**What is the uncertainty in MODIS aerosol optical depth in the vicinity of clouds?**

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**Introduction**

- MODIS dark-target (DT) algorithm retrieves aerosol optical depth (AOD) using a Look Up Table (LUT) approach
- Global comparison of AOD (collection 6) with ground-based sun photometers gives an Estimated Error (EE) of ±0.04 (10%) over ocean. However, EE does not represent per-retrieval uncertainty
- For retrievals that are biased high compared to AERONET, here we aim to closely examine the contribution of biases due to presence of clouds and per-pixel retrieval uncertainty

**Approach**

- We calculate the per-pixel retrieval uncertainty from:
  a) Atmospheric correction  
  b) Variability in reflectance in 10 km retrieval area  
  c) Aerosol model assumption  
  d) Surface albedo  
  e) Cloud contamination or enhanced radiation in vicinity of clouds
- Our aim is to quantify the uncertainty in retrieved AOD due to as many different sources as we can and identify the relatively dominant source of uncertainty in AOD retrieval

**Per-Pixel Retrieval Uncertainty**

**Validating Per-pixel Retrieval Uncertainty**

When compared to ground-based AERONET sun-photometers, clearly the performance of the algorithm is different over various regions and seasons.

- For most data-points within the EE envelope (dashed lines), the uncertainty is within EE of retrievals over ocean
- For retrievals with high uncertainty, the AERONET AOD standard deviation is large in many cases and there are exceptions to this too
- For outliers, the per-pixel uncertainty is necessarily large — lets take a close look at an outlier below

**Cloud Contamination Issue**

- Cloud-contaminated pixels are indicated by the normal distribution of AOD difference (Δτ) = (τ - τ0) of MODIS AOD retrieval. The uncertainty in retrieved AOD seems to lie mostly within ±0.05

**Exercise 2: Investigating Reflectance “Sorting” in Clear and Cloudy Areas**

- Sorting: Standard retrieval uses clear-sky (cloud masked) pixels, keeps only 5% – 7.5% and calculates mean reflectance (filtered reflectance)
- Here we examine AOD retrieved from filtered (C6, AOD) vs. Unfiltered reflectance
- AOD difference in (i) Clear-sky areas is less than 0.004 (ii) Cloudy regions is mostly within ±0.05

**Exercise 1: Results**

- Notice blues and reds in spatial distribution of AOD difference  
  - [Figure 3a]: there is low and high bias around cloudy regions  
  - AOD Difference Histogram (Figure 3b) shows:
    - Gaussian shape  
    - Δτ = ±0.05  
    - Most differences within ±0.03  
    - Reasonable overall cloud screening  
    - Low Quality flags => Clouds contamination

**Conclusions**

- We have characterized AOD uncertainty at 550 nm, due to standard deviation of reflectance in 10 km retrieval region, uncertainty related to gas (H2O, O3) absorption, surface albedo, and aerosol models
- The uncertainty in retrieved AOD seems to lie within the estimated over ocean error envelope of ±0.03 +10%
- Regions between broken clouds tend to have higher uncertainty
- Compared to C6 AOD, a retrieval omitting observations in the vicinity of clouds (≤ 1 km) is biased by about ±0.05  
- For homogeneous aerosol distribution, clear-sky retrievals show near zero bias
- Close look at per-pixel reflectance histograms suggests retrieval possibility using median reflectance values

**Future Work**

- Develop statistics and perform a global land - ocean evaluation of as many uncertainty sources as we can
- Further investigate uncertainty due to biases from cloud, snow contamination

**References**

- Cox, C., and W. Munk, Slopes of the sea surface deduced from the photographs of sun glint, Bull.SulpStn.Wheaton.Oceanog.6,40 – 488, 1956

**Questions?**

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