PROBA4COAST - Coastal Turbidity Derived From The PROBA-V Global Vegetation Satellite

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RESEARCH QUESTION AND USER NEEDS

» Can we use Proba-V, a global vegetation mission, for Turbidity/SPM monitoring in coastal areas?
» Is there a need to develop a dedicated marine atmospheric correction?
» How do results compare with MODIS turbidity and can we combine both?
» How do results compare with turbidity derived from modelling and can we use Proba-V for cal/val of the model?

Turbidity =
optical property (ISO, 1999: 90° side-scattering of light at 860 nm with respect to Formazin)

Suspended Particulate Matter (SPM) =
mass concentration
Overall atmospheric correction workflow

Development of iCOR for Proba-V

De Keukelaere et al., 2018
SWIR-based AOT

PROBA-V Projected TOA data

- Calculate Rayleigh corrected reflectance
- Select clear water pixels
- Calculate median $\alpha$(NIR,SWIR) over clear water pixels
- Select aerosol model
- For all water pixels: select AOT for which $p_w$(SWIR)=0

AOT for each water pixel

Cloud mask & Land/water mask

MODTRAN LUT

MODTRAN LUT

https://earth.esa.int/web/sppa/activities/instrument-characterization-studies/pv-lac-coast
TSM/TURBIDITY ALGORITHM

TSM = $A^\rho \frac{R_w(\lambda)}{1 - \frac{R_w(\lambda)}{C^\rho}}$ (Nechad et al., 2010)

Global turbidity algorithm and regional T/TSM calibration (Dogliotti et al., 2015)
Comparision with AERONET stations:

- Zeebrugge MOW1 (51.362° N; 3.120° E)
- Thornton_Cpower (51.533° N; 2.955° E)
VALIDATION - WATER LEAVING REFLECTANCE

SWIR-based

BLUE

RED

NIR

\[ y = 0.9129x + 0.0026 \]
\[ R^2 = 0.7808 \]

\[ y = 1.0227x + 0.0054 \]
\[ R^2 = 0.8519 \]

\[ y = 1.4788x + 0.0052 \]
\[ R^2 = 0.2502 \]
CEFAS Smartbuoys

- Autonomous systems
- Turbidity typically collected every 30 minutes at 1m depth
- Data is freely available
TURBIDITY VALIDATION

Y-error bars: std of Proba-V derived turbidity within 1kmx1km around Smartbuoy location

X-error bar: std of buoy turbidity measurements performed within 1 hour of the PROBA-V acquisition

May-2014 till Dec 2016
Proba-V 100m

Scatterplot Proba-V vs buoy turbidity
3 Regions of about 400km². Expected:
- Outlet Thames & Scheldt → Large fluctuations driven by river dynamics
- Middle North Sea → Lower concentrations
TSM SCATTERPLOTS

Thames

\[ Y = -7.39 + 1.36 X \]
\[ R^2 = 0.84 \]

Middle

\[ Y = 1.24 + 0.69 X \]
\[ R^2 = 0.59 \]

Scheldt

\[ Y = -1.09 + 1.19 X \]
\[ R^2 = 0.70 \]
TSM TIME-SERIES ANALYSIS
TSM TIME-SERIES ANALYSIS

Thames

MODIS

PROBA-V

TSM (mg/L)

2016

2017

0 20 40 60 80 100

Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr May

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TSM TIME-SERIES ANALYSIS
TSM TIME- SERIES ANALYSIS

Middle

MODIS
PROBA-V

TSM (mg/L)

2016

2017
TSM TIME-SERIES ANALYSIS
TSM TIME-SERIES ANALYSIS

MODIS
PROBA-V

Scheldt
TURBIDITY / TOTAL SUSPENDED MATTER - CONCLUSIONS

» Turbidity shows good correlation with CEFAS turbidity buoys
   \( R^2 = 0.73; \) Slope = 0.81; Offset = 2 mg/L

» Proba-V and MODIS show good agreement
   » Similar patterns in the water
   » Time series comparable
   » Good regression coefficients
     \( R^2 = 0.59 - 0.7; \) Slope = 0.69 - 1.36; Offset = -7 - 1.24 mg/L
TELEMAC-MASCARET

» Telemac-2D: two-dimensional flows
  → Flow velocities + water level
» Tomawac: wave propagation
  → Wave energy + characteristics (wave height, direction, period)
» Sisyphe: morphodynamics and sediment transport
  → Depth-averaged sediment concentrations + sediment fluxes + bed evolution

Conversion to surface concentrations!

Modification of reference height, settling velocity

Calibration period = April 2015
Validation period = March to July 2016

Remote sensing image - cropped based on modelling area (mg/L)

Simulated SPM concentration map (mg/L)

Image 5: 14/03/2016 12:10:00
Visual comparison (3)

Remote sensing image - cropped based on modelling area (mg/L)

Simulated SPM concentration map (mg/L)

Image 9: 03/04/2016 11:20:00
Visual comparison (5)

Remote sensing image - cropped based on modelling area (mg/L)

Simulated SPM concentration map (mg/L)

Image 13: 12/04/2016 11:20:00
Median TSM concentration over the window of Zeebrugge for the remote sensing data (red) and the modelling results (blue).

Median TSM concentration offshore (4) for the remote sensing data (red) and the modelling results (blue).
The pragmatic approach to convert depth averaged to surface concentration for SPM seems to work well in a first approach.

SPM concentrations retrieved from remote sensing are very valuable for model calibration. This will undoubtedly lead to improvements in model process formulations.
THANK YOU!