Maritime Battlespace Awareness and Prediction: Environmental Decision Superiority for Assured Access

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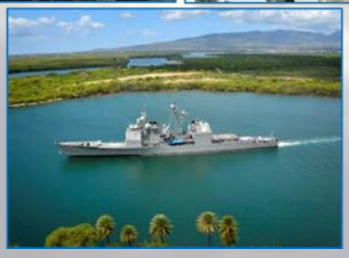
Although many people think of weather as inherently unpredictable, and discussing the inaccuracy of the local forecast is often a favorite pastime, today's forecast skill at three to four day lead times is actually better than the forecast was at even one day 30 years ago. The military has always relied on accurate ocean and weather prediction as a critical part of intelligence preparation for planned operations. As far back as 350 B.C. in "The Art of War", Sun Tzu advised "Know the ground, know the weather; and your victory will then be total." Through better understanding of the underlying physics, increased use of satellite-based and autonomous observations, and the use of more powerful supercomputers, ocean and atmospheric modeling, simulation and prediction have improved dramatically at short to medium range lead times—to the point where the forecast accuracy (skill) for conditions at a day or two may be approaching the limits of deterministic predictability. As our understanding of the underlying maritime processes has improved, a new opportunity exists for extending the forecast to longer lead times as a set of probabilities rather than an exact value while quantifying forecast uncertainty to permit proactive, deliberate planning rather than reactive hazard avoidance and mitigation.

"Battlespace Awareness will require enhanced information content, advanced means to rapidly sense, collect, process, analyze, evaluate and exploit intelligence regarding our adversaries and the operating environment. Our information will serve as the basis from which nearly all decisions will be made, enabling our forces to more effectively maneuver and coordinate actions that target and engage enemy forces. [Our forces will] access predictive weather, spectrum and network models that are fully coupled with land, air, ocean, sea ice and cyber models and incorporate ensembles, variable resolutions and confidence levels to produce more accurate [long range] weather forecasts." - *Information Dominance Roadmap 2013-2028*



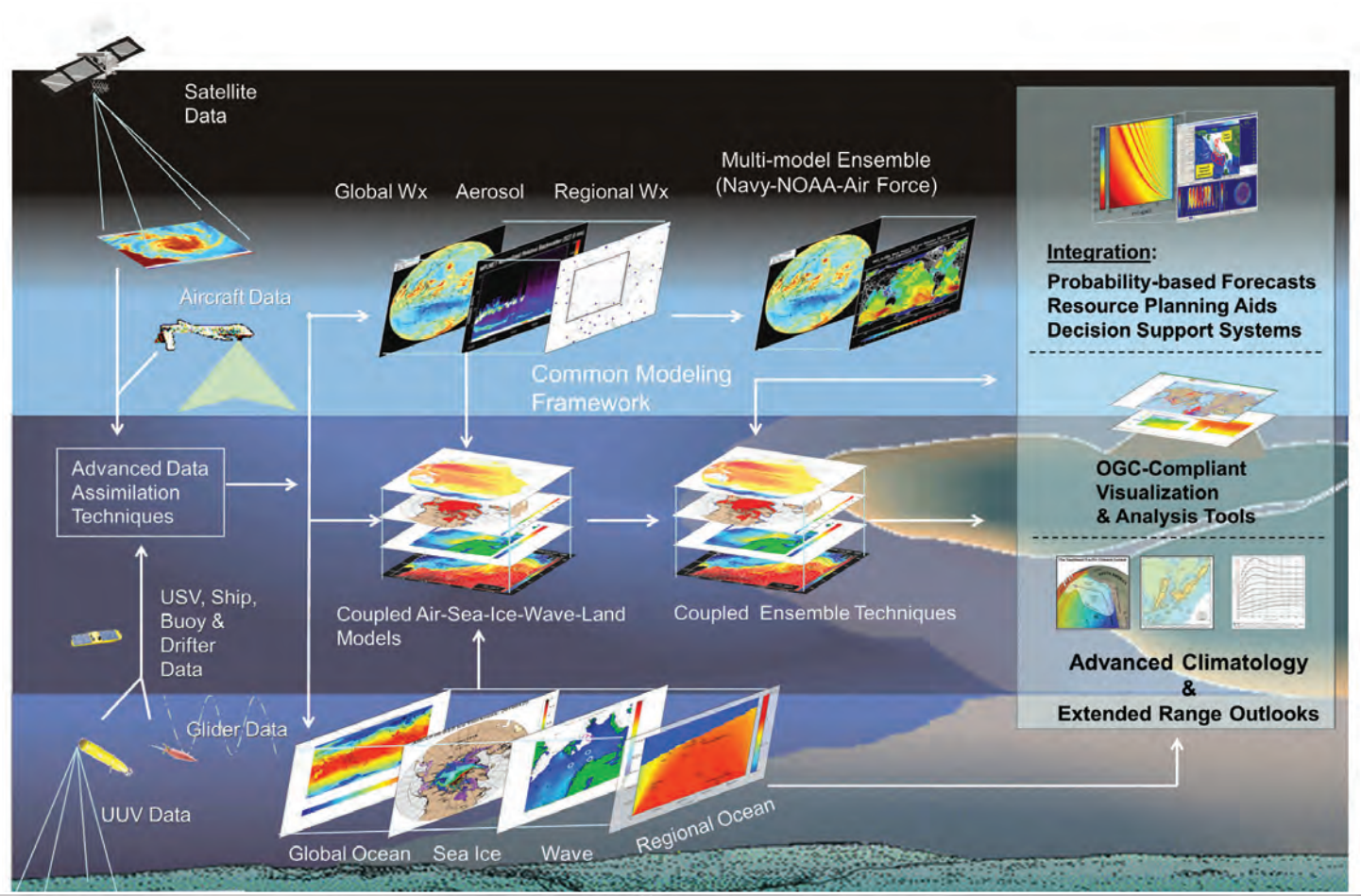
Current operational prediction of the maritime battlespace environment requires large, dedicated supercomputers, access to local civilian observational networks and large bandwidth between the supercomputer sites that generate the forecasts and the military leaders that need to account for the expected environmental conditions. Beyond that, the Fleet reverts to climatological average conditions that vary seasonally and regionally, but do not capture the operationally relevant variability.

In the future, the Navy's Earth System Prediction Capability (ESPC) will provide probabilistic decision guidance on safety and effectiveness of military operations from the bottom of the ocean to the top of the atmosphere, from the tropics to the poles, and at every scale from the tactical through the strategic. This effort is called "Earth System" Prediction because it seamlessly integrates ocean, atmosphere, land and ice numerical forecast models into a single architecture that better represents what happens in the real world.

By 2020, Navy ESPC will fully address Fleet and Combatant Commander (COCOM) meteorology and oceanography METOC prediction requirements and capability gaps with a 32-day lead coupled global ensemble system, a regional Arctic model focused on emerging surface and air missions at high latitudes, and provide 90-day multi-month to seasonal guidance for global force position planning, Fleet transits and cooperative security and training evolutions.

Additionally, new capabilities in signal processing and data assimilation will reduce our dependence on direct civilian *in situ* environmental observations in data-scarce or data-denied environments through increased use of satellite remote sensing, autonomous platforms and local tactical sensor data. As every platform in the Fleet becomes an information node, the local sensor conditions will be seamlessly integrated into an organic tactical prediction capability to bridge the gap for communications-limited users in the network.

With skillful integrated prediction at the supercomputer centers extending from days to weeks, units at the tactical edge will be able to access the most likely conditions several days in advance when last connected to the tactical cloud, and then use local updates on a lightweight forecast model to fully enable local battlespace awareness and maneuver warfare.



Overview of how environmental decision support to the DoD is generated by the Naval Meteorology and Oceanography Command (NMOC). Military, civilian, and international weather and ocean observations are blended with a previous forecast to establish the current battlespace environmental conditions. Complex numerical models are then run on Department of Defense and Navy High Performance Supercomputers to predict the most likely future conditions based on this initial state, as well as probabilities that critical platform, sensor or weapon limitations might be exceeded. This information is then disseminated to Fleet and Force users globally for safety of flight and navigation and effective and efficient operational planning. The Earth System Prediction Capability research program is developing a system to extend the useful range of these predictions from reactive timescales of a few days to proactive timescales of weeks to months.