

# Balloon-borne, ground-based and satellite observations of the Hunga Tonga Hunga Ha'apai volcanic plume during the BraVo campaigns

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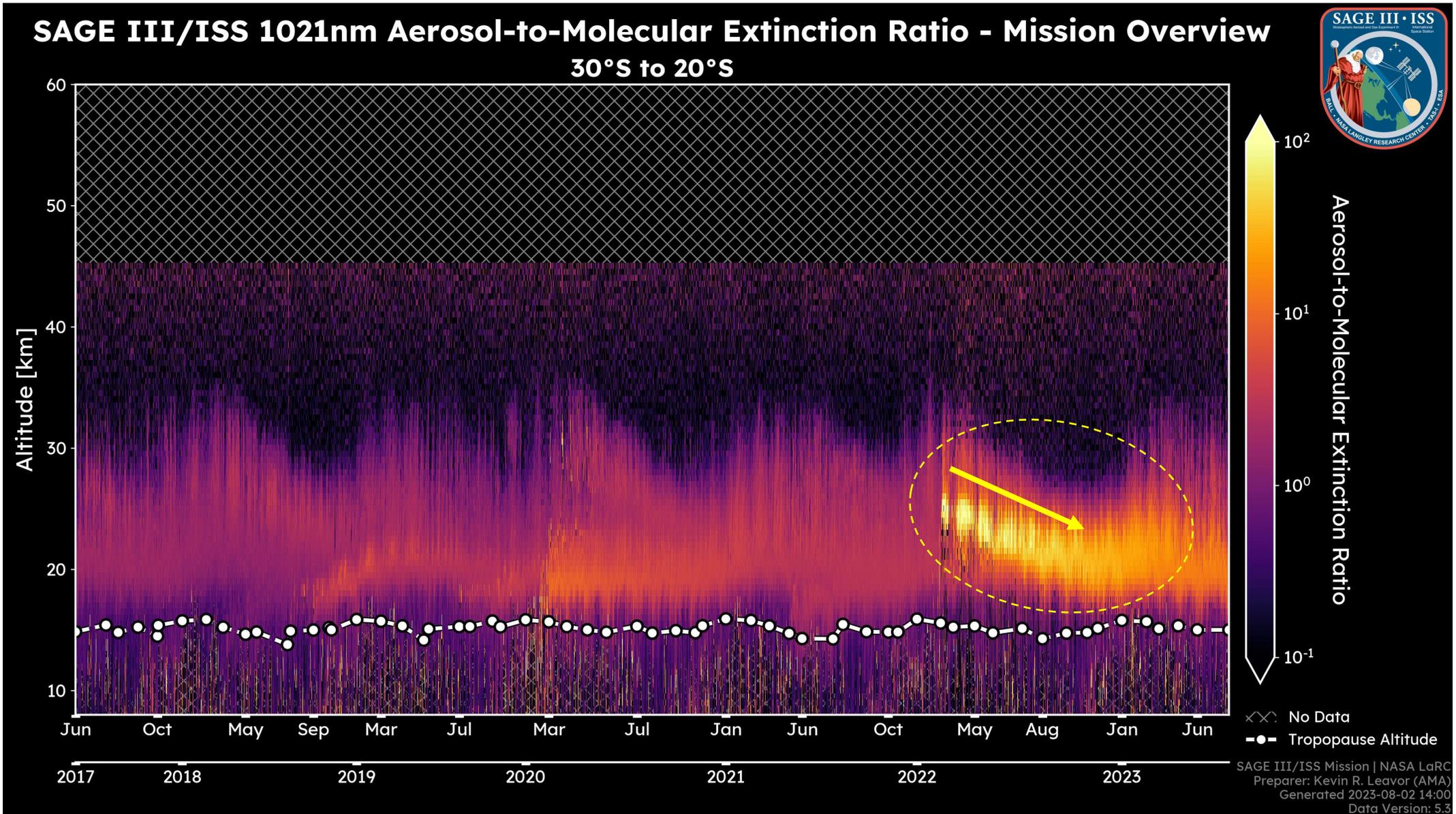
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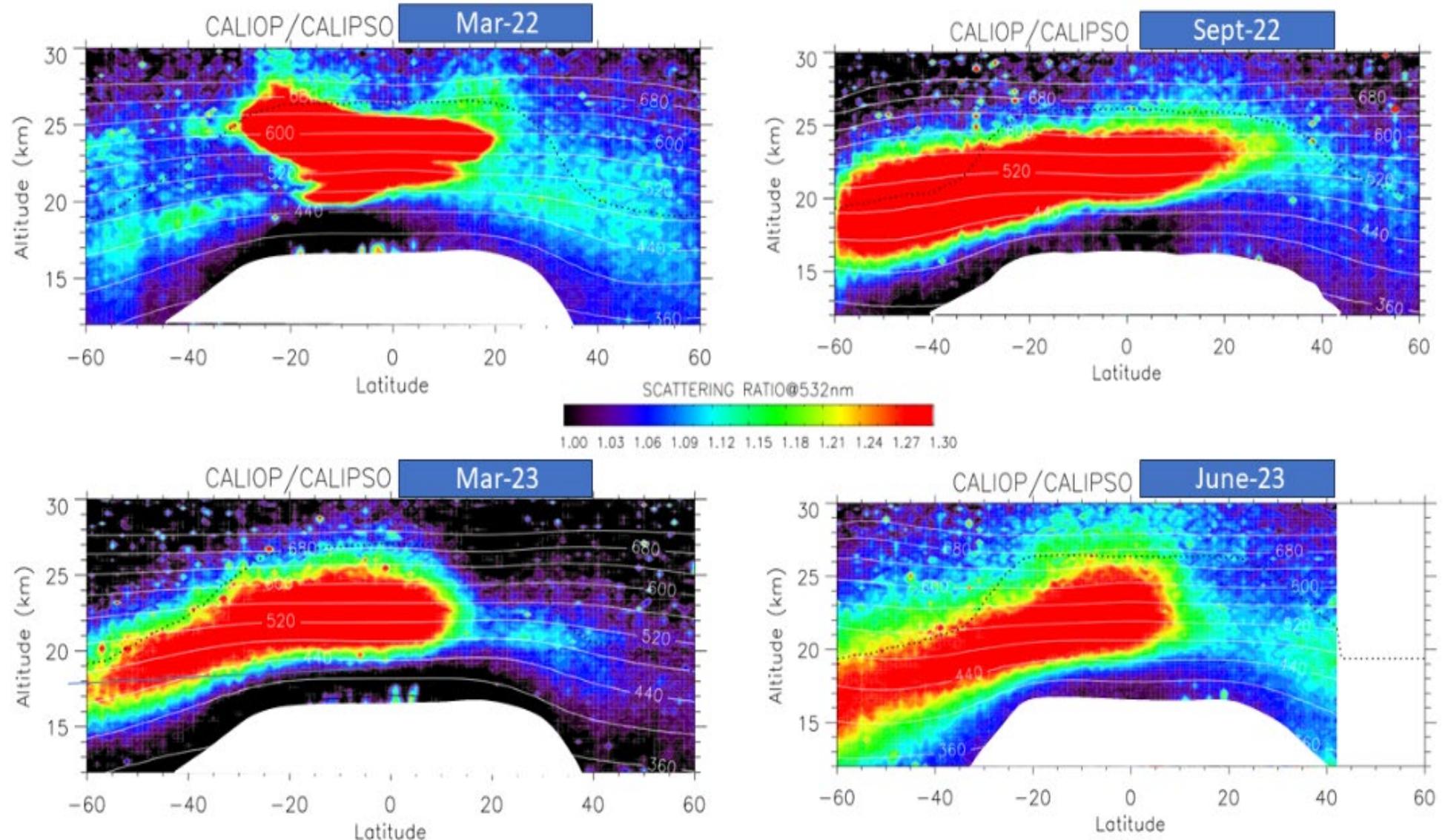
# Outline

- Balloon measurements of the HTHH plume during the BraVo campaigns
- Co-located SAGE III/ISS and balloon measurements during and after one year of the BraVo campaigns
- Sedimentation of large particles from the HTHH plume & comparison with size retrieval
- Chemical composition of the HTHH plume
- Summary & Future directions

# SAGE III/ISS Observations of the HTHH aerosols



# CALIPSO Observations of the HTHH Plume



Scattering ratio derived using method given by [Vernier et al. \(2009\)](#)

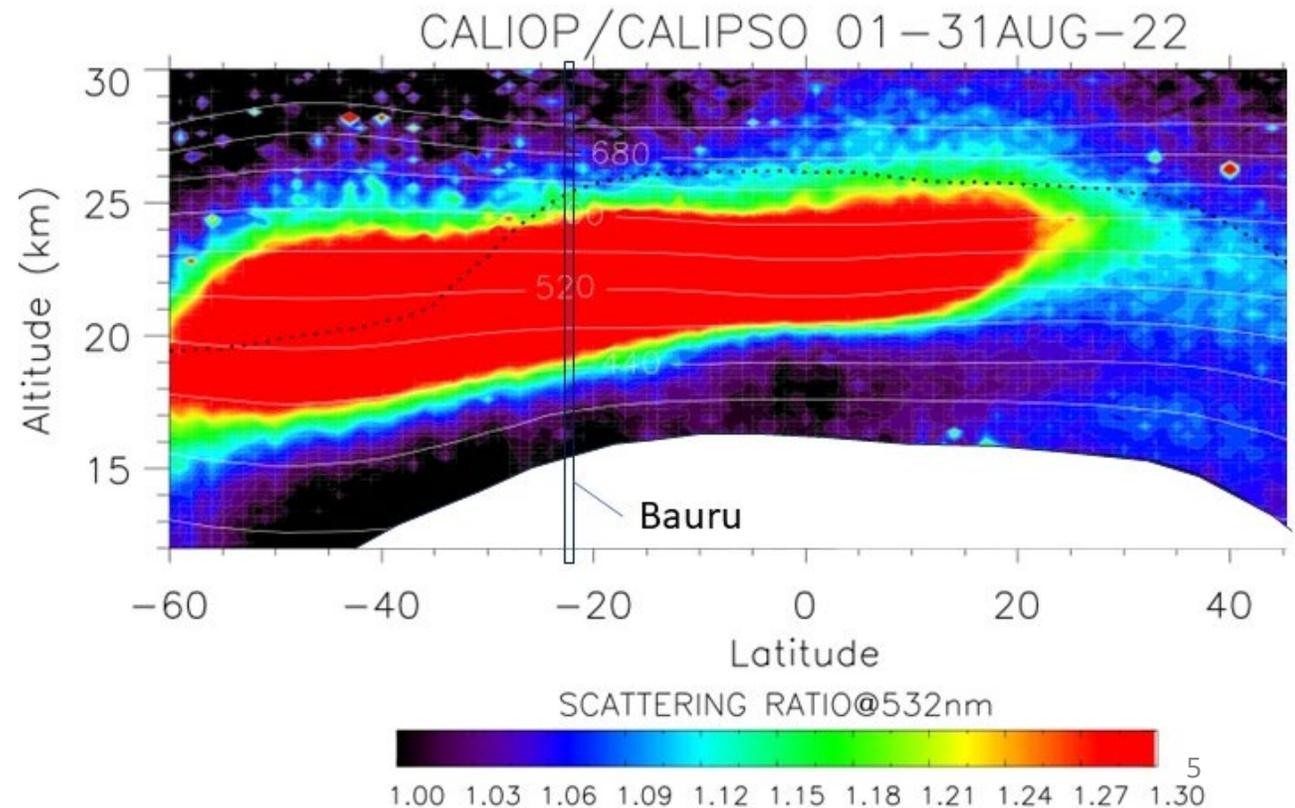
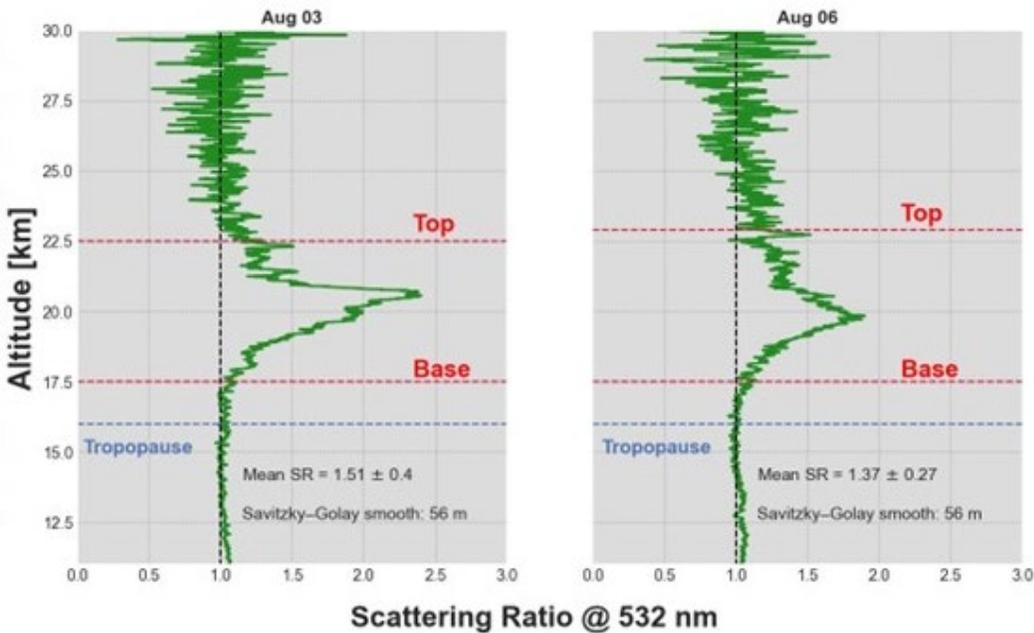
Downwelling of the HTHH plume over the Southern Hemisphere

# Brazil Volcano Experiment- BraVo Campaign



- Ground-based lidar observations from Bauru and Dao Paulo.
- Balloon observations between May, and November 2022.
- Extensive campaigns in May, & August 2022.

Ground-based lidar Bauru



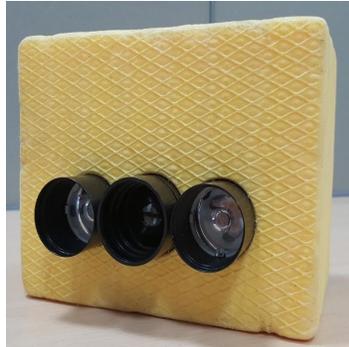
# Balloon-borne Instruments used during the BraVo Campaigns

## iMet-1 Radiosonde



- T, P, RH, u, & v
- GPS location

## Compact Optical Backscatter Aerosol Detector (COBALD)



- A two-wavelength backscatter sonde
- Backscatter ratio (BSR) at 455 nm (blue) & 940 nm (IR) wavelengths.
- Color Ratio =  $BSR_{940}/BSR_{455}$

## En-Sci ECC Ozone sonde (NOAA GML)



- Potassium iodide based ECC.
- Ozone mixing ratio profile.

## Cryogenic Frost-point Hygrometer



- Based on chilled mirror principle
- Frost-point temperature
- Water vapor mixing ratio &  $RH_{ice}$

## iMet-4 Radiosonde



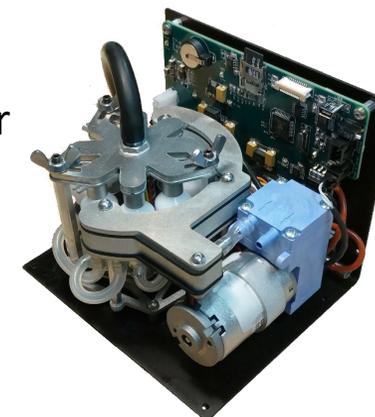
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## Particle Plus 9301 OEM Series Particle Counter (NPOPC)

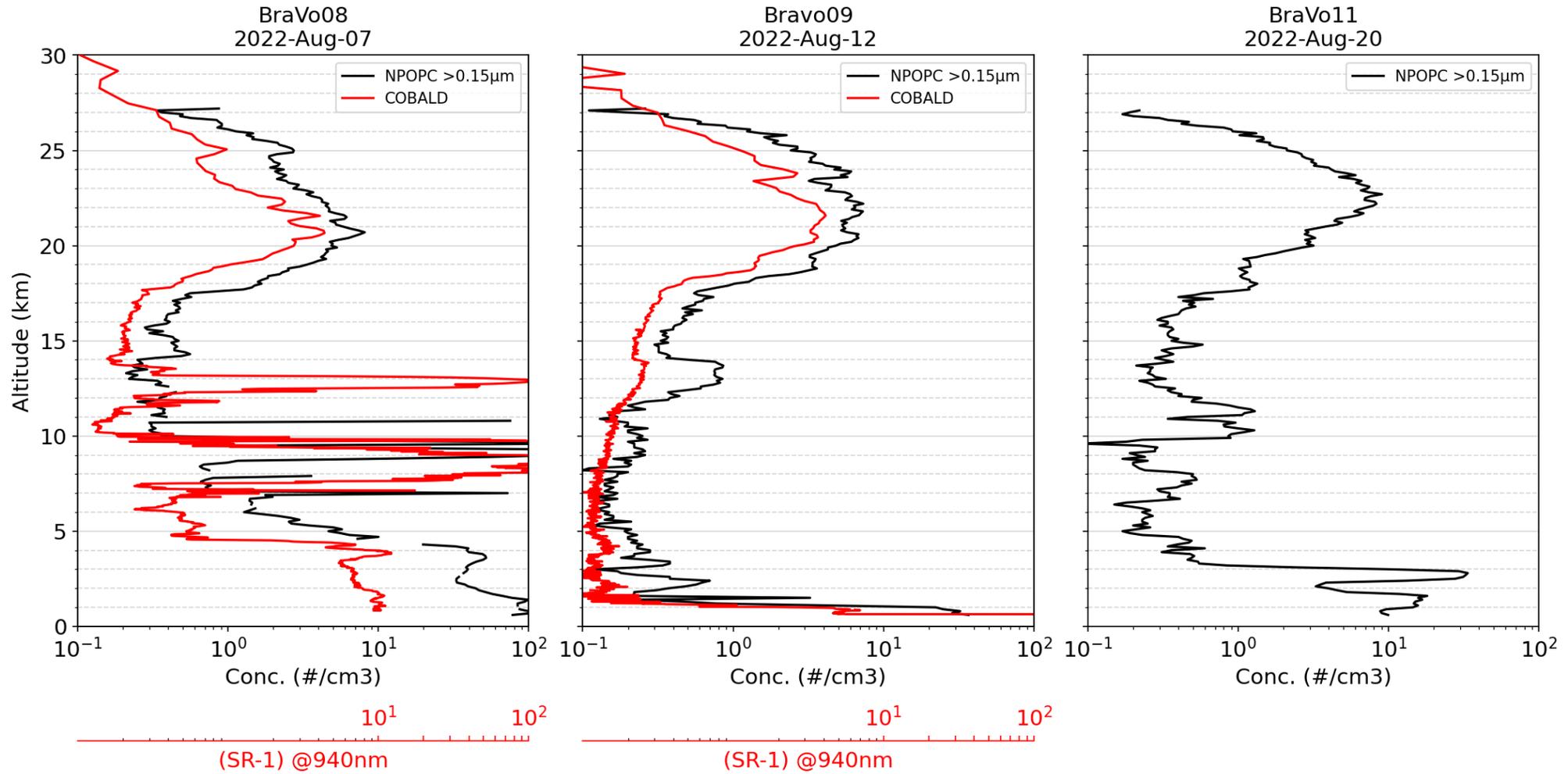
- Laser diode based optical particle counter
- Particle counts at 30 size channels every 2 seconds
- Size range: 0.3 -10  $\mu\text{m}$  (diameter)
- Flow: 2.83 LPM (0.1 CFM)

## Brechtel Filter Sampler



- Eight filters or TEM grids with software actuated sampling.
- Samples collected on filters used for ion-chromatography

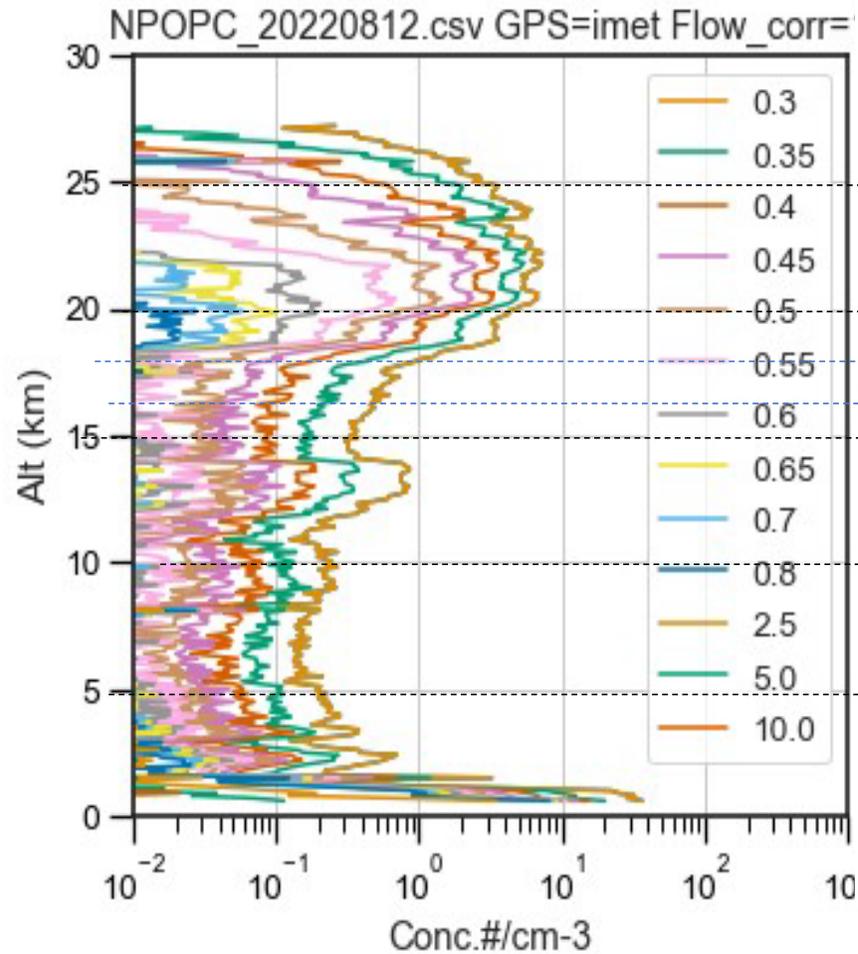
# Qualitative Comparison between POPC and COBALD during the BraVo 2022 campaign



# Co-located SAGE III/ISS and Balloon measurements of Aerosols during BraVo

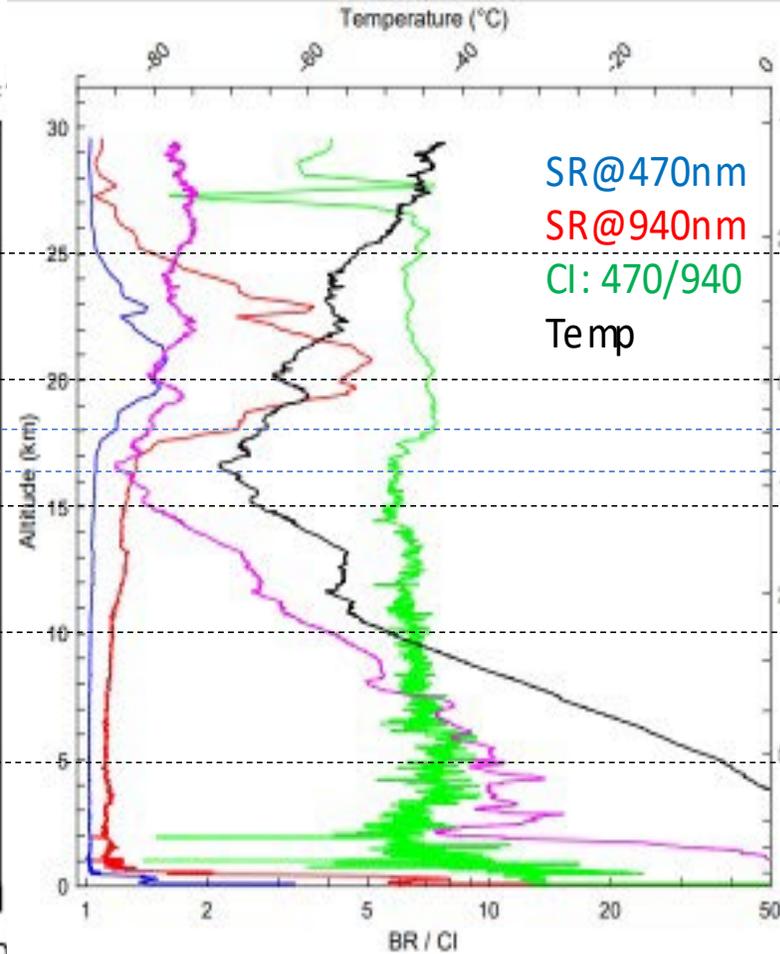
(a)

POPC 08122022



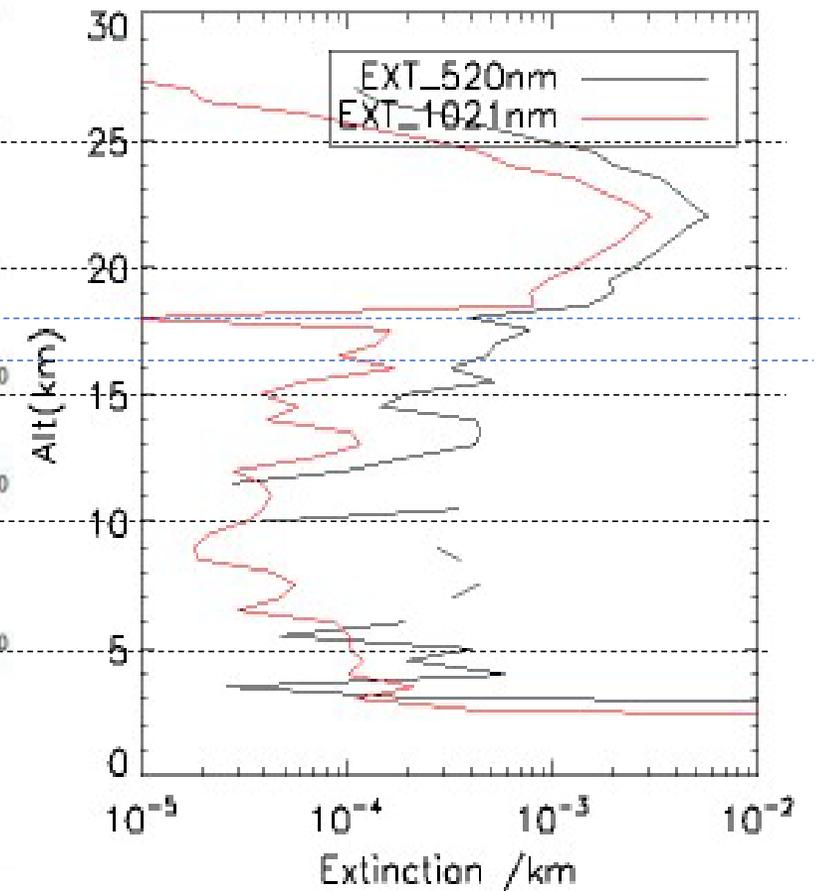
(b)

COBALD 08122022

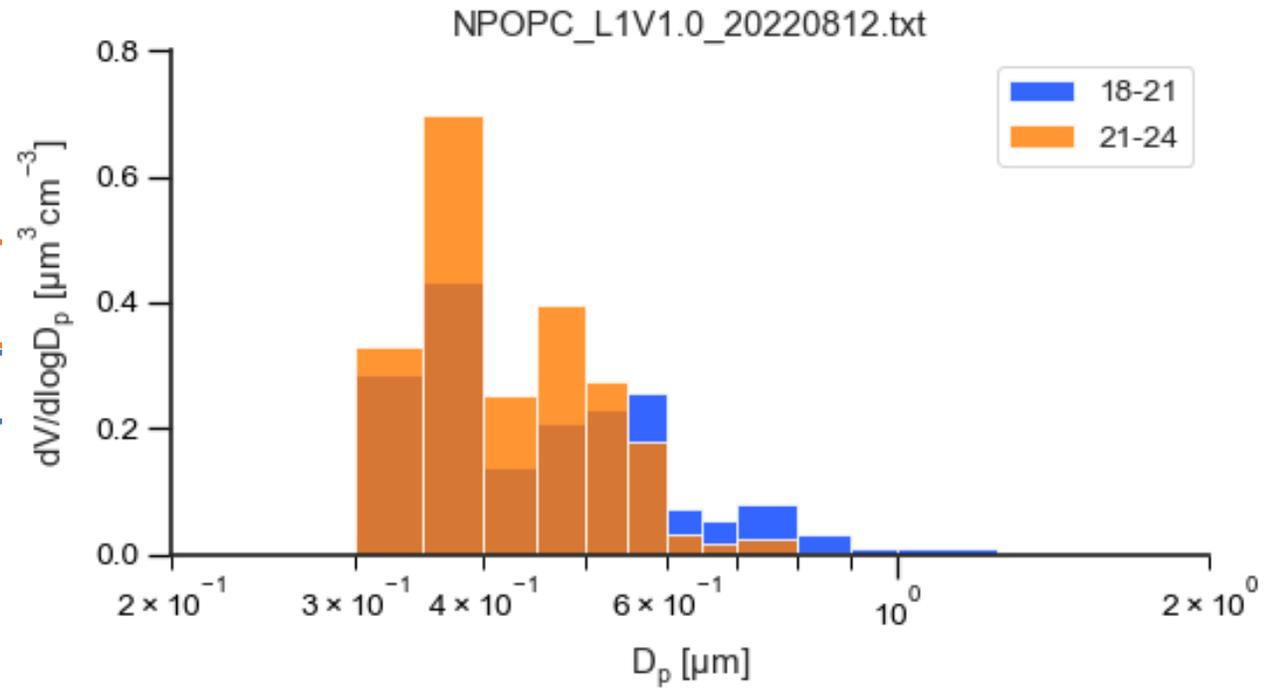
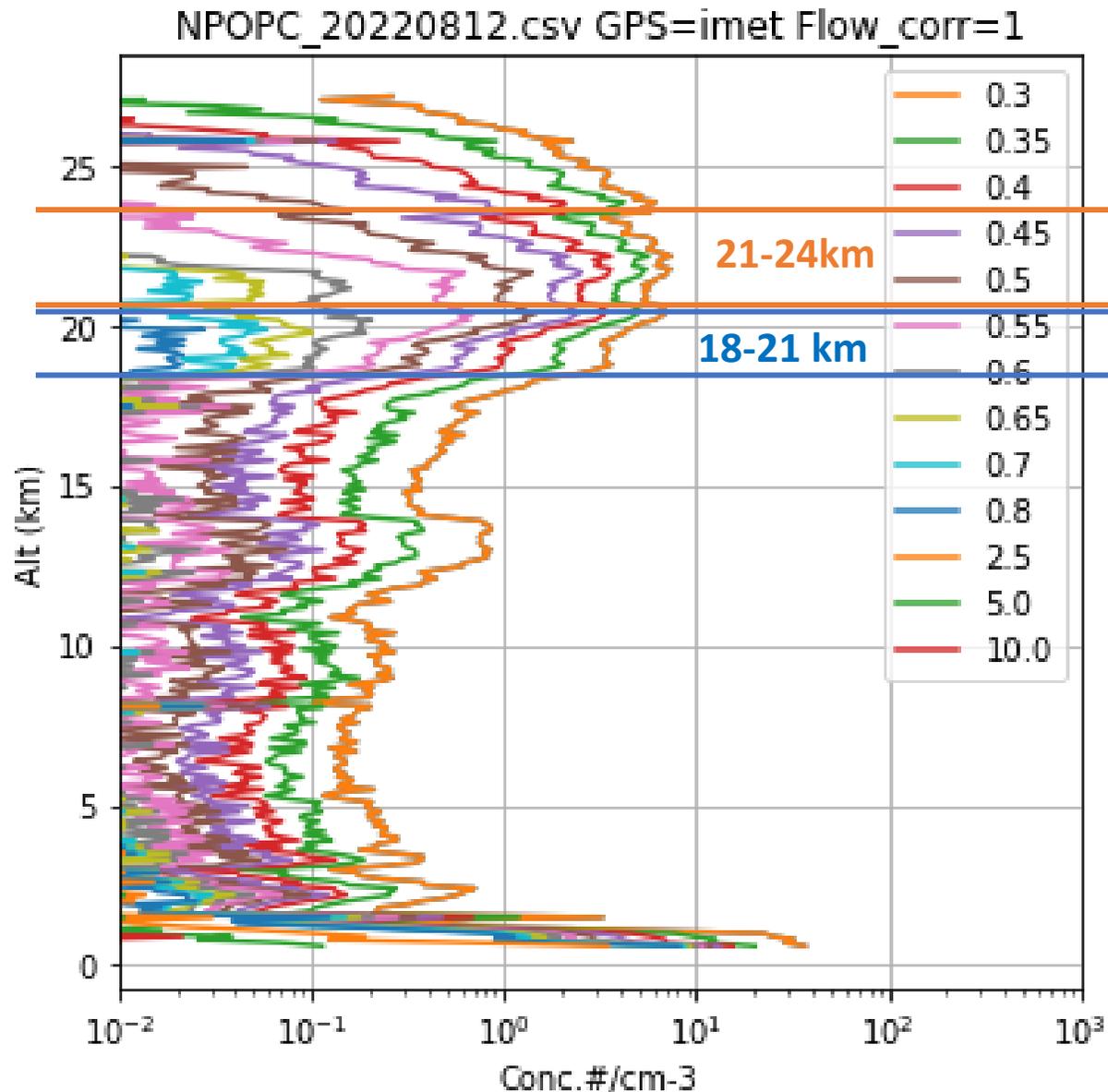


(c)

SAGE III/ISS 08122022

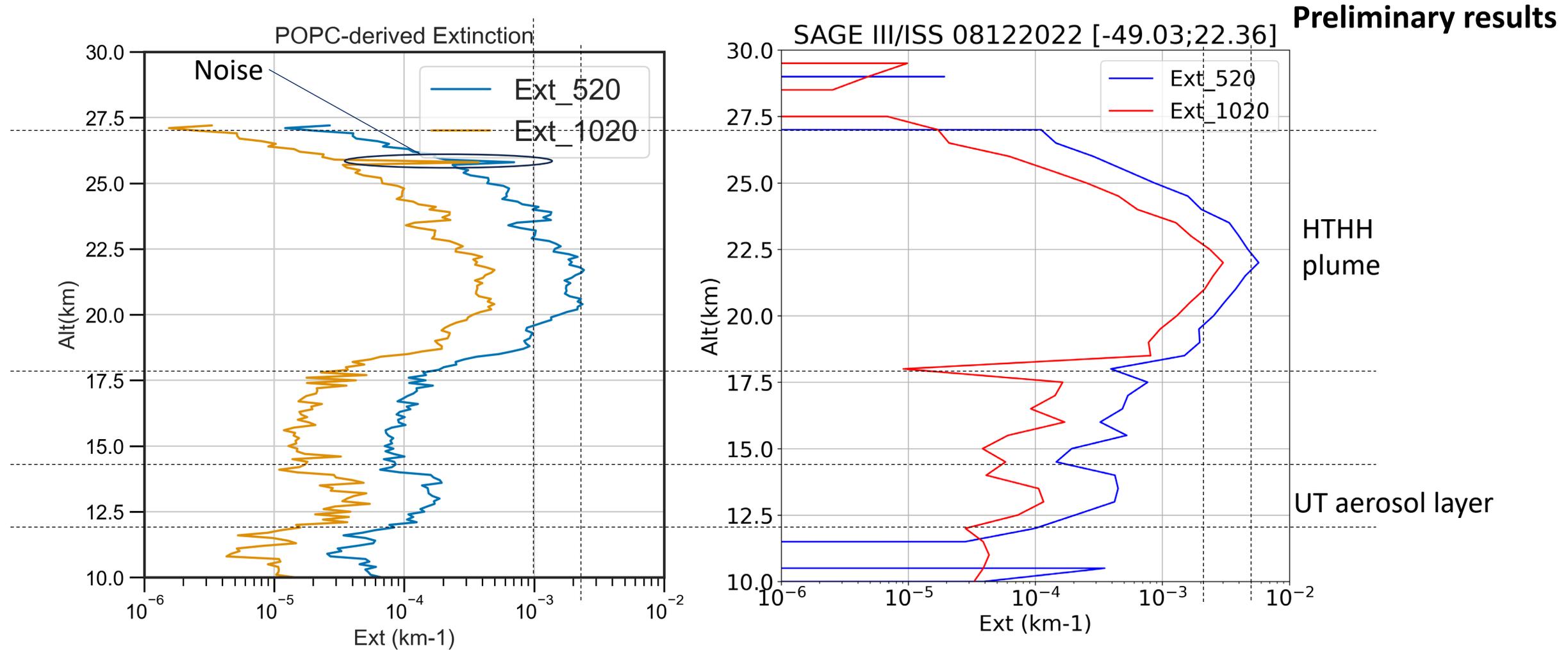


# Size distribution Altitude-dependence



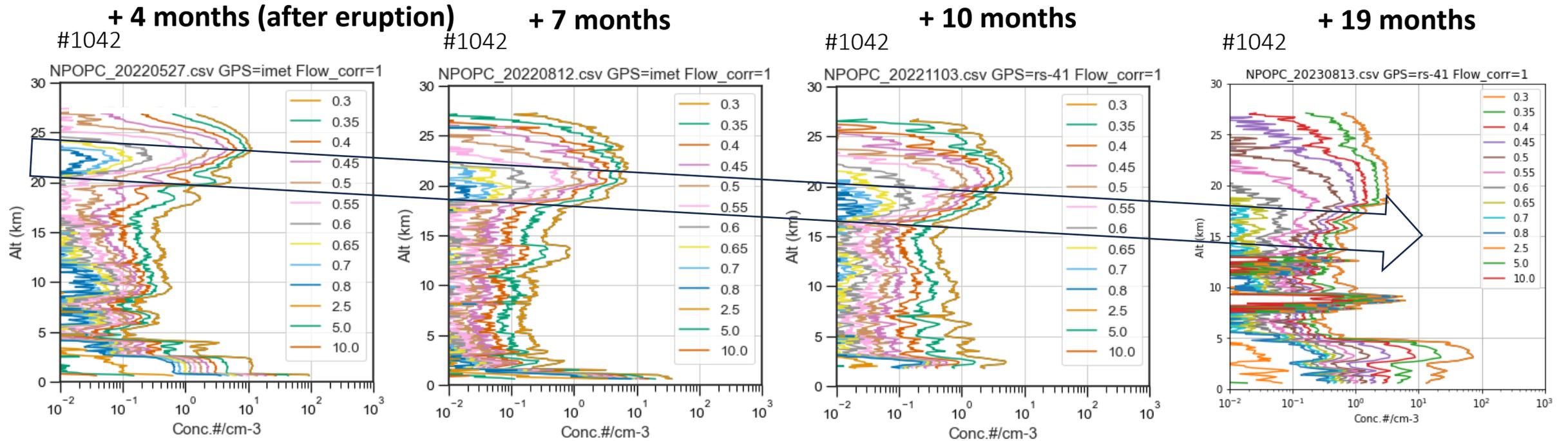
- Volume distribution show a mode of larger particles at the bottom of the HTHH plume
- 3 different modes for the bottom plume near 0.35-0.4 μm; 0.5-0.6 μm and 0.7-0.8 μm
- Differ from simplistic view of a unimodal distribution
- Could indicate the presence of different types of aerosol

# Aerosol Extinction from Co-located SAGE III/ISS and Balloon measurements for HTHH plume



- POPC and SAGE III see qualitatively the same atmospheric layers (HTHH, UT aerosol layer)
- POPC derived extinction using refractive Index of sulfate aerosol (Knepp et al., 2022)
- SAGE III/ISS extinction larger by a factor 2 [Mie coefficient calculated using size distribution rather than fit]

# Sedimentation of Large particles from the HTHH plume



- HTHH aerosol size information derived from POPC during the first 19 months after the eruption from Brazil
- Large particles [ $d > 0.7-0.8 \mu\text{m}$ ] settling due to sedimentation
- Could the larger particle be made of something else than sulfate ?

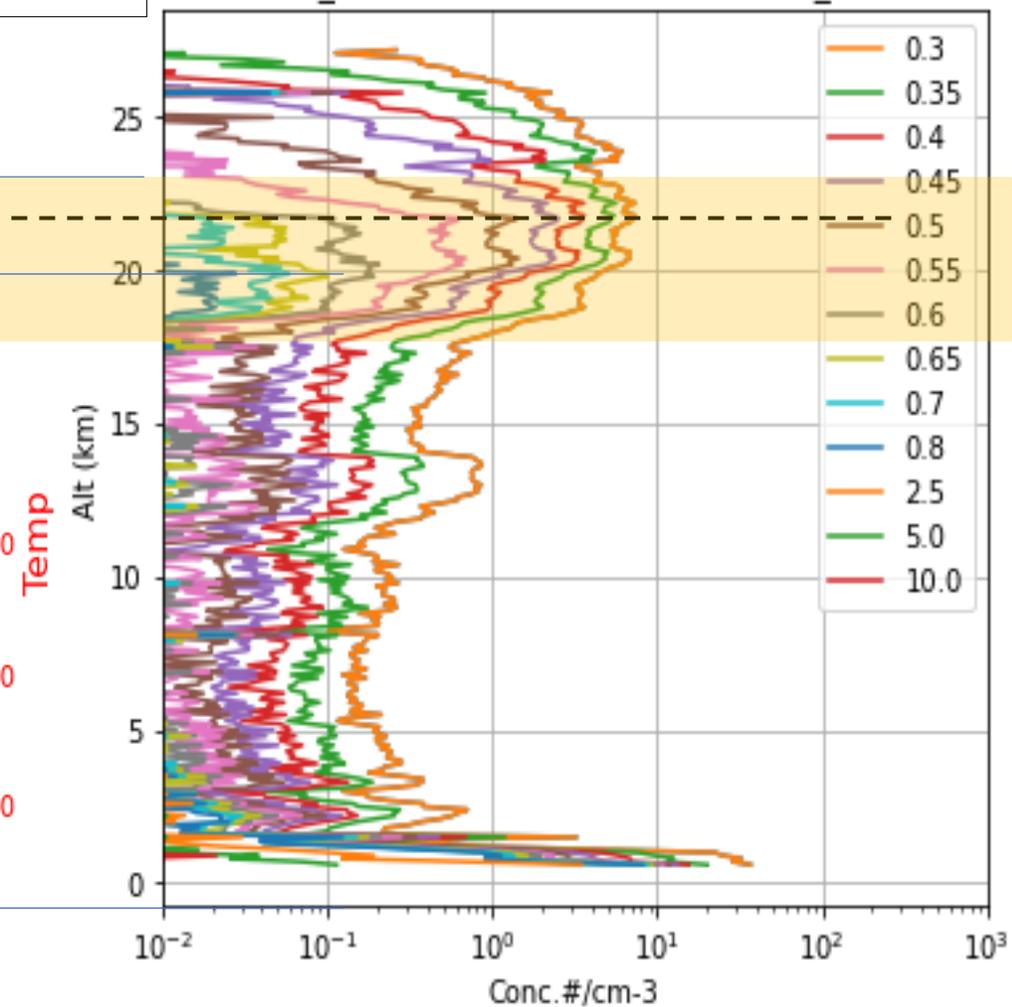
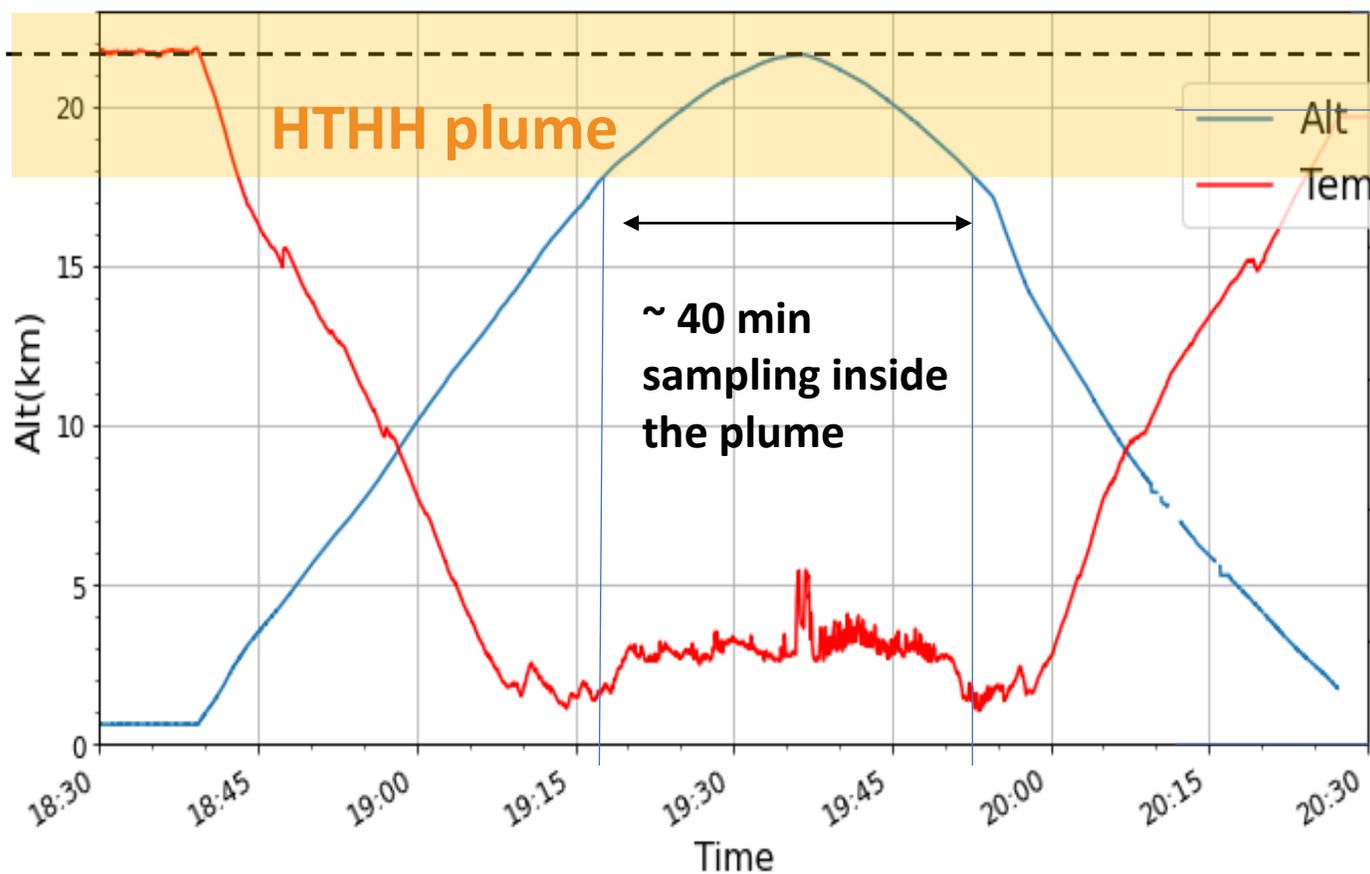


The balloon-controlled system allowed reaching 40 min of sampling inside the HTHH plume

## Chemical Composition of the HTHH plume

NPOPC\_20220812.csv GPS=imet Flow\_corr=1

### Balloon flight on 08/16 with the Aerosol Sampler



# Sample Extraction and Ion Chromatography Analysis



Filters were unloaded in a Laminar Air Flow & preserved in dry ice until analysis using Pre-sterilized instruments

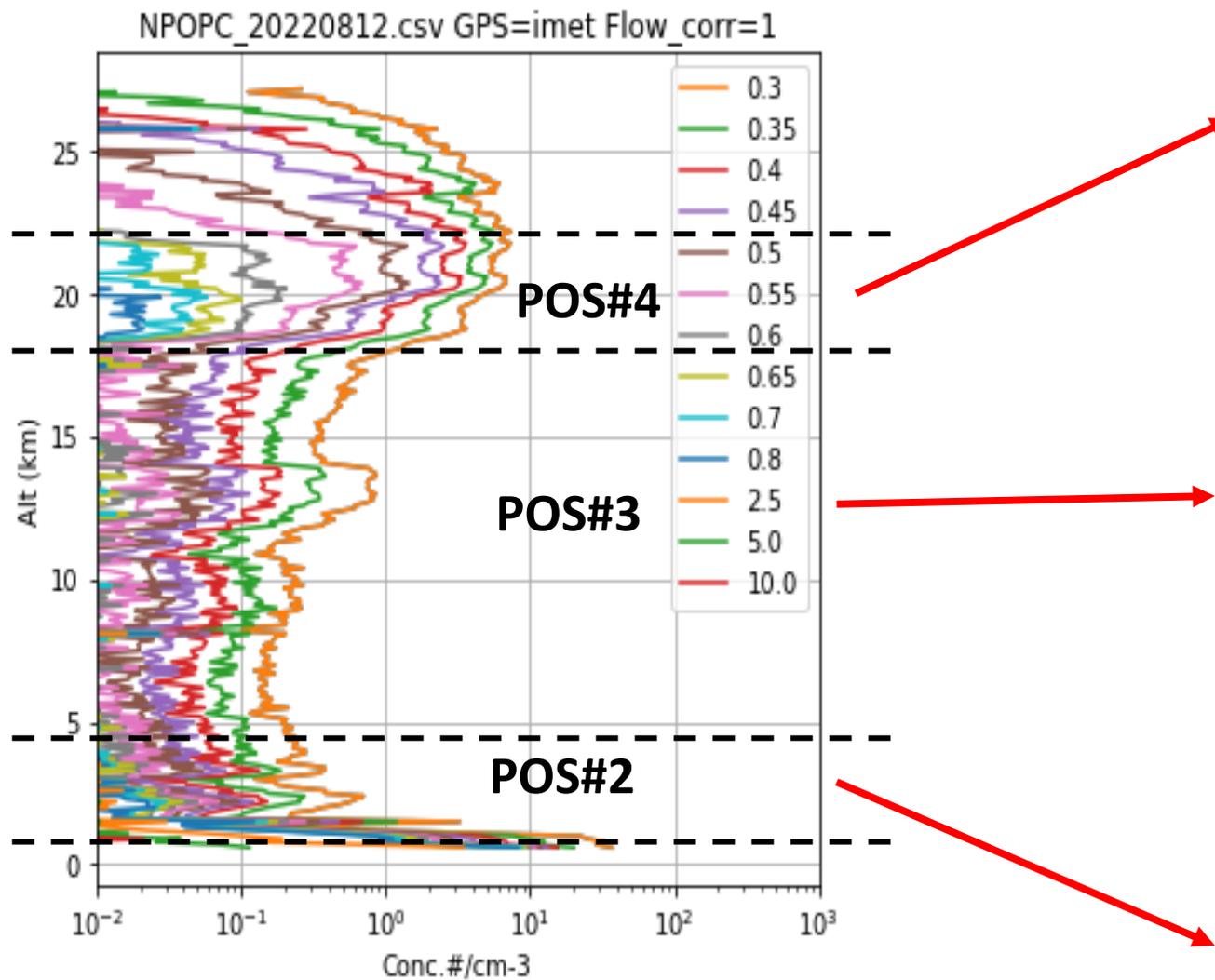


Aerosol extraction & Calibration of the IC Unit using ultra-pure Water in preparation for analysis.

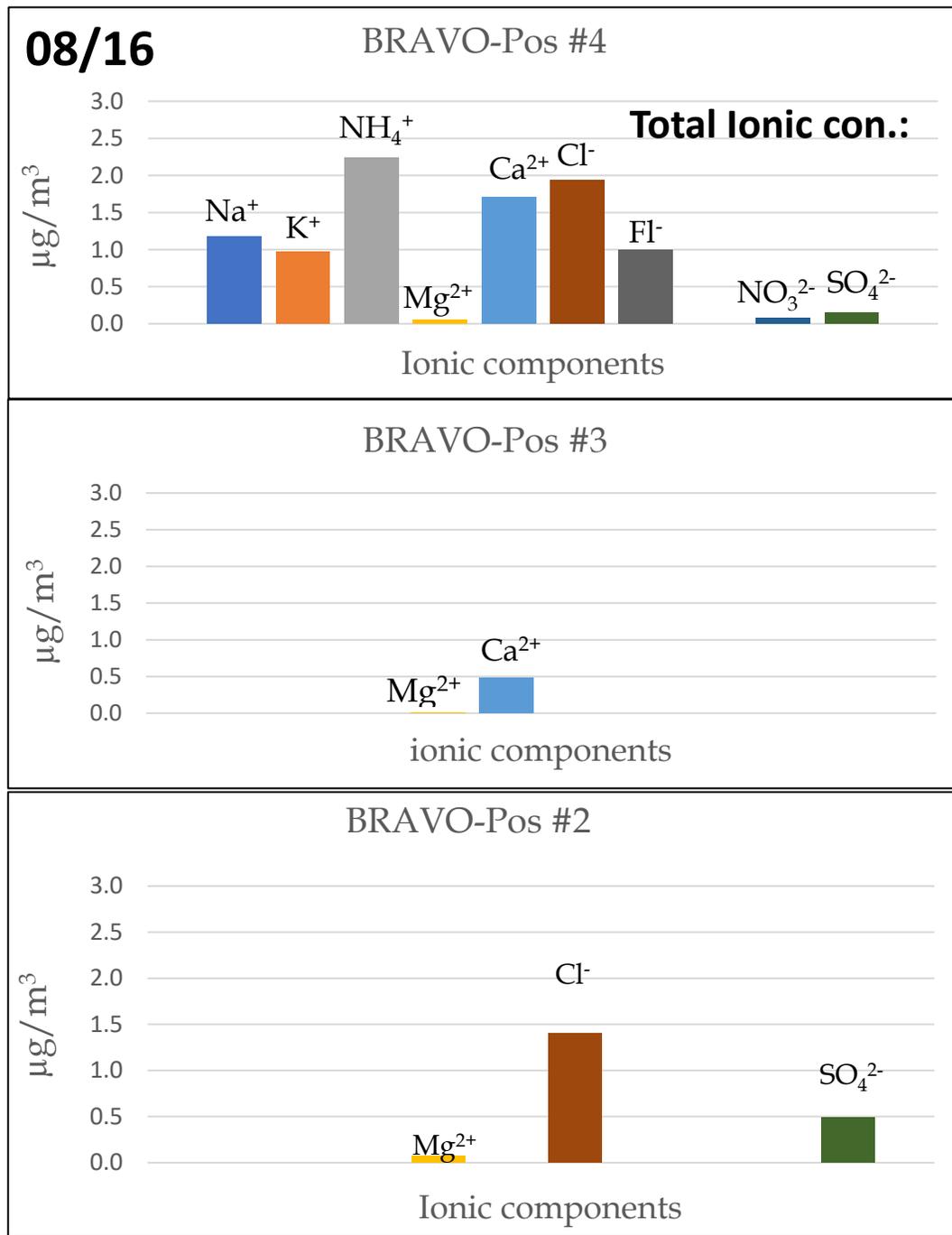


Reagent-free IC System (Detection limit-0.01  $\mu\text{g/L}$ )

# Results from POPC and Ion Chromatography



Assuming aerosol concentration profile obtained on 08/12 for sampler flight 08/16 and mass density of sea salt : **Expected aerosol collected : 3.4  $\mu\text{g}/\text{m}^3$**



# Summary and Future Directions

## Summary:

- Balloon-borne measurements of the HTHH plume were conducted during the Brazil Volcano (BraVo) field campaign after four months of the HTHH eruption.
- BraVo campaign provided physical and chemical characteristics of the HTHH plume.
- Both aerosols and water vapor measurements inside the HTHH plume were obtained and validated with co-located SAGE III/ISS observations.
- Larger particles in the HTHH plume were seen to sediment with time
- Controlled balloon flight allowed to sample the HTHH plume for ~40 minutes.
- Ion chromatography of the collected HTHH sample confirmed presence of sea salts confirming the submarine source of the HTHH plume.

## Future Directions:

- Plan to continue balloon measurements of the HTHH plume from Brazil with co-located SAGE III/ISS measurements.
- Impact of downwelling HTHH plume on cirrus cloud properties.

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Thank you!