MONOCLE

Multiscale Observation Networks for Optical monitoring of Coastal waters, Lakes and Estuaries

Micro- to macroscale water quality product validation to address global data gaps: presenting new technologies from H2020-MONOCLE

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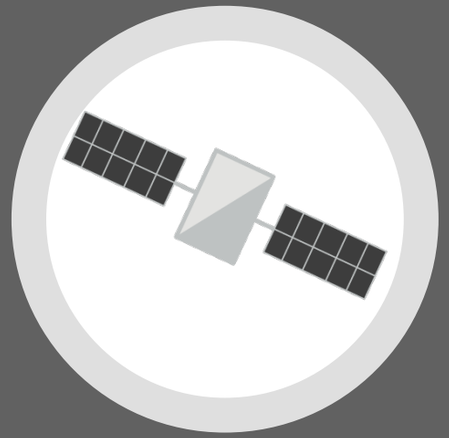
Key objectives

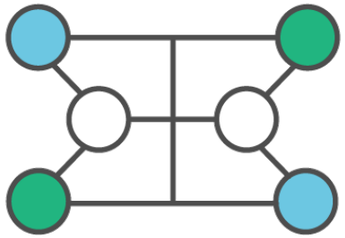
Lower the cost of in situ data collection for satellite validation

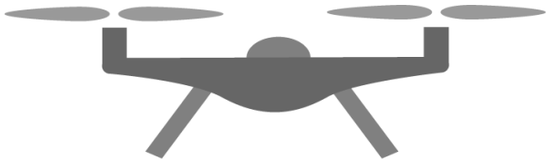
- Focus: optically complex lakes and coastal waterbodies
- Include: atmospheric and water radiometry
- Develop: sensors and platforms
  - Radiometry + water transparency / stratification
  - Long-term autonomy (maintenance, power)
  - Citizen science

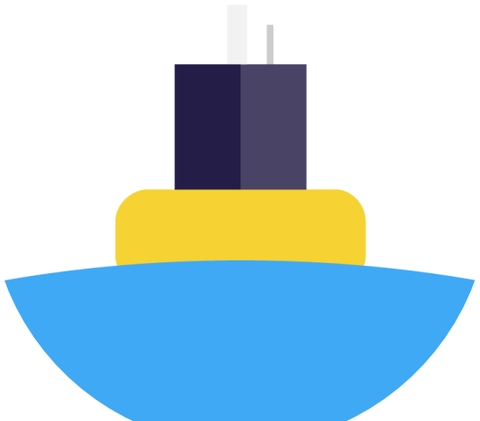
Improve data accessibility

- Sensor connectivity
- FAIR data, OGC standards
- Near real-time processing





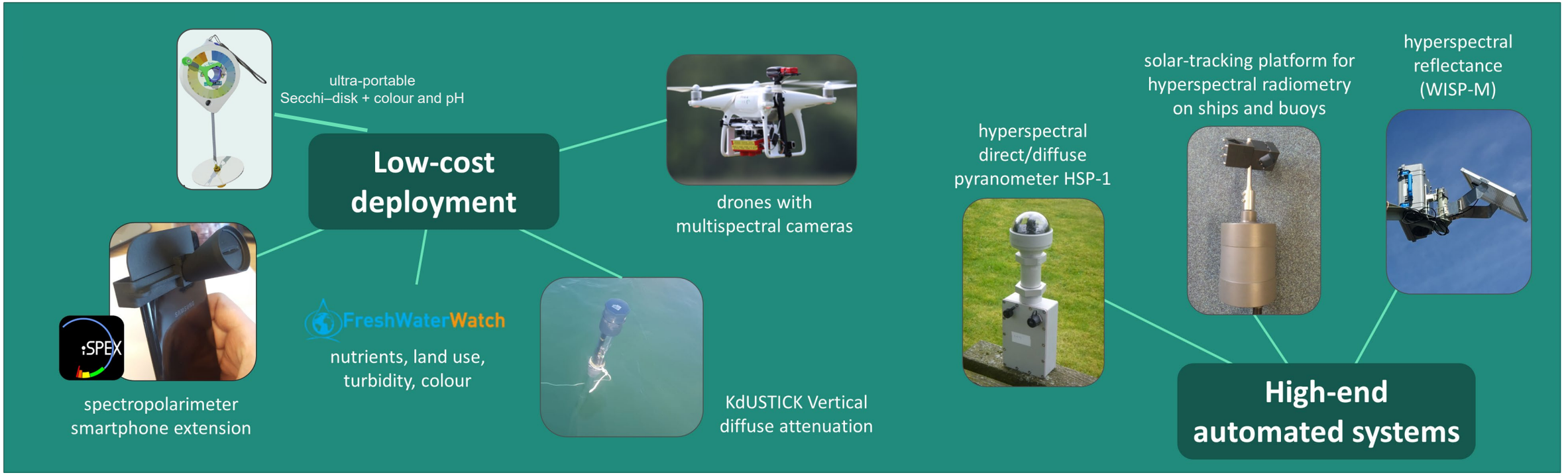




MONOCLE sensors and platforms

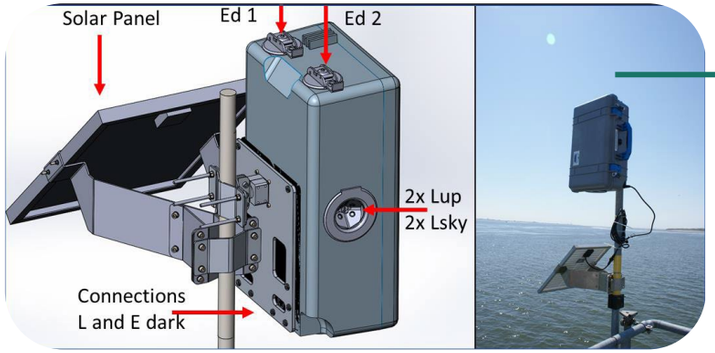
More participation:

More automation:



For the latest technical specs, videos and training materials, visit
monocle-h2020.eu/Sensors_and_services

Automated radiometry systems

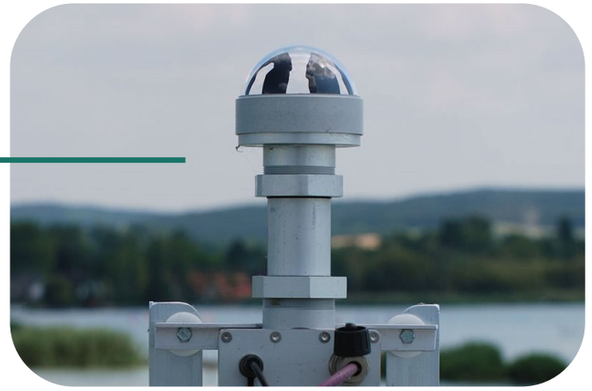


WISPstation by **Water Insight** for stationary water-leaving Reflectance with two azimuth angles, 350-1100 nm, sub-nm resolution. €25k (with tech support, data handling).

So-Rad (Solar-tracking radiometry platform) by **PML** for water-leaving Reflectance with existing sensors, providing azimuth angle control. €5k component cost (excl. radiometers). Open-source.

PML | Plymouth Marine Laboratory

Peak Design HSP-1
(Hyperspectral Pyranometer) for global and diffuse downwelling irradiance, 3-nm resolution over 350-950*nm range, no moving parts. €11-17k target

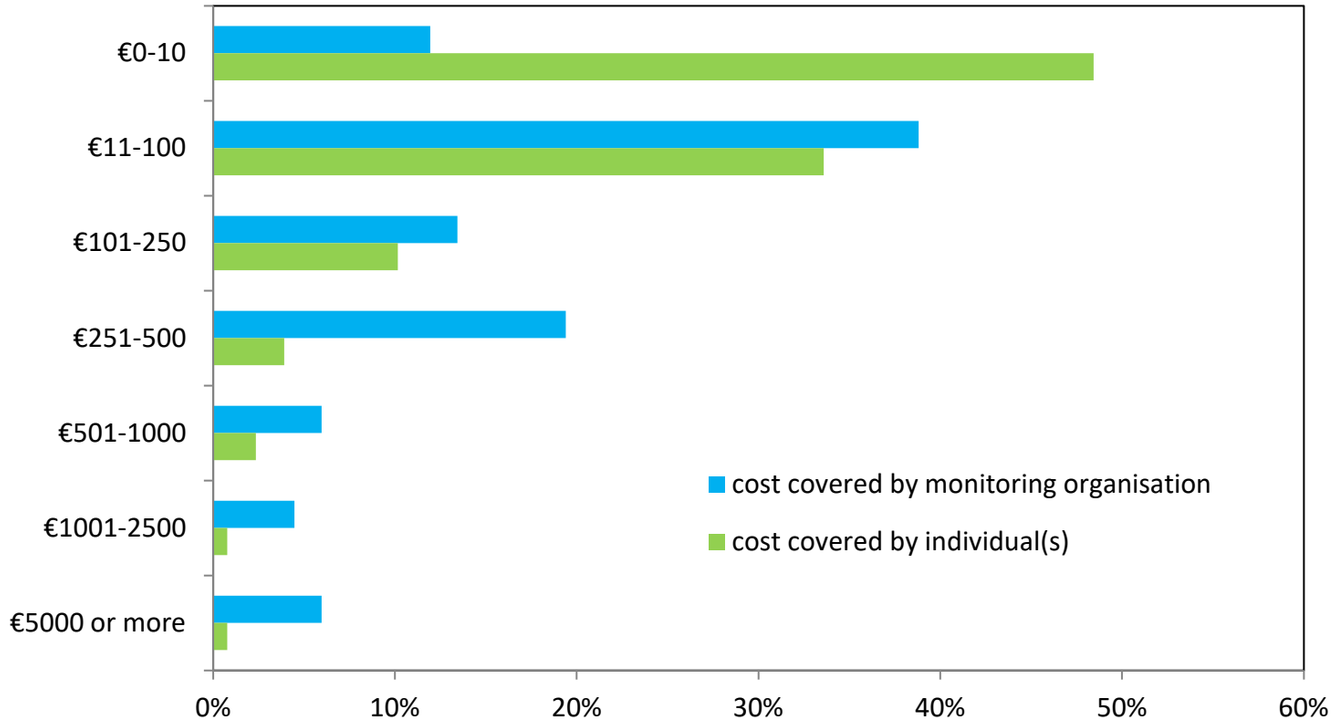


Peak Design

All instruments supports remote, low-power operation and monitoring, cellular data transfer and configuration, and OGC-compliant metadata.

Low-cost sensor price target

“What would be a reasonable price for a sensor operated by a volunteer to measure your main variable of interest?”



Survey response puts optimal price for volunteer-operated sensors in €10-€100 bracket

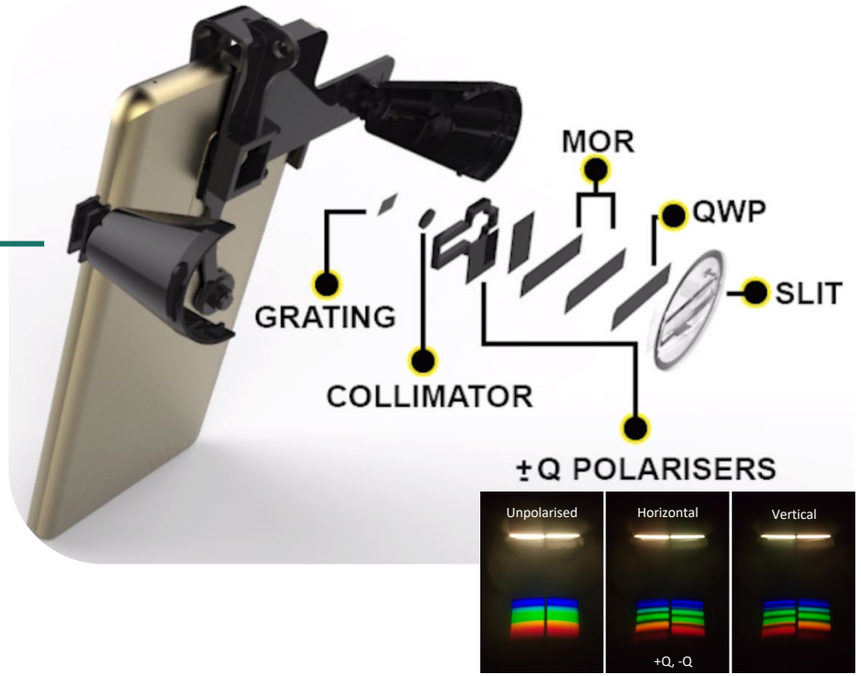
Low-cost: manually operated radiometry

Drone-based solutions by **VITO**
target water-leaving Reflectance from on-board RGB cameras (low-cost) as well as optional multispectral payload, supported by flight planning and data processing service MapEO-water. For ‘pro-sumers’.

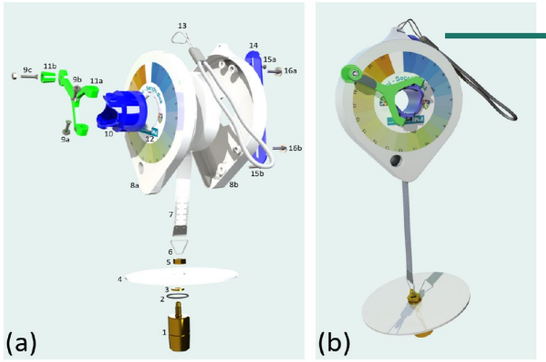
vito

iSPEX 2 by **Leiden University** clips onto smartphone to provide hyperspectral reflectance (with polarization) using Mobley protocol (with photographer grey card) in the 400-690 nm range. Comes with app (by **DDQ**) and camera calibration database. €15-25

Universiteit Leiden



Transparency, vertical attenuation, stratification



Mini Secchi-disk by **Brewtek** & **PML**, portable disk with Forel-Ule colour index, pH paper attachment and supporting App (by **DDQ**). Open source, 3D-printable parts, approx. €60.

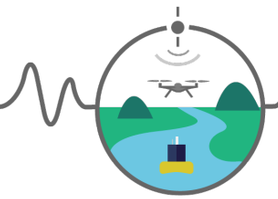
Vertical attenuation using **KdUStick** by **CSIC**: chained light sensors with controller and telemetry (<€500). **KdUMod** is a more capable, modular package including RGB and temperature profiling (€2k freshwater, €6k marine)

EARTHWATCH® INSTITUTE

FreshWater Watch by **Earthwatch**

Includes Turbidity tube, nutrient kit at around €60 per citizen/year. Used globally in citizen science projects.

Availability of each solution (devices and data)



Instrument / platform	Available from	Data route(s)
Hyperspectral pyranometer (HSP)	Prototypes from Peak Design, UK (in discussion with global supplier)	MONOCLE geoserver (WMS, WFS)
Solar-Tracking Radiometry platform (So-Rad)	Plymouth Marine Laboratory, UK	MONOCLE geoserver (WMS, WFS)
WISPStation	Water Insight, NL	WISPcloud API
MapEO UAV data processor	VITO, BE	VITO geoserver (WMS, WCS)
FreshWater Watch	Earthwatch Europe, UK	FWW geoserver (WMS, WFS)
KdUINO devices	Self-build with open-source kits.	CSIC geoserver (in development, WMS, WFS)
iSPEX 2 spectropolarimeter	Mass production underway. Distribution license with Pocket Science (DDQ)	Pocket Science (DDQ) (on European Open Science Cloud)
Mini-Secchi disk	Brewtek, UK	MONOCLE geoserver & Pocket Science (DDQ) App

Data flows

Example software stack for MONOCLE instruments:

Parse

PostgreSQL

GeoServer

Data Processing
- Calibrations
- Quality Control
- Monitoring
- Alerting

Sensors and Apps
Send data + metadata
- Time and location
- Sensor, platform, operator id
- Data usage license, ownership
- ..sensor specific info

ParseServer receives data from mobile Apps (iSPEX 2, Mini-Secchi) and HSP1, So-Rad systems.

Data are semi-structured.
(missing fields, new fields accepted)

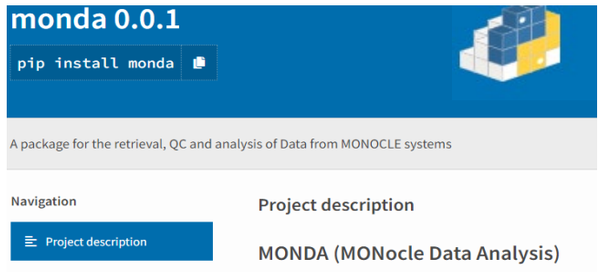
Data are s**tructured, processed in near real-time** for each application and publicly exposed through public **GeoServer** if data license allows:
- Web Map Service
- Web Feature Service (csv, JSON, etc.)

User then points GIS at layer of interest

Sensor and client side scripts hosted on https://github.com/monocle-h2020
Metadata recommendations: MONOCLE D5.3 System user and developer handbook. 10.5281/zenodo.4589027

Example use

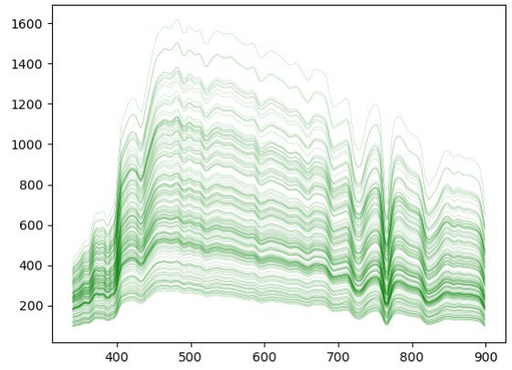
Using *monda* Python package to query and inspect data from a So-Rad




```
import numpy as np
import monda
from monda.sorad.data_access import sorad_access as access
from monda.sorad.data_analysis import sorad_plots as plots
import datetime
import matplotlib.pyplot as plt

#choose time window and sensor platform
start_time = datetime.datetime(2022,5,15)
end_time = datetime.datetime(2022,5,19)
platform = 'PML_SR004'

#request data from WFS server
response = access.get_wfs(platform=platform, (start_time, end_time), layer='rsg:sorad_public_view_3c_full', count=1000)

# extract some data fields from response
wl = np.arange(response['result'][0]['c3_wl_grid'][0], response['result'][0]['c3_wl_grid'][1], response['result'][0]['c3_wl_grid'][2])
ed = access.get_llspectra(response, 'ed_', wl)

# plot Ed spectra
p = [plt.plot(wl, e, '-k', lw=0.1) for e in ed]
```

Data are fetched from geoserver layer:

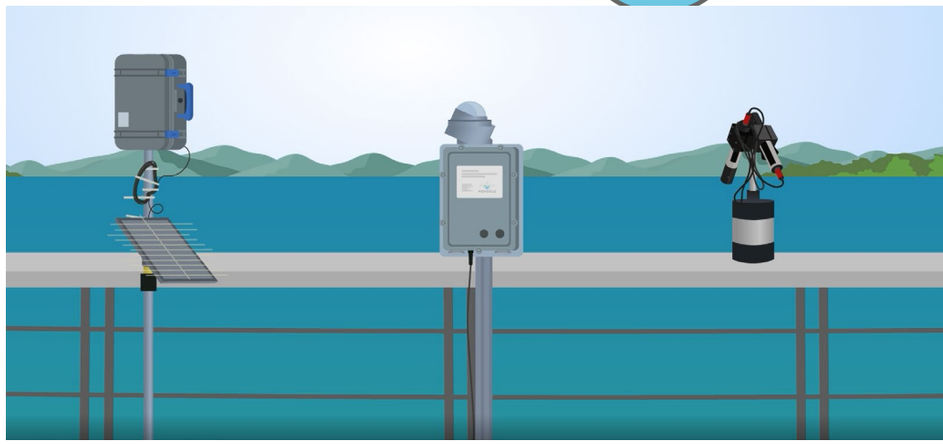
```
| INFO | 1561 features matched
| INFO | Need to page the request: 2 pages
| INFO | Page 0, starting at count 0: 1000 features
| INFO | Page 1, starting at count 1000: 561 features
```



Fields available:

```
>>> response['result'][0].keys()
dict_keys(['id', 'time', 'platform_id',
'sample_uuid', 'platform_uuid', 'gps_speed',
'rel_view_az', 'tilt_avg', 'tilt_std', 'license',
'c3_rmsd', 'c3_resid', 'c3_delta', 'c3_rho_s',
'c3_rho_dd', 'c3_rho_ds', 'c3_alpha', 'c3_beta',
'c3_updated', 'c3_wl_grid', 'c3_rrs', 'lt_wl',
'lt_spectrum', 'ls_wl', 'ls_spectrum', 'ed_wl',
'ed_spectrum', 'lon', 'lat'])
```

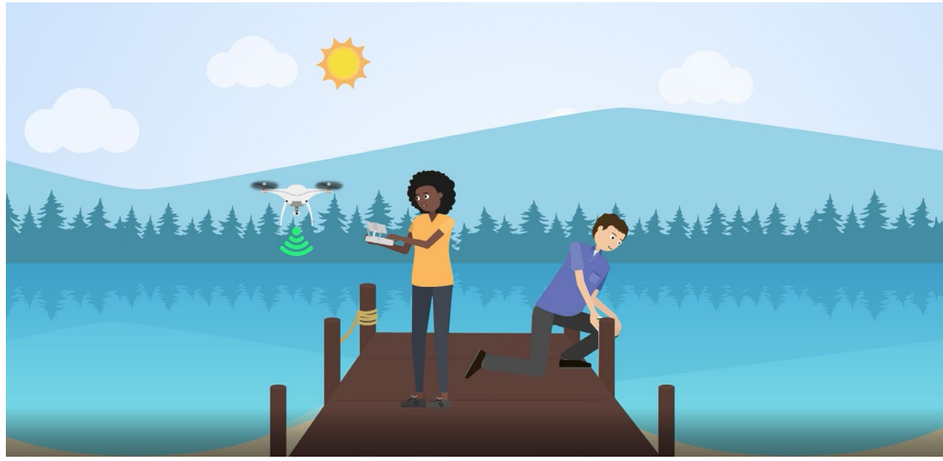
Summary / take-home messages



Innovative solutions were developed to obtain **water and atmosphere radiance** for satellite cal/val at multiple scales of observation using autonomous instruments, drones and smartphones.

Capital and/or maintenance cost**s were reduced compared to existing solutions** through combination of innovative optics, robotics, 3d printing, low-power solutions and smartphones, and a common (but open) data back-end.

Low-cost devices range €25 to several €100s. Note: Low-cost devices are not yet ‘Citizen Science’. Need to envelop the tech in sustained engagement projects, ideally with national agencies.



OGC compatible data flows give near real-time access to new observation data and **include calibration info, data ownership and data licence**. See next talk by Tom Jordan (PML) on how we combine sensors to derive more reliable in situ R_{rs}.

Let’s grow these sensor networks! Get in touch to use the developed backend, add sensors, or join as a developer!

Invitation to discuss

MONOCLE Virtual conference

16th June 2022 12:00 – 16:00 CET

For stakeholders in research, industry, government

Session 1: Stakeholder perspectives, discussion

Session 2: Q&A with instrument developers

Please register to receive a meeting link:

https://www.smartsurvey.co.uk/s/monocleworkshop/
https://tinyurl.com/monocleworkshop

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