Determining and modeling the source and transport of aerosols through the use of CALIPSO

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Outline

- What is CALIPSO? (Recap)
- How is it used to monitor aerosols?
- Vertical Feature Masks (VFM)
- Feature Classification Flags
- Paper 1
- Paper 2
- Example Data Analysis
- Little bit into how CALIPSO can be used to study biological oceanography

What is CALIPSO? (RECAP)

- The Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observation (CALIPSO)

- Aerosol particles form through a combination of physical, chemical, and biological processes (Coakley et al., 1983)

- Aerosols can impact climate directly through the absorption and scattering of solar radiation

- Aerosols can indirectly affect climate through serving as cloud condsenation nuclei and affecting the formation of clouds (Pio et al., 2007; Winker et al., 2010).

- CALIPSO is used to ascertain the role of aerosols in shaping Earth's weather, climate, and air quality

How is CALIPSO used to study aerosols?

- Equipped with a payload of three nadir-viewing instruments
- Builds on top of Lidar In-space Technology Experiment (LITE)
- Two-wavelength polarization-sensitive lidar tools
- The Cloud-Aerosol Lidar with Orthogonal Polarization (CALIOP) – primary instrument
- CALIOP provides vertical profiles of total backscatter at the 1064 nm and 532 nm wavelength thereby deriving profiles of aerosol type and clouds
- Provides fine vertical and horizontal resolution in forming global views and constructions of aerosol distribution

What are vertical feature masks (VFM)?

- Vertical feature masks are useful in my data analysis – Image from Jia et al., 2015

- Describes the vertical and horizontal distribution of cloud and aerosol layers observed by the CALIPSO lidar

- Range bin characterized by a single 16-bit integer

- Various bits in the integer represent flags

- Flags describe some aspect of the data that is measured

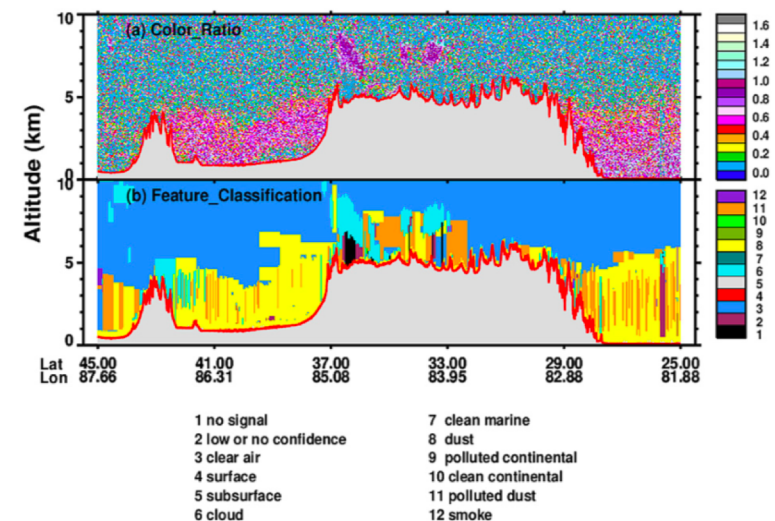- Image describes partitioning between aerosol subtypes within a VFM

Fig. 3. The altitude-orbit cross-section of the color ratio (a) and classified particles (b) on 15 June 2009 along the CALIPSO orbit path.

What are feature classification flags?

- For each layer detected in CALIPSO backscatter data, feature classification flags are derived

- These flags report:
  - Feature type (cloud vs aerosol vs stratospheric layer
  - Feature subtype
  - Ice-water phase (clouds only)
  - Amount of horizontal averaging required for layer detection

Bits	Field Description	Bit Interpretation
	Feature Sub-type	
10-12	If feature type = aerosol, bits 10-12 will specify the aerosol type	0 = not determined 1 = clean marine 2 = dust 3 = polluted continental 4 = clean continental 5 = polluted dust 6 = smoke 7 = other

Paper 1: Source and transportation of summer dust over the Tibetan Plateau (Jia et al.)

- Situated in TP

- Black line indicates CALIPSO Orbital Path

- CALIPSO used to detect that the TP is subject to heavy loading of dust aerosols during the summer

- Source and transportation of dust observed from the Taklimakan Desert, Gurbantunggut Desert, and Great Indian Thar Desert
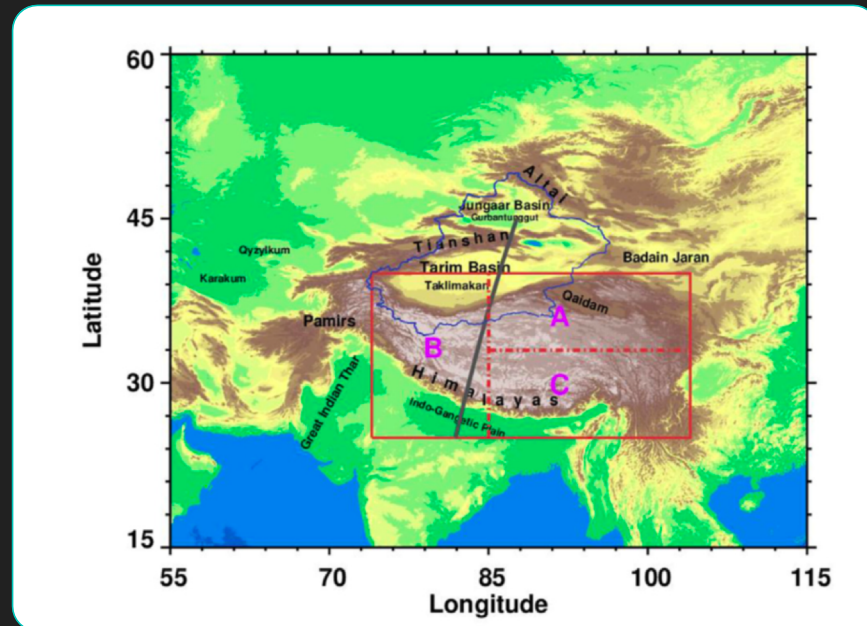
Jia et al. continued

- Gray indicates topography of TP

- Aerosols are green-yellow-orange

- Clouds white-gray

- Aerosol optical depth – measure of how much light prevented from reaching ground by aerosol particles
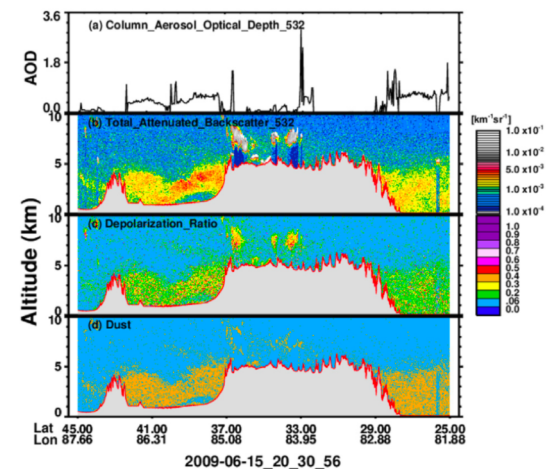
- Dense dust plumes observed

Fig. 2. Aerosol optical depth at 532 nm of the entire air column (a), altitude-orbit cross-sections of the total attenuated backscattering coefficient at 532 nm (b), depolarization ratio (c) and the detected dust particles (d) on 15 June 2009 along the CALIPSO orbit path.

Jia et al. continued

- Feature classification flags!

- Focus on VFM

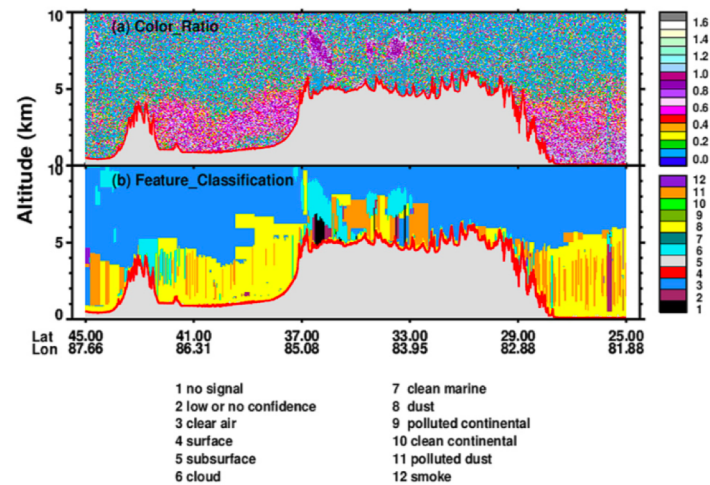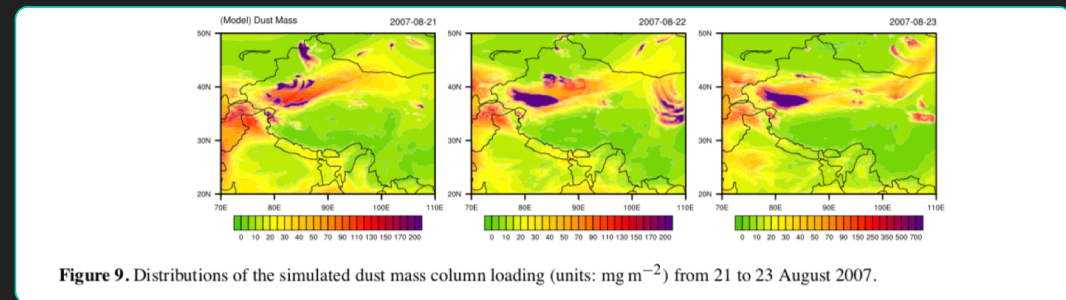- Thick dust plumes on both northern and southern slope of TP

Fig. 3. The altitude-orbit cross-section of the color ratio (a) and classified particles (b) on 15 June 2009 along the CALIPSO orbit path.

Paper 2: Modeling study on the transport of summer dust and anthropogenic aerosols over the Tibetan Plateau (Liu et al., 2015)

- Very similar to Jia et al., 2015 (coauthors on both papers)

- Primarily a modeling and simulation study

- Studied the properties of aerosols in the TP

- Constructed models of aerosol transport and compared simulated results with satellite observations

- CALIPSO used to detect dust events through profiles of total attenuated backscatter in 532 and 1064 nm channel

- Also studied transport of dust

Figure 9. Distributions of the simulated dust mass column loading (units: mg m^{-2}) from 21 to 23 August 2007.

How might CALIPSO be used to study biological oceanography?

- I am interested in determining associations between microbial community structure and aerosol formation with CALIPSO

- No good reference information of something similar attempted besides dust

- Volatile organic compounds produced by biological activity

- The formation of aerosols from VOC released by terrestrial biota has been well-explored

- Despite considerable effort, major questions remain in examining aerosol formation from biogenic marine VOC (Hu et al., 2013).

- The incomplete characterization of the role of ocean ecology is seen as a major obstacle for the improved understanding of radiative balance and its effect on global climate (Vallina et al., 2006).

Example Data Analysis

CALIPSO LIDAR backscatter in the context of ocean color:

- By linking such data on a global scale, with an additional element of microbial diversity, we can better understand the ecological mechanisms underlying aerosol production in the marine environment.
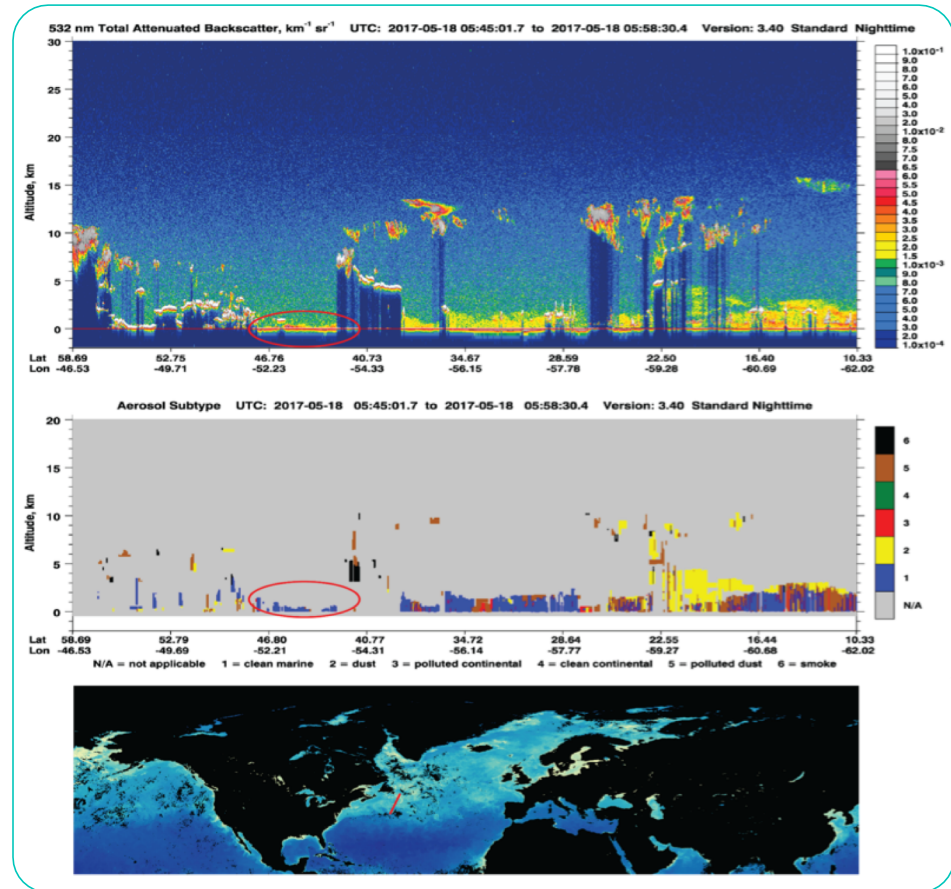
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