N92-14517

A. Title of Research Task: Particle Chemistry Impactor Experiment.

B. Investigators and Institutions:

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C. Abstract of Research Objectives:

Polar stratospheric cloud particles are collected on impactors and investigated with regard to physical and chemical properties to help explain the importance of heterogeneous chemical reactions for stratospheric ozone depletion.

D. Summary of Progress and Results:

The nitric, hydrochloric and sulfuric acid content of stratospheric aerosol particles collected at 18 km altitude during the 1987 Airborne Antarctic Ozone Experiment (AAOE) was determined. Nitric acid was found to condense at 193.6±3.0 K. Analysis of the July-October 1987 Stratospheric Aerosol Experiment (SAM)II satellite 18 km data shows a threshold temperature 194.5±5.7 K of polar stratrospheric cloud (PSC) particle formation. The similar temperature thresholds of both observations strongly suggest that nitric acid is a component of polar stratospheric clouds. This is important for two reasons. First, it proves that chlorine activation takes place at the surface of PSC particles by converting chemically inert chlorine nitrate to chlorine radicals that can react with ozone. Second, if the PSC particles are large enough to settle out from the stratosphere, the possibility of nitric acid removal can result in the denitrification of the stratosphere. This would inhibit chlorine nitrate formation and prolong the catalytic destruction of ozone by chlorine.

E. Journal Publications:

R.F.Pueschel, K.G.Snetsinger, J.K.Goodman, O.B.Toon, G.V.Ferry, V.R.Oberbeck, J.M.Livingston, S.Verma, W.Fong, W.L.Starr, and K.R. Chan, Condensed Nitrate, Sulfate, and Chloride in Antarctic Stratospheric Aerosols, J.Geophys.Res., in press.

J.Goodman, O.B.Toon, R.F.Pueschel, K.G.Snetsinger, and S.Verma, Antarctic Stratospheric Ice Crystals, J.Geophys.Res., in press.

R.F.Pueschel, P.Hamill, and M.P.McCormick, Observational Evidence of Nitric Acid in Polar Stratospheric Clouds, Geophys. Res. Lett., submitted.

SUPPORT OF THE HARVARD ClO/BrO INSTRUMENT FOR THE PREPARATION, EXECUTION, AND DATA REVIEW FOR THE ARCTIC VORTEX MISSION

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Abstract

The Airborne Arctic Stratospheric Experiment was designed to determine if the abundances of stratospheric trace species in the wintertime arctic polar vortex were perturbed, as they are in the antarctic polar vortex, and to study the mechanisms responsible for the perturbations. In the absence of ozone depletion, elevated levels of ClO provide one crucial indicator of the change of the polar stratosphere. The Harvard University ClO/BrO instrument, mounted on the NASA ER-2 high altitude aircraft, was used to measure, in situ, the mixing ratios of both ClO and BrO during the AASE mission. The scientific objectives were to explore the abundances of ClO and BrO in a variety of environments near and in the arctic polar vortex, and to determine to what extent ClO abundances are elevated, and why.

Summary of Progress and Results

The Airborne Arctic Stratospheric Experiment was highly successful, and the initial results were released as a statement of preliminary findings. The Harvard ER-2 instrument performed well during the fourteen flights toward the polar vortex from Stavanger, Norway, the four transit flights between Moffett Field, California, and Stavanger, and the five test flights from Moffett Field. One of the most outstanding results was that the ClO abundances inside the polar vortex in mid-February were as high as 1.1 ppbv. This elevated amount of ClO is comparable to amounts seen during the Airborne Antarctic Ozone Experiment in September, 1987. Another result was that ClO abundances were elevated over the entire altitude range surveyed -- 14 to 19 km -- and that the ClO abundances were observed to be greater than 0.5 ppbv for four days in a row in early February. These observations indicate that the air inside the arctic vortex was extensively perturbed.

A rich and diverse mixture of environments was encountered during the AASE flights. ClO and BrO were observed both inside and outside the vortex, in and out of sunlight, and at a variety of altitudes. The variations of these species during changes in these conditions are powerful tools to understanding the photochemical mechanisms, and are being studied by a number of methods.

Publications

Several are in preparation.

NASA Research Summary

A. Measurements of Chemical Constituents in the Arctic Stratosphere

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C. Objectives of this research in 1988 and 89 were for the Optical Techniques project of NCAR's Atmospheric Chemistry Division to use its airborne Fourier transform spectrometer aboard NASA aircraft to measure total column amounts of various chemical species within and in the vicinity of the northern polar vortex, and to analyze results from Arctic and Antarctic field observations.

D. Activities in 1988 and 89 have been divided between field observations and data analysis. In January 1988 we cooperated with the NASA Langley Dual-polarization Aerosol Lidar (McCormick and Poole) to fly a number of missions aboard the NASA Wallops P3 aircraft based in Andenes, Norway. Ten research flights were conducted at latitudes up to 84N. Stratospheric observations with the NCAR spectrometer were made during five flights. Analysis of the 2000 infrared spectra recorded during the program is still underway.

During six weeks in January and February 1989 our experiment was deployed aboard the NASA Ames DC-8 aircraft as part of the Airborne Arctic Stratospheric Expedition (AASE) based in Stavanger, Norway. Eleven research flights were flown and more than 7000 high resolution infrared spectra were recorded covering the spectral range from 700 to 5000 cm^{-1}.

Results from our observations during AASE have been presented at a meeting of the AASE participants and further analysis to derive column amounts of O_3, NO, NO_2, HNO_3, $ClONO_2$, HCl, HF, N_2O, CH_4 and F11 are in progress.

Analysis of the large data set from the 1987 Airborne Antarctic Ozone Experiment (AAOE) and meetings to discuss the results have continued during this period and have resulted in the publications listed below.

E.

Airborne measurements of stratospheric constituents over Antarctica in the austral spring 1987: 1. Method and ozone observations, William G. Mankin and M. T. Coffey, accepted by *J. Geophys. Res.*

Airborne measurements of stratospheric constituents over Antarctica in the austral spring 1987: 2. Halogen and nitrogen trace gases, M. T. Coffey, William G. Mankin, and A. Goldman, accepted by *J. Geophys. Res.*

Nitrogen and chlorine species in the spring Antarctic stratosphere: Comparison of models with AAOE observations, J. M. Rodriguez, M.K.W. Ko, N. D. Sze, S. D. Pierce, J. G. Anderson, D. W. Fahey, K. Kelly, C. B. Farmer, G. C. Toon, M. T. Coffey, L. E. Heidt, W. G. Mankin, K. R. Chan, W. L. Starr, J. F. Vedder, and P. McCormick, accepted by *J. Geophys. Res.*

Intercomparison of ozone measurements over Antarctica, J. J. Margitan, G. A. Brothers, E. V. Browell, D. Cariolle, M. T. Coffey, J. C. Farman, C. B. Farmer, G. L. Gregory, J. W. Harder, D. J. Hofmann, W. Hypes, S. Ismail, R. Jakoubek, W. Komhyr, S. Kooi, A. J. Krueger, J. C. Larsen, W. G. Mankin, M. P. McCormick, G. H. Mount, M. H. Proffitt, A. R. Ravishankara, A. L. Schmeltekopf, W. L. Starr, G. C. Toon, A. Torres, A. F. Tuck, A. Wahner, and I. Watterson, accepted by *J. Geophys. Res.*

Airborne observations of chemical constituents in the Antarctic winter stratosphere, William G. Mankin and M. T. Coffey, accepted by *Proceedings of the Quadrennial Ozone Symposium* (Deepak Publishing).

A. Measurements of Chemical Constituents in the Antarctic Stratosphere

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C. Research Objectives: 1) To measure the amounts of sulfate and nitrate ion in the particulate phase of the stratospheric aerosol from the NASA ER-2 aircraft. 2) To measure the amounts of nitrate ion in the vapor phase of the sampled air.

D. Progress: The data from the Airborne Antarctic Ozone Experiment has been analyzed and presented. The results show the Antarctic polar vortex to be characterized by background levels of sulfate. The vortex air is depleted in nitrate by comparison with the air outside the vortex but there is still 1 to 3 ppbv of nitrate within the vortex. The vortex air contains more fluoride than extra-vortex air.

The multi-filter sampler was flown on the Airborne Arctic Stratospheric Experiment (AASE). The data from those flights is being processed at present and it will be submitted for publication in the AASE special issue of GRL.

E. "Filter measurement results from the Airborne Antarctic Ozone Experiment" by B.W. Gandrud, P.D. Sperry, L. Sanford, K.K. Kelly, G.V. Ferry and K.R. Chan is in press in the AAOE special issue of JGR.

A. Measurement of Particle Size and Number Concentration with an FSSP-300 on the ER-2

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C. Research Objectives: To measure the size and number concentration of particles in the 0.4 to 20.0 micrometer diameter range from the NASA ER-2 aircraft.

D. Progress: A new instrument from Particle Measurement Systems was checked on 4 flights aboard an NCAR aircraft prior to test flights on the ER-2. These flights pointed out problems with the detectors which were rectified before the ER-2 test flights. The instrument was flown successfully on all the Airborne Arctic Stratospheric Experiment (AASE) flights. The data from these flights is being processed at present and will result in 2 papers to be submitted for publication in the AASE special issue of GRL.

E. "Calibration of the Forward Scattering Spectrometer Probe used on the ER-2 during the AAOE" by D. Baumgardner, J.E. Dye and B.W. Gandrud is in press in the AAOE special issue of JGR. Publications from the AASE mission will be forthcoming.