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Modelling air-water gas exchange in the Mediterranean Sea

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Air-water exchange of mercury was found to be the most important sink of Hg for the water compartment of the Mediterranean Sea (Rajar et al. 2007). Therefore, it is very important to determine the evasion and deposition quantities in order to improve the knowledge on mercury cycling on both regional and global scales. Real-time coupling of usually incompatible water and atmospheric models is a difficult task. In order to avoid recoding the models that deal with Hg biogeochemistry in both environmental compartments, we tried a few other approaches to air-water exchange simulations. In all the computations, Wanninkhoff's (1992) gas-exchange model was used as described in Gardfeldt et al. (2003).

On the regional scale (the entire Mediterranean Sea), where space variability of forcing factors, circulation and Hg concentrations are relatively high, we applied two models. The PCFLOW3D aquatic model was used in the water compartment and the RAMS-Hg atmospheric model calculated meteorology as well as Hg concentrations in the air and Hg deposition. Seasonally averaged circulation and Hg concentrations were calculated in water, while in the air, the results of real-time computations were averaged over time periods of approximately one week. The output of both models was used in the gas-exchange model and in this way the simulation results were significantly improved compared to the results of modelling with water and/or air model alone (Žagar et al. 2007, Voudouri et al. submitted).

On the local scale (the Gulf of Trieste, Northern Adriatic) where temporal variability of all the input data prevails over their space variability, a different approach was used: hourly-averaged wind over the computational domain and the measured Hg concentrations in water and air were taken into account. The evasion and deposition were calculated using a spreadsheet. Wind velocity data was ranged into several intervals (e.g. 0-3 m/s, 3-4 m/s… 13-14 m/s, etc.) and annual evasion was calculated by summing the partial results for all wind intervals, according to the Hg concentrations in water and air. The same computation was performed using the PCFLOW3D model with annual wind-data series. The comparison showed a relatively poor agreement, only within a factor of two.

However, a correct approach, particularly with larger domains, would require accounting for both space and time variability of data. Thus we prepared an interface to extract meteorological data from GRIB (gridded binary) files, provided by IASA (http://forecast.uoa.gr). The high-resolution water temperature and wind data are extracted and placed into a database, which is further used in three different ways: 1) transfer of wind data in the grid used by the PCFLOW3D model and their further use for computation of real-time circulation and evasion processes; 2) use of seasonally or monthly averaged circulation fields previously simulated by the PCFLOW3D model and use of real-time space varying wind exclusively in the gas-exchange model, and 3) use of the measured Hg concentrations in water, determination of the area belonging to each measured concentration and further use of ranged wind velocities and temperature within each area to determine evasion, using the same principle as for the local scale (described above). All three experiments are in progress.

Further upgrade of the gas-exchange model is also necessary, since the agreement between measurements and simulations is only within a factor of two. After a comparison of several gas-exchange models, Andersson et al. (2006) suggested that the model proposed by Nightingale et al. (2000) is probably the most appropriate tool for the calculation of Hg evasion.

After improving both the model and the input data, a significant improvement of modelling results is expected and thus an important contribution to general knowledge on mercury cycling in the Mediterranean will be achieved. The same principle could also be used for modelling air-water exchange of other gases (e.g. CO_2).

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