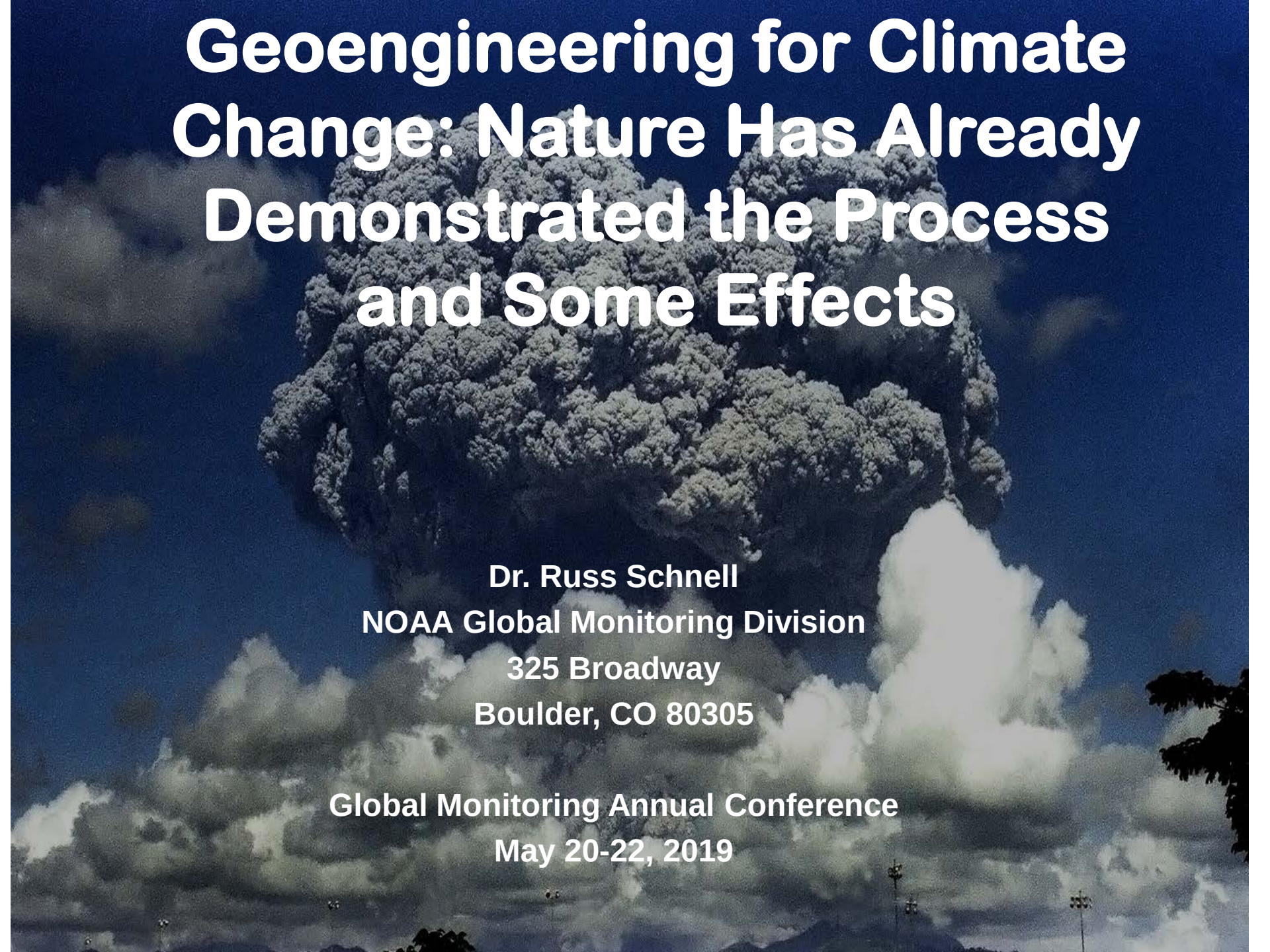


Geoengineering for Climate Change: Nature Has Already Demonstrated the Process and Some Effects

Dr. Russ Schnell

NOAA Global Monitoring Division

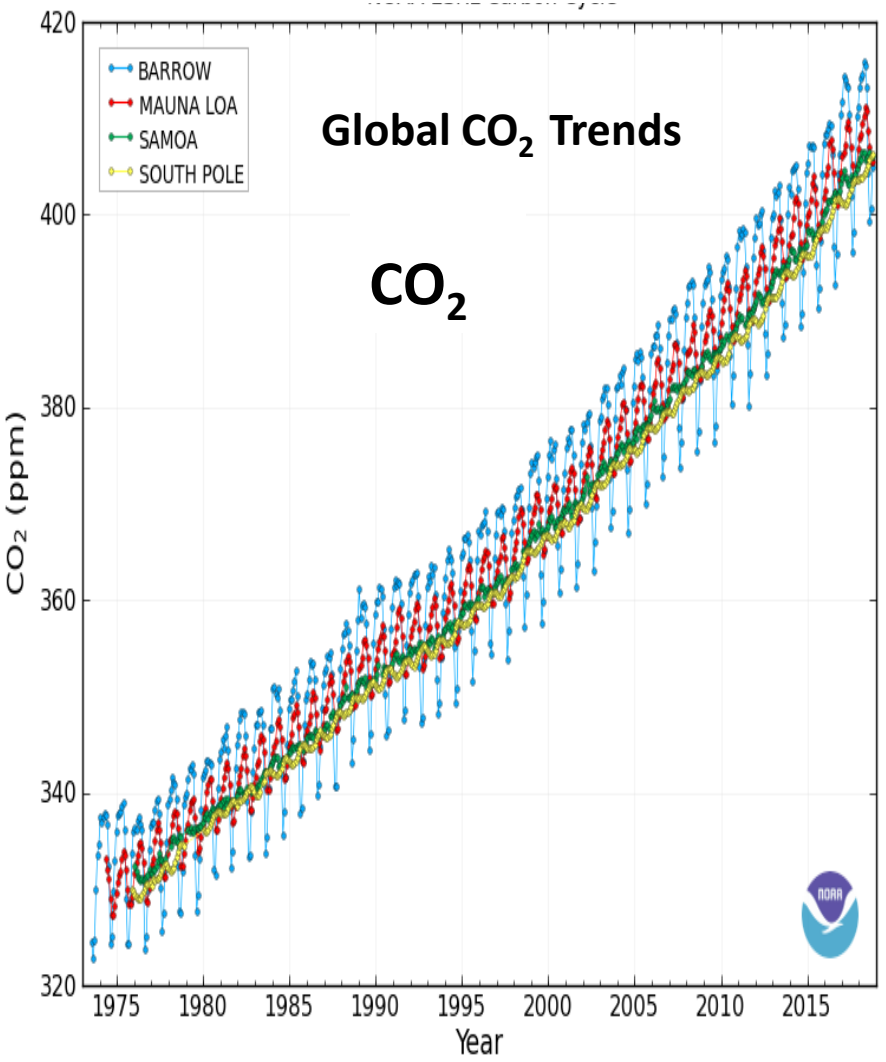
325 Broadway

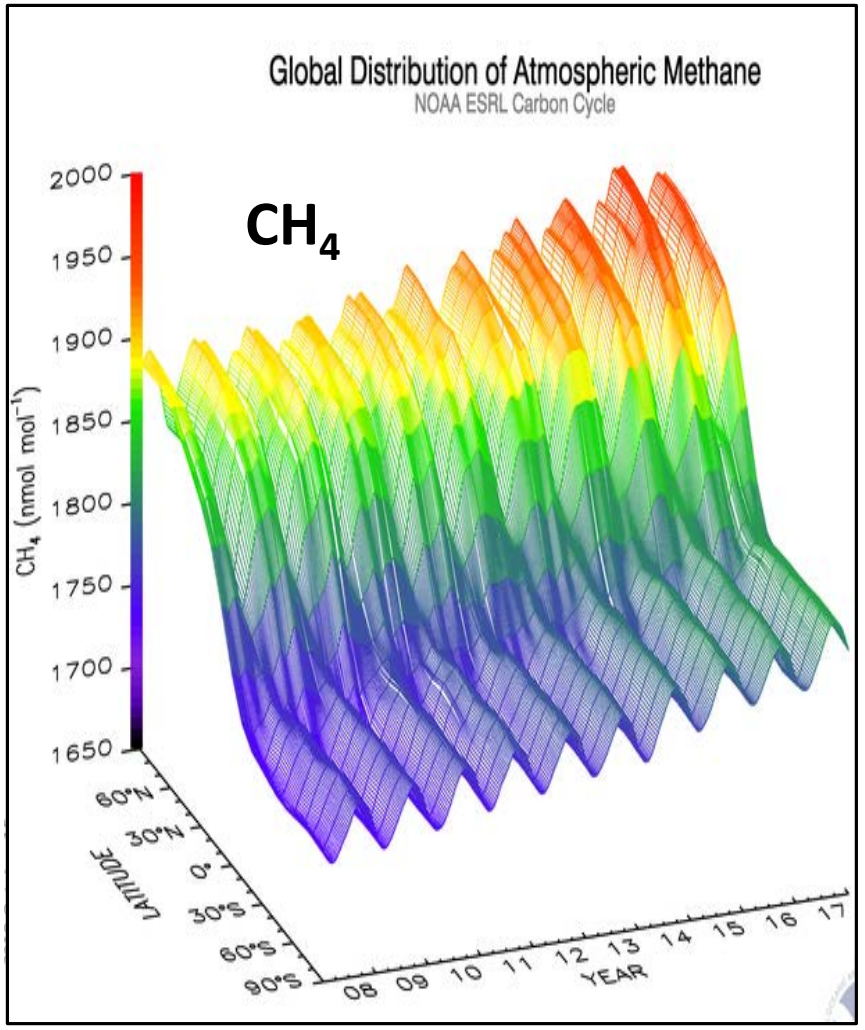
Boulder, CO 80305

Global Monitoring Annual Conference

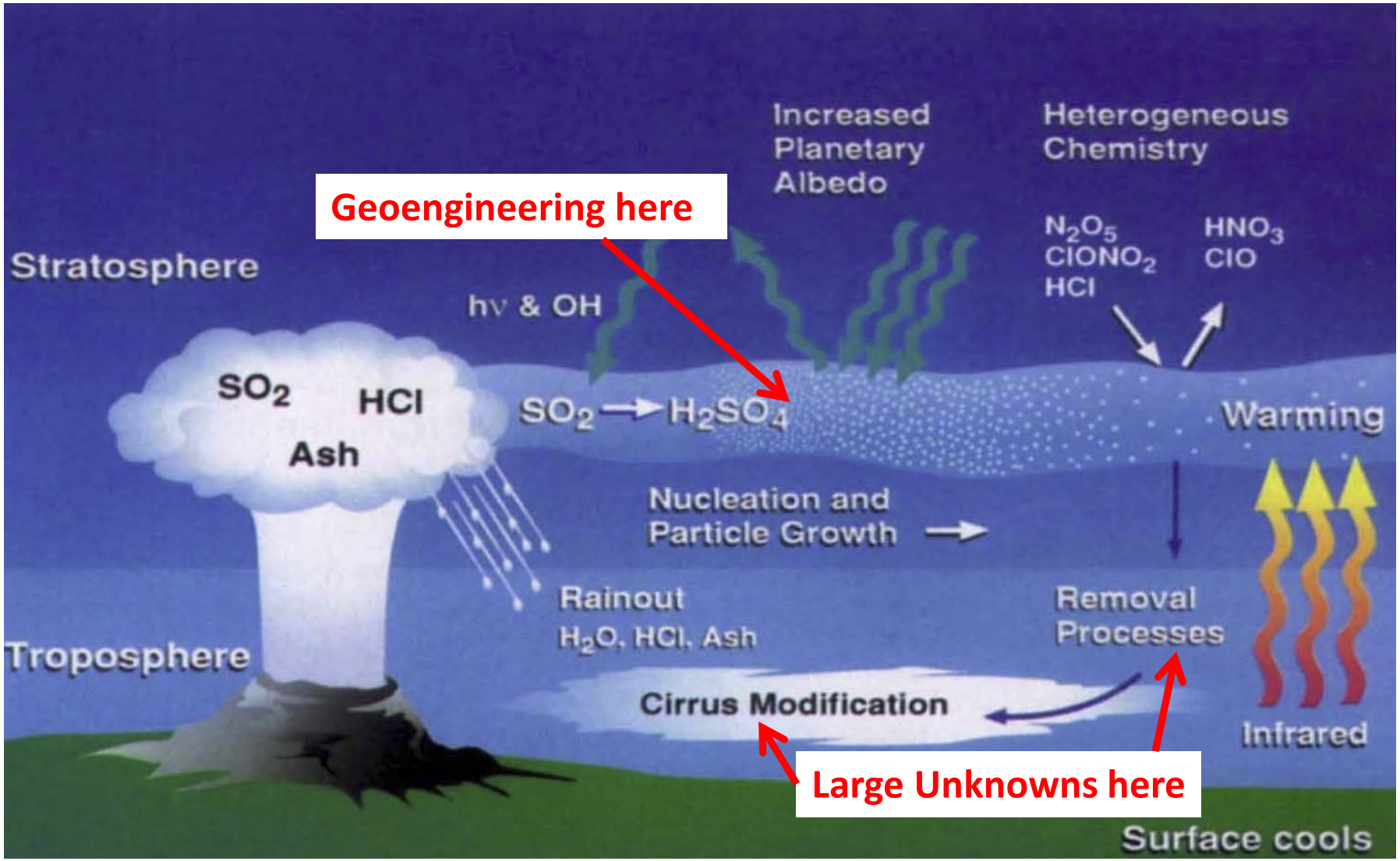
May 20-22, 2019

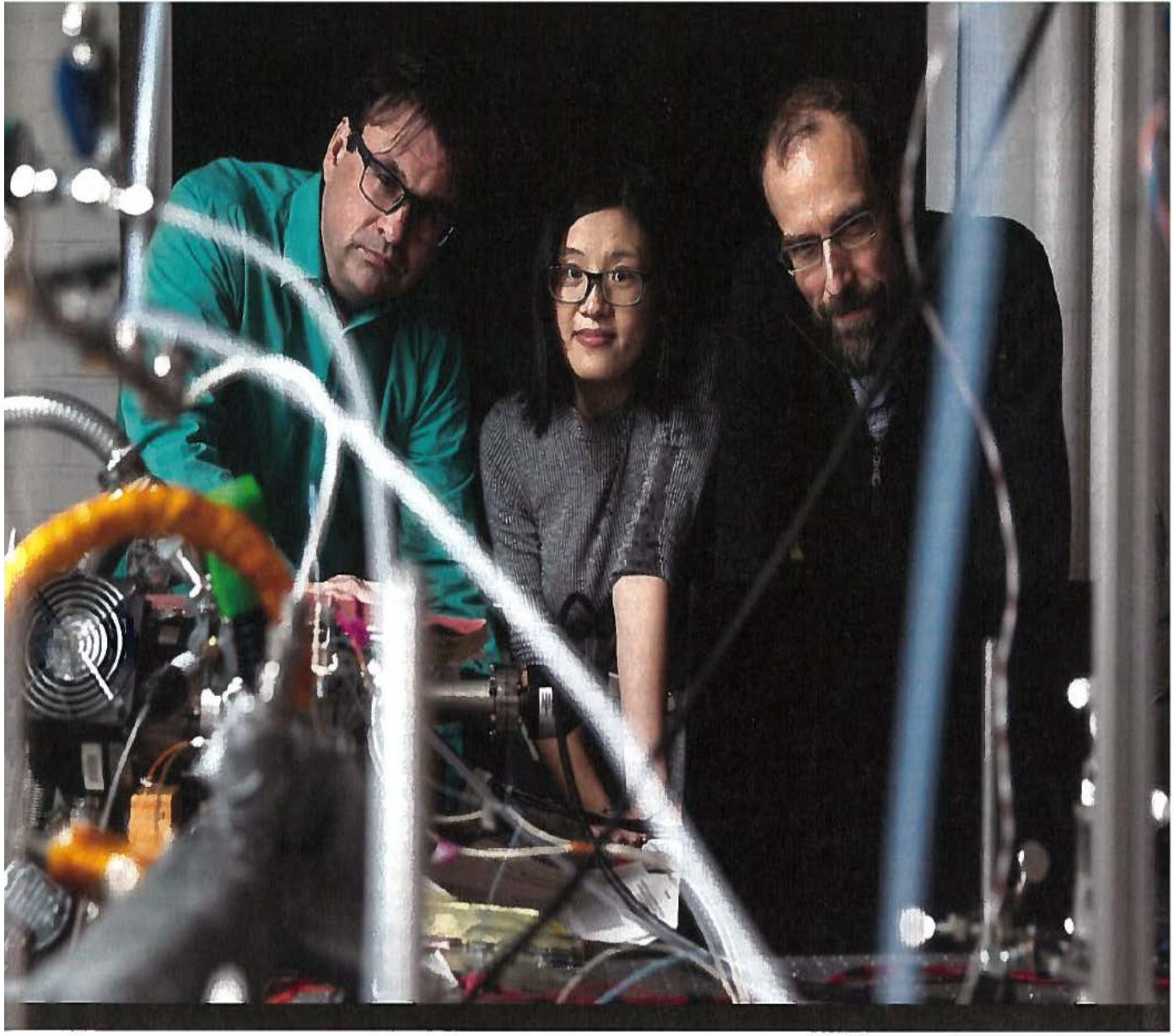
Increasing Atmospheric CO_2 and CH_4 is Unplanned Geoengineering





Volcanic eruptions provide test cases for the effects of planned stratospheric geoengineering. NOAA Global Monitoring Division has measured such natural effects in Hawaii and the Arctic.



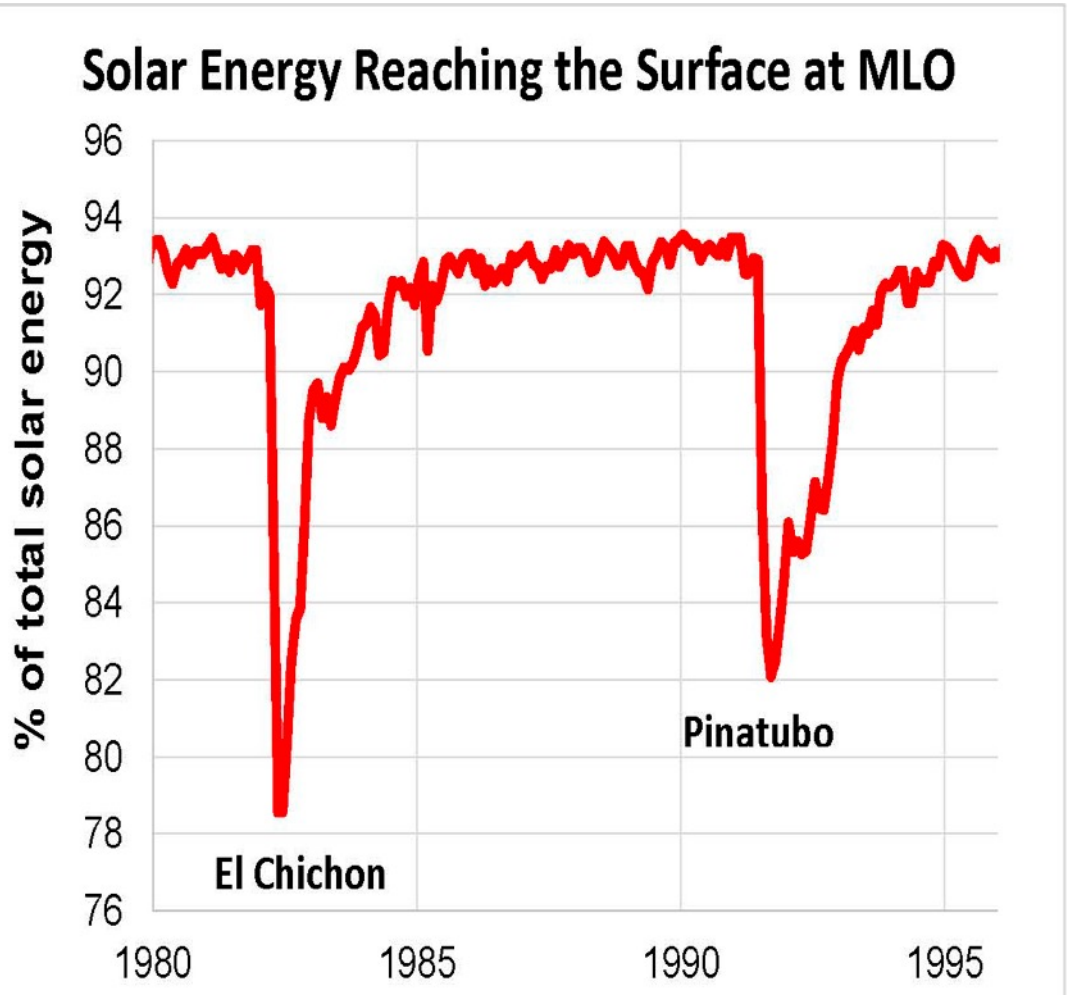


"THE SUN DIMMERS: With dire climate scenarios on the horizon, researchers are getting serious about solar geoengineering."
(***Nature*****,** *563*, November 2018, page 613- 615).

Overt Stratospheric Geoengineering may be coming soon.

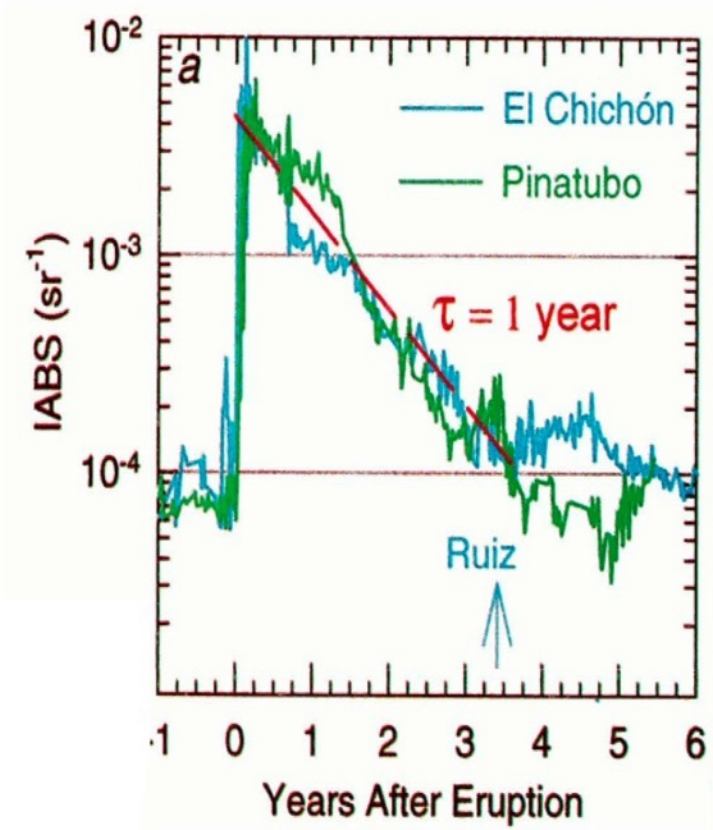
Frank Keutsch, ZhenDai and David Keith (left to right), Harvard University, have been funded to conduct the "**Stratospheric Controlled Perturbation Experiment (SCoPEx)"** for releasing calcium carbide into the stratosphere from balloons, possibly in **2020.**

El Chichon (March 1982) and Pinatubo (June 1991) Volcanic Aerosols, Mauna Loa Observatory (MLO)



At MLO, the El Chichon eruption had a greater effect on solar radiation than Pinatubo.

Stratospheric Aerosol over MLO

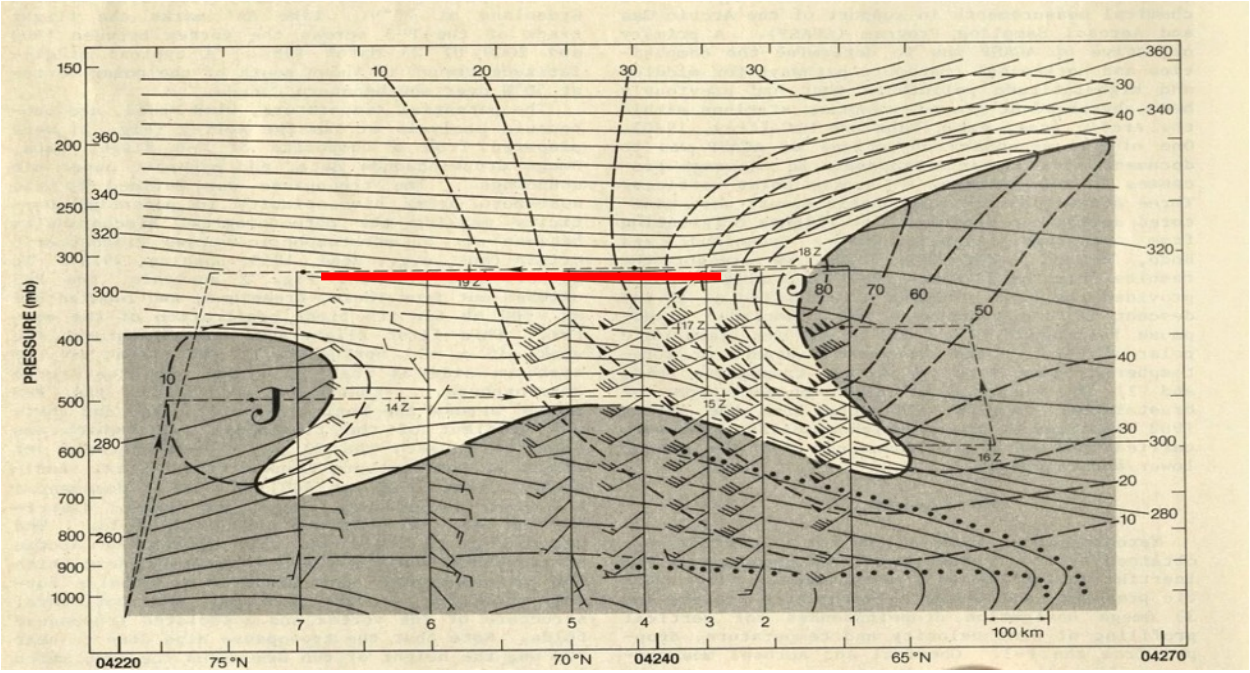


El Chichon and Pinatubo aerosols had similar lifetimes

(Barnes and Hofmann (1997), Lidar measurements of stratospheric aerosols over MLO), *GRL, 25,* 1923-26).

NOAA WP-3 Measurement of EL Chichon and Pinatubo Aerosols in the Arctic

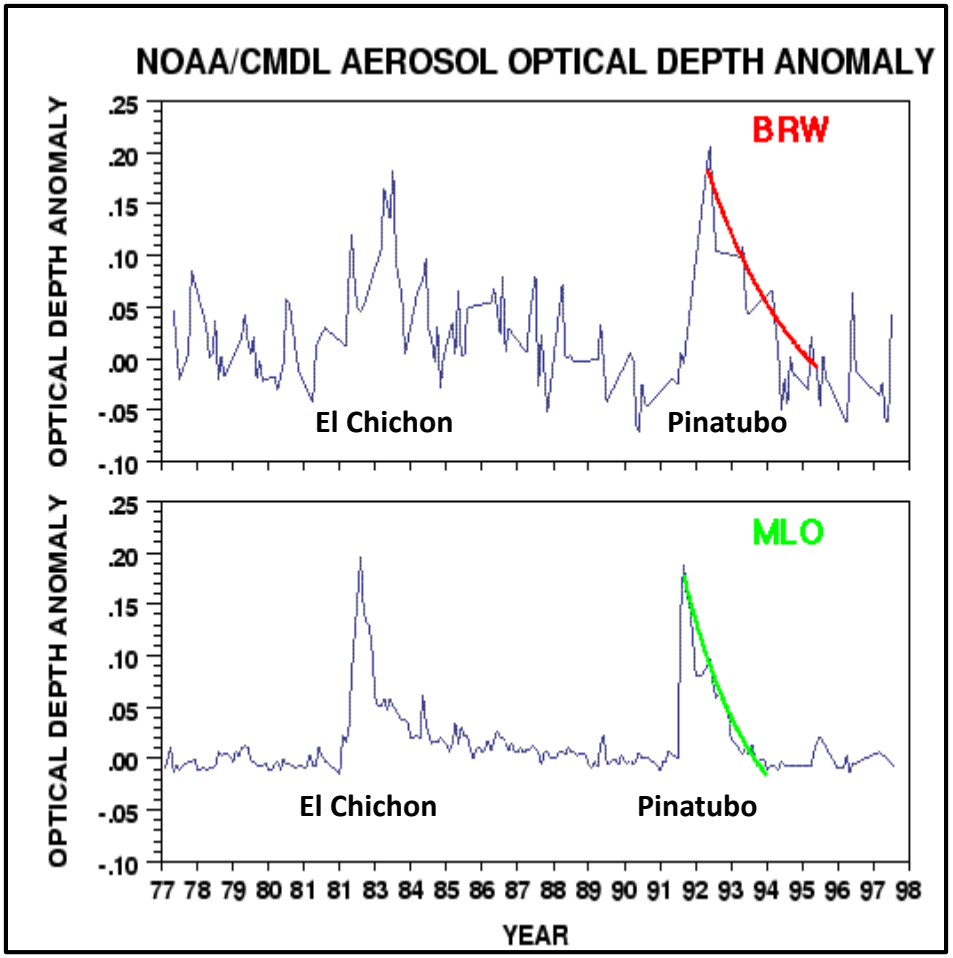
A heavily instrumented gas and aerosol measuring NOAA WP-3D flew month-long missions covering the Arctic off Alaska, Canada, Greenland, Norway and Svalbard in spring 1983, 1986, 1989 and 1992. It took 30 people to operate. (*Arctic Gas and Aerosol Sampling Program: AGASP)*.



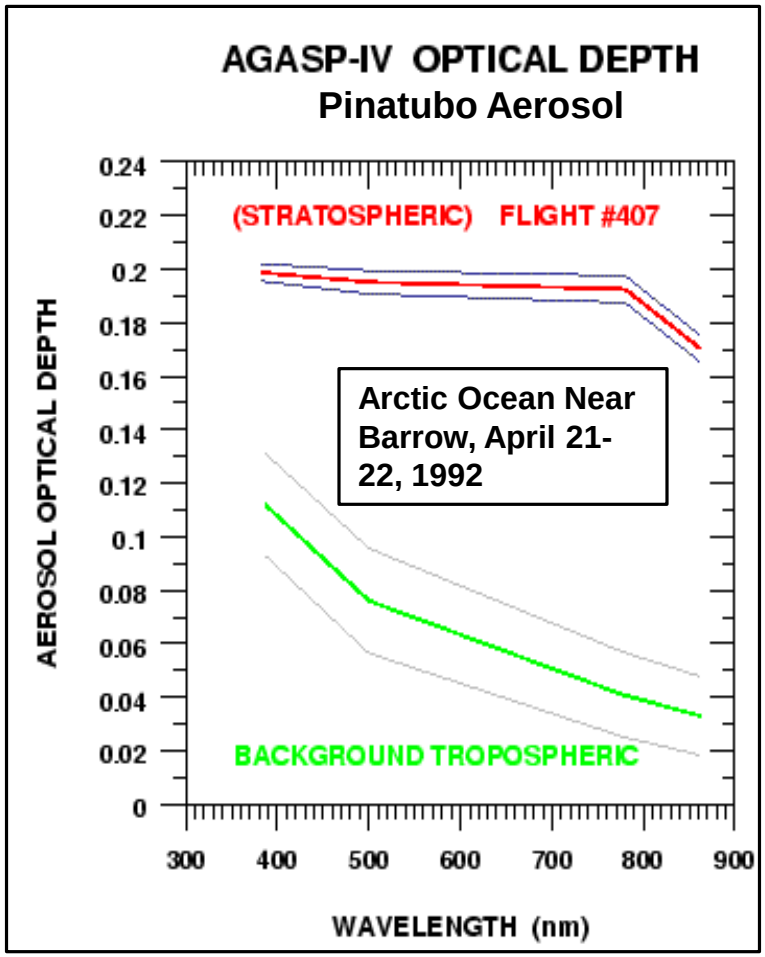
On March 14, 1983 the NOAA WP-3D was dedicated to measuring El Chichon eruption debris in a stratospheric fold west of Thule, Greenland. The **red line** shows the track along which El Chichon aerosol shown in the following figure was collected.

Optical Depth Records from Barrow, Mauna Loa and Arctic Aircraft Measurements

Surface Measurements

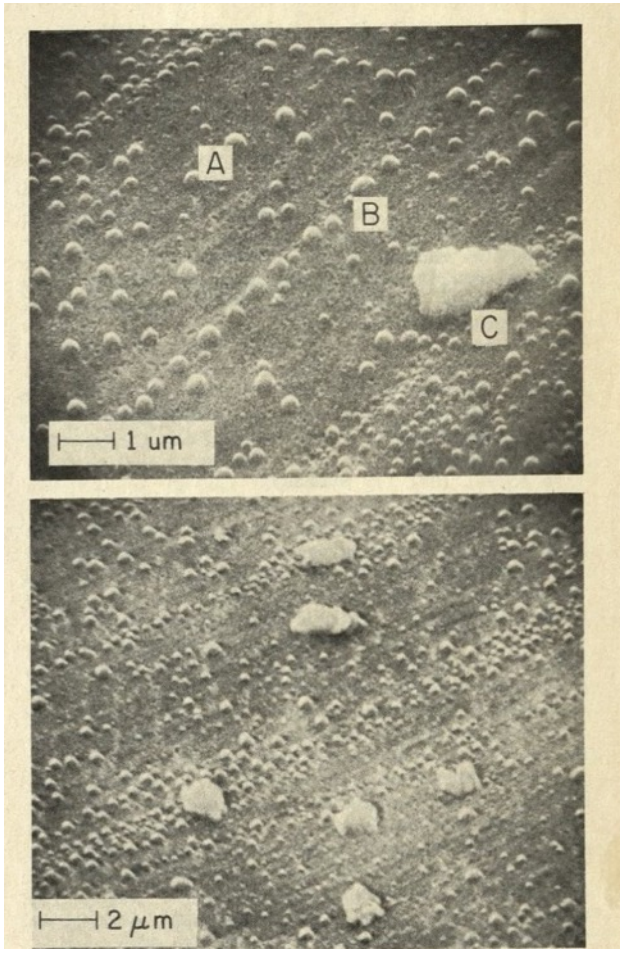


Airborne Measurements

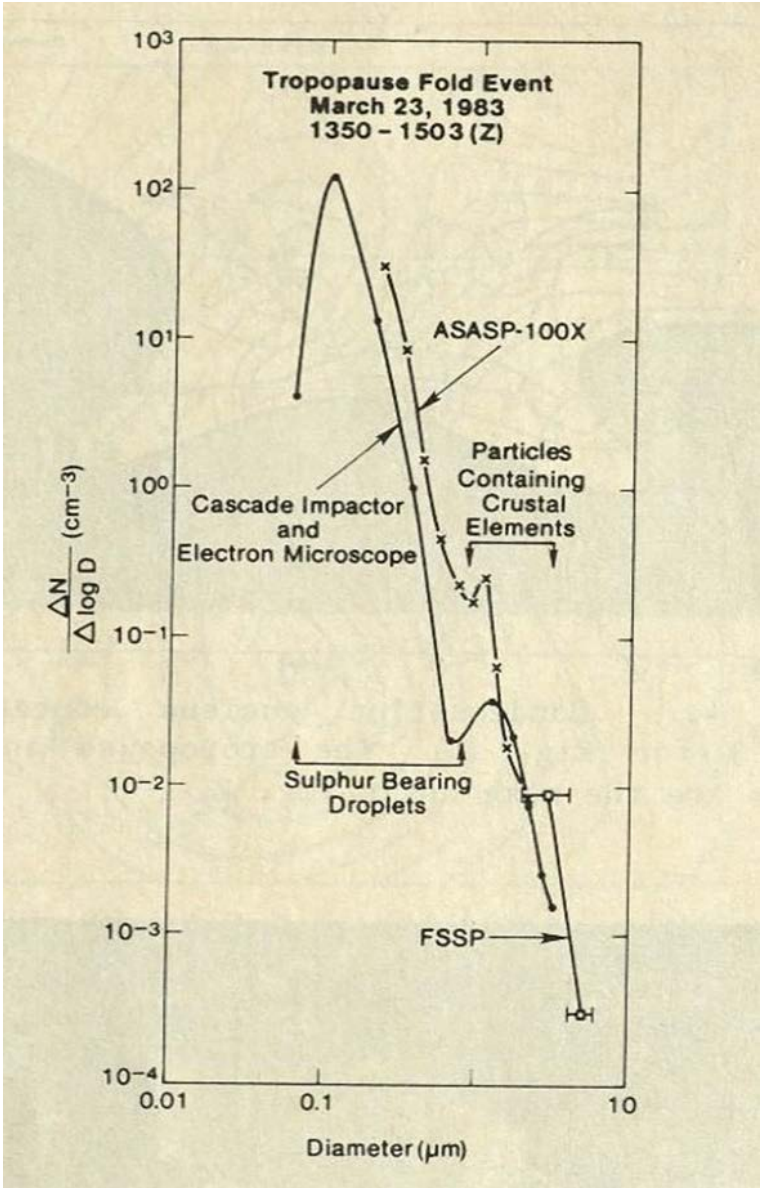


Pinatubo aerosol took longer to fall out in the Arctic than at a sub-tropical latitude.

El Chichon Debris in the Arctic Stratosphere, One Year Post Eruption

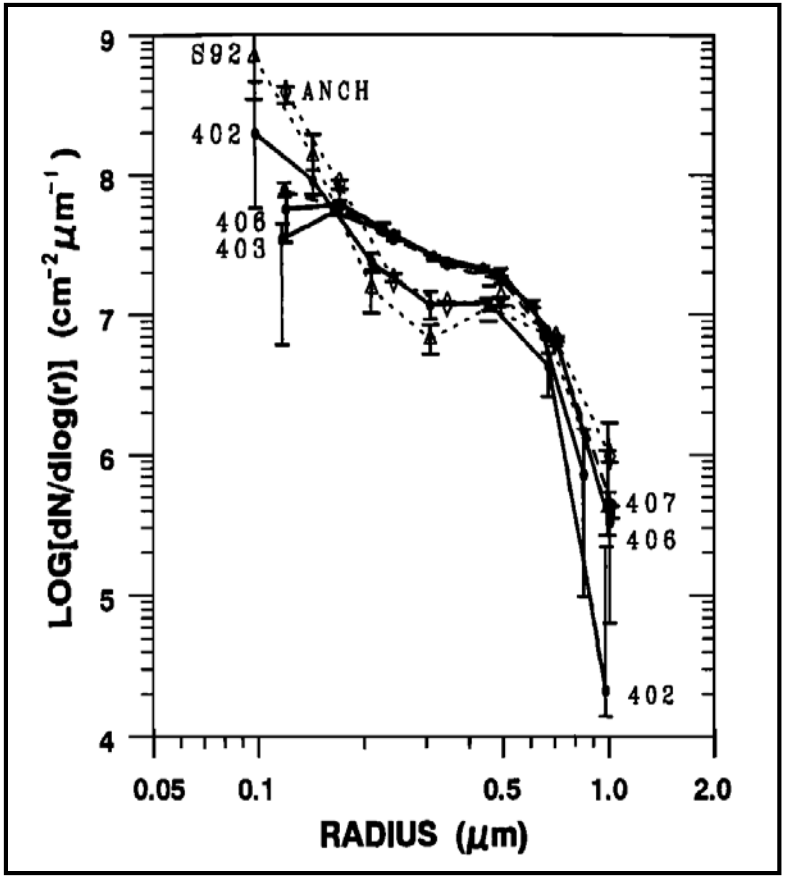


El Chichon crustal material and H_2SO_4 droplets in the Arctic stratosphere, March 23, 1983.

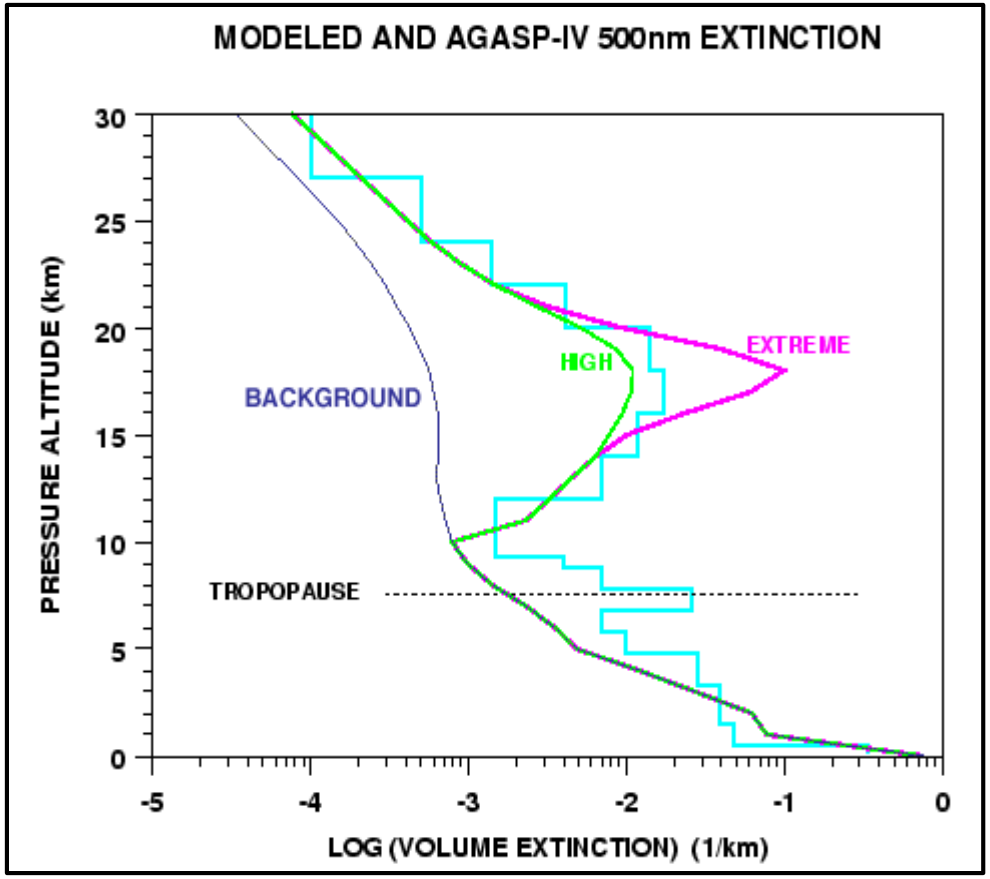


El Chichon aerosol size spectra from 6786 particle sizes measured on Nucleopore filters with an electron microscope and with ASAP-100X and FSSP NOAA WP-3D wing mounted probes. (Shapiro et al., 1984, *G.R.L., 11*, 421-424.)

Measured and Modeled Extinction and Aerosol Size Distributions Derived from Airborne Optical Depth Data

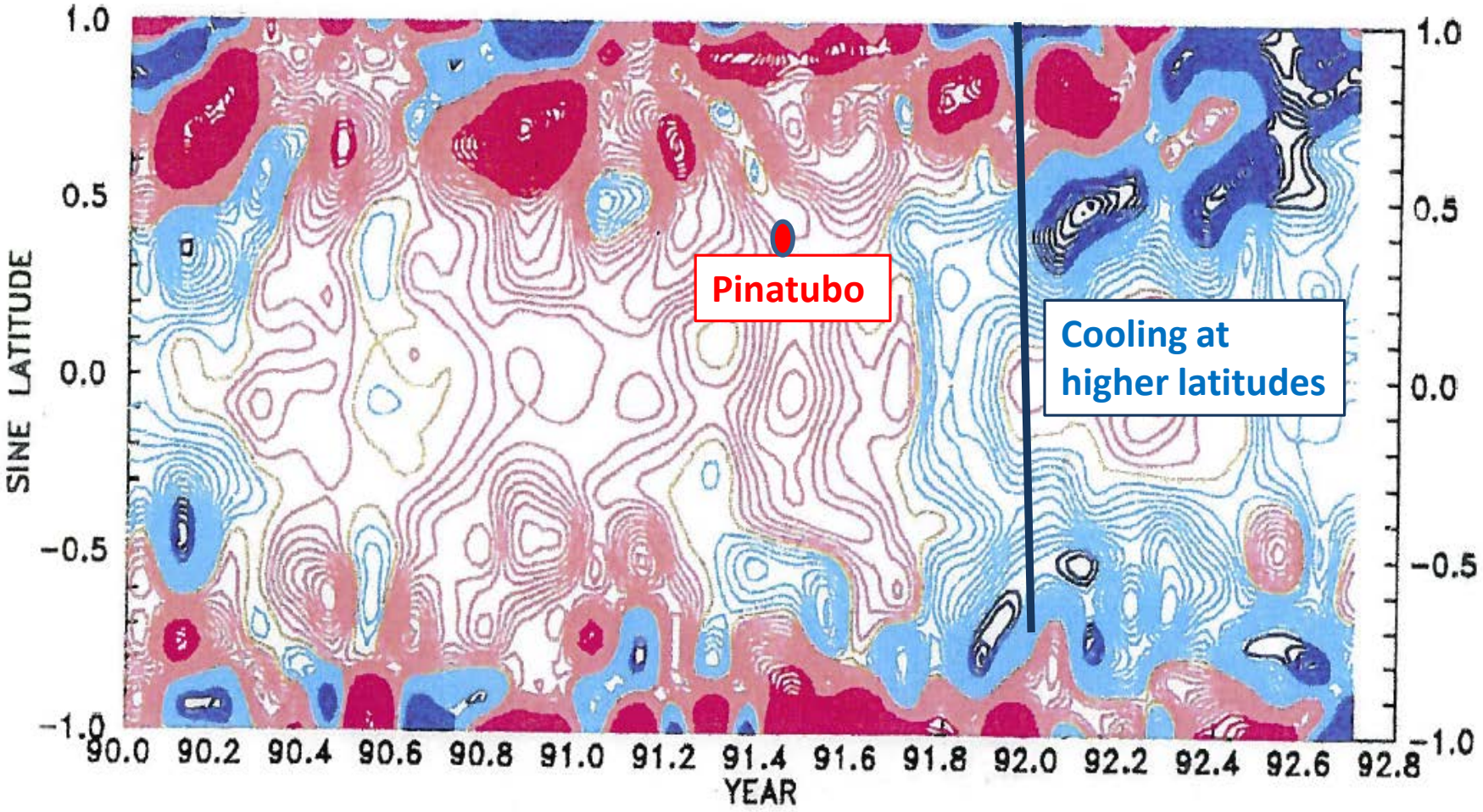


Effective aerosols size distributions inferred from the optical depths for WP-3D flights in the U.S. Arctic sector, March-April 1992.



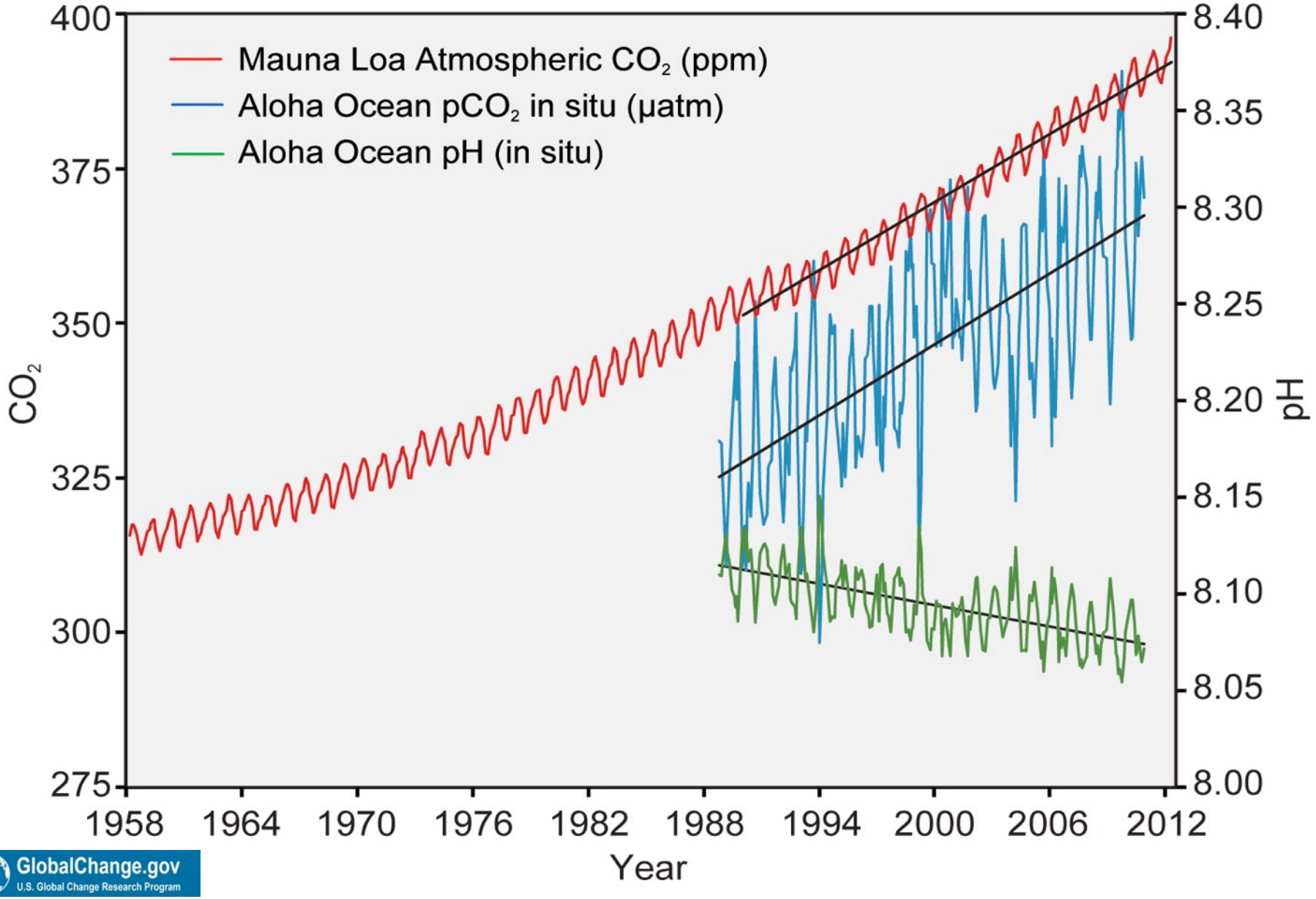
Measured volume extinction on April **11,1992 (blue line)** compared to models from LOWTRAN 7 with tropopause height on that day for reference.

Atmospheric Cooling from Pinatubo Aerosols



Zonal mean MSU temperature anomalies. **Pink and red** areas are above the 10-year average and the **light and dark blue** areas are below average. Contour level is 0.05^0C. By September 1991 the global and northern hemisphere temperatures had decreased by $0.5\ ^0$C and 0.7^0C respectively. (Dutton and Christy,1992, *G.R.L. 19,* 23, 213-2316).

Oceans Absorb CO_2 and Become Acidic



GlobalChange.gov
U.S. Global Change Research Program

Summary

- Aerosol effects on solar radiation from volcanic effluents have been well document by NOAA in the sub-tropics and Arctic.
- These data are readily available, but have rarely been utilized in models used to predict stratospheric geoengineering effects.
- Even if atmospheric temperatures could be stabilized by the geoengineering proposals being put forward, the effects on stratospheric chemistry and cloud nucleation must be better understood.
- Even if stratospheric geoengineering was able to turn down the thermostat, greenhouse gases must still be controlled, because:
- Ocean acidification will still be a problem with dire consequences for marine life as we know it.

Conclusion

"Political economy suggests that geoengineering is likely to be used, and certain to be contentious" ***(The Economist, A Hot Mess, April 27, 2019, pg. 66).***

Volcanic Aerosols Affect Sunlight On Earth