

ISEO: Improving the lake Status from
Eutrophy towards Oligotrophy



fondazione
cariplo

Partner presentation CNR-IREA

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Consiglio Nazionale delle Ricerche



Brescia, 18/06/2019

Work-package WP4: Implementation actions and expected results

IREA will set up a remote monitoring of the lake surface, having as an aim a daily imaging of the lake surface:

- Preparation of initial test datasets and population.*
- Calibration and validation of algorithms for image processing.*
- EO time series for Lake Iseo will be processed in order to retrieve water constituents*

Work-package WP2: Implementation actions and expected results

A sub-task is finalized to use macrophytes and SAV as proxies of the local impacts of human activities and external nutrient inputs

Work-package WP7

The dissemination activity is carefully explained in the Dissemination section of this application

3° year activities

- Processing satellite images in order to produce water quality maps (Chl-a, Turbidity, Surface temperature and macrophytes characterization);
- Field campaign on 10 July to collect data for validation of water quality maps and macrophytes maps;
- Dissemination of the results



Article

Spatiotemporal Dynamics of Submerged Aquatic Vegetation in a Deep Lake from Sentinel-2 Data

Nicola Chirardi ¹, Rossano Bolpagni ^{1,2,*}, Mariano Bresciani ¹, Giulia Valerio ¹, Marco Pilotti ¹ and Claudia Giardino ¹

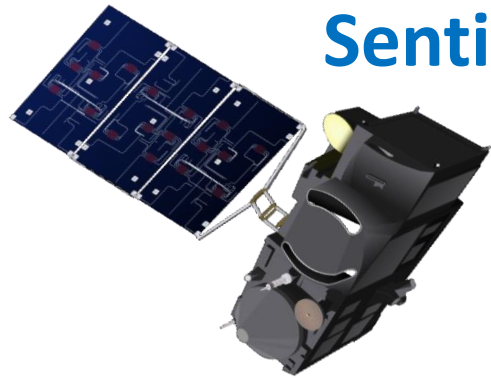
EO data & processing

- **Landsat-8** (water quality, surface temperature)
(85 images)
- **Sentinel-2** (water quality, SAV)
(90 images)
- **Sentinel-3 OLCI** (water quality) 2017-2018
(~ 125 images)
- **Sentinel-3 SLSTR** (water quality) 2017-2018
(~ 150 images)
- **MERIS** (water quality time series) 2003-2012
(~ 200 images)

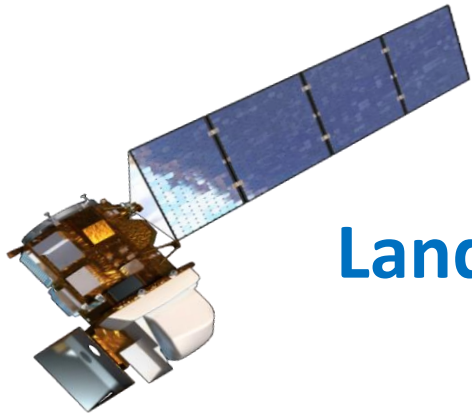
Overview of satellite data



Sentinel-2A / 2B



Sentinel-3A / 3B



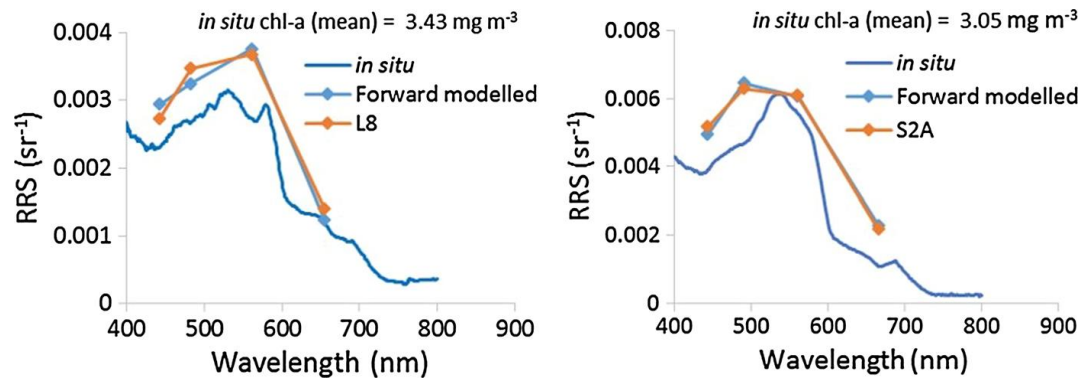
Landsat-8

	MSI
Bands	13 (443-2190 nm)
Spatial Resolution	10 -20-60 m
Temporal resolution	10 days (5 with S2B)
Launch time	23/06/2015 – 07/03/2017

Sensore ottico a bordo	OLCI - SLSTR
Bands	21 (443-1020 nm) - 2 (10850 – 12020 nm)
Spatial Resolution	300 m - 1000 m
Temporal resolution	1-2 days
Launch time	16/02/2016 – 25/04/20018

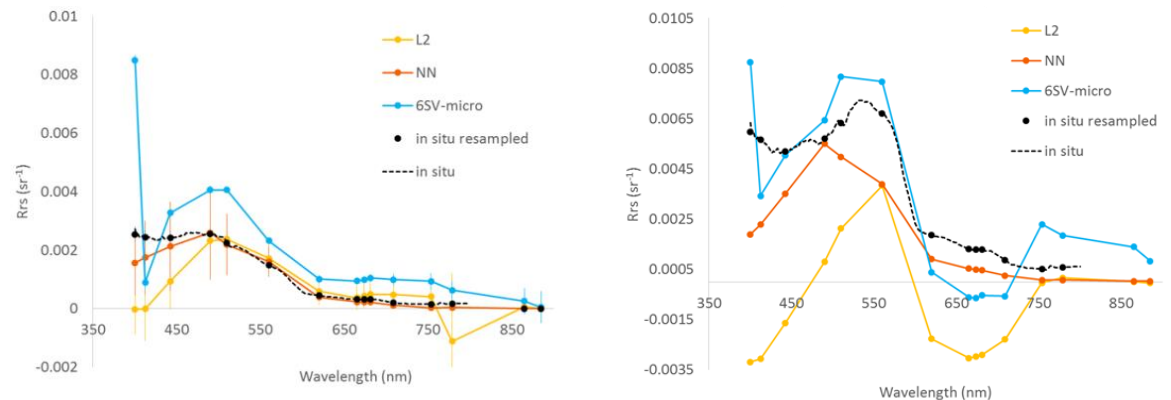
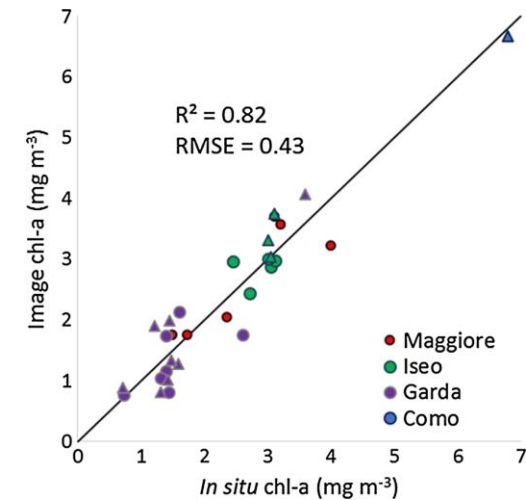
	OLI - TIRS
Bands	9 (443-1380 nm) - 2 (10900-12000 nm)
Spatial Resolution	30 m - 100 m
Temporal resolution	16 days
Launch time	11/02/2013

Validation



In situ measurements, BOMBER simulation and Remote Sensing products of RRS, from L8 image of Lake Maggiore on 24/9/2015 (a) and from S2A image of Lake Iseo on 26/9/2016 (b)

Chl-a concentration measured in situ (x-axis) and estimated from remote sensing data (y-axis), RMSE and Coefficient of determination R^2 . Triangles and circles indicate, respectively, S2A and L8 products. Solid line is the bisector of the first quadrant



Comparison of different methods of atm corr for S3-OLCI

Validation – confusion matrix

Table 1. Confusion matrix depicting the agreement of earth observations classified data with respect to in situ surveys. RM, deep water, and BS.

		In Situ			
		RM	BS	Deep Water	Producer's Accuracy
Classified	RM	29	1	1	93.5%
	BS		7		100.0%
	Deep Water		1	8	88.9%
User's Accuracy		100.0%	77.8%	88.9%	93.6%



- Deep water
- Bare sediment
- Rooted macrophytes

Validation – abundance

		In situ		
		< 0.66	> 0.66	Producer's accuracy
Classified	< 0.66	34	3	91.9%
	> 0.66	0	35	100%
User's accuracy		100%	92.1%	95.8%



Spring 2017
(average)



Summer 2017
(average)



Autumn 2017
(average)

28/06/2016

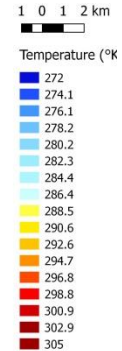


27/08/2016

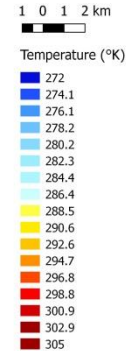


Products – Landsat Surface Temperature [K] (2018)

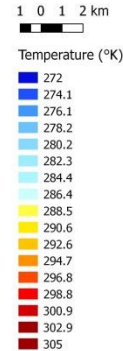
02/04/2018



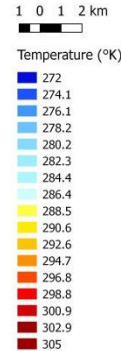
18/04/2018



05/06/2018



21/06/2018



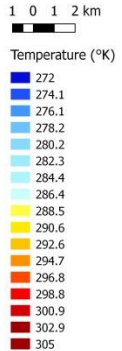
07/07/2018



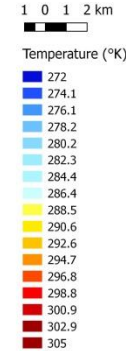
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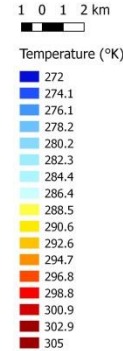
23/07/2018



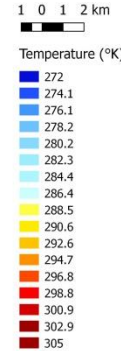
15/08/2018



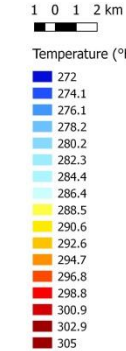
09/09/2018



28/11/2018

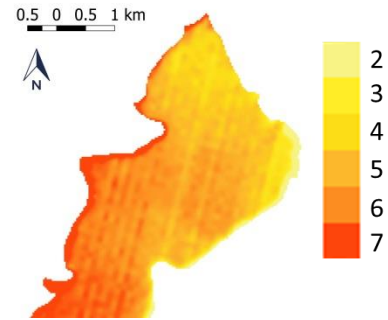


14/12/2018

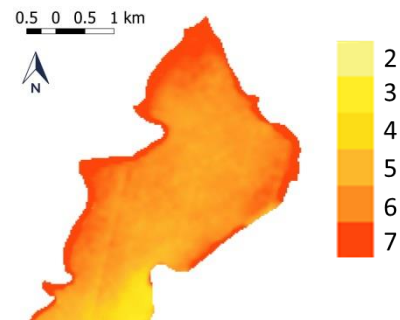


Products – Landsat Surface Temperature [°C] (2018)

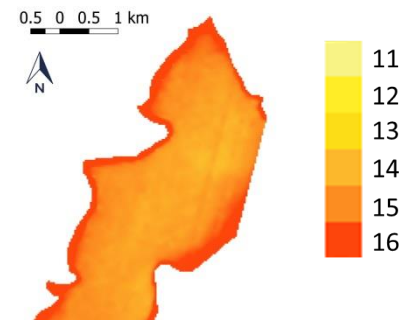
19/01/2018



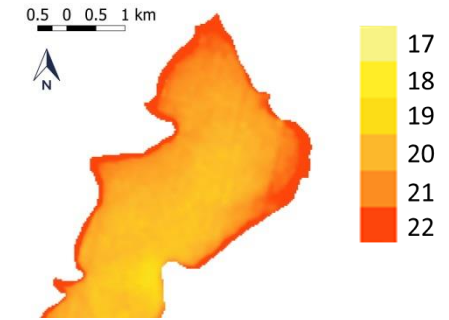
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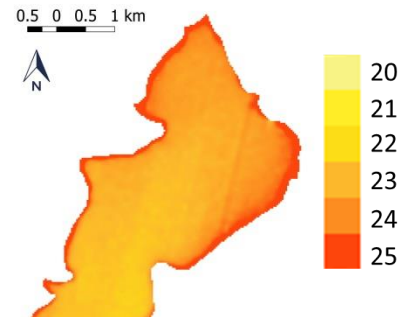
18/04/2018



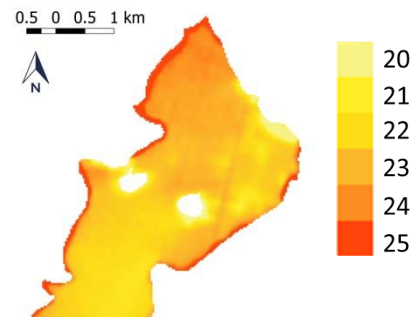
05/06/2018



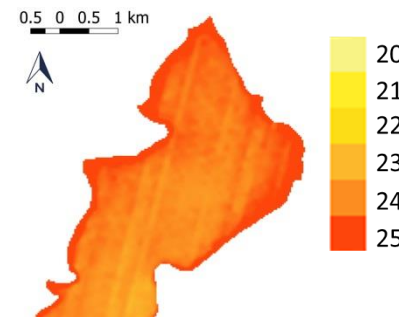
21/06/2018



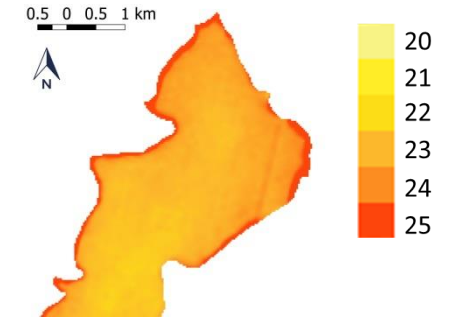
07/07/2018



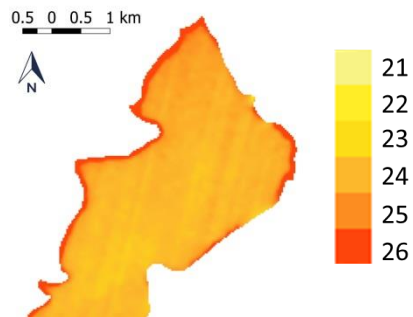
14/07/2018



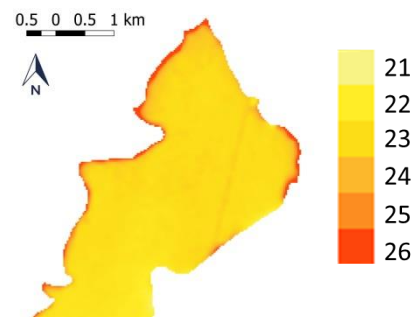
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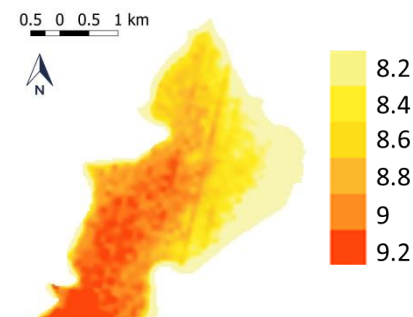
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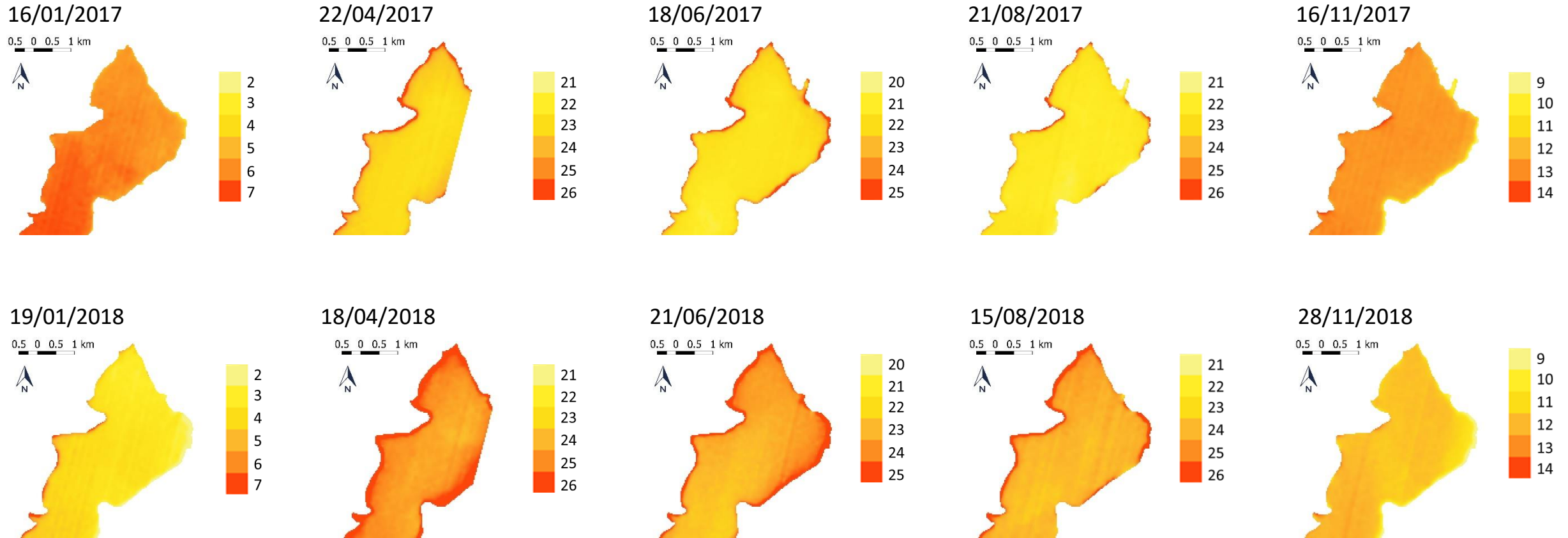
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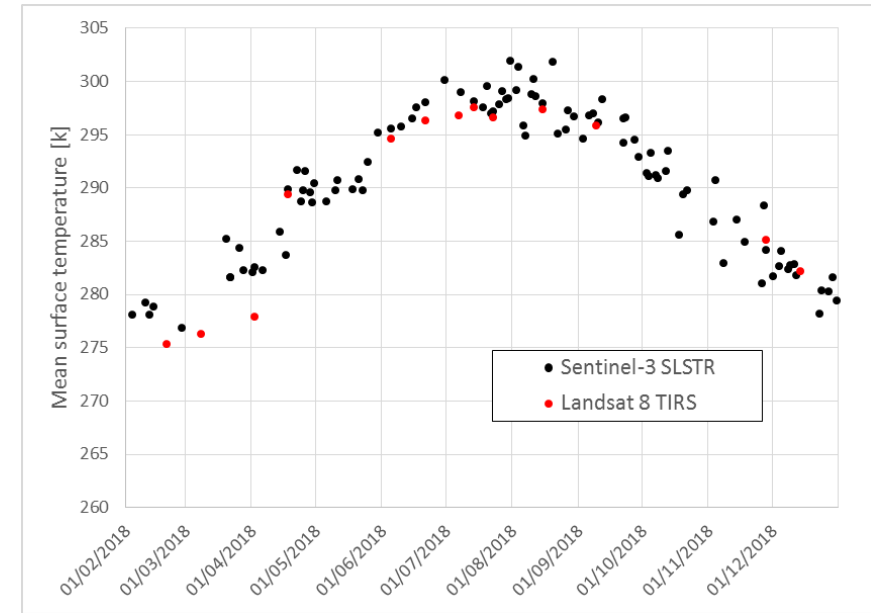
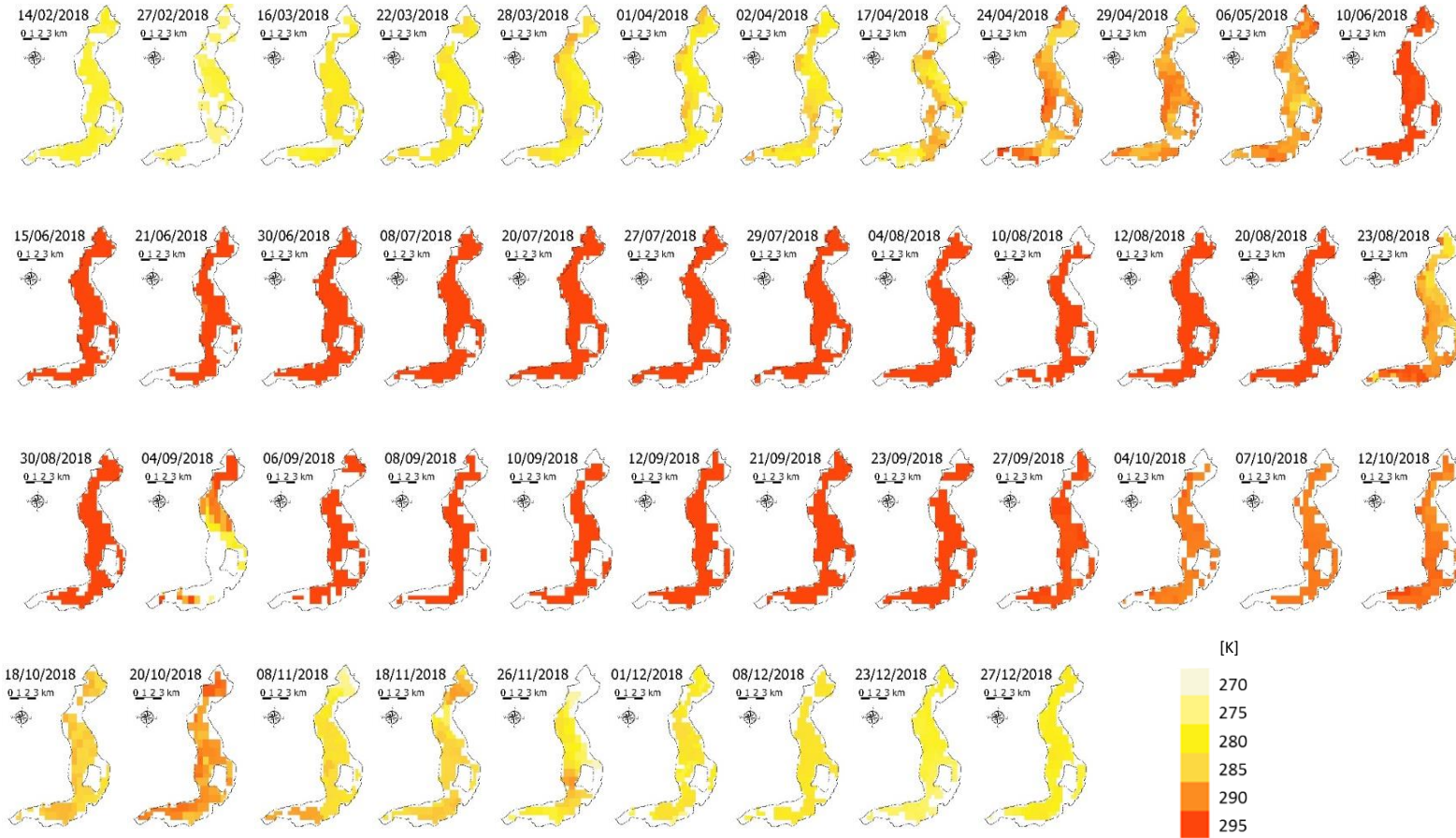
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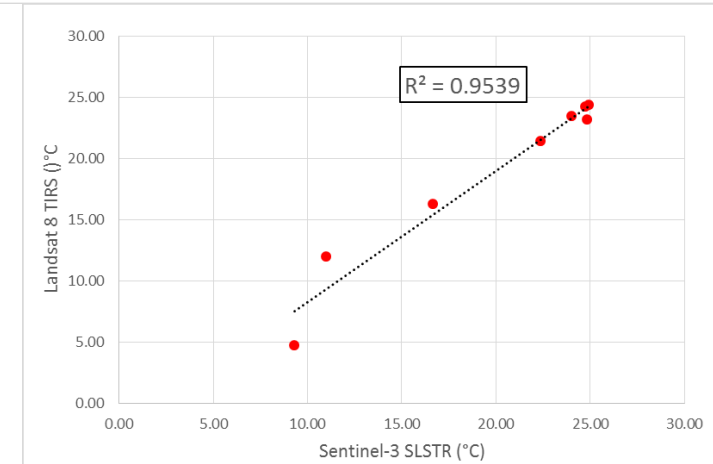
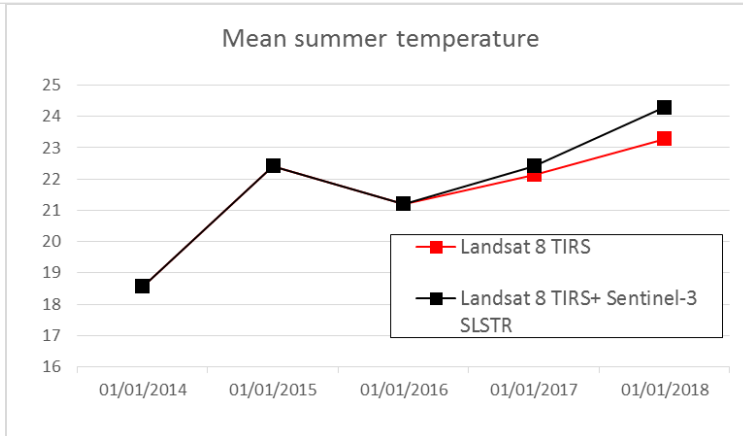
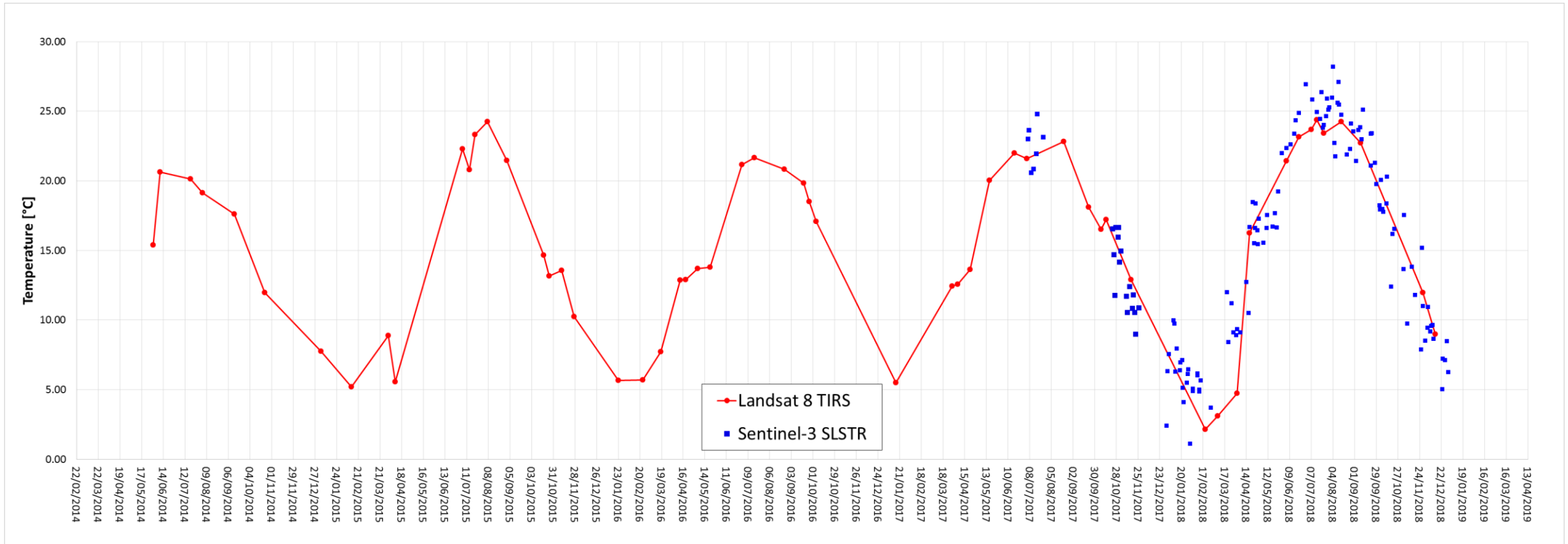
Comparison – Landsat Surface Temperature [°C] (2017-2018)



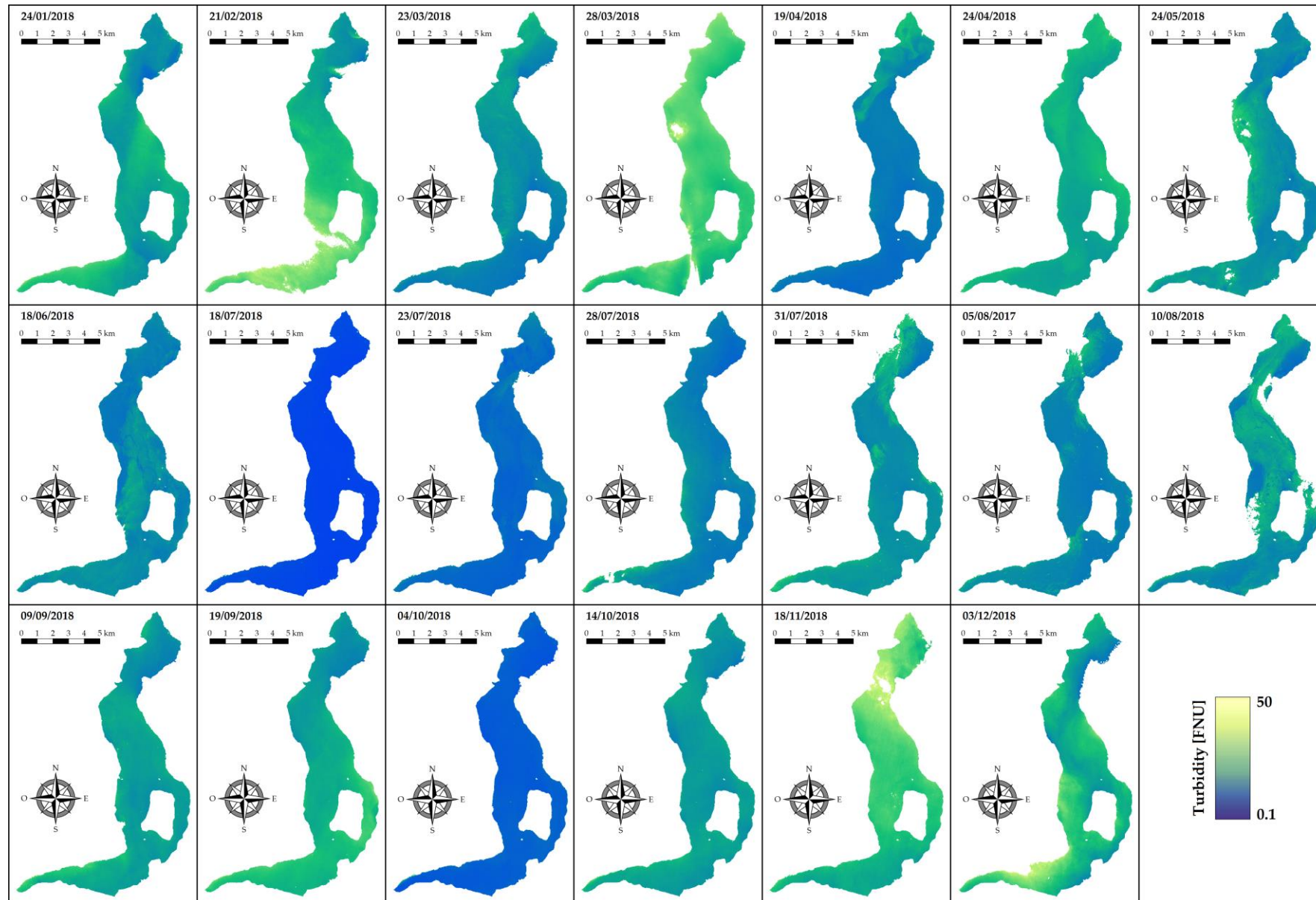
Products – S3A Surface Temperature [K] (2018)



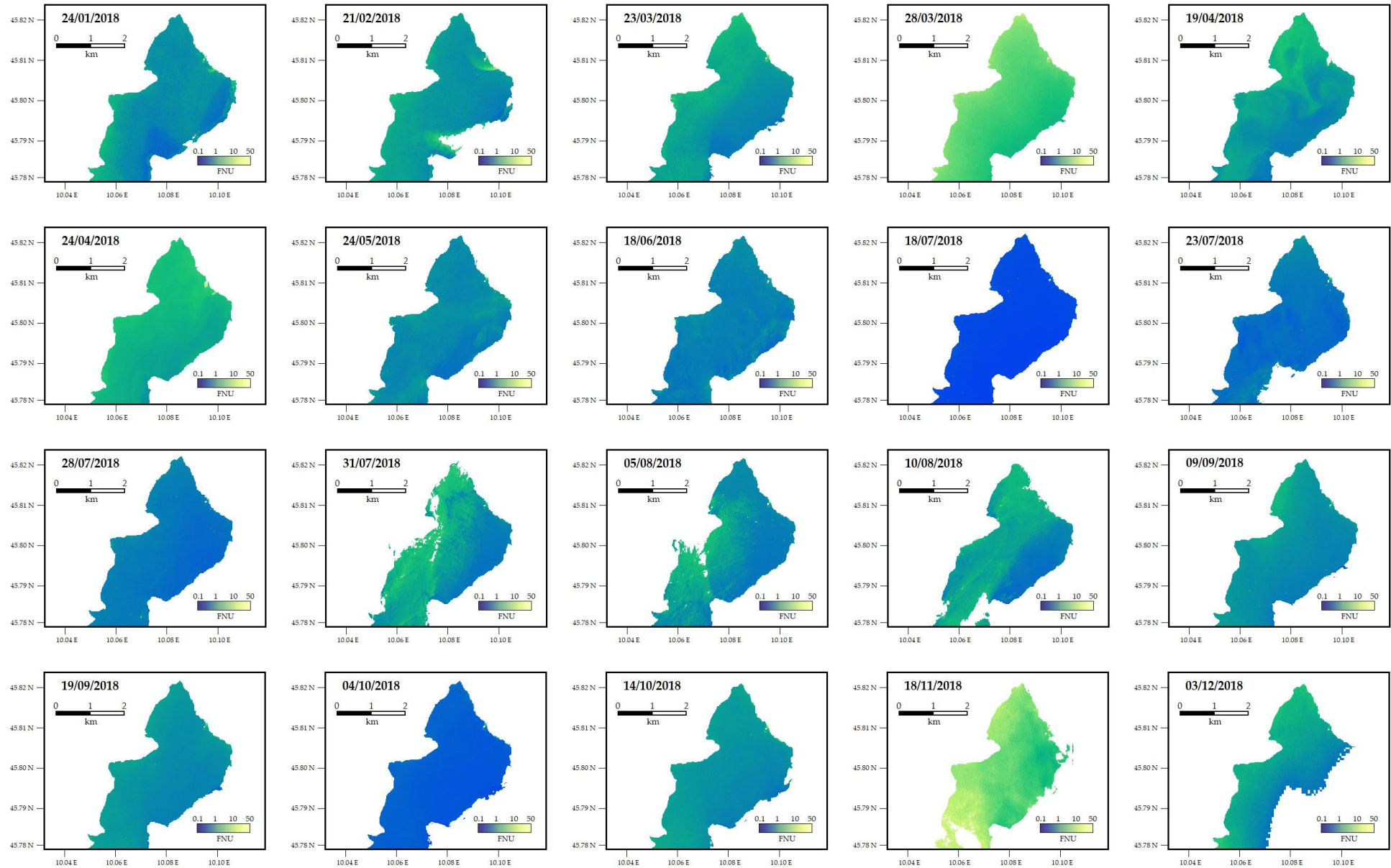
Products comparison – Temperature [°C] (2014-2018)



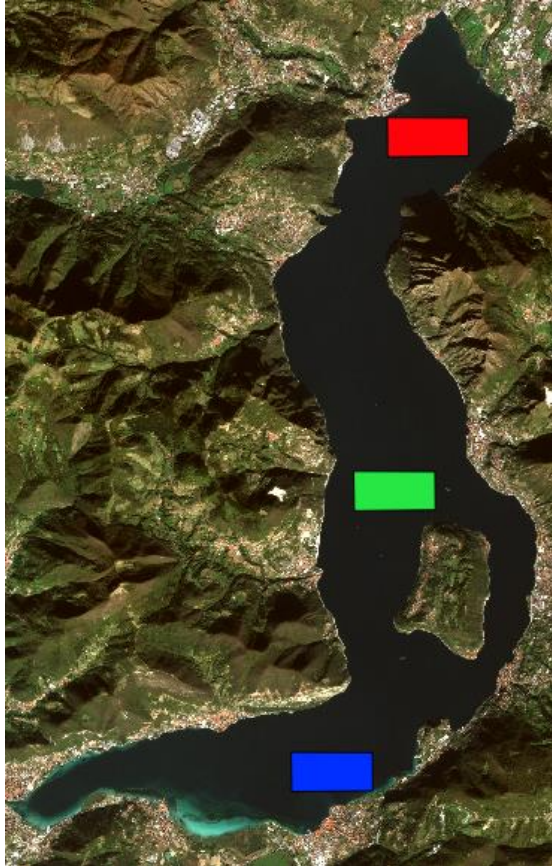
Products – S2Turbidity [FNU] (2018)



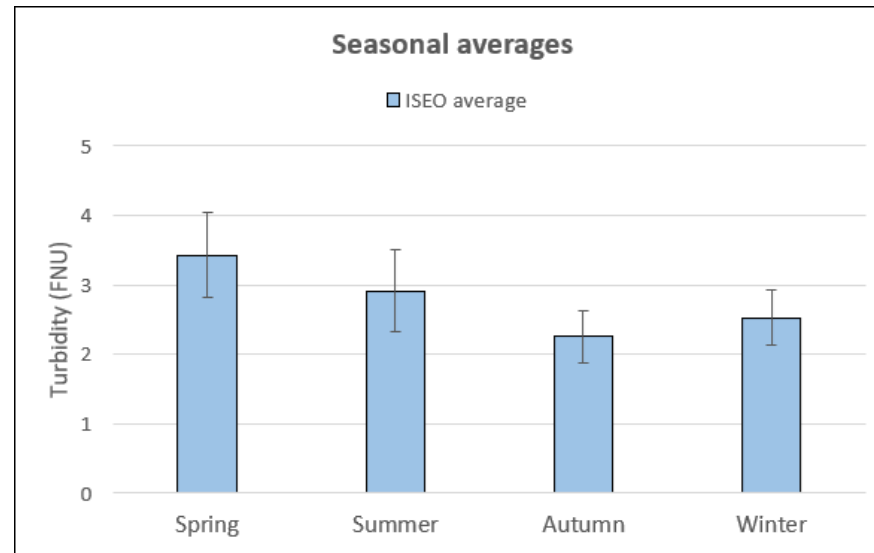
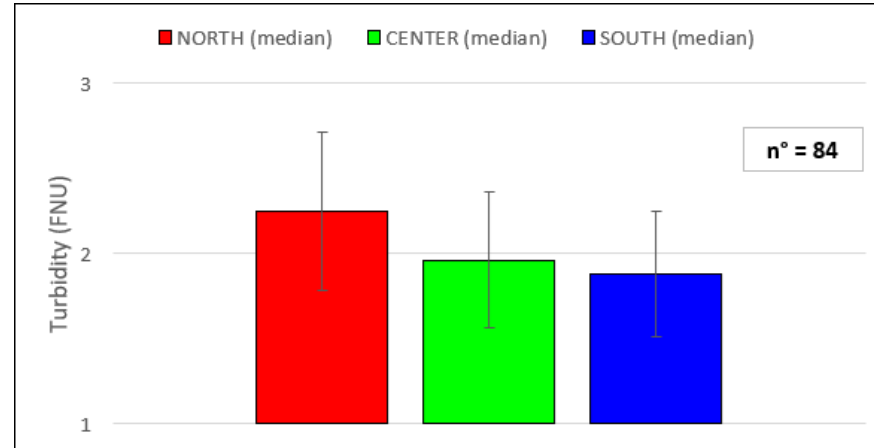
Products – S2Turbidity [FNU] (2018) - NORTH



Turbidity over the years [FNU] (2013-2018)



ROI used for statistical analysis.
North (red), Centre (green),
South (blue)

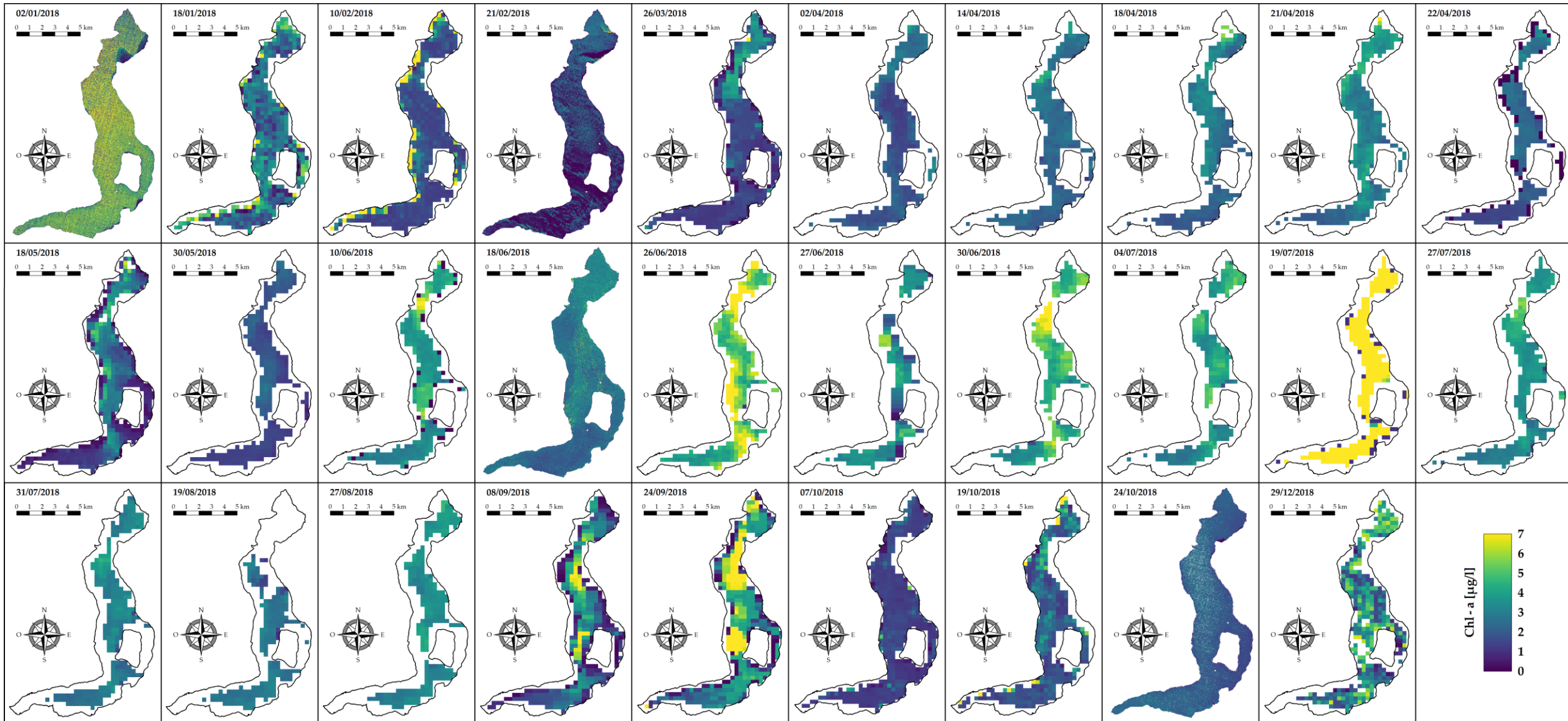


Date	Weekly cumulative rain [mm]	NORTH average [FNU]
13/05/2013	55,0	7,79
31/07/2018	24,6	8,15
18/11/2018	12,6	9,73

Comparing the medians of the three areas analysed, the northern part has on average a higher turbidity value, while comparing the seasonal averages of the entire lake, the value decreases from spring to autumn/winter.

The table above shows one of the possible causes of the high turbidity, i.e. the abundant precipitation.

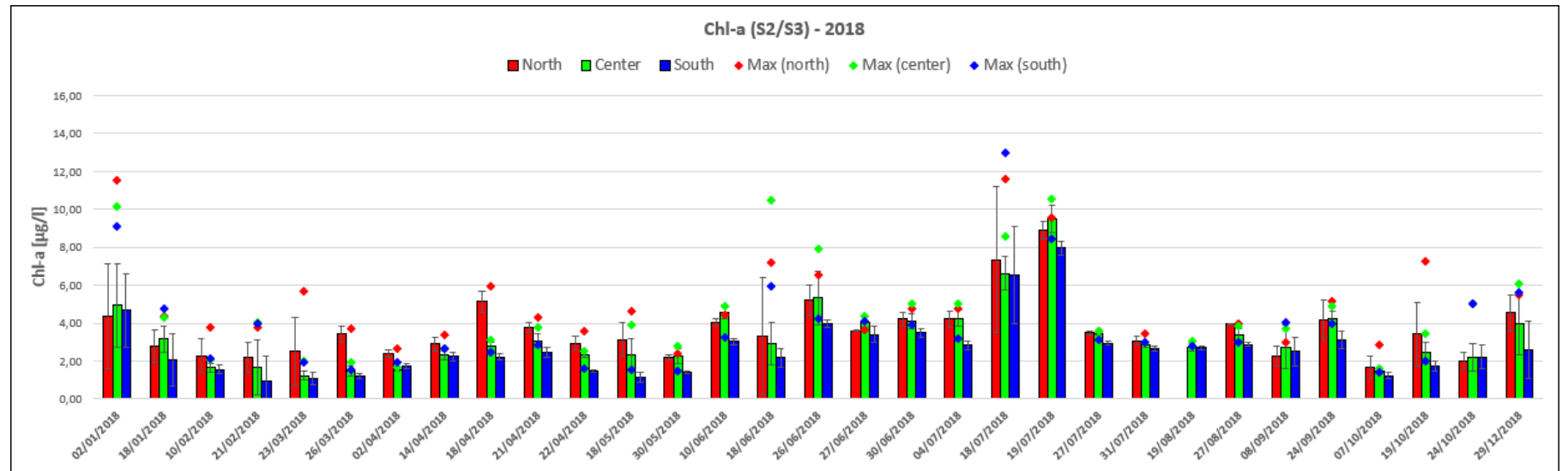
Products – S2/S3 Chl-a [$\mu\text{g}/\text{l}$] (2018)



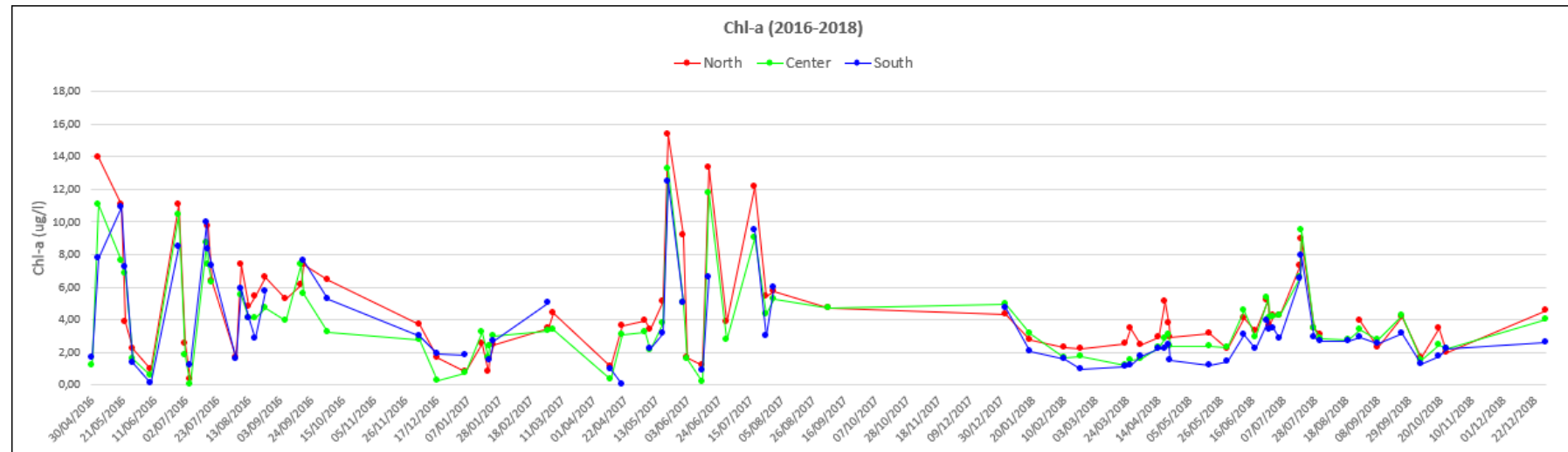
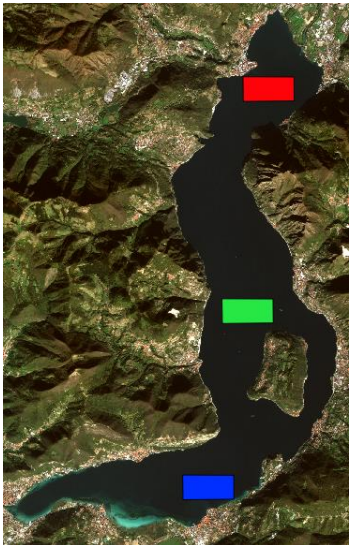
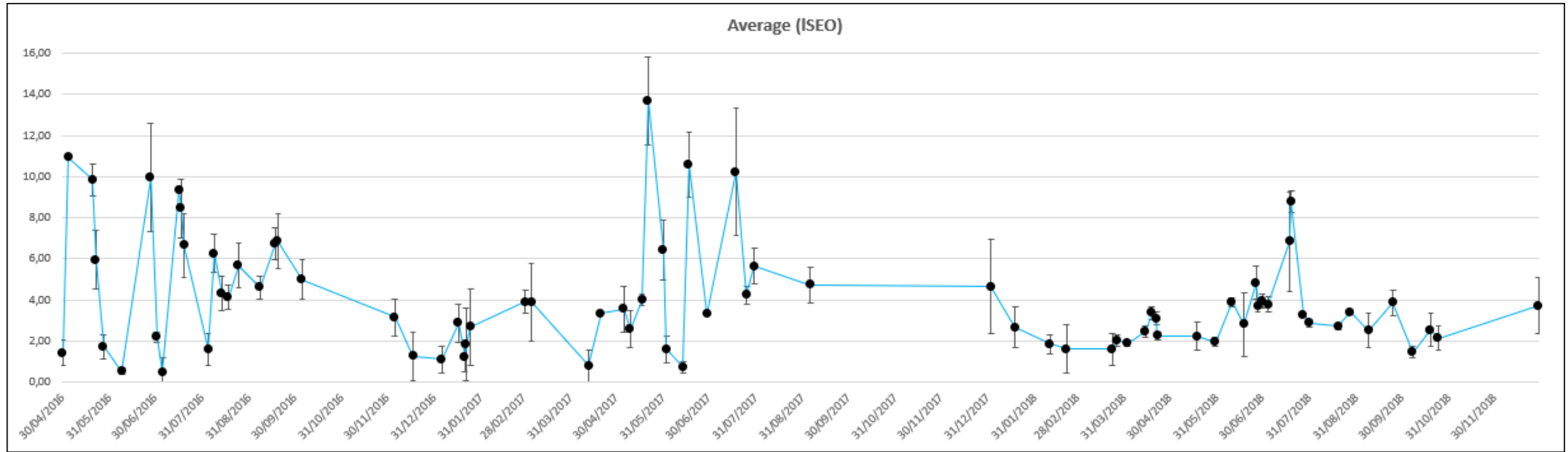
Chl-a spatial analysis (2018)



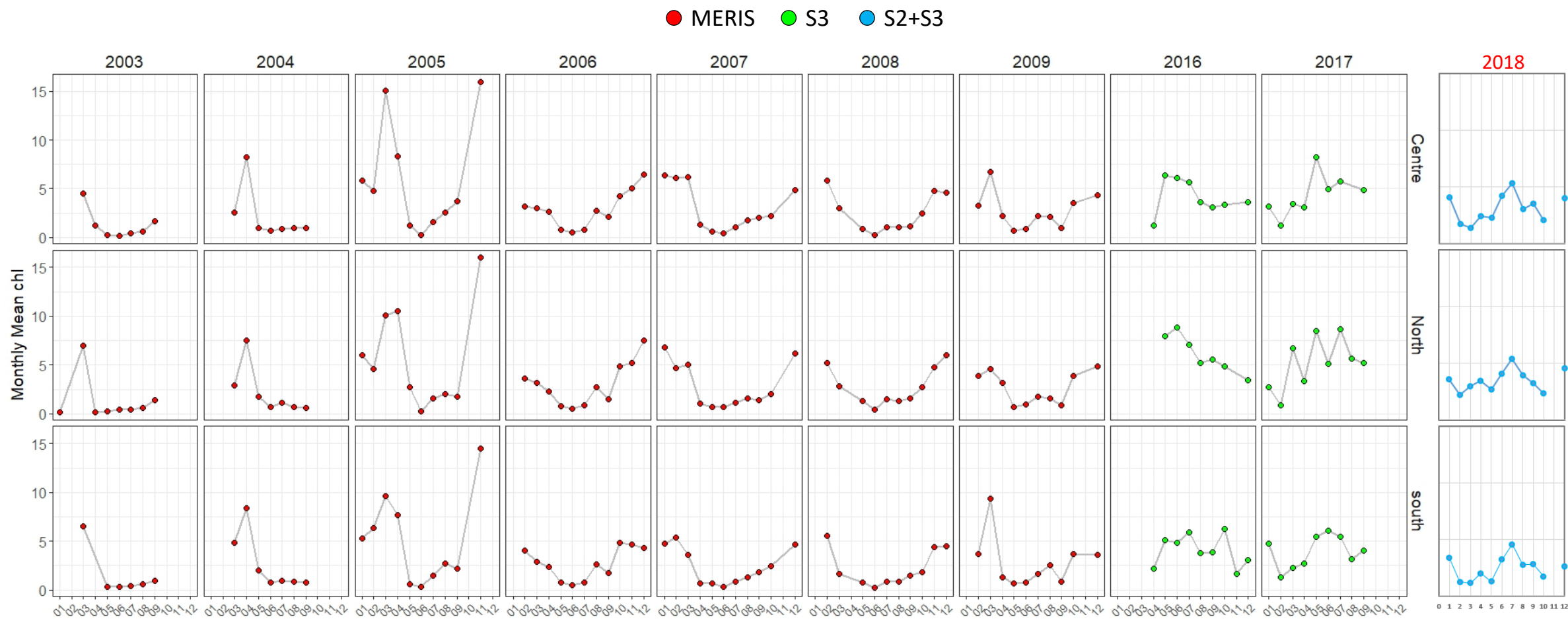
ROI used for statistical analysis.
North (red), Centre (green),
South (blue)



Chl-a over the years [$\mu\text{g/l}$] (2016-2018)



Chl-a Time series integration (S3 OLCI & MERIS)



WFD classification
(based on Chl-a)

High
Good
Moderate
Poor
Bad

	Iseo
2003	
2004	
2005	
2006	
2007	
2008	
2009	
2010	
2011	
2012	
2013	
2014	
2015	
2016	
2017	
2018	

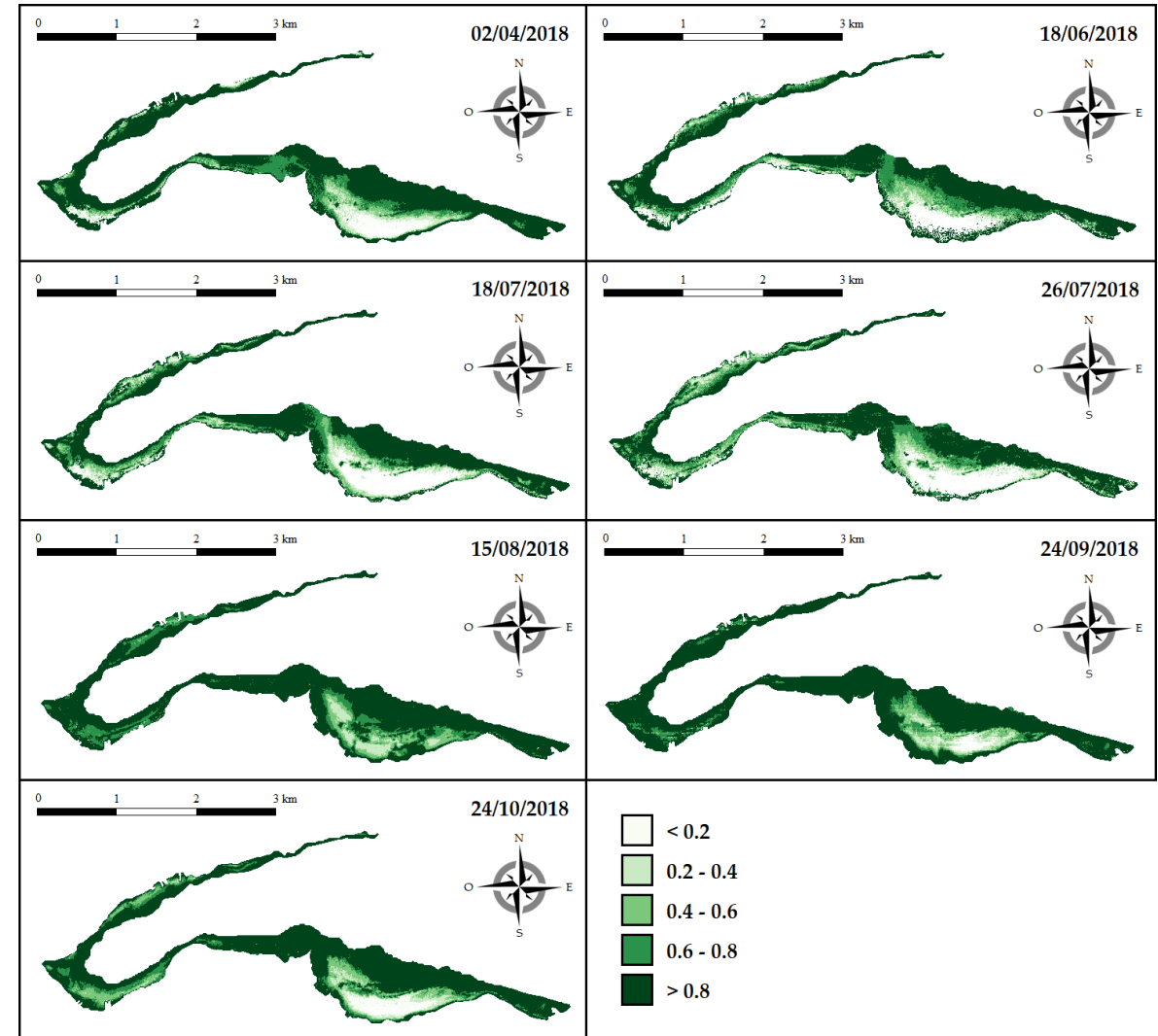
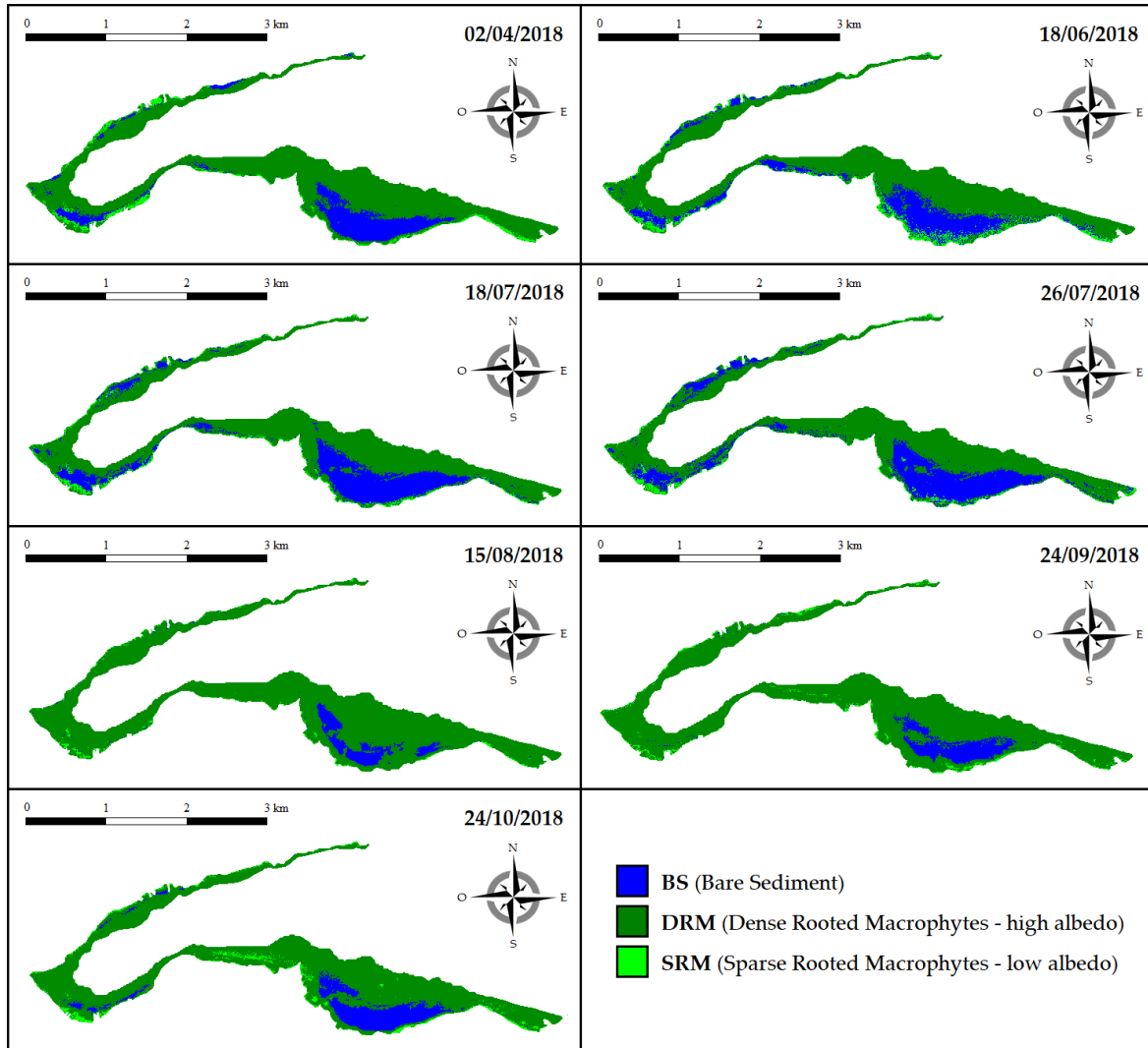
	Median value	Median annual Sen slope
Seasonal Kendall Test	1.65	0.104

Considering all available values since 2003 to 2018, Seasonal Kendall test revealed a slight increasing trend for Lake Iseo

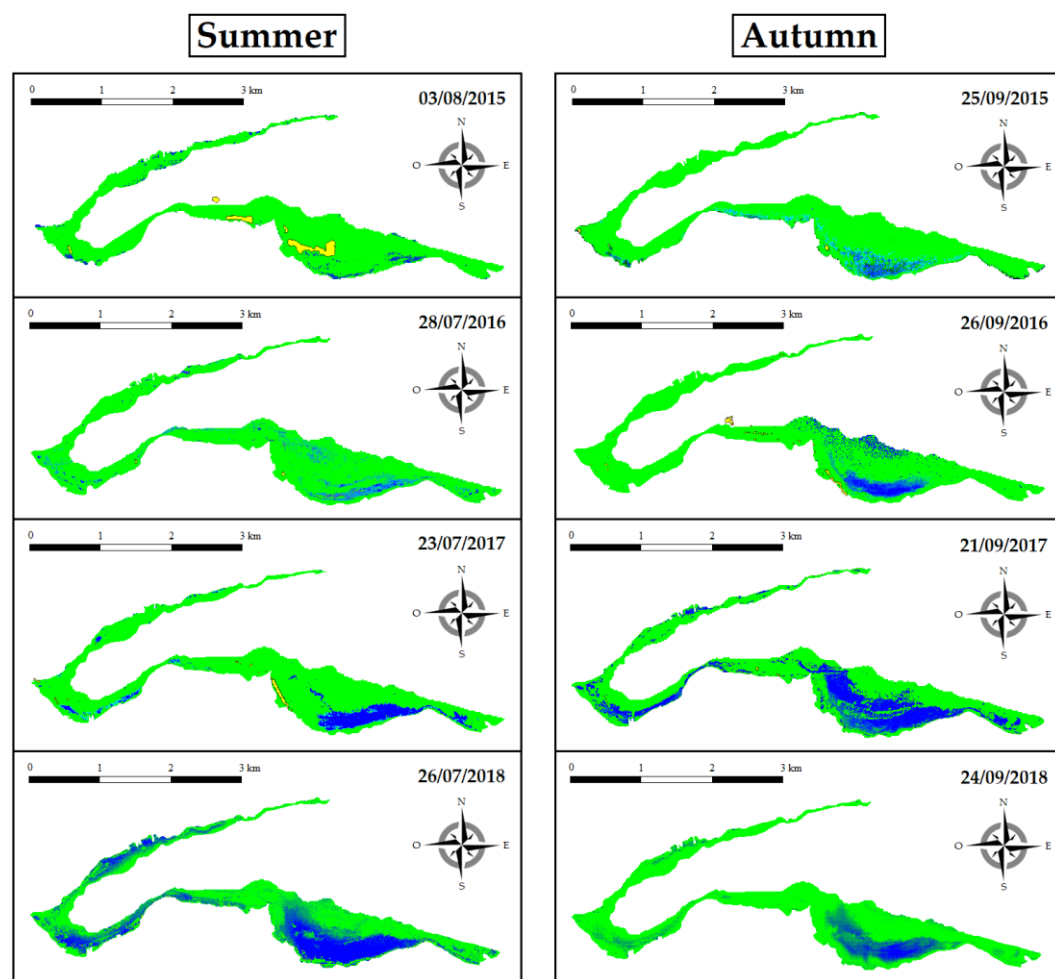
	Slope per year	Standard Error	p-value
Seasonal Adjusted Trend test	0.082	0.035	0.019

Seasonal Adjusted Trend test, confirming the trend for Lake Iseo

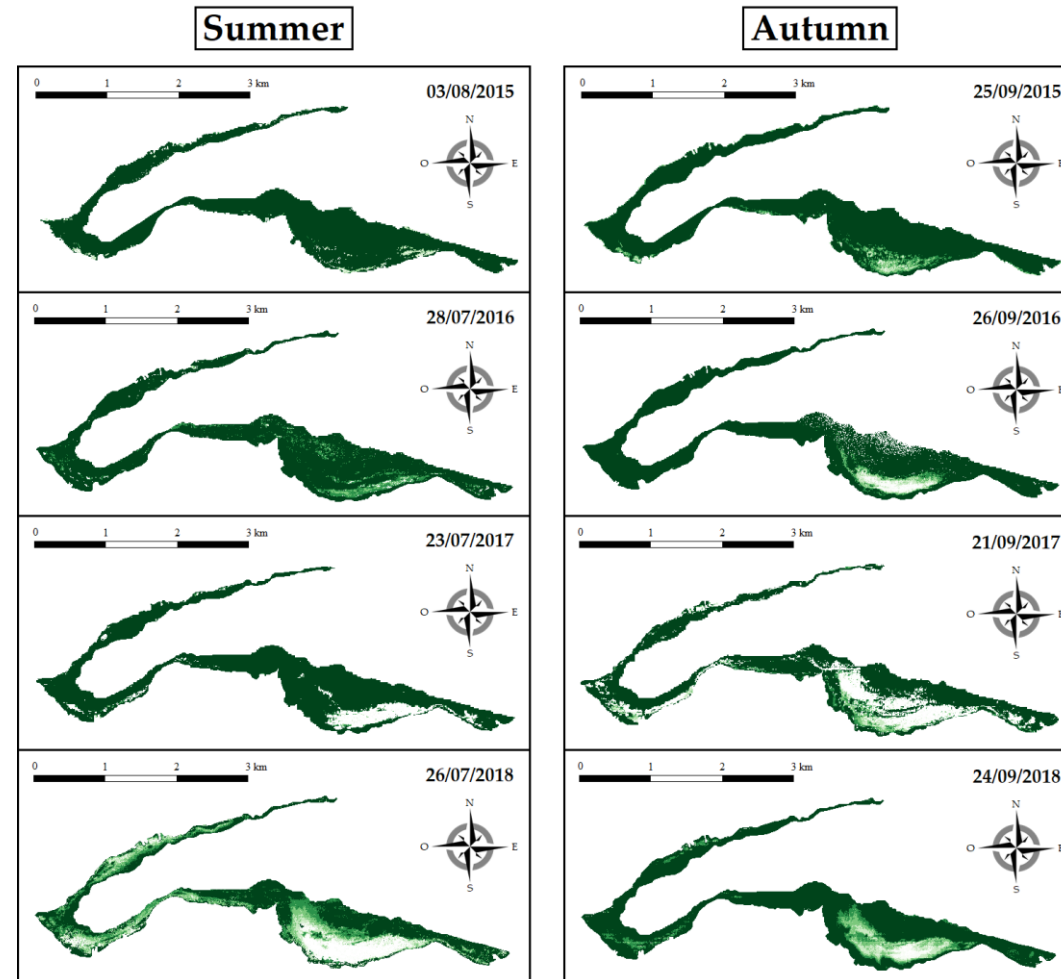
Macrophytes dynamics & Abundance (2018)



Macrophytes years comparison (2015-2018)

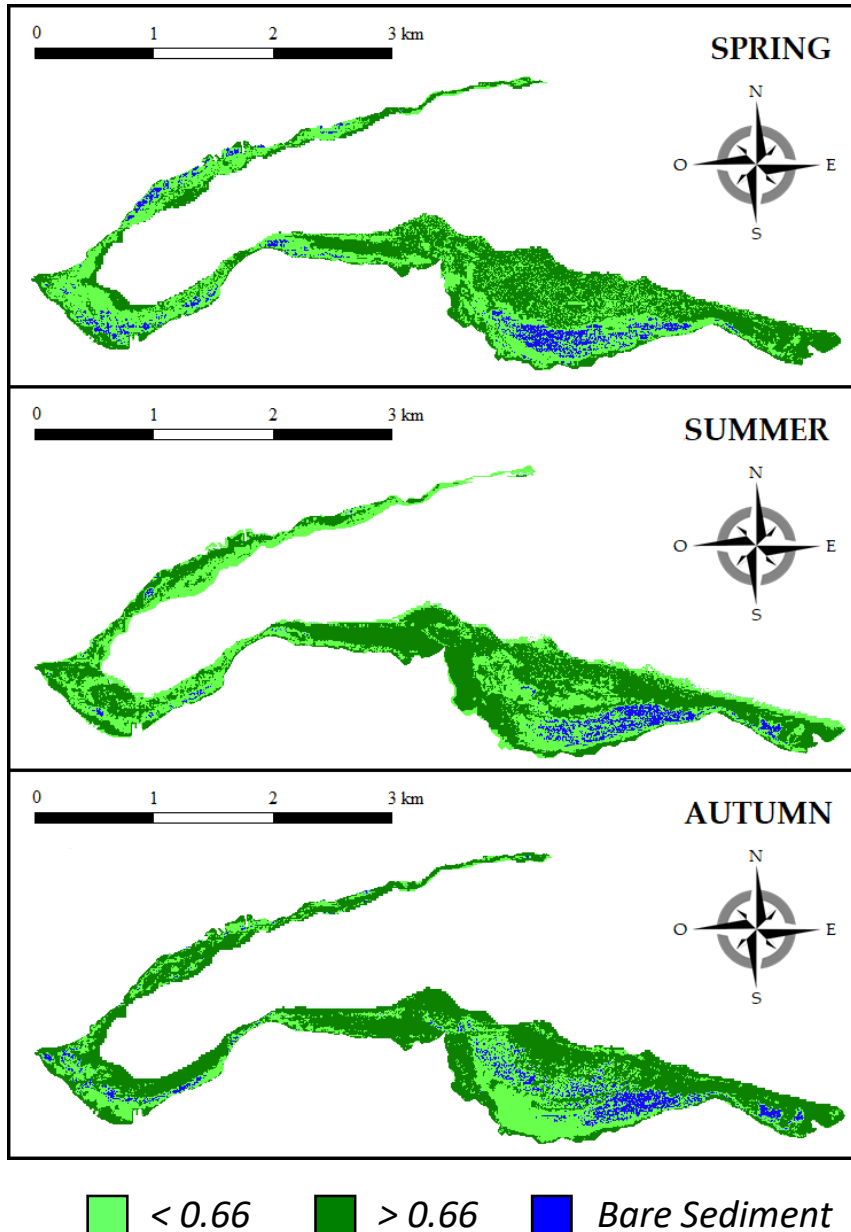


BS (Bare Sediment) RM (Rooted Macrophytes) FM (Floating Macrophytes)



< 0.2 0.2 - 0.4 0.4 - 0.6 0.6 - 0.8 > 0.8

Biomass

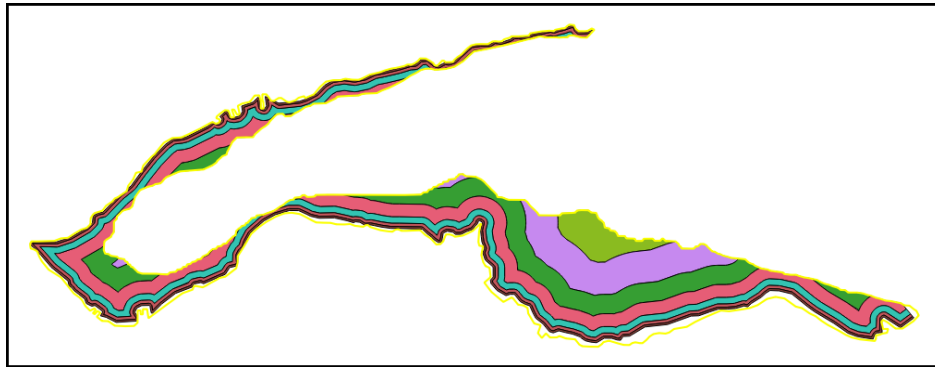


	Area (ha)	
2017	< 0.66	> 0.66
Spring	57,75	161,30
Summer	65,65	175,66
Autumn	41,55	195,61

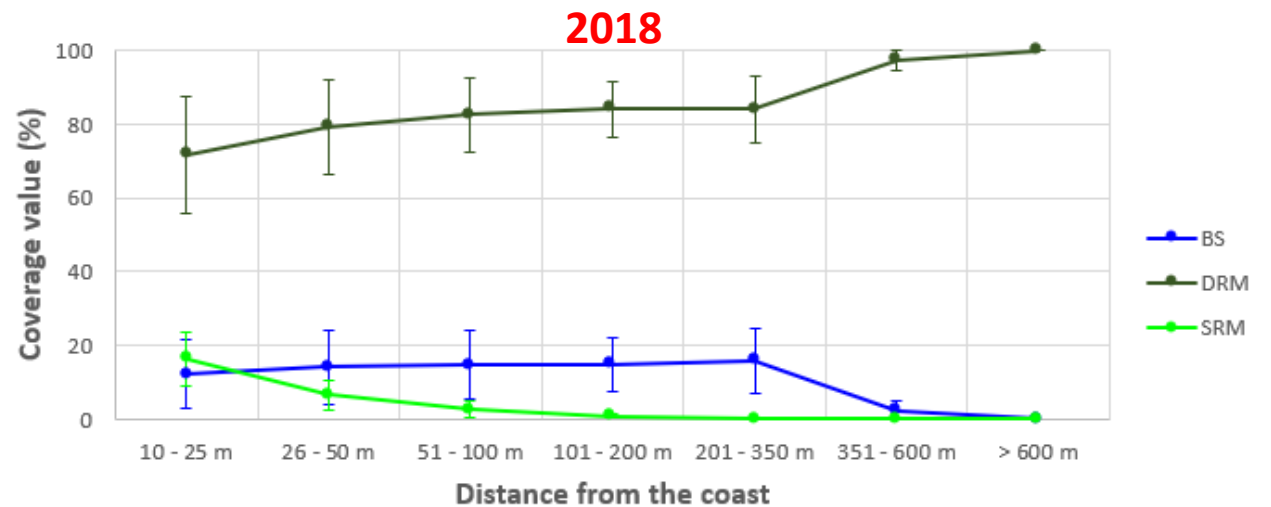
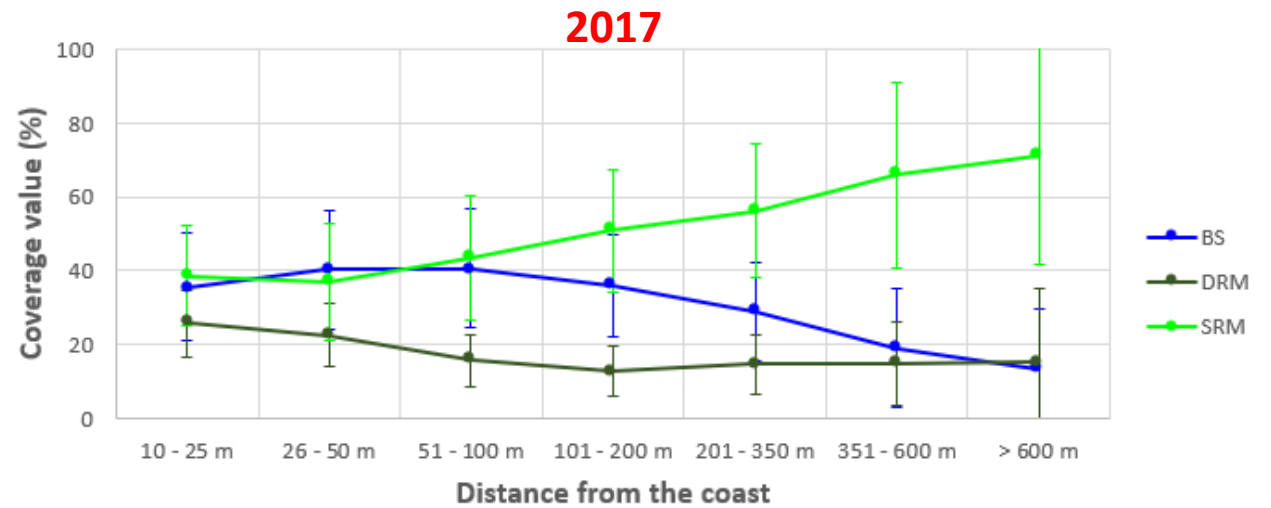
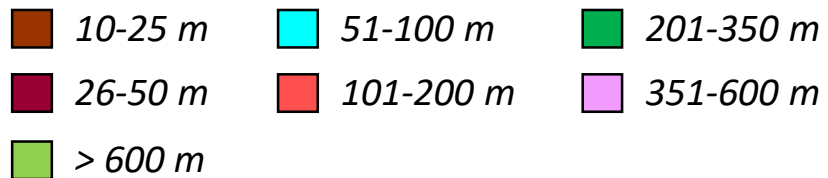
Average biomass [g m2]	
< 0.66	> 0.66
5,4	134,1

Biomass (average) [t]	
Spring	219,422
Summer	239,105
Autumn	264,557

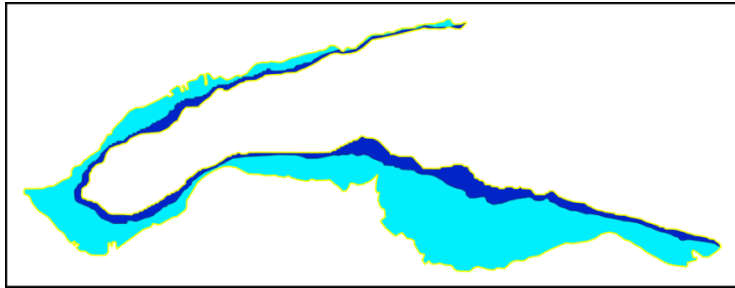
Spatio-temporal analysis – Distance from the coast




Distance from the coast:




Spatio-temporal analysis – Bathymetry

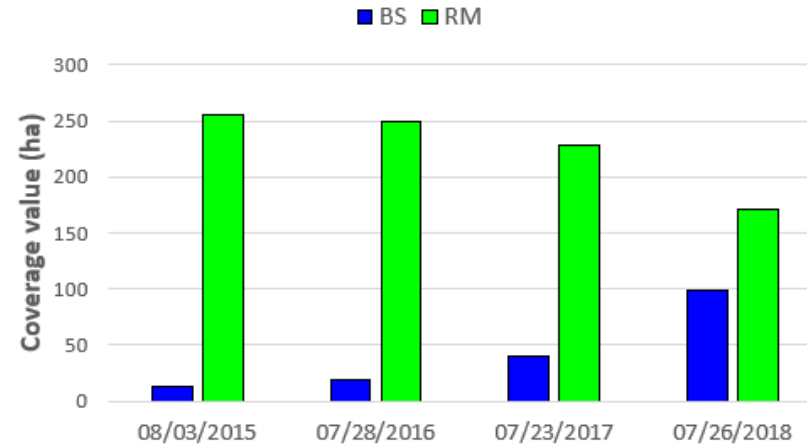


Bathymetry:

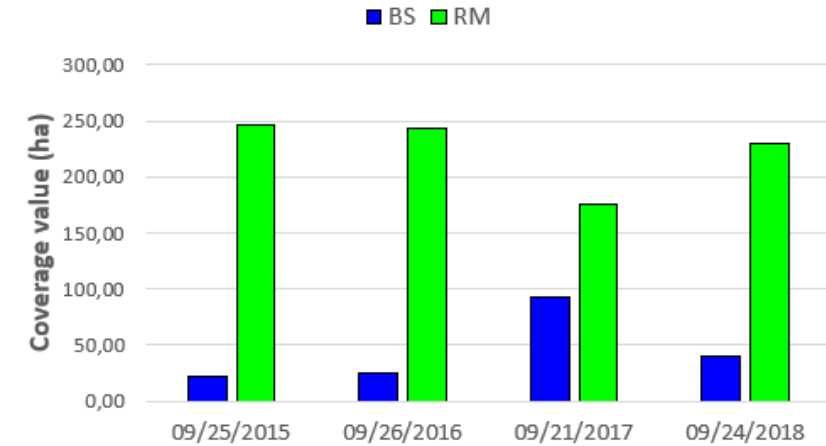
 0-5 meters

 5-10 meters

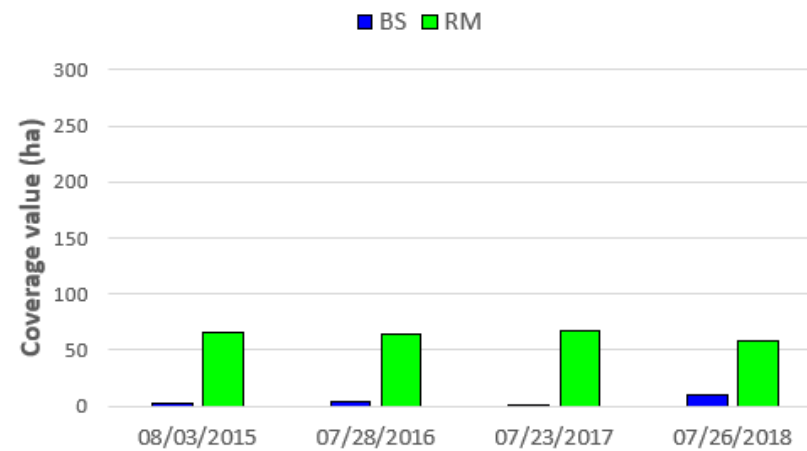
Summer (0-5 m)



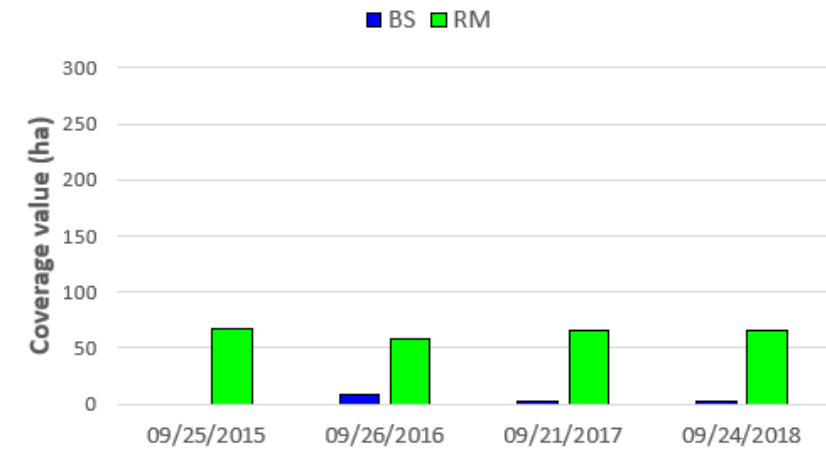
Autumn (0-5 m)



Summer (5-10 m)



Autumn (5-10 m)



Dissemination

Paper (journal & proceeding)

- Bresciani M., Cazzaniga I., Austoni M., Sforzi T., Buzzi F., Morabito G., Giardino C. (2018). ***Mapping phytoplankton blooms in deep subalpine lakes from Sentinel-2A and Landsat-8***. Hydrobiologia
- Pilotti, M., Valerio, G., Giardino, C., Bresciani, M. and Chapra, S.C., (2018). ***Evidence from field measurements and satellite imaging of impact of Earth rotation on Lake Iseo chemistry***. *Journal of Great Lakes Research*, 44(1), pp.14-25.
- Ghirardi, N., Bolpagni, R., Bresciani, M., Valerio, G., Pilotti, M., & Giardino, C. (2019). ***Spatiotemporal Dynamics of Submerged Aquatic Vegetation in a Deep Lake from Sentinel-2 Data***. *Water*, 11(3), 563.
- Mariano Bresciani (a), Nicola Ghirardi (b), Rossano Bolpagni (a,b), Daniele Nizzoli (b), Marco Bartoli (b), Giulia Valerio (c), Marco Pilotti (c), Claudia Giardino (a). ***Analisi multitemporali delle variazioni areali delle macrofite del Lago d'Iseo da dati Sentinel-2***

Dissemination

Conference (oral/poster)

- ESA-Living Planet Symposium 2019. R. Bolpagni, M. Bresciani, N. Ghirardi, G. Valerio, M. Pilotti, C. Giardino. Sentinel-2 reveals spatiotemporal dynamics of submerged aquatic vegetation in Lake Iseo (Italy). Milano, 13-17 May 2019, MiCo - Milano Congressi Milan, Italy
- XXII National Conference ASITA, 2018. *Analisi multitemporali delle variazioni areali delle macrofite sommerse del Lago d'Iseo da dati Sentinel-2*. M. Bresciani, N. Ghirardi, R. Bolpagni, D. Nizzoli, M. Bartoli, G. Valerio, M. Pilotti, C. Giardino. 27-29 November, 2018, Bolzano.
- XXVIII Congresso Società Italiana di Ecologia 2018. Multi-approach investigation of macrophytes of Iseo Lake combining remote sensing with structural and elemental data. R. Bolpagni, M. Bresciani, N. Ghirardi, D. Nizzoli, D. Longhi, A. Scibona, G. Valerio, M. Pilotti, P. Viaroli, Claudia Giardino. Cagliari, 12-14/09/2018
- ELLS-IAGLR "Big Lakes - Small World" 2018. **Satellite Remote Sensing of Chlorophyll-a in Subalpine Italian Lakes in the last 15 Years**. M. Bresciani, C. Giardino, D. Stroppiana, I. Cazzaniga. 23-28 September, 2018 Evian (France).
- EGU General Assembly 2017. *Assessing heat fluxes and water quality trends in subalpine lakes from EO*. Cazzaniga I., Giardino C., Bresciani M., Elli C., Valerio G., Pilotti M. Geophysical Research Abstracts, Vol. 19, EGU2017-19233-1, 2017.
- ASLO 2017 Aquatic Sciences Meeting. *Qualification of water quality retrieval from OLI-MSI-OLCI for European inland waters*. Giardino C. et al., 2017. Feb 26 – Mar 3, 2017, Honolulu, Hawaii.
- ESA- 1st Sentinel-2 Validation Team Meeting *Assessment of atmospheric correction methods of Sentinel-2 in Italian lakes*. Cazzaniga I. et al., 2016. Roma, Novembre 2016.
- CNR-ISE 2016. **Immagini satellitari per lo studio e il monitoraggio dei laghi**. Bresciani M., Cazzaniga I., Giardino C. Pallanza, 25-10-2016.

Education

Education

- PhD thesis of Ilaria Cazzaniga (2019), *Processing and analysis of last generation satellite data for monitoring optically complex waters*; Tutor: prof. R. Colombo, Co-tutor: dott.ssa C. Giardino. PhD in Chemical, Geological and Environmental Sciences, XXXI cycle, University of Milan-Bicocca.
- Thesis of Nicola Ghirardi (2018); *Variazione spazio-temporale delle macrofite radicate sommerse del lago d'iseo (2015-2017) mediante un approccio combinato tra immagini telerilevate e osservazioni in situ*. Supervisor Bartoli M., Co-supervisor Bresciani M. University of Parma.
- Theses of Chiara Elli (2017) Tesi di Laurea: *LAGO D'ISEO: remote sensing per il bilancio energetico e lo studio dei parametri biogeofisici*. Politecnico di Milano, Ingegneria per l'Ambiente e il Territorio. Relatore: Gianinetto M.; Co-relatore: C.Giardino, M. Bresciani, I. Cazzaniga.



Economic reporting

	Budget	Expenditure
a6 Consultants/contractors	26278.50	28074.44
a9 Current expenses	900.00	900.00
a10 other operating expenses (travels and dissemination)	3721.50	4570.74
Total	30900.00	33545.18

RIF. INVIO	Soggetto / Partner che ha sostenuto la spesa	VOCE DI SPESA	NUMERO DELLA FATTURA (oppure altro titolo di spesa)	DATA DELLA FATTURA (oppure altro titolo di spesa)	DITTA / FORNITORE	DESCRIZIONE DEI BENI / SERV. (oppure qualifica del Personale)	IMPORTO COMPLESSIVO (valuta locale)	IMPORTO PAGATO in valuta (imputato al prog.)	ITALIA / ESTERO	Tasso di cambio	Data di conversione	IMPORTO PAGATO espresso in € (imputato al prog.)	IMPORTO PAGATO espresso in € (Iva non detraibile)	IMPORTO COMPLESSIVO	IMPORTO PAGATO (imputato al prog.)	IMPORTO PAGATO (Iva non detraibile)	PERSONALE - ore tot. mese	PERSONALE - ore per il prog.	AUTOC / DOC.
1	IREA	A10 - Altre spese GESTIONALI	NL 20 del 17/03/2017	Mandato 20000/2017	BRESCIANI MARIANO	Missione BRESCIANI - SARNICO 04/04/2016 - KICK OFF MEETING	10.00	10.00	ITALIA			10.00	10.00	10.00	10.00	10.00			Autoc.
1	IREA	A10 - Altre spese GESTIONALI	NL 23 del 17/03/2017	Mandato 20000/2017	BRESCIANI MARIANO	Missione BRESCIANI - ISEO 26/09/2016	149.00	149.00	ITALIA			149.00	149.00	149.00	149.00	149.00			Autoc.
1	IREA	A10 - Altre spese GESTIONALI	NL 21 del 17/03/2017	Mandato 20006/2017	CAZZANIGA ILARIA	Missione CAZZANIGA - SARNICO 04/04/2016 - KICK OFF MEETING progetto "ISEO"	10.00	10.00	ITALIA			10.00	10.00	10.00	10.00	10.00			Autoc.
1	IREA	A10 - Altre spese GESTIONALI	NL 19 del 17/03/2017	Mandato 20020/2017	GIARDINO CLAUDIA	Missione GIARDINO - SARNICO 04/04/2016 - LICK OFF MEETING progetto "ISEO"	122.71	122.71	ITALIA			122.71	122.71	122.71	122.71	122.71			Autoc.
1	IREA	A10 - Altre spese GESTIONALI	NL 130 del 14/09/2017	Mandato 78565/2017	BRESCIANI MARIANO	Missione BRESCIANI a Brescia del 26/04/2017	10.50	10.50	ITALIA			10.50	10.50	10.50	10.50	10.50			Autoc.
1	IREA	A06 - Personale non strutturato	Compenso 80/2017	Mandato 64321/2017	CAZZANIGA ILARIA	Compenso del mese di LUGLIO 2017	1,971.42	1,971.42	ITALIA			1,971.42	1,971.42	1,971.42	1,971.42	1,971.42			Autoc.
1	IREA	A06 - Personale non strutturato	Compenso 91 del 09/08/2017	Mandato 65646/2017	CAZZANIGA ILARIA	Compenso del mese di AGOSTO 2017	1,971.42	1,971.42	ITALIA			1,971.42	1,971.42	1,971.42	1,971.42	1,971.42			Autoc.
1	IREA	A06 - Personale non strutturato	Compenso 102 del 24/08/2017	Mandato 80254/2017	CAZZANIGA ILARIA	Compenso del mese di SETTEMBRE 2017	1,971.42	1,971.42	ITALIA			1,971.42	1,971.42	1,971.42	1,971.42	1,971.42			Autoc.
1	IREA	A06 - Personale non strutturato	Compenso 110 del 24/08/2017	Mandato 80263/2017	PINARDI MONICA	Compenso del mese di SETTEMBRE 2017	2,239.34	2,239.34	ITALIA			2,239.34	2,239.34	2,239.34	2,239.34	2,239.34			Autoc.
1	IREA	A10 - Altre spese GESTIONALI	Odm 170 del 26/07/2017	Impegno 9120000406/2017	BRESCIANI MARIANO	Missione BRESCIANI a Iseo del 26/07/2017	142.50	142.50	ITALIA			142.50	142.50	142.50	142.50	142.50			Autoc.
1	IREA	A06 - Personale non strutturato	Impegno n. 9120000359/2016	Mandato in lavorazione/2017	PINARDI MONICA	Compenso del mese di OTTOBRE 2017	2,239.34	2,239.34	ITALIA			2,239.34	2,239.34	2,239.34	2,239.34	2,239.34			Autoc.
2	CNR-IREA	A06 - Personale non strutturato	1-15 DICEMBRE 2017	14/12/17	PINARDI MONICA	ASSEGNI STA DI RICERCA	1,119.82	1,119.82	ITALIA			1,119.82	1,119.82	1,119.82	1,119.82	1,119.82			Autoc.
2	CNR-IREA	A10 - Altre spese GESTIONALI	Missione n. 406	15/02/18	BRESCIANI MARIANO	RICERCATORE	32.95	32.95	ITALIA			32.95	32.95	32.95	32.95	32.95			Doc.
2	CNR-IREA	A06 - Personale non strutturato	16-31 DICEMBRE 2017	15/02/18	PINARDI MONICA	ASSEGNI STA DI RICERCA	1,228.20	1,228.20	ITALIA			1,228.20	1,228.20	1,228.20	1,228.20	1,228.20			Autoc.
2	CNR-IREA	A06 - Personale non strutturato	Gennaio 2018	26/02/18	PINARDI MONICA	ASSEGNI STA DI RICERCA	2,456.40	2,456.40	ITALIA			2,456.40	2,456.40	2,456.40	2,456.40	2,456.40			Autoc.
2	CNR-IREA	A10 - Altre spese GESTIONALI	ACQ PUBLIC N. 107	26/03/18	Springer Nature Customer Service Center GmbH	Pubblicazione scientifica "Mapping Phytoplankton blooms"	2,684.00	2,684.00	ITALIA			2,684.00	2,684.00	2,684.00	2,684.00	2,684.00			Doc.
2	CNR-IREA	A10 - Altre spese GESTIONALI	ACQ PUBLIC N. 145	30/03/18	ELSEVIER	PUBBLICAZIONE JGLR	862.52	862.52	ITALIA			862.52	862.52	862.52	862.52	862.52			Doc.
2	CNR-IREA	A06 - Personale non strutturato	1-10 MARZO 2018	13/04/18	PINARDI MONICA	ASSEGNI STA DI RICERCA	792.35	792.35	ITALIA			792.35	792.35	792.35	792.35	792.35			Autoc.
2	CNR-IREA	A06 - Personale non strutturato	GIUGNO 2018	18/07/18	BOLPAGNI ROSSANO	ASSEGNI STA DI RICERCA	1,200.96	1,200.96	ITALIA			1,200.96	1,200.96	1,200.96	1,200.96	1,200.96			Autoc.
2	CNR-IREA	A06 - Personale non strutturato	AGOSTO 2018	09/08/18	BOLPAGNI ROSSANO	ASSEGNI STA DI RICERCA	2,251.62	2,251.62	ITALIA			2,251.62	2,251.62	2,251.62	2,251.62	2,251.62			Autoc.
2	CNR-IREA	A06 - Personale non strutturato	SETTEMBRE 2018	04/10/18	PINARDI MONICA	ASSEGNI STA DI RICERCA	1,651.61	1,651.61	ITALIA			1,651.61	1,651.61	1,651.61	1,651.61	1,651.61			Autoc.
2	CNR-IREA	A10 - Altre spese GESTIONALI	MISSIONE N.368	15/10/18	BRESCIANI MARIANO	RICERCATORE	136.00	136.00	ITALIA			136.00	136.00	136.00	136.00	136.00			Doc.
2	CNR-IREA	A10 - Altre spese GESTIONALI	MISSIONE N.476	15/10/18	BRESCIANI MARIANO	RICERCATORE	12.50	12.50	ITALIA			12.50	12.50	12.50	12.50	12.50			Doc.
2	CNR-IREA	A10 - Altre spese GESTIONALI	MISSIONE N.477	15/10/18	BRESCIANI MARIANO	RICERCATORE	18.01	18.01	ITALIA			18.01	18.01	18.01	18.01	18.01			Doc.
2	CNR-IREA	A10 - Altre spese GESTIONALI	MISSIONE N.368	10/12/18	BRESCIANI MARIANO	RICERCATORE	90.05	90.05	ITALIA			90.05	90.05	90.05	90.05	90.05			Doc.
2	CNR-IREA	A06 - Personale non strutturato	FEBBRAIO 2019	18/03/19	BOLPAGNI ROSSANO	ASSEGNI STA DI RICERCA	2,251.62	2,251.62	ITALIA			2,251.62	2,251.62	2,251.62	2,251.62	2,251.62			Autoc.
2	CNR-IREA	A10 - Altre spese GESTIONALI	MISSIONE N.343		BRESCIANI MARIANO	RICERCATORE	210.00		ITALIA										Doc.
2	CNR-IREA	A10 - Altre spese GESTIONALI	MISSIONE N.344		BRESCIANI MARIANO	RICERCATORE	80.00		ITALIA										Doc.
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