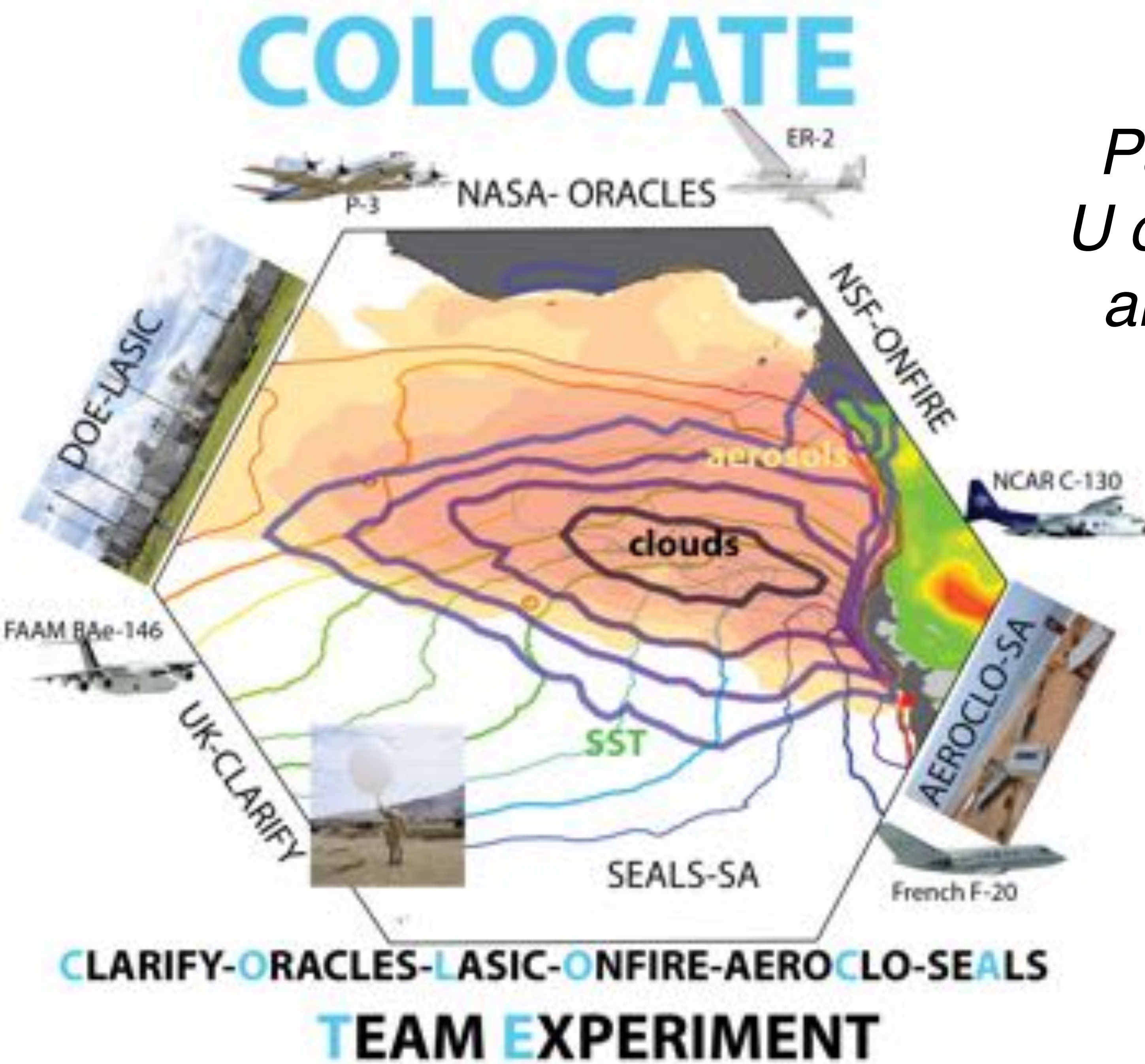
Smoke and clouds above the southeast Atlantic: combined observational and modeling strategies to probe absorbing aerosol's impact on climate



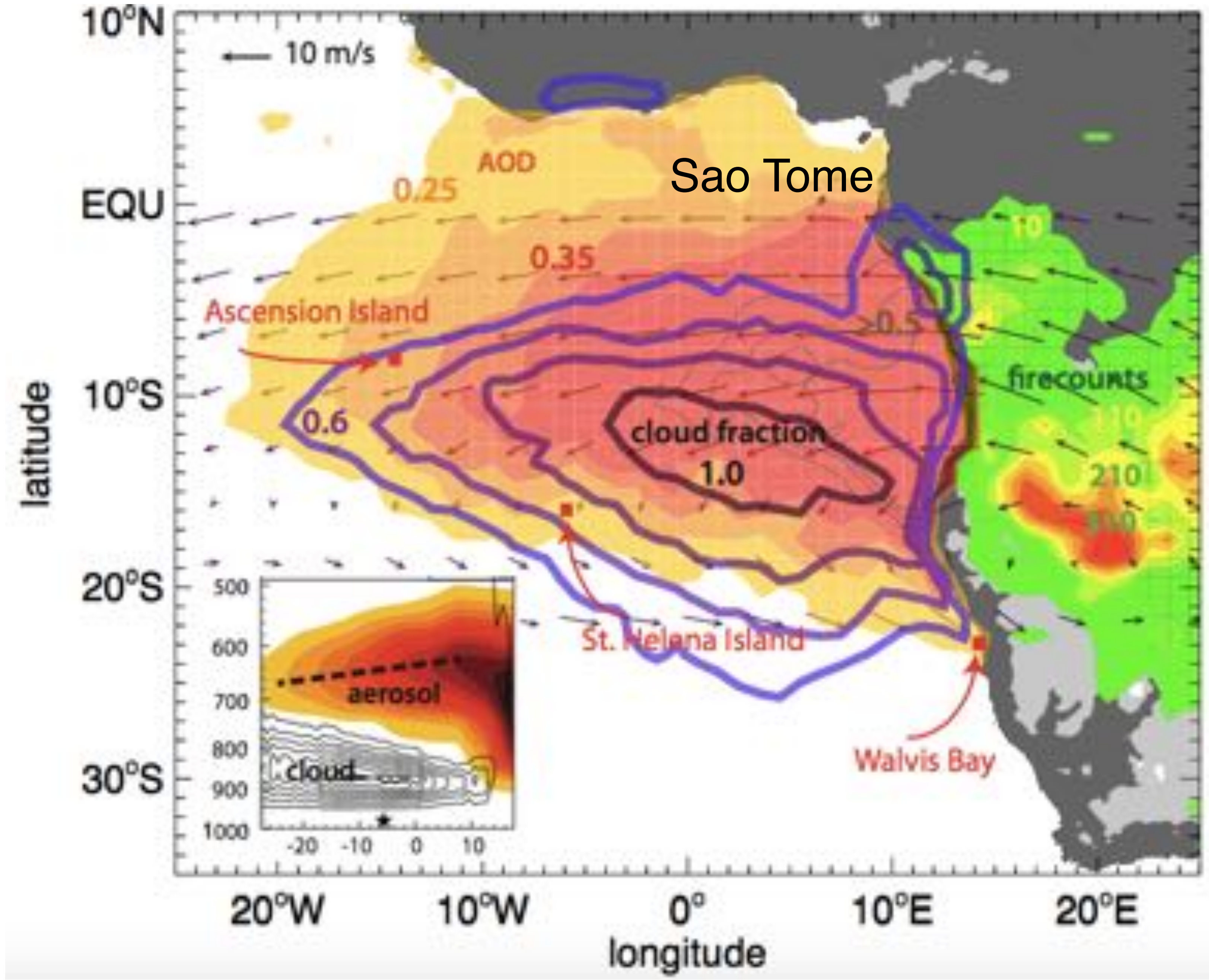
Paquita Zuidema
U of Miami/RSMAS
and many others

upcoming campaigns span 2016-2018; not quite right for next CPT

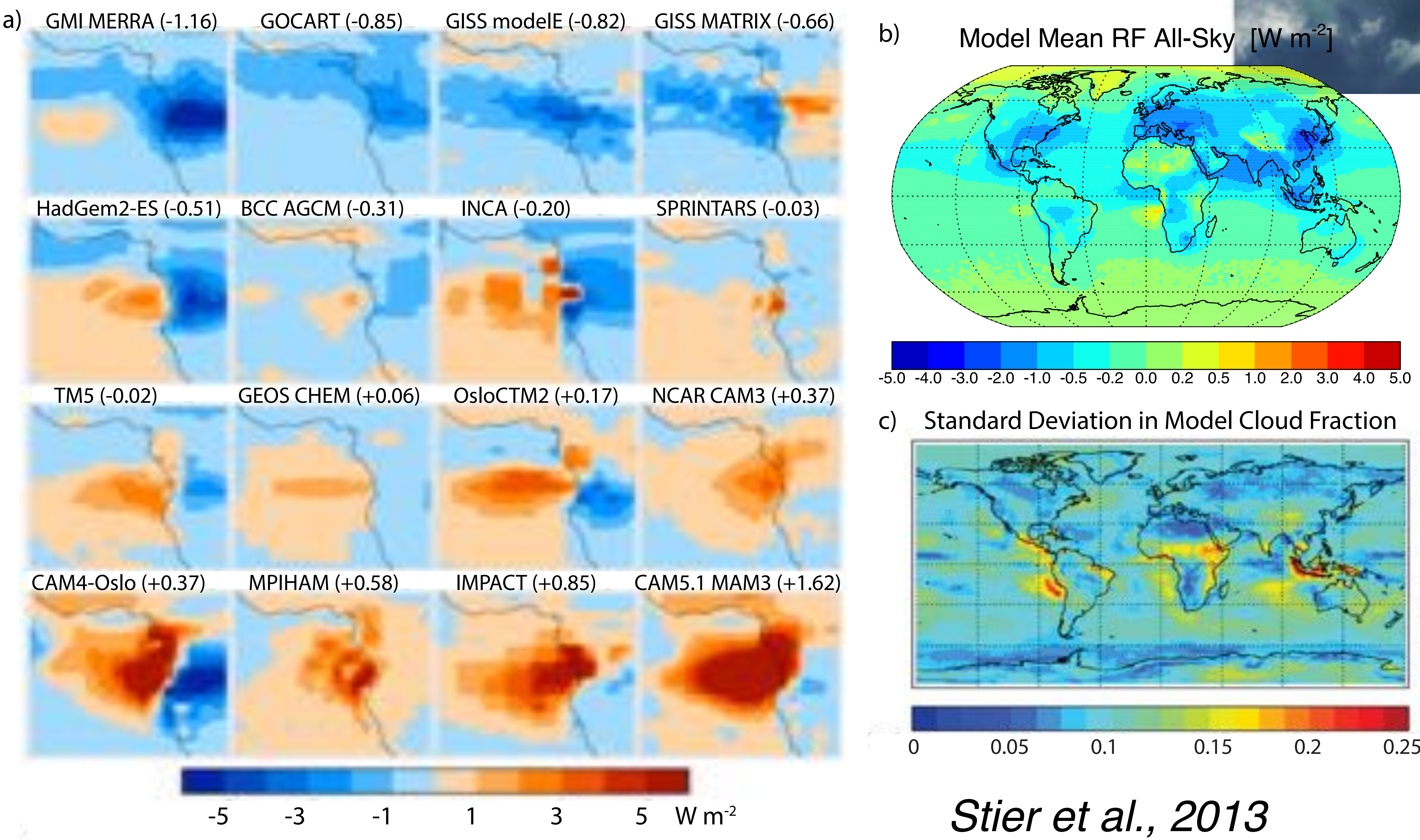
- UK ‘CLARIFY’: BaE-146 plane Aug-Sep 2016, Walvis Bay, Namibia. PI: Jim Haywood
- NASA: EVS-2 ‘ORACLES’: 2016, 2017, 2018 P-3 & ER-2, Bay, Namibia, PI: Jens Redemann, Deputy PI: Rob Wood, EVS-2 PM: Hal Maring
- DOE ‘LASIC’: AMF1 2016-2017 (17 mo.) @ Ascension Is. ARM PM: Sally McFarlane; ASR PMs: Ashley Williamson/ Shaima Nasiri
- NSF ‘ONFIRE’: C-130 plane Aug-Sept 2017, Sao Tome. ~$7.5M. NSF PM: Anjuli Banzmai
- France, South Africa pursuing coastal/land studies

independent EU-funded oceanographic effort focusing on south Atlantic SST biases: PREFACE. coordinator: Noel Keenlyside free-tropospheric winds advect smoke from African continental fires over the southern Atlantic stratocumulus deck, from July-November

September

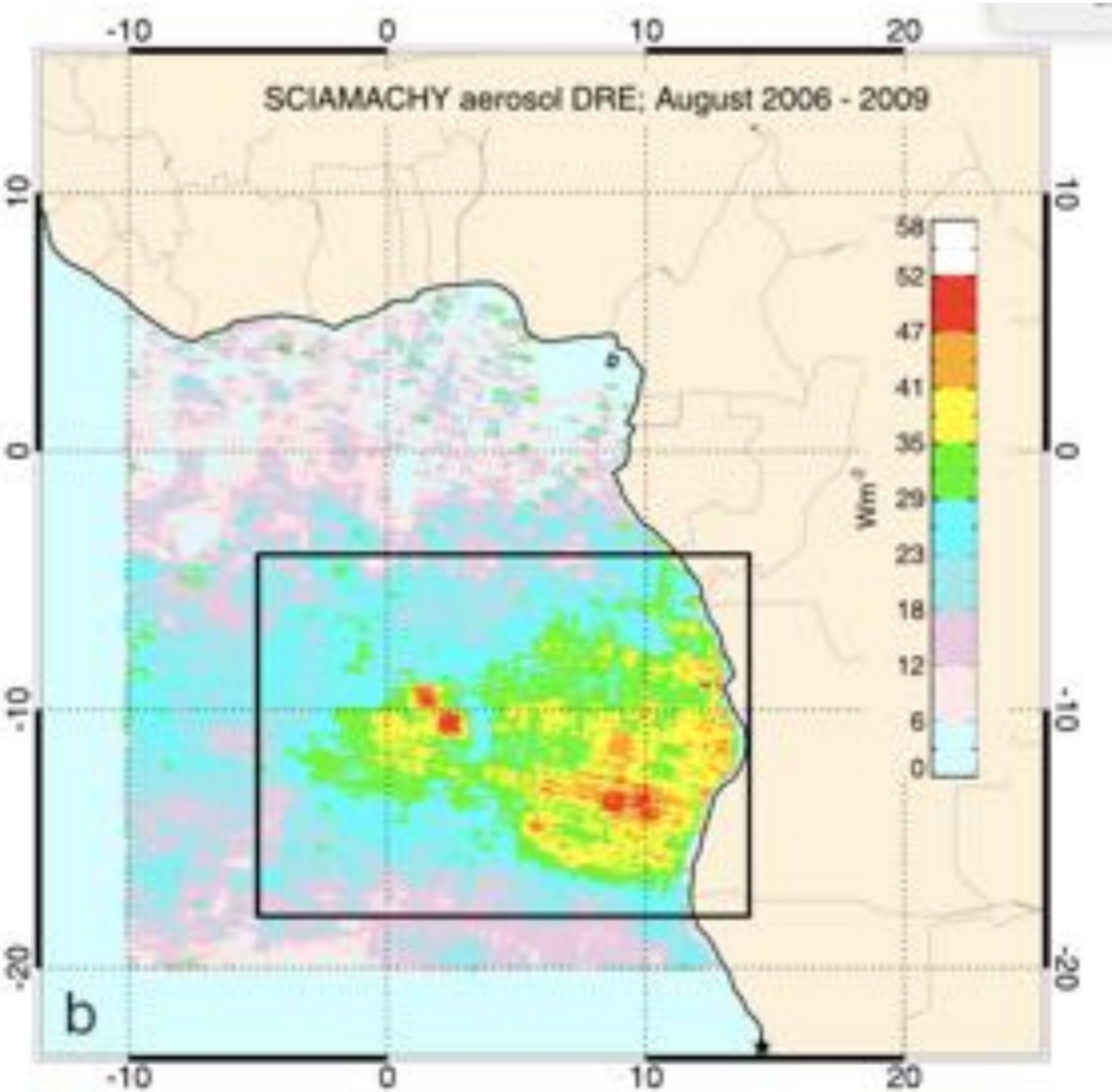


direct radiative effect from biomasss burning aerosols is a global maximum over the southeast Atlantic, but, varies significantly in global aerosol models, in part because of differences in the underlying low cloud fraction



Stier et al., 2013

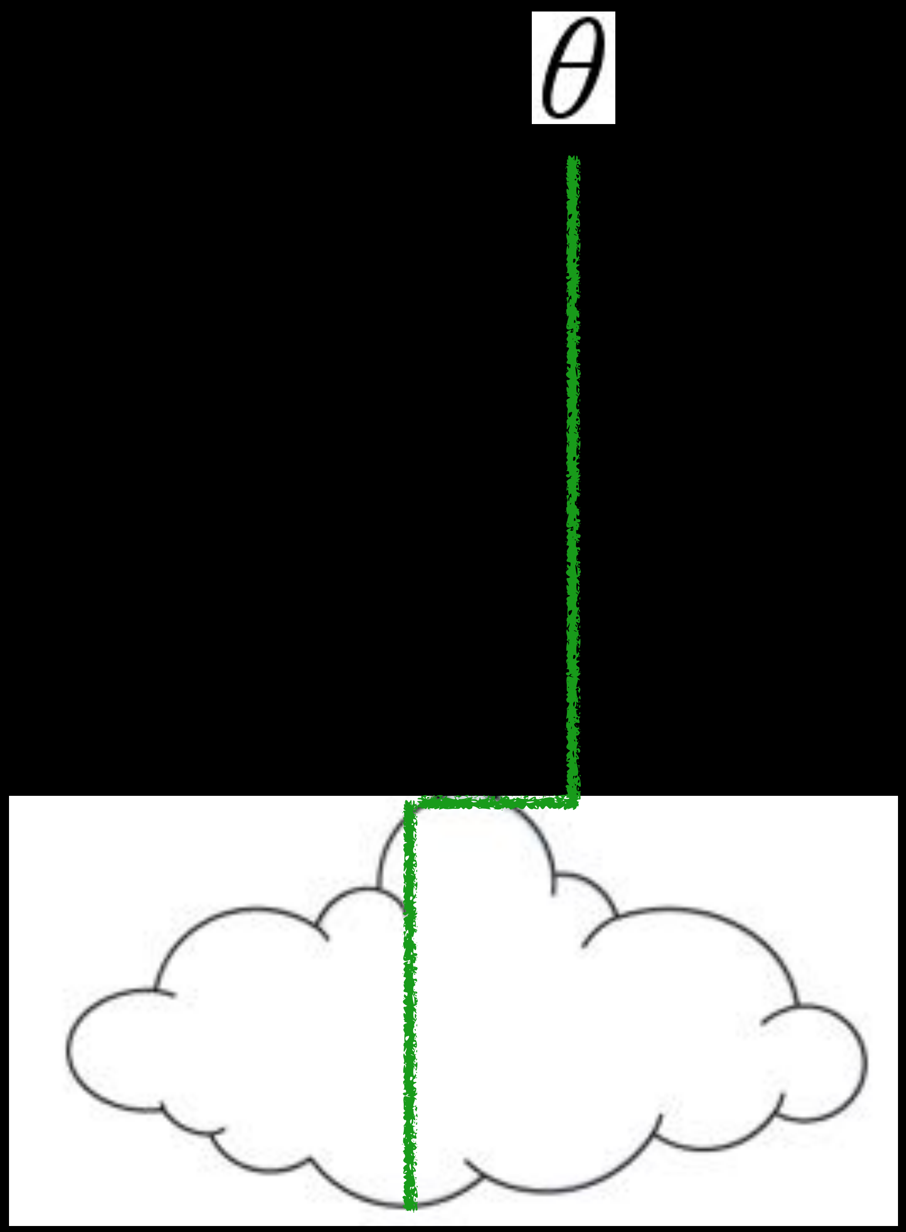
…satellite observations suggest far higher direct radiative effects… (clouds?)

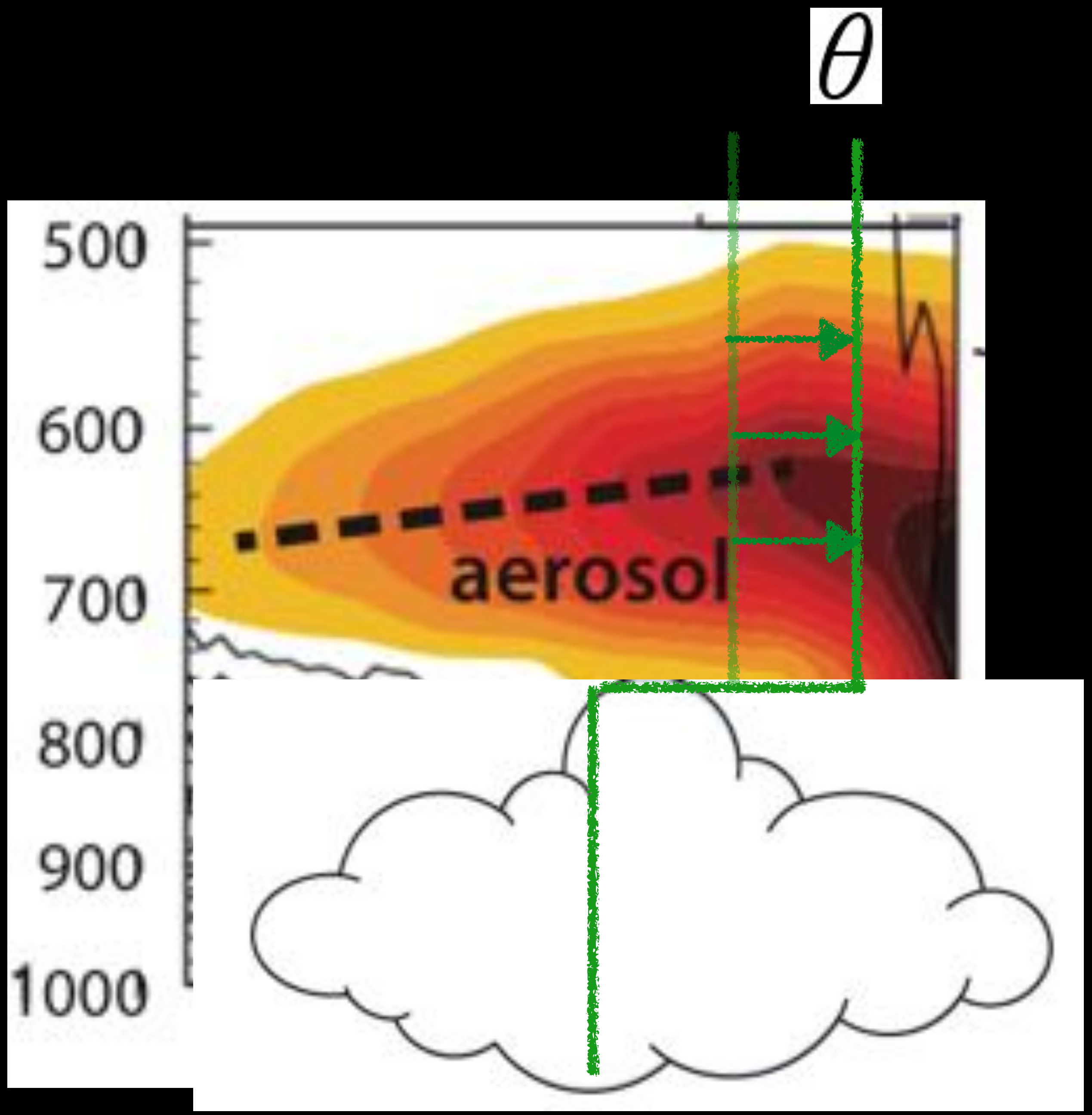


de Graaf et al., 2014 GRL

main aerosol-cloud interaction is semi-direct effect

shortwave-absorbing aerosols above low clouds can increase cloud fraction if the aerosols increase cloud-top-inversion-level stability

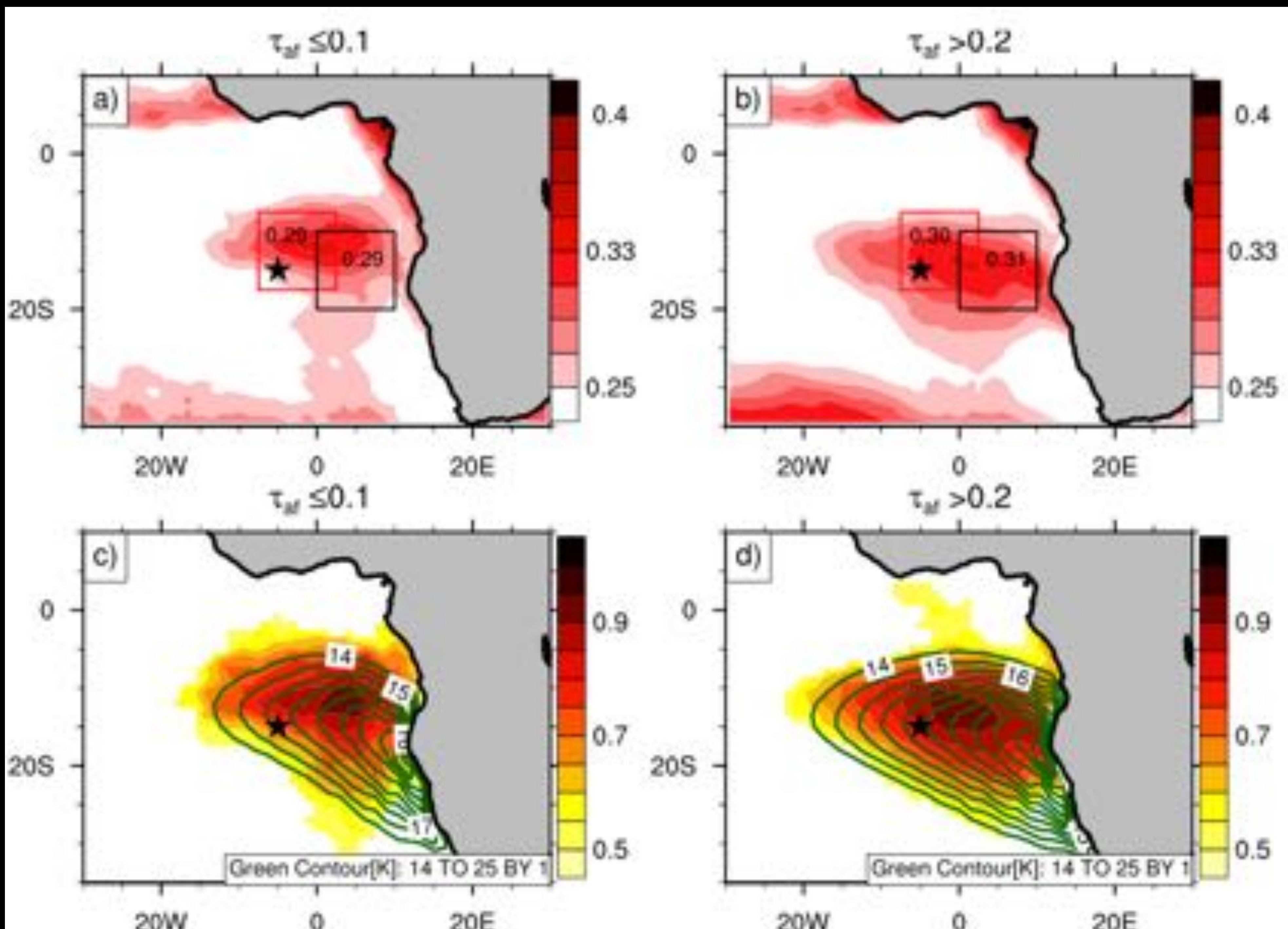




supported in satellite observations

caveat: meteorology

pristine polluted



10-yr Aug-Sept composite means

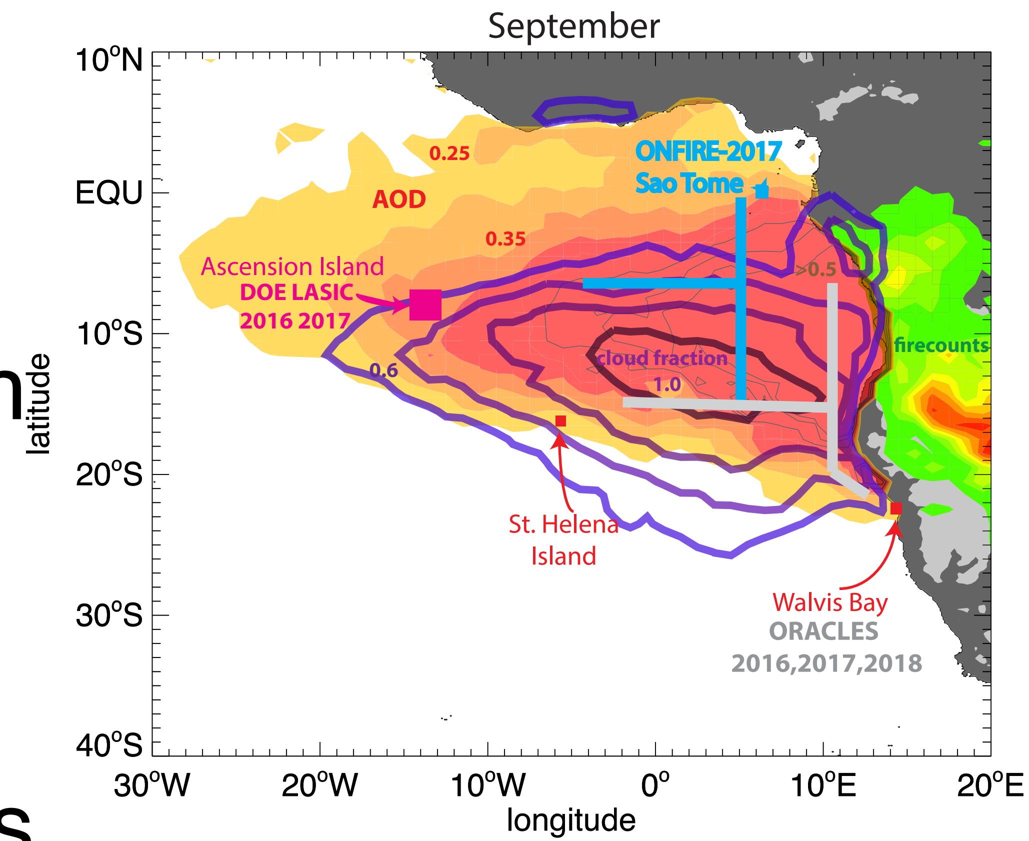
CERES albedo

MODIS low cloud fraction (yellow-red)

ERA-I $\theta_{800} - \theta_{1000}$ green

Adebiyi et al., 2015, JCLIM

modeling plans:



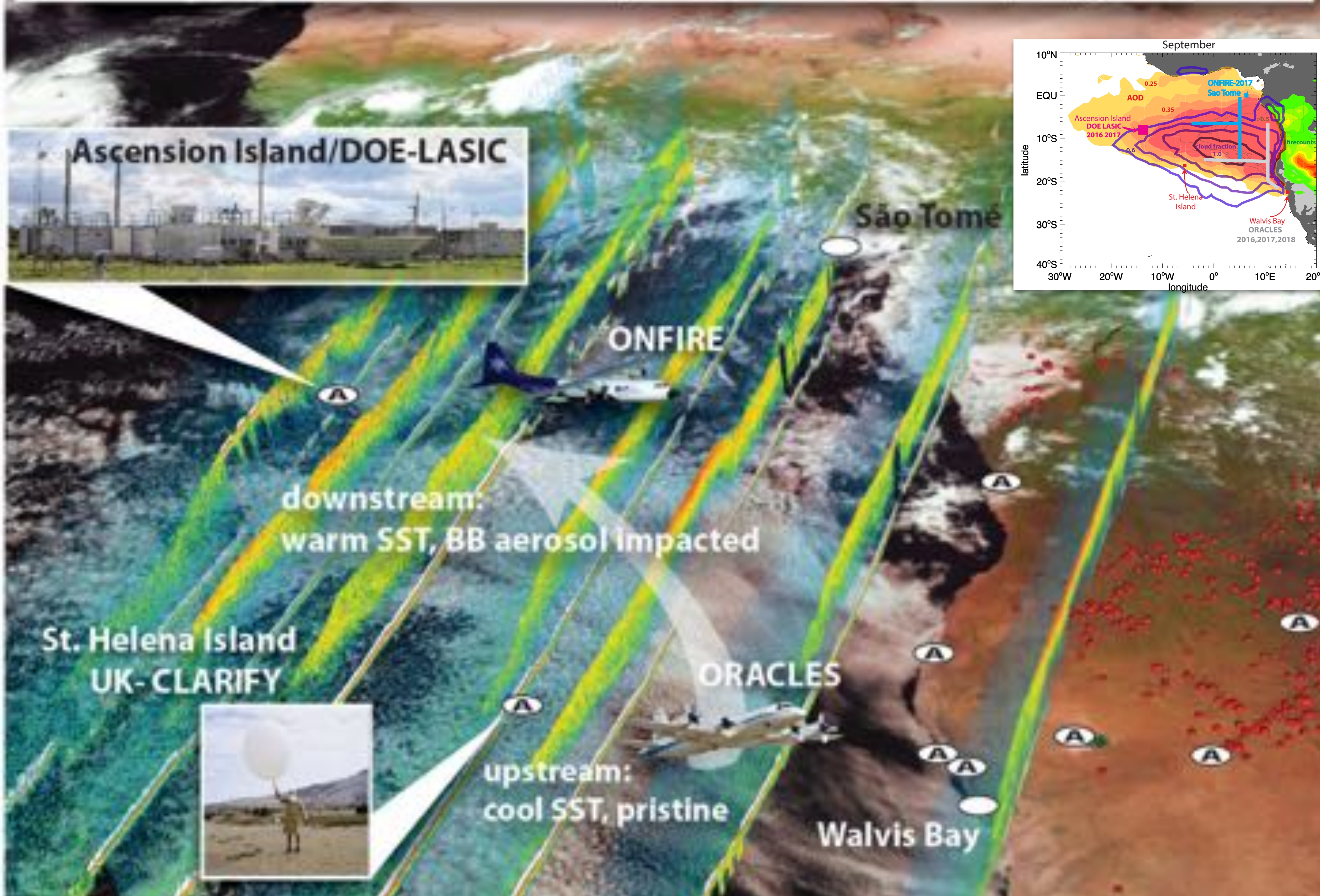
- NASA/NSF campaigns both devote 1/2 flight time to ‘survey’ flights along regular lat/lon lines (e.g., VOCALS). future model intercomparisons

- modelers explicitly involved spanning a range of scales
- notable: AEROCOM, NASA aerosol data assimilation

Timeline:

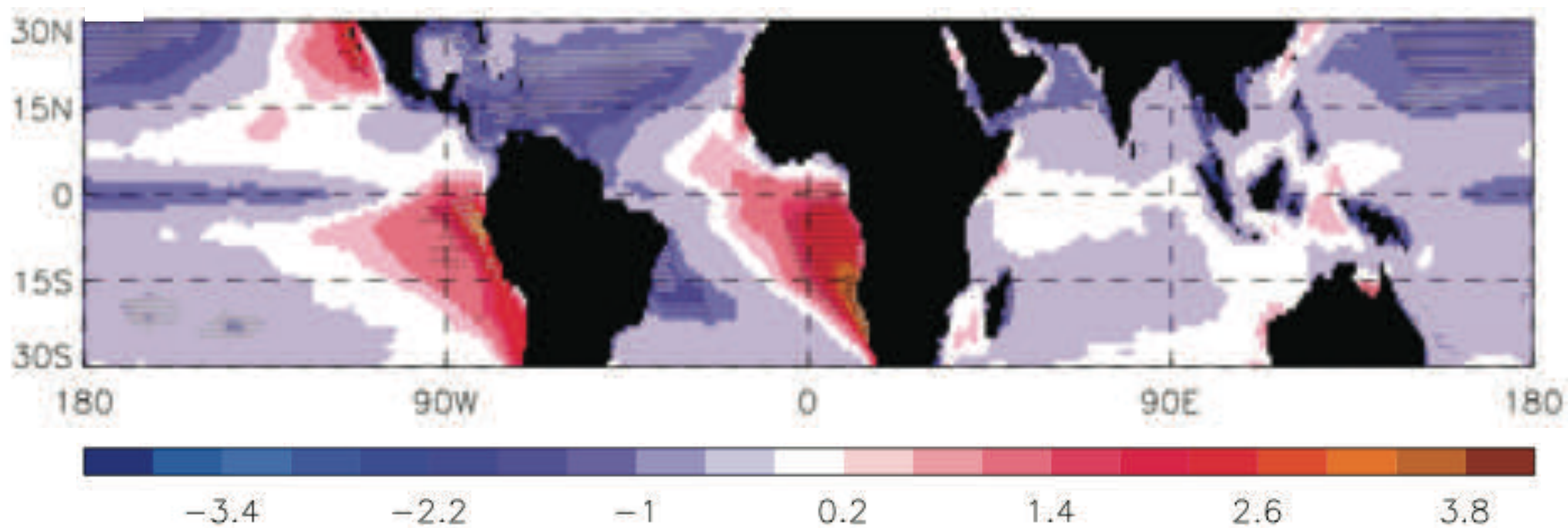
- today’s focus is on campaign planning:
- encourage modeler involvement through regular proposals
- input from current CPTs would be useful

Opportunities for documenting Lagrangian evolution of low clouds during SE Atlantic campaigns

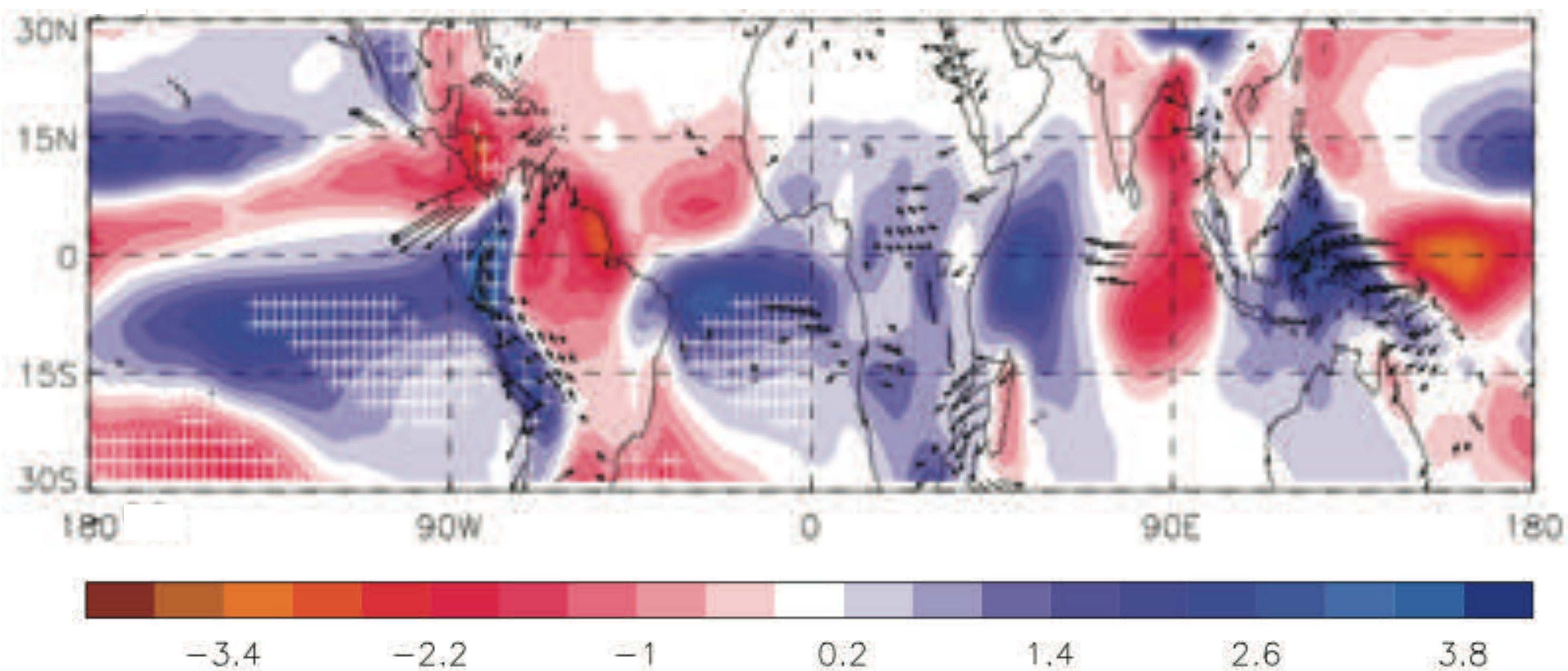


low clouds considered a leading cause of the tropical SST biases

AR5 (25 models): SST - Hadley SST [K]
Annual mean 1960-2004



AR5 (25 models): Precip - CMAP [mm/day]
Annual mean 1979-2004



Toniazzo and Woolnough, 2013

Challenges and Future Prospects for Reducing Coupled Climate Model SST Biases in the Eastern Tropical Atlantic and Pacific Oceans

A White Paper by the
U.S. CLIVAR Eastern Tropical Oceans Synthesis Working Group

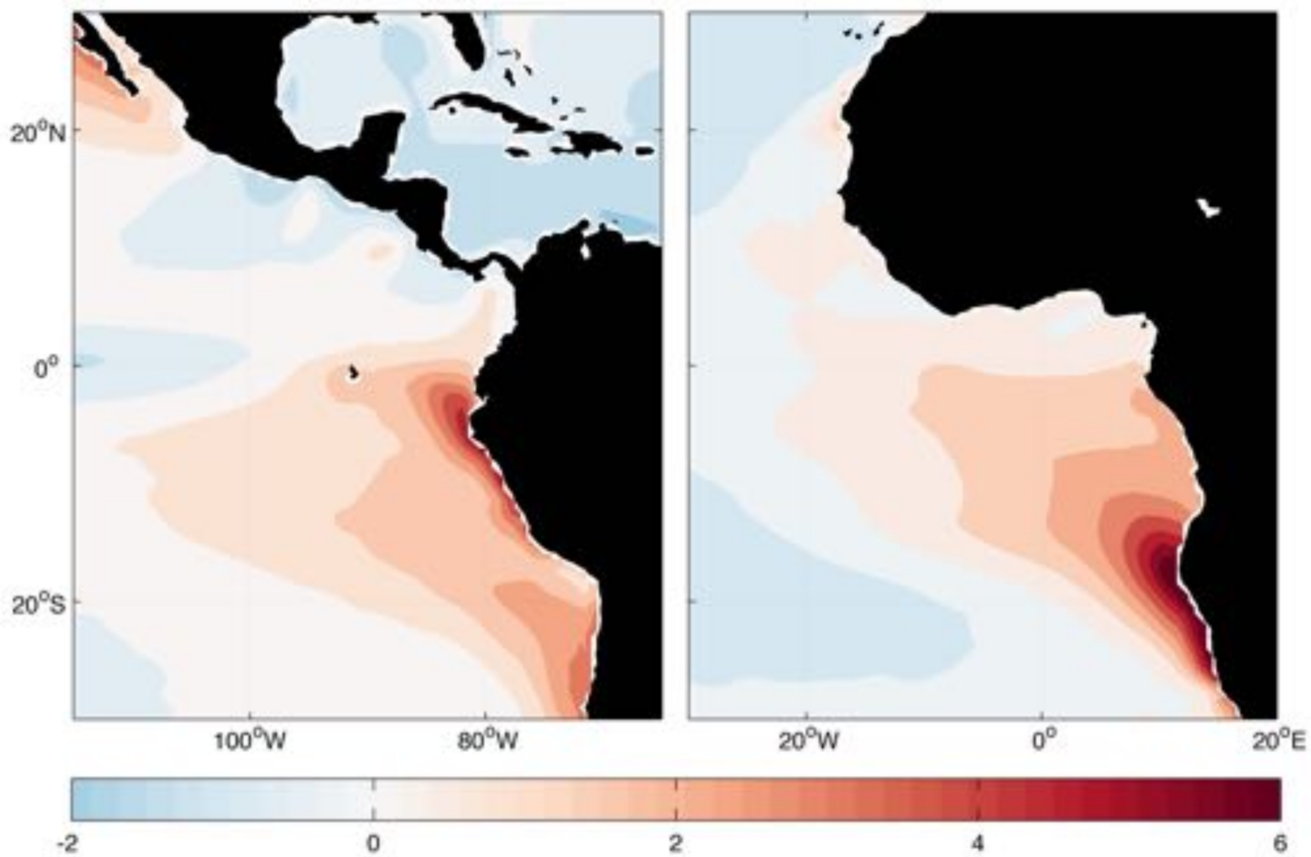
Paquita Zuidema, U of Miami; Ping Chang, Texas A&M U; Brian Medeiros, National Center for Atmospheric Research (NCAR); Ben Kirtman, U. of Miami; Roberto Mechoso, U of California - Los Angeles; Ed Schneider, Center of Ocean-Land-Atmosphere (COLA) Studies; Justin Small, NCAR; Ingo Richter, JAMSTEC; Thomas Toniazzo, U. of Bergen; Seiji Kato, NASA-Langley; Tom Farrar, Woods Hole Oceanographic Institute; Simon de Szoeke, Oregon State University; Peter Brandt, GEOMAR; Rob Wood, U of Washington; Katinka Bellomo, U of Miami; Eunsil Jung, U of Miami; Mingkui Li, Ocean University of China, Qingdao (OUC); Zhao Xu, OUC; Zaiyu Wang, COLA; Christina Patricola, LNL-Berkeley

Summary
Coupled climate models typically display sea surface temperatures (SSTs) in the eastern Atlantic and Pacific basins that are warmer than observed, and too symmetric a climate about the equator. The US CLIVAR Working Group on Eastern Tropical Ocean Synthesis provides herein its assessment of the current state of knowledge about the SST biases, with the aim of identifying promising areas for future work. A summary of the newer findings is:

• The most pronounced SST model biases occur in the southeast Atlantic, with the connection to the equatorial biases not yet well well-understood.
•Hindcast experimentation indicates that, in models, the dominant processes establishing the eastern basin SST biases are model-dependent.
• The processes responsible for cooler eastern basin sea surface temperatures differ between the Pacific and Atlantic, with oceanic processes appearing to be more important for the southeast Atlantic.
• The oceanic processes maintaining the southeast Atlantic SST distribution include the shallow oceanic Angola Dome thermocline at 10S and southward Angola Current meeting the northward Benguela Current at the Angola-Benguela Front at 18S. These coastal features affect offshore SSTs through low-level atmospheric temperature and moisture advection, with the contribution to cooling by oceanic eddies unknown.
• The importance of oceanic eddy-mixing processes to the offshore SST cooling in the southeast Pacific still lacks a robust consensus.
• Remote bias experiments suggest the southeast Atlantic SST biases deliver a larger global impact than those of the southeast Pacific, by also warming and moistening the southern Pacific basin.
• The seasonal cycle in the southern hemisphere stratocumulus cloud fraction can provide a useful model metric, in that it is inadequately captured by many but not all models.
• The stratocumulus decks' cloud fractions are underestimated even when the SST field is unbiased, implicating the atmospheric model component as the origin of the cloud error.
• Causes for coastal versus offshore cloud fraction model errors may differ.
• The gridded surface flux datasets used to assess coupled climate models can themselves overestimate the leading term - the amount of shortwave radiation entering the ocean - by ~ 10 W m^{-2} in the stratocumulus regions.
• Improvements in spatial resolution improve depiction of the equatorial cold tongue more than that of the coastal oceanic upwelling regions. This reflects difficulty in representing the narrow coastal wind fields.
• Fieldwork is elucidating causes for SST and cloud errors in the southeast Pacific, and just beginning for the Atlantic.
• Ongoing relevant European-funded Atlantic fieldwork is focusing on oceanic processes, while upcoming US-funded efforts will examine the low cloud response to the shortwave-absorbing aerosol.

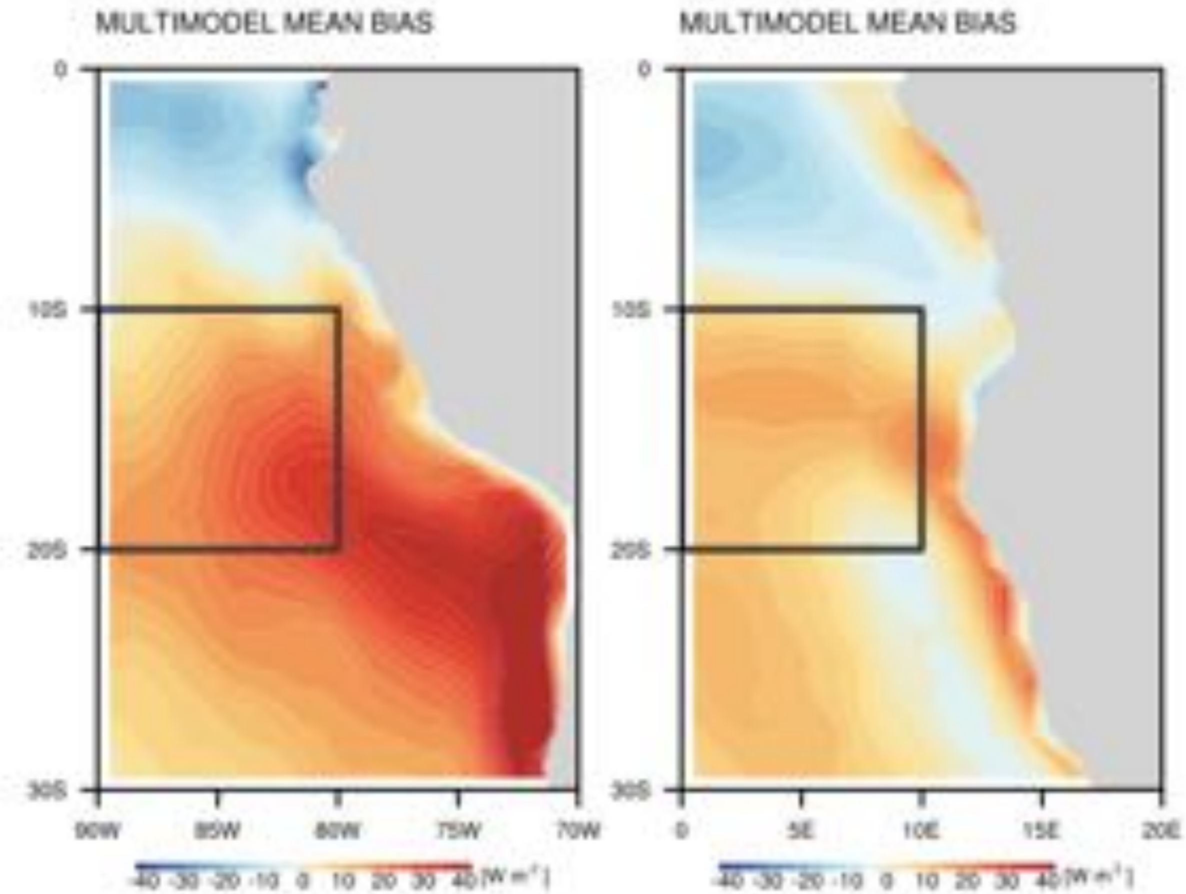
Recommendations
• Individual modeling centers should be encouraged to identify and improve their model's bias origins as these are model-dependent.
• We encourage the development of high resolution coupled models with a concurrent emphasis on parameterization development for vertical mixing and finer-scale oceanic and atmospheric dynamics.
• We encourage further model improvement incorporating data from recent and upcoming field campaigns.
• We encourage a focus on the model representation of the eastern basin coastal oceanic upwelling regions.
• We encourage fuller quality control and assessment of available buoy measurements and of gridded surface flux products, towards improving their use as climate model validation datasets

bias origins may differ between the two basins



CMIP5 SST biases averaged from 1984-2004

relative to the Reynolds climatology.



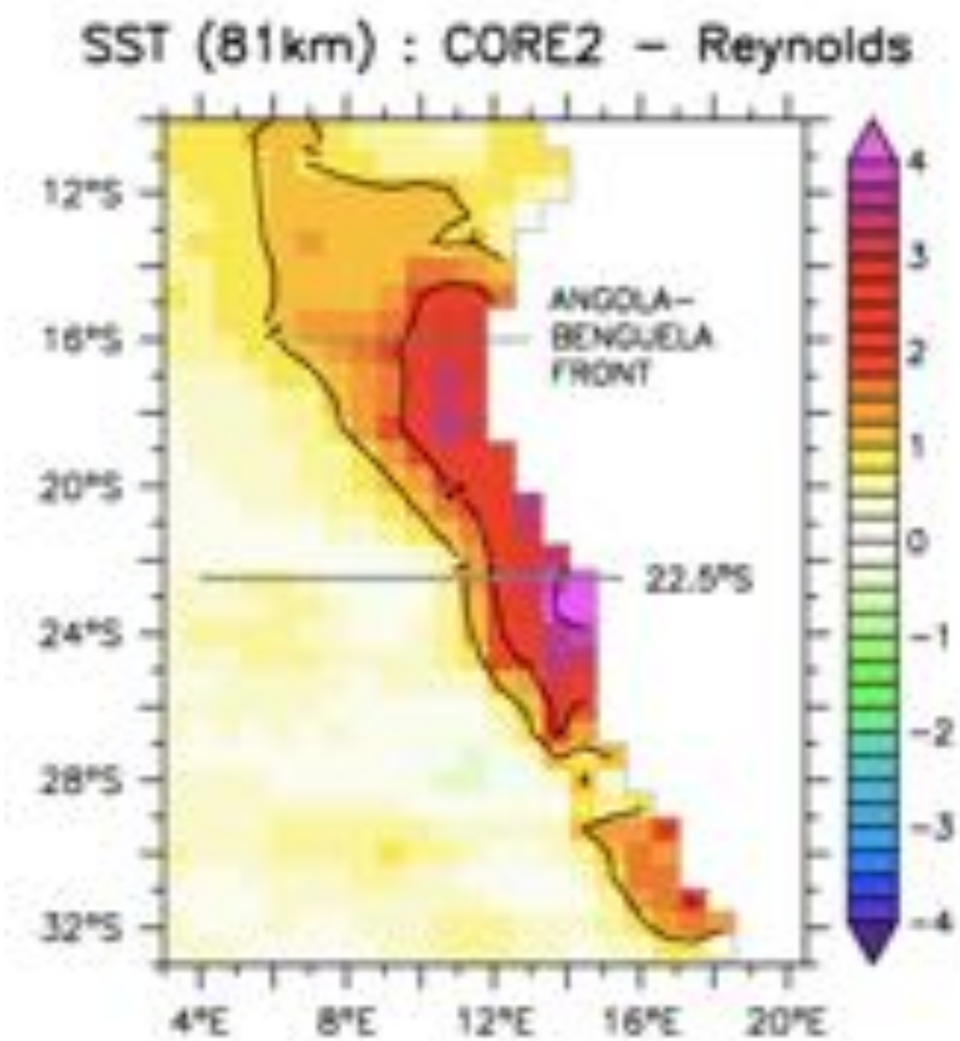
net shortwave bias wrt CERES EBAF (2000–2013) based on

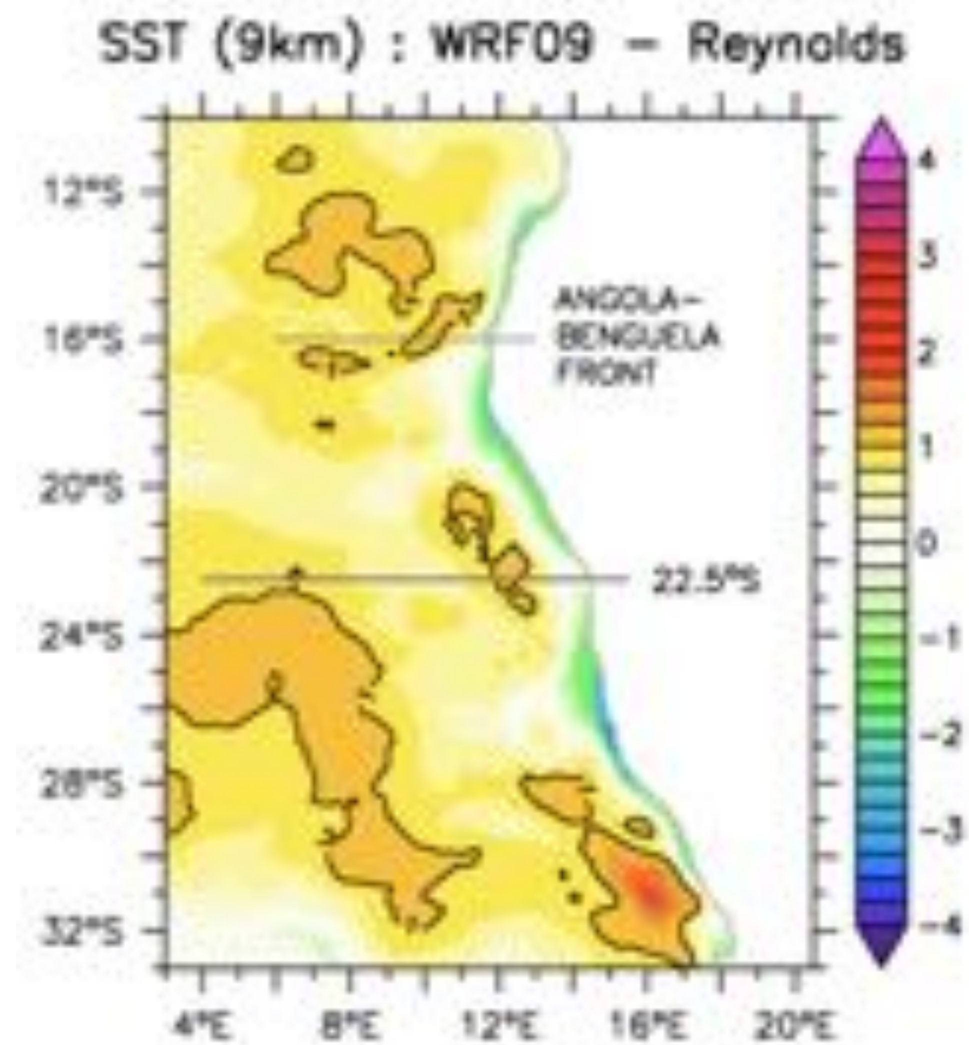
44 CMIP5 models using 'historical' simulation monthly mea

(years 1950--1999, all months)

posters by Justin Small and by Christina Patricola highlight importance of the eastern basin atmospheric coastal jets

- very narrow regions (in contrast to western boundary currents)
- sensitive to wind structure (as opposed to wind strength)
- processes affecting coastal/offshore low clouds differ

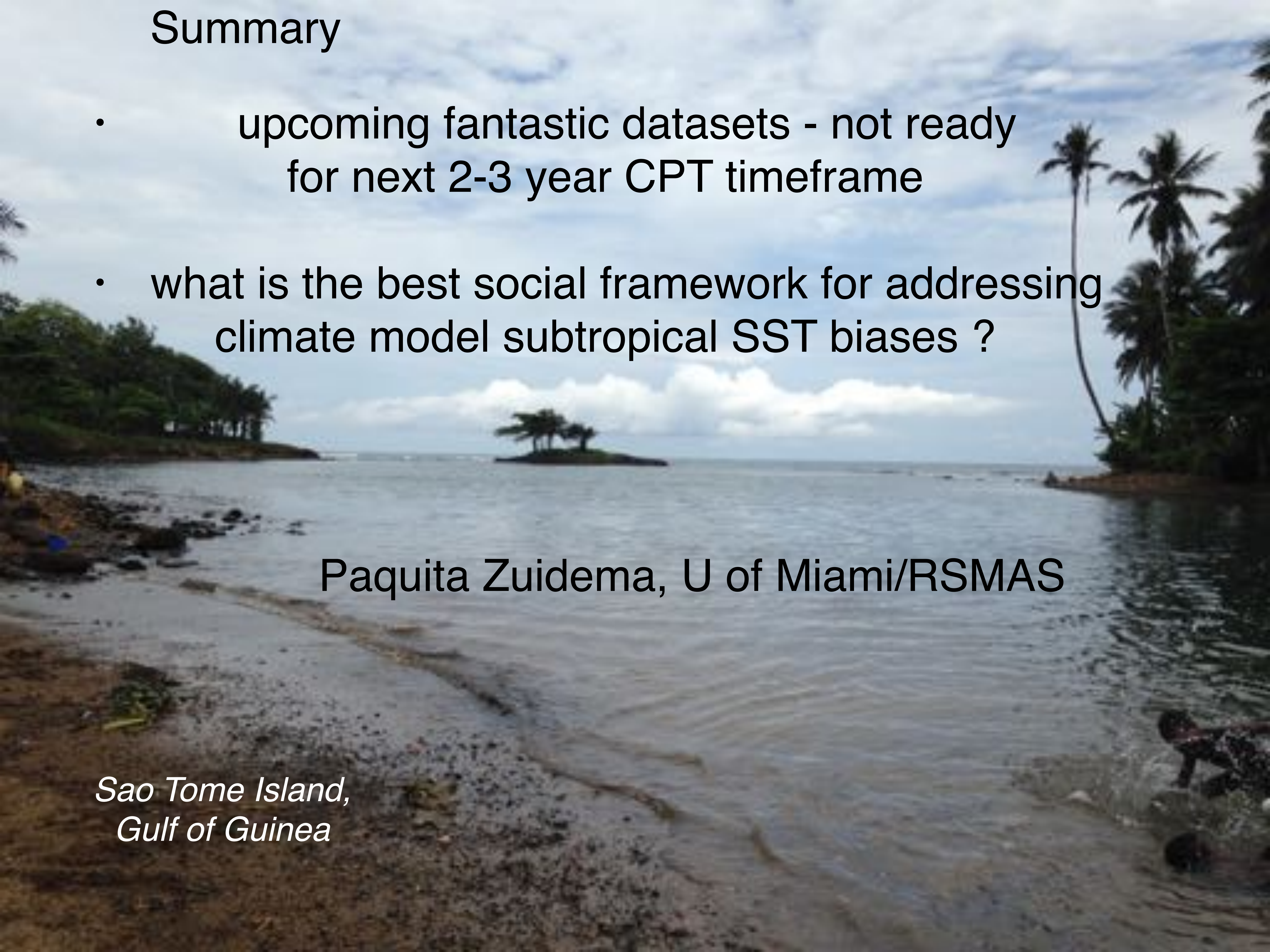




Summary

- upcoming fantastic datasets - not ready for next 2-3 year CPT timeframe
- what is the best social framework for addressing climate model subtropical SST biases ?

Paquita Zuidema, U of Miami/RSMAS



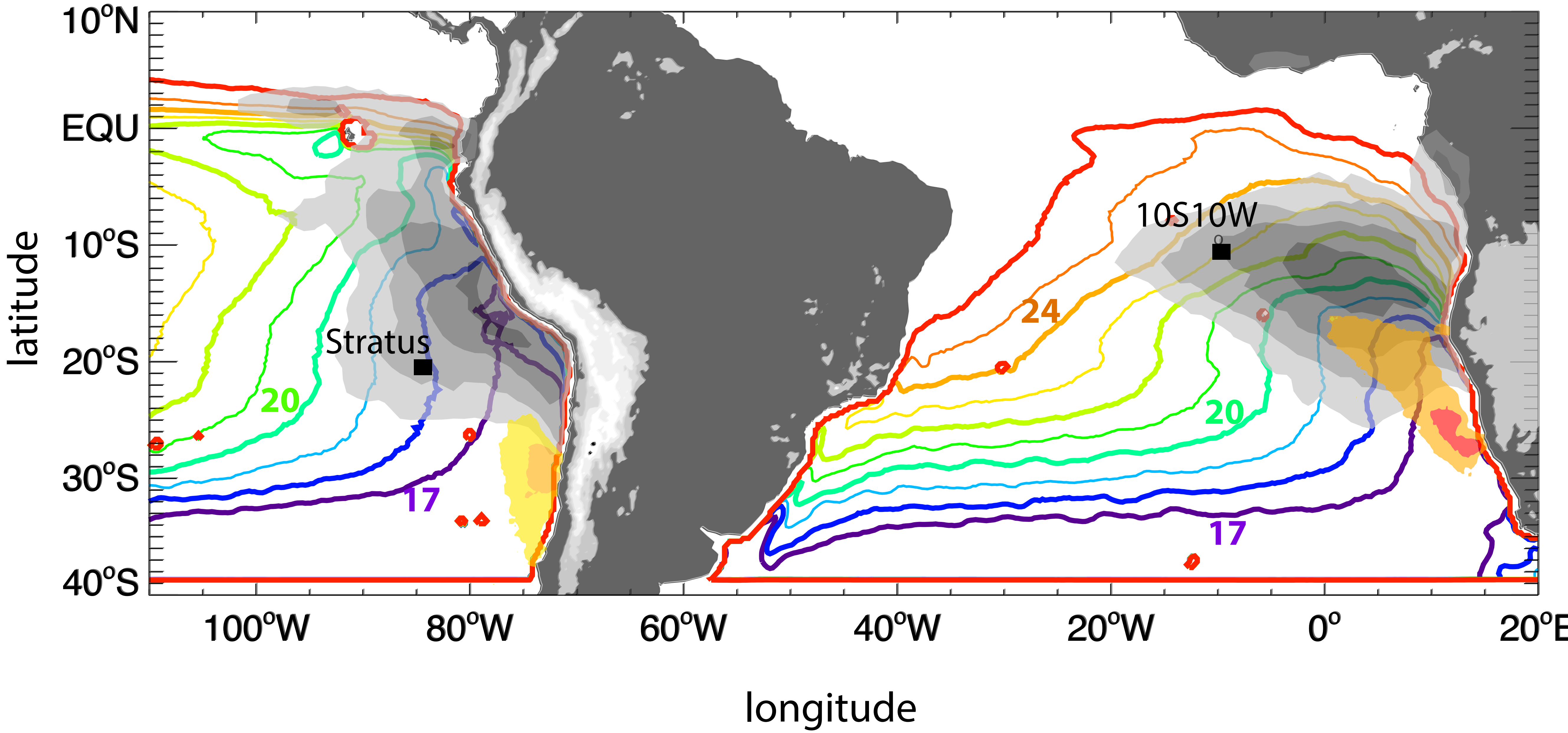
Sao Tome Island, Gulf of Guinea

extra slides

posters by Justin Small and by Christina Patricola highlight importance of the eastern basin atmospheric coastal jets

- very narrow regions (in contrast to western boundary currents)
- processes affecting coastal/offshore low clouds differ

clim. September clouds (MODIS, grey), SST (TMI), coastal winds (QuikScat, color contours)



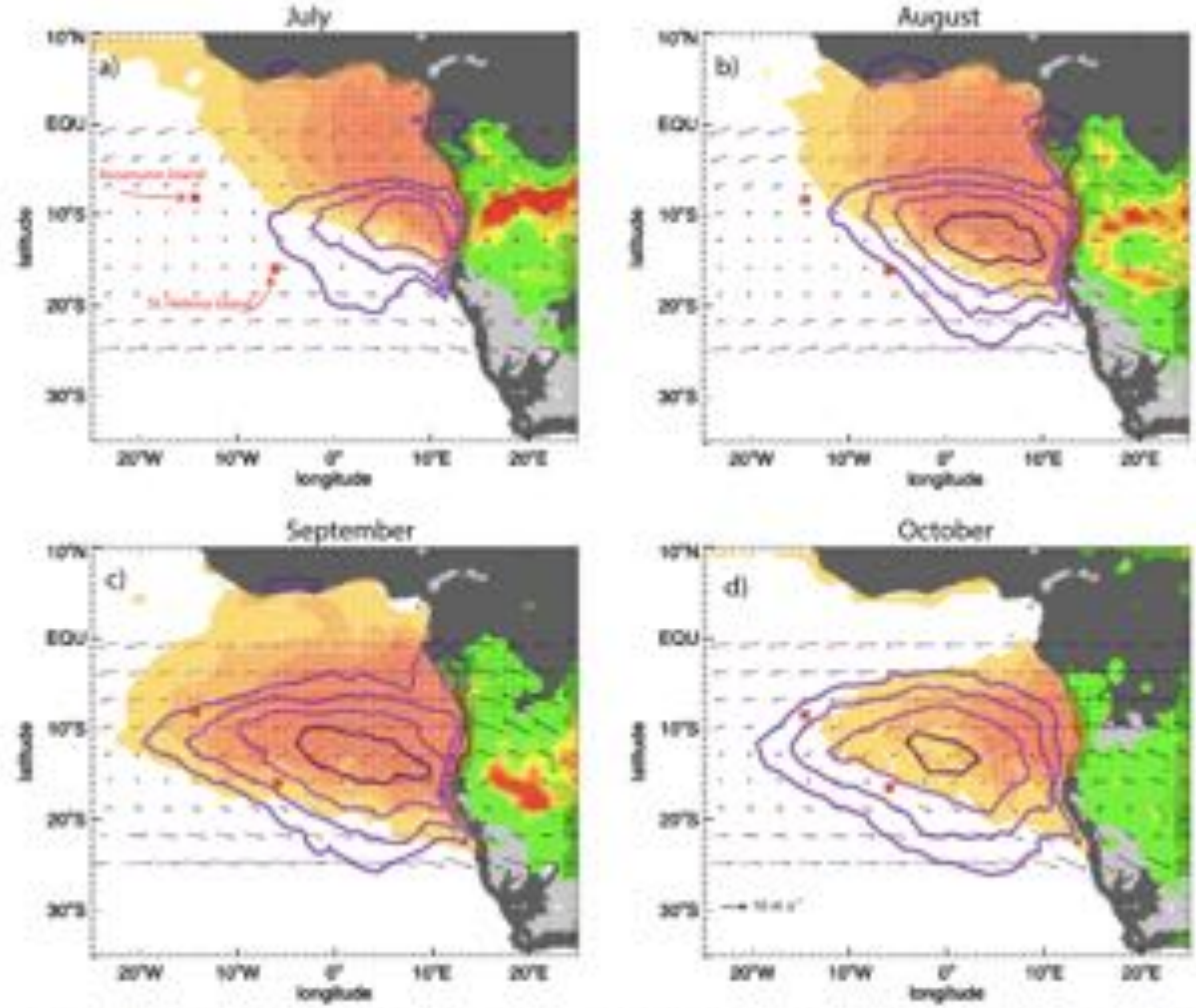


FIG. 5. (a) July, (b) August, (c) September, and (d) October MODIS mean 2002–12 cloud fraction (blue to black contours, 0.6–1.0 increments of 0.1), fine-mode aerosol optical depth (yellow-red shading indicates 0.25–0.45 in increments of 0.05 and very light black contour lines indicate 0.5–0.7 in increments of 0.1), fire pixel counts (green–red shading, 10–510 in increments of 50), and ERA-Interim 2002–12 monthly-mean 600-hPa winds. Red squares indicate Ascension Island and St. Helena Island.