A new perspective on aerosol direct radiative effects in South Atlantic and Southern Africa

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Outline

• Motivation
• Data and methods
• Results
• Summary

Biomass burning in Southern Africa

Field experiments 2016-2018

Zuidema et al. 2016, BAMS

http://research.metoffice.gov.uk/research/obr/aerosol/safari.html
Radiative effects of aerosol above cloud differ in magnitude and sign when compared to cloud-free cases.

Current satellite aerosol product still deficient for providing global picture of aerosols above all surfaces.
Objectives

• To develop an algorithm to retrieve aerosol properties above different scenes (clouds, ocean, land) using MODIS multispectral sensor.

• To estimate the combined direct radiative effects of all scenes using radiative transfer calculations.
Objectives: 4 scenes in a case study

1. Over ocean
2. Over land
3. Above cloud (ocean)
4. Above cloud (Land)
AOD retrieval and DRE calculations within elevated aerosol clusters
Spectral signatures

Reflectance vs. Wavelength

Cloud only
Aerosol above cloud (ocean)
Aerosol above cloud (land)
Aerosol over land
Aerosol over ocean
### Data and Methods

#### Supplementary data information
- **CALIOP L2 (night and day):** Aerosol clusters (>50km)
- **OMI Aerosol Index**
- **MODIS (cloud, aerosol, surface type)**
- **Pixel heterogeneity**

#### 1. Scene Identification
- CALIOP (aerosol)
- OMI Aerosol Index
- MODIS (cloud, aerosol, surface type)
- Pixel heterogeneity

#### 2. Input
- Radiance
- Solar zenith angles
- View zenith angles
- Relative azimuth angles
- Spectral surface albedo (land only)
- Aerosol properties

#### 3. Look-up table
- AOD
- COD
- Cloud effective radius (ocean only)
- Aerosol properties

#### 4. Output
- Instantaneous flux (Wm⁻²)

**Radiative Transfer Model**
Results: AOD retrieval (cloud-free only)
Results: More AOD retrieval from 4 scenes

How do their direct radiative effects differ?
Results: Aerosol direct radiative effects (Wm\(^{-2}\))

<table>
<thead>
<tr>
<th>Aerosol</th>
<th>Ocean</th>
<th>Land</th>
</tr>
</thead>
<tbody>
<tr>
<td>(cloud-free)</td>
<td>-10</td>
<td>-20</td>
</tr>
<tr>
<td>(above cloud)</td>
<td>+50</td>
<td>+150</td>
</tr>
</tbody>
</table>

Direct radiative effect = Background – aerosol

\[+25 \text{ Wm}^{-2} \text{ combined}\]
Direct radiative effects depend on sun angle

(A)

Wm$^{-2}$

Solar zenith angle

5°S 15°E

(Chang and Christopher 2017)
Conclusions

- Retrieval for aerosol above 4 major scenes are conducted for SE Atlantic and Southern Africa.
  - Over ocean
  - Over land
  - Above cloud (over ocean)
  - Above cloud (over land)

- The combined aerosol direct radiative effects are affected by underlying scenes.

- In-situ measurements are necessary to refine satellite algorithms and reduce uncertainties in radiative transfer calculations.
Recent Publications


• Chang, I. and S. A. Christopher, 2017: The impact of seasonalities on the direct radiative effects and radiative heating rates of absorbing aerosols above clouds. (under revision)

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Mean cloud optical depth decreases during the day
MOD04 and this study