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Spatial and seasonal variation of pCO_2 and air-sea CO_2 flux in the Devi estuary, east coast of India

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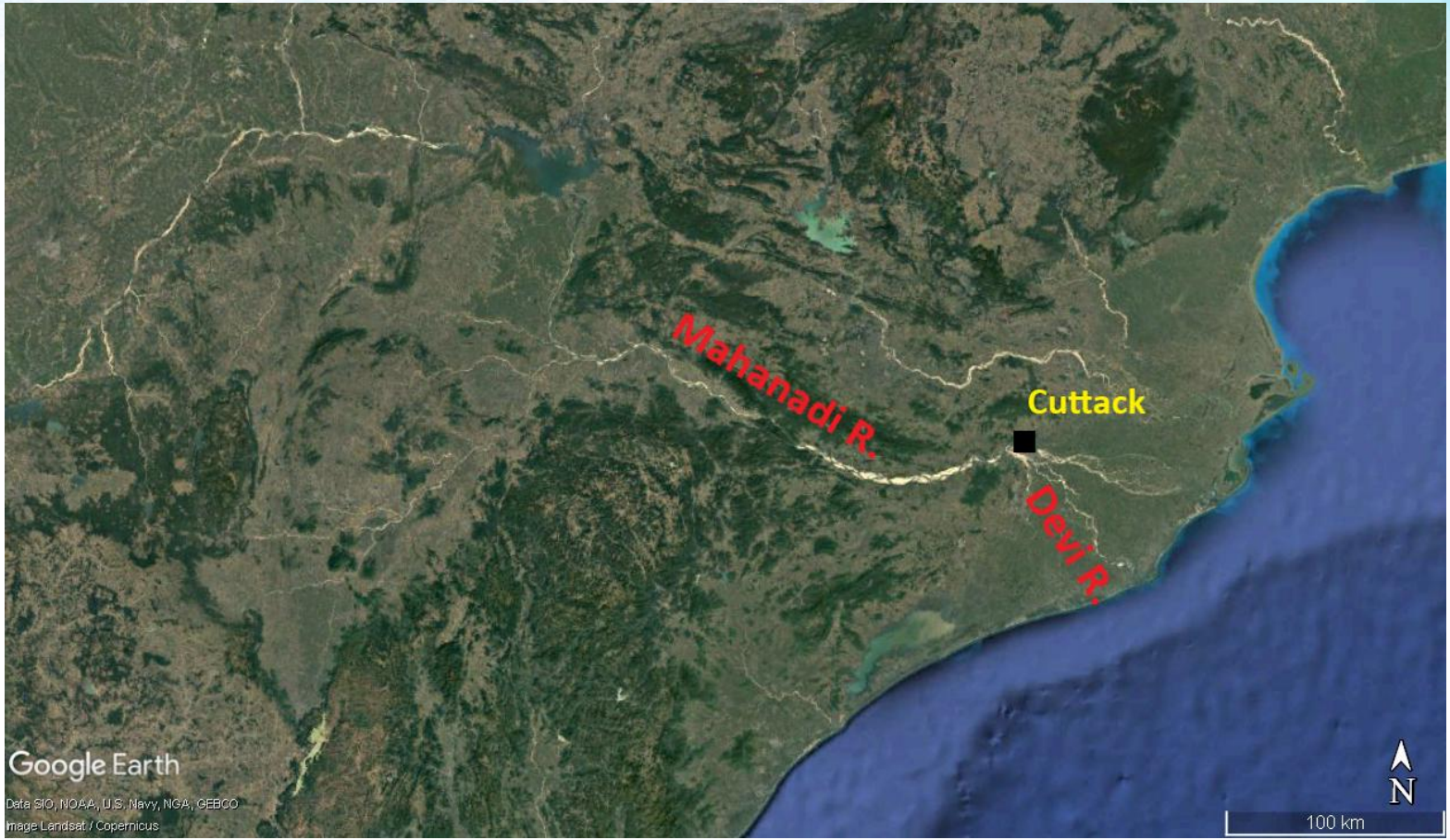
- The rate of exchange of CO_2 at the air-water interface depends on gas transfer velocity, *k* (Evans et al., 2013).

- Variation in *k* results mostly due to differences in wind speed as well as water depth and channel width of the estuary.

- For example, studies on most of the Asian estuaries have reported lower fluxes than European and North American estuaries even though the former ones have higher pCO_2 (water).

- This low flux has been observed due to lower wind speed in these Asian coastal areas than the latter (Chen et al., 2013).

Study Area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Methodology

- Sampling was conducted over a period of one year (2018–19) during summer (May 2018), monsoon (September 2018) and winter (February 2019) periods.
- Temperature, pH, electrical conductivity (EC), salinity, dissolved oxygen (DO), dissolved oxygen saturation (DO%) and total dissolved solids (TDS) of water samples were measured in-situ using HORIBA multi-parameter water quality meter.
- The estimation of chlorophyll was done following standard procedure of Jeffrey and Humphrey (1975).
- The pCO_2 was calculated from the pH and dissolved inorganic carbon (DIC) values using following equation (Cai and Wang, 1998).

$$pCO_2 = (DIC \times [H^+]^2) / ([H^+]^2 + [H^+] \times K_1 + K_1 \times K_2] \times K_H)$$

K_H is the solubility of CO_2 in mmol m^{-3} μatm^{-1} (Weiss, 1974).
K_1 and K_2 are the dissociation constants of carbonic acid (Roy et al., 1993)

The air-water CO_2 efflux (ϕ; mmol C m^{-2} d^{-1}) was calculated using the following equation:

$$\Phi = k_{CO2} \times K_H \times (pCO_{2(water)} - pCO_{2(air)})$$

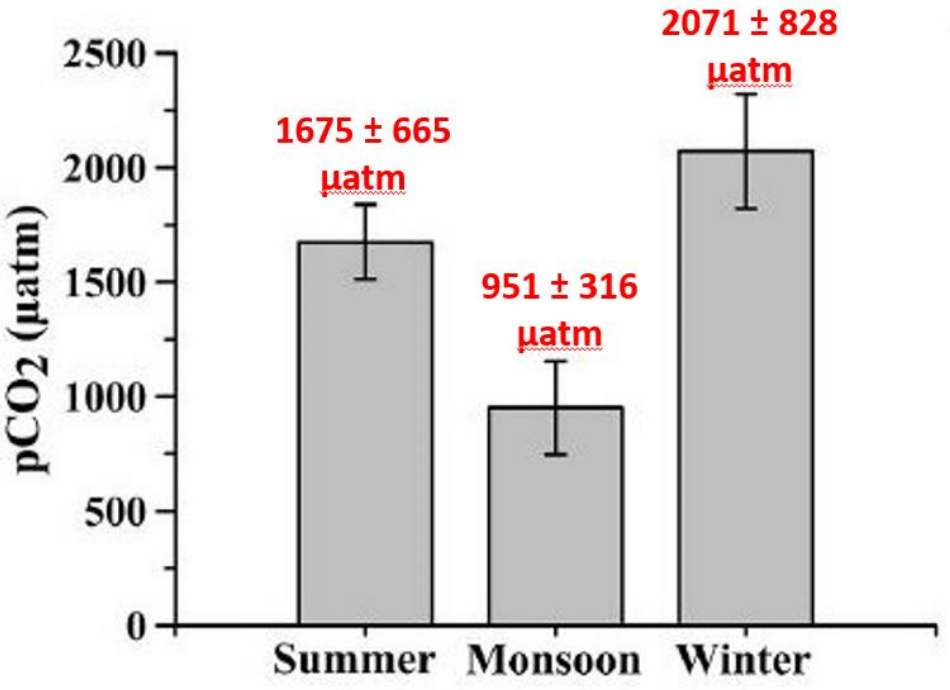
k_{CO2} is the gas transfer velocity (m d^{-1}) of CO_2.

Results and Discussion

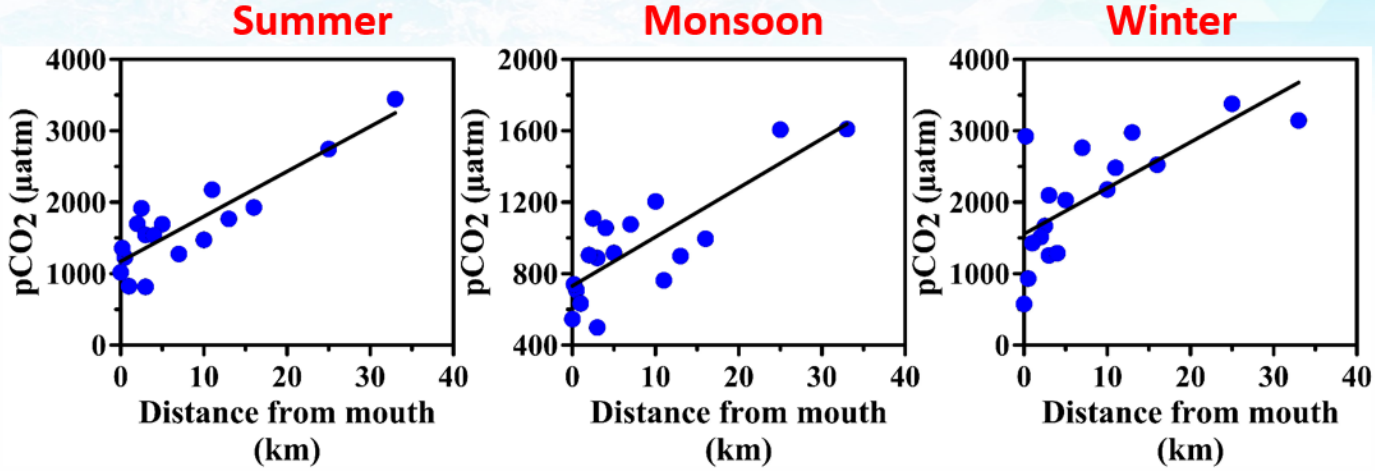
The average pCO_2 in the Devi river estuary is 1565 ± 782 µatm which was higher than that of the atmosphere.

Seasonal variation in pCO_2

- Decrease in DIC in monsoon due to heavy rainfall results in reduction in pCO_2.
- During monsoon, residence time is smaller due to high water flow rate.
- Low water flow during winter increases the residence time in winter period.



Spatial variation in pCO_2

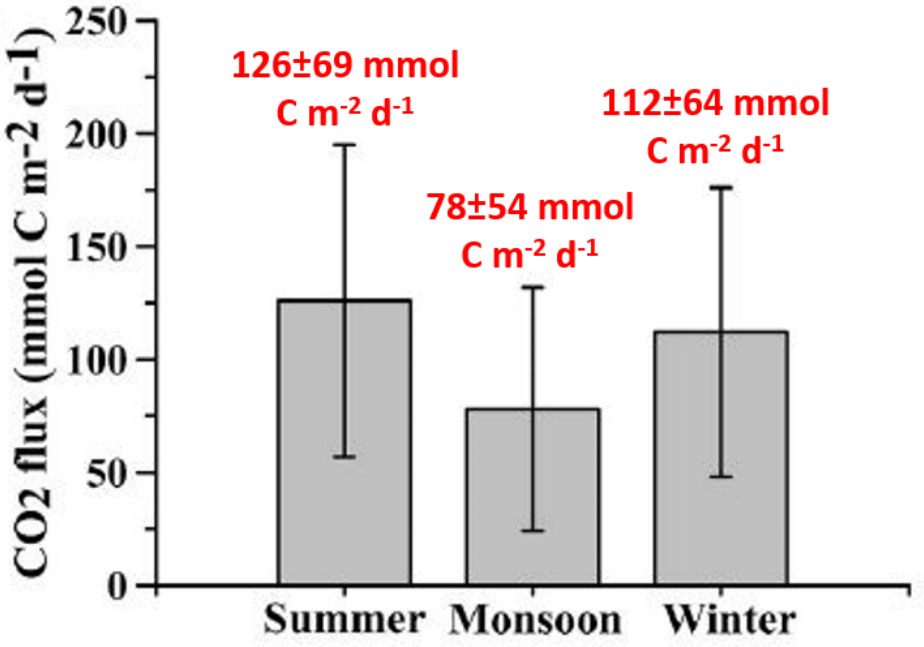


- Solubility of CO_2 decreases with increase in salinity (Weiss, 1974).
- Direct discharge of organic matter from urban sources to upper estuary leads to the production of pCO_2 by the process of bacterial respiration.

Air-sea CO_2 exchange

k_{600} (cm/hr)			Annual flux ($molC\ m^{-2}\ yr^{-1}$)
Summer	Monsoon	Winter	
11.88±2.26	10.70±1.95	5.66±1.89	40.06±7.53

The annual CO_2 efflux from the Devi river estuary was approximately 40.1 ± 7.5 mol C m^{-2} yr^{-1}.



Akhtar et al., 2021. Applied Geochemistry, 131, pp. 105003

Summary

- The Devi river estuary acts as a significant source of CO_2 to the atmosphere.
- Degradation of organic matter rather than primary productivity is a major controlling factor for pCO_2.
- Seasonal variations in CO_2 flux from the estuary are constrained by surrounding parameters such as wind speed and temperature.
- It contributes a significant annual flux of approximately 0.003–0.006% of the global CO_2 flux from estuaries.
- This study shows the importance of small-scale estuaries in the global carbon budget, and highlights the role of various local-scale atmospheric factors in controlling the pCO_2 and its flux to the atmosphere.

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