ON LINE ARCHIVE OF STORM PENETRATING DATA

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ABSTRACT

A web-based archive is being built by the South Dakota School of Mines and Technology (SDSMT) and the National Center for Atmospheric Research (NCAR) for airborne observations collected with the SDSMT armored T-28 research aircraft, during 15 years of summer thunderstorm field projects from 1989-2003. The entire data set includes detailed meteorological, microphysical, electrical, and complex specialized observations from 18 field projects. This archive is built to serve the atmospheric science community by providing convenient open access to these unique data along with the background information needed to interpret it. The data will be stored in digital format at the Earth Observing Systems Laboratory (EOL) at NCAR.

1. INTRODUCTION

The South Dakota School of Mines and Technology (SDSMT) armored T-28 aircraft was developed as a result of a successful proposal submitted in 1967 to the National Science Foundation (NSF) by R.A. Schleusener and P.B. MacCready to develop an aircraft for *in situ* observations in hailstorms. The scientific motivation was to better understand the microphysical and dynamical processes governing the development and growth of hail in thunderstorms. Robin Williamson, of Williamson Aircraft Co., with his associates modified the original T-28 aircraft by covering it with armor to protect the aircraft for hailstorm penetrations. After the modifications were complete, the T-28 was capable of performing hailstorm penetrations to altitudes up to about 25,000 ft (7.6 km) and was able to withstand impacts of hailstones up to 7.5 cm in diameter at 100 m/s relative speed with minimal damage. This aircraft proved to be suitable for obtaining detailed microphysical information within these storms to address the various hypotheses proposed to explain hail production.

2. PROJECTS

Research flights began in 1970, and the aircraft became fully operational in support of the National Hail Research Experiment (NHRE) in northeastern Colorado in 1972. Staff from NCAR contributed significantly to development of observation capabilities during NHRE. Between 1972 and 2003 the aircraft participated in more than two dozen cooperative field programs (some multi-year) focused on convective storm phenomena. *In situ* observations in hailstorms in northeastern Colorado, southeastern Montana, central Switzerland, eastern Alberta, central Oklahoma, and western and central North Dakota contributed fundamentally to the understanding of how hail develops in various regions around the world.

In 1987, SDSMT entered into a cooperative agreement with NSF to operate the armored T-28 as a national airborne research facility. The NSF support provided under the cooperative agreements supported steadily improving instrumentation and data acquisition, as well as development of improved data quality control procedures. In addition, a suite of software useful for data analysis was developed and provided on request to users. In 2004 the aircraft was withdrawn from the community pool of lower atmospheric observing facilities sponsored by NSF. During the 17 summer convective seasons within this period, the aircraft supported 18 projects concerned with development of rain and hail, thunderstorm electrification, remote detection of convective turbulence, transport and dispersion of cloud seeding material within storms, effects of cloud seeding on storm microphysical evolution, and verification of polarimetric radar hydrometeor signatures.

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3. INSTRUMENTATION

The microphysical instrumentation on the aircraft initially included a Johnson-Williams cloud water meter, and a formvar replicator and a foil impactor custom designed and built by R. Williamson. This relatively simple, but novel for its time, instrumentation allowed the aircraft to document microphysical characteristics of storm interiors covering the spectrum from cloud droplets to hailstones. Beginning in the later 1970's with the addition of digital electronic instrumentation for observing hydrometeors ranging in size from cloud droplets to hailstones, the aircraft became a valuable tool for verifying *in situ* the presence of various classes of hydrometeors in convective storms, furthering the understanding of precipitation development processes and hydrometeor signatures in polarimetric weather radar data. Combinations of *in situ* hydrometeor instrumentation as well as a gas analyzer for tracer studies were employed in cloud seeding studies beginning in 1987 and extending into the mid-1990's. In the 1990's capabilities for electrical observations were developed to support fundamental research into convective storm electrification. Beginning in 2001 new instrumentation for natural trace gases was developed for the aircraft and used in studies of chemical processes associated with lightning discharges.

4. DATA

The digital data beginning in 1989 were acquired using a data acquisition system designed and built by Science Engineering Associates (SEA). Data acquisition systems built by SEA are employed on a number of heavily-used research aircraft and the SEA data format is well-known in the airborne atmospheric science community. On the T-28, most instruments were sampled once per second, but some (e.g., electric fields) were routinely sampled at rates up to 20 per second. Data types include:

- Digital numerical values derived from analog voltage output from instruments such as temperature and pressure probes, with values recorded at rates as high as 20 Hz, but most commonly at 1 Hz
- Digital output from optical array probes, such as the Particle Measuring Systems (PMS) OAP-2D-C probe, and the custom-built hail spectrometer, archived in the relatively widely-used SEA digital format, allowing reconstruction of particle shadow images
- Digital output from particle spectrometers such as the PMS Forward Scattering Spectrometer Probe (FSSP), and the custom-built hail spectrometer, consisting of particle size distributions archived digitally
- Digital output from five cylindrical rotating-shutter electric field mills
- Digital output from a GPS navigation system
- Digital and analog flight videos from 1998-2003

The T-28 facility staff at SDSMT has developed a suite of software for surveying and analyzing these digital data. Currently, we have a package of software that runs in the proprietary IDL programming environment. Graphical displays of analog data, displays of hydrometeor shadow images, and statistical analysis of analog and image data, are all possible with this package.

5. ARCHIVE STRUCTURE

A web-based archive is being built by SDSMT and NCAR for airborne observations collected during field projects from 1989-2003 when the SEA data system was used. The entire data set includes detailed meteorological, microphysical, electrical, and complex specialized observations from 18 field projects. We are developing a web-based package for browsing these data, and an extensive on-line help utility. Examples of pages from the graphical user interfaces for this package are shown in Figures 1 through 3. Figure 1 shows data from a pass through a severe thunderstorm. Figure 2 shows the same data, but an inner window shows the aircraft track for the entire flight with the time period during which the data were collected highlighted. Figure 3 shows a help screen describing one of the probes used to obtain the data plotted.

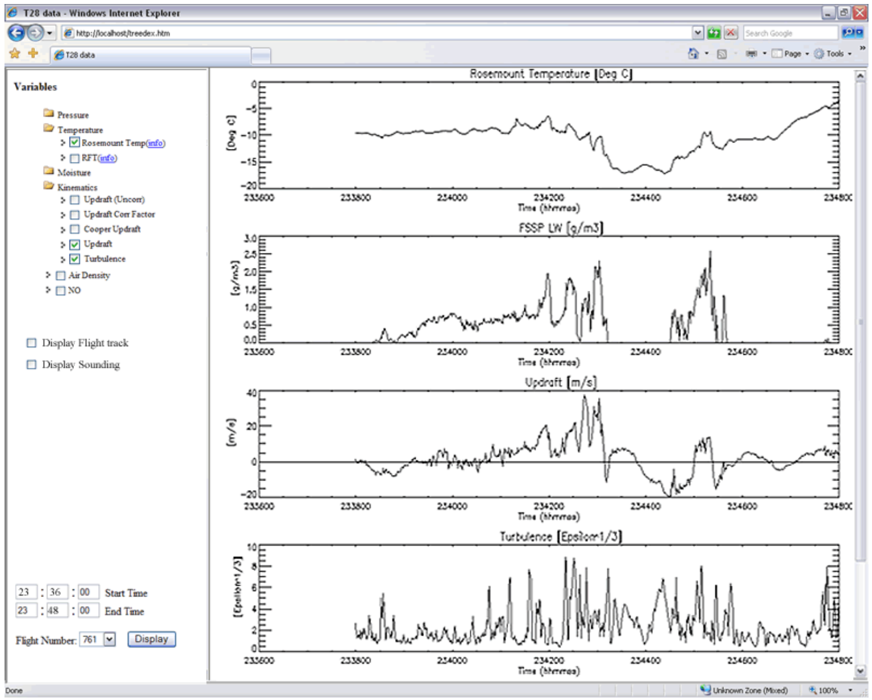

Figure 1. Data from a flight through a severe thunderstorm showing temperature, cloud liquid water concentration (FSSP LW), vertical wind (updraft) and turbulent eddy dissipation rate (turbulence) as the aircraft passed northwestward through the storm.

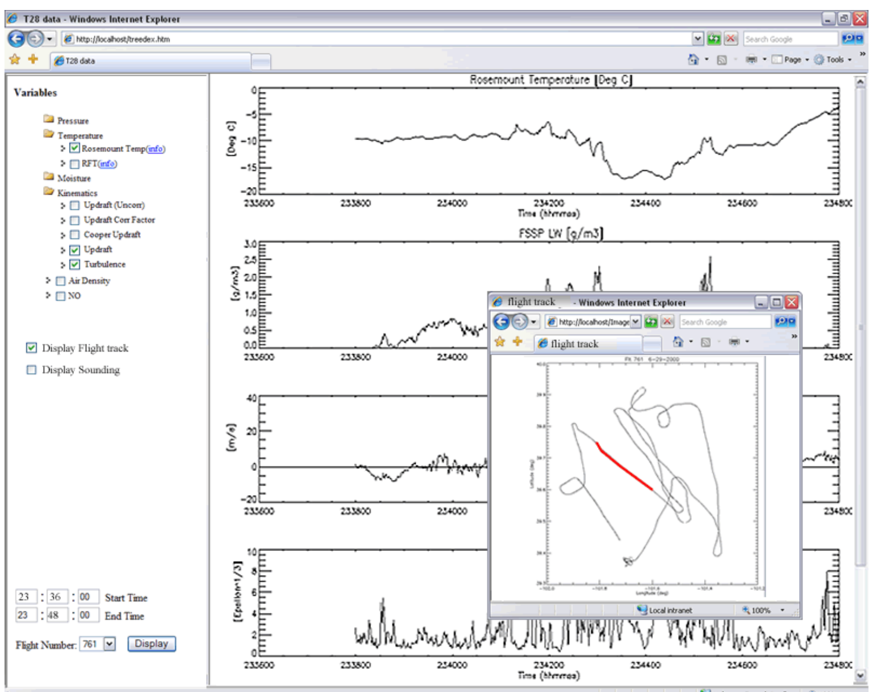

Figure 2: Same as Figure 1, but with an inner window showing the flight track for the entire flight. The data plotted were obtained along the portion of the track highlighted in red.

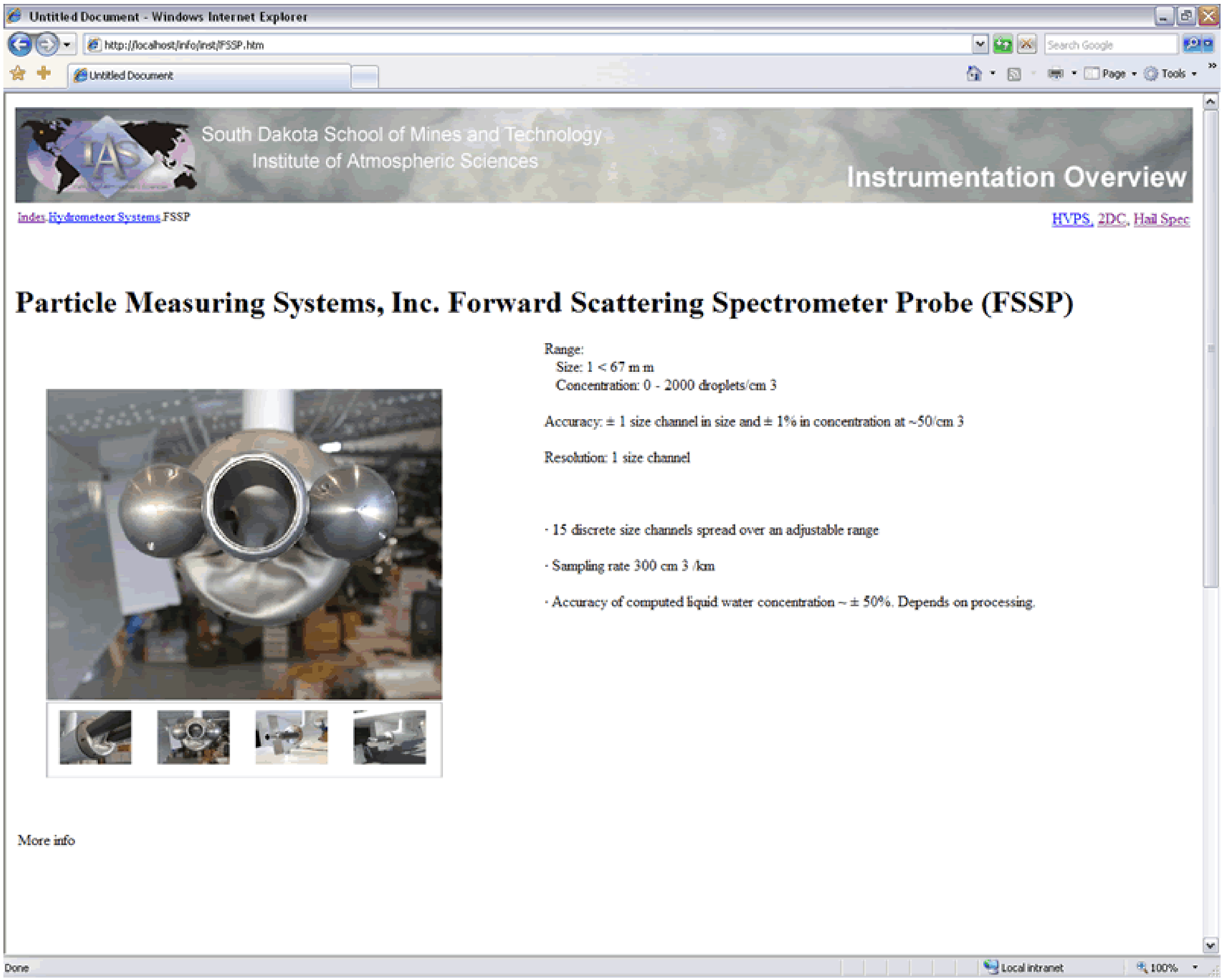

Figure 3: Example of a screen providing information on aircraft instrumentation, in this case the Forward Scattering Spectrometer Probe (FSSP) manufactured by PMS.

The goal is to make the data readily searchable and to allow simple analyses on-line. For deeper analysis, both the data and sophisticated analysis software will be downloadable so users can process and analyze data on their own computers. Data format will be compatible not only with SDSMT software, but also with software developed at NCAR for analysis of data from NCAR aircraft.

In addition to archiving data with supporting SDSMT software, we are developing a bibliography of relevant theses, dissertations, and papers based on analysis of observations from the field projects in which the aircraft participated, and also other papers discussing the analysis and interpretation of data from instruments of the type carried on the T-28. Finally, supporting data from project radars, mesonets, and other specialized observing systems, and from the operational meteorological data stream, will be linked to the corresponding projects. The archive will be merged into the comprehensive field project archive being assembled by EOL containing data from numerous community field projects.

6. CONCLUSIONS

The goal of this work is to provide an easily accessible archive of data from a unique observing platform. This archive will be available to researchers and the broad community of atmospheric science educators and students interested in convective storm phenomena. This archive will make possible continued studies of storm development and microphysical evolution in different convective environments of the sort that have been conducted in the past, but based on new insights continually being brought forward in the convective storm research community. These studies might include examinations of the links between microphysical evolution and electrification, characterization of icing, turbulence, lightning, and other aviation hazards in storm environments, hydrometeor identification for projects with multiparameter radar data, or climatology of thunderstorm microphysical characteristics in different geographic regions. With most field programs, only a relatively small fraction of the data from a few of the most interesting days is studied in detail. Much of the data in the archive has not been carefully analyzed, and in pursuit of new hypotheses not yet anticipated.

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