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## Analog data assimilation of along-track nadir and SWOT altimetry observations in the Western Mediterranean Sea

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## Partners



## References

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## 1. Abstract

The **growing availability of ocean data** brought forth by recent advancements in remote sensing, in situ measurements and numerical models supports the **development of data-driven strategies** as a powerful, computationally-efficient **alternative to model-based approaches** for the **interpolation of high-resolution, gap-free, regularly-gridded sea surface geophysical fields from partial satellite-derived observations**.

In this work, we investigate such data-driven strategies for the **spatio-temporal interpolation of Sea Level Anomaly (SLA) fields** in the **Western Mediterranean Sea** from **satellite-derived altimetry data**. We develop and evaluate an **Analog Data Assimilation (AnDA)** framework, which exploits **patch-based analog forecasting operators**. **Two different types of altimetry data** are assimilated: **along-track nadir data** and **wide-swath SWOT altimetry data**. Using an **Observing System Simulation Experiment (OSSE)**, we demonstrate the **relevance of AnDA as an improved interpolation method**, particularly for **mesoscale features** in the **20-100 km horizontal scale range**. Results report an **SLA reconstruction RMSE (correlation) improvement of 42% (12%) with respect to Optimal Interpolation (OI)**, and suggest an **additional potential gain** when the **joint assimilation of SWOT and along-track nadir observations** is considered.

## 2. Analog Data Assimilation

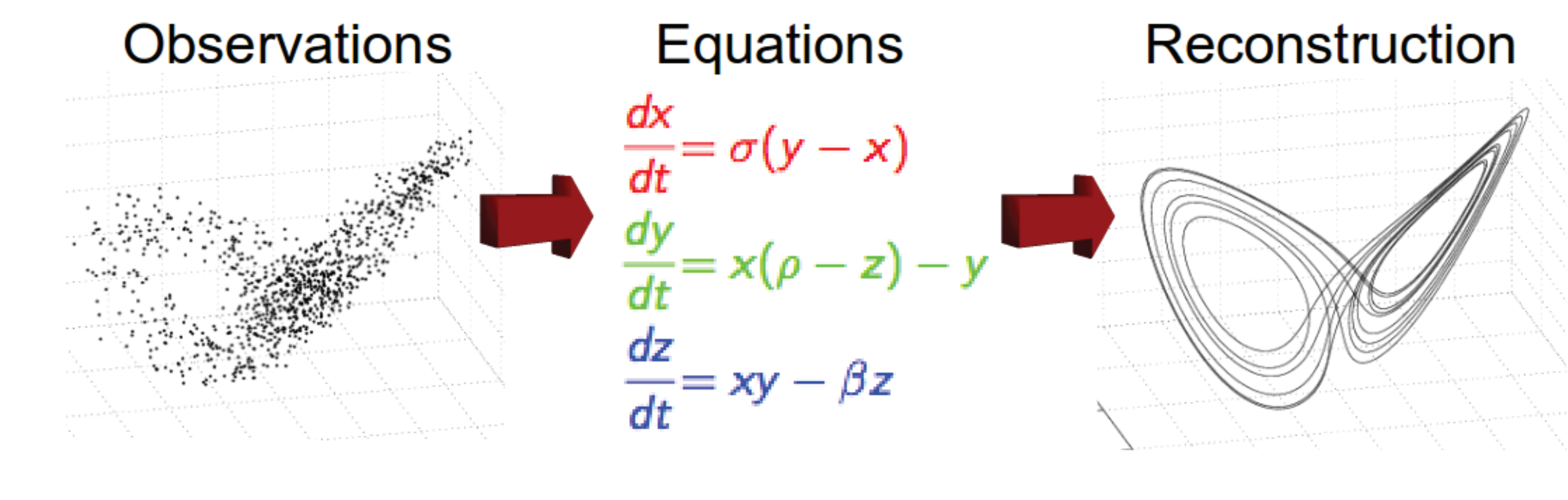
**Data Assimilation:** Combine a model and observations for reconstruction

- ▶ Observations can be noisy and/or partial
- ▶ Models can be non-consistent with observations, uncertain or even unknown
- ▶ Running models can be computationally expensive

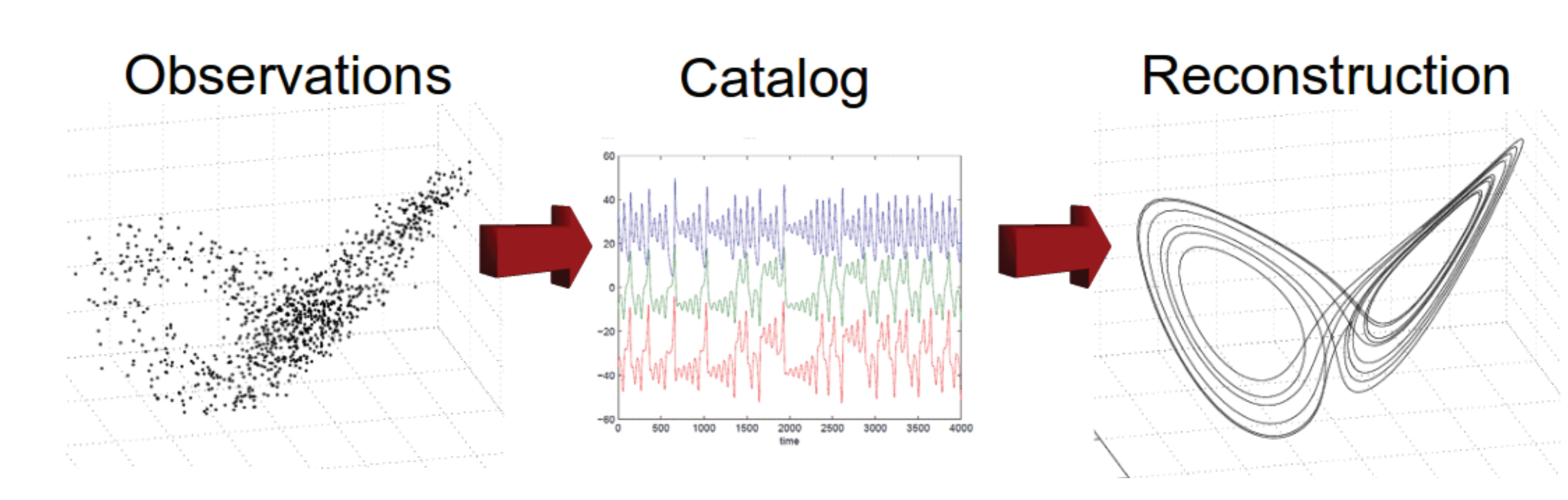
**Idea:** Replace the model-based forecasting step of data assimilation with a data-driven approach

- ▶ Dynamical models can be built directly from a catalog of realistic simulations of system state dynamics
- ▶ Forecast can be made by exploiting the similarity between the current state and simulated states within the catalog

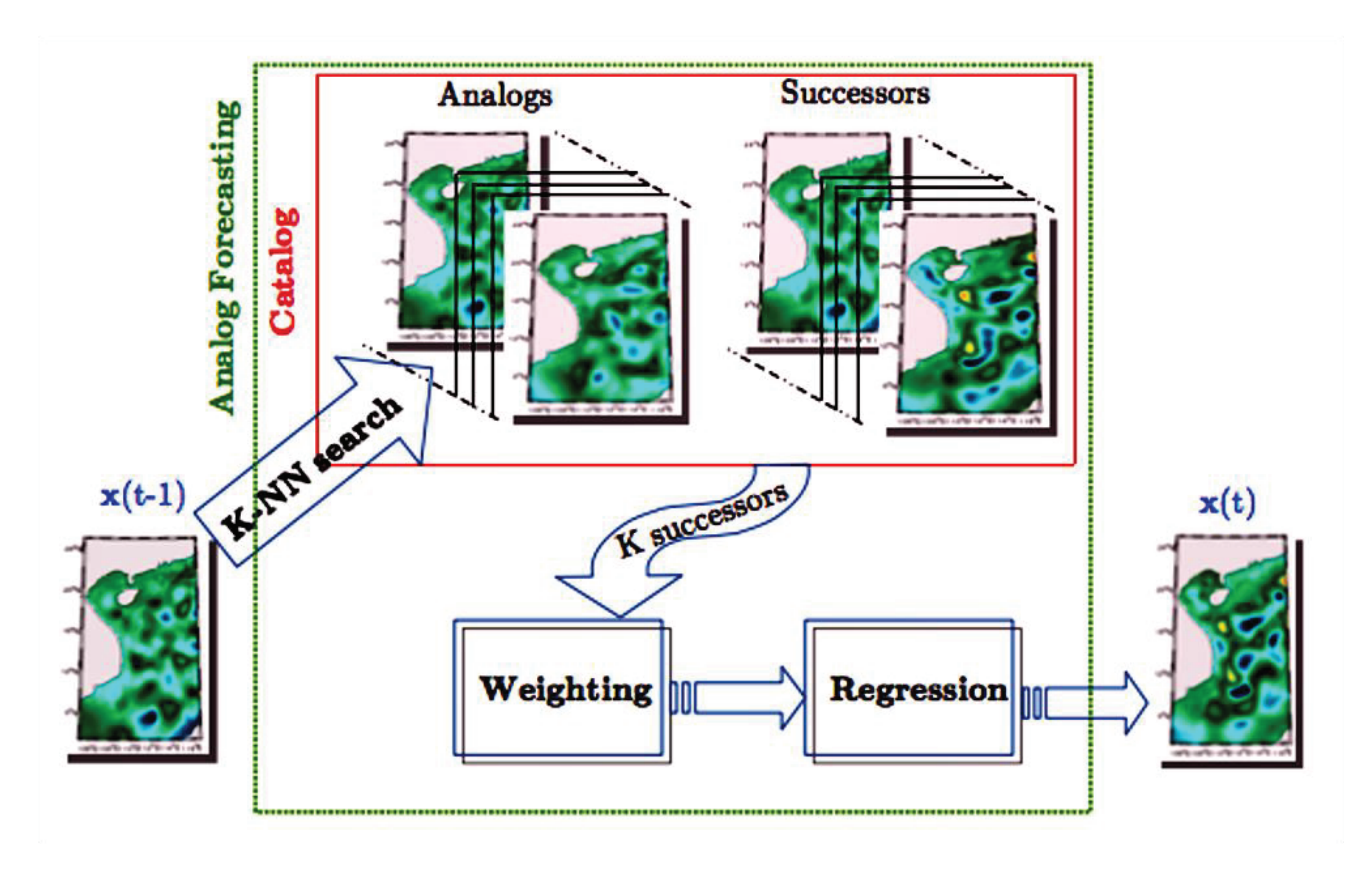
## Classic data assimilation [1]



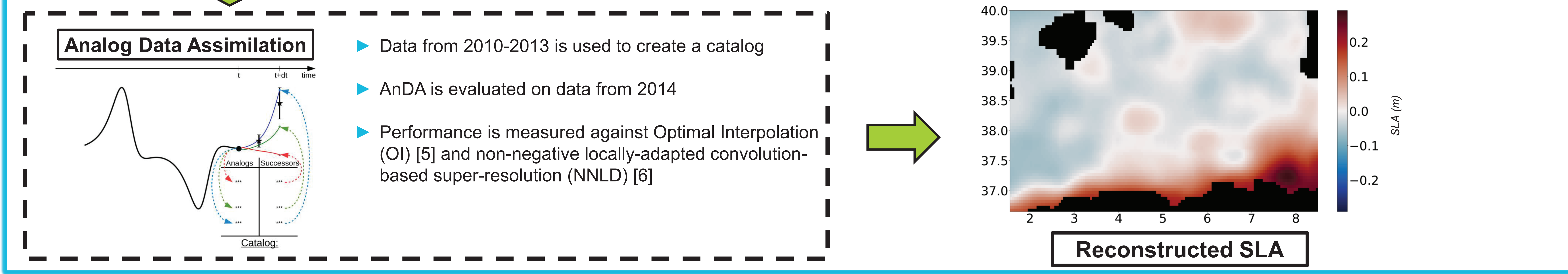
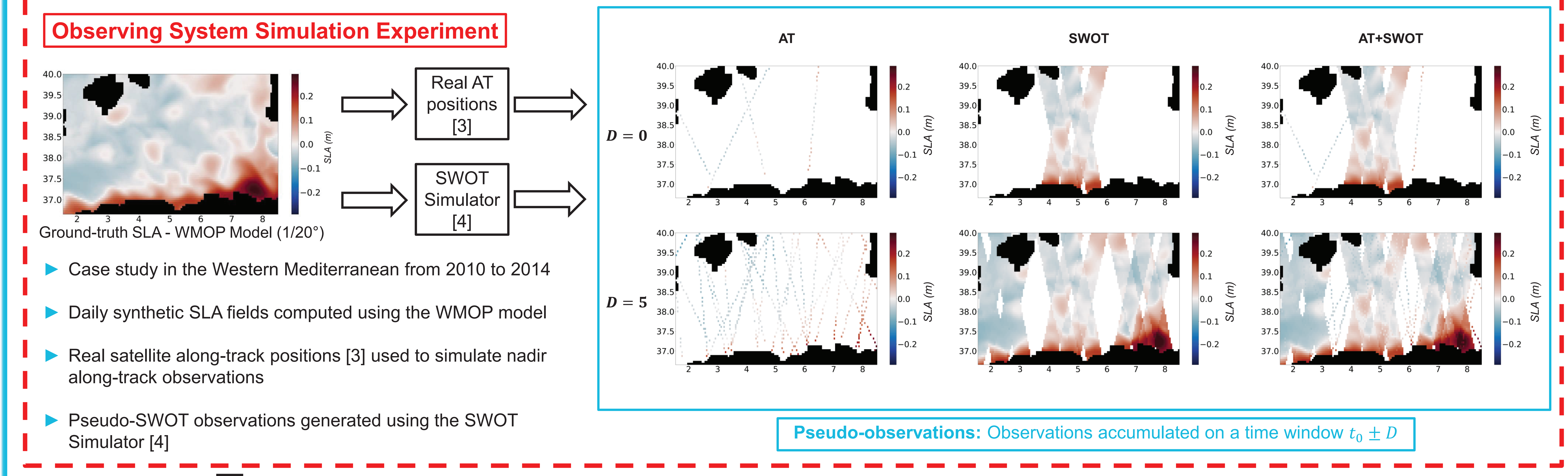
## Analog data assimilation [2]



## Analog Data Assimilation for Geophysical Fields



## 3. Ocean Observing System Simulation Experiment



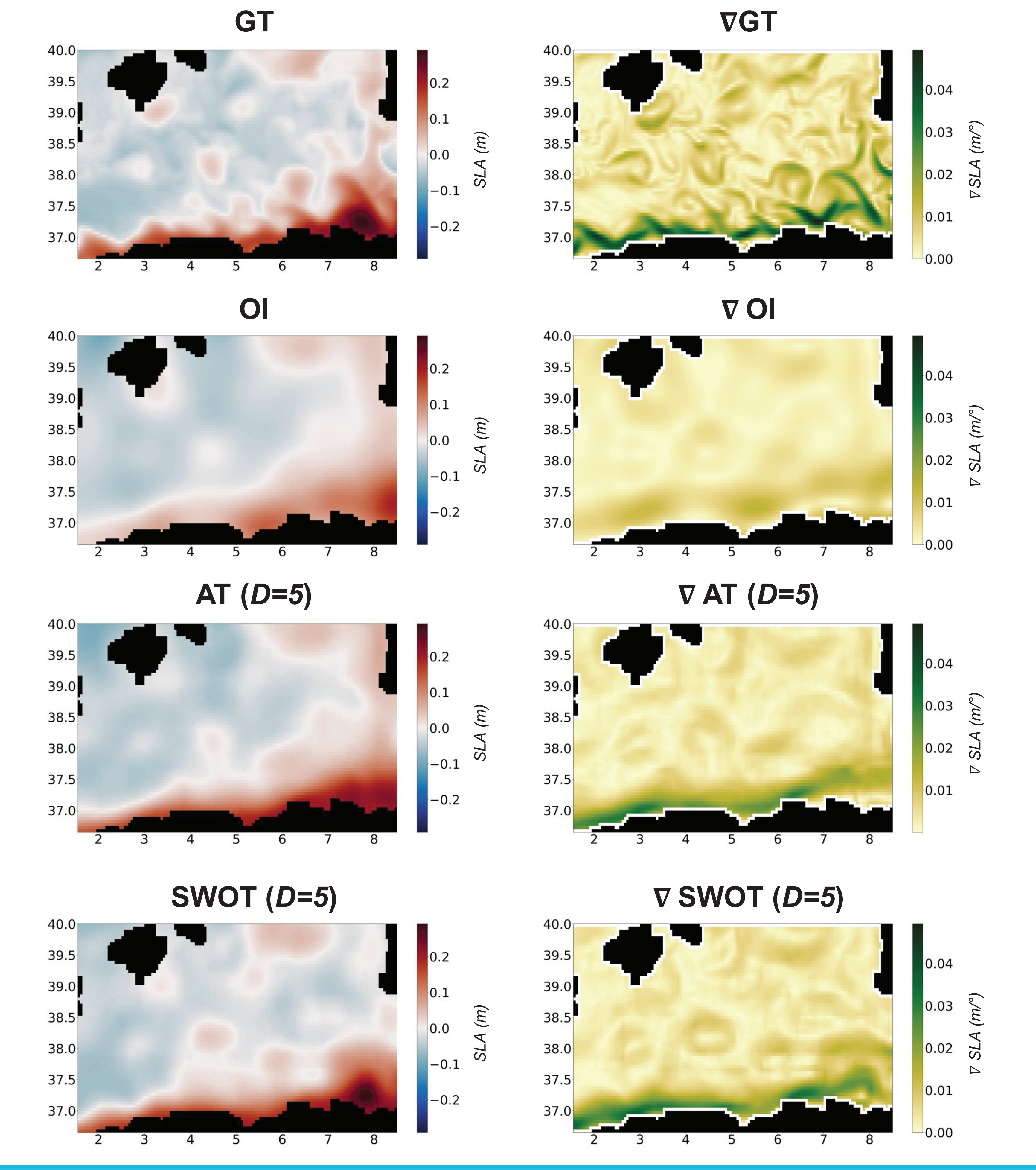
## 4. Results

**Table 1:** RMSE (Correlation) for AnDA using SWOT observations with different noise settings. Best result in **bold**. Result for OI [5] and NNLD [6] given as reference.

Setting	SLA	∇SLA
No noise	0.02156 (0.9388)	0.004515 (0.7726)
KaRIN noise	0.02166 (0.9383)	0.004530 (0.7724)
All noise sources	0.03926 (0.8042)	0.005999 (0.5736)
OI	0.03389 (0.8447)	0.006661 (0.6050)
NNLD	0.02127 (0.6957)	0.004513 (0.5892)

**Table 2:** RMSE (Correlation) for AnDA using different combinations of SWOT and AT observations. Best result in **bold**. Result for OI [5] and NNLD [6] given as reference.

Setting	SLA	∇SLA
AT (D = 0)	0.02397 (0.9197)	0.005524 (0.7023)
AT (D = 5)	<b>0.01966 (0.9464)</b>	0.004687 (0.7679)
SWOT (D = 0)	0.02156 (0.9388)	0.004515 (0.7726)
SWOT (D = 5)	0.02523 (0.9200)	0.004474 (0.7678)
Both (D = 0)	0.02043 (0.9445)	0.004448 ( <b>0.7805</b> )
Both (D = 5)	0.02428 (0.9254)	<b>0.004424 (0.7745)</b>
OI	0.03389 (0.8447)	0.006661 (0.6050)
NNLD	0.02127 (0.6957)	0.004513 (0.5892)



## 5. Conclusion

We developed an **application of the Analog Data Assimilation (AnDA)** to the **reconstruction of SLA fields** in the **Western Mediterranean Sea** from satellite altimetry data, namely **satellite along-track nadir data** and **wide-swath SWOT data**. The AnDA framework can be regarded as a means to **exploit high-resolution numerical simulation datasets** for the **reconstruction of SLA fields from partial satellite observations**. The reported OSSE support the relevance of AnDA with respect to state-of-the-art approaches (OI and NNLD). For instance, we report a clear **improvement of 42% (12%) in terms of SLA RMSE (correlation)** and **30% (27%) in terms of SLA gradient RMSE (correlation) with respect to OI** when considering **along-track nadir data**. Our experiments also suggest an **additional potential improvement** from the **joint assimilation of SWOT and along-track nadir observations**. However, **additional preprocessing** should be carried out to **filter out the correlated noise in SWOT data**. Future work will focus on **combining such preprocessing strategies with the AnDA framework** in order to **develop useful tools to process real observations from the future SWOT altimetry mission**. Other interesting research avenues include the **combination of the different sources of altimetry data** as well as **considering additional ocean dynamical tracers** (e.g. sea surface temperature, sea surface salinity, ocean color, etc.). The **exploitation of structural information present in wide-swath observations**, for example by means of numerically resolved SLA gradients and/or finite size Liapunov exponents (FSLE), is also an appealing research direction.