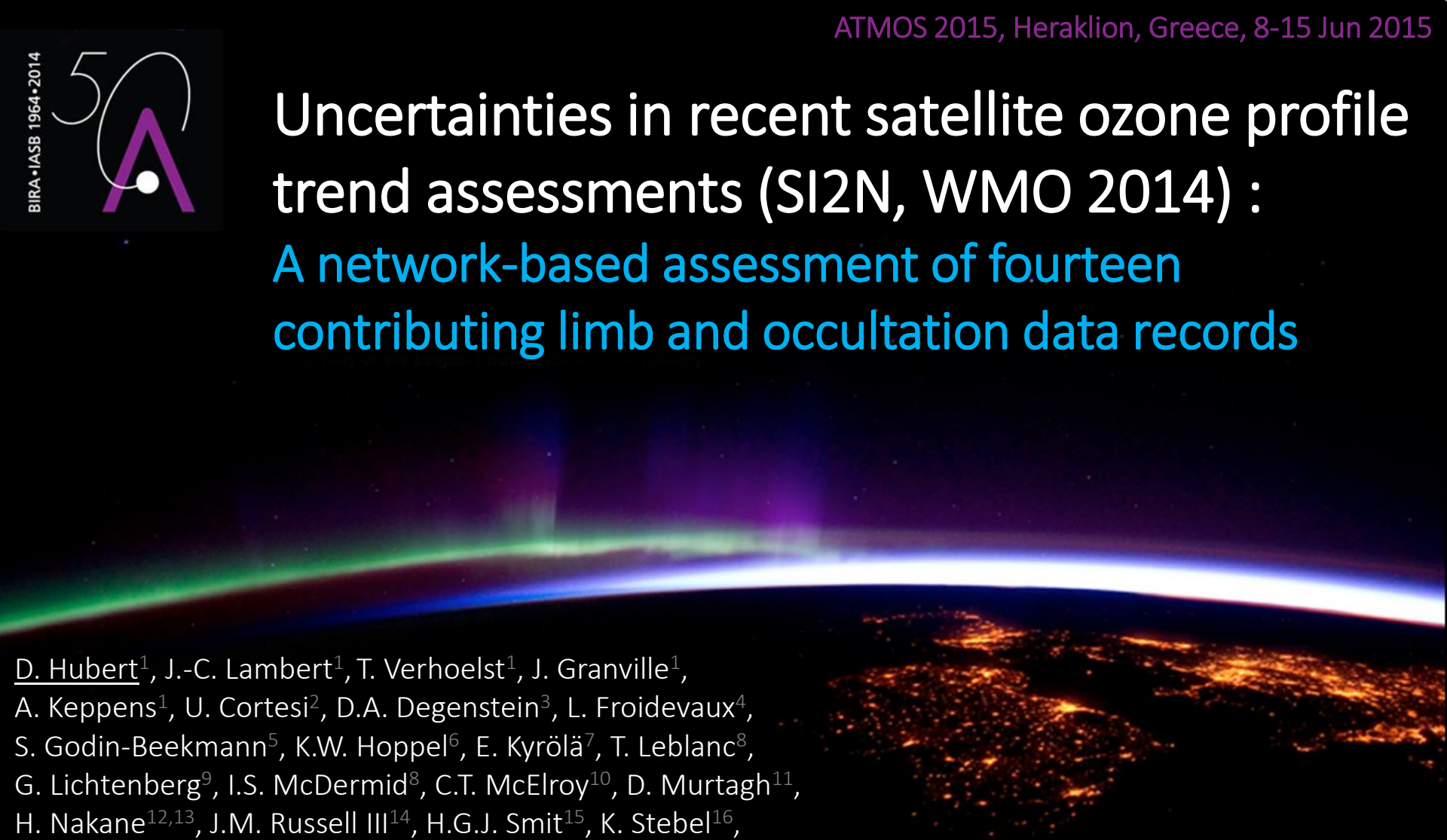
ATMOS 2015, Heraklion, Greece, 8-15 Jun 2015

Uncertainties in recent satellite ozone profile trend assessments (SI2N, WMO 2014) :

A network-based assessment of fourteen contributing limb and occultation data records

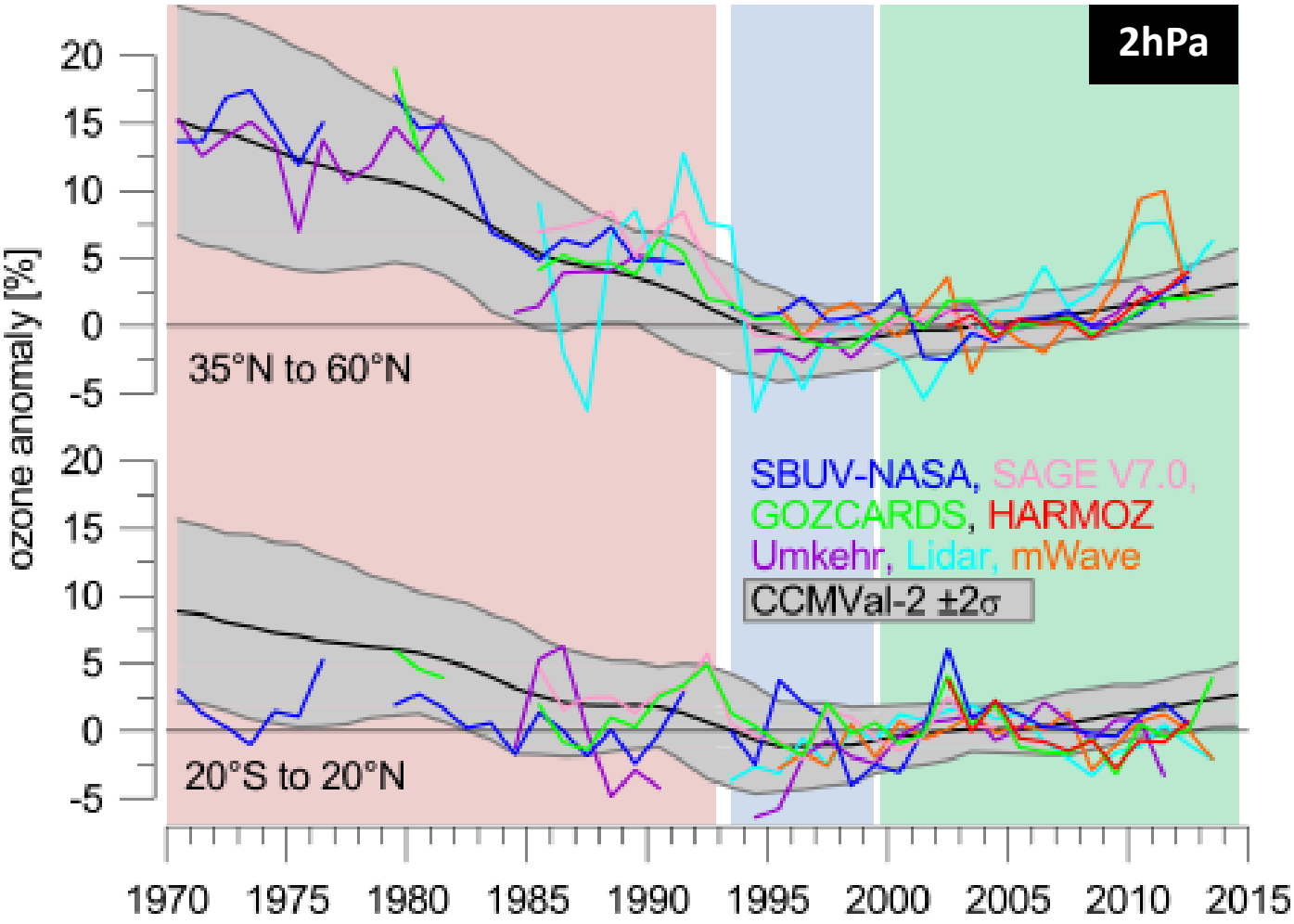


D. Hubert[1], J.-C. Lambert[1], T. Verhoelst[1], J. Granville[1], A. Keppens[1], U. Cortesi[2], D.A. Degenstein[3], L. Froidevaux[4], S. Godin-Beekmann[5], K.W. Hoppel[6], E. Kyrölä[7], T. Leblanc[8], G. Lichtenberg[9], I.S. McDermid[8], C.T. McElroy[10], D. Murtagh[11], H. Nakane[12,13], J.M. Russell III[14], H.G.J. Smit[15], K. Stebel[16], W. Steinbrecht[17], R. Stübi[18], D.P.J. Swart[19], G. Taha[20,21], A.M. Thompson[21], J. Urban[11], J.A.E. van Gijsel[22], P. von der Gathen[23], K.A. Walker[24] and J.M. Zawodny[25]

[1] BIRA-IASB, [2] IFAC-CNR, [3] U Saskatchewan, [4] JPL-Pasadena, [5] LATMOS-IPSL, [6] NRL, [7] FMI, [8] JPL-TMF, [9] DLR, [10] U York, [11] Chalmers U, [12] Kochi U, [13] NIES, [14] CAS, [15] FJ-IEK8, [16] NILU, [17] DWD, [18] MeteoSwiss, [19] RIVM, [20] USRA, [21] NASA-GSFC, [22] KNMI, [23] AWI, [24] U Toronto, [25] NASA-LaRC

Acknowledgements

ESA Ozone_cci, BelSPO/ProDEx A3C



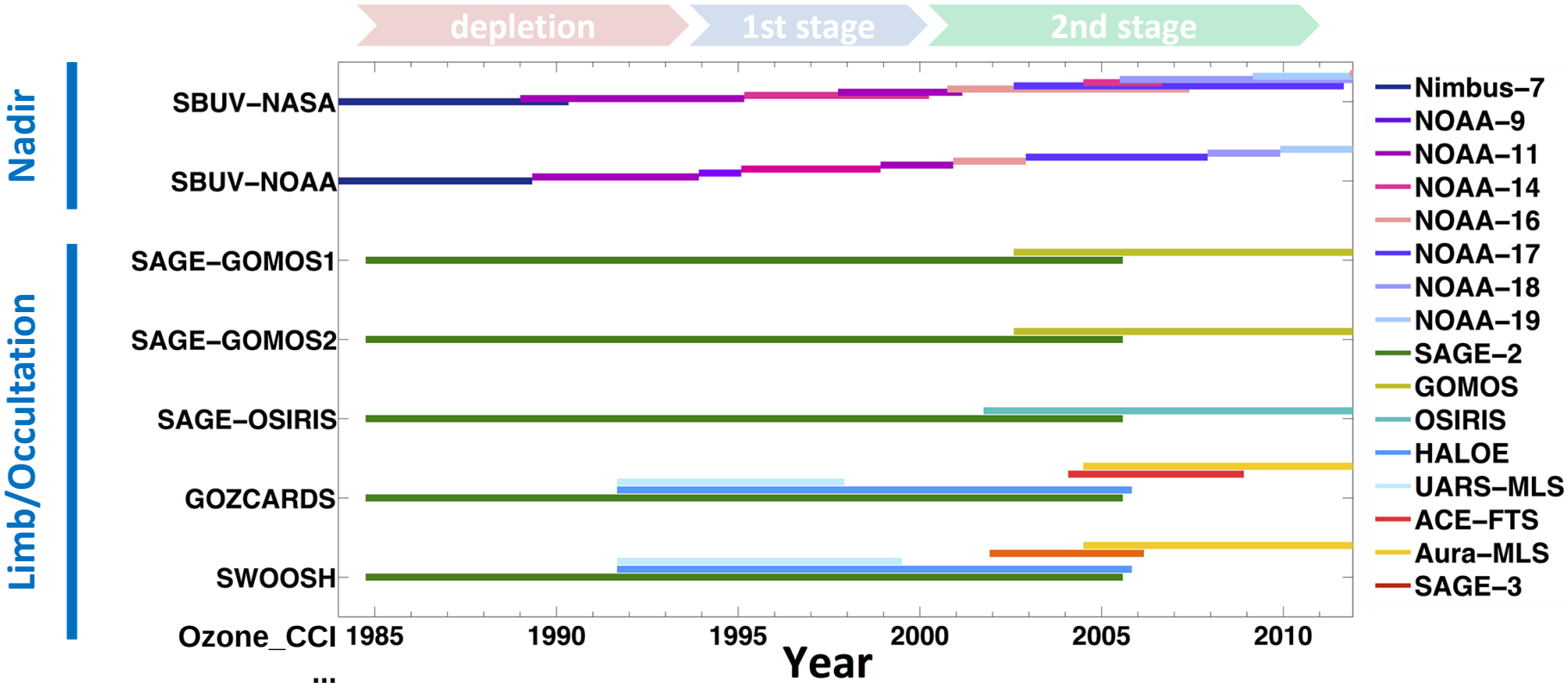
WMO 2014
Ozone Assessment

SI2N initiative
(special issue in
ACP/AMT/ESSD)

See talk by
J. Staehelin

Courtesy
WMO Rep. #55, 2015

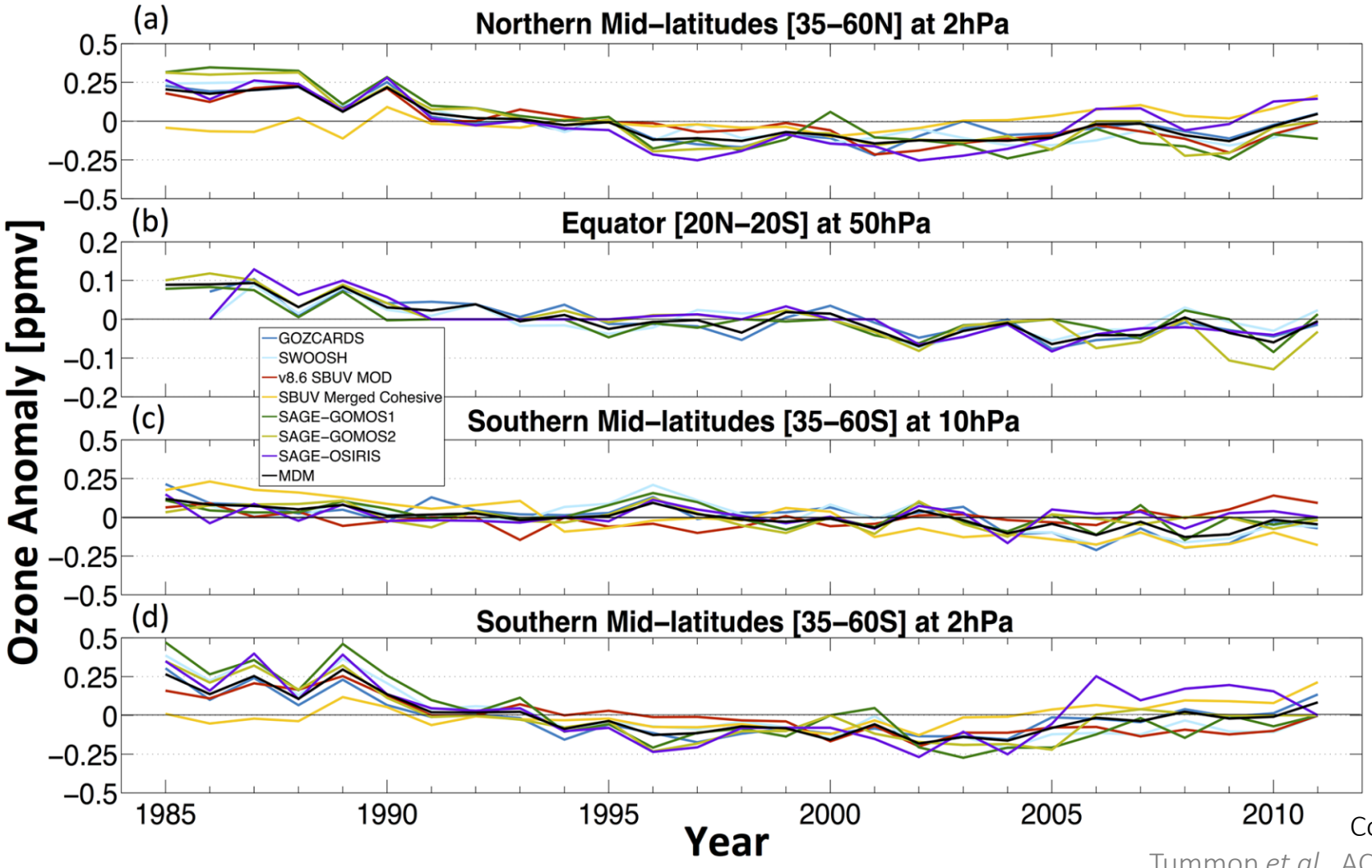
Ongoing debate…
"Is there significant evidence for the second stage of ozone recovery?"



Courtesy
Tummon *et al.*, ACP 2015

SI2N, WMO, CCI, GOZCARDS, …

Most activities focus on merging different satellite records.

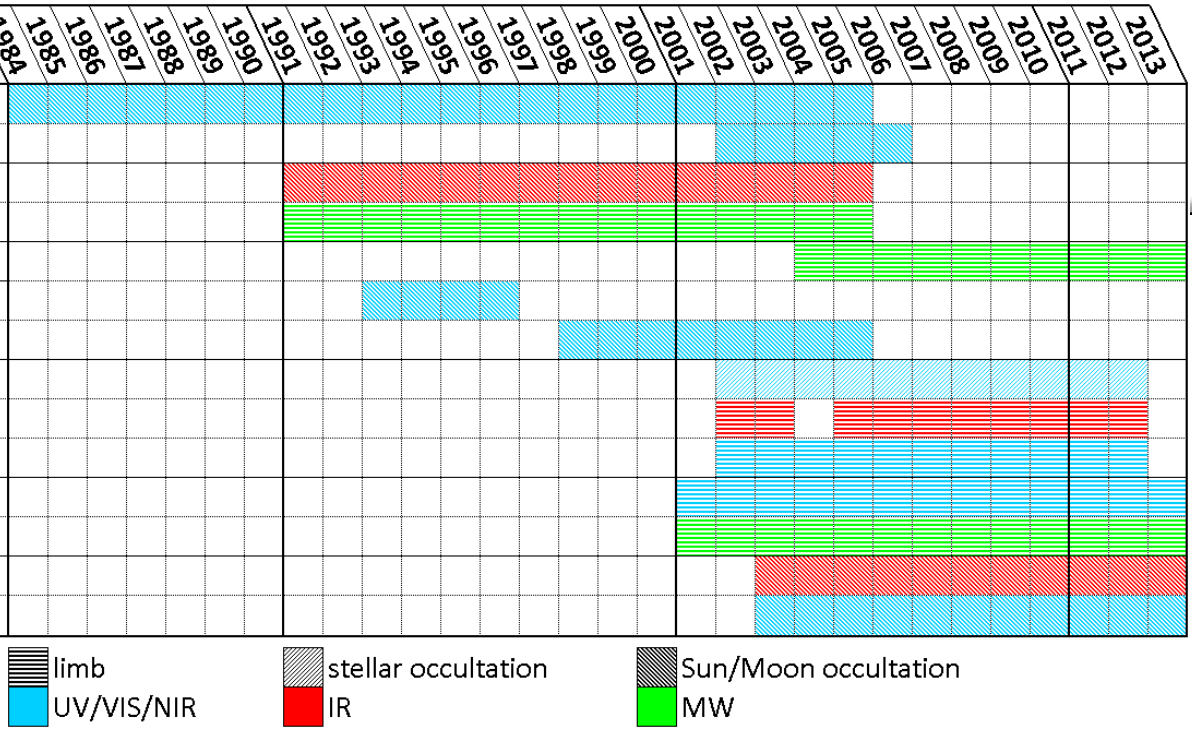


Courtesy Tummon *et al.*, ACP 2015

Tummon *et al.*, ACP (2015)…

"For the limb/occultation data sets […] the choice of instrument records to be merged was found to have a greater impact than the choice of merging technique."

MISSION	SOUNDER	VERSION
ERBS	SAGE II	LaRC v7.0
Meteor-3M	SAGE III	LaRC v4.0
UARS	HALOE	LaRC v19
	MLS	JPL v5
EOS Aura	MLS	JPL v3.3
SPOT 3	POAM II	NRL v6
SPOT 4	POAM III	NRL v4
Envisat	GOMOS	IPF 6.01
	MIPAS	ML2PP 6.0
	SCIAMACHY	SGP 5.02
Odin	OSIRIS	U Sask v5.07
	SMR	U Chalm v2.1
SCISAT-1	ACE-FTS	U Water v3.0
	MAESTRO	v1.2 VIS



Ground-based assessment of the bias and long-term stability of fourteen limb and occultation ozone profile data records

D. Hubert[1], J.-C. Lambert[1], T. Verhoelst[1], J. Granville[1], A. Keppens[1], J.-L. Baray[2], U. Cortesi[3], D. A. Degenstein[4], L. Froidevaux[5], S. Godin-Beekmann[6], K. W. Hoppel[7], E. Kyrölä[8], T. Leblanc[9], G. Lichtenberg[10], C. T. McElroy[11], D. Murtagh[12], H. Nakane[13,14], J. M. Russell III[15], J. Salvador[16], H. G. J. Smit[17], K. Stebel[18], W. Steinbrecht[19], K. B. Strawbridge[20], R. Stübi[21], D. P. J. Swart[22], G. Taha[23,24], A. M. Thompson[24], J. Urban[12,†], J. A. E. van Gijsel[25], P. von der Gathen[26], K. A. Walker[27,28], E. Wolfram[16], and J. M. Zawodny[29]

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[2]Laboratoire de Météorologie Physique, Observatoire de Physique du Globe de Clermont-Ferrand, France
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Accepted for AMTD
(online in the next few weeks)

Analysis methodology
Three design principles

I. Compare fourteen limb/occultation satellite records to co-located ground-based observations
   - NDACC/WOUDC/SHADOZ ozonesonde: ground up to ~33 km
   - NDACC stratospheric ozone lidar: tropopause up to ~47 km

II. Minimize number of manipulations of satellite record

   e.g. by using satellite profile grid & representation for the comparison

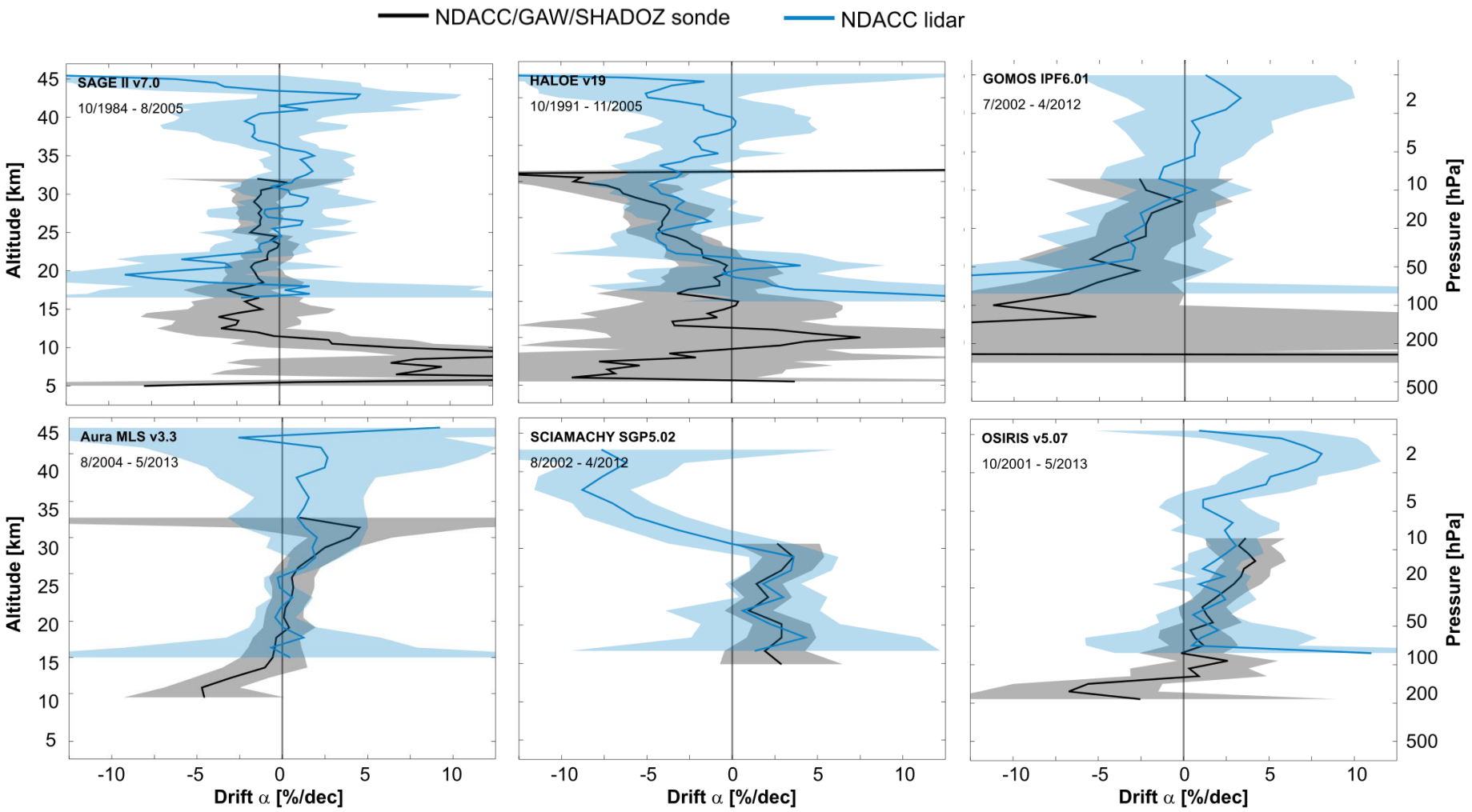
III. Harmonized analysis framework using robust statistical techniques

   apart from some unavoidable differences in preprocessing, all analysis steps and code is identical
   → observed inconsistencies between records are hence unlikely of methodological nature

Study vertical (and meridian) structure of

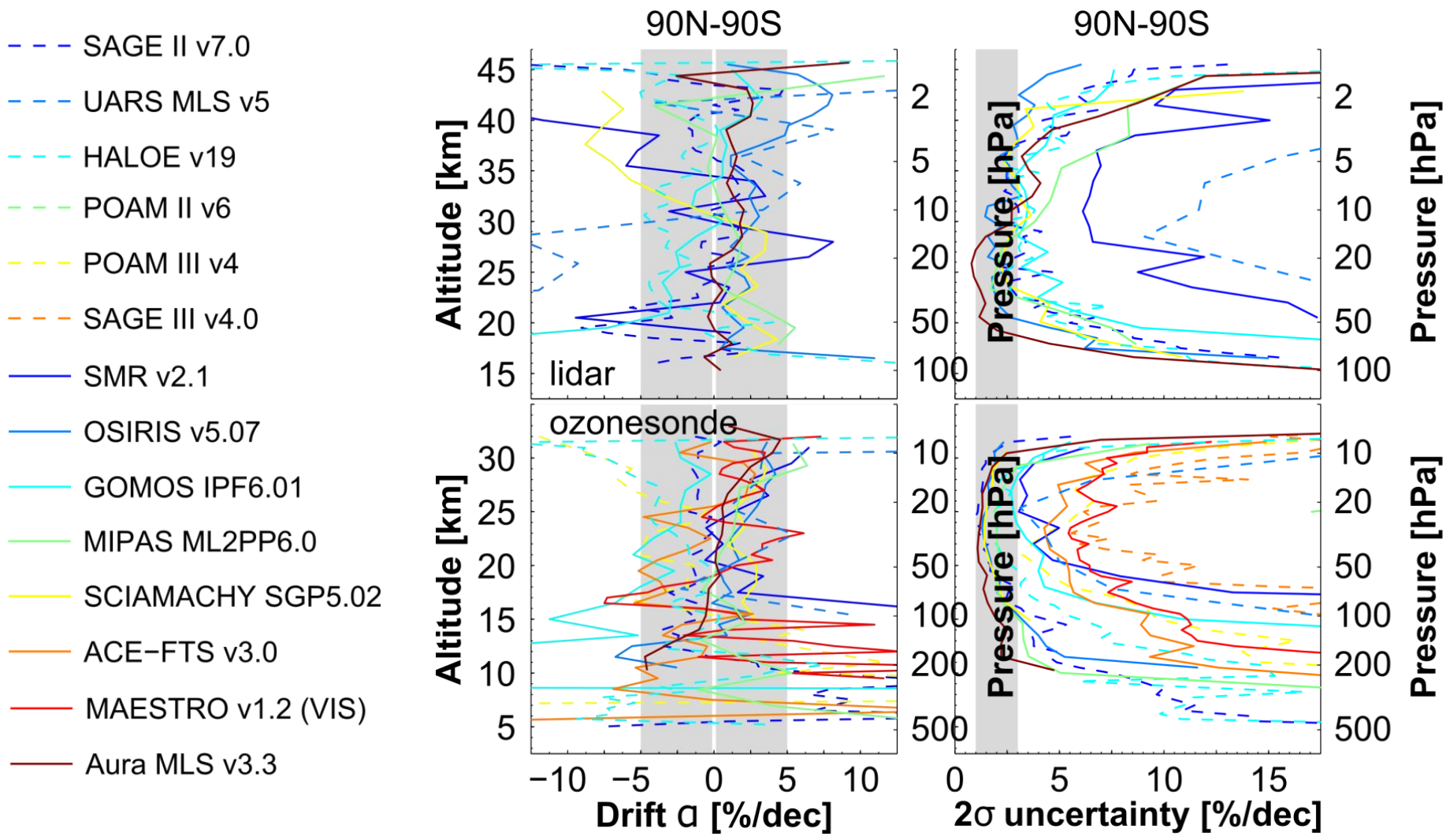
$$\Delta x_i(z,t) = 100 \times \frac{x_{SAT,i}(z,t) - x_{GND,i}(z,t)}{x_{GND,i}(z,t)}$$

- Long-term stability
- Bias
- Short-term variability
- + impact auxiliary data



Long-term stability averaged over ground network

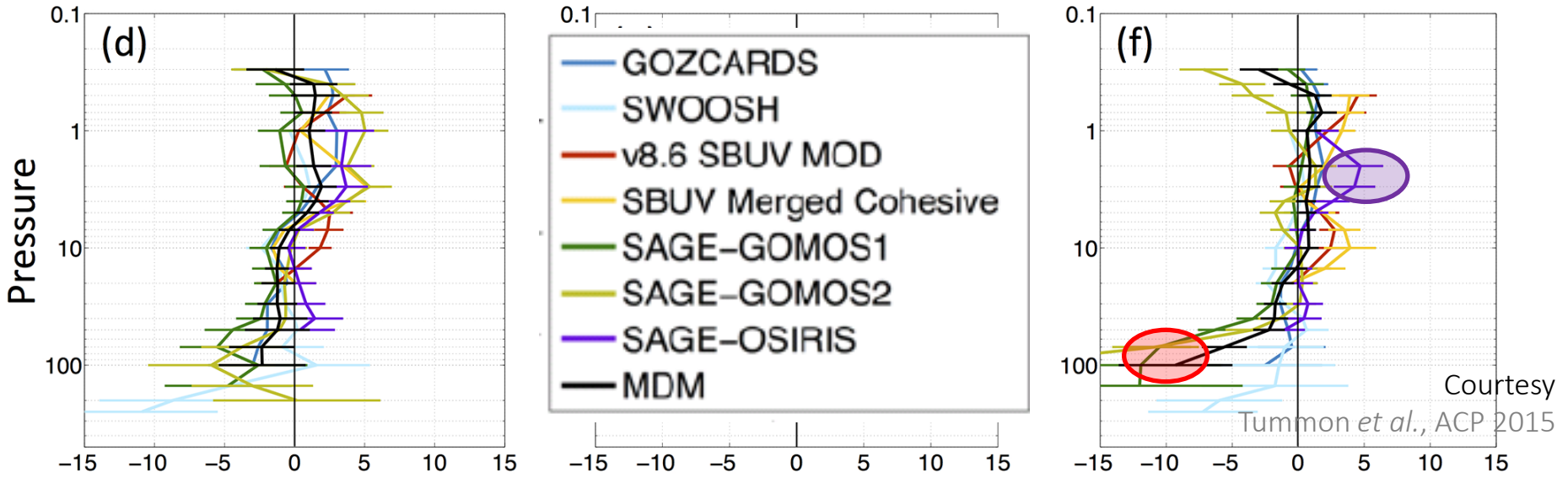
- Excellent agreement between ozonesonde and stratospheric ozone lidar results
- Some satellite records drift significantly



Multi-mission consistency long-term stability

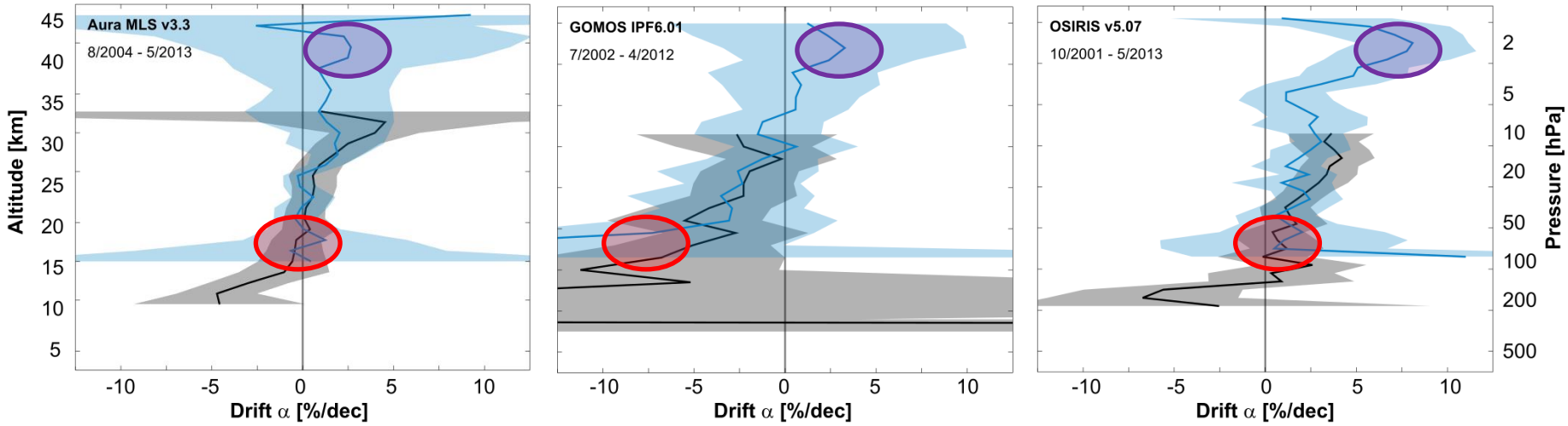
- Instrumental drift typically less than ±5% per decade, some less than ±3% per decade
- Some records drift significantly by up to ± 8% per decade
- 2σ uncertainty is larger than 5% per decade for half of the records

Trend 1998-2011



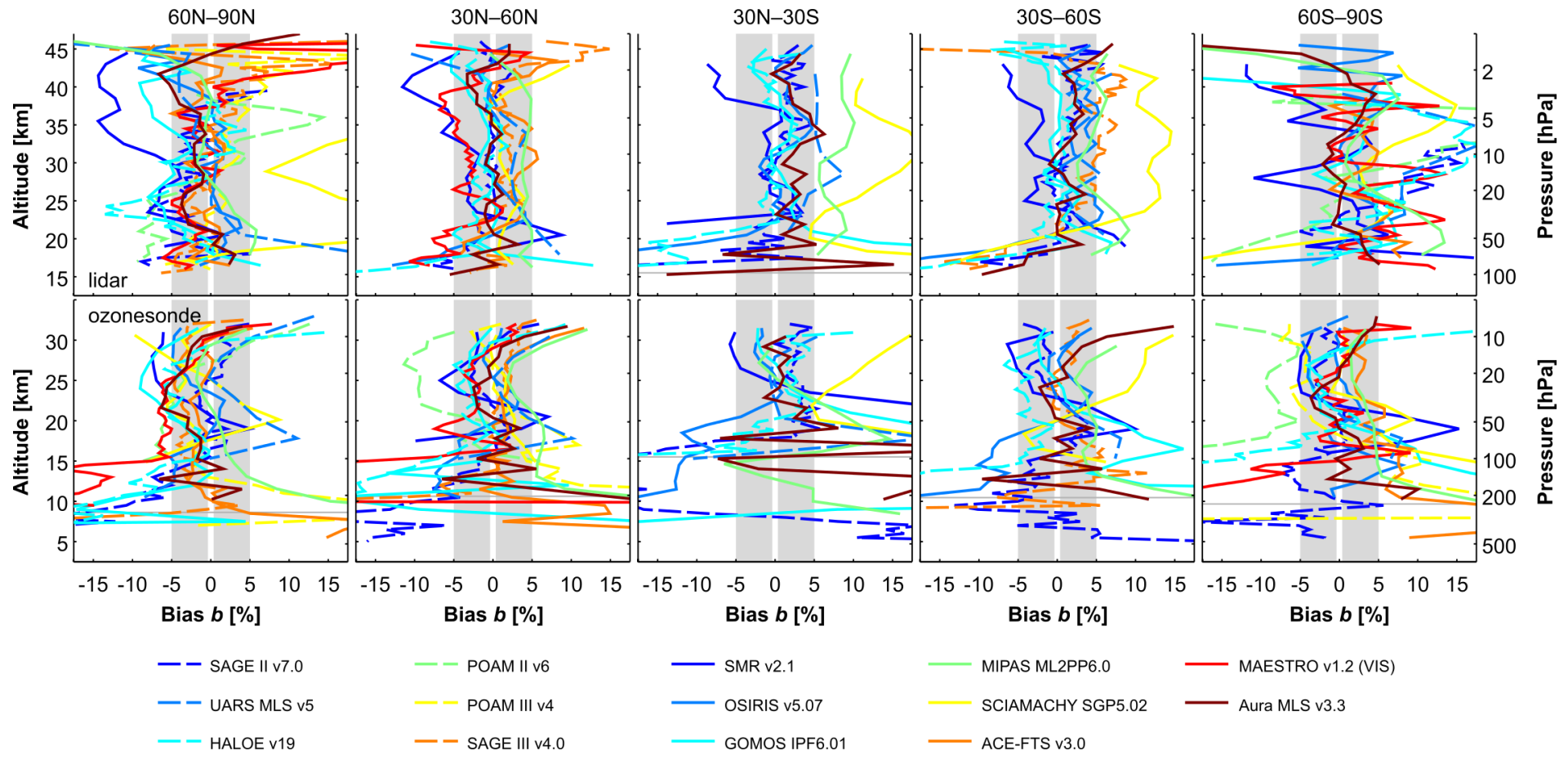
Courtesy
Tummon *et al.*, ACP 2015

Drift last decade



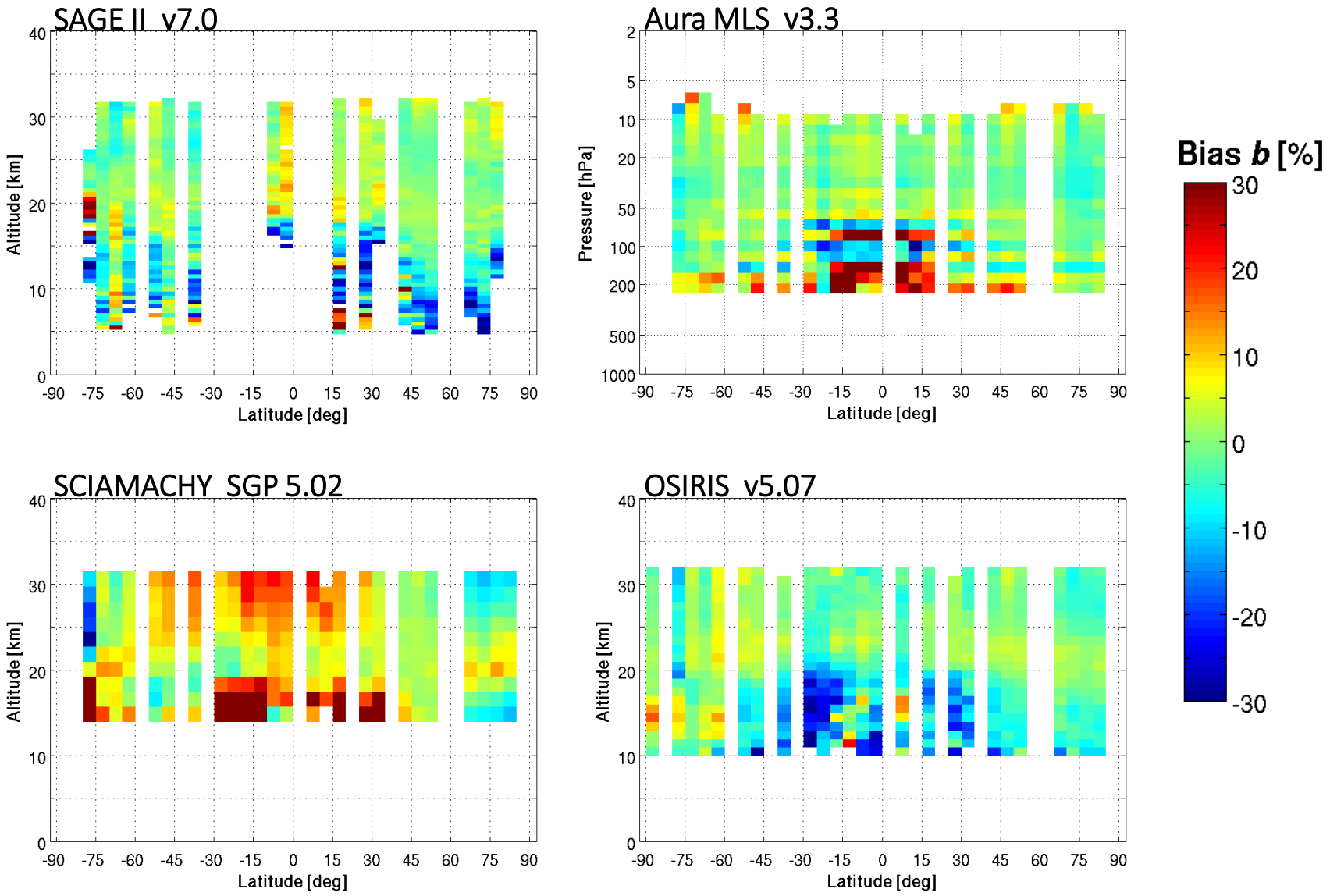
Trend differences can be explained by drift!

There may be more latitudinal structure than can be detected by our method.

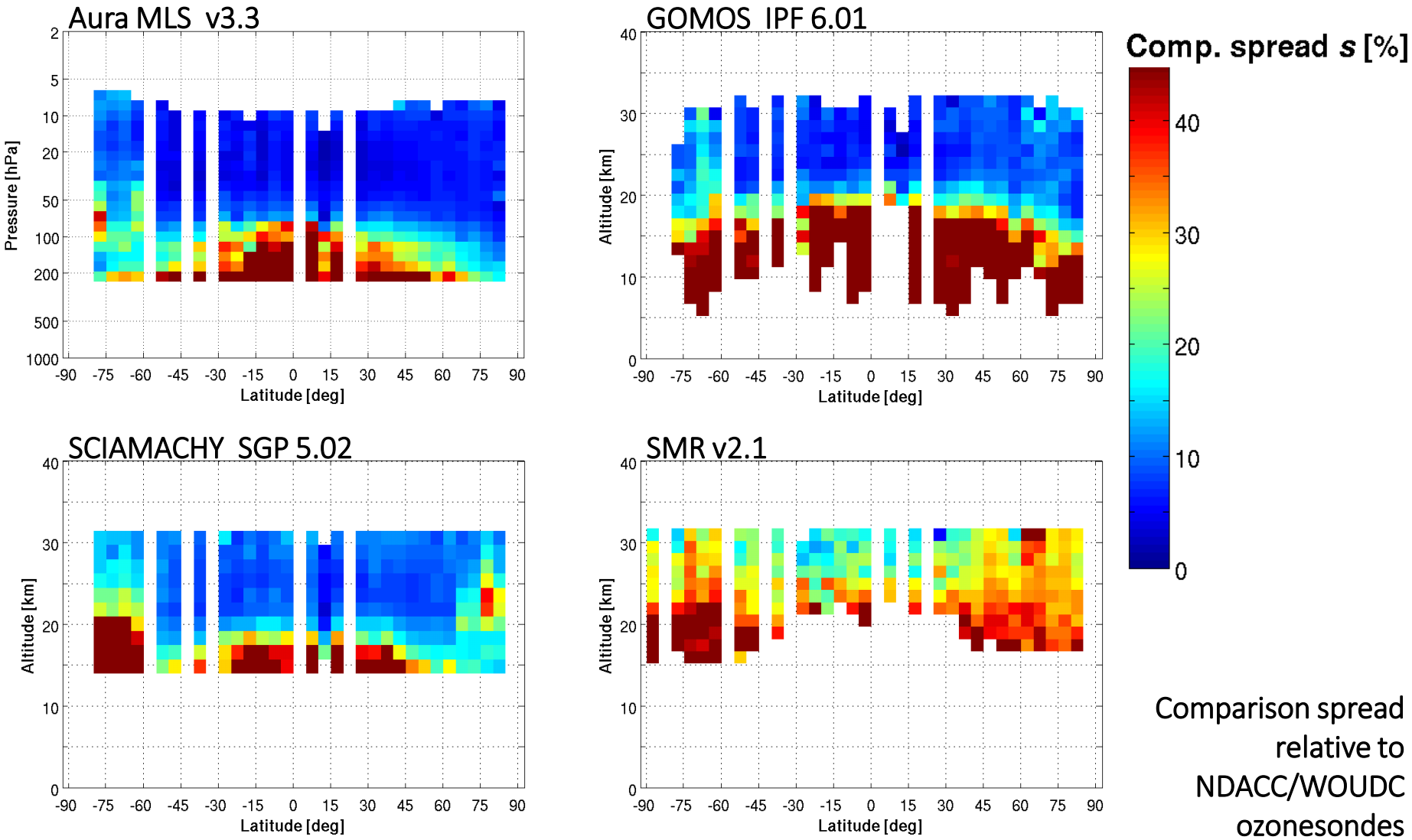


Multi-mission consistency overall bias

Median bias generally less than ±5%, but there are complicated patterns which merging schemes must correct for in sufficient detail.



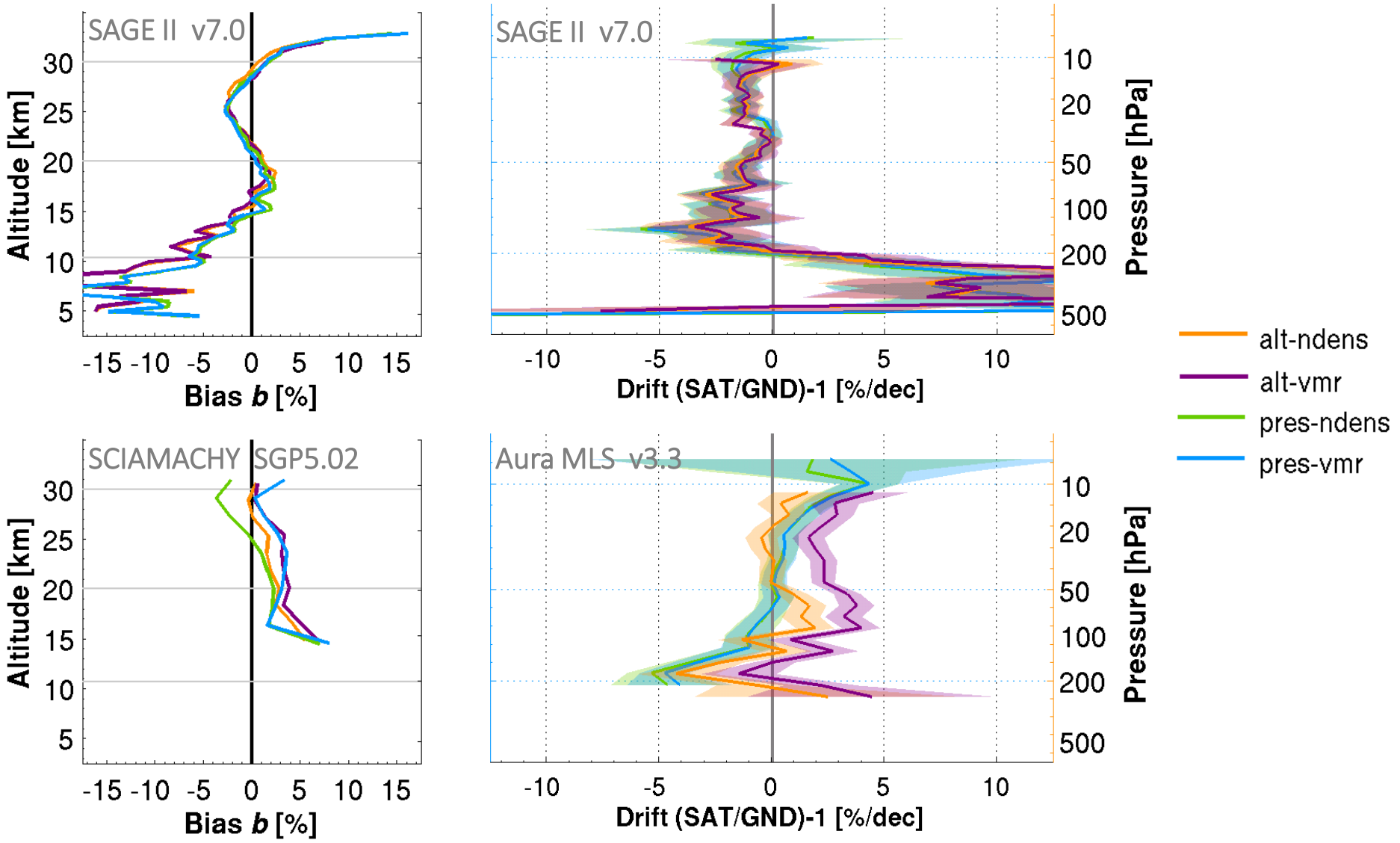
Bias relative to NDACC/WOUDC ozonesondes



Comparison spread relative to NDACC/WOUDC ozonesondes

Multi-mission consistency short-term variability

Generally less than 5-12%, but some records require (a lot) more averaging.
This may be challenging for merging schemes at high spatio-temporal resolution.



All of the previous may be modified when converting to another representation

- A few instruments provide biased/drifting auxiliary information.
- Merging schemes should use a common source of pT, of high quality.

Conclusion & outlook

The limb/occultation ozone profile data sets are mutually very consistent between 20-40 km, but there are challenges for merging schemes

- a few records drift significantly
- complicated bias patterns exist
- some records are more noisy
- some auxiliary data sets introduce artefacts

The recently observed differences in profile trends can be (partially) ascribed to instrument drift.
Therefore, the debate whether the 2nd stage of ozone recovery has started is not (yet) settled.

Drift detection threshold is about 3-4% per decade, further progress may come from

- longer time series
- more homogeneous ground-based records (e.g. O3S-DQA)

→ **Multi-instrument comparison studies are vital for any merging activity or trend assessment.**