NOAA Earth's Radiation Budget (ERB) Initiative
FY20 End-of-Year Project Report

Project Title: Balloon Baseline Stratospheric Aerosol Profiles (B^{2}SAP)

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FY20 Period of Performance: 1 June 2020 – 31 May 2021

Plain-language Project Summary: Approximately every two weeks since 1 June 2020, we have launched a small meteorological balloon carrying compact, lightweight instruments to measure vertical profiles of water vapor (WV), ozone (O_3), and aerosol number and size distribution from the surface to the middle stratosphere (~28 km). These profiles are being compiled to characterize the background state and variability of radiatively important aerosols, WV and O_3 in Earth's stratosphere. In several profiles, we have observed perturbations in stratospheric composition after intense Australian wildfires and two strong volcanic eruptions that injected material directly into the stratosphere. The ongoing measurements will help us to better understand how these natural events alter stratospheric composition, especially the number and size distribution of aerosols, and how these perturbations evolve with time.

Project Description: During the first operational year of the B^{2}SAP project, we launched 24 instrumented balloons from Boulder (NCAR Marshall Field Site) to measure vertical profiles of water vapor (WV), ozone (O_3), and aerosol number and size distribution (140 nm – 2.5 µm) from the surface to the middle stratosphere (~28 km). These soundings complement GML's multi-decadal program of routine balloon launches from Boulder to monitor stratospheric O_3 and WV, as well as the more recently developed program of coordinated launches by CSL and GML for SAGE III/ISS satellite retrieval validation from Boulder and Lauder, New Zealand. The in situ measurements collectively provided by these balloon soundings at Boulder and other locations will provide a unique dataset that documents the background state of Earth's stratosphere and provides insight into variability in the stratospheric aerosol size distribution that is difficult to constrain from satellite observations. In these profile measurements, we have observed the effects of multiple stratospheric injection events, from intense Siberian and Australian wildfires and by moderate volcanic eruptions, that perturbed the stratospheric aerosol loading. The ongoing measurements will help us to better understand how these natural events alter stratospheric composition, especially the number and size distribution of aerosols, and how these perturbations evolve with time. We plan to perform additional soundings (as possible) to sample more such events in the future. We have begun work on another component of the project, developing a method for small balloon measurements of aerosol optical depth, at least during periods of increased stratospheric aerosol loading, using a miniature sunphotometer.

Methods: The balloon payloads we have launched for this program include a NOAA Frost Point Hygrometer (FPH), an Electrochemical Concentration Cell (ECC) ozonesonde, and a Portable Optical Particle Spectrometer (POPS) that measure WV, O_3, and aerosol number and size distribution, respectively. A radiosonde that measures temperature, pressure, horizontal winds and balloon location

(GPS) is also included. Balloons carrying this combined payload have thus far been launched approximately every two weeks from Boulder, Colorado (40°N) and every three months from Lauder, New Zealand (45°S), through collaboration with colleagues at NIWA. We are also continuing with development and plans to try flying a miniature sunphotometer that could allow direct determination of stratospheric aerosol optical depth.

Outcomes: We have produced a (roughly) bi-monthly record of vertical profiles (to ~28 km) of stratospheric aerosol number and size distribution that will be used to examine stratospheric aerosol variability. Measurements of O_3 and WV vertical profiles have proven to be important for the interpretation of the aerosol observations, as well as serving to continue and even expand the long-term records of these measurements. Our intent for year 1 of this project was to build an initial climatological record of the "background" state of the stratosphere in the northern (Boulder) and southern (Lauder) mid-latitudes, during all seasons. An added bonus for this first year was that we also detected evidence for direct stratospheric injections of aerosols by naturally occurring wildfires and volcanic eruptions, and we continue to assess their impacts on stratospheric composition.

Accomplishments: During the first year of this project (1 June 2020 – 31 May 2021) period we conducted 24 B^2SAP balloon launches at Boulder to obtain stratospheric aerosol, O3 and WV profiles, 12 of which also served as spatiotemporally coincident SAGE III/ISS validation profiles. This accomplishment met our first year goal of ~2 profiles/month at Boulder. To date, we have begun discussions with the staff of NOAA's Mauna Loa Observatory about them performing quarterly launches of the B^2SAP payload to supplement their current balloon launch schedule of weekly ECC and monthly FPH + ECC soundings. There is also a plan in place to collaborate with NIWA personnel on a few trial balloon launches at Ross Island, Antarctica, during the upcoming Austral summer. These activities are meant to investigate and hopefully demonstrate the possibility of expanding the B^2SAP project to a subtropical and Antarctic site in the future.

Presentations & Publications: Data from the B^2SAP Boulder profiles were included in analyses presented in talks by E. Asher and D. Hurst at GML's virtual Global Monitoring Annual Conference (GMAC) in July 2020, talks by E. Asher and E. Hall at the virtual SAGE III/ISS Science Team meeting in October 2020 and a talk by M. Todt at GML's virtual GMAC in May 2021. Two publications describing the B^2SAP aerosol measurements are in preparation.

Challenges: COVID-19 made this collaborative effort between two NOAA laboratories challenging because of NOAA's requirements for physical separation. This included not only the tedious combining and testing of instruments from both laboratories that were assembled into each payload, but also the launch day demands of working together while minimizing contact. There were COVID-related delays in our attempts to increase the frequency of sonde launches at Boulder, and to hire two new CIRES employees to support the project. There was also an increased burden of regular payload retrieval operations on existing CSL personnel.