The Pliocene and IPCC - How does the Pliocene inform the future?

Dan Lunt

(1) The IPCC (Intergovernmental Panel on Climate Change)

(2) How can the past (Pliocene) inform the future?

(3) Climate sensitivity in the Pliocene
   (a) Direct estimates of climate sensitivity
   (b) Emergent constraints
   (c) Earth system sensitivity

(4) Ways forward
IPCC (Intergovernmental Panel on Climate Change)

- Created in 1988, the objective of the IPCC is to provide governments at all levels with scientific information that they can use to develop climate policies.

- Its role is to assess the scientific, technical and socio-economic literature relevant to understanding climate change, its impacts and future risks, and options for adaptation and mitigation.

- Working Group I deals with The Physical Science Basis of Climate Change, Working Group II with Climate Change Impacts, Adaptation and Vulnerability and Working Group III with Mitigation of Climate Change.

- 6th Assessment report (AR6) due 2021 (WG1). First Order Draft due 7th April!
Box 1: Outline of the WGI AR6

Summary for Policy Makers
Technical Summary

Chapter 1: Framing, context, methods
Chapter 2: Changing state of the climate system
Chapter 3: Human influence on the climate system
Chapter 4: Future global climate: scenario-based projections and near-term information
Chapter 5: Carbon budgets, biogeochemical cycles and feedbacks
Chapter 6: Short-lived climate forcers and air quality
Chapter 7: The Earth’s energy budget, climate feedbacks, and climate sensitivity
Chapter 8: Water cycle changes
Chapter 9: Ocean, cryosphere, and sea level change
Chapter 10: Linking global to regional climate change
Chapter 11: Weather and climate extreme events in a changing climate
Chapter 12: Climate change information for regional impact and risk assessment

Each chapter is expected to build on all available lines of evidence, including:

- paleoclimatic evidence;
How can the past inform the future?

- Past climates provide a window on a world very different to our own. If the drivers of past change are similar to those in the future, the past time period may be an analogue for future change…

- Past climates provide geological data that we can use to test our climate models that are used for future projection.

- Past climates allow us to quantify key metrics such as climate sensitivity.

- Past climates allow us to estimate long-term changes that cannot be simulated with models.
How can the Pliocene inform the future?

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Foster et al, 2017
How can the Pliocene inform the future?

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Dowsett et al, 2012

Salzmann et al, 2008

Dowsett et al

Hill et al
How can the Pliocene inform the future?

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How can the Pliocene inform the future?

- Past climates provide geological data that we can use to **test** our climate models that are used for future projection.

IPCC, 2013
How can the Pliocene inform the future?

- Past climates allow us to **quantify** key metrics such as climate sensitivity.

“Climate Sensitivity”

- Equilibrium global mean near-surface air temperature increase given a doubling of atmospheric CO$_2$

- High-profile metric because with it, we can answer questions such as:
  - “I want to limit warming to 1.5°C; what CO$_2$ concentration is allowed”
  - “I think CO$_2$ concentrations will reach 1200 ppmv by the year 2100, what will the warming be?”
  - [also an input to many economic and impact models]
Huge effort to characterise this number….

And IPCC….

<table>
<thead>
<tr>
<th>IPCC Assessment Report</th>
<th>“Likely” Range [°C]</th>
<th>Best Estimate [°C]</th>
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<td>FAR (1990)</td>
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<td>AR5 (2013)</td>
<td>1.5 – 4.5</td>
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<td>AR6 (2021?)</td>
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Climate Sensitivity

(1) Direct estimates

Estimate CO$_2$ concentrations of the Pliocene, and estimate global mean temperature, we can estimate Climate Sensitivity. Potentially very powerful!

“likely” range 3.05-4.35 °C

Martinez-Boti et al., 2015
(2) Emergent constraints

Carry out multiple Pliocene simulations with different models, and multiple future simulations with the same models.

Is there a relationship between the ability of models to correctly predict the past, and their climate sensitivity in the future?

“likely” range 2.35-3.25 °C

Hargreaves and Annan, 2016
Climate Sensitivity

[illustrative only – IPCC pdf has a "long tail" shape, not gaussian]
How can the Pliocene inform the future?

- Past climates allow us to estimate long-term changes that cannot be simulated with models.

Long-term feedbacks associated with vegetation and ice increase climate sensitivity by ~50% on “long” timescales.  

*Lunt et al, 2010*
Ways forward

- Move towards a smaller window of time in the Pliocene

- More independent geological data

- Better models

- More robust statistics for model-data comparisons

Haywood et al, 2013