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The metabolic balance of the surface ocean along two Atlantic Meridional Transects

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The metabolic state of the Atlantic Ocean subtropical gyres is currently a matter of debate. On the one hand, measurements of instantaneous oxygen production and respiration rates by bottle incubations indicate consistent heterotrophy (production < respiration) prevailing throughout large areas. On the other hand, geochemical tracers and particle fluxes suggest that these large oceanic ecosystems are net autotrophic or in metabolic balance. We aimed to elucidate this discrepancy through combining instantaneous rate measurements by conventional O_2 bottle incubations [Serret et al., 2001] with a new geochemical approach using continuous measurements of surface water O_2/Ar ratios [Kaiser et al., 2005], to derive the metabolic balance of the subtropical gyre during two Atlantic Meridional Transect (AMT) cruises in May/June and October/November 2005. In case of the instantaneous rate measurements, the change of O_2 was recorded after incubating for 24 h in borosilicate bottles at five light levels representing the euphotic zone. For the continuous O_2/Ar measurements, we used a membrane-inlet mass spectrometer (MIMS). The O_2/Ar ion current ratios measured by MIMS were calibrated by discrete bottle samples, which were analysed after the cruise for their O_2/Ar ratio and oxygen triple isotope composition using isotope ratio mass spectrometers. The O_2/Ar ratio measurements are complemented by precise and accurate measurements of the surface O_2 concentrations by an O_2 optode, calibrated by Winkler titration. A direct comparison of net community production (NCP) measured by bottle incubations and NCP estimated from O_2/Ar ratios and wind speed-based gas exchange parameterisations is not always possible, because bottle incubations are designed to measured NCP throughout the euphotic zone, where O_2/Ar ratio measurements of surface waters are representative of the mixed layer. To compensate for this, we occasionally took water samples from CTD profiles to measure O_2/Ar

ratios below the mixed layer. A first evaluation of the O_2/Ar results indicates net autotrophy throughout the subtropical gyres of the Atlantic Ocean, throughout both cruises. In contrast, bottle incubations give a more mixed picture, with regions of net autotrophy alternating with heterotrophic patches. Since the O_2/Ar data give such a consistent picture both in time and space, it is increasingly unlikely that the biological oxygen fluxes are directed into the subtropical gyres, which would correspond to net heterotrophy. In turn, this means that bottle incubations are not suitable to correctly represent the net metabolic balance over larger temporal and spatial scales.