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The importance of 'invisible' dissolved organic carbon along the land-ocean aquatic continuum

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Land-ocean dissolved organic carbon (DOC) fluxes are a significant and changing component of the global carbon cycle. The current paradigm assumes that these fluxes are dominated by chromophoric or 'coloured' material (cDOC). DOC is often characterised and quantified using optical tools which specifically target this fraction. However, multiple studies point towards a potentially sizeable non-coloured or optically 'invisible' DOC (iDOC) pool which is not covered by such characterisations. Only a handful of studies have directly investigated iDOC, and so its source, composition, behaviour, and geographic prevalence remain poorly understood.

Here we show that iDOC accounts for 21 % (0.23 Tg C yr^{-1}) of annual riverine export in Great Britain (GB), with spatial variation in catchment-scale mean annual export depending upon forest cover and mean dairy cattle density. Using > 2,900 samples from across a range of geo-climatic settings across five continents we find a similar result: iDOC accounts for 26 % of the measured DOC flux in freshwaters. Our results indicate that iDOC is more prevalent in systems with a high degree of anthropogenic influence and/or a high residence time.

We also show that estuarine DOC behaviour is driven by the contributions of cDOC and iDOC, at least within GB estuaries: cDOC almost universally exhibits conservative transport, whilst apparent non-conservative bulk DOC transport is typically caused by fluctuations in the iDOC fraction.

We conclude that iDOC is a globally significant fraction of the land-ocean carbon flux, the broad scale importance of which has been largely overlooked. This has fundamental implications for (1) our understanding of aquatic biogeochemistry and (2) the use and interpretation of optical parameters as they relate to DOC characterisation and quantification.

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