SOURCE CONSTRAINTS AND TRANSLOCATED DEGRADATION OF TERRESTRIAL ORGANIC MATTER USING SIBERIAN ARCTIC SHELVES AS RECEPTORS

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Introduction

The massive quantities of carbon stored frozen around the Arctic, in soils on land and in sediments of the shallow subsea, may act as “capacitors” of the global carbon system. The potential for carbon release to affect the global carbon cycle, and climate, is seen from the sheer magnitude of these Arctic pools. The global atmosphere holds 760 Pg CO₂ and 5.3 Pg CH₄. About one-third to half of the global soil carbon is held in the top 1-3 m of tundra-taiga permafrost PF (~1000 Pg-C) with deeper layers below as Deep-PF (~400 Pg-C) and in Pleistocene Ice Complex Deposit permafrost (ICD-PF, ~400 Pg-C), lining 4000 km of the East Siberian Arctic coast (see Figure). There is reasonable understanding of the terrestrial inland permafrost carbon (PF-C) distribution in the top 1-3 m and that thawing will lead to release of CO₂ and CH₄ this century, but there are large uncertainties regarding both magnitudes and mechanisms of release and fate processes. Similarly, the coastline of the East Siberian Arctic Seas (ESAS, the World’s largest shelf sea) is lined with old ICD-PF that is retreating by meters/year (see Figure), causing extensive turbidity of ESAS coastal waters, yet with great spatial variability in terrestrial organic matter (TerrOM) remobilization. In order to overcome the landscape heterogeneity and the stochastic nature of e.g. erosional release processes, we use the ESAS in an inverse approach – as a natural integrator of the TerrOM releases from both the river drainage basins and from the erosion of ICD-containing bluffs (Vonk and Gustafsson, 2013). We are equally interested in the transport and translocated degradation affecting the released TerrOM. This presentation will synthesize results from ESAS expeditions over the past 1-2 decades with new and unpublished results, including extensive coverage of δ¹³C, δ¹⁴C, biomarkers and sedimentological properties.

Results and Discussions

The sources of released terrOM have been increasingly constrained using great rivers and the ESAS as natural integrators through a combination of biomarkers and δ¹³C/δ¹⁴C on bulk-C and on compound level. There are significant gradients in sources both E-W (e.g., vanDongen et al., 2008; Gustafsson et al., 2011; Feng et al., 2013; Karlsson et al., 2016) and S-N across each shelf sea (e.g., Vonk et al., 2012) and between water column DOM, POM and sedimentary OM (e.g., Vonk et al., 2010; Karlsson et al. 2016). The largest source of OC to ESAS sediments is not rivers or marine plankton – it is coastal erosion of old ICD. Our initial limited dataset (Vonk et al., 2012) has now been much expanded (see Figure), as has the end-member database while the statistical source apportionment method has been refined. They combine to show more efficient cross-shelf transport of river-borne “topsoil-PF” compared to ICD-PF and a
clear distinction in sources of TerrOM between western and eastern ESAS regimes separated roughly along 165E, consistent with the local oceanography.

There have been good strides also in understanding degradation of TerrOM exported to ESAS. Studies are demonstrating continuous offshoreward degradation of all TerrOM, yet with large differences between compound classes (e.g., Vonk et al., 2010; Tesi et al., 2014; Sparkes et al., 2016; Bröder et al., 2018). Physical association of TerrOM with different sediment components, and sorting of the sediments exert first-order control on TerrOM distribution and degradation (Tesi et al., 2014, 2016; Salvado et al., 2015). An expanded dataset on specific surface area (SSA) and CuO oxidation products reveals spatial patterns across ESAS not seen in published studies. The combination of compound-specific radiocarbon analysis of terrestrial biomarkers with SSA-normalized TerrOM signals constrains the ambient degradation rates and fluxes during the 3–4000 year timescale of cross-shelf transport (Bröder et al., 2018). The degradation of TerrOM causes severe ocean acidification of the ESAS (Semiletov et al., 2016).

Investigations of sources and fate of TerrOM on the ESAS – the World’s largest shelf sea—provides a window to constrain permafrost-C remobilization and to study mechanisms of transport and degradability of different components of released terrestrial organic matter.

References


