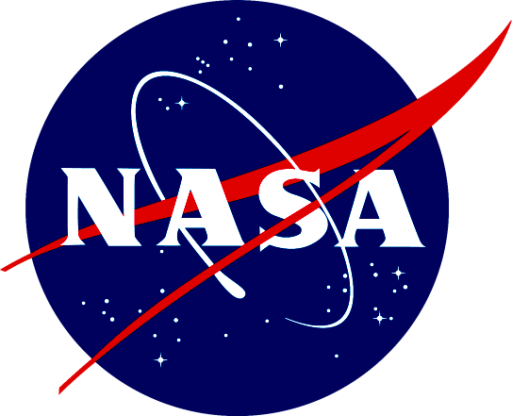
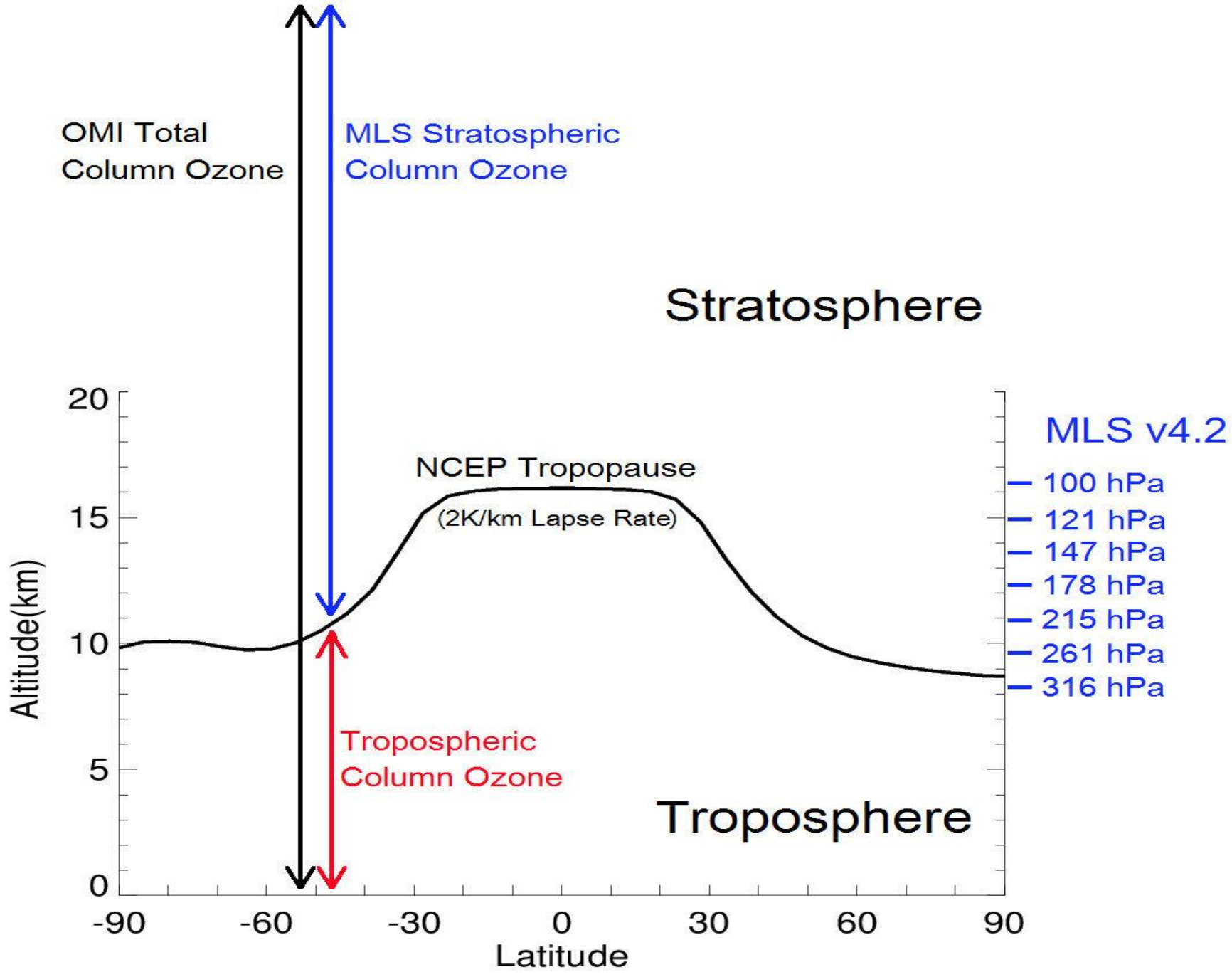


SCIENCE SYSTEMS AND APPLICATIONS, INC.

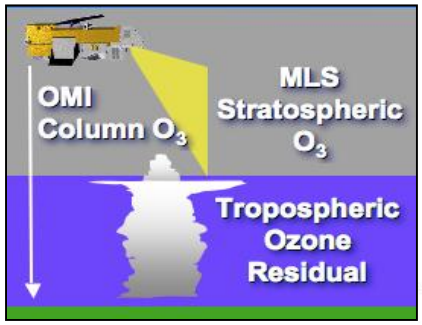
Measuring Tropospheric Ozone with MLS and OMI

Gordon Labow
Jerry Ziemke
P.K. Bhartia

October, 13, 2016

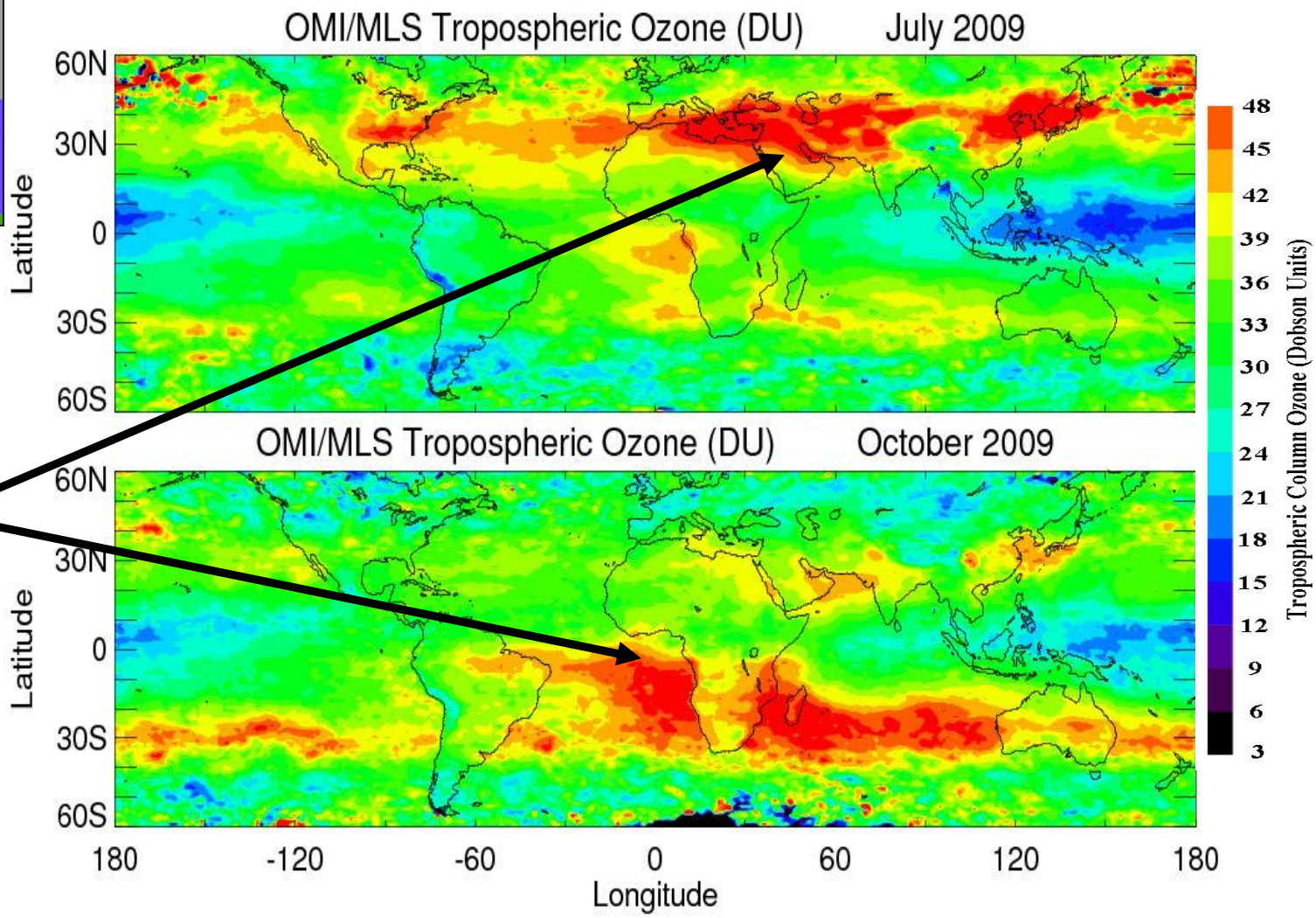

OMI Total
Column Ozone
MLS Stratospheric
Column Ozone
Stratosphere
NCEP Tropopause
(2K/km Lapse Rate)
MLS v4.2
100 hPa
121 hPa
147 hPa
178 hPa
215 hPa
261 hPa
316 hPa
Tropospheric
Column Ozone
Troposphere
Altitude(km)
20
15
10
5
0
-90
-60
-30
0
30
60
90
Latitude

Tropospheric Ozone from OMI/MLS

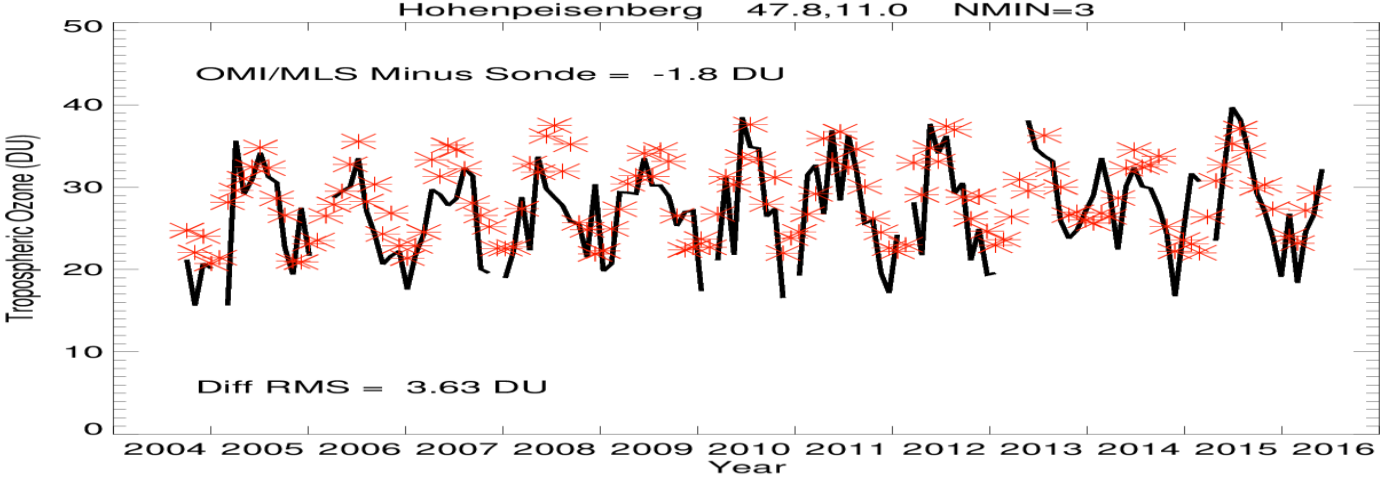


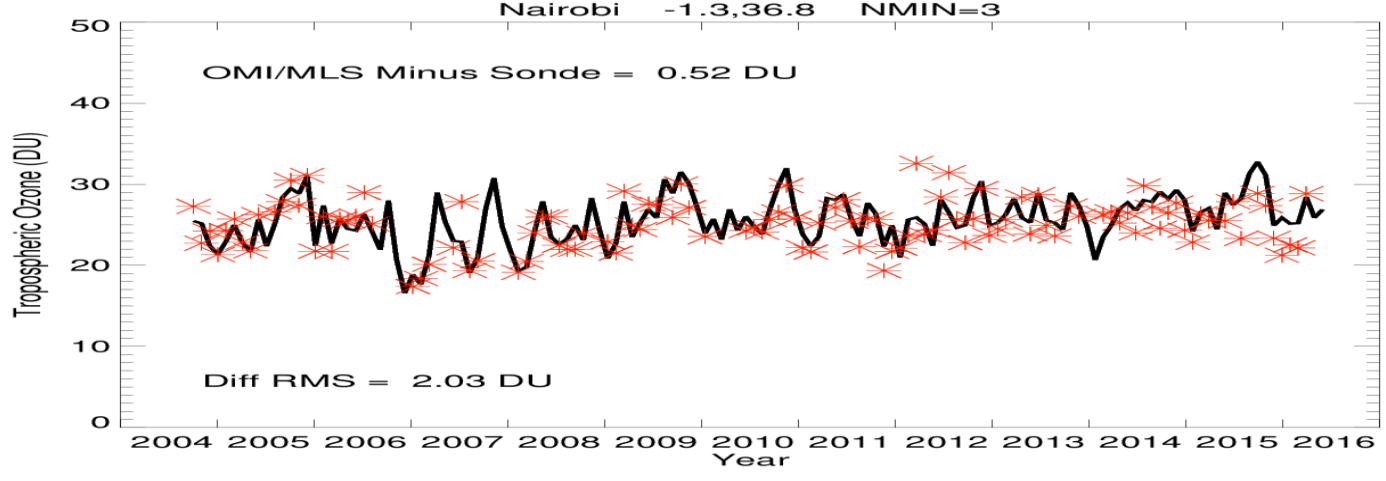
Where does all this tropospheric ozone in mid-latitudes come from?

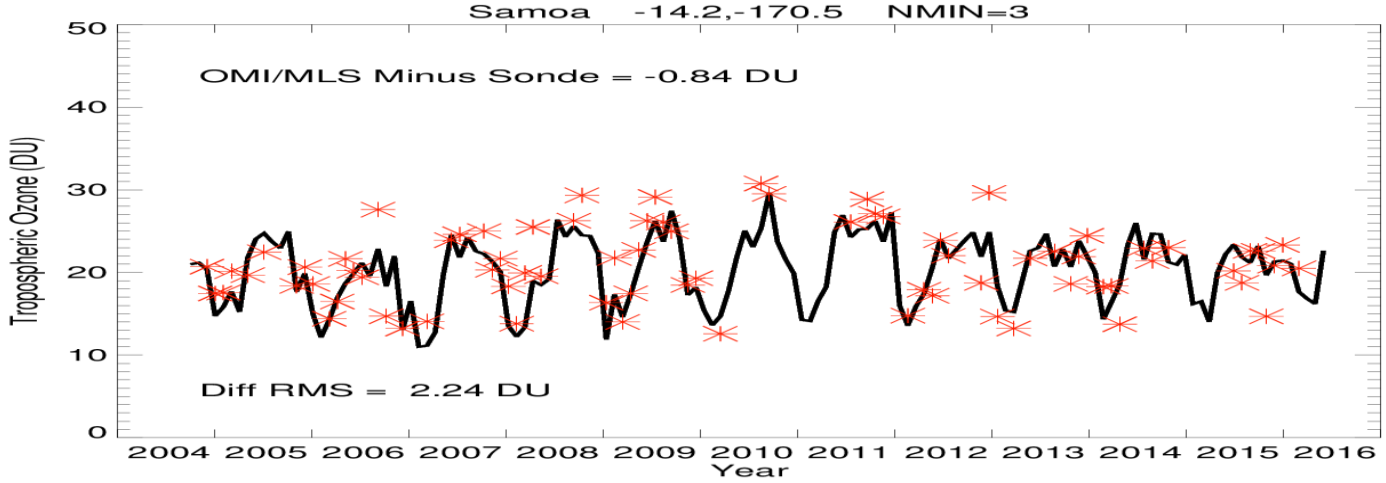
Answer:
STE, lightning, pollution, and biomass burning



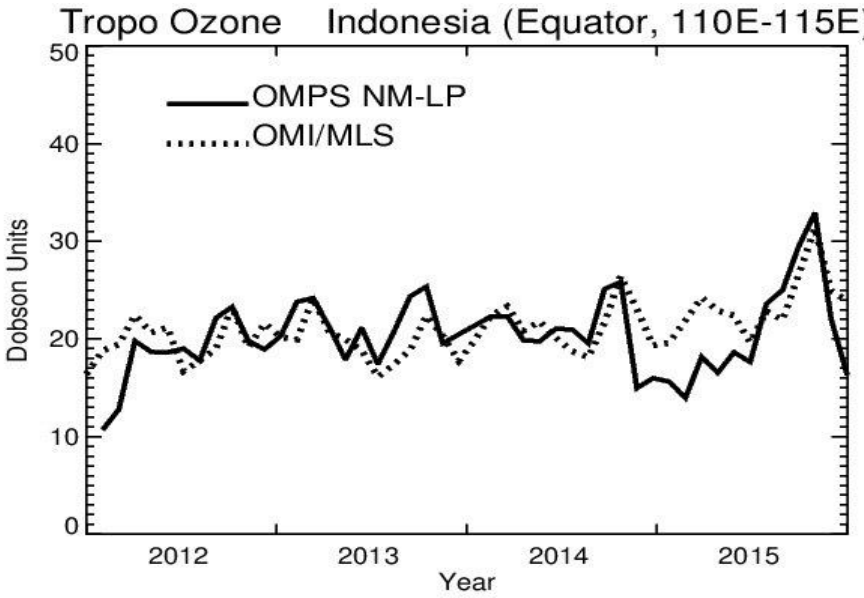
Maps of tropospheric column ozone during the month of largest amounts in the Northern Hemisphere (July) and Southern Hemisphere (October).

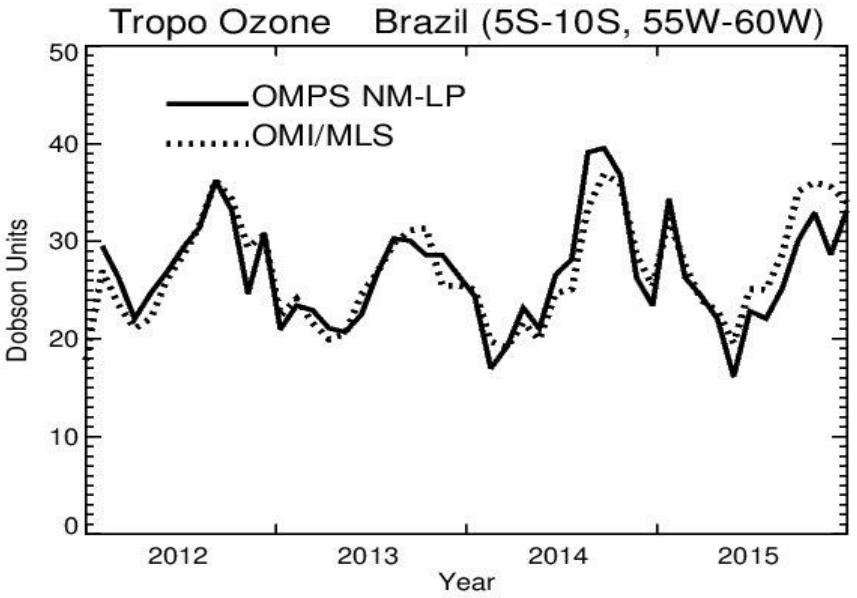

Hohenpeisenberg 47.8,11.0 NMIN=3
OMI/MLS Minus Sonde = -1.8 DU
Diff RMS = 3.63 DU
Tropospheric Ozone (DU)
Year

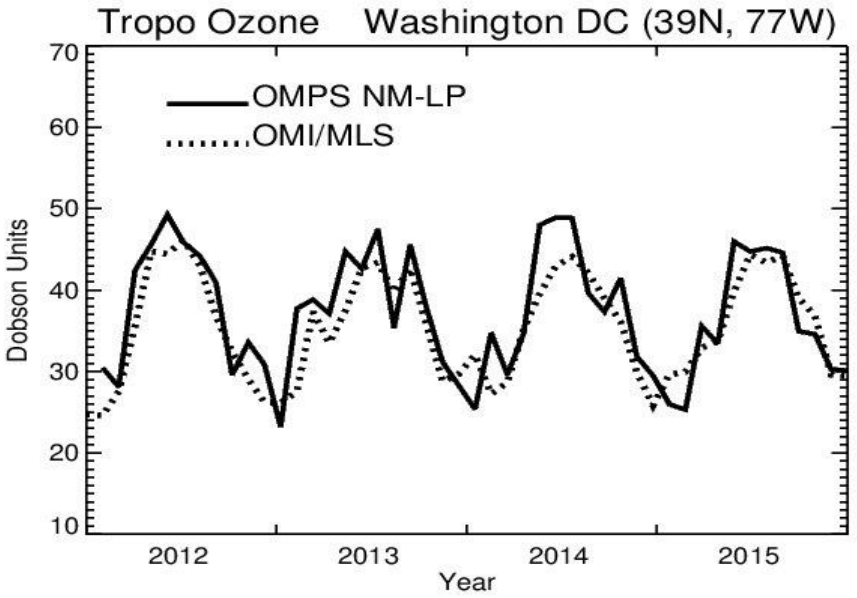

Nairobi -1.3,36.8 NMIN=3
OMI/MLS Minus Sonde = 0.52 DU
Diff RMS = 2.03 DU
Tropospheric Ozone (DU)
Year

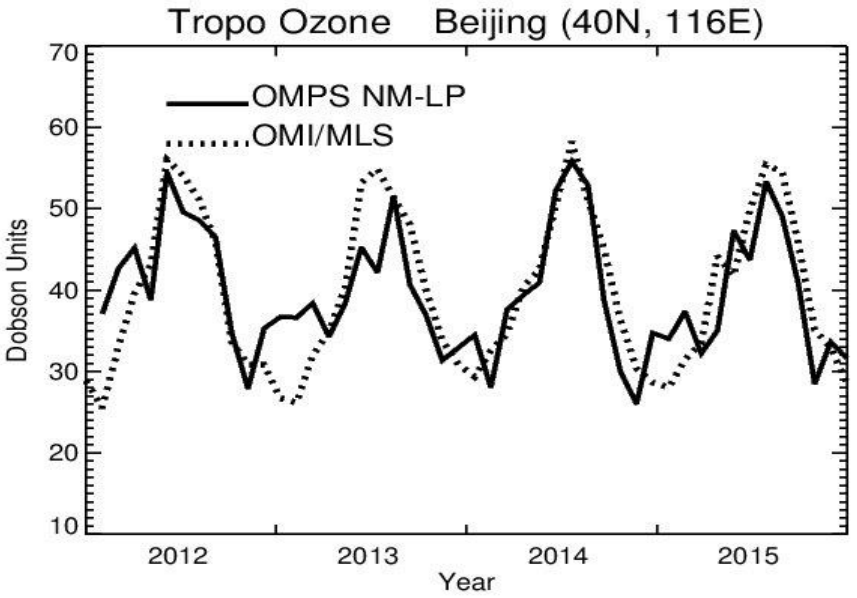

Samoa -14.2,-170.5 NMIN=3
OMI/MLS Minus Sonde = -0.84 DU
Diff RMS = 2.24 DU
Tropospheric Ozone (DU)
Year

Comparisons to OMPS Nadir Mapper-Limb Profiler Tropospheric Ozone



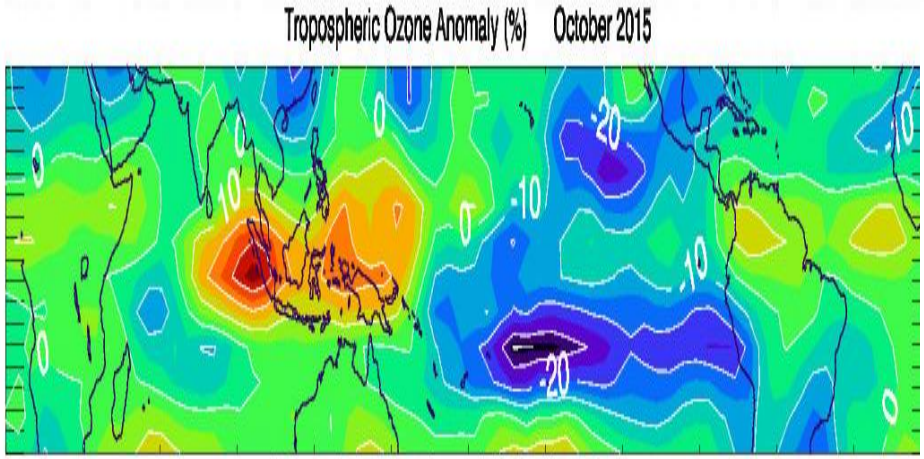


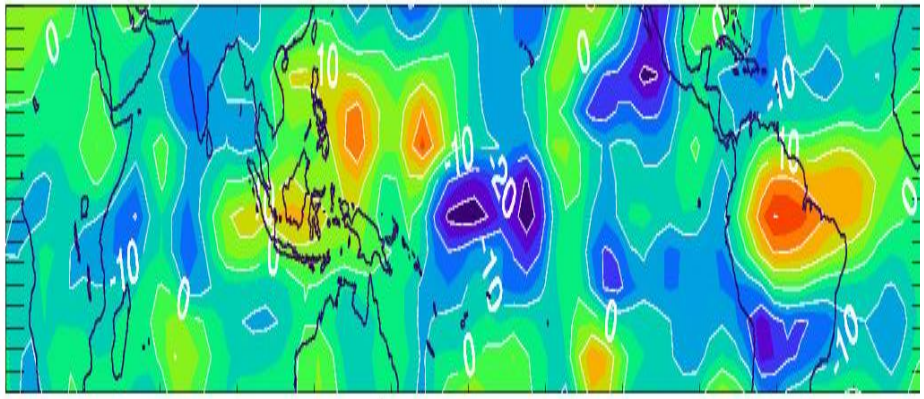




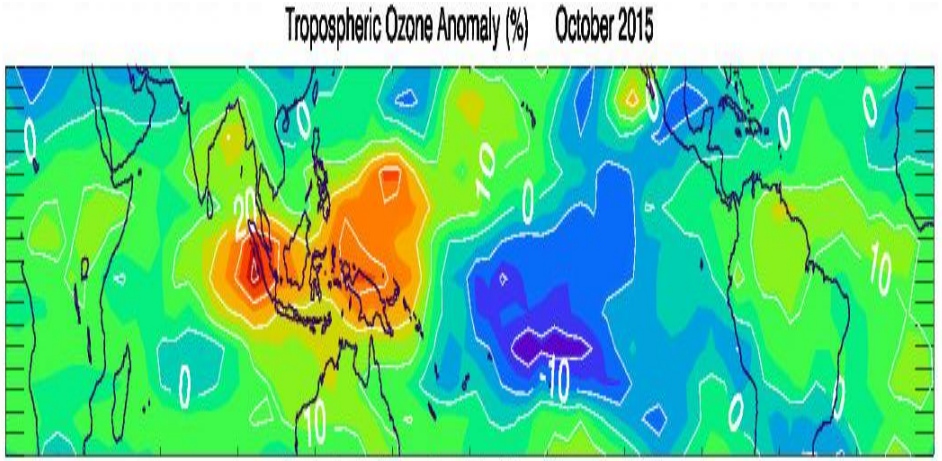
OMPS NM-LP: Tropospheric Ozone Anomalies During the 2015-2016 El Nino

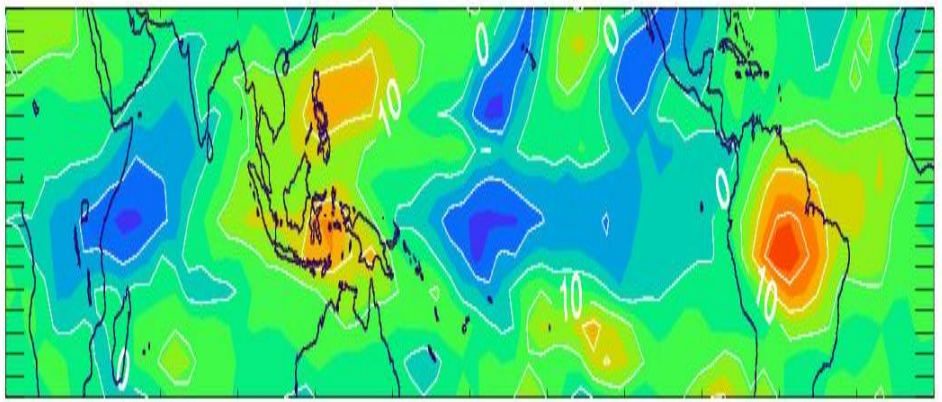
OMPS NM-LP

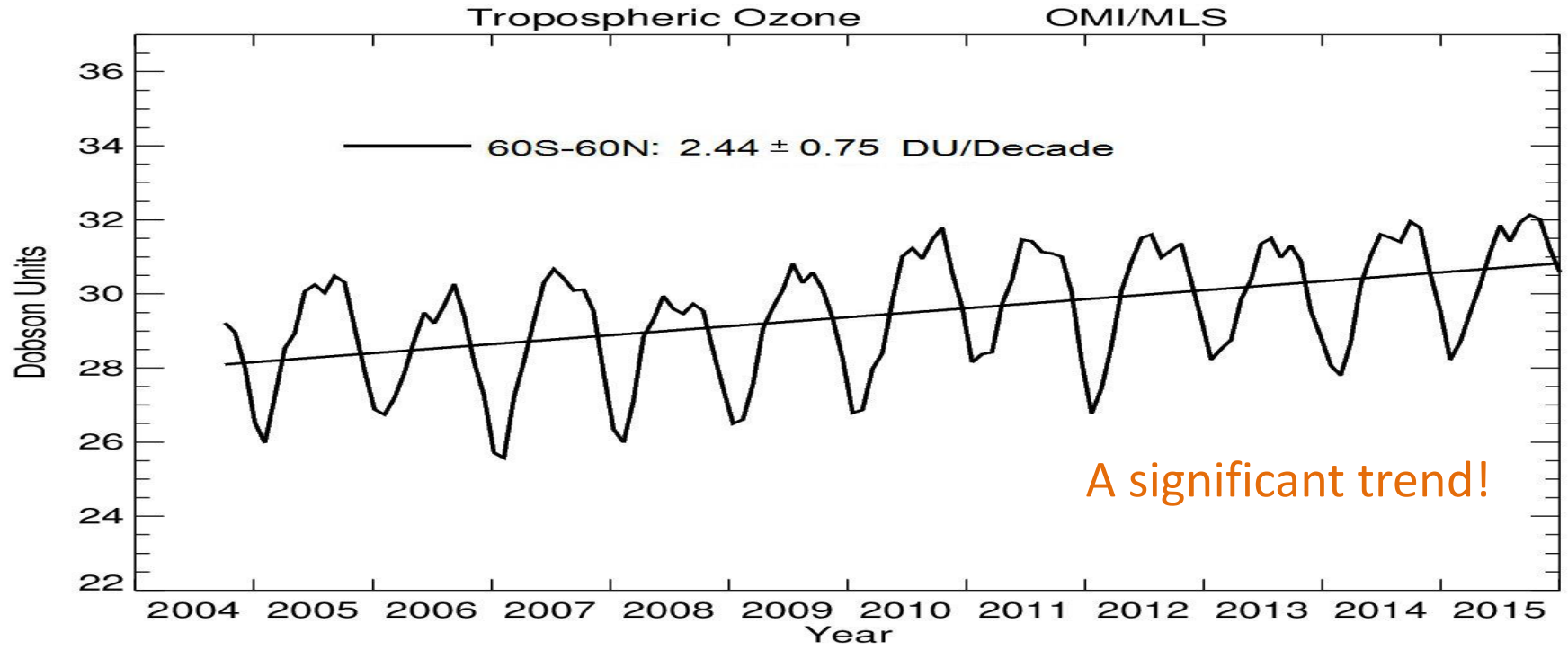


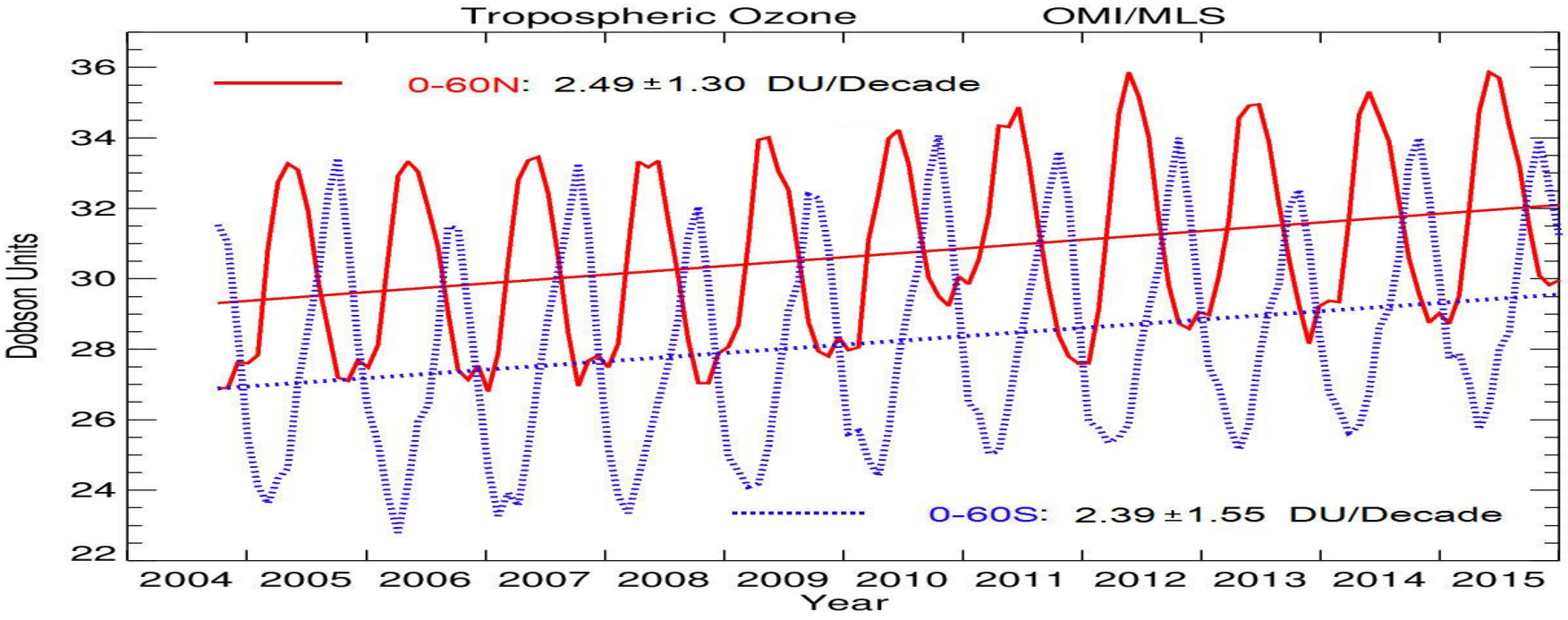


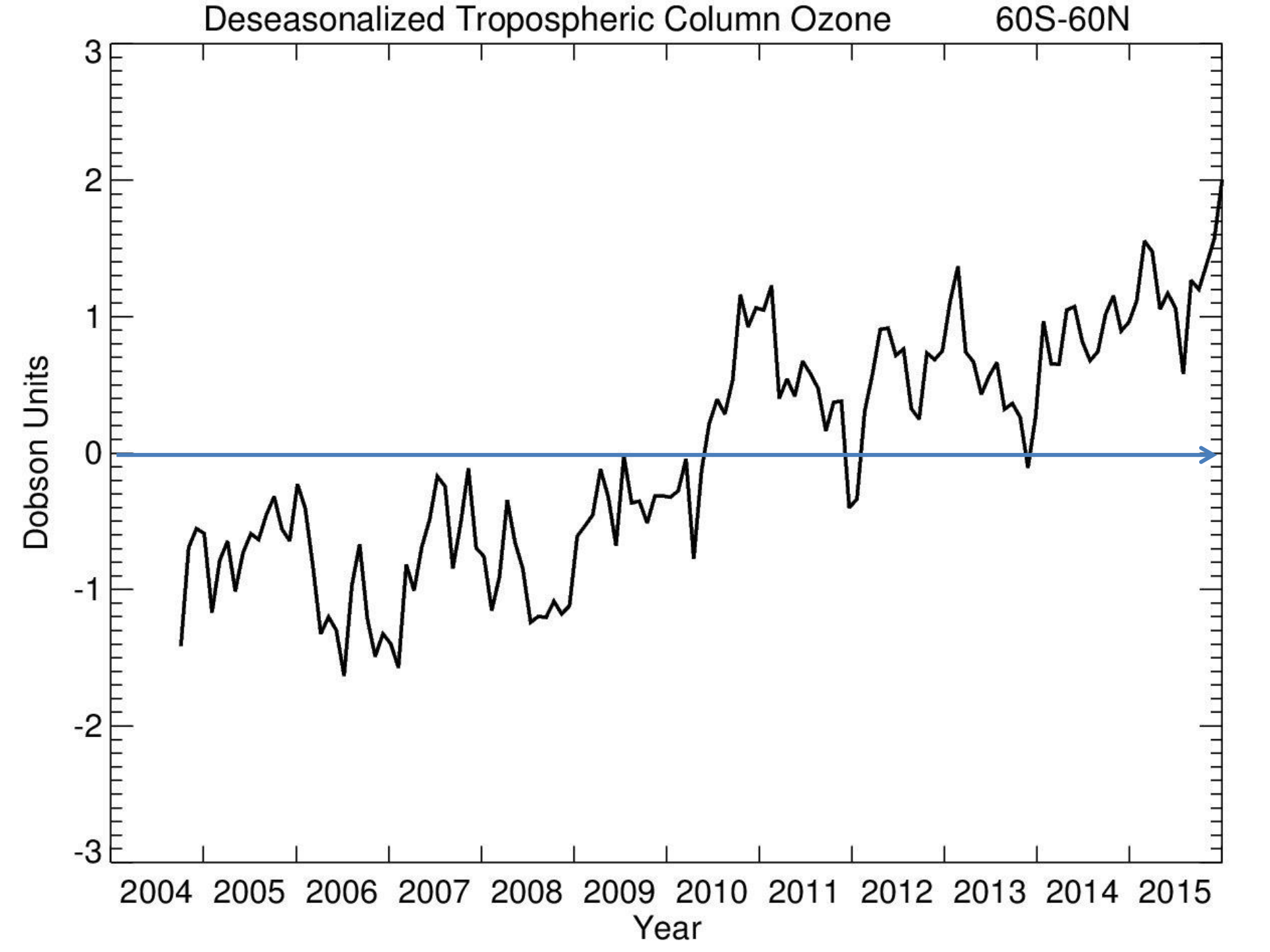
OMI - MLS

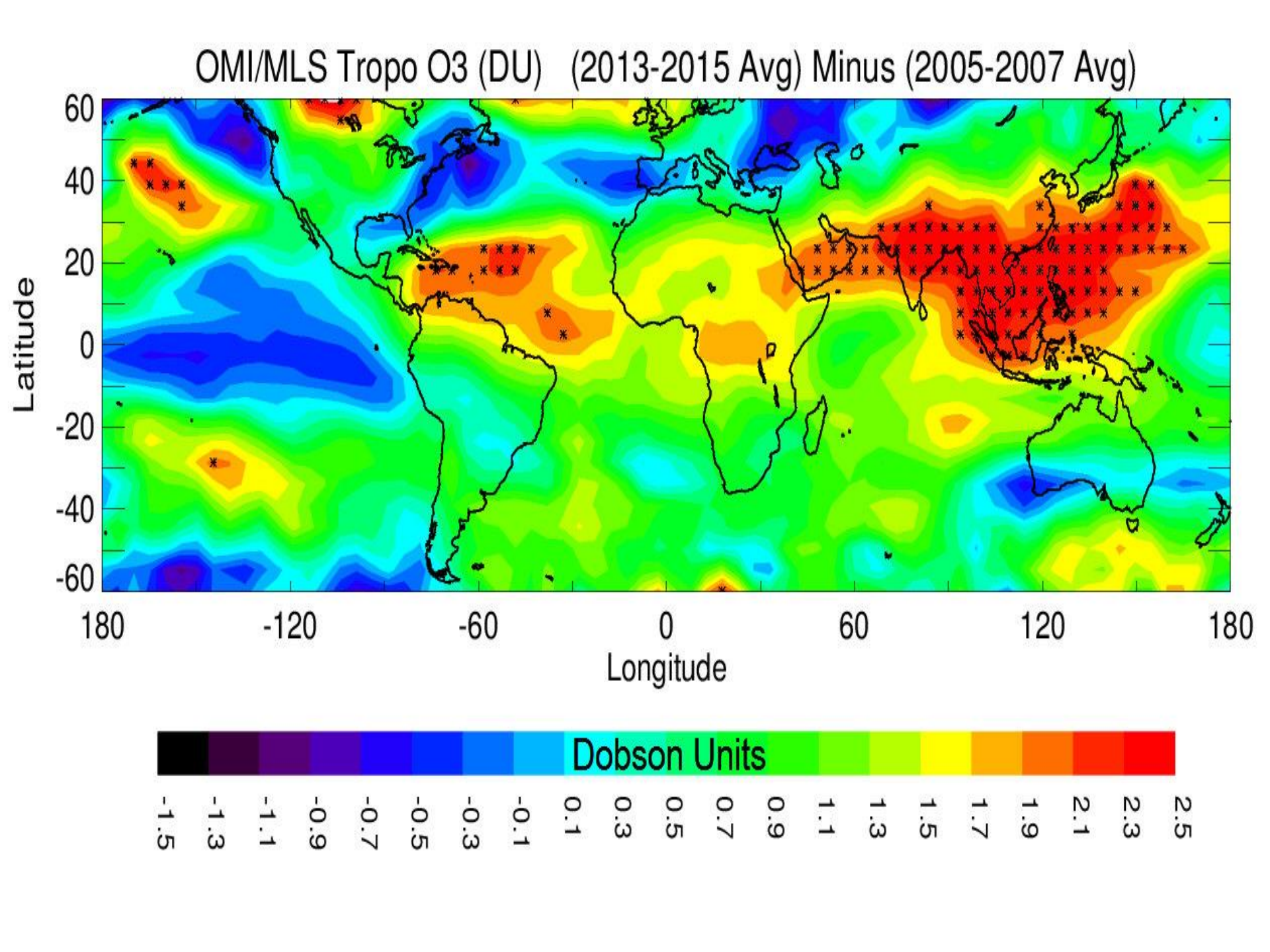





Tropospheric Ozone
OMI/MLS
60S-60N: 2.44 ± 0.75 DU/Decade
A significant trend!
Dobson Units
Year
36
34
32
30
28
26
24
22
2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015


Tropospheric Ozone
OMI/MLS
0-60N: 2.49 ± 1.30 DU/Decade
0-60S: 2.39 ± 1.55 DU/Decade
Dobson Units
Year
36
34
32
30
28
26
24
22
2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015


Deseasonalized Tropospheric Column Ozone
60S-60N
Dobson Units
3
2
1
0
-1
-2
-3
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
Year

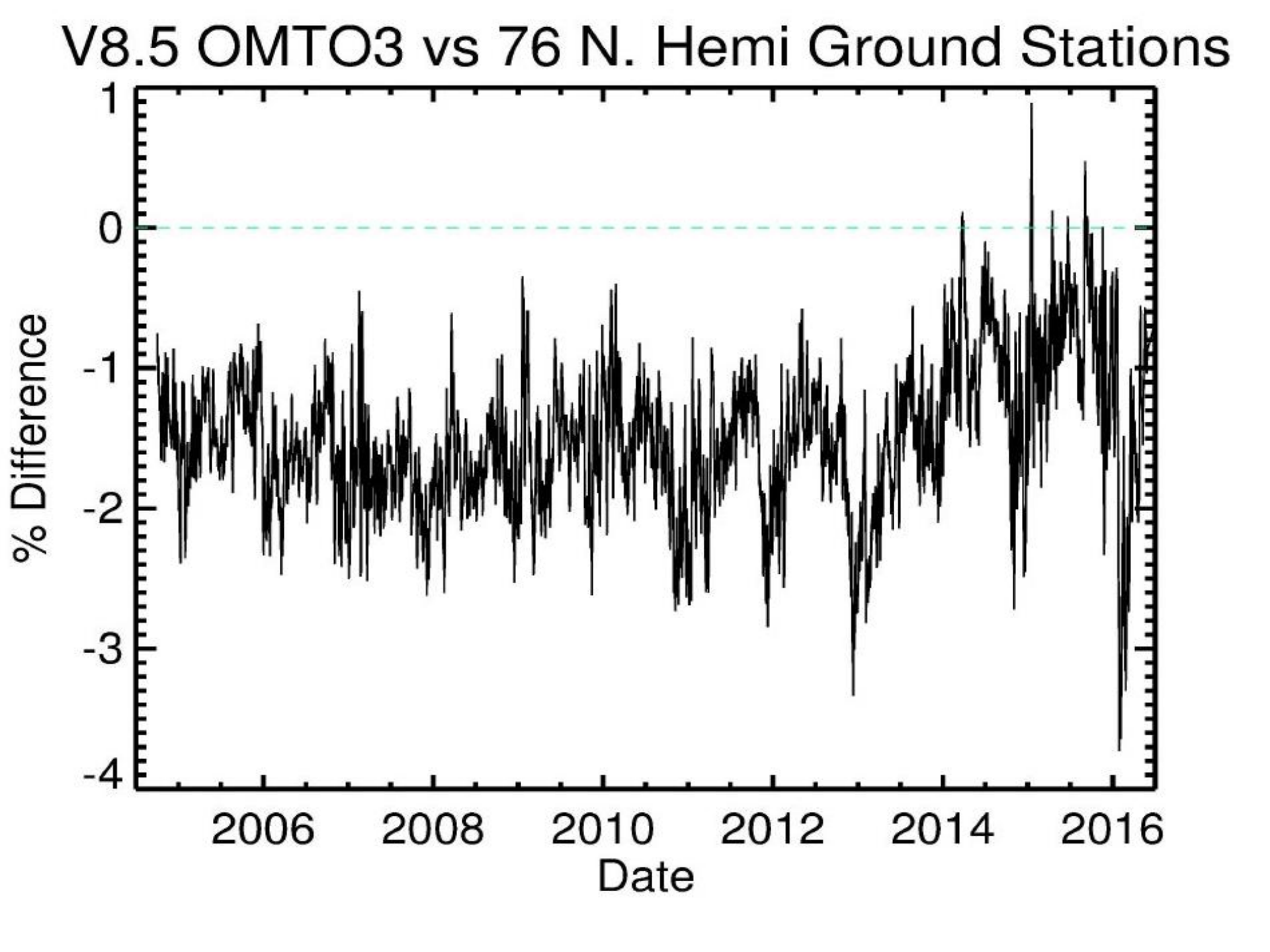

OMI/MLS Tropo O3 (DU) (2013-2015 Avg) Minus (2005-2007 Avg)
Latitude
60
40
20
0
-20
-40
-60
180
-120
-60
0
60
120
180
Longitude
Dobson Units
-1.5
-1.3
-1.1
-0.9
-0.7
-0.5
-0.3
-0.1
0.1
0.3
0.5
0.7
0.9
1.1
1.3
1.5
1.7
1.9
2.1
2.3
2.5

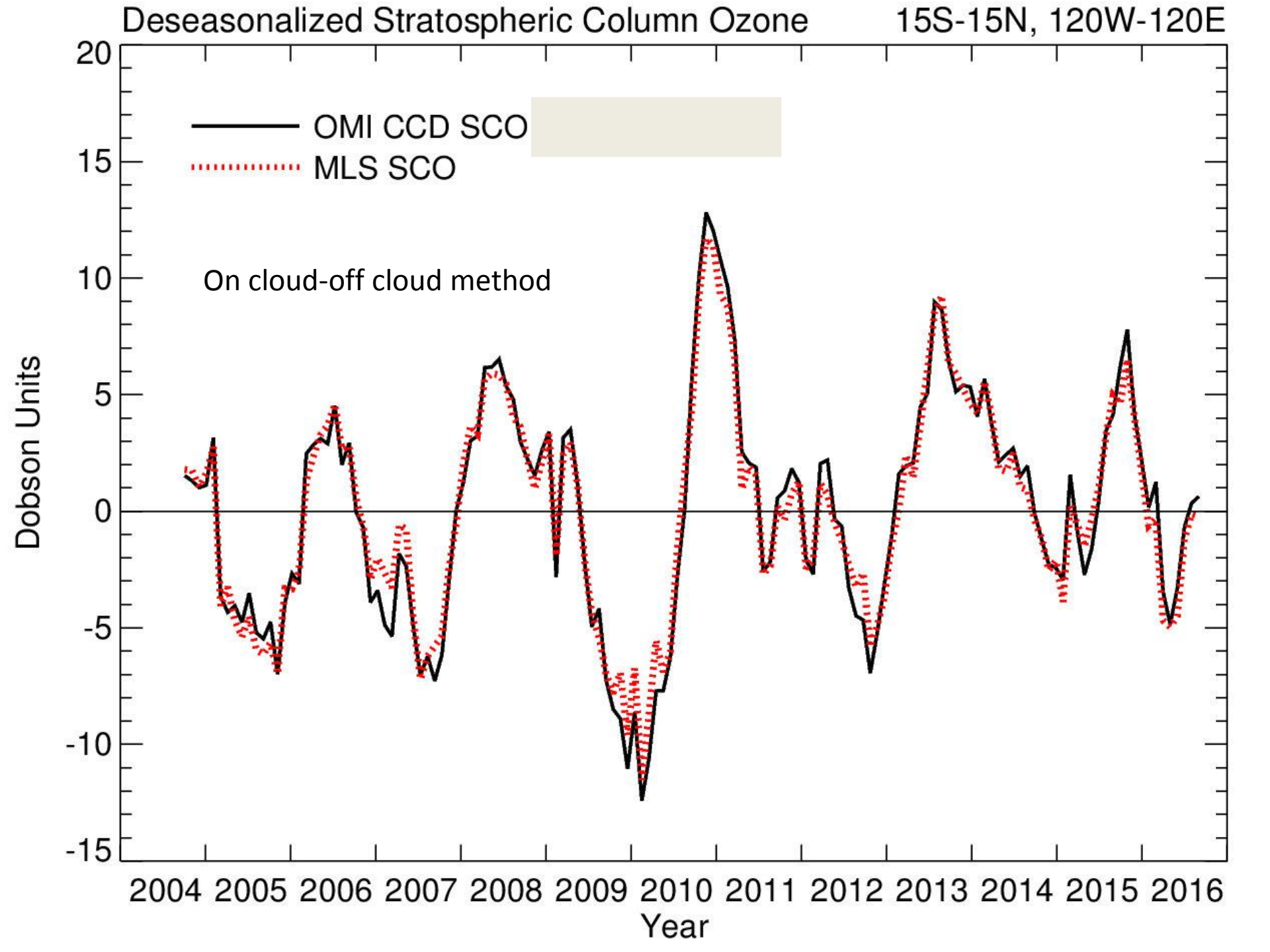
3 or 4 Possibilities:

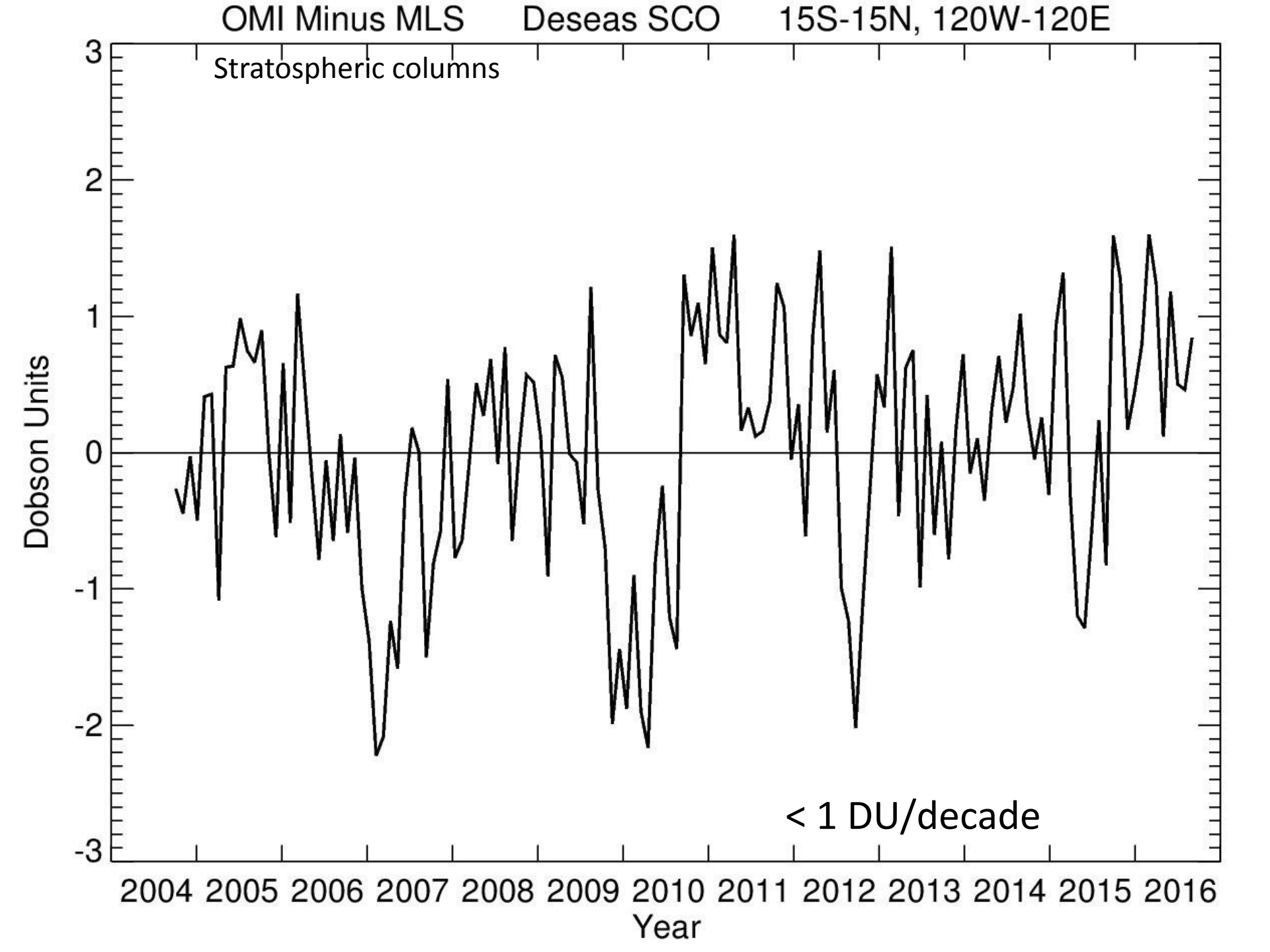
1) OMI is drifting and/or
2) MLS is drifting

OR

The change is real


V8.5 OMTO3 vs 76 N. Hemi Ground Stations
% Difference
1
0
-1
-2
-3
-4
2006
2008
2010
2012
2014
2016
Date


Deseasonalized Stratospheric Column Ozone
15S-15N, 120W-120E
OMI CCD SCO
MLS SCO
On cloud-off cloud method
Dobson Units
20
15
10
5
0
-5
-10
-15
2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016
Year


OMI Minus MLS Deseas SCO 15S-15N, 120W-120E
Stratospheric columns
Dobson Units
3
2
1
0
-1
-2
-3
2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016
Year
< 1 DU/decade

So we believe the trend is predominately real.

OMI is drifting by a small amount

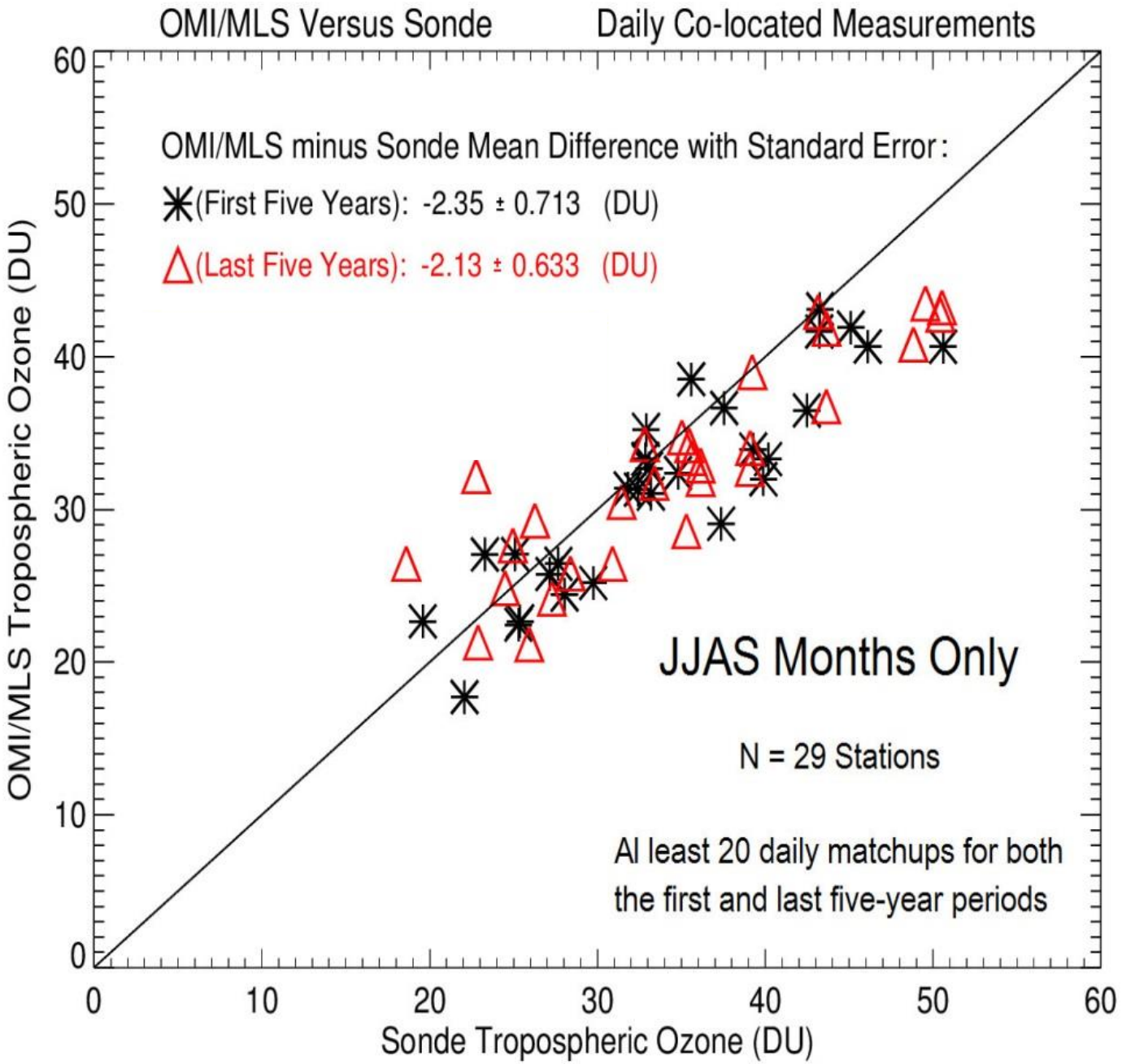
Work in progress

(will be corrected in V9 processing)

What do we have to offer the climate community?

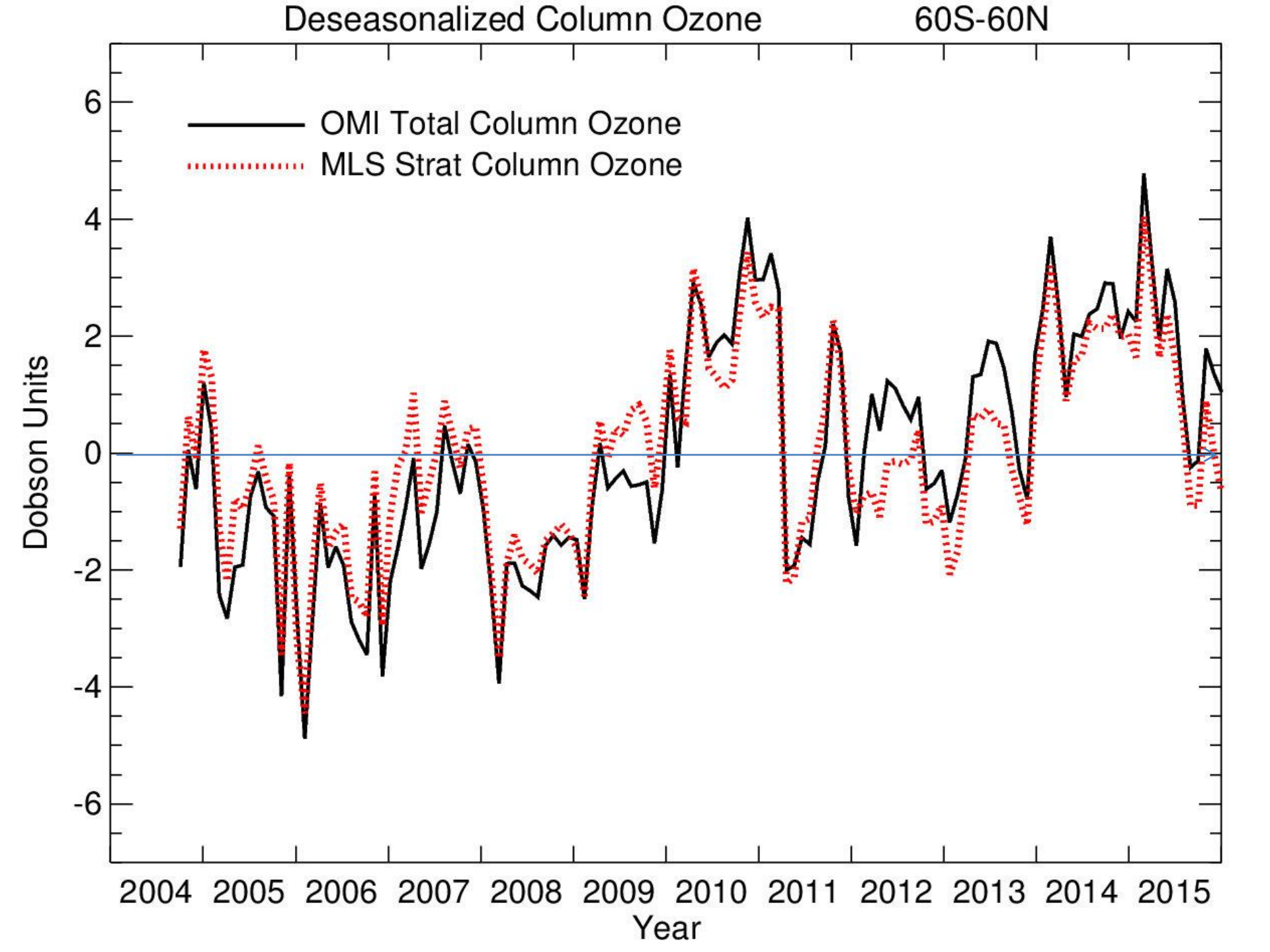
- 60N-60S tropospheric ozone maps (weekly/monthly)
- 25N-25S tropospheric ozone maps (daily)
- Long-term tropospheric ozone trends

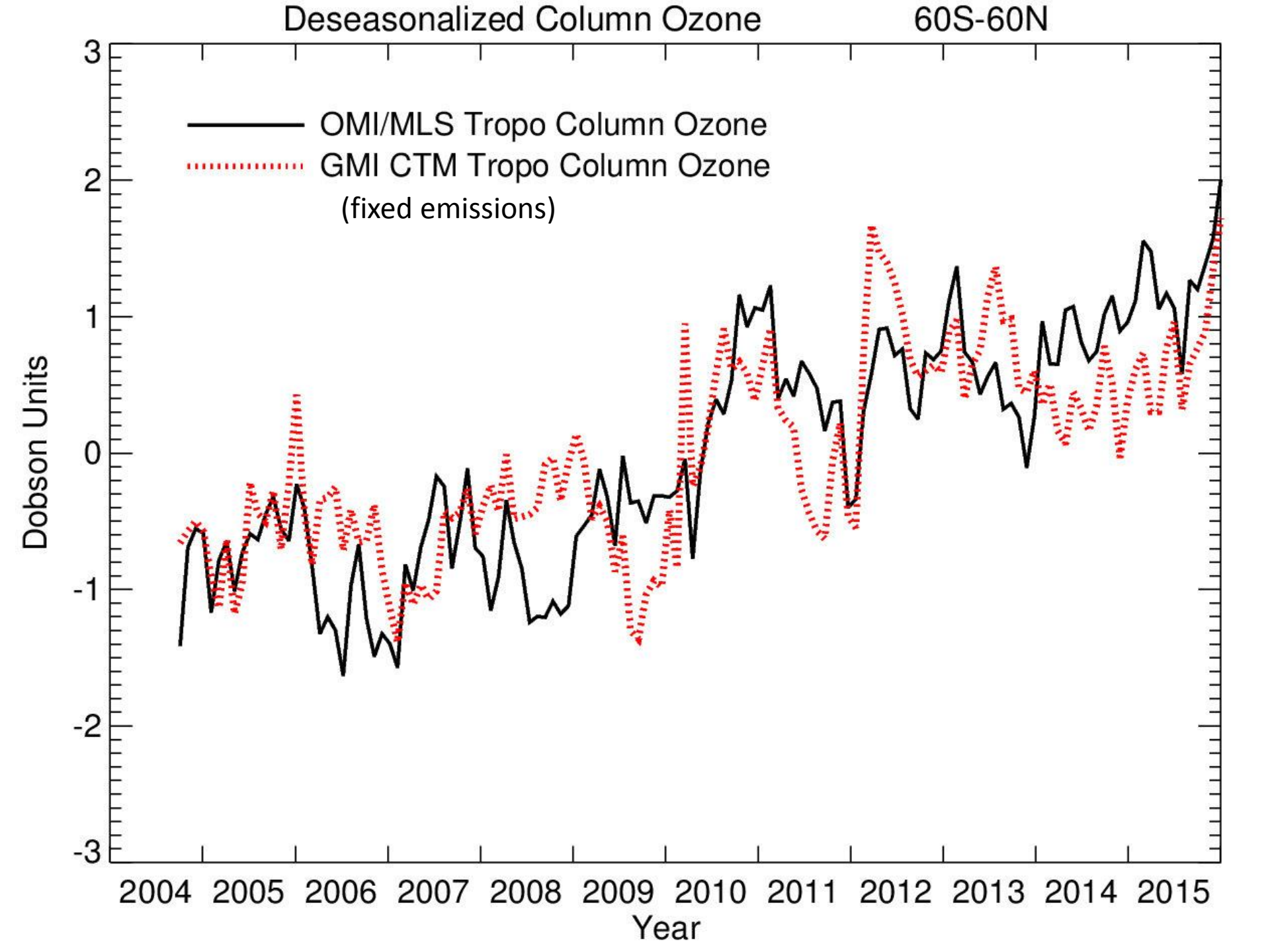
  2004-present with MLS/OMI and 1979-2003 with cloud slicing method (on-cloud/off-cloud) from mappers for 15N-15S only.
- Will use OMPS when AURA ends

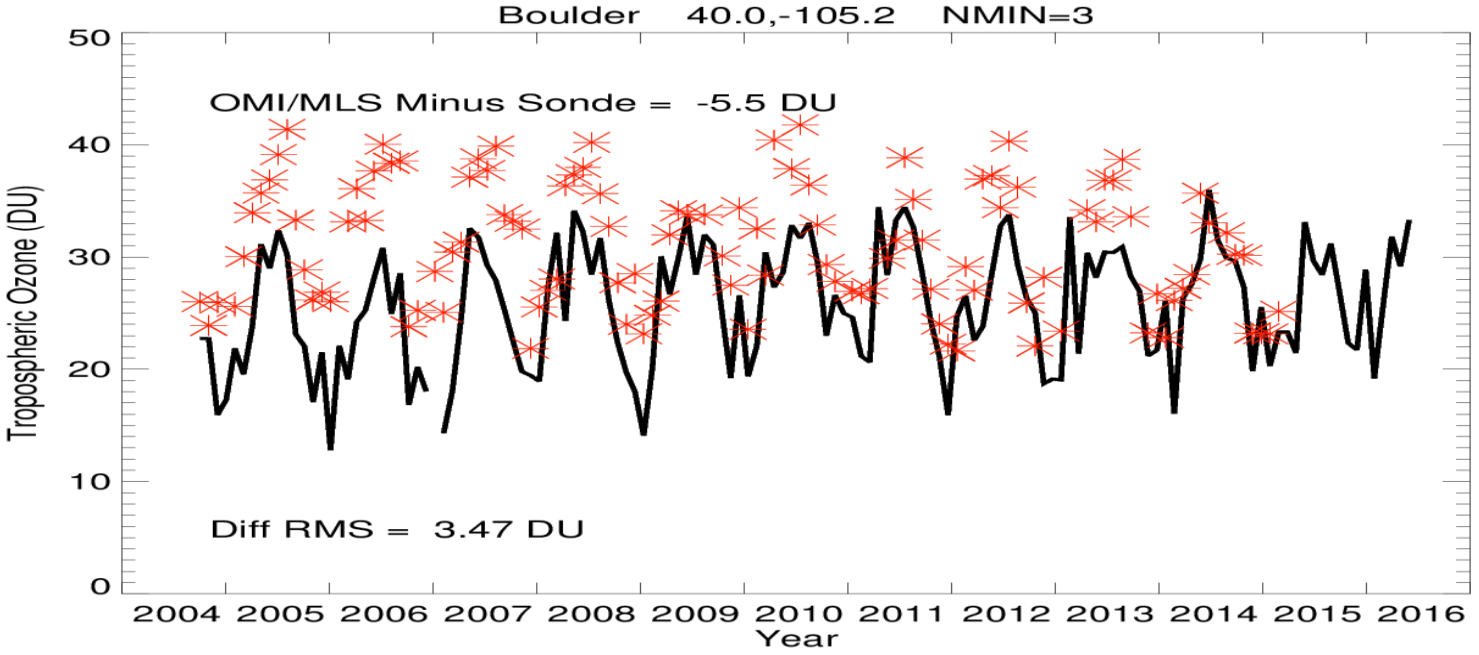


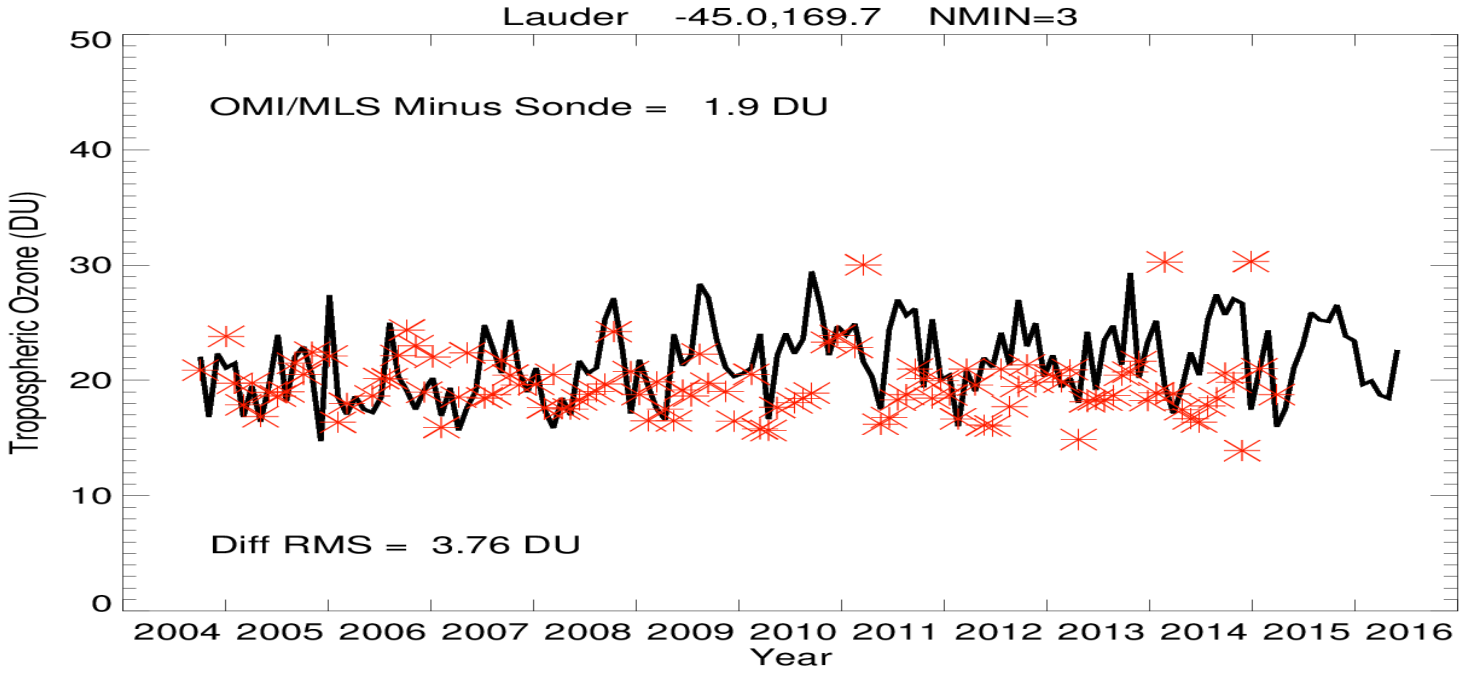
DATA: First and last 5-year periods from October 2004 through May 2016

- Good agreement
- Very small mean offset of ~2 DU
- No measurable drift


Deseasonalized Column Ozone
60S-60N
OMI Total Column Ozone
MLS Strat Column Ozone
Dobson Units
6
4
2
0
-2
-4
-6
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
Year


Deseasonalized Column Ozone
60S-60N
OMI/MLS Tropo Column Ozone
GMI CTM Tropo Column Ozone
(fixed emissions)
Dobson Units
3
2
1
0
-1
-2
-3
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
Year


Boulder 40.0,-105.2 NMIN=3
OMI/MLS Minus Sonde = -5.5 DU
Diff RMS = 3.47 DU
Tropospheric Ozone (DU)
0
10
20
30
40
50
2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016
Year


Lauder -45.0,169.7 NMIN=3
OMI/MLS Minus Sonde = 1.9 DU
Diff RMS = 3.76 DU
Tropospheric Ozone (DU)
0
10
20
30
40
50
2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016
Year