2nd Ocean Carbon from Space workshop

24-26 November 2025 Online

Optimizing Lagrangian drifter deployment for ocean color validation coupling kinematical models, remote sensing, and in situ data

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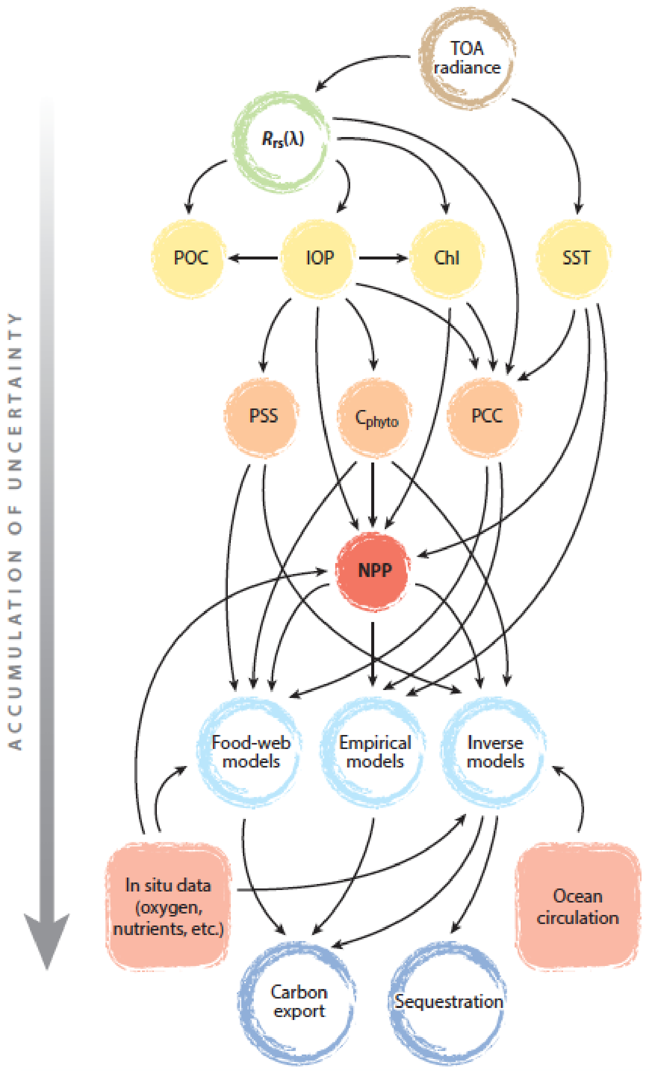
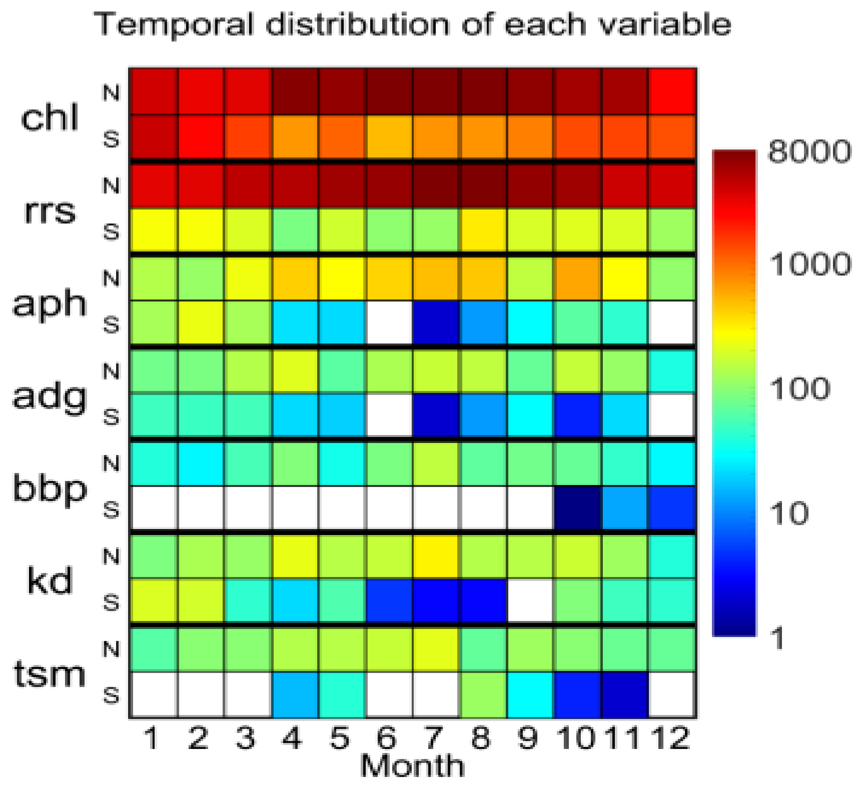
30/10/2025

Motivations



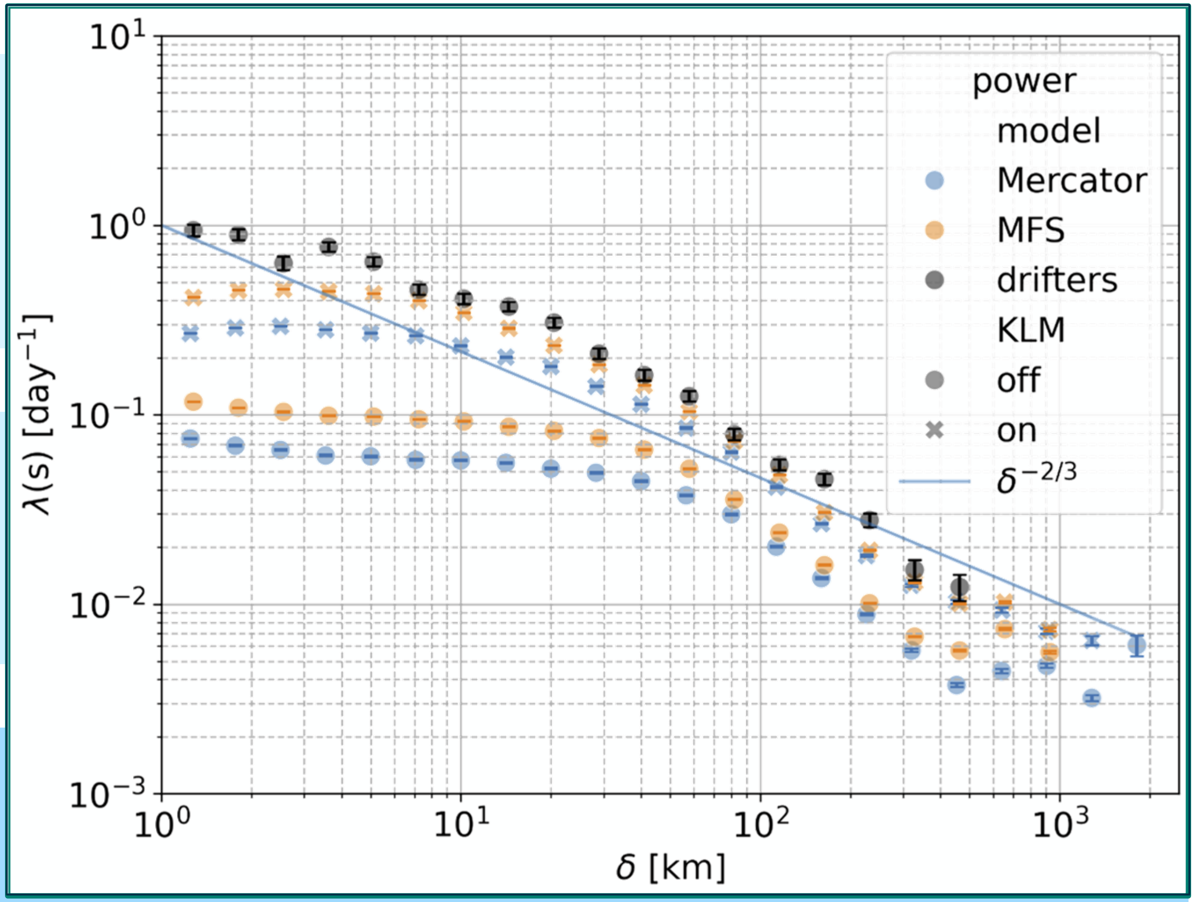
- **Biogeochemical products** accumulate **uncertainty** from satellite input to NPP/carbon export (left).
- In-situ **multispectral b_{bp}** observations are extremely scarce.



- Existing data have **poor spatial/temporal coverage** (right).
- **INSPIRE** aims to close this gap with a new Observing System using **BGC-SVP drifters** + **Lagrangian modelling** + satellite b_{bp}.

Lagrangian Kinematic Model (LKM)

Importance:
- Ocean models miss small-scale turbulence → unrealistic dispersion.
- LKM adds deterministic sub-grid chaotic motions → realistic Lagrangian behaviour.

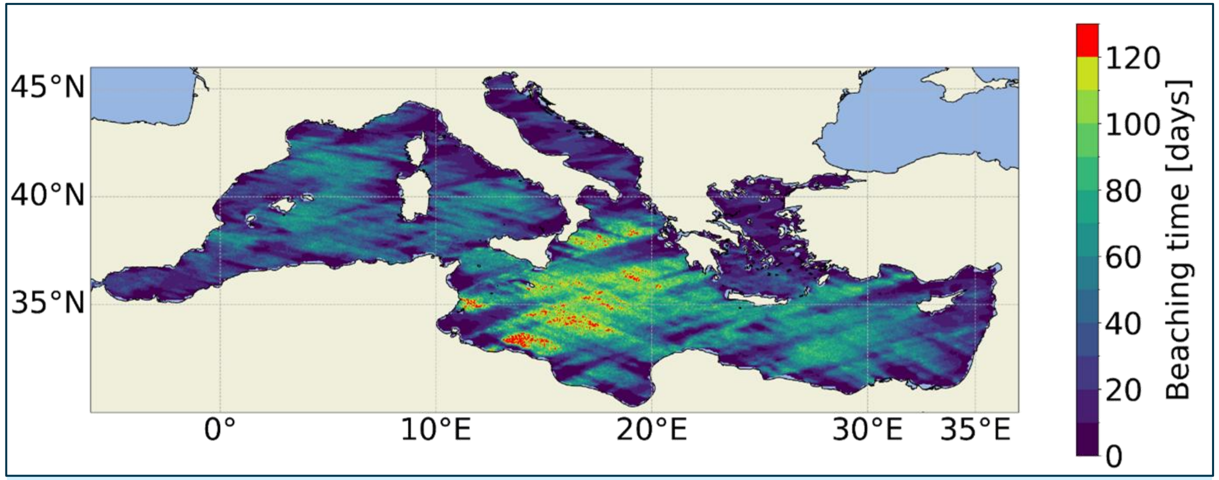


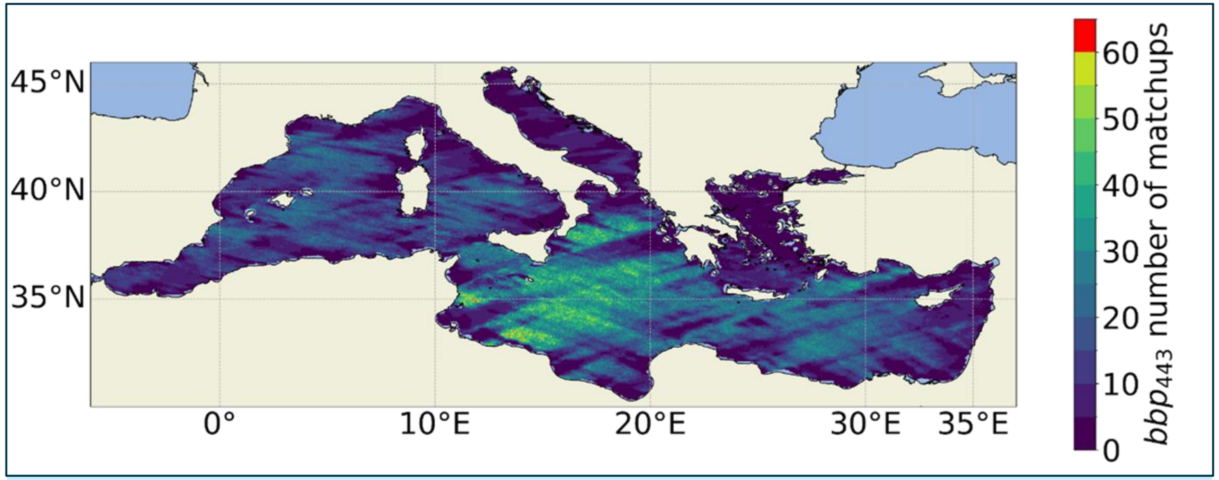
Calibration:
- Tune LKM parameters so that **FSLE (model + LKM) ≈ FSLE (drifters).**
- Use FSLE as scale-dependent error-growth metric.

Result:
- MFS and Mercator underestimate dispersion at small scales.
- LKM **restores** correct scaling; **MFS+LKM** best matches drifters.

All results shown in this presentation are included in Busatto et al. (2025), currently under review on Science of Remote Sensing.

Results





Beaching Time
Average number of days before a simulated drifter **grounds**.
Each month we release **synthetic drifters**, advect them for 1 year, and record the time at which they **hit land**.

- **Long lifetimes** → stable **open-sea regions** (Ionian, Levantine).
- **Short lifetimes** → dangerous **coastal areas** (Adriatic, Gulf of Lion).

Potential Matchups
Number of days in which the drifter passes over a pixel with **valid bbp retrieval**
Sampling each trajectory daily against bbp satellite date and counting all **valid coincidences**.

- **Eastern Mediterranean** has year-round high matchup potential.
- Matchups **peak in spring–summer** (low cloud cover).

***b_{bp}* Binning** (sampling different trophic regimes)
Fraction of matchups falling into predefined ***b_{bp}* intervals**, representing ultra-oligotrophic → hypertrophic waters.
For each trajectory and each month, we classify each matchup into one of **nine *b_{bp}* bins** and average across 21 years to obtain seasonal maps.

- **Eastern Mediterranean** → ultra-oligotrophic bins.
- **Central–Western basins** → oligotrophic/mesotrophic bins.
- **Adriatic & Gulf of Lion** → productive, high-b_{bp} bins.
- Ensures the OS samples the **full biogeochemical dynamic range**.

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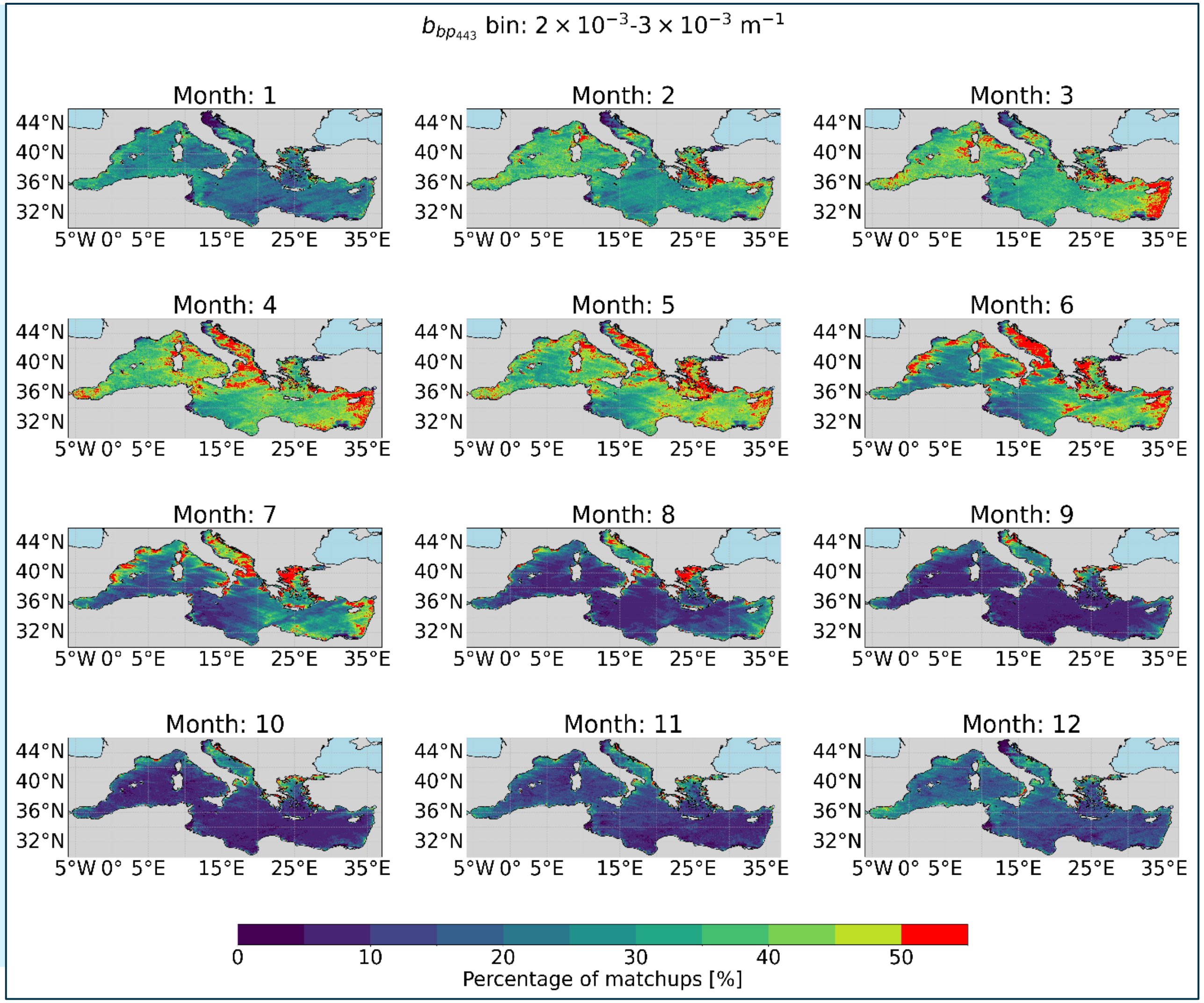
Conclusions

1. **Year-round, high-yield region**
    1. **Central Levantine Basin** → all seasons.
    2. Long drifter lifetimes, frequent valid b_{bp} matchups, and a stable oligotrophic regime ideal for baseline validation.
2. **Seasonal "boost zones"**
    1. **Libyan shelf** (July–September): strong summertime matchup density.
    2. **South-eastern Ionian** (April–October): long lifetimes + high matchup frequency.
    3. **Alboran–Algerian corridor** (spring): mesoscale activity and Atlantic inflow enhance sampling of low-to-intermediate b_{bp} bins.
3. **Targeting productive regimes**
    1. **Gulf of Lion** (winter): best for sampling productive/high-bbp bins.
    2. **Adriatic Sea**: river discharge + blooms → access to eutrophic regimes.
    3. Useful when the goal is to validate **high-b_{bp} retrievals**.
4. **Regions to avoid** (unless targeting extreme bbp)
    1. Northern Adriatic and winter Gulf of Lion:
        1. Very short beaching times,
        2. persistent cloud cover,
        3. rapid drifter loss and low matchup yield.



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Future perspectives

Filling observational gaps (1- and 5-years timescales)

- BGC-SVP drifters provide continuous b_{bp} measurements when satellites fail (clouds, night, glint).
- They capture sub-daily and intra-pixels variability and complement satellite coverage.

Toward an operational system (1- and 5-years time scales)

- The INSPIRE OS can be extended to other variables (e.g., Chl, Rrs) and to other basins globally (e.g., Pacific, Atlantic Oceans).
- Supports uncertainty quantification for current and future missions (e.g., PACE/OCI, ESA CHIME, Sentinel Next Generation).

Coordinated and development of a drifter deployment network (10 years timescales)

- Deployments can be shared across research groups and ships of opportunity.
- Enables year-round coverage, sampling of all trophic regimes, and efficient global validation following what has been done for SST

Multi-platform synergy (5 to 10 years timescales)

- Combining drifters, BGC-Argo, moorings and satellites creates a scalable, multi-scale observing system.