Improving Ocean Forecasts With Subsurface Data Assimilation In The Northeast Shelf Of New Zealand

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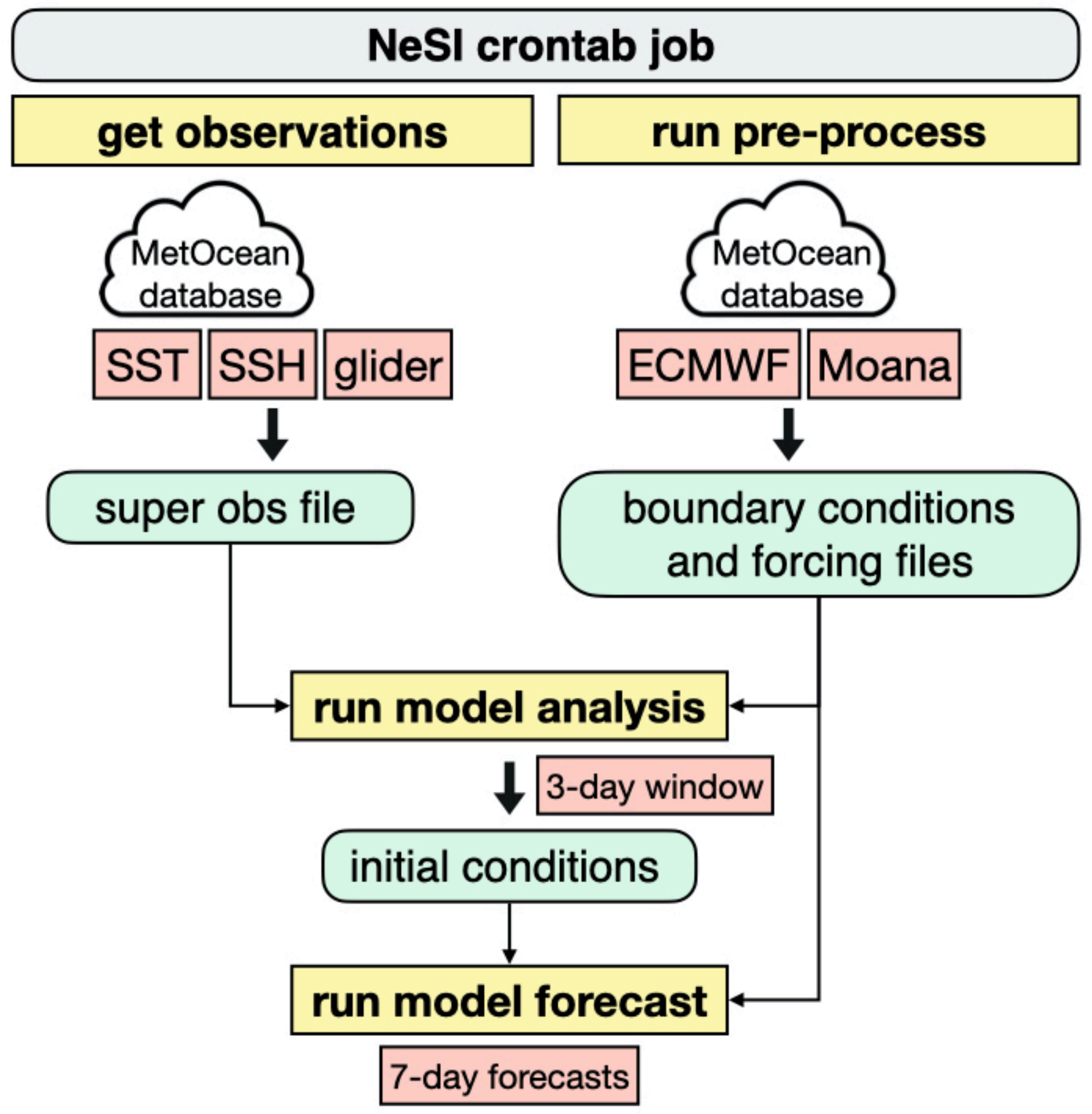
Introduction

A state-of-the-art ocean forecast system combines model and observations to provide the best representation of the ocean state. Our hypothesis is that substantial gains are obtained by assimilating subsurface high-resolution data from ocean gliders. Our goals are to implement a proof-of-concept forecast system with data assimilation in the northeast shelf of New Zealand, to evaluate model performance and to quantify the impact of adding subsurface data on the modeled ocean currents.

Model configuration

The model is based on the Regional Ocean Modeling System (ROMS) with an Incremental Strong-Constraint 4-D Variational scheme. The 2-km model grid is forced with ECMWF and nested into the Moana (NZ-wide) ROMS model (https://www.moanaproject.org/hindcast). The system is designed to assimilate satellite sea surface temperature (SST), sea surface height (SSH), and glider temperature (T) and salinity (S) over a 3-day window, which provide initial conditions to 7-day forecasts. Glider measurements were taken along the shelf break and continental slope during 2022 autumn season. The forecasts were performed for a total of 4 weeks, from March to April. Two experiments were conducted: E1, with satellite and glider assimilation, and E2, with satellite only.



NeSI crontab job

get observations

run pre-process

MetOcean database

SST SSH glider

MetOcean database

ECMWF Moana

super obs file

boundary conditions and forcing files

run model analysis

3-day window

initial conditions

run model forecast

7-day forecasts

Figure 1: Workflow of the operational forecasts for the Northeast New Zealand shelf running on the New Zealand eScience Infraestructure (NeSI) cluster.

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Results

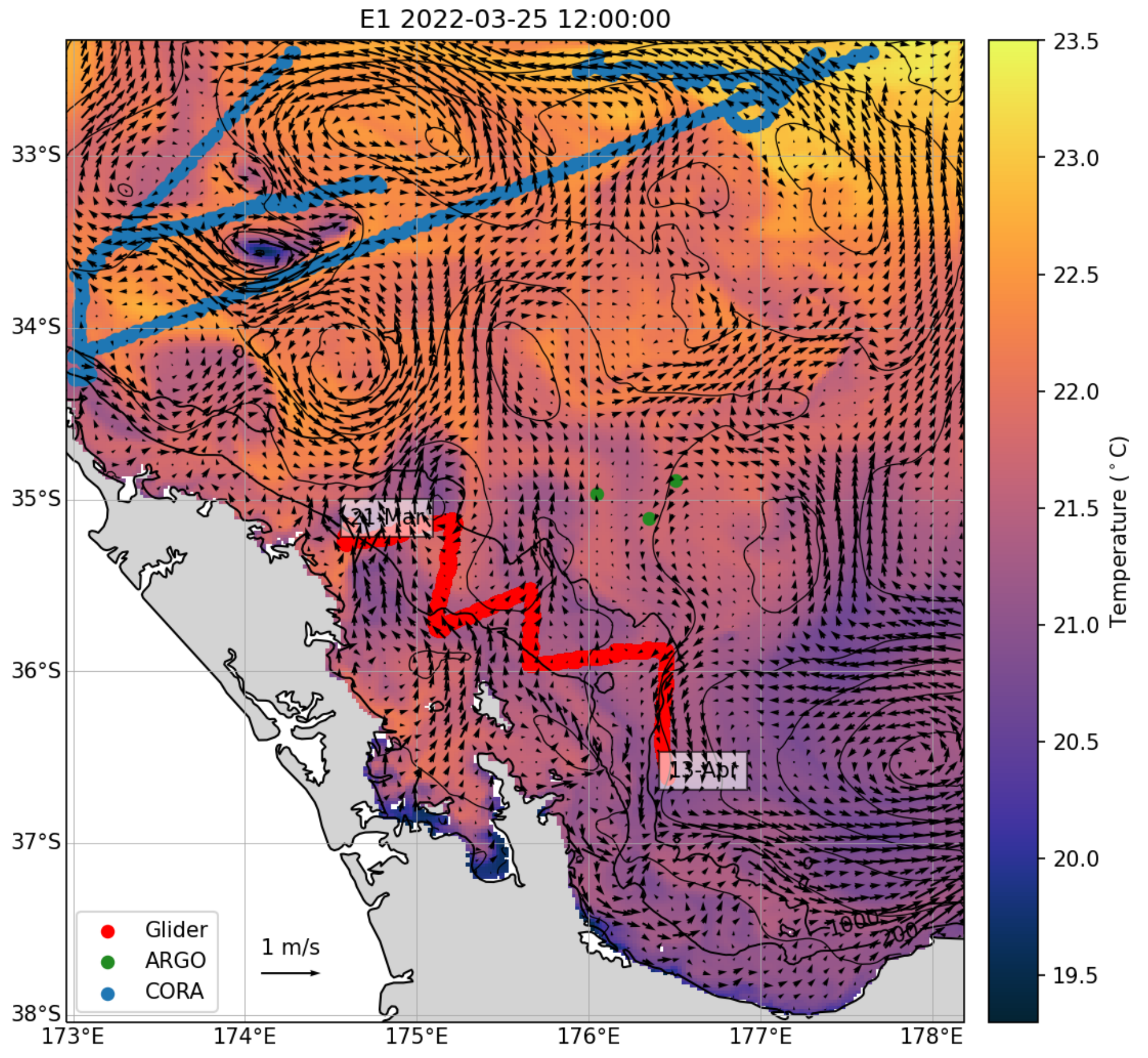

Figure 2: Modeled SST (color scale) and surface currents (black arrows) from E1 (satellite and glider) averaged over a day. The glider trajectory is shown in red. The independent datasets are shown in green (ARGO profiles) and blue (CORA surface drifters).

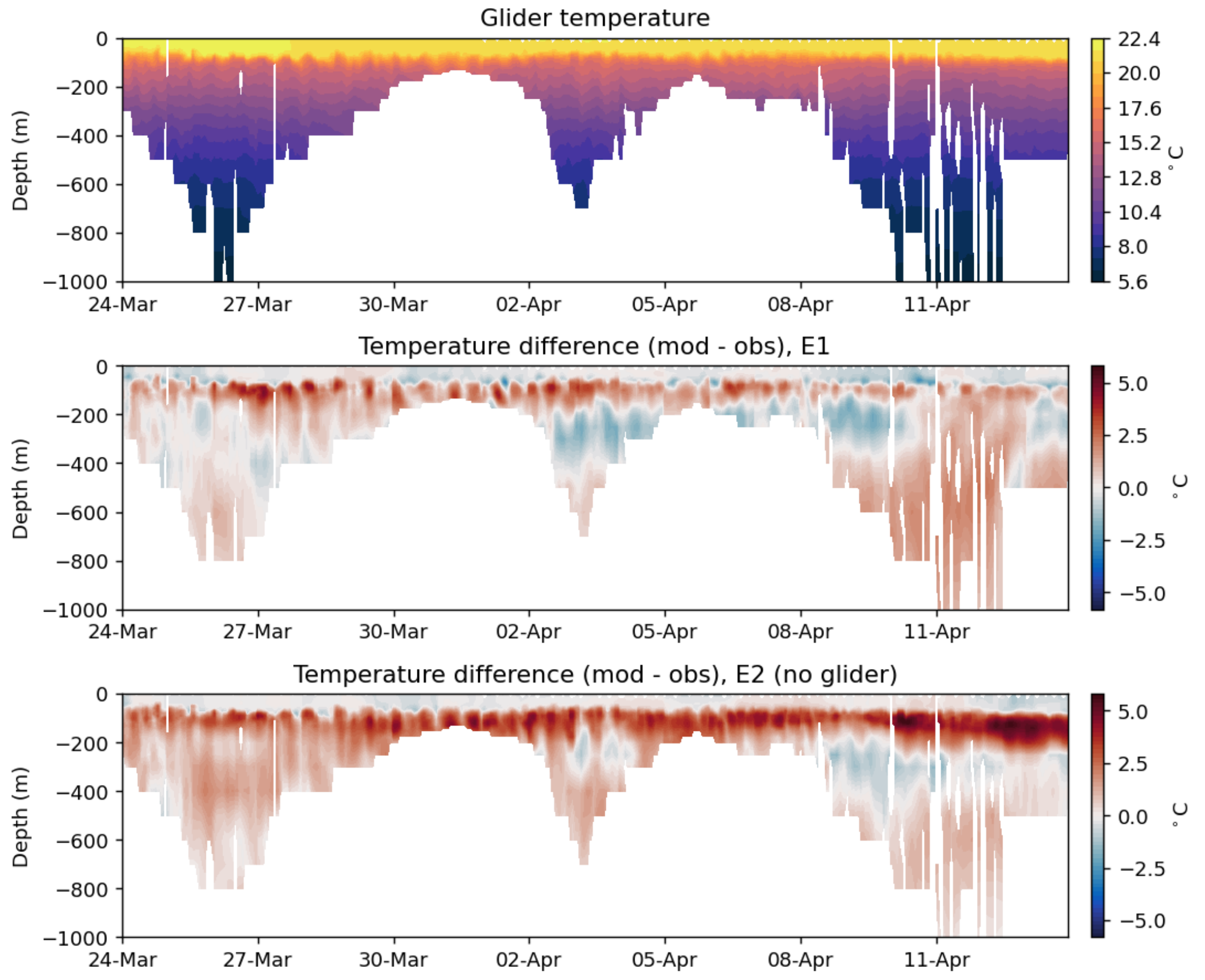

Figure 3: Glider T as a function of depth and time (top panel). Difference between modeled and observed T for E1 (middle panel) and E2 (bottom panel). Positive differences (red) mean that the model is warmer than the observation.

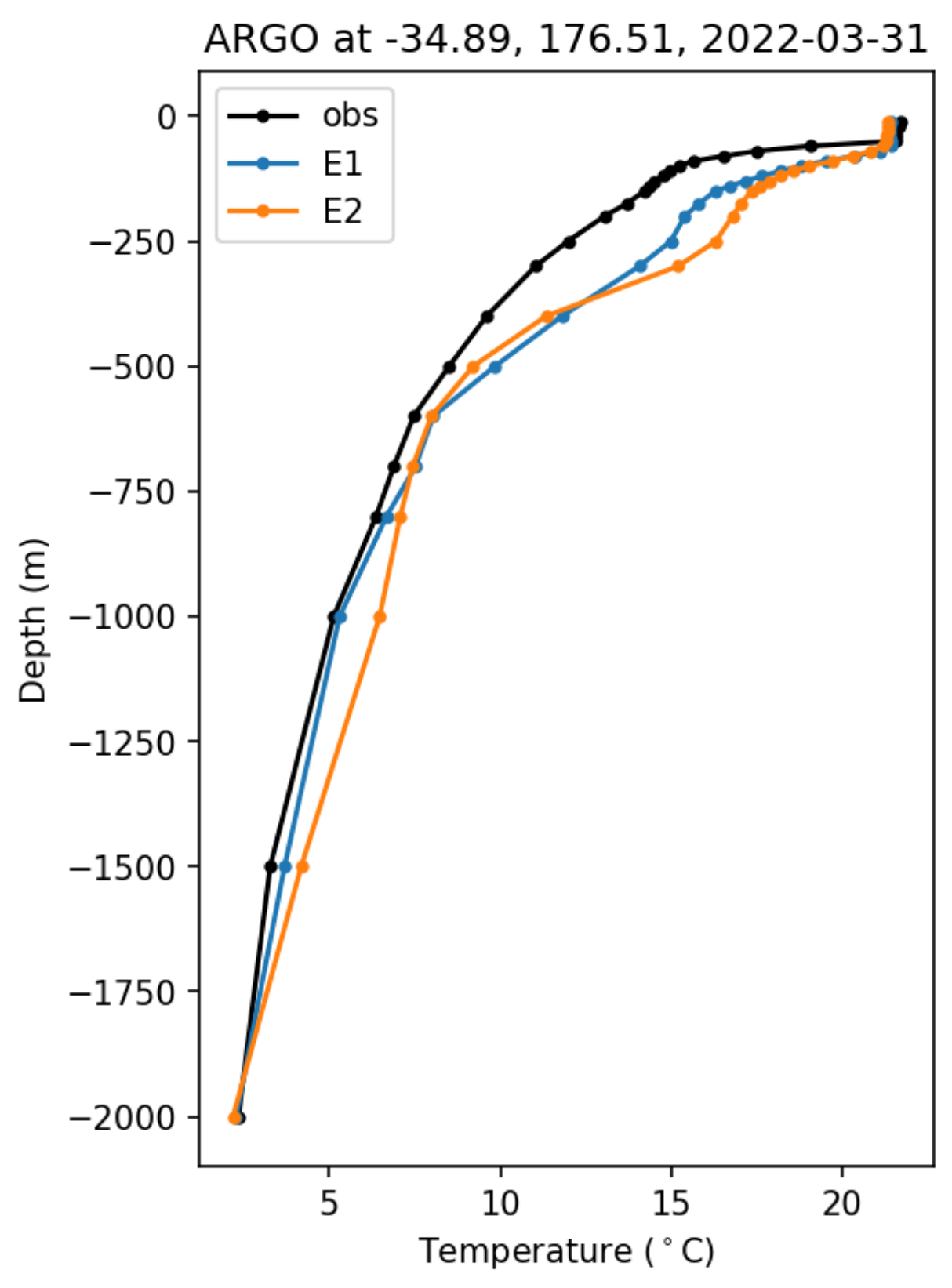

Figure 4: T profile from ARGO (black) and E1 (blue) and E2 (orange) experiments.

Discussion

The summary of model validation is shown in Table 1. The RMSE relative to the assimilated data was computed from the model nowcasts (first 24 h of each forecast cycle). The RMSE against independent T data represent the average over horizontal space and model forecast horizon.

Model performance of SST was better in E2 (no glider) for assimilated (SST) and independent (CORA) data, similar to what was found by Pasmans et al. (2019).

Greater improvement is seen for the 3D T when glider is assimilated, as shown by the bigger RMSEs in E2 for glider T and ARGO by 72% and 57%, respectively.

Figure 3 shows that the difference of the T over depth and time is bigger in E2 (no glider) and that the biggest improvement occur bellow the mixed layer depth.

The next step is to evaluate the impact of glider assimilation on the ocean currents dynamics.

Table 1: Root mean square error (RMSE) of model experiments in relation to the assimilated data (SST, SSH and glider) and the independent data (ARGO profiles and CORA surface drifters).

RMSE	E1 (sat and glider)	E2 (no glider)
SST (°C)	0.39	0.34
SSH (m)	0.09	0.10
Glider T (°C)	**1.21**	**2.08**
Glider S	0.18	0.17
ARGO T (°C)	**1.80**	**2.83**
CORA T (°C)	0.52	0.46

References

Pasmans, I., Kurapov, A. L., Barth, J. A., Ignatov, A., Kosro, P. M., & Shearman, R. K. (2019). Why Gliders Appreciate Good Company: Glider Assimilation in the Oregon−Washington Coastal Ocean 4DVAR System With and Without Surface Observations. *Journal of Geophysical Research: Oceans*, *124*(1), 750-772.