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# Developing a Sustainable Lake Forecasting System

## INTRODUCTION

◆ A Coastal Forecasting System uses weather forecasts and observations as inputs to a numerical computer model to make a prediction of water levels, 3-D lake temperature, currents, wave heights and related environmental variables.

◆ Numerical models have been developed to simulate and predict physical, biological and ecological processes of oceans and lakes and now can be integrated and run simultaneously at a much higher spatial and temporal resolutions with the advances in high performance computing and software engineering.

◆ New approaches such as model coupling, data assimilation and ensemble forecasting techniques have been applied to hydrodynamic and weather models to improve the accuracy of model predictions.

◆ We use the NOAA Great Lakes Operational Forecasting System as an example to highlight the development of such an operational forecasting system, to describe current modeling/data technologies and to identify challenges of transition from research to operational systems as well as lessons learned that may benefit the European lakes research community.

## A HIGH RESOLUTION FORECASTING SYSTEM
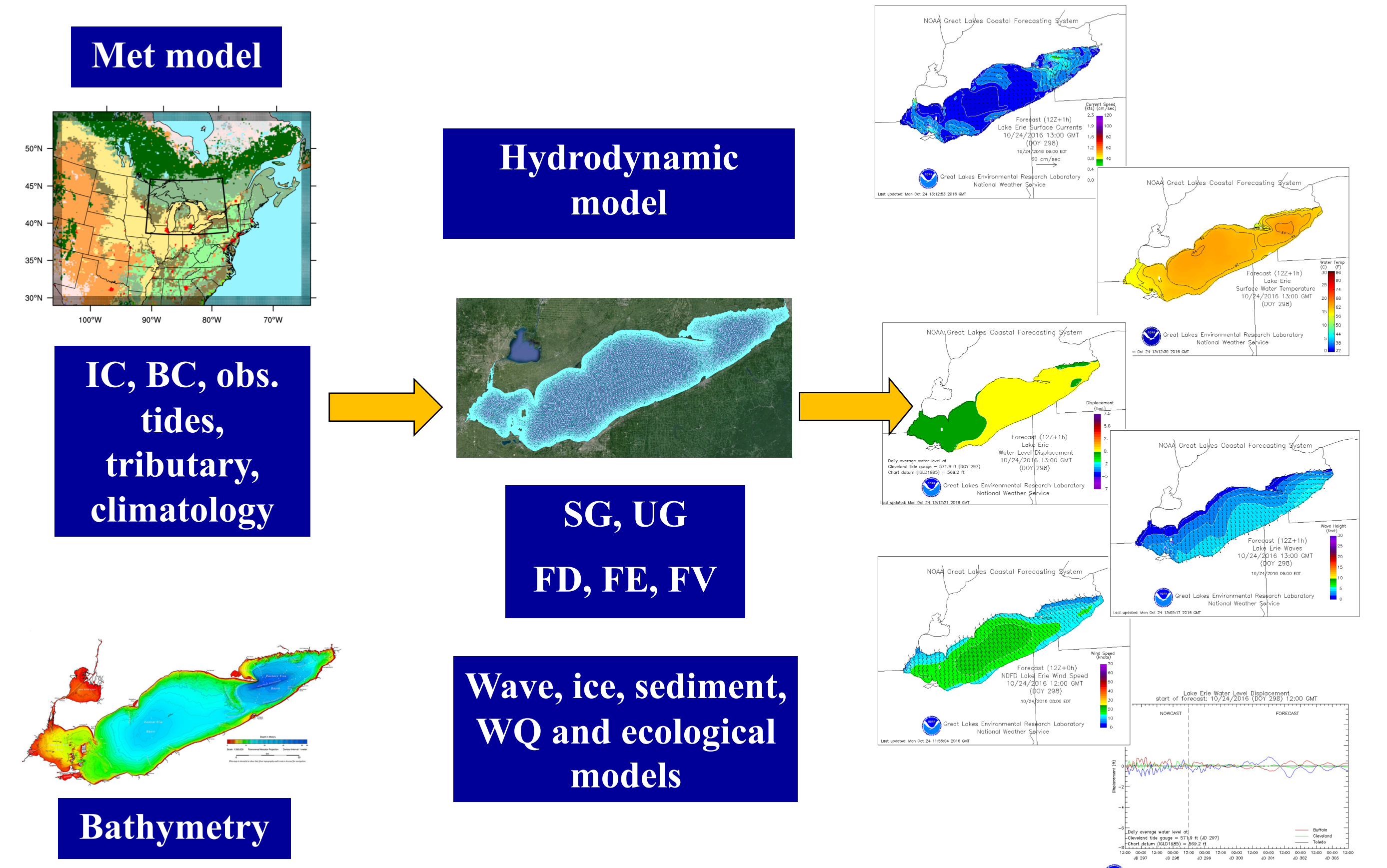


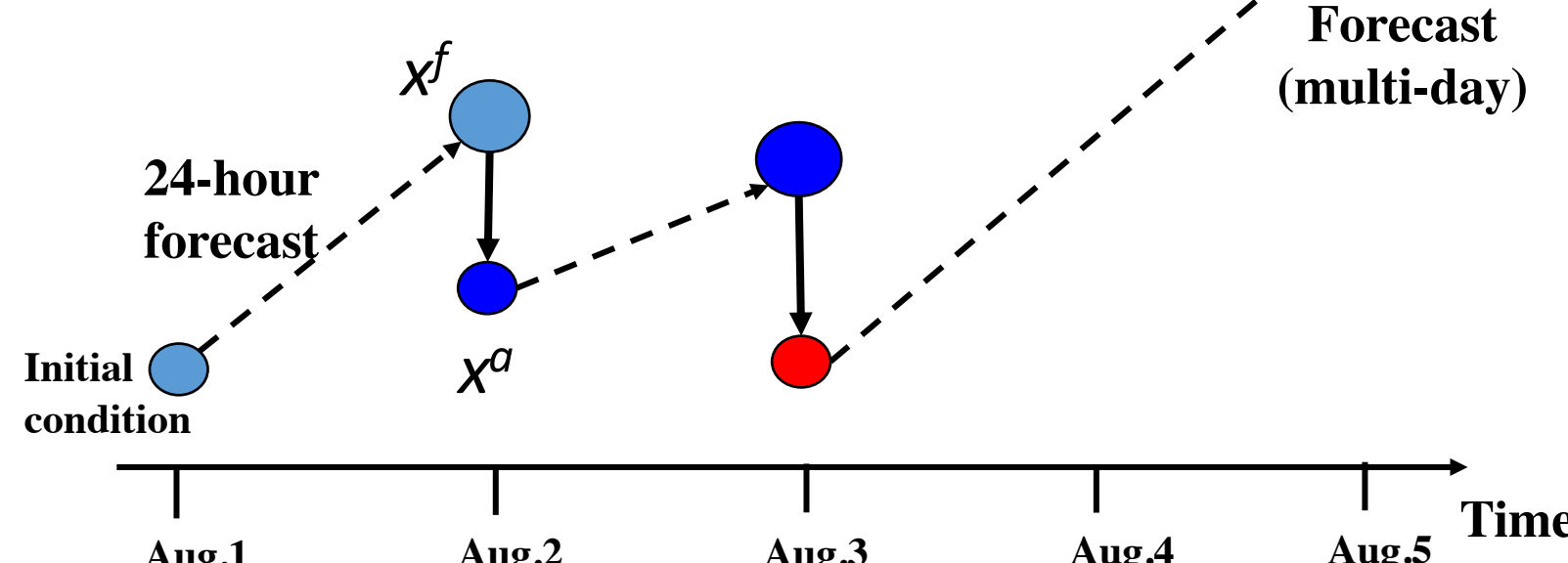## MODEL COUPLING AND DATA ASSIMILATION

### Bio-physical 3D models
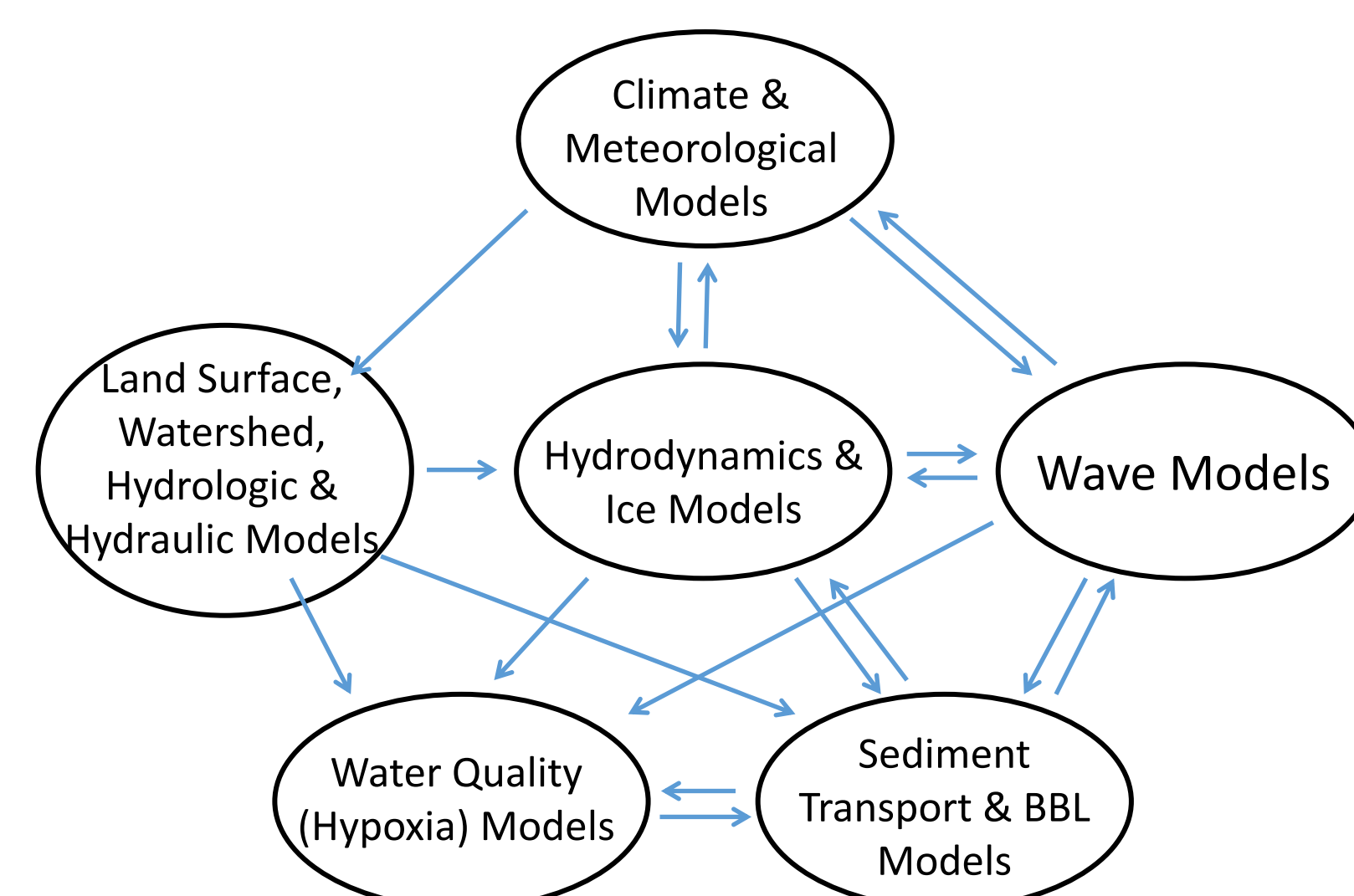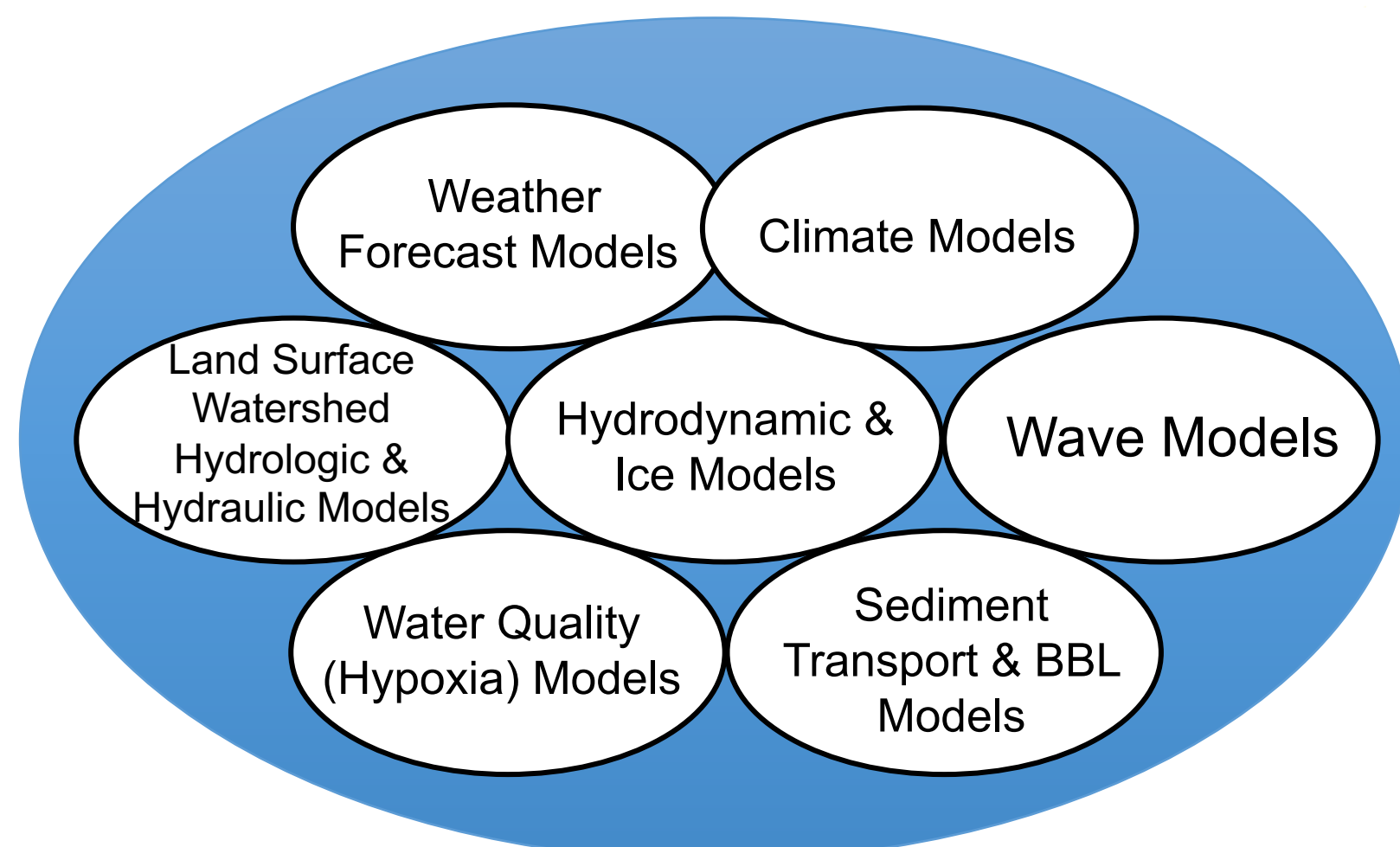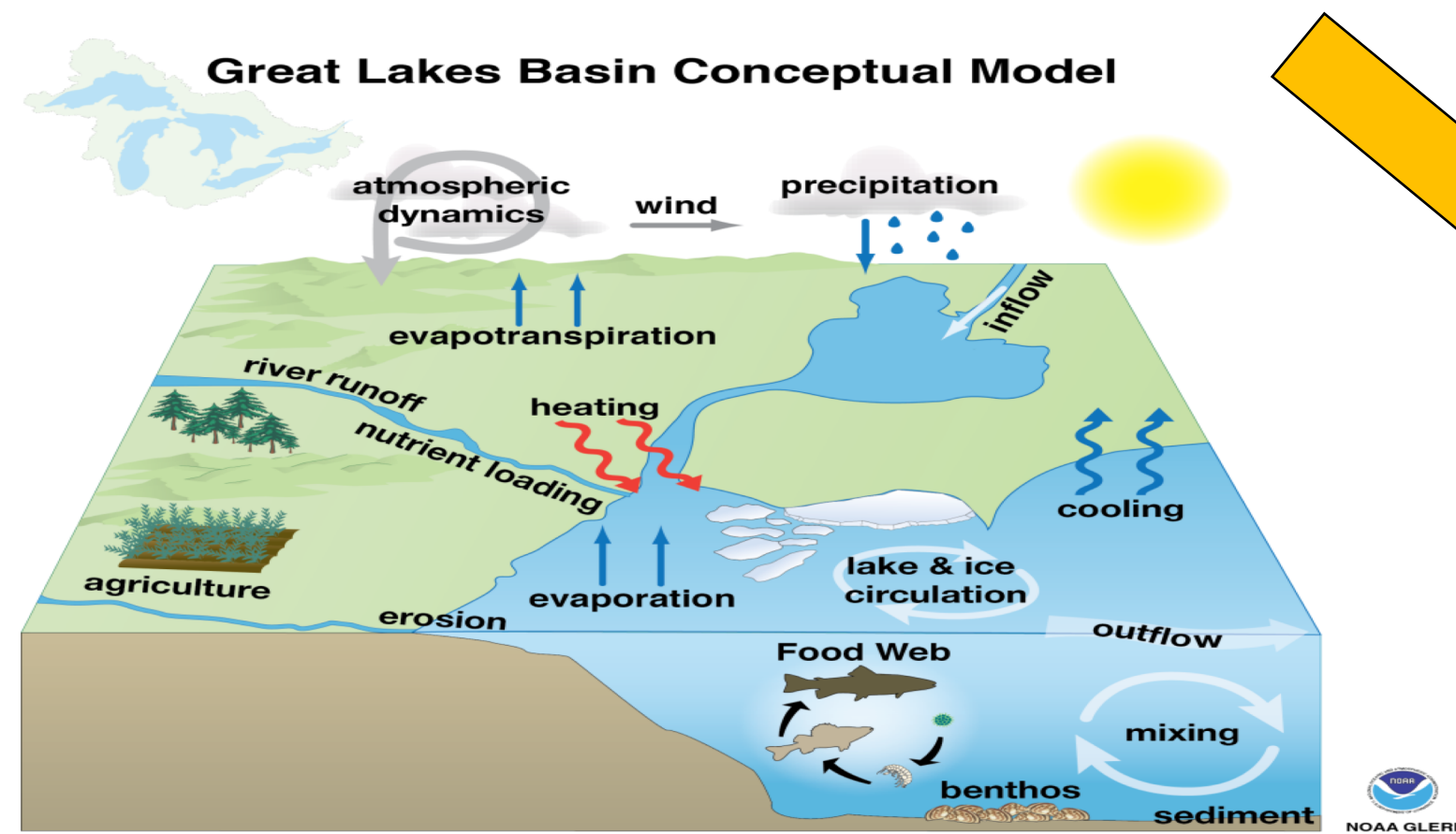


### Data Assimilation:

◆ **Optimal Interpolation (OI)**
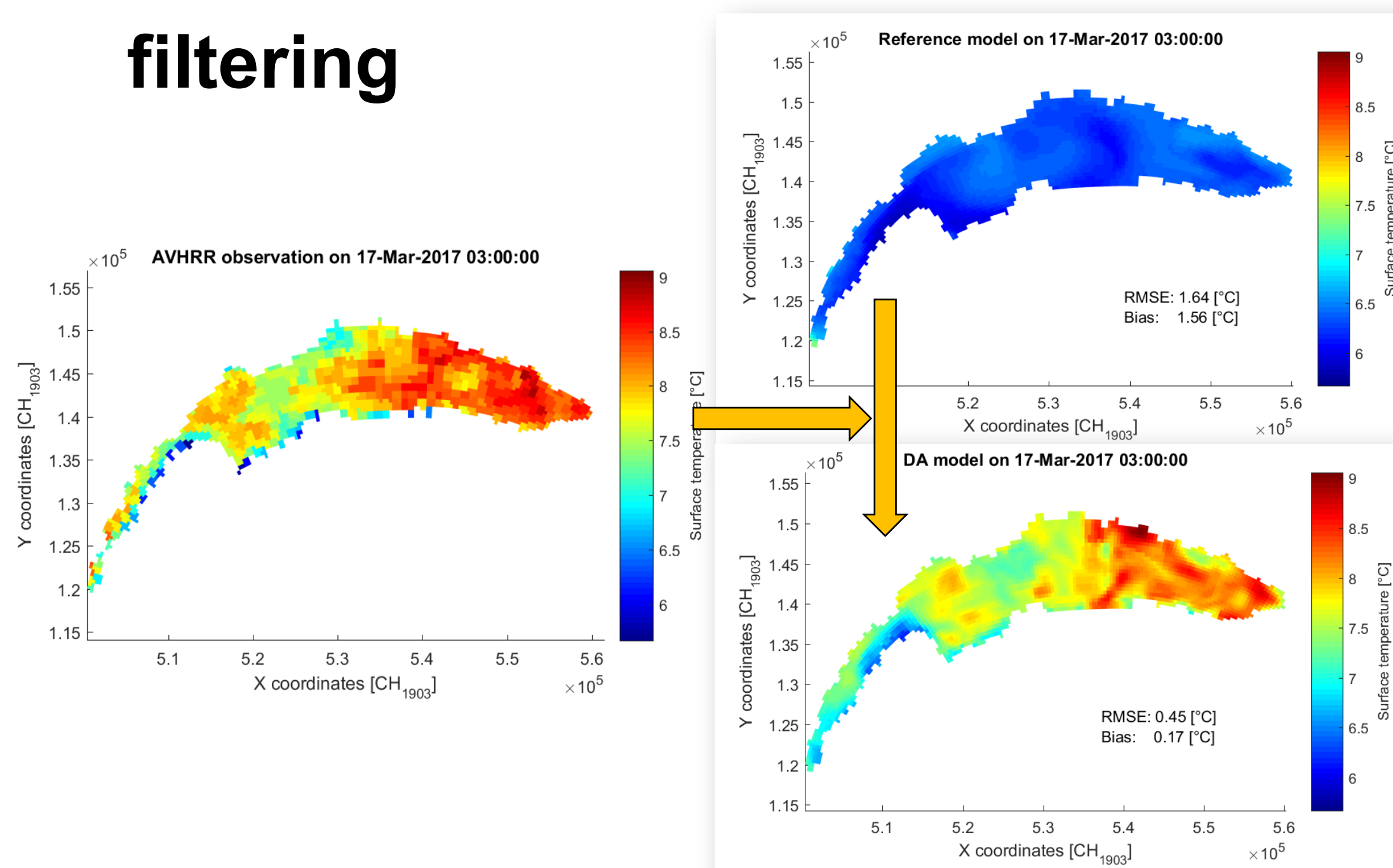◆ **Nudging**
◆ **3D-Var, 4D-Var**

3-dimensional variational (3DVAR) method:
$$J = 0.5\ (x\text{-}x^f)^T\ B^{-1}\ (x\text{-}x^f) + 0.5\ (h\ x\text{-}y)^T\ R^{-1}\ (h\ x\text{-}y)$$
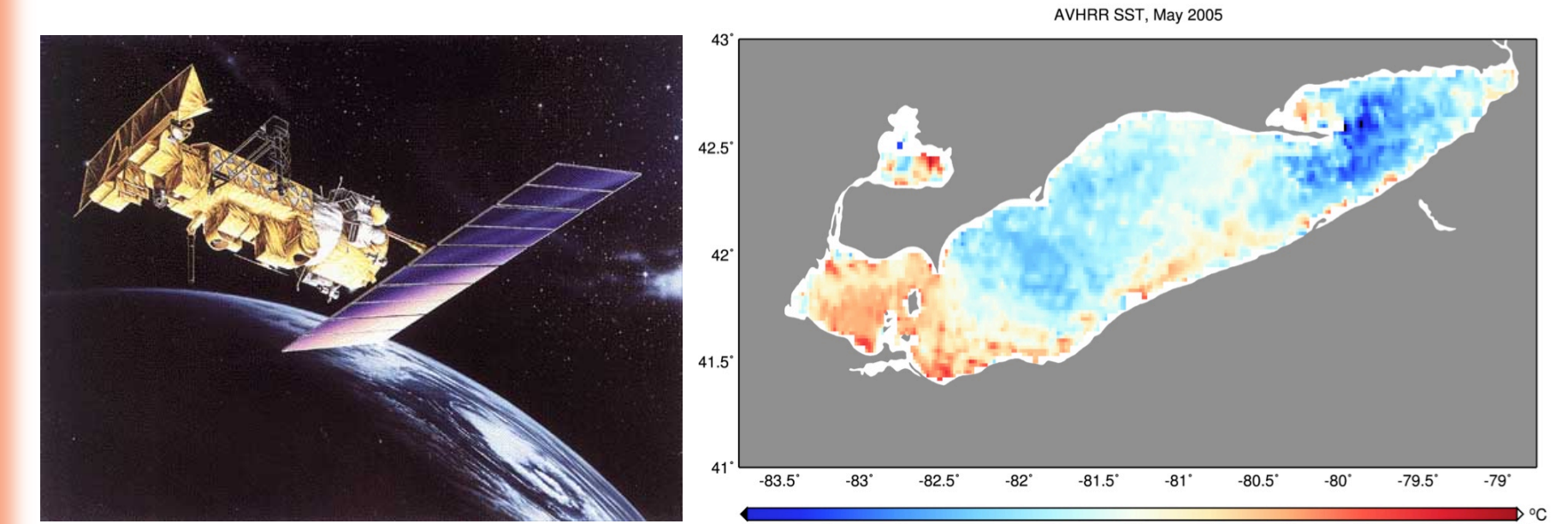
$$x^a = x^f + \delta x^f$$
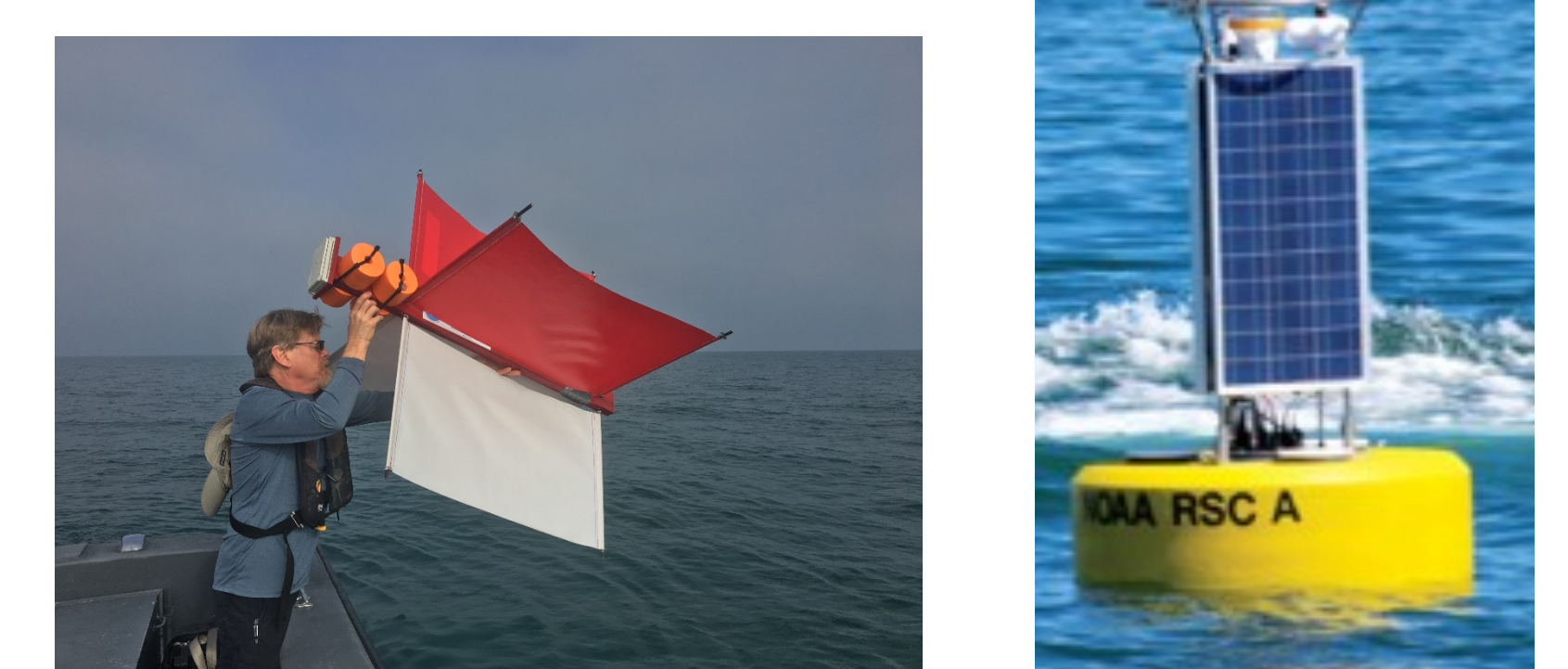


◆ **Ensemble Kalman filtering**
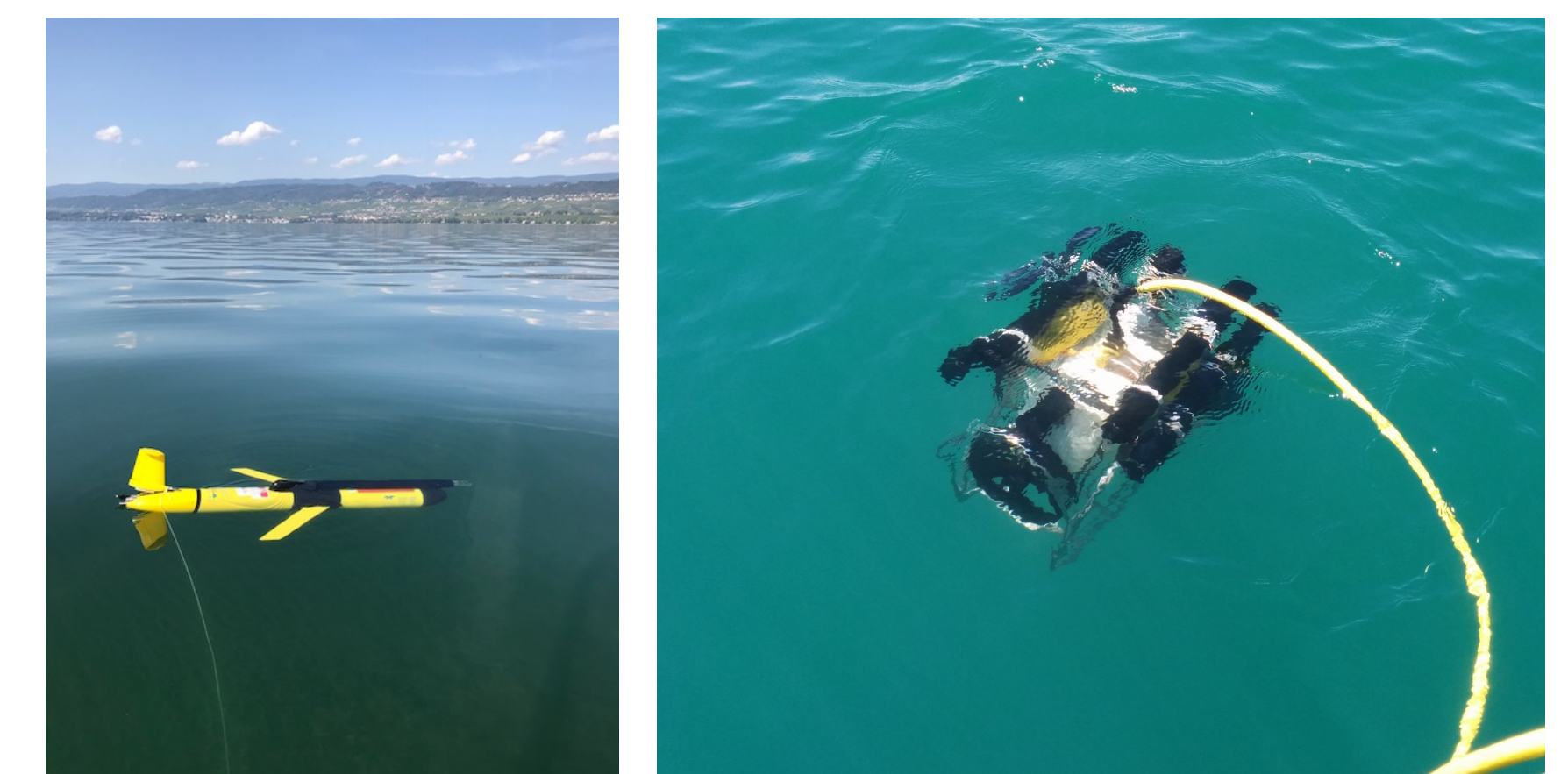


### Observations:

◆ **Remote sensing**



◆ **In-situ campaigns and stations**



◆ **AUVs & rovers**



## LESSONS LEARNED AND CHALLENGES

◆ Real-time monitoring networks
◆ Take full advantage of remote sensing and in-situ datasets
◆ Bi-national collaboration
◆ Engage stakeholders and users early
◆ Model coupling and Data Assimilation
◆ Competent teams that trust each other
◆ Frequent communications
◆ Adequate resources (staff and funding)
◆ Standard Operating Procedure and training

◆ Double resolution:     10X
◆ Model Coupling:        10X
◆ Data Assimilation:     10X
◆ Ensemble approach:     30X

### > 30,000X existing HPC power