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Atmospheric nitrogen deposition over the Mediterranean, Black Sea and Europe as simulated by the WRF-CMAQ model system

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Significant amounts of nutrients are provided to the ecosystems by atmospheric deposition. Recent studies have shown deposition of nitrogen (N) is likely to further increase in the future. Monitoring of deposition can be very challenging and can provide data of only limited geographical coverage. Atmospheric chemistry and transport models can provide integrated view of the temporal and spatial variations of dry and wet deposition over local to global scales, although they require extensive validation against observations. In the present study, the mesoscale WRF-CMAQ modeling system is used in order to estimate the atmospheric N deposition over Europe for the year 2008. About 2 to 3 times higher inorganic N deposition fluxes are computed compared to gaseous organic N deposition fluxes for the studied areas of the Mediterranean, the Black Sea and the continental Europe. In the Mediterranean basin, slightly larger annual N fluxes are calculated in the East basin compared to the west basin. Differences are attributed to differences in emissions and precipitation patters in these region. Comparison to available observations associates the model estimates with about 40% of uncertainty. N dry deposition is estimated to be the main contributor to total N deposition in all regions in agreement with the observations. Simulated N deposition fluxes generally maximize in fall and minimize in spring, following the seasonal variation of precipitation and emissions. The simulations show that on an annual basis, 84% of the European forests receive the critical nitrogen load of 1 gN m-2 yr-1. Results show that annual atmospheric N input to the Mediterranean Sea is 54% higher than the riverine N input. Two times higher atmospheric N input to the East Mediterranean Sea compared to West Mediterranean Sea is simulated, similar to the riverine N input. Regarding the Black Sea, riverine N input is 3 times higher compared to the atmospheric N input. On the other hand, the model largely underestimates the reported atmospheric N deposition over the Black Sea by a factor of 3. Comparisons with riverine and other N inputs to the Mediterranean and Black seas indicate the significance of atmospheric deposition over the marine ecosystems, particularly over the Mediterranean Sea.