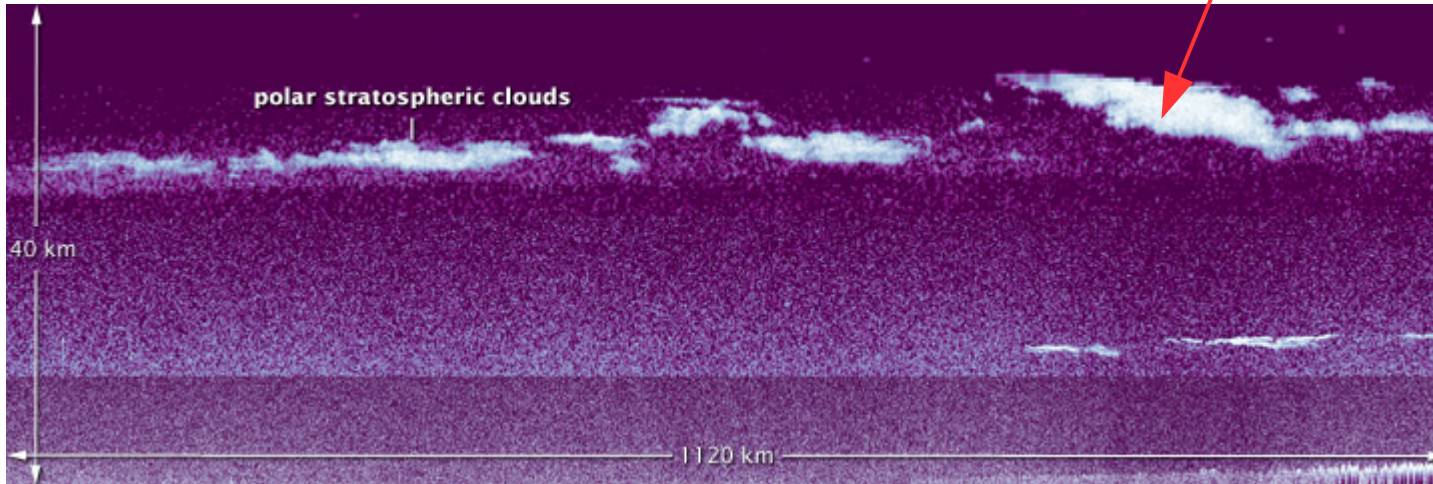


Polar Stratospheric Ozone

Polar Stratospheric Clouds (PSC)



Usually High Polar Stratospheric Cloud (PSC), Typical below 25 km

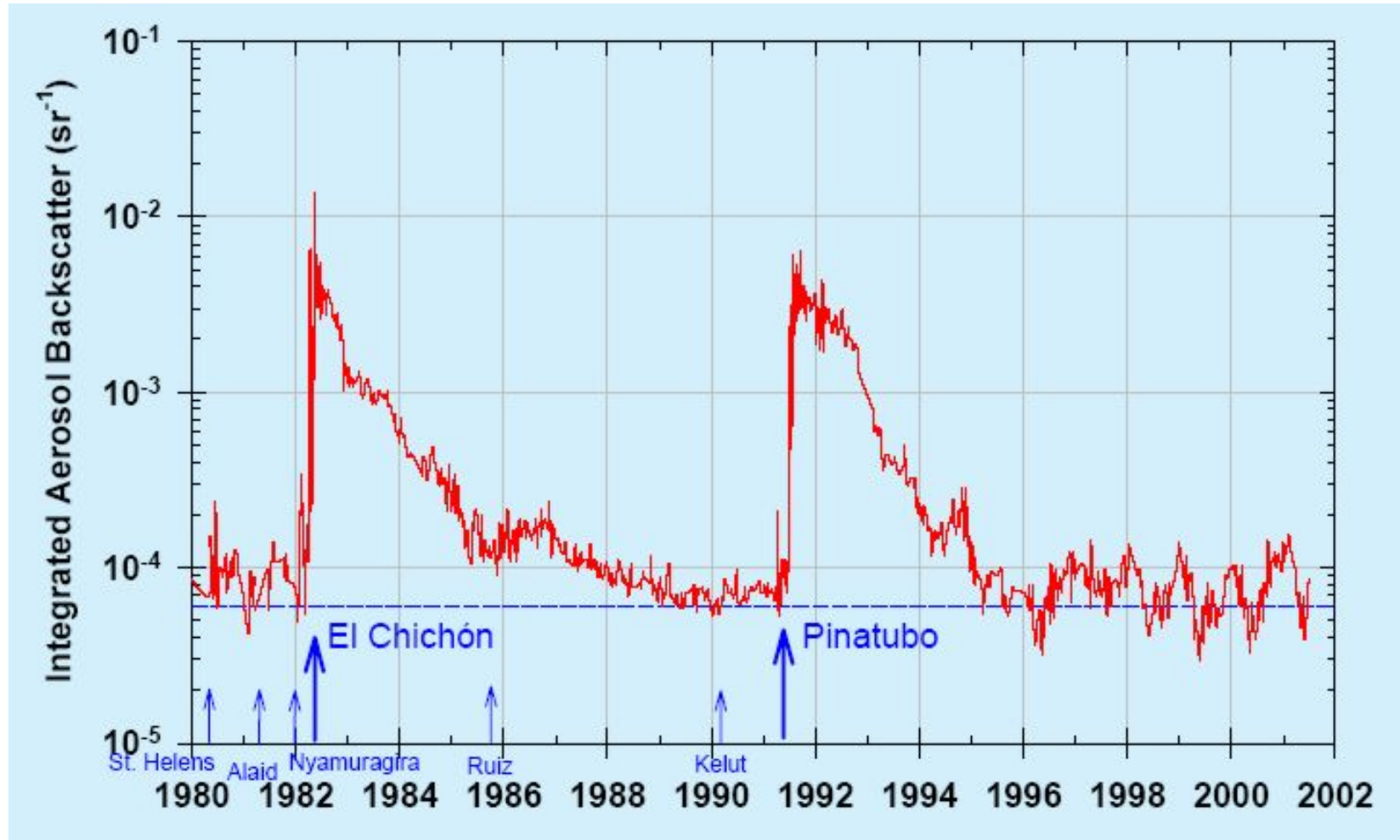
January 4, 2011

Total Attenuated Backscatter ($\times 10^{-4}$ /km/sr)



Source: <http://earthobservatory.nasa.gov/IOTD/view.php?id=49187>

Stratospheric Aerosols



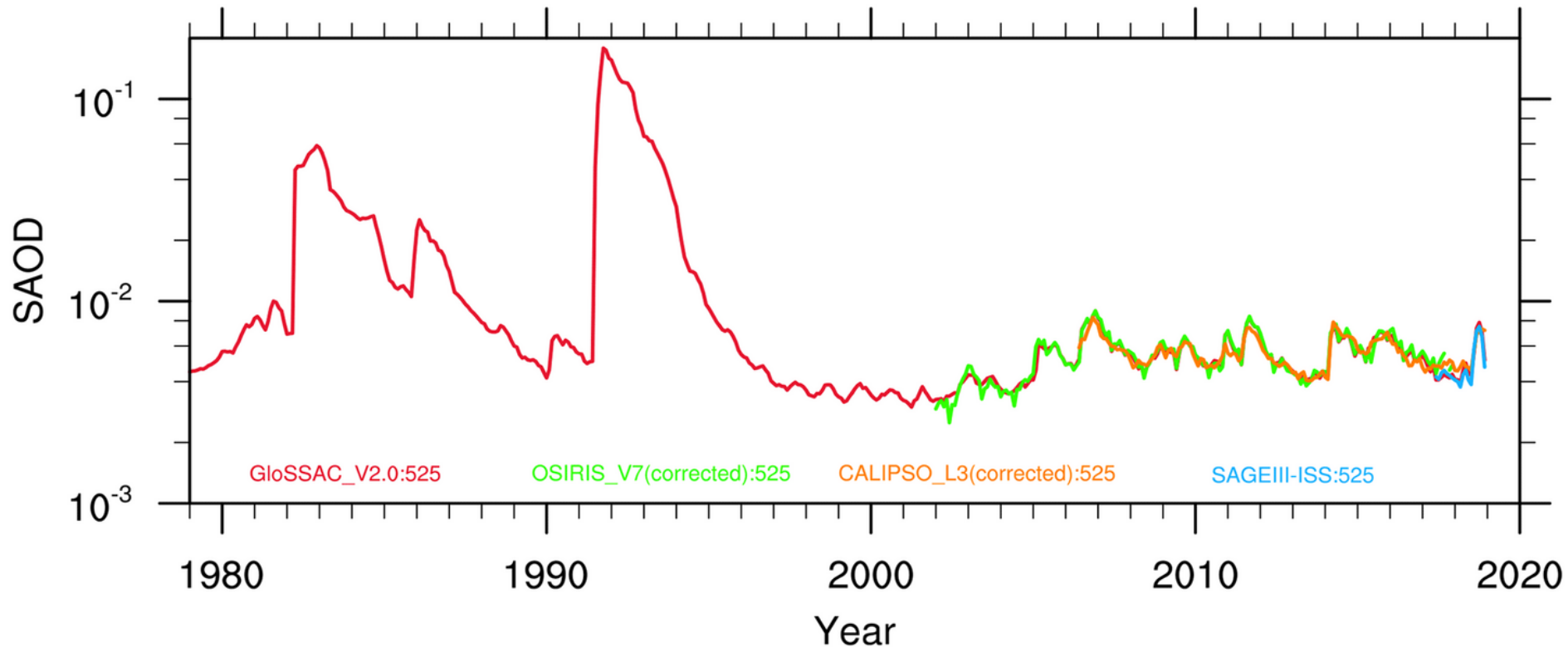
Lidar measurements at Mauna Loa Observatory showing the integrated laser light backscattered from the 15-33 km region of the stratosphere. Volcanic eruptions which perturbed the stratosphere and increased the stratospheric aerosol loading are indicated.

Source: <http://www.esrl.noaa.gov/gmd/about/ozone.html>

Stratospheric Aerosols

(b)

20° S–20° N



Zonally averaged monthly stratospheric aerosol optical depth (SAOD) at 525 nm.

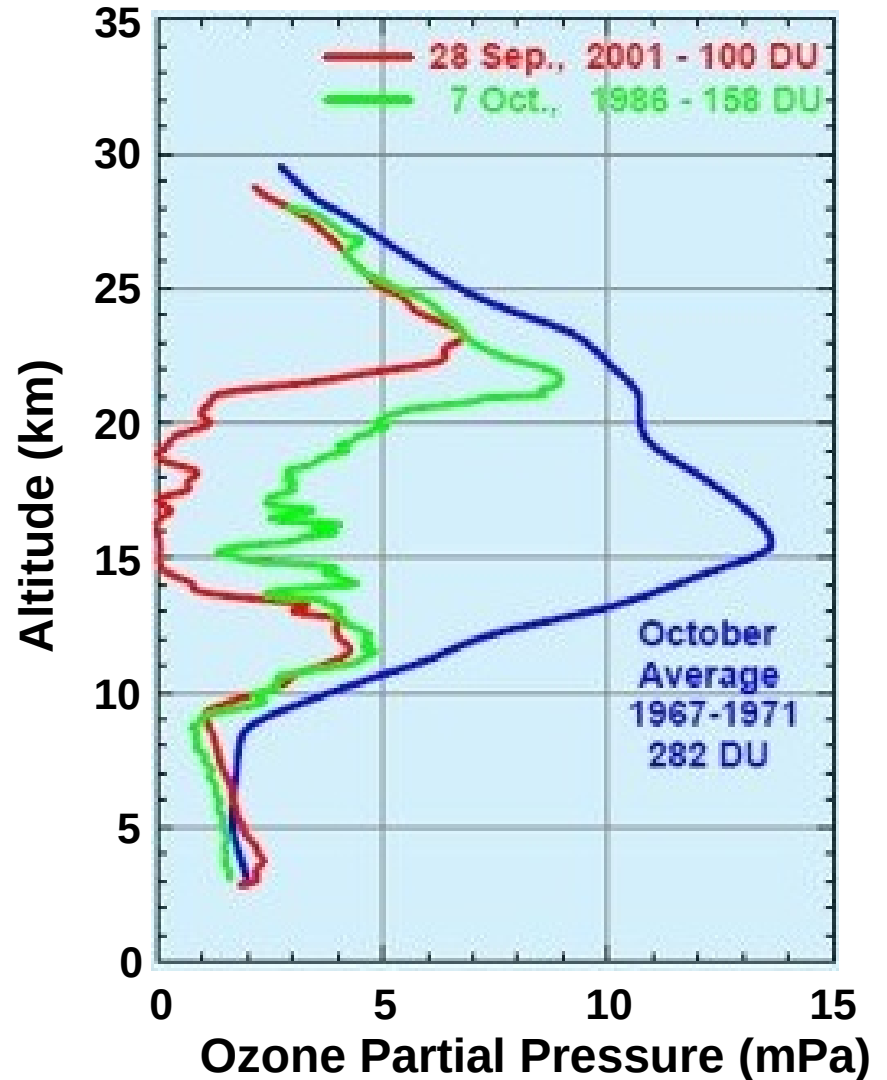
Source: <https://essd.copernicus.org/articles/12/2607/2020/>

Decline of Ozone at the South Pole

South Pole Ozone and H₂O Balloon

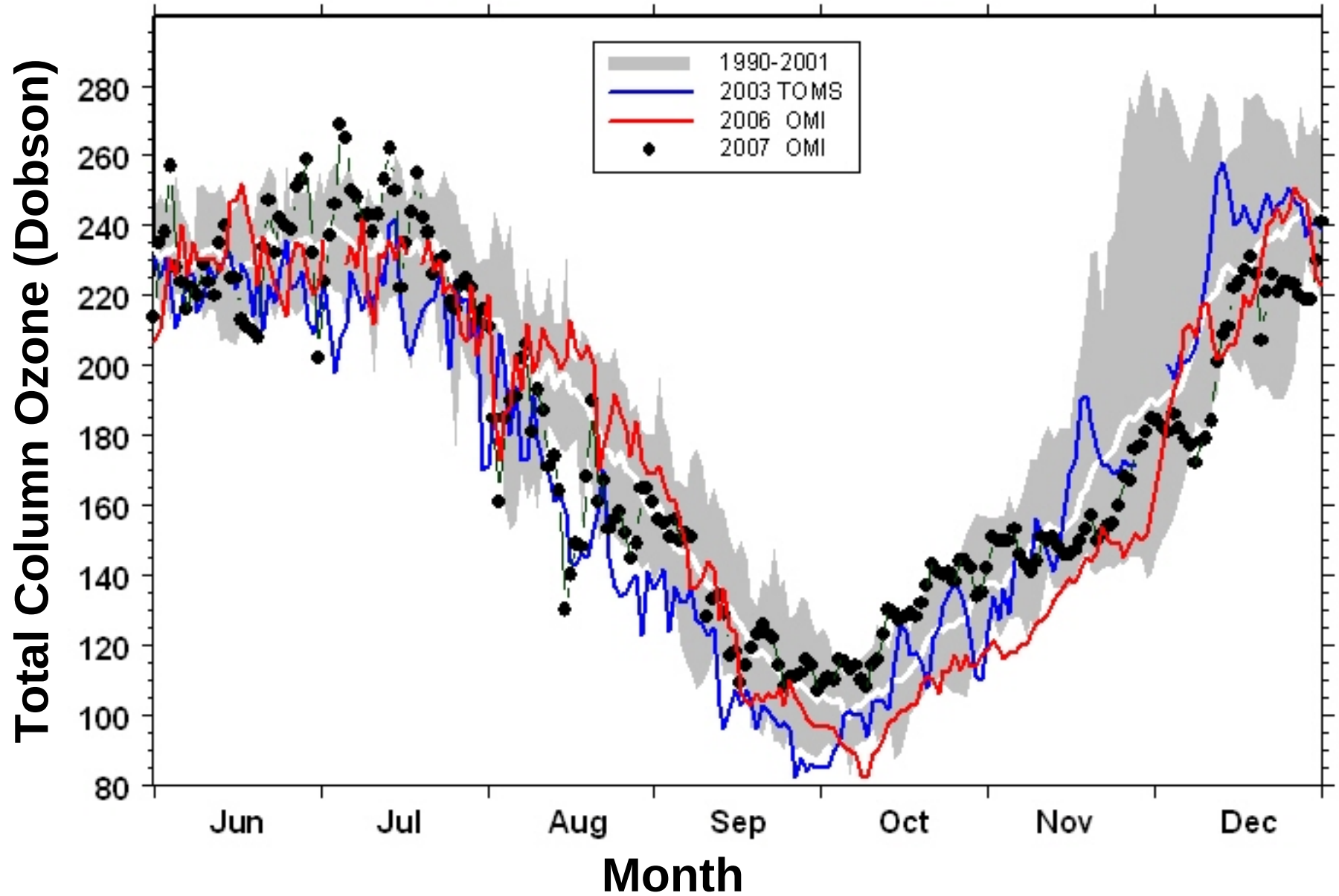


South Pole Ozone at Maximum Depletion

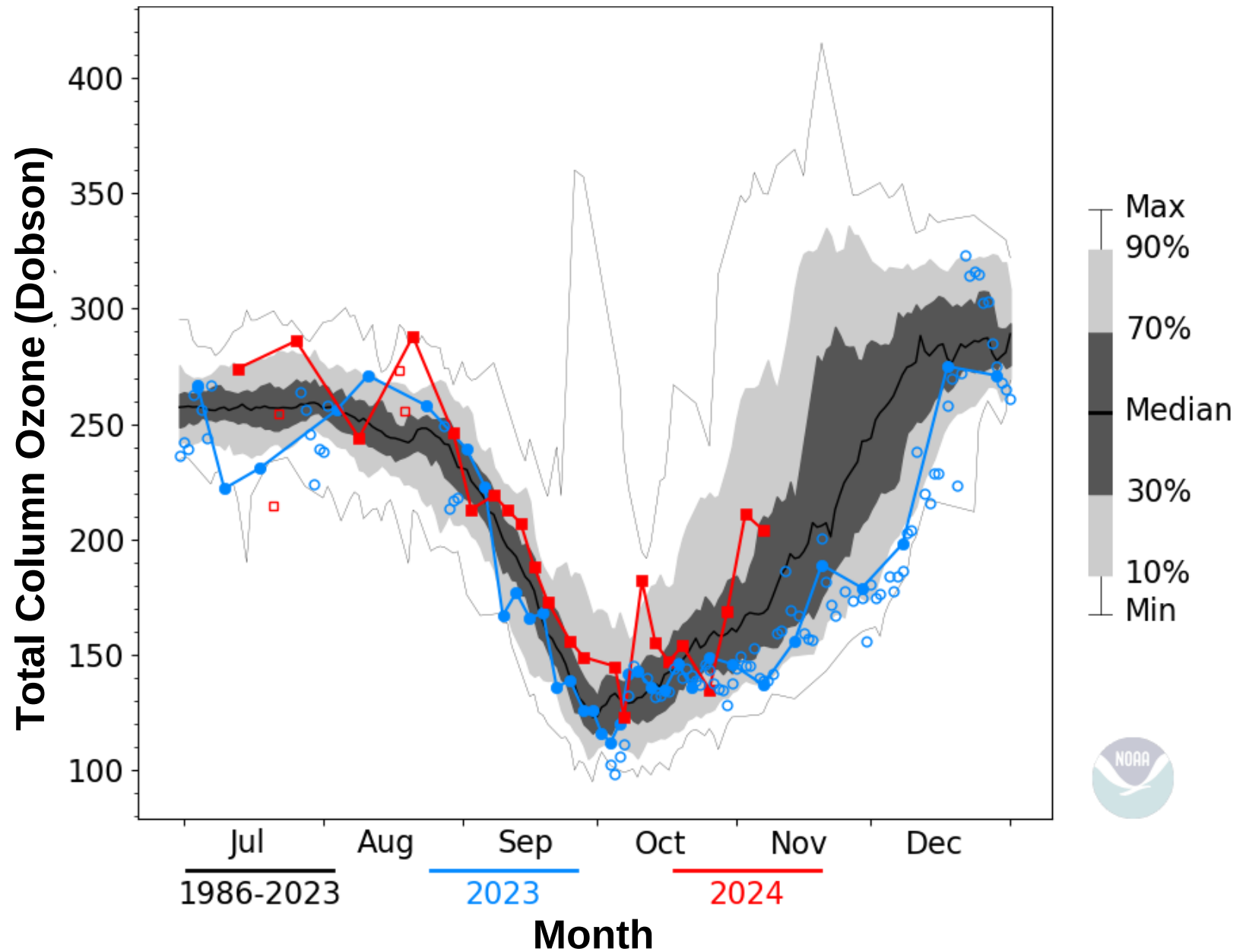


Source: <http://www.esrl.noaa.gov/gmd/about/ozone.html>

Ozone Minimum (40 °S – 90 °S)



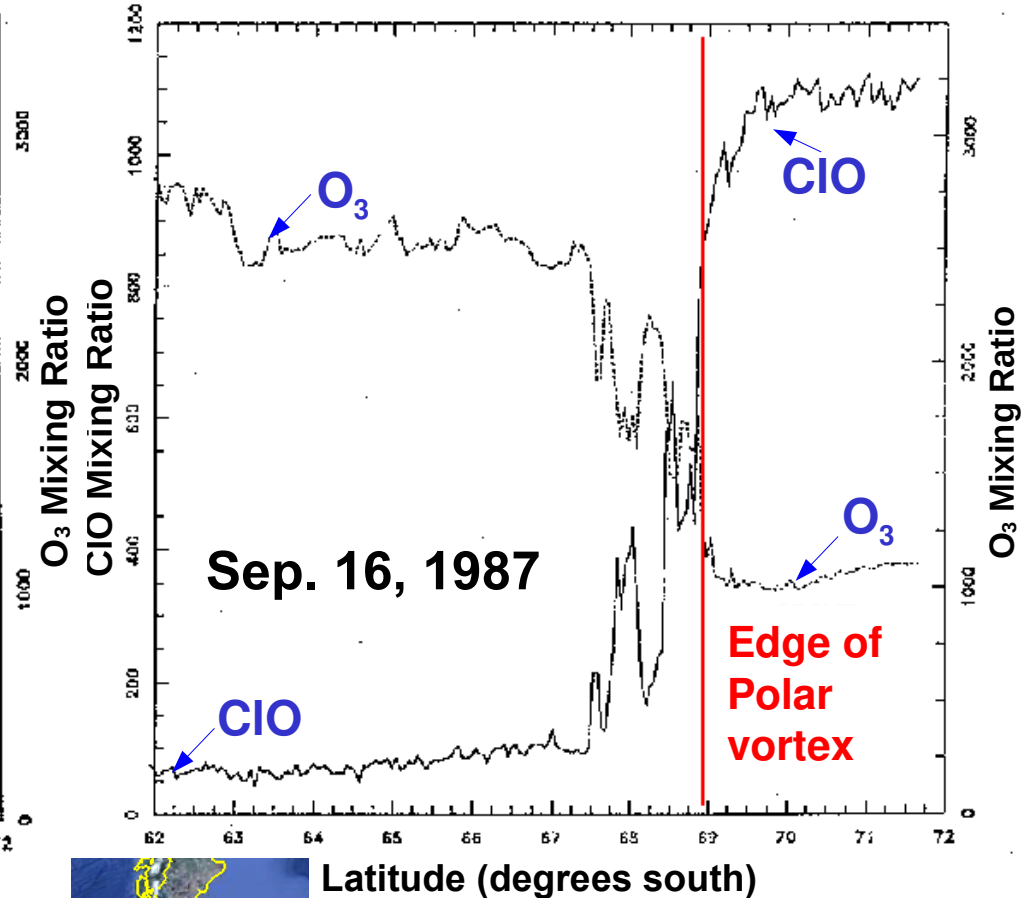
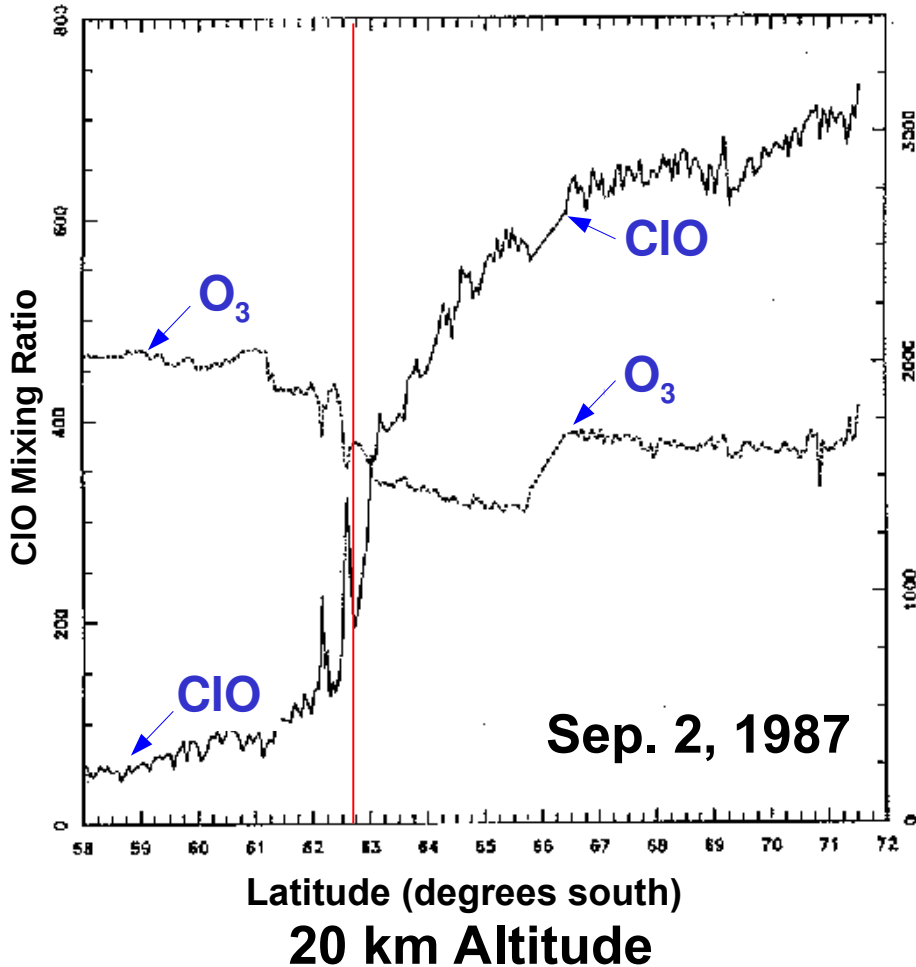
South Pole



Source: https://gml.noaa.gov/dv/spo_oz/spototal.html

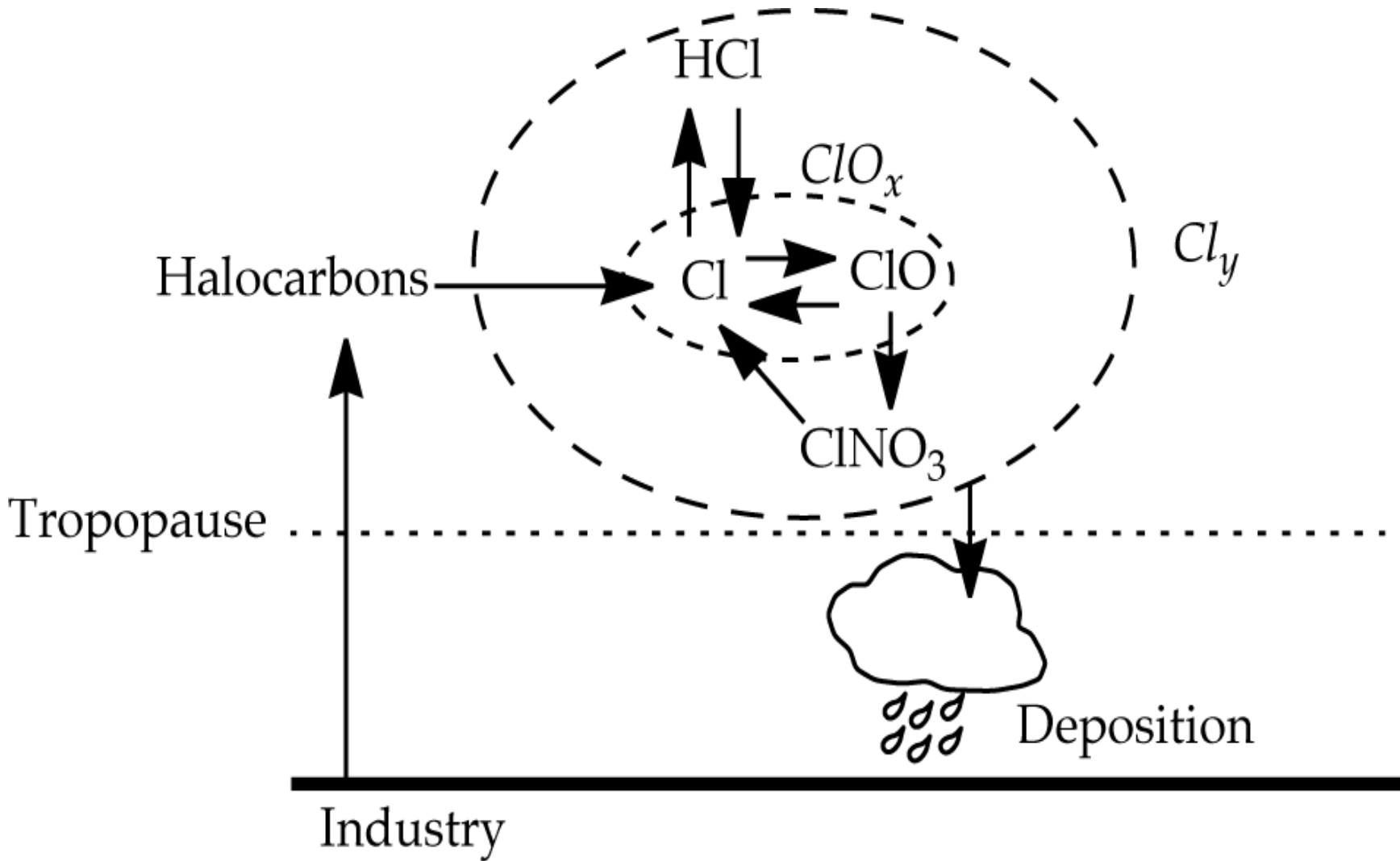
High Chlorine Monoxide (ClO) in Polar Vortex

September 1987 ER-2 Aircraft Measurements at 20 km Altitude South of Punta Arenas



Measurements by Jim Anderson's Group (Harvard).
Courtesy of Daniel J. Jacob

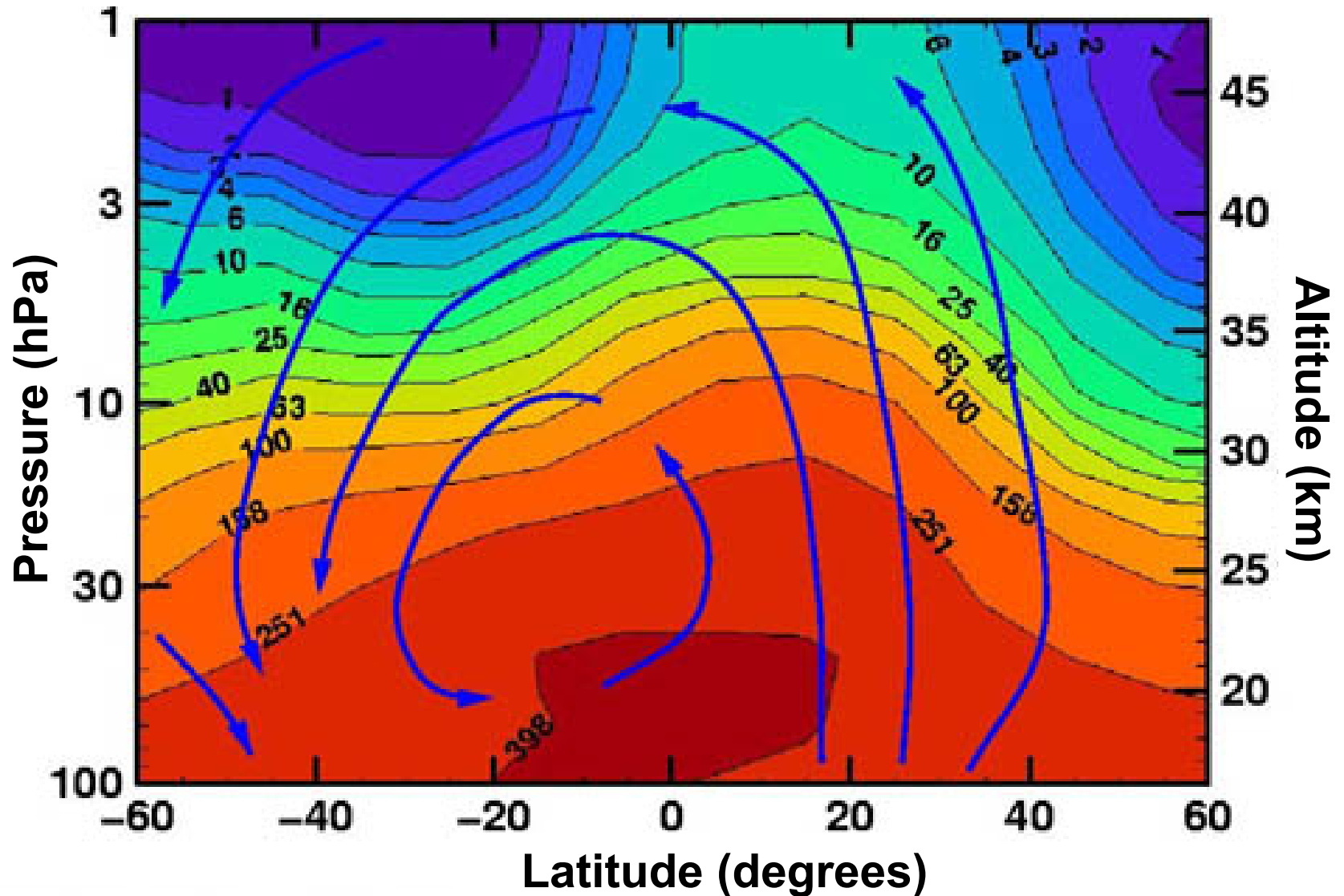
Cycling of ClO_x and Cl_y



Polar Stratospheric Cloud (PSC) provide the surfaces necessary to convert inactive to active chlorine (ClO) leading to polar ozone loss.

Courtesy of Daniel J. Jacob

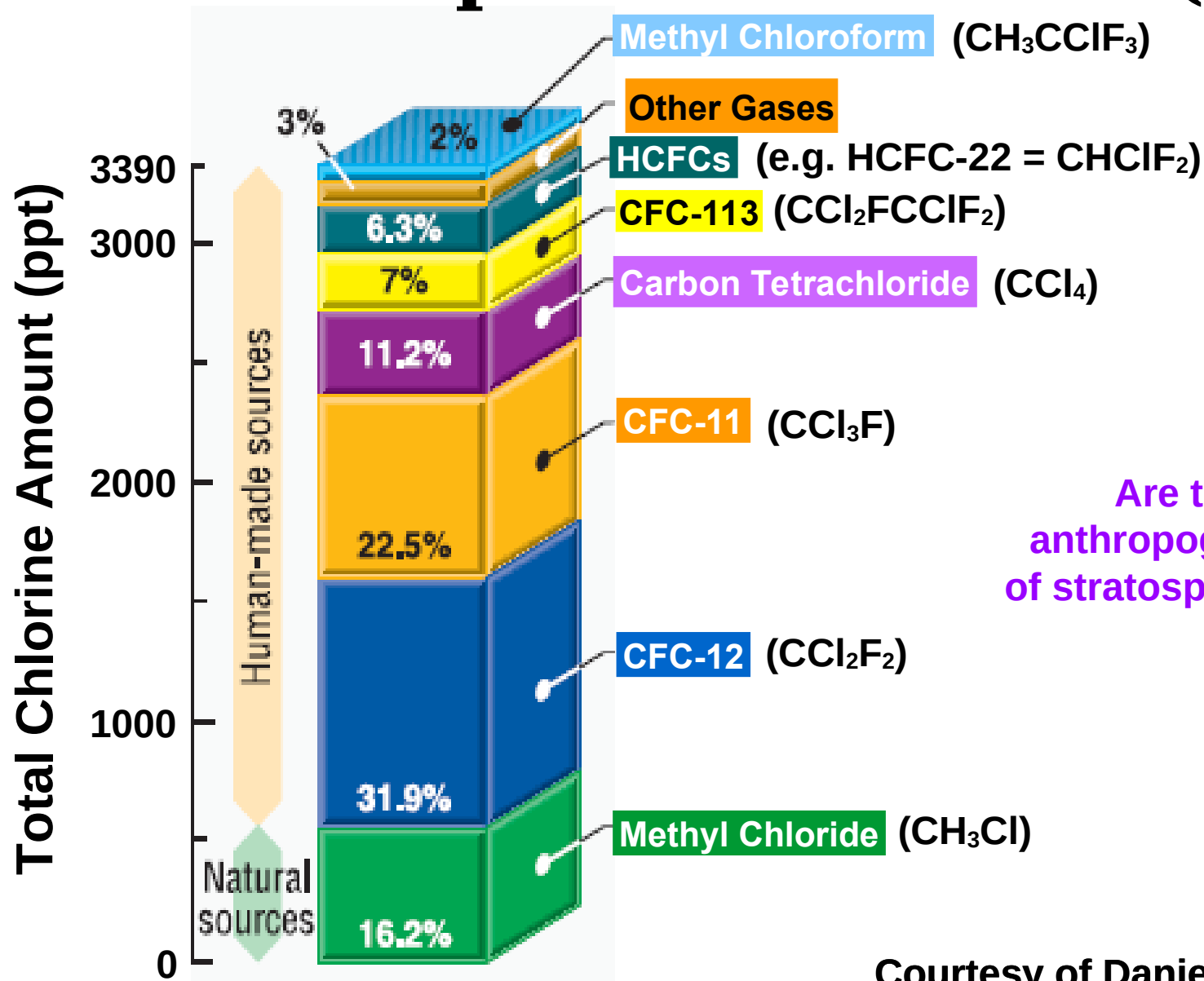
Distribution of CF_2Cl_2 (CFC-12)



UARS-CLAES, June-July 1992

Source: http://www.ccpo.odu.edu/~lizsmith/SEES/ozone/class/Chap_1/1_Js/1-07.jpg

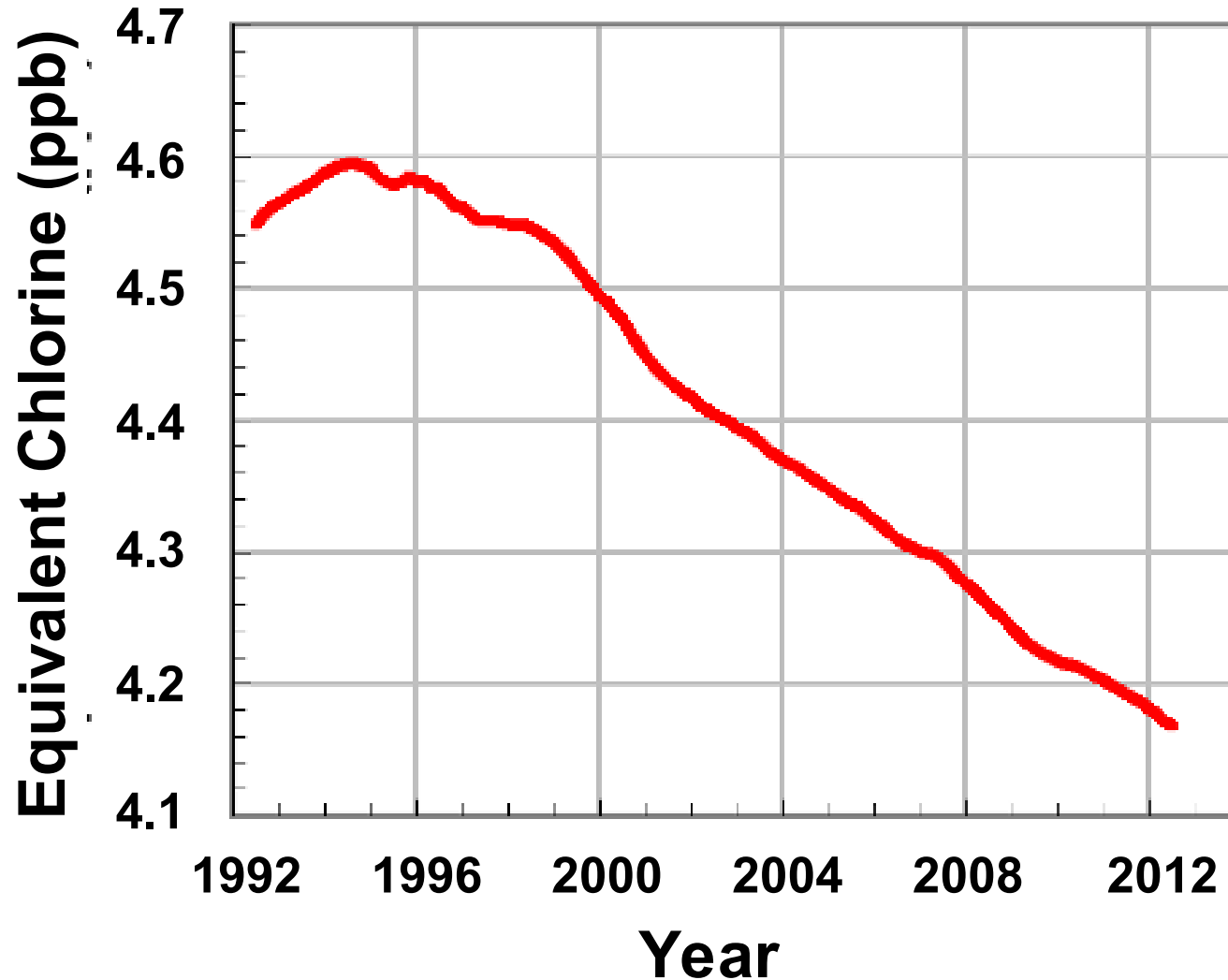
Source Gas Contribution To Stratospheric Chlorine (2004)



Are there only
anthropogenic sources
of stratospheric chlorine?

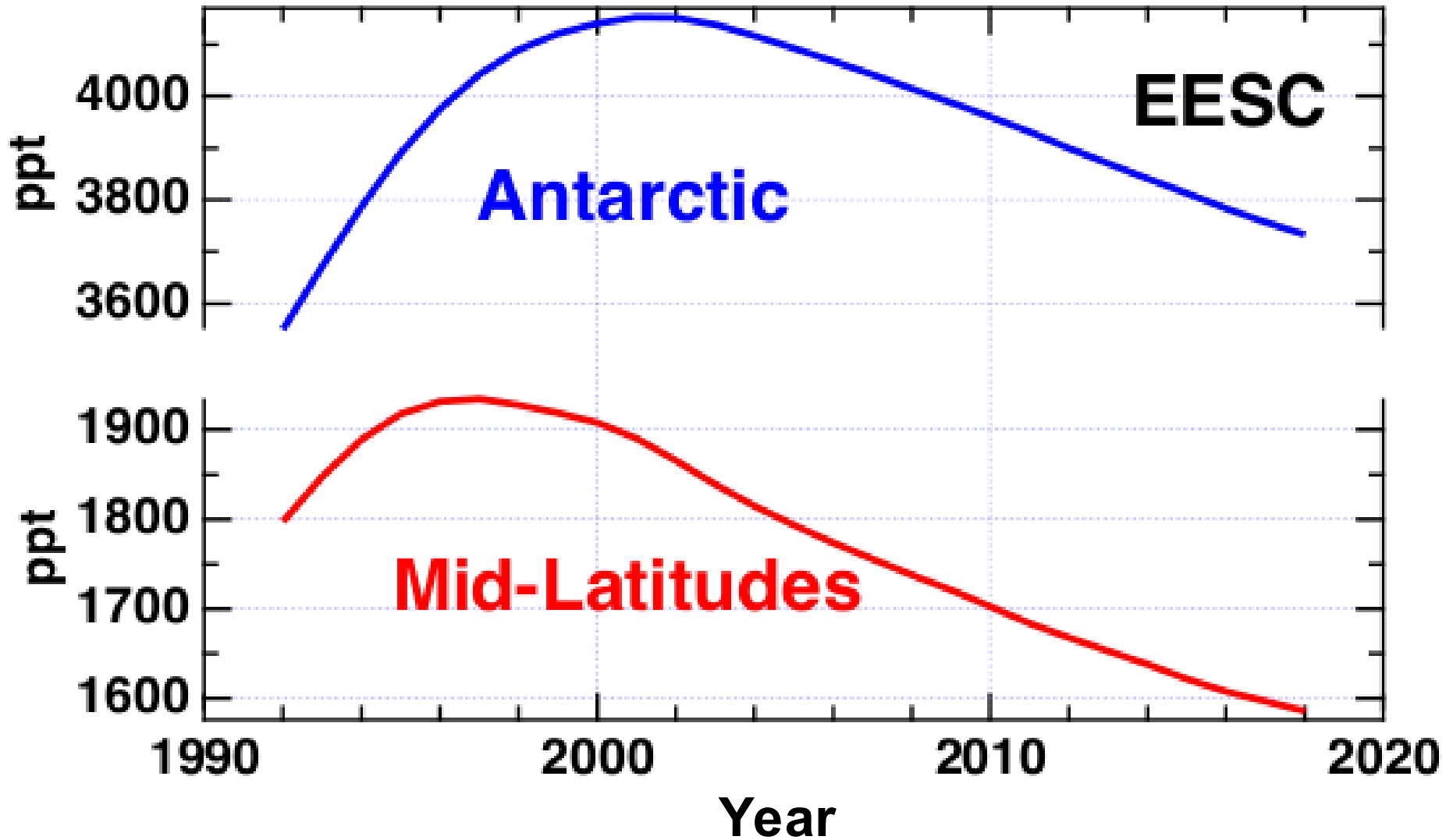
Courtesy of Daniel J. Jacob

Global Equivalent Atmospheric Chlorine (All Chlorine and Bromine Compounds)



Source: <http://www.esrl.noaa.gov/gmd/about/ozone.html> (Accessed Dec. 2013)

Effective Equivalent Stratospheric Chlorine (EESC)



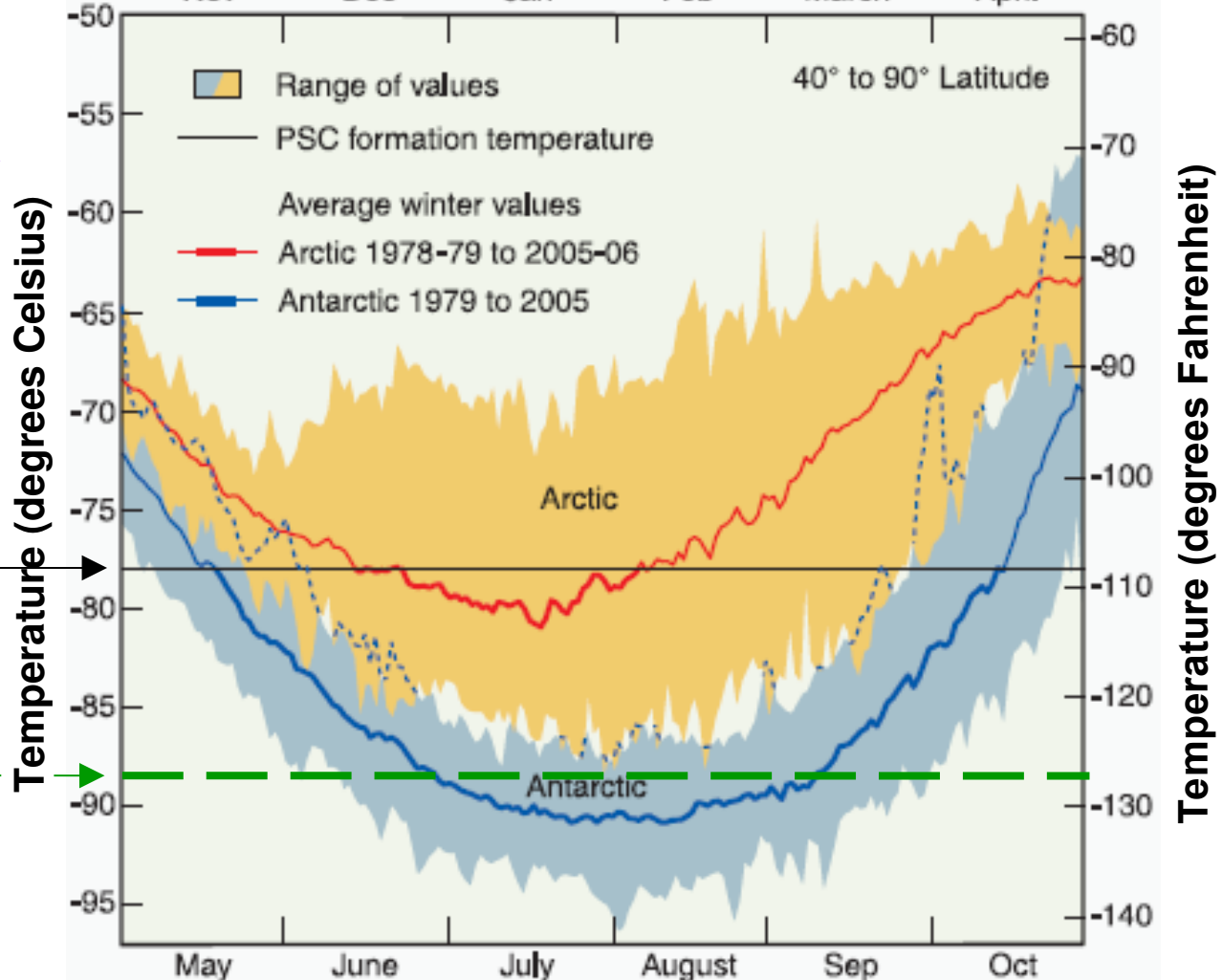
Source: https://gml.noaa.gov/hats/graphs/Total_Halogen_Layout.png (Nov. 2024)

Polar Stratospheric Cloud (PSC)

Minimum Air Temperature in the Polar Lower Stratosphere Arctic Winter

Nov Dec Jan Feb March April

Type I PSC,
Source, Wikipedia



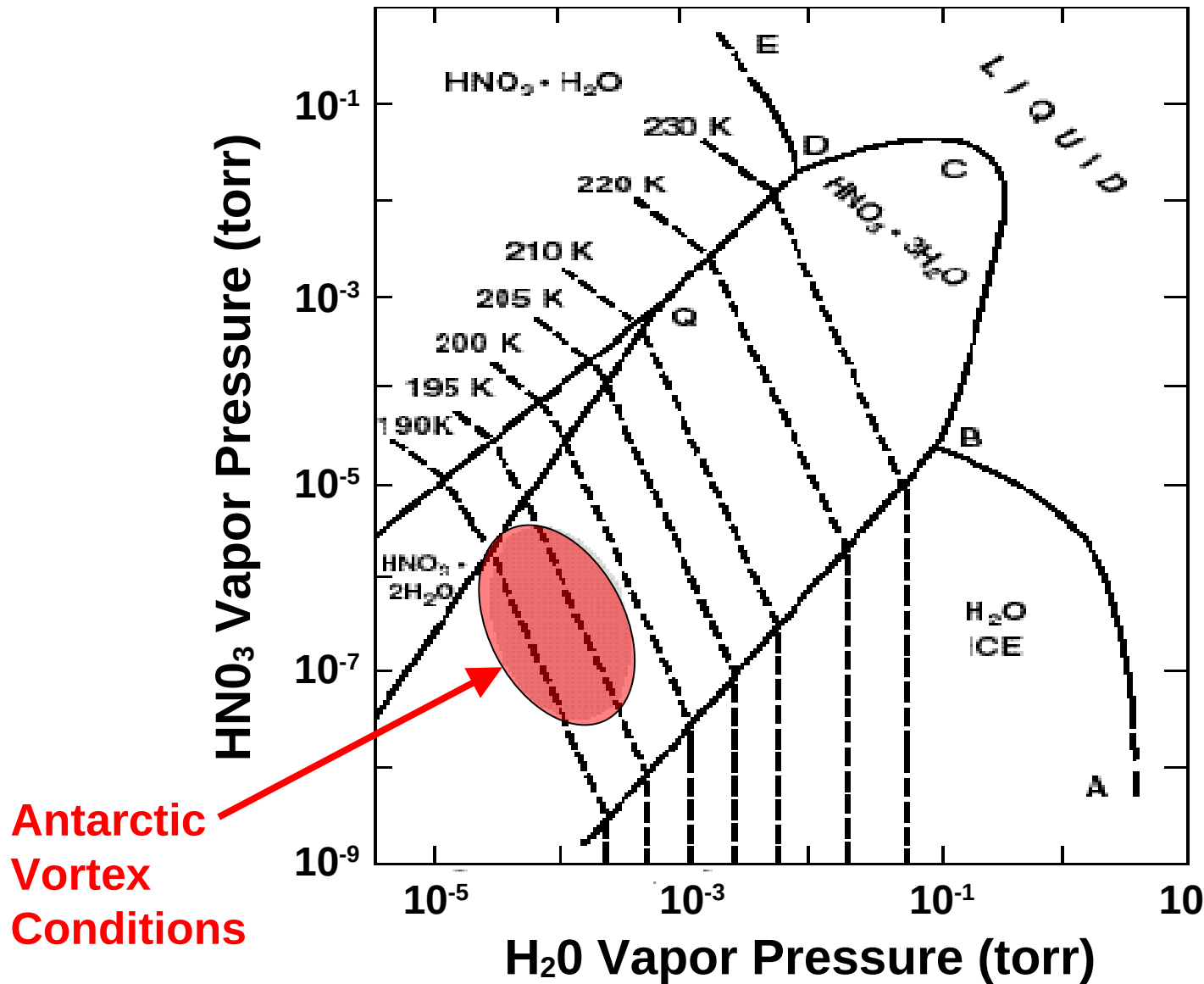
PSC Formation
(Type I PSC -78 °C)

Frost Point of Water -
Water Ice Only
(Type II PSC -88 °C)

Courtesy of Daniel J. Jacob

Antarctic Winter

HN0₃-H₂O Phase Diagram

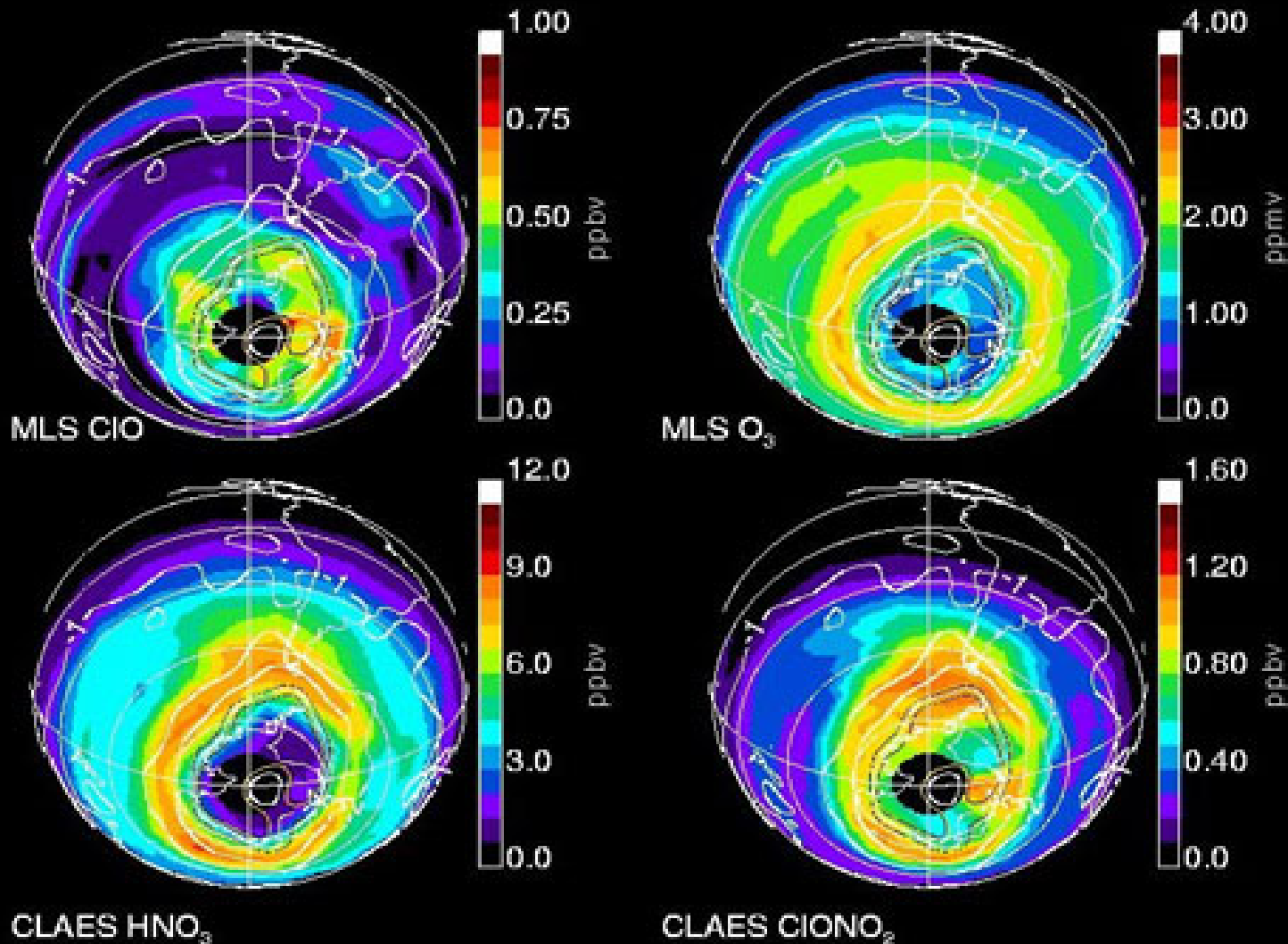


Courtesy of
Daniel J. Jacob

PSCs are not water but nitric acid trihydrate (NAT) clouds.

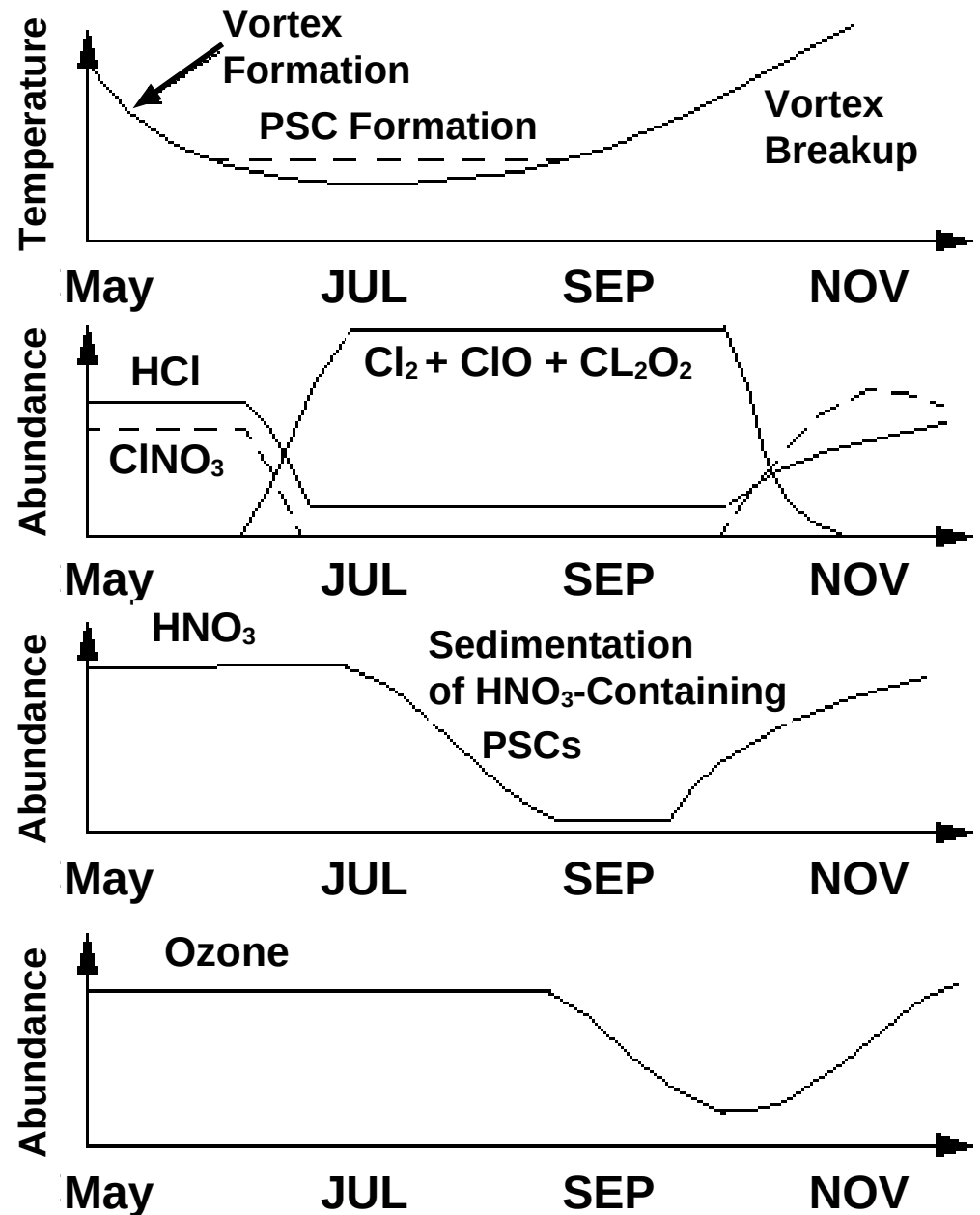
Denitrification in the Polar Vortex: Sedimentation of PSCs

UARS Data, Sept. 17 1992, $\theta = 460\text{K}$



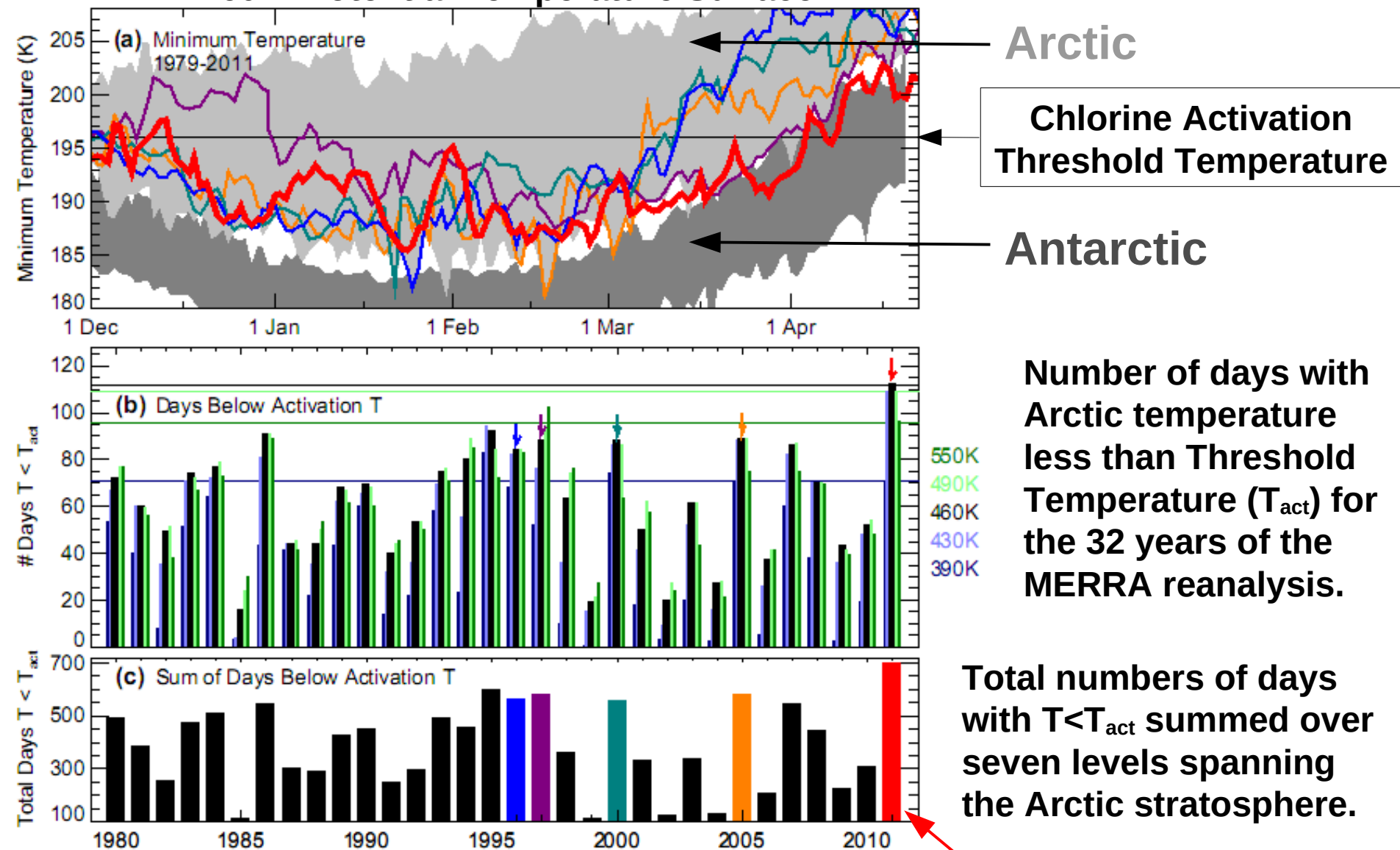
Chronology of Antarctic Ozone Hole

Vortex formation is due to radiation balance and the occur is predictable, more so than the vortex breakup.



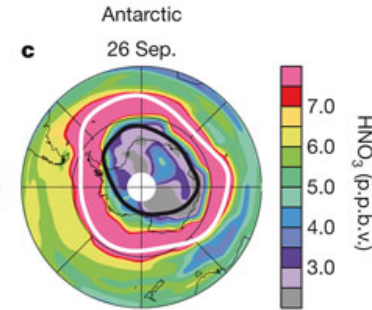
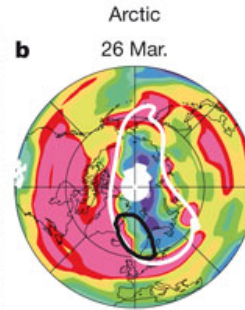
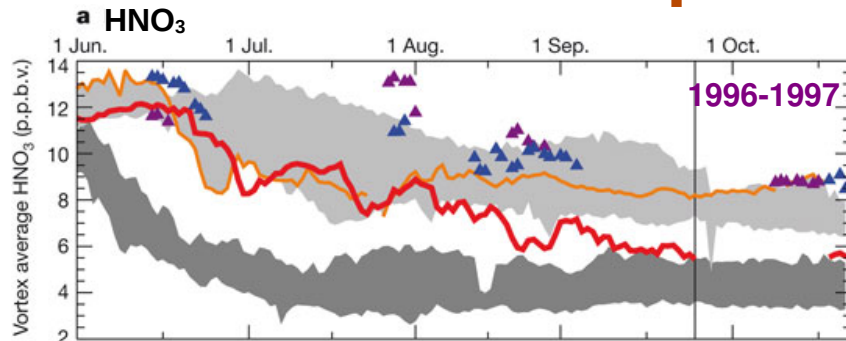
Polar Winter Temperature Statistics

460 K Potential Temperature Surface

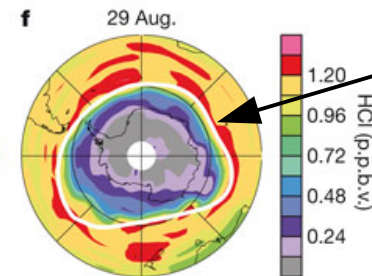
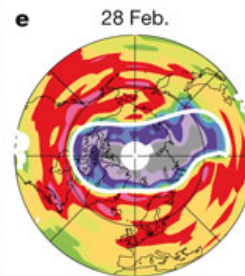
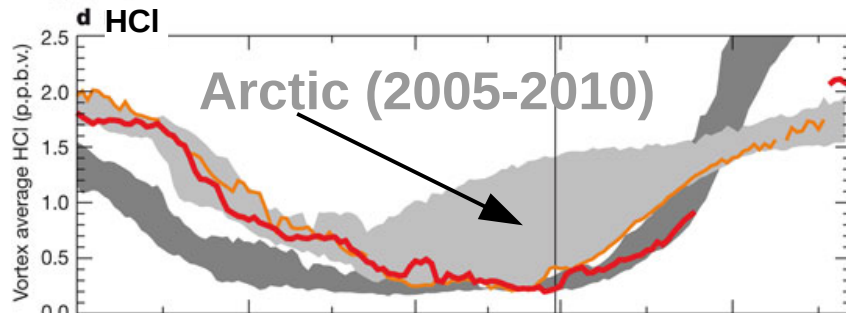


Source: doi:10.1038/nature10556

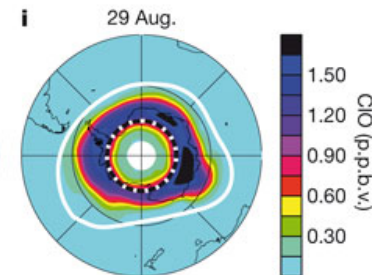
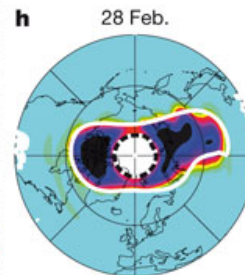
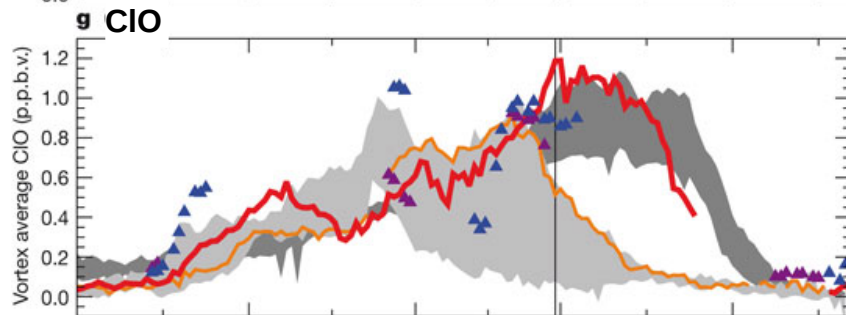
Lower Stratosphere Chemical Composition



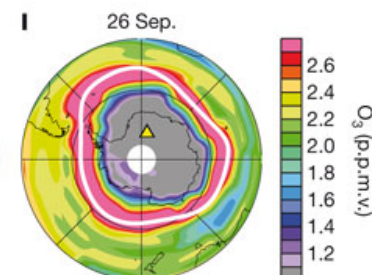
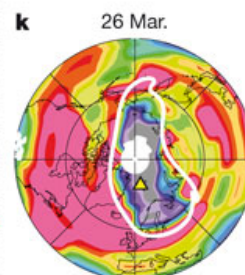
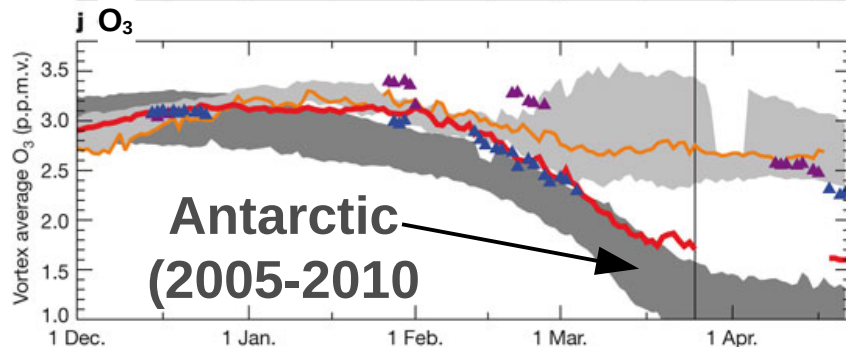
**485 K
Potential
Temperature
(~20 km)
(~50 hPa)**



**Averaging
on left plots
are within
white
contour.**



**Arctic 2011 values
given by orange
line, and Antarctic
2010 values
given by red line.**

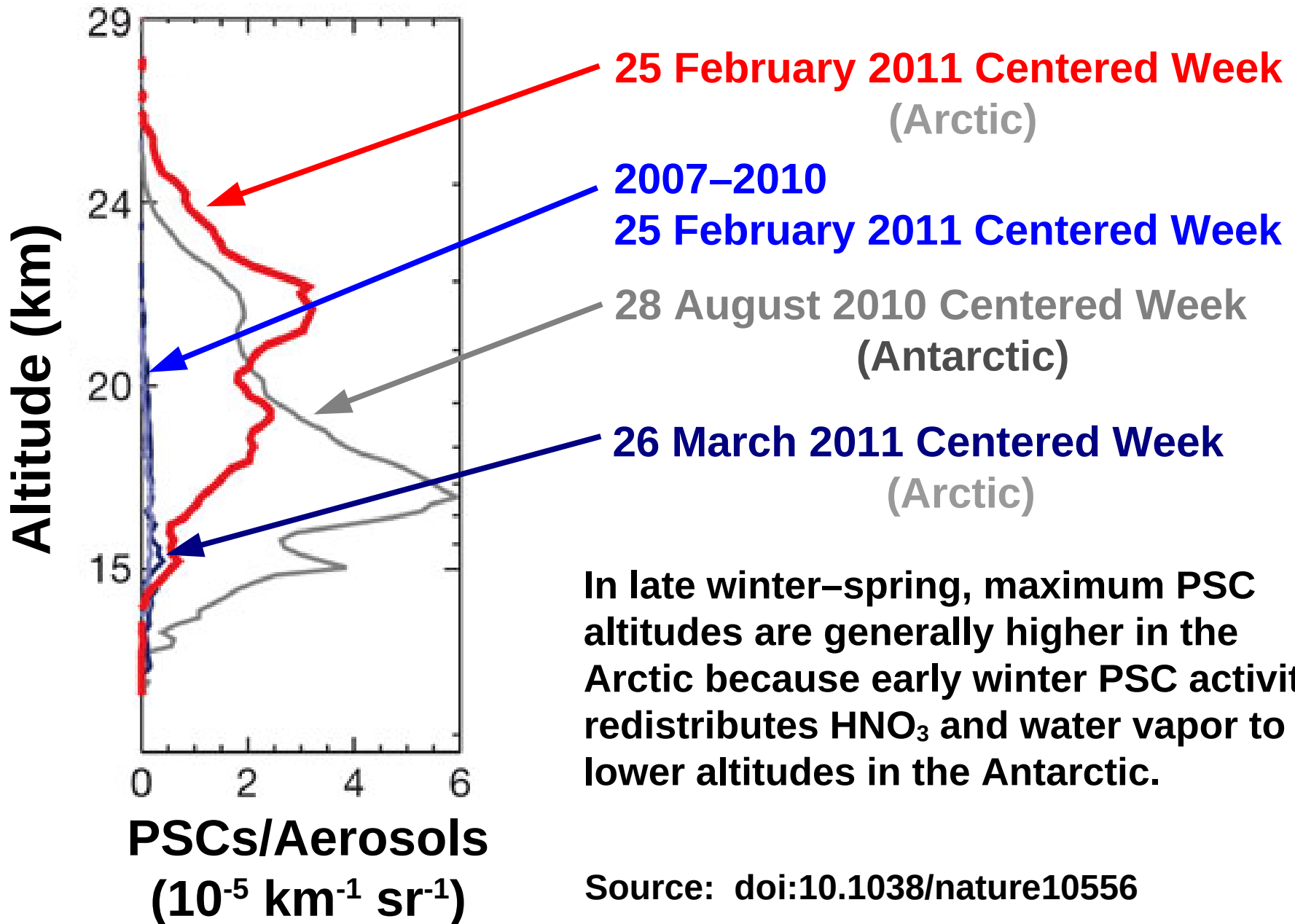


**Yellow triangles
are the profiles
locations.**

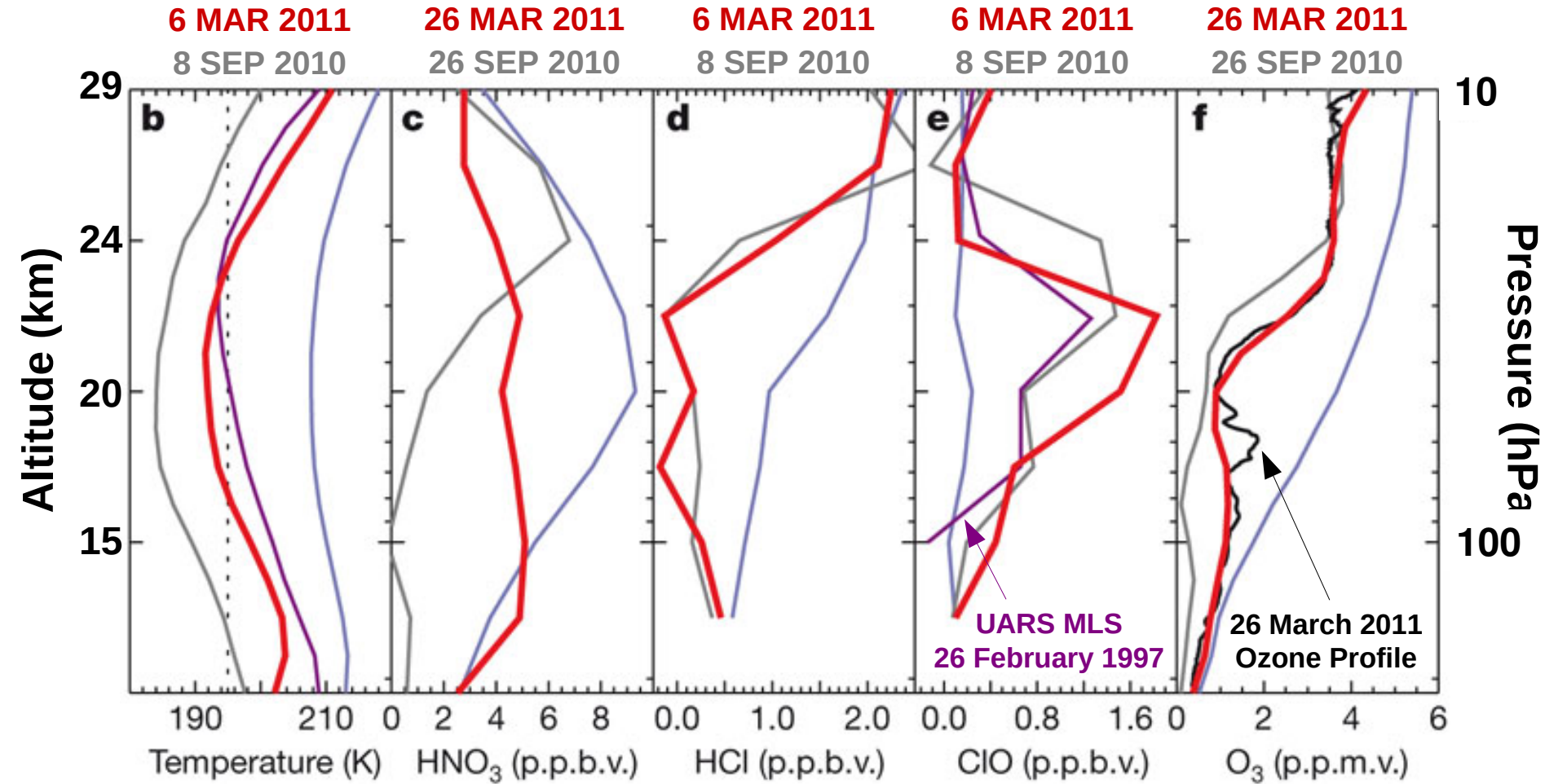
Aura MLS

**Source:
doi:10.1038/nature10556**

Aerosols Vertical Profiles



Chemical Vertical Profiles



Arctic: 4x15 latitude x longitude box around 79 N, 12 E

Antarctic: 4x15 latitude x longitude box around 79 S, 12 E

7-day average for 2005–10 (1980–2010 for temperature)

[Same location as red line values]

Source:

doi:10.1038/nature10556