Quantifying Carbon Cycle-Climate Feedbacks

Jonathan Moch
Mentors: Thomas Froelicher, Keith Rodgers, and Jorge Sarmiento
Feedbacks Overview

• Feedback = amplification or suppression of an initial input into a complex system

• Positive or negative
  – E.g.: Permafrost melt, CO$_2$ fertilization

• Objective: Deconstruct Carbon Cycle – climate feedbacks

• Useful for comparing models and getting at mechanisms
MULTI-MODEL AVERAGES AND ASSESSED RANGES FOR SURFACE WARMING

Global surface warming (°C)

Year

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A2
A1B
B1
Year 2000 Constant Concentrations
20th century

B1
A1T
B2
A1B
A2
A1FI
Terminology

• $\alpha = K / \text{ppm CO}_2$
  - Linear transient climate sensitivity

• $\beta = \text{GtC} / \text{ppm CO}_2$
  - Sensitivity of carbon uptake to atmospheric CO$_2$

• $\gamma = \text{GtC} / K$
  - Sensitivity of carbon uptake to temperature change

Friedlingstein et al, 2006; Gregory et al, 2009; Roy et al, 2010
$\Delta T^r = \alpha \Delta C^r_A$

$\Delta C^r_L = \beta_L \Delta C^r_A$

$\Delta C^r_O = \beta_O \Delta C^r_A$

$g = -\alpha (\gamma_L + \gamma_O) / (1 + \beta_L + \beta_O)$.

$\Delta C^c_O = \beta_O \Delta C^c_A + \gamma_O \Delta T^r$
Influence of Starting Point on Transient Ocean Gamma
Conclusions

• ESM2M relatively unresponsive
• Feedback factors are not actually linear
• Regressions yield different results from instantaneous slope when started from different points
• Regional differences appear to converge after spin-up
  – Less clear on a global scale
• Larger magnitude β and γ if ignore spin-up, smaller α
• Intra-model uncertainty much smaller than inter-model uncertainty
  – Might make a difference on the margins