living planet symposium | BONN 23–27 May 2022

TAKING THE PULSE OF OUR PLANET FROM SPACE

Spatio-temporal data fusion of Sentinel-2 and Sentinel-3 ocean color products using a hybrid reconstruction-based and learning-based approach

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1. i-Sea 2. Telespazio France 3. CoLAB +ATLANTIC

23/05/2022

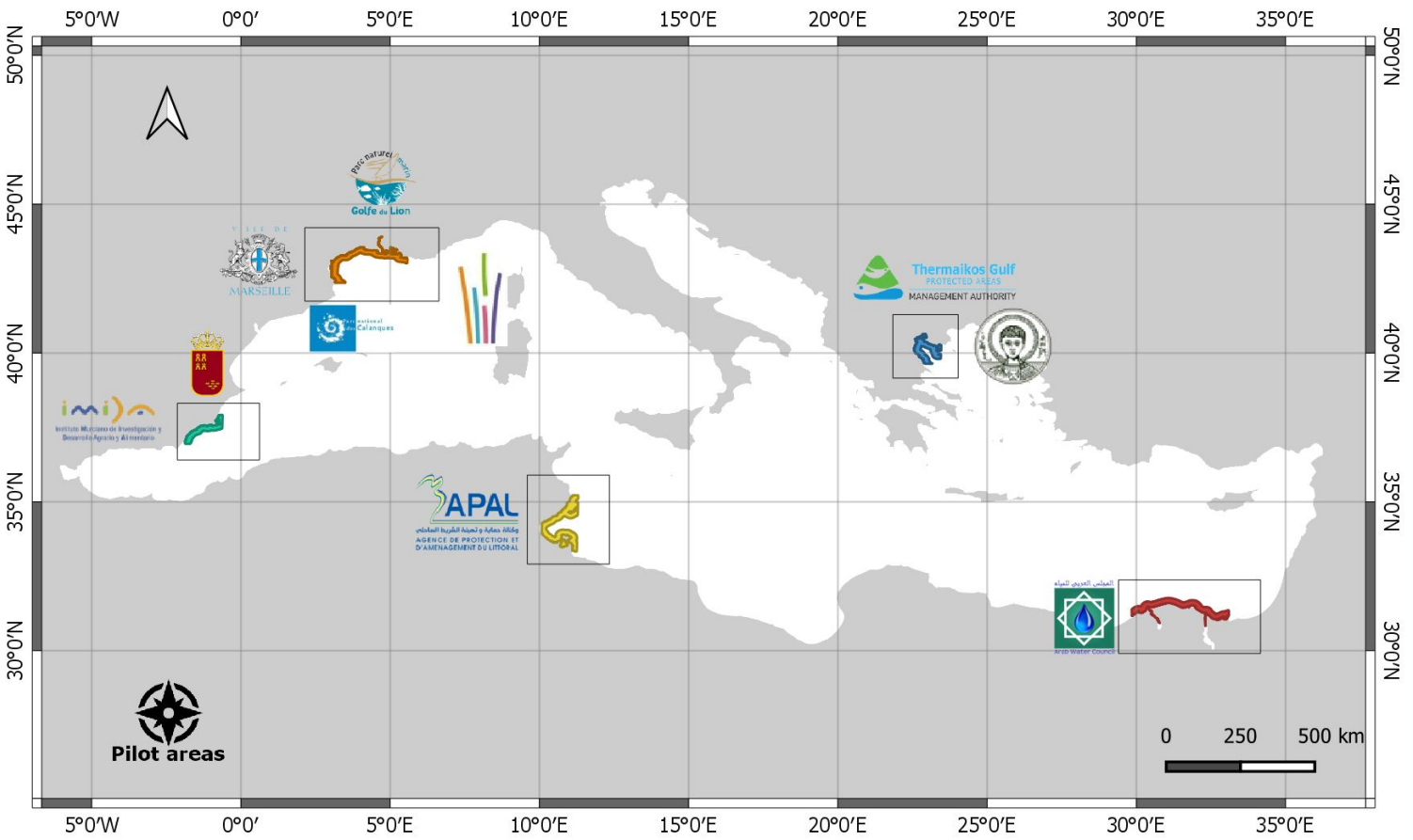
Context of the project

MEDITERRANEAN Regional Initiative

LAND-BASED POLLUTION ASSESSMENT & MONITORING IN THE MEDITERRANEAN COASTAL WATERS

Main objective

Develop and produce **daily high-resolution**, **gap-free** maps of EO **water quality** products by using **data fusion** techniques to combine the high temporal resolution of **S3-OLCI** and high spatial resolution of **S2-MSI** data



https://medeos.deimos.pt/

MedEOS is a project funded by ESA Mediterranean Regional Initiative within Future-EO - Science for Society programme (2020-2022), under the Grant Reference: AO/1-10376/20/I-EF

European Space Agency

Context of the project

TELESPAZIO
a LEONARDO and THALES company

S2/S3 EO direct products

- Total Suspended Matter (TSM)
- Turbidity (TUR)
- Chl-a Concentration (CHL)
- Secchi Depth (ZSD)
- Colored Dissolved Organic Matter (DOM)

i-Sea

S2/S3 spatio-temporal data fusion

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suez

EO indirect products

- Fecal bacterial contamination indicators
- Eutrophication indicators
- Harmful Algal Blooms
- Global environmental anomaly detection

- River plume monitoring

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esa European Space Agency

Spatio-temporal data fusion reconstruction-based approach

T0 : Fine Resolution (T0 fine) & Coarse Resolution (T0 coarse) images acquired on the same day

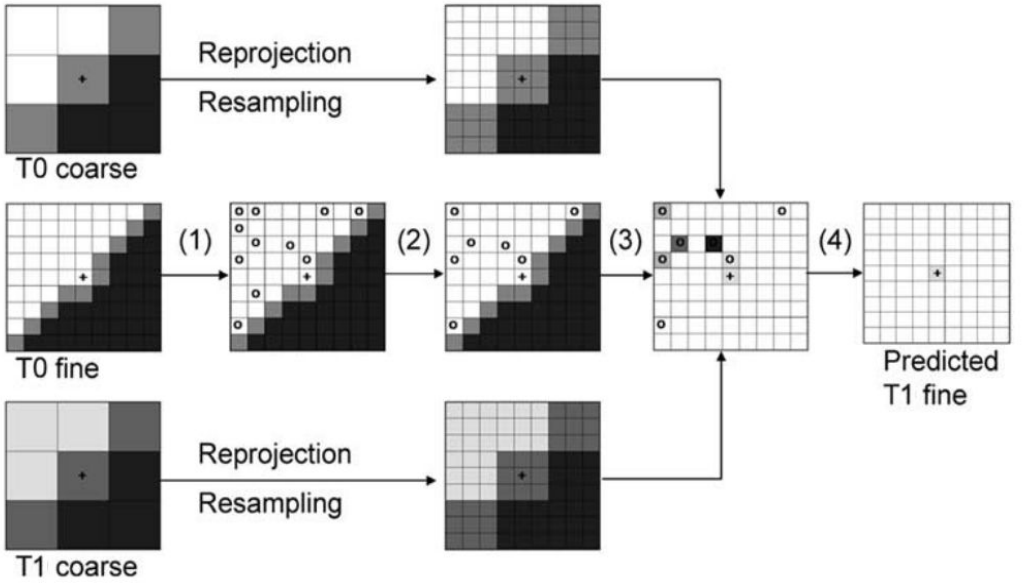
T1 : Only Coarse Resolution images acquired (T1 coarse)

STARFM decision rules

T1 fine pixels predicted with a weighted set of decision rules based on:

- spectral difference between S2 and S3
- temporal difference between S3 T0 and S3 T1
- distance between central pixel and candidate pixel

STARFM



Source: On the Blending of the Landsat and MODIS Surface Reflectance: Predicting Daily Landsat Surface Reflectance, Gao et al. 2006

Main hypothesis
Objects do NOT drastically change between T0 and T1

Spatio-temporal data fusion reconstruction-based approach

Spatio-temporal data fusion reconstruction-based approach

Spatio-temporal data fusion for ocean color

Main challenges

Highly dynamic environment

Lower reflectance values on water

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Higher sensitivity to atmospheric correction, BRDF, sunglint, noise

Differences between S2 and S3 spectral bands

Target high resolution (20m)
<<<
Input coarse resolution (300m)

STARFM decision rules

T1 fine pixels predicted with a weighted set of decision rules based on:

- spectral difference between S2 and S3
- temporal difference between S3 T0 and S3 T1
- distance between central pixel and candidate pixel

Data fusion performed on EO direct products to limit the impact of differences in water surface reflectance between S2 and S3

How can we trick data fusion reconstruction based approach to work in highly dynamic ocean environment ?

Spatio-temporal data fusion for ocean color - database building

Data selection recursive process

Large time-series of S2/S3 EO direct product dataset

↓

Extraction of S3 patches

↓

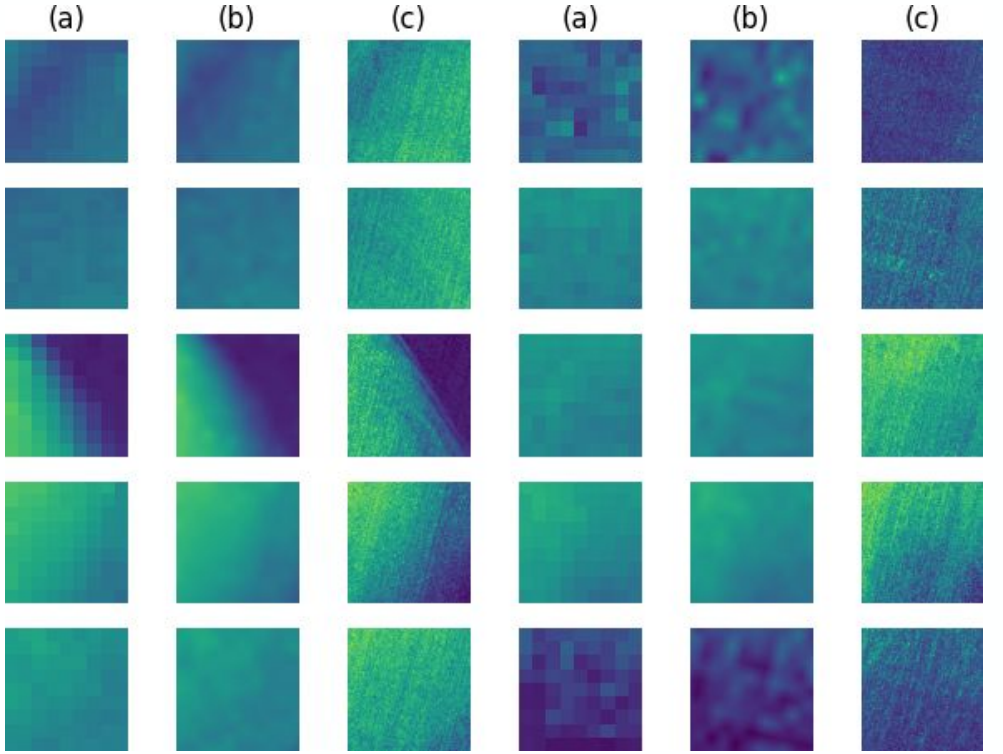
for each S3 patch,

- compute statistical distance with all S3 patch in database
- if distance > adaptive threshold, patch included in database with its corresponding S2 patch
- else, patch discarded

↓

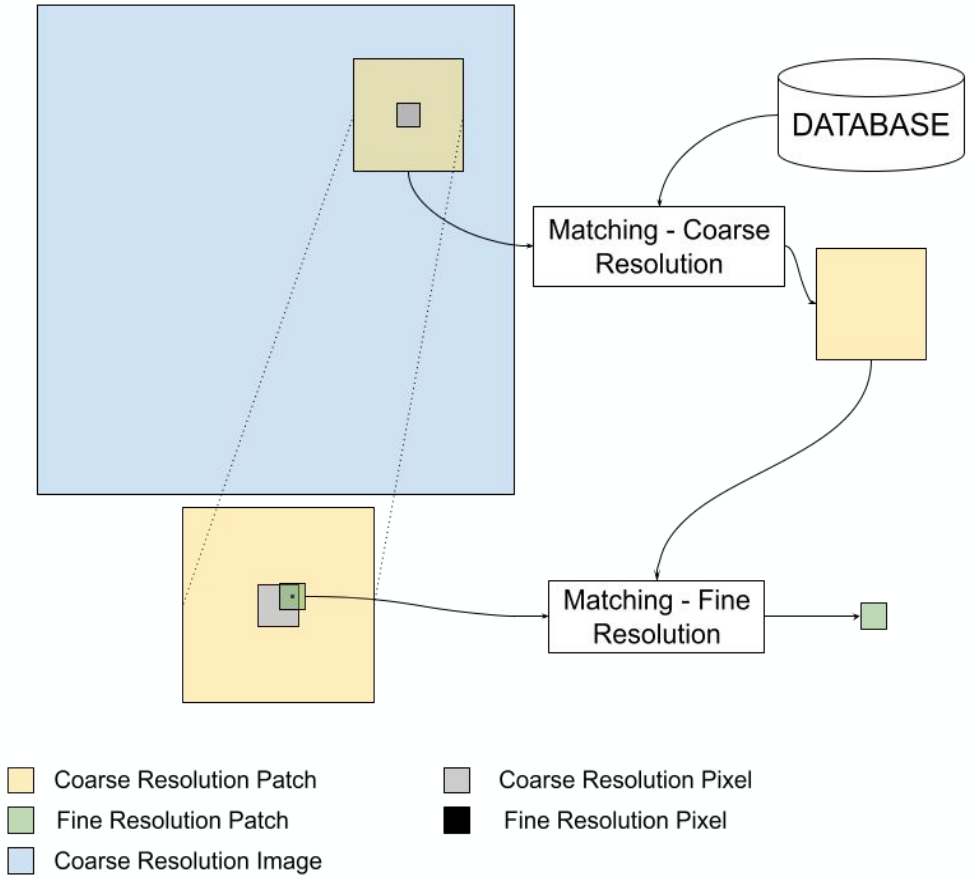
Correction of bias S2 vs S3

pairs of S2/S3 reference database



Extract of the reference database built from pairs of S2 and S3 products. (a) S3 patches coarse resolution, (b) S3 patches fine resolution, (c) S2 patch the same day as S3 product.

Spatio-temporal data fusion for ocean color - matching analysis



Coarse and fine matching analysis

S3 product on targeted day T1

for each patch around pixels of S3 T1 product

- find S3 patch with most similar statistical content in reference database at coarse resolution →**Coarse matching analysis**

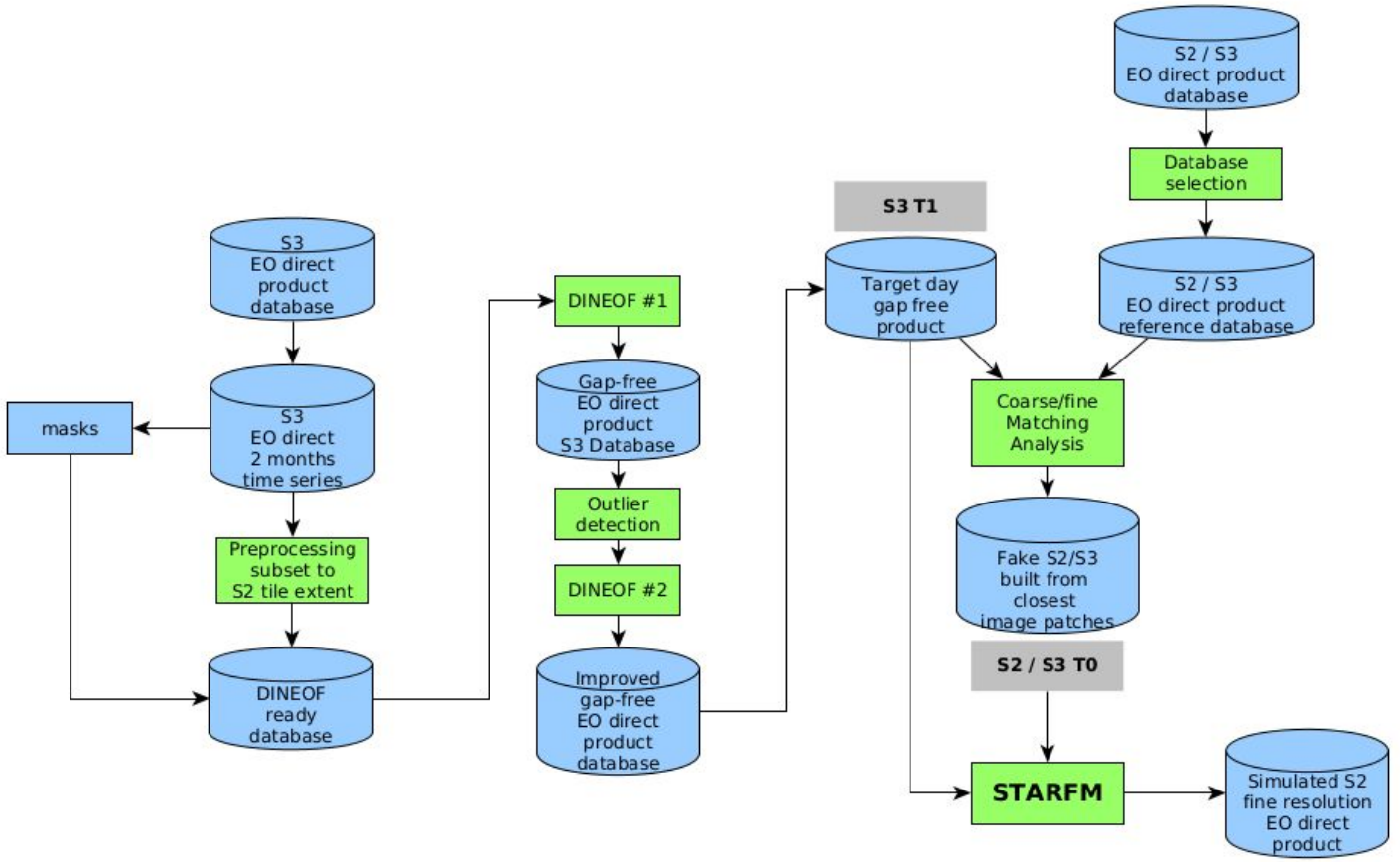
→ “S3 T0”

- New database is build from all patches derived from S3 patch ‘coarse resolution’ resampled at fine resolution
- find S3 patch with most similar statistical content in new database at fine resolution → **Fine matching analysis**

→ “S2 T0”

Triplets of “S3 T0”, “S2 T0” and S3 T1 → **STARFM**

Spatio-temporal data fusion for ocean color - proposed strategy



General workflow of the Gap-filling and Data Fusion processing chain

Main steps:

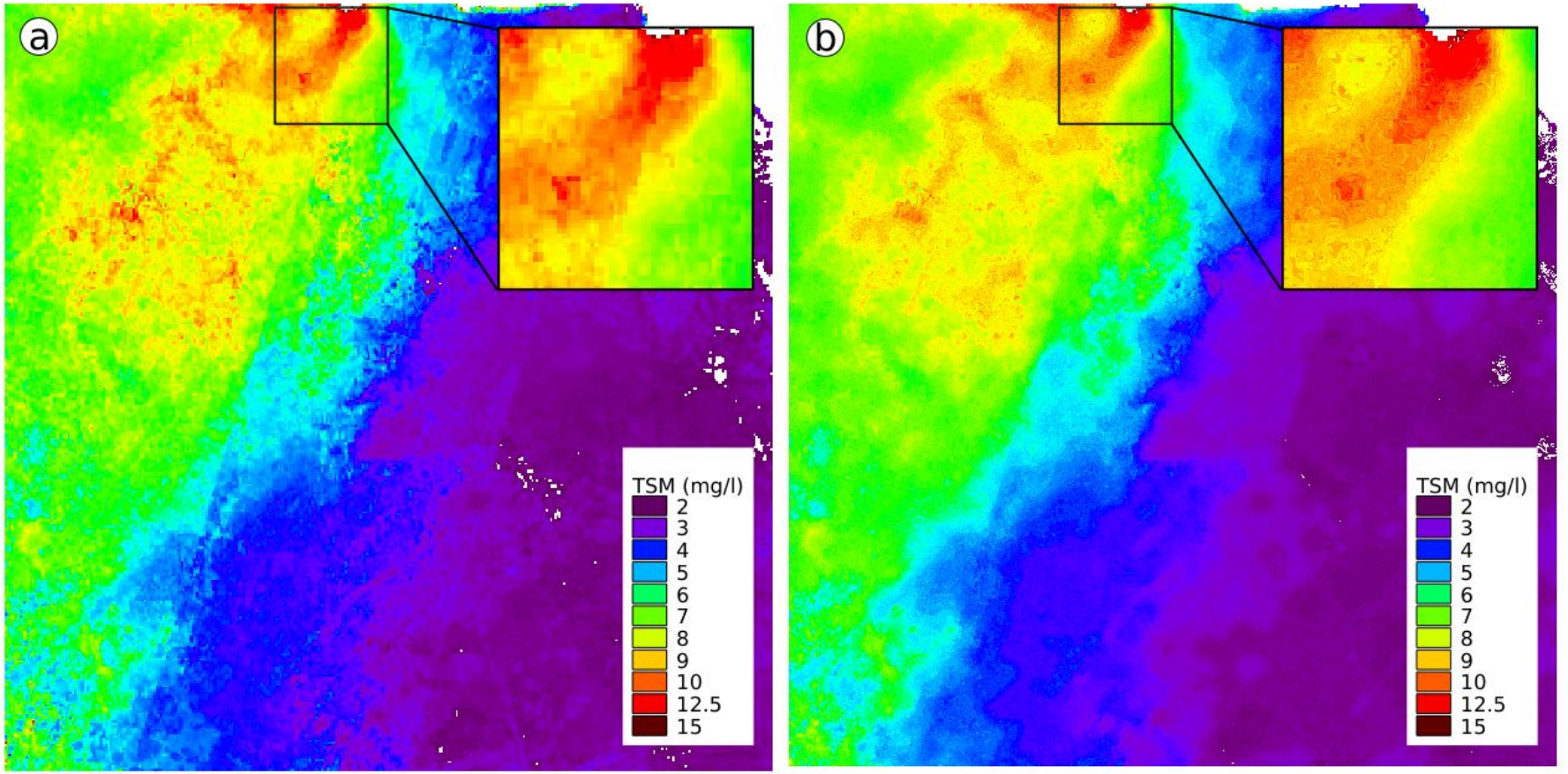
- **Gap-filling** (DINEOF) of S3 EO direct products with outlier detection

- **Data selection** on S2/S3 EO direct products dataset to build a reference database

- Coarse and fine **matching analysis** to derive artificial S2/S3 image pair

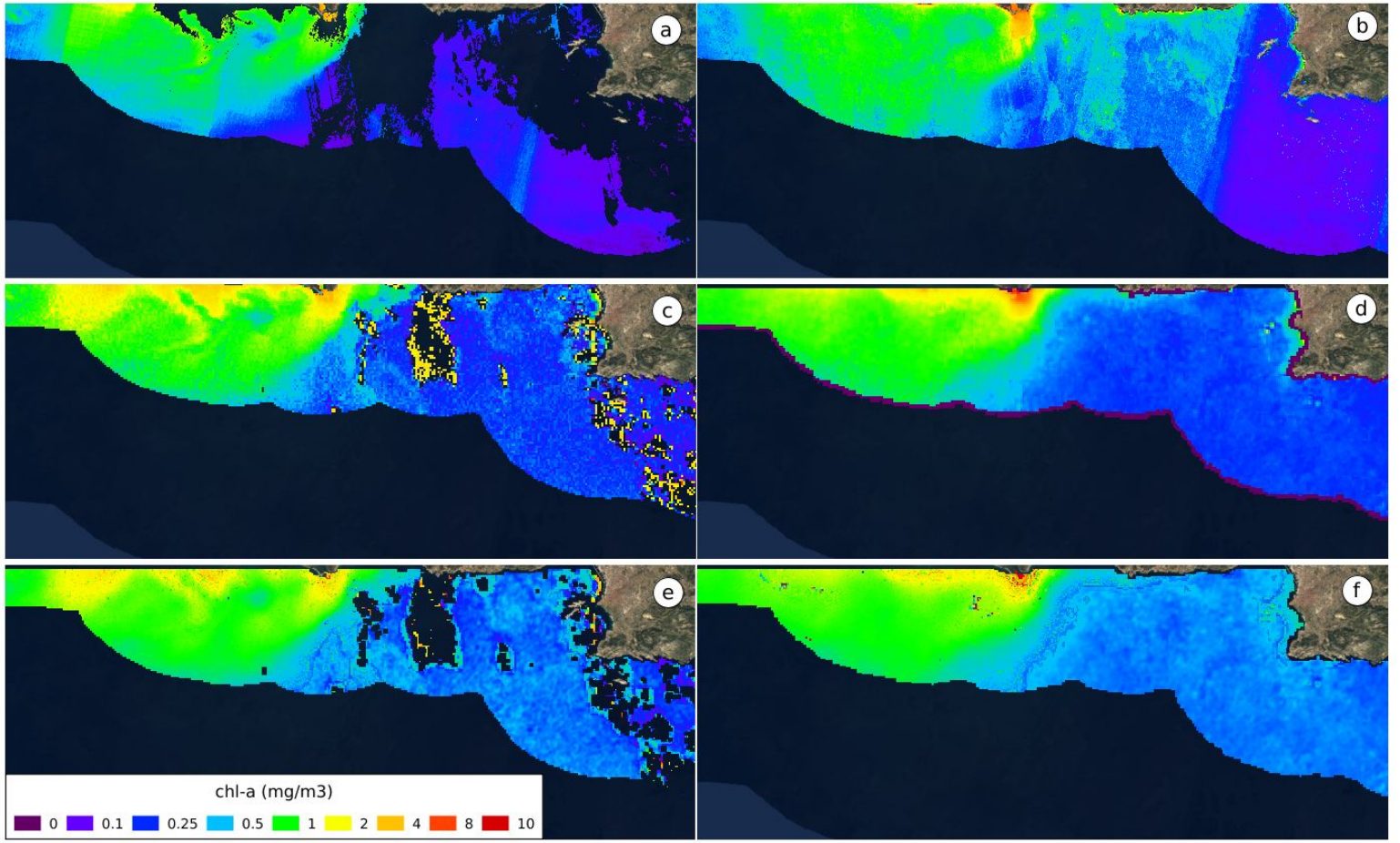
- **STARFM** to simulate S2 EO direct product at fine resolution

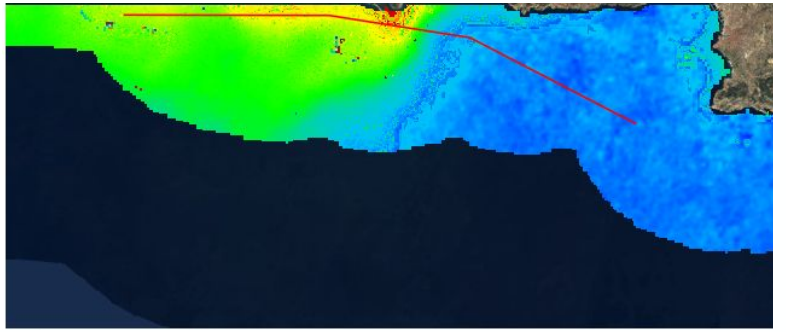
Spatio-temporal data fusion for ocean color - example of results



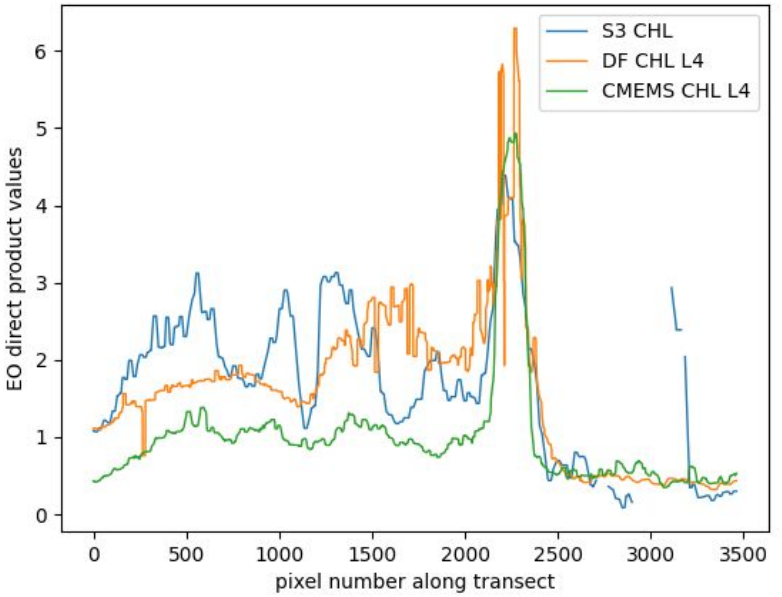
Example of preliminary results on TSM - (a) S3 derived TSM product after gap-filling at 300m, (b) TSM data fusion output at 20m

Spatio-temporal data fusion for ocean color - example of results





Comparison with CMEMS OCEANCOLOUR_MED_BGC_HR_L4_NRT_009_211



Visual comparison between (a) 100m CMEMS HR OC CHL L3, (b) 100m CMEMS HR OC CHL L4, (c) 300m S3 CHL, (d) 300m S3 CHL after DINEOF gap-filling, (e) 20m CHL product after data fusion without gap-filling, (f) 20m CHL product after data fusion with gap-filling.

Spatio-temporal data fusion for ocean color - conclusions and next steps

Conclusions

Spatio-temporal data fusion for water applications is **not straightforward**

More efficient to apply data fusion **at the product level** rather than at the reflectance level

Tricking data fusion state-of-the-art approaches with proposed database and matching analysis is working

Computation time is compatible with operational application

BUT

Artefacts are present and results are not fully realistic

Next steps

Production phase I - **ongoing**

Pre-validation - **ongoing**

MTR → July 2022 **Go** / **no Go**

Production Phase II - starting this summer

Larger scale validation with in-situ data

Refining of the output resolution

End-user's uptake

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Thank you for attention

MedEOS project - Land-based pollution assessment & monitoring in the Mediterranean coastal waters

E3.06.1 Mediterranean Regional Applications and Science

Wednesday 1:30 PM - room Nairobi 3-4

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