

Solving the Global Warming Problem will be Difficult

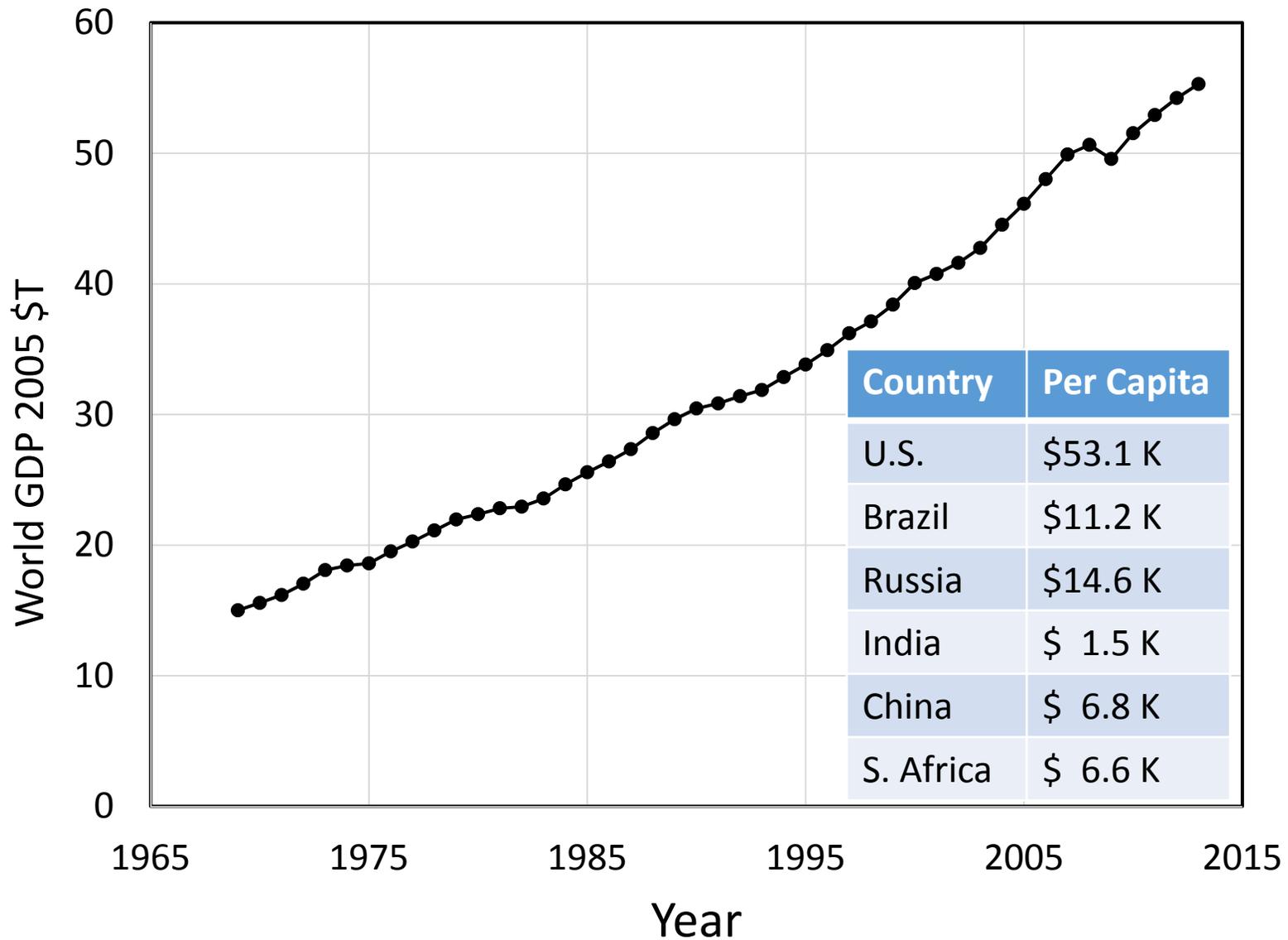
Countries with Largest Known Fossil Fuel Reserves

Russia	\$40.7T
Iran	\$35.3T
Venezuela	\$34.9T
Saudi Arabia	\$33.0T
U.S.	\$28.5T

Top 2014 Fortune 500 (Revenues)

Wal-Mart Stores	\$476 B
Exxon Mobil	\$408 B
Chevron	\$220 B
Berkshire Hathaway	\$182 B
Apple	\$171 B
Phillips 66	\$161 B

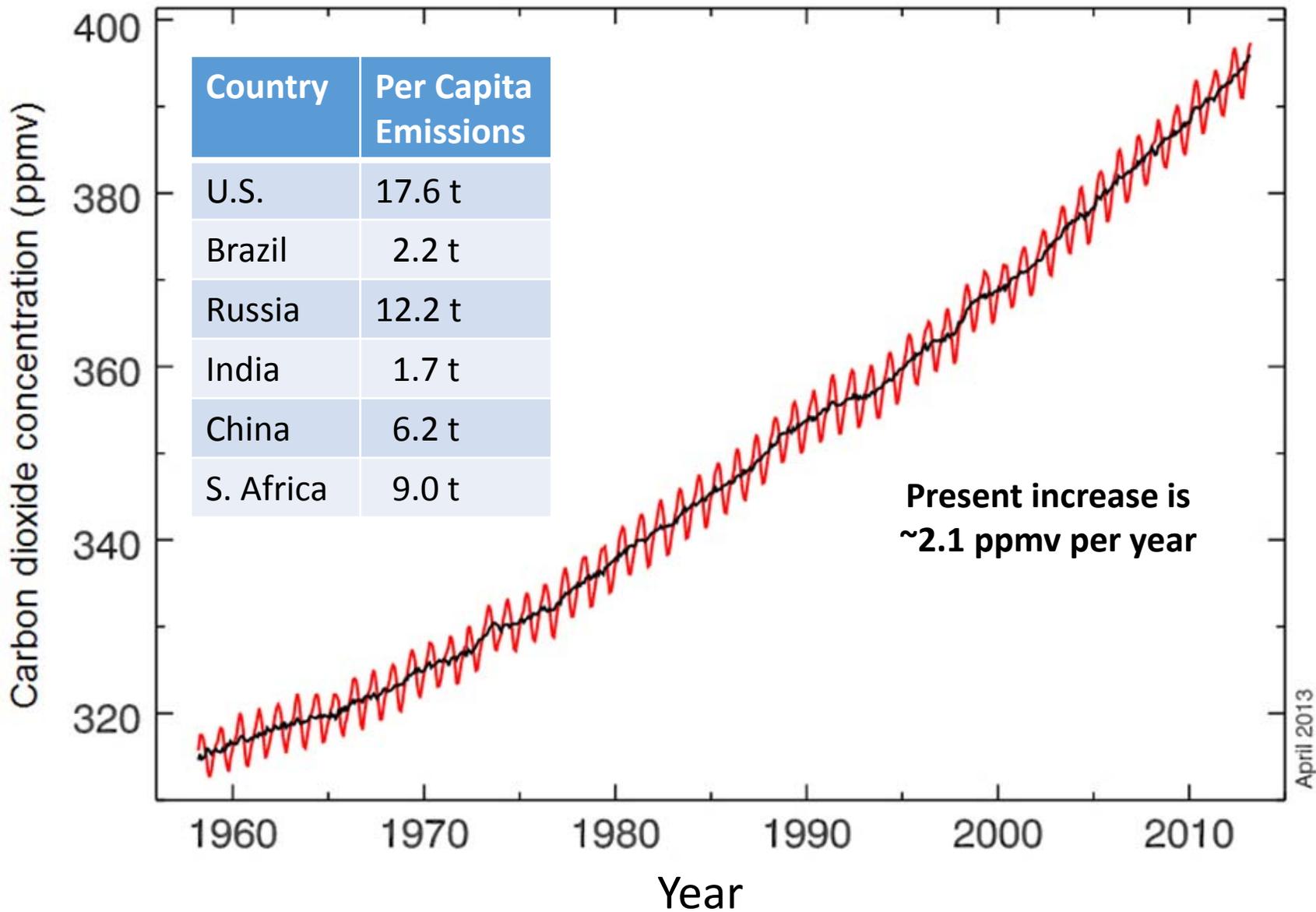
People Desire a Standard of Living Similar to the U.S.



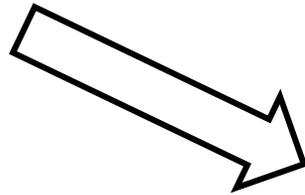
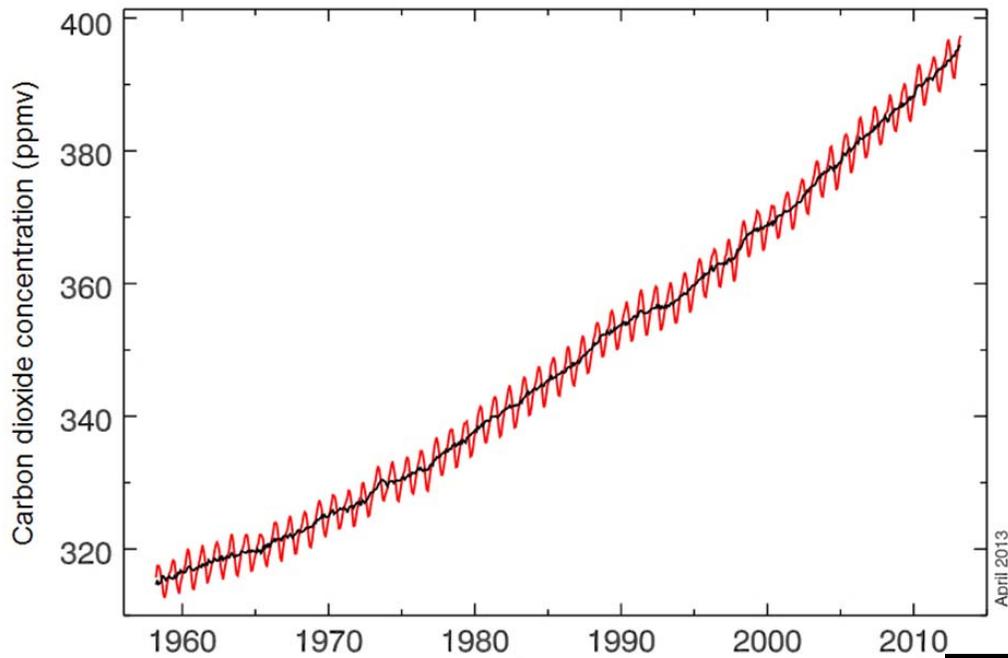
[Per Capita 2013 GDP in current U.S. \$s] <http://data.worldbank.org/indicator/NY.GDP.PCAP.CD>

[World GDP 2005 \$T] <http://www.ers.usda.gov/data-products/international-macroeconomic-data-set.aspx>

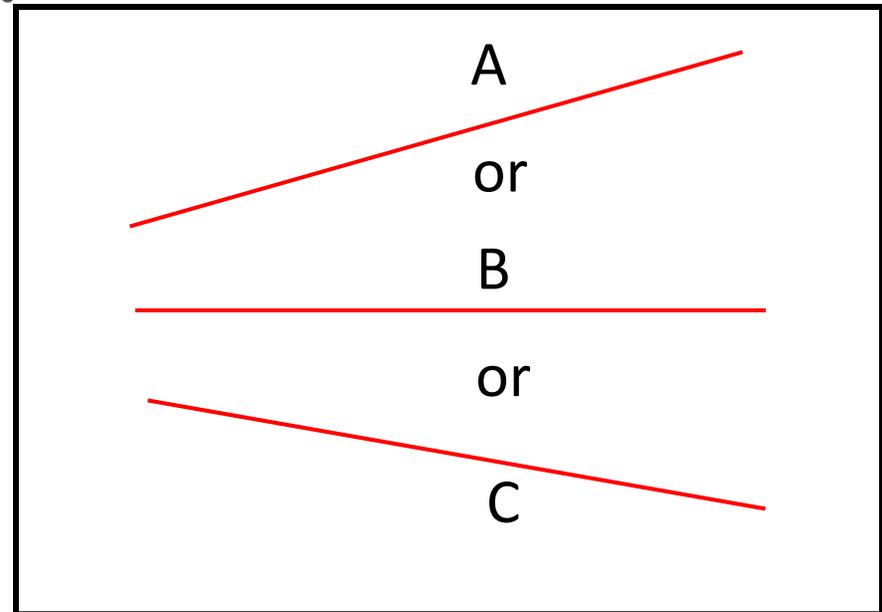
“Keeling” Curve



Need to Better Understand the Consequence of Greenhouse Gas Emissions

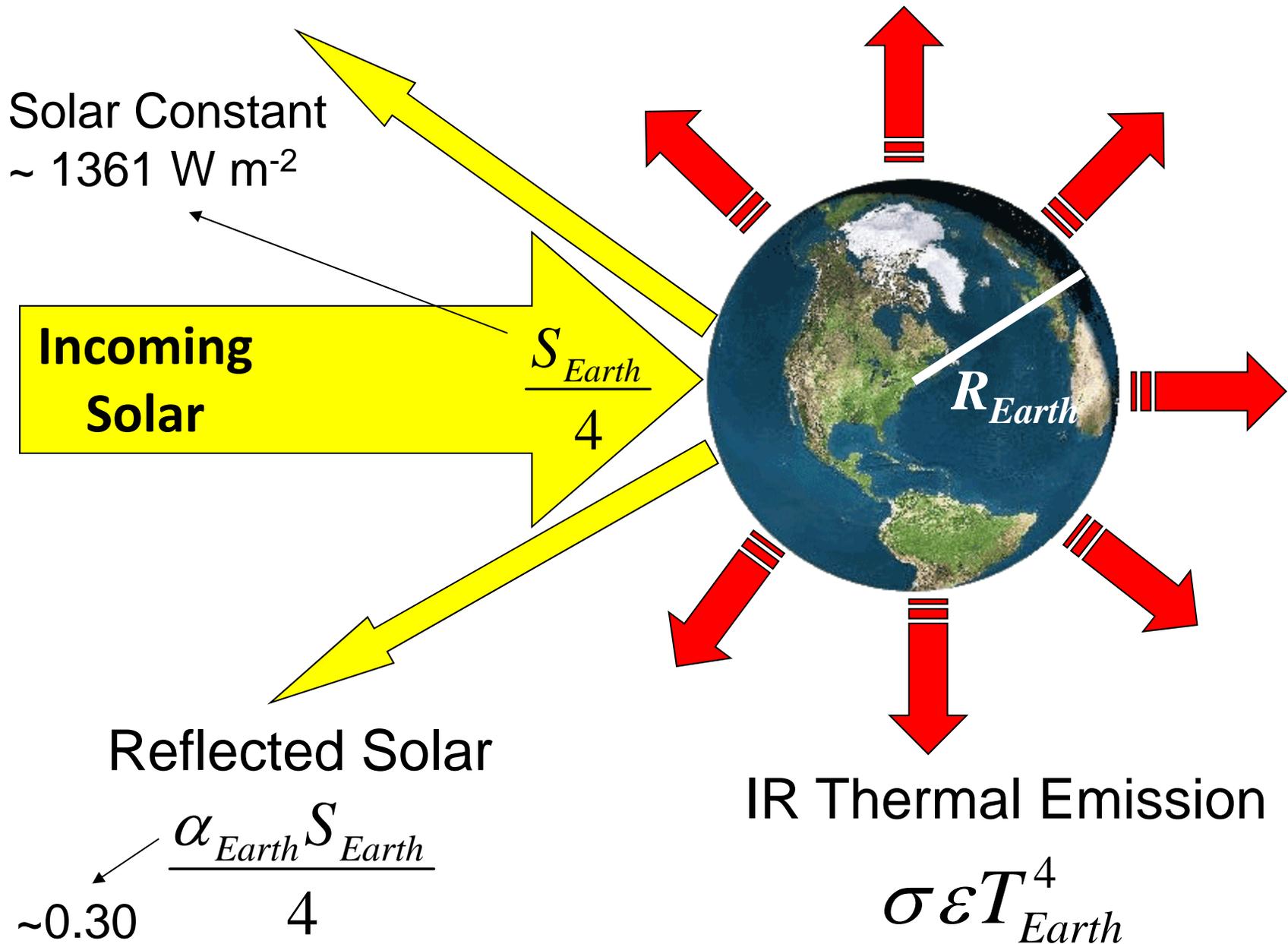


Climate Variable



Time

Earth's Energy Balance



Two Climate Measurement Strategies

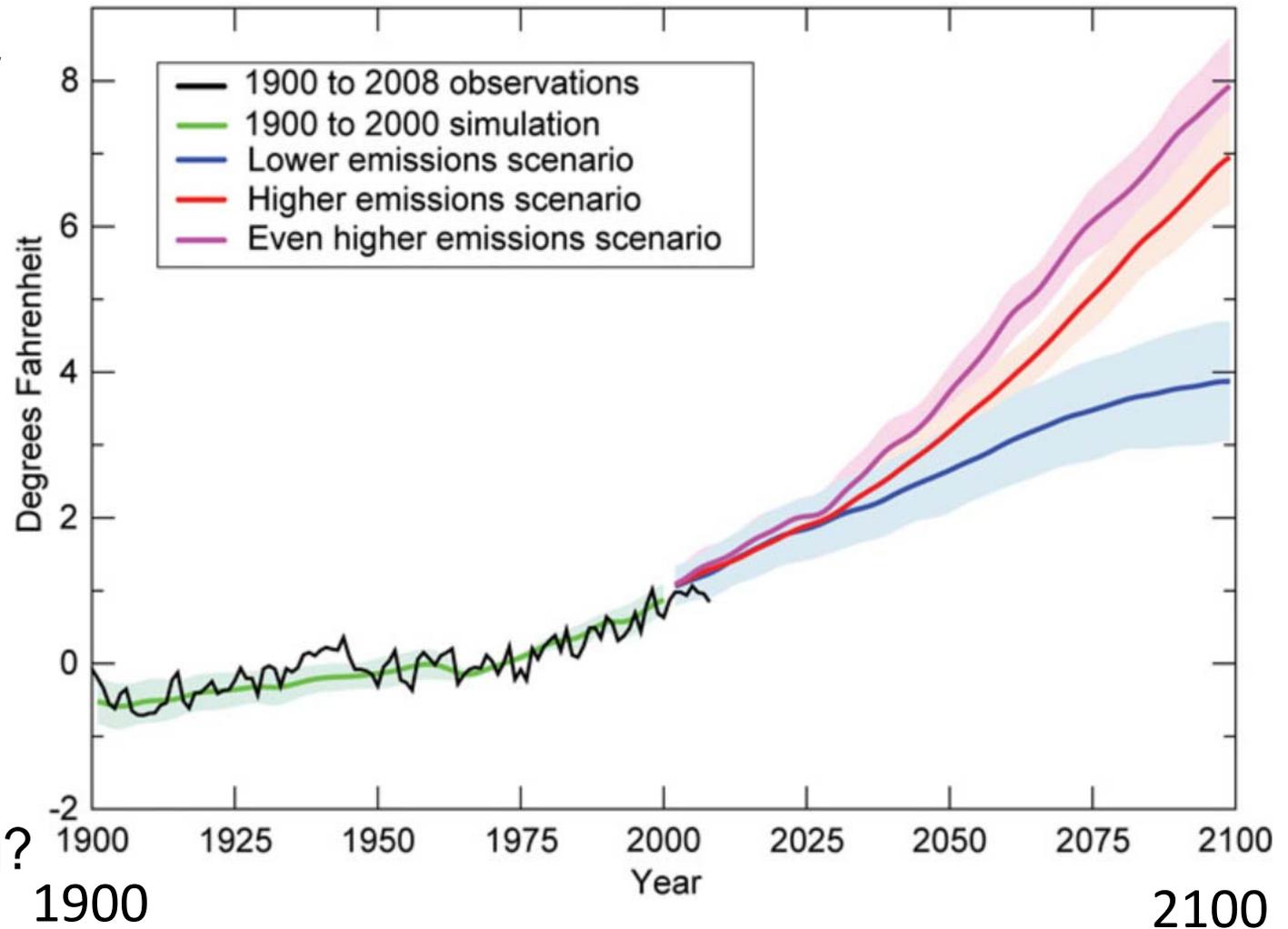
- Understand the phenomenology and have the models predict the trends.
 - requires high-quality models guided and validated by targeted measurements
- Extrapolate measured time series (climate data records) to determine the trends.
 - requires accurate, long-term measurements

Measurement Challenges

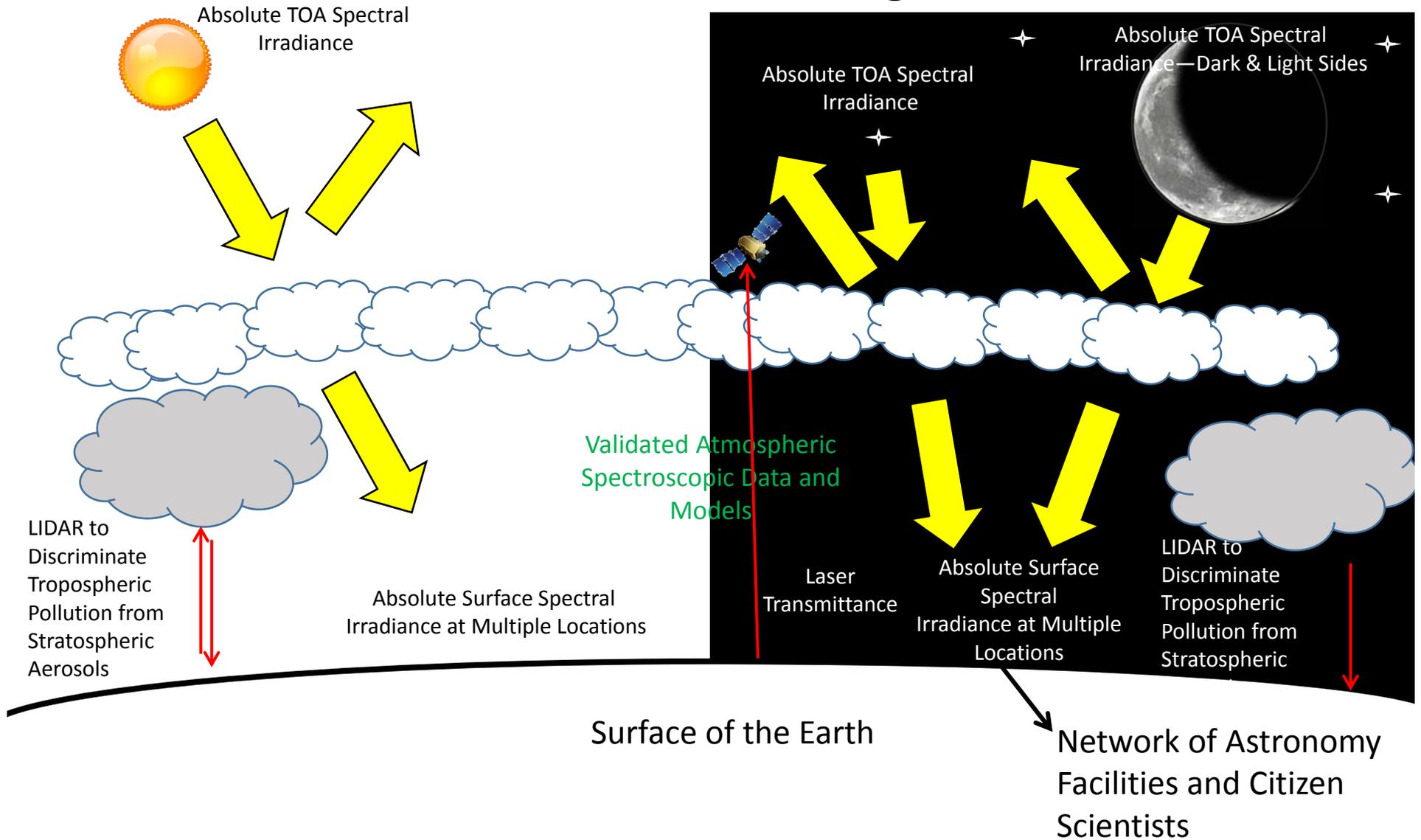
- Small decadal changes in climate variables
- Highly variable weather noise
- Natural short-term climate variations
- Require measurement comparability independent of organization and time
- Major policy and economic impacts and ramifications

Looking to the Future—Many Outstanding Questions Remain that Require a Measurement Science Response

- How much, how fast?
- Impact?
- Regional differences?
- Mitigation?
- Other threats?
- Geoengineering?



Solar Radiation Management



Note: A 1 K change in surface temperature corresponds to an $\sim 0.7\%$ (9.6 W m^{-2}) change in top-of-the-atmosphere solar irradiance