FIRE vs FIRE

Tom Crowley and Gabi Hegerl, Univ. of Edinburgh
Global Temperatures (1856-2006)

Global Temperature Anomalies (°C)

Year

Data from Climate Research Unit
Univ. of East Anglia  U.K.
Conclusions of IPCC Chapter 9 AR4 (Hegerl, Zwiers et al) about solar forcing in the 20\textsuperscript{th} century

**Greenhouse gas forcing has very likely caused most of the observed global warming over the last 50 yrs**

Based on distinguishing time-space pattern of warming between solar and ghg forcing.

However, the response to solar forcing could be underestimated by climate models.

Early 20\textsuperscript{th} century warming may have a solar contribution, results vary between studies.

Other contributors: early greenhouse gas signal or internal variability with warming pattern centered around North Atlantic
Comparison of Tree Ring/Ice Core Reconstruction with Alpine Glacial Advances

Temperature Variations (°C)

Year

N. Hemisphere Alpine Glaciers

Observ.Inst 30-90N sm10
Paleo.CH5.est.
2000 Year Climate Reconstruction

![Graph showing temperature reconstruction over 2000 years.](image)

- Y2k.2.temp(Z)
- Inst.30-90N

Year

Temperature Reconstruction
Comparison of Two Cosmogenic Indices

C14 Bond sol.

Be10/Lean

Year AD Bond
Is Solar Significant?

Y2k and solar variations are shown in the graph. The smoothed temperature variations (°C) are plotted against the year. The correlation coefficient, $r = 0.2$, indicates a weak positive correlation between the two variables.
Extruding a core

Geoffrey Hargreaves, Curator
USGS/National Ice Core Laboratory
Global Volcanism (1500-2000)

Global Radiative Forcing (W/m²)

Year AD
30-90N Volcanism vs Temperature Reconstruction

Year

30-90N

Jones
Model-Data Comparisons for 30-90N

- \( r^2 \) (1480-1840):
  - all forcing - 60.4
  - volcanism - 38.4
  - solar - 5.4

30-90N Anomalies (°C)

Year
## Detection of forced change in records of last millennium

<table>
<thead>
<tr>
<th>record</th>
<th>Briffa</th>
<th>CH-blend</th>
<th>Mann</th>
<th>Esper</th>
<th>Moberg</th>
</tr>
</thead>
<tbody>
<tr>
<td>volc</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>solar</td>
<td>No</td>
<td>No (\text{(Yes 1100on)})</td>
<td>No (\text{(Yes periods)})</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Ghg+aer</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Not robust</td>
</tr>
<tr>
<td>Res std</td>
<td>0.09 57%</td>
<td>0.09 70%</td>
<td>0.07 49%</td>
<td>0.15 70%</td>
<td>0.11 61%</td>
</tr>
</tbody>
</table>

Hegerl et al., *J Climate* 2007
“Hope springs eternal in the human breast” Alexander Pope
10 year bandpass at 512 years peak with 10 years low resolution
(intra-interpolate Y2K data into 10 year resolution)
Comparison of power spectra from last three glaciations

NGRIP  MIS 3 HSG  MIS 6 HSG  MIS 8 HSG
A Fly in the Ointment…

Covariance of Volcanism and C14?

Year AD

C14.Bond.sol.
Volc sm20
Keeping Things in Perspective…

Future Greenhouse Projections vs the Past

- EBM.all
- Observations (30-90N)
- Future (A2 Scenario)
- Future (B2 Scenario)

Temperature Variations (°C)

Year AD/BC
Ice core Holocene $^{14}$C
Calendar Years; 10 year sampling
AD 1970 - BC 9670
Solar Forcing vs N. Atlantic Sea Ice

(Data Courtesy G. Bond)
Global Temperature vs
Two Best Constrained Forcing Terms

Global Radiative Forcing Perturbations (W/m²)

Global Temperature Anomaly (°C)

Year

1880 1900 1920 1940 1960 1980 2000
Total Solar vs Observations

\[ y = -0.24576 + 2.1392x \quad R = 0.60804 \]

Temperature Anomaly (°C) vs Year

- Net Solar
- Jones sm5