COLLABORATIVE RESEARCH PROJECTS IN SUPPORT OF FNMOC OPERATIONAL MISSION

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LONG TERM GOALS: The long term goal of this research is to execute collaborative research projects with the Fleet Numerical Meteorology and Oceanography Center (FNMOC). The collaboration involves NPS Meteorology faculty, NPS students conducting thesis research, and FNMOC personnel. The collaboration projects will address FNMOC's operational needs and will advance the understanding of marine meteorology.

OBJECTIVES: The specific objectives are the support NPS METOC thesis projects that support the FNMOC mission. Projects on scatterometer winds and NOGAPS forecasting of weather elements were selected for support in FY 97.

APPROACH: This is an "umbrella" effort to fund collaborative research projects by NPS meteorology department faculty and students and by FNMOC personnel. The specific projects supported under this proposal were developed by mutual agreement between an NPS thesis student, an NPS-Meteorology faculty member (Thesis Advisor) and an FNMOC employee with whom the NPS personnel will collaborate. The project was approved by the Chairman of the NPS Meteorology Department and by the FNMOC Technical Director, and it was initiated by a Thesis Project Description signed by all parties. This report will describe the NPS theses started under this project and sharing of responsibility between NPS and FNMOC.

The most important criteria for support are that the work be collaborative, that is addresses an operational need of FNMOC, that is represents an educationally viable thesis for the NPS student, and that it advances the science of marine meteorology. On a regular basis, FNMOC prepares a list of potential projects of highest current interest, along with a point of contact for each project, and it is expected that many, but not necessarily all, of the collaborative projects will come from this list.

WORK COMPLETED: There are two collaborative research projects underway with support received in FY97. They are:

Topic: Evaluation of FNMOC Scatterometer Derived Winds
/Student: John D. Whalen, LCDR, USN

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NPS Advisor: K. L. Davidson
FNMOC Collaborator: C. Skupniewicz
Brief Description: This study is an evaluation of scatterometer (ERS-1/2) obtained surface winds available to the fleet from FNMOC. The evaluation will be based on comparisons with *in-situ* winds obtained from specially instrumented CG's (AEGIS). The two Norfolk-based CG's with special surface observing METOC instruments by Johns Hopkins University Applied Physics Laboratory (JHU/APL) provided the *in-situ* data. The two ships deployed for two-months (June and July1997) across the North Atlantic to the Baltic and return. Continuously measured and recorded variables are pressure, and port and starboard (aft of mid-ship) air temperature, humidity, vector wind and SST. The instrumentation and collection procedures are designed to estimate EM refractive properties such as the evaporation duct. Surface layer refractive properties are very wind speed dependent if thermal stratification occurs. These data now are made available to NPS investigators upon completion of the deployment, that includes a 4-day participation in BALTOPS Phase II, in the Baltic Sea. The ships are expected to experience a wide variation of surface conditions. The ships will be in the scatterometers swath often enough to draw some conclusions on the usefulness of scatterometer winds for operational purposes.

The approach is that NPS will gather FNMOC scatterometer winds for the ship transit and operating areas. The algorithms for the wind retrievals already have been established. Geographic areas for scatterometer wind retrieval will be determined by NPS. The scatterometer wind files are ported to the NPS IDEA laboratory where they are merged with other winds (fields and ship reports) and other information available through data networks. The scatterometer fields and ship observed winds are merged with CG (JHU/APL and bridge) winds and comparisons made. The CG (JHU/APL) winds are considered as the reference and the relative accuracy, emphasizing speed, of the others evaluated.

Scaling parameters for surface layer refraction profiles will be calculated from the JHU/APL data. The impact of differences on evaporation duct height estimates will be determined. A second focus of the study (if time is available) will be to evaluate the FNMOC refractive index and evaporative duct support using the continuous *in-situ* data available.

Topic: An NWP-Perfect Prog Model for Selected Weather Elements
Student: Brian Bommarito, LT, USN
NPS Advisor: J.-M. Chen and C.-P. Chang
FNMOC Collaborator: Dr. Mary Alice Rennick
Brief Description: The goal of the thesis project is to build a prototype statistical forecast model that uses NWP output to forecast weather elements such as ceiling height and probability for precipitation at particular locations. This is in response to one of the FNMOC request items to develop a weather element forecast model that uses NOGAPS and NORAPS outputs. Eventually, for operational applications, the NOGAPS and NORAPS/COAMPS will be the NWP model to provide the NWP output, but there is not long enough homogeneous data from any of these models. So the approach in this project is to develop "Perfect Prog" model. The gridded data from NCEP reanalysis are used to develop a regression model to predict the weather elements at selected location that are

of interest to Navy operations. The development will include control tests to evaluate the skill range based on standard Brier and other skill scores.

One of the most important considerations is the proper selection of the predictor fields. This is mainly to minimize the sensitive round-off errors due to multicollinearities, as most meteorological data are highly intercorrelated. Thus, extensive stepwise regression and similar techniques are usually required in building the model output statistics or perfect prog models. Since the time period for a thesis project is limited, the conventional step-wise regression for model output statistics will be too time-consuming.

Instead, this project use a two-step principal component analysis (PCA) on the predictor fields to remove multicollinearity and to maintain reliability through truncation. The first step is to preprocess each predictor fields with a PCA. A portion of the resultant principal components (PC's) are selected by considering the individual correlation coefficient between each PC and the predictand. The second step is to normalize the chosen PC's of each predictor field and combine them to form a single data set. The combined set is then subjected to a PCA with the resulting PC's used as the direct predictor elements to construct the regression model.

Since all PC's are not intercorrelated, there is no problem of multicollinearity in the above procedure. There remains a potential problem of reliability for the trailing components that are now normalized. This is a significant problem because the maximization of reliability and the maximization of predictability are inherently conflicting with each other, therefore additional variance truncations and correlation re-evaluations may need to be performed. The actual degree of these will depend on the time available in the thesis project.

RESULTS: NPS Deliverables: NPS theses, both to be completed in March 1998, will describe (1) the accuracy of scatterometer derived winds compared to bridge and field derived winds (The differences between FNMOC and **in-situ** evaporation duct estimates will be included if there is time.) and (2) a NOGAPS perfect-prog model for selected weather elements.

IMPACT: Impact is not known at this time.

TRANSITIONS: Transitions are not known at this time.

RELATED PROJECTS: LCDR Whalen's thesis is related to a SPAWAR funded continuous surface measurement program while LT Bommarito's work is related to Professor Chang's NOGAPS tropical analysis work funded by NRC.

REFERENCES:

Bommarito, B. (1988) An NWP-Perfect Prog Model for Selected Weather Elements, M.S. Thesis, Naval Postgraduate School, Department of Meteorology, Monterey, CA 93943, to be completed March 1988.

Whalen, J. D. (1988) Evaluation of FNMOC Scatterometer Derived Winds, M. S. Thesis, Naval Postgraduate School, Department of Meteorology, Monterey, CA 93943, to be completed March 1988.