Ozonesondes Show Record Low Stratospheric Ozone in the Arctic in 2011

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Photo by Andy Clarke February, 2005 Summit Horizon

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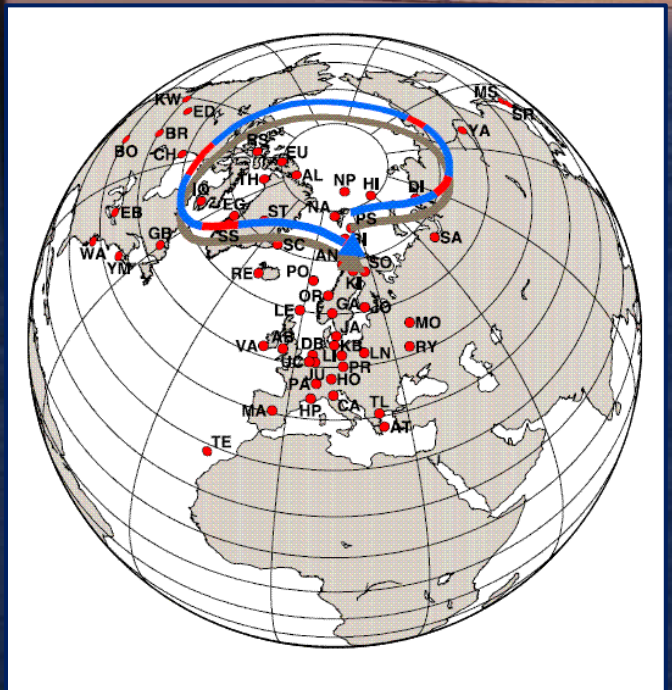


Match program coordinates ozonesonde launches in the northern hemisphere (Arctic-midlatitude) in order to separate dynamics (transport) from ozone loss chemistry

- 12 Arctic and 2 Antarctic campaigns since the early 90s (*EU + national. funding*)
- 35 stations
- ~500-1200 ozonesondes per winter
- >1000 match events per winter

Ozonesondes Show Record Low Stratospheric Ozone in the Arctic in 2011

A brief look at this year's Arctic "*ozone hole*" from:

- EGU April, 2011 presentation by Marcus Rex and Match Team

Arctic stratospheric ozone loss in winter 2011 compared to Antarctic ozone holes

- Paper submitted to Nature (April)

"*Unprecedented Arctic Ozone Loss in 2011: An Echo of the Antarctic" by Match/ozonesonde and satellite groups* (NASA, Royal Netherland Met Inst.).

- OMI satellite images.
- Summit Station ozonesondes & compare to South Pole.

Photo by Andy Clarke February, 2005 Summit Horizon

NATIONAL GEOGRAPHIC Daily News

First North Pole Ozone Hole Forming?

"Put on your sunscreen"—damaging air mass could drift far south.

Stratospheric clouds in the Arctic (file picture) worsen ozone loss, experts say.
Photograph from Picture Press/Alamy

Christine Dell'Amore
National Geographic News
Published March 22, 2011

Spawned by strangely cold temperatures, "beautiful" clouds helped strip the Arctic atmosphere of most of its protective ozone this winter, new research shows.
The resulting zone of low-ozone air could drift as far south as New York, according to experts who warn of increased skin-cancer risk.

But a continuing high-altitude freeze over the Arctic may have already reduced ozone to half its normal concentrations—said research leader Markus Rex, a physicist for the Alfred Wegener Institute for Polar and Marine Research in Bremerhaven, Germany.

Before spring is out, "we may even get the first Arctic ozone hole ...

Published online 16 May 2011 | Nature |
doi:10.1038/news.2011.293

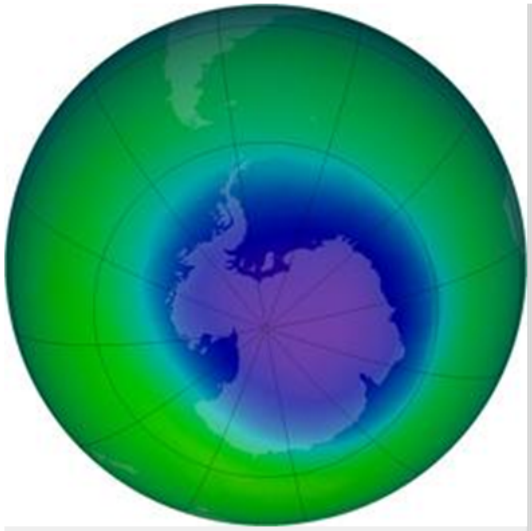
News

First signs of ozone-hole recovery spotted

Antarctic ozone layer bouncing back after the phase-out of chlorofluorocarbons.

James Mitchell Crow

The hole in the ozone layer over Antarctica is starting to heal, say researchers in Australia. The team is the first to detect a recovery in baseline average springtime ozone levels in the region, 22 years after the Montreal Protocol to ban Chlorofluorocarbons (CFCs)



The average size of the Antarctic ozone hole in October 2010. Its recovery has so far been masked by annual fluctuations.

NASA

nature news

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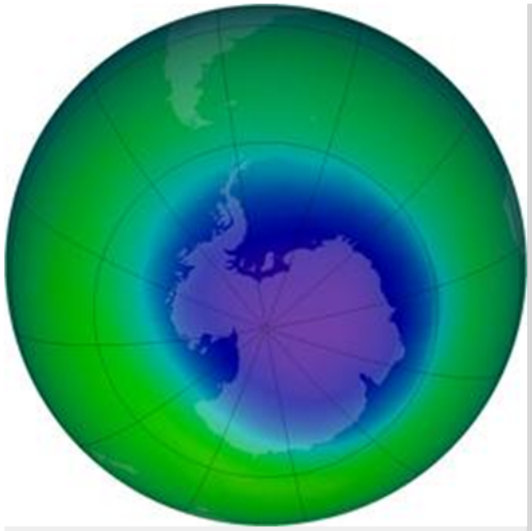


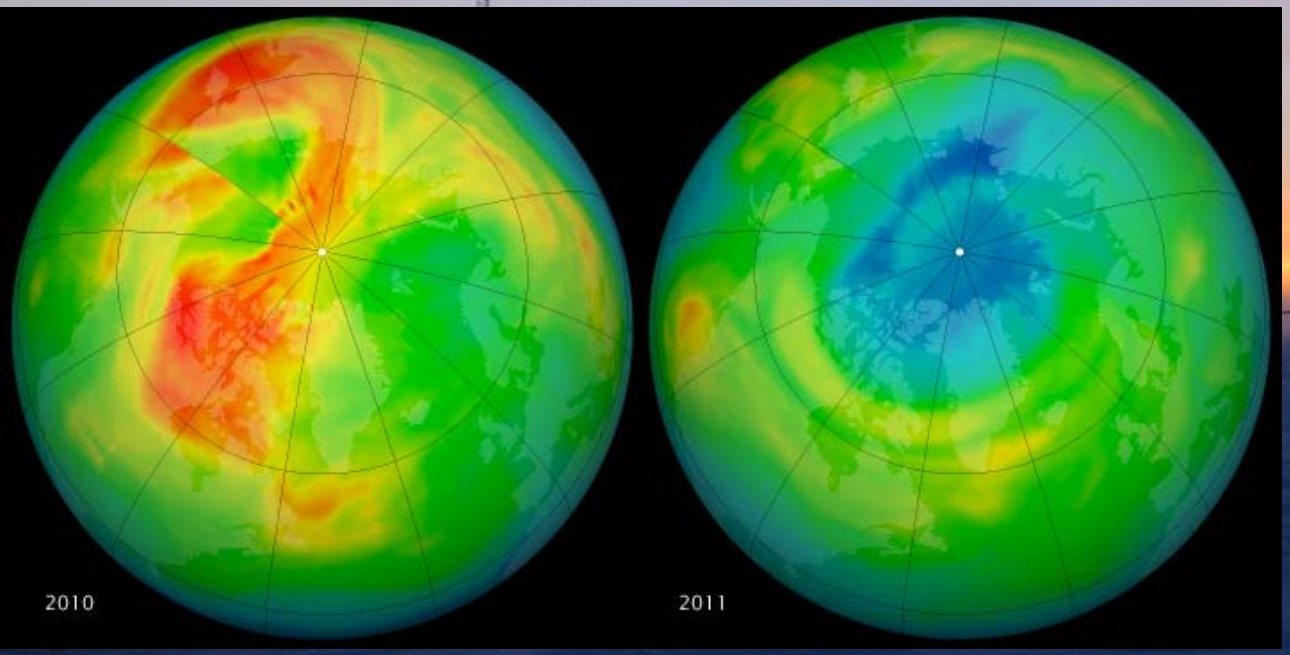
The average size of the Antarctic ozone hole in October 2010. Its recovery has so far been masked by annual fluctuations.

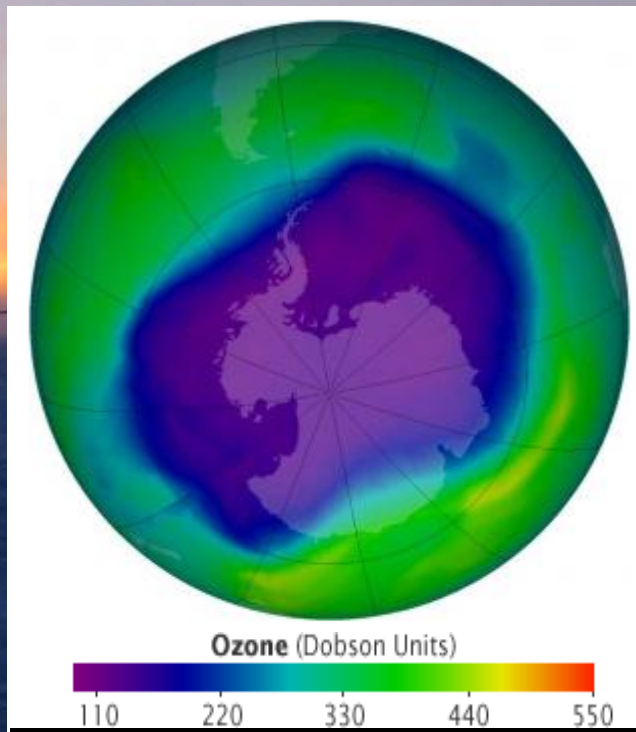
NASA

- *Ozone-hole recovery date definition*
- *how conservative are the analysis methods that are used.*

OMI satellite images of 2011 ozone loss region in the Arctic compared to 2010 and the Antarctic record breaking depletion in 2006

2010 ARCTIC **2011 ARCTIC** **RECORD AREA 2006 ANTARCTIC**





Sept/Oct, 2006 the average area of the ozone hole was the largest ever observed, at 29 million square kilometers. *NASA*

Antarctica lowest column ozone:

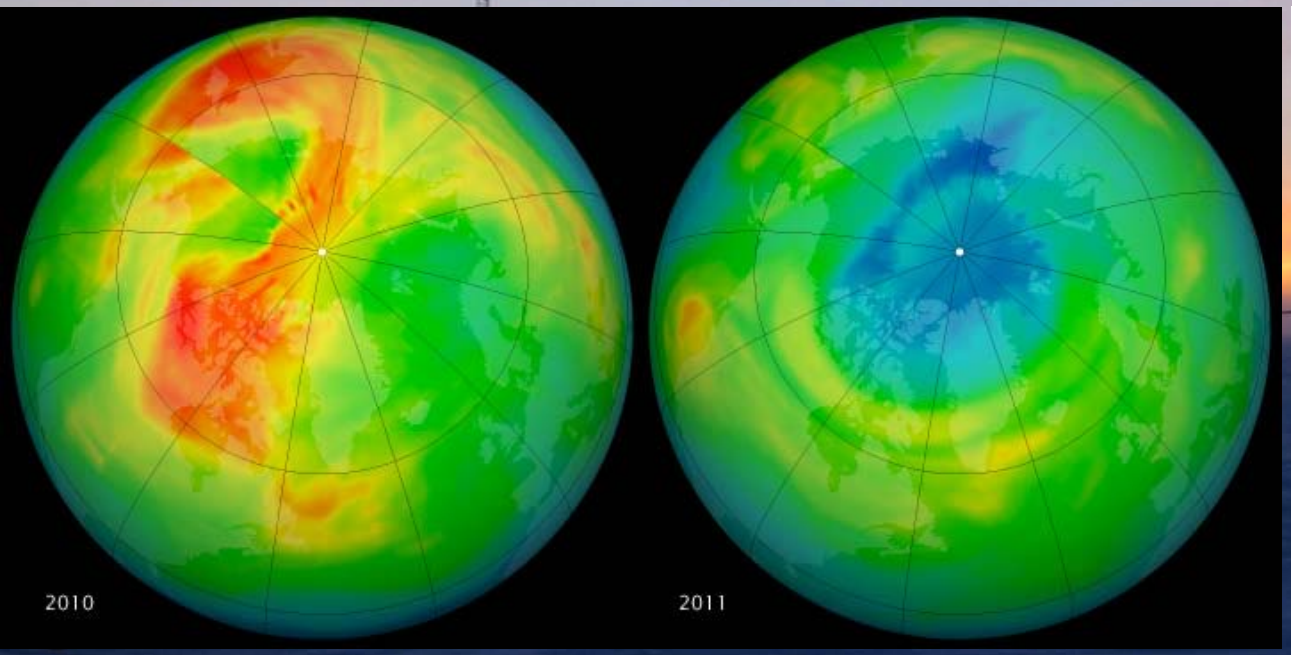
Oct 2006

OMI 85 DU

GMD ozsonde 93 DU

2010 ARCTIC

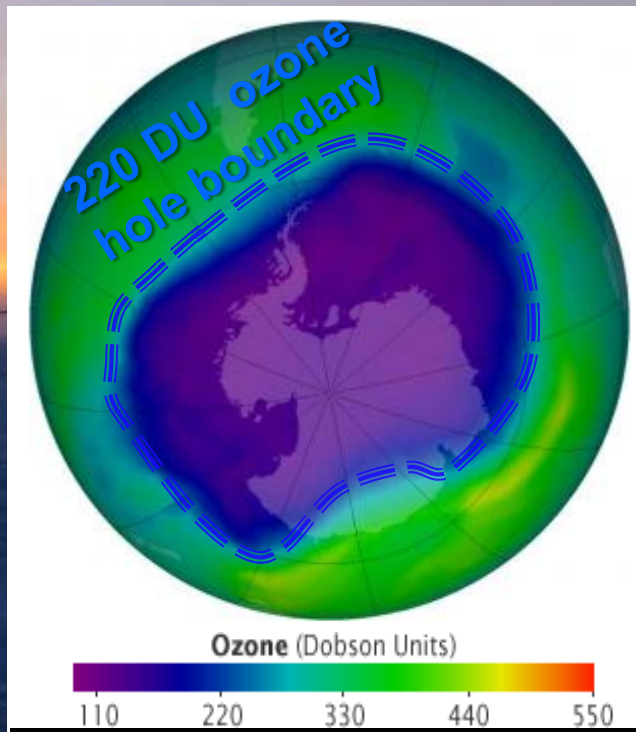
2011 ARCTIC



"Unprecedented Arctic Ozone Loss in 2011: An Echo of the Antarctic"

Arctic ozone hole < 250 DU total column and mixing ratios < 1 ppmv several km

RECORD AREA 2006 ANTARCTIC



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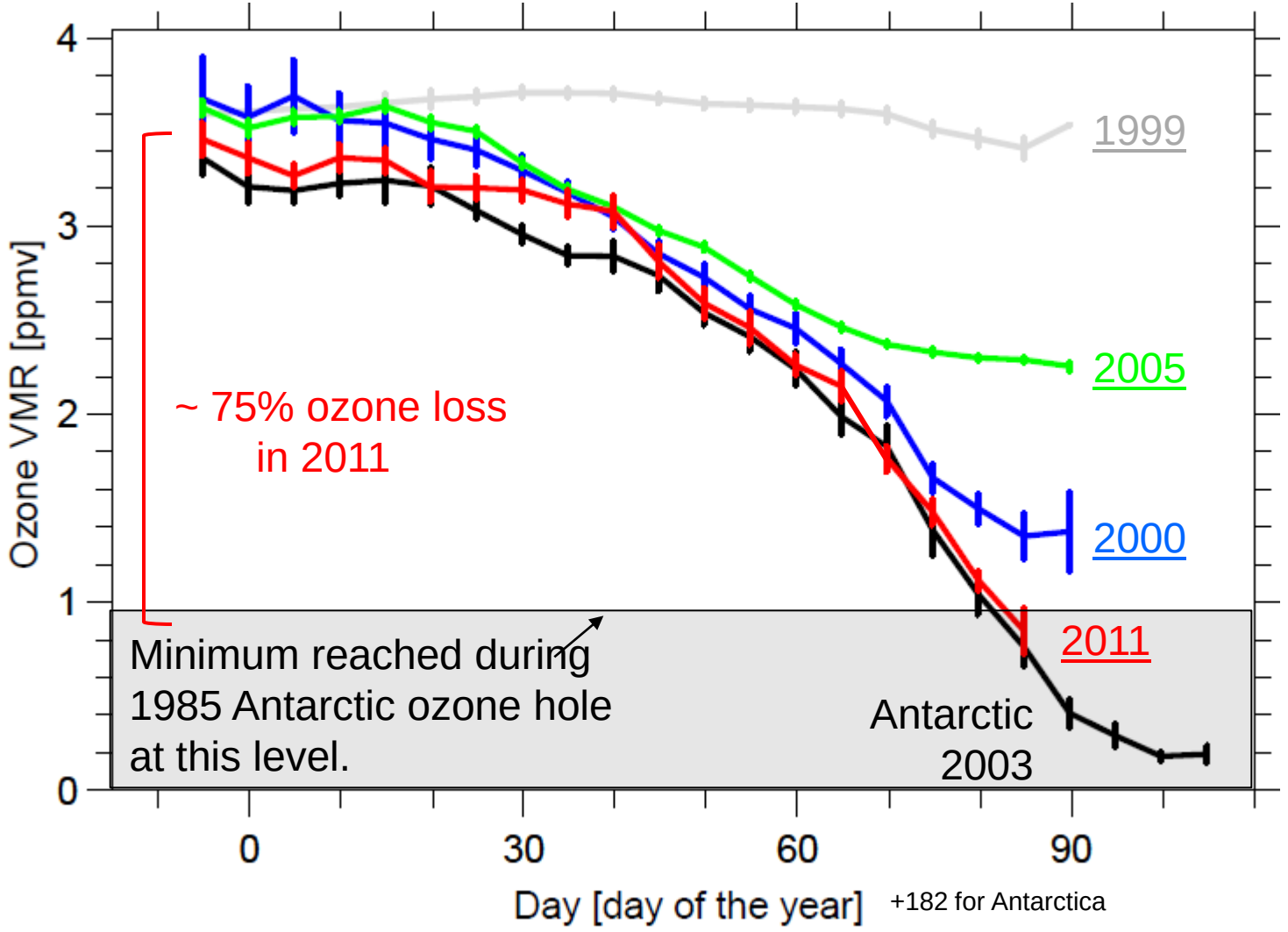
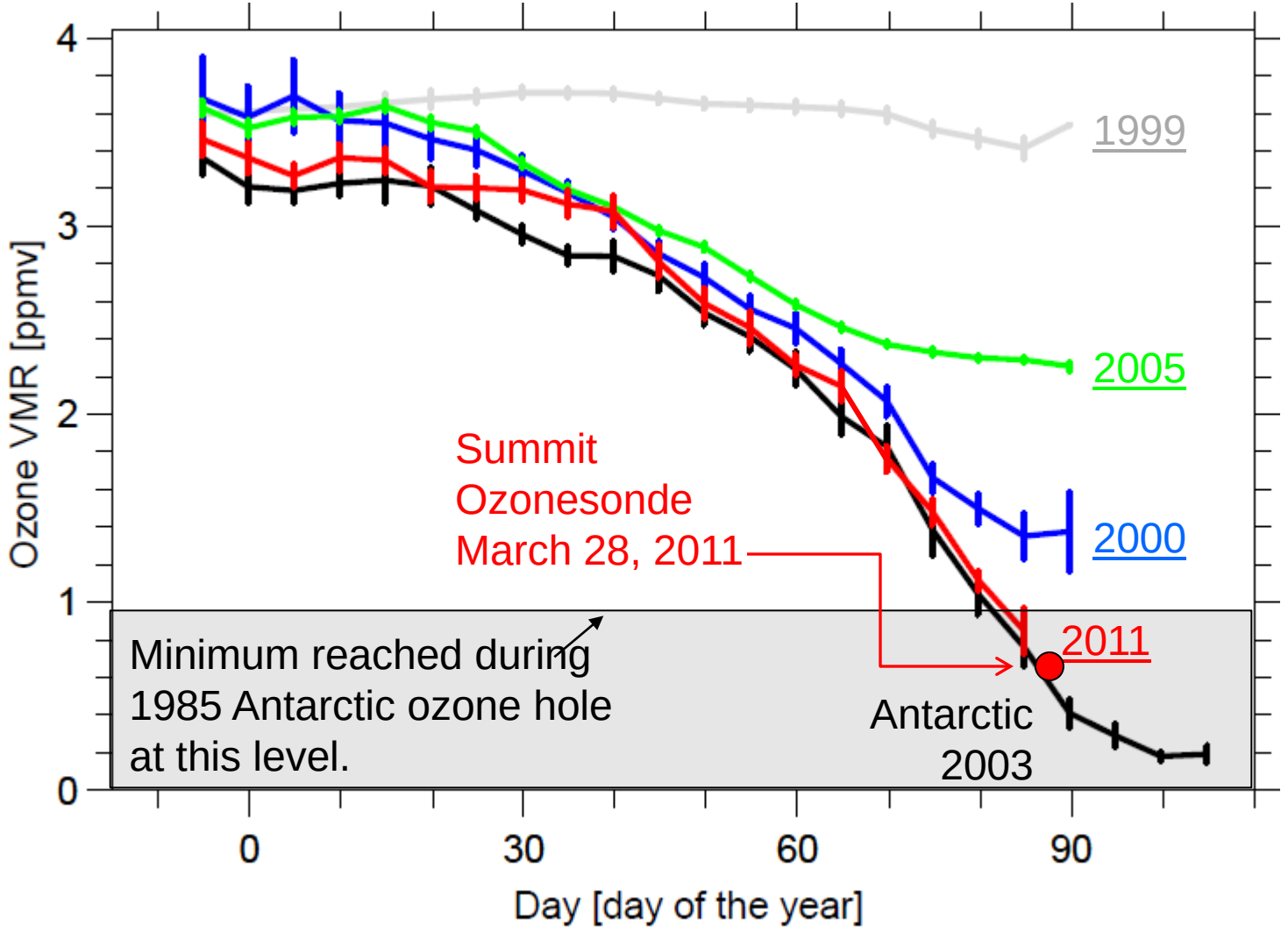
Average ozone inside vortex @ eΘ=465K



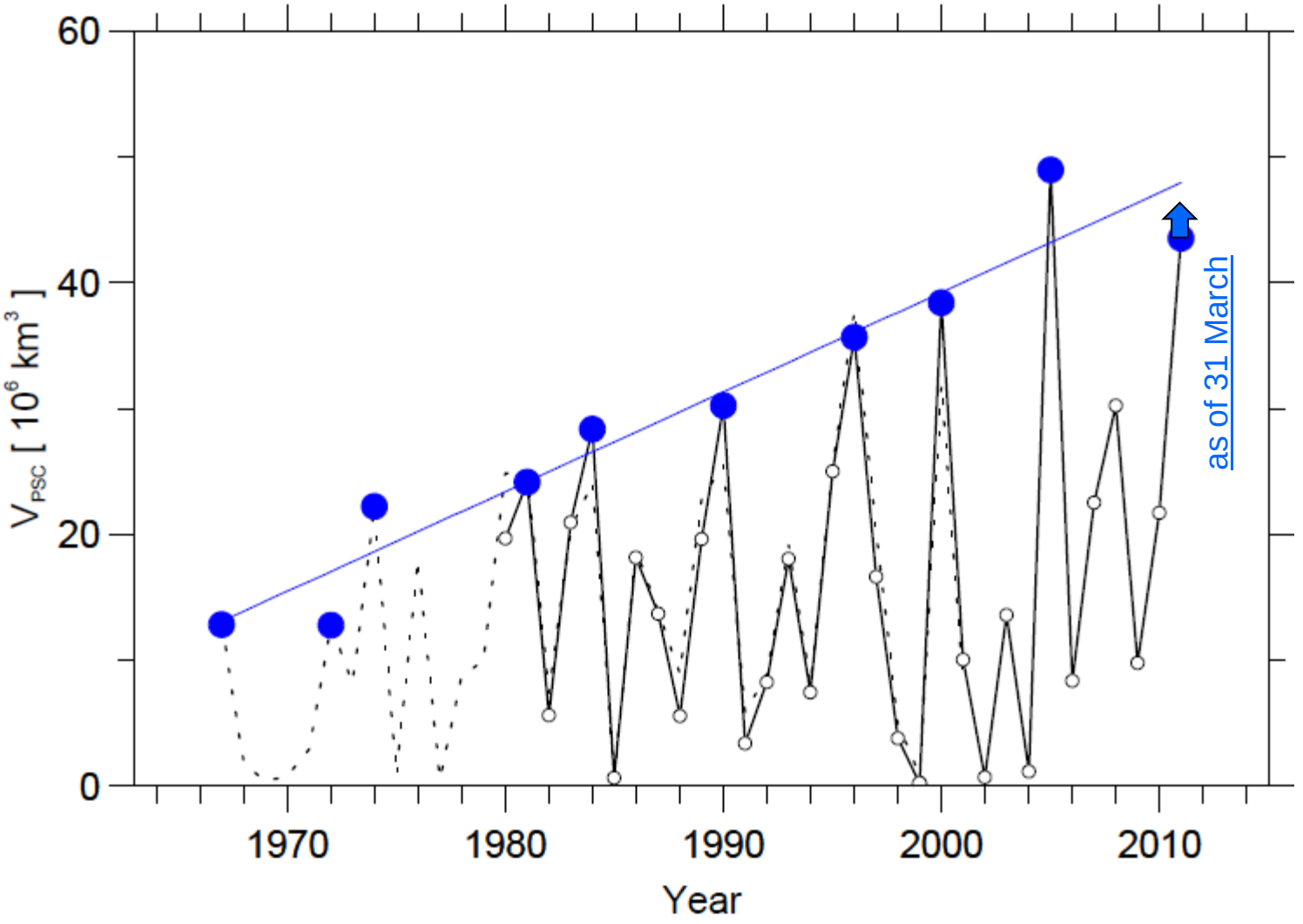
- M. Rex (Match) *Arctic stratospheric ozone loss in winter 2011 compared to Antarctic ozone holes*

Average ozone inside vortex @ eΘ=465K



- M. Rex (Match) *Arctic stratospheric ozone loss in winter 2011 compared to Antarctic ozone holes*

Long term evolution of volume of air over arctic suitable for PSC formation (V_{PSC}) ~ <-78C



- M. Rex (Match) *Arctic stratospheric ozone loss in winter 2011 compared to Antarctic ozone holes*

OZONESONDE LAUNCH RECORD:
SUMMIT STATION: Feb 2005 - present ~ 300 ozonesondes
SOUTH POLE continuous 1986 – present ~ 1620 ozonesondes

SUMMIT

GREENLAND

72.6 º North

38.5 º West

Elevation:

3202 Meters

Summit Station, Greenland 72.6 º North April 15, 2011

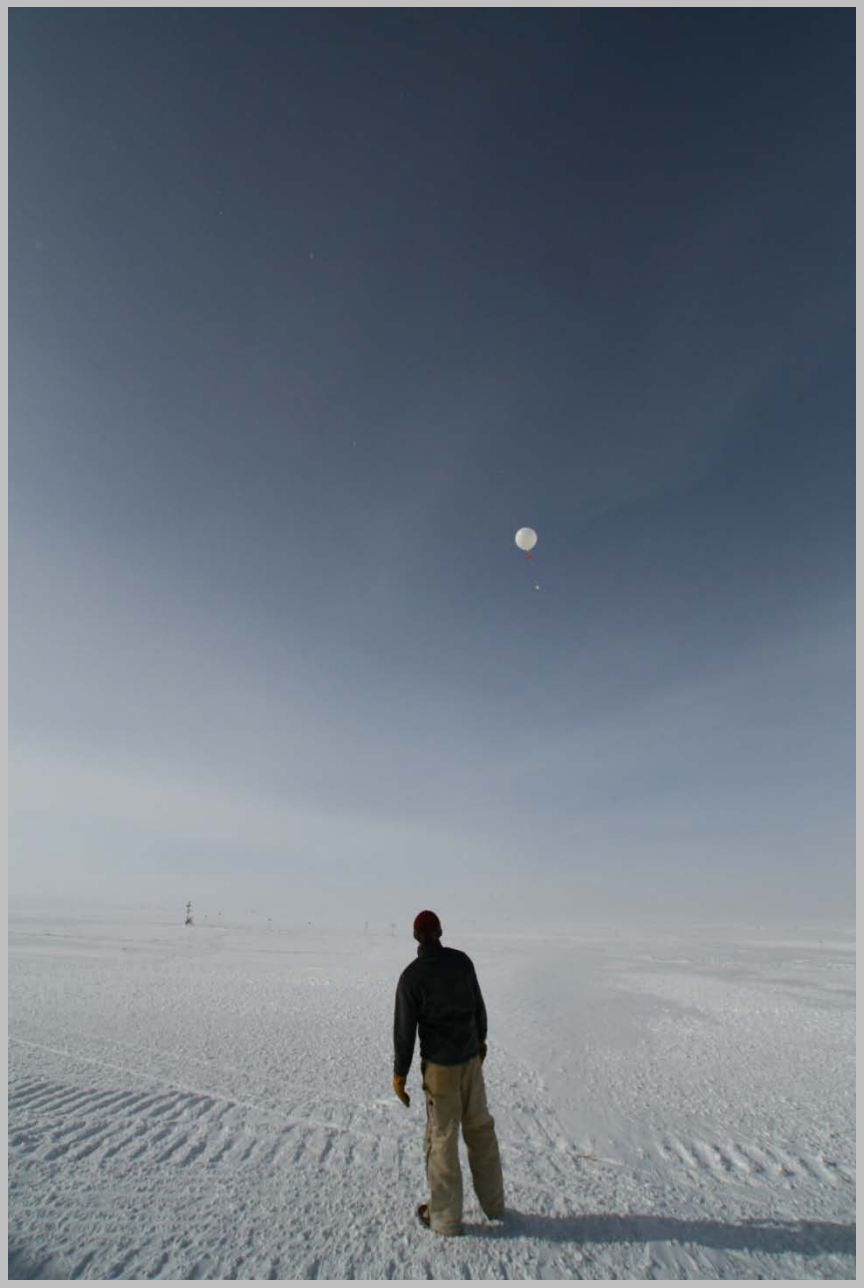
Summit Science Techs in 2010/2011

NSF provides ozonesondes

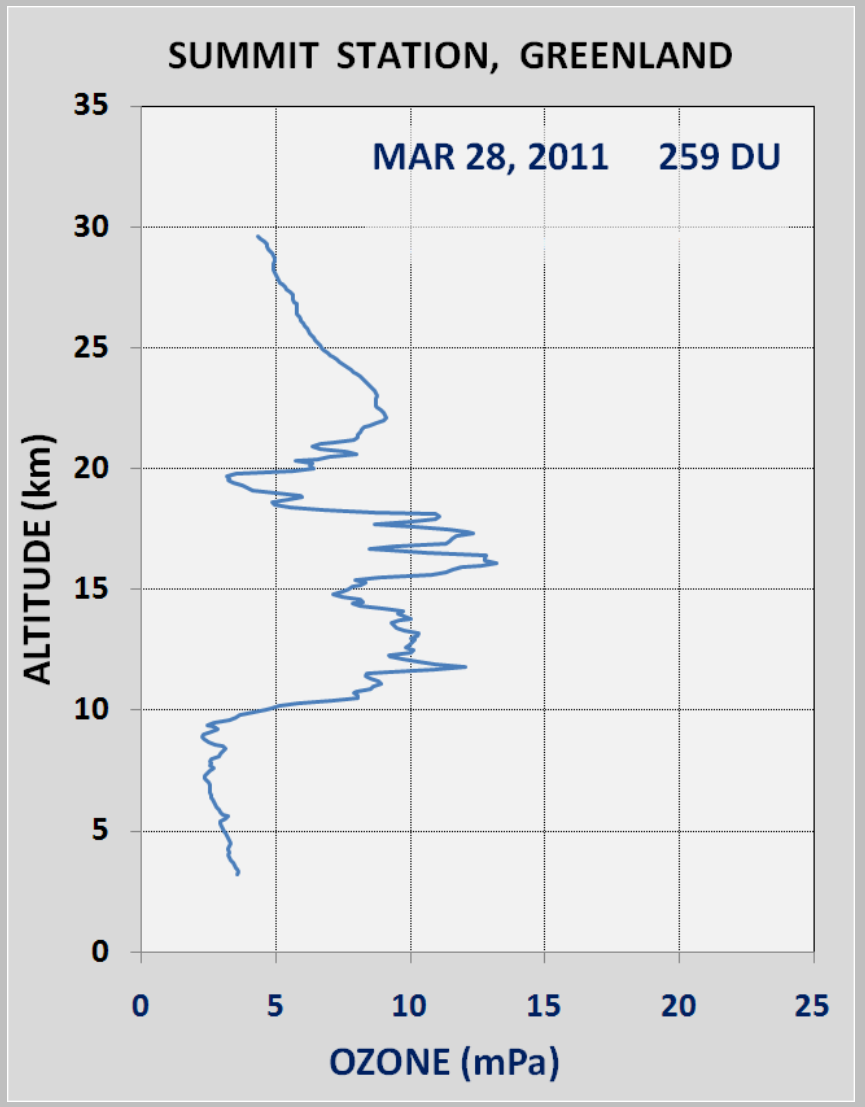
Launch 1 ozonesonde per week

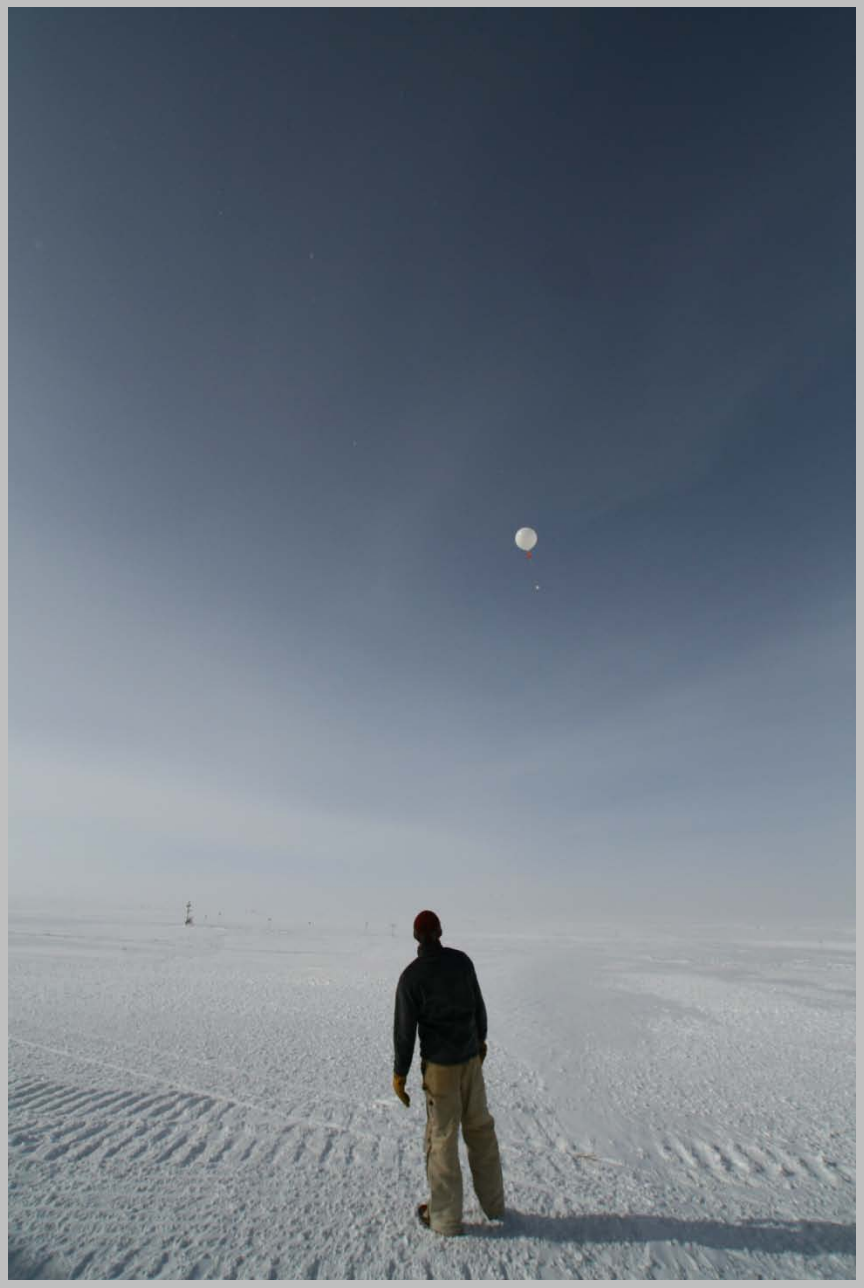
Wait on Match request to adjust weekly launch schedule.

plastic balloon vs rubber balloon



Selected Minimum profile for Summit 2011





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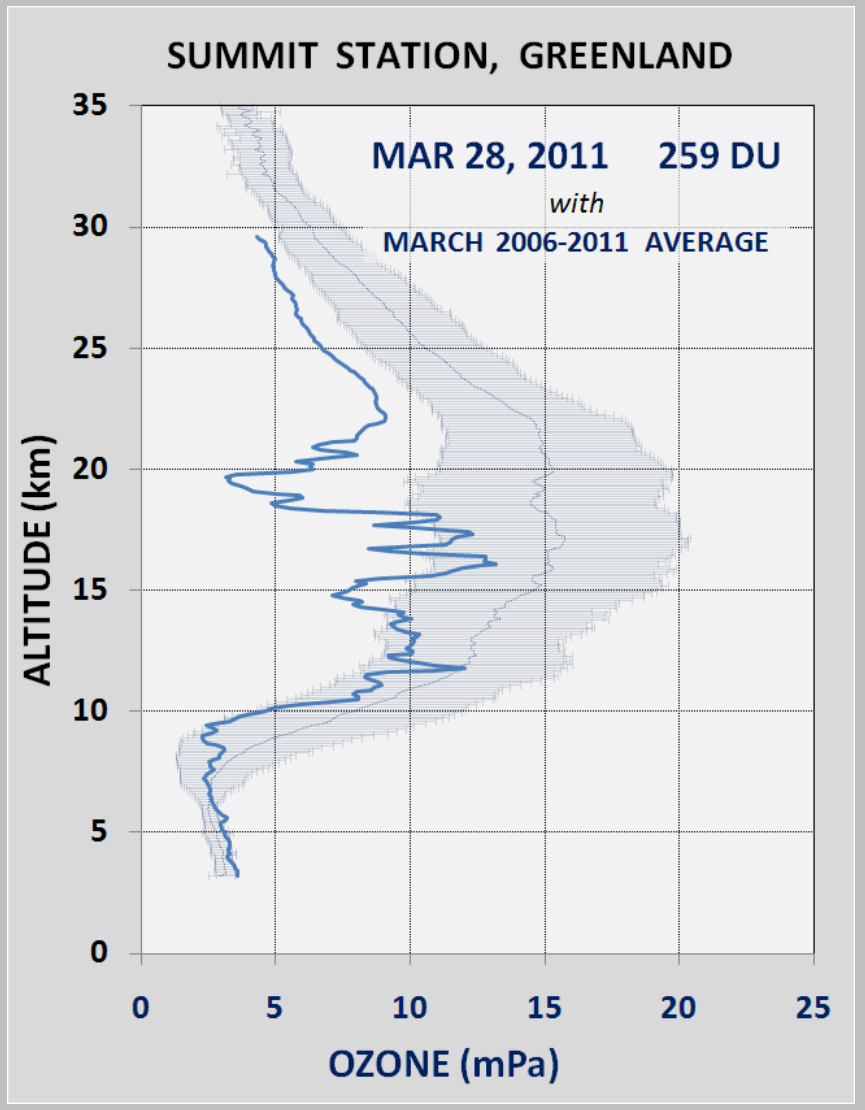
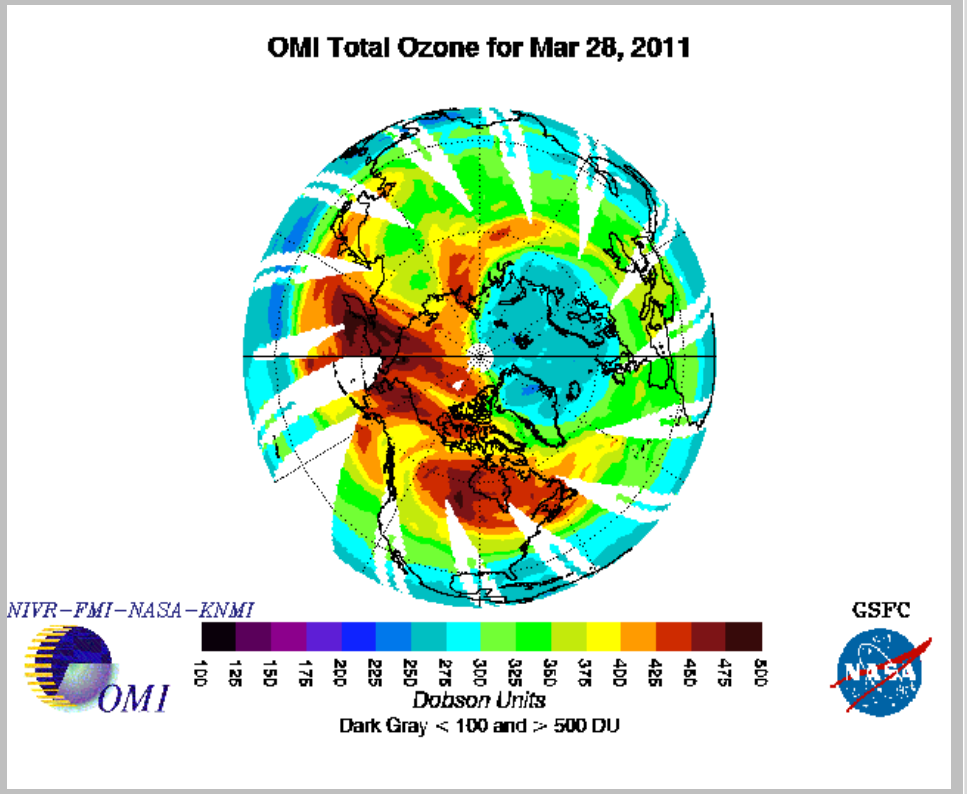
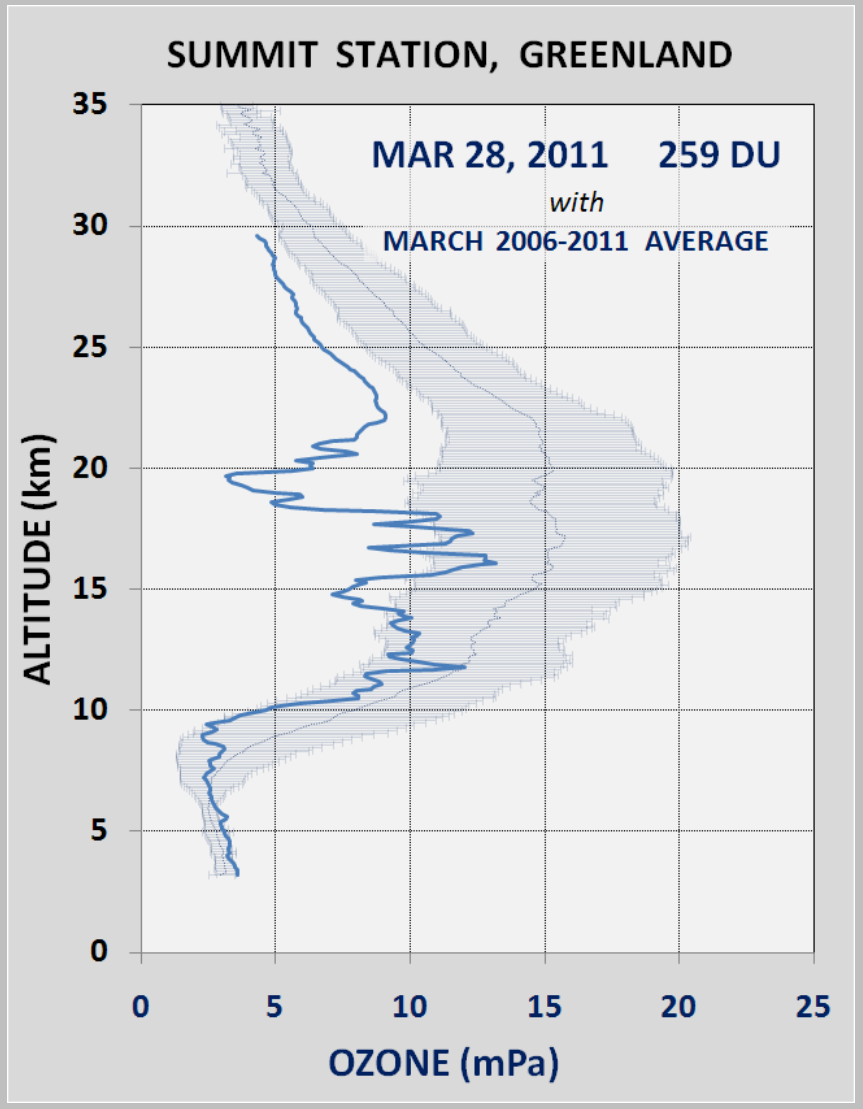
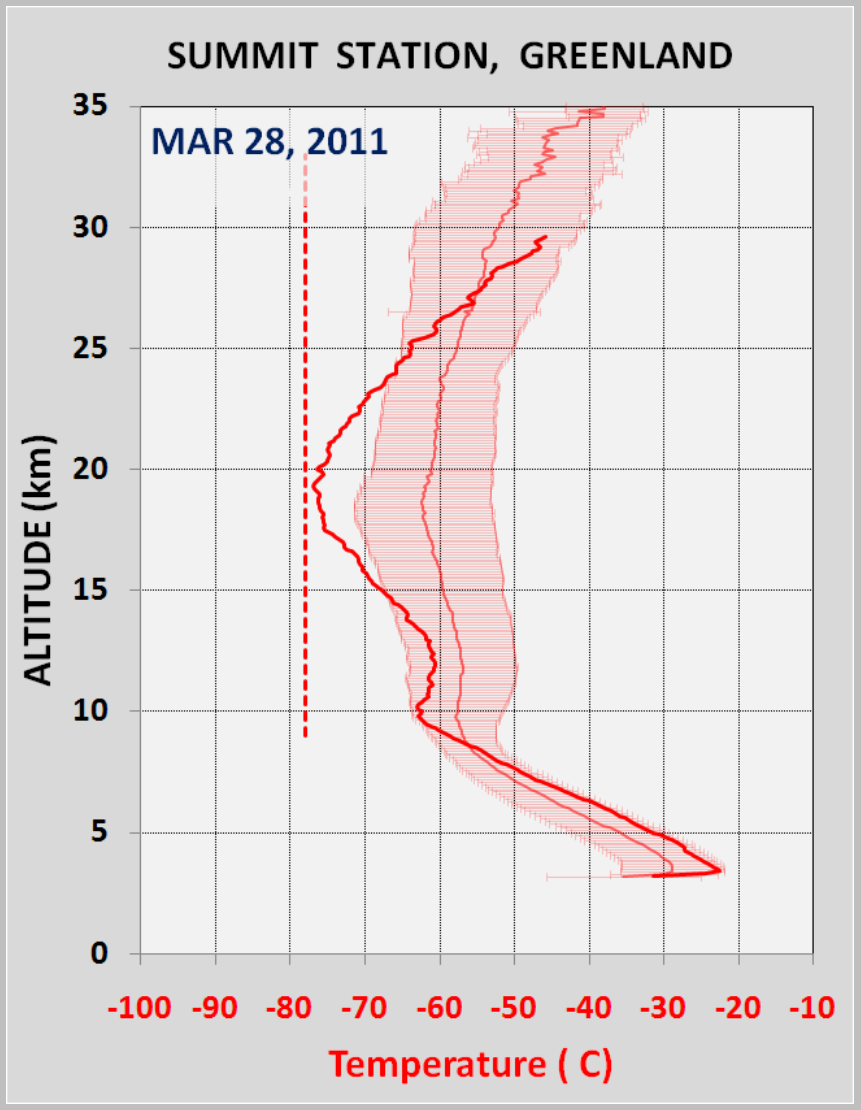


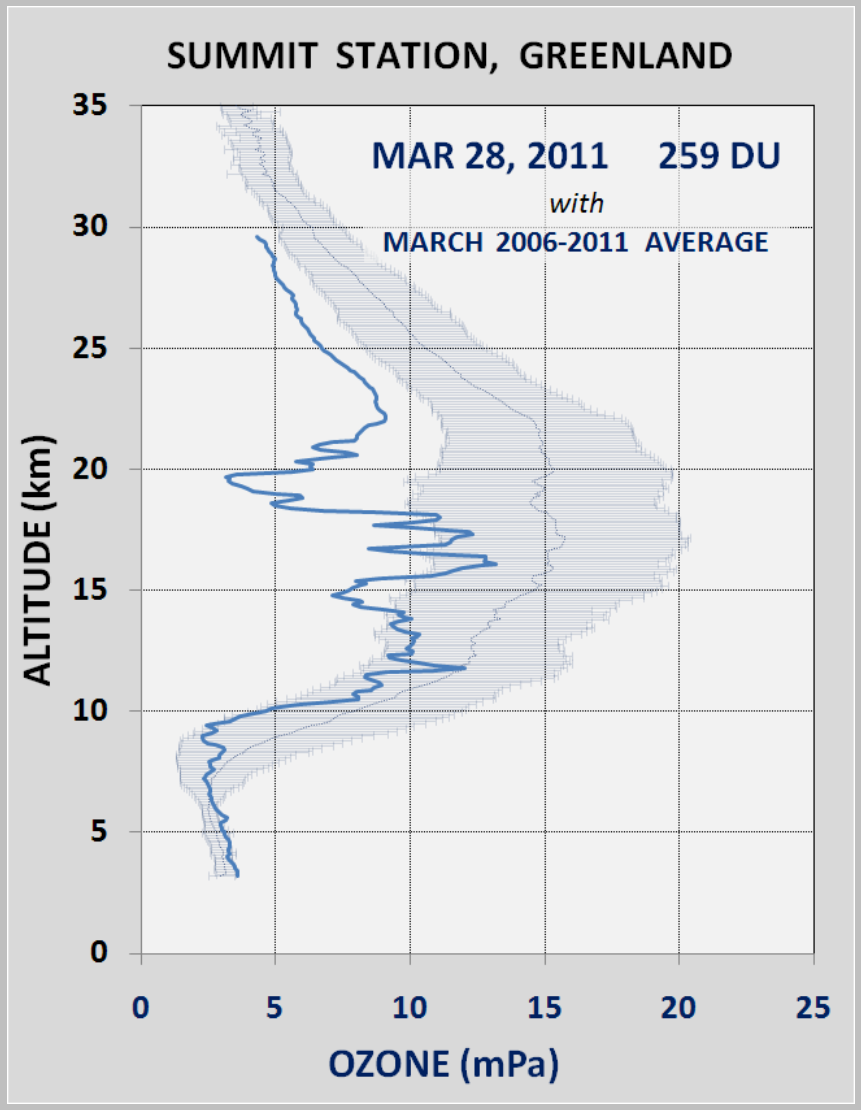
OMI Satellite view of total column ozone on March 28, 2011



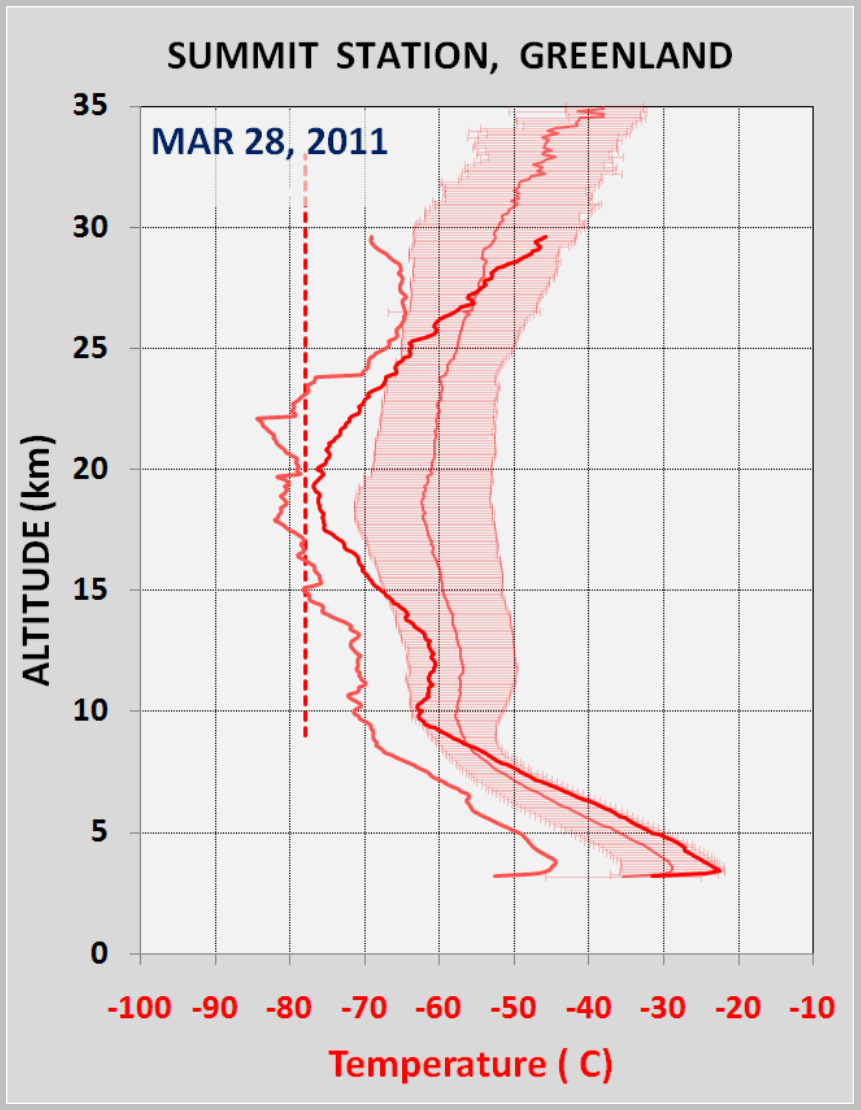


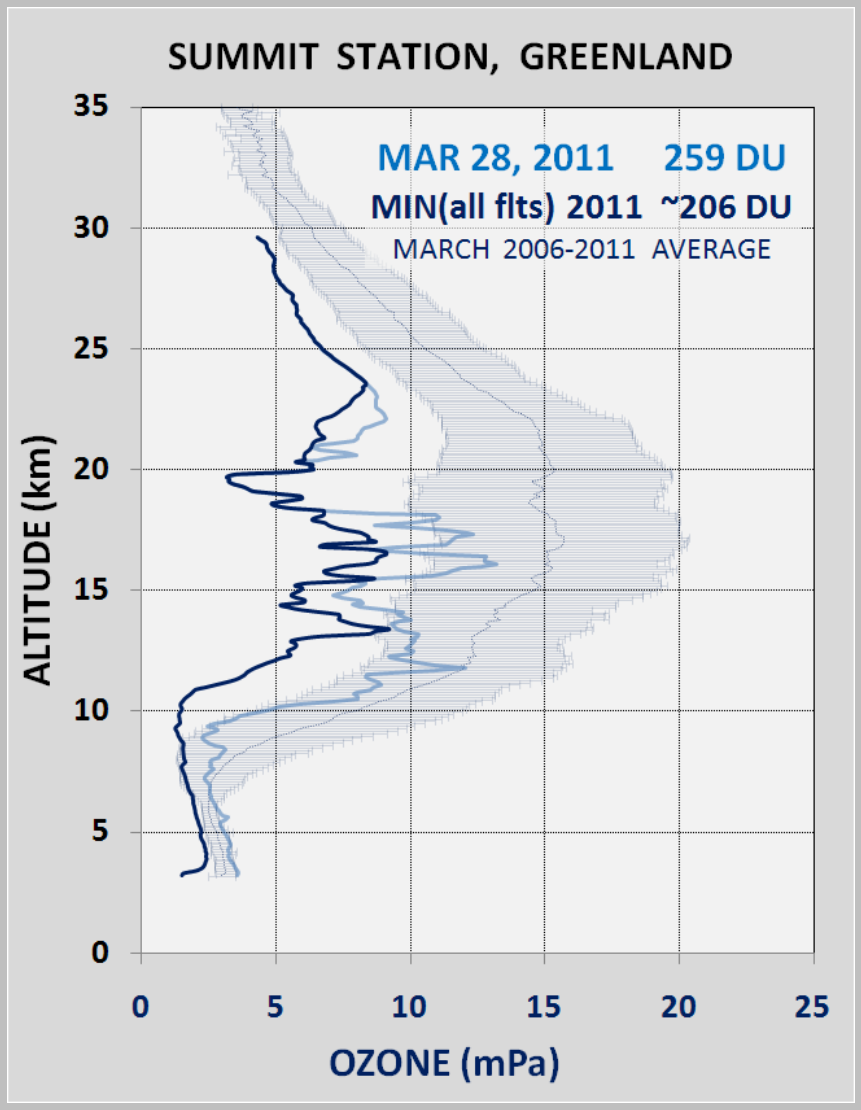
Polar stratospheric cloud (PSC) threshold temperature of -78 C.



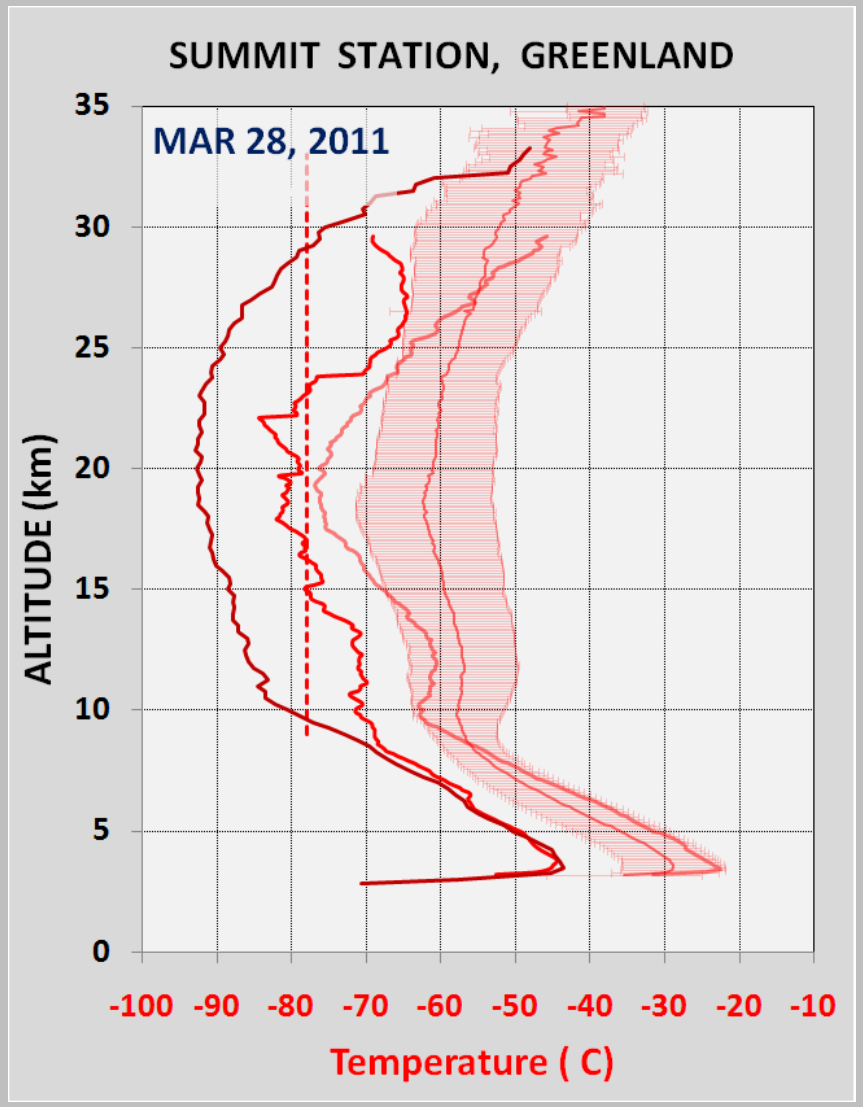


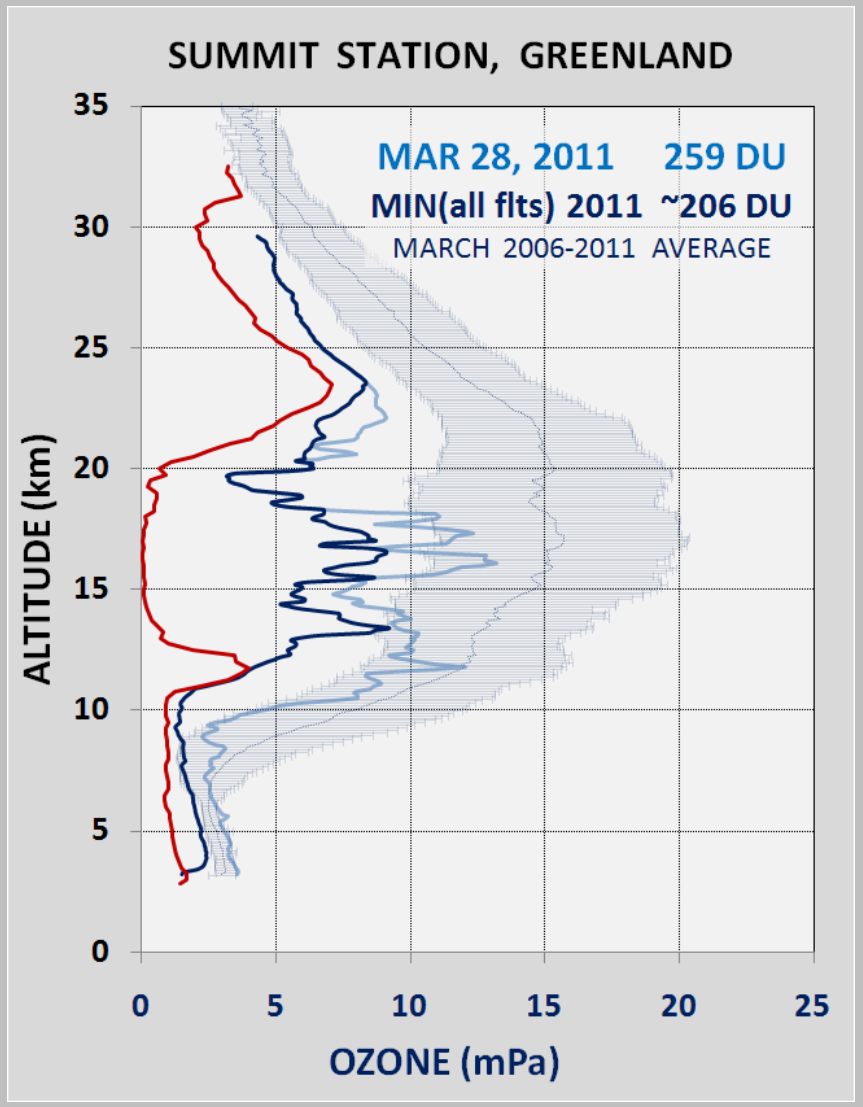
Summit: All altitude levels of minimum temperature and minimum ozone from December, 2010 to April, 2011



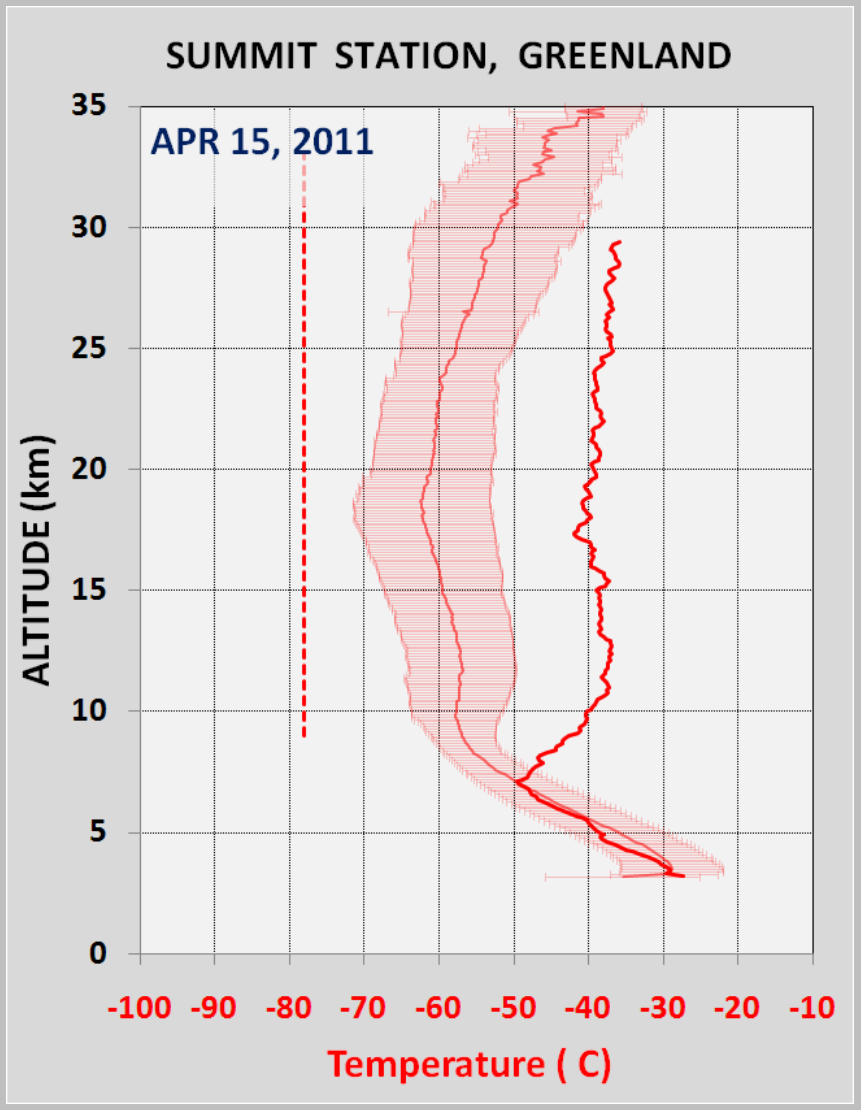


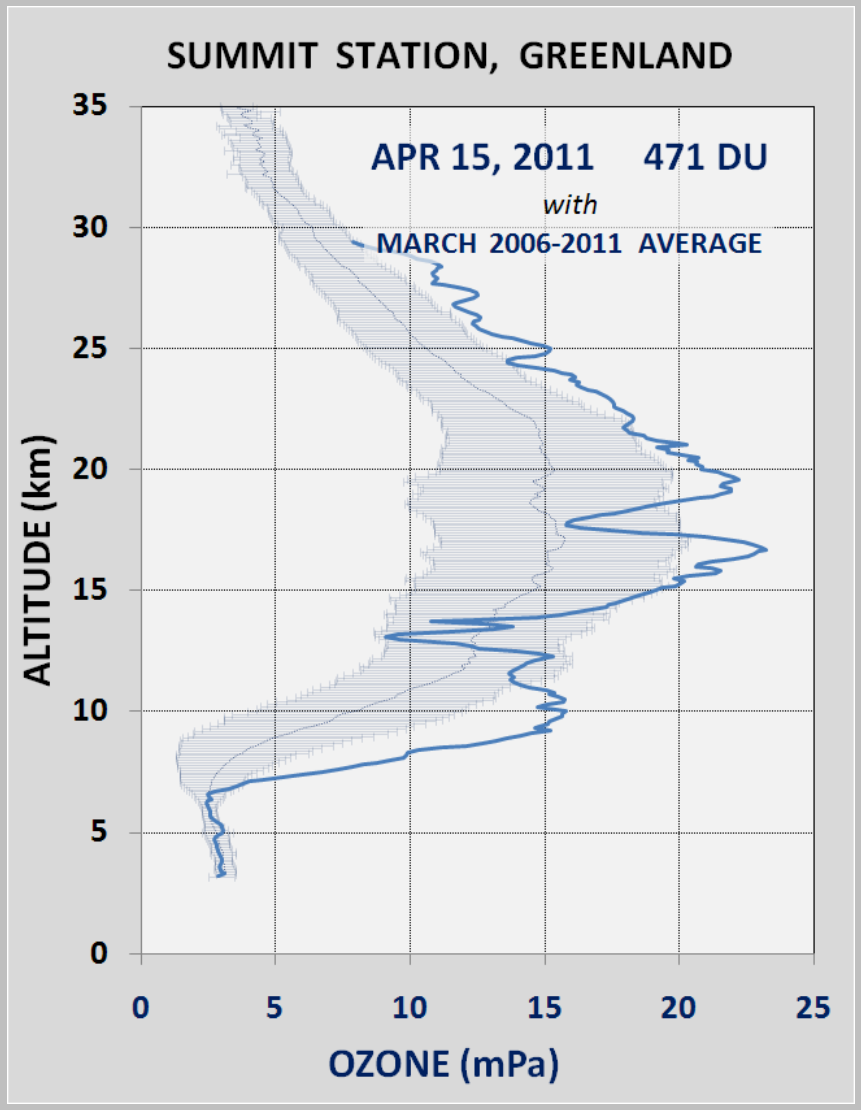
Comparing to South Pole ozonesonde measurements: minimum temperatures and minimum ozone observed from July to October.





The vortex breakup brings warm temperatures and high ozone





Conclusions

MATCH CAMPAIGN:

- Chemical loss of ozone in Arctic winter 2011 is larger than in any previous winter since frequent ozonesonde measurements started in the Arctic in 1991.

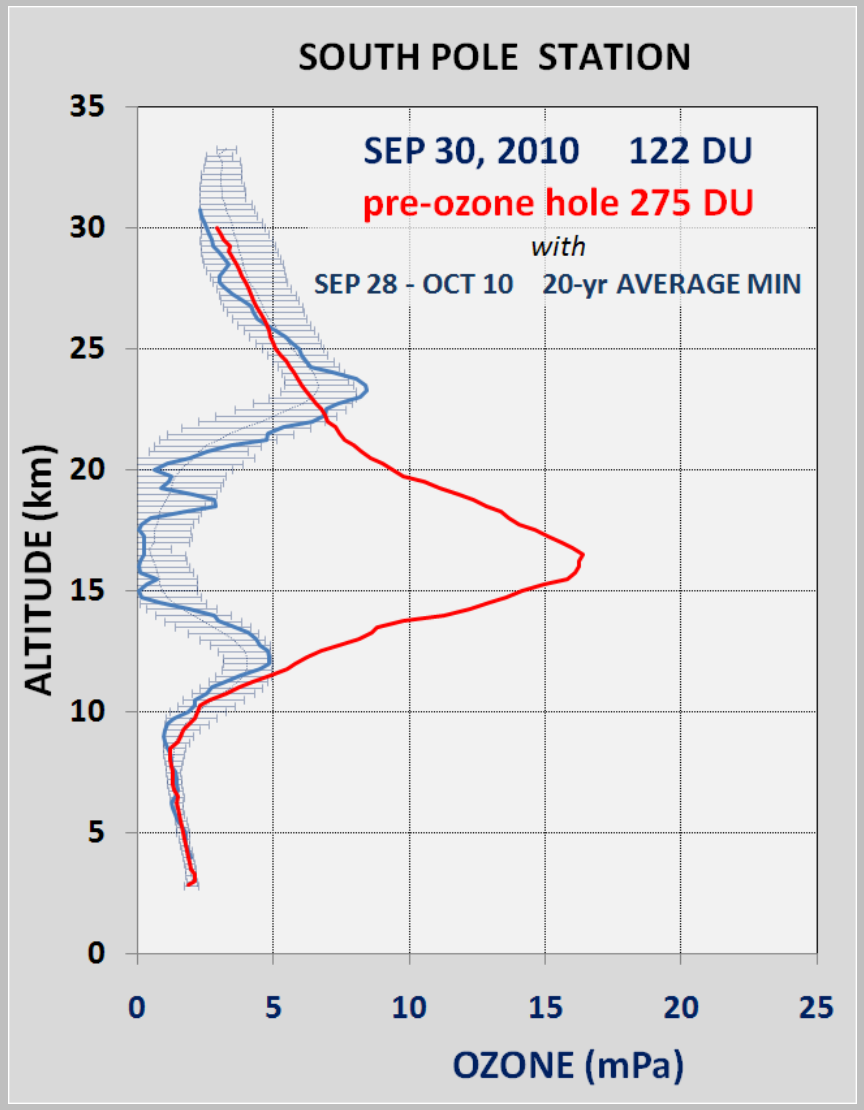
- Ozone loss by April 1: over 70% loss over ~3-4km vertical region occurred. Local losses exceed 80%.

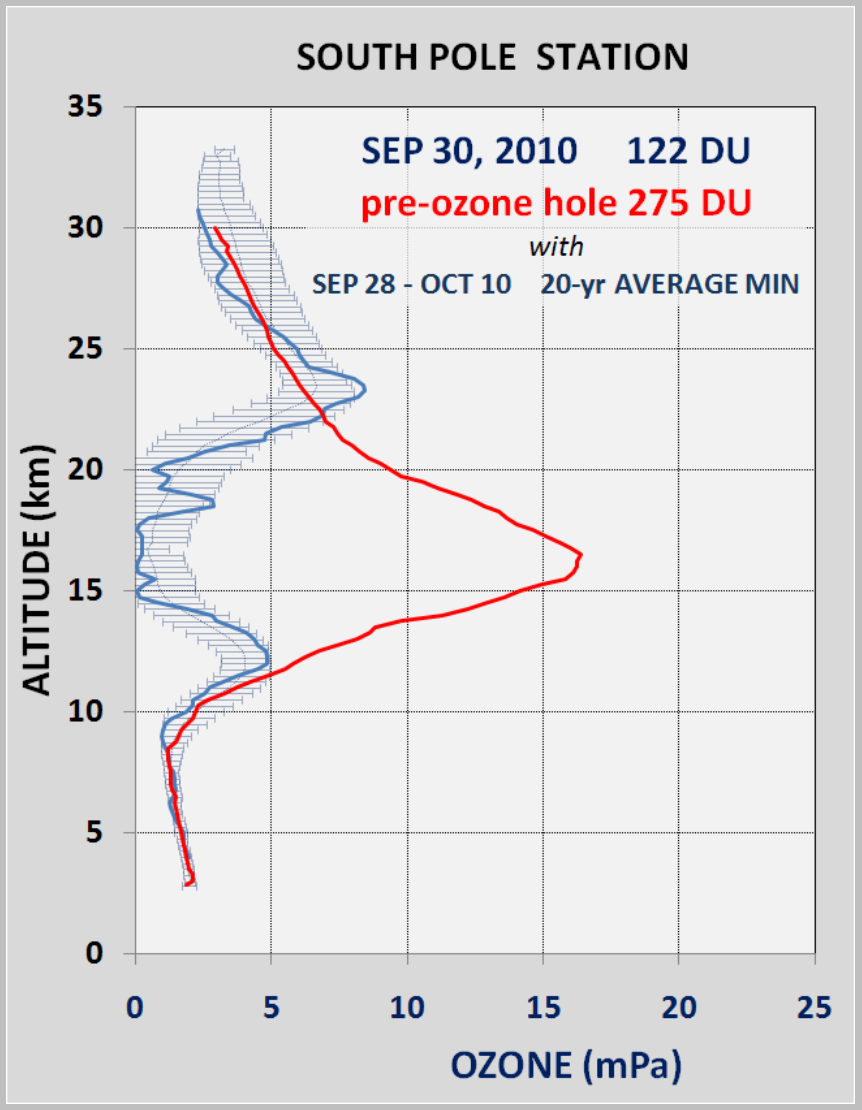
- The degree and vertical distribution of ozone loss is very similar to the 1985 Antarctic ozone hole.

- Increasing degrees of stratospheric ozone loss during some Arctic winters since the 1990s can be related to long term change in climatic conditions (tendency for colder temperatures and increase in V_{PSC}).

SUMMIT OZONESONDES:

- Lowest total column measured on March 28, 2011 (259 DU) with estimated losses of 60-70% at 17-20 km which was similar to losses reported by Match campaign.


SOUTH POLE STATION
SEP 30, 2010 122 DU
pre-ozone hole 275 DU
with
SEP 28 - OCT 10 20-yr AVERAGE MIN
ALTITUDE (km)
0
5
10
15
20
25
30
35
0
5
10
15
20
25
OZONE (mPa)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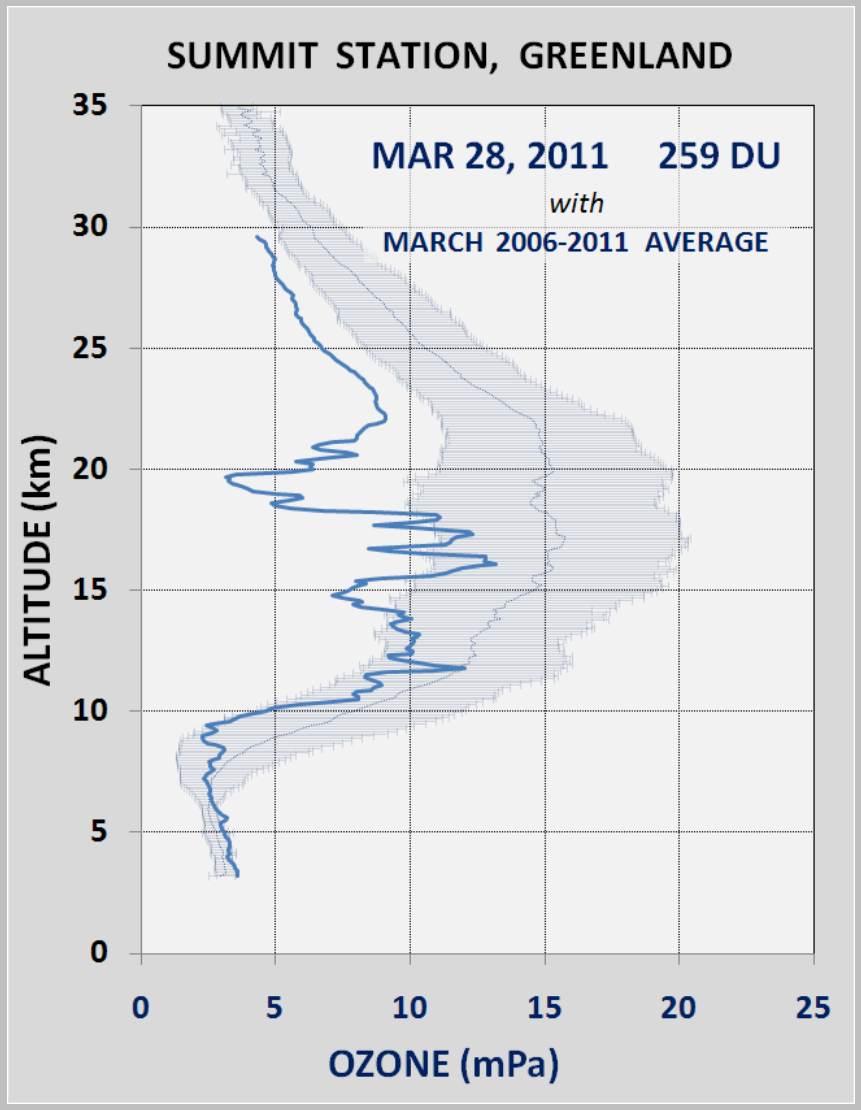
35


SUMMIT STATION, GREENLAND
MAR 28, 2011 259 DU
with
MARCH 2006-2011 AVERAGE
ALTITUDE (km)
OZONE (mPa)
0
5
10
15
20
25
30
35

Conclusions

MATCH CAMPAIGN:

- Chemical loss of ozone in Arctic winter 2011 is larger than in any previous winter since sufficiently frequent ozonesonde measurements started in the Arctic in 1991. Based on long term evolution of V_{PSC} and concentrations of ODS we can state that it is very likely the largest anthropogenic loss ever in the Arctic.

- Ozone loss by April 1: over 70% loss over ~3-4km vertical region occurred. Local losses exceed 80%.

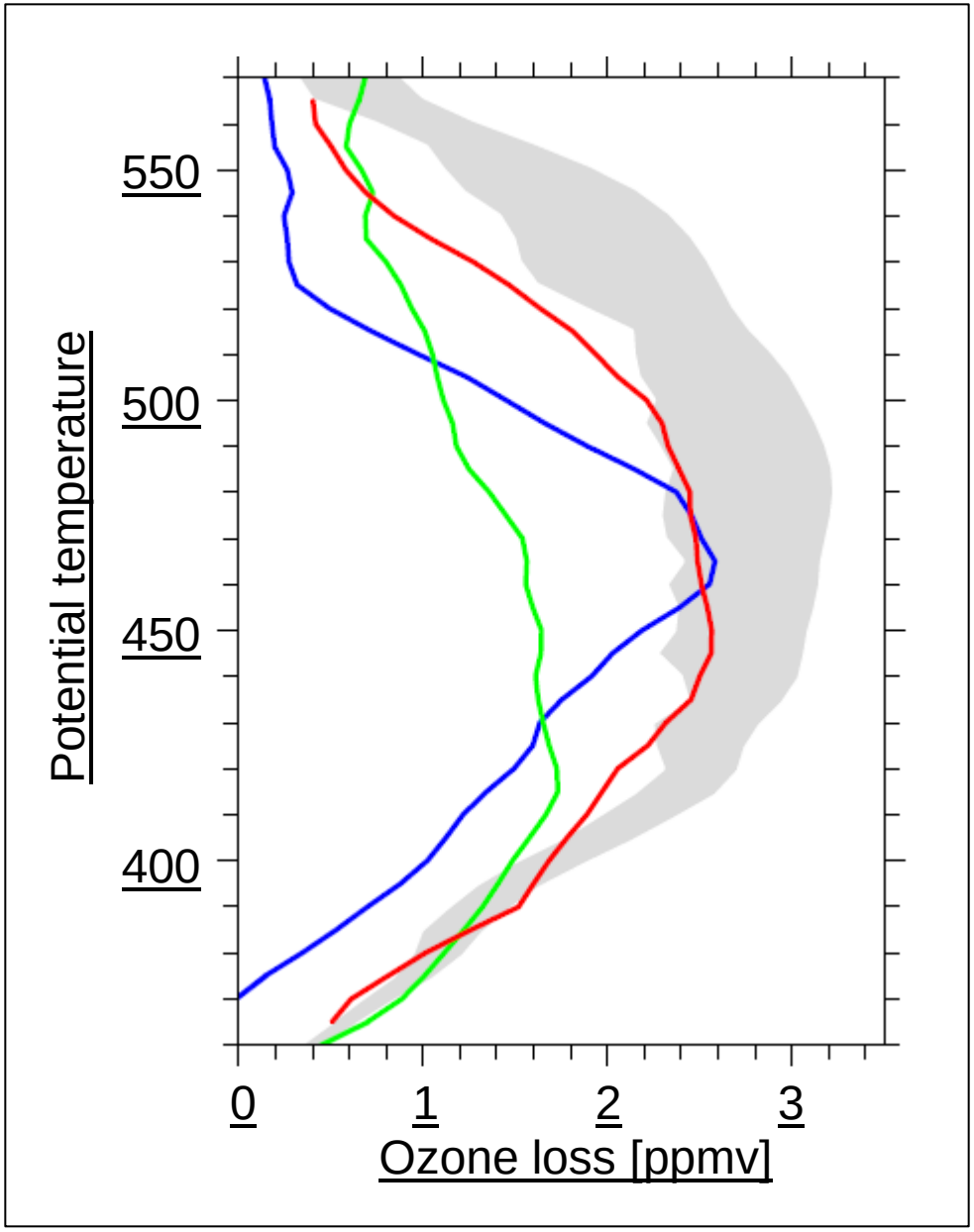
- The degree and vertical distribution of ozone loss is very similar to the 1985 Antarctic ozone hole.

- The previously noted tendency that the cold Arctic winters became colder over the past four decades (Rex et al., 2004; 2006) has continued.

- Increasing degrees of ozone loss during some winters since the 1990ies were the result of this long term change in climatic conditions in the Arctic winter stratosphere.

Rex et al.. Arctic ozone loss and climate change, GRL, 2004

Rex et al., Arctic winter 2005: Implications for stratospheric ozone loss and climate change, GRL, 2006



Ozone loss profiles
Arctic - Antarctic

Antarctic:

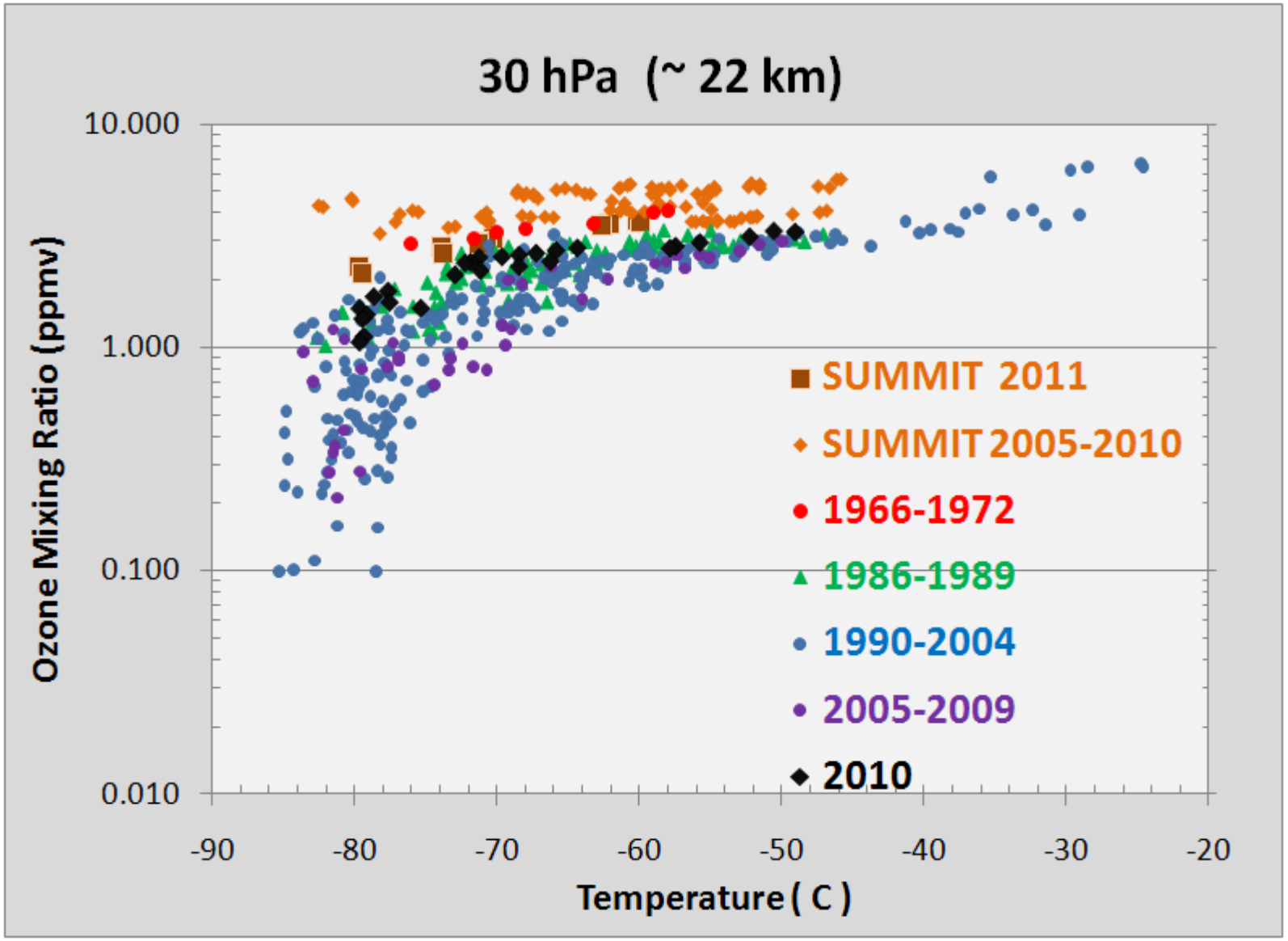
Ozone hole range
(indicated by 1985 & 2003)

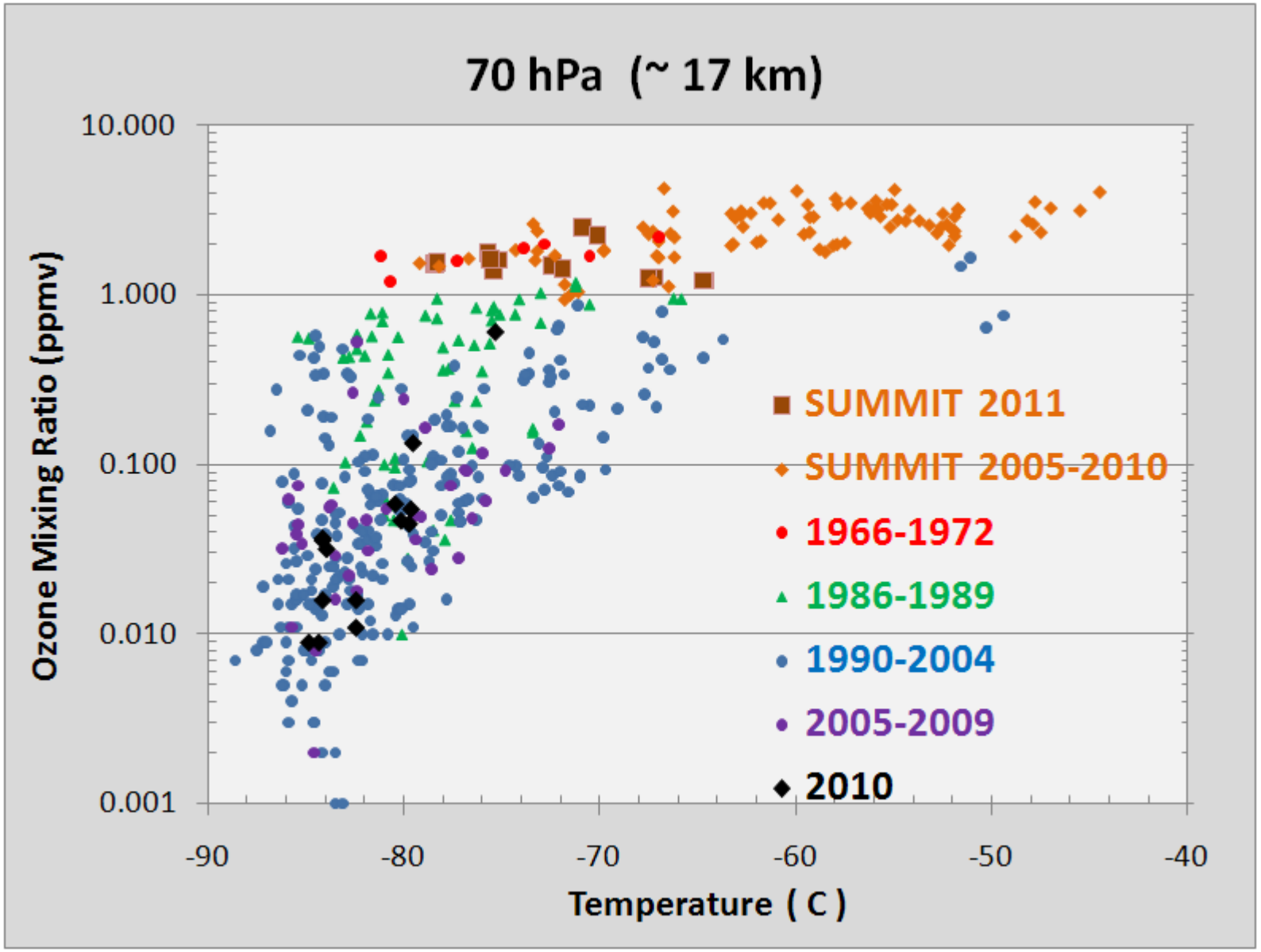
Arctic:

2000

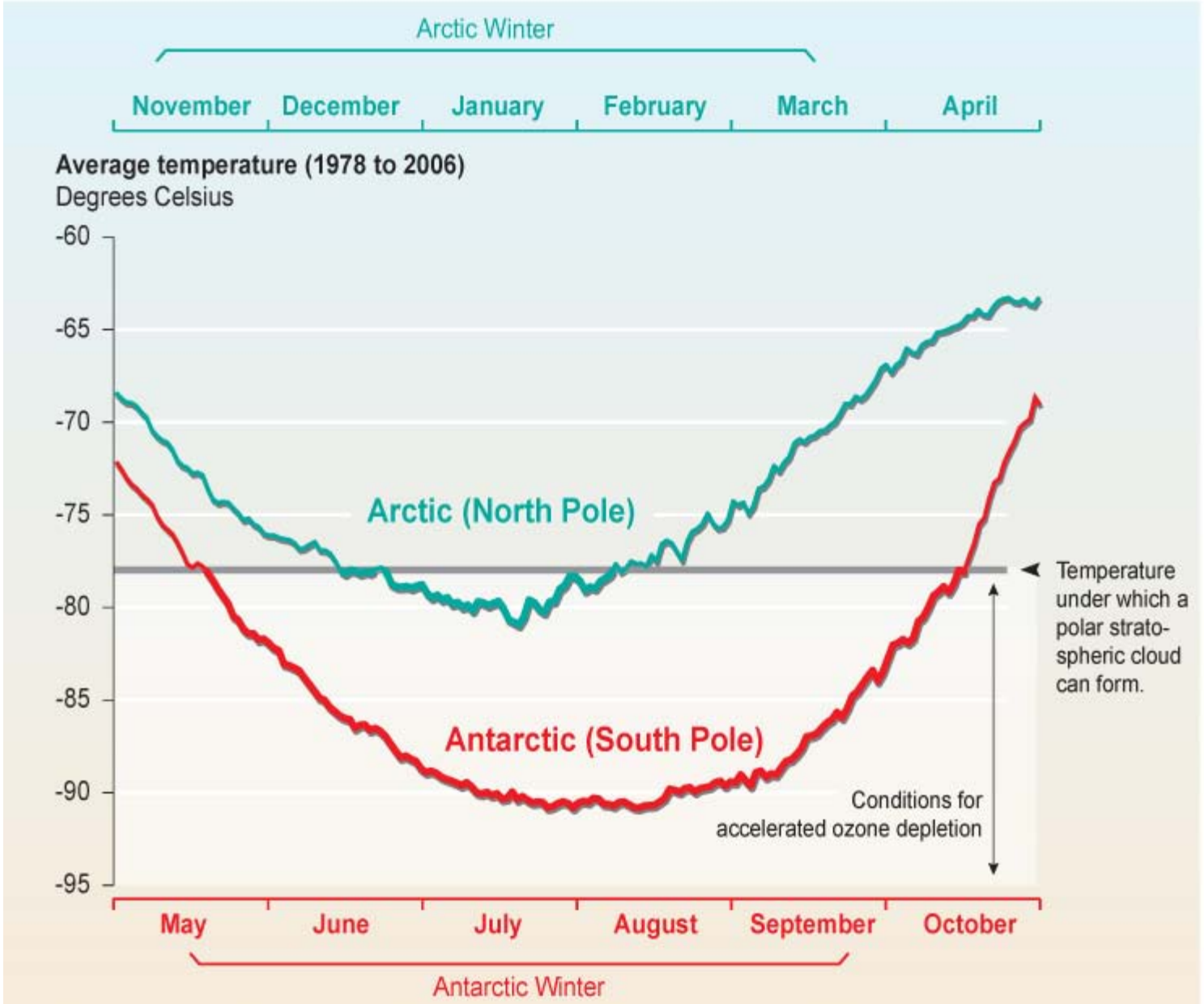
2005

2011 (as of March 31)


30 hPa (~ 22 km)
10.000
1.000
0.100
0.010
Ozone Mixing Ratio (ppmv)
-90
-80
-70
-60
-50
-40
-30
-20
Temperature (C)
SUMMIT 2011
SUMMIT 2005-2010
1966-1972
1986-1989
1990-2004
2005-2009
2010


70 hPa (~ 17 km)
10.000
1.000
0.100
0.010
0.001
Ozone Mixing Ratio (ppmv)
-90
-80
-70
-60
-50
-40
Temperature (C)
SUMMIT 2011
SUMMIT 2005-2010
1966-1972
1986-1989
1990-2004
2005-2009
2010

THE COLDER ANTARCTIC WINTER DRIVES FORMATION OF THE HOLE IN THE SOUTH



Source: *Twenty Questions and Answers about the Ozone Layer: 2006 Update*, Lead Author: D.W. Fahey, Panel Review Meeting for the 2006 ozone assessment.

Summery:

- By measuring the ozone loss over the Arctic with the Match approach discrepancies in our current understand of ozone depletion became evident.
- In order to put modelling efforts on a stronger base a Match campaign was successfully performed in the Antarctic .
- The building of the “ozone hole” was quantified with the Match approach. That happened during the time of highest chlorine loading in the stratosphere.
- Due to the more stable conditions in the Antarctic vortex new insights will be achieved by comparing Arctic and Antarctic data.
- An improvement in the model results has already taken place by implementing new kinetics – but this is ongoing work!

Summary

Arctic

- O_3 loss rates during December
- O_3 loss rates remain stable within their 1σ uncertainty although the number of match events were halved in the tests
- O_3 loss of 62 DU for the 400 – 500 K potential temperature

Antarctic

- O_3 loss started in June
- O_3 loss rates in the same range as we have found in the Arctic
- O_3 loss of 150 DU for the level for the 400 – 550 K potential temperature

Satellite Match Approach

- Process full vertical range
  => Profiles of ozone loss rates and biases
- Include long lived tracers (ILAS 2 – ILAS 2 matches) to test the Match approach
- Include measurements in the Arctic
- Include more satellites and other species