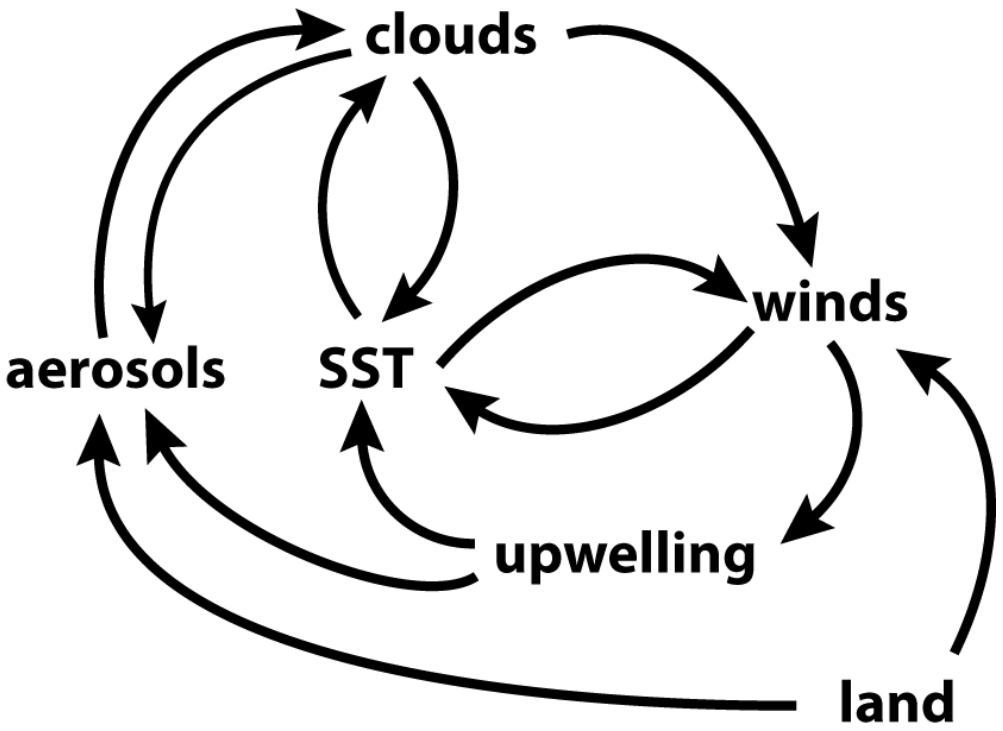
Research aircraft needs for shallow cloud systems and the PBL

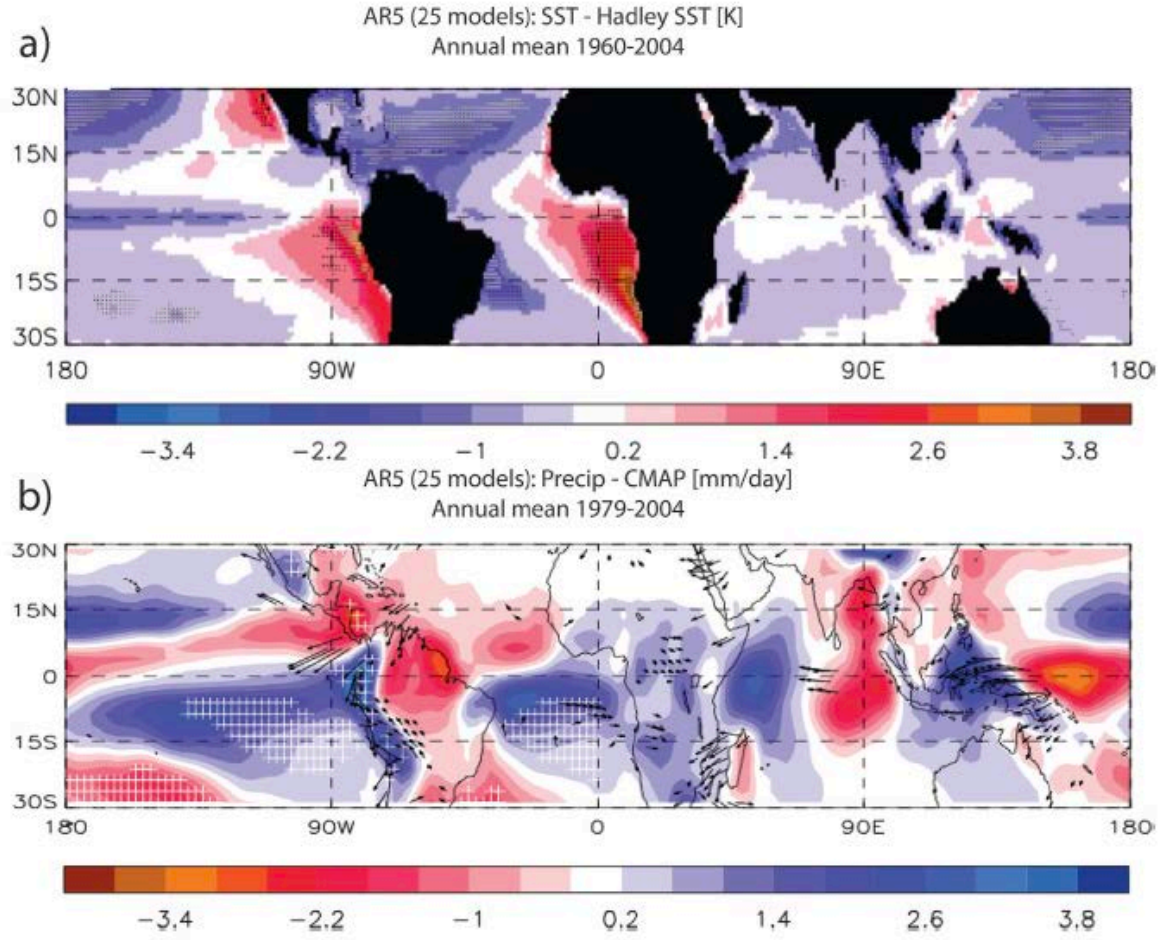


NASA Decadal Survey themes impacted:

- Coupling of the water and energy cycles.
- Extending and Improving Weather and Air Quality Forecasts.
- Reducing Climate Uncertainty and Informing Societal Response.

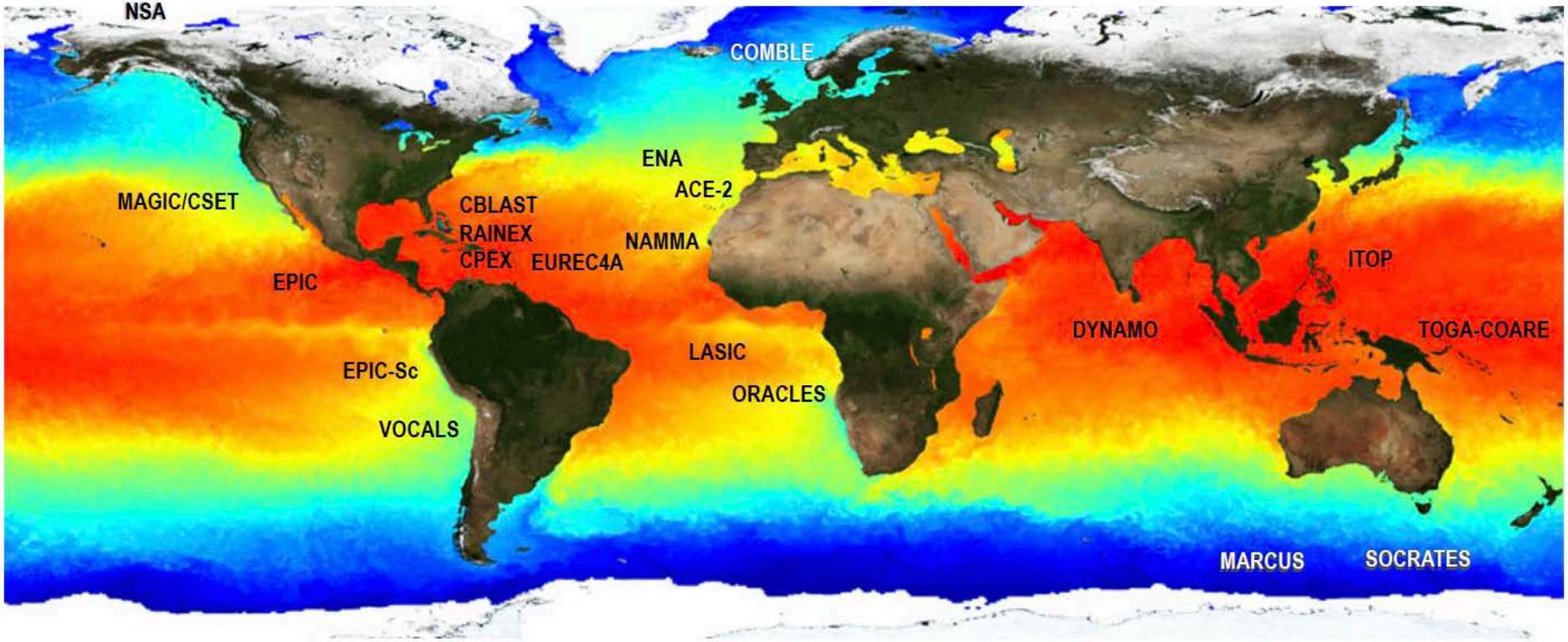
Strongly-coupled PBL system: Models poorly represent these key processes

Low cloud and PBL biases in models hinder subseasonal to centennial forecasting skill



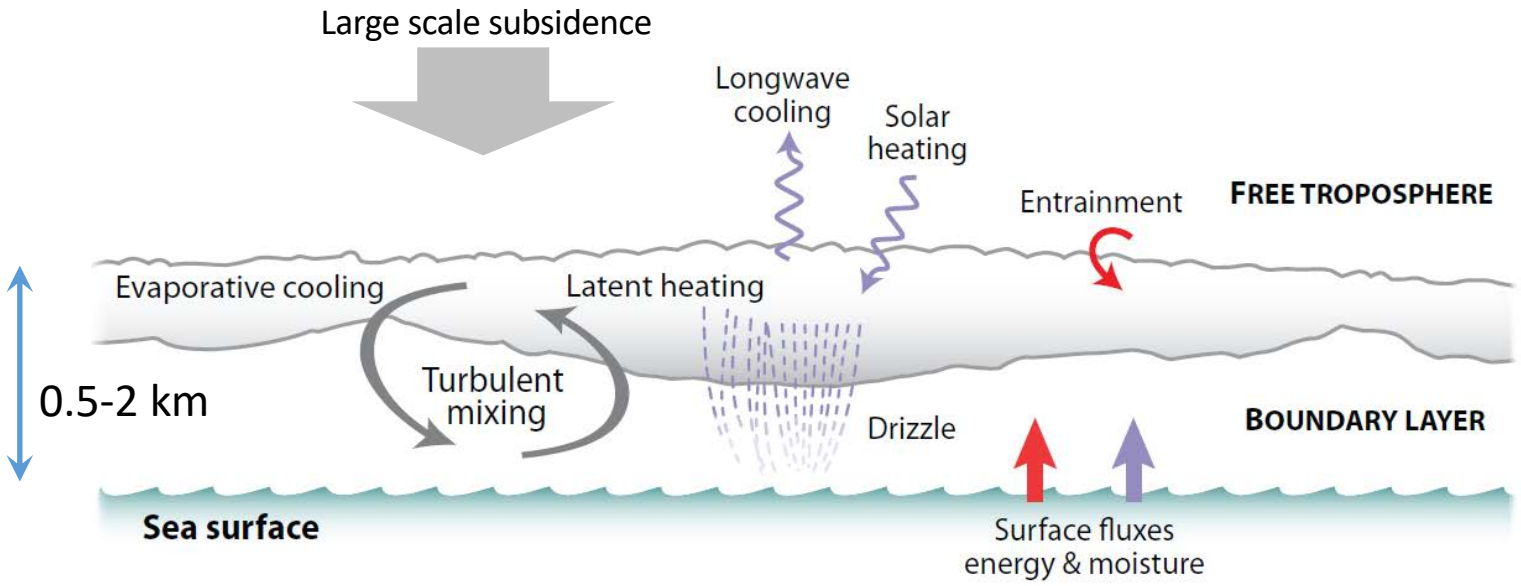
Zuidema, P., et al. (2016). Challenges and Prospects for Reducing Coupled Climate Model SST Biases in the Eastern Tropical Atlantic and Pacific Oceans: Bull. Amer. Meteorol. Soc., 97, 2305–2328.

Remote PBL locations are critical and need long-range airborne platforms



Recent field campaigns with marine PBL focus (Shuyi Chen/Rob Wood)

Cloud-topped marine PBL – key processes

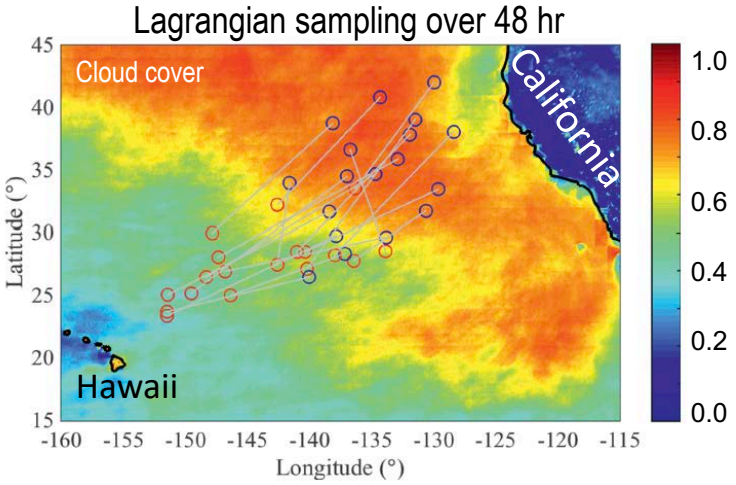


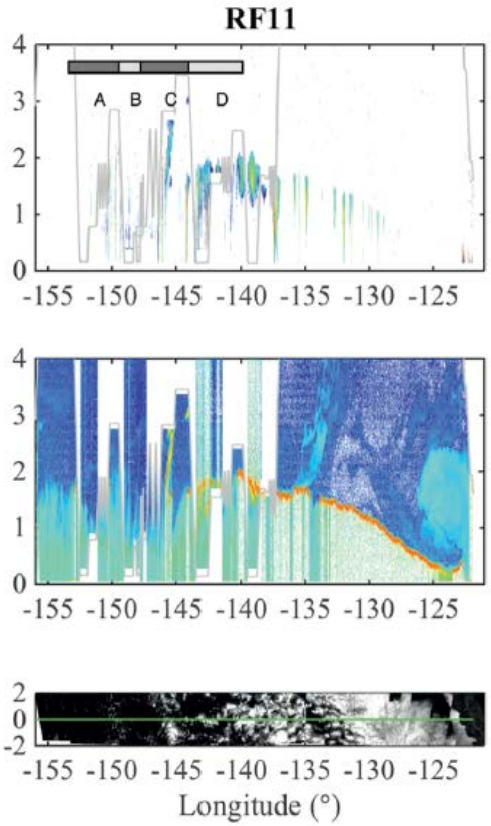
W-1: ***What planetary boundary layer (PBL) processes are integral to the air-surface (land, ocean and sea ice) exchanges of energy, momentum and mass****, and how do these impact weather forecasts and air quality simulations? [MOST IMPORTANT]*

W-9: ***What processes determine cloud microphysical properties and their connections to aerosols and precipitation?***

W-10: ***How do clouds affect the radiative forcing at the surface*** *and contribute to predictability on time scales from minutes to subseasonal?*

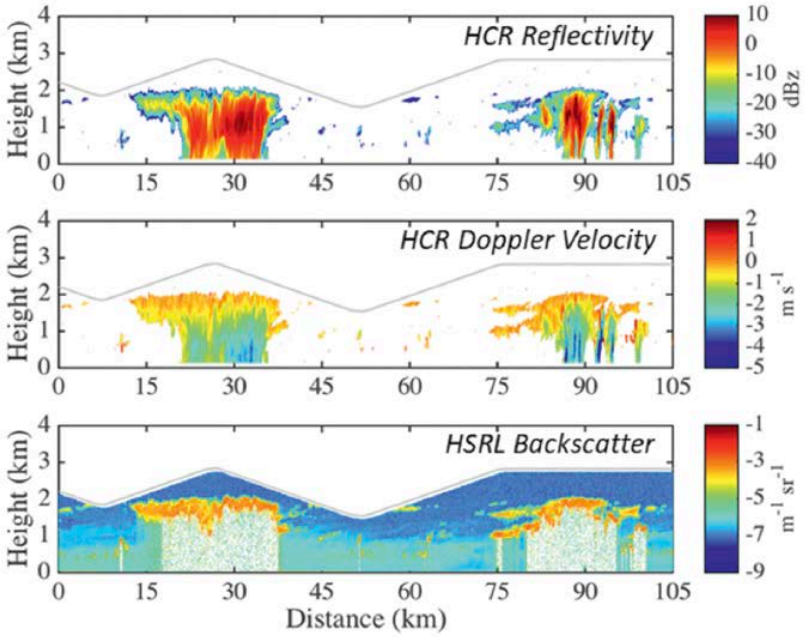
Low clouds are an inherently multi-scale problem





Spatial mapping of PBL transitions over 2500 km

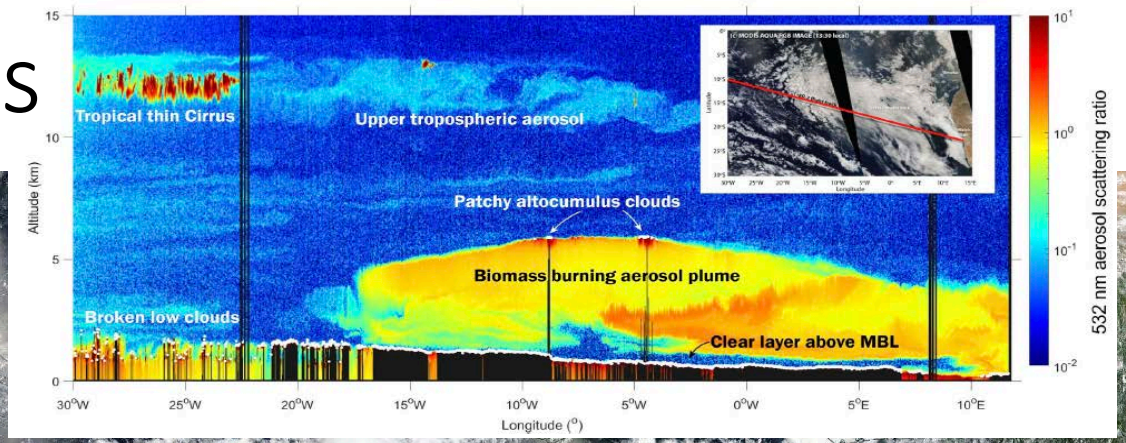
Radar and lidar sampling of precipitating low cloud cells from 100m-100km

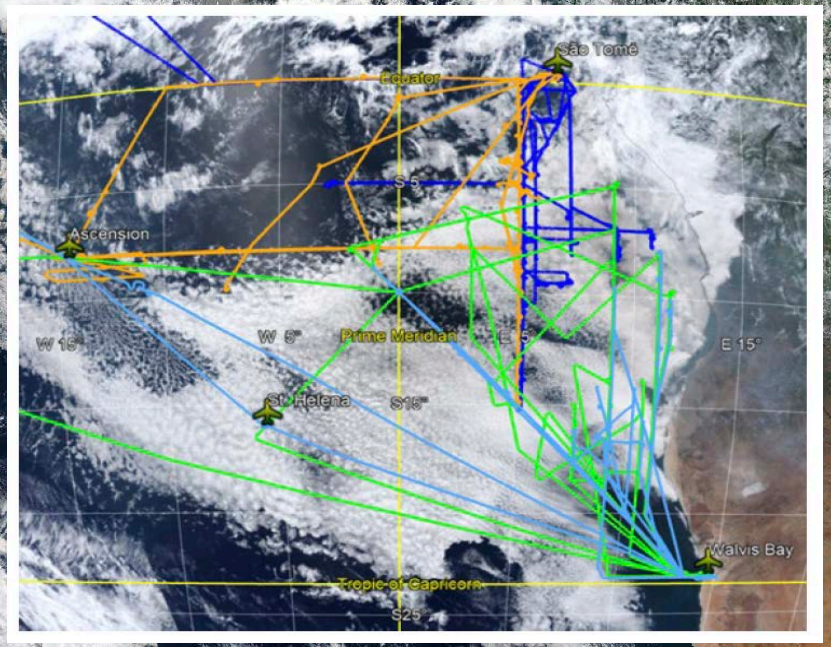


Albrecht, B., et al. (2018). Cloud System Evolution in the Trades (CSET): Following the Evolution of Boundary Layer Cloud Systems with the NSF–NCAR GV. *BAMS*, 100, 93–121.

Spatial scales from 1-5000 km. Temporal evolution from minutes to days

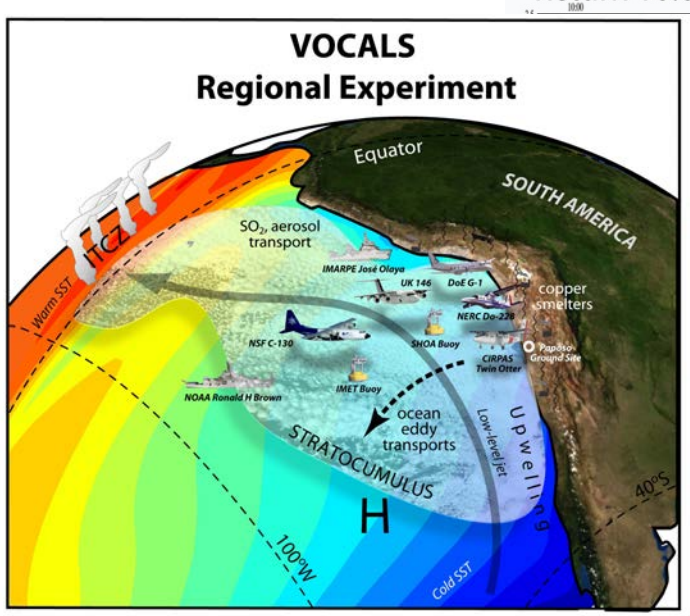
Large scales

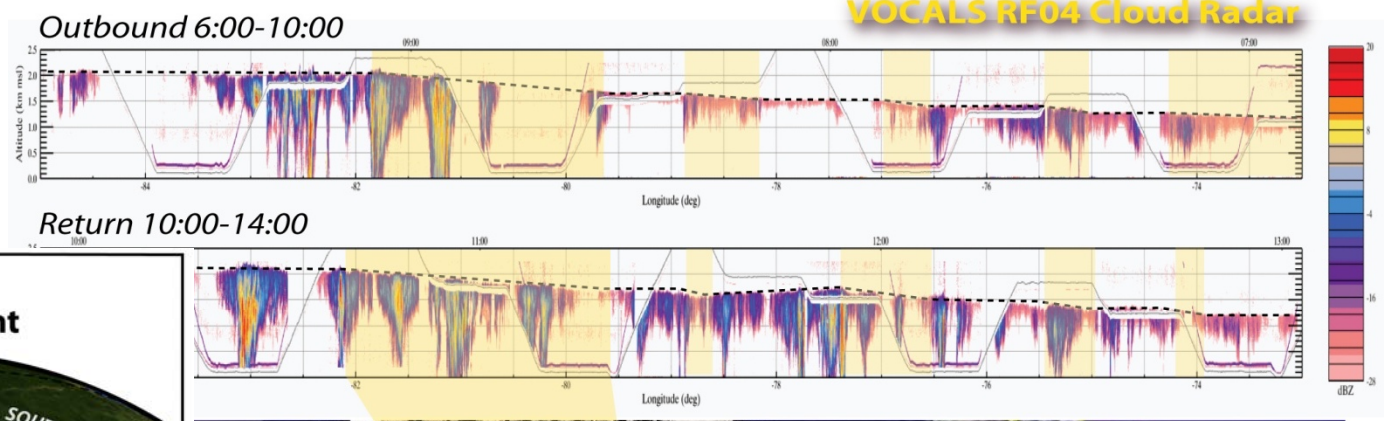


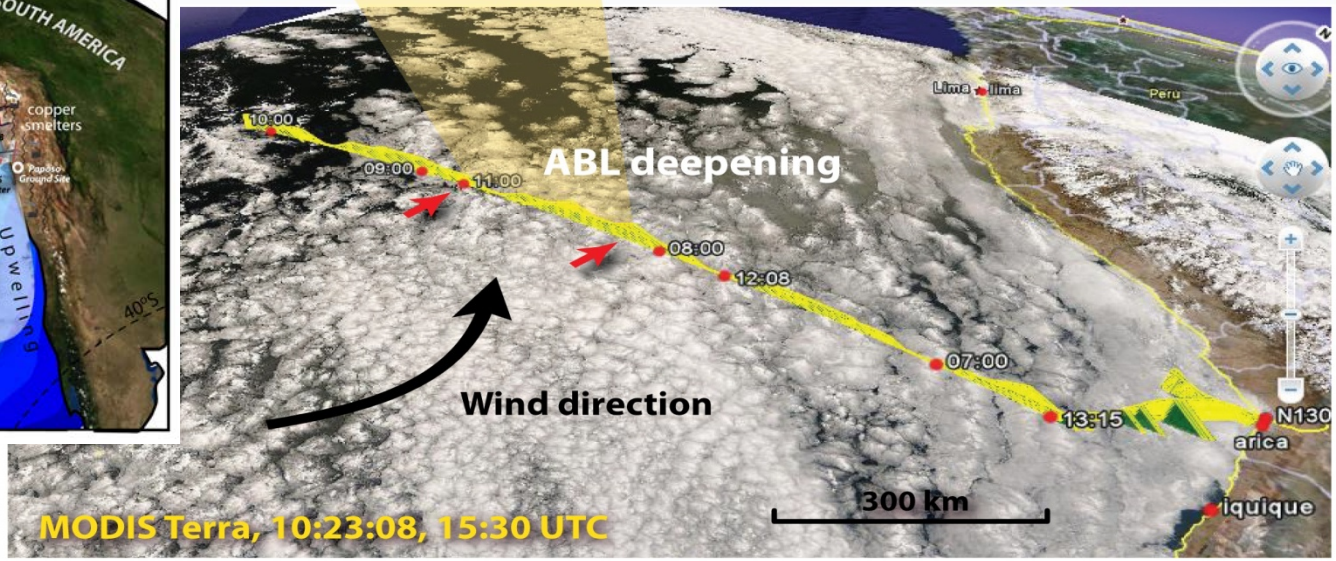


Redemann et al..: An overview of the ORACLES (ObseRvations of Aerosols above CLouds and their intEractionS) project: aerosol-cloud-radiation interactions in the Southeast Atlantic basin, Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2020-449, in review, 2020

Increasing focus on mapping of PBL cloud systems







1500 km offshore

Coast

Multi-sensor synergy needed for progress on cloud-precipitation-dynamics interactions

Radar/lidar

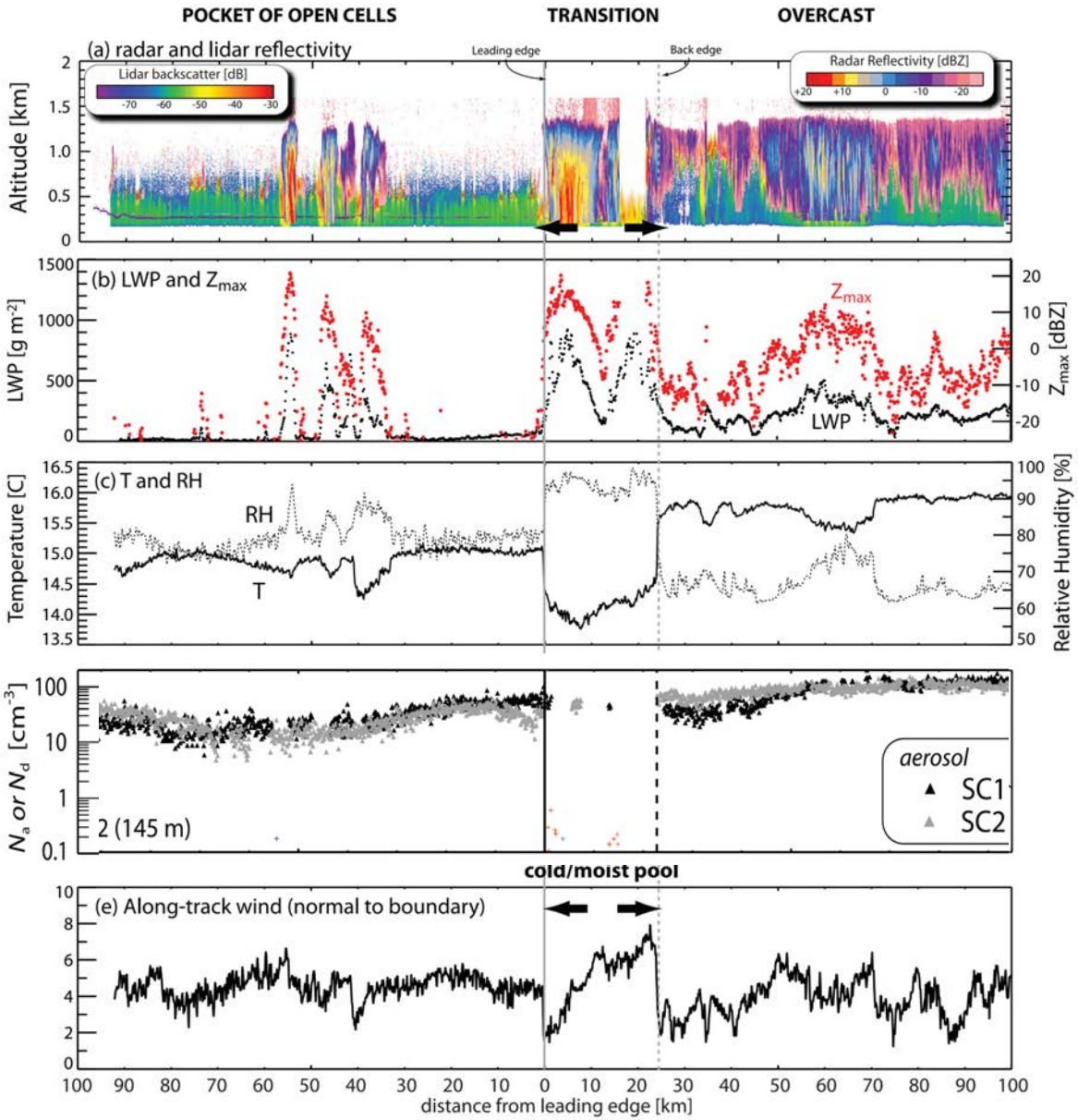
Microwave radiometry

Thermodynamics

Aerosol physics and chemistry

Winds/dynamics

VOCALS RF06, NCAR/NSF C-130
Remote SE Pacific



Airborne sampling needs for PBL weather systems

- PBL weather systems are multi-scale (km to 1000 km; mins-days); many are far from land.
- Understanding coupling between PBL weather systems and the circulation is key to improving forecast model skill
- Long-range aircraft capable of carrying payloads including lidar, radar, passive remote sensing and comprehensive aerosol instrumentation
  - GV has excellent range but relatively low payload
  - Miniaturization of instruments is helping but this is challenging for many instruments (e.g. mass spectrometry, lidars)
  - Large platforms provide better student training opportunities
- Multi-platform sampling (2+ aircraft) attractive but challenging logistically, especially in remote locations
- Smaller aircraft serve as excellent platforms for targeted and near-coastal/island studies
  - UAS are showing promise but more suited to routine sampling at a fixed location