The Climate in Climate Economics

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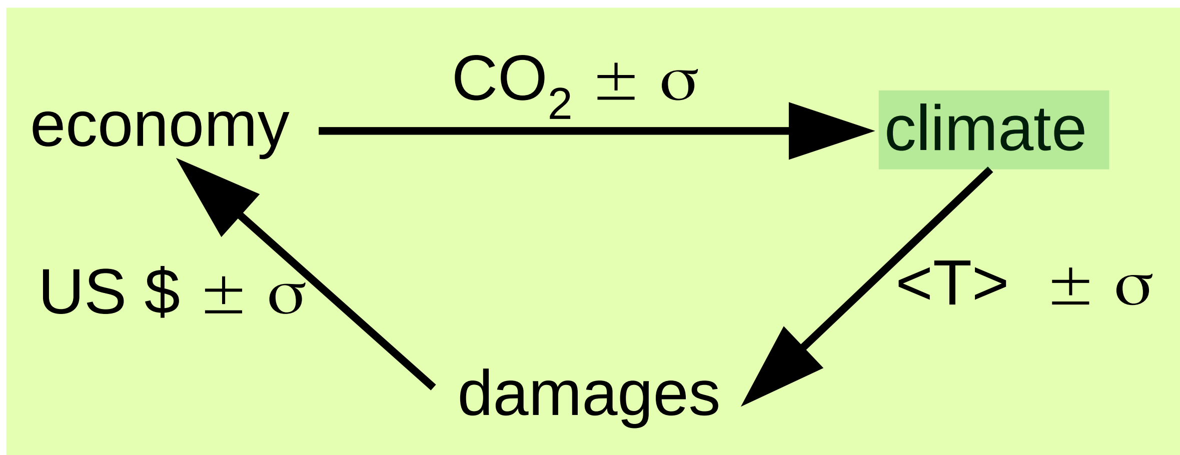
[Paper in preparation]



climate = cheap Climate Emulator (CE)

= ‘google translate’, ‘emissions → temperature change’

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Are Economists Getting Climate Dynamics Right and Does It Matter?

[Simon Dietz et al., J. of. Ass. of Env. and Res. Economists, 2021]

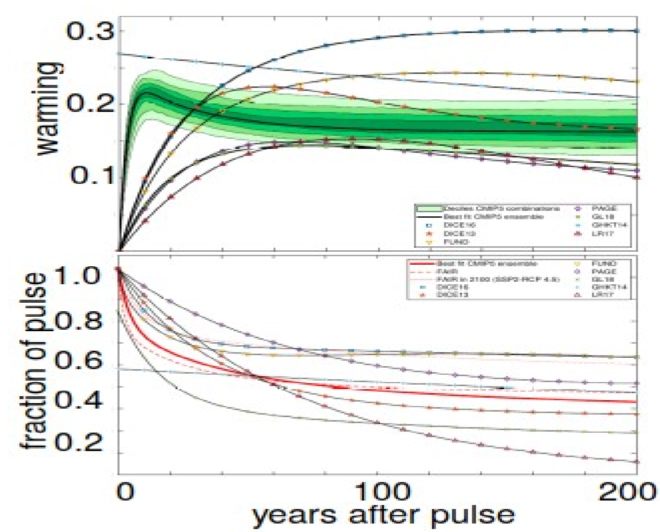
Their answers: **No, they don't.**
Yes, it does.
Conclude: CE too simple, especially carbon cycle.

We argue: even simple CE may do a proper job *if properly calibrated*

Our example: DICE-2016 and its re-calibrated variant, CDICE

Dietz et al. bench mark: decay of a 100 GtC puls to present day atmosphere

Dietz et al. find: too long delay from emission to warming; results in too low carbon prices and too high sensitivity to discount rate



Concrete example: CE in DICE

1) CO_2 emissions →

Atmosphere (AT)
Upper Ocean (UO)
Lower Ocean (LO)

→ CO_2 concentrations (atmosphere)

2) CO_2 concentrations → $F_t = F_{2XCO2} \dfrac{\log(M_t^{AT}/M_{EQ}^{AT})}{\log(2)} + F_t^{EX}$ → forcing

3) forcing →

Atmosphere + Upper Ocean (AT)
Lower Ocean (OC)

→ temperature T (global mean)

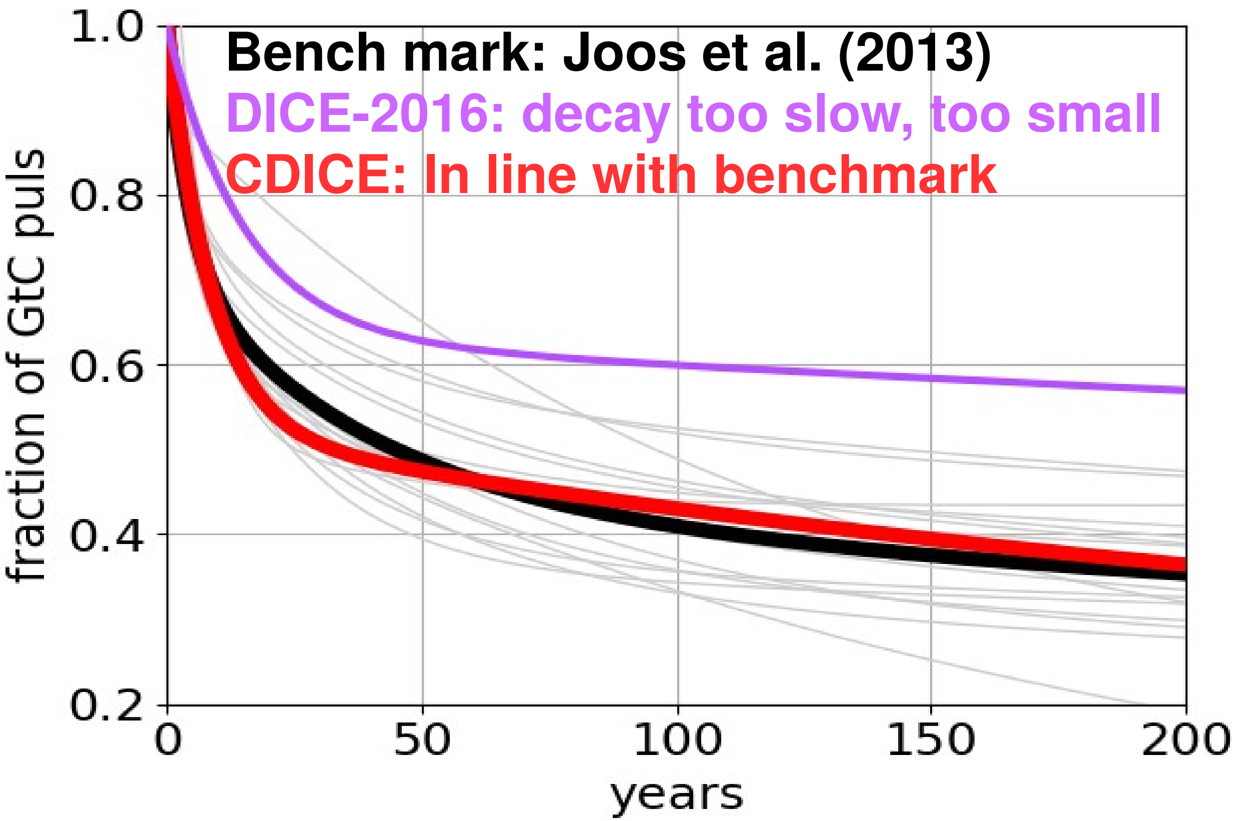
1) Carbon Cycle:	4 free parameters	→ calibration	[3x3 matrix]
2) Forcing:	1 free function (F^{EX})	→ choice	
3) Temperature:	4 free parameters	→ calibration	[2 ODEs]

Bottom Line: important to calibrate each element independently!

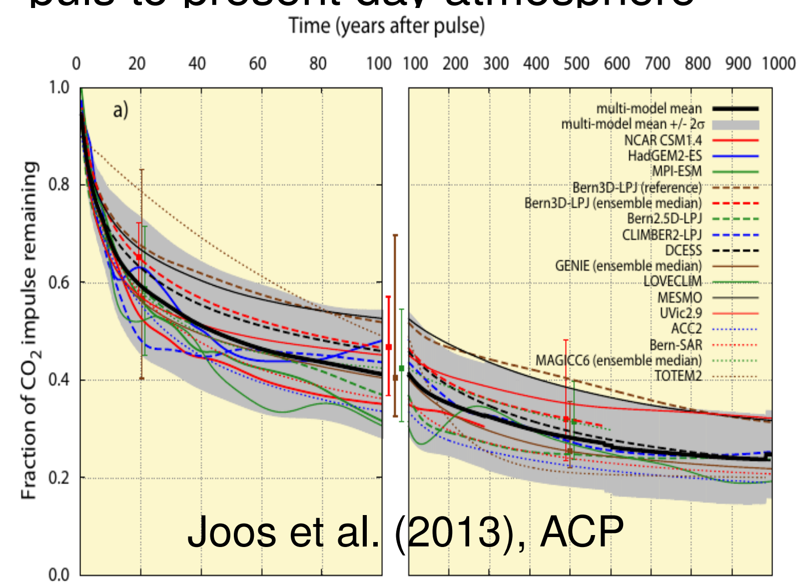
Calibrating the Carbon Cycle of the CE

Bench Mark: decay of 100 GtC pulse to present day atmosphere

Carbon Cycle: 4 free parameters → calibration



bench mark data: decay of 100 GtC puls to present day atmosphere



Calibrating temperature of CE

Bench Mark: instantaneous 4 x CO2 wrt 1850

Temperature: 4 free parameters → calibration

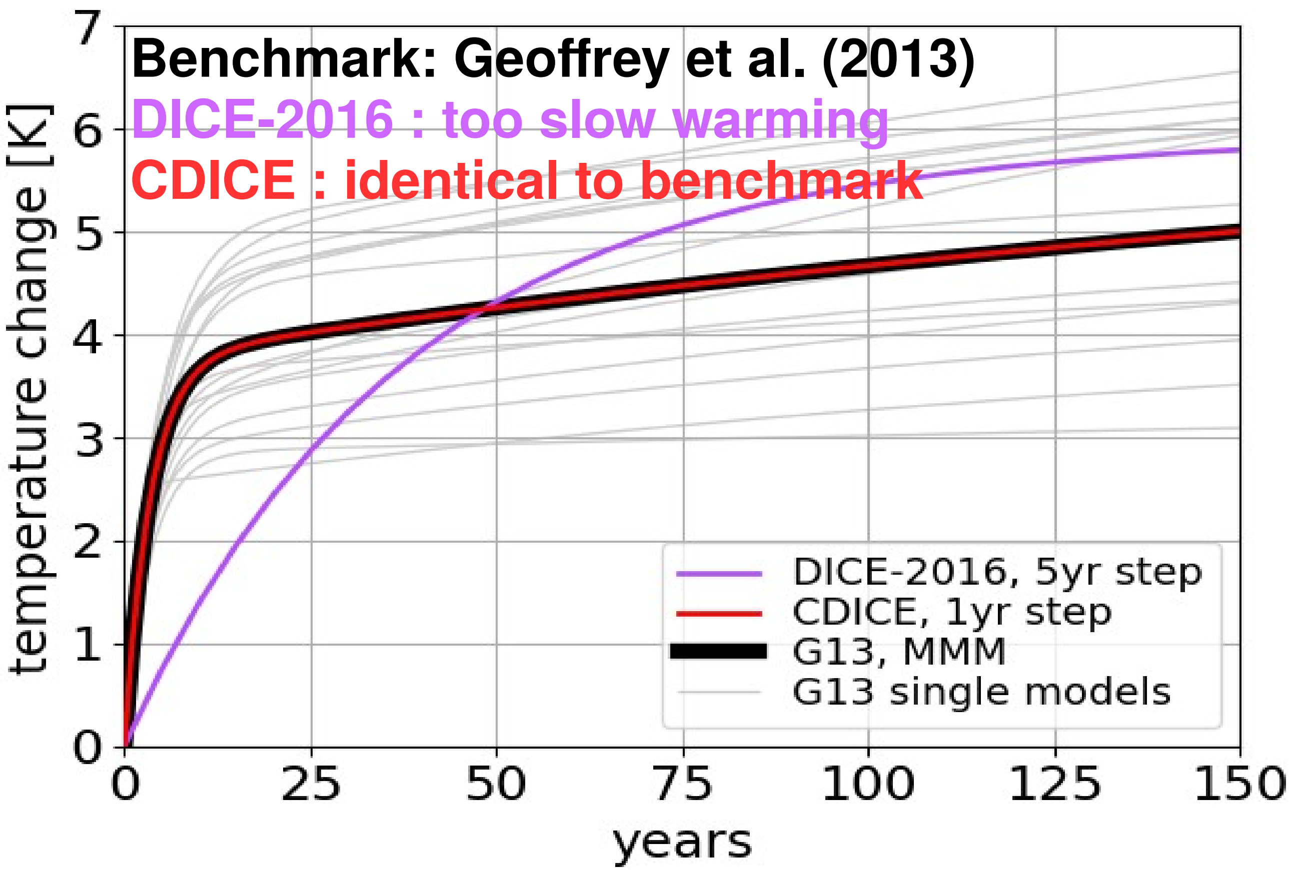
DICE & benchmark:
same functional form

$$T_{t+1}^{AT} = T_t^{AT} + \Delta_t \cdot c_1 \left(F_t - \lambda T_t^{AT} - c_3 \left(T_t^{AT} - T_t^{OC} \right) \right)$$

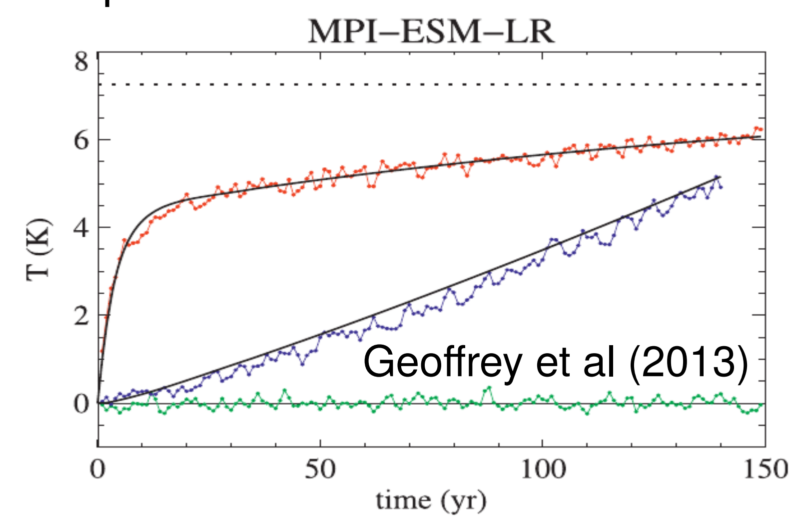
$$T_{t+1}^{OC} = T_t^{OC} + \Delta_t \cdot c_4 \left(T_t^{AT} - T_t^{OC} \right)$$

$$C \frac{dT}{dt} = \mathcal{F} - \lambda T - \gamma (T - T_0)$$

$$C_0 \frac{dT_0}{dt} = \gamma (T - T_0) .$$



bench mark data: temperature response to instantaneous 4 x CO2



Emerging property: Transient Climate Response

idealized test, temperature upon (strong) gradual 1% per year CO_2 increase

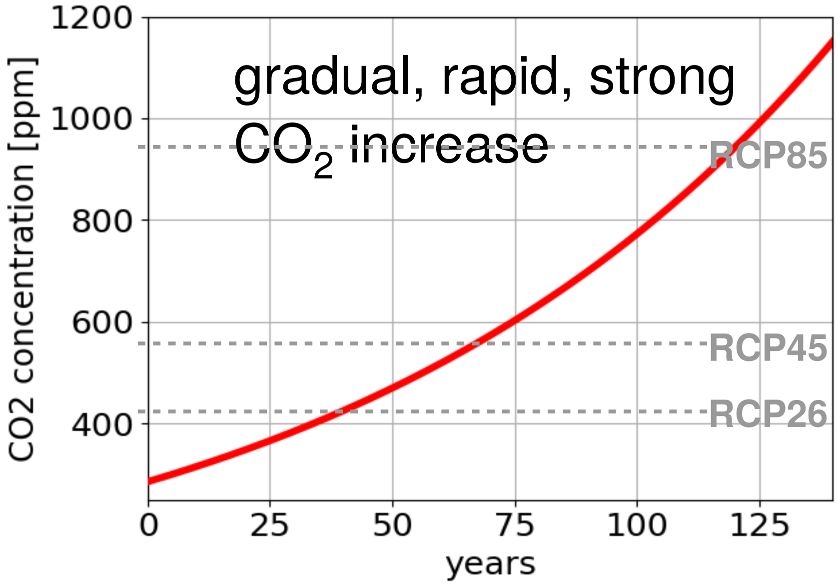
Benchmark: CMIP5

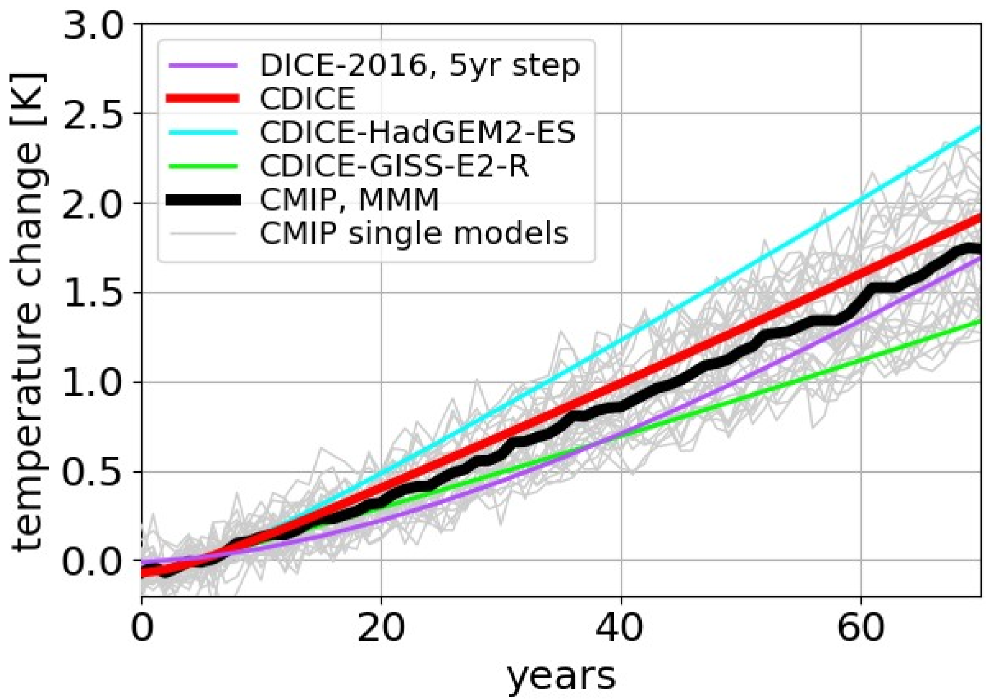
DICE-2016

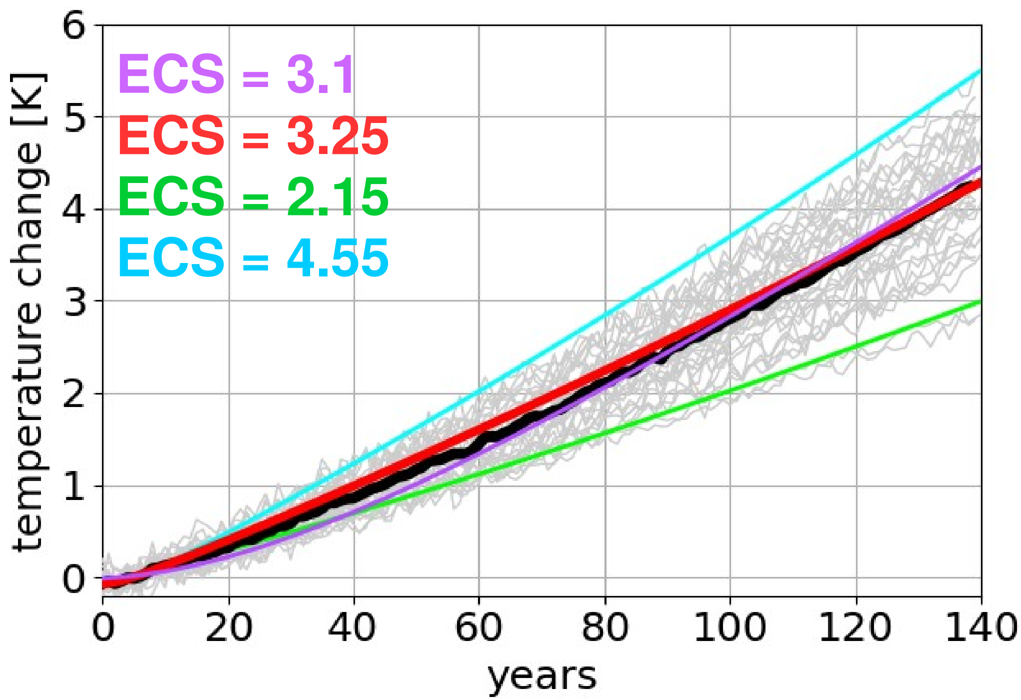
In line with CMIP5 [due to strong emissions]

CDICE

In line with CMIP5 [also for extreme ECS]







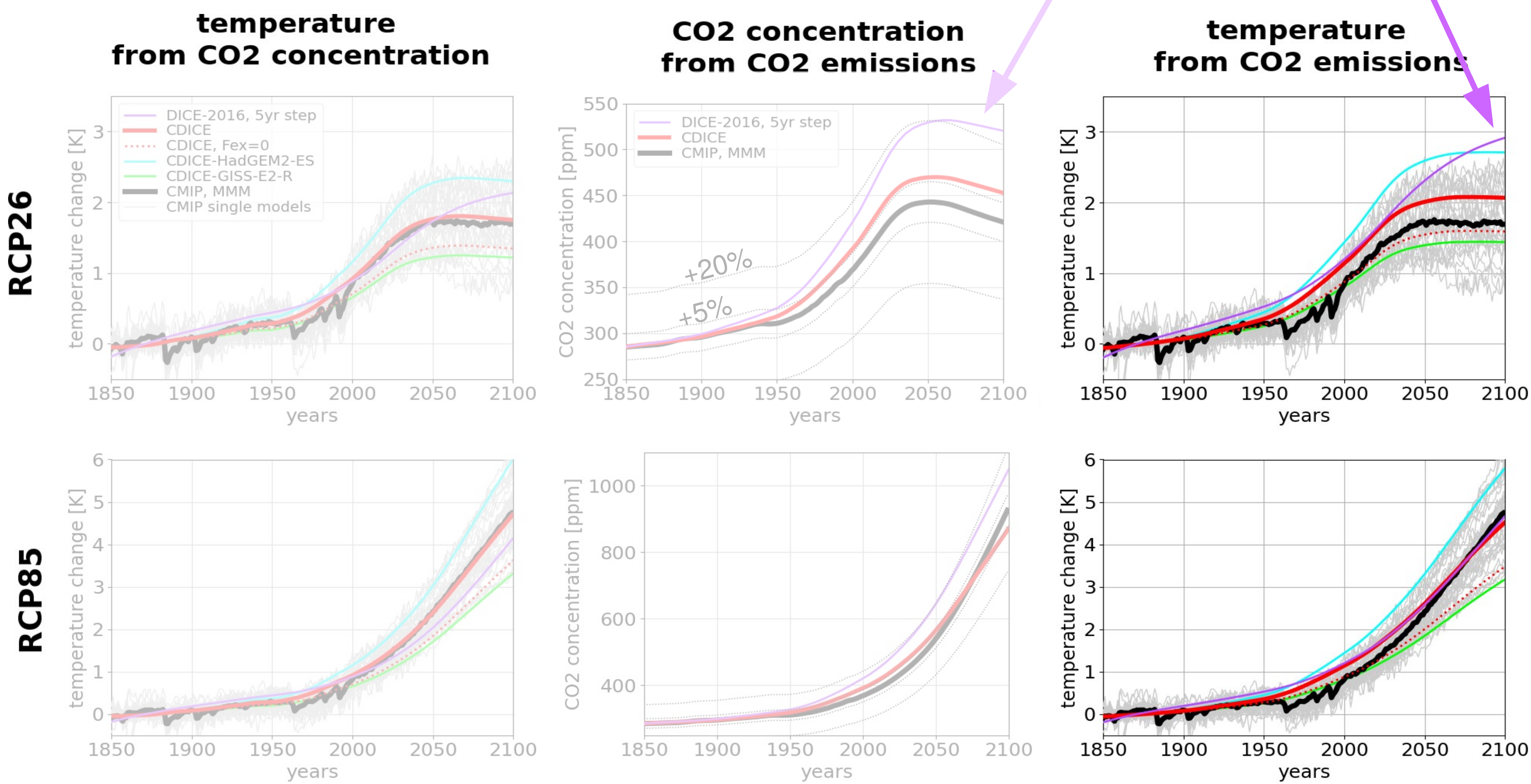
Emerging property: CMIP5 historical + RCP26 | RCP85

‘real world test’, examine performance of climate model & role of F^{EX}

Benchmark: CMIP5

DICE-2016: for RCP85 in line with CMIP5, for RCP26 too much CO_2 & too warm

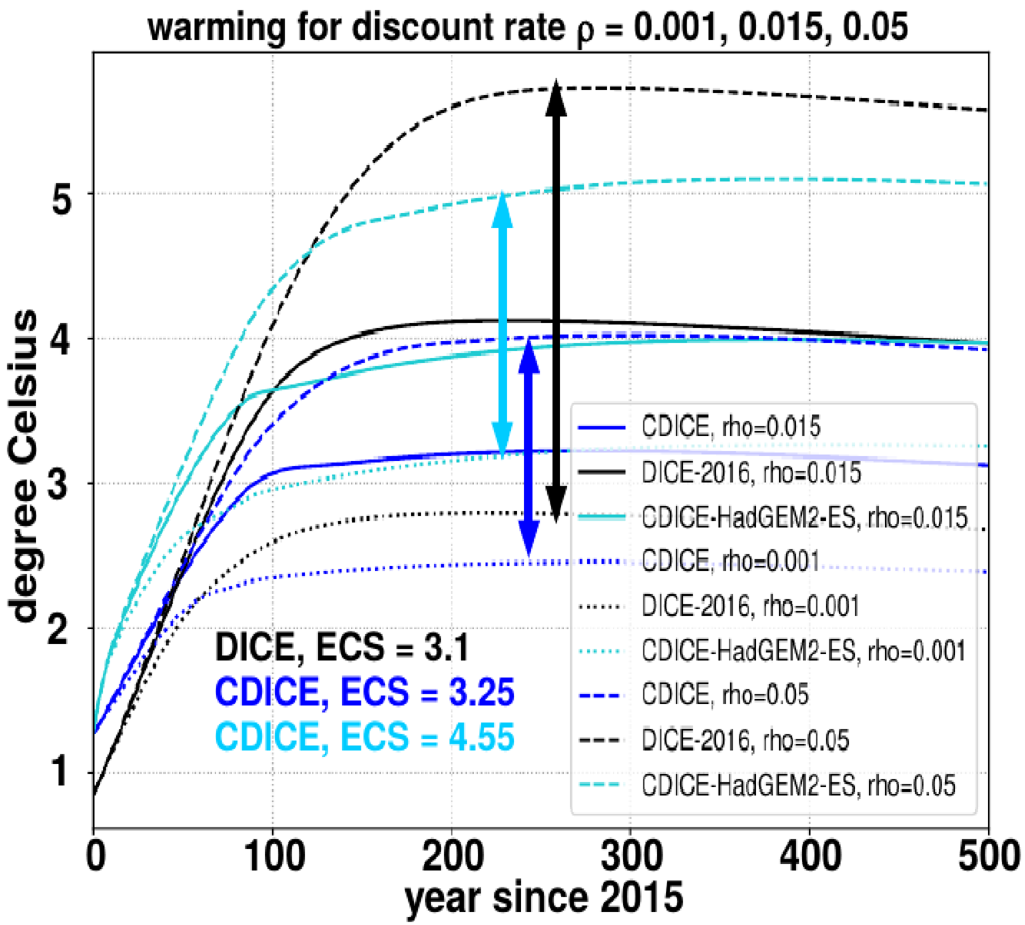
CDICE: in line with CMIP5

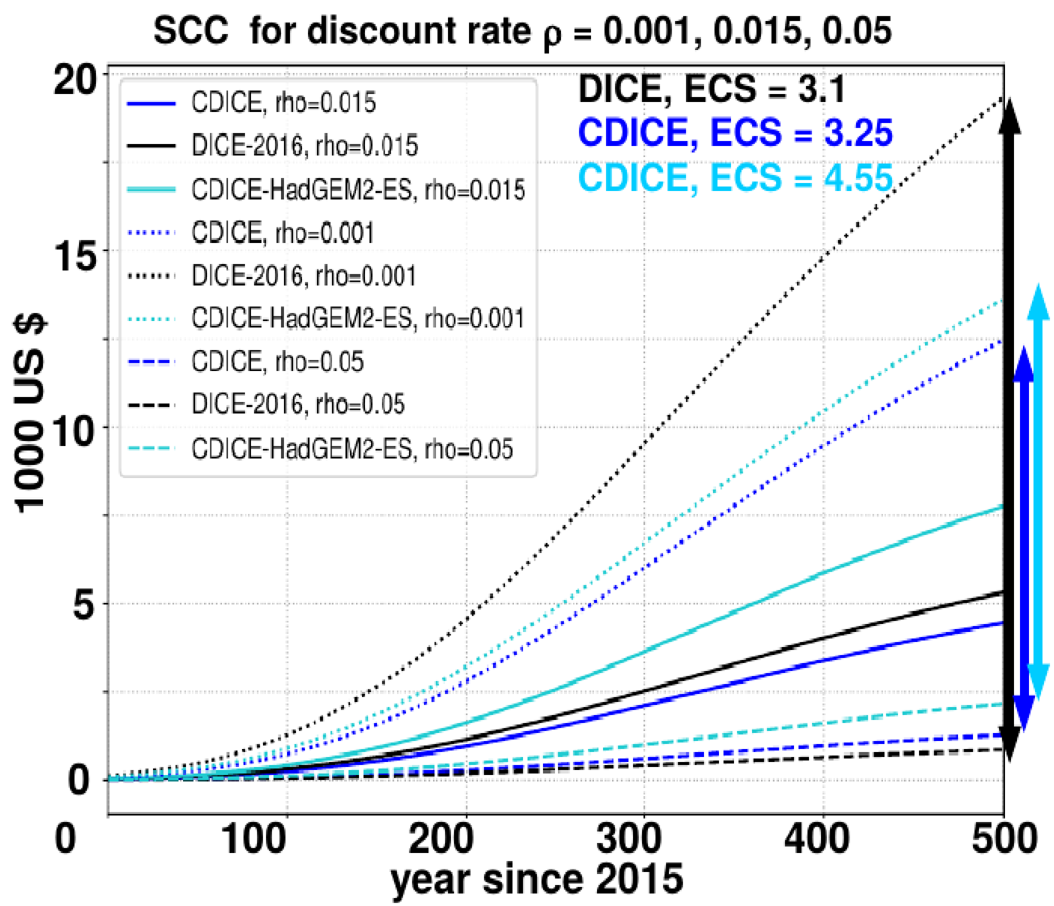


Impact on economy?

CDICE, the re-calibrated version of DICE-2016, shows

- **Reduced optimal warming**
- **Reduced sensitivity to discount rate**





Take home messages

Climate econ needs cheap CEs to model ‘emissions → temperature change’

CE must correctly cover each step – it matters for econon

[CO_2 emissions → CO_2 concentration → forcing → temperature change]

4 tests to calibrate & evaluate your CE: [easy to implement, public data only]

2 benchmarks [one for carbon cycle (CC), one for temperature]

1 idealized test [1% CO2 increase / yr, TCR]

1 ‘real world test’ [CMIP5, test CC + temperature + F^{EX}]

‘sane RCP85’ $\not\Rightarrow$ ‘sane optimal abatement’ or ‘sane CE’

Towards a CE 2.0: small & negative emissions, go regional (pattern scaling) extremes, tipping points, uncertainty, beyond temperature (e.g. ocean acidification)