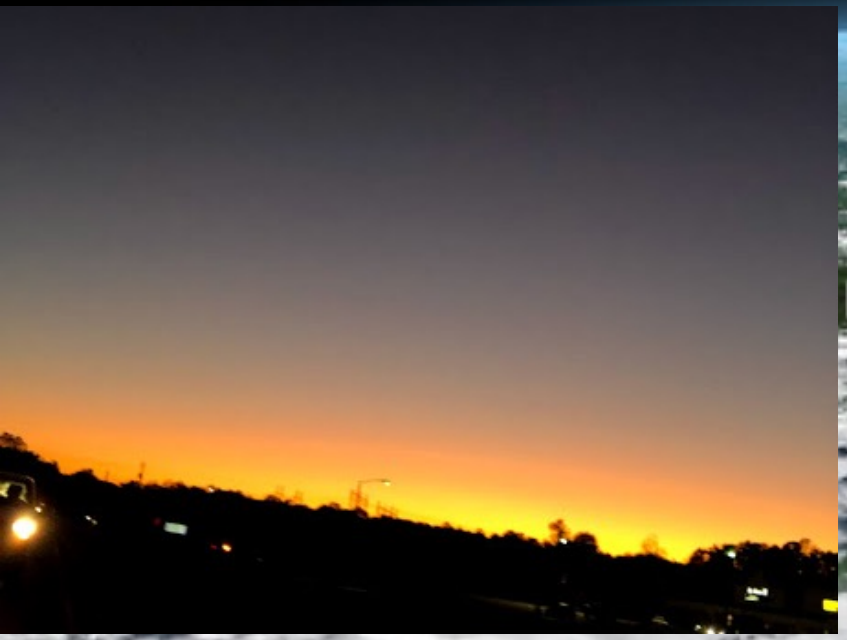
The 2019 Raikoke Eruption



J-P. Vernier, H. Choi, D. Fairlie, A. Pandit, J. Mau, H. Liu and T. Knepp

SAGE III/ISS Science Team, Oct 30th 2019

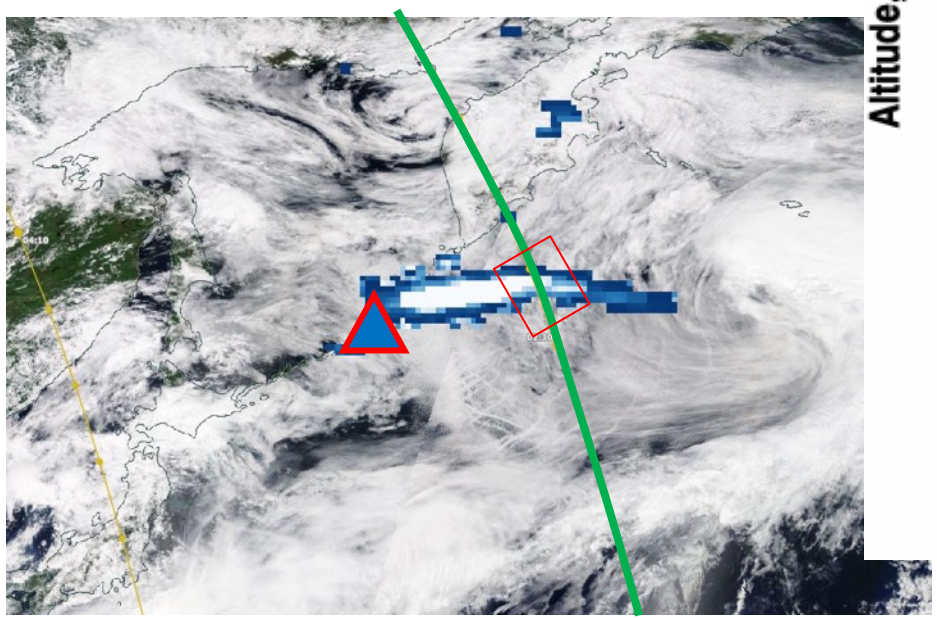
Outline

- Raikoke volcanic eruption : Initial Phase and mass of SO_2 Injected
- CALIPSO observations of the Raikoke plume
- SAGE III/ISS observations of the Raikoke plume
- Vertical transport of the plume into the Stratosphere
- Trajectory mapping of the plume with CALIPSO
- Comparison with SAGEIII/ISS
- VODDKA balloon campaign

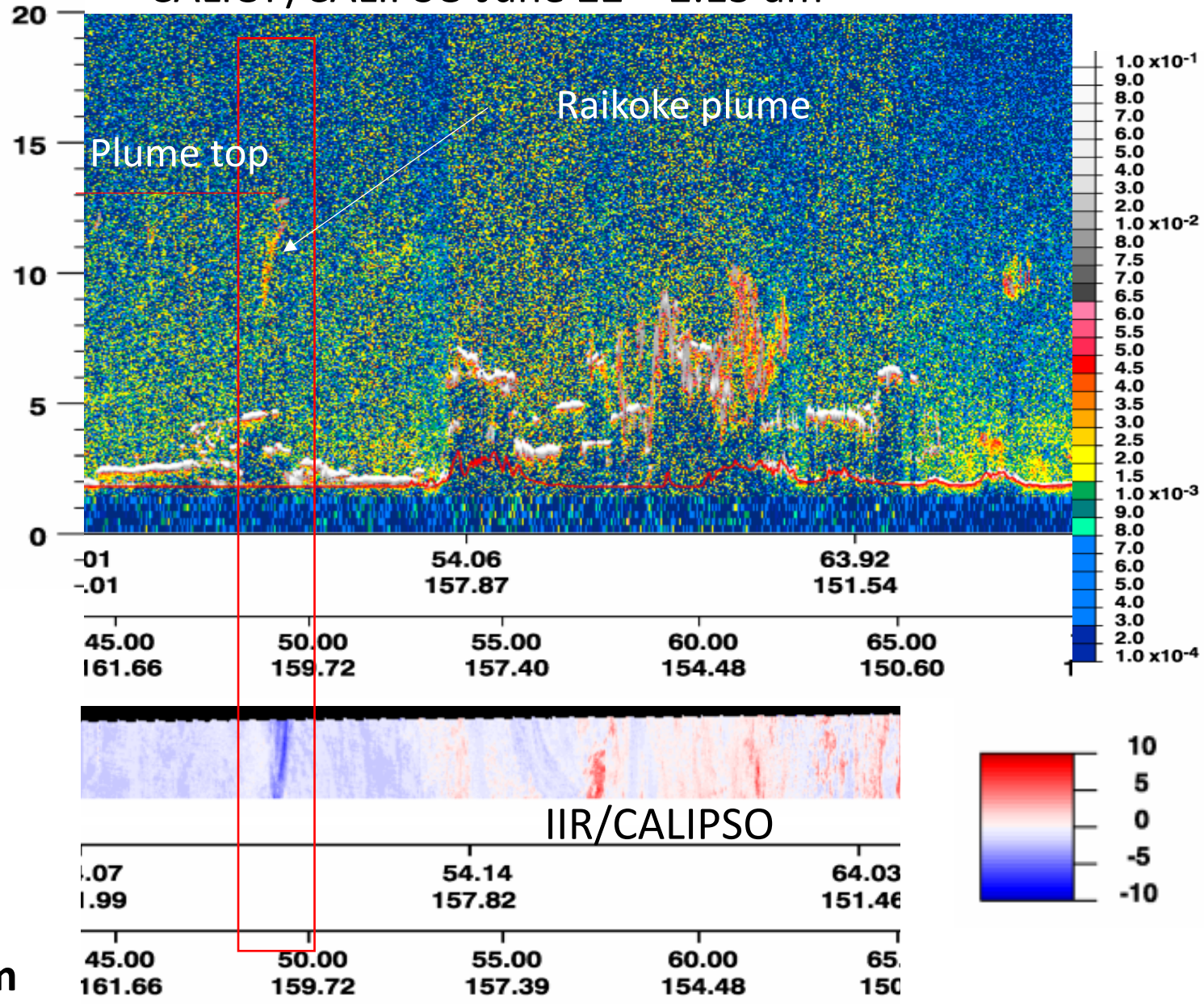
The Raikoke Eruption: June 22nd 2019

Plume injection height from CALIPSO

SO2 from OMPS/NPP June 22nd 2019



CALIOP/CALIPSO June 22nd 2.15 am

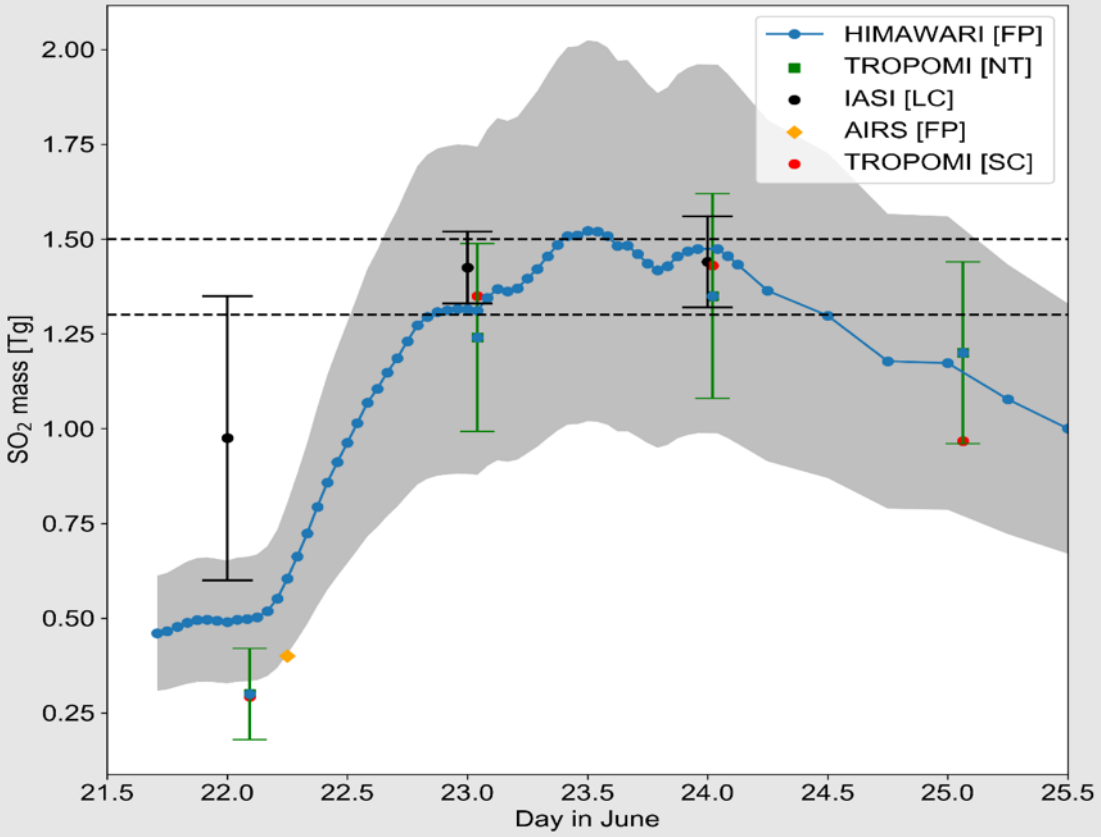


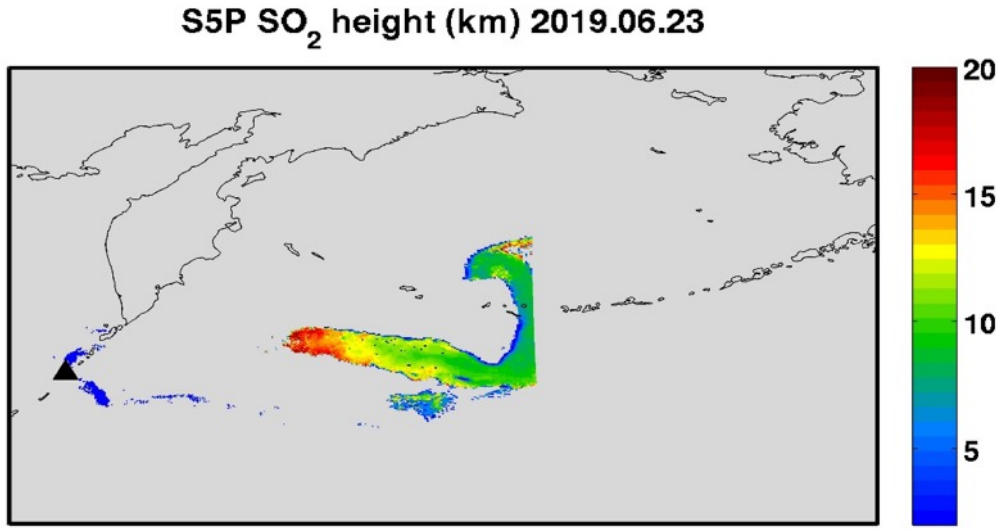
- SO2 plume from OMPS/NPP with quasi-coincident CALIPSO overpass
- Infrared Imager on CALIPSO shows ash plume (negative values on brightness temperatures due to absorption)
- **Plume Top derived from CALIPSO: 13 km**

VolRes Community Response after the Raikoke Volcanic Eruption

- VolRes: sub-activity of SPARC-SSiRC
- 182 members through ssircvolcano-owner@mpimet.mpg.de
- Goal: to be prepared for the next major volcanic eruption
- https://wiki.earthdata.nasa.gov/display/volres/Volcano+Response

Time series of total SO_2 mass observed by satellites





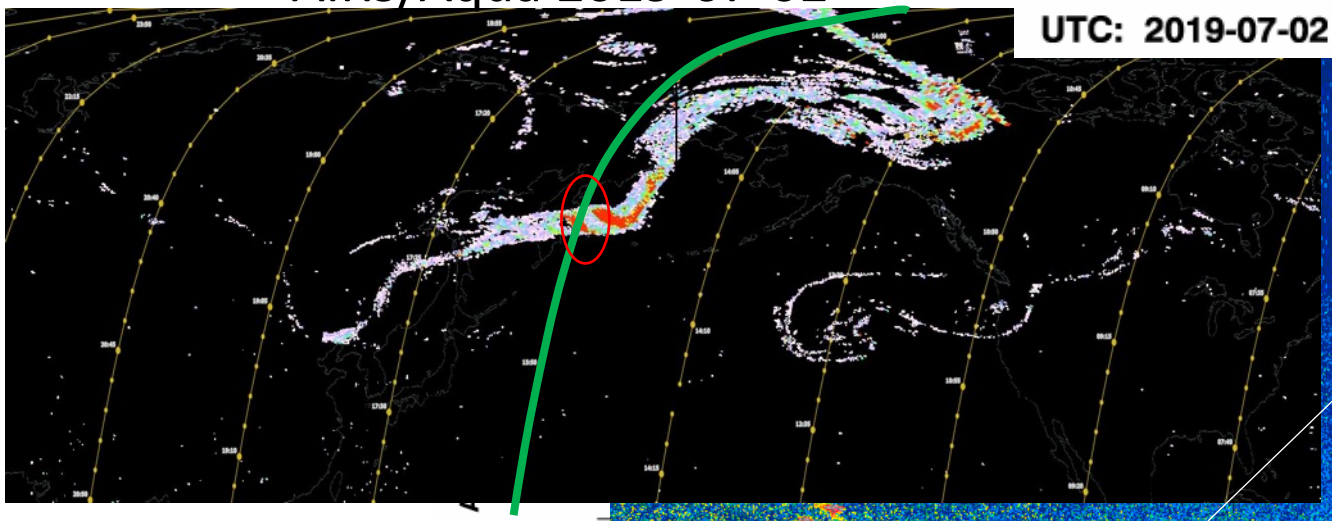
Summary of total SO2 loadings and plume injection heights after the 2019 Raikoke eruption:

- **Raikoke volcano Location : (153.2° E, 48.3° N),**
- Eruption Time **: 21 June 2019 at 18UTC to 22 June 2019 at 03:00 UTC**
- SO2 injection **: 1.5+/-0.2 TG**
- Plume height **: 7-15 km**

Fred Prata, Simon Carn, Lieven Clarisse, Nicolas Theys

Observations of the Raikoke volcanic plume one week after the eruption

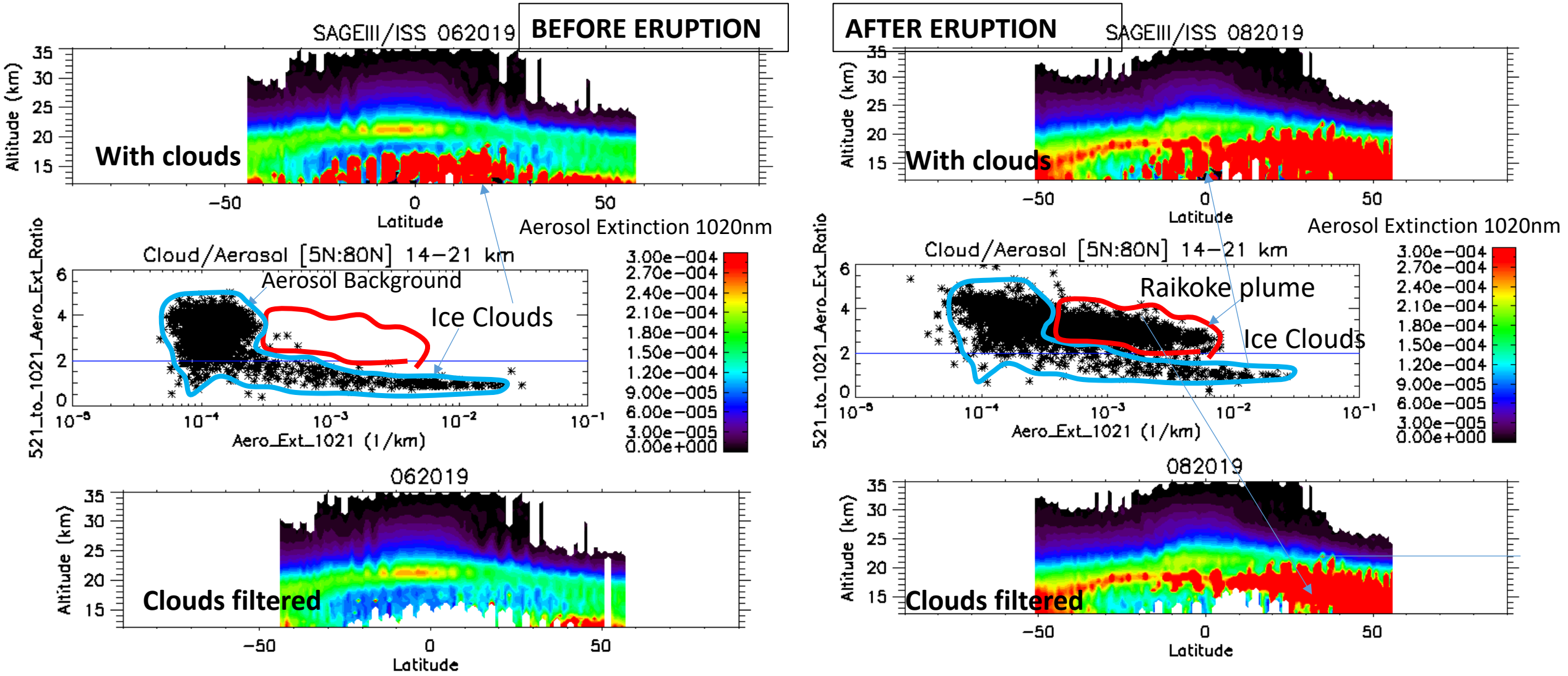
AIRS/Aqua 2019-07-02



CALIPSO

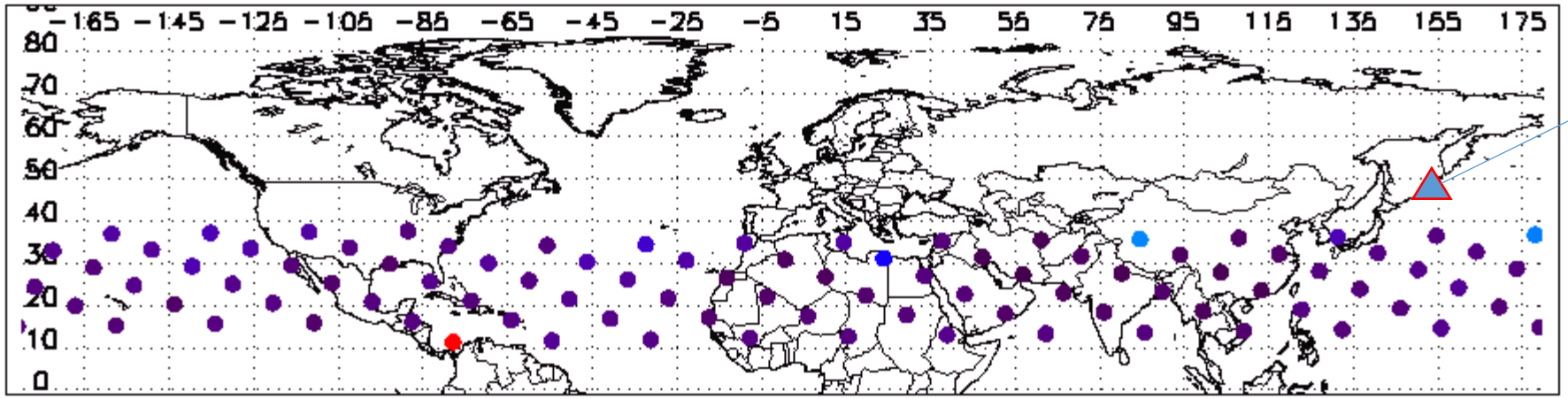
- Quasi-collocated observations of SO2 and aerosols from AIRS/Aqua and the CALIPSO lidar
- Large extension of the plume from Russia to N. America
- Plume vertical extension between 9 and 16 km, Diffuse volcanic ash/sulfate in commercial aviation airspace

Raikoke plume observations by SAGE III/ISS: Cloud-Aerosol Discrimination

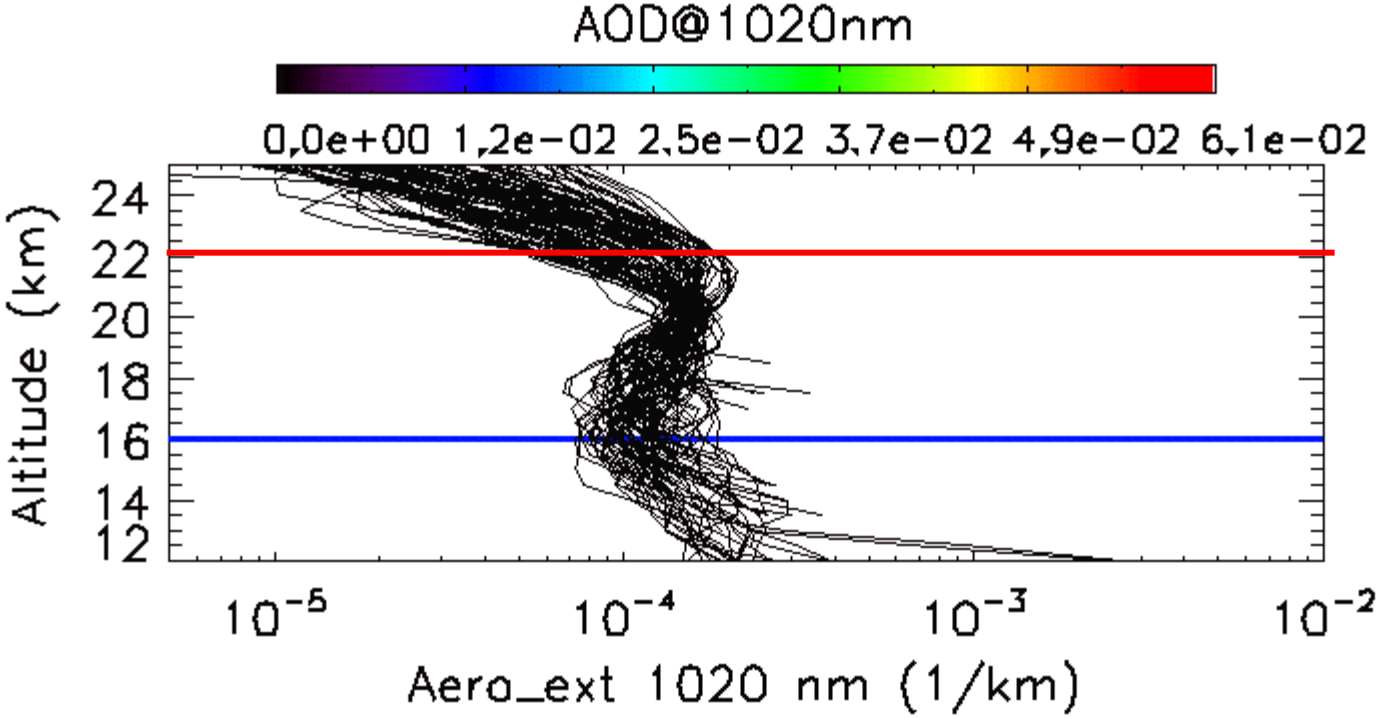


- Diffusion diagrams show the signature of the Raikoke plume in August 2018
- NH largely affected/ Ulawun also erupted a week after Raikoke

SAGE III/ISS 6– 8 6– 13



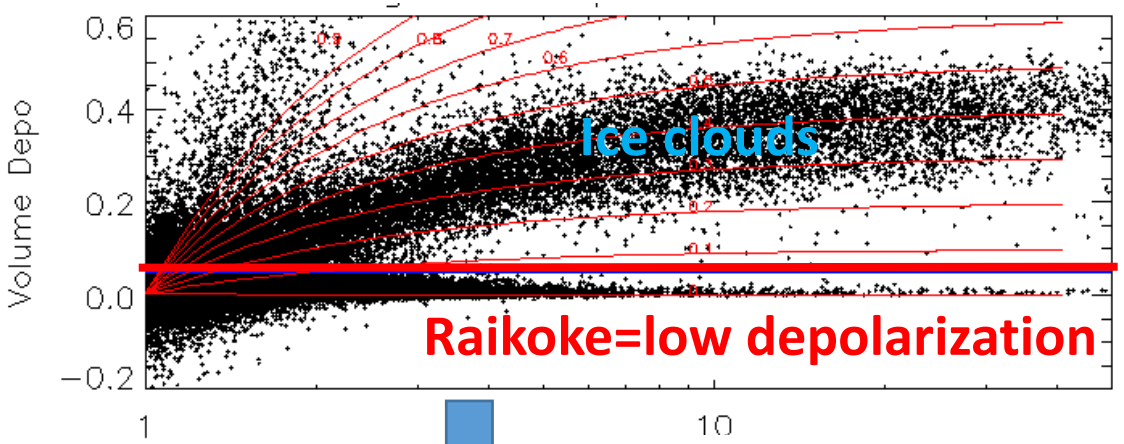
Raikoke



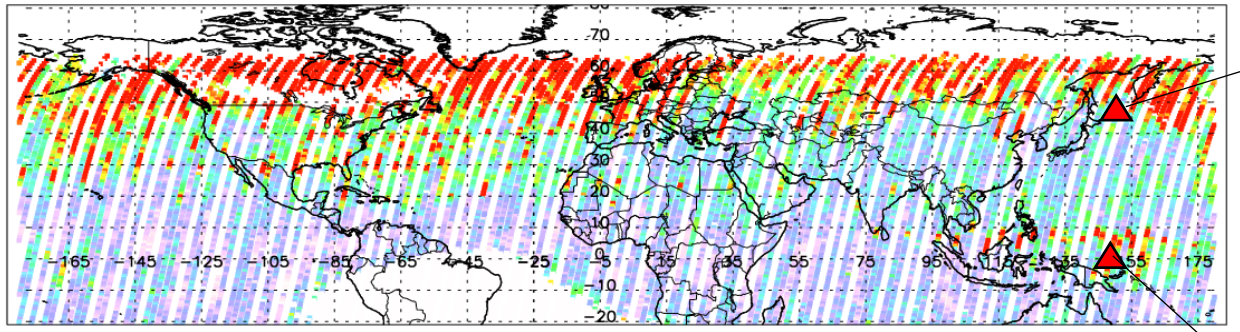
Ascent of the Raikoke plume into the Stratosphere

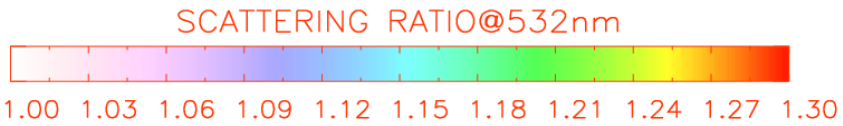
Raikoke plume observed by CALIPSO

11-20 AUG 2019

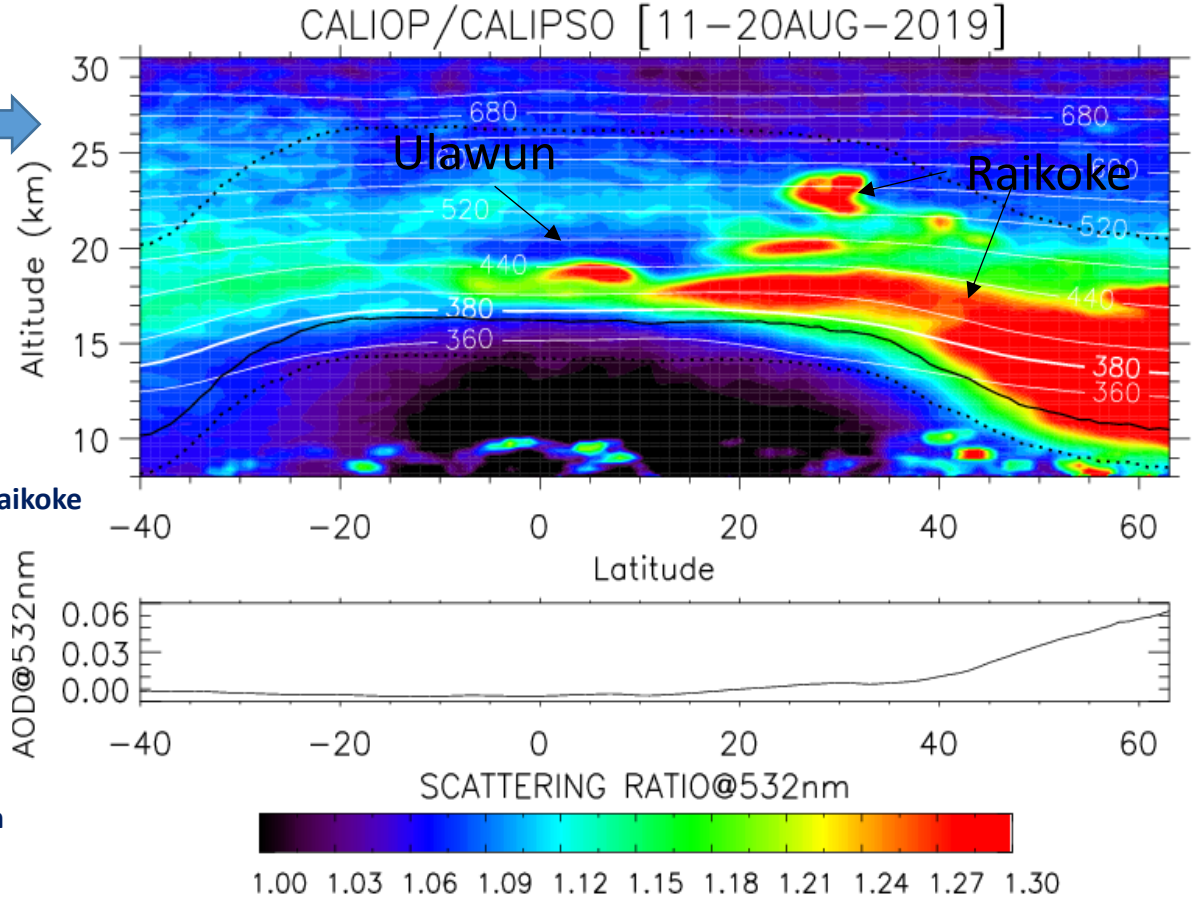


Trop-1km: Trop+10km





Cloud-Filtered

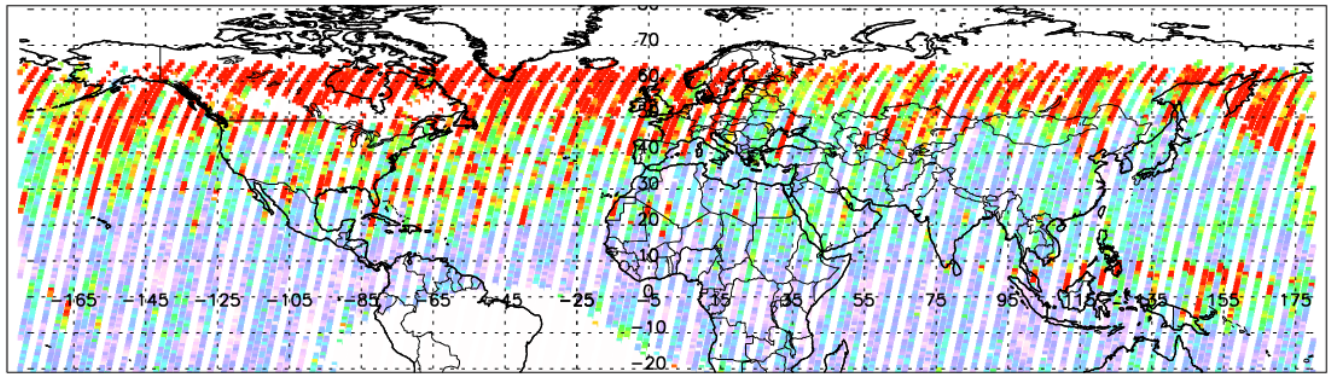


- Another plume is observed in the tropics consistent with the Ulawun eruption
- Transport of the Raikoke plume up to 22-23 km : diabatic lofting of absorbing aerosols ?

Trajectory mapping of CALIPSO observations

Step 1: Analysis of the CALIPSO data

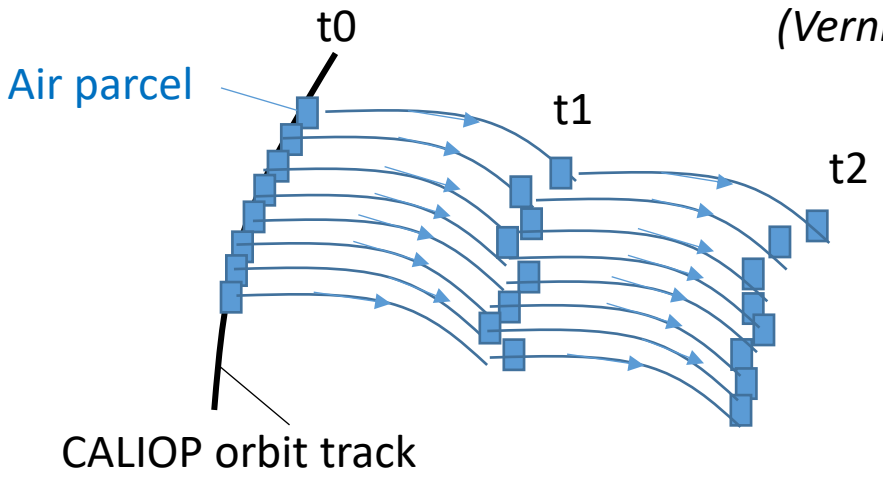
CALIPSO 11-20 August 2019 (trop-trop+10km)



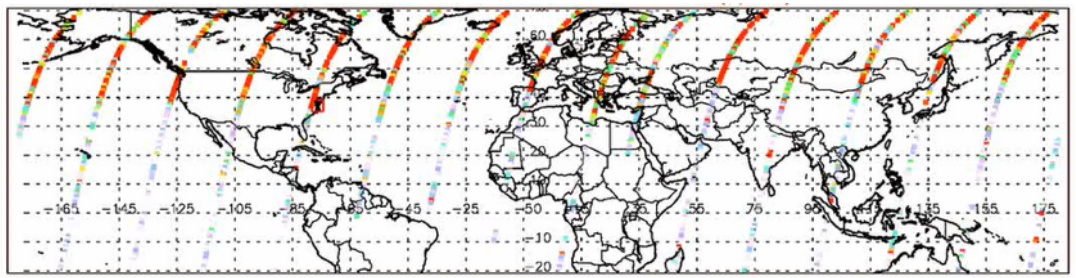
SCATTERING RATIO@532nm

1.00 1.03 1.06 1.09 1.12 1.15 1.18 1.21 1.24 1.27 1.30

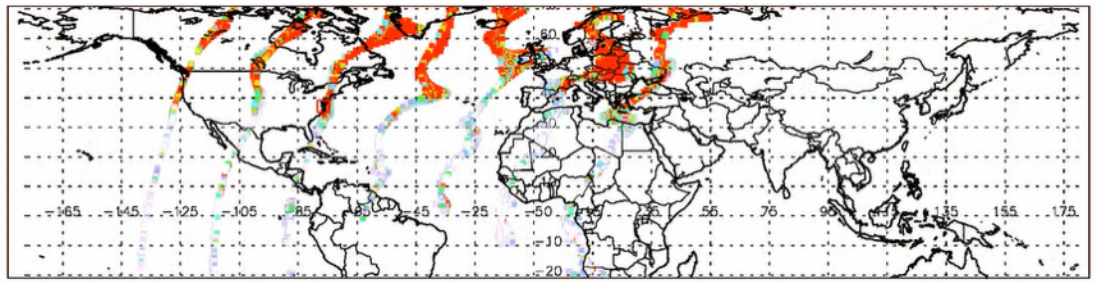
(Vernier et al., 2013, JAMC)



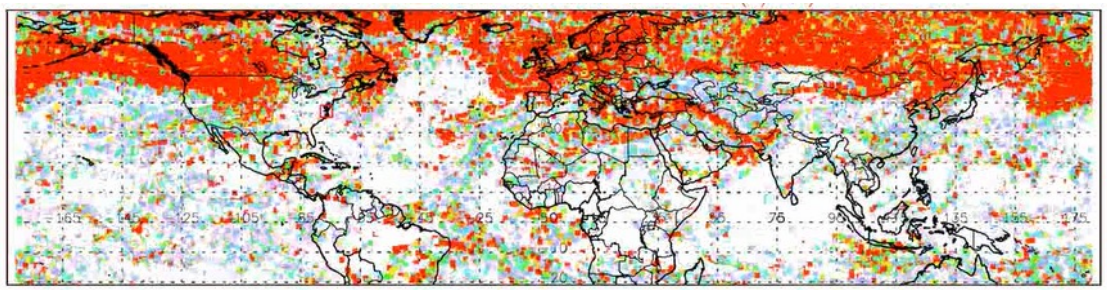
Step 2: Initialization of the trajectory model



Step 3: Run trajectory model forward in time

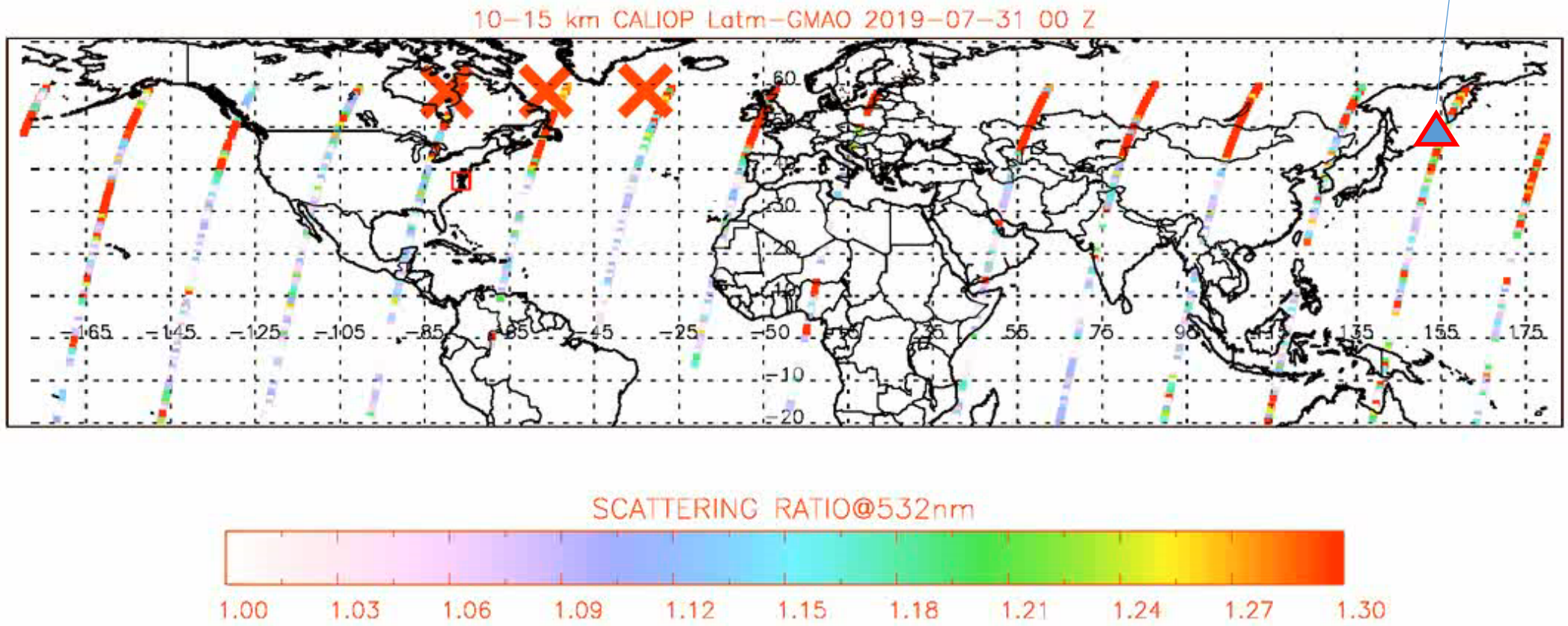


Step 4: Plume reconstruction



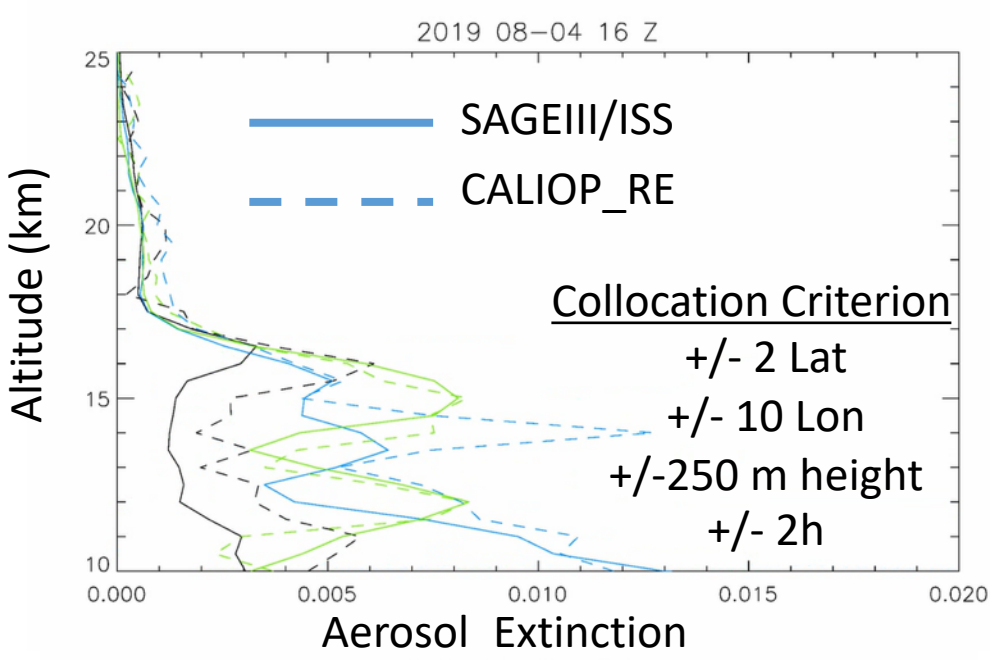
CALIPSO trajectory maps (07/31-08/09)

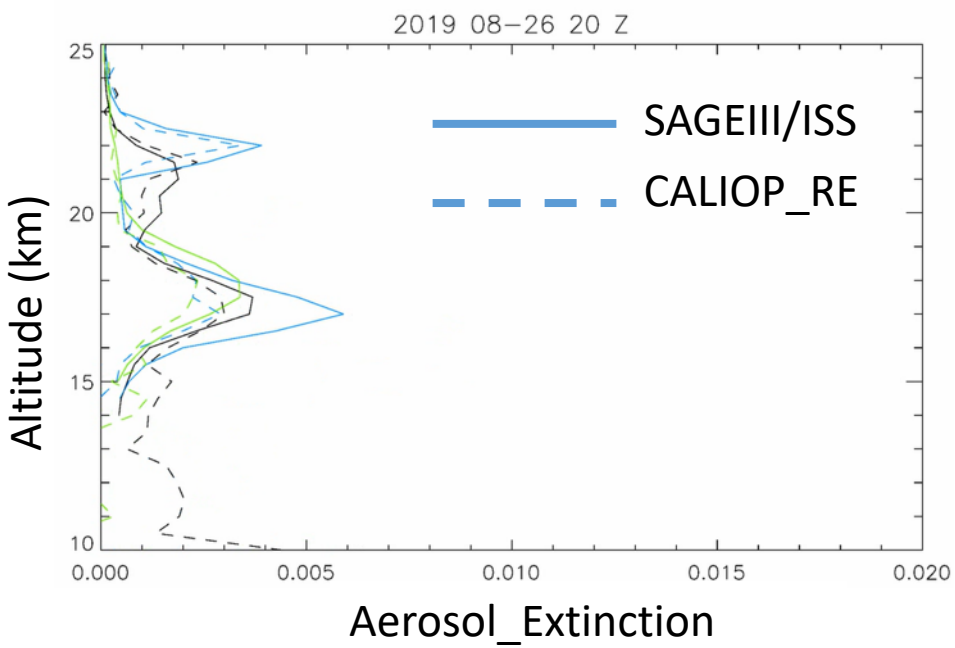
Raikoke

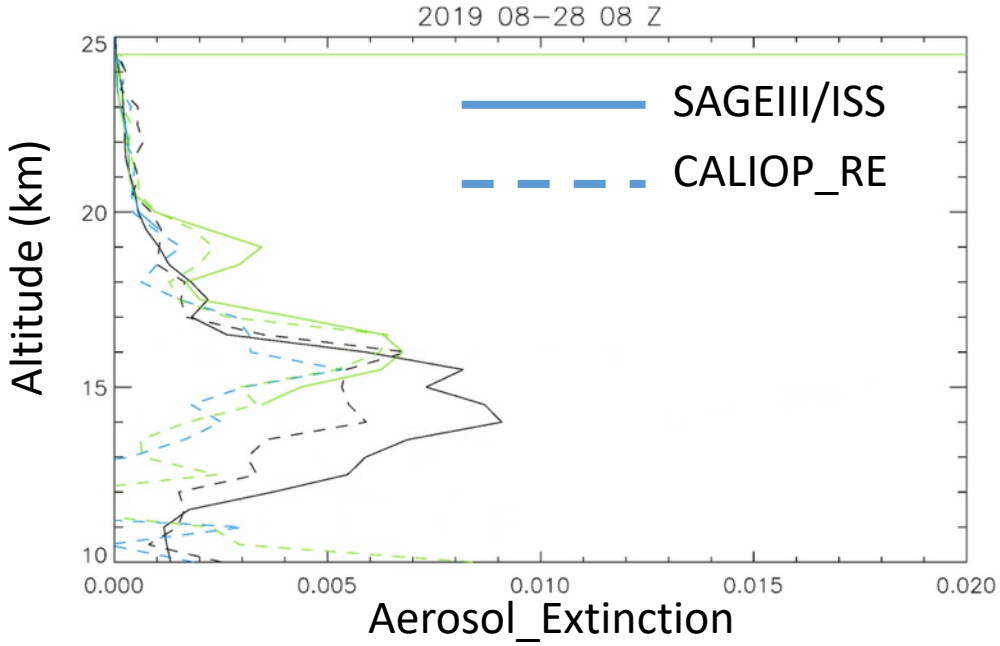


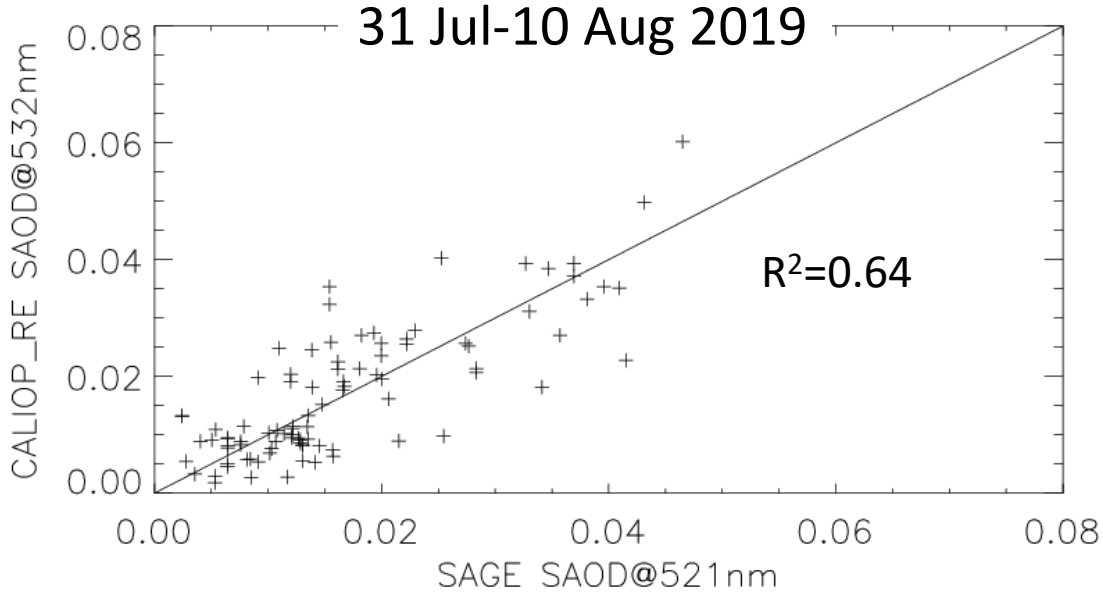
X SAGE III/ISS

Comparison between SAGE III/ISS and CALIPSO Reconstructed profiles

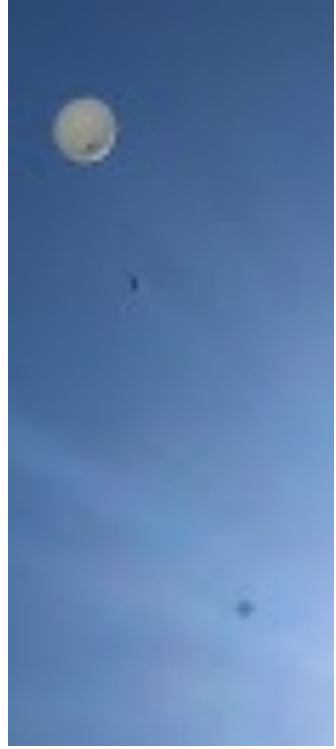


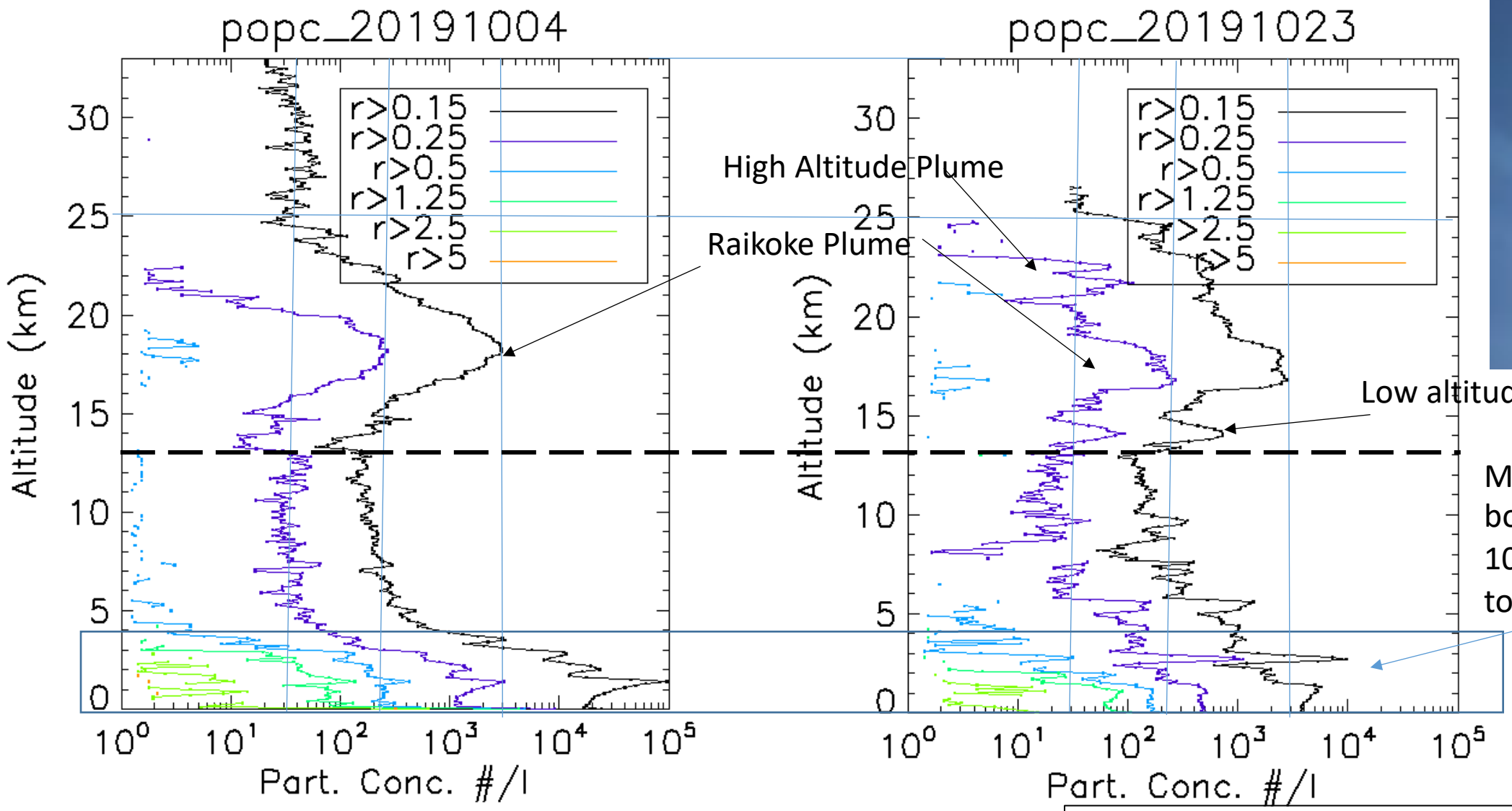






VOlcanic plume Dispersion and Decay after the 2019 RaiKoke strAtospheric eruption: VODDKA project



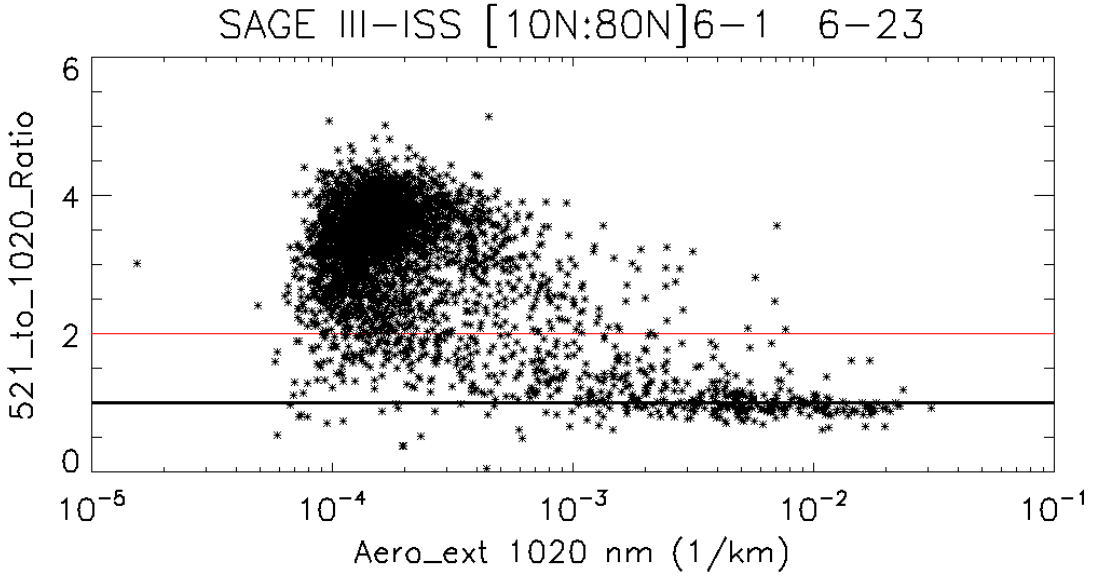


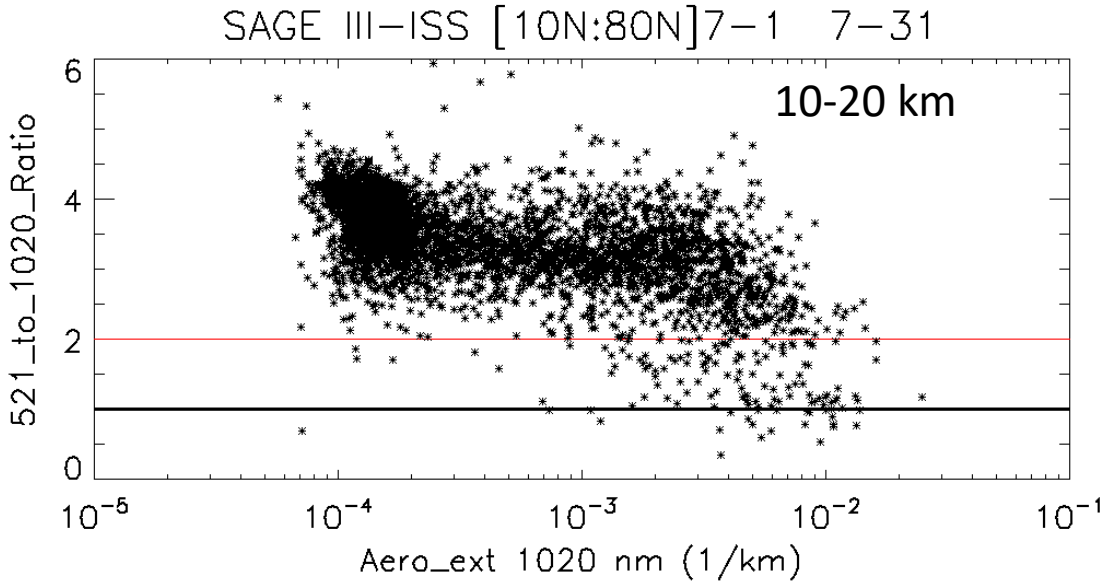
Balloon flights from NASA Langley

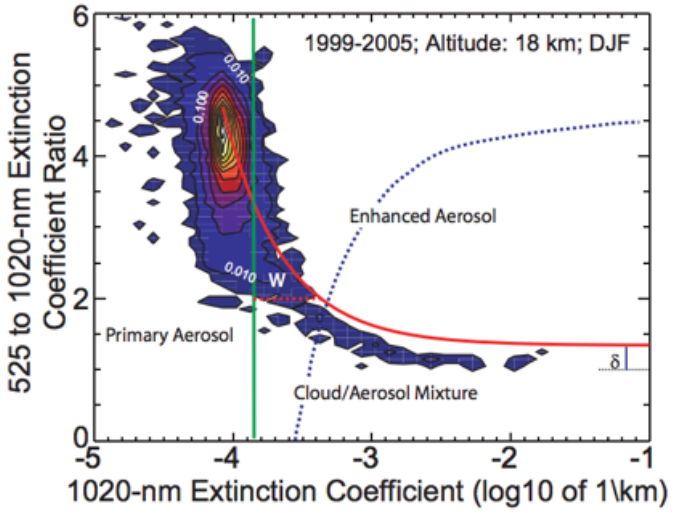
Conclusions

- Raikoke eruption was one of the largest eruption of the last 10 years with ~1.5 Tg of SO_2
- Satellite Observations from SAGEIII/ISS and CALIPSO show its dispersion into the stratosphere
- Vertical transport of the plume up to 25 km is unusual, not observed from previous eruptions, mechanisms yet to be understood
- VODDKA: Balloon field campaign to get more information on the microphysical and chemical properties of the plume; Planned collocation flights with CALIPSO and SAGE III/ISS

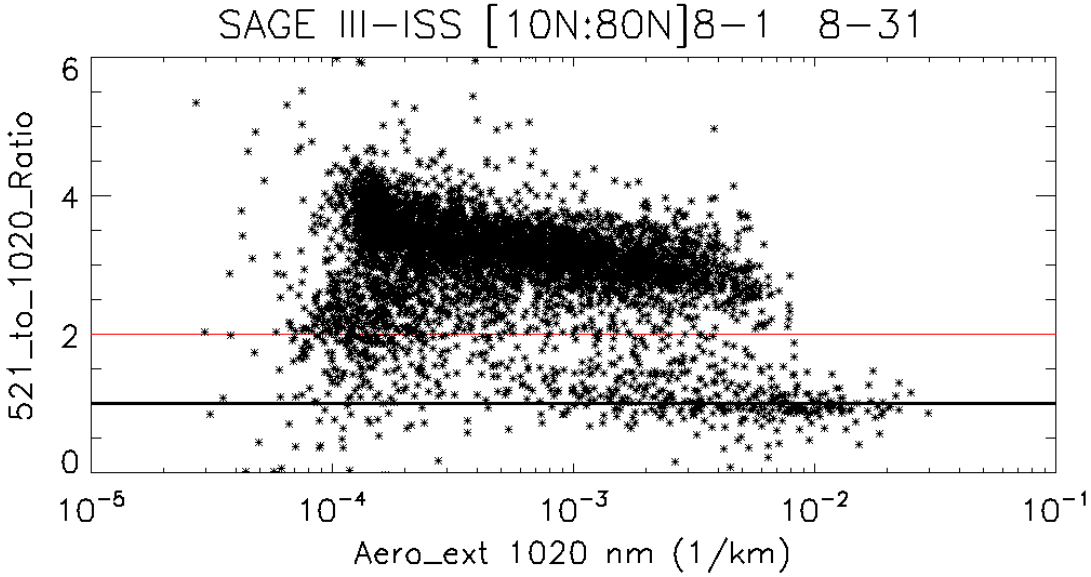
Raikoke plume observed by SAGE III/ISS: Cloud-Aerosol Discrimination





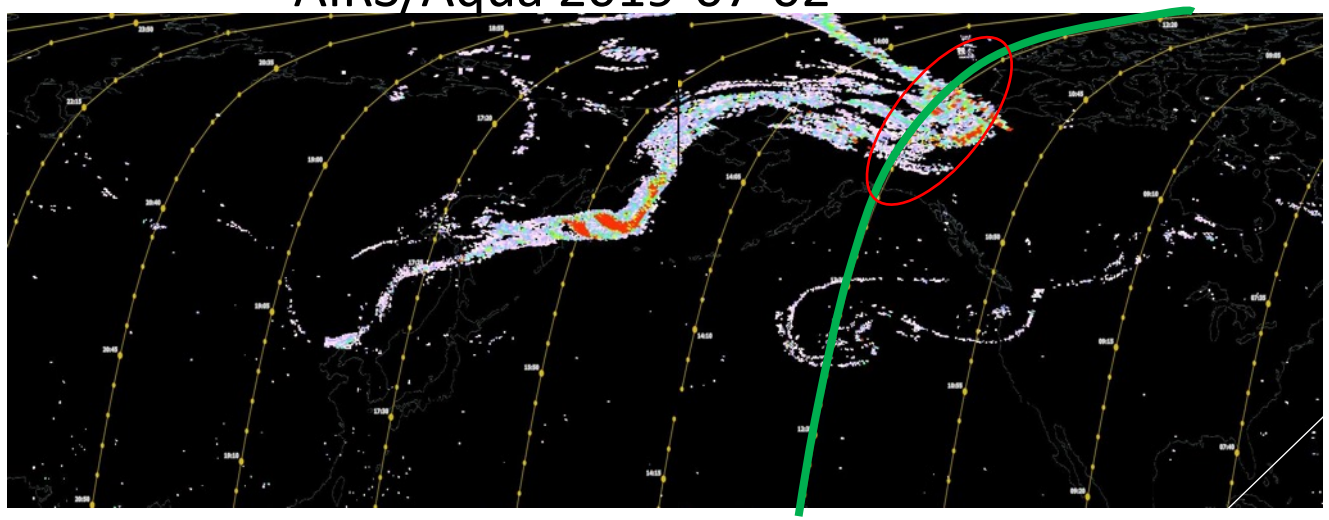


Thomason 2013

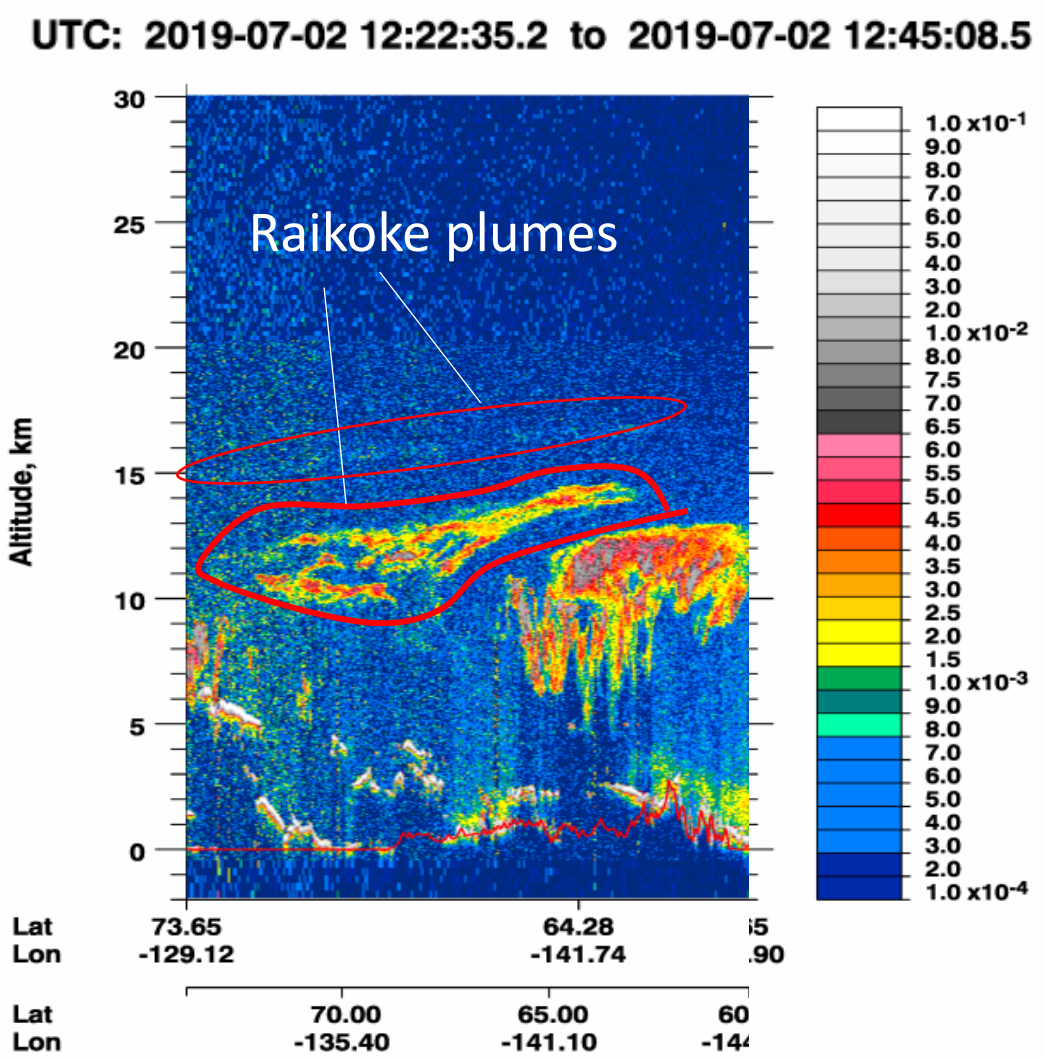


CALIOP/CALIPSO and AIRS/Aqua observations of the Raikoke volcanic plume

AIRS/Aqua 2019-07-02



CALIPSO/CALIOP



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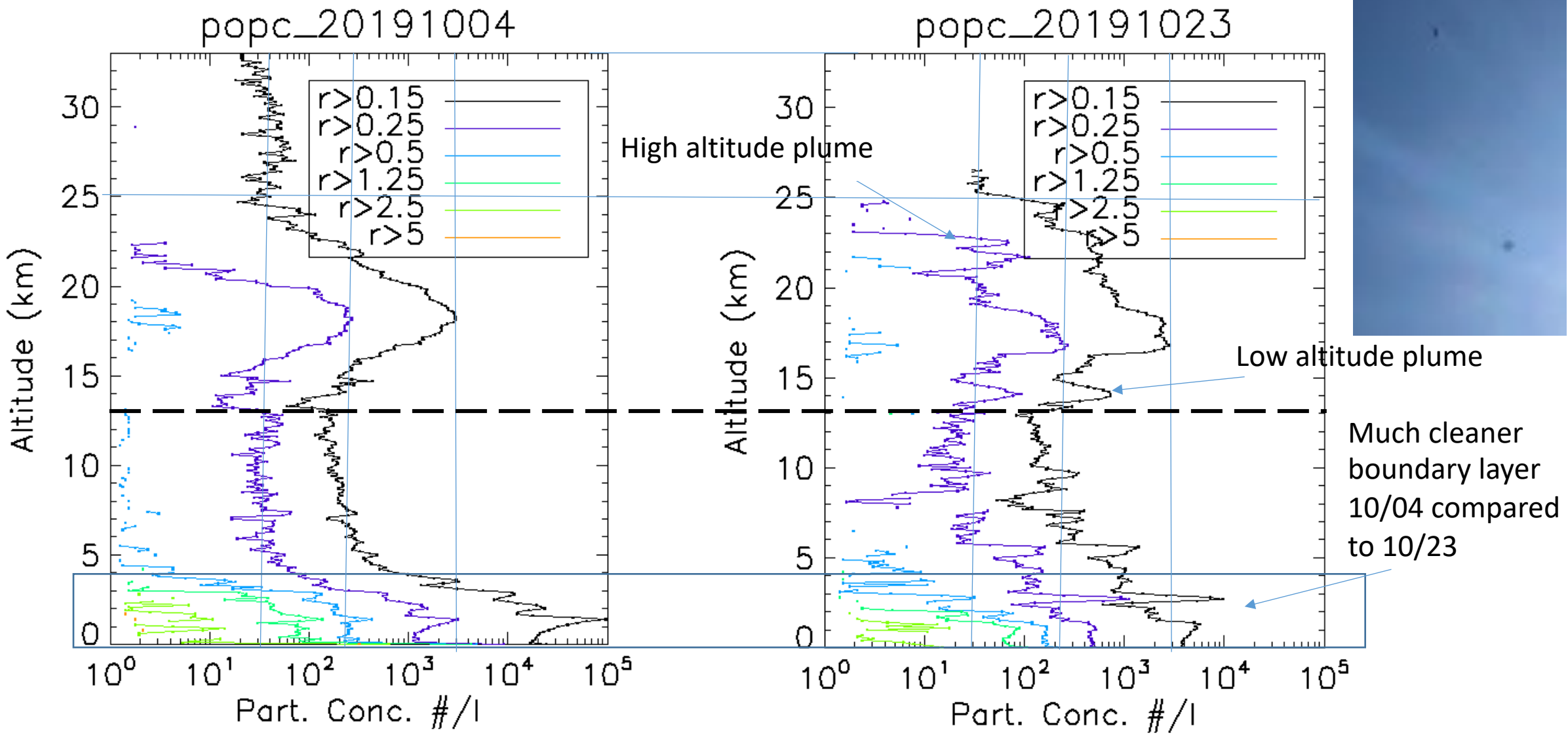
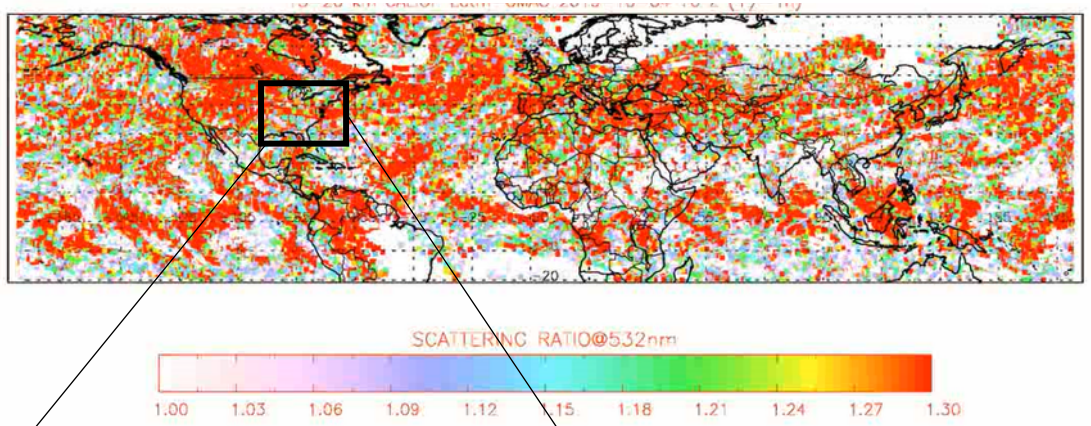
Volcanic plume Dispersion and Decay after the 2019 RaiKoke strAtospheric eruption

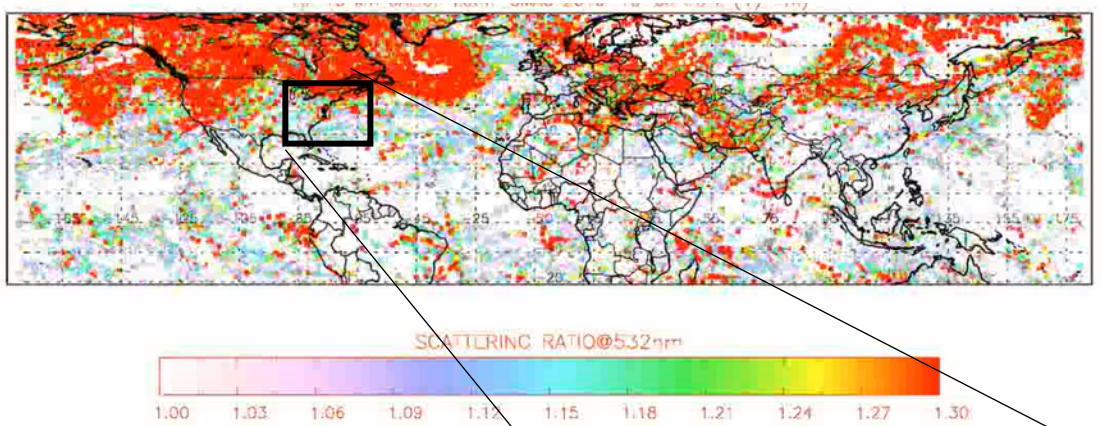


CALIPSO Trajectory-Mapped and Balloon OPC measurements of the Raikoke Volcanic Plume

10/04/2019 16UTC CALIPSO-Traj **[15-20 km]**

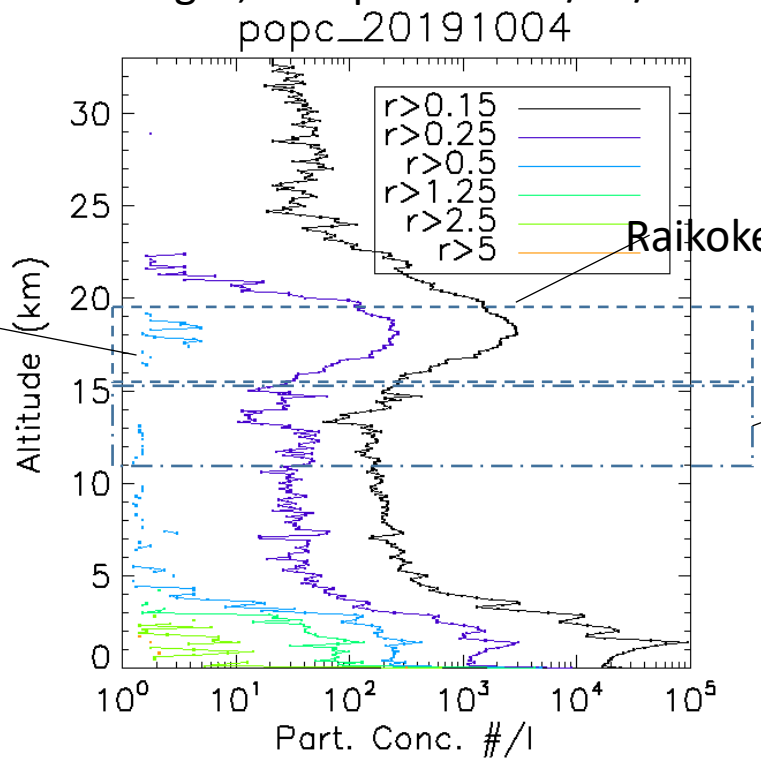


10/04/2019 16 UTC CALIPSO-Traj **[10-15 km]**

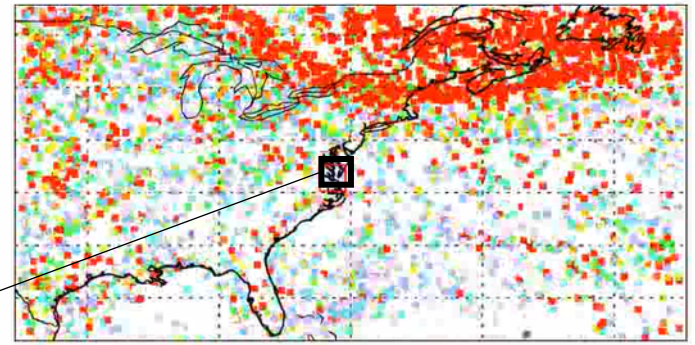


Zoom Eastern US

Balloon OPC Flight, Hampton VA 10/04/2019 14 UTC



Zoom Eastern US



OPC measurements from a balloon flight carried out from NASA Langley detected the Raikoke Volcanic Plume between 15 and 22 km

The Raikoke volcanic plume was trajectory mapped from 7 days of CALIPSO observations prior to the balloon observations on 10/04