# Does model resolution impact its Climate Sensitivity ?

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### 4xCO2 inferred Equilibrium Climate Sensitivity (iECS)



<sup>(</sup>Gregory et al., 2004)



#### **4xCO2** surface warming







#### **Global distribution of shortwave, longwave and net radiation feedbacks**

We use feedback relationships of the form:

 $\partial \mathcal{X} = \lambda_x \, \partial T$ 

where  $\mathcal{X}$  is a flux, T is surface temperature, and  $\lambda_x$ is a feedback parameter (slope) that linearly relates changes in  $\mathcal{X}$  and T.



9

ε

0 W m<sup>-2</sup> K<sup>-1</sup>

m

9-

6



#### **Regional contributions to radiation feedbacks**

The global feedback parameter  $\lambda_x$  can be written as a weighted sum of local feedbacks  $\lambda_{x;k}$ 

 $\lambda_x = \sum_k a_k A_k \, \lambda_{x;k}$ 

where  $a_k$  is the the areal fraction of region k, and  $A_k$  is the regional warming amplification factor ( $\partial T_k = A_k \ \partial T$ )





#### **Ocean response under abrupt-4xCO2**

Annual mean AMOC at 45°N

m.

80

year

60





20

40

20

.5

10

5

AMOC@45°N (Sv)

Mean meridional Ocean Heat Transport

#### Sea Ice and albedo response under abrupt-4xCO2

Annual mean Sea Ice area

Annual mean high-latitude (> 60°) effective surface albedo.

 $(F_{S Down.} - F_{S Net} / F_{S Down.})$ 







#### **1%CO2 Experiment and TCR**





#### **1%CO2 surface warming**





## Summary

- abrupt 4xCO2 and 1%CO2 increase simulations have been performed using CESM HR (0.25° / 0.1°) and CESM LR (nominal 1°) configurations
- both iECS and TCR are very similar across resolution
- large differences in local warming amplification with a hemispheric asymmetry resulting in relatively more/less warming in the Northern/Southern Hemisphere, respectively, in CESM HR and CESM LR have been identified
- contributions from radiation feedback have been exanimated
- AMOC (and associated OHT) have been linked to the difference in regional warming amplification under an abrupt 4xCO2 concentration increase
- So... Does model resolution impact its Climate Sensitivity ?
  - ➡ No according to iECS and TCR
  - But I hope I convinced you that the answer is actually more nuanced









**Data acquisition:** The datasets are served to the community through the NSF NCAR Research Data Archive (<u>RDA</u>). Datasets archived on the RDA can be accessed within the CISL computing environment or downloaded over HTTP or Globus transfer for fast, secure, and reliable way to use elsewhere. A copy of the archive is stored in Campaign Storage and so is readily accessible by NCAR HPC system users and by individuals who have access to this system.



# CESM High-Resolution Simulations (CESM1.3; 0.1° ocn; 0.25° atm)

500-year PI control; 80-year 1%CO<sub>2</sub>; 150-year 4xCO<sub>2</sub>; 10-member (1850) 1920-2005 historical; 10-member 2006-2100 transient w/ RCP 8.5: 10-member 2006-2100 transient w/ RCP6.0; 1-member 2006-2100 transient w/ RCP4.5; 1-member 2006-2100 transient w/ RCP2.6; 3-member 1970-2020 Ozone withholding; 3-member 1950-2014 AMIP: All HighResMIP coupled and AMIP; 5 cycles of 1958-2018 OMIP (w/ BGC); Decadal Predictions (1980-2023; HRDP); and Corresponding low-res (~1°) simulations



Visualization Credit: Matt Rehme, Visualization Services and Research Group, NSF NCAR CISL

Datasets are available to the community.



Chang et al. (2020, JAMES)

