National Oceanography Centre

MSM, NOC Liverpool, UK

Salt flux and volume transport in a tidal dynamic delta

Yujuan Sun, Lucy Bricheno, Kevin Horsburgh

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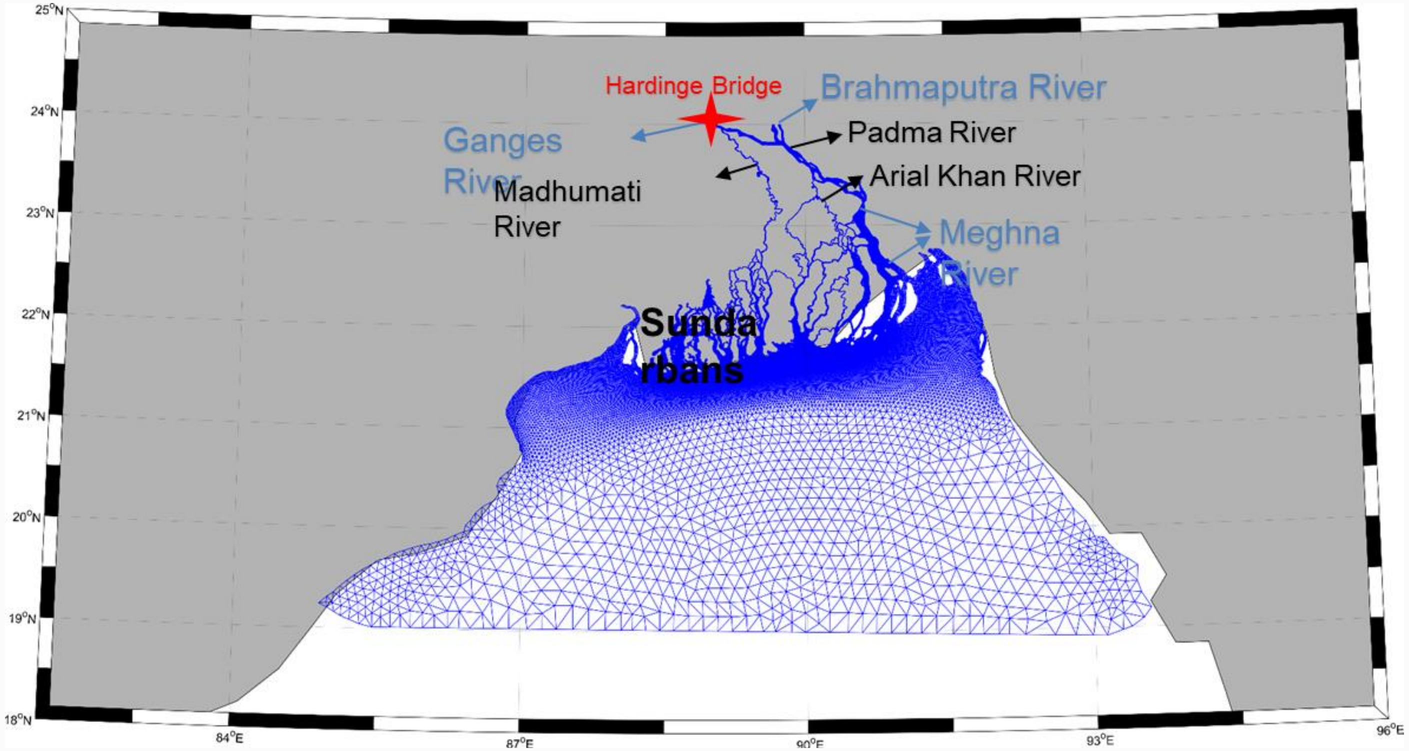
Model Implement



(1) Simulation time period is from 1 July, 2018 to 1 July, 2019.

(2) River discharge is obtained from a downscaled Global Climate River Model, with the well projection of river discharge to the end-of-century (Whitehead et al., 2018).

(3)Salinity are obtained from the CMEMS 1/12^{o} reanalysis for initial and boundary conditions.

(4) Surface forcing is from the ERA5.

(5) Temperature is constant of 22^{o}C.

(6) Observations: In-situ T/S observations (16 Jan to 8 Feb, 2019), obtained from U Glasgow; River discharge measurements at 4 stations, from BUET.

Simulation validation

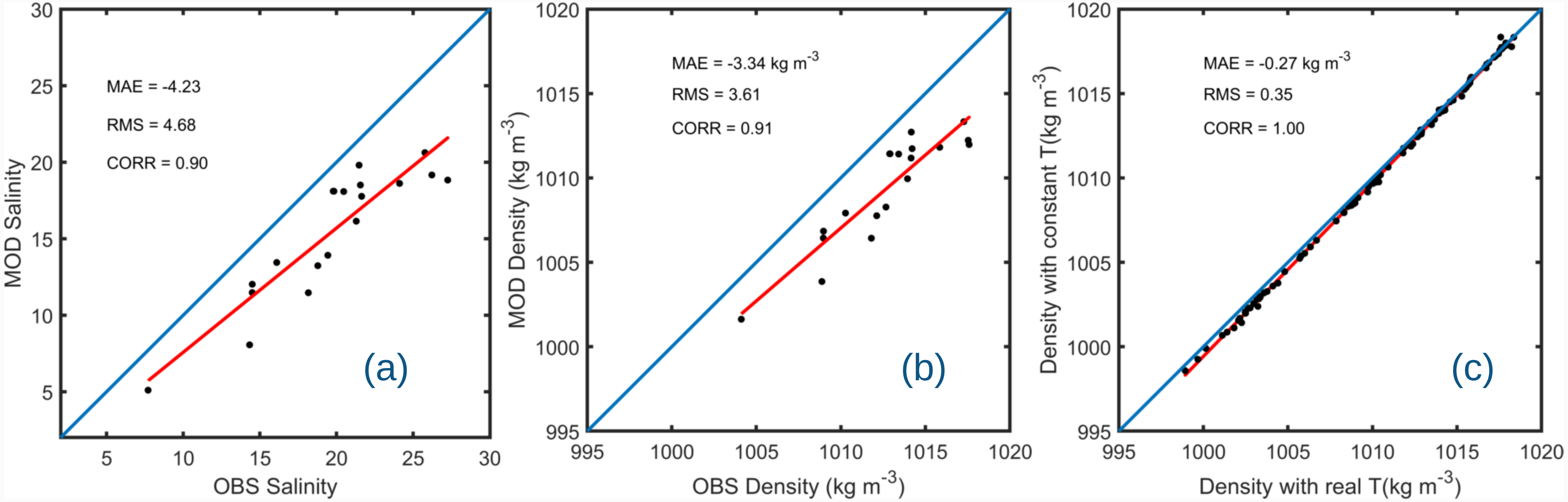
The bias may be caused:

(1) In situ T/S data was taken from fish samples, where is well mixed at small streams.

(2) Model uncertainties: lack observations in river discharge, river temperature, bathymetry in narrow river channels etc.

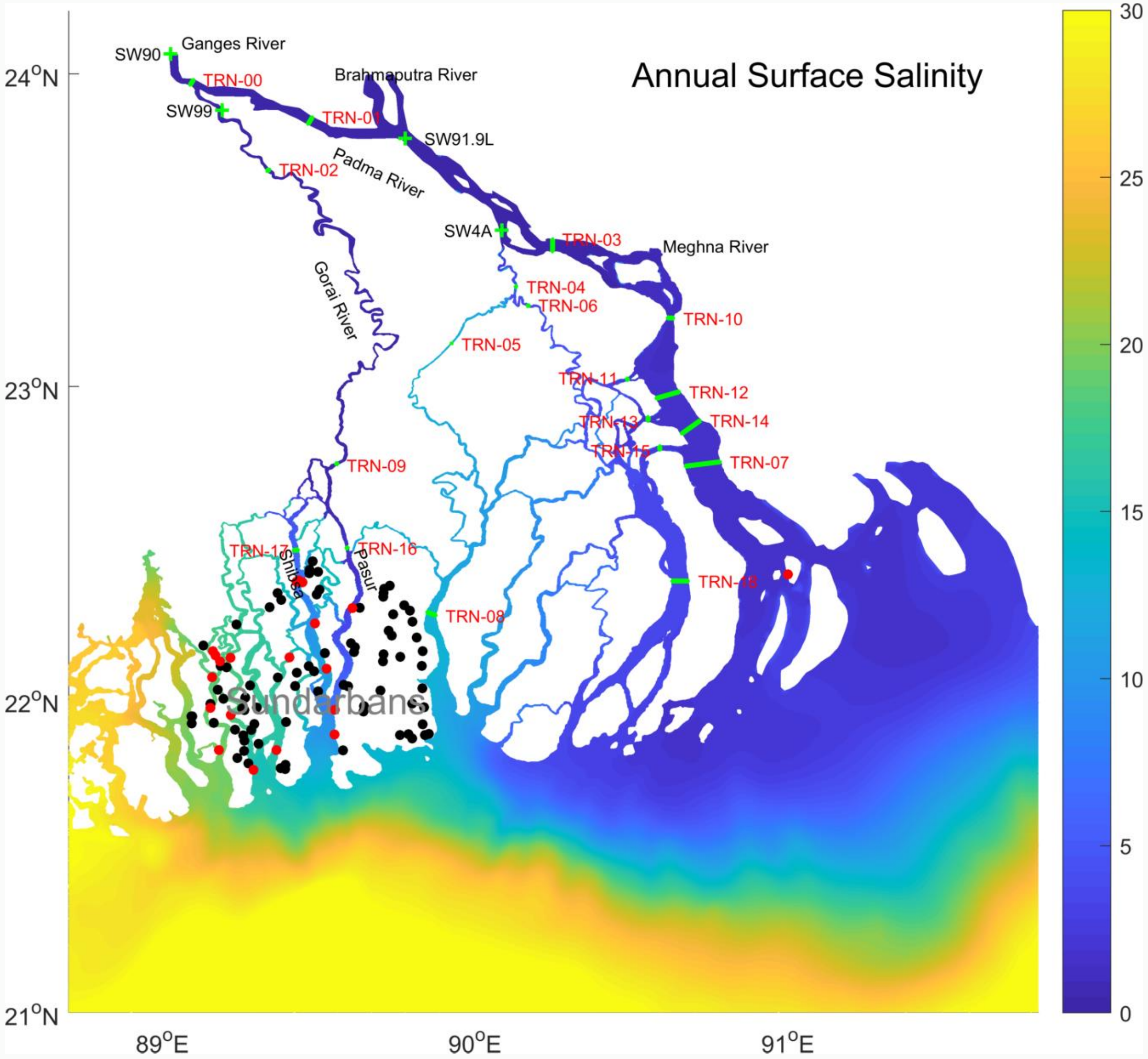
(3) The river forcing is a model climatology – we are missing real river discharge.

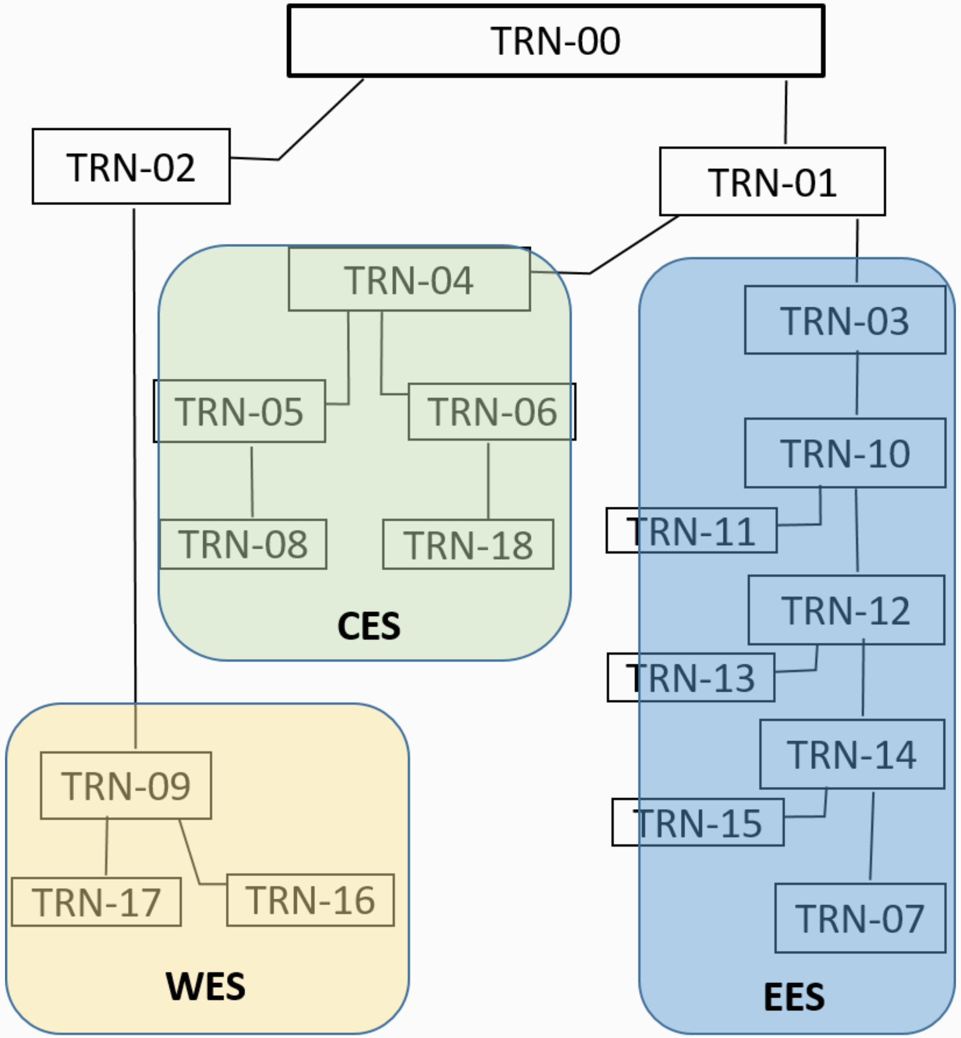
Scatterplots of (a) water salinity, between in situ observed salinity and simulated salinity; (b) water density, between observations and simulations; (c) observational water density calculated with real temperature and with constant temperature of 22 ^{o}C.



River flow network model

To summarise the flow in the delta, we chose **19** transects which best represent the main channels.

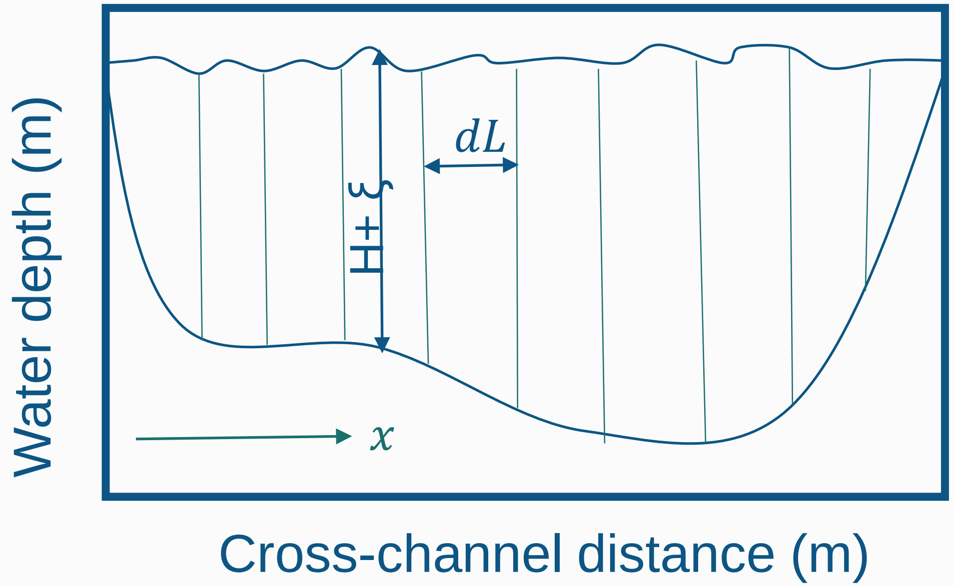




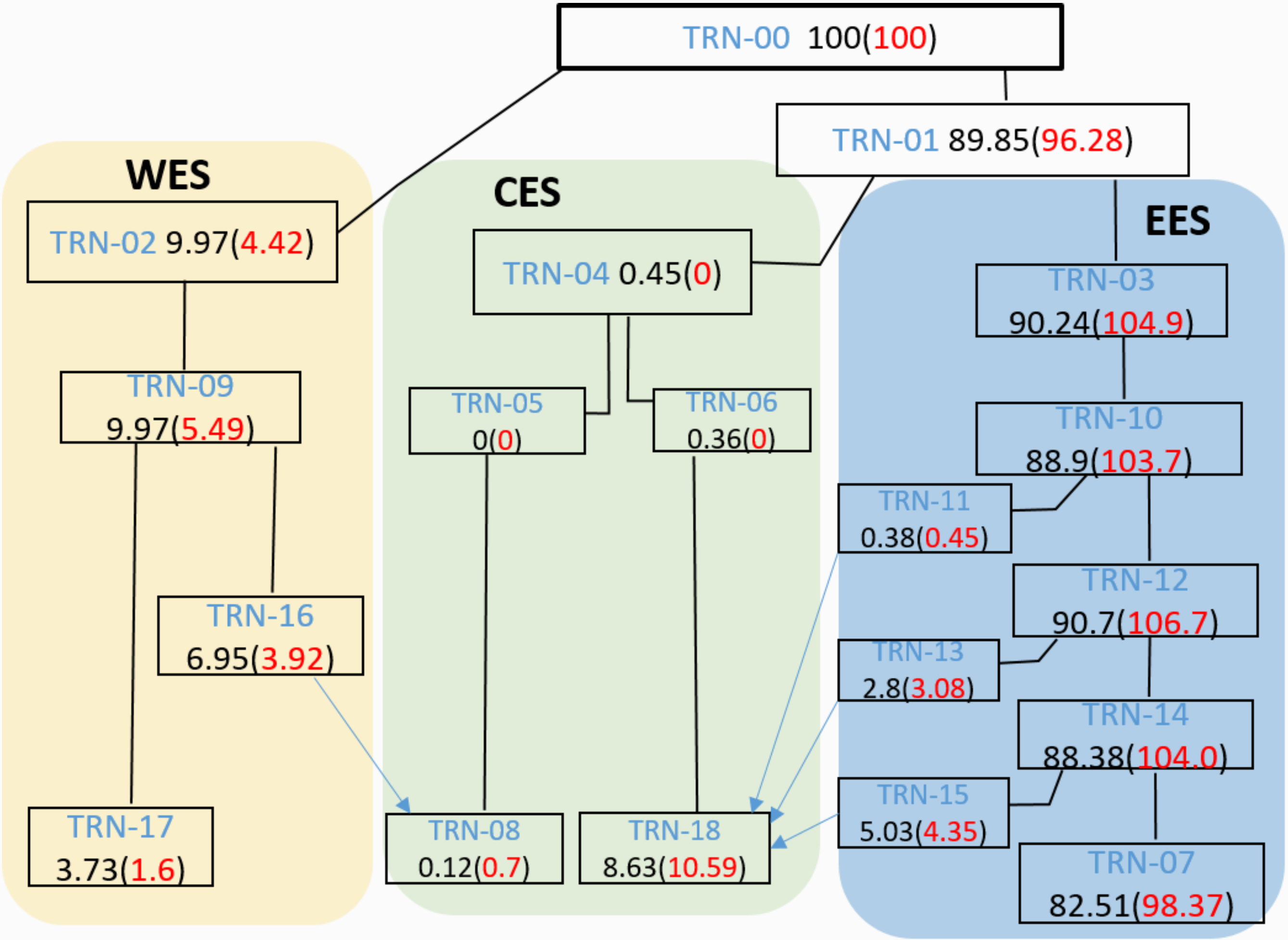
<u>Method</u> to separate tidal & subtidal volume (salt) transports

$$F_{Vtot} = \int U^* \cdot dA,\ F_{Vr} = \langle F_{Vtot} \rangle,\ F_{Vtide} = F_{Vtot} - F_{Vr}$$
$$F_{Stot} = \int S \cdot U^* \cdot dA,\ F_{Sr} = \langle F_{Stot} \rangle,\ F_{Stide} = F_{Stot} - F_{Sr}$$

dA is the sub-sectional area
S is salinity
U^* is cross-sectional velocity
$< >$ is Low-pass filter
F_{Vtot}, F_{Stot} is instantaneous transports
F_{Vr}, F_{Sr} is subtidal (residual) transports
F_{Vtide}, F_{Stide} is tidal transports.



River flow budget in wet and dry seasons



Method to separate subtidal transports *(Lerczak et al., 2006)*

$$\phi_o = \frac{1}{A_o}\left\langle \int\int \phi(y,z,t)\,dA \right\rangle$$

$$\phi_\varepsilon(\lambda,\sigma) = \left\langle \frac{h+\xi}{h}\phi \right\rangle - \phi_o,$$

$$\phi_T(\lambda,\sigma,t) = \phi - \phi_o - \phi_\varepsilon,$$

$$A_o = \int dA = \int \big(H + \xi(x)\big)dL$$

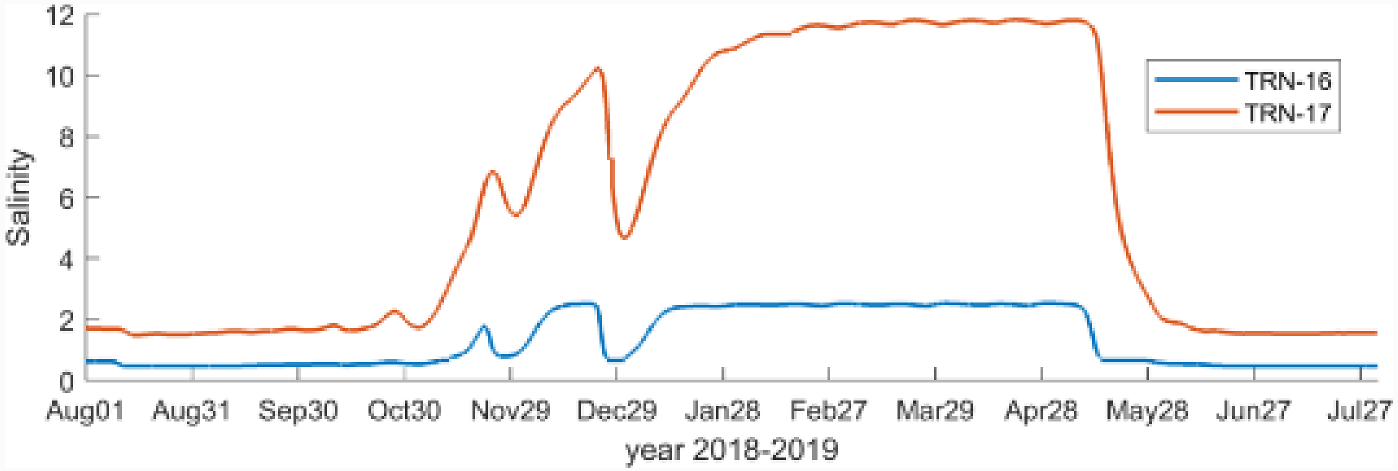
ϕ : refers to either *u* or *S;*
ϕ_o : tidally-averaged and cross-sectionally averaged;
ϕ_ε : tidally-averaged and cross-sectionally varing;
ϕ_T : tidally and cross-sectionally varing;
A_o : the low-passed cross-sectional area;
$< >$: a low-pass filter.

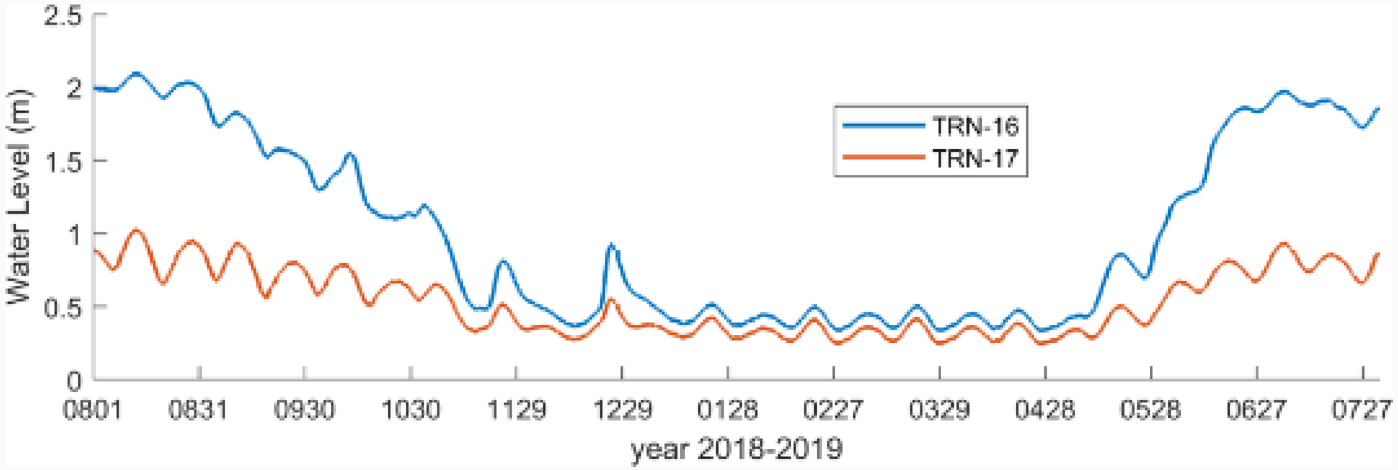
$$F_{Sr} = <\iint (u_o + u_e + u_T)(S_o + S_e + S_T)dA>$$

$$= <\iint (\underbrace{u_o S_o}_{C1} + \underbrace{u_e S_e}_{C2} + \underbrace{u_T S_T}_{C3} + u_o S_e + u_e S_o + u_o S_T + u_T S_o + u_e S_T + u_T S_e)dA>$$

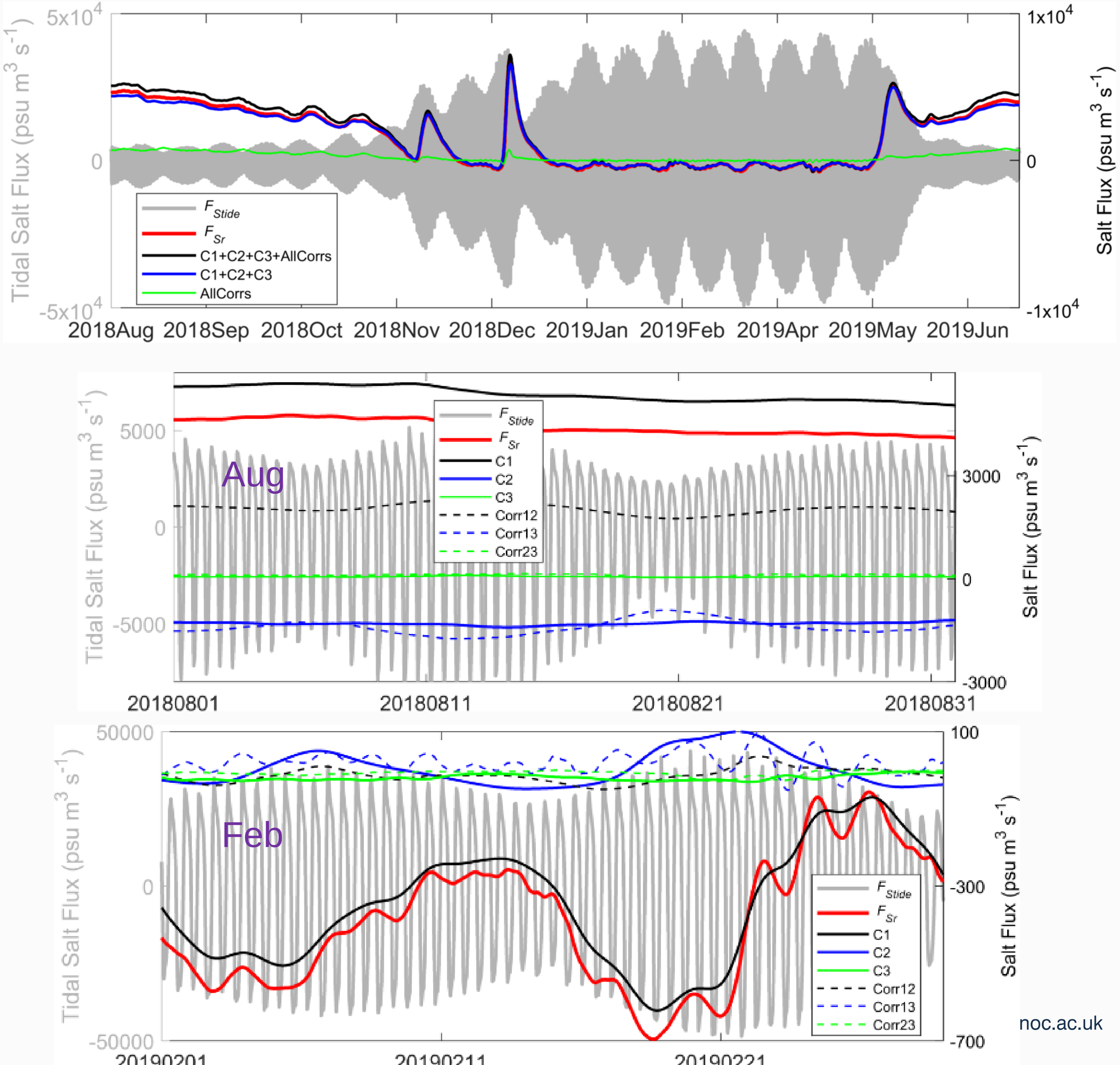
Correlation terms

Salt Intrusion in WES





Salt Intrusion in WES



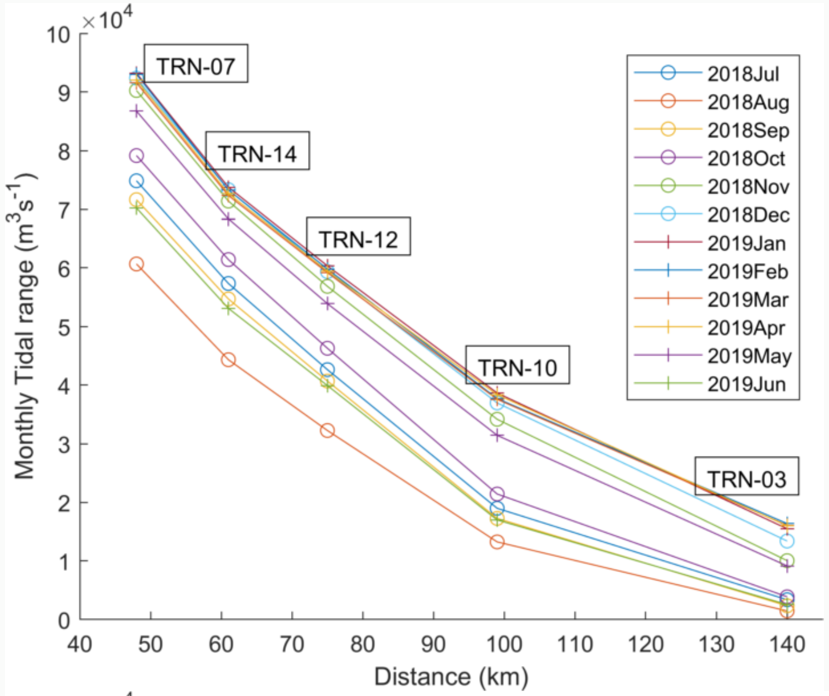
Tidal propagation in EES

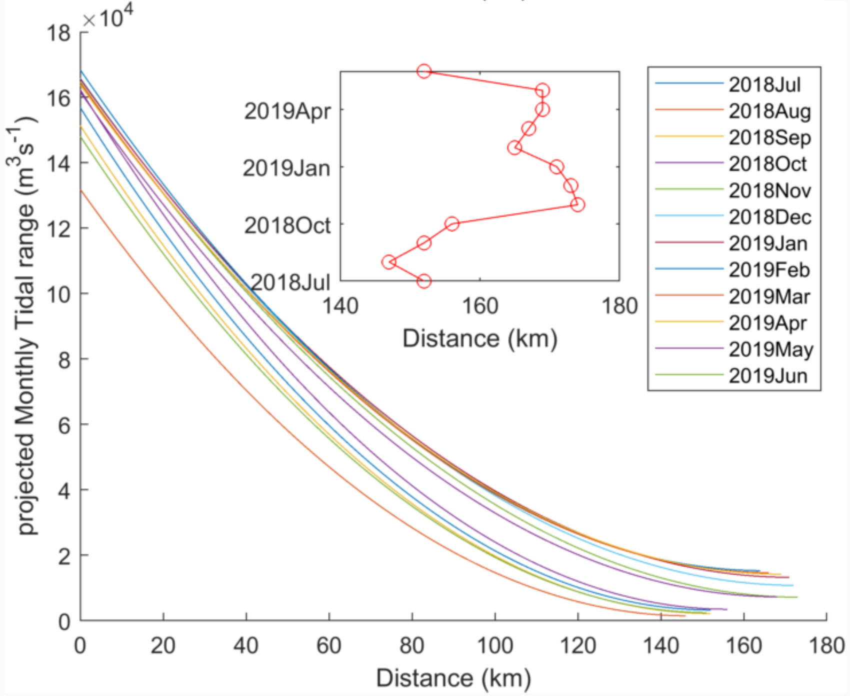
$$|F_{Vtide}(x)| = |F_{Vtide}(0)|\, e^{rx}$$

$$|F_{Vtide}(x)| = |F_{Vtide}(0)| \left(1 + rx + \frac{(rx)^2}{2!} + \cdots\right)$$

$R_{Vtide} = ax^2 + bx + c$, where $(\frac{dR_{Vtide}}{dx} < 0)$

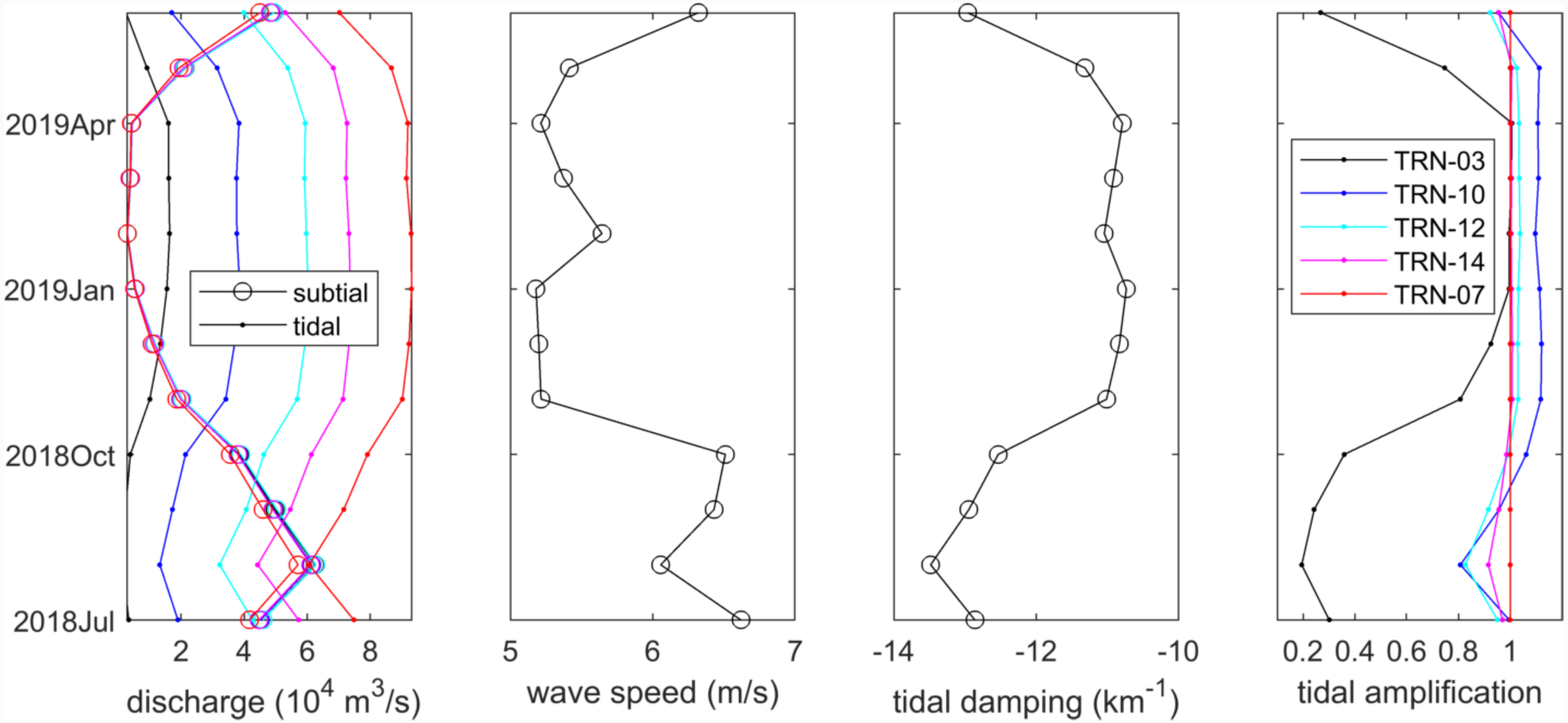
$|F_{Vtide}(0)|$ represents the amplitude of F_{Vtide} at river mouth. r is the damping modulus (m^{-1}). R_{Vtide} represents the range of F_{Vtide}. a (with units m/s) is the tidal wave speed, b (with units m^2/s) is the diffusive coefficient, and c (with units m^3/s) is the range of tidal discharge at river mouth.





Tidal propagation in EES

We introduce a coefficient $\gamma = \frac{b}{c}$, which physically represents the tidal damping scale of tidal discharge.



Conclusions

1. Simplify the complex channels in Bangladesh delta, to a river flow network model, by selecting 19 in total transects. Thus, the river flow budget at three Estuary systems can be estimated in both dry and wet seasons.
2. Strong seasonal variations of river discharge corresponds to the seasonal tidal transports.
3. Severe salt intrusion happens in Western Estuary System in dry season, with salinity increasing by 10 psu. Subtidal salt flux varies fortnightly in February, attributed to the effect of the compound tidal signals, while fluctuations are caused by the interactions of river discharge and sub-sectional variations.
4. Tidal propagation is examined by fitting the tidal discharge Range to a quadratic equation of distance from river mouth. Then, the tidal propagation parameters (maximum distance of tidal propagation, tidal wave speed, tidal damping coefficient of tidal discharge)can be estimated.

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Thank you!

YUSUN@NOC.AC.UK