SUMMARY OF THE NORTH PACIFIC ENVIRONMENTAL SATELLITE WORKSHOP FOR COASTAL AND MARINE APPLICATIONS

Todd D. Sikora
Millersville University
Millersville, Pennsylvania

Carl F. Dierking
NOAA/National Weather Service
Weather Forecast Office
Juneau, Arkansas

Nathaniel S. Winstead
Johns Hopkins University
Applied Physics Laboratory
Laurel, Maryland

Abstract

This paper summarizes the North Pacific Environmental Satellite Workshop for Coastal and Marine Applications, which was held 29-30 May 2007 at The University of Alaska Southeast, Juneau, AK. The two goals of the workshop were:

1) to provide a forum for presentation and discussion of research and development regarding the application of environmental satellite data to a variety of coastal and marine issues in the North Pacific Ocean; and

2) to solicit feedback from the local user community regarding current and desired environmental satellite user products.

This paper outlines the workshop's 21 oral presentations, two panel discussions, and the resulting list of recommendations.

Corresponding Author: Todd D. Sikora
Department of Earth Sciences, Millersville University,
P.O. Box 1002 Millersville, PA 17551-0302
Email: Todd.Sikora@millersville.edu

1. Introduction

Operational *in situ* coastal and marine meteorological data within the Alaska region of the North Pacific Ocean basin is generated from a number of sources. Near the shoreline, the NOAA/National Weather Service (NWS) National Data Buoy Center (NDBC) operates Coastal Marine Automated Network (C-MAN) stations while the NWS and NOAA/National Ocean Service (NOS) operate coastal stations. Farther away from the shore, NDBC operates moored buoys, and Environment Canada operates moored and drifting buoys. Figure 1 shows the distribution of this *in situ* data network centered on Alaska. From this figure, it is clear that *in situ* coastal and marine meteorological data in the North Pacific Ocean is concentrated near-shore and is widely spaced. Thus, marine users in this region have come to rely on satellite remote sensors. Even NDBC provides access to the latest satellite scatterometer data in the vicinity of the surface observation platforms listed on their online maps.

In order to address the environmental satellite user needs of the coastal and marine communities of the North Pacific Ocean, the North Pacific Environmental Satellite Workshop for Coastal and Marine Applications was conceived as part of a Cooperative Program for Operational Meteorology, Education and Training (COMET) Partners Project between the NWS Weather Forecast Office (WFO) Juneau and Millersville University of Pennsylvania (MU). The workshop was held 29-30 May 2007, at the University of Alaska Southeast (UAS), Juneau, Alaska. Additional workshop sponsors were the NOAA/National Environmental Satellite, Data, and Information Service (NESDIS) and Johns Hopkins University Applied Physics Laboratory (JHUAPL). The workshop was attended by 37 participants from government (federal, state, and local), private, and educational institutions across the United States and Canada. Participants represented a variety of disciplines including meteorology, hydrology, fisheries, hazards response, and law enforcement.

There were two primary goals of the workshop:

1) to provide a forum for presentation and discussion of research and development regarding the application of environmental satellite data to a variety of coastal and marine issues in the North Pacific Ocean

2) to solicit feedback from the local user community regarding current and desired environmental satellite user products. In order to accomplish these goals, the workshop consisted of five, invited ½-hour oral presentations and 16 plenary 15-minute talks. In addition, a 1½ hour panel discussion was held on each workshop day.

The final workshop agenda, including abstracts for each talk, can be viewed on line at: http://pajk.arh.noaa.gov/training/sat/workshop.html.

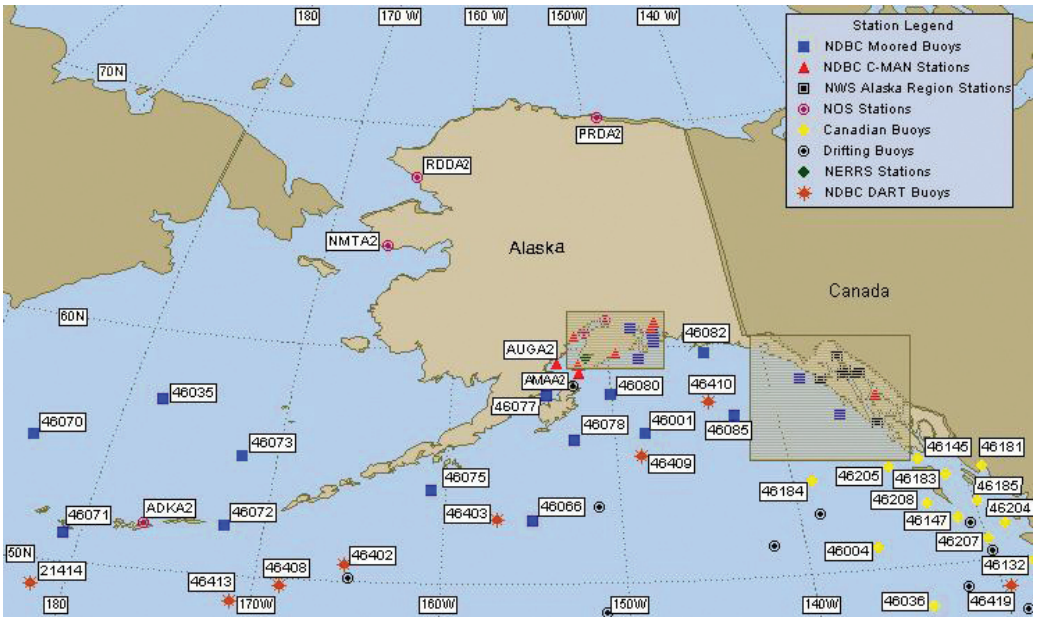

Fig. 1. NDBC map of marine observation platforms within the Alaska region.

2. Workshop Day 1

The workshop commenced on 29 May with welcoming remarks by Mr. Tom Ainsworth, Meteorologist-In-Charge, WFO Juneau. Mr. Ainsworth stressed that the workshop presented a unique opportunity for interaction between the research and user communities. He encouraged attendees to use the opportunity to develop collaborations on employing satellite remote sensing data for the diagnosis, prediction, conservation, and management of the North Pacific Ocean's coastal and marine resources. Mr. Ainsworth was followed by the five invited speakers.

First, Dr. Kevin Schrab (NWS Office of Science and Technology) offered details on the latest polar-orbiting and geostationary satellites from a national perspective. Numerous examples of coastal and marine forecast applications were presented. Mr. William Pichel (NESDIS

Center for Satellite Applications and Research) spoke next, reviewing three types of active microwave satellite sensors: (1) altimeters, (2) scatterometers, and (3) synthetic aperture radars (SAR). Altimetry applications include monitoring global sea level changes, storm intensity, ocean currents, and sea ice. Both scatterometer and SAR data (Fig. 2a and 2b) allow for the diagnosis of near-surface wind information. Scatterometers provide the marine wind vector at a resolution on the order of 1 to 10 km. SAR provides marine wind speed at a resolution on the order of 0.1 to 1 km.

Mr. Pichel was followed by Mr. Gary Hufford (NWS Alaska Region Headquarters), who examined domestic and foreign satellite resources that complement or meet the operational needs of the NWS in Alaska. A common theme expressed by Mr. Hufford and the previous two speakers was that current satellite needs are greater than ever. Moreover, these needs are being satisfied, in part, via partnerships between government and private entities, both domestic and foreign. Mr. Hufford emphasized that for operational purposes, timely data are needed—within 15 minutes (optimum) to one hour (acceptable). Data that are several hours old are generally no longer operationally useful.

Next, Dr. Donald Atwood of the Alaska Satellite Facility (ASF) spoke. ASF provides near real-time SAR data and derived products in support of operations at NESDIS, the National Ice Center, and the Canadian Ice Service. ASF SAR data is employed in the analysis of marine wind, ocean features, ocean waves, sea ice, river ice, glacier movement, bathymetry, natural and man-made slicks, and ship detection. Due to the large array of SAR applications, the research and operational user demand is great and at times competing.

The final invited presentation was by Mr. Pichel. This talk focused on the Alaska SAR Demonstration (AKDEMO) project. AKDEMO is now in its 8th year. AKDEMO provides experimental SAR products for meteorology, oceanography, fisheries, natural hazards, and law enforcement activities - see examples online at: www.orbit.nesdis.noaa.gov/sod/mecb/sar/. Mr. Pichel briefly reviewed the development of future SAR systems, including the Japanese Advanced Land Observing System, with its Phased Array L-band SAR.

Following the invited talks, a panel discussion was held with Don Atwood, Bill Pichel, and Gary Hufford serving as panelists. The panel discussion focused on the following questions:

- What experimental, or potentially new, satellite products hold the most promise for benefits to commercial and scientific users along the Pacific coast of North America?
- What enhancements to current datasets are most needed (quality, frequency, resolution, reliability, etc)?
- How can governmental, educational, and private entities work together to improve access, availability, and continued support of these important satellite datasets in the North Pacific Ocean?
- How can we best promote those needs?

Healthy discussions ensued. The outcome of this and the second panel discussion resulted in the list of workshop recommendations found at the end of this document.

The remainder of the first workshop day was occupied by four plenary talks. Mr. Carven Scott (WFO Anchorage) reviewed the incorporation of high-resolution polar-orbiting satellite data into the WFO Anchorage forecast process. Mr. Scott provided examples of forecast and warning improvements that were the result of these new data sources. Mr. Carl Dierking (WFO Juneau) introduced a web-based educational module on dynamic feature detection using a satellite palette. Mr. Dierking spoke on behalf of Mr. James Cummine, who was unable to be in attendance. Then, Dr. Matthew Heavner and Dr. Eran Hood of UAS concluded the first workshop day with two talks presenting an overview of a sophisticated sensor web project. The project, called Southeast Alaska Monitoring Network for Science, Telecommunications, Education, and Research (SEAMONSTER), has a goal to semi-autonomously reconfigure various ground and space sensor assets based on the sensed environment.

That evening, workshop attendees were treated to warm Juneau hospitality at a local salmon and halibut bake.

3. Workshop Day 2

The second day of the workshop contained the remaining 12 plenary talks. Mr. James Truitt (WFO Juneau) led off the day with a discussion of the use of Advanced Microwave Sounding Unit-derived geopotential thickness gradients in the forecast process. Mr Truitt presented a case in which satellite-derived thicknesses could be used to assess the intensity of storm development.

A recurring theme throughout the workshop, and especially within the remainder of Day 2, was the importance of SAR data in research and operations conducted by the participants. For example, due to its unequaled high resolution, SAR-derived wind speed imagery is being used in forecast offices with marine responsibilities from the Aleutians to the Pacific Northwest.

Dr. Nathaniel S. Winstead (JHUAPL) reviewed several methods by which wind speed is derived from SAR imagery. Dr. Winstead then presented recent research wherein SAR-derived wind speed from these methods were compared to wind speed from buoys within the Gulf of Alaska. Good agreement was found. Dr. Winstead stressed that *a priori* knowledge of the wind direction is necessary to generate SAR-derived wind speed.

Following Dr. Winstead, Dr. Laurie Neil (Meteorological Service of Canada) presented a user-friendly SAR-derived wind speed tool currently employed by forecasters at the Pacific Storm Prediction Centre, Vancouver, BC. Ms. Tracey Ress (WFO Juneau) then described how QuikSCAT and SAR-derived wind speed imagery have been used operationally at WFO Juneau. After describing the marine forecast challenges in Southeast Alaska waters, Ms. Ress presented examples of how high resolution SAR imagery has been used to improve forecasts in the inner channels, while QuikSCAT wind vectors have been beneficial forecasts for the offshore marine areas.

Dr. Todd D. Sikora (MU) proposed a wind speed assessment product for use in the face of wind direction uncertainty. The product consists of an image pair showing the maximum and minimum SAR-derived wind speed field. The maximum and minimum SAR-derived wind speed is generated by forcing the wind direction to be either perpendicular or parallel to the radar look direction, respectively. Dr. Sikora demonstrated the product using the case of a barrier jet along the Alaska coast.

Following Dr. Sikora, Mr. Carl Dierking (WFO Juneau) presented the results of a compositing study focused on the use of SAR-derived wind speed as a means to characterize marine wind speed within the complex terrain of the inner channels of Southeast Alaska, for various synoptic flow patterns. SAR-derived wind speed composites were categorized by synoptic flow pattern to produce wind climatology for coastal marine areas. Mr. Dierking presented examples utilizing the wind climatology, such as evaluating the location of anemometers, and adding greater detail to wind forecast grids.

Because of the high-resolution attribute of SAR, wind speed imagery derived from SAR often reveals the signatures of mesoscale meteorological phenomena, such as vortex streets, gravity waves, and katabatic winds (Fig. 2b). (Examples of these and other meteorological phenomena visible within SAR wind speed imagery are provided within *High Resolution Wind Monitoring With Wide-Swath SAR: A User's Guide*, available online at: www.star.nesdis.noaa.gov/sod/mecb/sar/PUBLICATIONS/windguide.html). Moreover, the mesoscale nature of storms, such as polar mesoscale cyclones, is often observed. Dr. Xiaofeng Li (I.M. Systems Group, Inc) presented research wherein SAR-derived wind speed imagery of these phenomena were examined in concert with

Fig. 2(a)

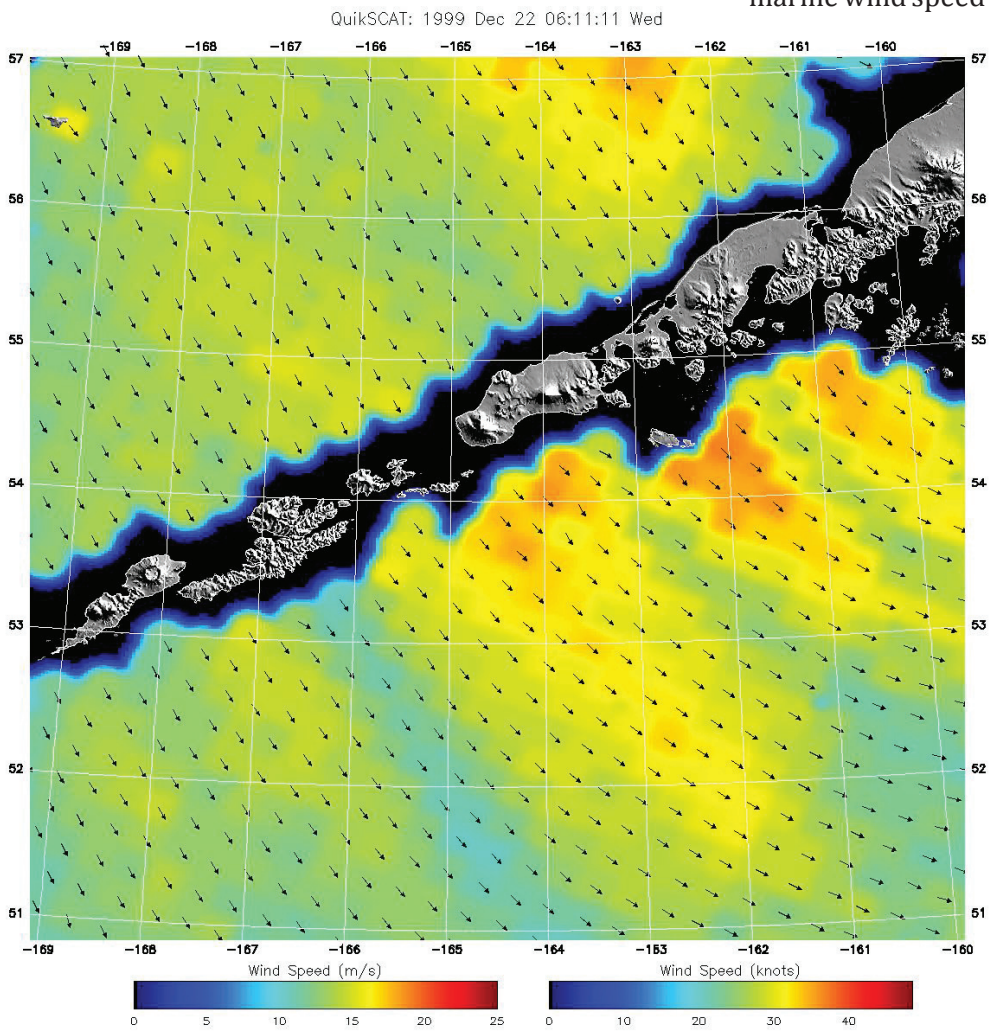

Fig. 2(a). Comparison of QuikSCAT wind vectors and SAR-derived wind speed for the Alaska Peninsula at the same valid time. In Fig. 2b (facing page), QuikSCAT wind vectors are overlaid on the SAR-derived wind speed image. Where these vectors disappear, there is agreement between the QuikSCAT and SAR-derived wind speeds. *Images are provided courtesy of Frank Monaldo, JHUAPL.*

analytical and numerical weather prediction models. The result is a more complete description of the physical morphology of the phenomena than permitted by SAR or models alone.

Mr. Joel Curtis (WFO Juneau) provided a presentation on his recent participation in an experiment aimed at verifying SAR-derived wind speed within the inside waters of Southeast Alaska. Mr. Curtis was one of several captains supporting the experiment who sailed their instrumented small craft under many SAR overpasses during sometimes extreme meteorological conditions. Mr. Curtis's *in situ* wind speed data are currently being compared to that derived from SAR.

Following Mr. Curtis, Ms. Rachel Potter (University of Alaska, Fairbanks) outlined the Alaska Ocean Observing System (AOOS) custom website for the city of Barrow, available online at: http://ak.aoos.org/barrow. This page currently utilizes near real-time SAR and Moderate Resolution Imaging Spectroradiometer (MODIS) data to infer various geophysical parameters, such as the location of the ice edge, in order to inform community users and researchers about ice conditions in the area. While SAR is an active microwave satellite instrument, MODIS utilizes the passive sensor Advanced Microwave Scanning Radiometer – Earth Observation System (AMSR-E, available online at: www-nsidc.colorado.edu/data/amsre/) to derive sea ice products.

Mr. Pichel presented two of the three remaining workshop talks. The first talk was on the GhostNet project (GhostNet description available online at: http://marinedebris.noaa.gov/projects/ghostnet.html#bkgrnd). The goal of GhostNet is to detect marine debris in the North Pacific Ocean using multi-sensor satellite and aircraft remote sensing, information on surface drift from models and buoys, and recovery of said debris. Two successful GhostNet field programs have been conducted, one in the Gulf of Alaska in 2003 and one in the North Pacific Subtropical Convergence Zone north of the Hawaiian Islands in 2005. In the Gulf of Alaska, debris was found predominantly in large eddies and in the North Pacific Subtropical Convergence, a large quantity of debris (including 122 nets) was observed in the vicinity of the Transition Zone Chlorophyll Front north of Hawaii during three observation flights. Mr. Pichel's last talk covered the characteristics of oil spills and corresponding ship signatures in SAR imagery. Mr. Pichel focused on the Selendang Ayu grounding and associated oil and soybean spill that occurred on Unalaska Island on 8 December 2004.

Between Mr. Pichel's last two talks, Dr. Fabrice Collard (BOOST Technologies) discussed the retrieval of surface wave parameters from SAR. Dr. Collard compared wave spectra derived from SAR to buoy wave spectra recorded at NDBC station 46029, offshore of the Columbia River estuary. Overall good agreement is found between *in situ* and SAR observations, over a wide range of wave heights and directions, including waves propagating in the radar azimuth direction, and varying incidence angles. Dr. Collard demonstrated that the extraction of hurricane swell wave parameters from RADARSAT-1 ScanSAR images (RADARSAT-1 description available online at: http://www.space.gc.ca/asc/eng/satellites/radarsat1/default.asp) and the global tracking of ocean swell using ENVISAT

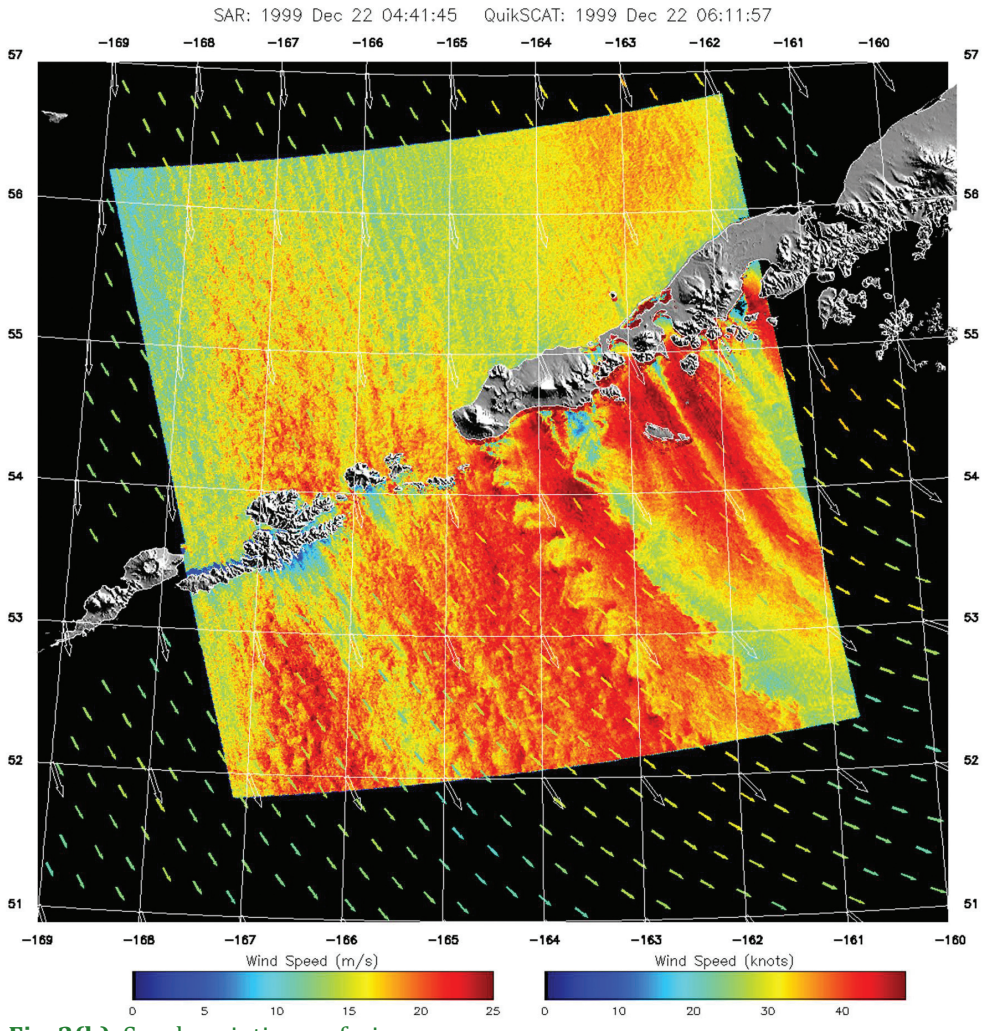

Fig. 2(b). See description on facing page.

ASAR Wave Mode data (ENVISAT description available online at: http://envisat.esa.int/) are also possible.

Following the Day 2 plenary talks, a second panel discussion was held. The panelists were Mr. Carven Scott, Dr. Laurie Neil, and Mr. Joel Curtis. The second panel discussion focused on the following questions:

- Are there specific geographic areas within the North Pacific Ocean (and/or temporal frequencies) that are critical or of higher priority than other areas for coverage for winds, waves, vessel positions, etc.?
- How do these areas vary seasonally? What other special satellite products have critical geographic or time sensitive needs?
- What would be preferred methods for providing access to specialized satellite products and in what form (raw, processed), in order to meet the needs of a diverse user group?

Once again, healthy discussions ensued. The outcome of this panel discussion was combined with the results of the Day 1 panel discussion and summarized in the list of workshop recommendations found in the following section.

4. Workshop Conclusion and Recommendations

Mr. Ainsworth provided concluding remarks upon the end of the second panel discussion. It was agreed that the workshop was very successful and should become an annual event. WFO Anchorage agreed to hold the 2008 follow-on workshop. Attendees were pleased at the number of opportunities the workshop afforded to satisfy user input and initiate new collaborative partnerships, most notably transferring science and technology from research and development to operations, and new marine service possibilities for the public-private partnerships. The talks and especially the panel discussions resulted in following list of recommendations.

- Develop customer awareness and education plans to expose new and existing satellite products to a wider audience and to provide more educational material on the use of these products.
- Develop satellite-derived climatological wave data for use in coastal flood warnings.
- Endeavor to make satellite pass schedules more public and accurate.
- Ensure availability of standardized satellite data sets.
- Improve collaboration between satellite product producers and satellite user groups, especially when competing for limited resources.
- Improve frequency of coverage, timeliness, and reliability of SAR-derived products.
- Increase awareness of the importance of National Polar-orbiting Operational Environmental Satellite System data to the North Pacific Ocean user community.
- Increase availability of satellite data onboard ships.
- Investigate the feasibility of a satellite-based atmospheric geopotential thickness product.

After the end of the formal workshop at UAS, attendees were invited to tour WFO Juneau. Many attendees took advantage of this opportunity. Mr. Carl Dierking and Ms. Tracey Ress are thanked for leading the tour groups.

Acknowledgments

The authors are grateful to the University of Alaska Southeast (UAS) for providing the meeting facility and audio-visual technical assistance. Ms. Ursula Jones (NWS) is thanked for contributing many hours of administrative support.

This workshop was supported in part by COMET Partners Project S06-58385.

The Authors

Dr. Todd D. Sikora is an Assistant Professor of Meteorology at Millersville University. Dr. Sikora received his B.S. (1990), M.S. (1992), and Ph.D. (1996) in Meteorology from The Pennsylvania State University.

Carl F. Dierking is the Science Operations Officer at the NOAA/National Weather Service, Weather Forecast Office Juneau. Mr. Dierking received his B.S. in Atmospheric Science from Purdue University in 1973.

Dr. Nathaniel S. Winstead is a Senior Meteorologist at The Johns Hopkins University Applied Physics Laboratory. Dr. Winstead received his B.S. in Mathematics from Duke University in 1993. Dr. Winstead received his M.S. (1995) and Ph.D. (1999) in Meteorology from The Pennsylvania State University.