Regionally Variable Dust Lidar Ratios Using CALIOP Measurements and Model Simulations

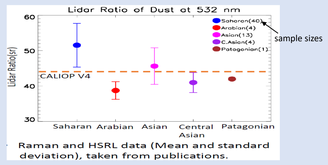
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[5]NASA Goddard Space Flight Center, Greenbelt, MD

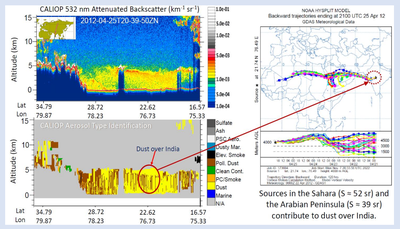
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- Extinction retrievals from the backscatter measurements by CALIOP mostly use a constant lidar ratio (LR), globally. For dust 44 sr is used in version 4.
- Raman lidars and HSRL retrievals suggest significant variation of dust LR depending on sources, due to differences in mineralogy.
- We present a scheme to derive regionally variable dust lidar ratios which could be of use for CALIOP reprocessing and for future space borne elastic lidars.

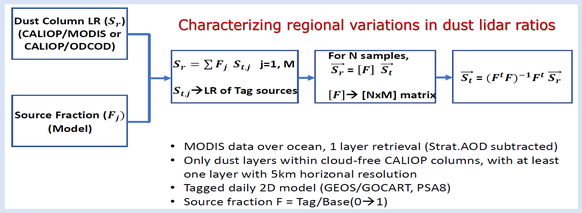
Regionally Variable Dust Lidar Ratios



- Dust LRs from Raman and HSRL show significant regional variations

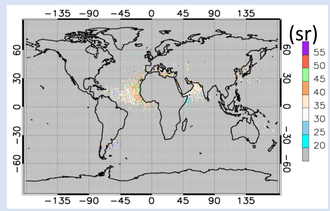


- Regional dust sources with different LR can contribute to observed dust at any location —> Dust mixture

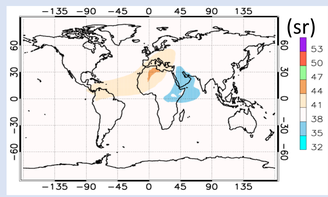


- ---Estimate column LR (S_r) by constraining the CALIOP attenuated backscatter from a column with only dust by independent estimate of AOD, either from collocated MODIS data or from the recently released Ocean Derived Column Optical Depth (ODCOD).
  ---Calculate mass fraction of dust in the column from different sources from GEOS-GOCART model (F_j) runs tagged to sources.
  ---Assume the estimated column LR to be a linear combination of LRs from the different regional sources (S_t).
  ---Retrieve S_t using CALIOP and model data over the mission period.
- Climatological regional source LRs (S_t) combined with the model fractions (F_j) provide mixed (variable) dust LRs anywhere on the globe or use in extinction modules.

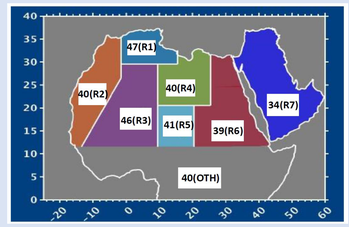
Regionally Variable Lidar Ratios using CALIOP and MODIS



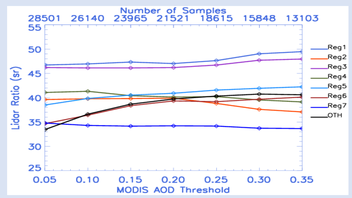
- Column LRs from of dust from CALIOP backscatter and collocated MODIS AOD for 2006-2013 (AOD>0.2)



- Global variable dust LRs using S_t and climatological mass fractions for the source regions.



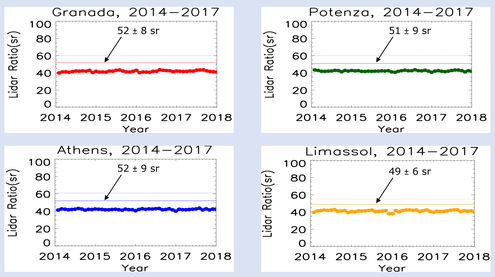
- Retrieved dust LRs (S_t) for 7 primary source(R1-R7) regions tagged by GEOS-GOCART model. OTH stands for all sources outside the primary ones.



- Higher AOD thresholds generally lead to similar values of tagged LRs for most regions.

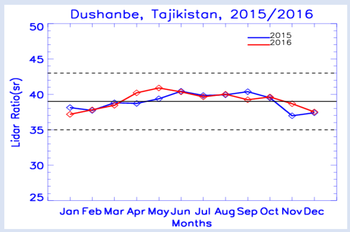
Preliminary Assessment of Variable Dust Lidar Ratios

Saharan Dust



- Comparison of lidar ratios of Saharan dust derived using the regional lidar ratios and corresponding model fractions (dots) with those from Raman lidars (solid lines are means over 2014-2017 and dashed lines are uncertainties) at 4 EARLINET stations (Soupiona et al., 2020; https://doi.org/10.5194/acp-20-15147-2020). The derived lidar ratios show a persistent low bias at all stations and the reason is not clear at this time.

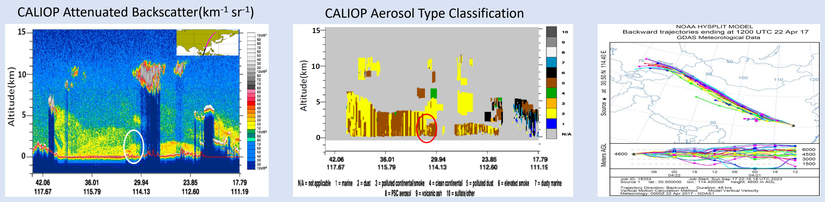
Central Asian Dust



- Dust lidar ratio at Dushanbe, Tajikistan for various months during 2015-2016 as calculated from tagged LR and model fractions. The solid black line shows the LR retrieved from Raman lidar during the CADEX campaign, with the dashed lines showing the reported uncertainties (Hofer et al., 2020; https://doi.org/10.5194/acp-20-9265-2020).

Taklamakan Dust

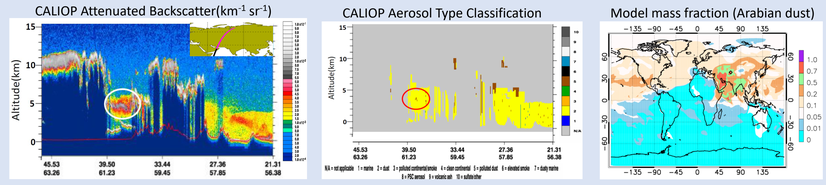
2017-04-22T18-16-53ZN



- Dust over China as seen by CALIOP on April 22, 2017.
- Raman lidar at Wuhan (30.5°N,114.4°E) on this day retrieved 48±8 sr for dust (Peng et al., 2021; https://doi.org/10.1364/OE.427864).
- Back trajectories from Wuhan show Taklamakan as the source.
- Using retrieved tagged LRs and model fractions for this day give LR of 40 sr.

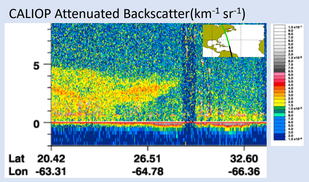
Arabian Dust

2015-04-13T21-59-16ZN

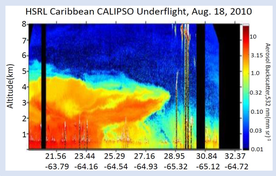


- Raman lidar at Dushanbe (38.5°N, 68.8°E) detected dust plumes on April 13, 2015 between 2-5 km (Hofer et al., 2017; https://doi.org/10.5194/acp-17-14559-2017).
- CALIOP also measured strong dust layers in nearby areas (red circle) near 2-5 km (left and middle).
- Model dust mass fractions for this day show outflow of dust from Arabian deserts accounting for ~72% of dust at Dushanbe (right, diamond)
- Tagged LRs and model fractions yield a LR of 36 sr in agreement with Raman lidar retrieval.

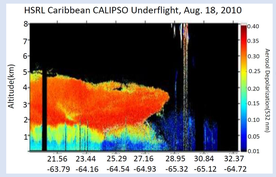
CALIOP/HSRL validation flight, 2010-08-18T17-19-08ZD



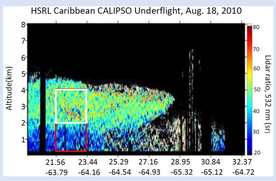
- CALIPSO total attenuated backscatter shows strong aerosol plume over the Caribbean.



- collocated HSRL backscatter shows very similar plume structure.



- High depolarization ratios from HSRL suggest non-spherical dust particles.



- For data within white box, mean LR from HSRL = 49 ± 8.4 sr
- For data within red box, mean LR from HSRL = 42 ± 11.3 sr
- Using retrieved tag lidar ratios and model dust mass fractions→ 44sr, in close agreement with HSRL.