

# The joint SPARC/IO<sub>3</sub>C/WMO/NDACC Initiative on Past Trends in the Vertical Distribution of Ozone

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N.R.P. Harris (Univ. of Cambridge)

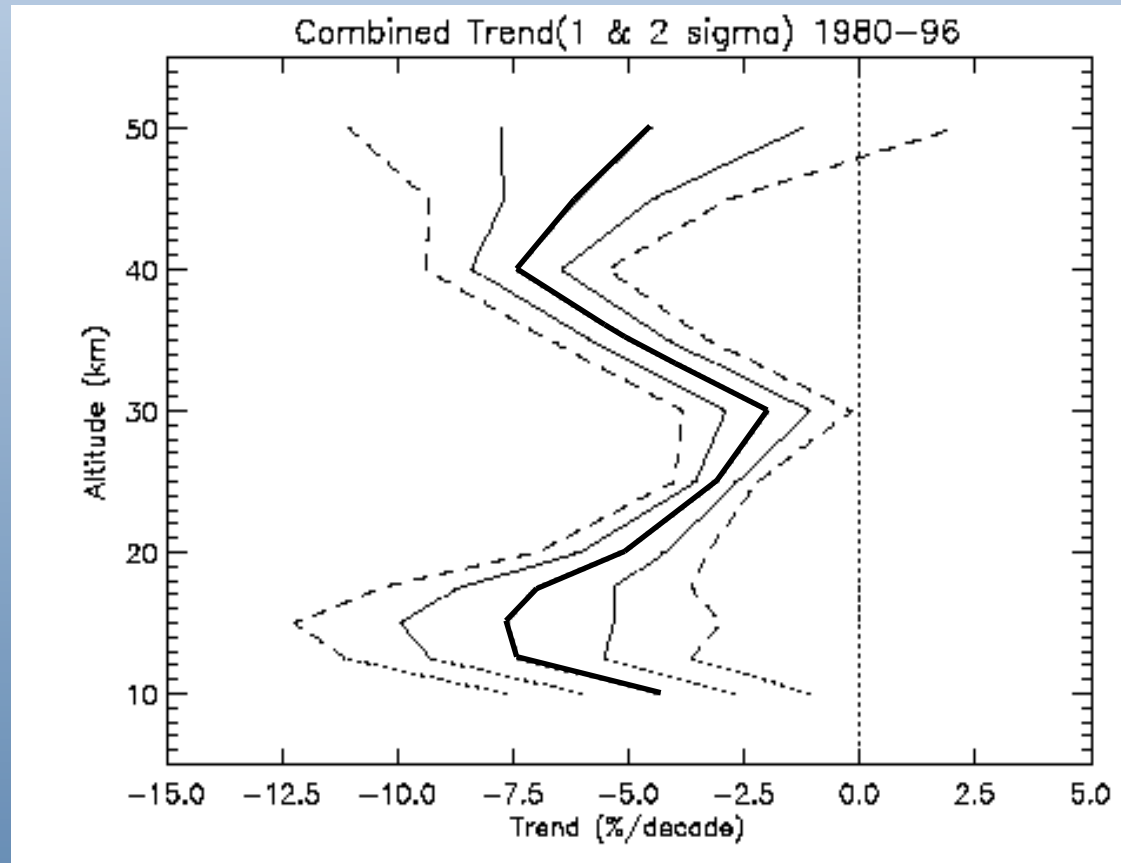
J. Staehelin (ETH Zürich)

R.S. Stolarski (Johns Hopkins University)

F. Tummon (ETH Zürich)

and many more

# SI<sup>2</sup>N - Motivation



Estimate of mean trend using Umkehr, SAGE I/II, SBUV/SBUV2, and ozonesonde measurements at northern mid-latitudes (heavy solid line). Combined uncertainties are also shown as 1s (light solid line) and 2s (dashed line).

*(Harris et al., SPARC Report No.1, 1998.)*

# SI<sup>2</sup>N - Objectives

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Monitoring the global  
ozone layer

Detection and  
attribution of ozone  
recovery

critical examination of the pattern and  
time sequence of ozone change

Requires accurate knowledge of altitude, latitude, and  
seasonal structure of the ozone variability

High quality measurements with well defined and  
described uncertainties

# SI<sup>2</sup>N - Objectives

## Long-term ozone changes

### Long-term satellite records

*J. Tamminen, R. Wang*

SAGE II reprocessing (1984-2005)  
SAGE extensions (1979-81; 2005 on)  
SBUV consolidation (1979-now)

### Umkehr (Dobson & Brewer)

*T. McElroy, I. Petropavlovskikh*

Brewer data collection  
Retrieval improvement & QA/QC  
40 yr record with increasing coverage

### Ozonesondes

*S. Oltmans, H. Smit*

Homogenised data set  
Clear documentation  
40 yr record with increasing coverage

## Climate variability

### The last decade (satellite)

*M. van Roozendaal, L. Froidevaux*

ODIN, ACE, Envisat, Aura  
Existing projects  
SPARC Data Initiative

### Ground-based systems

*NDACC Working groups*

Lidar, microwave and FTIR  
Internal consistency  
Mainly from ~1990 on

**+ 1 on the issues  
associated with  
merging**



# SI<sup>2</sup>N - Workshops

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- Workshop 1: Geneva/Switzerland, January 25-27, 2011
- Workshop 2: Maryland/USA, April 16-18, 2012
- Workshop 3: Helsinki/Finland, September 18-19, 2013
- $\approx$  between 30 to 50 attendees each time

# SI<sup>2</sup>N - Publications

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- Joint SI<sup>2</sup>N special issue of ACP, AMT and EESD
- $\approx$  40 research papers in the special issue at the moment
- $\approx$  5 research papers in other journals
- 3 overview papers:
  1. Measurements  
(lead: B. Hassler (NOAA); AMT, accepted)
  2. Validation  
(lead: J.-C. Lambert (BIRA); not submitted yet)
  3. Trends  
(lead: N.R.P. Harris (Cambridge); not submitted yet)

# SI<sup>2</sup>N - Measurements

	1960s	1970s	1980s	1990s	2000s	2010s
Ozonesondes						
Dobson/Brewer	Dobson			Brewer		
Lidar						
FTIR						
Microwave						
<b>Ground-based</b>						
SAGE		SAGE I	SAGE II		SAGE III	
HALOE						
ILAS/ILAS-II				ILAS	ILAS II	
POAM				POAM II	POAM III	
ACE-MAESTRO						
ACE-FTS						
<b>Satellite-based</b>						
GOMOS						
LIMS						
MLS				UARS	Aura	
MIPAS						
Odin-SMR						
SMILES						
SCIAMACHY						
Odin-OSIRIS						
SBUV		BUV				
GOME/GOME-2						
OMI						
IASI						

# SI<sup>2</sup>N - Measurements

		1960s	1970s	1980s	1990s	2000s	2010s
● Ozonesondes	★						
● Dobson/Brewer	★	Dobson			Brewer		
● Lidar	★						
● FTIR	★	Ground-based					
● Microwave	★						
● SAGE	★		SAGE I	SAGE II		SAGE III	
HALOE							
ILAS/ILAS-II					ILAS	ILAS II	
POAM				POAM II		POAM III	
● ACE-MAESTRO							
● ACE-FTS	★	Satellite-based					
● GOMOS	★						
LIMS							
● MLS	★				UARS	Aura	
● MIPAS	★						
● Odin-SMR	★						
SMILES	★						
● SCIAMACHY	★						
● Odin-OSIRIS	★						
● SBUV	★		BUV				
GOME/GOME-2							
● OMI							
IASI							

● Participated in SI<sup>2</sup>N



★ Related publication in the special issue

## SI<sup>2</sup>N – trend studies


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- What happened to ozone globally over the last 40+ years?
- How different does that evolution look for different regions in the stratosphere and different latitudinal regions?

## SI<sup>2</sup>N – trend studies

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- What happened to ozone globally over the last 40+ years?
- How different does that evolution look for different regions in the stratosphere and different latitudinal regions?

 A single measurement system is not able to provide this information

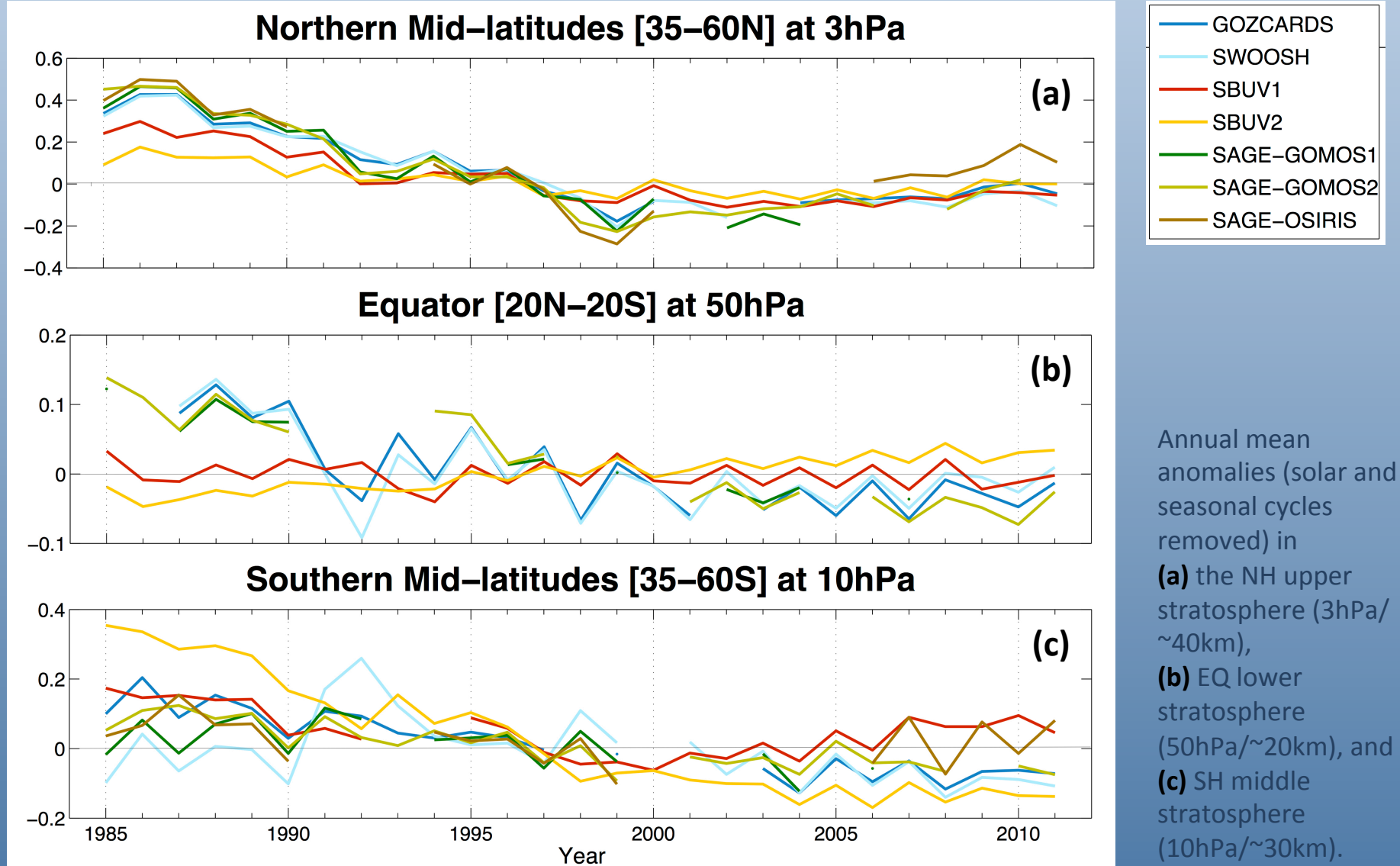
 Data sets merged from different measurement systems

## SI<sup>2</sup>N - merged data sets

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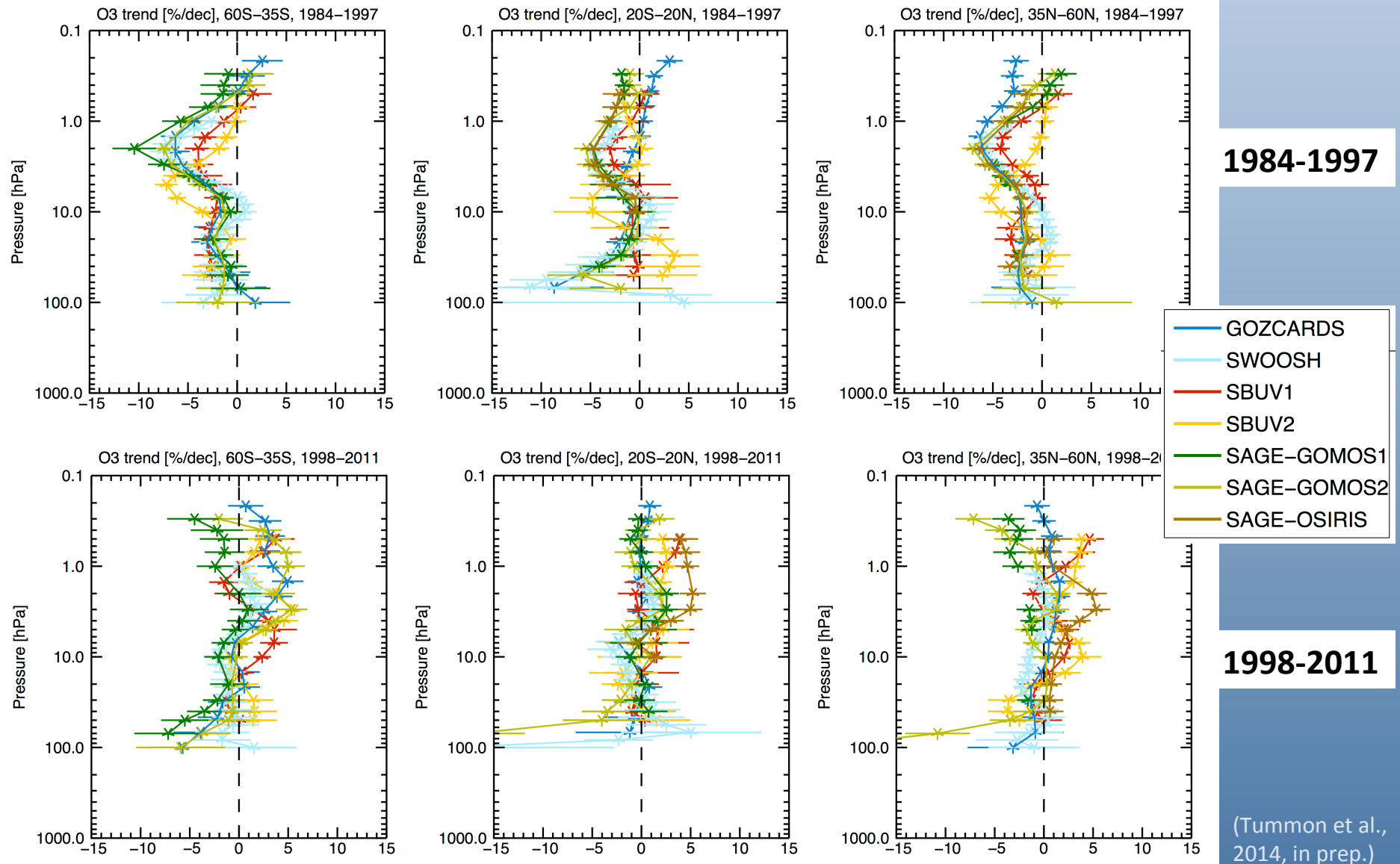
- 7 altogether
- 7 different ways of combining different measurements
- Single measurement system: SBUV (2x)
- Two measurement systems: SAGE II and OSIRIS, SAGE II and GOMOS (2x)
- Multiple measurement systems: GOZCARDS, SWOOSH

# SI<sup>2</sup>N - merged data sets: anomalies



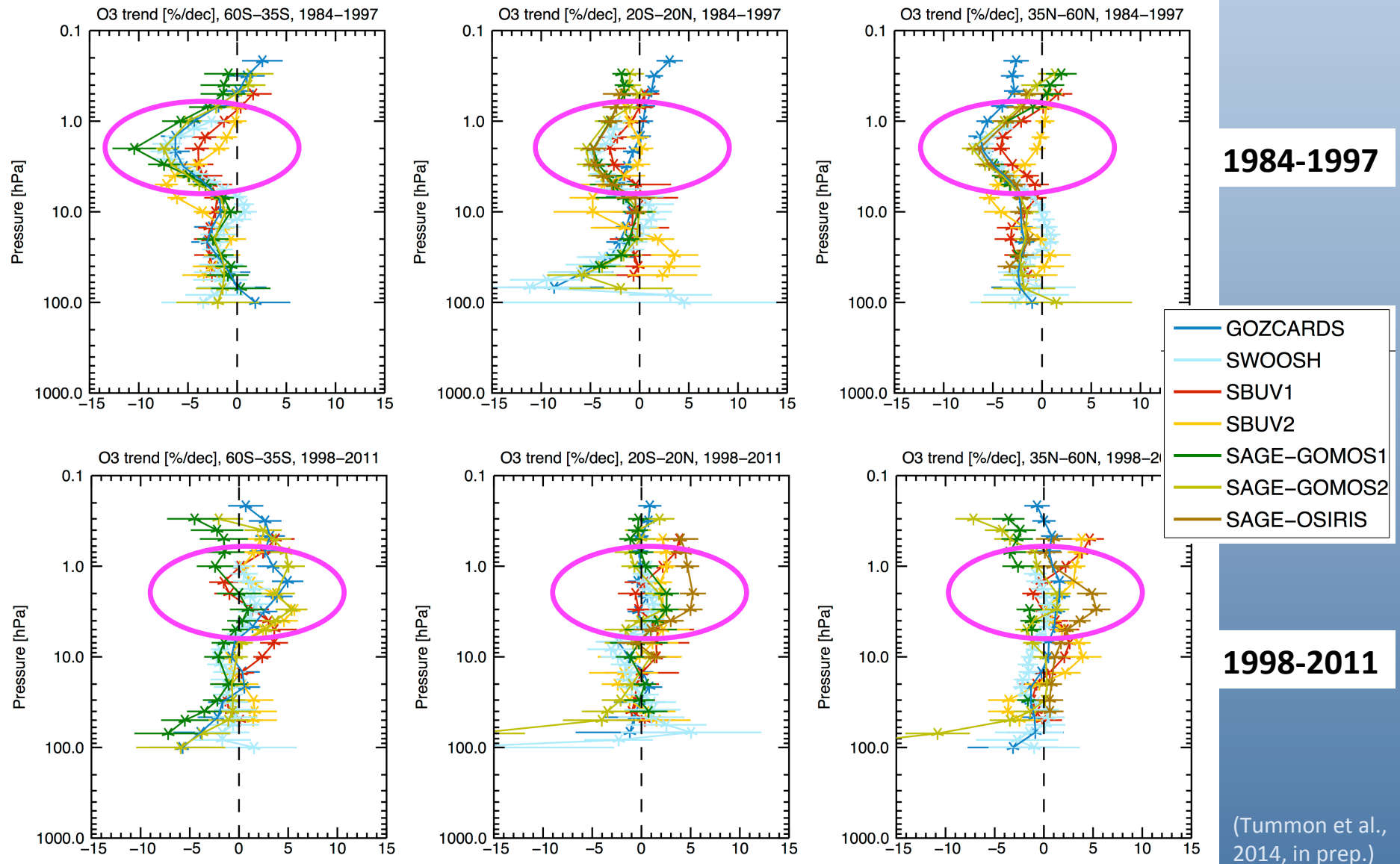


# SI<sup>2</sup>N - merged data sets: trends



Latitude average of annual trends (in %/decade) for 1984-1997 (top row) and for 1998-2011 (bottom row), SH (left), EQ (middle), NH (right).

# SI<sup>2</sup>N - merged data sets: trends



Latitude average of annual trends (in %/decade) for 1984-1997 (top row) and for 1998-2011 (bottom row), SH (left), EQ (middle), NH (right).

(Tummon et al.,  
2014, in prep.)

## SI<sup>2</sup>N - merged data sets: lessons learned

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- Merged data sets only way to determine multi-decadal trends
- Errors in merging are similar to decadal stability and significant compared to ozone trends.
- Careful work needed to improve and refine approaches and data sets (c.f. temperature).
- Getting close to unambiguous detection of ODS-related increase in O<sub>3</sub>.

## SI<sup>2</sup>N – suggestions/recommendations

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- Ground-based measurement systems absolutely essential to validate the merged data sets (long-term measurements, different regions of the globe, not just total column ozone, but ozone profiles...)
- Merging/continuing records should be a point of consideration for planning future observational systems (satellite and ground-based)

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Thanks!