Validation of ocean colour satellite products in coastal waters (HIGHROC project)

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Outline

1. Objectives
2. Satellite data and products
3. Methods (validation)
4. Test sites / In situ data
5. Results
6. Conclusions and Perspectives

Objectives

The HIGHROC (**HIGH spatial and temporal Resolution Ocean Colour**) project develops the next generation coastal water products and services from ocean colour space-borne data

Uncertainties associated to satellite products are quantifield at regional scales and provided to scientists and users

highroc.eu

2014-2017

Satellite data and products

High Spatial resolution: **S2plus**

Landsat—OLI (30 m), Sentinel2-MSI (20 m)

Medium resolution: **S3plus**

MODIS, VIIRS, OLCI (250 - 1000 m)

High Temporal resolution: **GEO**

MSG-SEVIRI (15 mn, 4000 m)

L2R products: **nLw, Rrs, rhow**

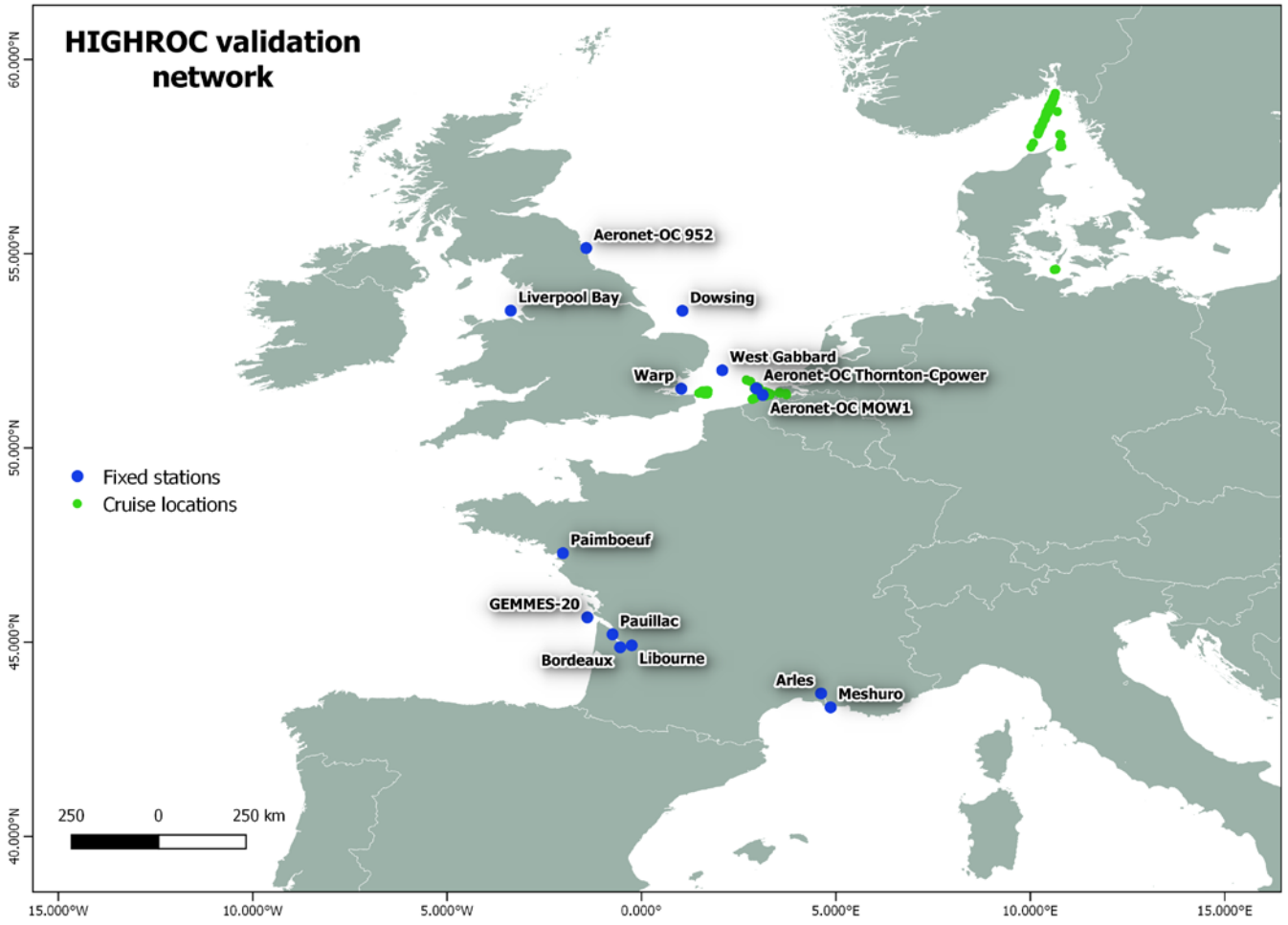
L2W products: **SPM, TUR, Chla, Kd, IOPs**

Methods (validation)

- Regional algorithms
  AC (MUMM, NIR-SWIR, SWIR, SR) + L2W inversions
- Routine processing at regional scales
  S2plus (VITO), S3plus (BC), GEO (RBINS)
- Match-ups
  Quality control of satellite products and field data
  Protocols adapted to test sites (1 to 3×3 pixels, +/-1h to +/-3h)
- Quantification of uncertainties
  As the differences in % between satellite products and field measurements (slope, NRMSE, MAPE)

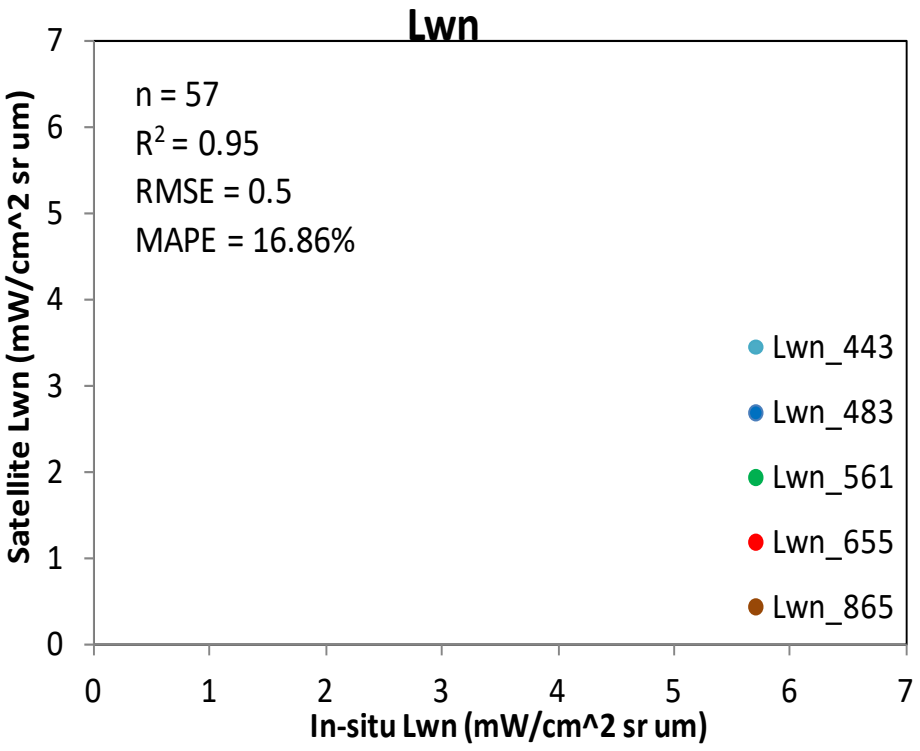
Test sites / In situ data

- Multi test sites (from clear to highly turbid waters)
- Field data from ferries, oceanographic cruises, autonomous fixed platforms

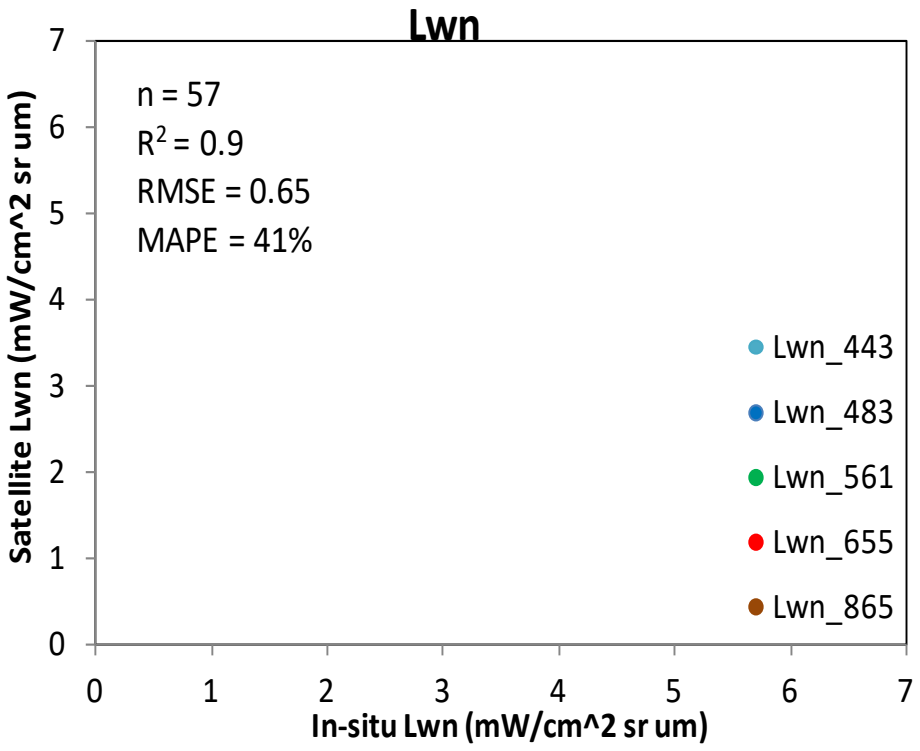


Results: atmospheric corrections (S2plus)

➔ **Match-ups between OLI-derived (SWIR AC) & Aeronet-OC MOW1 nLw (SNS)**



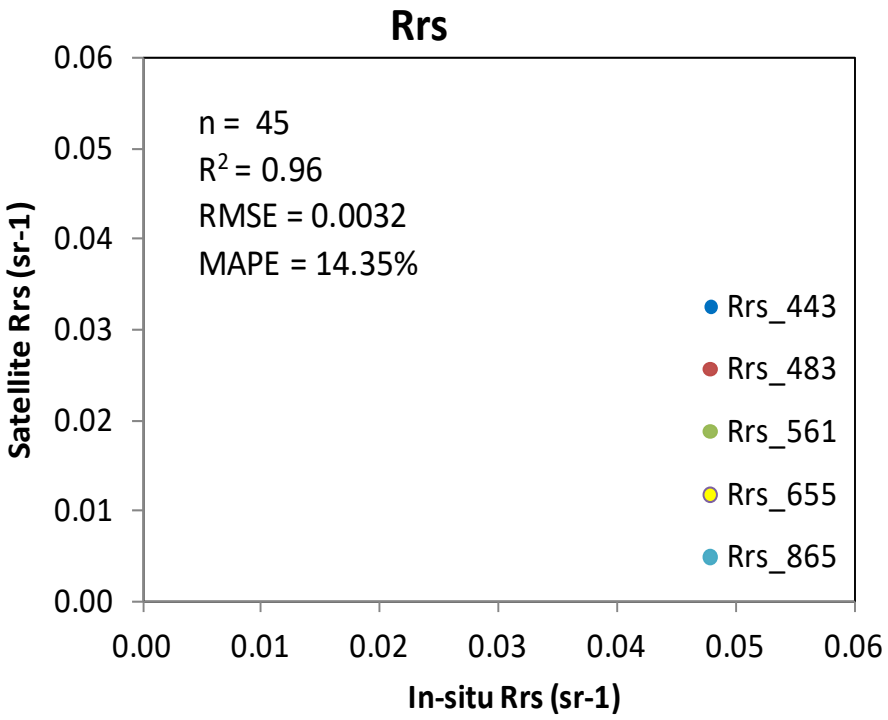
1×1 pixel +/-0.5h



3×3 pixels +/-0.5h

Results: atmospheric corrections (S2plus)

➔ **Match-ups between OLI-derived (SWIR AC) & in situ R_{rs} (Gironde estuary)**



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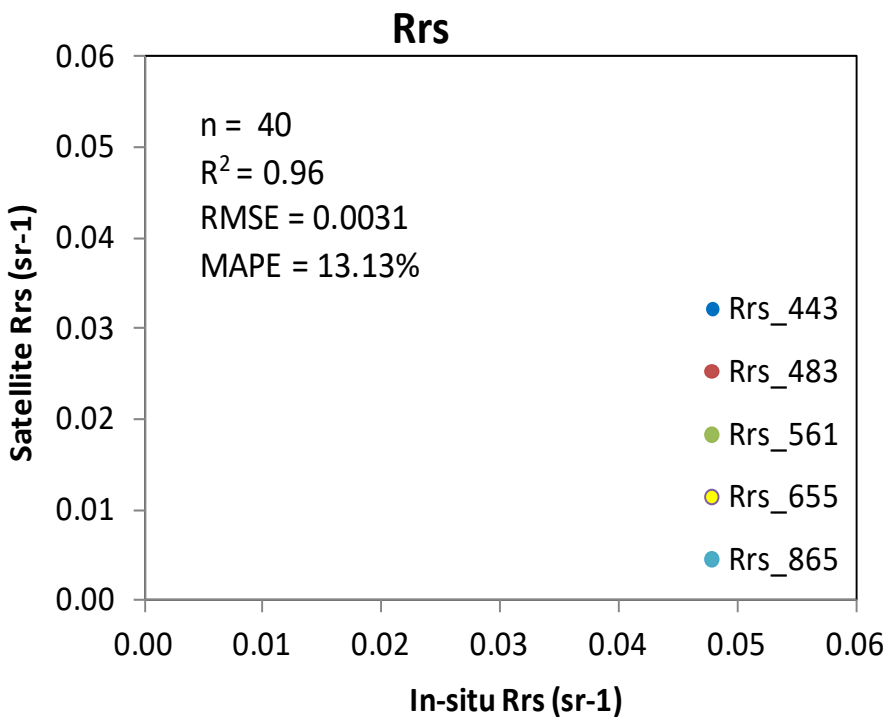
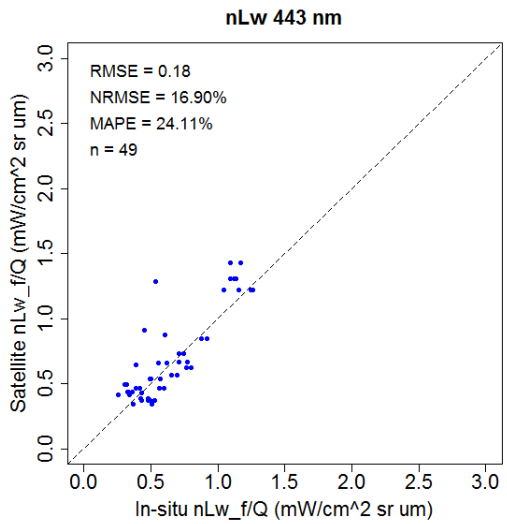
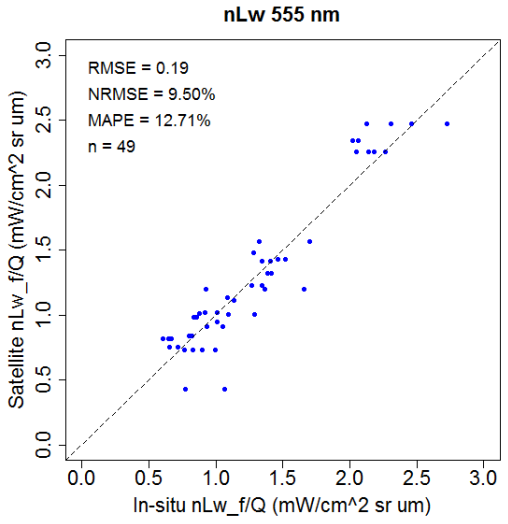
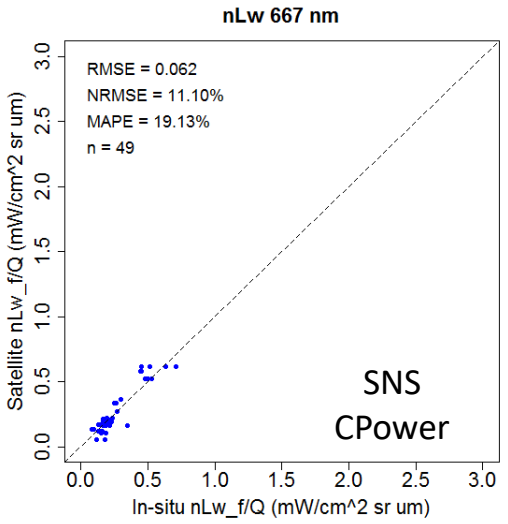


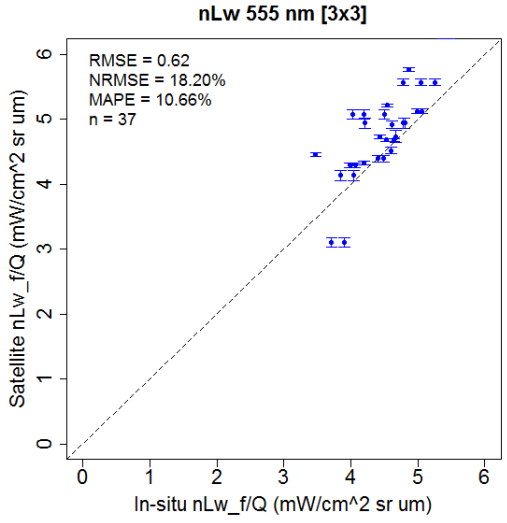
3×3 pixels +/-0.5h

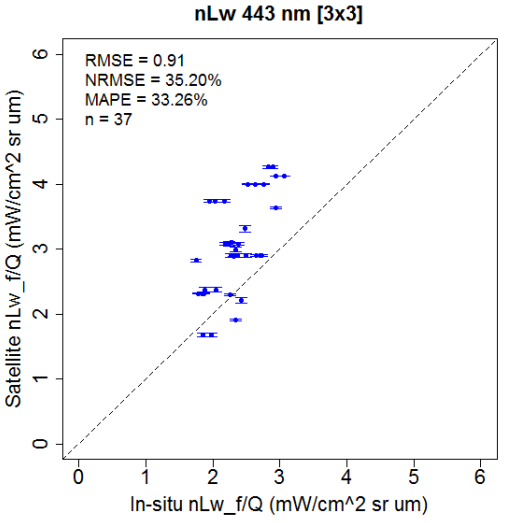
Results: atmospheric corrections (S3plus)

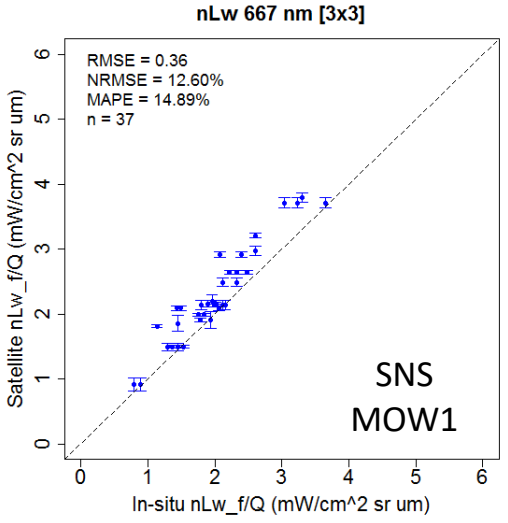






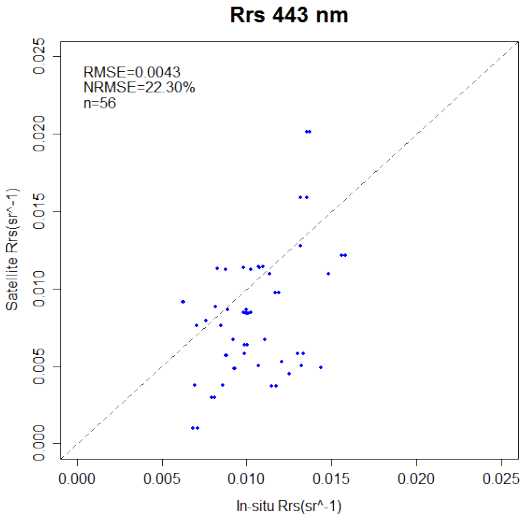


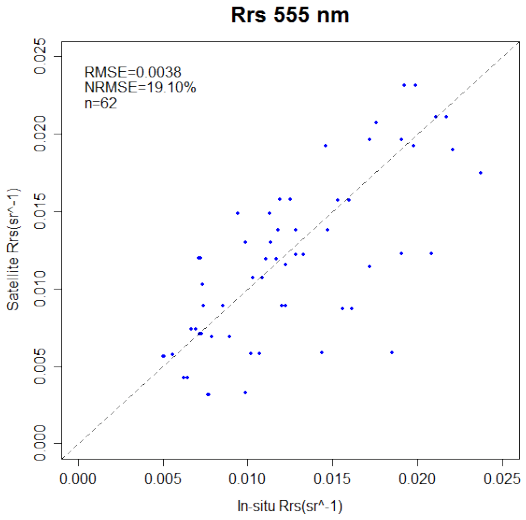


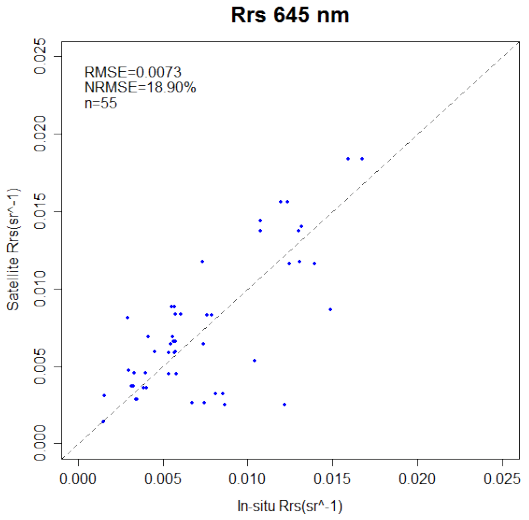


➔ NRMSE on multi-spectral nLw and Rrs varying from 10 to 25%

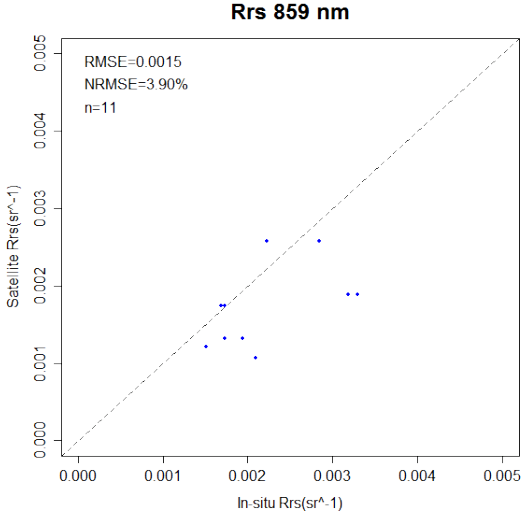
Results: atmospheric corrections (S3plus)







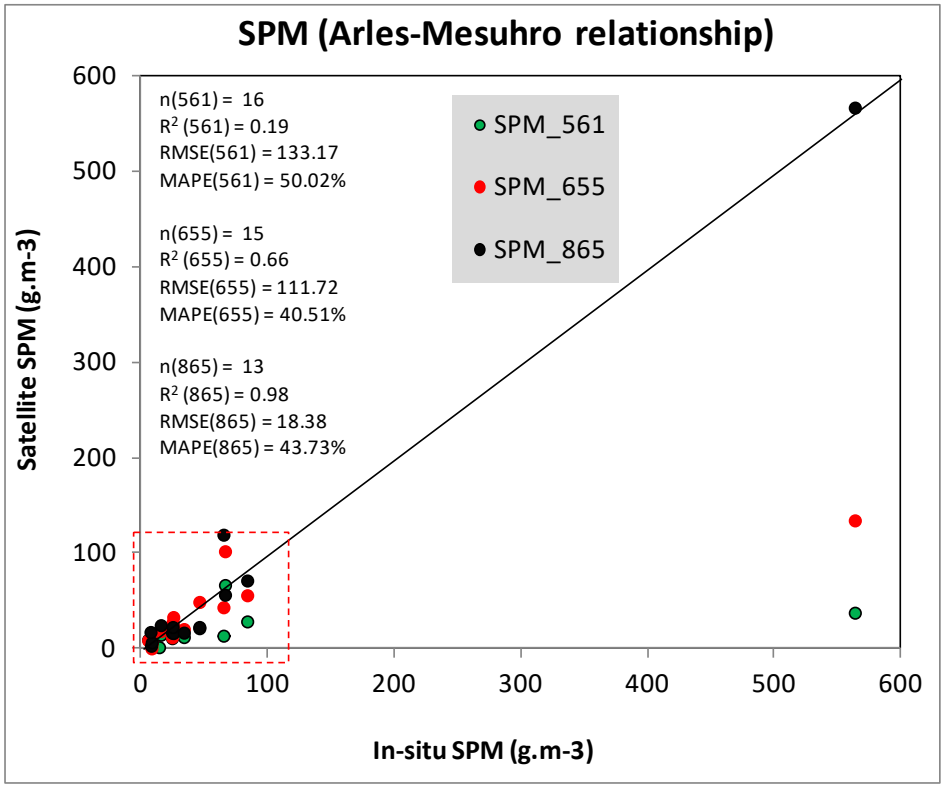
Rhône Mesurho

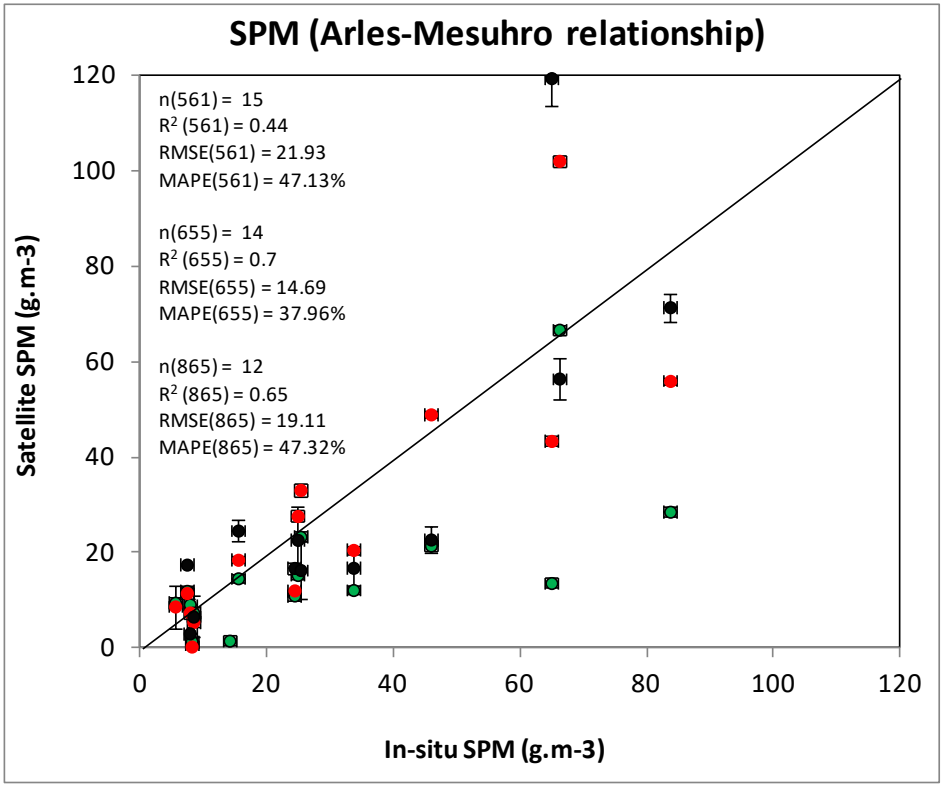


➔ NRMSE on multi-spectral nLw and Rrs varying from 10 to 25%

Results: TUR and SPM retrievals (S2plus)

➔ **Match-ups between OLI-derived and in situ SPM (Rhône River mouth) using an adaptative (green > red > NIR) algorithm**



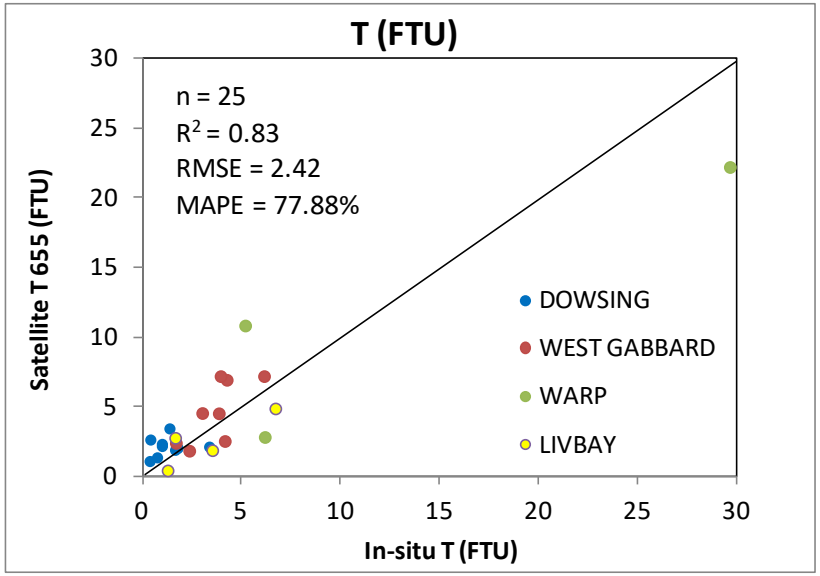


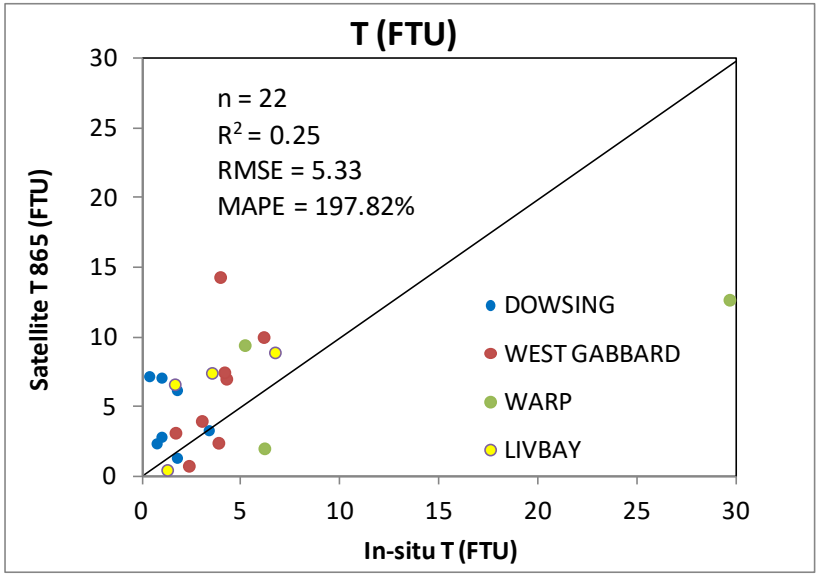
1×1 pixel +/-0.5h

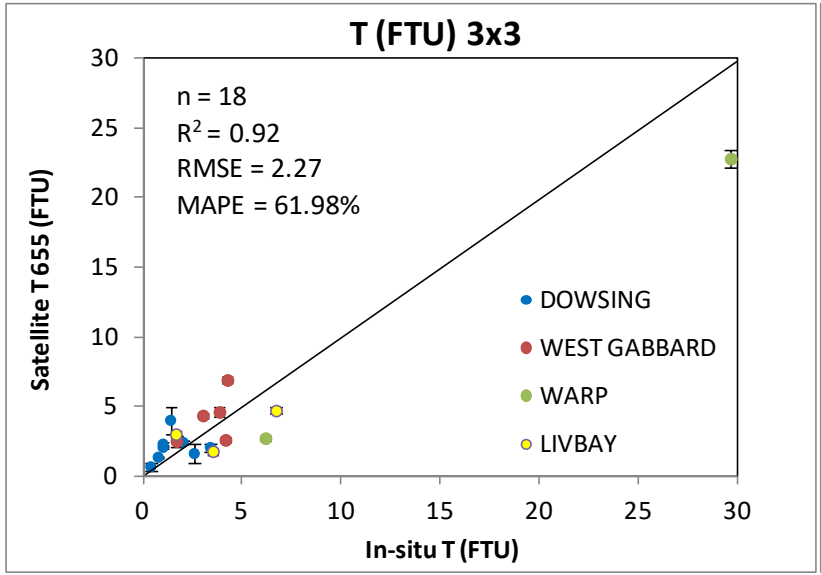
3×3 pixels +/-0.5h

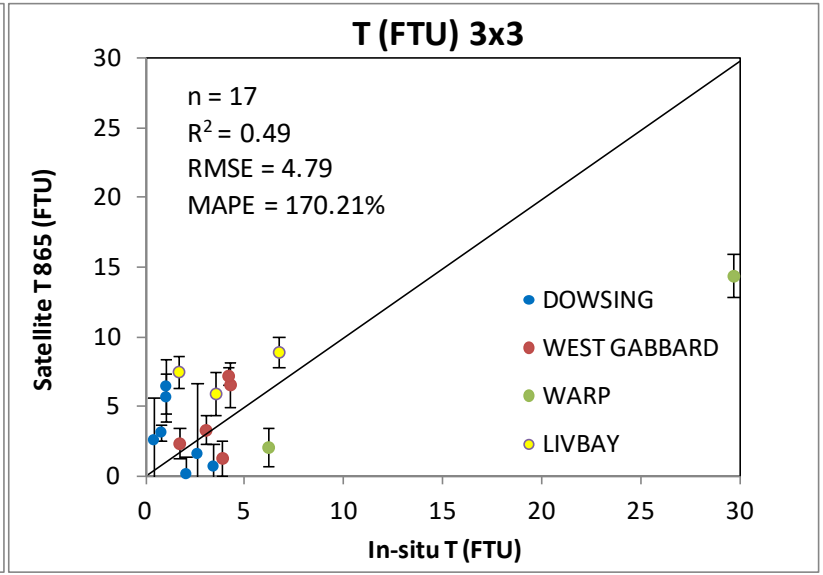
Results: TUR and SPM retrievals (S2plus)

➔ **Match-ups between S2plus- and Smartbuoy-derived TUR (SNS)**





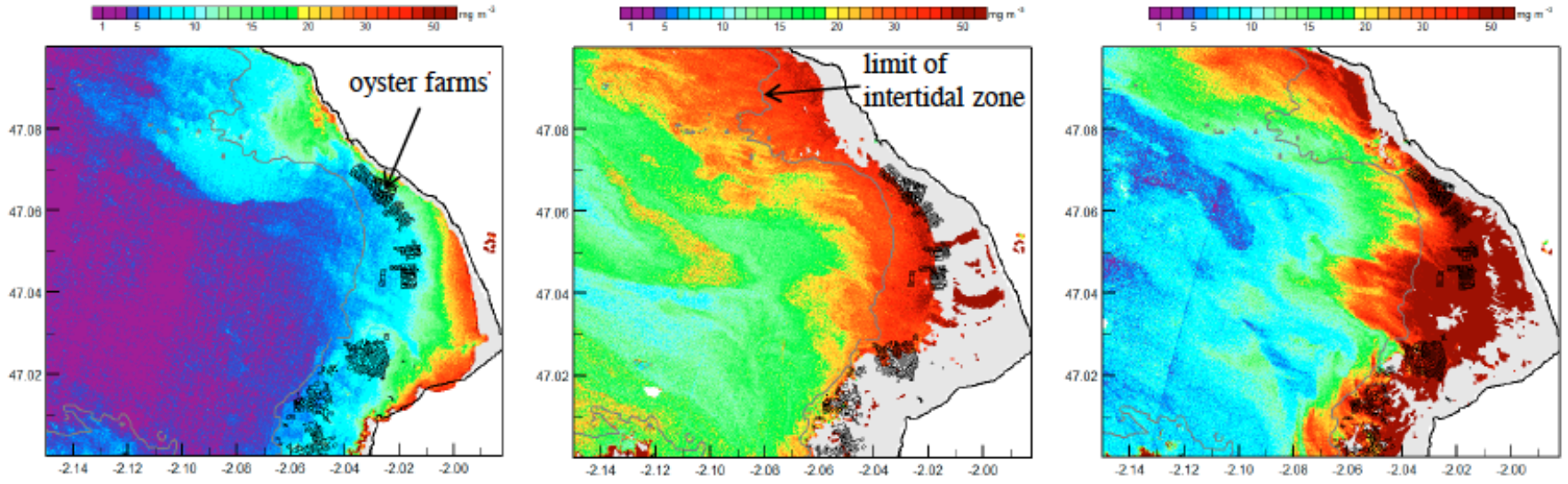




Results: Chla retrieval (S2plus)

- **Chla mapping at 20 m spatial resolution (S2-MSI)** (Gernez et al. 2017) based on Gons et al. (2005) algorithm (a_{phy}(675))

R_{rs}(NIR) → b_b(NIR) → a_{phy}(665) → Chla



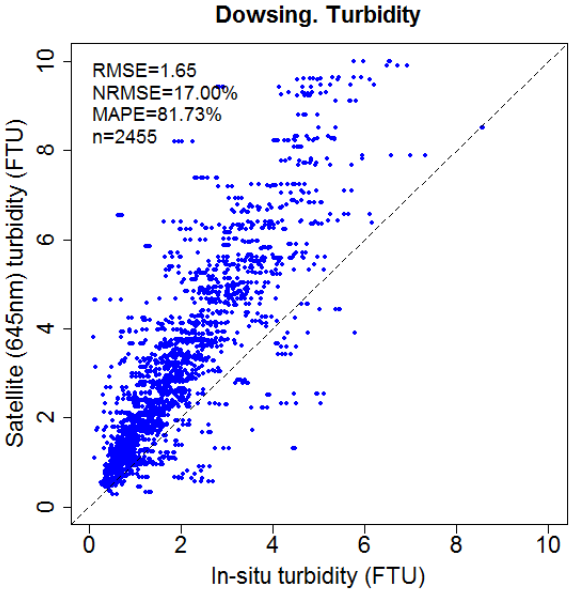
2016-03-18 (high tide) 2016-04-07 (low tide) 2016-04-27 (ebb)

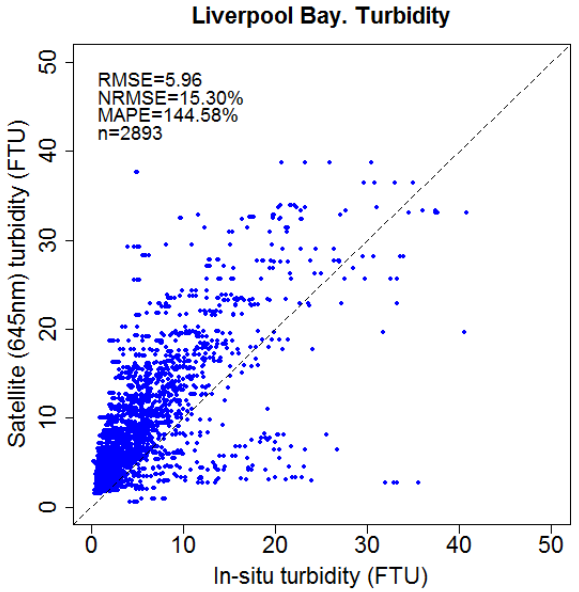
Ongoing validation exercise…

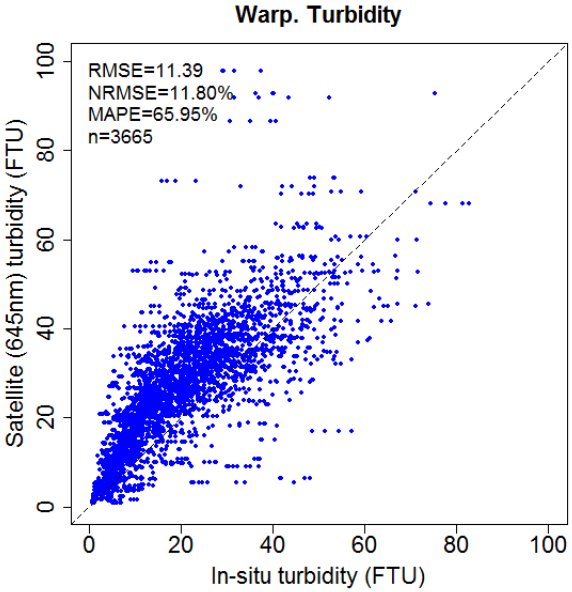
Results: TUR retrieval (S3plus)

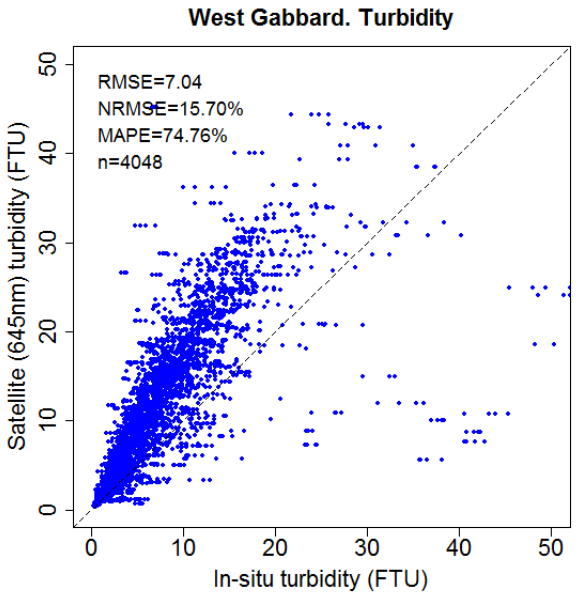
In the SNS, numerous TUR match-ups (here 1×1) with Smartbuoys data

…some remaining calibration issues?





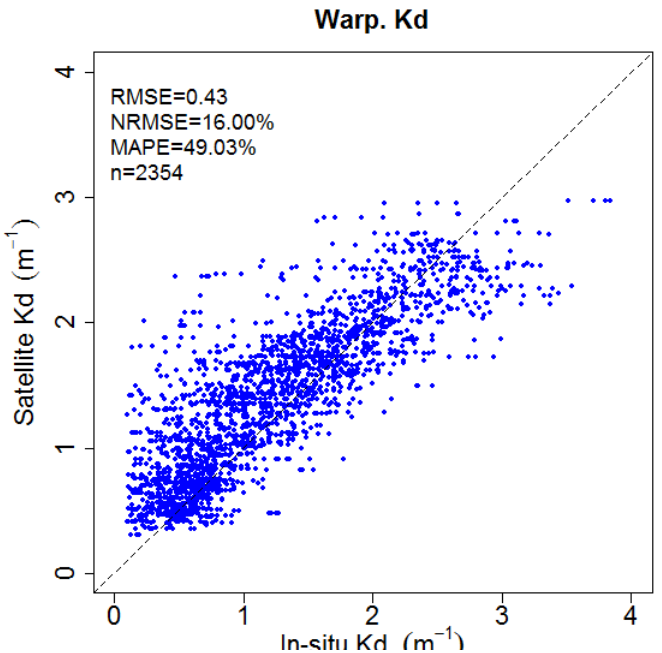


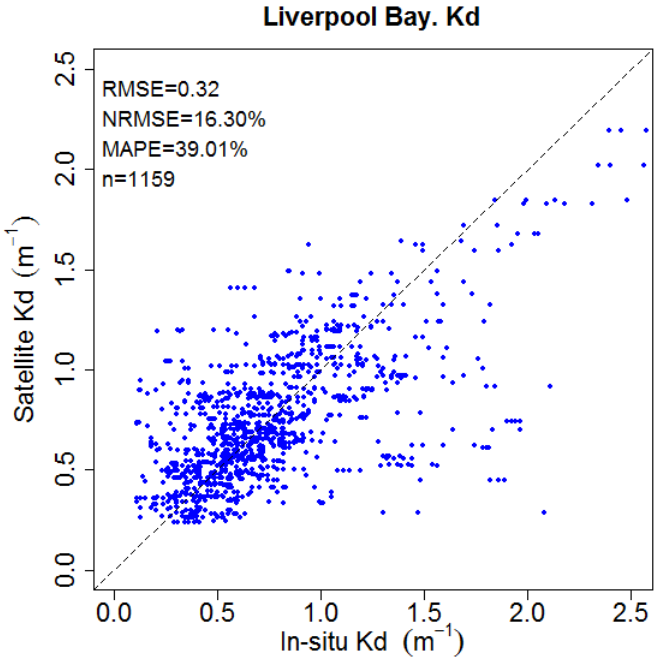


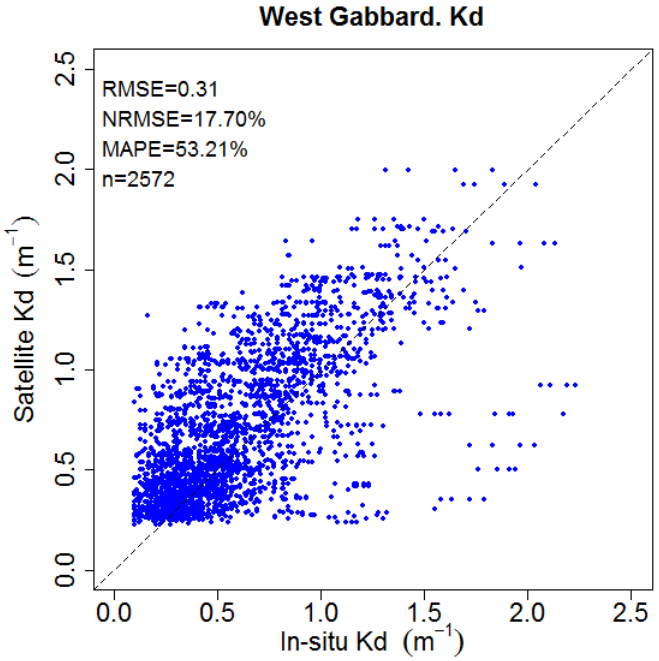
Results: Kd retrieval (S3plus)

In the SNS, numerous K_d match-ups (here 1×1) with Smartbuoys data

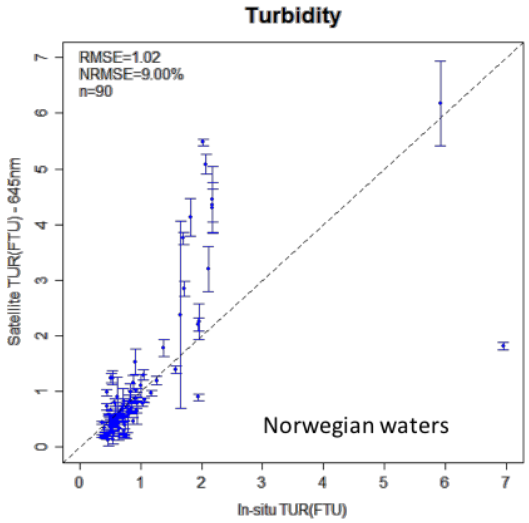
…and satisfactory results

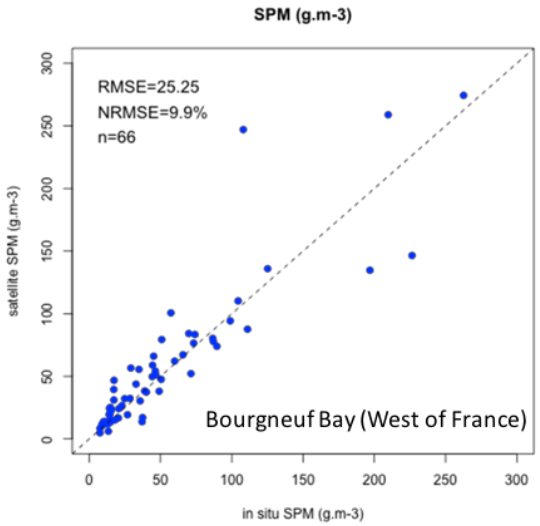


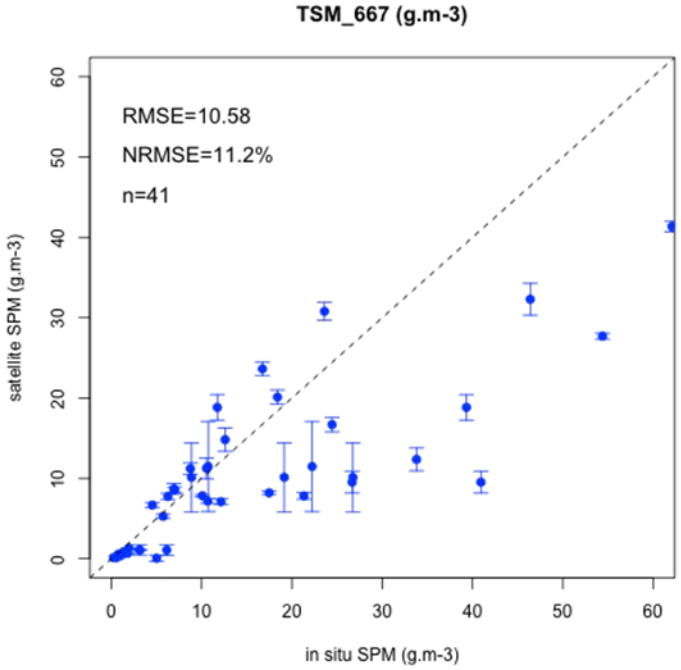


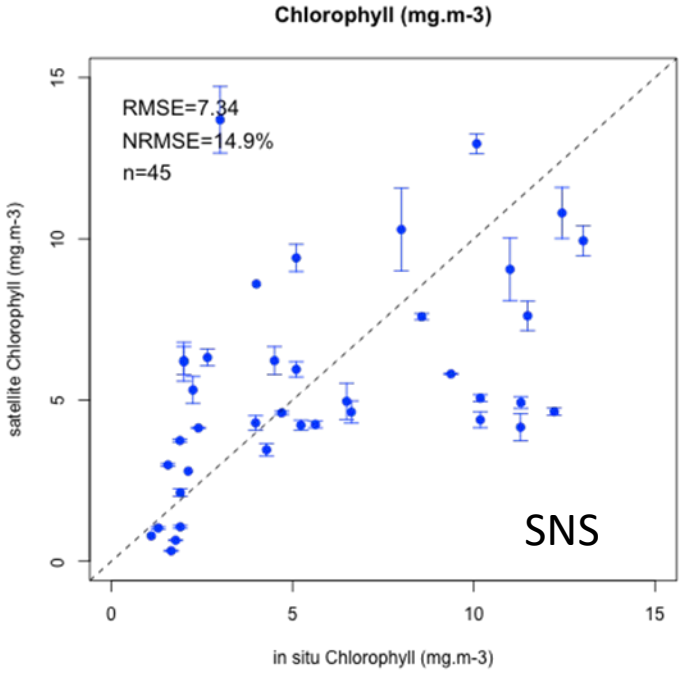


Results: TUR, SPM and Cha retrievals (S3plus)



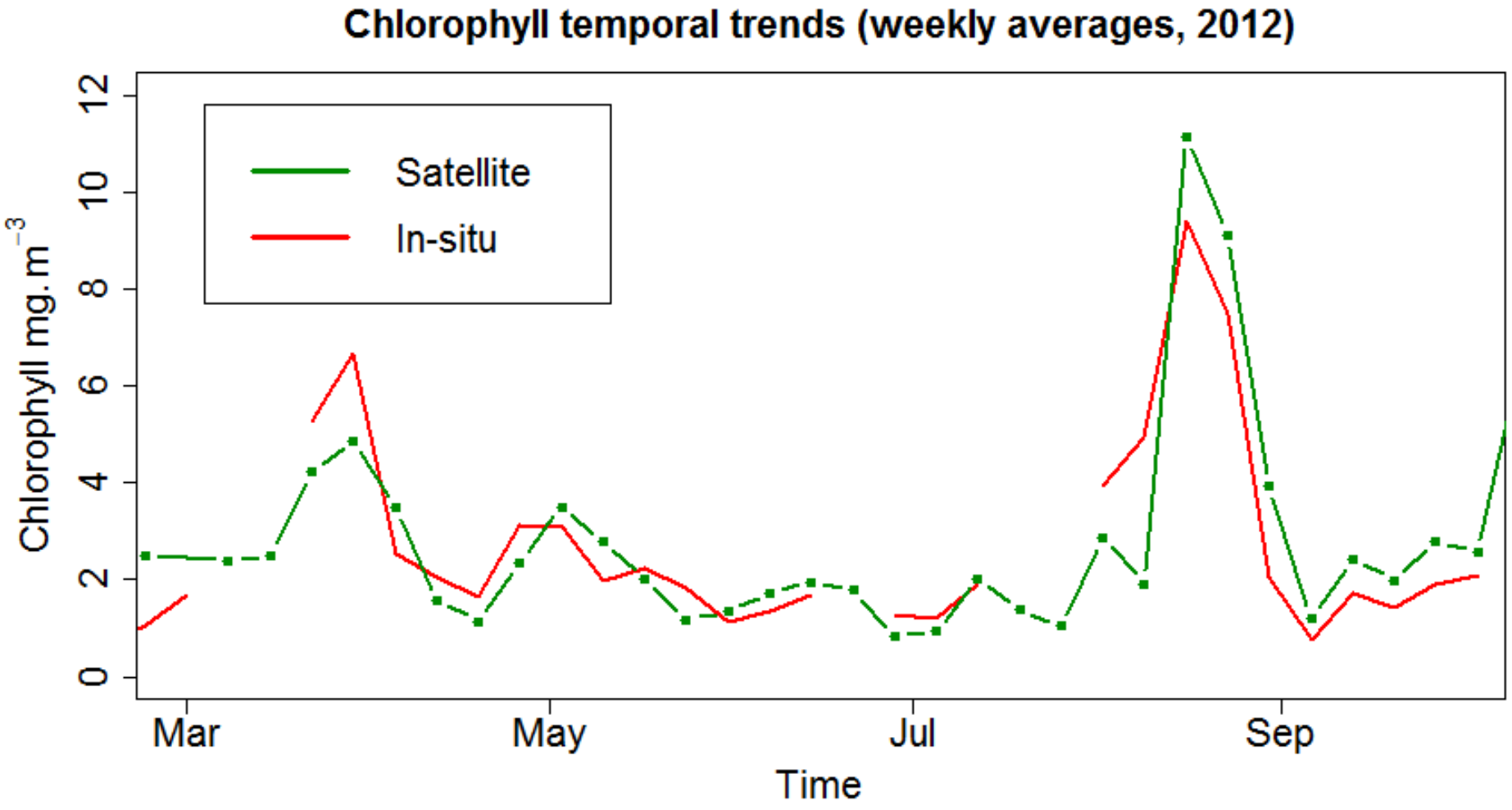




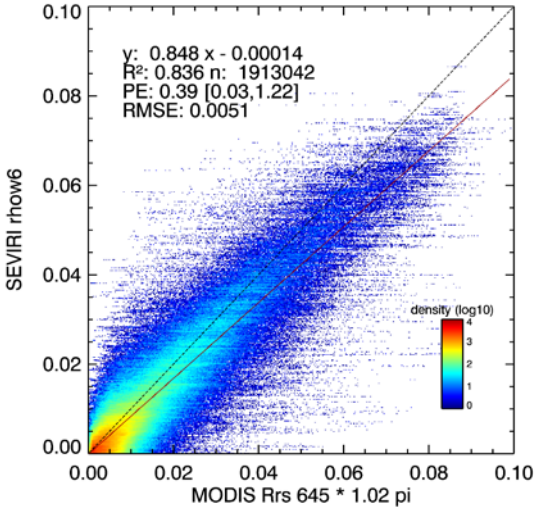


➔ Match-ups between S3plus satellite products (TUR, SPM, Chla) and shipborne measurements reveal typical differences (NRMSE) lower than 15%

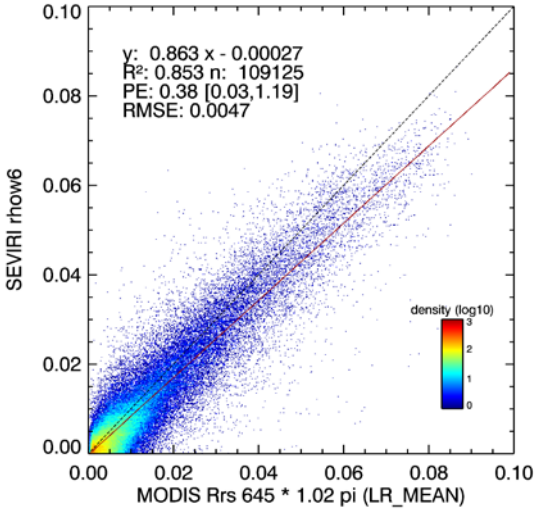
Results: Chla retrieval (S3plus)



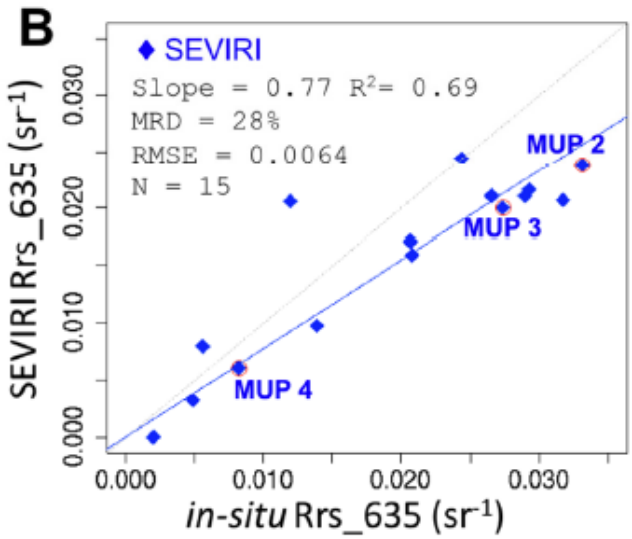
Results (GEO)



LR SEVIRI (SNS)
HR MODIS



LR SEVIRI (SNS)
LR MODIS (avg HR)



SEVIRI vs in situ
Rhône River plume

Vanhellemont et al. (2013)

Ody et al. (2016)

Conclusions / Perspectives

- Significant efforts made to develop multi-sensor OC algorithms to remote sense L2R (nLw, Rrs) and L2W (TUR, SPM, Chla, Kd) products at high spatial and temporal resolutions

- A large database with many quality match-ups was established to quantify the uncertainties associated to OC satellite products in coastal waters: 10-25% (NRMSE) for L2R and L2W

- Issues remain concerning the accurate remote sensing retrieval of Chla concentrations in turbid coastal waters

- Validation of high spatial (S2-MSI) remotely-sensed Chla concentrations in turbid waters

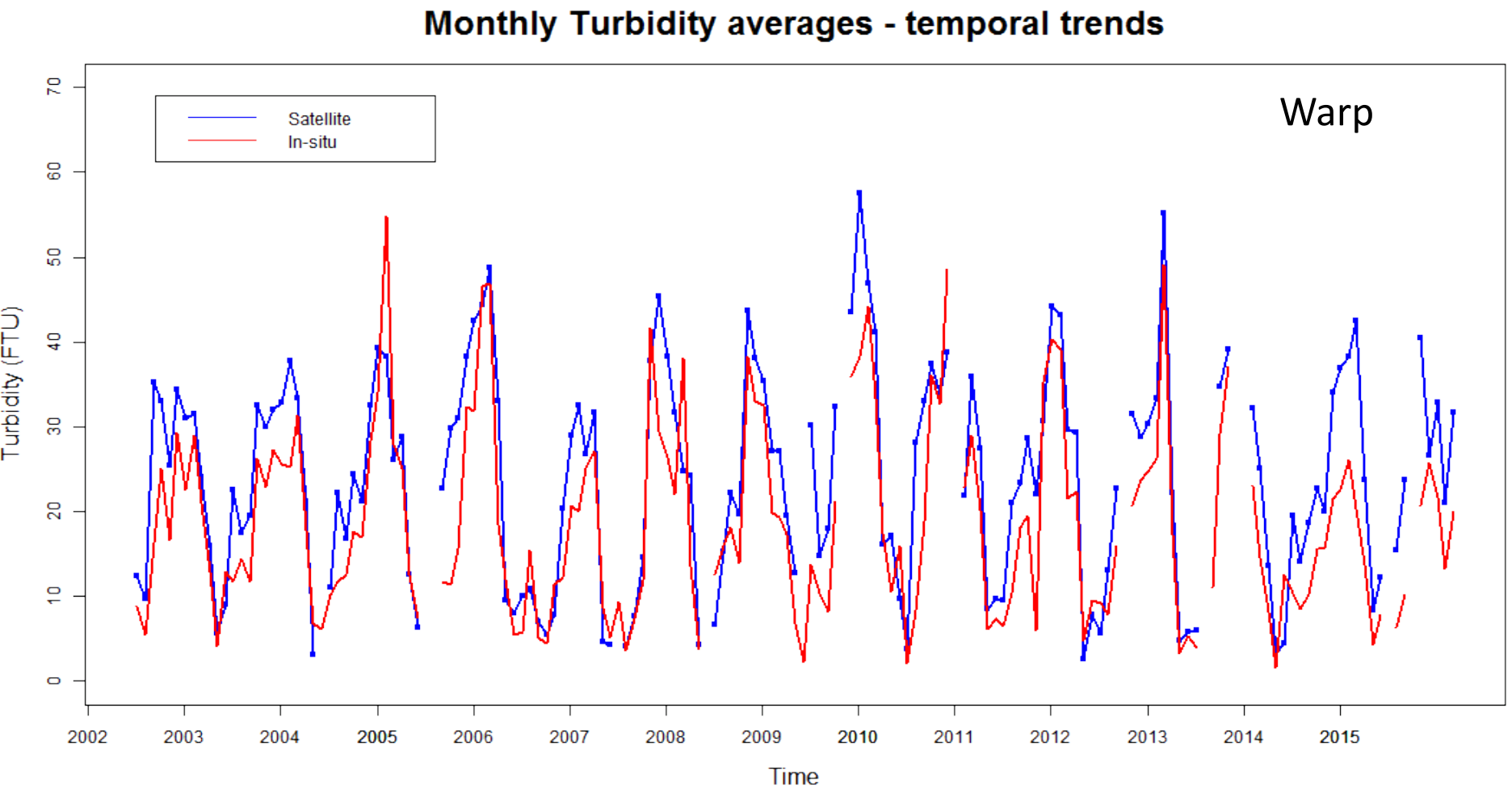
- Validation of VIIRS and OLCI (S3plus) satellite products

- High spatial and temporal remote sensing of OC products opens new perspectives for the monitoring of coastal waters

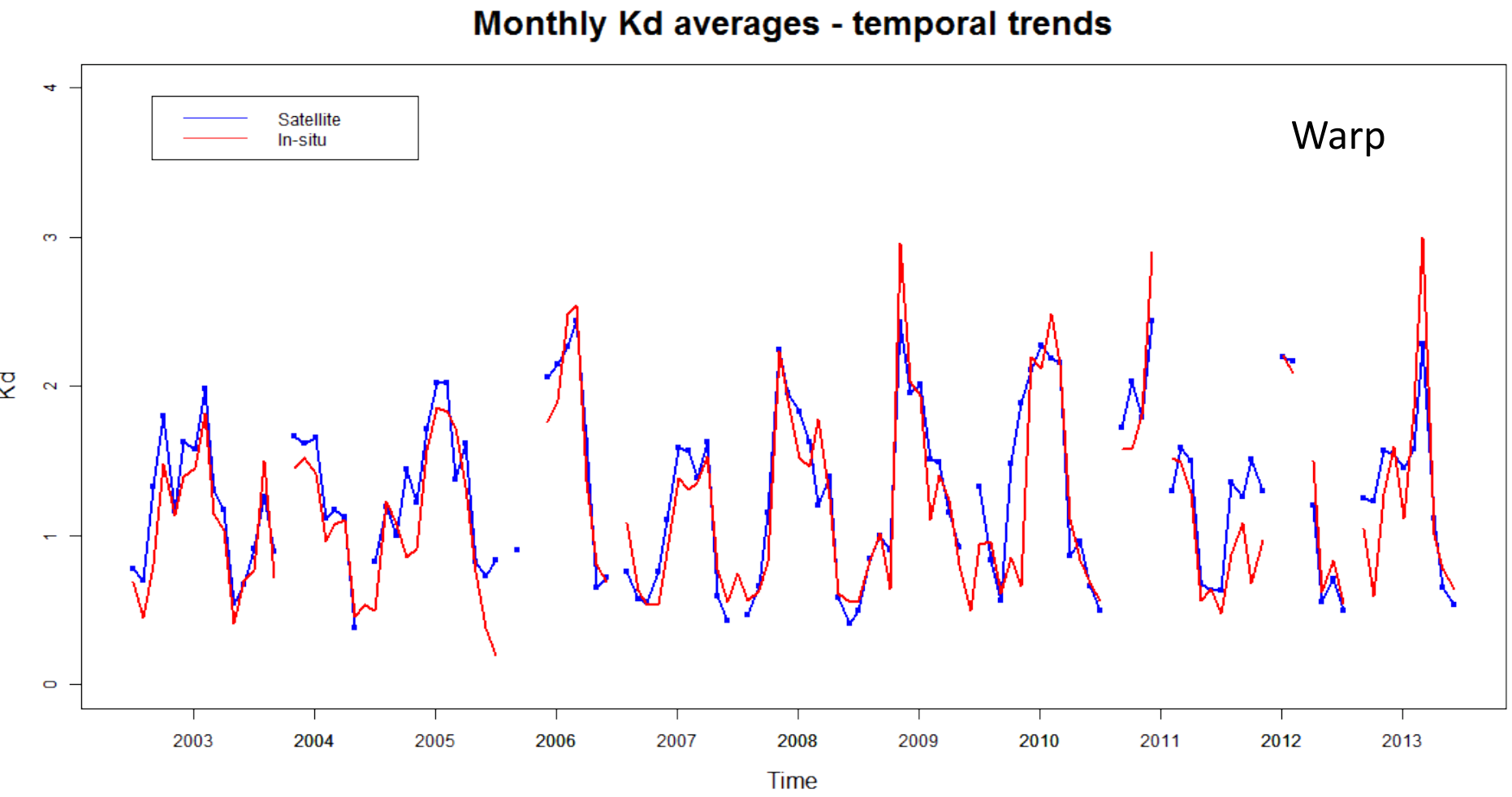
Selected publications

- Novoa S., Doxaran D., Ody A., Vanhellemont Q., Lafon V., Lubac B. and P. Gernez (2017). **Atmospheric Corrections and Multi-Conditional Algorithm for Multi-Sensor Remote Sensing of Suspended Particulate Matter in Low-to-High Turbidity Levels Coastal Waters.** Remote sensing, 9, 61.
- Gernez P., Doxaran D. and L. Barillé (2017). **Shellfish aquaculture from space: potential of Sentinel2 to monitor tide-driven changes in turbidity, chlorophyll concentration and oyster physiological response at the scale of an oyster farm.** Frontiers in Marine Science, in press.
- Baeye M., R. Quinn, S. Deleu, M. Fettweis, (2016). **Detection of shipwrecks in ocean colour satellite imagery.** Journal of Archaeological Science, 66, 1–6.
- Doxaran D. & Leymarie E. & Nechad B. & Dogliotti A.-I. & Ruddick K. & Gernez P. & Knaeps E. (2016**). Improved correction methods for field measurements of particulate light backscattering in turbid waters.** Optics Express, 24(4), 3615–3637.
- Kwiatkowska E. & Ruddick K. & Ramon D. & Vanhellemont Q. & Brockmann C. & Lebreton C. & Bonekamp H. (2016). **Ocean colour opportunities from Meteosat Second and Third Generation geostationary platforms** . Ocean Science, 12, 703–713.
- Ody A., Doxaran D., Vanhellemont Q., Nehad B., Novoa S., Many G., Bourrin F., Verney R., Pairaud I. et B. Gentili (2016). **Potential of High Spatial and Temporal Ocean Color Satellite Data to Study the Dynamics of Suspended Particles in a Micro-Tidal River Plume.** Remote Sens. 2016, 8(3), 245-279.
- Capuzzo, E., Stephens, D., Silva, T., Barry, J., & Forster, R. M. (2015). **Decrease in water clarity of the southern and central North Sea during the 20th century.** Global change biology, 21(6), 2206-2214.
- Vanhellemont Q. & Ruddick K. (2015). **Advantages of high quality SWIR bands for ocean colour processing: Examples from Landsat-8**. Remote Sensing of Environment, 161,89–106.
- Ruddick K., Brockmann C., De Keukelaere L., Doxaran D., Knaeps E., Forster R., Jaccard P., Lebreton C., Ledang A.-B., Nechad B., Norli M., Sorensen K., Stelzer K., Vanhellemont Q. & Van der Zande D. (2014). Processing and exploitation of Sentinel-2 data for coastal water applications: The HIGHROC Project . In: Proceedings of the Sentinel-2 for Science Workshop held in Frascati, Italy, 20-23 May 2014, ESA SP-726.

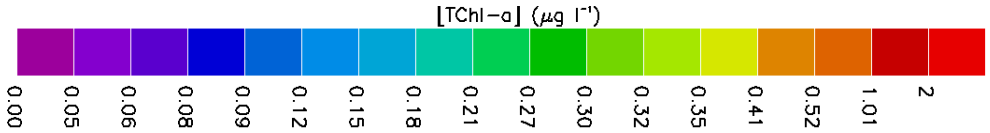
Extra slides

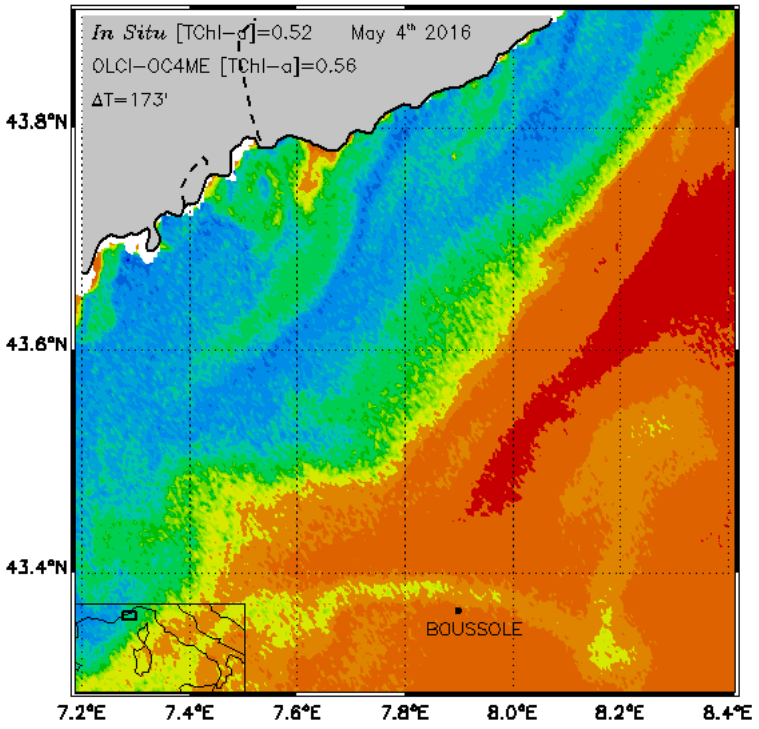


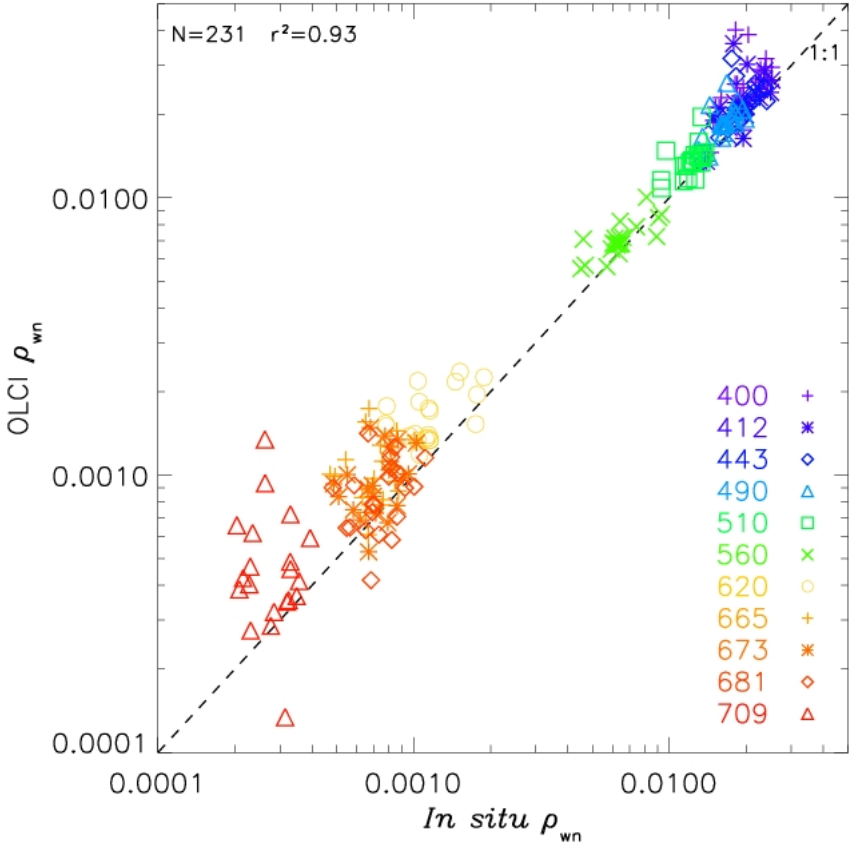
Extra slides



Extra slide: BOUSSOLE

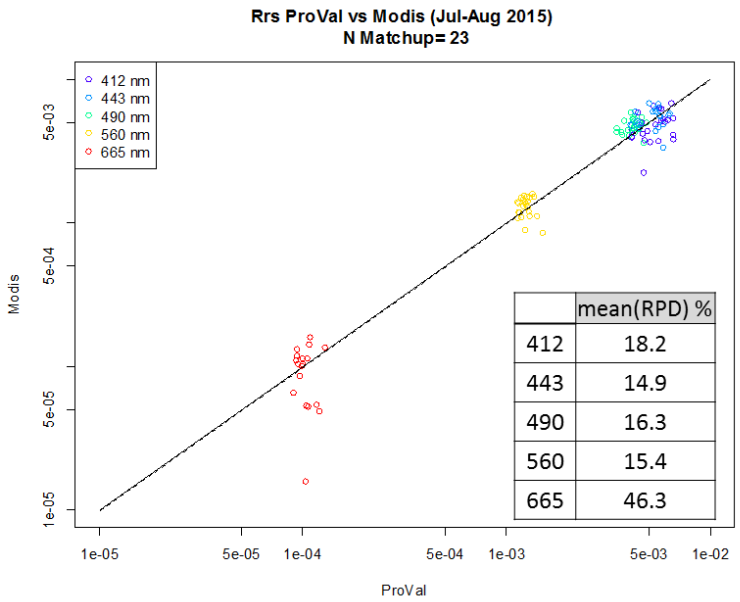


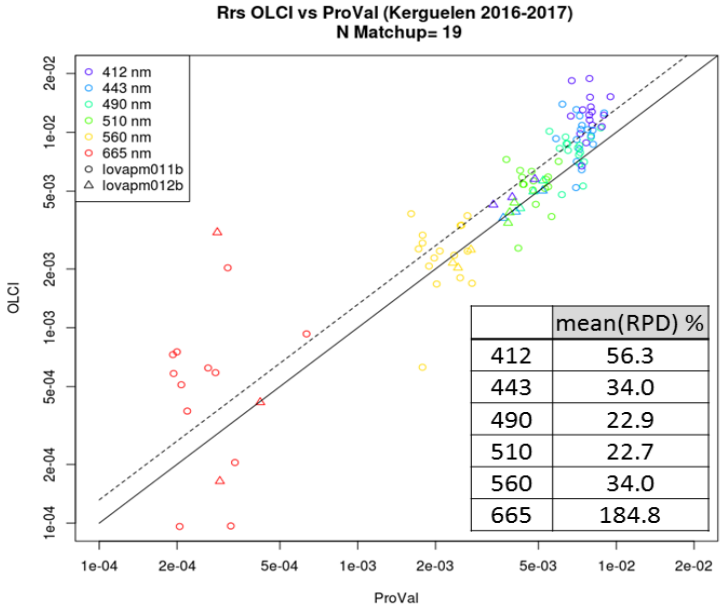




ProVal

An Argo float dedicated to the validation of ocean color data





- CTD
- 2 sensors E_d-L_u

E_d : 380, 412, 443, 490, 510, 560, 665 nm + PAR

Lu : 380, 412, 443, 490, 510, 560, 665 nm

- Tilt and compass sensors
- Chla, backscattering, CDOM