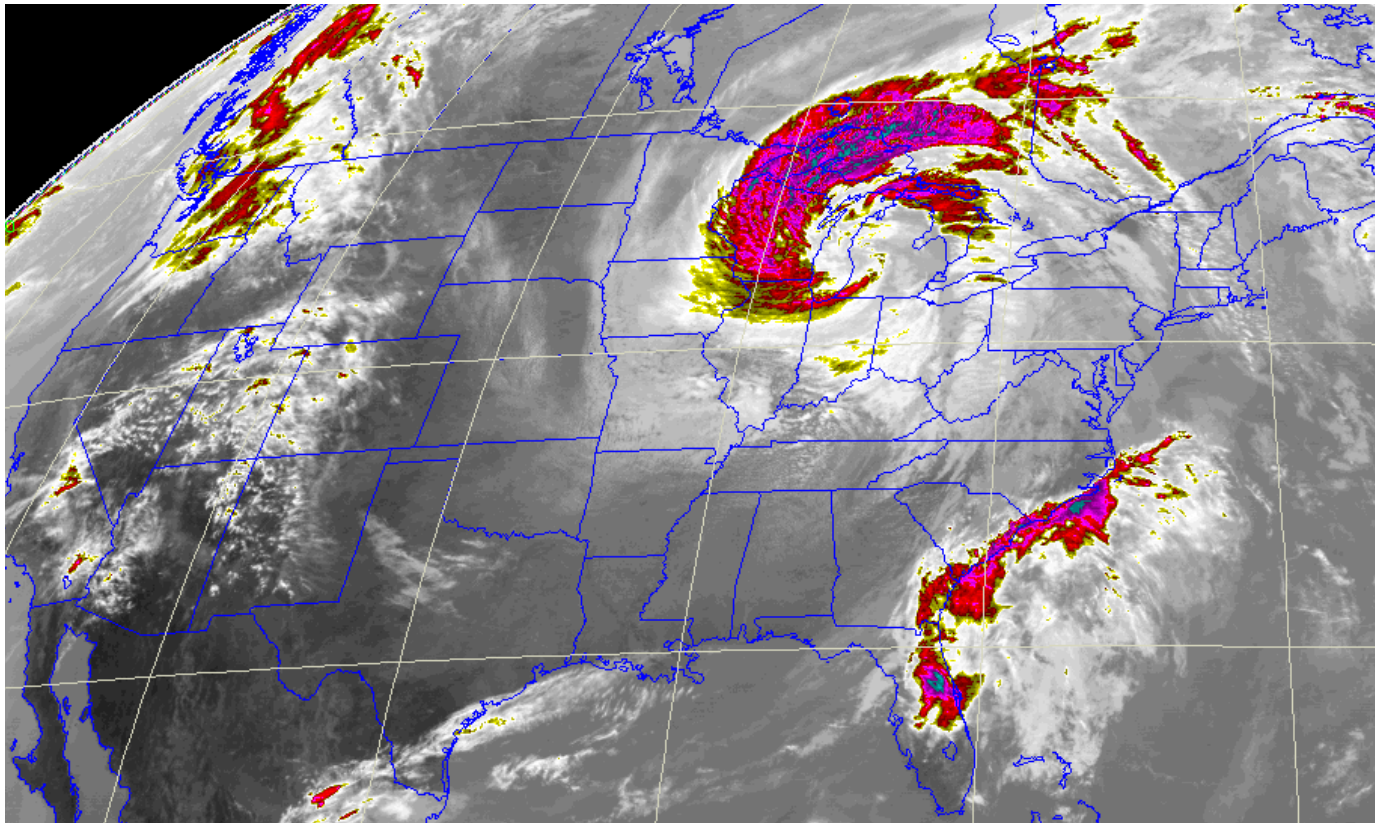
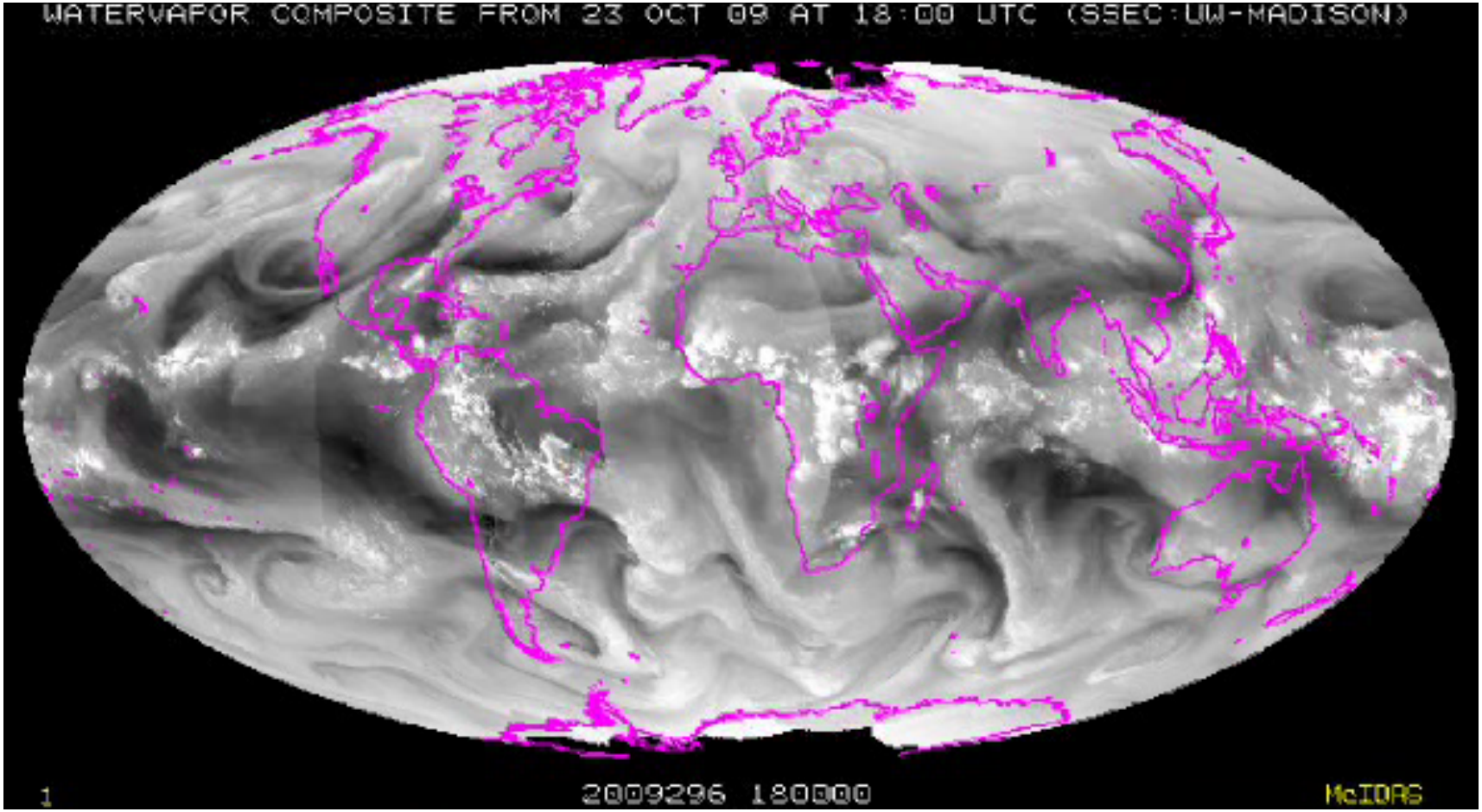
The Distinction Between Weather and Climate

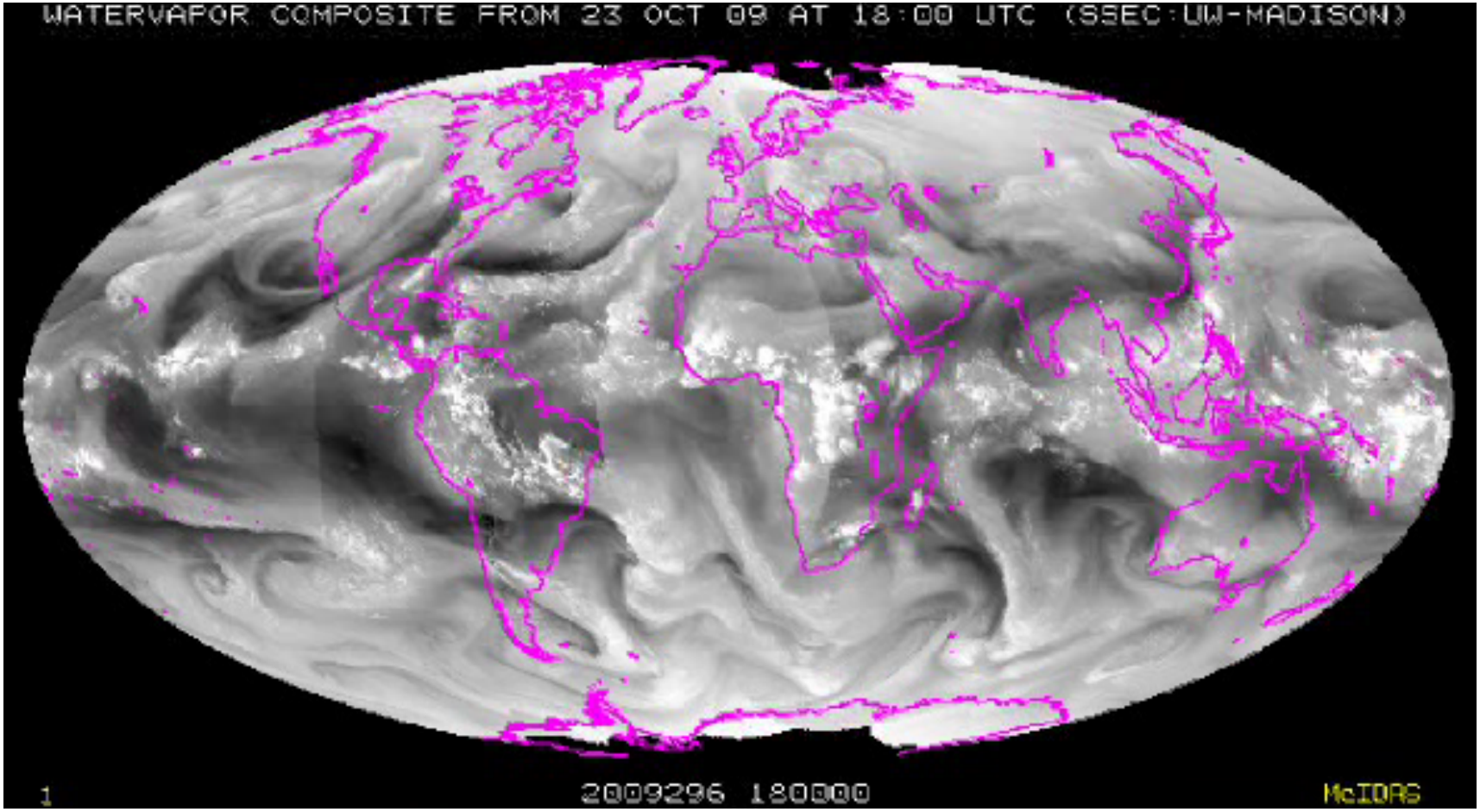


Jonathan E. Martin
Department of Atmospheric and Oceanic Sciences
University of Wisconsin-Madison

The Parade of Weather Systems



The Parade of Weather Systems



Weather is an initial value problem

What is Climate?

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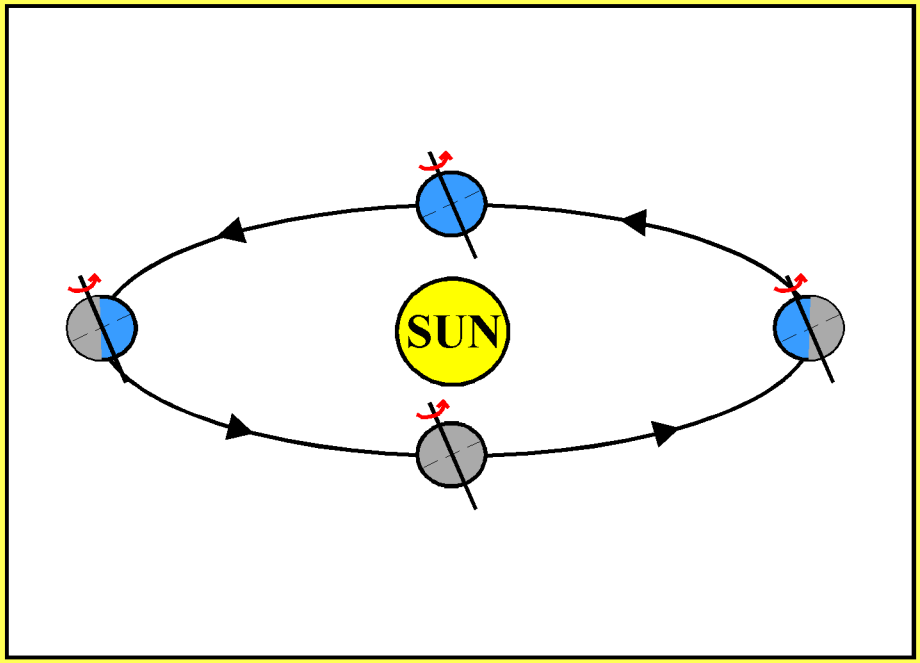
"Climate is the thermodynamic/hydrodynamic status of the global boundary conditions that determine the concurrent array of weather patterns." (Bryson, 1997)

Climate is a boundary value problem



The mean state of the climate system is determined by

- *Emission of radiation by the Sun*
- *Earth's rotation rate and orbital characteristics*
- *Composition of the atmosphere*

Baseball and Boundary Conditions

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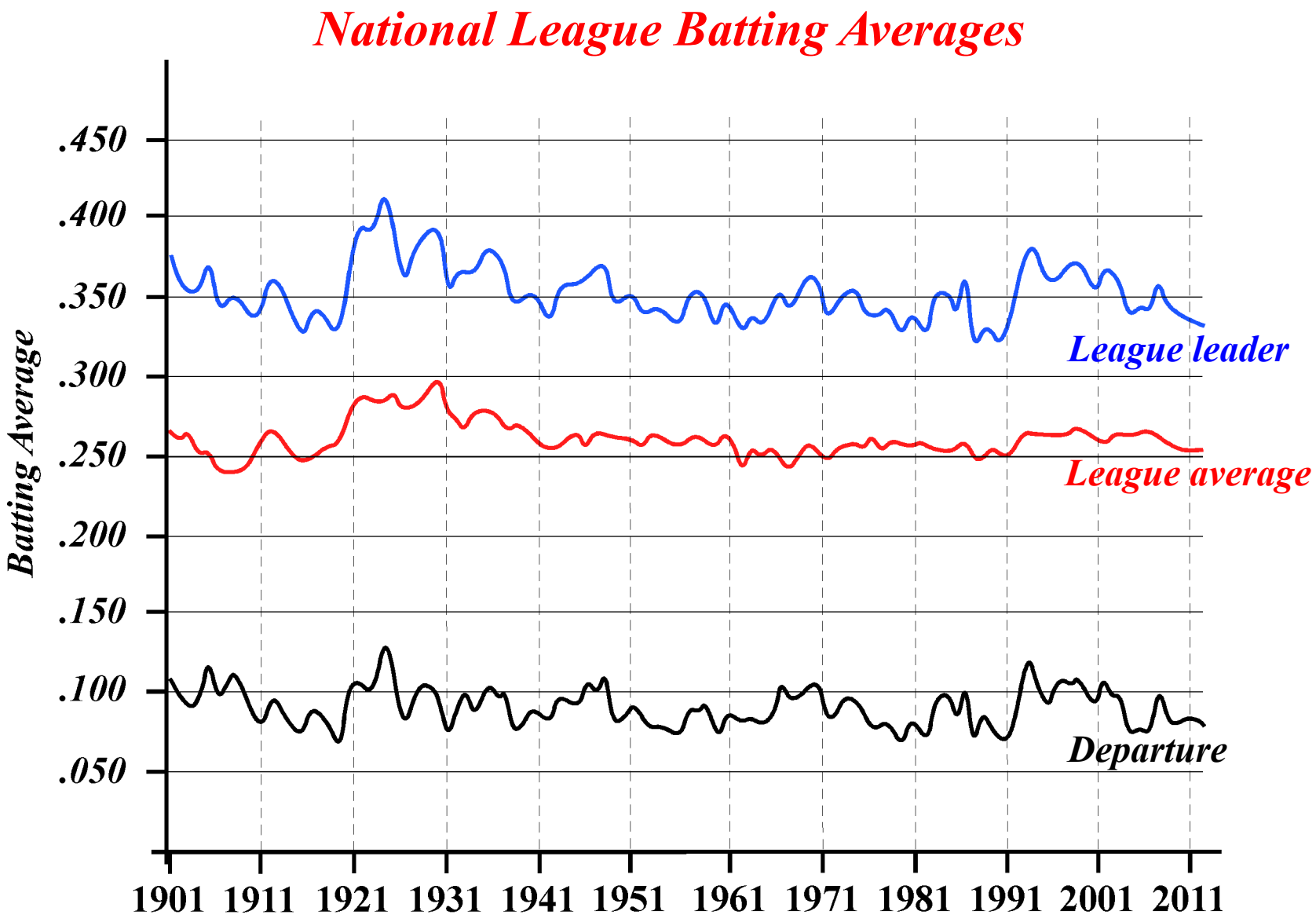
This collection of conditions determines the nature of the game (frequency and types of offensive success, dominance of pitching), not the outcome of any given contest


National League Batting Averages
Batting Average
.450
.400
.350
.300
.250
.200
.150
.100
.050
League leader
League average
Departure
1901
1911
1921
1931
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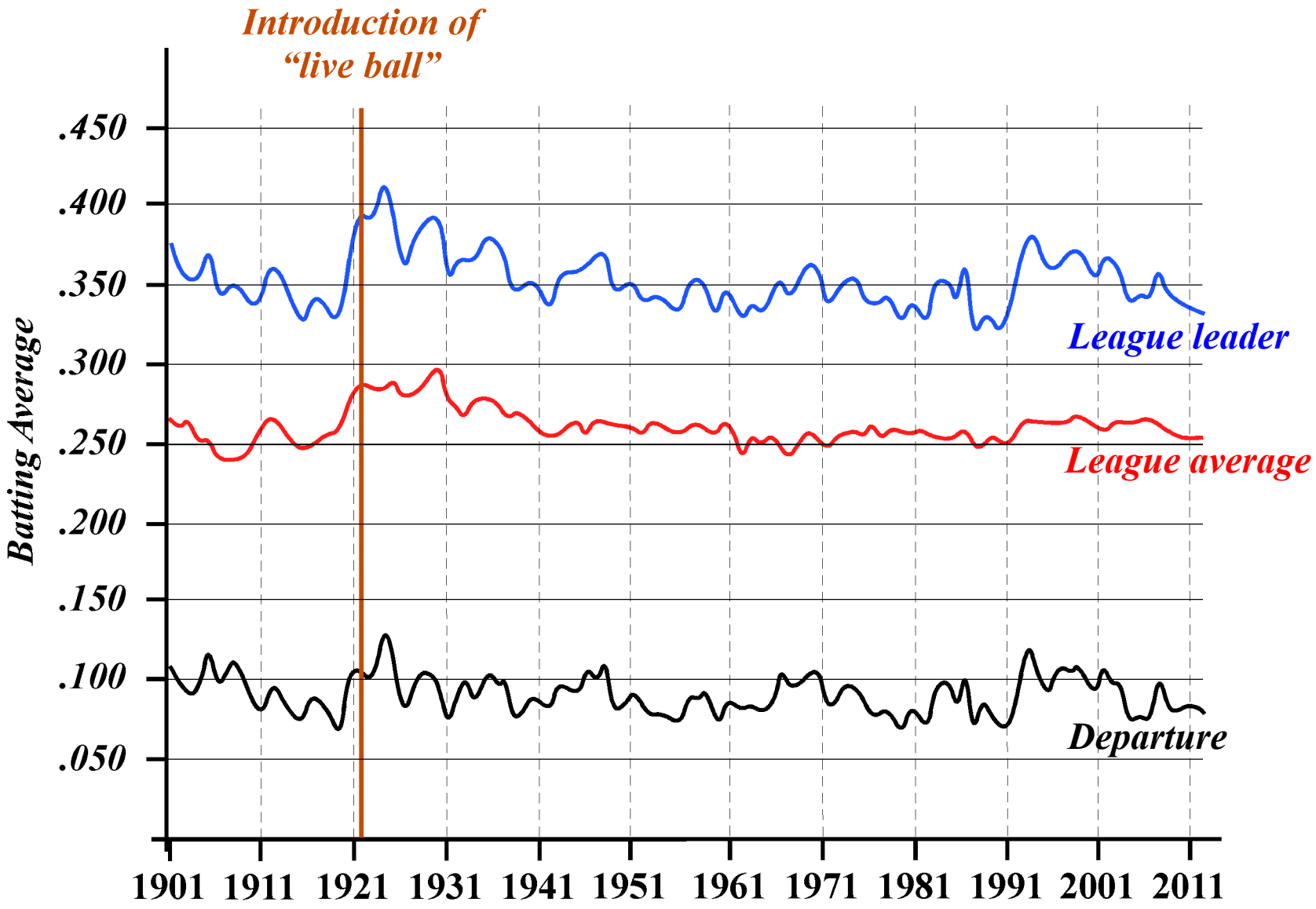
Introduction of
"live ball"
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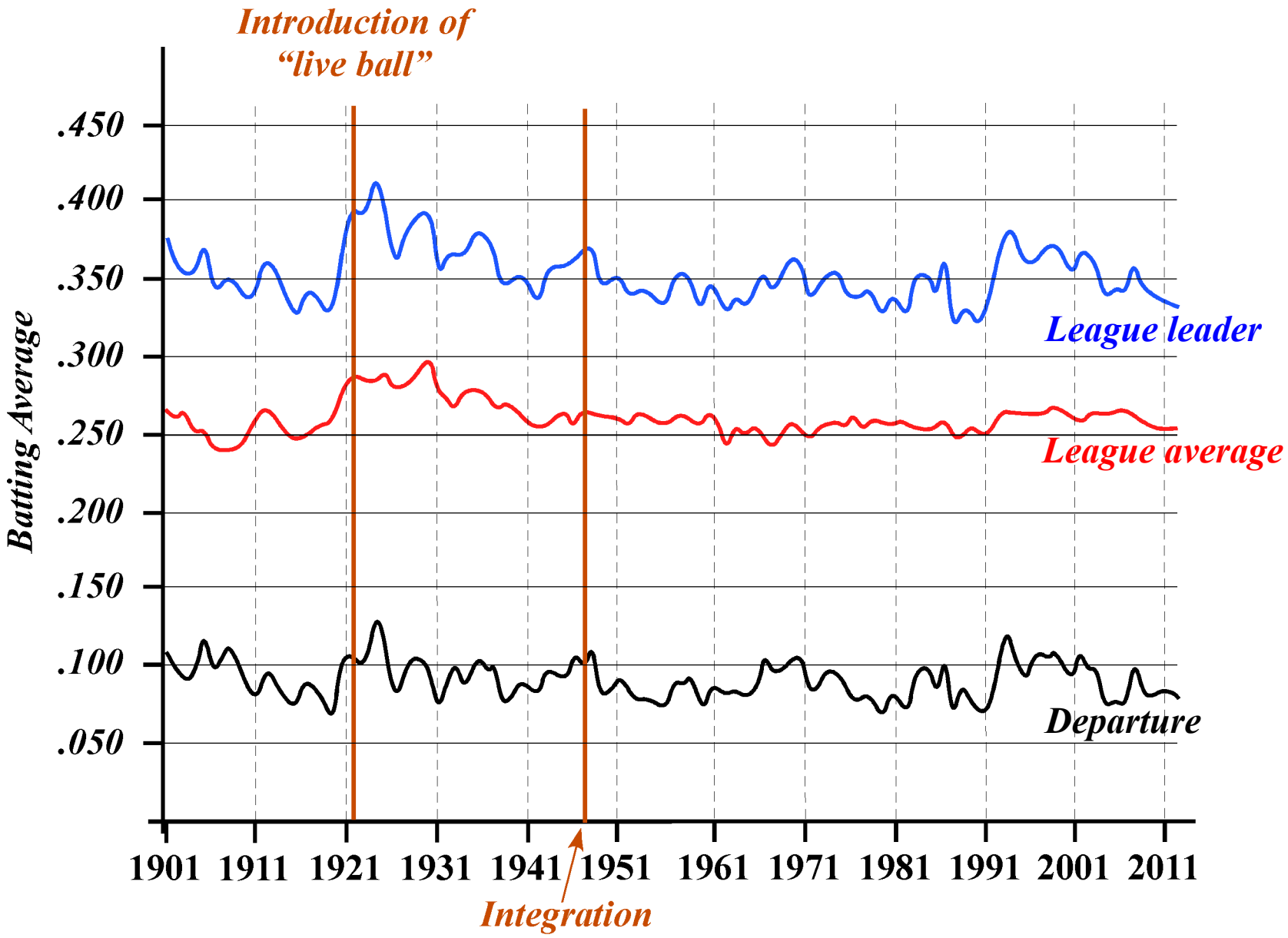
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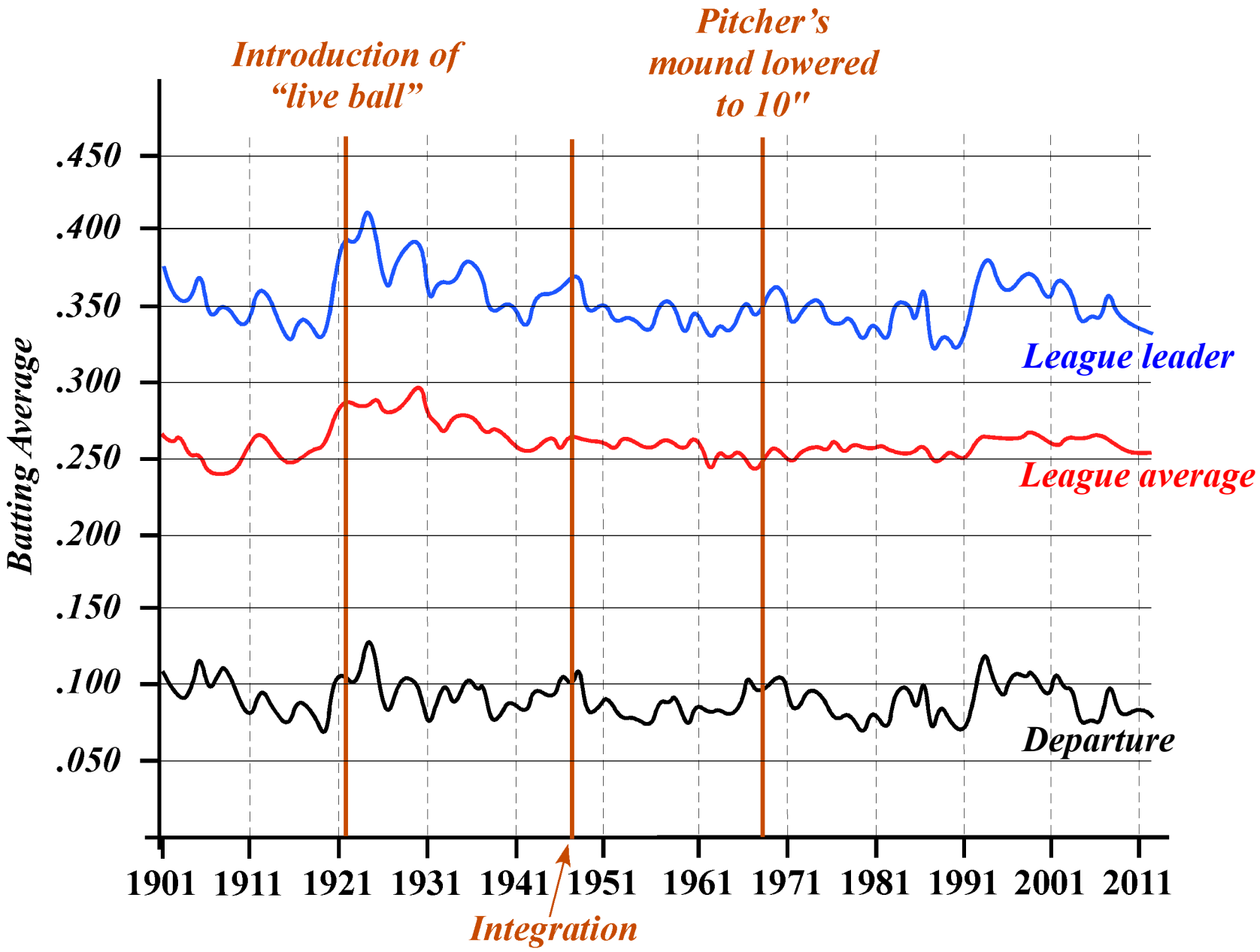
Integration


Introduction of "live ball"
Pitcher's mound lowered to 10"
Batting Average
.450
.400
.350
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.050
League leader
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Departure
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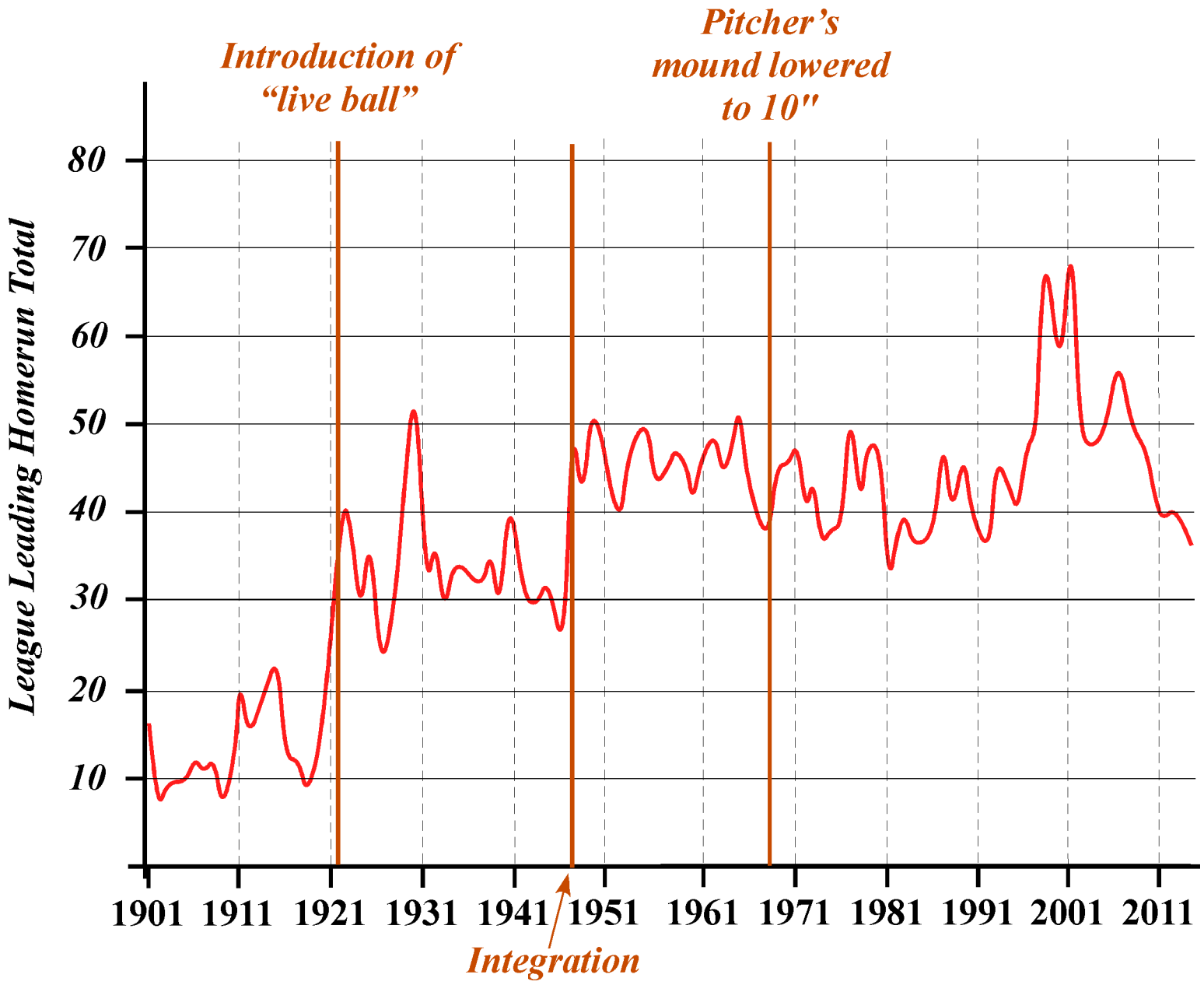
Introduction of
"live ball"
Pitcher's
mound lowered
to 10"
League Leading Homerun Total
80
70
60
50
40
30
20
10
1901
1911
1921
1931
1941
1951
1961
1971
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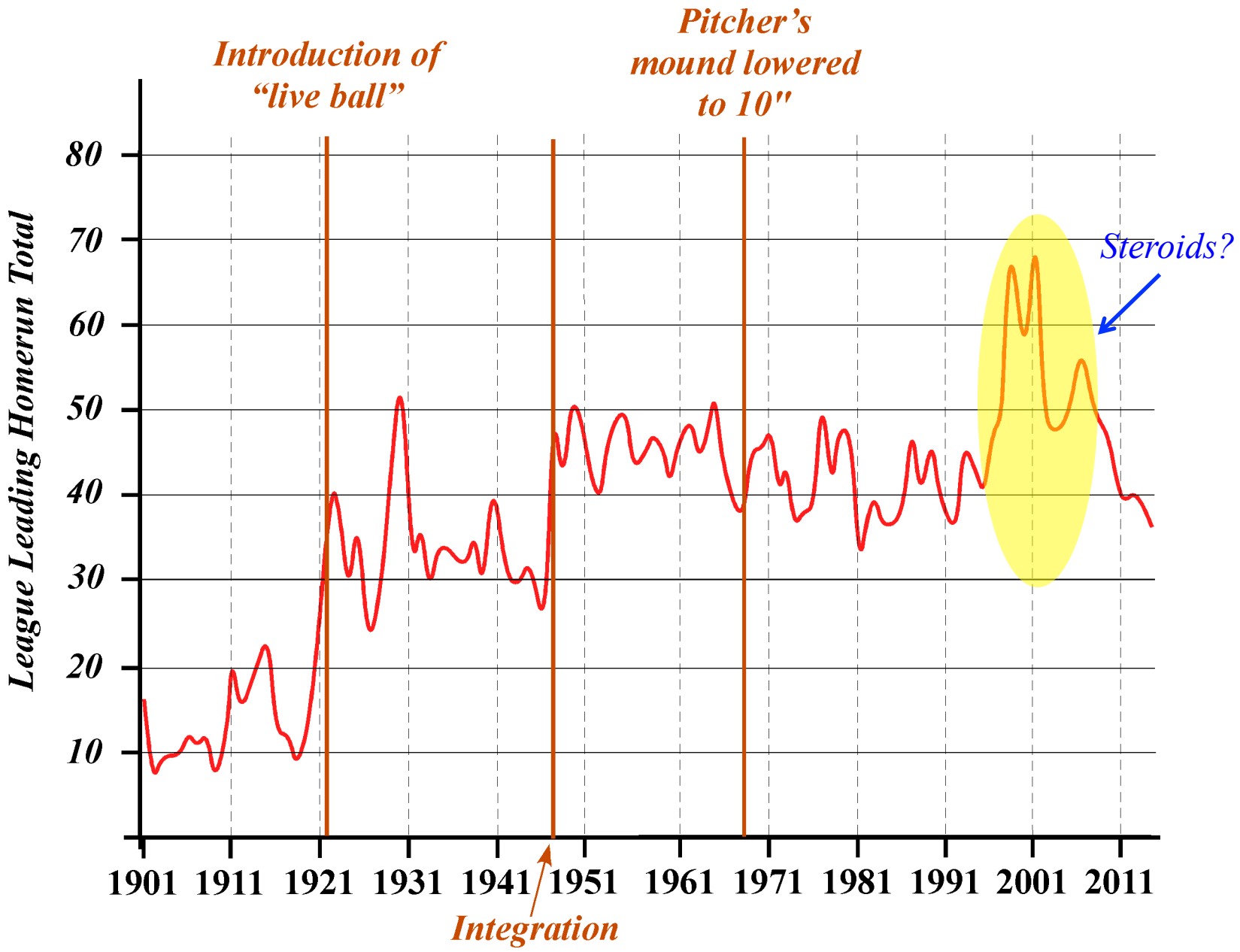
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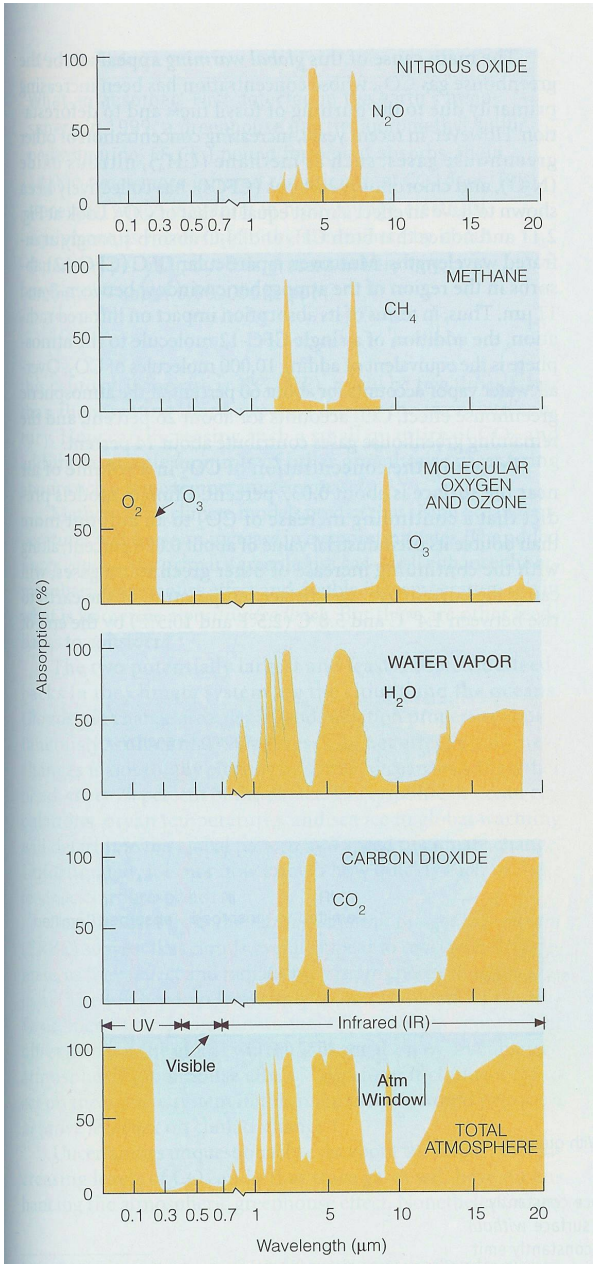
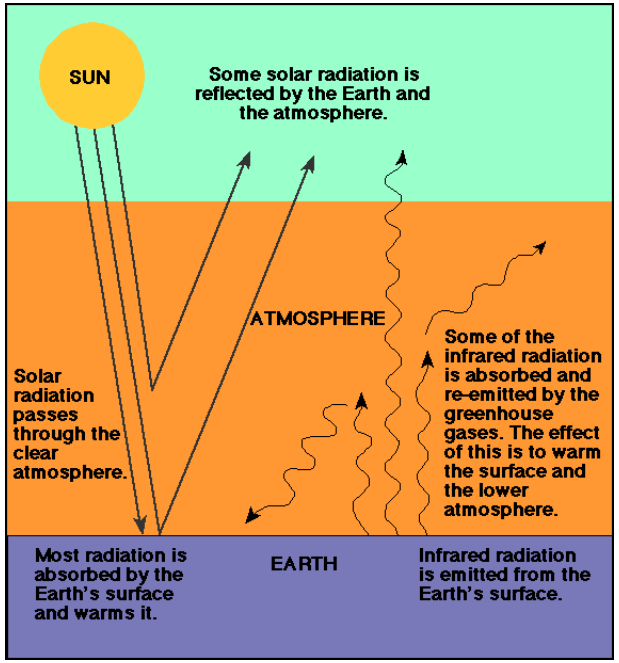
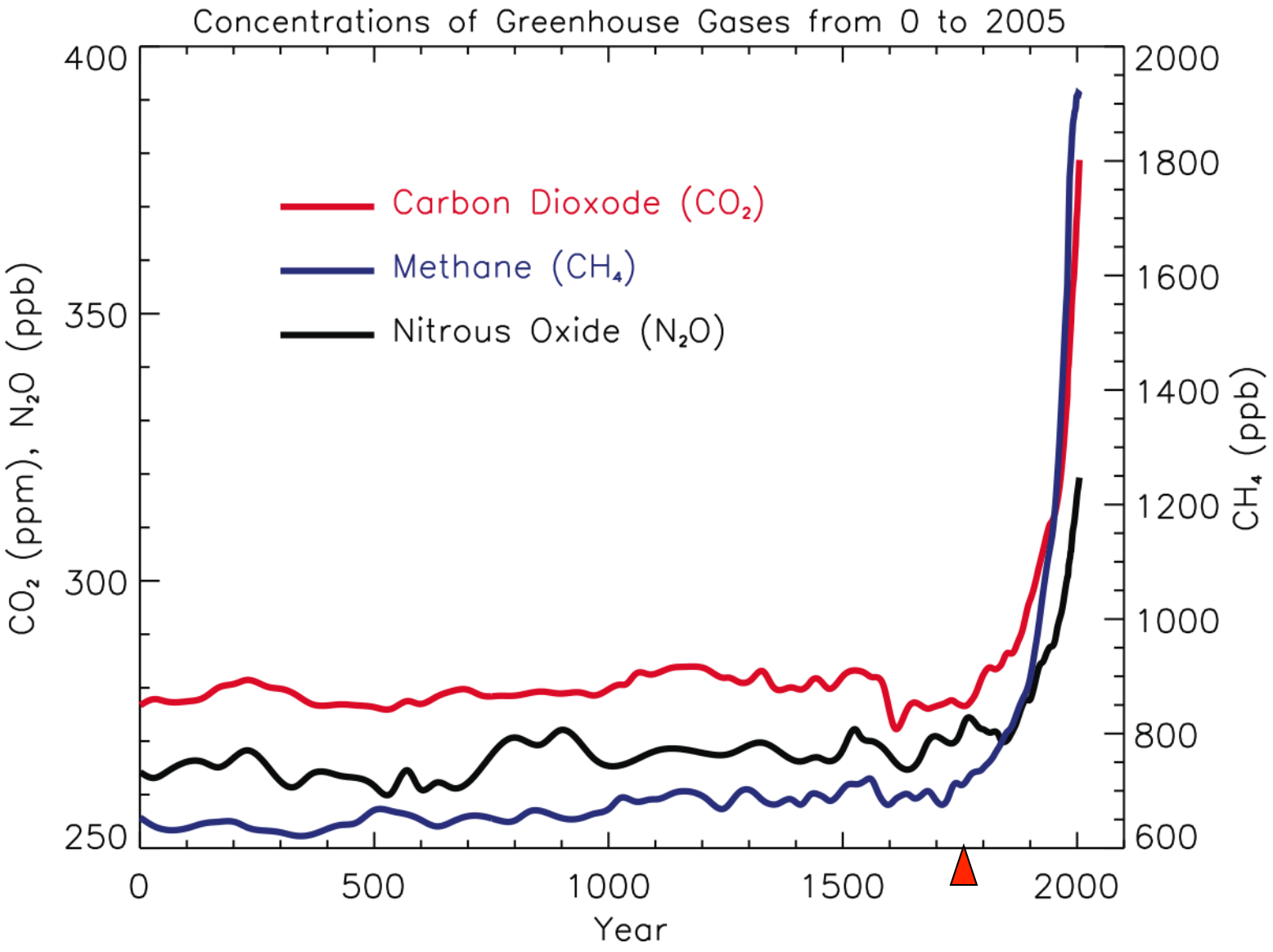


A number of different chemical constituents in our atmosphere have the characteristic that they are transparent to solar radiation but translucent to infra-red radiation. Such gases are known as *greenhouse gases*.





Increase in some greenhouse gases in last 2000 years

A large amount of the increased CO_2 has come from the burning of fossil fuels

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Atm. CO_2 has roughly tracked the rate of growth of fossil fuel consumption
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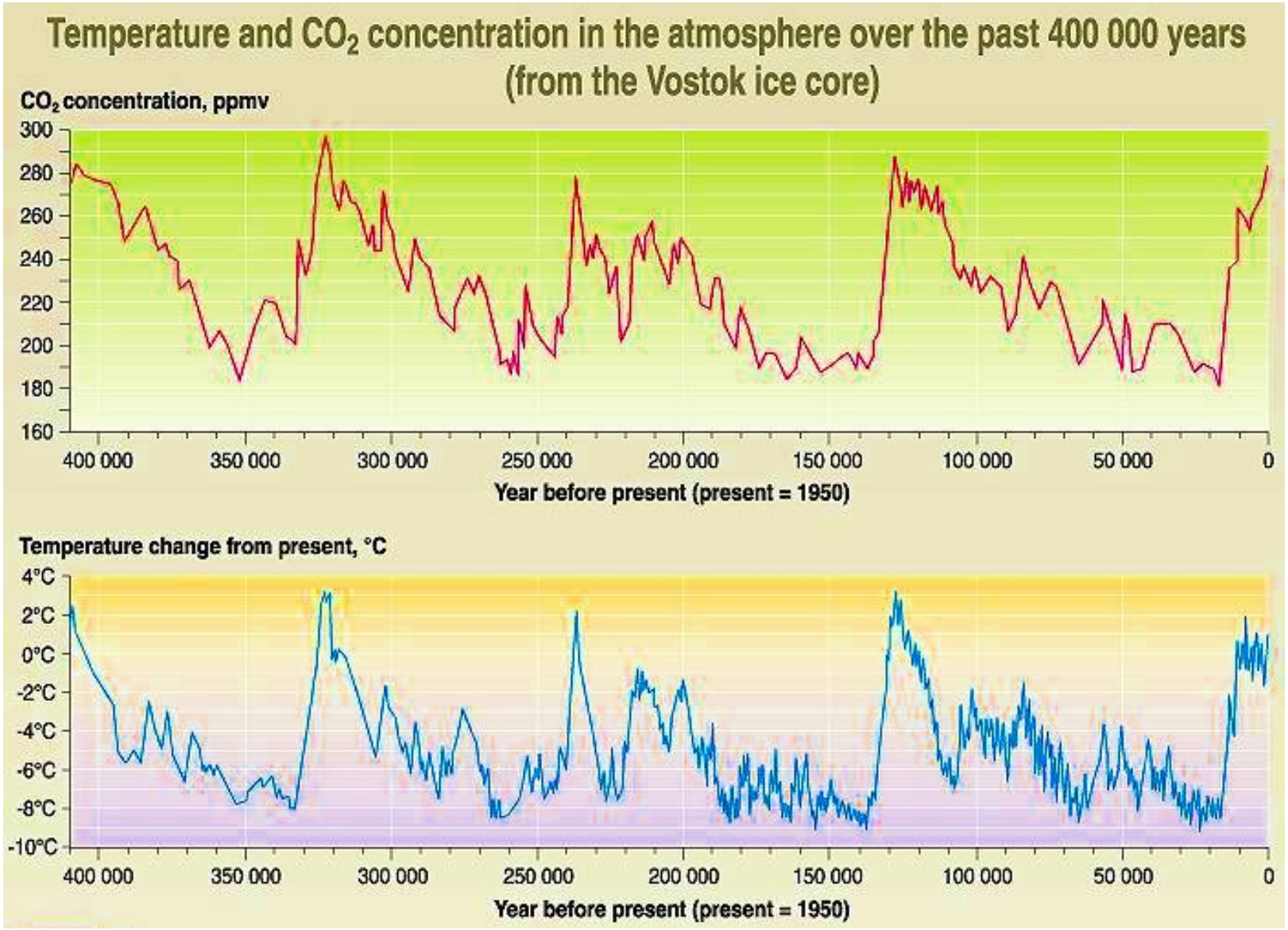
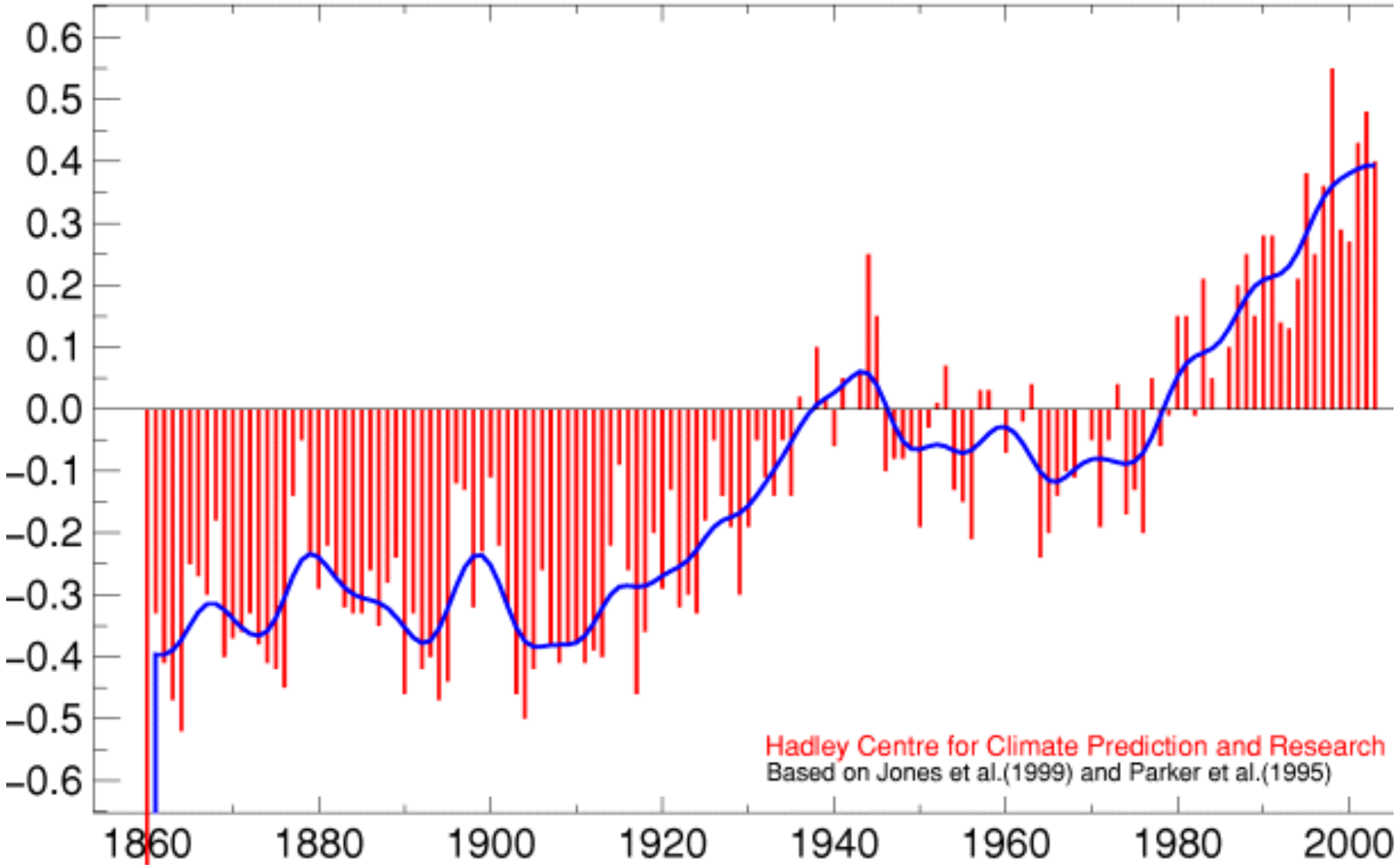
Atm. O_2 is decreasing at ~3 ppmv yr^{-1}, consistent with the addition of CO_2 by combustion



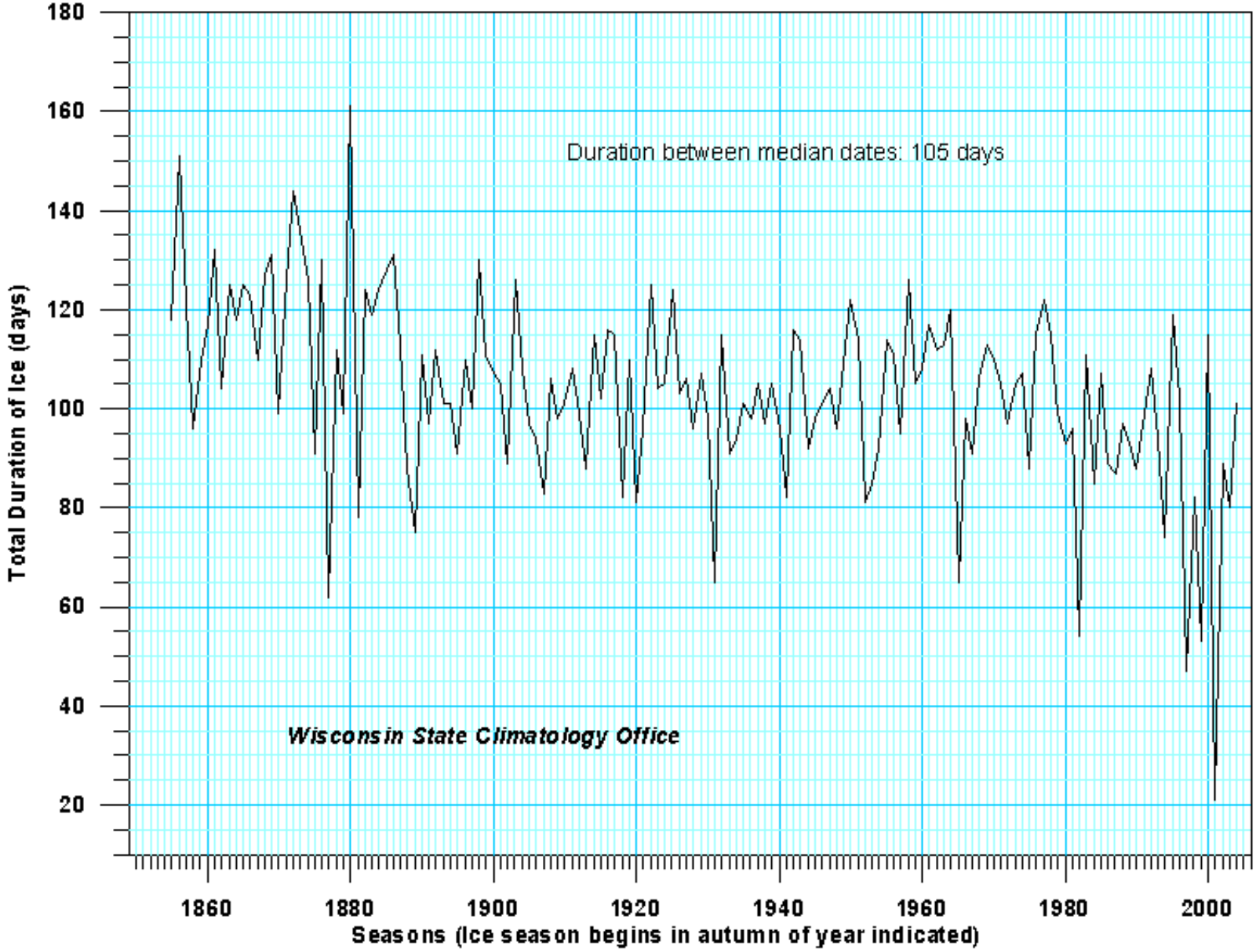
Global average temperature follows atm. CO_2 concentrations!



The global average temperature has risen ~1°C in 150 years

(CO_2 fraction increased from 315 to ~400 ppmv since 1958)

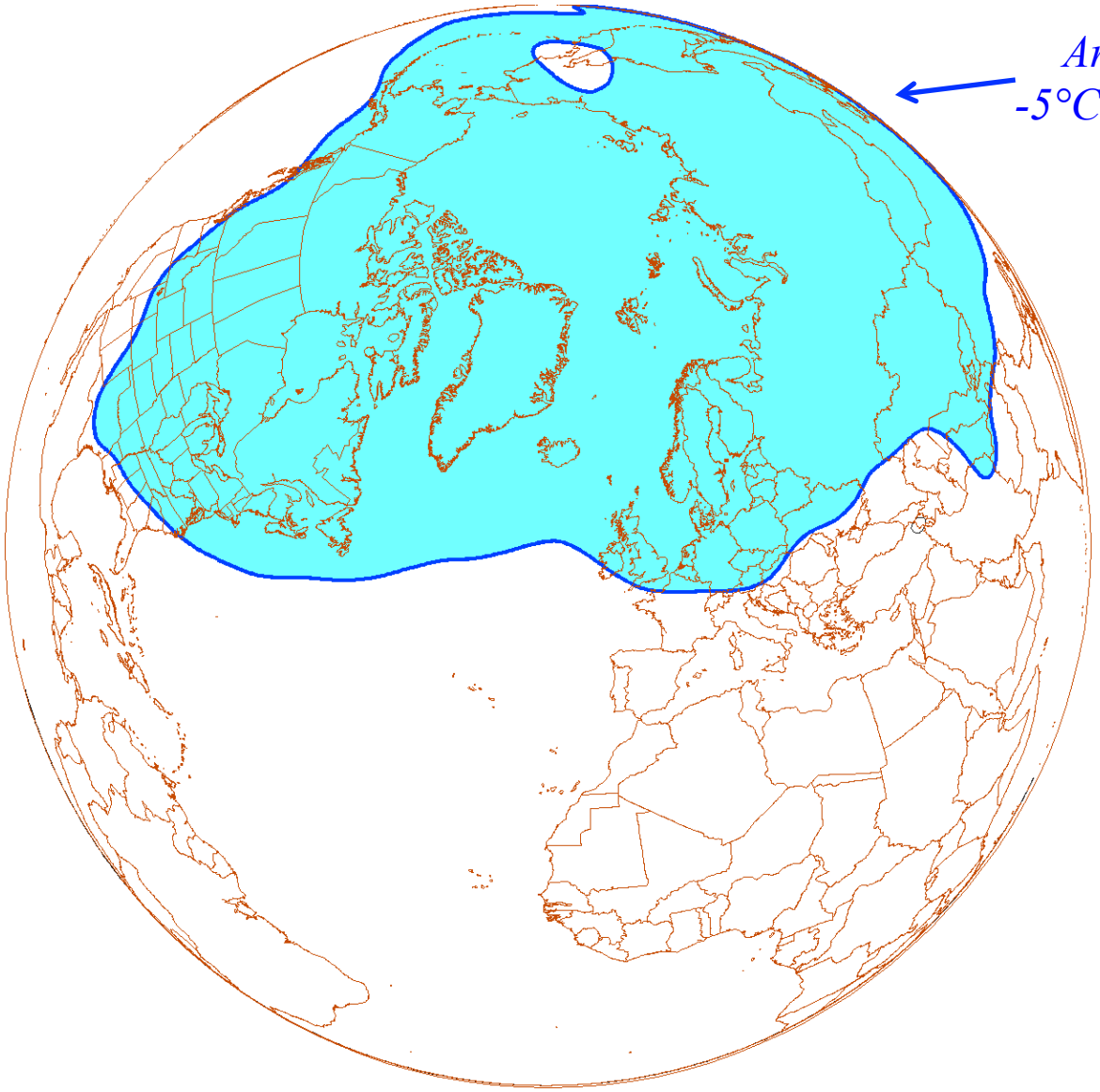
Duration of ice season on Lake Mendota



Lake Freeze/Thaw Data

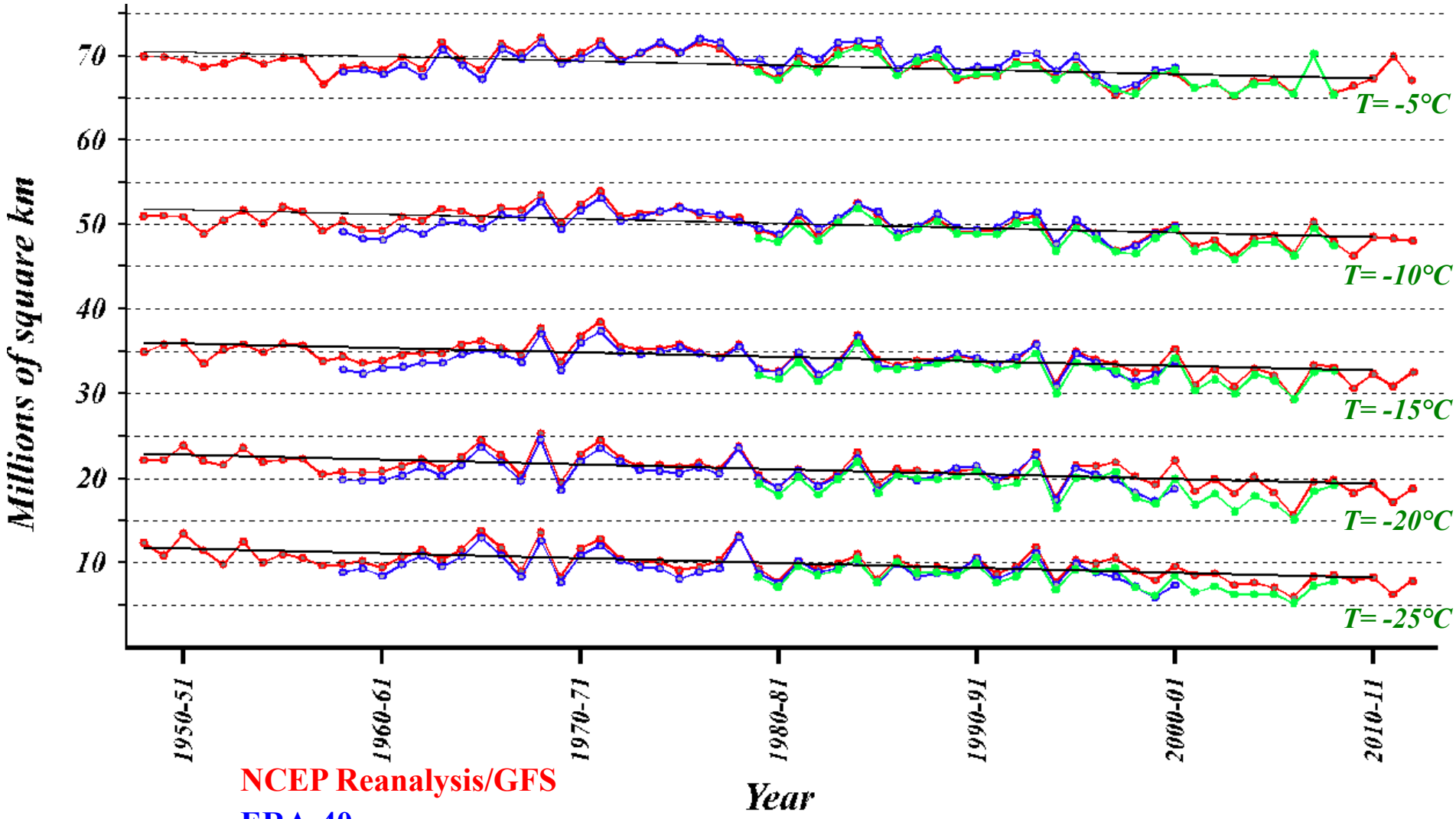
38 sites over the Northern Hemisphere were examined from 1846-1995. Results indicate a consistent warming pattern with an average of 8.7 days later for freeze dates and 9.8 days earlier for thaw dates.

J. Magnuson et al. (2000) *Science*



Trends in the Lower Tropospheric Wintertime Cold Pool Over the Past 65 Years

DJF Average Area : 1948/49 – 2012/13

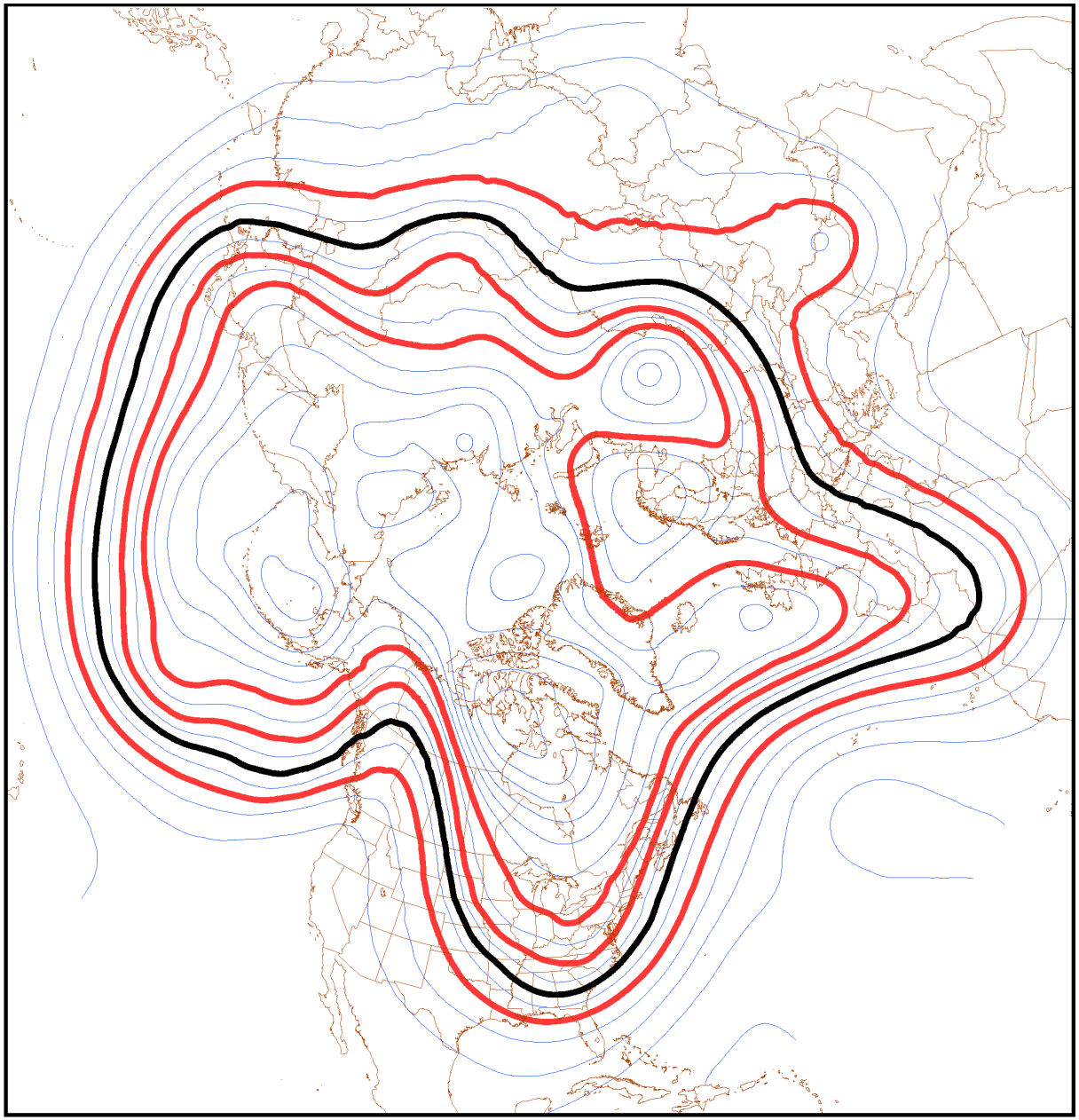


NCEP Reanalysis/GFS

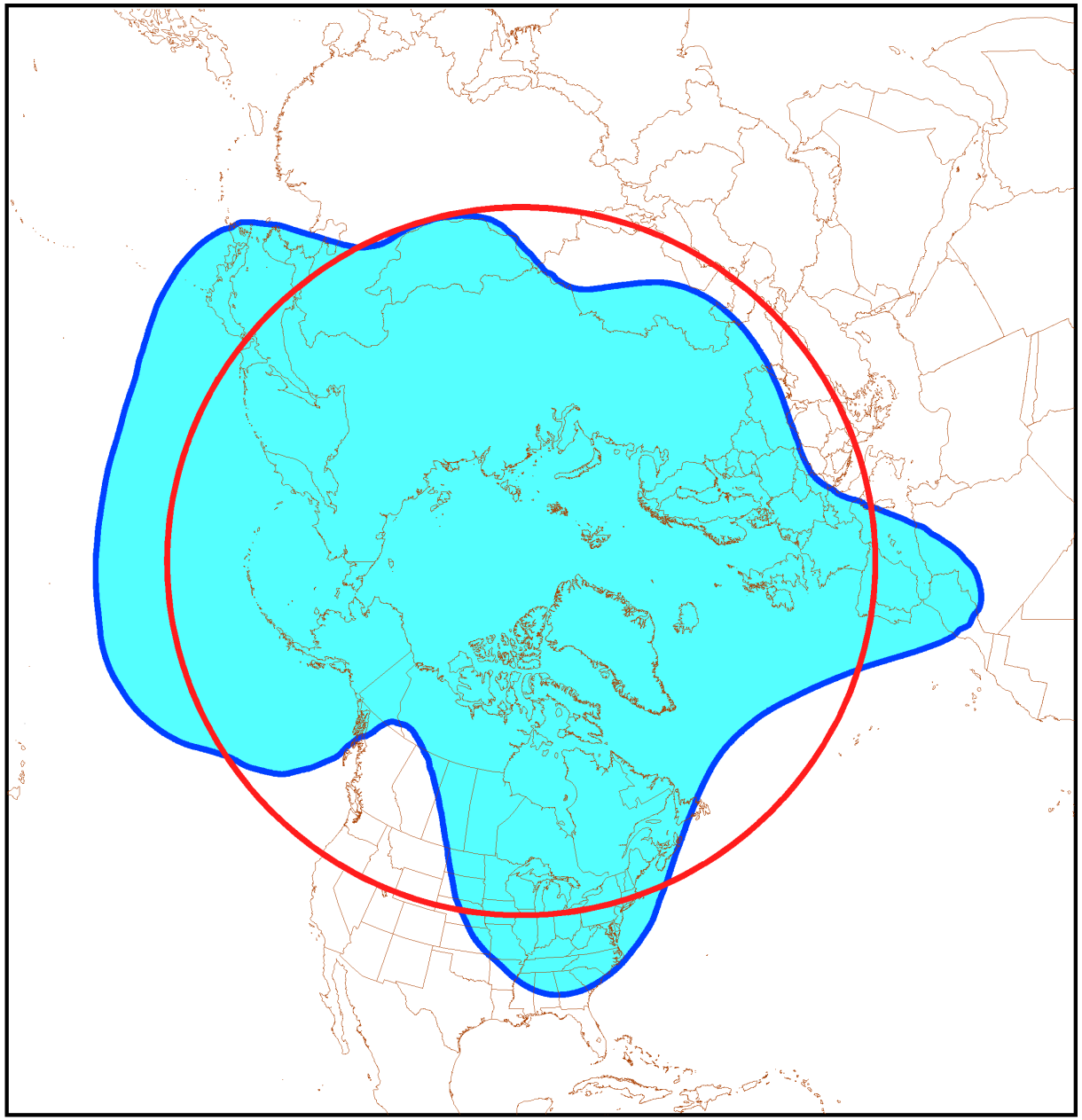
ERA-40

CFSR

Trends are significant at the 99.9% level



500 hPa Z 18 January 2014



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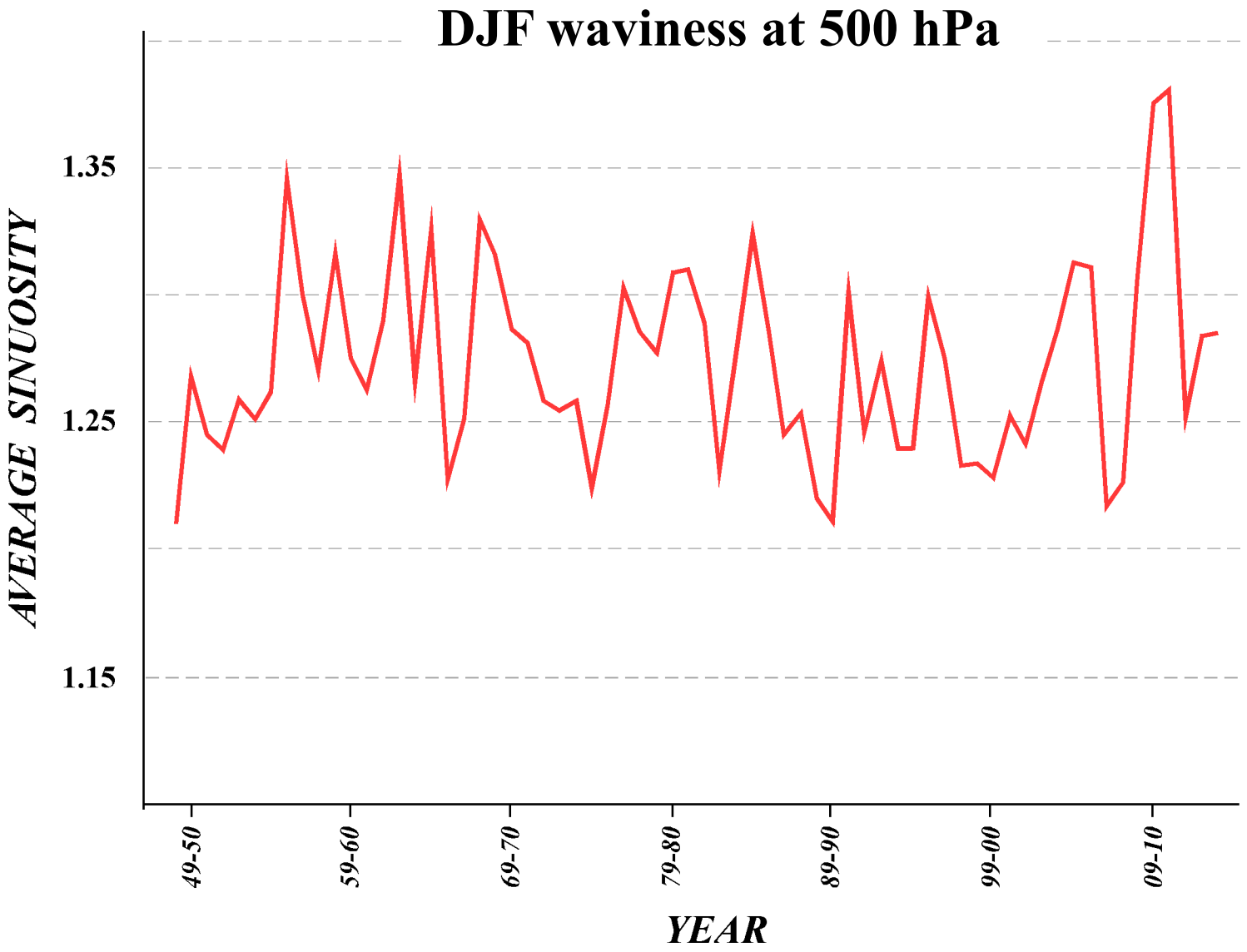
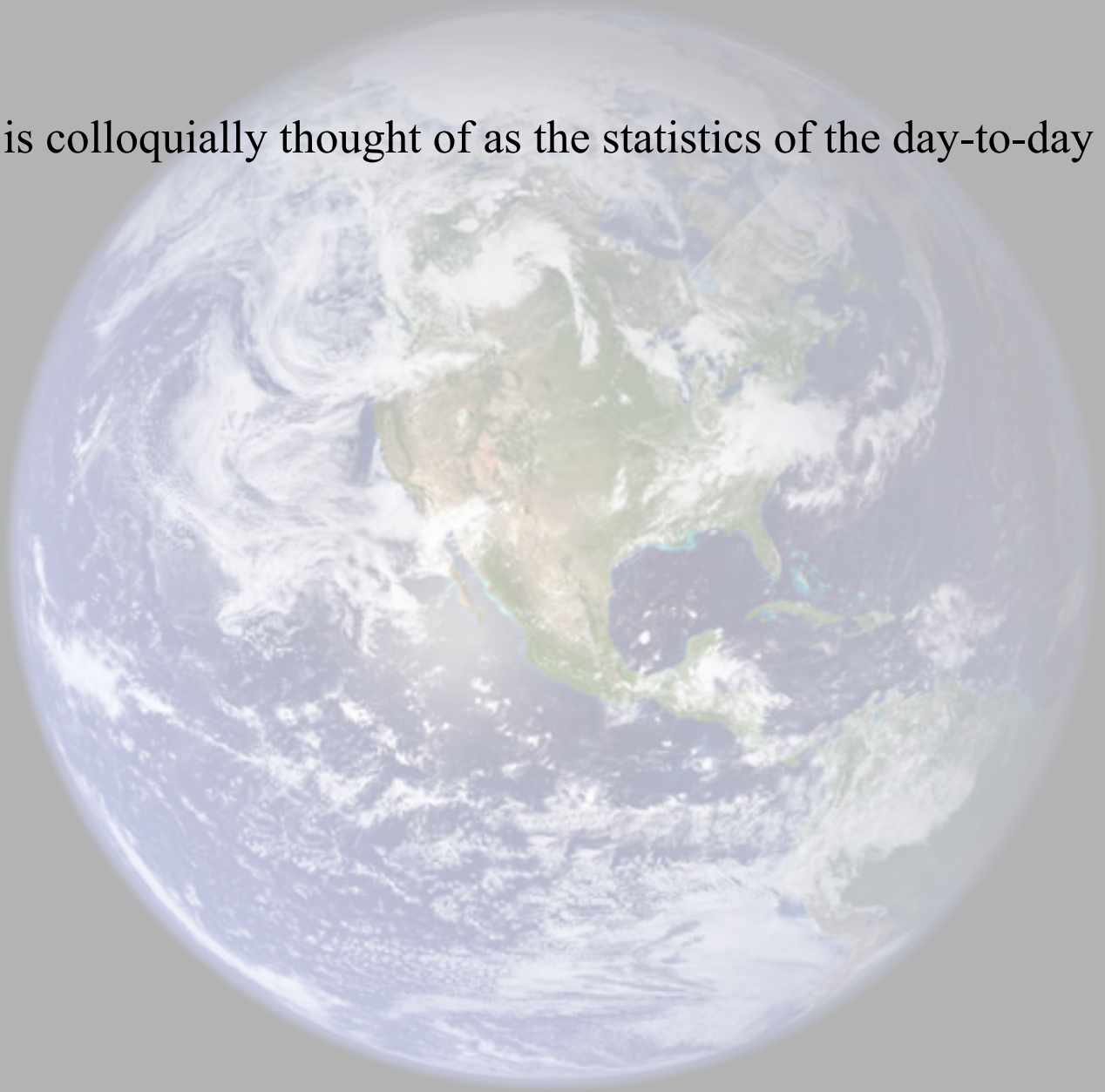


No clear trend in wintertime "waviness" of the flow

Climate is colloquially thought of as the statistics of the day-to-day weather



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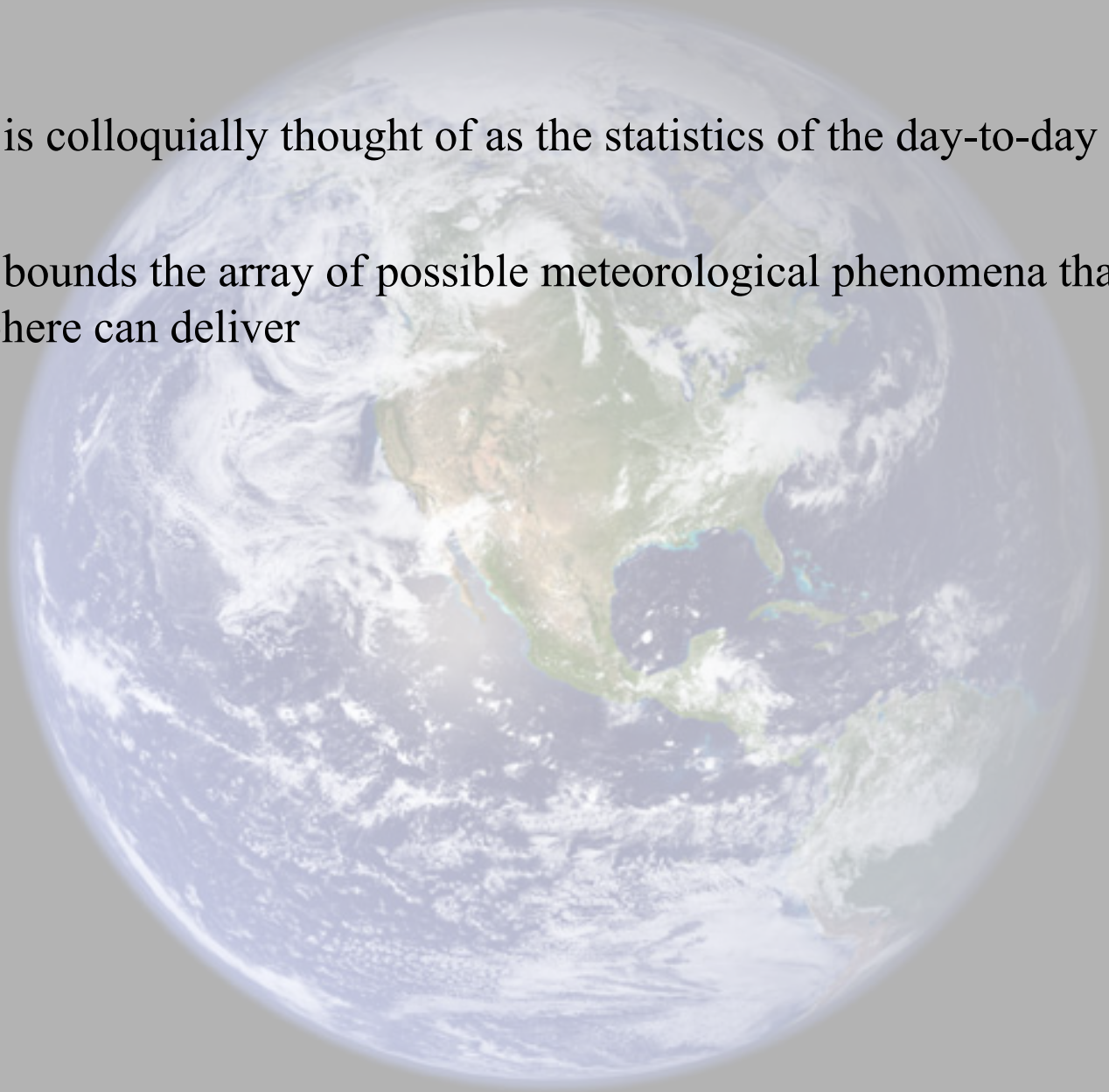
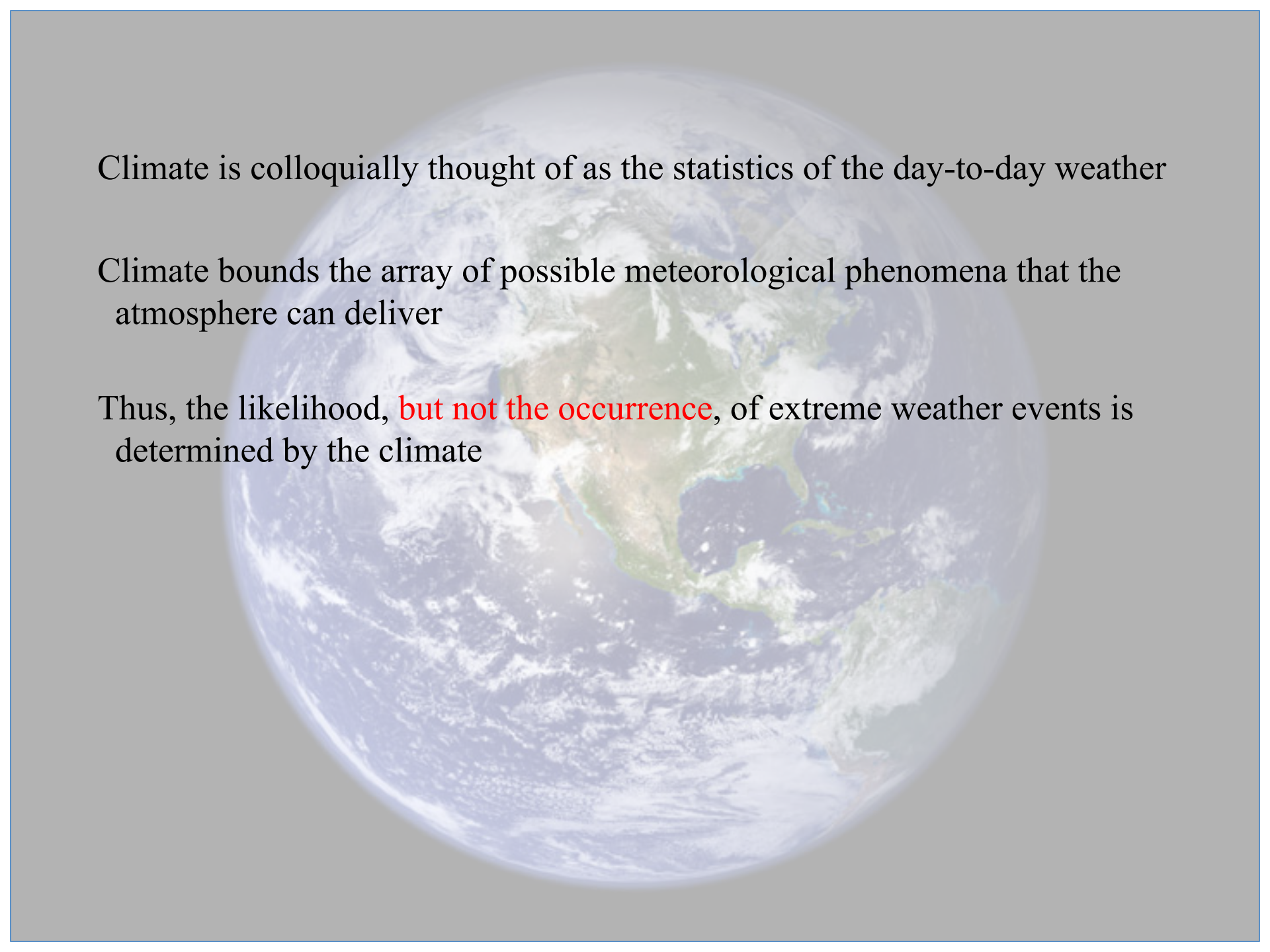
Climate bounds the array of possible meteorological phenomena that the atmosphere can deliver





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The chemical composition boundary condition has changed and so the bounds on possible extremes have also changed