MASTER OF SCIENCE
IN
METEOROLOGY AND PHYSICAL OCEANOGRAPHY

SHIP OPERATING CHARACTERISTICS AND THEIR IMPLICATION FOR SHIPTRACK FORMATION

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Shiptrack occurrence is restricted to a narrow range of environmental conditions and ship operating characteristics. Under environmental conditions favorable for shiptrack formation, not all vessels produce a track. Shiptrack producing diesel vessels are distinguished from non-shiptrack producing diesel vessels by a 17.7 percent higher rate of fuel use, 8.8 percent larger power plant size, and one knot higher transit speed. T-tests comparing these two populations indicate that power/transit speed, power*fuel/speed, power*fuel, tonnage/fuel use, power/hull cross-section, transit speed, power plant size, and rate of fuel use are tactically distinct (greater than 60% confidence level). These parameters and ratios of parameters may be useful in predicting the occurrence and non-occurrence of shiptracks.

DoD KEY TECHNOLOGY AREA: Other (Meteorology)

KEYWORDS: Shiptrack, AVHRR, T-Test, Level of Significance

MICROWAVE OBSERVATIONS OF MESOSCALE CONVECTIVE SYSTEMS DURING TROPICAL CYCLONE GENESIS IN THE WESTERN NORTH PACIFIC

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A better understanding of the role mesoscale convective systems (MCS) play in the genesis stages of tropical cyclones will increase the ability to predict their formation. This thesis studied polar-orbiter microwave and geostationary infrared satellite imagery to determine MCS structure and evolution during tropical cyclone genesis. Microwave imagery at frequencies of 19.35 GHz and 85.5 GHz were used to define convective and stratiform cloud areal amounts, percent coverage, and time-integrated rain rates. Collocations with geostationary infrared images are used to calibrate that imagery so that the hourly values may be calculated until another microwave image is available. Specifically, seven MCSs in two disturbances that eventually developed into tropical cyclones were analyzed. Two MCSs in non-developing storms are also described for contrast.

DoD KEY TECHNOLOGY AREA: Other (Meteorology)

KEYWORDS: Mesoscale Convective Systems, Microwave Satellite Imagery, Tropical Cyclone Genesis, Formation

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A COMPARISON OF THE NOGAPS AND GFDN DYNAMICAL TRACK PREDICTION MODELS DURING THE 1997 WESTERN NORTH PACIFIC TYPHOON SEASON

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The performance of both the U.S. Navy (NOGAPS) and regional (GFDN) dynamical track prediction models during the 1997 western North Pacific typhoon season is documented. In the context of the Systematic Approach of Carr and Elsberry, a knowledge base of six conceptual models (summary in Table 8.1) is proposed that associates recurring tropical cyclone (TC) forecast track errors with various types of TC and environmental structures. Twenty-one storms of the 27 analyzed have periods in which at least one significant track error source was identified. More situations (23) were identified in the NOGAPS forecasts than in the GFDN forecasts (14). Individual case studies are presented to illustrate recurring scenarios with poor performance in either the NOGAPS model, GFDN model, or both. Use of these conceptual models and their supporting case studies may allow the JTWC forecaster to better understand how the NOGAPS model and GFDN model may perform in specified synoptic environments. It is hoped that the JTWC forecaster can use the information in this study to provide more accurate TC tracks by rejecting inappropriate model guidance during future typhoon seasons in the western North Pacific. In addition, this study may provide feedback to dynamical model producers as to situations in which large track errors have occurred, in hopes that the model might be improved in the future.

DoD KEY TECHNOLOGY AREA: Other (Meteorology)

KEYWORDS: Tropical Cyclone Track Forecasting

STATISTICAL POST-PROCESSING OF NOGAPS TROPICAL CYCLONE TRACK FORECASTS

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A statistical post-processing technique is developed and tested to reduce the Navy global model (NOGAPS) track forecast errors for western North Pacific tropical cyclones during 1992-1996. In addition to the basic storm characteristics, the set of 42 predictors includes various track segments in the 00-72 h NOGAPS forecast as well as a 00-36 h backward extrapolation that is compared with the corresponding best-track positions. Although a NOGAPS forecast to at least 36 h is required to calculate the critical backward predictors, a reduced set of forward predictors that did not include the 48- and 72-h NOGAPS positions still produced the same improvement in track forecasts. Separate sets of statistical regressions are developed and tested for three subsets of the synoptic pattern/region combinations defined by Carr and Elsberry. For cyclones in the standard/dominant ridge combination, the improvement relative to NOGAPS is 61% after 12 h, and remains 8% after 72 h. For cyclones in the poleward/poleward-oriented pattern/region, the improvement over NOGAPS is 55% after 12 h, and 6% after 72 h. For a combination of cyclones in all remaining pattern/regions, the improvement relative to NOGAPS is 61% after 12 h, and 10% after 72 h. Comparison of these subsets with a single set of regression equations for all synoptic combinations showed no advantage obtained from using separate equation sets, so the single set is recommended. An independent test with all available 1997 NOGAPS forecasts decreased forecast track error by 50, 22, 12, 9, and 6% at 12, 24, 36, 48, and 72 h.

DoD KEY TECHNOLOGY AREA: Battlespace Environments

KEYWORDS: Tropical Cyclone Track Forecasting

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RESPONSE OF THE SOUTH CHINA SEA TO FORCING BY TROPICAL CYCLONE ERNIE (1996)

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The South China Sea (SCS) response to forcing by Tropical Cyclone Ernie (1996) was studied numerically using the Princeton Ocean Model (POM) with 20 km horizontal resolution and 23 sigma levels conforming to a realistic bottom topography. A fourteen-day experiment was conducted using a wind model that allowed for temporal variations of its translational speed, size and intensity. Restoring type salt and heat fluxes were used along with seasonal inflow/outflow at the open boundaries. The POM adequately simulated ocean responses to tropical cyclone forcing. Near-surface ocean responses simulated by the POM included strong asymmetrical divergent currents with near-inertial oscillations, significant sea surface temperature cooling, biased to the right of the storm track, and sea surface depressions in the wake of the storm. Subsurface responses included intense upwelling and cooling at the base of the mixed layer to the right of the storm track. Several unique features, caused by coastal interactions with storm forcing, were also simulated by the model. Along the coast of Luzon a sub-surface alongshore jet was formed, a warm anomaly off the northern tip of Luzon was significantly enhanced by surface layer convergence and storm surges simulated along the coasts of Luzon and Vietnam.

DoD KEY TECHNOLOGY AREA: Modeling and Simulation

KEYWORDS: South China Sea, Numerical Simulation, Tropical Cyclone Ernie (1996), Ocean Response to Tropical Cyclone Forcing

COMPARISON OF EVAPORATION DUCT HEIGHT MEASUREMENT METHODS AND THEIR IMPACT ON RADAR PROPAGATION ESTIMATES

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A study was performed to compare shipboard measurements of atmospheric parameters that impact the evaporation duct and its effect on the propagation of electromagnetic energy from the AEGIS AN/SPY-1 radars. Two ships, *USS Anzio* and *USS Cape St. George*, participated in the annual NATO exercise, BALTOPS, during the summer of 1997. They were equipped with an automated METOC sensor system, developed by Johns Hopkins University Applied Physics Laboratory, called SEAWASP. SEAWASP provided continuous measurement of parameters determining near surface refractivity and the evaporative duct throughout the cruise. SEAWASP data were compared with manual bridge observations in order to illustrate the difference in propagation conditions assessed by the two methods. Additionally, ERS-1 Scatterometer wind data were used in conjunction with SEAWASP data to determine the feasibility of incorporating satellite wind data in determining evaporative duct heights. The automated SEAWASP data was able to depict, with greater accuracy, the constantly changing duct height conditions whereas the bridge observations, made at hourly intervals, lacked temporal resolution, thereby missing much of the variation in duct height. The discrepancies in duct heights between the two measurement systems led to differing propagation ranges resulting in shorter reaction times to counter threats to the ship.

DoD KEY TECHNOLOGY AREAS: Battlespace Environments, Sensors

KEYWORDS: Environmental Data, Radio Physical Optics, Radar Performance Prediction, Refraction, Evaporative Duct, Engineer's Refractive Effects Prediction System