Progress Report for Period: 1/1/94 - 12/31/94

Title of Project: Recurvature Dynamics of a Typhoon
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Progress Report:

During this year we completed the development of a variable (very high) resolution global model. This was the Ph.D. dissertation of Dr. V. Hardiker; the dissertation abstract follows.

A conformal transformation suggested by F.Schimdt is followed to implement a global spectral model with variable horizontal resolution. A conformal mapping is defined between the real physical sphere (Earth) to a transformed (Computational) sphere. The model equations are discretized on the computational sphere and the conventional spectral technique is applied to solve the model equations.

There are two types of transformations used in the present study, namely, the Stretching transformation and the Rotation of the horizontal grid points. Application of the stretching transformation results in finer resolution along the meridional direction. The stretching is controlled by a parameter C as follows :

a). IF C > 1.0 : Contraction of latitudes in the northern hemisphere and dilation in the southern hemisphere.

b). IF C < 1.0 : Contraction of latitudes in the southern hemisphere and dilation in the northern hemisphere.

c). IF C = 1.0 : Identity transformation.

The rotation transformation can be used to relocate the North Pole of the model to any point on the geographic sphere. The idea is now to rotate the pole to the area of interest and refine the resolution around the new pole by applying the stretching transformation. The stretching transformation can be applied alone without the rotation.

A T-42 Spectral Shallow-Water model is transformed by applying the stretching transformation alone as well as the two transformations together. A T-42 conventional Spectral Shallow-Water model is run as the control experiment and a conventional T-85 Spectral Shallow-Water model run is treated as the benchmark (Truth) solution. RMS error analysis for the geopotential field as well as the wind field is performed to evaluate the forecast made by the transformed model. It is observed that the RMS error of the transformed model is lower than that of the control run in a latitude band, for the case of stretching transformation alone, while for the

total transformation (rotation followed by stretching), similar results are obtained for a rectangular longitude-latitude domain.

A multi-level global spectral model is designed from the current FSU global spectral model in order to implement the conformal transformation. The transformed T-85 model is used to study Hurricane Andrew. The control experiment in this study is a conventional T-170 spectral model. The performance of transformed model is clearly seen to be improved in describing the structure, intensity and motion of Hurricane Andrew, over the conventional FSU global spectral model.

Dr. Hardiker has completed his Ph.D. and is currently working at NRL in Monterey as a UCAR fellow. He is currently developing a high resolution version of the NOGAPS model. This has been a very fruitful collaboration with the Navy. At the Florida State University, we are continuing this work towards the analysis of the recurvature dynamics of hurricanes.

The second major area of activity is in physical initialization. In this overview we present a summary of results on the impact of physical initialization on various aspects of numerical weather prediction. These include the improvements in nowcasting and short range forecasting skill, the organization of meso-convective precipitating elements as typhoons form; calibration of surface fluxes using the TOGA - COARE data sets during the intensive observation period from its intensive flux array; the improvements in the hydrological budgets during flooding events; the spread reduction for an ensemble of hurricane track forecasts and in an overall improvement of cloud forecasts. Here we emphasize the need for a direct incorporation of the process within four-dimensional variational analysis procedures. The study also includes some recent results on physical initialization from the use of a very high resolution global model. Fundamentally this procedure improves the model-based initial rainfall, surface fluxes and diagnostic cloud amount. Physical initialization is a useful procedure for the nowcasting of rainfall. Correlation between model-based initialized rain and satellite/ raingauge-based rain over the tropics (for 6 hour averages and averaged over transform grid squares) is of the order 0.85. This compares with a correlation of around 0.3 for models which do not include physical initialization. The day one tropical rainfall forecast skill is also relatively high for the physically initialized experiments; the correlation is of the order 0.55. It should be noted that the lifetime of meso-convective systems is approximately one day whereas more organized tropical disturbances may last substantially longer. A major portion of the tropical rainfall is associated with these short-lived systems, hence the skill beyond one day degrades somewhat. However, the model does seem to capture the one day passage of meso-convective systems and their coupling to the large-scale, synoptic environment. The meso-convective systems illustrated exhibit a robust vertical structure of divergence, heating and vertical motion which is absent without physical initialization.

The organization of meso-convective systems (advected by the large-scale circulations and coalescence of the mesoscale elements) appears to play an important role in the formation of tropical storms. The vorticity associated with these mesoscale elements, however, does not exhibit any interesting organization during the forecast as the storms form. The Florida State University atmospheric global circulation model at the resolution T213 discerns the tight central circulation features and the outer rain bands of Hurricane Andrew (1992) which appear similar to the radar imagery; however, the storm as seen from the model is not on the exact scale as that of the radar. Further enhancement of resolution is needed to model tropical storms on a more realistic scale which is well known in the modeling community. Overall the results demonstrate that meso-convective elements are in fact simulated by very high resolution global models. It appears that very high resolution models with an augmented analysis using satellite data may soon aid in resolving the formation issue associated with tropical cyclones and cyclogenesis.

Mr. Greg Rohaly was a principle co-author of mine in the above study. He has recently joined the permanent staff of NRL at Monterey. Mr. Rohaly is currently implementing a complete physical initialization algorithm for the NOGAPS model.

During this year we held a major workshop on application of satellite data towards numerical weather prediction that was attended by Drs. Steve Payne, Andy Van Thuyl and Scott Sandgathe from NRL and ONR. The description of this conference is enclosed.

Publications of this year related to this project are listed as follows:

1995: (with L. Bounoua). An introduction to numerical weather prediction techniques. CRC Press 1-430. (In press) Text book.

1995: (with H.S. Bedi). An overview of physical initialization. J. Met. Atmos. Physics. (In press).

1995: (with H.S. Lee). Impact of physical initialization on cloud forecasts. (To appear in *Meteor. Atmos. Phys.*)

1995: (with S.K. Roy Bhowmik, Darlene Oosterhof, Gregg Rohaly and Naomi Surgi). Mesoscale Signatures within the Tropics Generated by Physical Initialization. (To appear in the *Monthly Weather Review*).

1995: (with H.S. Bedi , G.D. Rohaly , D.K. Oosterhof, R.C. Torres , E. Williford and N. Surgi). Physical Initialization. *J. Atmospheric Oceans* (In press).

1994: (with D. Oosterhof and D. Sukawat). Numerical prediction of a Bangladesh Tropical Cyclone. *Taiwan Journal of Atmosphere and Oceans*. **5**, 245-276.

11:30 **J. Welnman,** (NASA/GSFC): MM5 Mesoscale Model Impact on the Retrieval of Precipitation from SSM/I Measurements.

12:00 **LUNCH***

Chairperson: P. Arkin, (NCEP)

1:30 **K. Puri,** (BMRC): The Use of Satellite Data in NWP and its Performance in Operations at the Australian Bureau of Meteorology.

2:15 **S. Payne,** (NRL): The Impact of SSM/I Wind Data on Model Fields in the Tropics.

3:00 **BEVERAGE BREAK**

3:15 **A. Staniforth,** (RPN): A Variable Resolution Strategy for Mesoscale Forecasting in the Tropics.

4:00 **R. Daley,** (AES): Detecting Windfields from Constituent Observations: Scale Dependence and Observability Problems.

4:45 **A. Lorenc,** (UK MET): Towards Consistent Use of Humidity and Cloud Observations in Midlatitude NWP.

5:30 **ADJOURN**

THURSDAY, 17 NOVEMBER 1994

Observations and Modeling

Chairperson: J. Ahlquist, (FSU)

:00 **R.M. Aune,** (NOAA/NESDID): Assimilating Moisture Observations from Satellites.

:30 **X. Zou,** (NCAR): 4-D Variational Assimilation of Atmospheric Refractivity.

0:00 **BEVERAGE BREAK**

10:30 **P. Rasch,** (NCAR): Scale Dependence of Cloud Distribution in the Tropical Pacific: Comparison of Satellite Observations with Global Atmospheric Models.

11:00 **Y.-H. Kuo,** (NCAR): Assimilation of Precipitable Water into a Nonhydrostatic Mesoscale Model using a Variational Approach.

11:30 **A. Kasahara,** (NCAR): The Use of Precipitation Data for Diabatic Initialization of Global and Mesoscale Prediction Models.

12:00 **LUNCH**

Chairperson: J. Korotky, (NWS)

1:30 **L. Garand,** (AES): Operational Assimilation of Satellite Humidity Profiles Derived from GOES Data; Impact Studies.

2:00 **B. Simon,** (NCMRWF): Impact of ERS-1 Scatterometer Data on the Analysis and Prediction of a Severe Cyclonic Storm in the Bay of Bengal.

2:30 **A. Van Tuyl,** (NRL): Physical Initialization with the Arakawa-Schubert Scheme in the Navy's Operational Global Forecast Model.

2:30 **BEVERAGE BREAK**

3:15 **W. Wergen,** (Deutscher Wetterdienst): Impact of SATEM Data Experience at Deutscher Wetterdienst.

3:45 **D. Sharp,** (NWS): NEXRAD (WSR/88) and Satellite Data Calibration Issues.

4:15 **T.N. Krishnamurti,** Closing Remarks.

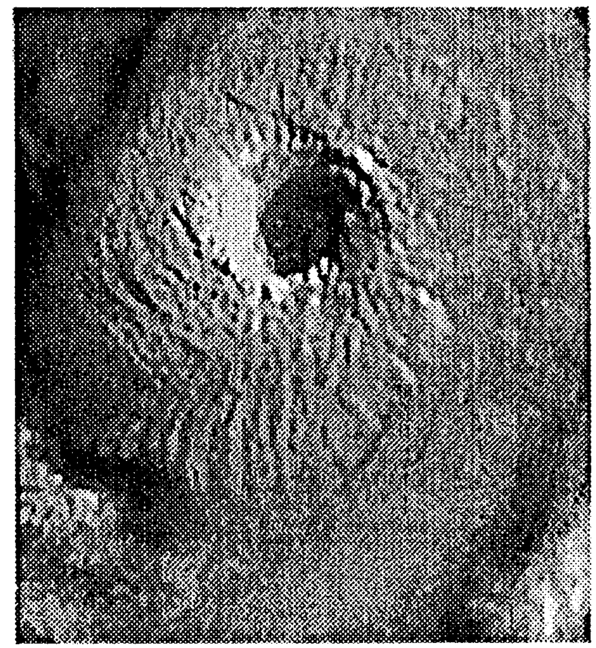
---Closure Of Conference---

CITM is a NOAA/National Weather Service sponsored Class IV Institute

Impact Of Satellite Products On Global Analysis And Medium Range Prediction

November 14 - 17, 1994
Tallahassee, FL U.S.A.

Conference presentations held at the Florida State University Center for Professional Development



Emily, 1993

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MONDAY, 14 NOVEMBER 1994

Satellite Observations

Chairperson: K. Kloesel, (FSU)

9:00 **L. Abele,** Provost, (FSU): Welcoming remarks.

9:10 **T.N. Krishnamurti,** (FSU): Introductory remarks.

9:20 **Bernard Meisner,** (SRHQ): Welcome from NWS.

9:30 **J. Simpson,** (NASA/GSFC): An Overview of TRMM.

10:15 **BEVERAGE BREAK**

10:45 **J. Purser,** (UCAR/NCEP): Objective Measures of the Information Density of Satellite Data.

11:30 **W. Smith,** (U. WISC): Advanced Versus Contemporary Satellite Soundings - Will They Make an Impact on NWP?

12:00 **LUNCH***

Chairperson: P. Ruscher, (FSU)

1:30 **E. Smith,** (FSU): Passive Microwave Techniques for Rain Rate Estimates.

2:00 **C. Velden,** (U. WISC): Winds Derived from Geostationary Satellite Moisture Channel Observations: Applications and Impact on NWP.

2:30 **BEVERAGE BREAK**

3:00 **P. Arkin,** (NCEP): A Comparison of Satellite-Derived Estimates of Tropical Oceanic Rainfall.

3:30 **ADJOURN:** Trip to Wakulla Springs. natural springs, alligators and dinner at Wakulla Springs Lodge and Conference Center

TUESDAY, 15 NOVEMBER 1994

Analysis, Initialization and Modeling

Chairperson: P. Stephens, (NSF)

9:00 **T. Hollingsworth,** (ECMWF): Satellite Observation and Data Assimilation at ECMWF.

9:45 **R. Burpee,** (NOAA): Operational Satellite Observations and Nmc Global Analyses: Examples From Major Eastern Pacific Hurricane Olivia of 1994.

10:00 **J. Evans,** (PSU): Precipitation Signatures of Various Classes of Organized Convection in the North Atlantic Ocean.

10:15 **BEVERAGE BREAK**

10:45 **T.N. Krishnamurti,** (FSU): Recent Advances in Physical Initialization.

11:30 **R. Treadon,** (FSU): Physical Initialization for the NMC Operational Model.

12:00 **LUNCH**

Chairperson: N. Surgi, (NHC)

1:30 **T. Tsuyuki,** (FSU): Variational Data Assimilation for the Tropics Using Precipitation Data.

2:00 **T. Matsumura,** (JMA): Diabatic Initialization for the Meso-scale Model using GMS Cloud Image.

2:30 **BEVERAGE BREAK**

3:00 **S.K. Mishra,** (NCMRWF): Physical Initialization for Tropical Analysis and Prediction.

3:45 **F. Robertson,** (NASA/MSFC): Divergent Circulations and Remotely-Sensed Cloud/Moisture Structure.

4:15 **L. Leslie,** (Univ of NSW): The Impact of Spatial and Temporal Distribution of Satellite Observations on Tropical Cyclone Data Assimilation.

5:00 **A. Bennett,** (OSU): Weak-constraint Four-dimensional Variational Assimilation, with a Global Primitive Equation Model and TCM-90 Data.

5:30 **ADJOURN**

6:00 **COCKTAILS & BANQUET (CPD)**

WEDNESDAY, 16 NOVEMBER 1994

Observations and Modeling

Chairperson: P. Ray, (FSU)

9:00 **E. Kalnay,** (NCEP): Environmental Modeling at NCEP.

9:45 **H. Diaz,** (NOAA/ERL): Precipitation Monitoring.

10:15 **BEVERAGE BREAK**

10:45 **J. Derber,** (NCEP): The Use of Indirect Satellite Observations in the NMC Global Model.

Cash lunches available Monday and Wednesday at the Conference Center. Trolley shuttle service available to downtown area restaurants