



International Policy on Wide Swath SAR Ocean Weather Data

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Significant benefits of wide swath synthetic aperture radar data for ocean weather observations have been demonstrated in principle. However, several obstacles must be overcome for this application to achieve its full potential as an operational system. Three themes emerge when considering these obstacles: data utility, data supply, and data policy. This article provides a summary of these issues, expands on several aspects of the data policy question, and closes with a series of recommendations. (Keywords: Ocean weather data, SAR data policy, Wide swath SAR.)

INTRODUCTION

The Emerging Coastal and Marine Applications of Wide Swath Synthetic Aperture Radar (SAR) Symposium was unique in that the invited participants included operational users, applied mathematicians, oceanographic and atmospheric scientists, and representatives of government agencies. The immediate objective of the symposium was to review the state of the art and to explore the future prospects for air–sea interactions as seen through spaceborne SAR data. The larger objective was to work toward an operational space-based sensing capability to observe detailed patterns of ocean weather over large areas in near–real time.

This symposium afforded the first substantive encounter between two rather disparate scientific communities, namely (SAR) oceanographers and (boundary-layer) atmospheric specialists. In general, each group discovered that its signals often were viewed by the other side as noise. Fruitful intellectual exchange

occurred across this boundary through the sharing of ideas, results, insights, and expectations. The scene was well illuminated by the data requirements and practical constraints that were compellingly conveyed by users and providers from the operational community.

The technical contributions to the symposium are well represented by the articles in this issue of the *Digest*. However, the nontechnical constraints that threaten to block operational deployment of a wide swath ocean weather observing system are less apparent. This article attempts to bring into clearer perspective the main themes that emerged from the meeting, gleaned from the content and counterpoint of the formal presentations as well as from the less formal exchanges among participants. These themes are suggested by the proceedings of the closing panel discussion, which are summarized in the next section. One of these themes—data policy—was challenged to some

degree by virtually all participants, yet it was not formally addressed by any of the contributors. Given its importance, aspects of national and international data policy that bear on the subject of ocean weather observations form the core of this article.

THE PANEL DISCUSSION

The panel discussion was designed to identify salient themes of the symposium. Members of the panel were Gary Hufford of the U.S. National Weather Service, Alaska; Jim Gower of the Institute of Oceanographic Sciences, British Columbia; David Benner of the U.S. National Oceanic and Atmospheric Administration/National Environmental Satellite, Data, and Information Service (NOAA/NESDIS); and Evert Attema of the European Space Agency (ESA). Each panelist opened with a 10-minute brief of his position. Subsequently, attendees were invited to offer their observations and to pose questions to the panelists.

The results are captured by 14 highlights which fall roughly into three themes: data utility (1–5), data supply (6–10), and data policy (11–14). The first two themes are addressed explicitly by the articles in this issue. Although the third theme is cited (or at least recognized) by many authors, little has been done to wrestle with data policy issues, especially the difficult question of pricing. Data policy considerations are addressed later in this article.

Points raised during the course of the panel discussion are summarized as follows:

1. Several organizational imperatives are implied if wide swath SAR data are to become operationally useful, e.g., adequate access to suitable wide swath SAR data sources, data continuity sufficient to support an operational commitment by users for at least 10 to 20 years, a standardized and user-friendly data product format, and adequate training so that operators and stakeholders can take full advantage of the promise of this rich source of information. Tasking and ordering, although less prominent aspects of an operational system, must be included explicitly in any plan that would merit broad acceptance.
2. Data and real-time environmental information from wide swath SARs would be enhanced by integration with data from other assets such as coastal radars and instrumented buoys. Greater attention should be invested in data assimilation and utilization of such resources.
3. The communication link capacity of modern *in situ* data buoys should be more fully exploited. For example, the data stream from these buoys could be enhanced to include wind measurement variances, information that normally is not included in the traditional parameter set.
4. A tutorial reference catalogue or pictorial atlas should be published that would profile the principal air–sea signatures encountered in SAR data, for which Radarsat, in particular, would be an excellent source. The two parallel purposes of such a catalogue would be *technical* (to document phenomena corresponding to image features) and *promotional* (to illustrate the richness of wide swath sea surface SAR observations). The Jet Propulsion Laboratory publication *Seasat Views Oceans and Sea Ice with Synthetic-Aperture Radar*¹ was cited as an excellent model.
5. Canada (the Canadian Space Agency, aided by the Canada Center for Remote Sensing and Radarsat International) should publish a Radarsat user's handbook (analogous to the *ERS-1 User's Handbook*²) to provide information sufficient to answer all questions likely to be encountered by those who would extract quantitative information from Radarsat digital image files.
6. If wide swath SAR (which, in this context, means ScanSAR) is to be exploited in scientific or operational applications, then the product must be calibrated. This, in turn, requires data product stability. Hence, all future wide swath SAR data products must include data product stability in their design, and the requisite calibration parameters must be provided to the users. Sponsors of satellite-based SAR systems, including especially Radarsat-2 and Envisat (once they are operational), should be prepared to offer users full access to the radar and processor parameter values relevant to their particular data sets.
7. Given that several SAR satellites will be in orbit over the next 5 years or so, it would benefit the user community greatly if those assets were coordinated, especially with respect to their coverage and phasing. Such coordination could be facilitated by existing entities like CEOS (Committee on Earth Observation Satellites) or IGOS (Integrated Global Observing Strategy).
8. There appears to be no funding source that would ensure long-term availability of wide swath SAR data. Agencies concerned with SAR systems (NASA, NOAA, ESA, the Japanese Space Agency [NASDA], etc.) should work together more effectively to mutually develop plans for space assets that would provide the needed data continuity through 2020.
9. Radarsat-2, and all subsequent SAR systems capable of wide swath imagery, should include a super wide swath mode covering as much as 750 to 800 km. In contrast to "conventional" wide swath modes of 500 km or less, such a super wide swath would have an enormous advantage for operational purposes to ensure large area coverage, enhance the effective rate of revisit, and increase the simultaneous view of large-scale phenomena.

10. "Operational" implies a long-term obligation to build, launch, and operate satellites that would generate suitable data with an assurance of continuity. Currently no nation or enterprise has long-term plans to include a commitment to SAR systems, let alone to provide continuity of wide swath data. NASA's stated policy, for example, is to obtain SAR data from commercial sources, even though such data are acknowledged to provide valuable new insight into large-scale processes.³ Envisat is to be the only one of its kind according to ESA. Reliance on commercial or single-opportunity missions stands in stark contrast to operational weather satellite systems whose planning, construction, and operational horizons span 20 years and more (see Winokur, this issue).
11. Operational use of wide swath SAR data requires the timely (i.e., less than 2 hours) distribution of useful data products. Both the technical and political constraints on the information systems must be designed to adapt such "timeliness."
12. If wide swath SAR ocean weather data are to be exploited routinely in large quantities, their cost must be low, which in practice means that the cost must fit within the budgets of the user agencies.
13. The pricing policy of (remote sensing) data continues to be problematic. ESA, NASDA, and NASA appear to be migrating toward a two-level policy: one set of prices if the data are for commercial purposes, and lower pricing for scientific purposes. On the other hand, operational weather data from NOAA are provided essentially free of charge by the United States, but are marketed as a commercial product in Europe.
14. Most (more than 90%) of the remote sensing data collected to date lie in archives, unused. What is the *missed*-opportunity cost of those data? It would be constructive if all such data were to be openly catalogued online and if generous (if not *gratis*) terms of access were granted to the public. Wide swath SAR data from ocean areas, for example, if latent by more than only a few days, have negligible commercial value, yet would have potentially large scientific value. Why let such a resource go to waste?

DATA UTILITY

Today, elementary qualitative questions, such as the ability of a SAR from space to image the moving surface of the sea, are no longer of concern. The standard is much higher. As evident in the preceding articles, remarkable progress has been made toward convergence on a geophysical calibration of wind field data over large ocean areas in near-real time based primarily on the interpretation of wide swath SAR

data. The need now is to document and publicize what is known, as suggested in highlight 4.

The main technical matters are outlined in the article by Beal (this issue), supplemented by the contributions that form the heart of this special issue. As is appropriate for an emerging and subtle quantitative measurement, substantive challenges remain that confront the extension of these techniques to more general conditions, and to greater operational reliability. The key technical questions now, at least, are well posed. One can be confident that they will be addressed successfully in the near future.

DATA SUPPLY

Data supply issues primarily concern questions about the continuity of SAR satellites beyond currently approved missions, and the properties of the data that might be supplied by such systems. The situation is summarized by Winokur in his keynote address. The main question is clear: Is SAR ready to make the transition from a scientific research tool to an operational sensor? As noted by Winokur, "operational" implies certain imperatives: continuity, timeliness, and reliably useful data products. The contrast is drawn between scientific (and national demonstration) SAR satellites, planned to continue through 2008 or so, and operational weather satellites committed through 2020, with implied continuity for perpetuity. Scientific satellites approved one by one (if at all) cannot be the basis for an operational capability. Operational users require continuity on decadal time scales, as noted earlier in highlight 10.

Continuity of operational SAR system capabilities could be fostered through international agreements. To accomplish this, suitable international forums must be convened to work in common cause toward that goal. As introduced by Winokur's remarks, and echoed by highlight 7, IGOS is one such opportunity. This theme is revisited later.

DATA POLICY

Various data policy concerns arise explicitly and implicitly in many of the articles in this issue. Highlights 11–14 especially point to data policy issues. Data policy threatens to become the pacing condition that could preclude the evolution of wide swath SAR ocean weather observations toward operational status.

In general, the four critical data policy issues that must be resolved if a wide swath SAR ocean weather system is to become an operational reality are (1) accessibility, (2) continuity, (3) timeliness, and (4) pricing. Of these, timeliness and pricing deserve further consideration. It is especially helpful when considering pricing to look at it in the context of the U.S.'s

history of remote sensing data policy, reviewed in the next subsection of this article. Following that review, the current situation is summarized. The major legislation that determines remote sensing data policy is the Remote Sensing Act of 1992, considered in the subsequent subsection. The closing subsection describes relevant aspects of IGOS. The general argument developed through this section and the related conclusions are that, for the special case of wide swath SAR ocean weather observations, the current U.S. policy provides an environment in which timeliness and data pricing issues could be resolved.

Background

Remote sensing data policy issues are not new. The global scientific and resource monitoring communities have faced similar challenges since the Space Age began in 1957. The International Space Year activities, for example, provided many forums for a discussion of data policy.⁴ Despite this heritage, inconsistencies remain in the policy of the United States and other space-faring nations on environmental and weather data that are gathered by nonoperational systems. Operational weather observations in the United States have been the purview of NOAA since 1960, and such data are made widely available at essentially no cost to the end user. In contrast, much of the remotely sensed data gathered by NASA or other space agency sponsors are available to users for a price.

In some cases, remote sensing instruments originally developed by NASA were subsequently adopted by NOAA and incorporated into their system of operational weather satellites. As such, their data became part of the weather data stream, and hence freely available.

What about data from those remote sensing instruments that were not adopted by NOAA? The data policy concerning the more complex and expensive systems such as imagers and SARs has been the most contentious. Pricing policy, in particular, has been controversial, fueled in part by political factors and special interest groups.⁵ In the early 1980s there was declining enthusiasm in the U.S. Congress for the government's support of NASA's Landsat satellite program. This attitude was reinforced by voices in the private sector that urged that the responsibility for all aspects of Landsat be migrated to a commercial status. These forces led to the Remote Sensing Act of 1984.⁶ The explicit expectation at the time was that all remote sensing data products would be sold at market prices, and that this approach should evolve into a financially self-sustaining enterprise. That experiment with a commercial approach to remote sensing data did not withstand the test of time. Both Congress and the remote sensing community subsequently acknowledged the need for a different strategy, in particular one which

differentiated between data having potential commercial value and data having primarily a scientific objective, i.e., noncommercial. This realization led to the Land Remote Sensing Act of 1992.⁷

Current Situation

Only one source of wide swath SAR data exists today, Canada's Radarsat. Those data are provided by Radarsat International (RSI). RSI, created by the Canadian Space Agency (CSA) as an integral part of their development plan for Radarsat, sells wide swath SAR data among its other remote sensing products on "commercial terms." Initially Radarsat data were made available to investigators selected through a competitive proposal process. These investigators had access to wide swath SAR data *gratis*, thanks to the terms of the formal agreements between Canada and the United States, and between RSI and CSA. These special situations are not necessarily sustainable or generalizable to the wider community.

"Commercial terms" means that the wide swath ScanSAR data may be purchased at published rates, about \approx \$4500 (1999 prices) per frame, each of which is (nominally) 500 km on a side. Operational observations of the ocean surface on a daily basis over large coastal areas would require thousands of such frames annually. Clearly, a global operational service cannot even be contemplated on such terms, no matter how compelling the benefits might be.

The Land Remote Sensing Policy Act of 1992

The Land Remote Sensing Act of 1992⁷ is the primary statement of the remote sensing data policy of the United States. The act opens with a set of findings, including an acknowledgment that the costs of remote sensing data products have impeded their use for scientific purposes and for other public sector applications. This lays the groundwork for a fundamental differentiation throughout the act between "commercial" and "noncommercial" purposes for remote sensing data. Unfortunately, two caveats are raised by this distinction. First, the act was written under the shadow of Landsat 7 concerns. Thus, many of its stipulations are land-oriented, and often are restricted explicitly to that satellite. Indeed, one could make a strong case that the provisions of the act were not anticipated to apply to ocean observations.

The second caveat is that the distinction between commercial and noncommercial suggests that all noncommercial data are for scientific purposes. In the passages that define these terms, the act does not explicitly assign environmental monitoring data to either category. In other sections, the act suggests that data for environmental monitoring and global climate change, as well as data deemed to be in the national

interest, are considered to be outside the commercial category. As a result, the pricing policy is interpreted inconsistently for environmental data derived from “remote sensing” satellites. Potential users prefer such data to be classified as noncommercial, whereas the organizations that sell remote sensing data almost always price environmental data at commercial rates. The commercial classification of environmental data—especially ocean weather data—runs counter to the public good for global and regional environmental monitoring, particularly for coastal, marine, and disaster early warning applications.⁸

The act clearly distinguishes between “unenhanced” and “value-added” data. For the former, allowable preprocessing includes radiometric and geometric calibration. This explicit description is important because the act empowers the government to provide *calibrated*, unenhanced data at marginal cost when the purpose is not commercial. Under the act, the price for unenhanced data from the government is only a few hundred dollars per frame, in contrast to the tenfold higher prices that had been charged by commercial suppliers for the same products. For example, earlier Landsat data are now being provided from archive, as per stipulations in the act. Commercial suppliers are not pleased.⁹ On the other hand, this practice sets a precedent that favors the lower marginal price classification for all environmental remote sensing data. It would be constructive, and a reasonable interpretation of the terms of the act, if wide swath SAR ocean weather data were stipulated to be in the public interest, in which case they would have to be provided to the public at non-commercial rates.

As a consequence of the Remote Sensing Act of 1992, NOAA was given the authority by presidential directive in 1994 for the review and issuance of licenses for operators of SAR satellites. A “plain language” version of the license provisions is available online.¹⁰ Among the several licensing conditions, one is that SAR data cannot be released within less than 24 hours of collection without special and prior approval from NOAA. Such a condition, if enforced, would jeopardize near-real-time systems that could otherwise help mitigate the risks of ocean weather and coastal hazards. It could be argued that this 24-hour restriction ought not to apply to wide swath SAR data over the ocean, because the license is explicitly meant to apply to land remote sensing. This is only one example of the act’s main ambiguity, i.e., its applicability to ocean remote sensing applications, especially large-area low-resolution ocean weather data, is not clear.

The 1992 act states the policy regarding the requirement for an operator’s license: If the U.S. government pays a substantial part of the development, fabrication, launch, or operations costs of a satellite system, then the operator must obtain a license. This is true for

foreign initiatives that would operate over or near the United States or its territories as well as for domestic programs. The stipulation includes the general provision that a license may be required if it is deemed to be in the national interest. Licensing may also require that unenhanced data are to be made available at marginal cost under the terms negotiated between the government and the licensee. Formally, the government is represented in these situations by the Secretary of Commerce.

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Radarsat-1 was not subject to the terms of a NOAA SAR operator’s license, but in the future foreign operators may have to obtain such a license if their data products are to be used domestically. In this connection, one should note the rather substantial proportion ($\approx 16\%$) of costs¹¹ provided by NASA in direct and indirect support of Canada’s Radarsat program. This could be interpreted to mean that the U.S. government could have required a license for Radarsat-1. A requirement for an operator’s license is under serious consideration by NOAA for Radarsat-2, although, as a consequence of NASA’s much smaller financial support for that mission, the case may be harder to justify.

For Radarsat-1, NASA successfully negotiated on behalf of certain government users access at no marginal cost for a favorable fraction of the expected data. However, the parties to the Memorandum of Understanding¹¹ did not anticipate the utility of wide swath SAR data over the ocean environment. Perhaps a specific provision for such data could be part of the terms and conditions of future licenses. Such a provision would be consistent with NASA’s stated policy to provide SAR data from nongovernment sources as part of their “data buy” policy. It would be constructive for NASA to implement such data buy agreements in the interests of the public good under the guidance of the spirit of the Remote Sensing Act of 1992.

The 1992 act includes specific clauses that ban commercialization of weather satellites, noting very clearly that “neither the President nor any other official of the Government shall make any effort to lease, sell, or transfer to the private sector, or commercialize, any portion of the weather satellite systems operated by the Department of Commerce or any successor agency.”

This section includes the more general guideline that it is not in the national interest to commercialize weather satellites. These statements raise a major implication, i.e., if wide swath SAR data over the ocean were stipulated to be "in the national interest," then such data would have to be made available by the operators under noncommercial rules. It follows that a license secured through NOAA for any radar remote sensing system in which the United States has a substantial investment should include terms to ensure that unenhanced data will be provided by the operator (domestic or foreign, public or private) according to the 1992 act.

There is a further possibility. Perhaps it would be appropriate to recognize the dual nature of SAR (and other) space-based remote sensing systems. In particular, wide swath SAR data over the coastal oceans is essentially a "weather satellite" data product, and should be classed as such. If so, that particular class of data product under those conditions would fall under the rules that govern operational weather satellites, which would be far better for the weather watch community than the noncommercial rules. Of course, if the same space asset were to be operated, say, in a high-resolution mode viewing a designated land area under request by a specific client for a "commercial purpose," then the provision of that data product would be guided by commercial protocol. For highly capable multimode systems such as modern SARs, this two-level approach seems to be consistent with the spirit of the Remote Sensing Act of 1992.

The Integrated Global Observing Strategy

In recent years the need to coordinate remote sensing systems and policies on an international scale has been recognized. That need motivated the formation and early development of IGOS.¹² IGOS is an association of national and multilateral organizations responsible for national and global environmental observations of the atmosphere, oceans, and land. Its purpose is to maximize the use and effectiveness of international strategic planning for monitoring and operational programs. Data policy issues are deemed of strategic importance and include accessibility, archiving, and continuity. (Pricing issues are not highlighted by IGOS, owing, in part, to the divergence of international opinion on this point.)

The IGOS umbrella document (November 1998) states that user requirements must be determined by establishing communications with the principal groups and institutions that use global environmental information for decision making, including international organizations, national governments, the private sector, and the scientific community. As noted by Winokur (this issue), it is through this mechanism that gaps in

coverage are to be identified and user-defined mission requirements established.

By mutual agreement, the IGOS strategies are grouped by "themes" to provide a coherent focus for obtaining user requirements against very specific objectives. In June 1999 the oceans theme was identified as the first priority for development, with completion of the strategic plan requested before the end of 1999. Under NASA leadership, this team was asked to present an ocean theme action plan, currently under development. Disaster management support is another priority theme that is relevant to the research covered in this issue.

It is timely to inform the IGOS Oceans Theme Team of the content and findings presented in this issue so that its strategic plan for ocean observation and monitoring might reflect this new body of research. Such communication is essential if IGOS is to give sufficient attention to the need for wide swath SAR data on ocean weather, and to set the stage for enlightened continuity of adequate space-based ocean data into the dawning millennium.

RECOMMENDATIONS

Through this collection of articles, the participating community has documented significant benefits of wide swath SAR for ocean weather and disaster observations. If these results are to bear fruit operationally, they must be disseminated and acted upon at both the national and international level. Two dominant considerations demand urgent attention: (1) the need for steps to ensure the continuity of wide swath SAR data collection, and (2) the implementation of data policies that would assure accessibility, improve timeliness, and guarantee appropriate pricing.

To help add substance to the concepts embedded in ocean weather and environmental observations by wide swath SARs, a focused demonstration project should be launched by the international community. Several candidate sites could serve as the focus of such projects. CEOS and its supporting agencies and member states would be a logical starting point for the necessary initiatives.

The Land Remote Sensing Policy Act of 1992 provides a strong, positive foundation for moving toward a national data policy that would be consistent with operational requirements and objectives of a SAR-based wide swath ocean weather observation system. Even though the act is land-oriented, most of its stipulations can be interpreted to apply to ocean weather sensing. However, such interpretation is fraught with ambiguity. It would be far better to draft a new act to establish an ocean remote sensing data policy, especially for environmental and weather observations, and to provide a framework to guide the migration of these

capabilities to operational status. An ocean remote sensing policy act would be consistent with the agreed upon agenda of IGOS as well as the U.S. leadership in striving for enlightened weather and remote sensing data policies.

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