Merged SAGE II – Ozone_cci –OMPS ozone dataset for trend studies

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Ozone_cci limb profile instruments

Vertical resolution 2-4 km

MIPAS
4.15 - 14.6 μm

SCIAMACHY

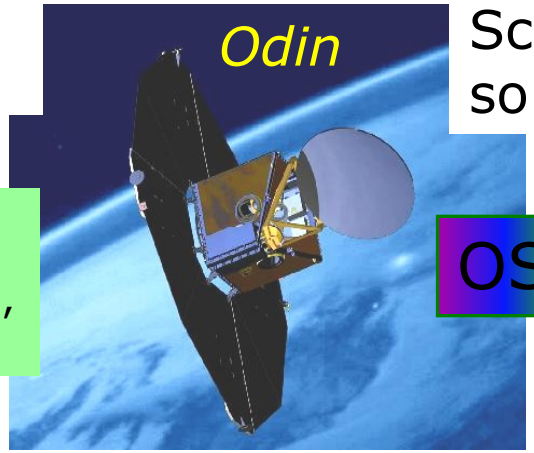
GOMOS

Night-time
Bright-limb

Emission spectra

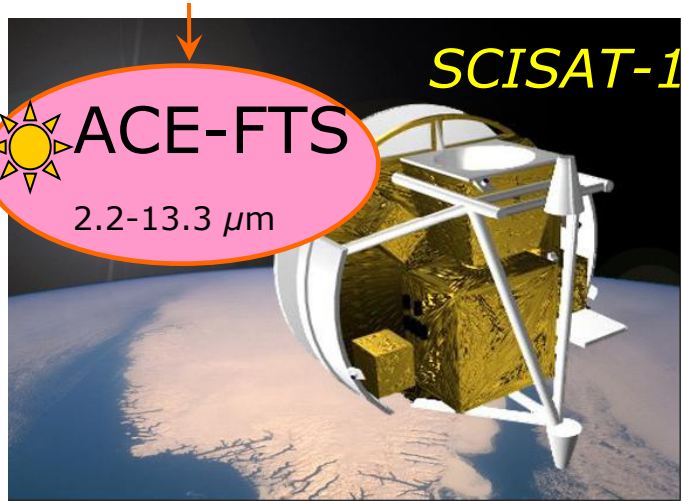
Scattered solar light

occultation



SMR
501.8GHz,
~0.6 mm

OSIRIS

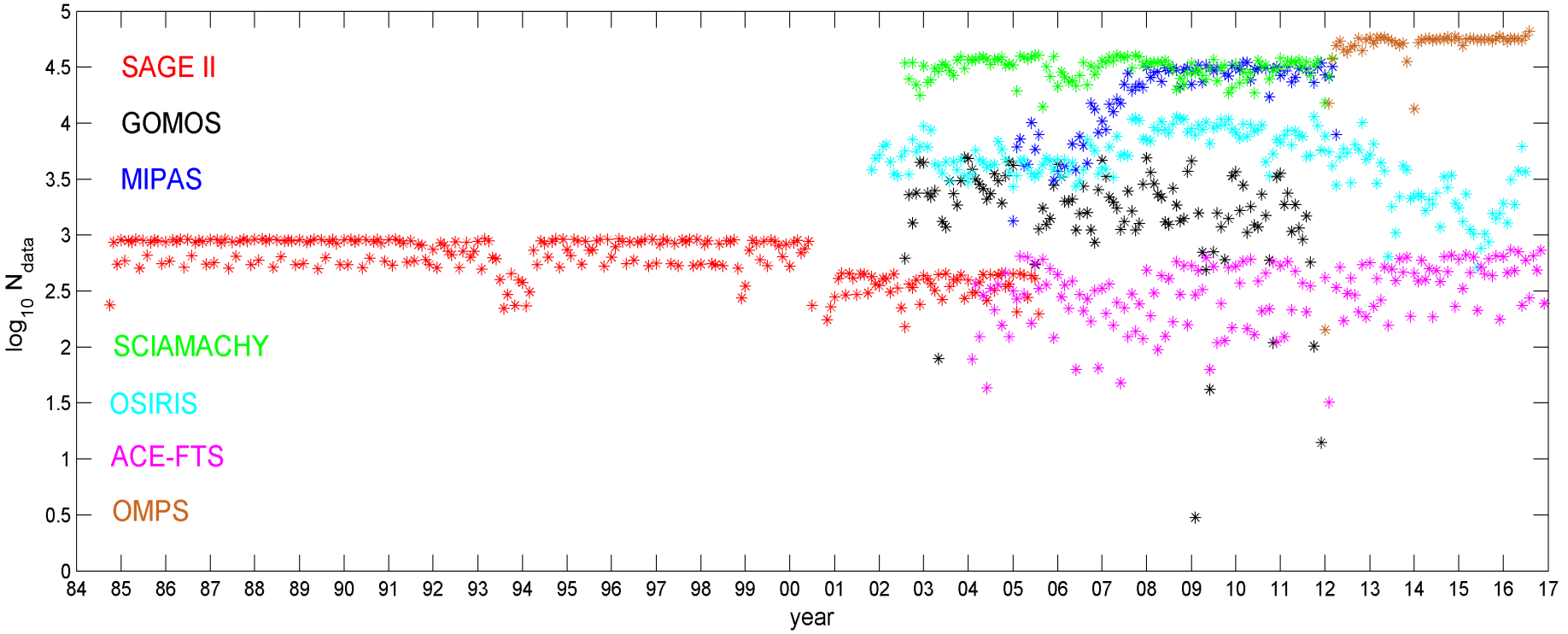


ACE-FTS
2.2-13.3 μm

SAGE II – Ozone_cci – OMPS datasets

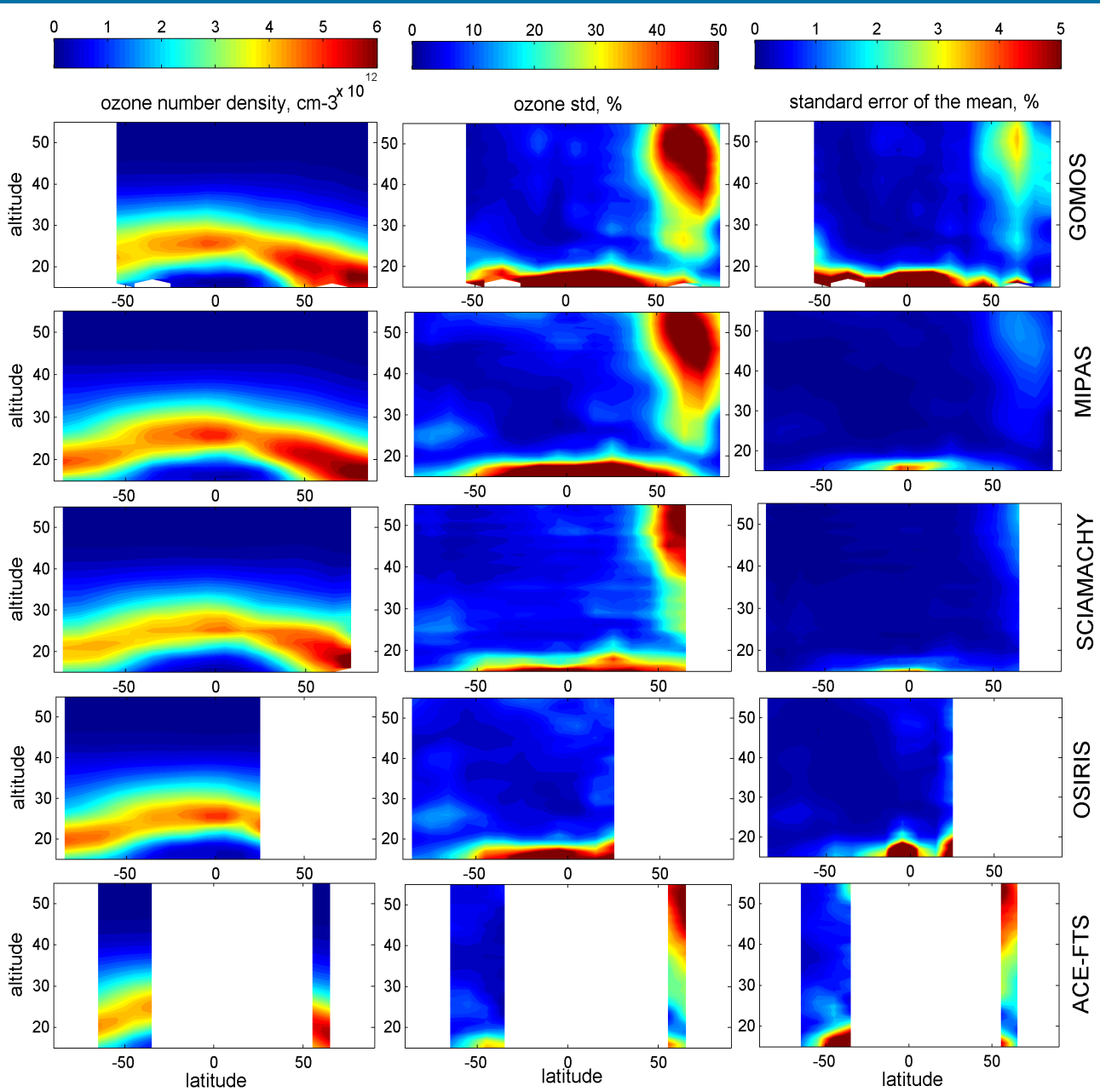
Instrument/ satellite	Processor, data source	Time period	Local time	Vertical resolution	Estimated precision	Profiles per day
SAGE II/ ERBS	NASA V7.0, original files	Oct 1984 – Aug 2005	sunrise, sunset	~1 km	0.5-5%	14-30
OSIRIS/ Odin	USask v 5.10, HARMOZ_ALT	Nov 2011 – July 2016	6 a.m., 6 p.m.	2-3 km	2-10%	~250
GOMOS/ Envisat	ALGOM2s v 1.0, HARMOZ_ALT	Aug 2002 – Aug 2011	10 p.m.	2-3 km	0.5–5 %	~110
MIPAS/ Envisat	KIT/IAA v.7, HARMOZ_ALT	Jan 2005 – Apr 2012	10 p.m., 10 a.m.	3-5 km	1–4%	~1000
SCIAMACHY / Envisat	UBr v3.5, HARMOZ and original files	Aug 2003- Mar 2012	10 a.m.	3-4 km	1-7%	~1300
ACE-FTS/ SCISAT	V3.5/3.6, HARMOZ_ALT	Feb 2004 – Dec 2016	sunrise, sunset	~3 km	1-3%	14-30
OMPS/ Suomi NPP	USask 2D, HARMOZ_ALT	Apr 2012- Aug 2016	1:30 p.m.	~1 km	2-10%	~1600

SAGE II – Ozone_cci – OMPS datasets



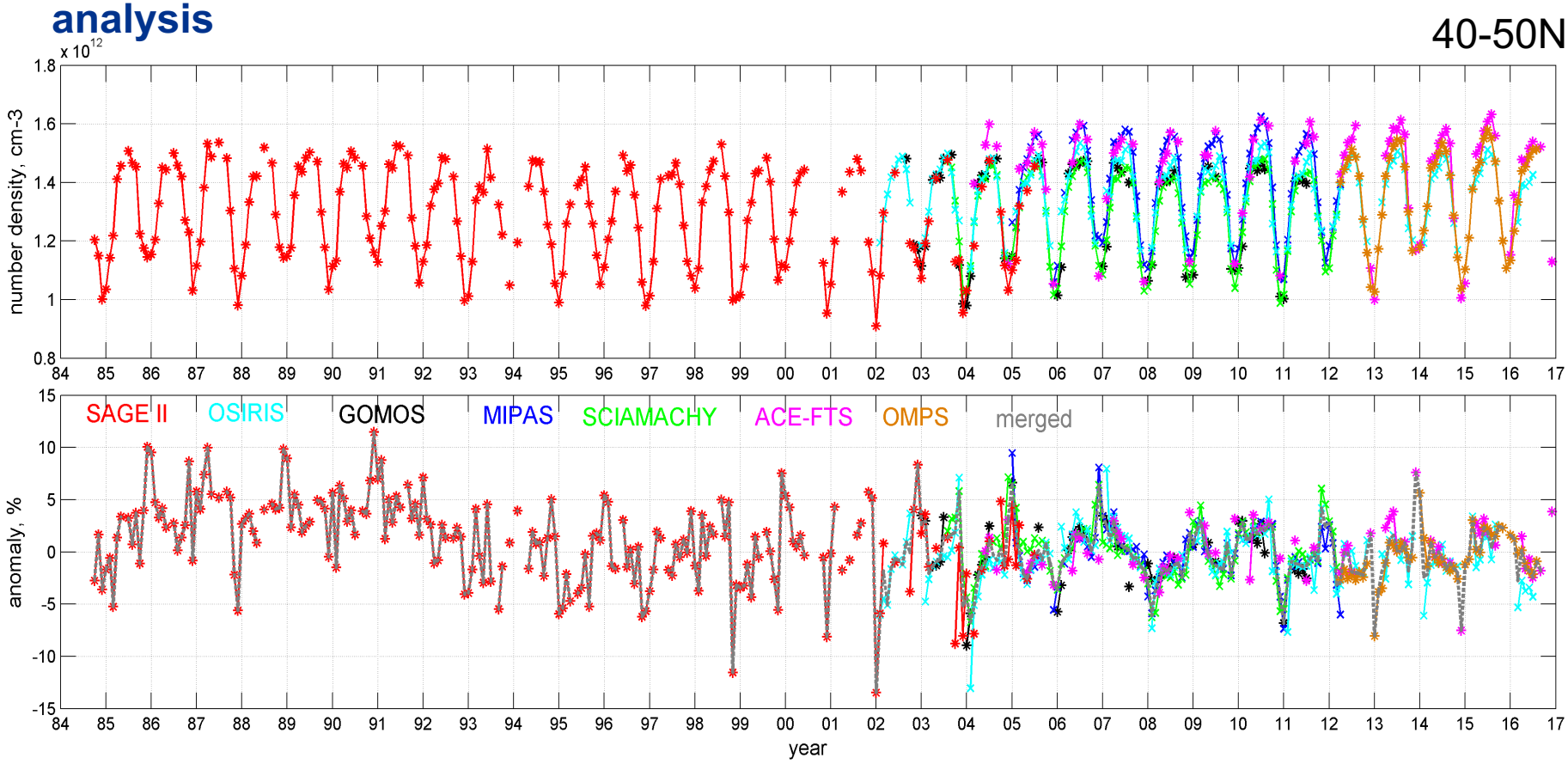
Examples of monthly zonal mean distributions

January
2008

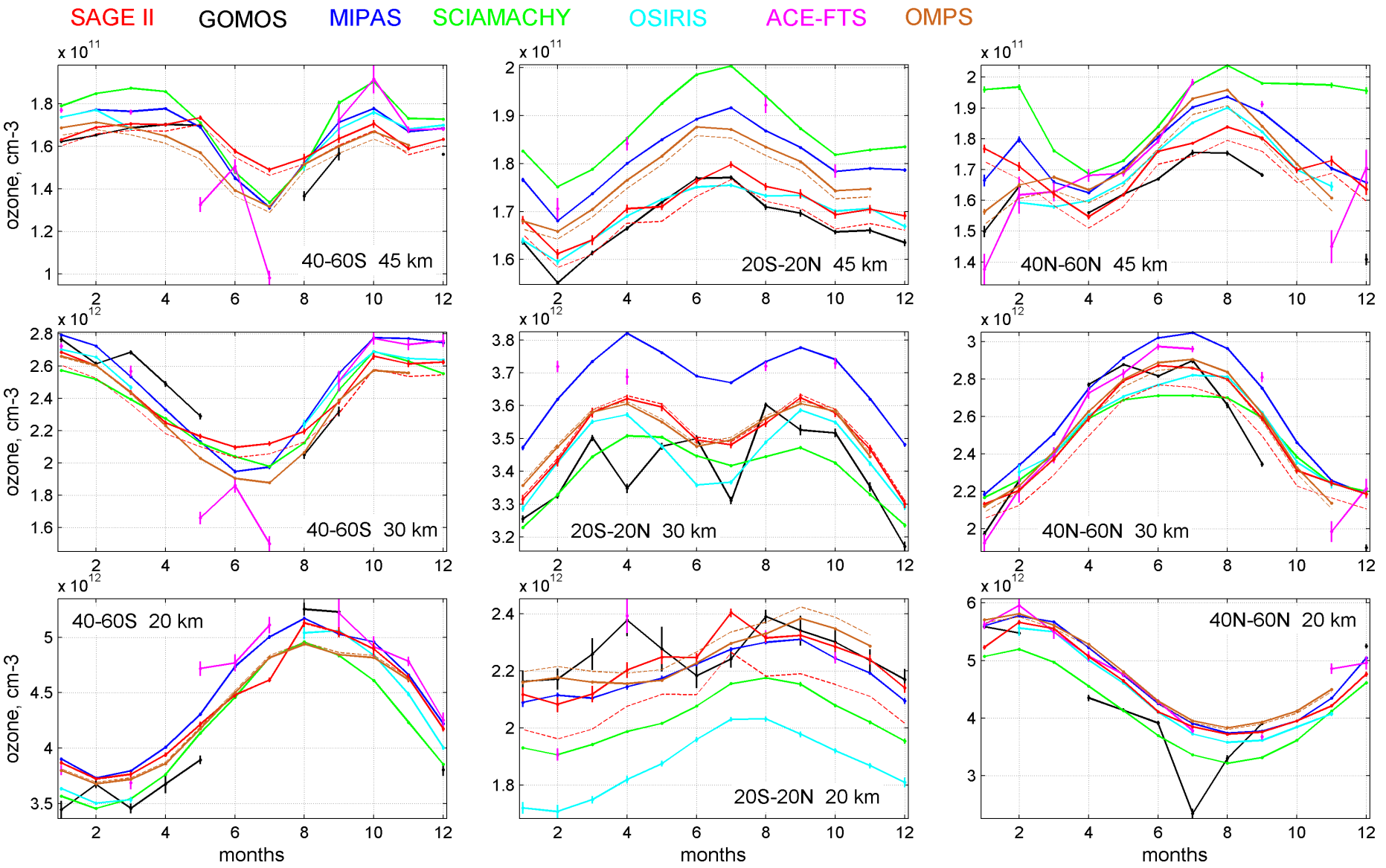


Approach for merging: using deseasonalized anomalies

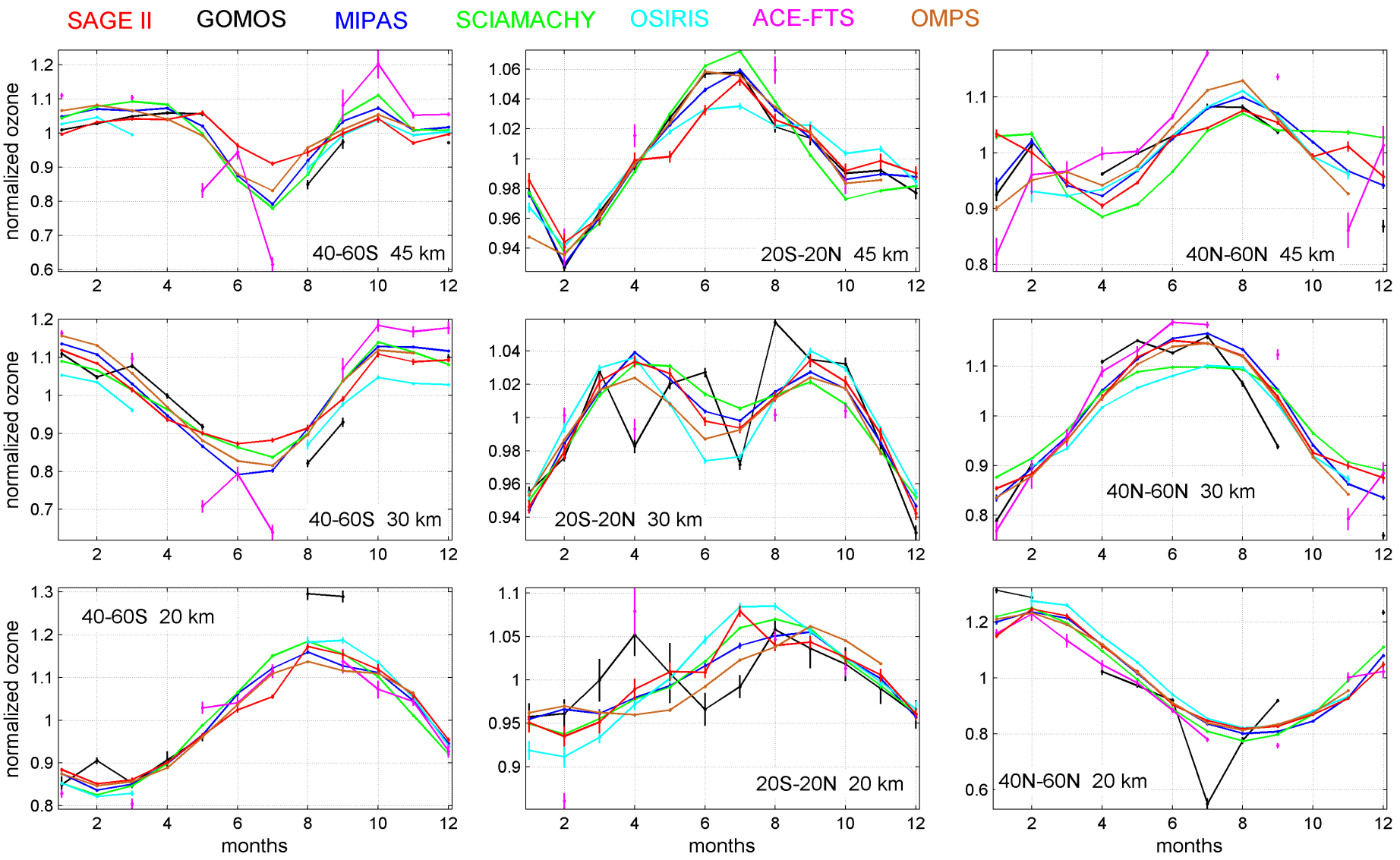
- The seasonal cycle is estimated and removed from the time series, for each dataset
- Biases are automatically removed
- No need to fit the seasonal cycle in the trend analysis by harmonics
- Deseasonalized anomalies are widely used in data merging and trends analysis



Examples of seasonal cycle

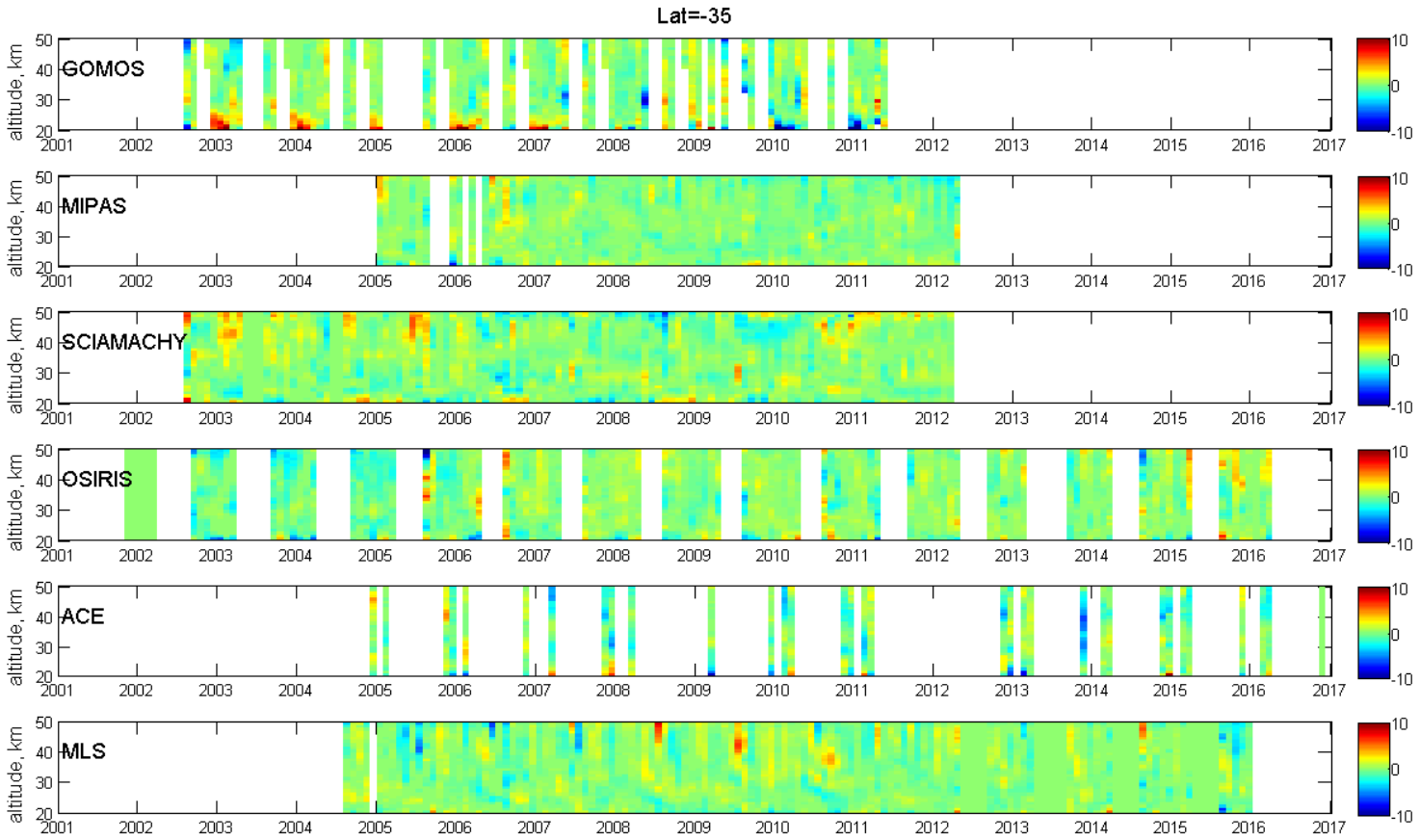


Amplitude of seasonal cycle



Data stability analyses of Ozone_cci datasets

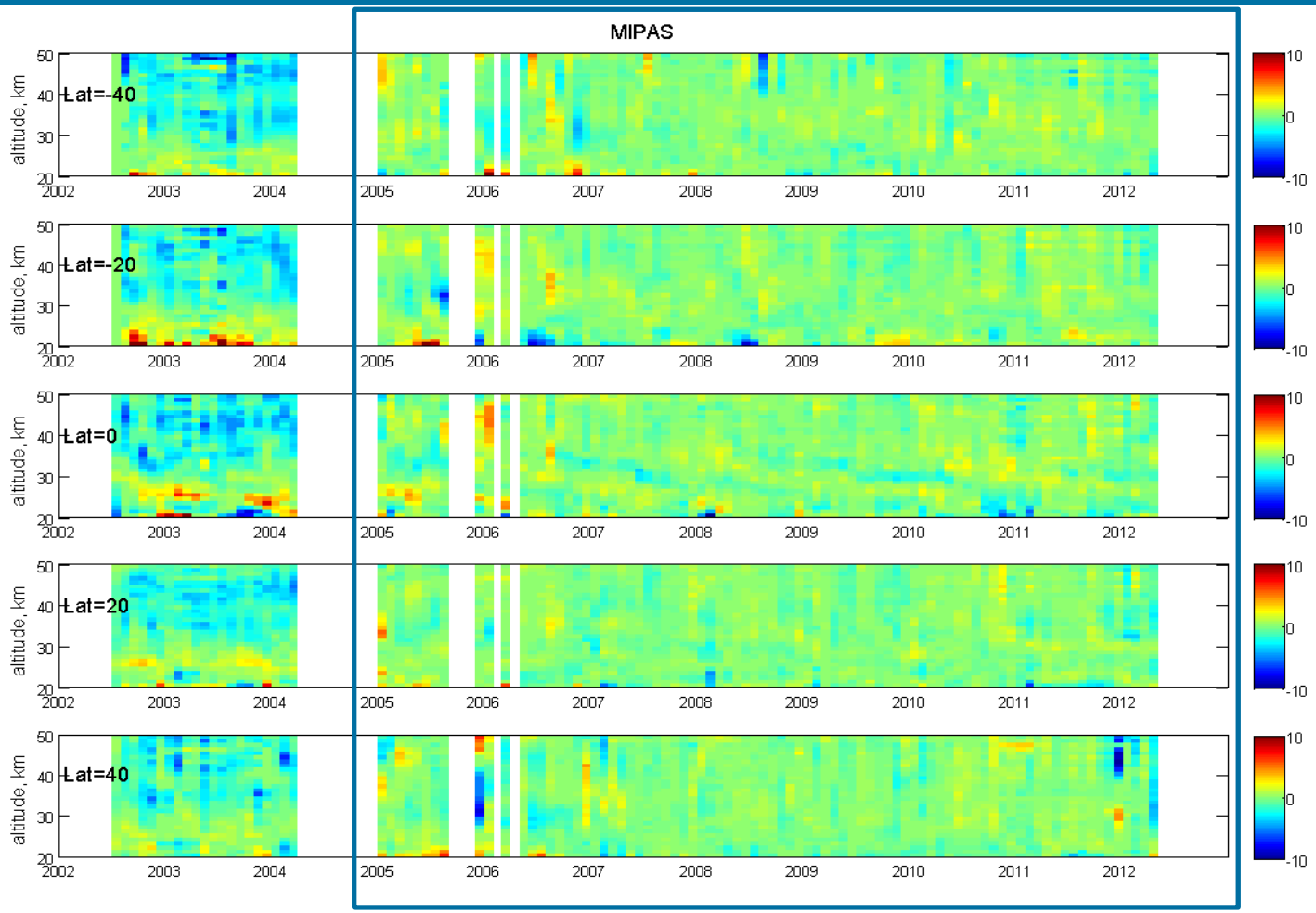
- **Evaluation of drifts with respect to the networks of ground-based instruments (D. Hubert et al.)**
  - Using collocated data
- **Analyses of deviations of deseasonalized anomalies from individual instruments from the median deseasonalized anomaly**



Example:
30-40 S

Deviation (%) from the median anomaly

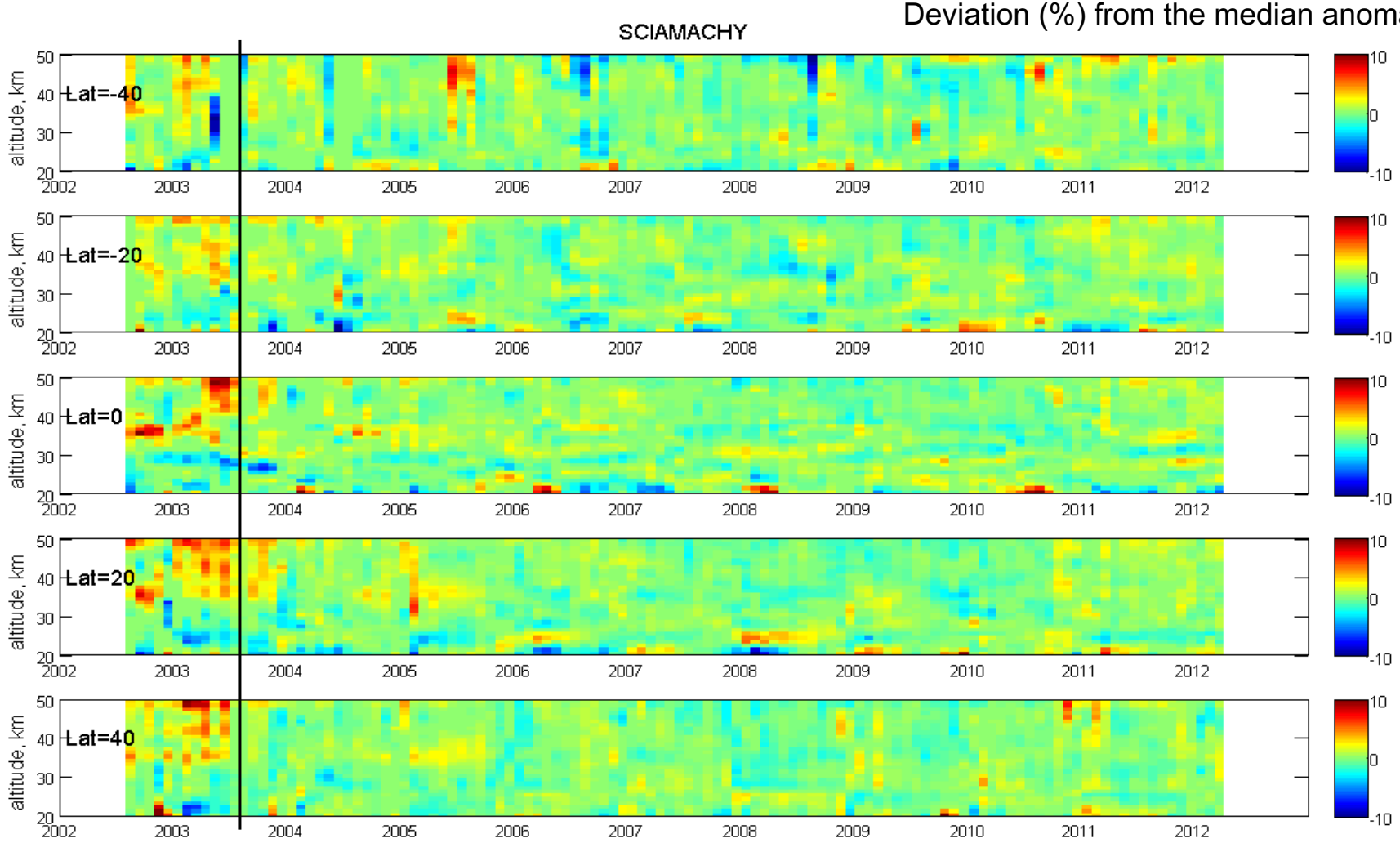
MIPAS: using the optimal resolution period only



Deviation (%) from the median anomaly

- **MIPAS data before 2005 (full-resolution) and after 2005 (optimal resolution) have different vertical resolution and should be considered as different datasets**
- **The full-resolution period is too short for reliable determination of deseasonalized anomalies**
- **It was decided using only the optimal resolution period (2005-2012)**

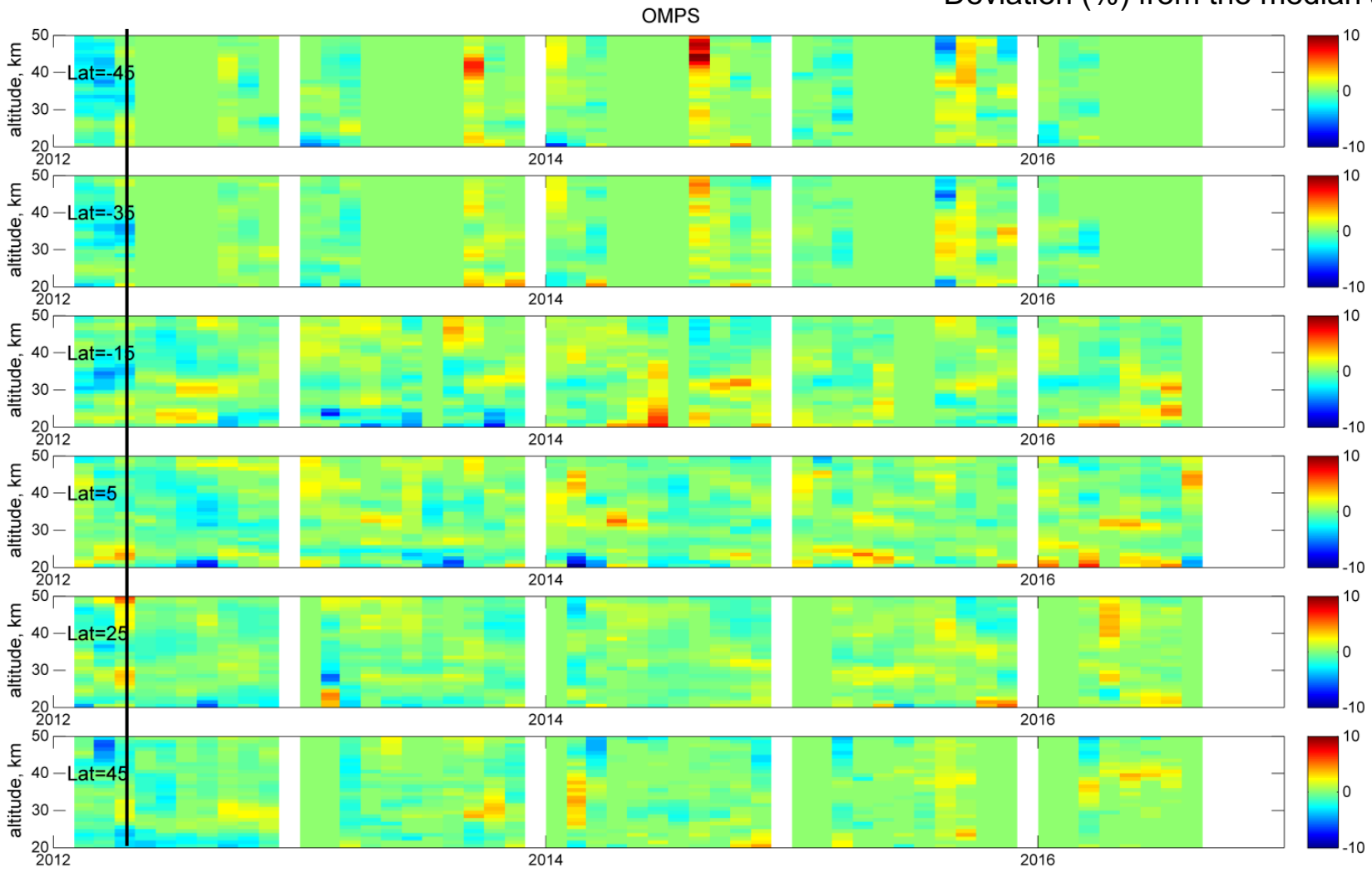
SCIAMACHY: using data after August 2003



Beginning of the SCIA mission: possible problems with pointing

OMPS: using data starting in April 2012

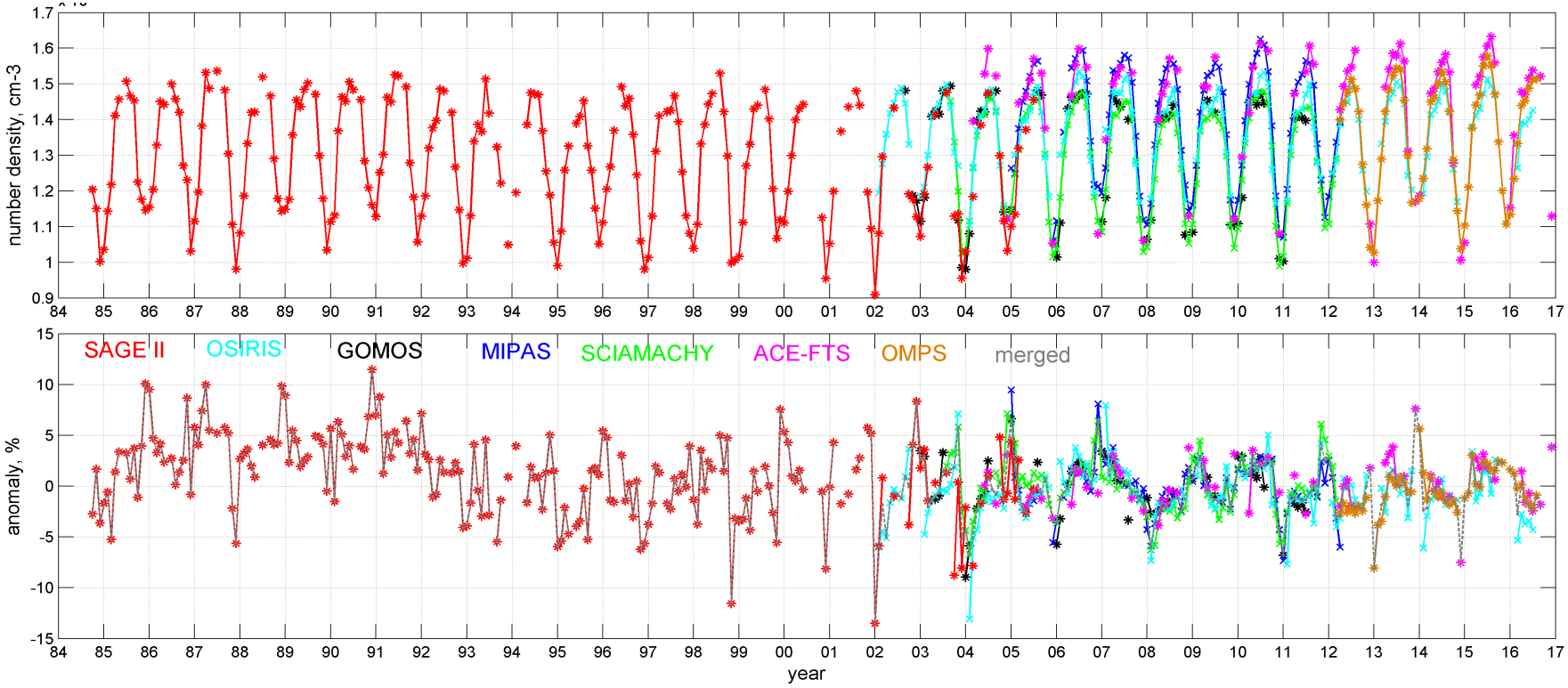
Deviation (%) from the median anomaly



Beginning of the OMPS mission: too scarce sampling and possible problems with pointing

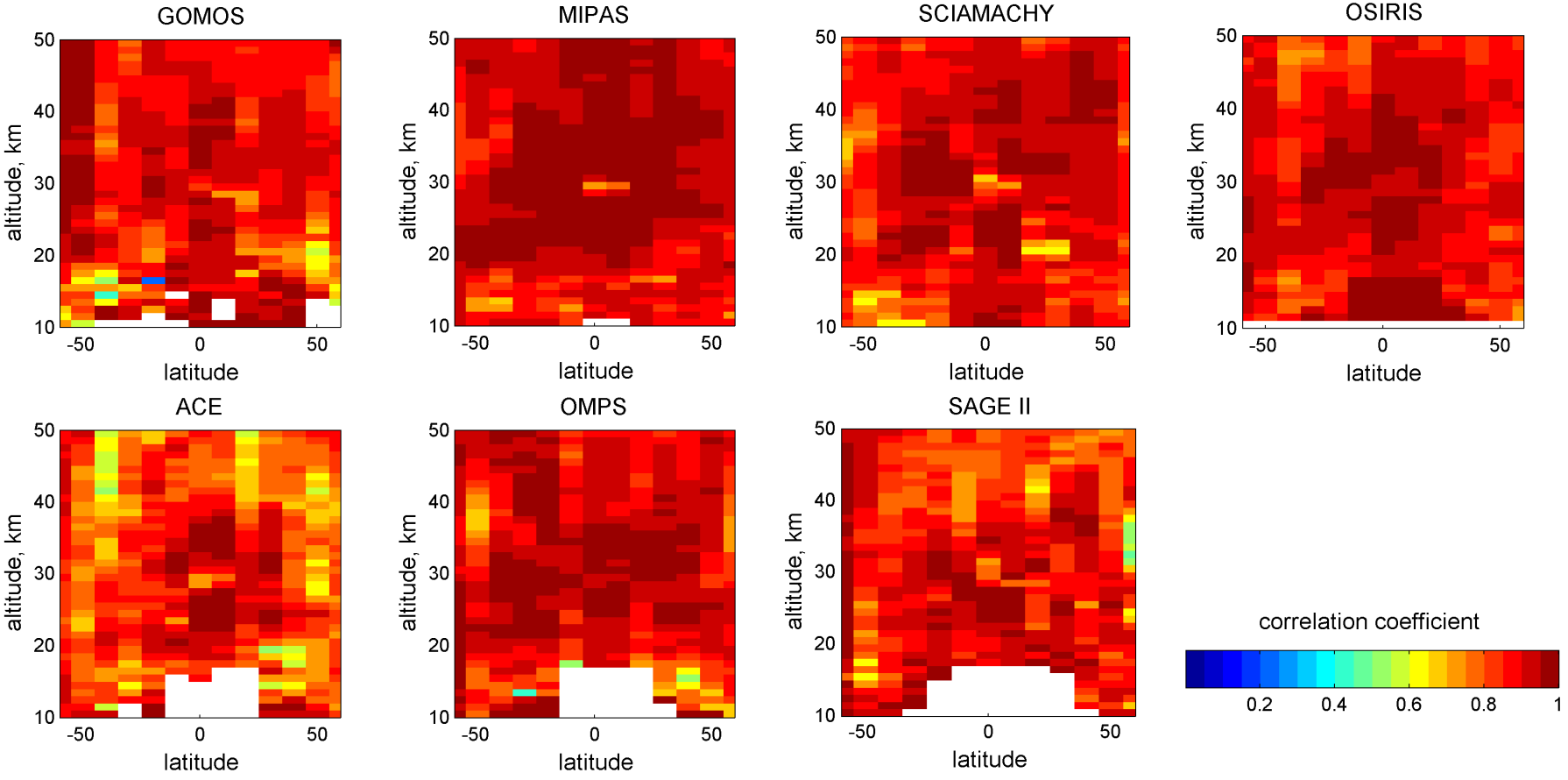
Data merging

- **The merged anomaly is the median anomaly of the anomalies from individual instruments, for each altitude level and for each latitude zone.**
- **Ozone_cci (OSIRIS, GOMOS, MIPAS, SCIAMACHY, ACE-FTS): seasonal cycle evaluated using 2005-2011**
- **SAGE II: seasonal cycle is evaluated in1985-2004, offset to the mean CCI anomaly in 2002-2004**
- **OMPS: seasonal cycle is evaluated in 2012-2016, offset to the mean CCI anomaly in 2002-2016**



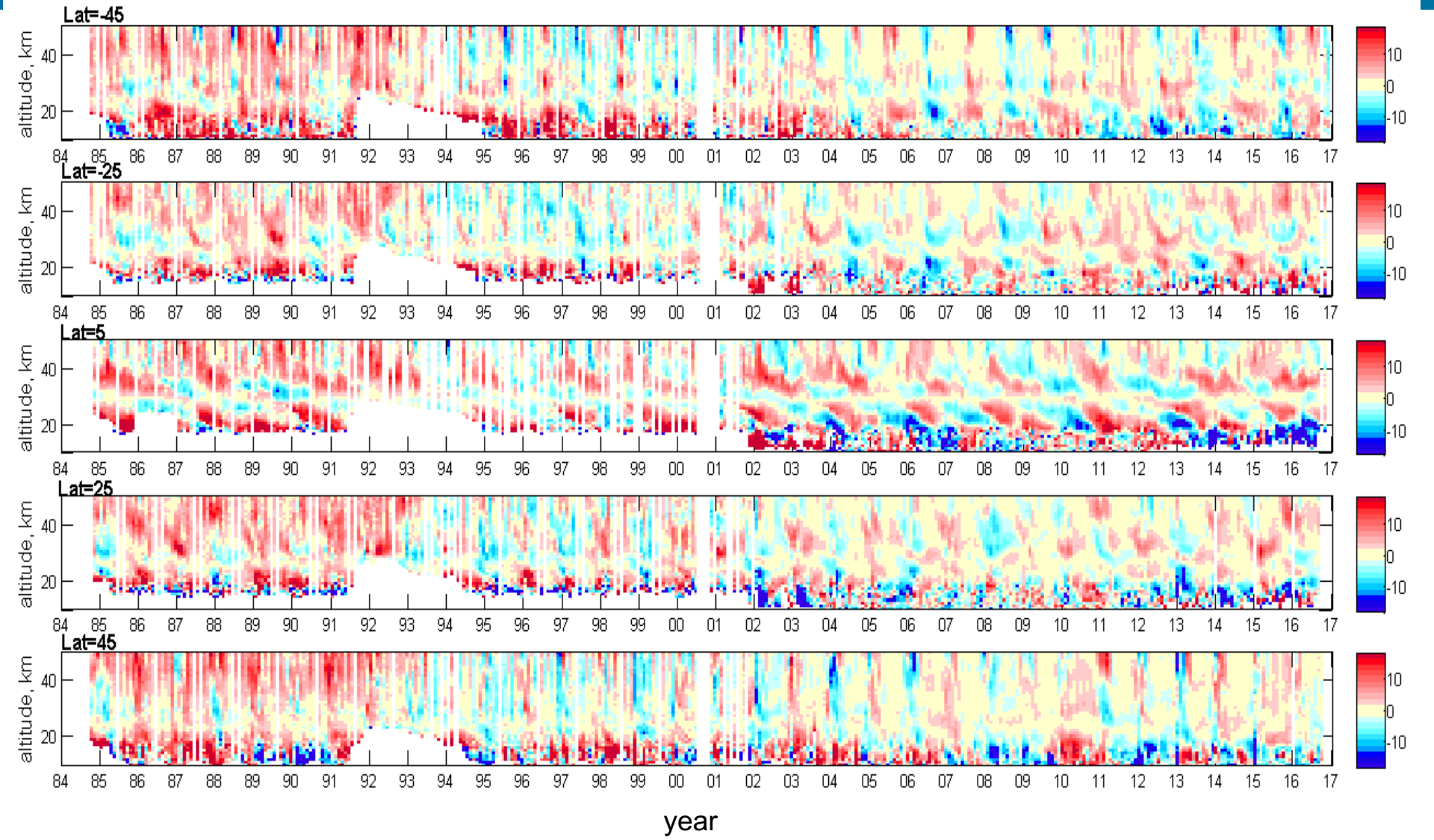
Top: monthly zonal mean ozone at 35 km in the latitude zone 40-50N. Bottom: individual deseasonalized anomalies and the merged anomaly (grey).

Very good correlation between data records from individual instruments



Correlation coefficient between individual and merged deseasonalized anomalies in the period 2001-2016, at latitudes 60°S - 60°N.

Examples of merged anomalies

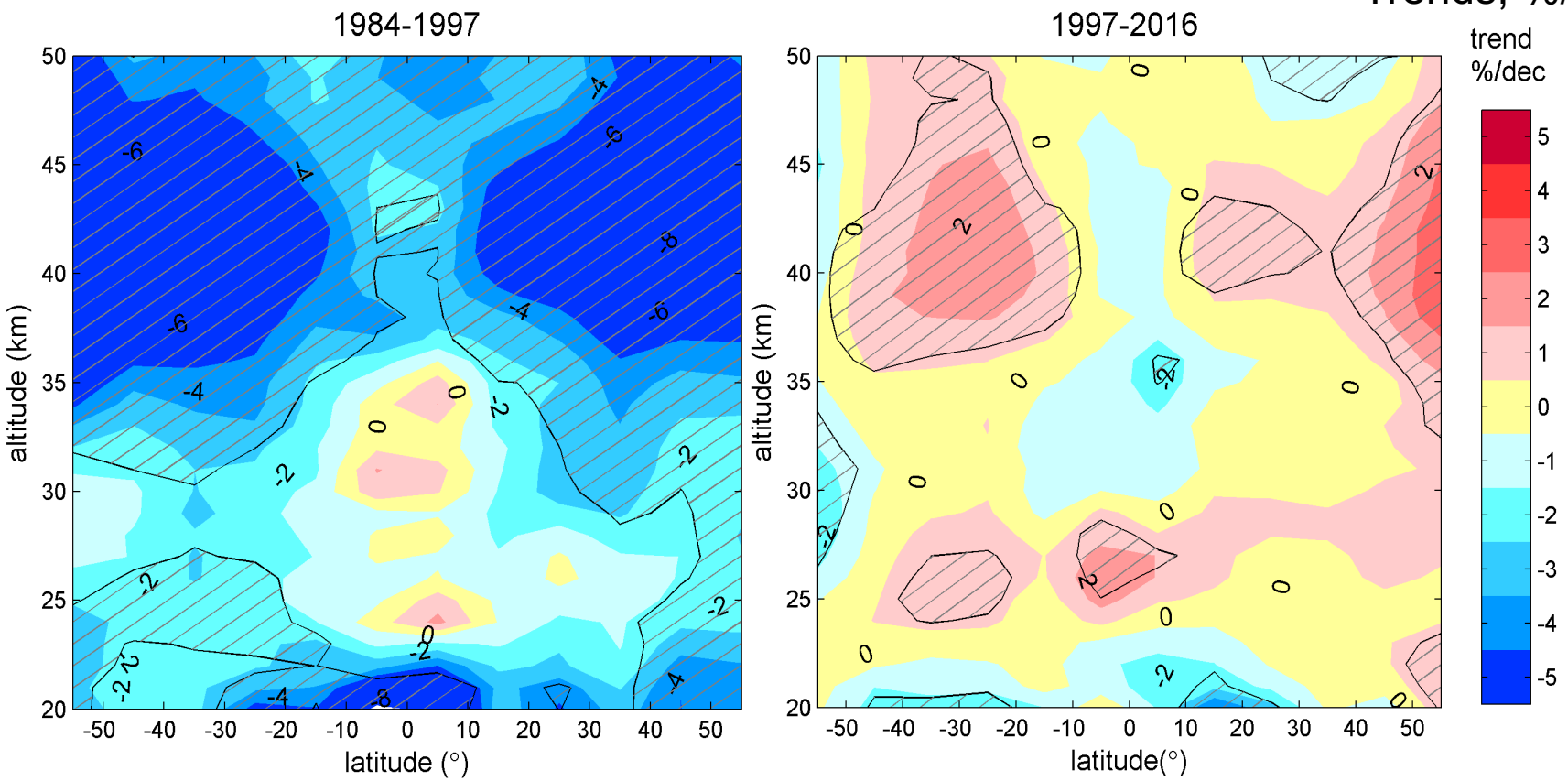


Deseasonalized anomalies in %, for several latitude zones

Assessment of ozone trends

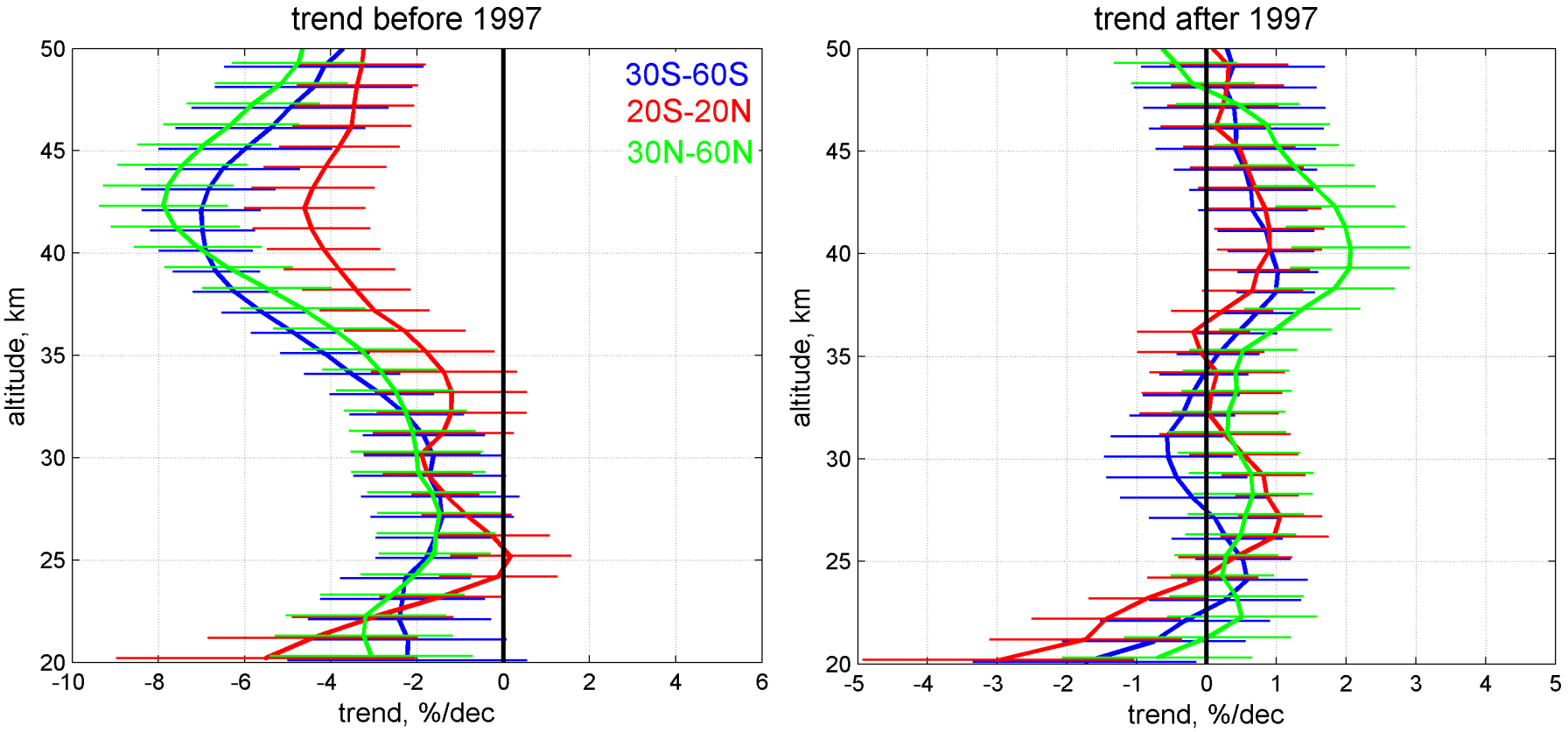
$$O_3(t) = PWLT(t,t_0) + q_1 QBO_{30}(t) + q_2 QBO_{50}(t) + s\,F_{10.7}(t) + d\,ENSO(t)$$

Trends, %/dec



Piece-wise linear trend with turnaround point in 1997, solar flux , QBO, ENSO
Shaded=statistically different from zero at 95% level

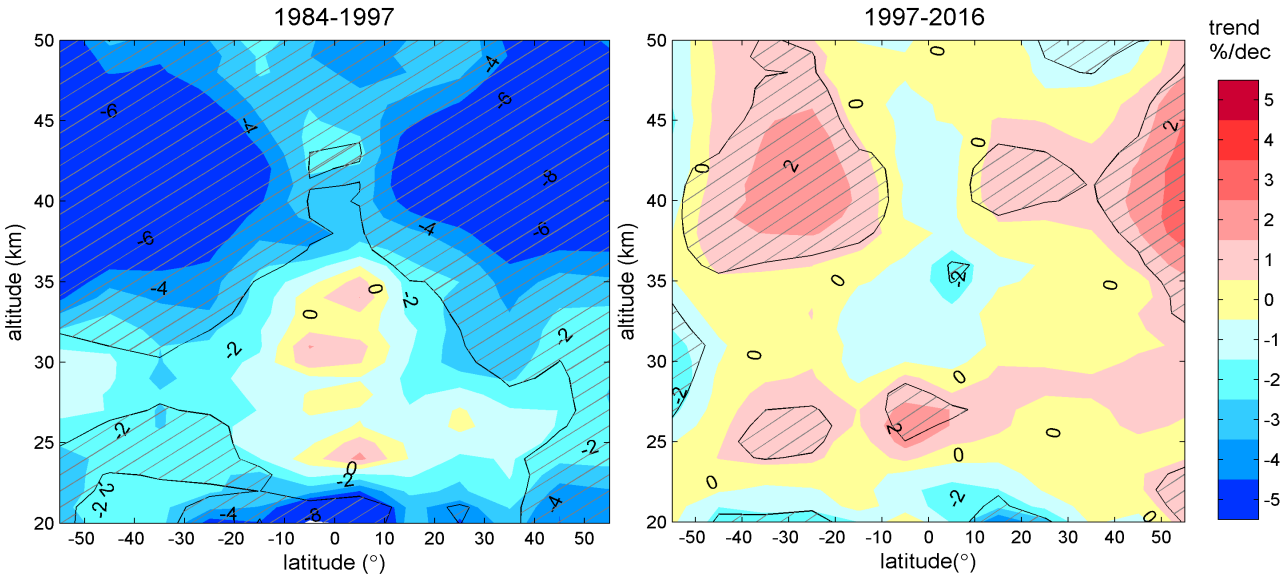
Trends on broad latitude bands



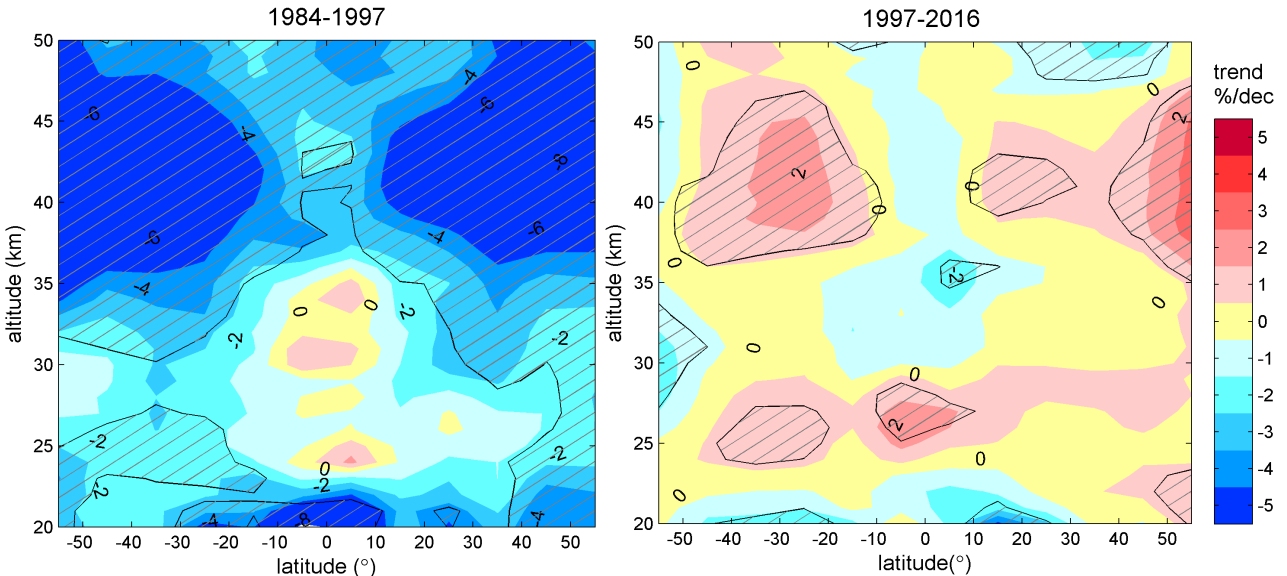
2σ error bars

Sensitivity to data filtering

How trends will change if not excluding initial periods of OMPS and SCIA data?



Filtered SCIA and OMPS data

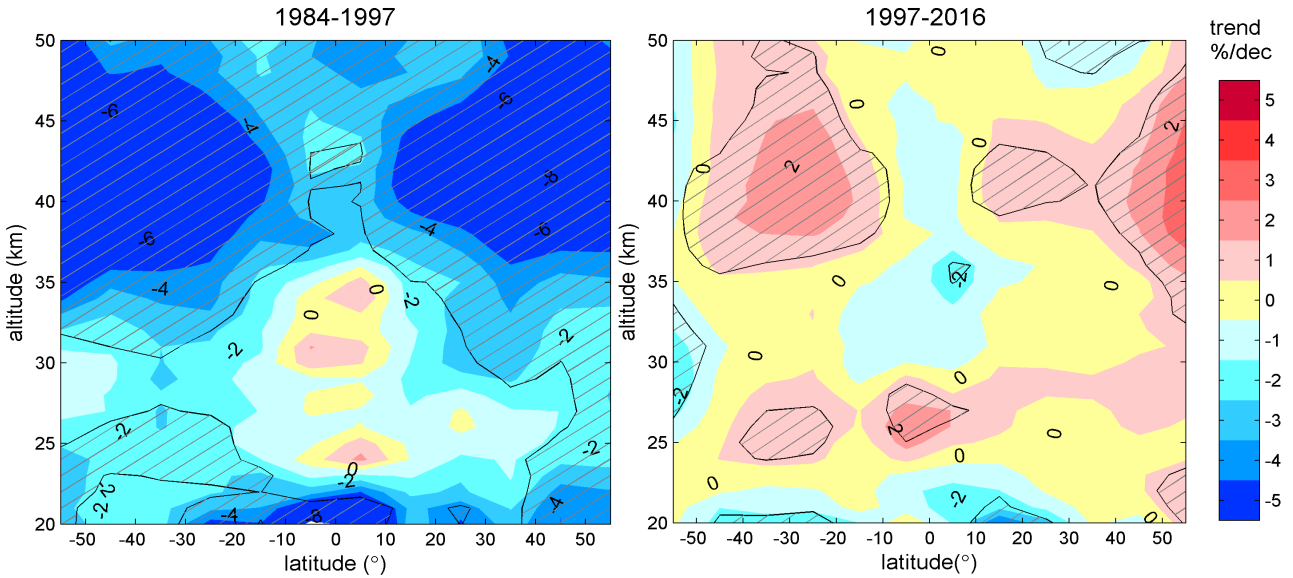


Not filtered SCIA and OMPS data

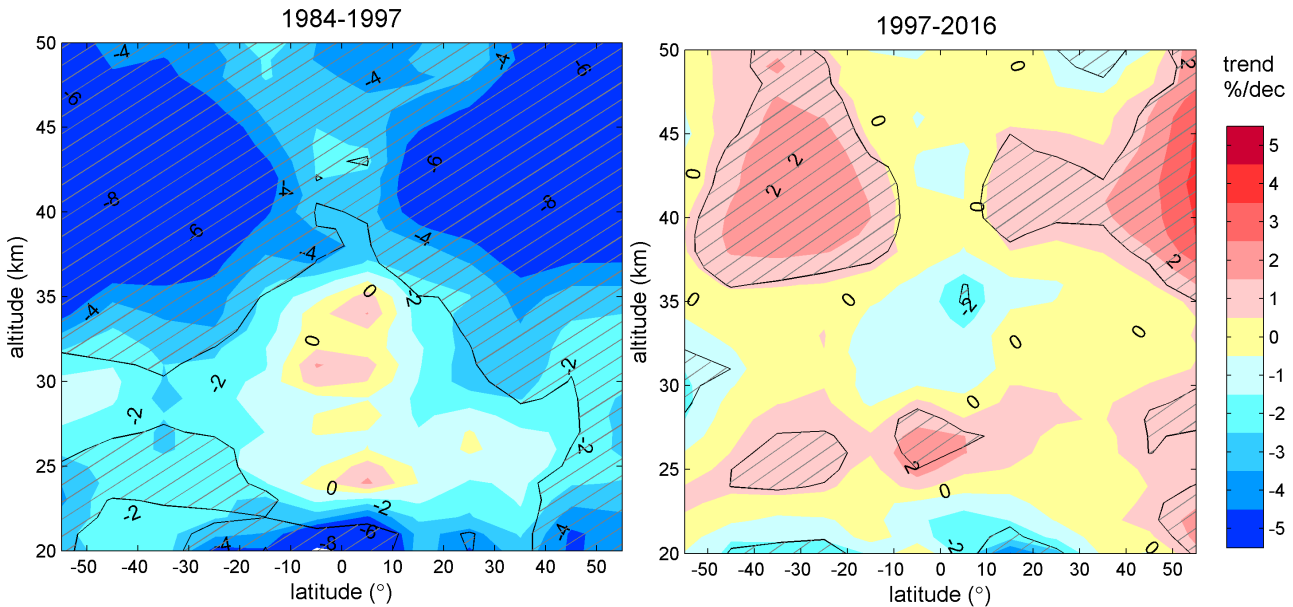
Very minor changes in evaluated trends after 1997

Using only instruments ”number density on altitude”

How trends will change if not using MIPAS and ACE-FTS data?



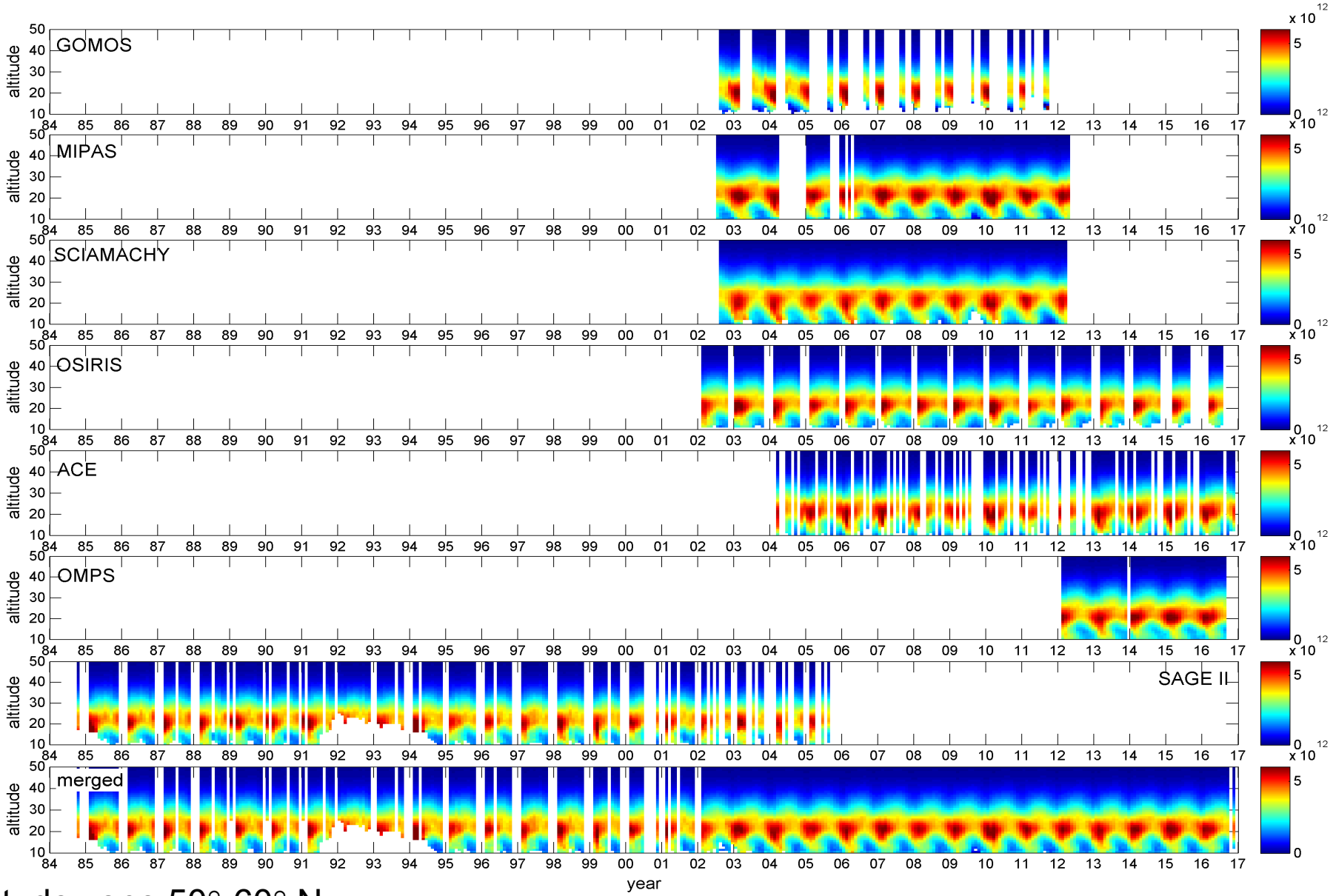
The main dataset



Without MIPAS and ACE-FTS

Minor changes in evaluated trends after 1997

Example of merged ozone profiles

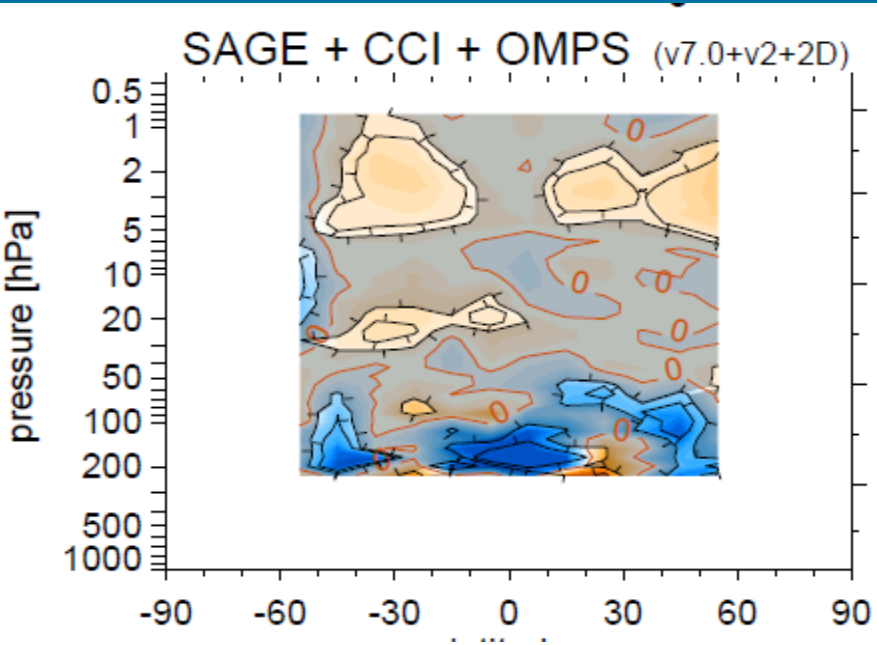


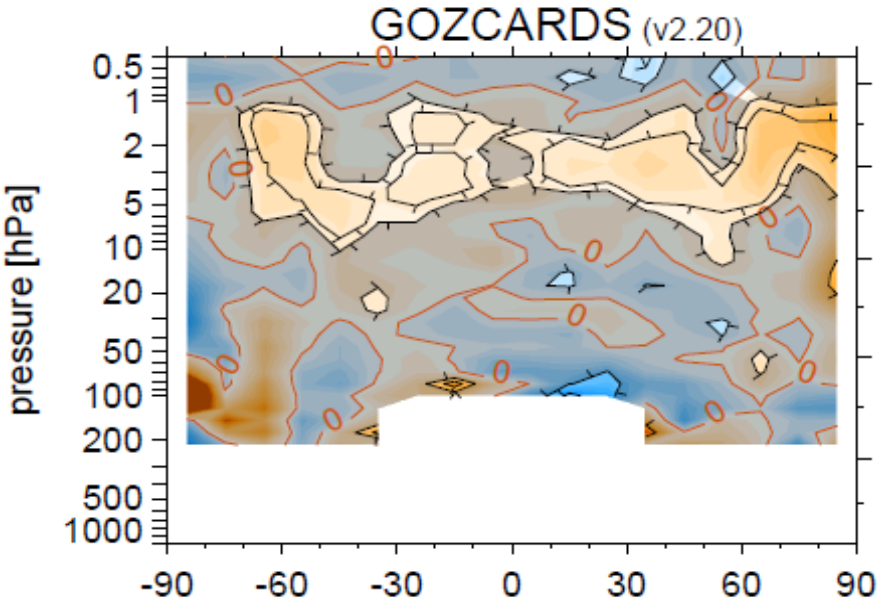
latitude zone 50°-60° N

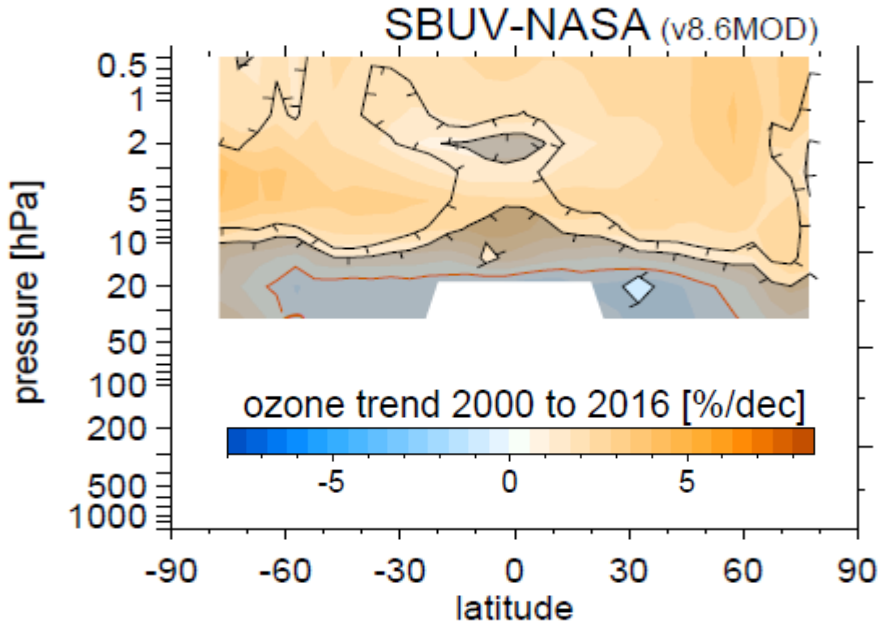
Summary

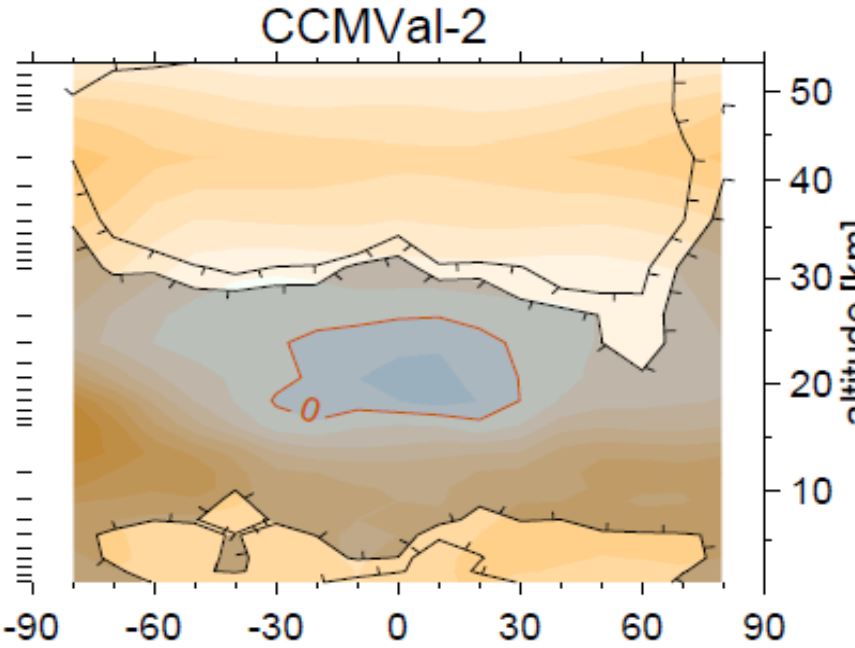
- **The merged SAGE II, Ozone_cci and OMPS dataset for trend analysis consists of merged deseasonalized anomalies of ozone**
  - The relative anomalies (presented in %) have zero mean over years 2005-2011
  - The ozone concentrations are also provided, but it is recommended using the anomalies directly for trend analysis
- **10° latitude zones from 90°S to 90°N**
- **The data are provided on altitude grid from 10 to 50 km (every km)**
- **October 1984 -July 2016**
- **Data format: netcdf-4**
- **The paper is submitted to ACP**

Study by W. Steinbrecht et al., ACP, 2017



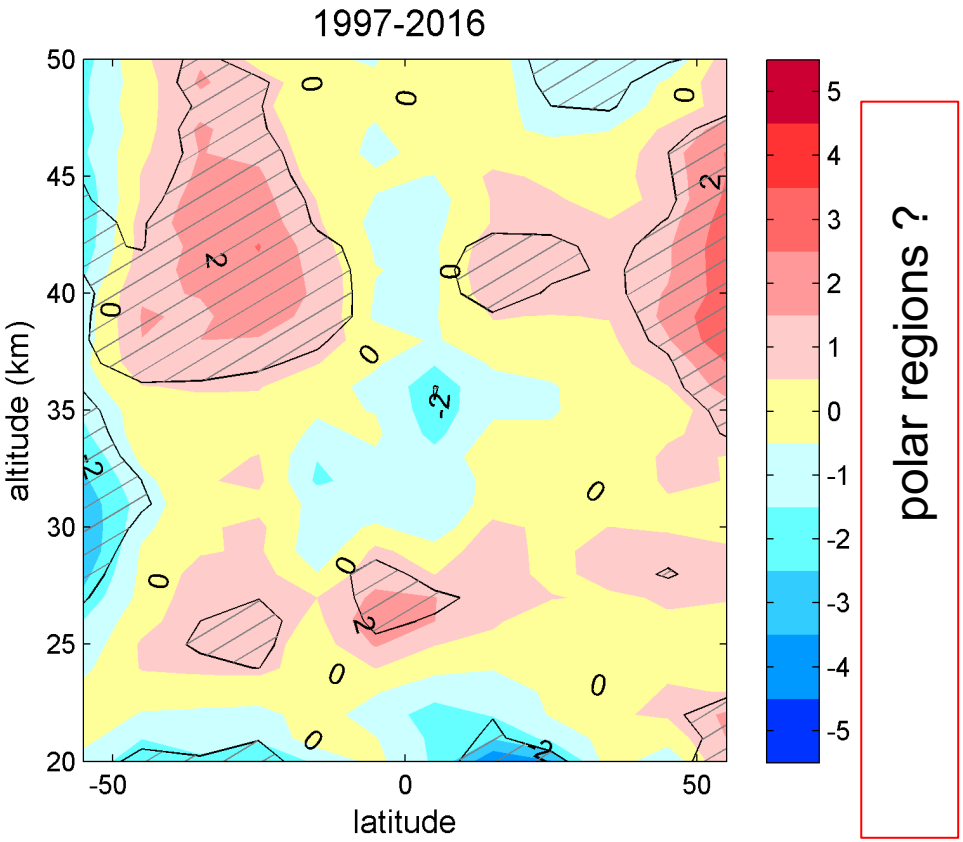






Ozone trends: open questions

mesosphere ?



polar regions ?

polar regions ?

UTLS ?

- For each of the specific regions, a specialized collection of datasets is required
- A special data analysis is needed
  - Separation by local time
  - Seasonal dependence of trends
  - Characterization of distributions
- All these are feasible