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Data rescue of stratospheric aerosol observations from lidar at Lexington, MA, and Fairbanks, AK, January 1964 to July 1965.

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We report the recovery and processing methodology of the first ever multi-year lidar dataset of the stratospheric aerosol layer. A Q-switched Ruby lidar measured 66 vertical profiles of 694nm attenuated backscatter at Lexington, Massachusetts between January 1964 and August 1965, with an additional 9 profile measurements conducted from College, Alaska during July and August 1964.

We describe the processing of the recovered lidar backscattering ratio profiles to produce mid-visible (532nm) stratospheric aerosol extinction profiles ($sAEP_{532}$) and stratospheric aerosol optical depth ($sAOD_{532}$) measurements.

Stratospheric soundings of temperature, and pressure generate an accurate local molecular backscattering profile, with nearby ozone soundings determining the ozone absorption, those profiles then used to correct for two-way ozone transmittance. Two-way aerosol transmittance corrections were also applied based on nearby observations of total aerosol optical depth (across the troposphere and stratosphere) from sun photometer measurements.

We show the two-way transmittance correction has substantial effects on the retrieved $sAEP_{532}$ and $sAOD_{532}$, calculated without the corrections resulting in substantially lower values of both variables, as it was not applied in the original processing producing the lidar scattering ratio profiles we rescued. The combined transmittance corrections causes the aerosol extinction to increase by 67 % for Lexington and 27 % for Fairbanks, for $sAOD_{532}$ the increases 66 % and 26 % respectively. Comparing the magnitudes of the aerosol extinction and sAOD with the few contemporary available measurements reported show a better agreement in the case of the two way transmittance corrected values.

The sAEP and sAOD timeseries at Lexington show a surprisingly large degree of variability, three periods where the stratospheric aerosol layer had suddenly elevated optical thickness, the highest $sAOD_{532}$ of 0.07 measured at the end of March 1965. The two other periods of enhanced $sAOD_{532}$

are both two-month periods where the lidars show more than 1 night where retrieved $sAOD_{532}$ exceeded 0.05: in January and February 1964 and November and December 1964.

Interactive stratospheric aerosol model simulations of the 1963 Agung cloud illustrate that although substantial variation in mid-latitude $sAOD_{532}$ is expected from the seasonal cycle in the Brewer-Dobson circulation, the Agung cloud dispersion will have caused much slower increase than the more episodic variations observed, with also different timing, elevated optical thickness from Agung occurring in winter and spring.

The abruptness and timing of the steadily increasing sAOD from January to July 1965 suggests this variation was from a different source than Agung, possibly from one or both of the two VEI3 eruptions that occurred in 1964/65: Trident, Alaska and Vestmannaeyjar, Heimey, south of Iceland.

A detailed error analysis of the uncertainties in each of the variables involved in the processing chain was conducted, relative errors of 54 % for Fairbanks and 44 % Lexington for the uncorrected $sAEP_{532}$, corrected $sAEP_{532}$ of 61 % and 64 % respectively.

The analysis of the uncertainties identified variables that, with additional data recovery and reprocessing could reduce these relative error levels. Data described in this work are available at https://doi.pangaea.de/10.1594/PANGAEA.922105 (Dataset in Review) (Antuña-Marrero et al., 2020).