STUDIES OF EMISSIONS AND ATMOSPHERIC COMPOSITION, CLOUDS AND CLIMATE COUPLING BY REGIONAL SURVEYS (SEAC^{4}RS) CAMPAIGN

THE POWER OF CONVECTION

NASA'S Studies of Emissions and Atmospheric Composition, Clouds, and Climate Coupling by Regional Surveys (SEAC^{4}RS) campaign studied how aerosols are injected into and influence upper tropospheric and lower stratospheric composition and chemistry. The campaign sought to answer:

- How does deep convection distribute aerosol particles and gases, including pollutants, in the atmosphere?
- How do gases and aerosols influence atmospheric chemistry and climate?

During multiple regional flights across the southeastern and southwestern United States, NASA incorporated measurements from satellites, research aircraft, weather balloons, and ground sites to measure atmospheric convection, composition, and chemistry. In particular, SEAC^{4}RS examined the role of pollution, large urban centers, agricultural fires, and areas of intense isoprene emissions in the southeastern United States, as well as wildfires and the North American monsoon in the southwestern United States.

WE HAVE LIFT-OFF

Data collected throughout the SEAC^{4}RS campaign revealed new clues into how convective forces lift particulate matter from the surface of the Earth into the atmosphere. The new data showed:

- **Deep convection can launch particles from Earth's surface directly into the upper troposphere and lower stratosphere.** During the SEAC^{4}RS campaign, chemical analyses of atmospheric composition taken at the convective boundary layer (CBL) near Earth's surface exactly matched those taken 30,000 feet above in the troposphere. This was the first time scientists had observed particulate matter from the CBL being directly injected into the upper troposphere.

- **Current climate models overestimate biogenic isoprene emissions from densely forested areas.** The Model of Emissions of Gases and Aerosols from Nature, version 2.1 (MEGAN) was found to overestimate isoprene emissions by up to 50% over the Ozarks in the southeastern United States.

- **Current modeling for large wildfire events do not properly account for day-to-night differences in emissions.** Data collected during the SEAC4RS campaign from multiple wildfires, including the California Rim Fire and wildfires in Idaho and Washington, showed that nocturnal estimates had to be enhanced by factor of 2 to 4 times to correlate with observed daily burned area.

- **Satellite measurements from MODIS and MISR reasonably estimate aerosol optical depth and particulate matter amounts.** Airborne measurements taken during the SEAC^{4}RS campaign confirmed that previous aerosol measurements from MODIS and MISR accurately reflected aerosols and particulate matter in the upper troposphere and lower stratosphere.

AEROSOLS, EARTH'S CLIMATE, AND YOU

Aerosols are small particles suspended in the atmosphere. They are the result of both natural and man-made events, including wildfires, thunderstorms, pollution, and more. Aerosols affect the temperature of the Earth by reflecting or absorbing solar radiation; however, too many aerosols could negatively impact the Earth's climate and, when injected into the upper atmosphere, could take years to be removed from the system.

Knowing how aerosols affect the atmosphere will help us better understand how natural hazards, extreme weather, and human activities will shape our planet in the future.

STUDYING EARTH'S ATMOSPHERE FROM SPACE

WHY NASA?

NASA's Earth Science Division (ESD) sees Earth's atmosphere differently—literally. ESD monitors and collects data remotely from space using highly sensitive instruments mounted on satellites hundreds of miles away. In order to ensure their satellites are accurate, ESD runs airborne field campaigns like SEAC^{4}RS to verify their results and get a deeper look at Earth's atmospheric composition and chemistry.

KEY INSTRUMENTS USED

NASA flew three different aircraft equipped with multiple instruments during the SEAC^{4}RS campaign, including:

- **DC-8**: Airborne science laboratory with a range of 5,400 nautical miles at altitudes from 1,000 to 42,000 feet for up to 12 hours. During the SEAC^{4}RS campaign, the DC-8 carried a payload of more than 30 scientific instruments. A few of those key instruments included:
    - **AOP**: Aerosol optical package, which includes the cavity ringdown (CRD) aerosol extinction spectrometer, a photoacoustic absorption spectrometer (PAS), and an ultra-high sensitive aerosol size spectrometer (UHSAS) to measure aerosol extinction, particle absorption, asymmetry, and black carbon content.
    - **DIAL**: Differential Absorption Lidar, which measures aerosol backscattering, depolarization ratio, extinction, optical depth, and ozone.
    - **PALMS**: Particle Analysis by Laser Mass Spectrometry, which measures single-particle aerosol composition.

- **ER-2**: High-altitude aircraft with a range of 5,000 nautical miles at altitudes up to 70,000 feet for up to 12 hours. During the SEAC^{4}RS campaign, the ER-2 carried a payload of 15 scientific instruments. A few of those key instruments included:
    - **ALIAS**: Aircraft Laser Infrared Absorption Spectrometer, which measures total water, total water isotopes, carbon monoxide, and carbon dioxide isotope ratios in real time.
    - **CPL**: Cloud Physics Lidar, which measures multi-wavelength measurements of cirrus, subvisual cirrus, and aerosols with high temporal and spatial resolution.
    - **eMAS**: Enhanced MODIS Airborne Simulator, which measured terrestrial and atmospheric processes, including 50-meter spatial resolution imagery in 38 spectral bands of cloud and surface features.

- **Learjet**: High-altitude aircraft with a range of 1,200 nautical miles at altitudes up to 45,000 feet for up to 3 hours. During the SEAC^{4}RS campaign, the Learjet measured cloud particle and droplet properties, including size, shape, phase, and concentration.