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Quantitative Computed Contribution of Raman Scattering to Water-leaving Radiances

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Many studies in the past have suggested that Raman scattering of the solar light-field due to energy absorption by vibrational modes of water molecules can contributes significantly to the signals observed by ocean remote sensing satellites. While radiative transfer models that qualitatively approximate the effect of water Raman scattering on water leaving radiances have been available for a while, a new version of the radiative transfer code MOMO, which enables the accurate and fully angle resolved inclusion of inelastic scattering sources, now allows more detailed quantitative analyzes of the effect on the light field in the ocean-atmosphere system.

With this new model, we have performed a sensitivity study regarding the effect of water Raman scattering on water leaving radiances and top of the atmosphere radiances in the spectral bands of the MERIS instrument. A simple bio-optical model was used to simulate cases with different chlorophyll concentrations representing a variety of Case-1 water types. Furthermore, the effect of sea water temperature and salinity on the fraction of Raman scattered radiation was determined.

The results show, that water Raman scattering in very clear water makes up for a fraction of 5-60% of the water leaving radiance in the MERIS bands examined between 412 and 885nm, and up to 37% if the oxygen A-band absorption channels are ommited. For a moderately turbid case with a chlorophyll concentration of 0.1 mg/m^3, which approximately represents the global mean, the Raman scattered radiance fraction still ranges between 1 and 11%. The study also showed, that the sea water salinity has a strong influence on the Raman fraction of the water leaving radiances, leading to an absolute increase of up to 8% if you move from saltwater (35 PSU) to fresh water. The maximum errors introduced to water-leaving radiances by neglecting the azimuthal dependence of Raman scattering, as done in many RT models, are in the range of 1-10%. Compared to the latter effects, water temperature variations have a smaller impact on the Raman scattered radiance fraction leaving the water body.