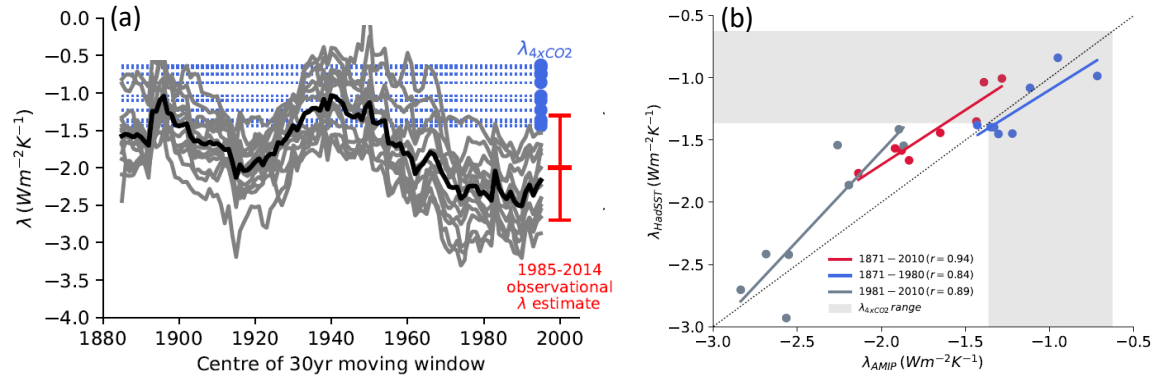


On the effect of historical SST patterns on radiative feedback

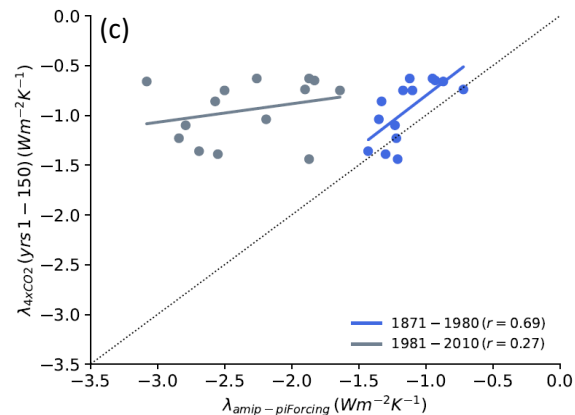
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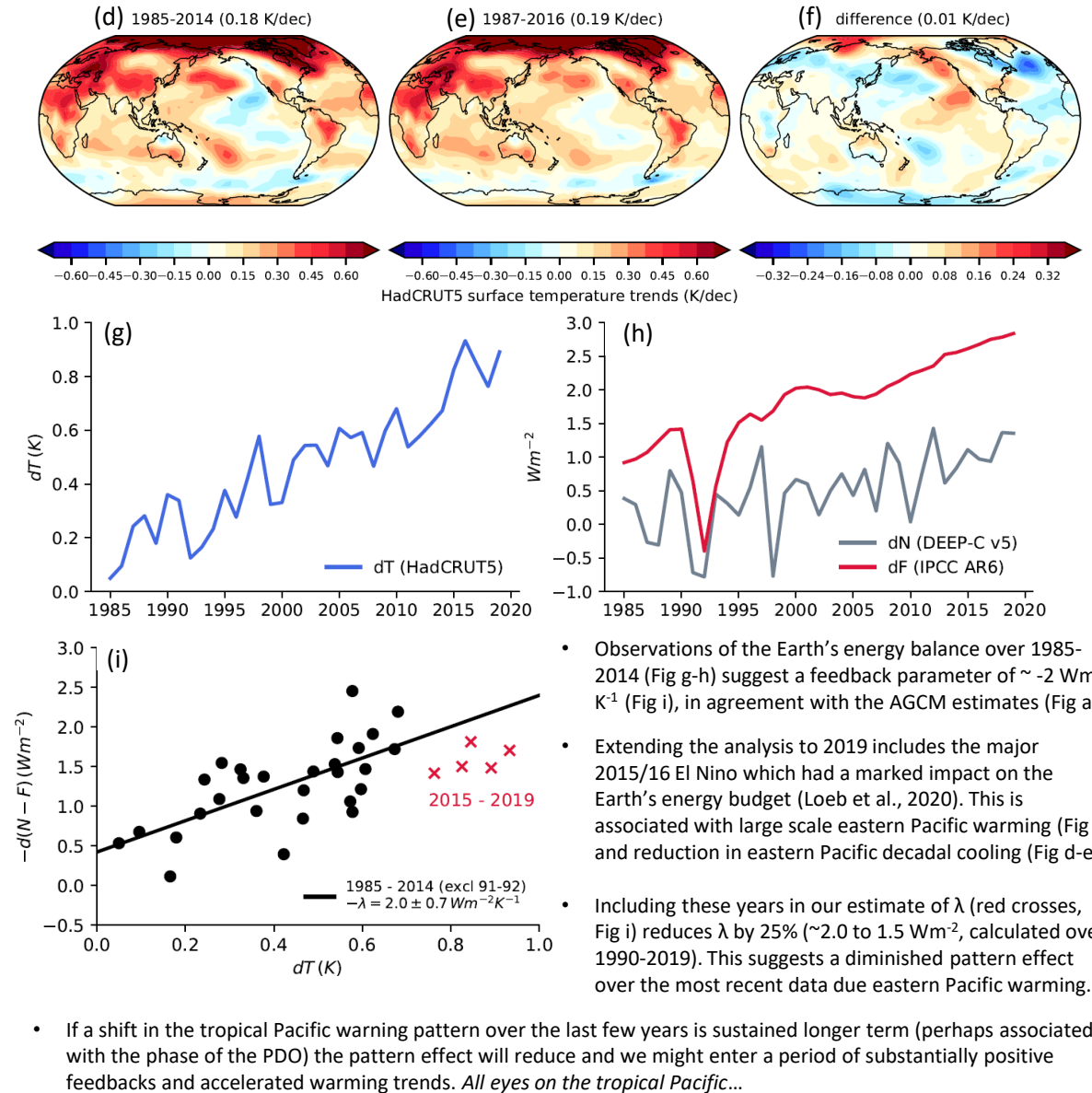
We define a pattern effect, $\Delta\lambda$, as the difference in radiative feedback over the historical period, λ_{hist} (in AGCM *amip-piForcing* simulations) and long-term ECS, $\lambda_{4\times\text{CO}_2}$ (in AOGCM *abrupt-4xCO2* simulation), so that $\Delta\lambda = \lambda_{4\times\text{CO}_2} - \lambda_{\text{hist}}$. We use 14 climate models from Andrews et al. (2018) and CFMIP3/CMIP6. We additionally repeat the simulations with 8 AGCMs using HadISST1 SSTs (rather than AMIP II) to test the sensitivity of $\Delta\lambda$ and λ_{hist} to underlying SST dataset. Finally we show the models are in agreement with the Earth's observed energy budget over recent decades.



- Despite the larger climate sensitivities of CMIP6 models, the key features identified in previous studies relating to the pattern effect are still robust (Fig a).
- λ_{hist} under AMIP II and HadISST1 SSTs are extremely well correlated (Fig b). For the historical record as a whole (1871-2010) they are simply related by an offset of $\sim 0.2 \text{ Wm}^{-2} \text{ K}^{-1}$ (Fig b, red dots). For 1871-1980, the pattern effect is small & independent of the SST dataset (somewhat by construction) (Fig b, blue). From 1980 onwards, λ_{hist} becomes strong (pattern effect large) and is slightly weaker in magnitude under HadISST1 SSTs (Fig b, grey).



- λ_{hist} from recent decadal climate change (1981-2010) is uncorrelated with $\lambda_{4\times\text{CO}_2}$ (Fig c, grey). This is unfortunate because the most recent decades are well observed and 'avoids' aerosol issue, so ought to have been desirable for constraining feedbacks and ECS. Yet here we show it is the worse period.
- λ_{hist} from earlier (1871-2010) climate change is correlated with $\lambda_{4\times\text{CO}_2}$ (Fig c, blue). This is also unfortunate because this period has poorer observational constraints and less signal, making it less desirable for constraining ECS.



- Observations of the Earth's energy balance over 1985-2014 (Fig g-h) suggest a feedback parameter of $\sim -2 \text{ Wm}^{-2} \text{ K}^{-1}$ (Fig i), in agreement with the AGCM estimates (Fig a).
- Extending the analysis to 2019 includes the major 2015/16 El Nino which had a marked impact on the Earth's energy budget (Loeb et al., 2020). This is associated with large scale eastern Pacific warming (Fig f) and reduction in eastern Pacific decadal cooling (Fig d-e).
- Including these years in our estimate of λ (red crosses, Fig i) reduces λ by 25% (~ 2.0 to 1.5 Wm^{-2} , calculated over 1990-2019). This suggests a diminished pattern effect over the most recent data due eastern Pacific warming.
- If a shift in the tropical Pacific warming pattern over the last few years is sustained longer term (perhaps associated with the phase of the PDO) the pattern effect will reduce and we might enter a period of substantially positive feedbacks and accelerated warming trends. *All eyes on the tropical Pacific...*