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Climate and human impacts on Lake Ammersee - Alterations in a normal range?

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Throughout the last decades of the 20th century, nutrient concentrations in some continental aquatic ecosystems increased due to human activities in their catchment areas. This is also possible to observe in the Lake Ammersee, situated in South-East of Germany, 30 km away from the City of Munich. The lake and its catchment area are representative of this type of central European water body and therefore will allow for analysis of how the lake responds to this kind of anthropogenic influence. Afterwards, in the middle of the 1980s, the problem of immense input of nutrients in the lake was detected and several management activities were carried out to keep nutrients away from this ecosystem. Hence, a trend of re-oligotrophication at the lake was observed after the middle of the 1990s. Parallel to this process, temperatures have been increasing in the northern hemisphere since the end of the 19th century. In this respect, an investigation of Lake Ammersee will be very appropriate since it may be possible to detect the difference between anthropogenic impact and possible alterations due to climate change. In this contribution, we investigated the direct anthropogenic and supra-regional climatic impacts triggered by global warming on Lake Ammersee during 1984 and 2009. Therefore we address the following questions: How do past water management activities in the Lake Ammersee catchment area affect the trophic development of the lake? What is the relationship between trophic variables chlorophyll-a concentration, water transparency or oxygen content in the lake? Is there a correlation between the signal of a changing climate and the trophic level of the lake? And, is it possible to distinguish between this (global) climate effect and direct anthropogenic pressure by land-use history? The study of dissolved oxygen, total phosphorus and chlorophyll-a, exposed a remarkable improvement in the trophic conditions of the lake. Nevertheless, a more intensive oxygen depletion in the hypolimnion can be detected by strong stratification. This is due to positive temperature anomalies (e.g. summer 2003) in comparison to the other summers in the investigation period. We recognized a transition period in the development of trophic levels during the years 1996/1997. Chlorophyll-a values are related to other trophic variables such as total phosphorus, dissolved oxygen and sight depths (R2 between 0.41 and 0.56).Concurrently, during the summer months, the upper epilimnion temperature increased (by about 0.8 K per decade), which was analogue to the thermal increase (about 0.6 K per decade) in the northern hemisphere (Pearson's correlation coefficient, omitting 2006, of 0.81). Deductive, in the case of Lake Ammersee, a decrease in nutrient input has in recent times (1997-2009) led to an improvement in the trophic state. This is basically due to measures taken to avoid negative anthropogenic impact. However, we show that the thermal stability of the lake responds to alterations triggered by climate change. For this reason the impact of climate change on trophic conditions will have to be monitored carefully in the future.