P2.5 MANAGEMENT OF DATA FOR THE NCAR S-BAND POLARIMETRIC RADAR

Robert A. Rilling[1], Jean Hurst, Richard A. Oye, and Scott Ellis
National Center for Atmospheric Research[2], Boulder, CO

1. INTRODUCTION

The NCAR S-band Polarimetric radar (S-Pol; Keeler, et al. 2000) is a highly capable, transportable research system that produces a variety of radar data parameters and products. Parameters include the full matrix of polarization measurables, the derived fields of precipitation accumulation (by several methods), particle identification, and refractive index (which is related to relative humidity). Additionally, S-Pol can be coupled with bi-static receivers, producing a multiple Doppler data stream (Wurman, et al., 1993).

The S-Pol radar includes a complement of fully networked computer systems to manipulate and display data in real-time, as well as for the analysis of previously collected data. The open and configurable computer systems architecture allows the addition or removal of various dedicated processors for the synthesis of data products. This facilitates S-Pol use as a test bed for development efforts, without affecting the fundamental operations of radar control and recording.

The research emphasis of S-Pol, combined with the complexity and flexibility of the computer systems, presents certain challenges to the management of S-Pol data. Data streams are not often the same for consecutive projects, and recording of the data stream occurs in different formats on devices scattered across a network. There are quality assurance issues associated with each data set, and generation of the final data sets and distribution of those data vary with the data or product type. It is difficult to create fully automated data management procedures for all data streams, and to alter these for the various deployments. Manpower for data management is also limited.

Presented here is a brief outline of data management at S-Pol. The information is presented to document a complex aspect of S-Pol operations that is not always apparent to S-Pol users, and to stimulate discussion leading to better/alternative methodologies.

2. S-POL DATA STREAMS

S-Pol records numerous data streams to various media types in different formats. Details of the formats can be found on the NCAR/ATD web site (http://www.atd.ucar.edu/data.html). Additionally, several summary products are compiled, including an archive of static images. Table 1 lists the data/product streams, sizes for an hour of S-Pol operation, and availability (by year).

Data Stream Type	Format	Mb hr $^{-1}$	98	99	00	01
Polarimetric radar Variables (base data)	VIRAQ	700	X	X	X	X
Precipitation estimators	DORADE Sweepfiles	100	X	X	X	X
Particle Identification (Vivekanandan, et al., 1999)	DORADE Sweepfiles	400		X	X	X
Anomolous Propagation and Refractive Index	DORADE Sweepfiles	500		X	X	X
Bistatic	NetCDF	500				X
Image summary	PNG or GIF	20		X	X	X

Table 1: Data available from S-Pol, showing data format, bandwidth, and availability in a given year. Formats are described on the ATD website.

Parameters recorded at S-Pol for the various data/product type are outlined in Table 2. There is some redundancy in the parameter complements, a feature that allows easier review of a given data set, but adds to the total byte load from the radar. The primary data stream is considered to be the VIRAQ-formatted data, and most of the product streams can be re-generated using the VIRAQ data as a starting point, albeit at a high price in terms of CPU and man hours (the Bistatic and refractive index data cannot be regenerated in post-processing).

Data/Product Type	Parameters
Polarimetric radar variables (base data)	Reflectivity and velocitiy complements, cross-pol, full matrix variables
Precip estimators	Reflectivity and vel complements, particle ID, precip estimators using reflectivity, reflectivity and differential reflectivity, specific differential propagation phase, etc
Particle Identification	(included with precip estimators)
Anom Propagation and Refractive Index	Reflectivity and vel complements, clutter discriminators
Bistatic	S-Pol reflectivity, power, SNR, velocity; reflectivity, power, SNR, and velocity for each Bistatic; multi-Doppler orthogonal velocity estimates.
Image summary	Images of parameters of researchers' choice.

Table 2: Mix of data available from the various data/product streams. A high level of redundancy exists between the data sets.

The VIRAQ data are simultaneously recorded by dual systems to increase data security. All data archiving is

---

[1] Corresponding author: R. Rilling, NCAR, PO Box 3000, Boulder, CO 80305-3000; Email: rilling@ucar.edu
[2] NCAR is sponsored by the National Science Foundation

currently done on DLT media (either 2000 or 8000 format), or CD-R in the case of the images.

3. THE S-POL DATA NETWORK

The computer network used for S-Pol in the Improvement of Microphysical PaRameterization through Observational Verification Experiment (IMPROVE, 2001) is shown in Figure 1. Within the S-Pol van, there are typically four or five networks, with different degrees of accessibility between them, depending upon the critical nature of the data flowing over a given network. Fig. 1 shows three of the local S-Pol networks; not shown is the sub-network for engineering displays, and the general user/scientist PC network. The requirement to transmit data in real time to the operations center at the University of Washington necessitated a separate network, on which ran many parallel processes for creation of S-Pol products. The Bistatic systems each had their own sub-networks, as well. The Mesoscale Alpine Programme (MAP) and the Severe Thunderstorm Electricfication and Precipitation Study (STEPS) had similar networks, but without Bistatic.

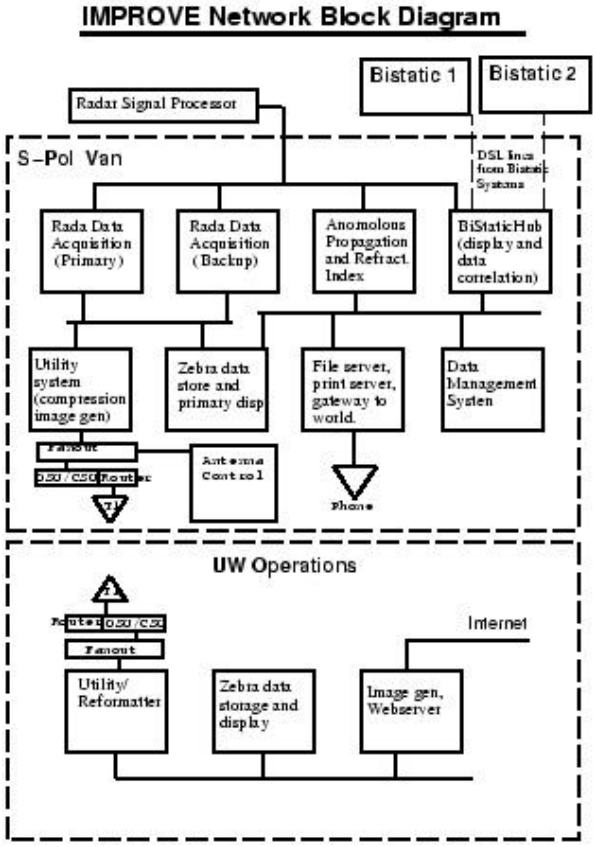

Figure 1. Computer network diagram for S-Pol during the IMPROVE, 2001, field project.

Generally, the sub-networks can work independently of each other, reducing chances that a research process will shut down essential data recording operations. Also, most processes run on a dedicated CPU, simplifying many aspects network design.

4. QUALITY ASSURANCE PROCEDURES

Because S-Pol is a transportable radar, hardware characteristics can be affected by the set-up and configuration processes. Special attention is therefore given to a full suite of quality assurance procedures. These procedures begin in the field with first transmission, and continue through the post-processing operations. Briefly, quality assurance procedures include:

- ranging and pointing checks
- systems gain verifications (through solar calibrations)
- differential reflectivity bias checks
- Linear depolarization ratio isolation checks
- self-consistent calibration checks
- on-going parameter review and monitoring for system changes
- test pulse monitoring

Quality control issues have occasionally stalled delivery of an S-Pol data set. This was the case for the MAP data, when minor hardware fluctuations caused small, varying, perturbations in differential reflectivity bias. Until these hardware problems could be adequately characterized, the MAP data could not be processed. The S-Pol radar had to first be returned from Italy and set up before diagnostic procedures could begin, resulting in a multi-month delay.

5. POST-PROCESSING AND ARCHIVING

S-Pol relies upon the SOLO (Oye, et al., 1995) radar data translators (the “translators”) to apply any corrections to S-Pol base data, properly derive all scientific variables, and convert from VIRAQ to either Universal Format or DORADE format (the distribution formats). Data are read from VIRAQ tape, and written to both an output DORADE tape and to temporary disk space in DORADE sweep file format. From disk, data are bundled into groups of sweep files and network-transferred to the NCAR Mass-Storage System (MSS). The MSS serves as the primary source of ATD S-Pol data, with the tape copy considered a site-separated backup. The tape copy can also be used for creation of distribution copies of the SPol data, particularly if translation to an alternate format is desired.

I/O bandwidth and translator calculations currently limit the speed of S-Pol base data processing to about four times real time for the VIRAQ data set.

Other data streams are handled in a less rigorous way, since many of these are developmental and require a high degree of scientist evaluation to determine proper processing methodology.

6. DATA DISTRIBUTION

Data distribution is either by network, or by tape media. Format for base data is either DORADE or Universal Format. Delivery by network speeds handling by ATD, but works well only when there is sufficient network bandwidth.

Along with data quality issues, distribution of a final data set may be delayed by preparation for follow-on field projects, reducing available manpower. Table 3 presents a summary of data distributions for S-Pol, showing time to full availability of base data and the media used.

Project	**Dates**	**Months to delivery (QC'd base data)**	Media
PRECIP98	Aug/Sep 98	10	Tape
TRMMLBA	Jan/Feb 99	7	Tape
MAP	Sep/Nov 99	15	Tape
STEPS	May/Jul 00	3	Network/tape
IMPROVE	Jun/Feb 01	2	Network

Table 3: Time to delivery of S-Pol QC'd base data. Data set size was similar for all projects: about 500-700 Gbytes. MAP data provision was delayed by hardware issues and preparation for the STEPS field project.

7. FUTURE WORK

ATD will continue to address the timeliness of data delivery for the S-Pol system. It is expected that data delivery will increasingly be done by network. ATD has developed a beta version Web interface/proxy for Mass-Store access (http://www.atd.ucar.edu/data.html) of all ATD project data, and will emphasize use of this tool in future data distributions (several Terabytes of project data are currently available with this tool). Other media, including DVD-RAM, are being considered for data distribution.

More rigorous procedures need to be developed for handling of the S-Pol non-base data sets. Particularly, Bistatic procedures must be developed.

In-field quality assurance procedures will continue to receive attention, with development and automation of additional techniques. Summary reports for the various field projects are in various stages of completion, and these must be completed.

Consideration is being given to a more centralized data model for use in the field at S-Pol, with the possibility of including a true file server and Terabyte raid system.

8. SUMMARY

S-Pol is a complex radar system that records several data streams and creates numerous data products. Efficient management of all S-Pol data is always evolving, with the emphasis on providing quality-assured data and value-added products to the end-user as quickly as possible.

Acknowledgements

NCAR, S-Pol, and this work, are supported by the National Science Foundation under cooperative agreement with the University Corporation for Atmospheric Research. In addition to the authors, S. Stringer and R. Neitzel contributed to the software tools used in S-Pol data management; J. Vinson, J. VanAndel and B. Slaten provide S-Pol network support.

References

Further information on all topics touched upon here may be found on the NCAR/ATD Web pages. See the ATD data and project pages, beginning with the URL:

http://www.atd.ucar.edu/atd_data.html

Keeler, R.J., J. Lutz, and J. Vivekanandan, 2000: S-Pol: NCAR's polarimetric Doppler research radar. IGARRS-2000, IEEE, Honolulu, HI, 24-28 July, 2000, 4pp.

Oye, R., C. Mueller, and S. Smith, 1995: Software for radar translation, visualization, editing, and interpolation. Preprints, 29th International Radar Meteor. Conf., AMS, Vail, Colorado, 9-13 July 1995.

Vivekanandan, J., D.S. Zrnic, S.M. Ellis, R. Oye, A.V. Ryzhkov, and J. Straka, 1999: Cloud microphysics retrieval using S-band dual-polarization radar measurements. *Bull. Amer. Met. Soc*., **80**, 381-388.

Wurman, J., S. Heckman, and D. Boccippio, 1993: A bistatic multiple Doppler radar network. *J. Appl. Meteor*., **32**, 1802-1814.