DIAGNOSING GLOBAL OCEAN WARMING FROM THE UPPER LAYERS TO THE ABYSS

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We examine 3 distinct layers, determined by available observations: upper (0-700m), intermediate (700–2000m) and abyssal (2000m-bottom)

Objectives

• Evaluate the consistency between CMIP5 models and observations

• Compare the observed warming to modeled-based estimates of multi-decadal variability
Global OHC (1860-2014)
CMIP5 Historical MMM and observational estimates

0-700m
Substantial cooling after Krakatoa, Agung

Warming rate faster after Agung

MMM warming rate appears faster than observed during hiatus period when including RCP8.5 (2005-2014)

Models: OHC(t) – OHC(t=1861), Obs:OHC(t) – OHC(t=1971)
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![Graph](image)

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**2000m-bottom**
- Heat uptake comparable to intermediate
- Abyssal MMM appears consistent with weakly constrained estimates
Individual Models: OHC changes during observational period

- Large spread in simulated upper & intermediate heat uptake
- Not all models warming too quickly during hiatus period
- Abyssal warming in all models, but some are cooling in intermediate layer

Upper (0-700m)
Intermediate (700-2000m)
Abyssal (2000m-bottom)
CMIP5 MMM Global OHC S/N as a Function of Timescale

Based on global integrals – no pattern (fingerprint) information

Variability amplitude decreases (with increasing time scale) more gradually in intermediate and abyssal layers

Both the 0-700m and 700-2000m warming appears significantly different from model-based variability estimates
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Summary

- Simulated global ocean heat uptake is sensitive external forcings, intrinsic variability and model formulation.

- CMIP5 simulations are broadly consistent with weakly constrained observations of intermediate and deep ocean heat uptake.

- Limited evidence suggests that warming at intermediate depths (≈700-2000m) is distinguishable from model-based estimates of multi-decadal scale variability.

- Despite poor observational coverage, formal fingerprinting analysis for the intermediate layer (700-2000m) may be feasible.