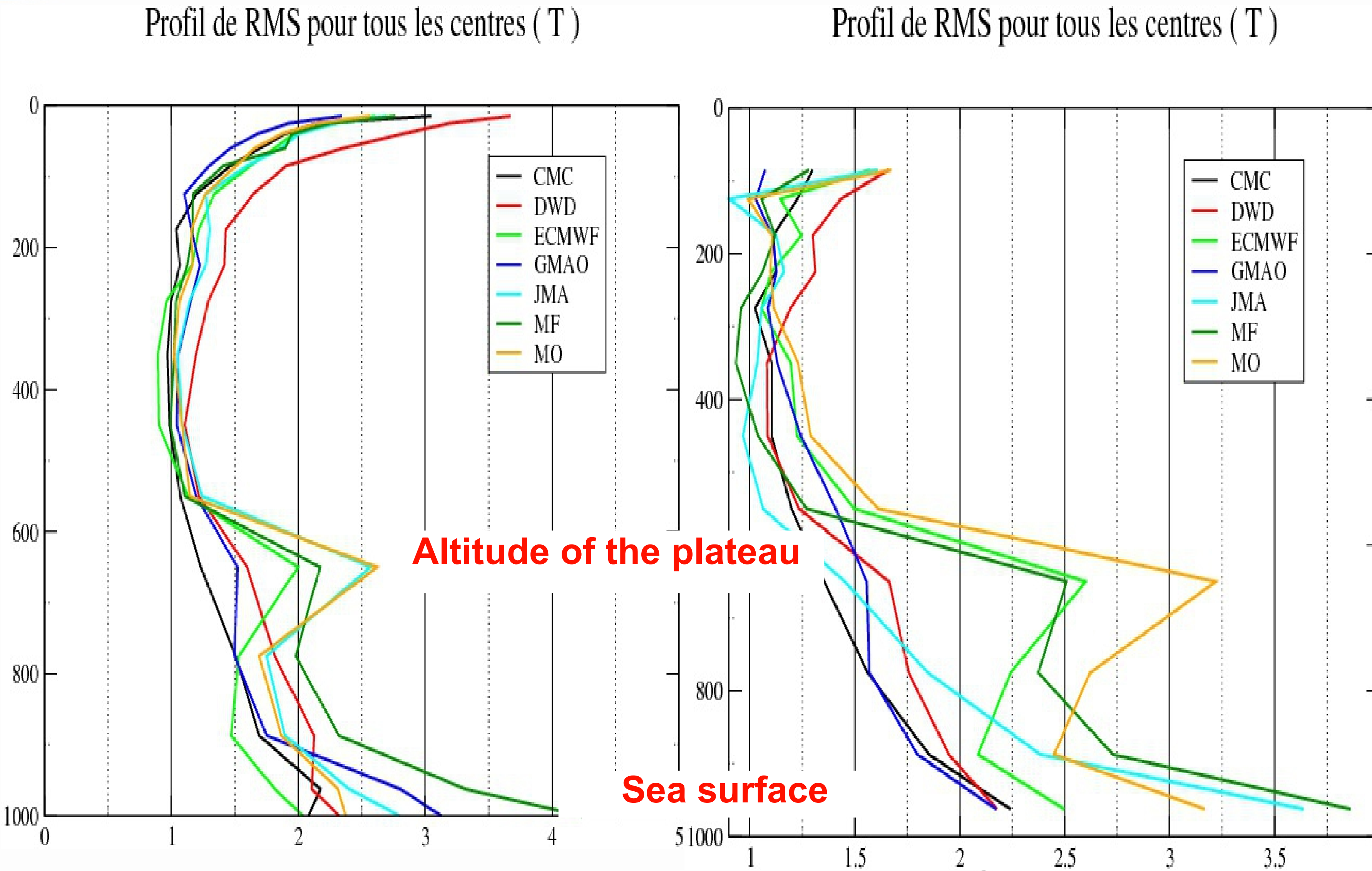
Model performance monitoring with dropsondes

Various centres participated, and provided statistics for both Antarctic radiosondes and Concordiasi dropsondes

CMC
DWD
ECMWF
GMAO
Meteo-France
Met Office
JMA



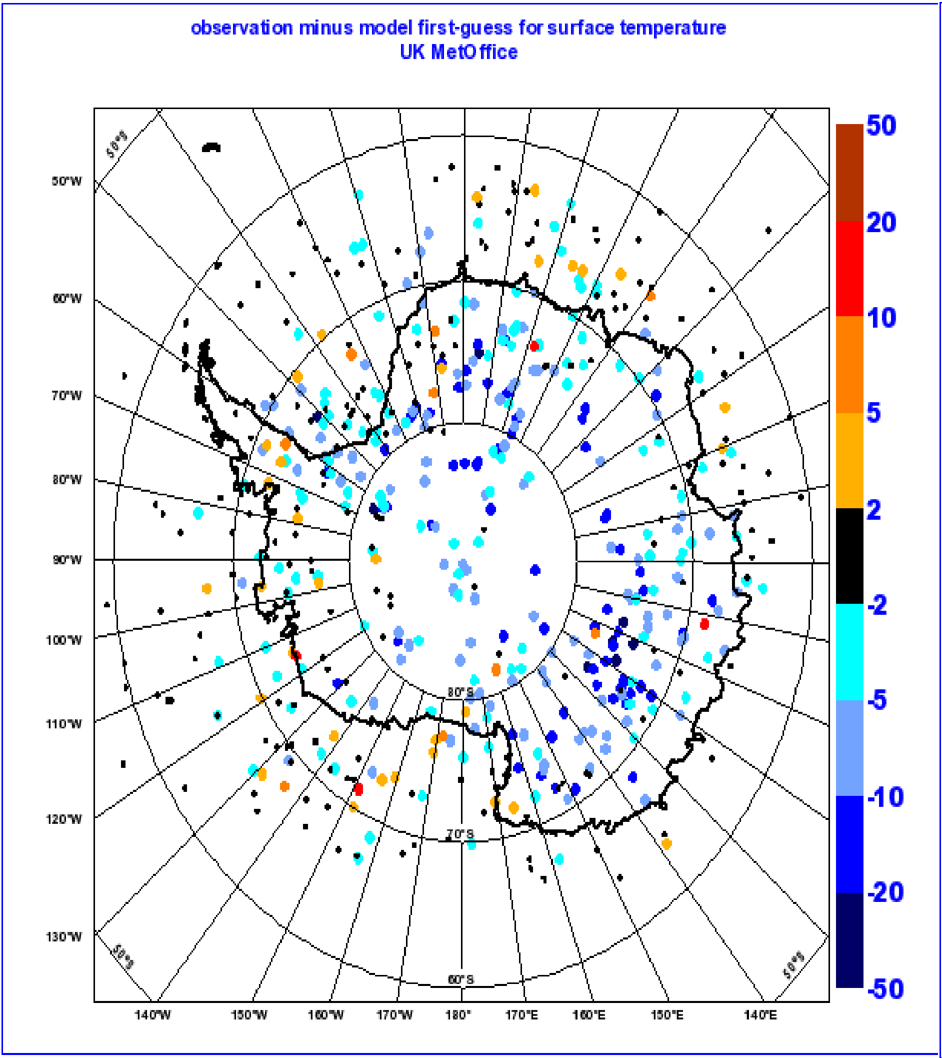
Comparison of O-G for radiosondes and dropsondes

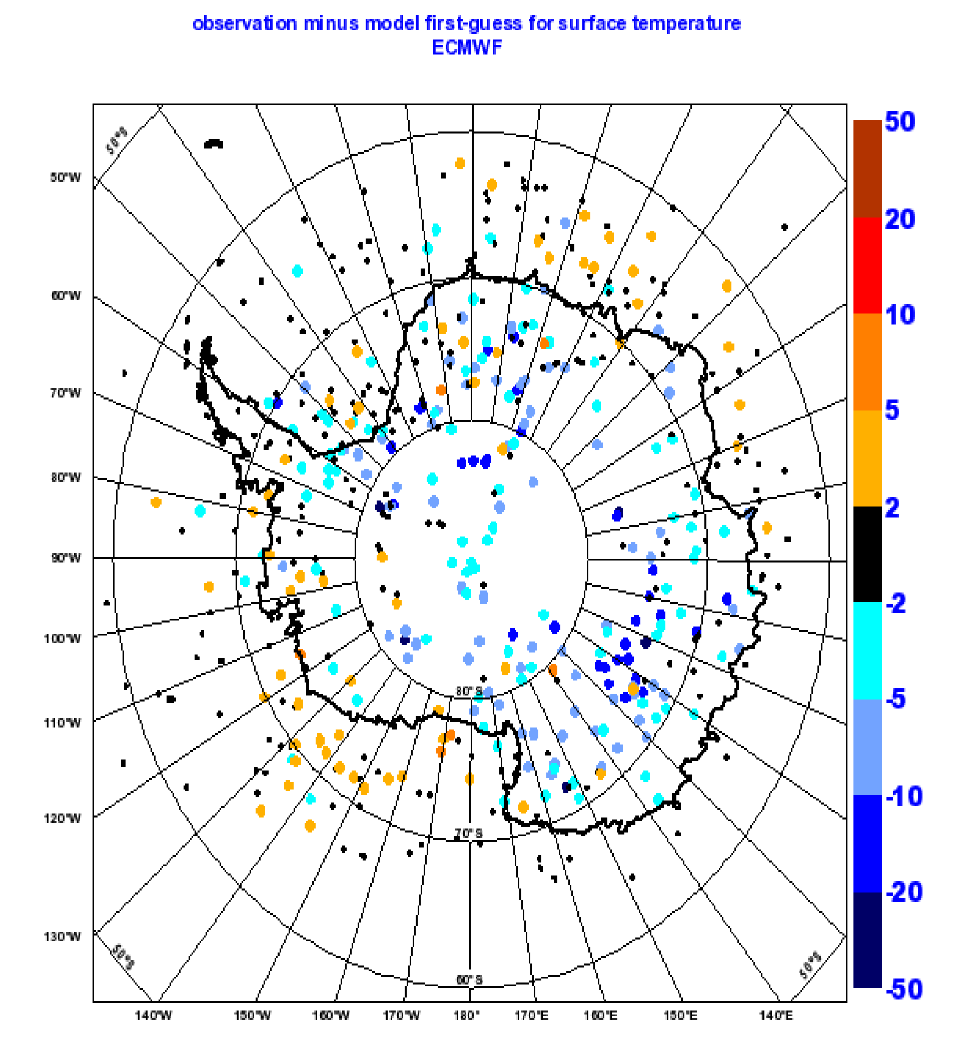


Temperature in K

METEO FRANCE
Toujours un temps d'avance

Largest errors in temperature near the surface: models not cold enough over inland Antarctica





Concluding remarks

Concordiasi provided an unprecedented data coverage of meteorological observations over Antarctica

Both dropsonde and gondola information seem to have a positive impact on forecast performance (preliminary results from NRL, DWD and MF)

Gondola temperature data at 60hPa shows the largest model errors in areas of strong gravity-wave activity

Dropsonde information confirms statistics obtained with radiosondes and provide a more global view

Most models have problems predicting the lowest level temperatures

http://www.cnrm.meteo.fr/concordiasi/

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 in on a quasi-Lagrangian vector
  - Compare PSC 14 w/ other flights (including Ucoz)
- … obviously lot of work to do in the coming years
- Very interested in doing a 'similar' campaign at low latitudes Strateole Phase 2
  - Waves dynamics, transport (dehydration), clouds, GCM accuracy

http://www.lmd.polytechnique.fr/VORCORE/McMurdoE.htm

Papers on Vorcore and Concordiasi so far…

Rabier, F., A. Bouchard, E. Brun, A. Doerenbecher, S. Guedj, V. Guidard, F. Karbou, V.-H. Peuch, L. E. Amraoui, D. Puech, C. Genthon, G. Picard, M. Town, A. Hertzog, F. Vial, P. Cocquerez, S. Cohn, T. Hock, H. Cole, J. Fox, D. Parsons, J. Powers, K. Romberg, J. VanAndel, T. Deshler, J. Mercer, J. Haase, L. Avallone, L. Kalnajsand, C. R.Mechoso, A. Tangborn, A. Pellegrini, Y. Frenot, A. McNally, J.-N. Thépaut, G. Balsamo and P. Steinle, 2010 : "The Concordiasi project in Antarctica" Bulletin of the American Meteorological Society. Bulletin of the American Meteorological Society, January 2010, 69-86.

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McDonald, A., and A. Hertzog, Comparison of Stratospheric Measurements made by CHAMP Radio Occultation and Strateole/Vorcore in-situ data, Geophys. Res. Lett., 35, L11805, doi:10.1029/2008GL033338, 2008.

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Boccara, G., A. Hertzog, R. A. Vincent, and F. Vial, Estimation of gravity-wave momentum fluxes and phase speeds from quasi-Lagrangian stratospheric balloon flights. 1: Theory and simulations, J. Atmos. Sci., 65, 3042-3055, 2008.

Hertzog, A., G. Boccara, R. A. Vincent, F. Vial, and Ph. Cocquerez, Estimation of gravity-wave momentum fluxes and phase speeds from quasi-Lagrangian stratospheric balloon flights. 2: Results from the Vorcore campaign in Antarctica, J. Atmos. Sci., 65, 3056-3070, 2008.

Boccara, G., A. Hertzog, C. Basdevant, and F. Vial, Accuracy of NCEP/NCAR reanalyses and ECMWF analyses in the lower stratosphere over Antarctica in 2005, J. Geophys. Res., 113, D20115, doi:10.1029/2008JD010116, 2008.