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Comparison of Two Ways of Assimilating SWOT Observations using NCODA-4DVAR

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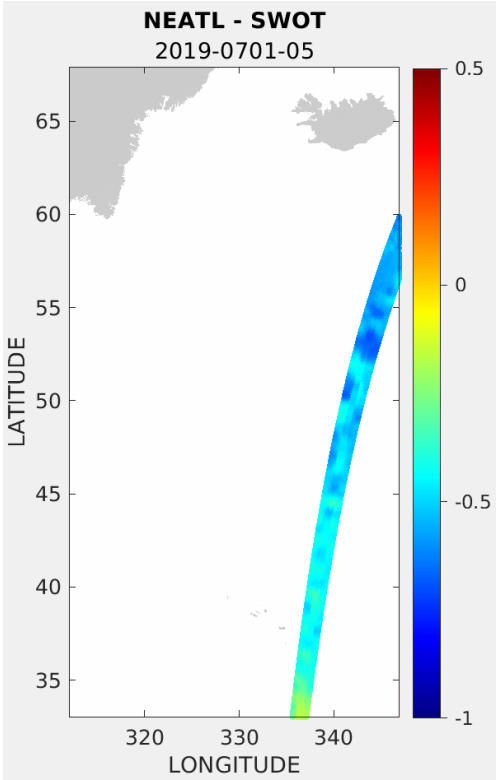
Ocean Dynamics and Prediction Branch

Overview

- **NASA's wide-swath Surface Water and Ocean Topography (SWOT) altimetry satellite**
  - sea surface height (SSH) observations
  - 1-2km spatial resolution over ~120km wide swath
  - 21 day repeat orbital cycle
- **Current operational data assimilation (DA) systems**
  - Designed for sparse datasets
  - Impacts the efficiency of assimilating dense observations
- **Investigate a direct approach for assimilating dense SSH observations**
- **Compare results with the current operational method**

Simulated SWOT Observations



SWOT SSH Observations

- Apply JPL's SWOT Simulator to provide simulated SWOT track locations and observations
- Observations sampled from a high-resolution operational model in the Northeast Atlantic Ocean

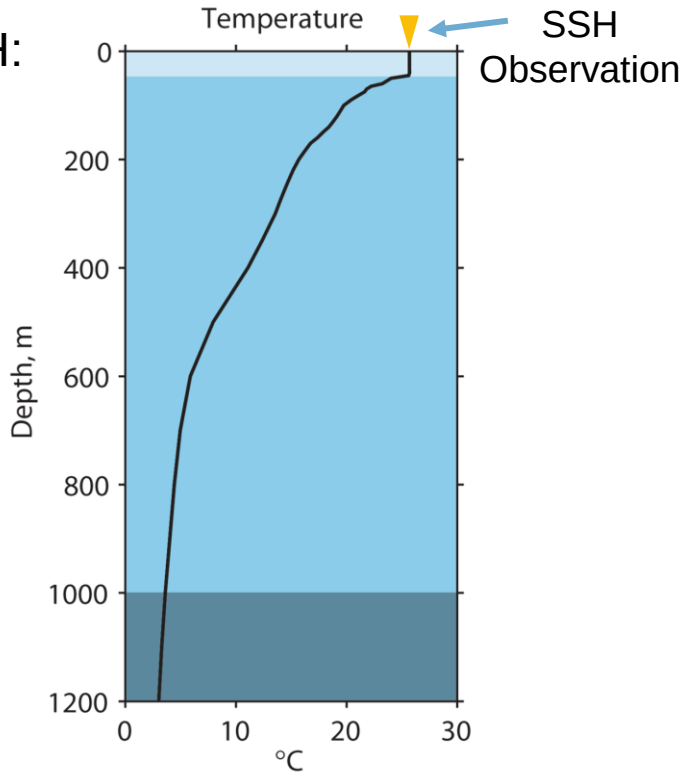
SWOT Simulator created by
Clement Ubelmann, Lucile Gaultier and Lee-Lueng Fu.
Jet Propulsion Laboratory, California Institute of Technology, CNES

Improved Synthetic Observation Profiles (ISOP)

Current operational method for assimilating SSH:

Improved Synthetic Observation Profiles (ISOP)

- Creates synthetic profiles of Temperature/Salinity
- Relies on statistical relationships between SSH and subsurface T/S
- Derived from very coarse historical observation coverage



Helber, R. W., T. L. Townsend, C. N. Barron, J. M. Dastugue, and M. R. Carnes. (2013). Validation Test Report for the Improved Synthetic Ocean Profile (ISOP) System, Part 1: Synthetic Profile Methods and Algorithm. NRL Report NRL/MR/7320, 13-9364

Direct Assimilation of SSH

Direct Assimilation of SSH

- Assimilates SSH observations directly with model SSH
- Substantial increase in the number of assimilated SSH observations

Four-Dimensional Variational (4DVAR) DA system

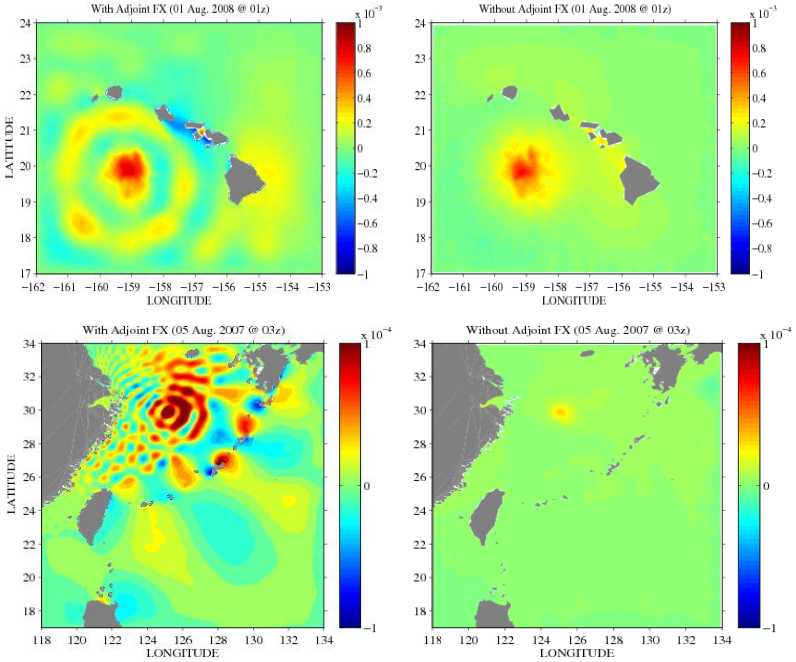
- Corrects over time and space
- Allows information from assimilated SSH observations to propagate to the subsurface

Ngodock, H., Carrier, M., Souopgui, I., Smith, S., Martin, P., Muscarella, P., and Jacobs, G.: On the direct assimilation of along-track sea-surface height observations into a free-surface ocean model using a weak constraints four-dimensional variational (4D-Var) method, Q. J. Roy. Meteor. Soc., 142, 1160–1170, https://doi.org/10.1002/qj.2721, 2015.

Direct Assimilation of SSH

Direct Assimilation of SSH in 4DVAR

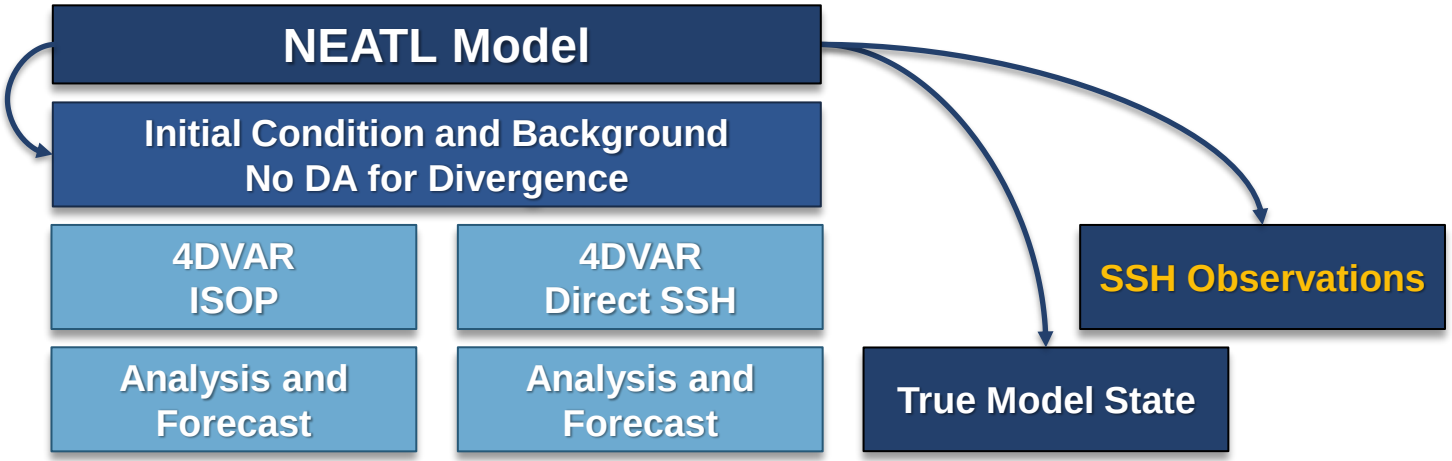
- Tangent linear and adjoint allows information from SSH to broadcast to the subsurface
- Surface gravity waves are a problem with free surface models
- SSH correction impulse in adjoint
- Tangent linear only corrects baroclinic portion in T/S



Technical Approach

Observing System Simulation Experiments (OSSE)

- Based on high-resolution model of the Northeast Atlantic Ocean (NEATL)

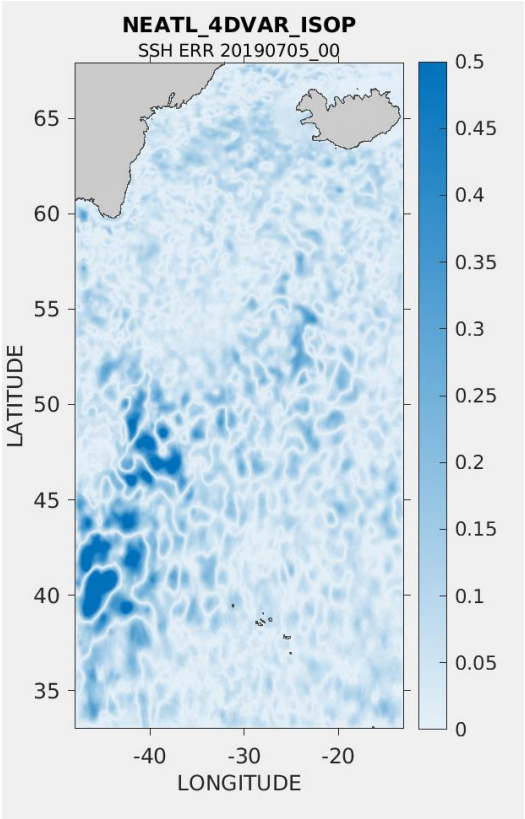


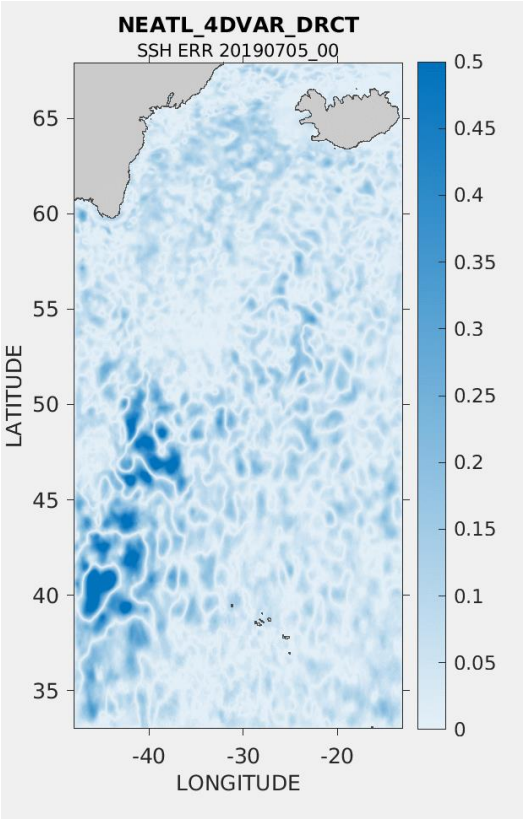
Navy Coupled Ocean Data Assimilation (NCODA, Cummings 2005)
Four-Dimensional Variational Method (4DVAR, Ngodock and Carrier 2014)

Absolute Error SSH

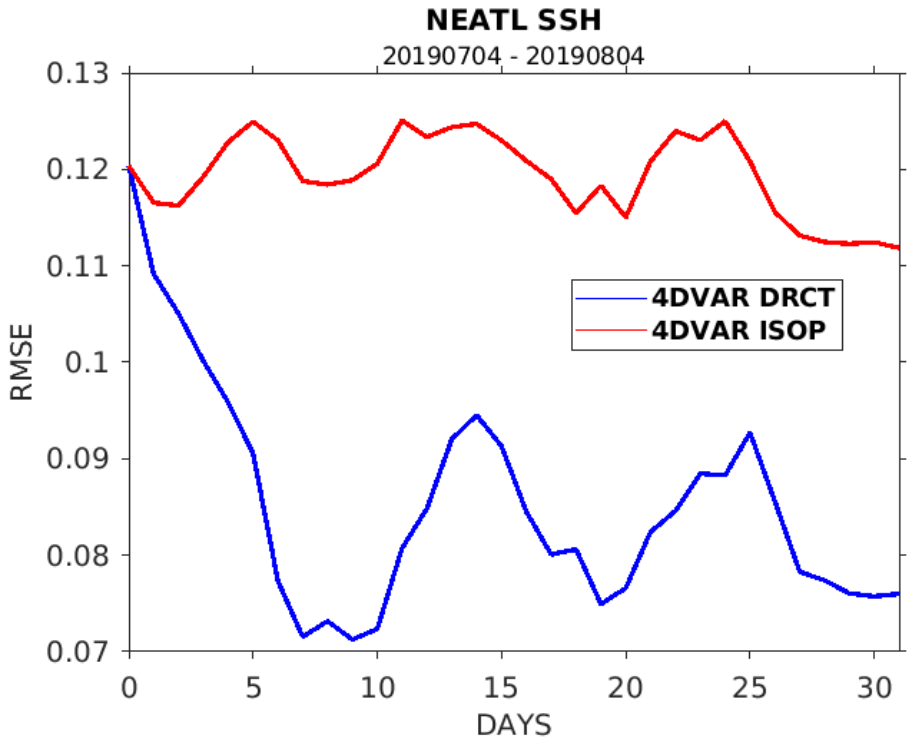
Absolute Error

- SSH error over time
- DA Model – True Model State
- First month (31 days) of model assimilating SWOT observations





Root Mean Square Error SSH



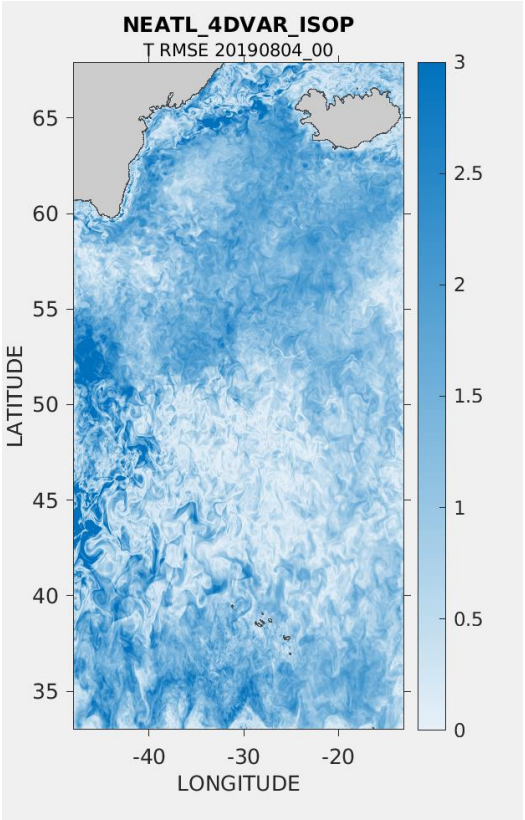
Root Mean Square Error (RMSE)

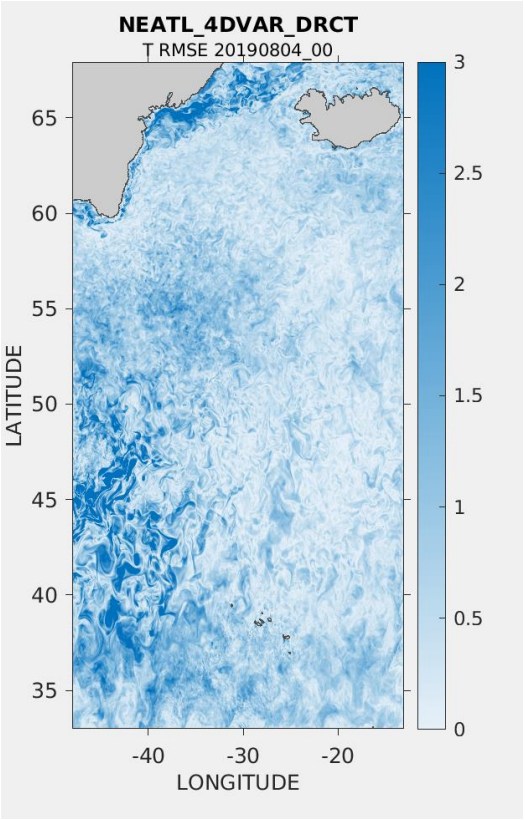
- RMSE of SSH
- DA Model vs True Model State
- First month (31 days) of model assimilating SWOT observations

RMSE Temperature 25m Depth

Vertical RMSE

- RMSE of temperature computed vertically over the first 25 meters of depth
- Analysis after one month (31 days) of assimilating SWOT observations





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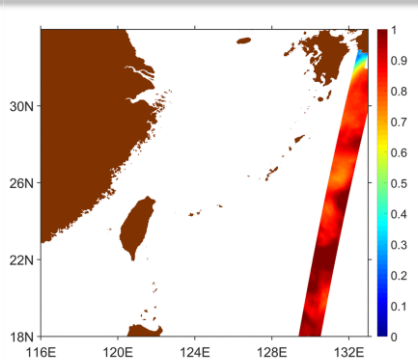

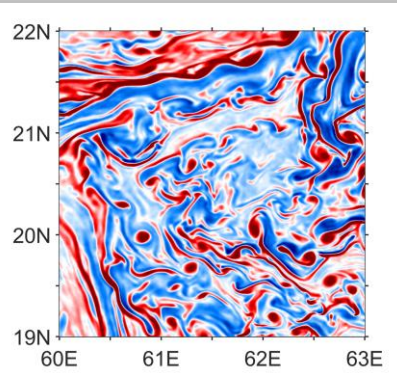

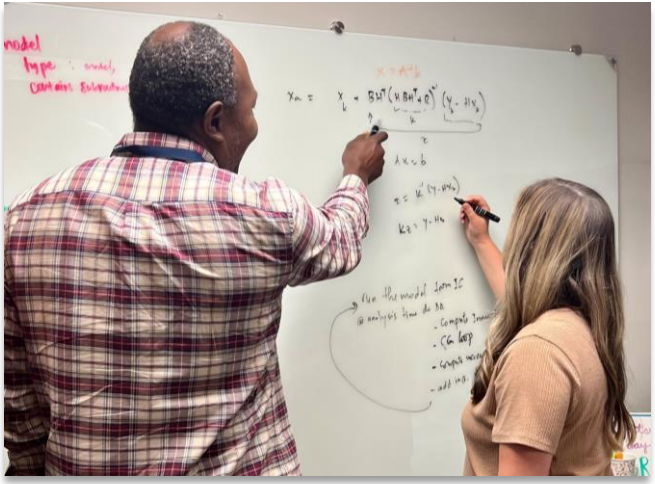

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