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Assessment of Greenhouse Gas Emission and nitrate leaching inventory from agricultural lands in the region of Thessaly (Greece) using the LandscapeDNDC model

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Agricultural productivity and food security depend on the application of nitrogen (N) fertilizers. Since the use of N fertilizers has increased, it allowed the world population to increase from 3 to well over 7 billion. Yields from arable systems increased by 45–70% since 1950. The excessive use of N fertilizers causes harmful effects to the environment, e.g. increased emissions of nitrous oxide (N2O), nitric oxide (NO), ammonia (NH3) to the atmosphere and leaching of nitrate (NO_3) into water bodies.
Our research focuses on the understanding of the regional and national N cycle in arable land. The approach is based on the application of the biogeochemical model LandscapeDNDC. The region of Thessaly is a part of central Greece with a total area of 14000sq.Km. The topography of Thessaly varies and consists of ca. 5000 Km2 lowland but also mountainous (approximately 2300 and 6500 for semi-mountainous and mountainous respectively) and coastal areas. The counties that constitute the region are Larisa, Magnesia, Trikala, Karditsa; the island cluster of Sporades (Skiathos, Skopelos, Alonissos etc.) is, also, regarded as part of the county of Magnesia. The plain of Thessaly is considered to be the largest lowland of the country mainly used for agricultural production (Kalivas and Kollias, 2001). The agricultural area accounts for around 410000ha, of which about 370000 is the arable land (Hellenic Statistical Authority, 2012). Almost 80 percent is covered by annual crops and 10 percent by tree cultivations. The crop/plant production of the region is around 14.2 percent of the production of the country (following the region of Central Macedonia).
Approach: We aggregated the mineral fertilizer sales to the agricultural area to assess the nitrogen mineral fertilizer use. Additionally, we aggregated the total livestock heads and dynamics in the region to estimate the production of organic fertilizer. The approaches lead to the derivation of the nitrogen fertilization input for the region. We constructed a typical crop rotation for the region consisting of the dominant cultivations: maize, winter wheat, clover, cotton, and winter barley. The agricultural management for the LandscapeDNDC model reflected 6 permutations of the crop rotation in combination with regional statistic data on crop irrigation. The fertilizer application for each crop in the 6 crop rotations was scaled based on the different crop nitrogen demands. For validation, we compared the greenhouse gas emission and nitrate leaching strengths assessed by the process based model with the IPCC Tier I approach. IPCC lead to 1.5 to 2.2 kg N2O-N /ha/year and 45 to 66 kg NO_3-N /ha/year.
We performed regional biogeochemical simulations to compile a regional nitrous oxide emission and nitrate leaching inventory for the region of Thessaly including the identification of hot moments and hotspots of nitrous oxide emissions and nitrate leaching.
We, also, present the total nitrogen balance of the agricultural system in order to provide other components of the nitrogen cycle such as ammonia volatilization, dinitrogen emissions, nitric oxide emissions, nitrogen content in harvest and changes in soil nitrogen stocks.