

**Operations Summary for the
Turbulence Characterization and Detection (TCAD)
Field Program**

Participating Agencies

National Aeronautics and Space Administration

AlliedSignal Corporation

National Center for Atmospheric Research

Rockwell-Collins Corporation

Colorado State University

South Dakota School of Mines and Technology

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Field Program**

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Many "*Thanks!*" to the pilots and crews of the three aircraft and their ground support teams, the CSU CHILL and Pawnee radar crews, and the NCAR Mobile CLASS operators

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Operations Summary for the Turbulence Characterization and Detection (TCAD) Field Program

Introduction

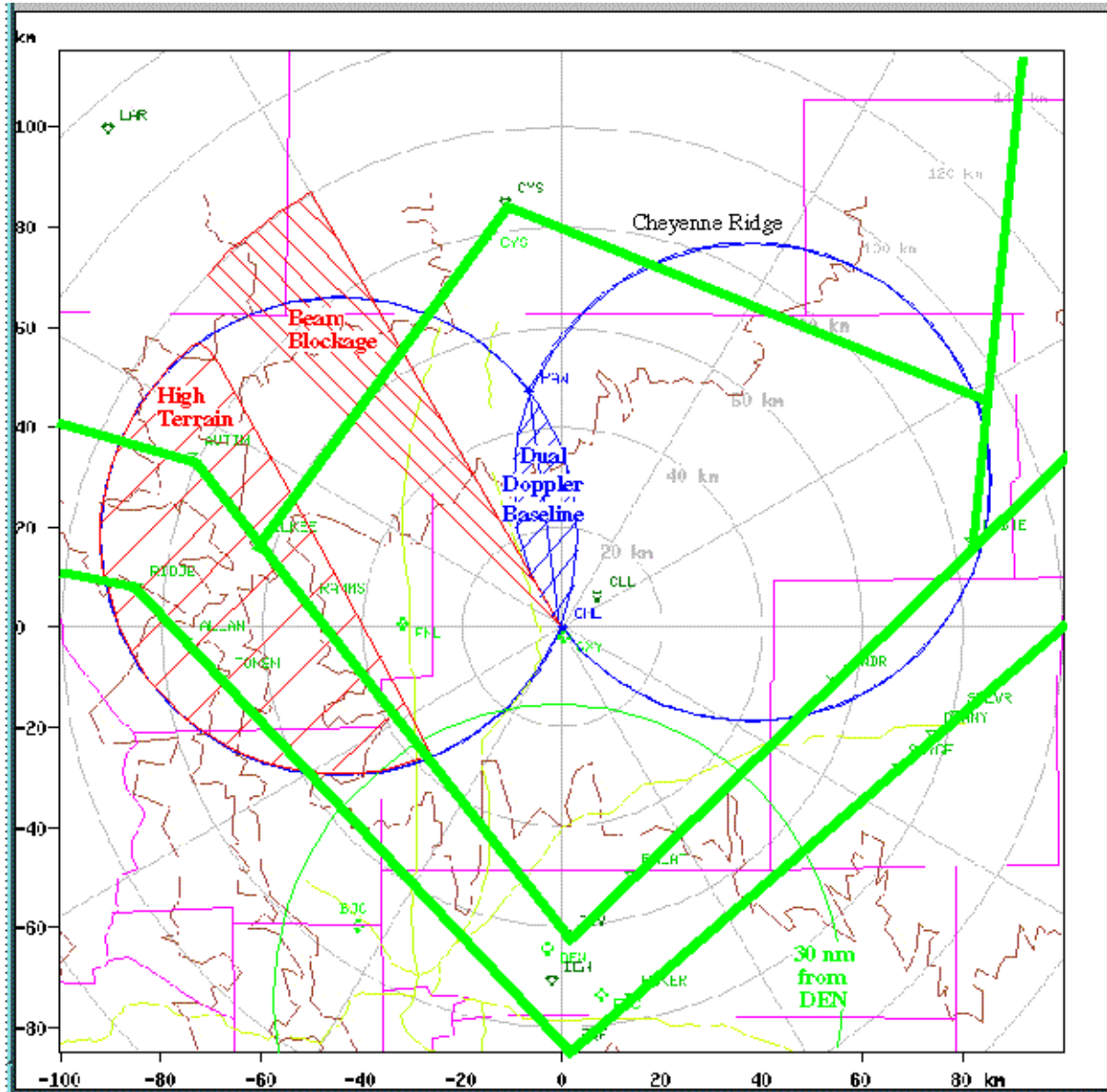
The Turbulence Characterization and Detection (TCAD) Field Program was a multi-agency field data collection program under the leadership of the National Aeronautics and Space Administration (NASA). Participating agencies include the National Center for Atmospheric Research (NCAR), the AlliedSignal Corporation and the Rockwell-Collins Corporation. The goal of the TCAD Field Program was to obtain radar measurements of turbulence within or near convective clouds in conjunction with in-situ turbulence measurements for the purposes of: 1) obtaining a data base to facilitate the development and testing of radar turbulence detection algorithms, 2) identifying correlations between observable cloud properties that exist within turbulent regions, and 3) obtaining truth data for comparisons to cloud numerical simulations and turbulence characterization studies.

The field program was conducted near Greeley, Colorado from 2 June to 25 June 1999. This program was funded by the NASA, the AlliedSignal Corporation and the Rockwell-Collins Corporation.

Conduct of Operations

The field program was conducted with three aircraft, two ground based Doppler radars, and a Mobile Cross-chain Loran Sounding System (CLASS) sounding van. The participating aircraft were the South Dakota School of Mines and Technology T-28 research, penetrating aircraft, the Rockwell-Collins Corporation Sabreliner and the AlliedSignal Corporation Convair 580. Each of the corporate aircraft were equipped with onboard, forward-pointing Doppler radars. The two ground-based Doppler radars were operated by the Colorado State University (CSU) and are called the CHILL and the Pawnee radars. These two radars are located such that the dual Doppler analysis lobes are oriented in a east-west configuration (see map on next page). The region defined by the dual Doppler lobes was considered the primary region of interest, although several flights were done outside the lobes when convection occurred only there. The Operations Center was at the CHILL radar site, where aircraft flight tracks could be superimposed over the CHILL radar fields and radio communications conducted. From the Operations Center, the aircraft were vectored to points of interest to fly coordinated missions. The NCAR Mobile CLASS van took daily soundings at CHILL before the start of operations and at other points of interest, as needed.

Operations were conducted for each day that deep convection was expected. Operations commenced at 1200 mountain daylight time (MDT) for the first part of the program and at 1300 MDT in the latter part of the program. A daily weather briefing was conducted by the meteorologist as the first order of business. Once convection was expected in the region of interest (see map on the following page), a launch signal was given to the aircraft. The aircraft flew as a "flight" on some occasions with 2 or 3 of the aircraft in the flight. At other times, an aircraft might fly alone.



A map showing the locations of the CHILL and Pawnee Doppler radars, their dual Doppler analysis lobes (blue intersecting circles), regions of low-level beam blockage from CHILL and high terrain (red hatched regions), fly-ways for the Denver International Airport (DEN) and the Cheyenne Airport (green lines), and the 30 nautical mile range ring from DEN (green circle). Distance scales along the X and Y axes are in kilometers east and north, respectively, from the CHILL radar. Range and azimuth markers are in kilometers and relative to true north (gray circles and lines). County and state lines are magenta, terrain contours are brown, and highways are yellow.

Each day for which flight operations occurred was sequentially numbered as a “Flight”. When aircraft operated independently, each set was given a different “Flight” number. For example, if the T-28 and the Convair flew in tandem while the Sabreliner flew at a higher altitude, two Flights would be recorded. For each penetration of a storm of interest, a “Run” was declared and numbered sequentially for each Flight. Runs were designated by start and stop times and generally were defined by the entry and exit of the storm of interest. This naming convention is followed throughout this document.

For all observational systems, the universal time convention (UTC) is used. In Colorado, mountain daylight time is 6 hours behind the universal time convention (i.e., 1200 MDT is 1800 UTC). All altitudes specified for the aircraft are relative to mean sea level (msl). Some unavoidable intermingling of the British and metric systems occurs in this document with regard to the units of distance (kilometers vs. nautical miles, feet vs. meters) and units of speed (meters per second vs. knots).

Structure of this Document

This document is meant to be a compilation of the daily operations for all equipment, a summary of the meteorological events, a summary of the pilot reports (pireps) for each Run, and a prioritized list of cases for analysis.

The first section of this document is entitled “Operational Summaries for Equipment” and lists pertinent information for the aircraft, the ground-based Doppler radars and the Mobile CLASS van. For the aircraft operational summary, the Flight and Run numbers are listed for each day of operations, the start and stop times of each Run are listed, the nominal flight altitude for each aircraft is given, and finally any comments or pireps are listed. For the ground-based Doppler radar operational summary, the start and stop times for data collection are listed for each day for the CHILL and Pawnee radars. On some occasions, real-time gif images were saved at three workstations (labeled “Andy”, “Cathy” and “Dave” in the table) at CHILL. When gif images are available, the start/stop times are listed for each. Radar fields typically included in the gif images include the reflectivity, radial velocity and spectrum width. Comments are listed for meteorological observations or radar operations. The Mobile CLASS operational summary lists, for each radiosonde launch, the date, the launch time, the location (latitude and longitude and description), and comments made by the operator.

The second section of this document is entitled “Summary Table of Storm Cases” and is intended to be a compilation of all pireps, personal field notes, radar operations and meteorological observations. Further, the AlliedSignal Corporation and the South Dakota School of Mines and Technology provided summaries of their preliminary analysis of their data that listed vertical accelerations (in g’s) for the Convair and the T-28 for some of the Runs. The T-28 g-force numbers were taken from the Humphrey accelerometer that uses a gyro-stabilizer. For level flight, the baseline g-force is 0. A positive g-force is an upward acceleration and a negative g-force is a downward acceleration. These g-force numbers are included in the table, and occasionally disagree with the verbal reports of turbulence intensity; however, both verbal reports and g-force levels are listed. Levels of severity for turbulence encounters from verbal accounts during operations are listed for each aircraft, along with other pilot reports for updrafts and downdrafts, heavy rain, the presence of spectral broadening on the airborne radars, among other reports of

interest. For each pilot report, the UTC time is given when it is available and was derived from the field notes of various personnel at the Operations Center. There may be slight temporal offsets in the data due to a slight time lag between the encounter and the radio communication. The ground-based radar operations are summarized in terms of the type of scans that were being performed and whether or not dual Doppler analysis may be possible near the aircraft locations. Scan types listed include: plan-position indicator (PPI), range-height indicator (RHI), 360 degree surveillance (SUR), and the aircraft-tracking mode (Track). In a few instances, the radar scanned in dual polarization mode and is listed as “dual pol”. In the table, priority cases have been identified by the NCAR and AlliedSignal Corporation organizations. The Rockwell-Collins Corporation has not yet identified all their priority cases, but space is allowed for this information to be added. This table is not meant to be the final analysis of any case study but to be used to select potential cases for further analysis. It may prove that, upon further inspection of the data, differing priorities could be assigned to particular cases.

The last section of the document is entitled, “Detailed Operational and Weather Summaries” and contains the Operations Log of the Operations Director, and a sample of CHILL reflectivity data for one of the Runs for most of the Flights. A table is shown that lists the times of all data sets archived by the NCAR, the CSU, the AlliedSignal Corporation, and the Rockwell-Collins Corporation. Archived data sets are available from NASA as detailed below. The data archived from NCAR include NEXRAD NIDS gif images from four radar sites, upper air soundings from five sites plus the Mobile CLASS soundings, Profiler data from all sites in the four state region (Colorado, Wyoming, Nebraska and Kansas), GOES-8 visible and infrared jpeg images that cover the Colorado regional scale and the national scale, surface meteorological data (METAR) from the four state region, national pilot reports, national airmets and convective sigmets, local storm reports from the four state region, and national severe weather reports. Flight times from the T-28, the Convair and the Sabreliner are listed as are the times of data archived from the ground-based radars. Following this table, are national and regional scale plots of meteorological data for that morning, generally near 15 UTC. The mean sea level surface pressure and wind fields are shown, and the 850 and 500 mb heights and temperatures are shown. A regional plot of surface data is analyzed for significant weather features, at the time closest to the launch of the first daily Mobile CLASS sounding. The last items shown for each day, are skew-T, log-P plots of the Denver 12 UTC sounding and the sounding taken by the Mobile CLASS before the start of operations.

Archival of Data

The NASA program office has archived all data taken during the field experiment. To request data, contact Ivan Clark, NASA Langley. His email address is i.o.clark@larc.nasa.gov and his telephone number is (757) 864-1500.

Operational Summaries for Equipment

Summary of Aircraft Operations

| Date (1999) & Flight Number | Run No. | Start Time (UTC) | Stop Time (UTC) | Aircraft Altitude (kft msl) (Con=Convair; Sab=Sabreliner, n/a = not available) | | | Comments (RTB=Return To Base) |
|--------------------------------------|------------|------------------------|-----------------------|--|-----|-----|---|
| | | | | T28 | Con | Sab | |
| June 2 Flight 1 | Run 1 | n/a | n/a | | | | Runs 1-3: Coordination flights. Run 4: Through cell on RTB. T28 had +2g and -1g at 2242 UTC. |
| | Run 2 | | | | | | |
| | Run 3 | | | | | | |
| | Run 4 | ~2241 | ~2243 | | | | |
| June 4 Flight 2 | Run 1 | ? | ? | n/a | | | Mountain convection with 20-25 dBZ. Light to light-moderate turbulence experienced. Run 3: Sab light chop, light precipitation. Run 4: Sab light turbulence. Sab reported slight turbulence above clouds at 013215 UTC (between runs). Run 5: Sab light turbulence, light precipitation. Run 6: Sab very light precipitation, lost 200 ft. |
| | Run 2 | 0057 | 0103 | | | | |
| | Run 3 | 0105 | 0109 | | 21 | | |
| | Run 4 | 0125 | 0127 | | n/a | 28 | |
| | Run 5 | 0136 | 013725 | | | 30 | |
| | Run 6 | 0141 | 014351 | | | 29 | |
| | Run 7 | 0152 | 0155 | | 26 | | |
| June 5 Flight 3 | Run 1 | 2030 | 2035 | 20 | 19 | 21 | Moderate turbulence experienced by all aircraft. |
| | Run 2 | 2038 | 204830 | 20 | 19 | 21 | |
| | Run 3 | 204830 | 205300 | 20 | 19 | 21 | |
| | Run 4 | 205400 | 210000 | 20 | 19 | 21 | |
| | Run 5 | 210000 | 211000 | 20 | 19 | 21 | |
| June 9 Flight 4 | Run 1 | 234600 | 235300 | 18 | 19 | 17 | All aircraft experienced in-cloud and out-of- cloud turbulence, mostly light with some moderate. Also had smooth flights. |
| | Run 2 | 235643 | 000600 | 18 | 19 | 17 | |
| | Run 3 | 000835 | 001500 | 18 | 19 | 17 | |
| | Run 4 | 002330 | 003200 | 15 | 14 | 16 | |
| | Run 5 | 003358 | 004145 | 15 | 14 | 16 | |
| | Run 6 | 004700 | 005900 | n/a | n/a | 16 | |
| June 10 Flight 5 | Run 1 | 225200 | 225800 | 18 | 19 | 17 | Run 1: Smooth ride. |
| | | | | | | | |
| June 11 Flight 6 | Run 1 | 203300 | 204049 | 18 | 19 | 17 | Mostly light turbulence on all runs. Heavy rain, strong updrafts and close lightning reported. Run 1: Turbulence out-of-cloud. |
| | Run 2 | 204725 | 205620 | 18 | 19 | 17 | |
| | Run 3 | 210717 | 211744 | 18 | 19 | 17 | |
| | Run 4 | 212041 | 213237 | 18 | 19 | 17 | |
| | Run 5 | 214206 | 214813 | n/a | 20 | n/a | |
| | Run 6 | 214530 | 215400 | | n/a | 20 | |
| June 11 Flight 7 | Run 1 | 235343 | 000600 | 16 | 15 | 17 | Light-moderate turbulence on most penetrations. Run 2: T28 had severe turbulence. |
| | Run 2 | 001038 | 002750 | 16 | 15 | 17 | |
| | Run 3 | 003538 | 004656 | 17 | 18 | 19 | |
| | Run 4 | 010159 | 010607 | n/a | 20 | 21 | |

Summary of Aircraft Operations

| Date (1999) & Flight Number | Run No. | Start Time (UTC) | Stop Time (UTC) | Aircraft Altitude (kft msl) (Con=Convair; Sab=Sabreliner, n/a = not available) | | | Comments (RTB=Return To Base) |
|--------------------------------------|------------|------------------------|-----------------------|--|------------------------|-----|---|
| | | | | T28 | Con | Sab | |
| June 12 Flight 8 | Run 1 | 204836 | 205249 | 22 | 23 | 21 | Run 2: T28 smooth ride; Sab moderate turbulence. Run 4: T28 had smooth ride and close lightning, Sab had light turbulence. Run 5: Con and Sab had light-moderate turbulence and rain. Run 7: Sab had rain, lightning and light turbulence. |
| | Run 2 | 210130 | 211137 | 22 | 23 | 21 | |
| | Run 3 | 211750 | 212208 | 20 | 21 | 19 | |
| | Run 4 | 212252 | 213017 | 20 | 21 | 19 | |
| | Run 5 | 214259 | 214857 | n/a | 24 | 24 | |
| | Run 6 | 215007 | 515602 | | 24 | 24 | |
| | Run 7 | 220439 | 220639 | | n/a | 26 | |
| June 14 Flight 9 | Run 1 | 205335 | 205613 | n/a | Down for repairs | 27 | Run 2: Light chop with rain. Runs 3 and 4: Light-moderate turbulence. Run 5: Light-moderate turbulence. Run 6: Severe turbulence (300 ft. altitude and 20-30 kt. airspeed excursions). Run 7: Light turbulence and rain. Run 8: Moderate-severe turbulence within "green" echo, also rain and ice. |
| | Run 2 | 210124 | 210400 | | | 29 | |
| | Run 3 | 211320 | 212120 | | | 29 | |
| | Run 4 | 212953 | 213327 | | | 33 | |
| | Run 5 | 213912 | 214518 | | | 30 | |
| | Run 6 | 215128 | 215650 | | | 28 | |
| | Run 7 | 220305 | 220918 | | | 27 | |
| | Run 8 | 221018 | 221353 | | | 27 | |
| June 14 Flight 10 | Run 1 | ~2045 | 205730 | 20 | Down for repairs | n/a | Run 1: Severe turbulence. Runs 3 and 4: Light-moderate turbulence. Run 5: Good bump at updraft boundary. Run 6: No turbulence. |
| | Run 2 | ~2100 | 210950 | 21 | | | |
| | Run 3 | 211200 | 211850 | 21 | | | |
| | Run 4 | 212000 | 212700 | 21 | | | |
| | Run 5 | 213600 | 214200 | 21 | | | |
| | Run 6 | 214600 | 215000 | 21 | | | |
| June 17 Flight 11 | Run 1 | 225600 | 230300 | 22 | 21 | n/a | Run 1: Healthy updrafts and light-moderate turbulence. Run 2: Heavy rain and moderate turbulence. Run 3: Light turbulence and rain. Run 4: Light-moderate turbulence, rain and ice. |
| | Run 2 | 230806 | 232200 | 22 | 21 | | |
| | Run 3 | 233400 | 234300 | 21 | 21 | | |
| | Run 4 | 234600 | 235500 | 19 | 19 | | |
| June 17 Flight 12 | Run 1 | 224910 | 225300 | n/a | n/a | 28 | Run 1: Light-moderate turbulence and mixed ice. Run 2: Light-moderate turbulence, rain, hail and lightning. Run 3: Light-moderate turbulence and lightning. Run 4: Light-moderate turbulence. Run 5: Escape to the east. |
| | Run 2 | 225720 | 230930 | | | 28 | |
| | Run 3 | 231743 | 232159 | | | 32 | |
| | Run 4 | 232437 | 233016 | | | 32 | |
| | Run 5 | 233705 | 234300 | | | 32 | |

Summary of Aircraft Operations

| Date (1999) & Flight Number | Run No. | Start Time (UTC) | Stop Time (UTC) | Aircraft Altitude (kft msl) (Con=Convair; Sab=Sabreliner, n/a = not available) | | | Comments (RTB=Return To Base) |
|--------------------------------------|------------|------------------------|-----------------------|--|-----|-----|--|
| | | | | T28 | Con | Sab | |
| June 18 Flight 13 | Run 1 | 211613 | 211927 | 22 | 21 | 23 | Run 1: All aircraft have smooth ride above cloud. Run 2: T28 and Con report light turbulence and rime ice. Run 3: Light turbulence reported by all aircraft. Run 4: Light turbulence. Run 5: Light turbulence and light chop. Run 6: Smooth ride, moderate precipitation and mixed ice. Run 7: Very light turbulence, rain, and fairly heavy icing. |
| | Run 2 | 212255 | 212729 | 22 | 21 | 23 | |
| | Run 3 | 213338 | 214044 | 20 | 19 | 21 | |
| | Run 4 | 214735 | 215410 | 20 | 19 | 21 | |
| | Run 5 | 215750 | 221015 | 17 | 16 | 18 | |
| | Run 6 | 221050 | 221504 | 17 | 16 | 18 | |
| | Run 7 | 221829 | 222851 | 17 | 16 | 18 | |
| June 19 Flight 14 | Run 1 | 210909 | 211836 | 19 | 18 | 20 | Run 1: Light turbulence. Run 2: Light turbulence. Run 3: Light-moderate turbulence. Run 4: Light-moderate turbulence and strong up/downdrafts reported by all. Run 5: Moderate turbulence and strong updrafts (600 ft./min). Run 6: Light-moderate turbulence, strong up/downdrafts (Con had +1500 ft./min) and heavy precipitation. Run 7: Light-moderate turbulence, strong updrafts, heavy precipitation. Run 8: Light-moderate turbulence, heavy precipitation, small hail, strong updrafts, and light turbulence on exit from cloud. |
| | Run 2 | 212036 | 212533 | 19 | 18 | 20 | |
| | Run 3 | 213403 | 214148 | 19 | 18 | 20 | |
| | Run 4 | 214755 | 215710 | 19 | 18 | 26 | |
| | Run 5 | 215810 | 220603 | 19 | 18 | 26 | |
| | Run 6 | 220840 | 221508 | n/a | 18 | 26 | |
| | Run 7 | 221837 | 222443 | | 18 | 26 | |
| | Run 8 | 222715 | 223139 | | 18 | 26 | |

Summary of Aircraft Operations

| Date (1999) & Flight Number | Run No. | Start Time (UTC) | Stop Time (UTC) | Aircraft Altitude (kft msl) (Con=Convair; Sab=Sabreliner, n/a = not available) | | | Comments (RTB=Return To Base) |
|--------------------------------------|------------|------------------------|-----------------------|--|-----|-------|---|
| | | | | T28 | Con | Sab | |
| June 20 Flight 15 | Run 1 | 222833 | 223319 | n/a | n/a | 22-25 | Run 1: Light chop, rain, hail, snow. |
| | Run 2 | 223757 | 224542 | | | 30 | Run 2: Light turbulence within good Doppler shears. |
| | Run 3 | 224813 | 225512 | | | 30 | Run 3: Light-moderate turbulence in "yellow" echo. |
| | Run 4 | 230012 | 230800 | | | 32.5 | Run 4: Strong up/downdrafts, light precipitation, light turbulence. |
| | Run 5 | 231136 | 231648 | | | 32.5 | Run 5: Light-moderate precipitation and turbulence. |
| | Run 6 | 231925 | 232317 | | | 32.5 | Run 6: Soft hail and light-moderate turbulence. |
| | Run 7 | 232415 | 232903 | | | 32.5 | Run 7: Moderate precipitation, lightning, light with occasional moderate turbulence. |
| | Run 8 | 233132 | 233526 | | | 32.5 | Run 8: Very heavy precipitation, strong up/downdrafts (500 ft./min), light-moderate turbulence. |
| | Run 9 | 234719 | 235302 | | | 31 | Run 9: Heavy precipitation, strong up/downdrafts and light-moderate turbulence. |
| | Run 10 | 235412 | 235505 | | | 31 | Run 10: No turbulence. |
| | Run 11 | 235812 | 000427 | | | 31 | Run 11: Moderate precipitation ("red" echo) and light turbulence. |
| | Run 12 | 000508 | 000902 | | | 31 | Run 12: Strong up/down-drafts (1500 ft./min), moderate precipitation, light-moderate turbulence. |
| | Run 13 | 001119 | 001840 | | | 31 | Run 13: Within elevated spectrum width, light-moderate turbulence. |
| June 20 Flight 16 | Run 1 | 224116 | 225052 | 20 | 19 | n/a | Run 1: Icing, light-moderate turbulence. |
| | Run 2 | 225413 | 230157 | 20 | 19 | | Run 2: Light to occasionally moderate turbulence. |
| | Run 3 | 230715 | 231440 | 20 | 19 | | Run 3: Icing, light-moderate turbulence. |
| | Run 4 | 231812 | 232704 | 20 | 19 | | Run 4: Marble-sized hail, strong up/downdrafts (2500 ft./min), moderate turbulence reported by T28. |
| | Run 5 | 233231 | 234145 | 20 | 19 | | Run 5: Moderate turbulence and 2000 ft./min updraft reported by Con. |
| | Run 6 | 234344 | 234745 | n/a | 19 | | Run 6: Light precipitation and turbulence. |
| | Run 7 | 235252 | 235623 | | 19 | | Run 7: Light-moderate turbulence. |
| | Run 8 | 235847 | 000306 | | 19 | | Run 8: Strong up/downdrafts and light rain. |
| June 21 Flight 17 | Run 1 | 222529 | 223117 | n/a | n/a | 24 | Run 1: Light precipitation and light turbulence within "yellow" echo. |
| | Run 2 | 224405 | 224917 | | | 24 | Run 2: Light precipitation/light turbulence. |
| | Run 3 | 225509 | 230010 | | | 24 | Run 3: No turbulence. |
| | Run 4 | 231402 | 232629 | | | 24 | Run 4: On RTB, hail, lightning and moderate turbulence below cloud base. |

Summary of Aircraft Operations

| Date (1999) & Flight Number | Run No. | Start Time (UTC) | Stop Time (UTC) | Aircraft Altitude (kft msl) (Con=Convair; Sab=Sabreliner, n/a = not available) | | | Comments (RTB=Return To Base) |
|--------------------------------------|------------|------------------------|-----------------------|--|-----|-----|--|
| | | | | T28 | Con | Sab | |
| June 21 Flight 18 | Run 1 | 222307 | 223238 | 18 | 19 | n/a | Run 1: Light with some moderate turbulence, lightning, and light icing. Run 2: Light precipitation, light turbulence, and light chop. Run 3: Light ice and light chop. |
| | Run 2 | 224456 | 225822 | 18 | 19 | | |
| | Run 3 | 225948 | 230626 | 18 | 19 | | |
| June 22 Flight 19 | Run 1 | 212100 | 212634 | n/a | n/a | 28 | Run 1: Light turbulence, light-moderate precipitation. Run 2: Light turbulence and no precipitation. Run 3: In "yellow" echo, light turbulence and moderate precipitation. Run 4: 0.25 to 0.5 inches of ice accumulation. Run 5: Light-moderate turbulence. Run aborted by ATC. Run 6: Through "yellow-red" boundary, light turbulence. Run 7: Light turbulence. Run 8: Light turbulence and light precipitation. Run 9: Strong, clear-air updrafts, more moderate bump on exit from cell. |
| | Run 2 | 212936 | 213547 | | | 28 | |
| | Run 3 | 214303 | 215136 | | | 25 | |
| | Run 4 | ? | 220006 | | | 25 | |
| | Run 5 | 220130 | 220210 | | | 25 | |
| | Run 6 | 220430 | 220815 | | | 25 | |
| | Run 7 | 221030 | 221454 | | | 25 | |
| | Run 8 | 221954 | 222647 | | | 25 | |
| | Run 9 | 222840 | 223235 | | | 25 | |
| June 22 Flight 20 | Run 1 | 211529 | 212330 | 19 | 20 | n/a | Run 1: Moderate turbulence within maximum shear region. Run 2: Light-moderate turbulence and heavy precipitation. Run 3: T28 had light chop outside of cloud with moderate turbulence within. Run 4: Light icing and light precipitation. Run 5: Heavy precipitation, no turbulence, hampered by bad communications. Run 6: Light precipitation, icing and light turbulence. |
| | Run 2 | 213000 | 213610 | 19 | 20 | | |
| | Run 3 | 214303 | 215412 | 19 | 20 | | |
| | Run 4 | 215926 | 220445 | 19 | 20 | | |
| | Run 5 | 221324 | 221600 | n/a | 20 | | |
| | Run 6 | 222810 | 223300 | | 20 | | |
| June 25 Flight 21 | Run 1 | 215420 | 215645 | n/a | 17 | n/a | Run 1: Light rain. Run 2: Light turbulence. Run 5: Bumpy ride and rain - within "yellow" echo. Run 6: Smooth ride. Run 7: Light turbulence and light icing. Run 8: Light turbulence and light icing. |
| | Run 2 | 215750 | 215926 | | | | |
| | Run 3 | 220700 | 221140 | | | | |
| | Run 4 | 221220 | 221530 | | | | |
| | Run 5 | 221915 | 222335 | | | | |
| | Run 6 | 222402 | 222556 | | | | |
| | Run 7 | 222812 | 223312 | | | | |
| | Run 8 | 223601 | 224028 | | | | |

Summary of Ground-based Doppler Radar Operations

| Date (1999) | CHILL | | Real-Time Gif Images from CHILL | | | Pawnee | | Comments |
|----------------|------------------------|-----------------------|------------------------------------|---------------|---------------|------------------------|-----------------------|---|
| | Start Time (UTC) | Stop Time (UTC) | “Andy” | “Cathy” | “Dave” | Start Time (UTC) | Stop Time (UTC) | |
| June 2 | n/a | | n/a | | | n/a | | Data not archived |
| June 3 | n/a | | n/a | | | n/a | | Data not archived |
| June 4 | 1803 | 0158 | n/a | | | 1851 | 0157 | |
| June 5 | 1834 | 2234 | n/a | 1625- 2235 | n/a | 1851 | 2214 | At Pawnee, pea-sized hail at 1950 UTC; marble-sized hail at 1953. |
| June 6 | n/a | | n/a | | | n/a | | Data not archived |
| June 7 | n/a | | n/a | | | n/a | | Data not archived |
| June 8 | n/a | | n/a | | | n/a | | Data not archived. LDR field fixed at CHILL |
| June 9 | 1948 | 0115 | 2017- 0023 | 2017- 0023 | 2017- 0023 | 2006 | 0103 | Pawnee down 2338-0004 UTC |
| June 10 | 1748 | 0050 | 2011- 0010 | 2017- 0010 | 1943- 0010 | 1930 | 0019 | At CHILL: flare echo at 281 deg/ 19 km at 2123 UTC |
| June 11 | 1932 | 0119 | n/a | 1920- 0111 | 1829- 0111 | n/a | | Pawnee down with antenna problems |
| June 12 | 1834 | 2255 | 1951- 0139 | 1848- 2256 | 1711- 2256 | 2032 | 2254 | |
| June 13 | 1807 | 2203 | 1815- 2116 | 1923- 2154 | 1807- 2154 | n/a | | Pawnee data not archived |
| June 14 | 1825 | 2304 | 1827- 2248 | 1824- 2248 | 1812- 2301 | 1854 | 2234 | |
| June 15 | n/a | | n/a | | | n/a | | Data not archived |
| June 16 | n/a | | n/a | | | n/a | | Data not archived |
| June 17 | 1930 | 0026 | 2001- 2351 | 2001- 0027 | 1946- 0027 | 1950 | 0023 | At CHILL, flare echoes observed |
| June 18 | 1739 | 2327 | 1937- 2248 | 1904- 2248 | 1916- 2340 | 1923 | 2240 | |
| June 19 | 1849 | 2349 | 2040- 2334 | n/a | 2039- 2349 | 1935 | 2253 | |
| June 20 | 2028 | 0029 | 2118- 0024 | 1958- 0024 | 1958- 0024 | 1955 | 0021 | |
| June 21 | 1935 | 0011 | 2131- 2330 | 1935 | 1701- 2355 | 1922 | 2337 | |
| June 22 | 1731 | 2301 | 1952- 2248 | 1952- 2248 | 1951- 2303 | 1936 | 2247 | |
| June 23 | n/a | | n/a | | | n/a | | Data not archived |
| June 24 | n/a | | n/a | | | n/a | | Data not archived |
| June 25 | 1845 | 2312 | n/a | 1938- 2312 | 2151- 2312 | 1932 | 2241 | |

| Summary of Mobile CLASS launches | | | | | |
|----------------------------------|-------------------|--------------------|---------------------|--------------------------------|--|
| Date | Launch Time (UTC) | Latitude (deg min) | Longitude (deg min) | Location | Comments |
| 19990602 | 17:07:52 | 40 26.85' | -104 37.92' | CHILL radar | Inversion at 600 mb; easterly surface winds |
| 19990602 | 23:06:16 | 40 38.06' | -104 19.20' | Briggsdale, CO | Thunderstorm developing W and SE; Strong surface gusts to 40 mph |
| 19990603 | 17:22:46 | 40 26.86' | -104 37.89' | CHILL radar | Lost signal near 350 mb |
| 19990604 | 16:52:46 | 40 26.86' | -104 37.87' | CHILL radar | Inversion at 775 mb; very dry w/ high S winds above; lost signal at 260 mb |
| 19990605 | 17:26:58 | 40 26.86' | -104 37.87' | CHILL radar | Tropopause near 212 mb |
| 19990605 | 20:46:55 | 40 35.79' | -104 42.51' | Ault, CO | Lost signal near 437 mb; very windy & moist |
| 19990606 | 17:55:13 | 40 26.85' | -104 37.96' | CHILL radar | Balloon went straight up; weak sporadic upper level winds; low level cirrus; weak surface westerlies |
| 19990606 | 18:55:30 | 40 26.86' | -104 37.90' | CHILL radar | |
| 19990607 | 16:59:08 | 40 27.73' | -104 30.75' | CHILL radar | Clear skies with few clouds over mountains. |
| 19990608 | 17:00:39 | 40 26.87' | -104 37.86' | CHILL radar | Calm surface winds; few high clouds to west; hot; dry |
| 19990609 | 17:09:24 | 40 27.04' | -104 37.11' | CHILL radar | Few good clouds to the west |
| 19990609 | 22:19:58 | 40 26.87' | -104 37.65' | CHILL radar | Clouds developing overhead & to the west; few raindrops |
| 19990610 | 18:20:51 | 40 26.88' | -104 37.86' | CHILL radar | Light surface winds; building cumulus to west; widely scattered clouds overhead |
| 19990610 | 20:57:11 | 40 26.86' | 104 37.97' | CHILL radar | Lost signal at 467mb; clouds developing; thunderstorms to WSW |
| 19990610 | 22:57:31 | 40 28.82' | -104 26.72' | Barnesville, CO | Thunderstorm to W dissipated; clear skies overhead |
| 19990611 | 17:12:32 | 40 26.87' | -104 37.96' | CHILL radar | Very dry with few winds at surface |
| 19990611 | 21:41:50 | 40 39.10' | -104 19.94' | 1 mile north of Briggsdale, CO | Very cloudy |
| 19990612 | 18:09:33 | 40 26.86' | -104 37.88' | CHILL radar | Lots of cumulus; winds from southeast |

| Summary of Mobile CLASS launches | | | | | |
|---|-------------------|--------------------|---------------------|---|---|
| Date | Launch Time (UTC) | Latitude (deg min) | Longitude (deg min) | Location | Comments |
| 19990613 | 18:15:45 | 40 26.86' | -104 37.96' | CHILL radar | Very light surface winds; inversions at 700 & 400 mb |
| 19990614 | 18:26:24 | 40 26.86' | -104 37.94' | CHILL radar | Inversion at 700 mb; anvil cloud overhead; light SE winds; mountains obscured |
| 19990614 | 23:23:54 | 40 23.64' | -104 33.64' | Kersey, CO | Sonde started back down at 400 mb; reason unknown |
| 19990616 | 18:51:25 | 41 05.97' | -104 51.02' | Cheyenne, WY | Launched into light drizzle on Cheyenne Ridge |
| 19990617 | 18:21:35 | 40 26.87' | -104 37.90' | CHILL radar | Broken cloud cover, mostly clear at end; some high cirrus clouds |
| 19990617 | 20:56:00 | 40 26.86' | -104 37.92' | CHILL radar | Cumulus congestus S; cumulus field NE; light easterly surface winds |
| 19990617 | 22:12:24 | 40 26.00' | -104 38.00' | CHILL radar | Cells building overhead; moderate SE winds |
| 19990618 | 18:00:00 | 40 26.85' | -104 37.88' | CHILL radar | Very hot w/ light easterly breeze |
| 19990618 | 20:54:40 | 40 26.87' | -104 37.88' | CHILL radar | |
| 19990619 | 18:31:56 | 40 26.87' | -104 37.87' | CHILL radar | Cumulus field to NW |
| 19990620 | 18:14:00 | 40 02.35' | -105 13.89' | NCAR, Boulder, CO | Cumulus field to NW through the SW |
| 19990621 | 17:07:59 | 40 02.00' | -105 13.00' | NCAR, Boulder, CO | |
| 19990622 | 20:14:40 | 40 26.86' | -104 37.86' | CHILL radar | Strong westerly outflow wind |
| 19990623 | 18:42:40 | 40 26.87' | -104 37.84' | CHILL radar | Small cumulus field to N; light easterly surface winds |
| 19990623 | 22:51:17 | 40 45.00' | -104 36.00' | House S of Roads 108 & 49 intersection, on 49 | Calm winds |
| 19990624 | 18:12:20 | 40 48.00' | -104 13.00' | CHILL radar | Sunny, hot, dry w/ no cumulus on the mountains |
| 19990625 | 18:31:55 | 40 26.85' | -104 37.98' | CHILL radar | Cumulus field to NW and cumulus congestus to SW; possible anvil cloud to S |
| 19990625 | 22:43:36 | 40 21.94' | -104 13.22' | N of Riverside Reservoir | Cumulus to the east |

Summary Table of Storm Cases