Variations of total ozone content and lower stratosphere temperature in Antarctic Region during winter-spring period

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Data, used in the work

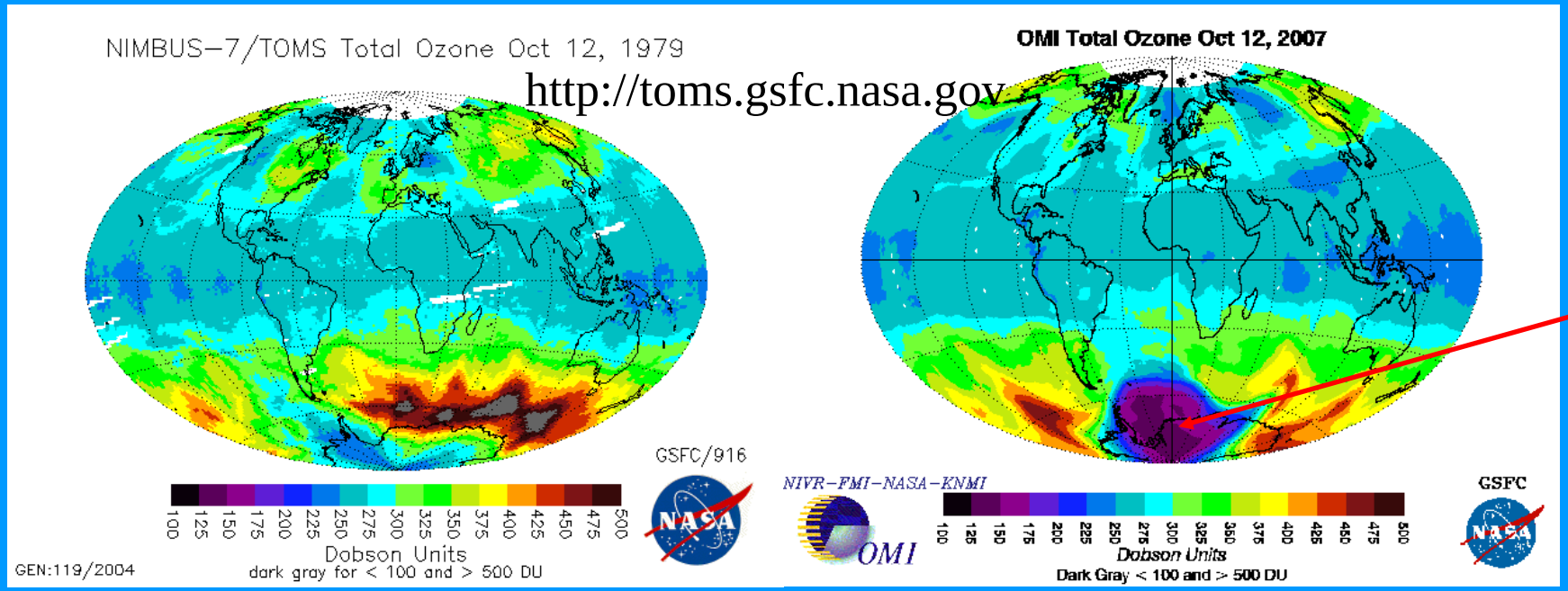
Total ozone: Total Ozone Mapping Spectrometer (TOMS) measurements during 1979 - 2005 and Ozone Monitoring Instrument (OMI) ones for 2006,

http://toms.gsfc.nasa.gov/ftpdata.html.

Geopotential heights and stratosphere temperature: National Centers for Environmental Prediction – National Center for Atmospheric Research (NCEP-NCAR) reanalysis,

http://www.cdc.noaa.gov/cdc/reanalysis.

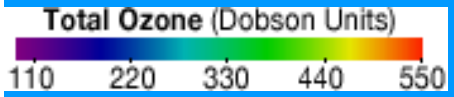
Total ozone content from satellite measurements



Ozone distribution on 12.10.1979 and 12.10.2007

Regular satellite measurements of total ozone content (TOC) had been carried out using TOMS (Total ozone mapping spectrometer) from 1978 (with a gap in 1994-96) till 2005 and have been prolonged with OMI (Ozone Monitoring Instrument) from 2004 hitherto. Presented work consists of the TOC distribution analysis in southern high latitudes.

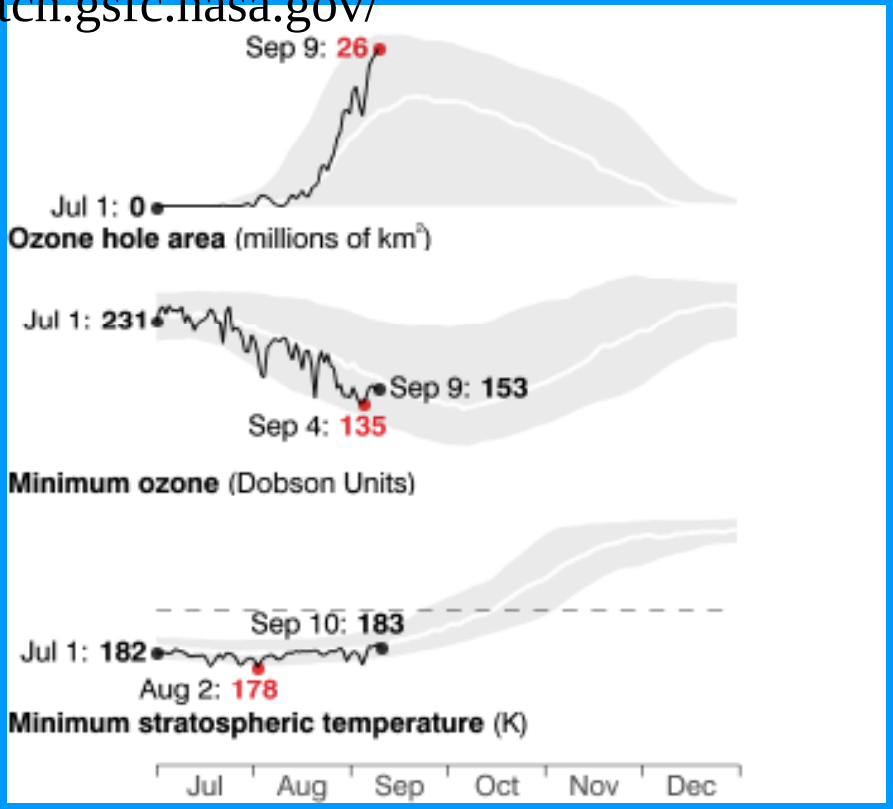
Ozone hole development



http://ozonewatch.gsfc.nasa.gov/

Total ozone distribution on 8.09.2008. White circle shows 65S latitude.

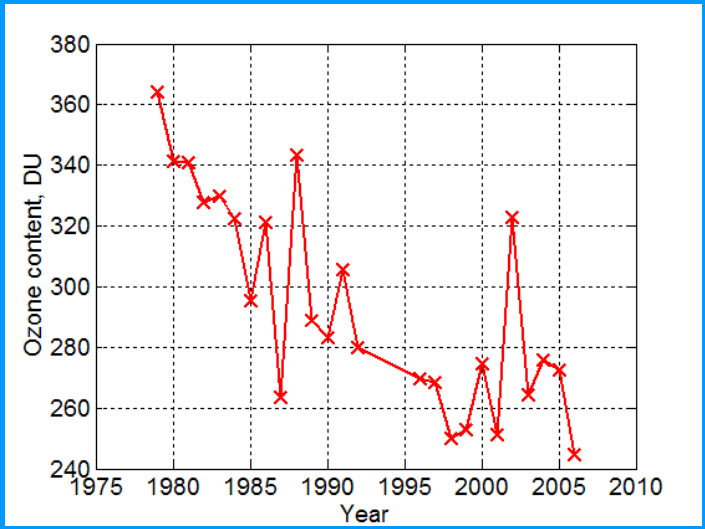
From mid-1980s, ozone hole exists in Southern high latitudes during August - December. Maximal ozone hole area (defined as region with TOC < 220 DU) exceeds $25 \cdot 10^6$ km^2.



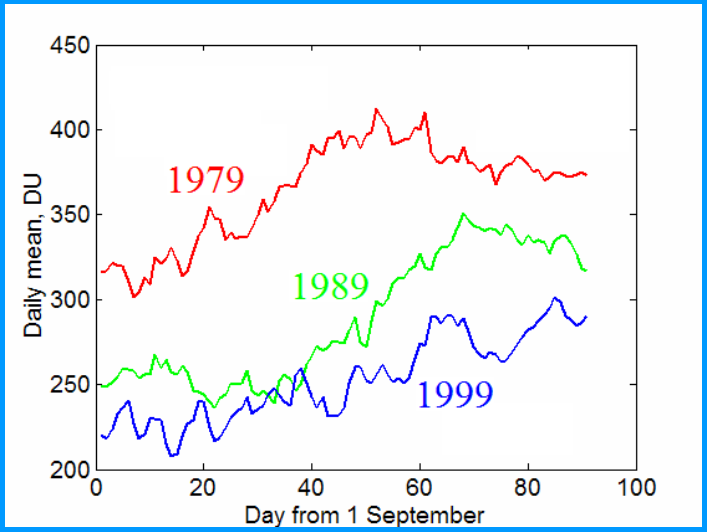
Changes of ozone hole area, minimum TOC and stratospheric temperature values comparatively with multi-year means.

TOC decrease in Antarctic Region

During last decades total ozone content in the Antarctic region has been decreased, especially during spring. From mid-1990s some stabilization has been observed. The satellite measurements show a global distribution of TOC values. The ozone content diminution is the largest in the high latitudes of Southern Hemisphere in spring (predominantly in September and October).

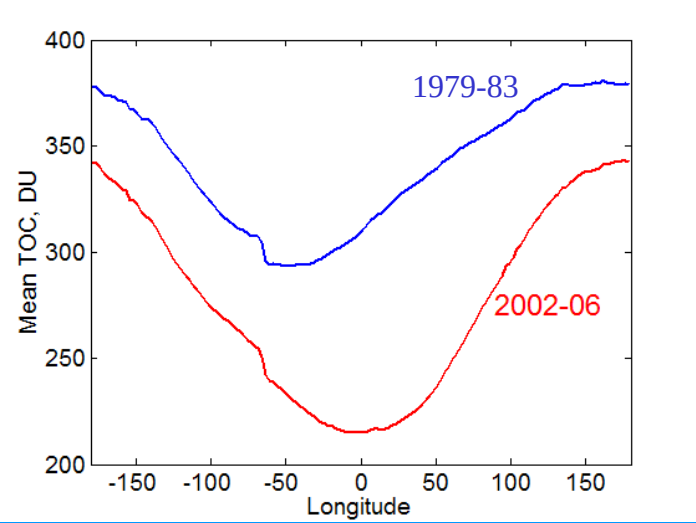


Long-term changes of the September-November zonal mean TOC at 65°S



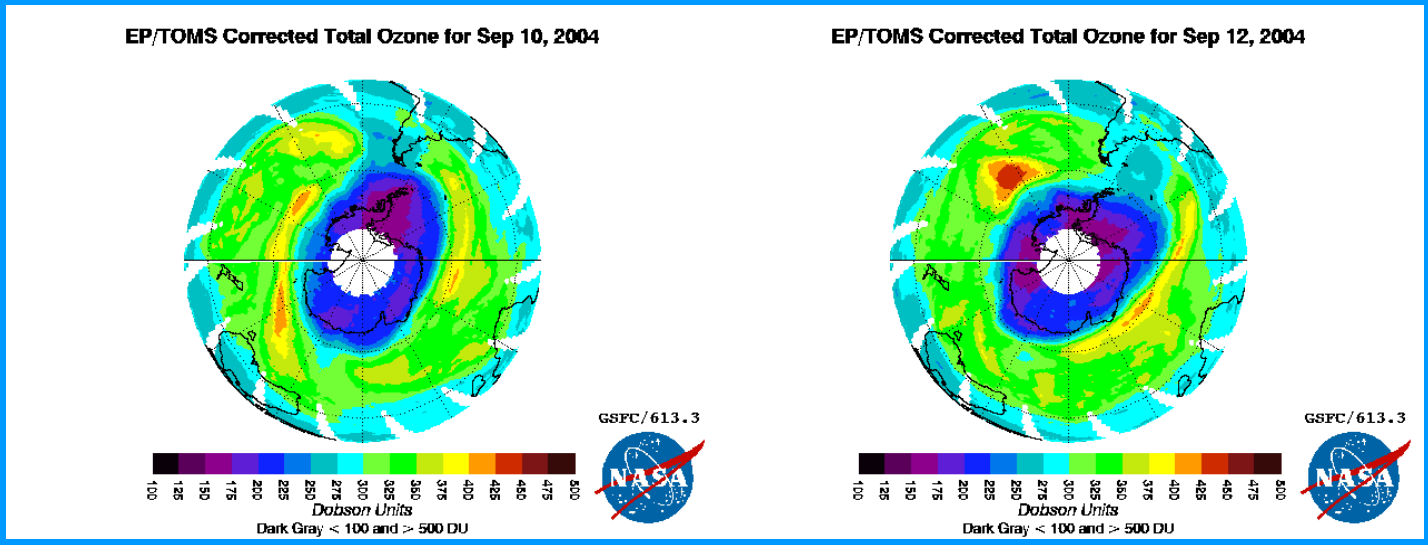
Daily mean TOC values for September-November at 65°S

Interannual changes of ozone distribution asymmetry

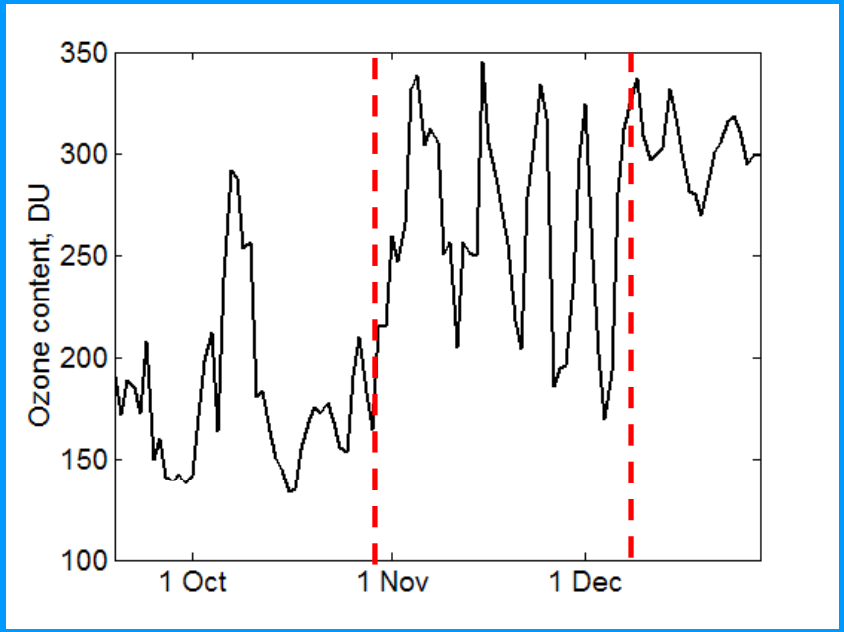


September-November averaged ozone distribution at 65°S for 1979-83 and 2002-06. A long-term TOC decrease is significant. The diminution is maximal in the region of low values, which shifted eastward.

Stationary and traveling planetary waves

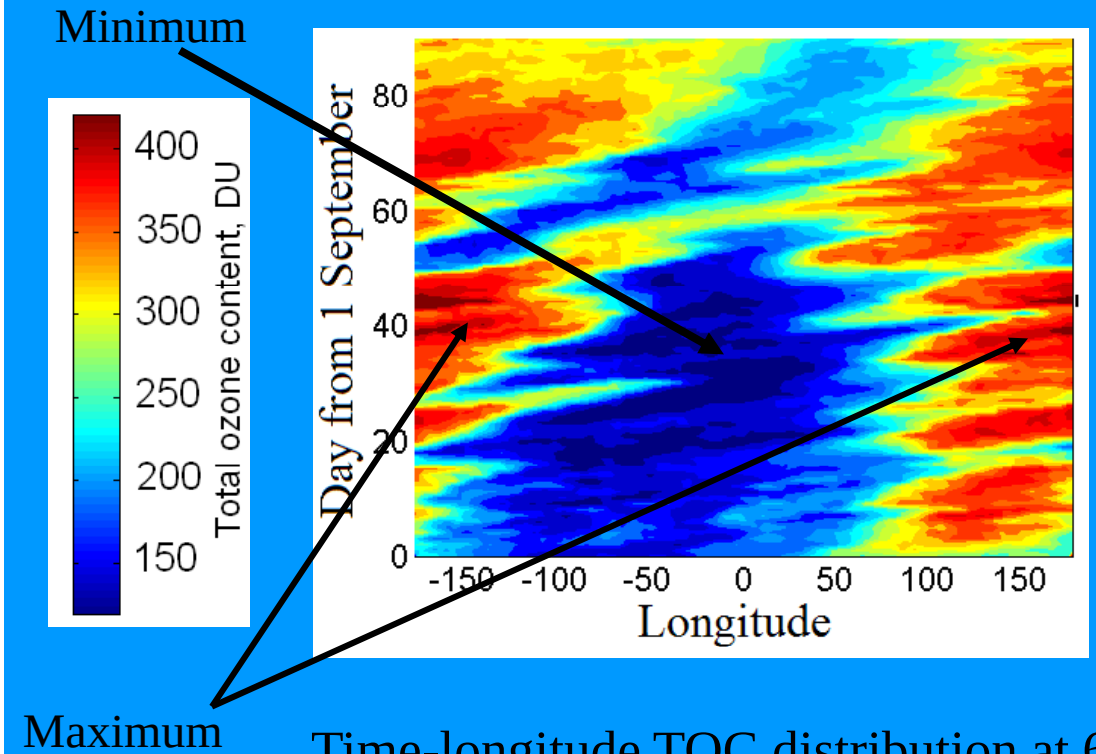


Ozone hole evolution in September 2004 (figures for 10.09 and 12.09)



Traveling wave influence (TOC variations at 65S, 64W in 1999)

Quasi-stationary wave in zonal distribution



Large-scale ozone variations are connected with the planetary wave propagation in stratosphere.

The planetary wave with zonal number 1 is prevailing in stationary distribution.

Time-longitude TOC distribution at 65ºS latitude during September-November 2005. Quasi-stationary wave 1 causes the low values over Southern Atlantic and high ones south of Australia and New Zealand. Wave amplitude is maximal in October.

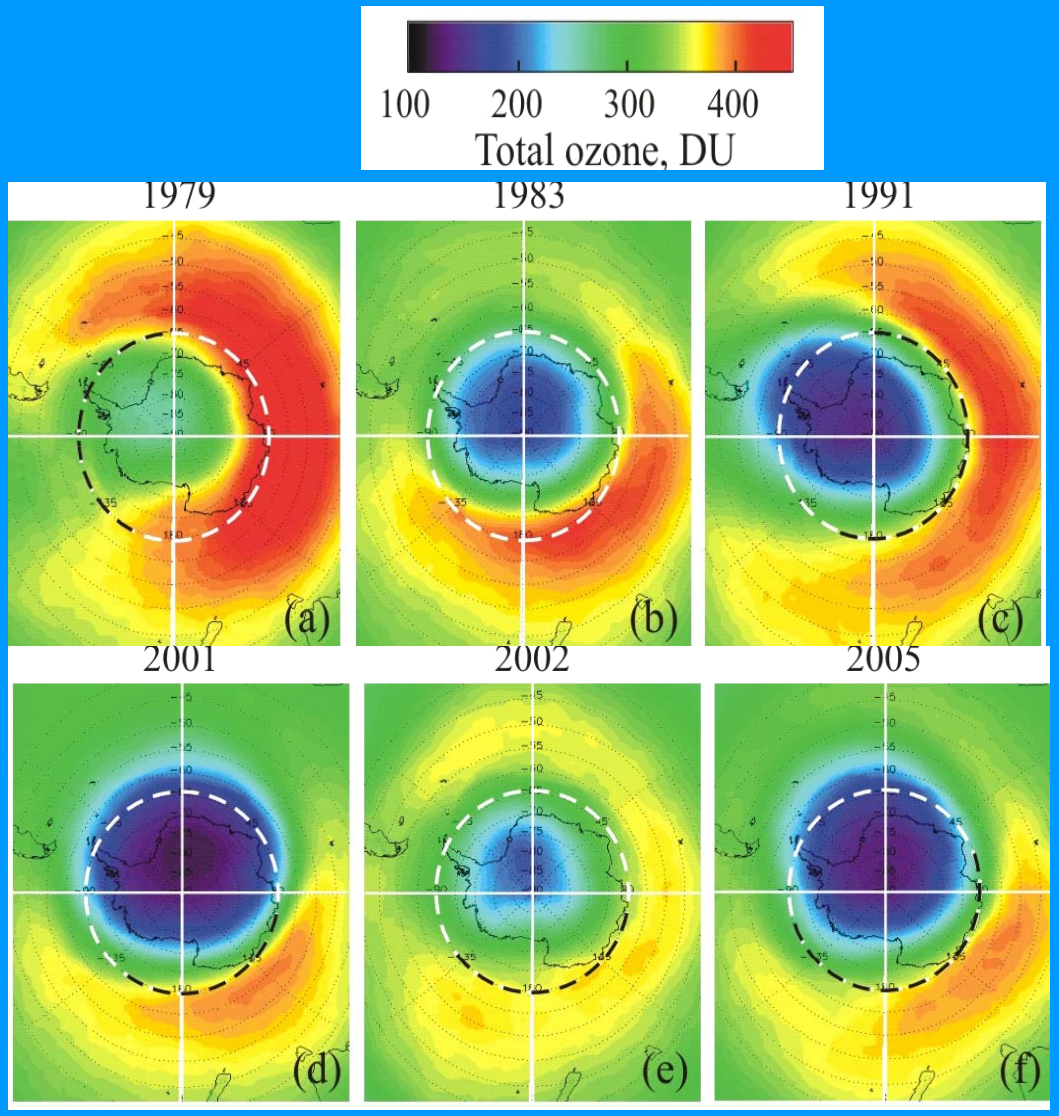
Ozone distribution in Southern Hemisphere

Asymmetry in total ozone content (TOC) distribution is a typical feature of the Antarctic atmosphere.

The asymmetry is conditioned by the planetary wave of zonal number $m = 1$.

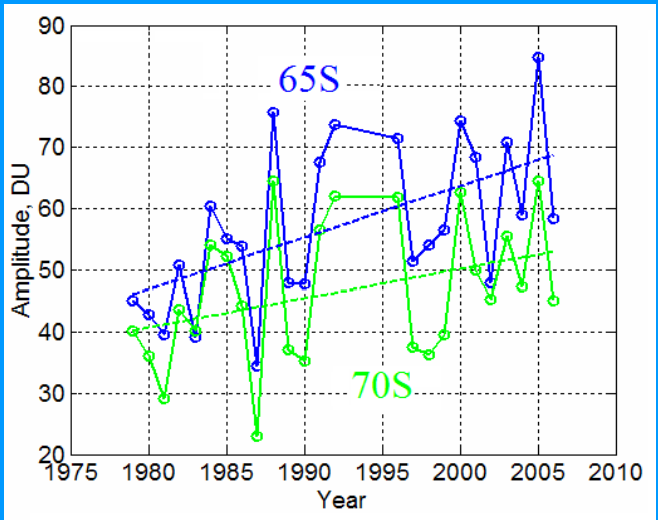
Respectively, the asymmetry relative to the Pole appears in stratosphere temperature horizontal distribution.

The **main goal** of this presentation is to present TOC and lower stratosphere temperature distribution in Antarctic Region during last decades.

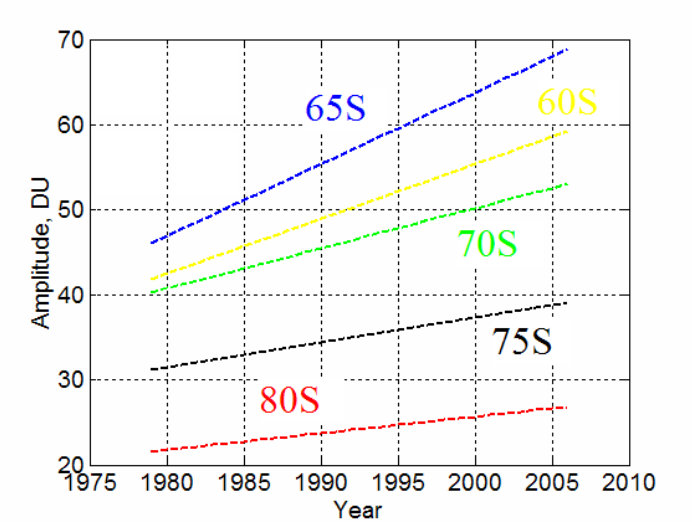


Ozone distribution in southern high latitudes (October mean). TOC in Dobson Units (DU) is shown by colour.

Amplitude variations



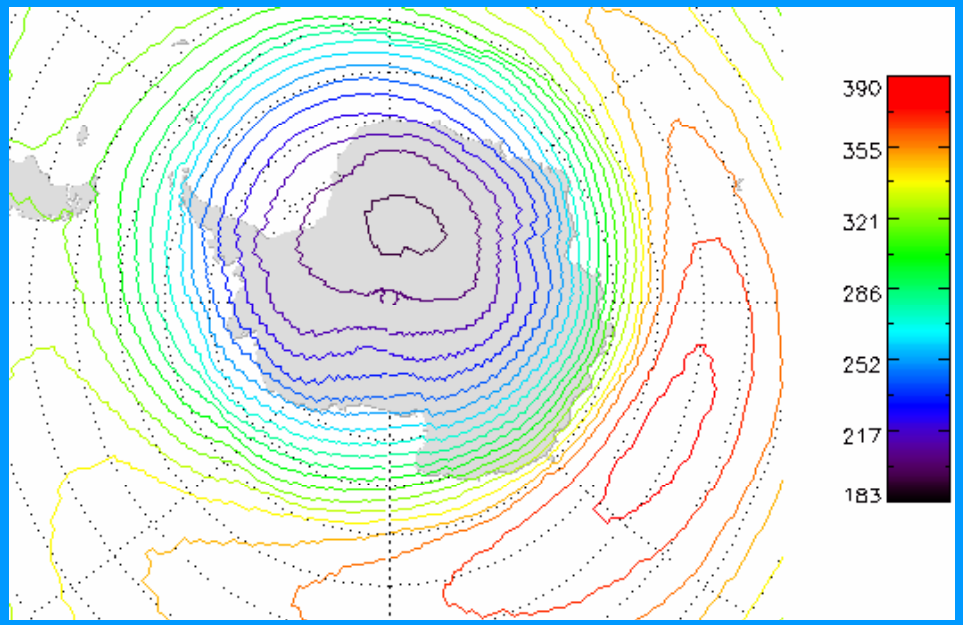
Amplitude of quasi-stationary wave at 65°S and 70°S in September-November. The increasing is higher at 65°S (8.4±2.6 DU/decade).

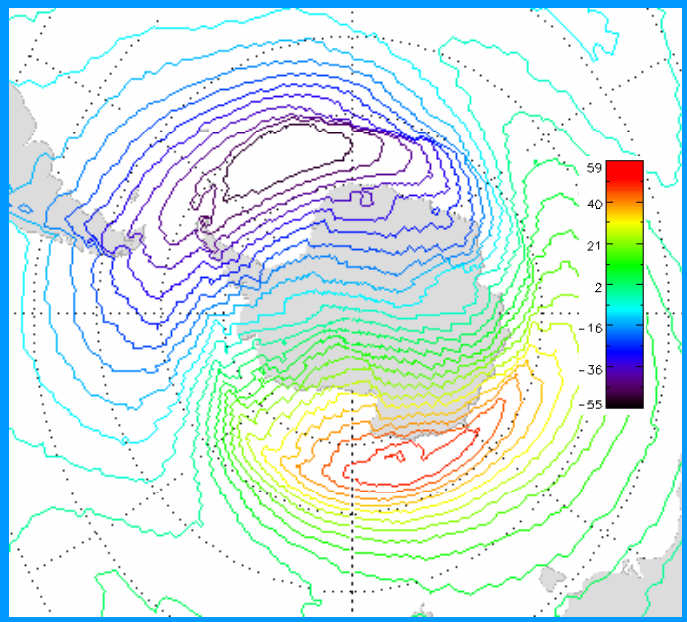


Linear trends of quasi-stationary wave amplitude for September-November. At 50°S and 55°S the trends are statistically insignificant (not shown). The amplitude and its increasing are the largest at 65°S, where the air masses of middle-latitude and polar origin exist.

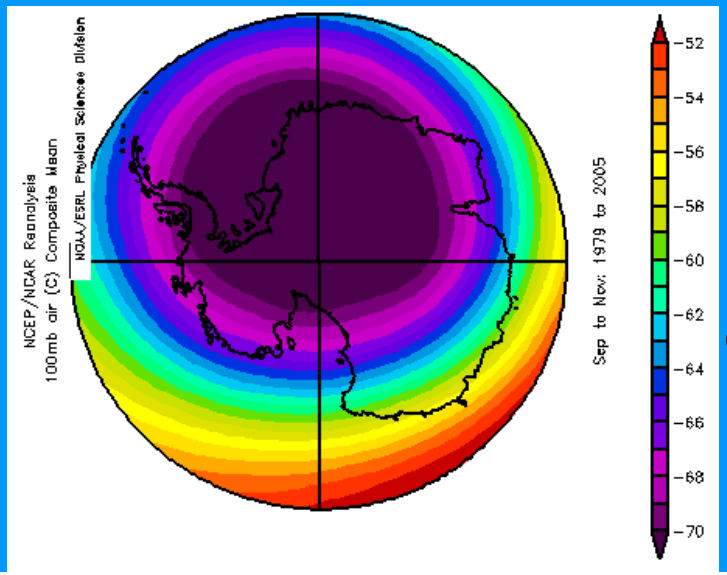
Total ozone climatology for spring 1979-2005

a





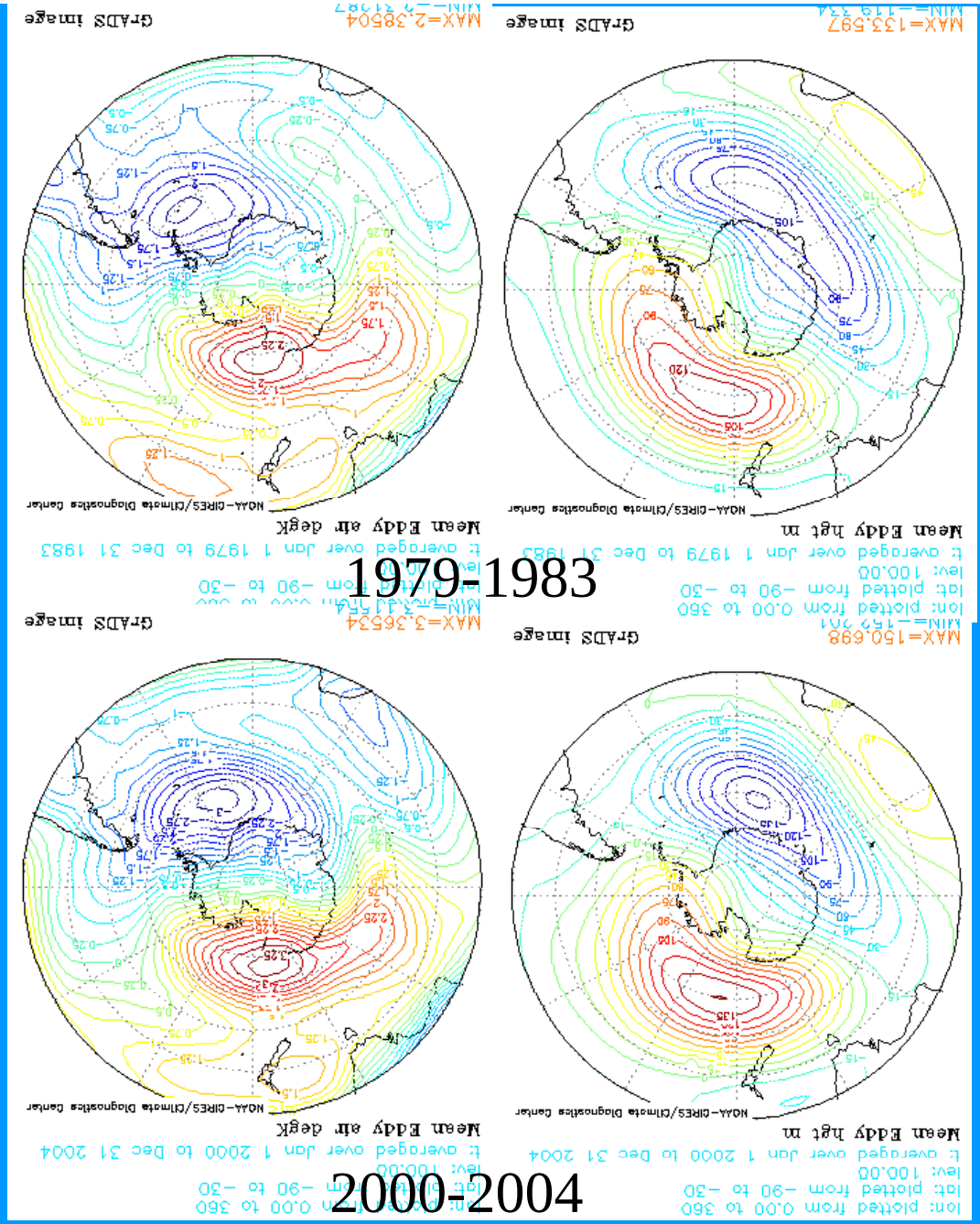
b



c

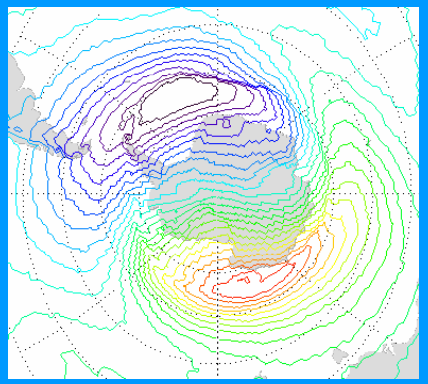
The 24-year mean distribution of (a) total ozone and (b) its deviation from zonal mean by TOMS data 1979-2005 for spring months September-November.

(c) Zonal asymmetry in temperature distribution at 100 hPa level for September-November 1979-2005

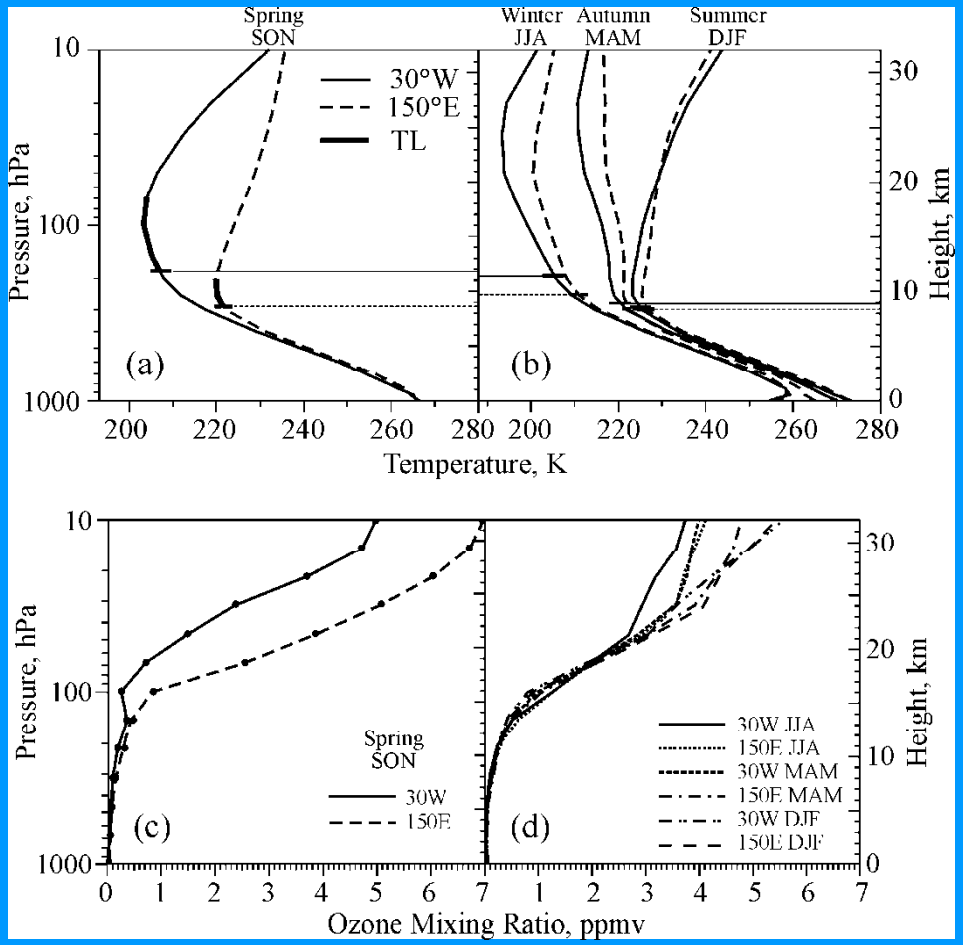


Stationary wave in temperature and geopotential heights at 100 hPa level

Temperature distribution is similar to total ozone one



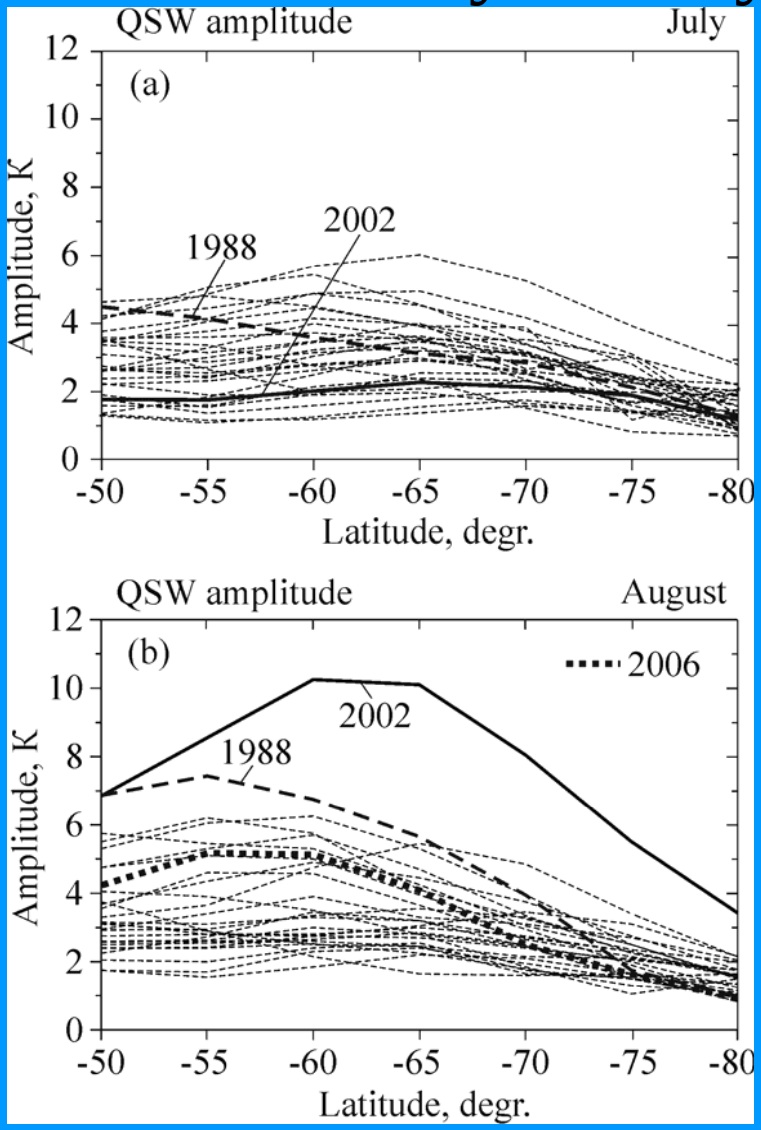
Ozone and stratosphere temperature distribution



The vertical temperature and ozone mixing in 2005 for tropopause zonal extrema at latitude 65°S, longitudes 30°W and 150°E for tropopause height zonal maximum and minimum, respectively.

In spring a decrease of lower stratosphere temperature exists in the ozone minimum region. During other seasons temperature differences between ozone extrema are small.

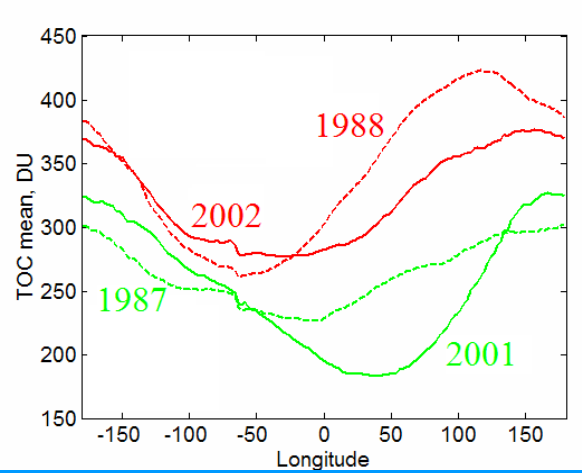
Zonal asymmetry of temperature wave



The strong temperature zonal asymmetry in 2002 followed sharp stratosphere warming in September with ozone hole splitting. The 1988 warming was slower and did not reach inner parts of stratospheric polar vortex.

Interannual variations of the latitudinal distribution of the stationary wave amplitude in the stratosphere temperature at pressure level 100 hPa in (a) July and (b) August 1979-2006.

The unexpected stratospheric processes in 1988 and 2002



Quasi-stationary wave at 65°S for September-November

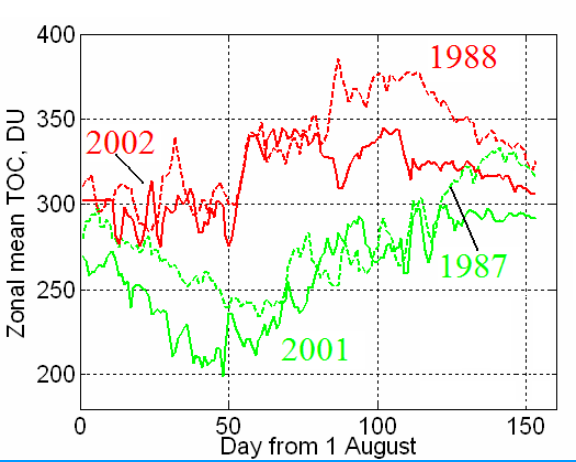
Anomalous features for 1988 and 2002 consist in:

the strong increasing of ozone zonal mean;

short-term ozone hole existence;

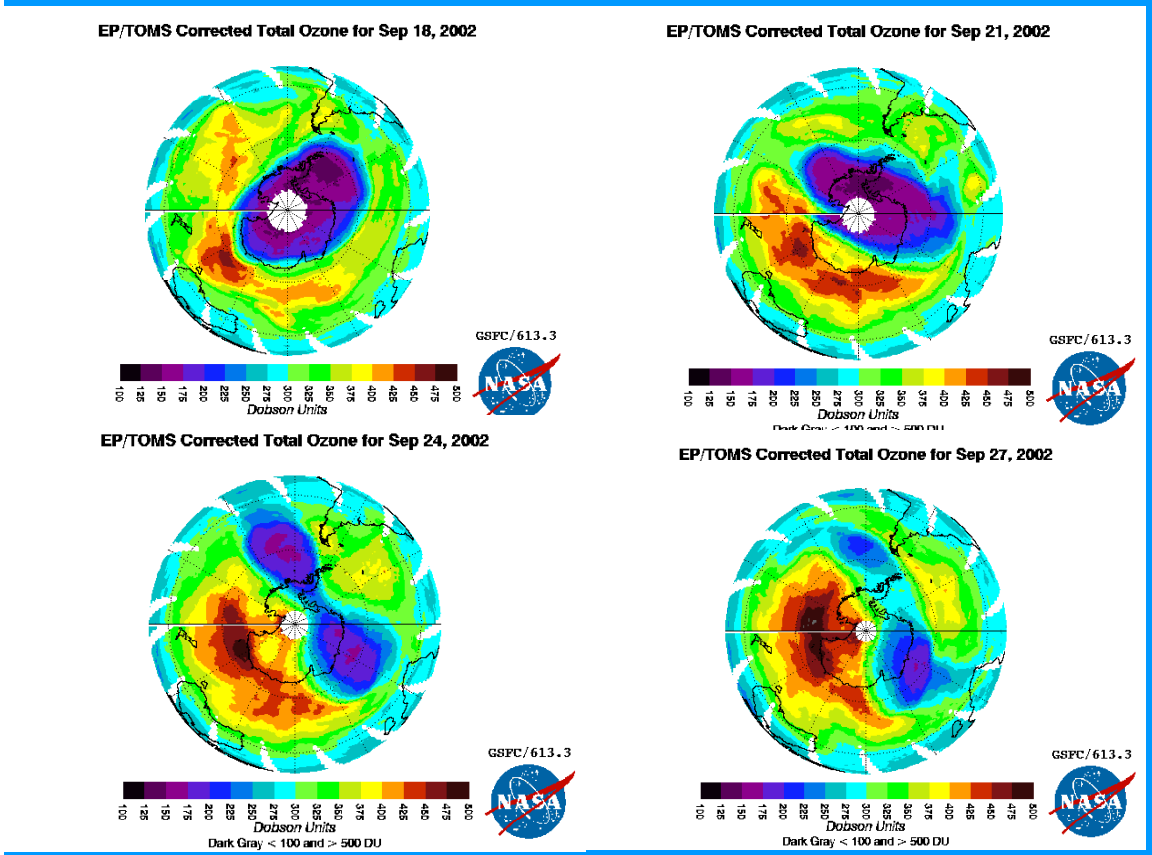
the increasing of PW amplitude during late winter – early spring;

westward displacement of wave maximum's and minimum's positions.

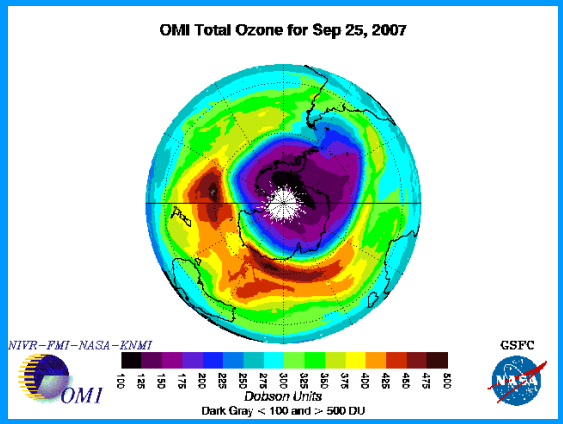


Daily averages at 65°S

Ozone hole in 2002 spring



Ozone hole splitting in September 2002



Typical ozone hole in September 2007

Conclusions

1. Ozone hole over Antarctic Region is systematically displaced toward Atlantic longitudinal sector. Ozone content distribution in zonal direction is very inhomogeneous due to this displacement.

2. During last decades zonal asymmetry in ozone distribution has increased. This process is caused by larger ozone losses in the high-latitude region. Wave amplitude and its trend are maximal in edge region of ozone hole at latitude near 65°S (respectively, 55-75 DU and ~8 DU/decade for September-November).

Conclusions-2

3. The asymmetry in lower stratosphere temperature distribution is connected with ozone content one. Maximal temperature differences are observed during ozone hole period.

4. Wave amplitude increase in August temperature in the Southern high latitudes resulted in a sharp 2002 stratosphere warming. Such increasing can be considered as a condition for estimation of the large stratospheric warming possibility in next months.