

Water Column Inventories of CFC-11 in the Indian Ocean

The CFC inventory has been used to quantify water mass formation (Smethie and Fine, 2001; Orsi et al., 2002), and it is an analogue for the physics of the invasion of anthropogenic CO₂ into the ocean. For global CFC-11 inventory, see Willey et al. (2004).

Inventories were calculated by linear interpolation of CFC-11 concentrations between the surface and the bottom. Criteria were established for including stations in the inventory to ensure that the vertical resolution at each station would not distort the calculated inventory: there had to be at least 10 bottles per station, at least five bottles in the upper 1500 m, and at least three bottles in the upper 500 m. For stations south of 40°S, bottom depth had to exceed 2000 m, and there must be at least one bottle within 800 m of the bottom. For the Indian Ocean, data were taken as measured, i.e., no age correction methods were used. The GMT program was used to get data onto a regular grid, and some re-contouring was done by hand after comparison with other properties (e.g., Reid, 2002). The inventories were averaged in 2.5° latitude by 5° longitude grids.

There is a decided lack of CFC data south of 32°S, between lines I6S and I8S. To estimate how much the lack of data influenced the inventory, maps of properties (e.g., salinity, oxygen, potential vorticity) were examined (e.g., Wyrcki, 1971; McCarthy and Talley, 1999; Reid, 2002). In the upper water column zonal gradients of properties were relatively small. In the bottom waters north of 40°S, property contours were oriented more in the southeast to northwest direction, than zonally. It is difficult to estimate how much the east-west variation of the bottom water contours in this small region (essentially 32°-40°S, 30°-80°E) affected the inventory. It is likely that the calculated inventory is

slightly high in the southeast and slightly low in the northwest. To some extent these effects cancel each other, and interpolation between lines I6S and I8S probably did not introduce significant error.

The total CFC-11 inventory in the Indian Ocean in 1995 was 100×10^6 moles. A hypsographic correction (Menard and Smith, 1966) was applied to the inventory. About 47% of the inventory was found south of 40°S , 50% between 40°S and the equator, and three percent north of the equator.

Lowest inventory values are in the Bay of Bengal and Arabian Sea. Similar to other properties, the inventory increases rapidly in the southward direction in the frontal regions between the equator and the South Indian subtropical gyre. It continues to increase southward through the gyre to a maximum associated with the subantarctic front and the Mode Water formation regions near 50°S . There is an inventory minimum centered at 60°S associated with the diversion of bottom waters by the Kerguelen Plateau ($60^\circ\text{-}85^\circ\text{E}$), and perhaps with upwelling of low-CFC deep waters. The inventory increases again in the southward direction to the Antarctic continent. To the east of the Kerguelen Plateau, the inventory remains high (>3 moles km^{-2}) due to the contribution of CFCs from bottom water along the Adelie Land coast and from the Ross Sea.