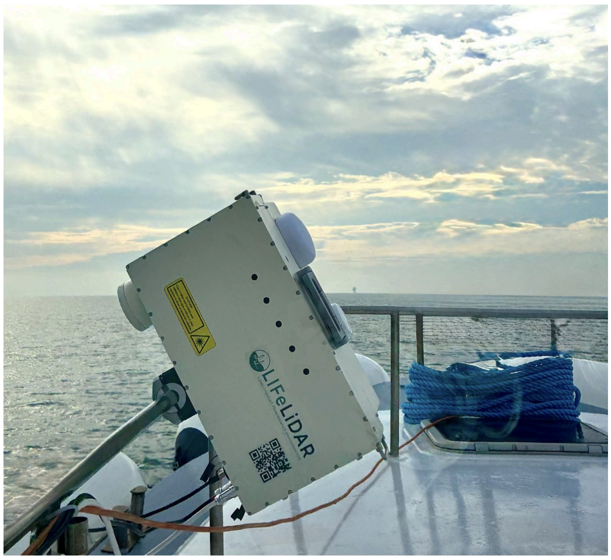
MULTI-WAVELENGTH FLUORESCENCE LIDAR

LIFL.11

Exploring the sea upper layer

Measures water quality along a vessel track, by day and by night.

LIFL.11 directs a pulsed laser at the water surface from a vessel. The water absorbs part of that light and re-emits it as fluorescence. Each substance emits at its own wavelengths, so the returned spectrum records what the water contains: phytoplankton pigments, dissolved organic matter, suspended sediment and oil. Measurement continues while the vessel is under way, so **a survey yields a continuous map rather than a set of discrete samples**.



RAIL-MOUNTED, UNDERWAY

3	48	10 Hz	21 kg	IP68
LASER LINES 266 / 355 / 532 NM	SPECTRAL BANDS 250 TO 800 NM	ALONG-TRACK RATE	MASS	MARINE-GRADE

BACKGROUND

The ocean covers more than seventy percent of the Earth's surface, yet it remains among the least systematically observed parts of the Earth system. The upper layer is the interface across which heat, gases and particles are exchanged. Pollutants, dissolved organic matter and pigments accumulate there, and water quality changes there fastest.

Satellites cannot resolve small-scale structure within that layer, and ship-based sampling records it one station at a time. A single satellite pixel covers ten metres of water, and few routine methods measure the variation inside it. LIFL.11 was developed for that scale.

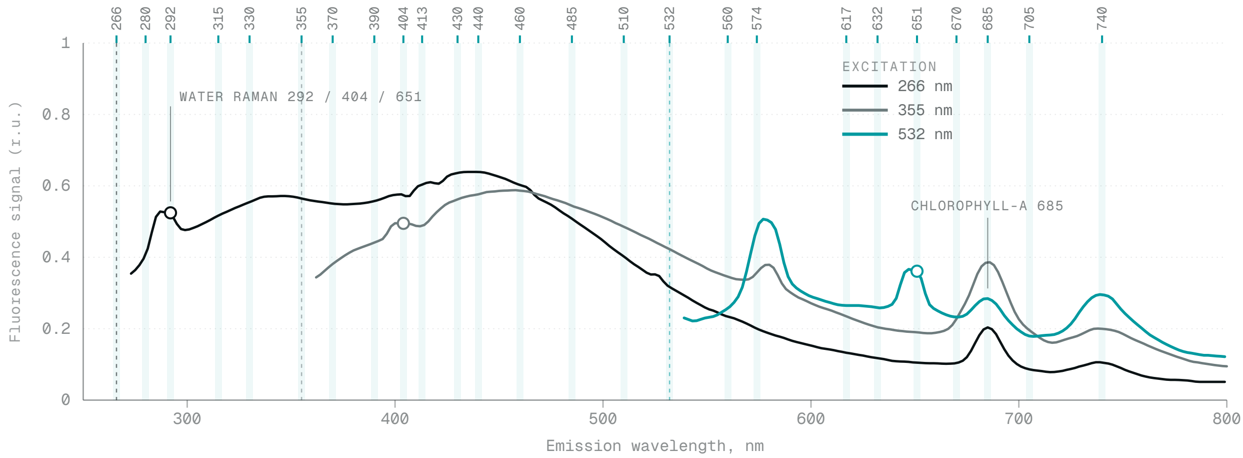
MEASURED PARAMETERS

Chlorophyll-a	CDOM	TSS	Oil-in-water
0.01 to 1000 mg·m^{-3}	a_{440} 0.001 to 0.15 m^{-1}	0.1 to 1000 g·m^{-3}	Films, emulsions, film thickness

- Phycoerythrin
- Phycocyanin
- Pigment ratios for bloom type
- DOM type
- TOC 0.1 to 100 g·m^{-3}
- Tryptophan
- Phenolics
- Crude against light oil
- Floating-litter signature

MEASUREMENT PRINCIPLE

A short laser pulse enters the water. Molecules absorb the pulse and re-emit part of it as fluorescence, each at its own wavelengths, so the returned spectrum is a record of the substances present. LIFL.11 resolves that spectrum in up to **48 narrowband channels between 250 and 800 nm**. Water also scatters a Raman line at a fixed offset from the excitation wavelength. That line serves as an internal reference: dividing the fluorescence signal by it yields a concentration on every shot, without a calibration target in the water.



Fluorescence emission of natural water under each excitation line, measured with LIFL.11. Aqua ticks mark 25 of the 48 selectable detection bands; peaks and FWHM are specified per instrument. The elastic return at 266, 355 and 532 nm is off-scale and is not drawn. Circles mark the water Raman lines at 292, 404 and 651 nm. The 685 nm peak is chlorophyll-a. Arbitrary units.

Transect

MAPPING, UP TO 10 HZ

Four selected bands are read at up to ten measurements per second while the vessel is under way. At about ten knots this gives roughly **twenty measurements within one 10 by 10 m satellite pixel**. The mode resolves patchy features: blooms, slicks, plumes and litter.

Station

FULL SPECTRUM, ABOUT 15 S

All 48 bands are acquired at a fixed point in about fifteen seconds. The mode characterises a water type in full and provides the reference point from which a transect is mapped outward.

MODEL VARIANTS

LIFL.11.1

355 + 532 NM

Biogeochemistry. The 355 nm line favours chlorophyll-a, CDOM and organic matter. The variant is intended for research, satellite calibration and validation, and water authorities.

LIFL.11.2

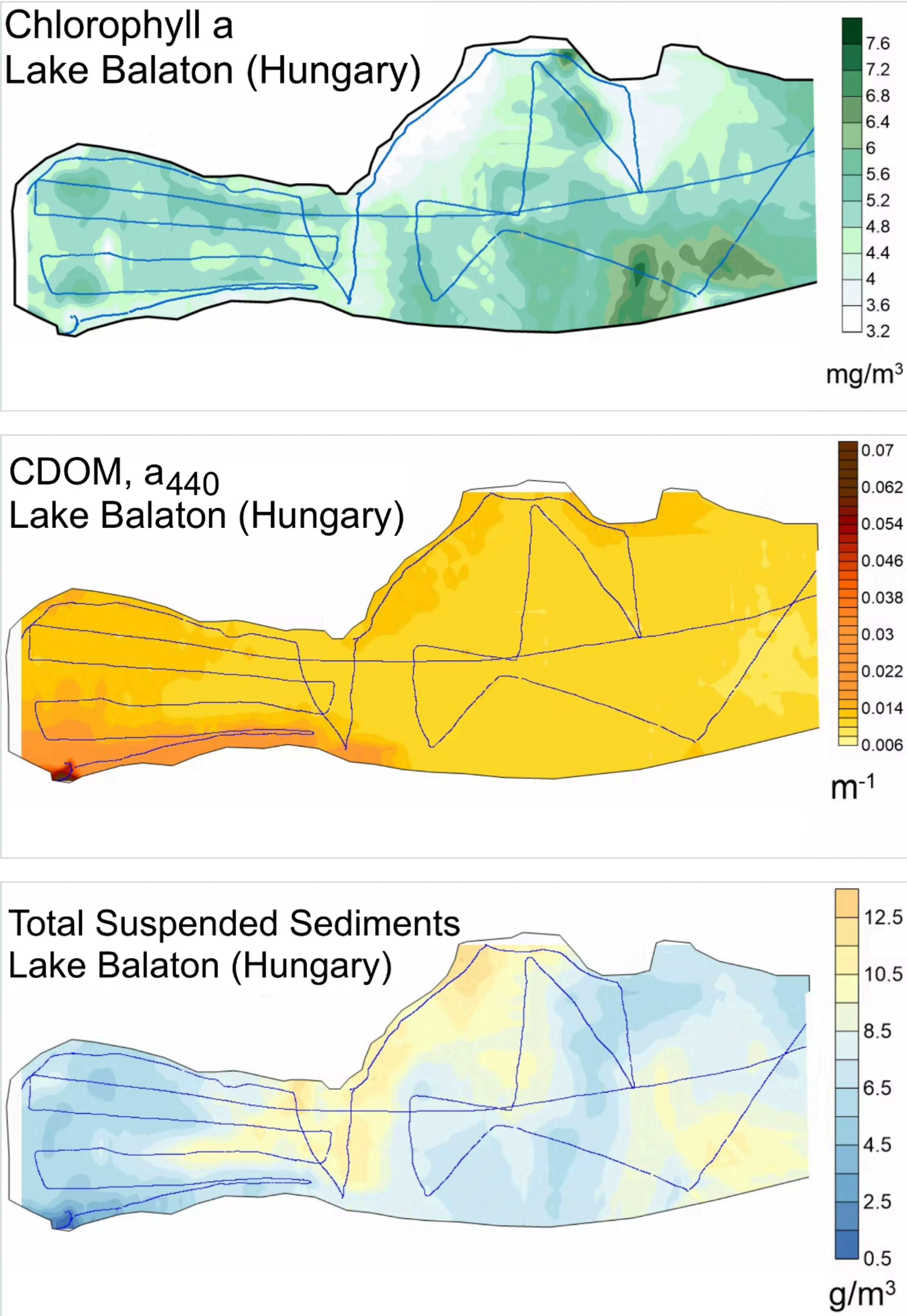
266 + 532 NM

Contamination. The 266 nm line excites aromatic compounds, bringing oil, tryptophan and phenolics within range. The variant is intended for ports, terminals, discharge compliance and spill response.

Three laser lines are available and each instrument is supplied with two of them. Both variants measure the four principal parameters.

FIELD RESULTS: ONE SURVEY, THREE PARAMETERS

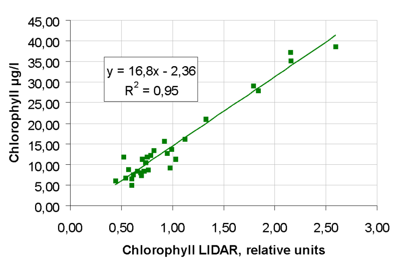
The three maps below were produced from a single survey track. No parameter was measured twice and none was derived from another: each is retrieved from the same returned spectrum, so **adding a parameter requires no additional ship time**. The maps resolve the structure between stations, which conventional sampling has to assume.



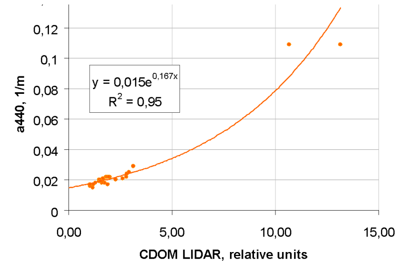
Lake Balaton, Hungary. One survey, 27 160 measurement points. Blue lines mark the vessel track; the fields between them are interpolated from it.

VALIDATION AGAINST LABORATORY SAMPLES

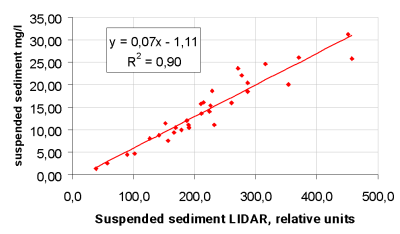
Water samples collected during field campaigns were analysed in a laboratory and plotted against the LiDAR retrieval at the same points. **The regressions below establish the accuracy of the retrieval**, and the same procedure sets the site-specific coefficients applied at the start of a campaign.



CHLOROPHYLL-A R^2 0.95



CDOM A_{440} R^2 0.95



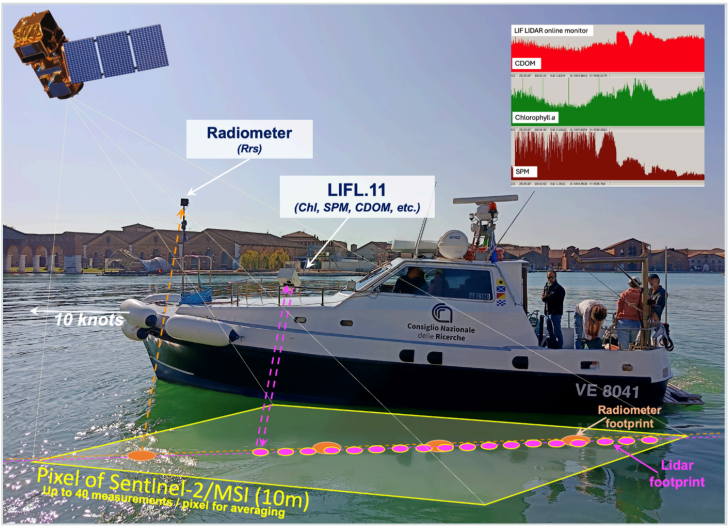
SUSPENDED SEDIMENT R^2 0.90

Laboratory analysis of water samples on the vertical axis, LiDAR signal on the horizontal. Chlorophyll-a and suspended sediment are linear; CDOM absorbance follows an exponential fit.

SUB-PIXEL SAMPLING FOR SATELLITE CALIBRATION AND VALIDATION

A satellite reports one value for a 10 by 10 m pixel and cannot describe the variation within it. Operating at 10 Hz at survey speed, LIFL.11 records about **twenty independent measurements inside that pixel**. A match-up can therefore be given an uncertainty rather than a single coincident value.

The same track supports bio-optical model development for MSI, OLCI, MODIS and PACE. Operated alongside **mHR.2** on the same vessel, a campaign also records hyperspectral reflectance, which is the quantity the satellite measures.



Co-located acquisition within one Sentinel-2 / MSI pixel: lidar footprint (magenta) and radiometer footprint (orange) along the same track at about ten knots, with chlorophyll-a, CDOM and suspended matter displayed in real time. ESA PHY2FLEX, Venice, October 2025, aboard a CNR vessel. The annotation in the figure dates from the 20 Hz prototype; at 10 Hz the count is about 20 per pixel.

PRACTICE

20+ years of LIF LiDAR work across 50+ water bodies

FIELD RECORD

ESA PHY2FLEX, Venice, October 2025

LITERATURE

Peer-reviewed Sentinel-2 and -3 cal / val, coastal plumes, turbid water

SUPPORTED BY

FRANCE DEEPTECH Quand la science entreprend
FRANCE 2030
LA FRENCH TECH CÔTE D'AZUR RÉGION SUD
Telecom Valley Animateur Azuréen Numérique
PÔLE MER MÉDITERRANÉE

SPECIFICATION

EXCITATION	266 or 355 nm, with 532 nm
PULSE ENERGY	10 mJ at 266 12 mJ at 355 and at 532
PULSE DURATION	4 ns
REPETITION RATE	Up to 10 Hz
RECEIVER	4-channel splitter, 12 narrowband filters each, 48 bands
SPECTRAL RANGE	250 to 800 nm
FULL SPECTRUM	48 bands in about 15 s
TELESCOPE	76 mm Newton, 1 to 50 m
SURFACE LAYER	0.5 to 5 m at 355 nm 1 to 10 m at 532 nm
PROFILING	To 50 m, about 0.5 m resolution at 532 nm, 2 Hz
GEOREFERENCING	GNSS and IMU at 10 Hz, context camera
CONTROL	Wi-Fi, 5G, LAN, RS485, from a laptop or a phone
POWER	100 to 230 V AC or 24 V DC under 80 W, after warm-up
OPERATING TEMP.	0 to +30 °C
STORAGE TEMP.	-20 to +70 °C
SIZE	44 × 33 × 28 cm
MASS	21 kg, IP68 marine-grade
OPTIONS	2-axis scanning gimbal Hyperspectral receiver, 380 to 750 nm, under 10 nm

APPLICATIONS

1 **Water-quality baselines and satellite calibration and validation**
RESEARCH INSTITUTES, ENVIRONMENTAL AGENCIES, WATER AUTHORITIES

2 **Bloom mapping and harmful-algal-bloom early warning**
COASTAL AND INLAND WATER QUALITY, AQUACULTURE, RESERVOIRS

3 **Oil spills and oil-in-water emulsion**
PORTS, TERMINALS, DISCHARGE COMPLIANCE, SPILL RESPONSE, COASTGUARD

4 **Wastewater plume and dissolved organic matter tracking**
ESTUARY AND OUTFALL MONITORING, INDUSTRIAL DISCHARGE OVERSIGHT

5 **Floating litter and plastics surveys**
MARINE-LITTER MAPPING, CLEAN-UP PLANNING

6 to 12 months

BUILD TIME

Supplied as a capital instrument and configured per campaign. Given the water body and the parameters required from it, the appropriate variant and band set can be specified.

POSITION IN THE INSTRUMENT STACK

LIFL.11 is the mobile survey instrument of the LIFeLiDAR stack. **mHR.2** adds satellite-comparable reflectance on the same vessel. **mFL.12** nodes installed on buoys and piers continue to report between surveys. Each instrument operates independently, and the stack is intended to be extended over time rather than acquired at once.

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