Hourly Aerosol Layer Height Information: GEO-XO perspective

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Algorithm & Products Panel
NOAA GeoXO Atmospheric Composition Town Hall
29 April 2021

A rising trajectory of geostationary satellites for air pollution

GEMS 02/18/2020; TEMPO & Sentinel-4, 2022/23

GEO-XO 2030?

Imager → Spectrometer

Kim et al., 2020
Chance et al., 2019
Zoogman et al, 2017

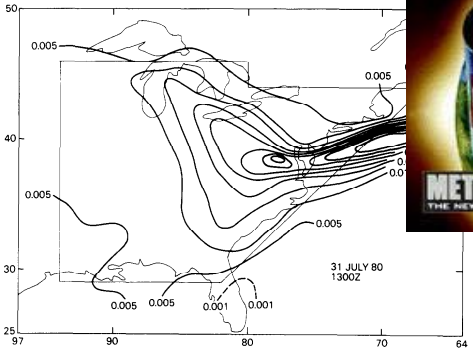
Fishman et al., 2012

Lahoz et al., 2012

Schmit et al., 2017

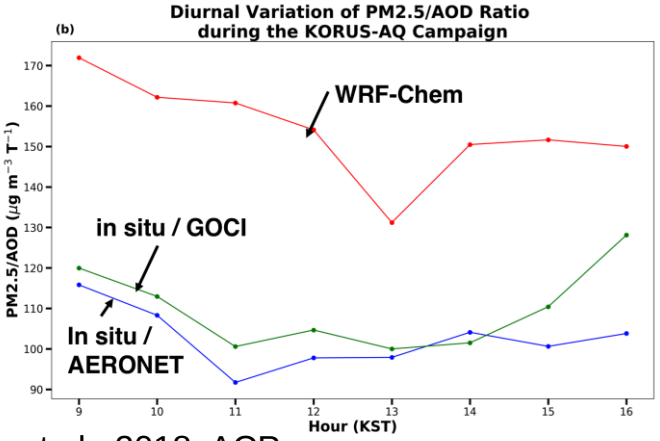
Lee et al., 2010.
RSE
6 visible
2 NIR

GOES-2



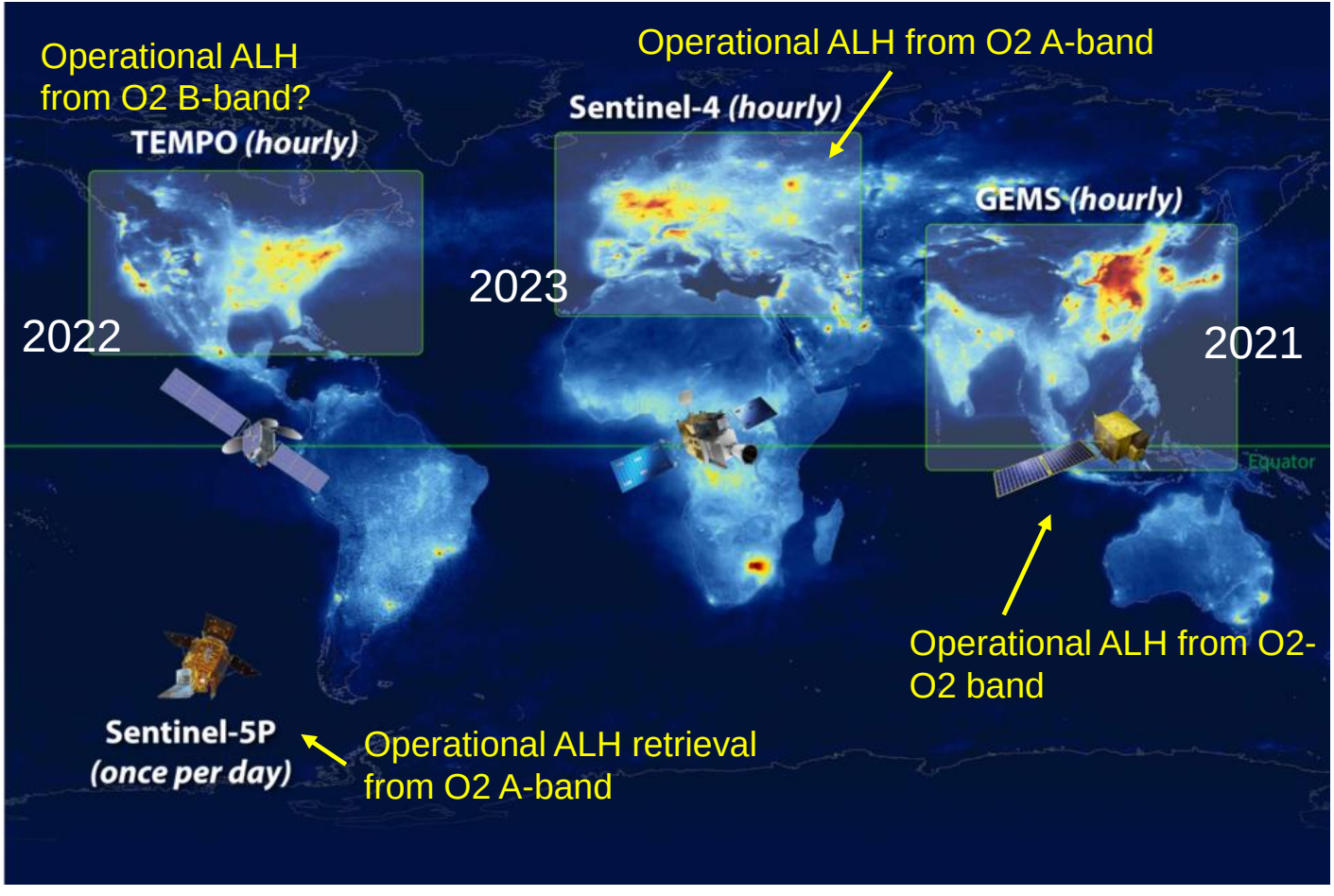
MSG, 8/28/2002
12 channels
2 visible

Fraser et a., 1984, AE



Lennartson et al., 2018, ACP

GEO constellation for Aerosol Layer Height mapping in the coming decade



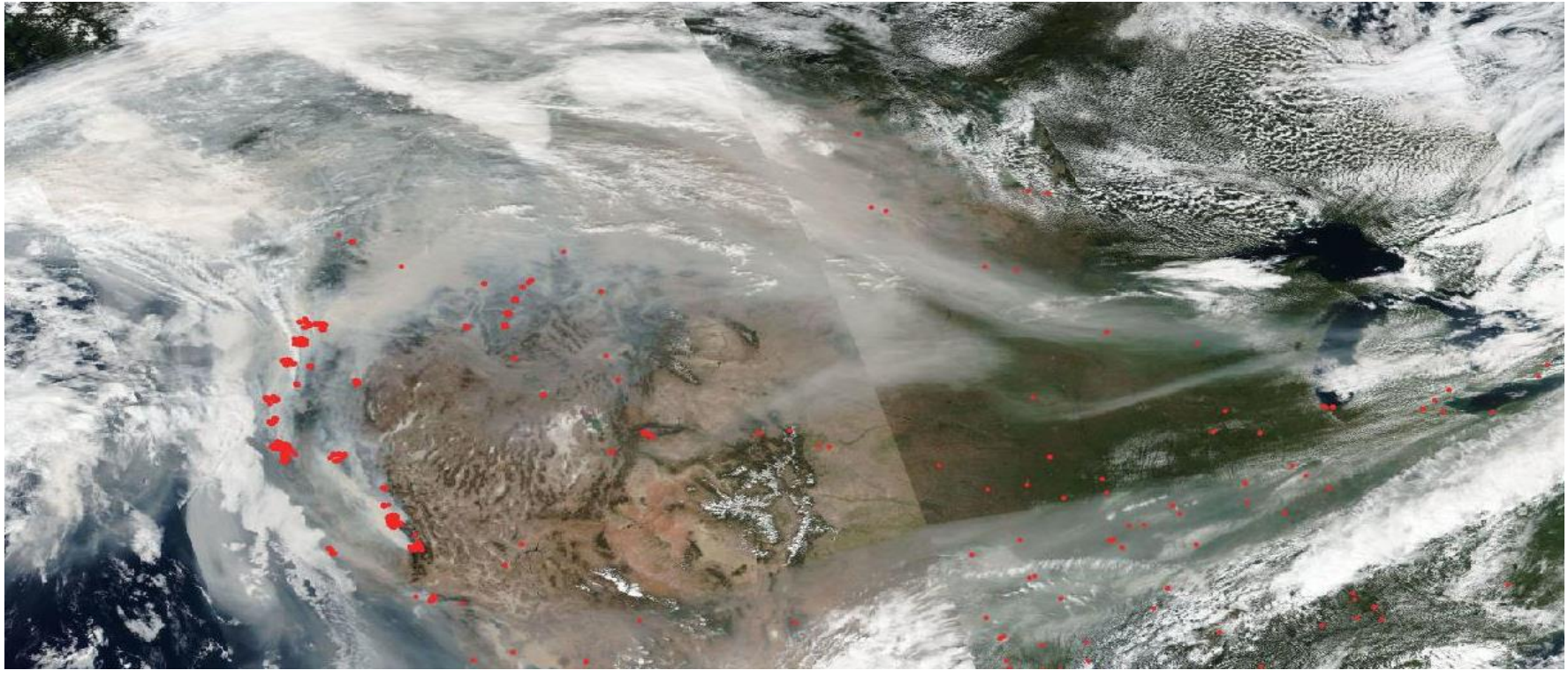
Geostationary and Extended Orbits (GEO-XO)

https://www.nesdis.noaa.gov/GEO-XO

Now in formulation

Is the smoke layer near the surface?

Smoke transport like this can be norm in 2030s

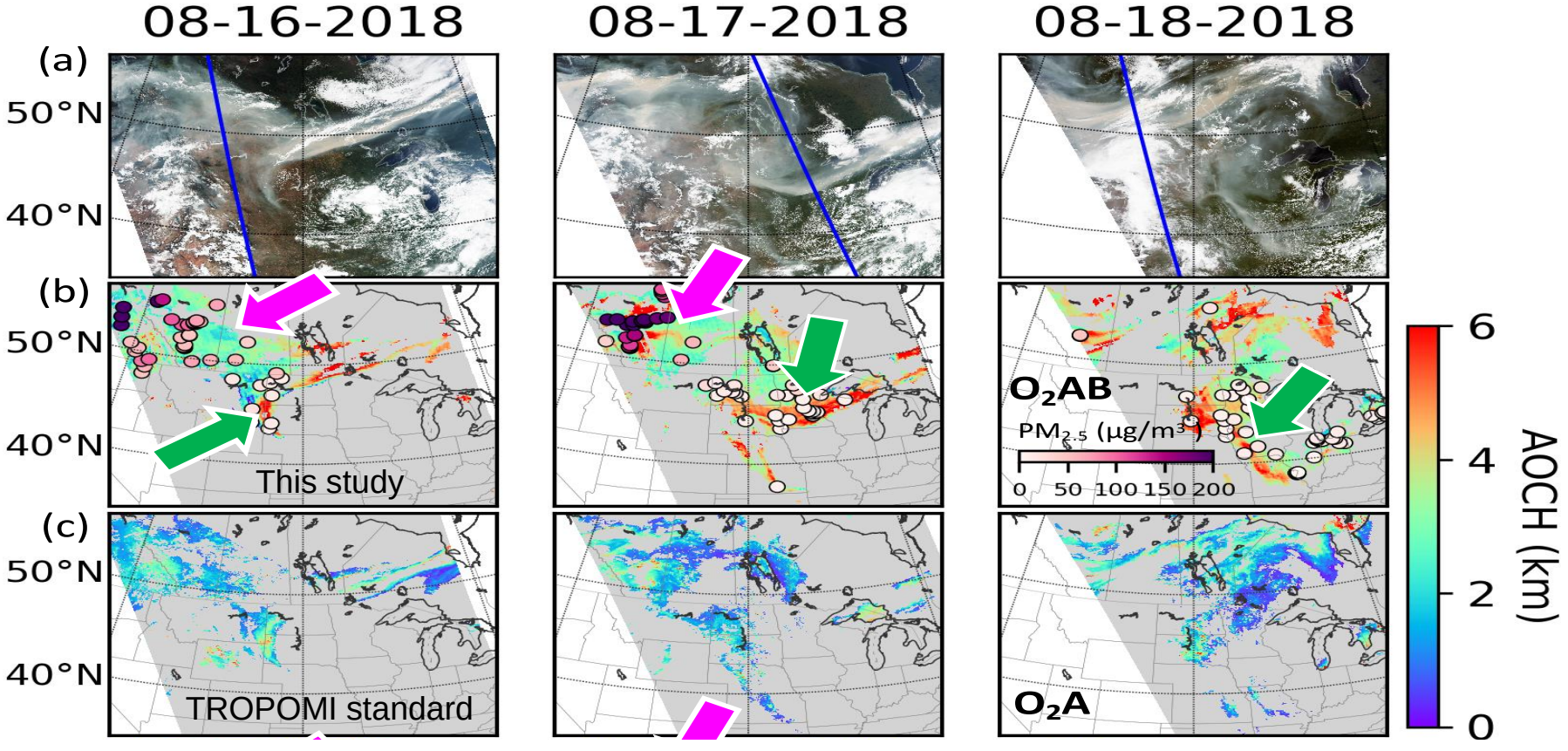


MODIS true color image and detected fires (red dots) on 16 Sep. 2020. Source: NASA World View.

Need 3D in real time !

Case Demonstration

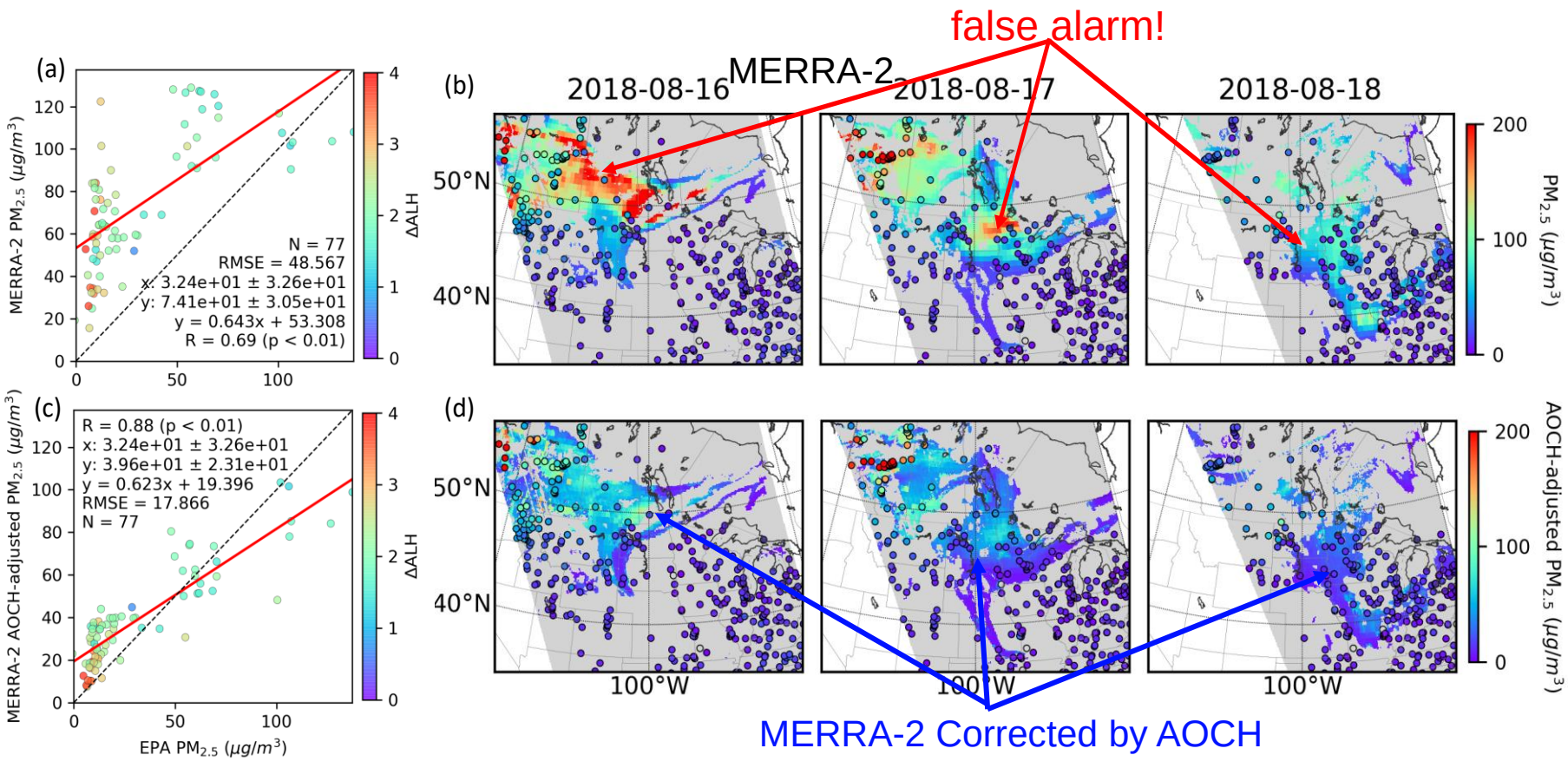
- Air quality forecast is needed by the state/local communities to make advisories/decisions for mitigating public exposure to air pollution.



Chen et al., in review, no cite or quote!

Improvement on prediction and analysis

- Aerosol layer height is one of the most needed information air quality mangers wants (based on HAQST group discussion on air quality forecast in smoke conditions).



Chen et al., in review, no cite or quote!

Summary

- **Nearly all modern optical sensing instruments have the capability and algorithm in place for mapping aerosol loading (e.g., AOD).**
- **Mapping surface 24-hour PM2.5 concertation, however, requires the information of aerosol vertical distribution that clearly has a *diurnal* variation.**
- **Leveraging the research algorithm development and operational data production from TEMPO, TROPOMI, and others, GEO-XO is well positioned for improving surface $PM_{2.5}$ estimates and forecast by providing hourly ALH retrieval, operationally.**
- **GEO-XO ACX instrument will be revolutionary for mapping and forecasting 3D air quality, bringing significant societal and economic benefits to the pubic in 2030s when the historic fires we saw in 2020 are likely to be the new norm.**

Thank you.

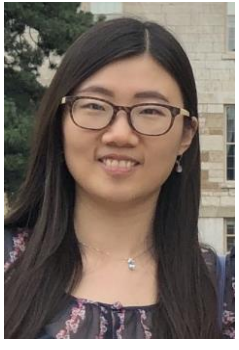
MURI

TEMPO
DSCOVR

GEO-XO

Xiaoguang Xu
UMBC

Xu, X., J. Wang, Y. Wang, and A. Kokhanovsky (2018), Passive remote sensing of aerosol height.https://doi.org/10.1016/B978-0-12-810437-8.00001-3



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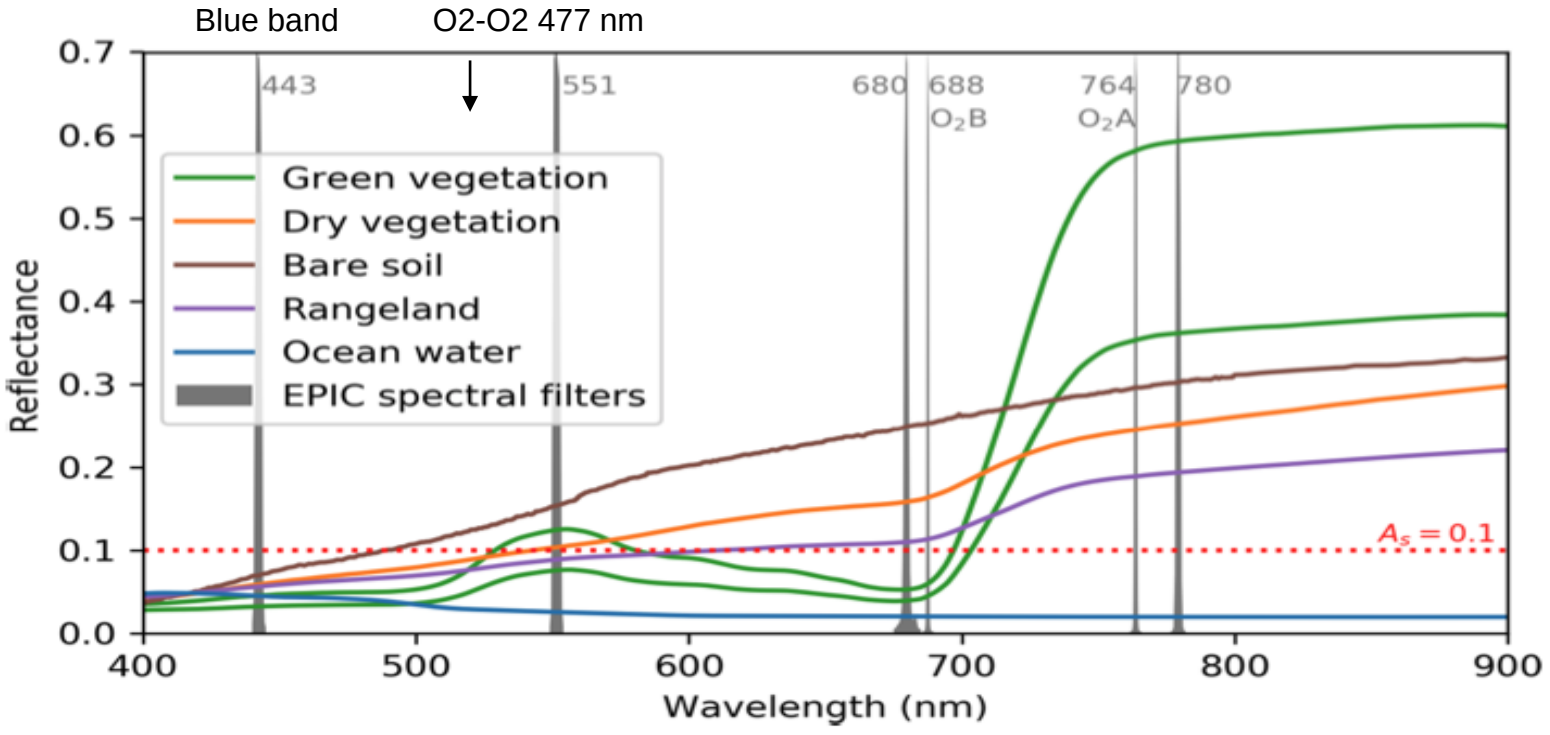
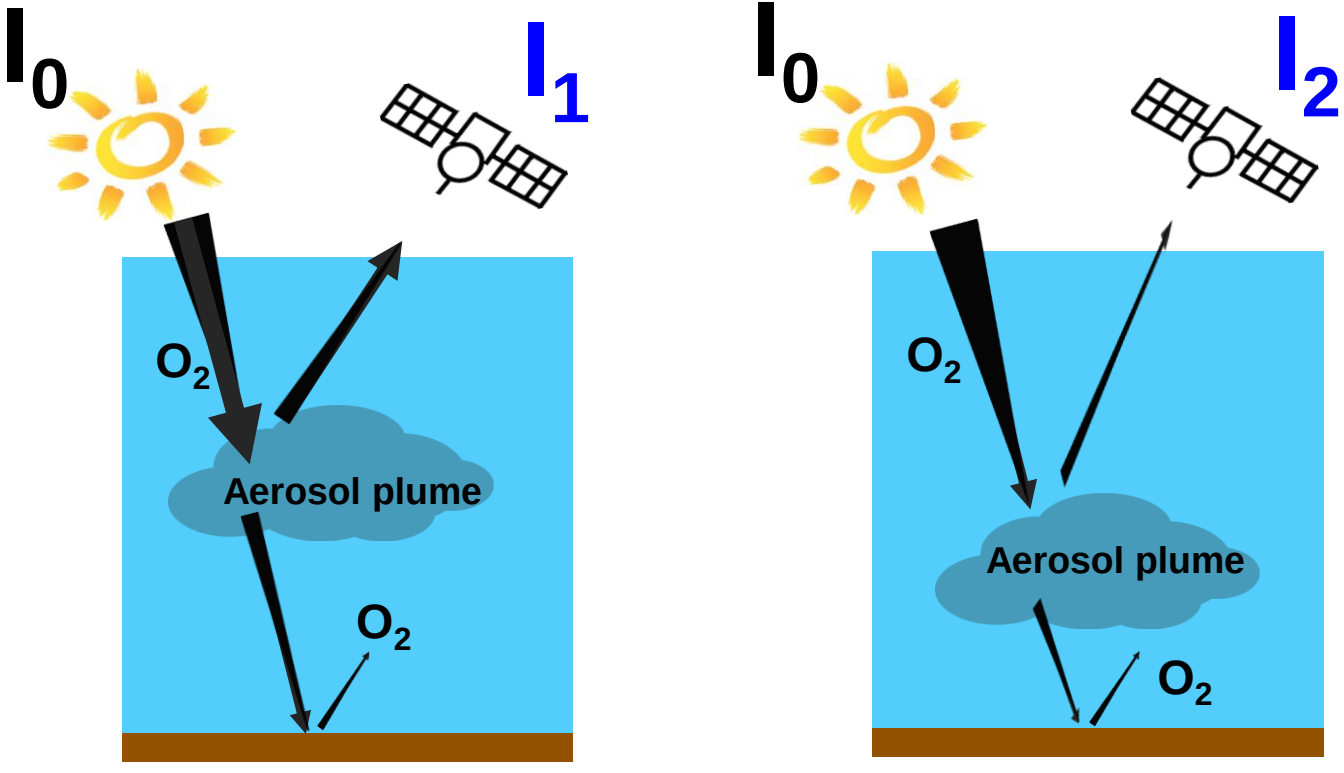
Oxygen absorption bands vs. surface reflectance spectra



O2 B-band has moderate absorption, stronger than O2-O2 at 477 nm and weaker than O2 A. O2 B-band also has very low surface reflectance, comparable if not lower than blue bands, due to Chlorophyll-a absorption.

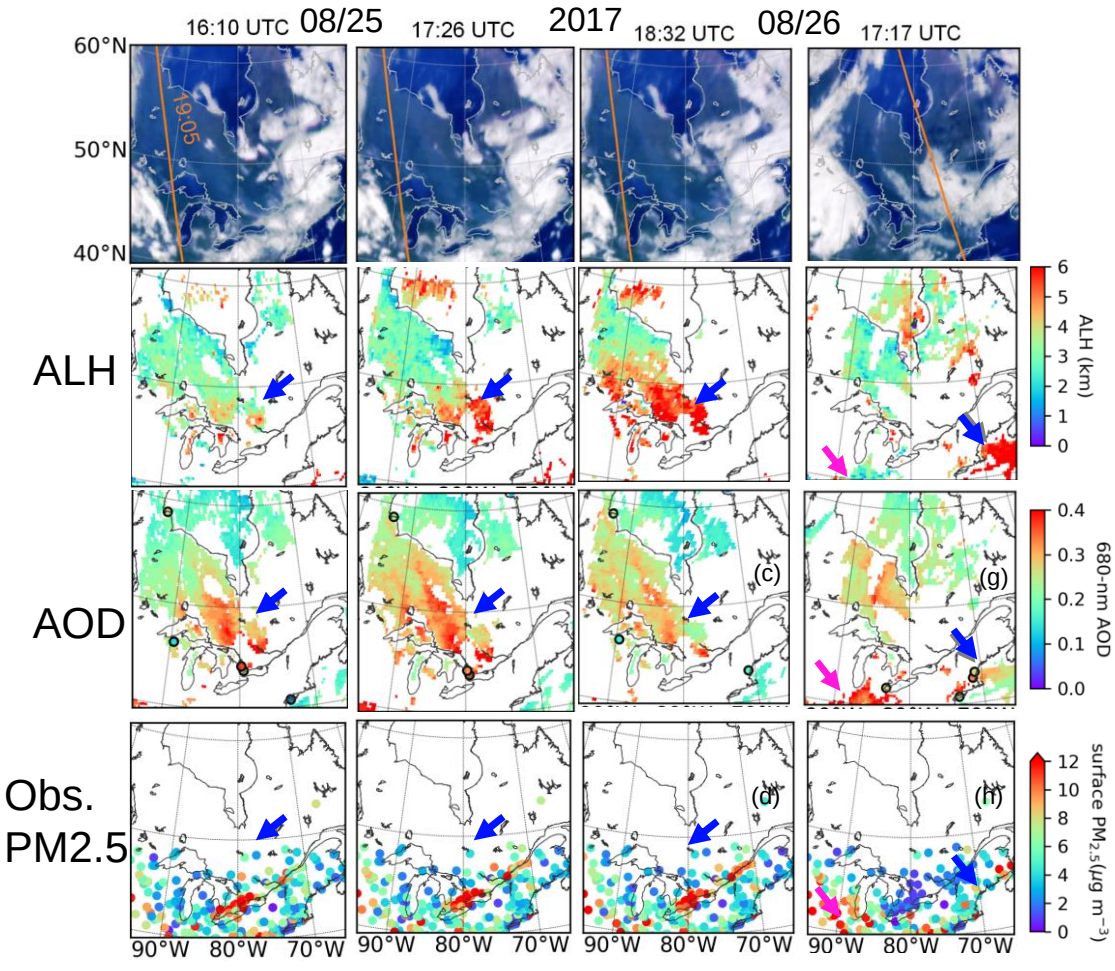
Oxygen absorption spectroscopy



$I_1 > I_2$

Implication to surface PM2.5 Air Quality Assessment

Xu et al., 2019, AMT



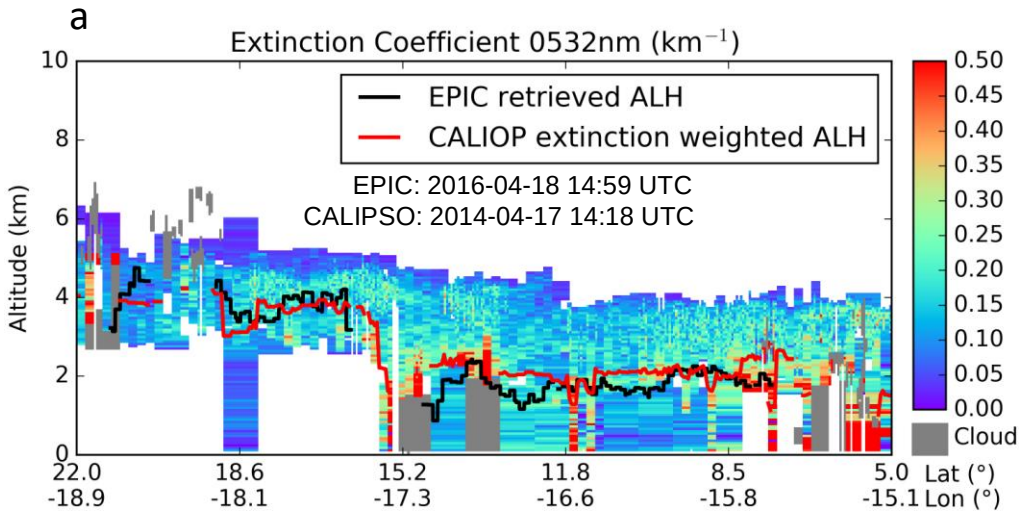
Location later affected by high AOD and descending layer of smoke

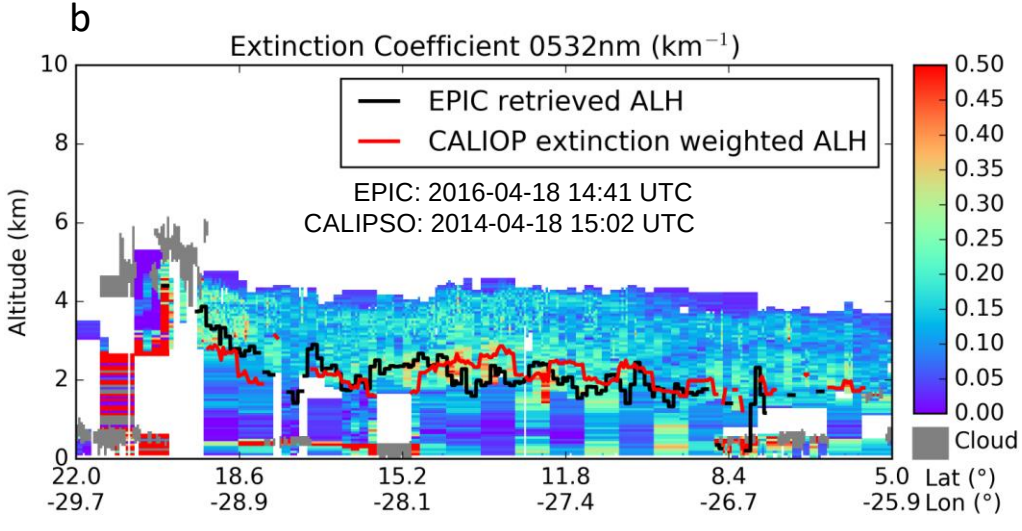
High surface PM2.5

Location later affected by high AOD and lofted layer of smoke

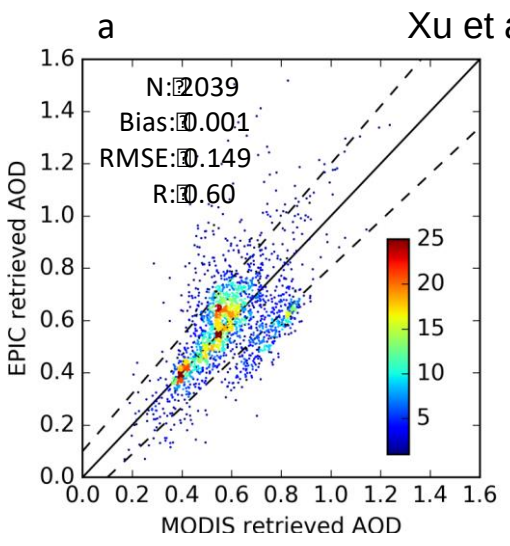
Low surface PM2.5

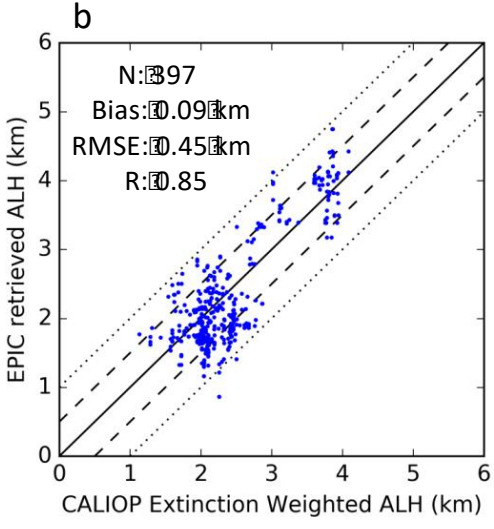
Validation with MODIS and CALIOP data





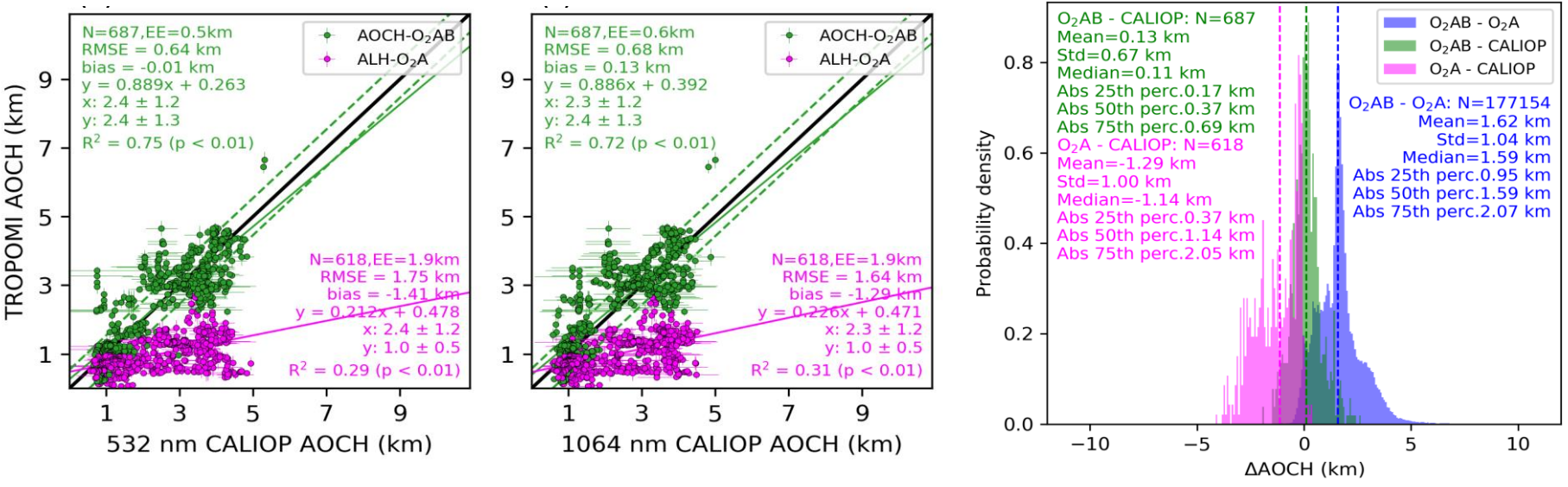
Xu et al., 2019, AMT





$$\mathrm{AOCH}_{\mathrm{CALIOP}} = \frac{\sum_{i=1}^{n} \beta_{\mathrm{ext},i}\, Z_i}{\sum_{i=1}^{n} \beta_{\mathrm{ext},i}}$$

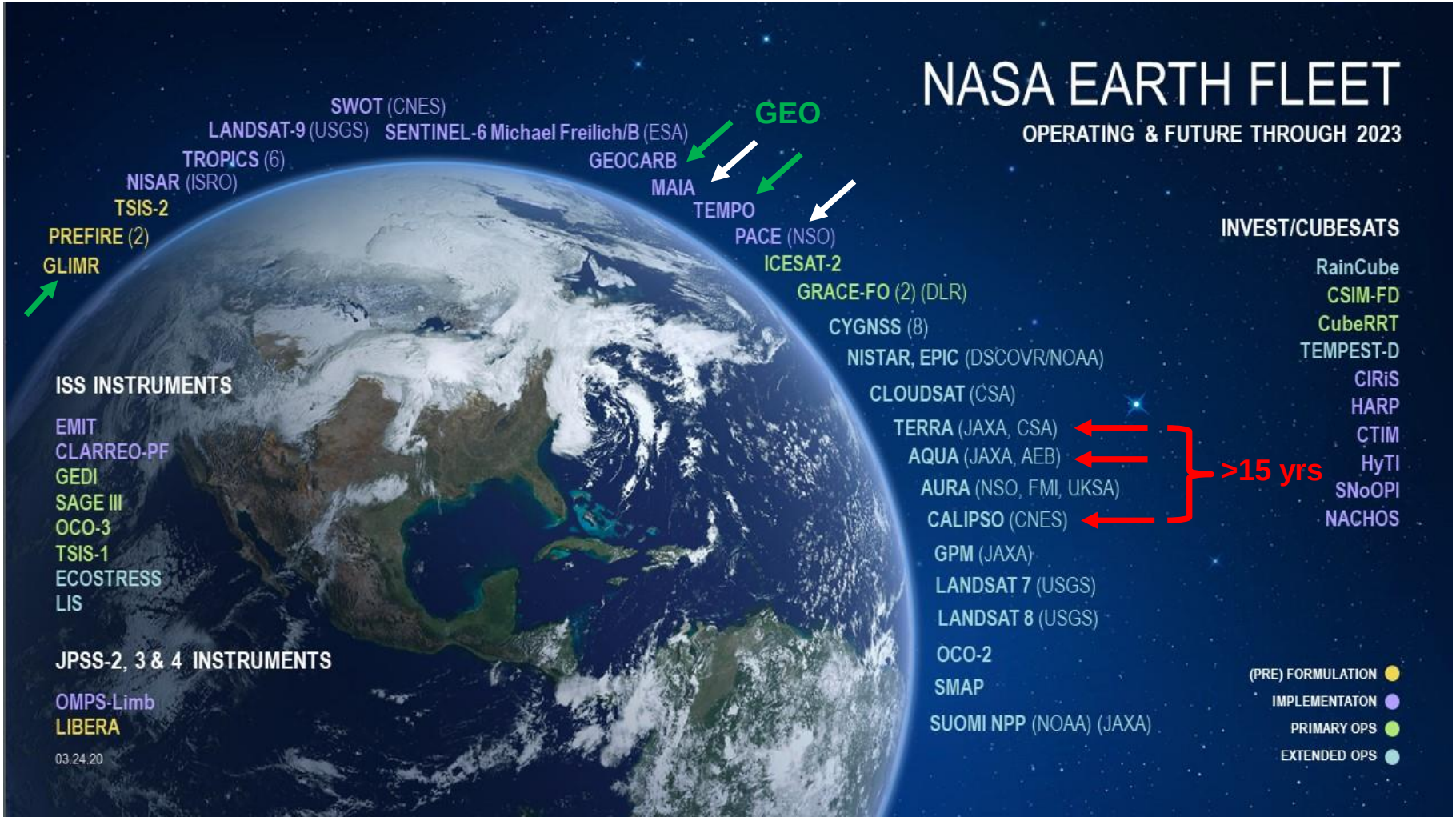
Validation

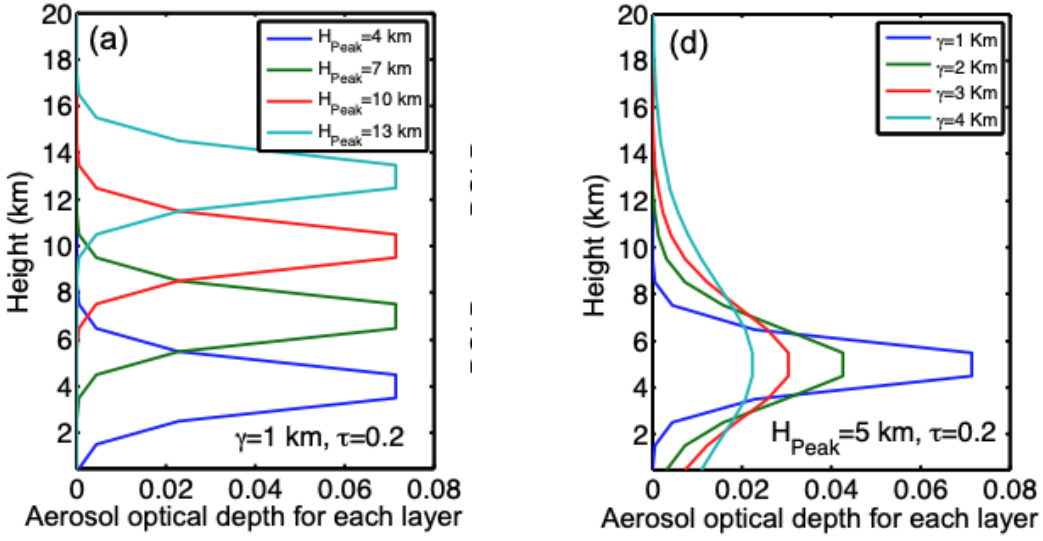


- TROPOMI operational ALH product based on O2 A-band has 1.5 km low bias (Nanda et al., 2020)

- This study using O2 A- and B-bands has mean bias of nearly zero in AOCH.

Thoughts for future directions



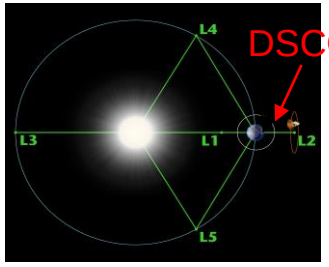


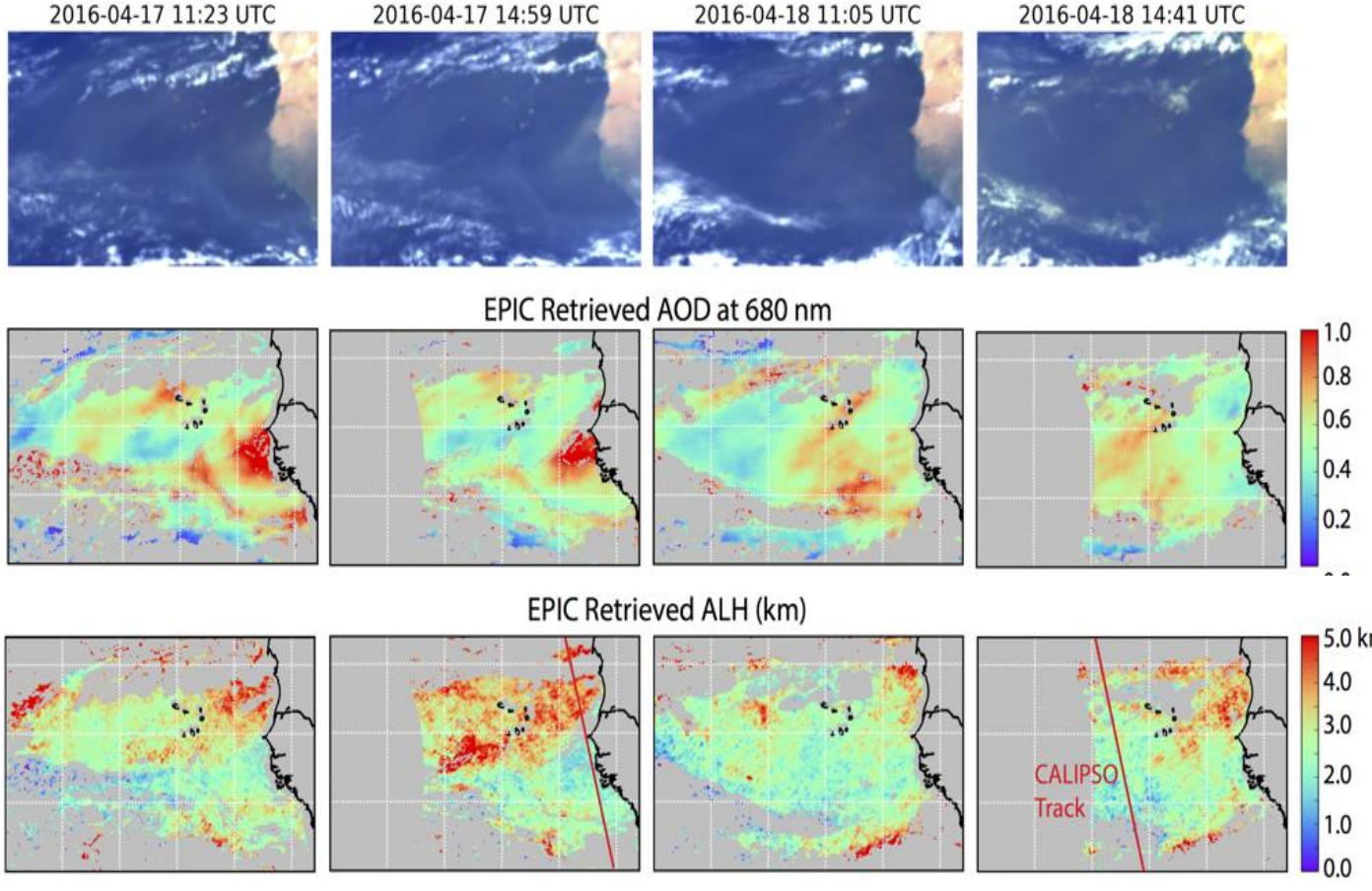
$$\tau_A(z) = K \frac{\exp(-\gamma|z - z_{peak}|)}{[1 + \exp(-\gamma|z - z_{peak}|)]^2} \tag{32}$$

where K is a constant related to τ_{a0}, γ is related to half-width constant σ by $\gamma = \ln(3+\sqrt{8})/\sigma$, and z_{peak} is the height having peak loading.

Ding et al., 2016, AMT

Retrieval of diurnal variation AOD from EPIC's O_2 A and B bands





- AOD field clearly indicates mass continuity; high close to the source, and low in downwind.
- ALH shows no relationship with AOD
- ALH varies 1 – 5 km.

Xu et al., 2017, GRL