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Combining remote sensing observations with limnologic analysis: A new tool to characterize the annual particle and sedimentation cycle of Lake Van (Turkey)

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The use of lake sediments for palaeoenvironmental reconstructions requires knowledge of the link between the lithology of sediments and the various states of the environment. A powerful approach to establish such a link is to investigate the modern sedimentation processes in a lake and how they vary as a function of measurable environmental (e.g. climatic) parameters. A standard tool to understand the particle relevant processes in the water column is the deployment of sediment traps with high temporal resolution, which yield seasonal time series of sinking particles. The particle characteristics together with the deduced variations of particle mass flux and geochemical indicators provide valuable information about varying particle fluxes and particle composition. These seasonal patterns eventually produce 'varves' (annual layers) in the lake's sediment record. To improve the gained knowledge a combination of sediment trap results and of remote sensing observations provides independent and valuable data with high spatial and temporal resolution. This combination is a new tool to achieve a comprehensive knowledge of particle processes within the epilimnion of lakes, as is shown from this case study of Lake Van (Eastern Anatolia, Turkey).

Lake Van, by volume the world's fourth largest hydrological closed lake (607 km3), is due to its size and known whitings (carbonate precipitations), ideal for remote sensing applications. The recent particle processes of Lake Van are of great interest for paleoenvironmental research as the lake is a key site within the International Continental Scientific Drilling Program (ICDP) for the investigation of Quaternary climate evolution in the Near East.

MERIS full-resolution Level 1 datasets, taken between 2006 and 2009, were processed successively with the Improved Contrast between Ocean and Land (ICOL) algorithm and with the standard Case-2-Regional (C2R) processor, which provides estimates of total suspended matter (TSM) concentration. The skill of the global algorithm to study the TSM variations, in the case of Lake Van, is tested by comparing the remotely-sensed TSM concentrations and the in-situ measured TSM concentrations. Correlation of in-situ and remotely-sensed TSM concentrations and turbidity values, measured at nine sampling locations, confirm (R=0.6) that the standard C2R processor produces appropriate TSM concentrations.

The true color images and TSM estimates show that the lateral turbidity distribution pattern is linked i) to the tributaries and distance to shore and ii) to surface currents, i.e. eddies triggering upwelling. The rivers carry allochthonous particles and dissolved calcium ions into the lake. This ion supply leads to carbonate precipitation and, together with the detrital particles, to turbidity increase close to inflows and shores, in particular within the Ercis Gulf.

The sediment trap-based particle fluxes between July 2006 and August 2009 show high fluxes during spring and autumn, and low fluxes during winter. This pattern agrees with the satellite-based TSM estimates illustrating high particle-concentrations from spring to autumn. Satellite data, showing high particle-concentration in the summer months, allow filling the gaps of sediment-trap data missing from that period. An exceptionally high carbonate-productivity peak during winter 2007, recorded with the sediment traps, could also be confirmed with satellite images. These refine the knowledge of the annual particle cycle due to their higher temporal and spatial resolution.

Whereas the additional benefit of remote sensing observations is manifold, some shortcomings remain: i) the

prerequisite of good weather conditions, ii) the limited signal depth of remote sensing radiances of 8 to 15 m water depth, while maximum particle concentrations lie in $\sim$35 m and iii) the lack of distinction between clastic input and carbonate precipitates; i.e. allochthonous vs. autochthonous particles.