Tracing the upper ocean’s ‘missing heat’

Caroline Katsman
Geert Jan van Oldenborgh

- Introduction
- Observations, model
- Natural variability
- Radiation effects
- Deep ocean
- Conclusions

Katsman, Caroline and G. J. van Oldenborgh, *Tracing the upper ocean’s ‘missing heat’*, GRL, accepted.
Observed and modelled UOHC (0-700m)

Model 17 runs 1950–2100 with ECHAM5/MPI-OM, 20c3m+sresa1b, no volcanoes
Observed and modelled PDFs of 8-yr trends

1990–2020: 3% of overlapping 8-yr trends are negative, so 57% chance of at least one negative in 31 years
Where did the heat go?

We’re missing $\mathcal{O}(2 \times 10^{22})$ J. What would have happened if it were put it in the

- upper ocean: 0.02 K temperature rise: not observed
- Atmosphere: 5 K temperature rise: not observed
- lithosphere: 1.2 K temperature rise: not observed
- cryosphere: 7.5 K temperature rise: not observed
- land ice: 2 cm sea level rise: not observed
- sea ice: melted all sea ice: not observed
- radiated to space: 0.2 W/m²: smaller than accuracy
- deep ocean: no observations
Radiation to space

(a) 8-yr mean net outgoing TOA vs. 8-yr trend in UOHC

slope = -0.45

(b) Regression of 8-yr TOA radiation on 8-yr UOHC trends
- Short-wave
- Long-wave

(c) Regression of 8-yr TOA total radiation on 8-yr global UOHC trends

(d) Regression of 8-yr UOHC trends on 8-yr mean Nino3.4
Heat transfer to the deeper ocean

(a) Slope = -0.35

(b) Correlation of 8-yr DOHC trends with 8-yr AMOC trend

(c) Regr local HC 1000-1500m on global HC 0-300m 1990-2020

(d) Correlation of 8-yr DOHC trends with 8-yr AMOC trend
Conclusions

- An 8-yr period without rise in UOHC is well within natural variability.
- In our model, on average 45% of the ‘missing heat’ is radiated to space, 35% into the deep ocean.
- The radiation is largely due to decadal ENSO (with lag).
- The deep ocean heating is partly due to AMOC variability (with lag).
- Recent behaviour of ENSO and deep convection support this hypothesis and point to an upcoming resumption of rise of UOHC.