

Supplementary material

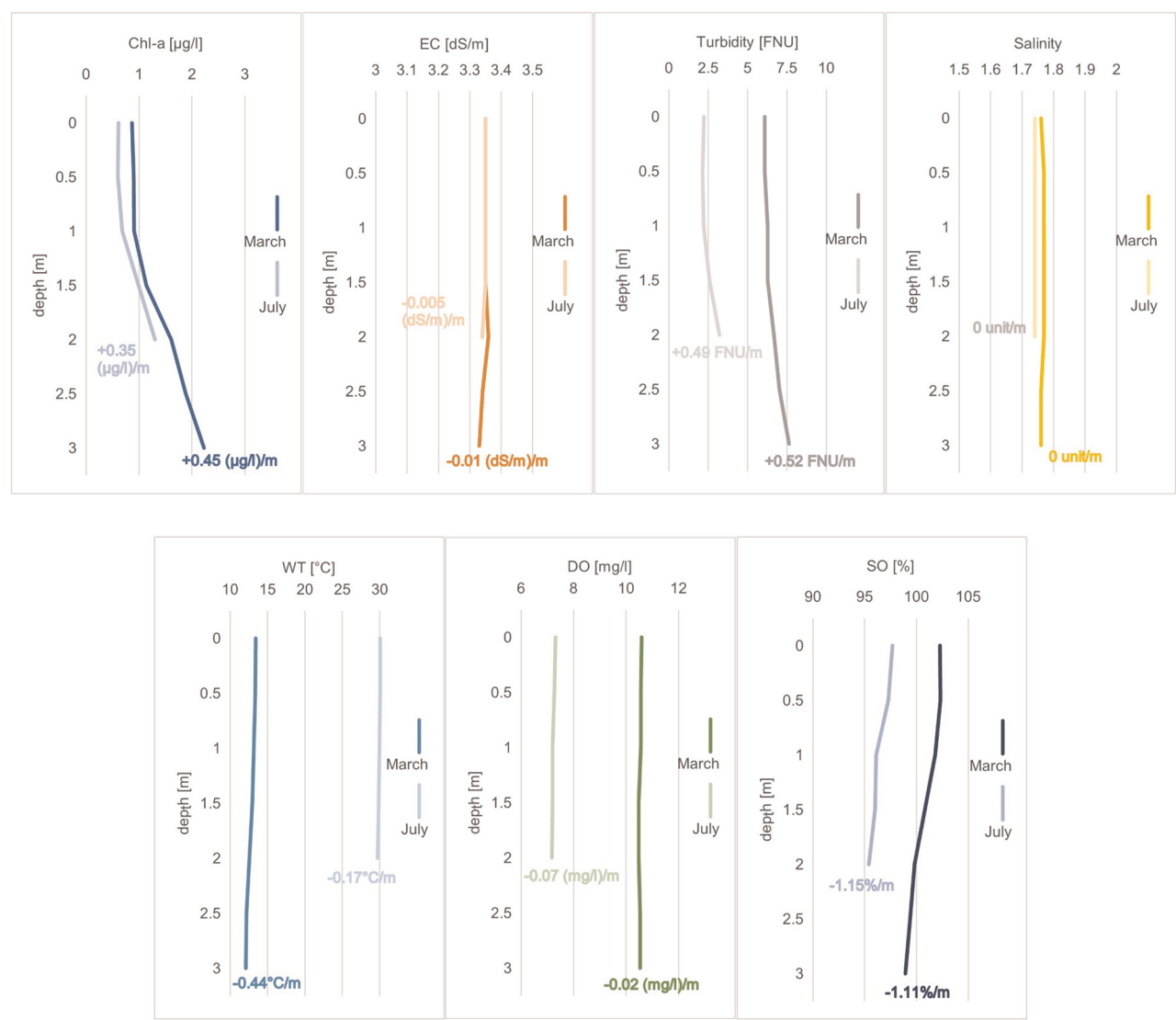


Figure S1: Vertical profiles of average parameter values measured every 30 min in March and July.

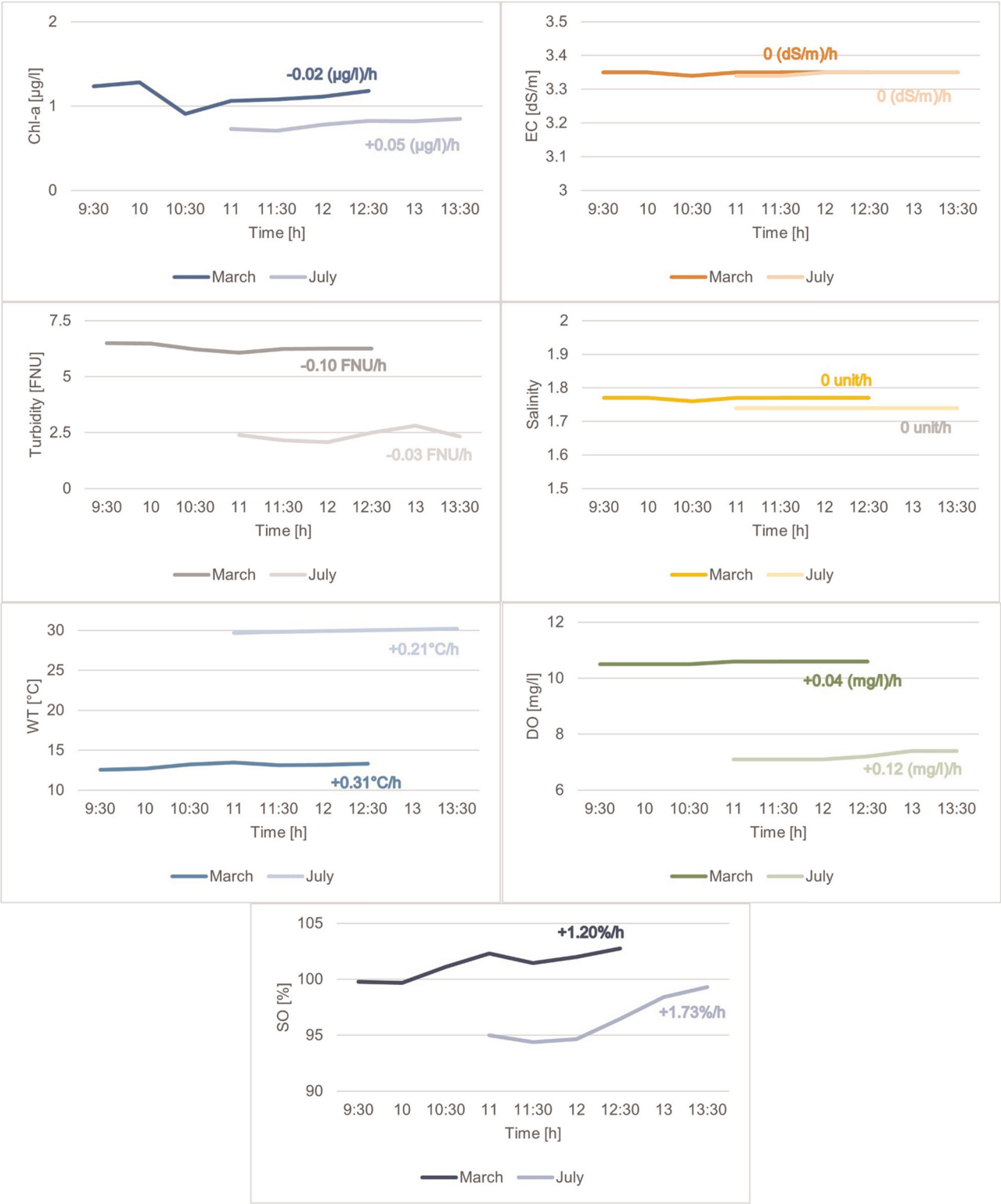


Figure S2: Temporal variation of median parameter values measured every 30 min in March and July.



Figure S3: Visualisation of RMSE (columns) and ME (lines) for various GIS spatial interpolation methods (SK – Simple Kriging, OK – Ordinary Kriging, UK – Universal Kriging, EBK – Empirical Bayesian Kriging, LPI – Local Polynomial Interpolation, IDW – Inverse Distance Weighted, GPI – Global Polynomial Interpolation) across different parameters: (a) Chl-a, (b) electrical conductivity, (c) turbidity, (d) salinity, (e) water temperature, (f) dissolved oxygen, and (g) oxygen saturation.

Table S1: Historical meteorological and water level data for Vrana Lake from 1990 to 2023

Type	Year	AT [°C]	PP [mm]	WL [m]
Historical data	1990	15.27	635	0.28
	1991	14.30	779	0.65
	1992	15.30	890	0.74
	1993	14.90	948	0.90
	1994	15.90	725	1.06
	1995	14.70	965	0.69
	1996	14.70	1024	0.96
	1997	14.90	524	0.81
	1998	15.28	753	0.91
	1999	15.10	846	1.07
	2000	15.60	834	1.06
	2001	15.10	710	1.32
	2002	15.40	840	0.59
	2003	15.70	612	0.91
	2004	14.90	1021	1.09
	2005	14.30	1123	1.09
	2006	14.90	664	1.21
	2007	15.70	516	0.49
	2008	15.70	634	0.32
	2009	15.50	1083	1.08
	2010	14.90	1036	1.09
	2011	15.90	436	0.56
	2012	15.73	700	0.31
	2013	15.63	1076	1.17
	2014	16.18	1269	1.39
	2015	15.99	849	1.13
	2016	15.87	791	0.94
	2017	15.70	829	0.63
	2018	16.39	1011	1.21
	2019	16.28	882	0.66
	2020	16.16	703	0.76
	2021	15.91	850	0.86
	2022	16.65	646	0.64
	2023	16.80	1007	1.12
Trends	Annually	+0.05°C/a	+2.28 mm/a	+3.12 mm/a
	Total	+1.54°C	+77.50 mm	+106.20 mm

Table S2: Meteorological and water level data for Vrana Lake for research period

Representative month	Measurement date	AT [°C]	WS [Beaufort number]	RH [%]	AP [hPa]	WL [m]	PP [mm]	PP [mm] – cube root transformation	SH [h]
Jul-23	17.07.2023	29.4	1.7	53	1015.5	1.12	0	0	13.7
Aug-23	18.08.2023	26.5	2.0	64	1013.3	0.90	0	0	12.4
Sep-23	27.09.2023	24.4	2.3	46	1015.4	0.75	11	2.22398	10.2
Oct-23	13.10.2023	19.3	1.7	85	1020.2	0.69	0	0	8.4
Nov-23	04.12.2023	5.8	1.7	56	1019.7	0.97	9	2.06456	5.6
Dec-23	19.12.2023	9.3	1.0	87	1022.5	1.15	0	0	7.8
Jan-24	11.01.2024	3.3	1.3	69	1021.2	1.15	0	0	8.3
Feb-24	19.02.2024	11.6	1.7	66	1022.3	1.29	0	0	2.4
Mar-24	14.03.2024	11.0	1.7	77	1017.1	1.42	35	3.27418	10.6
Apr-24	29.04.2024	17.9	2.0	60	1019.4	1.19	4	1.58740	13.2
May-24	24.05.2024	20.8	2.0	64	1017.4	0.99	0	0	12.5
Jun-24	17.06.2024	23.8	1.7	62	1015.3	0.86	0	0	14.4
Test for normality	Observations	12	12	12	12	12	12	12	12
	Sample	−0.1879	−0.4154	0.4254	−0.0772	0.0077	2.7150	1.1895	−0.7619
	Skewness								
	Sample Kurtosis	−1.2709	1.1101	−0.2546	−1.2572	−0.6469	7.8832	−0.0187	0.0946
	JB Test Statistic	0.8782	0.9613	0.3943	0.8022	0.2093	45.8148	2.8301	1.1654
	p-value	0.64462	0.61837	0.82106	0.66960	0.90062	0.00000	0.24292	0.55840

Table S3: A list of sampling stations and statistical values (mean, minimum, maximum, median, and a range of values) for measured parameters using YSI EXO2 probe

Representative month		Jul-23	Aug-23	Sep-23	Oct-23	Nov-23	Dec-23	Jan-24	Feb-24	Mar-24	Apr-24	May-24	Jun-24	Σ
Measurement date		17.07. 2023	18.08. 2023	27.09. 2023	13.10. 2023	04.12. 2023	19.12. 2023	11.01. 2024	19.02. 2024	14.03. 2024	29.04. 2024	24.05. 2024	17.06. 2024	12
Measured stations		3–21	2–21	2–13	2–21	2–21	2–21	2–5, 7–21	2–21	2–21	2–21	2–21	2–21	230
Parameter	Statistics													
Chl-a [µg/l]	Mean	0.55	0.90	1.53	1.15	1.62	0.97	1.09	0.81	1.06	0.46	0.59	0.82	0.94
	Min	0.35	0.65	1.10	0.88	1.38	0.68	0.85	0.60	0.67	0.15	0.44	0.52	0.15
	Max	0.82	1.16	1.99	1.97	2.39	1.67	1.76	1.20	1.60	0.78	0.87	1.49	2.39
	Median	0.49	0.90	1.49	1.09	1.55	0.94	1.04	0.78	1.10	0.44	0.58	0.81	0.90
	Range	0.47	0.51	0.89	1.09	1.01	0.99	0.91	0.60	0.93	0.93	0.93	0.93	2.24
	St. Dev.	0.17	0.13	0.29	0.23	0.22	0.20	0.20	0.15	0.23	0.14	0.12	0.24	0.39
	MAD	0.14	0.07	0.25	0.12	0.07	0.10	0.07	0.11	0.18	0.09	0.07	0.17	0.24
EC [dS/m]	Mean	4.53	4.58	4.59	4.60	4.64	4.35	4.15	3.69	3.39	3.08	3.10	3.09	3.96
	Min	3.59	4.21	4.51	4.41	4.12	4.18	3.71	3.33	3.00	2.67	2.70	2.66	2.66
	Max	4.68	4.73	4.64	4.65	4.80	4.52	4.25	3.81	3.51	3.22	3.18	3.16	4.80
	Median	4.50	4.65	4.60	4.61	4.72	4.34	4.19	3.76	3.45	3.12	3.15	3.14	4.19
	Range	1.09	0.52	0.13	0.24	0.68	0.34	0.54	0.48	0.51	0.51	0.51	0.51	2.14
	St. Dev.	0.25	0.14	0.03	0.05	0.19	0.11	0.12	0.14	0.14	0.14	0.13	0.12	0.65
	MAD	0.18	0.04	0.02	0.02	0.06	0.09	0.04	0.05	0.03	0.09	0.01	0.01	0.49
Turbidity [FNU]	Mean	1.71	14.43	10.59	9.51	9.63	2.11	3.13	2.63	6.06	3.25	4.00	3.71	5.76
	Min	0.73	13.47	9.43	8.89	9.18	1.47	1.78	2.09	4.47	2.90	3.56	3.11	0.73
	Max	2.75	15.93	11.55	10.15	10.27	3.07	4.93	3.02	7.83	4.10	4.43	4.56	15.93
	Median	1.47	14.55	10.74	9.51	9.63	2.03	2.98	2.62	6.16	3.20	3.95	3.76	3.85
	Range	2.02	2.46	2.12	1.26	1.09	1.60	3.15	0.93	3.36	3.36	3.36	3.36	15.20
	St. Dev.	0.53	0.66	0.59	0.39	0.31	0.35	0.76	0.25	1.14	0.30	0.25	0.36	3.96
	MAD	0.31	0.61	0.18	0.35	0.27	0.17	0.56	0.19	1.07	0.13	0.20	0.18	1.63
Salinity	Mean	2.42	2.44	2.46	2.46	2.49	2.31	2.20	1.96	1.79	1.62	1.62	1.61	2.10
	Min	1.90	2.23	2.42	2.36	2.19	2.23	1.95	1.75	1.57	1.39	1.40	1.37	1.37
	Max	2.50	2.53	2.49	2.49	2.58	2.41	2.25	2.02	1.85	1.70	1.66	1.64	2.58
	Median	2.40	2.48	2.46	2.47	2.53	2.31	2.22	2.00	1.82	1.64	1.64	1.63	2.22
	Range	0.60	0.30	0.07	0.13	0.39	0.18	0.30	0.27	0.28	0.28	0.28	0.28	1.21
	St. Dev.	0.14	0.08	0.02	0.03	0.11	0.06	0.06	0.08	0.08	0.08	0.07	0.07	0.36
	MAD	0.10	0.02	0.01	0.01	0.03	0.05	0.02	0.02	0.02	0.05	0.01	0.01	0.28
WT [°C]	Mean	29.25	25.11	18.93	21.51	8.52	6.64	5.24	10.96	12.74	16.72	23.21	25.75	16.98
	Min	28.37	24.37	18.59	20.79	7.76	6.37	4.47	10.74	12.35	15.94	22.82	25.38	4.47
	Max	30.22	26.23	19.42	22.17	9.17	7.27	6.07	11.40	13.31	17.50	23.70	26.31	30.22
	Median	29.09	25.03	18.91	21.57	8.47	6.64	5.28	10.91	12.74	16.71	23.12	25.68	17.16
	Range	1.85	1.86	0.83	1.38	1.41	0.90	1.60	0.66	0.96	0.96	0.96	0.96	25.75

(Continued)

Table S3: Continued

Representative month		Jul-23	Aug-23	Sep-23	Oct-23	Nov-23	Dec-23	Jan-24	Feb-24	Mar-24	Apr-24	May-24	Jun-24	Σ
DO [mg/l]	St. Dev.	0.53	0.55	0.25	0.37	0.35	0.23	0.38	0.19	0.27	0.44	0.27	0.29	7.87
	MAD	0.45	0.39	0.13	0.23	0.26	0.19	0.16	0.12	0.19	0.32	0.20	0.18	7.33
	Mean	9.24	8.65	9.09	9.94	11.33	12.01	12.36	10.85	10.44	10.46	9.73	9.38	10.33
	Min	8.29	7.60	8.70	9.30	10.80	11.10	12.00	10.70	10.10	10.20	9.40	8.80	7.60
	Max	10.80	9.50	9.30	10.40	11.60	12.20	12.60	10.90	10.70	11.00	10.40	10.50	12.60
	Median	9.17	8.65	9.15	9.95	11.35	12.05	12.40	10.90	10.50	10.40	9.70	9.30	10.35
	Range	2.51	1.90	0.60	1.10	0.80	1.10	0.60	0.20	0.60	0.60	0.60	0.60	5.00
	St. Dev.	0.63	0.37	0.16	0.29	0.20	0.22	0.18	0.07	0.13	0.18	0.26	0.40	1.15
SO [%]	MAD	0.45	0.15	0.10	0.18	0.15	0.05	0.10	0.00	0.10	0.10	0.20	0.20	0.85
	Mean	122.34	106.20	99.47	114.26	98.29	99.56	98.85	99.54	99.67	108.67	114.86	116.21	106.70
	Min	108.75	94.75	95.04	106.61	94.09	93.46	97.07	98.04	97.30	106.30	111.28	110.46	93.46
	Max	143.28	119.55	101.12	120.87	99.46	100.48	99.79	100.51	102.73	114.99	122.63	130.73	143.28
	Median	121.08	105.68	99.94	114.28	98.78	99.94	99.14	99.55	99.72	108.23	114.09	114.73	103.64
	Range	34.53	24.80	6.08	14.26	5.37	7.02	2.72	2.47	5.43	5.43	5.43	5.43	49.82
	St. Dev.	8.11	4.62	1.59	3.41	1.13	1.48	0.74	0.58	1.21	2.02	2.98	4.70	8.85
	MAD	6.10	2.03	0.75	1.85	0.27	0.35	0.40	0.28	0.88	1.25	1.61	1.94	4.95

Table S4: Comparison of interpolation methods using RMSE and ME as accuracy measures for each parameter

Interpolation Method	Chl- α		EC		Turbidity		Salinity		WT		DO		SO	
	RMSE	ME	RMSE	ME	RMSE	ME	RMSE	ME	RMSE	ME	RMSE	ME	RMSE	ME
Simple Kriging – Trend	0.36873	0.00003	0.65718	0.00010	3.99575	0.00048	0.36696	0.00006	7.97592	–0.00008	1.16632	0.00001	8.96418	–0.00038
Global Polynomial Interpolation – Second order	0.36807	–0.00006	0.66400	0.00004	4.04828	–0.00009	0.37078	0.00002	8.08375	0.00069	1.18081	–0.00020	9.08129	–0.00043
Simple Kriging – Optimized	0.37460	0.00730	0.65134	0.00737	3.96147	–0.01939	0.36365	0.00596	7.87438	0.10378	1.15401	0.02554	8.85096	–0.12312
Inverse Distance Weighted – Optimized	0.38833	0.00000	0.70634	0.00000	4.31279	0.00000	0.39443	0.00000	8.61556	0.00000	1.25279	0.00000	9.58389	0.00000
Inverse Distance Weighted – Default	0.38833	0.00000	0.70634	0.00000	4.31279	0.00000	0.39443	0.00000	8.61556	0.00000	1.25279	0.00000	9.58389	0.00000
Simple Kriging – Default	0.37503	0.00668	0.65265	0.00919	3.96681	–0.02673	0.36416	0.00651	7.87438	0.10365	1.15417	0.02567	8.86481	–0.13253
Global Polynomial Interpolation – Third order	0.37299	0.00002	0.67532	0.00007	4.11955	0.00029	0.37711	0.00004	8.23039	0.00066	1.19815	–0.00025	9.21398	–0.00057
Kernel (Local Polynomial Interpolation)	0.36993	0.00751	0.66294	–0.01139	4.04559	–0.01352	0.37018	–0.00629	8.07800	–0.00899	1.17784	0.00830	9.04910	0.09793
Empirical Bayesian Kriging – Default	0.38833	0.00000	0.70634	0.00000	4.31279	0.00000	0.39443	0.00000	8.61556	0.00000	1.25279	0.00000	9.58389	0.00000
Simple Kriging – Trend and transformation	0.36877	–0.00539	0.65769	0.02556	3.99621	–0.06077	0.36713	0.01060	7.97869	0.21052	1.16671	0.03023	8.96623	0.21883
Empirical Bayesian Kriging – Advanced	0.36850	0.01554	0.66932	0.07600	3.95395	0.06313	0.37346	0.03038	7.91331	0.41442	1.15447	–0.00826	8.94164	–0.43145
Ordinary Kriging – Optimized	0.37383	0.01752	0.67946	–0.01007	4.16955	–0.20150	0.37942	–0.00543	8.30816	–0.77938	1.21378	0.10919	9.26311	–0.58006
Ordinary Kriging – Default	0.37419	0.01610	0.68043	–0.01932	4.16955	–0.20150	0.37994	–0.01050	8.30816	–0.77938	1.21378	0.10919	9.26354	–0.57031
Universal Kriging – Optimized	0.39513	0.00407	0.72338	0.03318	4.46958	0.08133	0.40397	0.01904	8.71592	–0.12613	1.27897	0.01056	9.63265	–0.08465
Universal Kriging – Default	0.39513	0.00407	0.72326	0.03118	4.47018	0.07428	0.40397	0.01904	8.71592	–0.12613	1.28679	0.03514	9.66442	–0.02252

Table S5: Comparison of interpolation methods ranked by RMSE and ME accuracy measures

Interpolation Method	Average Rank	Highest Accuracy Rank (RMSE)	Lowest Bias Rank (ME)
Simple Kriging – Trend	4.3	3.6	5.0
Global Polynomial Interpolation – Second order	5.4	5.9	4.9
Simple Kriging – Optimized	5.7	2.4	9.0
Inverse Distance Weighted – Optimized	6.0	11.0	1.0
Inverse Distance Weighted – Default	6.0	11.0	1.0
Simple Kriging – Default	6.4	3.1	9.6
Global Polynomial Interpolation – Third order	6.4	7.7	5.1
Kernel (Local Polynomial Interpolation)	7.2	5.6	8.9
Empirical Bayesian Kriging – Default	7.3	11.6	3.0
Simple Kriging – Trend and transformation	7.9	4.6	11.3
Empirical Bayesian Kriging – Advanced	8.1	3.7	12.4
Ordinary Kriging – Optimized	10.6	8.7	12.6
Ordinary Kriging – Default	11.2	9.3	13.1
Universal Kriging – Optimized	12.4	14.1	10.7
Universal Kriging – Default	12.6	14.6	10.7