Chapter 1

Historical Overview

The JPL/NASA Aircraft SAR (AIRSAR) system traces its roots to the early 1970s when a coherent L-band radar was flown on the Ames Research Center CV-990 Airborne Laboratory. Even this first JPL SAR was a refurbished version of an L-band radar originally flown on an Aerobee rocket (Brown, 1969). The JPL SAR program was started with an L-band radar because one of the research areas in the early 1970s was to develop a radar for mapping the surface of Venus, and it was felt that L-band was the right frequency for penetrating the thick Venusian atmosphere.

In the early 1980s the JPL/NASA aircraft SAR underwent a number of modifications to allow the measurement of the full scattering matrix for each pixel, leading to the first operational imaging radar polarimeter. This radar also operated at L-band and flew a number of missions between 1983 and 1985 (Thompson, 1986). Due to the fact that the phase centers of the vertically and horizontally polarized antennas initially were offset (the so-called "baggage-door" antenna), initial polarimetric results were questionable. However, during the spring and summer of 1985, the baggage-door antenna was replaced by a microstrip patch array and excellent polarimetric data were acquired. On the night of 17 July 1985, the CV-990 aircraft blew tires on its take off roll at March Air Force Base in Riverside, California. The plane caught fire and was completely destroyed. Fortunately, all 19 crew members on board, including the radar crew, escaped without injury, but the JPL/NASA aircraft SAR was completely destroyed.

After this disaster, NASA provided funds to rebuild the imaging radar polarimeter. The new version, which eventually became known as the AIRSAR, was originally planned to operate in the fully polarimetric mode at both L- and C-band (24 and 5.6 cm wavelengths, respectively). With support from the Defense Advanced Research Projects Agency (DARPA), a P-band (68 cm wavelength) polarimeter was added. In addition to the three-frequency polarimetric capability, the addition of C- and L-band antennas on the front of the aircraft permits along-track interferometry at these frequencies. This new system became operational in late 1987 and flew its first mission in early 1988 on board a DC-8 aircraft operated by NASA's Ames Research Center. This campaign included sites in Alaska and the continental United States. Figure 1.1 shows the sites imaged during the first AIRSAR campaign.

Figure 1.1. *Geographic location of sites imaged during the 1988 AIRSAR campaign.*

Conducted in the summer of 1989, the second AIRSAR campaign included two major system improvements. The first was to replace the analog chirp by a digital chirp, while the second was the addition of a quick-look processor on board the DC-8. With the new digital chirp, range reference functions could be matched much better during processing, resulting in well-focussed images. The quick-look processor allows the radar crew to produce a reduced-resolution image in about 10 minutes while acquiring data. These products have proven invaluable not only for verifying that correct sites were imaged, but also for early photo-interpretation of images while the investigators are still at the site. The summer 1989 campaign covered sites in the United States, Canada, Western Europe, Greenland, and Iceland. Figure 1.2 shows the geographical location of sites imaged in the 1989 campaign. The 1989 campaign also saw the first participation of the AIRSAR in a Multi-Sensor Airborne Campaign (MAC) when data were acquired for the Geologic Remote Sensing Field Experiment.

Two campaigns were flown in 1990; the first during the spring and the second during the summer. The spring flights covered sites in Central America (Mexico, Guatemala, Belize, Honduras) as well as the United States. The summer flights covered sites in the continental United States, Canada, and Hawaii. The AIRSAR also participated in two Hydrology and two Ecology MACs. Figures 1.3 and 1.4 show the locations of sites imaged during the spring 1990 and summer 1990 campaigns, respectively. A near-real-time processor was introduced on the DC-8 for the 1990 data flights. Apart from ensuring that the actual

sites are covered during the data-collection flights, the real-time processor is also used for checking data quality at the time of data acquisition.

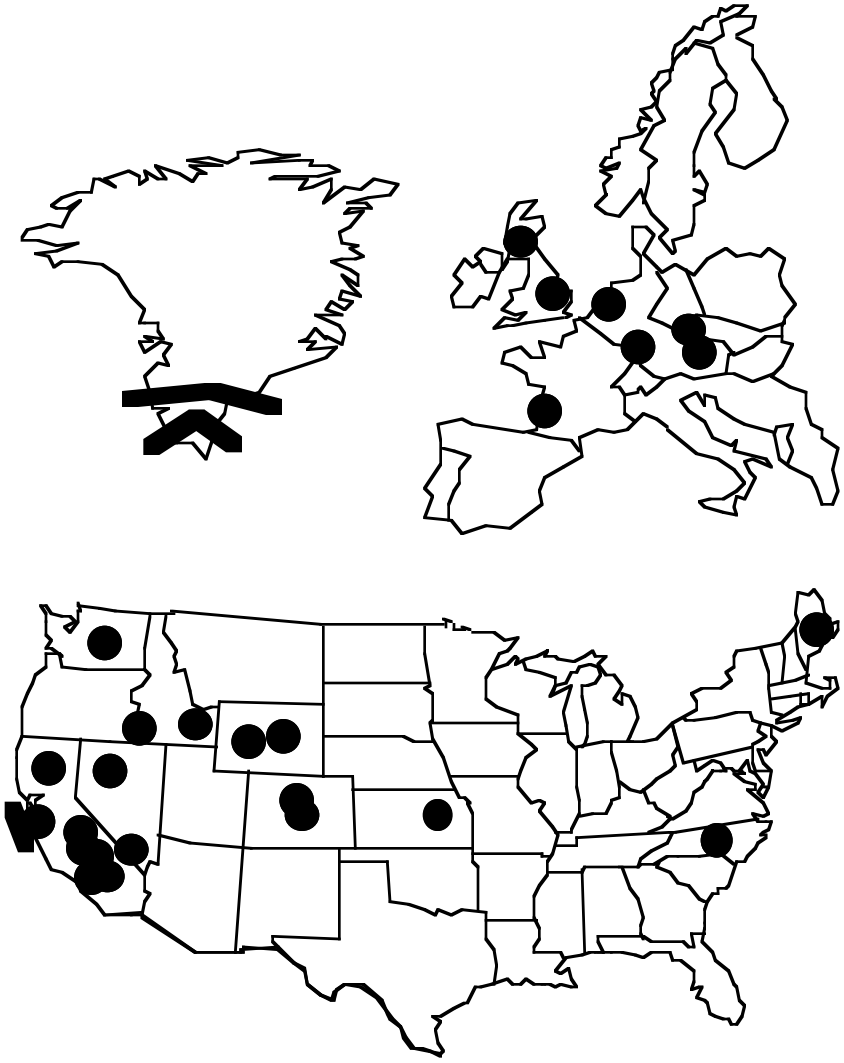

Figure 1.2. *Geographic location of sites where data were acquired with the AIRSAR system during the 1989 campaign.*

The third flight season was conducted during the spring and summer of 1991, and data were acquired in Austria, France, Germany, Greenland, Iceland, Italy, The Netherlands, Spain and the U.S.A. This was the most ambitious flight season yet, and the sites imaged are shown on the map in Figure 1.5. Four of the most recent AIRSAR campaigns are summarized in Table 1.1 below.

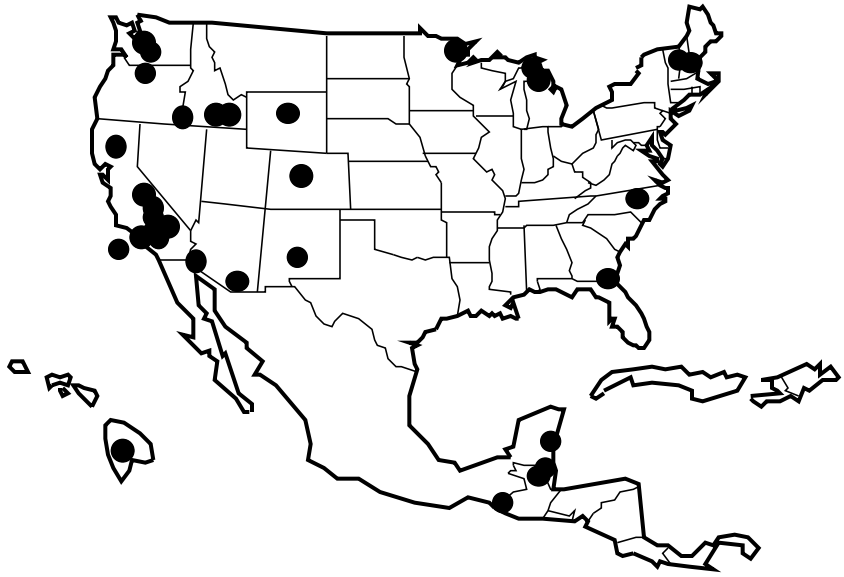

Figure 1.3. *Geographic location of sites where data were acquired with the AIRSAR system during the spring 1990 campaign.*

Table 1.1 *A comparison of four years of AIRSAR operations.*

Operations Year	1989	1990	1991	1992
Operations Window (months)	2	4	5+	3
Number of flight days	28	35	49	20
Number of operating bases	5	9	19	3
Investigators supported	8	33	61	12
Data collected (GBytes)	458	327	599	200
Scenes processed and distributed	55	95	175	350

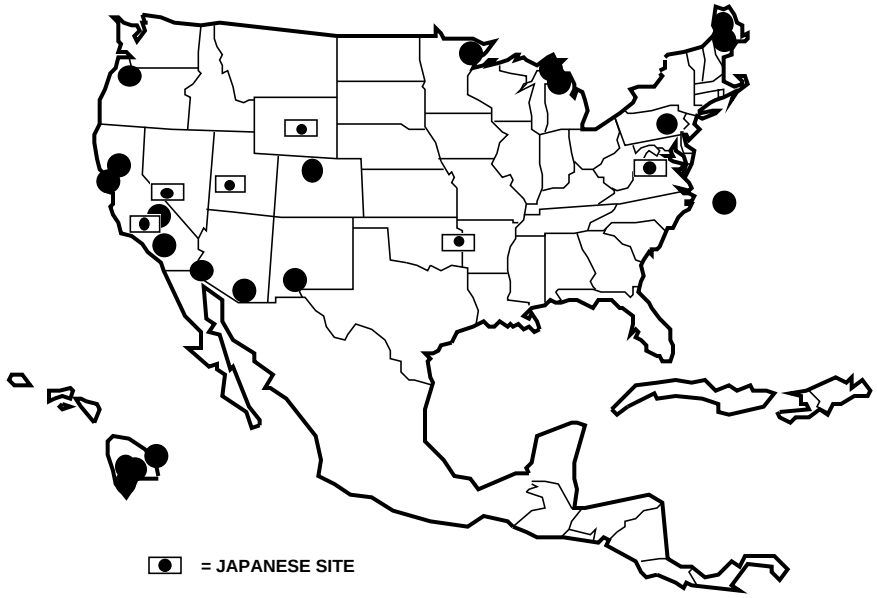

Figure 1.4. *Geographic location of sites where data were acquired with the AIRSAR system during the summer 1990 campaign.*

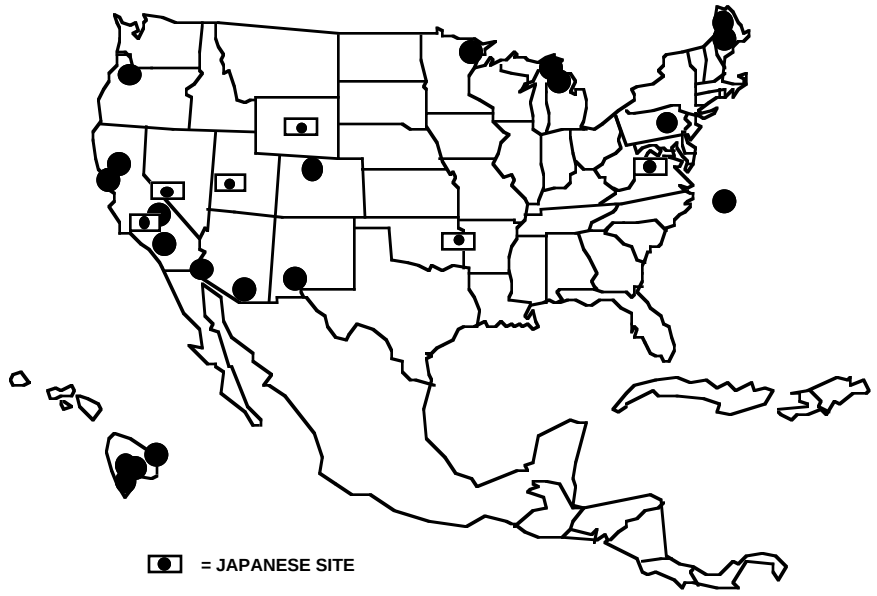

Figure 1.5. *Geographic location of sites where data were acquired with the AIRSAR system during the 1991 campaign.*

The AIRSAR system is currently the only existing three-frequency polarimetric SAR that can acquire polarimetric data at all three frequencies *simultaneously*. Data from all three radars are combined in the digital system, buffered and then stored on tape using High-Density Digital Recorders (HDDRs). These tapes are then transported back to JPL to be processed into standard frame products. Survey products are generated from the high-density digital tapes (HDDTs) using the real-time flight correlator and are distributed to investigators within two months of the end of the flight campaign. The investigators then submit processing requests to JPL for frame products of their sites of interest. These requests are processed in a sequential manner, by cycling through the list of investigators.

This report is intended to provide AIRSAR investigators with technical information about the AIRSAR system. Besides giving details on the hardware, we shall also discuss how campaigns are planned, how operations are conducted, and how processing of the data is done. We shall also give details of all the AIRSAR product formats and discuss calibration performed on AIRSAR products.