Improved limb measurements: what can they be used for?

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ESA Expert Meeting on Limb Sounding Bologna, March 7-8 2016



Outline of talk

A. SPARC implementation plan

B. Scientific Uses

- Trends
- Process understanding
- Use with models
- C. Relevance at this workshop

Thanks to:

Quentin Errera, Greg Bodeker





A: SPARC Implementation Plan 2016-2020

Stratosphere-troposphere Processes And their Role in Climate



A: SPARC Implementation Plan 2016-2020



A: SPARC Implementation Plan 2016-2020



Trends

What to measure?

O₃, H₂O, Brewer-Dobson Circulation, tracers (chemical & dynamical)

What to ensure?

Stability, reduced uncertainties, clear error analysis, better resolution near tropopause,

What to aim for?

Production of merged data sets – or at least seamlessly usable with other data sets

Questions:

Simultaneous fields (e.g. T)



B: Scientific Uses

Trends - age of air critical for understanding circulation changes





Figure 6. Top: Altitude–latitude cross-section of the model-error corrected linear increase of MIPAS AoA over the years 2002 to 2012, i.e. after including the model error and autocorrelations between the data points in the fit. Hatched areas indicate where the trend is not significant, i.e. it is smaller (in absolute terms) than its 2σ uncertainty. Bottom: 1σ uncertainty of the trend in terms of years/decade.



B: Scientific Uses

Trends - age of air critical for understanding circulation changes





Figure 6. Top: Altitude–latitude cross-section of the model-error corrected linear increase of MIPAS AoA over the years 2002 to 2012, i.e. after including the model error and autocorrelations between the data points in the fit. Hatched areas indicate where the trend is not significant, i.e. it is smaller (in absolute terms) than its 2σ uncertainty. Bottom: 1σ uncertainty of the trend in terms of years/decade.

Haenel et al., ACP, 2015. Stiller et al., ACP, 2012.

1979-97



15

10

5

10

5 -10

-5 0

Northern hemisphere Various data sets Some merged

All sorts of important merging issues not addessed here!!

1979-97

1998-2012



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B: Scientific Uses Process understanding

- water entry to stratosphere and the stratospheric tape recorder
- polar ozone variability
- monsoons
- trop O₃ budget
- particle properties?,
- downward propagation?
- special products, e.g. during aircraft campaigns?

ozone, H₂O, CO, other tracers with different sources lifetimes



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leaving the mesosphere to experts.....



B: Scientific Uses Process understanding: H₂O



Time series of stratospheric H_2O [ppmv] between 10°S-10°N from two limb sounders without bias correction: UARS HALOE and Aura MLS.

Courtesy Karen Rosenlof

B: Scientific Uses Process understanding: polar ozone



Are the cold winters getting colder? What drives interannual variability in polar vortex?

Important for:

Understanding polar ozone loss Stratospheric role in weather

Courtesy WMO(2014), Markus Rex and Peter von der Gathen

B: Scientific Uses Process understanding: monsoon



Fadnavis et al., ACP, 2014

B: Scientific Uses

Process understanding: tropospheric O₃ budget

- Need to quantify transport of O_3 from stratosphere into troposphere
 - ~~~50% of tropospheric O_3 is from stratosphere
- Aim to understand interannual variability as well as provide mean for benchmark period
- Obviously O₃, but also other tracers at high resolution (CO, H₂O....) where there is a strat:trop contrast

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- model validation
- data assimilation
- combined model / measurement studies

C: Use with models Model validation

Start with



Standard deviation of the multi-instrument mean (MIM) multi-annual mean datasets for O_3 , H_2O , CH_4 , N_2O , CFC-11, CFC-12, CO, HF, and SF₆ (color contours). The black contour lines in each panel represent the MIM trace gas distribution for each species. The number of instruments included is given by the right-hand grey bar.

C: Use with models Model validation

IGAC/SPARC Chemistry-Climate Model Initiative ccm

http://www.met.reading.ac.uk/ccmi/

Real value in making 2000-2020 an observational benchmark in order to improve CCMs (whether nudged or not)

but..... need to define what is meant

C: Use with models Data assimilation

Can meteorological data (+ models) enhance the composition measurements? Can composition measurements enhance meteorological reanalyses?

- Benchmark period, not whole of past record
- Tracers can improve stratospheric circulation
- Assimilated MIPAS N₂O, CH₄ data gives better comparison with ACE-FTS
- Stratospheric ozone radiative coupling important (including surface T)

Radiances?

Define a benchmark?



Timeline of high vertical resolution satellite Upper Troposphere / Stratosphere observations. Vertical black lines indicate design lifetime / end of prime mission; hatching indicates potential extended mission operations.

Courtesy Nathaniel Livesey (NASA-JPL)

So what?

Twin approach

- 1. Core measurements (ECVs)
 - Improve quality and resolution
 - Ensure rigorous uncertainty analysis and clarity for user
 - Stability critical
 - Complementary to other measurements
 - MLS AURA probably best current satellite instrument
 - how to extend/ improve / add information
 - Ground measurements
 - best calibrated in principle
- 2. Trace species for scientific studies
 - Improve existing ones
 - Develop new ones

