

Validation of the MACC atmospheric composition global forecasting service

Henk Eskes (KNMI)

*On behalf of the partners of
the MACC VAL sub-project*

NORS/NDACC/GAW workshop
5 to 7 November 2014
Brussels, Belgium



Names of contributors

Global validation:

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Validation report editors:

H.J. Eskes (KNMI), V. Huijnen (KNMI), A. Wagner (DWD), M. Schulz (MetNo), E. Botek (BIRA-IASB), E. Katragkou (AUTH)

Modelling teams, feedback:

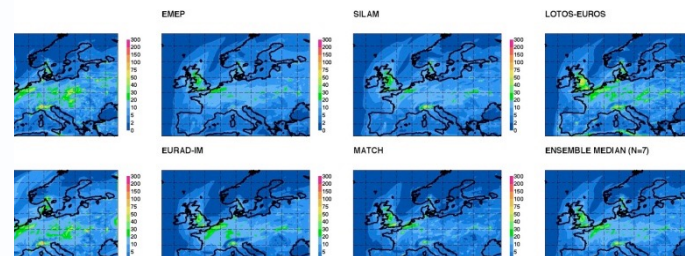
GRG team, AER team, GDA team

MACC III <http://www.gmes-atmosphere.eu>



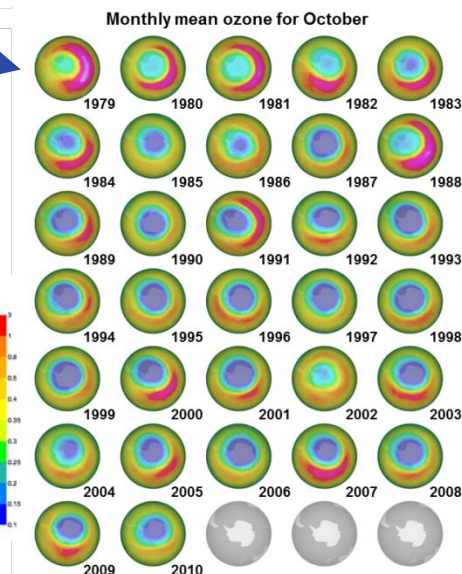
**Air-quality
ensemble
forecasts**

**and
(re-)analyses**



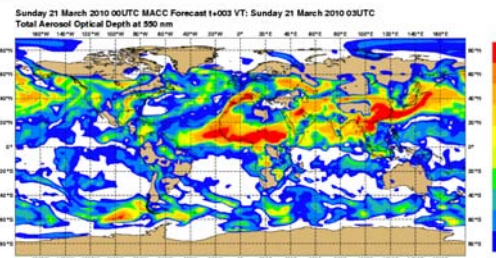
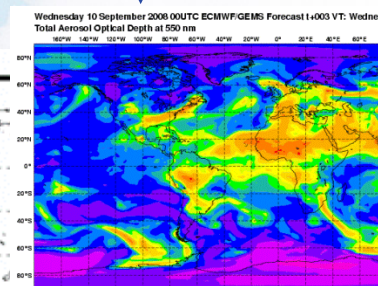
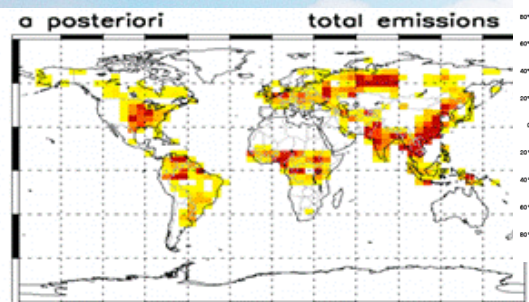
**Stratospheric
ozone records**

Global Aerosol



**Monthly methane
emissions**

**Global
Gases**

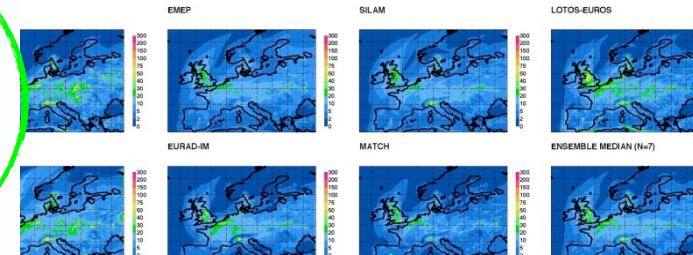


...And many more services.



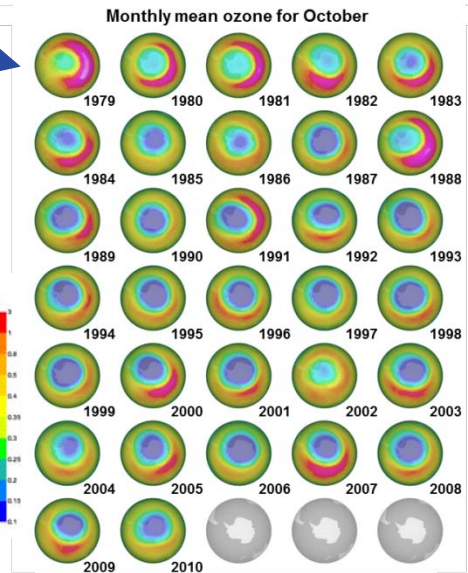
**Air-quality
ensemble
forecasts**

**and
(re-)analyses**



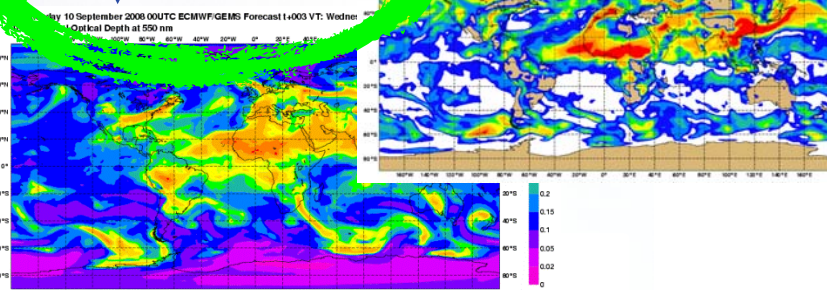
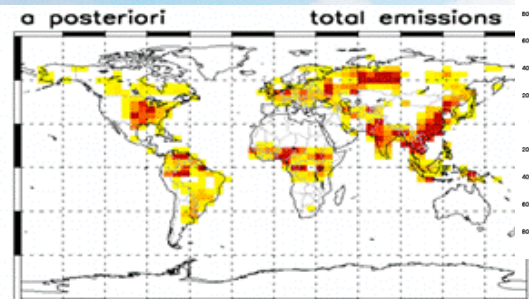
**Stratospheric
ozone records**

Global Aerosol



**Monthly methane
emissions**

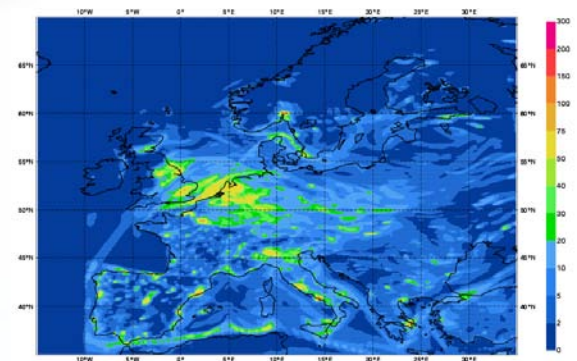
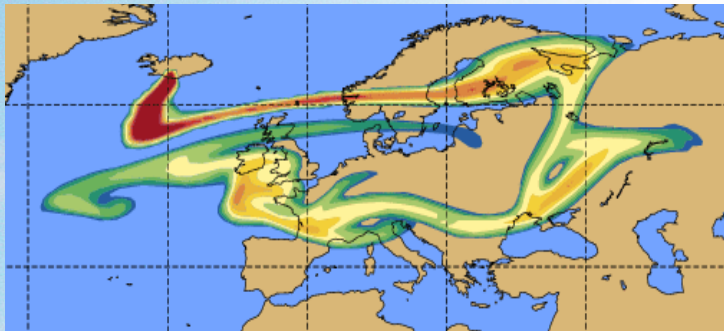
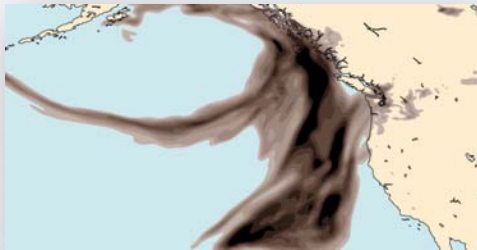
**Global
Gases**



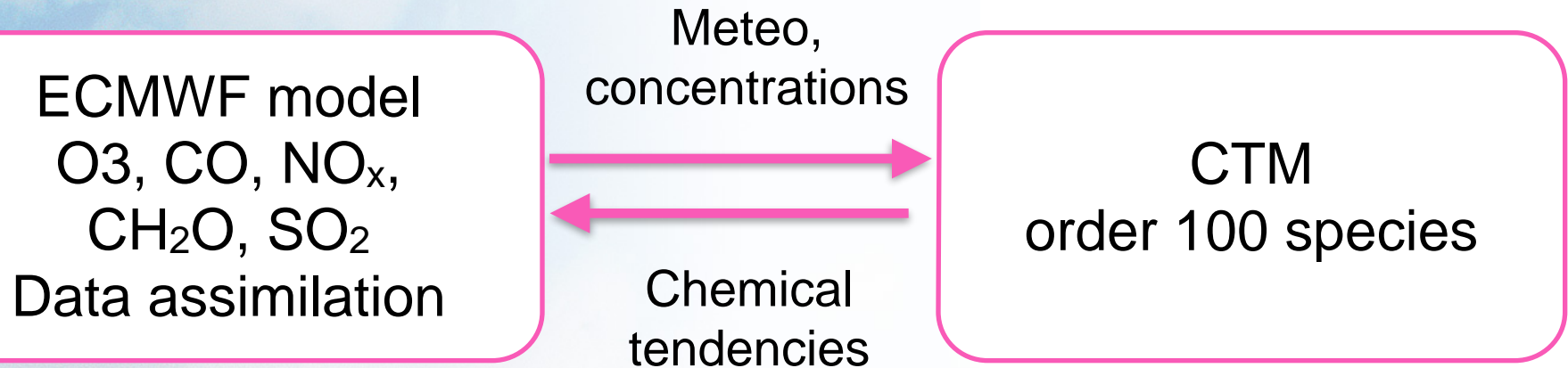
...And many more services.

High concentration events

- Dust storms
- Major fire events, smoke plumes
- Air pollution events
- Ozone hole
- Volcanoes



Global composition NRT forecast runs assessed (MACC-II)



- **MACC_osuite**
Pre-operational MACC DA/FC run
- **MACC_esuite**
Test run of next o-suite
- **MOZART-IFS FC** without data assimilation
- **TM5-IFS FC** without data assimilation
- Stratosphere: BASCOE, SACADA, Ozone multisensor reanalysis

Global composition NRT forecast runs assessed (MACC-III)

C-IFS
ECMWF model
Order 100 species
Data assimilation

**Chemistry
Aerosol
code**

- **MACC_osuite**
C-IFS TM5 inline chemistry model
- **Reference run without data assimilation**
C-IFS TM5
- **Under development (all inline chemistry)**
C-IFS MOZART
C-IFS MOCAGE
C-IFS BASCOE-TM5

Products assimilated/validated (current status)

Species, vertical range	Assimilation	Validation
Aerosol, optical properties	MODIS Aqua/Terra AOD	AOD, Ångström: AERONET, GAW, Skynet, MISR, OMI, lidar
Aerosol, speciation	-	-
O ₃ , stratosphere	MLS, GOME-2A, GOME-2B, OMI, SBUV-2	Sonde, lidar, MWR, FTIR, ACE-FTS, OSIRIS, OMPS, BASCOE and MSR analyses
O ₃ , UT/LS	Indirectly constrained by limb and nadir sounders	IAGOS, sonde
O ₃ , free troposphere	Indirectly constrained by limb and nadir sounders	IAGOS, sonde
O ₃ , PBL / surface	-	Surface ozone: WMO/GAW, NOAA/ESRL

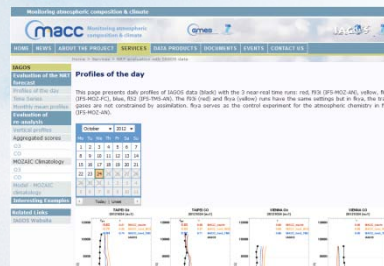
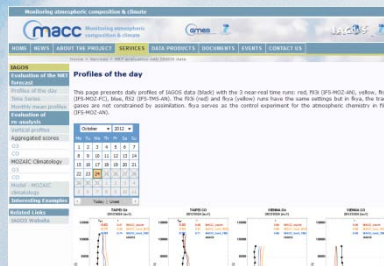
Products assimilated/validated (continued)

Species, vertical range	Assimilation	Validation
CO, UT/LS	-	IAGOS
CO, free troposphere	IASI, MOPITT	IAGOS, MOPITT, IASI
CO, PBL / surface	Indirectly constrained by satellite IR sounders	Surface CO: WMO/GAW, NOAA/ESRL
NO ₂ , troposphere	OMI, partially constrained due to short lifetime	SCIAMACHY, GOME-2, UV-Vis DOAS
HCHO	-	GOME-2, UV-Vis DOAS
SO ₂	OMI (Individual volcanic eruptions and strong sources)	-
Stratosphere, other than O ₃	-	NO ₂ column only: SCIAMACHY, GOME-2
Troposphere, other species	-	-
UV-Index	Constrained by assimilation of ozone and aerosol AOD	COST UV Index Database

Validation in MACC: components and timeline



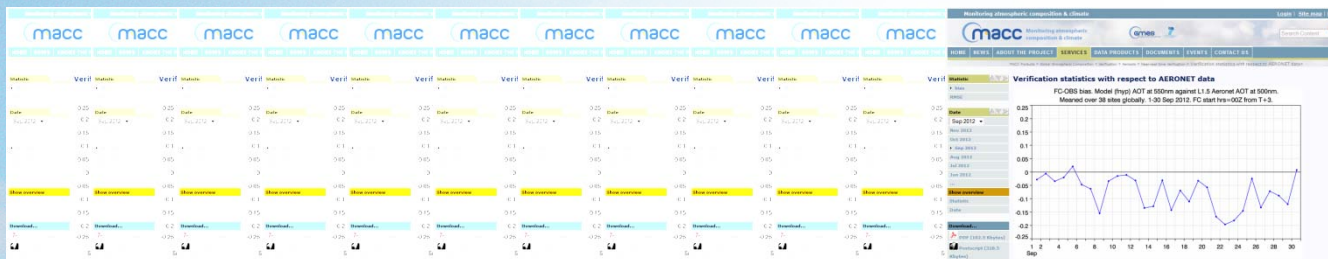
validation reports
 -> near-real time
 (every 3 months)
 -> reanalysis
 -> e-suite
 (regular updates)



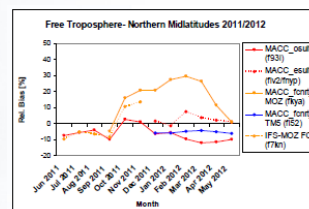
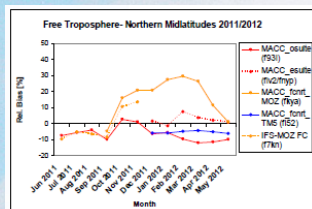
web pages
 (irregular updates)



Time

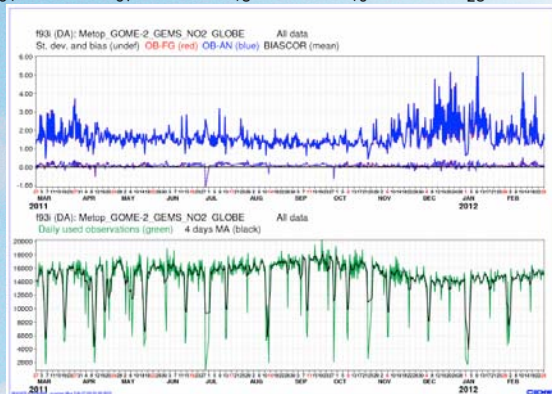
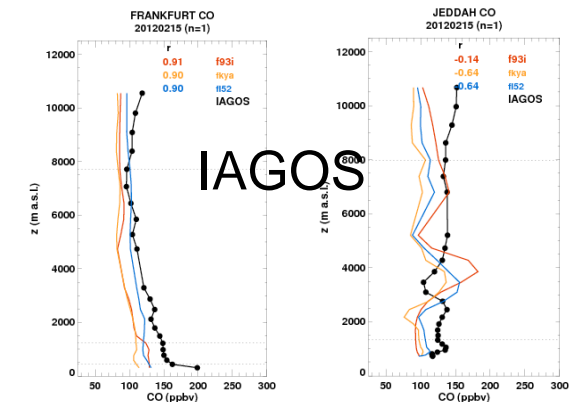
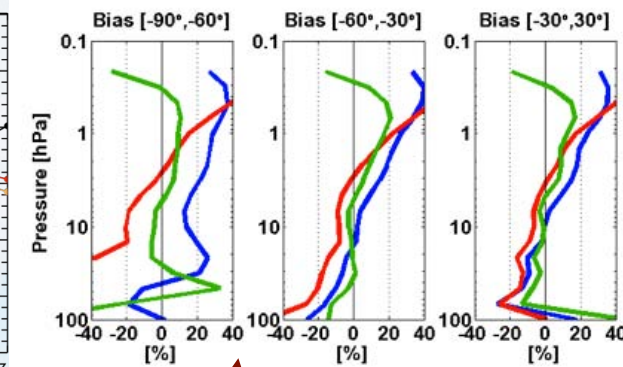
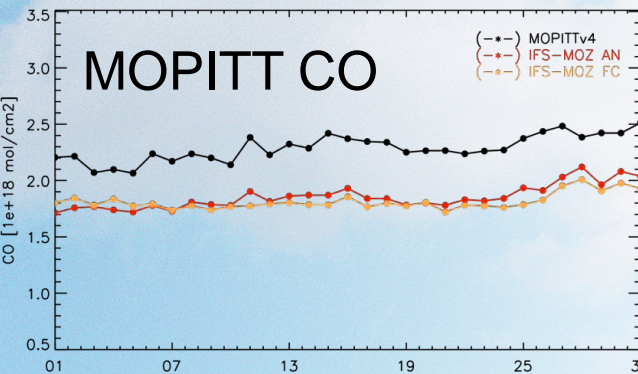
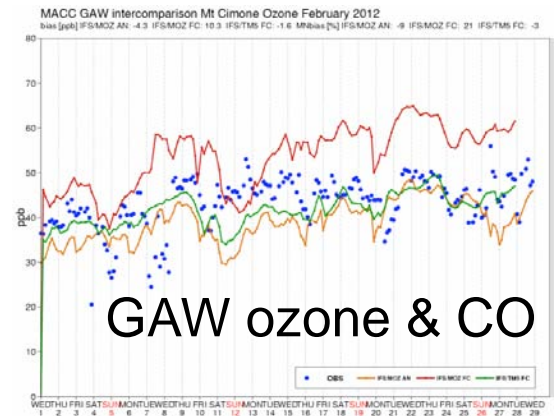
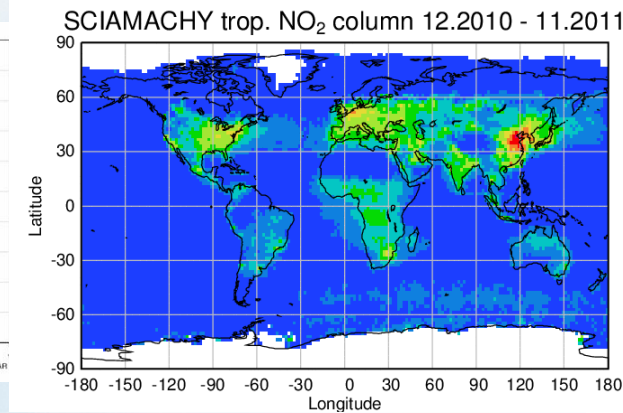
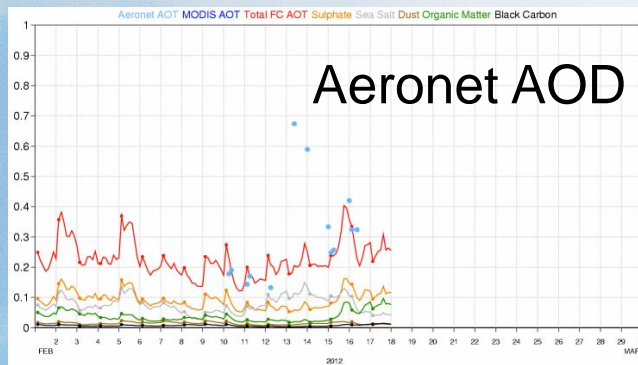


NRT monitoring
 (daily updates)



quick look feedbacks
 (test new model versions)

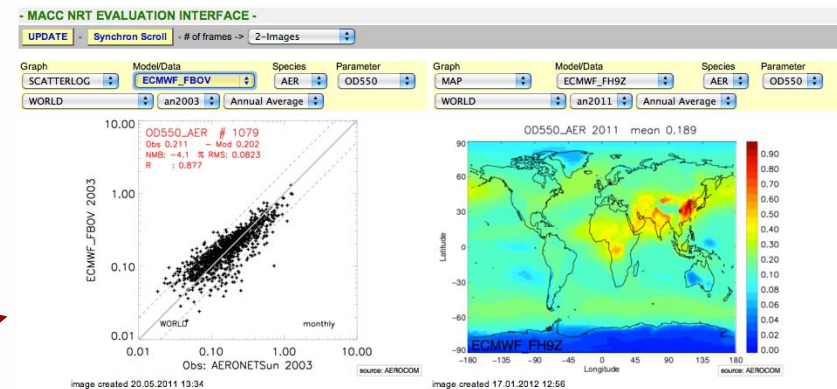
Validation websites: overview



Stratosphere

Routine monitoring

Aerocom



Validation websites: NORS

Intercomparison Selection

PARAMETER

AEROSOL	2
CH2O	4
CH4	1
CO	2
NO2	3
O3	10

MODEL TYPE

fnyp	9
g4e2	13

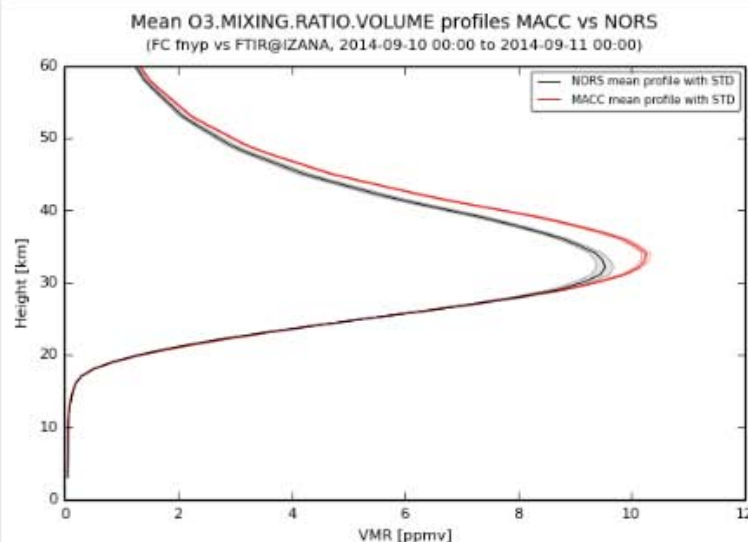
INSTRUMENT TYPE

FTIR	8
LIDAR	2
MWR	2
UVVIS.DOAS.DIRECTSUN	1
UVVIS.DOAS.OFFAXIS	1
UVVIS.DOAS.ZENITH	3

Reports

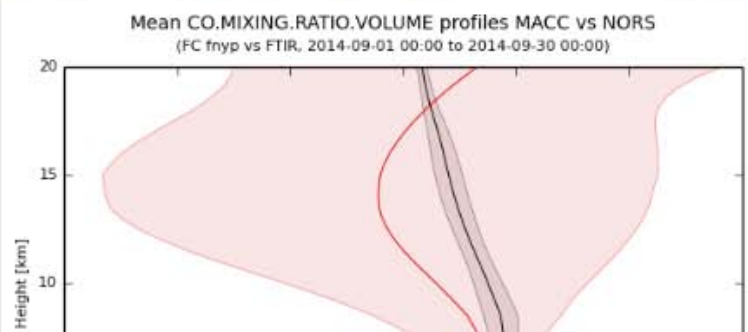
O3-fnyp-FTIR, KIT@IZANA: 2014-09-10 - 2014-09-11

[zip](#) [pdf](#)



CO-fnyp-FTIR, [ALL]@[ALL]: 2014-09

[zip](#) [pdf](#)



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IZANA	71
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LA.REUNION.MAIDO	40
LA.REUNION.STDENIS	7
LAUDER	15
MAUNA.LOA.HI	16
NY.ALESUND	38
XIANGHE	34
ZUGSPITZE	29

AFFILIATION

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CNRS.LATMOS	18
INTA	22

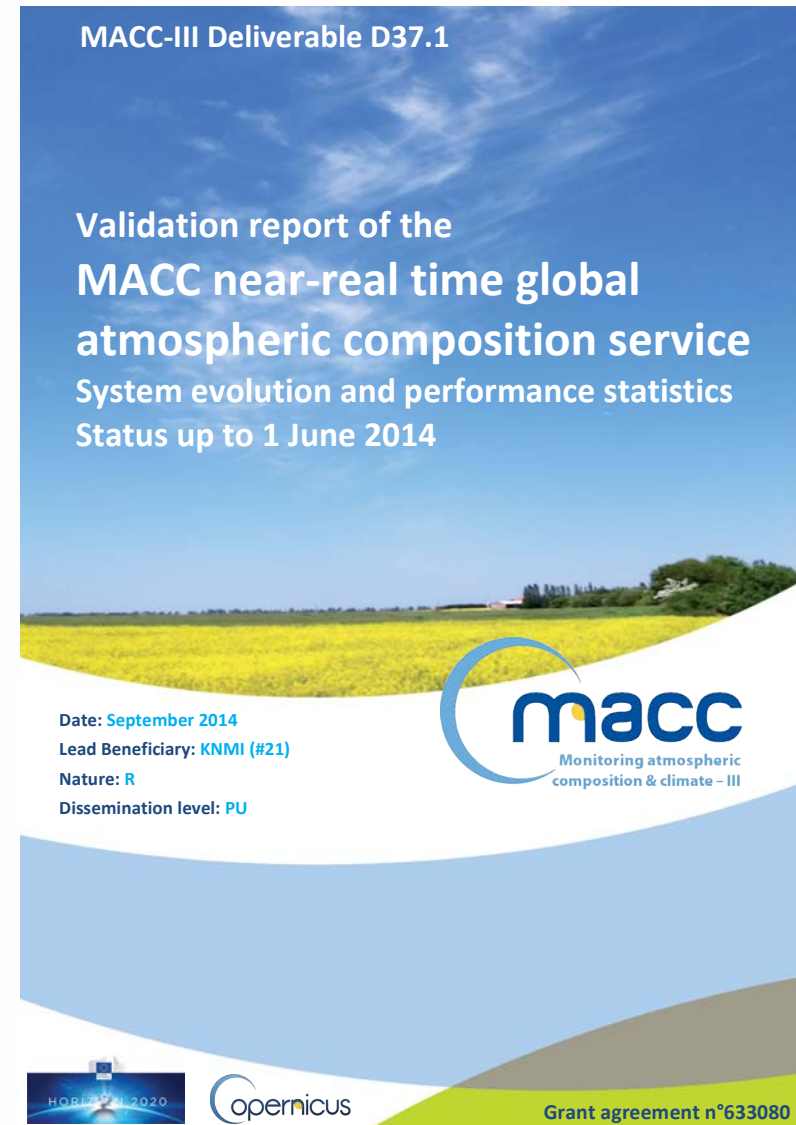
Results: Validation report NRT global service

VAL report September 2014

- **Summary for users**
- **Overview of model configurations and changes**
including availability statistics
- **Detailed validation results**
- **Case studies:**
Dust, fire, pollution episodes
Low stratospheric ozone
- **Annex: methodology**

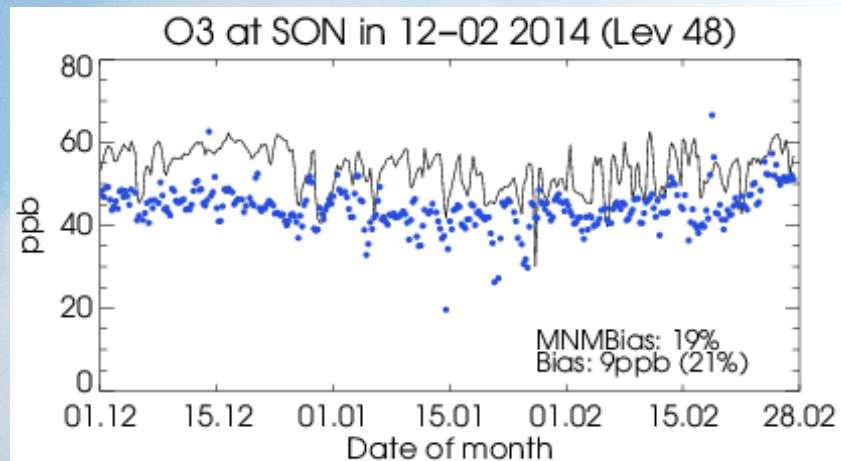
Last report: period up to 1 June 2014

(Updates every 3 months)

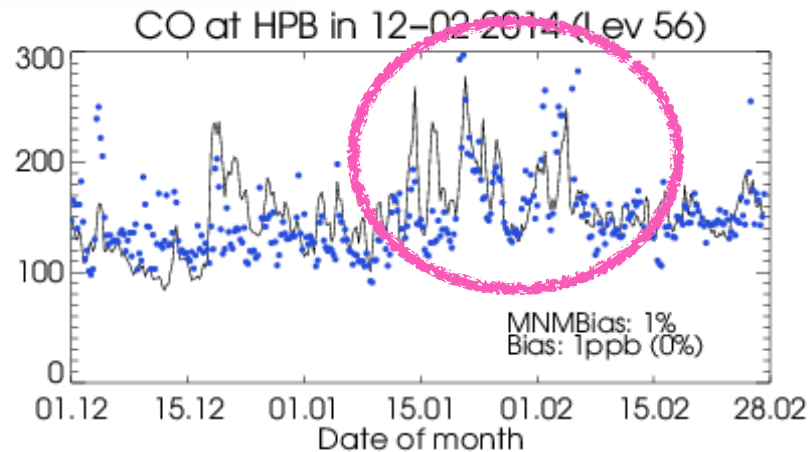
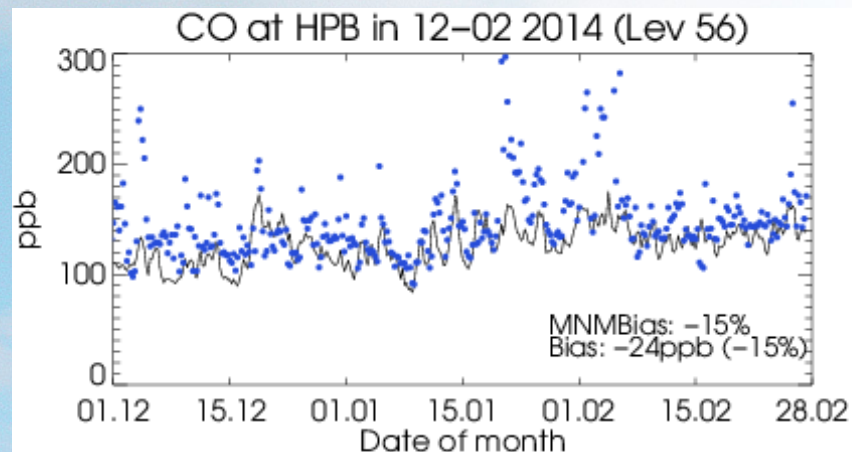
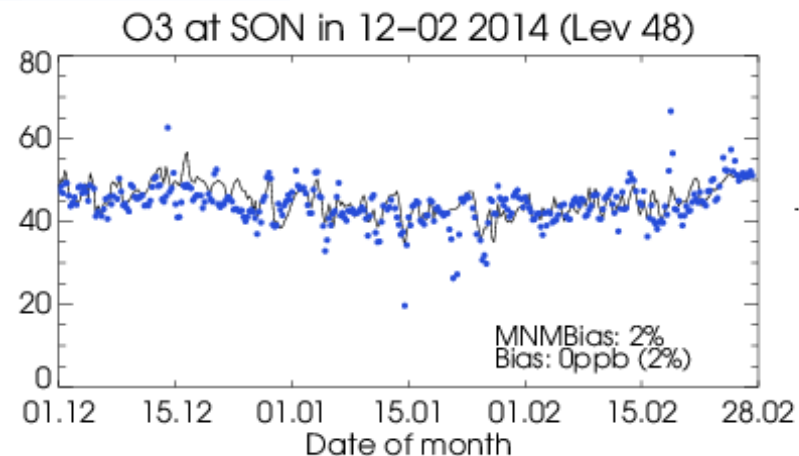


Validation report NRT global service: C-IFS

o-suite, MOZART-IFS



C-IFS (TM5) stand-alone



C-IFS showing skill in producing fine-scale variability in several cases

Quick verification of the e-suite

Includes:

- Summary
- Detailed validation plots



Available a few weeks before the end of the e-suite period,
To help in the decision to replace the current o-suite

Latest version: September 2014

Upgrade from coupled system to C-IFS

MACC-III Deliverable D38.1

Upgrade verification note:
Evaluation of the e-suite (g4e2)
for the period
December 2013 - August 2014

Date: September 2014
Lead Beneficiary: KNMI (#21)
Nature: R
Dissemination level: PU

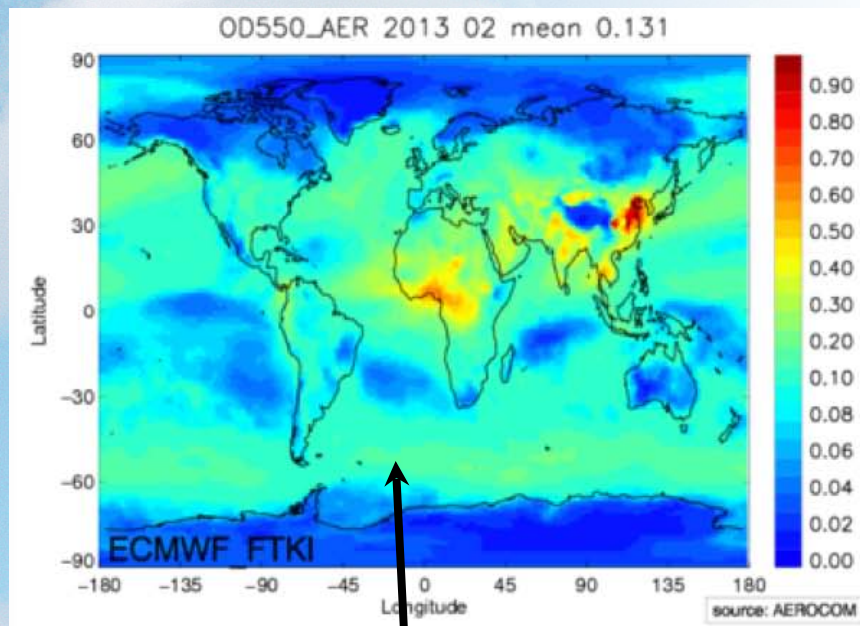


Grant agreement n°633080

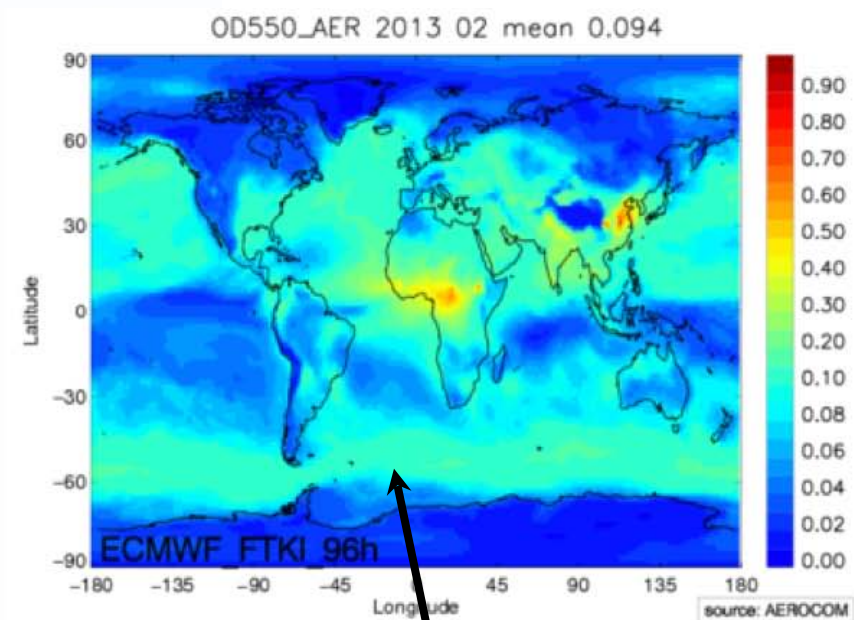
Quick verification of the e-suite: aerosols

Example e-suite report 2013:

The e-suite aerosol model quickly loses mass, and
Angstrom exponent much larger than o-suite



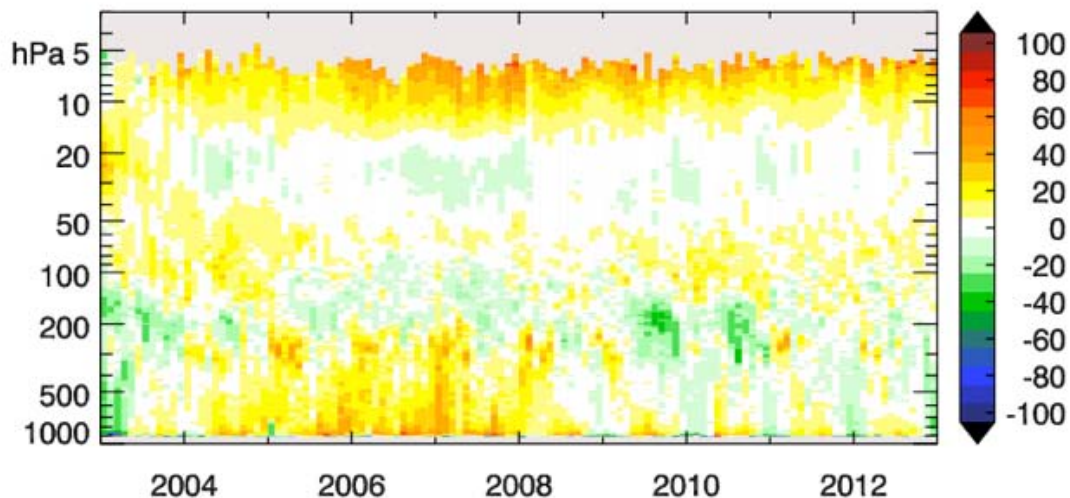
Analysis



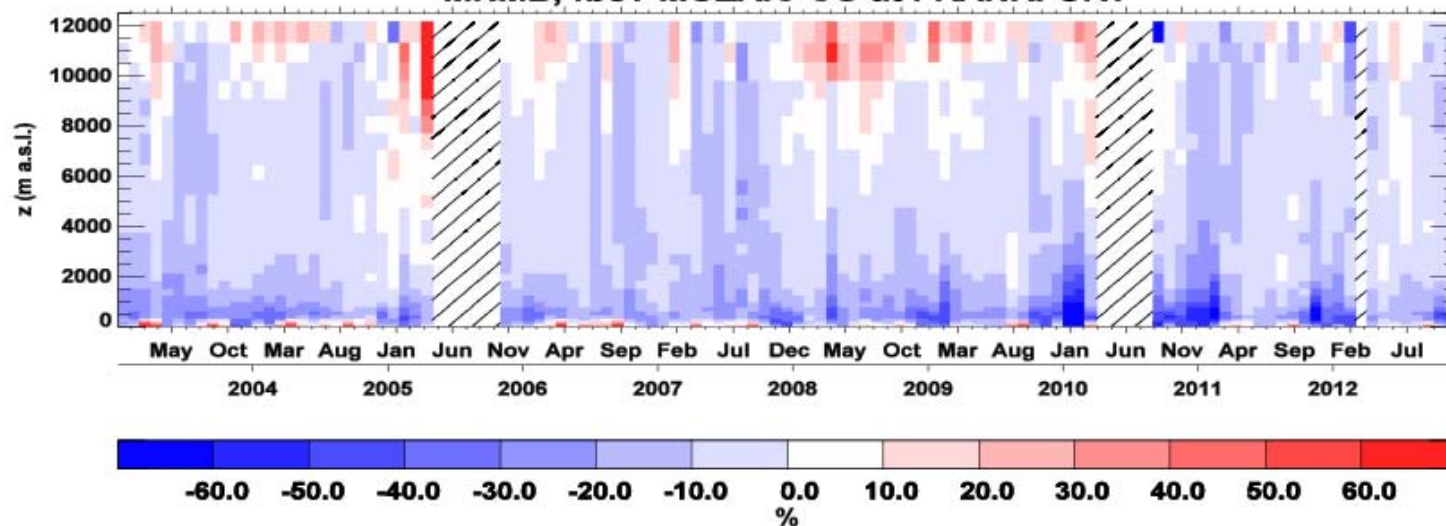
96 hour forecast

Validation report global reanalysis, 2003-2012

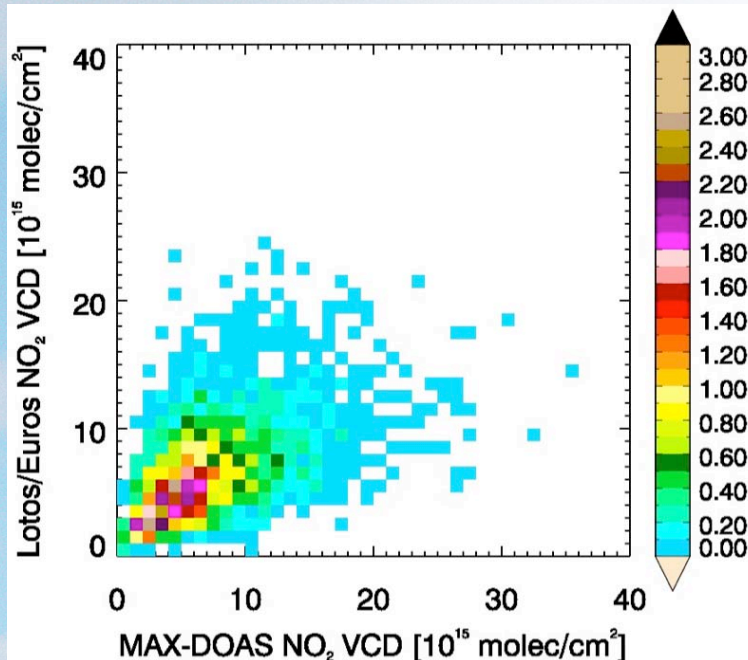
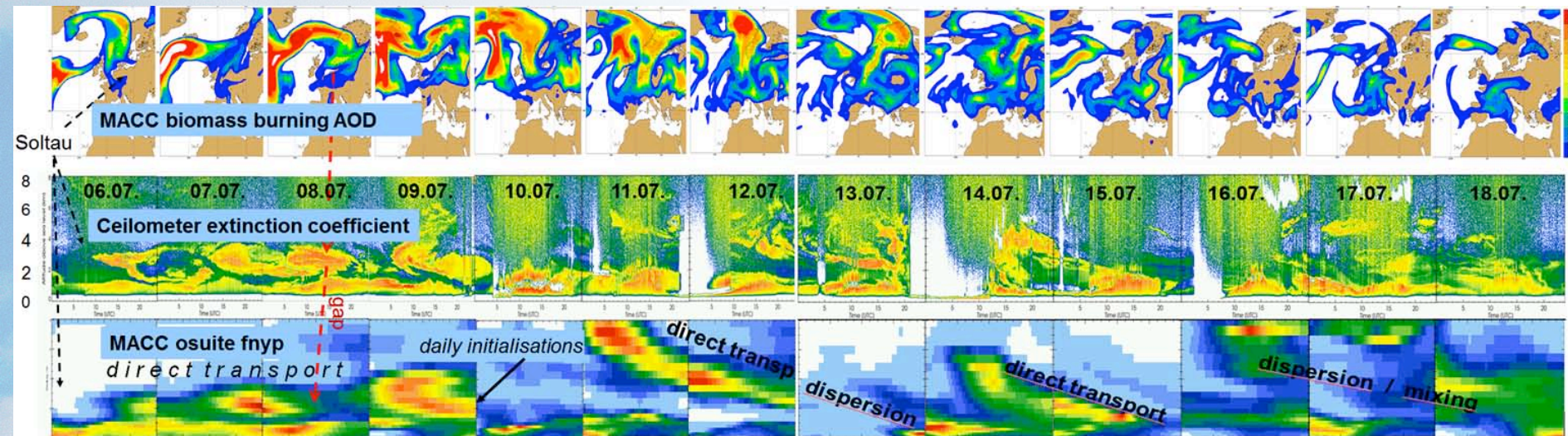
Monthly-mean analysis-sonde (rean) profiles
for GO3 (% diff mPa) over Hohenpeissenberg
from 2003 to 2012



MNMB, fbov-MOZAIC CO at FRANKFURT



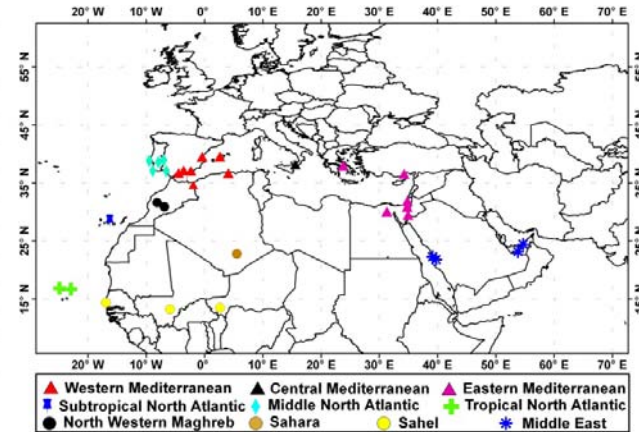
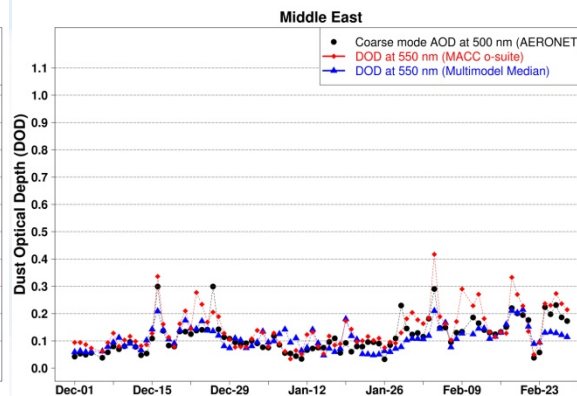
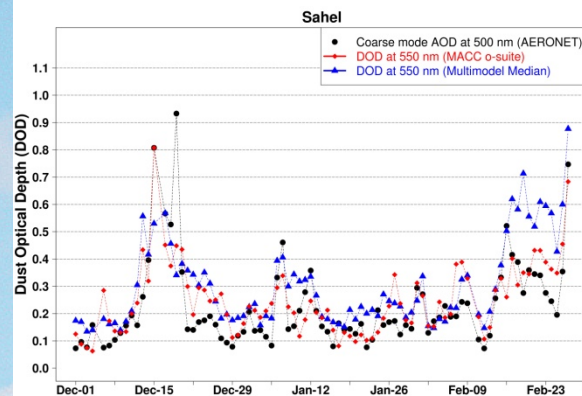
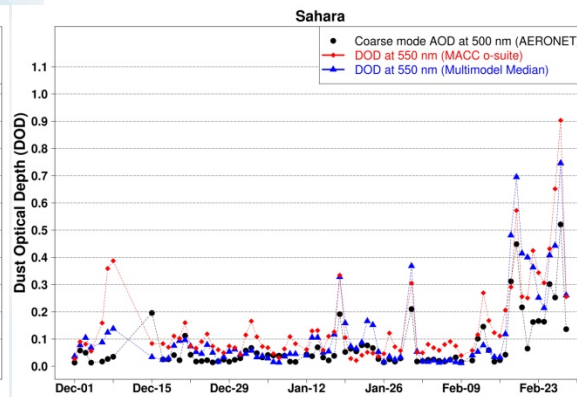
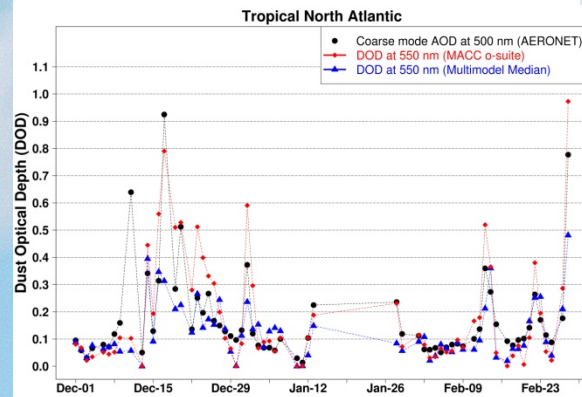
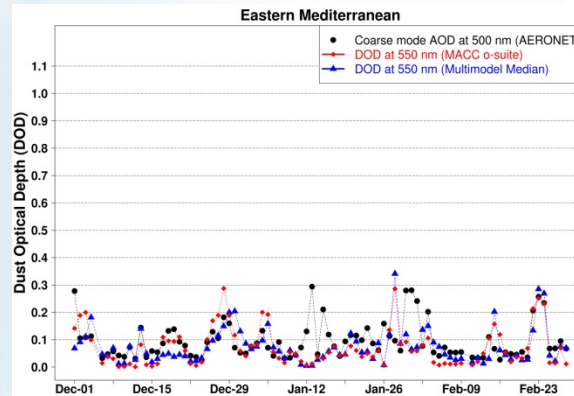
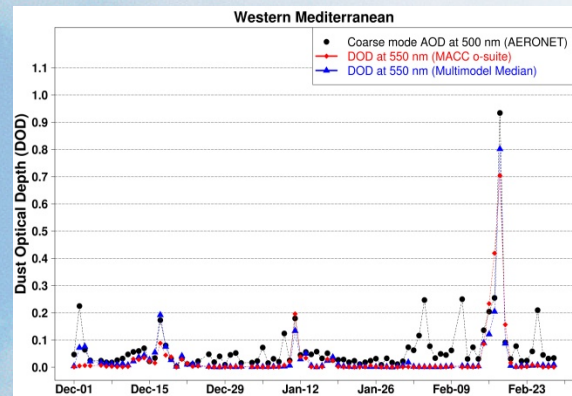
Research: Use of Ceilometer and MAX-DOAS



Biomass Burning AOD
over Europe
from 6-18 July 2013
(H. Flentje, DWD)

MAX-DOAS (Bremen) against
the regional model LOTOS-EUROS
(A. Blechschmidt, IUP)

Case studies: Sahara desert dust



Comparing MACC
dust optical depth
with SDS-WAS
model median:
good skill in
capturing sand
plumes

(E. Cuevas)

User involvement

Reports are meant first of all to serve users.

Summaries reports ordered by user areas of interest:

- Climate forcing
- Regional air quality
- Stratospheric composition & UV
- Extreme events

Interaction with users

- Examples: AQMEII group of modellers, UK Met Office
- Interaction facilitated by interface subproject (INT):
MACC-II / GMES-PURE user workshop June 2013

Scoring approach

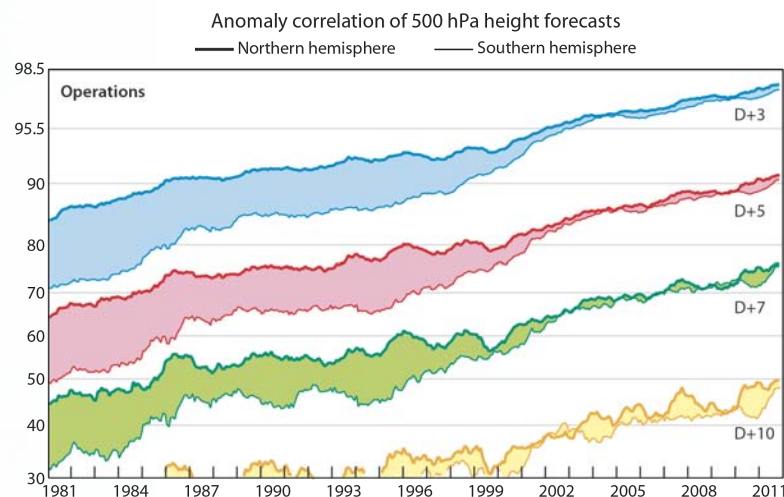
Develop „headline scores” with meaning relevant to user groups

Research: Development of (multiple) skill scores

The steps of the proposed user-oriented approach are:

- Choose a Copernicus-atmosphere application area
- Identify user knowledge requirements for this application area
- Identify species involved and available reliable observational data sets
- Identify the perfect skill / no skill reference
- Identify relevant accuracy measures
- Translate the accuracy measures into skill scores:
a quantity without dimension, between 0 (no skill) and 1 (perfect skill),
based on the references.

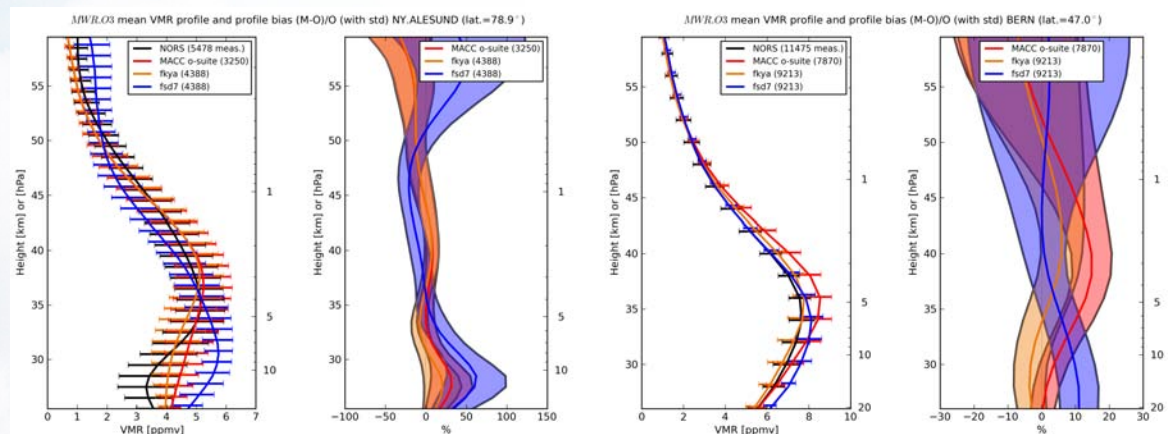
Work in progress ...



Future: MACC-III and CAMS

- Continue 3-monthly updates of validation reports and E-suite evaluation reports
- Extend sources of validation data, e.g. NORS
- Extend number of services with validation report, e.g. BASCOE
- Homogeneous presentation of validation results project-wide: web site, content reports, scores, user feedback
- Error characterization
- Headline scores, use-motivated skill scores

(NORS example)



Conclusions

The MACC system shows a clear skill in describing and predicting the **day-to-day variability** of atmospheric composition,

- > for tropospheric and stratosphere,
- > aerosol and gases,
- > related to events
(dust outbreaks, fires, pollution, volcanoes, ozone depletion)

Data requirements for validation:

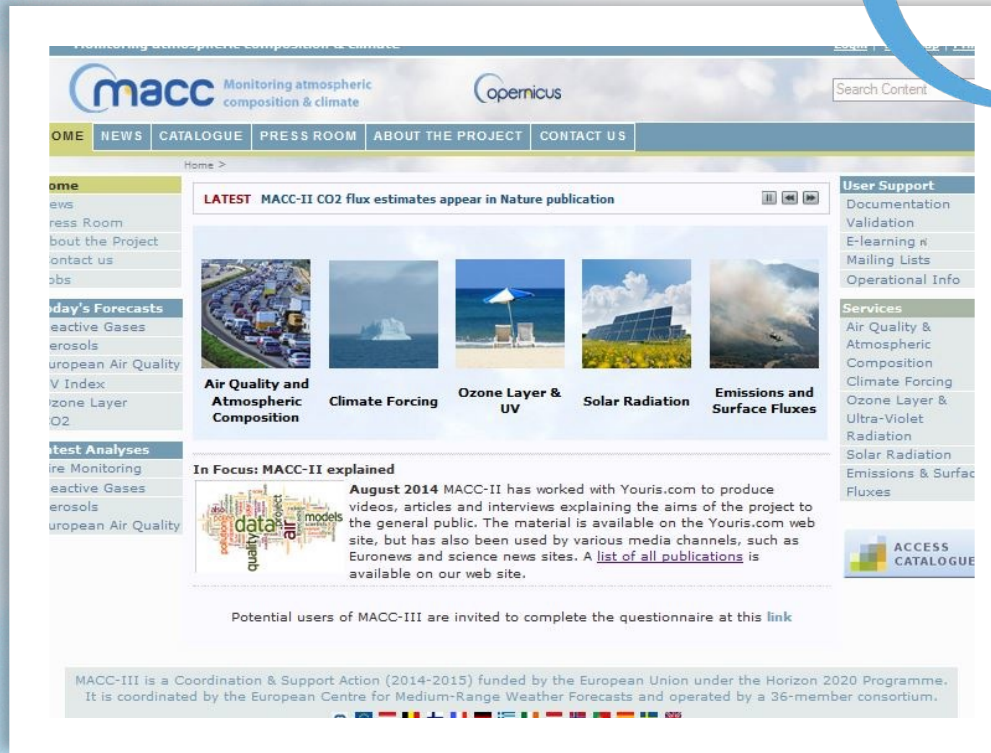
- Real-time availability within a day
- Availability within a month for the validation reports
- Long-term, high quality, coverage
(e.g. NDACC, IAGOS, GAW)

To document progress of the MACC system

Validation reports available on the MACC website:

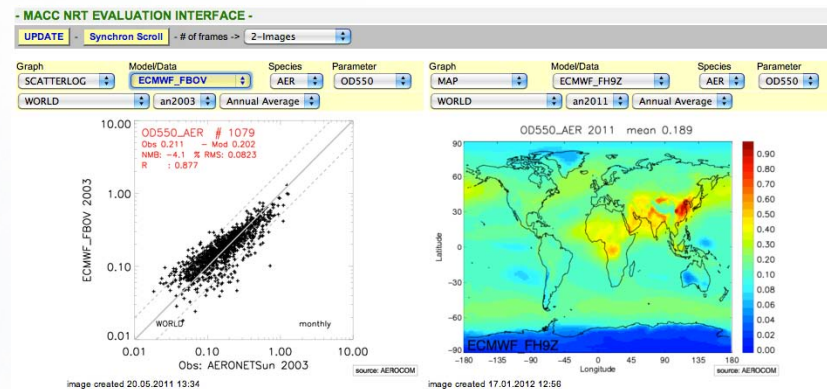
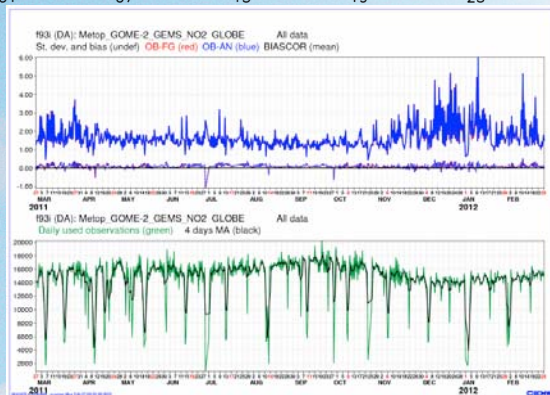
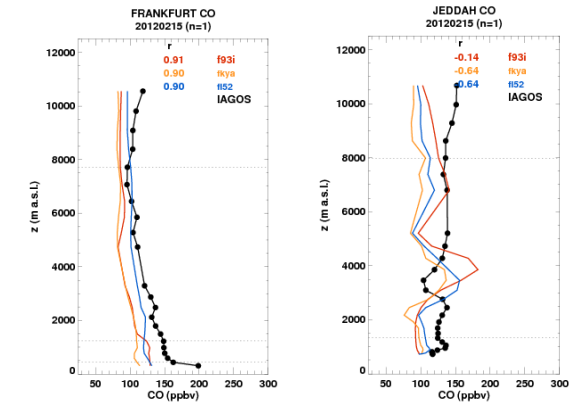
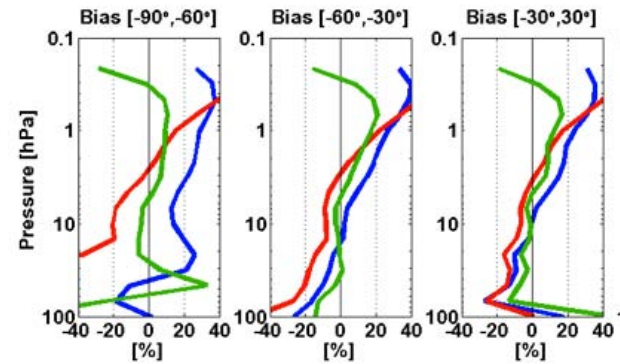
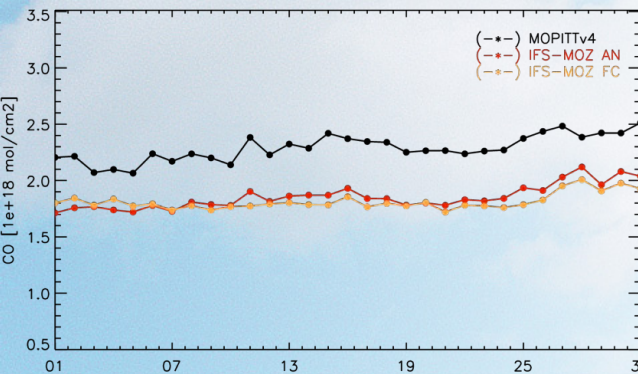
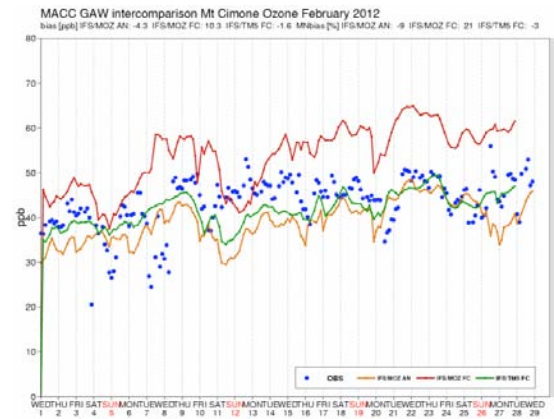
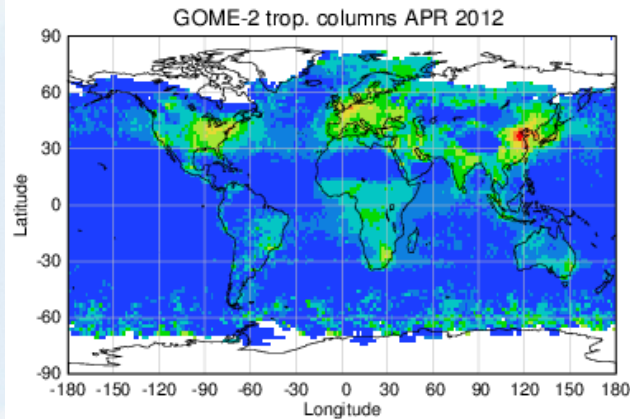
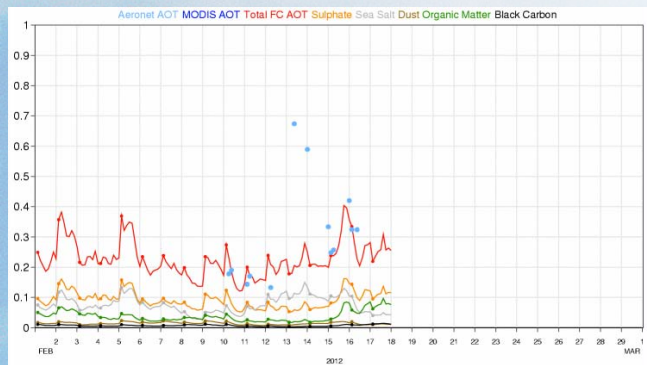
<http://copernicus-atmosphere.eu>





Website:
<http://www.copernicus-atmosphere.eu>
Contact:
info@copernicus-atmosphere.eu

Global validation: websites



Papers for special issue

Submitted:

Lefever, et al., Copernicus atmospheric service for stratospheric ozone: validation and intercomparison of four near real-time analyses, 2009–2012, Atmos. Chem. Phys. Discuss., 2014.

E. Cuevas, et al., The MACC-II 2007-2008 Reanalysis: Atmospheric Dust Evaluation and Characterization over Northern Africa and Middle East, submitted to Atmos. Chem. Phys.

In preparation

Evaluation of the MACC operational forecast system - potential and challenges of global near-real-time modelling with respect to reactive gases in the troposphere". Annette Wagner.

"Validation of the near-real time MACC global system". Henk Eskes.

"Evolution of the MACC aerosol model performance". Michael Schulz.

Evaluation of MACCII global reanalysis surface ozone". Eleni Katragkou.

"MOZAIC observations and MACC re-analysis in the UTLS". Audrey Gaudel.

Validation report for ozone column 30jr reanalysis



Ozone Multi-Sensor Reanalysis (MSR)

Use all available UV-Vis total column satellite products (TOMS, SBUV, GOME, SCIAMACHY, OMI, GOME-2)

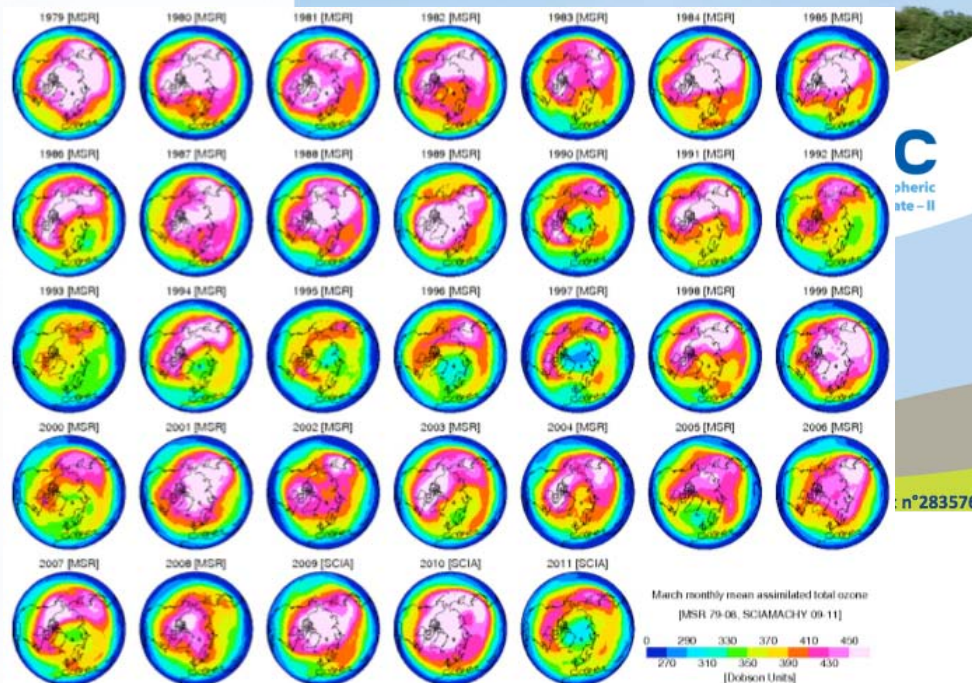
Calibrated with Brewer-Dobson

Validation report published in January 2013

When MSR-2 will appear, the report will be updated

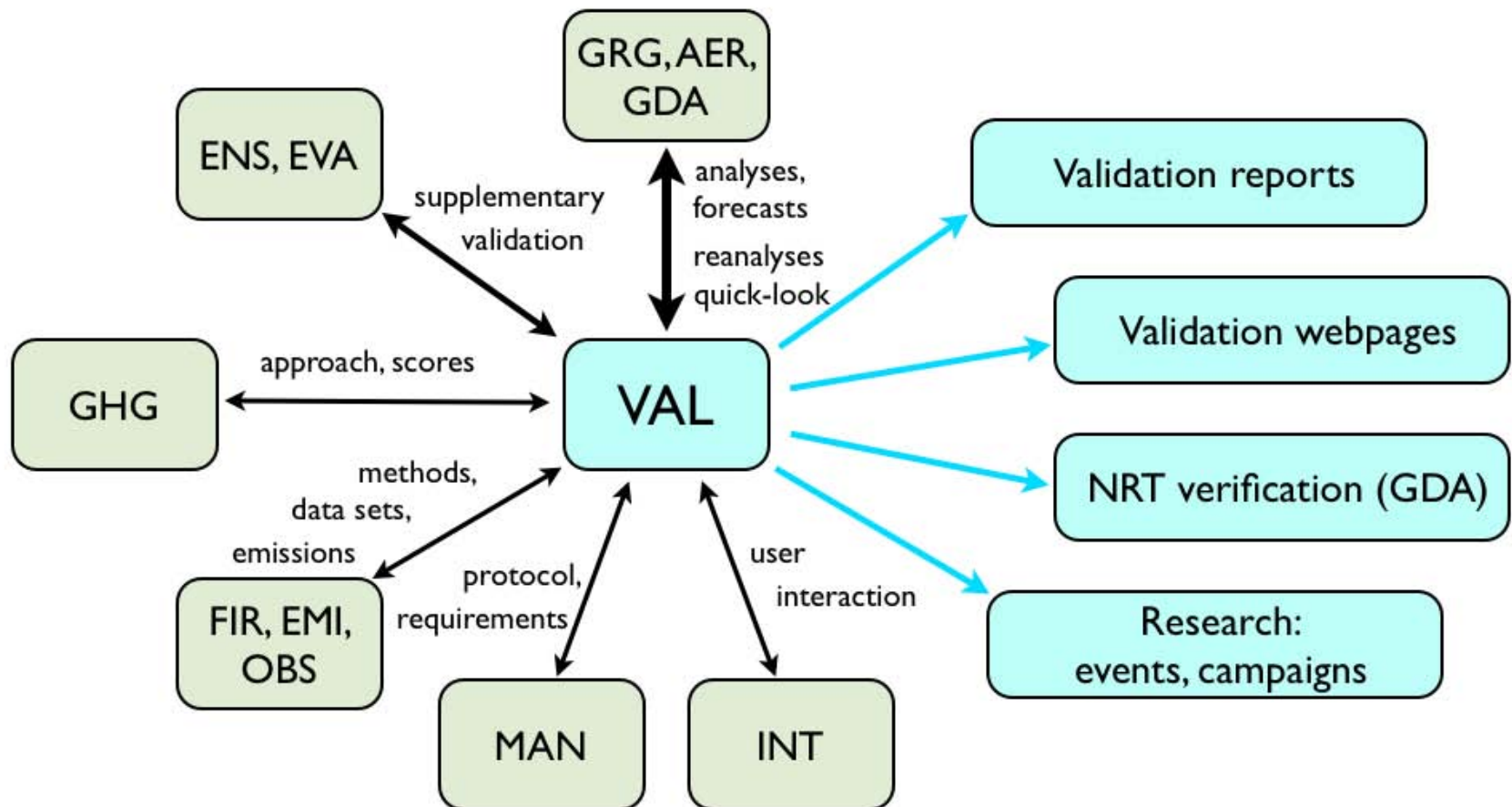
MACC-II Deliverable D_83.3

Validation report of the
MACC 30-year multi-sensor
reanalysis of ozone columns
Period 1979-2008



Role of VAL in the MACC-II production chain

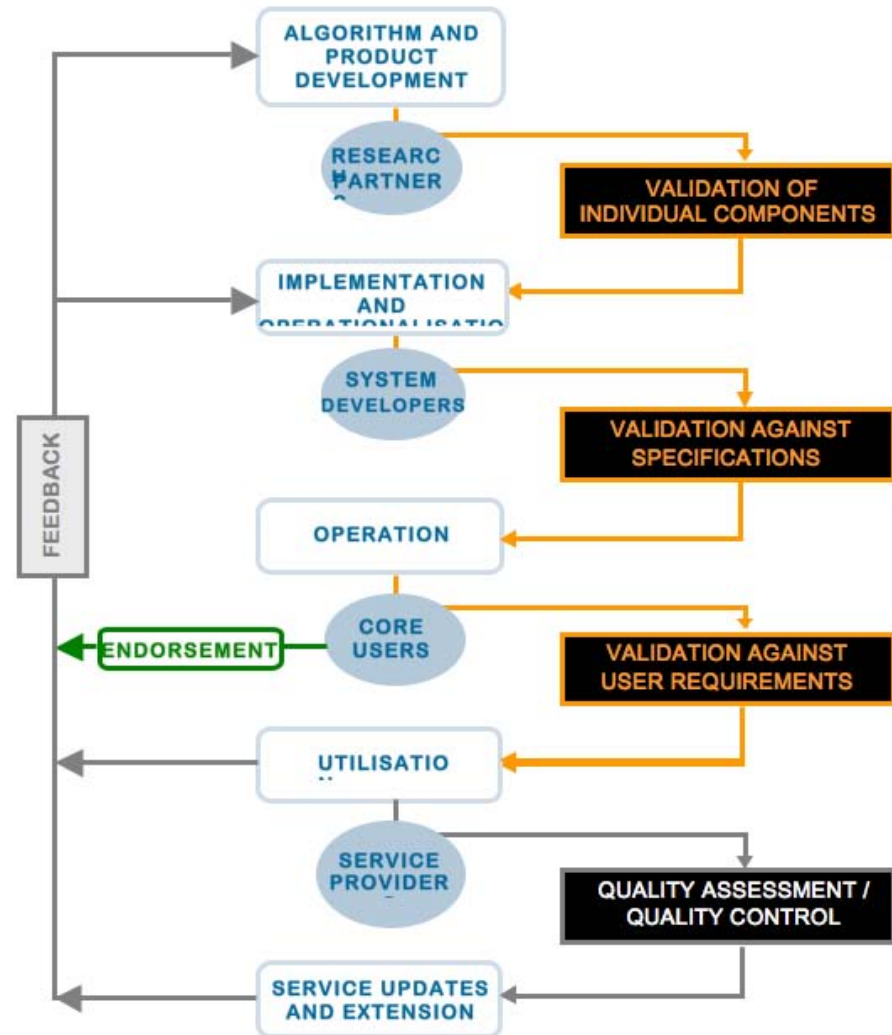
- Principle (long-term goal):
all services in the catalogue should be accompanied by an up-to-date validation report, essential for users



Service Validation Protocol v2 (BIRA-IASB)

J.-C. Lambert

“High-level” validation requirements will be adopted as much as possible in the validation reports of MACC-II



Validation report global reanalysis, 2003-2012

Covering the full 10-year period

Chapters:

- Summary for users
- Overview of model configurations and changes
- Detailed validation results
- Case studies
- Validation methodology

Update frequency:

- 6 months during production
- one final update at end of MACC-II

Version 4 published in July 2014

