Constraints on Ocean Heat Uptake from the Atmospheric Argon to Nitrogen Ratio

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Over 90% of all additional heat trapped on Earth by atmospheric greenhouse gases will eventually accumulate in the ocean. However, due to temporally and spatially sparse sampling of the oceans, our best estimates of ongoing ocean warming vary considerably. Here, we present a recently developed, globally integrated approach to quantifying ocean heat uptake through observations of the atmospheric argon to nitrogen ratio (Ar/N_2).

Water temperature determines the solubility of the chemically inert noble gas Ar and N_2 in the oceans. A warming ocean releases proportionally more Ar than N_2 to the atmosphere (Ar is twice as soluble as N_2), where the gases are rapidly mixed on a time-scale of about one year. Atmospheric mixing thus intrinsically integrates the ocean warming signal globally and makes discrete local observations a powerful measure of global ocean heat uptake.

Ultra-high precision Ar/N_2 data collected continuously at five stations in the Scripps CO_2 flask network, consistently suggest stronger ocean warming over the last 15 years than other observational estimates based on *in situ* temperature readings. Moreover, previously published observations of stratospheric trace gases ratios including Ar/N_2 show a significant gravitational fractionation well below the mesosphere. Therefore, variability in stratospheric circulation can modulate tropospheric Ar/N_2. This is supported by a correlation of our tropospheric Ar/N_2 observations with variability in the quasi-biennial oscillation of stratospheric wind direction over the equator. These results will be discussed in the context of measurement uncertainties and complexities in the geochemistry of N_2 and Ar.

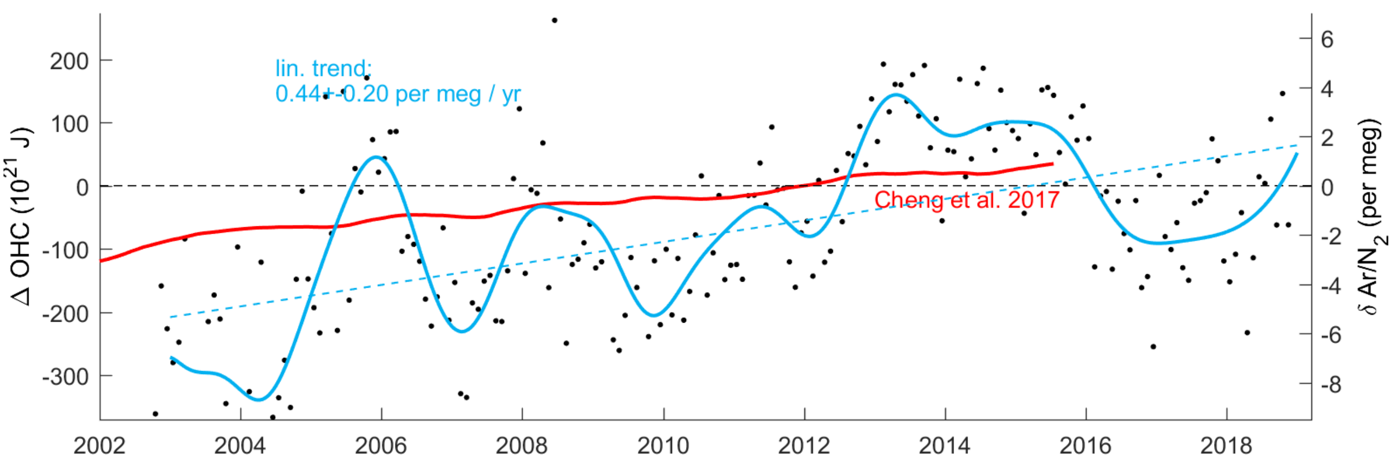

Figure 1. Evolution of the global tropospheric Ar/N_2 record compared to the Quasi-Biennial Oscillation (QBO) Index (i.e., NOAA ESRL PSD 30-mb average zonal wind at the equator), and the total ocean heat content anomaly (Cheng et al., 2017). Monthly mean Ar/N_2 data (black dots, right axis) are calculated from seasonally detrended observations at five different observing stations. Ar/N_2 is translated to ocean heat content anomalies (left axis) using a sensitivity of 2.57 per meg per 100 ZJ (Keeling et al., 2004).