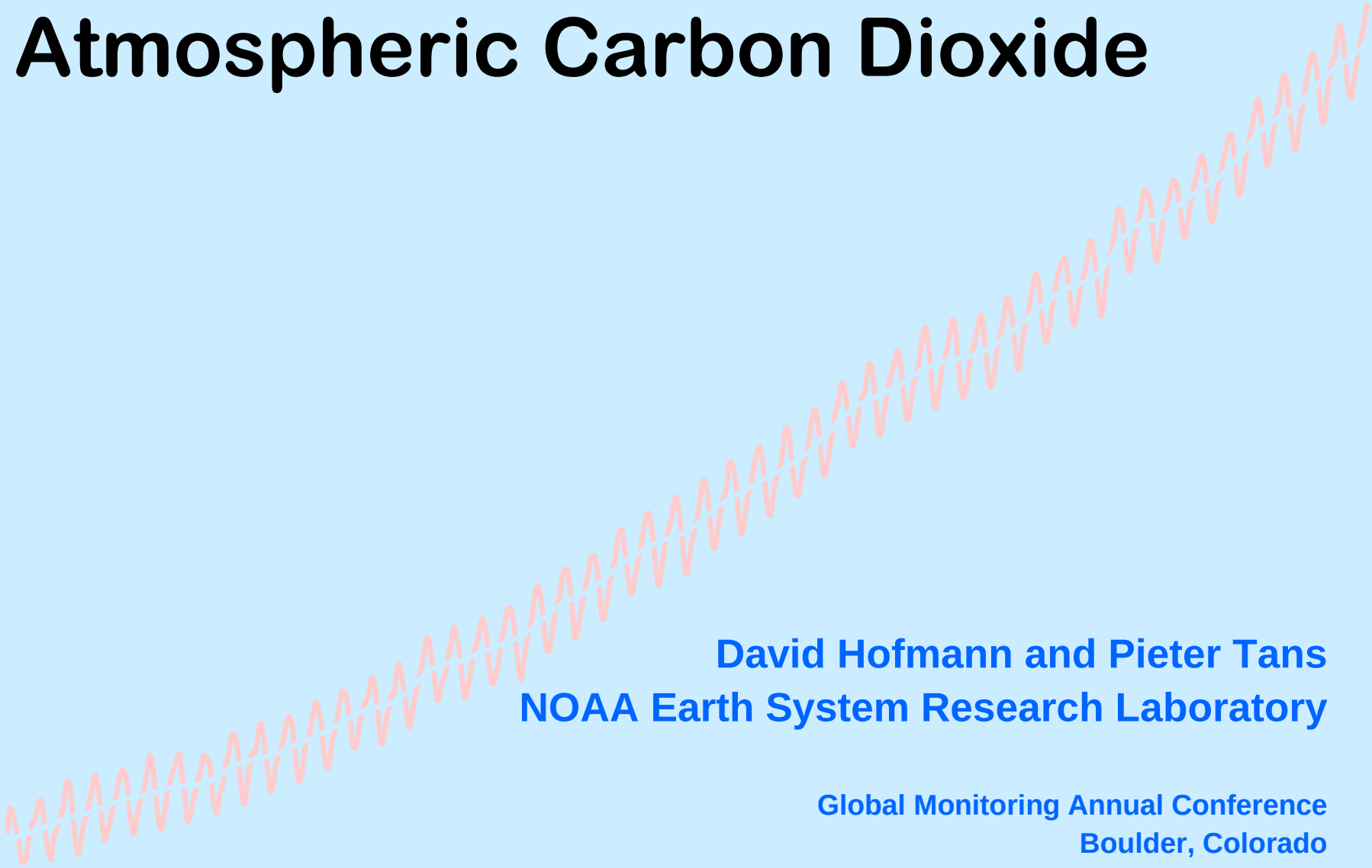
A New Look at Anthropogenic Atmospheric Carbon Dioxide



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NOAA Earth System Research Laboratory

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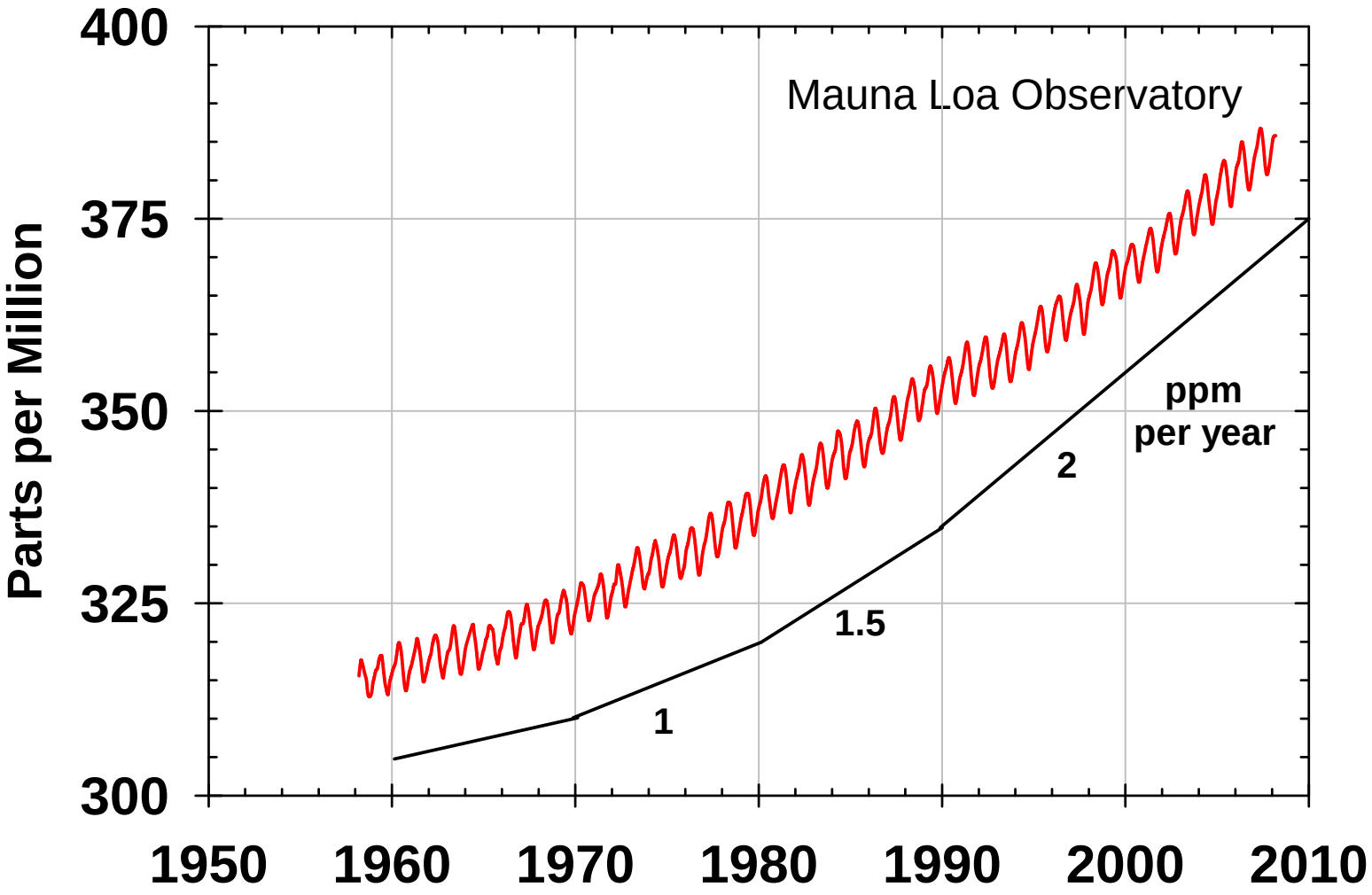
NOAA CIRES

Atmospheric CO_2 Growth Rates Have Been Increasing



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Surge in carbon levels raises fears of runaway warming

•David Adam Environment correspondent
•The Guardian,
•Friday January 19 2007
•Article history

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This article appeared in the Guardian on Friday January 19 2007 on p1 of the Top stories section. It was last updated at 15:45 on September 07 2007.

Mist and pollution over London. Photograph: Matthew Fearn/PA

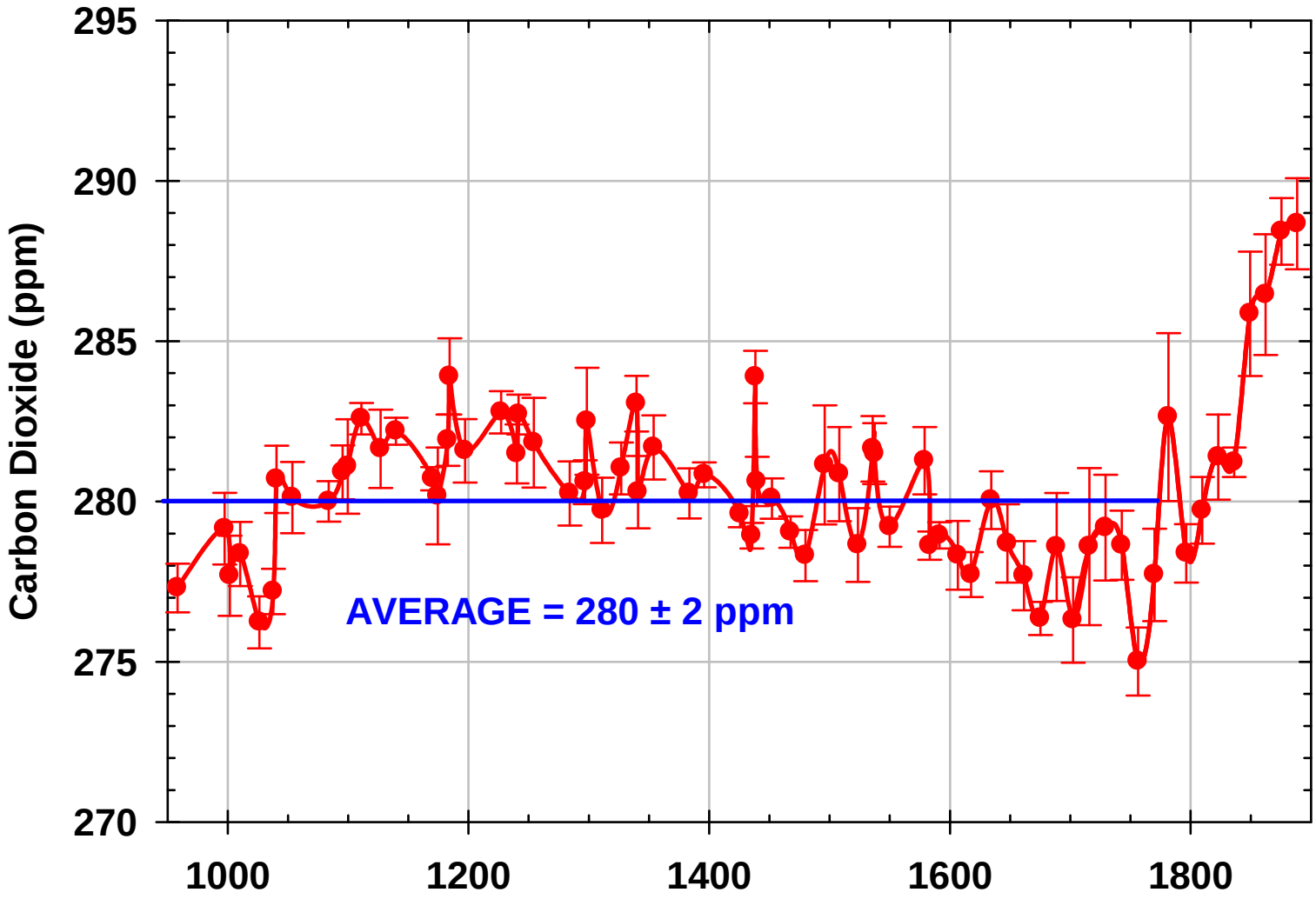
Carbon dioxide is accumulating in the atmosphere much faster than scientists expected, raising fears that humankind may have less time to tackle climate change than previously thought. From 1970 to 2000 the concentration rose by about 1.5ppm each year…. the carbon dioxide level has risen by an average 2.2ppm each year since 2001. Experts are puzzled because the spike, which follows decades of more modest annual rises, does not appear to match the pattern of steady increases in human emissions….

Processing the Mauna Loa and Global CO_2 Records:

- Remove the seasonal variation (technique for filtering data to remove the seasonal variation first described by Thoning et al., *J. Geophys. Res. 94*, 8549-8565, 1989).

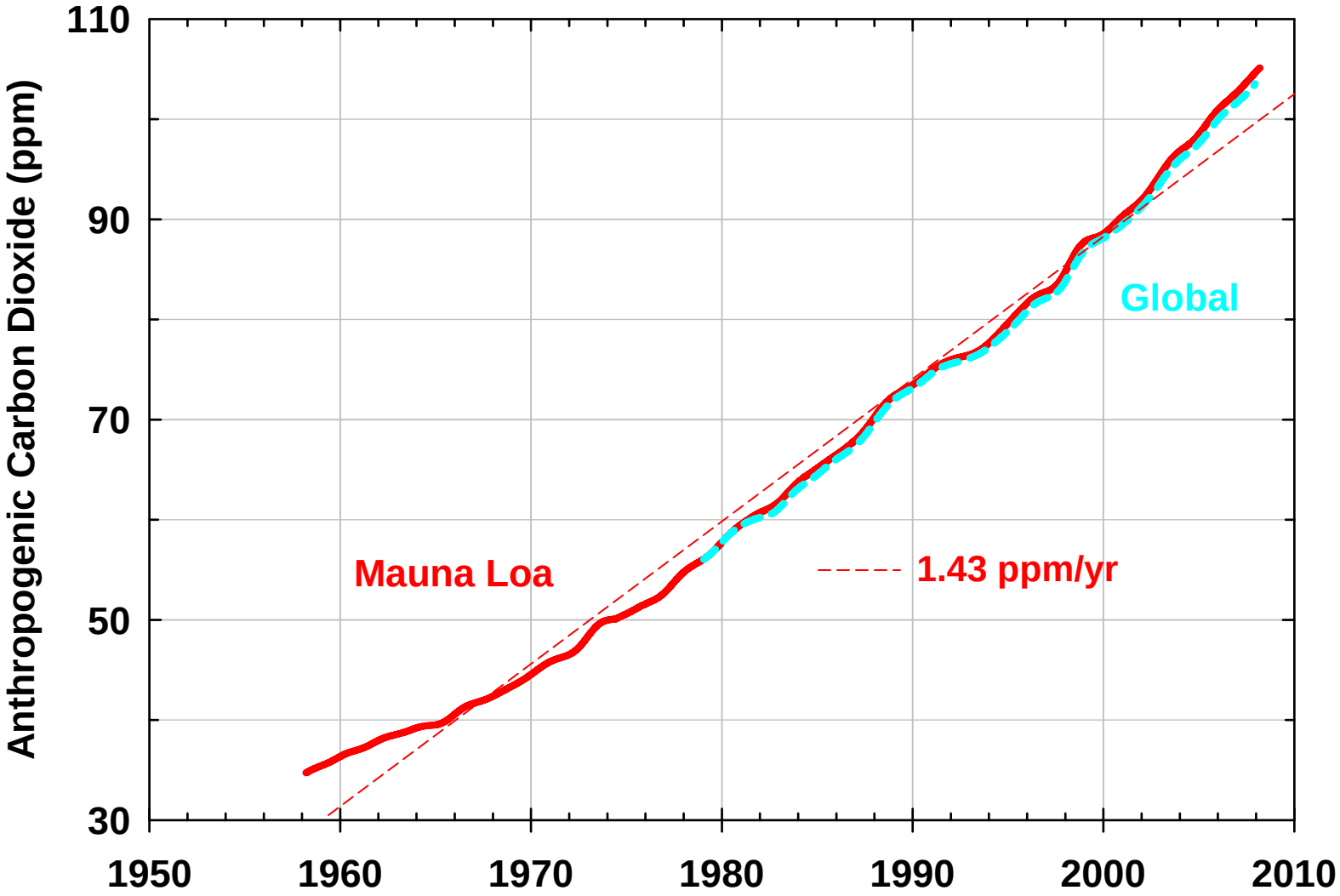
- Remove the pre-industrial component. Reduce the CO_2 concentration to that which is changing, the anthropogenic component.

Antarctic Ice Cores – Preindustrial Carbon Dioxide



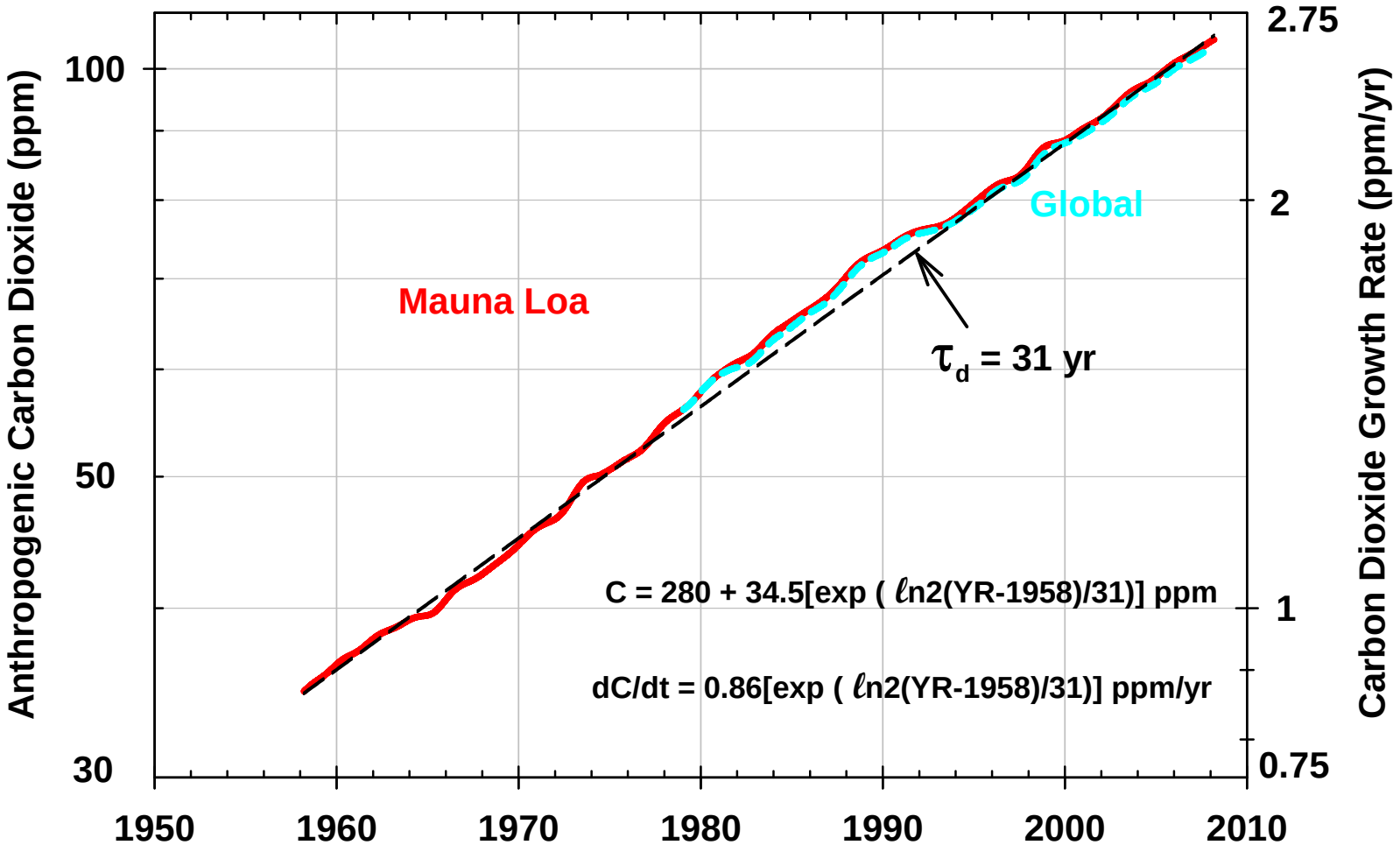
Ice Core Data: Siegenthaler, U., E. Monnin, K. Kawamura, R. Spahni, J. Schwander, B. Stauffer, T.F. Stocker, J.-M. Barnola and H. Fischer. 2005. Supporting evidence from the EPICA Dronning Maud Land ice core for atmospheric CO2 changes during the past millennium. *Tellus 57B*, 51-57(7).

The Mauna Loa and Global Deseasonalized Record



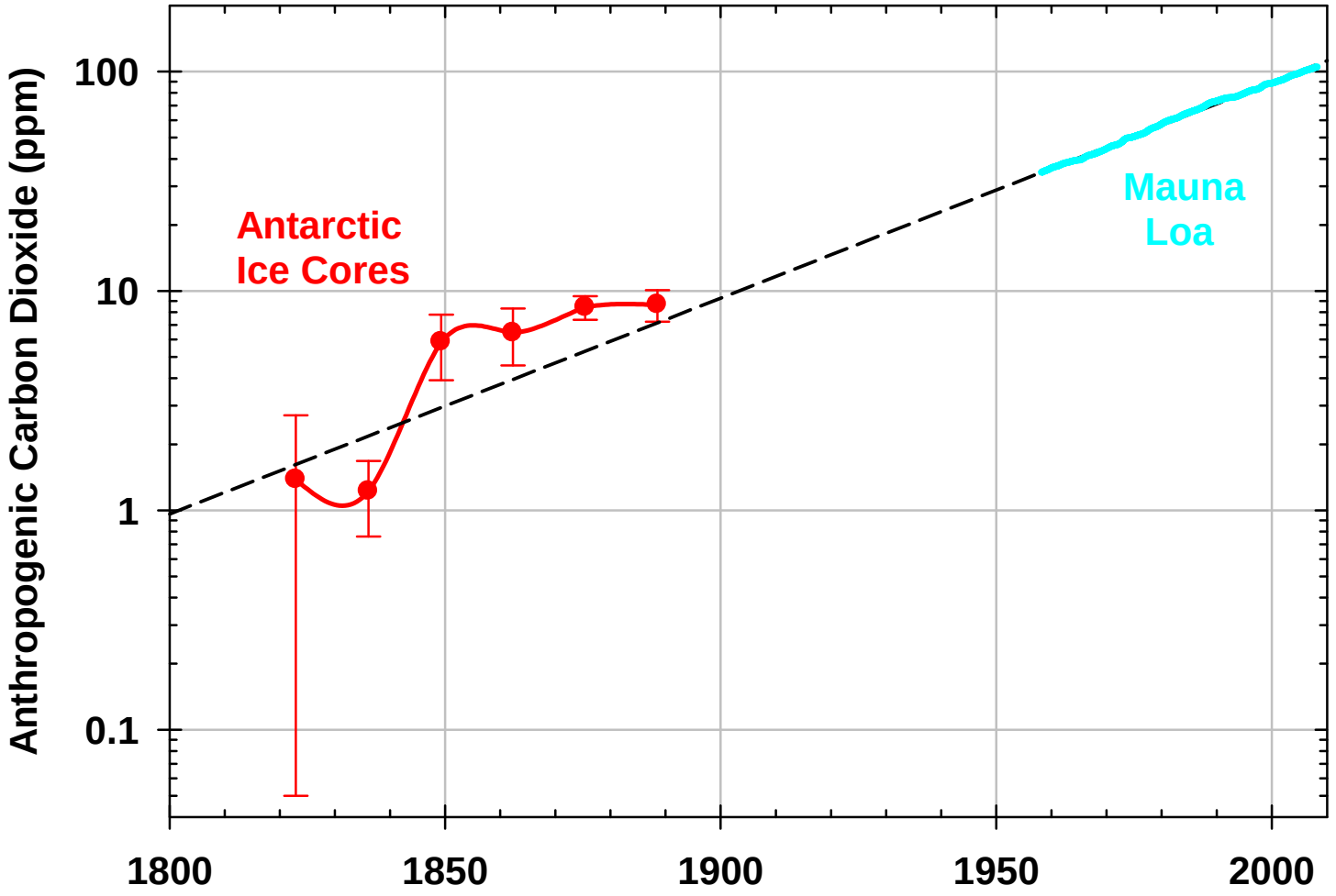
Semi-logarithmic Presentation of the Data

(exponential functions are straight lines)



$$dC/dt \sim C \sim e^{t/\tau}$$

Extrapolating Back in Time



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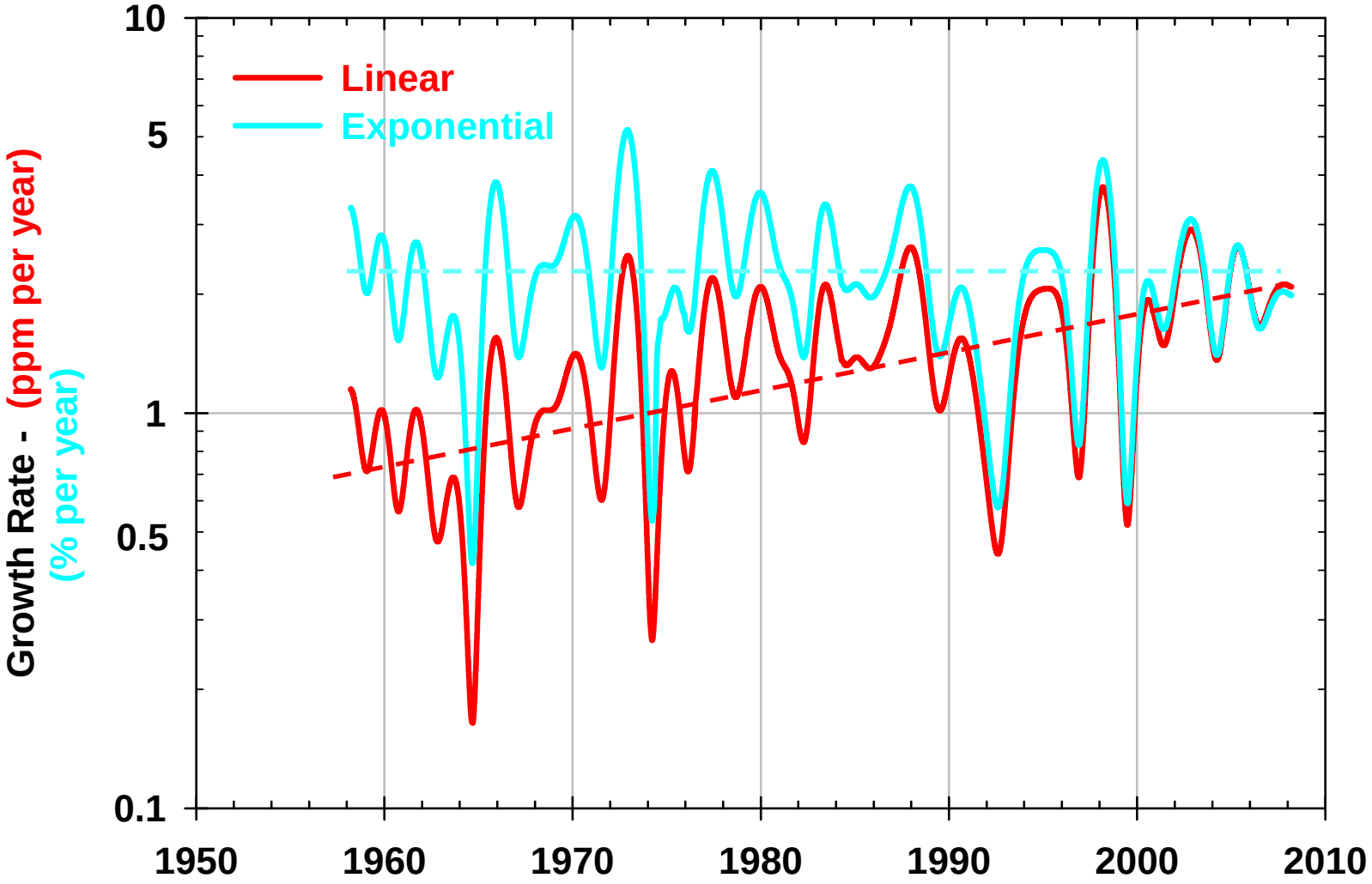
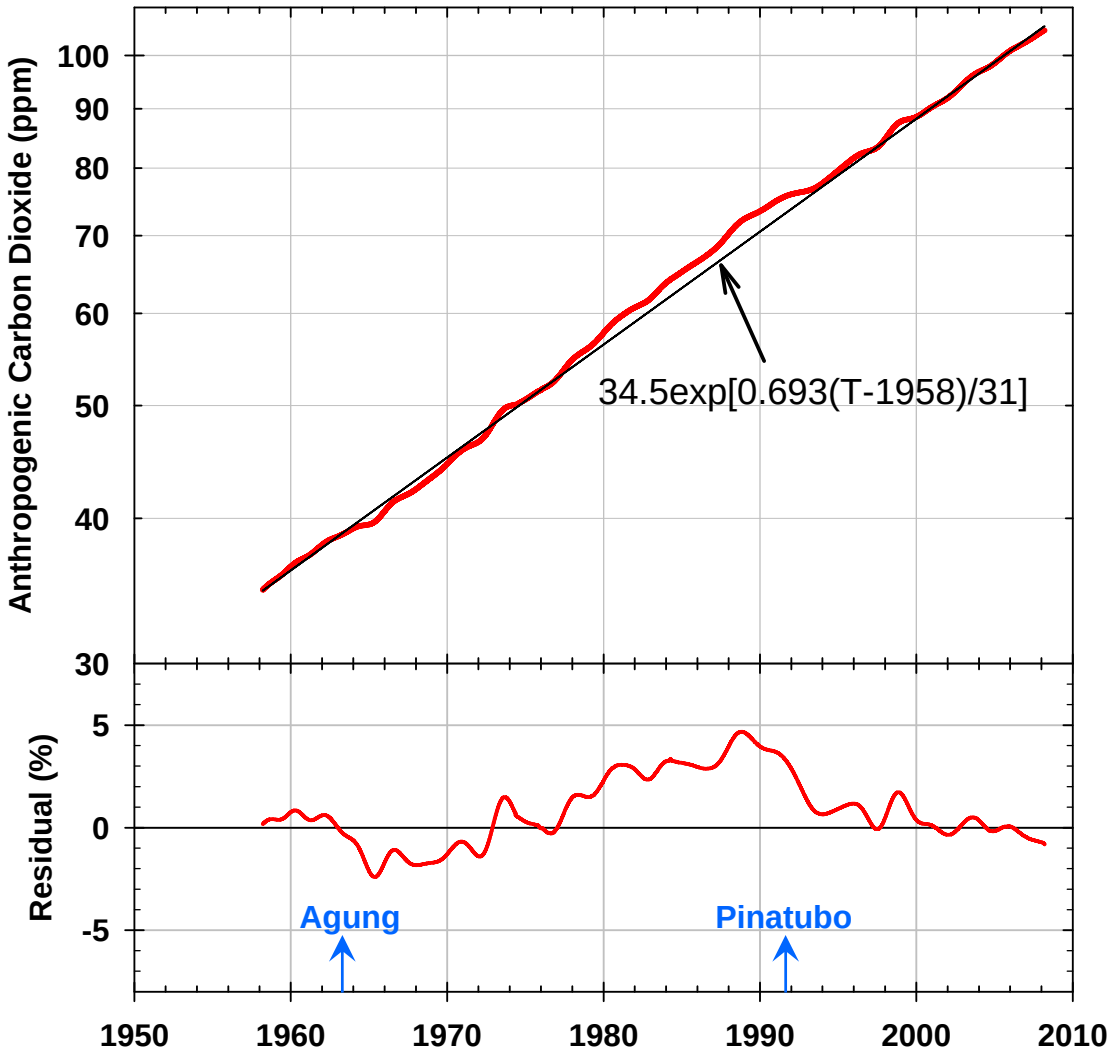
While the linear CO_2 growth rate has increased from ~0.5 to ~2 ppm/yr, the exponential growth rate has remained ~ constant at about 2.3 %/yr

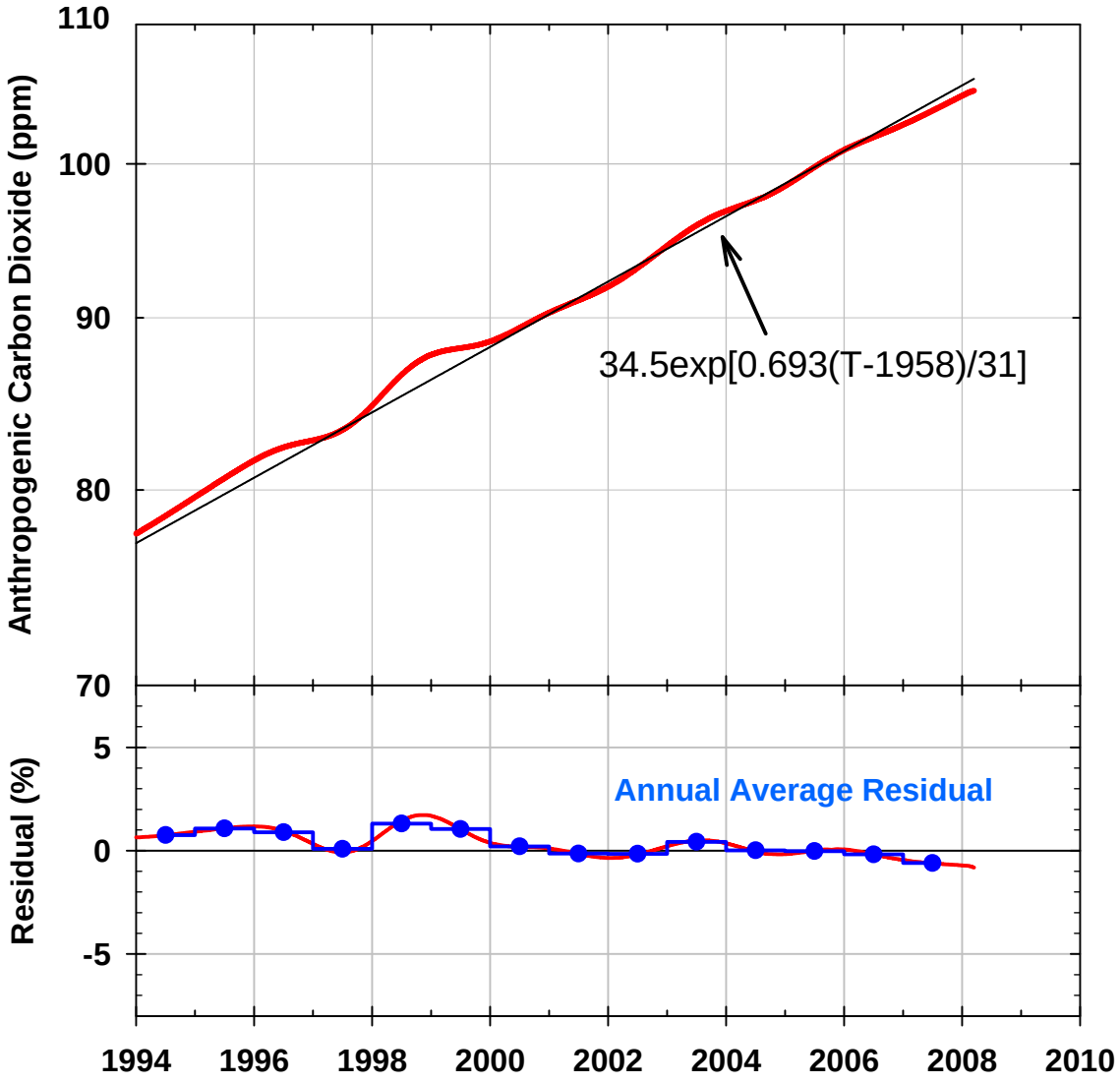


Using the residuals (data – function) for analysis



The two largest negative excursions of the residuals followed major volcanic eruptions. There were no significant changes following major ENSOs (e.g.,1982-83 and 1997-98), although the 1982 ENSO may have offset an effect from the 1982 El Chichón eruption.

For the past 14 Years, the residual has been ~ ± 1 %



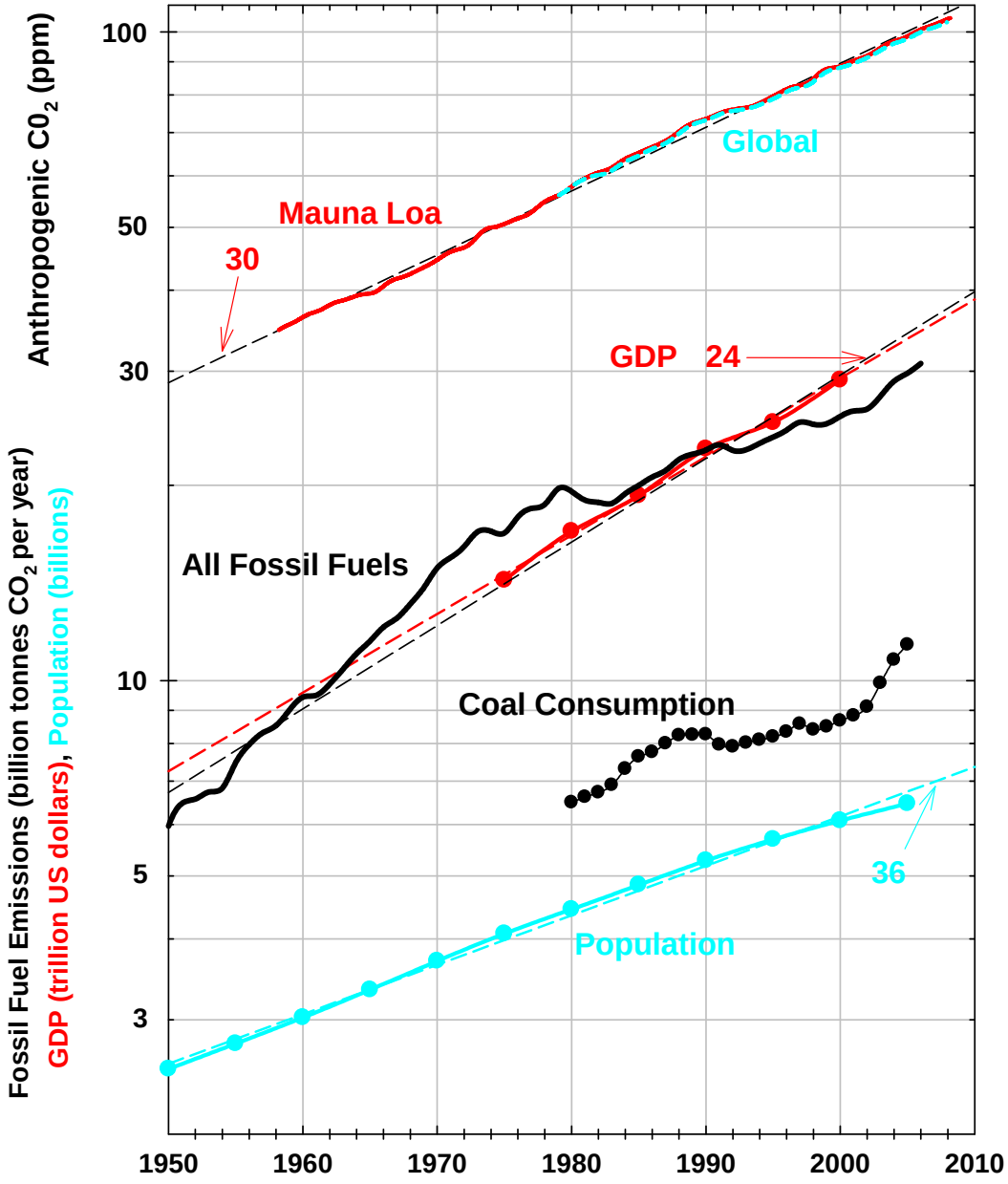
The annual average residual may be a useful index for detecting a deviation away from exponential growth in the future

WHY EXPONENTIAL?

One would expect atmospheric carbon dioxide to follow fossil fuel emissions closely, however, this does not seem to be the case. The slowdown in emissions following the 1973 "oil crisis" was not reflected in the CO_2 record, nor was the reduced emission rate after 1980 (τ_d increased from 16 to 45 years).

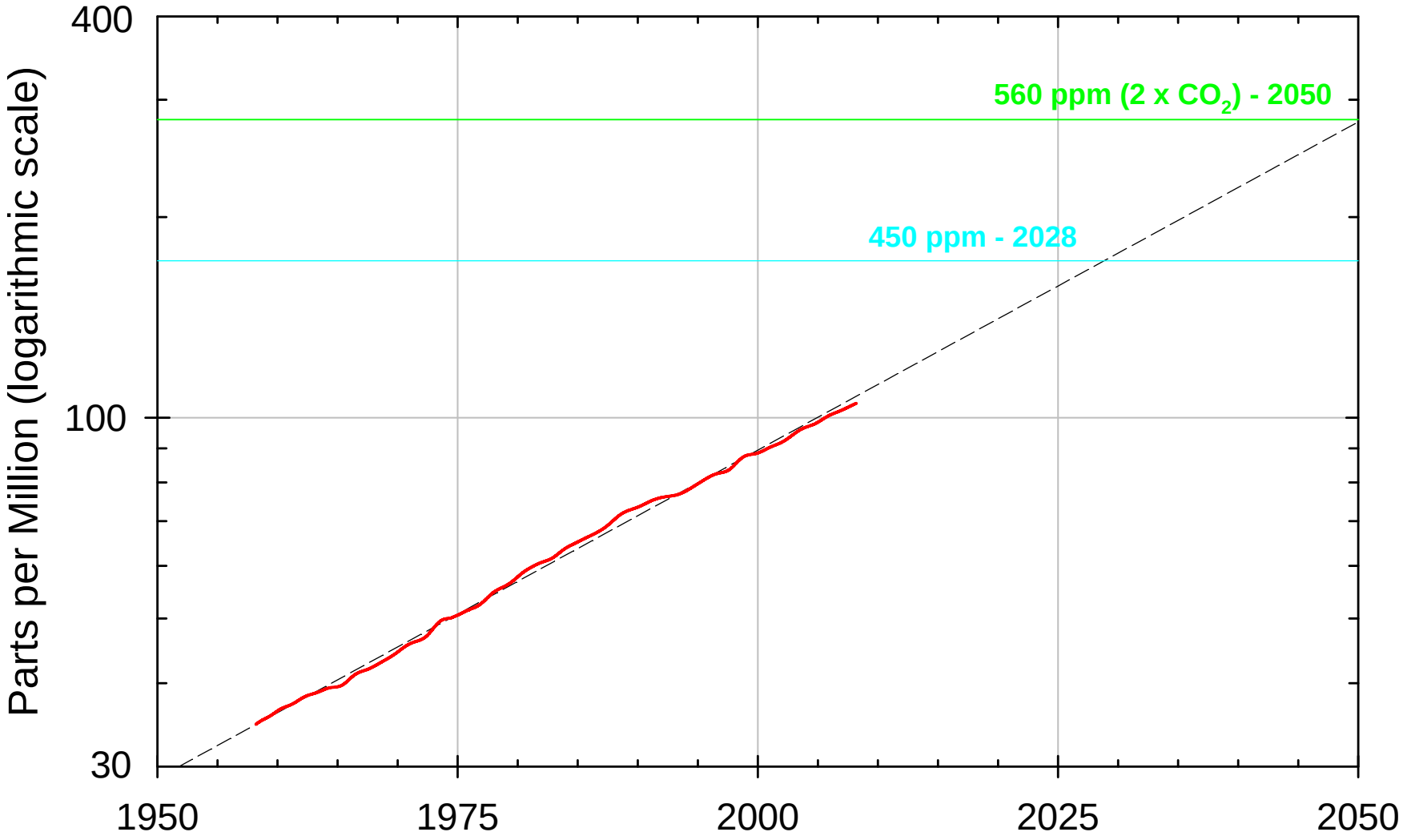
Exponential increases are normal outcomes when the increase in a quantity depends on how much of the quantity exists: dC/dt ~ C.

Some that affect carbon dioxide are the world population and domestic production. They affect atmospheric CO_2 through both sources and sinks and have similar growth rates.



Sources: United Nations: unstats.un.org
Energy Information Admin: eia.doe.gov/iea/carbon.html
Carbon Dioxide Information Analysis Center: cdiac.ornl.gov
Hofmann et al. (2006)

Time to 450 ppm and 2 x CO_2 for Business as Usual



SUMMARY

- The deseasonalized anthropogenic component of atmospheric carbon dioxide has increased exponentially even before atmospheric measurements began. This explains why the linear growth rates have been increasing with time.

- The reduction in fossil fuel emissions following the “oil crisis” of 1973 did not appreciably affect the exponential growth in the CO_2 level at Mauna Loa, nor has the recent upturn in coal consumption, a lesson for the future. Volcanic eruptions, on the other hand, seem to cause a near instantaneous response, reducing the growth rate.

- The exponential behavior of CO_2 is expected considering that both Global Domestic Product and population are increasing exponentially with similar rates of growth. For these components, the exponential relation, $dC/dt \sim C$, is clearly expected (people and wealth beget more people and wealth). It is likely that exponential growth in CO_2 will continue until the close tie to GDP and population is broken through alternate energy sources, CO_2 sequestration and regulation.

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