First products from ESA Aerosol_cci

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and the Aerosol_cci team

DLR

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Analysis steps

- Improve algorithms: Workshops + experiments (1 month)
  - Optical models, cloud masks, (surface)
  - Post-processing (cloud contamination, bright surface)

Holzer-Popp, et al., AMT 2013

- Select algorithms: Round robin exercise (4 months)
  - Best versions for all algorithms

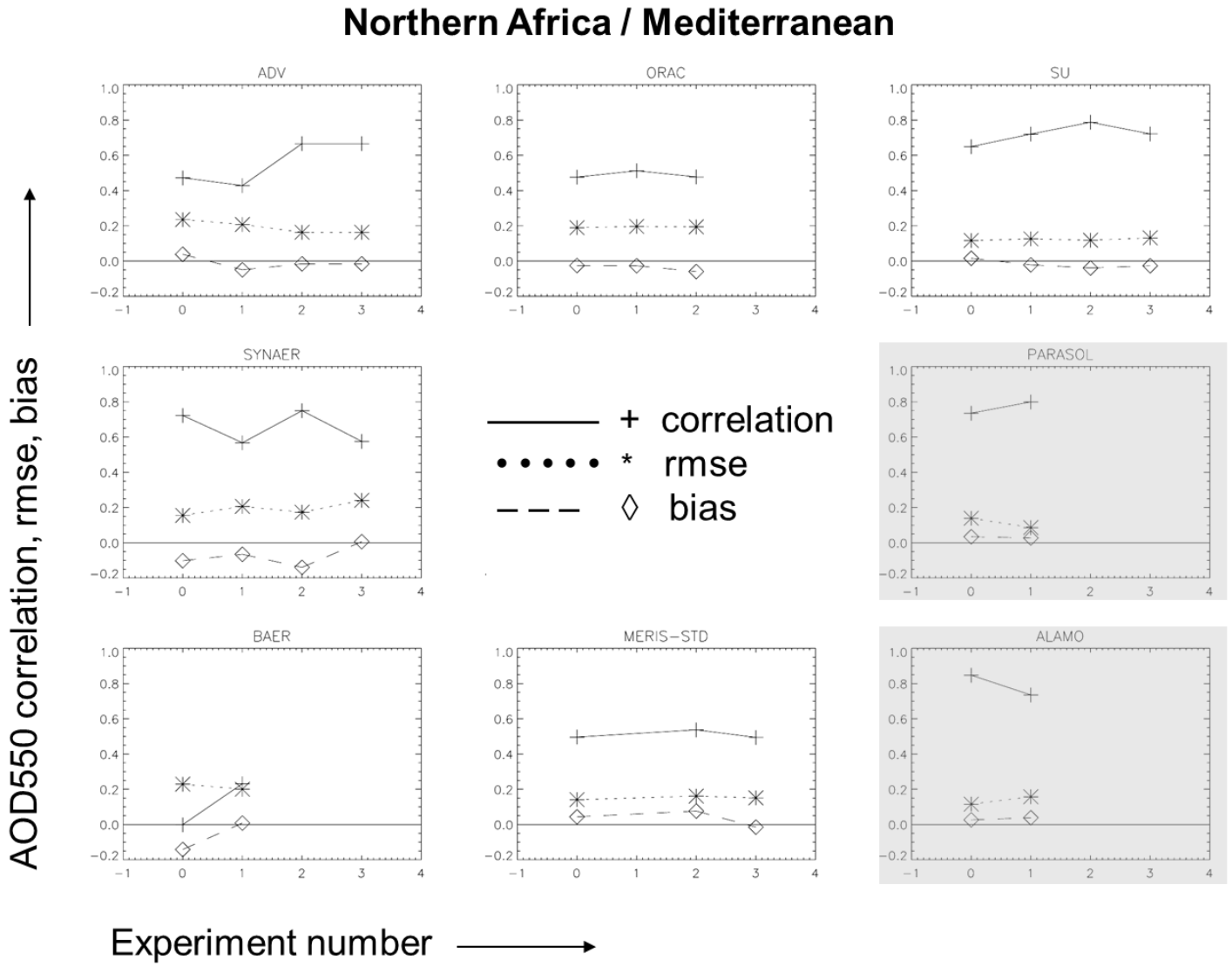
de Leeuw et al., RSE 2013, in press

- Produce selected ECV products (entire 2008)

Kinne, et al., in preparation

- At all steps application of the same validation tools and statistics
  - Level 2 and level 3
  - Global + regional statistics
  - Scoring (spatial / temporal correlation)
  - Against AERONET / MAN + MODIS / MISR / CALIPSO

Regional comparisons



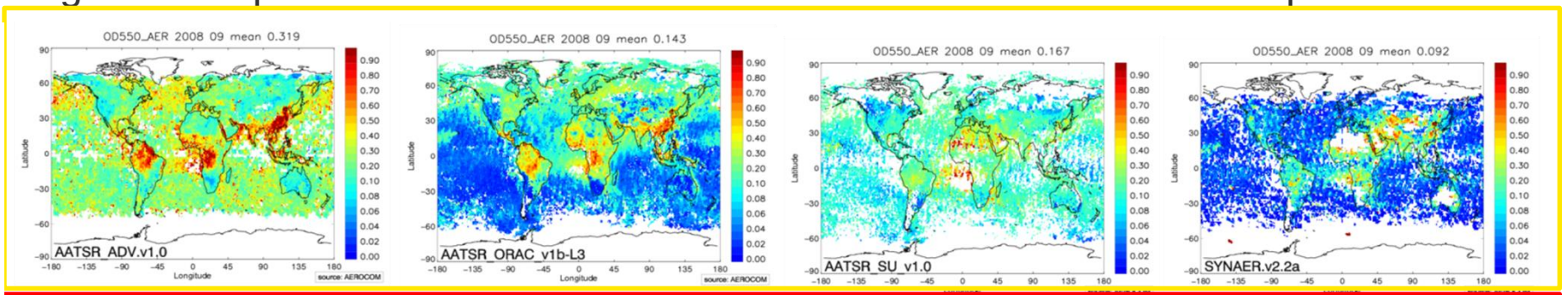
Improve algorithms

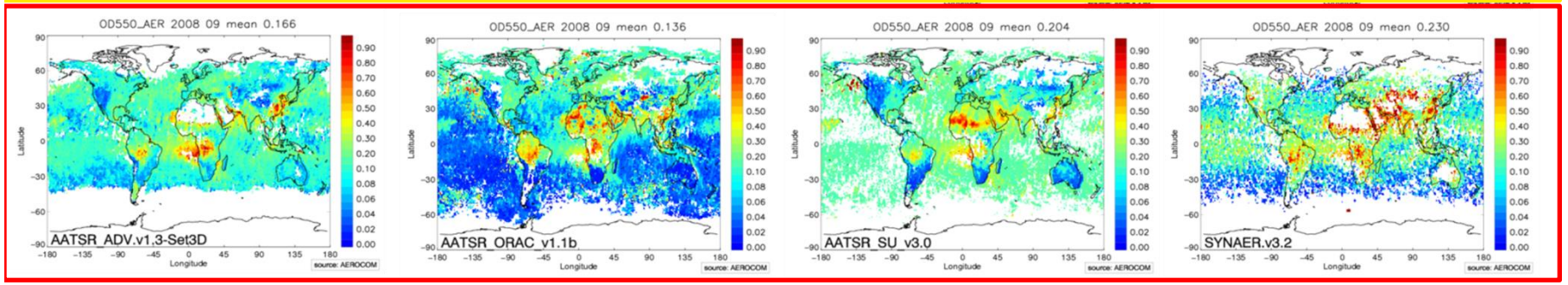
- Intensive algorithm experiments led to improvement before round robin exercise
- Large differences between baseline datasets were significantly reduced
- Products are approaching reference datasets quality and GCOS needs
- Algorithm improvement continued after RR and used in ECV dataset production

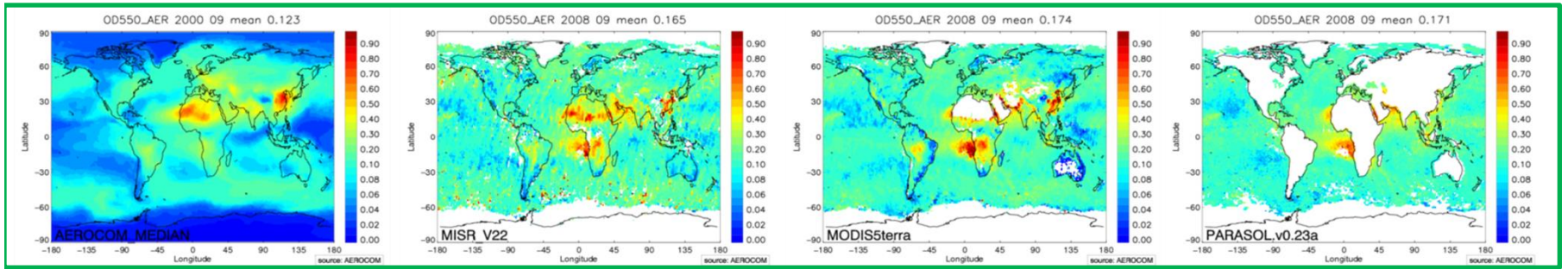
Baseline

RR results

”reference”







Select algorithms: AATSR4Land Common point filter

Algorithm name	NumObs #	R-CORR	RMS	NMB %	RMSbc
AATSR_ADV.v1.42	1394	0,822	0,102	-29,7	0,105
AATSR_ORAC.v2.02	1394	0,823	0,091	-9,4	0,091
AATSR_SU_v4.0	1394	0,863	0,081	-7,7	0,083
MISR_V31_1x1	276	0,856	0,085	-11,2	0,081
MODIS5.1aqua	1185	0,749	0,114	7,1	0,108
MODIS5.1terra	1285	0,744	0,114	1,5	0,113

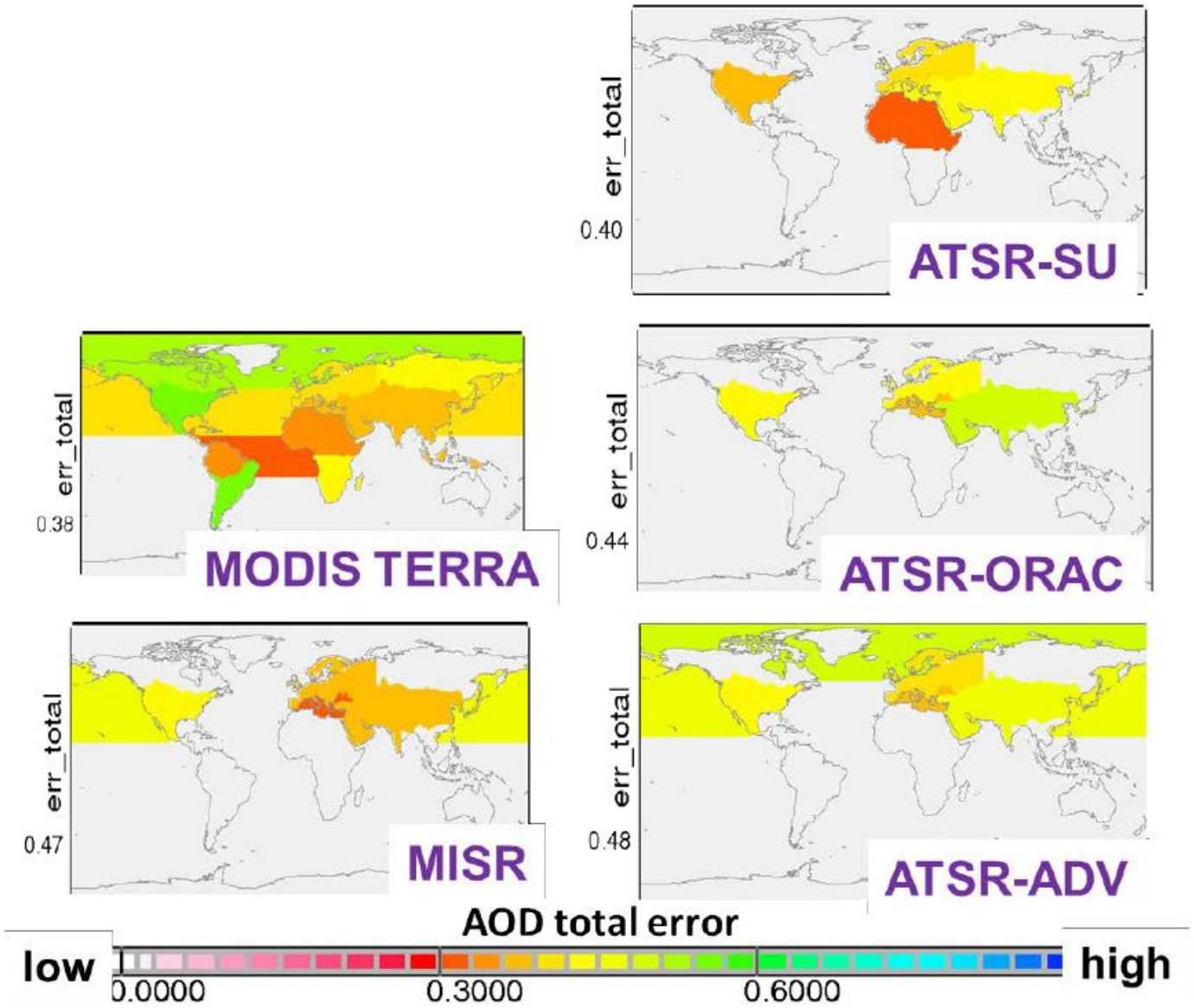
- Common point filter reduces number of data points
- AATSR: in general high correlation, low RMS
- SU v4.0 has highest R, lowest RMS, better than all reference data sets
- All AATSR retrievals outperform MODIS5.1
- AATSR has significantly less coverage

Lv3: AATSR4Sea
Common point filter

Algorithm name	NumObs	R-CORR	RMS	NMB	RMSbc
AATSR_ADV.v1.42	87	0,884	0,06	21,10	0,06
AATSR_ORAC.v2.02	87	0,889	0,09	17,90	0,06
AATSR_SU_v4.0	87	0,781	0,08	-11,50	0,08
MISR_V31_1x1	5	0,984	0,06	3,64	0,07
MODIS5.1aqua	64	0,916	0,05	4,79	0,05
MODIS5.1terra	57	0,905	0,05	1,39	0,05

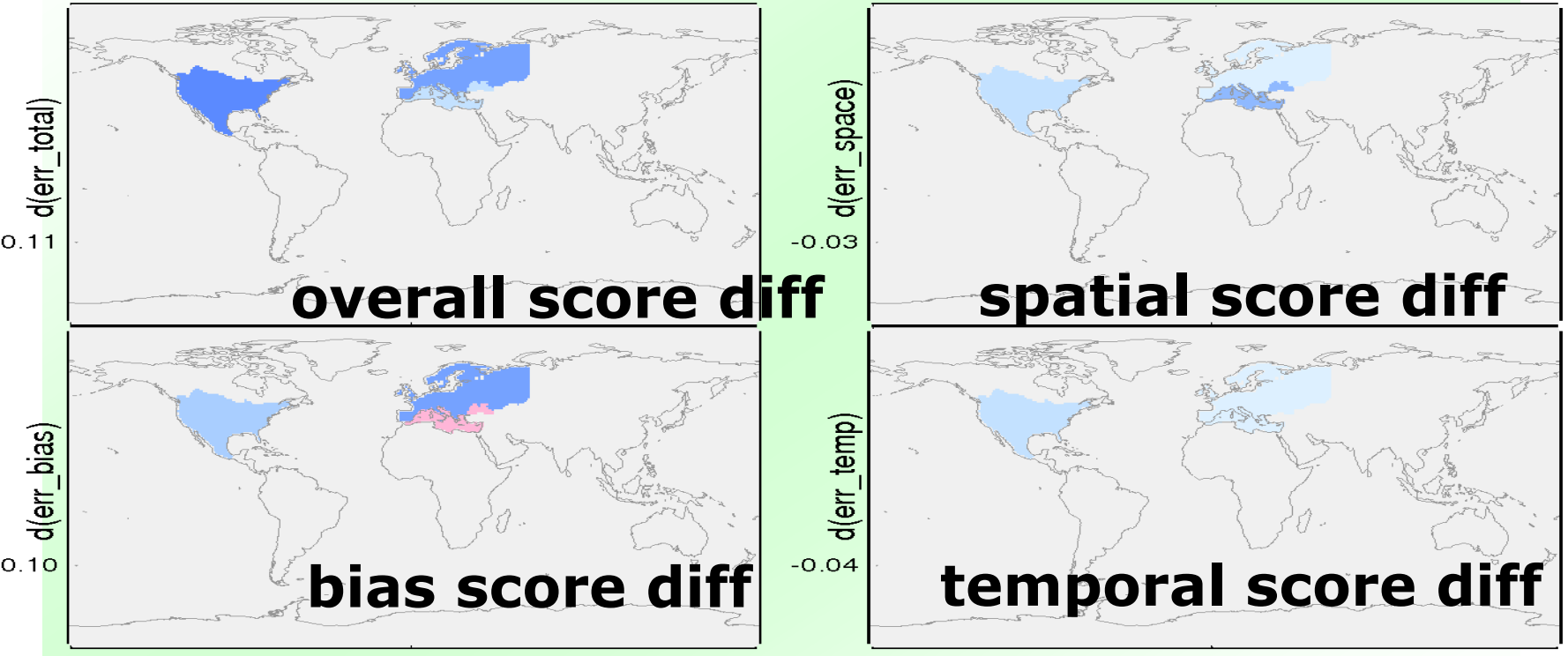
- Low number of reference measurements!
- AATSR: in general high correlation, low RMS
- ADV1.42 and ORAC 2.02 have highest R
- AATSR retrievals are weaker than reference datasets

Validated products: Lv3 scoring (correlations x,t)



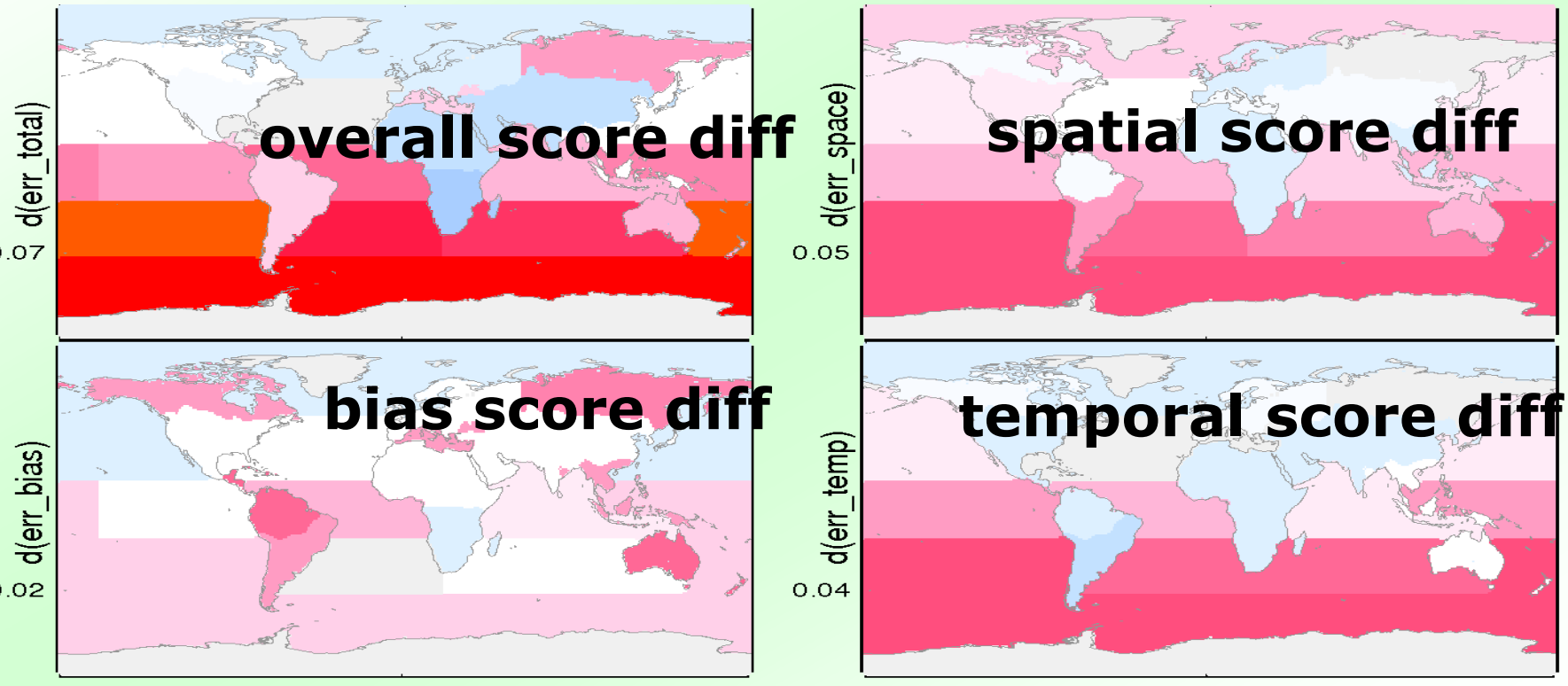
Improvements (SU v4.0-1.0) vs. AERONET

- **Scores ATSR Swansea 4.0 versus Swansea 1.0 established against AERONET**



Improvements (SU v4.0-1.0) vs. MODIS

- **Scores ATSR Swansea 4.0 versus Swansea 1.0 established against MODIS daily data**

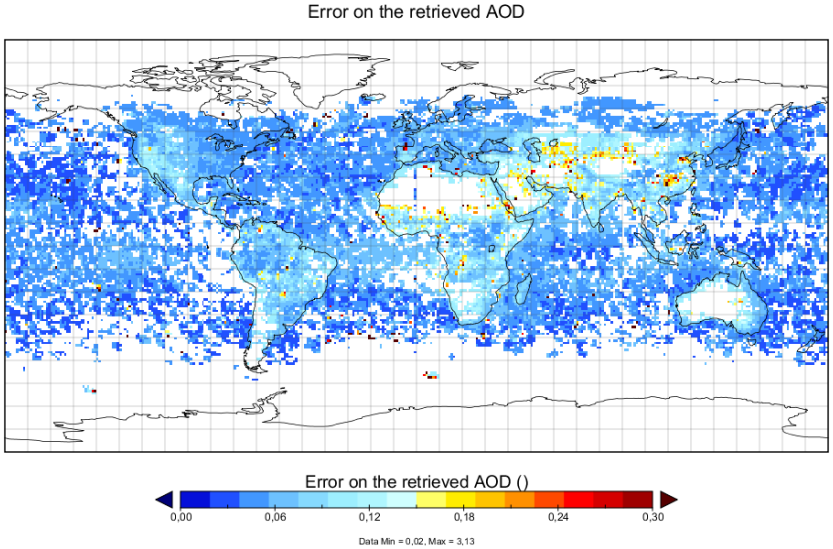


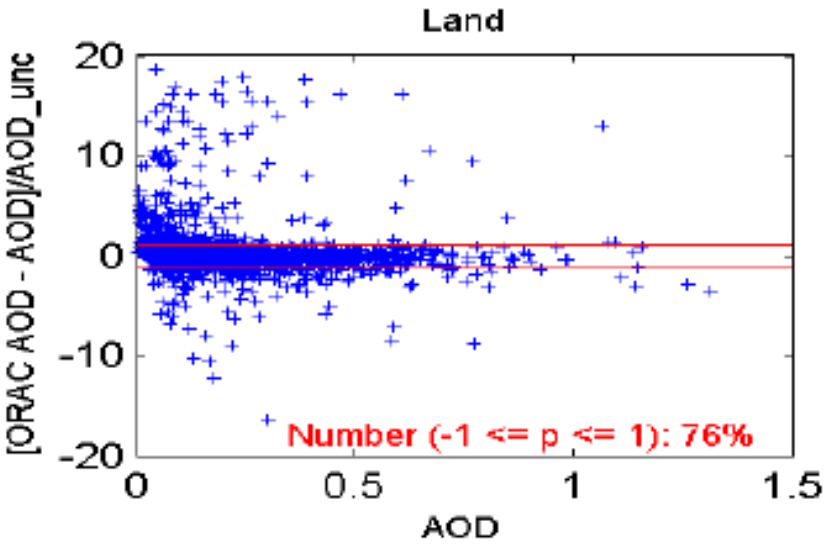
Aerosol_cci products

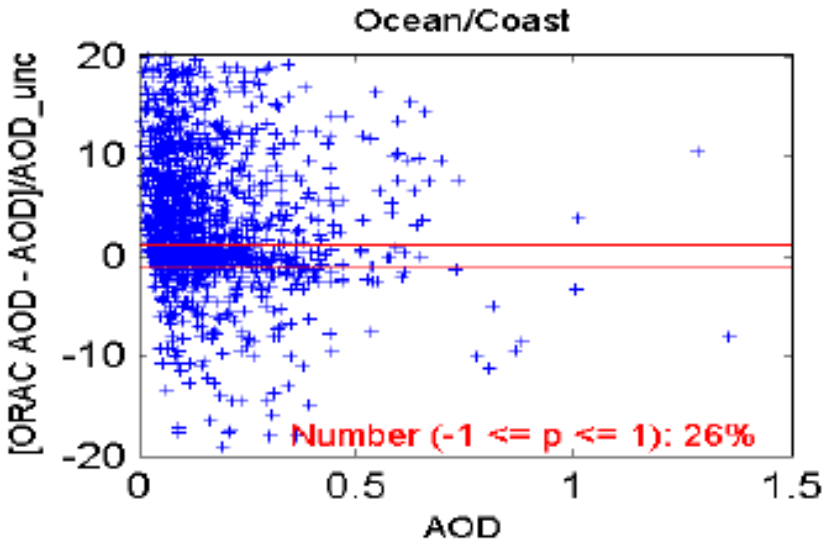
Parameter	Sensor (Algorithms)	Coverage
AOD, Ångström	ATSR-2 + AATSR (ADV, SU, ORAC)	2008 (2000), global (1995 – 2012)
AOD, Ångström	MERIS (ALAMO)	2008, over ocean
AOD, Ångström	POLDER	2008, over ocean
Absorbing Aerosol Index	OMI (GOME, TOMS)	1978 – 2012, global
Stratospheric extinction	GOMOS (SCIAMACHY)	2008, global
AOD, Ångström	MERIS (BAER, STD)	2008, global
AOD, aerosol type	SCIA/AATSR (SYNAER)	3/6/9/12 2008, global
AOD, Ångström	AATSR/MERIS	3/6/9/12 2008, global
Stratospheric extinction	GOMOS/OSIRIS (merged)	2003, global
AOD, aerosol properties	POLDER (multi-pixel algorithm)	Example scenes, land
Absorbing AOD (SSA)	AATSR	Examples, glint areas

All products contain pixel level uncertainties / flags

Pixel level uncertainties (SYNAER, ORAC v2.02)





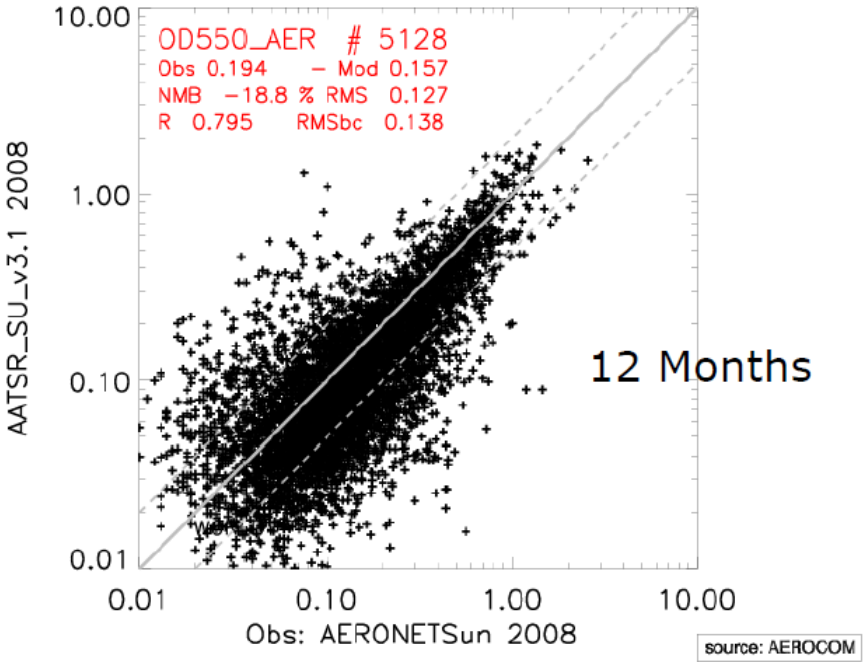


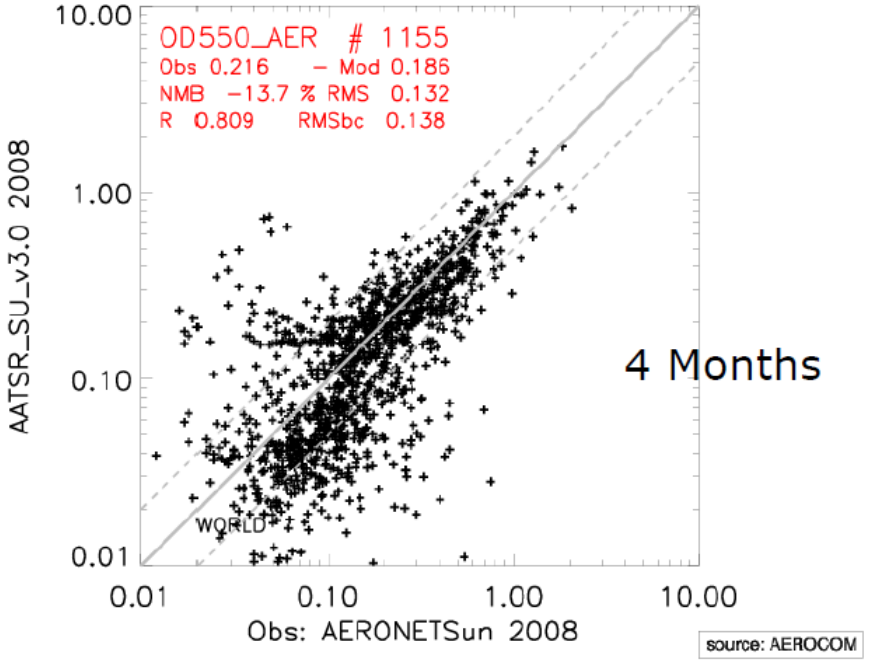
Example product sheet

Characteristics	Information
name	**SU algorithm v4.0** ENVISAT / AATSR + ERS-2 / ATSR-2
provider	Swansea University
contact	P.R.J.North@swansea.ac.uk
parameters	4 AOD, 3 mixing fractions, Ångström coefficient
algorithm features	**Main principle: Dual view**
	Cloud mask: ESA standard
	Aerosol model: Aerosol_cci 4 common components
	Surface: BRDF model
	Other: -
main advantage	**17 year time series, high accuracy, good cloud filter**
limitations	**coverage (512 km swath), accuracy over ocean**
rmse/bias/correlation (land)	0.08 / -0.01 / 0.86 (daily 1° ADO550 vs. AERONET – 1394 pts.)
rmse/bias/correlation (sea)	0.08 / -0.02 / 0.78 (daily 1° AOD550 vs. AERONET – 87 pts.)
coverage	2008, global (except polar latitudes)
resolution	Daily, 10x10 km2
continuation	Sentinel-3 / SLSTR

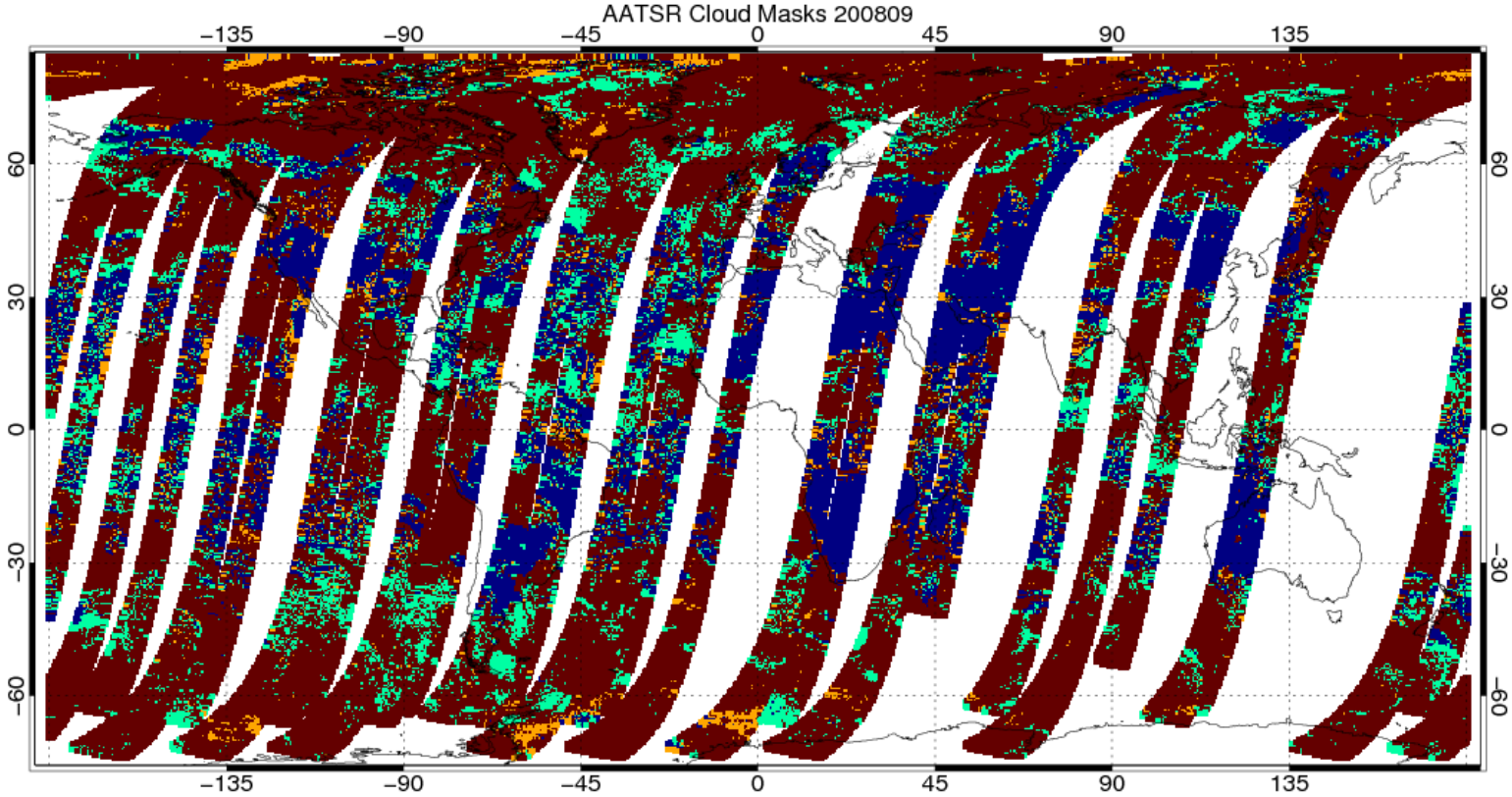
Was the 4 months analysis representative for the 12 months?

Model name	NumObs	R-CORR	RMS	NMB	RMSbc
AATSR_SU_v3.0	1155	0,809	0,132	-13,7	0,138
AATSR_SU_v3.1	5128	0,795	0,127	-18,8	0,138





Consistency of cloud masks Aerosol_cci / Cloud_cci

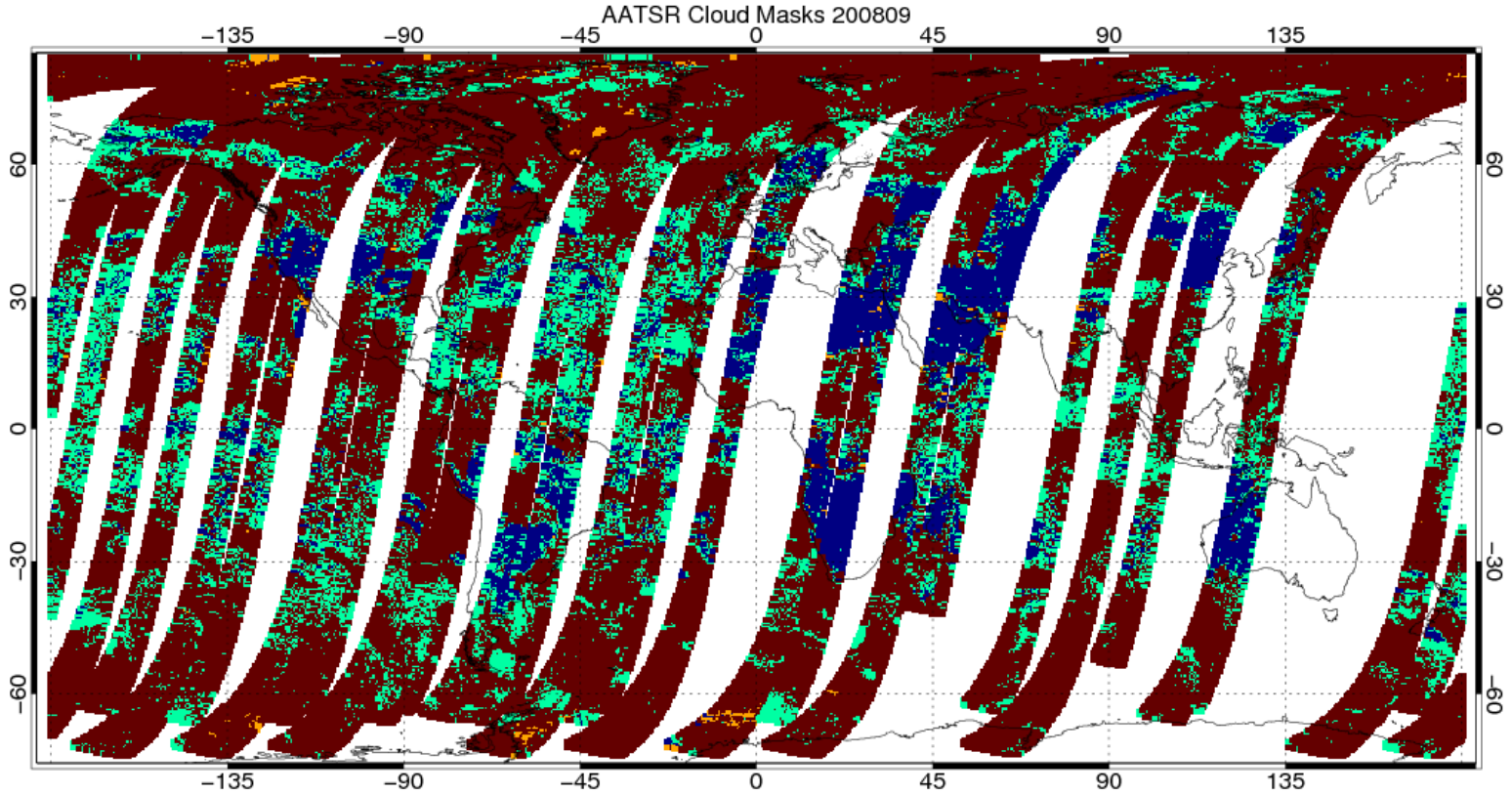


5 selected days Sep 2008

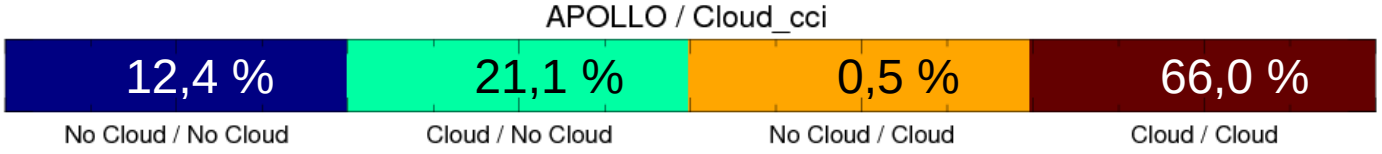
APOLLO / Cloud_cci

20,7 %	12,8 %	3,2 %	63,4 %
No Cloud / No Cloud	Cloud / No Cloud	No Cloud / Cloud	Cloud / Cloud

Consistency of cloud masks Aerosol_cci / Cloud_cci

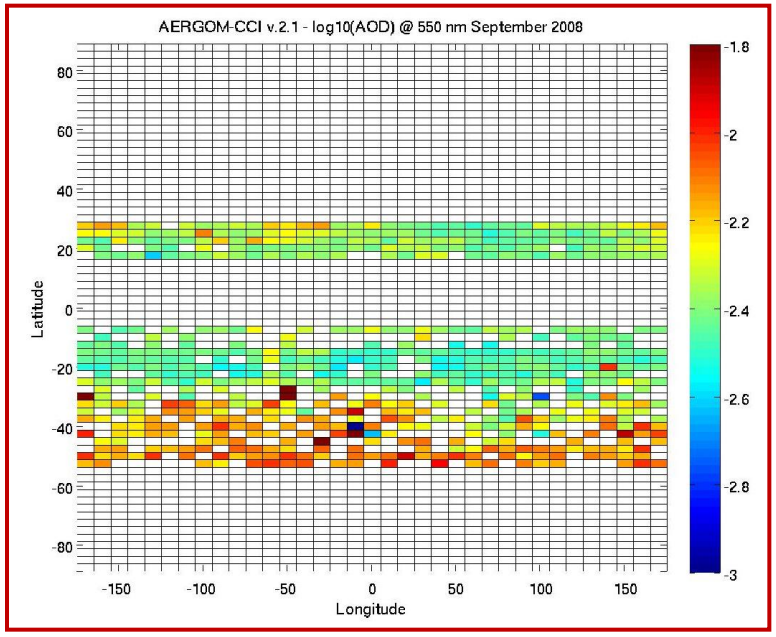


5 selected days Sep 2008 – safety zone excluded by Aerosol_cci

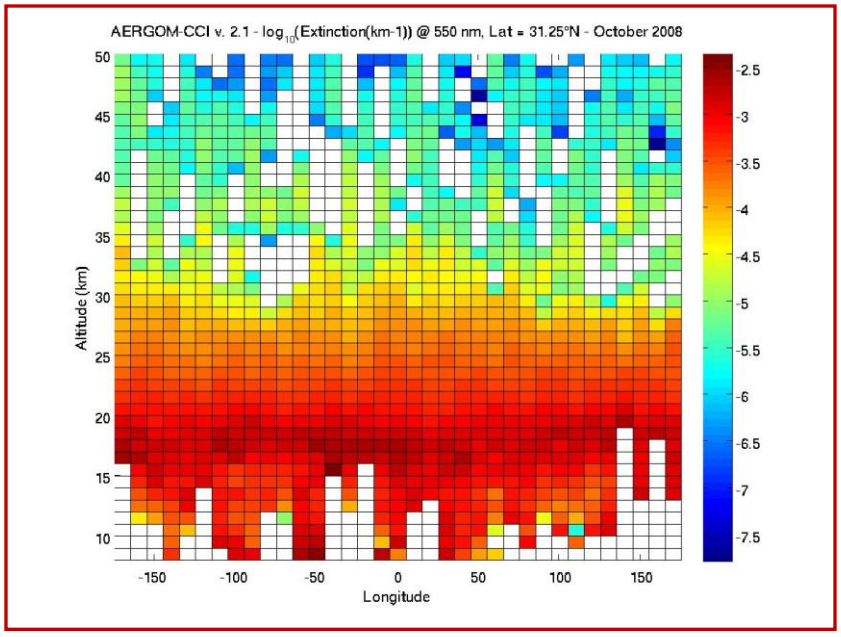


Advantages of the GOMOS product

- 3D resolution in the stratosphere as needed for atmospheric and climate modelling, geoengineering, atmospheric retrieval
- Insight into spatially resolved particle size information
- Occultation experiment retrieval based on robust techniques to provide reference datasets for limb sounders



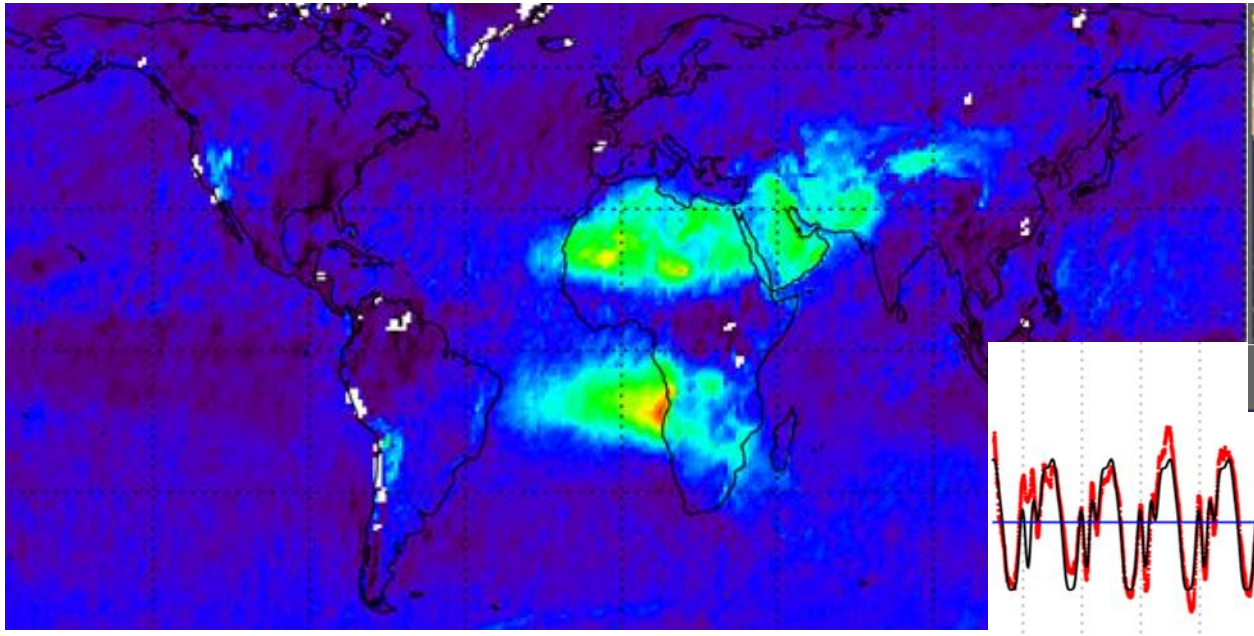
Stratospheric AOD550

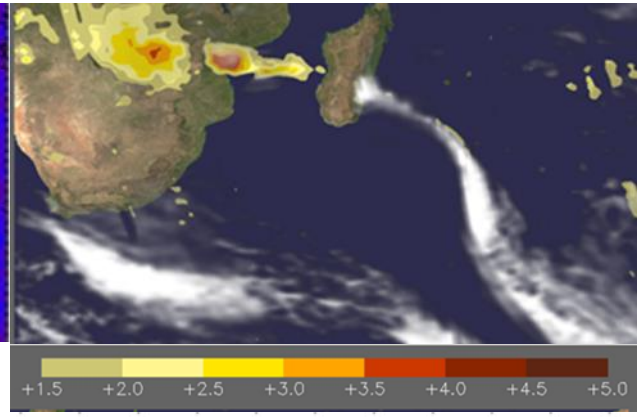


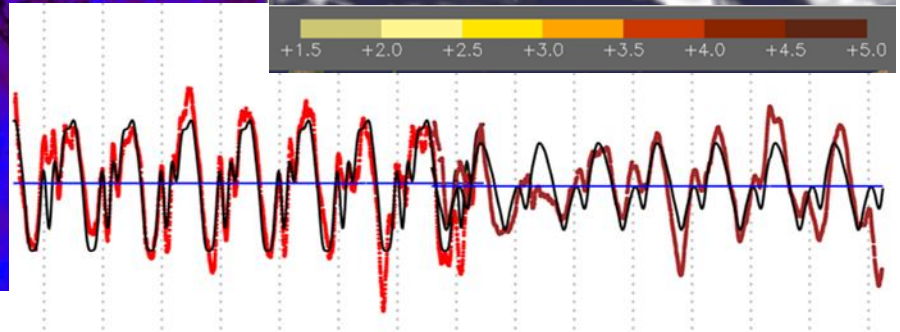
Zonal extinction profiles

Advantages of the Absorbing aerosol index

- Indication of absorbing aerosols not hindered by cloud coverage
- Long-term record: 30+ years of daily, global data
- Can be used together with AOD for simple aerosol typing
- Connection between measurement & models via AAI simulation
- Tools for AAI error characterization and quantification







Aerosol_cci Phase 2
Proposed products 2014/15

Parameter	Sensor (Algorithms)	Coverage (planned) - status
AOD, up to 4 wavelengths	ATSR-2 + AATSR (ADV, SU, ORAC)	1995 – 2012
	AATSR / MERIS	2003 - 2012
	PARASOL	1996, 1998, 2006 – 2015 (selected land regions)
	SYNAER	2003 - 2012
Dust AOD	IASI	2006 - 2015
Stratospheric extinction, AOD, size parameter	GOMOS	1984 - 2005
	SAGE-II, ODIN, OSIRIS, GOMOS	2003 – 2012
Sentinel demo datasets	SLSTR AOD TROPOMI AAI	2015

All products contain pixel level uncertainties

Information + data

Documentation freely available at

http://www.esa-aerosol-cci.org/

Public open data access at

http://www.icare.univ-lille1.fr/archive/index.php?dir=CCI-Aerosols/

(user: cci / password: cci)

with acknowledgement to ESA CCI program

Lessons learned (1)

- critical mass of experts / open exchange on problems and solutions highly beneficial; including active involvement of users
- 3 steps meaningful to consolidate discussions into improved datasets
- round robin exercise: statistical significance with four months of global data (in 4 seasons); seasonal + regional analysis needed
- prototype system “near science” ensures flexibility for changing user requirements, algorithm, analysis tools

Lessons learned (2)

- 3 AATSR algorithms performing almost equal -> combination needs further investigation (uncertainty-weighted ensemble, combination over different regions) – requires harmonized uncertainties
- Uncertainties demonstrated but need further consolidation and harmonization
- Aerosol type information (Ångström exponent, mixing fractions, pre-scribed aerosol type, absorption AOD) needs further work - highly relevant for applications (e.g. aerosol-cloud interaction)
- Further work needed on surface treatment (nadir algorithms), cloud clearing
- different AOD algorithms and instruments valuable to show uncertainties

GCOS requirements

variable	resolution			accuracy	Stability [/ decade]	Aerosol_cci
	Horizontal [km]	Vertical [km]	Temporal			
Aerosol optical depth (column)	5-10	N / A	4 h	Max (0.03; 10%)	0.01	**P1: accuracy** **P2: 17 years** **P2: SEVIRI**
Single scattering albedo (column)	5-10	N / A	4 h	0.03	0.01	**P1: qualitative** **P2: round robin**
Aerosol layer height	5-10	N / A	4 h	1 km	0.5 km	**P1: -** **P2: round robin**
Aerosol extinction coefficient (profile)	200-500	1k (~10km) 2k (~30km)	1 week	10%	20%	**P1: accuracy** **P2: 30 years**

Lv3: AATSRLand Regions

No filter

Ranking:

Filter	ADV	ORAC	SU 3.1	SU4.0
China	1	4	2	3
India	3	2	1	4
East asia	1	4	2	3
Europe	1	3	4	2
Samerica	2	3	4	1
Nafrica	2	3	1	4
Namerica	1	4	3	2
DJF	1	2	4	3
MAM	2	4	1	3
JJA	1	3	2	4
SON	4	2	2	1
Average:	1,75	3	2,625	2,5

Common point filter

Ranking:

Filter	ADV	ORAC	SU 3.1	SU4.0
China	3	2	1	4
India	3	2	1	4
East asia	3	2	1	4
Europe	2	4	3	1
Samerica	3	2	4	1
Nafrica	3	4	2	1
Namerica	2	4	3	1
DJF	2	3	4	1
MAM	3	4	1	2
JJA	1	4	2	3
SON	4	2	3	1
Average:	2,5	3,375	2,75	1,375

Average excluding china, India and east asia due to low number of measurements

Why more than one AOD product?

- Different sensors
  - Information content differs
  - Depending on type / number of observations (multi-spectral, multi-angle, polarization)

- Different algorithms for one sensor (AATSR, MERIS)
  - Significant learning curve from comparisons and team
  - A possible measure of uncertainty
  - 3 AATSR algorithms reach similar high quality
  - Validation is limited in data sparse regions (ocean, Southern hemisphere)
  - No single algorithm performs best everywhere
  - Testing ensemble or combined products ongoing

Aerosol_cci products main advantages

- accuracy
  - Very high: PARASOL over ocean and 3 AATSR algorithms
- Coverage
  - ATSR-2 + AATSR enable time series 1995 – 2012
- Information content
  - Very high for PARASOL, good for AATSR
  - Absorption qualitative with absorbing index
  - Vertical with stratospheric product
- General
  - 3 year intensive team dialogue /efforts improved data
  - Significant improvement against baseline algorithms
  - Similar quality to MODIS / MISR over land
  - Pixel level uncertainties / quality indices
- Documentation at Aerosol_cci website