CoastVal: a Dedicated Coastal Colour Validation Platform

Sinéad McGlynn, Karl Moore
TechWorks Marine
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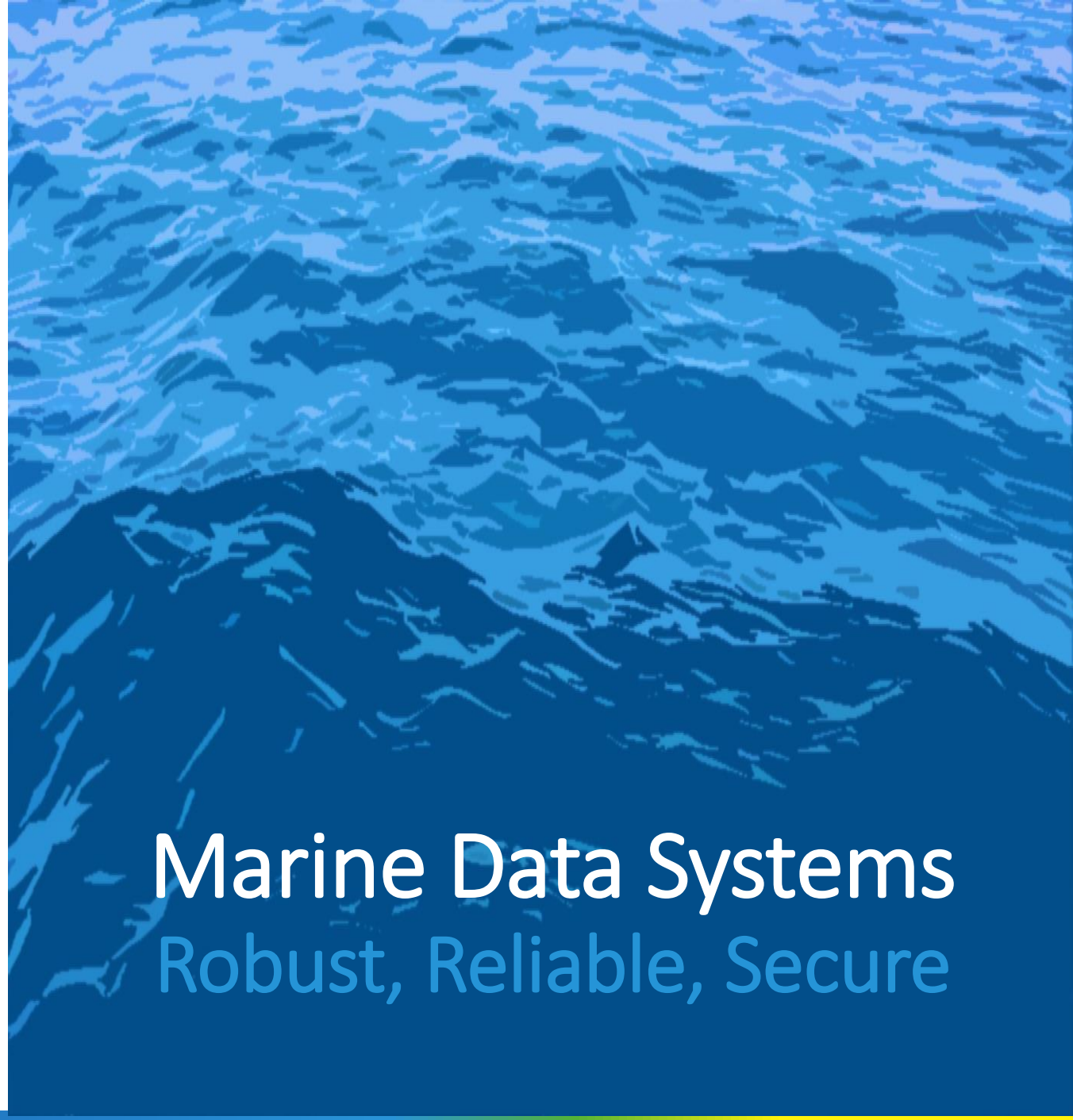


CoastVal Overview

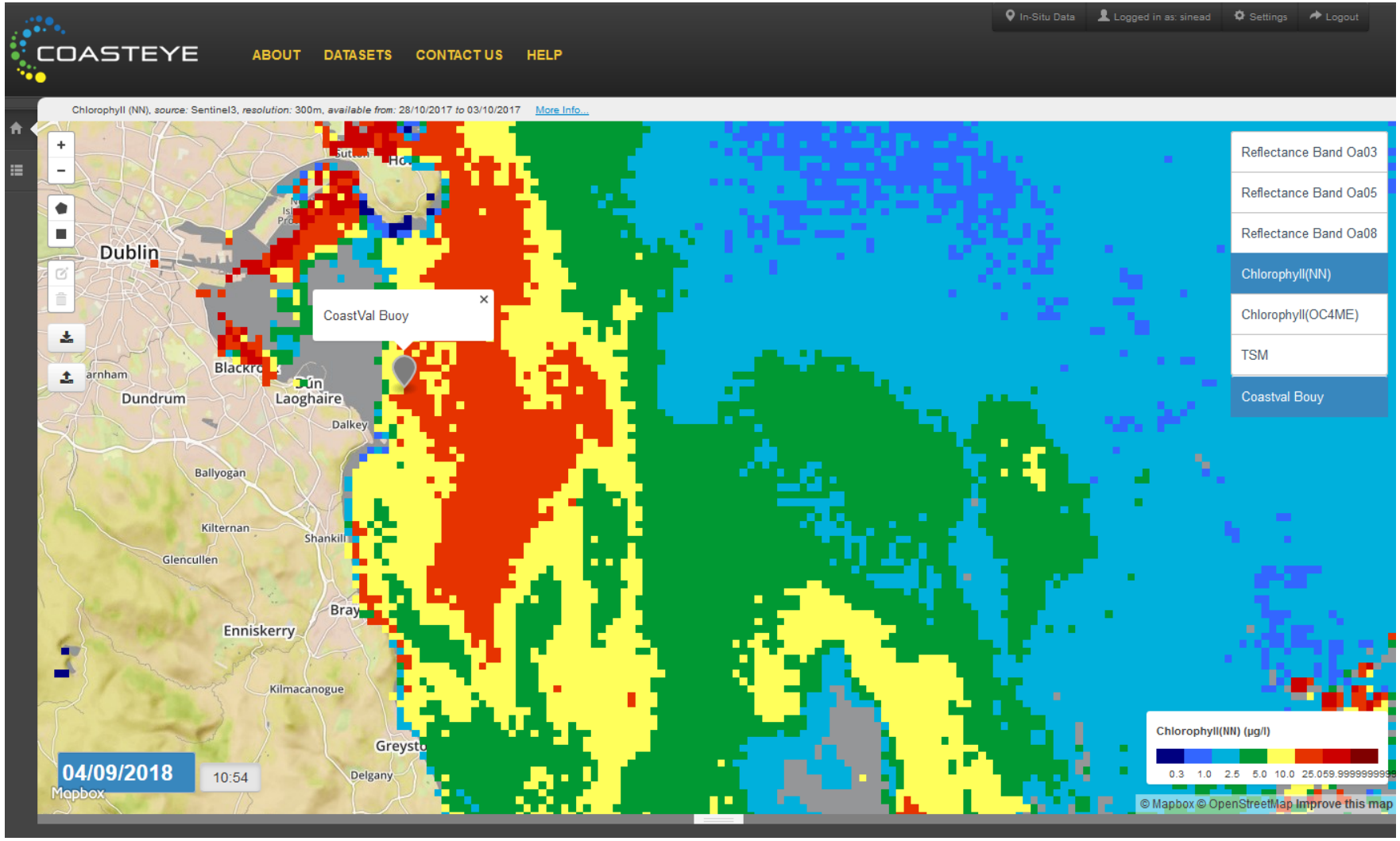
- 2 year ESA-funded project, September 2016-18
- Part of Sentinel 3 Validation Team activities
- Aim: develop a dedicated coastal colour observation platform for validation studies
  - Potential to establish long-term coastal colour observatory infrastructure
- Challenging environment: “hypercoastal” region at high latitude with strong tidal effects

Aims of Deployment

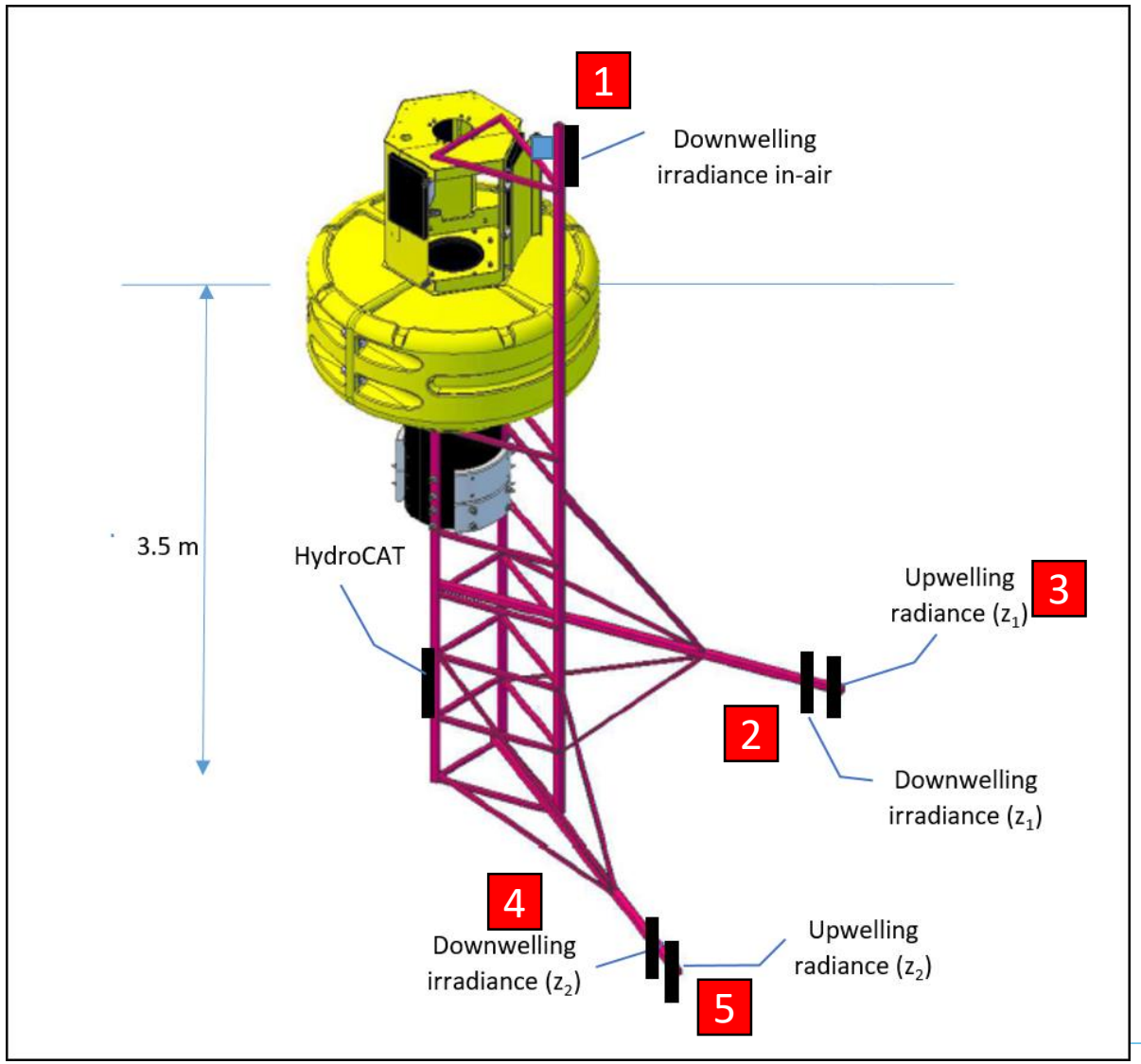
- To demonstrate the end-to-end performance of the system
  - data acquired and transmitted in near real-time through in-house TMBB system
- To enable viewing of the sensors and system status on the TWM CoastEye platform
- To monitor deployment site conditions and study the effects of these conditions on the data

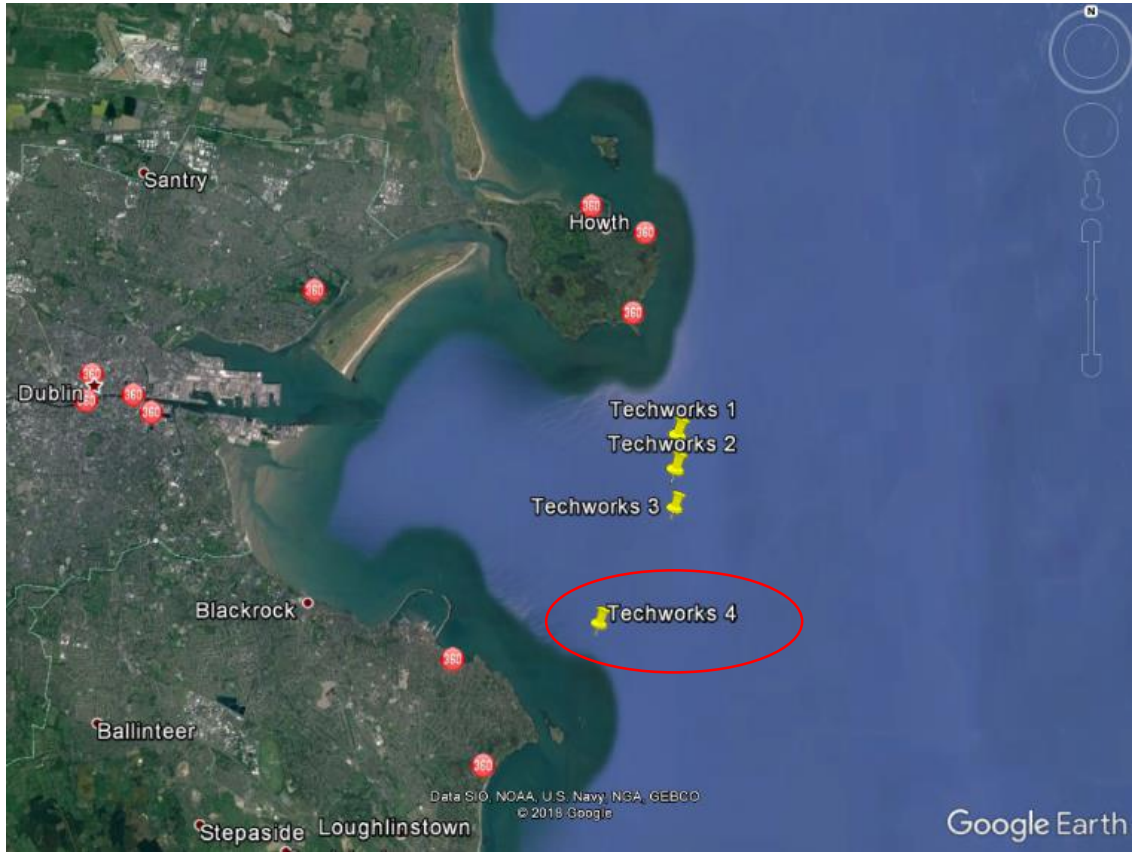
Validation Study

1. Generate quality controlled water-leaving radiance and reflectance incorporating correction factors (buoy platform, local conditions);
2. Match the output with satellite data from S3;
3. Determine the uncertainty budget for individual parameters and final radiometric products



Structure and Location



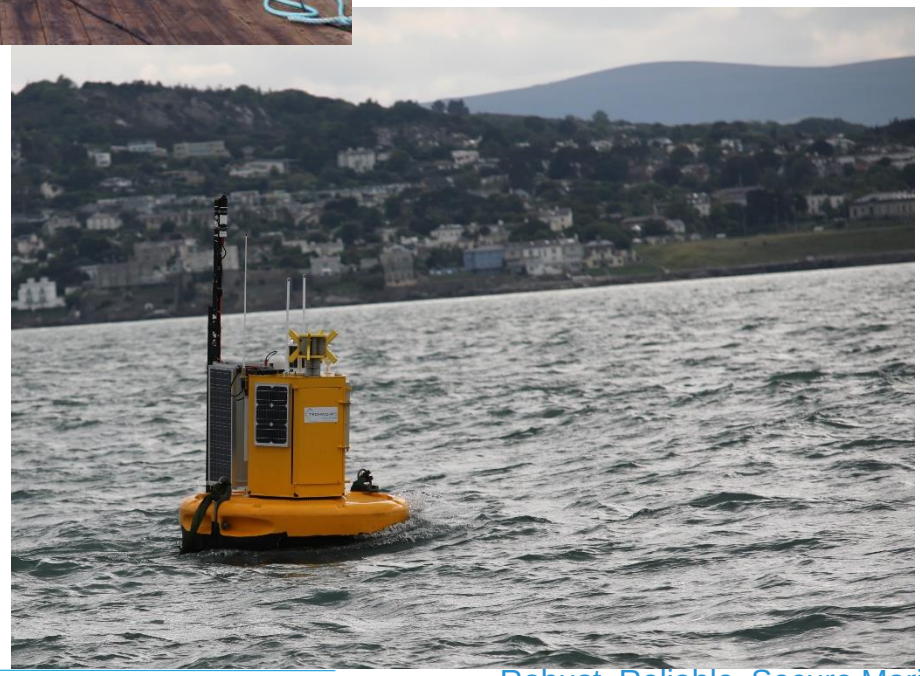


Advantages of CoastVal design

- **CoastVal avoids direct shadowing of sensors** with two-point moorings that ensure sensor arms face into the sun (southerly direction) and by filtering of data
- **High latitudes with low solar zenith angles work to reduce self-shading error**
- **Buoy platform is only small fraction of downwelling light field (<3%)**
- **Simultaneous acquisition of spectra** offsets environmental variability and high-frequency tilt observations allows for data filtering to maintain a desired accuracy level

  (This dataset may also prove valuable in characterising the impact of the environmental variability on the observed radiance)

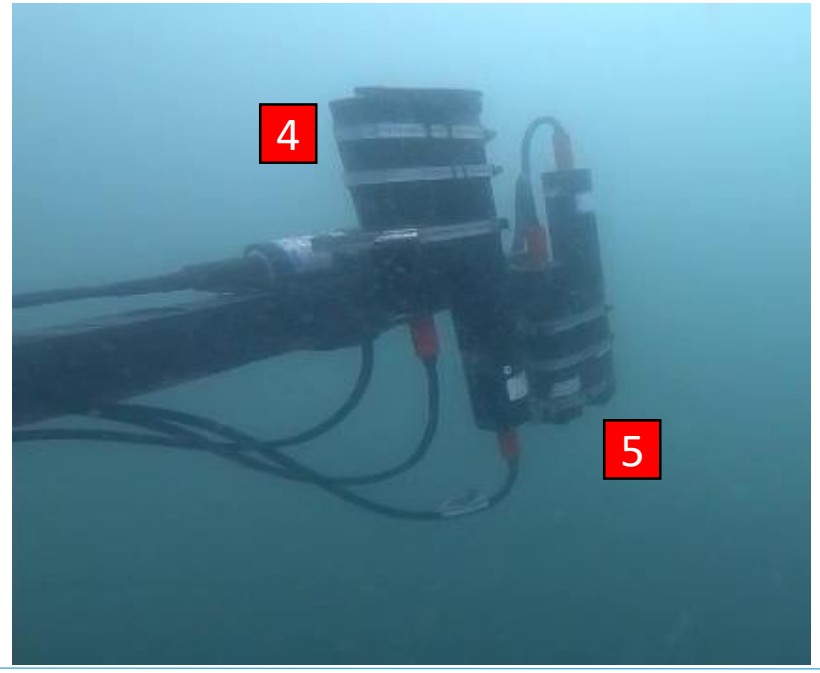
Deployment in Dublin Bay

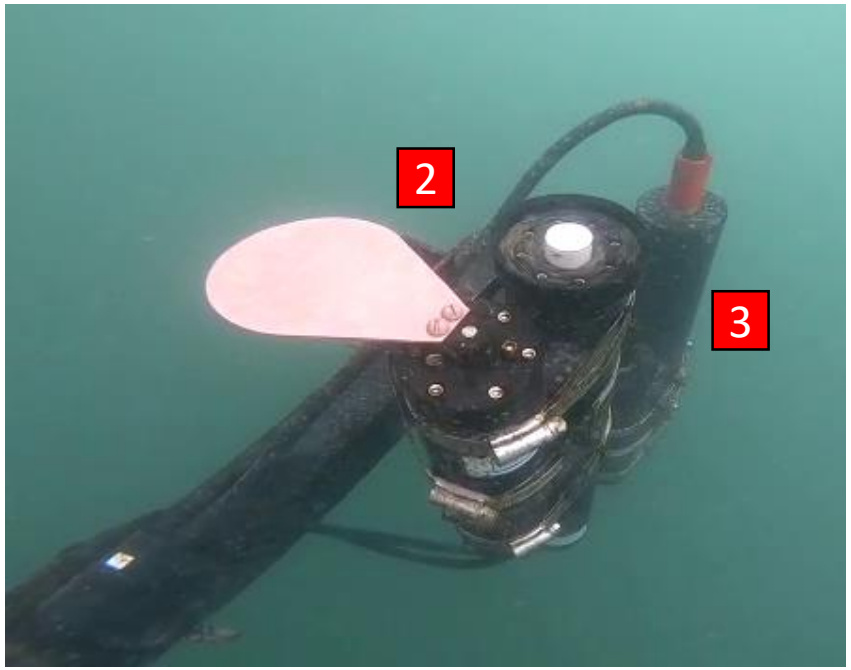


Radiometers

5 Satlantic HyperOCRs (Hyperspectral Ocean Colour Radiometers)

- a downwelling in-air irradiance sensor, $E_d^{0+}(\lambda)$ 1
- two downwelling in-water irradiance sensors with anti-fouling bio-wiper, $E_d(\lambda, z)$, and
- two upwelling in-water radiance sensors with anti-fouling bio-wiper, $L_u(\lambda, z)$

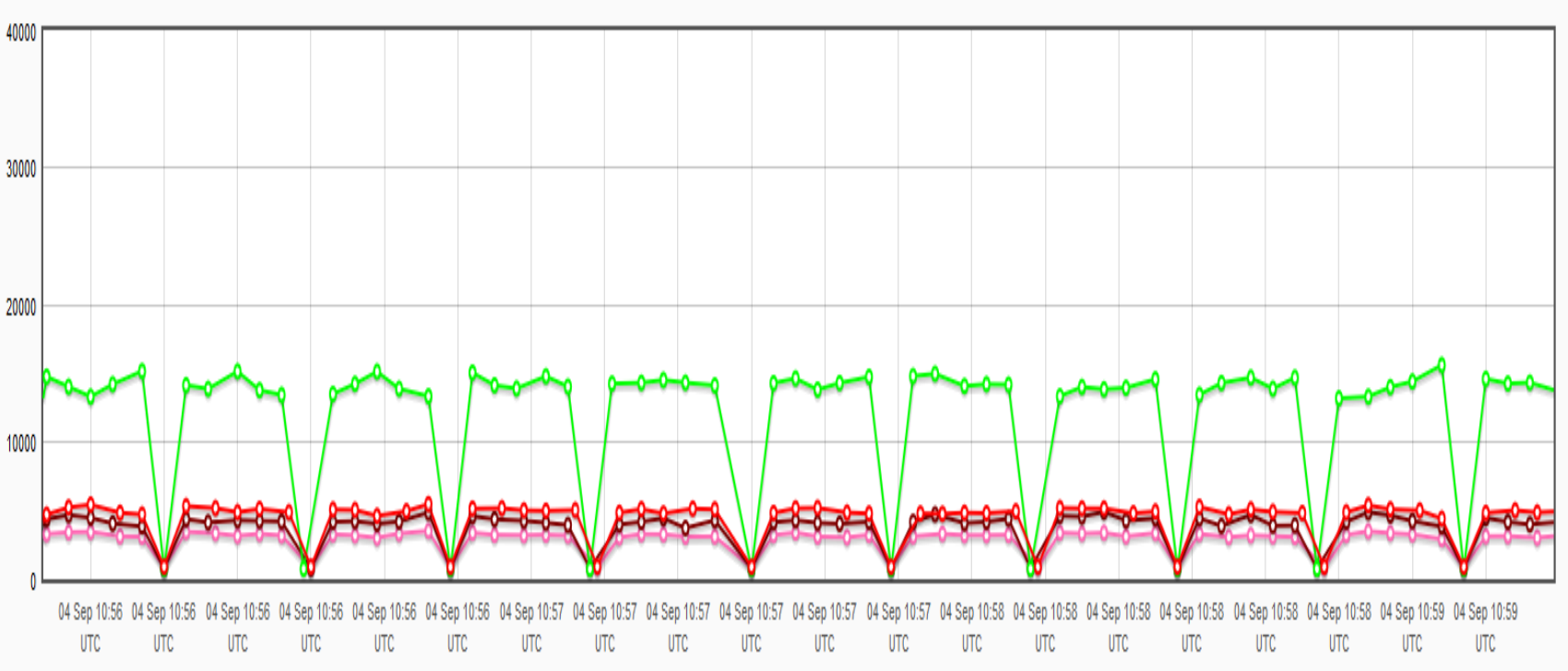




Validation steps

- Acquire synchronous light/dark frames from HyperOCRs along with high resolution platform inclination
- Apply manufacturer's radiometric calibration and apply background subtract
- Convolute with Spectral Response Function of Sentinel 3A bands
- Filter
  - extreme tilt angles – estimate of useable data after filtering
  - Implement instrument self-shading correction - radiance sensors
  - excessive pitch and roll
  - excessive self-shading – buoy orientations, solar angles
- Apply correction for instrument self-shading

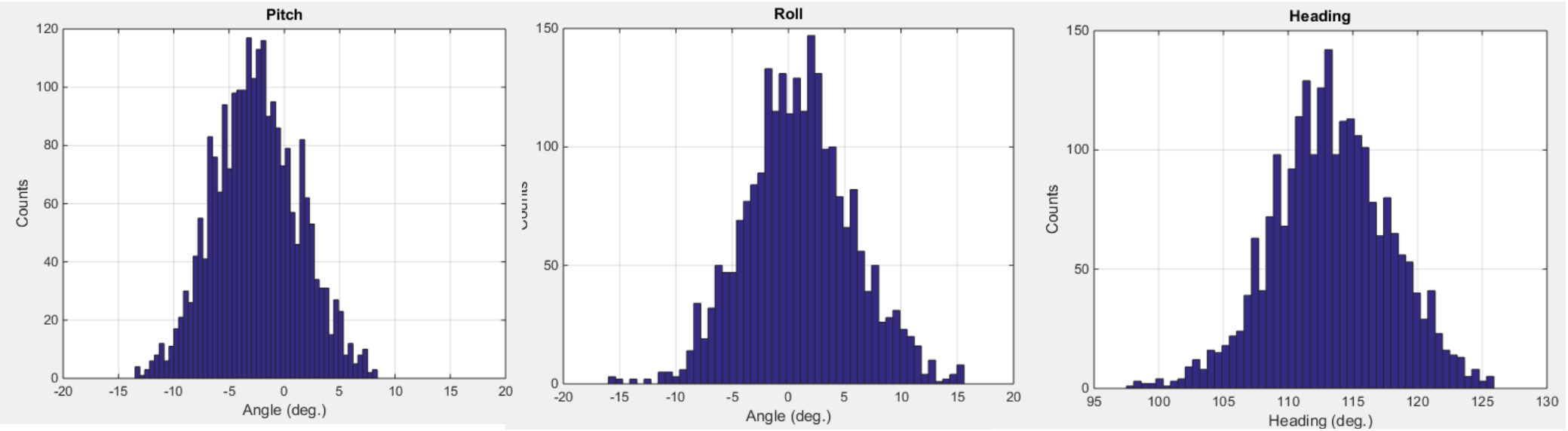
Light/Dark Frames Acquisition Sequence



Acquisition sequence for 4 HyperOCRs taken from CoastEye archives. Note: Every 5 light frames is followed by a dark frame simultaneously across all sensors.
(Levels are taken by averaging their respective spectra around 500 nm).

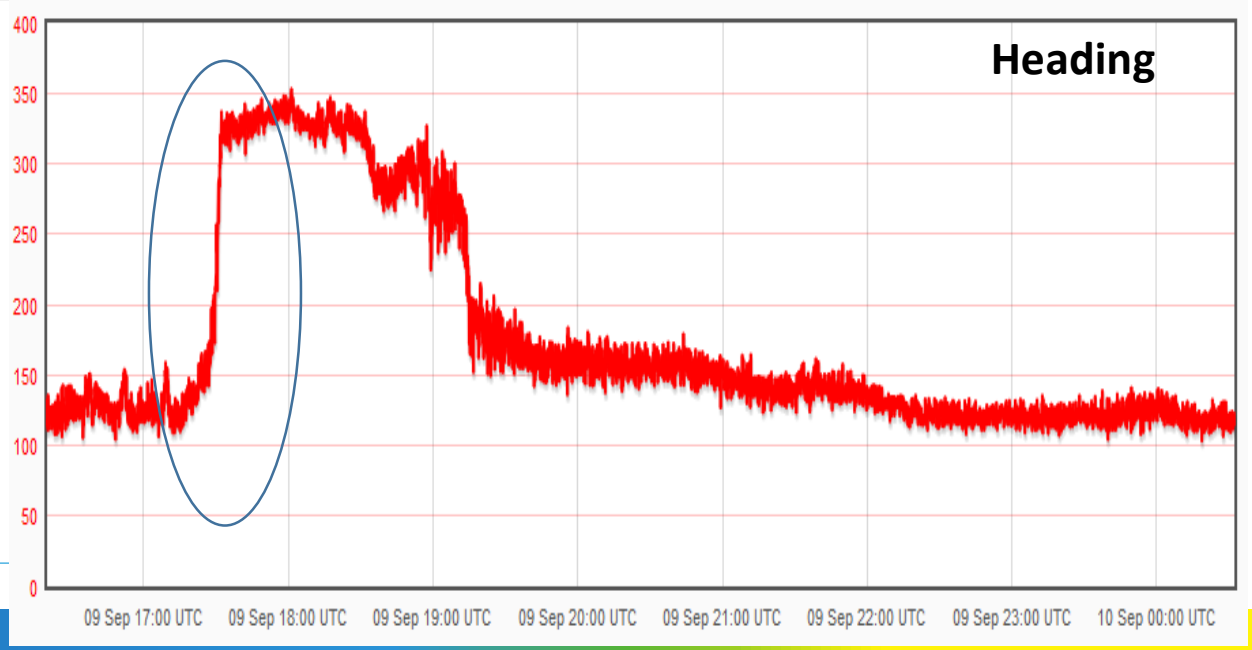
- Data is collected and sent back to CoastEye
- Files typically 2 MB in size
- 8-10 minutes' worth of in-situ observation
- 84 frames/radiometer acquisitions

Buoy Platform Performance

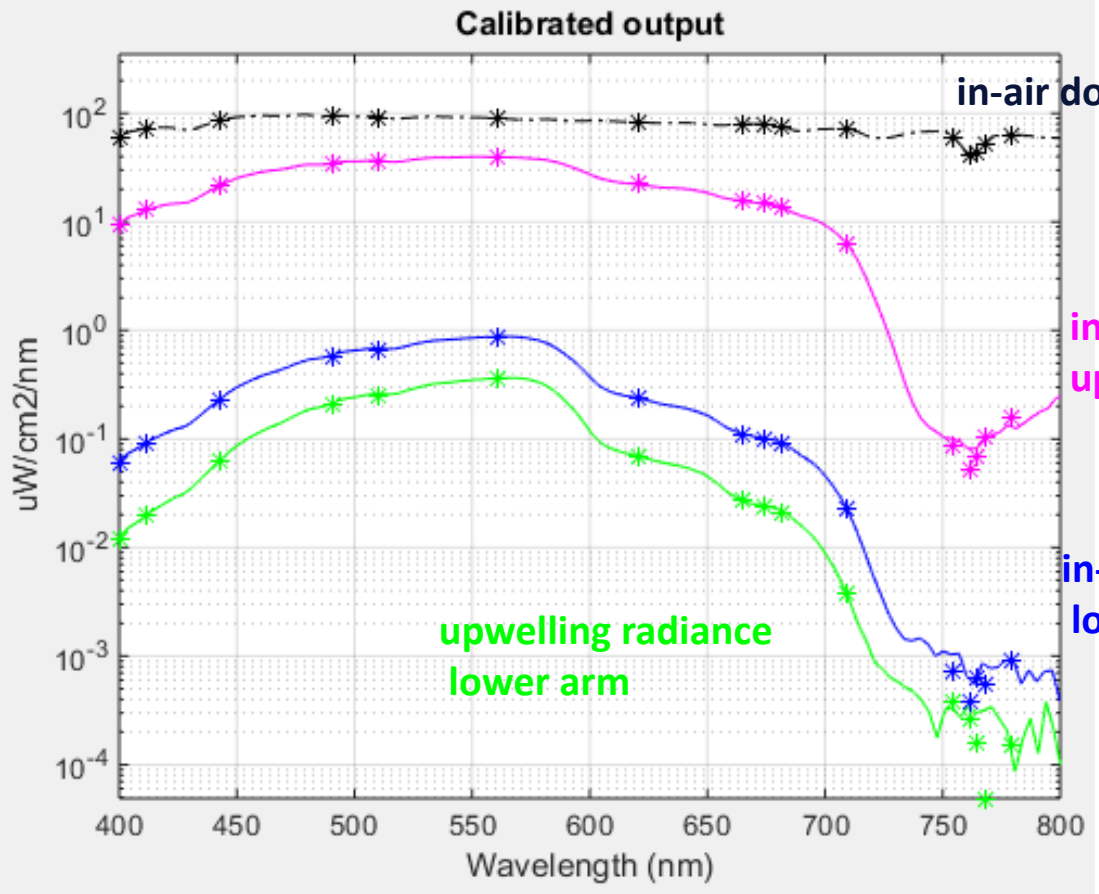


Pitch, roll, heading over 10 min interval with no tidal effects

- Buoy change of orientation with tides can be very quick to assume constancy in other variables esp. water optical properties, tides, etc.
- => the current situation is ideal provided such data collected on clear day.

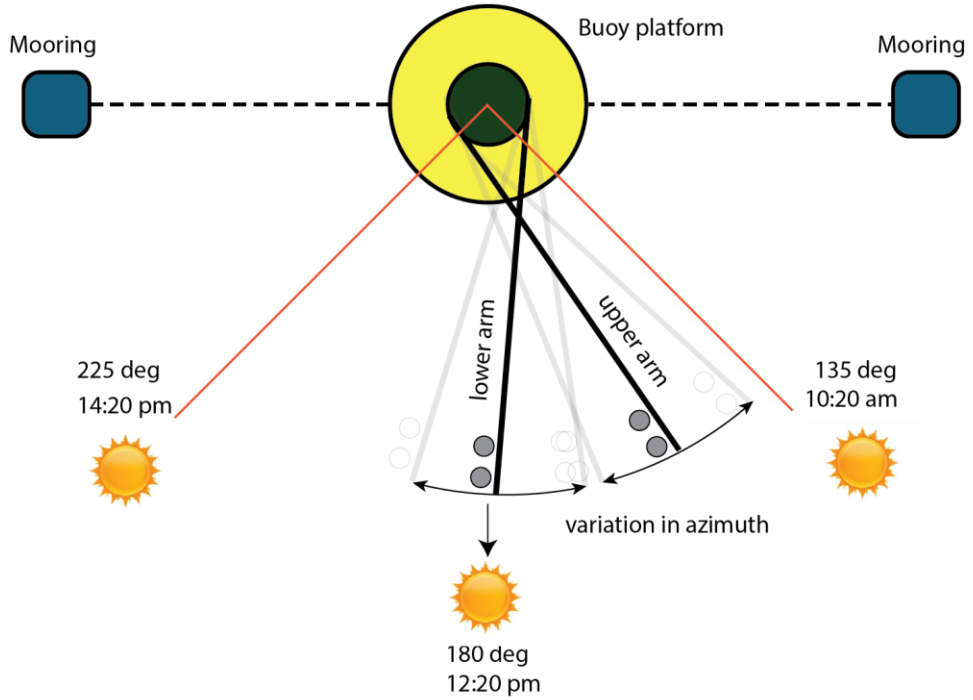


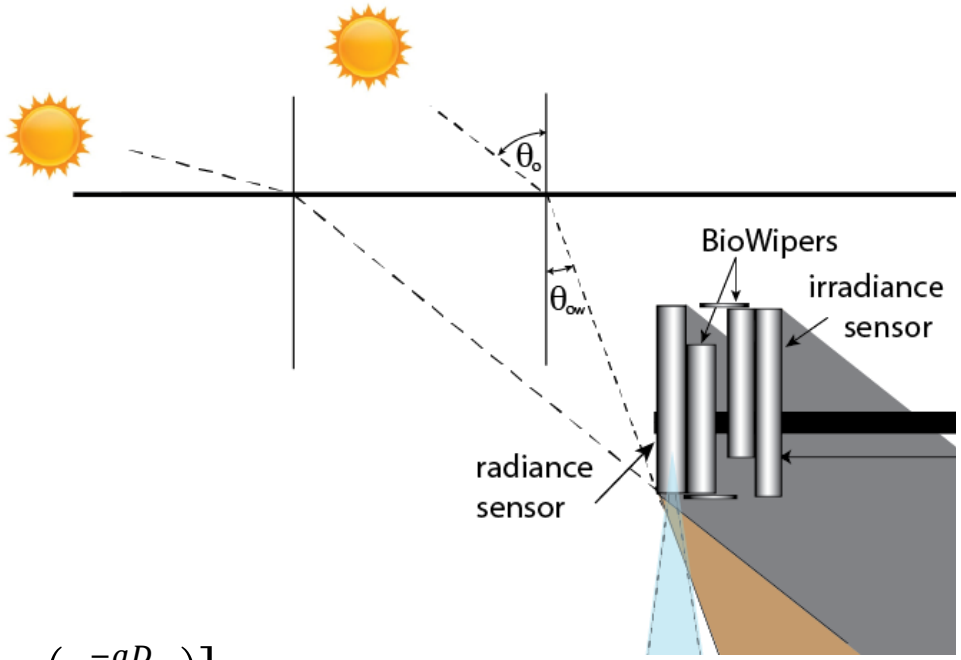
Spectral output



Background subtracted and calibrated output radiometrically calibrated for wavelength and response. Stars represent radiometric value after spectrum response functions (SRF) have been applied for each satellite band. (Downwelling irradiance lower arm temporarily out of commission.)

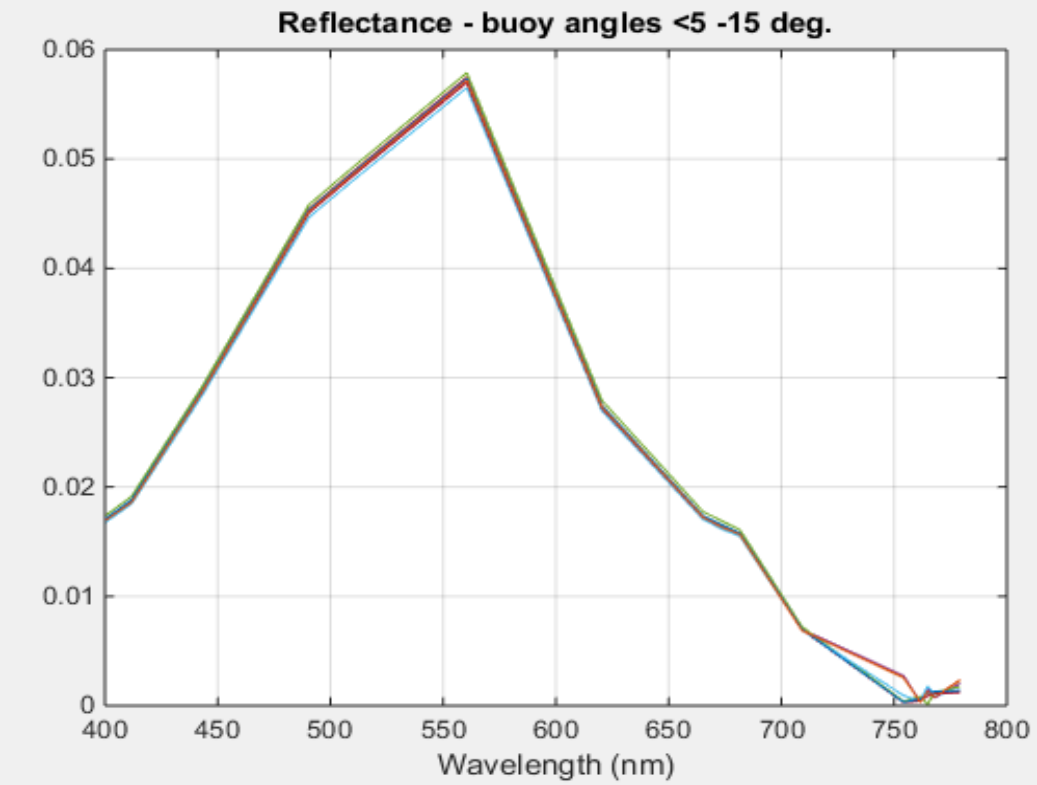
Instrument Self-shading



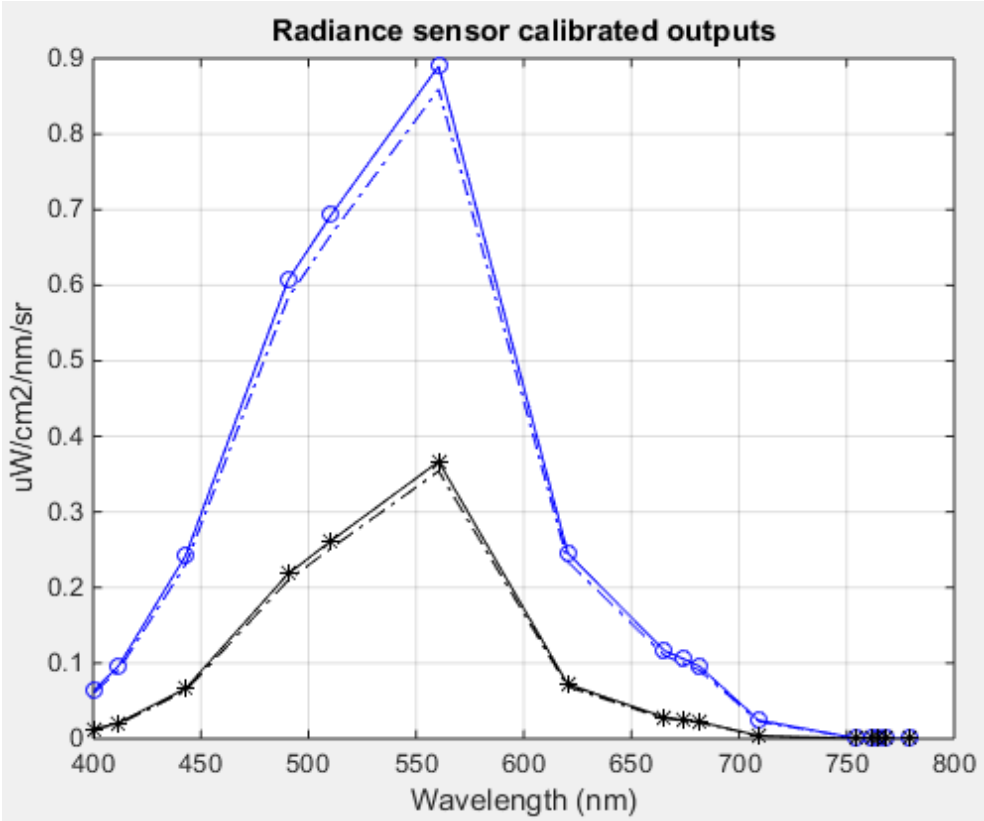


$$\epsilon = \left[1 - exp^{\left(\frac{-aD}{tan\theta_{ow}}\right)}\right]$$

Self-shading effects



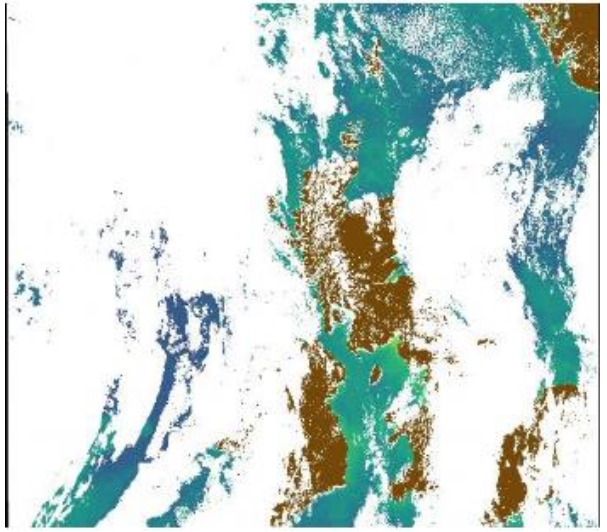
Reflectance calculated on same data with different platform tilt angle tolerances. Variation in varying the acceptance of data from ±5° to ±15°.



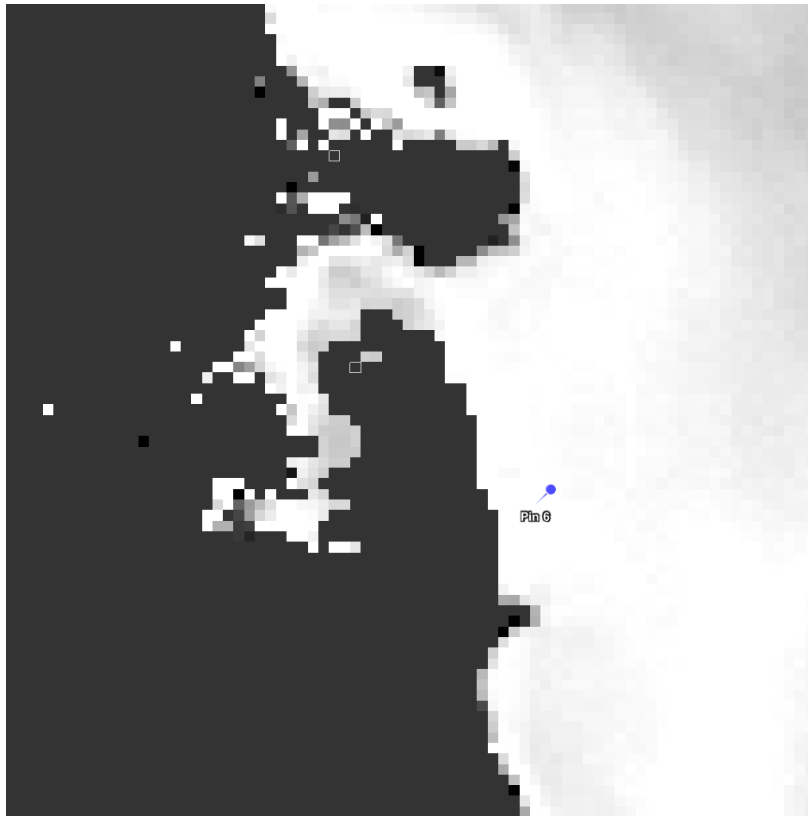
Upper and lower radiance sensors with self-shading correction applied (solid line with circles/stars)

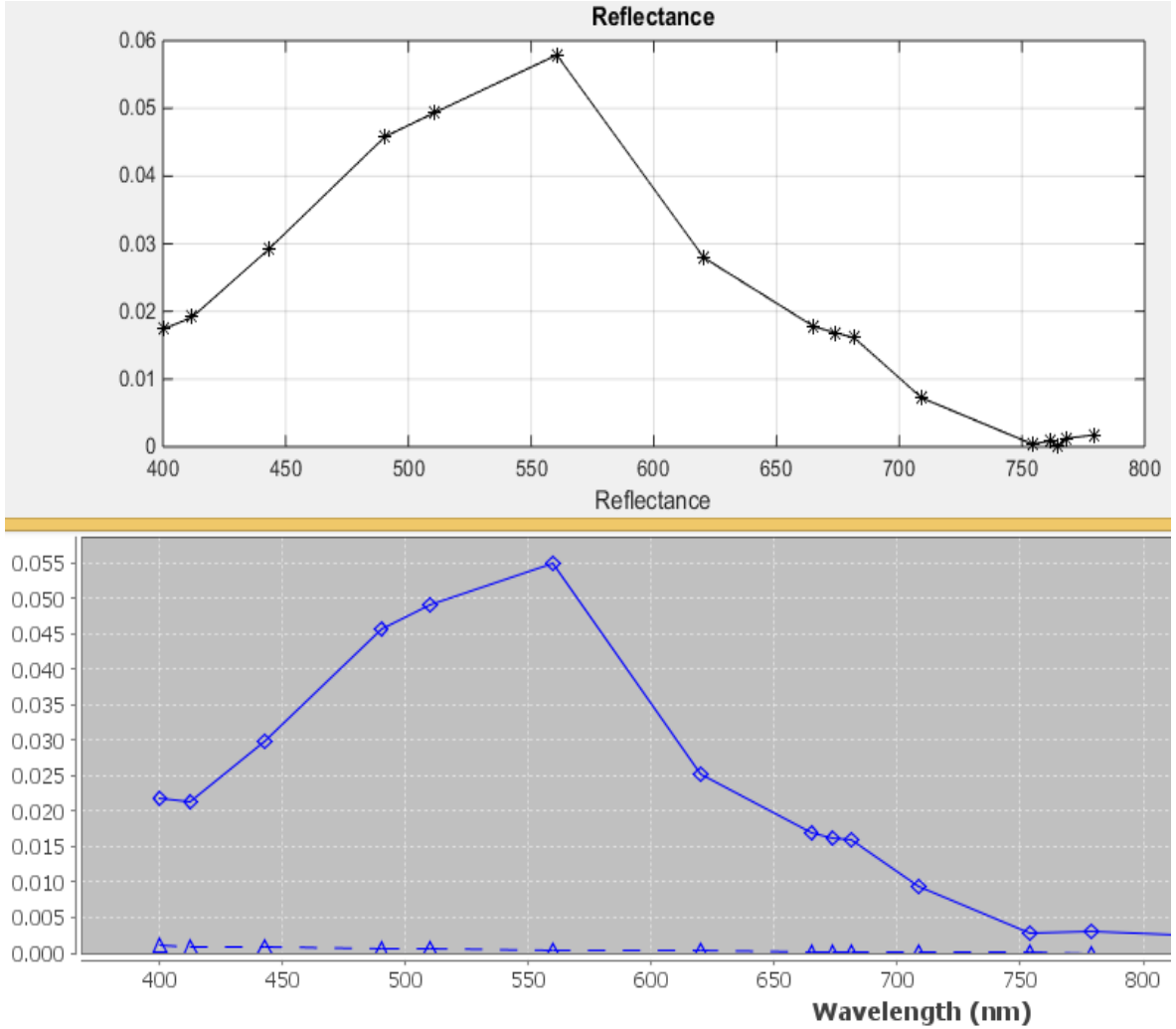
Sentinel 3 Overpass

4 Sept 2018: 10:54 UTC



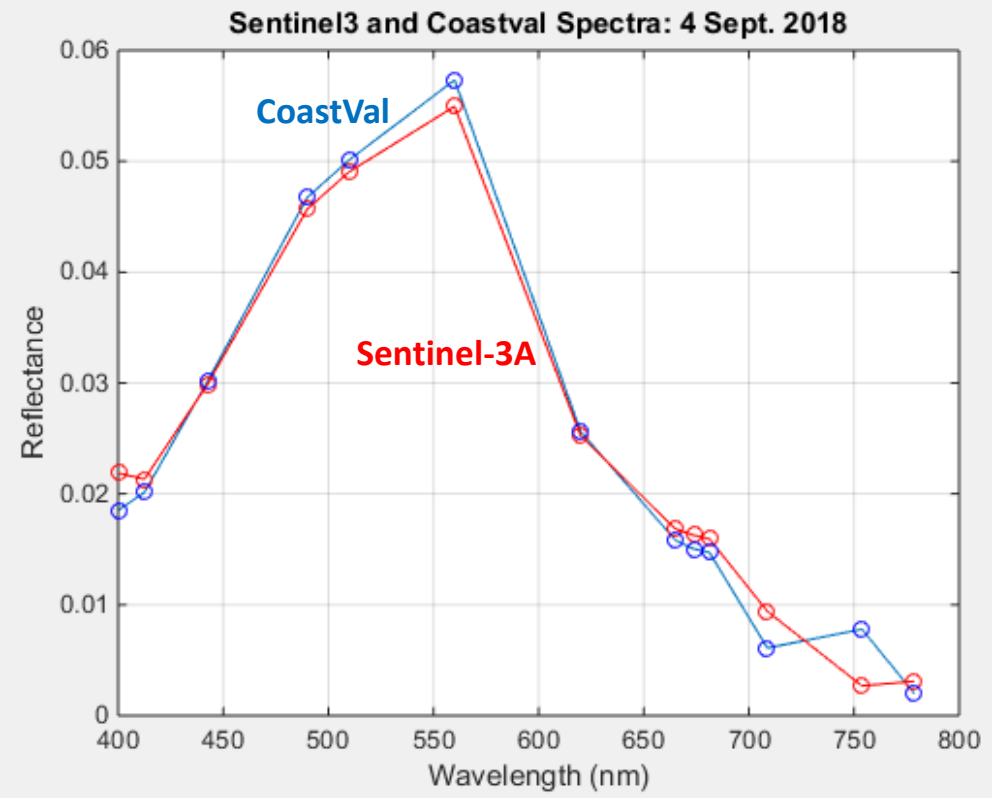
Validation

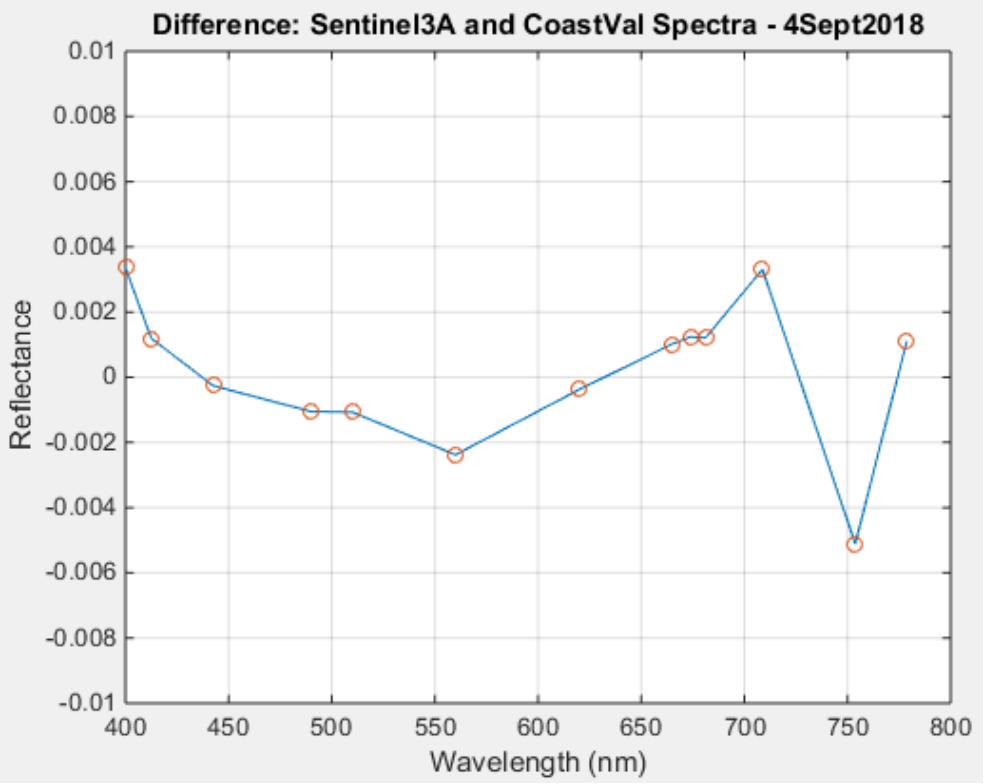




Comparison of Sentinel 3A (bottom graph) and in situ spectral reflectance data acquired with CoastVal (top graph). All 16 Sentinel bands in the region 400-800 nm are shown for the upper in situ profile. 4 September 10:54 UTC

Agreement


Sentinel3 and Coastval Spectra: 4 Sept. 2018
CoastVal
Sentinel-3A
Reflectance
Wavelength (nm)
0.06
0.05
0.04
0.03
0.02
0.01
0
400
450
500
550
600
650
700
750
800

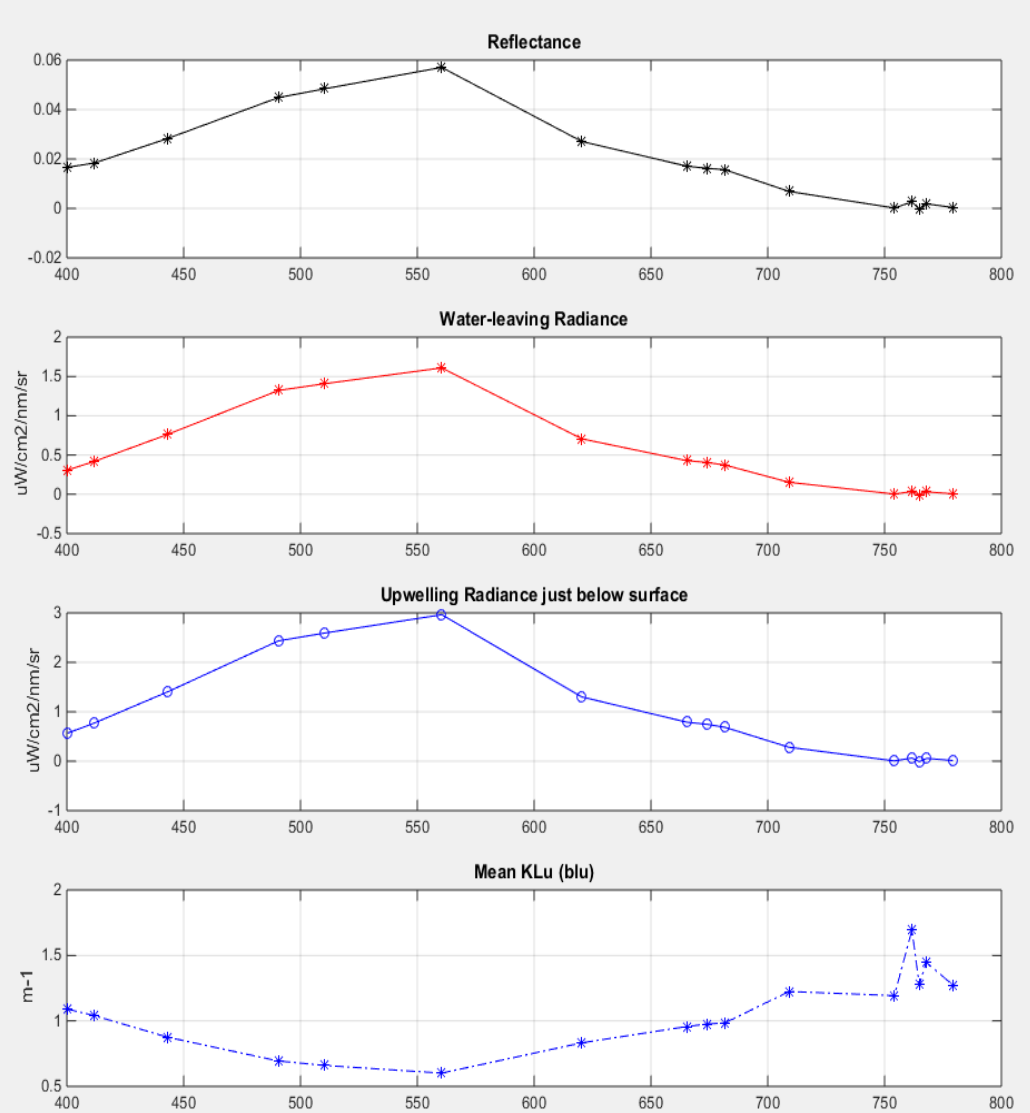

Difference: Sentinel3A and CoastVal Spectra - 4Sept2018
Reflectance
Wavelength (nm)
0.01
0.008
0.006
0.004
0.002
0
-0.002
-0.004
-0.006
-0.008
-0.01
400
450
500
550
600
650
700
750
800

Other Products

Sample In Situ Radiometric Products

Sample radiometric parameters measured with CoastVal system (using only 4 of its 5 hyperspectral sensors):

- Reflectance, ρ_w
- Water-leaving radiance at the water surface, L_w
- Upwelling radiance just below surface, L_u^{-o}
- Upwelling diffuse attenuation coefficient, K_{Lu}



HyperOCR Calibration Issues

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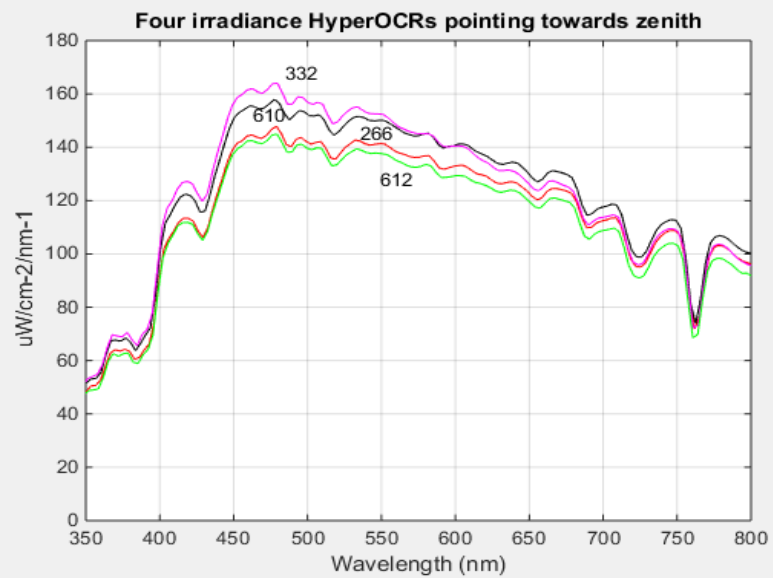
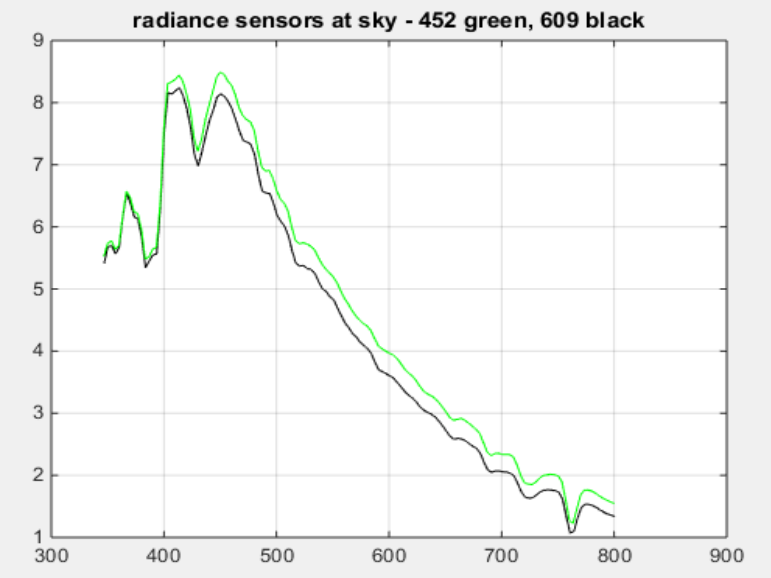
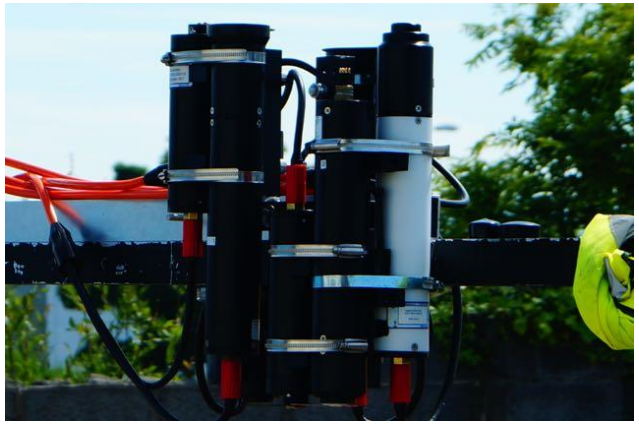
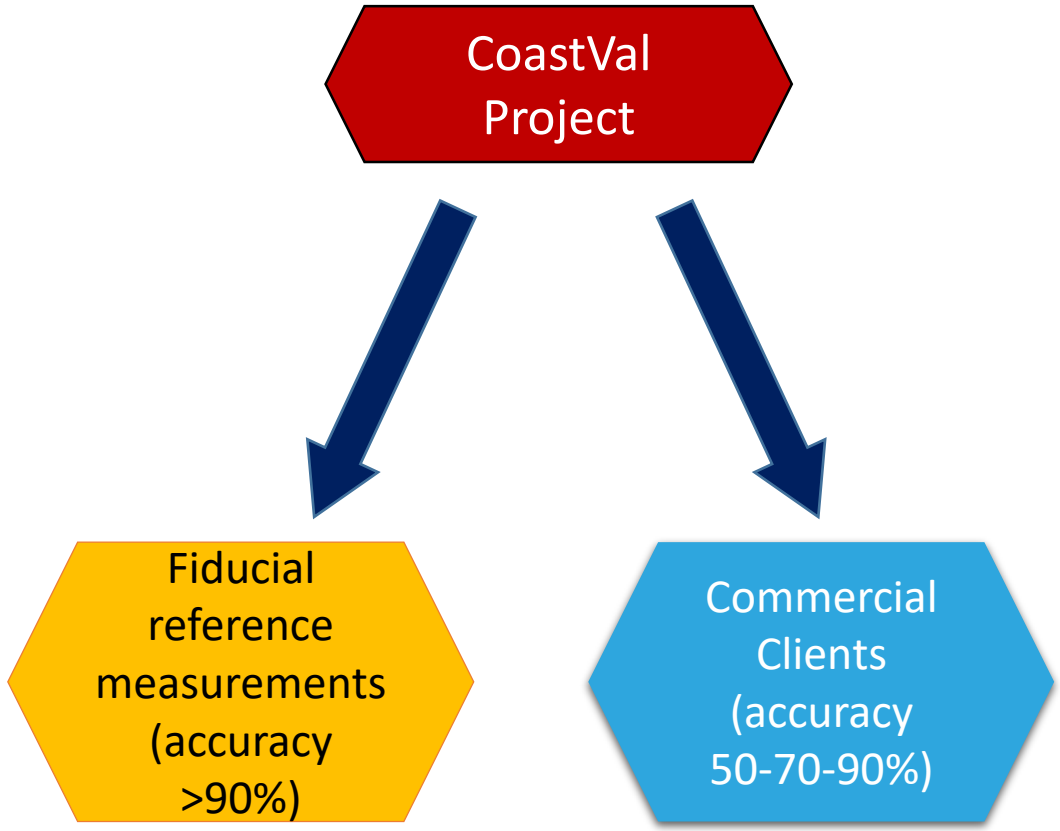






Next steps

- Sensor calibration & redeployment of buoy system
- Sentinel 2 high resolution comparisons
- Other satellites (e.g. smallsat constellations)
- Assessment of acceptable levels of accurate radiometric calibration to commercial end users
- Commercial service to users in dredging, construction, and environmental monitoring sectors



Thank you!

sinead.mcglynn@techworks.ie

@TechWorksMarine