ORACLES* Overview

*ObseRvations of Aerosols above CLouds and their intEractionS

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Africa is world’s largest emitter of biomass-burning aerosols: 50% of all carbon

Andela et al., 2014

Fig. 10. Relative contribution (%) from different regions to 1997–2009 average global total burned area and fire emissions of carbon,

v. d. Werf et al., 2010
Aerosol-radiation-cloud interactions over the SE Atlantic: What we know from satellite observations

- Centroid of Sc cloud patterns changes only slightly during season (Jul-Sep)
- Location of peak biomass burning moves southward

Adebiyi et al., 2015
2002-2012 climatology
In July-Oct. persistent **biomass burning aerosol layers** transported from Southern Africa above the SE Atlantic stratocumulus deck are predicted to exert...

...**significant direct, semi-direct and indirect forcings,**

...which change lower **tropospheric stability (LTS), LWP, cloud fractions,**

...causing **large surface air T cooling and shifts in precipitation patterns.**
ORACLES FIELD DEPLOYMENTS

- July, August, 2017
- September, October, 2016
- September, October, 2018

Adebiyi et al., 2015
2002-2012 climatology
Aerosol-radiation-cloud interactions over the SE Atlantic – International partners

**ORACLES, 2016-18** (U.S. – NASA)
Observations of Aerosols above Clouds and their interactions
• ER-2 + P-3 plus 2 new AERONET stations
• Multi-scale modeling

**CLARIFY, 2016-2017** (U.K.)
Cloud-Aerosol-Radiation Interactions and Forcing
• UK FAAM Bae-146
• Unified Model supported

**LASIC, 2016-17** (U.S. – DOE)
Layered Atlantic Smoke Interactions with Clouds
• DOE Mobile Facility
• 4x/8x daily sondes

**AEROCLO-sA, 2016-2017** (France)
Aerosols Clouds and Fog over the west coast of southern Africa
• Falcon F-20
• Ground-based in situ - PEGASUS

**SEALS-sA, 2016-?** (S. Africa)
Sea Earth Atmosphere Linkages Study in southern Africa
• Integrative, regional scale, ground-based, process-oriented
ORACLES 2016: Flights out of Namibia with NASA P-3 & ER-2

**NASA ER-2**
High-altitude (18km)
Remote sensing
Large spatial coverage
2016 only

**NASA P-3**
Profiles (0-8km)
In-situ + remote sensing
2016, 2017 & 2018

Coordinated flight segments
ORACLES 2017: Flights out of São Tomé with NASA P-3

Image: August Climatology
MODIS low cloud fraction contours (open blue)
MODIS aerosol optical depth (filled orange)
ORACLES 2017: Flights out of São Tomé with NASA P-3 … + ORACLES 2016 P3 flights

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ORACLES 2017: Flights out of São Tomé with NASA P-3
... + ORACLES 2016 P3 flights & ER2 flights

Image: August Climatology
MODIS low cloud fraction contours (open blue)
MODIS aerosol optical depth (filled orange)
ORACLES 2017 Routine Track vertical coverage

Building statistics for comparison to models
ORACLES 2016:
Aerosol loading along routine flight path was broadly consistent with multi-year climatology

LeBlanc, Segal-Rozenhaimer, 4STAR team
Data URL: http://science.arm.gov/~sleblanc/4STAR_ORACLES_2016/

MODIS fine-mode AOD climatology
MODIS total AOD climatology

4STAR (airborne) above-cloud AOD measurement

MODIS above-cloud AOD retrieval, courtesy of Meyer, Platnick, MODIS/eMAS teams
HSRL-2 captures detailed plume structure and mixing into Sc cloud deck!

- In 2016, on average, the smoke layer was in contact with low level clouds over 40% of the time, more frequently than assumed.

In situ cloud measurements indicate suppressed drizzle where BB mixing occurs!

- Higher cloud number concentration where aerosol mixing into the cloud layer occurs
- Relatively fewer drizzle-size droplets in locations of mixing

*Ferrare, Burton, Hostetler, HSRL-2 team (NASA LaRC)*

*McFarquhar, Poellot, Gupta (U of Illinois, UND)*
Process-level insight through a suite of coordinated in-situ & remote sensing measurements

In situ measurement:
- Aerosol:
  - Size dist.
  - Scattering
  - Absorption
  - Composition (SP2, AMS)
  + cloud properties...

Remote sensing:
- AOD
- Flux divergence
- Aerosols:
  - RSP
  - HSRL2: vertical distribution!
  + cloud properties...

eMAS imagery (ER-2)
- Schmidt, Cochrane, Gore (U of Colorado, ARC)
- Howell, Freitag, Dobracki (U of Hawaii)

Critical Albedo = 0.22
Process-level insight through a suite of coordinated in-situ & remote sensing measurements... with insights from models!

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- **Remote sensing:**
  - AOD
  - Flux divergence
  - Aerosols:
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    - HSRL2: vertical distribution
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- eMAS imagery (ER-2)

- Critical Albedo = 0.22

- Warming
  - Cooling
  - Top-of-layer radiative effect
  - Layer absorption

- Process-level insight through a suite of coordinated in-situ & remote sensing measurements... with insights from models!

- WRF-Chem - Pablo Saide and Greg Carmichael

- ORACLES single flight BC/org

- ORACLES-2016 all flights

- Howell, Freitag, Dobracki (U of Hawaii)

- Schmidt, Cochrane, Gore (U of Colorado, ARC)
ORACLES Model / observation comparison effort

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MODIS low cloud fraction contours (open blue)
MODIS aerosol optical depth (filled orange)

2017 “Routine” Flight Track
(5 flights + several w/ data on this track)

2016 “Routine” Flight Track
(6 flights)
ORACLES Model / observation comparison effort

STEP 1: Statistical comparisons over a set of transects

2016 ROUTINE TRACK

Ascension -- LASIC

St. Helena

TBD: 2017

{E-W transect for model gradient}

2016: frequent flights N-S
ORACLES Model / observation comparison effort

SET OF 3 POSTERS HERE ON THIS EFFORT:

Modeling comparisons to new observations from the southeast Atlantic:

Part 1 – Methodology (poster P-22 Paquita Zuidema)
Part 2 - Spatial distributions & sampling considerations (poster P-23 Yohei Shinozuka)
Part 3 - Aerosol Vertical Distributions (poster P-24 Sarah Doherty)

PROGRESS SO FAR:

• Set of metrics, statistics established within ORACLES measurement & modeling groups -- See posters & talk to us (Paquita, Yohei, Sarah & Jens)
• ORACLES aerosol modelers involved:
  • Pablo Saide (NCAR/UCLA), Greg Carmichael & Gonzalo Ferrada (U. of Iowa). Models: WRF-CAM5, WRF-AAM, WRF-Chem
  • Arlindo da Silva & Karla Longo (NASA GMAO). Model: GEOS5
• ORACLES partners:
  • UK Met office. Model: Experimental UM (CLARIFY)
  • Marc Mallet (Meteo France). Model: ALADIN-Climate
ORACLES Model / observation comparison effort

- **WE WELCOME OTHER MODELING GROUPS TO PARTICIPATE**
- A dedicated AeroCom activity?
- Leverage the existing AeroCom Biomass Burning activity?
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*Sakeda et al., 2011, JGR*

**Direct Radiative Forcing (W m\(^{-2}\) \(\tau^{-1}\))**

- **Positive TOA forcing**
- **Negative TOA forcing**

**Need to accurately model low clouds fields as well as aerosol**