CT12K and CL31 CEILOMETERS METEOROLOGICAL COMPARISON EVALUATION PLAN

For

Automated Surface Observing System (ASOS)

Software Version 2.79S

October 2008

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Weather Service
Office of Operational Systems
Field Systems Operations Center
Test and Evaluation Branch

TABLE OF CONTENTS

Acronyms iii
1.0 Introduction 1
2.0 Purpose 2
3.0 Evaluation Objectives 3
4.0 Evaluation Parameters 4
5.0 Assumptions and Limitations 5
6.0 Evaluation Management 6
6.1 Roles and Responsibilities 6
7.0 Evaluation Configuration 7
8.0 Evaluation Methodology 8
8.1 Data Collection 8
8.2 Data Processing 9
8.3 Evaluation and Analysis 9
9.0 Schedule and Reports 11
APPENDIX A: SAMPLE CASE STUDY DOCUMENT AND GRAPHS TO BE USED IN THE EVALUATION 12

TABLES

TABLE 1: ACCEPTABLE HEIGHT RANGE (FEET) FOR CL31 COMPARISON WITH CT12K 1 4
TABLE 2: RMSD RANGE (FEET) FOR CL31 COMP WITH CT12K 1 5
TABLE 3: SKY COVERAGE AMOUNTS AND PERCENTAGES (OCTANTS) 1 5
TABLE 4: NUMBER OF DESIRED CASES 1 9
TABLE 5: NUMBER OF DESIRED CASES FOR CLOUD AMOUNTS AND HEIGHTS CRITICAL FOR AVIATION SAFETY1 10
TABLE 6: EVALUATION AND REPORT TIMETABLE 1 11

Acronyms

ACU	Acquisition Control Unit
ASOS	Automated Surface Observing System
ASTM	American Society for Testing and Materials
ATIS	Automatic Terminal Information System
ATRB	ASOS Test Review Board
BKN	Broken
CHI	Cloud Height Indicator
CL31	Vaisala CL31 Replacement Ceilometer
COTS	Commercial Off The Shelf
CT12K	Current Vaisala 12K Ceilometer
CWA	County Warning Area
DAS	Data Acquisition System
DCP	Data Collection Platform
DCM	Direct Command Mode
FMH-1	Federal Meteorological Handbook-1
FSOC	Field Systems Operations Center
IFR	Instrument Flight Rules
LIFR	Low Instrument Flight Rules
METAR	Aviation Routine Weather Report
MVFR	Marginal Visual Flight Rules
NWS	National Weather Service
OCWWS	Office of Climate, Water, and Weather Services
OT&E	Operational Test and Evaluation
OOS	Office of Operational Systems
OPS24	OOS, Test & Evaluation Branch
OST	Office of Science and Technology
OVC	Overcast
PNS	Public Notification Statement
RFP	Request For Proposal
RMSD	Root Mean Square Deviation
SAIC	Science Applications International Corporation
SCT	Scattered
SFSC	Sterling Field Support Center
SIT	System Integration Test
SPECI	Aviation Selected Special Weather Report
ST	System Test
TAF	Terminal Aviation Forecasts
TIN	Technical Implementation Notice
TRG	Test Review Group
TTR	Test Trouble Report
VFR	Visual Flight Rules

VV	Vertical Visibility
WFO	Weather Forecast Office
WSH	National Weather Service Headquarters

1.0 Introduction

The current standard Cloud Height Indicator (CHI) for the Automated Surface Observing System (ASOS) is the National Weather Service (NWS) Vaisala CT12K laser ceilometer. This ceilometer reports clouds to a height of 12,000 feet.

In late 1998, Vaisala discontinued production of the CT12K, but agreed to support the existing ASOS ceilometers through 2007. The ASOS Product Improvement (PI) Program issued a Request For Proposal (RFP) for a 25,000-foot replacement ceilometer, an effort that included an extensive test of Commercial-Off-The-Shelf (COTS) ceilometers, and a second delivery and test of a modified COTS design to meet ASOS requirements. After extensive requirements specification compliance testing over several years at the NWS Sterling Field Support Center (SFSC) in Sterling, Virginia, the Vaisala CL31 25,000-foot ceilometer was selected to replace the current CT12K ceilometer (Test Report for Specification Compliance Testing of ASOS Replacement Ceilometer, Science Applications International Corporation (SAIC) 2006-2007).

During the winter of 2007 and spring of 2008, the ASOS PI Program conducted an extensive Specification Compliance Test at SFSC. CL31 Replacement Ceilometer Specification Compliance Test results were very good, especially below 12,000 feet (Test Report for Specification Compliance Testing of ASOS Replacement Ceilometer, SAIC 2008). The favorable results of the Specification Compliance Test allowed the ceilometer replacement program to enter the pre-production and limited-production phases of testing of Specification Compliance Test.

The pre-production and limited-production phase of Specification Compliance Testing is being conducted from the summer of 2008 through the spring of 2009 at SFSC. In addition to the Specification Compliance Testing, a System Integration Test (SIT) was performed on the test ASOS systems ST0 and ST1 at the SFSC and at NWS Headquarters (WSH) during August 2008.

A System Test (ST) will be conducted at SFSC and WSH in October 2008. After a successful ST, the next test will be an Operational Test and Evaluation (OT&E) at 23 selected operational ASOS sites that represent different climatic regimes of the United States. The OT&E is scheduled to start in November 2008 and continue for approximately three months.

In parallel with the above tests, a meteorological comparison evaluation will be conducted between the CL31 and the CT12K ceilometers. The purpose of this evaluation will be to determine characteristic differences between performance of the CL31 and the CT12K ceilometers such that the user community can be notified. This evaluation will initially take place at the SFSC in conjunction with ST during October 2008 and run through the winter of 2008-2009.

This document describes the CT12K and CL31 Ceilometers Meteorological Comparison Evaluation Plan, including purpose, test objectives, evaluation parameters, management, roles and responsibilities, methodology, and schedule.

2.0 Purpose

CL31 sensor specification compliance testing took place at the SFSC in Sterling, Virginia, and used raw ceilometer data, an in-house Data Acquisition System (DAS), and an Excel spreadsheet to collect and analyze the data. Specification compliance testing did not compare sky condition reports generated by the ASOS algorithms.

The purpose of the CL31 and CT12K Ceilometers Meteorological Comparison Evaluation is to assess the functional comparability of the ASOS algorithm output from the CL31 and CT12K ceilometers in weather conditions critical for aviation and weather forecasting. The NWS wants to ensure the replacement CL31 produces similar ASOS algorithm-generated cloud reports to those generated with the existing CT12K ceilometer. <u>This evaluation is for meteorological comparison purposes and is not a specification compliance test.</u>

This evaluation will document significant meteorological reporting differences (in cloud heights, defined in section 4.0 Table 2) between the two ceilometers when configured on the same ASOS. An analysis team will evaluate these differences using ASOS data collected remotely. The team will propose that any significant meteorological differences be documented in a Technical Implementation Notice (TIN) issued by NWS headquarters prior to the CL31 being switched to the primary (operational) sensor at OT&E sites. This information will be propagated by a Public Notification Statement (PNS) issued by the Weather Forecast Offices (WFO) as the switch occurs at the ASOS's within their County Warning Areas (CWA). If the analysis team cannot explain significant differences that might impact Terminal Aviation Forecasts (TAF) and general aviation safety, these problems will be provided to the ST/OT&E TRG, and assigned for operational impact and priority to fix according to the scheme provided in the ST/OT&E plans.

This evaluation will be an important component of the OT&E in determining when to switch the "operational" ASOS ceilometer sensor from the CT12K sensor to the CL31 sensor (i.e., The input from the analysis team will determine the final content of the TIN; and, the TIN issuance to the NWS user community is a prerequisite for the operational ceilometer switch). The ASOS sky condition algorithm output included in the 12-hour archive page (i.e., source for test sensor data) and the 5-minute observations (i.e., source for operational or primary sensor data) will be the basis for this comparison. The CL31 and CT12K Ceilometers Meteorological Comparison Evaluation will be performed on ASOS using the Acquisition Control Unit (ACU) firmware Version (V) 2.79S.

The evaluation will also compute the Root Mean Square Deviation (RMSD) between the generated CL31 and CT12K cloud reports. The RMSD equation (see section 8.3) was obtained from the American Society for Testing and Materials (ASTM) Standard, D

4430, “Standard Practice for Determining the Operational Comparability of Meteorological Measurements.”

This evaluation is not intended to evaluate the ASOS sky condition algorithm, since the ASOS sky condition algorithm has not changed. Rather, it is an evaluation of sky condition reports from the CL31 and CT12K sensors generated by the ASOS sky condition algorithm. RMSD differences and other parameters stated in this plan will be used to determine the comparability of the CL31 to CT12K. The intent of the evaluation is not to pass judgment on one sensor or the other, but to report any differences determined to be significant between the two sensors sky condition reports to the aviation and weather forecast user community. There will be no pass/fail criteria in this evaluation.

If differences in the ceilometer reports from ASOS (CL31/ CT12K) are seen, these differences will be quantified, and an explanation will be given as to why there are differences. A data analysis team comprising of meteorologists from OOS and the Office of Climate, Water, and Weather Services (OCWWS) is established for the duration of this evaluation to perform this task (See Section 6.0). An example of how the analysis of the data will be summarized is included in Appendix A.

If differences are too great (see Table 2 in Section 4 for an explanation of "comparable”, “some” differences, “significant” differences, and “great” differences) between the sky condition report from the CT12K and CL31 sensors, the data analysis team will discuss the differences and why they might exist, and report those differences to the ASOS Test Review Board (ATRB) for discussion. If the ATRB decides the differences are too large and will negatively impact aviation safety and TAF generation, ST/OT&E may be suspended until a suitable workaround or fix is generated and can be tested.

3.0 Evaluation Objectives

This evaluation is not intended to be an exhaustive analysis, but a “confidence” building evaluation where a set number of cases are compared. The following sections describe details of this evaluation. The objective of this meteorological comparison evaluation is to have confidence that the cloud reports (heights and amounts) generated by the new CL31 ceilometer are similar to the cloud reports generated by the existing CT12K ceilometer in conditions critical for aviation and weather forecasting, using specified conditions defined in this plan.

Another objective of the evaluation is to document any significant differences (using RMSD) in cloud reports (heights and amounts) between the CL31 and CT12K sensors and to distribute this information to pertinent users of the ceilometer data. Specifically, any significant differences will be included in a TIN, issued by the OCWWS in coordination with the OOS, for distribution to the NWS user community. The TIN will be distributed from WSH nationally in advance of the switchover to the CL31 as the primary sensor on the 23 ASOS sites participating in the OT&E. This information also will be propagated as a PNS issued locally by WFO’s announcing the new operational ceilometer

sensor for ASOS's in their CWA through the deployment phase of the CL31 sensor. The results of this evaluation will also be provided to the ATRB and will be used during the OT&E as input into the TIN for advanced notice of the switch and the determination when the CL31 can be configured as the operational sensor at the 23 OT&E ASOS sites (See Section 2.0). The overall criteria for this determination will be no differences exist that will negatively affect TAF generation or aviation safety. The data analysis will closely monitor the number of cases obtained during the evaluation. The team will summarize the results based on the cases to date (section 8.3, Table 4 and 5), evaluation parameters (section 4), and present the results to the ATRB for discussion and voting on proceeding to install the CL31 as the operational ceilometer at the OT&E sites.

4.0 Evaluation Parameters

The most important heights for accurate cloud reports for aviation operations and safety are below 3000 feet. The aviation flight categories for cloud heights are defined as:

Low Instrument Flight Rules (LIFR)
Instrument Flight Rules (IFR)
Marginal Visual Flight Rules (MVFR)
Visual Flight Rules (VFR)

Table 1 lists the heights associated with each of the aviation flight categories, and lists comparable limits for cloud heights when comparing the CL31 and CT12K ceilometers. Table 1 used Table 9-4: "Increments of Reportable Values of Sky Cover Height" in the Federal Meteorological Handbook -1 (FMH-1) as guidance.

TABLE 1: ACCEPTABLE HEIGHT RANGE (FEET) FOR CL31 COMPARISON WITH CT12K 1

AVIATION FLIGHT CATEGORY	HEIGHT (ft) (Cloud or Ceiling)	ACCEPTABLE HEIGHT DIFFERENCE (ft)
LIFR	$H < 500$	± 100
IFR	$500 \leq H < 1000$	± 100
MVFR	$1000 \leq H < 3000$	± 100
VFR	$3000 \leq H < 5000$	± 500
VFR	$5000 \leq H \leq 12000$	± 1000

Table 2 defines parameters for quantifying RMSD into categories for analysis based on the comparable height range of ± 100 (LIFR, IFR, MVFR), ± 500, and ± 1000 (VFR). This information will be used to categorize the amount of differences between the CT12K and CL31 ceilometer.

TABLE 2: RMSD RANGE (FEET) FOR CL31 COMP WITH CT12K 1

Height Range	Aviation Flight Category	Comparable	Some Differences	Significant Differences	Great Differences
CLR					
H < 500	LIFR	0 - 100	101 – 300	301 - 500	> 500
500 ≤ H < 1000	IFR	0 - 100	101 – 300	301 - 500	> 500
1000 ≤ H < 3000	MVFR	0 - 100	101 – 300	301 - 500	> 500
3000 ≤ H < 5000	VFR	0 - 500	501 – 1000	1001 - 1500	>1500
5000 ≤ H ≤ 12000	VFR	0 - 1000	1001 – 2000	2001 - 3000	>3000

Table 3 defines the acceptable sky coverage amounts when comparing the CL31 ceilometer to the CT12K ceilometer. Table 3 used Table 9.2: "Reportable Contraction for Sky Cover" in FMH-1 as guidance.

TABLE 3: SKY COVERAGE AMOUNTS AND PERCENTAGES (OCTANTS) 1

ALGORITHM CLOUD AMOUNT (OPERATIONAL)	SKY COVER (OCTANTS)	EXPECTED ALGORITHM CLOUD AMOUNT (TEST)
CLEAR (CLR)	0	CLR-FEW
FEW	1/8 - 2/8	CLR-FEW-SCT
SCATTERED (SCT)	3/8 - 4/8	FEW-SCT-BKN
BROKEN (BKN)	5/8 – 7/8	SCT-BKN-OVC
OVERCAST (OVC)	8/8	BKN-OVC
VERTICAL VISIBILITY (VV)	8/8	OVC-VV

5.0 Assumptions and Limitations

There is no reference (or "truth") sensor for the CL31 and CT12K Ceilometers Meteorological Comparison Evaluation. The CT12K and the CL31 sensors might produce different cloud reports under different conditions. RMSD will be used to determine the degree of comparability in accordance with ATSM standard D 4430. The CL31 sensor might actually perform better in circumstances because of its improved sensor design. An attempt will be made to explain any differences in cloud amounts and heights that are seen during the evaluation. The ATRB will decide whether to expand this evaluation to a subset of OT&E sites (that experience winter weather) if the number of desired cases is not observed at SFSC before the end of ST (November 2008). The start date of this evaluation is subject to change based on the start of other tests such as ceilometer ST. Report deliverables are also subject to change based on start dates of other tests.

6.0 Evaluation Management

This evaluation will be under the auspices of the ATRB. The ATRB will:

- Oversee and approve this plan.
- Make any decisions regarding the evaluation of the data and data analysis performed during this evaluation.
- Decide whether to expand this evaluation to a subset of OT&E sites if enough winter cases are not obtained at SFSC at the conclusion of the ST.
- Review and approve the final report.

There will also be close communication with the NWS regions on results of this evaluation during the evaluation period.

6.1 Roles and Responsibilities

Evaluation Manager

NWS OOS Field Systems Operations Center (FSOC), Test and Evaluation Branch (W/OPS24) will write the plan, prepare and provide interim presentations on progress, write the final report, lead the data analysis team, provide meteorological assistance and guidance in interpreting results (data analysis), and oversee (with the NWS Observing Systems Branch OPS22) progress on the collection of the data and data processing.

Data Analysis Team

A data analysis team is established for the duration of this evaluation. The team comprises the following meteorologists from WSH:

- Joseph Fiore (W/OPS24) - Team Leader
- Richard Parry, Chester Schmitt, and Jennifer Dover (W/OPS22),
- Richard Lewis, (W/OST32),
- Beth McNulty (W/OS23),
- Aaron Poyer (SFSC support contractor), and
- Barbra Childs (SFSC support contractor).

The data analysis team will ensure the cases identified in the case study matrix (Table 4) are validated. The team will interpret results on a "case by case" basis if there are significant differences (initially differences greater than the acceptable heights described in Table 1 and 2) in cloud reports between the two ceilometers. If more in-depth analysis is needed for significantly different cases, the OPS22 focal point at SFSC will coordinate support for this analysis with the support contractor at SFSC. The data analysis team will meet on a regular basis to discuss results, especially cases with significantly different cloud reports (cloud heights and cloud amounts). The Team Leader (W/OPS24) will provide status reports, and convene status meetings on progress for the evaluation on an as needed basis.

Data Technicians

Data acquisition and processing will be managed by the NWS OOS FSOC OPS22 focal point at SFSC. The NWS OPS22 focal point will coordinate support for data acquisition and processing (including the development of the spreadsheet and graphical output) with the support contractor at SFSC. The data will be collected (described in Section 8.1) from the ST1 ASOS at the SFSC, using Direct Command Mode (DCM) and an automated script file (ProComm) to get the required data three times a day to assure that no data gaps exist. This data will be converted (using macro's/script files) into files that can be imported into a spreadsheet for analysis.

The team will analyze the data using the evaluation criteria and evaluation metrics described in this plan. Data analysis (spreadsheet) results will be passed to W/OPS24 and the data analysis team by the NWS focal point at SFSC for incorporation into progress summaries and the final report.

7.0 Evaluation Configuration

The configuration of the SFSC ST1 ASOS used for this evaluation will initially include one ceilometer configured as the operational sensor (CT12K), and one ceilometer configured as the test sensor (CL31 limited production unit). The operational sensor will be mounted on the ASOS rail on the operational ceilometer pedestal. The test sensor will be mounted on a spare pedestal on the ASOS rail. The ST1 ASOS will operate in this mode for the first half of the evaluation (i.e., half of the cases desired are validated).

For the second half of the evaluation (i.e., until the remaining cases are validated) the primary and test ceilometer configuration will be switched (i.e., by dial into the sensors rather than a physical sensor swap on the ASOS pedestals). The CL31 will be configured as the primary sensor, and the CT12K will be configured as the test sensor. Right before this sensor configuration switch is made, the 12-hour archive of primary ceilometer and test ceilometer data will be downloaded along the 5-minute observations. Once the required data have been downloaded, the sensor configuration will be switched; the CL31 ceilometer will be configured as the primary sensor, and the CT12K will be configured as the test sensor. In this configuration, the CL31 will be the sensor that produces METAR and SPECI observations, and the sky condition (height and amount) that is displayed on the one-minute screen. The CT12K sensor will be the test sensor, and the CT12K data will be on the 12-hour archive test ceilometer page. NOTE: As policy, switching of the primary and test sensors will be performed only during fair weather conditions. After successful switch of the primary and test ceilometers, the ceilometer data for the new configuration will be checked to make sure that the sensors report the sky condition similar to the way the sensors reported the sky condition when the sensors were in the old configuration. 12-hour archive algorithm output (test sensor) and 5-minute observations (primary sensor) will be compared for the time immediately before and immediately after the switch. Graphs will be produced before and after the switch, which will provide a visual reference to assure that the sensors continue to report similar sky conditions before

and after the switch.

8.0 Evaluation Methodology

The CL31 and CT12K ceilometers meteorological comparison evaluation will initially be conducted on the ASOS at SFSC. The goal is to get enough cases (defined in Section 8.3) with favorable results at SFSC before the NWS begins the OT&E during November of 2008. If enough cases are not obtained at SFSC during the ST in October 2008, the ATRB will decide whether to expand this evaluation to a subset of OT&E sites that have favorable conditions for snow, wind, and freezing precipitation during the very cold winter months of 2009 (i.e., January and February). The expanded sites will also include sites that are representative of various climatic regions. The following are list of the ASOS sites selected by the data analysis team for the expanded evaluation during the OT&E:

1. CAR - Caribou, ME

2. GDP - Guadalupe Pass, TX

3. BIS - Bismarck, ND

4. JKL - Jackson, KY

5. PHX - Phoenix, AZ

6. HIO - Portland, OR

7. FAI - Fairbanks, AK

8. ITO - Hilo, HI .

The next section describes the data collection, data processing, and evaluation process.

8.1 Data Collection

Data collection and processing will take place at the SFSC on the ST1 ASOS. If enough cases are not obtained at SFSC before OT&E, this evaluation may be expanded to include the subset of OT&E ASOS sites list above in Section 8.0. These sites were selected because they are in geographical locations favorable to have the requisite weather conditions such as high winds, fog, freezing rain, and snow. The ability of the data collection and processing technicians to efficiently and effectively do their job was factored into limiting the number of OT&E sites used in the evaluation. Both the number of sites and their locations were selected to optimize the chances of obtaining more evaluation cases to make a quicker national deployment decision after the completion of OT&E.

8.2 Data Processing

Data collection and processing will be accomplished using Direct Command Mode (DCM) to download desired ASOS data three times a day (to ensure data continuity), using a ProComm script file. The script file will download the 12-hour archive high-resolution data (pages 1, 2, 4, 5) including visibility, present weather, temperature and dew point, ceilometer data from the operational sensor, ceilometer data from the test sensor, and ASOS Aviation Routine Weather Reports (METARs) and Aviation Selected Special Weather Report (SPECIs), 5-MIN observations, EDITLOGs, and SYSLOGs three times a day (via script file on ProComm) to make sure no data are lost. The primary script file will be run at SFSC, and a backup script file will be run at WSH in case there is a problem with the primary script file or communication at SFSC. The downloaded data (i.e., the ASOS sky condition algorithm output from the 5-MIN observations for the primary ceilometer, and ASOS sky condition algorithm output for the test sensor ceilometer data page) will then be run through a "script/macro" file. The script/macro will strip off undesired data, and generate a text file containing the ASOS primary sensor sky condition algorithm output every 5 minutes, and a text file containing the ASOS test sensor sky condition algorithm output every 5 minutes. These text files will then be imported into spreadsheets for analysis. Data processing will also include graphs of ASOS primary and test sensor sky condition algorithm height and amount data for selected cases. Examples of the graphs that will be generated during this evaluation are included in Appendix A.

8.3 Evaluation and Analysis

This evaluation will be grouped into the various weather conditions described in Table 4. Table 4 lists the number of desired comparison cases to be obtained for each aviation flight category. A "case" is defined as: a unique set of 30-minutes of continuous 5-minute observations (seven 5-minute observations) from the ASOS.

TABLE 4: NUMBER OF DESIRED CASES 1

Height Range	Aviation flight rule	CLR	FEW	SCT	BKN	OVC	VV	WIND >25KTS
CLR	VFR	16						
H <500	LIFR		5	5	15	15	10	1
500 ≤ H <1000	IFR		5	5	15	15	10	3
1000 ≤ H< 3000	MVFR		5	5	15	15	10	2
3000 ≤ H < 5000	VFR		4	4	10	10		
5000 ≤ H ≤ 12000	VFR		3	3	10	10		
TOTAL (225)		16	22	22	65	65	30	5

A total of 225 cases are desired for this evaluation. For the cloud amounts of BKN, OVC, and VV, and cloud heights <3000 feet that are most critical to aviation safety, the goal is to get 125 cases (60 with precipitation, 60 with no precipitation, 5 with high winds) for the three lowest aviation flight rule categories (LIFR, IFR, MVFR). Table 5 is a subset of Table 4 and summarizes the type and number of desired cases for precipitation, no precipitation, and wind categories.

TABLE 5: NUMBER OF DESIRED CASES FOR CLOUD AMOUNTS AND HEIGHTS CRITICAL FOR AVIATION SAFETY1

Heights: <3000 FT Amounts: BKN, OVC, VV	RAIN	RAIN	SNOW	SNOW	FOG MIST Drizzle	No Precip (NP)	High Winds
Precip Type	RA/+RA/ FZRA	-RA - FZRA	SN/+SN	-SN	FG BR DZ FZFG/FZDZ	NP	>25 KT
# CASES LIFR (41)	4	6	2	3	5	20	1
IFR (43)	4	6	2	3	5	20	3
MVFR (42)	4	6	2	3	5	20	2
Total (125)	12	18	6	9	15	60	5

In other words, the desired number of cases in Table 5 is 41 in LIFR conditions, 43 in IFR conditions, and 42 in MVFR conditions. If enough snow or freezing precipitation cases are not obtained at SFSC at the conclusion of ST, the ATRB will decide whether to expand this evaluation to a subset of OT&E sites that are favorable for obtaining cases need to complete the evaluation during OT&E.

In addition to the parameters for evaluation defined in Tables 1 and 3, analysis will include computation of the RMSD between the CL31 and CT12K cloud reports for categories in Table 1 and 3. The RMSD will be a cumulative value that changes as more cases are added to the category in Table 1 and 3.

The equation for the RMSD of the difference between simultaneous readings from two systems (CL31 and CT12K) measuring the same quantity in the same environment is:

$$C = \pm\sqrt{\frac{1}{N}\sum_{i=1}^{N}\left(X_{ai} - X_{bi}\right)^2}$$

Where:
X_{ai} = *i*th measurement made by one system,
X_{bi} = *i*th simultaneous measurement made by another system, and

N = number of samples used.
C = RMSD difference.

This equation can be found in"3.2.3 operational comparability (C)" of ASTM Standard, D 4430. A table that describes how RMSD values will be used can be found Appendix A of this evaluation plan.

Reportable differences determined from the analysis between the two sensors cloud reports will be documented in a Technical Implementation Notice (TIN) that will be distributed to the aviation and weather forecast user community.

9.0 Schedule and Reports

This "CL31 and CT12K Ceilometers Meteorological Comparison Evaluation" data collection will officially start when the ST for ceilometer replacement begins. The CL31 and CT12K meteorological comparison evaluation will then run in parallel with ST at SFSC, and the limited production compliance testing at SFSC. Upon direction from the ATRB, the evaluation may be expanded to run in parallel with the OT&E at a selected sub-set of OT&E sites (if enough test cases are not obtained). A tentative schedule for evaluation and reports is listed in Table 6.

TABLE 6: EVALUATION AND REPORT TIMETABLE 1

EVENT	START DATE	COMPLETION DATE
Evaluation Data Collection	Start of ST	Spring 2009**
Interim Report	Fall 2008**	Winter 2009**
ATRB Decision: Expand Evaluation to a Subset of OT&E Sites	November 2009 †	After enough cases are obtained at a subset of OT&E sites
Final Report	Start of OT&E †	1 Month after enough cases are obtained at a subset of OT&E sites

** If enough cases are obtained at SFSC
† If not enough cases are obtained at SFSC

APPENDIX A: SAMPLE CASE STUDY DOCUMENT AND GRAPHS TO BE USED IN THE EVALUATION

CL31 Ceilometer Meteorological Evaluation

Site	Date	Duration	Precipitation	Primary	Test
SRD	8/27/08	4.5 hours	-RA/BR/FG	12K	CL31

The following events occurred at the SFSC in Sterling, Virginia on 8/27/2008 and incorporated 9, 30-minute periods. The events were comprised of light rain, mist and fog, and no precipitation and were classified as LIFR, IFR, and VFR. The CT12K was the primary sensor and the CL31 was the test sensor for these events.

The results from these events show that there were no significant differences between the CT12K and the CL31 in heights or amounts. The differences were within the acceptable range.

Number of Cases based on the CT12K obtained to date.

Height Range	Aviation Flight Category	CLR	FEW	SCT	BKN	OVC	VV
CLR							
H < 500	LIFR				2	1	
500 ≤ H < 1000	IFR			1			
1000 ≤ H < 3000	MVFR						
3000 ≤ H < 5000	VFR		1		1		
5000 ≤ H ≤ 12000	VFR		2			1	
TOTAL			3	1	3	2	

Table 1 Number of Cases

Number of Cases (subset of Table 1)

Heights: < 3000 FT Amounts: BKN, OVC, VV	RAIN	RAIN	SNOW	SNOW	FOG/MIST/ DRIZZLE	No Precipitation
Precipitation Types	RA/+RA/FZRA	-RA/ -FZRA	SN/+SN	-SN	FG/BR/DZ/FZDZ	NP
TOTAL		2			1	

Table 2 Number of Cases

Tables 3 and 4 provide a preliminary example of how the RMSD will be presented.

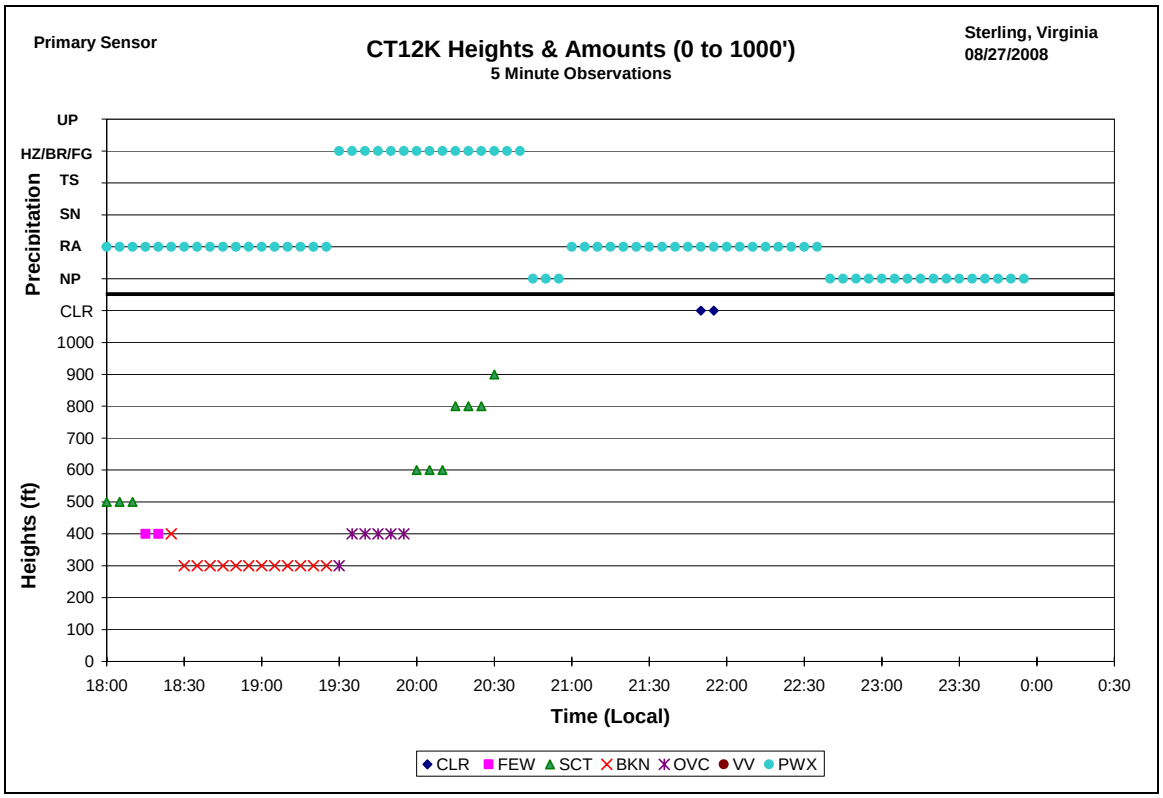
TABLE 3: Root Mean Square Deviation (CL31 Compared to CT12K)

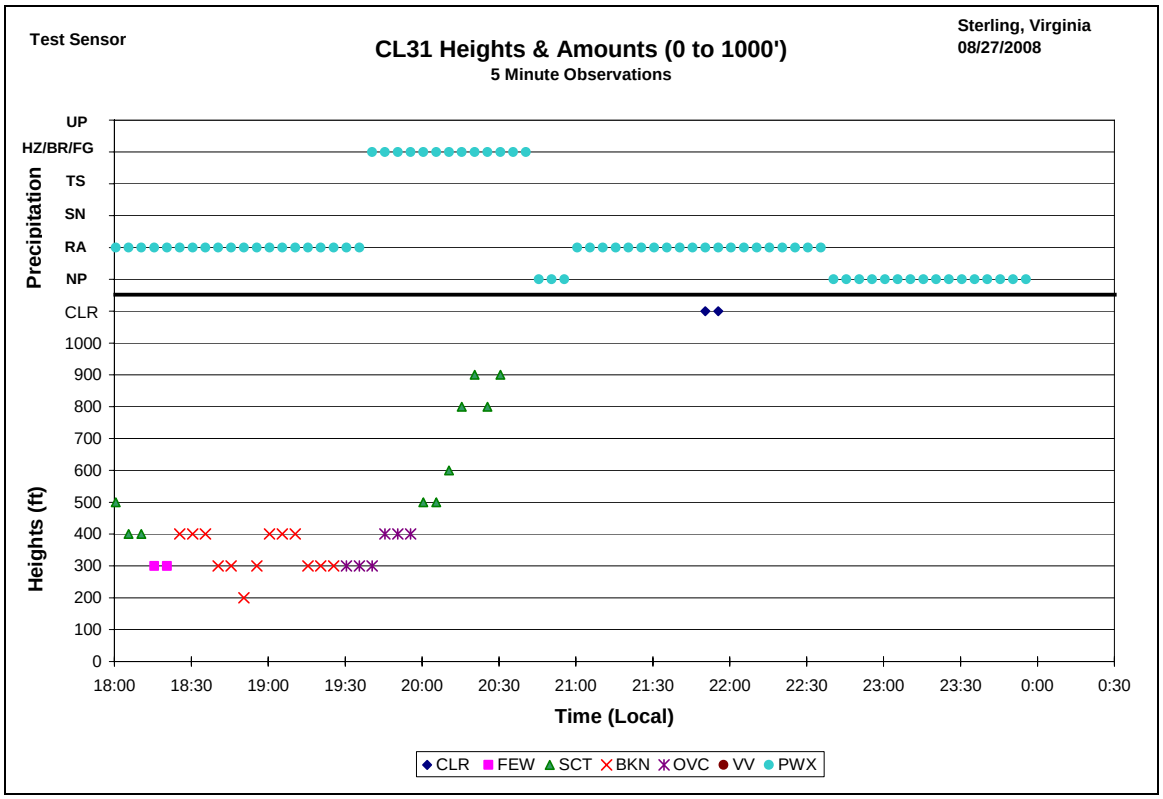
Height Range	Aviation Flight Category	CLR	FEW	SCT	BKN	OVC	VV
CLR			X	X	X	X	X
H < 500	LIFR	X	X	X			
500 ≤ H < 1000	IFR	X	X	X			
1000 ≤ H < 3000	MVFR	X	X	X			
3000 ≤ H < 5000	VFR	X					X
5000 ≤ H ≤ 12000	VFR	X					X
TOTAL							

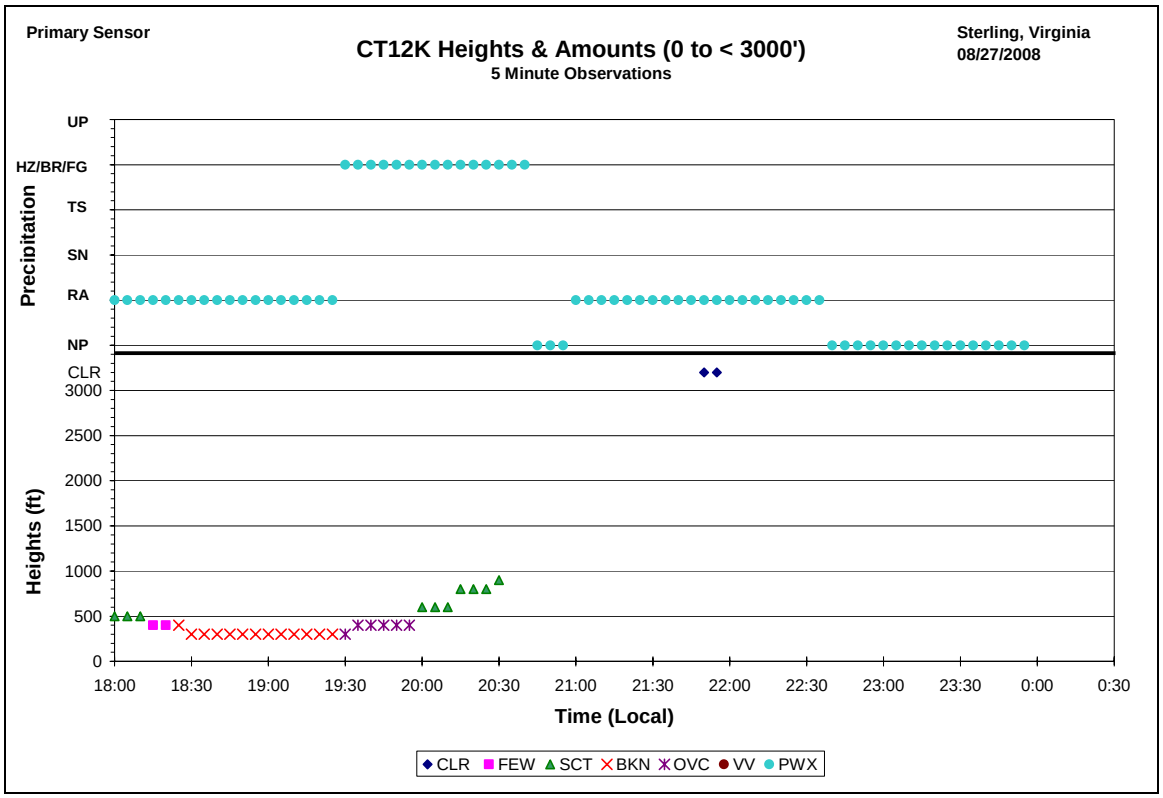
The "X" indicates cases where we will not need to compute the RMSD deviation. The RMSD should be cumulative as the number of cases increases. Perhaps it might be helpful to include the number of cases with the RMSD, [e.g., 0.567 / 20, (RMSD / # of cases)].

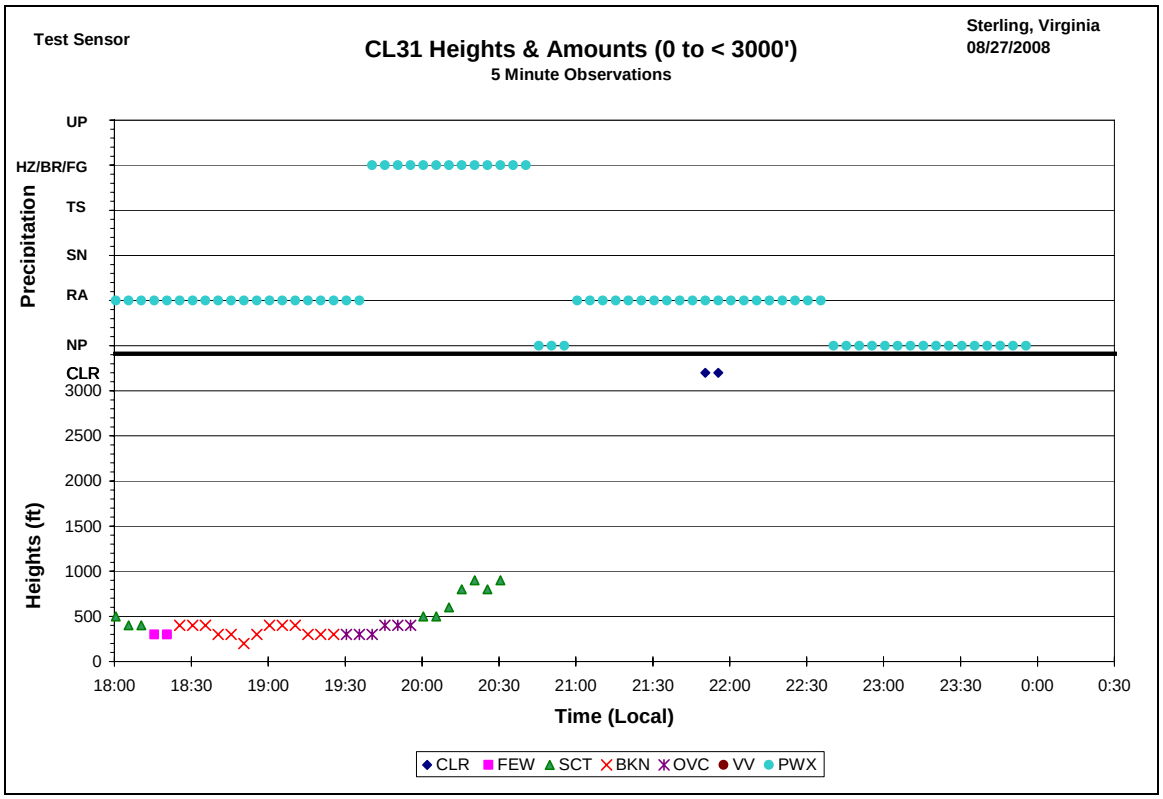
TABLE 4: Root Mean Square Deviation (CL31 Compared to CT12K)

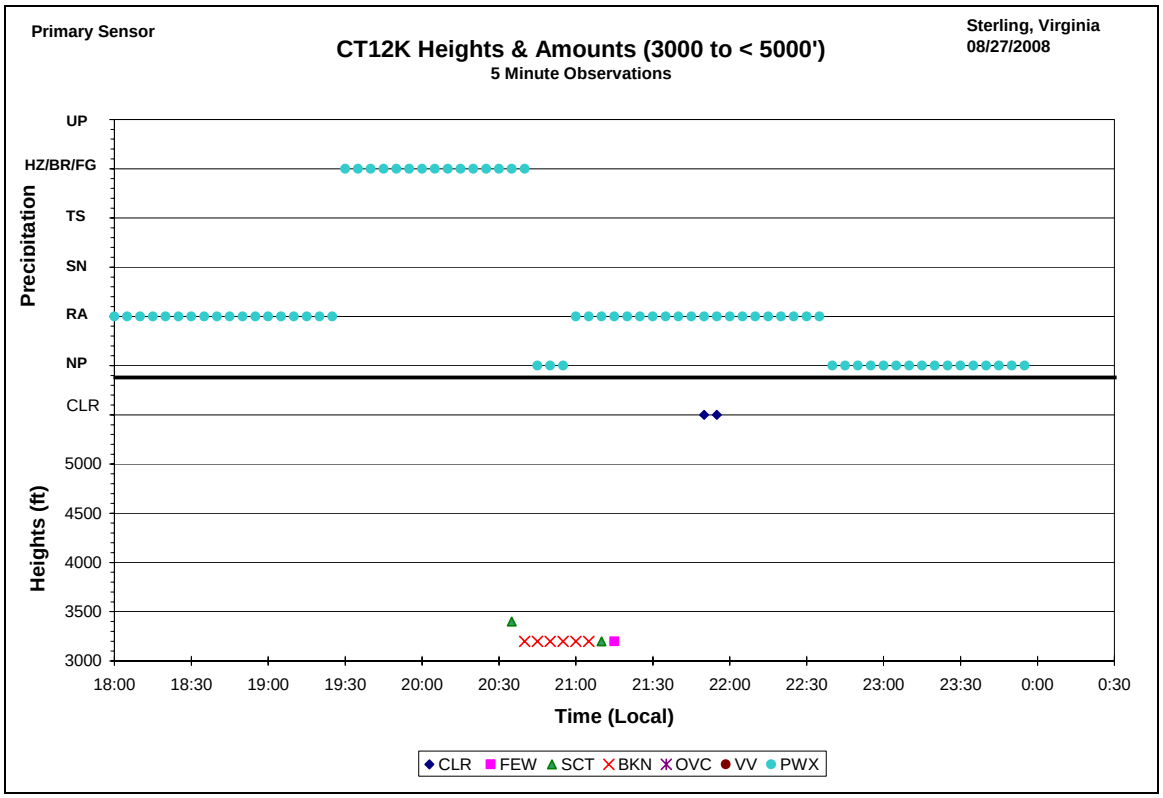
Heights: <3000 FT Amounts: BKN, OVC, VV	RAIN	RAIN	SNOW	SNOW	FOG MIST Drizzle	No Precip (NP)	High Winds
Precip Type	RA/+RA	-RA	SN/+SN	-SN	FG BR DZ FZFG	NP	> 25 KTS
RMSD							

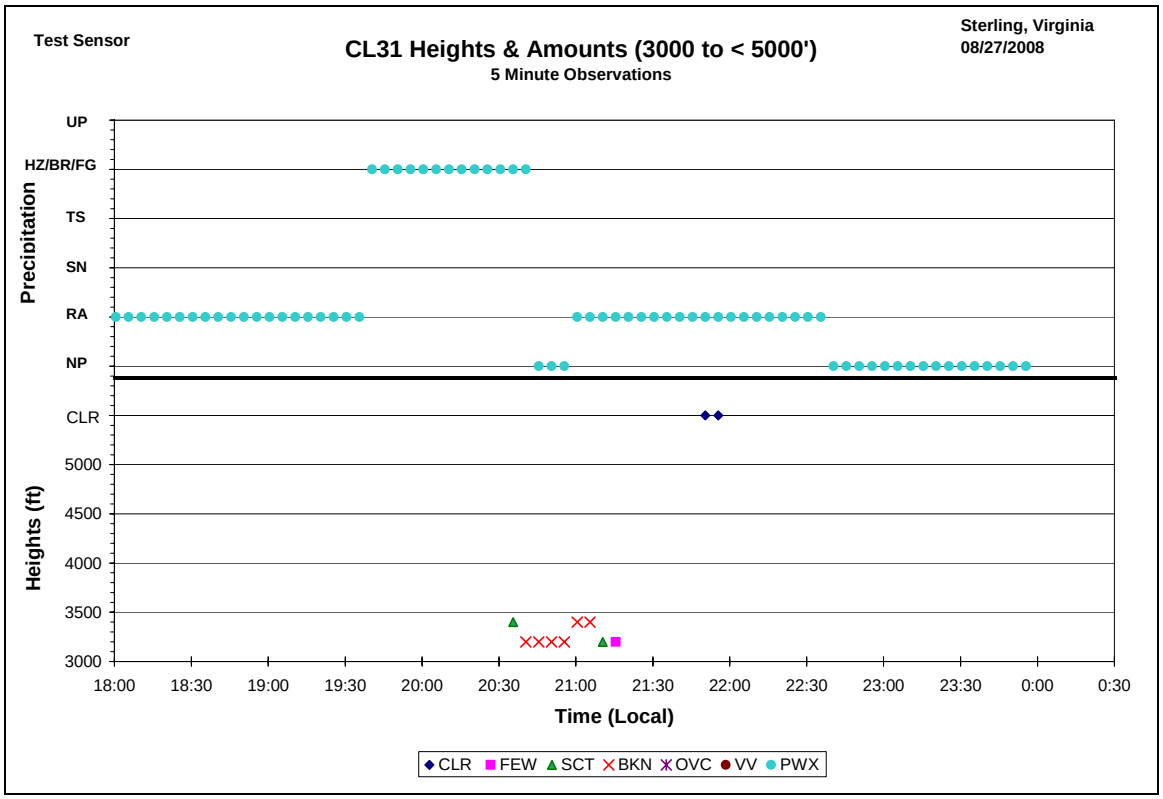

Primary Sensor
CT12K Heights & Amounts (0 to 1000')
5 Minute Observations
Sterling, Virginia
08/27/2008
Precipitation
UP
HZ/BR/FG
TS
SN
RA
NP
CLR
Heights (ft)
1000
900
800
700
600
500
400
300
200
100
0
18:00
18:30
19:00
19:30
20:00
20:30
21:00
21:30
22:00
22:30
23:00
23:30
0:00
0:30
Time (Local)
CLR FEW SCT BKN OVC VV PWX

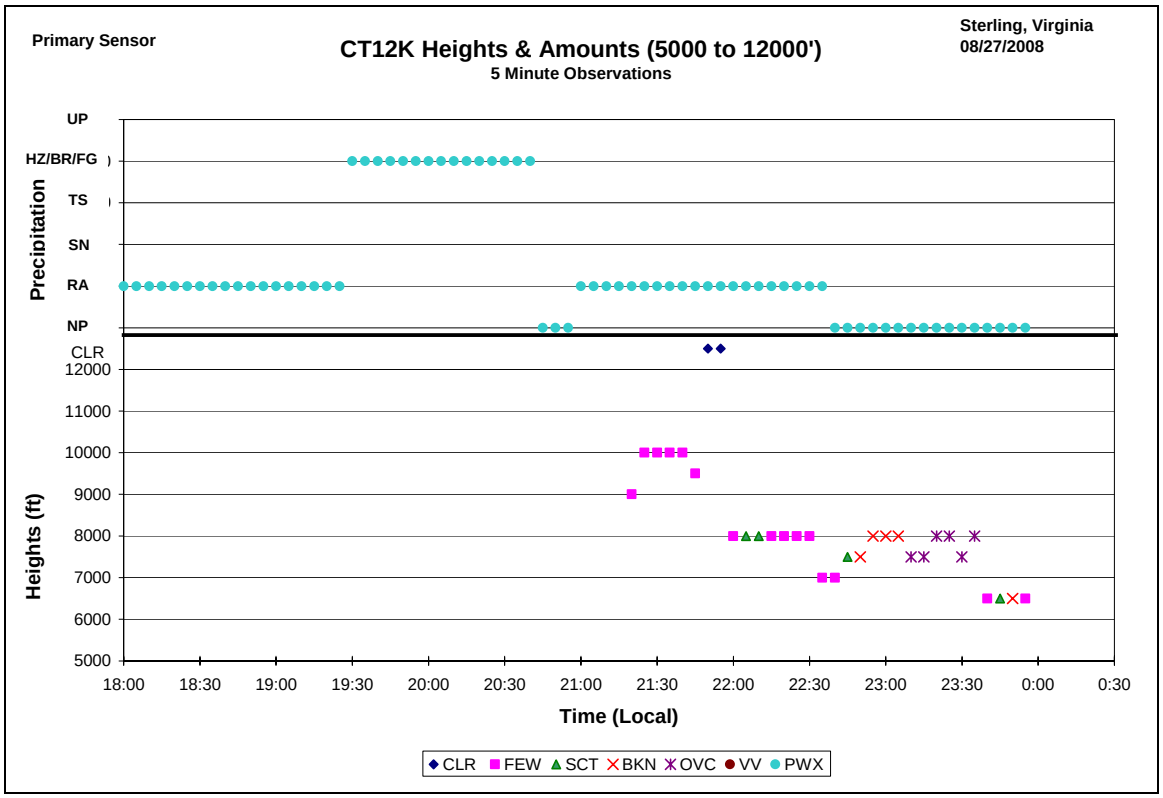

Test Sensor
CL31 Heights & Amounts (0 to 1000')
5 Minute Observations
Sterling, Virginia
08/27/2008
Precipitation
UP
HZ/BR/FG
TS
SN
RA
NP
CLR
Heights (ft)
1000
900
800
700
600
500
400
300
200
100
0
18:00
18:30
19:00
19:30
20:00
20:30
21:00
21:30
22:00
22:30
23:00
23:30
0:00
0:30
Time (Local)
CLR FEW SCT BKN OVC VV PWX

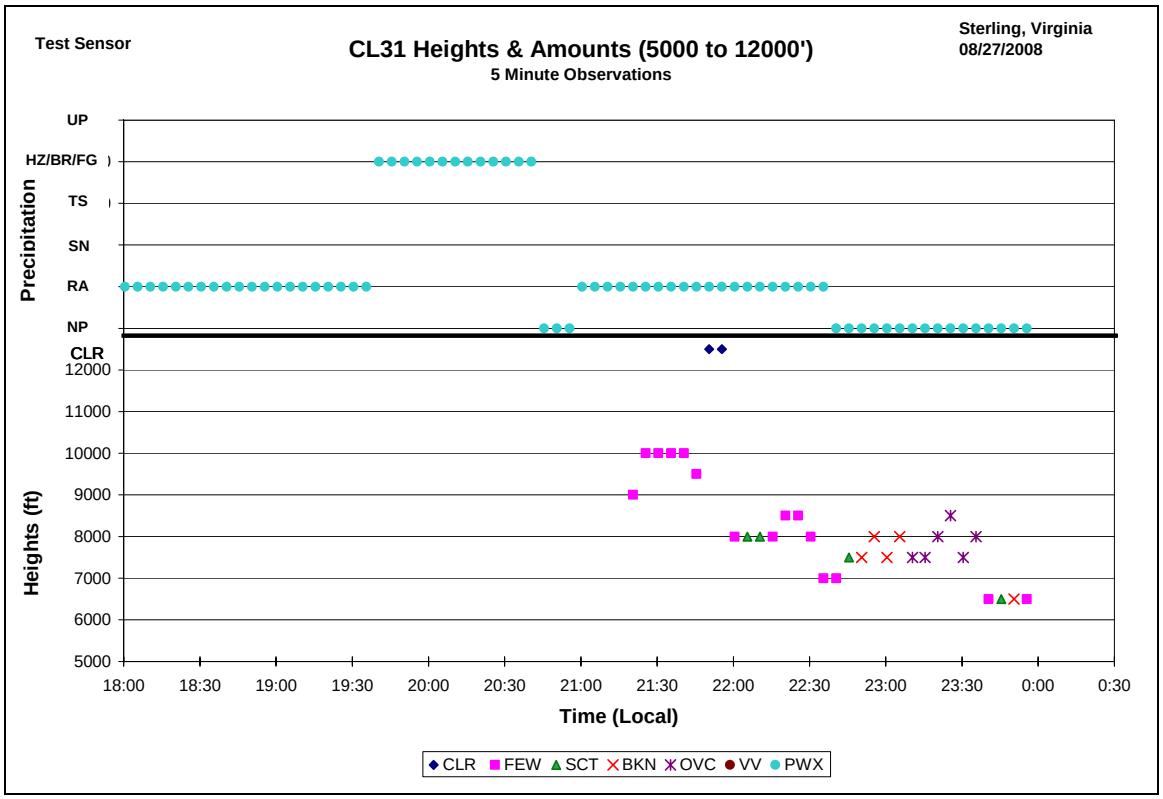

Primary Sensor
CT12K Heights & Amounts (0 to < 3000')
5 Minute Observations
Sterling, Virginia
08/27/2008
Precipitation
UP
HZ/BR/FG
TS
SN
RA
NP
CLR
Heights (ft)
3000
2500
2000
1500
1000
500
0
18:00
18:30
19:00
19:30
20:00
20:30
21:00
21:30
22:00
22:30
23:00
23:30
0:00
0:30
Time (Local)
CLR FEW SCT BKN OVC VV PWX


Test Sensor
CL31 Heights & Amounts (0 to < 3000')
5 Minute Observations
Sterling, Virginia
08/27/2008
Precipitation
UP
HZ/BR/FG
TS
SN
RA
NP
CLR
Heights (ft)
3000
2500
2000
1500
1000
500
0
18:00
18:30
19:00
19:30
20:00
20:30
21:00
21:30
22:00
22:30
23:00
23:30
0:00
0:30
Time (Local)
CLR FEW SCT BKN OVC VV PWX


Primary Sensor
CT12K Heights & Amounts (3000 to < 5000')
5 Minute Observations
Sterling, Virginia
08/27/2008
Precipitation
UP
HZ/BR/FG
TS
SN
RA
NP
CLR
Heights (ft)
5000
4500
4000
3500
3000
18:00
18:30
19:00
19:30
20:00
20:30
21:00
21:30
22:00
22:30
23:00
23:30
0:00
0:30
Time (Local)
CLR FEW SCT BKN OVC VV PWX


Test Sensor
CL31 Heights & Amounts (3000 to < 5000')
5 Minute Observations
Sterling, Virginia
08/27/2008
Precipitation
UP
HZ/BR/FG
TS
SN
RA
NP
CLR
Heights (ft)
5000
4500
4000
3500
3000
18:00
18:30
19:00
19:30
20:00
20:30
21:00
21:30
22:00
22:30
23:00
23:30
0:00
0:30
Time (Local)
CLR FEW SCT BKN OVC VV PWX


Primary Sensor
CT12K Heights & Amounts (5000 to 12000')
5 Minute Observations
Sterling, Virginia
08/27/2008
Precipitation
UP
HZ/BR/FG
TS
SN
RA
NP
CLR
Heights (ft)
12000
11000
10000
9000
8000
7000
6000
5000
18:00
18:30
19:00
19:30
20:00
20:30
21:00
21:30
22:00
22:30
23:00
23:30
0:00
0:30
Time (Local)
CLR FEW SCT BKN OVC VV PWX


Test Sensor
CL31 Heights & Amounts (5000 to 12000')
5 Minute Observations
Sterling, Virginia
08/27/2008
Precipitation
UP
HZ/BR/FG
TS
SN
RA
NP
CLR
Heights (ft)
12000
11000
10000
9000
8000
7000
6000
5000
18:00
18:30
19:00
19:30
20:00
20:30
21:00
21:30
22:00
22:30
23:00
23:30
0:00
0:30
Time (Local)
CLR FEW SCT BKN OVC VV PWX