The NOAA SABRE Project

Research on Stratospheric Aerosol processes, Budget and Radiative Effects

SABRE-Tropics Mission Brief

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SABRE Science Objectives and Goals

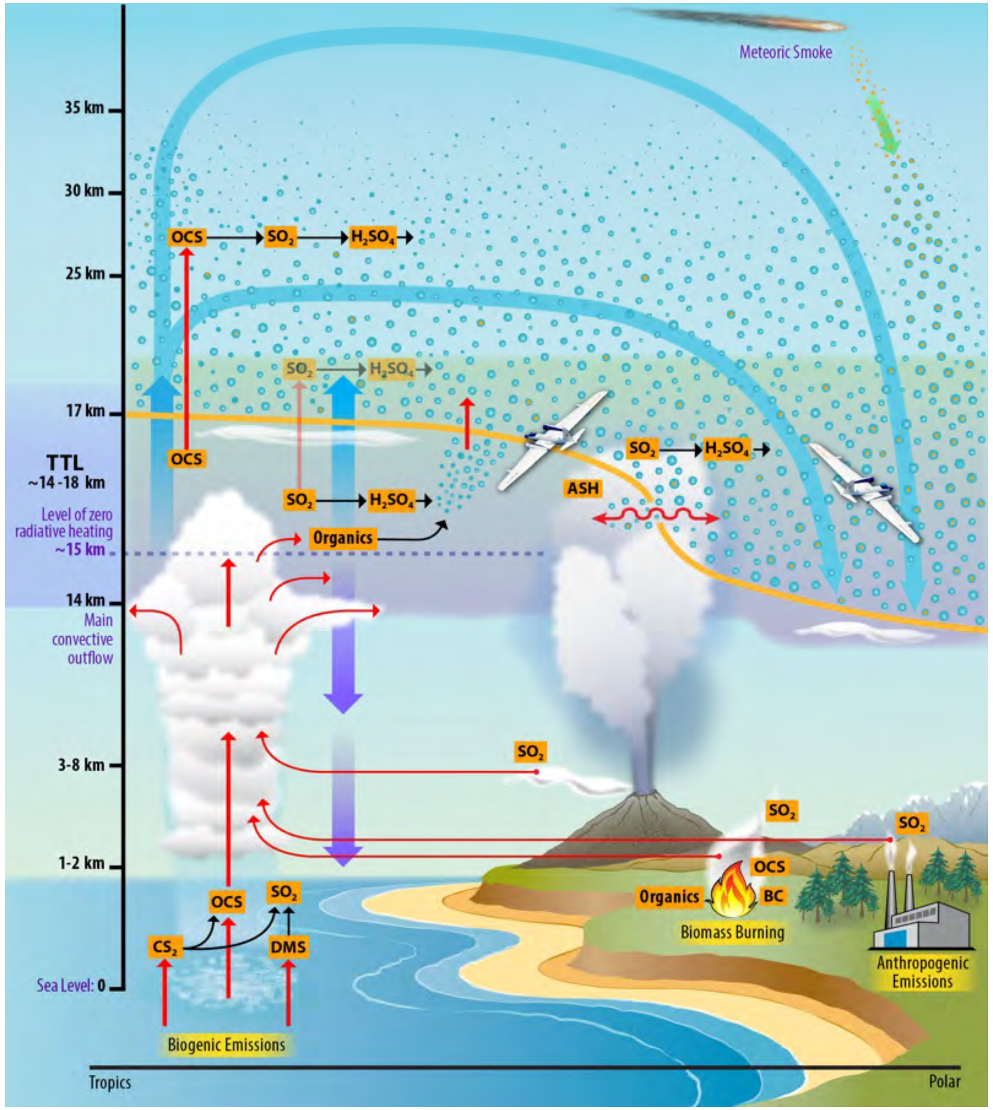
The SABRE mission, a component of the **NOAA Earth's Radiation Budget** (ERB) program, is an airborne science campaign to study the formation, transport, chemistry, microphysics and radiative properties of aerosols in the upper troposphere and lower stratosphere (UTLS). The multiple deployments in different regions and seasons will provide extensive, detailed measurements of stratospheric aerosol size distribution, composition and radiative properties along with relevant trace gas species, which are critical for improving the ability of global models to accurately simulate the radiative, dynamical and chemical impacts of changes in stratospheric aerosol loading.

The first SABRE science mission was flow in February-March 2023 from Alaska to sample high latitude, aged stratospheric aerosol

Highlight: *Identified and quantified the presence of metals from rockets/satellites in stratospheric aerosol, suggesting a possible impact on the stratosphere from rapidly increasing human space activity*

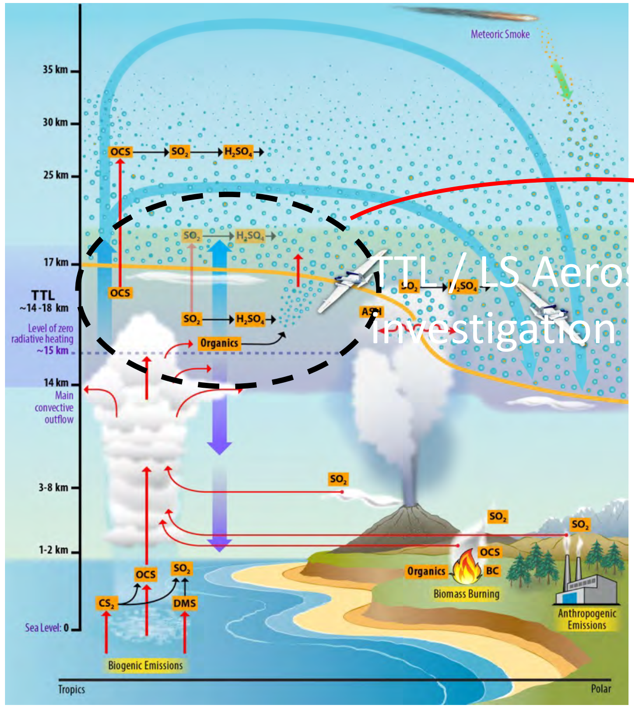
(Murphy et al., Proceedings of the National Academy of Sciences, 2023)

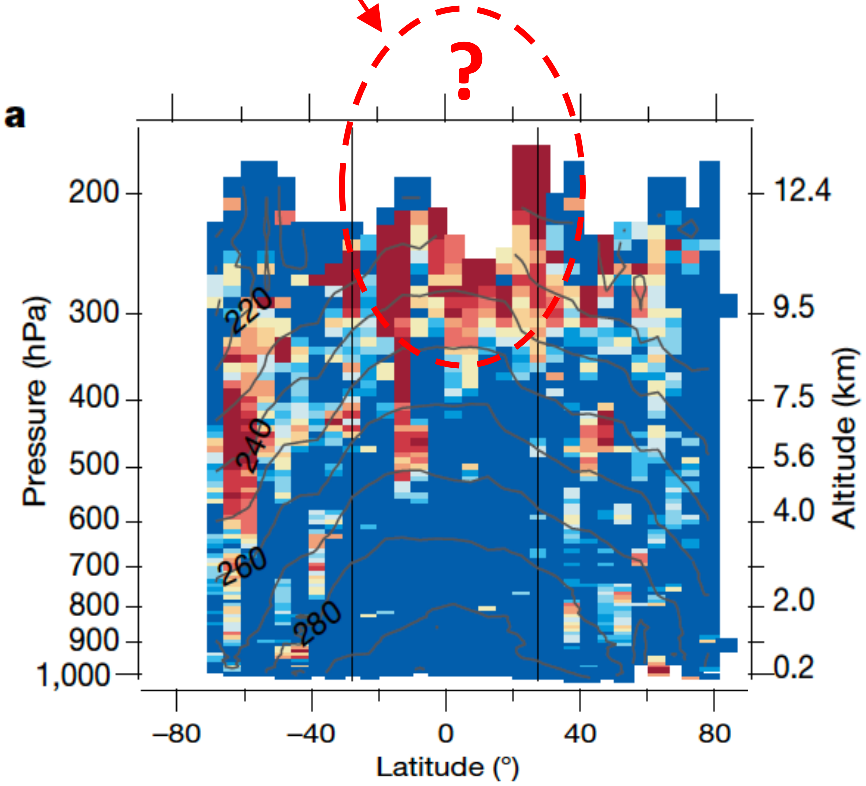
SABRE Science Objectives and Goals



- ☐ Characterize stratospheric aerosol size distributions, composition, and optical properties, as well as their spatial and temporal variability. Determine the sources and chemical, dynamical, and microphysical processes that determine the observed size distributions
- ☐ Constrain the sulfur budget of the background stratospheric aerosol layer and evaluate the chemistry of sulfur species in the stratosphere
- ☐ Determine the occurrence of new particle formation in the upper troposphere / lower stratosphere and its influence on stratospheric aerosol number and size distribution
- ☐ Characterize the evolution of stratospheric aerosol properties (microphysics, composition, and optical properties) following injection of aerosol and gas-phase aerosol precursors into the stratosphere by volcanic eruptions, wildfire pyrogenic events and anthropogenic activities such as rocket launches
- ☐ Quantify the impact of stratospheric aerosol variations on stratospheric ozone chemistry and stratospheric dynamics
- ☐ Quantify radiative forcing terms associated with anthropogenic perturbations (e.g. air traffic, rockets) to stratospheric aerosol

SABRE-Tropics: Stratospheric Entry Processes





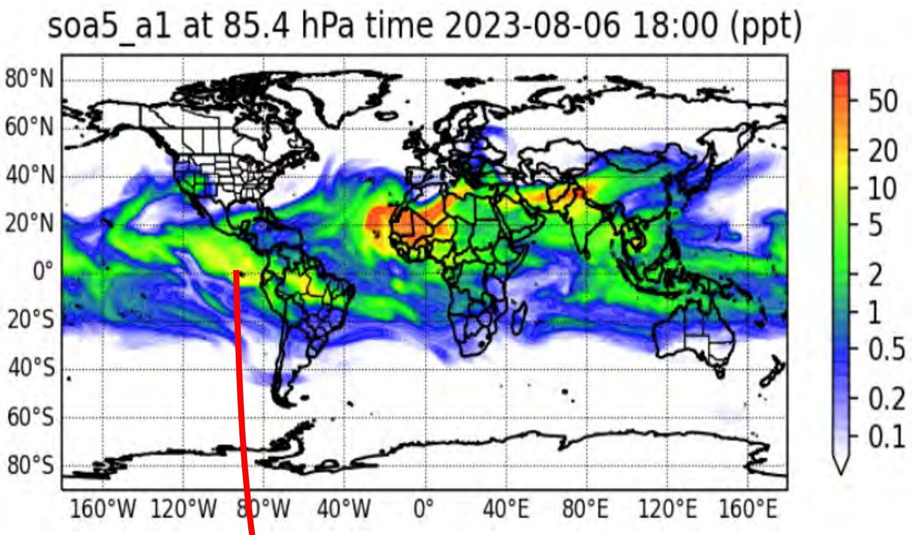
Williamson et al., Nature, 2019

Particle #/cm³ – tropical FT NPF

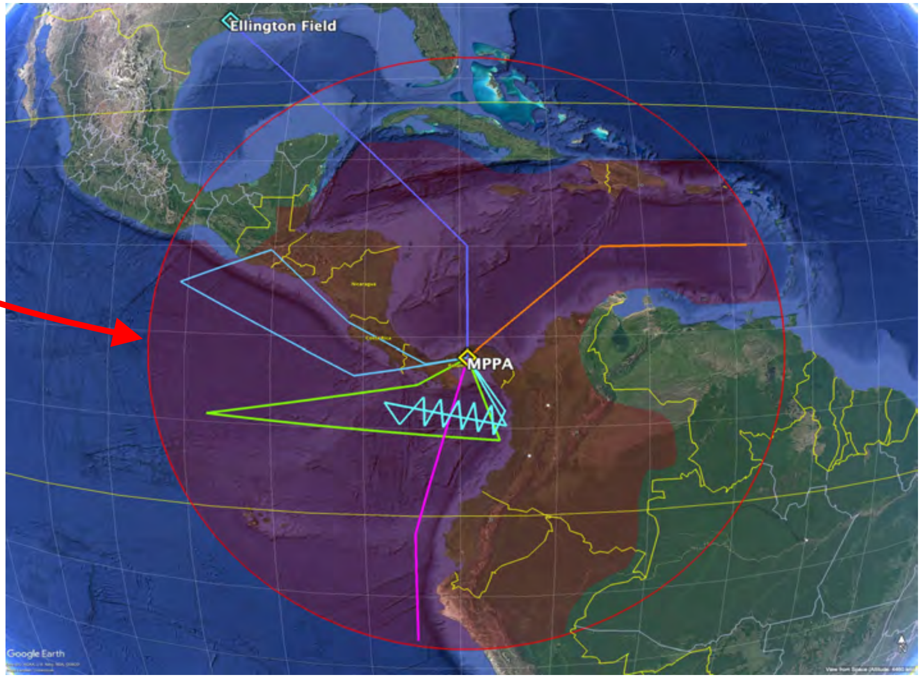
TTL / LS Aerosol processes investigation

- The Tropical Tropopause Layer (TTL) is the dominant pathway for transport of material, including aerosols and aerosol precursors, from the troposphere into the stratosphere
- NASA ATom mission in 201—2019 observed large signal of new particle formation in the tropical upper troposphere (to ~12 km, limited by altitude ceiling of the NASA DC-8)
- Influence of mixing vs in situ production on the aerosol properties of the TTL and tropical lower stratosphere
- Flights across the ITCZ and ideally into the southern hemisphere to study for interhemispheric gradients

SABRE-Tropics: Stratospheric Entry Processes



Global models with aerosol chemistry predict significant organic contribution to aerosol mass in the tropical lower stratosphere



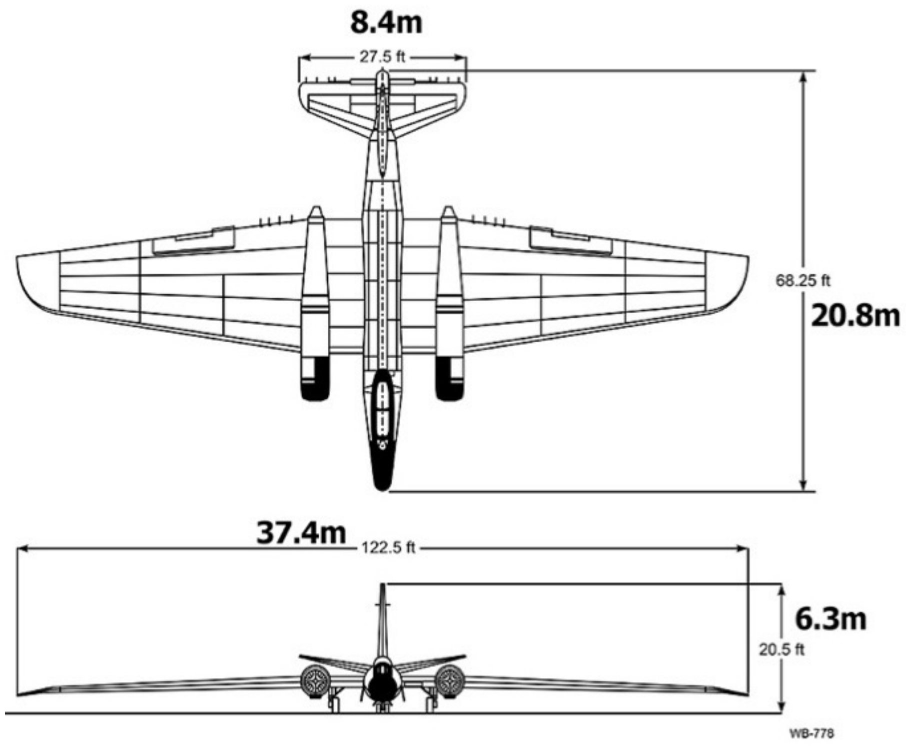
Deployment from MPPA airfield Panama showing notional flight tracks.
Red shading indicates SABRE-Tropics operations region

Tropical Stratospheric sampling from Panama

- WB-57 operations range of 1000 nmi operational radius permits sampling +/- 17° from deployment location
- Flights from Panama provide access to outflow from deep tropical convection over northern South America—some of the deepest continental convection on Earth
- Contribution from convectively lofted effusive volcanic sulfur emissions
- Sample transport of outflow from Asian and African monsoons transported across the Atlantic
- Panama at 9 °N allows flights to ~8 °S—across the ITCZ and into the southern hemisphere to examine interhemispheric gradients

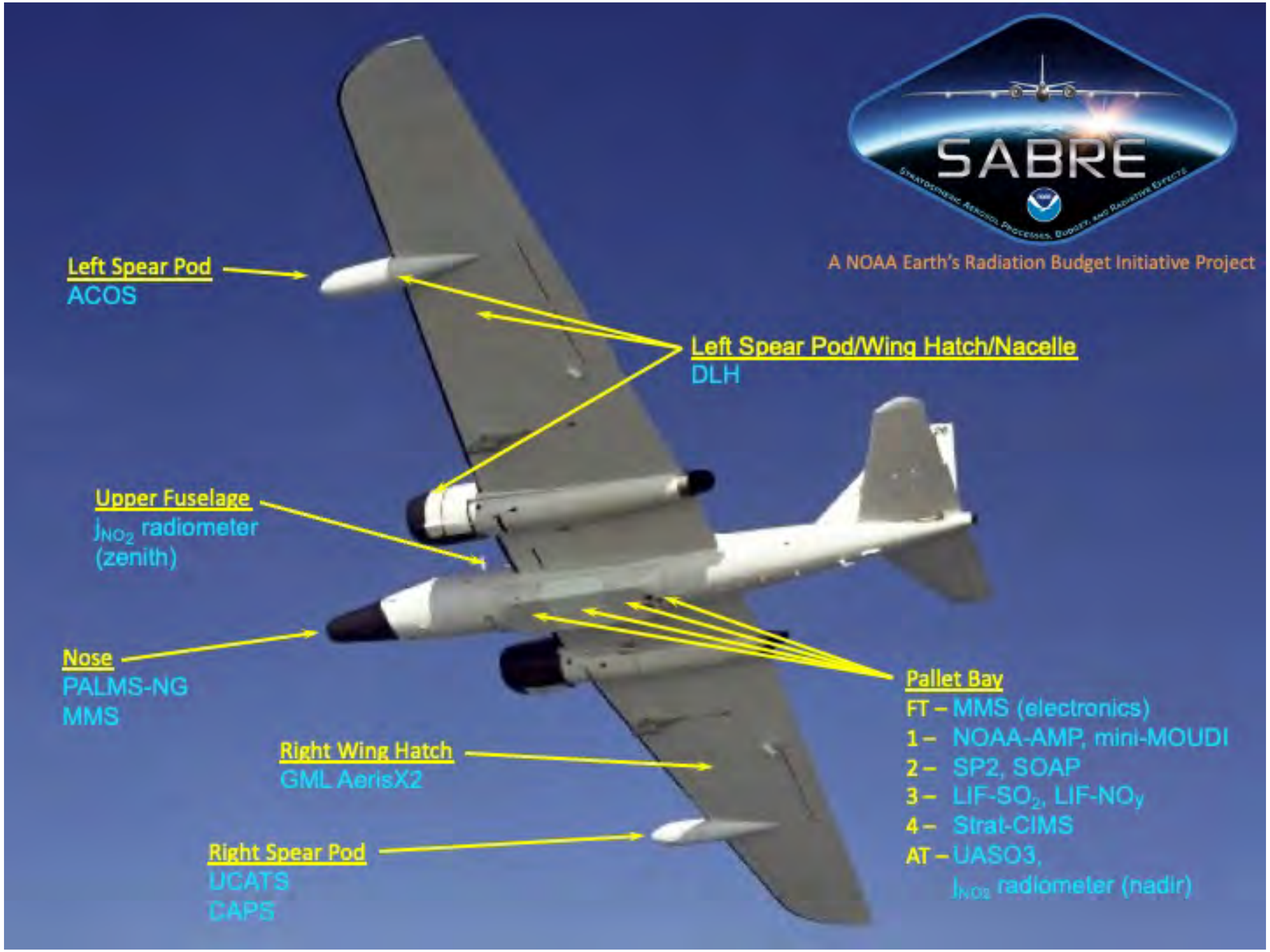
SABRE Operations Summary

- ***SABRE Tropical Mission Deployment:***
  6-8 weeks in July 15 – September 21, 2025
- ***Mission Tempo:*** 2-3 flights per week
- ***# of Mission Personnel:*** approximately 50



- To achieve the mission science goals, the SABRE flight schedule and flight plans will vary depending on the large-scale dynamical situation (e.g. long-range transport events, location of deep convection)
- Flight plans will be developed based on meteorological and global model chemical forecasts in the 24-48 hours prior to flight
- Flights will mostly be during daytime (morning take-off, afternoon landing), scheduled to avoid local weather; a few flights will target night-day (sunrise) or day-night (sunset) transitions
- Flight tracks will be adjusted in real-time during flight based on measurement data transmitted from the aircraft
- The WB-57 typically operates at altitudes between FL 430 (13 km) and FL 620 (19 km)

SABRE Science Mission WB-57 Payload



WB-57 Payload for SABRE science missions

- Payload layout
  - Pallets
  - Spear Pods
  - Nose

SABRE Science Payload

	Instrument	Measurement	Science
Aerosol:	**NMASS** condensation particle counter	Size distribution 4 – 55 nm	New particle formation
	UHSAS optical particle spectrometer	Size distribution 60 nm – 1 µm	Fine mode aerosol
	CMASS optical particle spectrometer	Size distribution 400 nm – 4 µm	Coarse mode aerosol
	SOAP cavity ringdown spectrometer	Aerosol extinction, aerosol absorption	Aerosol radiative properties
	PALMS-NG single particle laser ablation / ionization mass spectrometer	Aerosol composition	Aerosol types and formation processes (sources)
	SP2 intracavity laser incandescence spectrometer	Black carbon particle mass and number	Pyrogenic and primary anthropogenic aerosol tracer, radiatively important
	CAPS (Univ. Vienna) open path optical particle spectrometer	Cirrus cloud and coarse mode particle size and number	Radiative effects
	Mini-MOUDI (Harvard Univ.) aerosol impactor	Aerosol sample collector for offline analysis	Aerosol particle morphology and composition
Radiation:	j_{NO_2} filter radiometer	Shortwave (UV-vis) radiation	Photochemistry

	Instrument	Measurement	Science
State Parameters:	**MMS** (NASA ARC)	Temperature and pressure	Atmospheric state
Trace Gas:	**UASO3** UV photometer	O_3 mixing ratio	Stratospheric ozone layer, chemical coordinate
	LIF-SO2 laser indued fluorescence photometer	SO_2 mixing ratio	Aerosol precursor, volcanic emissions
	ACOS integrated cavity tunable diode laser absorption spectrometer	OCS and CO mixing ratios	OCS is a key precursor for stratospheric sulfate aerosol; CO is a tracer for recent tropospheric influence
	LIF-NO laser indued fluorescence photometer	NO and NO_2 mixing ratios, total reactive nitrogen (NO_y)	Stratospheric ozone chemistry, transport
	Strat-CIMS chemical ionization mass spectrometer	Halogen species, acids, reactive nitrogen species	Stratospheric ozone chemistry, aerosol precursors
	DLH (NASA LaRC) open path diode laser absorption spectrometer	Water vapor	Radiatively and photochemically important in the stratosphere
	UCATS + Aeris(x2) (NOAA GML) gas chromatograph and TDL spectrometers	N_2O, CO, CO_2, CH_4, SF_6, CFCs	Stratospheric dynamics (age of air)

SABRE Contacts

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