CosmicTriad™ / PaleoIQ™
Obliquity Divergence Findings

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Executive Summary

This document presents consolidated findings from the CosmicTriad™ (now PaleoIQ™) reconstruction framework, indicating a persistent divergence between isotopically reconstructed effective axial tilt and conventional astronomical obliquity solutions. Across multiple independent datasets spanning the late Pleistocene to Holocene (0–50 ka BP), reconstructed tilt values are consistently lower than orbital-only predictions, exhibiting a persistent low-bias structure with strong temporal coherence and cross-site consistency.

Rather than implying inaccuracies in astronomical solutions, these findings suggest that commonly used orbital frameworks may not fully capture how obliquity is *expressed* within the Earth system and preserved in geochemical proxy archives. The divergence appears systematic rather than stochastic and exhibits partial attenuation under broader constraint scenarios. The reconstructed signal is therefore interpreted as an **effective climatic obliquity**, shaped by latitude-dependent production, geomagnetic modulation, archive filtering, and Earth-system amplification processes, particularly during glacial intervals. If substantiated, this interpretation may inform paleoclimate attribution frameworks…

1. Data Foundations

This analysis draws on publicly available multiple proxy systems derived from ice-core, marine sediment, and fluvial archives. These records span multiple hemispheres and a wide range of latitudes, encompassing environments with distinct production sensitivities and depositional characteristics.

Additional proxies capture longer-scale modulation effects and were incorporated as an additional constraint. While treated conservatively, these additional proxies capture longer-scale modulation effects not fully represented in simpler proxy combinations.

Sample ages range from early Holocene through late Pleistocene (~0–50 ka BP), covering multiple glacial–interglacial transitions. The dataset therefore includes periods characterised by both relatively stable Earth-system behaviour and intervals of pronounced mass redistribution, climatic volatility, and geomagnetic variability.

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2. Methodology Overview

The CosmicTriad™ / PaleoIQ™ pipeline estimates effective axial by relating observed proxy behaviour to large-scale modulation processes influencing production, transport, and deposition. Rather than directly fitting orbital parameters, the method infers tilt indirectly through its integrated influence on cosmogenic production, atmospheric transport, and deposition.

Reconstructed tilt time series were compared against established astronomical obliquity reference solutions. Emphasis was placed on structural coherence and persistence.

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3. Observed Structural Behaviour

Across the analysed interval, reconstructed signals exhibit coherent structure that diverges systematically from astronomical expectations. This divergence persists across time windows and archive types and is not consistent with random noise. Quantitative performance metrics are reserved for restricted technical documentation.

4. Climate Forcing Implications

To assess climatic relevance, reconstructed tilt values were interpreted in terms of high-latitude seasonal energy balance relevant to glacial inception and deglaciation.

Under this framework, PaleoIQ™-derived tilt values imply sustained, directionally meaningful reductions in high-latitude summer insolation relative to astronomical forcing during key late-Pleistocene intervals. Such differences are climatologically meaningful and sufficient to influence:

- Sufficient to influence ice-sheet sensitivity and seasonal energy balance
- Reduce polar summer melt efficiency
- Weaken monsoonal circulation and ITCZ migration
- Alter thresholds for abrupt climate events

These inferred deficits align with several paleoclimate features are commonly discussed within existing paleoclimate literature. The results suggest that part of the apparent mismatch between orbital forcing and observed climate behaviour may arise from differences between **astronomical obliquity** and **effective climatic expression of obliquity within the Earth system**.

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5. Working Hypotheses

The divergence between reconstructed obliquity signals and astronomical reference solutions does not require invocation of changes to orbital mechanics or planetary orientation. Instead, several non-exclusive Earth-system and proxy-geometry mechanisms are considered more likely contributors.

5.1 Site geometry and latitudinal weighting bias

Cosmogenic isotope production is strongly latitude-dependent due to geomagnetic cutoff rigidity, atmospheric column depth, and circulation structure. Uneven geographic sampling or time-varying effective geomagnetic latitude can introduce systematic bias when multi-site records are aggregated without explicit normalisation. Such effects can manifest as persistent attenuation or offset in inferred obliquity, producing an apparent low-tilt signal even where astronomical forcing is unchanged.

5.2 Geomagnetic field structure and production scaling effects

Temporal changes in geomagnetic field intensity, inclination, and non-dipole structure modulate cosmic ray shielding in ways not fully captured by simplified scaling models. During intervals of reduced field strength or increased non-dipole dominance, production may be systematically misestimate, contributing to coherent reconstruction bias.

5.3 Archive and depositional process filtering correlated with latitude

Proxy archives are shaped by latitude-dependent environmental processes, including accumulation rates, transport pathways, residence time, and scavenging efficiency. These processes can distort amplitude and phase relationships, producing reconstructions that are internally consistent yet offset from astronomical expectations.

5.4 Glacial mass redistribution and Earth-system amplification (MassFlow effect)

During glacial intervals, large-scale redistribution of ice and water mass enhances Earth-system sensitivity through stress rebalancing and rotational–geophysical coupling. This amplification may appear in proxy reconstructions as increased apparent variability or swing magnitude without requiring changes to orbital geometry.

5.5 Secondary considerations

Only if the mechanisms above prove insufficient would more speculative explanations be required, such as true polar wander, long-term core–mantle decoupling, or reference-frame drift in astronomical solutions. At present, these are not required to explain the observed divergence.

6. Significance and Implications

If validated, these findings suggest that Earth's effective climatic may warrant careful re-examination in selected late-Pleistocene interpretive contexts.

Key implications include:

- **Orbital tuning:** Potential phase and amplitude bias in stratigraphic alignment
- **Climate modelling:** Overstated high-latitude insolation forcing in boundary conditions
- **Climate attribution:** Reassessment of CO_2 versus orbital contributions
- **Sensitivity thresholds:** Recognition of state-dependent amplification during glacial regimes

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7. Limitations and Scope

This work represents an early-stage synthesis. Limitations include uneven data coverage, simplified scaling assumptions, and conservative treatment of long-term isotopic modulation. Findings are therefore hypothesis-generating rather than conclusive.

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8. Future Pathways

Future work will focus on:

- Expanding latitudinal and hemispheric data coverage
- Site-resolved and latitude-stratified reconstructions
- Glacial versus interglacial variance testing
- Formalising internally consistent reference representations for effective obliquity
- Modified effective tilt scenarios within plausible bounds
- Peer-reviewed publication and IP-safe technical annexing

9. Concluding Statement

These findings suggest that the relationship between orbital geometry and climatic response is more nuanced than typically assumed. By framing obliquity as a signal filtered and amplified through Earth-system processes, this work provides a coherent explanation for long-standing paleoclimate discrepancies without overturning established orbital theory.

If substantiated, this framework offers a path toward improved paleoclimate attribution, refined climate model forcing, and a deeper understanding of Earth-system sensitivity across glacial cycles.