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Comparison of single- and multi-channel AOD revisited

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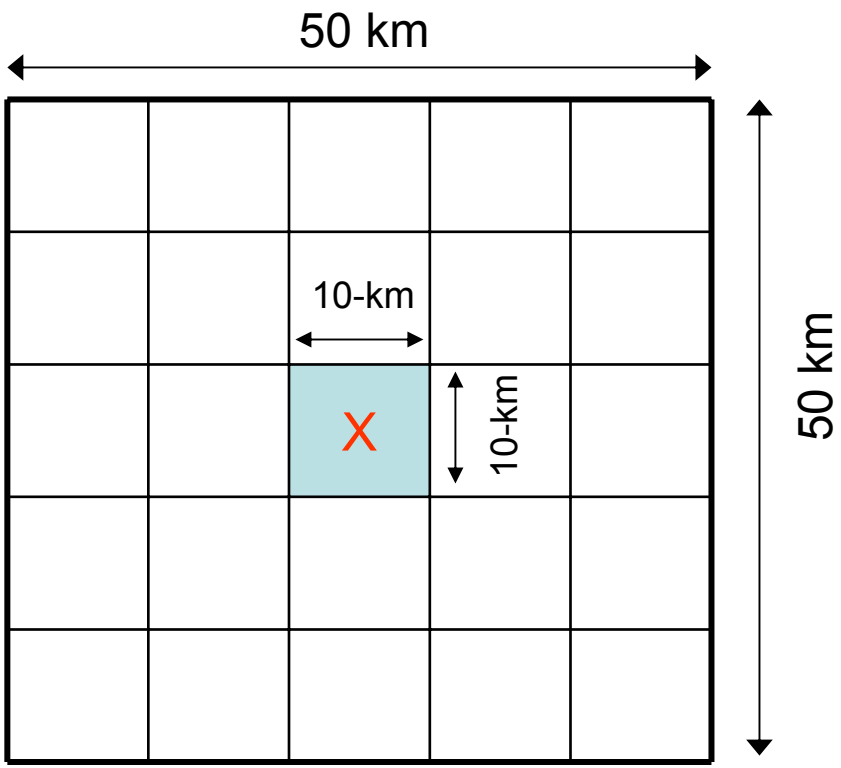
Objective and Strategy

- Motivation:
  - Two aerosol products are reported in the CERES SSF data:
    a) derived from the NASA/GSFC multi-channel MODIS AOD and
    b) estimated from MODIS reflectances with the NOAA/NESDIS single-channel algorithm.
- Objective:
  - Compare single-channel and multi-channel retrievals of AOD when **only** the algorithms differ.
- Strategy:
  - Retrieve single-channel AOD_S at 25 oceanic locations from reflectances in the NASA/GFSC MODIS Atmosphere Parameters Subset Statistics (MAPSS) dataset.
  - Compare AOD_S with multi-channel (level 2 MOD04, MYD04) AOD_M from MAPSS.

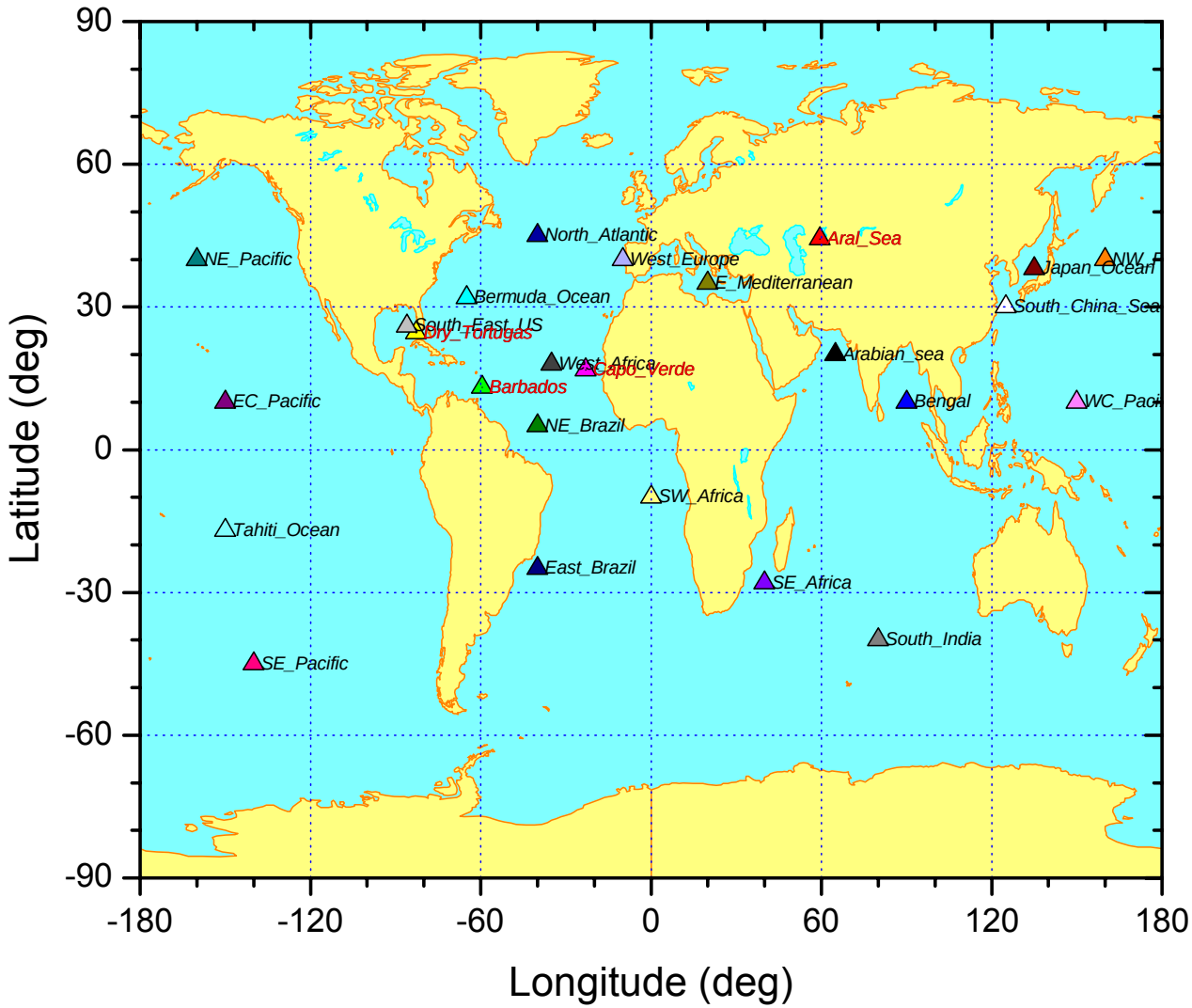
The MAPSS data



MODIS Atmosphere Parameters Subset Statistics (MAPSS) dataset has spatial statistics for 5 by 5 boxes:

- the reflectance at the middle point in a 5 by 5 box,
- AOD at the middle point in a 5 by 5 box,
- average of 10-km reflectances in a 5 by 5 box used in AOD retrieval,
- average of 10-km AOD in a 5 by 5 box.

MAPSS sites used



25 sites representing different dominant aerosol types are selected for this study

Only three sites (in red) have SP.

Revisiting the Problem

- Results presented at the 2nd CERES-II meeting:
  - good agreement in 1632-nm channel AODs,
  - positive single-channel AOD bias in 644-nm channel,
  - scattering-angle dependent bias.
- So why again?
  - MODIS retrieval was revised (Collection 5).
  - MAPSS reflectances are from L2 not L1 as previously assumed. They are already “corrected” for gas absorption!
    - Previous study accounted for gas absorption twice, thus over estimated AOD.

MAPSS Reflectance Checks

- Reflectances in the original L2 HDF files were compared to those in MAPSS.
  - Identical reflectances.
- The locally implemented MODIS code, for which the L2 HDF files are direct inputs, was used to retrieve the AOD.
  - Identical AODs.
- Conclusion: MAPSS reflectances are indeed corrected for gas absorption.

Single-Channel AOD Retrievals

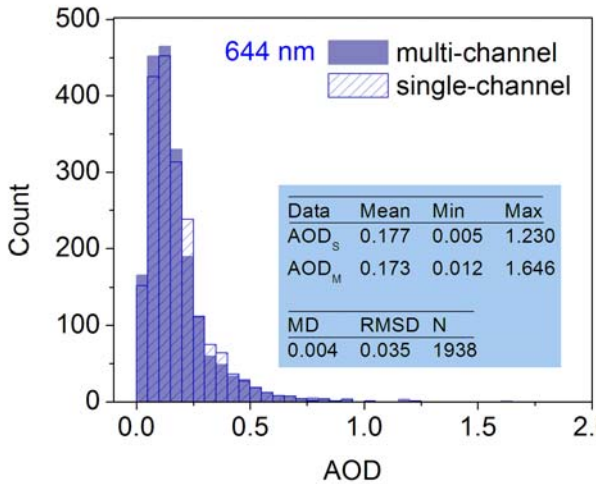
- *Calculated new LUT*
  - Same procedure as for CERES, but no gas absorption.
- *AOD retrieval from 10-km reflectance:*
  - for **anti-solar** side of orbit, and solar zenith < 70^{o}, sensor zenith < 60^{o}:
    - Collection 5 Terra/MODIS:
      - 02/2000 – 06/2007 (31 months)
      - Missing: 10-11/2000; 05/2001-03/2005; 10/2005-06/2006
    - Collection 5 Aqua/MODIS: 07/2002 – 06/2007 (34 months)
      - Missing: 06/2003-06/2004; 08/2004-12/2004;10/2005/-03/2006; 02-03/2007

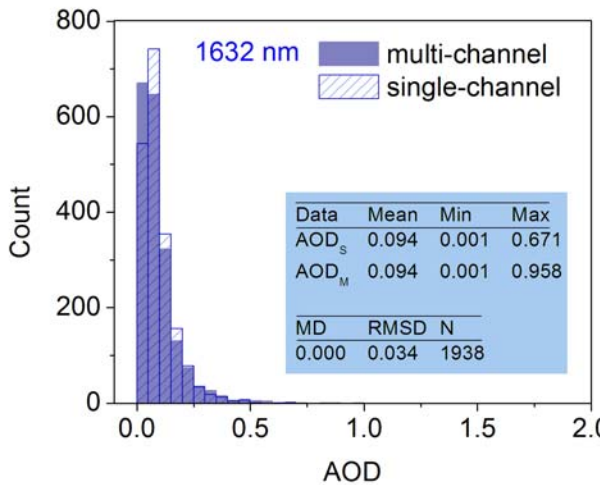
AOD is retrieved from the 644-nm and 1632/2119-nm channels.

AOD Histograms

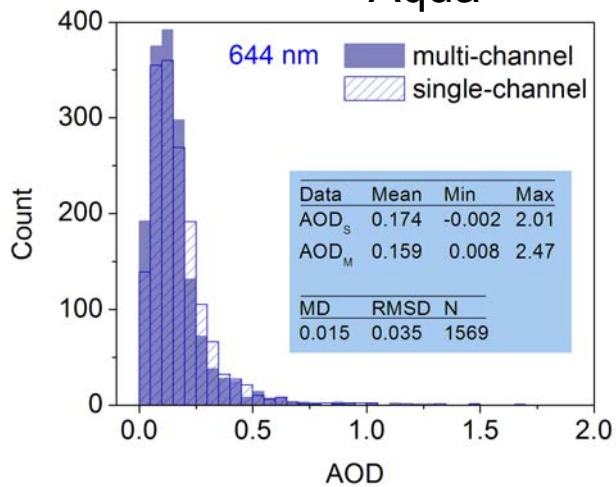
10-km MODIS/Terra/Aqua reflectance

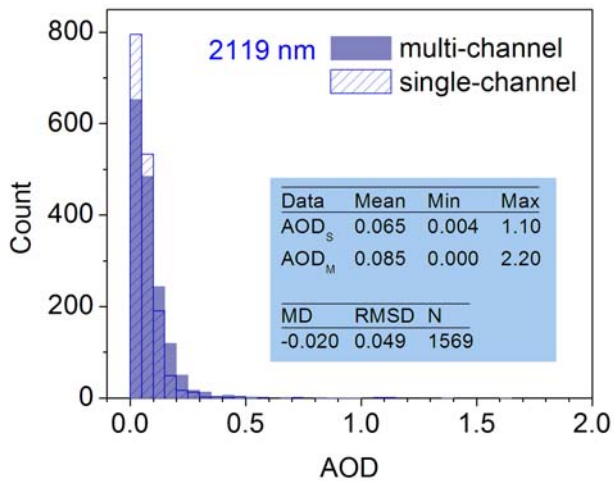
Terra





Aqua





Mean difference MD for Terra is small; it is larger for Aqua.

AOD_S-AOD_M

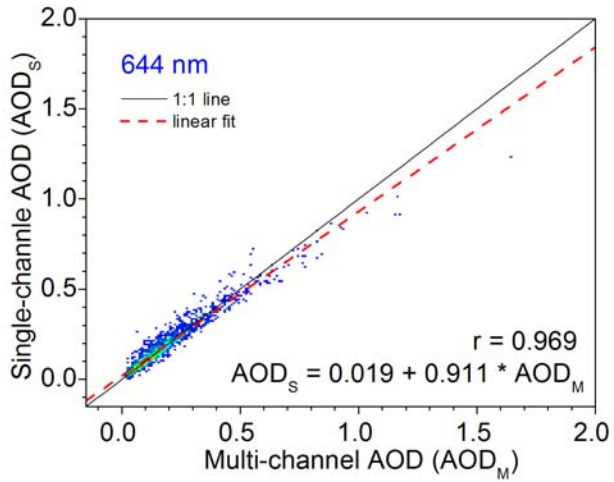
	10-km	50-km
	Terra	
644 nm	0.004	0.002
1632 nm	0.000	-0.005
	Aqua	
644 nm	0.015	0.014
2119 nm	-0.020	-0.029

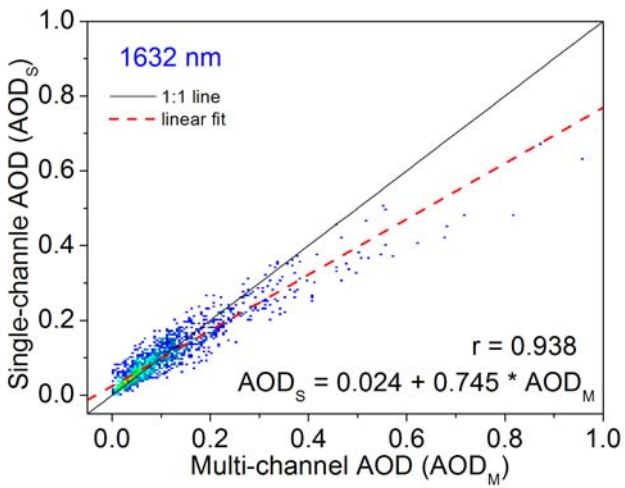
50-km statistics of MD are similar to those for the 10 km central MAPSS pixel.

AOD Scatter Plot

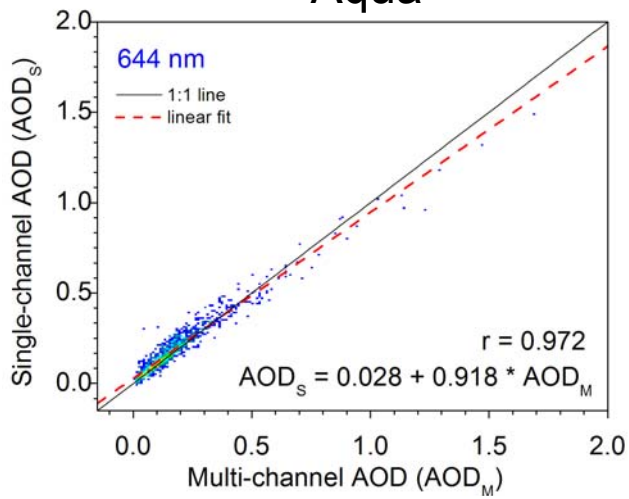
10-km MODIS/Terra/Aqua reflectance

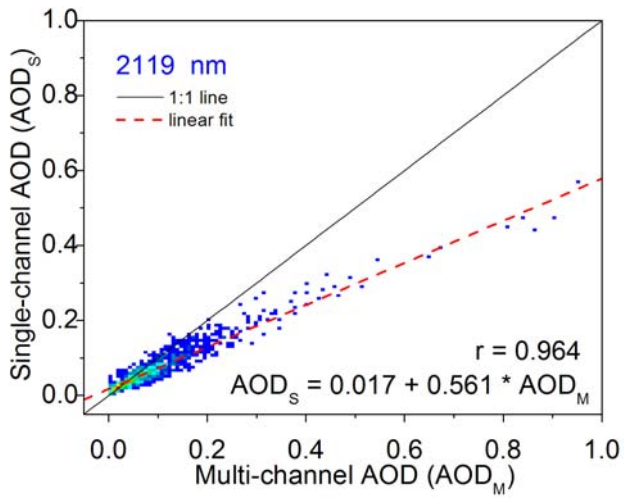
Terra





Aqua





Scatter plot of single-channel AOD vs. multi-channel AOD at 644 nm and 1632 (2119) nm for the single-channel geometry.

Relative to the multi-channel AOD, single-channel AOD is larger/smaller at small/large AOD.

In Search of Explanation

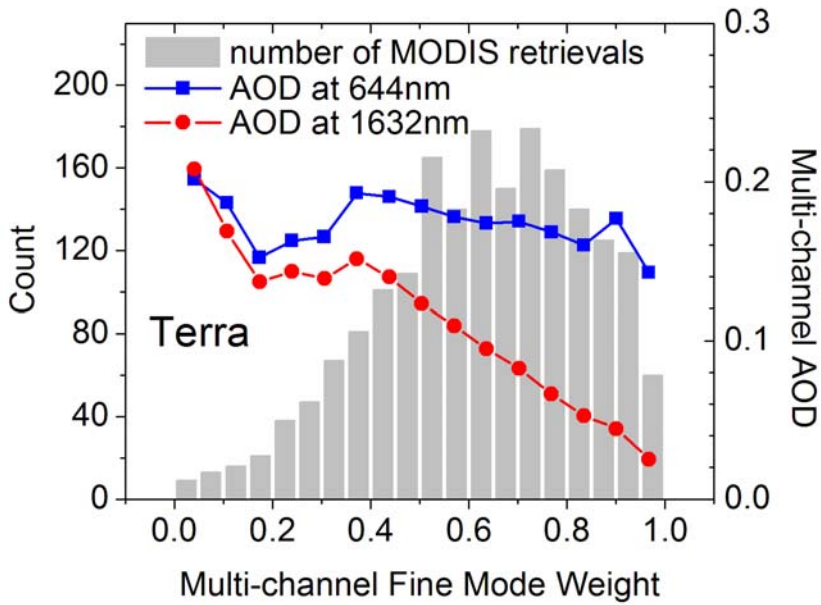
$AOD_S > AOD_M$ at small AOD

- Compared MODIS and single-channel LUTs with AOD=0
  - $R_S < R_M$
  - converted $R_S - R_M$ to AOD with SS approx.
  - not large enough to explain offset.

$AOD_S < AOD_M$ at large AOD

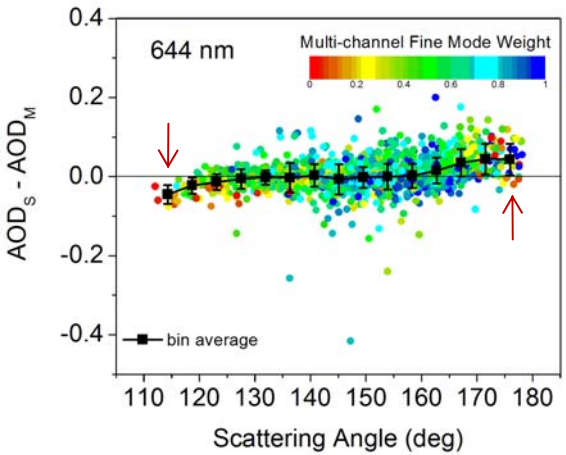
- More obvious as wavelength increases
- Large AOD is usually associated with large particles according to MODIS
  - Partially explains single- and multi-channel AOD difference (next slide)

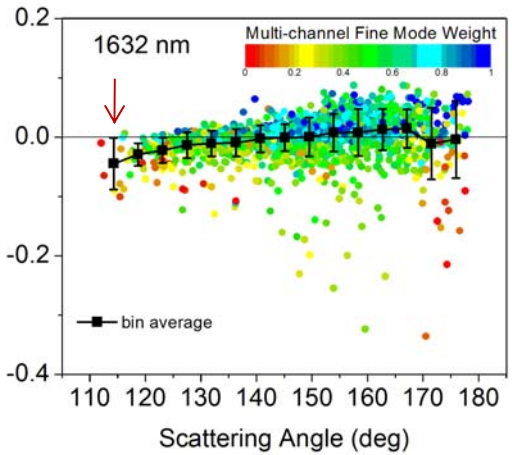
Wavelength (nm)	R_s-R_m	AOD_S-AOD_M	Offset	
			Terra	Aqua
644	-1.058E-3	0.013	0.019	0.028
1632	-2.809E-4	0.005	0.024	
2119	-1.839E-4	0.004	0.017	

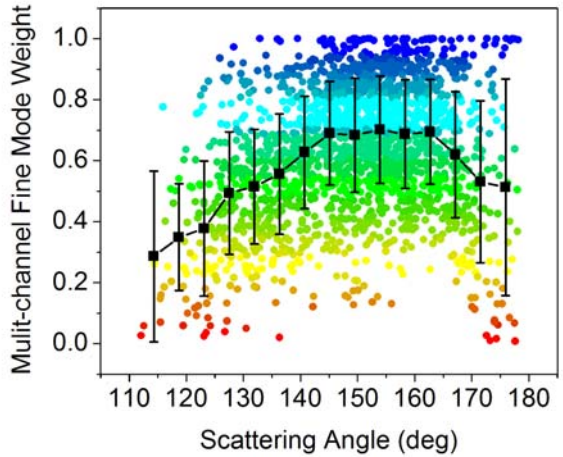


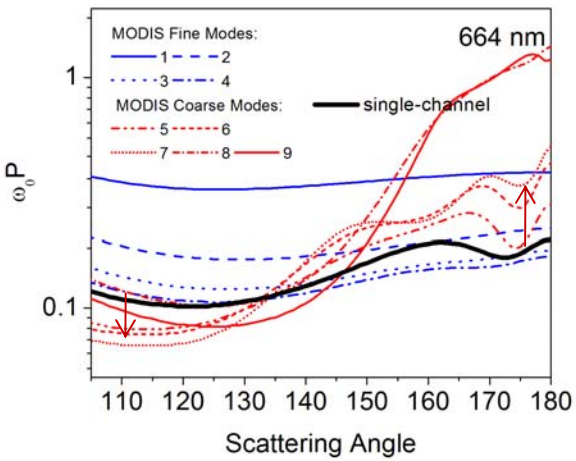
AOD Difference vs. Scattering angle

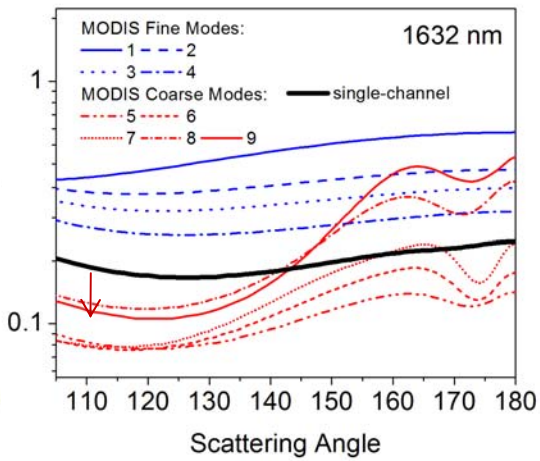
MODIS/Terra 10-km Reflectance











- $AOD_S < AOD_M$ at lower end of scattering angle range; reverse is true at upper end at 644 nm.
- AOD at these scattering angles is associated with larger particles.
- Single- and multi-channel phase function differences may explain the AOD difference.

Summary

- Compared single- and multi-channel AOD derived from the same “aerosol” reflectance at oceanic sites.
- Good agreement between S and M products in spite of substantial algorithm differences.
- Agreement is better for Terra than Aqua (not clear why).
- Scattering angle dependence of the AOD difference can be partially explained by the different aerosol models applied in the retrievals.
- On average:
  - $AOD_S > AOD_M$ at 644 nm
  - $AOD_S \geq AOD_M$ at 1632 nm
  - $AOD_S \leq AOD_M$ at 2119 nm