Volcanic Aerosol from June 2019 Onward Observed by Raman Lidar

Geraint Vaughan, David Wareing and Hugo Ricketts
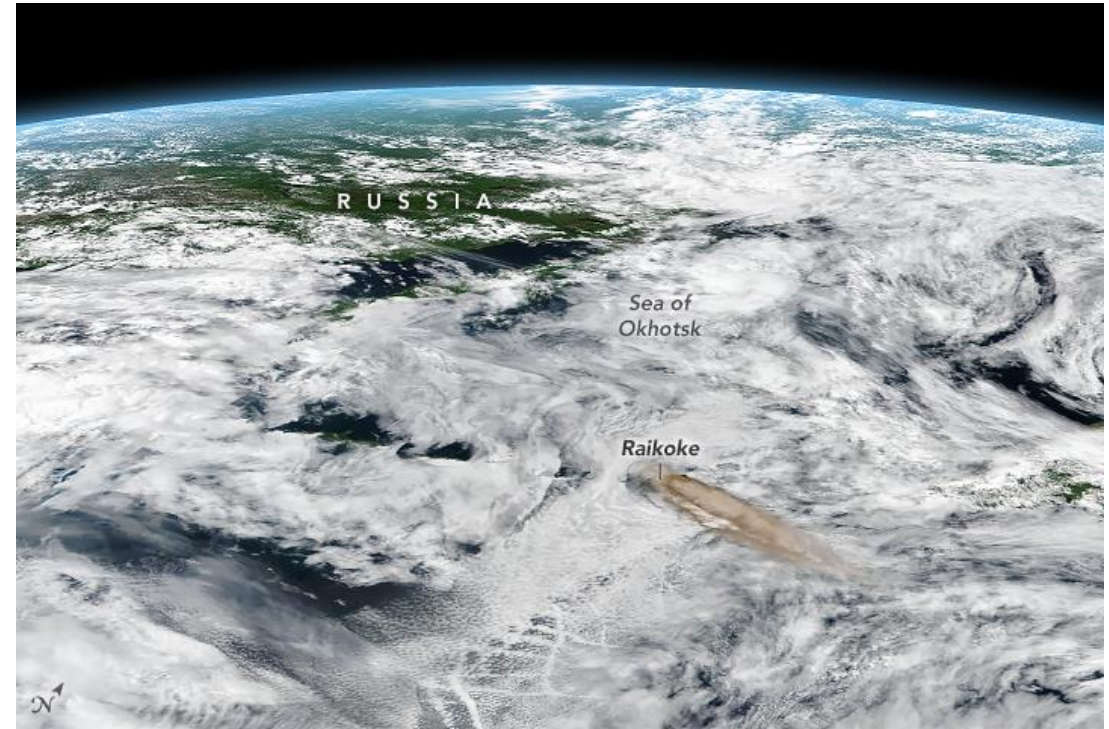
National Centre for Atmospheric Science

University of Manchester
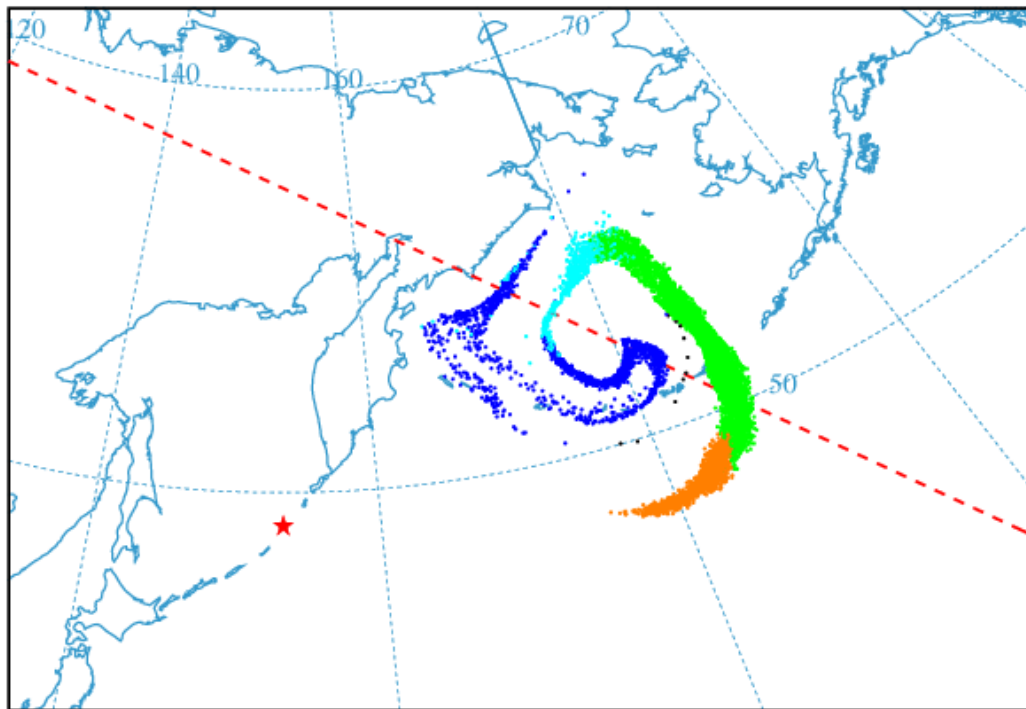
UK

Eruption June 22nd 2019, Kuril Islands

48.29N
153.25E

Large plume of ash and SO_2 injected into the stratosphere, initially up to 17 km (Calipso)
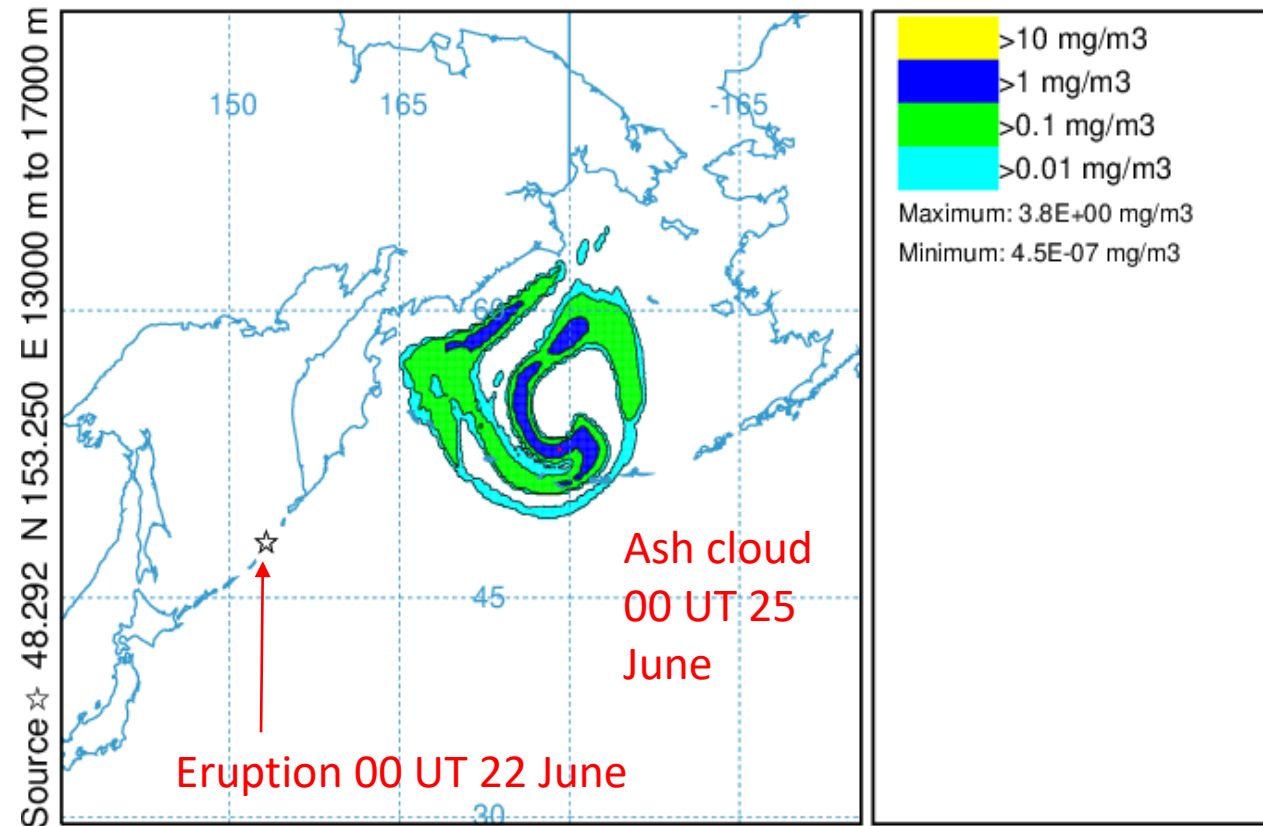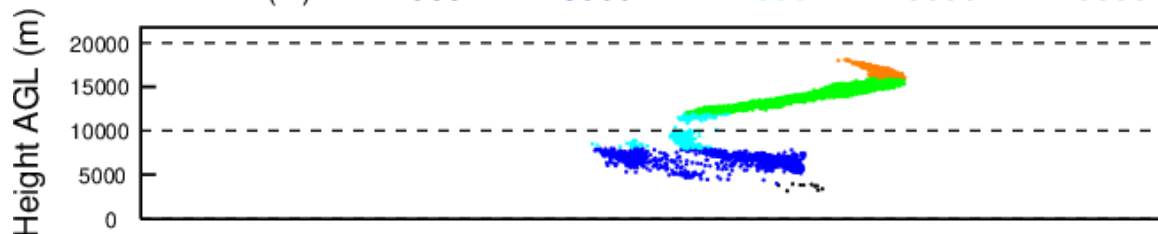Estimated 1.5 Tg SO_2. Eruption started 4.00 local time (1800 21st GMT)

https://earthobservatory.nasa.gov/images/145226/raikoke-erupts

Ash dispersion for first 72 hours

Ash cloud 00 UT 25 June

Eruption 00 UT 22 June

Dispersion was slow, with material staying in the vicinity of the eruption for a few weeks

200 hour (8 day) forward trajectories, 13, 15, 17 km

NOAA HYSPLIT MODEL
Forward trajectories starting at 1800 UTC 21 Jun 19
GDAS Meteorological Data

13 km

Job ID: 12379   Job Start: Thu Jan 30 12:22:31 UTC 2020
Source 1   lat.: 48.000000   lon.: 153.000000   height: 13000 m AGL

Trajectory Direction: Forward   Duration: 200 hrs
Vertical Motion Calculation Method: Model Vertical Velocity
Meteorology: 0000Z 15 Jun 2019 - GDAS1

NOAA HYSPLIT MODEL
Forward trajectories starting at 1800 UTC 21 Jun 19
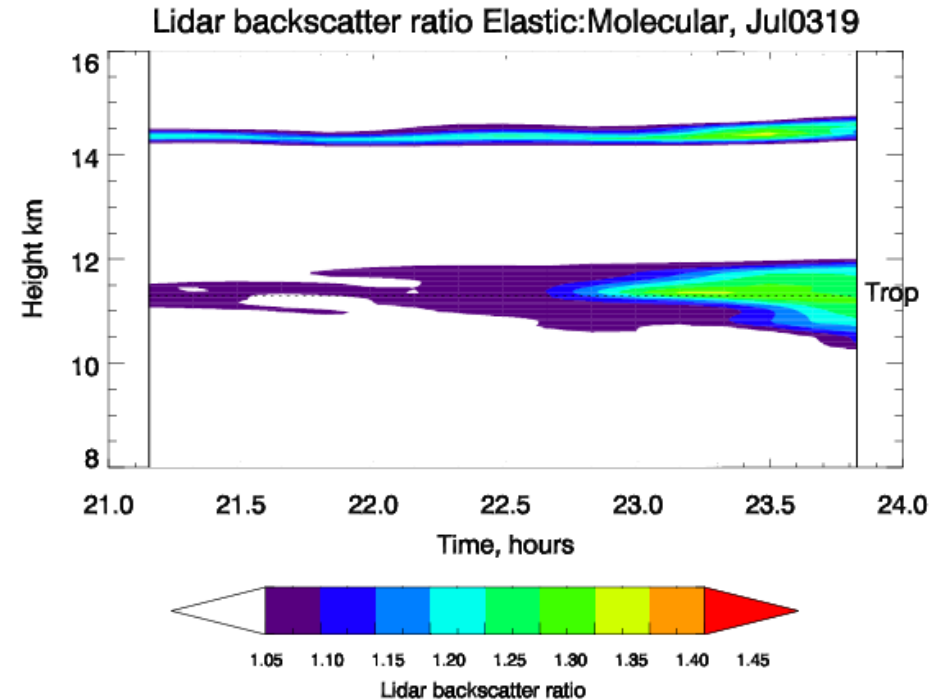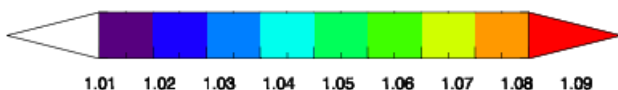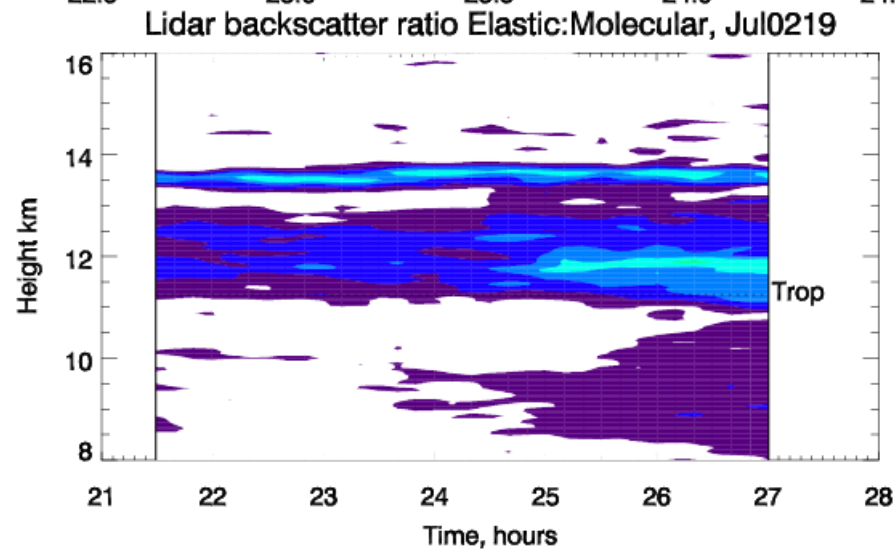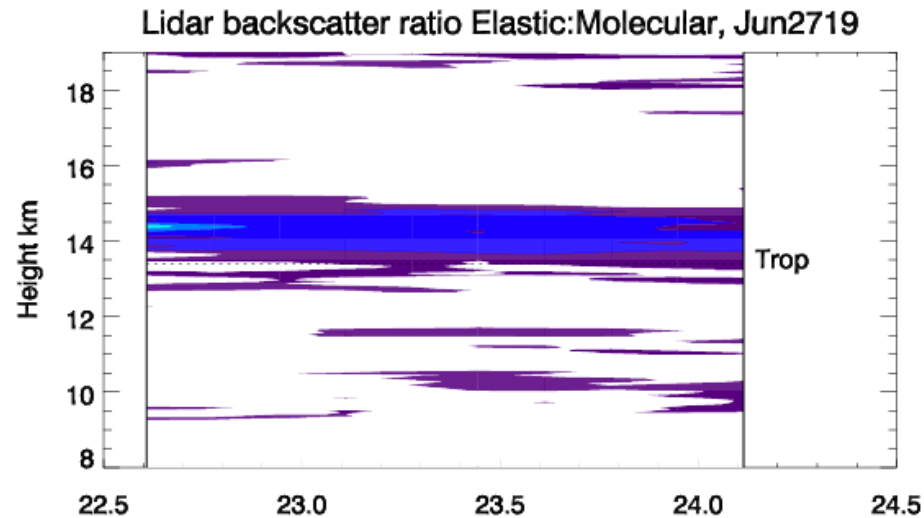GDAS Meteorological Data

15 km

Job ID: 12692   Job Start: Thu Jan 30 12:26:18 UTC 2020
Source 1   lat.: 48.000000   lon.: 153.000000   height: 15000 m AGL

Trajectory Direction: Forward   Duration: 200 hrs
Vertical Motion Calculation Method: Model Vertical Velocity
Meteorology: 0000Z 15 Jun 2019 - GDAS1

NOAA HYSPLIT MODEL
Forward trajectories starting at 1800 UTC 21 Jun 19
GDAS Meteorological Data

17 km

Job ID: 12848   Job Start: Thu Jan 30 12:28:03 UTC 2020
Source 1   lat.: 48.000000   lon.: 153.000000   height: 17000 m AGL

Trajectory Direction: Forward   Duration: 200 hrs
Vertical Motion Calculation Method: Model Vertical Velocity
Meteorology: 0000Z 15 Jun 2019 - GDAS1

Volcano products in the lower stratosphere stay near the source region up to 30 June

200 hr forward trajectories from 00 h 30 Jun

Volcano products in the lower stratosphere stay near the source region up to 8 July
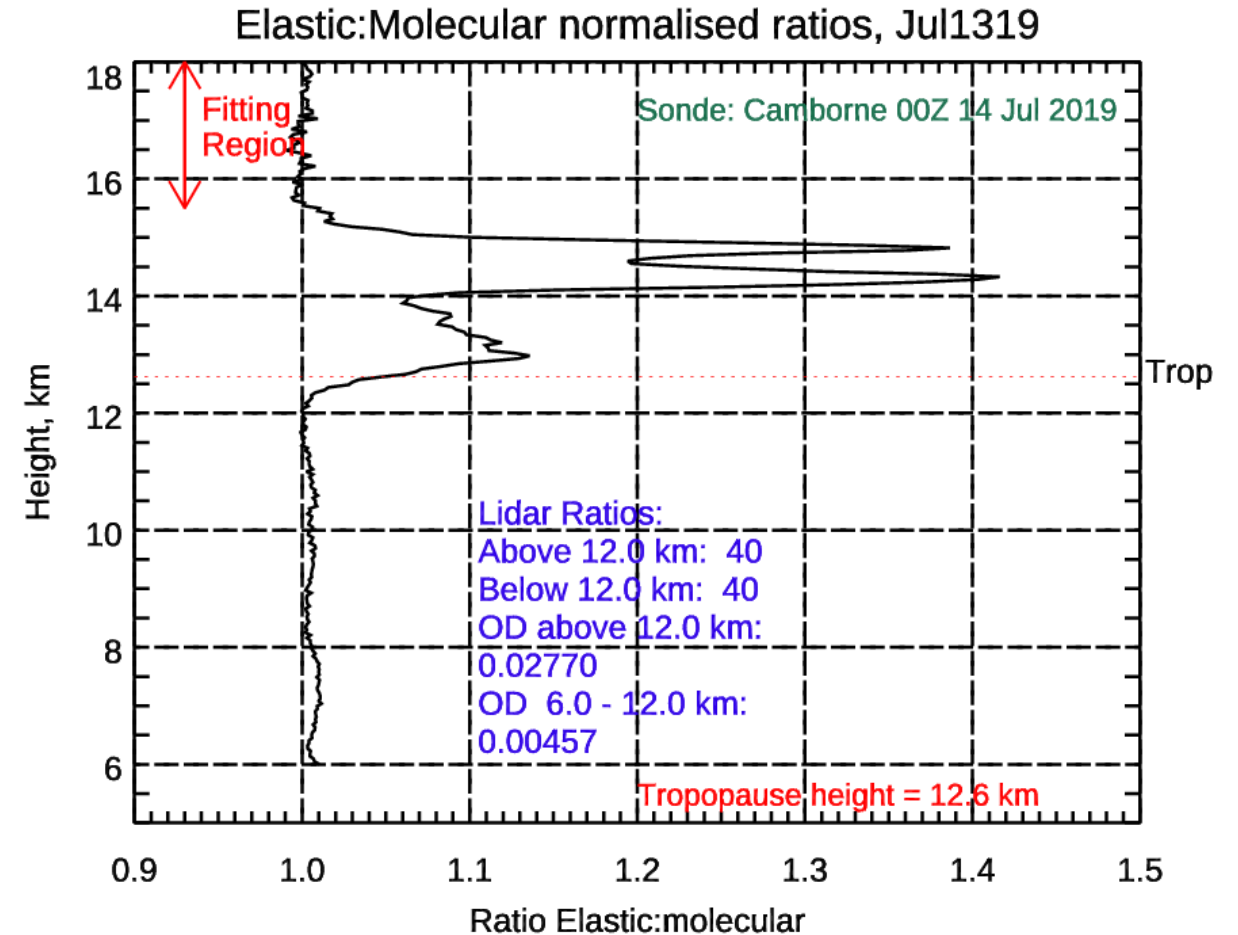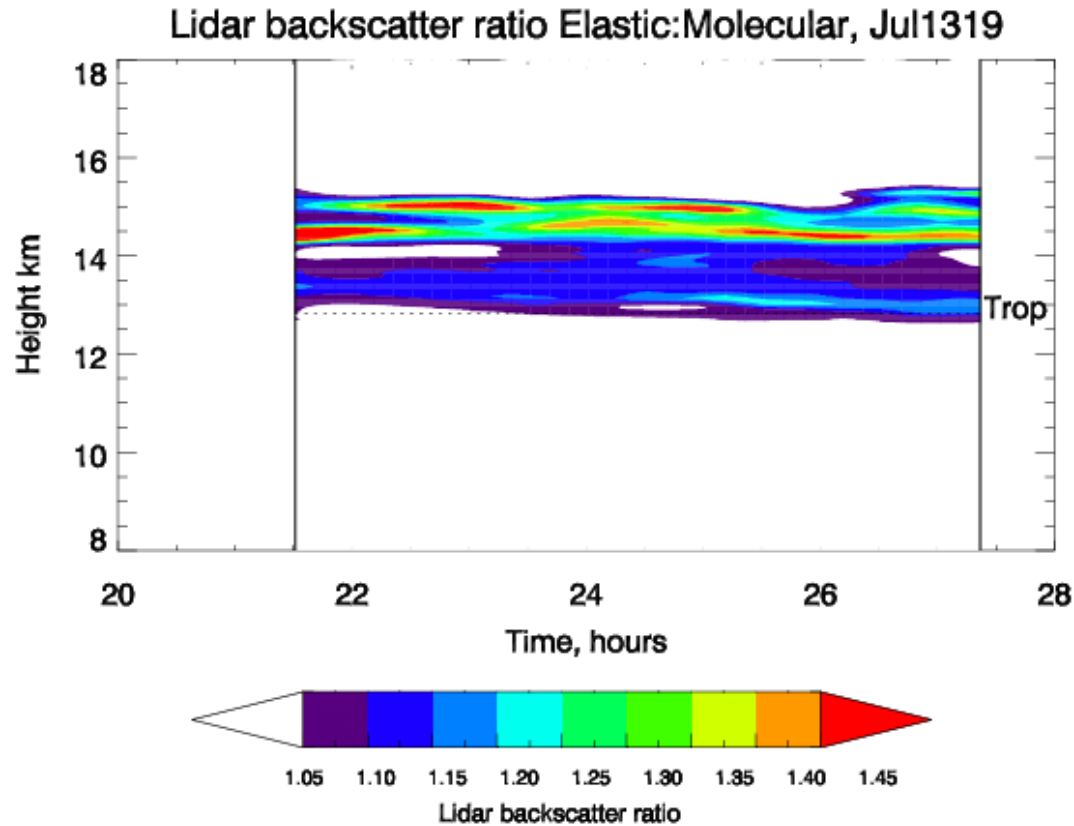
Lidar measurements

- 355 nm laser beam
- Elastic and Raman channels, single polarisation (parallel)
- Elastic channel configured for stratosphere, signals extend to ~30 km
- Raman channel very noisy in stratosphere
- Nearby contemporaneous radiosonde profile used to generate air-only profiles, fitted to lidar profile above the aerosol
- Allowance for particle extinction made using assumed lidar ratio. Value chosen to return backscatter ratio to 1 where there was no aerosol
- For very long runs (> 10 hrs), average of Raman data allowed independent estimate of optical depth

PyroCu convection? Too early for volcano

Lidar backscatter ratio Elastic:Molecular, Jun2719

Lidar backscatter ratio Elastic:Molecular, Jul0219

Lidar backscatter ratio Elastic:Molecular, Jul0319

Note scale change for 3 July plot: layer at 15 km with maximum backscatter ratio 1.3 and OD .006 (lidar ratio = 40)
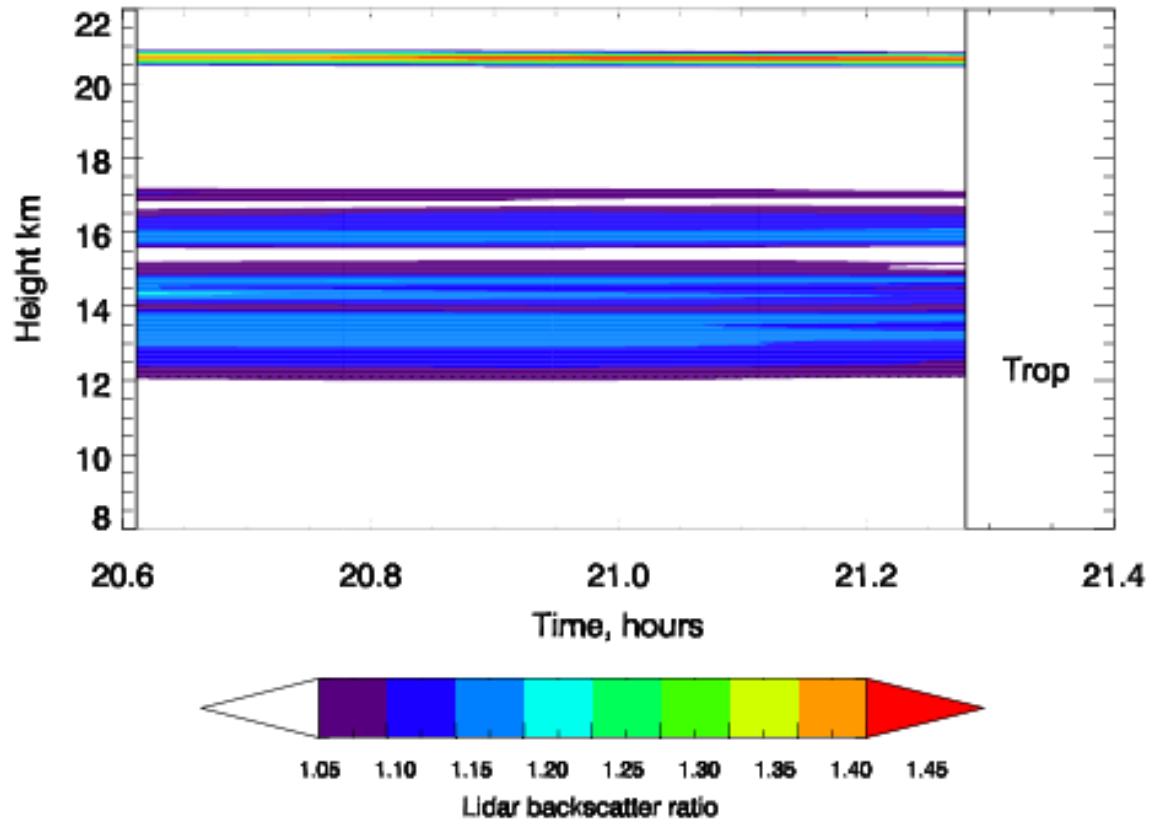
Arrival of main aerosol cloud

Lidar backscatter ratio Elastic:Molecular, Jul1319

Elastic:Molecular normalised ratios, Jul1319

Sonde: Camborne 00Z 14 Jul 2019

Lidar Ratios:
Above 12.0 km: 40
Below 12.0 km: 40
OD above 12.0 km:
0.02770
OD 6.0 - 12.0 km:
0.00457

Tropopause height = 12.6 km

Sonde is the radiosonde used to calculate the molecular backscatter profile

High-altitude aerosol layer
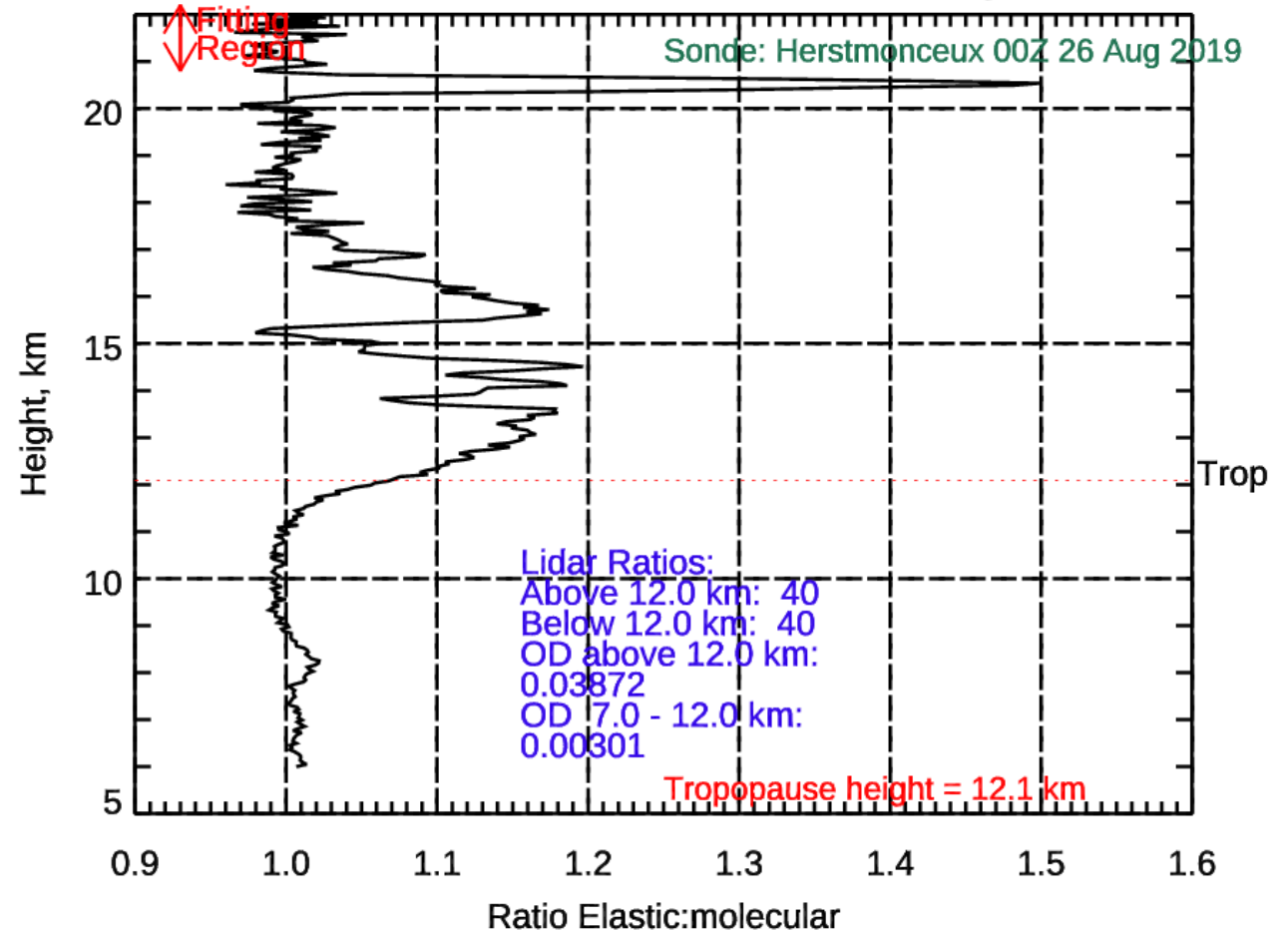
Optical Depth Evolution
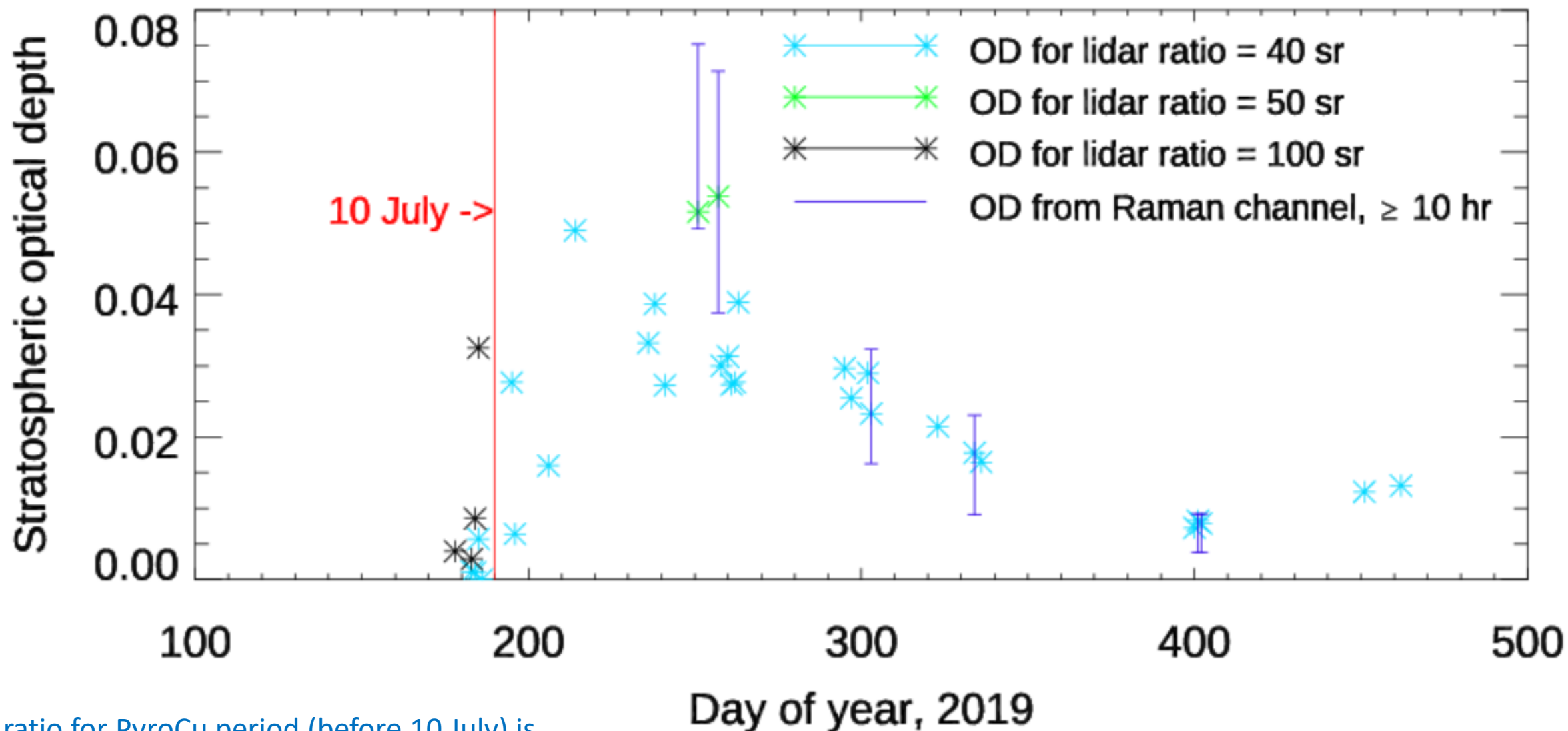
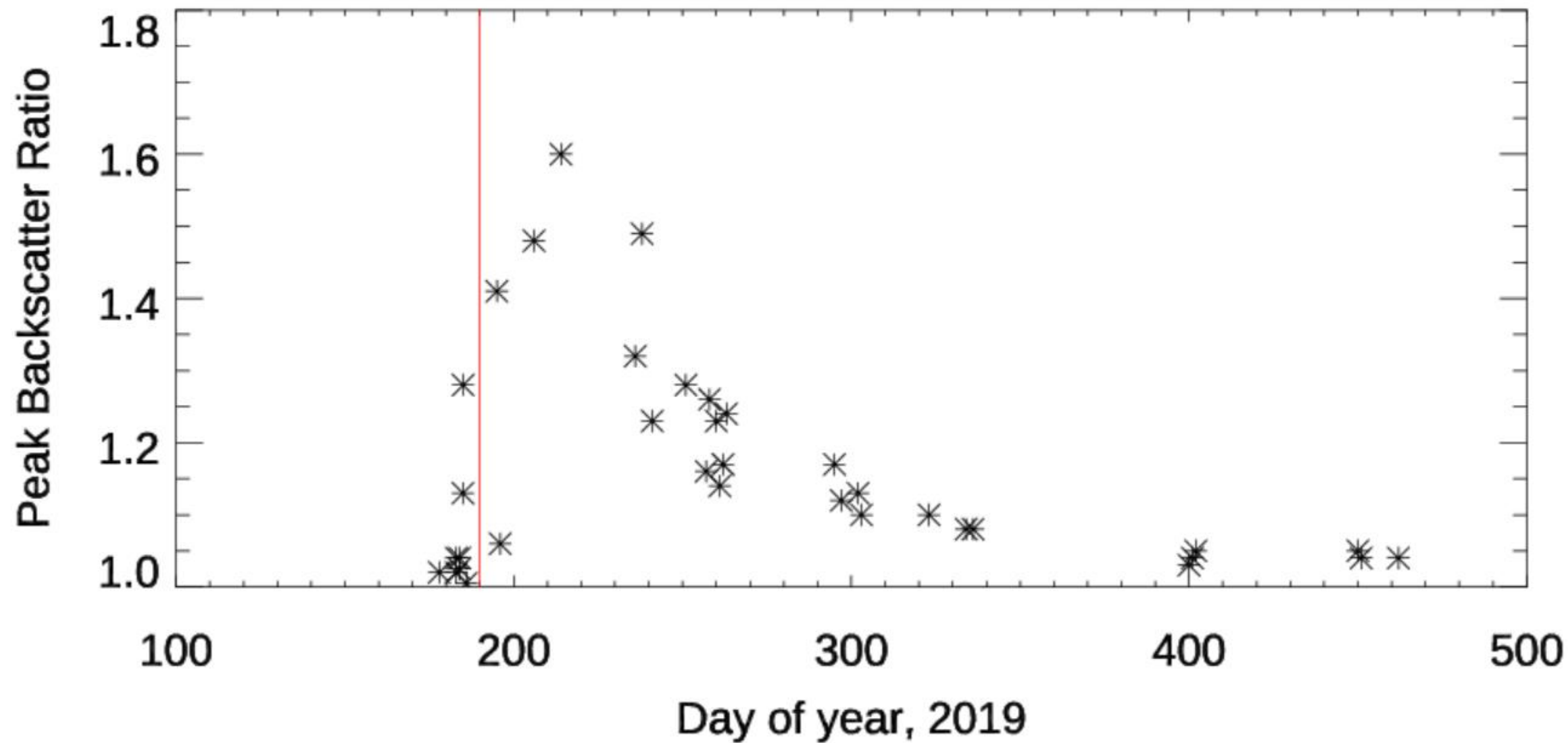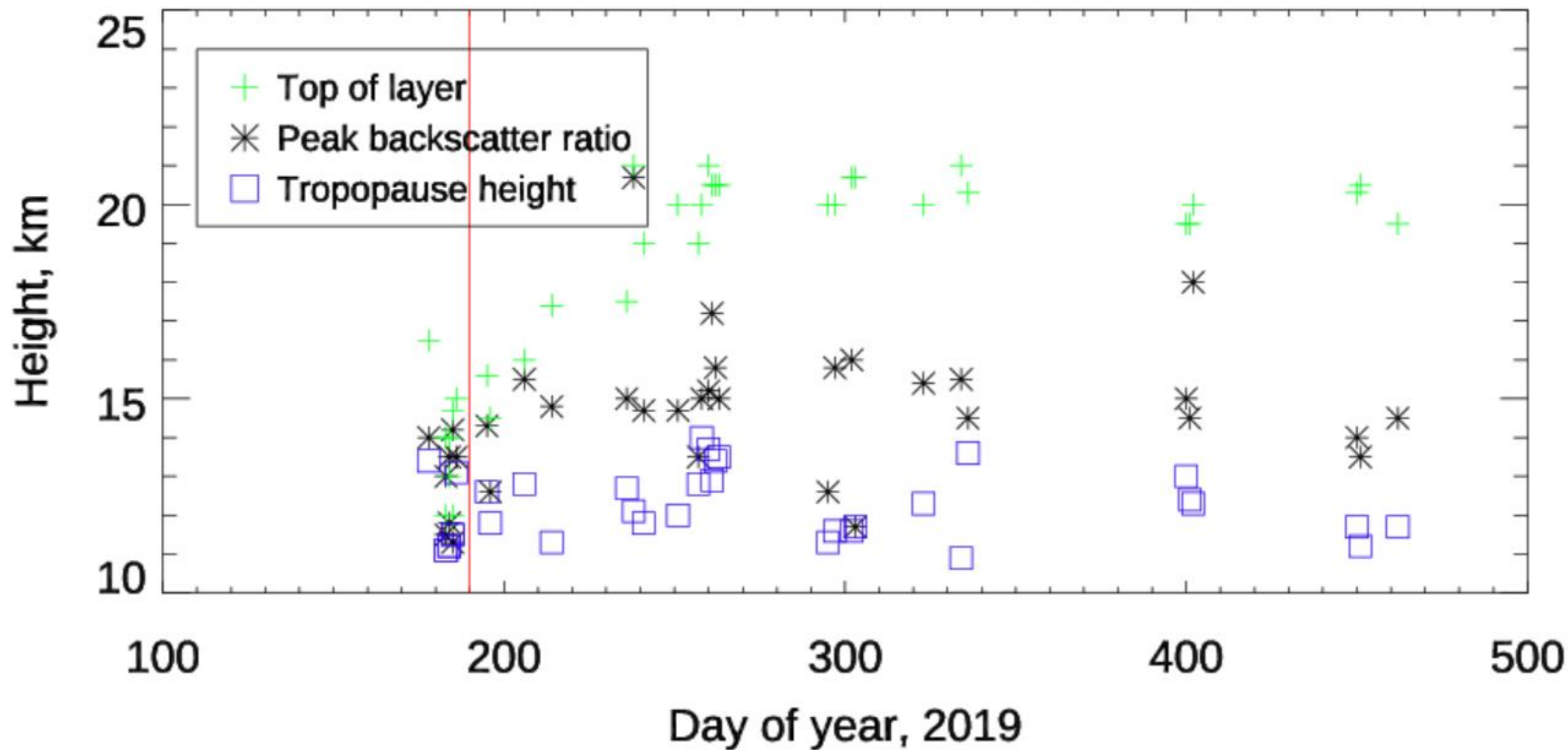Lidar ratio for PyroCu period (before 10 July) is artificially high because particles are not spherical and lidar does not detect ⊥ polarisation component
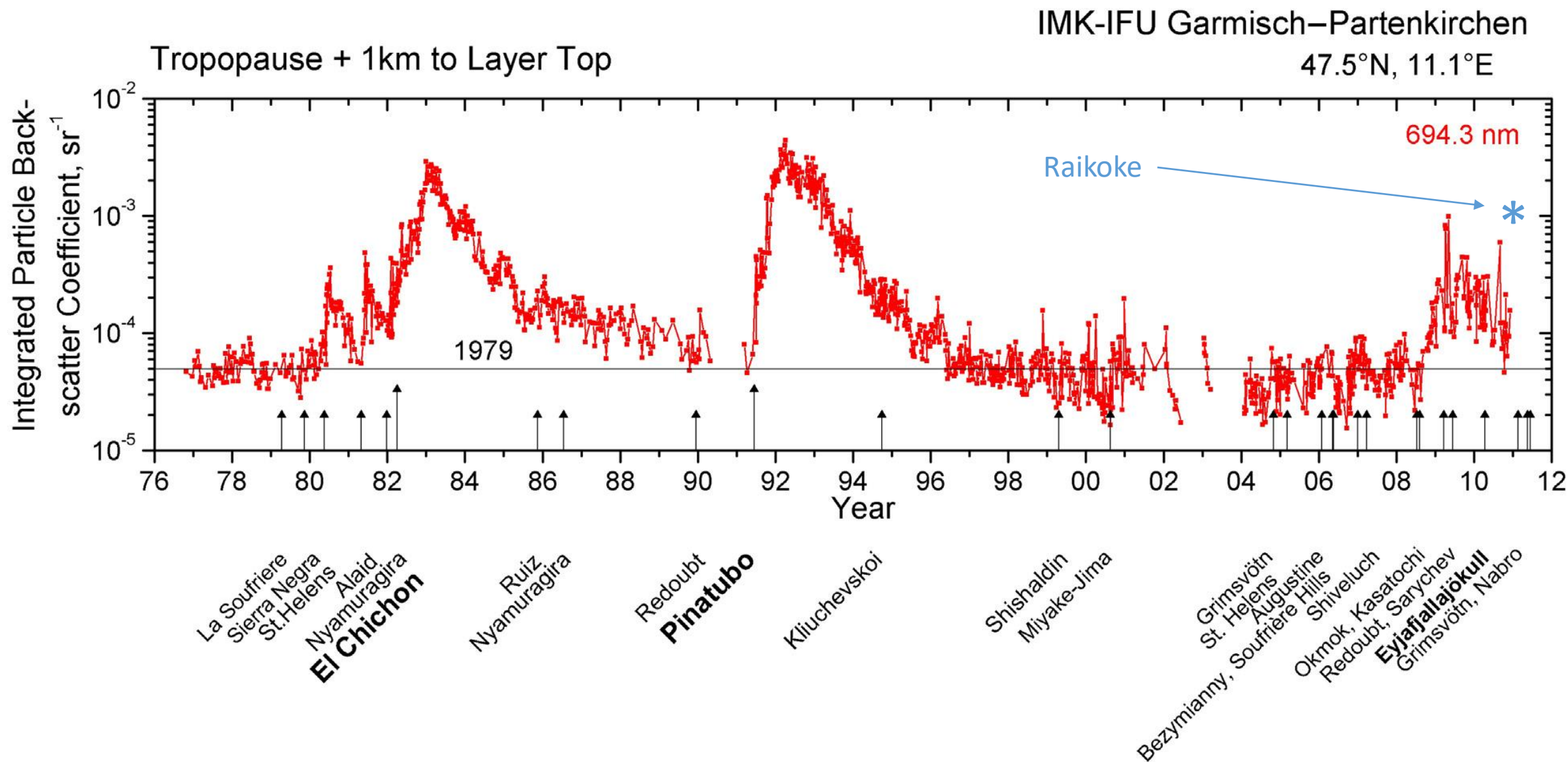
Data before 10 July are too soon for volcanic cloud

Peak Backscatter Ratio

Layer heights

IMK-IFU Garmisch–Partenkirchen
47.5°N, 11.1°E

Tropopause + 1km to Layer Top

Trickl et al Atmos. Chem. Phys., 13, 5205–5225, 2013

Conclusions

- Raikoke the most significant volcano to affect the stratosphere since Pinatubo

- Still aerosol present – measurements continuing but weather has been poor and covid virus now also a problem

- Lidar ratio of 40 consistent with Raman observations