How the different retrieval approaches effect the aerosol optical depth
+ European CDRs

Larisa Sogacheva & Aerosol_cci team

AEROSAT-2016, Beiging, China

Outlines

- European aerosol CDRs
- ADV/ORAC/SU AOD retrieval algorithms
- (A)ASTR aerosol products.
    - Yearly/seasonal/monthly means
    - AOD daily products. Retrieval in different environments. Test cases
    - AOD validation
    - Cloud masking comparison
    - Surface reflectance results (and validation)
- Conclusions

remote sensing

MDPI

Article

Development, Production and Evaluation of Aerosol Climate Data Records from European Satellite Observations (Aerosol_cci)

Thomas Popp [1,*], Gerrit de Leeuw [2,3], Christine Bingen [4], Christoph Brühl [5], Virginie Capelle [6], Alain Chedin [6], Lieven Clarisse [7], Oleg Dubovik [8], Roy Grainger [9], Jan Griesfeller [10], Andreas Heckel [11], Stefan Kinne [12], Lars Klüser [1], Miriam Kosmale [1], Pekka Kolmonen [2], Luca Lelli [13], Pavel Litvinov [8], Linlu Mei [13], Peter North [11], Simon Pinnock [14], Adam Povey [9], Charles Robert [4], Michael Schulz [10], Larisa Sogacheva [2], Kerstin Stebel [15], Deborah Stein Zweers [16], Gareth Thomas [17], Lieuwe Gijsbert Tilstra [16], Sophie Vandenbussche [4], Pepijn Veefkind [16,18], Marco Vountas [13] and Yong Xue [19]

GCOS principles/requirements for satellite CDRs

- Accuracy and stability
- Documentation
- Testing
- Regular assessments
- Operational data access
- User support
- Uncertainties have to be classified
- 30 or more years time series
  - Satellites have shorter lifetime -> CDR must be built from the multiple data records, taking into account not identical characteristics of the instruments, launched as satellite series

Popp et al., 2016

Parameter	Sensor (Algorithms)	Coverage (planned) - status
AOD (4 λ) FM-AOD, Angström exponent	Dual view VIS-TIR **ATSR-2 + AATSR** (3 algorithms)	1995 – 2012 (2016 – 2030 SLSTR)
Dust AOD Round robin	Thermal IR spectrum **IASI** day+night (4 algorithms)	2013 (2006 – 2015) (- 2024 METOPs)
AOD, Angström exponent, SSA Quasi-reference	Polarisation / multi-angle multi-pixel VIS **PARASOL** (GRASP)	2008 (1996, 1998, 2006 – 2015) selected land regions (2020 – 3MI)
Stratospheric extinction, AOD, size	Star occultation VIS **GOMOS**	2002-2012
AAI	UV ratio index **Multi-sensor**	1978 - 2013

T.Popp

Other Euripean aerosol products

Sensor/ algorithm	Parameters	Coverage	link
ODIN OSIRIS	Strat. extinction vertical profiles	2001-present	osirus.usask.ca
PARASOL Ocean	AOD (670nm, 865nm), Å, FM AOD,CM AOD, SSA	2005-2013	www.icare.univ-lille1.fr
PARASOL Land	FM AOD (865nm)	2005-2013	www.icare.univ-lille1.fr
MSG SEVIRI	AOD (ocean)	2003-present	www.icare.univ-lille1.fr
Envisat MERIS ALAMO	AOD (ocean, 550nm, 865nm), fine mode fraction, R_{eff}, altitude	2002-2012	www.icare.univ-lille1.fr

Cyclic evolution to produce CDRs (Aerosol_cci project)

Popp et al., 2016
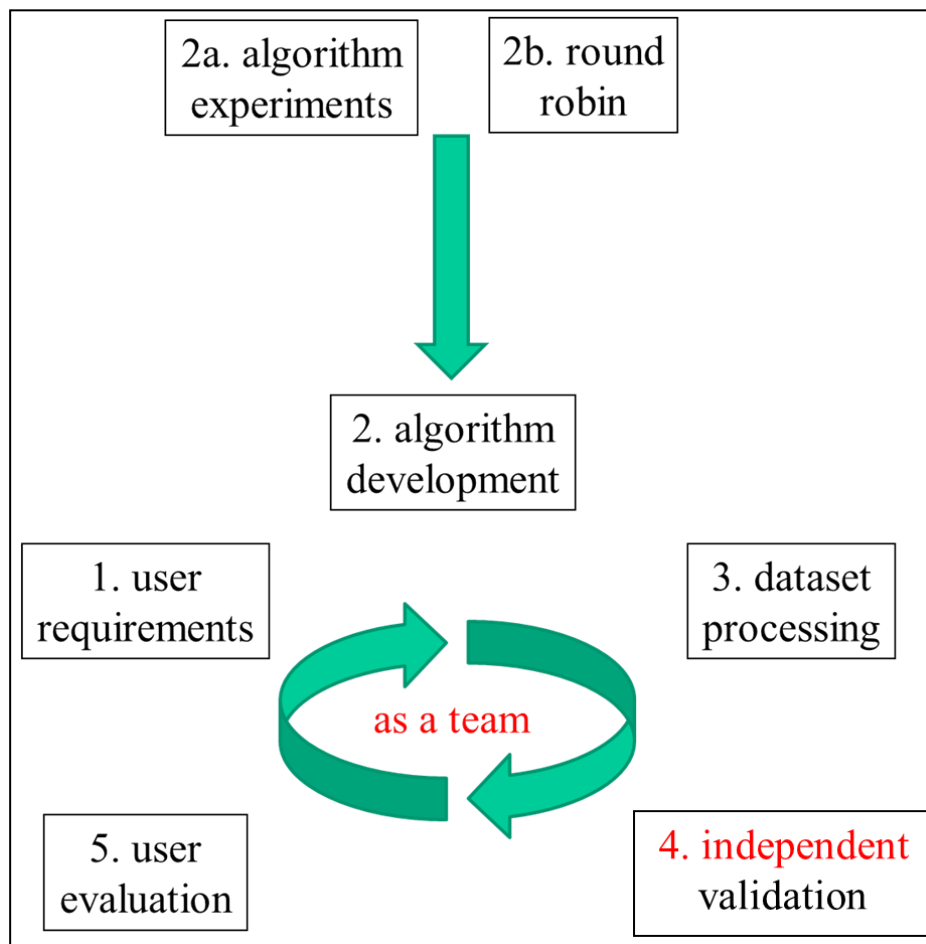
ATSR2-AATSR AOD time series

OD550 seasonal MODMEAN WORLD
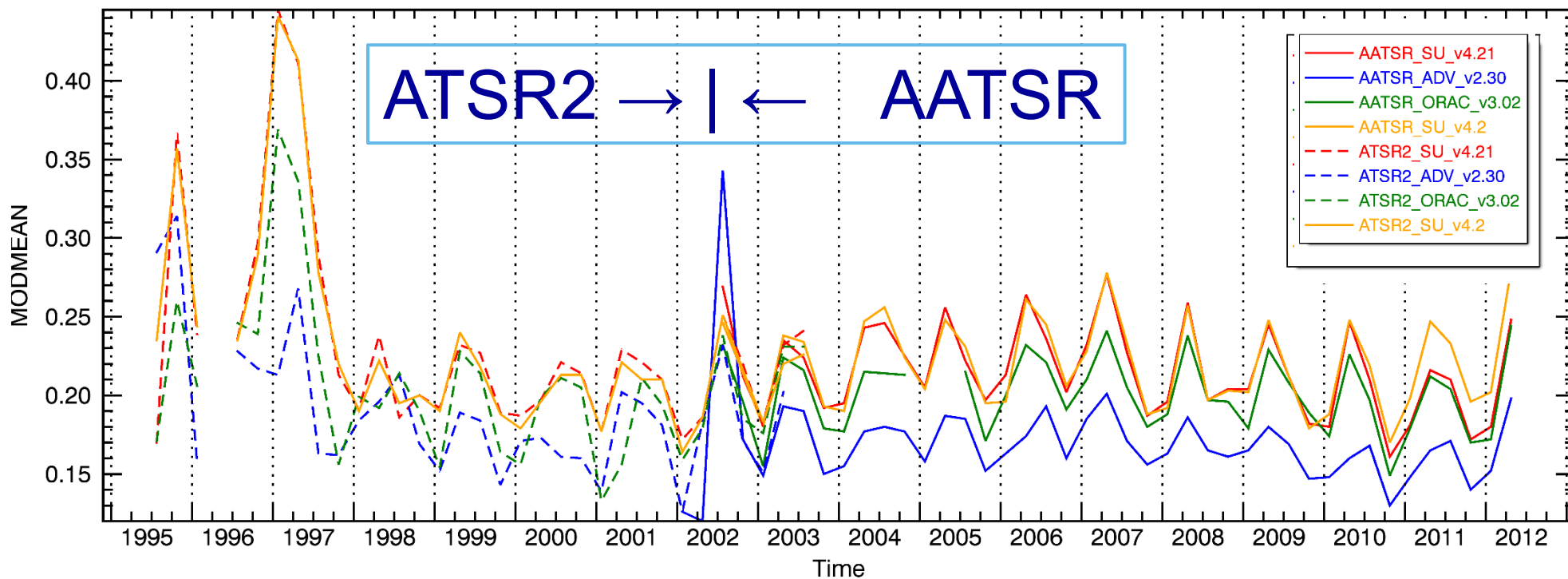
source: AEROCOM

ATSR2-AATSR
Fine mode AOD time series
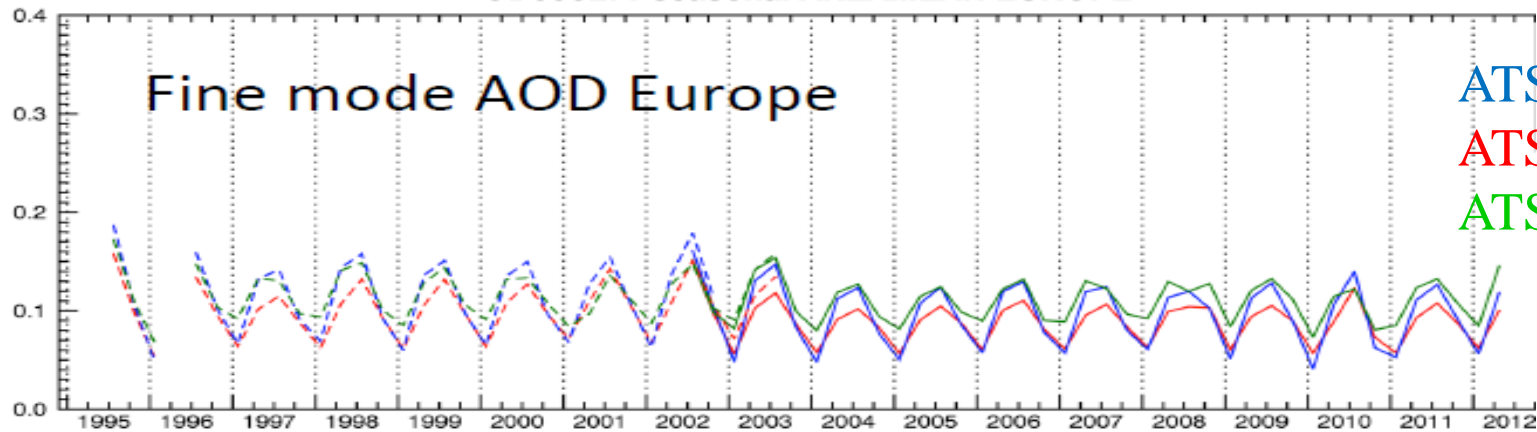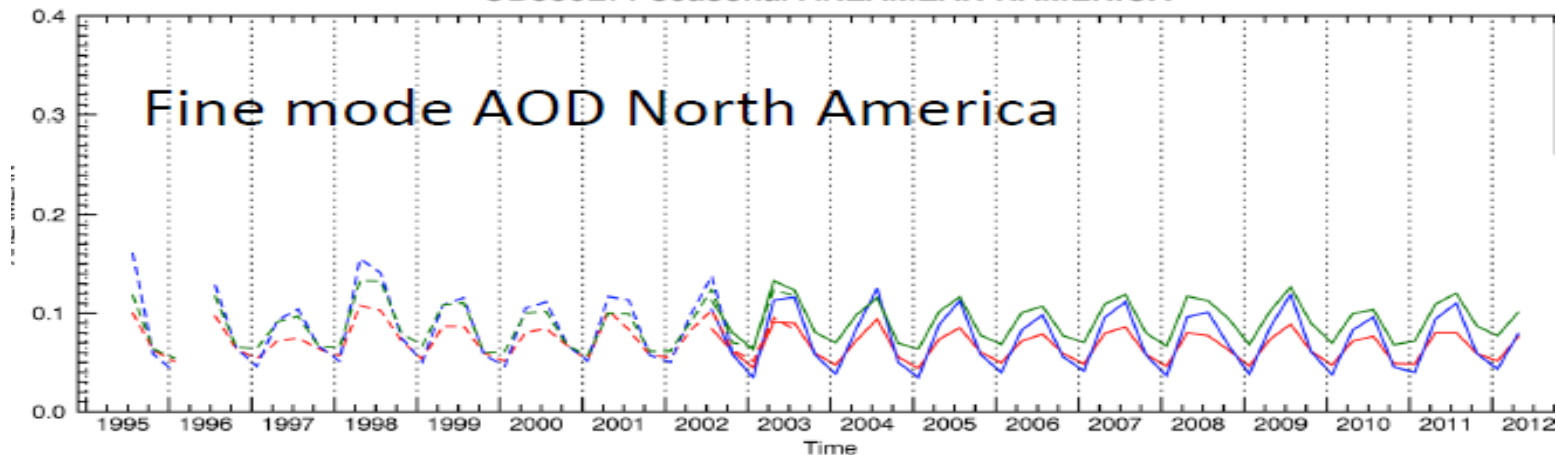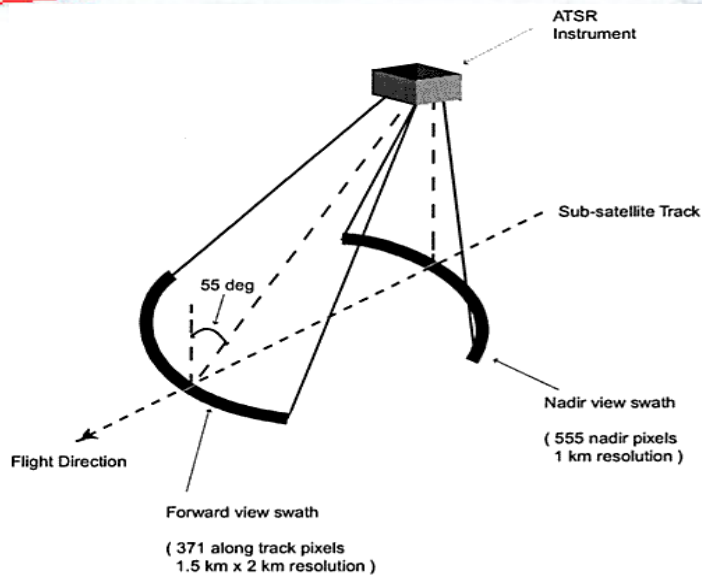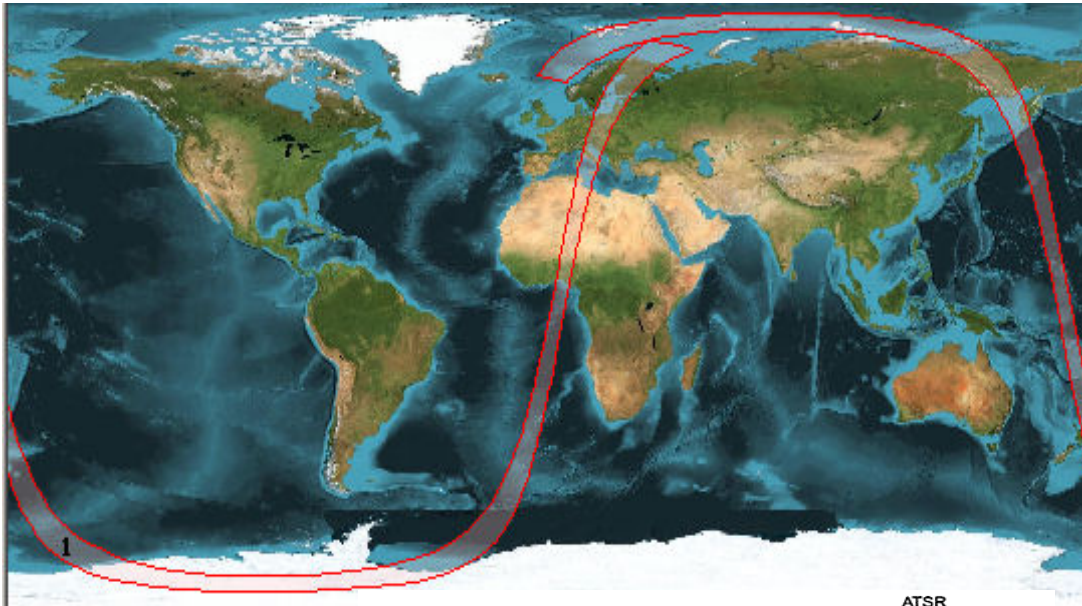
(A)ATSR

• (A)ATSR is dual-view radiometer

• has two viewing angles: forward at 55° , and nadir

•ATSR2 (ERS-2), 1995-2003

•AATSR (ENVISAT), 2002-2012

•->17 years AOD time series

•Sun synchronous

•Equator overpass time 10:00

•Swath 500km
•Spatial resolution 1 x 1 km
• 5-6 days global coverage
Spectral Channels
    • IR: 1.6, 3.7, 10.85, and 12 µm
    • VIS: 0.555, 0.67, and 0.865 µm

ATSR Instrument

Sub-satellite Track

55 deg

Flight Direction

Nadir view swath

(555 nadir pixels
1 km resolution)

Forward view swath

(371 along track pixels
1.5 km x 2 km resolution)

ADV/ORAC/SU algorithms (short description)

	ADV	ORAC	SU
Land algorithm	the dual view capability is used to effectively eliminate the contribution of the surface reflection to the TOA reflectance, using the k-ratio approach, and retain only the atmospheric path radiance (Flowerdew & Haigh, 1975)	Land: a surface reflectance parameterisation, similar to that employed by the SU-ATSR land algorithm is utilised	Land: Parameterised model of the surface angular anisotropy; the dual-view capability of the instrument (North, 2002)
Ocean algorithm	Only one (nadir or forward) AATSR view is used; Cox and Munk ocean surface description (1954)	the ocean surface reflectance model of Sayer et al. (2010) is used to provide an a priori surface constraint	model to exploit the low ocean leaving radiance at red and infra-red channels at both nadir and along-track view angles (Bevan et al., 2012).
Aerosol models	ACCI aerosol models (de Leeuw et al., 2015)	ACCI aerosol models; Option to use the set of 10(+) aerosol types	ACCI aerosol models
Cloud screening	4 cloud tests (Kolmonen et al., 2015) + cloud post-processing (Kolmonen et al., 2015, Sogacheva et al., 2016)	AATSR standard cloud mask + additional tests (ask ORAC team for more details)	AATSR standard cloud mask+ additional tests (Plummer, 2008) + cloud post-processing (Kolmonen et al., 2015)

ADV/ORAC/SU algorithms cloud mask comparison

- … is ongoing process
- Aerosol CCI Phase1
  - cloud mask comparison between all 3 algorithms
  - Exercise to use AATSR APOLLO cloud mask
  - Intercomparison with Cloud CCI cloud mask
- Aerosol CCI Phase2
  - comparison with "true" cloud mask
- Globe Temperature cloud mask comparison
- Cloud CCI cloud mask proposed by RAL

AATSR AOD, L3, 2007
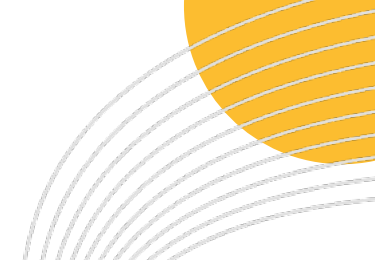
OD550_AER 2007 mean 0.173

AATSR_ADV.v2.30_plume
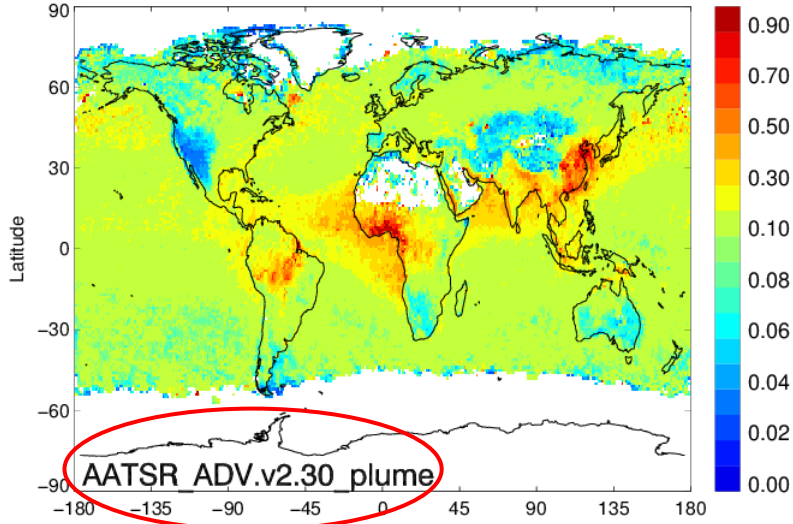
OD550_AER 2007 mean 0.168

AATSR_ORAC_v3.02

source: AEROCOM
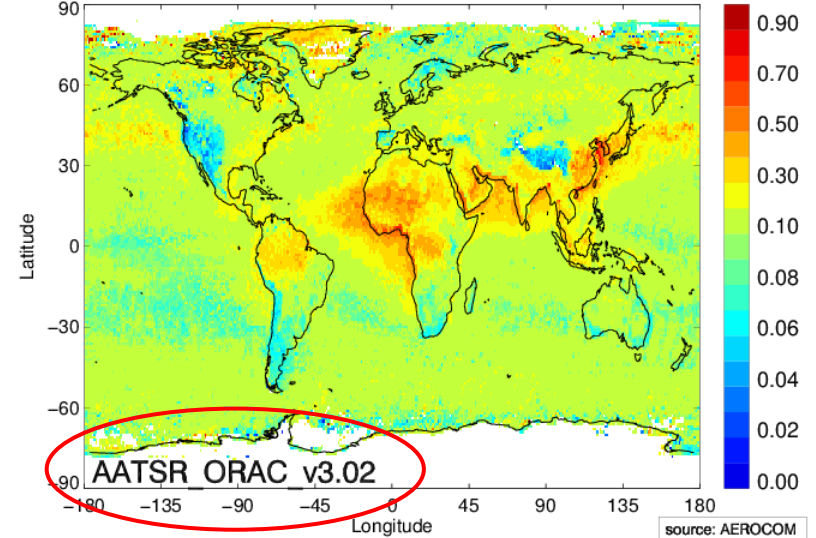
OD550_AER 2007 mean 0.147

AATSR_SU_v4.21

source: AEROCOM

Globe   A-SA-SA

● ADV
● ORAC
● SU
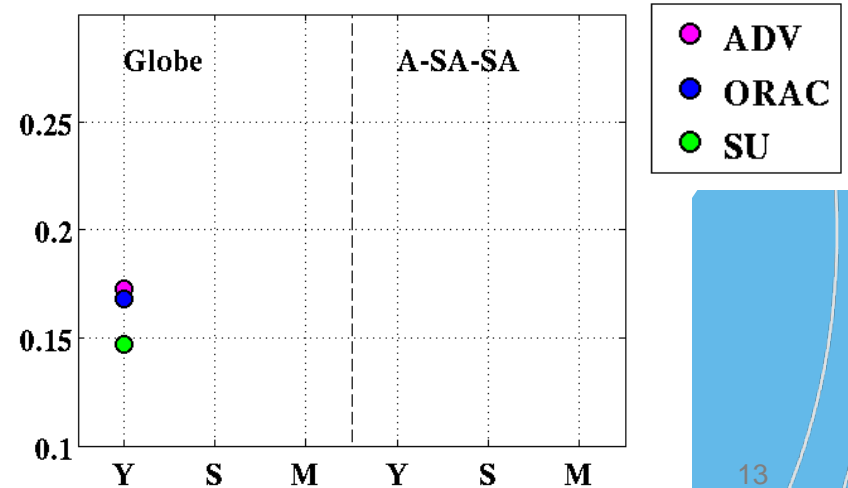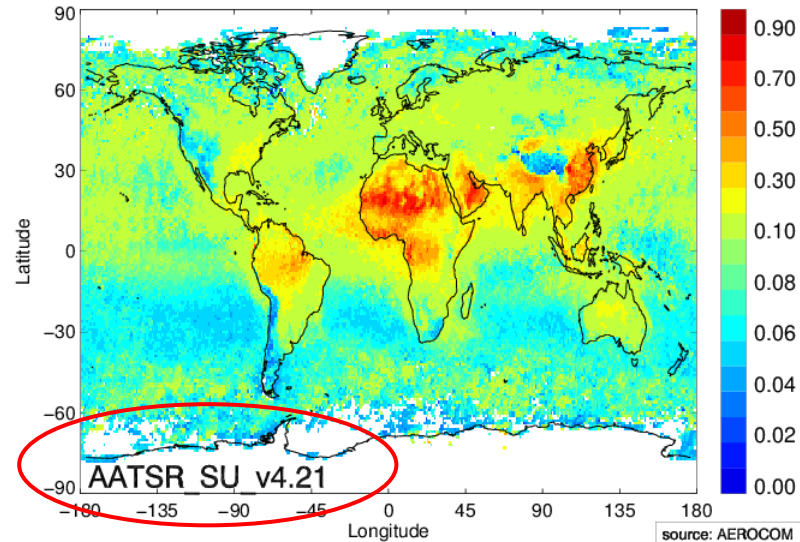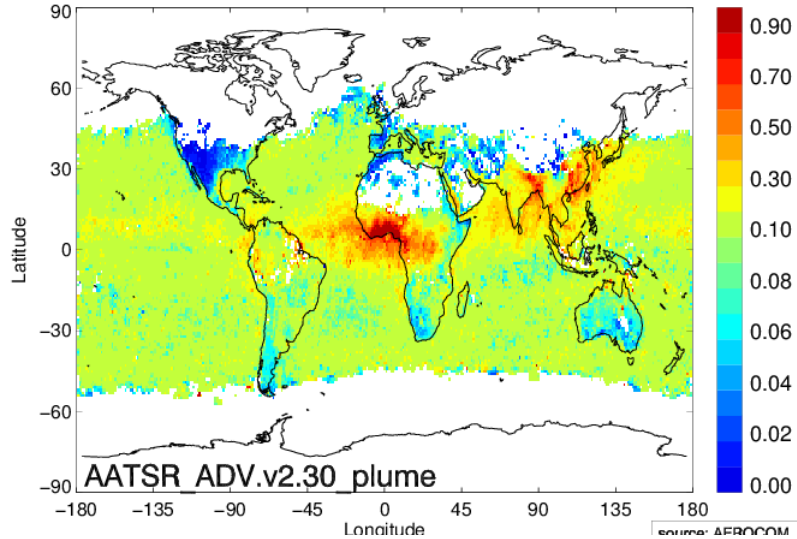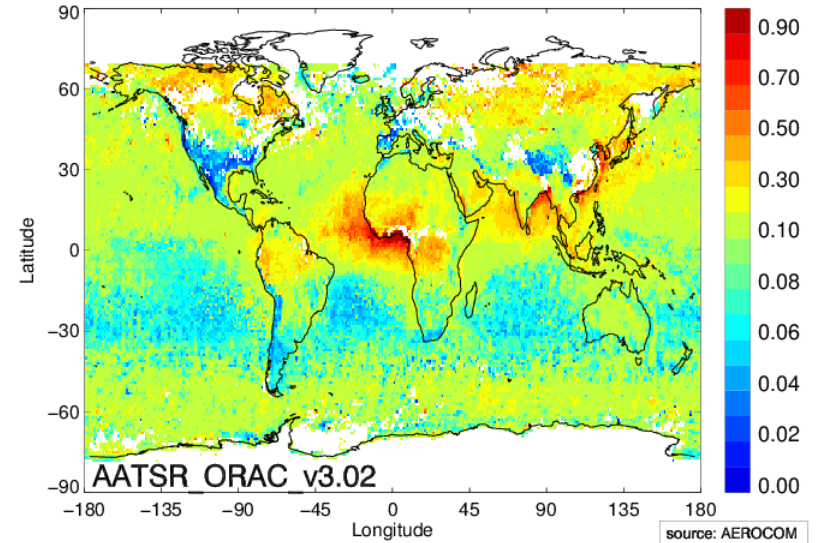
AATSR AOD, L3, 2007, DJF
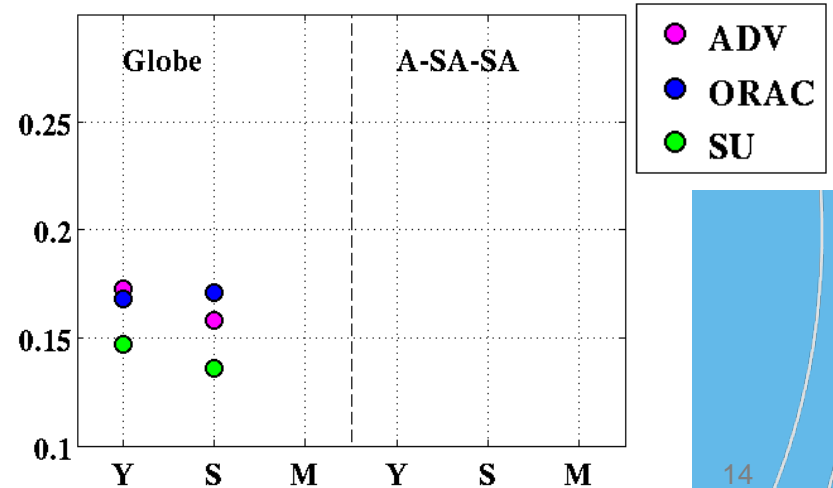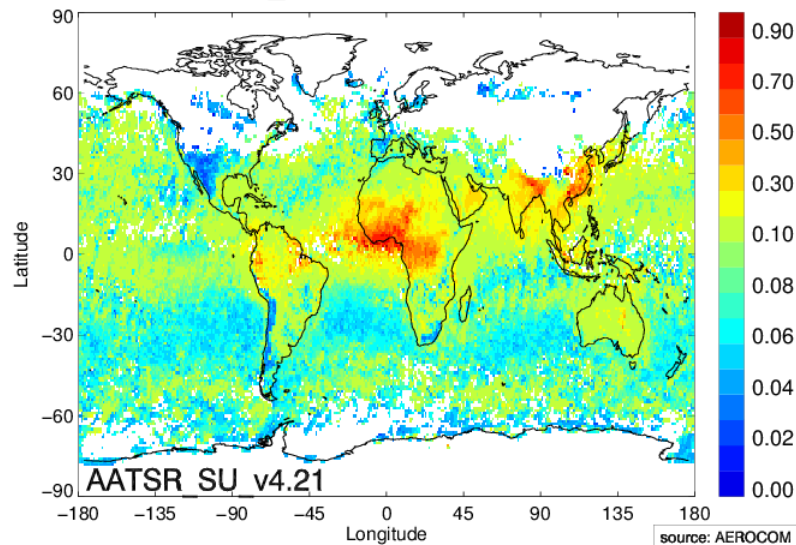
AATSR AOD, L3, 2007, January
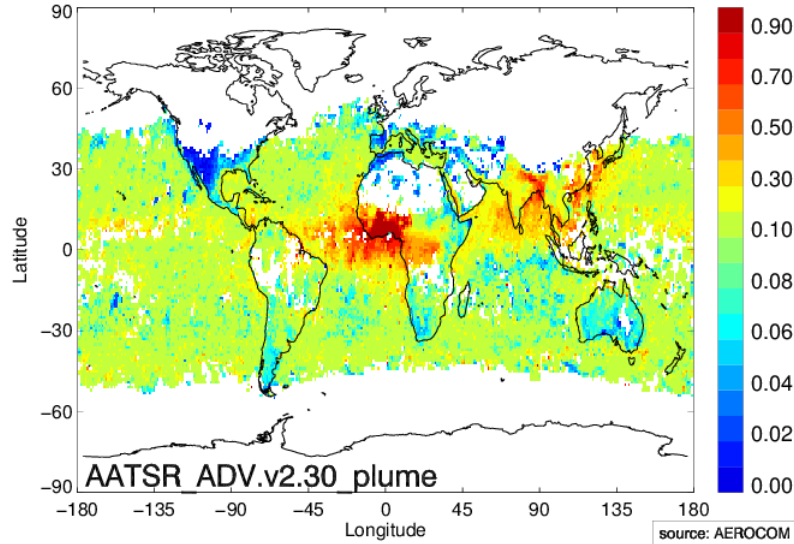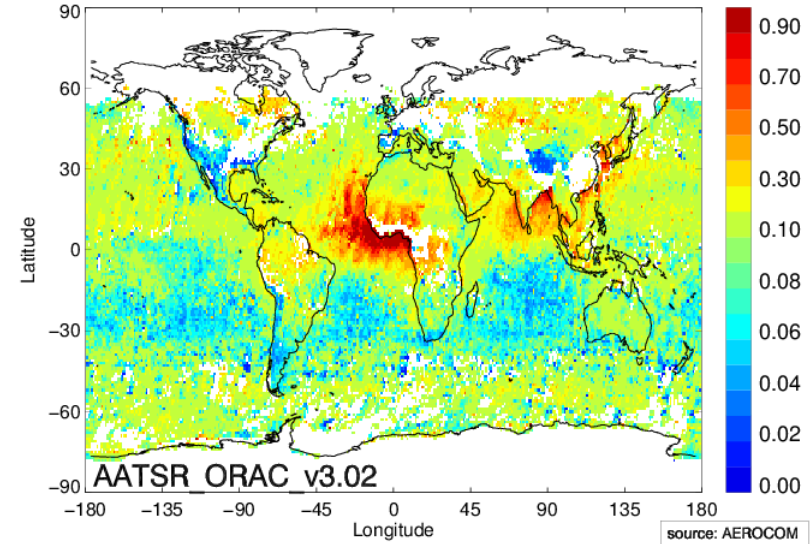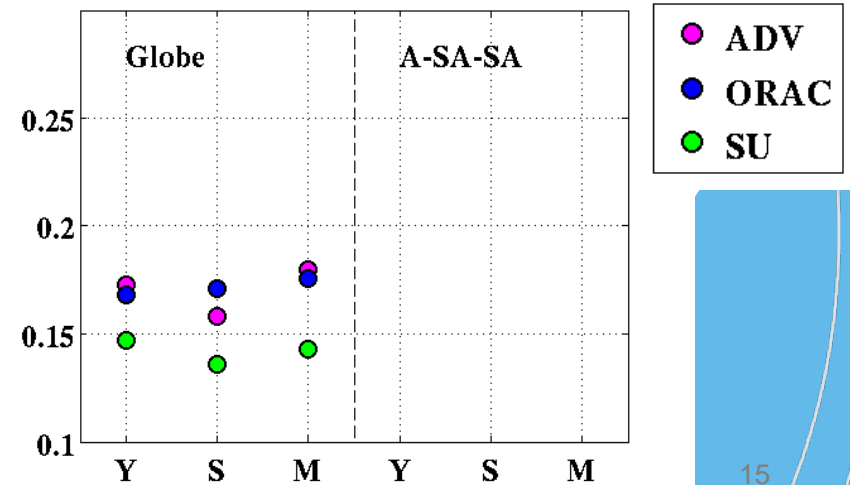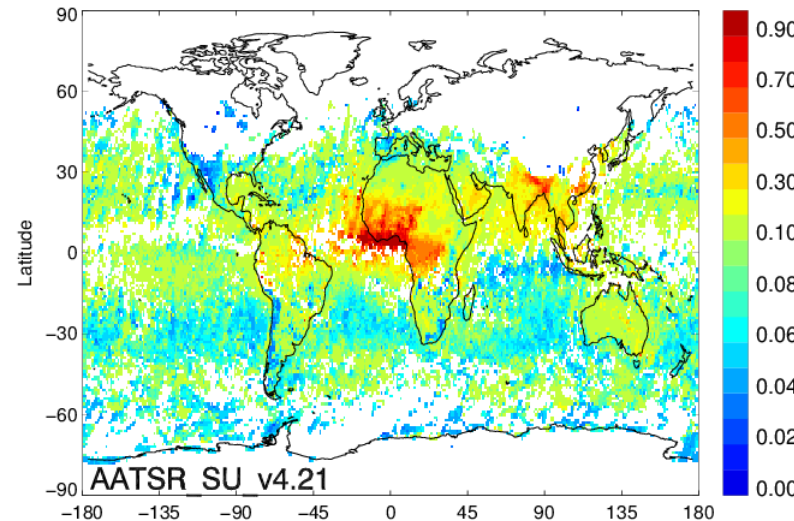
AOD (2007) validation with AERONET

L2 AOD, 2007

ADV, Ver 2.30c4p (area mean 0.188)

ORAC, Ver 3.02 (area mean 0.228)

SU, Ver 4.3 (area mean 0.203)

4.10.2016
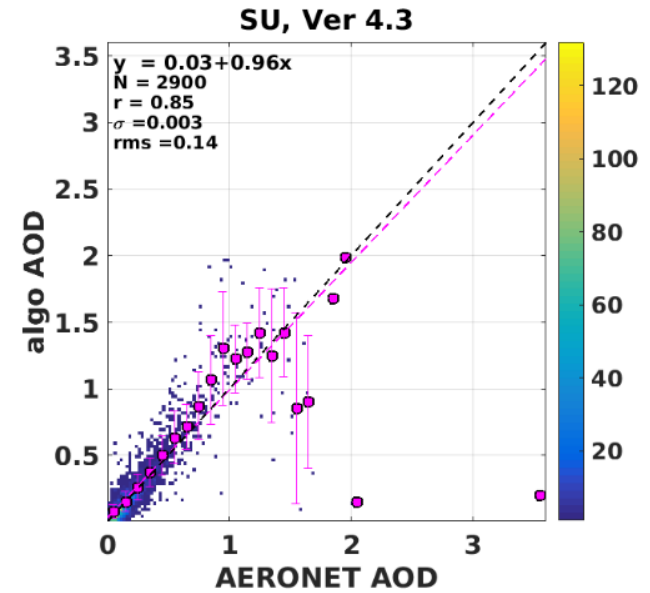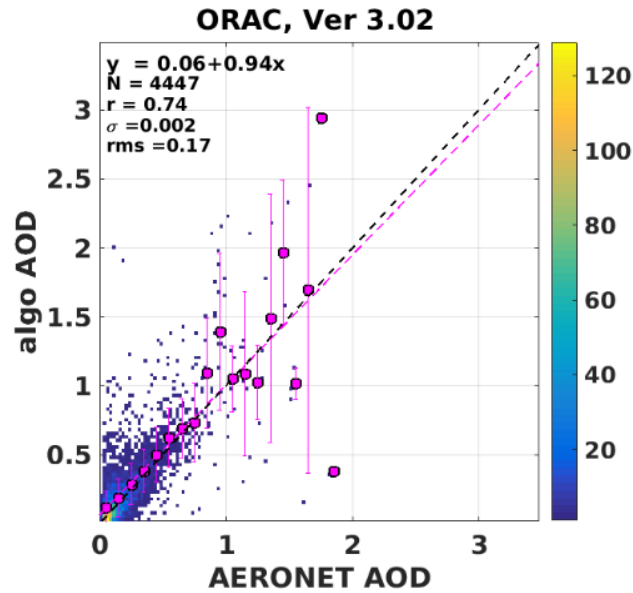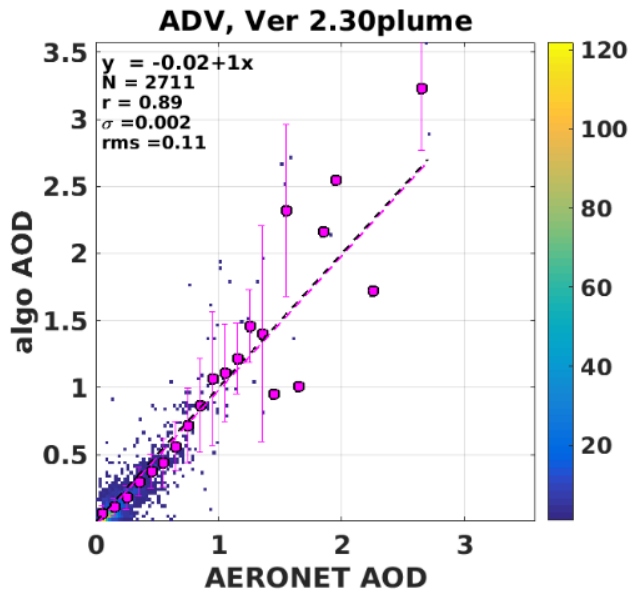
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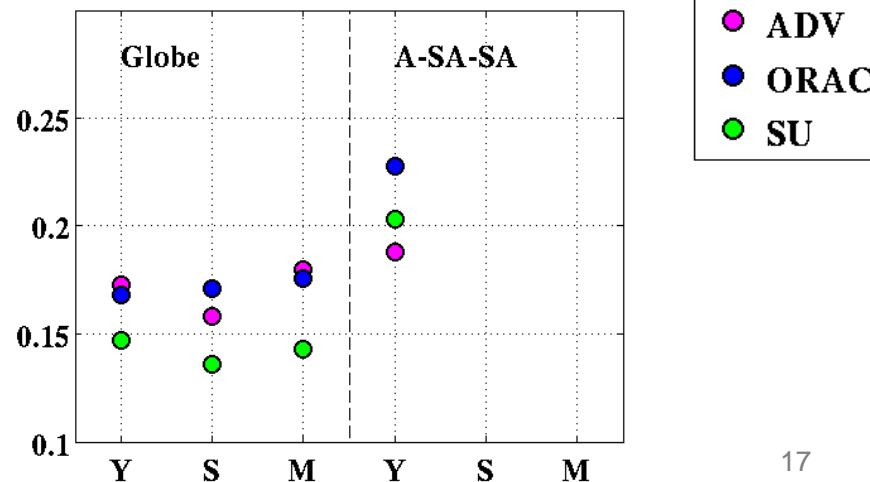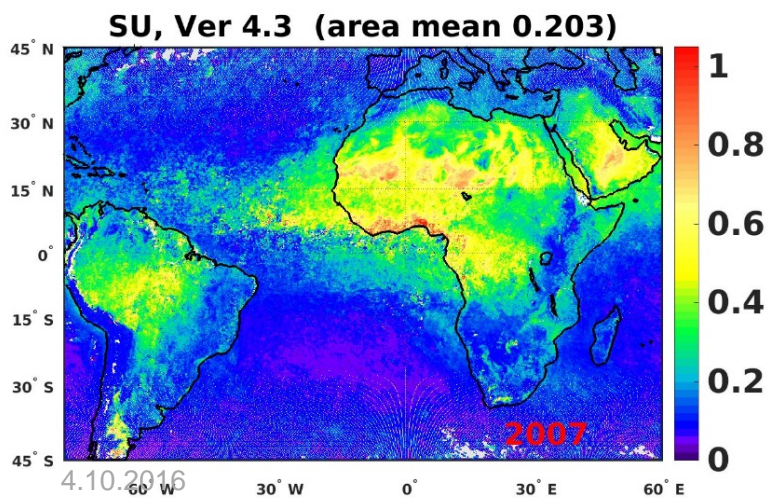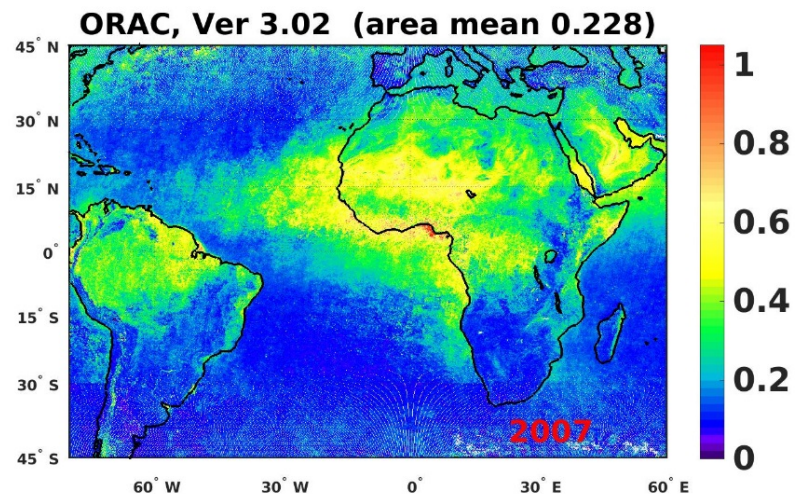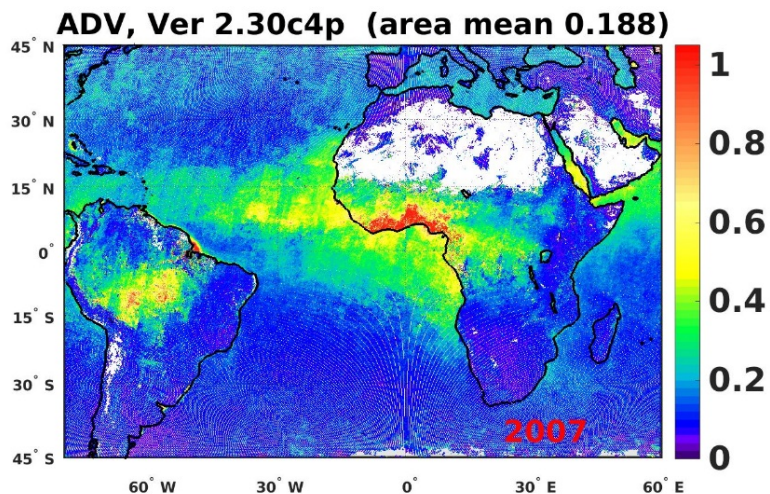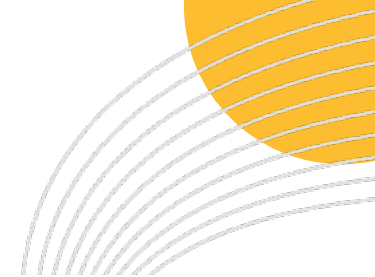
L2 AOD, 2007, DJF

ADV, Ver 2.30c4p (area mean 0.172)
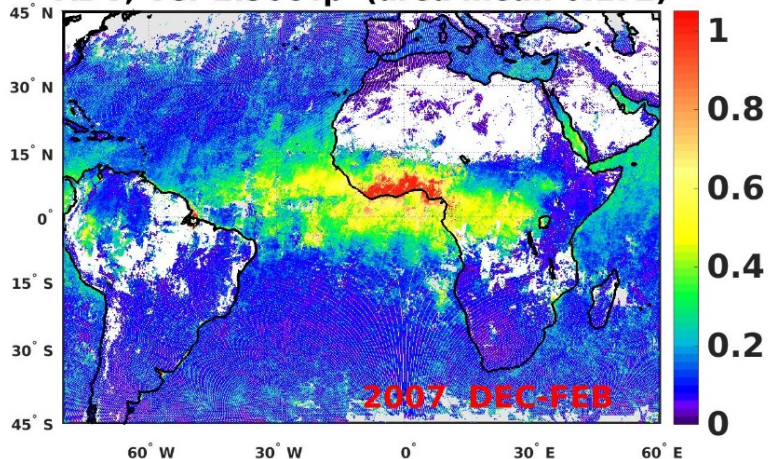
ORAC, Ver 3.02 (area mean 0.202)
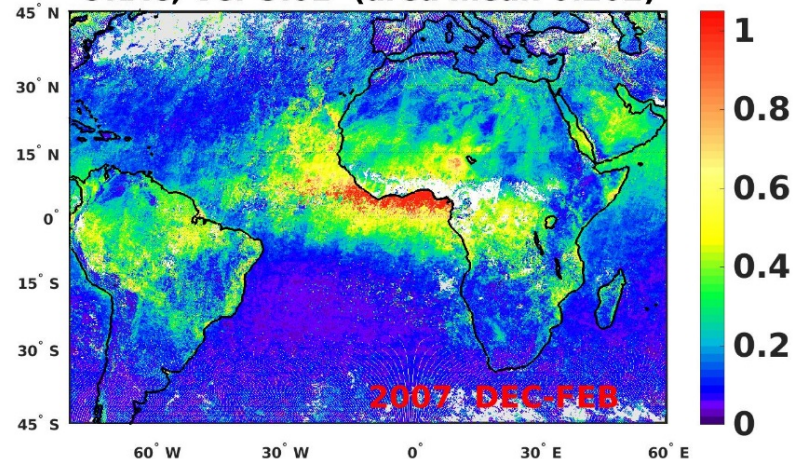
SU, Ver 4.3 (area mean 0.162)

L2 AOD, 2007, January

ADV, Ver 2.30c4p (area mean 0.192)
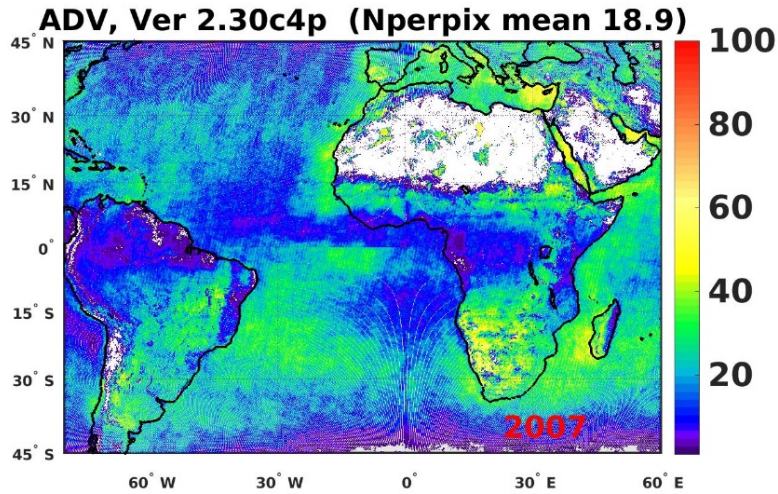

ORAC, Ver 3.02 (area mean 0.229)

SU, Ver 4.3 (area mean 0.18)
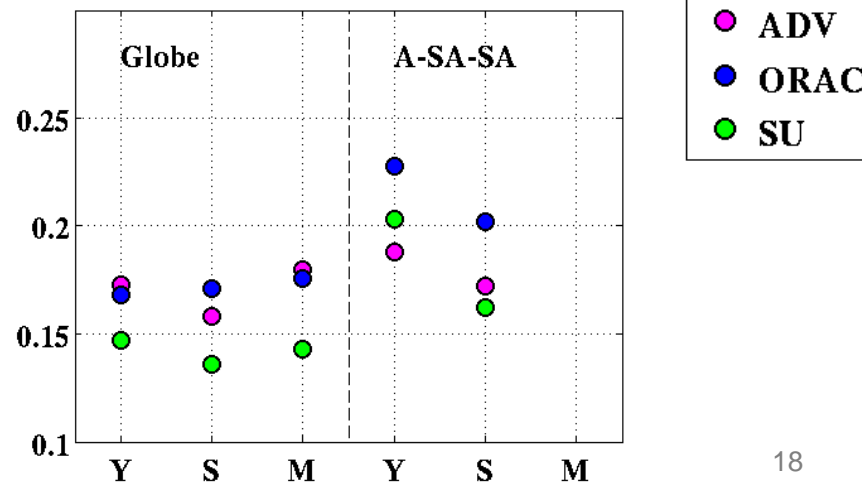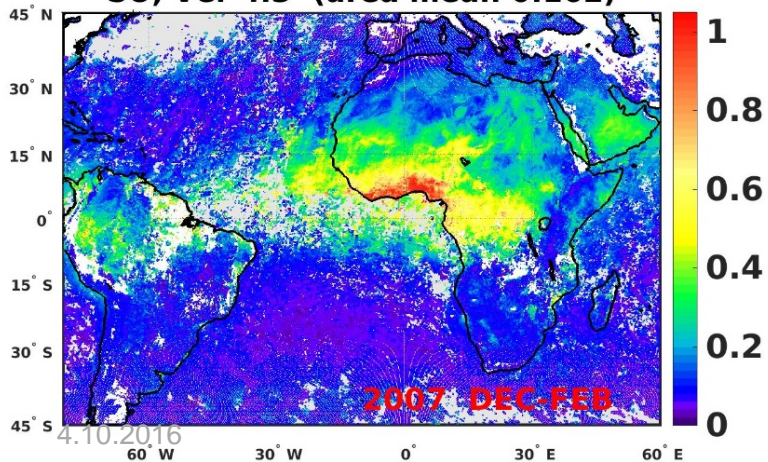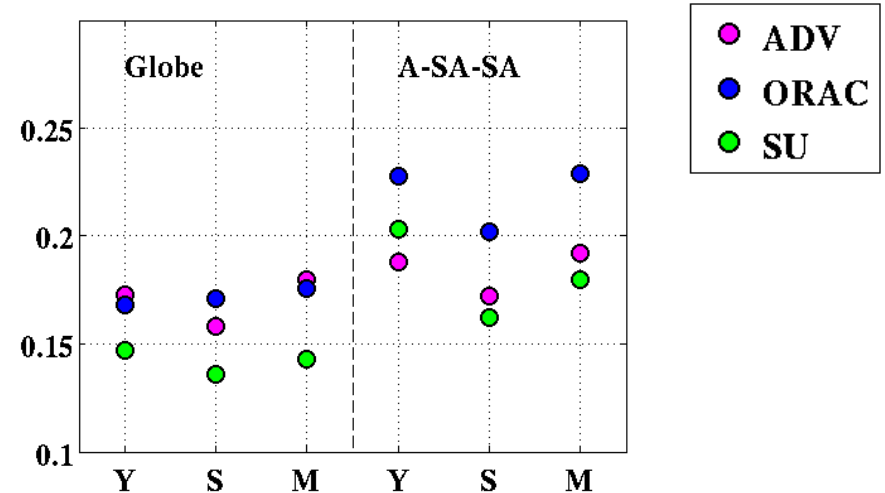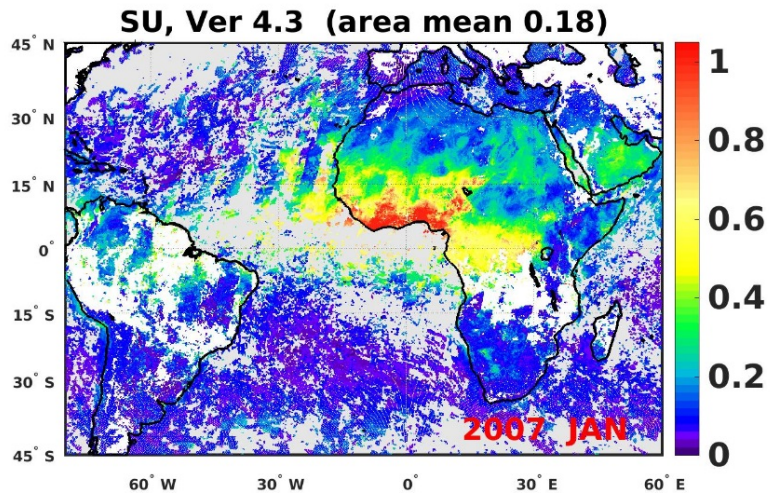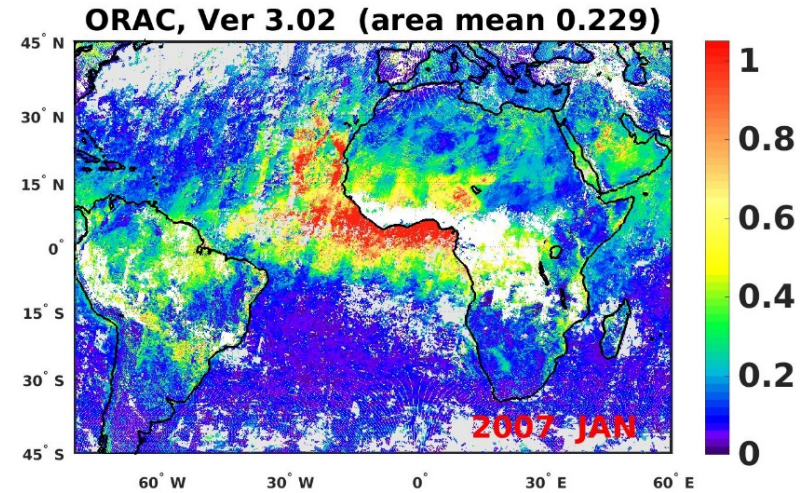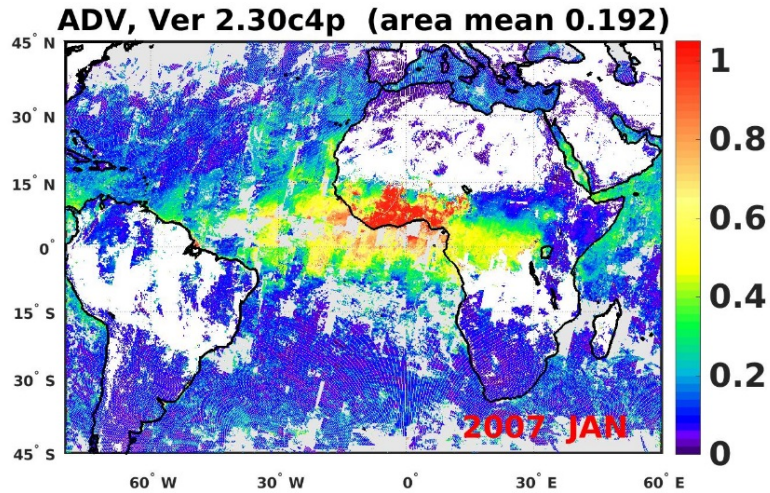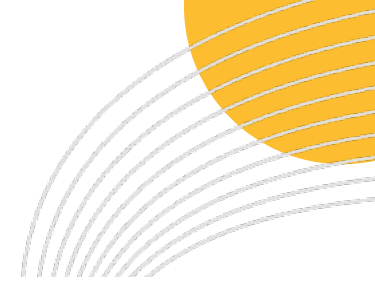
L2 AOD difference, 2007
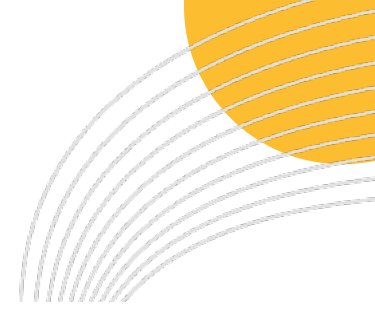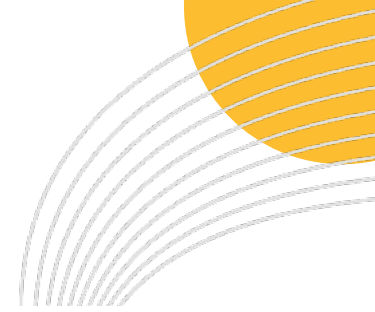
ADV-SU AOD (mean difference 0.001)
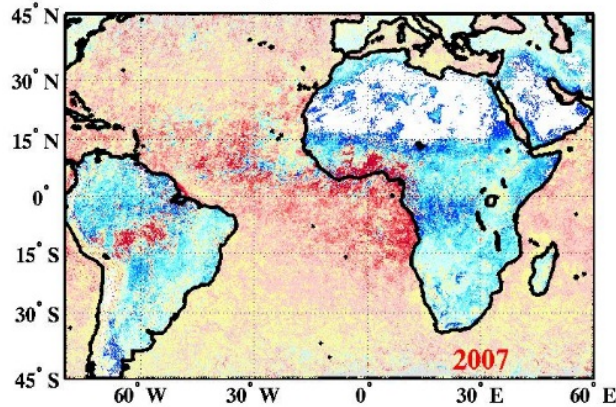
ORAC-SU AOD (mean difference 0.023)

ADV-ORAC AOD (mean difference -0.03)
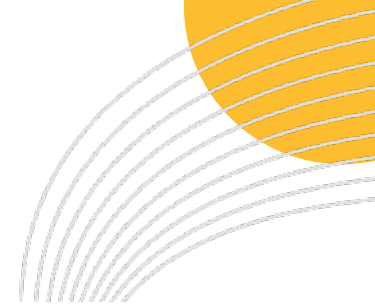
ADV-SU AOD (mean difference 0.008)
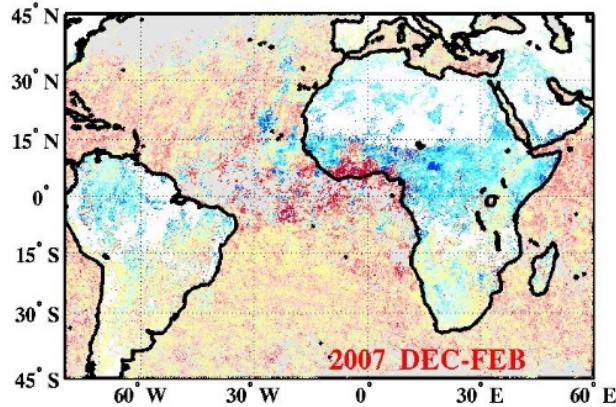
ORAC-SU AOD (mean difference 0.034)
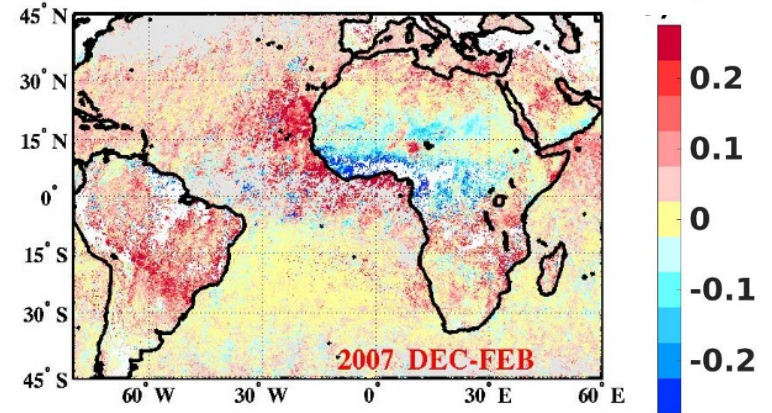
ADV-ORAC AOD (mean difference -0.027)
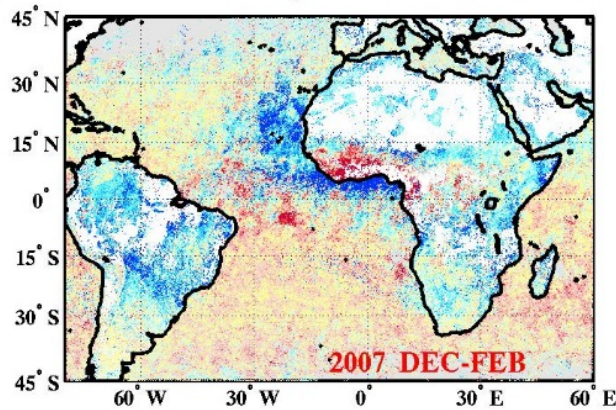
L2 AOD difference, 2007, DJF

ADV-SU AOD (mean difference 0.001)
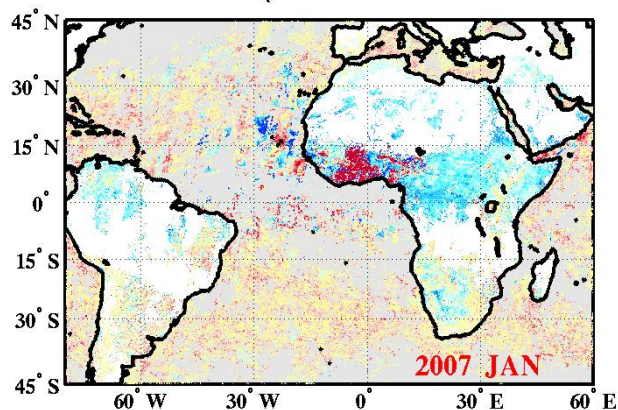
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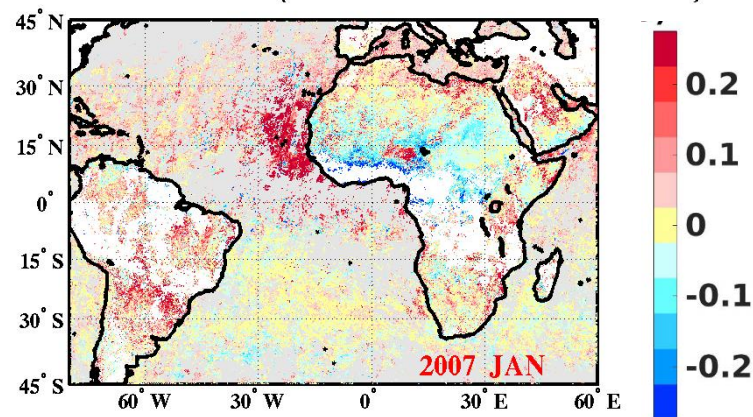
ADV-ORAC AOD (mean difference -0.035)

Npix , 2007

FINNISH METEOROLOGICAL INSTITUTE

ADV, Ver 2.30c4p (Nperpix mean 18.9)

ORAC, Ver 3.02 (Nperpix mean 32.8)

SU, Ver 4.3 (Nperpix mean 20.2)

Npix , 2007, DJF

ADV, Ver 2.30c4p (Nperpix mean 4.7)

2007 SEP-NOV
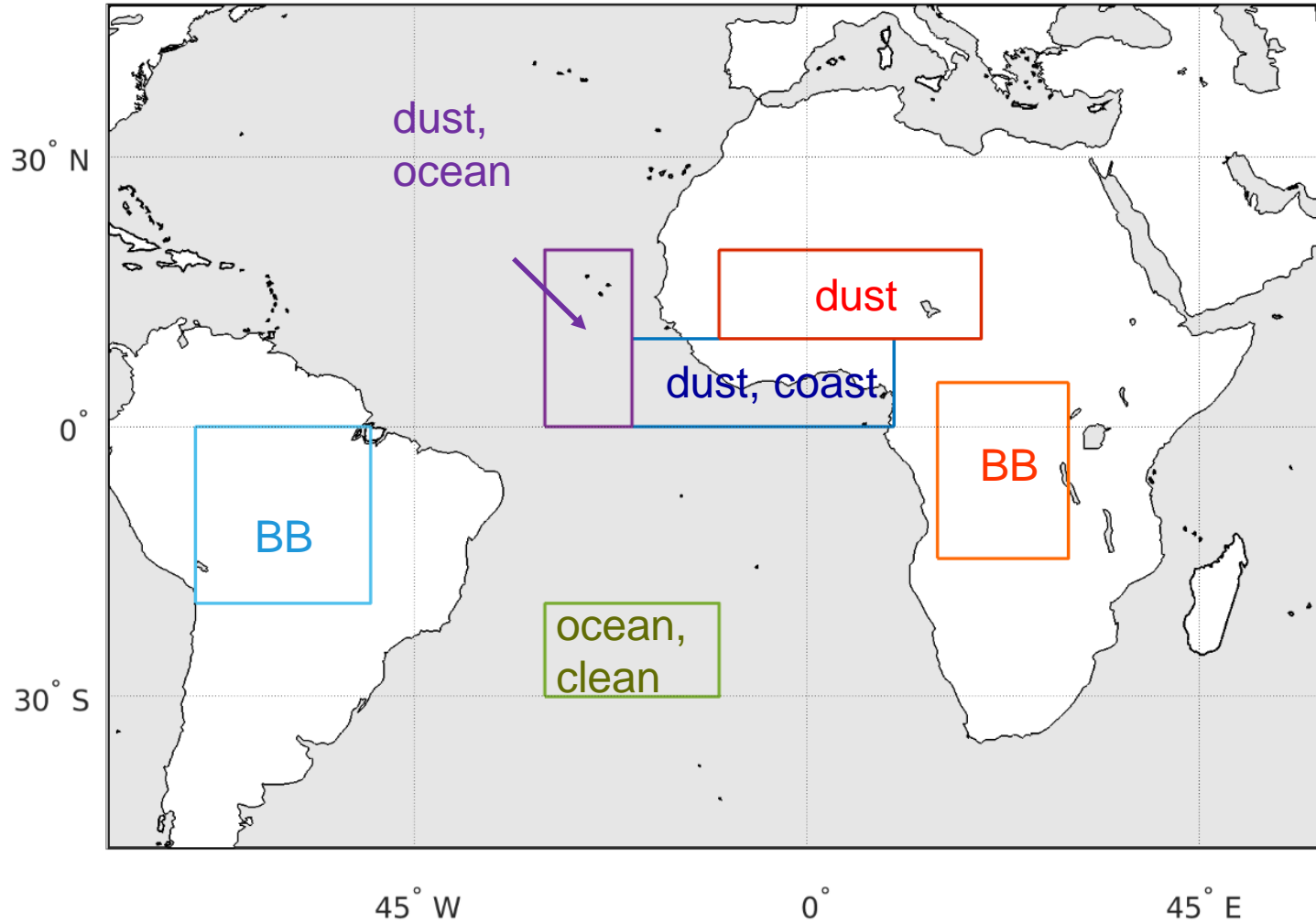

ORAC, Ver 3.02   (Nperpix mean 8.1)

2007 SEP-NOV

SU, Ver 4.3   (Nperpix mean 5.9)

2007 SEP-NOV
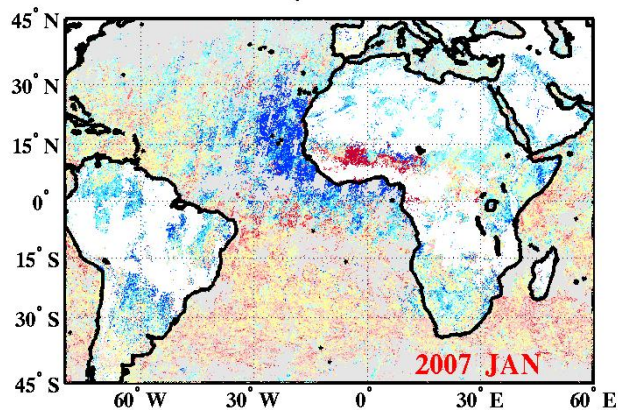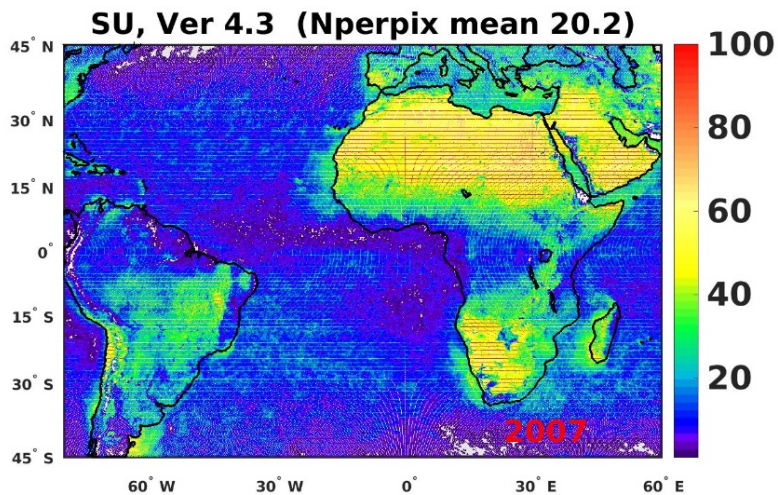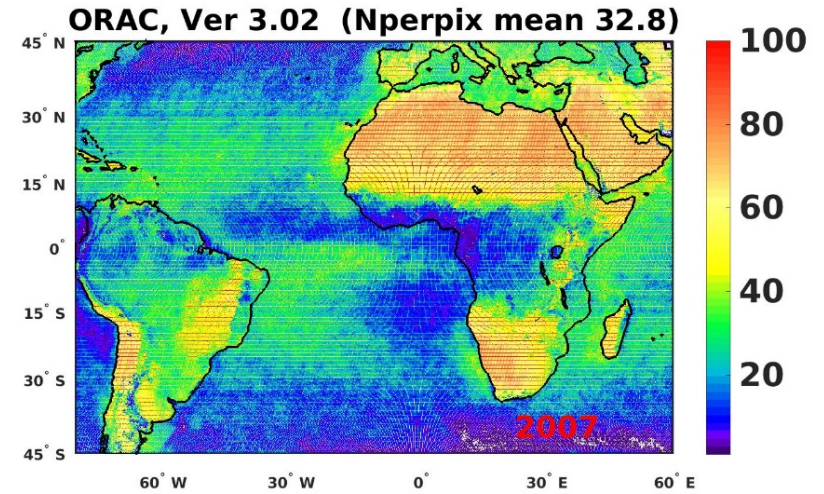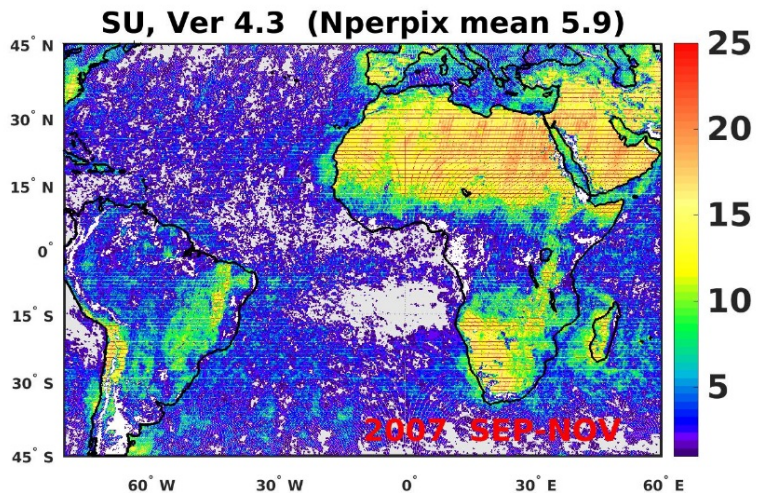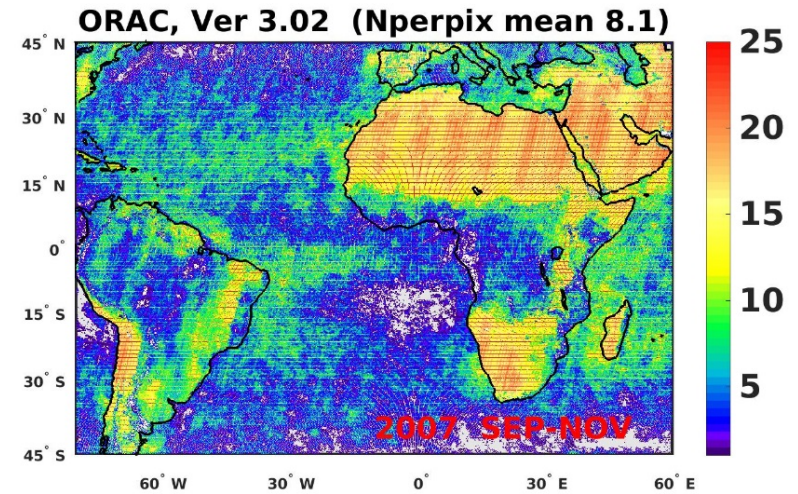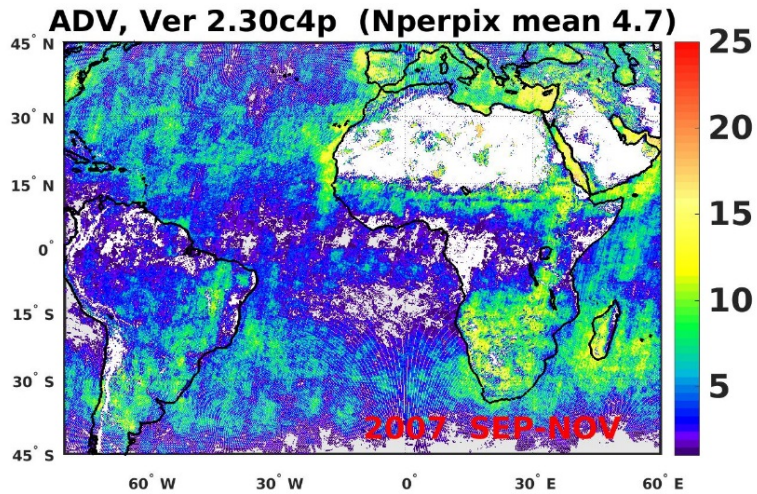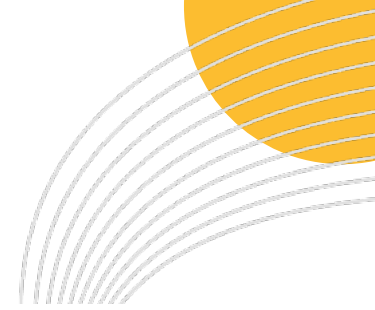
Npix , 2007, January

ADV, Ver 2.30c4p (Nperpix mean 2.2)

2007 JAN

ORAC, Ver 3.02 (Nperpix mean 3.2)

2007 JAN

SU, Ver 4.3 (Nperpix mean 2.6)

2007 JAN
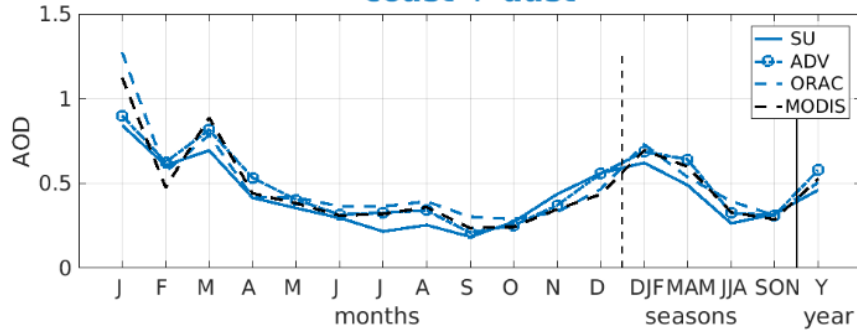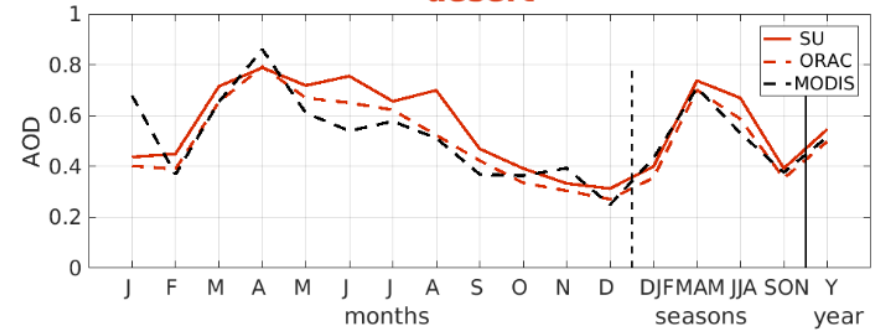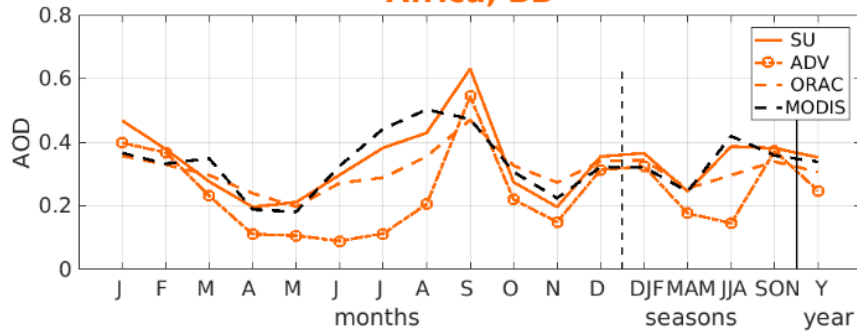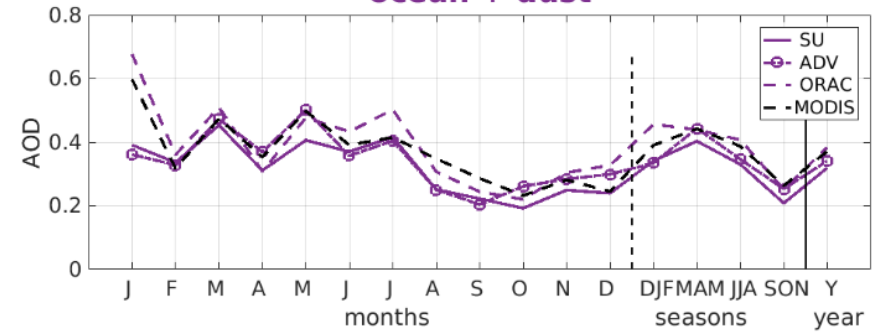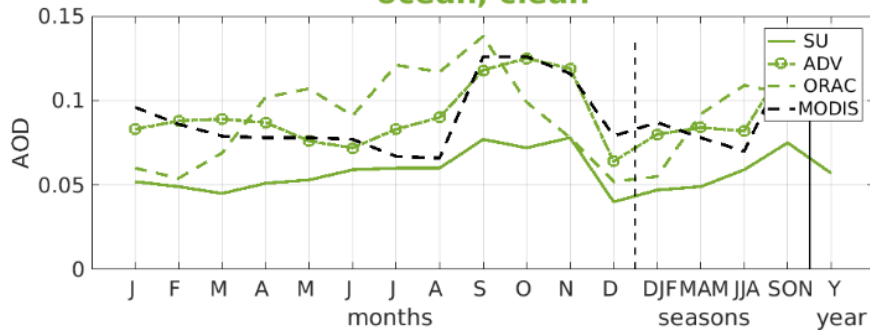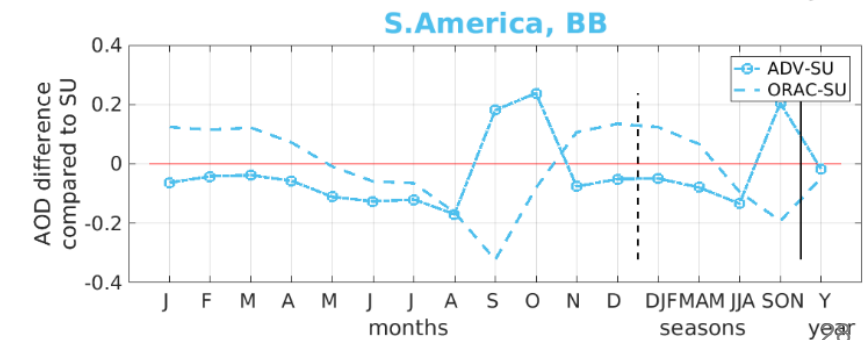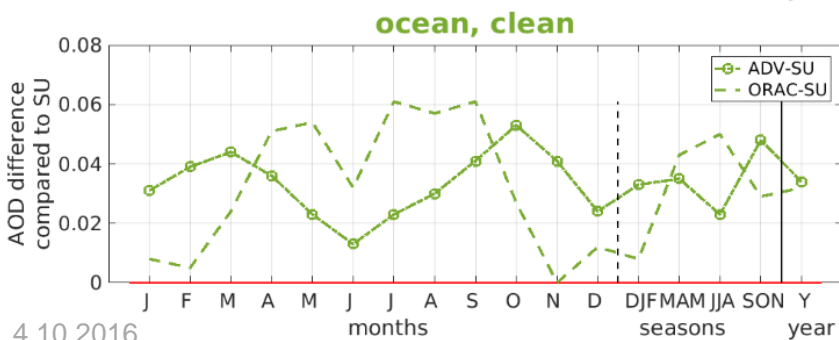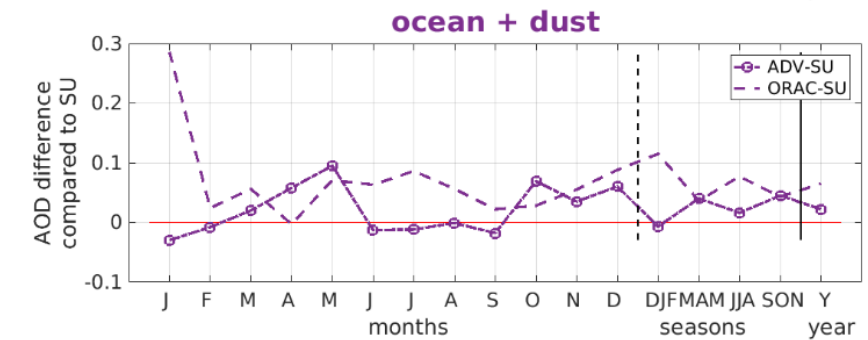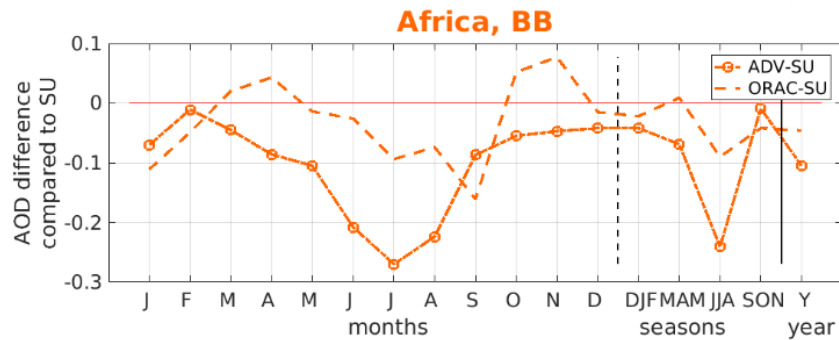
AOIs

AOD yearly cycles for AOIs

AOD yearly cycles for AOIs compared to SU

AOD yearly cycles for AOIs compared to MODIS
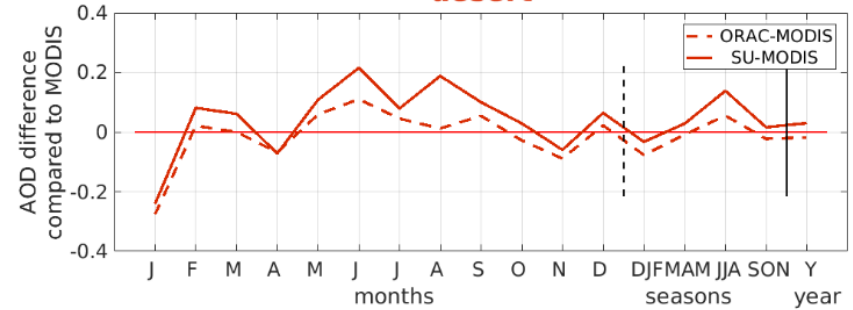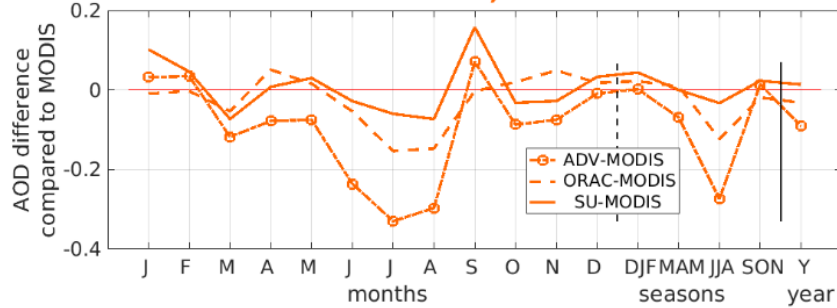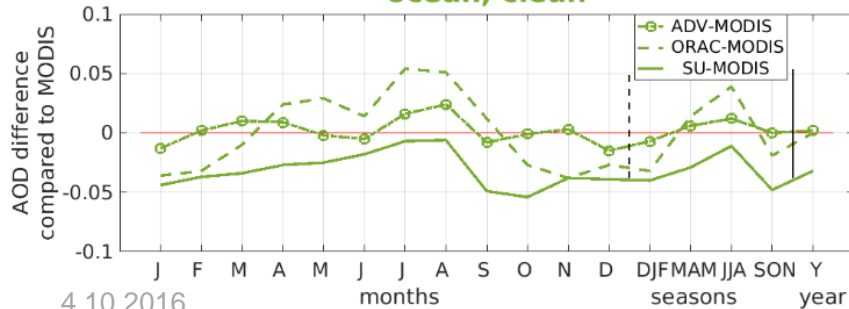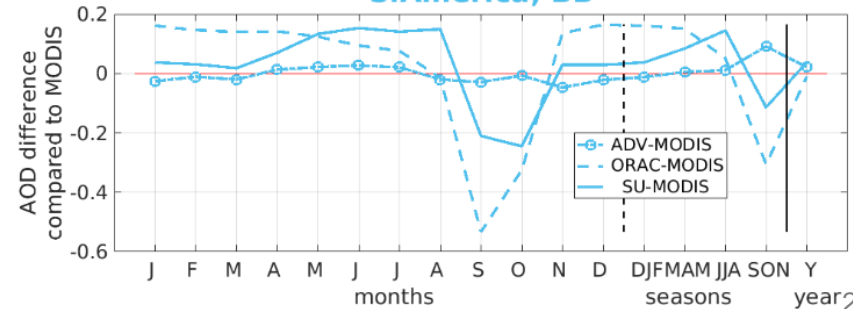
AERONET validation for different land types (ADV)

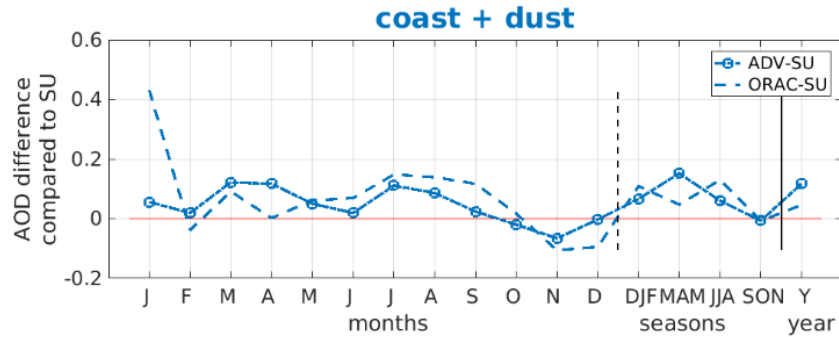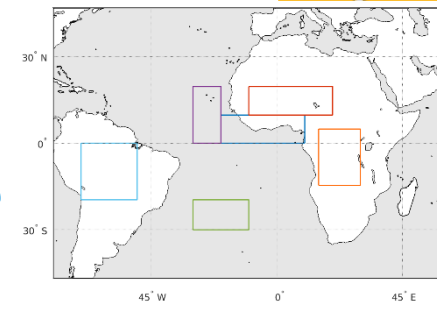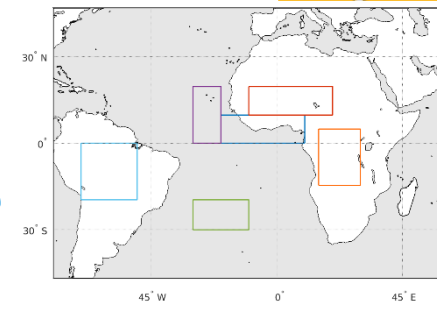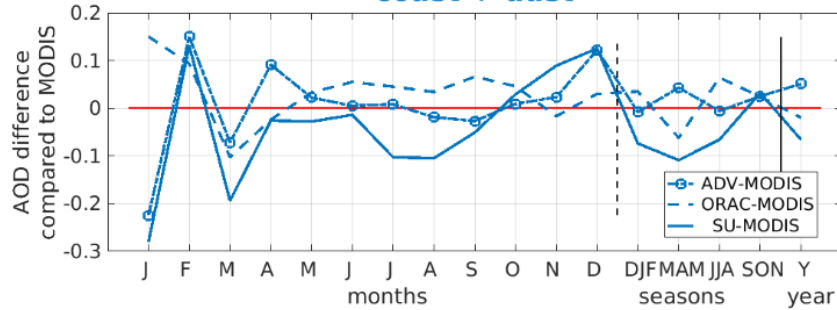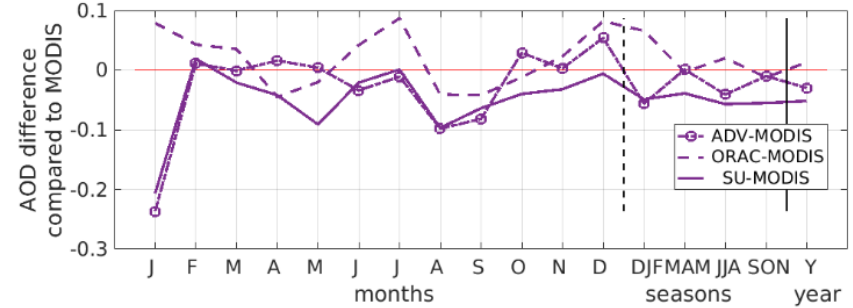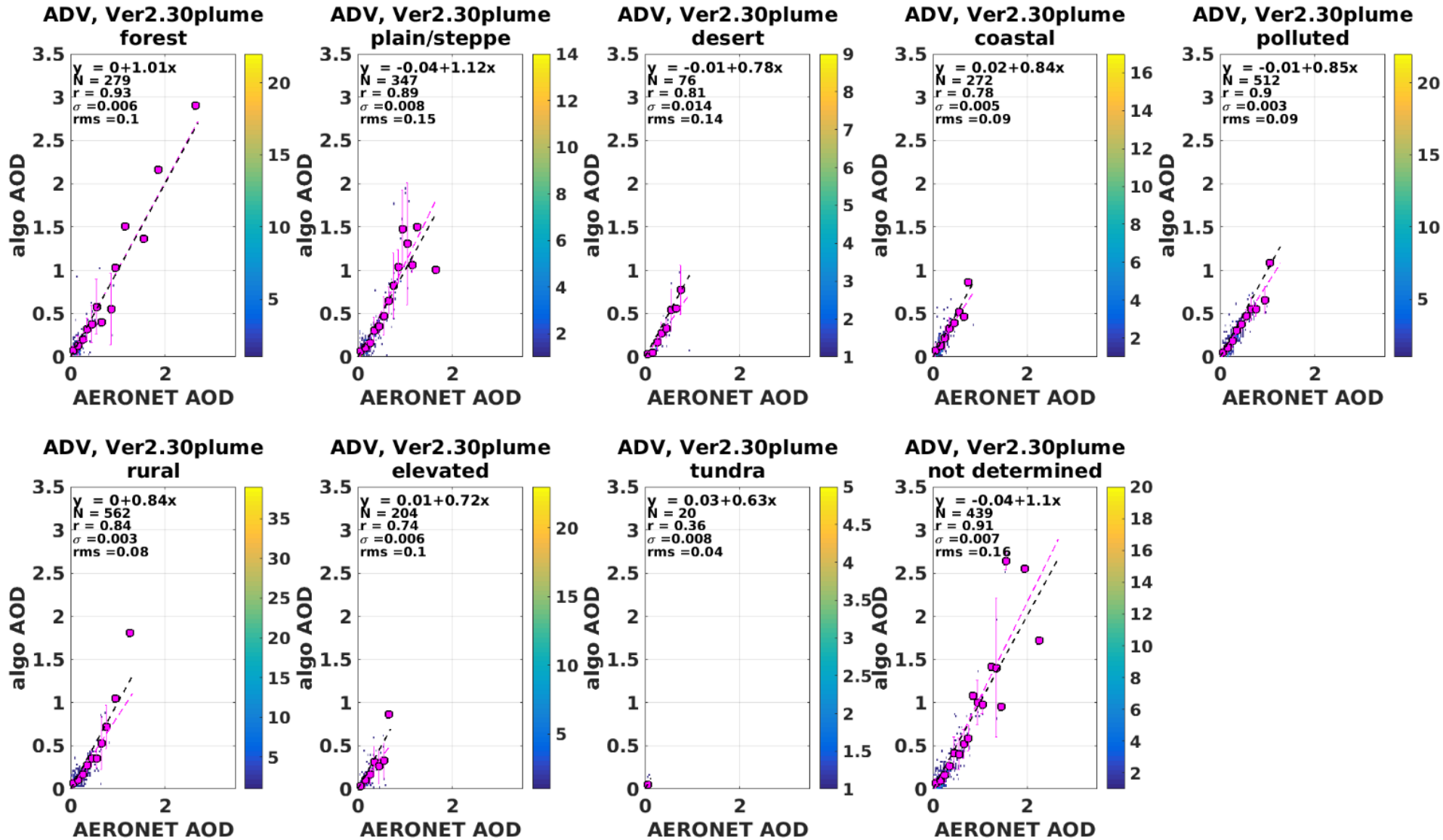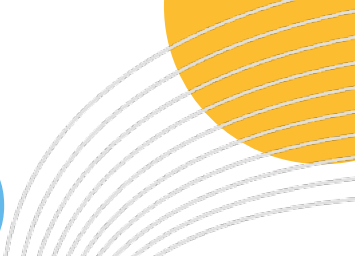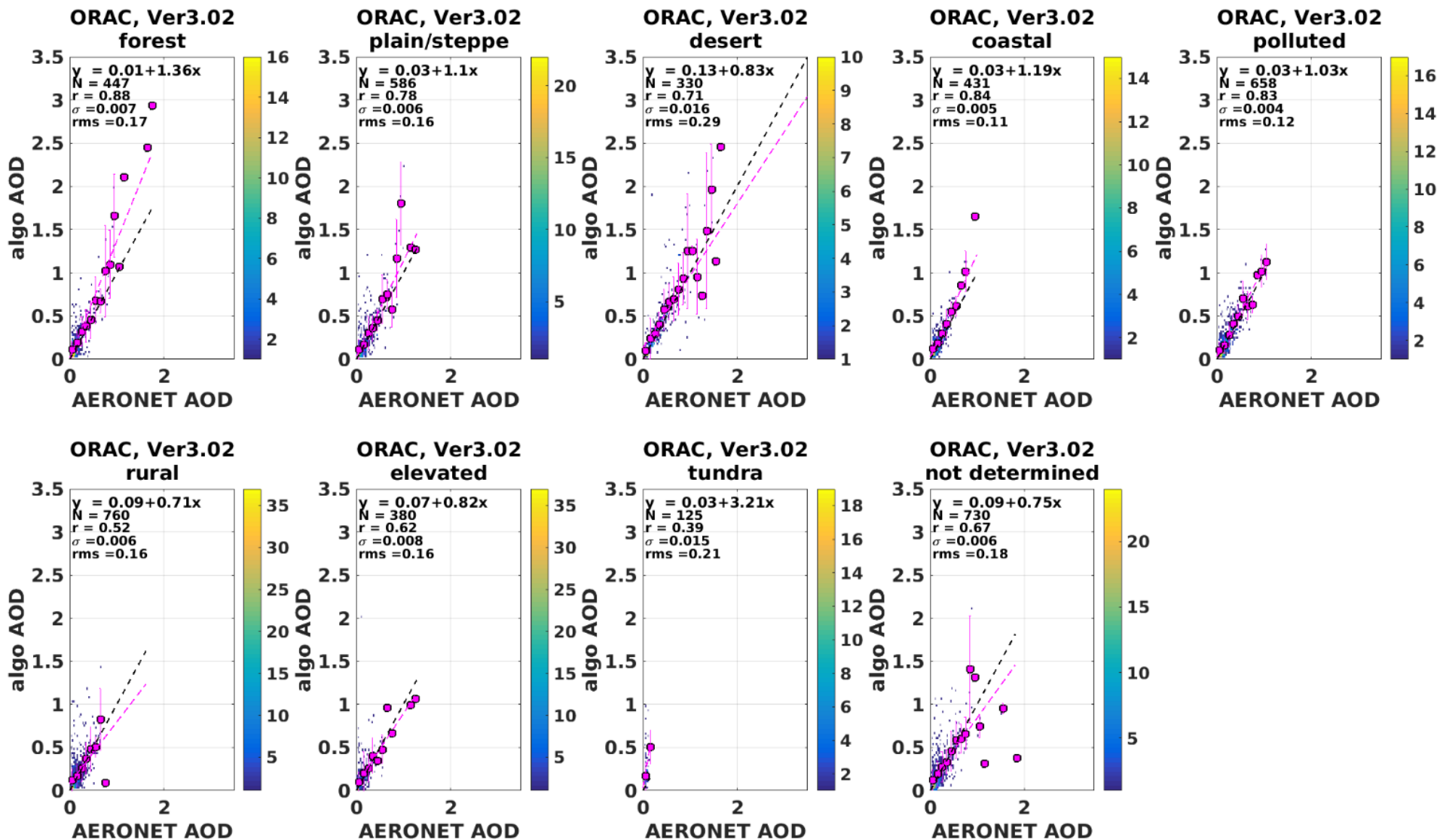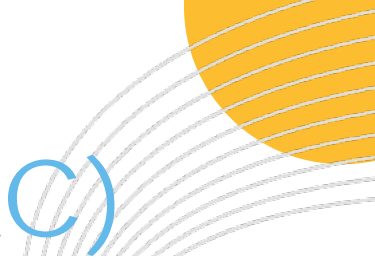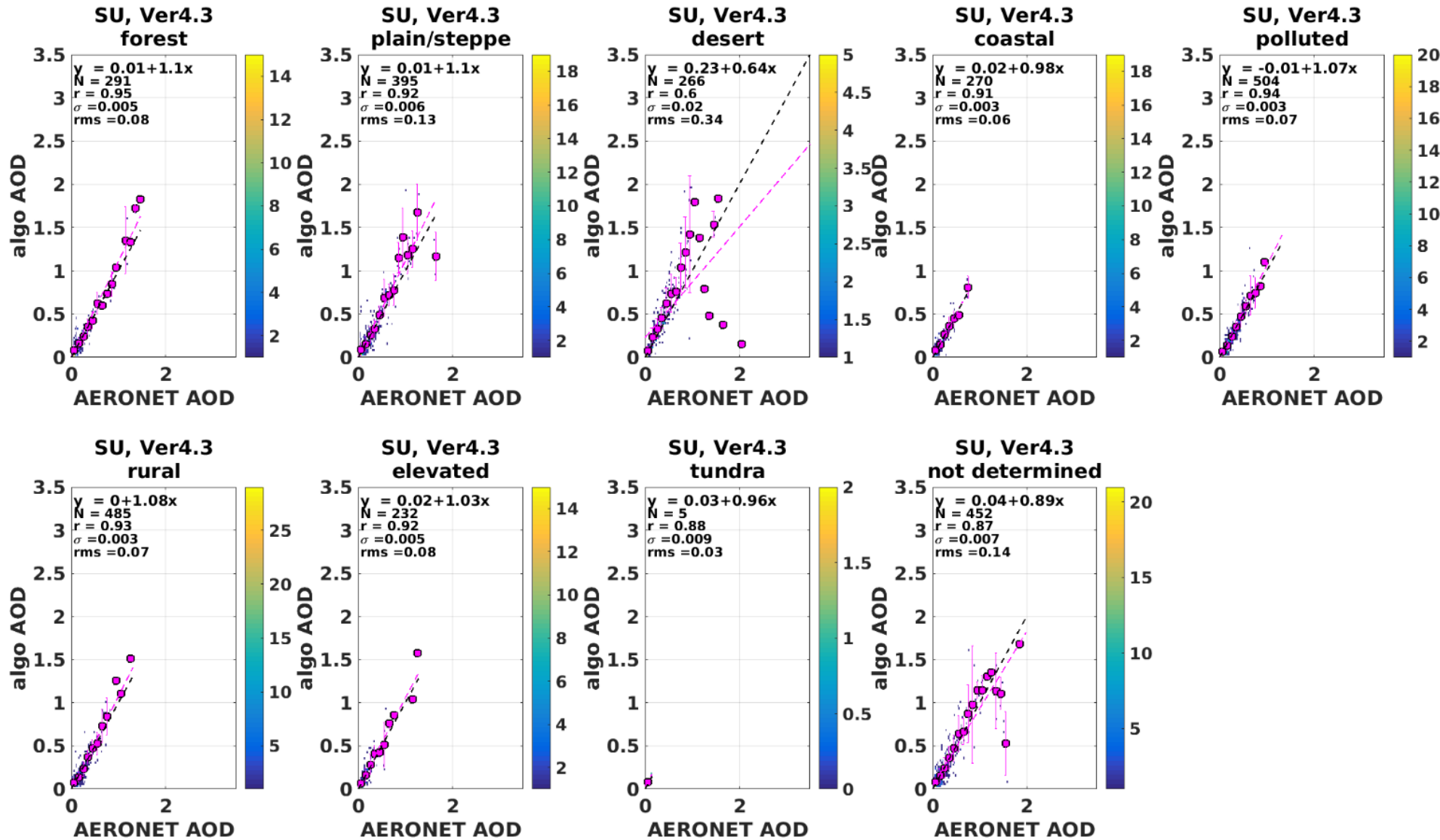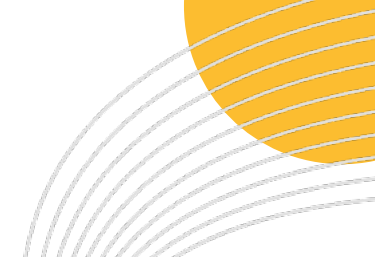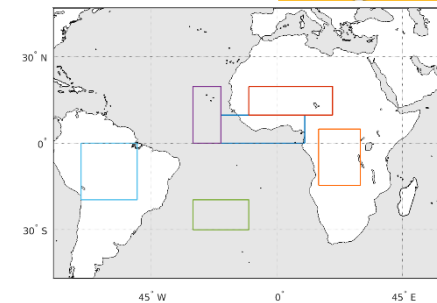# AERONET validation for different land types (ORAC)

AERONET validation for different land types (SU)

% of Npix retrieved, compared to SU
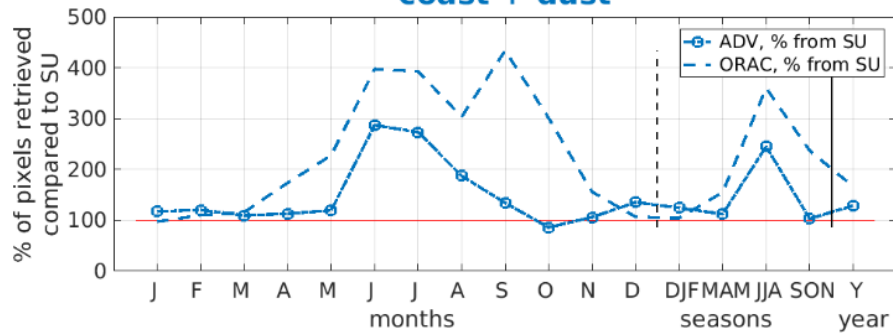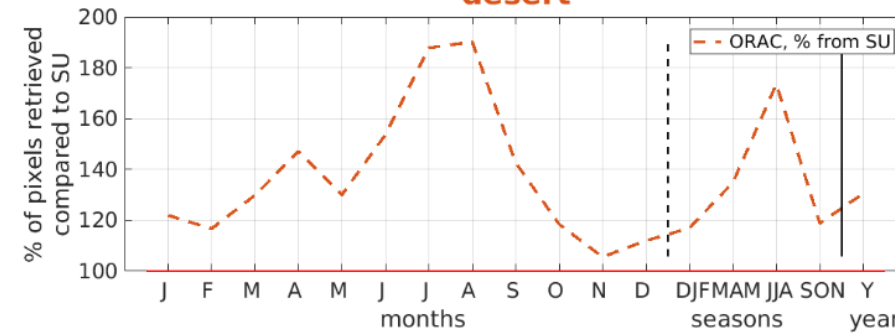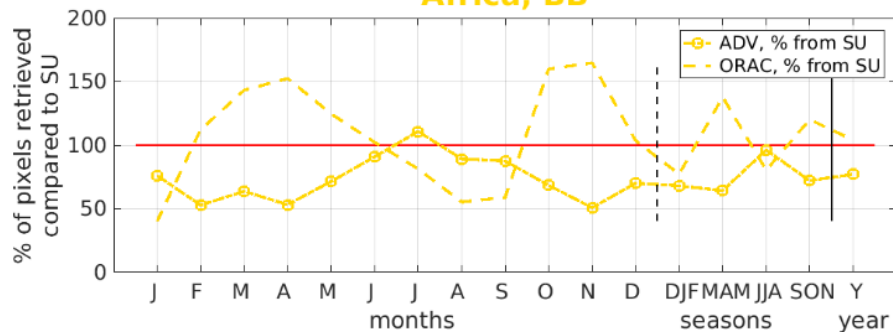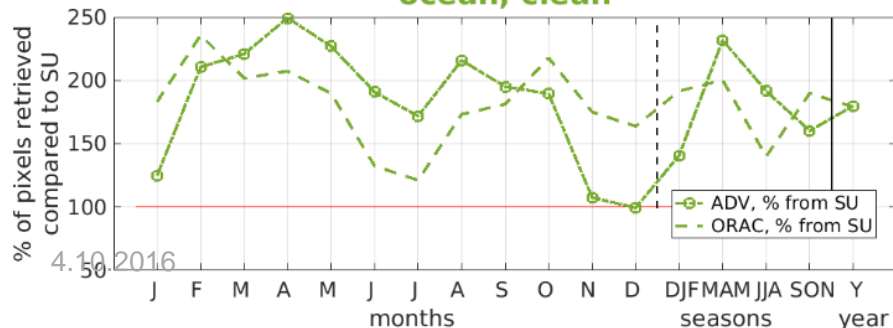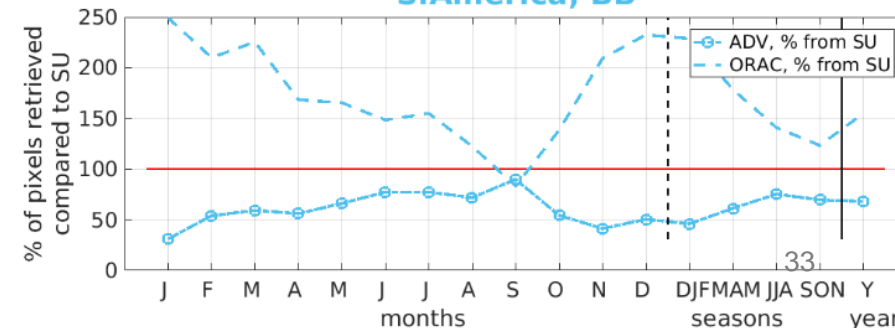
List of test cases

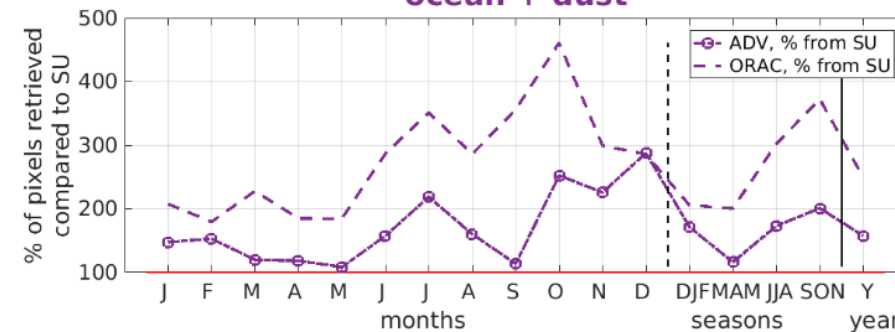|		Case description	Date	L2 file name (ADV)
1	a	Saharan dust, ocean	20070102	20070102090103-ESACCI-L2P_AEROSOL-AER_PRODUCTS-AATSR-ENVISAT-ADV_25311-v2.30.nc
	b		20070108	20070108091231-ESACCI-L2P_AEROSOL-AER_PRODUCTS-AATSR-ENVISAT-ADV_25397-v2.30.nc
	c		20070225	20070225090354-ESACCI-L2P_AEROSOL-AER_PRODUCTS-AATSR-ENVISAT-ADV_26084-v2.30.nc
2	a	Africa, BB	20070809	20070809073743-ESACCI-L2P_AEROSOL-AER_PRODUCTS-AATSR-ENVISAT-ADV_28445-v2.30.nc
	b		20070812	20070812074328-ESACCI-L2P_AEROSOL-AER_PRODUCTS-AATSR-ENVISAT-ADV_28488-v2.30.nc
	c		20070814	20070814082050-ESACCI-L2P_AEROSOL-AER_PRODUCTS-AATSR-ENVISAT-ADV_28517-v2.30.nc
	d		20070901	20070901071442-ESACCI-L2P_AEROSOL-AER_PRODUCTS-AATSR-ENVISAT-ADV_28774-v2.30.nc
3	a	Africa, dust	20070402	20070402083213-ESACCI-L2P_AEROSOL-AER_PRODUCTS-AATSR-ENVISAT-ADV_26599-v2.30.nc
	b		20070512	20070512091525-ESACCI-L2P_AEROSOL-AER_PRODUCTS-AATSR-ENVISAT-ADV_27172-v2.30.nc
	c		20070612	20070612094118-ESACCI-L2P_AEROSOL-AER_PRODUCTS-AATSR-ENVISAT-ADV_27616-v2.30.nc
4	a	Dust over ocean	20070114	20070114110436-ESACCI-L2P_AEROSOL-AER_PRODUCTS-AATSR-ENVISAT-ADV_25484-v2.30.nc
	b		20070312	20070312111314-ESACCI-L2P_AEROSOL-AER_PRODUCTS-AATSR-ENVISAT-ADV_26300-v2.30.nc
	c		20070622	20070622110732-ESACCI-L2P_AEROSOL-AER_PRODUCTS-AATSR-ENVISAT-ADV_27760-v2.30.nc
5	a	Australia	20070330	20070330000329-ESACCI-L2P_AEROSOL-AER_PRODUCTS-AATSR-ENVISAT-ADV_26551-v2.30.nc 20070330233152-ESACCI-L2P_AEROSOL-AER_PRODUCTS-AATSR-ENVISAT-ADV_26565-v2.30.nc
	b		20070729	20070729000043-ESACCI-L2P_AEROSOL-AER_PRODUCTS-AATSR-ENVISAT-ADV_28283-v2.30.nc 20070729232906-ESACCI-L2P_AEROSOL-AER_PRODUCTS-AATSR-ENVISAT-ADV_28297-v2.30.nc
6	a	China, winter coverage	20070104	20070104025600-ESACCI-L2P_AEROSOL-AER_PRODUCTS-AATSR-ENVISAT-ADV_25336-v2.30.nc
	b		20070125	20070125015534-ESACCI-L2P_AEROSOL-AER_PRODUCTS-AATSR-ENVISAT-ADV_25636-v2.30.nc
7	a	China, summer emissions	20070607	20070607021548-ESACCI-L2P_AEROSOL-AER_PRODUCTS-AATSR-ENVISAT-ADV_27540-v2.30.nc
	b		20070816	20070816021548-ESACCI-L2P_AEROSOL-AER_PRODUCTS-AATSR-ENVISAT-ADV_28542-v2.30.nc
8	a	Pacific, clean	20070107	20070107162632-ESACCI-L2P_AEROSOL-AER_PRODUCTS-AATSR-ENVISAT-ADV_25387-v2.30.nc
	b		20070727	20070727174956-ESACCI-L2P_AEROSOL-AER_PRODUCTS-AATSR-ENVISAT-ADV_28265-v2.30.nc
9	a	Amazon, BB	20070913	20070913123927-ESACCI-L2P_AEROSOL-AER_PRODUCTS-AATSR-ENVISAT-ADV_28949-v2.30.nc
	b		20070929	20070929123633-ESACCI-L2P_AEROSOL-AER_PRODUCTS-AATSR-ENVISAT-ADV_29178-v2.30.nc
	c		20071005	20071005124803-ESACCI-L2P_AEROSOL-AER_PRODUCTS-AATSR-ENVISAT-ADV_29264-v2.30.nc

We were the L2 data:

- AOD
- Cloud fraction
- Fine mode AOD
- Dust AOD
- Angström
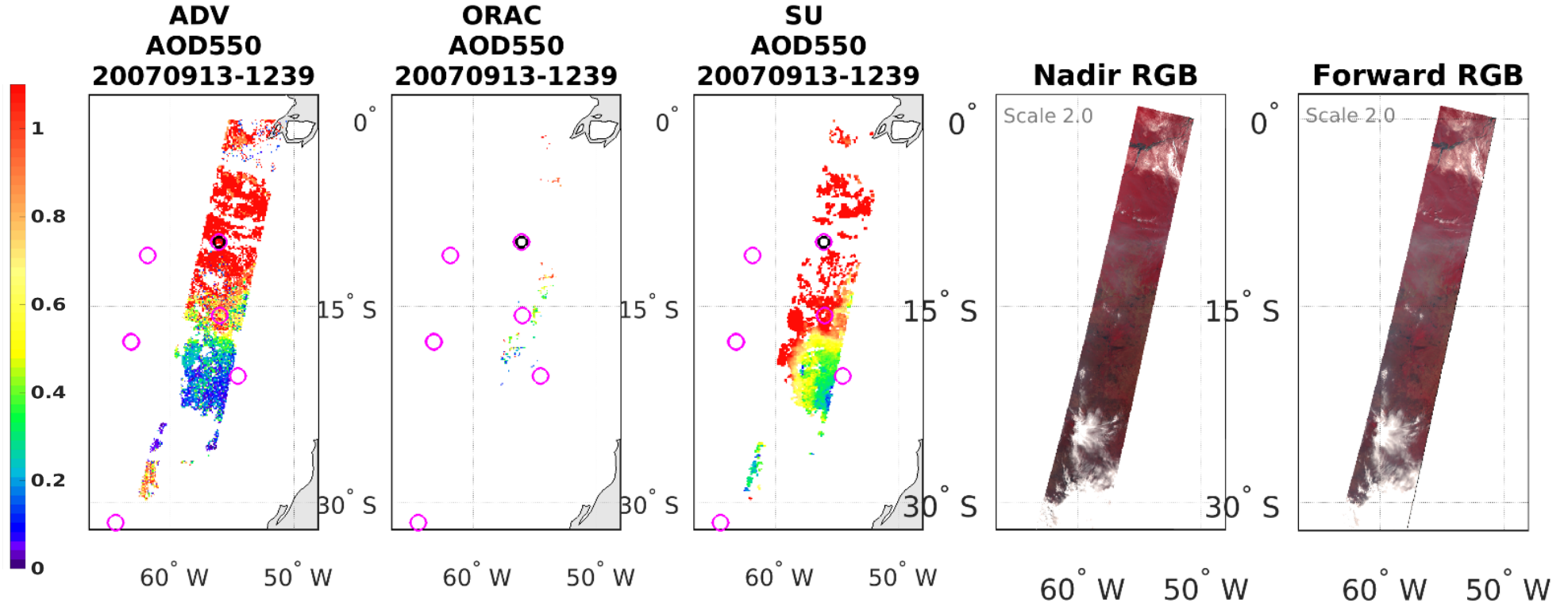- Surface reflectance

As reference:

- RGB images
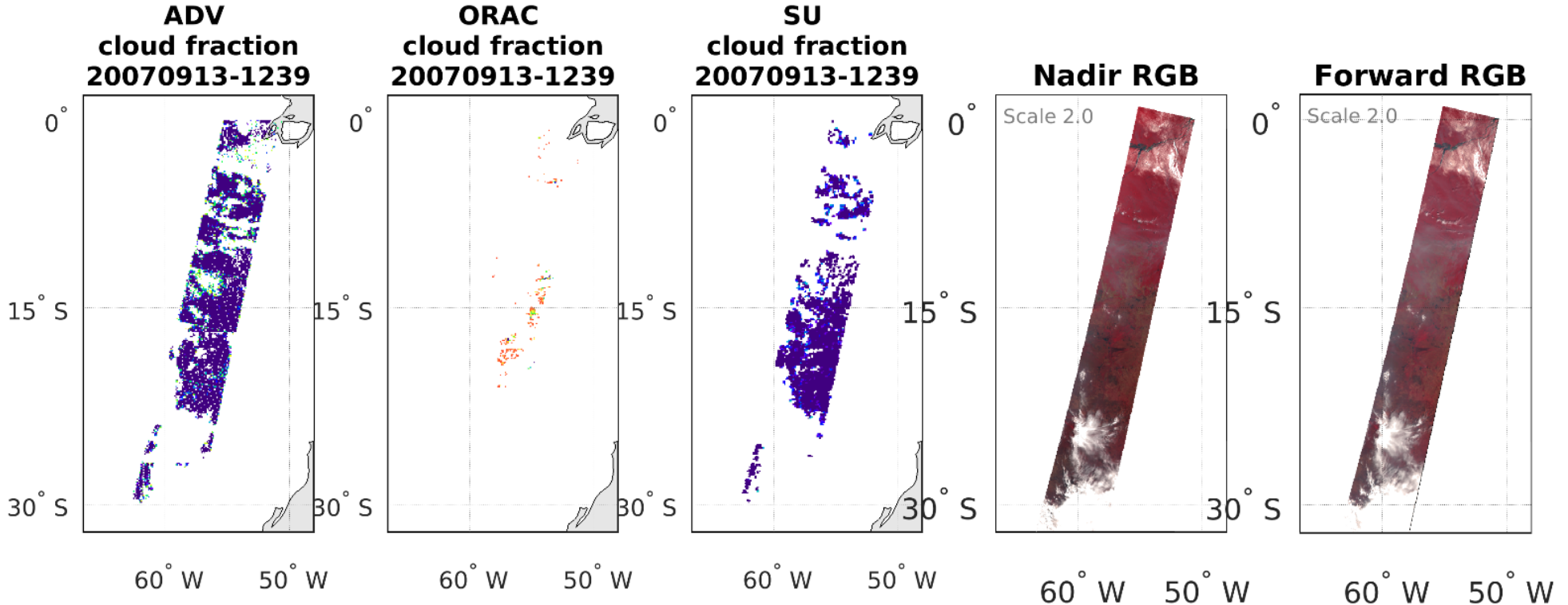- AERONET
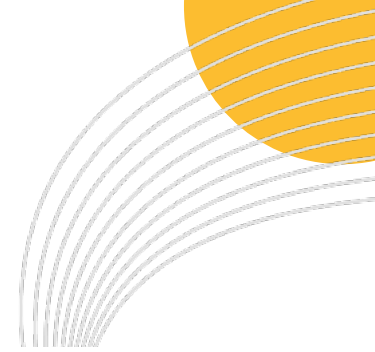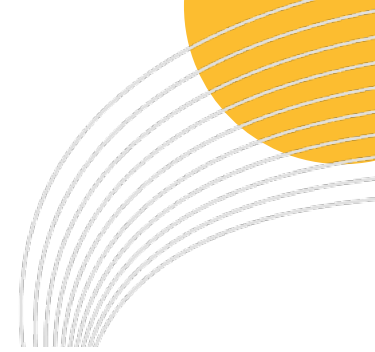- ASRVN
- GRASP surface reflectance
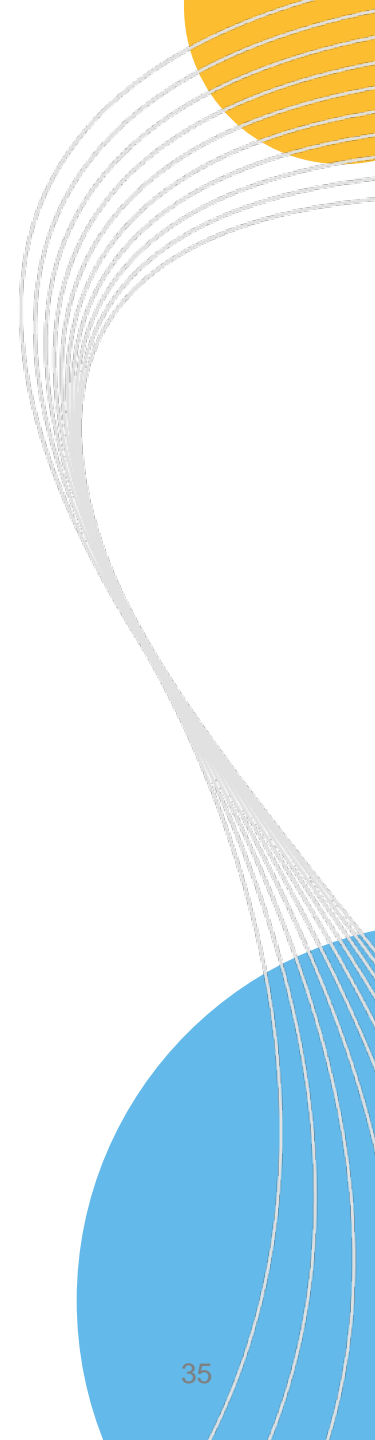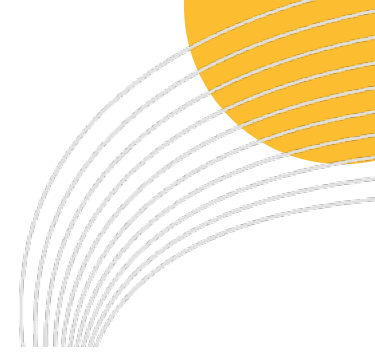
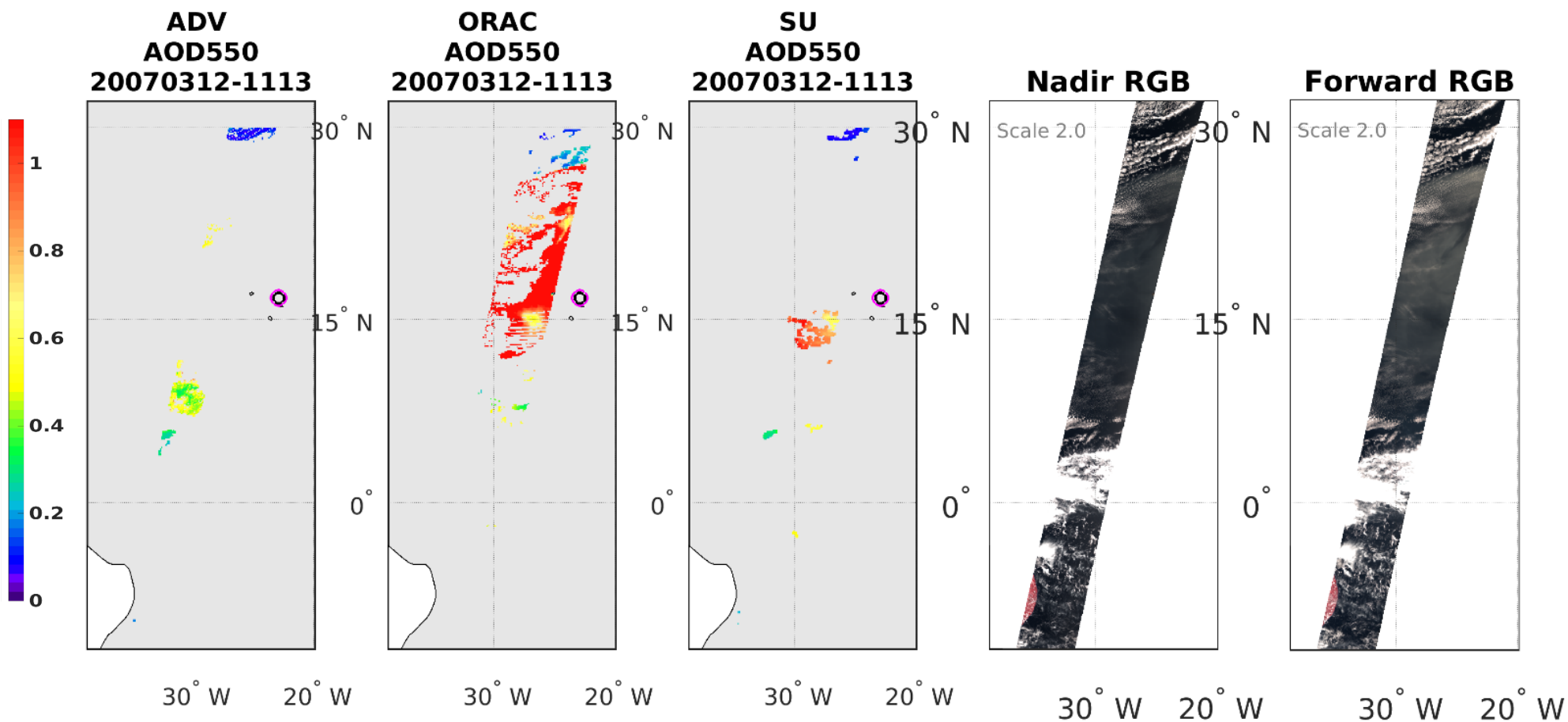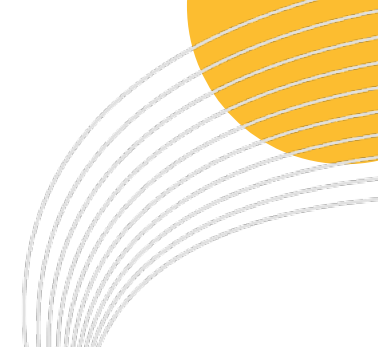# BB in South America AOD

BB in South America cloud fraction

ADV cloud fraction 20070913-1239

ORAC cloud fraction 20070913-1239

SU cloud fraction 20070913-1239

Nadir RGB

Forward RGB

BB in South America surface reflectance

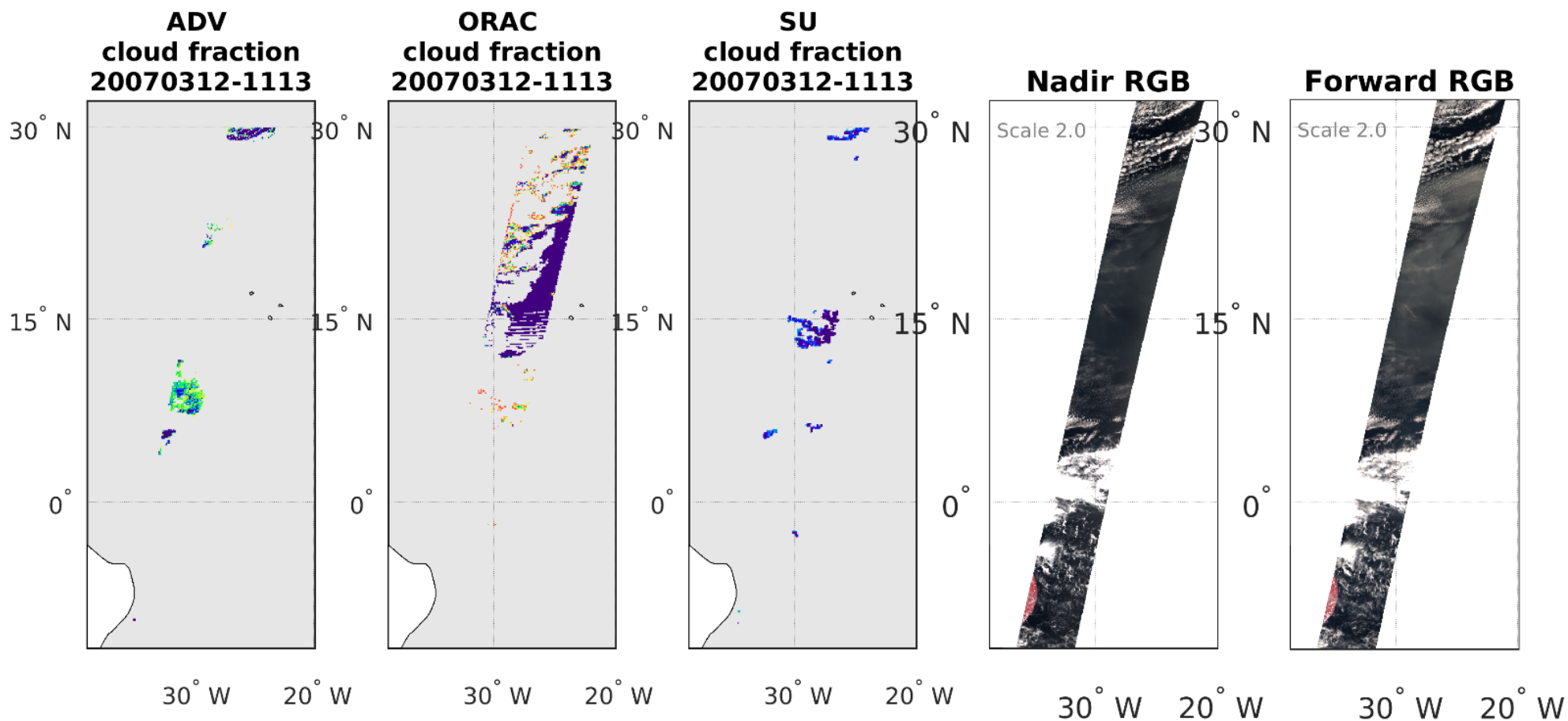ADV surface refl. 550 20070913-1239 | ORAC surface refl. 550 20070913-1239 | SU surface refl. 550 20070913-1239 | Nadir RGB | Forward RGB
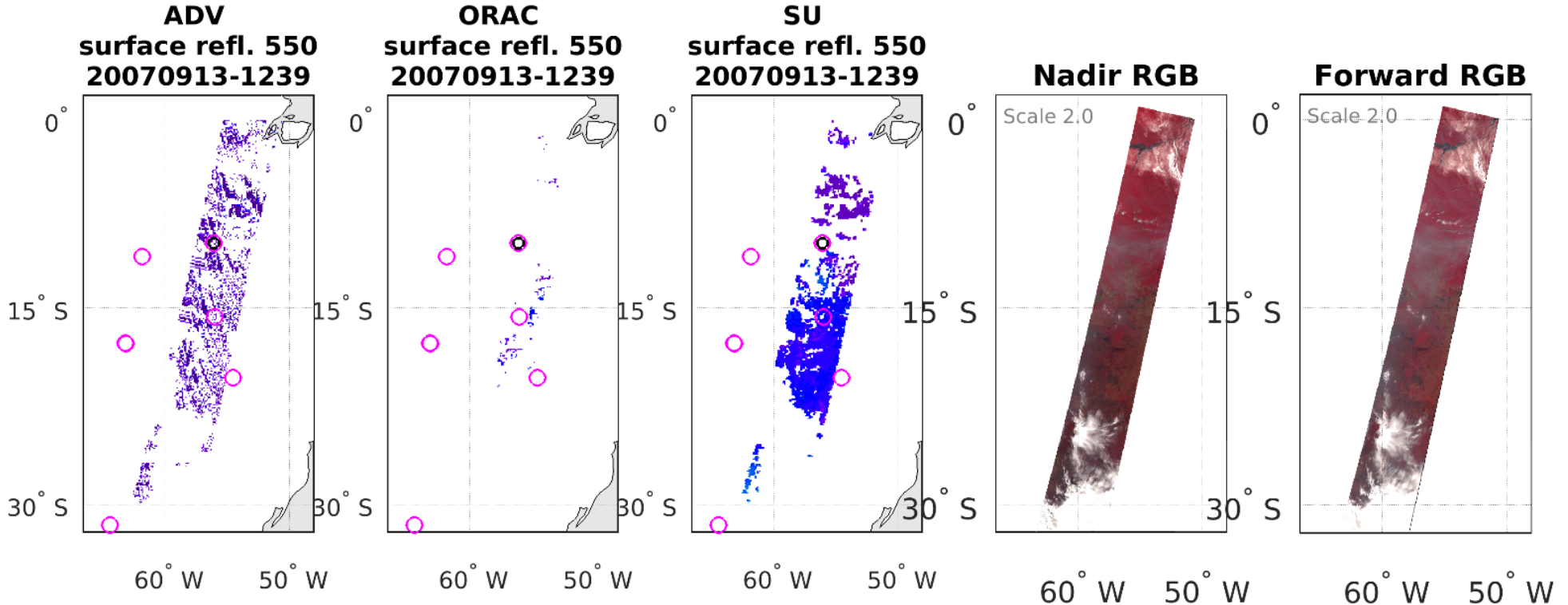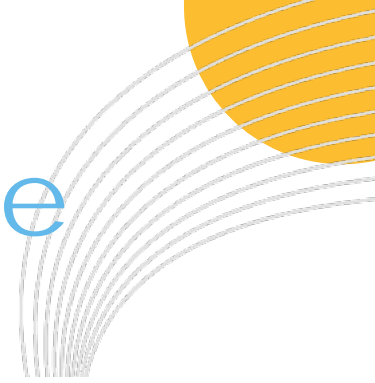
Dust over ocean AOD

Dust over ocean cloud fraction

ADV cloud fraction 20070312-1113

ORAC cloud fraction 20070312-1113

SU cloud fraction 20070312-1113

Nadir RGB

Forward RGB

Bright surface, coastal zone AOD

ADV
AOD550
20070102-0901

ORAC
AOD550
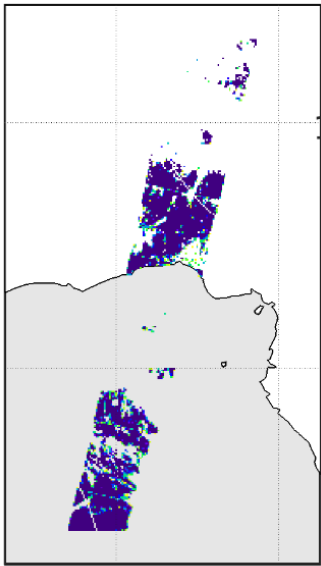20070102-0901

SU
AOD550
20070102-0901
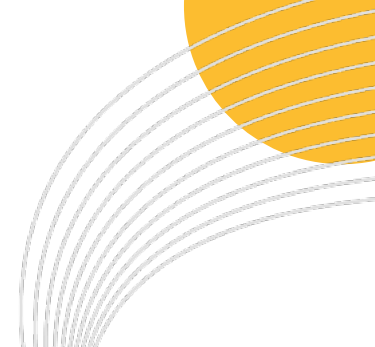
Nadir RGB
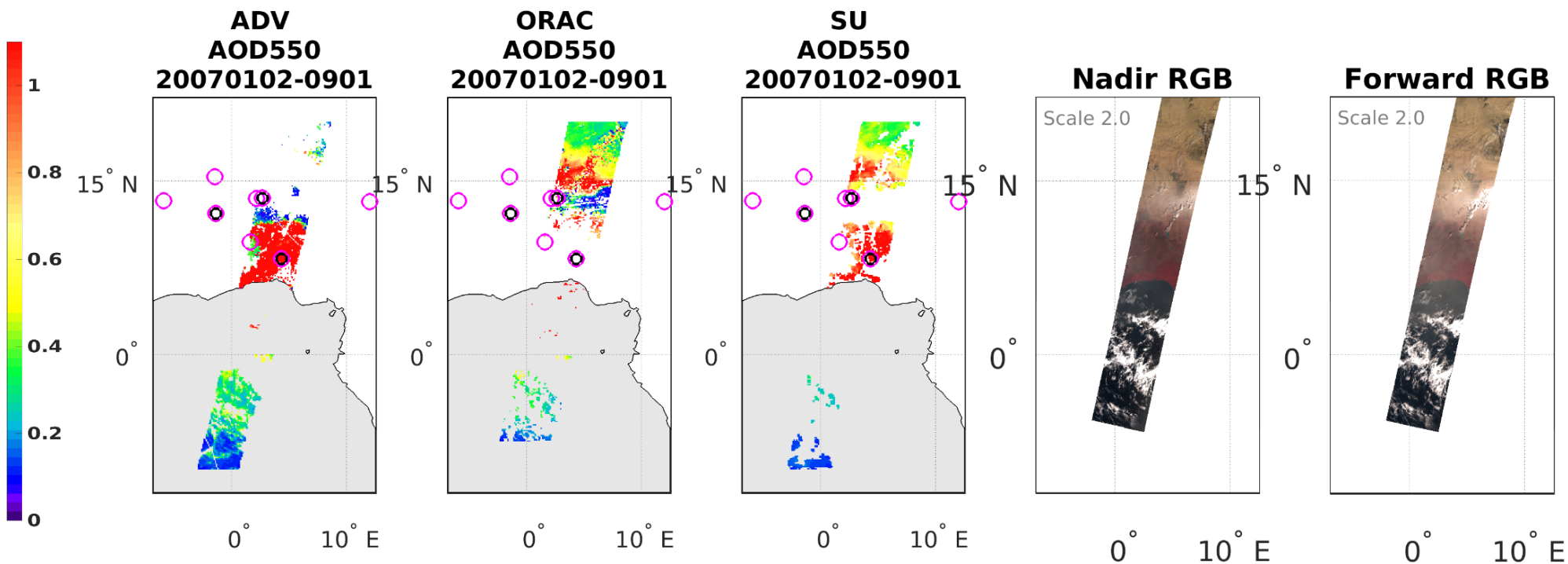
Forward RGB

Bright surface, coastal zone cloud fraction
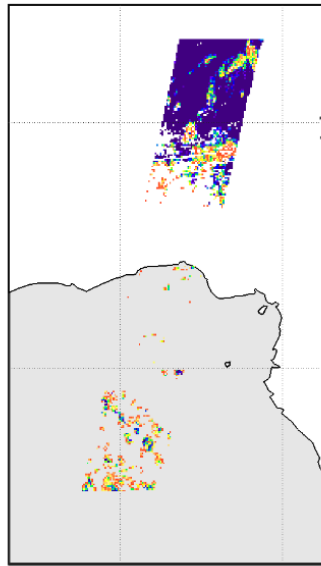

ADV cloud fraction 20070102-0901

ORAC cloud fraction 20070102-0901

SU cloud fraction 20070102-0901
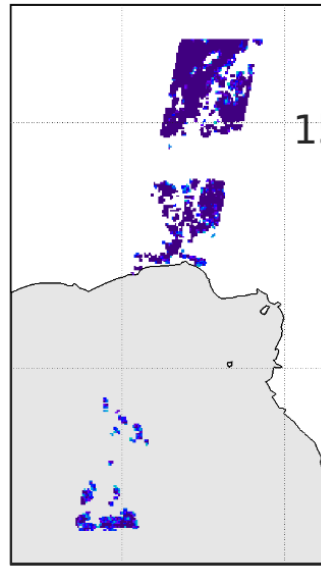
Nadir RGB
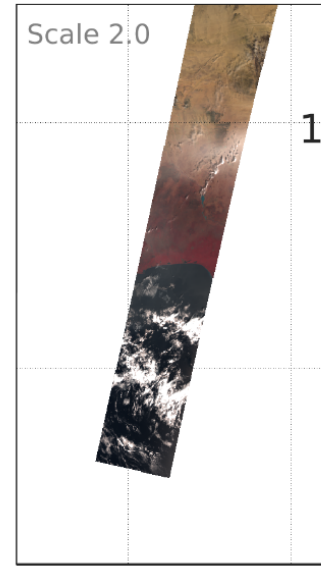
Forward RGB
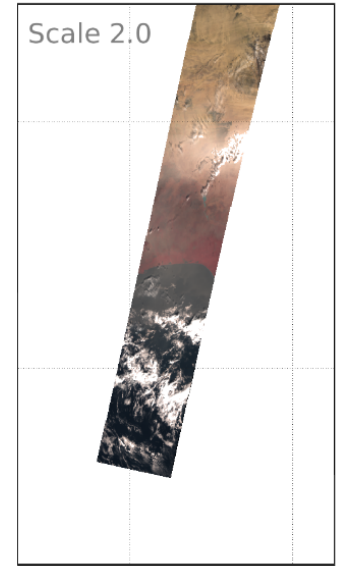
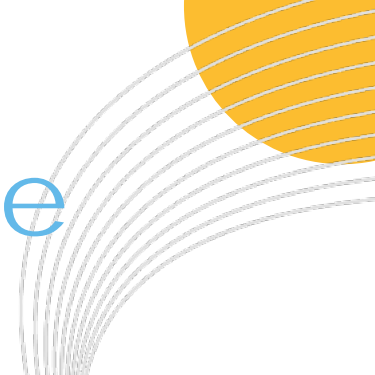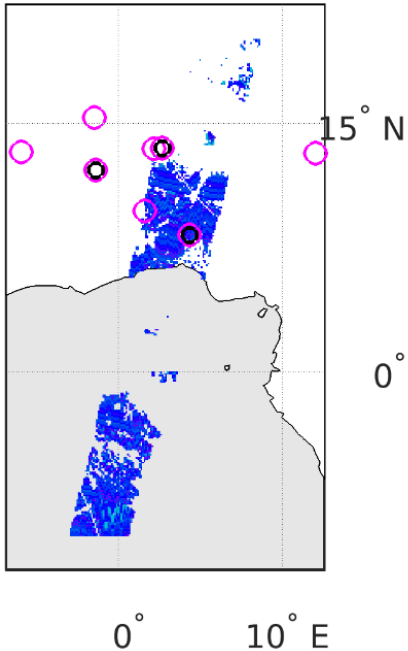# Bright surface, coastal zone surface rerflectance

ADV
surface refl. 550
20070102-0901

ORAC
surface refl. 550
20070102-0901
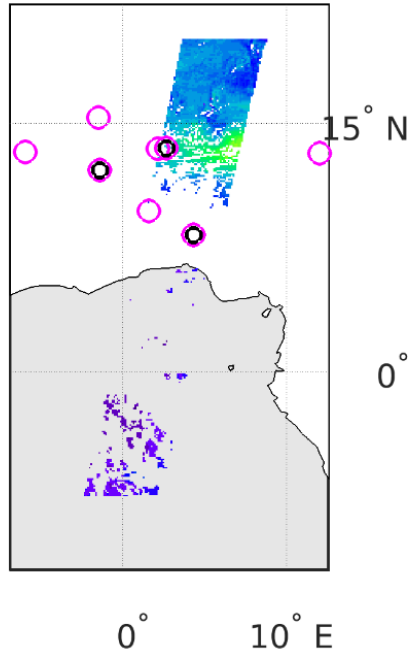
SU
surface refl. 550
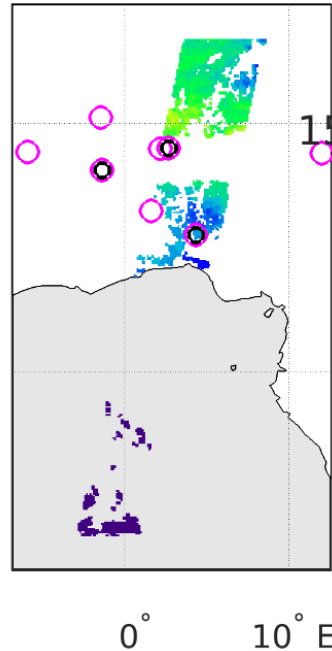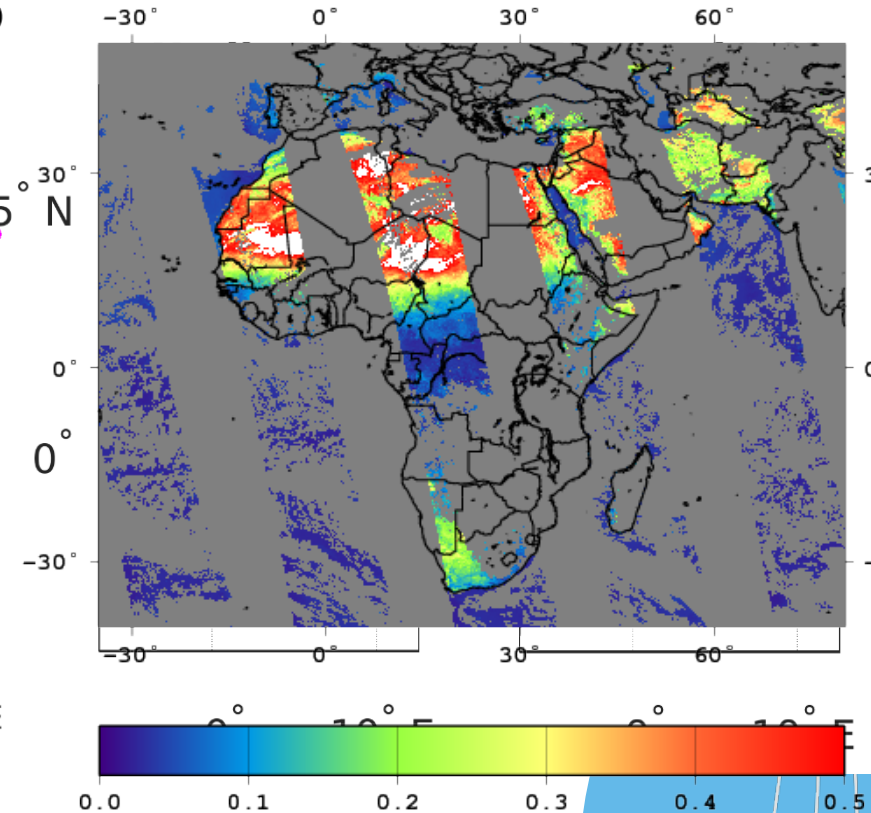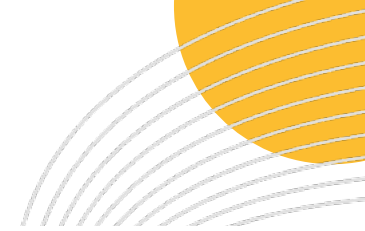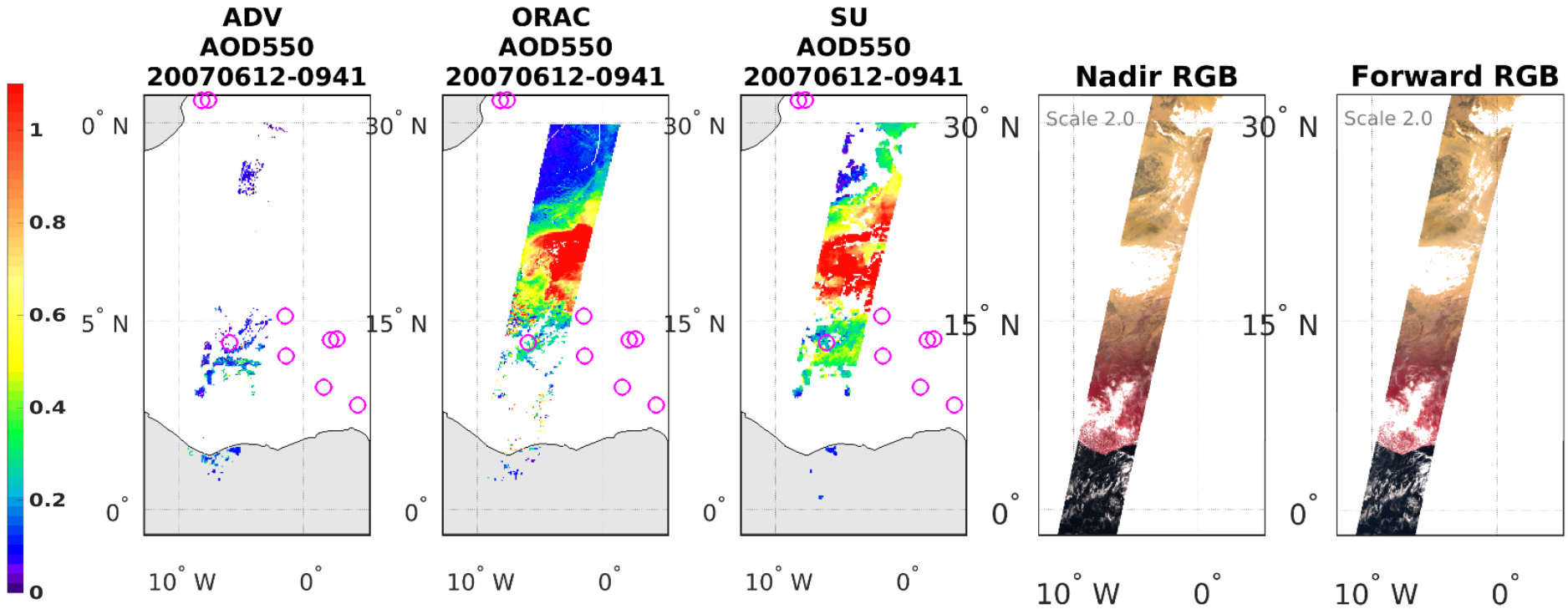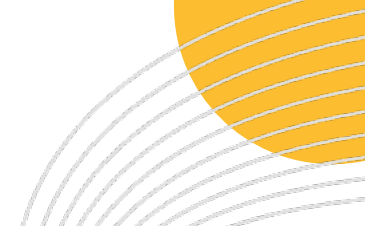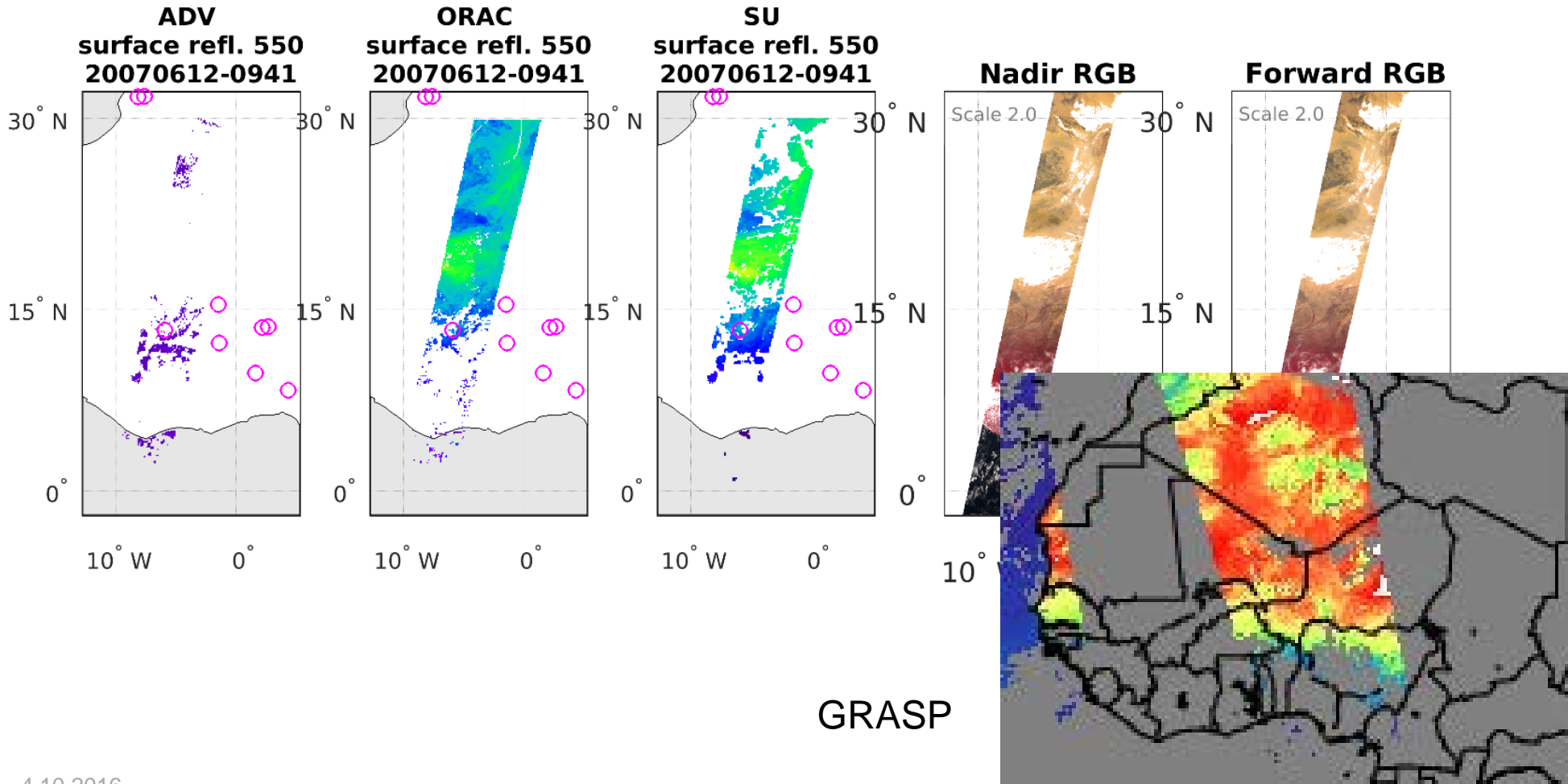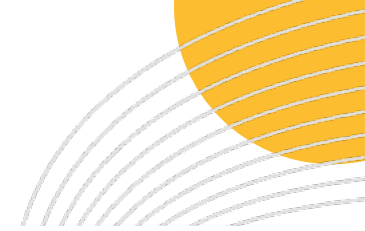20070102-0901

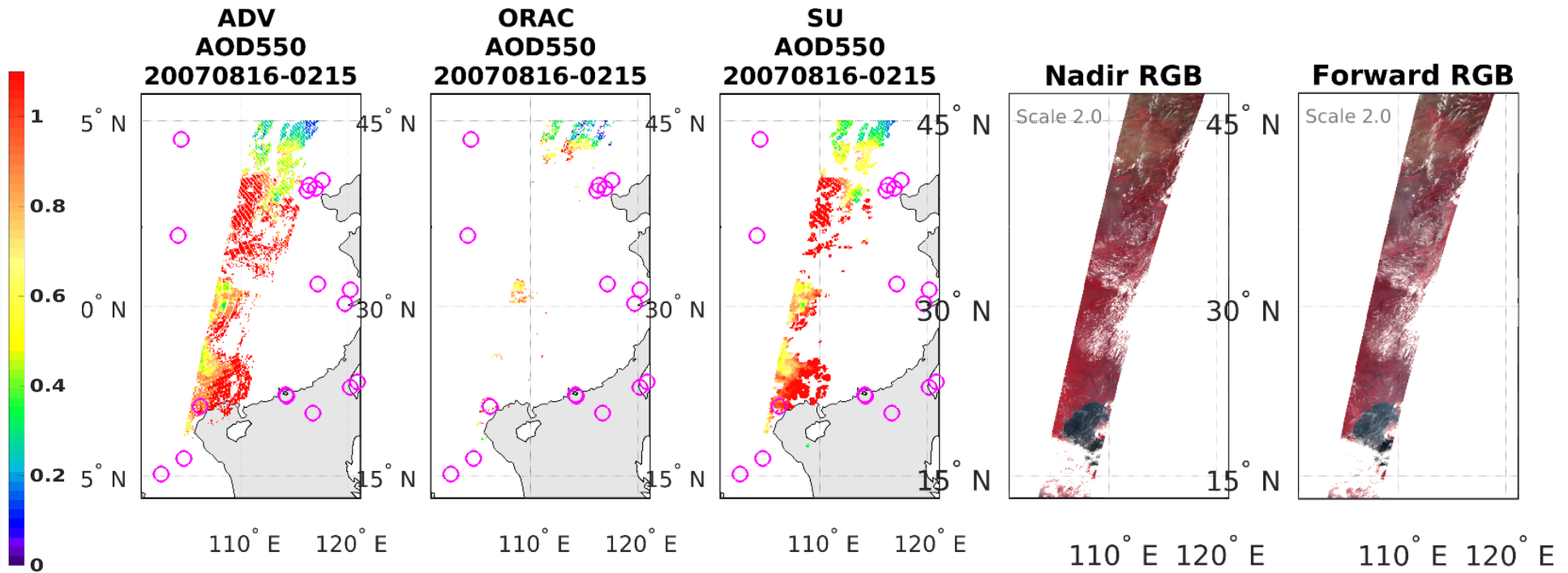GRASP/PARASOL SurfAlb670 2007-01-02
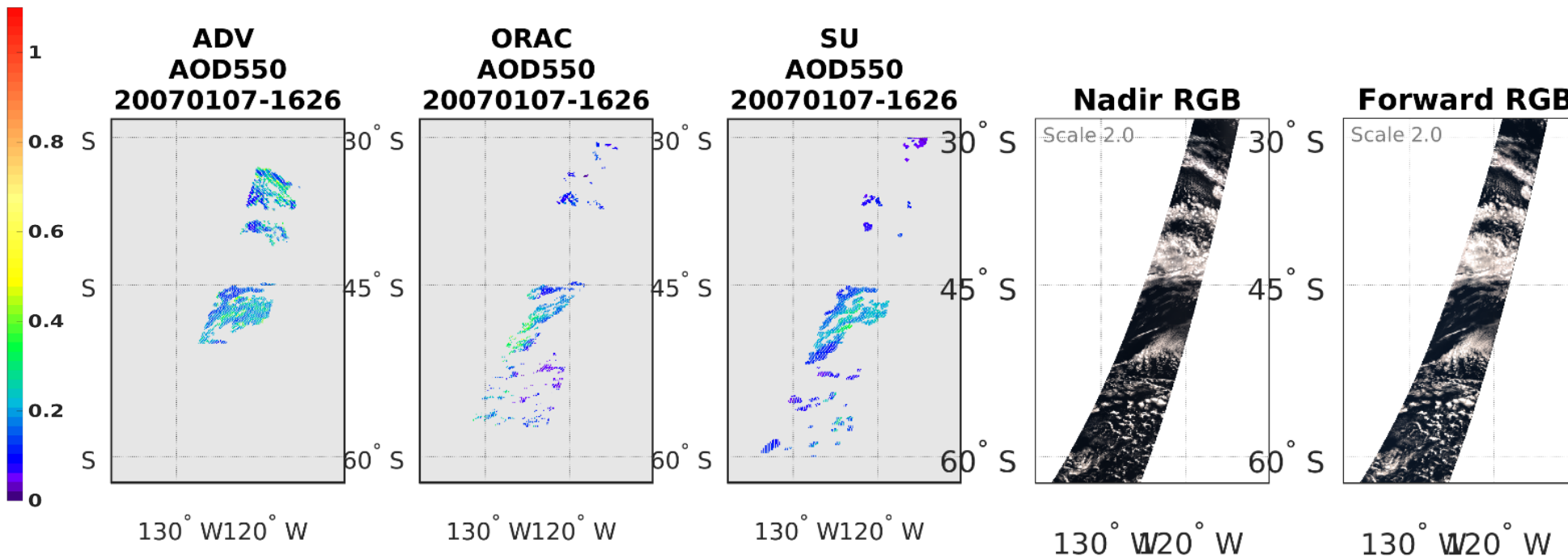
Bright surface, dust AOD

Bright surface, dust AOD

ADV surface refl. 550 20070612-0941

ORAC surface refl. 550 20070612-0941

SU surface refl. 550 20070612-0941

Nadir RGB

Forward RGB

GRASP

Pollution episode AOD

Clean ocean AOD

FINNISH METEOROLOGICAL INSTITUTE

		ADV	ORAC	SU
Case 1, Saharan dust land/sea	Cloud Clearing AOD555 FMAOD DAOD Å SR Comments:	more strict(ocean) no retrieval over bright surface	more strict(land) spectral dependence? low/problems?	more strict(ocean) lower higher (compared to ORAC) SR is higher for most of the cases
Case 2, BB Africa	Cloud Clearing AOD555 FMAOD DAOD Å SR Comments:	strict (compared to MODIS) low low low no retrieval over bright surface	strict, more strict(land)	strict (compared to MODIS)
Case 3, dust Africa	Cloud Clearing AOD555 FMAOD DAOD Å SR Comments:	 no retrieval over bright surface	Similar to SU low/problems? "levels" recognized Similar to SU	

To do:

- Complete the surface reflectance validation with ASRVN
- Complete case studies validation
- Run comparison and validation for common points
- Finalize the results
- Have a round table with ADV/ORAC/SU teams

Conclusions

- Validation with AERONET shows that all 3 AATSR algorithms perform well.
- Comparison of the daily products (or number of pixels retrieved) show that at certain conditions some algorithms screen high AOD events (e.g. ADV and SU often screen dust over ocean, ORAC screens biomass burning and pollution episodes)
- Cloud screening should be thoroughly revised!

Welcome to Helsinki, Finland