

Re-Constructing 3-Dimensional Volcanic Ash Plumes

using CALIOP/CALIPSO and NASA Langley Trajectory Model (LaTM)

- The 2019 Raikoke Eruption -

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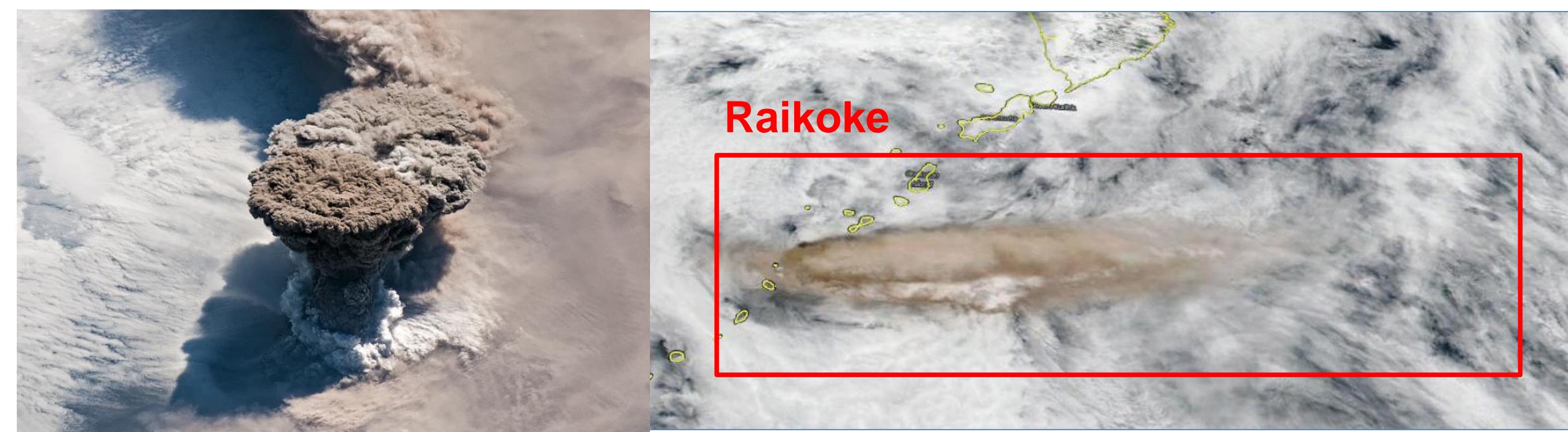
1. National Institute of Aerospace, Hampton, VA; 2. NASA Langley Research Center, Hampton, VA; 3. Universities Space Research Association, Columbia, USA

Background

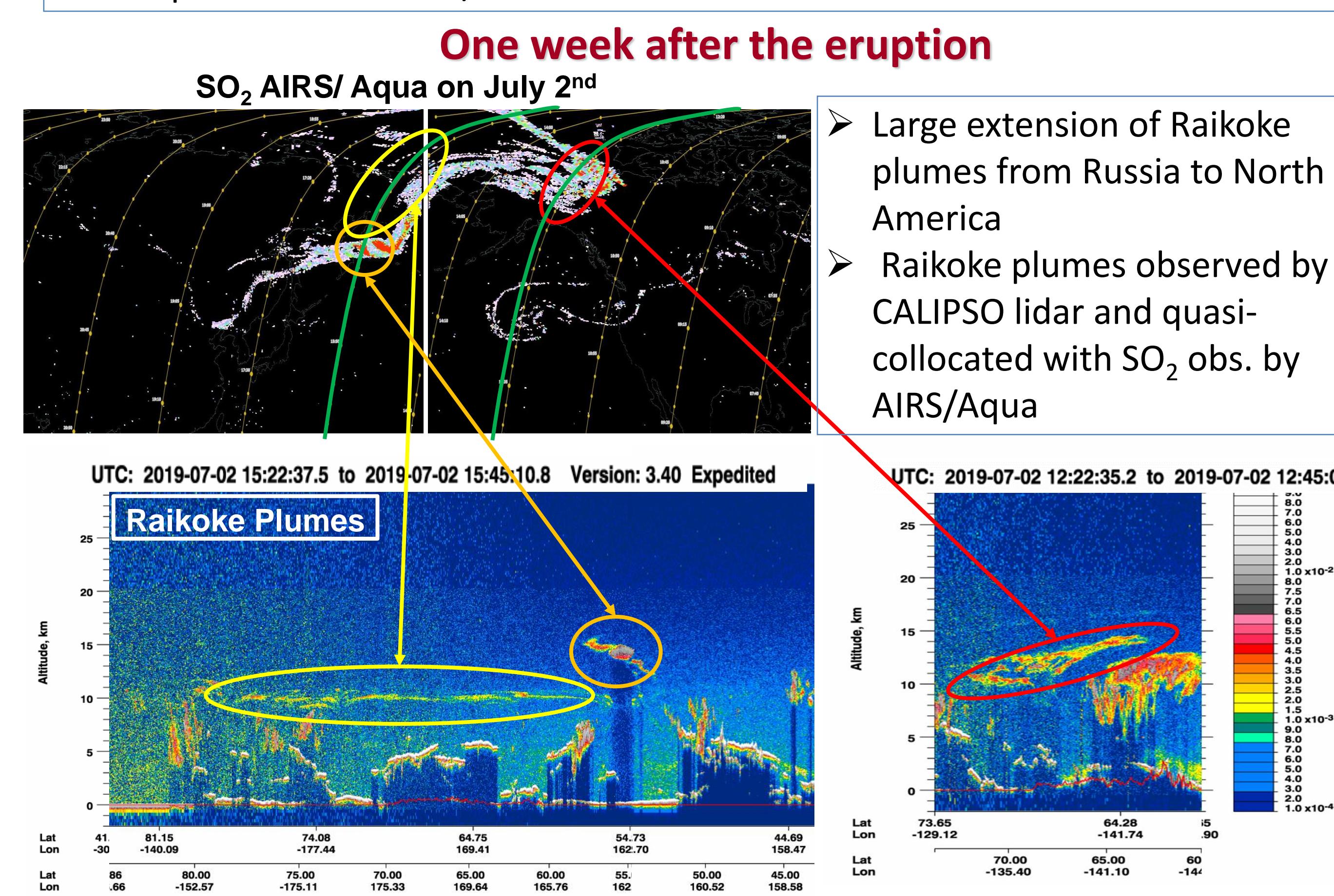
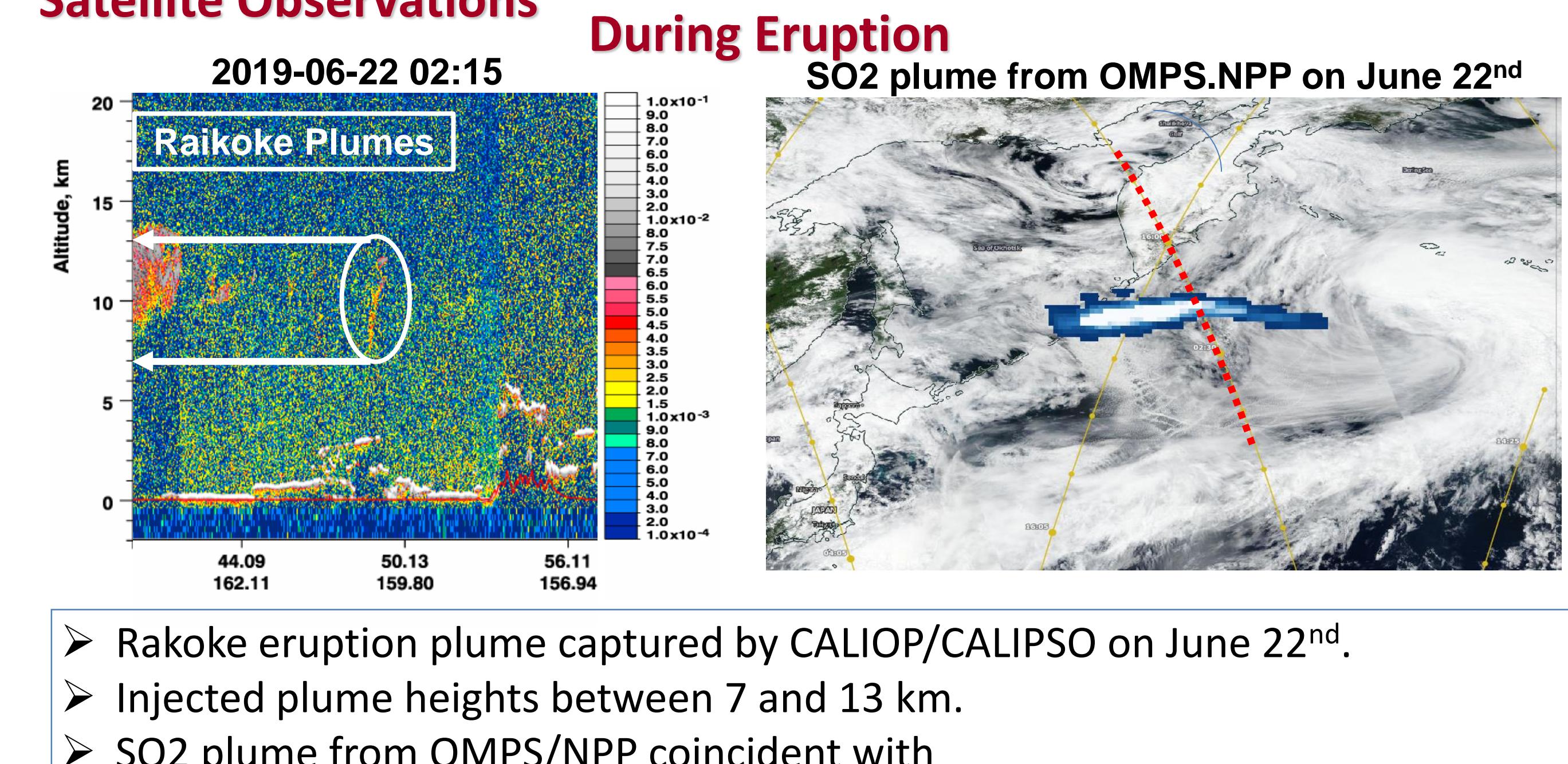
- Large volcanic eruptions are the primary sources of aerosols in the stratosphere and play an important role in the global climate system.
- The transformation of sulfur dioxide emitted by volcanoes into sulfuric acid droplets leads to a global cooling effect at the surface by enhanced reflection of solar radiation to space and reduced the earth's radiative budget for months to years.

The 2019 Raikoke Volcano

- Raikoke volcano, Kuril Islands (153.24°E, 48.29°N) eruption started at around 18 UTC on June 21, 2019 and ended at 03 UTC on June 22, 2019.
- Emission: 1.5 ± 0.2 Tg of SO₂ between 21st and 22nd.
- Plume height : 7-15 km based on several ultra-violet and infrared sensors as well as the Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observation (CALIPSO) space-based lidar.

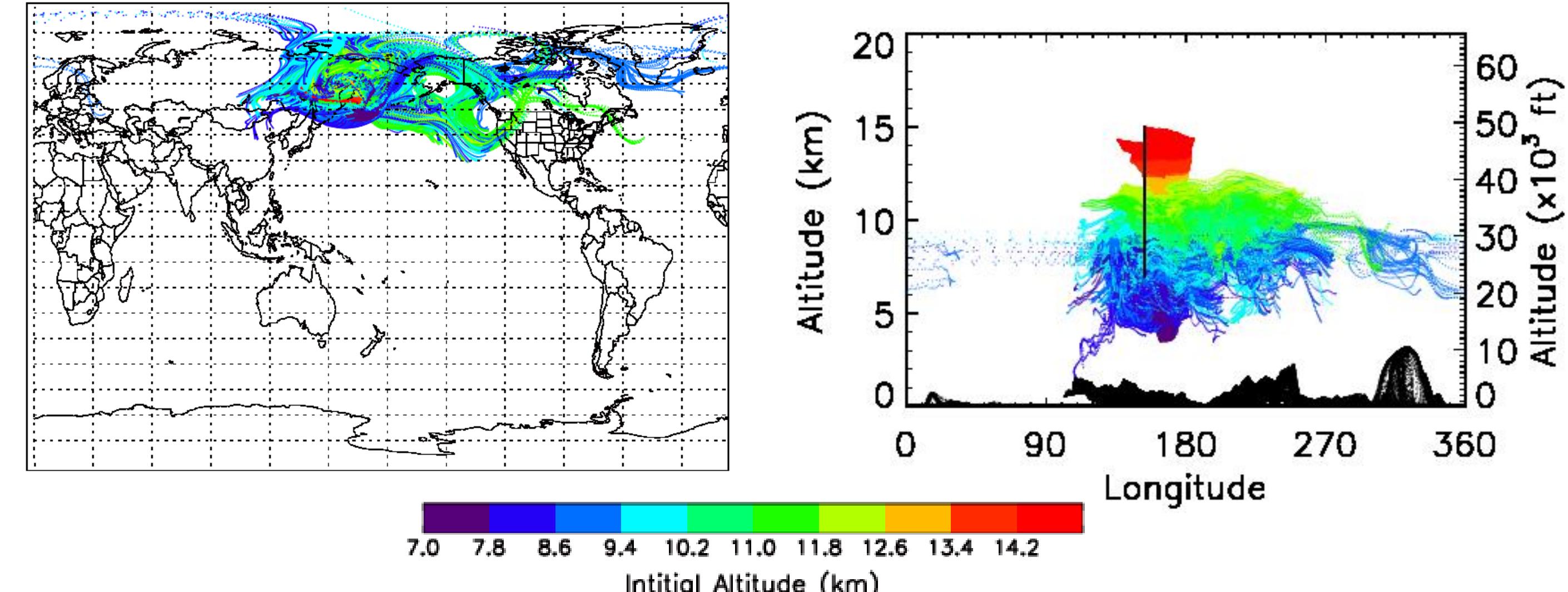


Satellite Observations



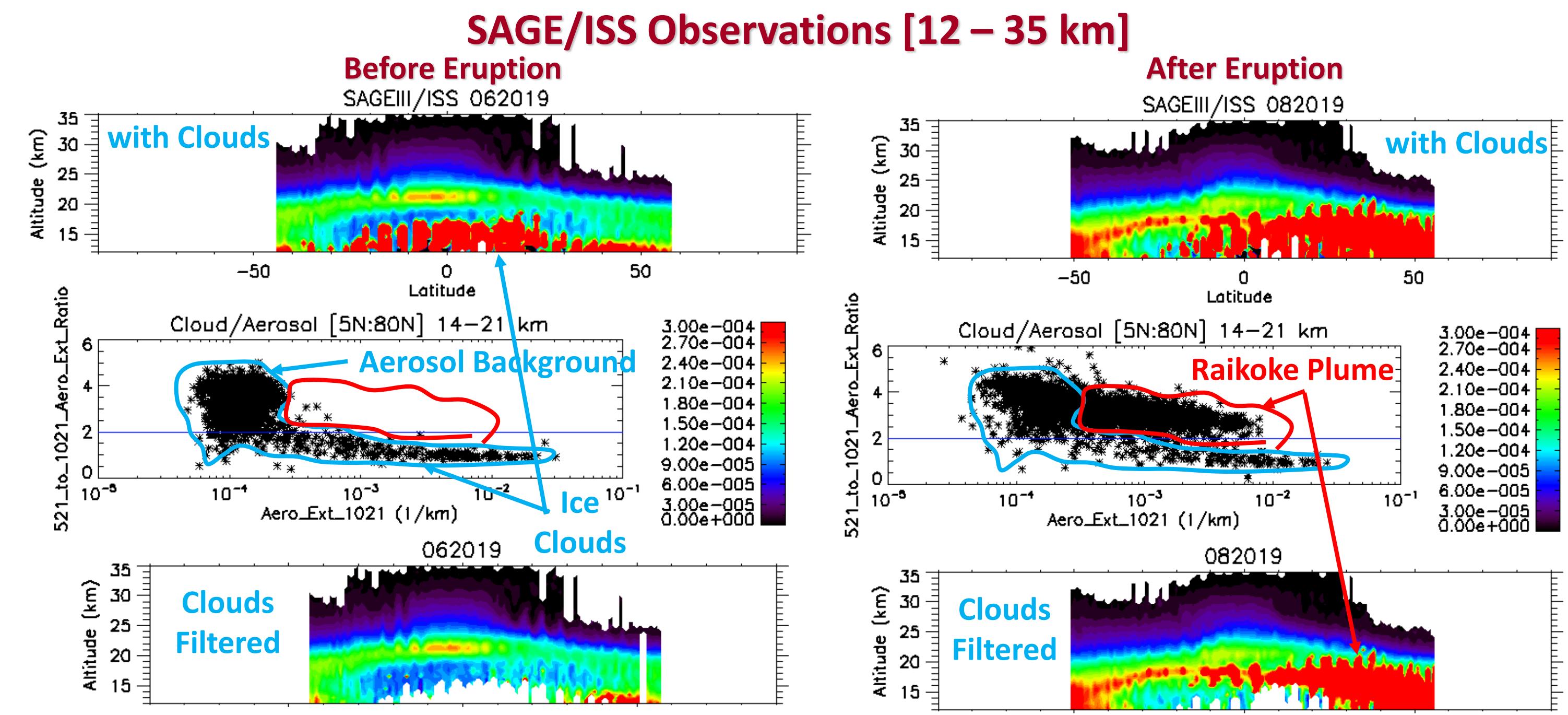
NASA Langley Trajectory Model (LaTM) w/ GEOS5 Forecast

GEOS5 FWD Traj @ 48.3N 153.2E, 20190621 240hr



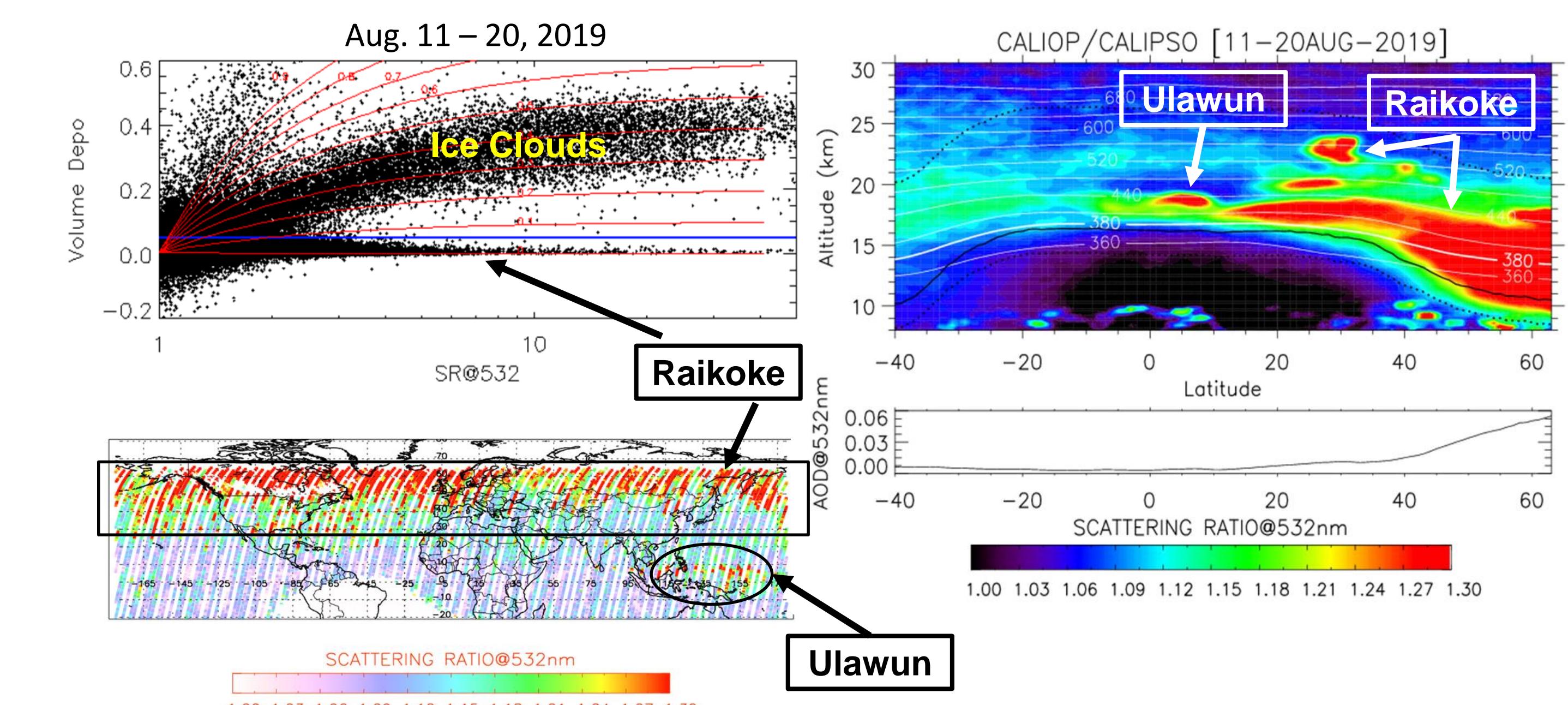
- NASA LaTM with GEOS5 10 days forecast output at the Raikoke volcano.
- The injection height estimated between 7 – 15 km based on SO₂ obs. from Copernicus Sentinel 5 Precursor Tropospheric Monitoring Instrument (S5P/TROPOMI) and CALIOP/CALIPSO.

RAIKOKE aerosol plume Analysis SAGE III/ISS and CALIOP/CALIPSO



- SAGE III/ISS zonal mean Extinction before and after cloud-clearing data using the diffusion diagram of Extinction ratios (521/1020nm) and extinction at 1020 nm.

CALIOP/CALIPSO

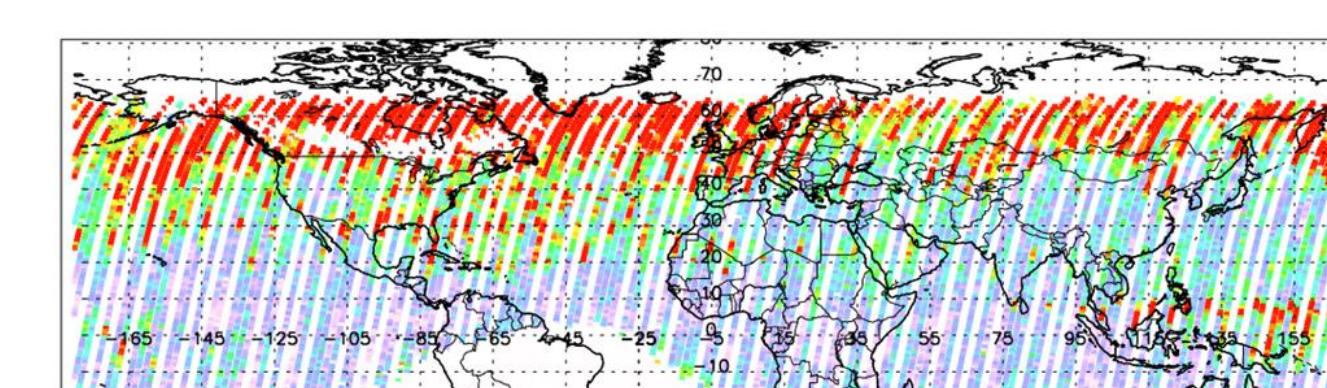


- Zonal Mean Scattering Ratio (SR) cross-section (Top-Right) with cloud-cleared using the depolarization diagram (Top-Left). Data used of those from the CALIPSO lidar between August 11 and 20, 2019.
- Another plume observed in the tropics consistent with the Ulawun eruption which also erupted on June 26, a week after Raikoke.

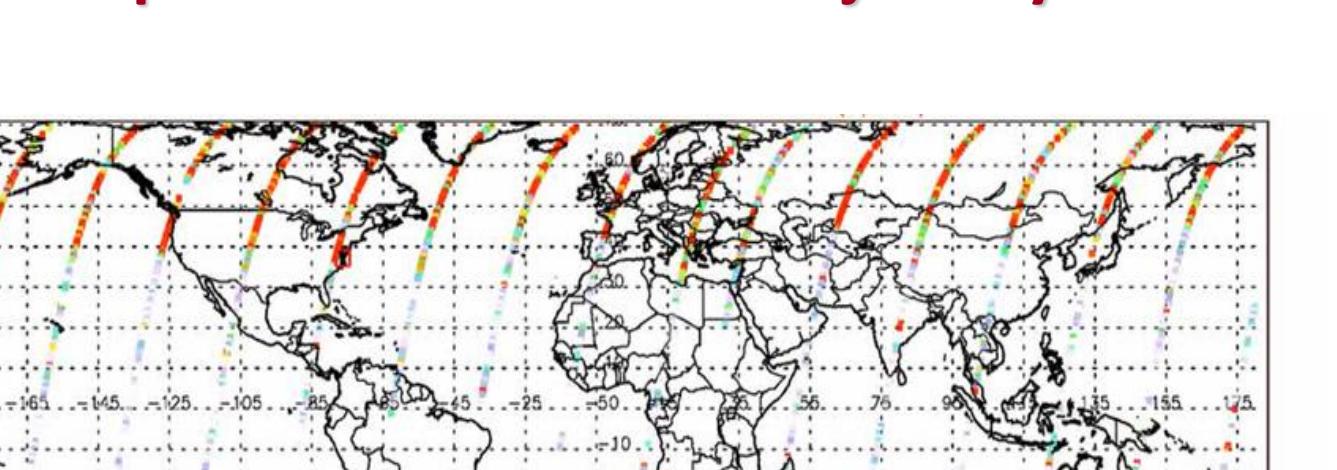
Trajectory Mapping of CALIPSO Observations [Aug. 11-20, 2019]

Step 1: Analysis of the CALIPSO Data

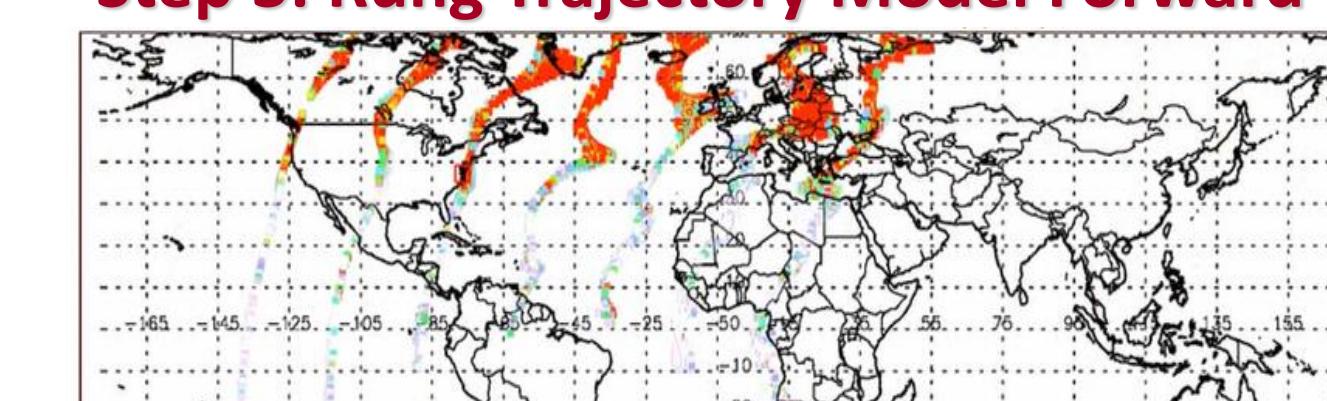
CALIPSO 11-20 August 2019 (trop-trop+10km)



Step 2: Initialization of Trajectory Model



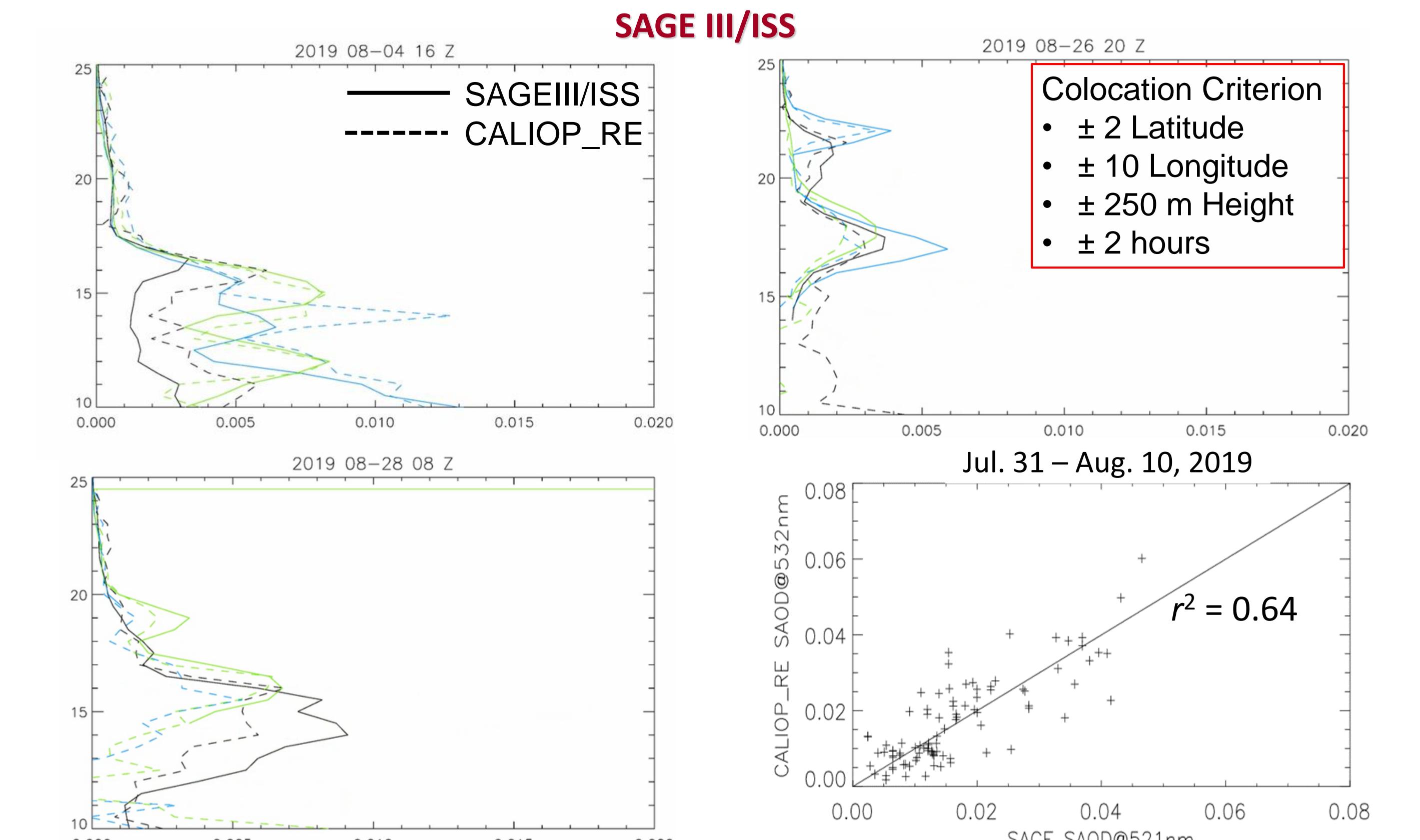
Step 3: Rung Trajectory Model Forward



Step 4: Plume Reconstruction

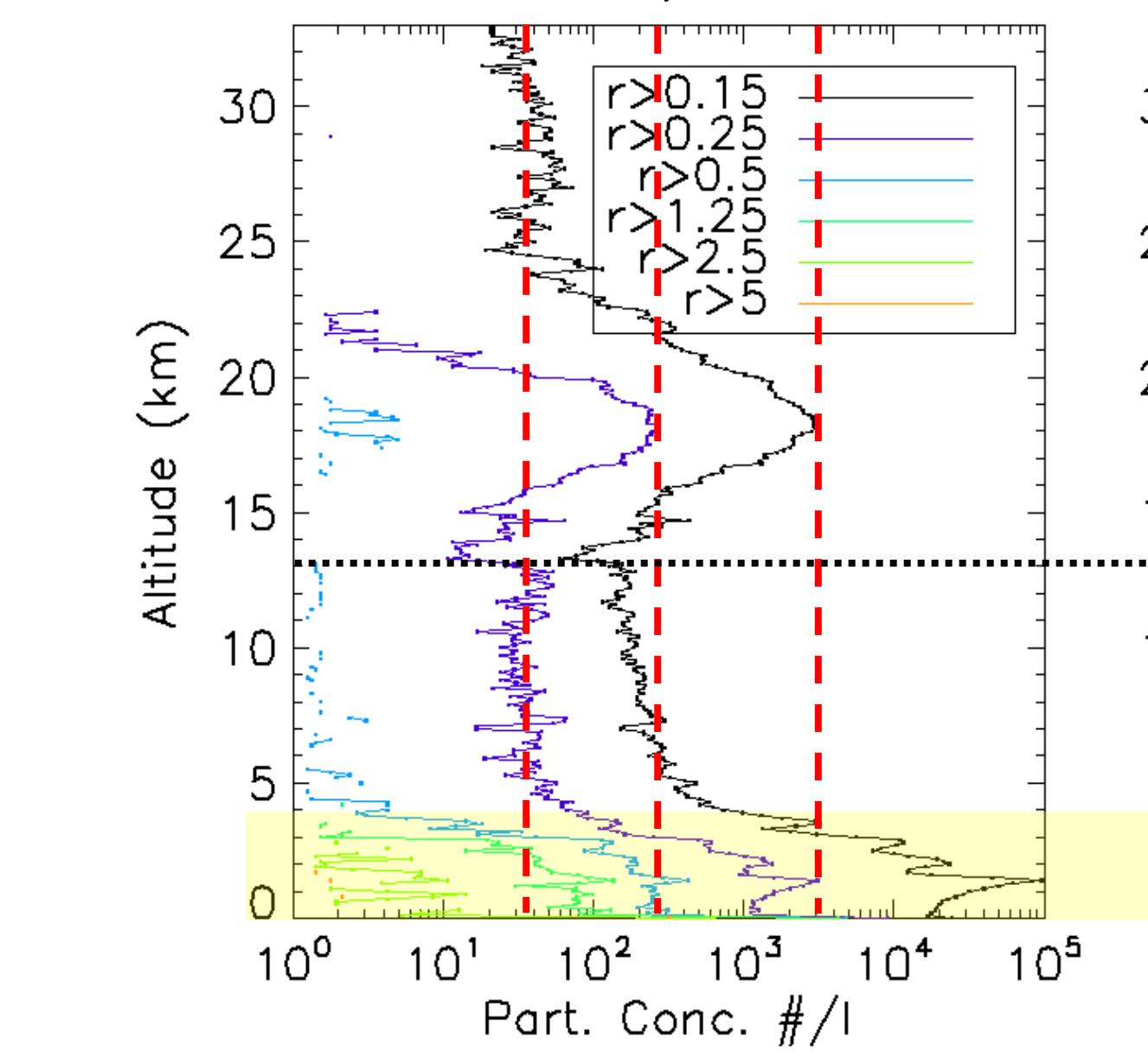


Evaluations of the Reconstructed CALIPSO Plumes with SAGE III/ISS

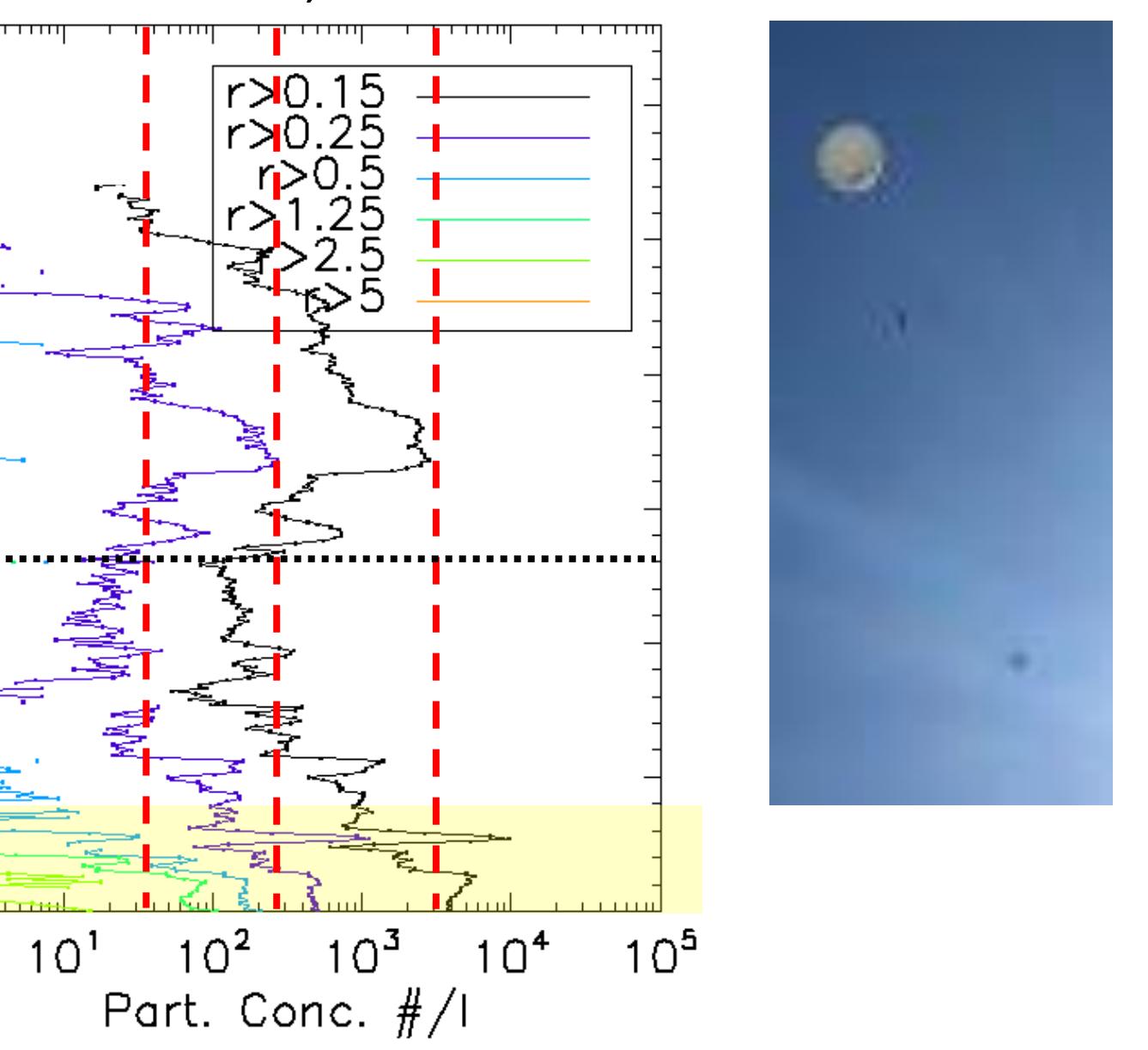


Balloon Campaign at NASA Langley to study aerosol size distributions of the Raikoke plume

Oct. 4, 2019



Oct. 23, 2019



Conclusions

- Vertical transport of the Raikoke plume up to 25 km from initial injection between 7-15 km. Mechanisms of transport? Influence of smoke?
- Satellite observations from SAGE III/ISS and CALIOP/CALIPSO show its initial dispersion into the stratosphere.
- Re-constructed 3-dimensional volcanic plumes using CALIOP/CALIPSO and NASA LaTM show good agreement with SAGE III/ISS. Goal: study the transport pathways.
- Balloon measurements from Langley: insights on plume microphysics.