



Climate change, CO₂ emission trends and mitigation portfolio

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13.-14. April 2011, Vilnius

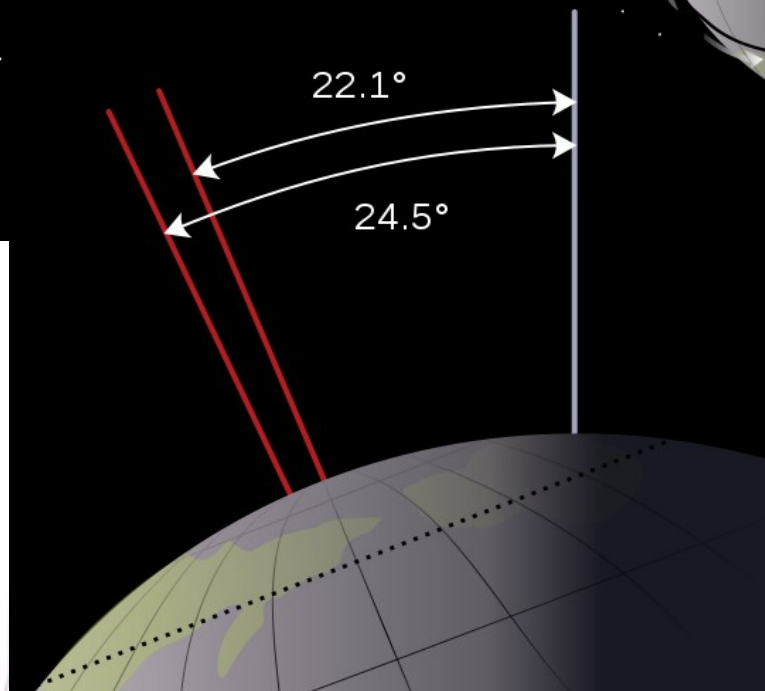
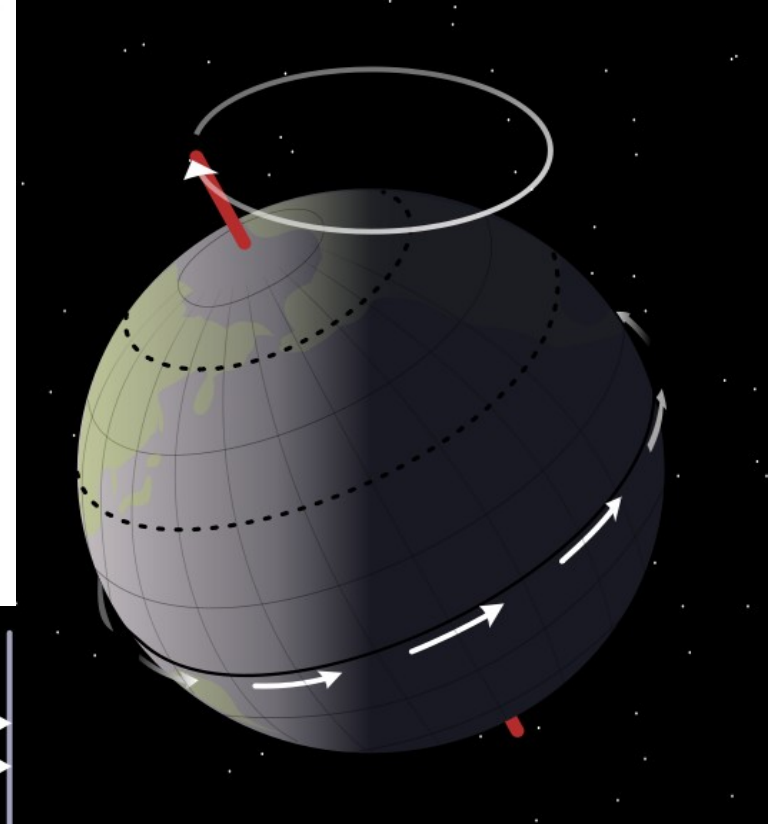
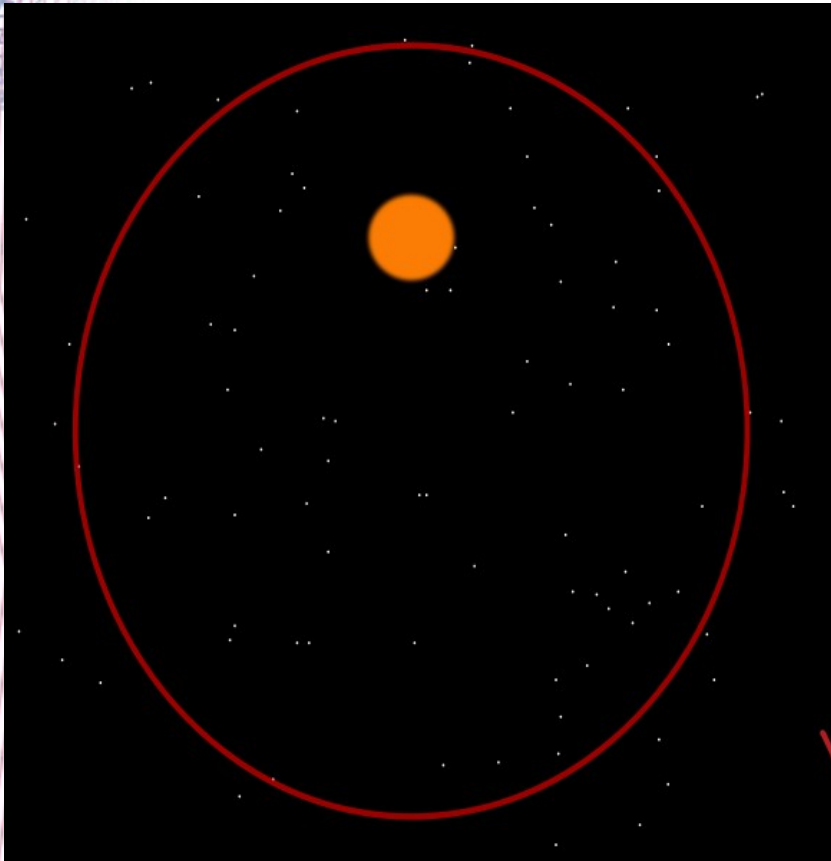
"CO₂ Capture and Storage - Response to Climate Change"

Sun → Earth



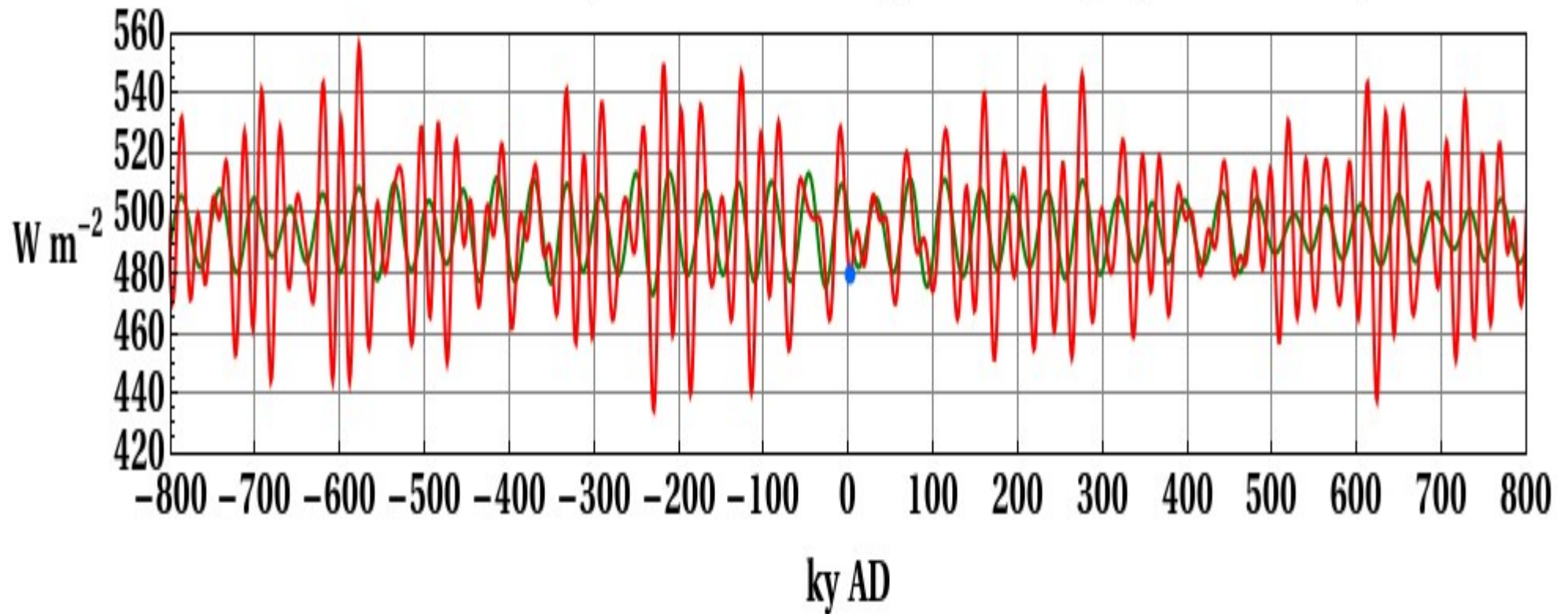
1366 W/m²

Orbital parameters

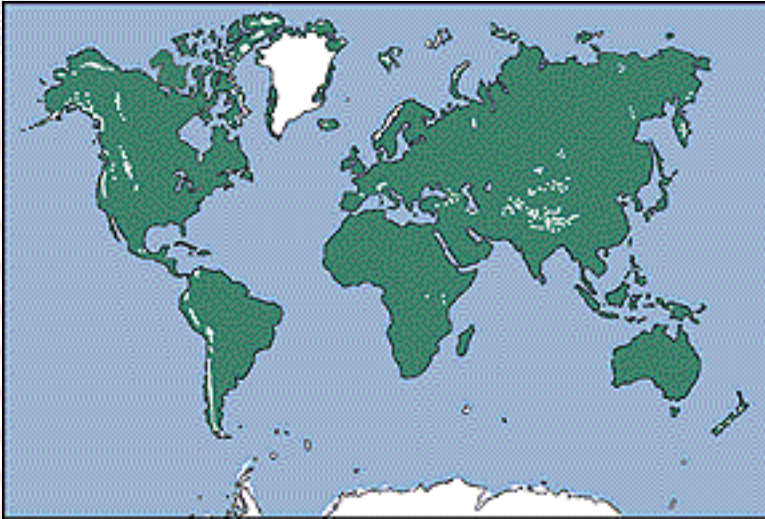


Milankovitch cycles

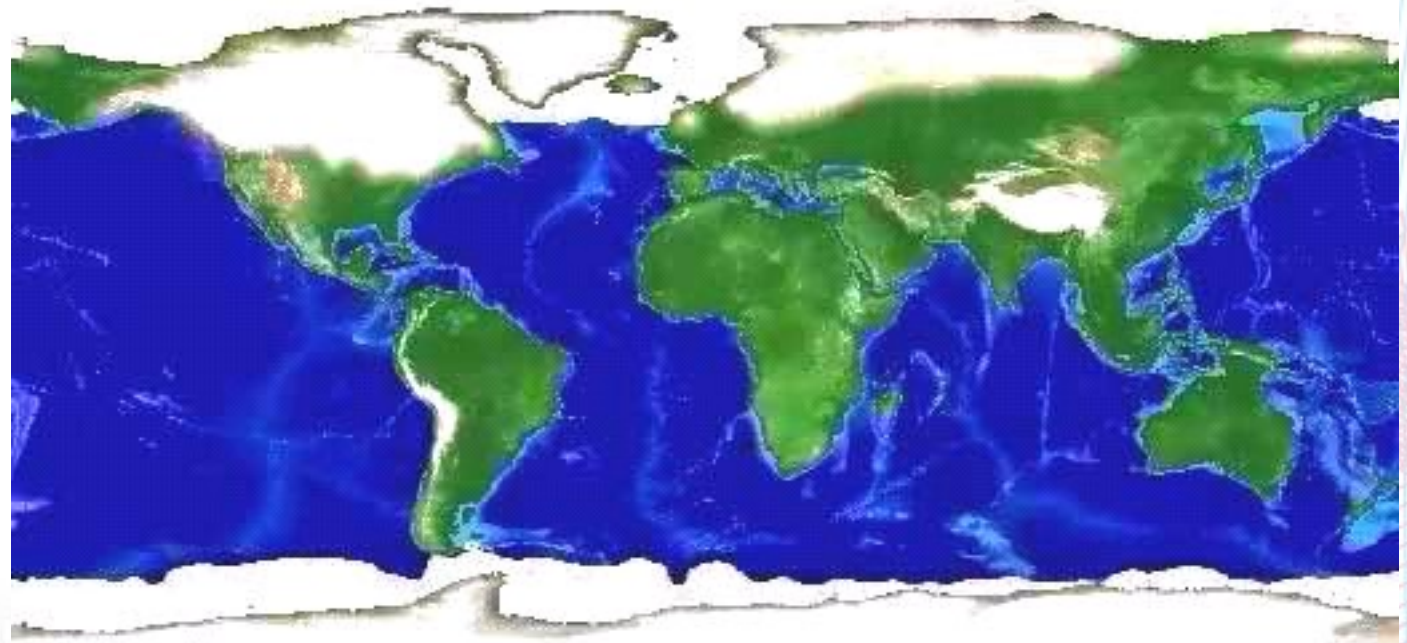
Insolation at 65 N, Summer Solstice (green is obliquity contribution)



Ice ages



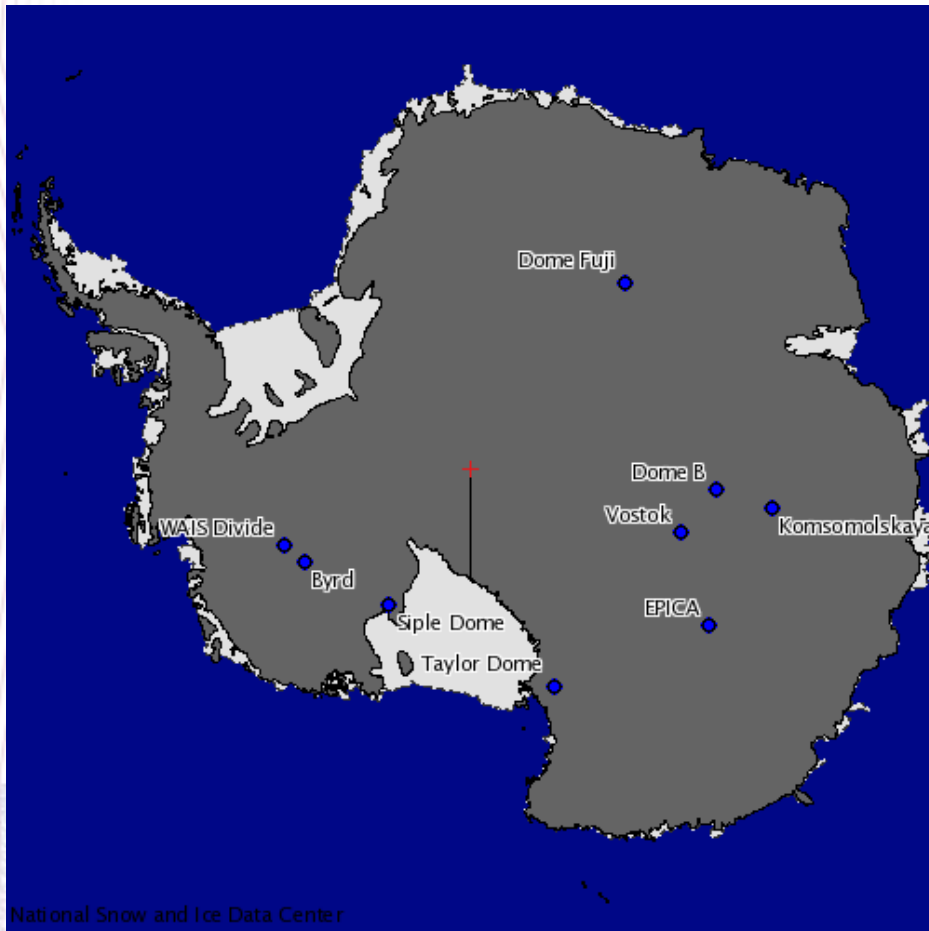
≈ 20 ky BP



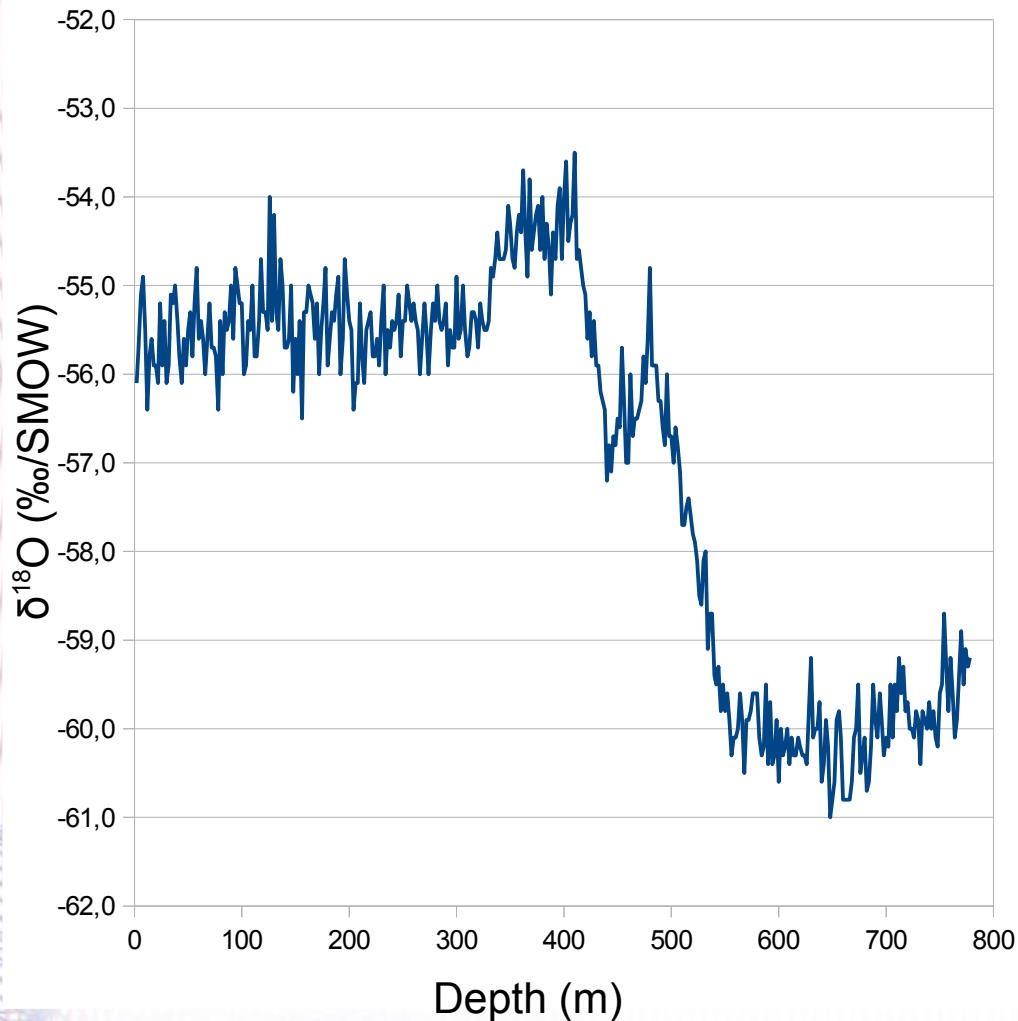
Rice University

Climate records in ice cores

- **Dome B:** Dome B Ice Core
- Location: 77.0833°S, 94.9167°E
- Depth: 780 m
- **EPICA Dome C:** European Project for Ice Coring in Antarctica
- Location: 75.1°S, 123.35°E (Concordia Station, Dome C)
- Depth: 3270 m
- Drilled: 1996-2004
- Timespan: ~890,000 years
- **Vostok :** Vostok Station
- Location: 78.4667°S, 106.8667°E
- Depth: 3623 m
- Drilled: 1993-1998
- Timespan: ~420,000 years (4 glacial cycles)



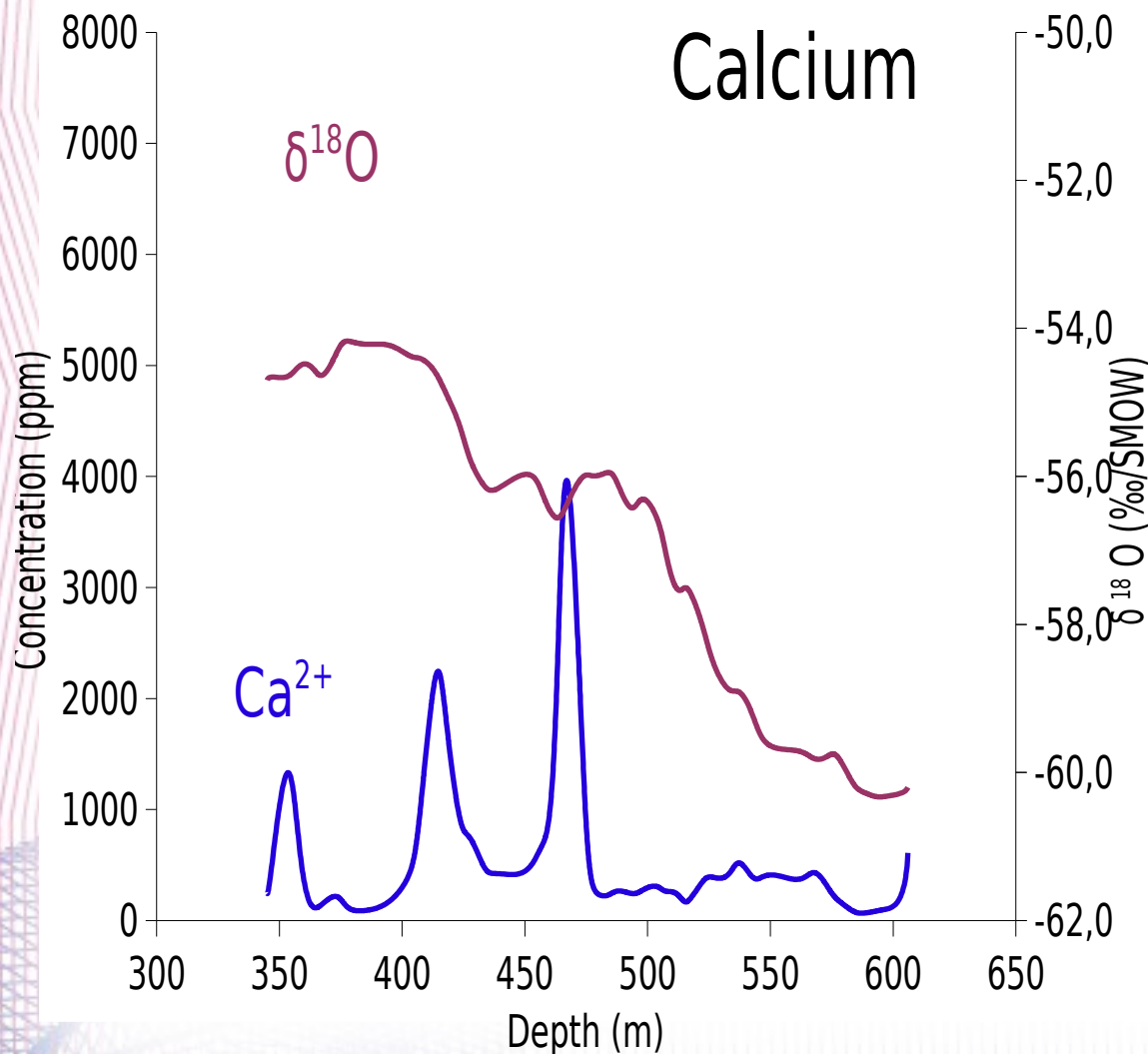
Dome B ↔ Inst. of Geology at TUT oxygen-18



Jouzel, J., Vaikmäe, R., Petit, J.R., Martin, M., Duclos, Y., Stievenard, M., Lorius, C., Toots, M., Melieres, M.A., Burckle, L.H., Barkov, N.I., Kotlyakov, V.M. 1995. The two-step shape and timing of the last deglaciation in Antarctica. - [Climate Dynamics](#), 11, 151--161.

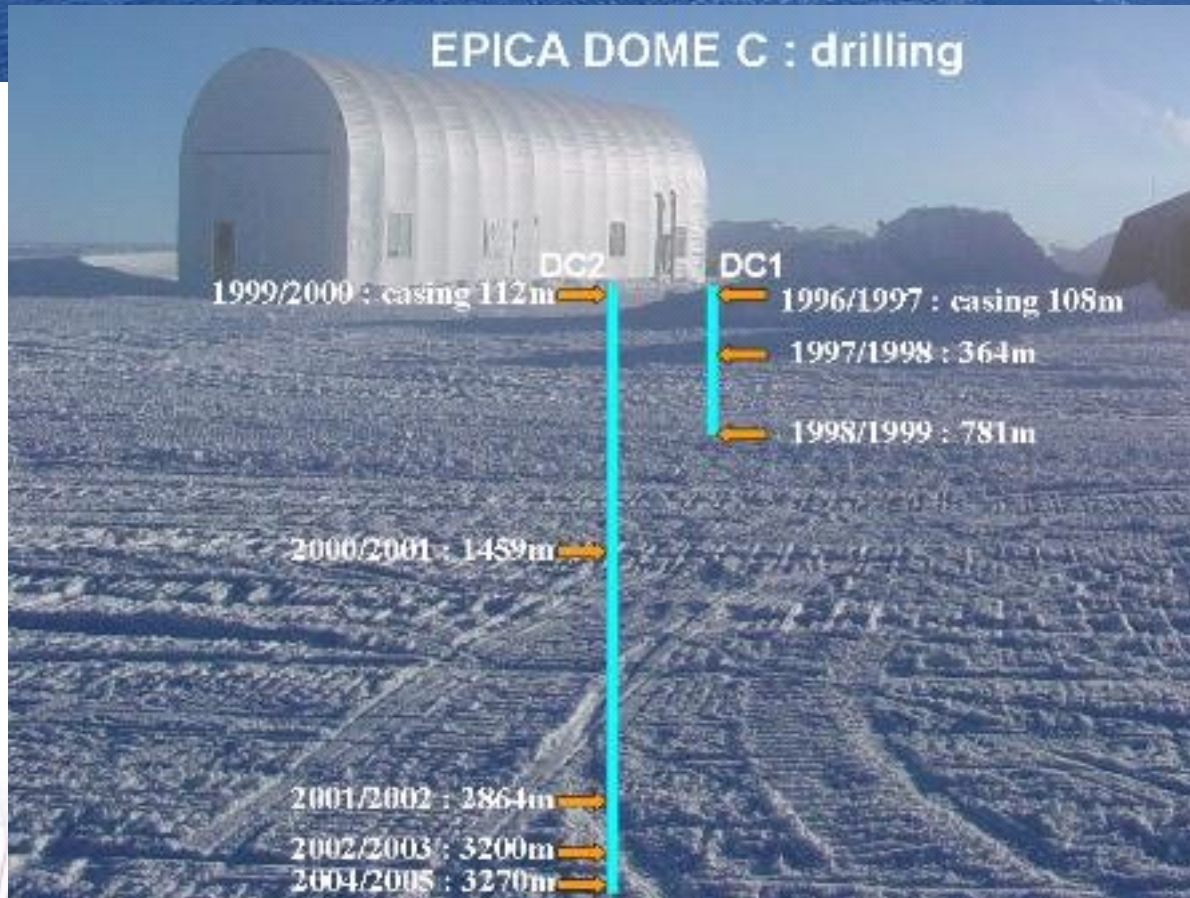
Dome B ↔ Inst. of Geology at TUT

major ions



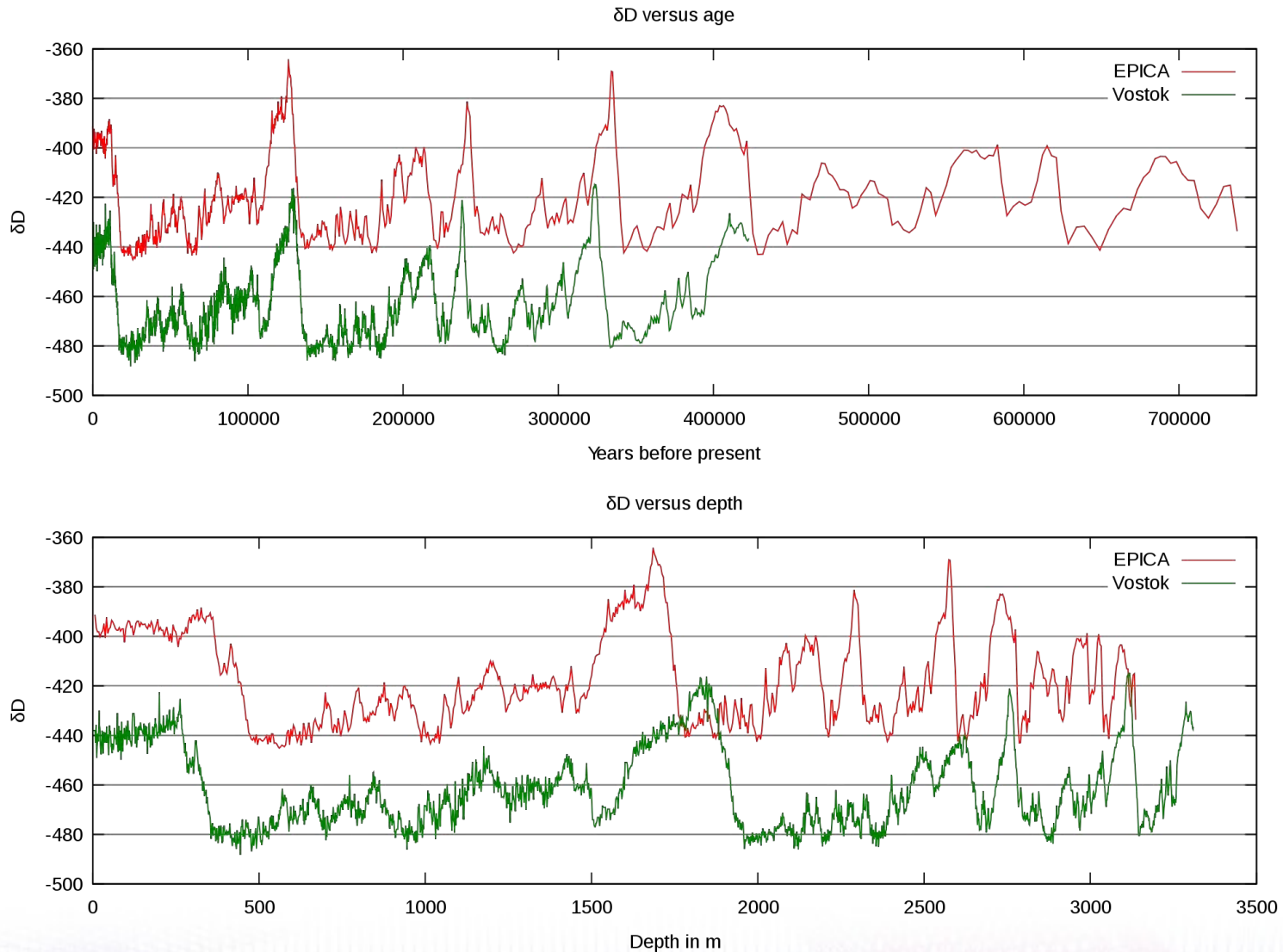
- *Ivask, J., Vaikmäe, R. 2004. Dome B ice core major ions concentration profiles and their relation to climate change during last deglaciation period. In: Terra Nostra. Selbstverlag der Alfred-Wegener-Stiftung, Berlin. 4, 225.*

Concordia Station, Dome C

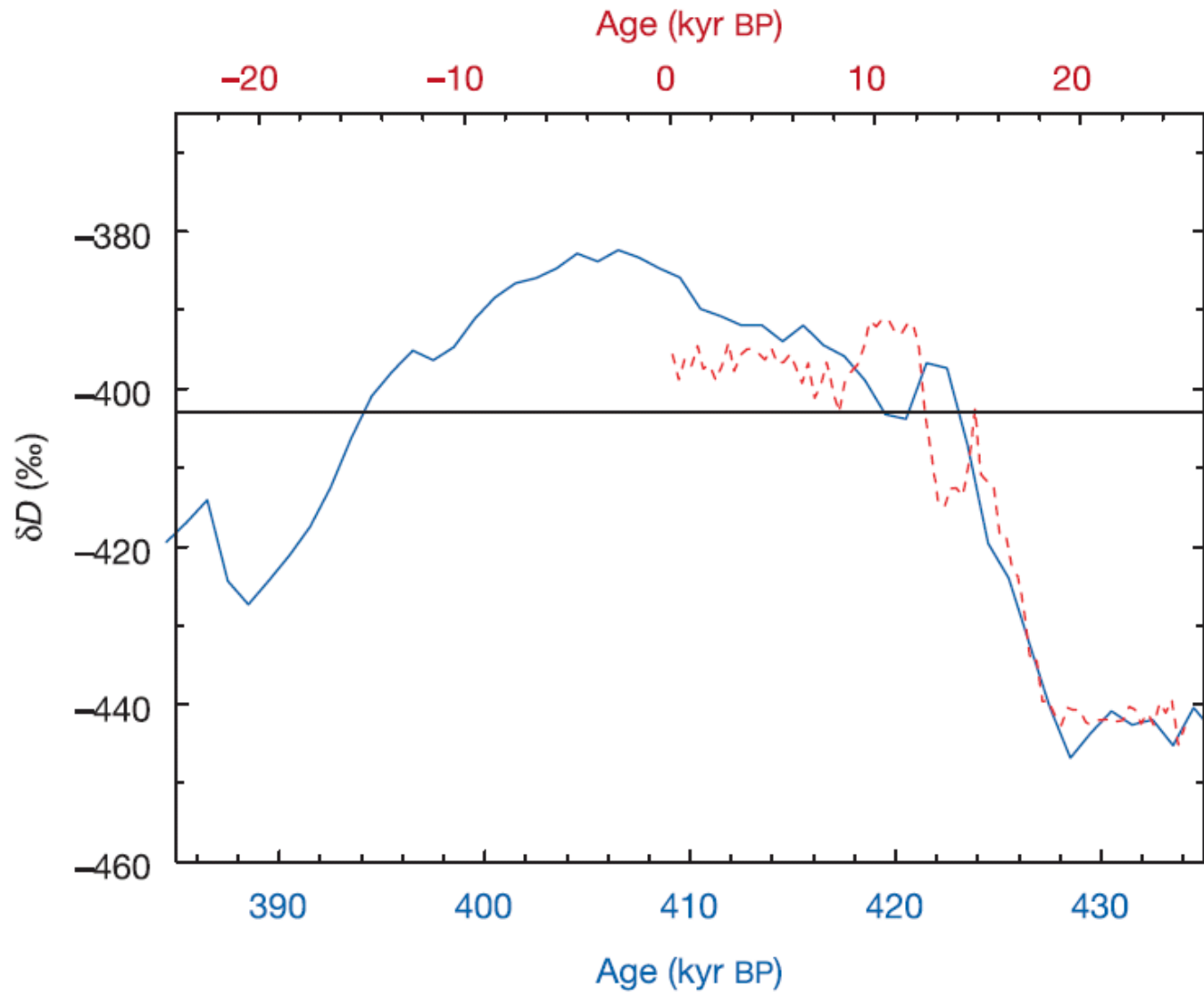


Climate records in ice cores

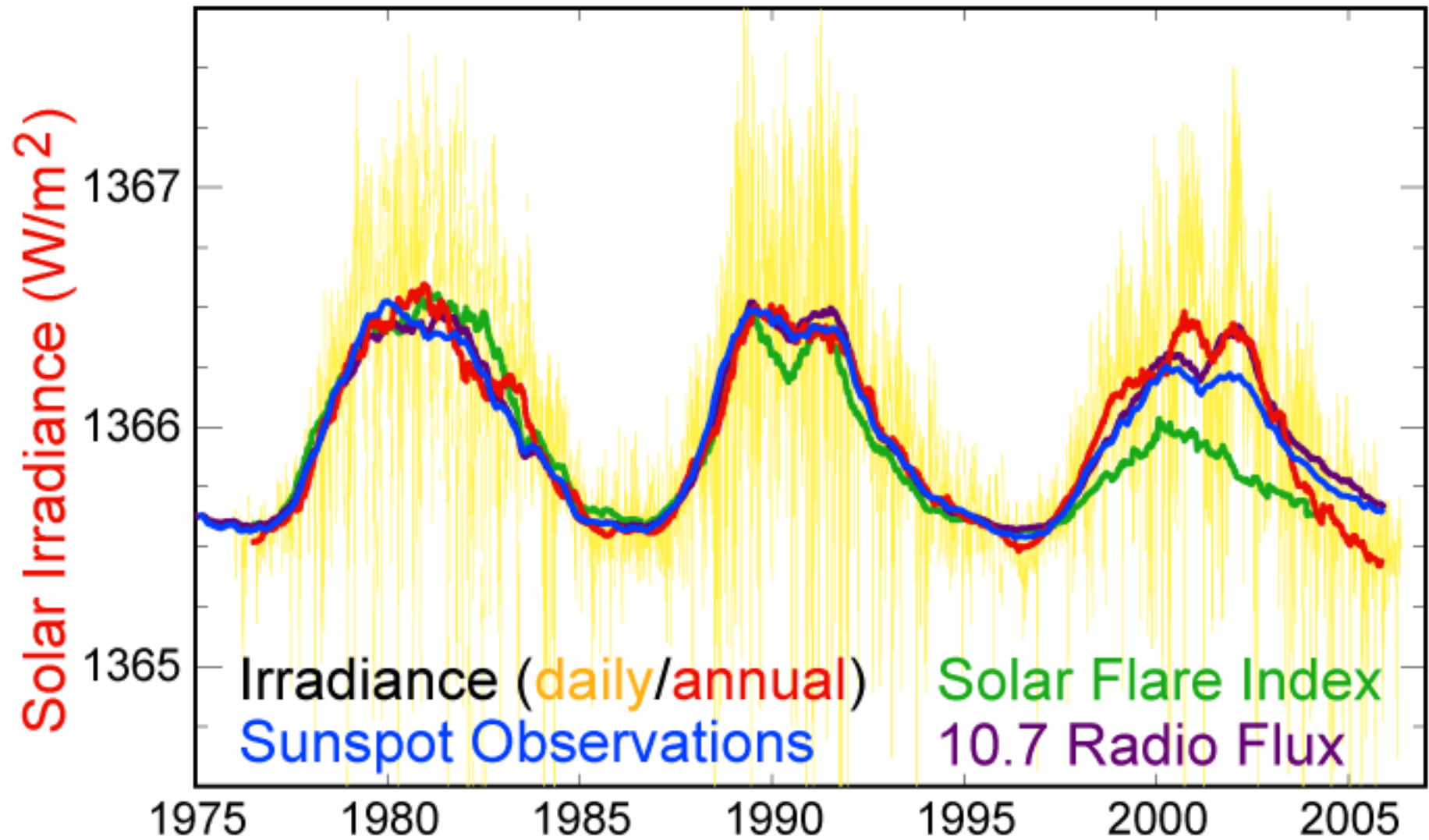
Dome C vs Vostok



Present vs past

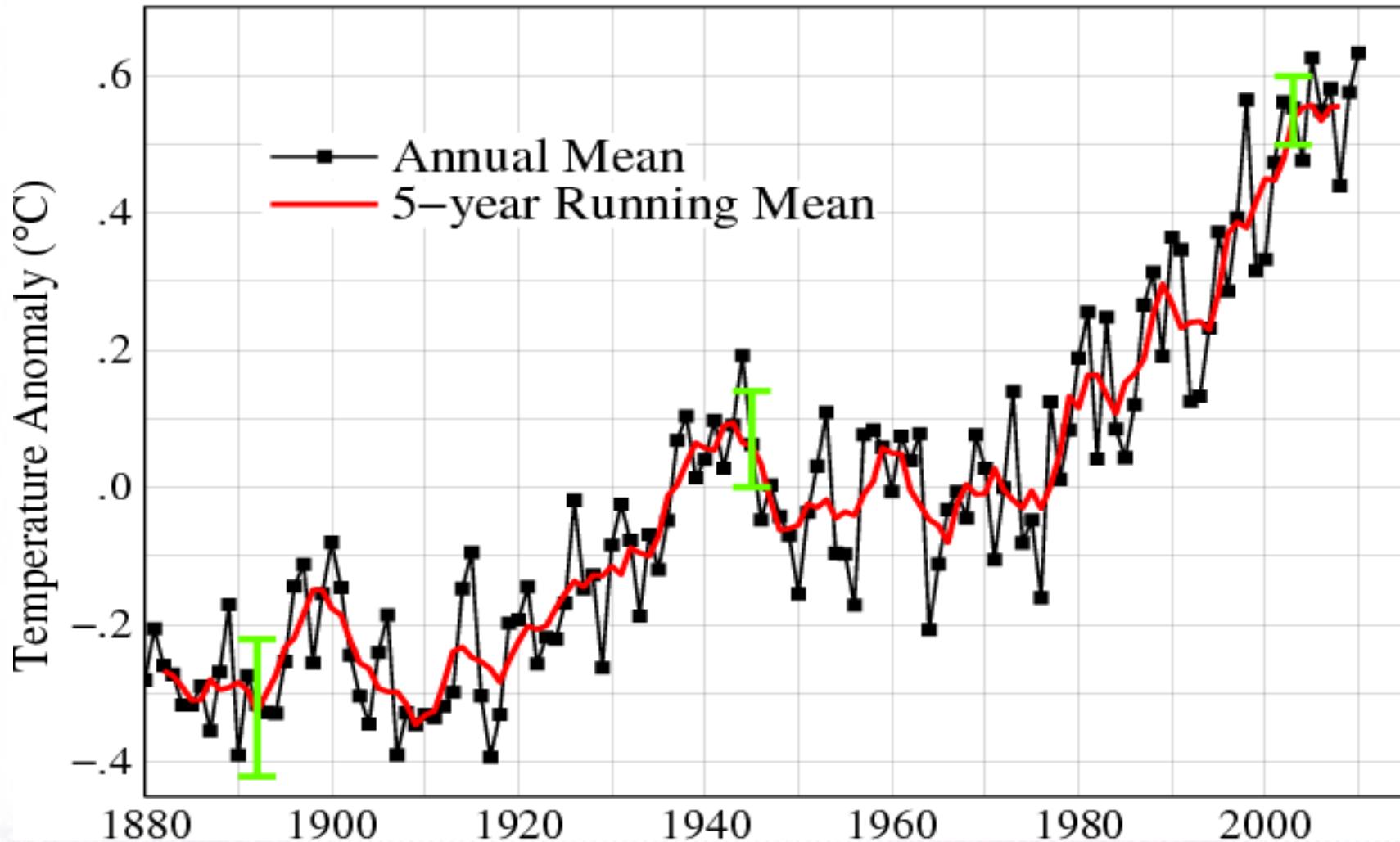


Solar cycle variations



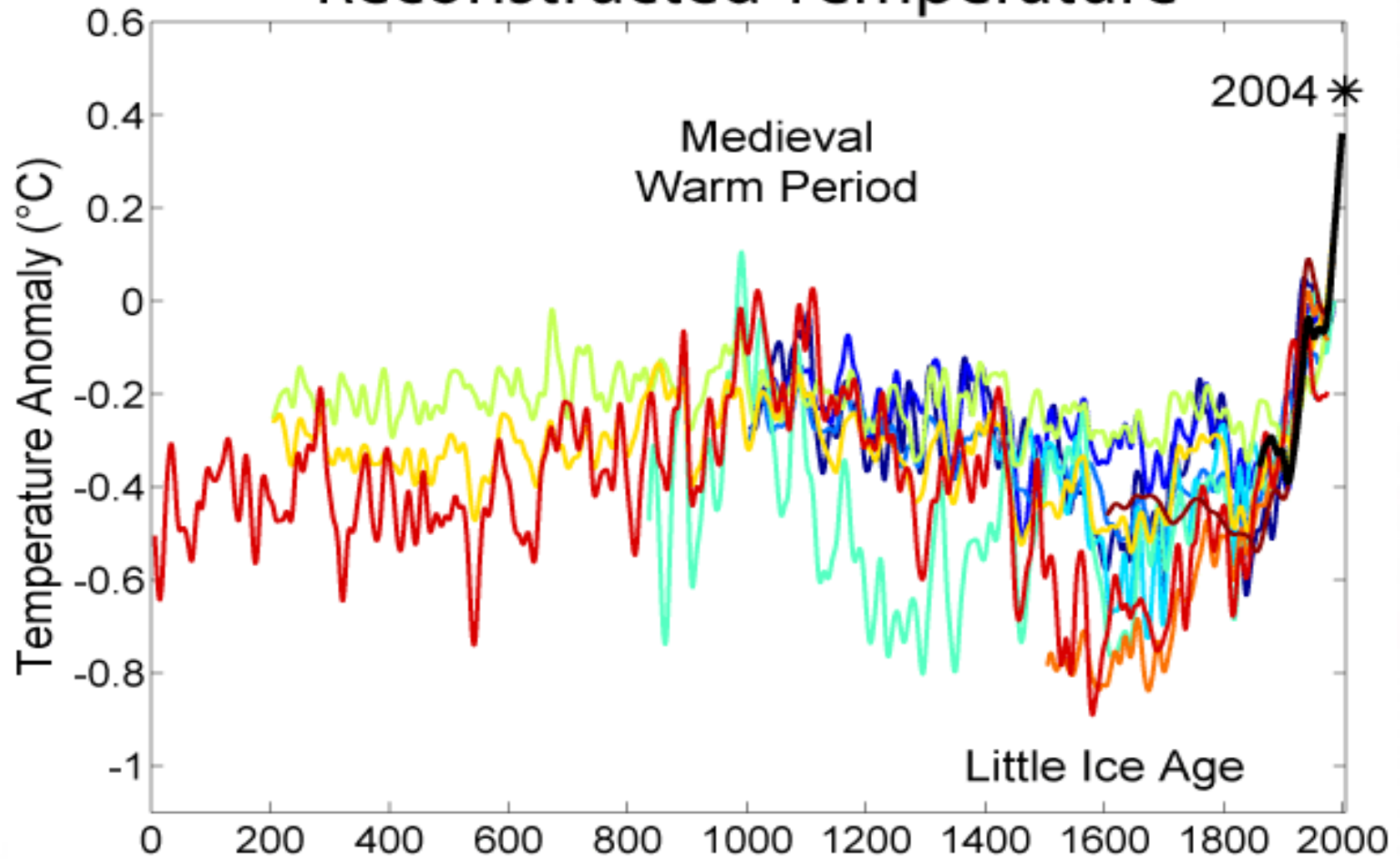
Recent global temperature change

Global Land–Ocean Temperature Index

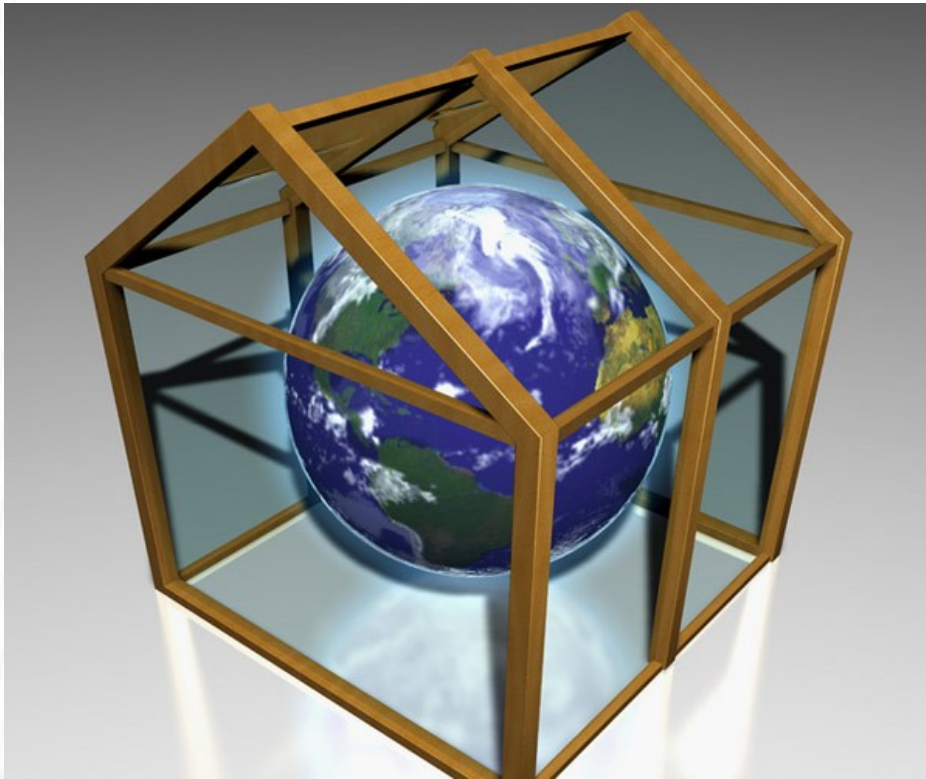


Last 2000 years

Reconstructed Temperature

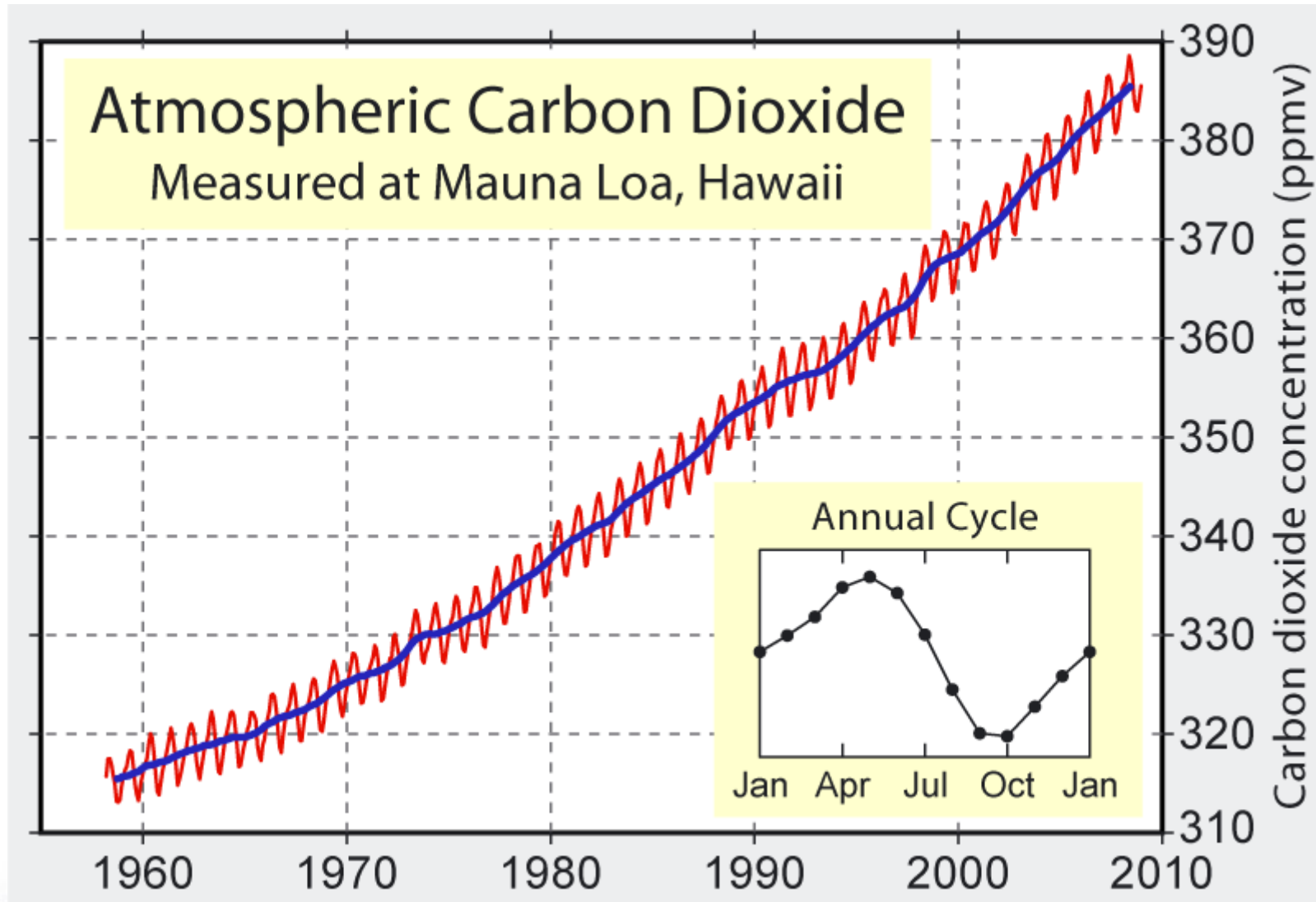


Earth atmosphere - greenhouse

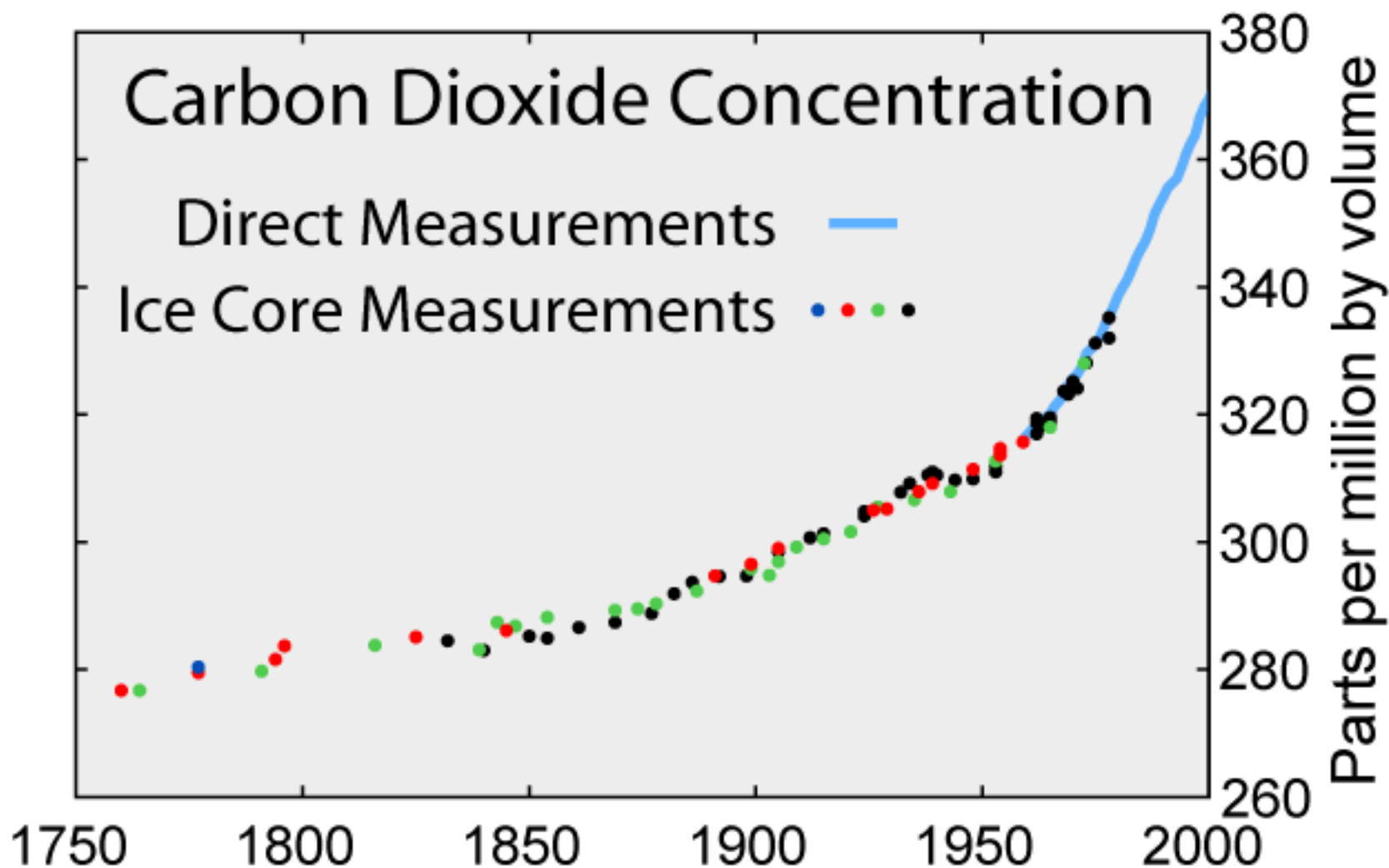


- **+ 33°C**
- **greenhouse gases**
- $\text{H}_2\text{O} \rightarrow 36\text{--}70 \%$
- $\text{CO}_2 \rightarrow 9\text{--}26 \%$
- $\text{CH}_4 \rightarrow 4\text{--}9 \%$
- $\text{O}_3 \rightarrow 3\text{--}7 \%$

Keeling Curve

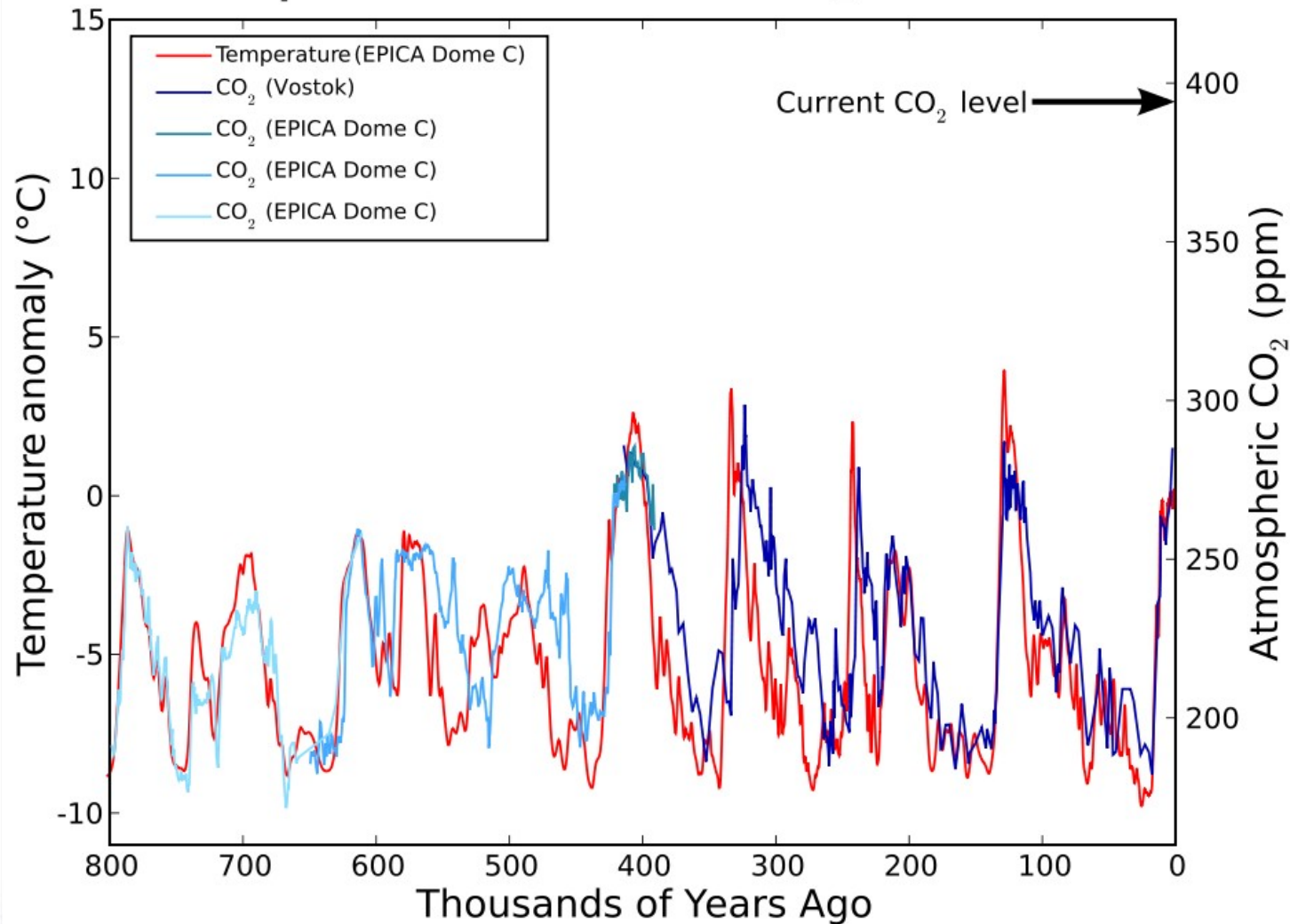


Increasing atmospheric CO₂ levels as measured in the atmosphere and reflected in ice cores.

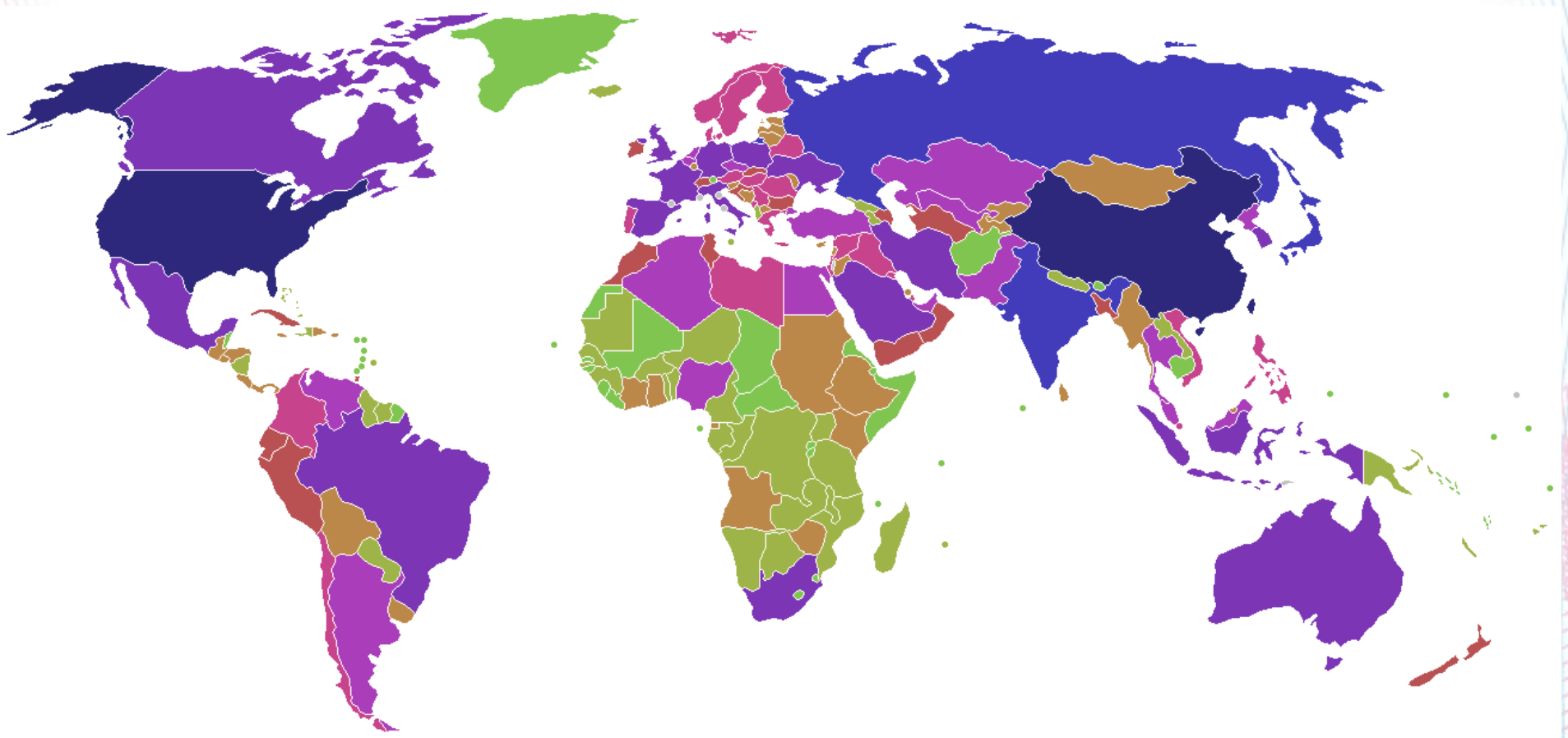


CO₂ 0.8 million year record

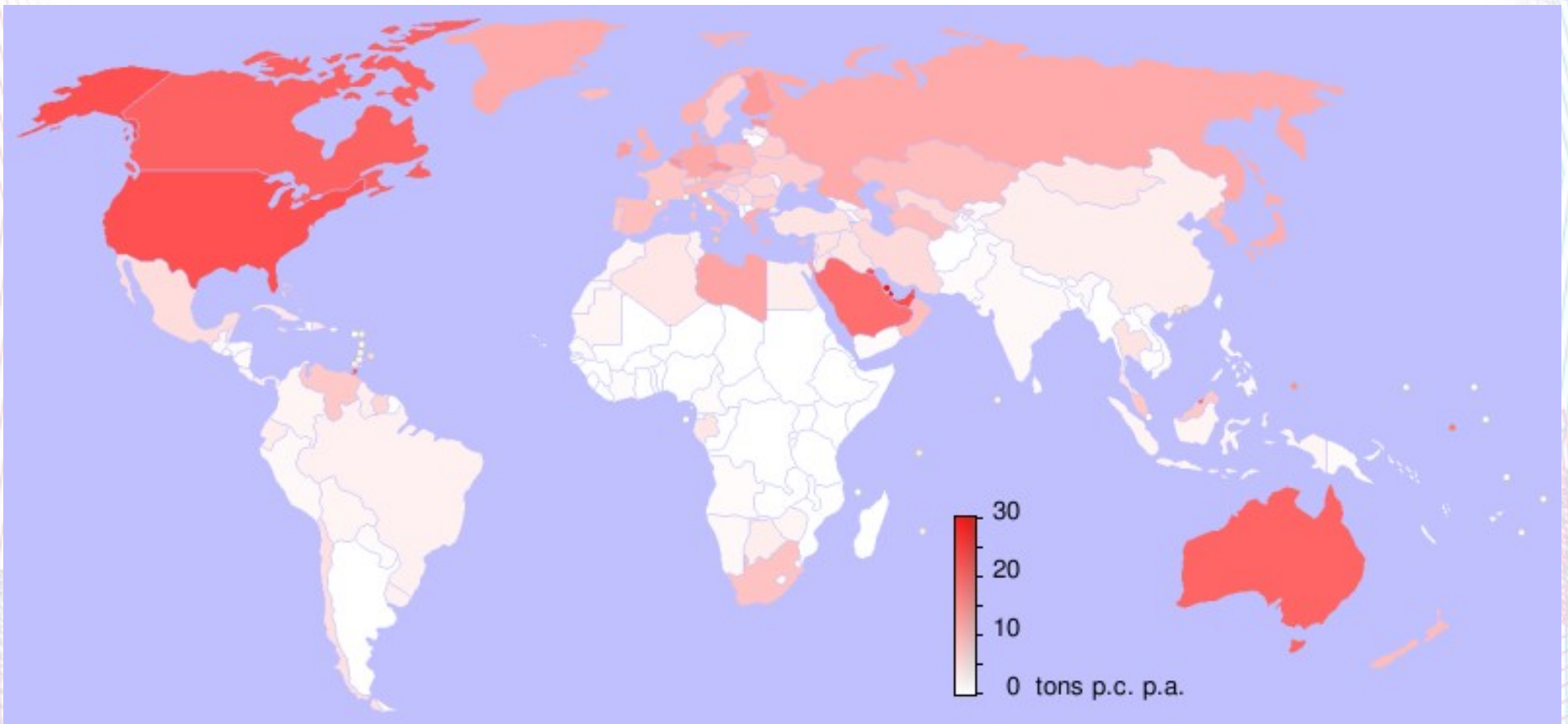
Temperature and CO₂ Records



Countries by carbon dioxide emissions via the burning of fossil fuels (blue the highest).



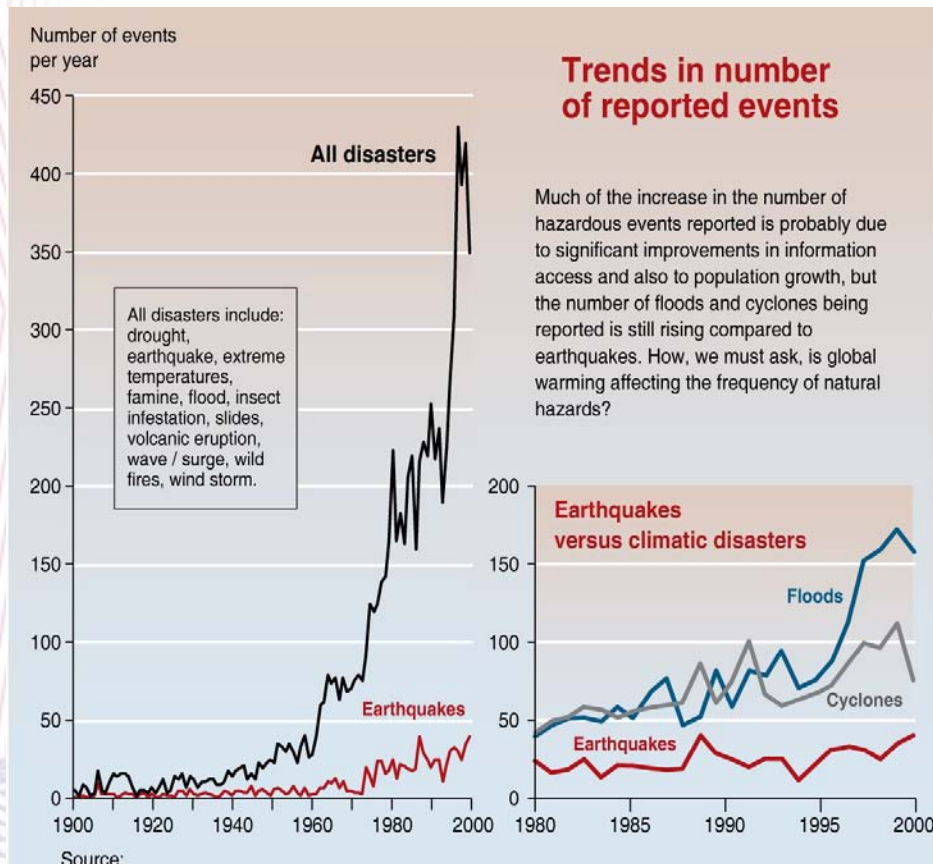
List of countries by carbon dioxide emissions per capita



Climate change mitigation

- **Alternative energy sources**
- Renewable energy
- Nuclear power
- Carbon intensity of fossil fuels
- **Energy efficiency and conservation**
- Transport
- Urban planning
- Building design
- Reforestation and avoided deforestation
- **Geoengineering**
- Greenhouse gas remediation
- Biomass
- Carbon air capture
- Carbon capture and storage
- **Societal controls**
- Population
- **Non-CO2 greenhouse gases**

Costs & benefits



- Stern Review
- at a maximum of 550ppm CO₂ by 2050
- cutting emissions to three quarters of 2007 levels
- costs would be in the range 1.0 to +3.5% of GDP

Is it really warming?

- are asking several “climate sceptic” websites like ICECAP - <http://icecap.us/>
- FAQ: Skeptic Arguments and What the Science Says -
- <http://www.skepticalscience.com/argument.php>
- FAQ: How to Talk to a Climate Sceptic -
- <http://www.realclimate.org/>

Thank you for your attention!