



# Exploring a simplified Slab Ocean Model (SOM)

**Using the Equilibrium Climate Sensitivity (ECS)  
to assess the validity of the simplified SOM.**

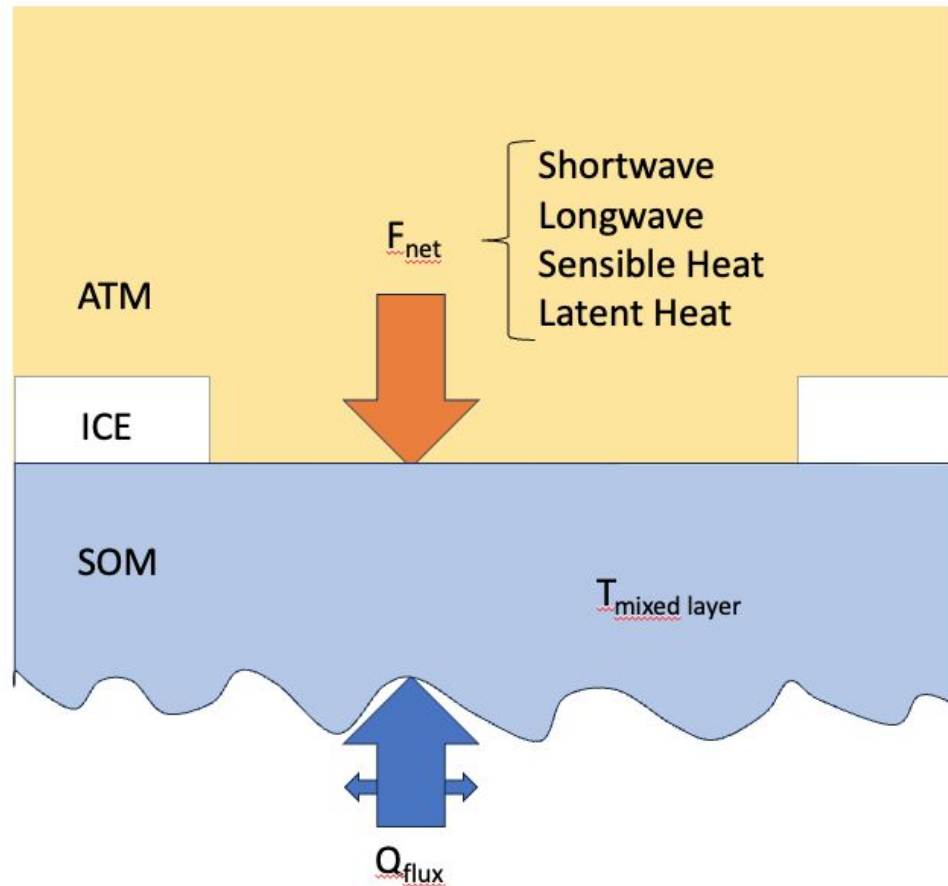
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# The Slab Ocean Model and prescribed ocean heat fluxes

## Slab Ocean Model (SOM)

SOM = mixed layer ocean model with prescribed ocean heat fluxes (“qflux”)



Estimate of **qflux** is **resource-intensive**

As **qflux** are computed from

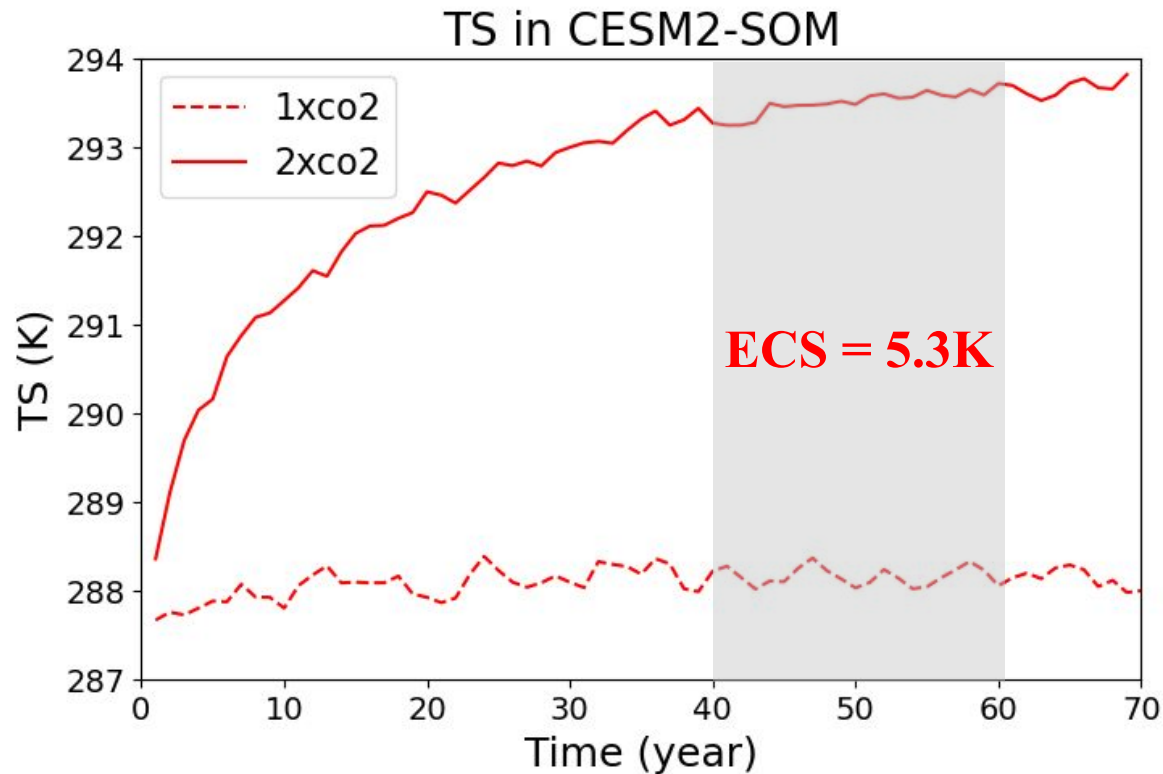
- a **well balanced coupled simulation**
- in the “**same configuration**”

**Motivation:** Developing a **simpler and cheaper SOM configuration** that preserves key aspects of the coupled system behavior.

**Method:** We evaluate the simplified SOM by its ability to represent **Equilibrium Climate Sensitivity (ECS)**.

# Estimating Equilibrium Climate Sensitivity (ECS) in CESM

- Estimates of the ECS are typically obtained using a **Slab Ocean Model (SOM)**
- **Why SOM? Equilibrium after 10s years (SOM) ↔ 1000s years (coupled model).**



## Typical SOM experiment with CESM

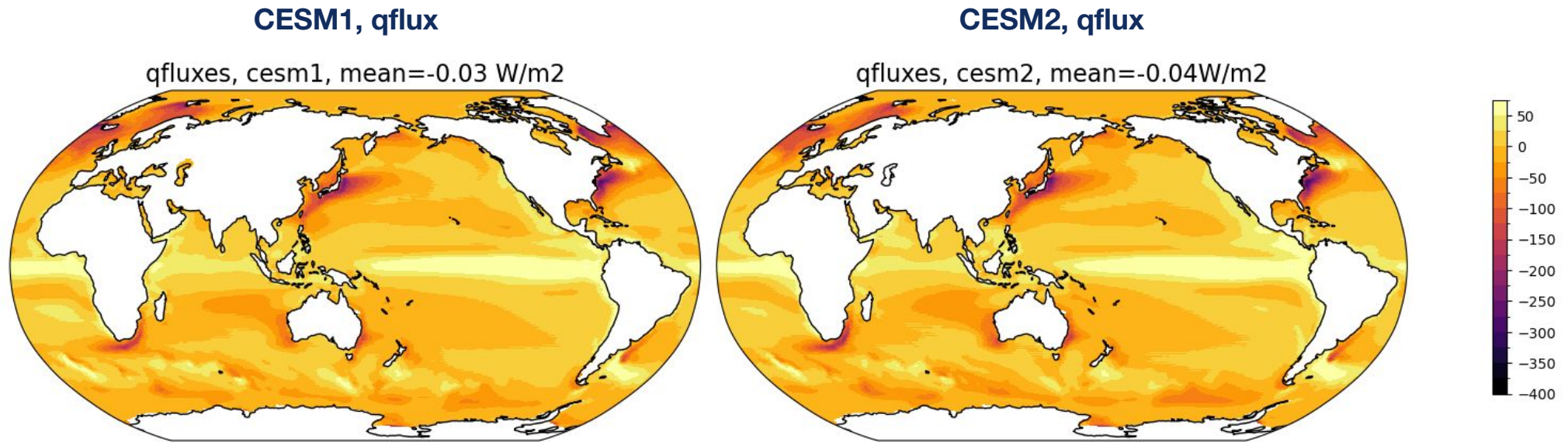
- 1xCO<sub>2</sub> and 2xCO<sub>2</sub> runs
- 1xCO<sub>2</sub>: no drift in global annual TS.
- 2xCO<sub>2</sub>: quasi-equilibrium after 40<sup>ish</sup> years
- ECS is obtained from years 40-60 (\*)

(\*) other methods exist (Gregory plot, radiative kernels...).  
Not covered here.



# Can we simplify the procedure to estimate the qfluxes?

How much do the **details of the qflux** matter in the assessment of the ECS?

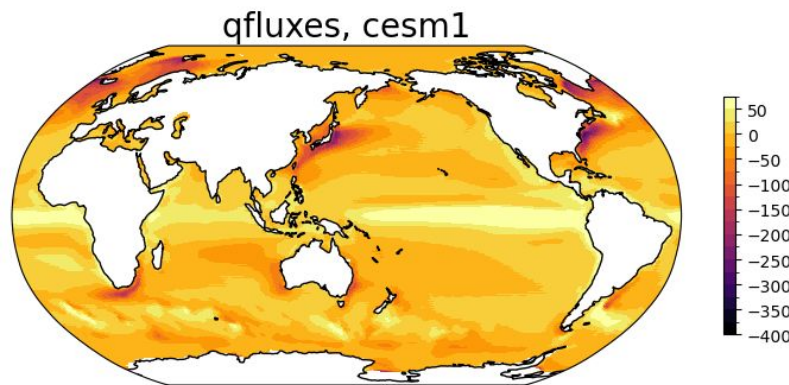
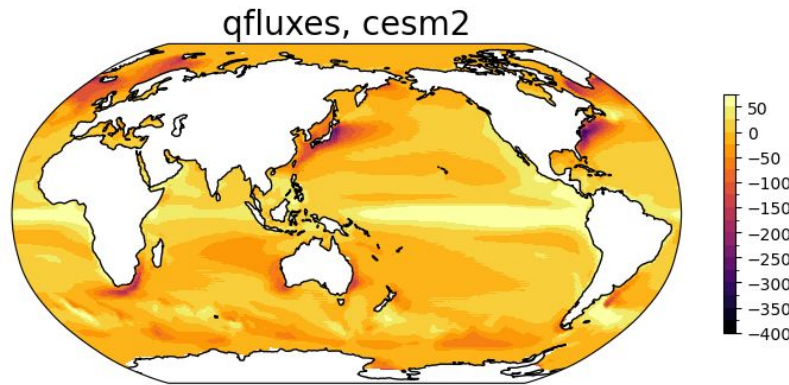


Two questions:

- Do we really need to compute qflux for **every model version**?
- Can we use an **idealized qflux** to assess the ECS?

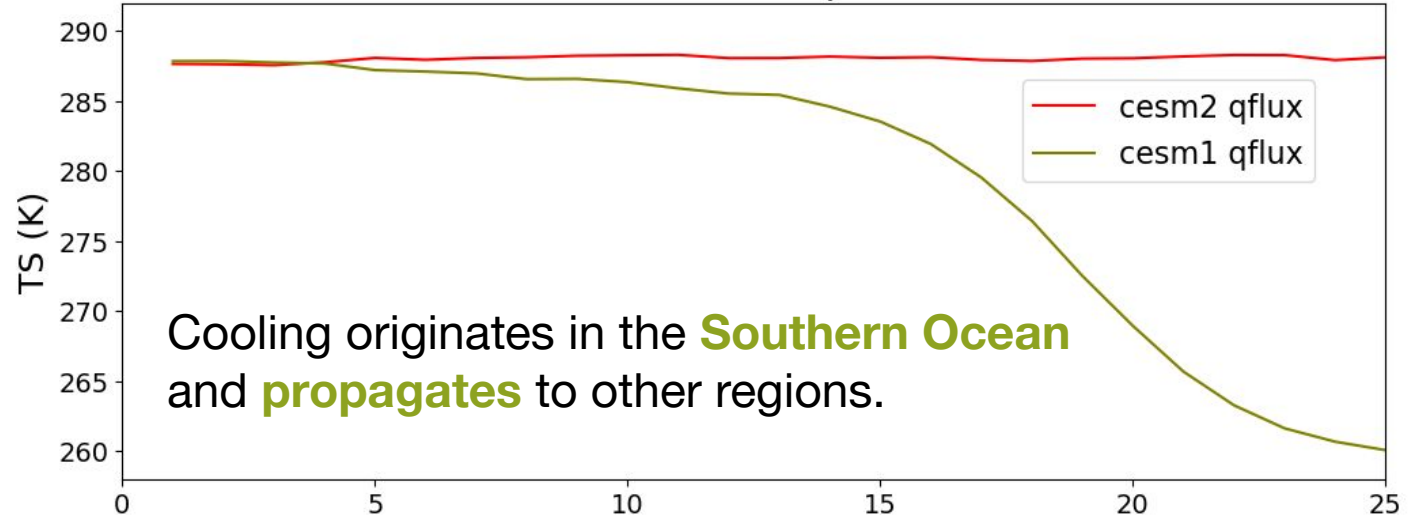
# Using qflux from another model version can lead to catastrophic cooling

Do we really need to compute qflux for **every model version**?

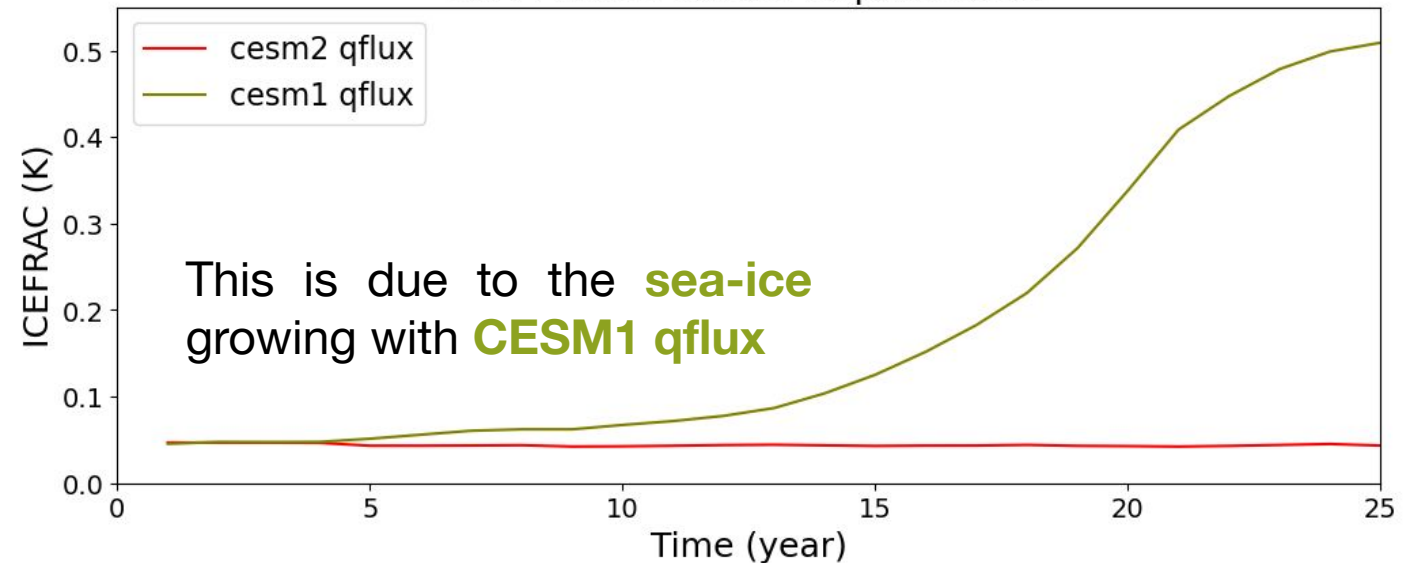


Swapping **CESM2 qflux** ↔ **CESM1 qflux**

TS in in 1xCO2 experiments



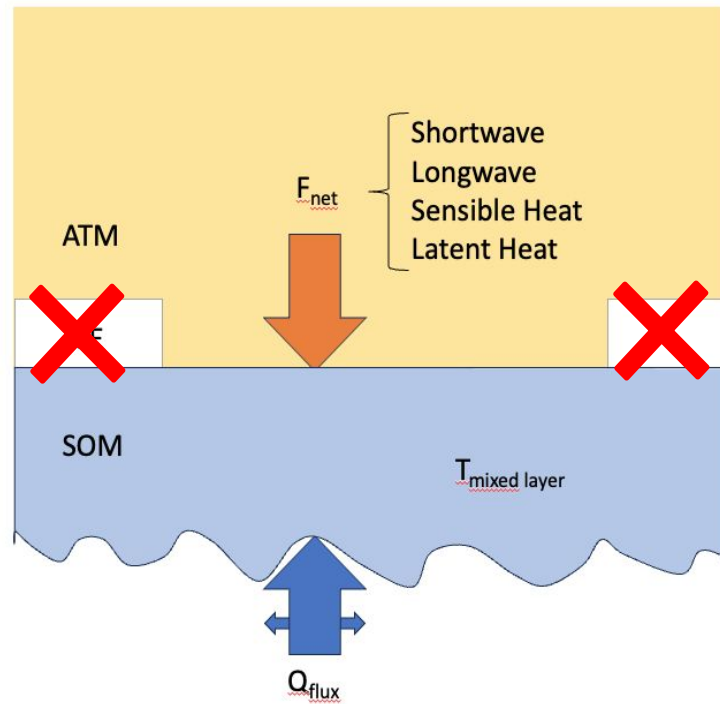
ICEFRAC in 1xCO2 experiments



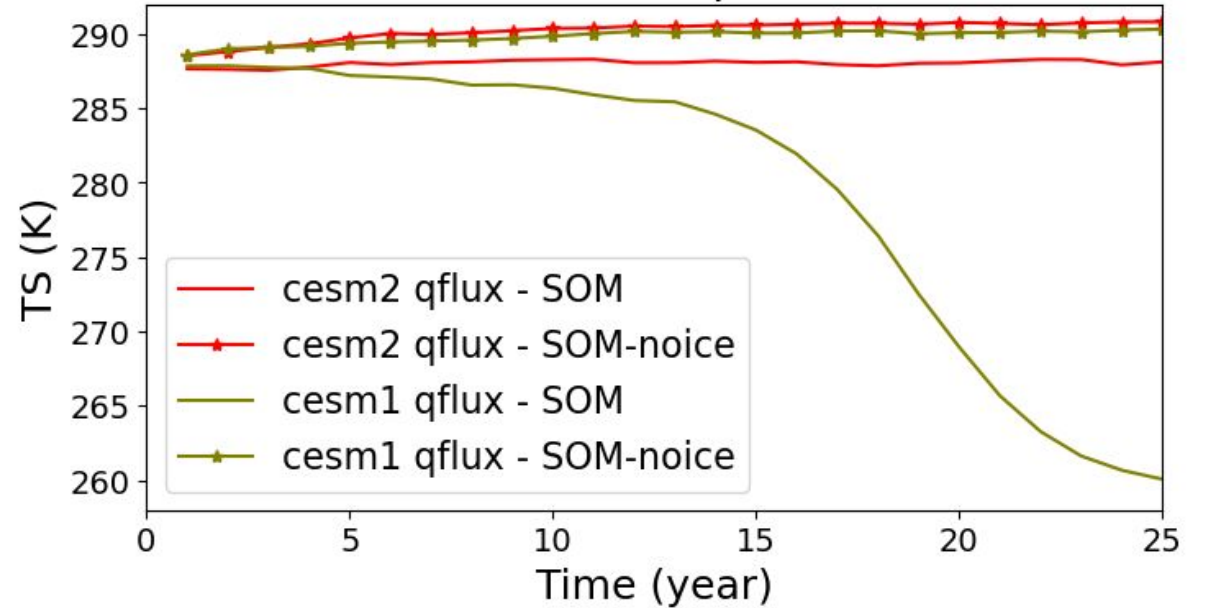
# The SOM-noice

## SOM-noice

Model  
without  
sea-ice



## TS in 1xCO<sub>2</sub> experiments

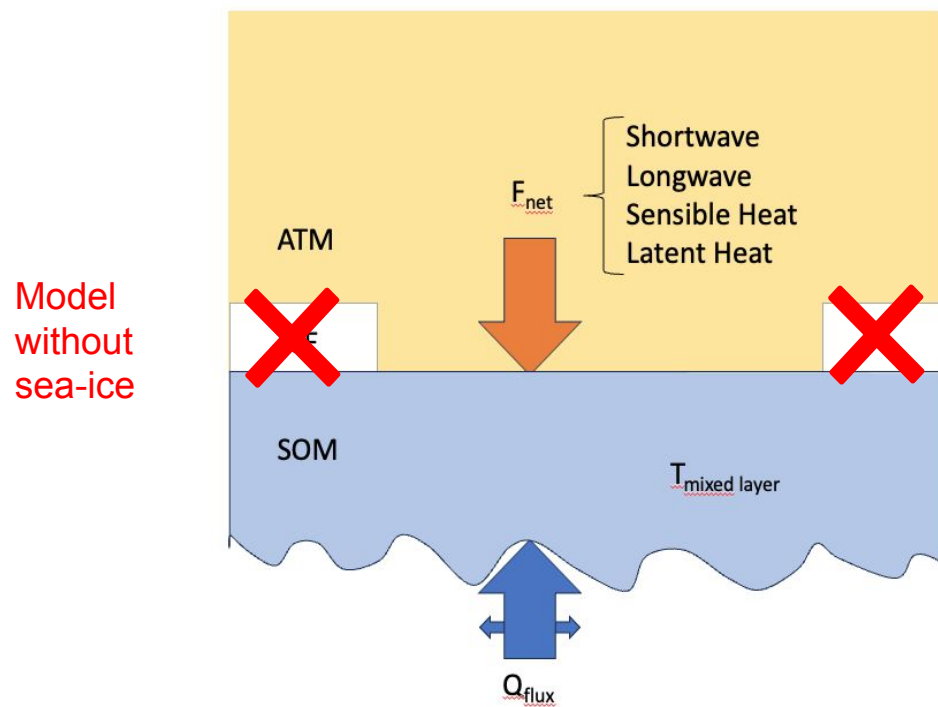


## The SOM-noice

- stabilizes at warmer temperatures (expected)
- allows to use qflux from other model versions

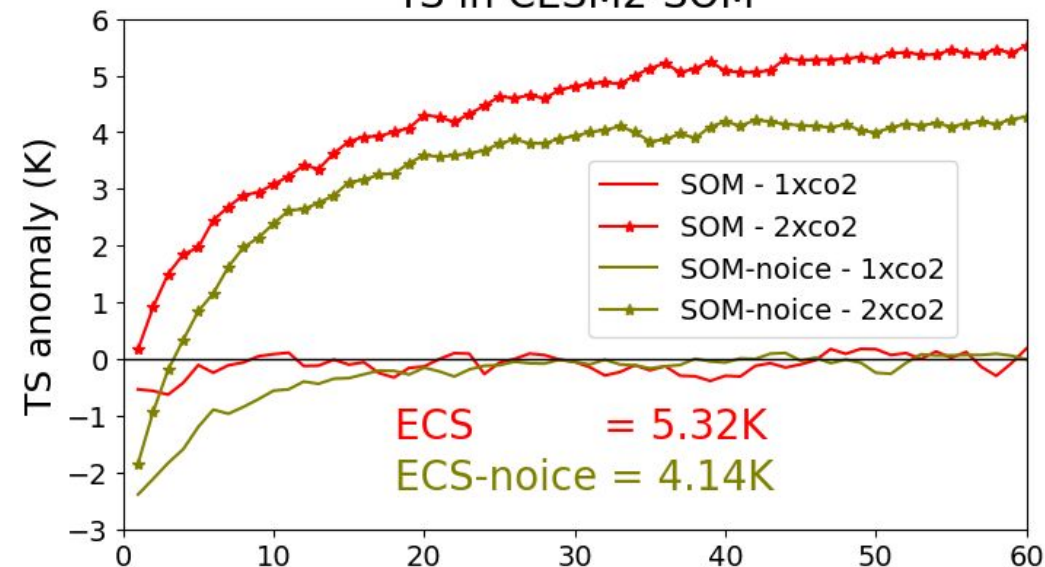
# Using SOM-noise to estimate ECS-noise

## SOM-noise

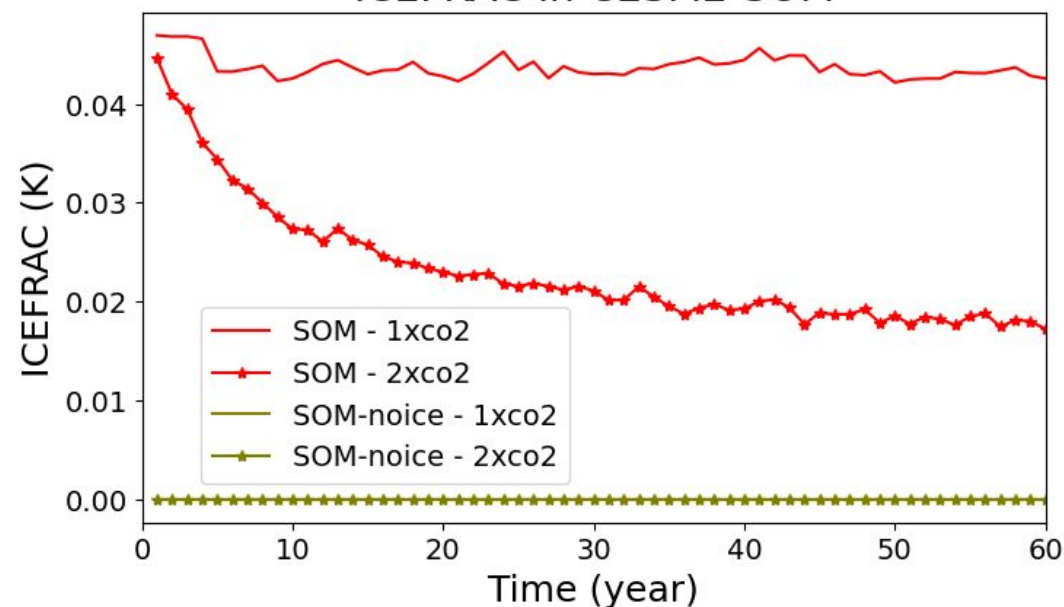


The **ECS-noise** is **1.2K** lower than ECS  
**Sea-ice feedback** is missing in the **SOM-noise**.

## TS in CESM2-SOM



## ICEFRAC in CESM2-SOM





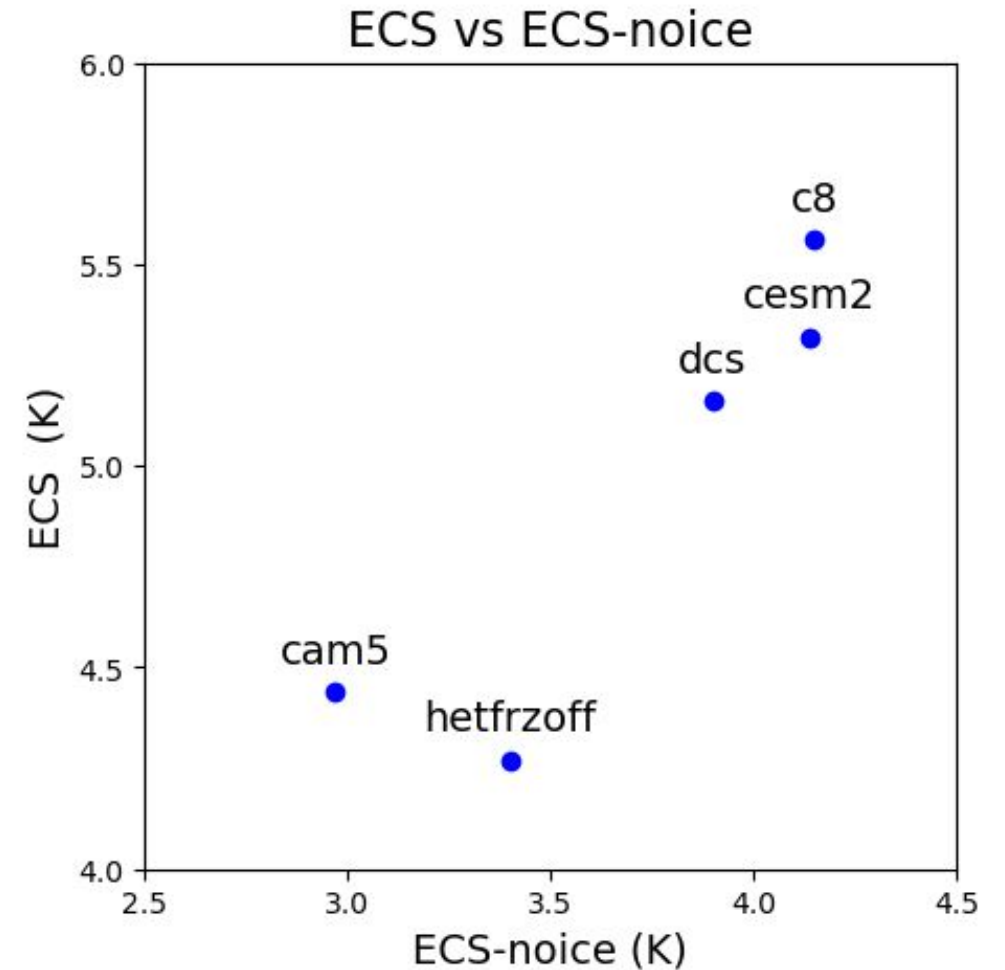
# Relationship between ECS and ECS-noise

## Parameters/physics affecting ECS

| Parameters/Physics | Value            | References            |
|--------------------|------------------|-----------------------|
| hetfrzoff          | on->off          | Zhu et al, 2022       |
| dcs                | 500->250 microns | Duffy et al, 2024     |
| c8                 | 3->4             | Duffy et al, 2024     |
| cam5               | cam6->cam5       | Gettelman et al. 2012 |

### References

Duffy et al. (2024): <https://doi.org/10.1175/JCLI-D-23-0250.1>  
Gettelman et al (2012) <https://doi.org/10.1175/JCLI-D-11-00197.1>  
Zhu et al. (2022) <https://doi.org/10.1029/2021MS002776>

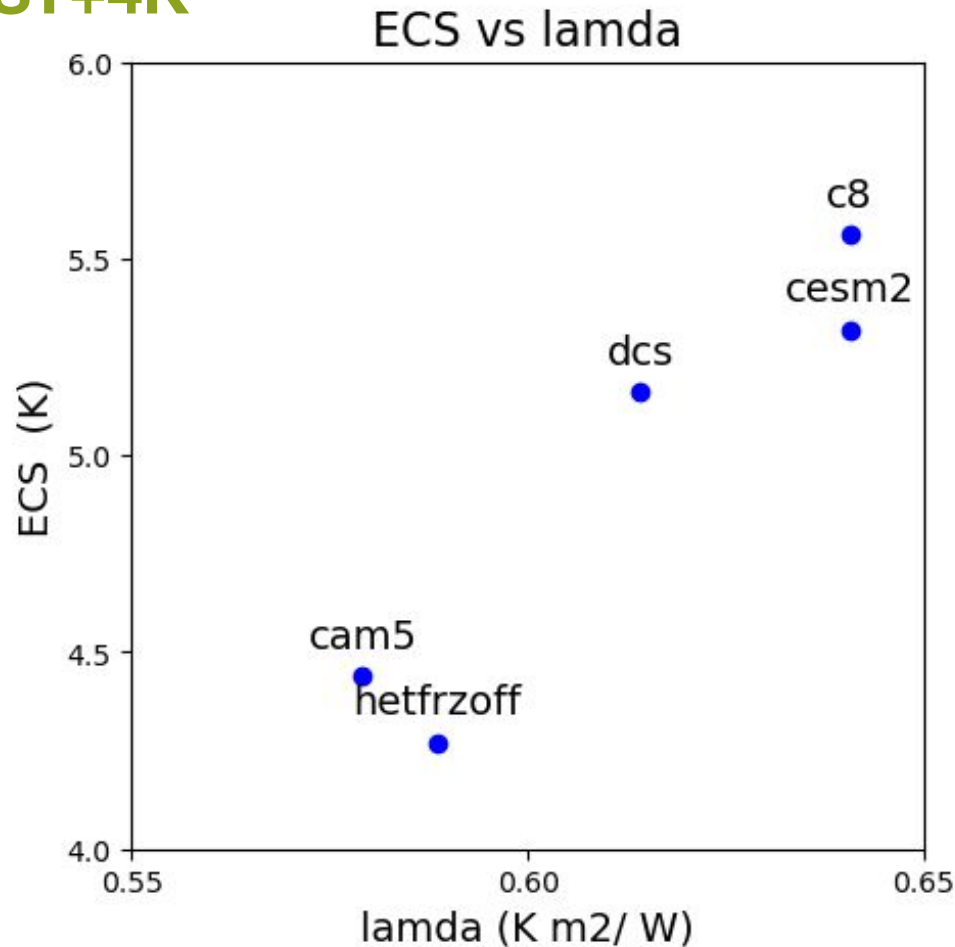


The **ECS-noise** is a decent indicator of ECS changes during model development

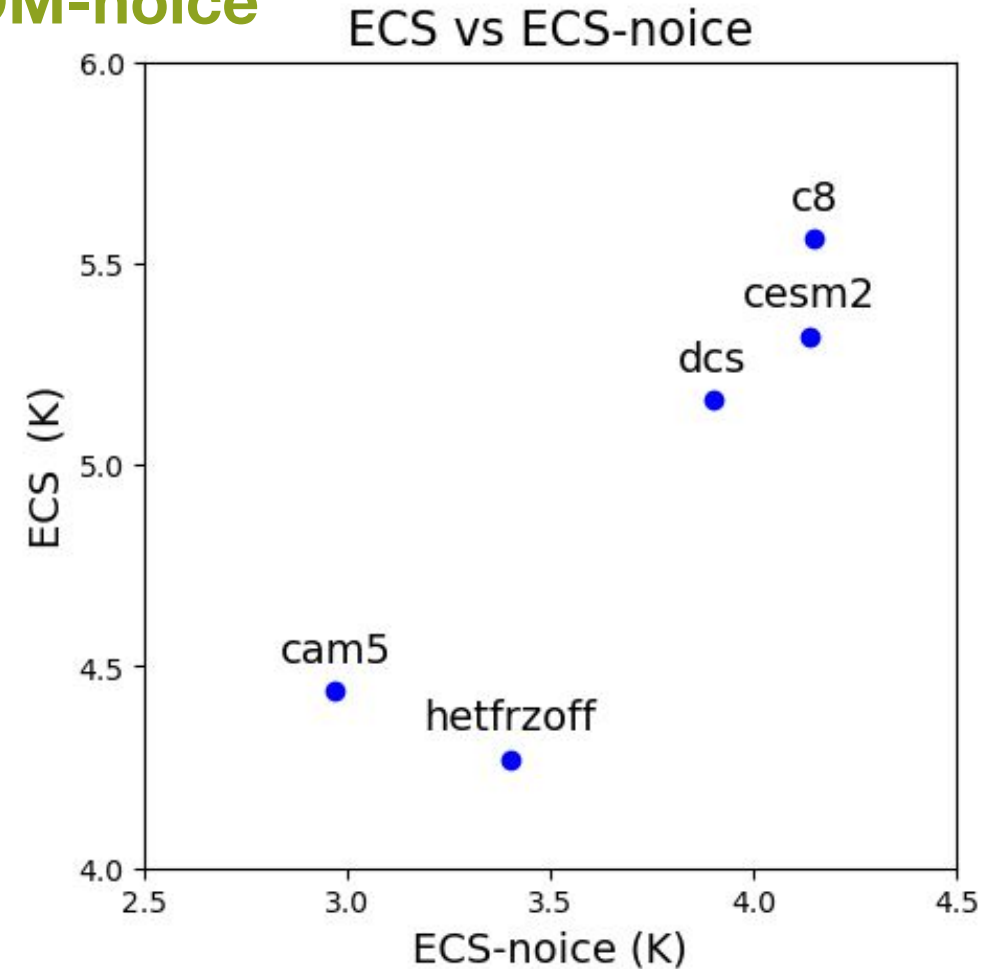


# How does it compare to other simplified methods: SST+4K $\leftrightarrow$ SOM-noice?

## SST+4K



## SOM-noice

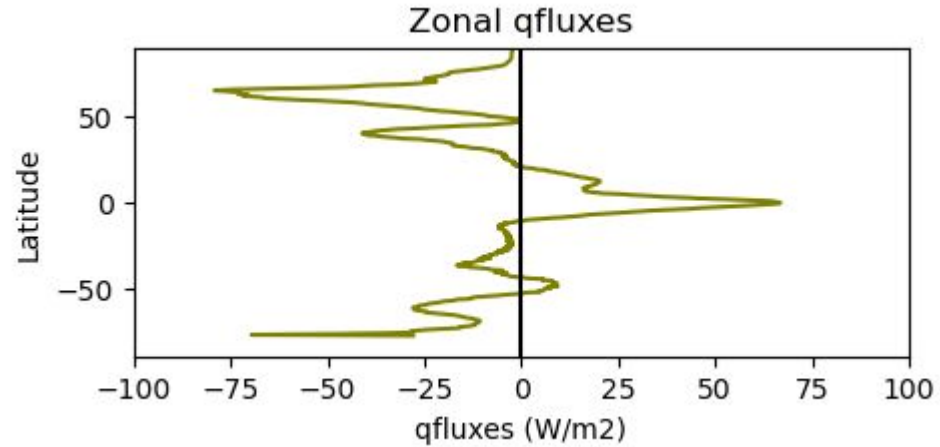
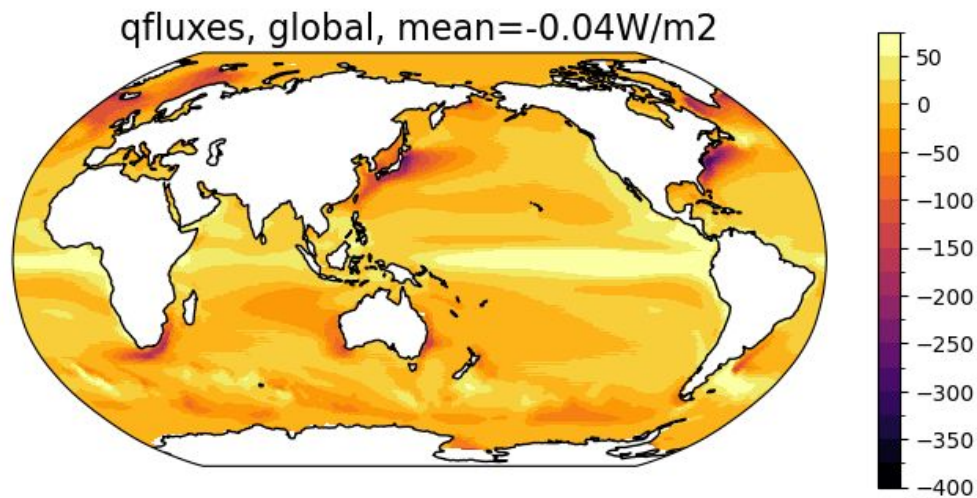


The **SOM-noice** produces predictions **similar to SST+4K runs**.

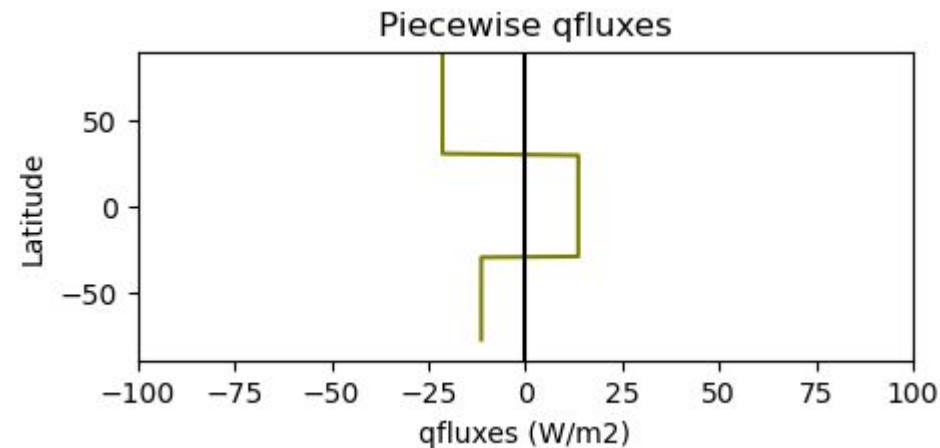
The **SOM-noice** has the potential to investigate important aspects of **ocean heat fluxes**.

# SOM-noise with idealized forcing

As the SOM-noise is not as sensitive to details of the qflux between model versions, we explore the use of **idealized qflux**.

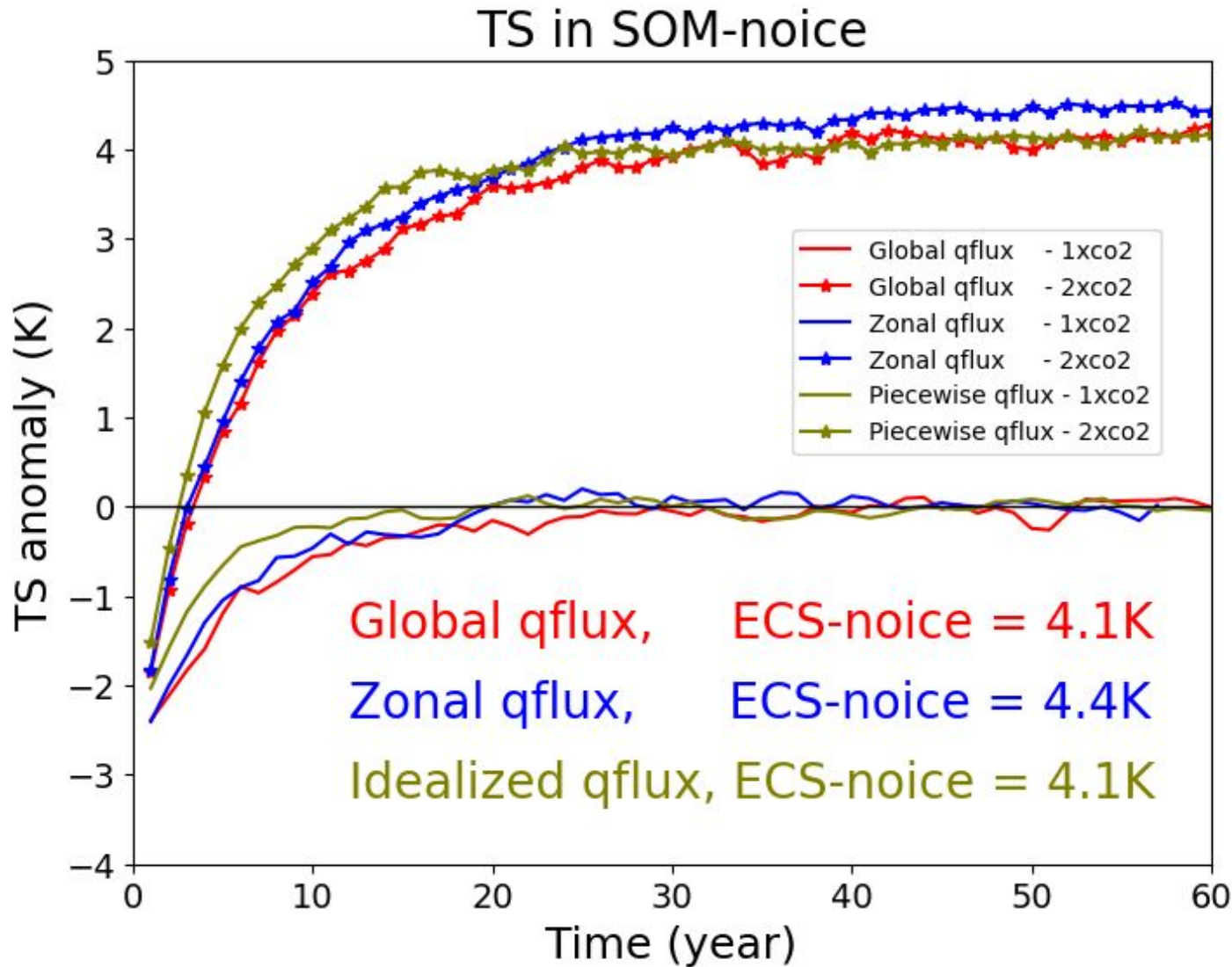


**Zonal**



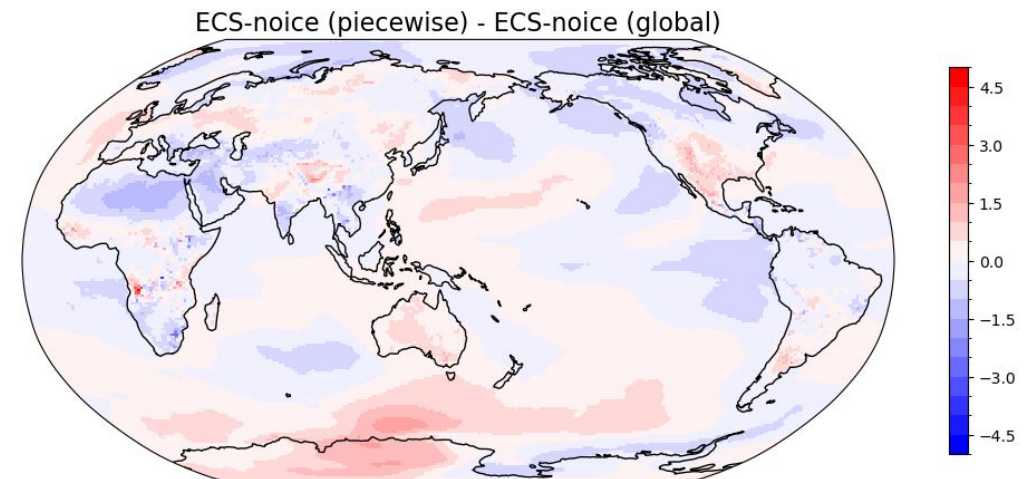
**Piecewise**

# Results with idealized forcing



**Zonal and idealized qflux produce similar ECS-noise to global qflux**

**A caveat is that ECS is a single number that doesn't reflect regional differences.**



# Summary

- Our goal was to explore a **simplified Slab Ocean Model**
  - We develop the **SOM-noice** with **idealized qflux**.
  - We assess its **performance** on the **Equilibrium Climate Sensitivity**.
- The **SOM-noice** allows us to predict the **changes in ECS** during to **parameters/physics**
  - Using **idealized qflux** produce **ECS similar to full global qflux**.
  - A caveat is that **ECS** is a single number that doesn't reflect **regional differences**.
  - The **SOM-noice** has the **potential to learn about the coupled system** and show how the coupled system is **sensitive to details and structure of qflux**.
- **Next step:**
  - Examine **regional differences** between **idealized** and **full q-fluxes**

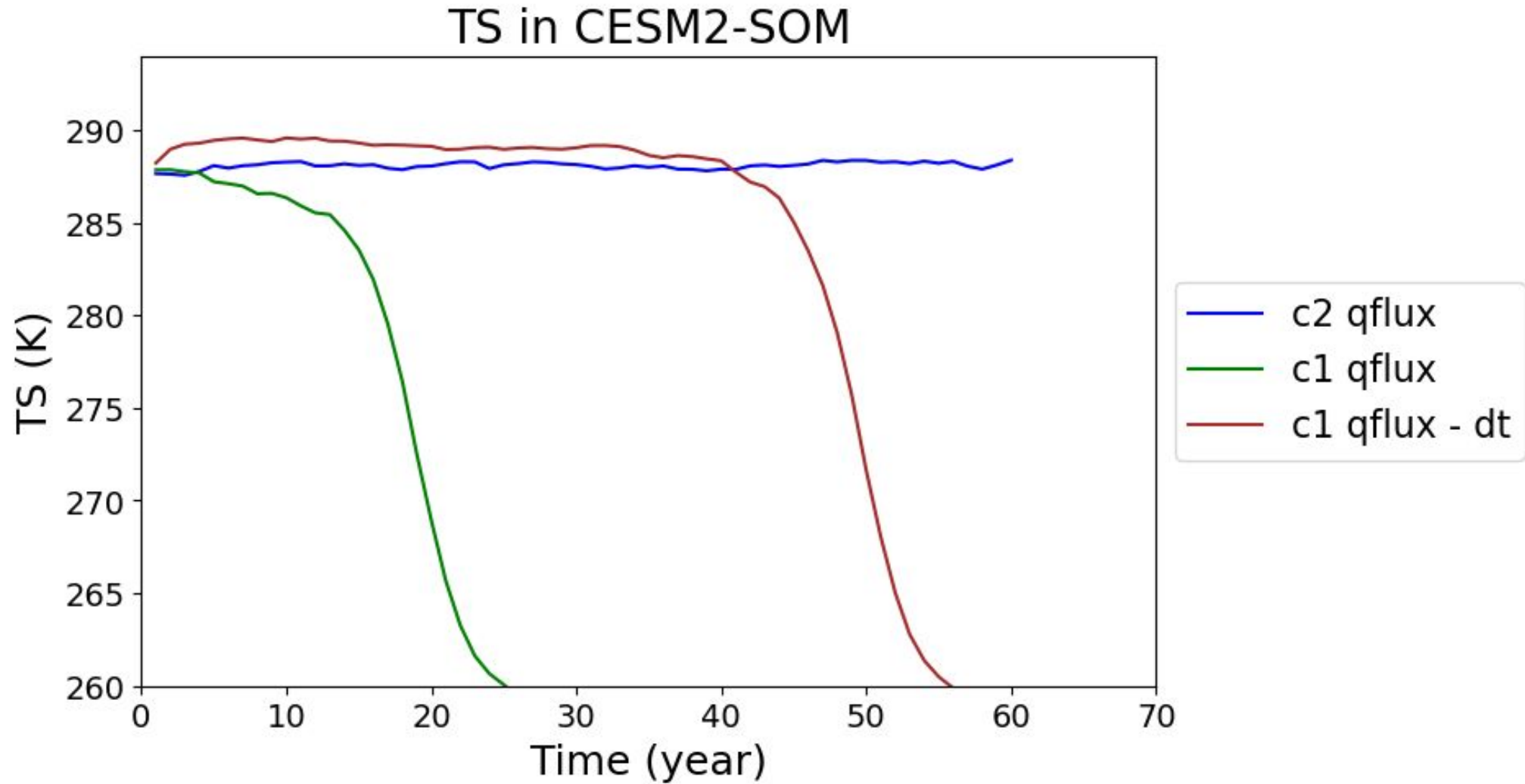


Questions ?



# Increasing dt for stability

Decreasing timestep doesn't help fixing cooling.



# TS in 1xco2 experiments

TS equilibrate warmer in SOM-noice

TS(SOM-noice) - TS(SOM)

