Aerosols

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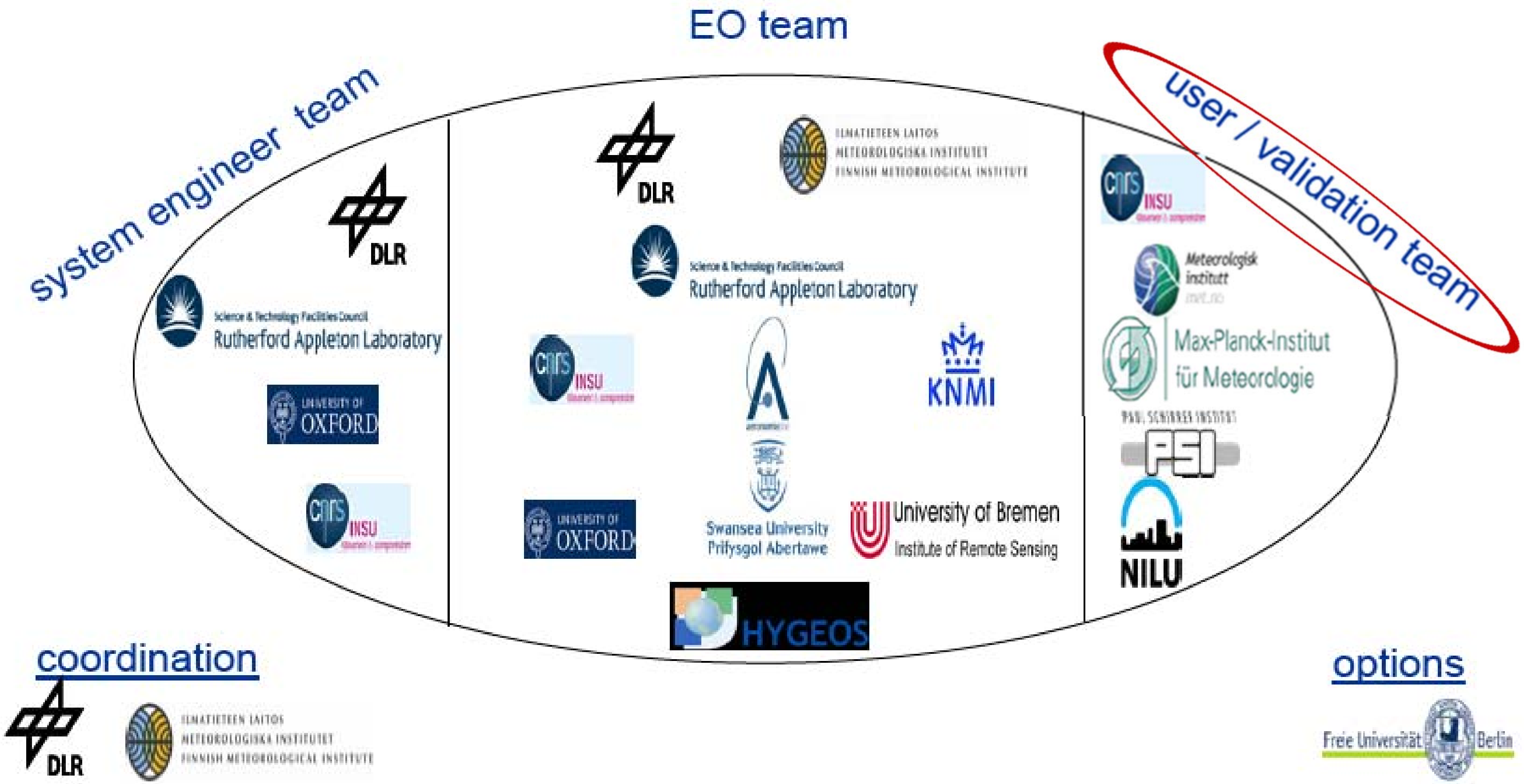
& the Aerosol_cci team

aerosol_cci team



The cooperation of the EO team and the user/validation team appeared extremely useful for algorithm improvement !

Introduction to ESA's Aerosol-cci

ESA climate change initiative (CCI):

- The goal of the ESA climate change initiative is to produce essential climate variables (ECV) using satellite data, following GCOS requirements
- Users and advisors: climate change community
- Focus on European satellites; not exclusively
- 13 different areas, among which aerosols

Aerosol-cci brings together the most prominent European aerosol retrieval groups

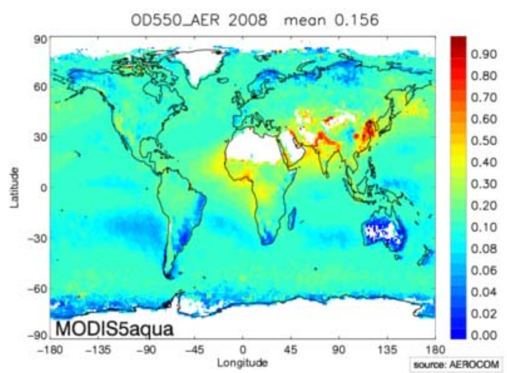
Non-European groups contribute

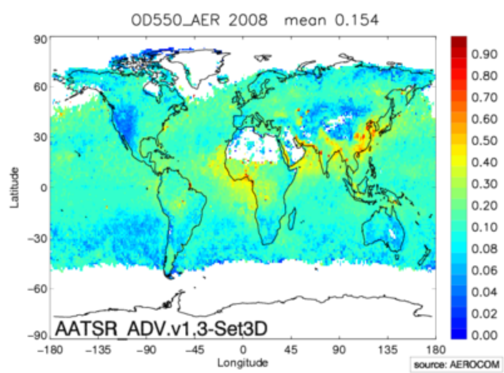
Aerosol-cci:

- Started July 2010, 3 years
- Work closely with AEROCOM
- Independent validation
- Initial focus on understanding differences between different algoritmhs and algorithm improvement
- Baseline algorithms: status at start of project
- Round Robin for 4 months in 2008: March, June, September and December

Over-arching scientific challenges

- Requirements (GCOS, Users)
  - At the start of the project, no algorithm could meet the requirements
  - All algorithms provided different baseline results
  - Results from all algorithms were less good than the ”standard” (MODIS, MISR)
- Understand differences between algorithms
- Can algorithms be improved to meet requirements?
- Can algorithms be improved to provide results closer to the ”standard”?
- Are the results good enough to provide useful ECVs??

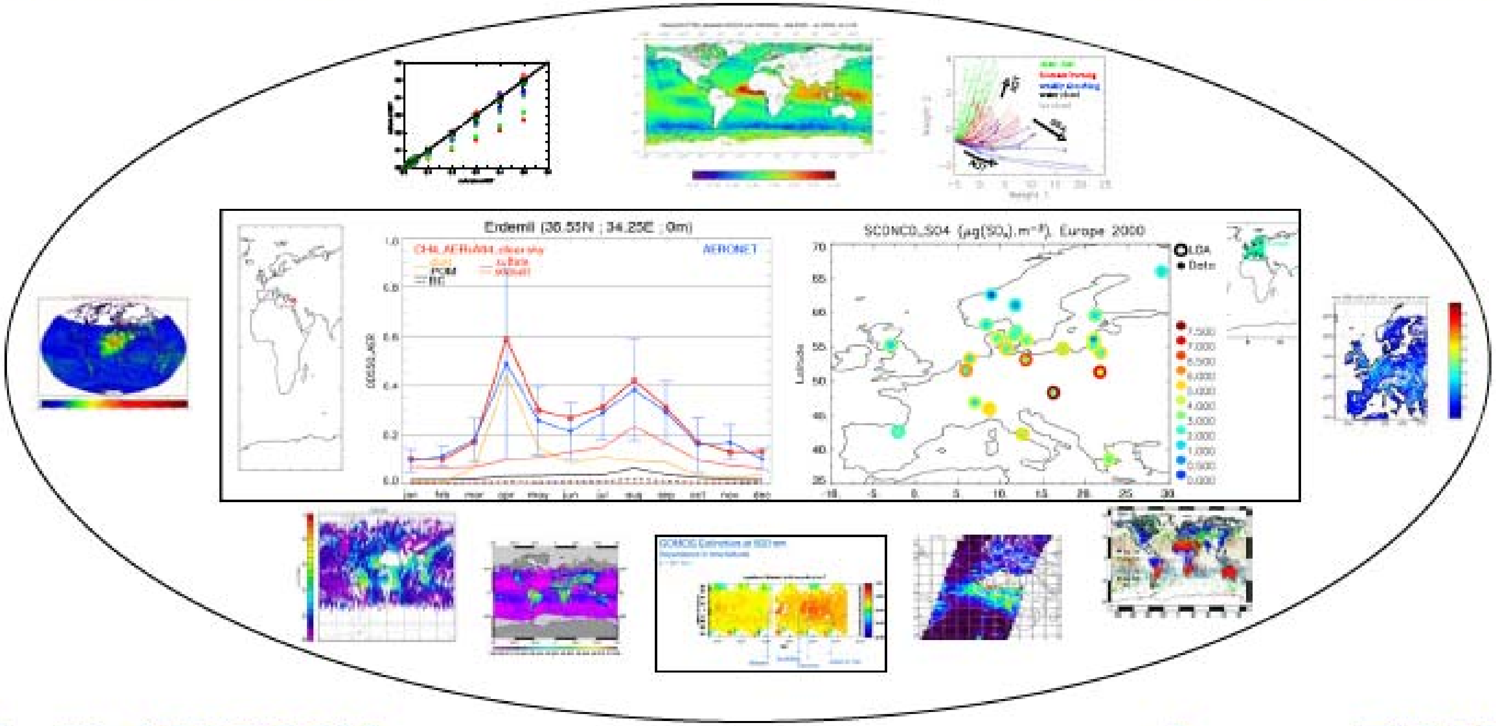




aerosol_cci concept

understand differences of various products

integrate major European EO teams



work with AEROCOM user community

focus on ENVISAT and European sensors

Specific challenges (Aerosols)

- An aerosol is a suspension of particles in a medium, in this case the atmosphere
- Often the term ”aerosol” only refers to the particles
- These particles have many degrees of freedom:
  - Size (<10 nm to > 100 µm)
  - Concentrations depend on size and can vary from ~60 in the clean atmosphere to over 10^6 in the polluted atmosphere
  - These paramters depend on sources, transformation processes, removal
  - Chemical composition very variable depending on sources
  - Chemical composition varies with size
- As a consequence, the optical properties, used in the retrieval, are very variable
- All of these vary by region
- Short life cycle (hours-days)

Specific challenges (Aerosol retrieval)

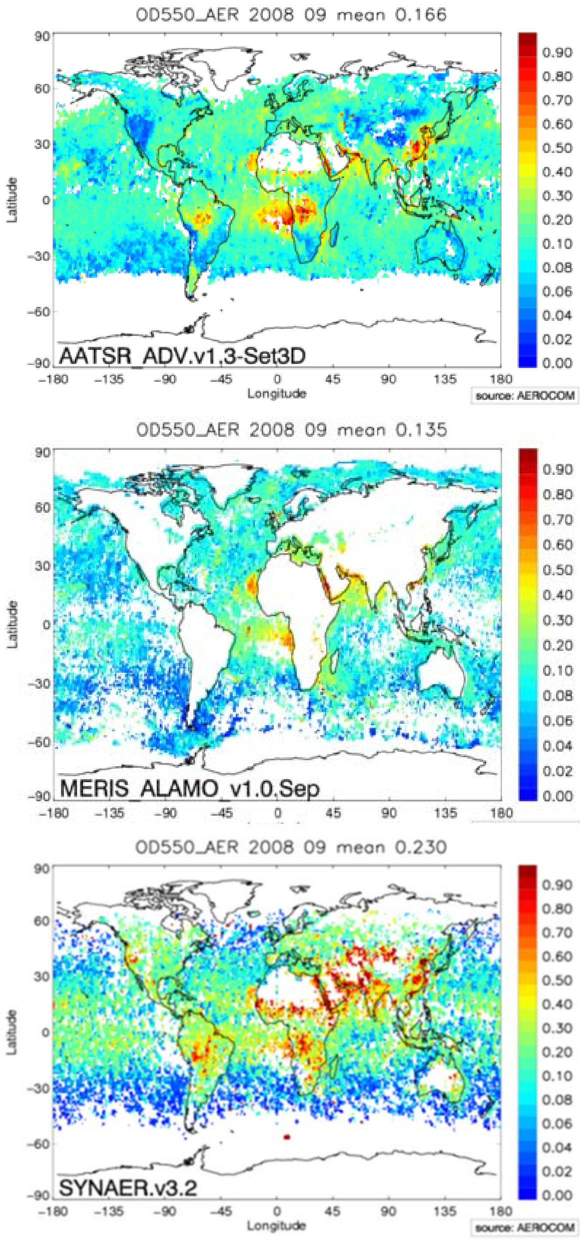
- Presence of clouds
  - Clouds have a much larger reflectance than most aerosols
  - Sub-visible clouds (e.g, high Ci) hard to detect and correct for
- Underlying surface
  - Dark?
  - Surface reflectance surfaces can overwhelm the aerosol reflectance
- Separation of aerosol signal at TOA from that of clouds and surface very important
- and often inadequate!
- Trace gases
- Error estimates (very important!)

Specific challenges (Instruments)

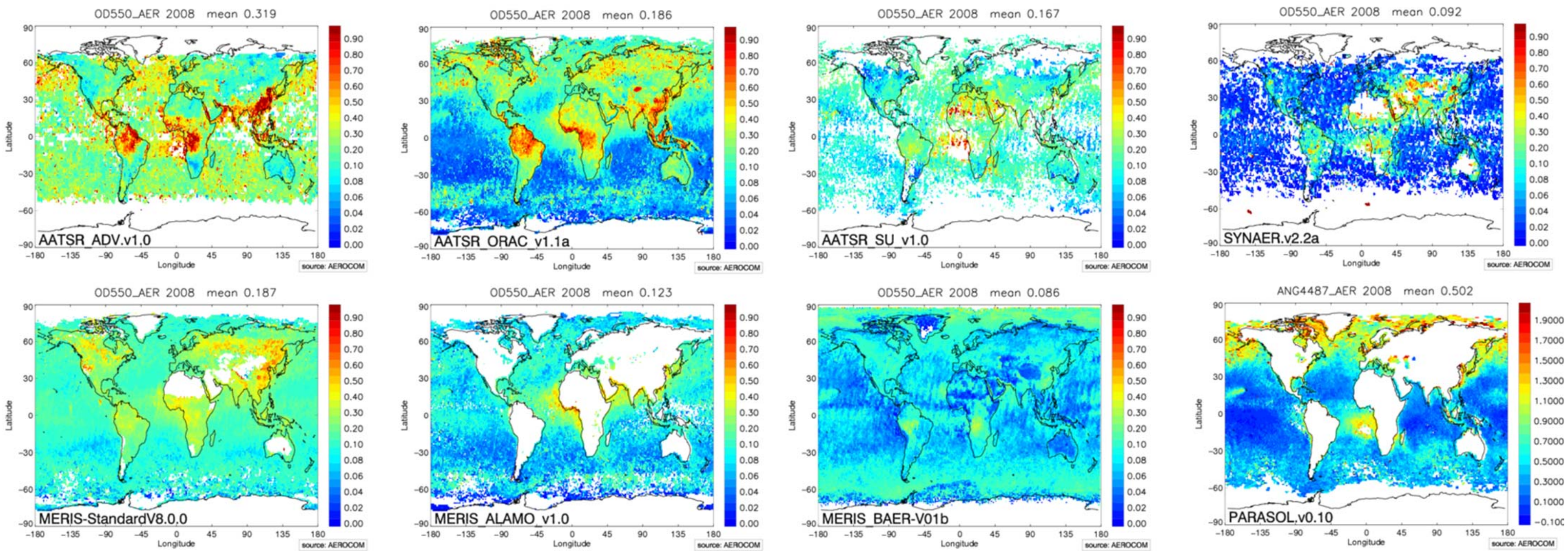
- Information content
  - Instruments usually not designed for aerosol retrieval
- Instrument calibration
- Instrument signal stability:
  - Drift
  - Degradation
- Validation
- For multiple view: collocation of views

Aerosol retrieval algorithms

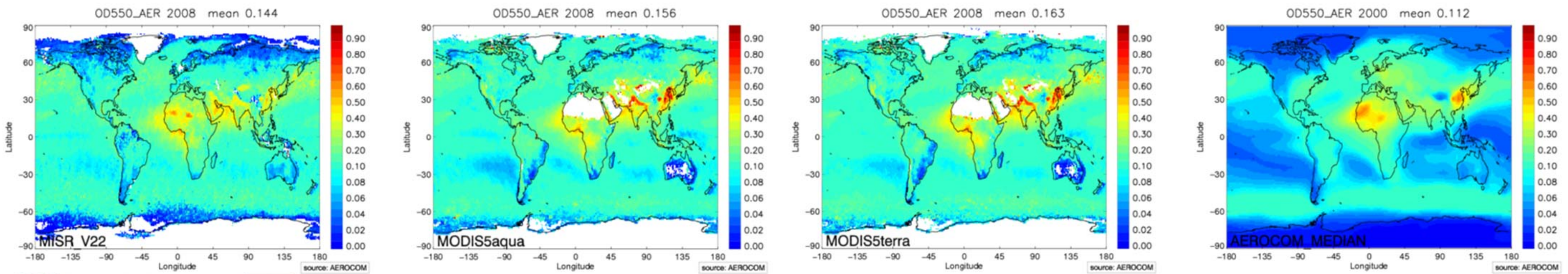
- AATSR ADV (FMI / Univ. Helsinki)
- AATSR ORAC (Oxford University / RAL)
- AATSR SU (Swansea University)
- AATSR+SCIAMACHY SYNAER (DLR)
- MERIS standard (testing by HYGEOS)
- MERIS ALAMO (ocean only, HYGEOS; complimentary retrieval)
- MERIS BAER (Univ. Bremen)
- PARASOL (ocean only; LOA)
- OMI AAI (KNMI)
- GOMOS stratospheric extinction profile (BIRA)



Baseline algorithms



Reference data sets:



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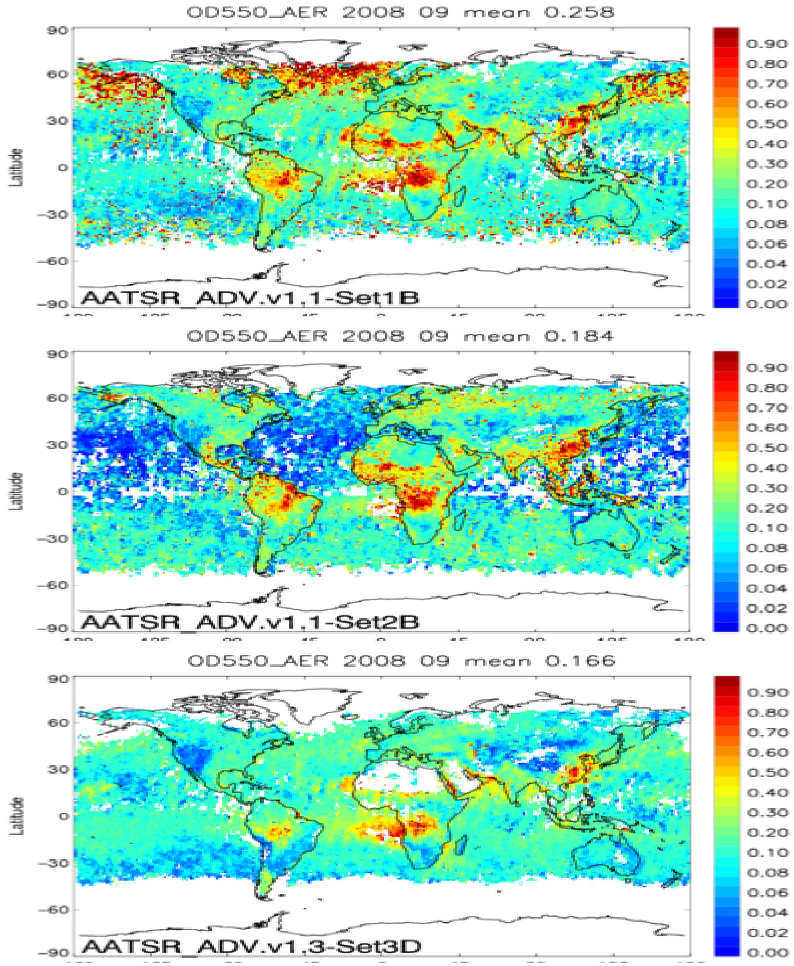
Response to scientific challenges

1. **Understand the strengths and weaknesses of each algorithm.**
   - Analysis and comparison of algorithms
   - Comparison of products for September 2008 (global)
   - Sensitivity to major assumptions and modules:
     - optical aerosol properties
     - cloud masking
     - surface treatment.
   - Selection of individual algorithms for the round robin exercise
2. **Round robin exercise: Characterization of product uncertainties and pixel errors**
   - inter-comparison of 4 months of global data (1 month per season) with
     - ground-based reference datasets (AERONET)
     - other satellite data (MODIS, MISR)
3. **Identify best modules or combinations of modules for each sensor**
4. **Production and validation of annual global datasets for 2008 (other years are optional) including their uncertainties.**

Aerosol-cci (activities)

- AATSR L1 corrections (drift)
- Systematic tests: run algo’s in a harmonized way to determine strengths and weaknesses
  - Aerosol models
  - Cloud mask (on-going)
  - Surface (on-going)
- Improve algorithms
- Implementation non-spherical particles
- Validation and comparisons
- Error characterization
- September 2008
- Round Robin for 4 months

September 2008



Sets 1,2, 3 refer to how the fine and coarse mode models were combined esa

Aerosol Components

aerosol component	refract index real p. (55µm)	refract index imag p. (.55µm)	reff (µm)	geom. st dev (σ_i)	variance (ln σ_i)	mode#. radius (µm)	comments	aeroso layer height
Dust	1.56	0.0018	1.94	1.822	0.6	0.788	non-spherical	2-4km
sea salt	1.4	0	1.94	1.822	0.6	0.788	AOD threshold constraint#	0-1 kn
fine mode weak-abs	1.4	0.003	0.140	1.7	0.53			
fine mode strong-abs	1.5	0.040	0.140	1.7	0.53			

ref_index_imag_440nm

Possible Combinations:

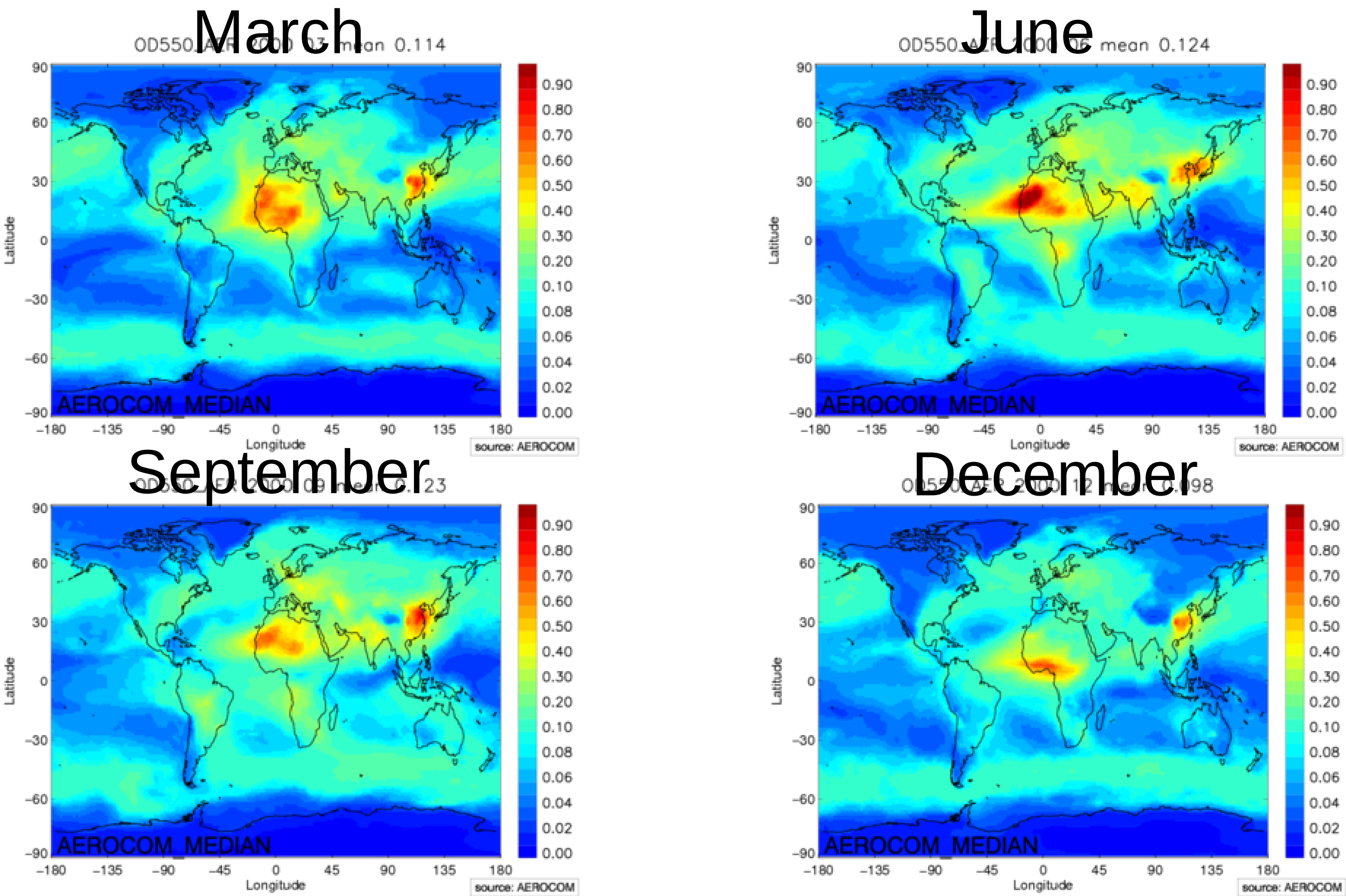
1. Mix FM1 & FM2 > FM
2. Mix CM1 & CM2 > CM
3. Mix FM & CM

Possible combination of *a priori* mixtures based on AEROCOM / AERONET climatology

§Dubovik et al., 2002

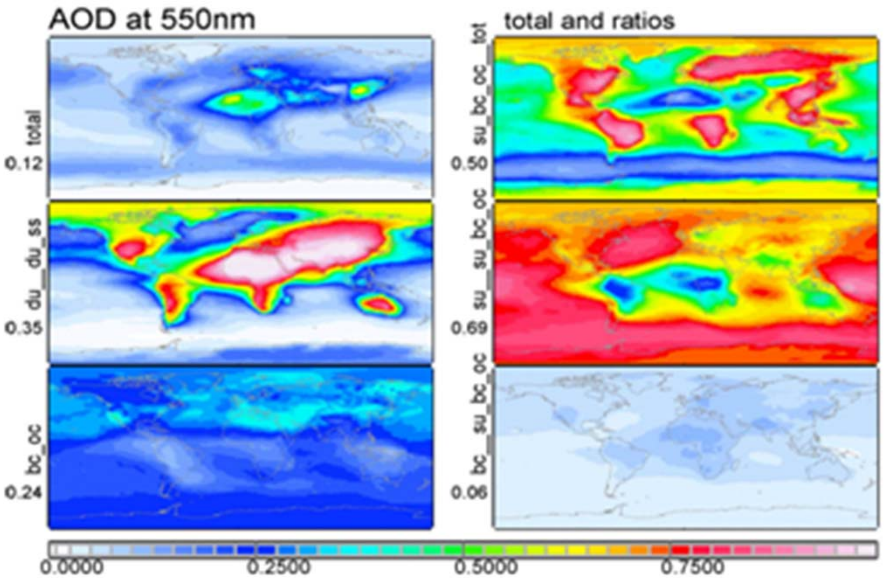
AEROCOM Climatology

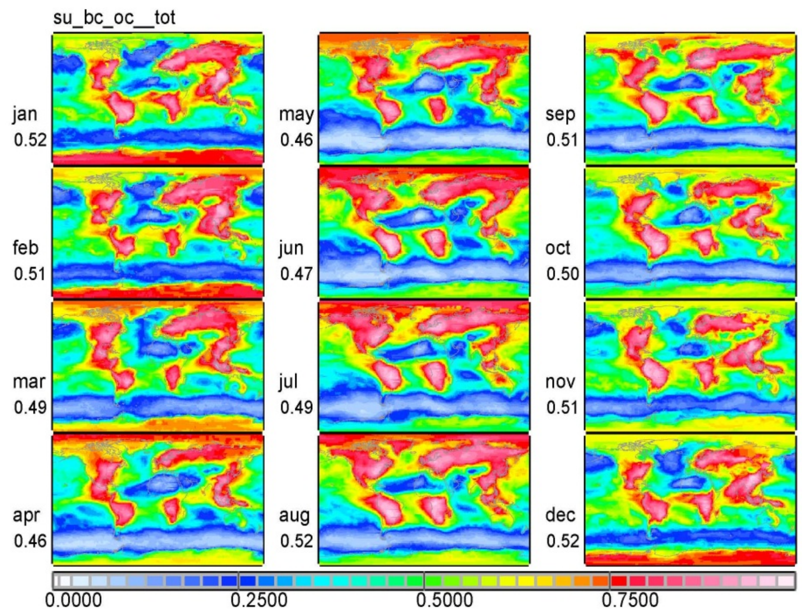
AEROCOM median, monthly distribution of aerosol components, derived from 12 global models; only used as a priori for the occurrence of aerosol types /mixtures, per region and per month, AOD is not used



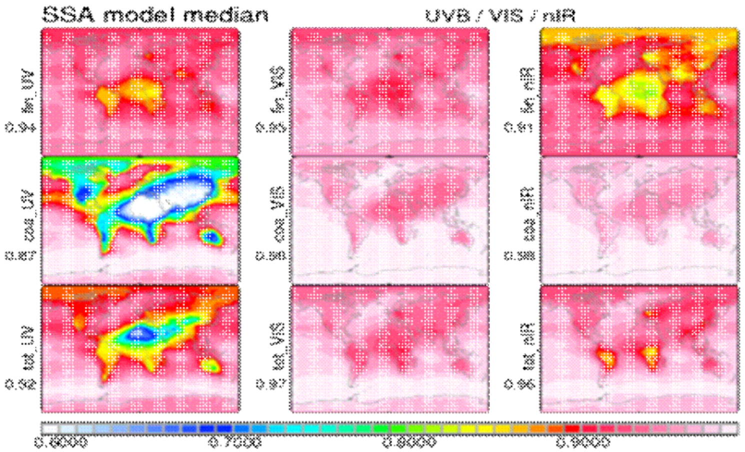
Aerosol Climatology

AEROCOM median





AOD fractions;
example: annual



Fine mode fraction;
example: monthly

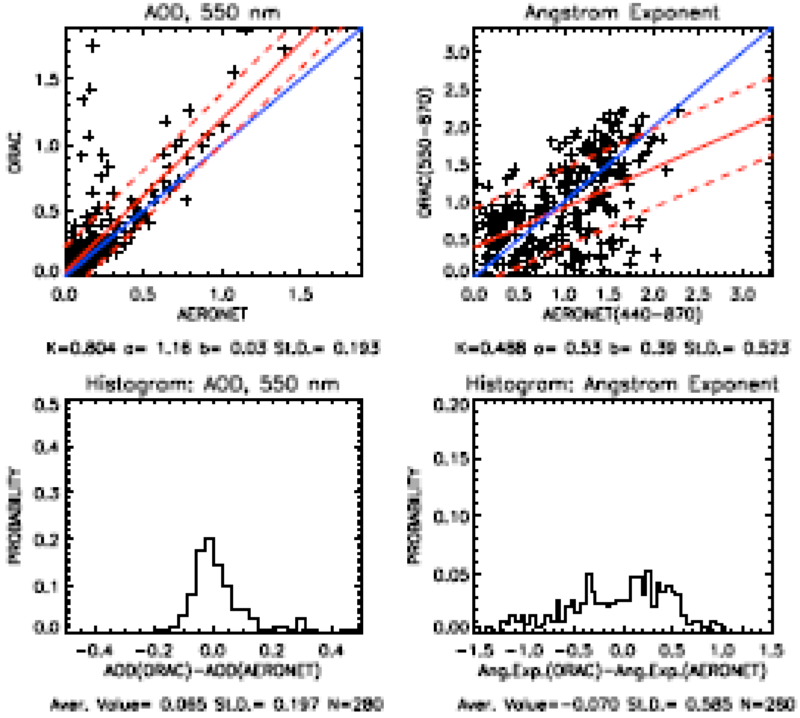
SSA: UVB VIS NIR

Aerosol-cci

Analysis tools

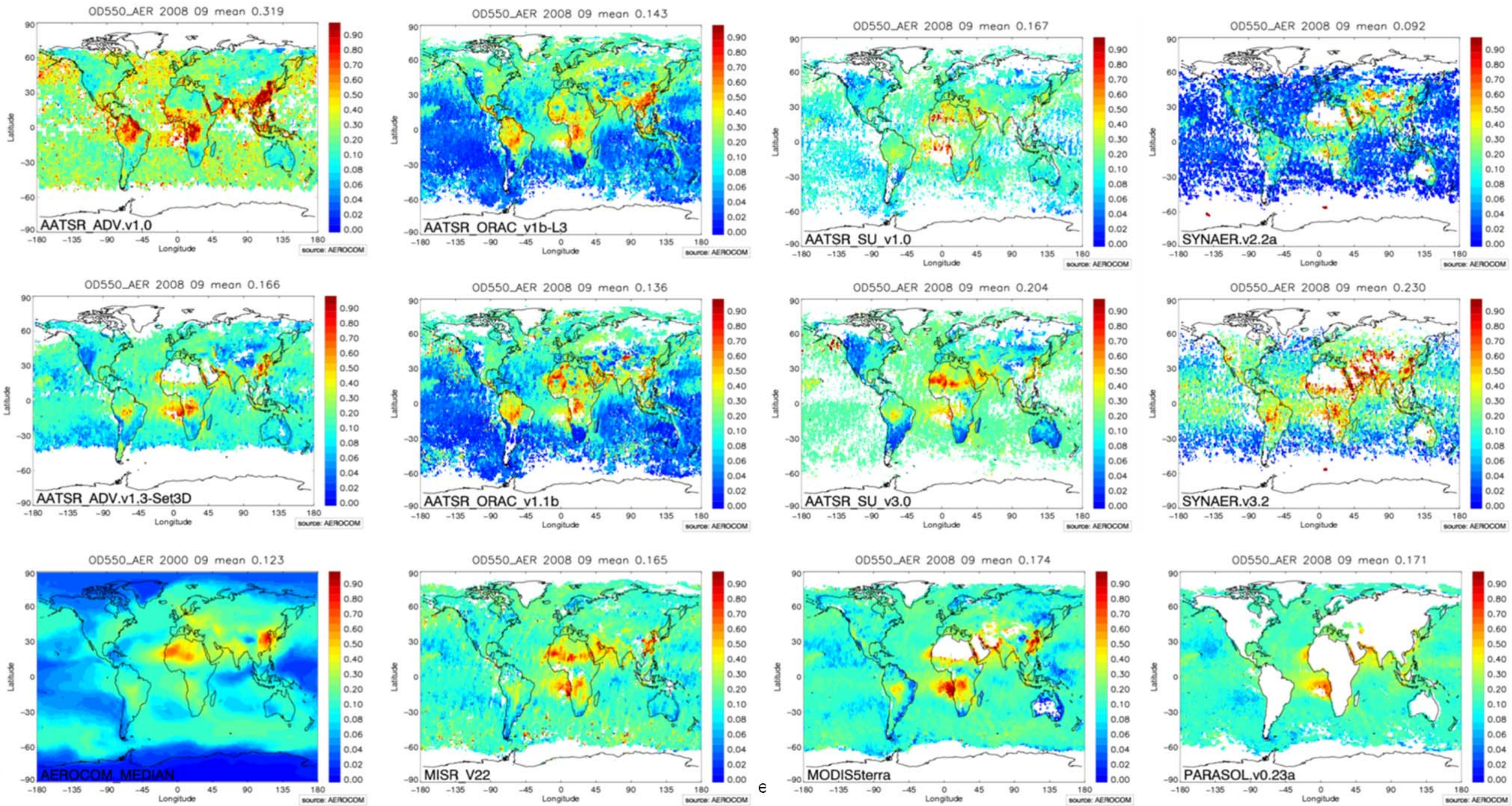
- ICARE statistical inter-comparison (level2)
    - versus AERONET
    - versus other satellites (MODIS, MISR, POLDER)
- MPI scoring (level2)
    - Spatial and temporal patterns, bias, noise
    - versus AERONET
- AEROCOM model inter-comparison (level3)

ICARE L2 for ORAC, 4 months over ocean:



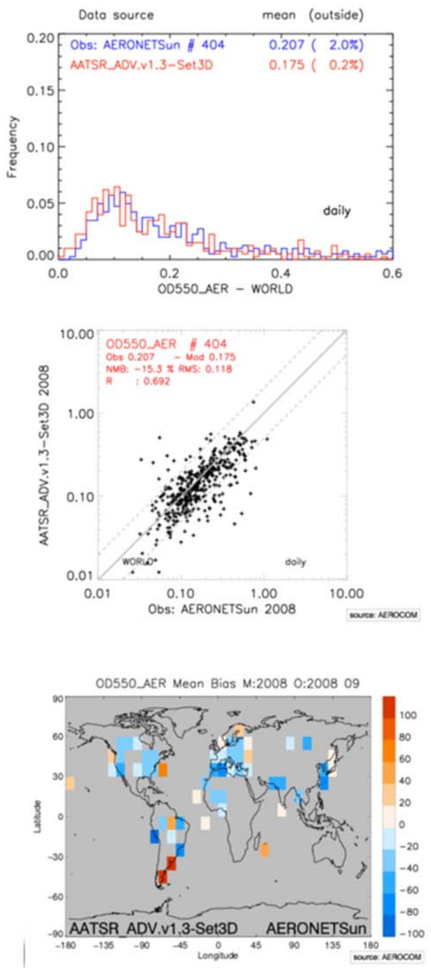
L3 comparisons (AATSR algorithms)

Top to bottom: Baseline,
RR results (best algorithm selected by each group),
Comparisons with AEROCOM median and other algorithms

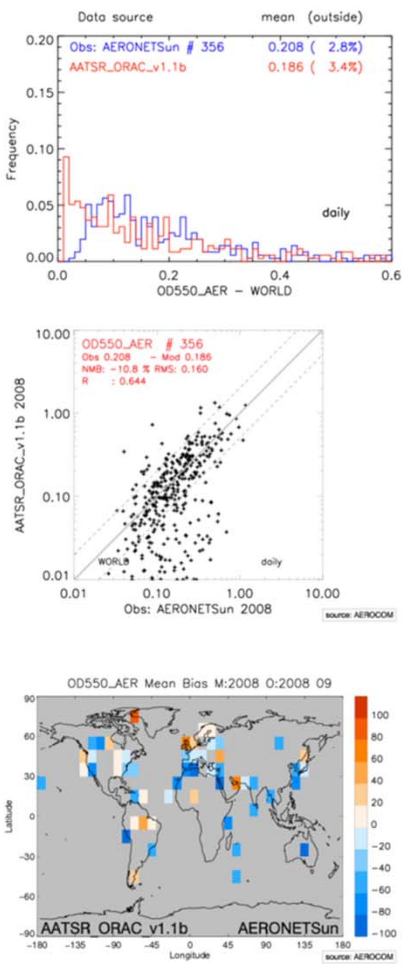


L3 comparisons

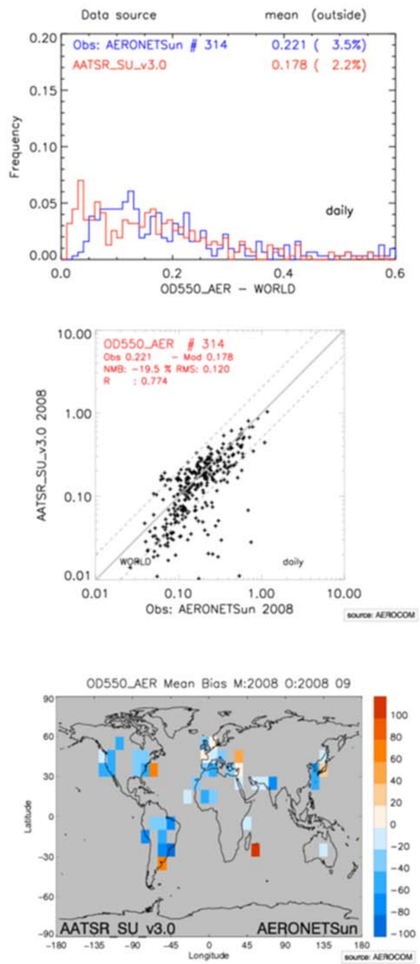
ADV:



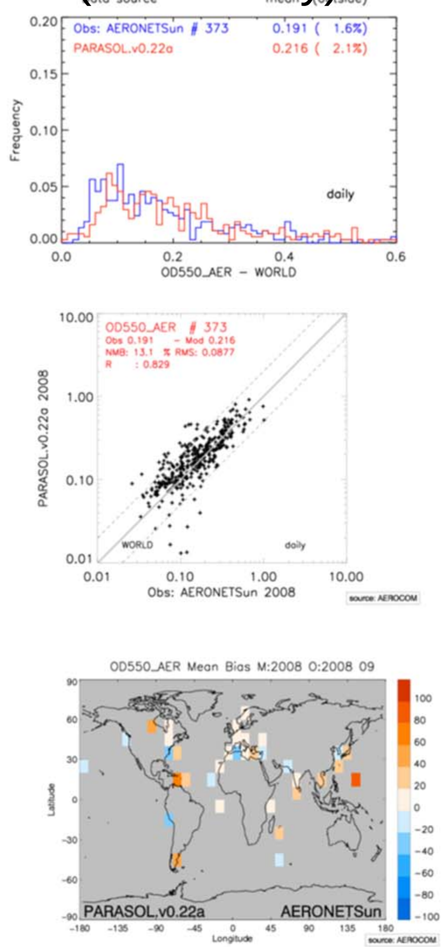
ORAC:



SU



PARASOL (ocean only)



Achievements

- The Aerosol-cci work has lead to significant improvement of almost all retrieval algorithms, differences between algorithms have reduced and results are closer to the those of MODIS and MISR
- Algorithm improvement based on test results, possibly exchange of modules
- Most improvement obtained from:
  - intensive debugging and reconsideration of the codes
  - Improved cloud screening
  - Cloud edge detection and screening
  - Quality control and removal of suspect data
- Scoring based on statisitcs. L2, L3 give similar ranking for AATSR algorithms, with slightly better performance of one algorithm, but slightly better performance of other algorithm for other conditions
- Best solution is a combination of AATSR algorithms
- PARASOL and ALAMO ready for use over ocean
- Other algorithms needs some more work

Anticipated outcomes

- Global AOD for 1 year (2008)
  - ATSR-2 for 1997
- Temporal resolution fom 1 day (single orbits) to 1 year
- Includes uncertainties per pixel
- Option for a complete series of ATSR-2 and AATSR observations (1995-2012)
- ENVISAT lost per 8 April 2012 (AATSR, MERIS, SCIAMACHY)
- Continuations with other sensors: PARASOL, SYNAER with GOME-2 / AVHRR
- Sentinel 3: SLSTR and OLCI (for AATSR and MERIS)

Product Specification

Product name	Parameter(s)	sensors	level	comment
Tropospheric / total column products				
Single-sensor AOD / type	Multi-spectral AOD Aerosol type probability	ATSR-2 / AATSR MERIS POLDER	Level2,3	Multi-spectral AOD depending on instrument caabilities Ångström coefficient can be derived from multi-spectral AOD. Aerosol type may include information on fine / coarse mode fraction and chemical components, which together best describe the observations
Synergetic AOD / type	Multi-spectral AOD Aerosol type probability	AATSR/SCIAMACHY ATSR-2/GOME AVHRR/GOME-2	Level2,3	
AAI	Absorbing aerosol index averaging kernel	OMI SCIAMACHY GOME	Level2,3	
Merged AOD / type	Multi-spectral AOD Aerosol type probability	Combining several level2 with appropriate weighing	Level3	
Aerosol type "climatology"	Aerosol type probability / dominant aerosol type	All AOD products	Level3	Based on one year of data
Stratospheric products				
Extinction	Gridded extinction profile	GOMOS (SCIAMACHY)	Level3	

Acknowledgements

The Aerosol-cci project is supported by the European Space Agency ESA as part of the ESA climate change initiative.

The Aerosol-cci work is a collective effort of the Aerosol-cci partners, including both EO algorithm development teams, model and validation teams and system engineering teams. In particular the feedback from the modeling community has significantly contributed to the progress in EO algorithm development.

Thank you for your attention