

# Supplementary Materials

**Table S1.** Water level stations in the Odra River mouth area and their specific long-term water levels over the period 2008/2009–2019/2020.

Station	Station code	Location <sup>1</sup>	Gauge null datum <sup>2</sup>	Min (cm)	Max (cm)	Range (cm)	STD (cm)
Świnoujście	SW	Pomeranian Bay, at 2.3 km of the Świnoujście-Szczecin Fairway	+3.20	−132	136	266	20.3
Dziwnów	DZ	Outlet of the Dziwna Strait into Pomeranian Bay	−0.95	−113	116	220	19.4
Trzebież	TR	Szczecin Lagoon, at 36.5 km of the Świnoujście-Szczecin Fairway	−5.00	−93	115	208	18.4
Wolin	WL	Outlet of the Dziwna Strait into Szczecin Lagoon	−5.00	−86	102	186	18
Szczecin (Long Bridge)	MD	At 37 km of Western Odra = 66.5 km of the Świnoujście-Szczecin Fairway	−5.00	−92	119	209	19.3
Szczecin (Podjuchy)	PD	Eastern Odra, at 734 km of the Odra Waterway	−5.01	−95	127	221	20.3
Gryfino	GR	Eastern Odra, at 718.5 km of the Odra Waterway	−5.00	−80	130	209	22.9
Widuchowa	WD	At 701.8 km of the Odra Waterway	−5.00	−113	219	331	34.3
Bielinek	BL	At 672.5 km of the Odra Waterway	−5.00	−162	375	537	93.6
Gozdowice	GZ	At 645.3 km of the Odra Waterway	−5.00	−145	301	446	78.4

<sup>1</sup>source: [18]

<sup>2</sup>source: [8], the Normall-Null (NN) ordnance datum

Min – the difference between minimum and mean values in years 2008/09 to 2019/20

Max – the difference between maximum and mean values in years 2008/09 to 2019/20

STD - standard deviation

**Table S2.** Principal component loadings (PC), eigenvalues and percentage of explained variance for water levels in the Odra River mouth area

Station	PC1 <sup>1</sup>	PC2
SW	<b>−0.846</b>	−0.349
DZ	<b>−0.868</b>	−0.373
TR	<b>−0.956</b>	−0.233
WL	<b>−0.943</b>	−0.248
MD	<b>−0.977</b>	−0.111
PD	<b>−0.970</b>	0.037
GR	<b>−0.918</b>	0.306
WD	−0.663	0.692
BL	−0.226	<b>0.952</b>
GZ	−0.203	<b>0.947</b>
Eigenvalue	6.544	2.767

Explained variance (%)	65.44	27.67
Explained cumulative variance (%)	65.44	93.11

Note: 1bold font denotes values exceeding 0.7

Table S3. Principal component loadings (PC), eigenvalues and percentage of explained variance for water levels in the Odra River mouth area during the periods with exceeded alarm level at Świnoujście

Station	PC1 <sup>1</sup>	PC2	PC3
SW	−0.362	−0.211	<b>−0.809</b>
DZ	−0.621	0.029	−0.626
TR	<b>−0.965</b>	−0.188	0.104
WL	<b>−0.959</b>	−0.124	0.042
MD	<b>−0.975</b>	−0.140	0.110
PD	<b>−0.962</b>	−0.157	0.135
GR	<b>−0.977</b>	0.030	0.162
WD	<b>−0.821</b>	0.425	0.206
BL	−0.172	<b>0.978</b>	−0.064
GZ	−0.103	<b>0.981</b>	−0.124
Eigenvalue	5.914	2.242	1.178
Explained variance (%)	59.14	22.42	11.78
Explained cumulative variance (%)	59.14	81.56	93.34

Note: 1bold font denotes values exceeding 0.7

Table S4. Principal component loadings (PC), eigenvalues and percentage of explained variance for water levels in the Odra River mouth area during the October 2009 storm surge

Station	A		B	
	PC1 <sup>1</sup>	PC2	PC1	PC2
SW	0.670	−0.607	<b>0.871</b>	−0.257
DZ	<b>0.796</b>	−0.505	<b>0.869</b>	−0.312
TR	<b>0.993</b>	−0.003	<b>0.991</b>	−0.041
WL	<b>0.984</b>	0.015	<b>0.985</b>	−0.039
MD	<b>0.995</b>	−0.004	<b>0.993</b>	−0.038
PD	<b>0.994</b>	0.028	<b>0.992</b>	0.005
GR	<b>0.989</b>	0.071	<b>0.990</b>	0.028
WD	<b>0.982</b>	0.125	<b>0.985</b>	0.080
BL	<b>0.807</b>	0.574	<b>0.802</b>	0.570
GZ	0.134	<b>0.876</b>	0.044	<b>0.968</b>
Eigenvalue	7.628	1.743	8.032	1.436
Explained variance (%)	76.28	17.43	80.32	14.36
Explained cumulative variance (%)	76.28	93.7	80.32	94.68

Note:

A – synchronous correlations

B – correlations incorporating k=10 hour offset for SW series and k=5 hour offset for DZ series

<sup>1</sup>bold font denotes values exceeding 0.7

Table S5. Principal component loadings (PC), eigenvalues and percentage of explained variance for water levels in the Odra River mouth area during the February 2011 storm surge

Station	A		B	
	PC1 <sup>1</sup>	PC2	PC1	PC2
SW	0.365	<b>−0.839</b>	<b>−0.816</b>	−0.330
DZ	0.447	<b>−0.843</b>	<b>−0.890</b>	−0.320
TR	<b>0.967</b>	−0.191	<b>−0.969</b>	−0.176
WL	<b>0.952</b>	−0.204	<b>−0.948</b>	−0.229
MD	<b>0.967</b>	−0.158	<b>−0.972</b>	−0.122
PD	<b>0.976</b>	−0.066	<b>−0.980</b>	−0.035
GR	<b>0.950</b>	0.226	<b>−0.936</b>	0.248
WD	<b>0.829</b>	0.472	<b>−0.780</b>	0.464
BL	−0.648	−0.595	0.383	<b>−0.882</b>
GZ	−0.532	−0.541	0.189	<b>−0.863</b>
Eigenvalue	6.354	2.443	6.868	2.111
Explained variance (%)	63.54	24.43	68.68	21.11
Explained cumulative variance (%)	63.54	87.98	68.68	89.79

Note:

A – synchronous correlations

B – correlations incorporating k=7 hour offset for SW and DZ series

<sup>1</sup>bold font denotes values exceeding 0.7

Table S6. Principal component loadings (PC), eigenvalues and percentage of explained variance for water levels in the Odra River mouth area during the January 2019 storm surge

Station	A		B	
	PC1 <sup>1</sup>	PC2	PC1	PC2
SW	−0.637	<b>0.750</b>	<b>−0.943</b>	0.236
DZ	<b>−0.707</b>	0.689	<b>−0.876</b>	0.373
TR	<b>−0.983</b>	−0.062	<b>−0.991</b>	0.042
WL	<b>−0.973</b>	−0.152	<b>−0.983</b>	−0.050
MD	<b>−0.989</b>	−0.001	<b>−0.985</b>	0.122
PD	<b>−0.989</b>	−0.003	<b>−0.985</b>	0.118
GR	<b>−0.990</b>	−0.055	<b>−0.988</b>	0.047
WD	<b>−0.986</b>	−0.096	<b>−0.985</b>	−0.004
BL	<b>−0.892</b>	−0.421	<b>−0.858</b>	−0.436
GZ	<b>−0.790</b>	−0.289	−0.616	<b>−0.727</b>
Eigenvalue	8.149	1.336	8.609	0.949
Explained variance (%)	81.49	13.36	86.09	9.49

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Explained cumulative variance (%)	81.49	94.85	86.09	95.58
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Note:

A – synchronous correlations

B – correlations incorporating k=11 hour offset for SW series and k=8 hour offset for DZ series

<sup>1</sup>bold font denotes values exceeding 0.7