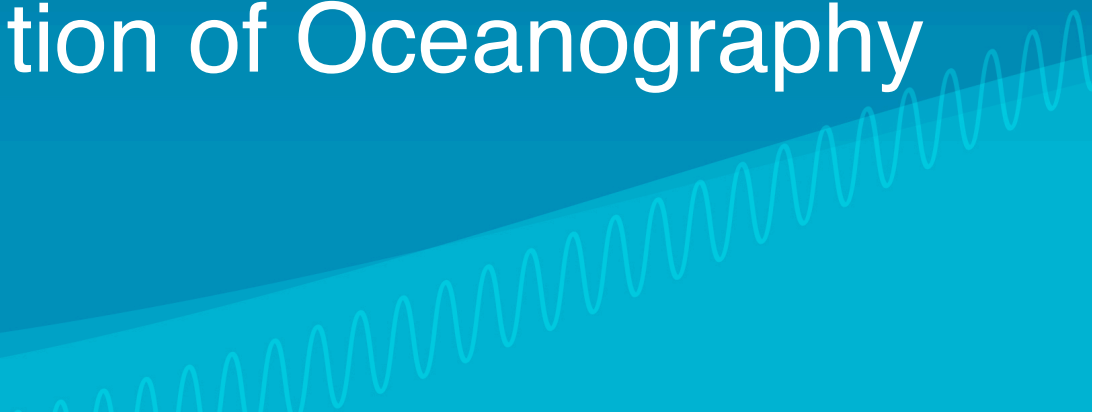


"Lessons from Mauna Loa: On the value
of continuous time series."

Ralph Keeling
Scripps Institution of Oceanography



IGY CO₂ Program

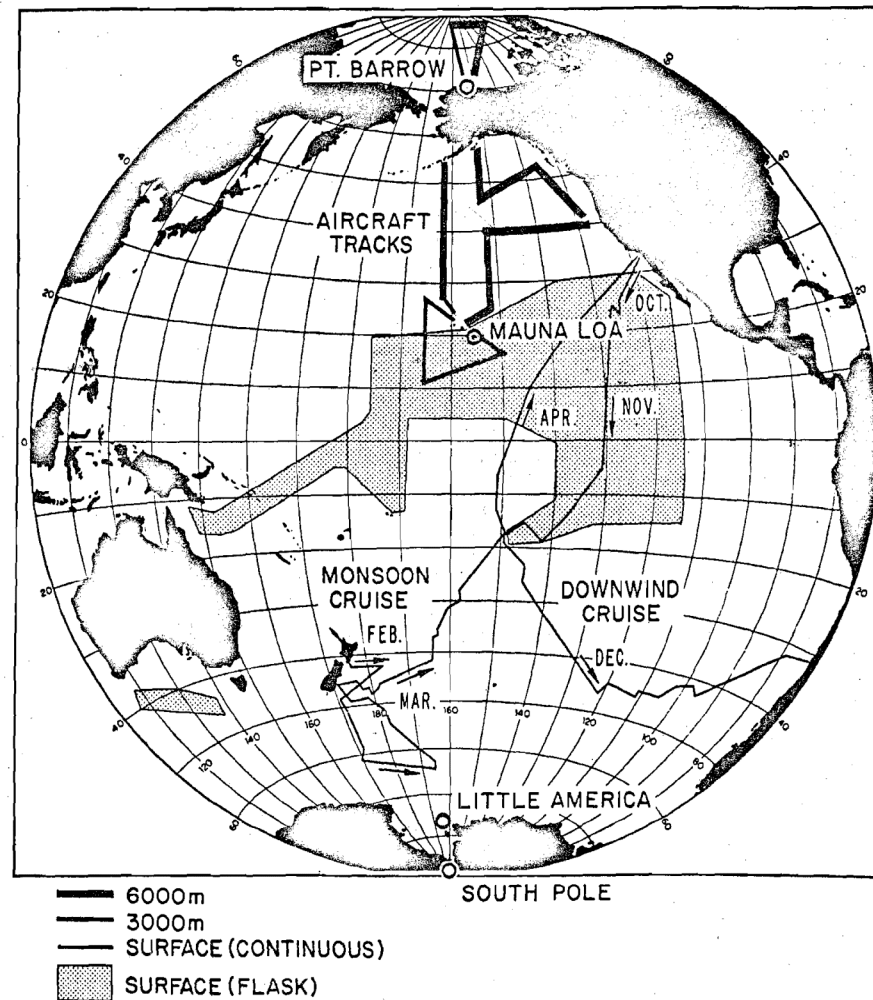
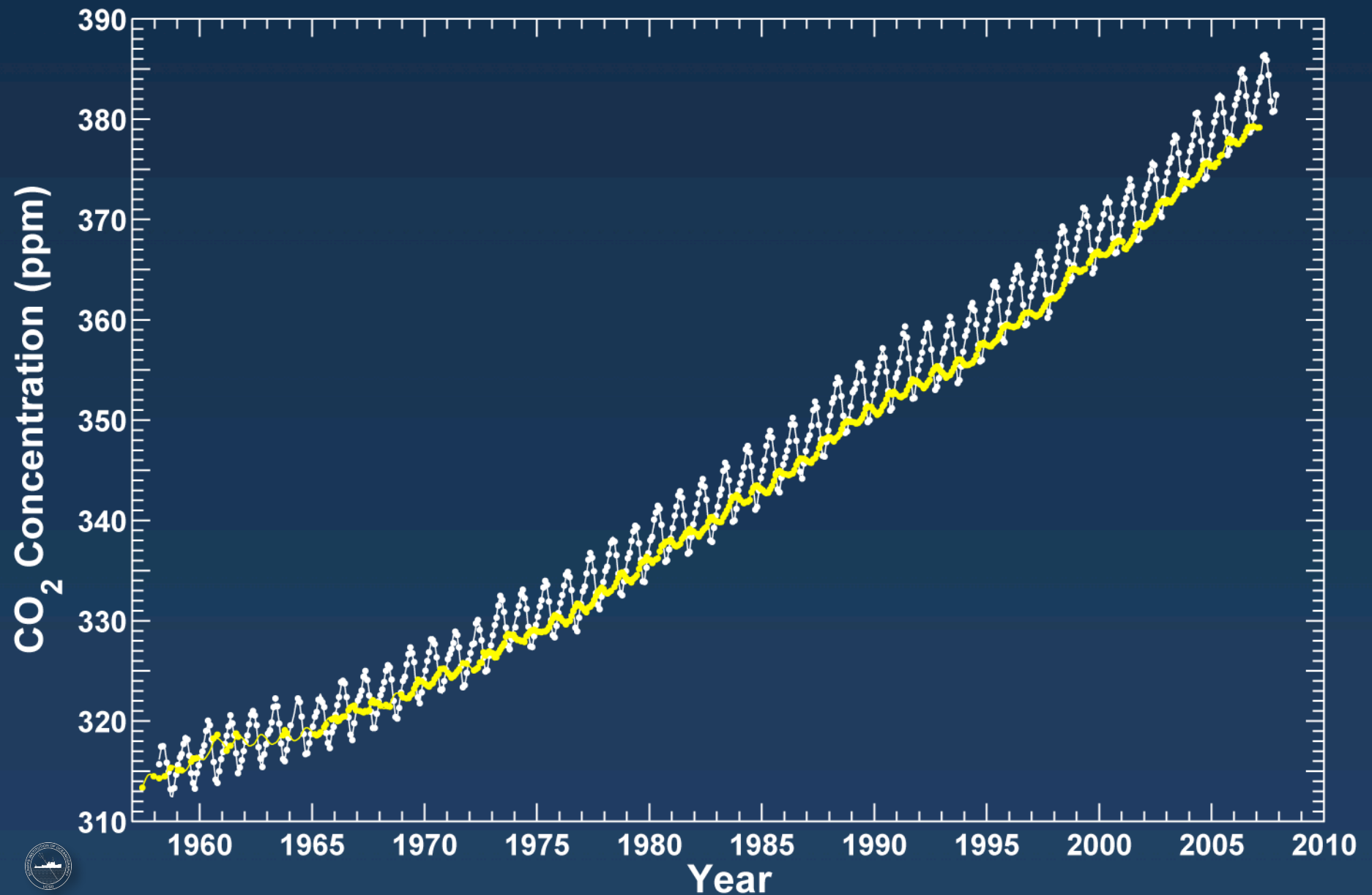


Fig. 1. Location of stations and tracks for sampling atmospheric CO₂. Location for surface flask sampling, except Downwind and Monsoon cruises, is highly generalized. Indian Ocean is not shown.

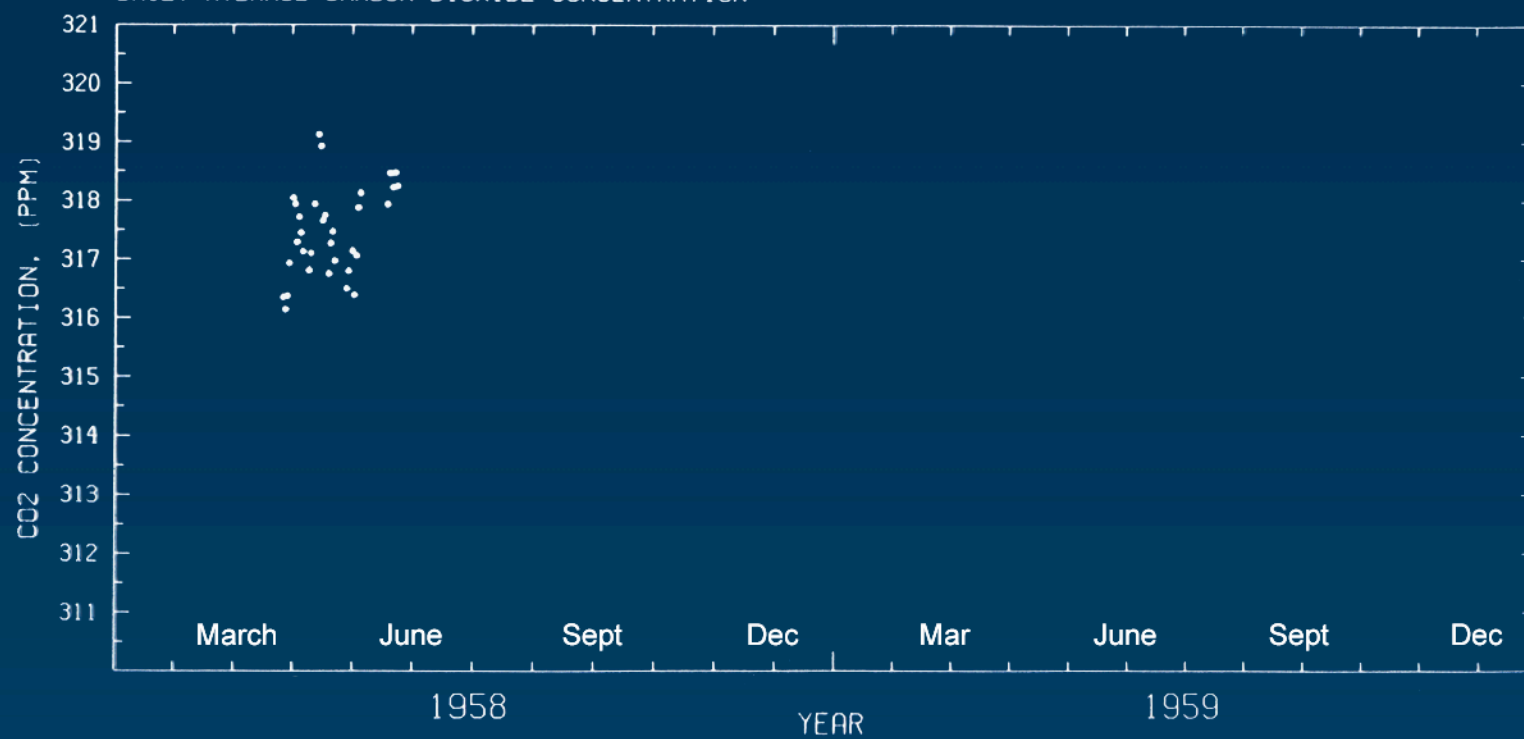


Mauna Loa and South Pole Records



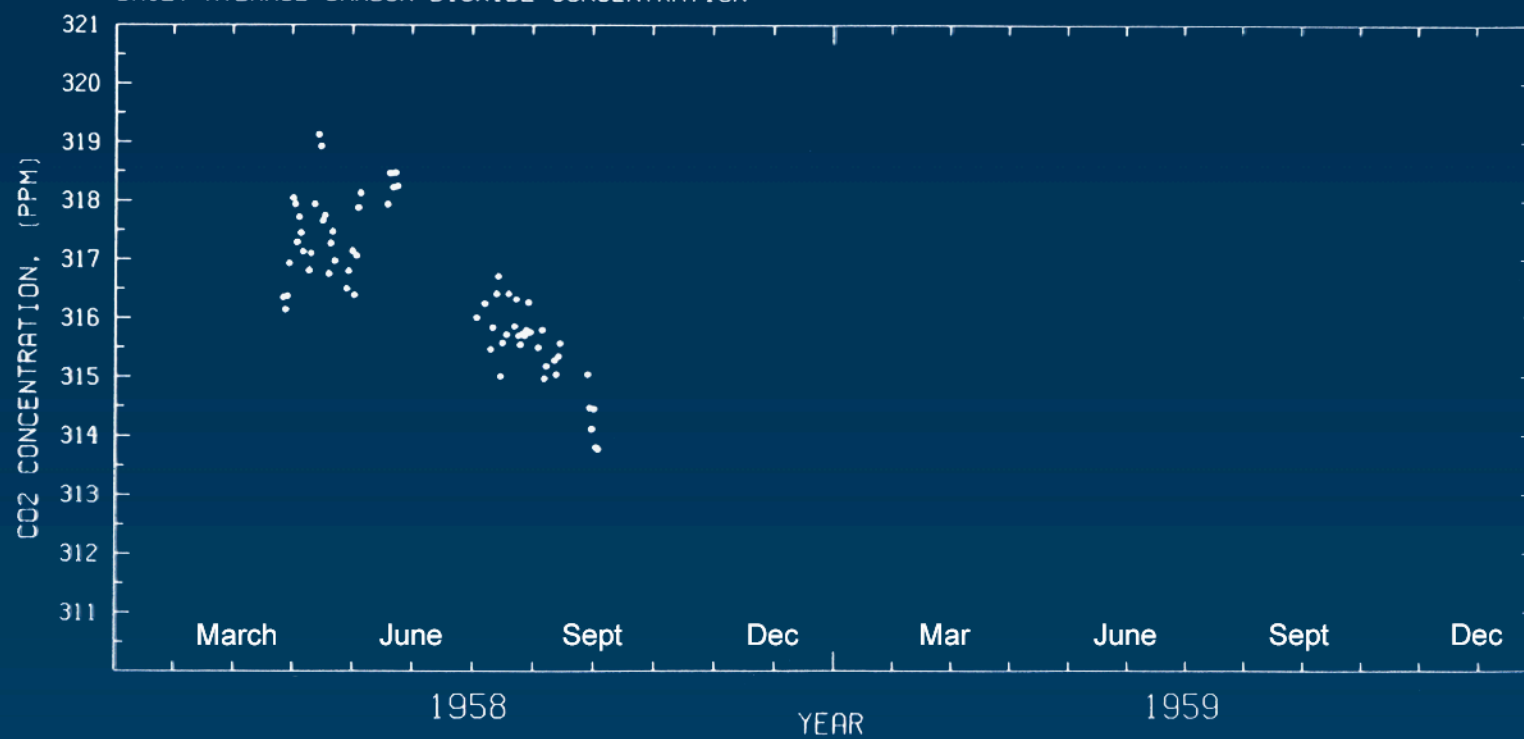
MAUNA LOA OBSERVATORY, 1958-59

DAILY AVERAGE CARBON DIOXIDE CONCENTRATION

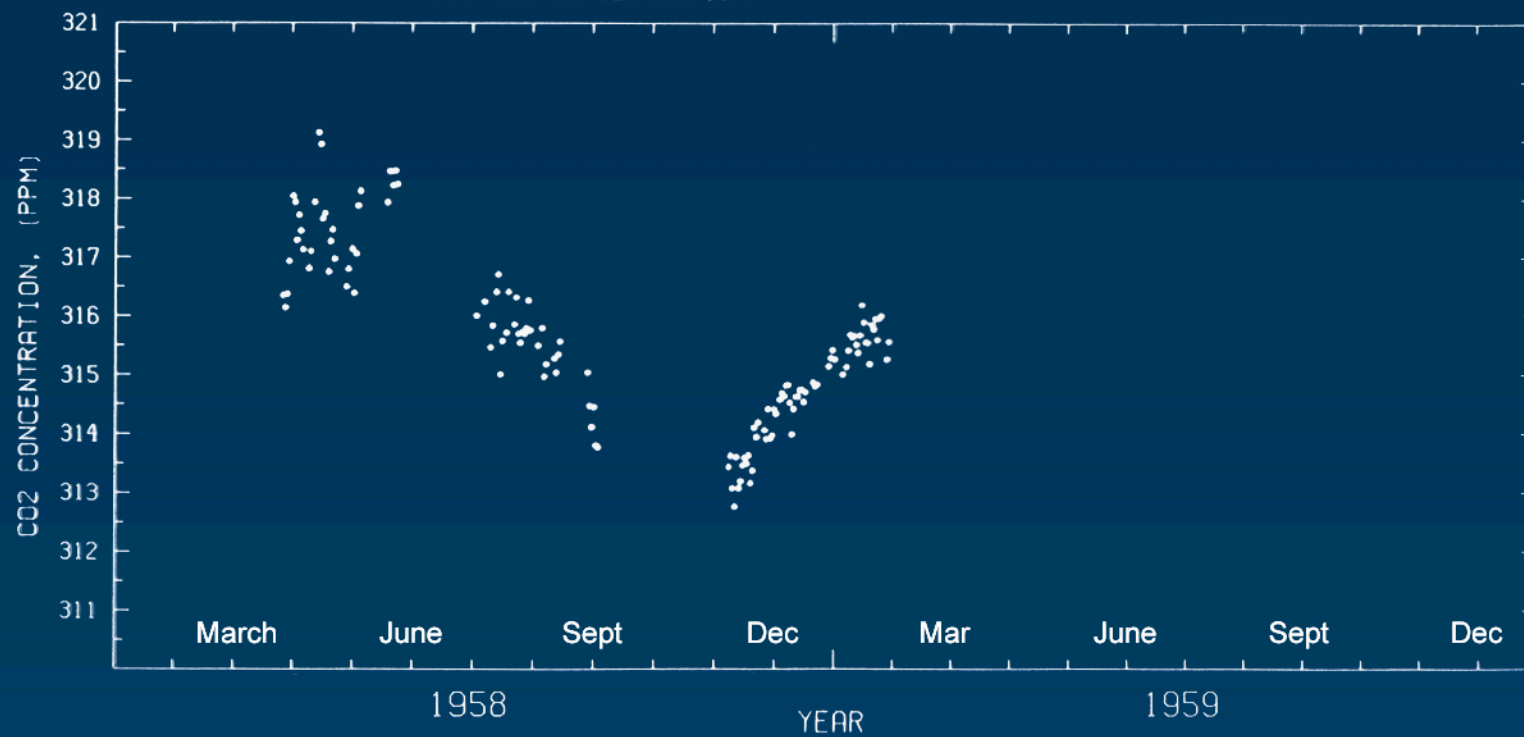


MAUNA LOA OBSERVATORY, 1958-59

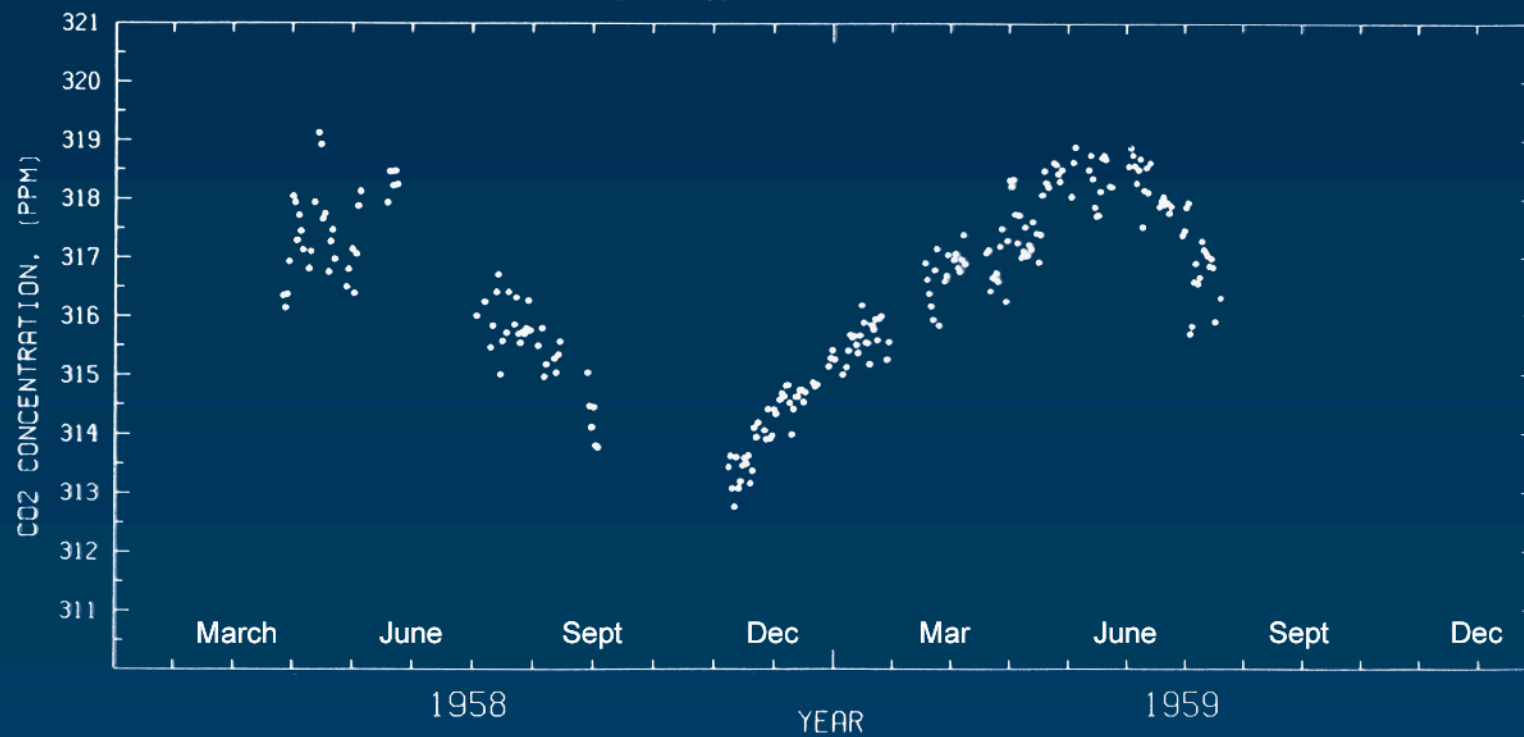
DAILY AVERAGE CARBON DIOXIDE CONCENTRATION



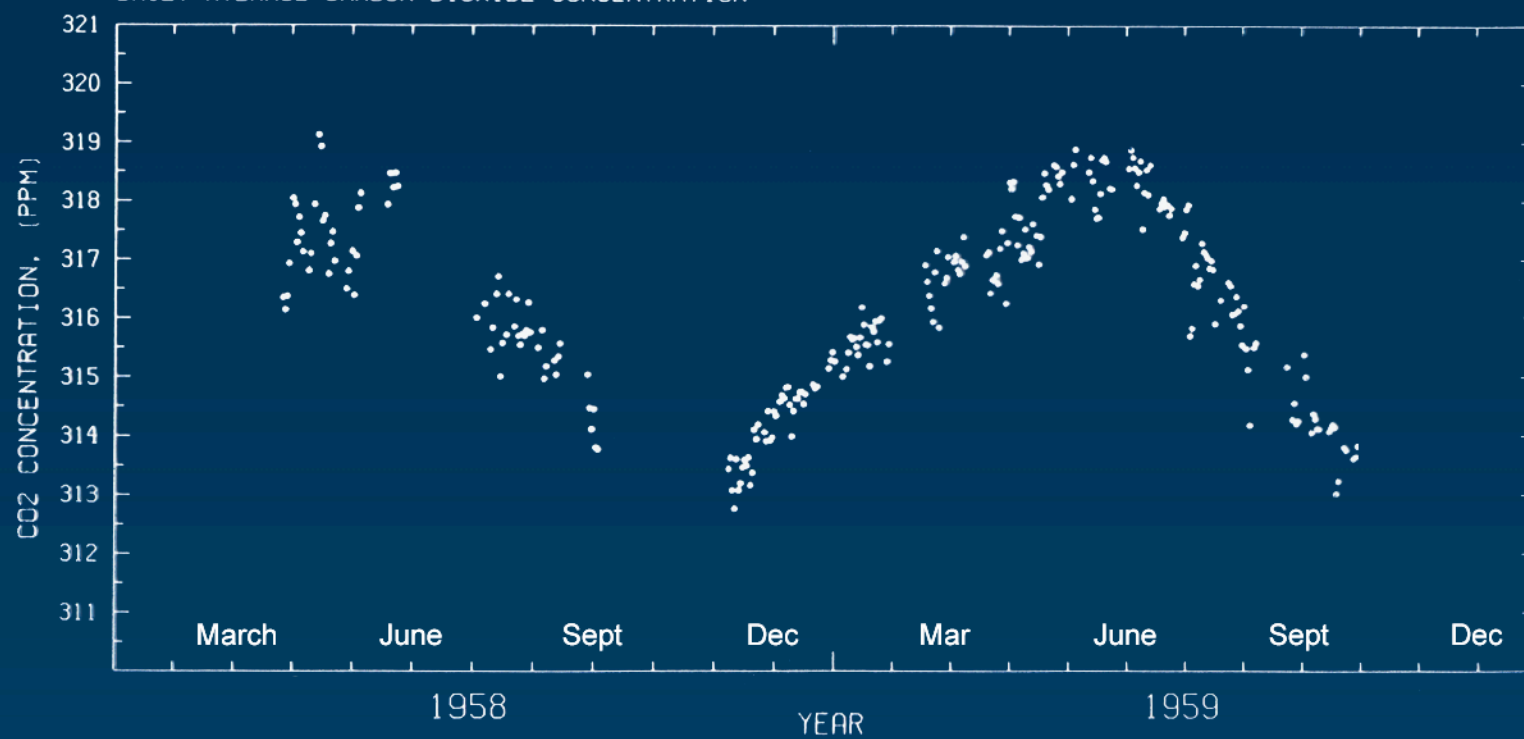
MAUNA LOA OBSERVATORY, 1958-59
DAILY AVERAGE CARBON DIOXIDE CONCENTRATION



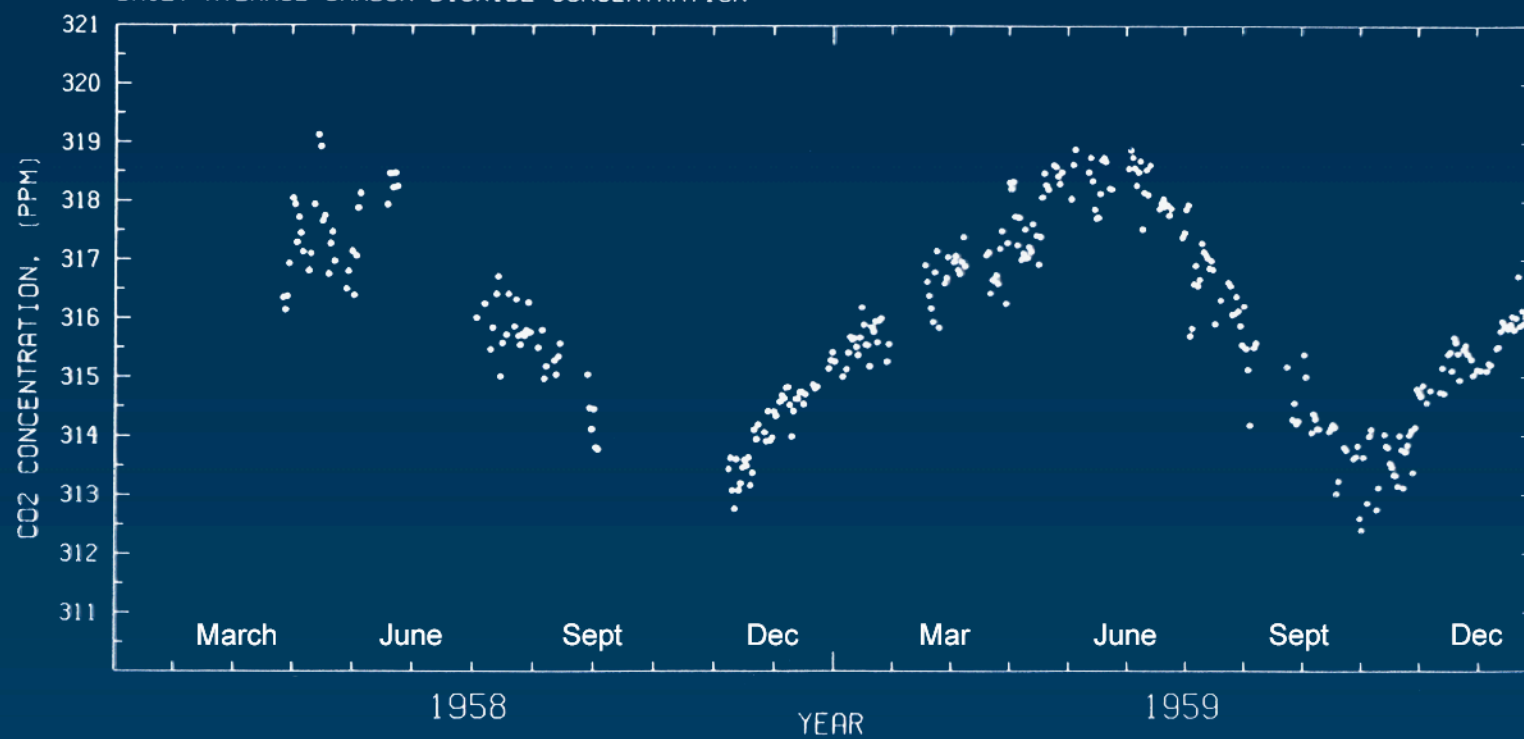
MAUNA LOA OBSERVATORY, 1958-59
DAILY AVERAGE CARBON DIOXIDE CONCENTRATION



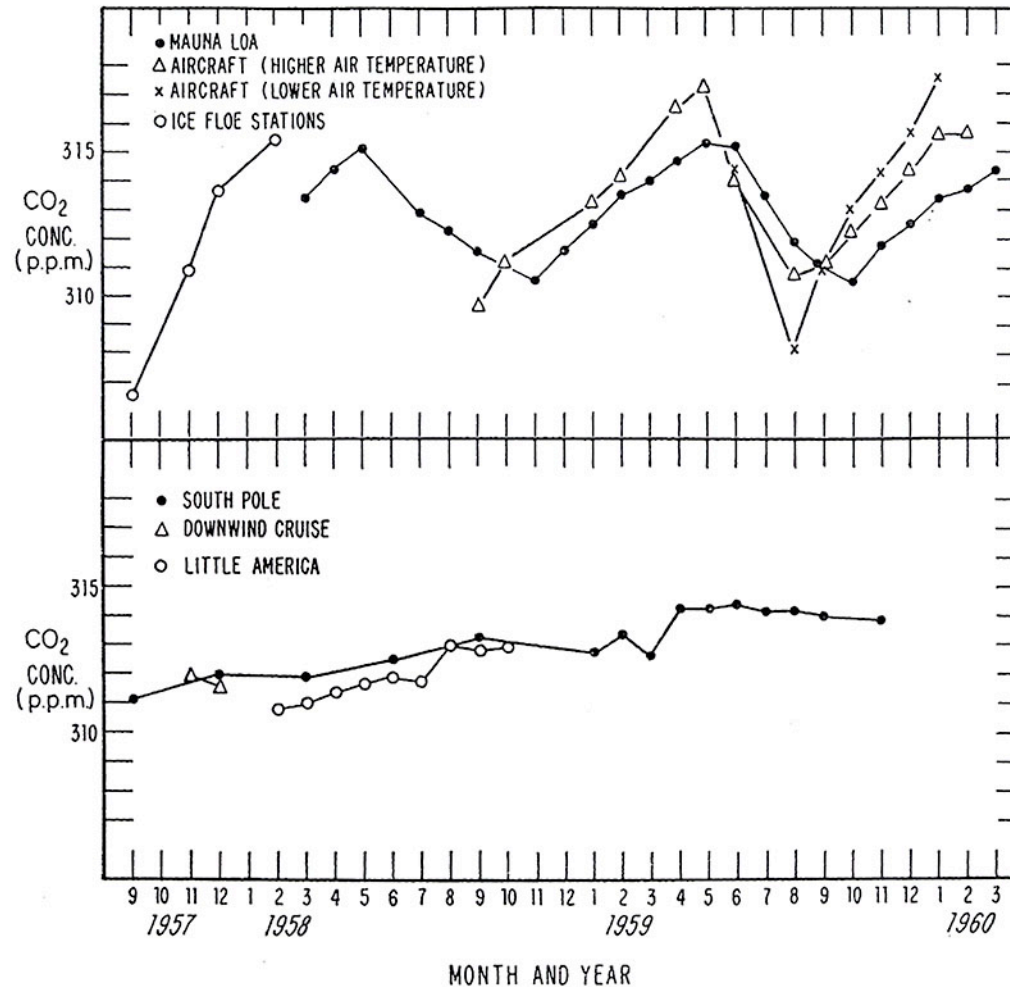
MAUNA LOA OBSERVATORY, 1958-59
DAILY AVERAGE CARBON DIOXIDE CONCENTRATION



MAUNA LOA OBSERVATORY, 1958-59
DAILY AVERAGE CARBON DIOXIDE CONCENTRATION



Keeling 1960 Tellus Publication



Pales, J.C. and Keeling, C.D., 1965. Concentration of Atmospheric Carbon Dioxide in Hawaii. *Journal of Geophysical Research*, 70: 6053-6076.

Brown, C.W. and Keeling, C.D., 1965. Concentration of Atmospheric Carbon Dioxide in Antarctica. *Journal of Geophysical Research*, 70, 6077-6085

Revelle, R., Broecker, W., Craig, H., Keeling, C.D. and Smagorinsky, J., 1965. Atmospheric Carbon Dioxide, Report of the Environmental Pollution Panel President's Advisory Committee, November 1965. The White House, pp. 111-133.



Charles D. Keeling in 2005:

“When I began to measure atmospheric carbon dioxide and carbon in ocean water, just 50 years ago this year, my work was praised for showing more precisely than earlier studies how carbon was distributed in nature.”

“When I persisted in making measurements of the same kind because I found the results interesting as pure knowledge, I was supported by program managers of science - up to a point. This point was reached in 1972, after 17 years of my studies.”

¹On the acceptance of the Tyler Environmental Prize in 2005



Charles D. Keeling quote:

“At this juncture in my career I was told explicitly that a line needed to be drawn between what part of my work constituted basic research and what part was not basic research because it was routine monitoring”.



Charles D. Keeling quote:

“The repetitive measurements of my program, even while I was attempting to improve them, I was told, should be relinquished to a government agency assigned responsibility for such measurements and even for where they should be made.”

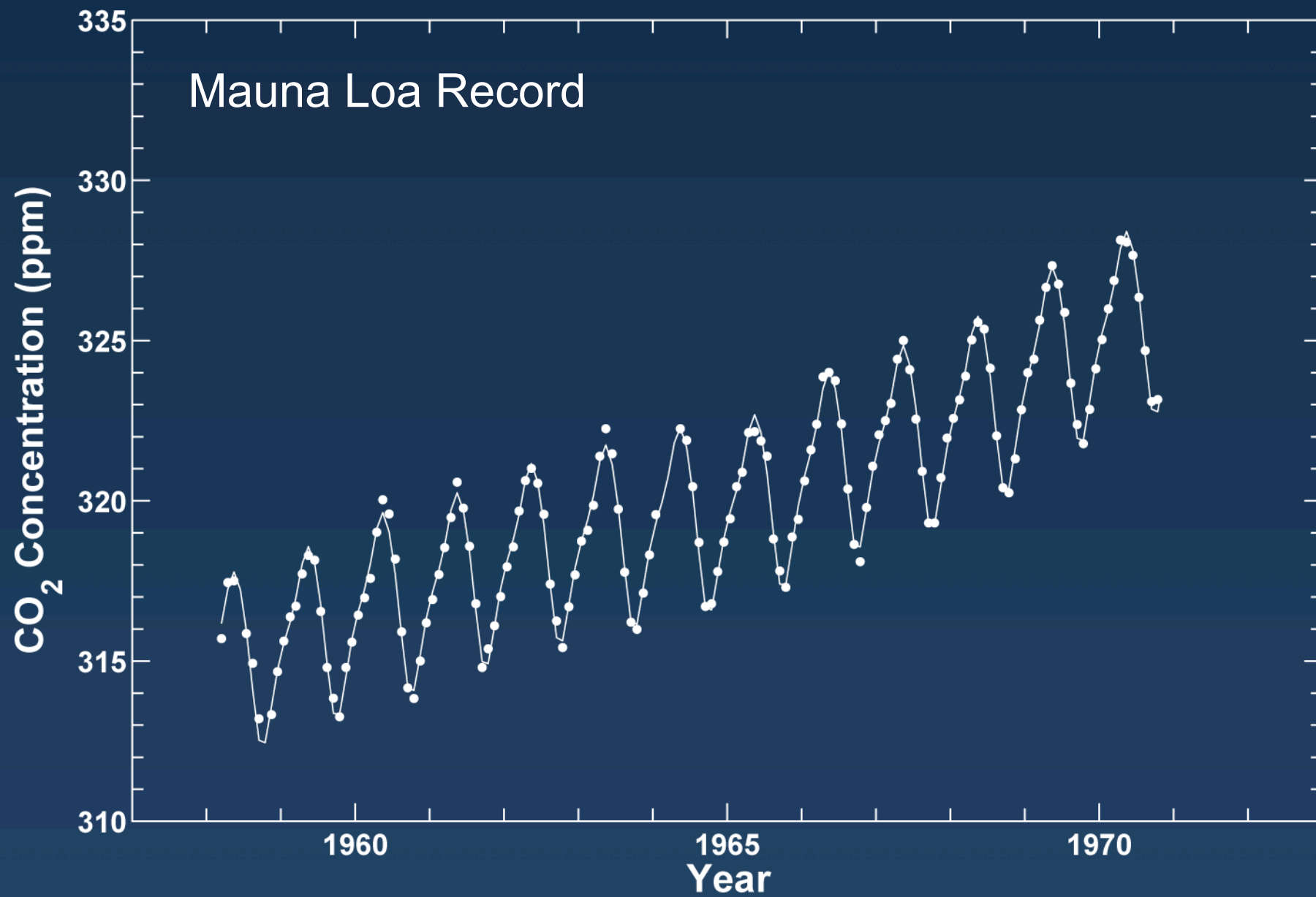


The argument for terminating Scripps program
hinged on two assumptions:

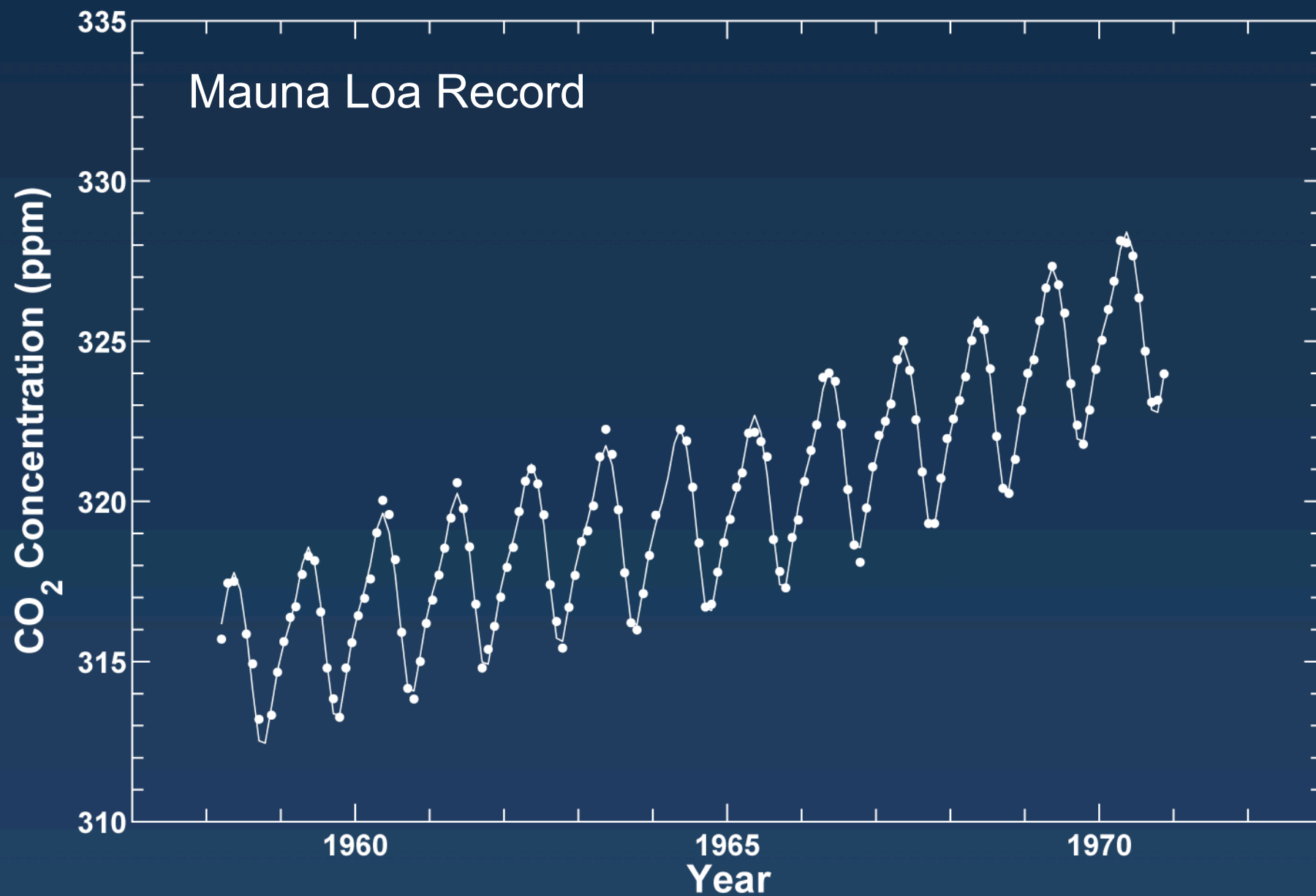
- (1) The effort was dominated by the task of
making repetitive measurements.
- (2) Repetitive measurements necessarily fall
outside the scope of basic scientific research.



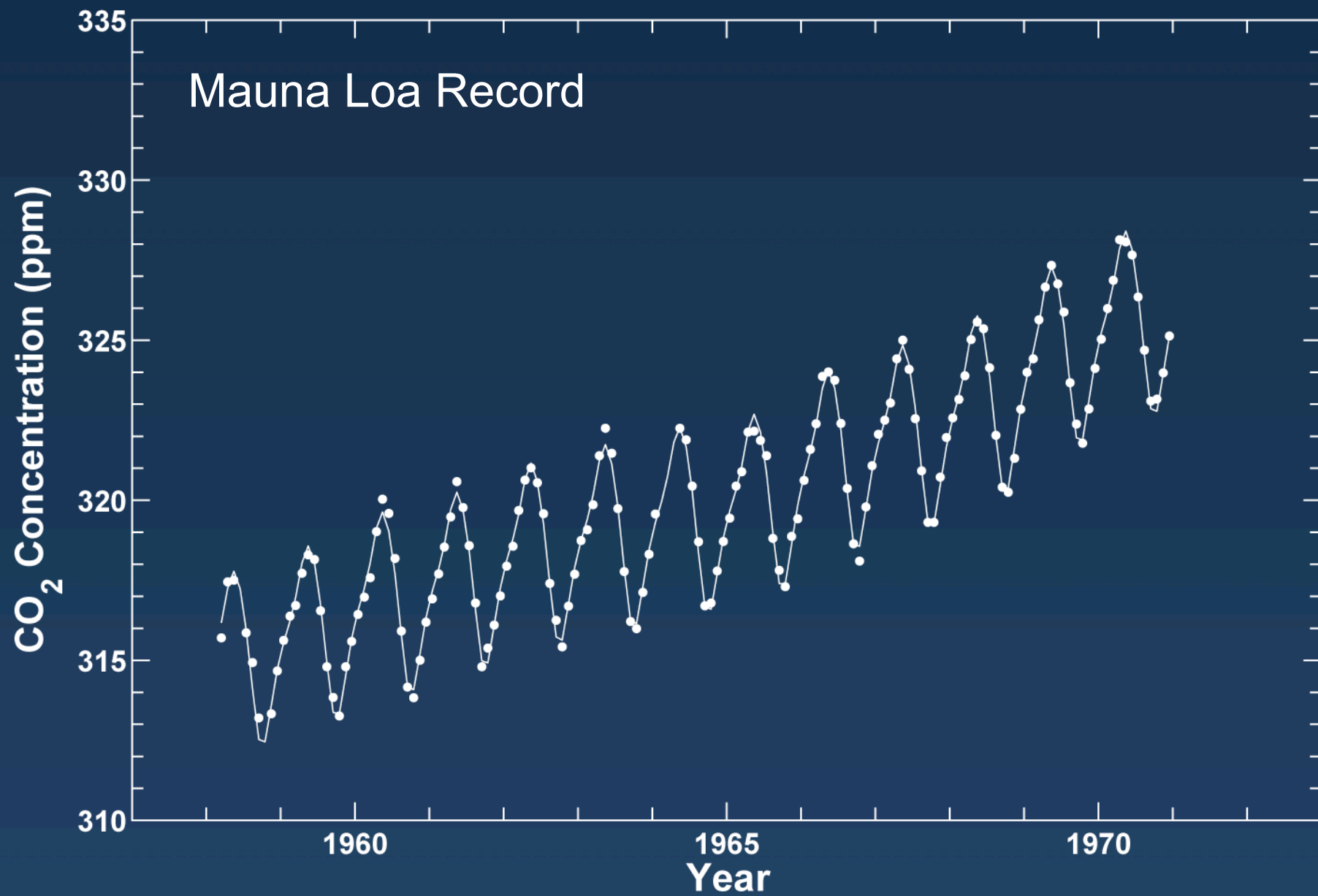
Mauna Loa Record



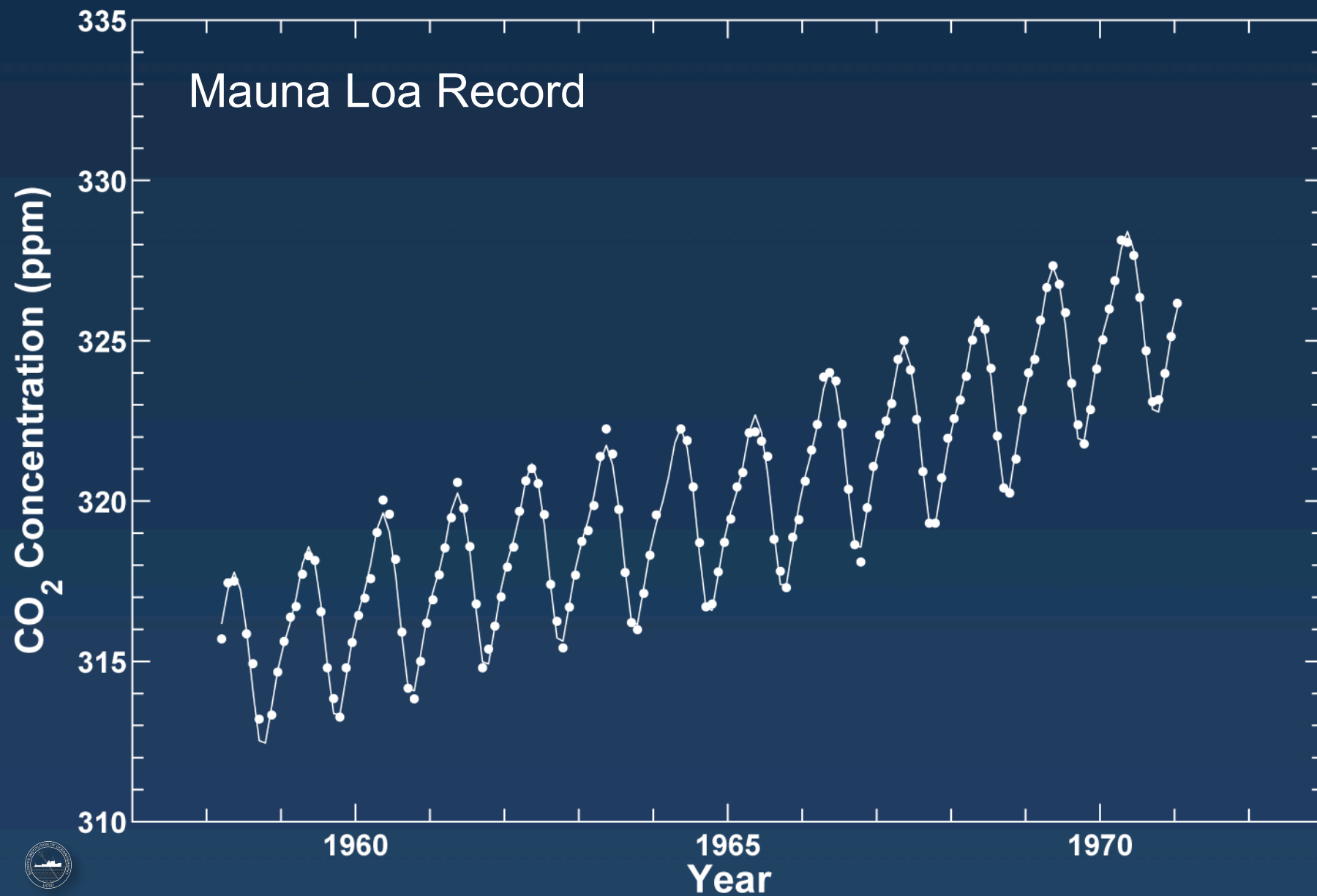
Mauna Loa Record



Mauna Loa Record

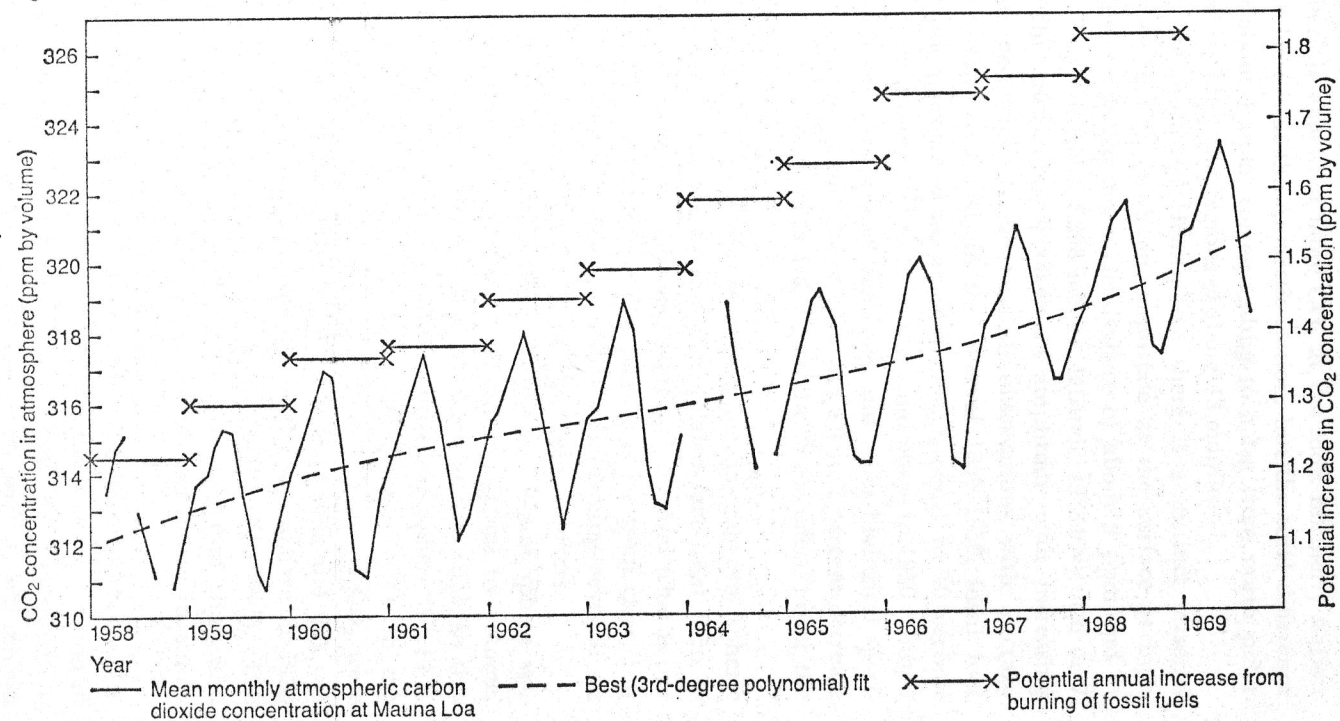


Mauna Loa Record



The Airborne Fraction, as of 1970

Figure 1.2 CO₂ Concentration from Burning of Fossil Fuels



Sources: Monthly (Pales and Keeling, 1965), (Bainbridge, 1970); Best fit (Cotten, 1970); Annual increase (United Nations, *World Energy Supplies*)

From: "Man's Impact on the Global Environment", 1970, report of the Study of Critical Environmental Problems (SCEP).



Addressing systematic errors

Manometry - 1959/1961, 1970, 1974.

Revision of estimated CO₂ rise rate.

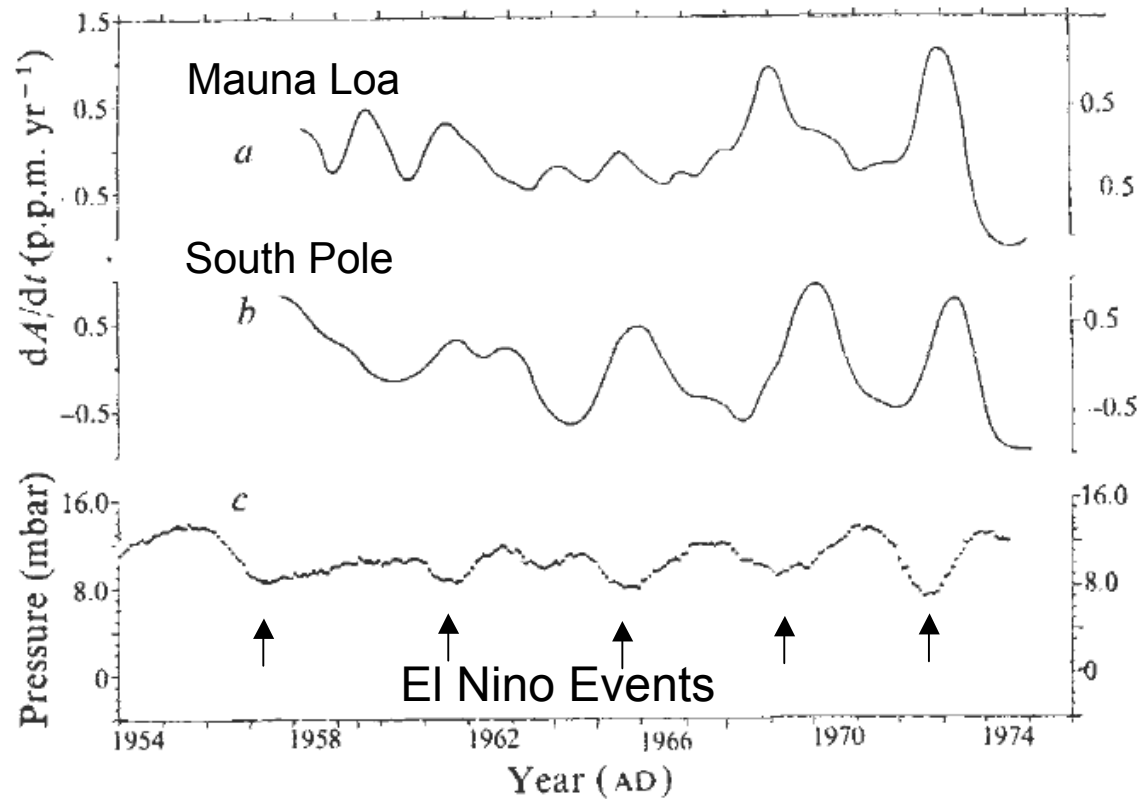
Carrier gas effect, discovered ~1972

Revision of absolute CO₂ values of ~+3 ppm

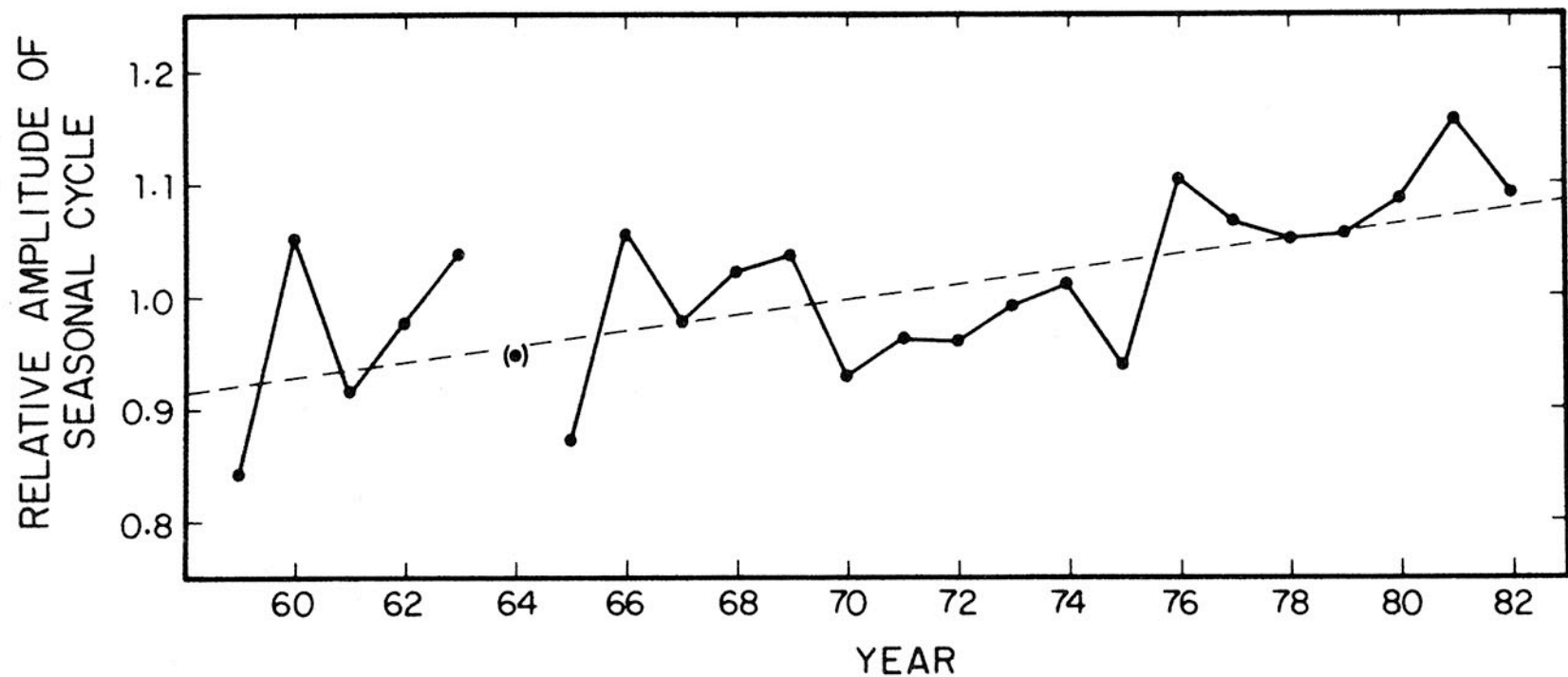


Discovery CO₂ of El Niño connection

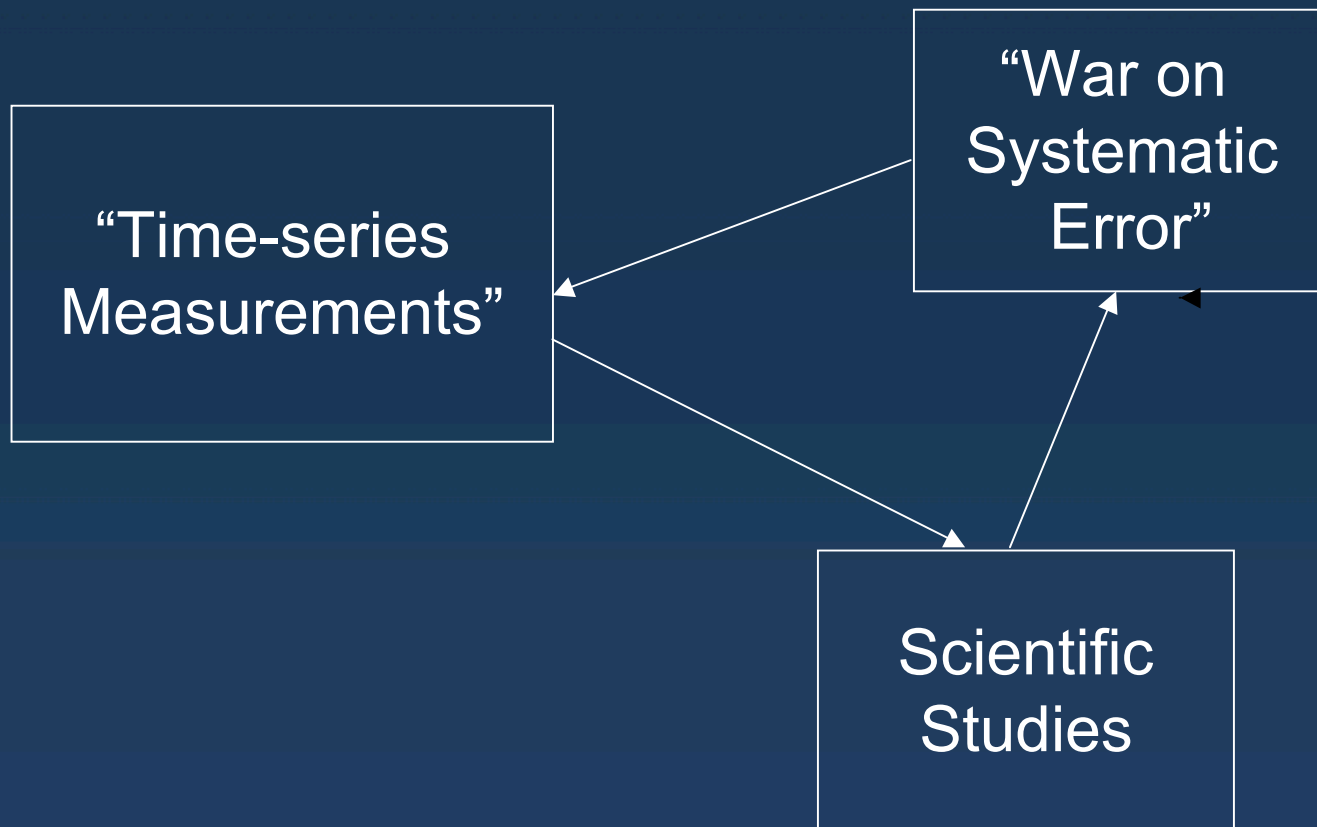
Bacastow, R.B., 1976. Nature, 261pages 116-118.



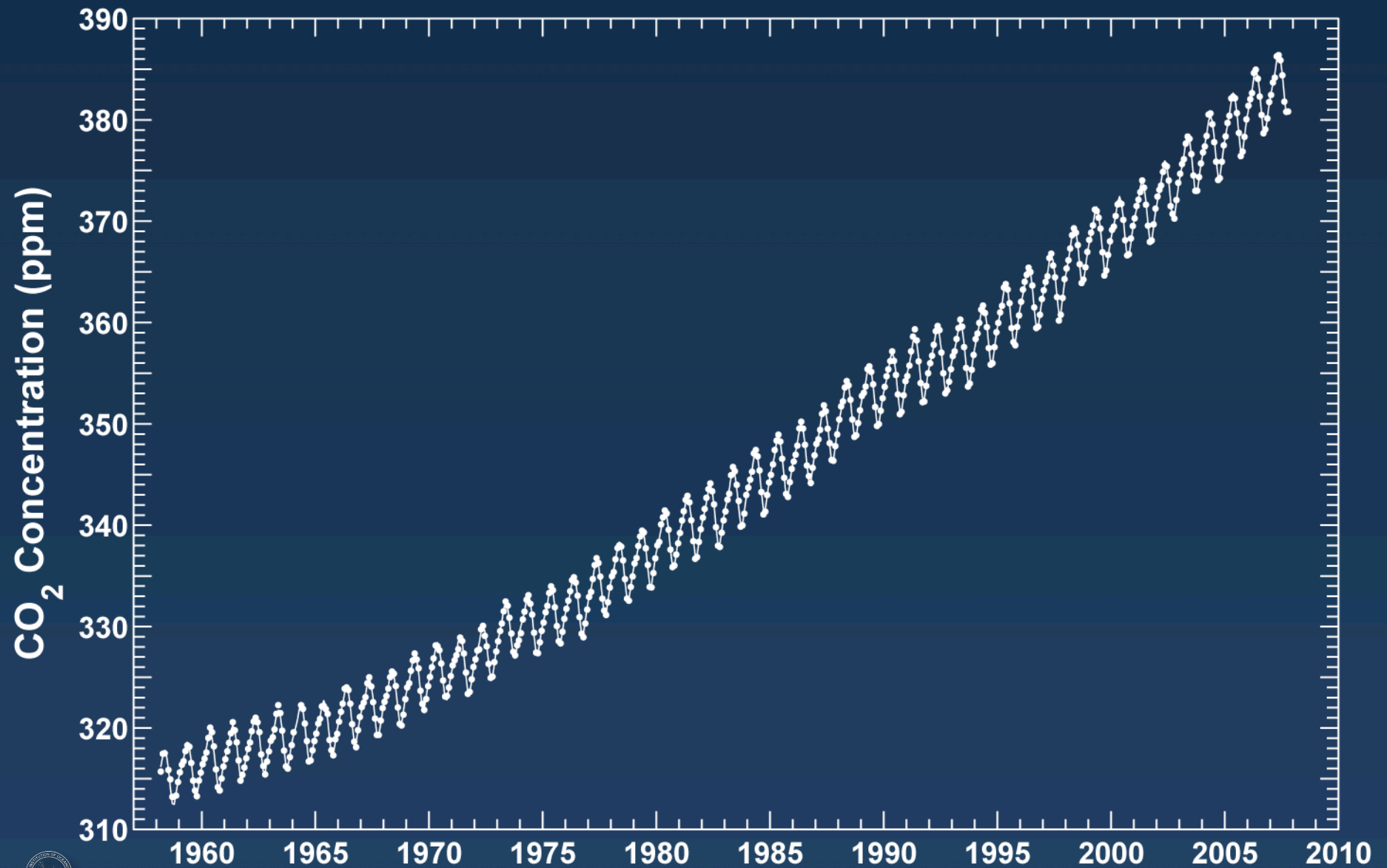
Changes in Seasonal Amplitude



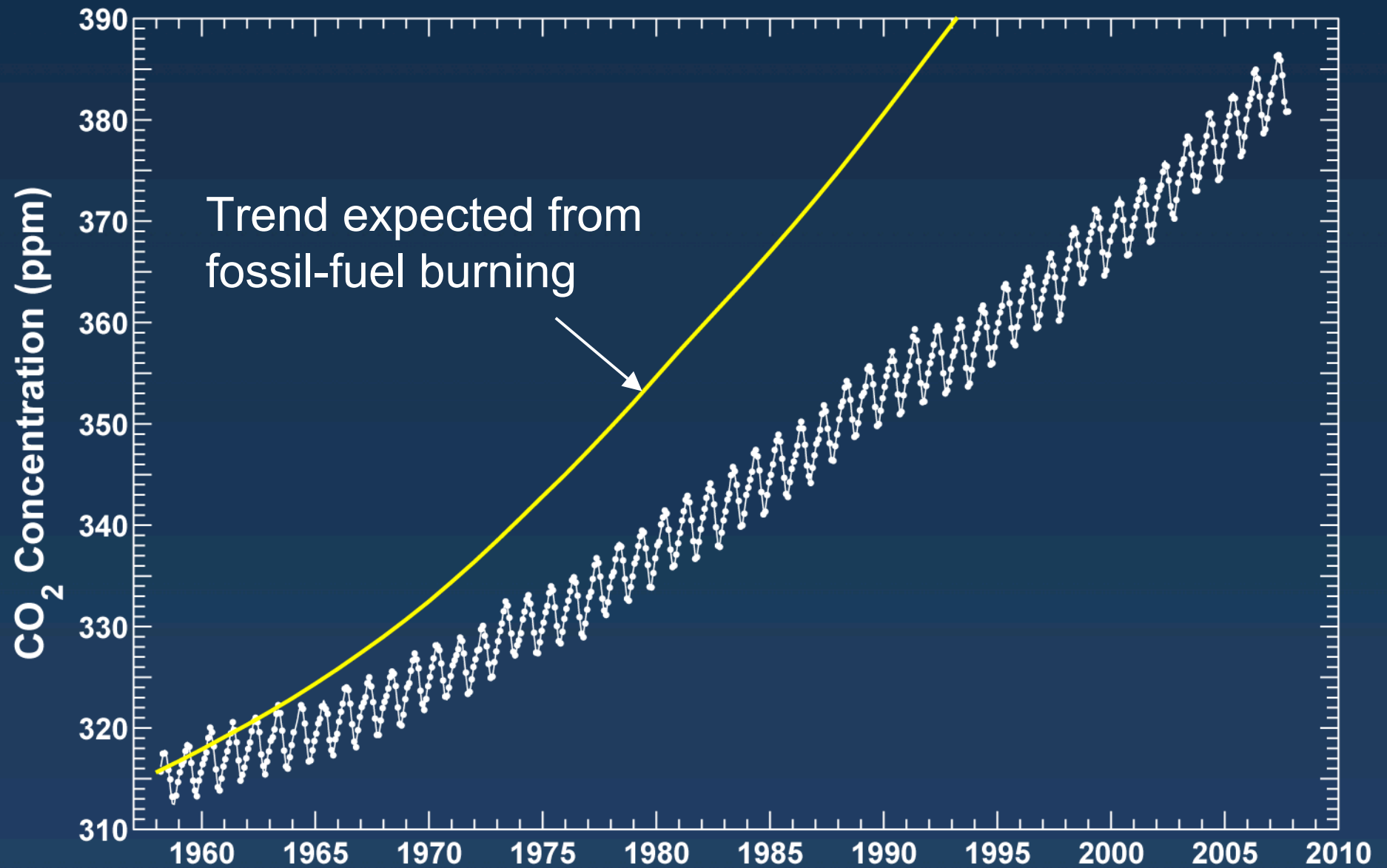
Elements of CO₂ program



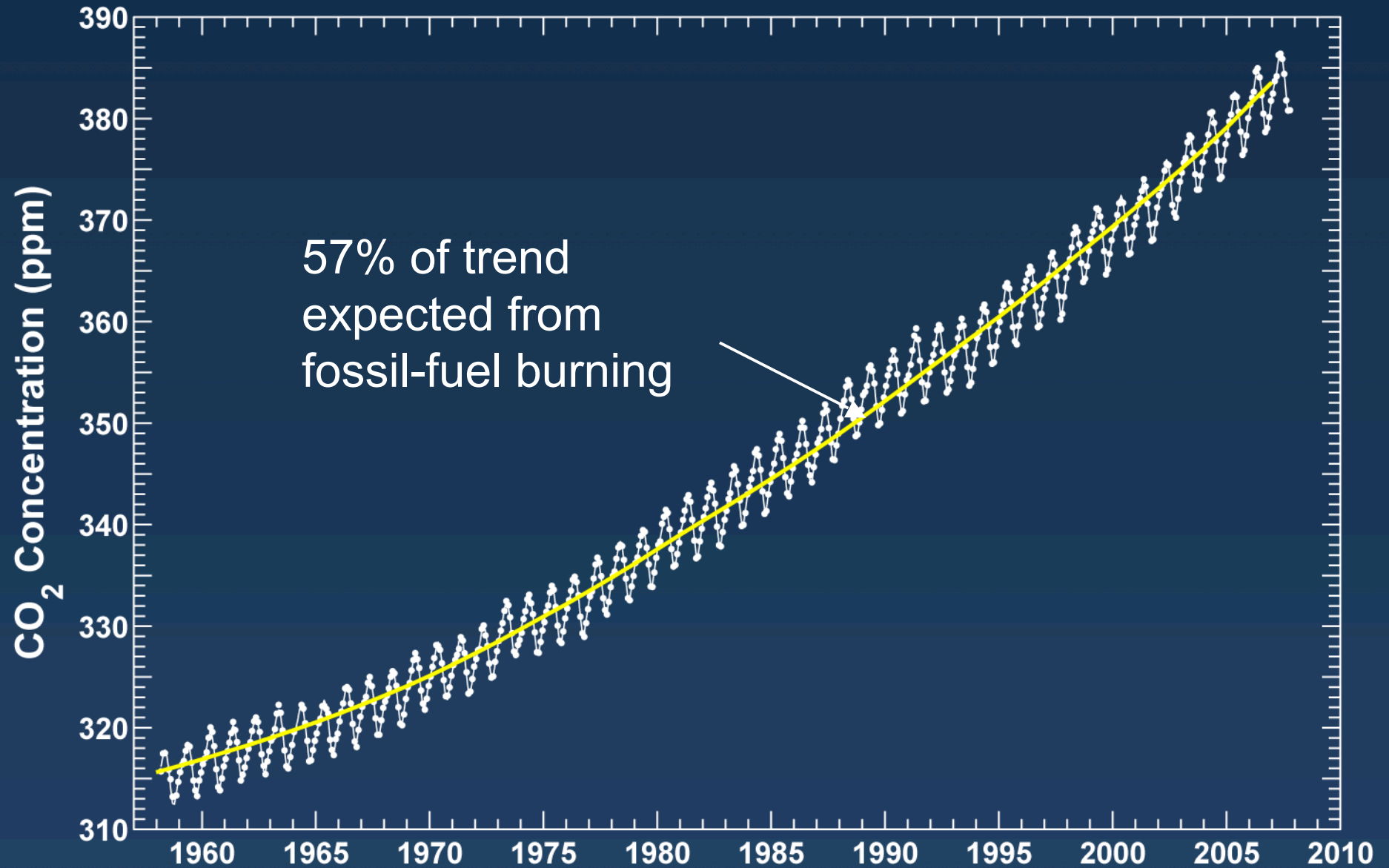
Mauna Loa Record



Mauna Loa Record



Mauna Loa Record

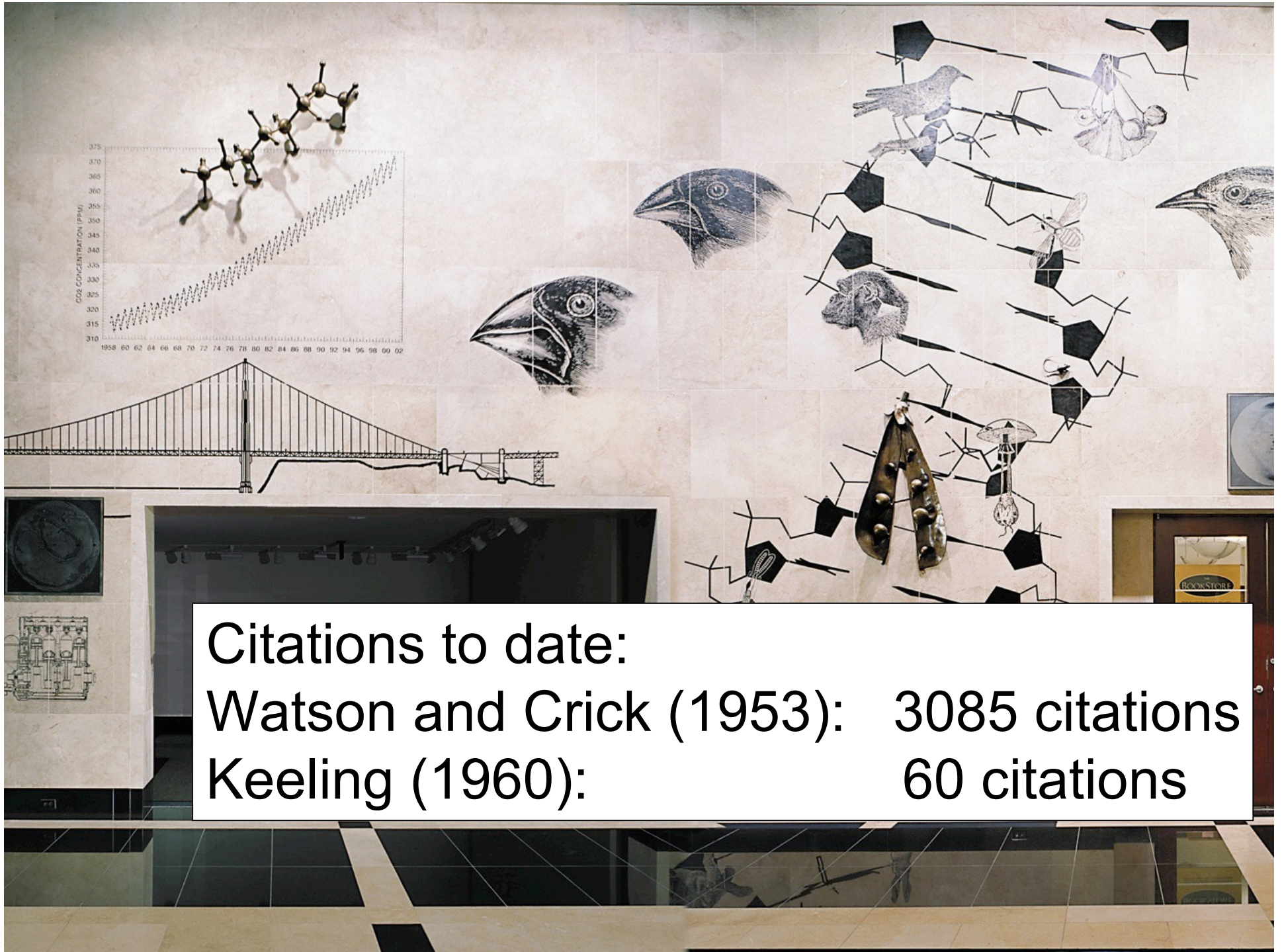


A Few Lessons:

- (1) For Mauna Loa record, point of diminishing scientific return has never been realized.
- (2) Quality of record has hinged on in intimate involvement of scientists.
- (3) Quality also hinges on redundancy.
- (4) Normal measures of scientific impact underestimate actual importance.





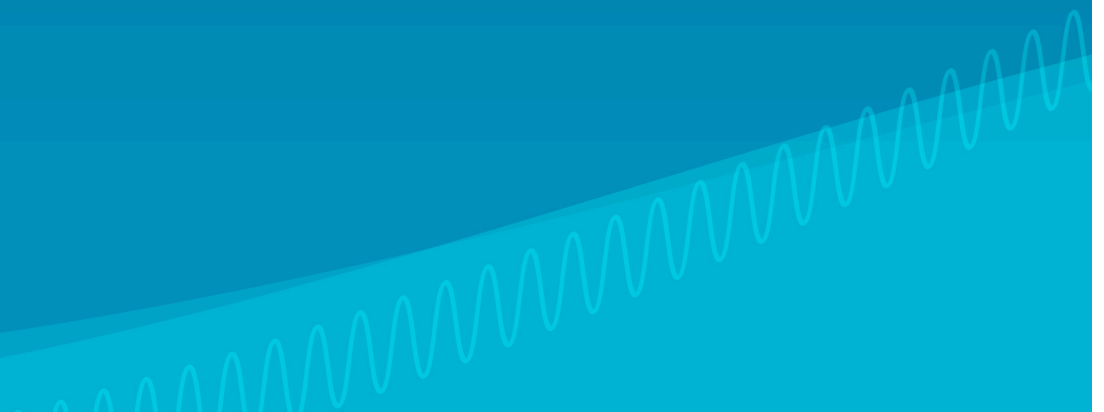


Citations to date:

Watson and Crick (1953): 3085 citations

Keeling (1960): 60 citations

Thank you



Thank you

