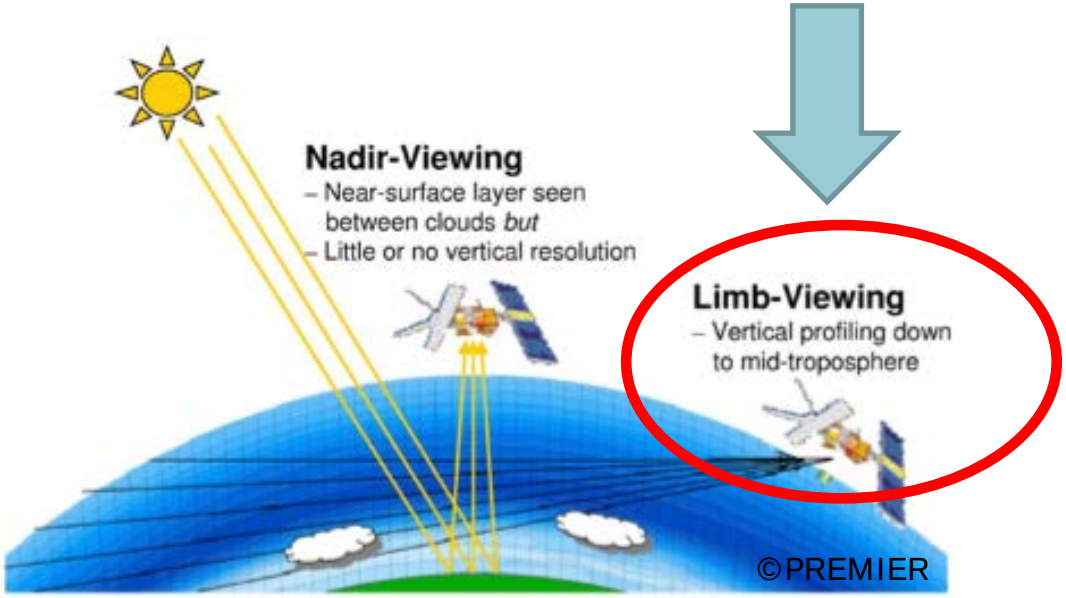
The 'Limb Gap': Perspectives on Future Operational Ozone Profile Monitoring Needs



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Vincent-Henri Peuch, Alison Waterfall, Jolyon Reburn, and Brian Kerridge

ESA ATMOS 2015, June 2015, Crete

Study Objectives

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The 'Operoz' study (Oct 2014 – Feb 2015)
OPERational OZone observations using limb geometry

i. To further establish ***user requirements*** for an ***operational*** mission targeting ***ozone*** profiles at high vertical resolution

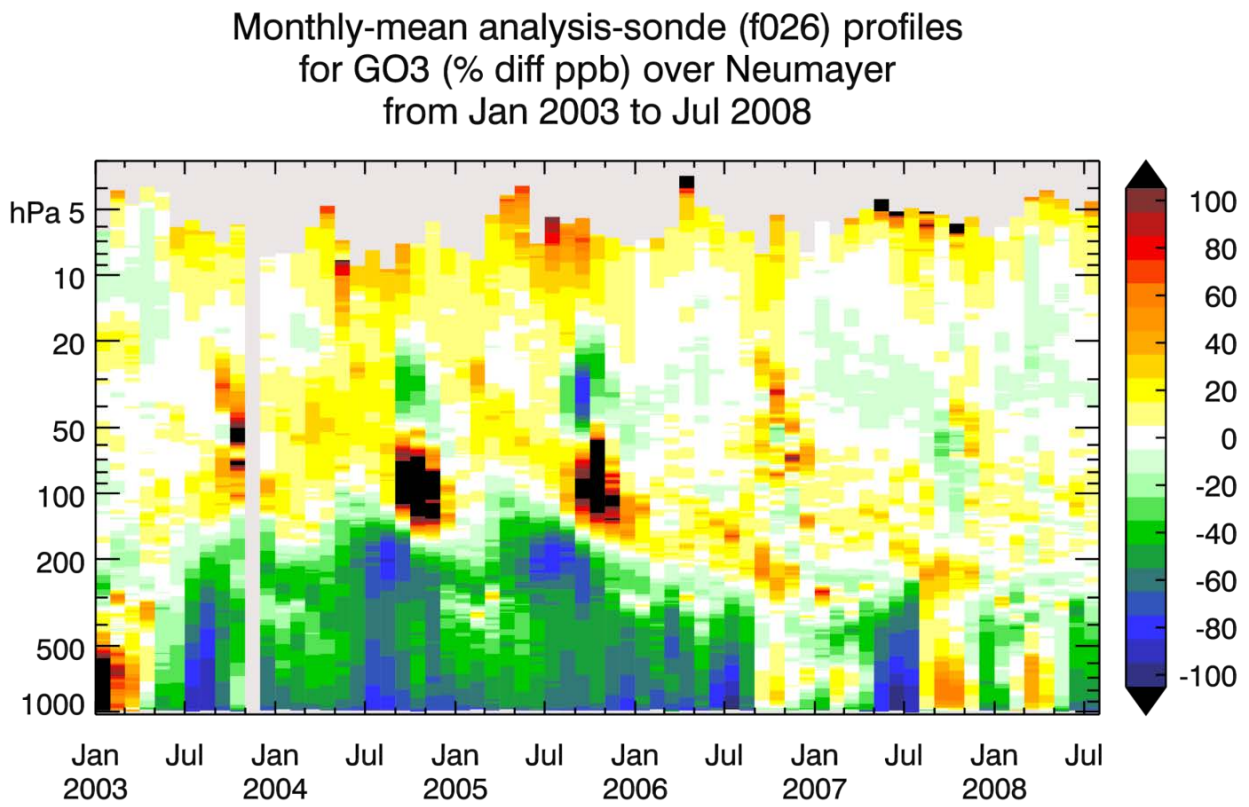
ii. To identify the ***observational gaps*** w.r.t. user needs taking into account planned operational (nadir) missions and ground networks

iii. Perform a reality check on the observational requirements and identify options for a ***small to medium size satellite mission***

=> Based on proven concepts and present-day knowledge of potentially available measurement techniques

=> Detailing GMES-Pure recommendations to EU for the evolution of the Copernicus Space Segment w.r.t. ozone profile monitoring needs

Degradation in the lower stratosphere and the troposphere in the period Jul 2003 - Sep 2006, during which no limb profile data from either MLS or MIPAS were assimilated:



MIPAS used in 2003; MLS used from January 2006 onwards + OMI total columns from July 2007 onwards.

Long-term monitoring

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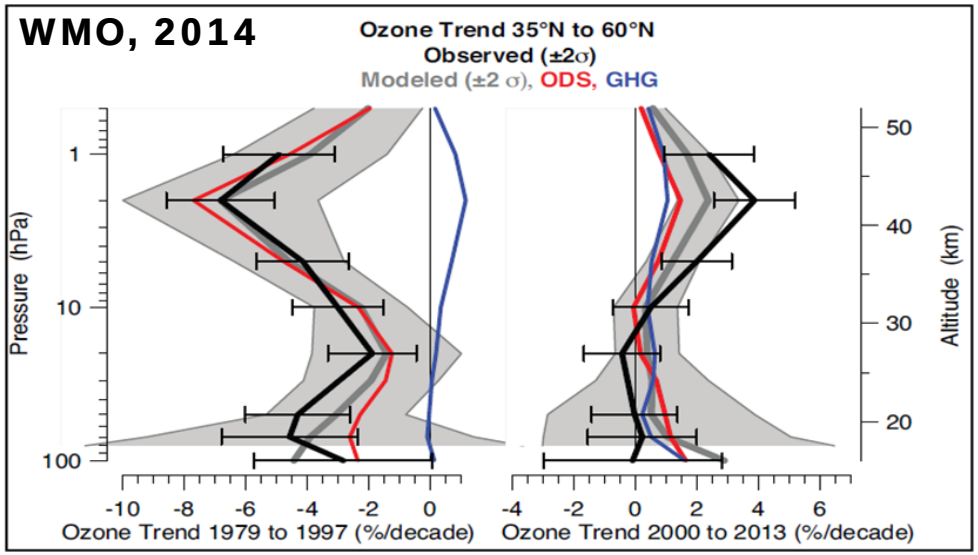
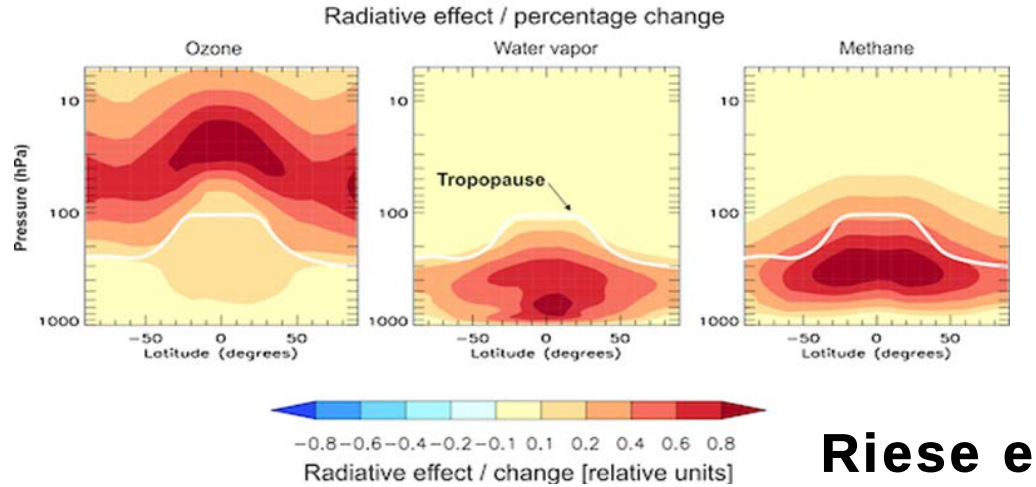
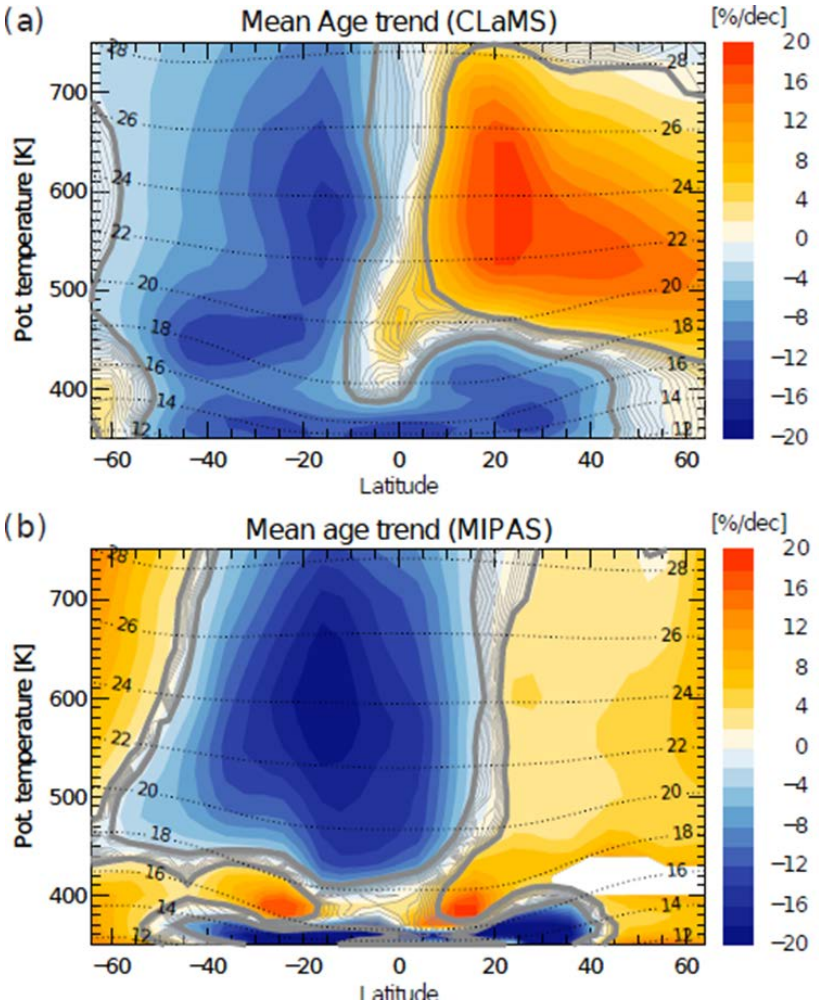




Riese et al.



Ploeger et al.

Minimum operational limb mission

An ozone-only limb mission in support of operational services and long-term monitoring with:

- ✓ Global coverage, including polar night, on a daily basis,
- ✓ Dense spatial sampling,
- ✓ Covering the entire stratosphere from stratopause to tropopause,
- ✓ Stringent stability requirements on decadal time scales, and
- ✓ Near-real time availability

Operoz Summary of Observational Requirements Table

Operational services and Long-term monitoring
Minimum Mission ('Priority A')

+ (a) Brewer-Dobson Circulation ('Priority B')
+ (b) Stratospheric Chemistry ('Priority B')
+ (c) Tropospheric Ozone ('Priority B')

Timeliness: < 3h (LS, MS)
Long-term stability (O_3 observations):
1% / 3% per decade
Across-track sampling (O_3 observations):
100 / 200 km (UT, LS, MS) over a swath of ≥ 400 km (c)

Observable	Along-track sampling (km)	Horizontal coverage	Vertical resolution (km)	Vertical coverage (km)	Update frequency	Uncertainty(1)
O_3	***100 / 200***	***Global (incl. polar night)***	***1 / 2***	***LS***	***12h / 24h***	***8% / 16% or 50 / 100 ppbv***
O_3	***100 / 200***	***Global (incl. polar night)***	***1 / 2***	***MS***	***12h / 24h***	***4% / 8% or 50 / 100 ppbv***
O_3	***200 / 400***	***Global (incl. polar night)***	***2 / 4***	***US***	***Daily/weekly;*** 12h / 24h (b)	***4% / 8%***

Reality check

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Measurement Type	*Along-track sampling (km)*	*Hori-zontal coverage*	*Night-time measure-ments*	*Vertical sampling (km)*	*Vertical coverage (km)*	*Update Frequency (hours)*	*Uncer-tainty*	*Stability*
Nadir UV								
Nadir IR								
Occultation								
Infrared Limb Emission								
(Sub-)mm Limb Emission								
Shortwave Limb Scattering								

Mission Extensions

Highest priority mission extensions would include:

- ✓ **Attribution** of *why* ozone is changing
  - ➢ Through transport changes and variability (passive tracers)
  - ➢ Through chemistry changes and variability (chemical active components)
- ✓ Combining the monitoring of stratospheric and **tropospheric ozone**

Other identified important mission extensions would include:

- ✓ Combination with ***stratospheric water vapour and stratospheric aerosol*** profiling
- ✓ Coverage of the ***mesosphere***
- ✓ ***Troposphere-to-Stratosphere transport*** including the role of the Asian monsoon

Mission extensions

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Abilities to meet each of the desirable ('Priority B') mission extensions

Mission Extension	Observable	Shortwave Scattering				Infrared Emission				(Sub-)mm Emission			
		UT	LS	MS	US	UT	LS	MS	US	UT	LS	MS	US
'Brewer-Dobson Circulation'	SF_6												
	CH_4												
	N_2O												
	CFC-11												
	CFC-12												
	H_2O												
	HCl												
'Stratospheric Chemistry'	Temperature												
	HNO_3												
	HCl												
	H_2O												
	Ext. coef.												
	CH_4												
	N_2O												
	$ClONO_2$												
	BrO												
'Tropospheric Ozone'	O_3												

Summary

- User requirements and minimum mission objectives: Copernicus services and long-term global monitoring (trends, climate)

  - ***near-real time*** availability; global coverage; dense spatial sampling
  - stringent ***stability*** (multi-mission; decadal)
  - ozone vertical profiling down into the UTLS and during polar night

* Primary mission extensions to ***attribute*** short-term and long-term ozone profile changes:

  (i) Brewer-Dobson circulation
  (ii) Stratospheric Chemistry
  (iii) Stratospheric and tropospheric ozone observations combined

* Reality check small mission

  - Limb Emission: IR and/or MM, concepts: STEAMR, Atmo-SAT,..
  - Limb Scatter: JPSS-2/OMPS (2021+), concepts: CATS, ALTIUS, ISS/SCIA,..
  - Occultation ISS/SAGE-III(2016+), concept ALTIUS,..

Further Recommendations

(1) Technology developments and evolution of proposed concepts over the last decade should be taken into consideration, with a view to defining and optimizing a compact, low cost concept.

(2) User needs for high vertical resolution are not limited to operational ***ozone*** profiling:

- stratospheric water vapor
- temperature
- stratospheric (volcanic) aerosol layers
- cirrus clouds
- other trace gases

A similar study including a reality check would be needed to establish wider long-term operational needs based on limb view

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User requirements for monitoring the evolution of stratospheric ozone at high vertical resolution

Partners

Koninklijk Nederlands Meteorologisch Instituut
Ministerie van Verkeer en Waterstaat

Royal Netherlands Meteorological Institute (KNMI) – The Netherlands

JÜLICH FORSCHUNGSZENTRUM

Forschungszentrum Jülich (FZJ) – Germany

ECMWF

European Centre for Medium-range Weather Forecasting (ECMWF) – UK

Universität Bremen*

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Science & Technology Facilities Council
Rutherford Appleton Laboratory

Rutherford Appleton Laboratory (RAL) – UK