hydrology

Review

Integrating Remote Sensing Methods for Monitoring Lake Water Quality: A Comprehensive Review—Supplementary Materials

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Abstract: Remote sensing methods have the potential to improve lake water quality monitoring and decision-making in water management. This review discusses the use of remote sensing methods for monitoring and assessing water quality in lakes. It explains the principles of remote sensing and the different methods used for retrieving water quality parameters in complex waterbodies. The review highlights the importance of considering the variability of optically active parameters and the need for comprehensive studies that encompass different seasons and time frames. The paper addresses the specific physical and biological parameters that can be effectively estimated using remote sensing, such as chlorophyll-α, turbidity, water transparency (Secchi disk depth), electrical conductivity, surface salinity, and water temperature. It further provides a comprehensive summary of the bands, band combinations, and band equations commonly used for remote sensing of these parameters per satellite sensor. It also discusses the limitations of remote sensing methods and the challenges associated with satellite systems. The review recommends integrating remote sensing methods using *in situ* measurements and computer modelling to improve the understanding of water quality. It suggests future research directions, including the importance of optimizing grid selection and time frame for *in situ* measurements by combining hydrodynamic models with remote sensing retrieval methods, considering variability in water quality parameters when analysing satellite imagery, the development of advanced technologies, and the integration of machine learning algorithms for effective water quality problem-solving. The review concludes with a proposed workflow for monitoring and assessing water quality parameters in lakes using remote sensing methods.

Keywords: water quality monitoring; decision-making; optically active parameters; computer modelling; band combinations; sensors

Analysis of Water Quality Parameters Using Satellite Sensors and Spectral Bands.

Table S1. Selected remotely measurements of chl-α using various sensors and spectral bands, band combinations, and band equations (R in band combinations represents the reflectance at a certain wavelength).

Band Combination	Sensor	Band/Equation	Reference
Ratio between green and red	Landsat-5 TM	B3 (630-690 nm)/B2 (520-600 nm)	[75,79]
	PROBA-CHRIS	R_{706}/R_{561}	[99]
Ratio between NIR and red	AISA	$R_{699-705}/R_{670-677}$	[36]
	AISA	$(R_{700}-R_{781})/(R_{662}-R_{781})$	[101]
	AISA	R_{710}/R_{670}	[35]
	AISA	$(1/R_{666}-1/R_{704})*R_{723}$	[66]
	AISA	R_{704}/R_{666}	[66]
	CASI	R_{705}/R_{678}	[70]
	CASI-2	R_{710}/R_{670}	[35]
	HICO	$(1/R_{686}-1/R_{703})*R_{735}$	[147]
	HyMap	R_{705}/R_{678}	[70]
	HyperOCR	$(1/R_{672}-1/R_{712})*R_{749}$	[65]
	Envisat MERIS	$(1/R_{660–670}-1/R_{700–730})*R_{740–760}$	[62]
	Envisat MERIS	$(1/R_{660–670}-1/R_{703.75–713.75})*R_{750–757.5}$	[60]
	Envisat MERIS	$(1/R_{665}-1/R_{708})*R_{753}$	[59,148]
	Envisat MERIS	R_{708}/R_{665}	[59,148]
	Envisat MERIS	R_{672}/R_{704}	[149]
	Envisat MERIS	R_{708}/R_{664}	[95]
	Envisat MERIS	$(1/R_{660}-1/R_{692})*R_{740}$	[63]
	Envisat MERIS	$(1/R_{622}-1/R_{693})*(1/R_{740}-1/R_{705})$	[63]
	Envisat MERIS	B9 (703.75-713.75 nm)/B7 (660-670 nm)	[150]
	Envisat MERIS	R_{709}/R_{665}	[151]
	Envisat MERIS	(B9 (703.75-713.75 nm)-B7 (660-670 nm))*(B9 (703.75-713.75 nm)+B7 (660-670 nm))	[49]
	Terra MODIS	$R_{743–753}/R_{662–672}$	[60,62]
	Terra MODIS	R_{665}/R_{748}	[149]
	Terra MODIS	R_{700}/R_{670}	[81]

		PROBA-CHRIS	R_{706}/R_{672}	[152]
		Sentinel-2 MSI	R_{705}/R_{665}	[69]
		Sentinel-3 OLCI	$(1/R_{665}–1/R_{705}) \times R_{752}$	[41]
		Sentinel-3 OLCI	R_{665}/R_{709}	[69]
Ratio between green and blue		EO-1 Hyperion	R_{490}/R_{550}	[57]
		EO-1 Hyperion	R_{467}/R_{559}	[68]
		Landsat-5 TM	B2 (520-600 nm)/ B1 (450-520 nm)	[77]
		Envisat MERIS	(B5 (555-565 nm)-B2 (437.5-447.5 nm))*(B5 (555-565 nm)+B2 (437.5-447.5 nm))	[49]
		WorldView-2	B1 (400-450 nm)/B3 (510-580 nm)	[10]
Ratio between blue and red		Landsat-7 ETM+	B1 (450-515 nm)/B3 (630-690 nm)	[98,153]
		Landsat-8 OLI	$(R_{630-680}-R_{433-453})/(R_{630-680}+R_{433-453})$	[154]
Single band	Blue	Landsat-5 TM	B1 (450-520 nm)	[155]
		MIVIS	R_{440}	[58]
		Terra MODIS	B8 (405-420 nm)	[72]
	Red	PROBA-CHRIS	$R_{650-690}$	[156]
	Green	Daedalus ATM	B3 (520-600 nm)	[157]
		Landsat-5 TM	B2 (520-600 nm)	[158]
		Terra MODIS	B11 (526-536 nm)	[72]
		Terra MODIS	B4 (545-565 nm)	[72]
	NIR	Terra MODIS	B2 (840-876 nm)	[72]
Multiple bands		PROBA-CHRIS	B8 (581.345-596.935 nm), B9 (613.7-627.1 nm), B10 (641.27-656.25 nm), B11 (661.44-672.12 nm), B12 (672.15-683.21 nm)	[159]
		Ikonos OSA	B1 (450–530 nm), B2 (520–610 nm), B3 (640–720 nm), B4 (770–880 nm)	[100]
		Landsat-5 TM	B1 (450-520 nm), B2 (520-600 nm), B3 (630-690 nm), B5 (1550-1750 nm), B6 (10400-12500 nm)	[89]
		Landsat-5 TM	B1 (450-520 nm), B2 (520-600 nm)	[74]
		Landsat-5 TM	B1 (450-520 nm), B3 (630-690 nm)	[51,78,115]
		Landsat-5 TM	B1 (450-520 nm), B2 (520-600 nm), B3 (630-690 nm)	[67,115]
		Landsat-5 TM	B1 (450-520 nm), B3 (630-690 nm), B4 (760-900 nm)	[115]
		Landsat-5 TM	B1 (450-520 nm), B2 (520-600 nm), B3 (630-690 nm), B4 (760-900 nm)	[74]
		Landsat-5 TM	B1 (450-520 nm), B2 (520-600 nm), B3 (630-690 nm), B4 (760-900 nm), B5 (1550-1750 nm), B7 (2080-2350 nm)	[73]

	Landsat-8 OLI	B5 (850-880 nm), B6 (1570-1650 nm), B7 (2110-2290 nm)	[80]
	Landsat-8 OLI	B1 (433–453 nm), B2 (450-515 nm), B3 (525-600 nm), B4 (630-680 nm)	[64]
	Envisat MERIS	B7 (664 nm), B8 (680.5 nm), B9 (708 nm)	[24]
	Terra MODIS	B1 (645 nm), B2 (859 nm), B3 (469 nm), B4 (555 nm)	[31]
	Terra MODIS	B1 (620-670 nm), B4 (545-565 nm)	[72]
	PlanetScope	B2 (465-515 nm), B4 (547-583 nm), B6 (650-680 nm), B8 (845-885 nm)	[80]
	Sentinel-2 MSI	B4 (649.6-679.6 nm), B5 (697.1-711.1 nm), B6 (733.5-747.5 nm), B11 (1568.7-1658.7 nm), B12 (2115.4-2289.4)	[80]
	Sentinel-3 OLCI	B1 (392.5-407.5 nm), B4 (485-495 nm), B6 (555-565 nm), B8 (660-670 nm), B9 (670-677.5 nm)	[71]

Table S2. Sensor data for various waterbodies including waterbody type, country, study area, mean depth, study duration, method for retrieval of chl-α based on satellite imagery, range of measured chl-α values (minimum and maximum), and a correlation coefficient (R^2) between satellite imagery and chl-α *in situ* values.

Sensor	Waterbody type	Waterbody	Country	Study area [km²]	Surface area category	Mean depth [m]	Mean depth category	Study Duration	Method	Chl-α min [μg/l]	Chl-α max [μg/l]	R^2	Refer-ence
Landsat-5 TM	Lakes	Küçükçek-mece Lake	Turkey	15.22	large	~10	shallow	1 month	multiple regression	0.62	3.99	0.513	[73]
Landsat-5 TM	Reservoirs	Beaver Res-ervoir	Arkansas, USA	103	very large	18	deep	9 months in 4 years (through-out)	ANN	1.4	10	0.53	[74]
EO Hype-rion-1	Lakes	Garda Lake	Italy	368	very large	133	deep	1 month	analytical	0.5	12	0.59	[57]
Terra MODIS	Lakes	Chaohu Lake	China	780	very large	2.5	very shal-low	4 months	NN	5.2	33.9	0.632	[72]
Landsat-7 ETM+	Estuary	Pensacola Bay	Florida, USA	373	very large	6	shallow	1 month	regression	1.14	23.23	0.67	[153]
Landsat-5 TM	Lakes	Reelfoot Lake	Tennessee, USA	296.4	very large	1.5	very shal-low	1 month	regression	66	188.59	0.705	[79]
EO Hype-rion-1	Lakes	Atitlán Lake	Guatemala	132	very large	188	deep	3 months	semi-em-pirical	1.01	10.91	0.7054	[68]

MIVIS	Lakes	Trasimeno Lake	Italy	124	very large	4.5	shallow	1 month	analytical	0.75	4.3	0.71	[58]
Landsat-5 TM	Lakes	Piccolo Lake	Italy	0.14	small	18	deep	1 month	multiple regression	1.11	4.57	0.72	[75]
Landsat-5 TM	Lakes	Grande Lake	Italy	0.41	small	9	shallow	1 month	multiple regression	4.63	11.35	0.72	[75]
Envisat MERIS	Lakes	Taihu Lake	China	2338	very large	1.9	very shallow	5 months in 2005 for calibration and 1 month in 2007	semi-analytical	1	89	0.8	[63]
PROBA-CHRIS	Reservoirs	Rosarito	Spain	14.75	large	5.8	shallow	5 months	regression	0	100	0.8	[152]
Landsat-5 TM	Lakes	Arreo Lake	Spain	0.07	small	5.3	shallow	6 years (throughout)	-	0.4	20	0.82	[77]
Sentinel-3 OLCI	Lakes	Balaton Lake	Hungary	596	very large	3.5	shallow	6 months	ML, NN	2	55	0.83	[71]
Landsat-5 TM	Reservoirs	Bull Shoals Reservoir	Arkansas, USA	~400	very large	20	deep	4 months in 2 years (July, December, February, and July)	regression	1	7	0.84	[76]
Envisat MERIS	Lakes	Balaton Lake	Hungary	596	very large	3.5	shallow	5 years (throughout)	NN	0.016	120	0.87	[24]
Envisat MERIS	Estuary	Tampa Bay	Florida, USA	~1000	very large	4	shallow	9 sessions in 13 years (throughout)	non-linear regression	2	80	0.88	[151]
CASI HyMap	Lakes	Wumm Lake	Germany	1.2	medium	max 36 m	deep	4 months in 3 years (May-September)	semi-empirical	1	3	0.89	[70]
CASI HyMap	Lakes	Bramin Lake	Germany	0.75	small	max 3 m	very shallow	4 months in 3 years (May-September)	semi-empirical	50	100	0.89	[70]

Envisat MERIS	Lakes	Zeekoevlei Lake	South Africa	2.58	medium	1.9	very shallow	1 month	empirical	61	247.4	0.964	[95]
Landsat-5 TM	Lakes	Chagan Lake	China	0.37	small	1.5	very shallow	1 month	empirical, NN	5	30	0.98	[67]
Ikonos OSA	Estuary	Golden Horn	Turkey	28	large	max 35 m	deep	1 month	multiple regression	2.32	53.77	0.992	[100]
Landsat-5 TM	Lakes	Iseo Lake	Italy	61	large	124	deep	1 month	empirical	5.5	7.7	0.999	[78]
CASI-2 AISA	Lakes	Loch Leven & Esthwaite Water	UK	1-13.3	small-large	3.9-6.4	shallow	2 months	empirical, semi-analytical	3.85	56.7	0.863	[35]
Sentinel-2 MSI Sentinel-3 OLCI	Lakes	4 lakes	Latvia, Estonia	40-270	large-very large	1.6 - 7	very shallow-shallow	8 months	semi-empirical	6.3	120	0.84	[69]
Sentinel-3 OLCI	Lakes Reservoirs River	9 waterbodies	USA, Australia, China	2250	very large	2	very shallow	6 years (throughout)	ML	2.8	285.5	0.91	[41]
PROBA-CHRIS	Lakes Reservoirs	10 Mazurian lakes	Poland	0.05-11	small-large	1-14	very shallow-shallow	1 month	empirical	0	55	0.89	[99]
AISA	Lakes	11 lakes	Finland	1-111	small-very large	2-85	very shallow-deep	3 years	regression	0	100	0.937	[101]
AISA	Lakes	11 lakes	Finland	1-111	small-very large	2-85	very shallow-deep	4 months in 3 years (May, August)	empirical	1	100	0.91	[36]
Sentinel-2 MSI	Lakes	9 small and 2 large lakes	Estonia	1-47800	medium-very large	2.2-11.9	very shallow-shallow	3 sessions in 1 month	semi-empirical	3.6	72.9	0.83	[52]

Sentinel-2 MSI	Reservoirs	13 reservoirs	Oklahoma, USA	4-188	medium-very large	4-20	shallow-deep	3 years	empirical	0.6	540	0.85	[80]
Terra MODIS	Lakes	15 lakes	Minnesota, USA	6-410 ha	small-medium	2-9	very shallow-shallow	1 month	nonlinear regression	1.8	397	0.99	[81]
Landsat-7 ETM+	Lakes	12 Rotorua lakes and Lake Taupo	New Zealand	0.3-80.6	small-large	7-60	shallow-deep	2 months	empirical	6	136	0.91	[98]

Table S3. Selected remotely measurements of turbidity using various sensors and spectral bands, band combinations, and band equations (R in band combinations represents the reflectance at a certain wavelength).

Band Combination		Sensor	Band/Equation	Reference
Ratio between green and red		Landsat-5 TM	B3 (630-690 nm)/B2 (520-600 nm)	[79]
Ratio between NIR and red		AISA	R_{850}/R_{550}	[160]
Single band	NIR	AISA	R_{714}	[101]
		AISA	$R_{705\text{-}714}$	[36]
		Landsat-7 ETM+	B4 (770-900 nm)	[84]
		PROBA-CHRIS	B31(706-712 nm)	[87]
	Red	HICO	R_{646}	[147]
		Landsat-5 TM	B3 (630-690 nm)	[155]
		Landsat-5 TM	B3 (630-690 nm)	[87]
		Landsat-7 ETM+	B3 (630-690 nm)	[155]
		Landsat-7 ETM+	B3 (630-690 nm)	[87]
Multiple bands		Terra ASTER	B1 (520-600 nm), B2 (630-690 nm), B3 (780-860 nm)	[83]
		Terra ASTER	B1 (520-600 nm), B2 (630-690 nm), B3 (780-860 nm)	[83]
		Landsat-5 TM	B2 (520-600 nm), B3 (630-690 nm), B6 (10400-12500 nm), B7 (2080-2350 nm)	[89]
		Landsat-5 TM	B1 (450-520 nm), B3 (630-690 nm)	[115]
		Landsat-5 TM	B1 (450-520 nm), B3 (630-690 nm), B4 (760-900 nm)	[115]
		Landsat-5 TM	B2 (520-600 nm), B3 (630-690 nm)	[115]
		Landsat-5 TM	B1 (450-520 nm), B3 (630-690 nm), B4 (760-900 nm)	[67]
		Landsat-5 TM	B1 (450-520 nm), B2 (520-600 nm), B3 (630-690 nm),	[73]

		B4 (760-900 nm), B5 (1550-1750 nm), B7 (2080-2350 nm)	
	Landsat-8 OLI	B4 (630-670 nm), B5 (850-880 nm)	[86,88]
	Landsat-8 OLI	B2 (450-510 nm), B4 (630-670 nm)	[161]
	Landsat-8 OLI	B3 (525-600 nm), B4 (630-680 nm), B5 (850-880 nm), B7 (2110-2290 nm)	[80]
	PlanetScope	B4 (547-583 nm), B6 (650-680 nm), B8 (845-885 nm)	[80]
	Sentinel-2 MSI	B2 (460.2-525.2 nm), B4 (649.6-679.6 nm), B8 (780.3-885.3 nm), B12 (2115.4-2289.4)	[80]
	Sentinel-2 MSI	B3 (542.3-577.3 nm), B4 (649.6-679.6 nm), B5 (697.1-711.1 nm), B12 (2115.4-2289.4)	[85]

Table S4. Sensor data for various waterbodies including waterbody type, country, study area, mean depth, study duration, method for retrieval of turbidity based on satellite imagery, range of measured turbidity values (minimum and maximum), and a correlation coefficient (R^2) between satellite imagery and turbidity *in situ* values.

Sensor	Waterbody type	Waterbody	Country	Study area [km²]	Surface area category	Mean depth [m]	Mean depth category	Study Duration	Method	Turb. min [NTU]	Turb. max [NTU]	R^2	Reference
Landsat-5 TM	Lakes	Reelfoot Lake	Tennessee, USA	296	very large	1.5	very shallow	1 month	regression	4.1	20	0.537	[79]
Landsat-8 OLI	Reservoirs	El Guájaro Reservoir	Columbia	116	very large	5	shallow	1 month	empirical	13.5	117	0.6419	[88]
Landsat-5 TM	Lakes	Küçükçekmece Lake	Turkey	15	large	~10	shallow	1 month	multiple regression	2.9	33.5	0.822	[73]
Landsat-5 TM Landsat-7 ETM+	Reservoirs	Asprokremmos Reservoir	Cyprus	2590	very large	~50	deep	6 months (April-October 2010)	regression	7.94	26.3	0.85	[87]
PROBA-CHRIS	Reservoirs	Asprokremmos Reservoir	Cyprus	2590	very large	~50	deep	6 months (April-October 2010)	regression	7.94	26.3	0.9	[87]
Landsat-5 TM	Reservoirs	Guanting Reservoir	China	253	very large	7.1	shallow	2 times in 1 month	empirical	2.133	142	0.937	[89]
Landsat-5 TM	Lakes	Chagan Lake	China	0.4	small	1.5	very shallow	1 month	empirical, NN	5	180	0.98	[67]

Terra ASTER	Lakes	Qaroun Lake	Egypt	200	very large	8	shallow	2 months	empirical	0	85	0.998	[83]
PlanetScope	Reservoirs	13 reservoirs	Oklahoma, USA	4-188	medium-very large	4-20 m	shallow-deep	3 years	empirical	0	966	0.79	[80]
Landsat-7 ETM+	Lakes	34 shallow lakes in the Waikato region	New Zealand	0.05 - 34	small-large	max 1.8 - 8.7 m	very shallow-shallow	6 sessions during summer in 10 years	empirical	75	275	0.924	[84]

Table S5. Selected remotely measurements of SDD using various sensors and spectral bands, band combinations, and band equations (R in band combinations represents the reflectance at a certain wavelength).

Band Combination		Sensor	Band/Equation	Reference
Ratio between red and green		Landsat-5 TM	B3 (630-690 nm)/B2 (520-600 nm)	[75,79]
Ratio between NIR and red		AISA	$(R_{670-677}-R_{747-755})/(R_{699-705}-R_{747-755})$	[36]
		Envisat MERIS	R_{708}/R_{664}	[95]
Ratio between NIR and green		AISA	$(R_{521}-R_{781})/(R_{700}-R_{781})$	[101]
Ratio between blue and red		Landsat-7 ETM+	B1 (450-515 nm)/B3 (630-690 nm)	[98]
		PROBA-CHRIS	$(R_{410}+R_{651})/R_{680}$	[99]
Ratio between blue and green		Landsat-5 TM	B1 (450-520 nm)/B2 (520-600 nm)	[78]
		PlanetScope	B2 (465-515 nm)/B3 (513-549 nm)	[92]
Single band	Red	Landsat-5 TM	B3 (630-690 nm)	[76,158]
		Terra MODIS	B1 (620-670 nm)	[72]
	NIR	Terra MODIS	R_{710}	[81]
Multiple bands		Ikonos OSA	B1 (450–530 nm), B2 (520–610 nm), B3 (640–720 nm)	[100]
		Ikonos OSA	B1 (445-516 nm), B3 (632-698 nm)	[162]
		Landsat-5 MSS	B1 (500-600 nm), B2 (600-700 nm)	[163]
		Landsat-5 TM	B1 (450-520 nm), B2 (520-600 nm), B3 (630-690 nm)	[75,164]
		Landsat-5 TM	B1 (450-520 nm), B2 (520-600 nm)	[77]
		Landsat-5 TM	B1 (450-520 nm), B3 (630-690 nm)	[51,94,97,115,162,163,165]
		Landsat-5 TM	B1 (450-520 nm), B4 (760-900 nm)	[115]
		Landsat-5 TM	B1 (450-520 nm), B2 (520-600 nm), B4 (760-900 nm)	[115]

	Landsat-7 ETM+	B1 (450-515 nm), B3 (630-690 nm)	[84,166]
	Landsat-7 ETM+	B3 (630-690 nm), B7 (2090-2350 nm)	[96]
	Landsat-8 OLI	B1 (433-453 nm), B2 (450-515 nm), B4 (630-680 nm)	[166]
	Landsat-8 OLI	B2 (450-515 nm), B4 (630-680 nm)	[166]
	Landsat-8 OLI	B3 (525-600 nm), B4 (630-680 nm), B5 (845-885 nm)	[80]
	PlanetScope	B2 (465-515 nm), B6 (650-680 nm), B8 (845-885 nm)	[80]
	Sentinel-2 MSI	B3 (542.3-577.3 nm), B4 (649.6-679.6 nm), B7 (773.3-792.3 nm), B12 (2115.4-2289.4)	[80]

Table S6. Sensor data for various waterbodies including waterbody type, country, study area, mean depth, study duration, method for retrieval of SDD based on satellite imagery, range of measured SDD values (minimum and maximum), and a correlation coefficient (R^2) between satellite imagery and SDD *in situ* values.

Sensor	Waterbody type	Waterbody	Country	Study area [km²]	Surface area category	Mean depth [m]	Mean depth category	Study Duration	Method	SDD min [m]	SDD max [m]	R^2	Reference
Landsat-5 TM	Lakes	Reelfoot Lake	Tennessee, USA	296.40	very large	1.5	very shallow	1 month	regression	0.16	0.33	0.588	[79]
Terra MODIS	Lakes	Chaohu Lake	China	780	very large	2.5	very shallow	4 months	NN	0.25	1.2	0.628	[72]
Landsat-5 TM	Lakes	Arreo Lake	Spain	0.06	small	5.3	shallow	6 years	-	1.33	7.53	0.63	[77]
Landsat-7 ETM+	Lakes	Champlain Lake	Canada-USA	1269	very large	19.5	deep	3 months in summer	empirical	0	3	0.8	[96]
Envisat MERIS	Lakes	Zeekoevlei Lake	South Africa	2.58	medium	1.9	very shallow	1 month	empirical	0.23	0.39	0.801	[95]
Landsat-5 TM	Lakes	Grande Lake	Italy	0.4	small	9	shallow	1 month	multiple regression	0.25	1	0.82	[75]
Landsat-5 TM	Lakes	Piccolo Lake	Italy	0.14	small	18	deep	1 month	multiple regression	3	3.75	0.82	[75]
Landsat-5 TM	Lakes	Iseo Lake	Italy	61	large	124	deep	1 month	empirical	4.6	6.8	0.852	[78]

Landsat-5 TM	Lakes	Bung Boraphet Lake	Thailand	148	very large	1.2	very shallow	3 sessions in spring in 2 months	linear regression	0.2	2.5	0.929	[97]
Landsat-5 TM	Reservoirs	Bull Shoals Reservoir	Arkansas, USA	~400	very large	20	deep	4 months in 2 years	regression	1.2	5	0.96	[76]
Ikonos OSA	Estuary	Golden Horn	Turkey	28	large	max 35 m	deep	1 month	multiple regression	0.8	6.5	0.989	[100]
PlanetScope	Lakes	2 lakes in Lower Amazon Floodplain	Brazil	984-1600	very large	1.6-4	very shallow-shallow	1 month	empirical	0.6	1.94	0.816	[92]
PROBA-CHRIS	Lakes Reservoirs	10 Masurian lakes	Poland	5-1100 ha	small-large	1-14	very shallow-shallow	1 month	empirical	0	6	0.95	[99]
AISA	Lakes	11 lakes	Finland	1-111	small-very large	max 2-85 m	very shallow-deep	3 years	regression	0.3	7	0.926	[101]
AISA	Lakes	11 lakes	Finland	1-111	small-very large	max 2-85 m	very shallow-deep	4 months in 3 years	empirical	0.4	7	0.86	[36]
Landsat-7 ETM+	Lakes	12 Rotorua lakes and Lake Taupo	New Zealand	0.3-80.6	small-large	7-60	shallow-deep	2 months	empirical	0.78	4.23	0.82	[98]
Sentinel-2 MSI	Reservoirs	13 reservoirs	Oklahoma, USA	4-188 km2	medium-very large	4-20	shallow-deep	3 years	empirical	0.08	4	0.8	[80]
Terra MODIS	Lakes	15 lakes	Minnesota, USA	6-410 ha	small-medium	2-9	very shallow-shallow	1 month	nonlinear regression	0.2	6.1	0.52	[81]
Landsat-7 ETM+	Lakes	34 lakes in the Waikato region	New Zealand	0.05 – 34.4	small-large	max 1.8 - 8.7 m	very shallow-shallow	6 sessions during summer in 10 years	empirical	0.05	3.04	0.67	[84]

Table S7. Selected remotely measurements of WT using various sensors and spectral bands, band combinations, and band equations.

Band Combination		Sensor	Band/Equation	Reference
Single band	TIR	Landsat-5 TM	B6 (10400-12500 nm)	[77,78,167–169]
		Landsat-7 ETM+	B6 (10400-12500 nm)	[105,170]
		Landsat-8 TIRS	B10 (10600-11190 nm)	[171]
Multiple bands		Terra ASTER	B8 (2295-2365 nm), B10 (8125-8475 nm), B11 (8475-8825 nm), B13 (10250-10950 nm)	[83]
		Landsat-8 TIRS	B10 (10600-11190 nm), B11 (11500-12510 nm)	[172]
		Terra MODIS	B31 (10780-11280 nm), B32 (11770-12270 nm)	[104,173]
		Terra MODIS	B31 (10780-11280 nm), B32 (11770-12270 nm)	[107]
		NOAA-9, -11, -12, -14, -16, -17, -19 AVHRR	B4 (1030-1130 nm), B5 (1150–1250 nm)	[106]

Table S8. Sensor data for various waterbodies including waterbody type, country, study area, mean depth, study duration, method for retrieval of WT based on satellite imagery, range of measured WT values (minimum and maximum), and a correlation coefficient (R^2) between satellite imagery and WT *in situ* values.

Sensor	Waterbody type	Water-body	Country	Study area [km^2]	Surface area category	Mean depth [m]	Mean depth category	Study Duration	Method	WT min [°C]	WT max [°C]	R^2	Refer-ence
Terra AS-TER	Lakes	Qaroun Lake	Egypt	200	very large	8	shallow	2 months	empirical	29.7	31.2	0.535	[83]
Terra MODIS	Lakes	Urmia Lake	Iran	2366	very large	7	shallow	46 sessions in 4 years	empirical	3.5	32	0.92	[104]
Landsat-7 ETM+ Landsat-5 TM	Lakes	Stechlin Lake	Germany	4.52	me-dium	max 70	deep	9 sessions in 10 months (Febru-ary-November 2000)	empirical	2.5	21.5	0.921	[105]
Terra MODIS	Lakes	2 lakes	Sweden	5650 - 1912	very large	28 - 41	deep	23 sessions in 2 years between April and Octo-ber (2002-2003)	empirical	1	22	0.9928	[107]

NOAA AVHRR	Lakes	4 lakes	Switzerland-France, Hungary, Sweden & Finland	580 - 1900	very large	3 - 153	shallow-deep	120 sessions in 6 years for 4 lakes (2 x 3 years)	linear regression	1	29	0.792	[106]

Table S9. Selected remotely measurements of salinity using various sensors and spectral bands, band combinations, and band equations.

Band Combination	Sensor	Band/Equation	Reference
Ratio between SWIR 2 and SWIR 1	Landsat-5 TM	B7 (2080-2350 nm)/B5 (1550-1750 nm)	[174]
Multiple bands	Terra ASTER	B3 (780-860 nm), B5 (2145-2185 nm), B7 (2235-2285 nm)	[83]
	Landsat-5 TM	B1 (450-520 nm), B4 (*760-900 nm*), B6 (10400-12500 nm)	[175]
	Landsat-8 OLI	B2 (450-515 nm), B3 (525-600 nm), B4 (630-680 nm)	[109]
	Landsat-8 OLI	B2 (450-515 nm), B5 (850-880 nm), B10 (10600-11190 nm), B11 (11500-12510 nm)	[175]
	Sentinel-2 MSI	B2 (460.2-525.2 nm), B3 (542.3-577.3 nm), B4 (649.6-679.6 nm), B6 (733.5-747.5 nm), B7 (773.3-792.3 nm), B8 (780.3-885.3 nm)	[108]
	Sentinel-2 MSI	B2 (460.2-525.2 nm), B3 (542.3-577.3 nm), B4 (649.6-679.6 nm)	[109]

Table S10. Sensor data for various waterbodies including waterbody type, country, study area, mean depth, study duration, method for retrieval of salinity based on satellite imagery, range of measured salinity values (minimum and maximum), and a correlation coefficient (R^2) between satellite imagery and salinity *in situ* values.

Sensor	Waterbody type	Waterbody	Country	Study area [km²]	Surface area category	Mean depth [m]	Mean depth category	Study Duration	Method	SS min	SS max	R^2	Reference
Sentinel-2 MSI	Lakes	Urmia Lake	Iran	2917	very large	7	shallow	4 sessions in 3 months (2xApril, June and July 2021)	ML	30.7	36.1	0.657	[108]
Sentinel-2 MSI	Lakes	Urmia Lake	Iran	2917	very large	7	shallow	2 months (April and June 2019)	ANN	6.5	32	0.94	[109]

Table S11. Selected remotely measurements of EC using various sensors and spectral bands, band combinations, and band equations.

Band Combination		Sensor	Band/Equation	Reference
Ratio between green and red		Landsat-8 OLI	B3 (525-600 nm)/B4 (630-680 nm)	[114]
Single band	Red	Landsat-8 OLI	B4 (630-680 nm)	[86]
	Blue	WorldView-2	B2 (450-510 nm)	[176]
Multiple bands		Terra ASTER	B3 (780-860 nm), B4 (1600-1700 nm), B8 (2295-2365 nm)	[83]
		Landsat-5 TM	B1 (450-520 nm), B2 (520-600 nm), B3 (630-690 nm)	[177]
		Landsat-8 OLI	B2 (450-510 nm), B3 (525-600 nm), B4 (630-680 nm)	[177]
		Landsat-8 OLI	B2 (450-510 nm), B3 (525-600 nm), B4 (630-680 nm), B6 (1570-1650 nm)	[88]
		Landsat-8 OLI	B1 (430-450 nm), B2 (450-510 nm), B3 (525-600 nm), B5 (850-880 nm), B6 (1570-1650 nm)	[161]

Table S12. Sensor data for various waterbodies including waterbody type, country, study area, mean depth, study duration, method for retrieval of EC based on satellite imagery, range of measured EC values (minimum and maximum), and a correlation coefficient (R^2) between satellite imagery and EC *in situ* values.

Sensor	Waterbody type	Waterbody	Country	Study area [km^2]	Surface area category	Mean depth [m]	Mean depth category	Study Duration	Method	EC min [mS/cm]	EC max [mS/cm]	R^2	Refer-ence
Landsat-8 OLI	Lakes	Wular Lake, Kashmir	India	189	very large	5.8	shallow	1 month	empirical	0.014	0.3	0.615	[86]
Landsat-8 OLI	Reservoirs	El Guájaro Reservoir	Columbia	116	very large	5	shallow	1 month	empirical	0.54	1.82	0.6994	[88]
Landsat-8 OLI	Lakes	Qaroun Lake	Egypt	200	very large	8	shallow	1 month	stepwise regression	42.86	52.55	0.87	[114]