Quantifying Carbon Cycle-Climate Feedbacks

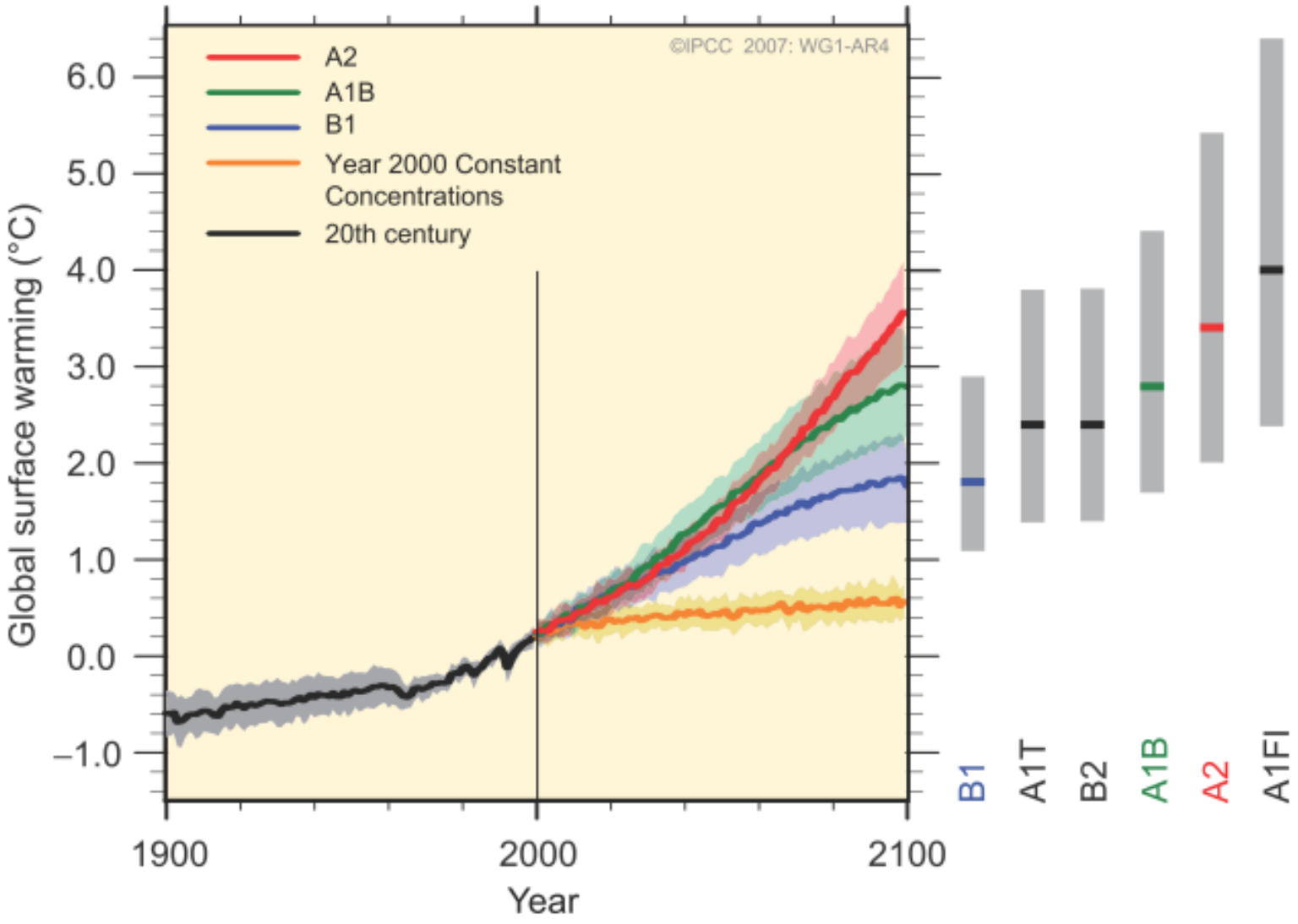
Jonathan Moch

Mentors: Thomas Froelicher, Keith Rodgers, and Jorge Sarmiento

Feedbacks Overview

- Feeback = 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

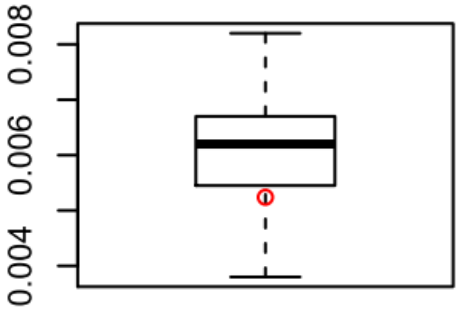


Terminology

- α = K / ppm CO_2
  - Linear transient climate sensitivity
- β = GtC / ppm CO_2
  - Sensitivity of carbon uptake to atmospheric CO_2
- γ = GtC / K
  - Sensitivity of carbon uptake to temperature change

Friedlingstein et al, 2006; Gregory et al, 2009; Roy et al, 2010

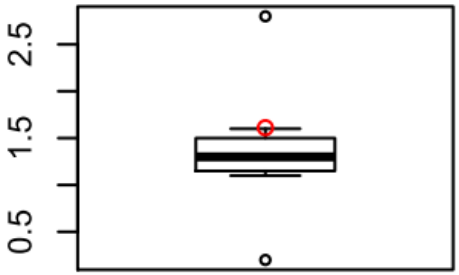
Alpha



0.00524

$\Delta T^c = \alpha \Delta C_A^c$

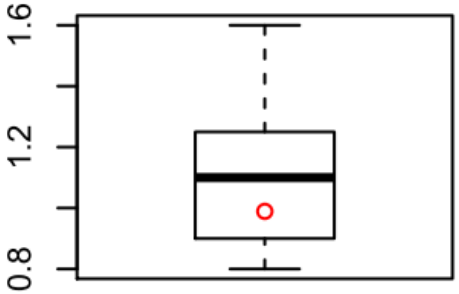
Beta Land



1.611129

$\Delta C_L^u = \beta_L \Delta C_A^u$

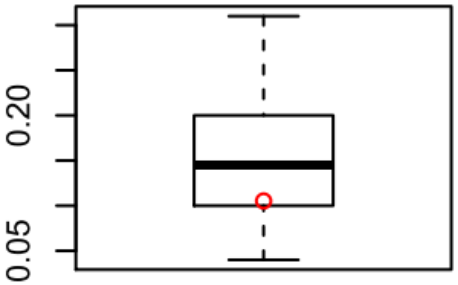
Beta Ocean



0.9890785

$\Delta C_O^u = \beta_O \Delta C_A^u$

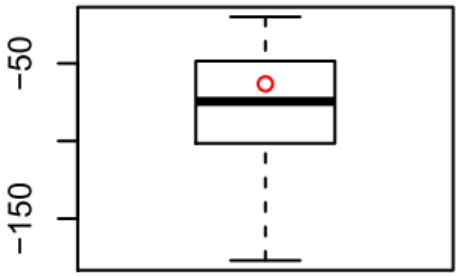
Gain



0.1052739

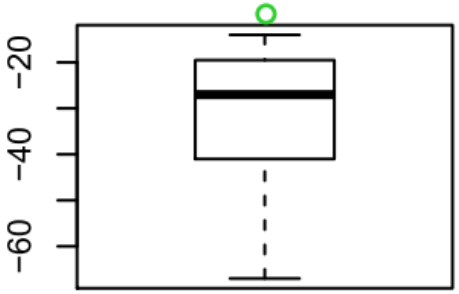
$g = -\alpha(\gamma_L + \gamma_O)/(1 + \beta_L + \beta_O).$

Gamma Land



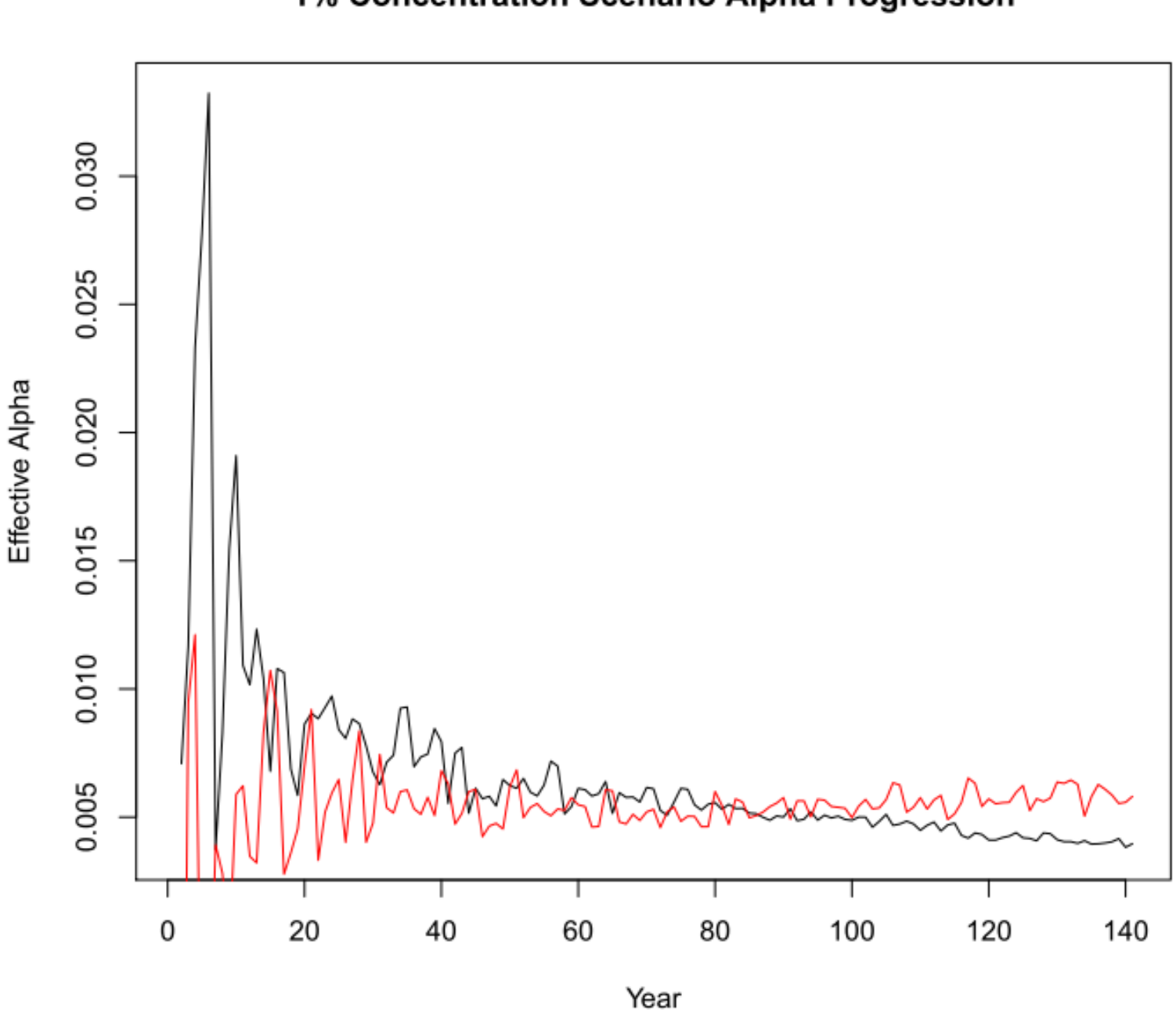
-63.17894

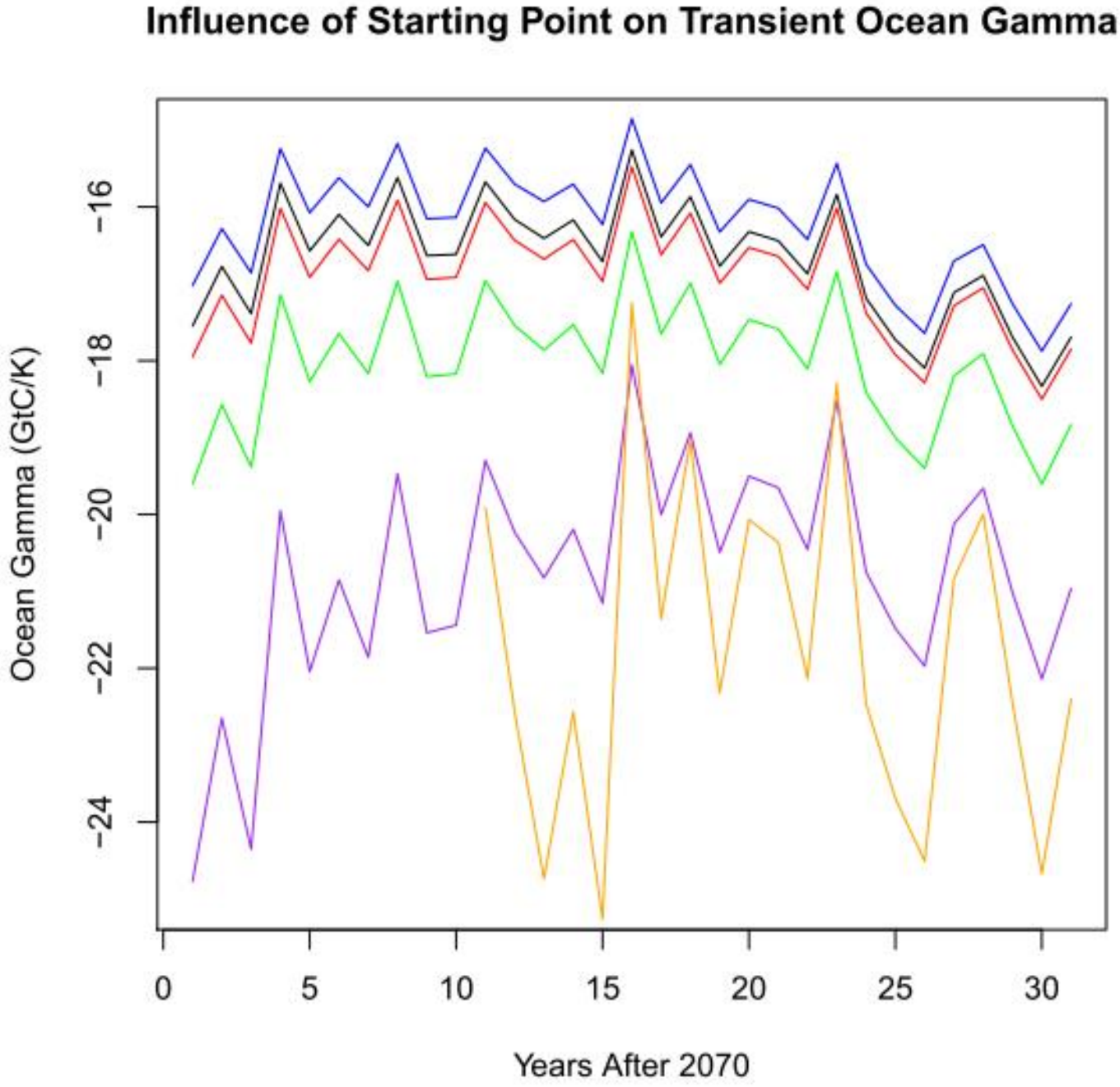
Gamma Ocean



-7.290276

$\Delta C_O^c = \beta_O \Delta C_A^c + \gamma_O \Delta T^c$


1% Concentration Scenario Alpha Progression
Effective Alpha
0.005
0.010
0.015
0.020
0.025
0.030
0
20
40
60
80
100
120
140
Year


Influence of Starting Point on Transient Ocean Gamma
Ocean Gamma (GtC/K)
−16
−18
−20
−22
−24
0
5
10
15
20
25
30
Years After 2070

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