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The role of turbulence in the cycling of persistent organic pollutants in the North Sea

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The role of turbulence in the cycling of two selected persistent organic pollutants (POPs), γ-HCH and PCB 153, in the North Sea is presented and discussed using output from a combined very high resolution hydrodynamic (Hamburg Shelf Ocean Model, HAMSOM) and Fate and Transport Ocean Model (FANTOM). POPs in the ocean are subject to a wide range of processes including mechanical, chemical, physical, and biological processes. Large amounts of POPs enter the North Sea system through atmospheric deposition and river inputs, with additional contributions coming from bottom sediments and adjacent seas. POPs processes are calculated with the FANTOM model, and include: advection-diffusion of a POP (advection-diffusion calculated with the HAMSOM); exchange between the atmosphere and the water column (gas, dry and wet deposition, volatilization); exchange between the water column and sediment; river input; exchange at the open boundaries; and degradation in water and in sediment. POPs are classified as being generally hydrophobic (like PCB 153), so they tend to sorb to particulate organic matter (POM) in the water column before sinking into the sediment. Lesser hydrophobic POPs (like γ-HCH) dissolve more in water and a smaller proportion of them are found in sediment. Because they are persistent, POPs have long half-lives and so remain in sediment for long periods (generally years to tens of years). POPs in sediment are resuspended by strong bottom currents, particularly in shallow water as the result of storms, mostly during winter, when high winds effects can result in very strong bottom currents. These resuspended POPs repartition between organic material and dissolution in water and lead to increased volatilisation of the POP to the atmosphere which can result in the delivery of large amounts of POPs to Europe, particularly during storm events. Strong currents will transfer the POP horizontally before it can sink back down to the sediment, thereby changing concentrations and distributions in sediment. Pre-storm sediment POP concentrations may or may not be recovered in the time period following the storm, which depends on a number of factors including the hydrophobicity of the substance, the amount already contained in the system and the amount of it entering the system. Results from a ten year present day run (1996-2005) and three ten year scenario runs (2006-2015, 2046-2055, 2090-2099) are presented. Distributions of near-bottom turbulent diffusivity coefficients and POP distributions are presented and discussed, as are the effects of the turbulence on the different POP model processes.