Satellites for Lake Monitoring and Management – Fact Sheet

Linking lake research with end users for positive environmental outcomes

LERNZ
Lake Ecosystem Research New Zealand

Satellite Coverage

A fleet of satellites orbit our planet observing the Earth for a range of objectives. The view from space allows imaging of wide swaths of the Earth at intervals from daily to fortnightly depending on the satellites' orbits. For example, Sentinel-2 satellites of the European Space Agency cover the entire Earth's surface every 5 days (Figure 1).

The size of the feature that the satellite can map depends on the resolution of the sensor, or the size of each pixel of the image in units of meters. This resolution is different for each satellite and ranges from <0.5 m (e.g., WorldView-3) to 300 m (e.g., Sentinel-3).

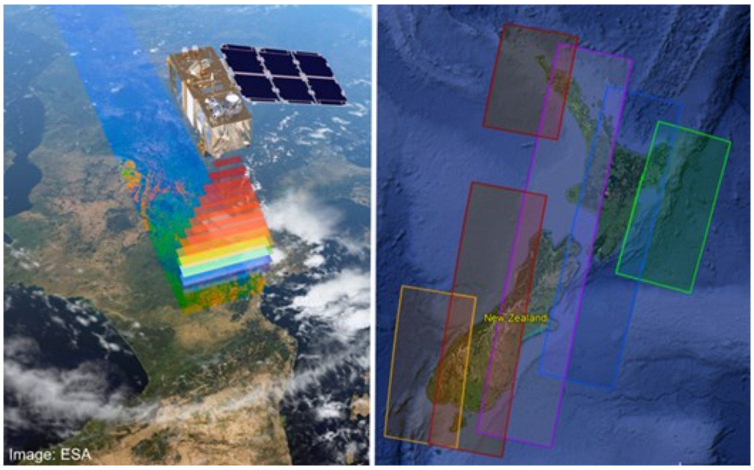

Figure 1: Sentinel-2 imaging paths are about 290 km wide. Ground coverage by Sentinel-2a is shown for five orbits in 2018 within an 8-day period.

Sensors

Instruments on-board earth observation satellites either record the return signal from an energy source emitted by the satellite (e.g., microwaves, lasers, radar) or sunlight reflected by the surface. The reflection wavelength of light varies with water body and land cover type. This change in the wavelength (i.e., colour) can be used to detect changes in species of agricultural crops, the health of vegetation and the concentrations of algae and suspended particles in lakes and oceans.

Detecting Water Quality from Space

Light emerging from a body of water is a different colour than incident solar radiation due to absorption and scattering by water molecules, suspended particles and dissolved substances. Water without absorbing and scattering constituents is violet-blue. The main constituents that give water colour, other than blue, are phytoplankton pigments such as chlorophyll *a*, suspended particulate matter and coloured dissolved organic matter (Figure 2). Satellites can measure the colour of light leaving the water which allows scientists to back-calculate the concentrations of these water quality parameters.

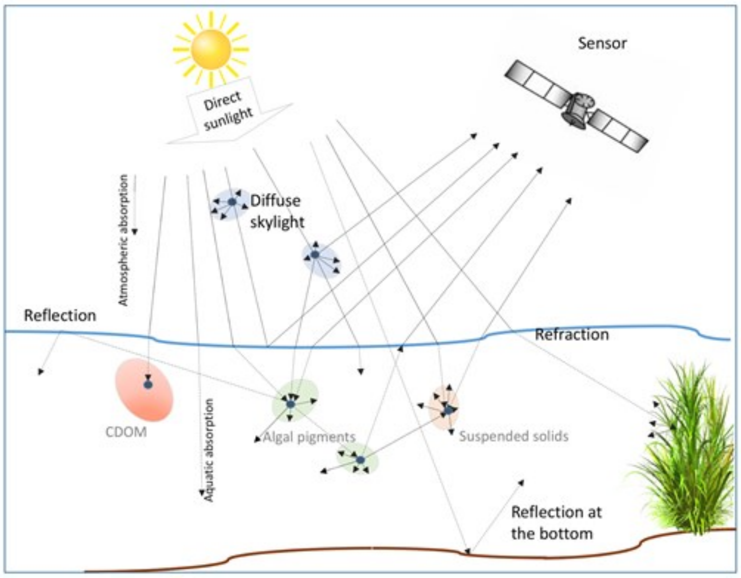

Figure 2: Illustration of the main optical processes determining the amount and spectral composition (colour) of sunlight reaching a satellite sensor. CDOM: coloured dissolved organic matter.

One limitation of light-sensing satellites is their dependence on a clear sky. Frequent cloud cover over New Zealand means that not every image produces useful data with some locations having a better chance for image capture. It is estimated that Sentinel-2 with a 5-day revisit period will produce at least one clear image per month of any location, and up to four clear images per month in most parts of the country.

Satellites for Lake Monitoring and Management – Fact Sheet Continued

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Lake Water Colour

Algorithms such as those employed for water clarity depend on the availability of in situ observations, and are therefore only valid for the lakes for which they were determined. Water colour as perceived by the human eye (true colour) does not require any prior knowledge and can be calculated for any water body. Water colour is intrinsically linked to chlorophyll *a*, suspended particulate matter and CDOM and is a useful integrating measure of ecosystem health. A methodology establishing quantitative observations of lake colour at the national scale provides an overview of the diversity of New Zealand lakes. Water colour parameters from almost 45,000 Landsat 8 observations over four years from 1486 lakes were calculated (Figure 3). The most important findings were:

- New Zealand lake colours vary from deep blue to orange-red. This is almost the full globally observed range of water colours; and
- Both geophysical and anthropogenic factors, such as catchment land use, provide environmental control of lake colour, suggesting that colour can be used for environmental monitoring.

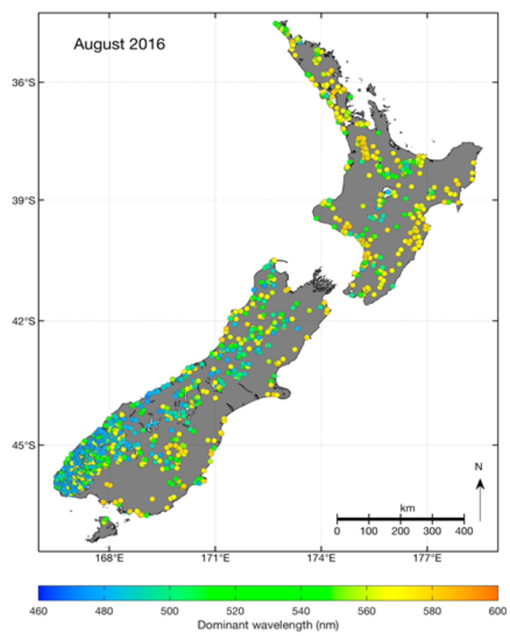

Figure 3: Water colour of 1486 New Zealand lakes expressed as dominant wavelength from observations using the Operational Land Imager on Landsat 8 during August 2016.

Water Clarity

Water clarity is an important water quality attribute which is typically measured noting the depth at which a black and white disk (Secchi disk) lowered into the water disappears from view. Eighteen years of Secchi disk depth measurements from seven lakes in the Bay of Plenty region were used to generate an algorithm to predict this depth from satellite data. This relationship can be used to predict water transparency in the entire lake in every new image (Figure 4).

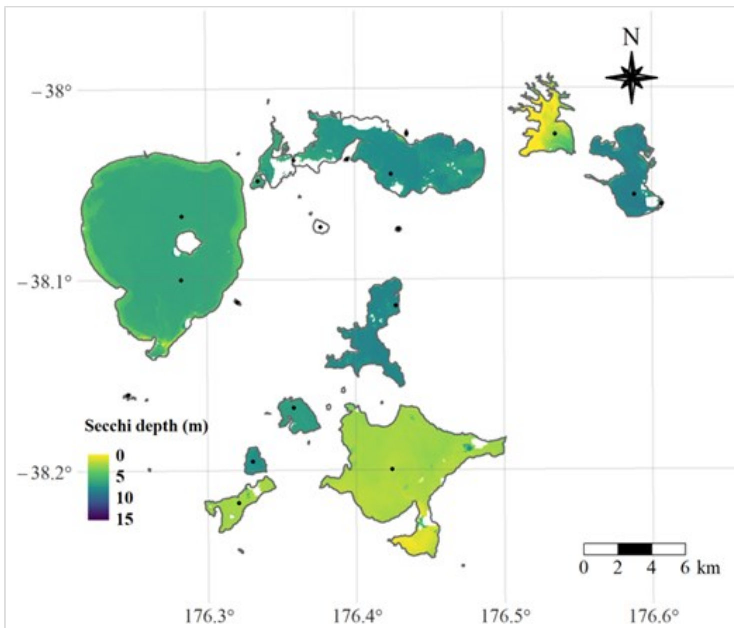

Figure 4: Secchi disk depth in the Rotorua lakes derived using an empirical relationship between in situ observations and the blue, green and red wavebands from the Landsat series of satellites.

Conclusions

Remote sensing is an effective way to image thousands of lakes in a short period of time. The information gained can assist in regular monitoring of water quality and provide insights into ecological and anthropogenic processes.

Satellites have become a reliable and cost-effective source of data on water quality attributes for environmental monitoring programmes conducted by local, regional and national governments and their stakeholder groups.

Lehmann MK, Nguyen U, Allan M, van der Woerd H. 2018. Colour classification of 1486 lakes across a wide range of optical water types. Remote Sensing 10(8): 1273. https://doi.org/10.3390/rs10081273

Lehmann MK, Nguyen U, Muraoka K, Allan MG. 2019. Regional trends in remotely sensed water clarity over 18 years in the Rotorua Lakes, New Zealand. New Zealand Journal of Marine and Freshwater Research, 1-23. https://doi.org/10.1080/00288330.2019.1609051