Ozone_cci

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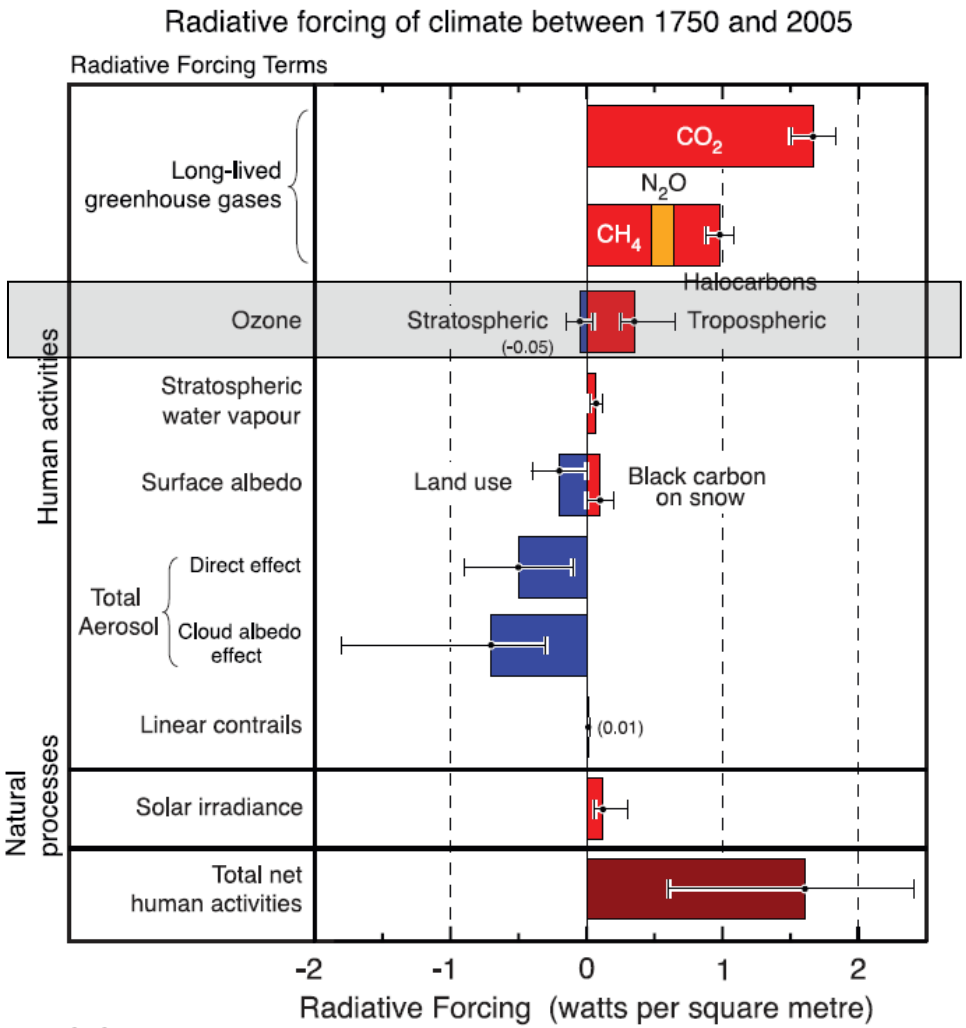
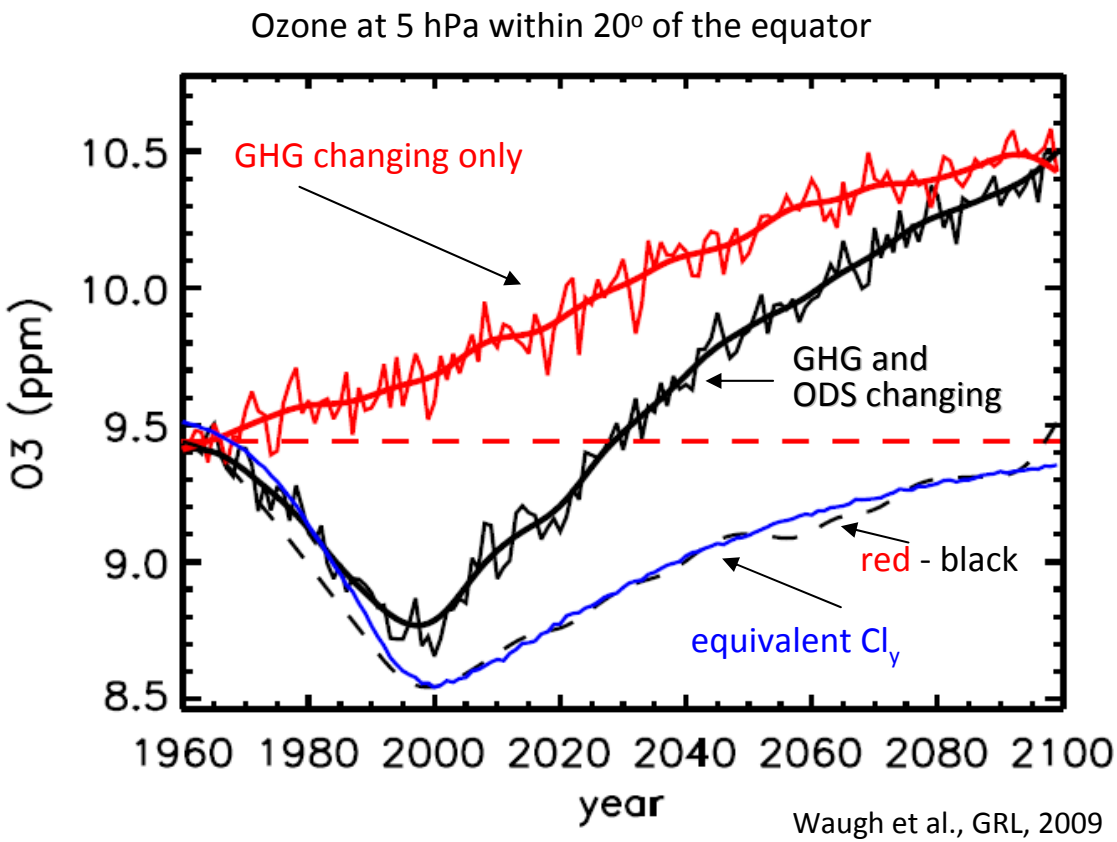
Climate impact of ozone changes



IPCC, AR4

- Ozone impact climate both directly and indirectly through its chemical interactions with other gases
- Tropospheric ozone provides the 3rd largest positive radiative forcing
- Forcing opposite in stratosphere and troposphere. Future evolution of stratospheric ozone strongly linked to climate change.
- Main uncertainties on RF related to vertical distribution of ozone changes. Uncertainties are largest at tropopause where radiative forcing by ozone is maximum.
- Upper stratospheric ozone is key for early detection of ozone recovery.

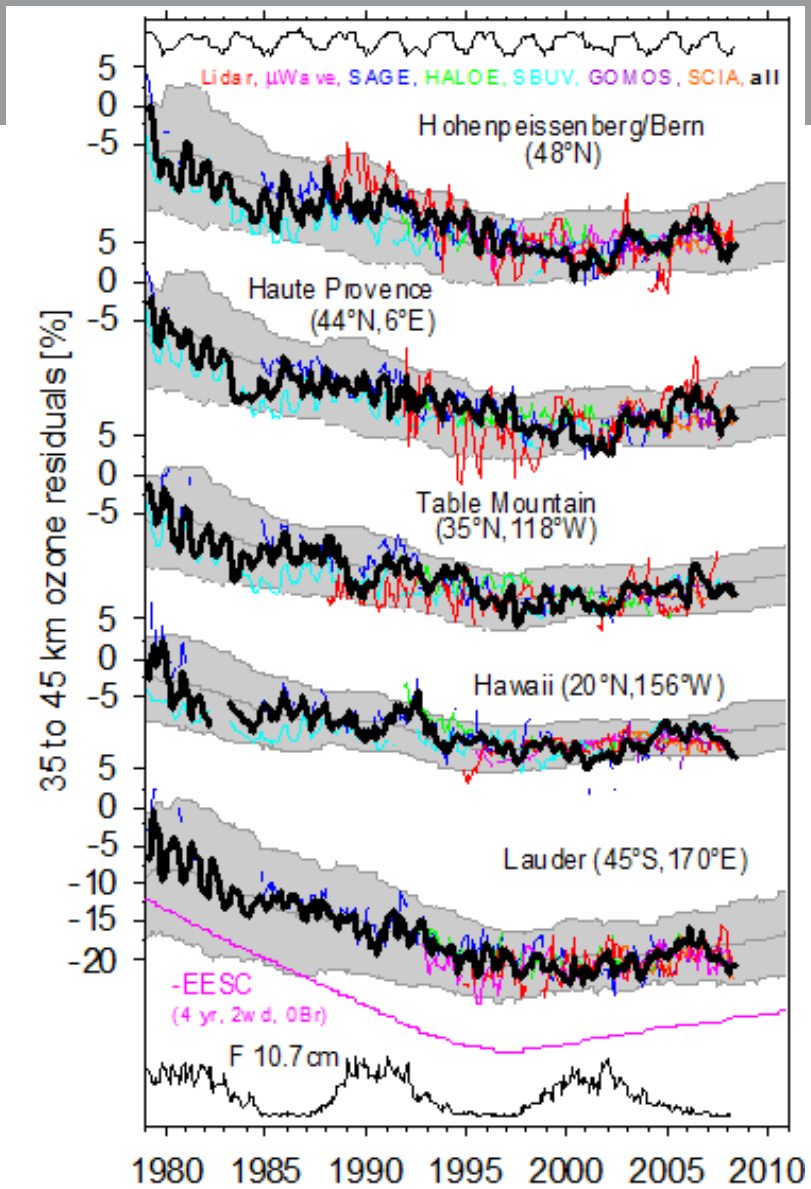
Upper stratosphere and ozone « super » recovery



Waugh et al., GRL, 2009

"A particularly important region for detecting ozone recovery, and eventually *super-recovery* is the upper stratosphere. This region is less variable than the lower stratosphere and ozone there is dominated by photochemical processes."

IGACO-O3 Implementation Plan 2008-2011

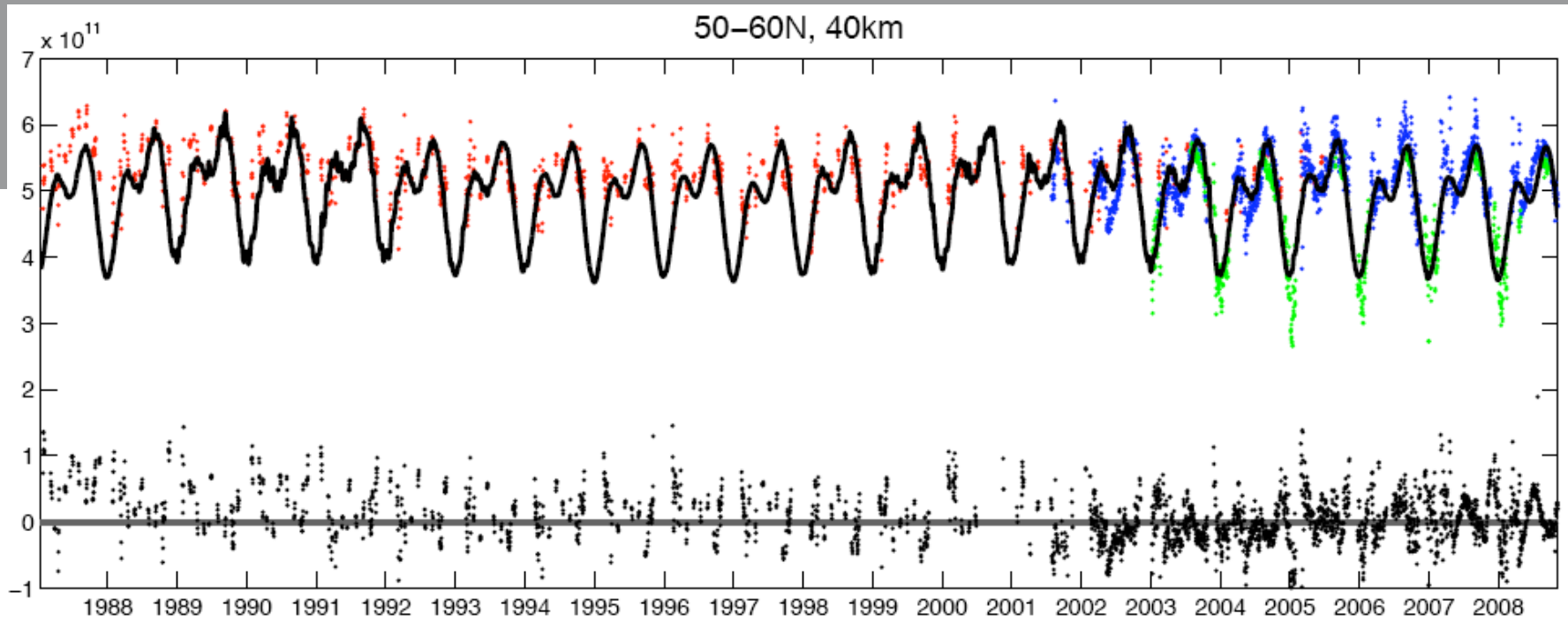


Ozone anomalies from 1979 to early 2008 from different data sets at five NDACC stations

Grey underlay: CCMVal model simulations

The thin black lines at the top and bottom show negative 10 hPa zonal wind at the Equator as a proxy for the QBO, and 10.7 cm solar flux as a proxy for the 11-year solar cycle, respectively. The thin magenta line near the bottom shows inverted Effective Stratospheric Chlorine as a proxy for ozone destruction by chlorine.

From Steinbrecht *et al.* [2009]



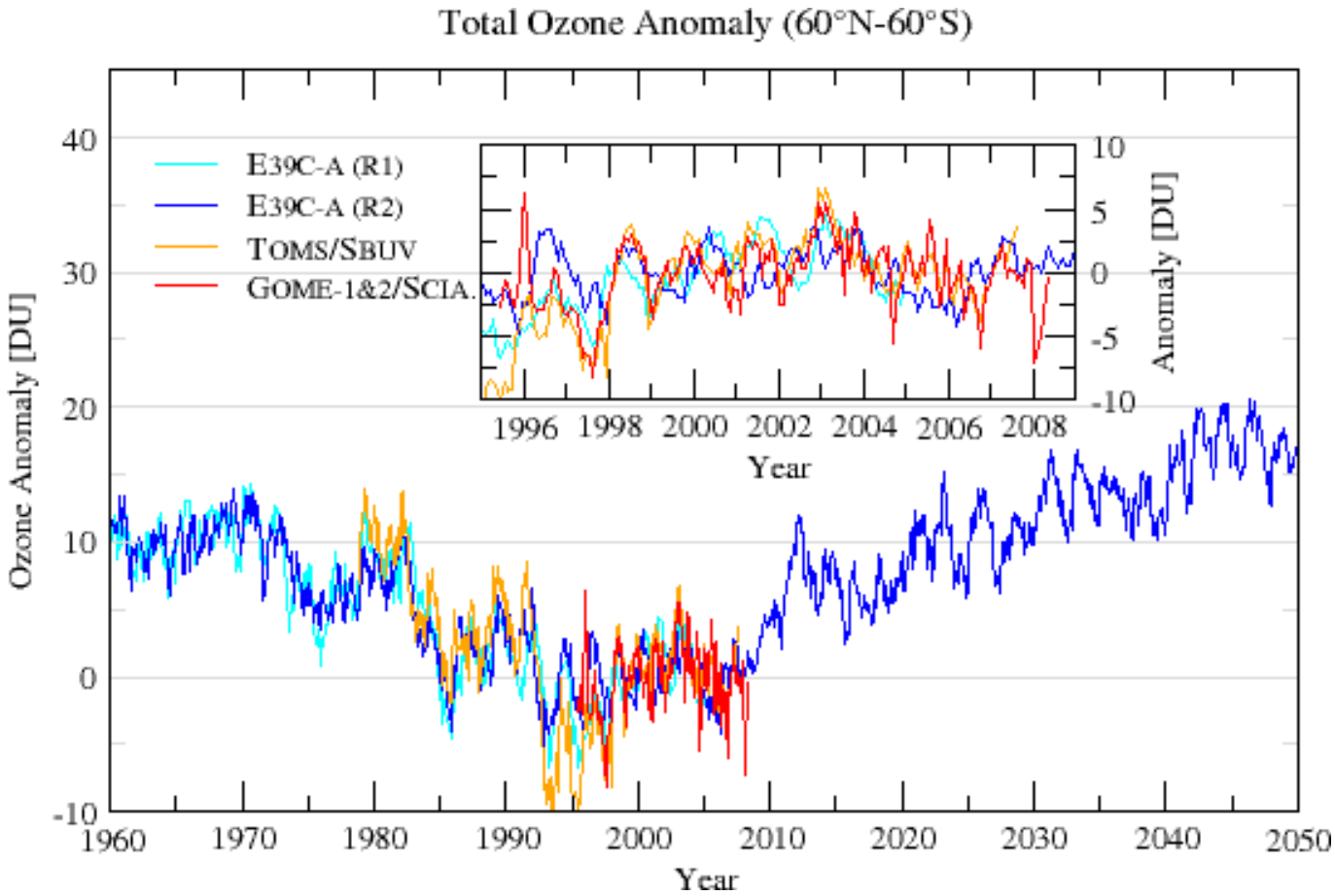
Ozone at 40 km in the 50-60°N lat band

SAGE II data is in red, blue dots are OSIRIS and green are GOMOS

The fitted trend is in black and includes:
- QBO (10 hPa and 30hPa)
- solar cycle (F10.7micro m)
- Annual (2 hamonics: sin and cos)
- Semi-annual (2 hamonics: sin and cos)
- constant

Courtesy of Simo Tukiainen and Erkki Kyrölä, FMI

Comparison of data derived from satellite and a CCM



E39C-A (R1/R2), Stenke et al., ACP 2009

GOME/SCIAMACHY/GOME-2, update of Fig. 9 in Loyola et al., IJRS 2009

Ozone_cci project

Aims:

- **Develop, produce and validate** long-term series of high quality global observations of atmospheric ozone derived from multiple satellite instruments.
- **Evaluate the impact** of the resulting improved Ozone ECV data products in a climate perspective
- Explore **system specifications** for ozone ECV production

GCOS requirements: the starting point

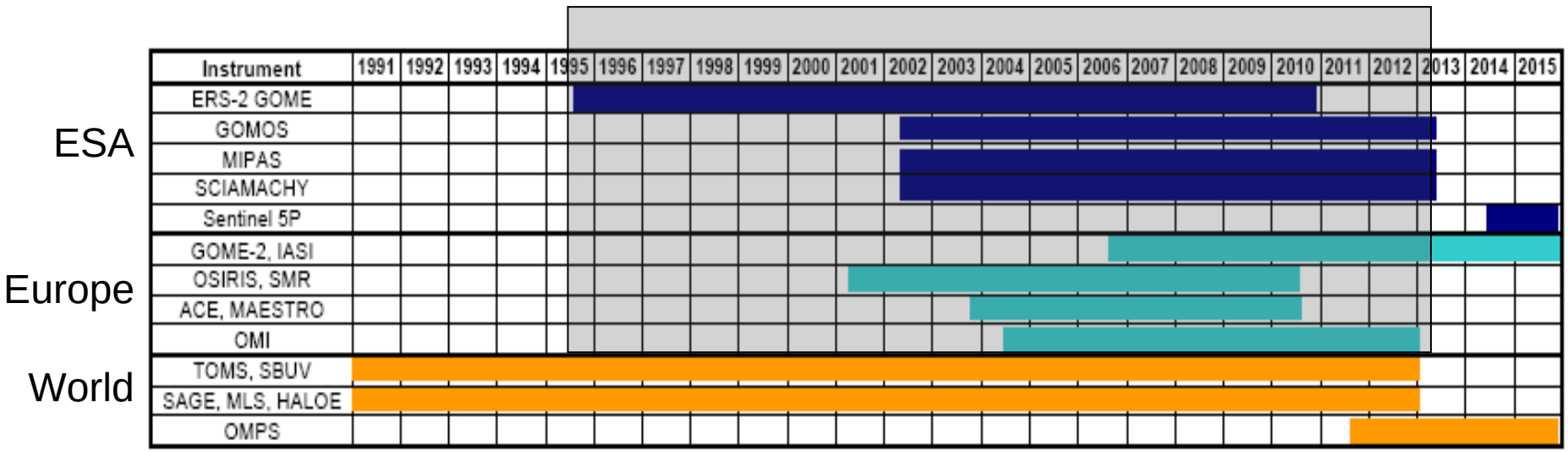
GCOS Requirement		Current Status
• Accuracy:	10% trop - 5% strat	20% trop, - 5% strat
• Spatial resolution:	5-50 km trop – 50-100 km strat	>20 km
• Vertical resolution:	0.5 km trop – 3km strat	5 km trop, 1-5km strat
• Temporal resolution:	3-hourly	Daily
• Stability:	1-0.6%	1% total column, >3% profiles

?

Critical review of GCOS requirements for ozone ECV products:

- **Accuracy, resolution, stability**
- What can be achieved using **current sensors** ?
- Which improvement can be expected from planned **future sensors** ?
- Can we refine the requirements from a **specialised climate user community** perspective, according to science and assessment goals, and altitude region (e.g. UT/LS) ?
- Is there a need to revise/refine the GCOS requirements for ozone ?

Satellite instruments and data sets



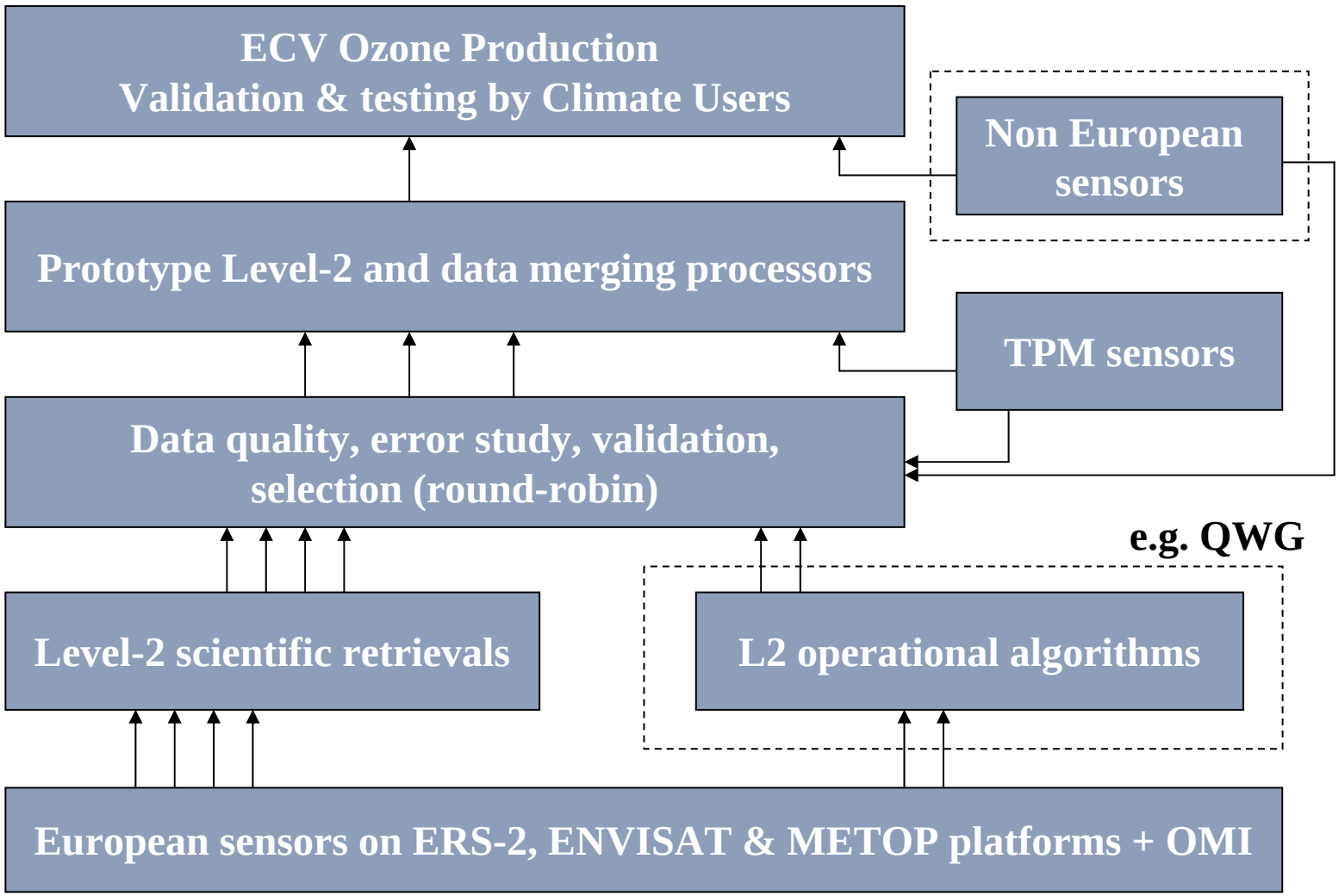
- Ozone ECV products to be developed:
  - **Total ozone** from all ESA UV-Vis nadir sensors
  - **Ozone profiles** from all European **UV-Vis nadir** sensors
  - **Ozone profiles** from ENVISAT & TPM **limb & occultation** sensors

- CCI focuses on ESA and TPM (European) sensors
- Non-european sensors are used for validation and quality assessment

The ozone_cci consortium

Belgian Institute for Space Aeronomy (BIRA-IASB) German Aerospace Center (DLR)	**Total ozone algo., Val., Modeling, Syst. Eng.**
Royal Netherlands Meteorological Institute (KNMI) Rutherford Appleton Laboratory (RAL)	**Nadir ozone profiles, Modeling, Syst. Eng**
University of Bremen (IUP) Karlsruhe Institute of Technology (KIT) Laboratoire Atmosphères, Milieux, Observations Spatiales (LATMOS) Finnish Meteorological Institute (FMI)	**ENVISAT limb/occ. profiles**
Aristotle University of Thessaloniki (AUTH) University of Athens (NKUA) Royal Meteorological Institute of Belgium (KMI-IRM) Federal Office of Meteorology and Climatology MeteoSwiss	**Validation**
University of Cambridge (UCAM)	**Climate modeling**

Ozone_cci concept



Nadir ozone UV retrieval algorithms

Nadir UV radiances
GOME, SCIAMACHY & GOME-2
Improvements through vicarious calibrations

Total columns

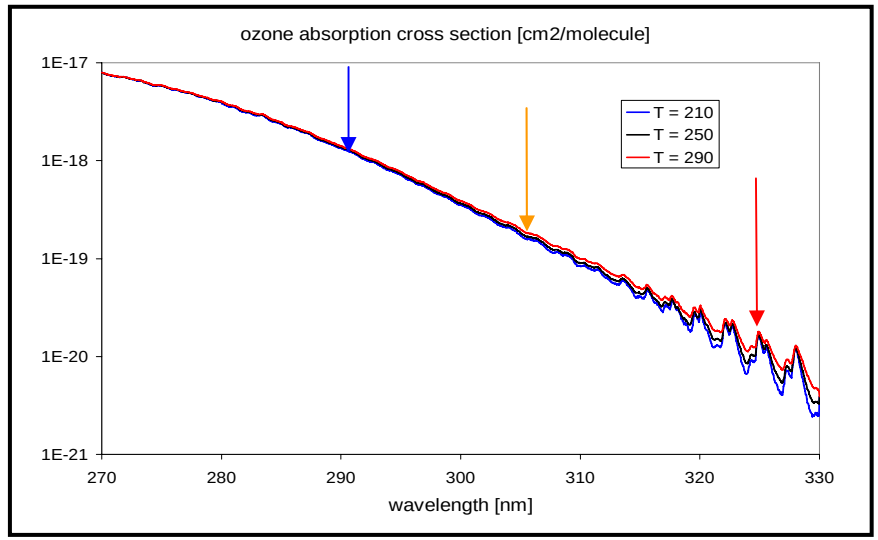
L2 algorithm improvements for GOME, SCIA & GOME-2

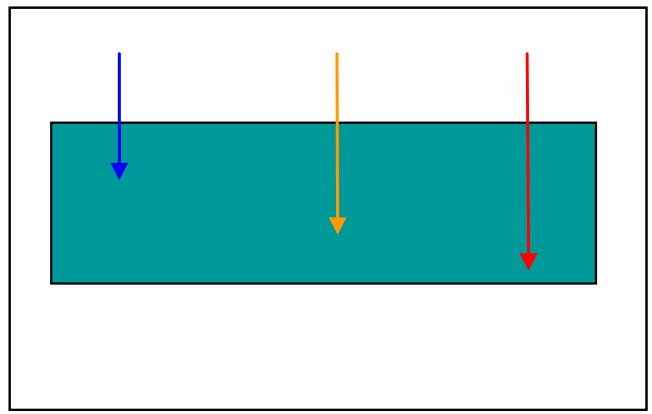
Baseline: GDP-5 direct-fitting type algorithm

Nadir profiles

Merged RAL and KNMI OPERA/OMI algorithms (all ESA sensors + OMI)

Optimised for all altitude incl. Trop.





Algorithms ENVISAT limb/occ. sensors

- Links established with ENVISAT Quality Working Groups
- Major focus on the characterization of individual data sets (sampling, geographical coverage, horizontal and vertical resolution) and on the error budget

SCIAMACHY → IUP scientific algorithm (full altitude coverage)

GOMOS → operational product (IPF v. 5 or 6)

MIPAS

- Selection among 4 competing algorithms (round-robin exercise)
- Full involvement of MIPAS SQWG through consultancy mechanism

Error analysis

- Random and systematic errors, accuracy & precision
- Error budget
- Validation (and geophysical validation of error bars)
- Time evolution of errors
- Quality flagging
- Representation of averaging kernels („climatology“, LUT)

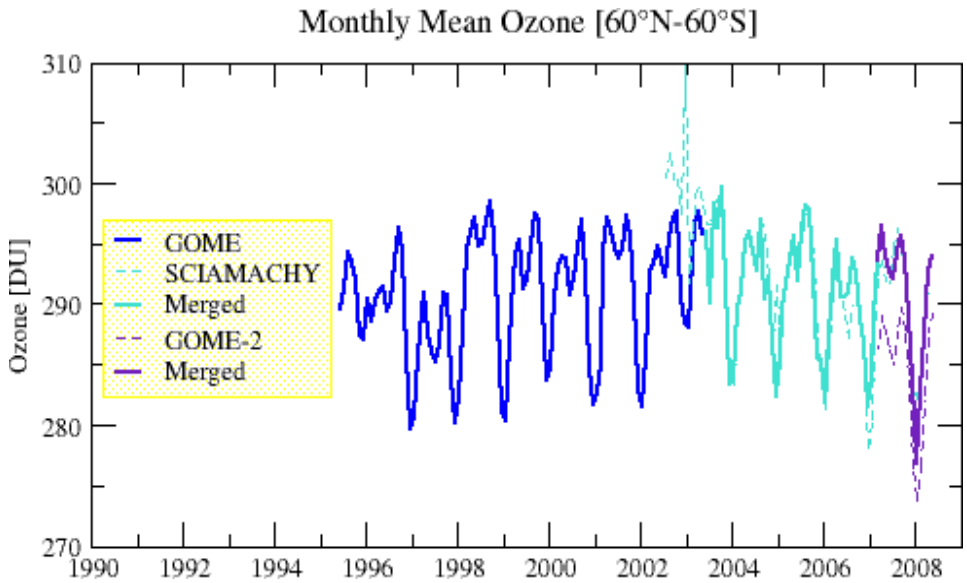
- Feedback to QWG & EUMETSAT regarding the operational processing

Data merging algorithms

The issue:

How to combine measurements from sensors having different sampling, resolution and bias ?

➔ Merging techniques



Ozone_cci approach

1) Reduce bias through homogeneisation of retrieval algorithms
2) Characterise data sets (full error budget, averaging kernels, bias, etc)
3) Derive correction factors based on reference agreed by scientific consensus
   → various possible approaches to be reviewed for each ozone product
4) Merge corrected data using error estimates and averaging kernels

Merging of limb/occultation sensors

- Merging of ENVISAT & TPM limb & occultation sensors is by far the most challenging
- Not attempted so far
- Key issues to be addressed
  - How to use errors from individual data sets in the merging and propagating these errors in the final merged product?
  - Different merging strategies are needed according to different requirements from data assimilation, CCMval, and trend assessments
- One expected key output of the ozone_cci project

Independent validation

VALT includes world-leading experts on ground network ozone measurements, having access to relevant data bases and critical knowledge of quality and maintenance of correlative data sets.

Full benefit is taken from ongoing cal/val activities

Table I: Ground-based data sets

Sensor	Data product type	Source of the data
Brewer UV spectrophotometer	Level 2, column	WOUDC, NDACC
Dobson UV spectrophotometer	Level 2, column	WOUDC, NDACC
DOAS UV-vis spectrometer	Level 2, column	NDACC
Baloon-borne ozonesonde	Level 2, profile	WOUDC, NDACC, SHADOZ
Lidar	Level 2, profile	NDACC
Microwave radiometer	Level 2, profile	NDACC

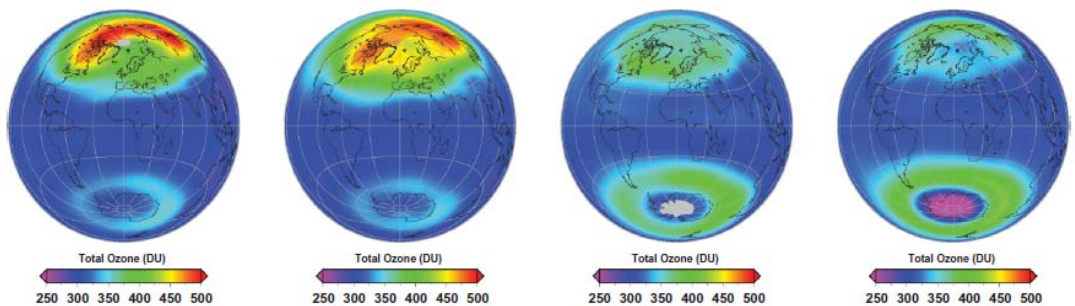
The basic procedure is to collect data from central data archives:

- World Ozone and Ultraviolet Data Centre (WOUDC, http://www.woudc.org)
- Network for the Detection of Atmospheric Composition Change (NDACC, http://www.ndacc.org)

Southern Hemisphere Additional Ozonesondes (http://croc.gsfc.nasa.gov/shadoz)

Link to climate modelling community and IPCC

- The project's Climate Research Group (CRG) involves three key partners providing a strong link to GCM community, which implies link to IPCC community as well.
- CRG specialised in climate research including strat-trop responses and feedbacks
- Strong involvement in SPARC CCMVal activity
- Participation as lead and/or co-authors in WMO/UNEP Assessment of Ozone Depletion report
- Several IO_3C members included in the consortium



Summary (1)

- Ozone-cci aims to develop, document, and produce validated long series of high quality global observations of atmospheric ozone derived from multiple satellite instruments
- Strong focus on algorithmic improvements, data characterisation, error budget and validation
- Comprehensive documentation will be produced
- All data and reports will be freely available to the scientific community

Summary (2)

- **Ozone-cci will result in:**
  - A major consolidation of European ozone data sets (column and profiles), through level 2 algorithmic improvements, consistent data merging, full data characterisation and error budget
  - Production of the first merged limb/occ. data set based on ENVISAT and TPM missions
  - Comprehensive validation against agreed common standards
  - Major advance in precisely quantifying status against GCOS requirements for ozone
  - Link to parallel efforts in the US (MOD project)