Aerosol layer height climatology derived from synergistic use of UV-VIS sensors

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Why Aerosol Height?

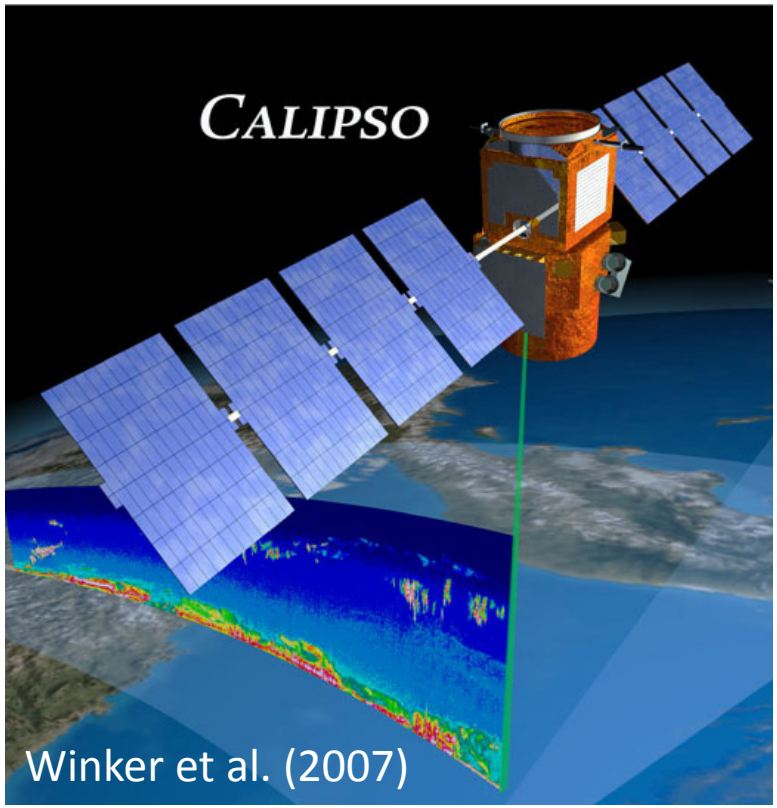
- Radiative effects:
  - Vertical profile of radiation field
  - Aerosol-cloud interactions

- Air quality:
  - Link between total column vs. surface-level aerosol concentrations
  - Different altitudes for different targets, i.e., surface air quality or aviation safety

- Aerosol transport modeling:
  - Indicative of long-range transport
  - Model evaluations for injection height

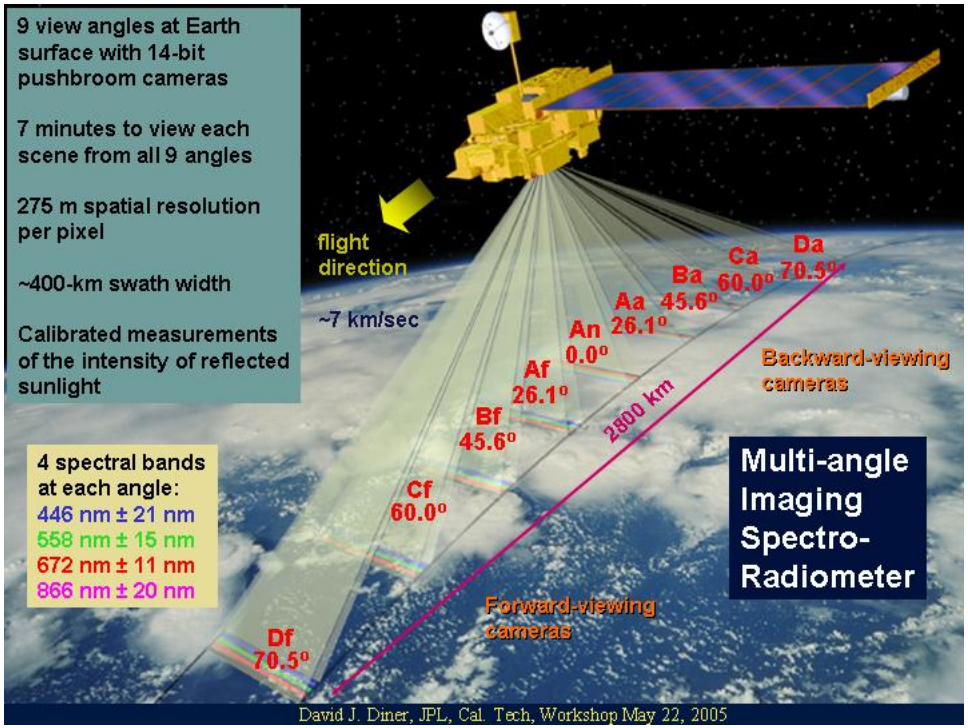
Aerosol Height from Space

Spaceborne lidar



Winker et al. (2007)

Multi-angle imaging



Moroney et al. (2002), Nelson et al. (2013)

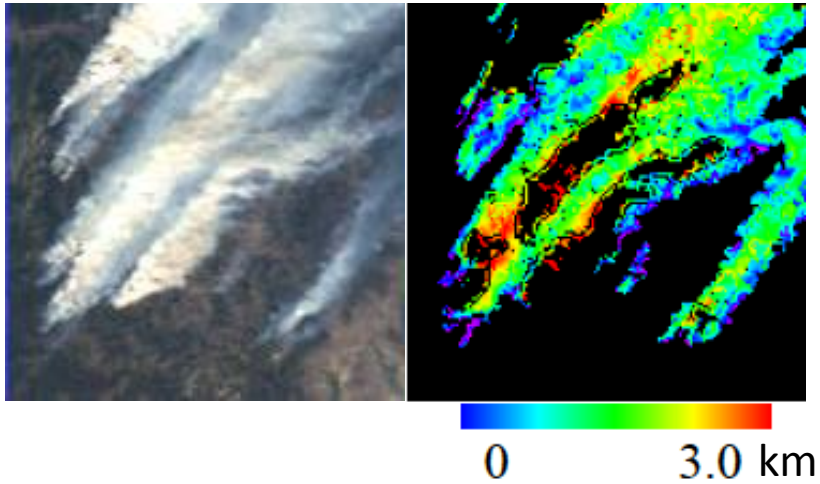
Beam width: 70 m at surface
Provides detailed vertical structure
Saturation for thick aerosol layers

Swath width: ~400 km
Provides a single layer height

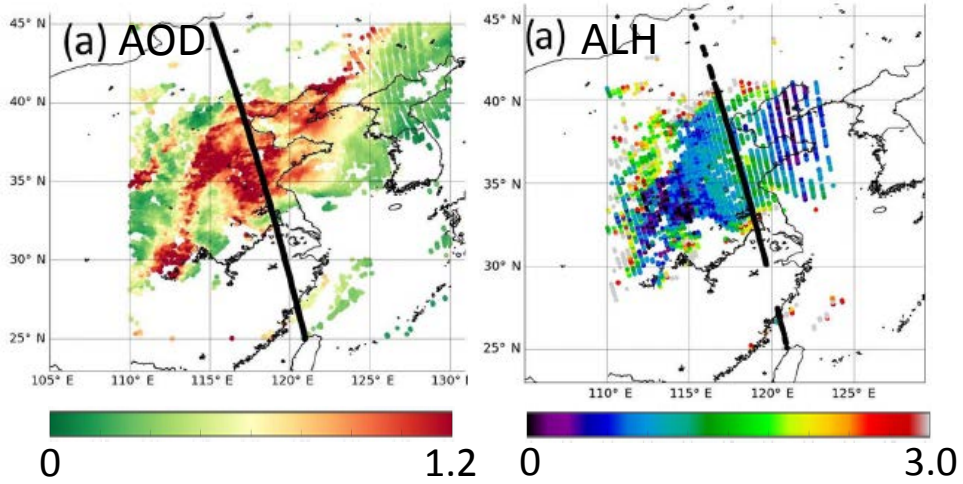
The objective is to provide the height of UV absorbing aerosols with daily global coverage using passive UV-VIS sensors

Aerosol Height from Space

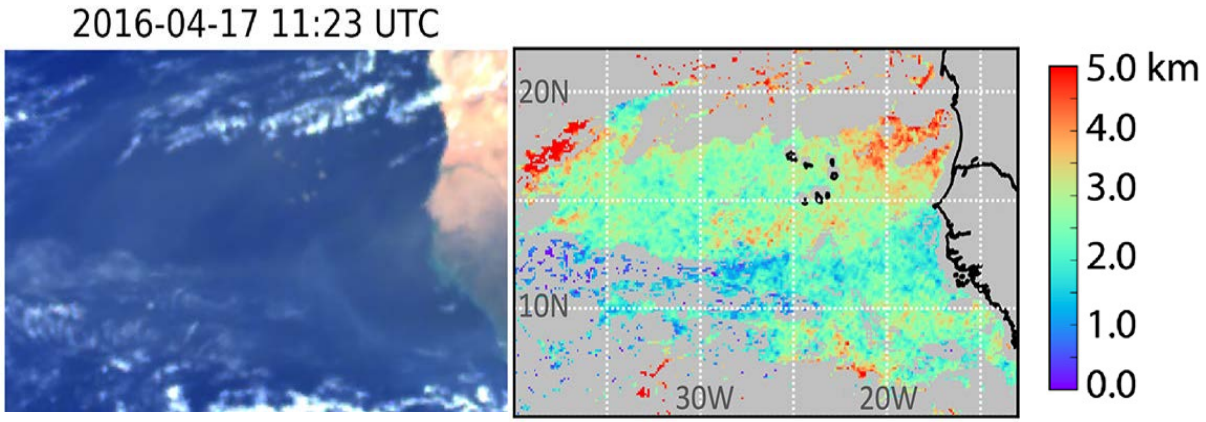
IR technique (Lyapustin et al., in press)



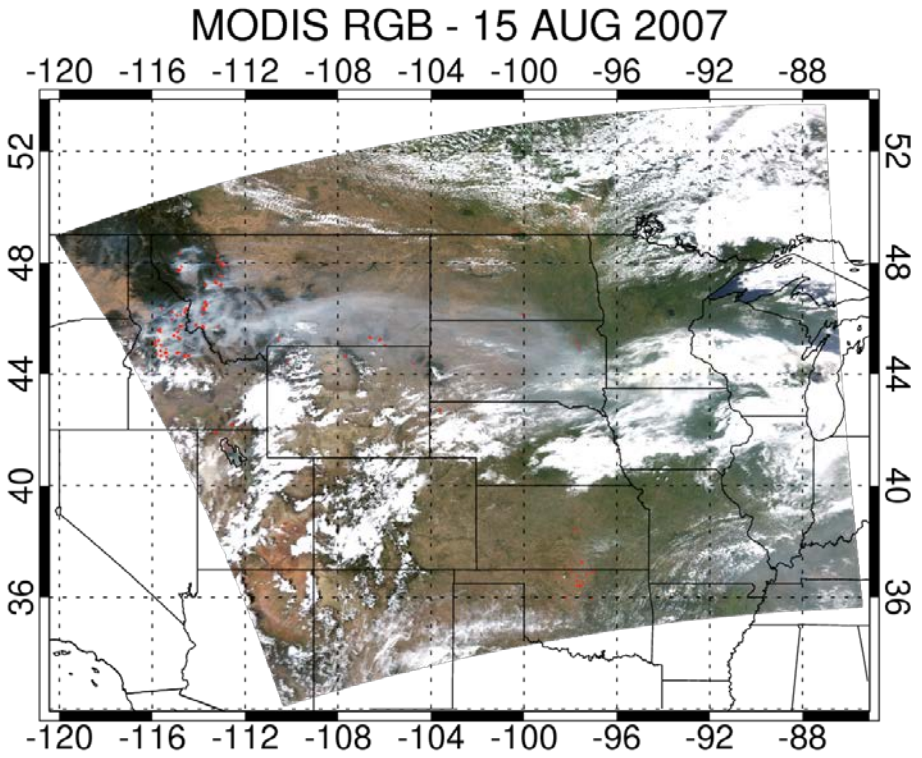
O_2–O_2 band (e.g. Chimot et al., 2018)

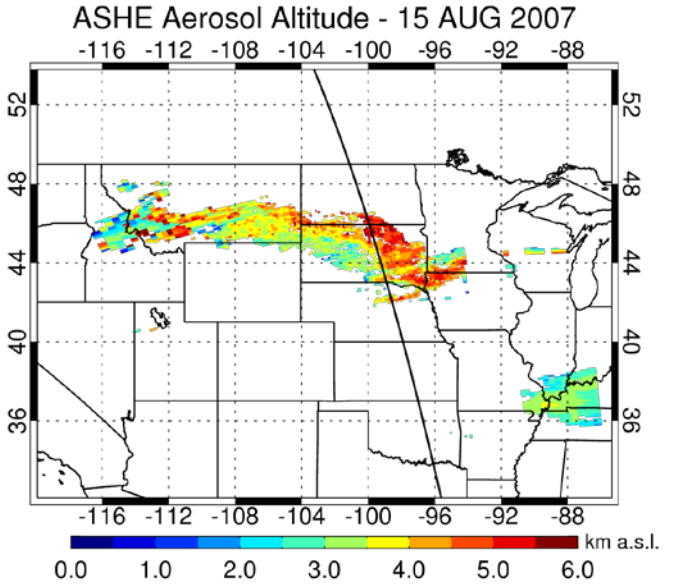


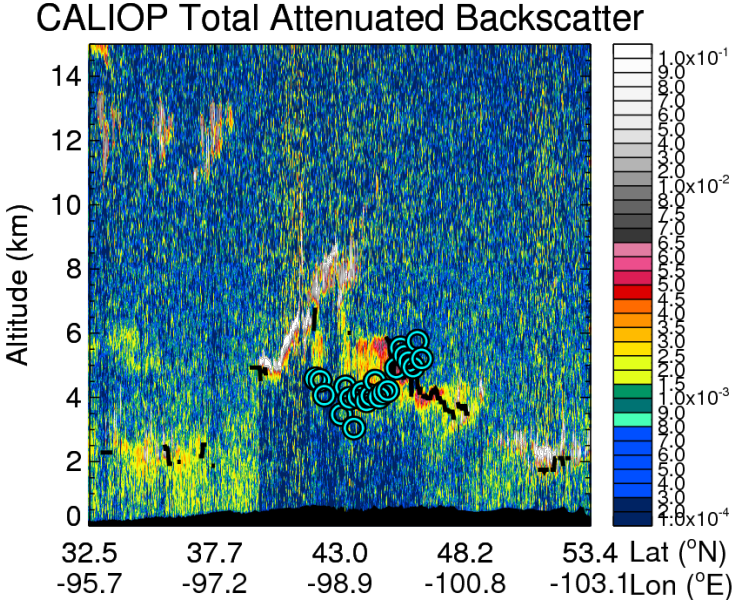
Oxygen A/B-band (e.g. Sanders et al., 2015; Xu et al., 2019)



Aerosol Single-scattering albedo and Height Estimation (ASHE)

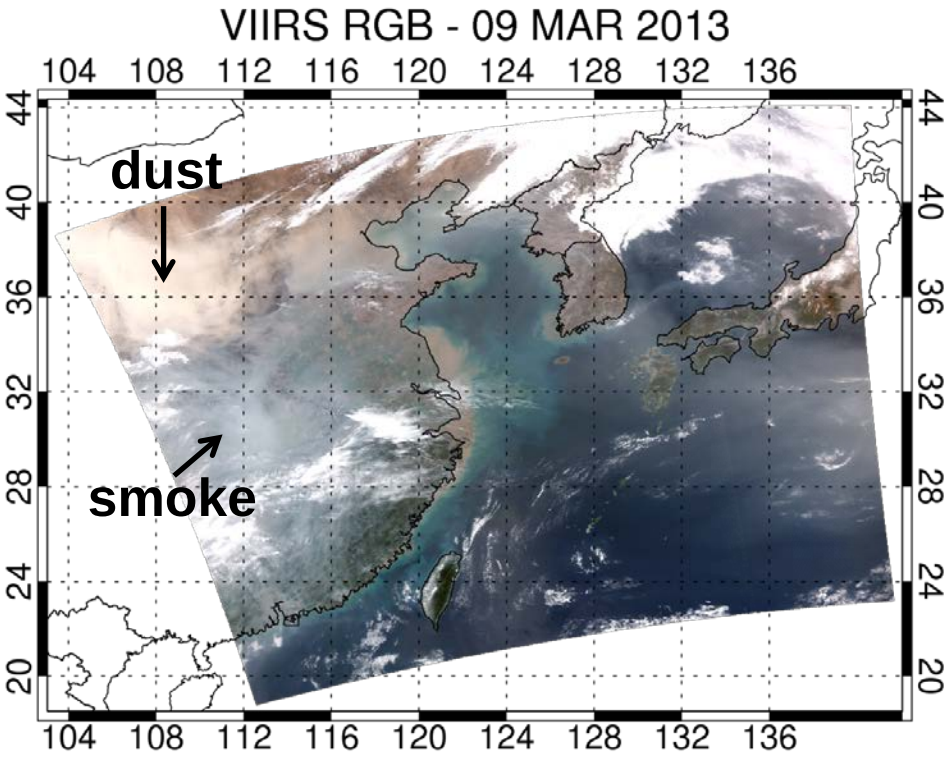


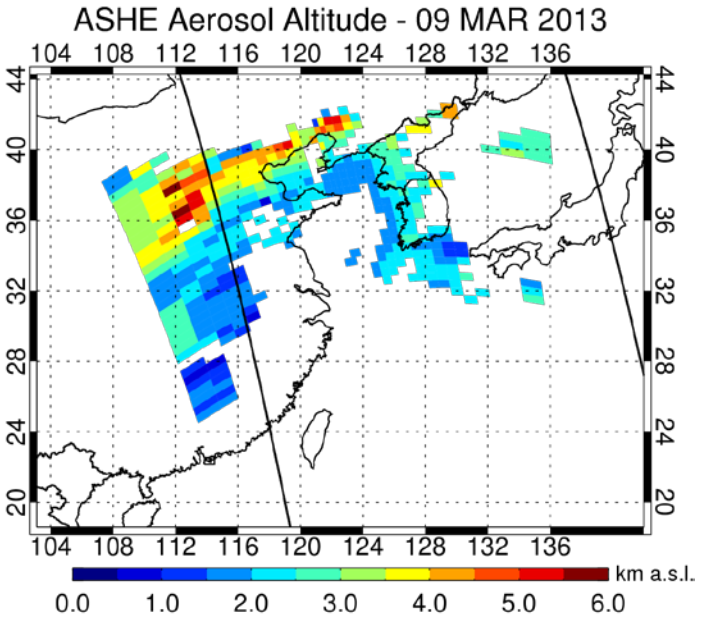


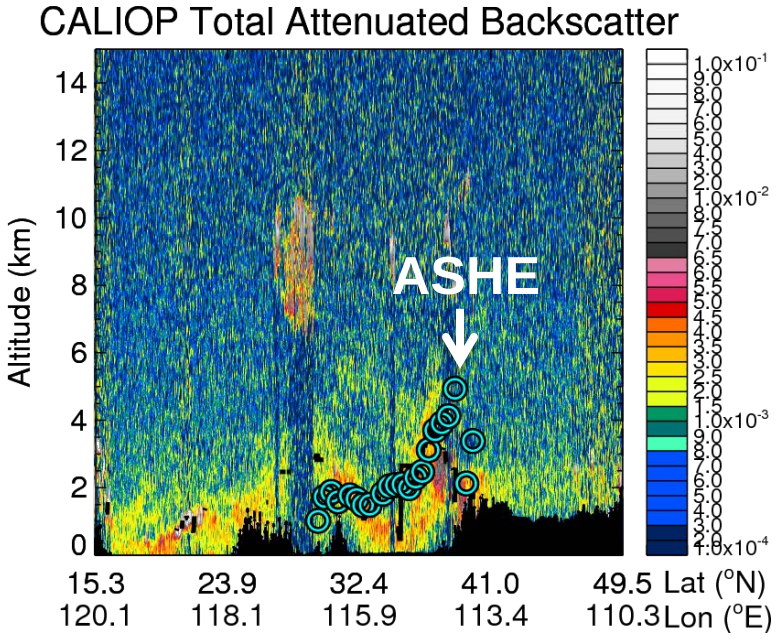


- Synergistic use of MODIS, OMI, and CALIOP
- UVAI ~ f(AOD, SSA, ALH)
- Applied to smoke aerosols only
- Smoke detection based on UVAI and Ångström exponent
- Jeong and Hsu (2008)

ASHE Extension to Nonspherical Dust



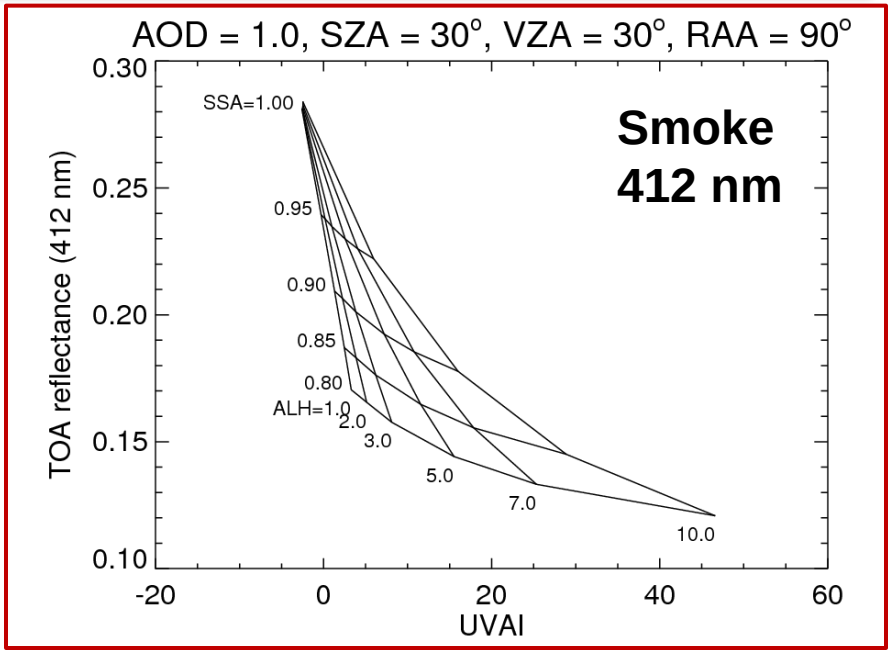


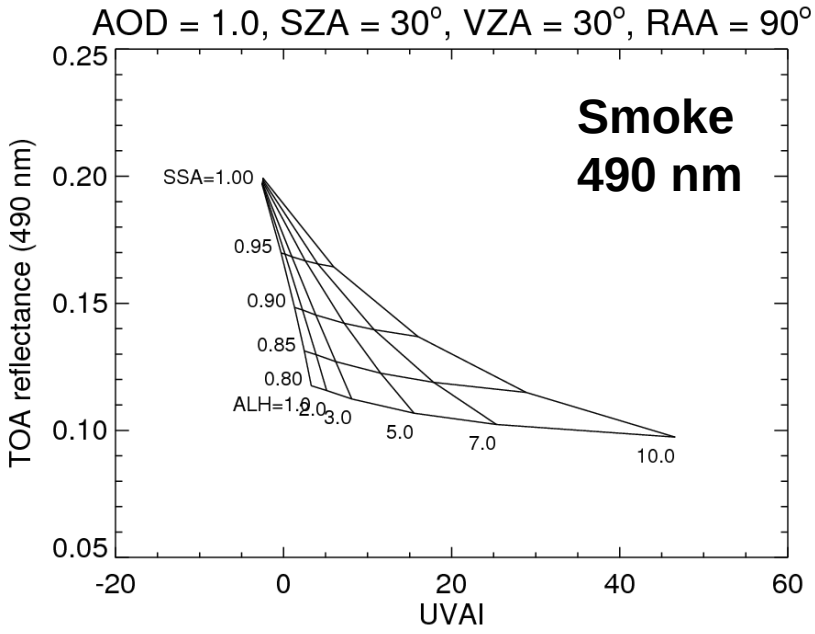


- Application extended to mineral dust layers and VIIRS/OMPS
- Lee et al. (2015, 2016)

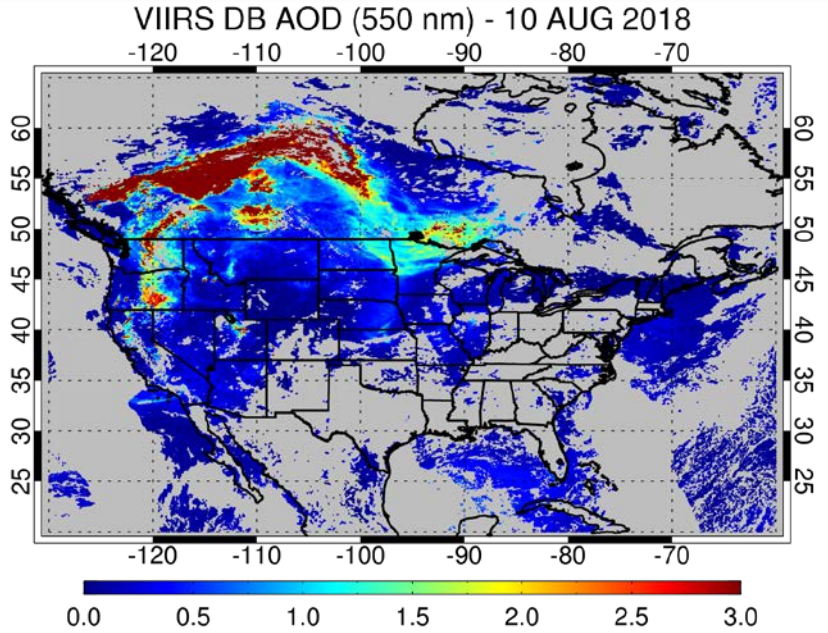
ASHE without CALIOP

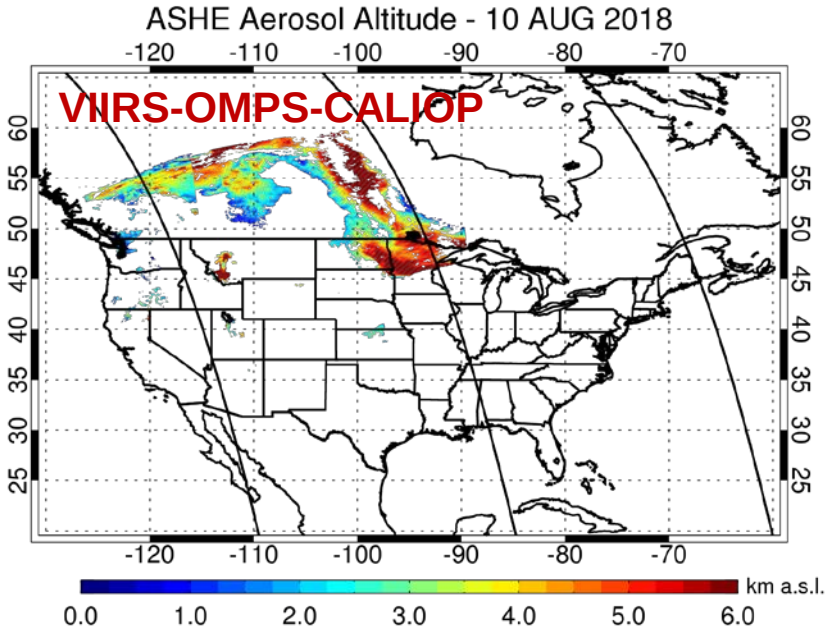
- Retrieves aerosol layer height and SSA using UVAI and 412 nm TOA reflectance
- AOD and surface reflectance constrained by VIIRS Deep Blue product
- Aerosol optical model:
  - Bimodal lognormal distribution
  - 550 nm fine-mode AOD fraction
  - Absorption AE
  - Nonspherical dust

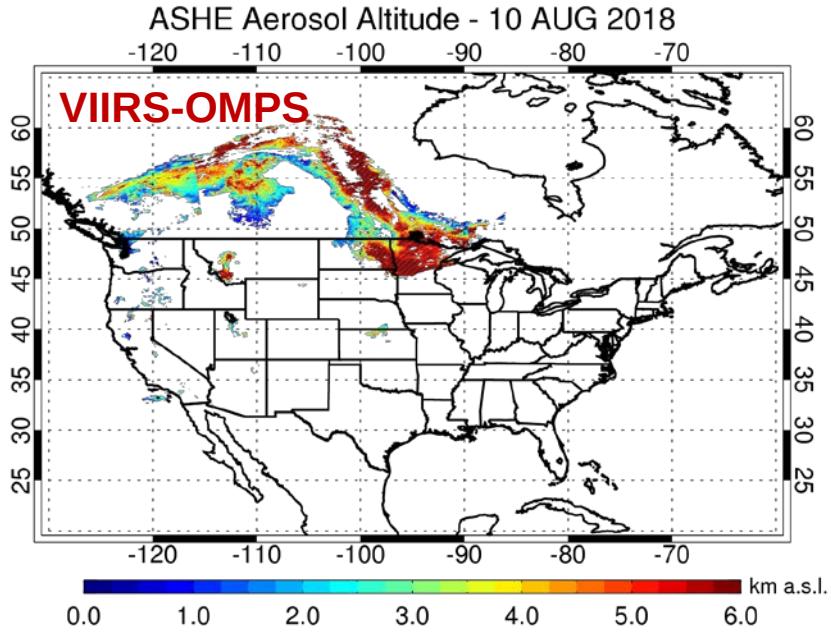




ASHE without CALIOP

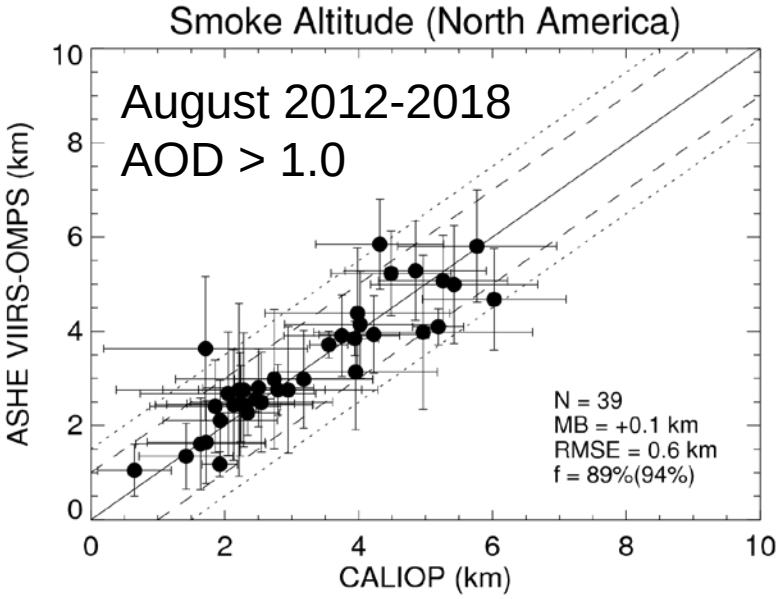




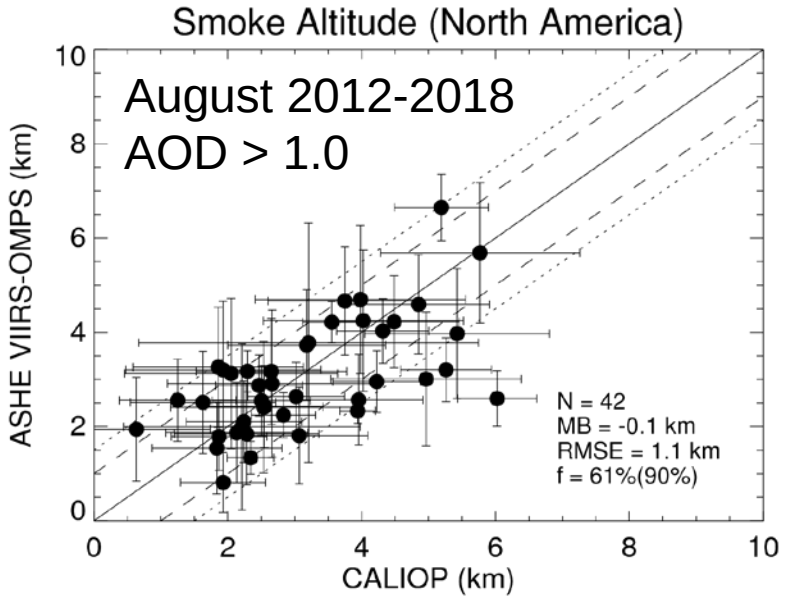


Evaluation against CALIOP over N. America

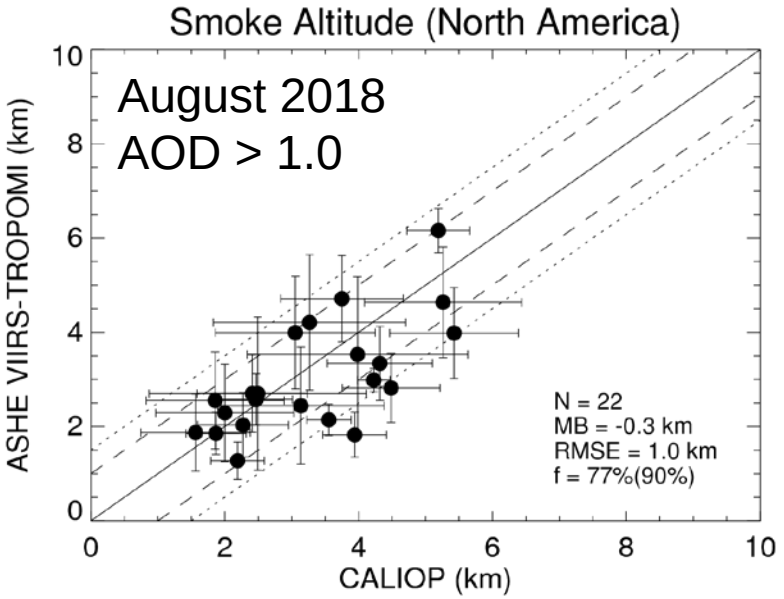
VIIRS-OMPS-CALIOP



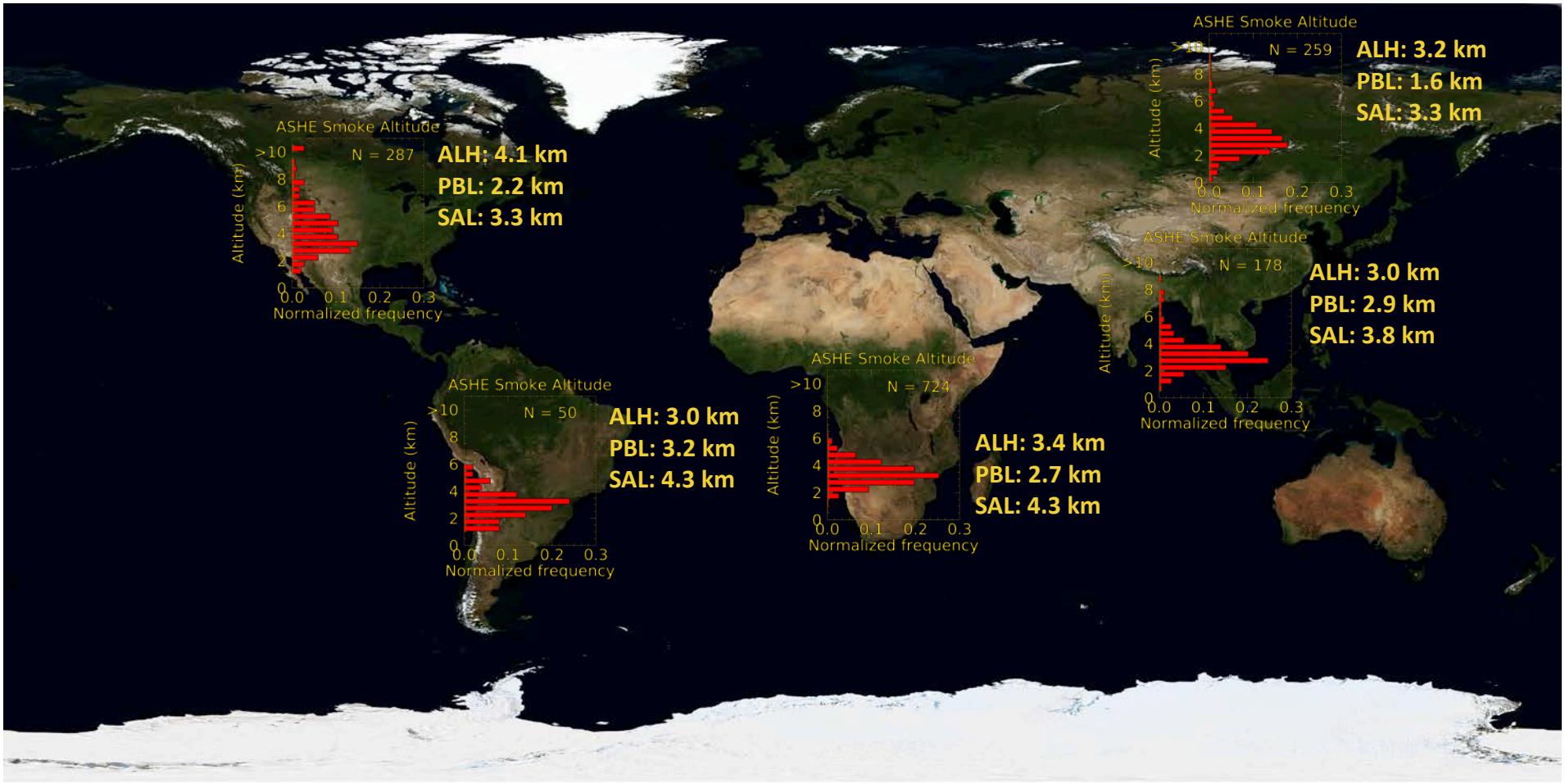
VIIRS-OMPS



VIIRS-TROPOMI

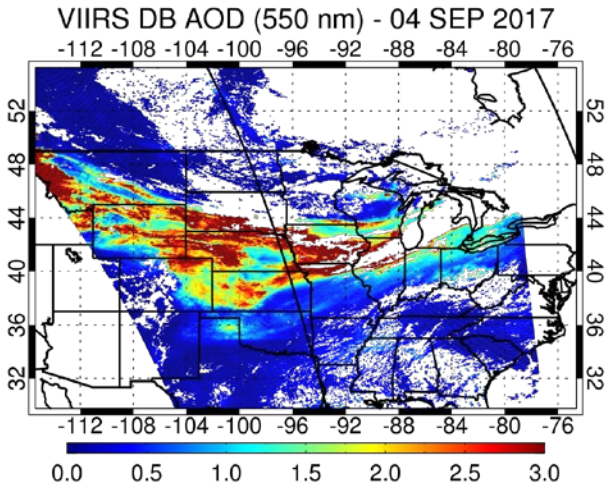


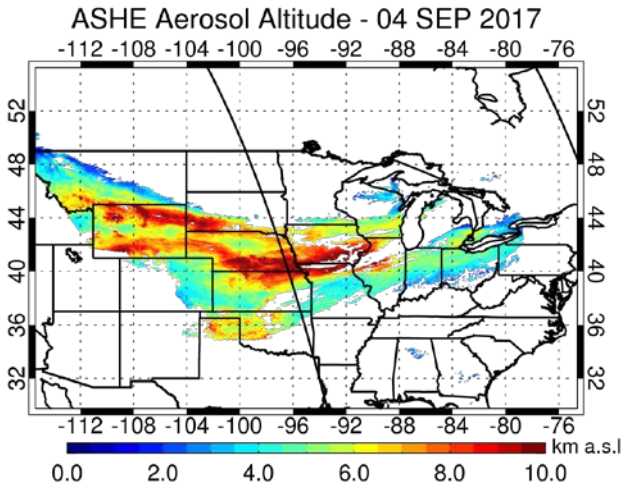
Smoke Altitude over Major Source Regions

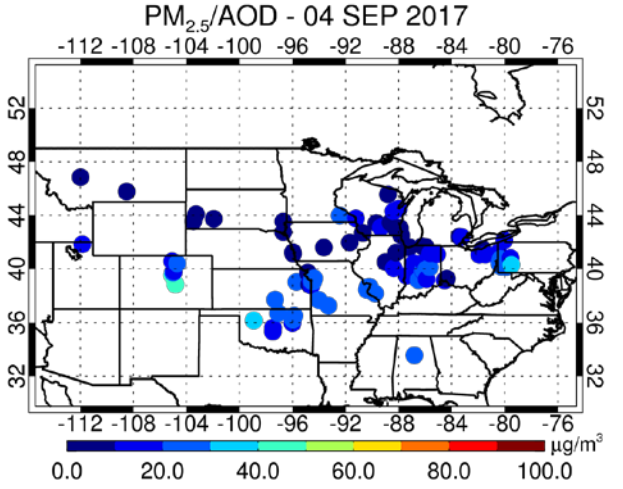


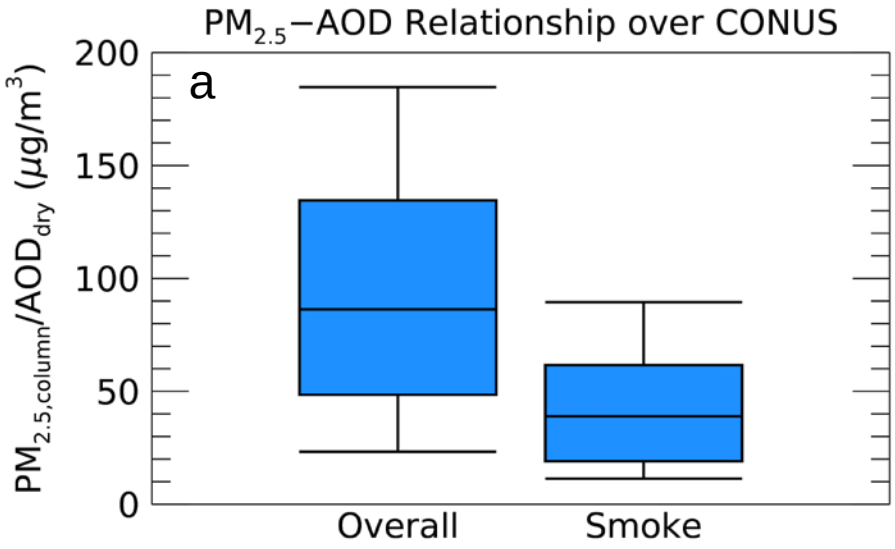
2012-2017	N.America	S.America	S.Africa	SE Asia	Siberia
Number of smoke pixels	598483	85077	1563502	233594	948922
Percentage above PBL	79%	25%	37%	36%	72%
Percentage above SAL	38%	9%	9%	8%	27%

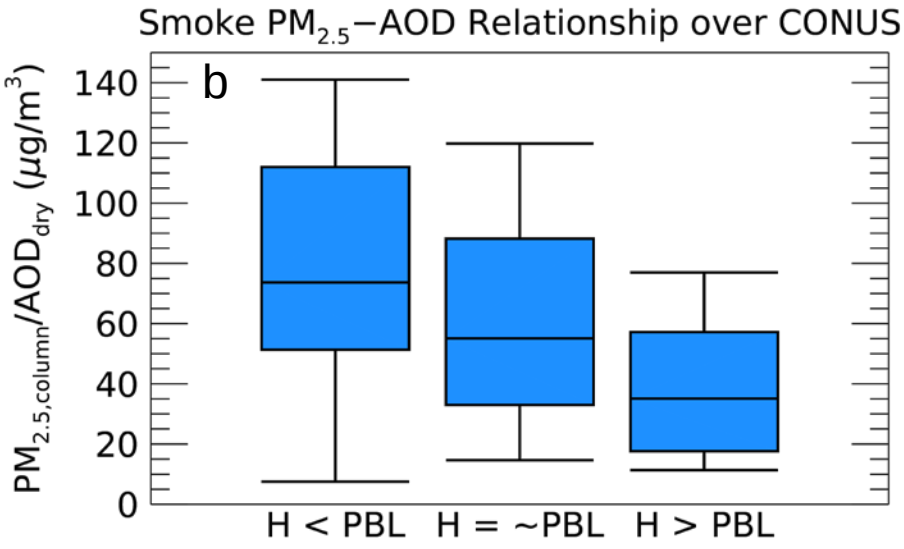
AOD-PM2.5 relationship for smoke aerosols











Summary and Conclusions

- Synergistic use of UV-VIS sensors or sensors with similar capability (TROPOMI, OCI/PACE, etc.) have potential to provide daily global aerosol height of biomass burning smoke and mineral dust.
- Present algorithm can run without CALIOP observations, significantly improving data coverage and facilitating the implementation in the operational processing system.
- Comparison against CALIOP over North America suggests retrieval accuracy within ~1-1.5 km when considering the entire transect for wildfire smoke cases.
- Since ASHE utilizes Level 2 aerosol products, it can directly benefit from future improvements to the data set. Improvements in AOD from V2 VIIRS DB and C7 MODIS DB are underway.
- The ASHE retrievals can inform Deep Blue of appropriate aerosol model and height for better AOD retrievals, which can in turn improve the performance of ASHE.

Saharan Dust Transport