Section 2.3. PACE Science Objectives

Aerosols

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With many contributions from the PACE SDT

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Section 2.3. PACE Aerosol Science Objectives
2.3.1. Aerosol Type and Optical Depth

Main Quantities:

- Aerosol ***Optical Depth*** (AOD)
- Aerosol ***Type***
  - -- Aerosol Single-scattering Albedo (SSA)
  - -- Aerosol Size & Shape
- Near-source Aerosol ***Plume Height***
- Monitor ***Extreme Events*** (Wildfires, Dust outbreaks, High Pollution days, Volcanoes, …)

Main Applications:

- Direct Aerosol Radiative Forcing (***DARF***)
- Constraining Climate Models for ***Aerosol-Cloud Interactions***
- Constraining Regional ***Air Quality*** and Aerosol Exposure Models
- Aerosol ***Transports***
- ***Trends***

Requires: Multi-angle, multi-spectral, polarimetric imager (ACE-class)

Section 2.3. PACE Aerosol Science Objectives

2.3.1. Aerosol Type and Optical Depth

Satellites

frequent, global *snapshots*; aerosol amount & aerosol type maps, plume & layer heights

Remote-sensing Analysis
- Retrieval Validation
- Assumption Refinement

Suborbital

targeted chemical & microphysical detail

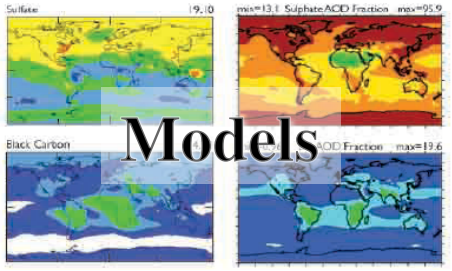
point-location time series

Regional Context

Aerosol-type Predictions

CURRENT STATE
- Initial Conditions
- Assimilation

Model Validation
- Parameterizations
- Climate Sensitivity
- Underlying mechanisms



Models

space-time interpolation,

DARF & Anthropogenic Component

calculation and prediction

Kahn, Survy. Geophys., 2011

Section 2.3. PACE Aerosol Science Objectives
2.3.2. MODIS/OMI Continuity & Enhancements

- OES would provide a single-view, multi-spectral, intensity-only imager
- ***Could*** duplicate much of the combined capabilities of MODIS and OMI
  - -- ***Aerosol Index*** (AI) over land, water, & some clouds
  - -- ***AOD*** over dark water and some land
  - -- ***Fine/Coarse AOD ratio*** over dark water
  - -- UV-Absorbing aerosol ***layer height*** and ***SSA*** constraints
  - -- Complements VIIRS, extends ***two-AOD-instrument*** (MODIS) record
  - -- ***Spatial Resolution***: higher than OMI, but coarser than MODIS
  - -- Possibly better type & height constraints MODIS or OMI alone
- Lacks (?) MODIS 1.38 μm & thermal IR channels used for cloud-clearing
- Not enough aerosol type information to meet ACE requirements
- Not clear whether the aerosol type information is adequate for PACE ***Atmospheric Correction***

Section 2.3. PACE Aerosol Science Objectives
2.3.3. Atmospheric Correction

- ***SeaWiFS*** Atmospheric Correction approach

  -- Obtain AOD and Aerosol Type from ***Red-NIR*** bands

  -- ***Extrapolate*** to Blue, UV (for PACE)

  -- ***Correlate*** with surface reflectivity at (MOBY) surface Buoy

Will this be adequate for PACE?

Ocean Color ***parameter sensitivity*** requirements →

*Ocean ***surface reflectivity*** sensitivity requirements (λ) →

TOA ***reflectivity*** sensitivity requirements (λ, AOD, type) →

Aerosol ***Type, AOD*** sensitivity requirements

Key Contributors: *Ahmad*, *Chowdhary*, *Frouin*, *Kahn*, *Masse*, *Wang*

(more on this in later presentations…)

Section 2.3. PACE Aerosol Science Objectives

2.3.4. *3MI Enhancements to PACE Aerosol Objectives*

- 3MI is an ***advanced POLDER***
  - -- Wider ***Spectral Range*** (388 or 410 μm to SWIR – 13 channels, 8 pol.)
  - -- Somewhat higher ***Spatial Resolution*** (4 km at nadir)
  - -- Wider ***Swath*** (114° field-of-view; 10 – 14 view angles)
- Better constraints on Aerosol Type, Over-land Retrievals, Cloud-clearing
- Better height-SSA constraints in the UV

Aerosol Type Impact on Atmospheric Correction

A. Sayer & *R. Kahn*

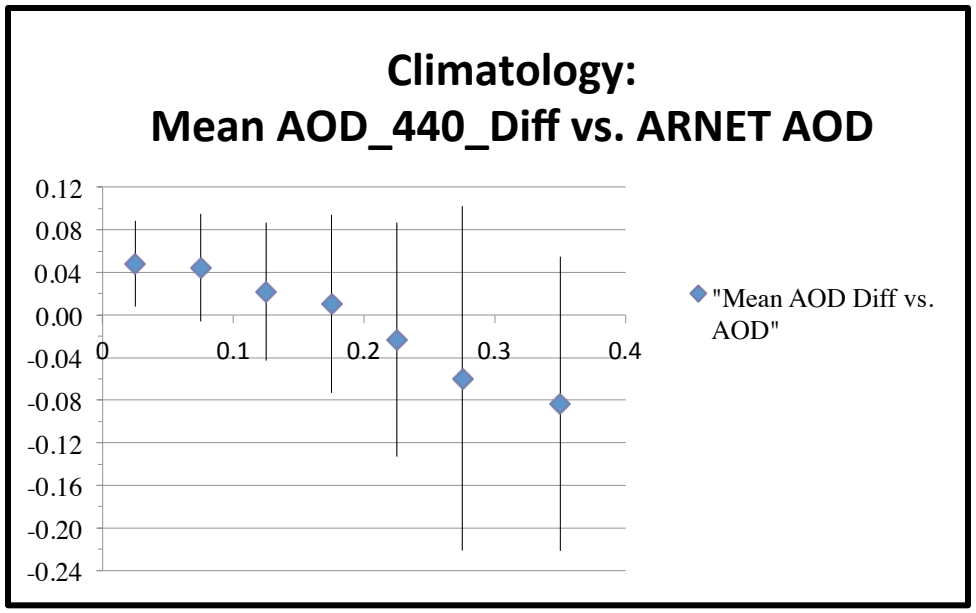
49 AERONET Sites; 16,154 SeaWiFS Coincidences

Site	Number matches	Climatological Mean (standard deviation) of AERONET AOD 380 nm	440 nm	500 nm	550 nm	SeaWiFS -AERONET Coincidences 675 nm	870 nm	Site Type	Region	Main Aerosol
Crozet Island	50	0.068 (0.043)	0.061 (0.041)	0.059 (0.042)	0.057 (0.040)	0.049 (0.037)	0.048 (0.034)	Island	S Indian Ocean	Maritime
Rottnest Island	219	0.080 (0.034)	0.063 (0.031)	0.062 (0.029)	0.059 (0.027)	0.051 (0.026)	0.044 (0.025)	Coastal Isl.	W Australia	Maritime
Reunion St. Denis	121	0.099 (0.045)	0.077 (0.034)	n/a (n/a)	0.064 (0.027)	0.053 (0.022)	0.046 (0.019)	Island	SW Indian Ocean	Maritime
Amsterdam Island	111	0.083 (0.040)	0.075 (0.038)	0.070 (0.037)	0.068 (0.036)	0.061 (0.037)	0.060 (0.037)	Island	S Indian Ocean	Maritime
San Nicolas	532	0.11 (0.067)	0.088 (0.056)	0.079 (0.048)	0.072 (0.043)	0.056 (0.035)	0.049 (0.030)	Coastal Isl.	S California	Maritime Pollution
Tahiti	344	0.098 (0.040)	0.083 (0.034)	0.079 (0.032)	0.074 (0.030)	0.061 (0.027)	0.054 (0.026)	Island	S Pacific	Maritime
Nauru	391	0.091 (0.041)	0.077 (0.036)	0.076 (0.035)	0.074 (0.035)	0.068 (0.034)	0.061 (0.034)	Island	SW Pacific	Maritime
Lanai	542	0.099 (0.055)	0.086 (0.048)	0.080 (0.042)	0.074 (0.038)	0.064 (0.033)	0.054 (0.028)	Island	Hawaii	Maritime
Trinidad Head	229	0.11 (0.076)	0.096 (0.067)	0.085 (0.059)	0.078 (0.054)	0.061 (0.046)	0.053 (0.039)	Coast	N California	Maritime
Coconut Island	230	0.10 (0.052)	0.090 (0.055)	0.085 (0.041)	0.082 (0.049)	0.073 (0.041)	0.061 (0.034)	Island	Hawaii	Maritime
Guam	82	0.10 (0.039)	0.092 (0.036)	0.093 (0.034)	0.088 (0.033)	0.074 (0.031)	0.068 (0.031)	Island	W Pacific	Maritime
Midway Island	342	0.11 (0.057)	0.097 (0.051)	0.093 (0.046)	0.089 (0.045)	0.078 (0.042)	0.071 (0.040)	Island	Central Pacific	Maritime
Azores	176	0.13 (0.067)	0.11 (0.060)	0.10 (0.054)	0.096 (0.051)	0.080 (0.047)	0.069 (0.044)	Island	E Atlantic	Maritime Dust
Gustav Dalen Tower	203	n/a (n/a)	0.14 (0.096)	0.11 (0.081)	0.098 (0.069)	0.069 (0.051)	0.056 (0.031)	Island	N Baltic Sea	Maritime-Cont.
Tudor Hill	94	0.16 (0.076)	0.14 (0.063)	0.12 (0.055)	0.11 (0.050)	0.089 (0.042)	0.083 (0.038)	Island	W N Atlantic	Maritime Dust
Ragged Point	131	0.12 (0.070)	0.11 (0.067)	0.11 (0.064)	0.11 (0.061)	0.091 (0.057)	0.088 (0.054)	Island	Barbados	Maritime Dust
Bermuda	340	0.17 (0.11)	0.14 (0.090)	0.13 (0.080)	0.11 (0.069)	0.091 (0.054)	0.075 (0.044)	Island	W N Atlantic	Maritime Dust
Cape San Juan	154	0.13 (0.087)	0.12 (0.080)	0.12 (0.075)	0.11 (0.073)	0.10 (0.068)	0.010 (0.067)	Island	Puerto Rico	Maritime Dust
Graciosa	20	0.16 (0.049)	0.15 (0.042)	0.13 (0.038)	0.12 (0.036)	0.11 (0.032)	0.091 (0.031)	Island	E Atlantic (Azores)	Maritime Dust
La Parguera	672	0.16 (0.084)	0.14 (0.075)	0.13 (0.068)	0.12 (0.065)	0.10 (0.058)	0.086 (0.054)	Coast	Puerto Rico	Maritime Dust
Santa Cruz Tenerife	355	0.16 (0.092)	0.14 (0.086)	0.13 (0.082)	0.12 (0.079)	0.11 (0.074)	0.092 (0.070)	Island	E Atlantic	Maritime Dust
Cabo Da Roca	350	0.17 (0.057)	0.15 (0.10)	0.11 (0.046)	0.12 (0.082)	0.091 (0.065)	0.075 (0.052)	Coast	Portugal	Continental
Gotland	261	0.18 (0.14)	0.15 (0.12)	0.13 (0.10)	0.12 (0.090)	0.086 (0.067)	0.068 (0.048)	Island	Baltic	Maritime-Cont.
Ersa	76	n/a (n/a)	0.18 (0.080)	n/a (n/a)	0.13 (0.061)	0.10 (0.052)	0.076 (0.046)	Island	Mediterranean	Maritime-Cont.
Key Biscayne	133	0.19 (0.12)	0.16 (0.099)	0.14 (0.084)	0.13 (0.073)	0.010 (0.057)	0.081 (0.046)	Coast	SE Florida	Maritime Pollution
Dry Tortugas	409	0.21 (0.12)	0.16 (0.10)	0.14 (0.086)	0.13 (0.075)	0.010 (0.059)	0.074 (0.046)	Island	Caribbean	Maritime Dust
Lampedusa	382	n/a (n/a)	0.18 (0.11)	n/a (n/a)	0.14 (0.087)	0.12 (0.077)	0.093 (0.068)	Island	Mediterranean	Dust Pollution
IMC Oristano	459	n/a (n/a)	0.19 (0.10)	n/a (n/a)	0.15 (0.078)	0.11 (0.066)	0.085 (0.055)	Island	Mediterranean	Dust Pollution
Dahkla	186	0.18 (0.091)	0.17 (0.090)	0.16 (0.090)	0.15 (0.088)	0.13 (0.083)	0.11 (0.078)	Coast	W Sahara	Dust
Helgoland	205	0.24 (0.16)	0.20 (0.13)	0.17 (0.11)	0.15 (0.098)	0.12 (0.073)	0.088 (0.053)	Island	N Sea	Maritime
COVE	712	0.26 (0.22)	0.21 (0.18)	0.18 (0.15)	0.15 (0.13)	0.11 (0.097)	0.071 (0.064)	Coast	Chesapeake	Pollution
Sevastopol	351	0.27 (0.14)	0.22 (0.11)	0.19 (0.094)	0.16 (0.082)	0.12 (0.063)	0.084 (0.048)	Coast	Black Sea	Maritime Pollution
Ascension Island	522	0.22 (0.13)	0.19 (0.11)	0.17 (0.097)	0.16 (0.090)	0.14 (0.076)	0.12 (0.063)	Island	S Atlantic	Maritime Smoke
MVCO	170	n/a (n/a)	0.21 (0.20)	0.18 (0.17)	0.16 (0.16)	0.11 (0.13)	0.070 (0.086)	Coastal Isl.	Martha's Vineyard	Maritime-Cont.
Forth Crete	731	0.26 (0.12)	0.22 (0.099)	0.19 (0.087)	0.17 (0.079)	0.13 (0.067)	0.10 (0.060)	Island	Mediterranean	Dust Pollution
Kaashidhoo	191	0.25 (0.13)	0.21 (0.11)	0.18 (0.096)	0.17 (0.085)	0.14 (0.070)	0.11 (0.054)	Island	Indean Ocean	Maritime Pollution
Messina	246	n/a (n/a)	0.22 (0.13)	n/a (n/a)	0.17 (0.10)	0.13 (0.088)	0.099 (0.076)	Coast	Sicily	Maritime Dust
Villefranche	546	n/a (n/a)	0.23 (0.15)	n/a (n/a)	0.17 (0.11)	0.12 (0.086)	0.087 (0.062)	Coast	S France	Maritime-Cont.
Capo Verde	579	0.19 (0.10)	0.20 (0.10)	0.17 (0.097)	0.18 (0.095)	0.17 (0.089)	0.15 (0.082)	Island	E Atlantic	Maritime Dust
Inhaca	83	0.30 (0.20)	0.24 (0.16)	0.20 (0.14)	0.18 (0.12)	0.15 (0.090)	0.097 (0.070)	Coastal Isl.	Mozambique	Cont-Smoke
MALE	79	0.28 (0.15)	0.24 (0.13)	0.21 (0.11)	0.19 (0.096)	0.16 (0.073)	0.11 (0.055)	Island	N Indian Ocean	Maritime Pollution
Shirahama	567	0.30 (0.16)	0.25 (0.14)	0.21 (0.12)	0.19 (0.11)	0.14 (0.085)	0.11 (0.062)	Coast	E Japan	Maritime Pollution
Venise	1388	0.35 (0.21)	0.27 (0.18)	0.23 (0.15)	0.19 (0.13)	0.14 (0.096)	0.091 (0.062)	Coast	Italy	Maritime-Cont.
IMS METU-Erdemli	918	0.33 (0.18)	0.27 (0.15)	0.23 (0.13)	0.20 (0.12)	0.15 (0.090)	0.11 (0.067)	Coast	SW Turkey	Maritime-Cont.
Arica	604	0.34 (0.14)	0.29 (0.12)	0.26 (0.11)	0.23 (0.095)	0.18 (0.075)	0.14 (0.051)	Coast	Chile	Pollution
MCO Hanimadhoo	120	0.35 (0.15)	0.30 (0.13)	0.27 (0.11)	0.24 (0.098)	0.19 (0.077)	0.14 (0.061)	Island	N Indian Ocean	Maritime Pollution
Dakar	392	0.27 (0.12)	0.27 (0.11)	0.24 (0.10)	0.24 (0.10)	0.22 (0.094)	0.19 (0.087)	Coast	Senegal	Dust
Hong Kong Hok Tsui	30	0.38 (0.14)	0.32 (0.13)	0.28 (0.11)	0.25 (0.094)	0.19 (0.073)	0.13 (0.047)	Coast	China	Pollution Dust
Gosan-SNU	126	0.40 (0.18)	0.33 (0.17)	0.29 (0.13)	0.26 (0.14)	0.20 (0.10)	0.16 (0.077)	Coastal Isl.	S Korea	Pollution Dust

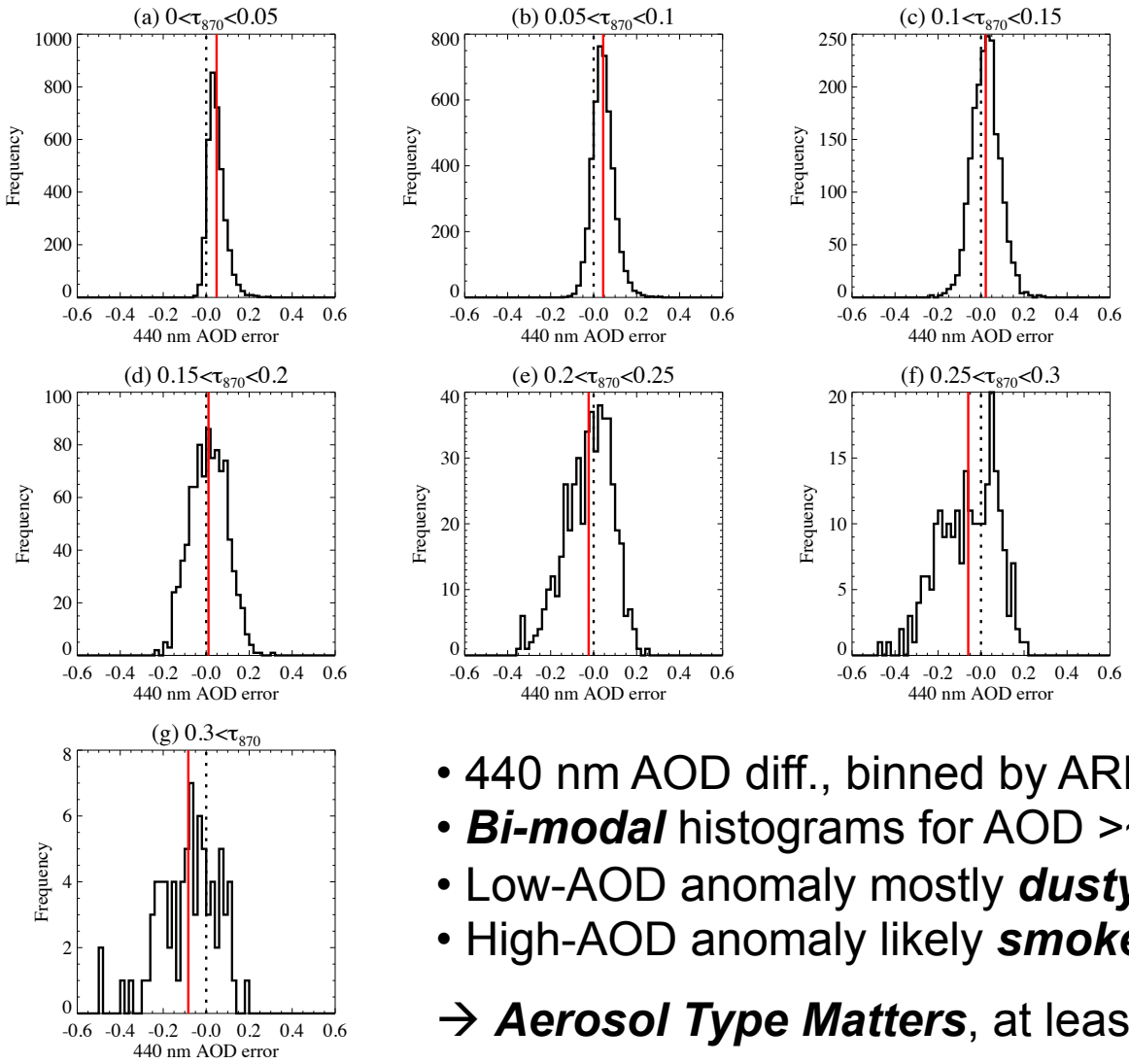
49 AERONET Sites; 16,154 SeaWiFS Coincidences

AOD_440:

[Calculated using ***SeaWiFS*** Algorithm] – [***AERONET***-Measured]



49 AERONET Sites; 16,154 SeaWiFS Coincidences



- 440 nm AOD diff., binned by ARNT AOD
- ***Bi-modal*** histograms for AOD >~ 0.2
- Low-AOD anomaly mostly ***dusty*** cases
- High-AOD anomaly likely ***smoke***, ***pollution***

→ ***Aerosol Type Matters***, at least qualitatively

See also: *Li et al*. 2003; *Schollaert et al*. 2003; *Ransibranmanakul* & *Stump*, 2006; *Ahmad et al*. 2010