ORACLES* Overview

*ObseRvations of Aerosols above CLouds and their intEractionS

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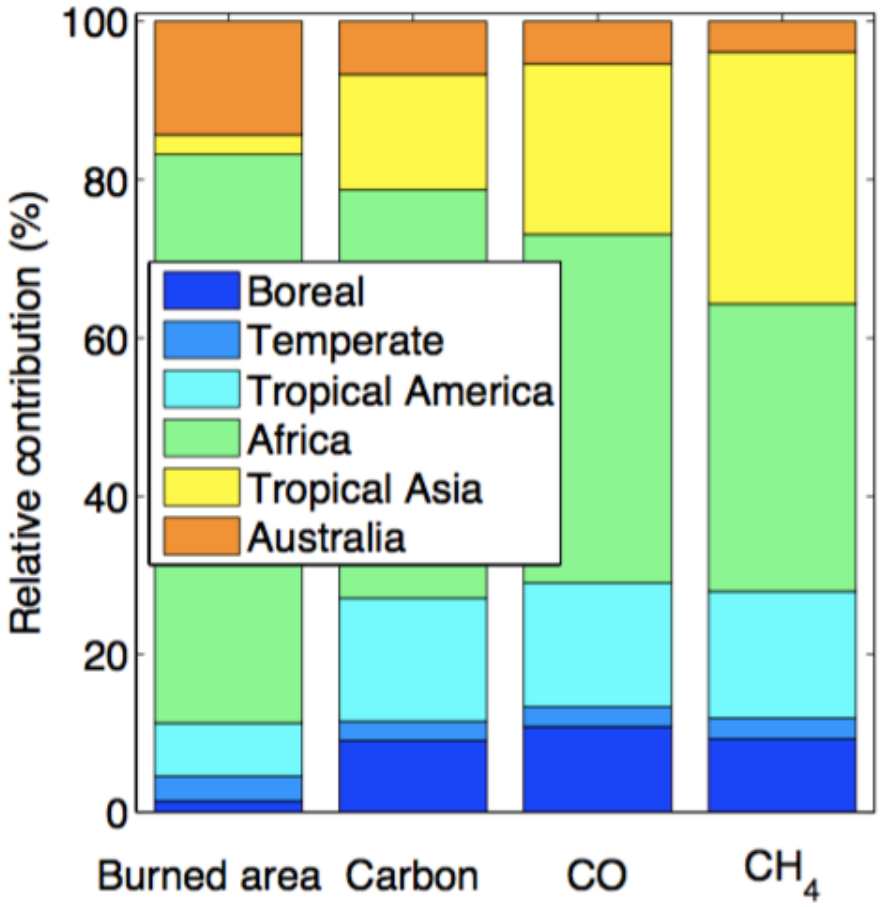
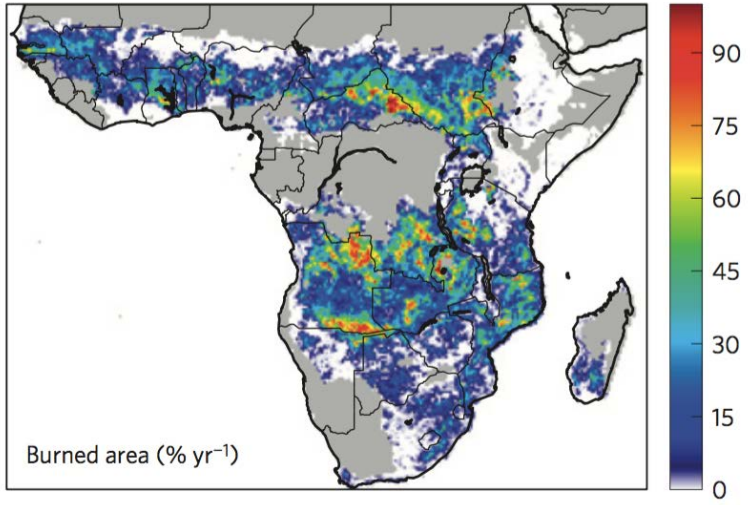
Africa is world's largest emitter of biomass-burning aerosols: 50% of all carbon





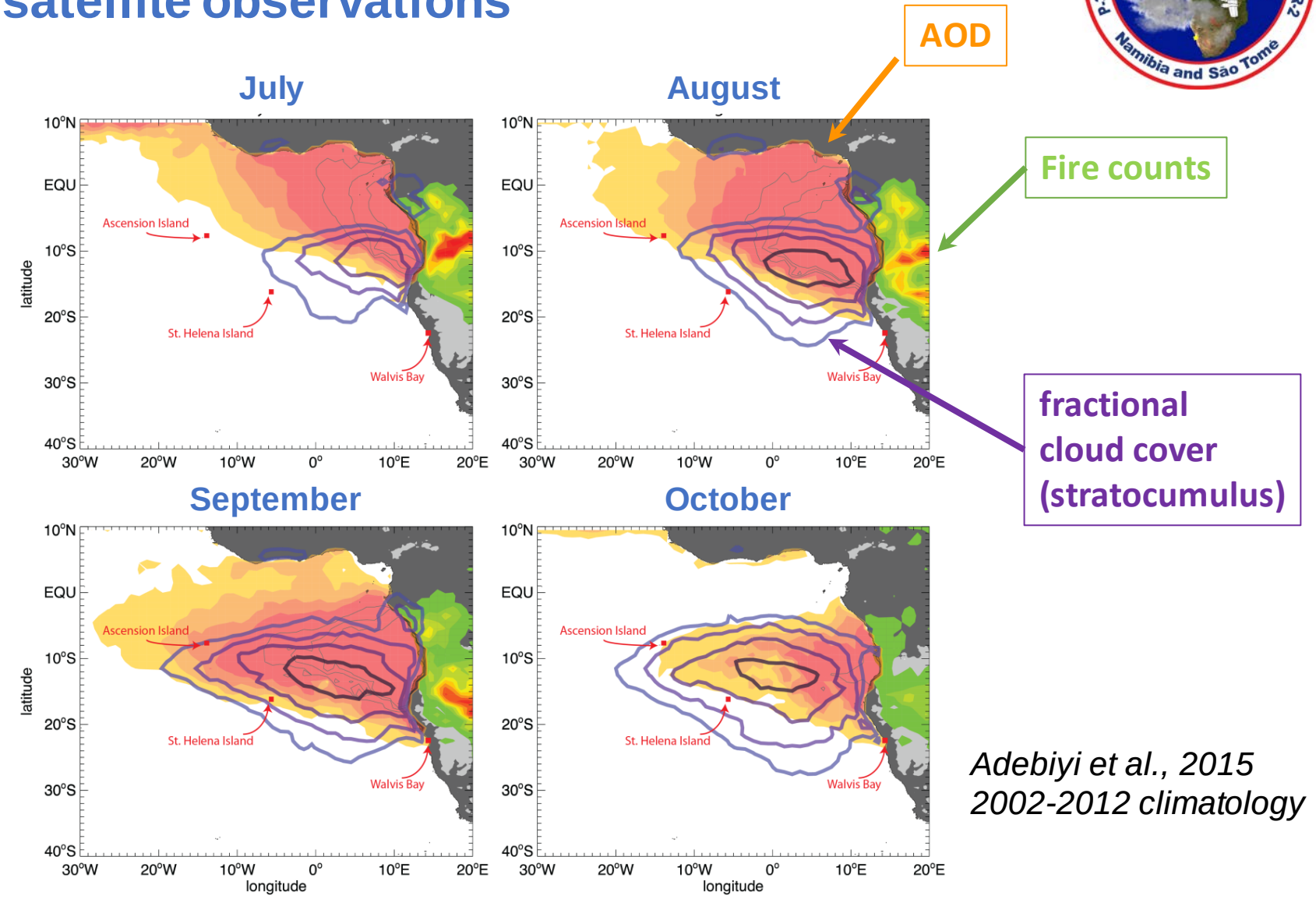
Andela et al., 2014

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

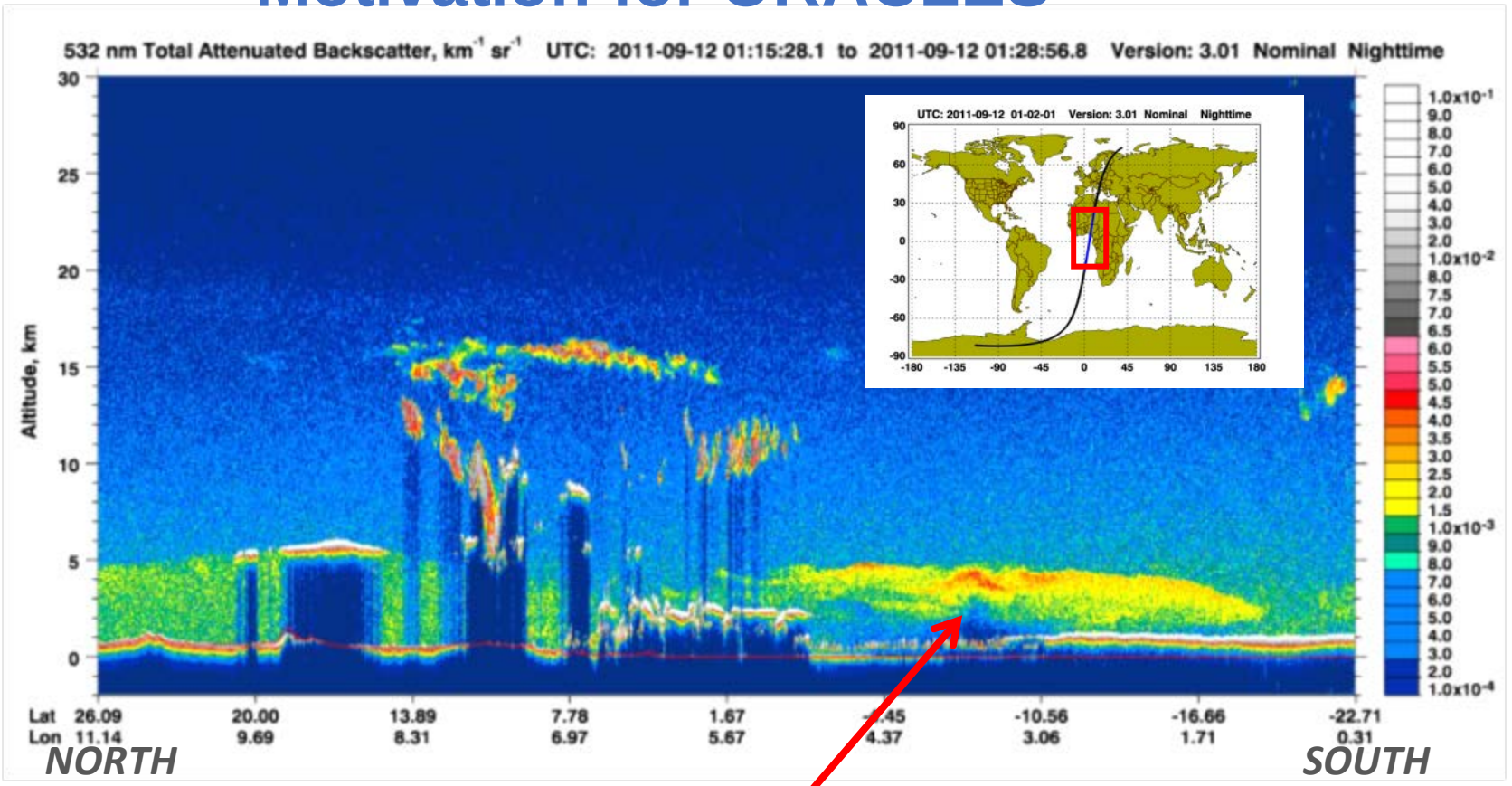
Aerosol-radiation-cloud interactions over the SE Atlantic: What we know from satellite observations

- 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

Aerosol-radiation-cloud interactions over the SE Atlantic: Motivation for ORACLES



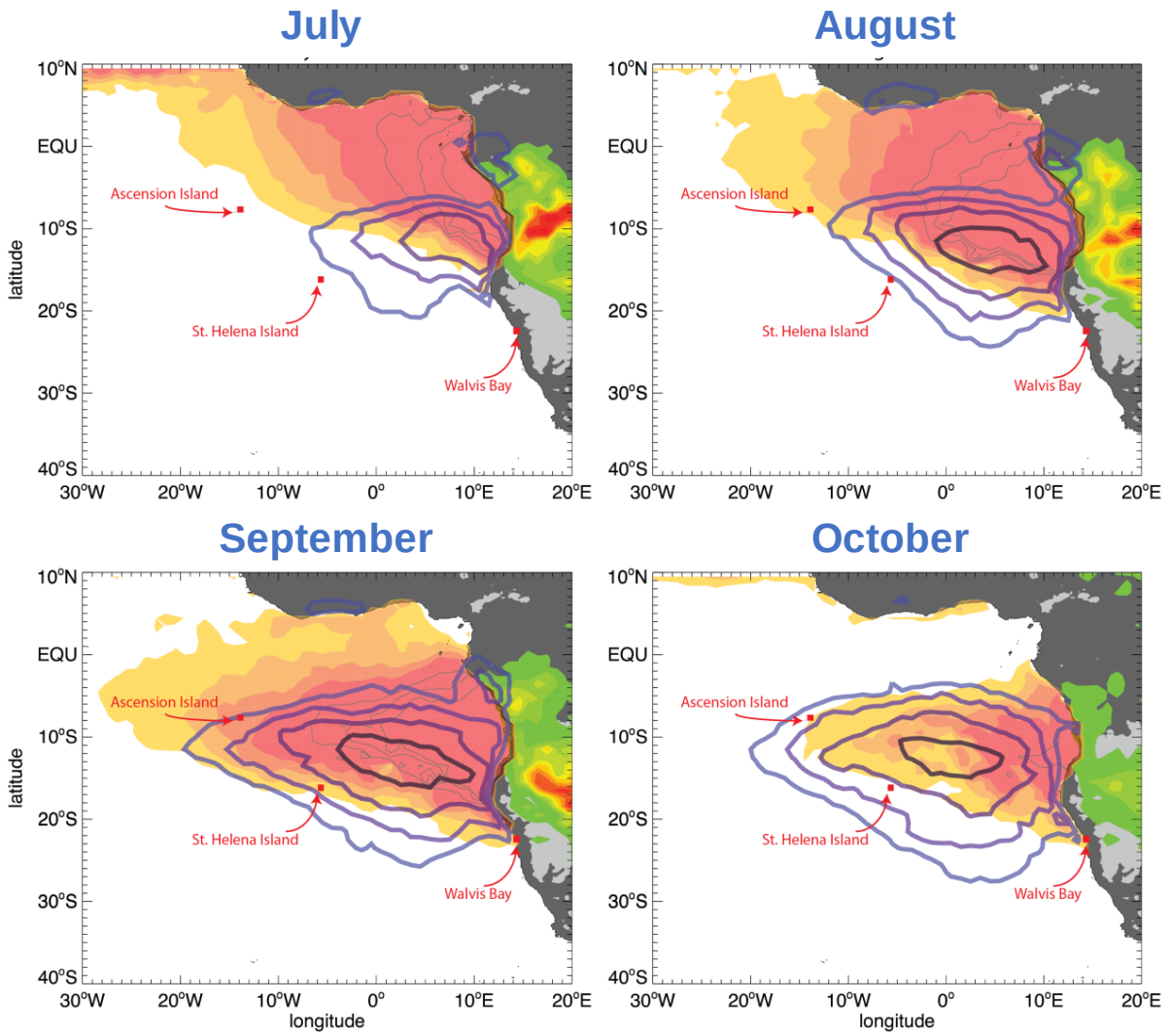
In July-Oct. persistent **biomass burning** **aerosol layers** transported from Southern Africa above the SE Atlantic stratocumulus deck are predicted to exert

…**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



August, 2017

September, 2016

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)

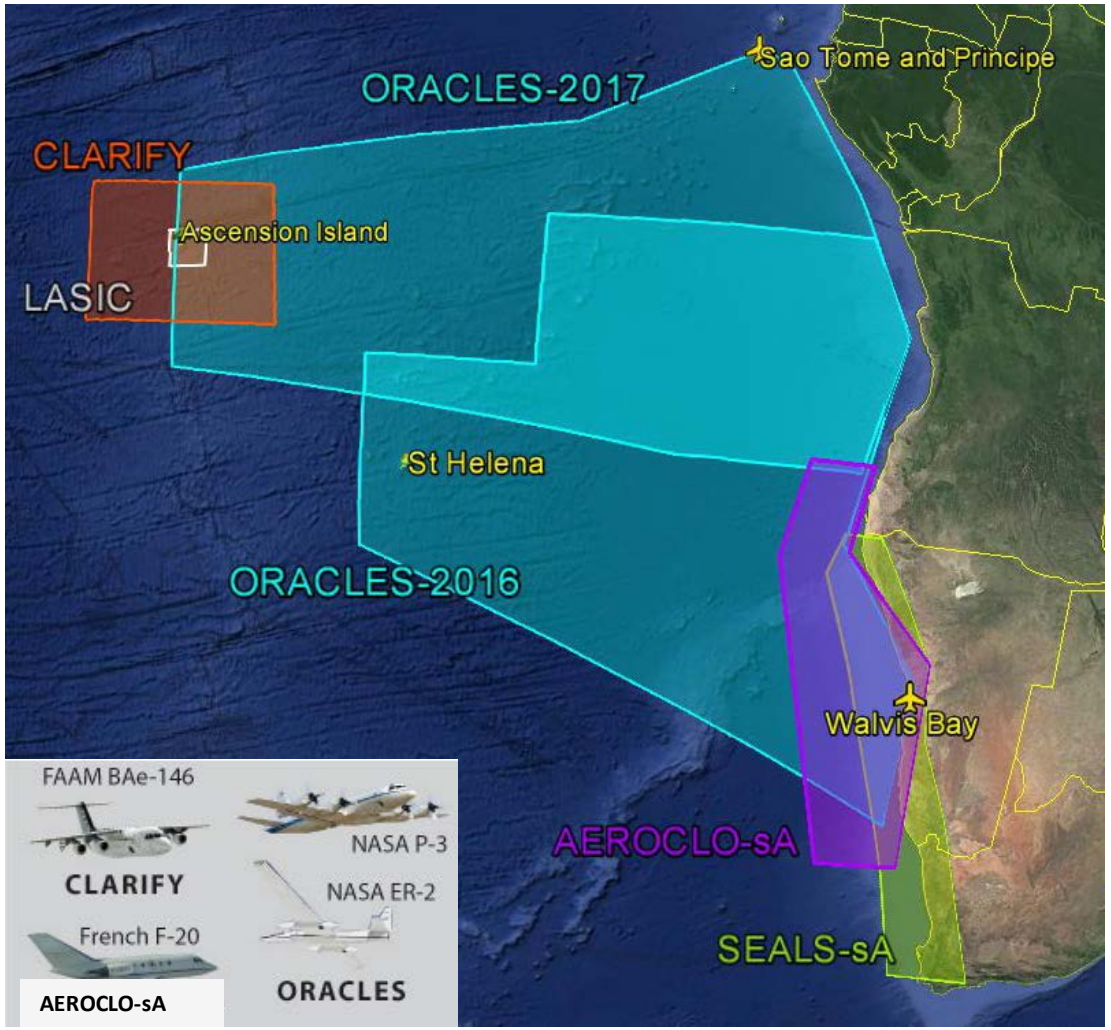
Aerosols Clouds and Fog over the west coast of southern Africa

- 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

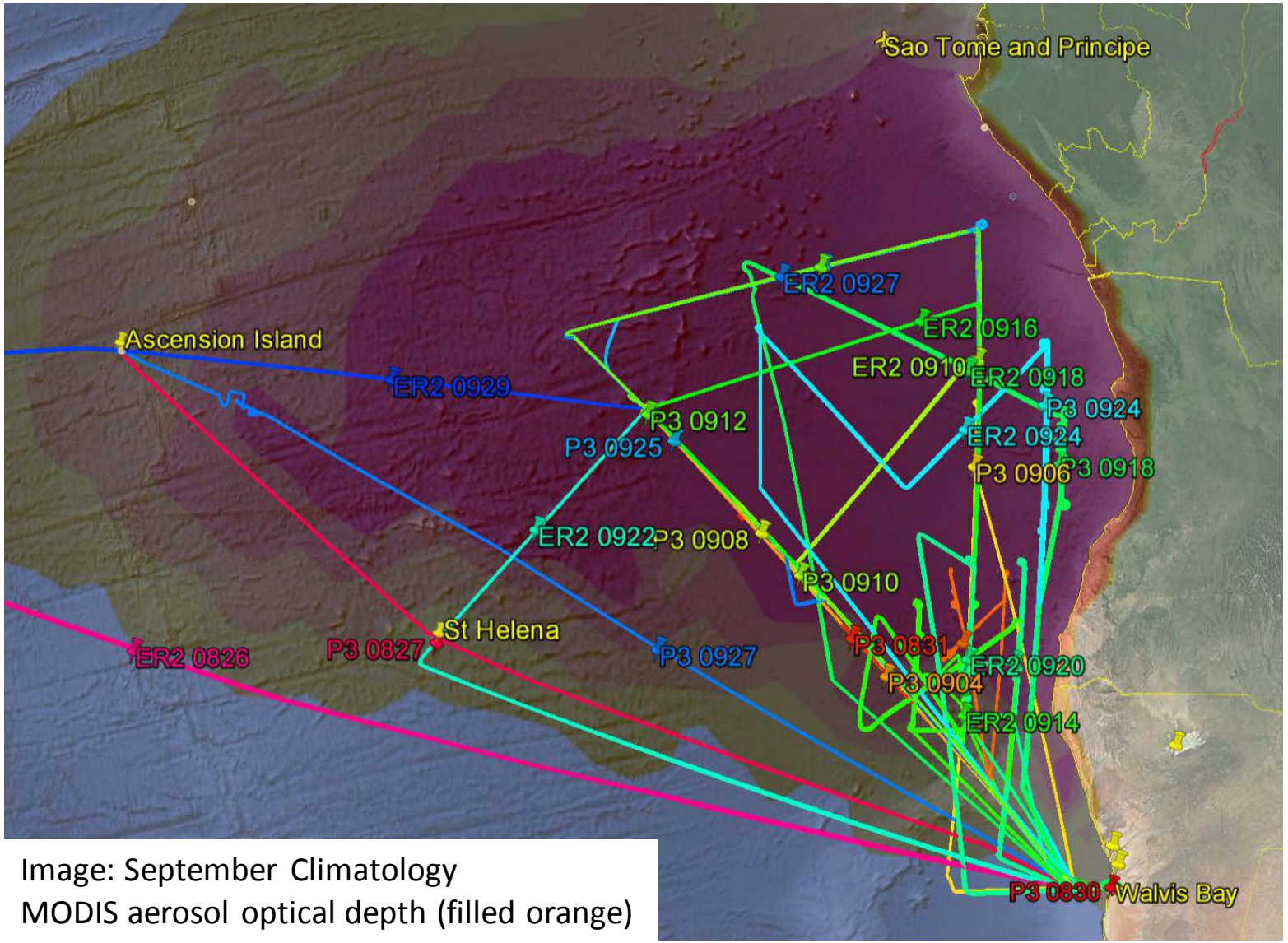


Image: September Climatology
MODIS aerosol optical depth (filled orange)

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

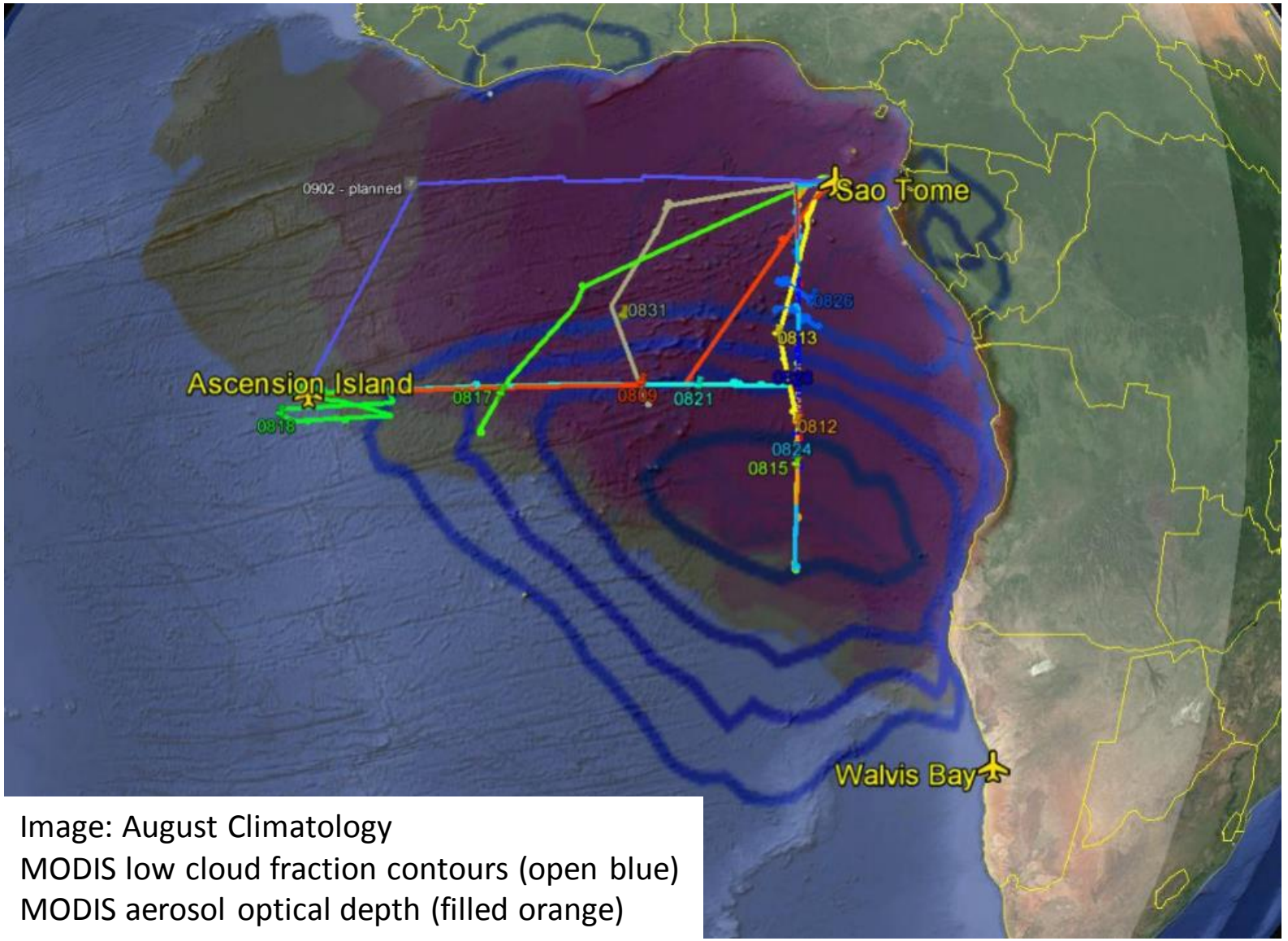
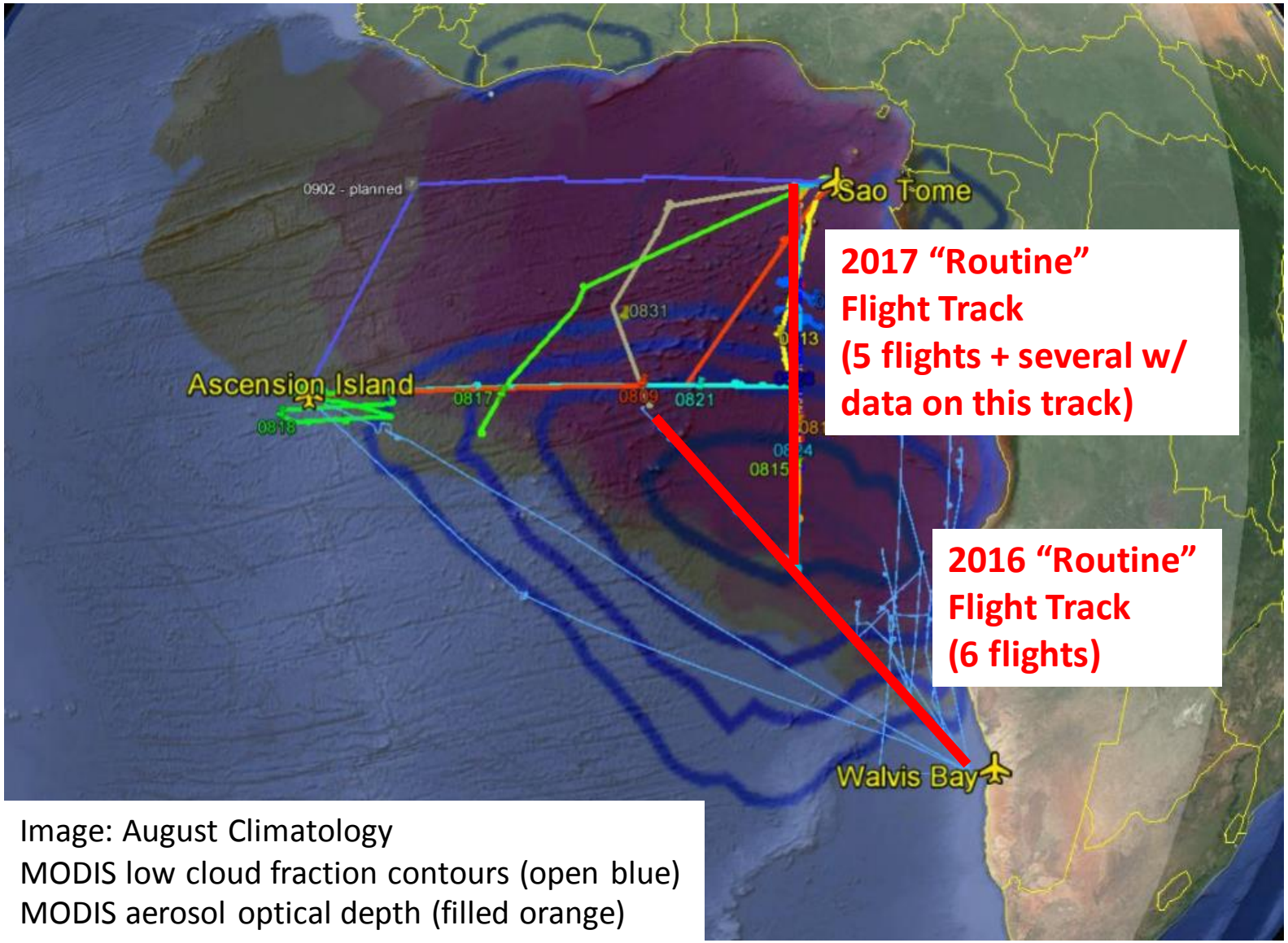


Image: August Climatology
MODIS low cloud fraction contours (open blue)
MODIS aerosol optical depth (filled orange)

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



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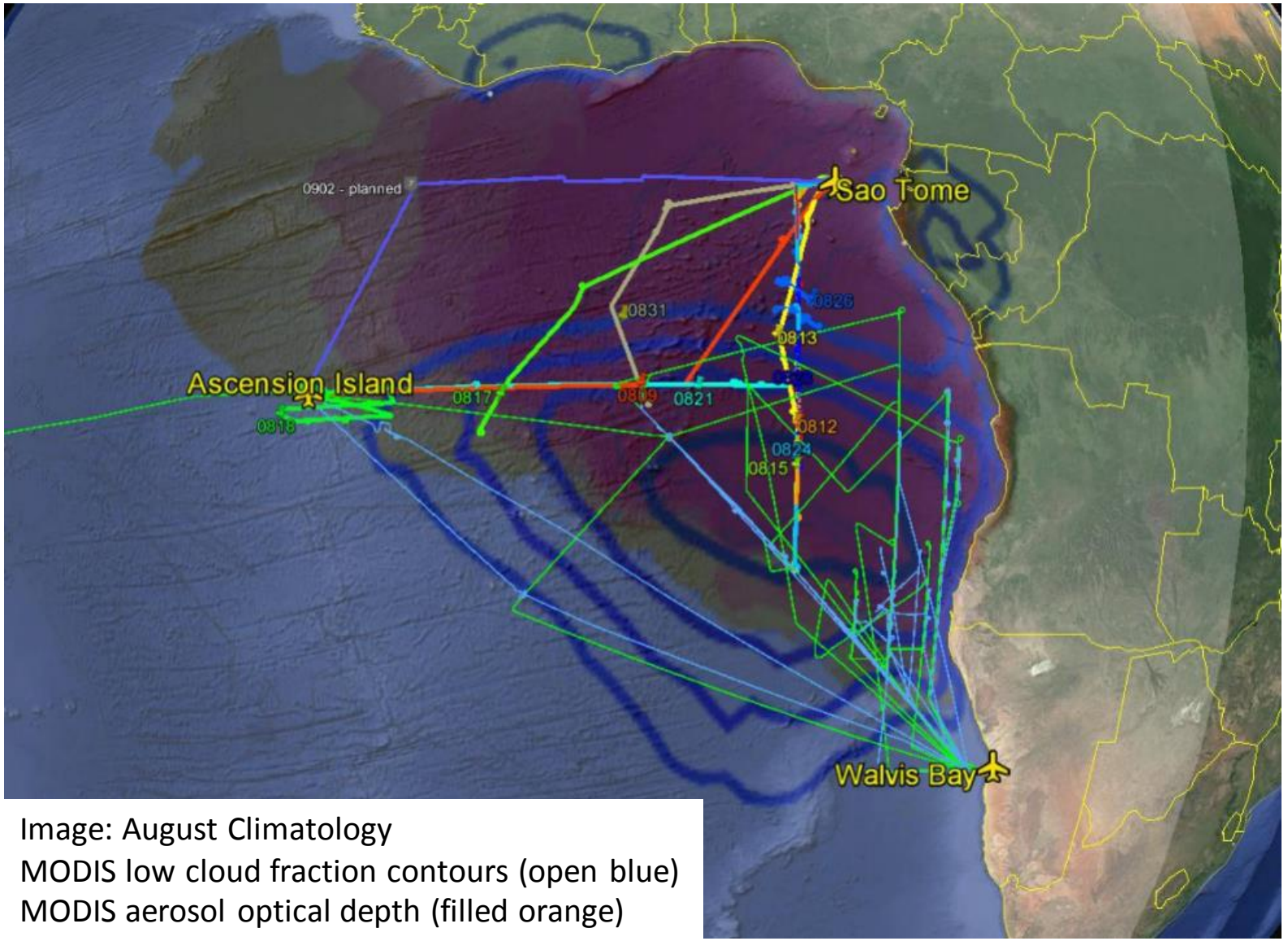
ORACLES 2017: Flights out of São Tomé with NASA P-3 … + ORACLES 2016 P3 flights & ER2 flights



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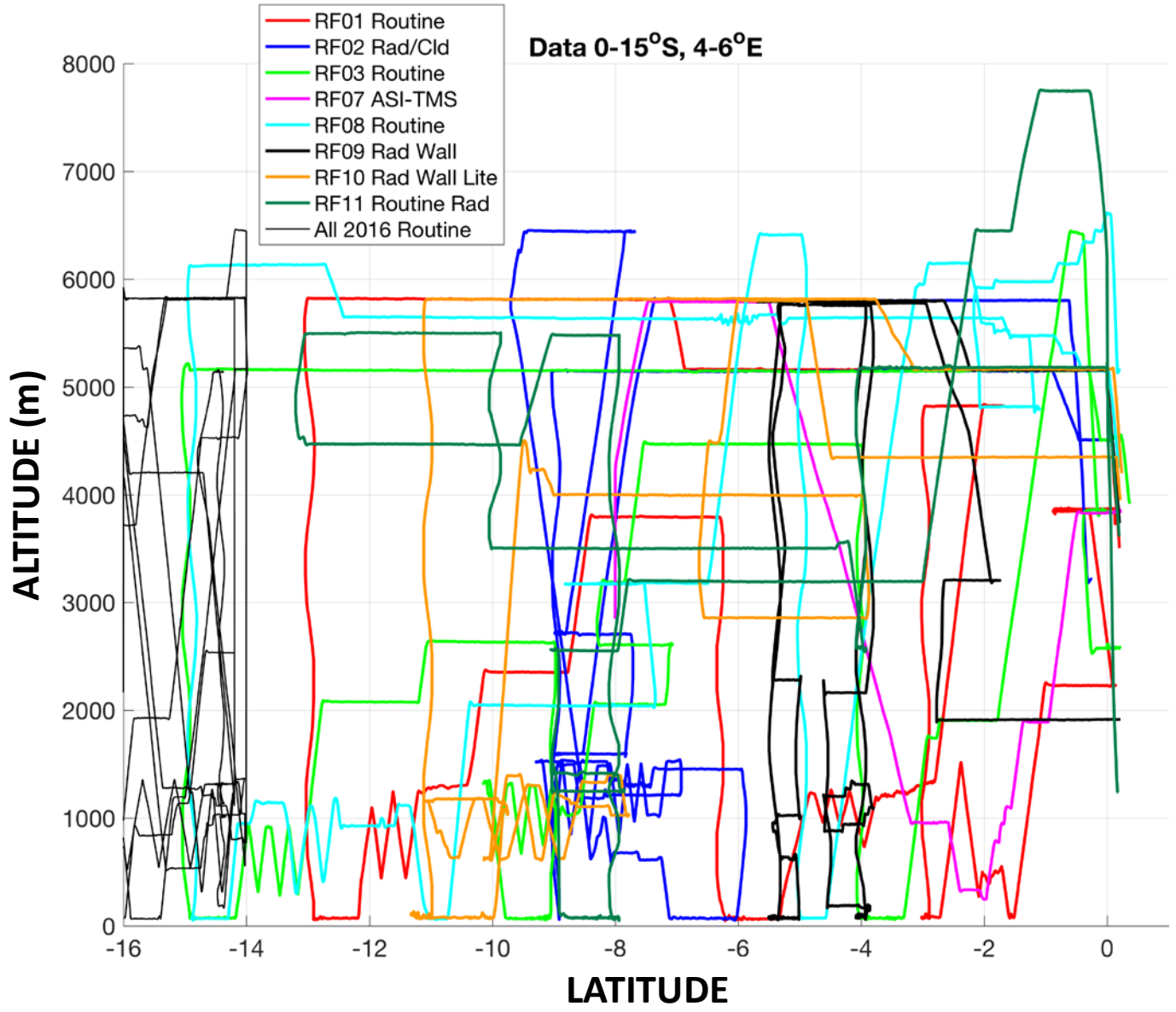
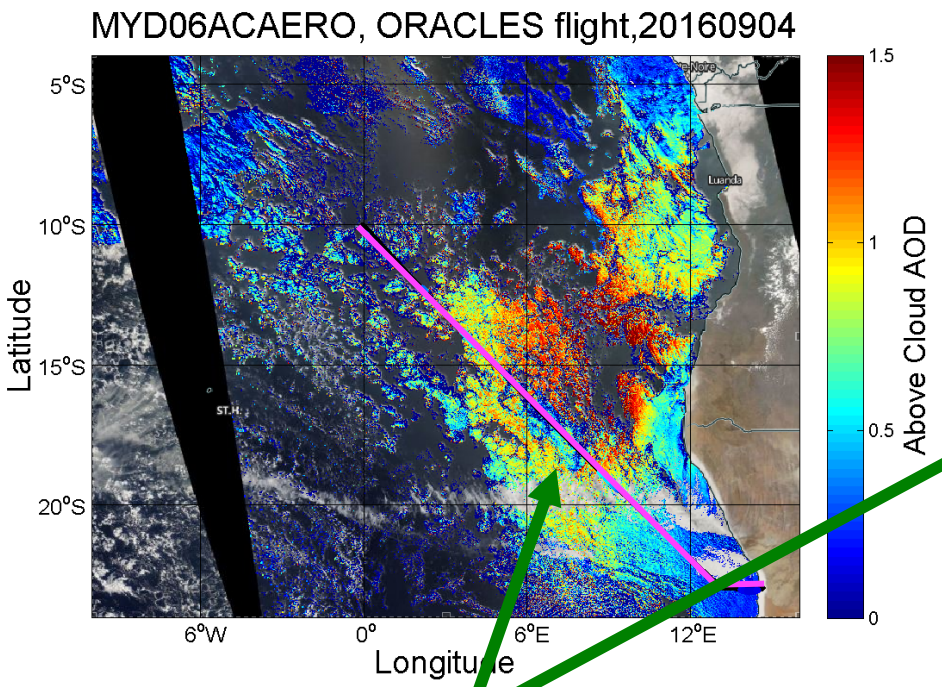
ORACLES 2017 Routine Track vertical coverage



Building statistics for comparison to models

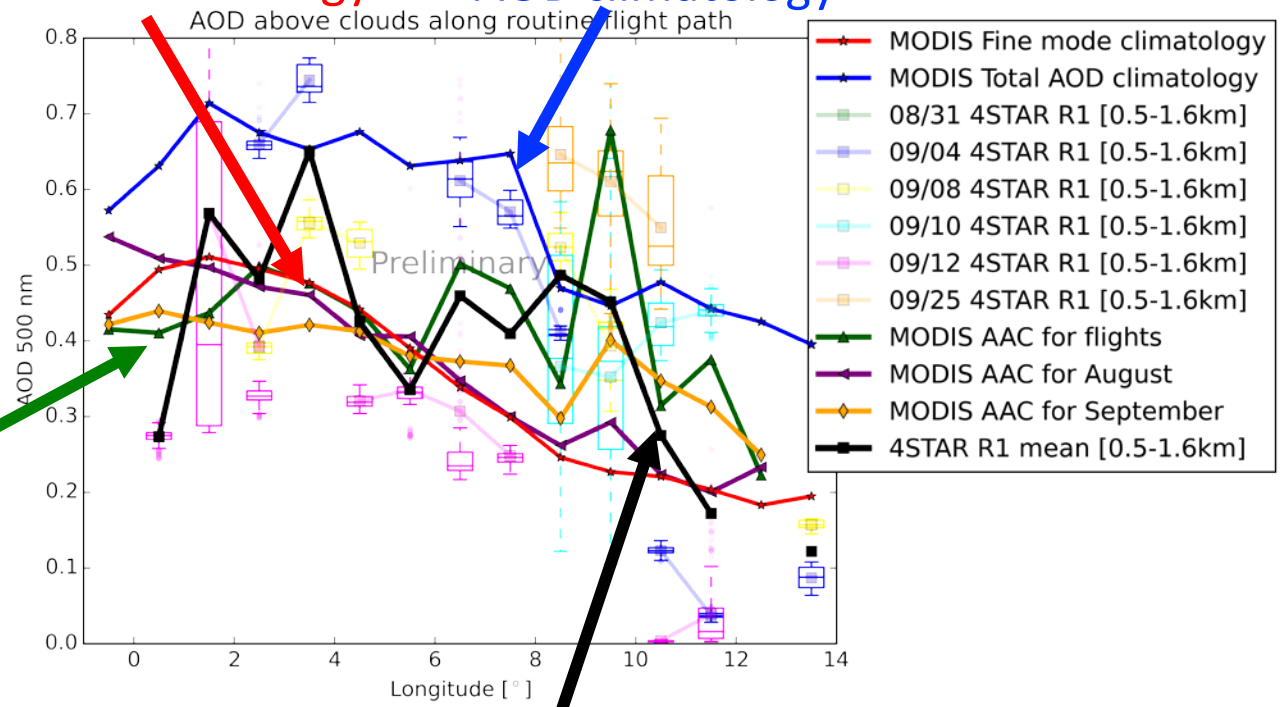
ORACLES 2016:

Aerosol loading along routine flight path was broadly consistent with multi-year climatology



MODIS fine-mode AOD climatology

MODIS total AOD climatology



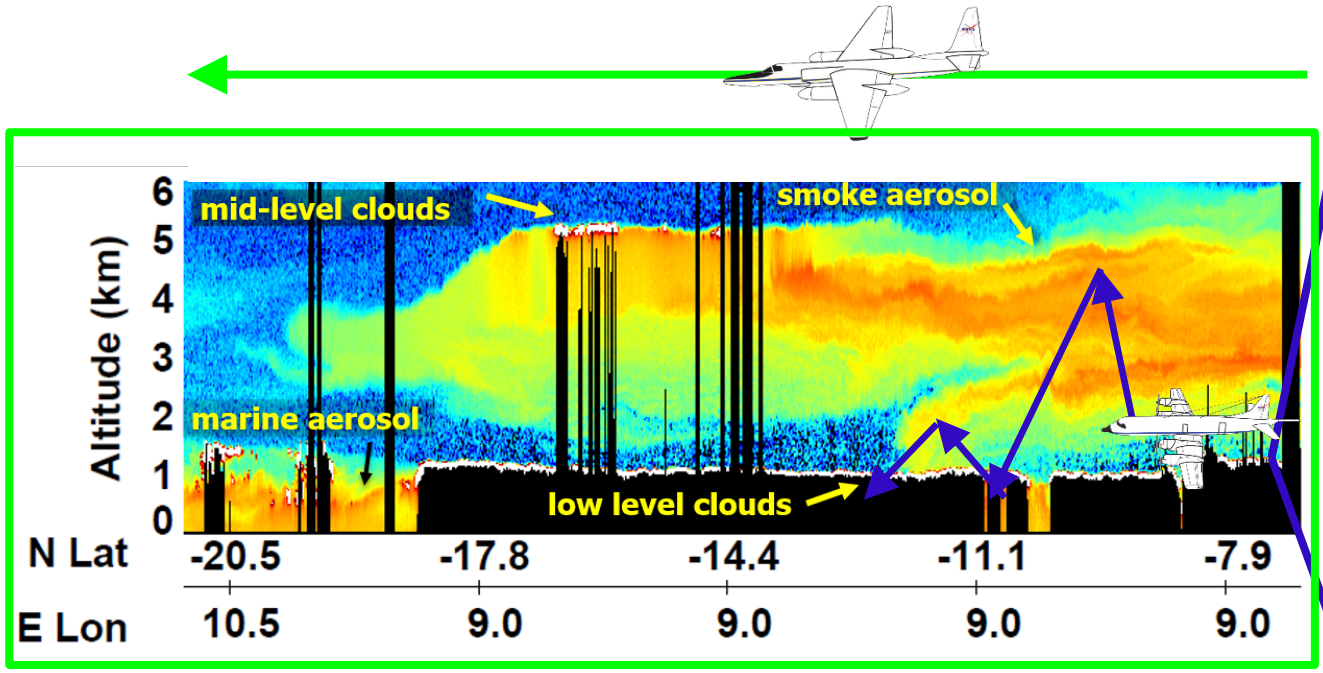
MODIS above-cloud AOD retrieval, courtesy of Meyer, Platnick, MODIS/eMAS teams

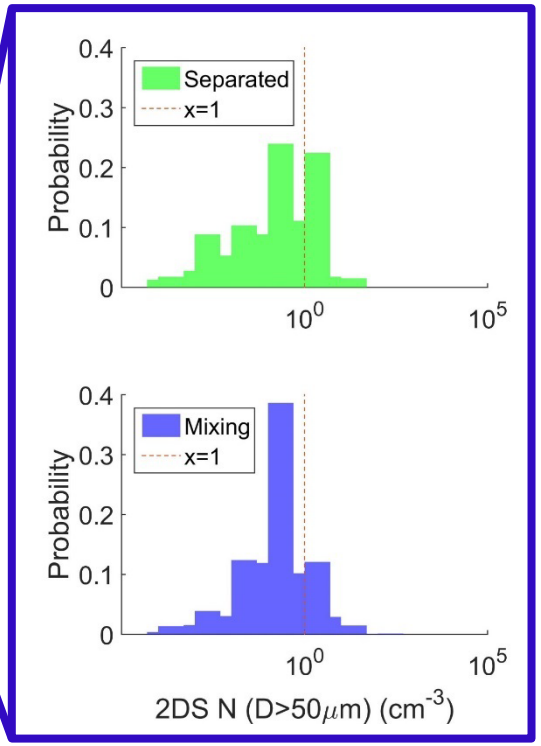
4STAR (airborne) above-cloud AOD measurement

LeBlanc, Segal-Rozenhaimer, 4STAR team

Data URL: http://science.arm.gov/~sleblanc/4STAR_ORACLES_2016/

Process-level insight through a suite of coordinated in-situ & remote sensing measurements





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.

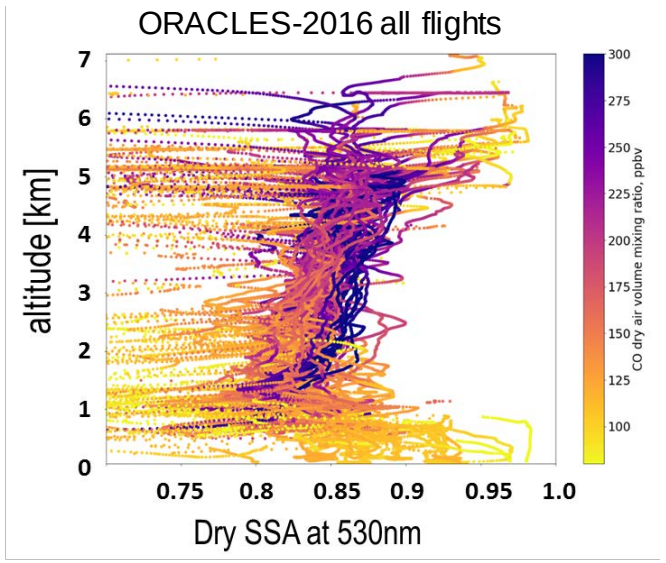
Ferrare, Burton, Hostetler, HSRL-2 team (NASA LaRC)

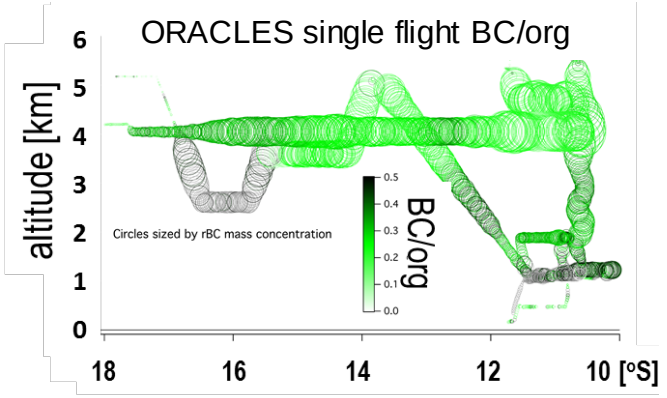
In situ cloud measurements indicate suppressed drizzle where BB mixing occurs!

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

McFarquhar, Poellot, Gupta (U of Illinois, UND)

Process-level insight through a suite of coordinated in-situ & remote sensing measurements





Howell, Freitag, Dobracki
(U of Hawaii)

In situ measurement:

Aerosol:

- Size dist.
- Scattering
- Absorption
- Composition (SP2, AMS)

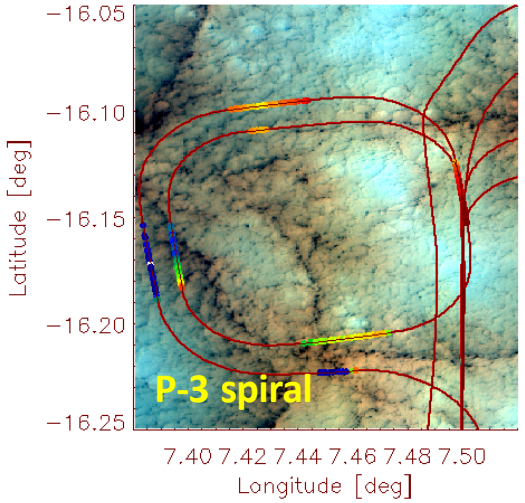
+ cloud properties…

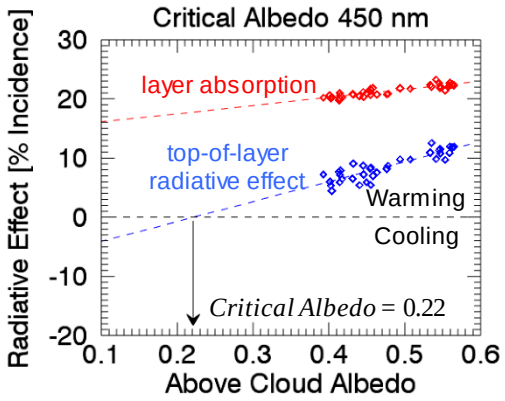
Remote sensing:

- AOD
- Flux divergence
- Aerosols:
  - RSP
  - HSRL2: vertical distribution!

+ cloud properties…

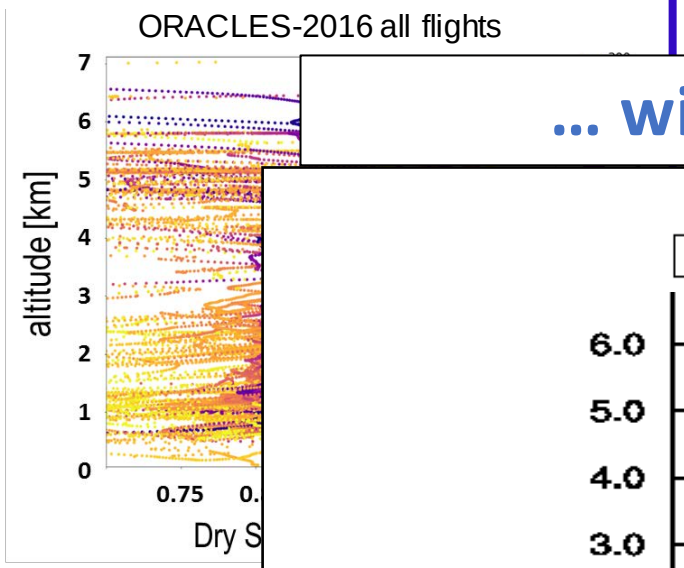
eMAS imagery (ER-2)

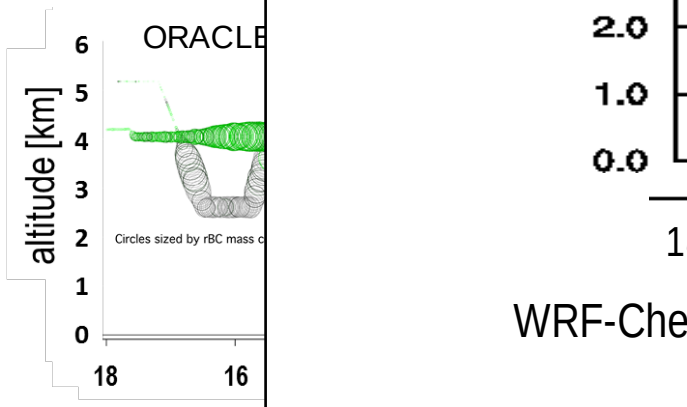




Schmidt, Cochrane, Gore
(U of Colorado, ARC)

Process-level insight through a suite of coordinated in-situ & remote sensing measurements

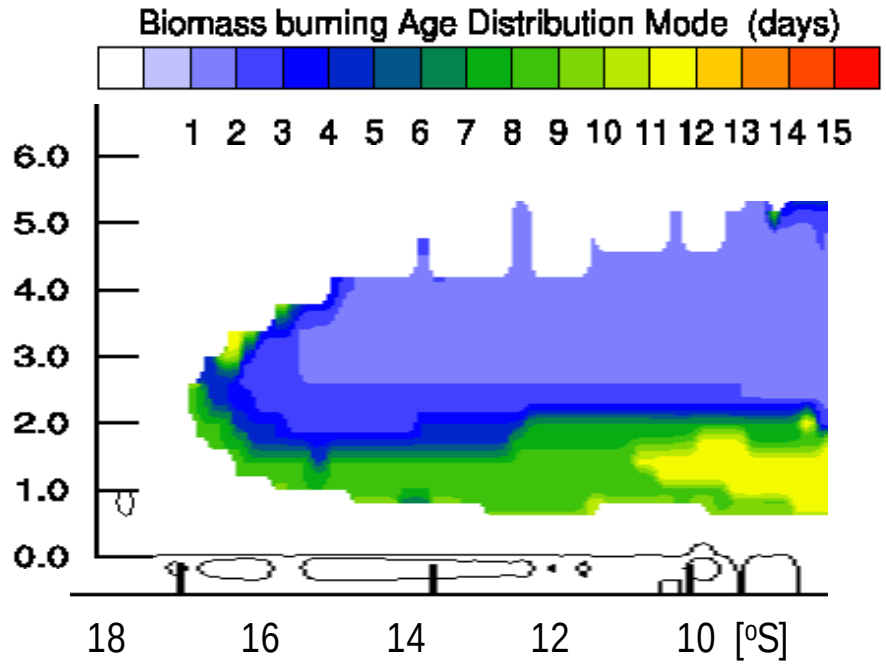




Howell, Freitag, Dobracki
(U of Hawaii)

In situ measurement:

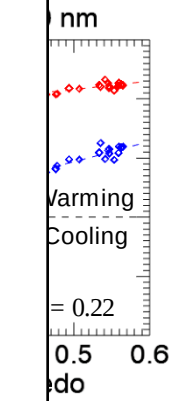
… with insights from models!



WRF-Chem - Pablo Saide and Greg Carmichael

+ cloud properties…

eMAS imagery (ER-2)



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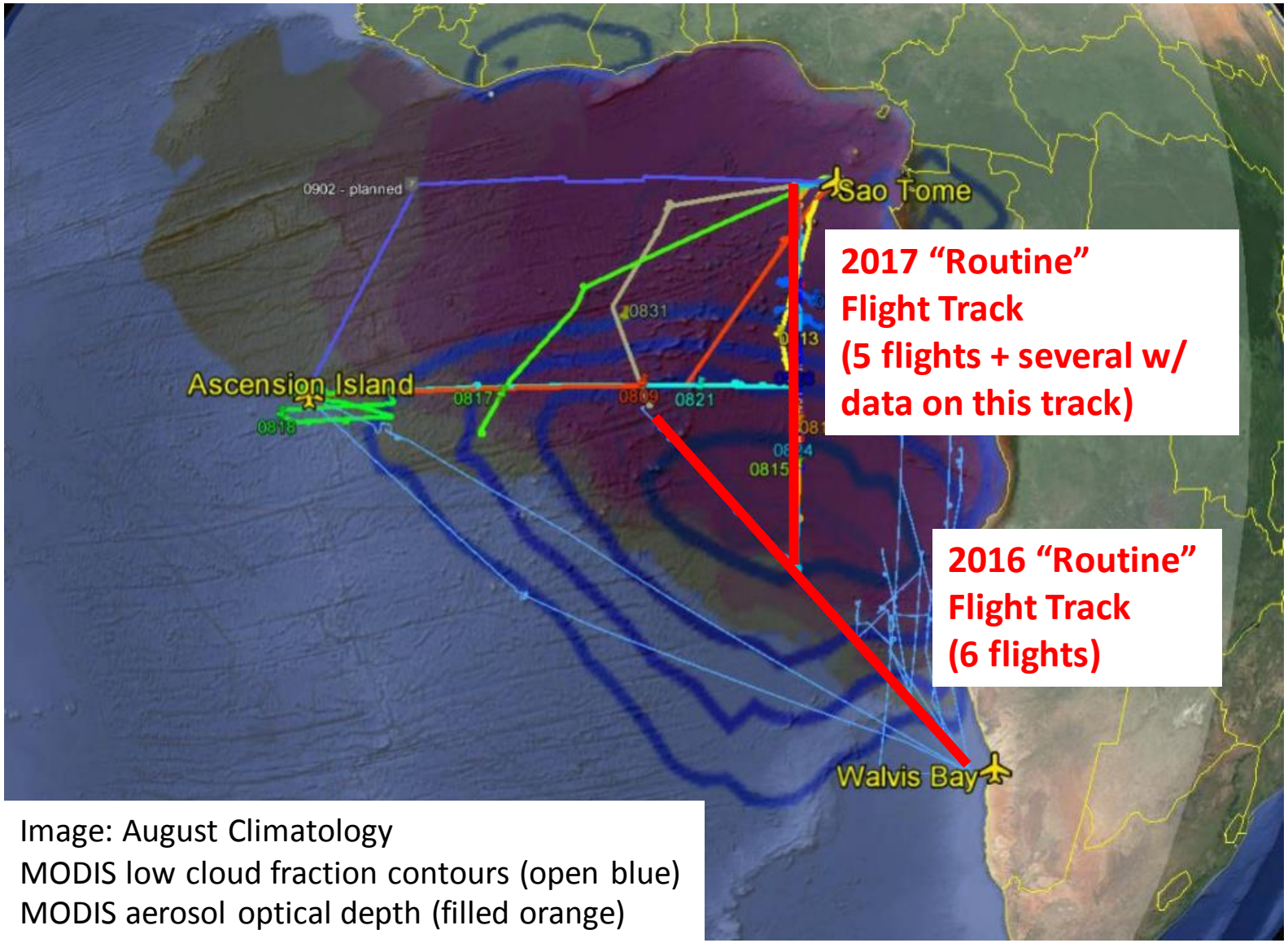
ORACLES Model / observation comparison effort



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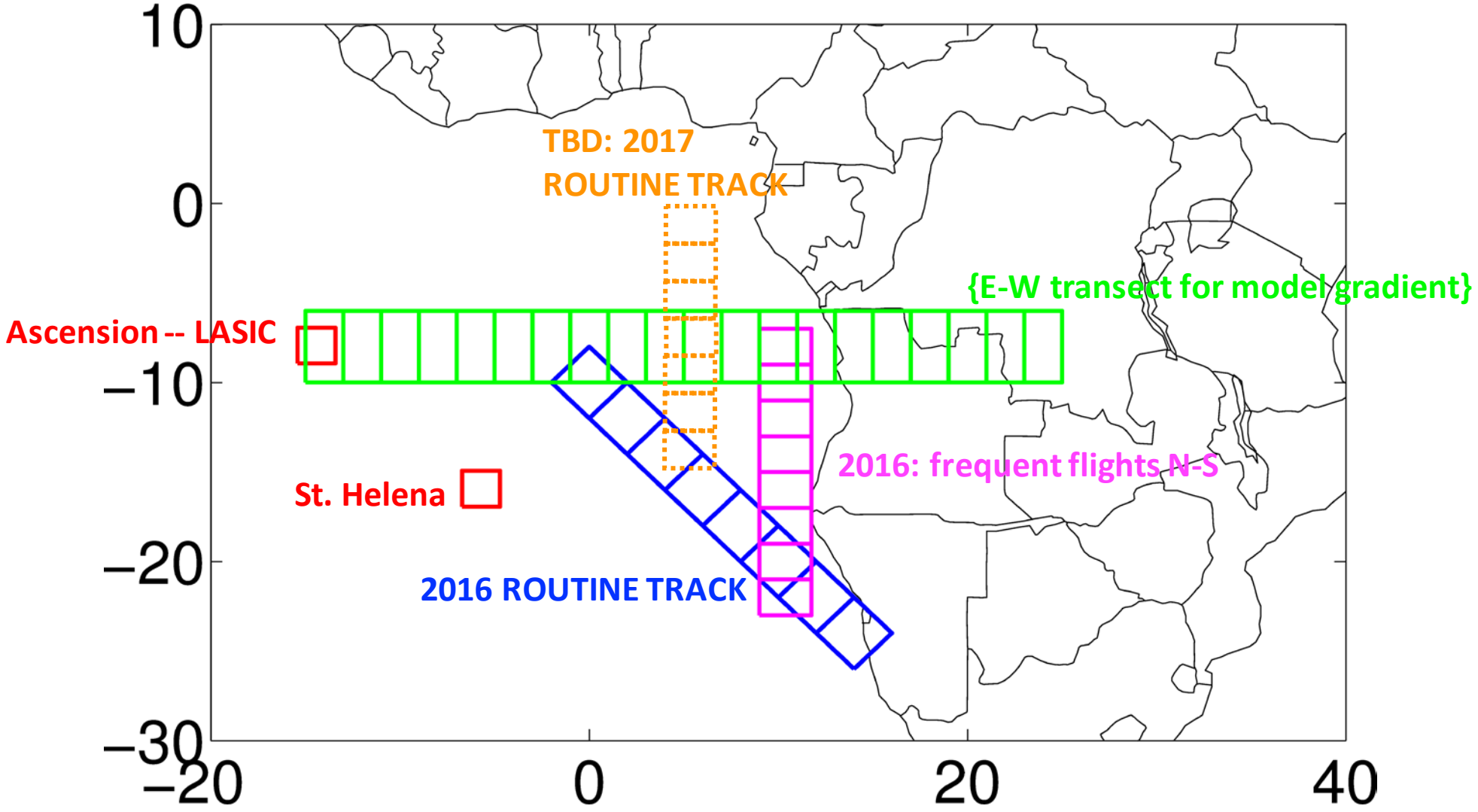
ORACLES Model / observation comparison effort

STEP 1: Statistical comparisons over a set of transects



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?**

ORACLES Model / observation comparison effort

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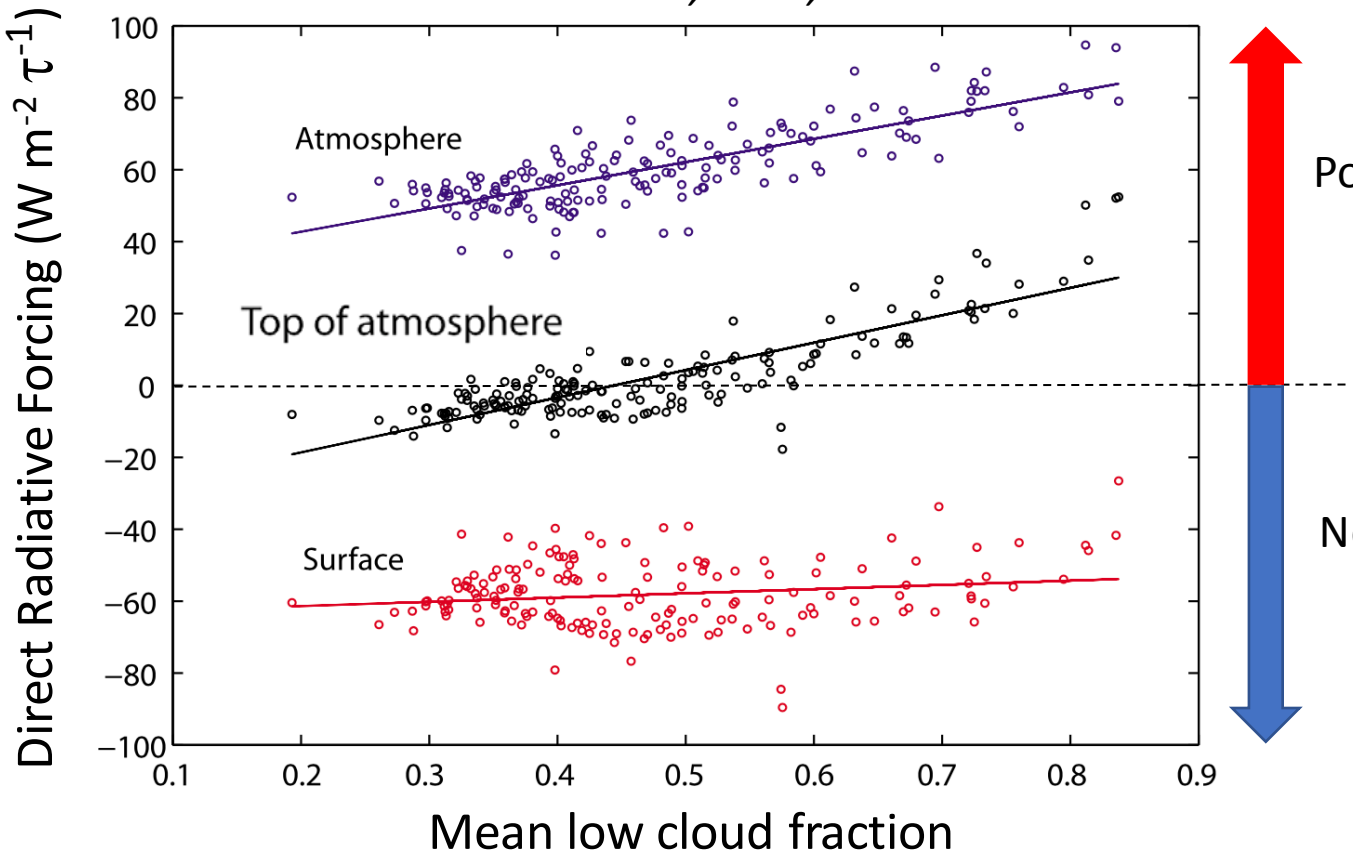
- **A dedicated AeroCom activity?**
- **Leverage the existing AeroCom Biomass Burning activity?**

Sakeda et al., 2011, JGR



Positive TOA forcing

NEED TO ACCURACTELY MODEL LOW CLOUDS FIELDS AS WELL AS AEROSOL

Negative TOA forcing