Portable Optical Particle Spectrometer and the the Value to Stratospheric Aerosol Research

eGMAC

Monday, July 20, 2020

Elizabeth (Lizzy) Asher[1,2], Troy Thornberry[1,2], RuShan Gao[2], Emrys Hall[1,3], Allen Jordan[1,3], Dale Hurst[1,3], David Fahey[2]

[1] Cooperative Institute for Research in Environmental Sciences, University of Colorado Boulder

[2] NOAA Chemical Sciences Laboratory, Boulder

[3] NOAA Global Monitoring Laboratory, Boulder

CIRES

Goal to increase observations of stratospheric aerosol and albedo

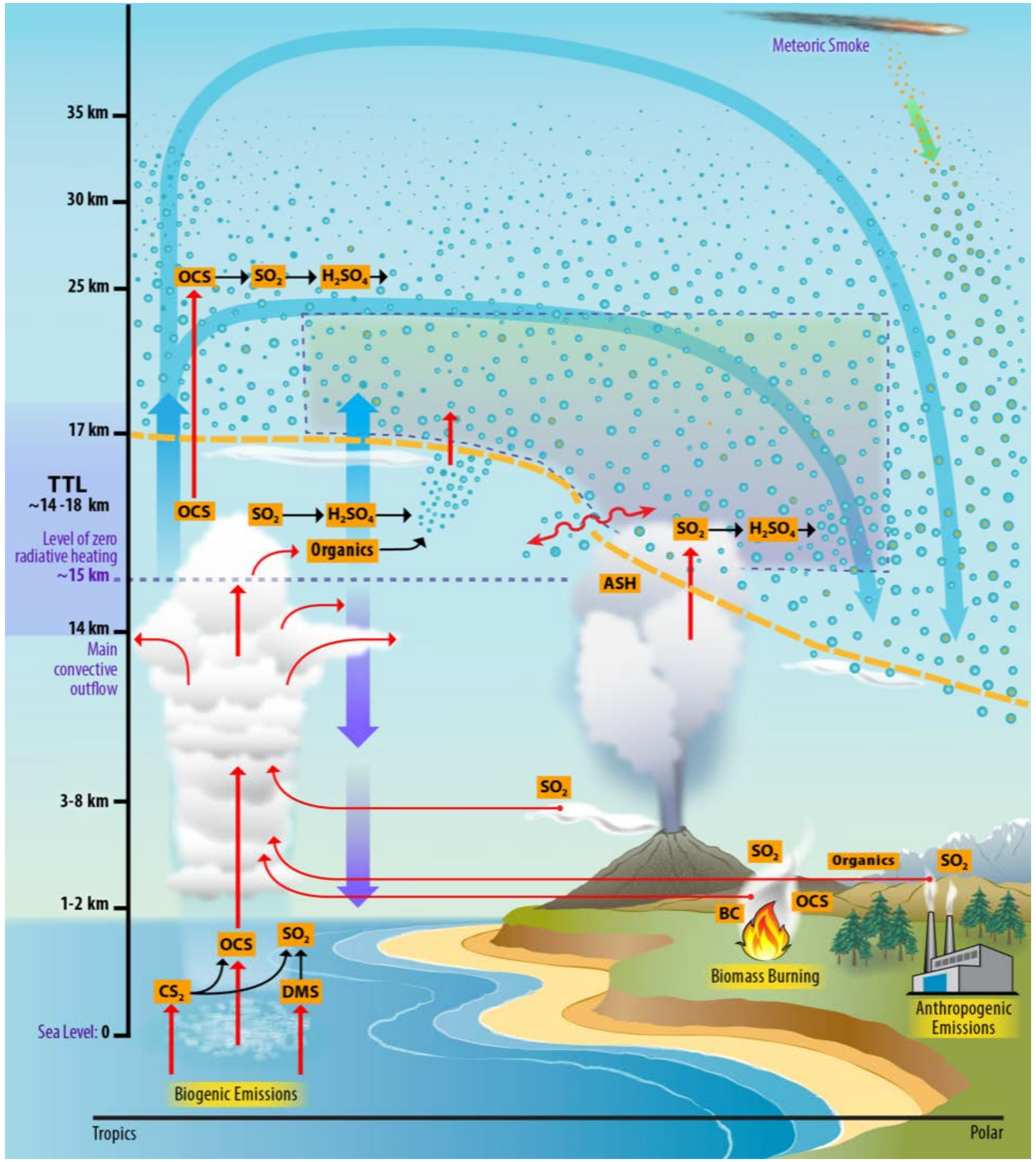


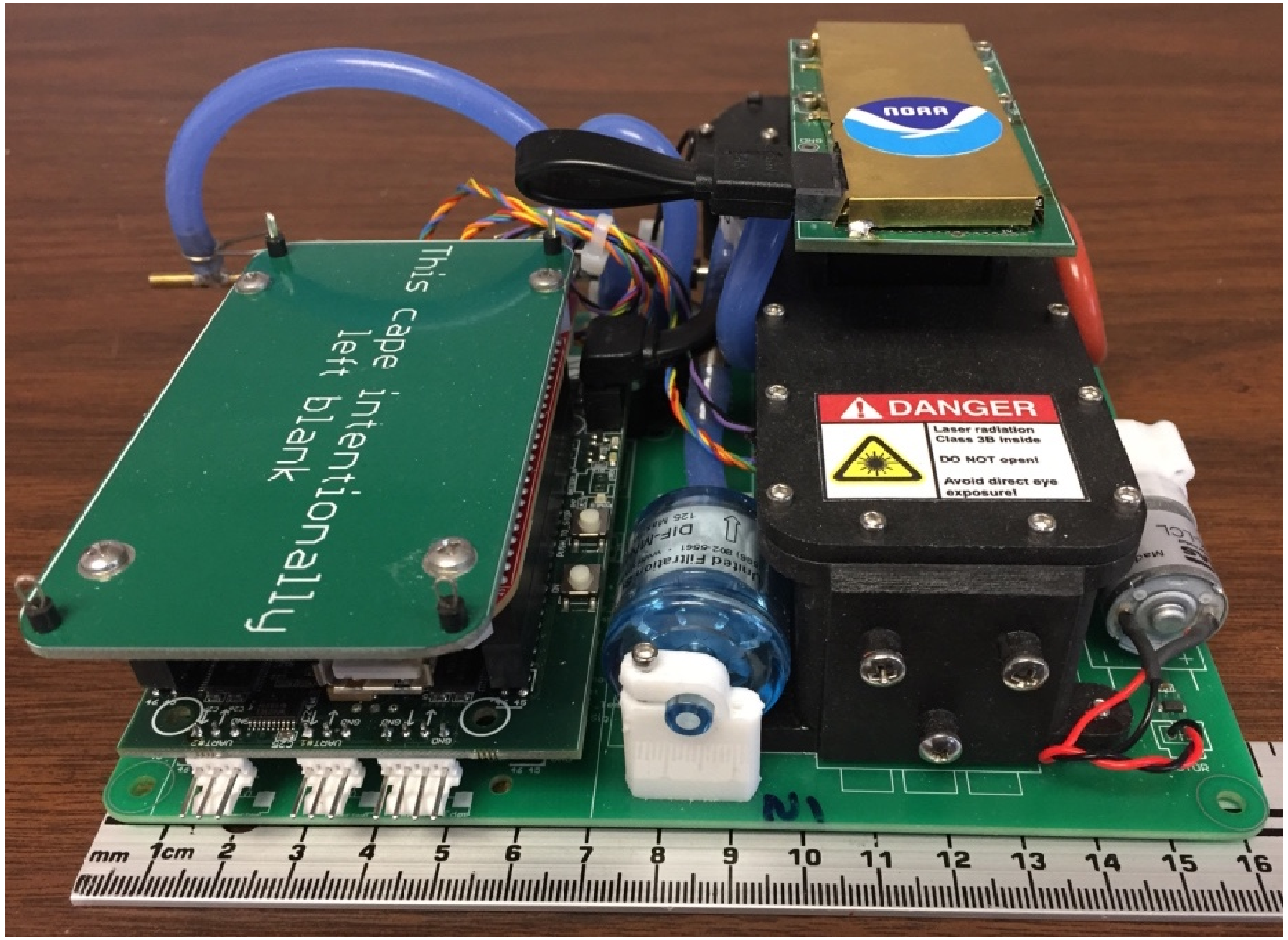
Figure adapted from Kremser et al., *Rev. Geophys.*, 2016.

- stratospheric aerosol is predominantly made up of sulfate, with contributions from organics and biomass burning aerosol**s**

- sulfate aerosols are naturally produced from from sulfur gases (e.g. SO_2 , OCS) lofted into the upper troposphere through large convective systems in the tropics or emitted from volcanoes

- *our goal is to explore and monitor stratospheric aerosol size distributions under b conditions, as well following natural injections of sulfate from explosive volcanic eruptions and very large fires*

Printed Optical Particle Spectrometer



POPS specifications:

- Single-particle detection
- 140 – 2500 nm diameter range
- 3 - 5.5 $cm^3\ s^{-1}$ sample flow
- 550 g
- 5 Watts

Gao et al., AS&T 2016

A brief timeline of POPS in the stratosphere

A powerful tool to explore and document stratospheric aerosol size and abundances since 2015

2015
First balloon flight ATAL measurements Kunming, China

2016
WB-57 Flights POSIDON

Gao et al. AS&T

2017
Global Hawk Flights EPOCH project

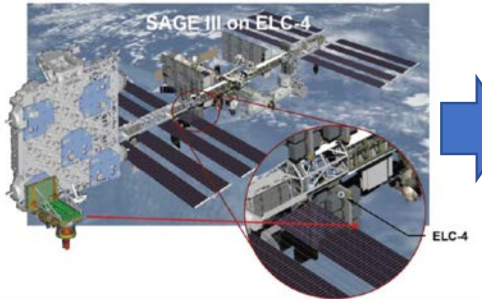
2018
Handix Scientific scales up production; commercially available POPS

2019 SAGE III-ISS aerosol retrieval validation efforts

~30 km

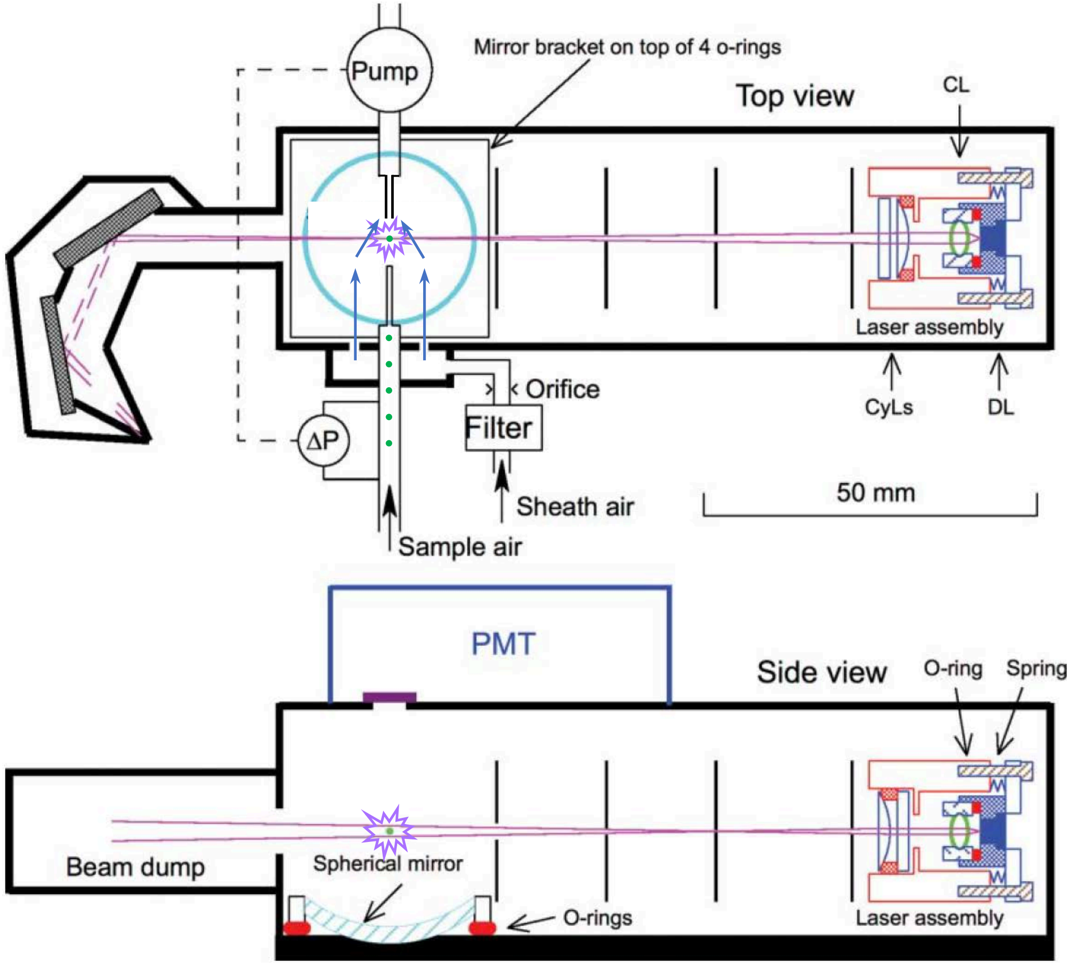
2020
ERB B2SAP project increases Boulder POPS sonde profiles to 2x/month


A light-weight, high-sensitivity particle spectrometer for PM2.5 aerosol measurements



Figures courtesy of RuShan Gao, NASA, and Handix Scientific

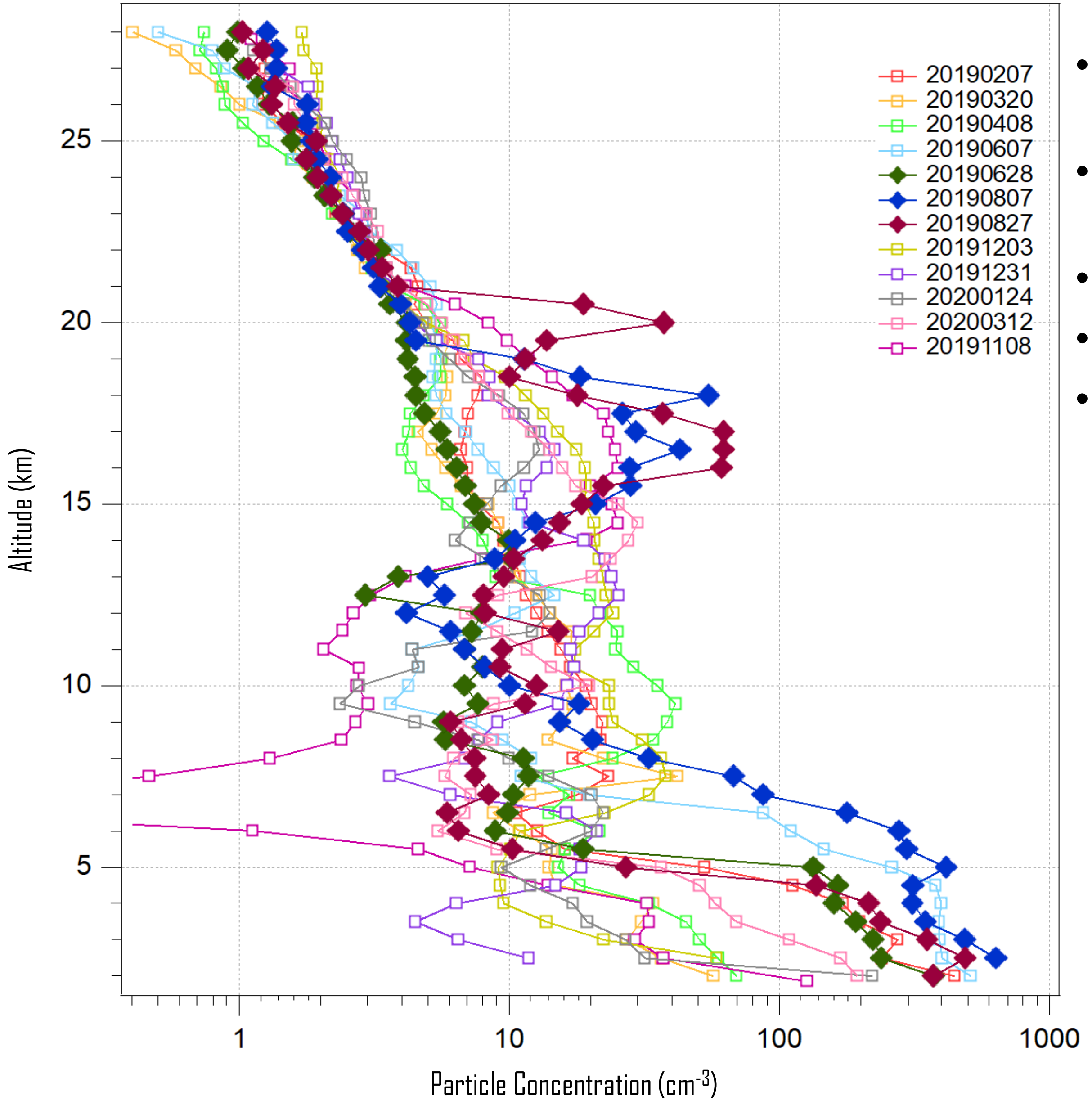
POPS Measurement is Simple and Robust



- POPS measures light scattered from a 405 nm (Blu-Ray) laser when a particle passes through the beam
- The intensity of the scattered light is a function of the particle size
- Peak height and width is recorded for each particle
- Calibrated Mie theory calculation used to determine particle size from the signal
- Requires assuming an index of refraction and spherical shape (a requirement for all optical particle sizing instruments)

Gao et al., AS&T 2016

One Full Year of POPS Balloon Launches in Boulder, CO



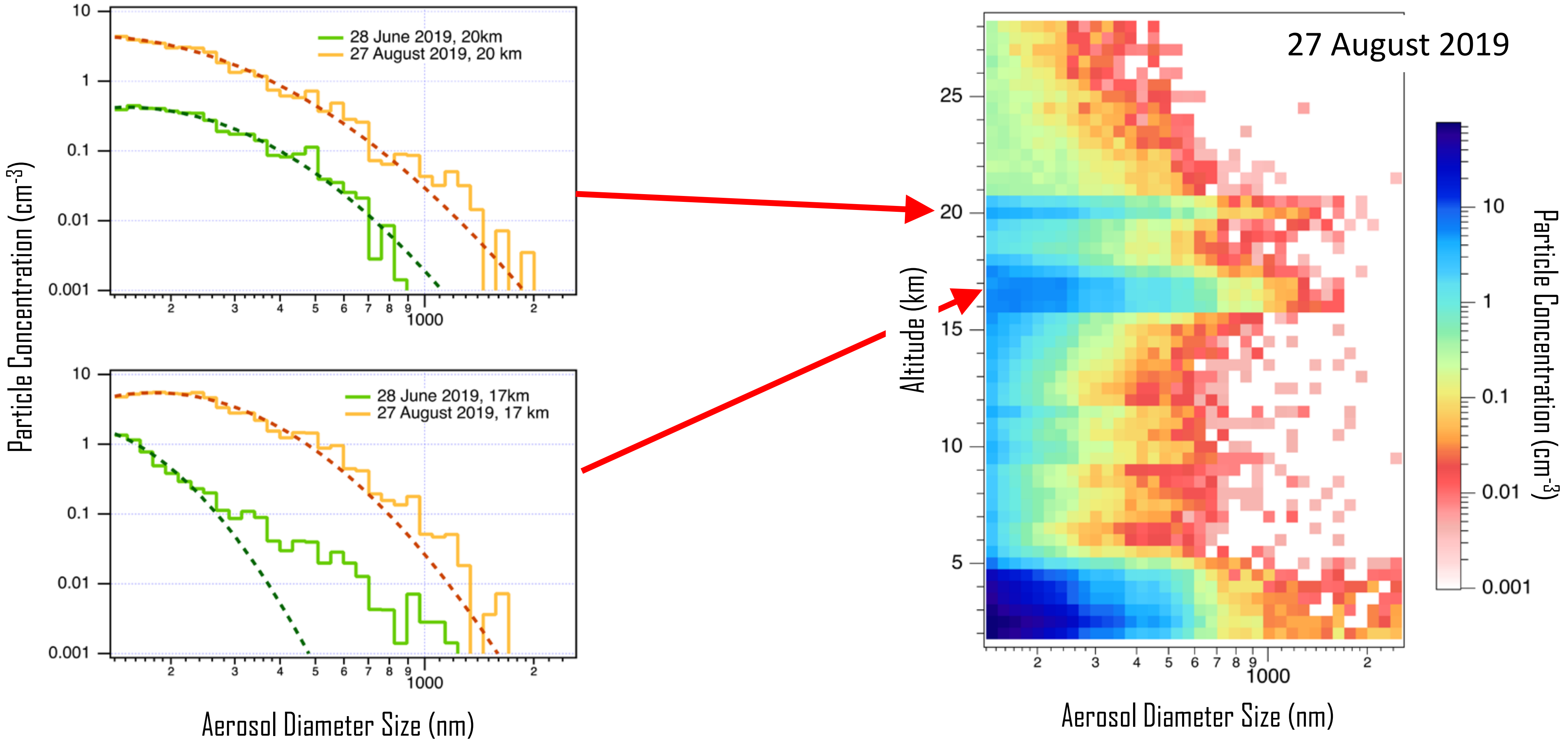
- NASA supported POPS measurements of stratospheric aerosols for SAGE III-ISS aerosol retrieval validation started in January 2019
- POPS sonde launches from Boulder (12/year), timed to match SAGE III-ISS observations
- 0.5 km average particle concentration vs altitude
- Using 36 size bins of particle diameter
- Starting in July 2020 with the NOAA ERB B^2SAP project, we expect to 26 launches from Boulder (one every two weeks)

Photo credit: Jim Elkins

Thornberry and Asher unpublished data

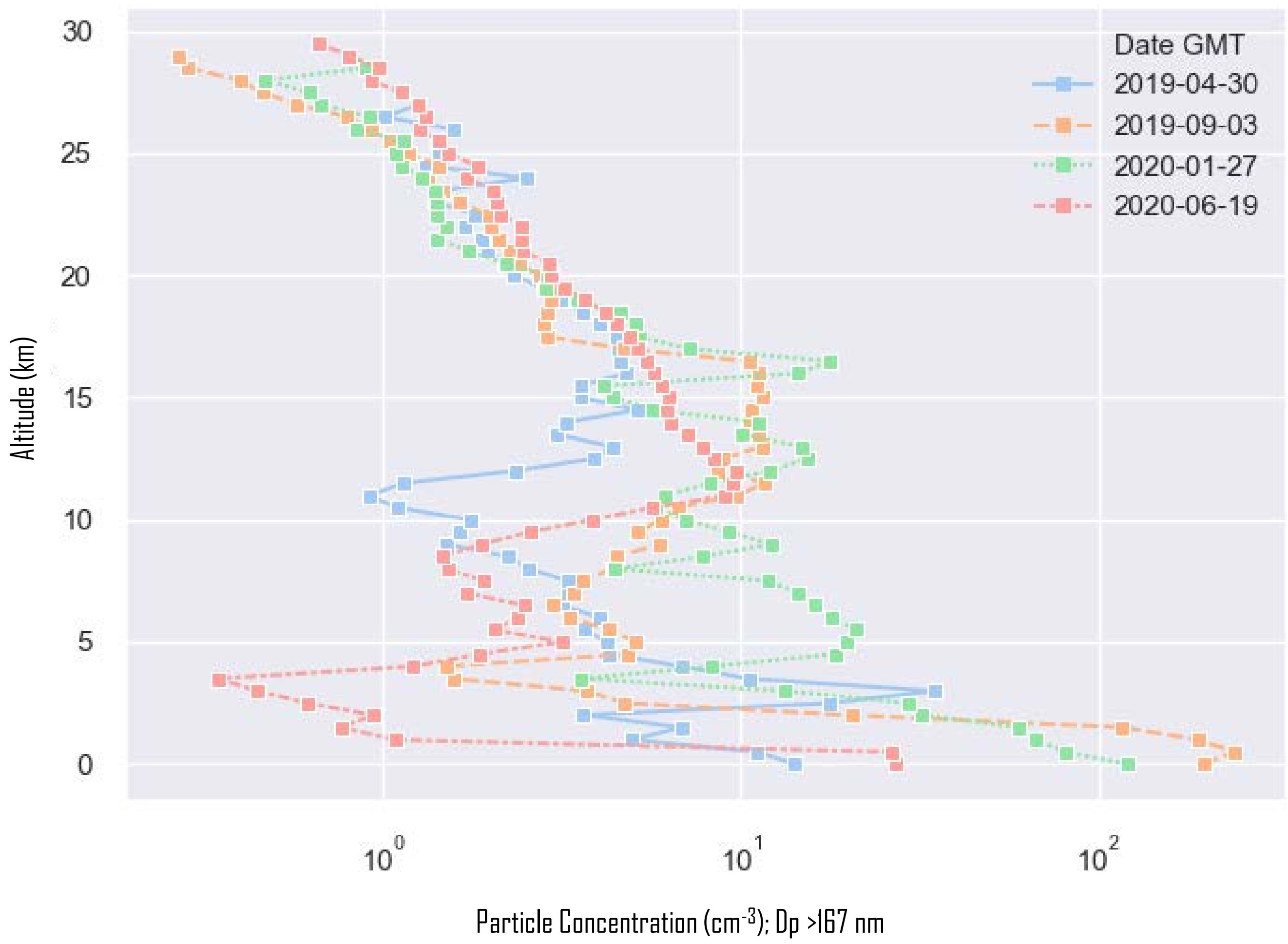
A Closer Look at Stratospheric Aerosol Structure

Aerosol size distributions



Thornberry and Asher unpublished data

Summary of Launches in Lauder, NZ



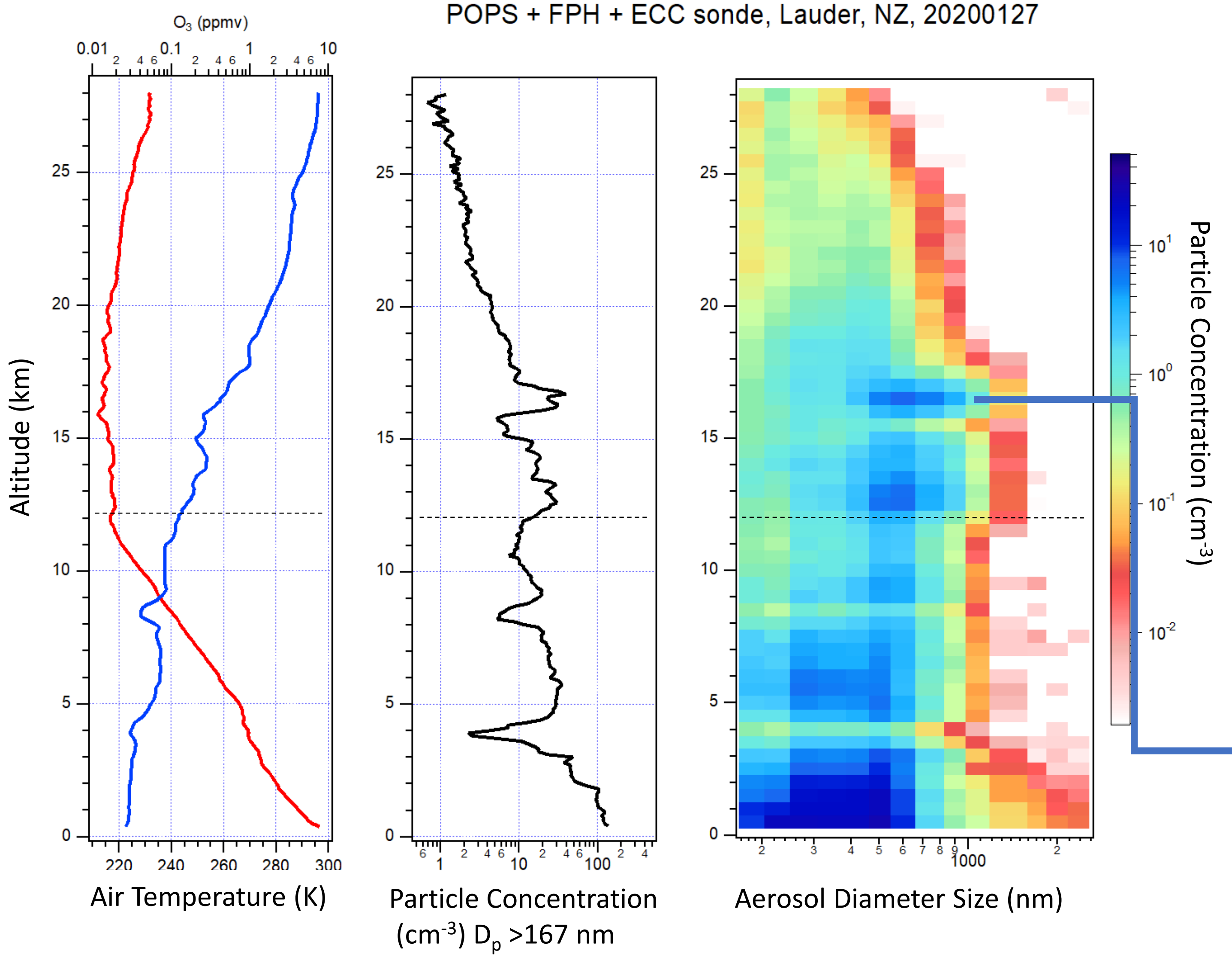
- POPS sonde launches from Lauder, NZ (4/year)
- 0.5 km altitude bins
- Currently 15 size bins based on particle diameter transmitted via iMET
- working on higher bandwidth iMet-54 for transmission of >36 bins, if desired

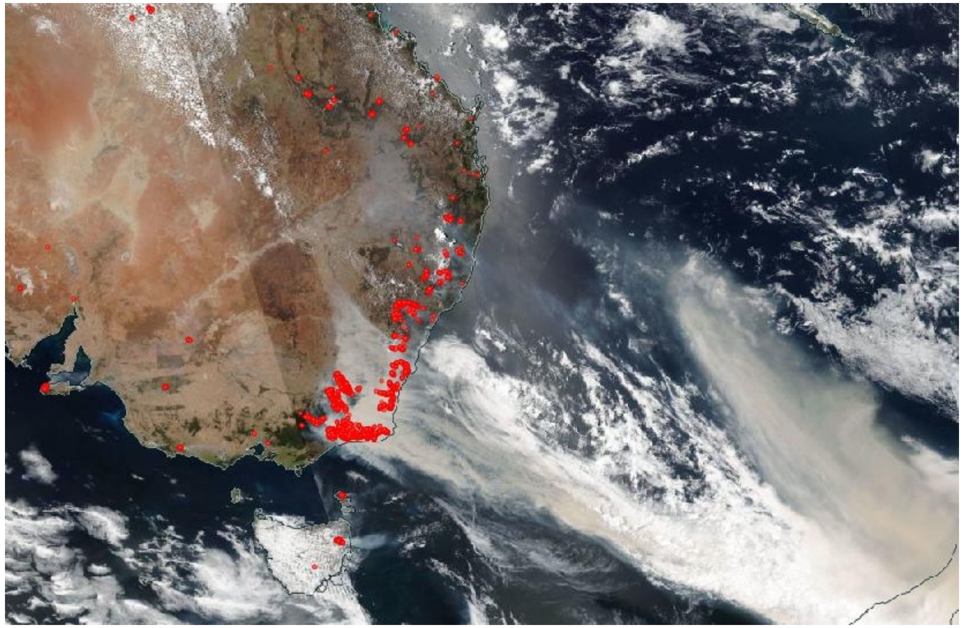
April 30, 2019

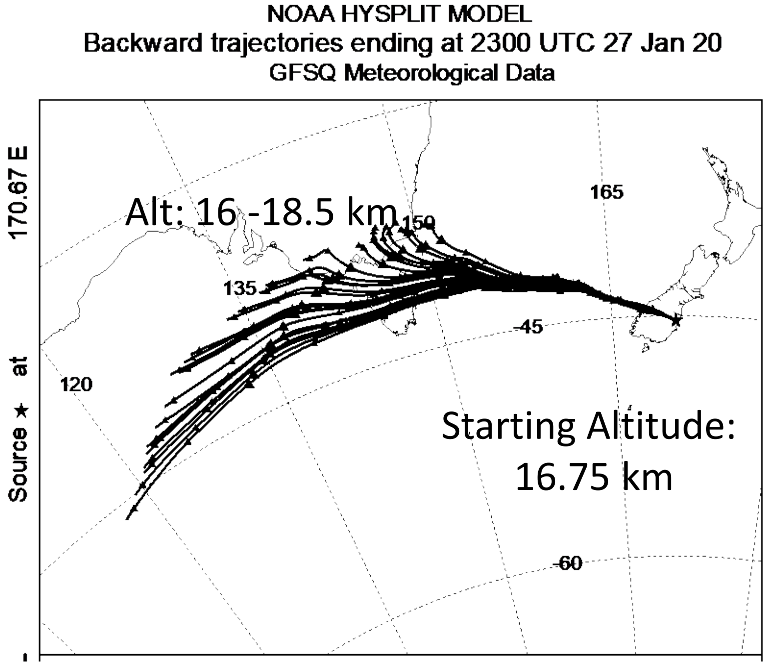
Thornberry and Asher unpublished data

Stratospheric aerosol enhancements appeared related to Australian bushfires

January 27, 2020



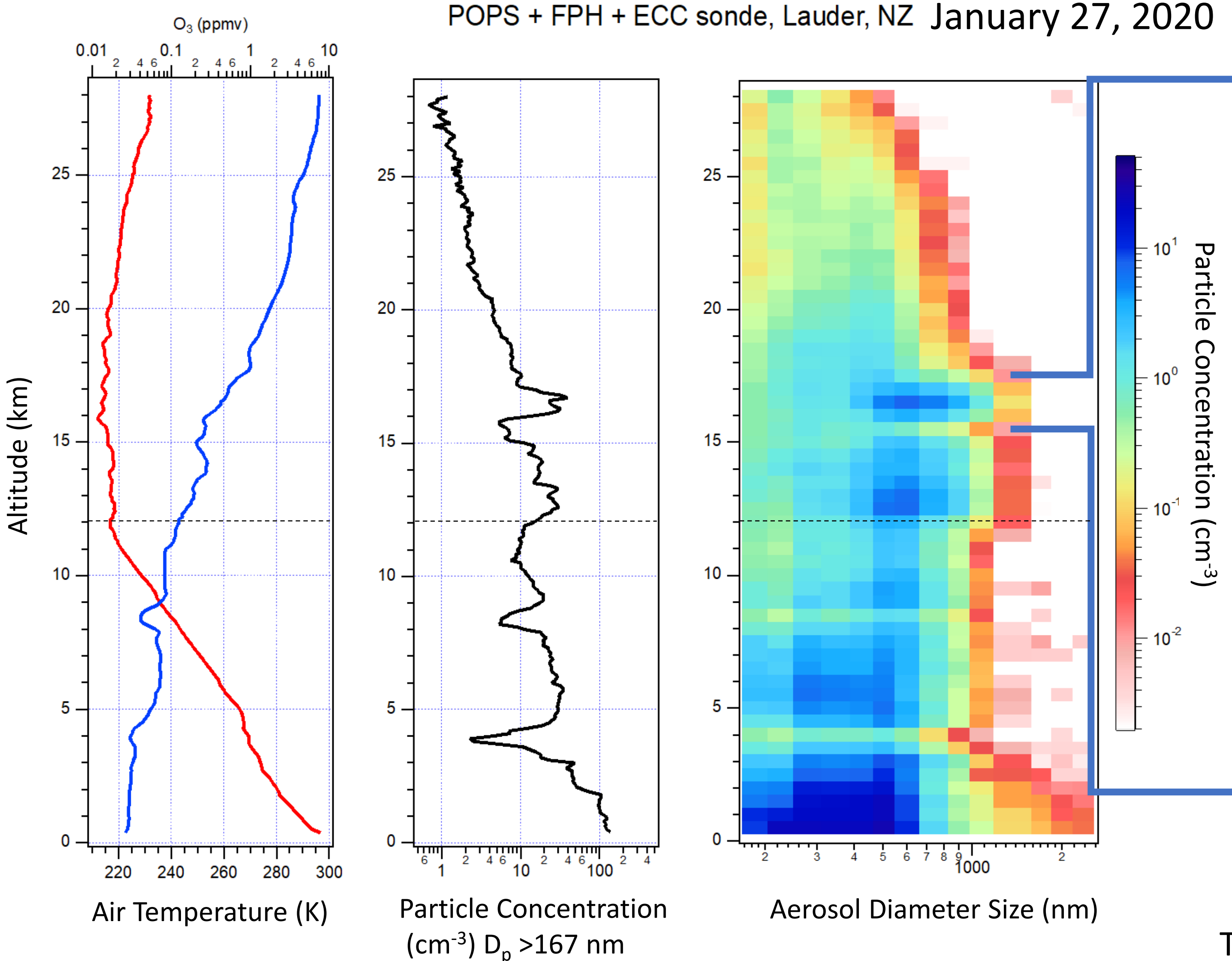


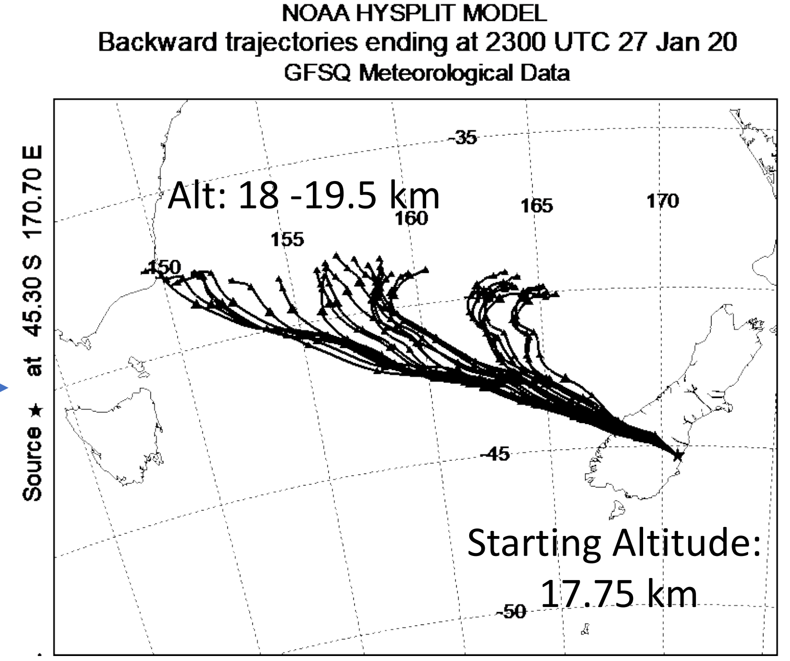


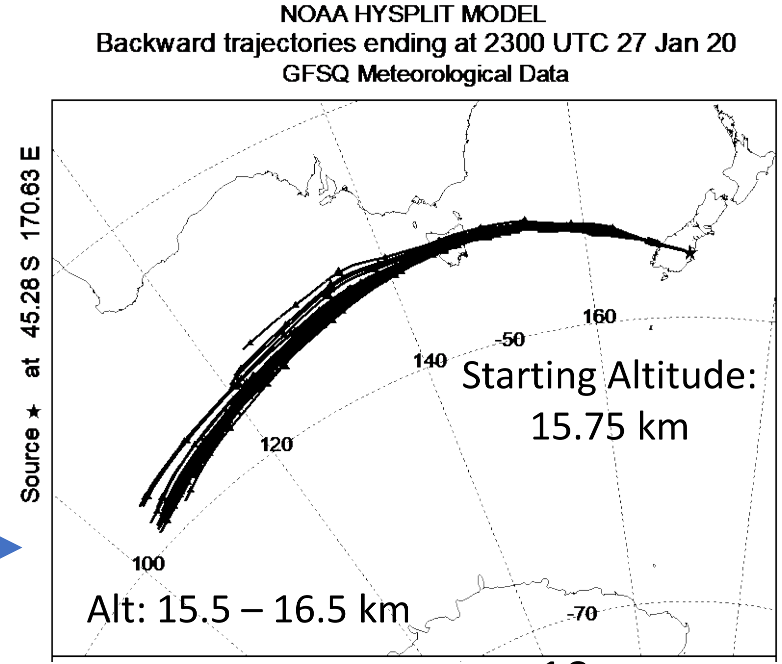
Thornberry and Asher unpublished data

Stratospheric aerosol enhancements appeared related to Australian bushfires

POPS + FPH + ECC sonde, Lauder, NZ January 27, 2020







Thornberry and Asher unpublished data

Conclusions

→ Reoccurring natural perturbations and the potential for future anthropogenic perturbations to stratospheric aerosol require frequent observations of aerosol distributions in the stratosphere, over a range of latitudes.

→ POPS has been used to explore and monitor stratospheric aerosol size distributions in both the northern and southern hemispheres in 2019-2020.

→ In one year, these launches have captured changes in size distributions of stratospheric aerosol, following both volcanic eruptions and very large fires.

→ Increasing the number of launches under the B^2SAP project will be used to further study the seasonal variability in stratospheric aerosol, and the influence of large volcanic and pyroCB events to determine a contemporary baseline of stratospheric aerosol.

Thank You

eGMAC

Monday, July 20, 2020

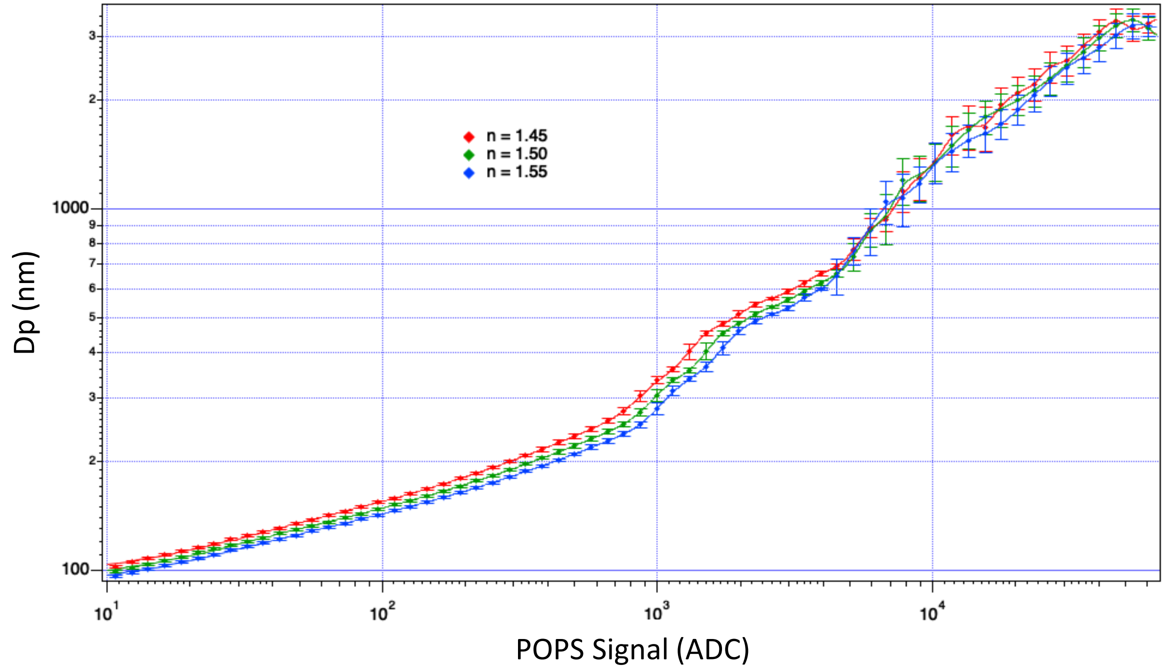
Elizabeth (Lizzy) Asher[1,2], Troy Thornberry[1,2], RuShan Gao[2], Emrys Hall[1,3], Allen Jordan[1,3], Dale Hurst[1,3], David Fahey[2]

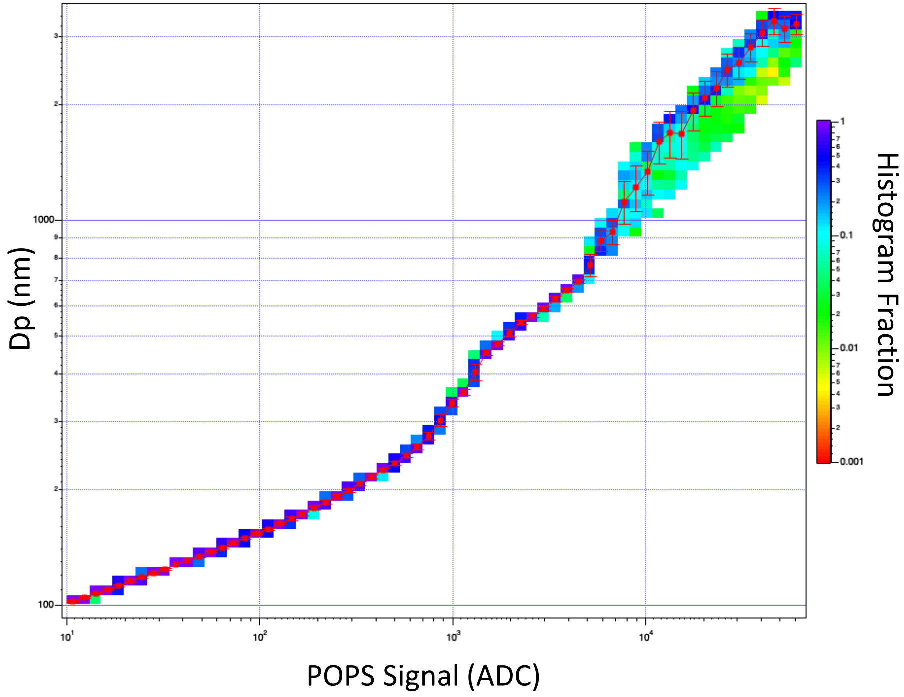
[1] Cooperative Institute for Research in Environmental Sciences, University of Colorado Boulder

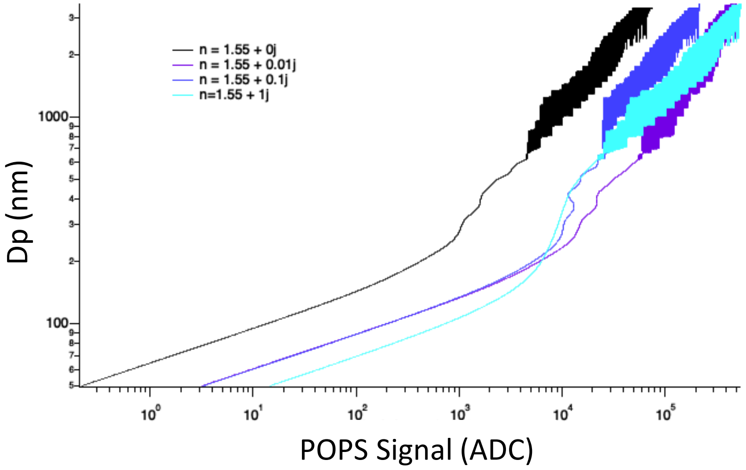
[2] NOAA Chemical Sciences Laboratory, Boulder

[3] NOAA Global Monitoring Laboratory, Boulder

Assuming an index of refraction for sizing







- Small differences in sizing between assumed indices of refraction, as long as there is not light absorbing aerosol
- Absorbing aerosol (i.e. black or brown carbon) has a complex index of refraction
- BB aerosols from very large fires, such as over Australia, may have a substantially higher uncertainty related to aerosol size distributions