



CMIP6 Analysis Online Poster Seminar

13.00-14.00 Tuesday 21 April





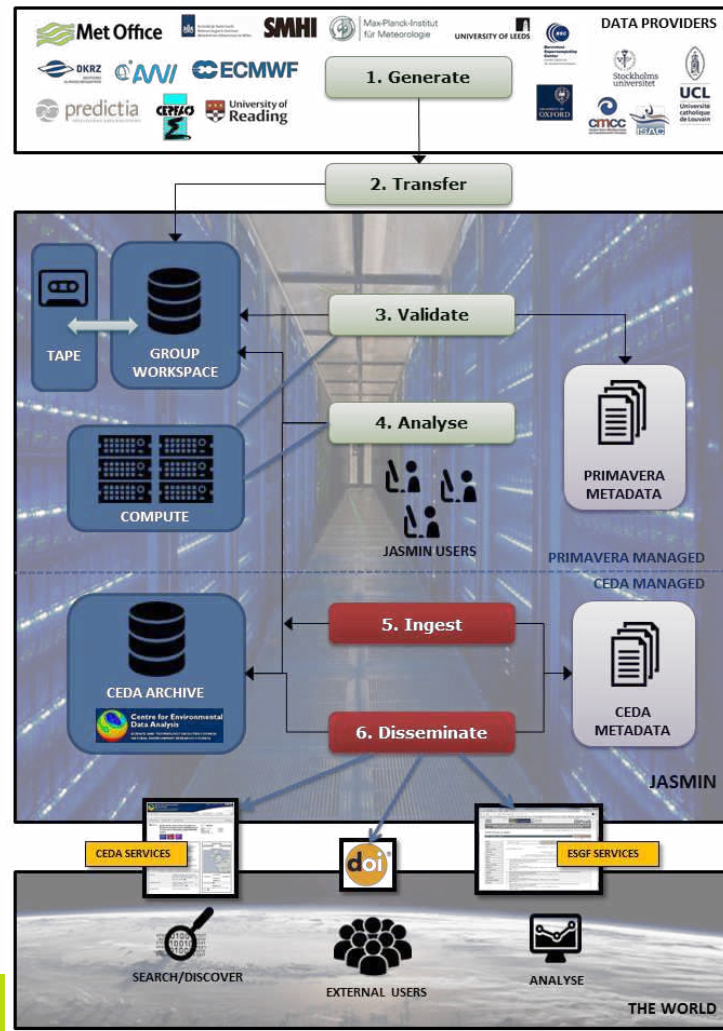
Jon Seddon

Met Office



The PRIMAVERA Project

- AMIP and coupled, historic and future simulations, at standard and high resolution from 7 different models submitted to HighResMIP and the CEDA archive (/badc/cmip6 at JASMIN)
- Almost 2 PB of data required the development of the Data Management Tool (DMT)



The following data has been received:

Project	Institute	Climate Model	highres-future
Amon	Variant Label	rsut	Variable Name
			Clear Filter

Project ▴	Institute ▴	Climate Model ▴	Experiment ▴	MIP Table ▴	Variant Label ▴	CMOR Name ▴	Start Time	End Time	Online Status	# Data Files	# Data Issues	Tape URLs	File Versions	Data Size	Request Retrieval?
CMIP6	CMCC	CMCC-CM2-HR4	highres-future	Amon	r1i1p1f1	rsut	2015-01-01	2050-12-31	online	432	0	et:...	v20190509	86.8 MB	<input type="checkbox"/>
CMIP6	CMCC	CMCC-CM2-VHR4	highres-future	Amon	r1i1p1f1	rsut	2015-01-01	2050-12-31	online	432	0	et:...	v20190509	969.0 MB	<input type="checkbox"/>
CMIP6	CNRM-CERFACS	CNRM-CM6-1-HR	highres-future	Amon	r1i1p1f2	rsut	2015-01-01	2050-12-31	online	3	0	et:...	v20190920	270.7 MB	<input type="checkbox"/>
CMIP6	CNRM-CERFACS	CNRM-CM6-1	highres-future	Amon	r1i1p1f2	rsut	2015-01-01	2050-12-31	online	4	0	et:...	v20190314	37.2 MB	<input type="checkbox"/>
CMIP6	EC-Earth-Consortium	EC-Earth3P-HR	highres-future	Amon	r1i1p1f1	rsut	2015-01-01	2050-12-31	partial	36	1	et:...	v20190412	704.8 MB	<input type="checkbox"/>
CMIP6	EC-Earth-Consortium	EC-Earth3P	highres-future	Amon	r1i1p1f1	rsut	2015-01-01	2049-12-31	offline	420	1	et:...	v20190909	260.0 MB	<input type="checkbox"/>
CMIP6	MOHC	HadGEM3-GC31-HM	highres-future	Amon	r1i1p1f1	rsut	2015-01-01	2050-12-30	online	36	0	mo...	v20190301	839.4 MB	<input type="checkbox"/>

cube_helper

- Carrying out analysis on CMIP data can be difficult due to inconsistencies in metadata across the datasets.
- Equalising metadata with Iris requires first identifying the inconsistency.
- Iris provides a couple functions for equalising attributes and time units, but it is up to the user how and when to use these.
- cube_helper is a Python module that acts as a wrapper for many common Iris functions, including removing inconsistent attributes.

The two scenarios show the steps needed to load an entire dataset of cubes, with the two different approaches:

With Iris:

```
import iris
from glob import glob
fnames = glob('path/to/cubes/*.nc')
cubes = iris.load(fnames)
iris.equalise_attributes(cubes)
iris.unify_time_units(cubes)
cube = cubes.concatenate_cube()
```

With cube_helper:

```
import cube_helper as ch
cube = ch.load('path/to/cubes')
```



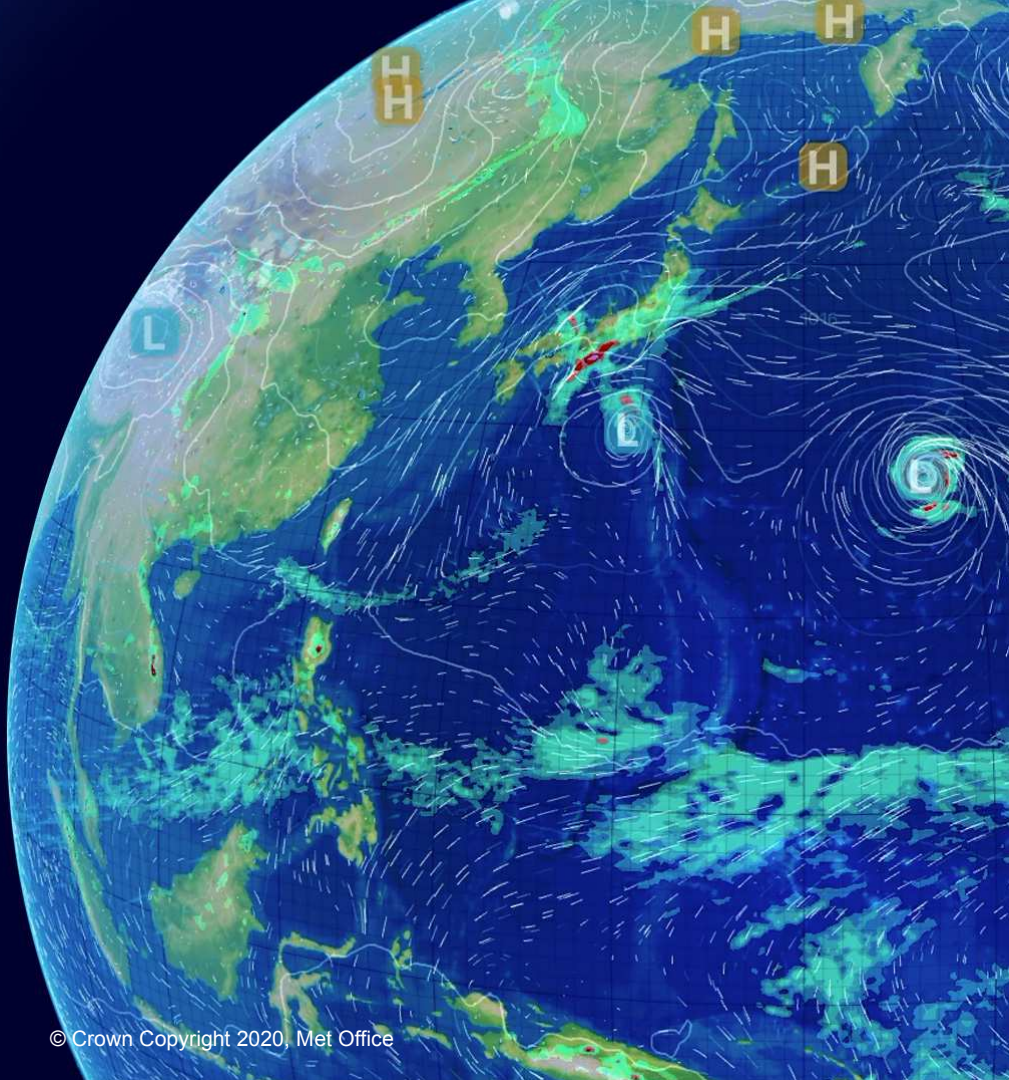
Catherine Hardacre

Met Office



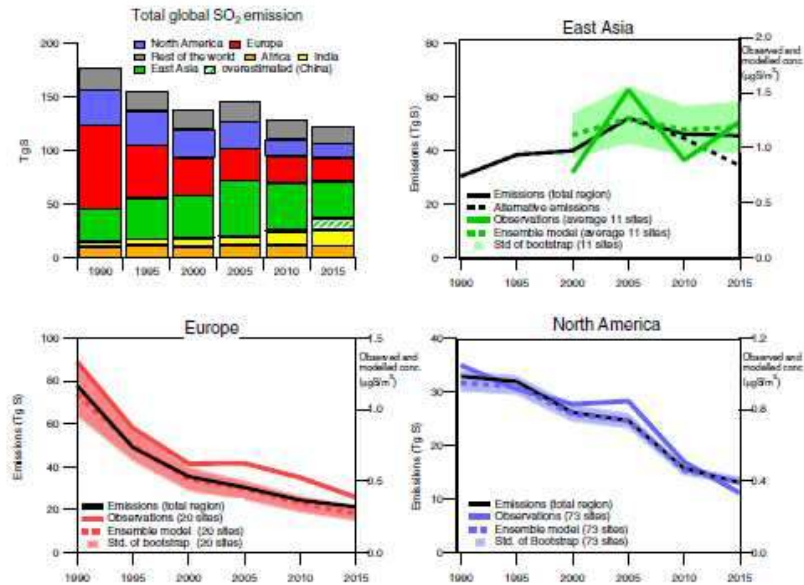
Evaluation of SO_2 and SO_4^{-2} in UKESM1

Catherine Hardacre, Jane Mulcahy,
Steve Rumbold, Colin Johnson and
Colin Jones



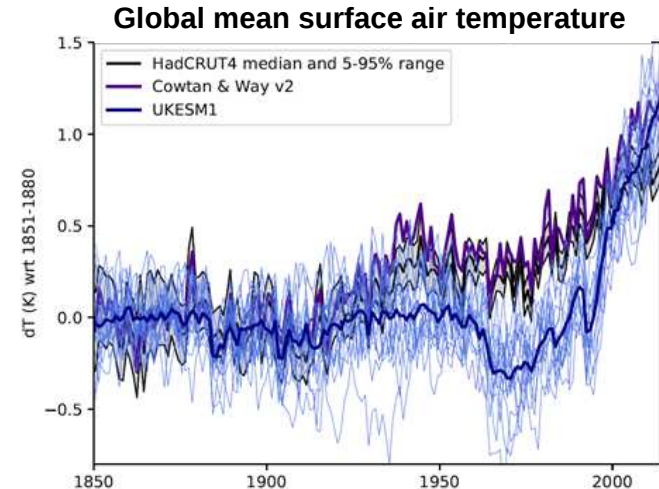
Background

1. Global trends in SO₂ emissions

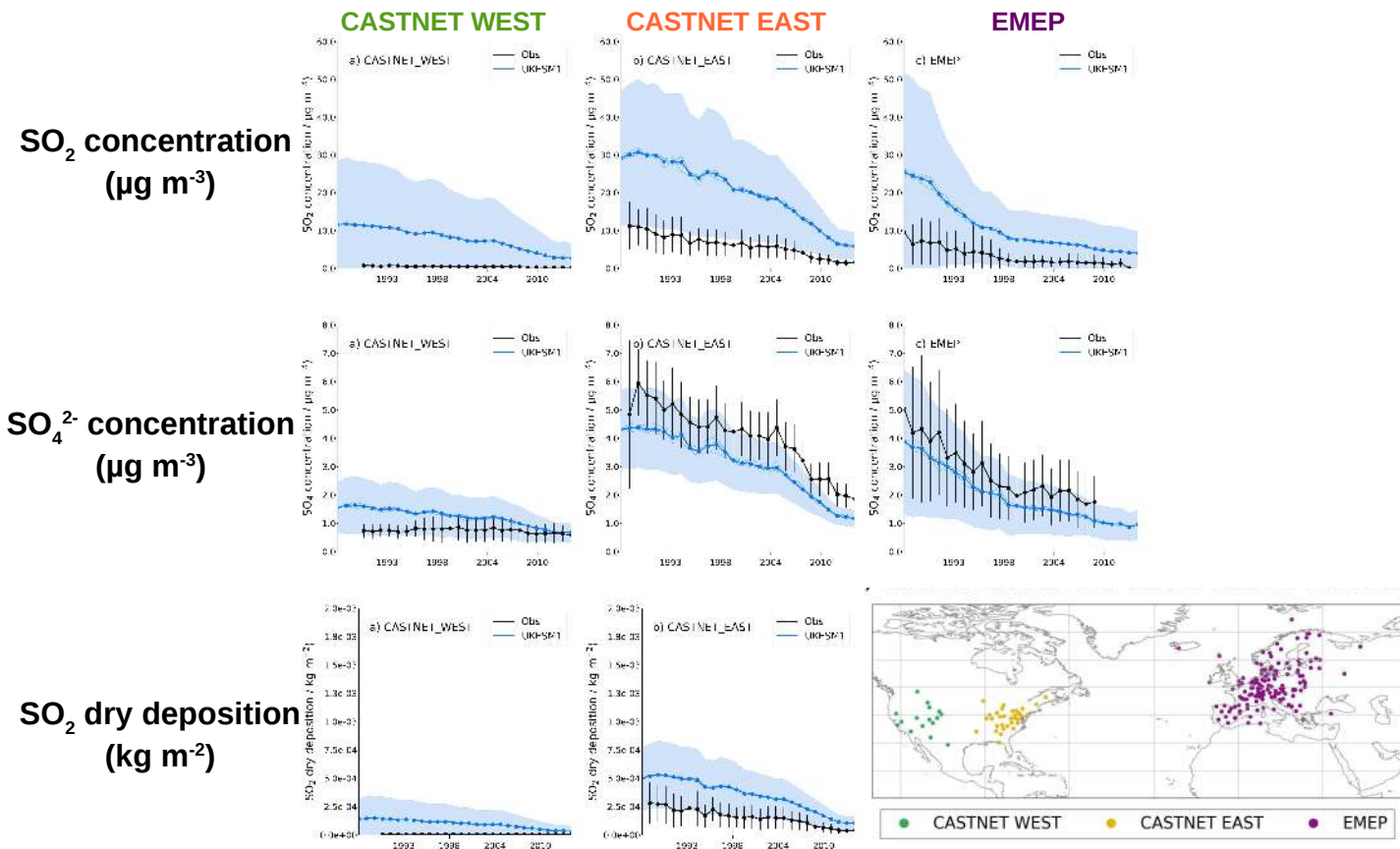


From Aas et al., Nature/Scientific Reports (2019) <https://doi.org/10.1038/s41598-018-37304-0>

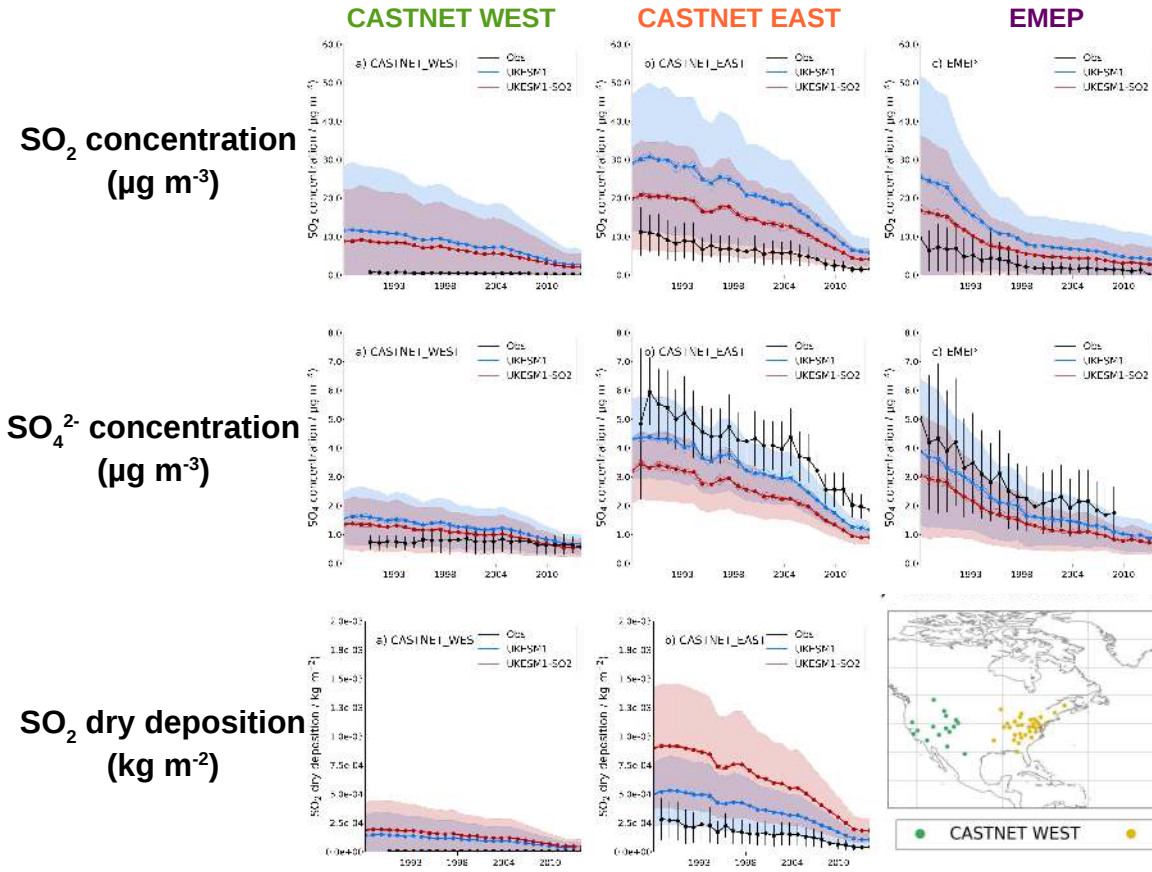
2. Development of UKESM1



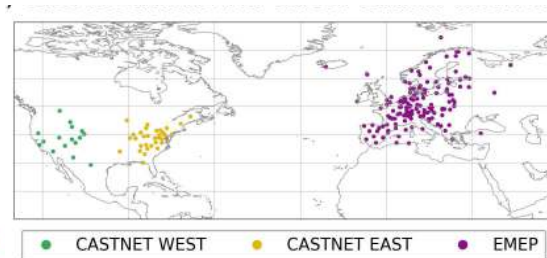
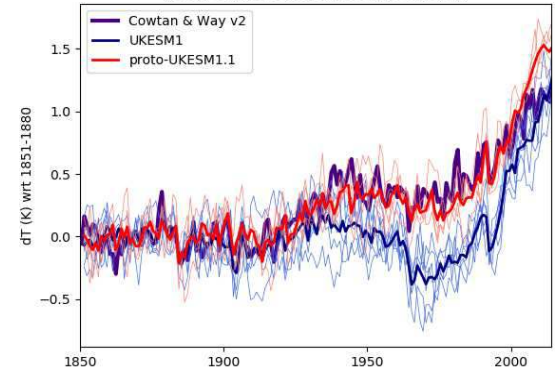
Model – observation comparisons: UKESM1



Model – observation comparisons: UKESM1 + SO₂ mods



Global mean surface air temperature





Jonah Bloch-Johnson

University of Reading



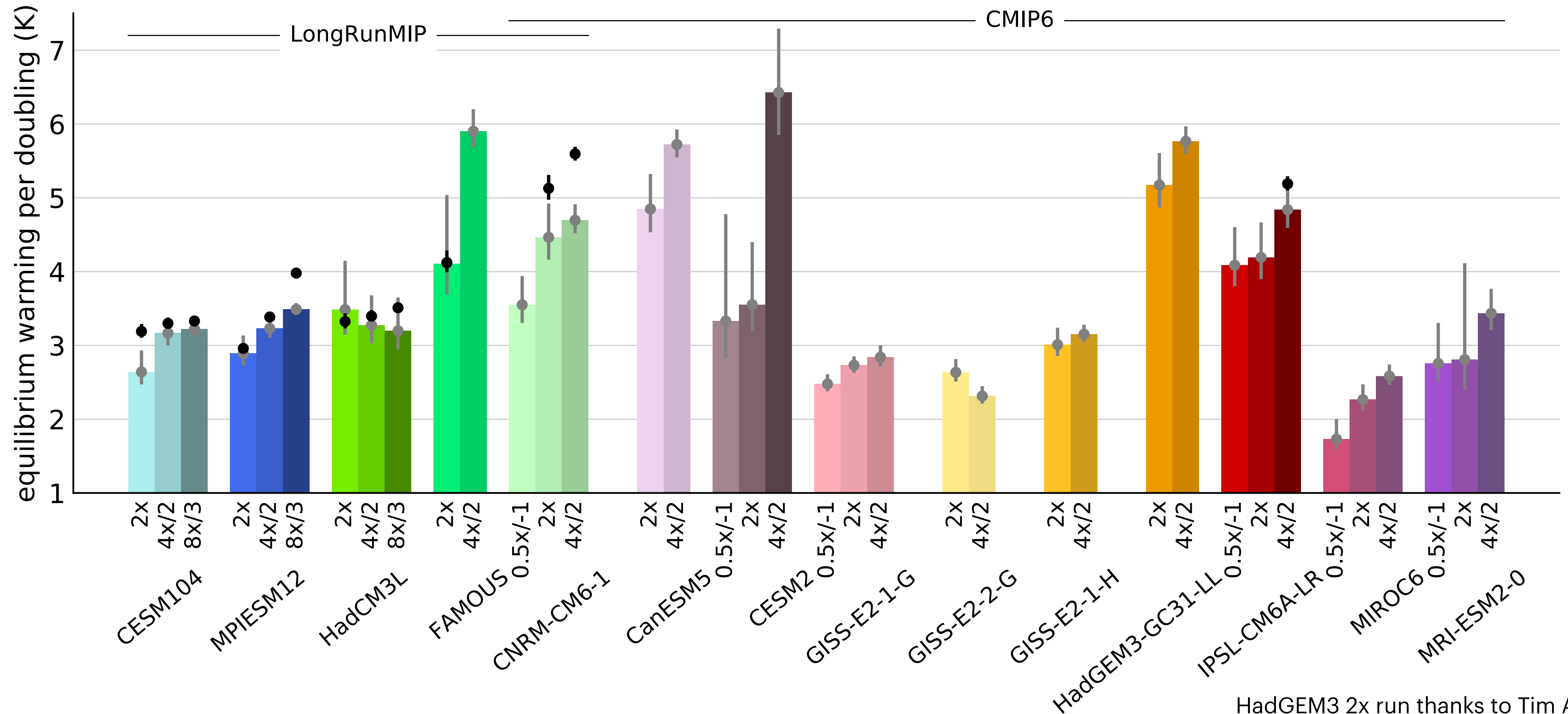
Climate sensitivity increases under higher CO₂ levels due to positive feedback temperature dependence

UK CMIP6 Online Poster Seminar - 21.4.20

Jonah Bloch-Johnson¹, Maria Rugenstein², Martin B. Stolpe, Tim Rohrschneider², Yiyu Zheng², and Jonathan Gregory^{1,3}

¹University of Reading ²Max-Planck-Institute for Meteorology ³Met Office Hadley Centre

The climate sensitivity (the equilibrium warming per CO₂ doubling) increases with CO₂ level.



The increase in forcing per CO₂ doubling is not large enough to explain the increase in sensitivity.

$$\Delta T_{eq}(C) = \frac{-F(C)}{\lambda}$$

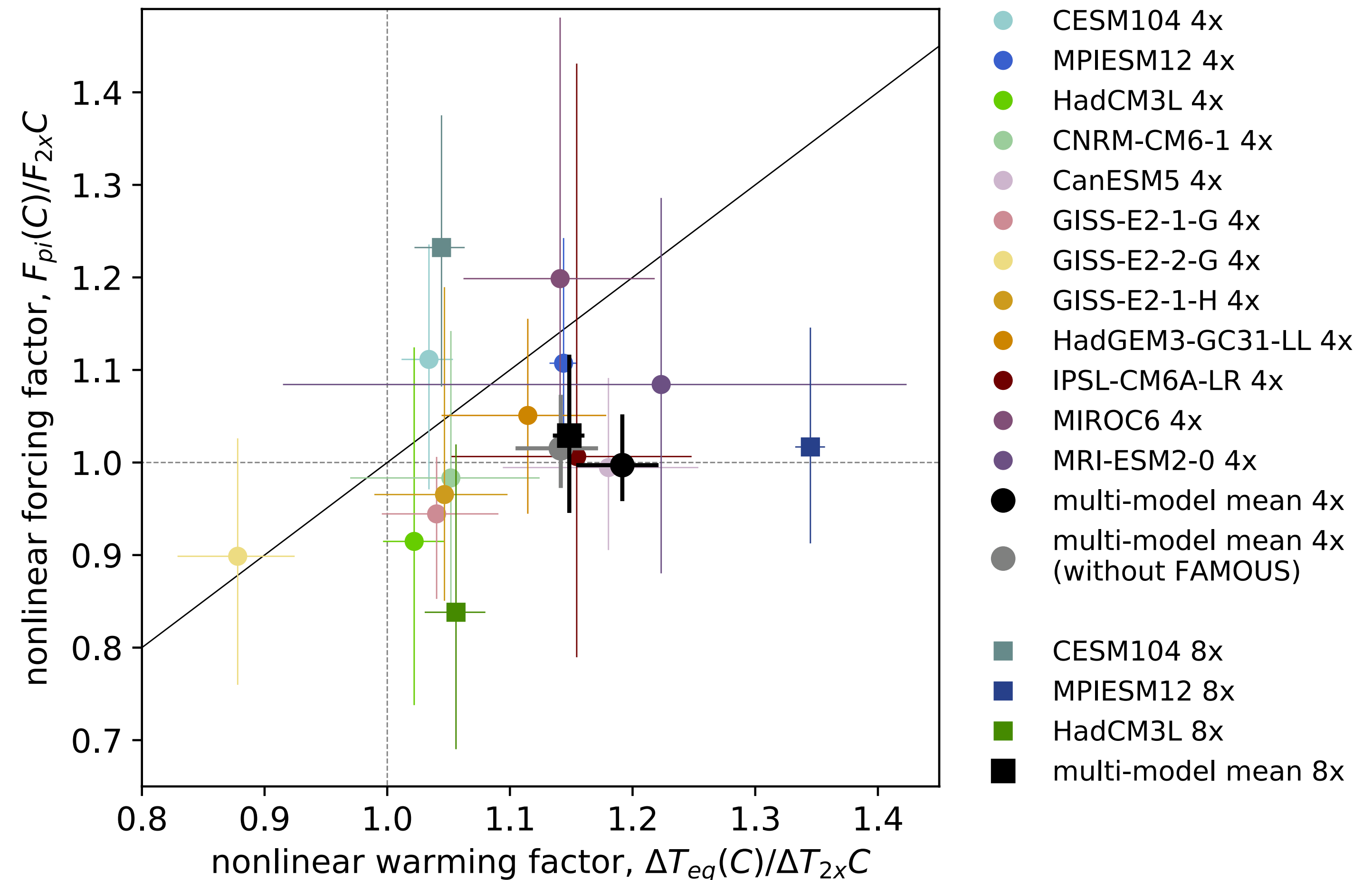
(eq. warming) (forcing) (feedback)

λ is constant if and only if

$$\frac{\Delta T_{eq}(C)}{\Delta T_{2x}C} = \frac{F(C)}{F_{2x}C}$$

factor by which
warming exceeds
linear approx.

factor by which
forcing exceeds
linear approx.



The net climate feedback has a positive temperature dependence for twelve of fourteen models.

$$-F(C) \neq \lambda \Delta T,$$

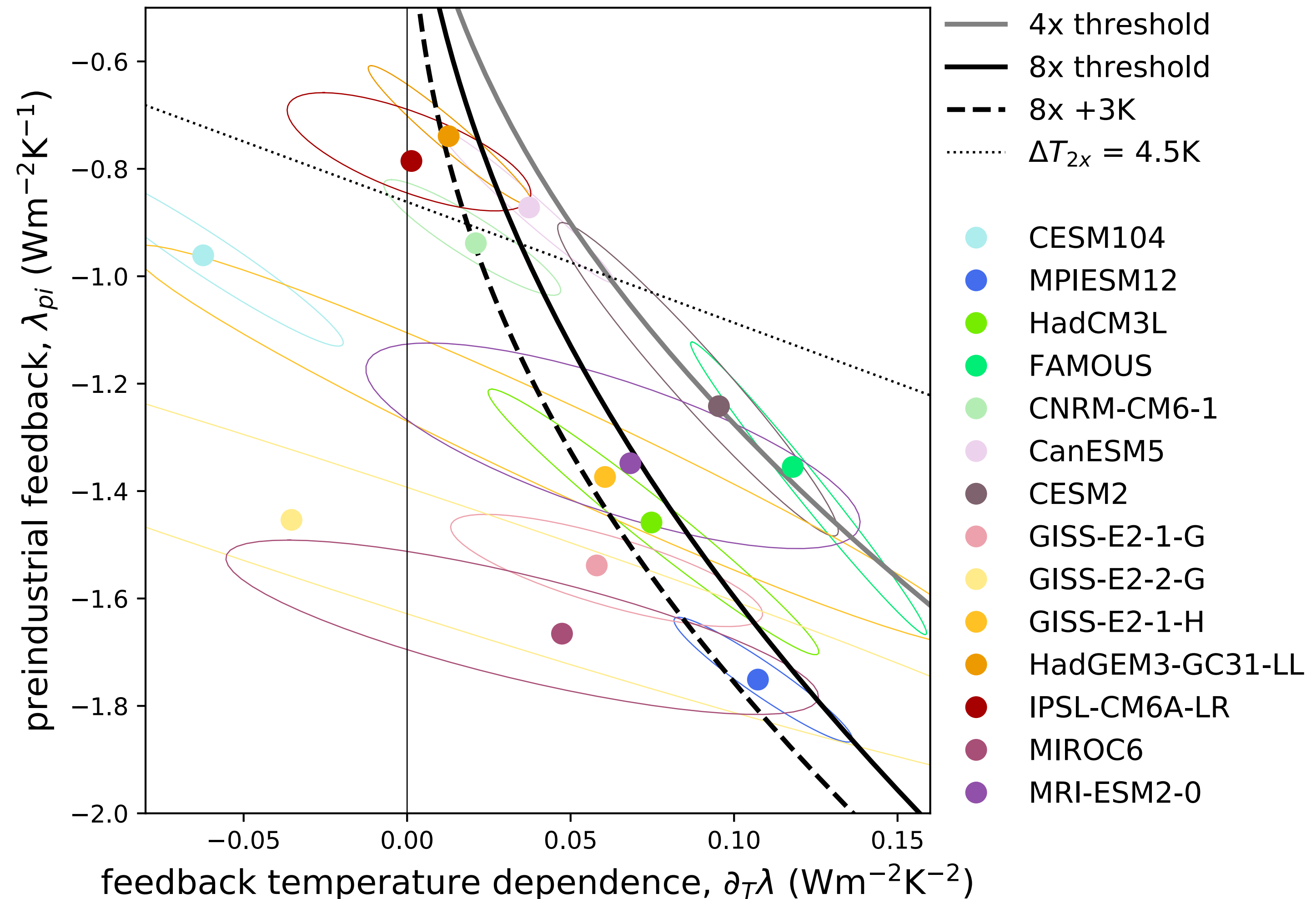
so include more terms...

$$-F(C) = \lambda_{pi} \Delta T + \partial_T \lambda \Delta T^2 + \partial_C \lambda \Delta T C$$

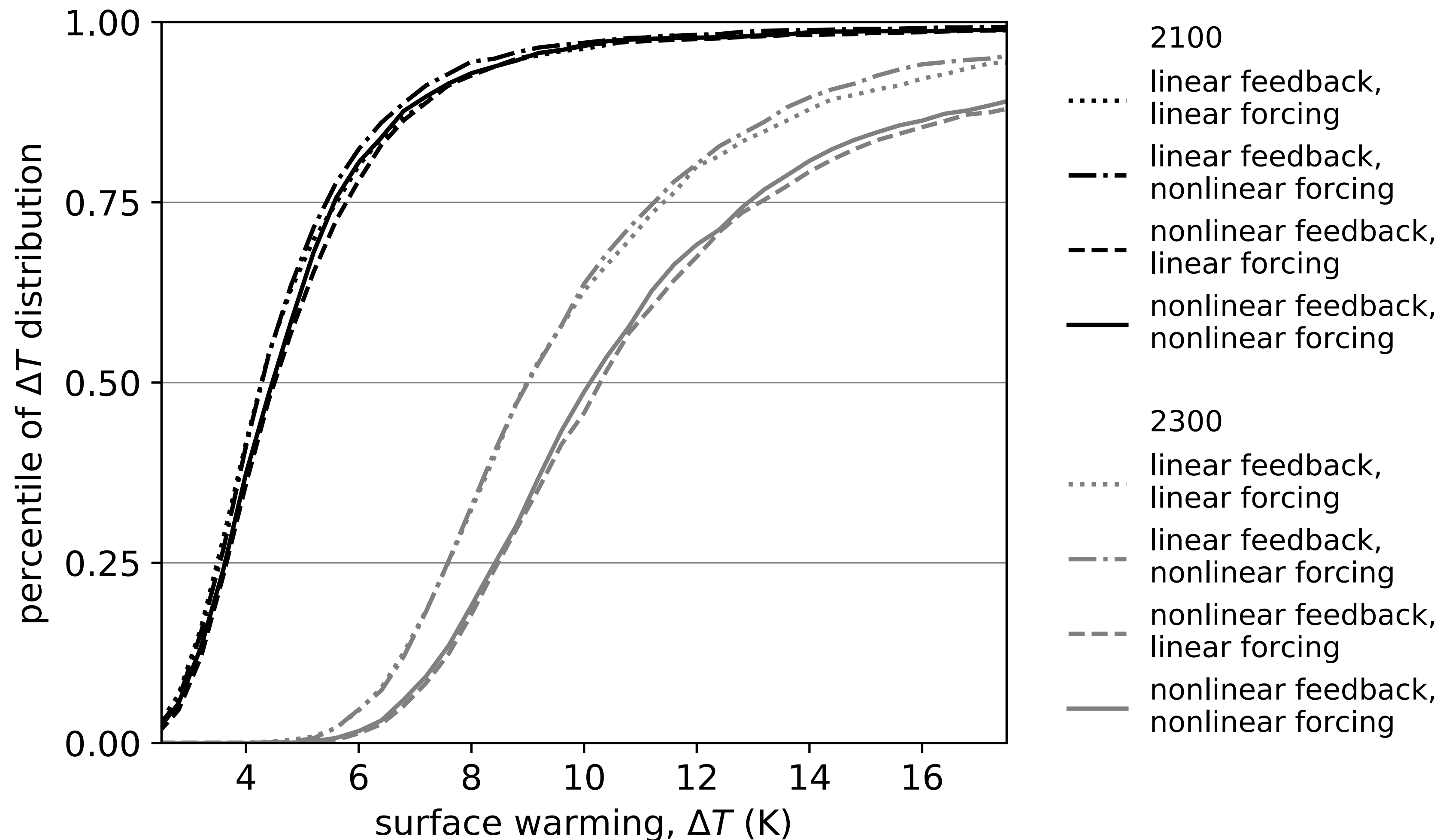
$$\lambda_{pi} \equiv \lambda(T_{pi}, C_{pi}) \quad \text{preindustrial feedback}$$

$$\partial_T \lambda \equiv \frac{\partial \lambda}{\partial T} \quad \text{feedback temperature dependence}$$

$$\partial_C \lambda \equiv \frac{\partial \lambda}{\partial C} \quad \text{feedback CO}_2 \text{ dependence}$$



Feedback temperature dependence only becomes important beyond 2100, and mostly affects the risk of high warming.



By 2300, feedback temperature dependence:

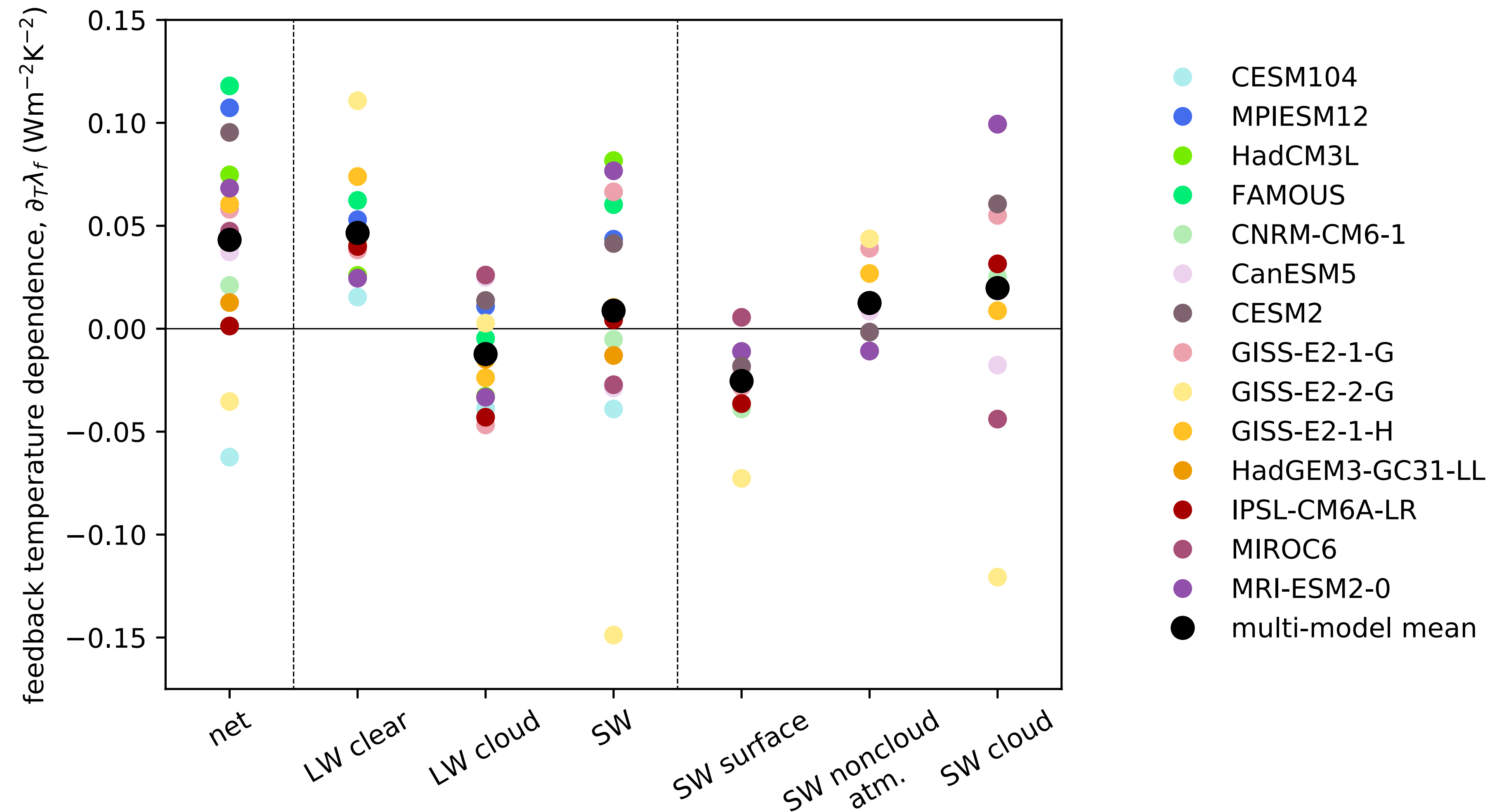
increases the 50th percentile of warming by 13% (1.1K)

increases the 80th percentile by 23% (3.5K)

introduces a 5% chance of runaway warming

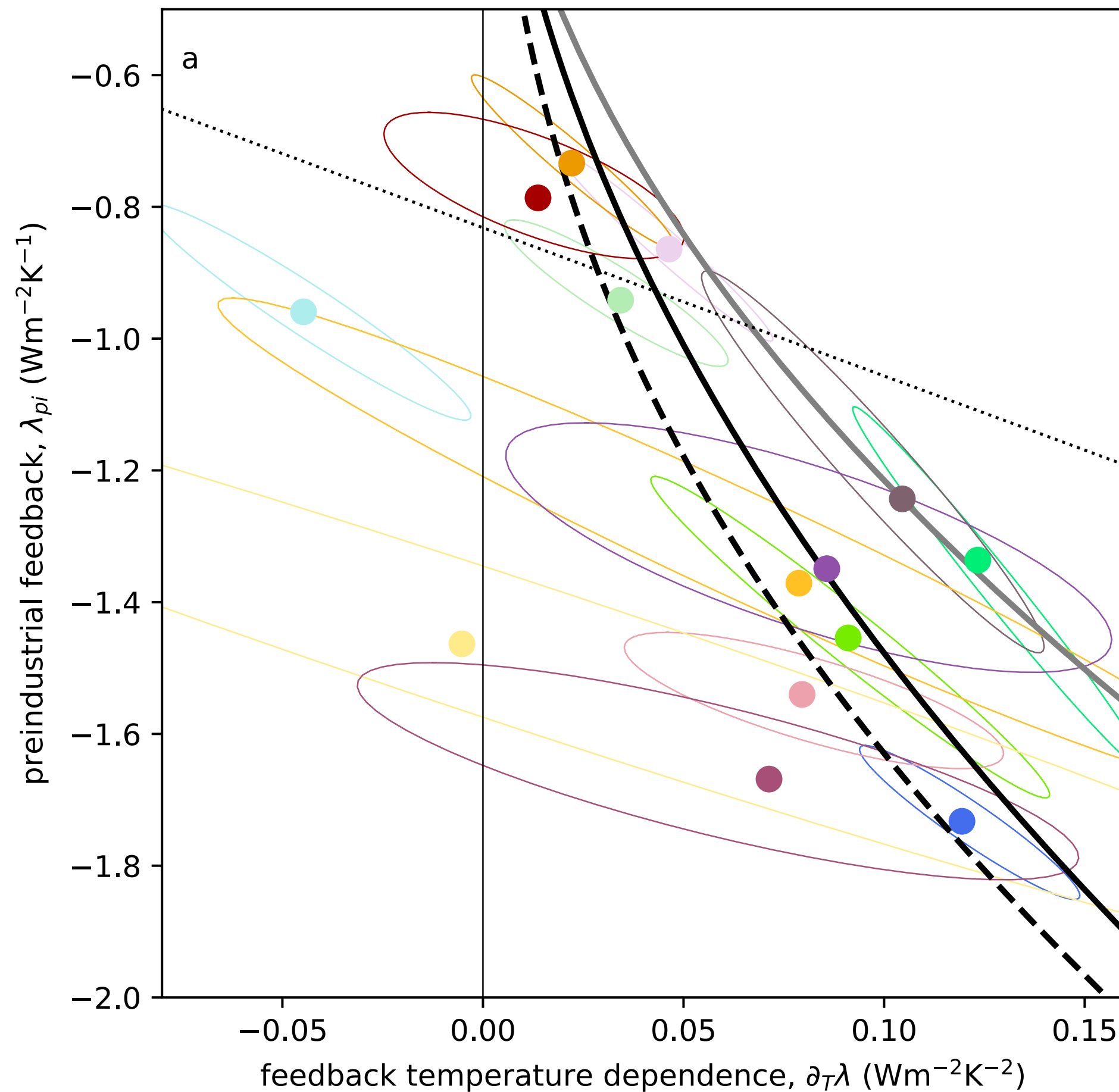
Extra slides

LW clear sky component makes feedback temp dependence positive, SW cloud gives it spread

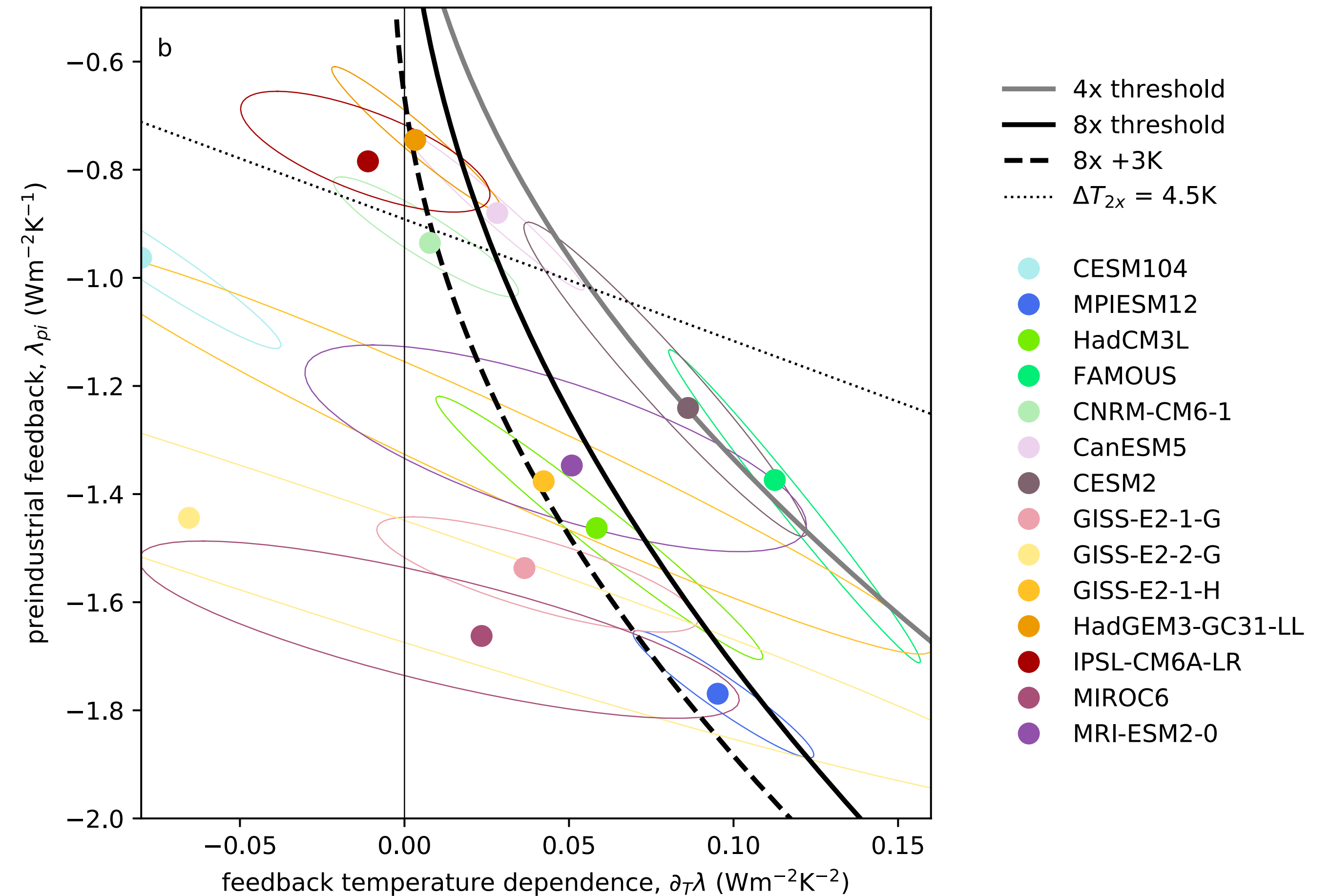


Feedback CO2 dependence does not significantly affect results

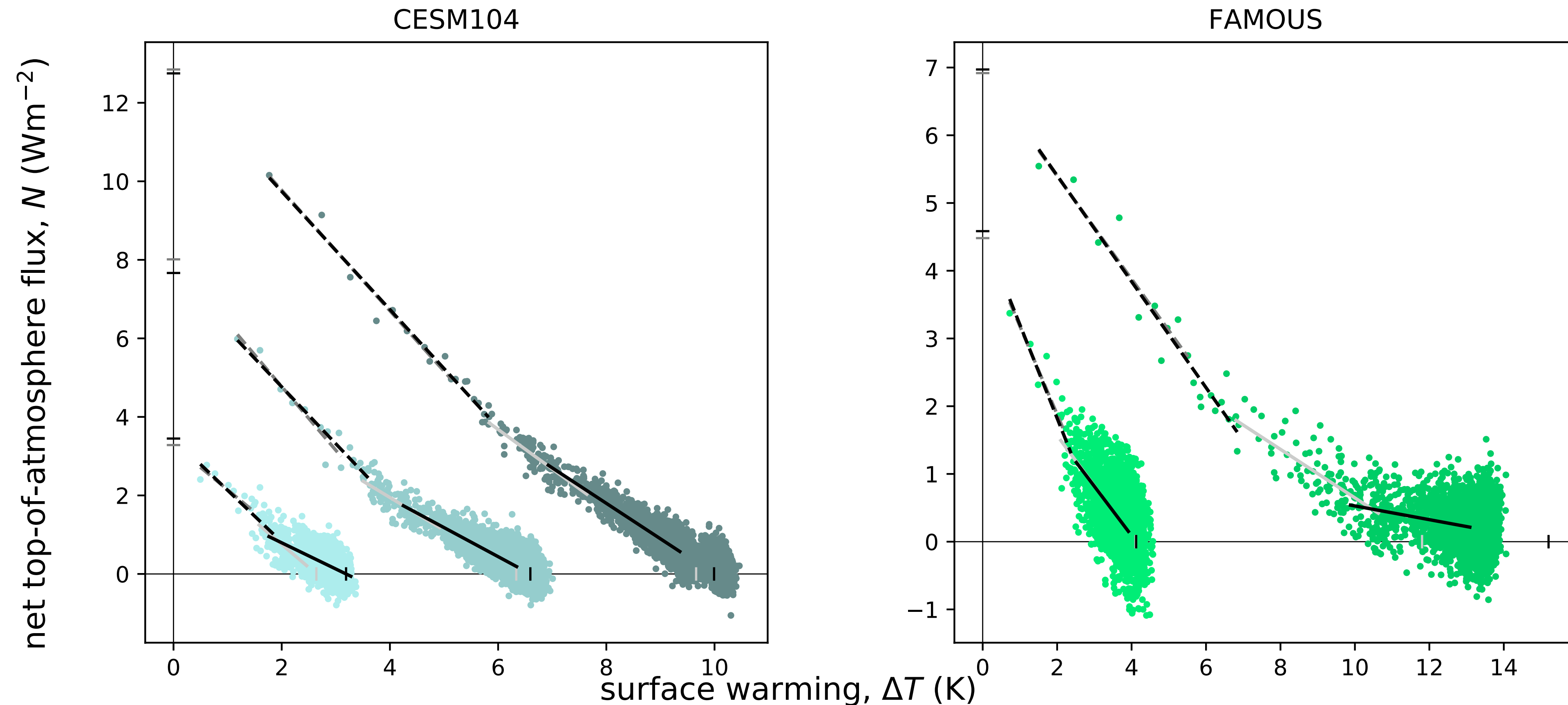
$$\partial_c \lambda \equiv -0.03 \text{ Wm}^{-2}\text{K}^{-1}\text{d}^{-1}$$



$$\partial_c \lambda \equiv 0.03 \text{ Wm}^{-2}\text{K}^{-1}\text{d}^{-1}$$



Feedback temperature dependence assumes T represents an “equilibrium pattern” and is only one cause of inconstant $\partial N/\partial T$





Nick Lutsko

Scripps Institution of Oceanography



Theory: relative contributions of specific humidity and potential temperature to θ_e changes

Constant RH, over ocean:

$$\frac{\Delta \theta_E}{\theta_E} \simeq \frac{\Delta \theta}{\theta} + \frac{L}{c_p T} \Delta q_v$$

$$\frac{\Delta \theta_E}{\theta_E} \simeq \frac{\Delta \theta}{\theta} + q_v \frac{0.07 L}{c_p} \frac{\Delta T}{T} \quad (\Delta q_v \simeq q_v 0.07 \Delta T)$$

$$\longrightarrow q_{v,L} > \frac{1}{174} \simeq 5.6 \text{ g kg}^{-1} = q_{v,0}$$

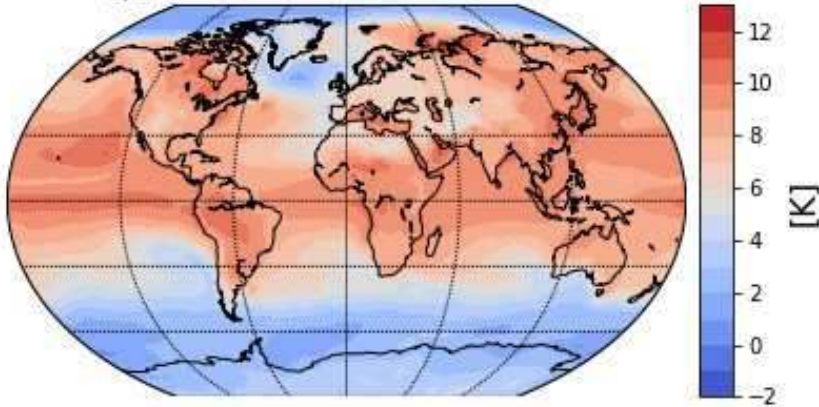
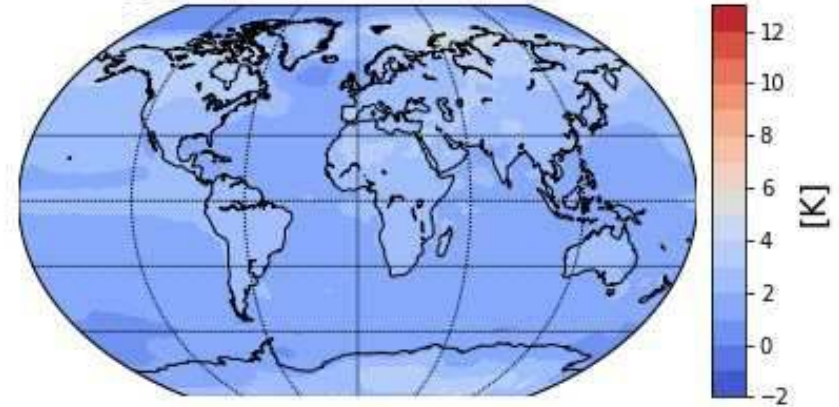
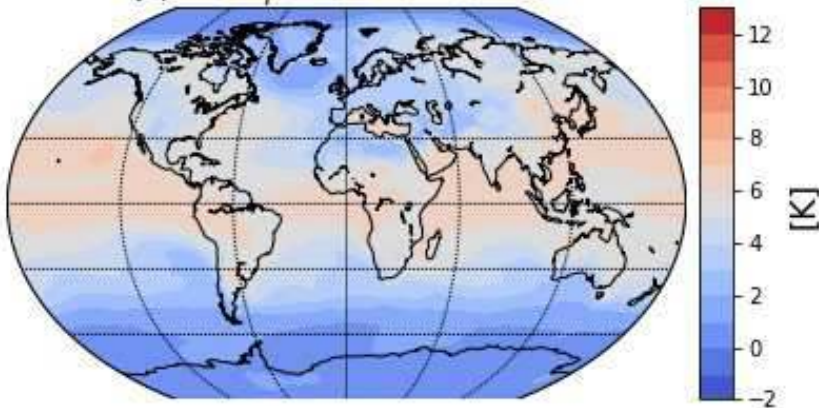
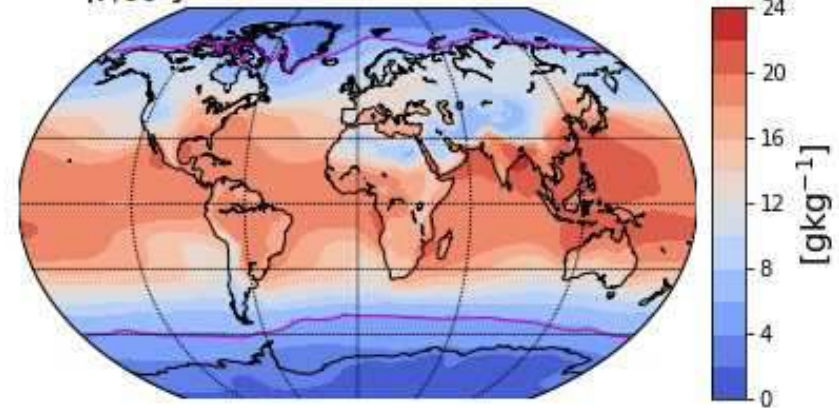
RH changes, over land:

$$q_{v,L} > \frac{A}{\gamma \left(174 + \frac{2490 \Delta RH_o}{RH_o \Delta \theta_o} \right)} = q_{v,0,L}$$

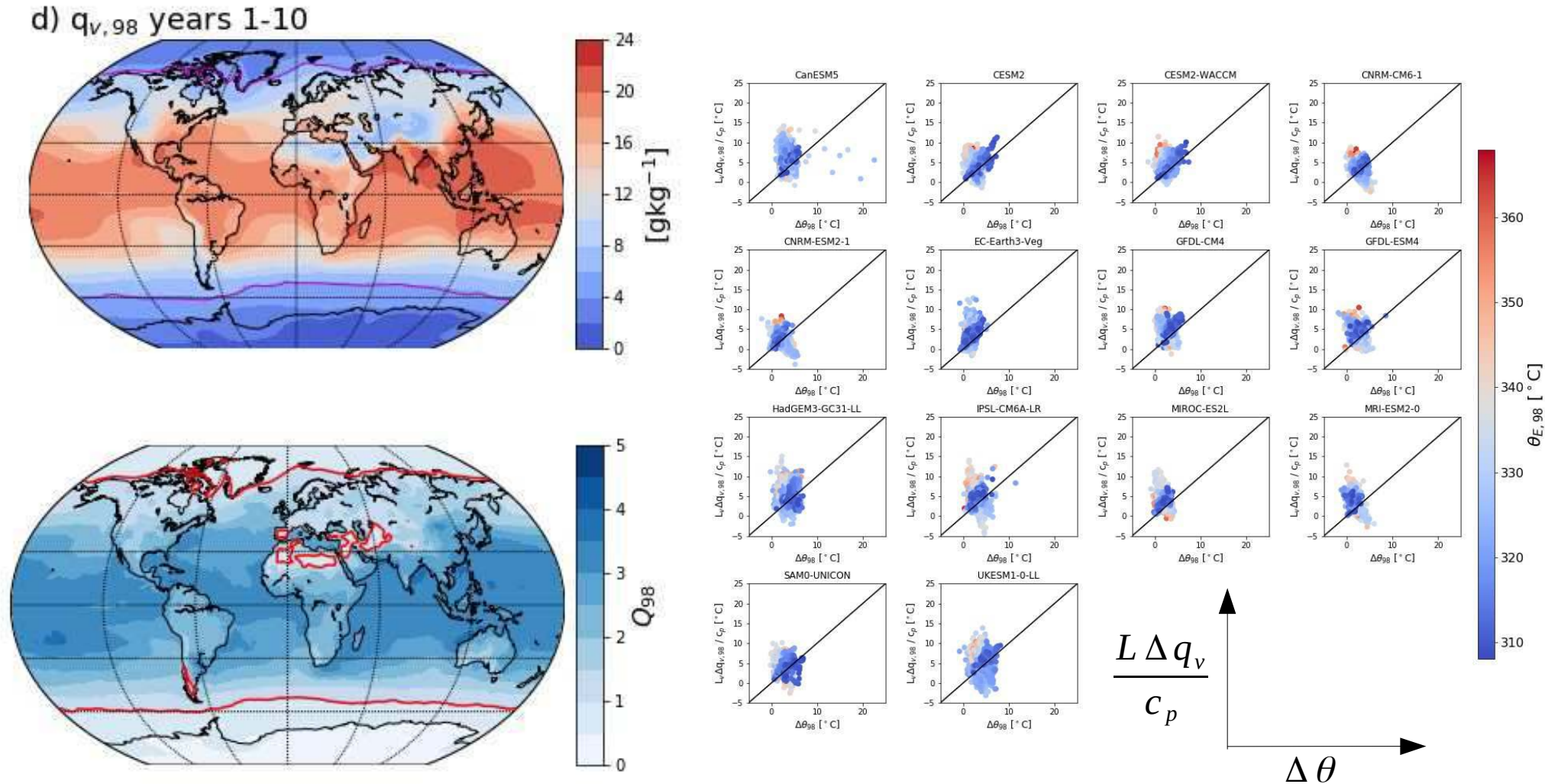
$$A = \frac{\Delta \theta_L}{\Delta \theta_o} \quad \gamma = \frac{q_{v,o}}{q_{v,L}}$$

$$q_{v,0,L} \simeq 1 - 2 \times q_{v,0}$$

In CMIP6 1% runs, pattern of $\Delta\theta_{e,98}$ strongly resembles pattern of $\Delta q_{v,98}$ – $r^2 > 0.9$, compared to $r^2 \sim 0.3$ for $\Delta\theta_{98}$

a) $\Delta\theta_{e,98}$ b) $\Delta\theta_{98}$ c) $L_v \Delta q_{v,98} / c_p$ d) $q_{v,98}$ years 1-10

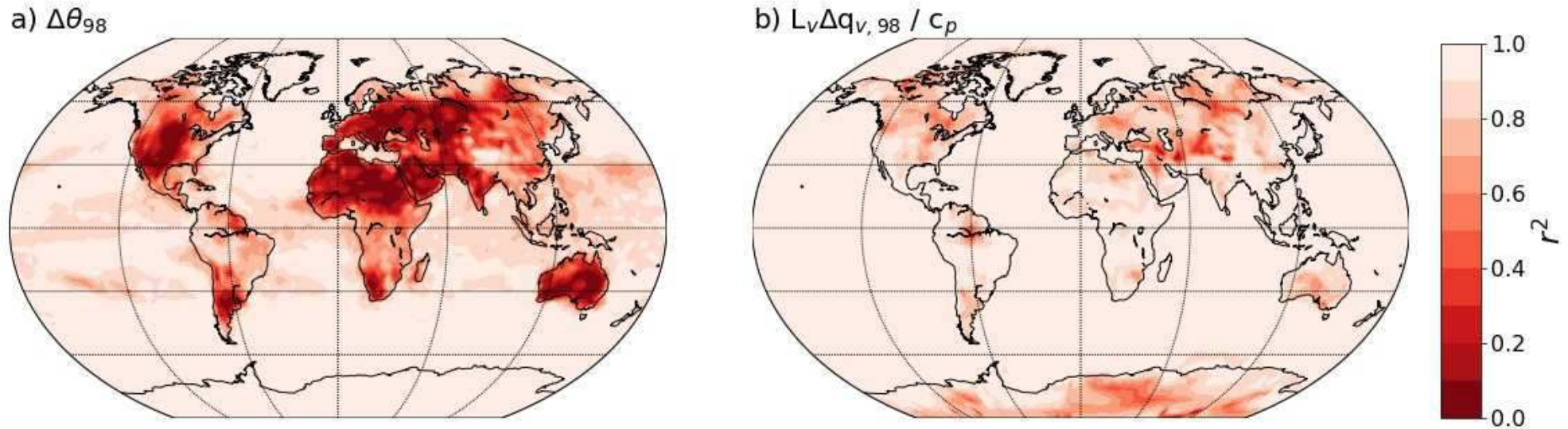
Matches theory, holds for seasonal changes, individual models, and when looking at changes in $\theta_{e,98} > 305K$



$$Q = \frac{L\Delta q_v}{c_p\Delta\theta}$$

$\Delta q_{v,98}$ also explains “uncertainty” (intermodel spread) in $\Delta\theta_{e,98}$ (also for seasonal changes)

Correlations across models with $\Delta\theta_{e,98}$:



SUMMARY: Because of rapid CC scaling + relative humidity changes, specific humidity changes vary from <0 to $>7\%^\circ\text{C}^{-1}$, whereas temperature increases by $(1/300 =) \sim 0.3\%^\circ\text{C}^{-1}$ → **specific humidity changes dominate heat stress changes**

(Can adjust for other heat stress metrics)



Valeriu Predoi

NCAS, Reading



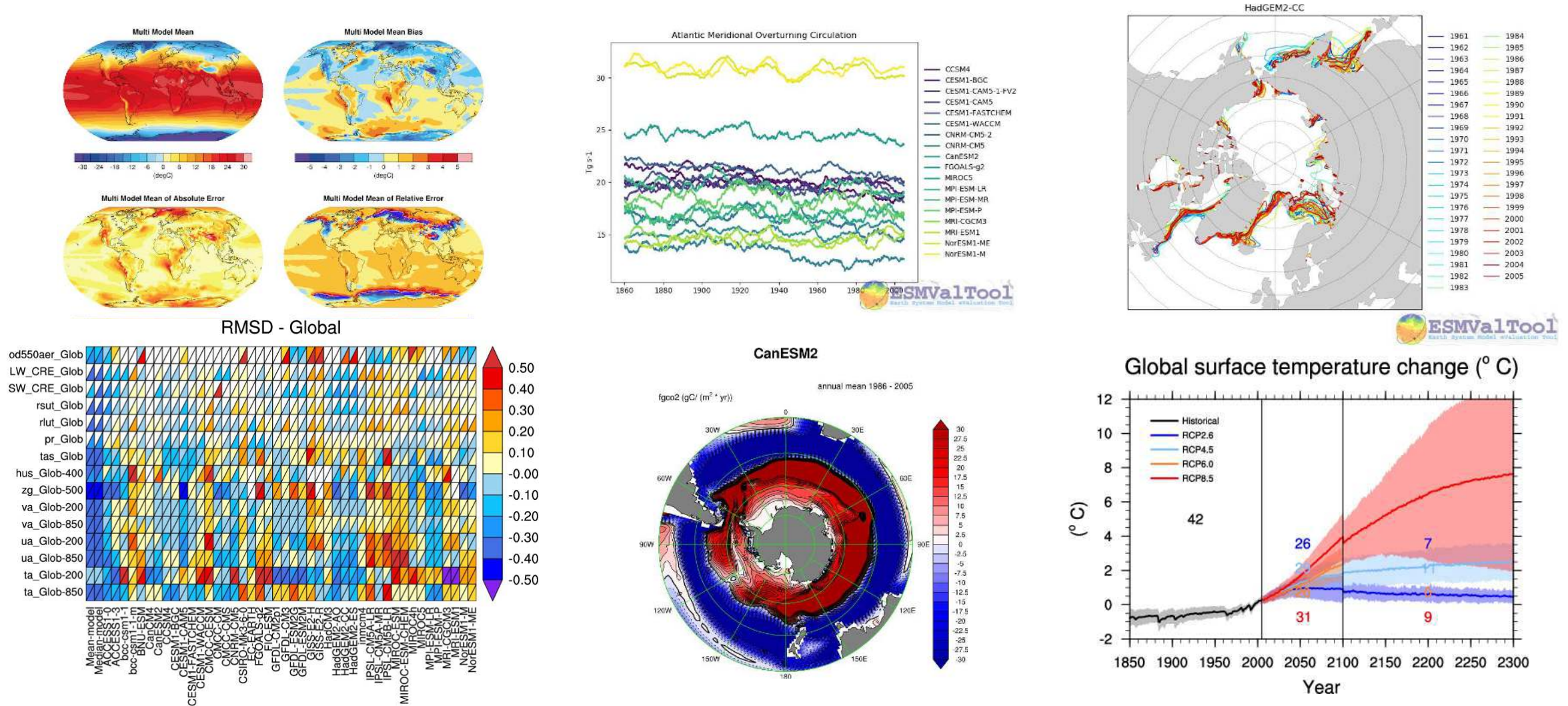
ESMValTool - A Community Driven Tool for Climate Model Evaluation and Analysis

Valeriu Predoi, Lee de Mora, Ranjini Swaminathan
(UKESM Core Group)

About ESMValTool

- **Earth System Model Evaluation Tool** - Coupled Model Intercomparison Project (CMIP) Evaluation
 - **Standardized** evaluation of model vs model, model vs obs, versions of same model
 - **Open Source**
 - Reproducibility and verification possible – important for science
 - Code on GitHub, conda-forge, PyPi
 - Support on GitHub – continuous integration, raising issues
- **Community Driven** (~40 participating institutions and > 70 CMIP models)
 - Powerful **preprocessor** functionalities – no need to repeat in code (pure Python)
 - **Diagnostics** – reuse or adapt and recycle diagnostics with well established analysis from peer reviewed literature (multiple languages)

Diagnostics



Source: <https://www.esmvaltool.org/gallery.html>

Using ESMValTool in the UK

- On CEDA's JASMIN server
 - Access to CEDA's ESGF node hosting CMIP/CORDEX archive
 - Access to large cache of CMOR-ized observational data sets
- Resources
 - Documentation <https://www.esmvaltool.org/docu.html>
 - GitHub Support <https://github.com/ESMValGroup/ESMValTool>
- Virtual ESMValTool Tutorials – will be announced on the mailing list
- Support: UK presence in the core development team, many diagnostic developers and loads of interest from the scientific community