

Re-Constructing 3-Dimensional Volcanic Ash Plumes using CALIOP/CALIPSO and NASA Langley Trajectory Model (LaTM) - The 2019 Raikoke Eruption -

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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.

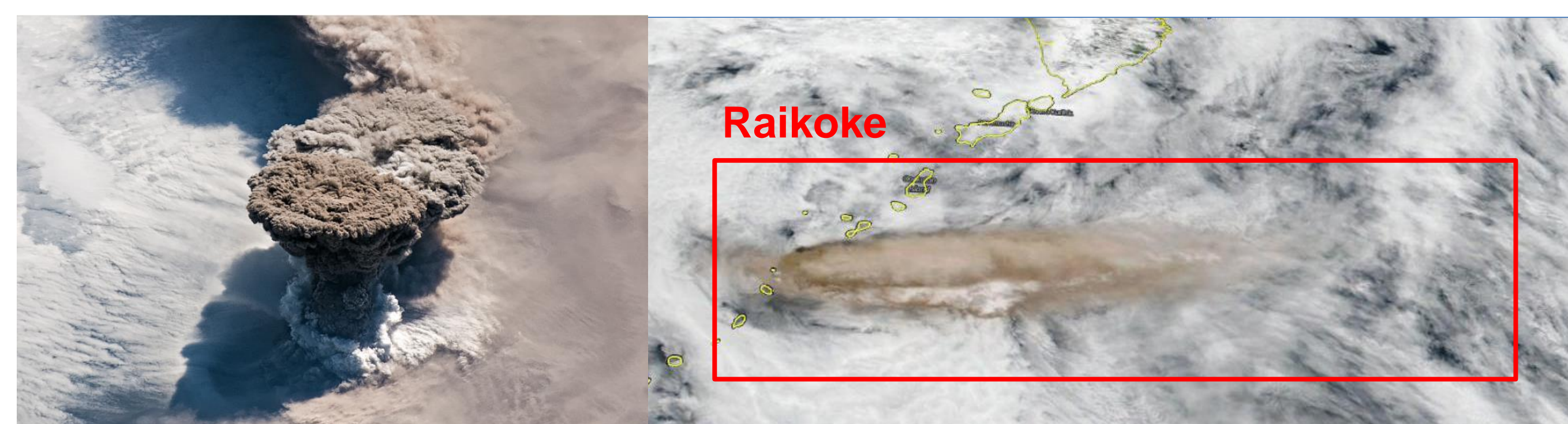
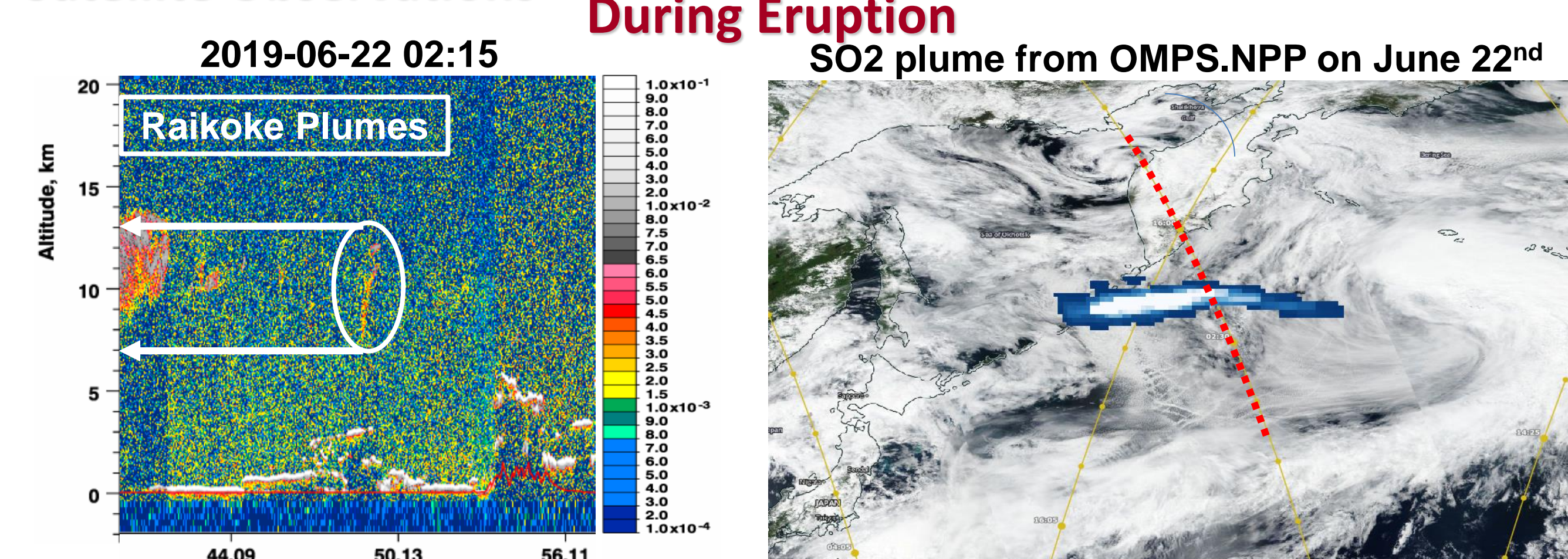


Photo International Space Station

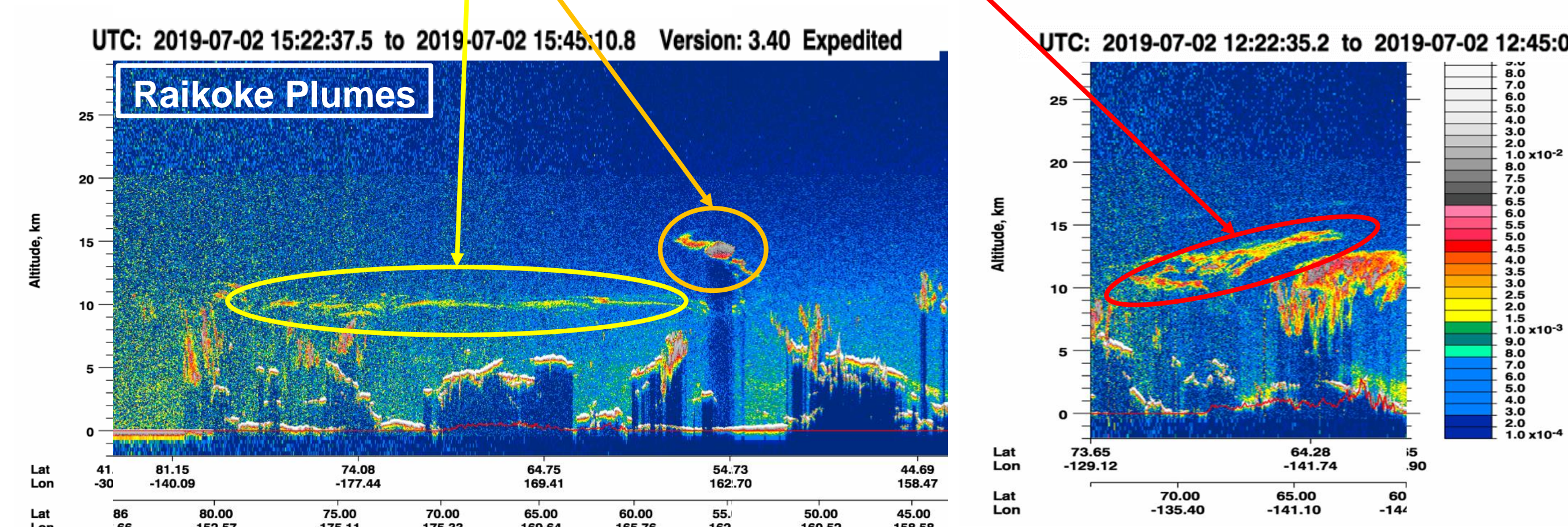
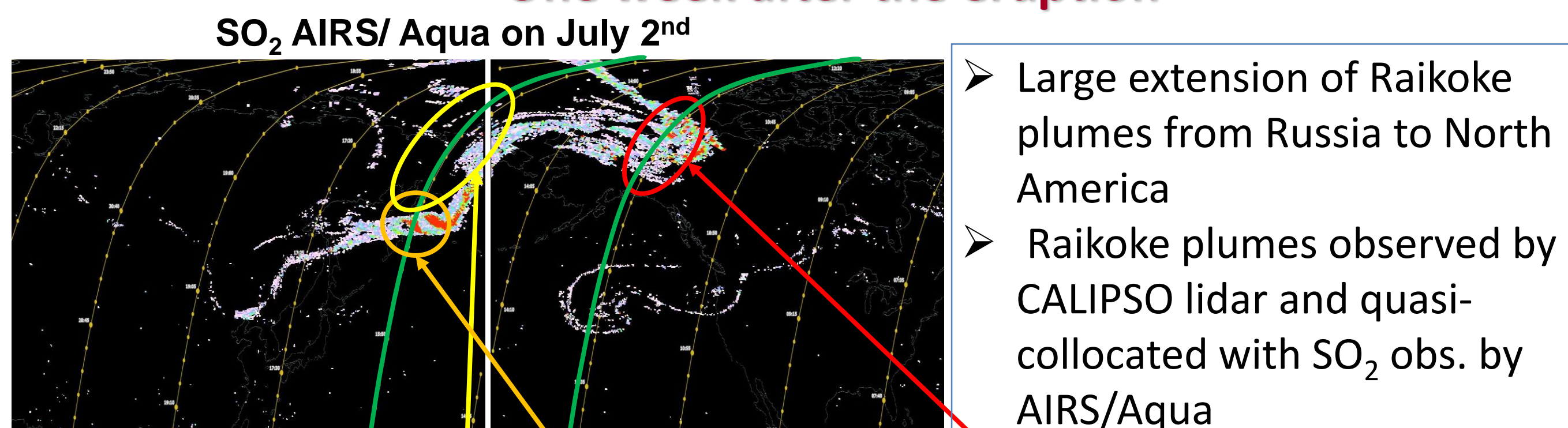
VIIRS/NPP on June 22nd

Satellite Observations

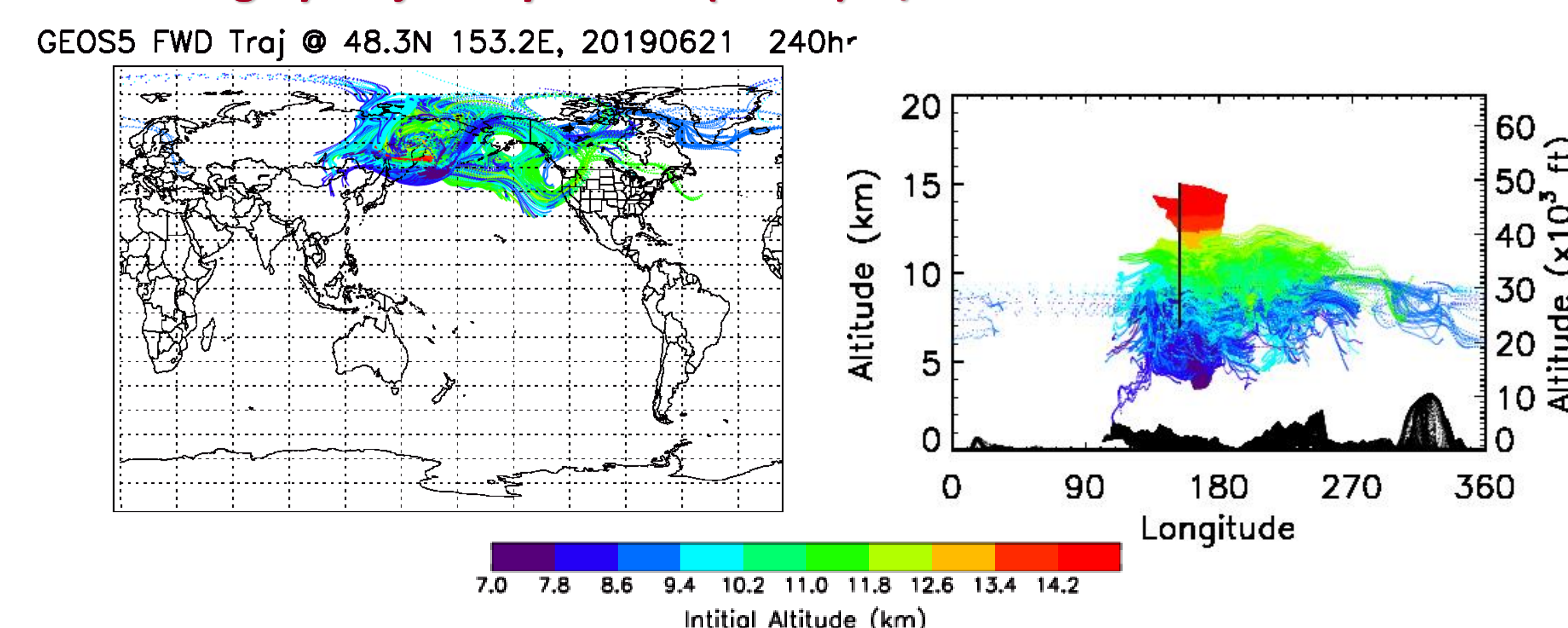


- Rakoke eruption plume captured by CALIOP/CALIPSO on June 22nd.
- Injected plume heights between 7 and 13 km.
- SO2 plume from OMPS/NPP coincident with

One week after the eruption

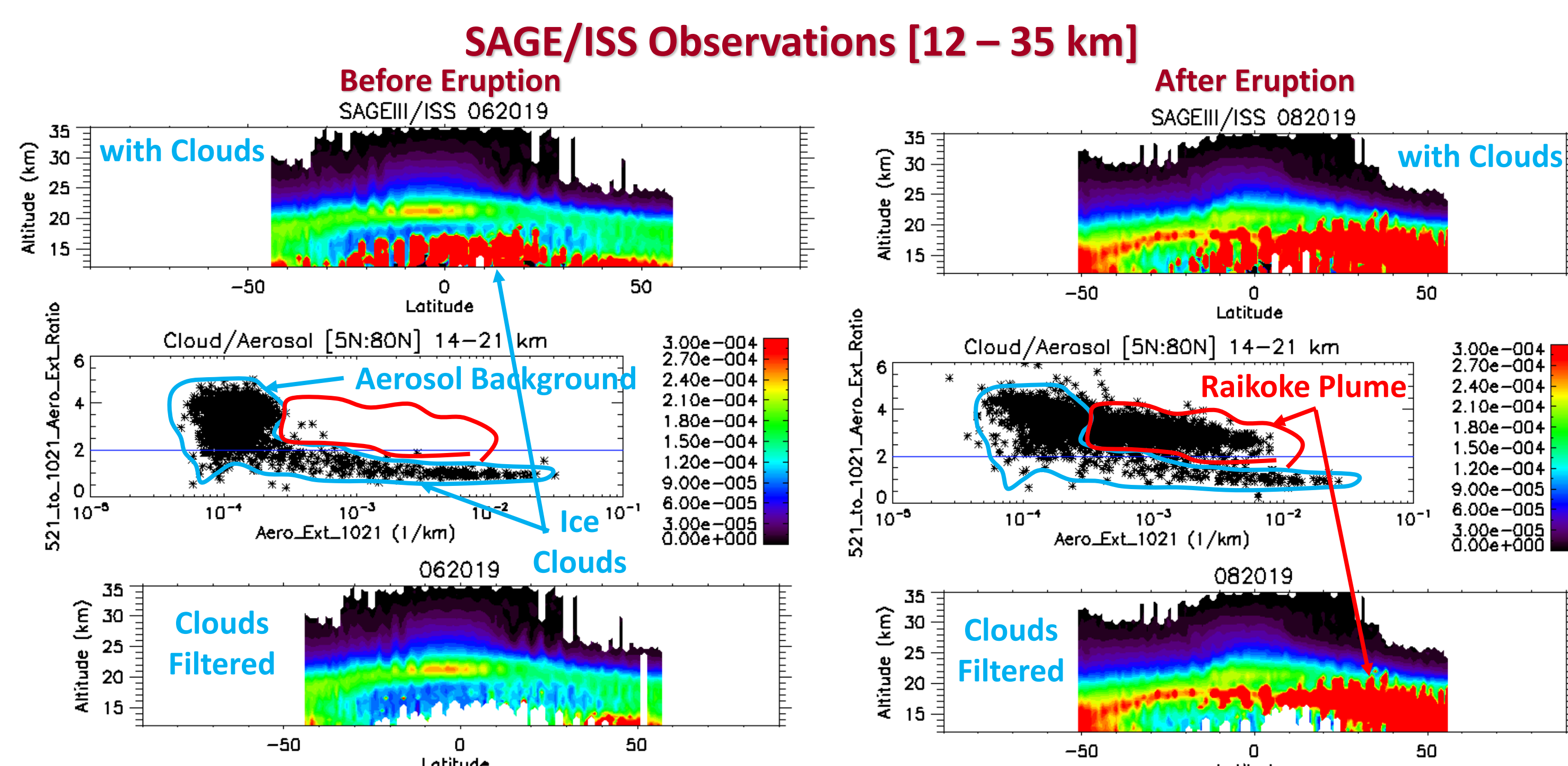


NASA Langley Trajectory Model (LaTM) w/ GEOS5 Forecast



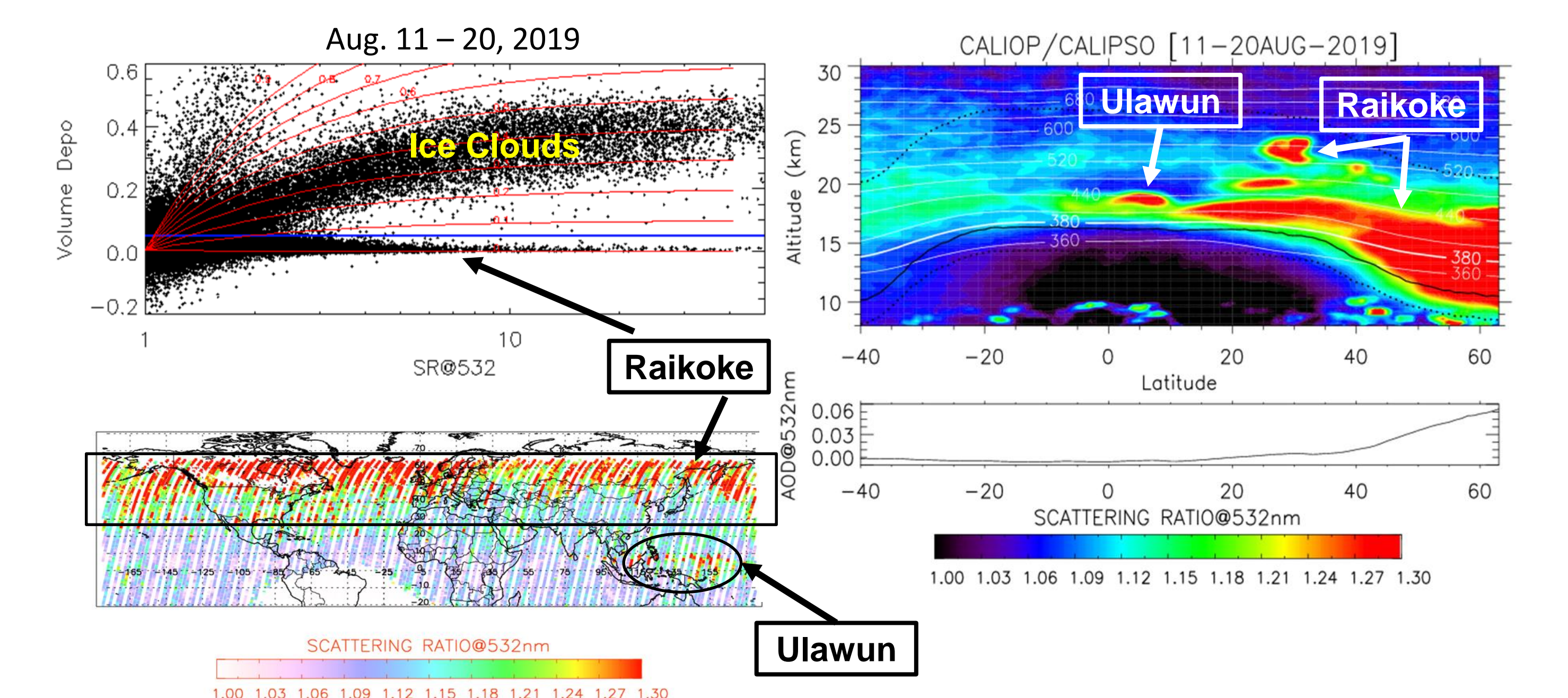
- NASA LaTM with GEOS5 10 days forecast output at the Raikoke volcano.
- The injection height estimated between 7 – 15 km based on SO₂ obs. from Copernicus Sentinel 5 Precursor Tropospheric Monitoring Instrument (S5P/TROPOMI) and CALIOP/CALIPSO.

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



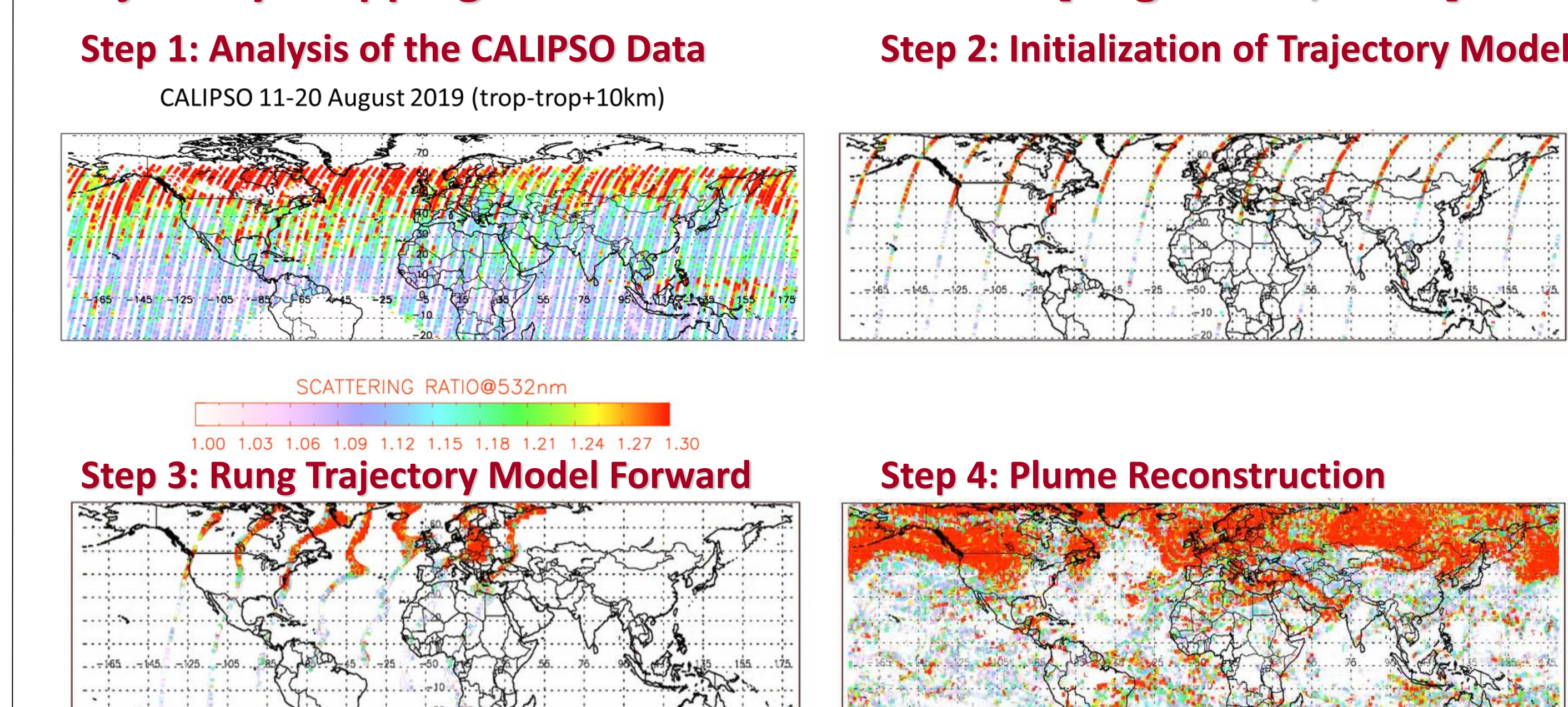
- SAGE III/ISS zonal mean Extinction before and after cloud-clearing data using the diffusion diagram of Extinction ratios (521/1020nm) and extinction at 1020 nm.

CALIOP/CALIPSO

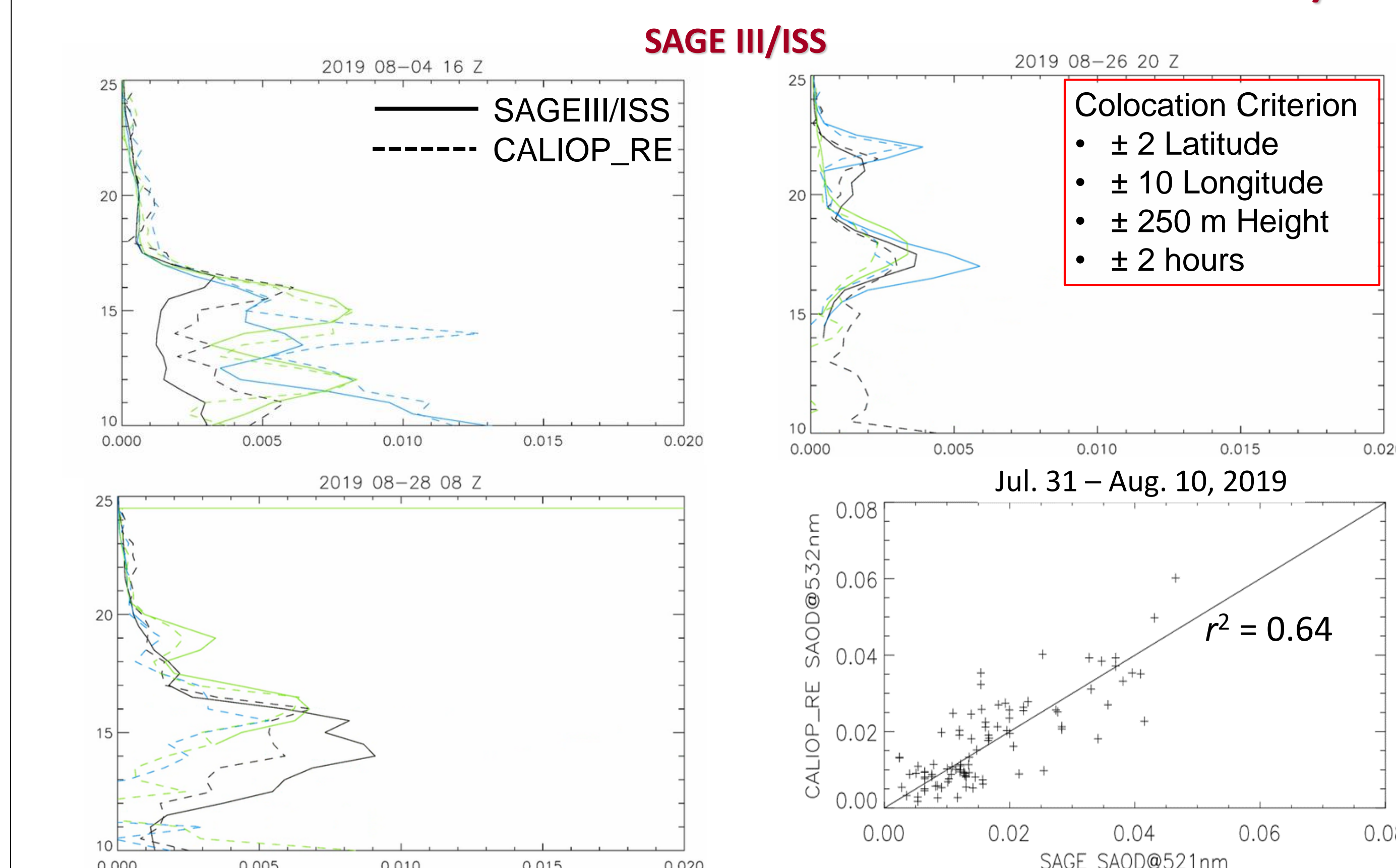


- Zonal Mean Scattering Ratio (SR) cross-section (Top-Right) with cloud-cleared using the depolarization diagram (Top-Left). Data used of those from the CALIOP lidar between August 11 and 20, 2019.
- Another plume observed in the tropics consistent with the Ulawun eruption which also erupted on June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

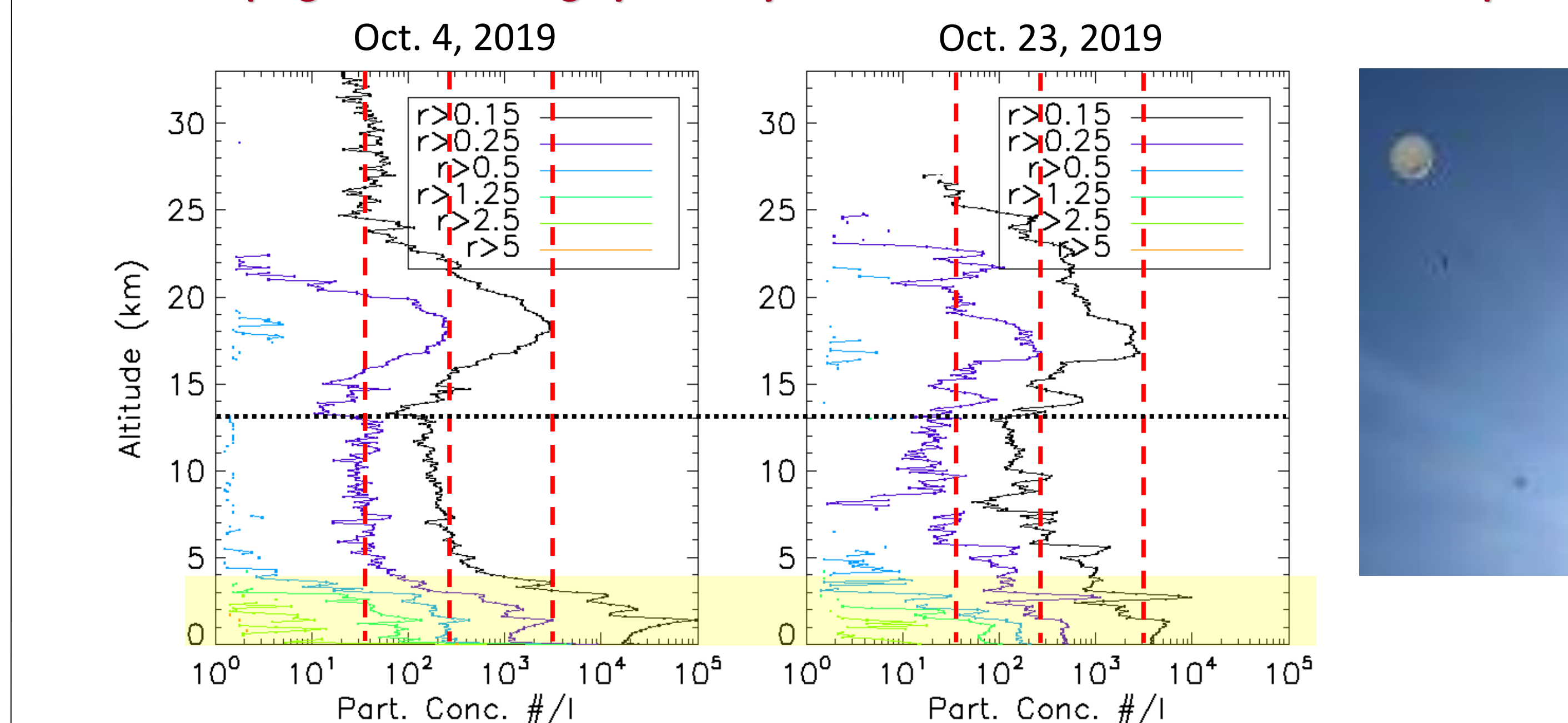
Trajectory Mapping of CALIPSO Observations [Aug. 11-20, 2019]



Evaluations of the Reconstructed CALIPSO Plumes with SAGE III/ISS



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



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.