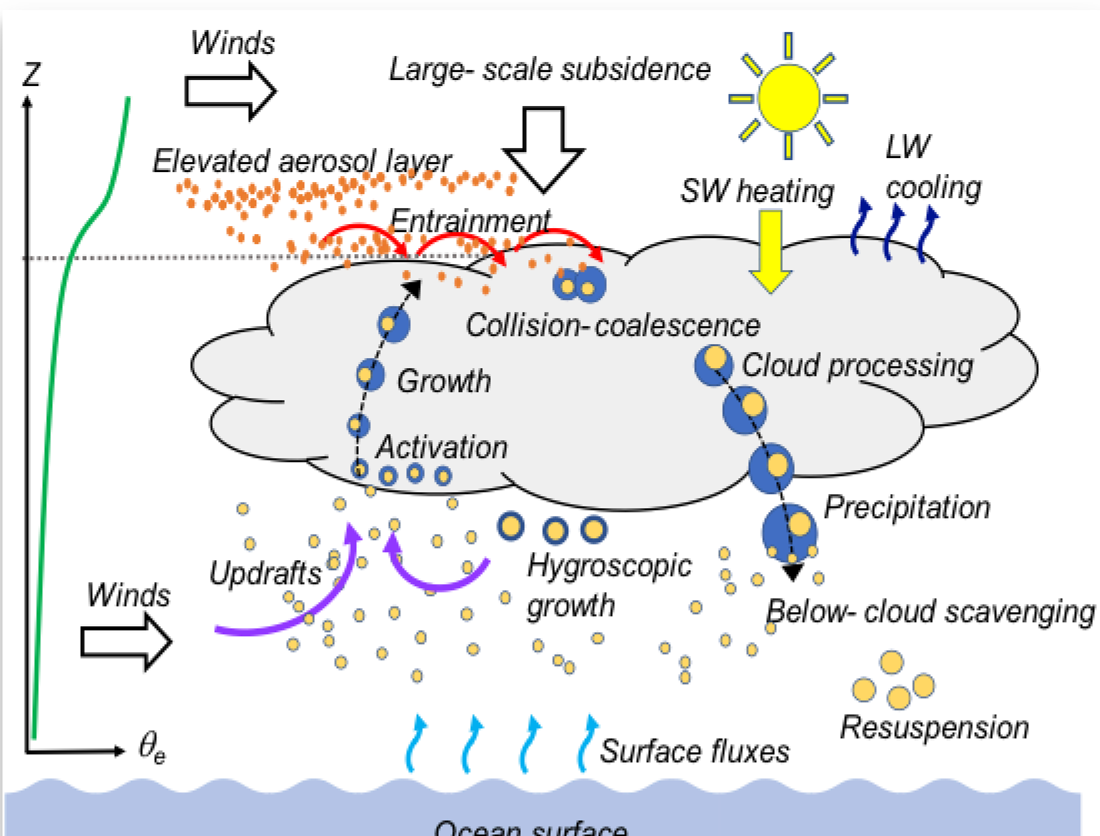
ACTIVATE: Science

Goals

Overarching goal: Robustly characterize aerosol-cloud-meteorology interactions using extensive, systematic, and simultaneous in situ and remote sensing airborne measurements with two aircraft and a hierarchy of models. ACTIVATE focuses on marine boundary layer (MBL) clouds that span the continuum of stratiform and cumulus clouds and include post-frontal conditions. Together, these clouds cover more than 45% of the ocean surface and exert a large net cooling effect.



ACTIVATE targets improved understanding and model representations of the illustrated aerosol-cloud-meteorology interactions.

ACTIVATE's Fundamental science goals:

1) Improve understanding and model representations of relationships between number concentrations of aerosol (N_a), cloud condensation nuclei (CCN), and cloud droplets (N_d) and the relationships between cloud micro/macro-physical properties;

2) Acquire a unique dataset for international model intercomparison and process-based studies;

3) Evaluate current remote sensing retrievals and prototypes for future satellite missions; and

4) Develop improved satellite-based N_d retrievals and CCN proxies.

Objectives

Science Objective 1: Quantify N_a-CCN-N_d relationships and reduce uncertainty in model cloud droplet activation parameterizations.

- How do these relationships depend on aerosol characteristics (e.g., amount, size, composition, type) and dynamic and thermodynamic properties?
- How consistent are these relationships across the complete range of spatial scales provided by airborne in situ and remote sensing measurements and satellite remote sensing retrievals?
- What are the magnitudes of the biases in the N_a-CCN-N_d relationships from satellite aerosol proxies? How do these translate to uncertainties in N_d parameterizations in current climate models?

Science Objective 2: Improve process-level understanding and model representation of factors governing cloud micro/macro-physical properties and how they couple with cloud effects on aerosol.

- What are the relationships between N_d, cloud micro/macro-physical properties, and meteorology?
- To what extent do uncertainties in N_a/cloud/meteorology relationships, within the targeted cloud regimes, in global aerosol-climate models come from biases in aerosols,

clouds, and meteorological factors? How can the identified model biases and uncertainties be reduced using the measurements?

- How can climate models better represent challenging cloud and meteorological conditions, such as post-frontal clouds and cold air outbreaks?
- What is the signature of cloud effects on the CCN budget (e.g., wet scavenging, aqueous processing, entrainment)?

Science Objective 3: Assess advanced remote sensing capabilities for retrieving aerosol and cloud properties related to aerosol-cloud interactions.

- How well and under what conditions can active and passive remote sensing retrievals provide improved measurements of N_d and proxies for CCN concentration?
- How well can a combination of remote sensors improve measurements of LWP?

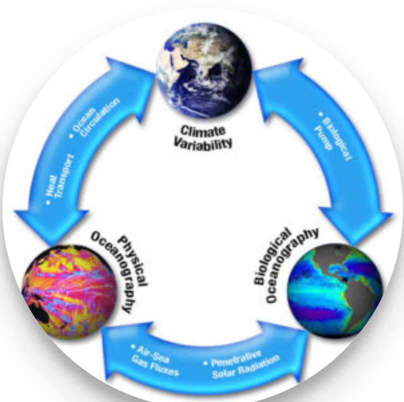
How will ACTIVATE advance our knowledge and understanding in:

Atmospheric Composition:

Uniquely provides comprehensive measurements of aerosol and cloud properties.

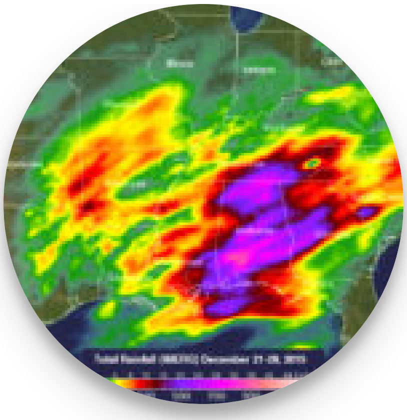
Water & Energy Cycle:

Provides detailed measurements of clouds and cloud properties relevant to precipitation and radiation.



Climate Variability and Change:

Improves understanding and model parameterizations for estimating the impacts of aerosols on cloud properties and reduces uncertainties and known biases in climate model simulations of clouds, leading to a better understanding of climate variability and projection of climate change.



Weather:
Improves understanding and model parameterizations for estimating the impacts of aerosols on cloud properties and reduces uncertainties and known biases in climate model simulations of clouds, leading to a better understanding of climate variability and projection of climate change.

Operations

ACTIVATE will deploy two complementary aircraft over the western North Atlantic Ocean – the NASA LaRC HU-25 Falcon and B-200 King Air. The HU-25 acquires in situ measurements below, in, and above clouds. The B-200 flies above clouds to remotely measure aerosols and clouds using the High Spectral Resolution Lidar-2 (HSRL-2), the Research Scanning Polarimeter (RSP), and deploys dropsondes to measure the atmospheric state. **Since both aircraft and the majority of in situ and remote sensing instruments are based at LaRC adjacent to the western Atlantic study region, ACTIVATE will acquire a statistically robust dataset through an extensive series of flights (~50 joint airplane missions per year) in each of three years (~600 hours and ~150 flights over three years for each airplane)**. We will sample a wide range of aerosol and cloud conditions by planning February–June flights.

Modeling

The modeling tools planned for ACTIVATE are:

- Weather Research and Forecasting (WRF) model
- Distributed Hydrodynamic Aerosol and Radiative Modeling Application (DHARMA)
- FLEXible PARTicle (FLEXPART) dispersion model
- Goddard Earth Observing Model, version 5 (GEOS-5)
- Atmospheric chemistry model coupled with GEOS (GEOS-Chem)
- GISS GCM, version E3 (GISS-E3)
- Community Atmosphere Model, version 5 (CAM5)
- Energy Exascale Earth System Model (E3SM)