What can paleoclimatology contribute?

What are the strengths and weaknesses of such estimates?

GEOL 437: Global Climate Change
5/3/18: Climate sensitivity

Key concepts

- Equilibrium climate sensitivity
- “fast” and “slow” processes in the climate system
Fast vs. slow processes in the climate system

• Radiation

• Circulation

• Water

• Carbon

• Interactions
Fast vs. slow processes in the climate system

Timescale

<table>
<thead>
<tr>
<th>Years</th>
<th>Decades</th>
<th>Centuries</th>
<th>Millennia</th>
<th>Multi-millennia</th>
<th>// Myr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clouds, water vapour, lapse rate, snow/sea ice</td>
<td>Upper ocean</td>
<td>CH₄ (major gas-hydrate feedback; for example, PETM)</td>
<td>Dust (vegetation mediated)</td>
<td>Entire oceans</td>
<td>Carbon cycle</td>
</tr>
</tbody>
</table>

Palaeosens Project Members (2012)
Results: 800kya to present

Palaeosens Project Members (2012)
Results: 20 Mya to present

- **a** This work:
  - Equilibrium $\Delta T$ (K)
  - Fast+slow feedbacks
  - Only fast feedbacks

- **b** RW_11:
  - Equilibrium $\Delta T$ (K)
  - Fast+slow feedbacks
  - Only fast feedbacks

- **c** JH_12:
  - Equilibrium $\Delta T$ (K)
  - Fast+slow feedbacks
  - Only fast feedbacks

- **d** All:
  - Equilibrium $\Delta T$ (K)
  - Only fast feedbacks
  - Fast+slow feedbacks

- $\text{CO}_2$ (p.p.m.v.)

Palaeosens Project Members (2012)
Another approach: perturbed physics experiment

- External Radiative forcing → Climate model → Simulation

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e.g. Frame et al., 2009, The climateprediction.net BBC climate change experiment: design of the coupled model ensemble, Phil. Trans. Royal Soc. A, 13 March 2009 vol. 367 no. 1890 855-870, doi: 10.1098/rsta.2008.0240. See also climateprediction.net and how you can help out with these efforts! Also see von Deimling et al (2006).
Another approach: perturbed physics experiment

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Results: 20kya relative to present

T.S. von Deimling et al.: Climate sensitivity estimated from ensemble simulations of glacial climate

Fig. 6 Inferring $\Delta T_{2x}$ from LGM data (interval method). Simulated annual mean tropical Atlantic SST cooling (averaged from 20°N to 20°S) is shown for correlated (blue dots, SIM_LGM) and uncorrelated parameter ensembles (orange dots, SIM_uncor_LGM). The red curve shows the linear fit to the correlated ensemble, the red dotted lines represent the fit error, conservatively estimated from the uncorrelated setting as the 5–95% of the spread of deviations from the fit. Only runs consistent with present day data are shown. Purple (green) dashed lines illustrate the range of $\Delta T_{2x}$ (including fit error bounds) consistent with a mean tropical Atlantic SST cooling of 3.0 ± 0.9°C.
Summary

• Equilibrium climate sensitivity estimates that incorporate the multiple timescales of climate system feedbacks, especially the slow feedbacks, require the paleoclimatic perspective (or really long simulations with all the slow mechanisms).

• Estimates from both slow and fast feedback timescales suggest the ECS could be larger than the Planck sensitivity – but there are large uncertainties.

• Next (5/8/18):
  – Discussion of HW10 results
  – Tues 5/8: work session at CHM 1215: projects/interpretation
  – Thurs 5/10: Course Summary and Wrap-up
  – Sat 5/12: Final exam (presentations): 8a-10a

• Reminder: Course Evals open through May 11\textsuperscript{th} (69% \rightarrow 100\%)!