Biosignatures in context

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Abstract

Biological activity has changed the Earth environment on a global scale. One metabolism - oxygenic photosynthesis - is responsible for changing the face of the Earth by converting 0.1% of the solar flux received at the surface into chemical energy. Most of the biosphere depends on this primary production of organic matter. Alternative primary biological production by chemo-autotrophic life relying on the internal heat flux has a negligible impact on the global geochemical cycles.
Considering life as we know it, global-scale biosignatures are thus expected to be linked with the possibility for life to use starlight. As a consequence, the surface liquid water "Habitable Zone" - while narrower than the region where life can exist - corresponds to the region where remote spatially-unresolved characterization could reveal signs of biological activity.
Knowing where to search does not, however, mean that we know what to look for. The most general way to search for signs of life may be to search for a strong thermodynamical disequilibrium in the atmosphere, which cannot be maintained by non-biological processes only. This being said, measuring this disequilibrium requires the knowledge of the elemental atmospheric composition, pressure and temperature. Detecting, or even measuring the amount of one or a few atmospheric species is in general insufficient to quantify this disequilibrium. Therefore, we emphasize that a detailed characterization of a planetary environment must precede any attempt to identify biosignatures. The fact that spectral features are known to be of biological origin on Earth (e.g. O3/O2 bands) should not interfere with the choice of future instruments for characterizing exoplanets. An in-depth exploration of the existing diversity of planetary environments/atmospheres should be seen as a prerequisite for the search for biosignatures.

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