Impact of Assimilating in-situ Data Sources on Model Predictions of Refractivity, Ducting and EM Propagation

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The performance of Numerical Weather Prediction (NWP) models is dependent upon the observational data sources that are assimilated at the start of every forecast cycle. A global network of data is routinely collected, preprocessed, and quality controlled in preparation for data assimilation (DA) via 4- or 3-dimensional variational methods. Such data include surface stations, buoys, ship-board and aircraft observations, satellite SST and winds, and vertical profiles from radio-sondes. However, many regions around the globe are data voids or have very sparse observations, often occurring across the world's oceans, seas, and large bodies of water. Further, NWP models are typically run at very high resolutions over a limited area to resolve features of the local mesoscale weather. In this case, there are few observations within the model domain to adjust and correct the state variables (i.e. winds, pressure, air and sea surface temperature, moisture). These variables are used to diagnose atmospheric refractivity, which is subsequently analyzed to yield the expected electromagnetic (EM) propagation regime of each layer of the atmosphere, revealing normal refraction, sub-refraction, super-refraction, or trapping conditions.

In this study, we simulate in-situ observations from environmental sensors already on U.S. Navy ships and aircraft, as well as additional hypothetical new sensors placed on various fleet platforms. Those data are assimilated independently and collectively to gauge their ability to impact NWP model performance for parameters important to EM propagation prediction. The relevant diagnostic parameters are the vertical profile of refractivity, the vertical gradient of refractivity, the EM propagation regime, and the evaporation duct (a surface duct oft present over water owing to the sharp moisture gradient due to evaporation), and the relevant metric is the mean absolute difference (MAD), between the control NWP run having traditional data and each NWP sensitivity run having traditional plus new in-situ data sources in the DA process. The MAD results suggest that substantial gains in model predictions can be realized if all of the current fleet sensor observations are assimilated. Ship board relative humidity measurements appear to have the greatest single impact of all potential new in-situ data sources investigated.