

Equilibrium Climate Sensitivity: How Accurate are a Slab Ocean Model and the Effective Sensitivity Method?

Gokhan Danabasoglu and Peter R. Gent

NCAR

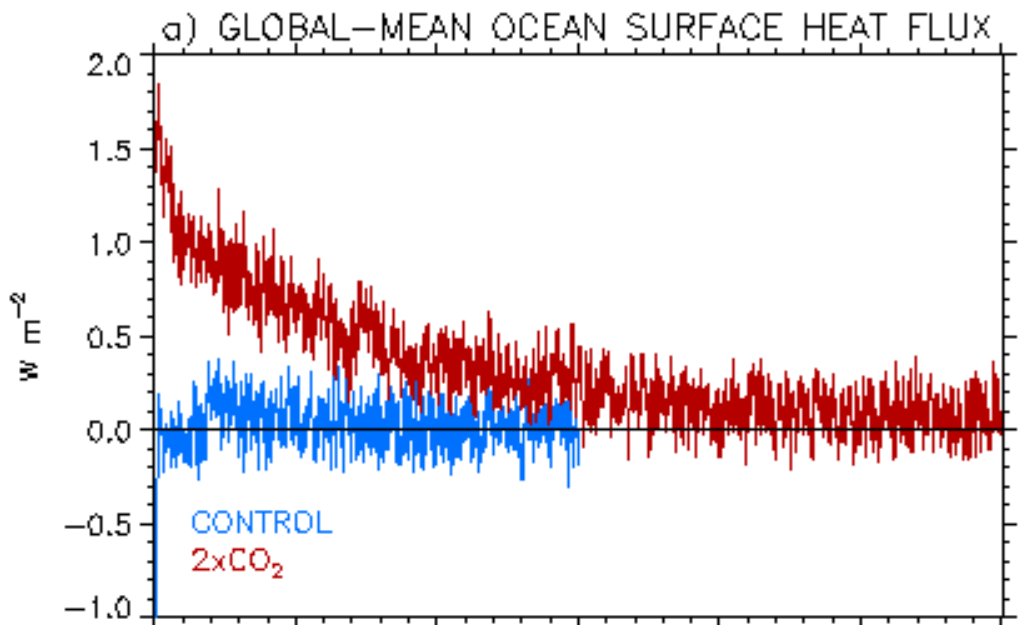
BACKGROUND

- Equilibrium Climate Sensitivity (ECS) is one of the measures used to describe climate system models.
- The ECS is defined as the model-simulated equilibrium change in global-mean surface temperature due to a doubling of the atmospheric CO_2 concentration.
- For practical purposes, the ECS is obtained using a Slab Ocean Model (SOM) instead of a full-depth, interactive ocean component (FDOM).
- An alternative approach is the Effective Climate Sensitivity method which provides an estimate of the ECS based on net Top of Atmosphere (TOA) fluxes and change in surface temperature during the first few decades of a CGCM integration (with FDOM) **without obtaining an equilibrium solution.**

This study aims to test

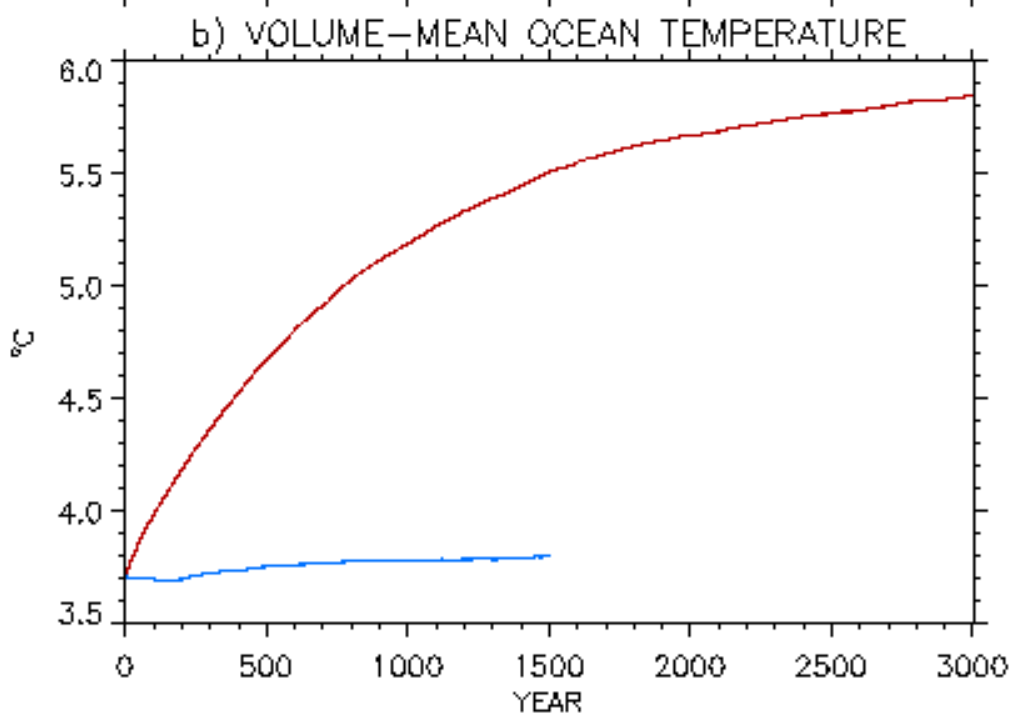
- whether the ECS calculated using a SOM is an accurate measure for the ECS of the full climate model that uses FDOM,
- whether the Effective Climate Sensitivity method produces an accurate estimate of the ECS.

We obtain equilibrium solutions of the CCSM3 T31x3 resolution version with 1990 and doubled CO_2 levels. These integrations are labeled as CONTROL and $2\times\text{CO}_2$, respectively.

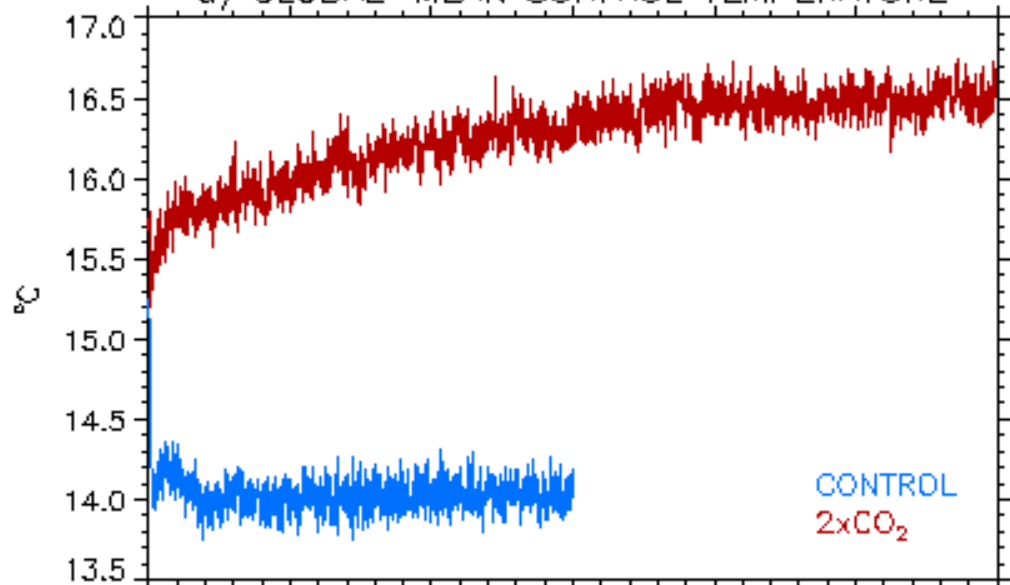


+ 0.08 $W m^{-2}$
(last 500 years)

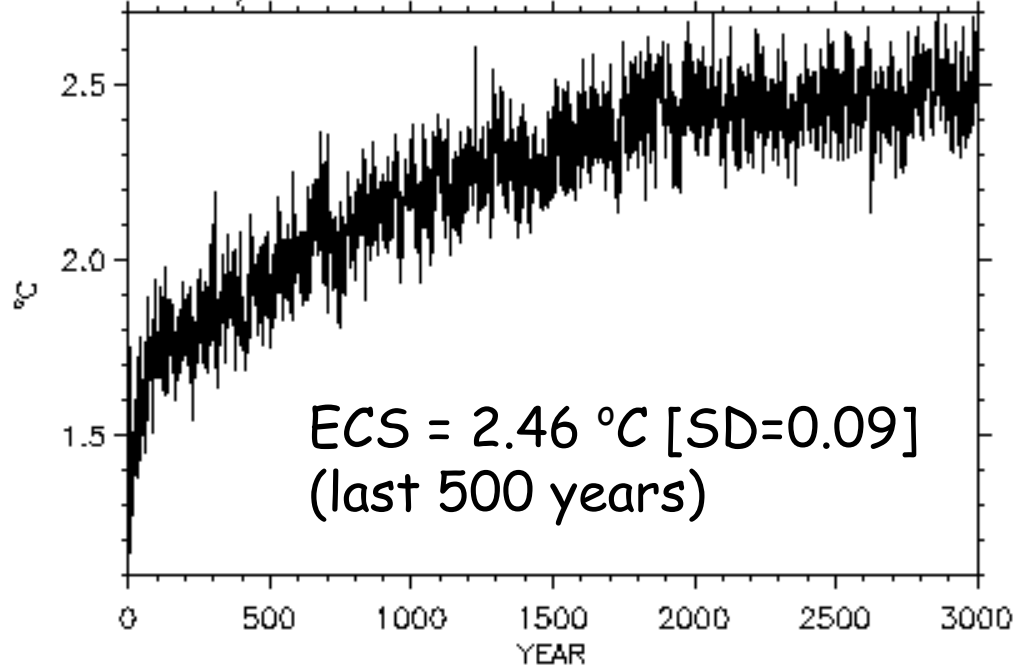
+ 0.02 $W m^{-2}$
(last 500 years)



a) GLOBAL-MEAN SURFACE TEMPERATURE

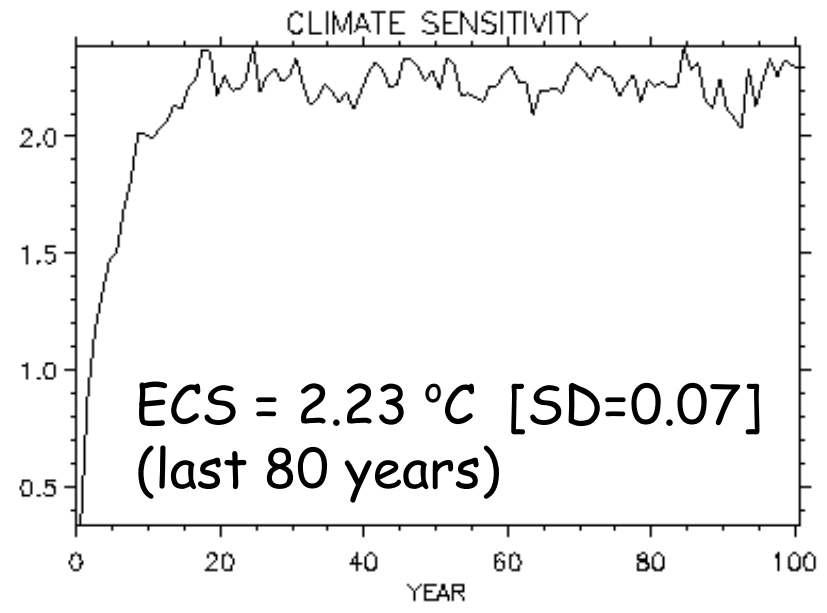


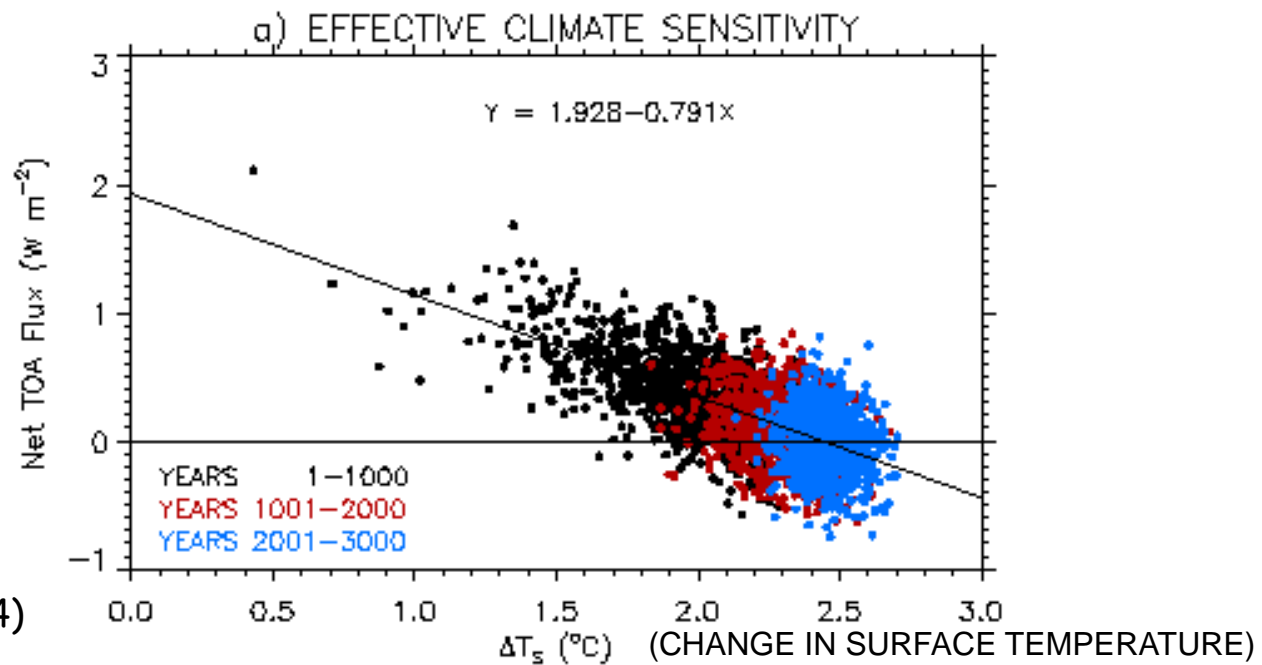
b) EVOLUTION OF CLIMATE SENSITIVITY



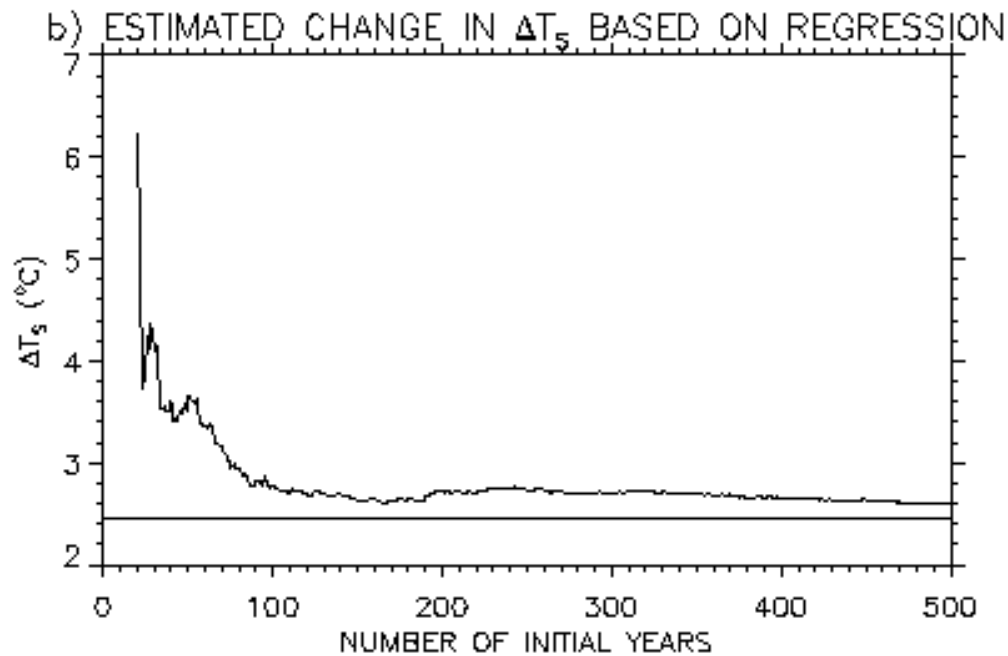
Equilibrium Climate Sensitivity
using SOM from Kiehl et al.
(2006, J. Climate): 2.32 °C

SOM





Gregory et al. (2004)



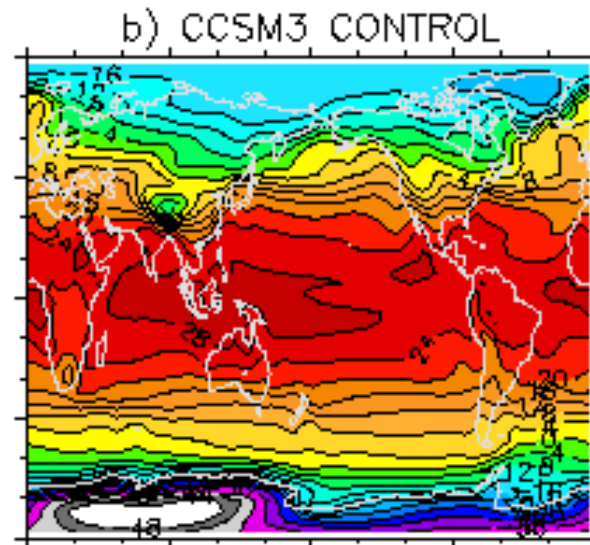
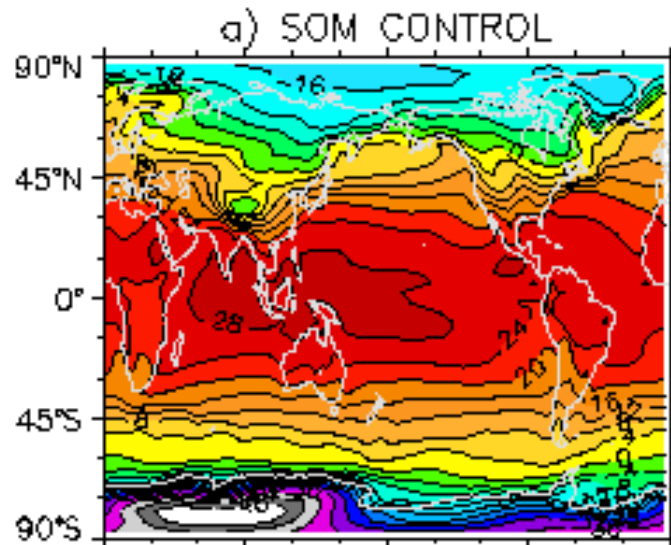
SUMMARY AND CONCLUSIONS

- The ECS of the CCSM3 low-resolution version obtained using either the full-depth, interactive ocean component or a SOM is rather similar, differing only by 0.15-0.20°C.
- This result indicates that the ocean mainly provides the required SST increase to rebalance the surface fluxes in response to increased forcing.
- The standard practice of using a SOM does give a good estimate of the true ECS.
- The Effective Climate Sensitivity approach does give an accurate estimate of the true ECS provided that this estimate is based on at least 150 year long 2xCO₂ experiments.

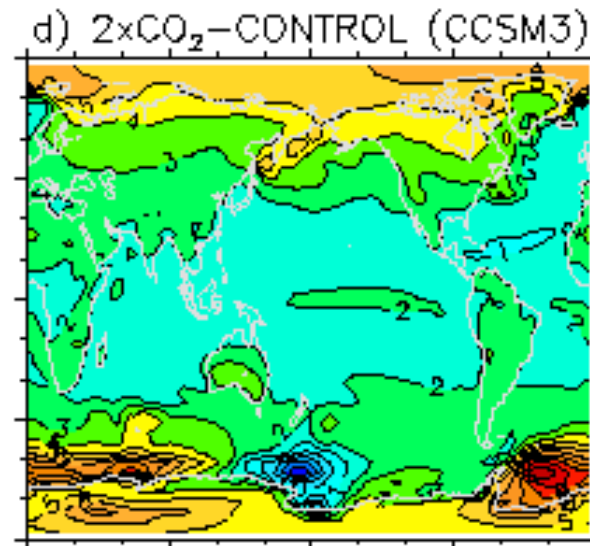
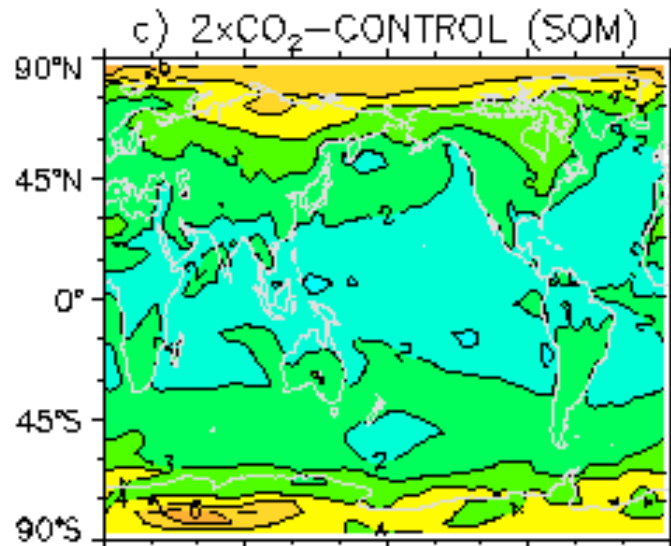
SURFACE TEMPERATURE

$\langle \text{SOM} \rangle - \langle \text{NCEP} \rangle = +0.8 \text{ } ^\circ\text{C}$

$\langle \text{CCSM3} \rangle - \langle \text{NCEP} \rangle = -0.5 \text{ } ^\circ\text{C}$



CI = 4 °C



CI = 1 °C

0° 90°E 180° 90°W 0° 0° 90°E 180° 90°W 0°