**Rethinking Climate Attribution: Plurality, Pulses, and the Case for Open Hypothesis Space**

**Abstract**

The prevailing paradigm holds that anthropogenic greenhouse gas (GHG) emissions account for essentially 100% of observed global warming since 1850. While this framing has policy utility, it risks prematurely collapsing the hypothesis space and filtering out alternative contributors. Recent anomalies, notably the 2023–2024 oceanic heat pulses, expose weaknesses in the assumption of gradual, atmosphere-led warming. This paper argues for a plurality-based approach: anthropogenic forcing is a material driver of recent warming, but bottom-up geophysical fluxes, deep-ocean dynamics, and solar–cloud coupling remain underexplored. Sound climate science and policy require that such alternatives remain live hypotheses, subject to severe tests, not dismissed as denial.

**1. Introduction**

The Intergovernmental Panel on Climate Change (IPCC) Sixth Assessment Report concludes with high confidence that human activity is the *principal* driver of observed warming since 1850, attributing ~1.07 °C of the 1.06 °C rise to anthropogenic causes [IPCC AR6, 2021]. This near-total attribution has become codified as “settled science.” Yet, when scientific frameworks cease to tolerate uncomfortable anomalies, they risk narrative overreach [Funtowicz & Ravetz, 1993; The Ethical Skeptic, 2023].

**2. Energy Balance and the Closure Test**

The fundamental accounting test is whether **top-of-atmosphere (TOA) energy imbalance (EEI)** and **full-depth ocean heat content (OHC)** close. On decadal scales, CERES satellite fluxes (~0.5–1.0 W m⁻²) align with observed OHC changes (~0.4–1.0 W m⁻²) [Loeb et al., 2021; von Schuckmann et al., 2023]. However, during 2023 the BAMS report noted an annual mean EEI of ~1.9 W m⁻² [Christensen et al., 2024], while OHC increments were ~12–23 ZJ (≈0.6–1.2 W m⁻²), leaving a gap of 0.5–1.1 W m⁻². Whether this mismatch reflects deep-ocean undersampling, satellite calibration drift, or unmeasured bottom-up fluxes remains unresolved.

**3. Anomalous Pulses: The 2023 Case**

In spring 2023, global SST rose sharply, preceding atmospheric warming by weeks [NOAA, 2023]. The North Atlantic marine heatwave exceeded prior records by >0.5 °C, accounting for nearly half of SST gains since 1995 in just weeks (Jones, 2023). This temporal order challenges the conventional atmosphere→ocean causal chain. Given the atmosphere’s heat capacity is equivalent to ~3 m of ocean water, such abrupt pulses are difficult to reconcile as air-driven. ENSO transition and aerosol reductions may contribute, but the magnitude and timing suggest internal or bottom-up release cannot be excluded [Hu et al., 2020; Peng et al., 2022].

**4. Deep and Abyssal Fingerprints**

Core Argo floats measure only to 2000 m, leaving the deep (>2000 m) and abyssal (>4000 m) oceans sparsely observed. Hydrographic repeats and early Deep Argo floats confirm warming at great pressures (4300–5900 m), with global deep uptake ~30–40 TW [Purkey & Johnson, 2010; Desbruyères et al., 2016]. Although small in absolute terms, a **change (∆T)** in geothermal flux — even +1 W m⁻² locally across <0.2% of the seafloor — could equal the planetary imbalance. Local hot spot fluxes of 10³–10⁴ W m⁻² at ridge systems [Baker et al., 1996] imply that small areal changes in activity could contribute significantly if synchronized.

**5. Plurality and Risk Ethics**

Overstating human dominance risks legitimizing intrusive control measures under the banner of “climate emergency.” Understating it fuels apathy and environmental neglect. Both collapse complexity into political slogans. The prudent stance is plurality: humans are *material contributors*, but natural Earth–Sun–ocean–geothermal processes remain immense. Policy grounded in resilience and stewardship avoids the extremes of punitive control or reckless disregard [The Ethical Skeptic, 2020].

**6. Conclusion**

The 2023–2024 ocean heat anomalies serve as a falsification probe. If repeated pulses continue to break closure between EEI and OHC, or if abyssal warming is shown to dominate increments, the null (anthropogenic-only) attribution will fail. Until then, plurality is the responsible epistemic stance. Science advances not by declaring premature singularity, but by keeping uncomfortable hypotheses live.

**References**

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