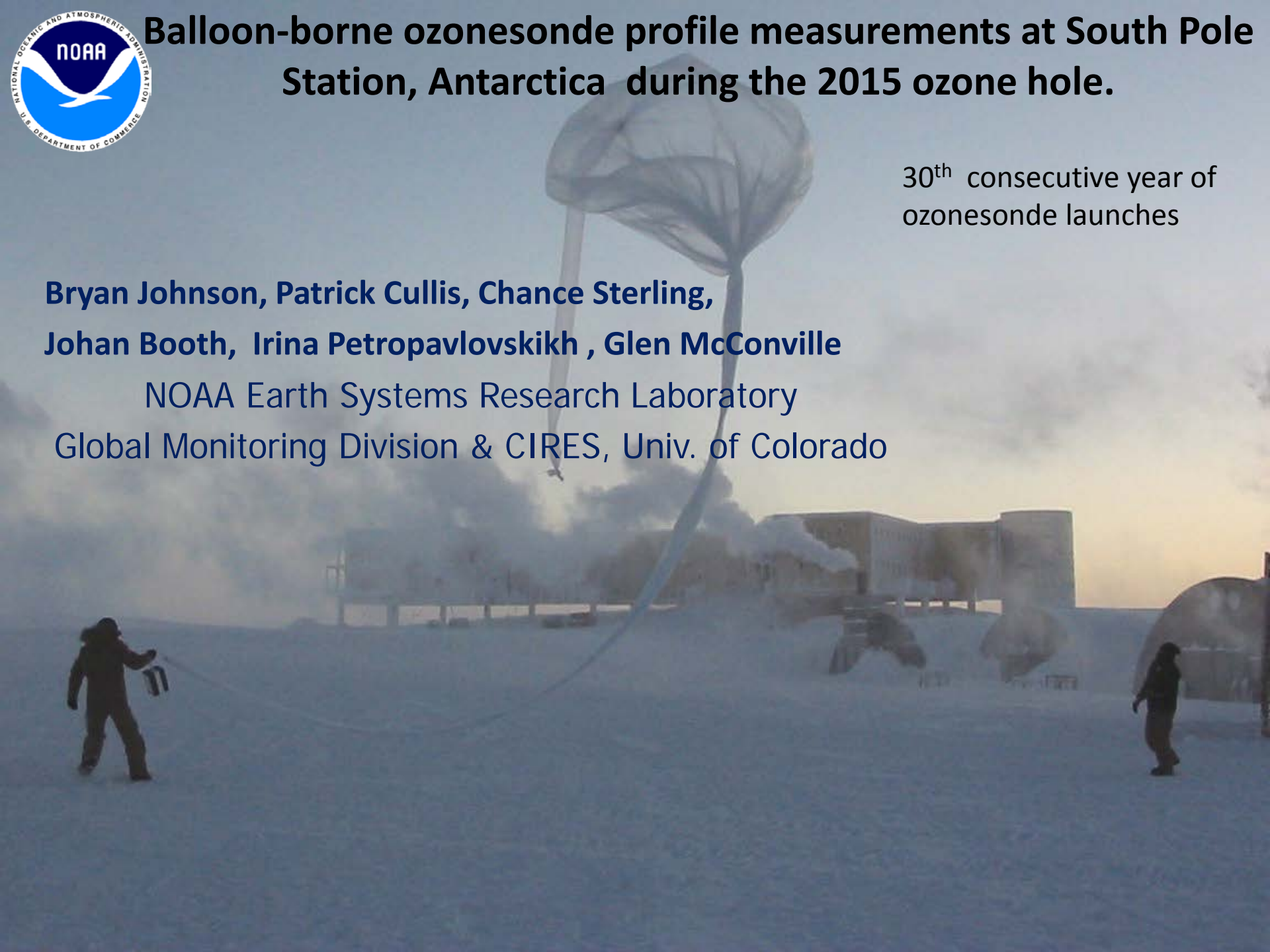


# Balloon-borne ozonesonde profile measurements at South Pole Station, Antarctica during the 2015 ozone hole.

30<sup>th</sup> consecutive year of ozonesonde launches

**Bryan Johnson, Patrick Cullis, Chance Sterling,  
Johan Booth, Irina Petropavlovskikh , Glen McConville**

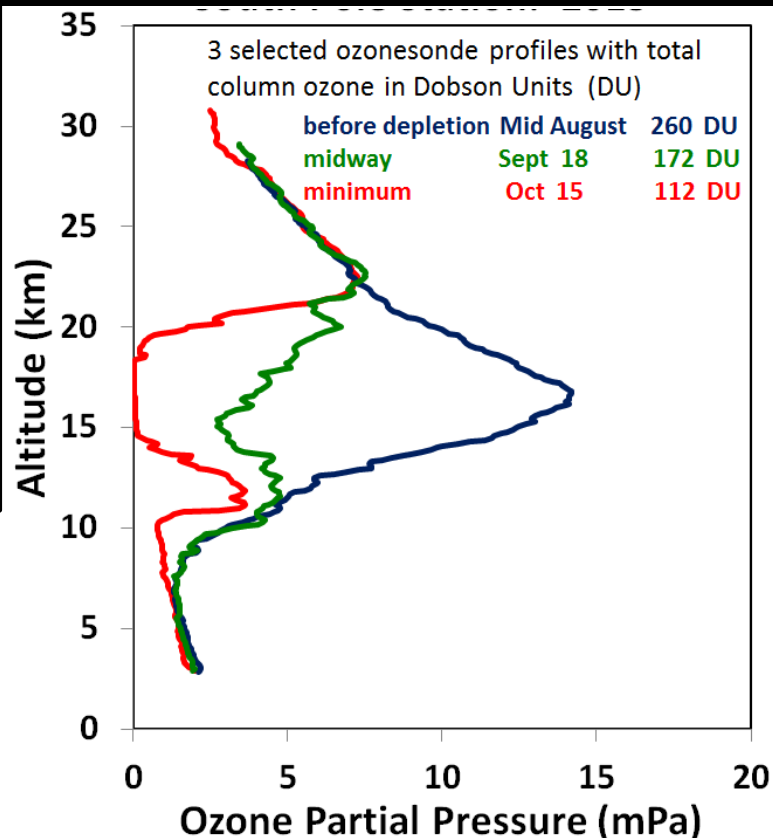
NOAA Earth Systems Research Laboratory  
Global Monitoring Division & CIRES, Univ. of Colorado



# South Pole ozonesondes 2015: 3 profiles representing depletion.



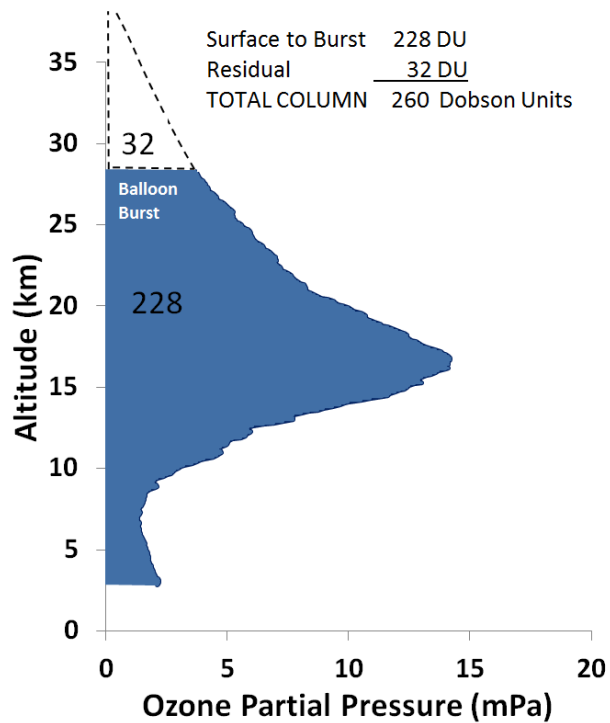
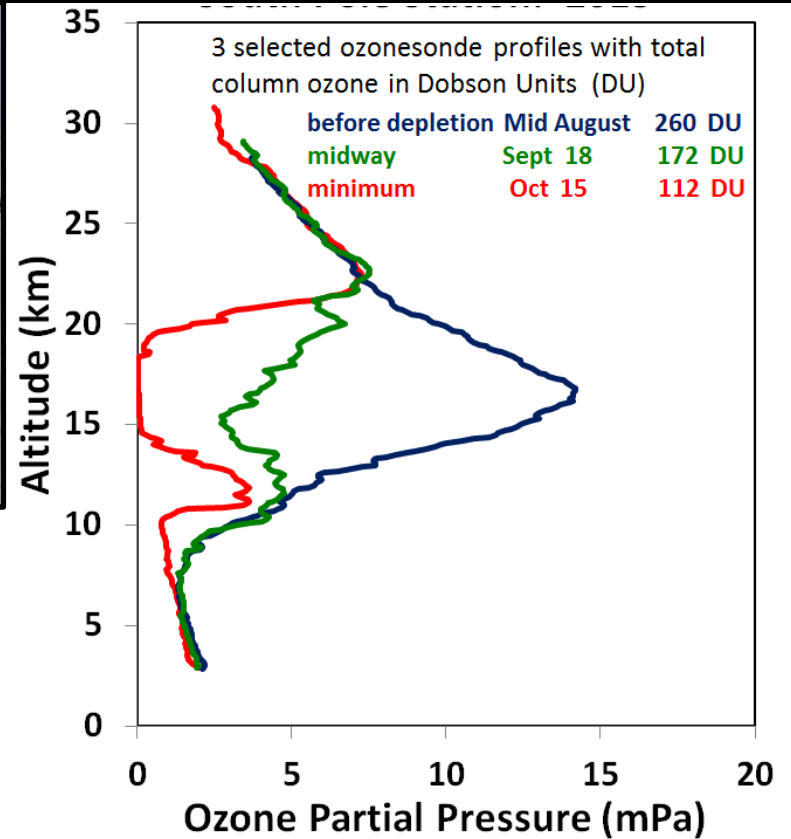
45-65 balloon launches per year since 1986



## Tracking the yearly ozone hole:

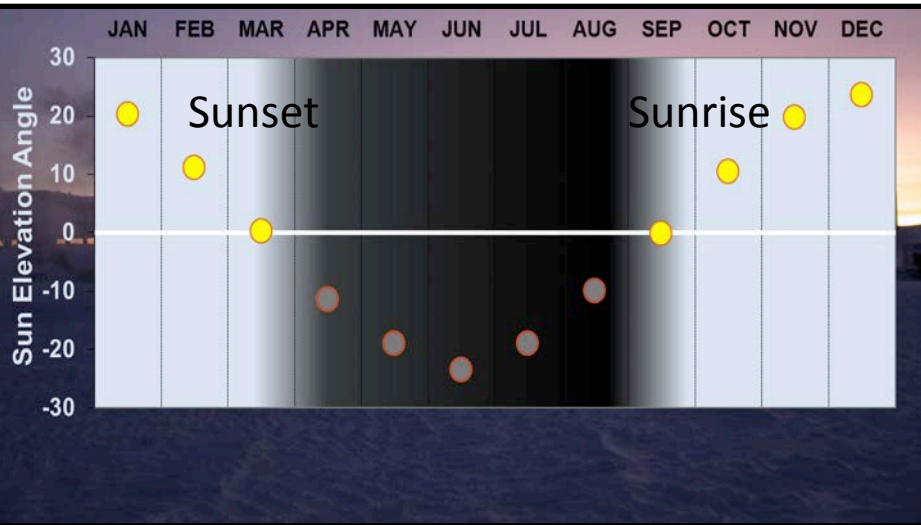
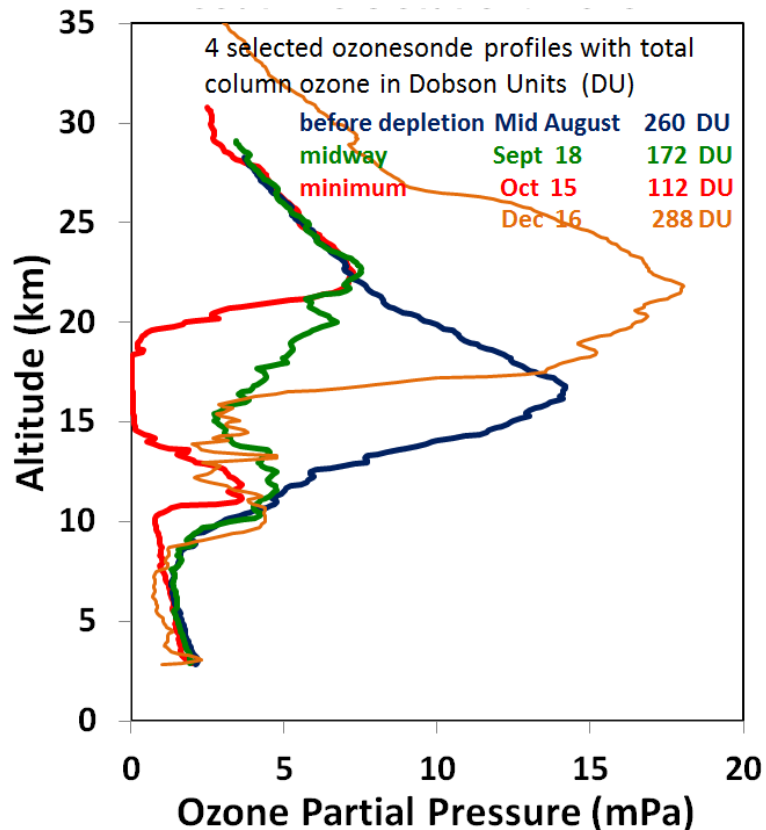
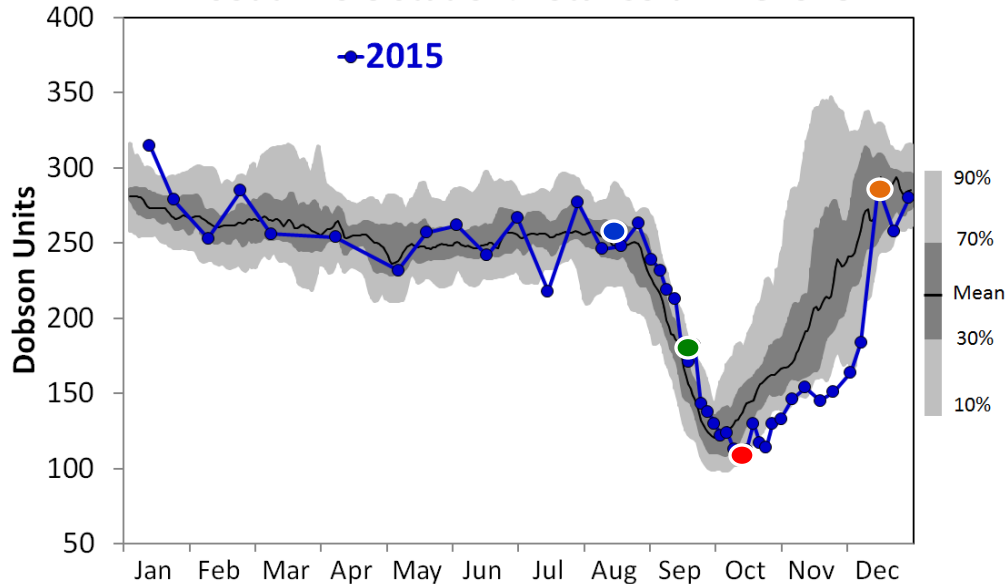
1. Minimum Total Column - **Oct 15 112 Dobson Units.**
2. Compare with Dobson Spectrophotometer & Satellite Total column.
3. How fast ozone drops within 14-21 km Layer during September (average).
4. Unusual events – 2015 was longest period before ozone hole vortex break up.

# Ozonesonde Total Column (Dobson Units)



# South Pole Total Column in 2015 – and ozone recovery profile

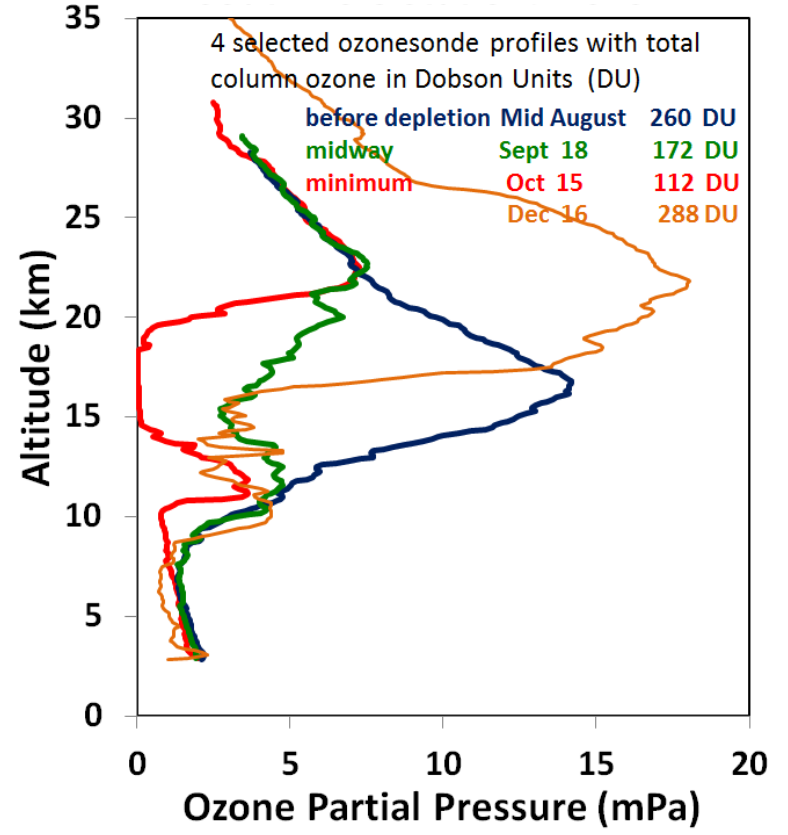
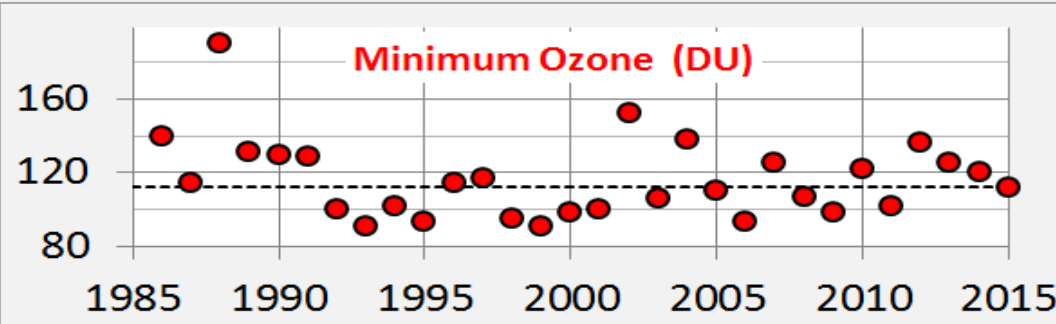
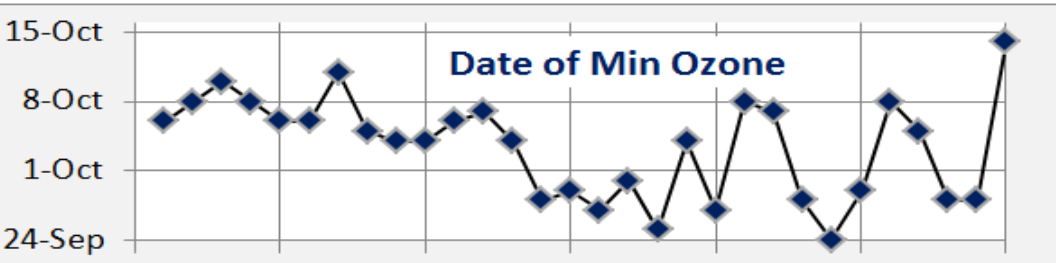
South Pole Station: Total Column Ozone



Two big advantages of ozonesondes

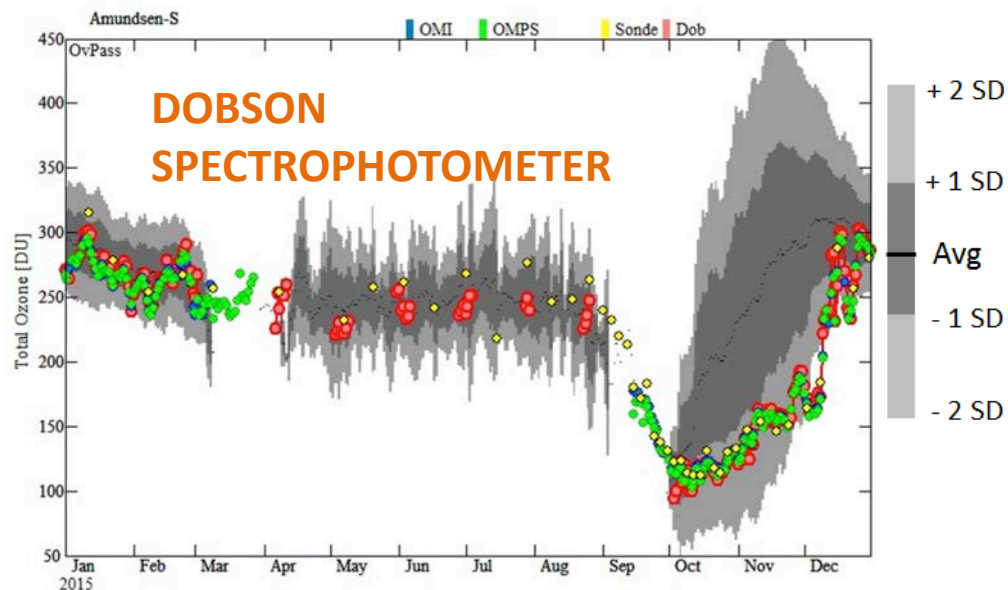
1. Measurements when dark.
2. High resolution profiles allow analyzing altitude intervals where most depletion occurs: 14-21 km layer at South Pole.

# Minimum Total Column: 15<sup>th</sup> lowest minimum in 30 year record.



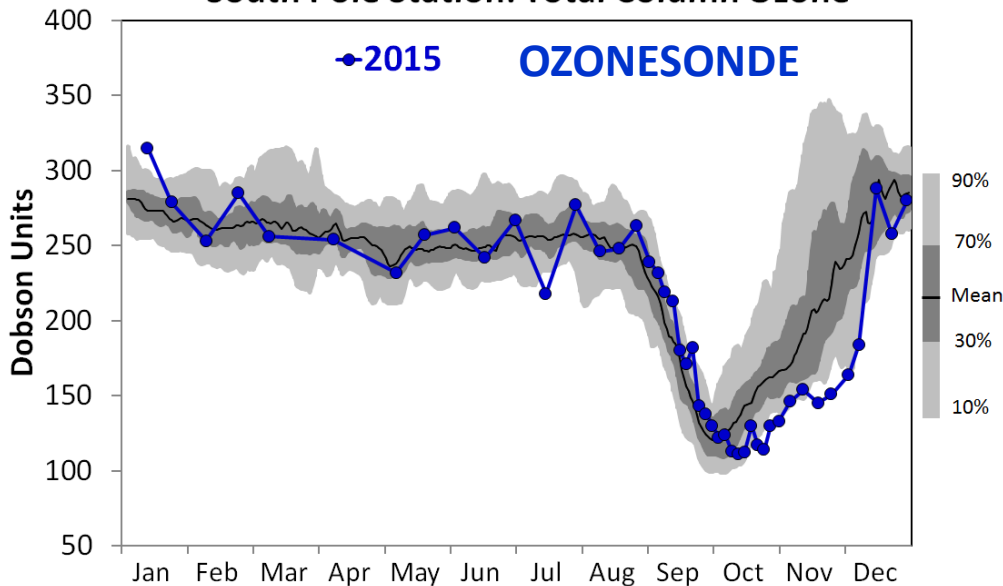
# COMPARE: with Dobson Spectrophotometer total column ozone.

Plot & data from Koji Miyagawa (visiting scientist), Bob Evans, Glen McConville



Dobson Spectrophotometer at South Pole.

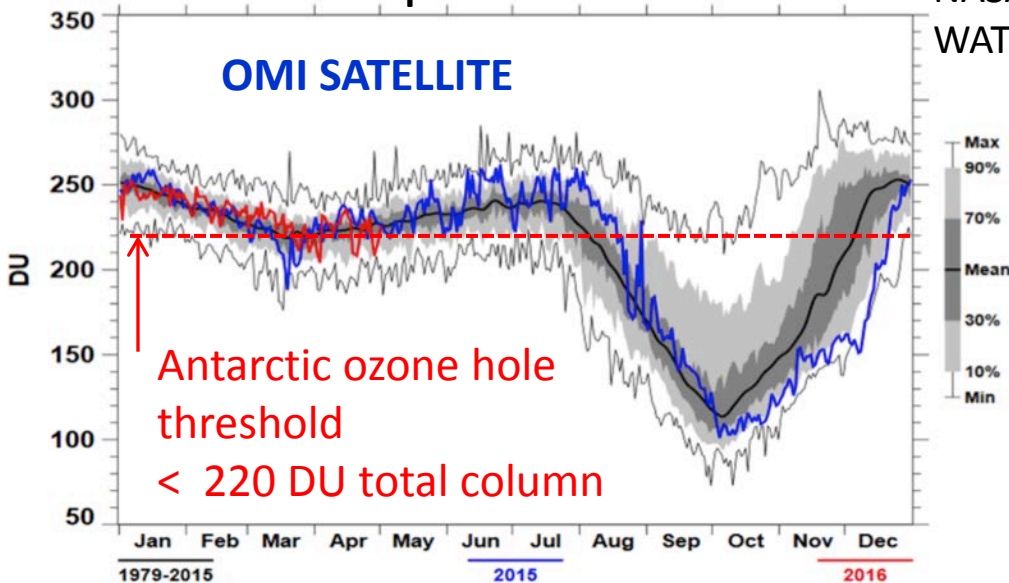
South Pole Station: Total Column Ozone



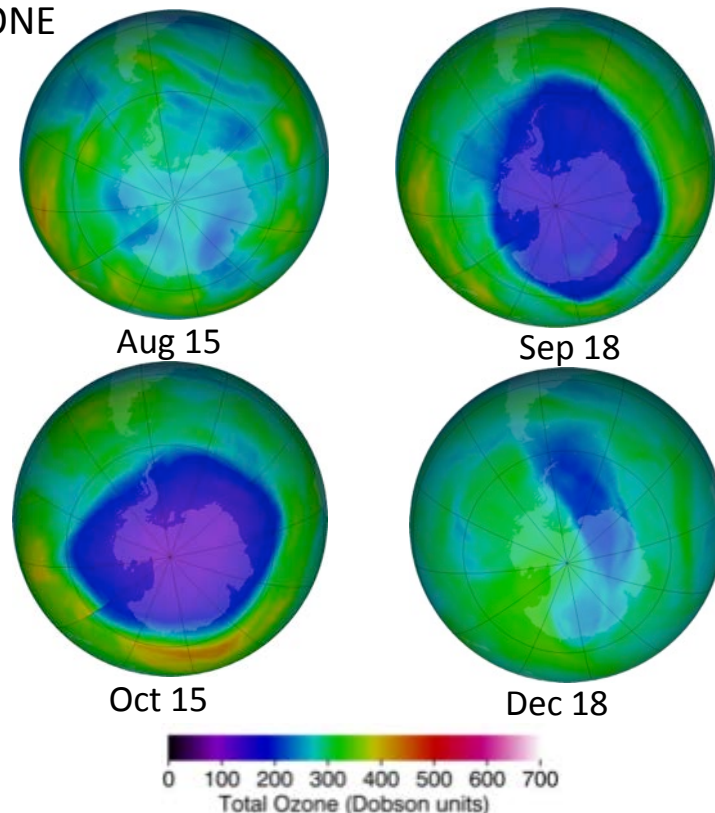
$$\begin{aligned} &\% \text{ Difference in Total Column} \\ & \text{(Dobson - Sonde)/Dobson} \\ & = -2 \pm 5 \% \end{aligned}$$

# COMPARE: OMI + MERRA satellite total column ozone.

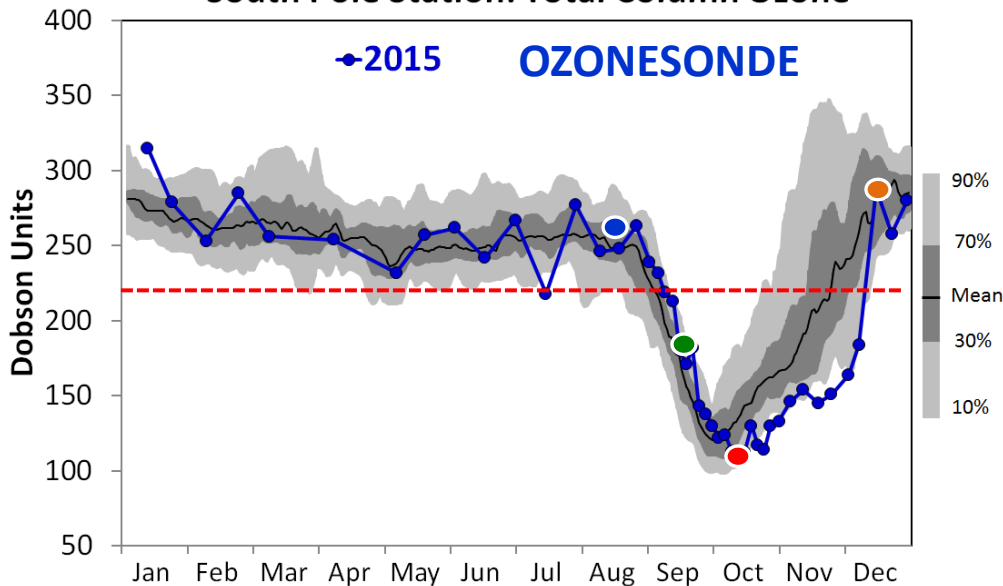
## S. Hemisphere min ozone:



## NASA OZONE WATCH

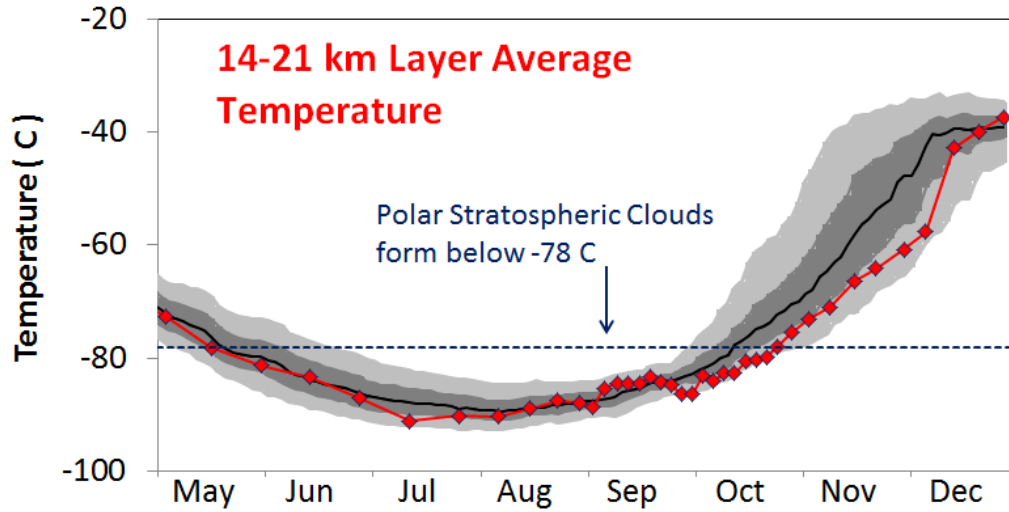
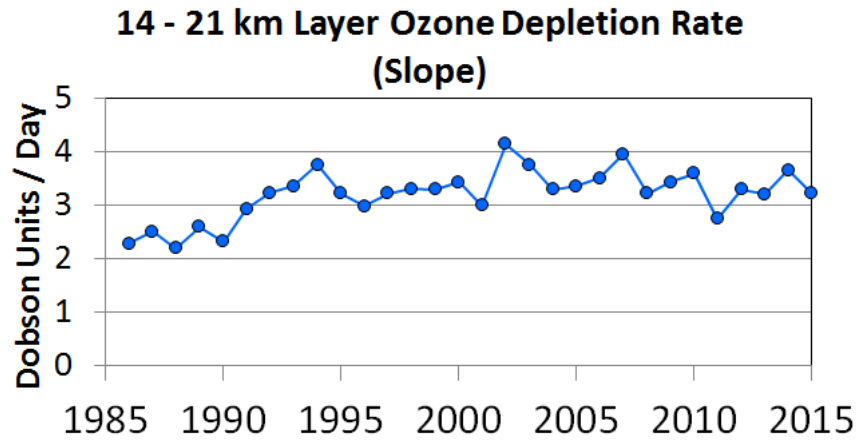
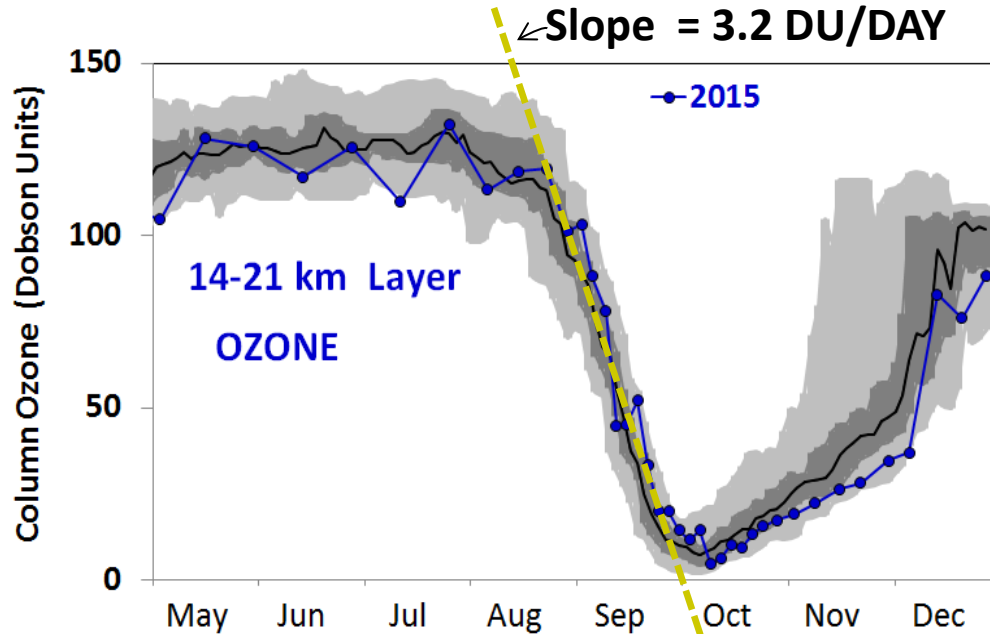


## South Pole Station: Total Column Ozone



$$\% \text{ Difference in Total Column} \\ (\text{OMI} - \text{Sonde}) / \text{OMI} \\ = -1 \pm 5 \%$$

# 14 – 21 kilometers: September depletion rate

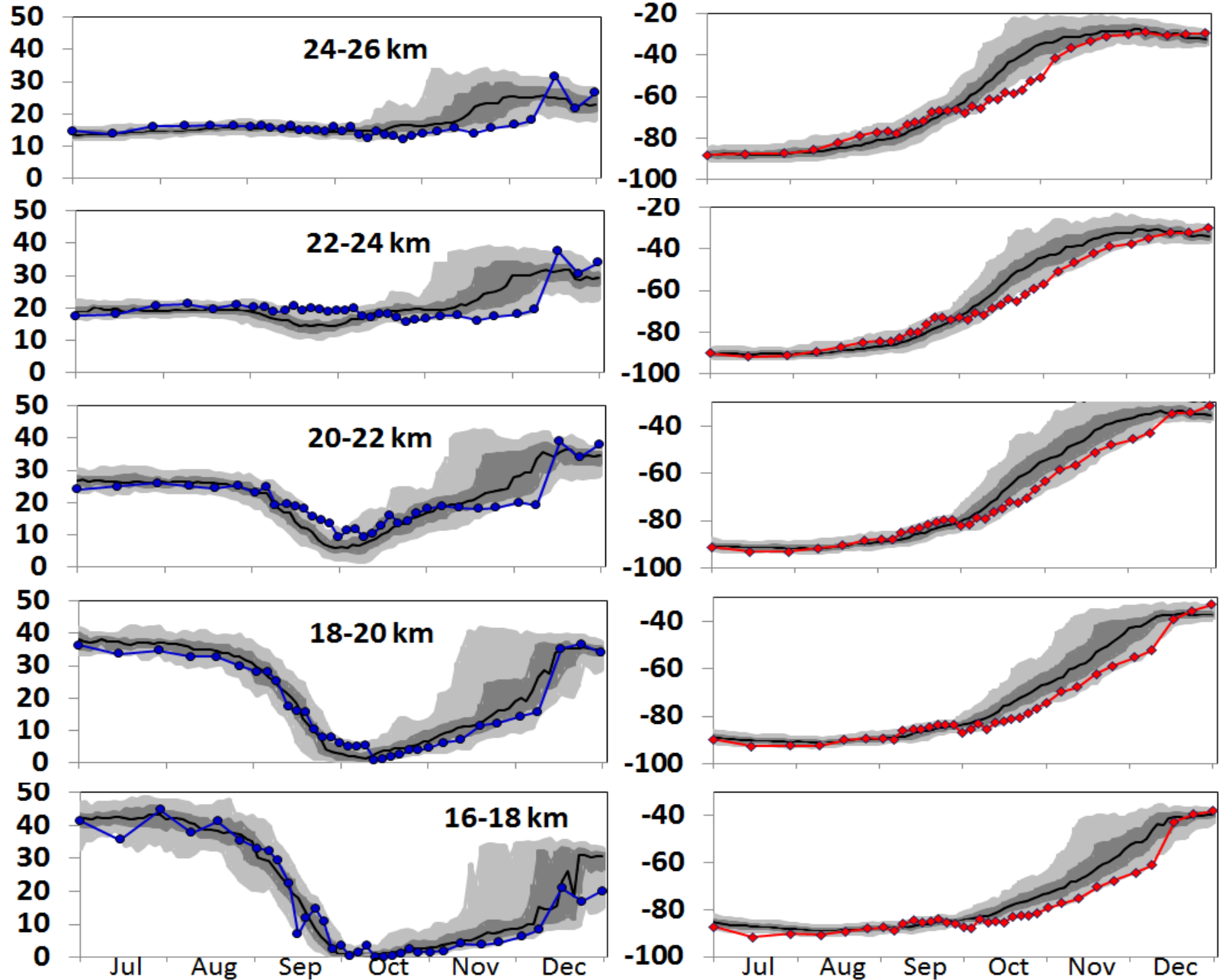


*July - October*

Altitude	Ambient Pressure
14 km	~ 108 hPa
21 km	~ 30 hPa

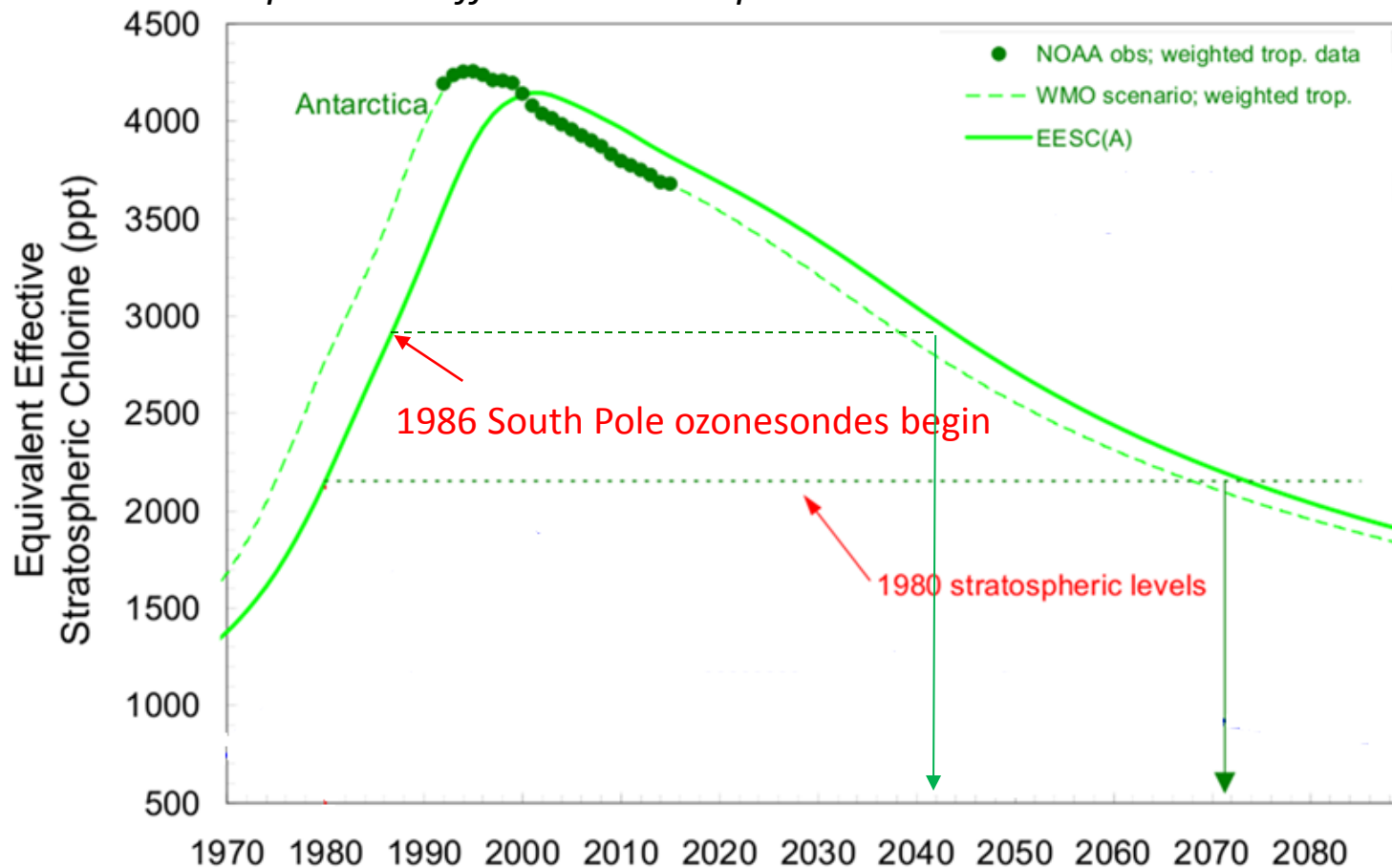


# Region above ozone depletion range (>22km) shows no change until Dec 16



# When to Expect first signs of recovery in the Antarctic ozone hole.

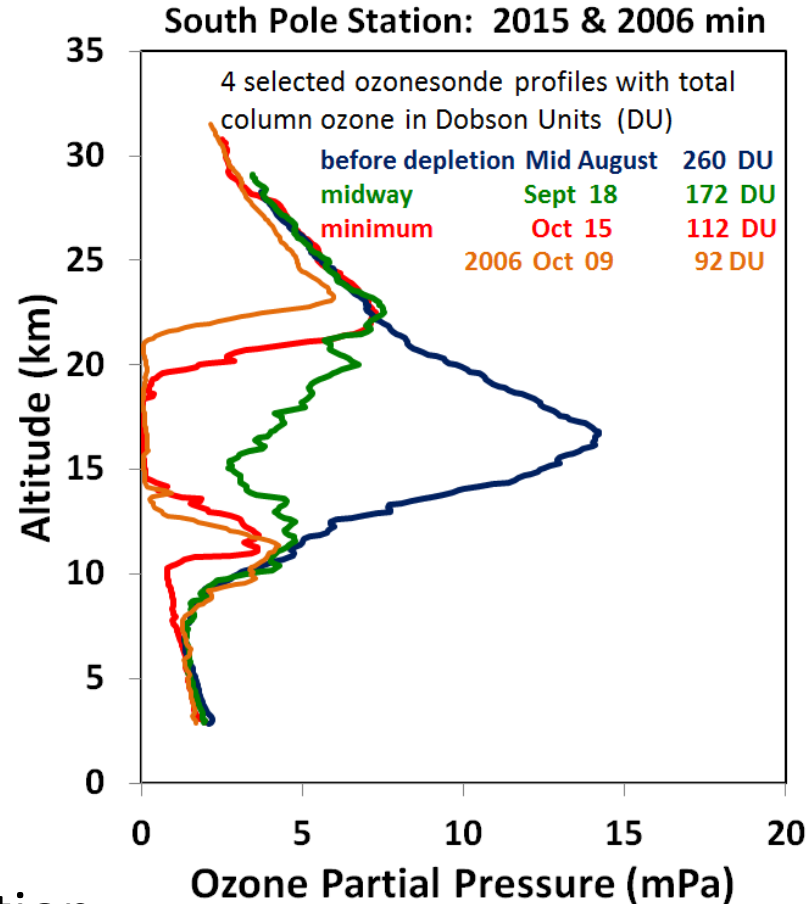
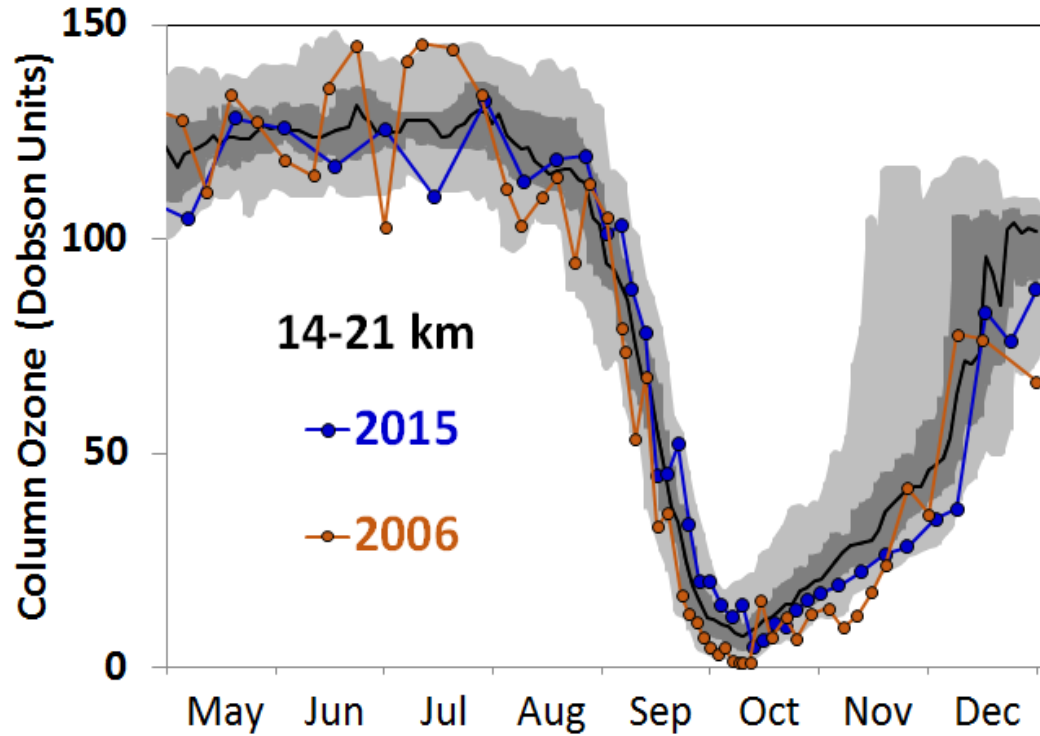
*Depends on relationship between ozone loss rate and Equivalent Effective Stratospheric Chlorine*



**The NOAA Ozone Depleting Gas Index: Guiding Recovery of the Ozone Layer** <http://www.esrl.noaa.gov/gmd/odgi/>

NOAA/ESRL/GMD Stephen Montzka, Geoff Dutton & James Butler

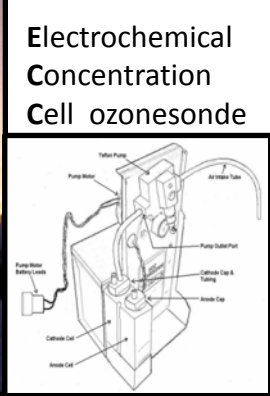
# One sign of improvement when comparing to similar vortex in 2006.



2006 : Record Antarctic Ozone Depletion

Year. South Pole minimum

Total Column = 92 DU    14-21KM = 1.2 DU



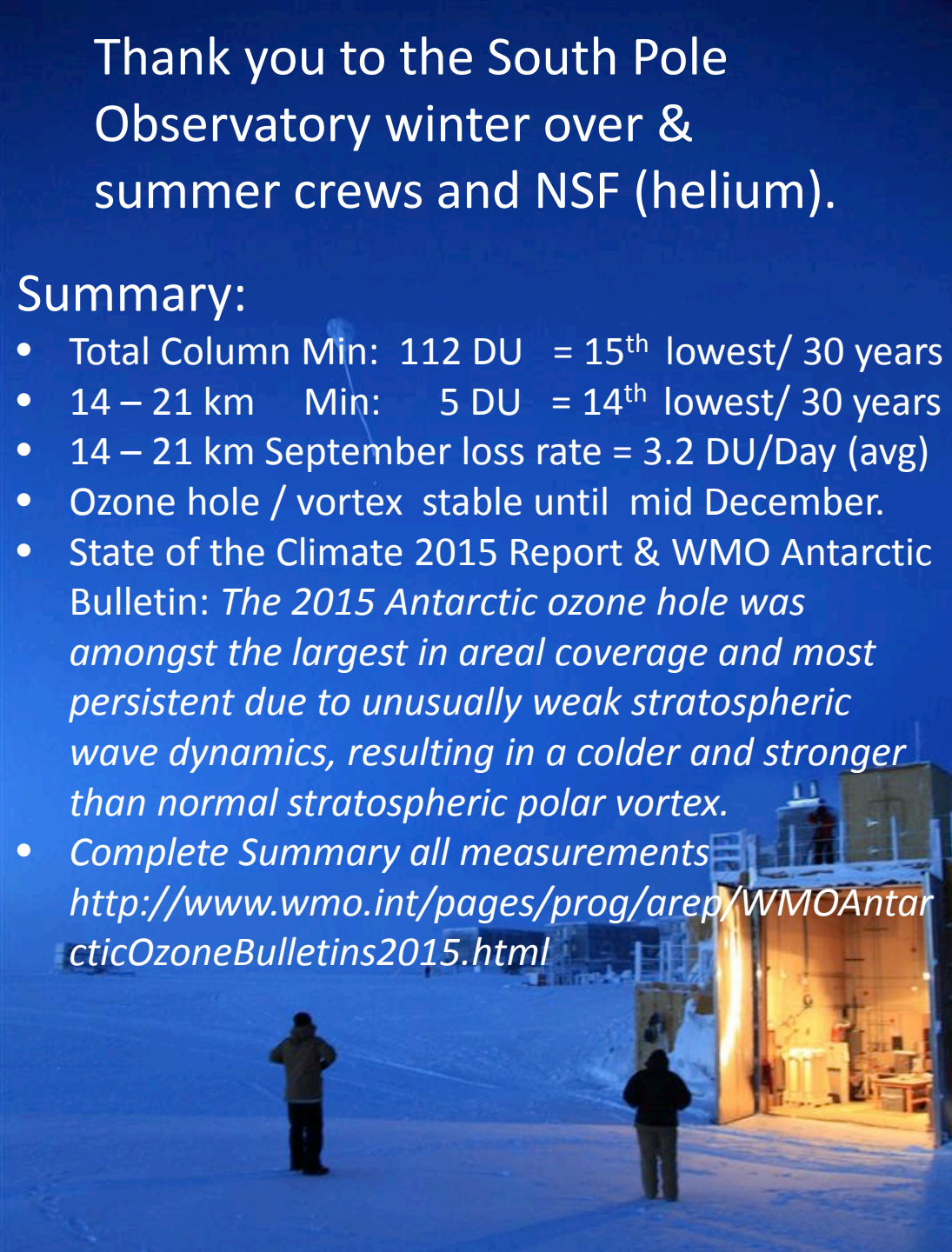
# South Pole Station



# Thank you to the South Pole Observatory winter over & summer crews and NSF (helium).

## Summary:

- Total Column Min: 112 DU = 15<sup>th</sup> lowest/ 30 years
- 14 – 21 km Min: 5 DU = 14<sup>th</sup> lowest/ 30 years
- 14 – 21 km September loss rate = 3.2 DU/Day (avg)
- Ozone hole / vortex stable until mid December.
- State of the Climate 2015 Report & WMO Antarctic Bulletin: *The 2015 Antarctic ozone hole was amongst the largest in areal coverage and most persistent due to unusually weak stratospheric wave dynamics, resulting in a colder and stronger than normal stratospheric polar vortex.*
- Complete Summary all measurements <http://www.wmo.int/pages/prog/arep/WMOAntarcticOzoneBulletins2015.html>



## South Pole Observatory Personnel: Winter Over and Summer Crew

Year	
2014-15	Jesse Milton, Station Chief (NOAA Corps) Johan Booth, Electronics Technician Andy Clarke, Technician (Nov-Jan)
2013-14	Joseph Phillips, Station Chief (NOAA Corps) Johan Booth, Electronics Technician Lance Roth, Technician (Nov-Jan)
2012-13	Kelli-Ann Bliss, Station Chief (NOAA Corps) Ross Burgener, Electronics Technician
2011-12	*Heather Moe, Station Chief (NOAA Corps) Johan Booth, Electronics Technician Don Neff, Technician (Nov-Jan)
2010-11	Christine Schultz, Station Chief (NOAA Corps) Johan Booth, Electronics Technician Andy Clarke, Technician (Nov-Jan)
2009-10	Nick Morgan, Station Chief (NOAA Corps) Johan Booth, Electronics Technician
2008-09	Marc Weekley, Station Chief (NOAA Corps) Patrick Cullis, Electronics Technician
2007-08	Amy Cox, Station Chief (NOAA Corps) Johan Booth, Electronics Technician Andy Clarke, Technician (Dec-Jan)
2006-07	Johan Booth, Station Chief Emrys Hall, Electronics Technician
2005-06	Stephanie Koes, Station Chief (NOAA Corps) Johan Booth, Electronics Technician
2004-05	Dan Simon, Station Chief (NOAA Corps) Glen Kinoshita, Electronics Technician
2003-04	Jason Seifert, Station Chief (NOAA Corps) Glen Kinoshita, Electronics Technician
2002-03	Loreen Lock, Station Chief Brian Vasel, Electronics Technician
2001-02	Loreen Lock, Station Chief Brian Vasel, Electronics Technician
2000-01	Paulene Roberts, Station Chief (NOAA Corps) Eric Sandberg, Electronics Engineer
1999-00	*Don Neff, Station Chief Andy Clarke, Chemist
1998-99	Joel Michaelski, Station Chief (NOAA Corps) Andy Clarke, Chemist
1997-98	*Nathan Hill, Station Chief (NOAA Corps) Eric Sandberg, Electronics Engineer
1996-97	*Mark Boland, Station Chief (NOAA Corps) Glen McConville, Electronics Technician
1995-96	*Ricardo Ramos, Station Chief (NOAA Corps) Jeff Otten, Electronic Technician
1994-95	Katherine McNitt, Station Chief (NOAA Corps) Jeff Otten, Engineering Technician
1993-94	Thomas Jacobs, Station Chief (NOAA Corps) Don Neff, Physicist
1992-93	Katherine McNitt, Station Chief (NOAA Corps) Carl Groeneveld (NOAA Corps) Raymond Dunn, Electronics Engineer
1991-92	Dale Tysor, Station Chief (NOAA Corps) David Gaines, Electronic Technician
1990-91	*John Lowell, Station Chief (NOAA Corps) Mike O'Neill, Physicist
1989-90	Carl Groeneveld, Station Chief (NOAA Corps) Fred Schrom, Electronics Technician, Computer
1988-89	Elizabeth Crozer, Station Chief (NOAA Corps) Mark Winey, Electronic Engineer
1987-88	*Rob Poston, Station Chief (NOAA Corps) Ted Mullen, Electronics Technician
1986-87	Scott Kuester, Station Chief (NOAA Corps) Patrick Reitelbach, Electronics Technician
1985-86	*Cliff Wilson, Station Chief (NOAA Corps) Brad Halter, Meteorologist

