Assessing heat fluxes and water quality trends in subalpine lakes from EO

Ilaria Cazzaniga[1,2], Claudia Giardino[1], Mariano Bresciani[1], Chiara Elli[3], Giulia Valerio[4], Marco Pilotti[4], and Karin Schenk[5]

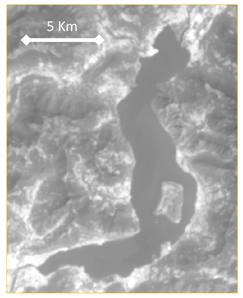
(1) CNR-IREA, Italy, cazzaniga.i@irea.cnr.it, (2) UNIMIB-DISAT-LTDA, Italy, (3) Politecnico di Milano, Italy, (4) UNIBS-DICATAM, Italy, (5) EOMAP, Seefeld, Germany

INTRODUCTION

Earth Observation (EO) techniques offer relevant data to integrate classical in situ limnological measurements aiming at frequent and synoptic monitoring of lakes. Within this study, EO data of deep clear lakes in the European subalpine ecoregion, which are showing a clear response to climate change with an increase of 0.017 ◦C/year of lake surface temperature[1], are exploited for understanding the changes of suspended sediments and energy fluxes in recent years . The investigation is focused on Lake Iseo, which has shown a significant deterioration of water quality conditions since the '70. Physic-based approach and field data are combined to derive LST, TSM, Evaporation rate and Heat storage from Landsat-8 images of the last three years. After the products validation, the technique is applied to Lake Garda. The results show the capability of Landsat-8 with its optical and thermal sensors, to investigate bio-physical parameters in the study area. This method will be extended to the ESA Sentinel-3 data, to increase the observations frequency.

Landsat-8 — TIRS (TIR-1), OLI

Digital Numbers DN



Radiometric calibration

Radiance TOA L_{TOA} [W m^{-2} sr^{-1} µm^{-1}]

Atmospheric correction:

$$L_{BOA} = \frac{L_{TOA} - \tau(1-\varepsilon)L_d - L_u}{\tau\,\varepsilon}$$

ε=water emissivity
τ=atmospheric transmittance
L_d, L_u=downwelling-upwelling radiance
τ, L_d, L_u calculated by Atmospheric Correction Parameter Calculator[2] using meteorological surface conditions.

+

Lake Mask using a lake shapefile

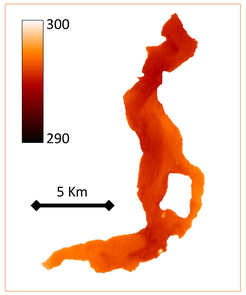
Radiance BOA L_{BOA} [W m^{-2} sr^{-1} µm^{-1}]

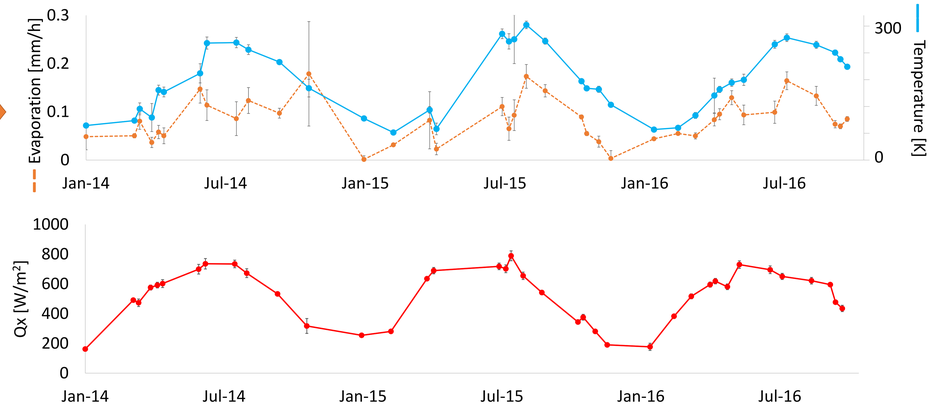
Surface Temperature estimation[4]:

$$T = \frac{k_2}{\ln\left(\frac{k_1}{L_{BOA}+1}\right)}$$

$k_2 = 1321.08$
$k_1 = 774.89$

Surface Temperature LST [K]





Atmospheric correction and TSM estimation through ACOLITE[3]:

- Pixel-based aerosol load and type estimation using SWIR bands
- Lake mask based on Rayleigh corrected reflectances at 1609 nm with a threshold of 2.15%

Additional manual masking of glint and shadows

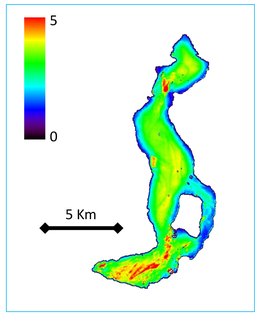
Water Reflectance ρ_W [-]

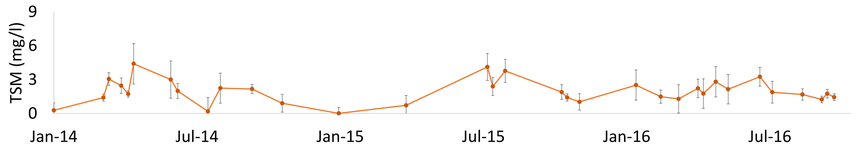
Surface Albedo calculation[5]:

$$\alpha = 0.356\rho_{WB2} + 0.130\rho_{WB4} + 0.373\rho_{WB5} + 0.085\rho_{WB6} + 0.072\rho_{WB7} - 0.0018$$

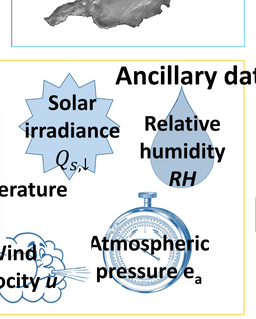
Shallow waters mask

Total Suspended Matter TSM [mg/m^3]





Albedo α [-]



Ancillary data

Heat budget calculation

$$R_n = Q_{cn} + Q_{an} - Q_w$$

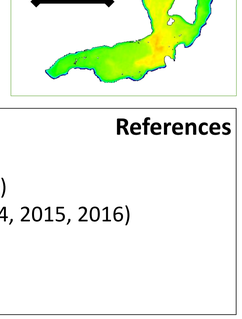
Q_{cn}= Shortwave solar net radiation $= (1-\alpha)\cdot Q_{s,\downarrow}$
Q_{an}[6]= Longwave atmospheric net radiation $= \sigma\ 0.986\ \varepsilon_a\ T_a^4$
Q_w = Longwave emitted radiation by the lake surface $= \sigma\ T^4 \varepsilon_0$

$$Q_x = R_n - Q_e - H$$

H = Sensible heat[6] $= \gamma f(T - T_a)$
Q_e = Latent heat[6] $= f(e_{w_{sat}} - e_a)$
e_{wsat} = Saturated Vapour Pressure
$f = 4.8 + 1.98 \cdot u + 0.28 \cdot (T - T_a)$
$\gamma = \frac{c_p \cdot p}{0.622 \cdot L_v}$
c_p = specific heat of air
L_v = vaporization latent heat

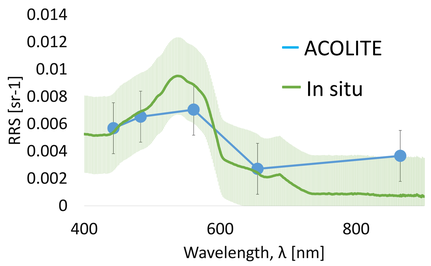
Evaporation Ev [mm/h]

Heat storage Q_x [W/m^2]



Validation

Atmospheric correction and TSM products were validated on the basis of in situ measurements of Remote Senisng Reflectance RRS and TSM concentration collected during field campaigns on 2016 on Lake Iseo, synchronous to the satellite overpass. LST and Rn products were validated using in situ measurements of pelagic station in Lake Iseo belonging to UNIBS Hydraulic group.

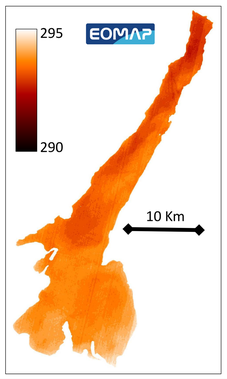


	RMSE
TSM	0.25 mg/l
LST	1.82 K
R_n	158 W/m^2

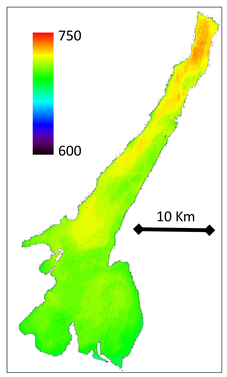
Lake Garda

The same method was used, using Turbidity, Surface temperature and surface reflectance maps produced by **EOMAP**, through **MIP** processor, over **Lake Garda**. First results are shown.

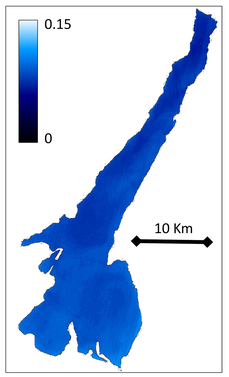
LST [K]



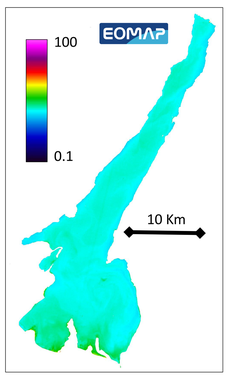
Qx [W/m^2]



Ev [mm/h]



Turbidity [ETU]



References

1. Pareth et al. 2017
2. (https://atmcorr.gsfc.nasa.gov)
3. Vanhellemont & Ruddick (2014, 2015, 2016)
4. Ritcher & Schläpfer, 2017
5. Liang, 2000
6. Brutsaert, 1975

space-O

fondazione cariplo
ISEO project