Low Ozone Events in the Southern Polar Summer Stratosphere as Indicated by Met Office Ozone Analyses

David Jackson[1], Yvan Orsolini[2], Ola Engelsen[2]

[1]Met Office, Exeter, UK [2]NILU, Kjeller, Norway

SPARC DAWG Workshop, Exeter, UK, 21-23 June 2010

Overview

- Summary of Met Office system and experiments
- Synoptic description of LOEs (in 2005)
- Role of dynamics in LOEs
- LOEs in 2006 and 2007
- Impact on UV radiation
- Summary

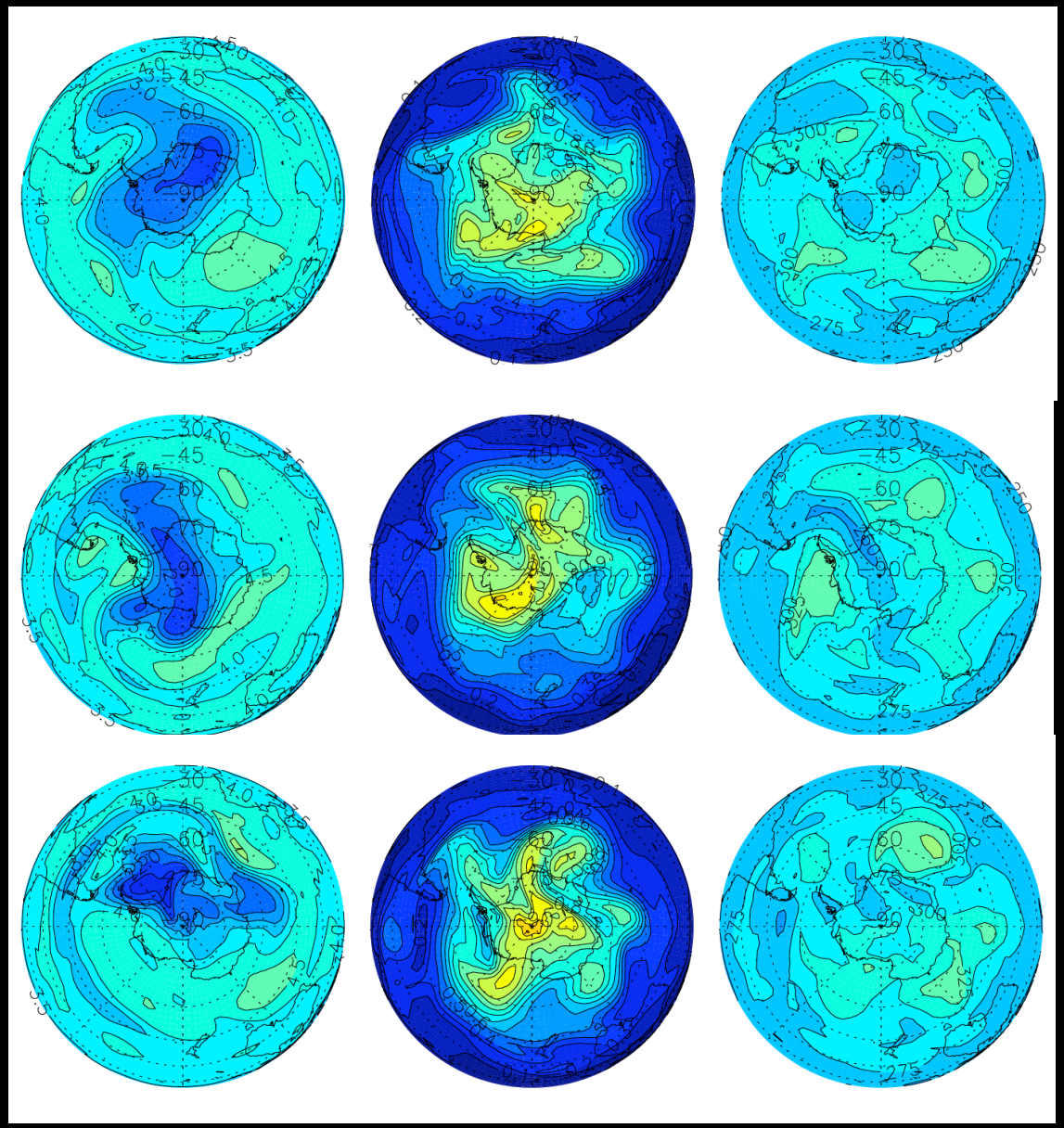
Ozone DA Overview

- Uses 3D-Var. GCM not CTM approach.
- Results shown for N48L50 model
- Parametrized ozone chemistry (Cariolle scheme)
- EOS MLS and SBUV/ 2 assimilated for the following periods:
  - 26 Jan – 10 Mar 2005
  - 2 Jan – 15 Feb 2006
  - 10 Jan – 20 Mar 2007

What is a “low ozone event”?

- LOEs are rapid transient decreases in total ozone that can occur in all seasons at mid/high latitudes
- At very high latitudes in summer there is ozone loss due to gas-phase chemistry (N and H catalytic cycles)
- Orsolini et al (2003) documented LOEs in northern summer polar stratosphere
- Jackson (2007) first reported LOEs in southern summer polar stratosphere. This study extends that work.
- Lower stratosphere in summer characterised by medium-scale quasi-stationary waves, wavenumber 4-6 (Schoeberl and Krueger (1983), Randel and Stanford (1985), Cariolle and Deque (1986).

Ozone: 31 hPa 100 hPa total column



31/01/05

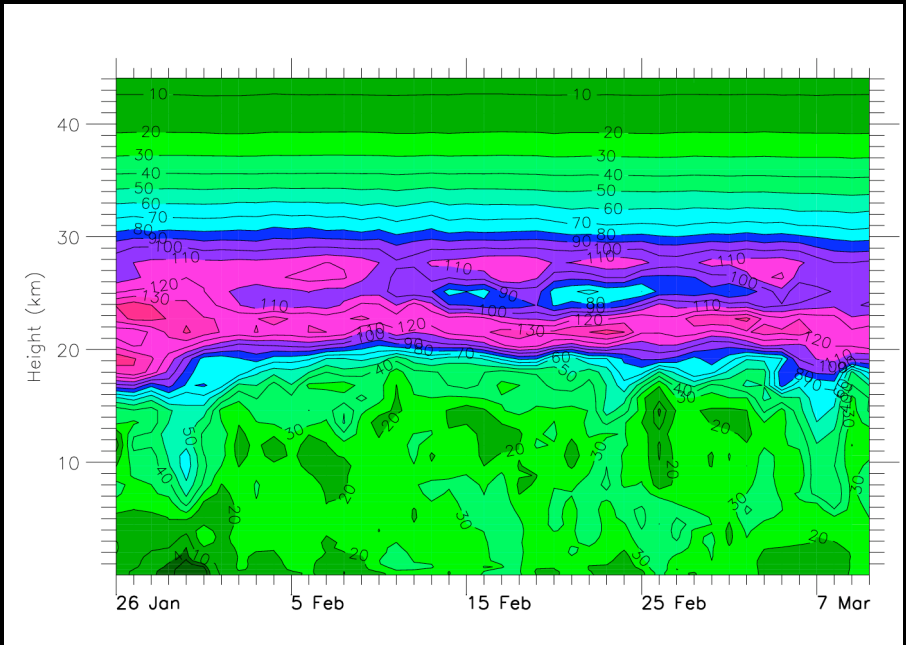
11/02/05

25/02/05

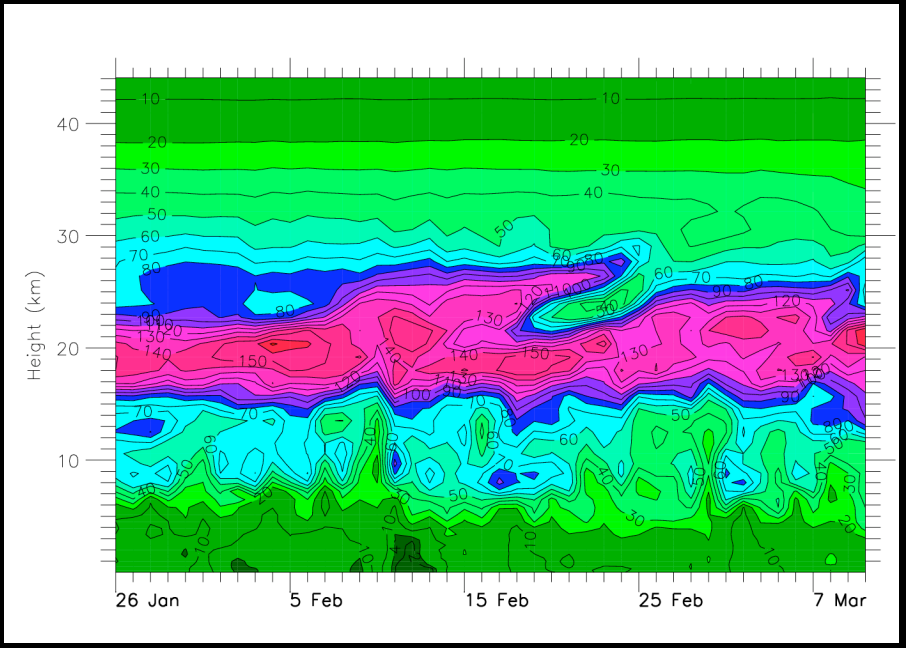
- 31 hPa: low O3 tongues drawn out from pole to lower lats.
- Most obvious over S America, Pacific
- 100 hPa: waveno 4-6 pattern. Low ozone drawn into high lats
- TO: low tongues eg over Weddell Sea on 11/02

Ozone partial pressures 04/05

Comadoro Rivadavia



San Martin



"Dents" near 25km, well into ozone layer. Frequent; clearly can influence ozone column

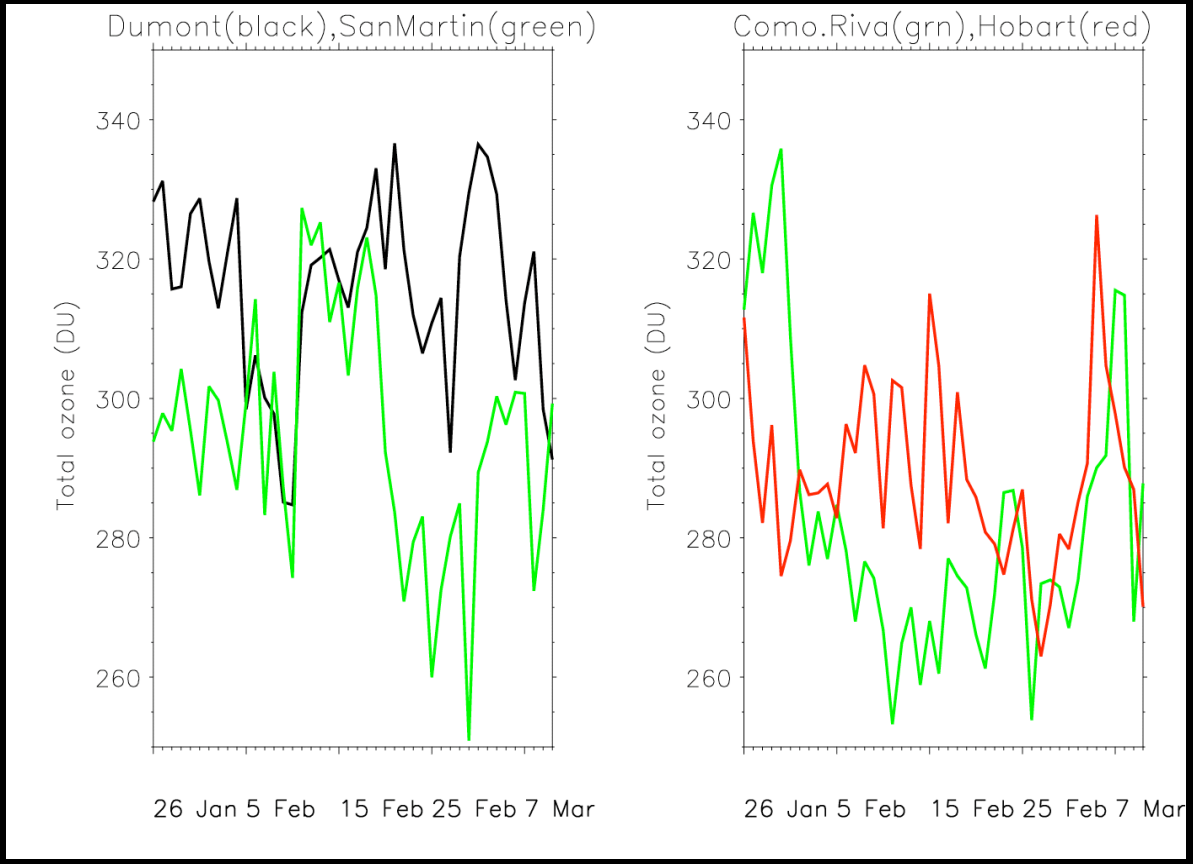
Total ozone timeseries

67/68S: Dumont D'Urville, San Martin

40-45S: Comodoro Rivadavia, Hobart

Lower ozone near S America (San Martin) than 180º round lat.circ.

Some similarities at 40-45S

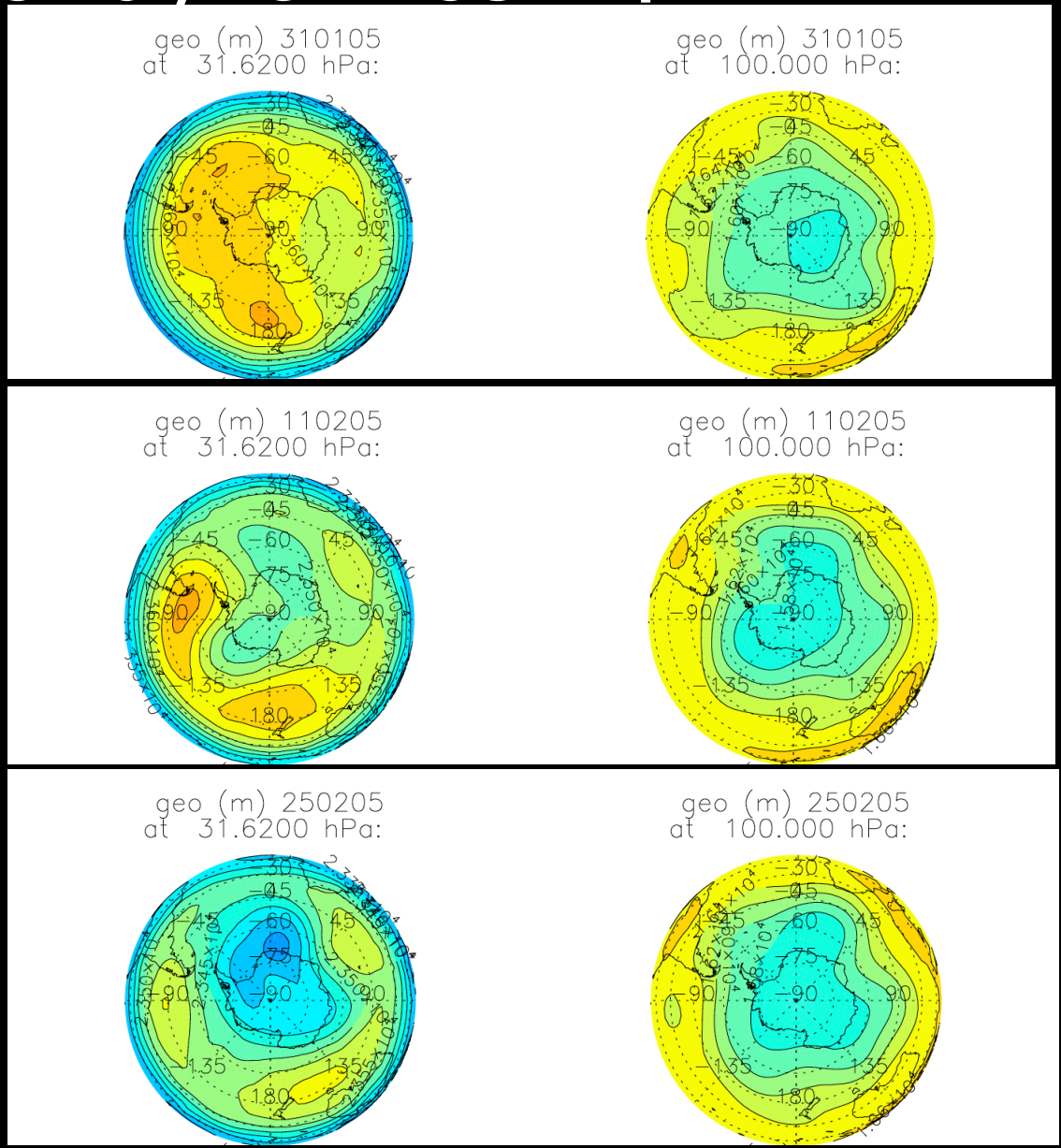


Role of dynamics: Φ

31 hPa: anticyclone breaks in January-early February , by mid-February two large anticyclones are seen to interact, the one near the tip of South America “feeding” on the main vortex remnant.

Zero wind line rises from LS to US during Feb.

100 hPa: waveno 4-6. anticyclones northward/ eastward of those at 31 hPa: aids superposition of low ozone. Baroclinicity.



Band-passed Φ

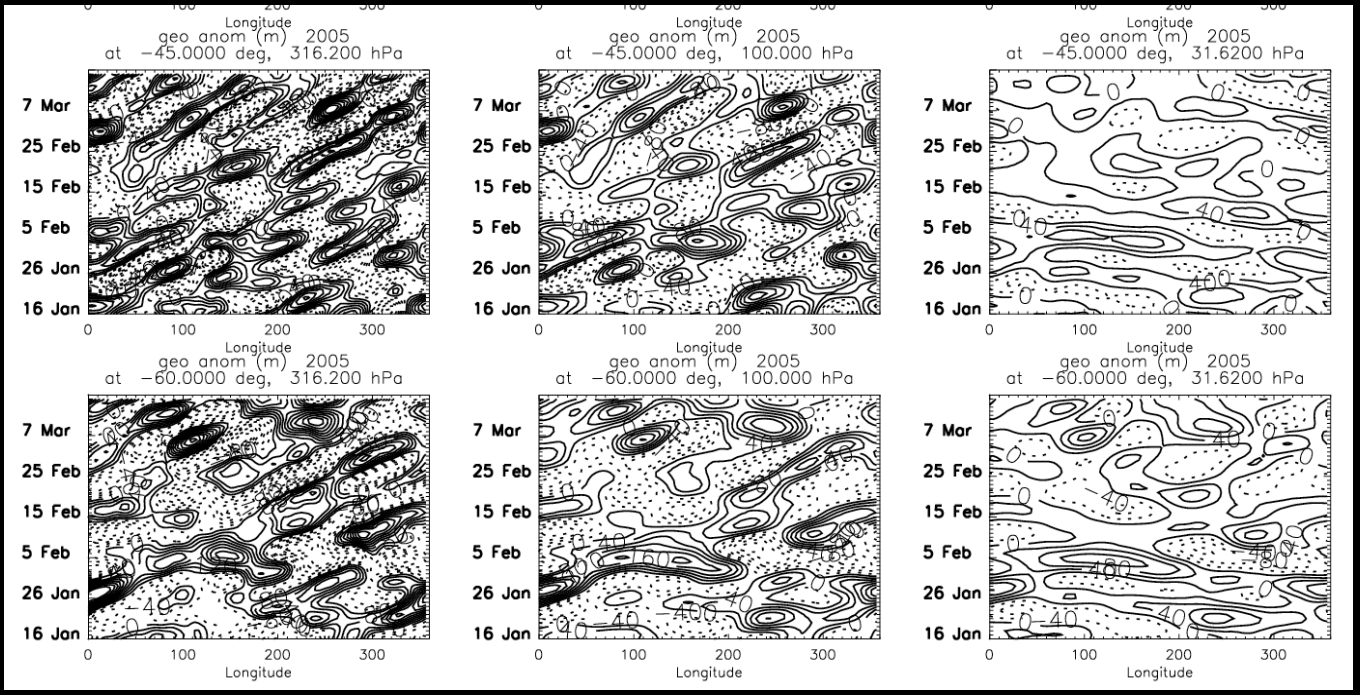
- Further insight can be obtained by band-passing geopotential height fields to select fluctuations between the synoptic and seasonal scales (Nishii and Nakamura (2004, 2005); Orsolini and Nikulin (2006))
- A low band pass filter is first applied to daily Met Office analyses to remove periods less than 8 days, and then anomalies are calculated between the filtered field and the 31 day running mean

Hovmuller of band-passed Φ

316 hPa 100 hPa 31 hPa

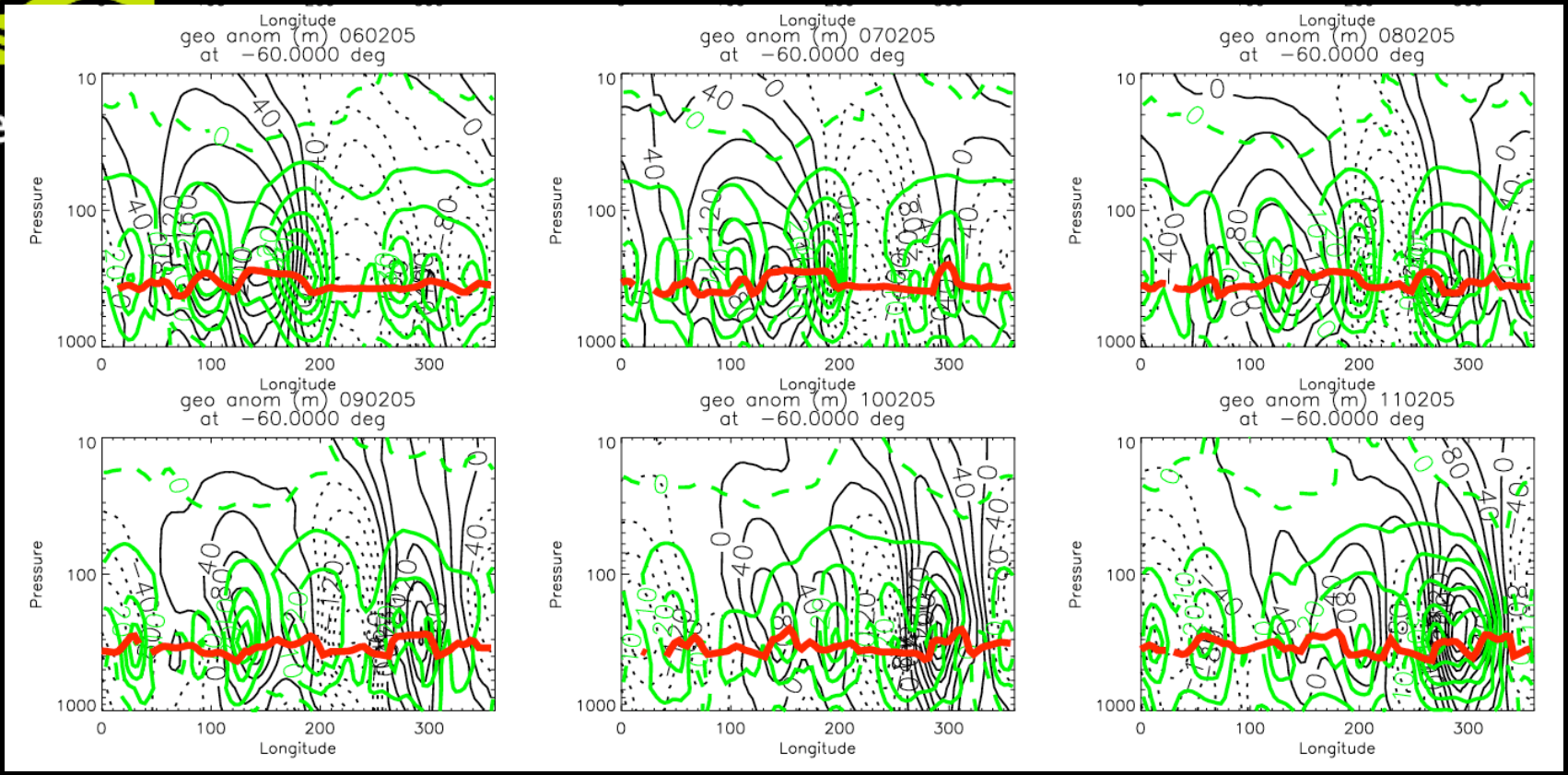
45S

60S



- W3-4 eastward at 45, 60S; 316, 100 hPa (eg Cariolle and Deque, 1986)
- Some westward waves at 60S (Shepherd and Tsuda, 2008)
- At 31 hPa – as above at 60S, but at 45 S now mainly westward. Most intense a/cyclones over S.America, Pacific

Band-passed Φ: timeseries example



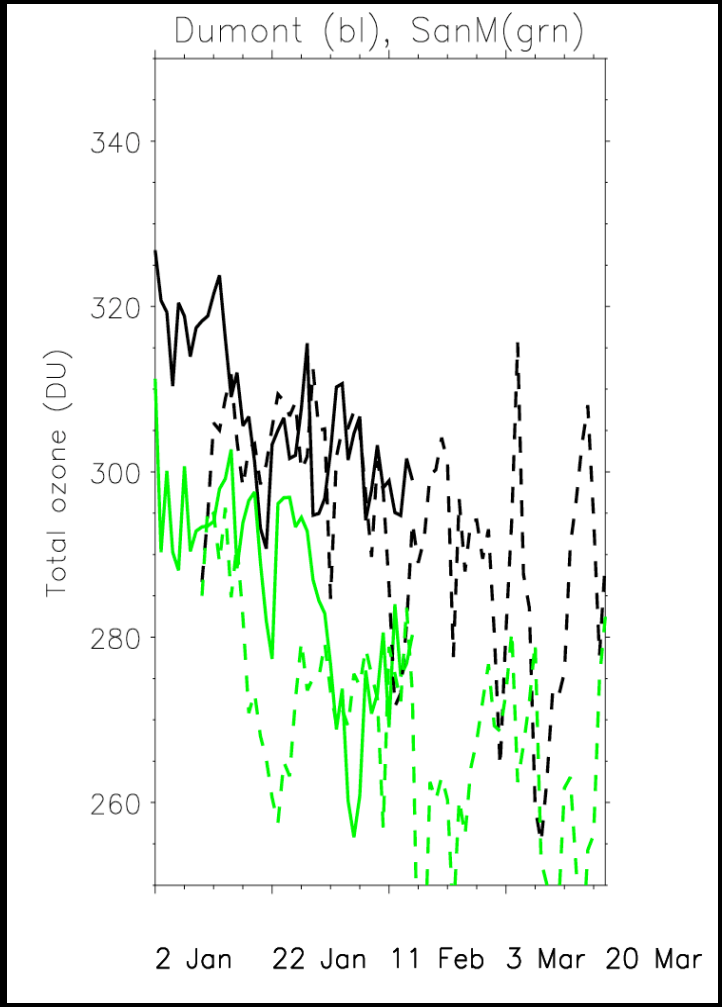
- 06/02/2005 – a/cyclone develops near 300^0, 350 hPa
- Over next days it grows and also extends rapidly upwards – large a/cyclone seen at 31 hPa on 11/02/2005
- Westward tilt with height – baroclinicity
- Transient – a/cyclone rapidly weakens after 11/02/2005

LOEs in 2006 and 2007

Total ozone lower at San Martin than Dumont D'Urville.

OMI total ozone shows crescent-like structure, with lower total ozone over S American tip than at other similar latitudes.

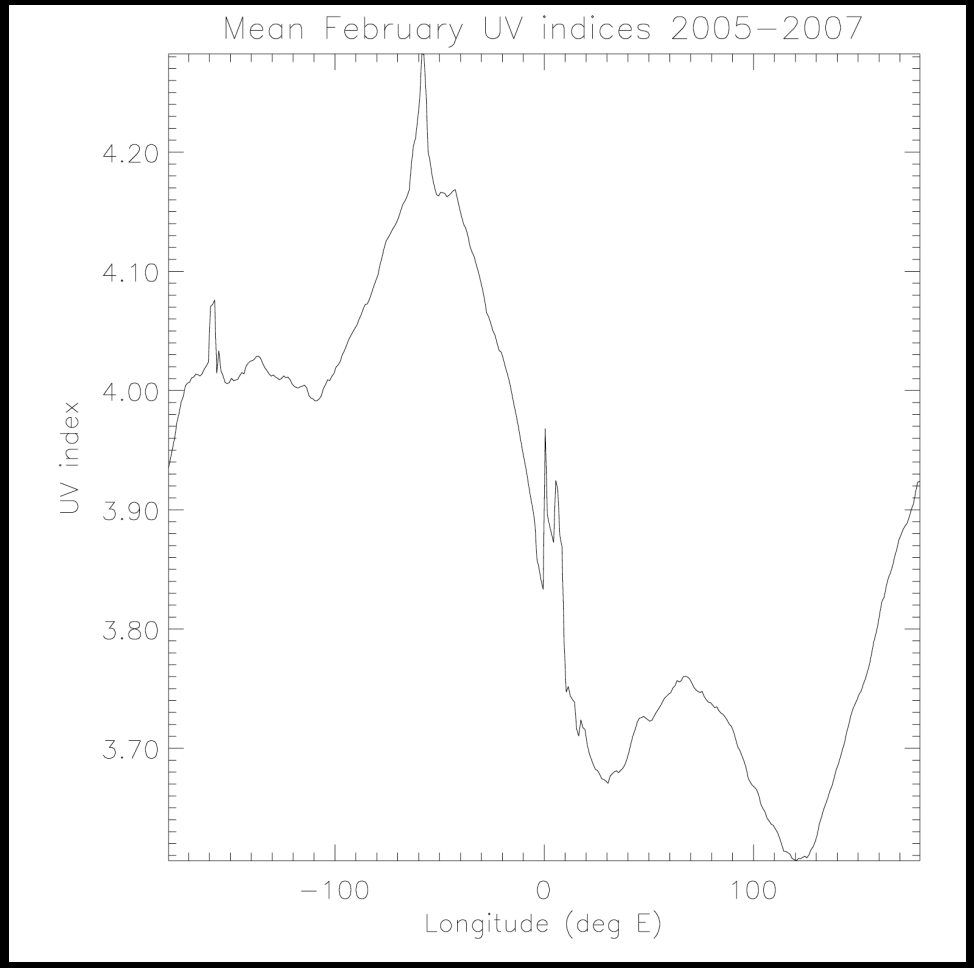
Low ozone tongues in both years generally very similar to those in 2005.



Solid: 2006. Dashed: 2007

Impacts – UV

- High UV anomaly over Weddell Sea
- Weddell Sea / Antarctic Peninsula makes up the most diverse and productive Antarctic marine ecosystem.
- UV radiation is known to affect strongly phytoplankton, aquatic primary production.
- Most such studies have focused on Antarctic spring. May be worthwhile to extend studies of the impact of enhanced UV radiation on the marine ecosystem to summer.



At 64.5S

Summary

- Met Office ozone analyses show low ozone events in southern summer polar stratosphere. Considerable similarity between 2005, 2006 and 2007.
- W4-6 waves seen (as with previous studies). Tilt with height => superposition of low ozone at 31 and 100 hPa.
- LOEs most often seen at Weddell Sea / tip of S America and Pacific longitudes; anticyclones appear to be more frequent at these locations.
- Evidence of reduced UV over above regions, and in particular Weddell Sea. Impact on marine ecosystem?
- Not clear why Weddell Sea is preferential region – Yuan et al (2009) show surface cyclones smaller & less dense than elsewhere – a clue?

Questions and answers