

Overview of CALIPSO- Enabled Applications

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CALIPSO Mission Summary

Launched April 2006

Sun-synchronous polar orbit at 705 km

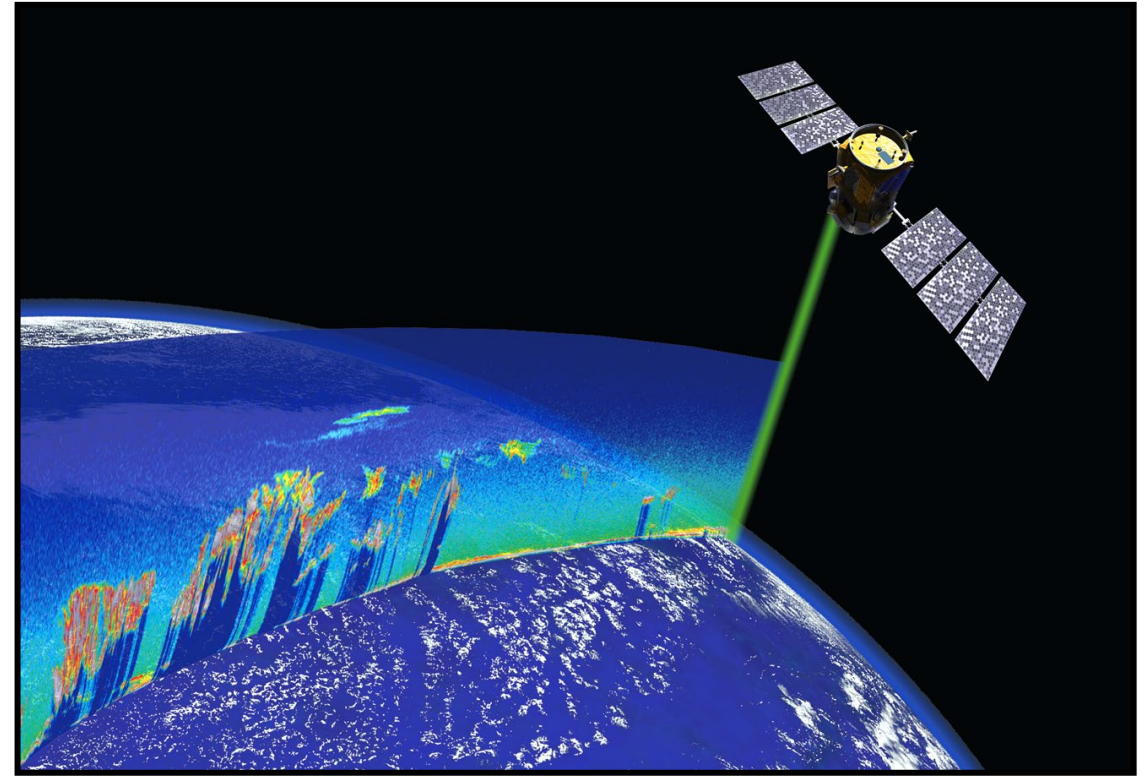
Equator crossing, 1:30 a.m./p.m.

CALIOP (elastic backscatter lidar):

- 532 nm, 1064 nm
- Depolarization at 532 nm

Current status:

- Spacecraft is healthy
- Science requirements of payload are still met
- Recent low laser energies in South Atlantic Anomaly
- End of science operations planned for September 2023



Primary data products

Level 1

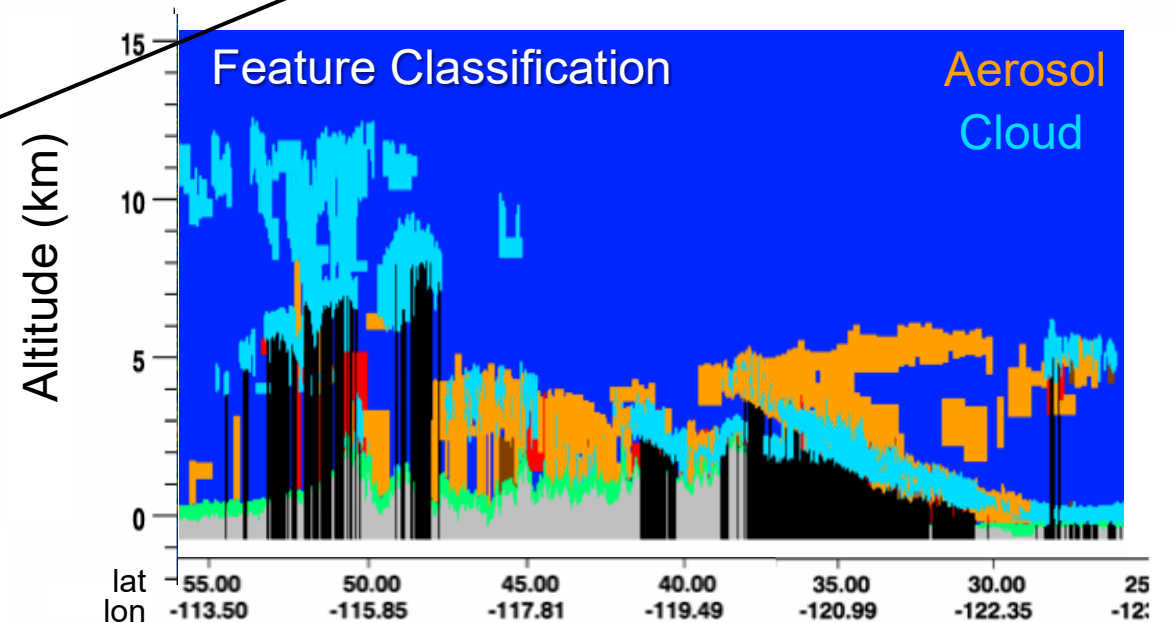
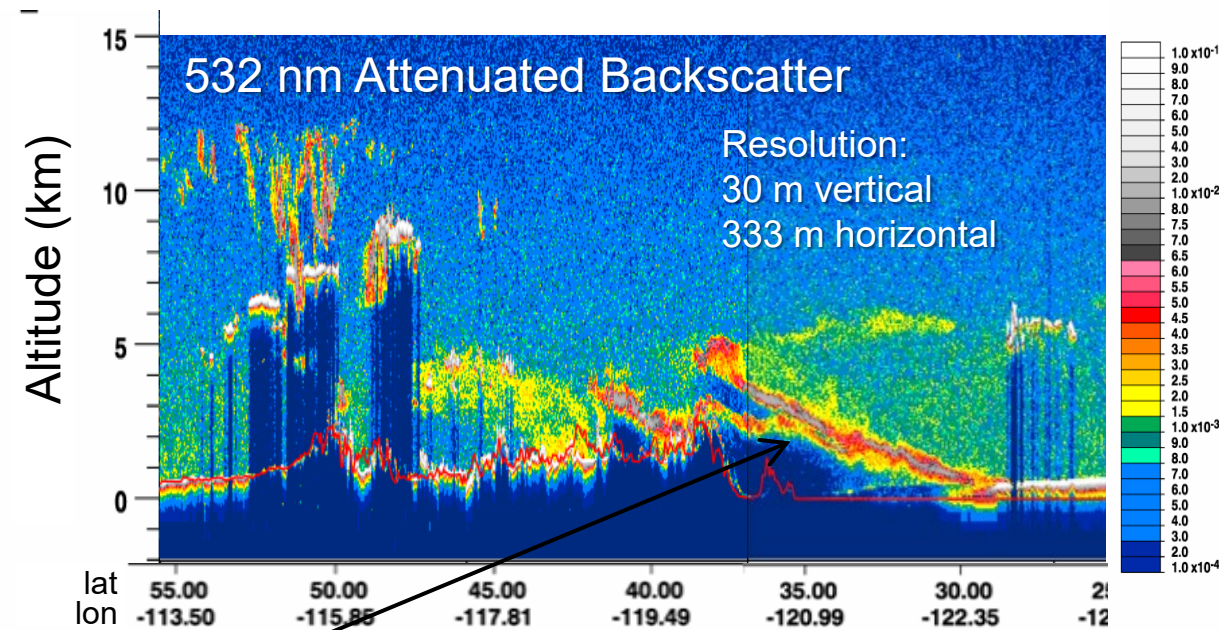
Attenuated backscatter at 532 nm and 1064 nm
Depolarization

Level 2

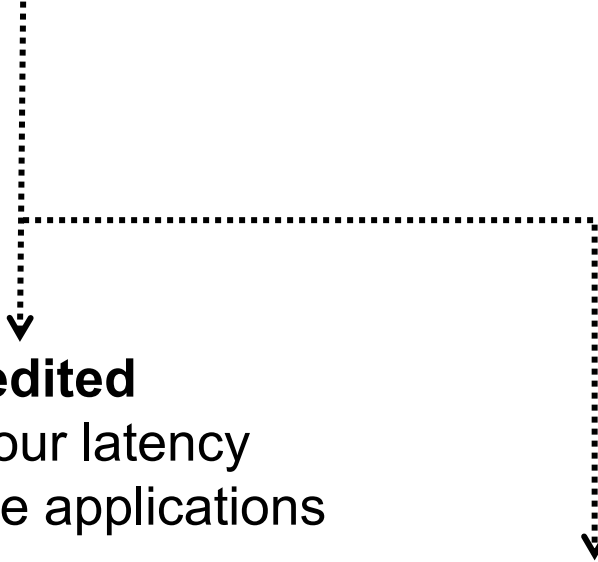
Layer top and base altitudes
Layer type (aerosol, cloud, surface)
Aerosol type, cloud ice-water phase
Vertical profiles of extinction



VIIRS/NPP, courtesy NASA Worldview



Data production streams

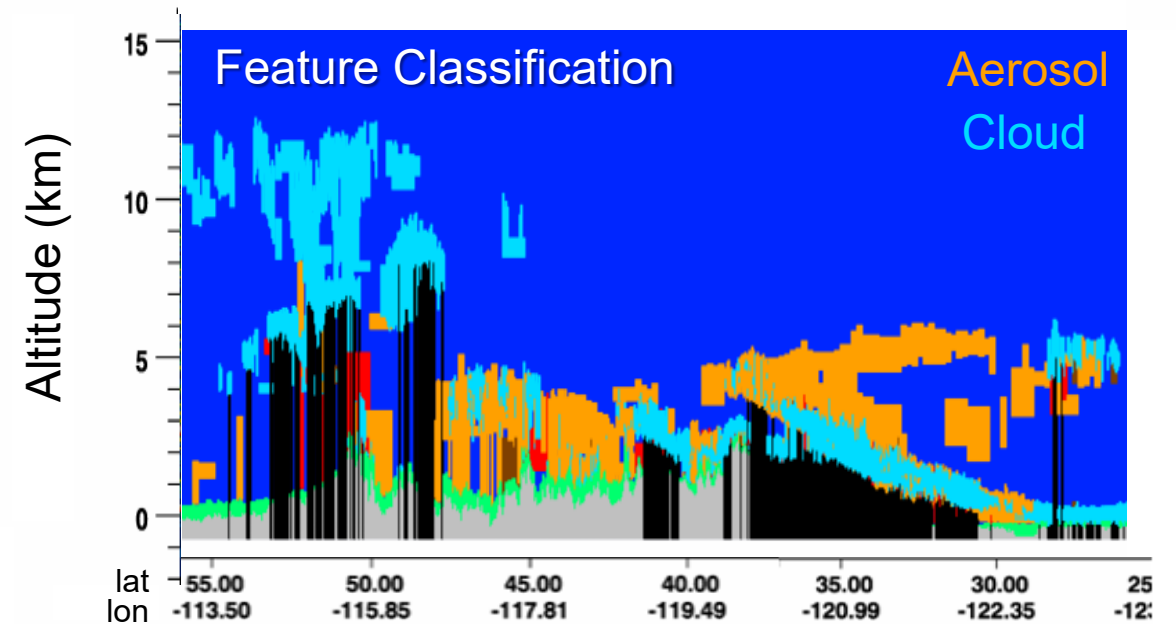
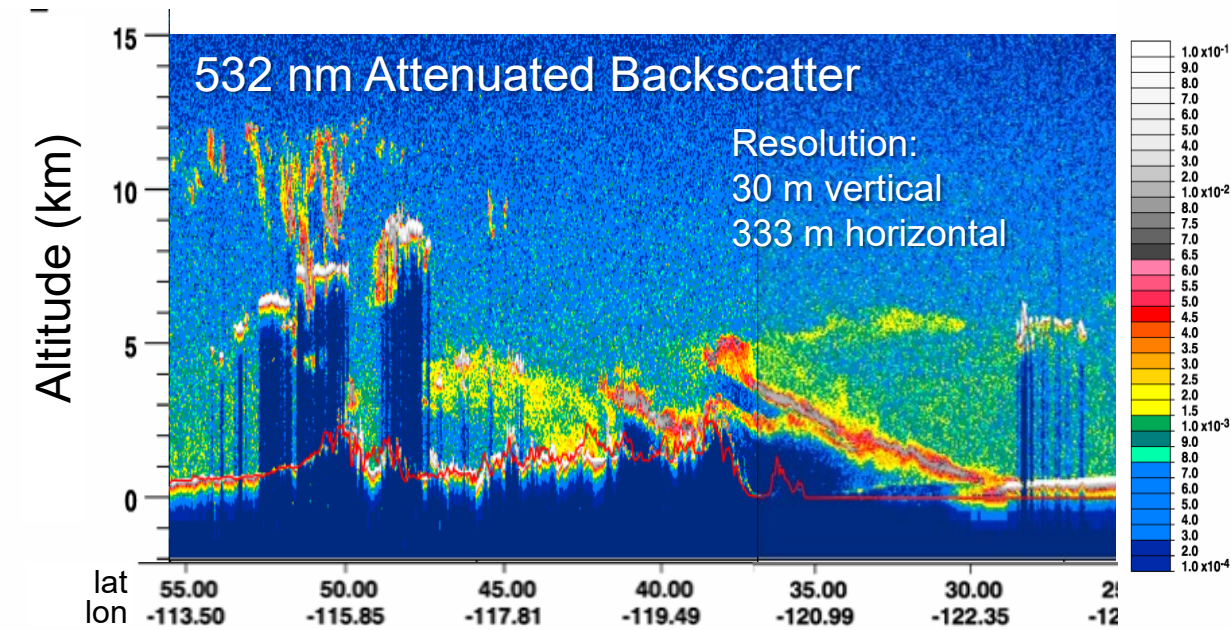


Expedited

12 – 24 hour latency
Near-real time applications

Standard

3 – 4 month latency
Science publication quality

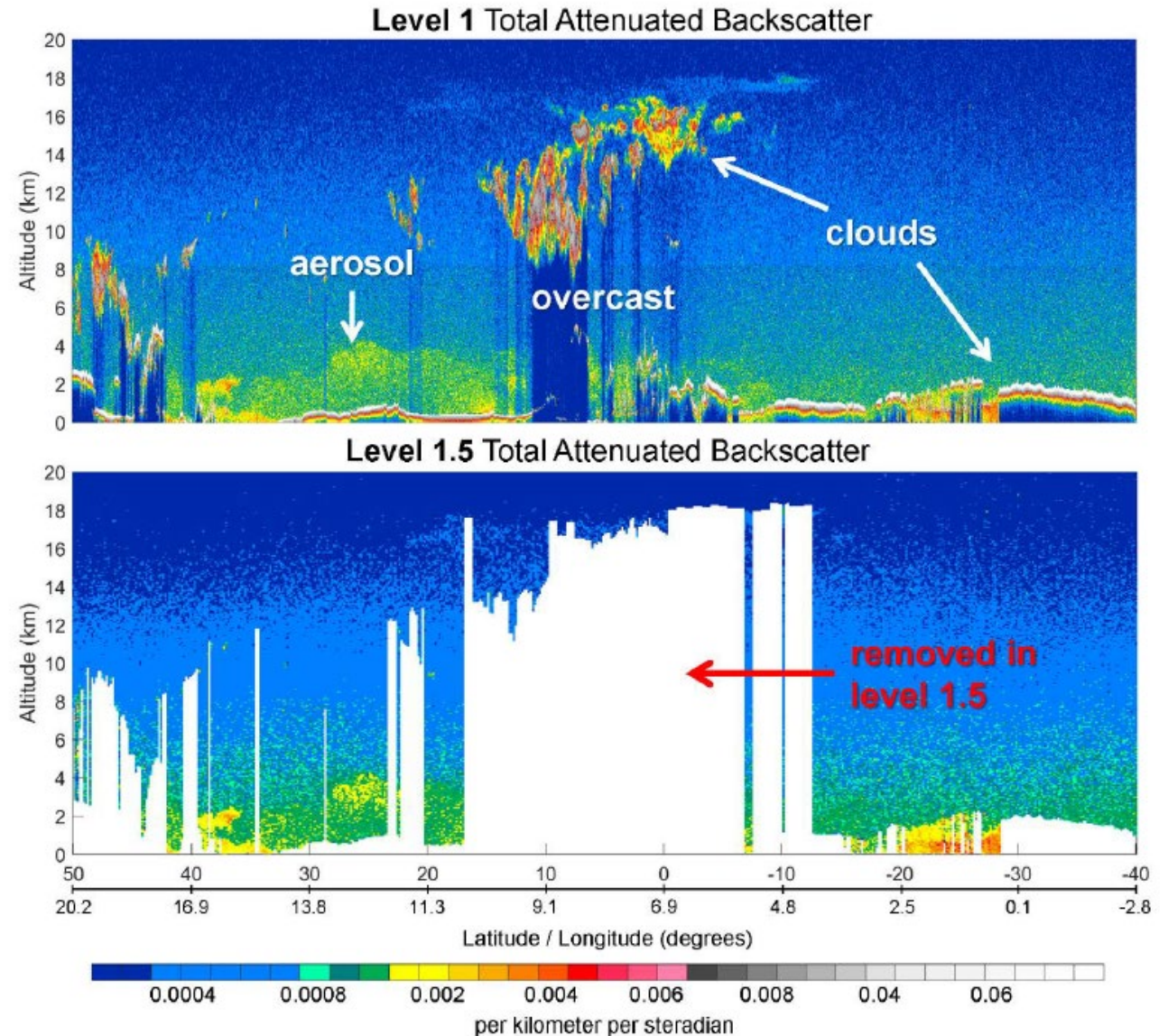


Level 1.5 expedited product

Intended for assimilation in aerosol forecasting models

- Cloud-cleared
- Coarsly-averaged
- Small file size (48 MB)
- FTP distribution

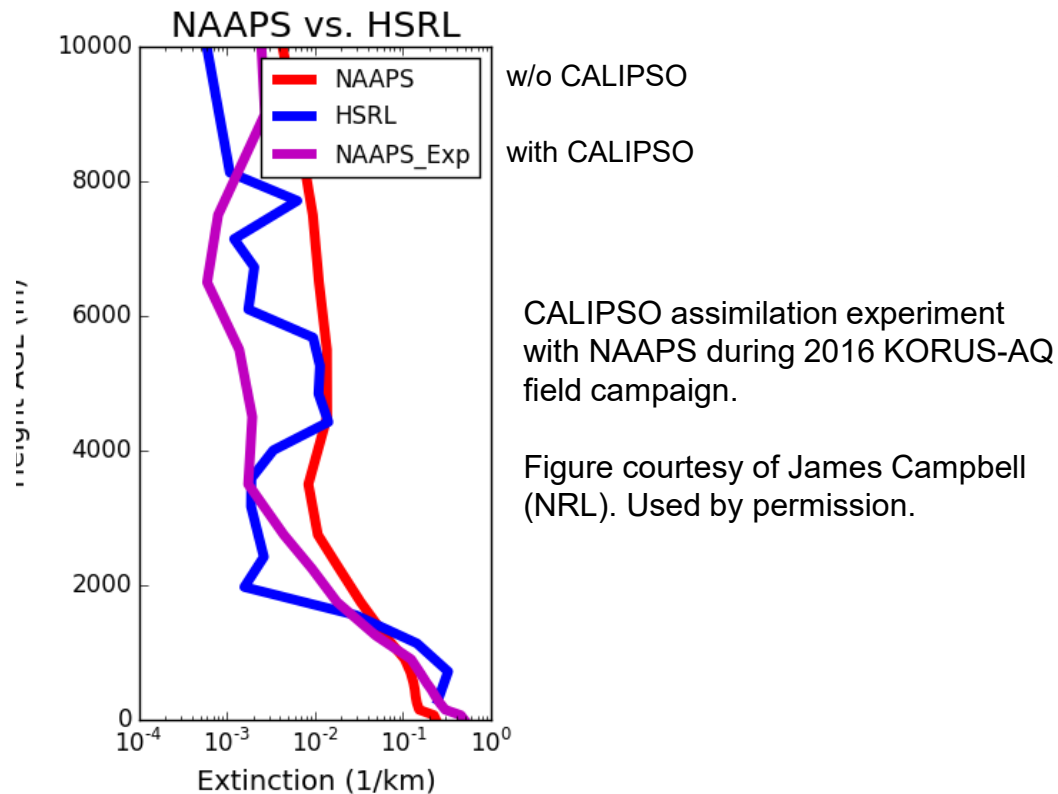
Designed in consultation with the International Cooperative of Aerosol Prediction (ICAP)



Aerosol assimilation and forecast models

CALIPSO's vertical observations of aerosol improves aerosol prediction models.

- CALIOP assimilation efforts for NAAPS – the Navy Aerosol Analysis and Prediction System (e.g., Campbell et al., 2010, Zhang et al., 2011)

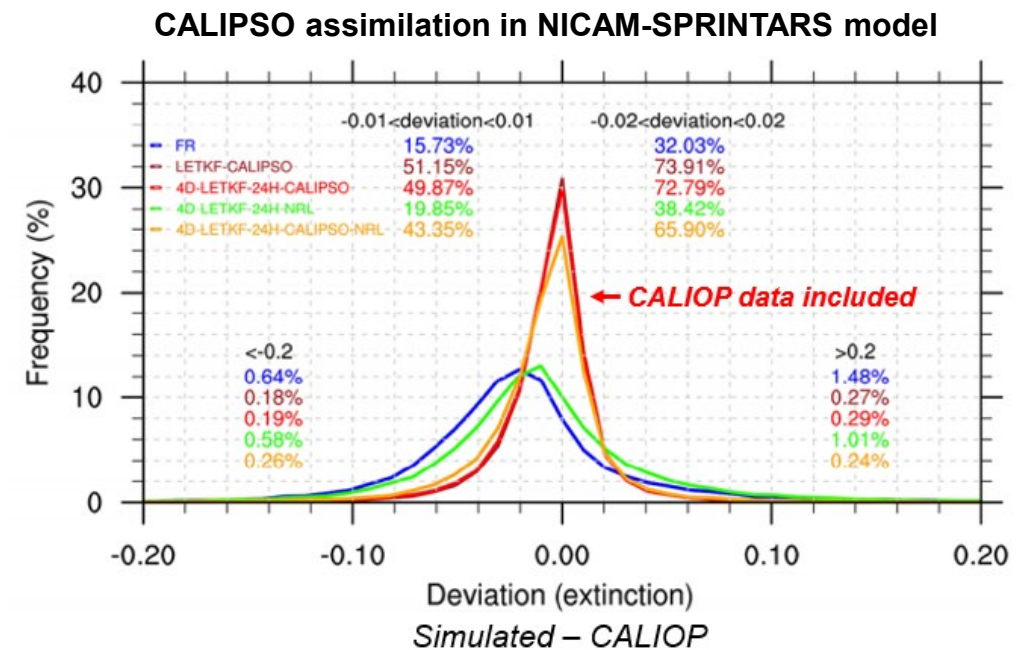


“... improves the vertical representation of the 00-hr aerosol analysis state in NAAPS, which is interpreted from improved globally-averaged AOD solved throughout the 48-hr model forecast...”

Aerosol assimilation and forecast models

CALIPSO's vertical observations of aerosol improves aerosol prediction models.

- European Centre for Medium-Range Weather Forecasts (ECMWF) assimilation experiments with CALIPSO level 1.5 and level 2 extinction (Angela Benedetti)
- Assimilation experiments with NICAM-SPRINTARS model atmospheric model (Cheng et al., 2019)



Adapted from Figure 2 of Chang et al., 2019. ([CC BY 4.0](#))

Cheng, Y., Dai, T., Goto, D., Schutgens, N. A. J., Shi, G., and Nakajima, T.: Investigating the assimilation of CALIPSO global aerosol vertical observations using a four-dimensional ensemble Kalman filter, Atmos. Chem. Phys., 19, 13445–13467, 2019.s

Smoke and ash transport modeling assessments

CALIPSO's vertical information on aerosol type, occurrence, and extinction enable validation of aerosol model forecast accuracy.

- CALIOP used to validate simulated plume heights for smoke and volcanic ash by the HYSPLIT model (Crawford et al., 2016).
- Used to validate 3D extent and movement of smoke within the NCEP GEFS-Aerosol model.

Smoke plume injection height validation:

- CMAQ injection heights assessed using backward trajectories connecting CALIOP smoke observations to MODIS fire detections (Baker et al., 2018).
- Machine learning and CALIOP observations used to create a predictive model for smoke injection height and risk of population exposure (Yao et al., 2018).

Air quality model evaluation

Model assessments:

- CALIOP AOD and aerosol extinction used to validate aerosol dispersion accuracy of the Regional Atmospheric Modeling System-CMAQ (Wu et al. 2017)
- CALIOP-derived PBL heights used to evaluate those predicted from WRF by the Ozone Transport Commission, a multi-state organization that advises the EPA on ozone-related issues in the NE and mid-Atlantic U.S.
- CALIOP used to characterize biases for upper-troposphere smoke forecasts in NOAA's Real-time Air Quality Monitoring System (RAQMS) .

Air quality assessments

Exceptional event analyses:

- Chattanooga/Hamilton County Air Pollution Control Bureau
- Texas Commission on Environmental Quality
- Georgia Department of Natural Resources

Accessibility of CALIPSO data for AQ analyses:

EPA's Remote Sensing Information Gateway (RSIG-3D)

<https://www.epa.gov/hesc/remote-sensing-information-gateway>

Aviation safety

Darwin Volcanic Ash Advisory Center (VAAC)

- Uses vertical information of CALIOP expedited imagery
- CALIPSO ash detections used to verify and calibration ash forecasts from the BoM's ACCESS model (Zidikheri et al., 2018)

Validation of volcanic aerosol height retrievals

- European Natural Airborne Disaster Information and Coordination System for Aviation (EUNADICS-AV)
- SCOPE-Nowcasting Volcanic Ash Algorithm Intercomparison project

Aircraft icing forecasts

- CALIPSO/CloudSat DARDAR product used to validate aircraft icing products used by NWS and NOAA's Aviation Weather Center.

Clouds and numerical weather prediction

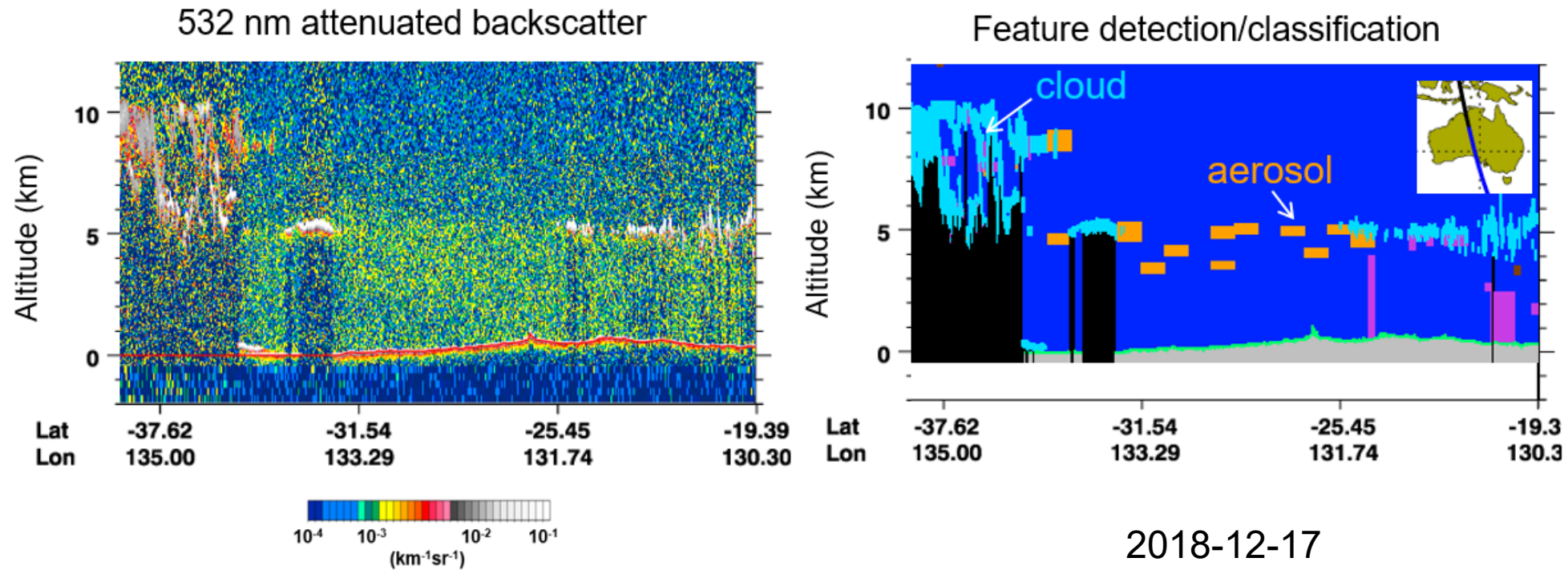
CALIPSO is an important validation source and algorithm development asset for operational geostationary meteorological satellites.

- Cloud observations are used for developing retrieval algorithms for cloud masks, ice-water phase, and layer height (e.g., Noh et al., 2017, Min et al., 2020).
- Cloud detections provide validation for atmospheric motion vector retrievals from Meteosat-10, Himawari-8, and the Geostationary Korea Multipurpose Satellite (Folger and Weisman 2016, Oh et al., 2019, Santek et al., 2019).
- Cloud observations are used to identify biases from undetected clouds in operational satellite data products that are ingested into NWP weather models (e.g., Huang et al., 2019, Marquis et al., 2017).

Where does CALIOP struggle?

- Optically thin aerosol over high albedo surfaces in the daytime

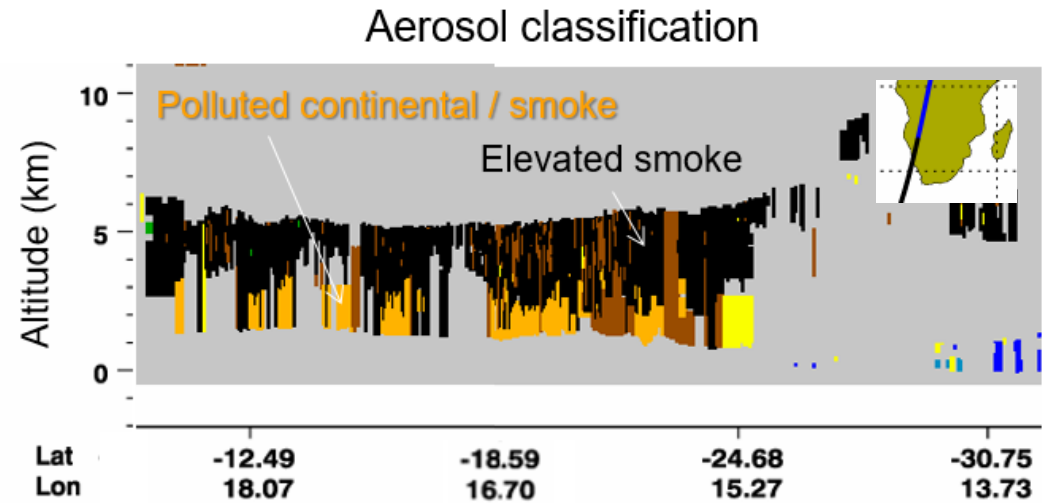
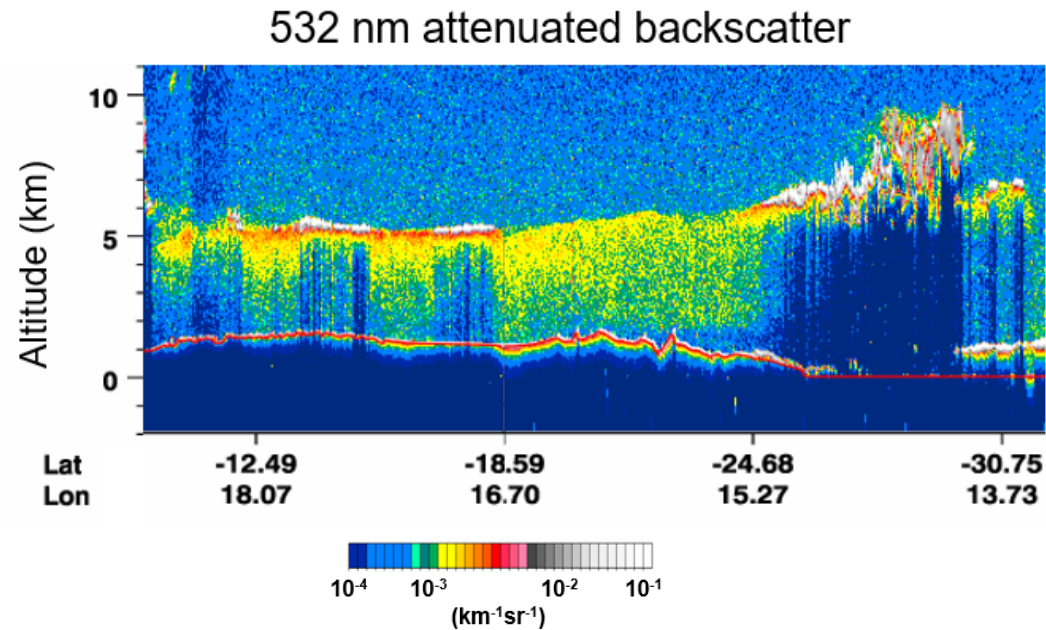
CALIPSO daytime observation over Australian desert



Where does CALIOP struggle?

- Optically thin aerosol over high albedo surfaces in the daytime
- Discriminating between near-surface smoke and urban pollution
 - Similar optical properties (low depolarization, preferential attenuation at 1064 nm)

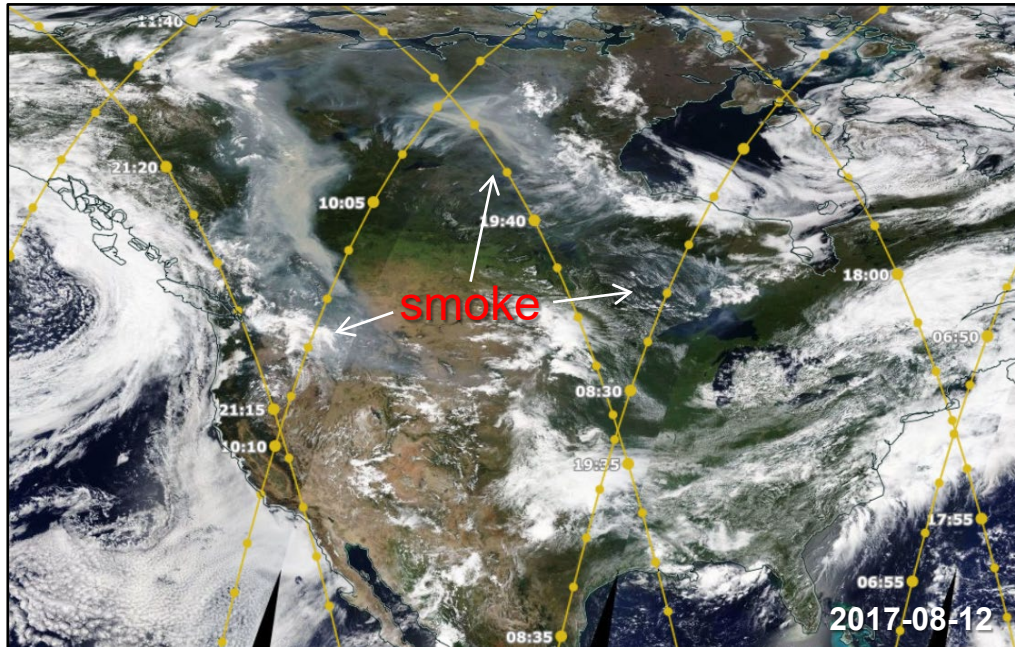
CALIPSO aerosol classification over southern Africa



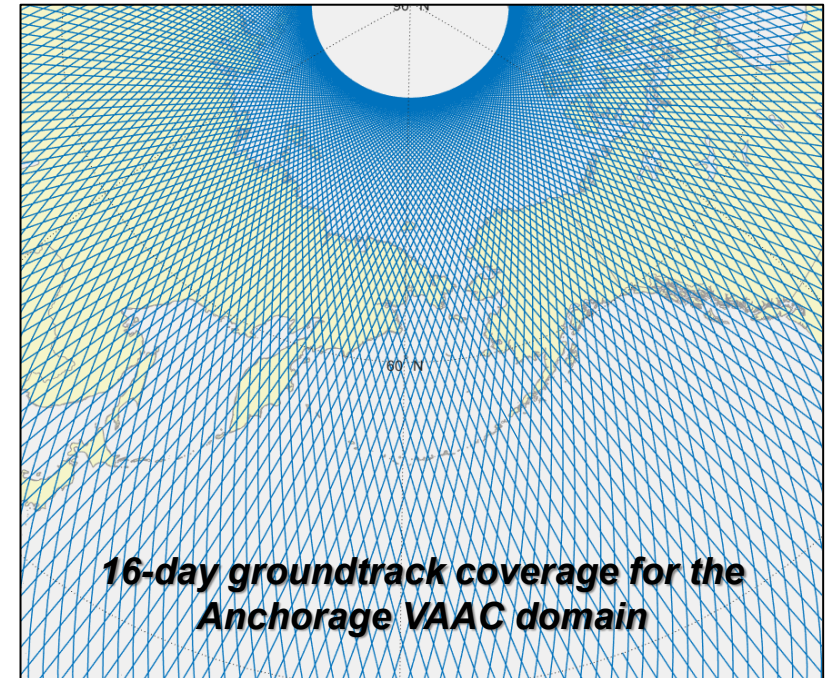
2014-09-21

Where does CALIOP struggle?

- Optically thin aerosol over high albedo surfaces in the daytime
- Discriminating between near-surface smoke and urban pollution
 - Similar optical properties (low depolarization, preferential attenuation at 1064 nm)
- Coverage, but not really...*the narrow swath of the laser beam is not a deal-breaker.*



MODIS Terra, CALIOP groundtracks. Courtesy NASA Worldview



Summary

The primary contribution of CALIPSO to applications is in the validation and development of tools used by operational agencies and for post-event analyses.

Vertical layer detection and cloud/aerosol discrimination are the most valued assets for applications.

Thanks!

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