Aurora Basin North Ice Coring Workshop

Data Use, Modelling and Volcanic Forcing

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Unlocking the secrets of the past 2000 years...
Boundary conditions over the past 2000 years

Insolation (2000 CE minus 0 CE)

Equivalent CO₂ concentration

Total solar irradiance

Radiative forcing due to volcanoes
Annual-mean Northern Hemisphere temperature
Annual-mean Northern Hemisphere temperature

Orbital + Greenhouse

Orbital + Greenhouse + Solar

$r = \pm 0.11$

$r = \pm 0.18$
Annual-mean Northern Hemisphere temperature

**Orbital + Greenhouse**
- Year CE: 500 to 2000
- Temperature anomaly (K)
- $r = +0.11$

**Orbital + Greenhouse + Solar**
- Year CE: 500 to 2000
- Temperature anomaly (K)
- $r = +0.18$

**Orbital + Greenhouse + Solar + Volcanic**
- Year CE: 500 to 2000
- Temperature anomaly (K)
- $r = +0.39$
Volcanic forcing during the 15th century

Northern Hemisphere (Gao et al, 2008)

Southern Hemisphere (Gao et al, 2008)

Global (Crowley et al, 2008)
Volcanic forcing during the 15th century

Northern Hemisphere (Gao et al, 2008)

Southern Hemisphere (Gao et al, 2008)

Global (Crowley et al, 2008)
NH temperature during the 15th century

Original volcanic forcing

Modified volcanic forcing
Correlation of MSLP with Law Dome precipitation (1979–2004)

van Ommen and Morgan (2010), Nat. Geosci.
Relationship is consistent over the full 1500 years...
... but modulated by natural variability

(a) 31 years

(b) 101 years
Scientific conclusions

- What the ice coring community can offer modellers:
  - An accurately-dated record of climate forcings over the past 2,000 years (particularly volcanic eruptions).
  - An accurately-dated record of changes in the local and remote climate.

- What modellers can offer the ice coring community:
  - Modelling can identify the drivers of past climate variability and change.
  - Modelling has a role to play in the process of palaeoclimatic reconstruction, with the models used to test the stability of relationships within the climate system.
A new index of volcanic impacts?

• April-May 2010 eruption of Eyjafjallajökull:
  – Total sulphate emissions of $\sim 0.075$ Tg (Carn et al, 2010)
  – Global GDP impact of US$ 5 billion (Oxford Economics)
  – Global GDP impact of 1 Tg sulphate $\sim$ US$ 67$ billion

• 2008-2009 Global Financial Crisis:
  – Global GDP impact of US$ 4.5$ trillion (World Bank/CIA)

• 1 GFC $\sim 67.5$ Tg sulphate

• Allows us to estimate the potential economic impact of a volcanic eruption if it were to take place tomorrow.

• A GFC is actually a very handy unit, as it’s about the limit of what the global financial system can handle.
The Volcanic GFC Index version 0
Extreme weather events of 535–536 CE (~ 1.5 GFCs)

- The sun was dark and its darkness lasted for eighteen months; each day it shone for about four hours; and still this light was only a feeble shadow; the fruits did not ripen and the wine tasted like sour grapes. - Michael the Syrian

- During this year [536 CE] a most dread portent took place. For the sun gave forth its light without brightness ... and it seemed exceedingly like the sun in eclipse, for the beams it shed were not clear. - Procopius of Caesarea

- Crop failures and famine worldwide

- Low temperatures, including summer snowfall, in China

- A “dense, dry fog” in the Middle East, China and Europe

- Drought in Peru, leading to the fall of the city of Teotihuacán

- Scandinavian elites sacrificed large amounts of gold, possibly to appease the angry gods and get the sunlight back