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The Effect of Obliquity on Stratospheric Humidity and Implications for Atmospheric Evolution

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Oxygen is widely considered to be a reliable biosignature in the search for life elsewhere [1]. However, several mechanisms create abiotic oxygen, or oxygen from non-biogenic sources. These mechanisms must be thoroughly characterized to rule out false positive identifications of life in the future. Previous experiments from 1-D planetary evolution models have predicted significant abiotic oxygen accumulation resulting from a variety of initial volatile inventories, but the production of abiotic oxygen from atmospheric water loss after the magma-ocean phase did not consider the effect of planetary obliquity [2]. 3-D Global Climate Models (GCMs) have shown that stratospheric humidity increases on planets with higher degrees of obliquity through enhanced seasonality, which should result in significant levels of atmospheric water loss [3]. However, the minimum obliquity necessary to trigger significant stratospheric humidity accumulation and subsequent water loss has not been studied.

We address this unknown obliquity parameter by using the ExoCAM GCM to quantify stratospheric humidity for a range of obliquity, insolation, and CO_2 levels. We then develop a parameterization for the 3-D stratospheric humidity concentration that can be used in long-term 1-D planetary evolution models to study the effect of higher degrees of obliquity on atmospheric water loss. Finally, we will discuss the consequences of these results in the context of abiotic oxygen production and exoplanet life detection.

References

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