Measurement and modeling of small-scale to meso-scale features in a western boundary current

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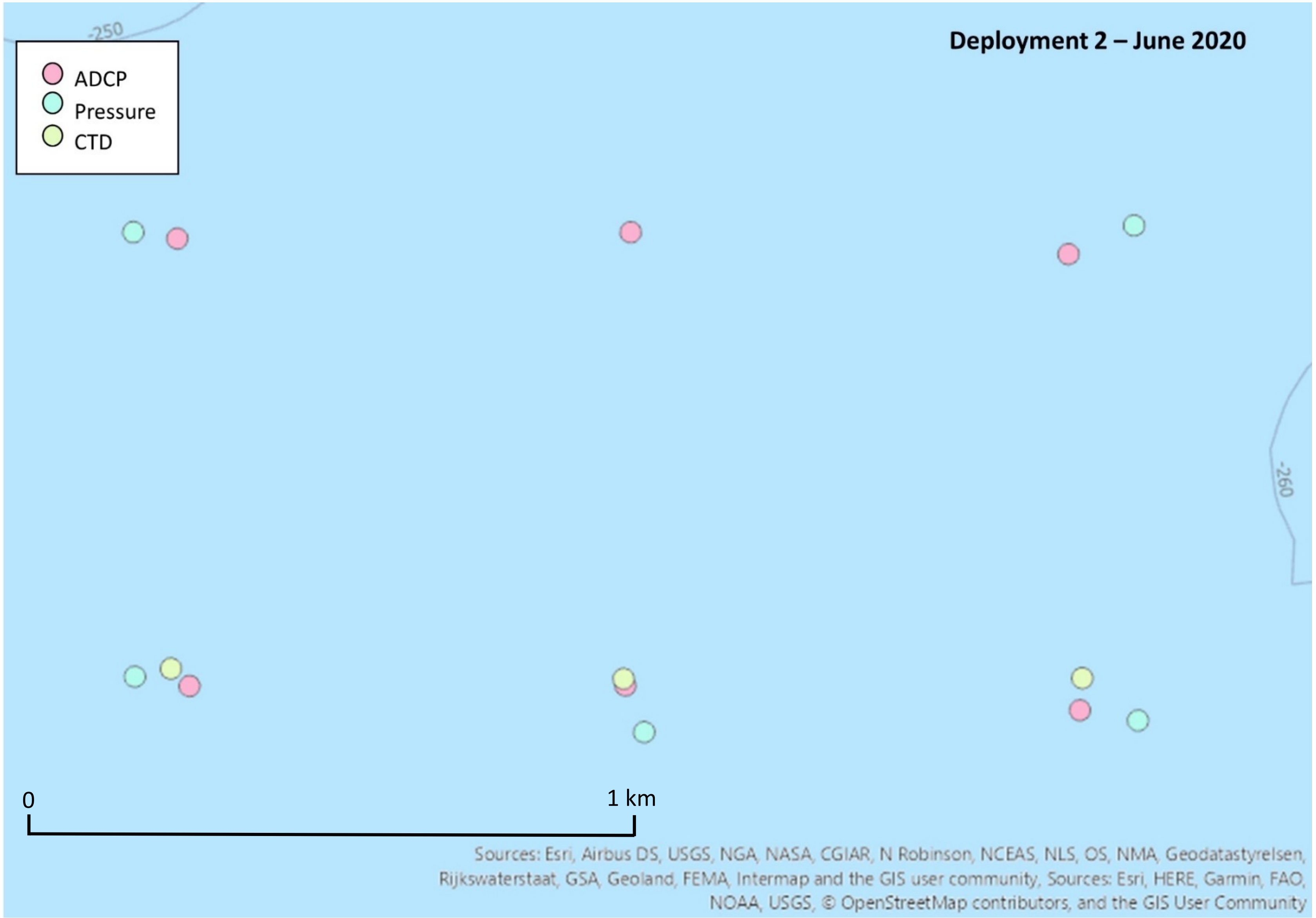
Introduction

- Predicting ocean circulation remains challenging because of modelling capabilities such as resolution.
- Sub-mesoscale flows have a length of 0.1-10 km and are sometimes difficult to observe in the ocean and model because of their short timescales and small length scales.
- Resolving the range of from small-scales (below 0.1 km) to sub-mesoscales is a big challenge in a strong current like a western boundary current.
- The Florida Current is characterized by intense mesoscale (>10 km), sub-mesoscale, and small-scale variability including a variety of features such as meanders, eddies, fronts, and internal waves that are caused by the flow over a variable bottom topography and air-sea interaction.
- Here we have implemented an engineering type modeling - Computational Fluid Dynamics (CFD) – to predict ocean circulation in strong currents in the range from small-scales to sub-mesoscales.

(Morey et al. 2017)

Study Area


Deployment 2 – June 2020
ADCP
Pressure
CTD
-250
-260
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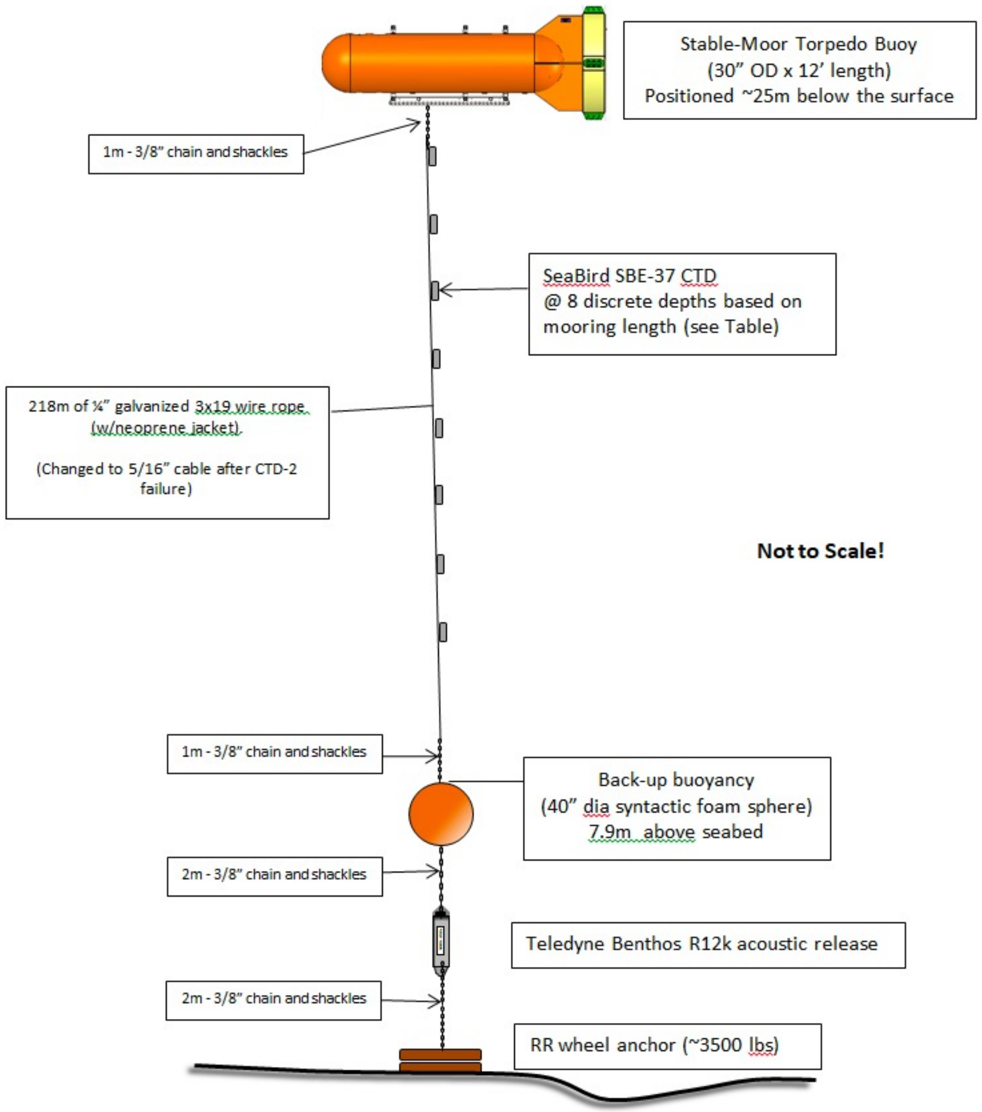
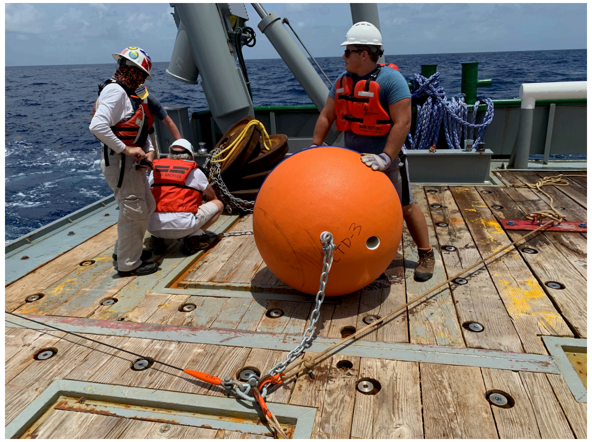
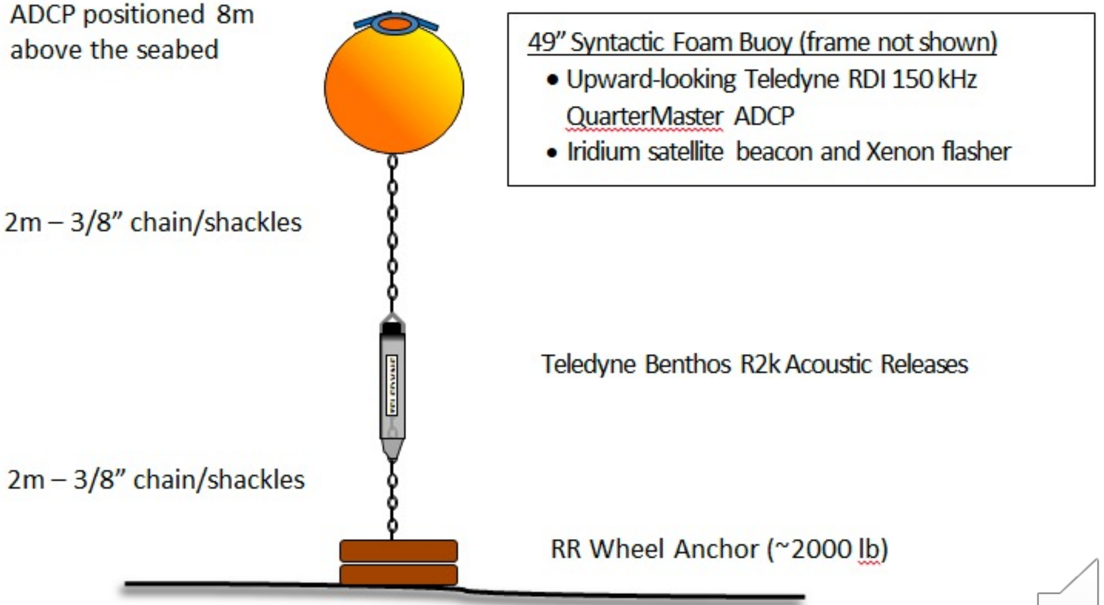
1 km
Sources: Esri, Airbus DS, USGS, NGA, NASA, CGIAR, N Robinson, NCEAS, NLS, OS, NMA, Geodatastyrelsen, Rijkswaterstaat, GSA, Geoland, FEMA, Intermap and the GIS user community, Sources: Esri, HERE, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors, and the GIS User Community

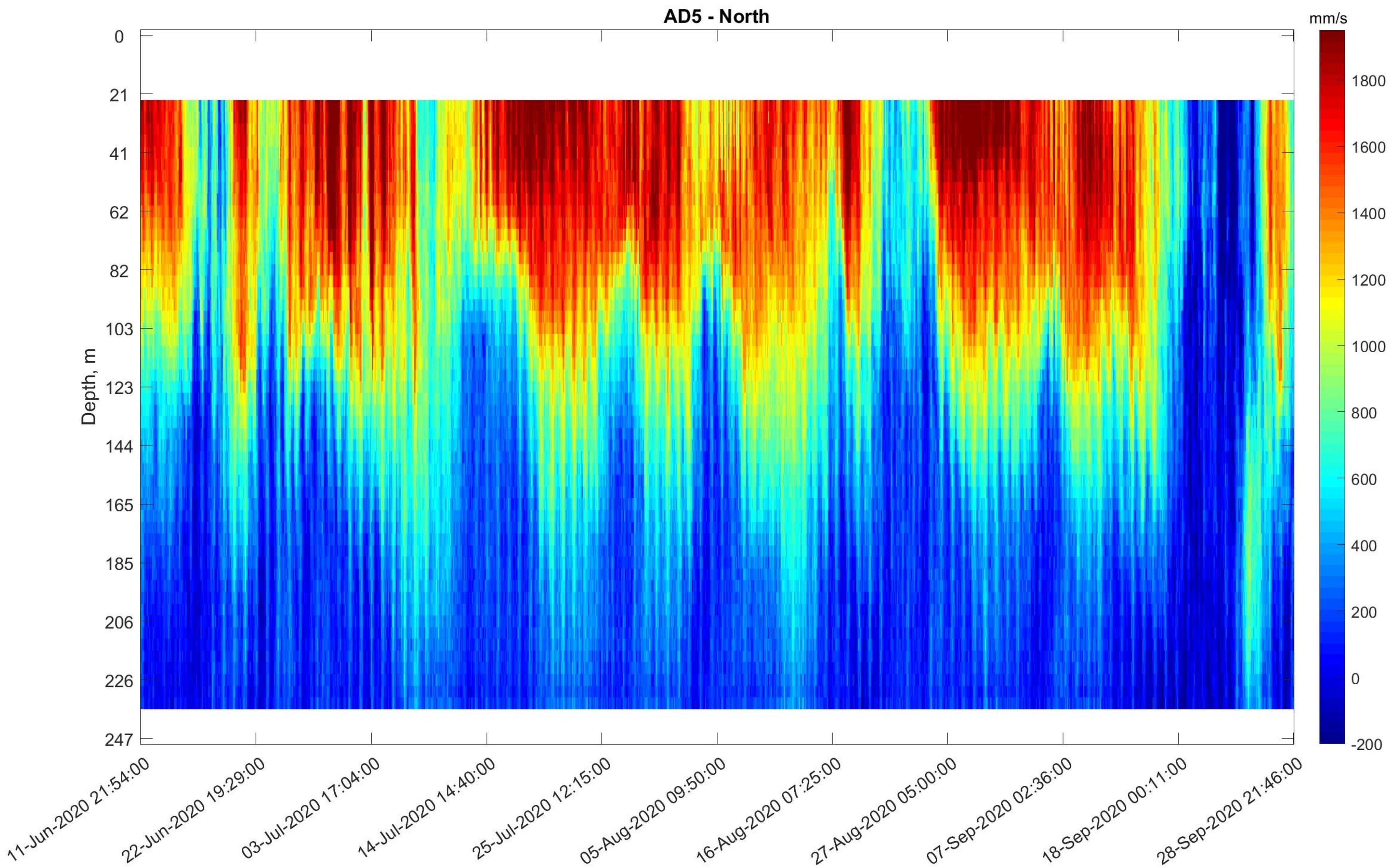
Measurements



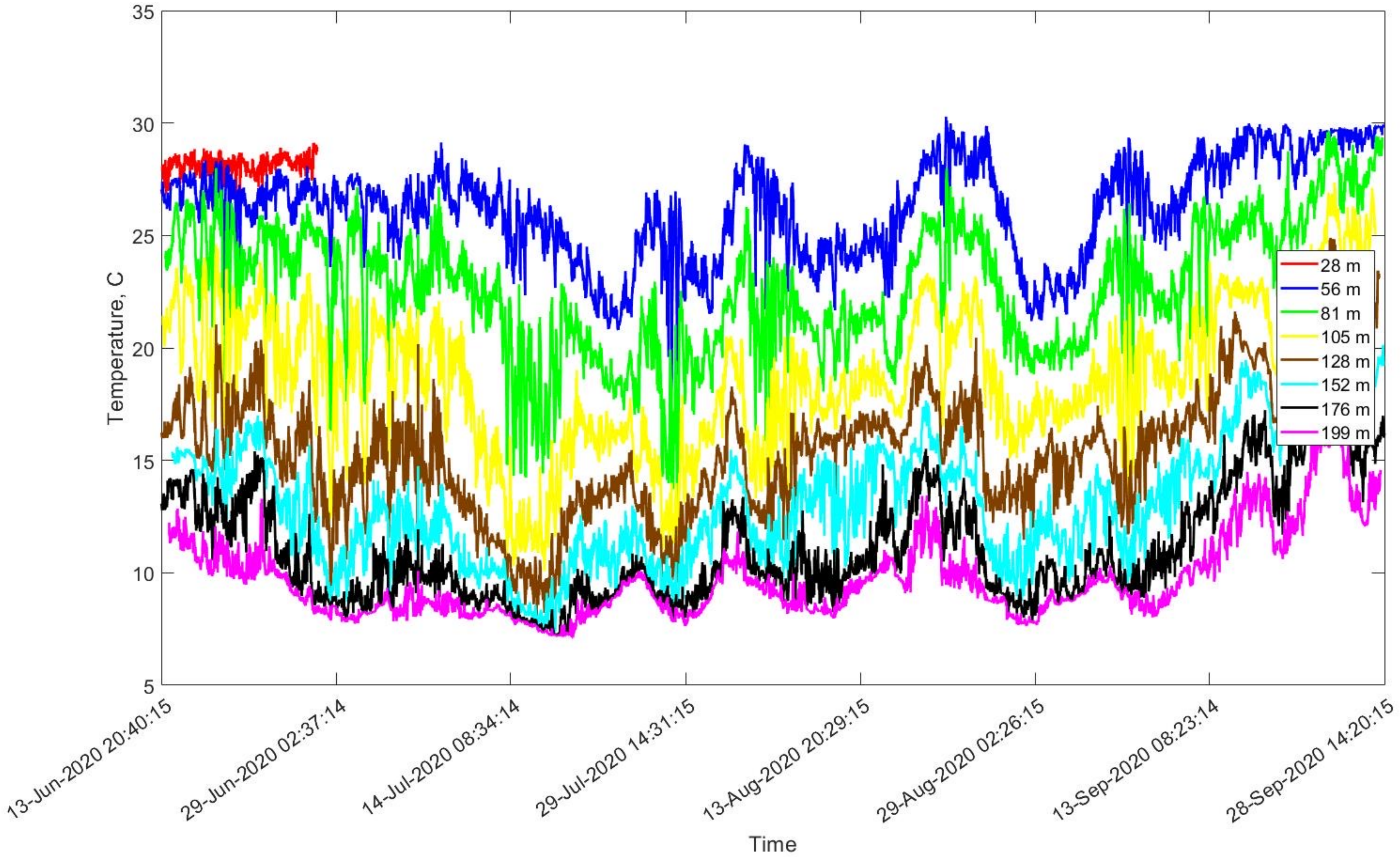




Measurements



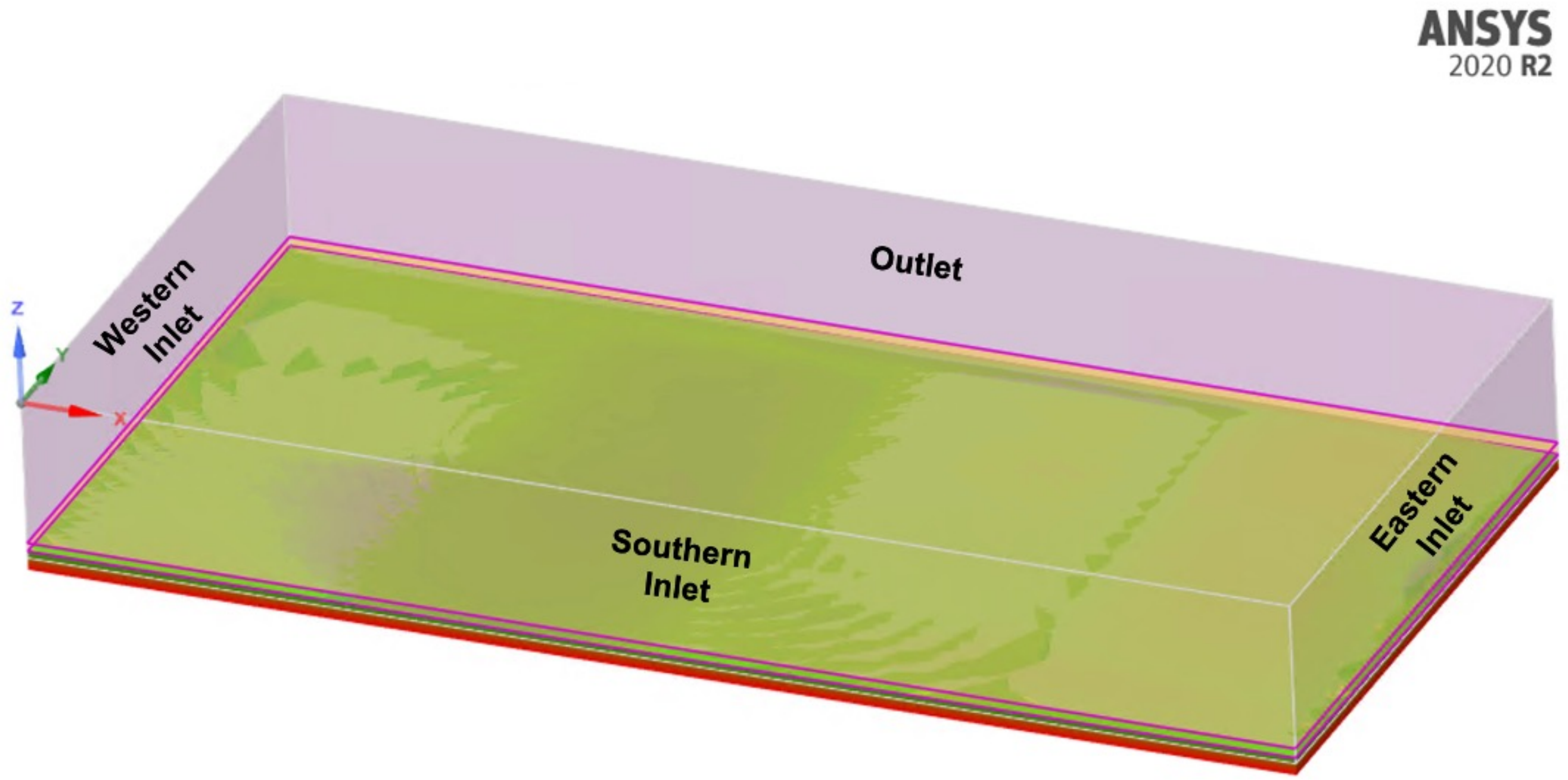
Measurements



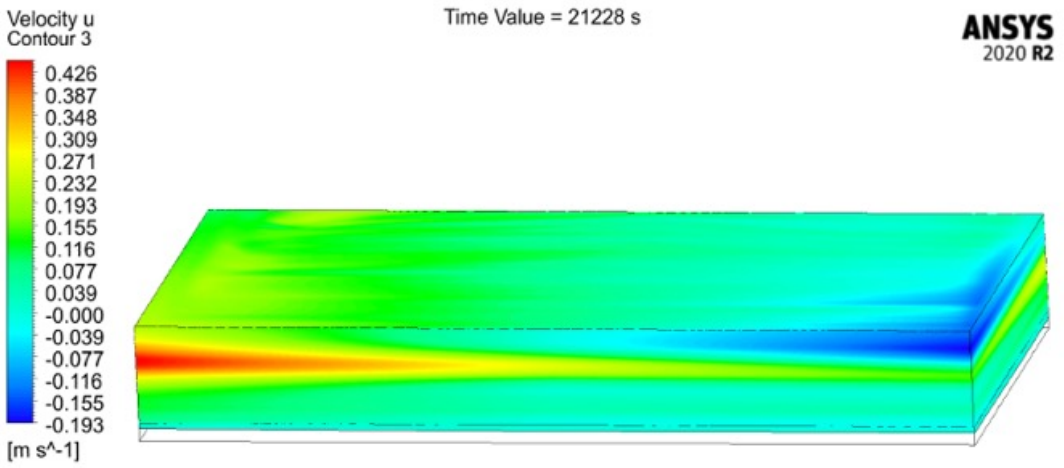
Computational Fluid Dynamics model

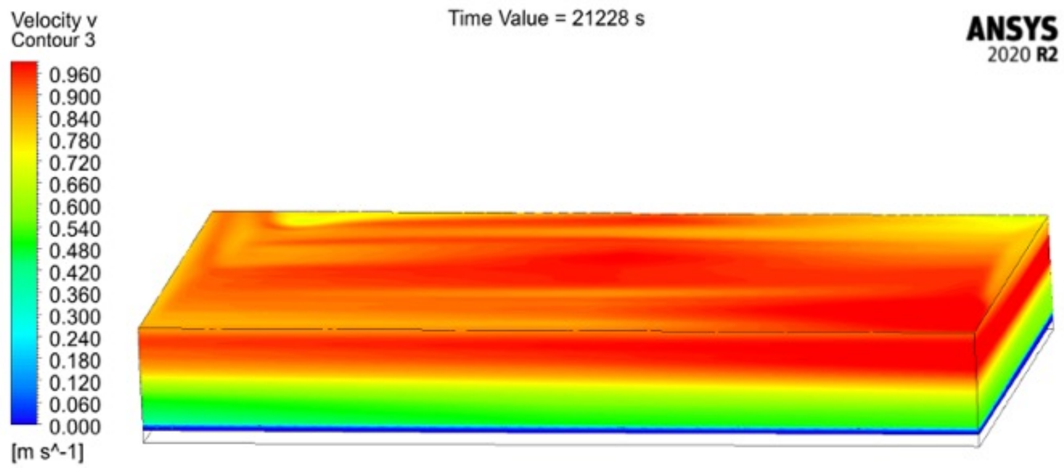
- ANSYS Fluent CFD software provides a large assortment of physical model capabilities, including flow, turbulence, multiphase, and heat transfer that have been validated and produce highly accurate results.
- CFD, while computationally expensive, provides a rigorous nonlinear treatment of the Navier-Stokes equations involved in modeling mass and momentum transfer, critical to fluid dynamics.
- In this work we demonstrate that validated CFD simulations combined with field data provide an effective way to assimilate available oceanic information and predict small-scale to sub-mesoscale processes in the area of interest within a certain time range.

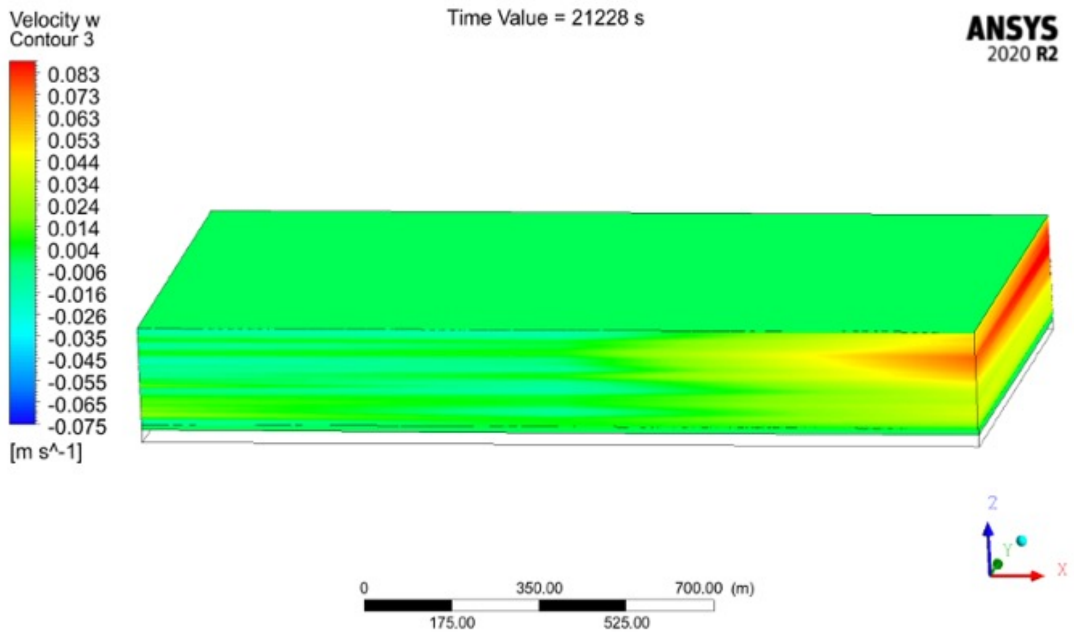
Model domain

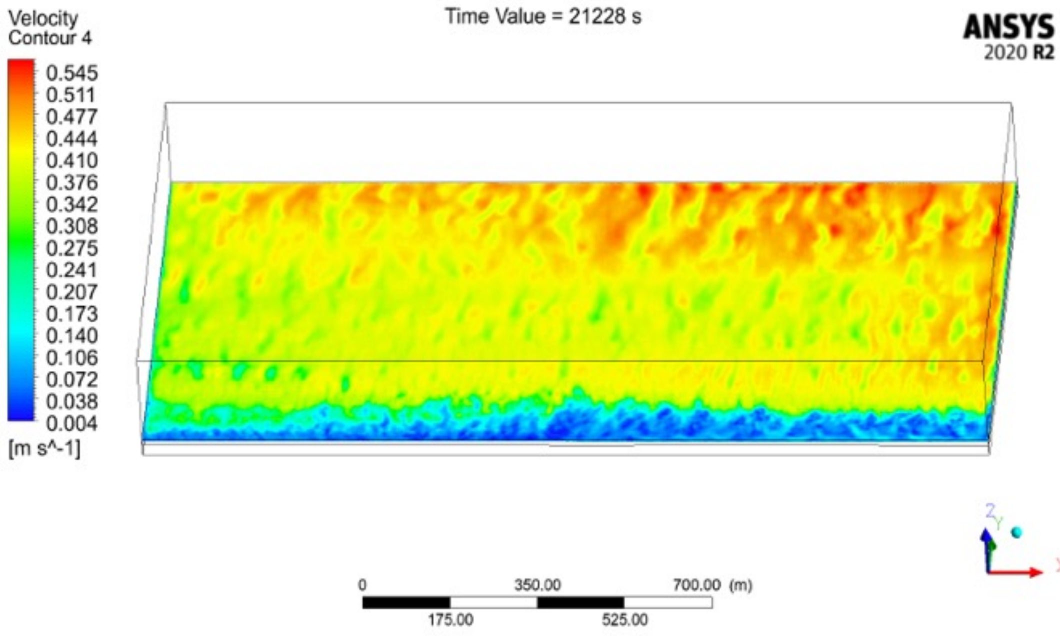


Results from CFD model

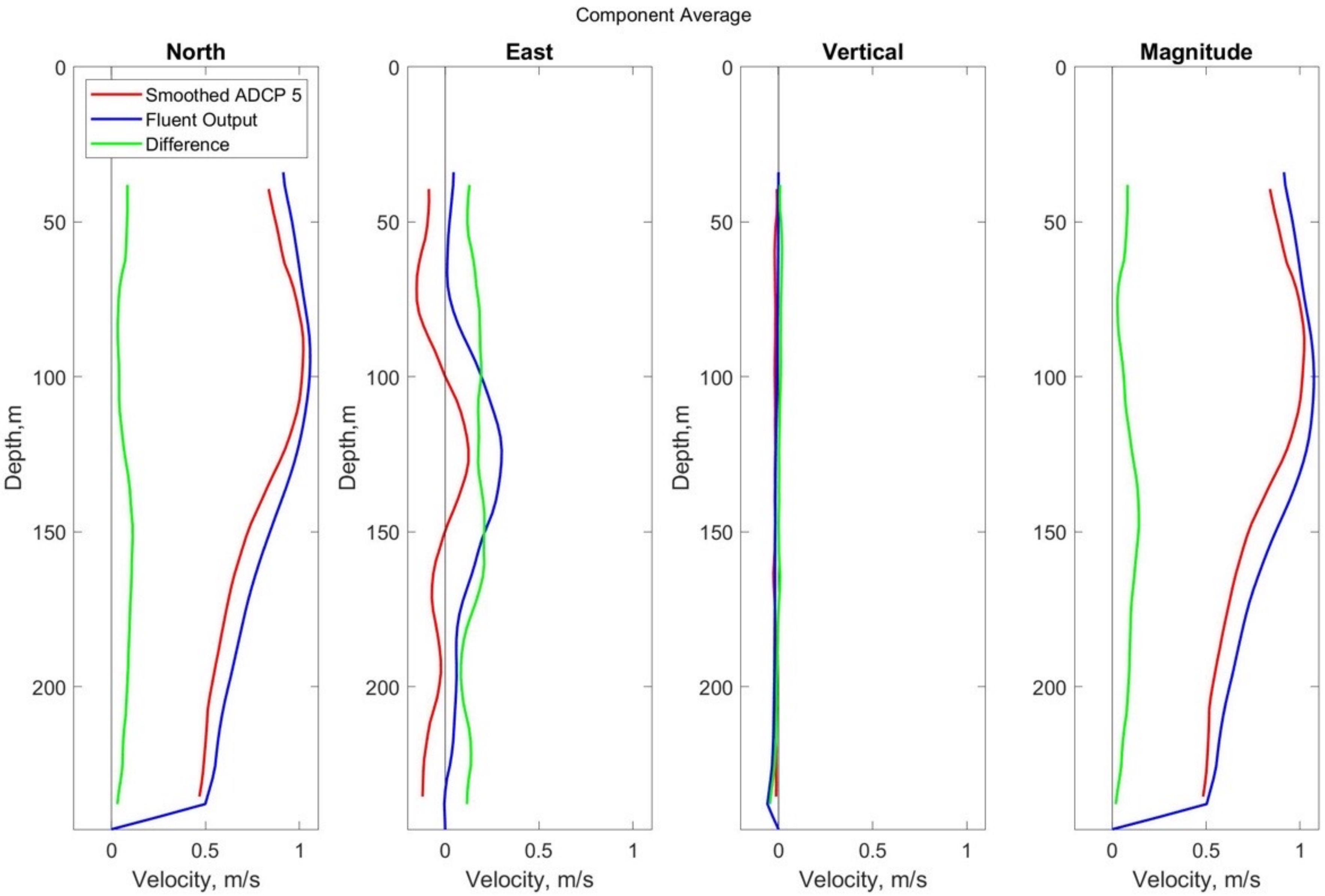








Model comparison to field data



Conclusions

- We have proposed a modeling approach for predicting the ocean circulation in strong currents in the range from small-scales to sub-mesoscales.
- This approach has been verified with field data from the Straits of Florida.
- According to the results of the field data comparison, the model has good predictive skills in the challenging environment of a strong western boundary current and is potentially able to cover the range of ocean features from small-scales to sub-mesoscales.
- This data assimilation approach combining field and modeling results may help to close the information gap between small-scale and sub-mesoscale ocean circulation in strong western boundary currents.
- We anticipate this result is a starting point for sophisticated high-resolution models applicable to western boundary currents in other locations such as the Kuroshio Current or Agulhas Current where circulation on small to medium scales is difficult to predict.

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