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Influence of recent droughts on carbon cycling in the Elbe estuary

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Climate projections show high temperature extremes, meteorological droughts and heavy precipitation events are set to increase across Europe (Barros et al., 2014), where the decadel average has already increaed, with temperature in 2002-2011 already 1.3°C±0.1°C above the 1850-1899 mean (Barros et al., 2014). The observed seasonal precipitation pattern presents drier summers and wetter winters across Europe, also mirrored in river flow changes. Across small river catchments in Europe from 1962 to 2004, winter period showed positive trends whereas summers were characterized by negative trends in river flow (Stahl et al., 2010). Such changes can alter the residence time of an estuary. Estuaries are biogeochemical hotspots, and critical zones for carbon cycling, and changes in the hydrological balance, still largely not well characterized, may influence processes within the water column.

The present study will assess the potential impacts of droughts on the carbonate system in the Elbe estuary. One of the largest in central Europe, the Elbe River catchment spreads over approximately 150,000 km^2 in four countries. Between 2014 and 2018, regions of Northern Germany have been under drought conditions during certain months (UFZ, 2018), reducing discharge in the Elbe River. From 2014, annual Elbe river discharge has been relatively low, where 2018 exhibited the lowest annual mean river discharge of 441 $m^3 s^{-1}$ since 1992. Model projections show the annual river discharge for the Elbe river is likely to remain low at 410 $m^2 s^{-1}$ in 2046-2055 compared to >550 $m^2 s^{-1}$ in 1960-1990 (Krysanova et al., 2005).

Analysis of the long-term FGG Elbe (Flussgebietsgemeinschaft Elbe) records of dissolved inorganic carbon (DIC) in the mid to lower Elbe estuary show that over spring and summer months DIC values have increased with time (1997-2018). In this period, DIC increased from the freshwater to the mesohaline region, followed by a decrease to the polyhaline zone. This is opposing to previous DIC patterns in the early 1980s, where DIC decreased towards the mid-estuary after which increased to the outer estuary. An increase in DIC in the mid-estuarine region coincided with increased turbidity and extended residence time, and during the productive months with higher organic matter from upstream regions. This could suggest that more time for heterotrophic activity and availability of labile organic matter, acts to enrich DIC within the water column in the turbid regions, thus changing carbon cycling within the estuary. Further analysis will focus on the changes in river discharge and inorganic carbon during the past two decades, thus inclusive of low discharge and drought conditions.