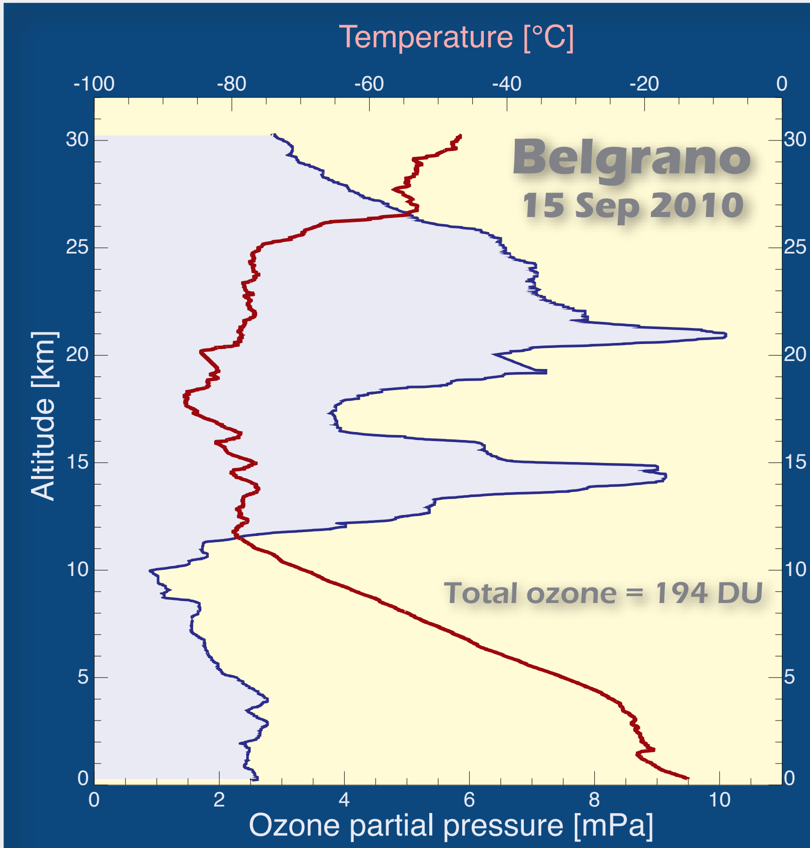
Antarctic Ozone Bulletin

No 2/2010



The vertical distribution of ozone is measured at the Argentine station Belgrano (77.88°S, 34.63°W, 255 masl) with electrochemical ozone sensors. The figure shows the observation made on 15 September 2010. The integrated ozone amount from the surface to the maximum altitude attained by the sonde (burst altitude) is 172 DU and the estimated residual from the top of the profile to the top of the atmosphere is 22 DU. These soundings are carried out in the framework of a collaboration between the Spanish Instituto Nacional de Técnica Aeroespacial (INTA) and the Instituto Antártico Argentino of the Dirección Nacional del Antártico (DNA-IAA).

World Meteorological Organization

Weather • Climate • Water

17 Sep. 2010

Global Atmosphere Watch

Executive Summary

During most of the winter the minimum temperatures at 50 hPa were close to or even below the long term average. Since early September the minimum temperature has increased more rapidly than the long-term average.

The average temperature over the 60-90°S region at 10, 30 and 50 hPa were close to or below the long-term mean until the middle of July. A sudden stratospheric warming that started around mid July and lasted until early August pushed the cold air away from the pole. The cold air mass was also less cold than at the same time in 2009. This warming event was particularly prominent at the 10 hPa level, featuring a temperature increase of more than 20 K, culminating on 31 July. During August the 60-90°S mean temperature decreased and reached the long term average towards the end of the month. Lower down in the atmosphere, from 70 hPa and down to 150 hPa, the 60-90°S mean temperature was much less affected by the late July perturbation. A new warming event is currently on the way and this has led to significant warming at 10 hPa and some warming also at 50 hPa.

Since the onset of NAT temperatures on 8 May the NAT volume was above or oscillating around the 1979-2009 average until mid July. The NAT volume reached a peak of 260 million km^3 in mid July. Then the sudden stratospheric warming event caused the NAT volume to drop to around 170 million km^3 over the course of the next two weeks and reaching the long term (1979-2009) low on some days. During August the NAT volume has remained well below the long term average, although it increased somewhat and reached the long term average towards the end of August. After that it followed the same decline which is normal for the season. The last few days the NAT volume has dropped faster than the long term mean in conjunction with the new warming event.

The geographical extent of the south polar vortex at the isentropic levels 460 K, 500 K and 550 K has been higher than the 1979-2009 average on almost every day since early April. It should be pointed out, however, that vortex size gives no direct indication of the degree of ozone loss that might occur later in the season.

The longitudinally averaged heat flux between 45°S and 75°S is an indication of how much the stratosphere is disturbed. From April to mid July the 45-day mean of the heat flux was lower than or close to the 1979-2009 average. In mid-July, the heat flux increased considerably in conjunction with the sudden stratospheric warming event. The heat flux also increased suddenly around 8 September in conjunction with the second warming event.

At the altitude of ~18 km the vortex is now almost entirely depleted of hydrochloric acid (HCl), one of the reservoir gases that can be transformed to active chlorine. The area affected by HCl removal is somewhat smaller than in recent years. In the sunlit collar along the vortex edge there is now up to 1.7 - 1.8 ppbv of active chlorine (chlorine monoxide, ClO). The mixing ratio of ClO is lower and the activated area is smaller than at the same date in recent years (back to 2004) .

Satellite observations show that the area where total ozone is less than 220 DU (“ozone hole area”) is low compared to recent years. However, the onset of ozone depletion varies considerably from one year to the next, depending on the position of the polar vortex and availability of daylight after the polar night.

Measurements with ground based instruments and with balloon sondes show some degree of ozone depletion at some sites located close to the vortex edge.

It is still too early to give a definitive statement about the development of this year's ozone hole and the degree of ozone loss that will occur. This will, to a large extent, depend on the meteorological conditions. However, the drop in the occurrence of polar stratospheric clouds since the middle of July and the comparatively small mixing ratios of chlorine monoxide point towards a relatively small ozone hole in 2010. The second warming event around mid September will also most likely slow down ozone depletion to a certain extent.

WMO and the scientific community will use ozone observations from the ground, from balloons and from satellites together with meteorological data to keep a close eye on the development during the coming weeks and months.

Introduction

The meteorological conditions in the Antarctic stratosphere found during the austral winter (June-August) set the stage for the annually recurring ozone hole. Low temperatures lead to the formation of clouds in the stratosphere, so-called polar stratospheric clouds (PSCs).

The amount of water vapour in the stratosphere is very low, only 5 out of one million air molecules are water molecules. This means that under normal conditions there are no clouds in the stratosphere. However, when the temperature drops below -78°C, clouds that consist of a mixture of water and nitric acid start to form. These clouds are called PSCs of type I. On the surface of particles in the cloud, chemical reactions occur that transform passive and innocuous halogen compounds (e.g. HCl and HBr) into so-called active chlorine and bromine species (e.g. ClO and BrO). These active forms of chlorine and bromine cause rapid ozone loss in sun-lit conditions through catalytic cycles where one molecule of ClO can destroy thousands of ozone molecules before it is passivated through the reaction with nitrogen dioxide (NO_2).

When temperatures drop below -85°C, clouds that consist of pure water ice will form. These ice clouds are called PSCs of type II. Particles in both cloud types can grow so large that they no longer float in the air but fall out of the stratosphere. In doing so they bring nitric acid with them. Nitric acid is a reservoir that liberates NO_2 under sunlit conditions. If NO_2 is physically removed from the stratosphere (a process called denitrification), active chlorine and bromine can destroy many more ozone molecules before they are passivated. The formation of ice clouds will lead to more severe ozone loss than that caused by PSC type I alone since halogen species are more effectively activated on the surfaces of the larger ice particles.

The Antarctic polar vortex is a large low-pressure system where high velocity winds (polar jet) in the stratosphere circle the Antarctic continent. Figure 1 depicts the vortex on 1, 9 and 17 August 2010. The region poleward of the polar jet includes the lowest temperatures and the largest ozone losses that occur anywhere in the world. During early August, information on meteorological parameters and measurements from ground stations, balloon sondes and satellites of ozone and other constituents can provide some insight into the development of the polar vortex and hence the ozone hole later in the season.

The situation with annually recurring Antarctic ozone holes is expected to continue as long as the stratosphere contains an excess of ozone depleting substances. As stated in the Executive Summary of the 2006 edition of the WMO/UNEP Scientific Assessment of Ozone Depletion, severe Antarctic ozone holes are expected to form during the next couple of decades.

For more information on the Antarctic ozone hole and ozone loss in general the reader is referred to the WMO ozone web page: http://www.wmo.int/pages/prog/arep/gaw/ozone/index.html.

Meteorological conditions

Temperatures

Meteorological data from the National Center for Environmental Prediction (NCEP) in Maryland, USA, show that stratospheric temperatures over Antarctica have been below the PSC type I threshold of -78°C since early May and below the PSC type II threshold of -85°C since late May, as shown in Figure 2. This figure also shows that the daily minimum temperatures at the 50 hPa level have been close to or below the 1979-2009 average until late August. In early September the minimum temperature increased faster than the long term mean and by mid September it is somewhat above the mean as seen in Fig. 2.

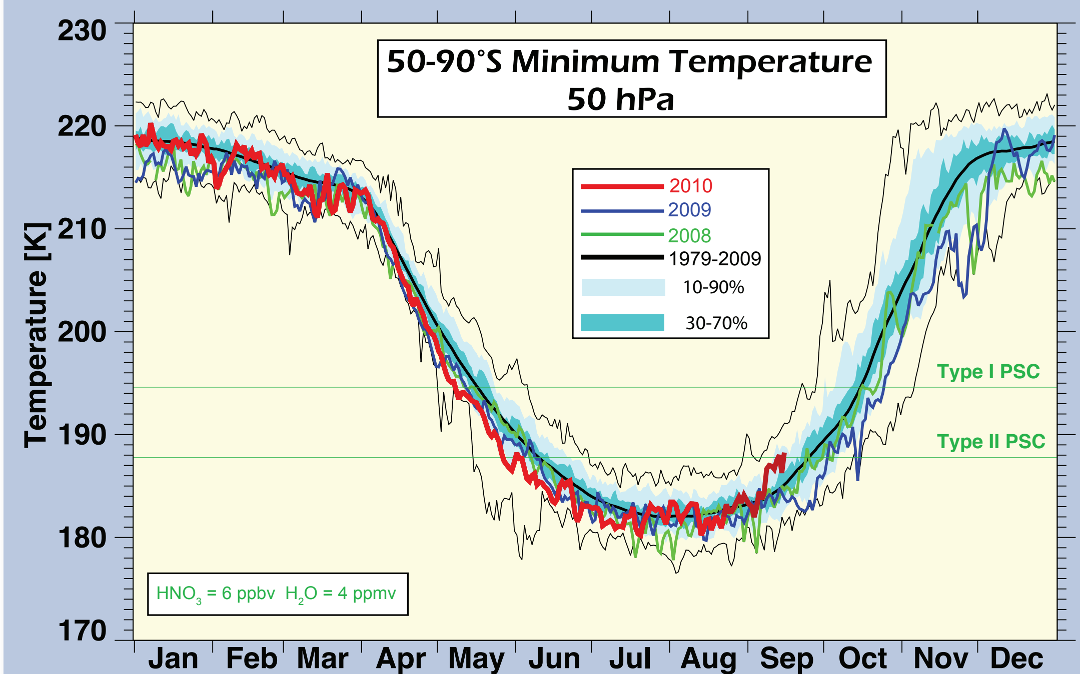


Figure 2. Time series of daily minimum temperatures at the 50 hPa isobaric level south of 50°S. The red curve shows 2010 (until 15 September). Data since the previous bulletin are shown in a deeper red colour. The blue line shows 2009 and the green line 2008. The average of the 1979-2009 period is shown for comparison in black. The thin black lines represent the highest and lowest daily minimum temperatures in the 1979-2009 time period. The light blue-green shaded area represents the 10th and 90th percentile values and the dark blue-green shaded area the 30th and 70th percentiles. The two horizontal green lines at 195 and 188 K show the thresholds for formation of PSCs of type I and type II, respectively. The plot is adapted from a plot downloaded from the Ozonewatch web site at NASA and based on data from NOAA/NCEP. The original plot was made by made by P. Newman (NASA), E. Nash (SSAI) and C. Long (NOAA).

Figure 3 shows temperatures averaged over the 60-90°S region at 10 and 50 hPa. It can be seen from the figure that the average temperature has been quite close to or below the long-term mean until the middle of July. A wavenumber-1 event that started around 21 July and lasted until 7 August pushed the cold air away from the pole. The cold air mass was also less cold than at the same time in 2009. This event is clearly visible at the 10 hPa level, featuring a large temperature increase (> 20 K) culminating on 31 July, as shown in the right hand panel of Figure 3. During August the 60-90°S mean temperature decreased (especially at 10 hPa) and reached the long term average at 50 hPa and decreased well below the mean at 10 hPa. The last few days a new warming event is on the way and this has led to a rapid increase of 60-90°S mean temperature at 10 hPa, as shown in the right hand panel of Figure 3.

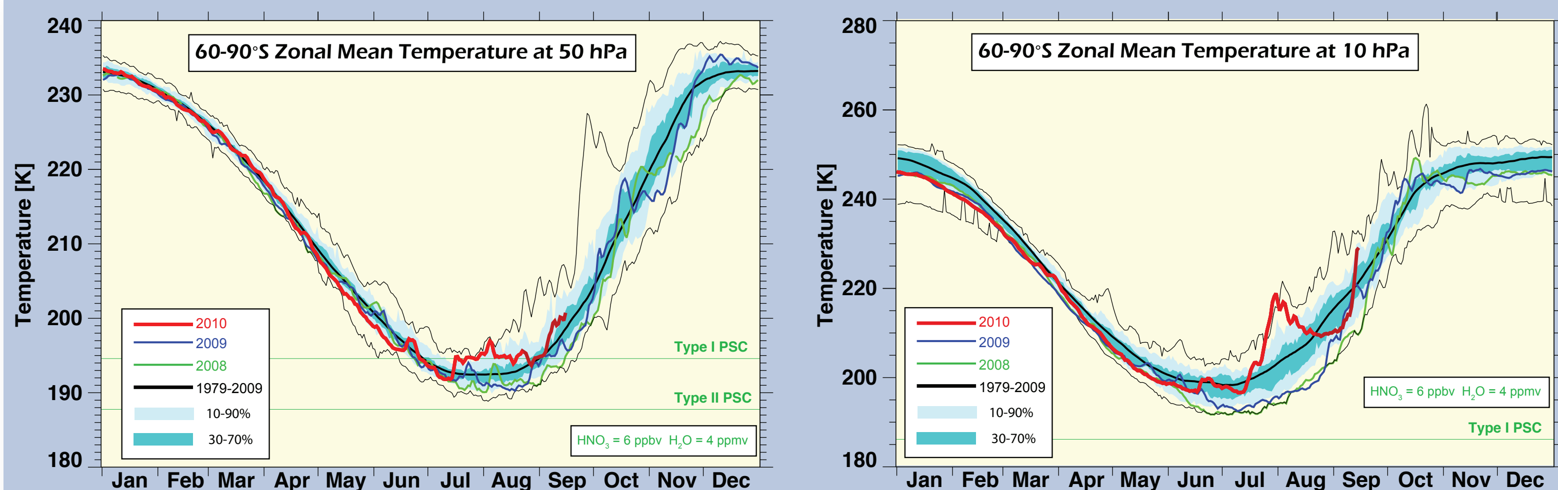


Figure 3. Time series of temperature averaged over the region south of 60°S at the 50 hPa level (left) and at 10 hPa (right). The red curve shows 2010 (until 15 September). The somewhat darker red section of the curve shows the development since the last Bulletin.The blue and green curves represent 2009 and 2008, respectively. The average of the 1979-2009 period is shown for comparison in black. The two thin black lines show the maximum and minimum average temperature for during the 1979-2009 time period for each date. The light blue-green shaded area represents the 10th and 90th percentile values and the dark blue-green shaded area the 30th and 70th percentiles. The plot is adapted from a plot downloaded from the Ozonewatch web site at NASA and based on data from NOAA/NCEP. The original plot was made by made by P. Newman (NASA), E. Nash (SSAI) and C. Long (NOAA).

Lower down in the atmosphere, from 70 hPa and down to 150 hPa, the 60-90°S mean temperature was much less affected by both warming events. The mean temperature over the 55-75°S region has behaved quite similarly to the temperature averaged over the 60-90°S region at all levels from 10 to 150 hPa.

PSC Area and volume

Since the beginning of July, temperatures low enough for nitric acid trihydrate (NAT or PSC type I) formation have covered an area of more than 20 million square kilometres at the 460 K isentropic level. Since the onset of NAT temperatures on 8 May the NAT area was above or oscillating around the 1979-2009 average until mid July. The NAT area reached a peak of 26 million km^2 on 14 July. Then the sudden stratospheric warming event discussed previ-

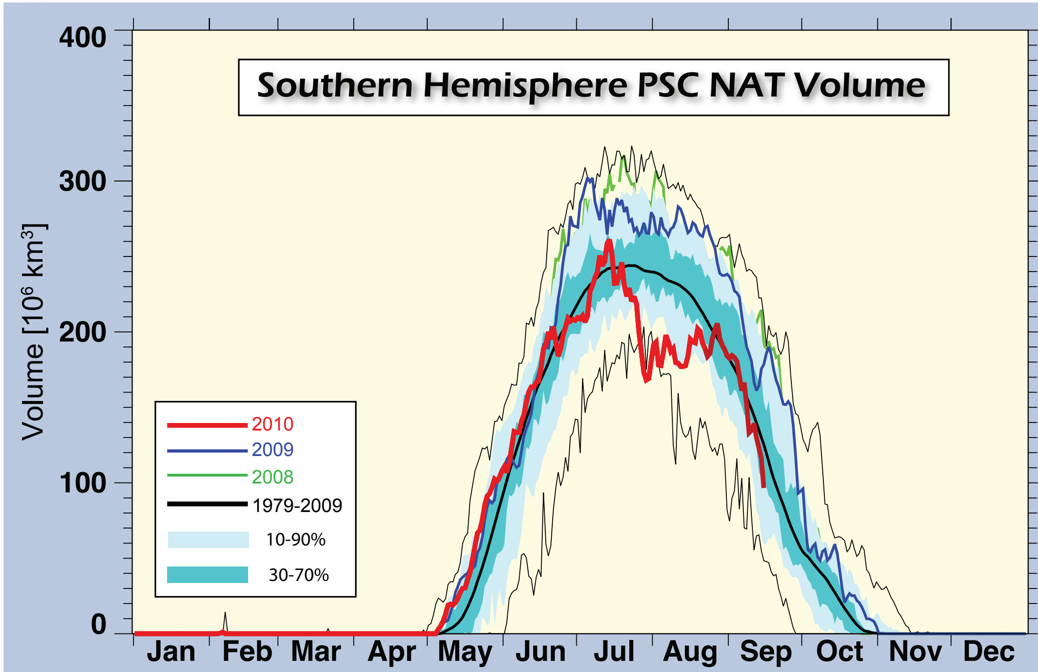


Figure 4. Time series of the volume of the region where temperatures are low enough for the formation of nitric acid trihydrate (NAT or PSCs of type I). The red curve shows 2010 (until 15 September). The blue and green curves represent 2009 and 2008, respectively. The average of the 1979-2009 period is shown for comparison in black. The two thin black lines show the maximum and minimum PSC area during the 1979-2009 time period for each date. The light blue-green shaded area represents the 10th and 90th percentile values and the dark blue-green shaded area the 30th and 70th percentiles. The plot is adapted from plots downloaded from the Ozonewatch web site at NASA and based on data from NOAA/NCEP.

ously caused the NAT area to drop to around 18 million km^2 over the course of the next two weeks and even reaching the long-term low on a couple of days. During August the NAT area has remained well below the long term average, although it increased somewhat from the 18 million km^2 reached at the end of July.

Rather than looking at the NAT area at one discrete level of the atmosphere it makes more sense to look at the volume of air with temperatures low enough for NAT formation. The so-called NAT volume is derived by integrating the NAT areas over a range of input levels. The daily progression of the NAT volume in 2010 is shown in Figure 4 in comparison to recent winters and long-term statistics. Since the onset of PSCs in early May, the NAT volume was above or close to the 1979-2009 average until mid July. The sudden stratospheric warming in late July caused the PSC volume to plummet to below the long-term minimum at the end of July. After that the PSC volume has remained low and well below the long term mean. During August the PSC volume increased slowly and reached the long term mean towards the end of the month. After that it followed the downward slope of the long term mean for some days and the last few days it has dropped rapidly and is now below the long term mean for this time of the year.

The area or volume with temperatures low enough for the existence of PSCs is directly linked to the amount of ozone loss that will occur later in the season, but the degree of ozone loss depends also on other factors, such as the amount of water vapour and HNO_3.

Vortex size and stability

The geographical extent of the south polar vortex at the isentropic levels 460 K, 500 K and 550 K has been higher than the 1979-2009 average on almost every day since early April. It should be pointed out, however, that vortex size gives no direct indication of the degree of ozone loss that might occur later in the season.

The longitudinally averaged heat flux between 45°S and 75°S is an indication of how much the stratosphere is disturbed. From April to mid July the 45-day mean of the heat flux was lower than or close to the 1979-2009 average. In mid-July, the heat flux increased considerably in conjunction with the sudden stratospheric warming event. During August it was oscillating around the long term mean. Around 8 September the heat flux increased rapidly again leading to the second warming event of the 2010 ozone hole season. An updated plot of the heat flux can be found here: http://ozonewatch.gsfc.nasa.gov/meteorology/flux_2010.html

Ozone observations

Satellite observations

The sun has come back to large parts of Antarctica and ozone depletion has started. Figure 5 shows minimum ozone columns as measured by the SCIAMACHY instrument on board ENVISAT in comparison with data for recent years back to 2003 (SCIAMACHY and GOME). Around the middle of September the minimum column was around 170 DU. Minimum ozone values are higher than in other years since 2003 for the same time of the year. On many days, higher than for any of the previous seven years for that time of the year.

Figure 6 (next page) shows satellite maps from OMI for 9 September for the years 2006 - 2010. It can be seen that the 2010 ozone hole is significantly less developed than in recent years.

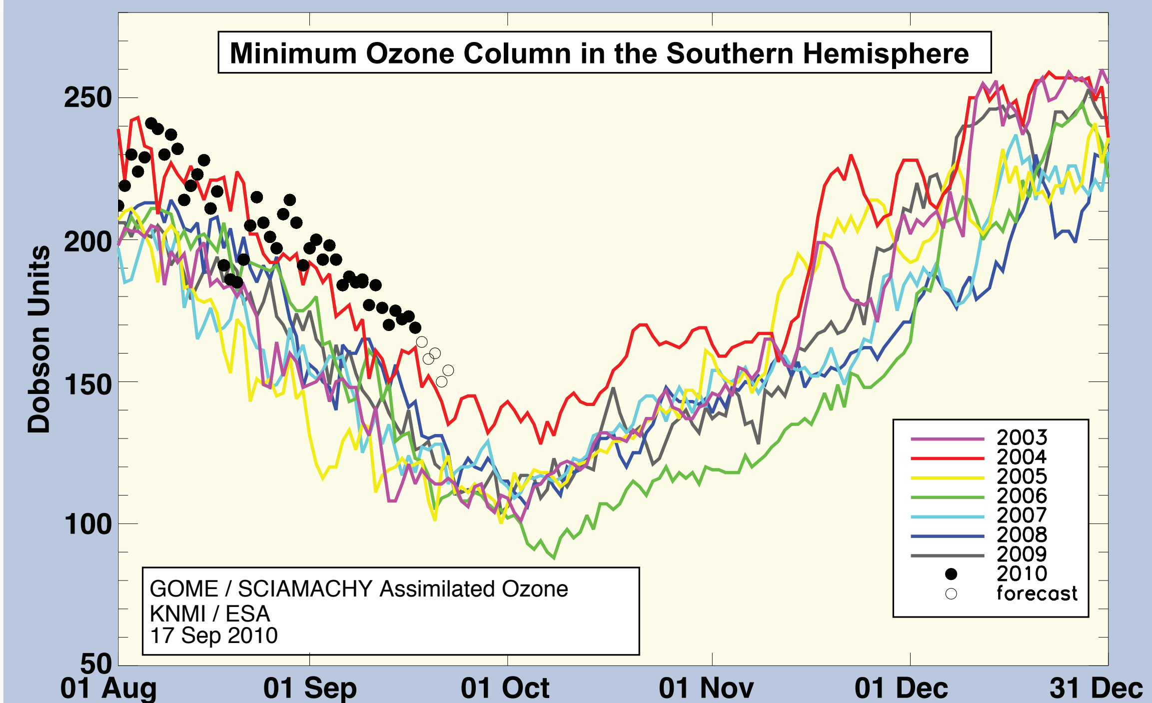


Figure 5. Daily minimum total ozone columns in the Southern Hemisphere as observed by GOME, and SCIAMACHY. The black dots show the SCIAMACHY observations for 2010 until 17 September. The data now show minimum ozone columns around 170 DU. The plot is provided by the Netherlands Meteorological Institute (KNMI) as part of the European project MACC.

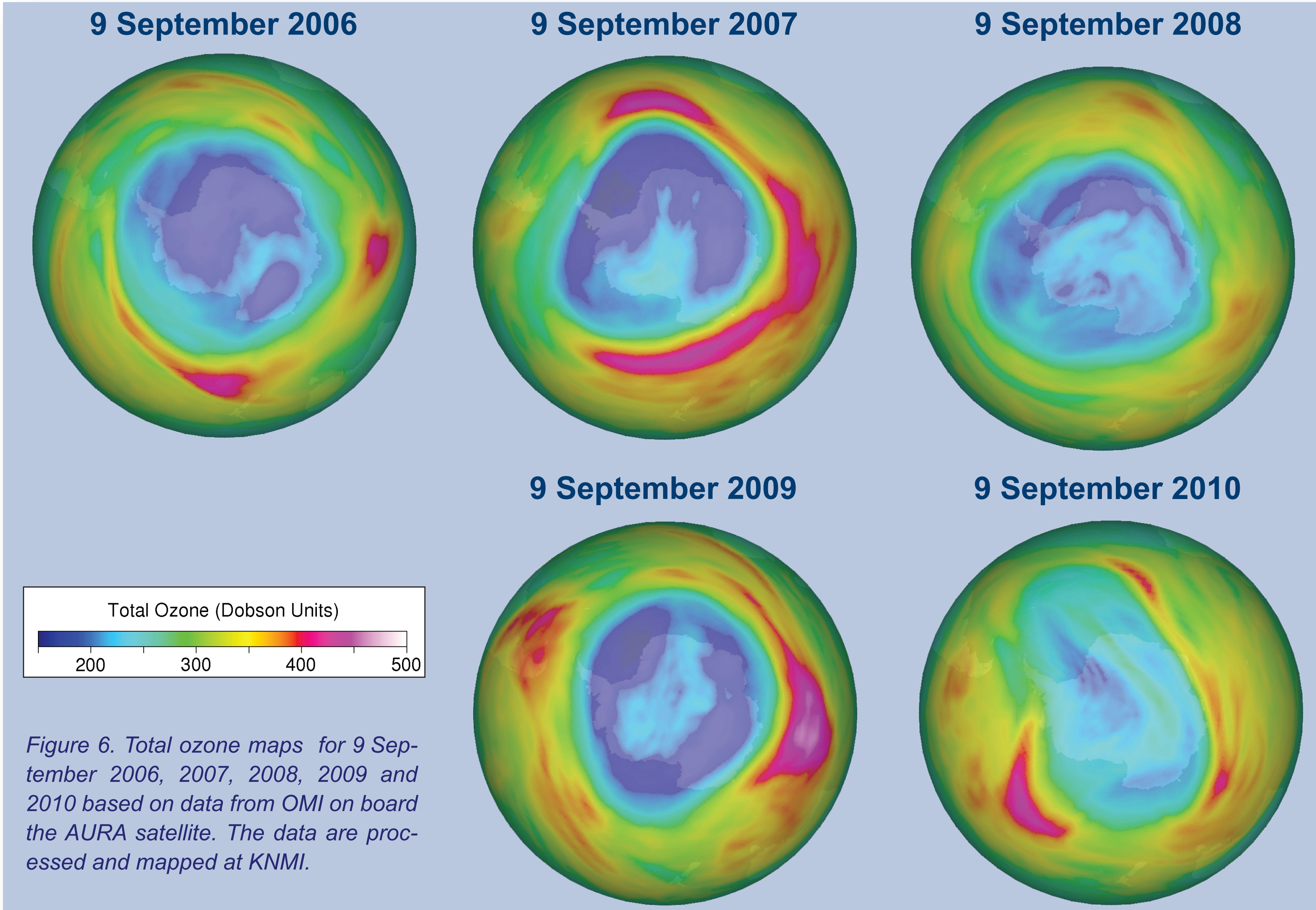


Figure 6. Total ozone maps for 9 September 2006, 2007, 2008, 2009 and 2010 based on data from OMI on board the AURA satellite. The data are processed and mapped at KNMI.

Ground-based and balloon observations

It is still early in the ozone hole season, but ozone depletion has started. Many stations now report ozone hole values (total ozone below 220 DU). On page 18 is a map showing the location of the stations described.

Arrival Heights

The GAW/NDACC station Arrival Heights (77.8°S, 166.2°E), operated by New Zealand, will start the observations after the polar night on 14 September. As soon as data are available, they will be reported here.

Belgrano

The vertical distribution of ozone is measured at Argentine station Belgrano (77.88°S, 34.63°W) with electrochemical ozonesondes. Six soundings have been carried out since the beginning of August. The observation carried out on 15 September 2010 is shown on the cover.

Davis

Ozonesondes are launched weekly during the ozone hole season from the Australian station Davis (68.58°S, 77.47°E). Figure 7 shows profiles measured from 16 June to 9 September. It is clearly seen that ozone depletion has set in and the profile of 9 September shows clear signs of ozone destruction around 15 km.

Dôme Concordia

Total ozone is measured with a SAOZ spectrometer at the French/Italian GAW/NDACC station at Dôme Concordia (75.10°S, 123.30°E, 3250 masl) on the Antarctic ice cap. The measurements started up again after the polar night on 29 July. The first few days total ozone was around 280-300 DU. Since the last bulletin total ozone has declined

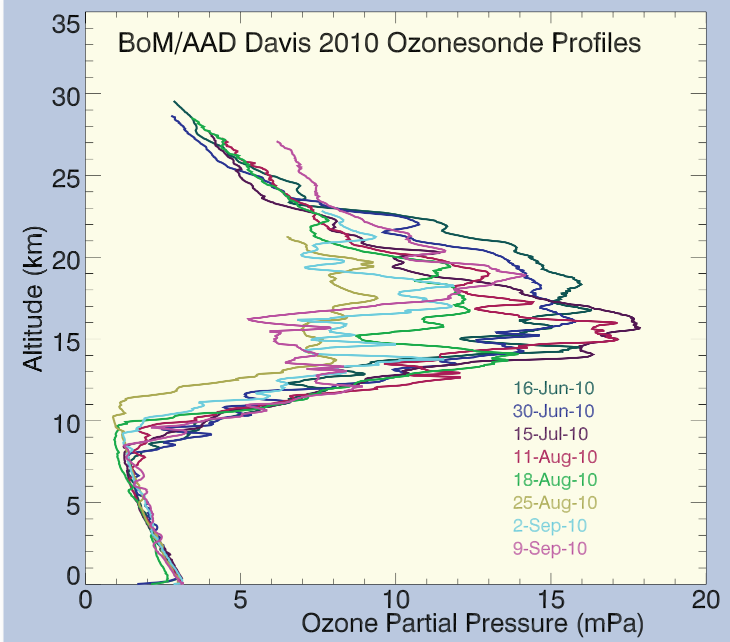


Figure 7. Ozonesonde profiles measured at the Australian station Davis. The station is managed by the Australian Antarctic Division of the Bureau of Meteorology.

and been around 250 DU, with a minimum on 1 September (217 DU). On 15 September total ozone was 233 DU.

Dumont d'Urville

The French GAW/NDACC station Dumont d'Urville (66.67°S, 140.02°E) is located at the polar circle, which allows for SAOZ measurements around the year. Since the beginning of August total ozone has declined from around 350 DU to around 200 DU on 8 September. After that total ozone has increased to over 300 DU on 12 September. The SAOZ spectrometer reports both sunrise and sunset values. On certain days there is a large difference between sunrise and sunset values, indicating that the station is located at the edge of the vortex.

Halley

Total ozone is measured with a Dobson spectrophotometer at the UK GAW station Halley (75.58°S, 26.71°W). The measurements started up again on 27 August after the polar winter. On satellite images one can see that the region with most ozone depletion has been located over this part of the Antarctic continent. This also shows up in the observations made at Halley, where twelve of the fifteen first days of September showed total ozone below 220 DU and with a minimum so far of 172 DU on 13 September.

Marambio

Ozone profiles are observed at the Argentine GAW station Marambio (64.2°S, 56.6°W) with ozonesondes. Eight ozonesondes were launched during August. Five sondes have been lunched so far in September. The ozone profile of 8 September shows a pronounced, but yet shallow, "bite-out" around 18 km. Total ozone estimated from this profile is 186 DU (156 DU by integrating the profile and 30 DU estimated from the burst altitude to the top of the atmosphere).

Mirny

At the Russian GAW station Mirny (66.55°S, 93.00°E) total ozone is measured with a filter instrument. In August total ozone has on most days been just below 300 DU and also above 300 DU on some days. On the 17th of August total ozone dropped to 223 DU, but it went back up to 295 DU on 22 August. From 23 to 30 August total ozone varied between 201 and 232 DU. During the first days of September total ozone varied between 205 and 284 DU. From 10 September total ozone has been around and above 300 DU.

Neumayer

The vertical distribution of ozone is measured with ozonesondes from the German GAW/NDACC station at Neumayer (70.65°S, 8.26°W). After the last Bulletin, sondes were launched on 30 August and on 6, 9 and 12 September. Figure 7 shows the ozone profile which was measured on 12 September. One can clearly see "bite-outs" due to ozone depletion. Satellite data shows that a region with low ozone passed over Neumayer on 12 September.

Novolazarevskaya

At the Russian GAW station Novolazarevskaya (70.77°S, 11.87°E) total ozone is measured with a filter instrument. At this station, measurements started on 15 August. From 19 to 22 August total ozone dropped from 294 to 177 DU. From 23 to 31 August total ozone varied between 184 and 248 DU. From 2 to 12 September all days have shown ozone hole values (below 220 DU) varying between 192 and 220 DU.

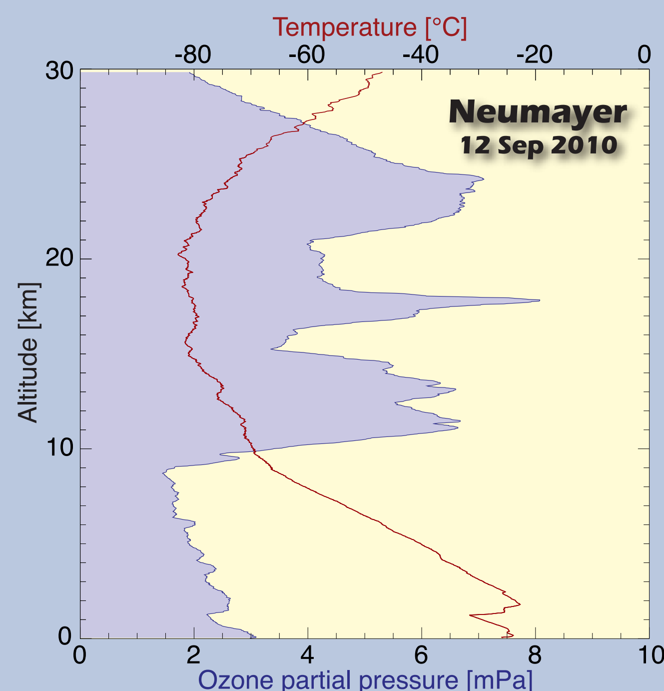


Figure 7. The vertical distribution of ozone over the Neumayer station on 12 September 2010 measured with an ECC ozonesonde. The blue-grey shaded region shows ozone, and the red curve is the atmospheric temperature.

Rothera

At the British GAW/NDACC station Rothera (67.57°S, 68.12°W) total ozone is measured with a SAOZ spectrometer. Since the station is close to the polar circle, observations can be carried out around the year. Total ozone has been oscillating between 240 and 340 DU most of the winter, as shown in Figure 8 (next page). In mid July total ozone dropped to about 225 DU before increasing again to more than 300 DU towards the end of July. After that, ozone dropped markedly and reached about 185 DU on 17 and 18 August. Then it increased again to almost 280 DU. In early September ozone dropped and reached a minimum so far this season on 7 September with 155 DU. After that ozone increased rapidly again to above 280 DU before it dropped to 219 DU on 15 September.

San Martin

The San Martin station (68.12°S, 67.10°W), operated by Argentina, is only 76 km from the Rothera station. On 19 August a total ozone column of 225 DU was observed. This corresponds well with the 219 DU measured at Rothera the same day. From 21 August until 15 September total ozone has varied between 169 DU (7 September) and 261 DU (29

August). The minimum on 7 September corresponds reasonably well to the minimum observed at Rothera on the same day.

Syowa

Total ozone is measured at the Japanese GAW station Syowa (69.0°S, 39.6°E) with a Dobson spectrophotometer. These measurements have been carried out since 1961. On 26 August total ozone dropped to 225 DU. This was the first sign of ozone depletion at Syowa. An ozonesonde profile from 24 August shows a bite-out around 15 km, which could be due to chemically-induced ozone destruction. The last days of August total ozone was around 250 DU. During the first week of September ozone first dropped to 191 DU on 4 September before it went back up to 268 DU on 7 September. After that total ozone has been well below 250 DU and a minimum so far for this season was observed on 16 September with 189 DU.

Vernadsky

Vernadsky station (65.15°S, 64.16°W) is run by the National Antarctic Scientific Centre of Ukraine. Total ozone is measured with a Dobson spectrophotometer. Observations recommenced after the polar night on 22 July, with initial results around 270-300 DU. During August total ozone values have dropped, reaching 205 DU on 17 August, the same day as one observed 184 DU at Rothera. From 19 August until 3 September, total ozone was well above 220 DU, but from 4 September it dropped rapidly and reached 174 DU on 7 September. After that ozone increased and reached 277 DU on 9 September.

Zhong Shan

Total ozone is measured at the Chinese Zhong Shan station (69.37°S, 76.37°E) with a Brewer spectrophotometer. During the last days of August, total ozone was around 280 DU, but on 3 September it dropped to 201 DU. Since then it has varied between 245 and 279 DU.

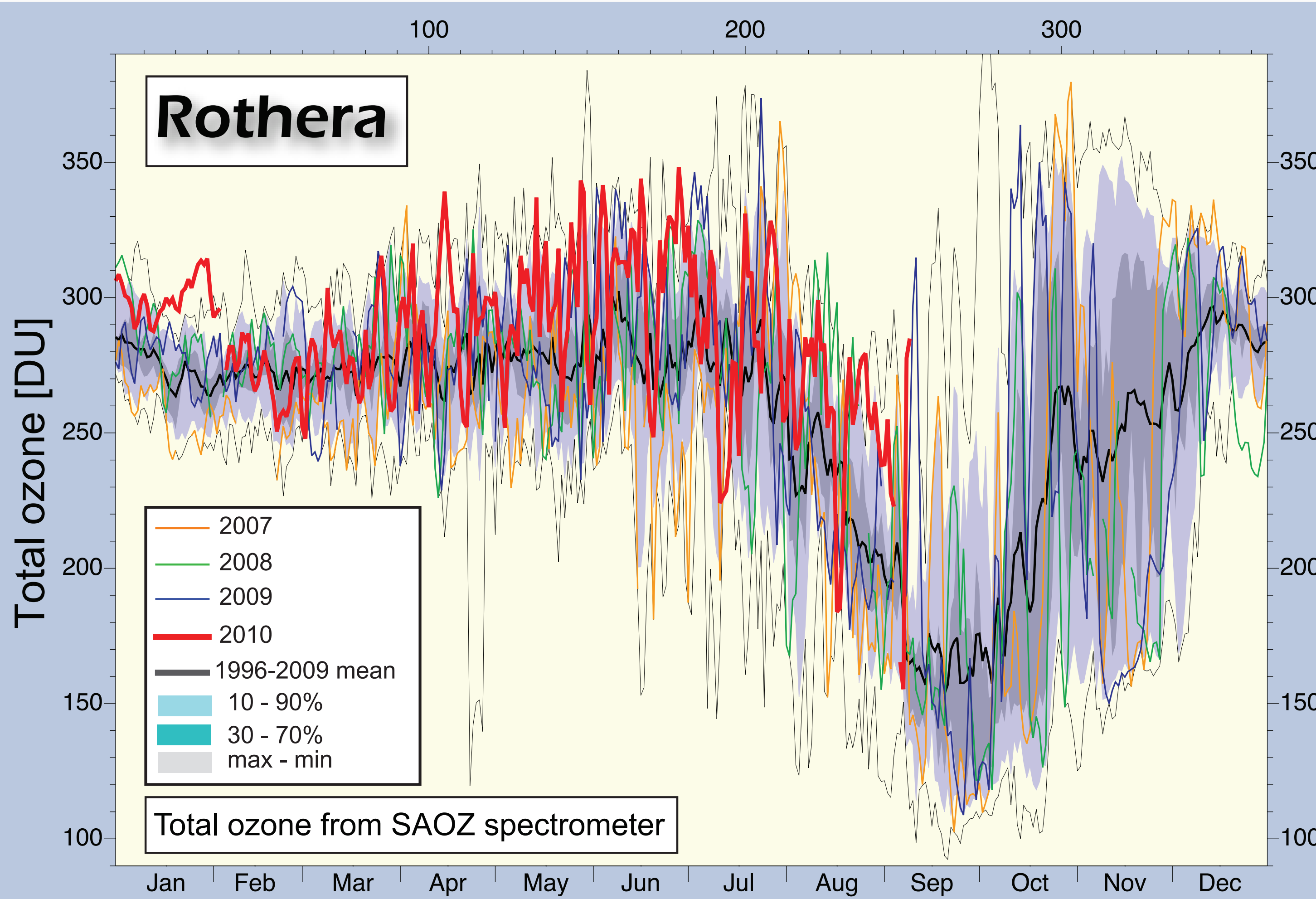
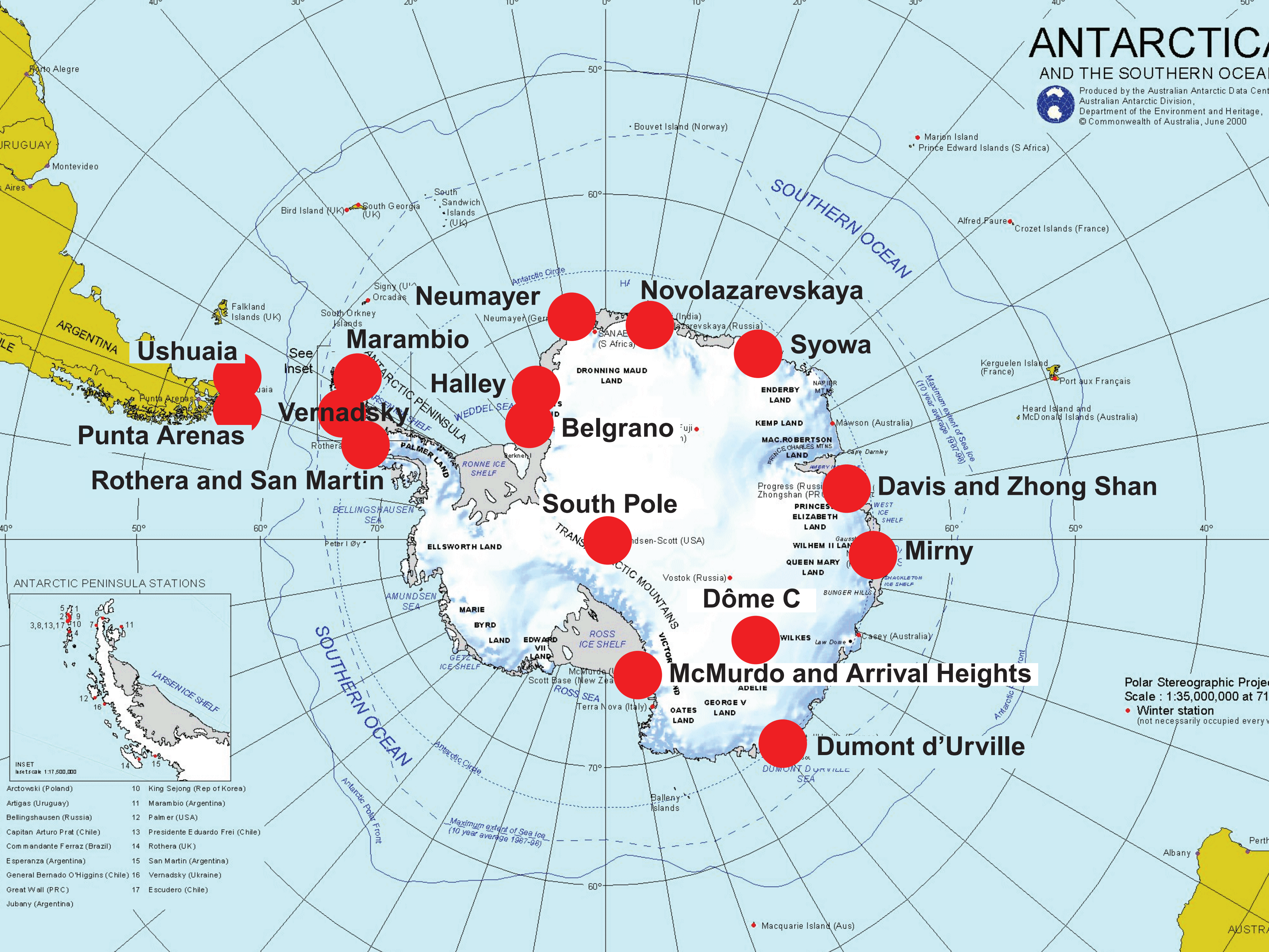


Figure 8. Total ozone measured at Rothera with a SAOZ spectrometer. The plot includes data until 9 September. The data should be considered preliminary.



ANTARCTICA
AND THE SOUTHERN OCEAN
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Neumayer
Novolazarevskaya
Syowa
Marambio
Ushuaia
Halley
Vernadsky
Belgrano
Punta Arenas
Rothera and San Martin
South Pole
Davis and Zhong Shan
Mirny
Dôme C
McMurdo and Arrival Heights
Dumont d'Urville
SOUTHERN OCEAN
Porto Alegre
URUGUAY
Montevideo
ARGENTINA
Falkland Islands (UK)
South Georgia (UK)
Bird Island (UK)
South Sandwich Islands (UK)
South Orkney Islands
Bouvet Island (Norway)
Marion Island
Prince Edward Islands (S Africa)
Alfred Faure
Crozet Islands (France)
Kerguelen Island (France)
Port aux Français
Heard Island and McDonald Islands (Australia)
Mawson (Australia)
Casey (Australia)
Vostok (Russia)
Terra Nova (Italy)
Scott Base (New Zealand)
Macquarie Island (Aus)
Balleny Islands
Peter I Øy
DRONNING MAUD LAND
ENDERBY LAND
KEMP LAND
MAC.ROBERTSON LAND
PRINCESS ELIZABETH LAND
WILHEM II LAND
QUEEN MARY LAND
WILKES
GEORGE V LAND
OATES LAND
MARIE BYRD LAND
EDWARD VII LAND
ELLSWORTH LAND
PALMER LAND
ANTARCTIC PENINSULA
WEDDELL SEA
RONNE ICE SHELF
ROSS ICE SHELF
ROSS SEA
BELLINGSHAUSEN SEA
AMUNDSEN SEA
DUMONT D'URVILLE SEA
TRANSANTARCTIC MOUNTAINS
Antarctic Circle
Antarctic Polar Front
Maximum extent of Sea Ice (10 year average 1987-98)
See Inset
ANTARCTIC PENINSULA STATIONS
INSET Inset scale 1:17,500,000
Arctowski (Poland)
Artigas (Uruguay)
Bellingshausen (Russia)
Capitan Arturo Prat (Chile)
Commandante Ferraz (Brazil)
Esperanza (Argentina)
General Bernado O'Higgins (Chile)
Great Wall (PRC)
Jubany (Argentina)
10 King Sejong (Rep of Korea)
11 Marambio (Argentina)
12 Palmer (USA)
13 Presidente Eduardo Frei (Chile)
14 Rothera (UK)
15 San Martin (Argentina)
16 Vernadsky (Ukraine)
17 Escudero (Chile)
Polar Stereographic Projection
Scale : 1:35,000,000 at 71
Winter station
(not necessarily occupied every year)
Albany
Perth

Chemical activation of the vortex

Satellite observations

The south polar vortex is now activated and primed for ozone depletion. The sun is on the way back after the polar winter and ozone depletion has been going on for some weeks already.

Figure 8 (upper row) shows the extent of removal of hydrochloric acid (HCl), which is one of the reservoirs for active chlorine, on the 6 of September for the four last years. As can be seen from the figure, HCl is almost completely removed inside the vortex at the 490 K isentropic level. Removal of HCl is an indicator of chemical activation of the vortex. It can be seen that the polar vortex is essentially devoid of HCl, but the area affected by HCl removal is somewhat smaller in 2010 than in the previous years.

Another indicator of vortex activation is the amount of chlorine monoxide (ClO). It should be noted, however, that ClO dimerises and forms $(ClO)_2$ in darkness. The dimer is easily cracked in the presence of sunlight. ClO will therefore be present in the sunlit parts of the vortex, whereas the dark areas will be filled with $(ClO)_2$, which is not observed by Aura-MLS. Figure 8 (lower row) shows the mixing ratio of ClO on the same dates as above. One can see an area of elevated ClO that forms a collar along the vortex edge. This collar constitutes the sunlit part of the vortex. It can be seen from the figure that 2010 is the year with the smaller amount of ClO among the four years shown here. Looking at data from 2004 to 2006 shows that also these years had a higher mixing ratio of ClO on the 6th of September than in 2010.

In the previous Bulletin it was stated that the smaller than usual area affected by HCl removal and the relatively low mixing ratio of ClO could indicate that ozone depletion might be less severe in 2010 than in most recent years. This is now evident as seen from the data presented in the next section.

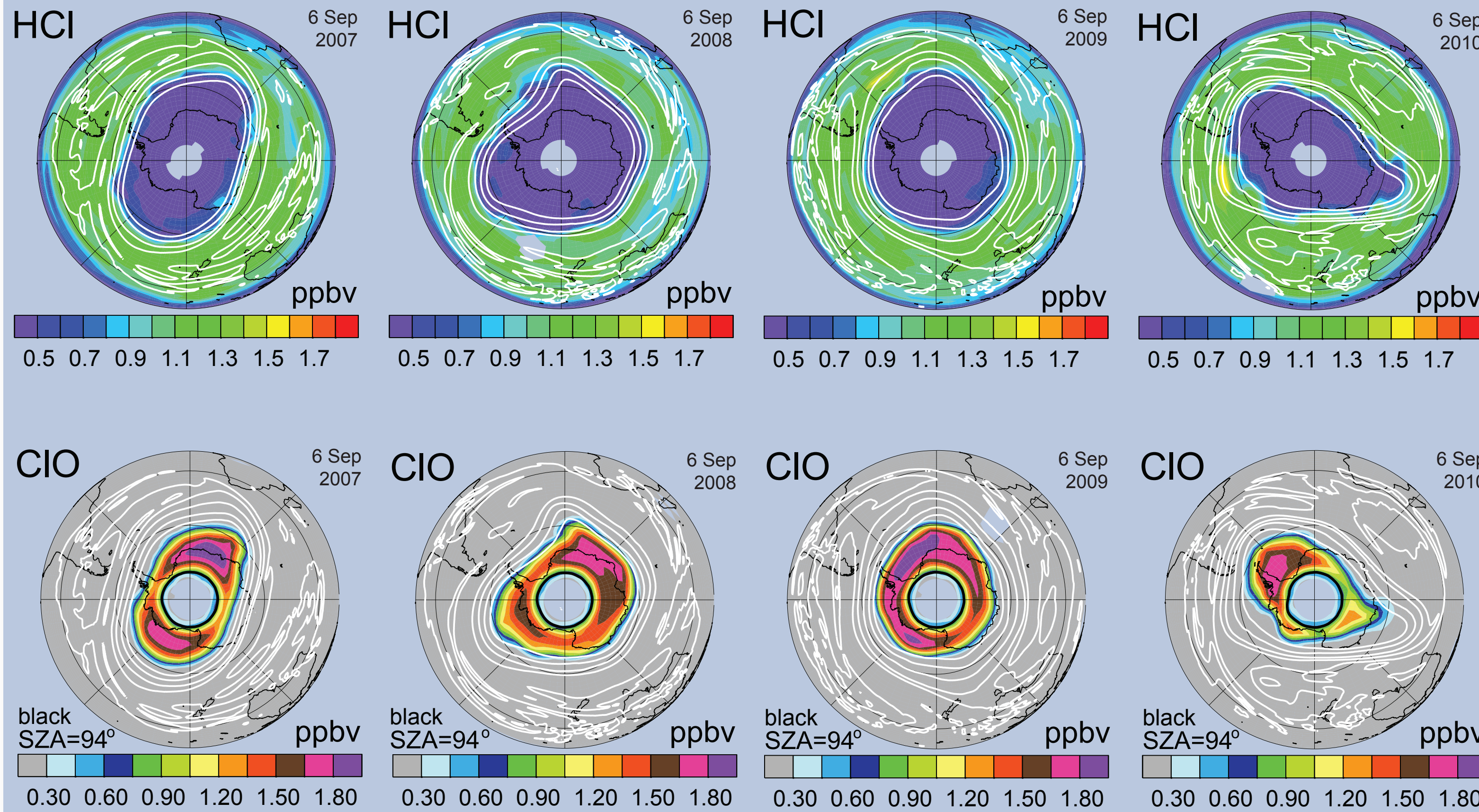

Figure 8. Upper row: Mixing ratio of HCl on 6 September 2007, 2008, 2009 and 2010 at the isentropic level of 490 K (~18 km). Lower row: Mixing ratio of ClO on the same four dates as above. The white contours indicate isolines of scaled potential vorticity. The maps are made at NASA's Jet Propulsion Laboratory and based on data from the Aura-MLS satellite instrument.

Ozone hole area and mass deficit

The area of the region where total ozone is less than 220 DU ("ozone hole area") as deduced from the OMI instrument on AURA is shown in Figure 9. During the first half of August, the area increased more slowly than at the same time in most of the recent years. Then the ozone hole area increased fast for a few days before it dropped back to zero. From the end of August the ozone area started to increase again but remained lower than for any other year since 2003. According to the forecast (open circles) it will reach the 2004 values around 20 September.

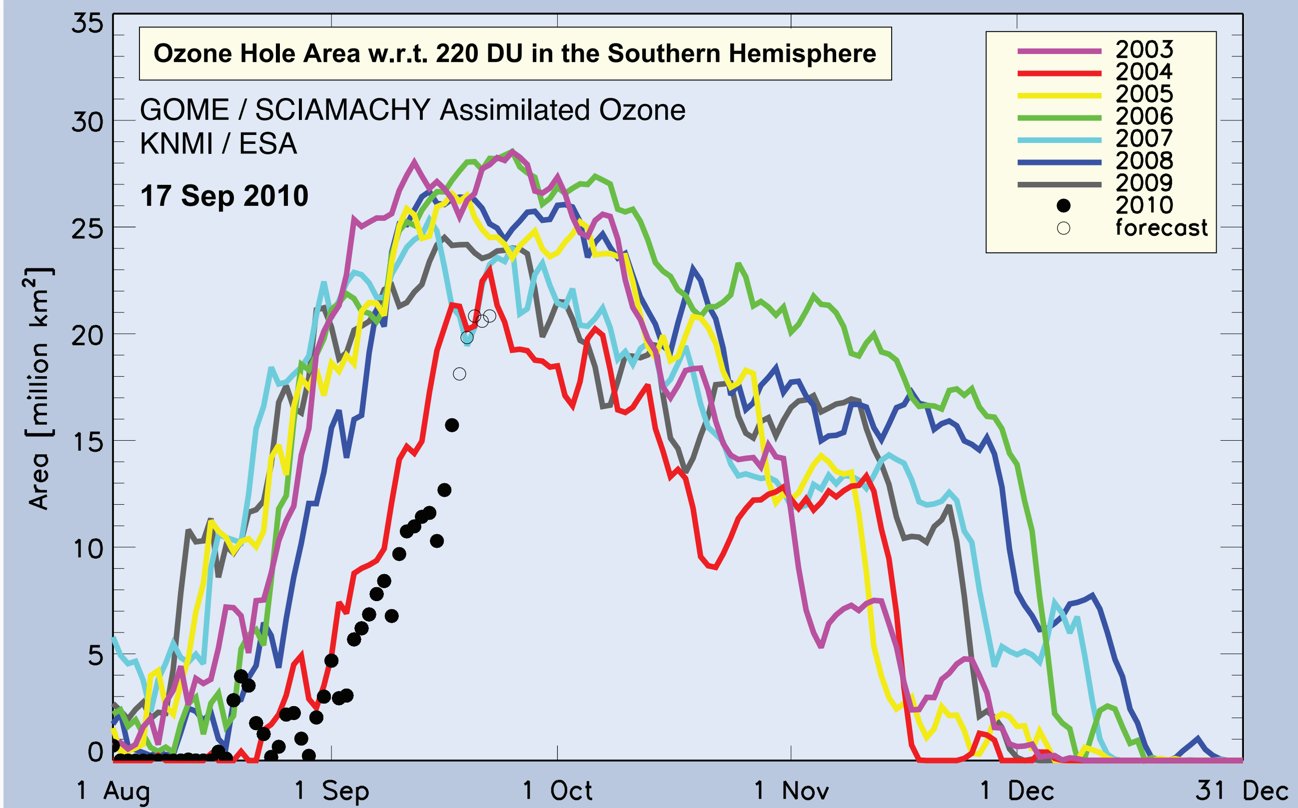

Figure 9. Ozone hole area for the years from 2003 to 2010 (black dots). The ozone hole area is the area of the region where total ozone is below 220 DU. The open circles represent a forecast for the five next days. This plot is produced by KNMI and is based on data from the GOME and SCIAMACHY satellite instruments.

Figure 10 shows the ozone hole area as deduced from the OMI satellite instrument. Also here it can be seen that the 2010 ozone hole has had a late start and that the area is considerably lower than in recent years at the same date. The ozone mass deficit is still small compared to recent years. Calculations based on SCIAMACHY data show that the mass deficit is approx. 7 megaton in mid September as opposed to 20-30 megaton for that time of the year during recent years. In 2004 the mass deficit was around 10 megaton in mid September.

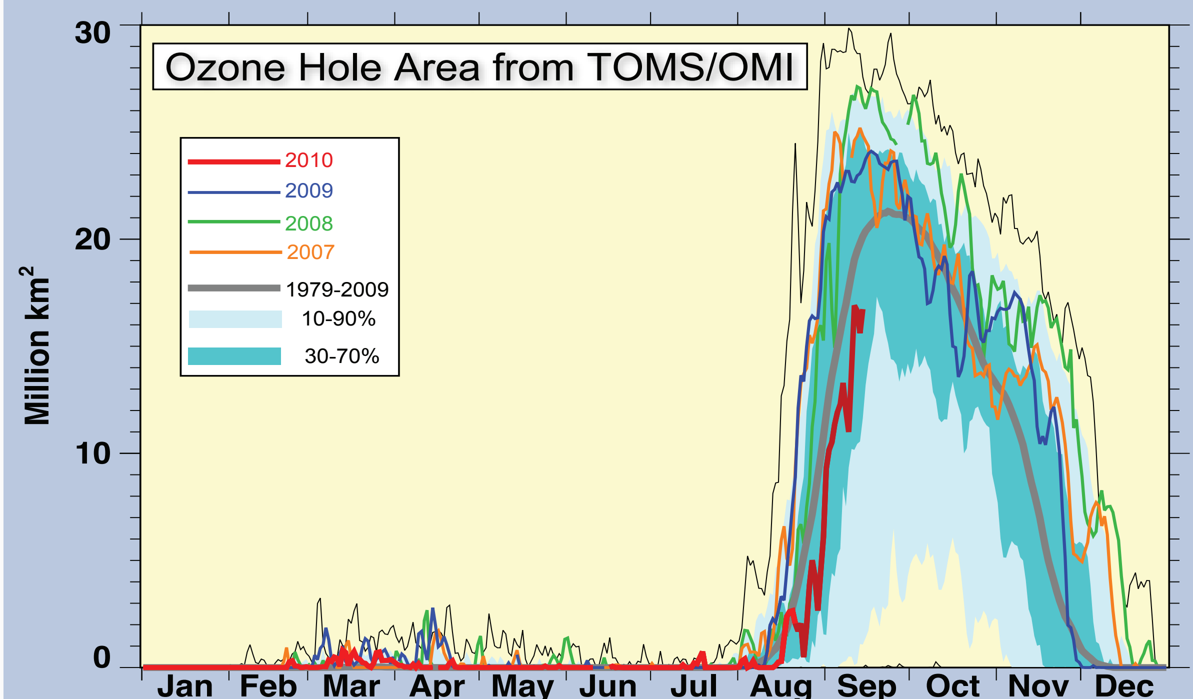

Figure 10. Area (millions of km²) where the total ozone column is less than 220 Dobson units. 2010 is showed in red (until 14 September). 2009 is shown in blue, 2008 in green and 2007 in orange. The smooth grey line is the 1979-2009 average. The dark green-blue shaded area represents the 30th to 70th percentiles and the light green-blue shaded area represents the 10th and 90th percentiles for the time period 1979-2009. The plot is adapted from a plot downloaded from the NASA Ozonewatch web site and is based on data from the OMI instrument on AURA and various TOMS instruments.

UV radiation

UV radiation is measured by various networks covering the southern tip of South America and Antarctica. There are stations in Southern Chile (Punta Arenas), southern Argentina (Ushuaia) and in Antarctica (Belgrano, Marambio, McMurdo, Palmer, South Pole). Reports on the UV radiation levels will be given in futures issues when the sun comes back to the south polar regions. Links to sites with data and graphs on UV data are found in the "Acknowledgements and Links" section at the end of the Bulletin.

Distribution of the bulletins

The Secretariat of the World Meteorological Organization (WMO) distributes Bulletins providing current Antarctic ozone hole conditions beginning around 20 August of each year. The Bulletins are available through the Global Atmosphere Watch programme web page at http://www.wmo.int/pages/prog/arep/gaw/ozone/index.html. In addition to the National Meteorological Services, the information in these Bulletins is made available to the national bodies representing their countries with UNEP and that support or implement the Vienna Convention for the Protection of the Ozone Layer and its Montreal Protocol.

Acknowledgements and links

These Bulletins use provisional data from the WMO Global Atmosphere Watch (GAW) stations operated within or near Antarctica by: Argentina (Comodoro Rivadavia, San Martin, Ushuaia), Argentina/Finland (Marambio), Argentina/Italy/Spain (Belgrano), Australia (Macquarie Island and Davis), China/Australia (Zhong Shan), France (Dumont d'Urville and Kerguelen Is), Germany (Neumayer), Japan (Syowa), New Zealand (Arrival Heights), Russia (Mirny and Novolazarevskaja), Ukraine (Vernadsky), UK (Halley, Rothera), Uruguay (Salto) and USA (McMurdo, South Pole). More detailed information on these sites can be found at the GAWSIS web site (http://www.empa.ch/gaw/gawsis).

Satellite ozone data are provided by NASA (http://ozonewatch.gsfc.nasa.gov), NOAA/TOVS (http://www.cpc.ncep.noaa.gov/products/stratosphere/tovsto/), NOAA/SBUV/2 (http://www.cpc.ncep.noaa.gov/products/stratosphere/sbuv2to/) and ESA/Sciamachy (http://envisat.esa.int). Satellite data on ozone, ClO, HCl and a number of other relevant parameters from the MLS instrument on the Aura satellite can be found here: http://mls.jpl.nasa.gov/plots/mls/mls_plot_locator.php.

Potential vorticity and temperature data are provided by the European Centre for Medium Range Weather Forecasts (ECMWF) and their daily T_{106} meteorological fields are analysed and mapped by the Norwegian Institute for Air Research (NILU) Kjeller, Norway, to provide vortex extent, PSC area and extreme temperature information. Meteorological data from the US National Center for Environmental Prediction (NCEP) are also used to assess the extent of PSC temperatures and the size of the polar vortex (http://www.cpc.ncep.noaa.gov/products/stratosphere/polar/polar.shtml). NCEP meteorological analyses and climatological data for a number of parameters of relevance to ozone depletion can also be acquired through the Ozonewatch web site at NASA (http://ozonewatch.gsfc.nasa.gov/meteorology/index.html).

Ozone data analyses and maps are prepared by the World Ozone and UV Data Centre at Environment Canada (http://exp-studies.tor.ec.gc.ca/cgi-bin/selectMap), by the Royal Netherlands Meteorological Institute (http://www.temis.nl/protocols/O3global.html) and by the University of Bremen (http://www.doas-bremen.de/). UV data are provided by the U.S. National Science Foundation's (NSF) UV Monitoring Network (http://www.biospherical.com/nsf).

UV indices based on the SCIAMACHY instrument on Envisat can be found here: http://www.temis.nl/uvradiation/

Ultraviolet radiation data from the Dirección Meteorológica de Chile can be found here: http://www.meteochile.cl

Data on ozone and UV radiation from the Antarctic Network of NILU-UV radiometers can be found here: http://www.polarvortex.org .

The Executive Summary of the 2010 WMO/UNEP Scientific Assessment of Ozone Depletion can be found here: http://www.wmo.int/pages/mediacentre/press_releases/documents/898_ExecutiveSummary.pdf

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The next Antarctic Ozone Bulletin is planned for 30 September 2010.