WSR-88D Tropical Cyclone Algorithm Working Group Meeting

Minutes

When: October 11, 1995, 1600-1730 LT

Where: 27th Conference on Radar Meteorology
Marriott's Vail Mountain Resort, Vail, CO

Participants: (see Attachment A for phone numbers and e-mail addresses)

Michael Black	NOAA/HRD	Les Lemon	Loral Defense Systems-East
Col. Tim Crum	NOAA/OSF	Bob Lipschutz	NOAA/FSL
Peter Dodge	NOAA/HRD	Frank Marks	NOAA/HRD (**co-convenor**)
John Gamache	NOAA/HRD	Colin McAdie	NOAA/NHC (**co-convenor**)
Paul Harasti	University of Toronto	Frank Roux	Lab. d'Aerologie, Toulouse, FR
Ian Harris	Hughs STX (Phillips Lab)	Dave Sharp	NOAA/NWS/Melbourne, FL
Peter Hildebrand	NCAR/ATD	John Tuttle	NCAR/MMM
Steve Holt	MITRE	Col. Andy White	NOAA/OSF
Jerry Klazura	NOAA/OSF	Vince Wood	NOAA/NSSL
Wen-Chau Lee	NCAR/ATD (**co-convenor**)		

1. Purpose:

The Office of the Federal Coordinator for Meteorology and the WMO have established statements recommending the development of tropical cyclone algorithms for use with landbased Doppler radars, and in particular WSR-88D radars:

- Action 93-2.2: a. Request Working Group on Hurricanes and Winter Storms Operations and/or NWS/Office of Meteorology seek approval to implement specialized operational modes or settings to optimize NEXRAD (*WSR-88D*) utility for tropical cyclones (p. 3, OFCM, 1993)

- Basic Research Priority Recommendations of IWTC-III: C.3 (III) Develop Doppler radar algorithms specifically designed for tropical cyclone situations (p. 11, WMO, 1995).

This meeting is an attempt to organize an international working group (Australia, Canada, France, India, Japan, Taiwan, and the United States) to develop and systematically test new and/or existing single Doppler radar algorithms for tropical cyclone detection, tracking, and wind field analysis.

2. Approach:

A two phase process is envisioned to develop operational tropical cyclone algorithms. Phase I entails the organization of a working group of scientists interested in the problem of developing tropical cyclone algorithms for single Doppler radars (this meeting). Participation in the working group is voluntary, as we have no funding source ready to sponsor the development of new algorithm ideas. However, in order develop and test ideas for possible tropical cyclone algorithms members of the working group would be given free access to:

- Statement of NHC's requirements for tropical cyclone description via landbased Doppler radar,
- Common WSR-88D Level II data set on a workstation at NHC that can be accessed via Internet with which to develop and test algorithms, and
- Documentation and software to read the WSR-88D Level II data.

The working group will meet periodically (every 6 mon.) to discuss progress and make plans for future efforts.

During Phase II proposed algorithms will be put on a common workstation at NHC and

undergo detailed testing using the whole 1995 WSR-88D data set. At the end of Phase II we should have a short list of algorithms for the Operations Support Facility (OSF) to implement. It is hoped that Phase II efforts will be eligible for funding under NOAA or the Office of the Federal Coordinator.

3. Algorithms (preliminary list): NHC requirements in Attachment B

- center finding-reflectivity (*TREC- Tuttle and Gall, Chaser-Griffin et al*) and velocity (*Wood's algorithm already published, extended VAP- Harasti*)
- center tracking (**combination of centers in time**)
- wind field description–various approaches are possible: kinematic properties of the vortex to actual estimate of the winds (*GBVTD- Lee et al, TREC- Tuttle and Gall, GBEVTD- Roux et al, extended VAP- Harasti, VAD based schemes-Donaldson et al*). **NHC must specify what they need.**
- Precipitation (**need specific one for tropical cyclones??**)
- Loral Data Systems algorithm suite (*P. Ray, et al*)
- Storm Surge (available in Loral suite)

We must also examine existing WSR-88D algorithms (e.g., mesocyclone, TVS, rainfall, etc.) for use in tropical cyclone conditions:

- How well do they perform?
- Can they be improved for use in tropical cyclones?
- Do we need separate versions for use in tropical cyclones?

Dave Sharp (SOO, NWS/KMLB) will coordinate an effort to evaluate current algorithm performance in tropical cyclones with Colin McAdie (NHC) and other interested SOOs.

4. Data Sets:

In 1995 Hurricanes Erin, Jerry, and Opal were observed by WSR-88D radars over Florida and surrounding waters. At the same time a number of complimentary data sets were collected by the NOAA WP-3D airborne radars, NCAR CP-2 radar, and AFRES WC-130 aircraft. These data sets are unique, including measurements from multiple platforms and instruments. It provides an opportunity to systematically test and certify many of the algorithms and provides a basis for developing new algorithms.

In Phase I, NHC and HRD will make 2 h of WSR-88D level II data from Hurricane Erin available on an FTP site for use in algorithm development. Erin was chosen to take advantage of the excellent WSR-88D coverage of the storm during its lifetime as it made landfall along the east coast and panhandle of Florida (Fig. 1). The first hour of data (10-11 volume scans) are from the Melbourne, FL WSR-88D (KMLB), 0600-0700 UTC, 2 August 1995, during Erin's landfall along the east coast of Florida (Fig. 2). The second hour of data (10-11 volume scans) are from the Mobile, AL WSR-88D (KMOB), 1600-1700 UTC, 3 August 1995, during Erin's second landfall along the Florida panhandle (Fig. 3). The volume scans will be stored in the WSR-88D level II format. Documentation on the level II data format and subroutines to decode the data will also be put on the FTP site.

Another suggestion made at the meeting was to also include on the FTP site an analog data set of a model wind field sampled from a simulated WSR-88D (e.g., Rankin vortex, divergent flow, combinations, etc.), for which we know the properties of the flow. The model data set would be a useful tool for algorithm development, and for intercomparison of results from the different algorithms. We will attempt to construct such an analog data set (Frank Roux and others have possible candidates) and make it available as soon as possible.

NHC and HRD will contact the working group meeting participants once the FTP site is operational. We also plan to construct a World Wide Web page to describe the working group effort and to facilitate interaction among the participants.

5. Algorithm intercomparison and verification:

Roughly 6 months after the data is made available via FTP the working group will reconvene at a convenient location and time to evaluate algorithm development and performance. The results from all the algorithms will be compared to independent data sources. A nice aspect of the Erin data set is that a number of independent data sources are available to assess the storm's position, track, kinematic structure, and rainfall. These independent data sets include:

- NOAA WP-3D airborne Doppler data sets from Erin
- HRD mesoscale surface wind analysis of reconnaissance and other surface data
- HRD WSR-74S data set in Erin from Palm Beach, FL NWS Office (PBI)
- NCAR CP-2 data set in Erin from Titusville, FL

The first three data sets are available at HRD and can be used to evaluate the algorithm performance.

6. Radar Operations (and/or modifications): specifically for tropical cyclones

OSF wants to know what radar operations procedures cause problems in tropical cyclone situations. The working group should document any problems encountered that relate to radar operations. The group documented three particular problems:

- PRF-range ambiguity ("purple haze" from range folding is a major problem)
- velocity unfolding (need to have different velocity unfolding for tropical cyclone situations)
- scan strategies (VCP-11 vs. VCP-21 to get more complete volume scans)

7. Funding:

No funding is currently available. The Technical Advisory Committee (TAC) for the WSR-88D sets the priorities for disbursement of funds for algorithm development and maintenance. Currently the TAC is coping with changes in the WSR-88D radar environment: finishing up the Loral Defense Systems contract; improving and updating existing algorithms; and migrating existing algorithms to an open architecture system. The TAC is aware of the formation of this working group and will monitor our progress (Colin McAdie will present a summary of this meeting at the next TAC meeting in December). They are encouraging us to define and test algorithms to meet NHC's needs, with the intent of funding completion of the algorithm development in the future. Hence, it is likely that by the time we finish our Phase I efforts funding will be available to continue on with Phase II. However, Phase I will have to be done "pro bono". Even though a promise of future funding can't be guaranteed, it seems likely that those who participate in Phase I, and develop successful algorithms, will have the inside track on any future funds for algorithm development.

ACTION ITEMS:

- Complete minutes and distribute to the attendees by Thanksgiving (Marks)
- Set up FTP machine at NHC and put the data sets on line by December (McAdie, Marks, Dodge)
- Present our plan to the TAC at their December meeting (McAdie, Marks)

References:

OFCM, 1993: Record of Actions 93-2 Meeting. *AHG/TCR Memorandum 93-4*, San Antonio, TX, July 1993. (attached)

WMO, 1995: *Proceedings of the Third WMO/ICSU International Workshop on Tropical Cyclones (IWTC-III)* Huatulco, Mexico, **WMO/TD No. 624,** 22 Nov. - 1 Dec. 1993.

Attachment A

Participants

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Attachment B

NHC WSR-88D Tropical Cyclone Algorithm Requirements

- **Priority 1**: Storm position and track. Calculate motion.
- **Priority 2**: Determine the maximum single-Doppler component in the radar volume.
- **Priority 3**: Determine the maximum total wind in the radar volume.
- **Priority 4**: Determine the total wind field at the level of maximum wind. Identify radii of maximum wind, 64 kt and 34 kt winds. Record parameters for trend analysis and quality control.
- **Priority 5**: Determine the total wind field at 10 m. Identify radii of maximum wind, 64 kt and 34 kt winds. Record parameters for trend analysis and quality control.
- **Priority 6**: Construct horizon-to-horizon vertical cut through maximum wind.
- **Priority 8**: Project rainfall accumulations for range of possible storm motions.
- **Priority 9**: Hodograph of vertical variation of the horizontal mean wind from surface to 200 mb.

- Estimates of the wind components need to be made with the following accuracy and resolution:

Total wind accuracy:	2 m s^{-1} or 4% of the wind magnitude
Range of total wind magnitude:	2-90 m s^{-1}
Vertical extent:	surface (0.01 km) - storm top (~17.0 km)
Horizontal extent:	≥50 km radii from the storm center, 360° in azimuth
Vertical resolution:	1.0 km
Horizontal resolution:	≤2.0 km
Temporal resolution:	≤6 min (each volume scan)

- Estimates of the rain rates need to be made with the following accuracy and resolution:

Rain rate accuracy:	2 mm h^{-1} or 25% of the rain rate magnitude
Range of rain rates:	2-300 mm h^{-1}
Vertical extent:	surface (0.1 km)
Horizontal extent:	≥50 km radii from the storm center, 360° in azimuth
Vertical resolution:	below bright band (~4.5 km)
Horizontal resolution:	≤2.0 km
Temporal resolution:	1 h