IASI dust algorithm inter-comparison within ESA‘s Climate Change Initiative

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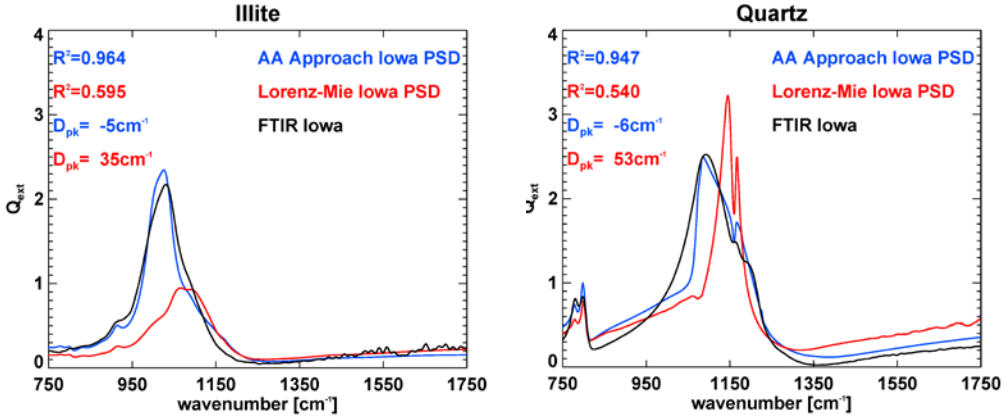
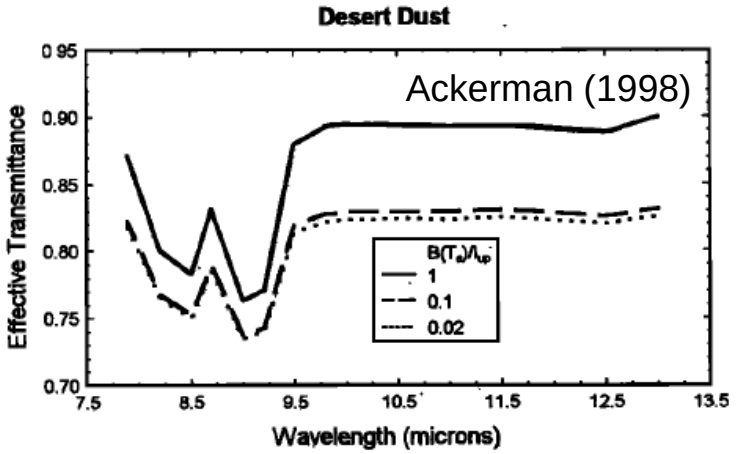
Dust signal in the terrestrial spectrum



Klüser et al. (2015, subm. to JQSRT)

Si-O vibration resonance produces rather strong dust signal with specific spectral shape in TIR window.

Dust layer height (contrast of T_{dust} and $T_{surface}$) and dust properties (size dist., part. shape & min. composition) strongly impact on IR signal.



Simplified model of atmospheric infrared radiation (*no scattering*):

$$L_{TOA}(\lambda) = \int_{atm} e^{-\frac{\tau_{atm}(\lambda,z)}{\cos(\Theta_v)}} \varepsilon_{sfc} B_\lambda(T_{sfc}) + (1 - e^{-\frac{\tau_{atm}(\lambda,z)}{\cos(\Theta_v)}}) B_\lambda(T_{atm}, z)\, dz$$

radiance | extinction | sfc. emis. | atmospheric emission

Dust remote sensing with IASI within ESA‘s CCI programme

- 4 European research groups provide dust retrieval results for IASI.
- The algorithms follow very different retrieval approaches.
- IASI dust AOD is retrieved at 10µm, also dust AOD at 0.55µm (transfer based on assumptions about optical properties or fixed external ratio) is provided at L2 (at sensor resolution) and L3 (1° averages subdaily, daily and monthly).
- Inter-comparison in „Round Robin“ exercise aims at learning about the performance of the different algorithms under varying conditions.
- The Round Robin experiment covers the full year 2013 and the domain 0°N-40°N / 80°W-90°E
- Statistical comparison with „CCI IASI Ensemble“ 10µm dust AOD, MISR 0.55µm nonspherical AOD and AERONET 0.55µm SDA Coarse Mode AOD.
- Within CCI a full mission processing for Metop-A is planned.

The IASI dust algorithms within Aerosol_cci

IMARS: *Infrared Mineral Aerosol Retrieval Scheme*

- Retrieval approach probabilistic scheme based on Singular Value Decomposition
- optical properties for non-spherical particles from the *asymptotic approximation approach**
- 8 size modes, 8 mineralogical mixtures, 7 minerals
- Joint retrieval for dust and (ice) clouds

* Klüser et al., submitted to JQRST

MAPIR: *Mineral Aerosol Profiling from Thermal Infrared Radiances*

- Retrieval approach:
  Rodgers OEM (ASIMUT + LIDORT)
  905-927 cm^{-1} & 1098-1123 cm^{-1}
  830-834 cm^{-1} added for T_s
- optical properties: Mie calculations
- Pre-filtering from IASI (H_2O-profiles, cloud filtering dust signature)
- Aerosol profile, AOD, averaging kernels, T_s

LMD

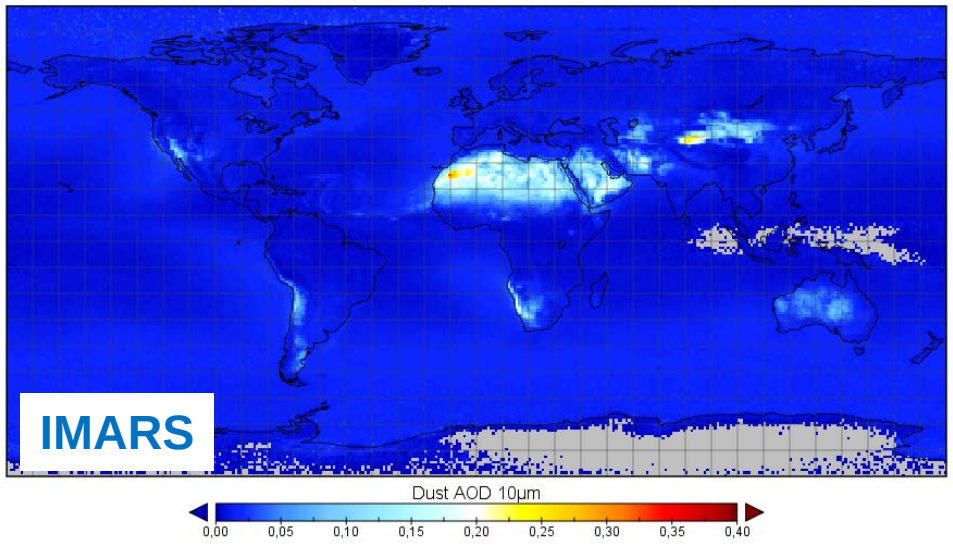
- Retrieval approach: Look Up Table (cloud free only)
- optical properties: Mie calculations for 2 ref. ind., 1 PSD
- Surface emissivity: IASI database (Capelle et al., 2012)
- Surface temperature is co-retrieved with AOD (10µm) and altitude

ULB

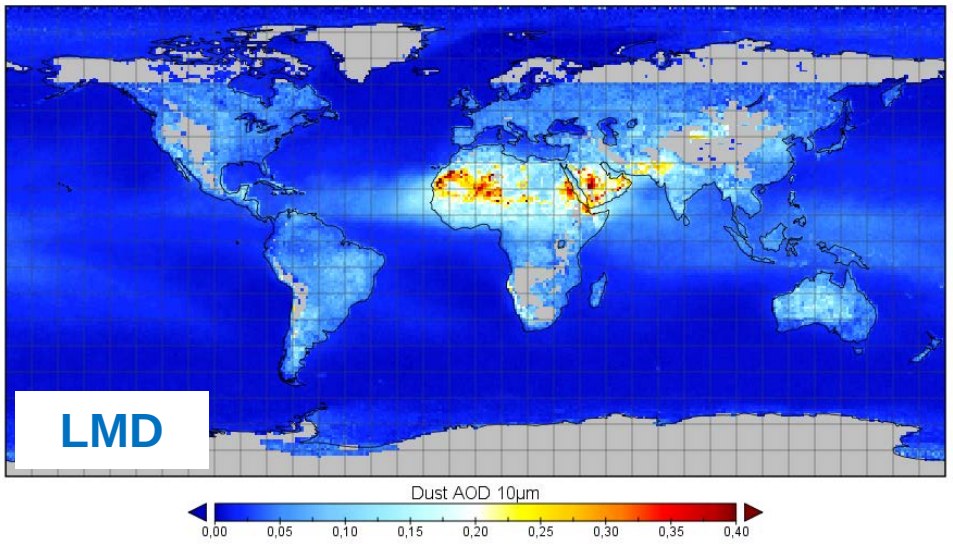
- Retrieval apporach: neural network
- Optical properties: Mie calculations
- Extension (‘quantification’) from statistical LDA method
- Separate networks for land/ocean
- Cloud-free data only
- Height from CALIPSO climatology

Annual Mean Dust AOD at 10µm for 2013

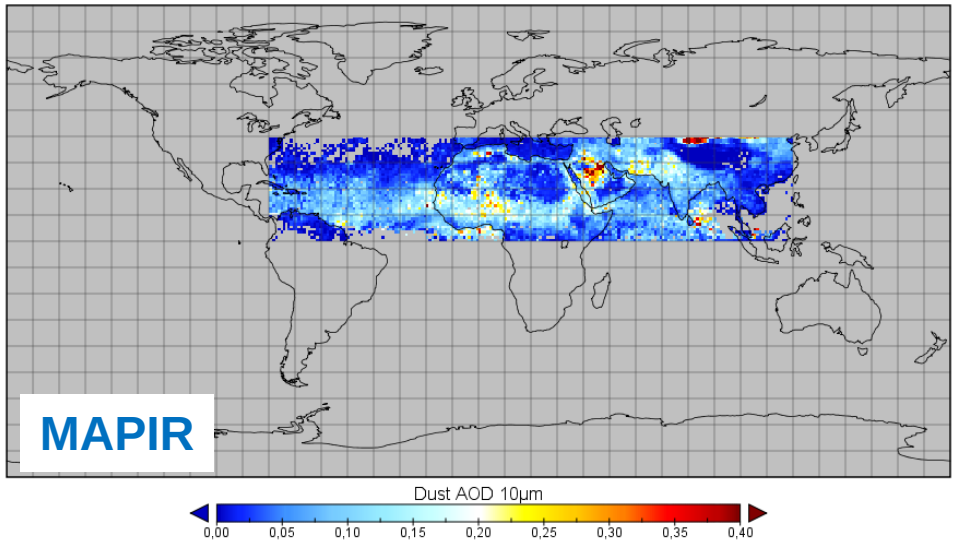
IMARS



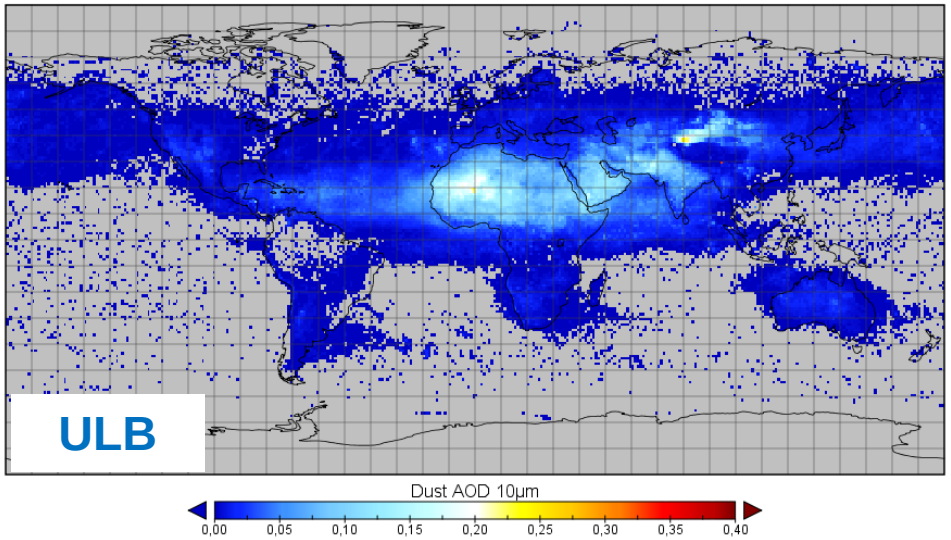
LMD



MAPIR

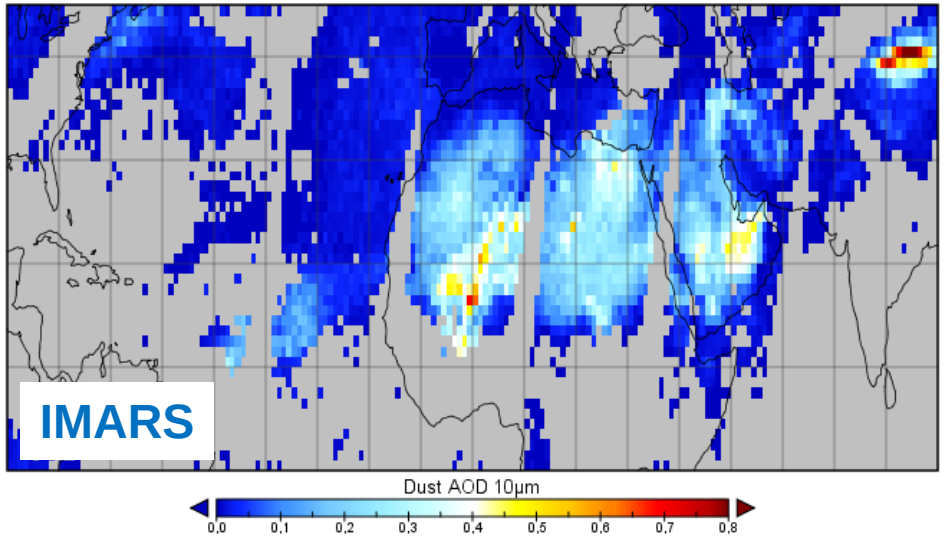


ULB

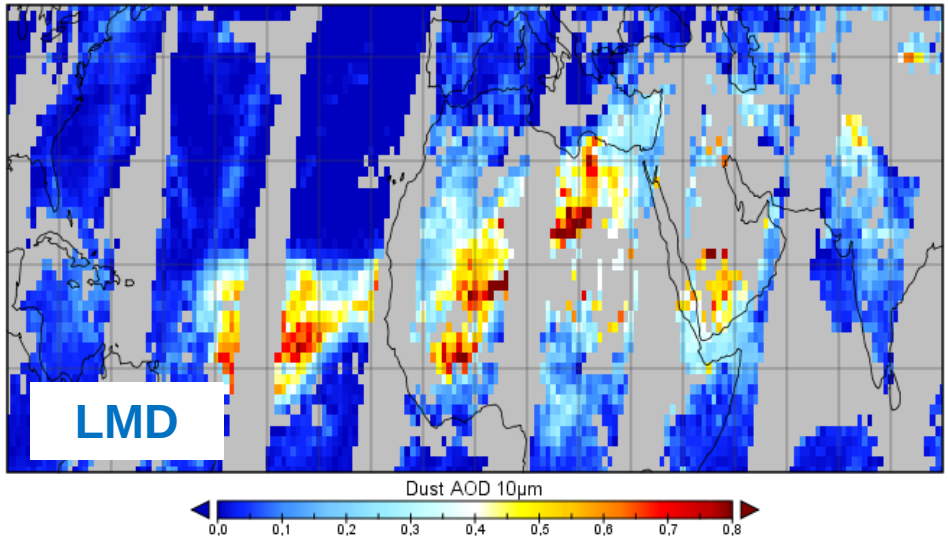


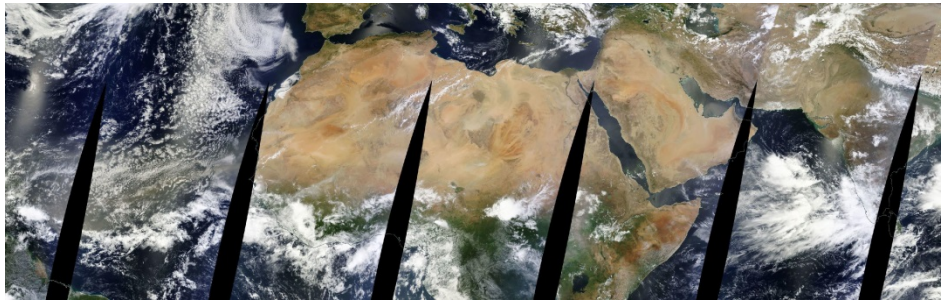
Dust AOD at 10µm for 02/06/2013 morning overpasses

IMARS



LMD

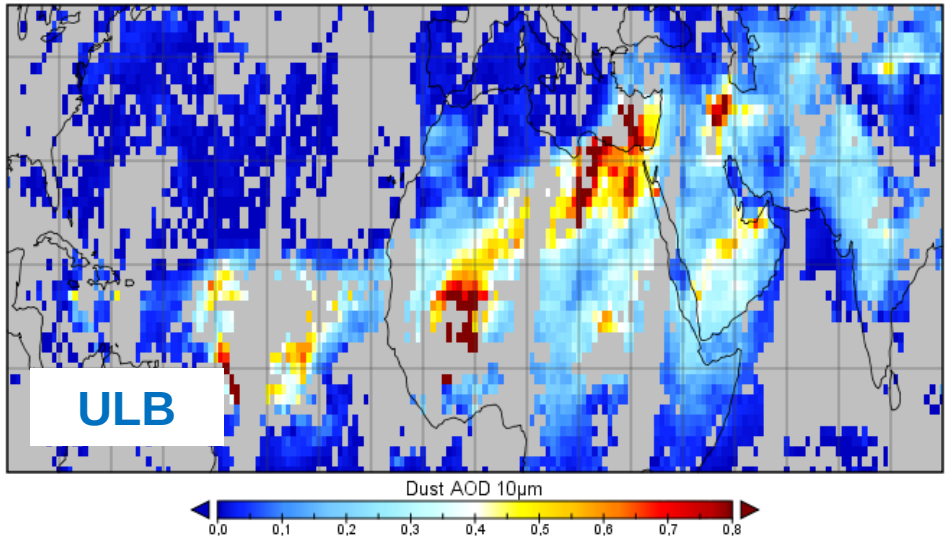




MODIS Terra RGB

Impact of different cloud masking strategies clearly visible.

ULB



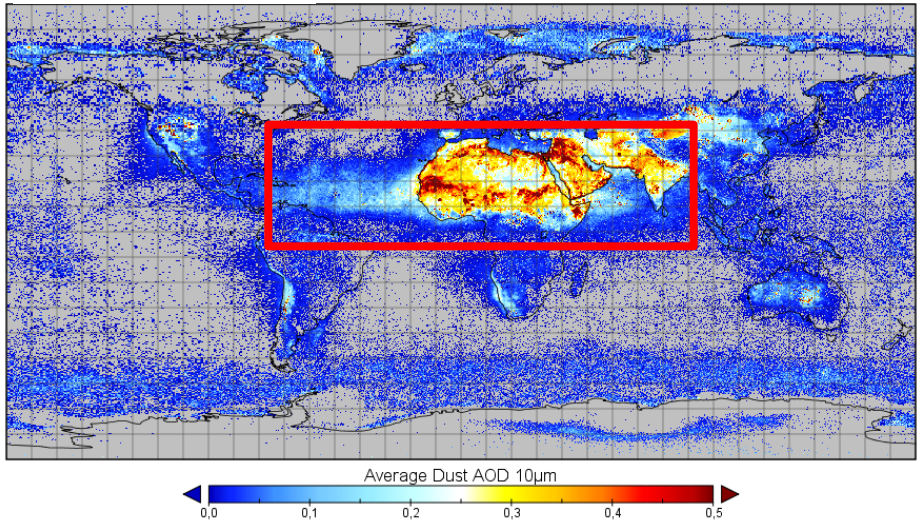
Inter-comparison: CCI Ensemble

Pupose of the ensemble in the inter-comparison:

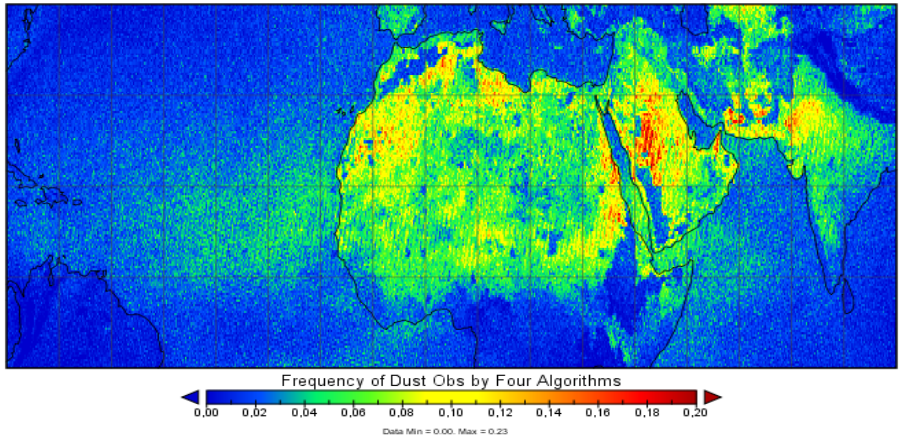
- There is no independent dataset of Dust AOD at TIR wavelengths.
- As 0.55µm Dust AOD from IASI is based on a couple of additional assumptions, we first need to compare at TIR wavelength.
- How do the IASI retrievals compare to each other?
- What are the comparison statistics in cases, where all four IASI retrievals show dust and how often does that happen?

Answer: produce CCI IASI Ensemble by averaging over all four dust retrievals in each FOV.

AOD at 10µm CCI IASI Ensemble



4 Algo. Dust Obs. Freq. (zoomed in)



max: 0.23 over desert

Inter-comparison with CCI IASI Ensemble

(evaluation for L2 $D\_AOD_{10\mu m}$, dust filter: $D\_AOD_{10\mu m}$>0.1, all four dusty)

Ocean	IMARS	MAPIR	LMD	ULB	CCI ENS
Dust Frequency	0.2%	0.7%	5.5%	1.7%	0.2%
Bias to ENS	-0.15	-0.04	+0.13	+0.04	---
RMSD to ENS	0.47	0.44	0.59	0.36	---
Correlation w/ ENS	0.50	0.65	0.60	0.69	1.00
Mean AOD 10µm	0.19	0.30	0.47	0.38	0.34

Land	IMARS	MAPIR	LMD	ULB	CCI ENS
Dust Frequency	9.0%	5.1%	12.2%	8.8%	4.5%
Bias to ENS	-0.15	+0.25	-0.06	-0.06	---
RMSD to ENS	0.44	0.89	0.39	0.40	---
Correlation w/ ENS	0.41	0.81	0.51	0.53	1.00
Mean AOD 10µm	0.22	0.63	0.31	0.31	0.37

Inter-comparison with MISR nonspherical AOD

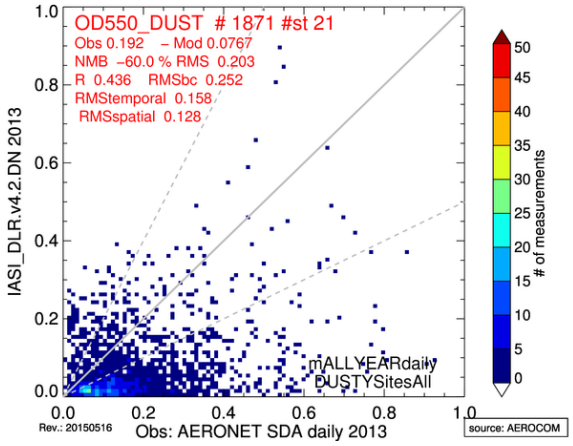
(evaluation for L2 D_AOD$_{0.55\mu m}$/MISR nonsp. AOD$_{0.55\mu m}$, dust filter: D_AOD$_{10\mu m}$>0.1, Nonsp_AOD$_{0.55\mu m}$>0.1)

Ocean	IMARS	MAPIR	LMD	ULB	MISR
Dust Frequency	0.2%	1.0%	6.7%	2.1%	6.1%
Bias to MISR	-0.10	-0.03	0.00	0.26	---
RMSD to MISR	0.48	0.90	0.51	0.64	---
Correlation w/ MISR	0.41	0.39	0.55	0.45	1.00
Mean AOD 0.55µm	0.49	0.53	0.53	0.71	0.57

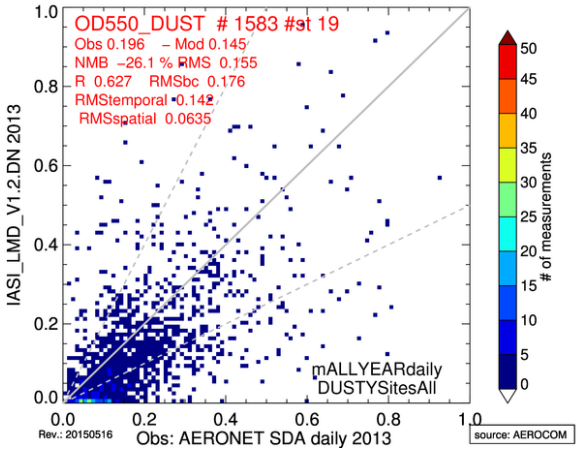
Land	IMARS	MAPIR	LMD	ULB	MISR
Dust Frequency	12.8%	7.3%	14.8%	11.8%	14.1%
Bias to MISR	-0.00	0.81	0.17	0.58	---
RMSD to MISR	0.55	1.82	0.68	0.86	---
Correlation w/ MISR	0.32	0.26	0.44	0.44	1.00
Mean AOD 0.55µm	0.32	1.17	0.38	0.73	0.34

L3 Evaluation with AERONET: Daily SDA Coarse Mode $AOD_{0.55\mu m}$

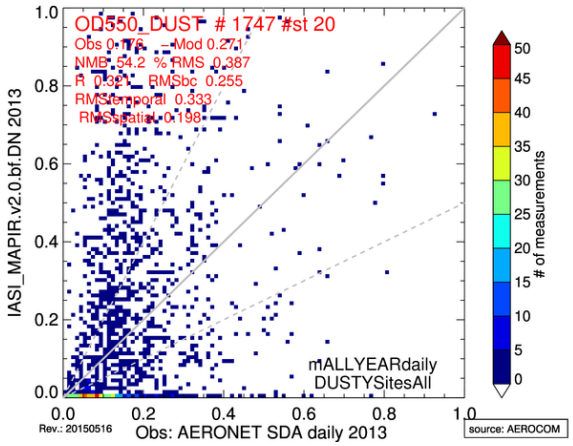
IMARS



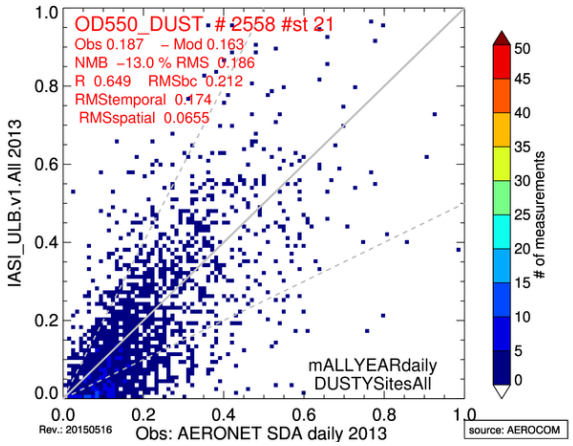
LMD



MAPIR



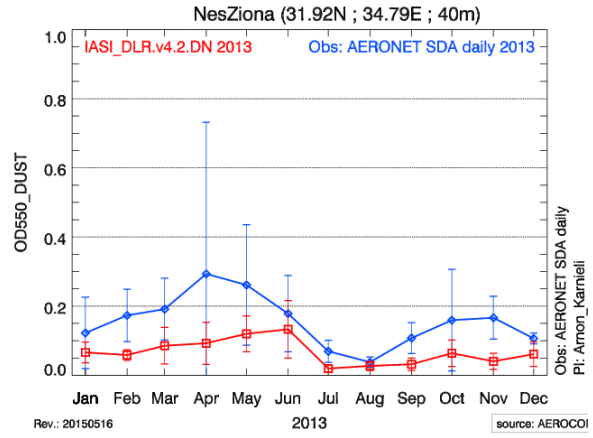
ULB



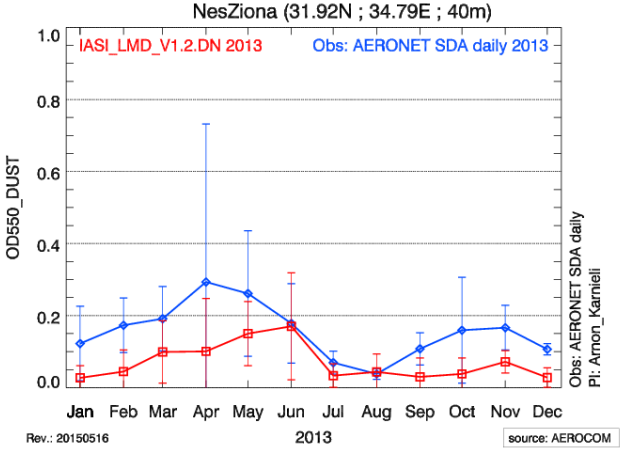
- AERONET SDA coarse mode AOD at „dusty“ sites
- comparison of daily 1° averages
- Correlations: (δRR)
  IMARS: 0.44 (+0.18)
  LMD: 0.63 (+0.13)
  MAPIR: 0.32 (+0.02)
  ULB: 0.65 (±0)
- RMSD:
  IMARS: 0.20 (-0.08)
  LMD: 0.16 (-0.07)
  MAPIR: 0.39 (-0.16)
  ULB: 0.19 (±0)

L3 Evaluation with AERONET: example for seasonal cycle

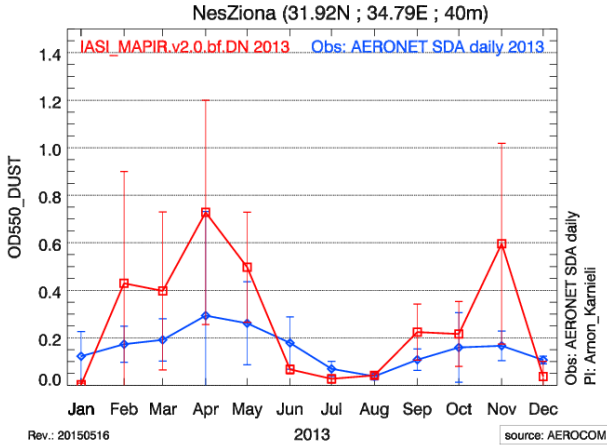
IMARS



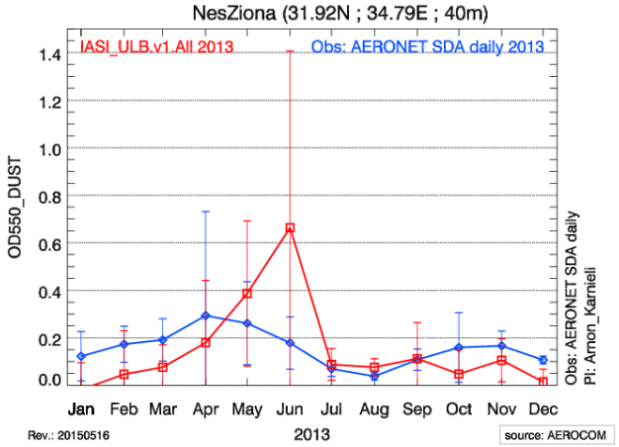
LMD



MAPIR



ULB



Example station:
Nes Ziona
(Israel)

Red:
IASI Dust AOD_{550}
Monthly Mean, 1° average

Blue: AERONET SDA
Coarse Mode AOD_{550}
Monthly Mean

Seasonal cycle of coarse mode AOD well captured by IASI Dust AOD.

Summary

- 4 algorithm inter-comparison of dust remote sensing with IASI within Aerosol_cci
- Intercomparison-exercise: full year 2013, 0°N-40°N/80°W-90°E
- All four retrievals follow different strategies and mathematical approaches.
- IASI Dust AOD is retrieved in TIR, transfer to 0.55µm is based on many assumptions → no straightforward way to evaluate 10µm Dust AOD.
- CCI IASI Ensemble: generated from all IASI dust observations.
- All retrievals capture the basic features of the global dust distribution and the seasonal cycles, also AODs are in the expected range.
- Improvements during last 6 months („Round Robin“ exerrcise) evident in AERONET comparisons.
- Mean AODs, seasonal cycles, dust frequencies as observed with MISR and AERONET are basically reproduced by the IASI algorithms.