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Seasonal trends of chemical weathering rate and CO_2 consumption yield in the Upper Ganga Basin

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Information about weathering fluxes is often included in carbon cycle models, making them critically important in the weathering-thermostat paradigm. The existing geochemical data from the central Himalayan region is mostly season specific and of very low resolution. Here we provide a new set of weekly-scale estimates of modern-day chemical weathering rates and CO_2 consumption yields from the upper Ganga basin (UGB) at the confluence of the Rivers Bhagirathi and Alaknanda at Devprayag. We carried out extensive sampling of the Alaknanda and Bhagirathi Rivers at a weekly resolution for a period of one year between December 2018 and December 2019. Additionally, we also sampled rainwater during the study period. To trace current chemical weathering rates and CO_2 consumption yields, we used a forward modelling approach. The results show that the chemical weathering rate and CO_2 consumption yield vary significantly on a seasonal scale. The silicate weathering rate in the Alaknanda basin was estimated as 9.3±0.2, 9.8±2.9, 29.3±8.5 and 12.2±3.6 t/km^2/year for winter (DJFM), pre-monsoon (AMJ), Indian Summer Monsoon (ISM, JAS) and post-monsoon season (ON), respectively, with an annual average of 14.5±9.3 t/km^2/year. In the Bhagirathi River, the silicate weathering rate was estimated as 11.7±1.7, 8.8±0.9, 7.7±1.5 and 5.2±0.9 t/km^2/year for winter, pre-monsoon, ISM and post-monsoon season, respectively, with an annual average of 9.1±2.7 t/km^2/year. CO_2 consumption yield via silicate weathering in the Alaknanda basin was 2.1±0.1×10^5, 2.1±0.7×10^5, 5.1±1.2×10^5 and 2.3±0.4×10^5 mol/km^2/year for the winter, pre-monsoon, ISM, and post-monsoon seasons, respectively, with an annual average of 2.8±1.4×10^5 mol/km^2/year. CO_2 consumption yield via silicate weathering in the Bhagirathi basin was 2.4±0.4×10^5, 2.0±0.1×10^5, 1.6±0.4×10^5 and 1.0±0.2×10^5 mol/km^2/year for the winter, pre-monsoon, ISM, and post-monsoon seasons, respectively, with an annual average of 1.9±0.6×10^5 mol/km^2/year. We find that weathering rates and CO_2 consumption yield were three times higher during the monsoon season compared to the non-monsoon season. The total rock weathering rate and CO_2 consumption via silicate weathering were 55±26 t/km^2/year and 2.4±0.7×10^5 mol/km^2/year respectively, in the UGB. Quantitative and qualitative analyses show that carbonate and silicate weathering dominate the river solute budget, followed by atmospheric input and minor contributions from evaporite dissolution and sulphide oxidation.