Lagrangian Ocean Analysis at NCMRWF

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Lagrangian ocean analysis provides powerful tools to study ocean dynamics, circulation, transport and mixing. This approach follows the Lagrangian perspective of fluid flow, which focuses on individual particles as they move through the ocean. Trajectories of virtual fluid particles are tracked through three-dimensional, time-varying velocity fields, from ocean general circulation models reanalysis/analysis/forecast or satellite observations. Initially, the Lagrangian methods have been mostly used to track the movement of fluid parcels in the ocean, using instruments like drifters and floats to study circulation. Lagrangian methods are gaining interest with the availability of high-resolution model outputs for development of many practical applications in the fields of physical, chemical and biological oceanography.

Recently, at the National Centre for Medium Range Weather Forecasting (NCMRWF), Lagrangian methods are adapted to carry out studies on three dimensional pathways, transports and mixing in the Indian ocean using the daily 8 year NEMOVAR ocean analysis produced at NCMRWF. The NEMOVar is a 3-D variational ocean data assimilation (ODA) system using the Nucleus European Modelling of the Ocean (NEMO) ocean model and the Los Alamos sea ice model (CICE) as physical model. The NEMO model system configuration at NCMRWF has quarter degree horizontal resolution with 75 layers in vertical. This system assimilates satellite and in-situ sea surface temperature (SST), in-situ temperature and salinity profiles in vertical, satellite sea level anomaly (SLA) observations and sea ice concentrations. The ocean analysis is used routinely to initialize the ocean forecast. This system has been used at NCMRWF from May 2016 and not included any change in this NEMO assimilation-forecast since then. The present study used the daily analysis generated by the NEMOVar for the last 8 years (2016 to 2024). The

Lagrangian ocean analysis presented here used this 8 years NEMOVar analysis of NCMRWF.

Different tools are developed using the Lagrangian analysis for monitoring and forecasting related to eddy movement & ocean fronts, pollution/plastic tracking/dispersal, marine environment and ecosystems, using the analysis and the forecast fields. The potential applications of Lagrangian analysis also include oil spill prediction, biological connectivity, search and rescue operations, fisheries management, monitoring & predicting of marine organisms, etc. The lagrangian analysis can be used in combination with satellite data and in-situ data to study biological processes like plankton dynamics, larval distributions and whale migrations.

It is planned to use of machine learning techniques to improve the accuracy of the Lagrangian analysis and improve computational efficiency. This helps in handling large datasets and complex analyses more effectively. These advancements enhance our ability for improved ocean monitoring and conservation efforts.