



## Supplement of

## Increasing seasonal variation in the extent of rivers and lakes from 1984 to 2022

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## **Supplementary Figures and Tables**

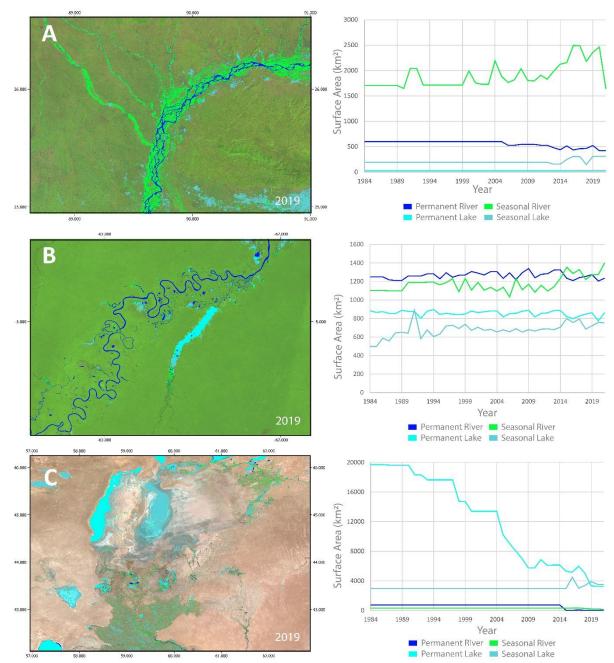


Figure S1: Examples of Water Surface Area Change - Examples of the changing water surface area of lakes and rivers over the past 38-years subdivided in permanent and seasonal water extent. See interactive map for time-series images.

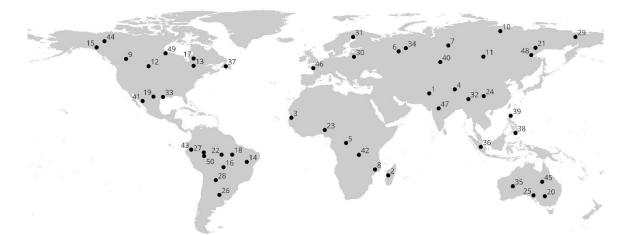


Figure S2: Sampled Validation Localities - Location of the 50 random locations that were manually interpreted over the 38-year timeframe. Numbers show the unique ID that correspond to the table in supplementary table S1.

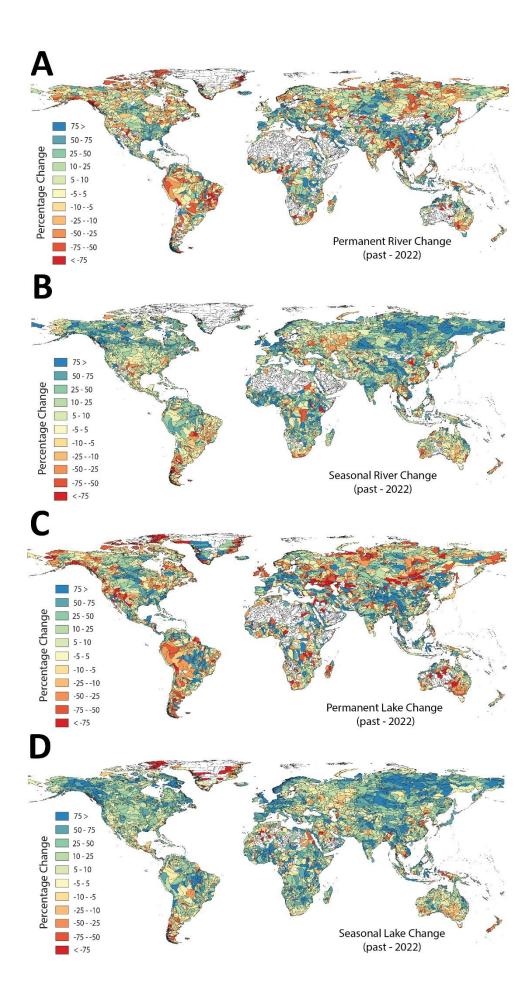


Figure S3: The Distribution of Water Surface Area Change - The spatio-temporal change in permanent and seasonal water surface area of rivers and lakes from first recorded observations to 2022.

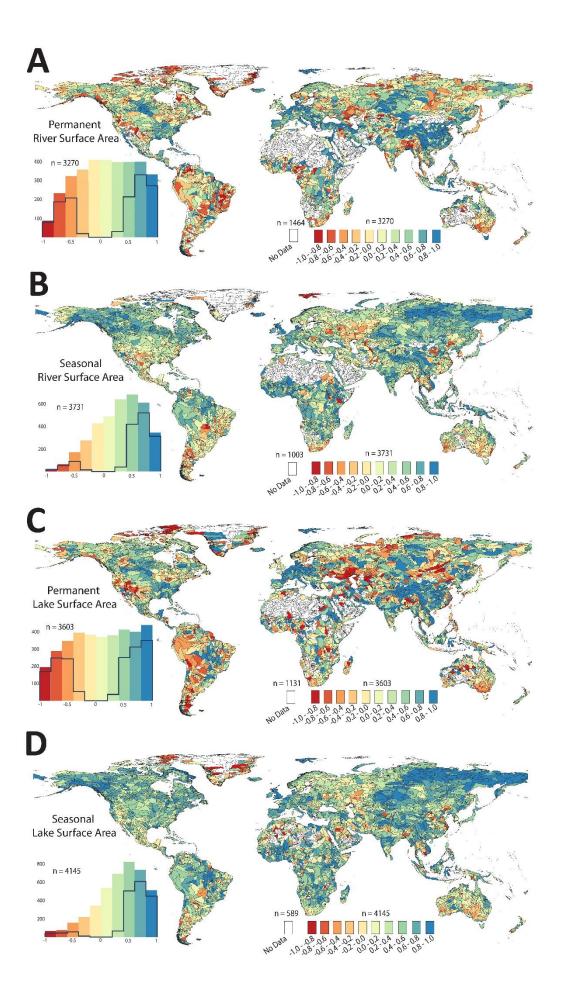


Figure S4: Show maps of catchments with statistically significant change in seasonal and permanent water surface area since 1984 for rivers and lakes. Spearman rank correlations are shown ranging from -1 to 1. The histogram for each map shows the spearman correlations with the line indicating the distribution of the statistically significant samples (n > 9).

1 70.894 31.732 84.50 89.48 77.52 76.58   2 45.292 -19.403 89.15 87.42 91.05 90.26   3 -15.161 16.560 86.79 88.47 92.74 92.53   4 86.865 34.271 96.27 95.28 93.40 88.20   5 18.991 0.785 99.80 99.74 99.62   6 51.818 57.946 68.33 89.24 93.31 78.31   7 82.833 61.577 95.92 98.36 99.07 94.79   9 -118.343 53.260 90.79 91.86 90.99 90.76   10 115.271 70.535 91.40 92.03 91.81   11 104.699 54.645 66.46 65.77 65.68 66.01   12 -104.278 48.685 97.36 97.34 96.48 96.49 99.47   14 -42.990 -10.964 90.79 <th>ID</th> <th>Lat</th> <th>Long</th> <th>1990</th> <th>2000</th> <th>2010</th> <th>2020</th>	ID	Lat	Long	1990	2000	2010	2020
3 -15.161 16.560 86.79 88.47 92.74 92.53   4 86.865 34.271 96.27 95.28 93.40 88.20   5 18.991 0.785 99.80 99.74 99.62   6 51.818 57.946 68.33 89.24 93.31 78.31   7 82.833 61.577 95.92 98.36 98.14 95.99   8 37.058 -15.690 98.91 98.96 90.99 94.79   9 -118.343 53.260 90.79 91.86 90.99 90.76   10 115.271 70.535 91.40 92.03 91.81   11 104.699 54.645 66.46 65.77 65.68 66.01   12 -104.278 48.685 97.36 97.34 96.48 96.43   14 -42.990 -10.964 90.79 91.64 90.23 91.29   15 -136.732 60.437 95.82 96.80	1	70.894	31.732	84.50	89.48	77.52	76.58
4 86.865 34.271 96.27 95.28 93.40 88.20   5 18.991 0.785 99.80 99.74 99.62   6 51.818 57.946 68.33 89.24 93.31 78.31   7 82.833 61.577 95.92 98.36 98.14 95.99   8 37.058 -15.690 98.91 98.96 99.07 94.79   9 -118.343 53.260 90.79 91.86 90.99 90.76   10 115.271 70.535 91.40 92.03 91.81   11 104.699 54.645 66.46 65.77 65.68 66.01   12 -104.278 48.685 97.36 97.34 96.48 96.64   13 -76.205 48.936 99.48 99.51 99.49 99.47   14 -42.990 -10.964 90.79 91.64 90.23 91.29   15 -136.732 60.437 95.82 96.8	2	45.292	-19.403	89.15	87.42	91.05	90.26
5 18.991 0.785 99.80 99.74 99.62   6 51.818 57.946 68.33 89.24 93.31 78.31   7 82.833 61.577 95.92 98.36 98.14 95.99   8 37.058 -15.690 98.91 98.96 99.07 94.79   9 -118.343 53.260 90.79 91.86 90.99 90.76   10 115.271 70.535 91.40 92.03 91.81   11 104.699 54.645 66.46 65.77 65.68 66.01   12 -104.278 48.685 97.36 97.34 96.48 96.64   13 -76.205 48.936 99.48 99.51 99.49 99.47   14 -42.990 -10.964 90.79 91.64 90.23 91.29   15 -136.732 60.437 95.82 96.80 96.73 99.67 99.66   18 -52.084 -6.434 98	3	-15.161	16.560	86.79	88.47	92.74	92.53
6 51.818 57.946 68.33 89.24 93.31 78.31   7 82.833 61.577 95.92 98.36 98.14 95.99   8 37.058 -15.690 98.91 98.96 99.07 94.79   9 -118.343 53.260 90.79 91.86 90.99 90.76   10 115.271 70.535 91.40 92.03 91.81   11 104.699 54.645 66.46 65.77 65.68 66.01   12 -104.278 48.685 97.36 97.34 96.48 96.64   13 -76.205 48.936 99.48 99.51 99.49 99.47   14 -42.990 -10.964 90.79 91.64 90.23 91.29   15 -136.732 60.437 95.82 96.80 96.23 95.59   16 -57.497 -14.276 85.13 89.38 97.52 91.61 97.14 97.25   20 1	4	86.865	34.271	96.27	95.28	93.40	88.20
7 82.833 61.577 95.92 98.36 98.14 95.99   8 37.058 -15.690 98.91 98.96 99.07 94.79   9 -118.343 53.260 90.79 91.86 90.99 90.76   10 115.271 70.535 91.40 92.03 91.81   11 104.699 54.645 66.46 65.77 65.68 66.01   12 -104.278 48.685 97.36 97.34 96.48 96.64   13 -76.205 48.936 99.48 99.51 99.49 99.47   14 -42.990 -10.964 90.79 91.64 90.23 91.29   15 -136.732 60.437 95.82 96.80 96.23 95.59   16 -57.497 -14.276 85.13 89.38 87.55 79.40   17 -76.198 53.523 99.63 99.77 99.67 99.66   18 -52.084 -6.434	5	18.991	0.785		99.80	99.74	99.62
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16 -57.497 -14.276 85.13 89.38 87.55 79.40   17 -76.198 53.523 99.63 99.77 99.67 99.66   18 -52.084 -6.434 98.23 98.38 98.38 97.92   19 -101.260 29.691 96.07 96.84 97.14 97.25   20 143.060 -32.410 70.67 76.40 72.57 77.59   21 137.212 60.154 85.20 86.42 82.34   22 -58.713 -6.511 99.49 99.51 99.51 99.48   23 5.667 8.902 97.62 97.11 96.55   25 135.950 -31.859 99.70 99.62 99.65 99.71   26 -60.033 -31.538 76.25 74.60 75.25 76.04   27 -69.799 -5.097 95.28 95.67 95.69 96.12   28 -62.332 -22.368 98.73	14	-42.990	-10.964	90.79	91.64	90.23	91.29
17-76.19853.52399.6399.7799.6799.6618-52.084-6.43498.2398.3898.3897.9219-101.26029.69196.0796.8497.1497.2520143.060-32.41070.6776.4072.5777.5921137.21260.15485.2086.4282.3422-58.713-6.51199.4999.5199.5199.48235.6678.90292.9794.5895.8324104.91930.05698.0297.6297.1196.5525135.950-31.85999.7099.6299.6599.7126-60.033-31.53876.2574.6075.2576.0427-69.799-5.09795.2895.6795.6996.1228-62.332-22.36898.7391.8093.0196.2329162.18966.95398.7098.9197.903023.93954.57491.5992.2091.8391.563123.37766.95184.9484.4684.9184.663295.37228.20597.3999.0198.7399.2333-95.28329.53787.4986.6686.0285.393456.29959.91691.8591.1293.3990.8735123.057-26.17291.3791.9192.5380.7736103.097-1.632 <t< th=""><th>15</th><th>-136.732</th><th>60.437</th><th>95.82</th><th>96.80</th><th>96.23</th><th>95.59</th></t<>	15	-136.732	60.437	95.82	96.80	96.23	95.59
18 -52.084 -6.434 98.23 98.38 98.38 97.92   19 -101.260 29.691 96.07 96.84 97.14 97.25   20 143.060 -32.410 70.67 76.40 72.57 77.59   21 137.212 60.154 85.20 86.42 82.34   22 -58.713 -6.511 99.49 99.51 99.51 99.48   23 5.667 8.902 92.97 94.58 95.83   24 104.919 30.056 98.02 97.62 97.11 96.55   25 135.950 -31.859 99.70 99.62 99.65 99.71   26 -60.033 -31.538 76.25 74.60 75.25 76.04   27 -69.799 -5.097 95.28 95.67 95.69 96.12   28 -62.332 -22.368 98.73 91.80 93.01 96.23   29 162.189 66.953 98.70	16	-57.497	-14.276	85.13	89.38	87.55	79.40
19-101.26029.69196.0796.8497.1497.2520143.060-32.41070.6776.4072.5777.5921137.21260.15485.2086.4282.3422-58.713-6.51199.4999.5199.5199.48235.6678.90292.9794.5895.8324104.91930.05698.0297.6297.1196.5525135.950-31.85999.7099.6299.6599.7126-60.033-31.53876.2574.6075.2576.0427-69.799-5.09795.2895.6795.6996.1228-62.332-22.36898.7391.8093.0196.2329162.18966.95398.7098.9197.903023.93954.57491.5992.2091.8391.563123.37766.95184.9484.4684.9184.663295.37228.20597.3999.0198.7399.2333-95.28329.53787.4986.6686.0285.393456.29959.91691.8591.1293.3990.8735123.057-26.17291.3791.9192.5380.7736103.097-1.63294.4194.5298.9192.0337-56.08548.63899.3199.1599.3499.1338124.7127.056 <td< td=""><th>17</th><td>-76.198</td><td>53.523</td><td>99.63</td><td>99.77</td><td>99.67</td><td>99.66</td></td<>	17	-76.198	53.523	99.63	99.77	99.67	99.66
20143.060-32.41070.6776.4072.5777.5921137.21260.15485.2086.4282.3422-58.713-6.51199.4999.5199.5199.48235.6678.90292.9794.5895.8324104.91930.05698.0297.6297.1196.5525135.950-31.85999.7099.6299.6599.7126-60.033-31.53876.2574.6075.2576.0427-69.799-5.09795.2895.6795.6996.1228-62.332-22.36898.7391.8093.0196.2329162.18966.95398.7098.9197.903023.93954.57491.5992.2091.8391.563123.37766.95184.9484.4684.9184.663295.37228.20597.3999.0198.7399.2333-95.28329.53787.4986.6686.0285.393456.29959.91691.8591.1293.3990.8735123.057-26.17291.3791.9192.5380.7736103.097-1.63294.4194.5298.9192.0337-56.08548.63899.3199.1599.3499.1338124.7127.05680.5184.0082.01	18	-52.084	-6.434	98.23	98.38	98.38	97.92
21137.21260.15485.2086.4282.3422-58.713-6.51199.4999.5199.5199.48235.6678.90292.9794.5895.8324104.91930.05698.0297.6297.1196.5525135.950-31.85999.7099.6299.6599.7126-60.033-31.53876.2574.6075.2576.0427-69.799-5.09795.2895.6795.6996.1228-62.332-22.36898.7391.8093.0196.2329162.18966.95398.7098.9197.903023.93954.57491.5992.2091.8391.563123.37766.95184.9484.4684.9184.663295.28329.53787.4986.6686.0285.393456.29959.91691.8591.1293.3990.8735123.057-26.17291.3791.9192.5380.7736103.097-1.63294.4194.5298.9192.0337-56.08548.63899.3199.1599.3499.1338124.7127.05680.5184.0082.01	19	-101.260	29.691	96.07	96.84	97.14	97.25
22-58.713-6.51199.4999.5199.5199.5199.48235.6678.90292.9794.5895.8324104.91930.05698.0297.6297.1196.5525135.950-31.85999.7099.6299.6599.7126-60.033-31.53876.2574.6075.2576.0427-69.799-5.09795.2895.6795.6996.1228-62.332-22.36898.7391.8093.0196.2329162.18966.95398.7098.9197.903023.93954.57491.5992.2091.8391.563123.37766.95184.9484.4684.9184.663295.37228.20597.3999.0198.7399.2333-95.28329.53787.4986.6686.0285.393456.29959.91691.8591.1293.3990.8735123.057-26.17291.3791.9192.5380.7736103.097-1.63294.4194.5298.9192.0337-56.08548.63899.3199.1599.3499.1338124.7127.05680.5184.0082.01	20	143.060	-32.410	70.67	76.40	72.57	77.59
235.6678.90292.9794.5895.8324104.91930.05698.0297.6297.1196.5525135.950-31.85999.7099.6299.6599.7126-60.033-31.53876.2574.6075.2576.0427-69.799-5.09795.2895.6795.6996.1228-62.332-22.36898.7391.8093.0196.2329162.18966.95398.7098.9197.903023.93954.57491.5992.2091.8391.563123.37766.95184.9484.4684.9184.663295.37228.20597.3999.0198.7399.2333-95.28329.53787.4986.6686.0285.393456.29959.91691.8591.1293.3990.8735123.057-26.17291.3791.9192.5380.7736103.097-1.63294.4194.5298.9192.0337-56.08548.63899.3199.1599.3499.1338124.7127.05680.5184.0082.01	21	137.212	60.154		85.20	86.42	82.34
24104.91930.05698.0297.6297.1196.5525135.950-31.85999.7099.6299.6599.7126-60.033-31.53876.2574.6075.2576.0427-69.799-5.09795.2895.6795.6996.1228-62.332-22.36898.7391.8093.0196.2329162.18966.95398.7098.9197.903023.93954.57491.5992.2091.8391.563123.37766.95184.9484.4684.9184.663295.37228.20597.3999.0198.7399.2333-95.28329.53787.4986.6686.0285.393456.29959.91691.8591.1293.3990.8735123.057-26.17291.3791.9192.5380.7736103.097-1.63294.4194.5298.9192.0337-56.08548.63899.3199.1599.3499.1338124.7127.05680.5184.0082.01	22	-58.713	-6.511	99.49	99.51	99.51	99.48
25135.950-31.85999.7099.6299.6599.7126-60.033-31.53876.2574.6075.2576.0427-69.799-5.09795.2895.6795.6996.1228-62.332-22.36898.7391.8093.0196.2329162.18966.95398.7098.9197.903023.93954.57491.5992.2091.8391.563123.37766.95184.9484.4684.9184.663295.37228.20597.3999.0198.7399.2333-95.28329.53787.4986.6686.0285.393456.29959.91691.8591.1293.3990.8735123.057-26.17291.3791.9192.5380.7736103.097-1.63294.4194.5298.9192.0337-56.08548.63899.3199.1599.3499.1338124.7127.05680.5184.0082.01	23	5.667	8.902		92.97	94.58	95.83
26-60.033-31.53876.2574.6075.2576.0427-69.799-5.09795.2895.6795.6996.1228-62.332-22.36898.7391.8093.0196.2329162.18966.95398.7098.9197.903023.93954.57491.5992.2091.8391.563123.37766.95184.9484.4684.9184.663295.37228.20597.3999.0198.7399.2333-95.28329.53787.4986.6686.0285.393456.29959.91691.8591.1293.3990.8735123.057-26.17291.3791.9192.5380.7736103.097-1.63294.4194.5298.9192.0337-56.08548.63899.3199.1599.3499.1338124.7127.05680.5184.0082.01	24	104.919	30.056	98.02	97.62	97.11	96.55
27-69.799-5.09795.2895.6795.6996.1228-62.332-22.36898.7391.8093.0196.2329162.18966.95398.7098.9197.903023.93954.57491.5992.2091.8391.563123.37766.95184.9484.4684.9184.663295.37228.20597.3999.0198.7399.2333-95.28329.53787.4986.6686.0285.393456.29959.91691.8591.1293.3990.8735123.057-26.17291.3791.9192.5380.7736103.097-1.63294.4194.5298.9192.0337-56.08548.63899.3199.1599.3499.1338124.7127.05680.5184.0082.01	25	135.950	-31.859	99.70	99.62	99.65	99.71
28-62.332-22.36898.7391.8093.0196.2329162.18966.95398.7098.9197.903023.93954.57491.5992.2091.8391.563123.37766.95184.9484.4684.9184.663295.37228.20597.3999.0198.7399.2333-95.28329.53787.4986.6686.0285.393456.29959.91691.8591.1293.3990.8735123.057-26.17291.3791.9192.5380.7736103.097-1.63294.4194.5298.9192.0337-56.08548.63899.3199.1599.3499.1338124.7127.05680.5184.0082.01	26	-60.033	-31.538	76.25	74.60	75.25	76.04
29162.18966.95398.7098.9197.903023.93954.57491.5992.2091.8391.563123.37766.95184.9484.4684.9184.663295.37228.20597.3999.0198.7399.2333-95.28329.53787.4986.6686.0285.393456.29959.91691.8591.1293.3990.8735123.057-26.17291.3791.9192.5380.7736103.097-1.63294.4194.5298.9192.0337-56.08548.63899.3199.1599.3499.1338124.7127.05680.5184.0082.01	27	-69.799	-5.097	95.28	95.67	95.69	96.12
3023.93954.57491.5992.2091.8391.563123.37766.95184.9484.4684.9184.663295.37228.20597.3999.0198.7399.2333-95.28329.53787.4986.6686.0285.393456.29959.91691.8591.1293.3990.8735123.057-26.17291.3791.9192.5380.7736103.097-1.63294.4194.5298.9192.0337-56.08548.63899.3199.1599.3499.1338124.7127.05680.5184.0082.01	28	-62.332	-22.368	98.73	91.80	93.01	96.23
3123.37766.95184.9484.4684.9184.663295.37228.20597.3999.0198.7399.2333-95.28329.53787.4986.6686.0285.393456.29959.91691.8591.1293.3990.8735123.057-26.17291.3791.9192.5380.7736103.097-1.63294.4194.5298.9192.0337-56.08548.63899.3199.1599.3499.1338124.7127.05680.5184.0082.01	29	162.189	66.953		98.70	98.91	97.90
3295.37228.20597.3999.0198.7399.2333-95.28329.53787.4986.6686.0285.393456.29959.91691.8591.1293.3990.8735123.057-26.17291.3791.9192.5380.7736103.097-1.63294.4194.5298.9192.0337-56.08548.63899.3199.1599.3499.1338124.7127.05680.5184.0082.01	30	23.939	54.574	91.59	92.20	91.83	91.56
33-95.28329.53787.4986.6686.0285.393456.29959.91691.8591.1293.3990.8735123.057-26.17291.3791.9192.5380.7736103.097-1.63294.4194.5298.9192.0337-56.08548.63899.3199.1599.3499.1338124.7127.05680.5184.0082.01	31	23.377	66.951	84.94	84.46	84.91	84.66
3456.29959.91691.8591.1293.3990.8735123.057-26.17291.3791.9192.5380.7736103.097-1.63294.4194.5298.9192.0337-56.08548.63899.3199.1599.3499.1338124.7127.05680.5184.0082.01	32	95.372	28.205	97.39	99.01	98.73	99.23
35123.057-26.17291.3791.9192.5380.7736103.097-1.63294.4194.5298.9192.0337-56.08548.63899.3199.1599.3499.1338124.7127.05680.5184.0082.01	33	-95.283	29.537	87.49	86.66	86.02	85.39
36103.097-1.63294.4194.5298.9192.0337-56.08548.63899.3199.1599.3499.1338124.7127.05680.5184.0082.01	34	56.299	59.916	91.85	91.12	93.39	90.87
37-56.08548.63899.3199.1599.3499.1338124.7127.05680.5184.0082.01	35	123.057	-26.172	91.37	91.91	92.53	80.77
<b>38</b> 124.712 7.056 80.51 84.00 82.01	36	103.097	-1.632	94.41	94.52	98.91	92.03
	37	-56.085	48.638	99.31	99.15	99.34	99.13
<b>30</b> 121 756 17 828 97 04 96 90 97 12 94 13	38	124.712	7.056		80.51	84.00	82.01
<b>5</b> 121.750 17.020 77.04 70.70 77.12 74.15	39	121.756	17.828	97.04	96.90	97.12	94.13

Table S1: Accuracy of Sampled Localities for 4 decades – Accuracy of the SARL database by locality in Figure S1 for the selected years of 1990, 2000, 2010 and 2020.

40	77.791	51.266	97.05	96.39	96.26	94.97
41	-108.008	26.964	85.24	93.54	93.51	92.17
42	27.017	-6.580	93.67	95.52	95.70	92.64
43	-77.695	-3.356	96.72	97.34	98.32	97.49
44	-131.809	64.267	49.04	50.65	51.02	50.57
45	141.417	-23.426	86.32	89.10	89.11	86.47
46	-1.515	47.446	97.67	96.78	96.57	96.46
47	76.800	22.362	92.86	93.84	89.54	88.21
<b>48</b>	134.582	55.612		72.17	73.79	70.74
<b>49</b>	-93.701	56.710	98.44	98.50	98.51	98.41
50	-69.636	-7.377	74.56	76.94	78.91	78.47