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Thermodynamics of saline and fresh water mixing in estuaries

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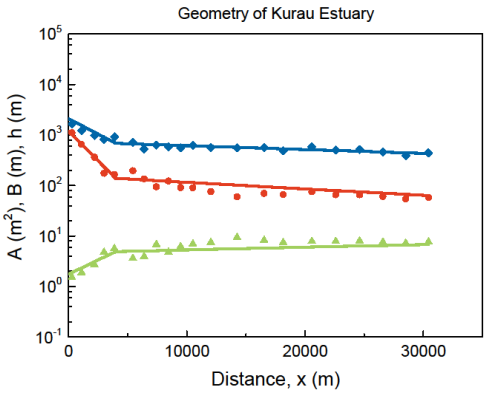
Supplement with " **Thermodynamics of Saline and Fresh Water Mixing in Estuaries** "

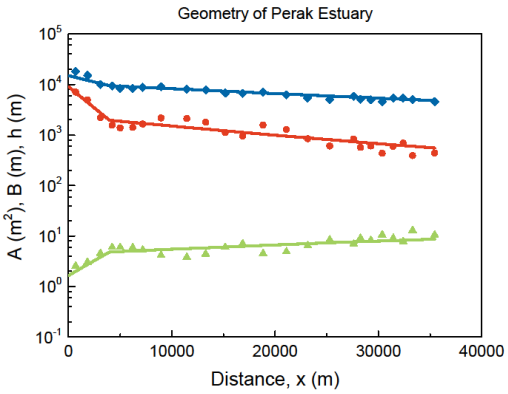
By: Zhilin Zhang and Hubert H.G. Savenije

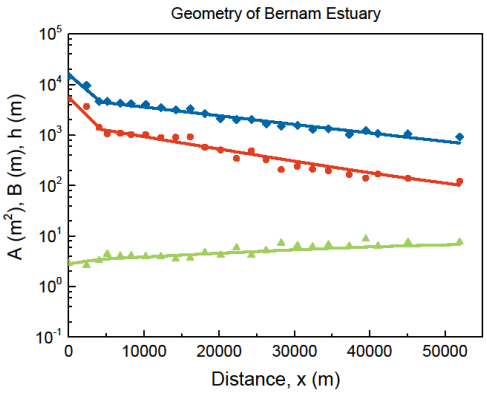
In this supplement we present the geometry of 23 estuaries in our database and the application of the new equation for the dispersion based on the maximum power (MP) concept in these estuaries.

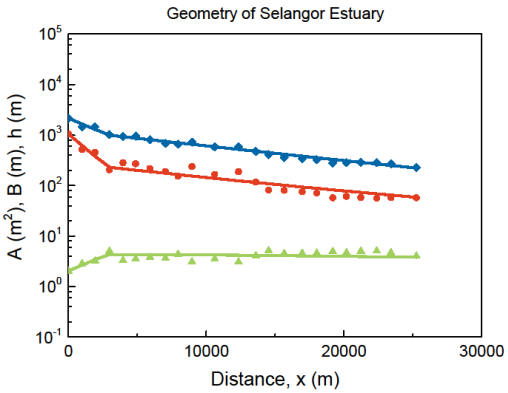
The geometrical data of the estuaries are presented in the Table S1, containing the cross-sectional convergence length of the seaward segment a_0, the cross-sectional area at the inflection point A_1, the cross-sectional convergence length of the main estuary segment a_1, the cross-sectional area of the river reach A_f, the same variables for the width, the location of the inflection point x_1, and the depth at the inflection point h_1.

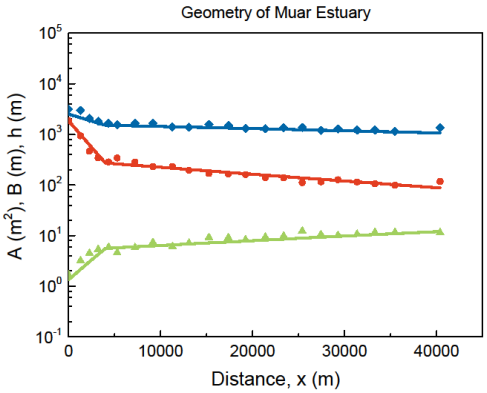
Table S2 presents the data for the applications of the MP equation to observations of salinity distributions in these estuaries. The table presents: the label referring to the estuary in Table S1, the date of observation, the tidal excursion E_0 , the tidal period T, the river discharge Q, the damping of the tidal wave δ_H, the salinity at the inflection point S_1, the boundary condition at the inflection point D_1, which follows from calibration.

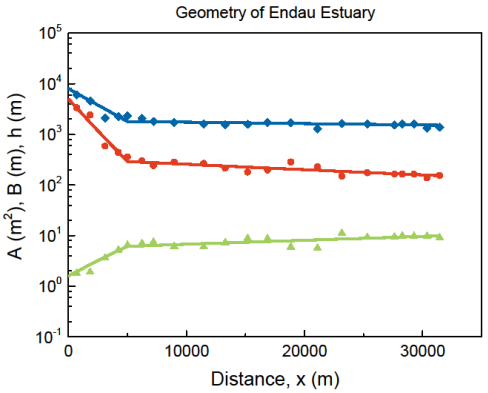

Geometry of Kurau Estuary
A (m²), B (m), h (m)
Distance, x (m)

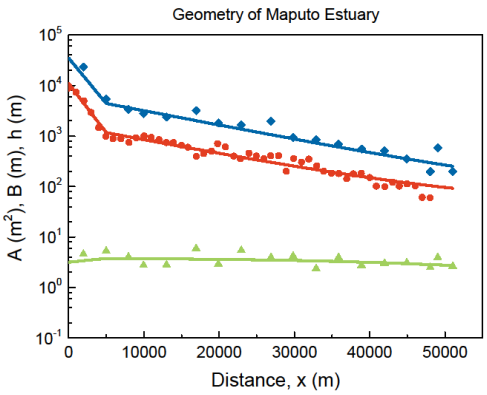

Geometry of Perak Estuary
A (m²), B (m), h (m)
Distance, x (m)

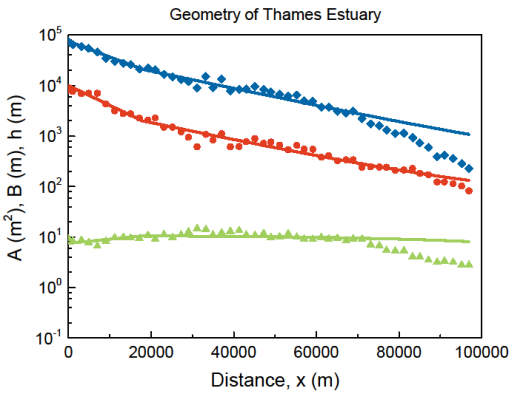

Geometry of Bernam Estuary
A (m²), B (m), h (m)
Distance, x (m)

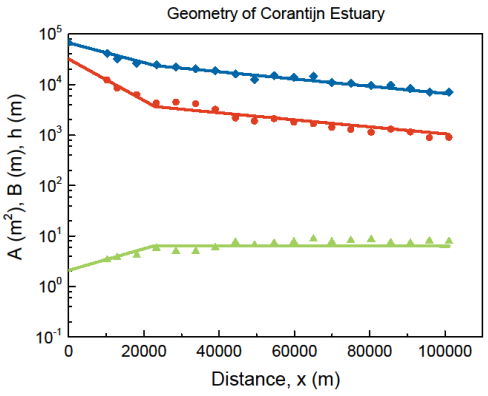

Geometry of Selangor Estuary
A (m²), B (m), h (m)
Distance, x (m)

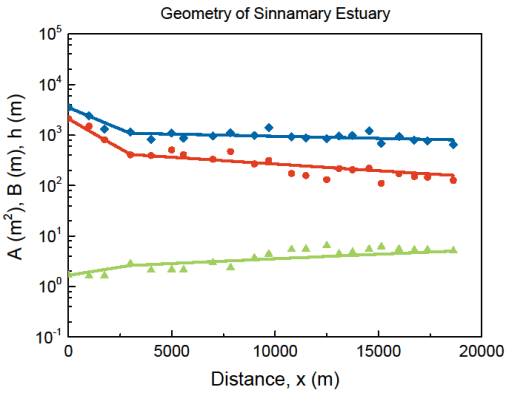

Geometry of Muar Estuary
A (m²), B (m), h (m)
Distance, x (m)

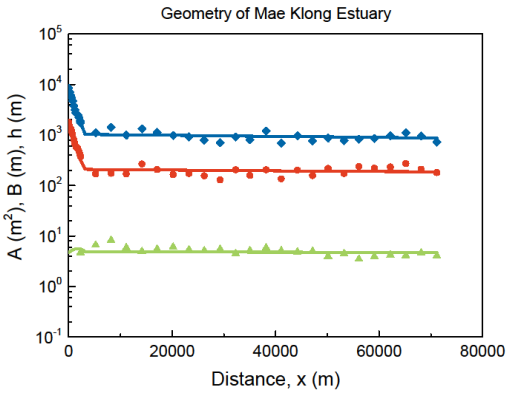

Geometry of Endau Estuary
A (m²), B (m), h (m)
Distance, x (m)

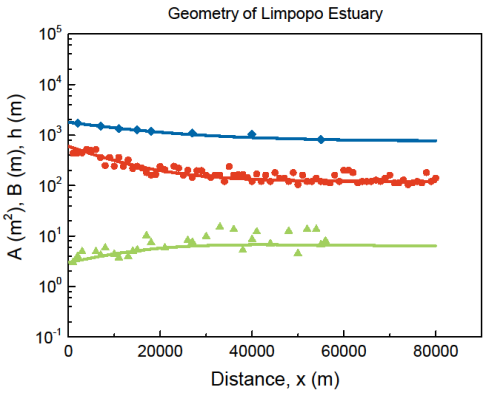

Geometry of Maputo Estuary
A (m²), B (m), h (m)
Distance, x (m)

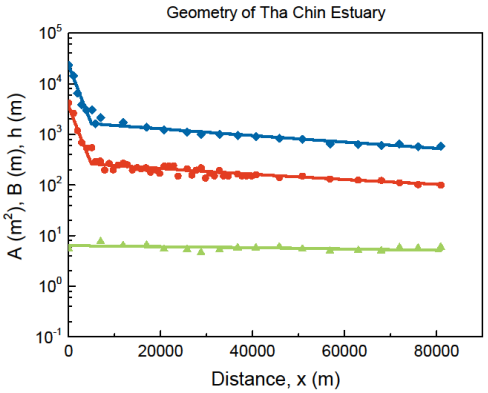

Geometry of Thames Estuary
A (m²), B (m), h (m)
Distance, x (m)

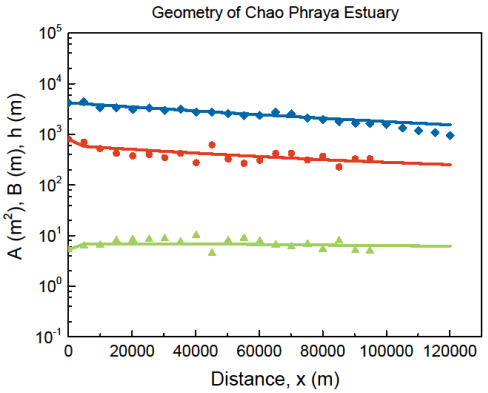

Geometry of Corantijn Estuary
A (m²), B (m), h (m)
Distance, x (m)

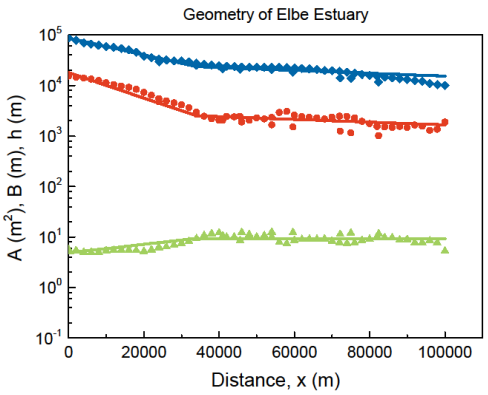

Geometry of Sinnamary Estuary
A (m²), B (m), h (m)
Distance, x (m)

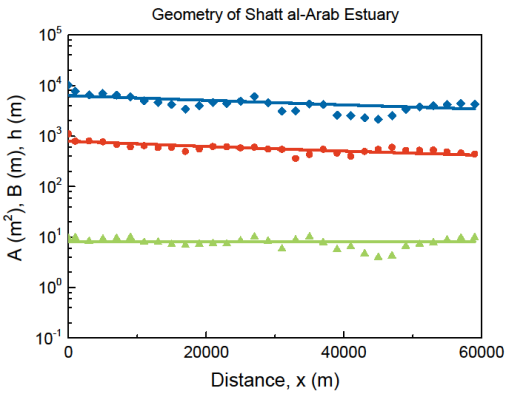

Geometry of Mae Klong Estuary
A (m²), B (m), h (m)
Distance, x (m)


Geometry of Limpopo Estuary
A (m²), B (m), h (m)
Distance, x (m)


Geometry of Tha Chin Estuary
A (m²), B (m), h (m)
Distance, x (m)


Geometry of Chao Phraya Estuary
A (m²), B (m), h (m)
Distance, x (m)


Geometry of Elbe Estuary
A (m²), B (m), h (m)
Distance, x (m)


Geometry of Shatt al-Arab Estuary
A (m²), B (m), h (m)
Distance, x (m)

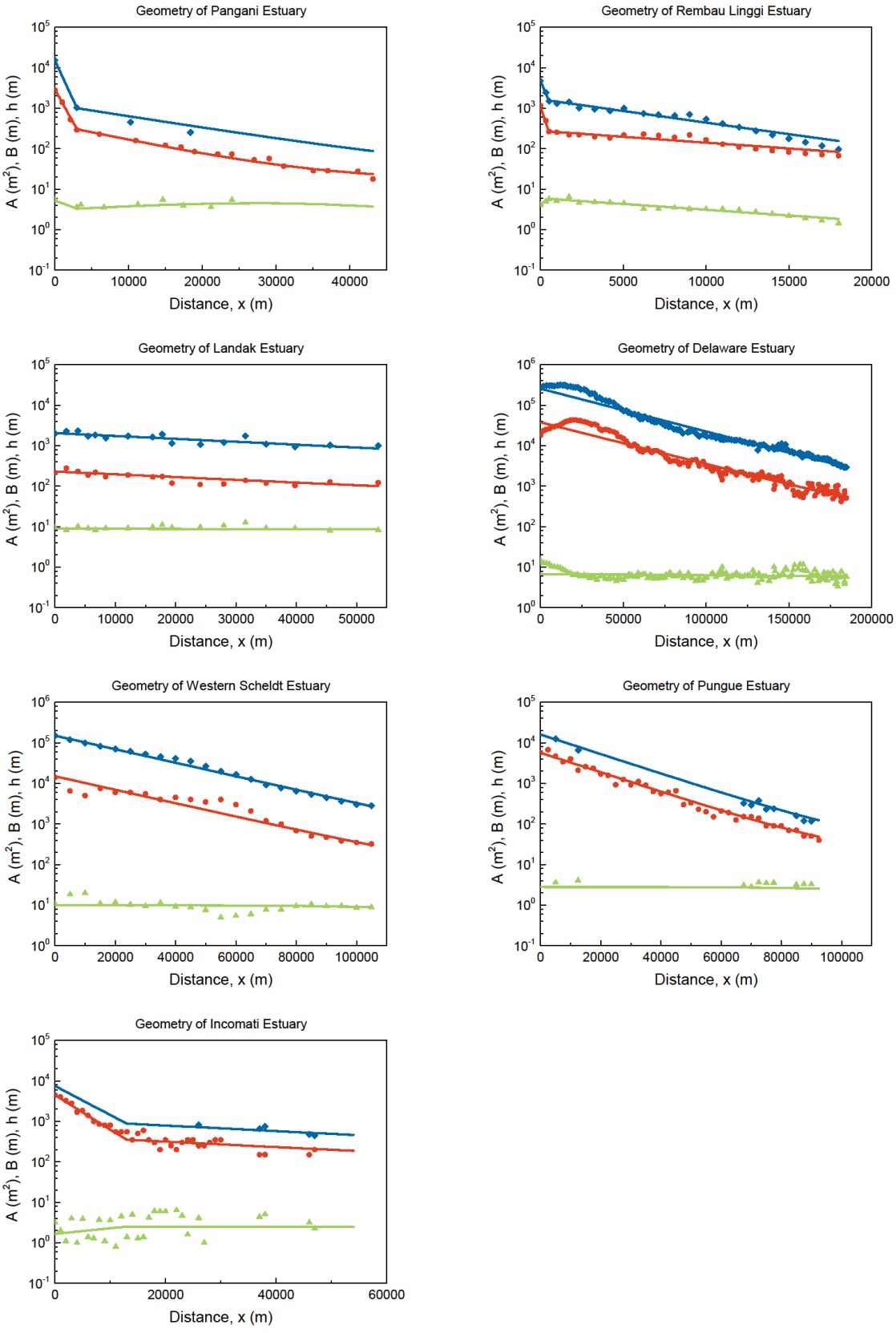
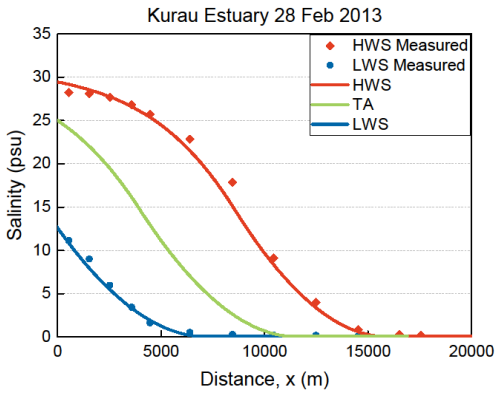
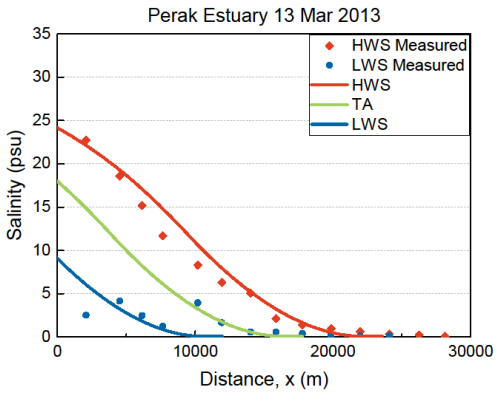
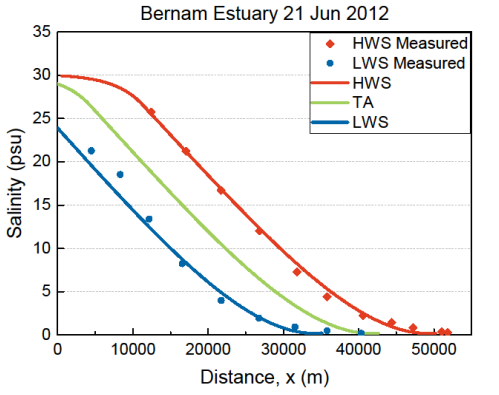
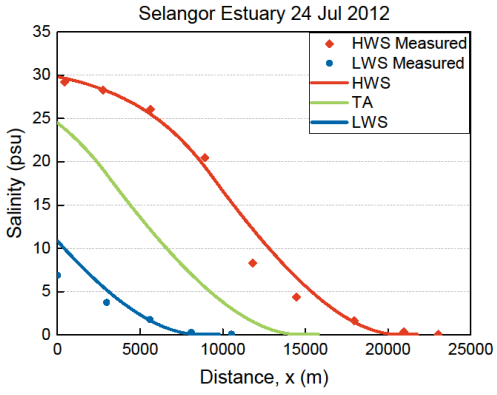


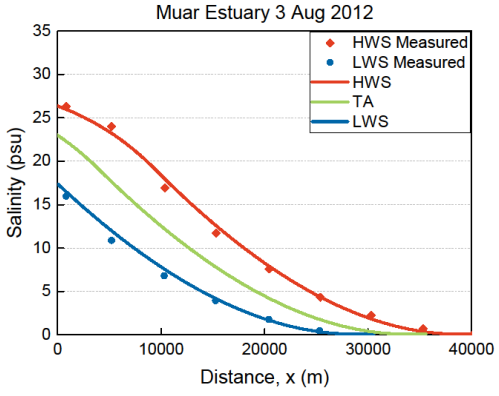
Figure S1. The geometrical data of the 23 estuaries

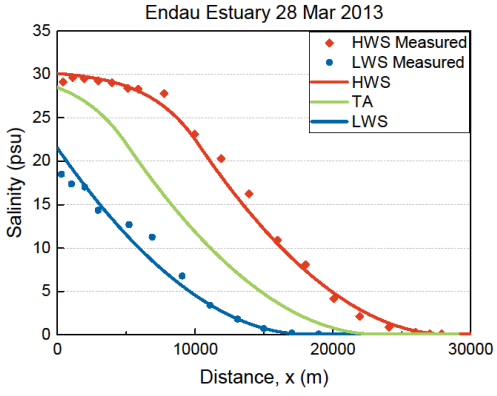

Kurau Estuary 28 Feb 2013
HWS Measured
LWS Measured
HWS
TA
LWS
Salinity (psu)
Distance, x (m)

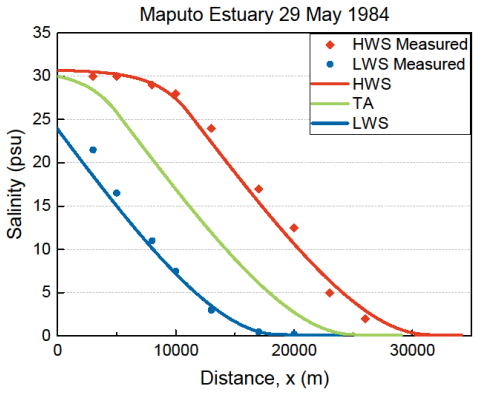

Perak Estuary 13 Mar 2013
HWS Measured
LWS Measured
HWS
TA
LWS
Salinity (psu)
Distance, x (m)


Bernam Estuary 21 Jun 2012
HWS Measured
LWS Measured
HWS
TA
LWS
Salinity (psu)
Distance, x (m)


Selangor Estuary 24 Jul 2012
HWS Measured
LWS Measured
HWS
TA
LWS
Salinity (psu)
Distance, x (m)


Muar Estuary 3 Aug 2012
HWS Measured
LWS Measured
HWS
TA
LWS
Salinity (psu)
Distance, x (m)


Endau Estuary 28 Mar 2013
HWS Measured
LWS Measured
HWS
TA
LWS
Salinity (psu)
Distance, x (m)


Maputo Estuary 29 May 1984
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HWS
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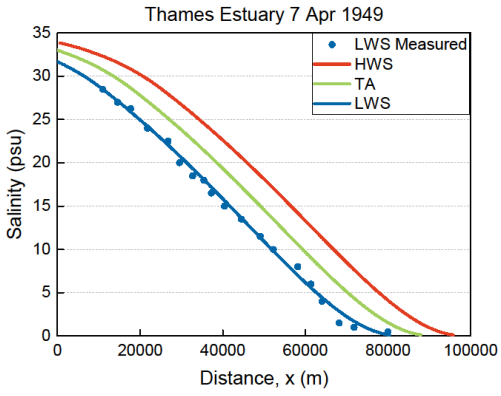
Salinity (psu)
Distance, x (m)


Thames Estuary 7 Apr 1949
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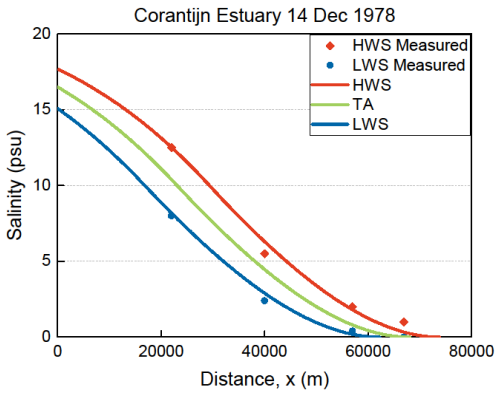
HWS
TA
LWS
Salinity (psu)
Distance, x (m)


Corantijn Estuary 14 Dec 1978
HWS Measured
LWS Measured
HWS
TA
LWS
Salinity (psu)
Distance, x (m)
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5
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15
20
0
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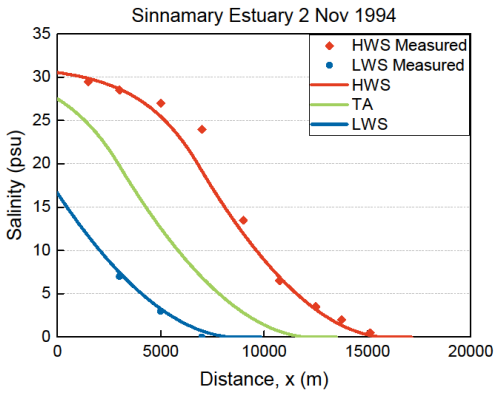
80000


Sinnamary Estuary 2 Nov 1994
HWS Measured
LWS Measured
HWS
TA
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Salinity (psu)
Distance, x (m)
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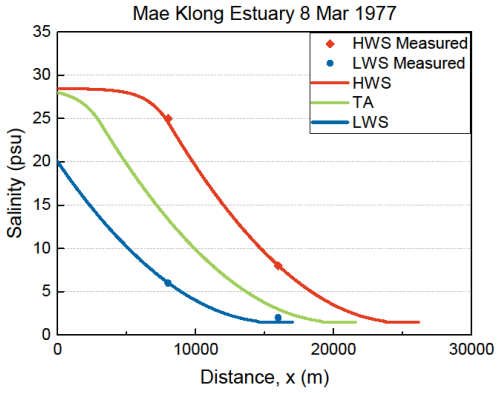
15000
20000


Mae Klong Estuary 8 Mar 1977
HWS Measured
LWS Measured
HWS
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Salinity (psu)
Distance, x (m)
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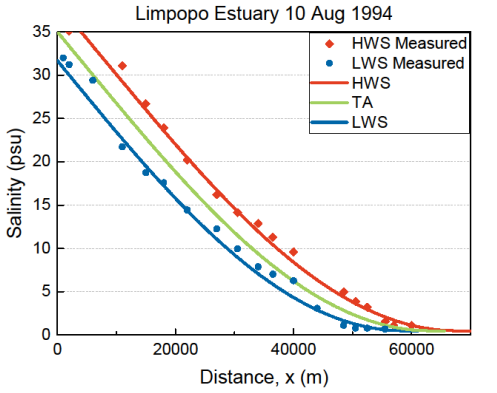
Limpopo Estuary 10 Aug 1994
HWS Measured
LWS Measured
HWS
TA
LWS
Salinity (psu)
Distance, x (m)
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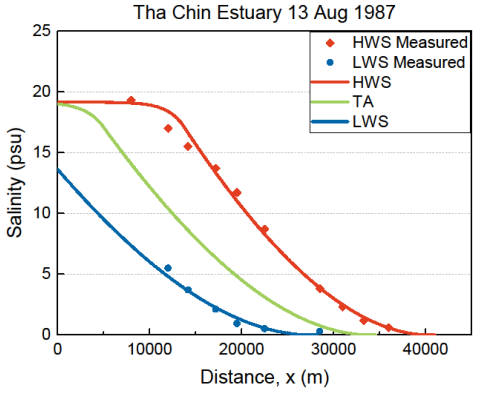
Tha Chin Estuary 13 Aug 1987
HWS Measured
LWS Measured
HWS
TA
LWS
Salinity (psu)
Distance, x (m)
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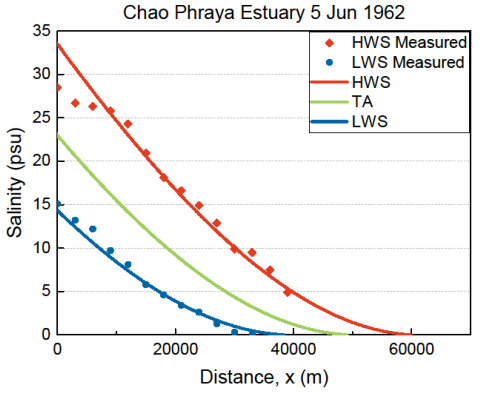
Chao Phraya Estuary 5 Jun 1962
HWS Measured
LWS Measured
HWS
TA
LWS
Salinity (psu)
Distance, x (m)
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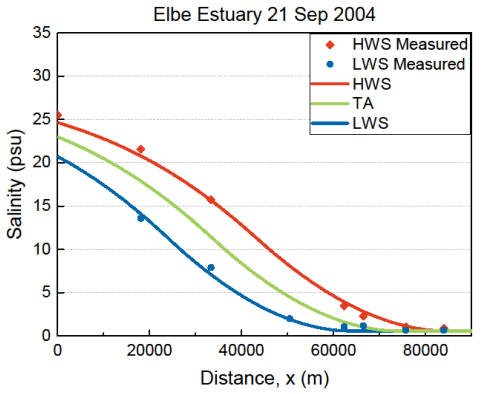
Elbe Estuary 21 Sep 2004
HWS Measured
LWS Measured
HWS
TA
LWS
Salinity (psu)
Distance, x (m)
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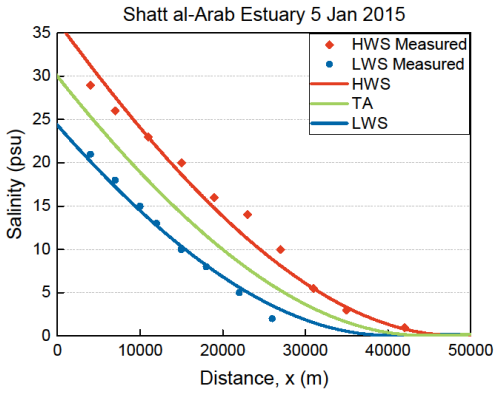
Shatt al-Arab Estuary 5 Jan 2015
HWS Measured
LWS Measured
HWS
TA
LWS
Salinity (psu)
Distance, x (m)
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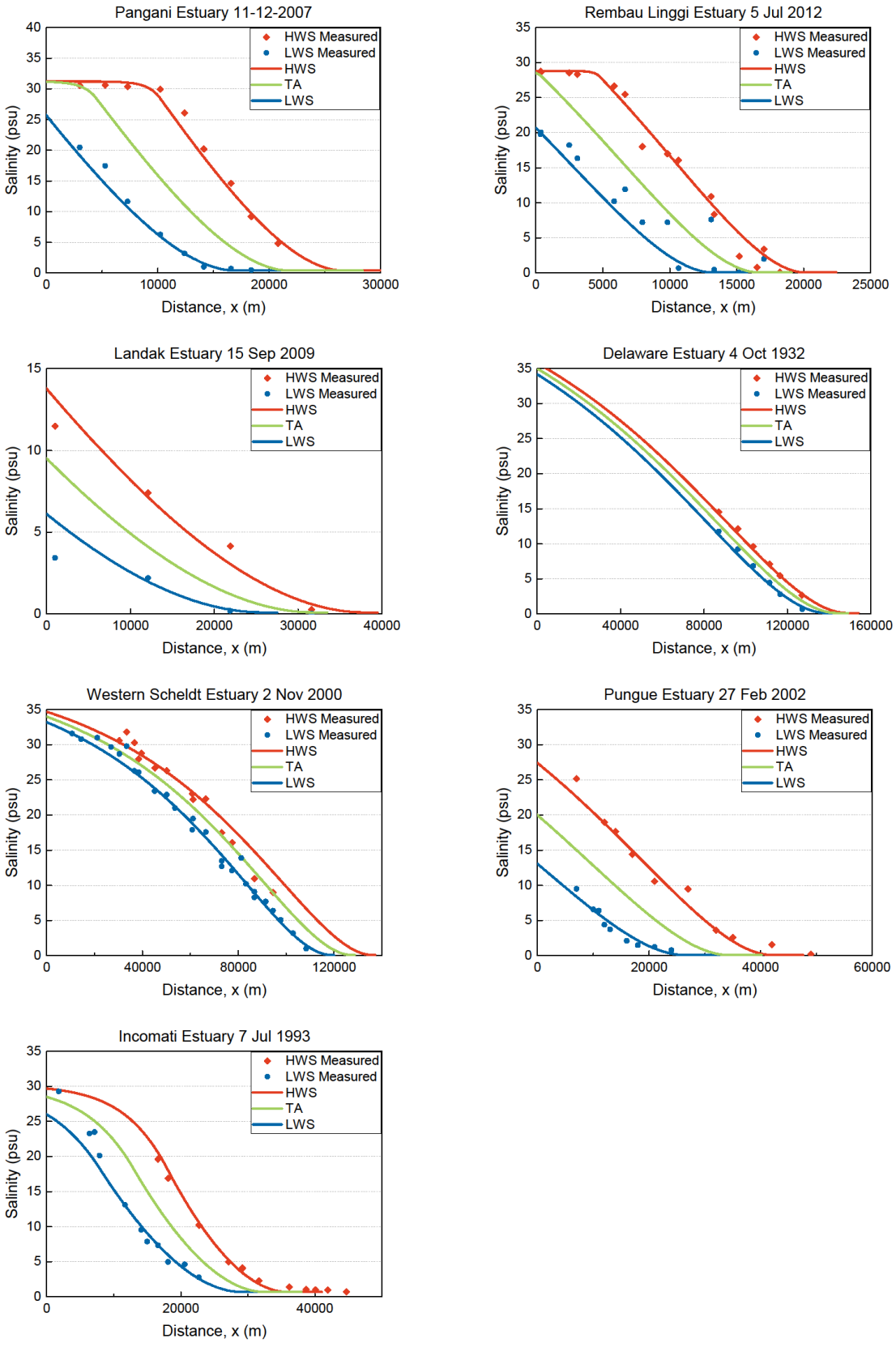

Figure S2. Applications of the MP equation in the 23 estuaries to observed salinity observations

Table S1. Geometrical data of 23 estuaries.

	Estuary	a_0	A_1	a_1	A_f	b_0	B_1	b_1	B_f	x_1	h_1
		m	m^2	m	m^2	m	m	m	m	m	m
1	Kurau	3500	683	55000	20	1800	139	30000	10	4000	4.9
2	Perak	8000	9452	40000	900	2500	1957	21000	150	4000	4.8
3	Bernam	3400	4482	25000	30	2900	1291	17000	25	4300	3.5
4	Selangor	3800	990	14000	25	1900	228	14000	15	3000	4.3
5	Muar	8000	1522	100000	15	2050	271	30000	10	4000	5.6
6	Endau	3300	1797	150000	50	1700	292	35000	30	5000	6.1
7	Maputo	2400	4402	15000	50	2200	1169	15000	40	5000	3.8
8	Thames	14000	20879	25000	200	11000	1987	25000	50	18000	10.5
9	Corantijn	22000	23650	60000	150	10500	3642	60000	70	23000	6.5
10	Sinnamary	2500	1082	50000	40	1800	413	15000	20	3000	2.6
11	Mae Klong	1350	1030	300000	260	1050	209	200000	130	3200	4.9
12	Limpopo	20000	1800	20000	750	11000	600	11000	120	0	3.0
13	Tha Chin	1850	1626	60000	90	1800	261	60000	40	5000	6.2
14	Chao Phraya	90000	4005	90000	600	12000	579	80000	150	5000	6.9
15	Elbe	26000	23674	150000	200	17000	2523	150000	100	34000	9.4
16	Shatt al-Arab	80000	6300	80000	800	60000	790	60000	200	0	8.0
17*	Pangani	1100	1000	15000	20	1300	303	11000	16	3000	3.3
18*	Rembau Linggi	450	1551	7500	5	350	267	14500	5	500	5.8
19*	Landak	60000	2050	60000	20	60000	230	60000	10	0	8.9
20*	Delaware	41000	255000	41000	180	42000	37655	42000	60	0	6.8
21*	Western Scheldt	26000	150000	26000	80	26000	15000	26000	40	0	10.0
22*	Pungwe	18000	16000	18000	30	18000	5700	18000	15	0	2.8
23*	Incomati	6000	886	60000	30	5000	353	60000	20	13000	2.5

Note: The estuaries with star-marked label are considered less reliable sets, while others are reliable sets.

Table S2. Data required for the application of the salt intrusion model to the observations in 23 estuaries

Label	Date	E_0	T	Q	δ_H	S_1	D_1
		m	s	m^3/s	(10^{-6}) 1/m	psu	m^2/s
1	28/02/2013	9400	44440	50	-6.3	16.1	309
2	13/03/2013	11000	44440	316	3	11.7	228
3	21/06/2012	14000	44400	42	1.7	26.5	261
4	24/07/2012	12700	44440	42	-3.7	18.5	310
5	03/08/2012	11000	44440	35	-2.68	19.1	370
6	28/03/2013	10500	44400	54	-1.3	18.0	261
7a	28/04/1982	13000	44440	25	2	28.9	74
7b	15/07/1982	8000	44440	8	2	31.9	43
7c	19/04/1984	13000	44440	120	2	22.0	284
7d	17/05/1984	13000	44440	50	2	24.1	129
7e	29/05/1984	12000	44440	40	2	25.8	130
8	07/04/1949	14000	44400	50	1.1	28.5	186
9a	09/12/1978	12000	44440	150	-1.7	11.6	157
9b	14/12/1978	13000	44440	130	-1.7	10.0	151
9c	20/12/1978	13000	44440	220	-1.7	8.4	231
10a	12/11/1993	8600	44440	168	-5	7.2	225
10b	27/04/1994	11000	44440	148	-5	5.6	189
10c	02/11/1994	7800	44440	112	-5	19.8	528
10d	03/11/1994	10000	44440	112	-5	13.8	343
11a	08/03/1977	10000	44400	60	-4.2	24.7	520
11b	09/04/1977	8000	44400	36	-4.2	26.2	493
12a	31/12/1982	8000	44440	2	1.7	35.0	55
12b	14/07/1994	7000	44440	5	1.7	35.0	85
12c	24/07/1994	8000	44440	5	1.7	35.0	100
12d	10/08/1994	8000	44440	3	1.7	35.0	70
13a	16/04/1981	15000	86400	55	-5.5	26.2	888
13b	27/02/1986	18500	44400	40	-10.6	22.8	479
13c	01/03/1986	14000	86400	40	-5.5	25.8	531
13d	13/08/1987	18500	44400	39	-10.6	17.1	396
14a	05/06/1962	24000	86400	63	-2.2	19.1	401
14b	16/01/1967	14000	86400	180	-2.2	8.7	503
14c	23/02/1983	19000	86400	100	-2.2	17.1	573
14d	29/01/1983	26000	86400	90	-2.2	20.3	641
15a	21/09/2004	20000	44440	200	2	11.2	185
15b	21/09/2004	18000	44440	200	2	11.1	185
16a	26/03/2014	10000	44000	114	-5	24.5	380
16b	16/05/2014	10000	44000	96	-5	29.0	380
16c	24/09/2014	15500	44000	58	-5	35.0	450
16d	05/01/2015	10000	44000	63	-5	30.0	250
17a	27/10/2007	14000	44440	15	-10	28.7	203
17b	11/12/2007	12000	44440	11	-10	28.4	130

18	05/07/2012	8700	44440	26	-14	27.9	246
19	15/09/2009	15000	86400	10	-6.7	9.5	90
20a	23/08/1932	8000	44440	120	0.7	13.0	100
20b	04/10/1932	9000	44440	72	0.7	35.0	55
21a	01/07/1987	10000	44440	90	2.8	31.0	150
21b	02/11/2000	12000	44440	220	2.8	34.0	400
22a	27/02/2002	21000	44440	200	-8.5	20.0	360
22b	01/03/2002	27000	44440	150	-8.5	20.0	420
23a	05/09/1982	9000	44440	2	-19.9	26.2	43
23b	23/06/1993	11000	44440	4	-19.9	20.2	49
23c	07/07/1993	13000	44440	4	-19.9	18.2	49