Calculation of super -resolution total suspended matter from Sentinel -2 and Sentinel -3 data: study of the dynamics in the North Sea.

Aida Alvera-Azcárate, Dimitry Van der Zande, Alexander Barth, Jean-Marie Beckers

LIÈGE université

museum
Operational Directorate Natural Environment
OD Nature I OD Natuur I DO Nature

27 May 2022

Multiscale analysis of Sentinel-2 and Sentinel-3 data

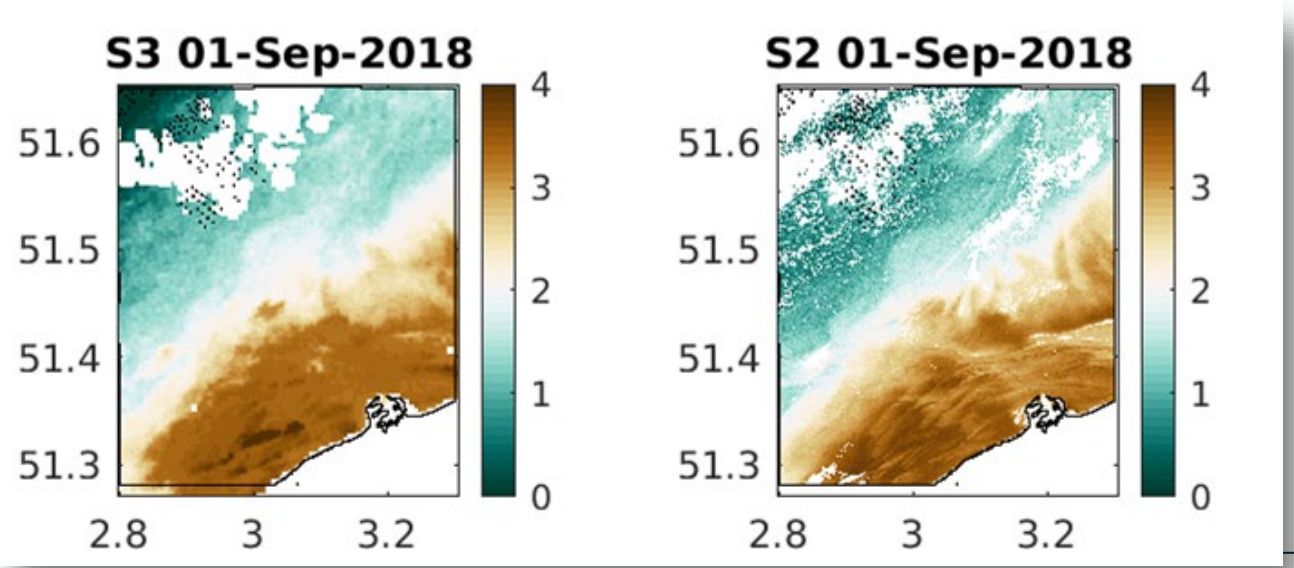
Sentinel-2 data have high spatial resolution (10 m) but 35 day temporal resolution

Sentinel-3 data have medium spatial resolution (300 m) and daily temporal resolution

Both are affected by the presence of clouds

They offer therefore a high degree of complementarity to be used jointly

- Identical atmospheric correction procedures and ocean colour algorithms used
- Shadows are a problem in Sentinel-2 data: removed using Alvera-Azcárate et al 2021 (RSE)

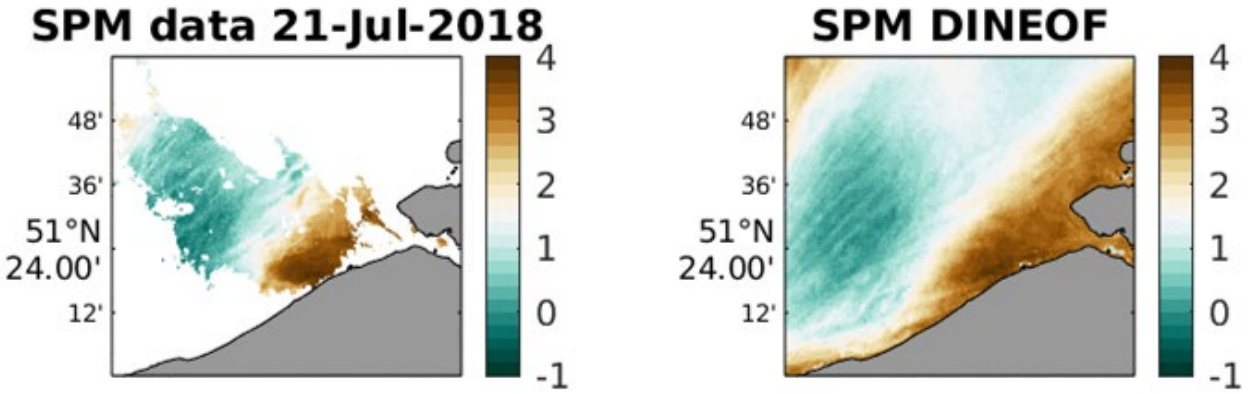


DINEOF (Data Interpolating Empirical Orthogonal Functions)

Technique to **fill in missing data** in geophysical data sets, based on a EOF decomposition

- **Truncated EOF basis** to calculate missing data (iterative method)
  - EOFs extract main patterns of variability
  - Reduced noise
- Optimal number of EOFs?: reconstruction error by cross-validation
- Uses EOF basis to infer missing data: **non-parametric**
- No need of a priori information (correlation length, covariance function...)
- Spatio-temporal coherence exploited to calculate missing values

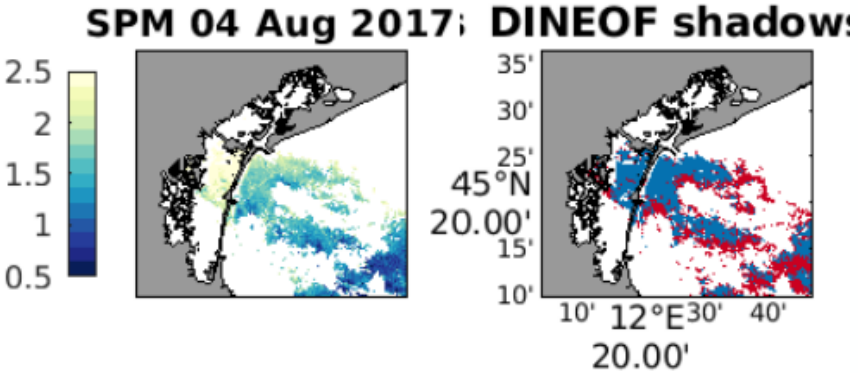
Beckers & Rixen (2003)
Alvera-Azcárate et al (2005)

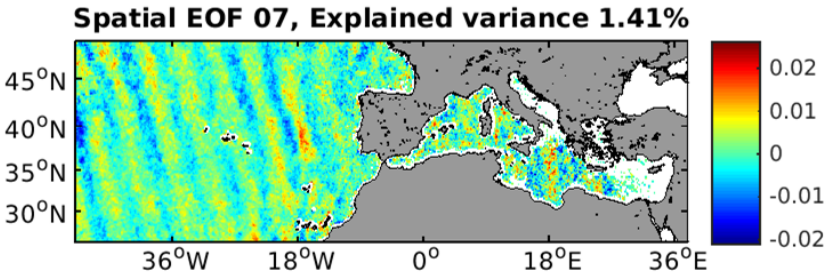


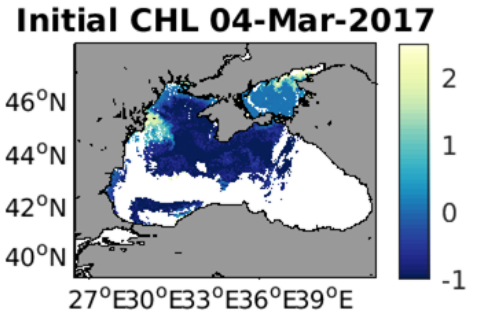
Example of Sentinel-3 SPM in the North Sea. Code at https://github.com/aida -alvera/DINEOF

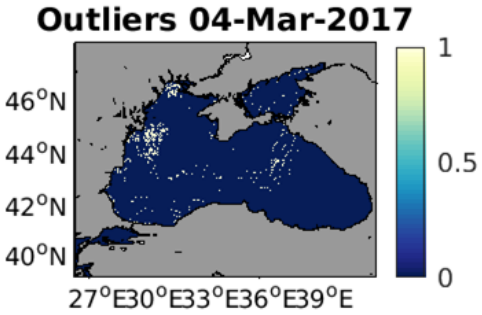
DINEOF

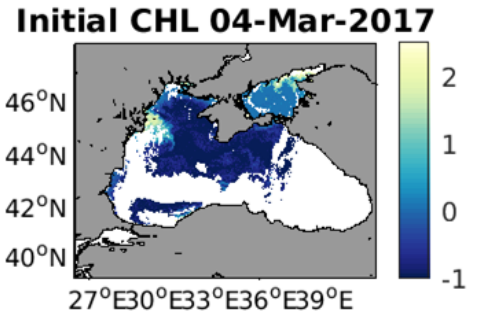
- Reconstruction of missing data (Alvera-Azcárate et al, 2005…)
- Removal of noise (Alvera-Azcárate et al, 2005…)
- Detection of outliers (Alvera-Azcárate et al, 2012; Alvera-Azcárate et al, 2015)
- 3D estimation of reconstruction error (Beckers et al, 2006)
- Removal of non-physical patterns (swath edges) (Alvera-Azcárate et al, 2016)
- Removal of cloud shadows (Alvera-Azcárate et al, 2021)
- **Enhancing spatial resolution**











DINEOF

DINEOF

or

?

DINEOF enhanced spatial resolution approach

- Test domain: Belgian coast of the North Sea

- First, Sentinel-2 data are checked for **cloud shadows**, and these are removed

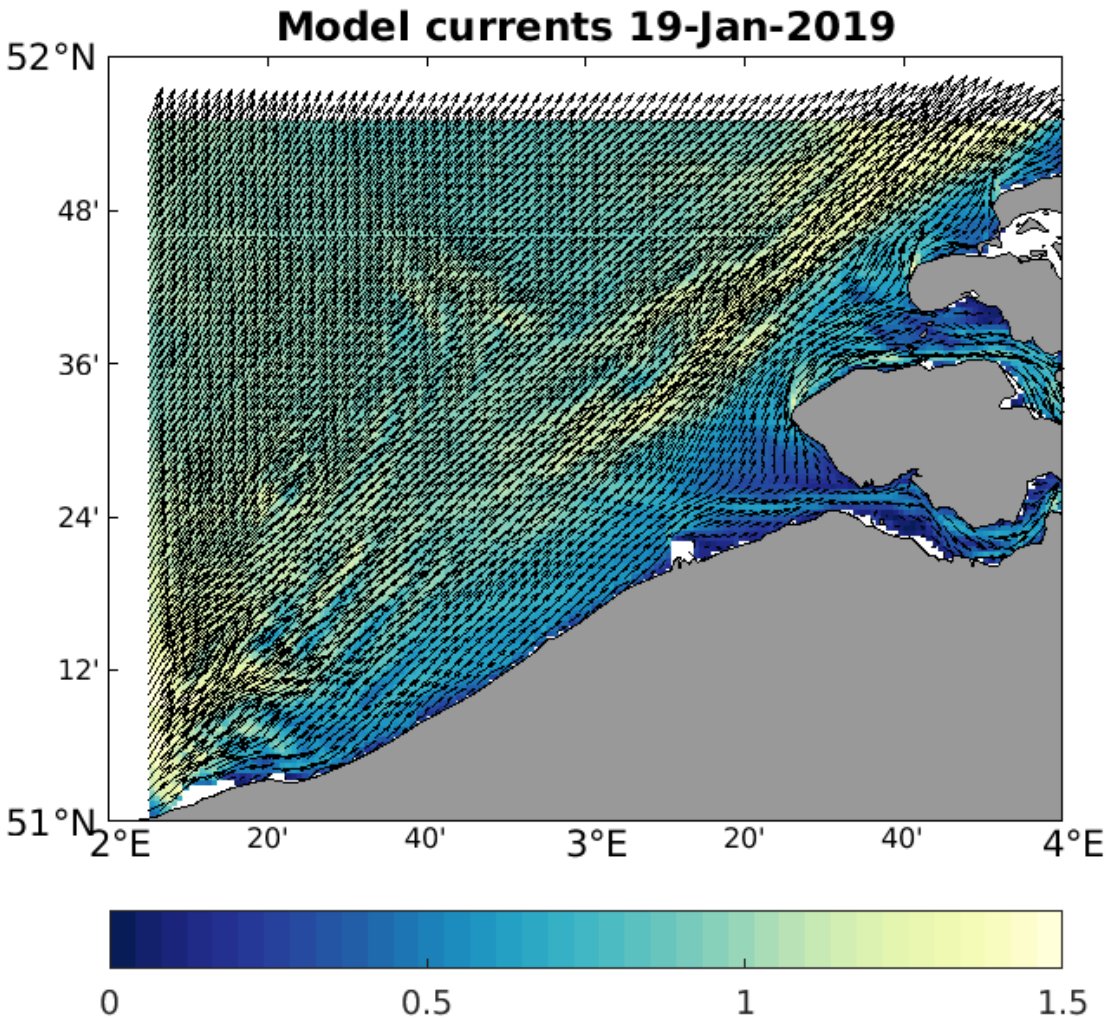
- A multi-platform dataset is built using Sentinel-2 data if available. If not, Sentinel-3 data interpolated at the Sentinel-2 resolution are used.

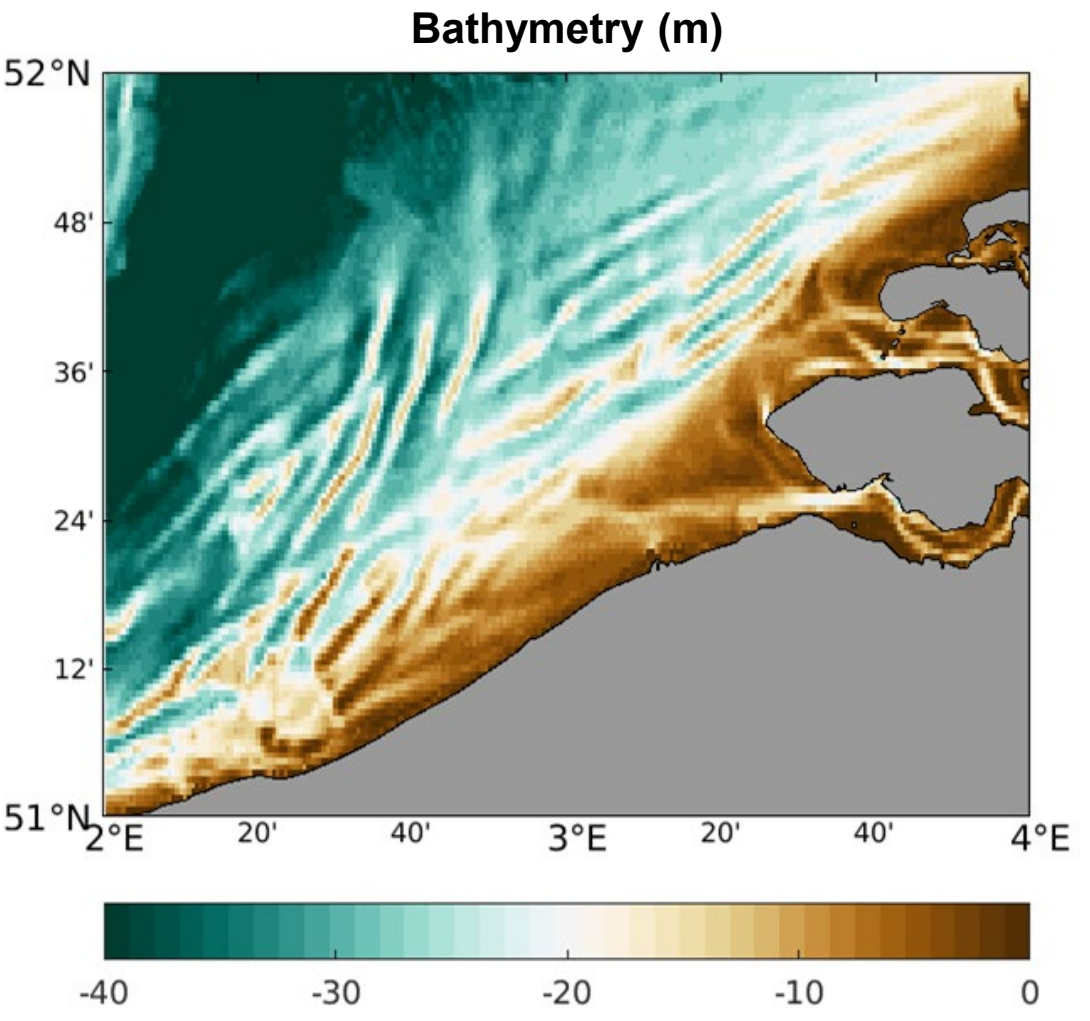
- This time series is analysed using DINEOF to reconstruct missing data, and EOFs extract the spatial variability of Sentinel-2 in regions where sufficient data are available.

- The results for Sentinel-3 days retain therefore at least part of the high spatial resolution information.

- Additional data: surface ocean currents from a hydrodynamics model at 1km resolution (https://odnature.naturalsciences.be/coherens/)

Ocean currents in the North Sea



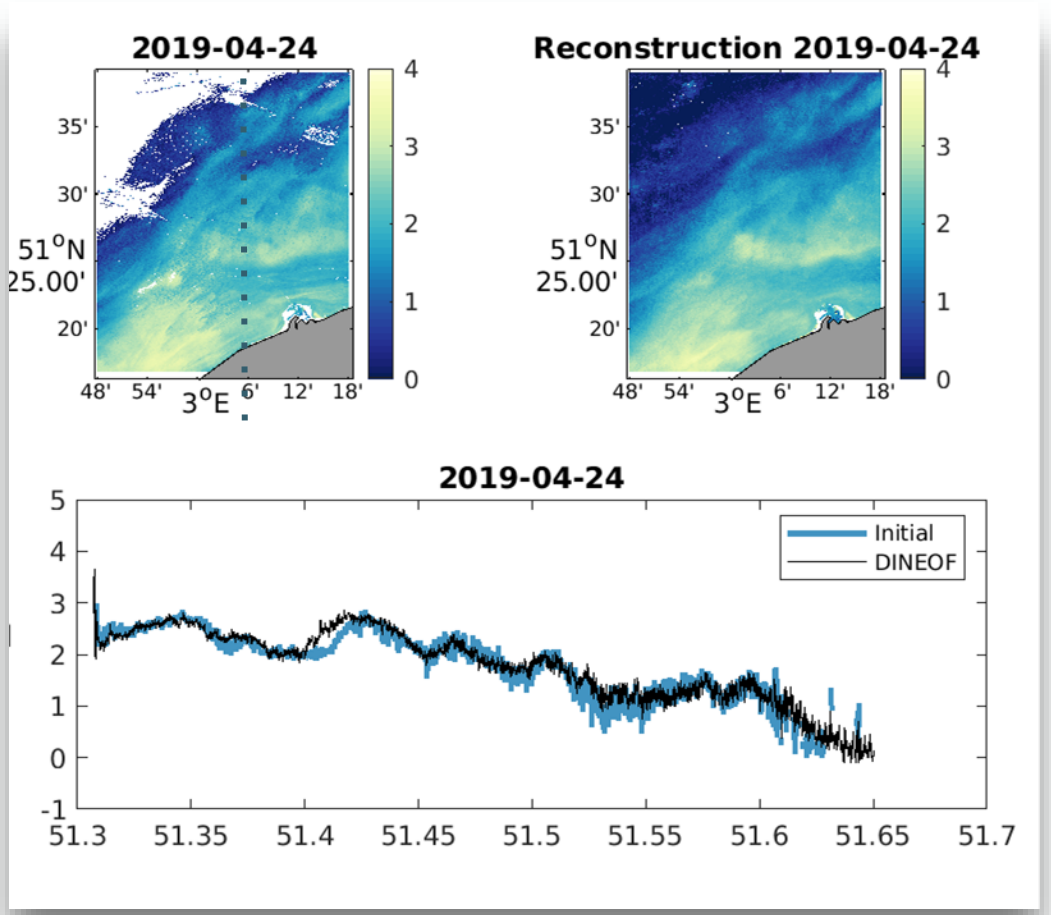


Some results

Snapshot of log(SPM) from a 6-month run

Clouds are reconstructed

Spatial variability increases in reconstruction

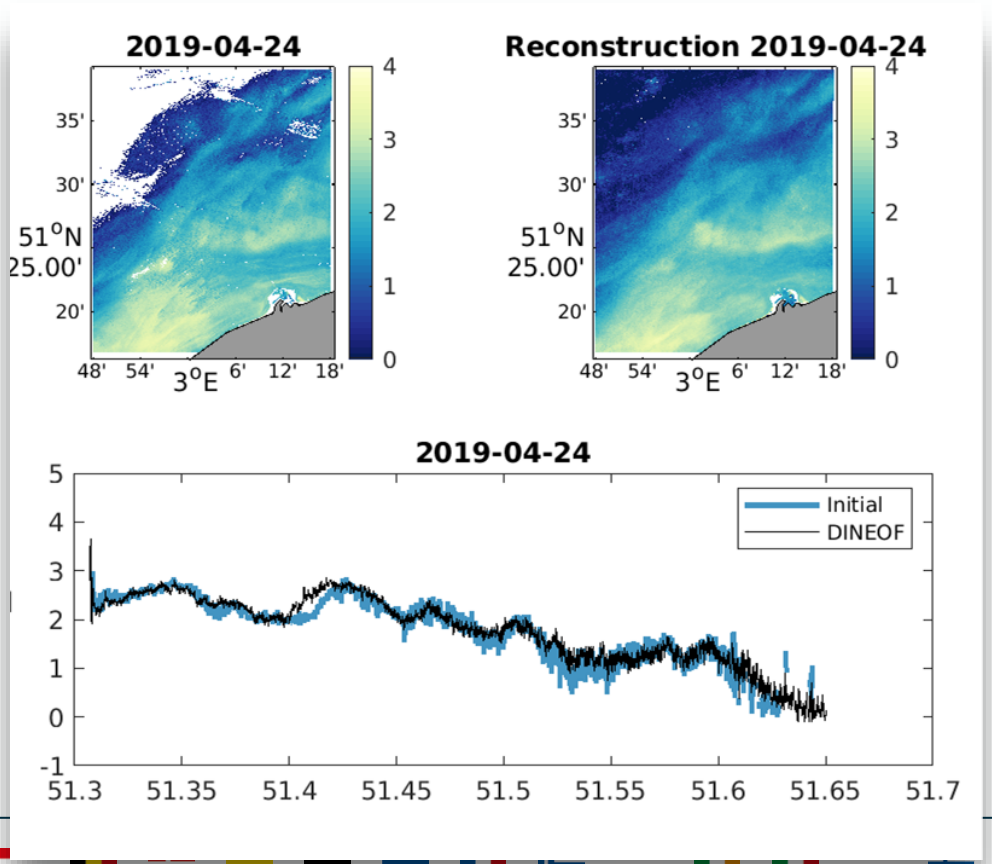


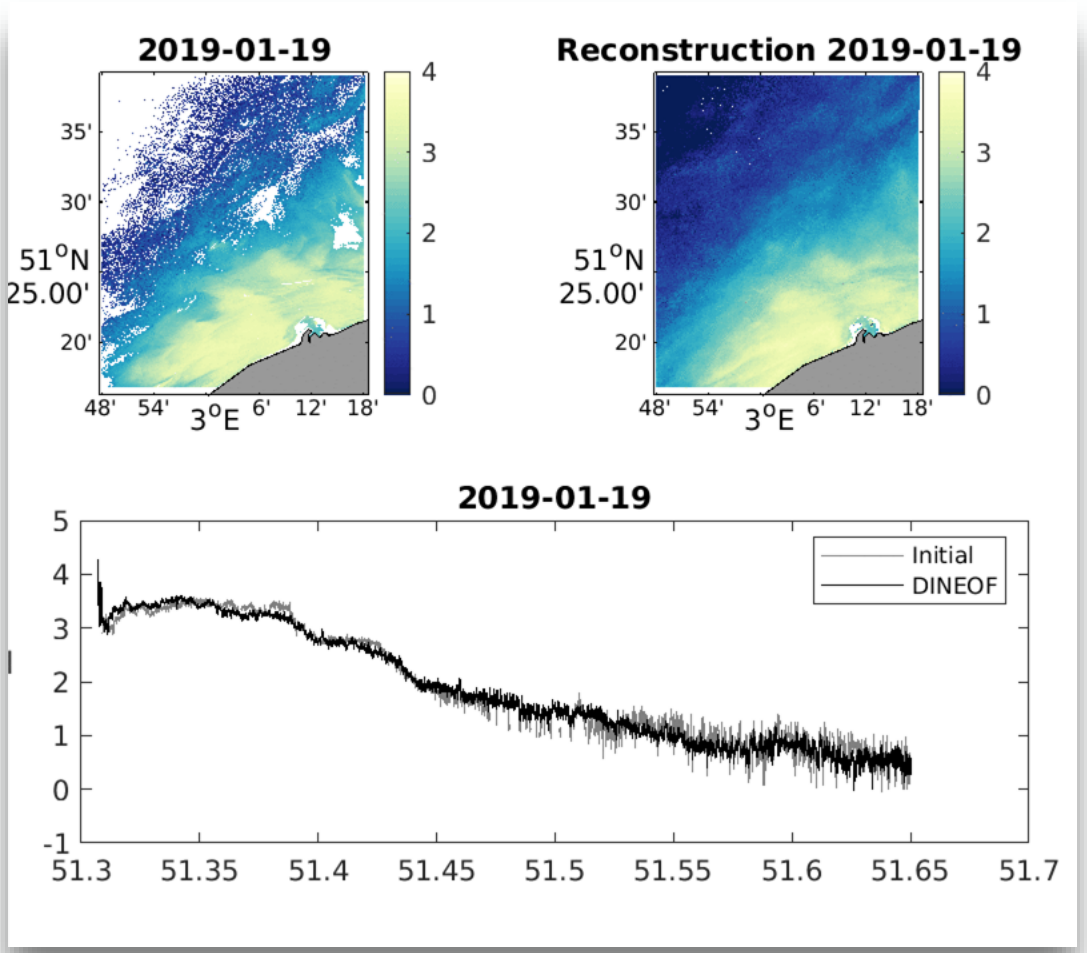
Some results

Snapshot of log(SPM) from a 6-month run

Clouds are reconstructed

Spatial variability increases in reconstruction

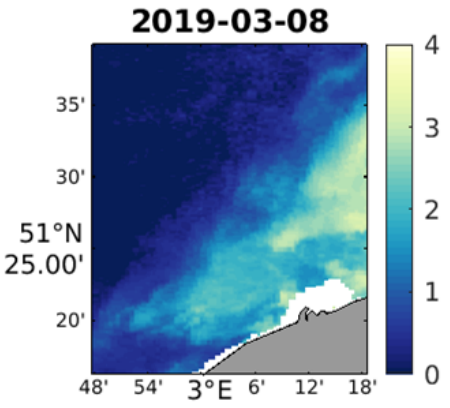


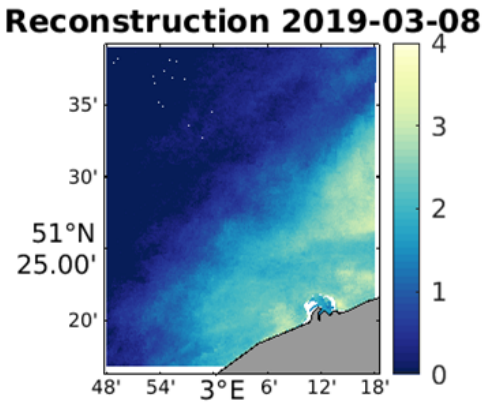


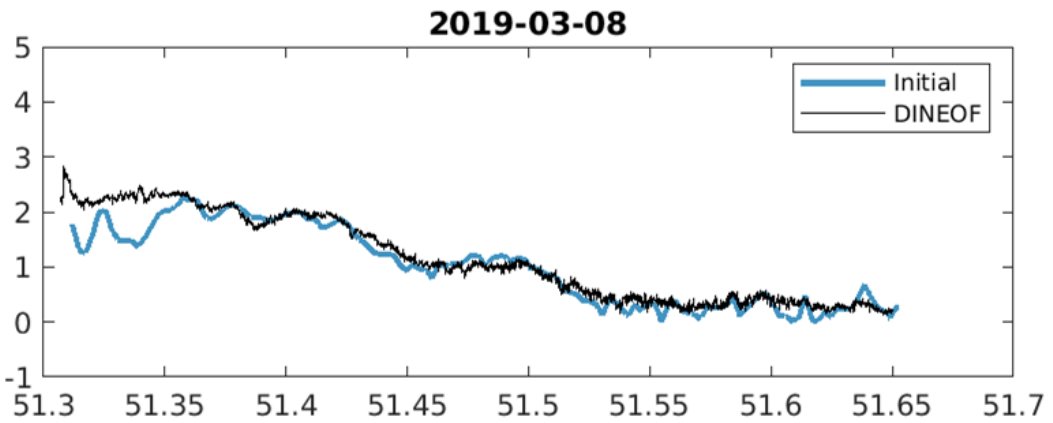
Some results

Benefit of using additional data in the reconstruction → ocean surface currents

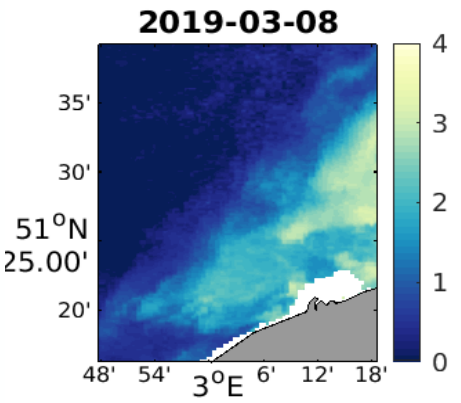
Only SPM

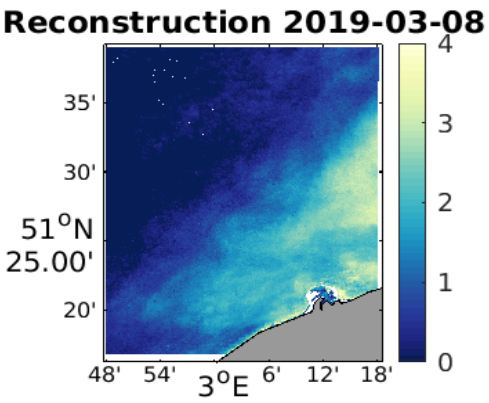


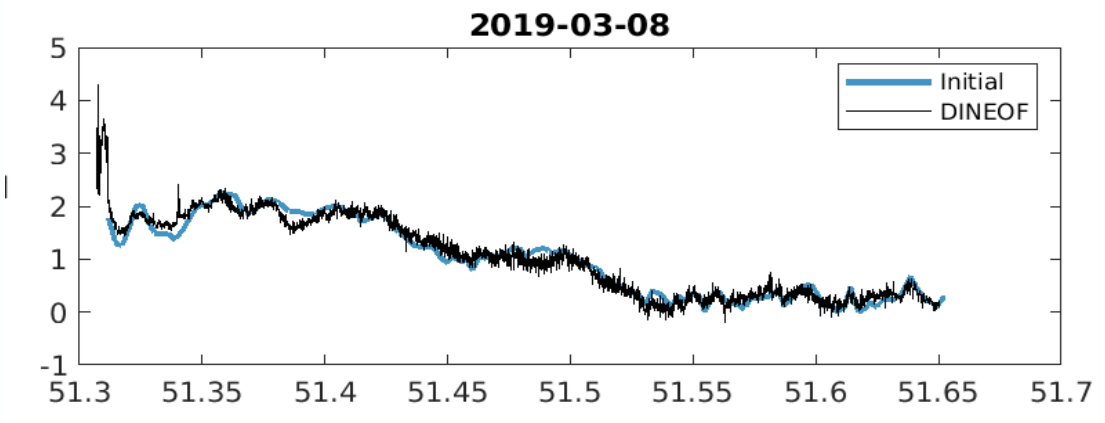




SPM + surface currents

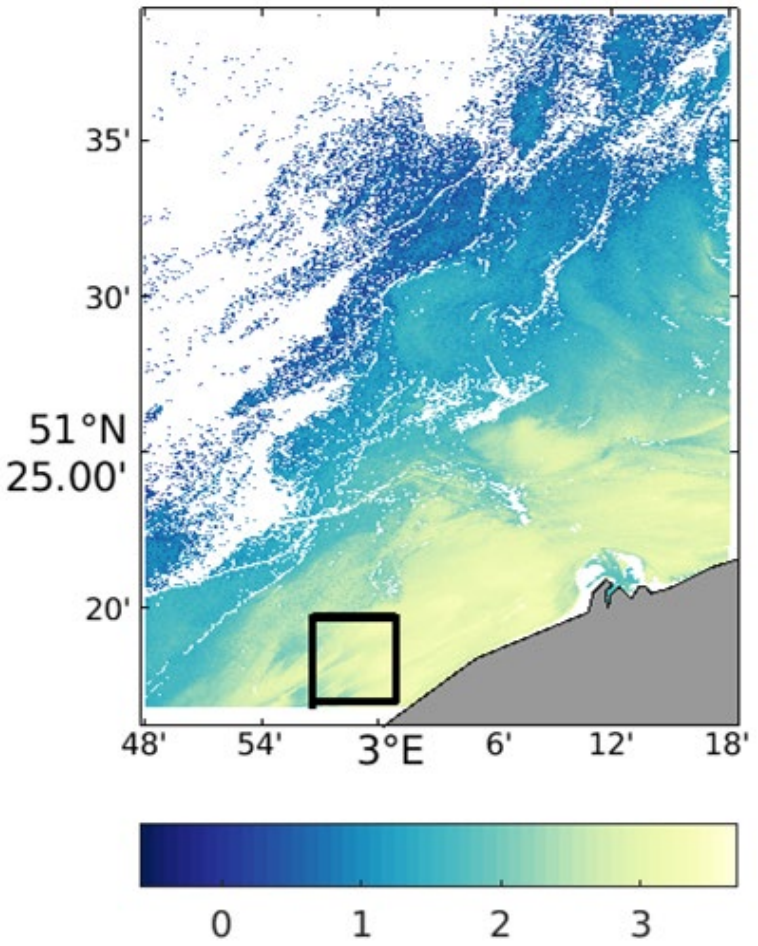




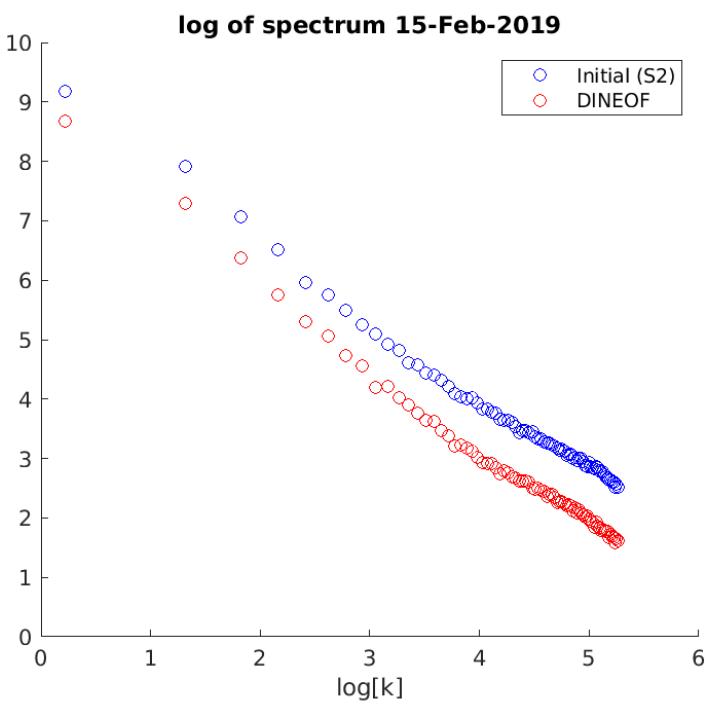


Some results: 2D power spectrum

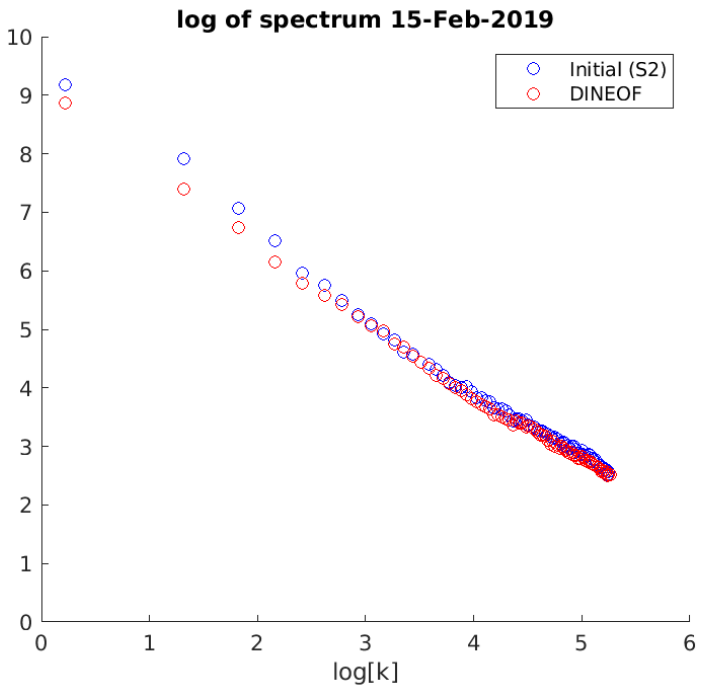
2D power spectrum realised in cloud-free areas



Only SPM



SPM + currents

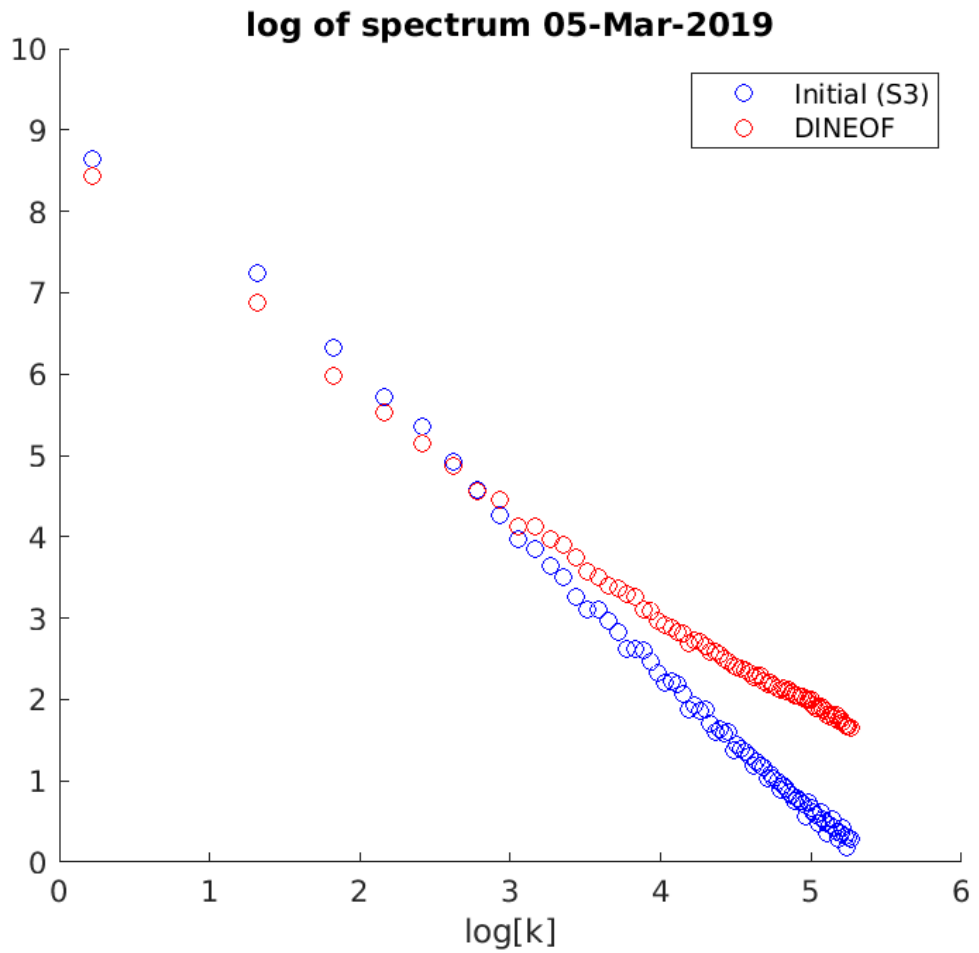


Reconstruction of SPM + currents increases energy at all scales

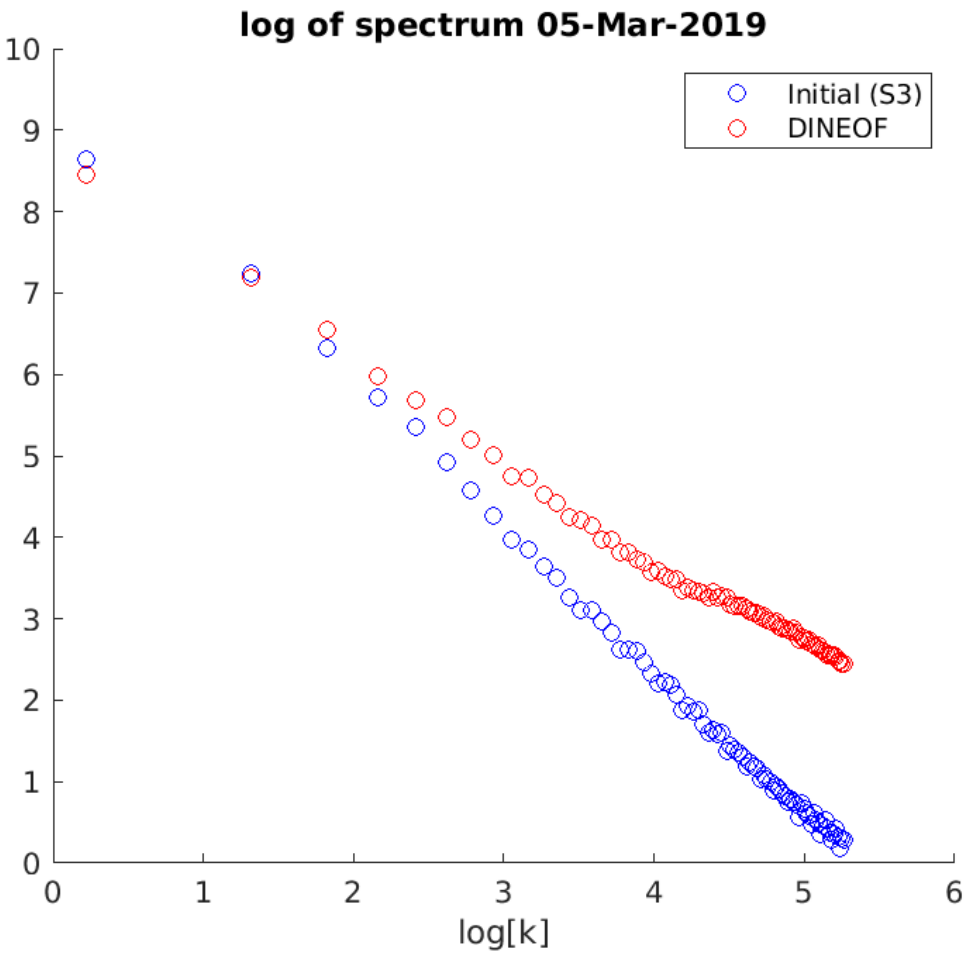
The spectrum maintains the level of energy of the initial image when adding currents

Some results: 2D power spectrum

Only SPM



SPM + currents

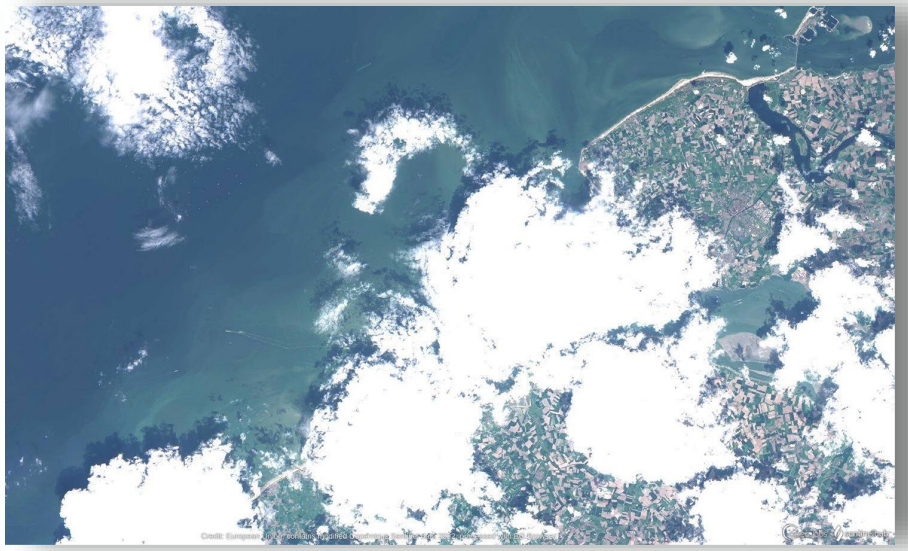


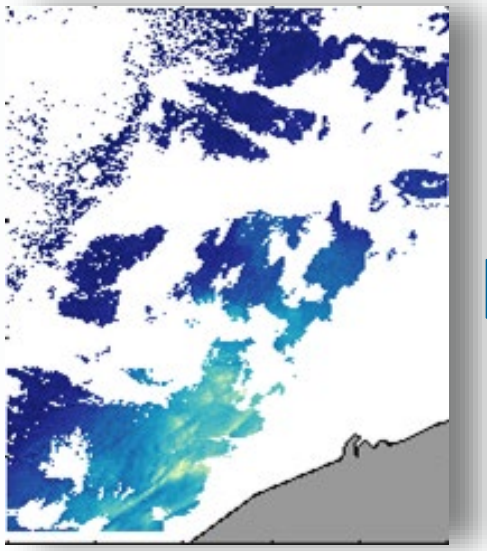
With initially S3 data, the reconstruction has higher energy

Conclusions

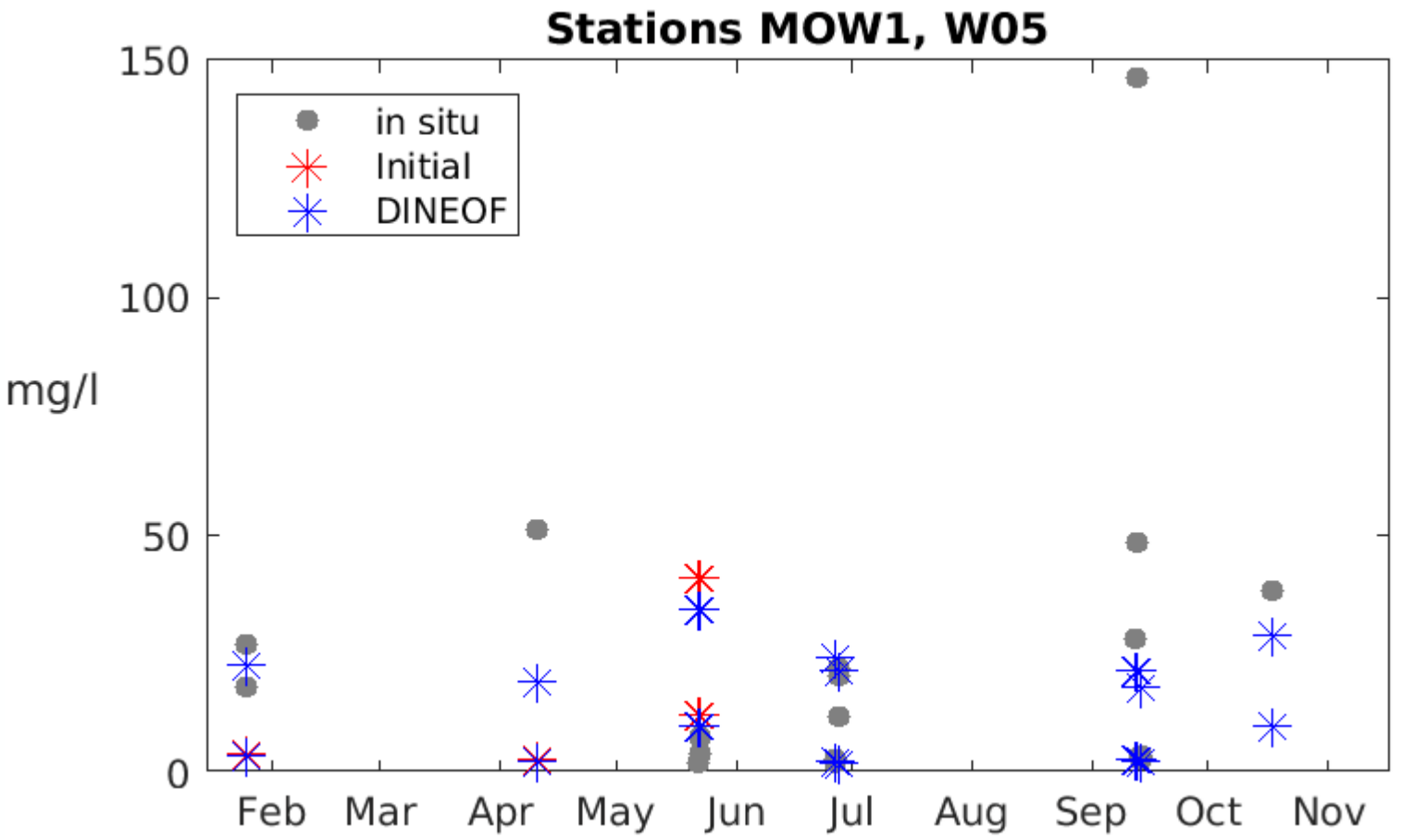
Synergy between Sentinel-2 & Sentinel-3 has been investigated

- Their different temporal & spatial resolutions allows for enhanced combinations of the two datasets
- Using DINEOF the effective resolution of Sentinel -3 data can be **enhanced**
- Creation of a high spatial resolution, daily time series of satellite data
- Influence of surface currents on ocean dynamics in complex coastal regions
- Addition of surface ocean currents appears to improve the reconstruction





On validation



- Few in situ locations
- High temporal resolution vs. daily satellite data
- Very high dynamics in SPM linked to tidal cycle