

AT-SEA DEMONSTRATION OF THE SPS-48E RADAR WEATHER EXTRACTION CAPABILITY

Paul R. Harasti*

Visiting Scientist Programs, University Corporation for Atmospheric Research, Boulder, CO, USA

Michael Frost, Qingyun Zhao and John Cook

Marine Meteorology Division, Naval Research Laboratory, Monterey, CA, USA

Lee J. Wagner

Atmospheric Propagation Branch, SPAWAR Systems Center, San Diego, CA, USA

Timothy Maese

Basic Commerce and Industries, Moorestown, NJ, USA

Shelley Potts

Science Applications International Corporation, Monterey, CA, USA

James Pinto, Dan Megenhardt, Ben Hendrickson, and Cathy Kessinger

Research Applications Laboratory, National Center for Atmospheric Research, Boulder, CO, USA

1. INTRODUCTION

The SPS-48E is a S-band, long range, air defense, volume scanning radar onboard US Navy aircraft carriers and large deck amphibious ships. It operates with multiple pencil beams in a mechanically rotating phased-array antenna that scans electronically in elevation, and completes a volume scan in 4 seconds. A Weather Extractor Computer (WEC) and a Weather Data Interface Card (WDIC) have been developed for the SPS-48E that provide Doppler data at the lowest three elevation scans and reflectivity data at all elevation scans in Universal Format (UF). The WEC and WDIC are part of the Hazardous Weather Detection and Display Capability (HWDDC) that provides real-time weather information to shipboard personnel. The HWDDC system taps into the SPS-48E radar returns without changing or interfering with the tactical target scanning configuration. See Maese et al. (2007) for more information on the SPS-48E and the HWDDC.

The Naval Research Laboratory (NRL), Monterey, CA, is working with SPAWAR Systems Center, San Diego, CA on their development of a system to transmit the UF files created by the HWDDC system onboard Navy ships to Fleet Numerical Meteorology and Oceanography Center (FNMOC) in Monterey. The plan is to incorporate the SPS-48E data into the Navy's Coupled Ocean/Atmosphere Mesoscale Prediction System (COAMPS®) forecast model and various nowcasting algorithms. The products from these nowcasts and forecasts would then be made available

to all US Defense forces through the FNMOC net-centric information system.

In January of 2006, a prototype HWDDC was successfully tested with a land-based SPS-48E at Navy facilities in Dam Neck, VA (Harasti et al. 2006; Maese et al. 2007). Later in February of 2006, the HWDDC was deployed onboard the USS PELELIU (LHA5) for a 6-month, at-sea demonstration (Fig. 1). This paper demonstrates the weather extraction and nowcasting capability of the SPS-48E via the display and analysis of archived UF data obtained during the USS PELELIU's encounter with hazardous weather near Hawaii on 22 February 2006. Quality control issues that are unique to radar data gathered on a ship at sea will also be demonstrated and discussed.



Fig. 1. The USS PELELIU, an amphibious assault ship, shown with the SPS-48E radar onboard.

*Corresponding author address: Dr. Paul R. Harasti, Marine Meteorology Division, Naval Research Laboratory, 7 Grace Hopper Avenue, MS-2, Monterey, CA 93943-5502; E-mail: Paul.Harasti@nrlmry.navy.mil.

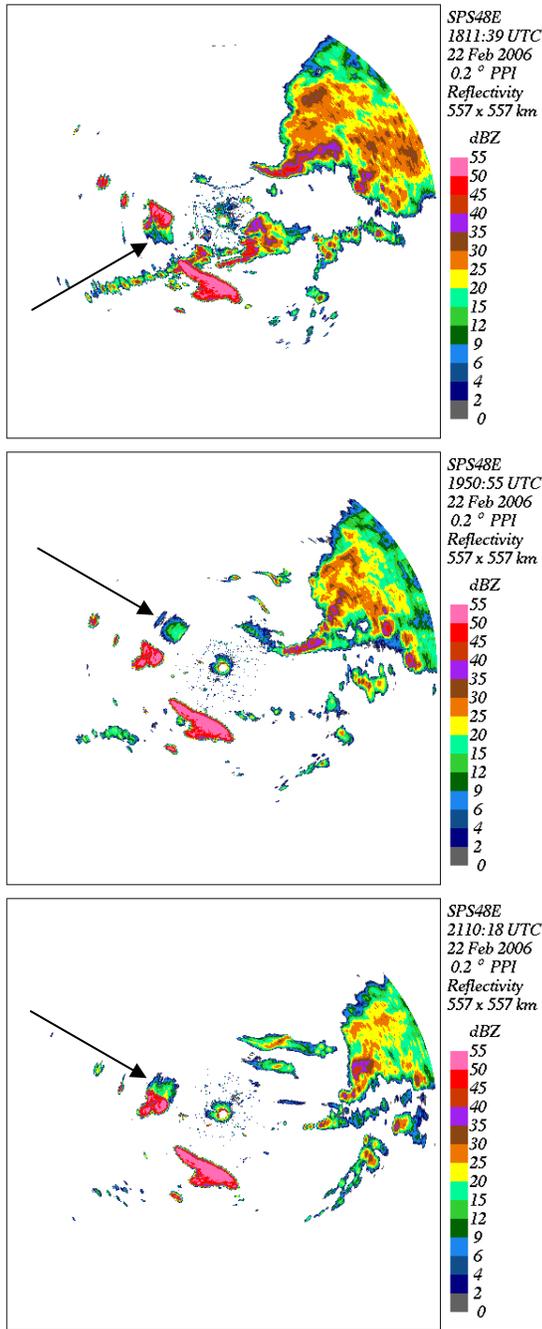


Fig. 4. Same as Fig. 3 except the ship heading was, from top to bottom, 260°, 308° and 291°, respectively.

which intensifies and elongates with time as it moves south-eastward. In the wake of the bow echo one can see precipitation within arc clouds, produced by gust fronts near the anti-cyclonic rotating, left-end of the bow, trying to propagate north-eastward upstream against the strong environmental north-westerlies. This interaction results in the elongation and flattening of the arc clouds while they intensify and appear quasi-stationary, or drift somewhat south-eastward, with time.

Sea clutter is clearly seen concentric to the radar while decreasing in reflectivity intensity with range out to a radial distance of ~30 km. There is also scattered, speckled sea clutter of low intensity visible beyond 30 km range from the radar. A notch in the reflectivity of the sea clutter can also be seen clearly in Figure 3. This notch is created by the radar-beam shadow of the ship's mast shown in Fig. 1 when the radar is pointing in the direction of the mast. The mast can also produce artifacts in the data, which we will refer to here as "ghost islands". These artifacts are produced when the antenna is pointed slightly off the land clutter (island). Referring to Fig. 5, the beam is reflected off the forward mast, and travels towards the island at an angle off what the radar expects, as shown by the solid red line. The radar 'thinks' the beam is traveling the path of the blue dashed line, and thus, the reflected beam path actually causes the radar to show a ghost island, or a false appendage to a real island or mainland coastline, where it 'thinks' the beam was pointed to. The black arrows shown in Figs. 3 and 4 point to examples of such artifacts.

The newest version of HWDDC, which wasn't ready for the USS PELELIU's version, includes surface clutter filtering, point target removal, second trip echo resolution, velocity dealiasing and basic SNR threshold checks for velocity/spectrum width. Therefore, sea and ground clutter, such as that shown in Figs. 3 and 4, will

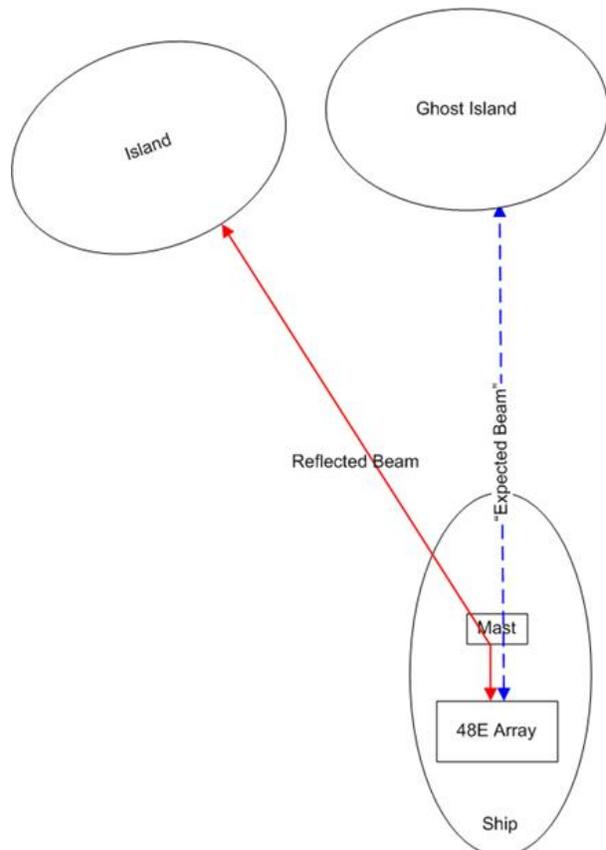


Fig. 5. Schematic showing the creation of a "ghost island" artifact caused by the radar-beam reflection off the ship's mast toward ground clutter and then back to the radar. See text for details.

be reduced in SPS-48E radar data used for weather information extraction at sea in the future. NRL-Monterey is working with Basic Commerce and Industries, Moorestown, NJ, and SPAWAR Systems Center, San Diego, CA, to design and implement a solution for the “ghost island” artifact problem. The radar data quality control methods described in Harasti et al. (2005) will also be implemented and adapted as necessary to deal with any remaining clutter and artifacts in the UF data.

4. TITAN STORM MOVEMENT FORECASTS

The three-dimensional radar reflectivity mosaic algorithm developed by Zhao et al. (2004) was also applied to the UF data obtained from the USS PELELIU on 22 February 2006. It was necessary to adapt the NRL UF data decoder and three-dimensional reflectivity mosaic system software to handle the moving radar coordinate system due to the ship’s velocity. Also, composite reflectivity data from the mosaic grid, covering 6.7° latitude by 7.1° longitude, were used by the NCAR TITAN the thunderstorm identification, tracking, analysis, and nowcasting (TITAN) software to produce short term (0-2 hour) forecasts of the SPS-48E data. TITAN can be used to extrapolate and trend existing areas of precipitation (delineated by a polygon representing a reflectivity threshold) out into the future. The software utilizes a sophisticated storm identification, analysis and tracking method that includes

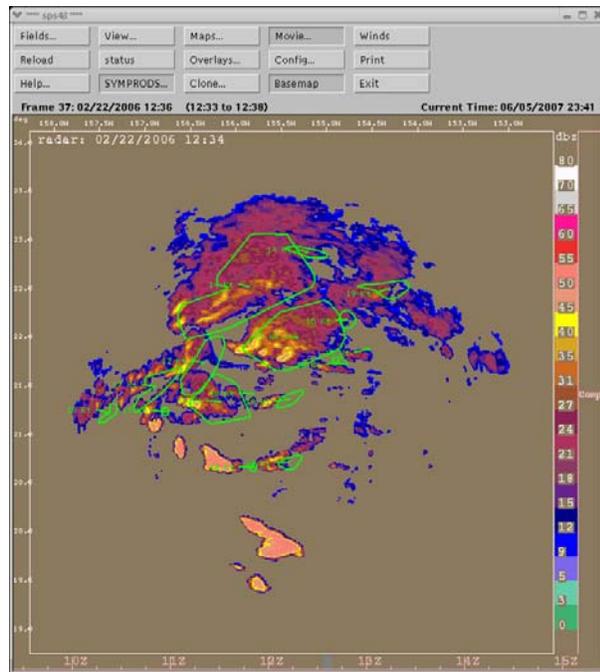


Fig. 6. TITAN forecasts of storms cells in the vicinity of the USS PELELIU at 1234 UTC 22 February 2006. The green-colored polygons are the 30-minute TITAN forecasts of the 25 dBZ contour at 1234 UTC with the forecast movement of the center of each polygon indicated by a straight, green-colored line with speed given in kt. The forecast evolution (dissipation or intensification) of the storm cells is indicated (if any) by the change in size of the polygons.

combinatorial optimization, and allowances for storm cell splits and mergers where applicable (Dixon and Weiner 1993).

Figure 6 shows the 30-minute TITAN forecasts of the 25 dBZ reflectivity contour of TITAN-determined storm cells at 1234 UTC 22 February 2006. TITAN is able to accurately forecast the position of the most of the tracked cells out to at least 20 minutes. In addition, TITAN’s forecasts of mergers, splits and dissipation of storm cells at other times were very successful. These additional results and more details of the overall accuracy of TITAN in this case will be presented at the conference.

5. SUMMARY AND FUTURE WORK

This paper demonstrates the capability of the SPS-48E data to provide valuable weather information that would be available in real-time on Navy nowcasting systems to support tactical decision making. Radar data quality control issues that are unique to a radar on a ship at sea are also demonstrated. Improved HWDDC and NRL software will be applied in the future to remedy these issues, in addition to seeking and implementing a solution to the “ghost island” artifact problem. This SPS-48E data and the adapted software will also be applied in the near future at FNMOC, Monterey, CA, to demonstrate radar data assimilation capability into the COAMPS® model. Various, useful nowcasting products, such as TITAN, will also be considered for the demonstration. The Navy aircraft carrier USS GEORGE WASHINGTON (CVN73) is being considered as a possible candidate in November 2007 to test the new HWDDC and provide the necessary UF data from the SPS-48E radar onboard for the demonstration at FNMOC in real-time.

6. Acknowledgements

The development of weather radar data quality control capability and radar data assimilation system development at NRL are sponsored by the Office of Naval Research (ONR), PE 0602435N, and the Oceanographer of the Navy (N84) via the Program Executive Office for Intelligence, Surveillance, Reconnaissance, and Information Operations (PMW 180), PE 0603207N. We would like to thank the many people involved in the HWDDC effort for their dedication and support. Special thanks go to the Program Executive Office-C41 and Space (PMW-180); J. Hunziker, H. Owen, and M. Harven of Basic Commerce and Industries, Moorestown, NJ; R. Wilcox, K. Koehler and CDR Gerald Cavalieri of SPAWAR Systems Center /PMW-180, San Diego, CA; Thomas Piwowar and CAPT Mike Huff; Will Lawson and colleagues at the Naval Surface Warfare Center–Virginia Beach; Officers and Crew of the USS PELELIU; and the Commander of Expeditionary Strike Group–3, USMC BGEN Carl Jensen.

COAMPS® is a registered trademark of the Naval Research Laboratory.

7. References

- Dixon, M., and G. Wiener, 1993: TITAN: Thunderstorm identification, tracking, analysis, and nowcasting – A radar-based methodology. *J. Atmos. Oceanic Tech.*, **10**, 785-797.
- Harasti, P. R., D. J. Smalley, M. E. Weber, C. Kessinger, Q. Xu, P. Zhang, S. Liu, T. Tsui, J. Cook, and Q. Zhao, 2005: On the development of a multi-algorithm radar data quality control system at the Naval Research Laboratory. *32nd Conference on Radar Meteorology*, Albuquerque, New Mexico, 24-28 October 2005, Amer. Meteor. Soc., 19pp (available online at http://ams.confex.com/ams/32Rad11Meso/techprogram/session_18898.htm).
- Harasti, P. R., J. Cook, Zhao, Q., L. J. Wagner, C. Kessinger, D. Megenhardt, J. Pinto, and B. Hendrickson, 2006: Extracting weather information from the SPS-48E for US Navy NOWCAST. *Proceedings of the Fourth European Conference on Radar in Meteorology and Hydrology, Barcelona, 18-22 September 2006*, 314-317 (also available online at <http://www.erad2006.org/>).
- Maese, T., J. Hunziker, H. Owen, M. Harven, L. Wagner, R. Wilcox, K. Koehler and CDR Gerald Cavalieri, 2007: Hazardous weather detection and display capability for US Navy Ships. *23rd Conference on Interactive Information and Processing Systems (IIPS)*, San Antonio, Texas, 14-18 January 2007, Amer. Meteor. Soc., 7pp (available online at http://ams.confex.com/ams/87ANNUAL/techprogram/paper_116804.htm).
- Zhao, Q, J. Cook, J. Schmidt, M. Frost, P. Harasti, and B. Gaudet, 2004: On the use of radar observations of reflectivity in verifying model hydrometeor fields. Preprints, 20th Conf. on Weather Analysis and Forecasting / 16th Conf. on Numerical Weather Prediction, Seattle, WA, 10-15 January 2004, Amer. Meteor. Soc., 4pp (available online at http://ams.confex.com/ams/84Annual/techprogram/paper_70689.htm)

