



Transport of anthropogenic CO₂ across the Prime Meridian in the Southern Ocean based on tracer observations

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To investigate the import of recently ventilated deep water into the Weddell Sea from easterly sources and the export of Weddell Sea Deep Water towards the east, we use a 22 years long time series (1984 to 2006) of chlorofluorocarbon (CFC) observations along the Prime Meridian. This allows us also to quantify the import and export of anthropogenic CO₂. We use Transit Time Distributions (TTDs) as a 1-dimensional model for representing anthropogenic CO₂. In a first tentative approach, the parameters of the TTD – mean transit time, transit time dispersion or mixing parameter, and dilution or admixture of water “old” enough to be CFC free – are adjusted to reproduce the observed CFC time series in the ventilated deep water cores on the Prime Meridian that are confined to the Antarctic continental slope and Mid Atlantic Ridge. However, by this approach contributions of anthropogenic CO₂ prior to the CFC period are mistreated. Alternatively, forcing the dilution to be zero, as has been used by various authors, raises the anthropogenic CO₂ values, but the TTDs have unrealistic high mean transit times (thousands of years) and extremely broad transit time spectra (ten-thousands of years) to reproduce the “old” CFC-free components. A more realistic approach is to account for these components by allowing for exchange of the ventilated cores with “old” deep interior water that originally are tracer-free. This generates a dilution that decreases in time, and the exchange is modelled as first-order mixing. The exchange rate is adjusted to CFC observations of fitting density intervals as the ventilated cores but in the Weddell Sea interior. This approach yields realistic mean transit times and transit time dispersions for the deep ventilated cores and a rather quick exchange of the cores with the inner ocean reservoir.

We derive the TTDs parameters by the CFC time series alone, without using any further constraints. With the derived TTDs we calculate the content of anthropogenic CO₂. We obtain 10.1 $\mu\text{mol/kg}$ that enter the Weddell Sea from the east and 9.5 $\mu\text{mol/kg}$ that leave it towards the east across the Prime Meridian in the ventilated deep water cores (for reference year 2006). In this study, we also regard time-dependent mixed layer tracer saturation and compare that case to the more common time-invariant source water saturations.