Glenda Project – Executive Summary – 2022

GLENDA PROJECT

Severe Weather Research Institute

Glenda Project – Purpose

The primary mission of the Glenda Project is to provide the capability to rapidly gather previously inaccessible localized microclimate data from altitudes ranging from ground level to over 100,000 feet and to return this data for immediate use.

The Glenda Project combines adaptable ground stations, reusable sounding rocket delivery systems, and rapidly deployable weather balloons, which places instrument packages into areas previously considered to be too hazardous or inaccessible using traditional platforms such as aircraft, helicopters, kites, etc.

Glenda Project – Skill Set

Accomplishing the multiple missions and purposes of Glenda requires an extremely diversified skill set.

The Glenda Team’s skill set ranges from hard-core aerospace engineering, remote sensing, logistics, drone piloting, videography, first response, emergency management, and systems integration to the people skills of public service, educational mentoring, and media communications.

With team member locations ranging from the West Coast to Tornado Alley, the Glenda Team is highly adaptable, highly mobile, and incredibly skilled to meet existing challenges and emergent opportunities.

Glenda Project – Team Organization

Dave Davis
Payload Development

Bob Pullman
Remote Sensing

Tim Quigg
WA Operations - East

John Ludwig
WA Operations - West

John Quigg
Videographer - Drones

Steve Thatcher
Research & Development

Sherrill Edwards
Launch Support Assistant

Eric Coran
Arkansas - Operations

Glenda Project – Data Collection Methods

Glenda has several methods for collecting data:

- Rocket Launched – Active Flight Data Collection Systems – Transmitters
- Weather Balloon Launched – Active Flight Data Systems – Radiosondes
- Rocket Launched – Passive Flight Data Collection Systems – Dataloggers
- Ground Stations

Glenda Project – Typical Flight Vehicles

9875 Booster

- 4” diameter booster, 3” diameter capsule
- Digital Radiosonde Active Payload with GPS
- GPS, and Temperature dual data logger payload
- 2,000 to 20,000 foot altitude envelope

FAR 101 Booster

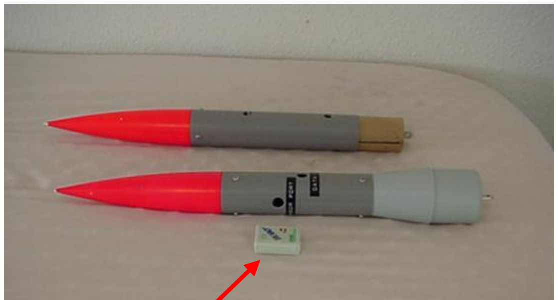
- 3” diameter booster, 2.125” diameter capsule
- GPS, and Temperature dual data logger Payload
- 2,500 foot altitude envelope
- Exempt from FAA Waiver Constraints

5475 Booster

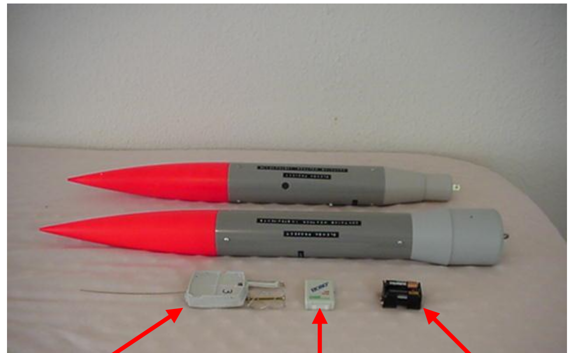
- 2.125” diameter booster, 3” diameter capsule
- Digital Radiosonde Active Payload with GPS
- GPS, and Temperature dual data logger payload
- 2,000 to 15,000 foot altitude envelope

Glenda Project – Typical Flight Payloads

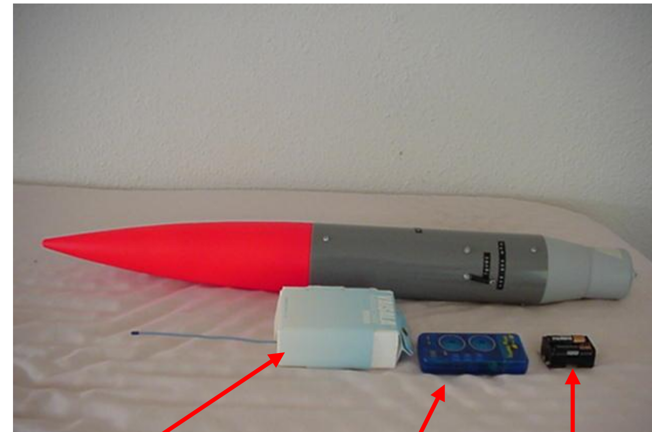
The Glenda project uses several different payload capsule configurations carrying a variety of instrumentation to gain weather-related information, and other micro-climate data.



Datalogger



Digital Radiosonde Datalogger Battery Pack



Analog Radiosonde Locator Beacon Battery Pack

54mm (2.125”) Capsules

- Datalogger Payloads..
- Measures Temperature& RH values at 1-sec intervals.
- Used by 54mm & 75mm boosters.

75mm (3”) Capsules

- Datalogger Payloads.
- Measures Temperature & RH values at 1-sec intervals.
- Digital Radiosondes transmitting temperature, RH, barometric pressure, and GPS coordinates.
- Used by 54mm & 98mm boosters.

98mm (4”) Capsule

- Analog Radiosonde transmitting temperature, RH, and barometric pressure.
- Audio location beacon.
- Used by 75mm boosters.

Glenda Project – Typical Flight Profile

2 – Intercept Phase

3 – Data Collection Phase

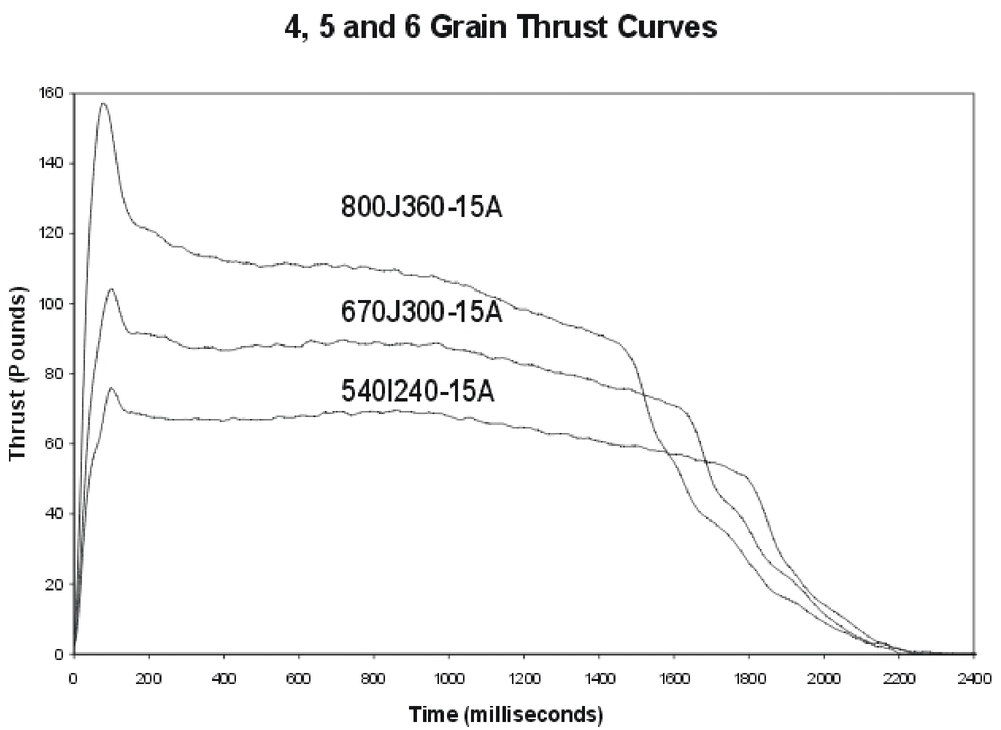
4 – Recovery Phase

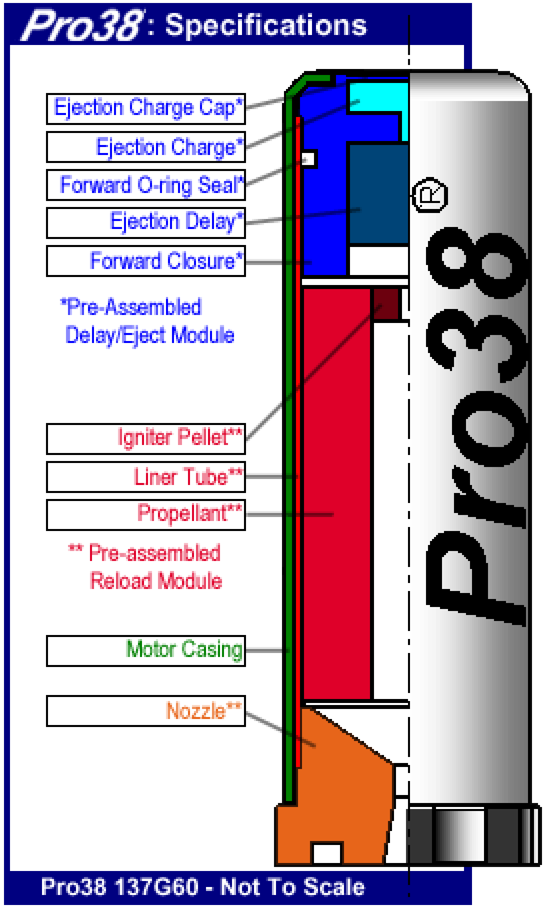
1 – Launch Phase

Note: Propulsion is provided by reloadable/reusable rocket motors giving the capability of rapid turnaround between flights.

Glenda Project – Propulsion

The Pro38/Pro54 rocket motor propulsion system is the first commercial thermoplastic propellant-based solid rocket motor and is produced by Cesaroni Technology, Inc., of Toronto, Canada. The Pro38/Pro54 is a modular, reloadable solid propellant rocket motor system designed primarily for use in launching small experimental payloads by universities, colleges, research institutes and sport rocketry enthusiasts.



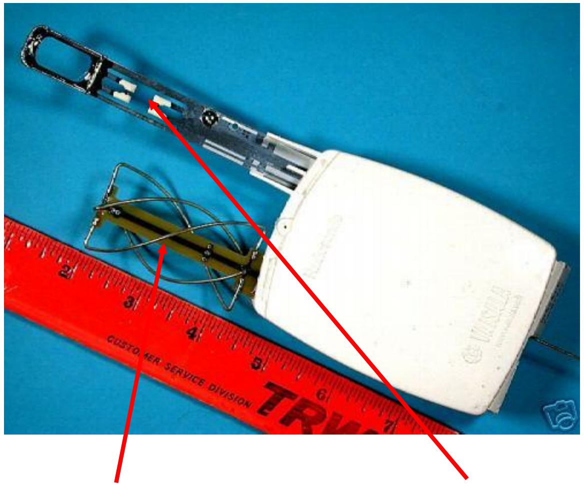


Glenda Project – Active Payloads – Transmitters

Converted Radiosonde Payloads

The Glenda Project uses converted radiosondes that are designed primarily for use with weather balloons. The circuitry and sensors are robust enough to function properly under thrust loads of the Glenda boosters and are compatible with NOAA/NWS radiosonde receiver systems.

The radiosonde contains instruments capable of making direct measurements of air temperature, humidity and pressure. These observed data are transmitted immediately to the ground station by a radio transmitter located within the instrument package.



Vaisala RS92 Radiosonde

Radiosonde Specifications:

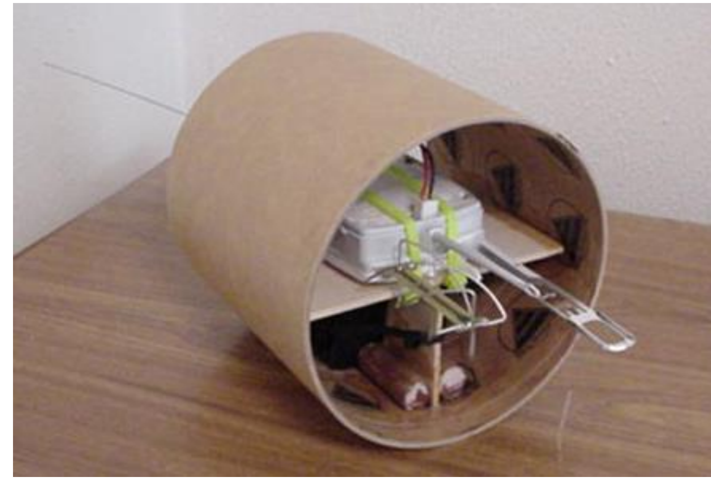
- Pressure range 3mb to 1060mb +/- 0.1mb
- Operating temperature range of -90°C to +60°C
- Relative Humidity from 0 to 100%
- Sampling Rate of once per second for the sensor suite
- Positioning data via GPS for payload location and wind velocity

Glenda Project – Active Payloads – Transmitters

Booster Launched Payload - Data Acquisition Flow Diagram

Sensor Data Transmitted from Capsule:

- Barometric Pressure Sensor Data
- Temperature Sensor Data
- Relative Humidity Sensor Data
- GPS - Payload Position Data



Active Payload cushioned within the flight capsule

Ground Receiver and Antenna System

Data recorded into laptop and graphically displayed

GPS – Ground Station/Intercept Vehicle Position Data

Glenda Project – Active Payloads – Application

A Typical Booster-Launched Payload Configuration

Mobile Ground Station/Intercept Vehicle

Isolated Laptop Power Supply

Telemetry Receiver

Cellular Modem w/ internet connection

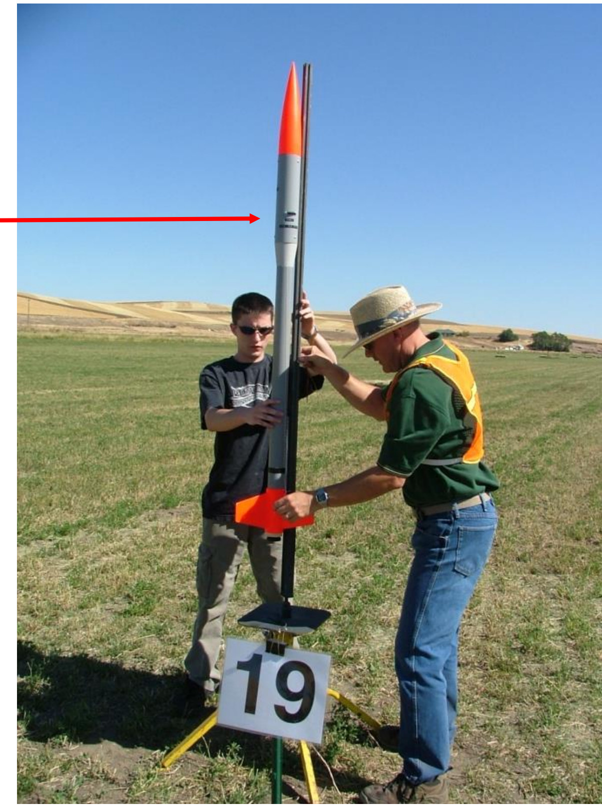
Laptop

Not Shown:

a) External Telemetry Receiver Antenna
b) External GPS Antenna
c) External Cellular Modem Antenna

Flight Vehicle

Payload Capsule

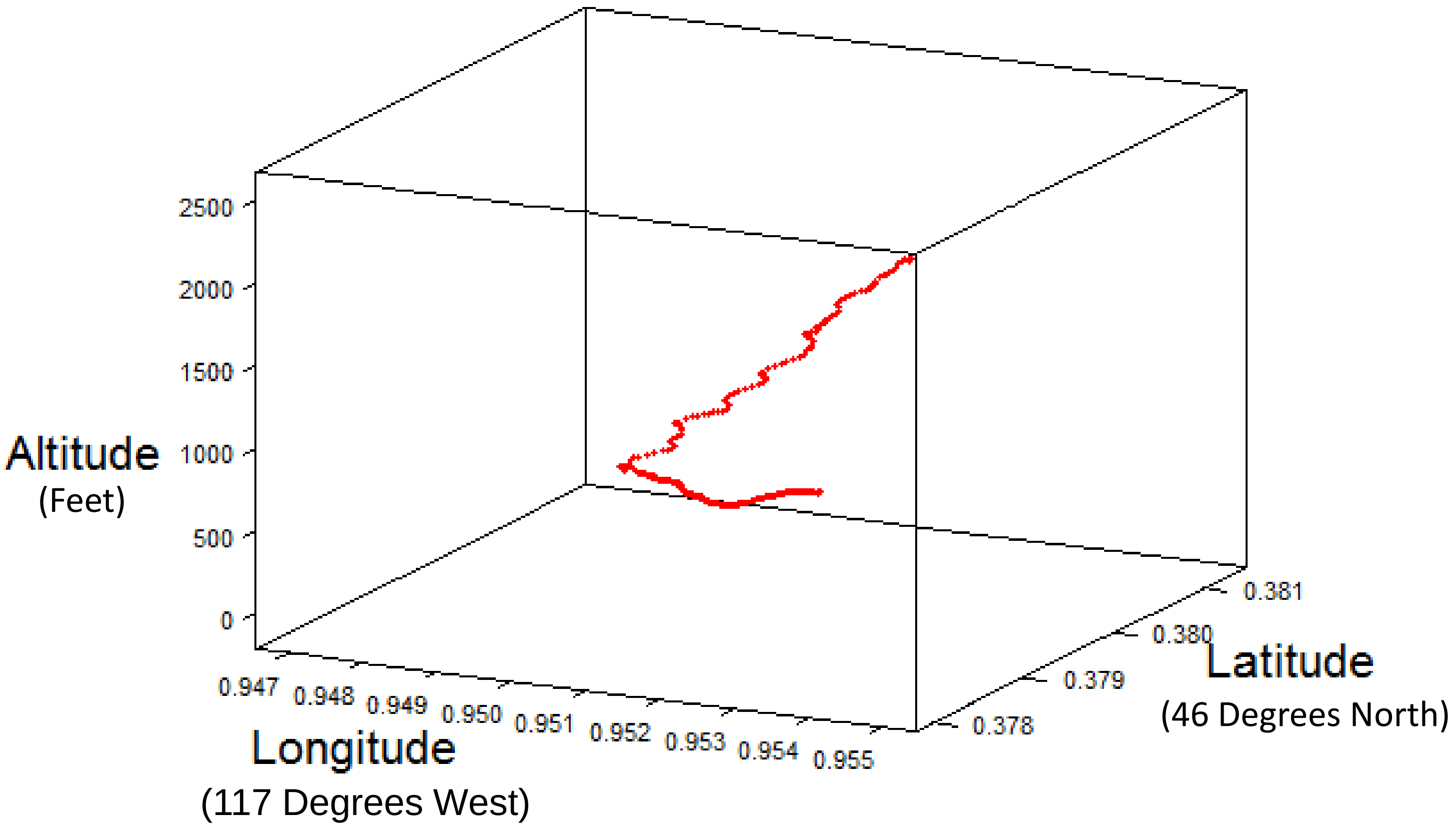


Length: 65”
Diameter: 3”
Dry Weight: 3.5 Pounds
Attainable Altitudes: 2,000 feet to 20,000 feet

Glenda Project – Active Payloads – Application

"Lone Tree" Launch Site – June 11, 2011

Latitude/Longitude/Altitude/Motion



Note: After an initial shift at altitude, due to the winds aloft, recovery was nominal.

Glenda Project – Active Payloads – Transmitters

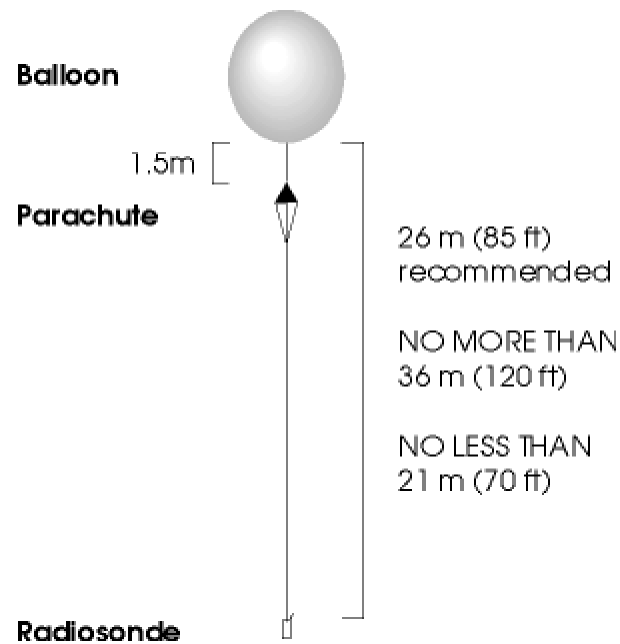
Balloon Launched Payloads – Radiosondes

In 2013, the Glenda Project expanded our flight capability to conduct weather balloon launches to an extended flight envelope of over 100,000 feet. The most significant challenge was developing the ground support equipment and infrastructure.

The signal/data processing systems were already in place, which made the transition to actual balloon launches rather seamless.

100 gram and 150 gram balloons

Parachute and Radiosonde de-reeler



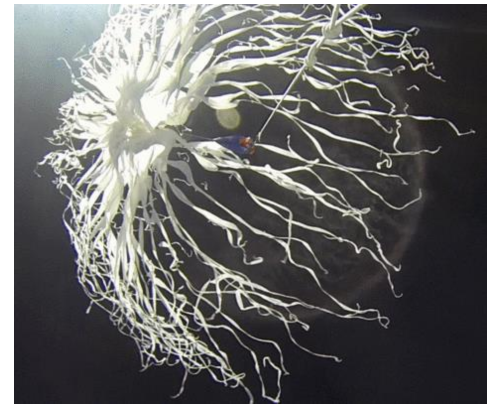
Glenda Project – Active Payloads – Transmitters

Balloon-Launched Payloads – Typical Flight Profile

2 – Data Collection Phase

At 100,000 feet, the temperature is around -40 degrees F with air pressure close to a vacuum

3 – Balloon Burst



1 – Launch Phase

4 – Recovery Phase

Glenda Project – Active Payloads – Transmitters

Ground Support Equipment (GSE) in support of balloon inflation

Integrated Pressure Regulator with "Tool Free" connector to Helium Tank

25 foot connection hose

Balloon "Stinger" with Helium Rated flow control/shut off valve

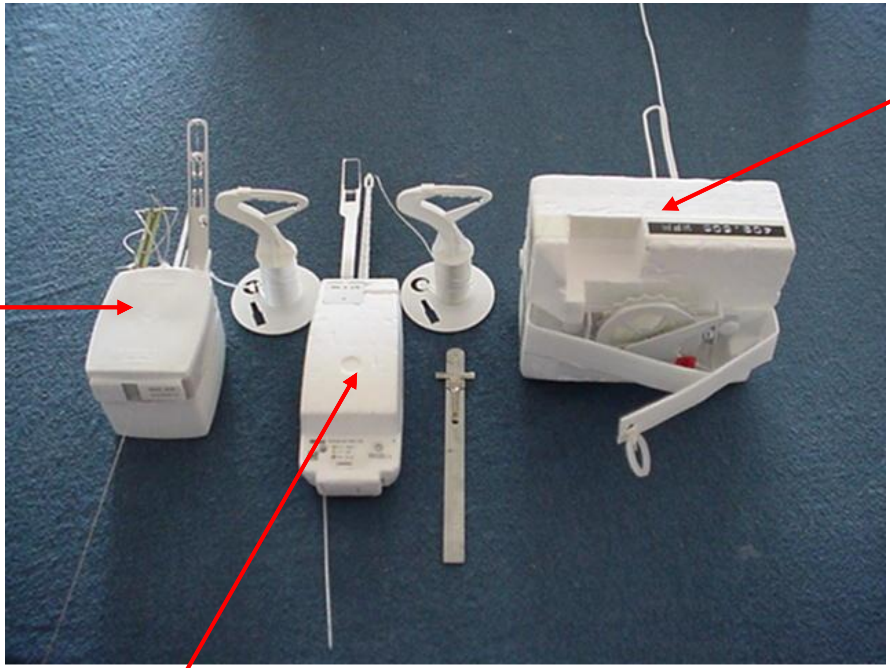
Un-inflated weather balloon on "Stinger."

Radiosonde Launch Platform

Glenda Project – Active Payloads – Transmitters

Balloon Launched Payloads – Radiosondes

The Glenda Project balloon payload launch capability consists of the Lockheed/Martin/Sippican (LMS-6), Vaisala RS41-SG(P), and Vaisala RS92-SG(P). Vaisala has discontinued the RS92 series, and they are becoming increasingly unavailable. Our flight envelope has expanded to over 100,000 feet, and our signal/data processing systems are already in place, making the addition of these new models a natural step in system evolution.

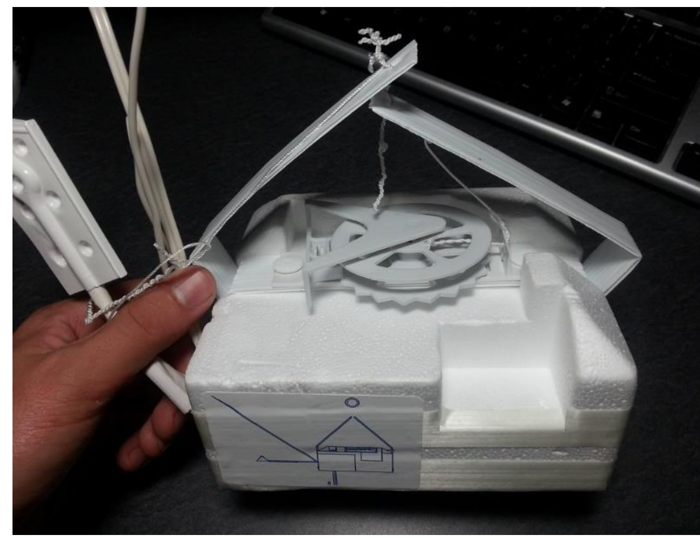


Glenda Project – Active Payloads – Transmitters

Balloon Launched Payloads – LMS-6 Radiosonde

The first example of this latest generation of radiosondes is the Lockheed/Martin/Sippican LMS-6. The LMS-6 utilizes current GPS receivers and sophisticated temperature and humidity sensing technology and processing, providing optimized meteorological, wind, and position data as the payload ascends through the atmosphere. Precision factory calibration of the radiosonde sensors eliminates the time and expense of preflight baseline checks, and lithium battery power extends deployment flight times.

<u>LMS-6 Characteristics:</u>



Dimensions: 153 x 127 x 75 mm

Weight: approx. 250g with built-in battery, de-reeler and string

Frequency: 16 synthesized WFM frequencies possible between 400.250 and 405.875 with a step of 375kHz

Power supply: 9 volt lithium battery (3 CR123A 3 volt lithium batteries on clips), 180 mA consumption

Modulation: GFSK - 4800 Bds

Transmitting power: 60mW

Sensors: Temperature: thermistor; Humidity: capacitive sensor. The payload location is determined by GPS (Trimble Copernicus module type 58048-10 with patch antenna)

3 Volt - CR123A Battery

Glenda Project – Active Payloads – Transmitters

Balloon-Launched Payloads – LMS-6 Radiosonde

Telemetry data processed using SONDE software from data streamed through the SDR receiver.

File Edit

General | History | Map | Altitude | Ascent

ID	frame	day	timestamp	latitude	longitude	meters	H Vel	Motion	V Vel	km	azimuth	elevation
7a2de6	1128	Sat	17:47:45.000	47.92102	-122.1906	86.47	0	207	-0.1	0.04	272.19	0.59
7a2de6	1129	Sat	17:47:46.000	47.92102	-122.1906	86.44	0	232	0	0.04	272.19	0.55
7a2de6	1131	Sat	17:47:48.000	47.92102	-122.1906	86.32	0	182	-0.1	0.05	272.16	0.4
7a2de6	1132	Sat	17:47:49.000	47.92102	-122.1906	86.36	0	138	0	0.05	272.16	0.45
7a2de6	1133	Sat	17:47:50.000	47.92102	-122.1906	86.32	5513.9	180	0	0.05	272.16	0.4
7a2de6	1135	Sat	17:47:52.000	47.92102	-122.1906	86.28	0.1	256	0	0.05	272.16	0.34
7a2de6	1136	Sat	17:47:53.000	47.92102	-122.1906	86.34	0	180	0.1	0.05	272.7	0.42
7a2de6	1138	Sat	17:47:55.000	47.92102	-122.1906	86.47	0	219	0.1	0.05	272.7	0.59
7a2de6	1139	Sat	17:47:56.000	47.92102	-122.1906	86.6	0	180	0.1	0.05	272.67	0.74
7a2de6	1141	Sat	17:47:58.000	47.92102	-122.1906	86.62	0	210	0	0.05	272.67	0.77
7a2de6	1142	Sat	17:47:59.000	47.92102	-122.1906	86.58	0	239	0	0.05	272.67	0.72
7a2de6	1144	Sat	17:48:01.000	47.92102	-122.1906	86.71	0	180	0.1	0.05	272.14	0.89
7a2de6	1145	Sat	17:48:02.000	47.92102	-122.1906	86.76	0	277	0.1	0.05	272.67	0.95
7a2de6	1147	Sat	17:48:04.000	47.92102	-122.1906	86.8	0	93	0	0.05	272.67	1
7a2de6	1148	Sat	17:48:05.000	47.92102	-122.1906	86.77	0	137	0	0.05	272.67	0.96
7a2de6	1149	Sat	17:48:06.000	47.92102	-122.1906	86.75	0	215	0	0.05	272.14	0.94
7a2de6	1150	Sat	17:48:07.000	47.92102	-122.1906	86.72	0	184	0	0.05	272.14	0.9
7a2de6	1151	Sat	17:48:08.000	47.92102	-122.1906	86.72	0	195	0	0.05	272.14	0.9
7a2de6	1152	Sat	17:48:09.000	47.92102	-122.1906	86.68	0	238	0	0.05	272.67	0.85
7a2de6	1154	Sat	17:48:11.000	47.92102	-122.1906	86.57	0	250	-0.1	0.05	272.67	0.71
7a2de6	1155	Sat	17:48:12.000	47.92102	-122.1906	86.5	0	288	-0.1	0.05	272.67	0.63
7a2de6	1156	Sat	17:48:13.000	47.92102	-122.1906	86.48	0	215	0	0.05	272.16	0.61
7a2de6	1157	Sat	17:48:14.001	47.92102	-122.1906	86.38	0	208	-0.1	0.05	272.16	0.48
7a2de6	1158	Sat	17:48:15.001	47.92102	-122.1906	86.4	0	212	0	0.05	272.16	0.5
7a2de6	1159	Sat	17:48:16.000	47.92102	-122.1906	86.44	5023.7	266	0	0.05	272.16	0.56
7a2de6	1160	Sat	17:48:17.000	47.92102	-122.1906	86.49	0	225	0	0.05	272.16	0.62
7a2de6	1161	Sat	17:48:18.000	47.92102	-122.1906	86.53	0	221	0	0.05	272.16	0.68
7a2de6	1162	Sat	17:48:19.000	47.92101	-122.1906	86.65	0	149	0.1	0.04	272.19	0.83
7a2de6	1163	Sat	17:48:20.000	47.92101	-122.1906	86.75	0	194	0.1	0.04	271.64	0.97
7a2de6	1164	Sat	17:48:21.000	47.92101	-122.1906	86.82	0	193	0.1	0.04	271.64	1.06
7a2de6	1165	Sat	17:48:22.000	47.92101	-122.1906	86.91	0	90	0.1	0.04	271.64	1.17
7a2de6	1167	Sat	17:48:24.000	47.92101	-122.1906	87.16	0	220	0.1	0.04	271.64	1.49

Temperature, barometric pressure, and humidity data processing capabilities are under development at the software developer.

Glenda Project – Active Payloads – Transmitters

Balloon-Launched Payloads – Vaisala RS41-SG(P) Radiosonde

The latest generation of radiosondes is the Vaisala RS41-SG(P), the replacement for the RS92. The RS41 utilizes current GPS receivers and sophisticated temperature and humidity sensing technology and processing, providing optimized meteorological, wind, and position data as the payload ascends through the atmosphere. Precision factory calibration of the radiosonde sensors eliminates the time and expense of preflight baseline checks, and lithium battery power extends deployment flight times.

<u>RS41-SG Characteristics:</u>

Dimensions: 155 x 63 x 46 mm

Weight: approx. 130g with external de-reeler and string

Frequency: 400.15 to 406.000 synthesized WFM frequencies

Power supply: 3 volt lithium battery (2 AA 1.5 volt lithium batteries on clips), 150 mA consumption – 240 minute life cycle

Transmitting power: minimum 60mW

Sensors: Temperature: Platinum Resistor; Humidity: Thin Film Capacitor. The payload location and barometric pressure is determined via GPS

Glenda Project – Active Payloads – Transmitters

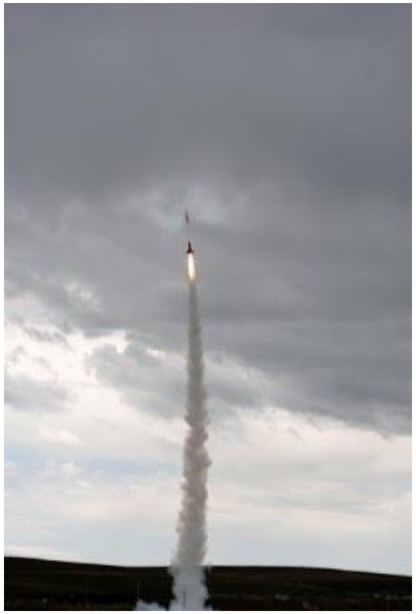
GPS Payload Tracking System – Intercept Teams

When payloads are launched into severe weather systems, one of the primary challenges, is their return.

This new generation of GPS radiosondes provides Glenda with the capability to track payload positioning in real time, combined with the location of the "intercept" vehicles position.

The radiosonde transmits its GPS position to the intercept vehicle, while that vehicle integrates its own position in relation to the moving capsule in real time.

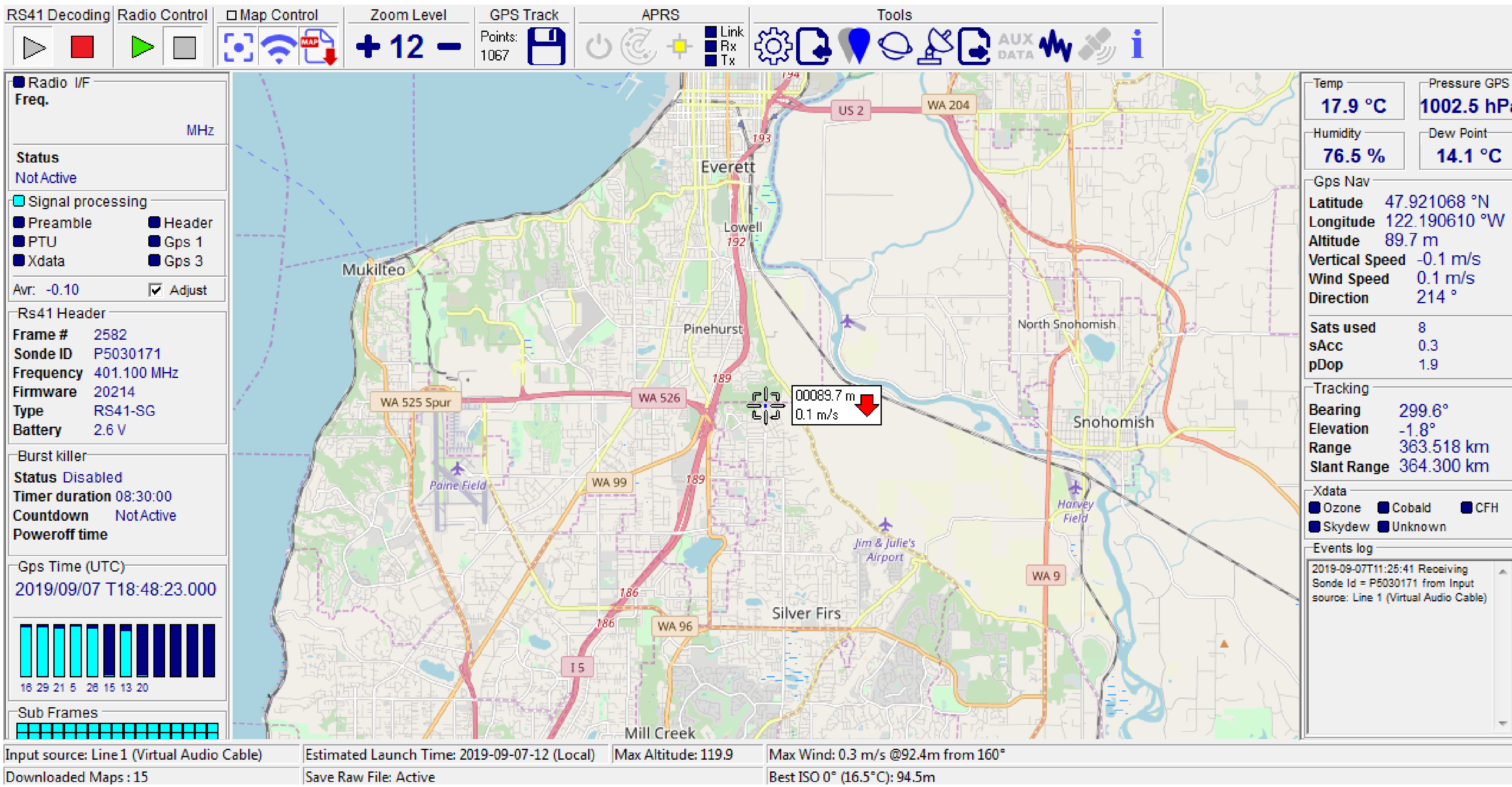
This capability of real time deployment, capture, and rapid return to flight allows for multiple intercepts with the same storm system.



Glenda Project – Active Payloads – Transmitters

Balloon-Launched Payloads – Vaisala RS41-SG Radiosonde

Telemetry data processed using RS41-Tracker software with data streamed through the SDR receiver.



Radiosonde set at 401.100 MHz WFM with a one second sampling rate with full mapping capabilities.

Glenda Project – Active Payloads – Transmitters

Balloon-Launched Payloads – Vaisala RS41-SG Radiosonde

Telemetry data downloadable into Excel format for rapid data processing post flight.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	Date	Time	Latitude	Longitude	Altitude	Battery Voltage	Sats used	Wind Speed	Wind Dir	Vertical Speed	Temperature	Pressure	Humidity	Dew point (deg)
2	09/07/19	18:27:47	47.921113	-122.190644	97.1	2.7	8	0.0	129	0.0	16.8	1001.6	81.1	13.8
3	09/07/19	18:27:48	47.921111	-122.190643	96.6	2.7	7	0.1	233	0.0	16.7	1001.7	81.2	13.7
4	09/07/19	18:27:49	47.921108	-122.190641	96.2	2.7	7	0.1	206	-0.1	16.6	1001.7	81.4	13.7
5	09/07/19	18:27:50	47.921106	-122.190641	95.7	2.7	7	0.1	125	0.0	16.7	1001.8	81.3	13.7
6	09/07/19	18:27:51	47.921104	-122.190640	95.4	2.7	7	0.2	339	0.0	16.6	1001.8	81.4	13.7
7	09/07/19	18:27:52	47.921100	-122.190638	94.9	2.7	7	0.0	266	0.0	16.6	1001.9	81.5	13.7
8	09/07/19	18:27:53	47.921097	-122.190636	94.4	2.7	7	0.0	331	-0.1	16.9	1002.0	80.3	13.8
9	09/07/19	18:27:54	47.921093	-122.190634	93.9	2.7	7	0.2	353	-0.1	17.0	1002.0	80.4	13.9
10	09/07/19	18:27:55	47.921090	-122.190633	93.6	2.7	7	0.1	91	-0.1	16.9	1002.1	80.6	13.8
11	09/07/19	18:27:56	47.921087	-122.190633	93.4	2.7	7	0.0	309	0.0	16.8	1002.1	81.0	13.8
12	09/07/19	18:27:57	47.921085	-122.190631	93.2	2.7	7	0.0	200	-0.1	16.8	1002.1	80.8	13.8
13	09/07/19	18:27:58	47.921083	-122.190630	93.1	2.7	7	0.1	334	0.1	17.0	1002.1	80.8	13.9
14	09/07/19	18:27:59	47.921080	-122.190629	93.0	2.7	7	0.0	303	0.1	16.9	1002.1	80.5	13.9
15	09/07/19	18:28:00	47.921080	-122.190629	93.0	2.7	7	0.1	222	0.0	16.9	1002.1	80.7	13.9
16	09/07/19	18:28:01	47.921079	-122.190628	93.0	2.7	7	0.1	21	0.0	16.9	1002.1	80.4	13.8
17	09/07/19	18:28:02	47.921078	-122.190628	92.9	2.7	7	0.1	218	0.0	16.8	1002.1	80.8	13.8
18	09/07/19	18:28:03	47.921079	-122.190629	92.9	2.7	7	0.1	165	0.1	16.9	1002.1	80.7	13.8
19	09/07/19	18:28:04	47.921079	-122.190630	92.8	2.7	6	0.1	187	0.0	17.2	1002.2	79.3	13.9
20	09/07/19	18:28:05	47.921078	-122.190630	92.5	2.7	6	0.1	160	0.1	17.3	1002.2	78.8	13.9
21	09/07/19	18:28:06	47.921078	-122.190631	92.3	2.7	6	0.0	55	0.0	17.2	1002.2	79.2	13.9
22	09/07/19	18:28:07	47.921078	-122.190631	92.0	2.7	6	0.1	333	0.1	17.2	1002.2	79.6	13.9
23	09/07/19	18:28:08	47.921079	-122.190631	92.1	2.7	6	0.0	219	0.0	17.0	1002.2	80.0	13.8
24	09/07/19	18:28:09	47.921080	-122.190632	91.8	2.7	6	0.0	42	0.0	16.8	1002.3	80.8	13.8
25	09/07/19	18:28:10	47.921082	-122.190633	91.8	2.7	6	0.1	127	0.0	16.8	1002.3	80.9	13.8
26	09/07/19	18:28:11	47.921084	-122.190634	91.8	2.7	7	0.2	349	-0.1	16.8	1002.3	81.1	13.8
27	09/07/19	18:28:12	47.921083	-122.190633	91.7	2.7	7	0.1	10	0.0	16.7	1002.3	81.3	13.8
28	09/07/19	18:28:13	47.921083	-122.190633	91.3	2.7	7	0.1	214	-0.1	16.7	1002.3	81.3	13.8
29	09/07/19	18:28:14	47.921083	-122.190631	91.0	2.7	7	0.1	16	-0.1	16.8	1002.4	81.2	13.8
30	09/07/19	18:28:15	47.921083	-122.190630	90.9	2.7	7	0.2	344	-0.1	16.8	1002.4	81.1	13.8
31	09/07/19	18:28:16	47.921083	-122.190629	91.0	0.0	7	0.0	274	-0.1	16.7	1002.4	81.4	13.8
32	09/07/19	18:28:17	47.921083	-122.190627	91.1	2.7	7	0.0	119	0.0	16.7	1002.4	81.5	13.8

Data is in metric format, with a one-second sampling rate. Battery voltage is captured, as well as several directional and Dew Point attributes not previously recorded.

Glenda Project – Active Payloads – Application

April 22, 2016 – Balloon-Launched Payload – Storm Intercept

On April 22, 2016, the Glenda Project launched a Vaisala RS-92 SGP radiosonde payload, testing our updated antenna and receiver ground station.

The April 22nd flight featured a 400-gram balloon filled with 50 cubic feet of helium. Projected flight altitude was approximately 90,000 feet. The RS-92 payload contained a GPS sensor plus a weather sensor suite telemetry package. Ground wind speed was around 10 mph with temperatures in the 70s.

Shortly after 3:15pm, a thunderstorm passed through the area, and the weather balloon and its associated payload were ingested into the storm system for a successful storm intercept.

Flight performance was impressive, and we achieved a viable data set from launch to balloon burst at just over 50,000 feet, continuing on under parachute until loss of signal at 41,000 feet due to the level of turbulence from the storm cell combined with earth curvature and local terrain.

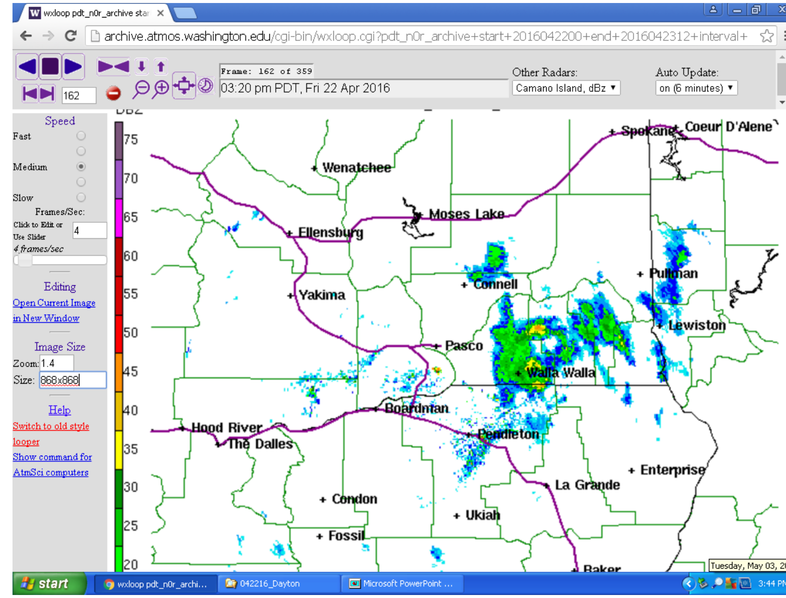
The following slides display the data collected from the flight.

Glenda Project – Active Payloads - Application

April 22, 2016 – Balloon-Launched Payload – Storm Intercept

Photo Courtesy of Liz Quigg

Visual of Storm Intercept



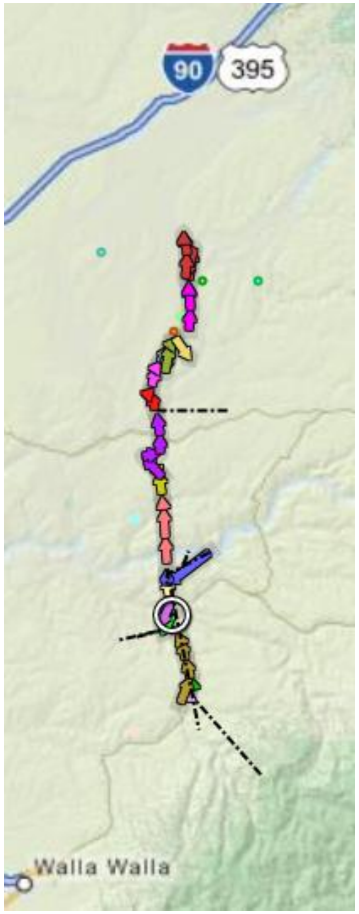
Pendleton, OR – Radar Track

The storm cell that was intercepted was tracked on Pendleton, OR, radar and visually by the intercept team. Our mobile ground station collected a viable data set, and that data is shown in the following slides as well.

Glenda Project – Active Payloads – Application

April 22, 2016 – Balloon-Launched Payload – Ground Track

Flight Simulation



Actual Flight Path

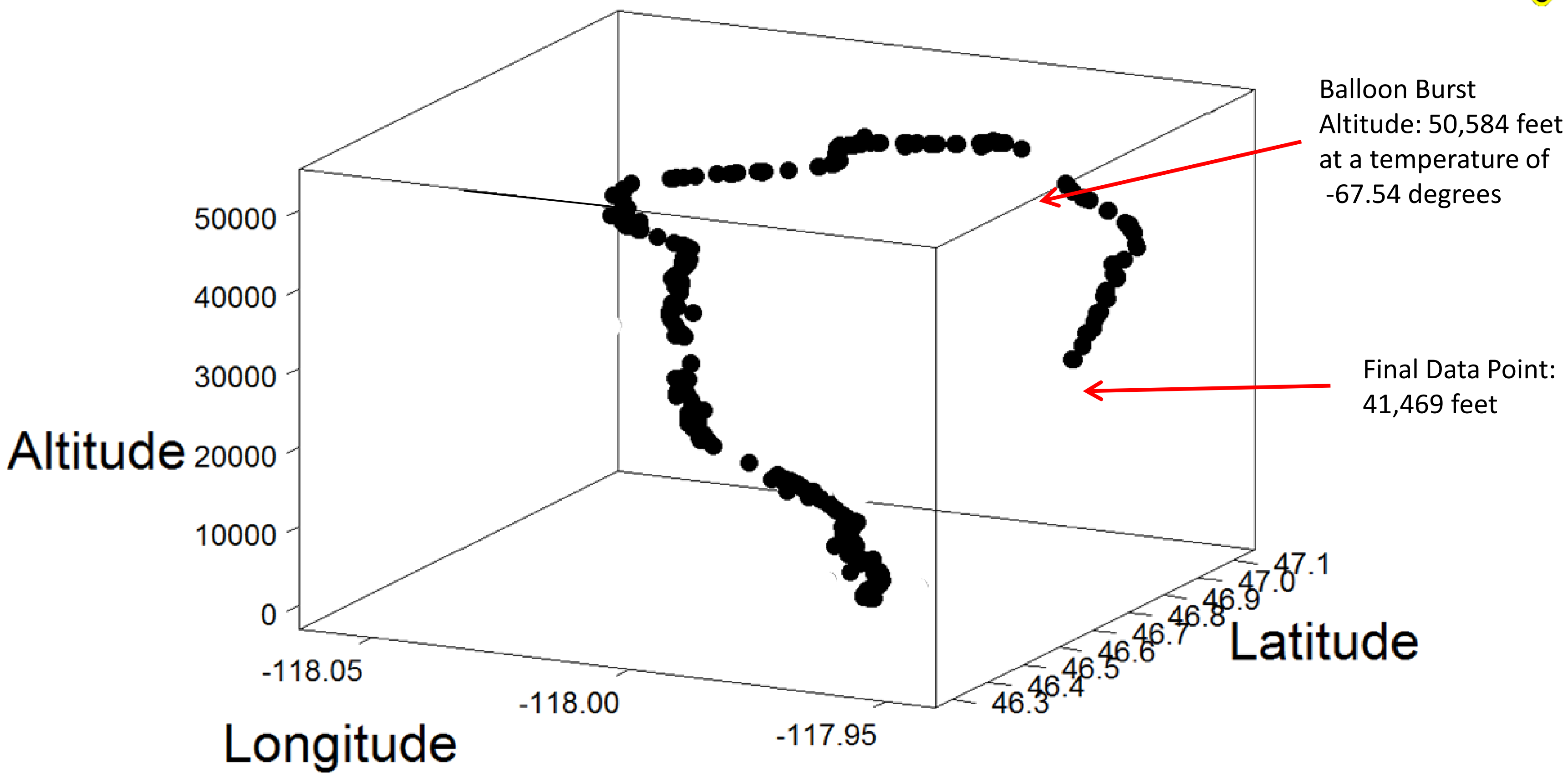
The actual flight trajectory ground track measured just over 60 miles before loss of signal and aligned very well with the pre-flight simulation.

After transition from launch conditions, the balloon was ingested into the passing storm system and followed its south to north storm track.

Ground wind speed exceeded 30 mph, while the storm ground track was close to 40 mph.

Glenda Project – Active Payloads – Application

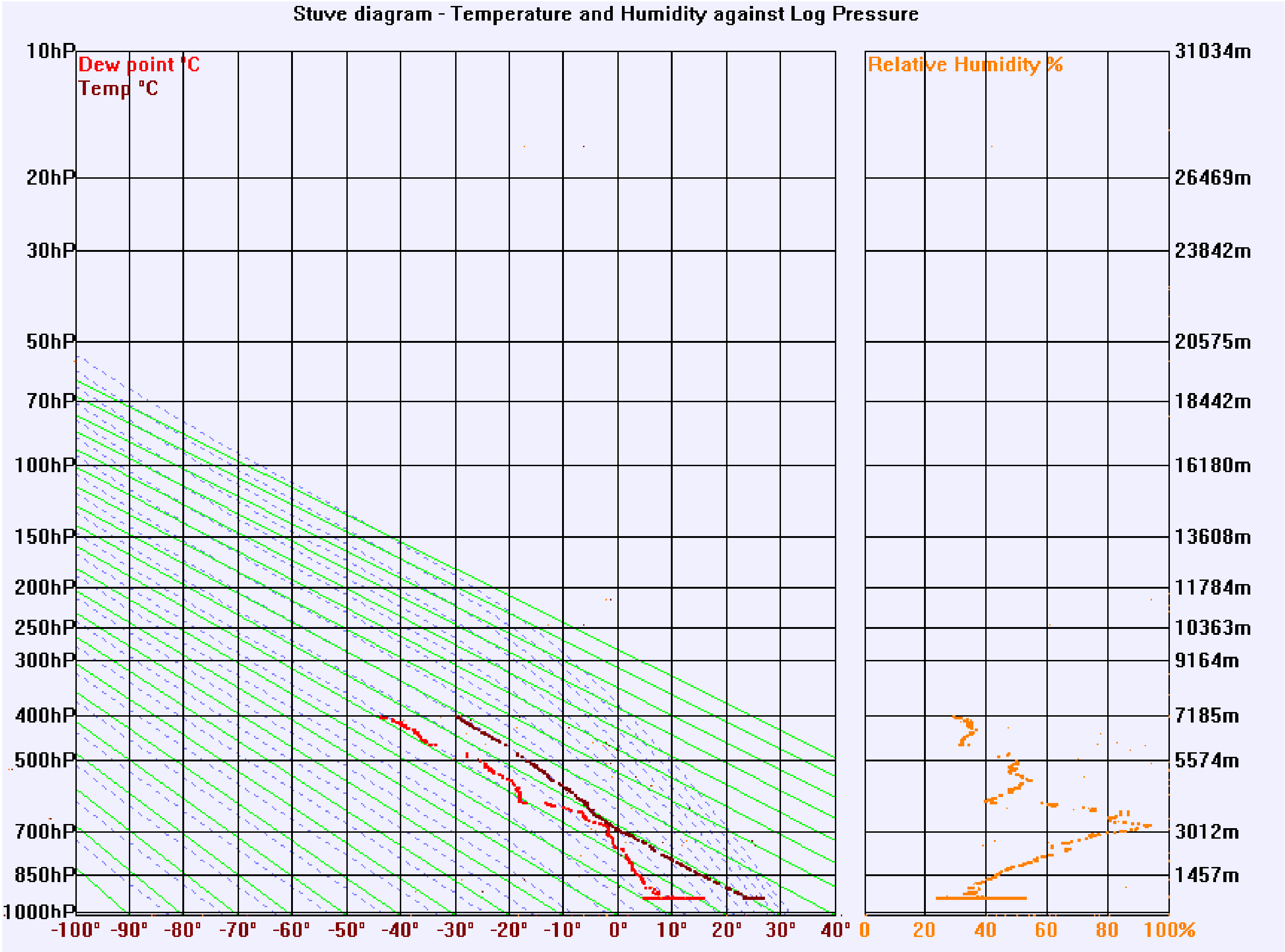
April 22, 2016 – Balloon-Launched Payload – Altitude Track



While the balloon ground track appears linear, the balloon and its payload followed the circulation of the storm cell and hovered along the top of the cell while also moving in a south to north path.

Glenda Project – Active Payloads – Application

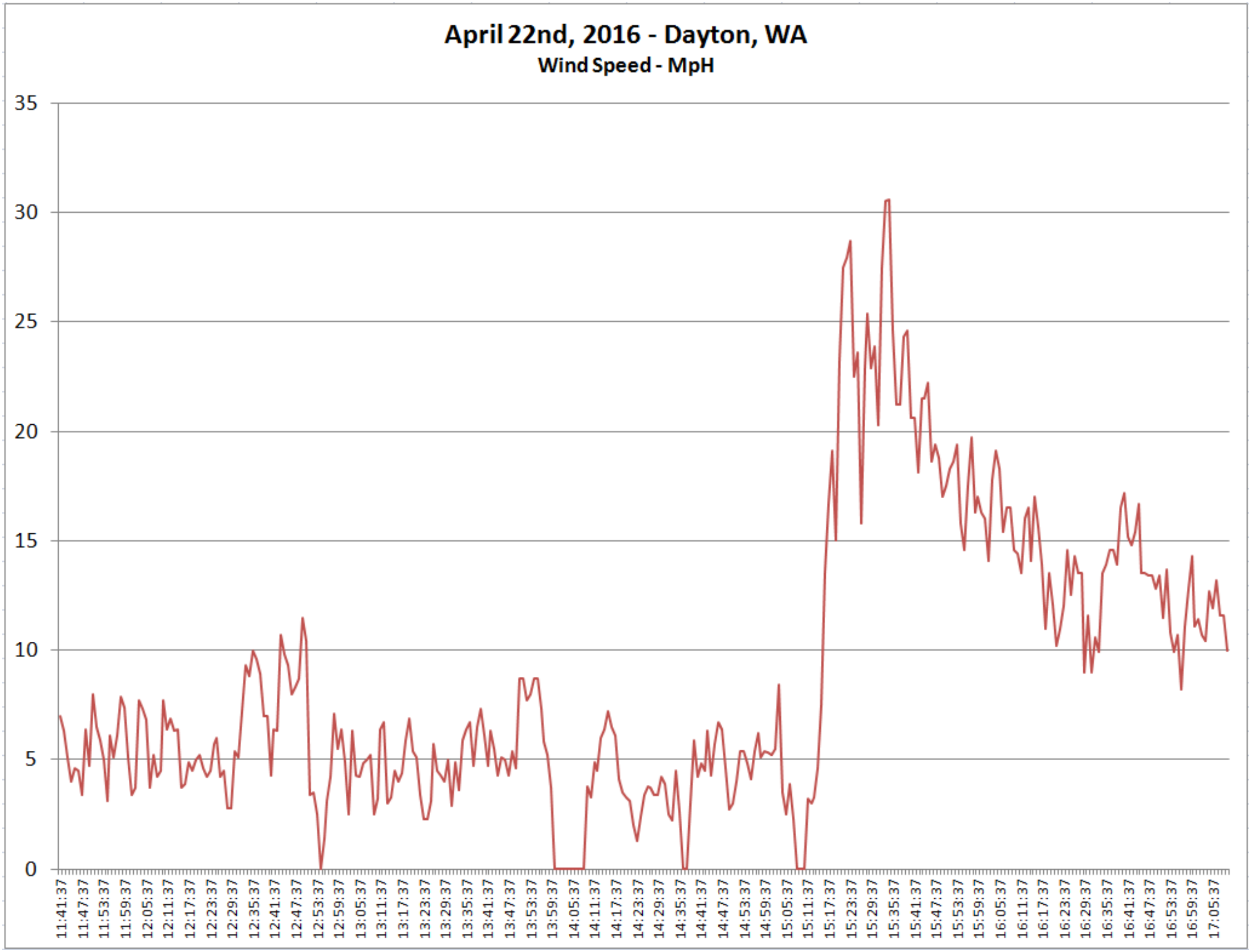
April 22, 2016 – Balloon-Launched Payload – Weather Sensor Data



The Sondemonitor software also provides Temperature, Dew Point, and Relative Humidity graphing capability vs. pressure/altitude.

Glenda Project – Active Payloads – Application

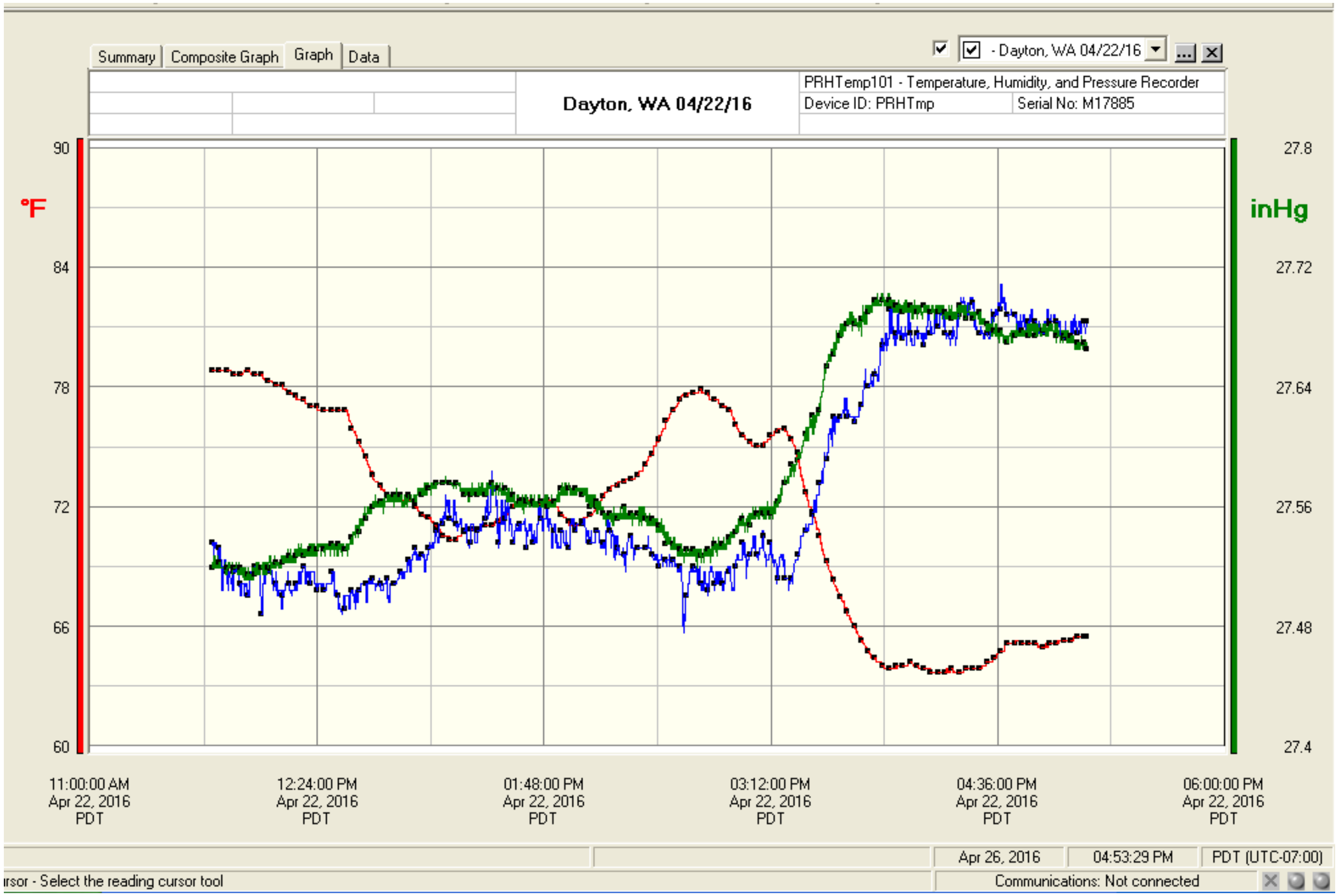
April 22, 2016 – Ground Station Data – Wind Speed



In parallel with the balloon launch, Glenda was also capturing ground condition data. The storm cell impacted our collection site just after 3:15 pm as the balloon payload was being ingested into the storm cell. Winds in excess of 30 mph were recorded. While not as impressive as our June 2012 storm intercept, it is still a significant accomplishment, as we've now added the balloon intercept capability.

Glenda Project – Active Payloads – Application

April 22, 2016 – Ground Station Data – Temp, Baro, RH

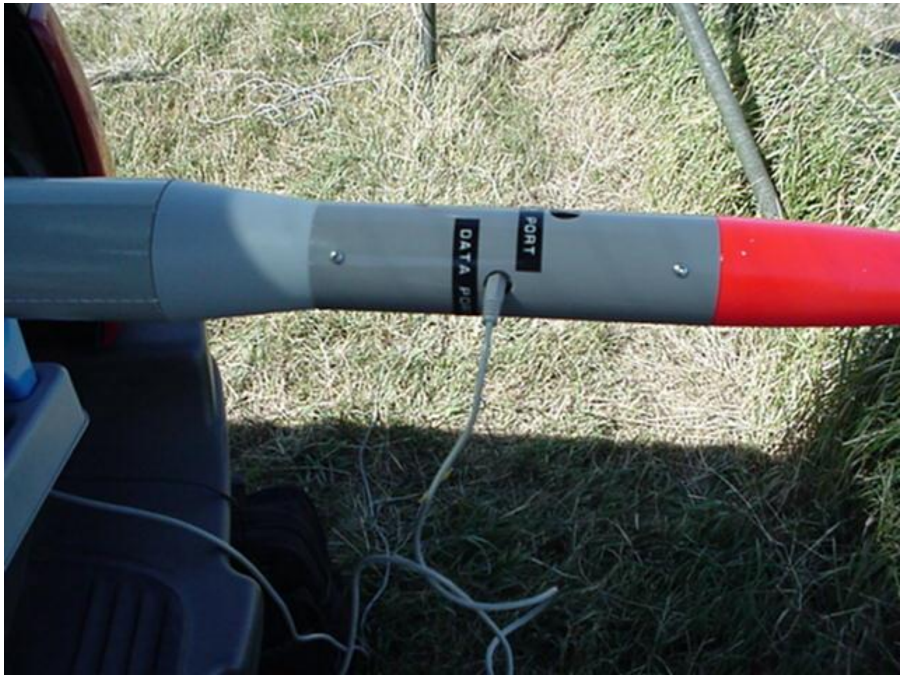


Temperature, Barometric Pressure, and Relative Humidity data were also being collected in real time at less than 2-second intervals during the storm intercept. A noticeable shift can be seen in the data as the storm cell passes over the collection site.

Glenda Project – Passive Payloads – Data Loggers

A data logger is an electronic instrument that records measurements over time. Typically, data loggers are small, battery-powered devices that are equipped with a microprocessor, data storage and sensors. Most data loggers utilize software on a personal computer to initiate the logger and view the collected data.

Prior to a Glenda launch, the data logger is connected to a laptop computer. Then, systems software is used to select logging parameters (sampling intervals, start time, etc.) and initiate the logger. The logger is then disconnected from the laptop and installed inside the Glenda payload capsule. Upon launch, the logger records each measurement and stores it in memory along with the time and date.



Post recovery, the logger is then reconnected to the laptop computer and the software is used again to read out the data and see the measurements as a graph, showing the profile over time. The tabular data can be viewed as well or exported to a spreadsheet for further manipulation.

Glenda Project – Passive Payloads – Data Loggers

Canmore GT-740FL GPS Data Logger

The GT-740FL is a single board GPS receiver/data logger featuring surface-mounted components and a power supply designed to withstand the higher thrust of the Glenda boosters.

Data Logger Specifications:

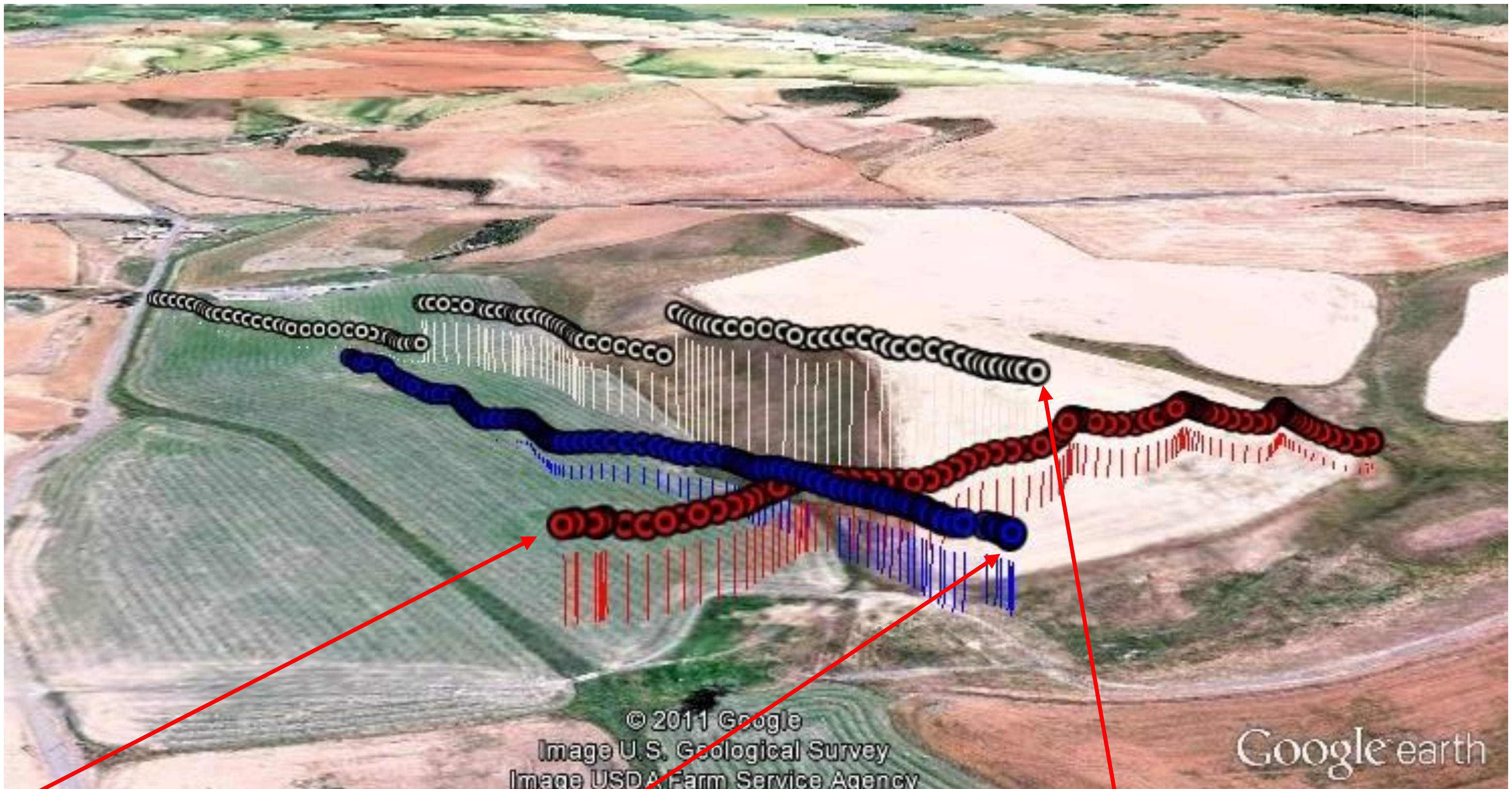
- 48-track verification channels
- SiRF IV low-power chipset
- Adjustable sampling rates from 1 second +
- Satellite signal reception sensitivity: -163dbm
- Position: +/- 2.5 meters CEP
- Data compatible with Google Earth
- Size/Weight: 0.625 x 1.17 x 2.75" (16 x 30 x 70 mm)/approx. 2.5 oz.(71 grams)
- Time to reposition: < 0.1 second average
- Time to boot: <34 seconds (cold), 1 second (hot)
- Ultra-low power consumption; over 56 hours continuous use
- Water resistant to IPX6 standard

Glenda Project – Passive Payloads – Application

GPS Data Logging

4D wind current mapping over local terrain.

(4D is latitude, longitude, elevation and velocity)



May 14th
7554 Booster – Aerotech I211
"Thunderstorm Intercept"
Apogee: 2,706 Feet
Ground-Level Wind Speed: 4.5 mph

June 11th
9875 Booster – CTI I170
Apogee: 2,211 Feet
Ground-Level Wind Speed: 10 mph

October 1st
7554 Booster – Aerotech I211
Apogee: 2,354
Ground-Level Wind Speed: 14.5 mph

Glenda Project – Passive Payloads – Data Loggers

MicroLite Temperature Data Logger

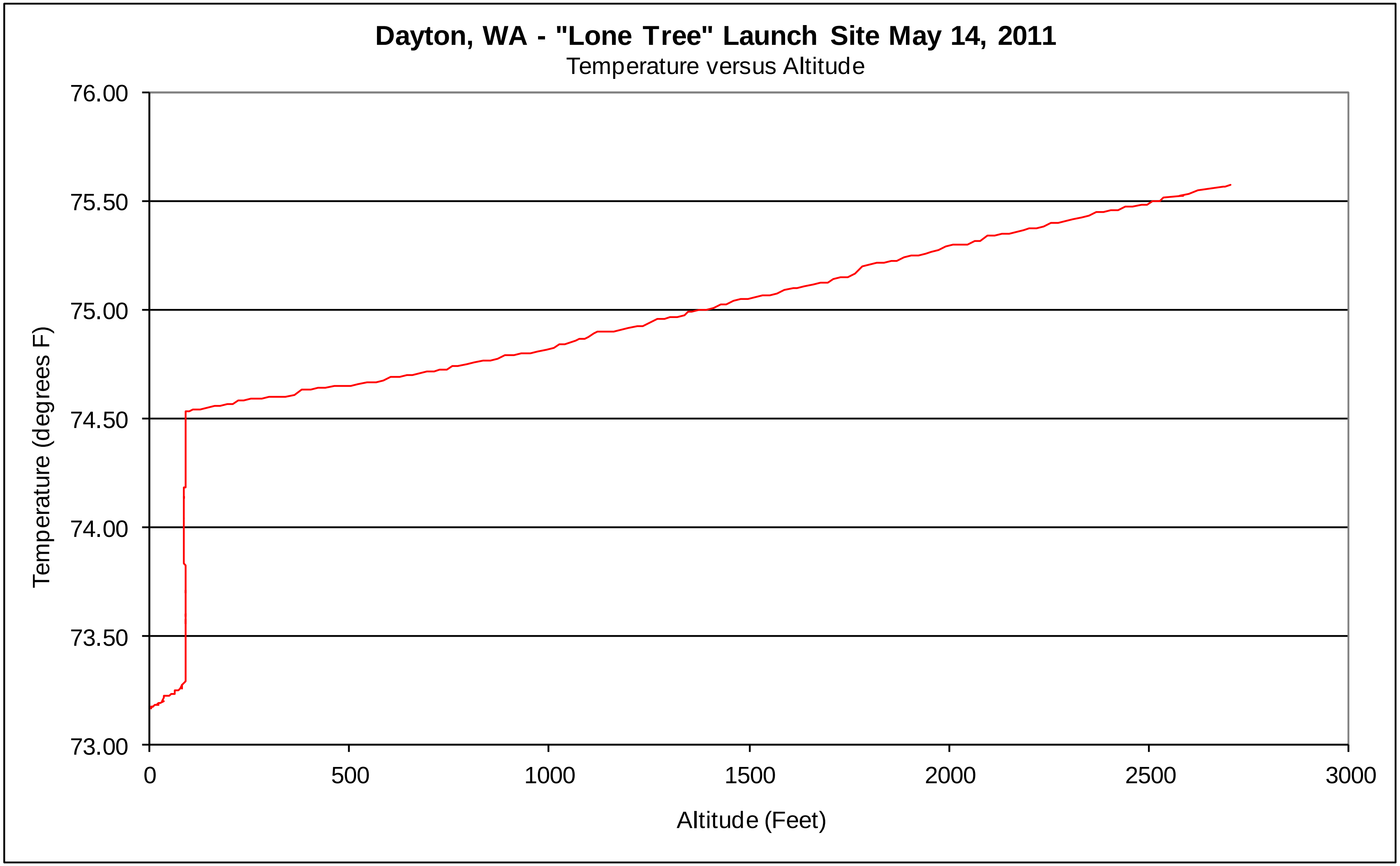
The MicroLite USB Data Logger is a small electronic device for monitoring and recording temperature. Manufactured to stringent IP68 standards, the MicroLite Logger is dustproof and is only 4.3” long and 1” thick. The data logger features a three digit LCD display, direct USB connection, wide temperature range, high accuracy and large sample memory. Data can be displayed on the small numeric screen or downloaded to the MicroLab Lite software via the USB 2.0 connector.

<u>Data Logger Specifications:</u>

- Internal Temp Sensor: -40°C to 80°C Thermal Conductor enabling a fast sensor response time
- Sampling Resolution A/D Resolution: 16Bit 0.1°C
- Data Storage Capacity: 16,000 Samples
- Sampling Rate: 1 sample per second to 1 sample per 2 hours
- Battery: Replaceable 3V Lithium Battery - CR2032
- Battery Life: 2 Years at 1-second Sampling Rate
- Dimensions: 11cm x 3.9cm x 2.6cm (4.3" x 1.5" x 1.0")
- Weight: 45.5 grams (1.6oz)
- Software: MicroLab Lite for Windows
- Standard Compliance: IP68, NEMA6 (30 minutes for 0.5 meter depth)

Glenda Project – Passive Payloads – Application

Temperature/GPS Data Logger – Temperature vs. Altitude
“Lone Tree” Launch Site – May 14, 2011



Glenda Project – Video Payloads

In May 2007, the Glenda Project deployed its "First Generation" camera probe called "Ranger Intercept," named for the lunar photographic missions from the 1960s.

While successful, the payload did not gather the high-resolution images required for viable analysis.

Since 2007, cameras and optics have matured to the point where high definition/high resolution images are now possible from compact/lightweight payloads.

In September 2014, Glenda successfully deployed a High-Definition digital movie camera as an auxiliary camera "pod" into our existing payload capsule. This increased resolution now provides a visual record of the environment captured by the on-board sensor suite.

May 2007 – "First Generation" Camera Flight

September 2014 – "Second Generation" Camera Pod

Glenda Project – Video Payloads – Application

September 13, 2014 – Deployment of the Next Generation "Ranger Intercept"

2. Mid - Boost

Photo Courtesy of Jon Preston

3. Apogee

4. Descent

5. Final Approach

1. Launch

Photo Courtesy of Jon Preston

6. Landing

Glenda Project – Ground Stations

Launching instrument packages into severe weather systems limits Glenda's ability to analyze the resulting data without knowing ground-level weather conditions to provide a basis for comparison.

This acknowledgement has driven the development of several different types of mobile ground stations where their usage can be adapted based on our mission and data requirements.

Some typical examples:

a) Digital Chart Recorders

b) Recording Anemometers

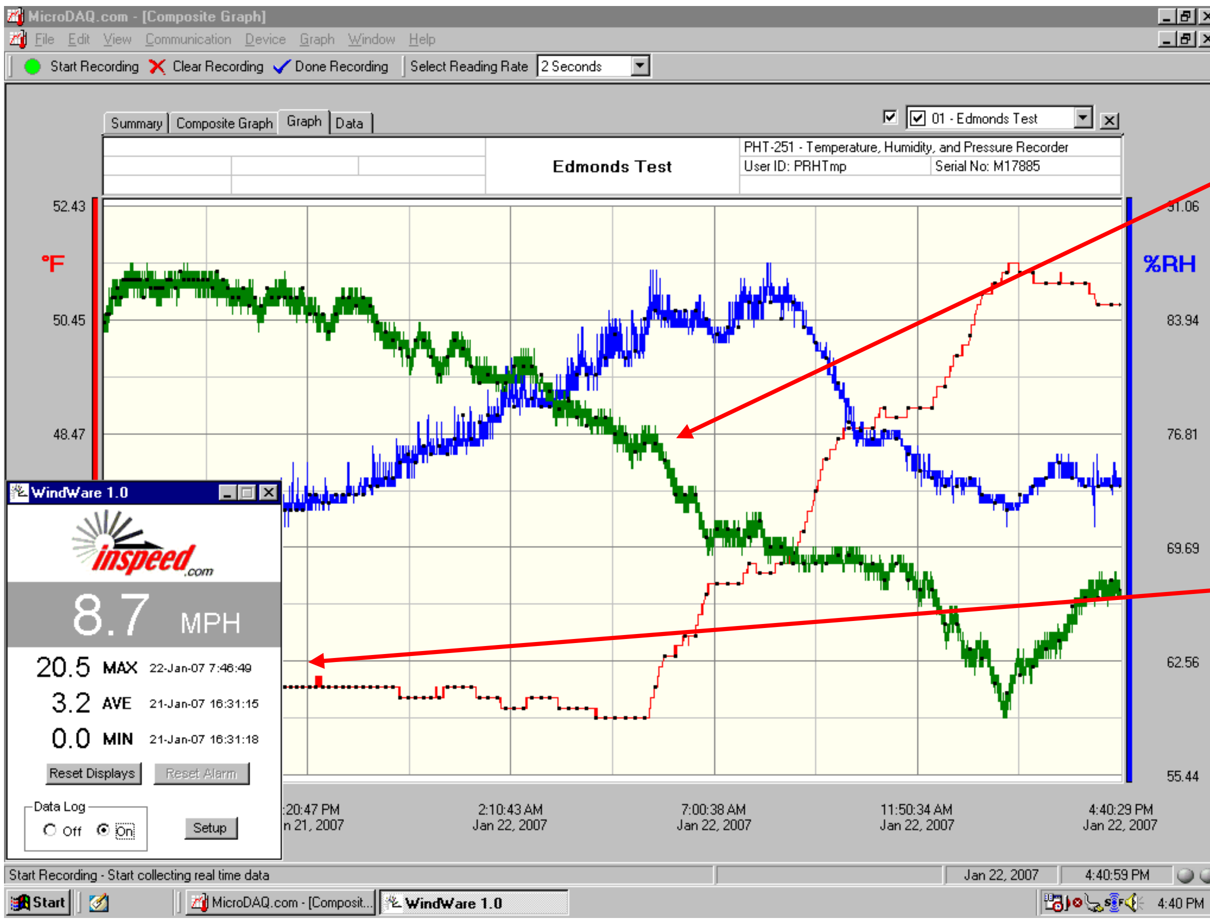
c) Coastal Environmental Weatherpak ground stations

d) Mobile Mesonet ground stations

Glenda Project – Ground Stations

Digital Chart Recorders

Glenda Project utilizes sensors combined with ground-based laptops to provide a digital chart record of ground baseline conditions mapped over time. The basic example below is a digital chart record of temperature, relative humidity, barometric pressure and wind speed at a test site.

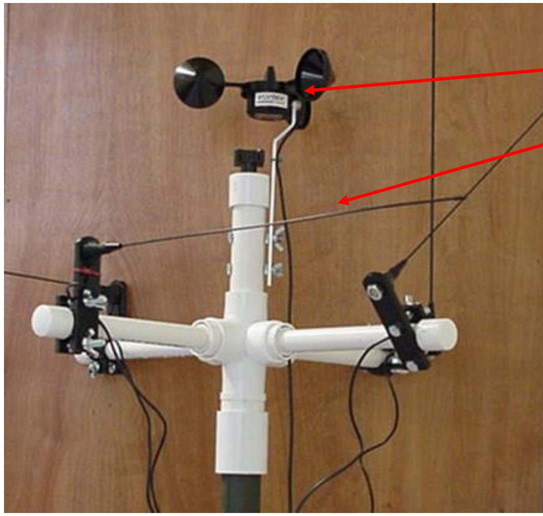


Temperature, Relative Humidity, & Barometric Pressure data using a Madgetech data logger with supporting software

Wind Speed data using InSpeed Anemometer and supporting software

Glenda Project – Ground Stations

Mobile Ground Station Mast System



<u>Removable/Adaptable Mast Sensor Head</u>

- In-Speed Anemometer
- Wide-Band Receiver Antennas for Radiosonde telemetry signals
- Mast System Interface Adapter
- Lightweight PVC/Fiberglass construction to reduce potential for lightning strike
- Antennas with 1.2 GHz capability to allow multiple frequencies and multiple radiosonde reception
- Mast head integrates with man portable mast system

Glenda Project – Weatherpak Ground Station

Coastal Environmental HazMat Weather Station

The Glenda Project has several Coastal Environmental Weatherpak mobile vehicle-mounted and wireless weather stations.

Some of its numerous features include:

- Wireless radio data Telemetry with a 5-mile range
- Self-aligning Fluxgate Compass
- Complete sensor suite to record Temperature, Relative Humidity, Barometric Pressure, Wind Speed, and Wind Direction.
- Weighs less than 10 pounds and is deployable in less than 60 seconds
- Highly portable with its own transit case
- Serial data interface to support data logging and display
- Alternate Power Sources from 120VAC to 12 VDC
- Tested and designed for HazMat and severe environments
- Capability to measure "Sigma Theta" to determine atmospheric instability

Mobile Deployment

Vehicle-Mounted

Glenda Project – Weatherpak MTR Ground Station

Coastal Environmental Wireless HazMat Weather Station

In 2016, the Glenda Project was able to obtain a Weatherpak MTR system, which provides additional system integration and data gathering capabilities. It also adds GPS capabilities to our ground-station network.

For 2019, a second MTR receiver was added, which now allows us both static and mobile capabilities to monitor multiple deployed stations in the field.

Sigma Theta Overview

“Sigma Theta” (ST) is a compound term with its origins coming from the Statistical community and the Physical Sciences.

The term “Sigma” comes from the Statistical community and is a mathematical term used to define the concept/process called “standard deviation.” Standard Deviation is a process used to explain the amount of variability within a data set. The higher the deviation, the higher the level of variability within the data set.

“Theta” comes from the Physical Sciences/Weather community as the term defining the angle of wind direction.

“Sigma Theta” translated means the amount of variability of the changes in wind direction within a dataset.

Robert Yamartino developed the “standard” ST model back in the 1980s, and it has been adopted by the HazMat/EPA community as their preferred model for measuring atmospheric stability using ground-based sensors and is calculated from the following equations:

Step 1: Compute the average sine of wind direction, the average cosine, and epsilon

$$S = \frac{1}{N} \sum_{i=1}^{N} \sin \theta_i \qquad C = \frac{1}{N} \sum_{i=1}^{N} \cos \theta_i \qquad \varepsilon = \sqrt{1-(S^2 + C^2)}$$

Step 2: Compute sigma theta as the arcsine of epsilon, and apply a correction factor

$$\sigma_\theta = \text{arcsine}(\varepsilon) \left[1 + \left(\frac{2}{\sqrt{3}} - 1 \right) \varepsilon^3 \right]$$

Glenda Project – Weatherpak Ground Station

Coastal Environmental Wireless HazMat Weather Station

Sigma Theta Overview

Frank Pasquill took the next step and determined levels of Sigma Theta for differing degrees of atmospheric stability. He created a seven-tiered system from “A” to “G,” where Class “G” reflects the most stable atmospheric condition, to Class “A,” which reflects the highest level of atmospheric instability.

His results are shown in the table below:

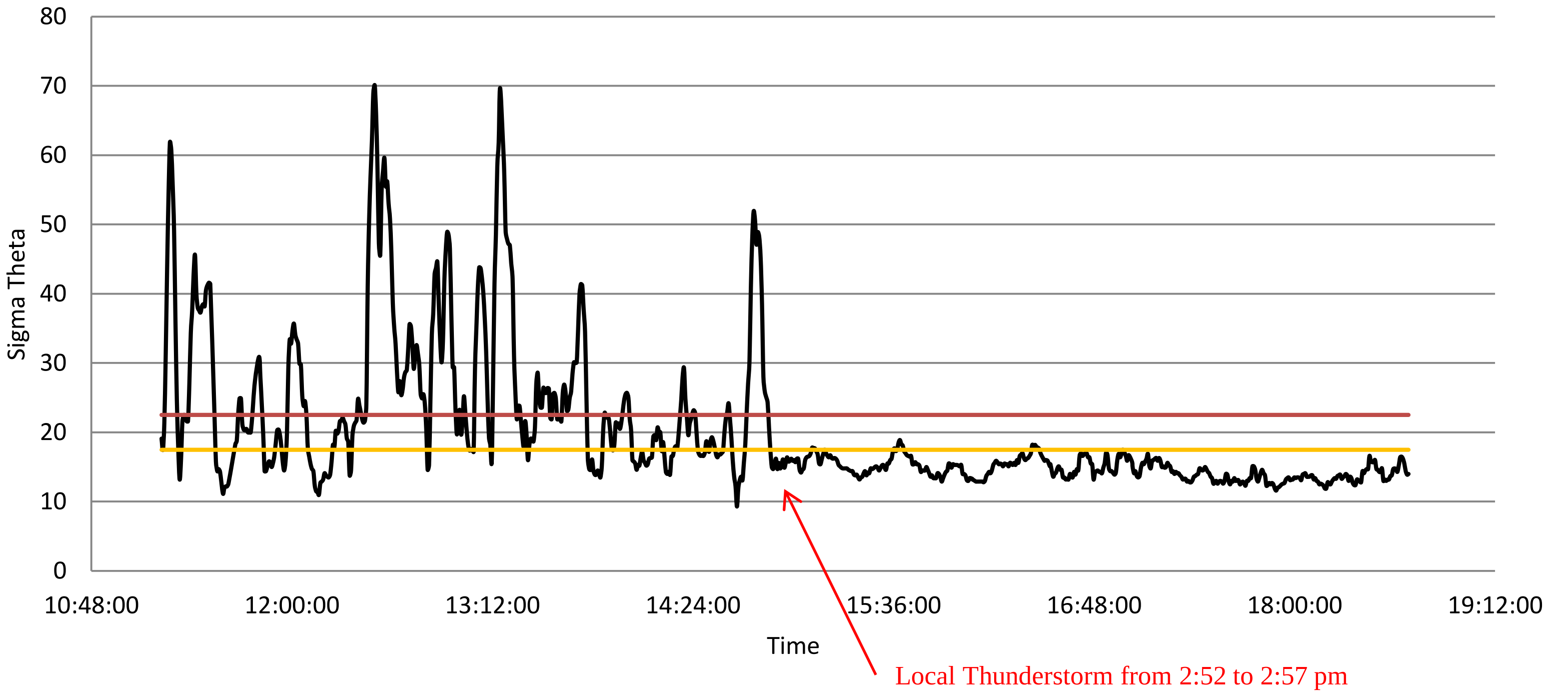
Stability Class		Description	Definition
1	A	Extremely Unstable	$22.5 \leq \sigma_\theta$
2	B	Moderately Unstable	$17.5 \leq \sigma_\theta < 22.5$
3	C	Slightly Unstable	$12.5 \leq \sigma_\theta < 17.5$
4	D	Neutral	$7.5 \leq \sigma_\theta < 12.5$
5	E	Slightly Stable	$3.8 \leq \sigma_\theta < 7.5$
6	F	Moderately Stable	$2.1 \leq \sigma_\theta < 3.8$
7	G	Extremely Stable	$\sigma_\theta < 2.1$

Based on this Stability Class table, we can now make determinations of atmospheric stability based on ground-station data and not have to rely on balloon-launched radiosondes or rocket launched payloads.

Glenda Project – Ground Station - Application

Dayton, WA - June 23, 2012

WeatherPak 400- Sigma Theta Atmospheric Stability



On June 23, the WeatherPak 400 was deployed on the south ridgeline above the BMR "Lone Tree" launch site.

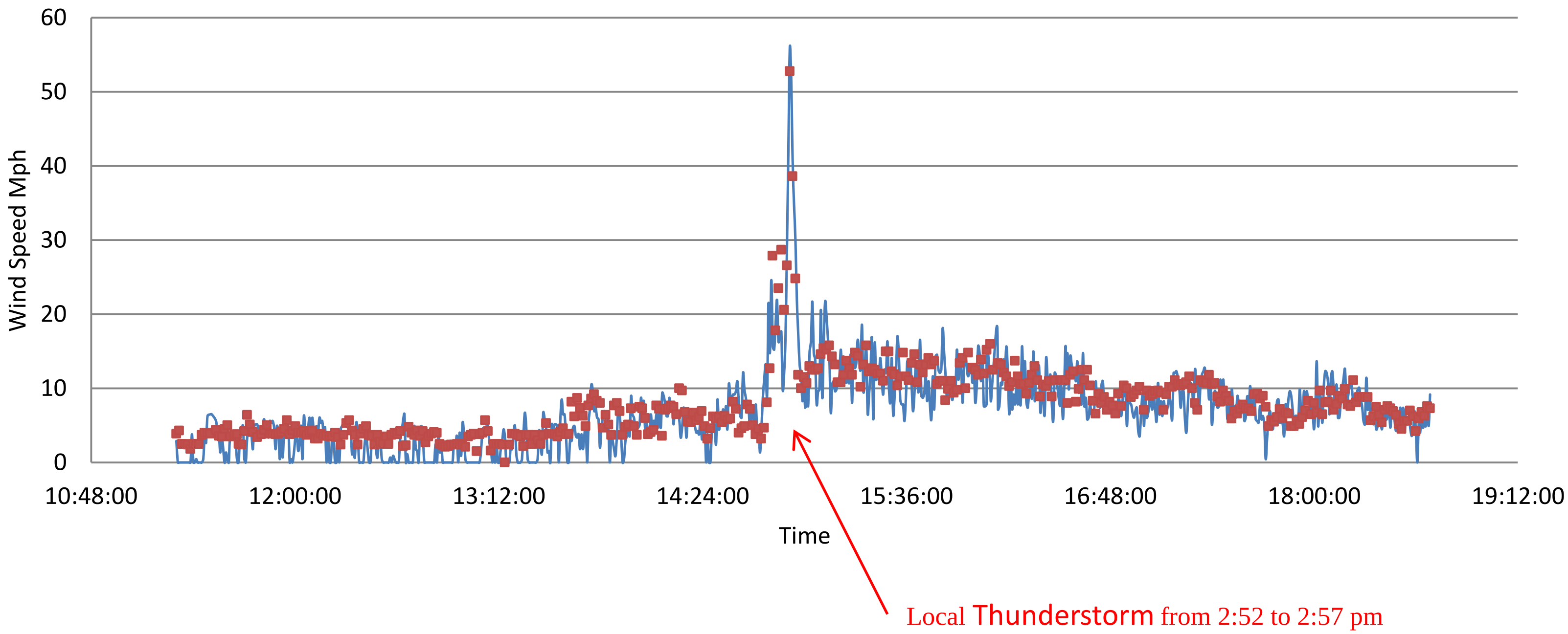
Sigma Theta values reflected "Extremely Unstable" conditions until the passage of a local thunderstorm from 2:52 to 2:57 pm where the Sigma Theta values returned to normal limits.

A case can now be made that Sigma Theta values can be used as a severe weather pre-cursor, and continued deployment opportunities are expected.

Glenda Project – Ground Station – Application

Dual Ground Station Deployment – South Ridgeline (Wireless)

Dayton, WA – June 23, 2012

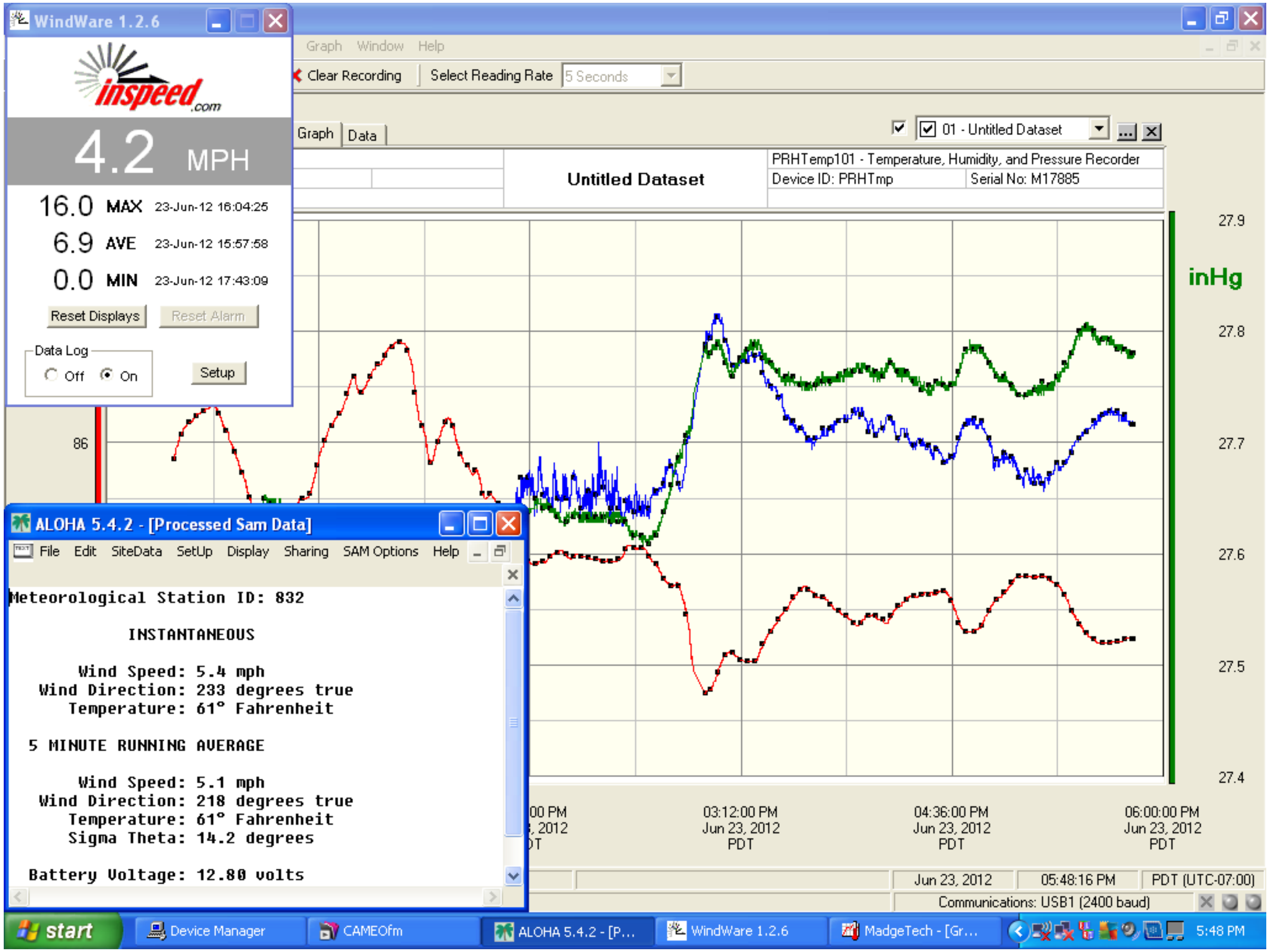


On June 23, our first dual deployment occurred as a thunder storm passed over two ground stations simultaneously. One station was the wireless WeatherPak, and the second was our hard-wired mobile station.

Glenda Project – Ground Station – Application

Dual Ground Station Deployment – Vehicle Mounted

Dayton, WA – June 23, 2012

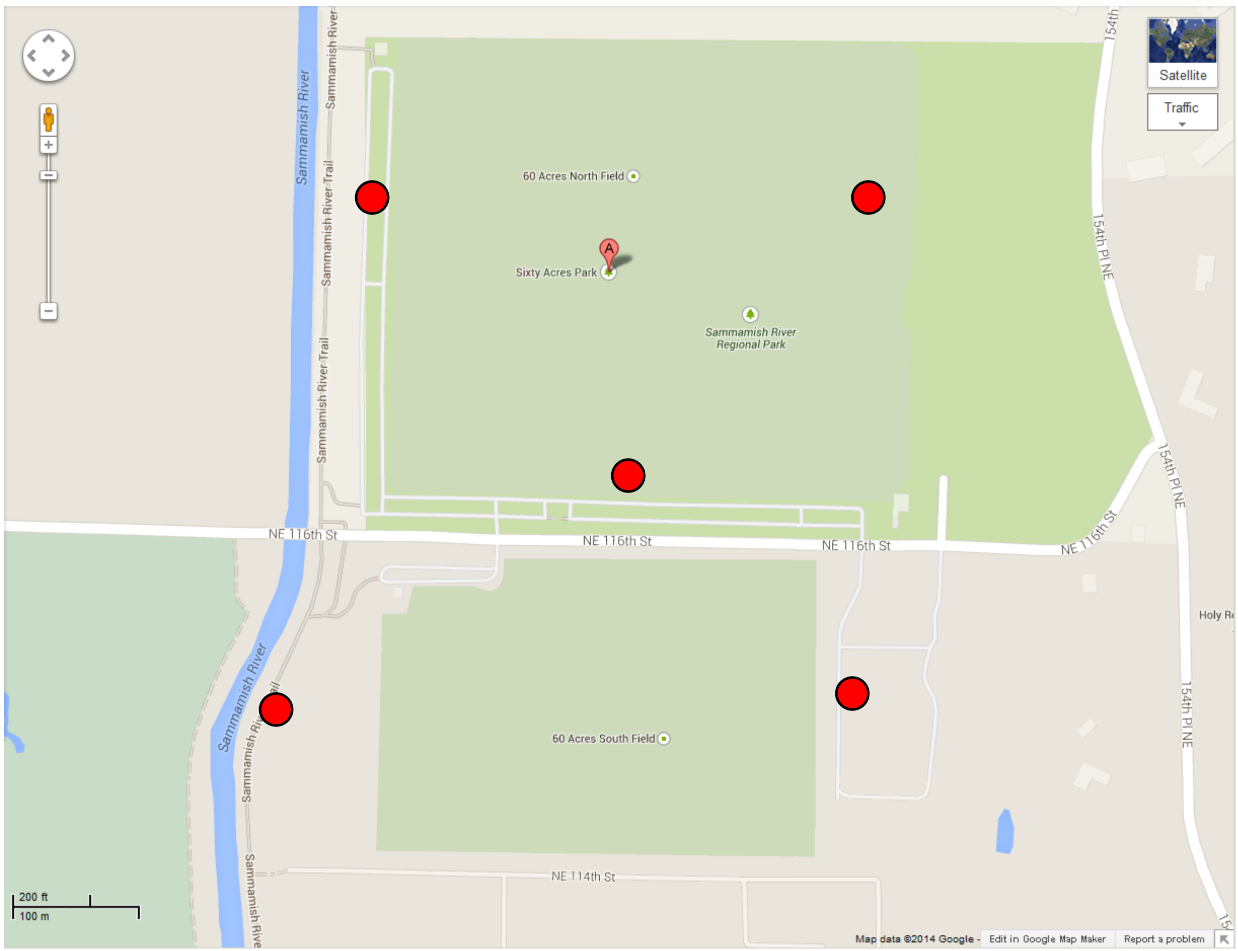


Data from both the wireless and vehicle-mounted ground stations were displayed side by side on a common interface for seamless integration.

Glenda Project – Ground Station – Application

GlendaNet – Integrated Ground Station Network

In September of 2014, the Glenda Project began deploying the GlendaNet, a set of Weatherpak weather stations monitoring "conventional" weather variables. Two of the Weatherpaks were wireless, with the third hard-wired to an intercept vehicle.

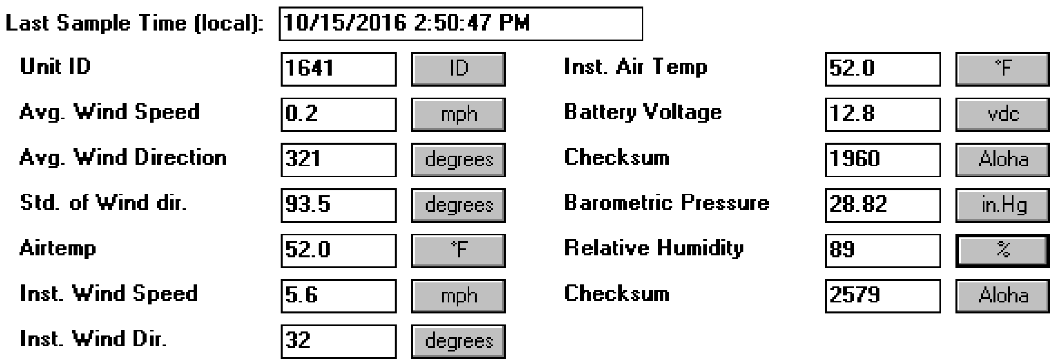


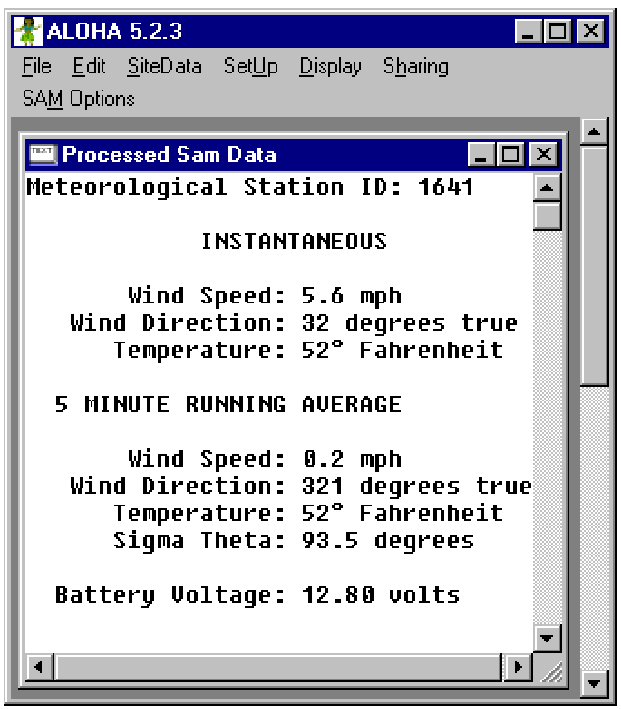
In 2015, the Glenda Project added additional wireless Weatherpak systems. In this deployment, only five are shown.

A wireless ground station network allows for a highly flexible system that can easily adapt to rapidly changing field conditions and provides a high level of confidence of data capture in the event a remote station is disabled during a severe weather intercept.

Glenda Project – Ground Station – Application

GlendaNet – Software and Data Integration





For 2016, the Glenda Project successfully integrated multiple software applications from a common data source.

Integration was achieved between the ALOHA Hazmat and Coastal Environmental's Intercept software using common data from a Weatherpak weather station.

This capability now allows more efficient and effective data processing requiring fewer deployed ground stations.

Glenda Project – Ground Station – Application

GlendaNet – Software and Data Integration

Photo Courtesy of Steve Thatcher

Photo Courtesy of Steve Thatcher

In October 2017, the Glenda Project successfully implemented an integrated "end to end" GlendaNet. This deployment of networked multiple ground stations using the MTR system allows common laptop data collection using the Coastal Environmental Intercept software and a combination of wireless and hard-wired stations.

Intercept [di.dis] - [Summary]

File Setup Utilities Window Help

10/11/2017 10:43:48 AM: WARNING: STATION: Timeout on Station #1806 (Gen 2)

		Unit ID	Avg. Wind Speed	Avg. Wind Direction	Std. of Wind dir.	AVG Airtemp	Inst. Wind Speed	Inst. Wind Dir.	Inst. Air Temp	Battery Voltage	Checksum	Barometric Pressure	Relative Humidity	Checksum
			mph	degrees	degree:	°F	mph	degree	°F	vdc	Aloha	in.Hg	%	Aloha
92	Vehicle Mount Test	92	2.5	207	30.1	52.7	2.5	232	52.7	11.9	1907			2248
1806	Gen 2	1806	3.6	208	24.0	51.8	2.2	205	51.8	12.7	2003	29.91	67	2638
2679	MTR	2679	2.7	112	39.3	52.3	3.1	168	52.3	14.5	2029	29.97	69	2676

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	Station #2679 (MTR),Hazmat													
2	Local Date and Time	Unit ID	Avg. Wind	Avg. Wind	Std. of Wir	AVG Airter	Inst. Wind	Inst. Wind D	Inst. Air Te	Battery Vo	Checksum	Barometric	Relative Hu	Checksu
729	11:39:34	2679	1.3	148	38.8	12.1	0.7	119	12.2	14.3	2038	1016	67	26[illegible]
730	11:39:43	2679	1.3	148	38.9	12.1	2.2	110	12.2	14.3	2027	1016	67	26[illegible]
731	11:39:44	2679	1.3	148	38.9	12.1	2.2	110	12.2	14.3	2027	1016	67	26[illegible]
732	11:39:53	2679	1.3	147	38.9	12.1	0.6	119	12.1	14.3	2036	1016	64	26[illegible]
733	11:39:56	2679	1.3	147	38.9	12.1	0.6	119	12.1	14.3	2036	1016	64	26[illegible]
734	11:40:03	2679	1.3	147	38.8	12.1	0.9	102	12.2	14.3	2031	1016	64	26[illegible]
735	11:40:04	2679	1.3	147	38.8	12.1	0.9	102	12.2	14.3	2031	1016	64	26[illegible]
736	11:40:13	2679	1.3	147	38.9	12.1	0.6	71	12.3	14.3	1987	1016	65	26[illegible]
737	11:40:15	2679	1.3	147	38.9	12.1	0.6	71	12.3	14.3	1987	1016	65	26[illegible]

Multiple Ground Stations – Multiple Receivers – Integrated Software & Platforms – Multi-Mission Supportability - All in a Mobile Environment

Glenda Project – Intercept Teams

Obtaining data from dynamic weather phenomena requires seeking out and intercepting storms, launching sensors into the heart of the disturbance, capturing the data, and returning the data for immediate processing and analysis. Hence the name, Intercept Team.

The Intercept Teams utilize Jeep Grand Cherokee four-wheel drive vehicles and other heavy-duty trucks equipped with specialized tires and suspension to navigate road debris and execute evasive maneuvers. When storm data is required, the teams immediately attach a weather station to the roof of the vehicle and then load a variety of pre-staged gear: instrument packages, laptop computers, satellite dishes, sensors, communications gear, portable rocket-launching stands, and weather rockets. Transforming from an ordinary vehicle to a fully operational weather-pursuit vehicle takes as little as five minutes.

Glenda Project – Intercept Teams – Application

Columbia County – Dayton, Washington

The Glenda Project principal Intercept Team is based in Columbia County Washington and is equipped with an extensive sensor suite from lightning detectors, GPS positioning data loggers, and anemometers, to real-time internet Doppler radar.

Using the Doppler radar coupled with onboard GPS navigation, the team can pinpoint their exact location, providing them the best possible opportunity to position themselves relative to storm system movement. Unlike other storm "chase" teams, this capability allows the Dayton Intercept Team to concentrate less on chasing storms and more on positioning themselves to intercept storms.

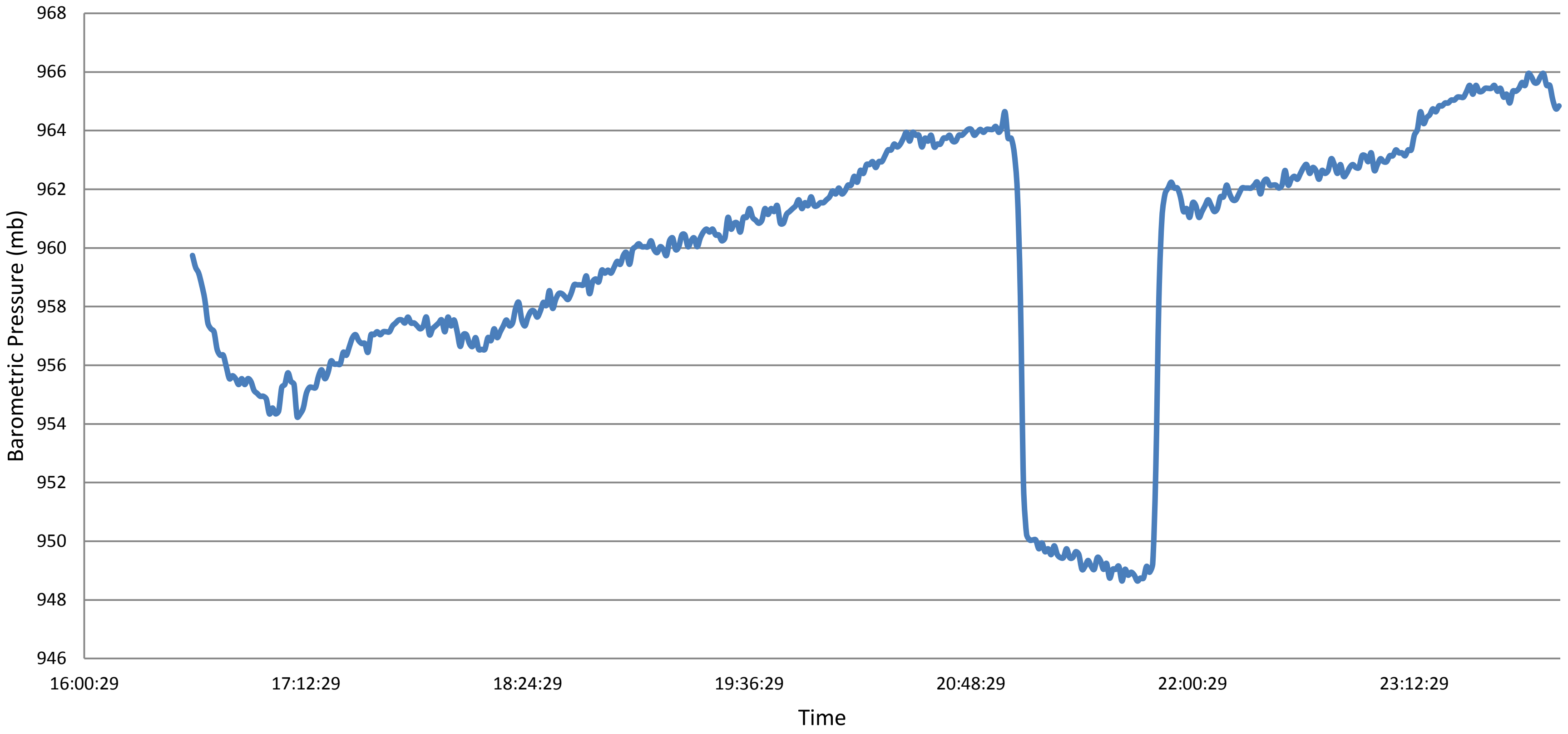
This intercept capability now allows the team to best support local first responders, allowing the team to suggest locations for responders to pre-deploy response assets into the field, which can allow for nearly instantaneous mitigation of severe weather impacts.

On July 8, 2012, while monitoring a severe weather incident, the intercept team detected and recorded a microburst thunderstorm over the north residential area of Dayton, Washington. Responding to the affected area, the team was able to assist with and coordinate emergency services response. They coordinated storm debris removal to assist with the response of fire, ambulance and law enforcement units and the evacuation of an elderly person trapped in their residence by storm debris. The team also assisted with crowd control until power was restored by the power company hours later. For the duration of the incident, the intercept team relayed all information and storm observations in real time to the Pendleton National Weather Service and to the local Emergency Management office, which resulted in local and regional severe weather alerts being issued.

Glenda Project – Intercept Teams – Applications

Dayton, WA – July 8, 2012

Barometric Pressure (mb) – 15-mb pressure drop during Micro Burst



The Columbia County/Dayton, WA, Intercept Team achieved a successful intercept of a microburst thunderstorm and recorded a 15-mb pressure drop during the event.

Glenda Project – Intercept Teams – Application

Columbia County – Dayton, Washington

As a result of the team's response to the July 8, 2012, storm emergency, local emergency services personnel asked to meet with the Dayton intercept team to integrate their unique strengths into community emergency planning and response. To facilitate this effort, the intercept team was equipped with a BK digital radio system that operates over narrow-band FM in the 155-mhz range. This system allows them direct radio communications with regional law enforcement, fire, ambulance and emergency management field units as well as the regional 9-1-1 public safety communications center. The team's integrated real-time Doppler and GPS capabilities have allowed them the opportunity to coordinate with local and regional fire departments during lightning storms to aid in the staging of fire assets to suppress lightning strike fires.

Glenda Project – Intercept Teams – Application

Columbia County – Dayton, Washington

In 2012, the Columbia County/Dayton, WA Intercept Team became the “eyes” for Emergency Management and First Responders in severe weather situations.

SKYWARN

Approaching Storms for Intercepts

Glenda Project – Remote Sensing

Glenda Research Facility – Malo, Washington

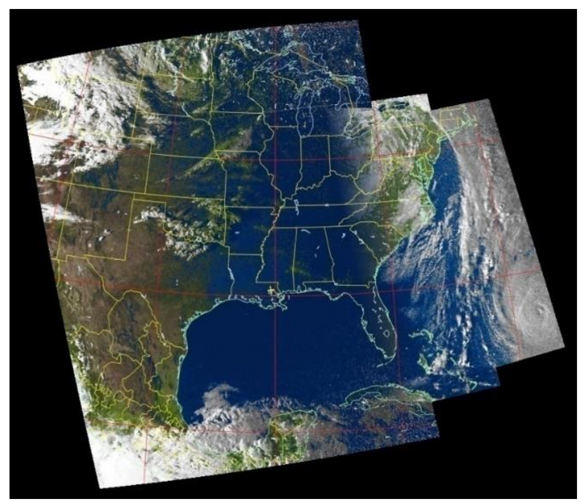
After the catastrophic floods of 2016, a key Glenda Project member decided to relocate from the Gulf Coast Flood Plain back to Washington State in 2019. This move brought the team closer together while still maintaining mission focus.

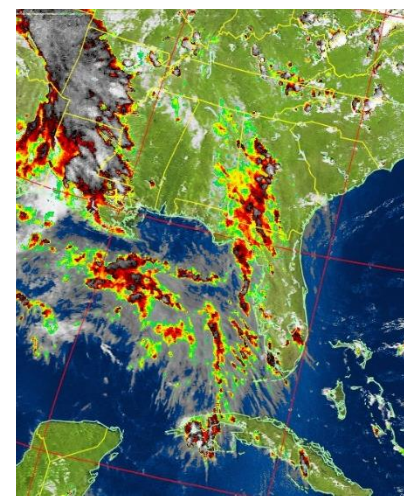
The Malo facility feeds out weather data in regular intervals as quickly as every two seconds depending on the need for data and weather conditions. We post real-time data, including radiation and EMF, via our website and radio transmissions. We feed directly to: NOAA and the National Weather Service, APRS via ham radio station KE5JJC both over the web and over 2-meter ham frequencies, Citizens Weather Observation Program, Hamweather, PRSWeather, WeatherBUG, and Weather Underground/The Weather Channel.

Glenda Project – Remote Sensing

Glenda Research Facility – Malo, Washington

Weather information is fed automatically into various computer processing centers as well as the National Weather Service (NWS). Because our information is sent at much shorter intervals than most typical airport weather stations, our data can be analyzed more quickly to assist NWS in deciding the appropriate alerts and warnings to issue. Because we can provide both mobile and base visuals, during major weather situations we can report additional information to the NWS via cell phone or NWS-monitored ham radio frequencies. The NWS will issue watches and warnings both over the air (weather stations and public networks) and over the web based on the information that we and additional stations send them. The NWS is of course, the official source for Emergency Management Centers.

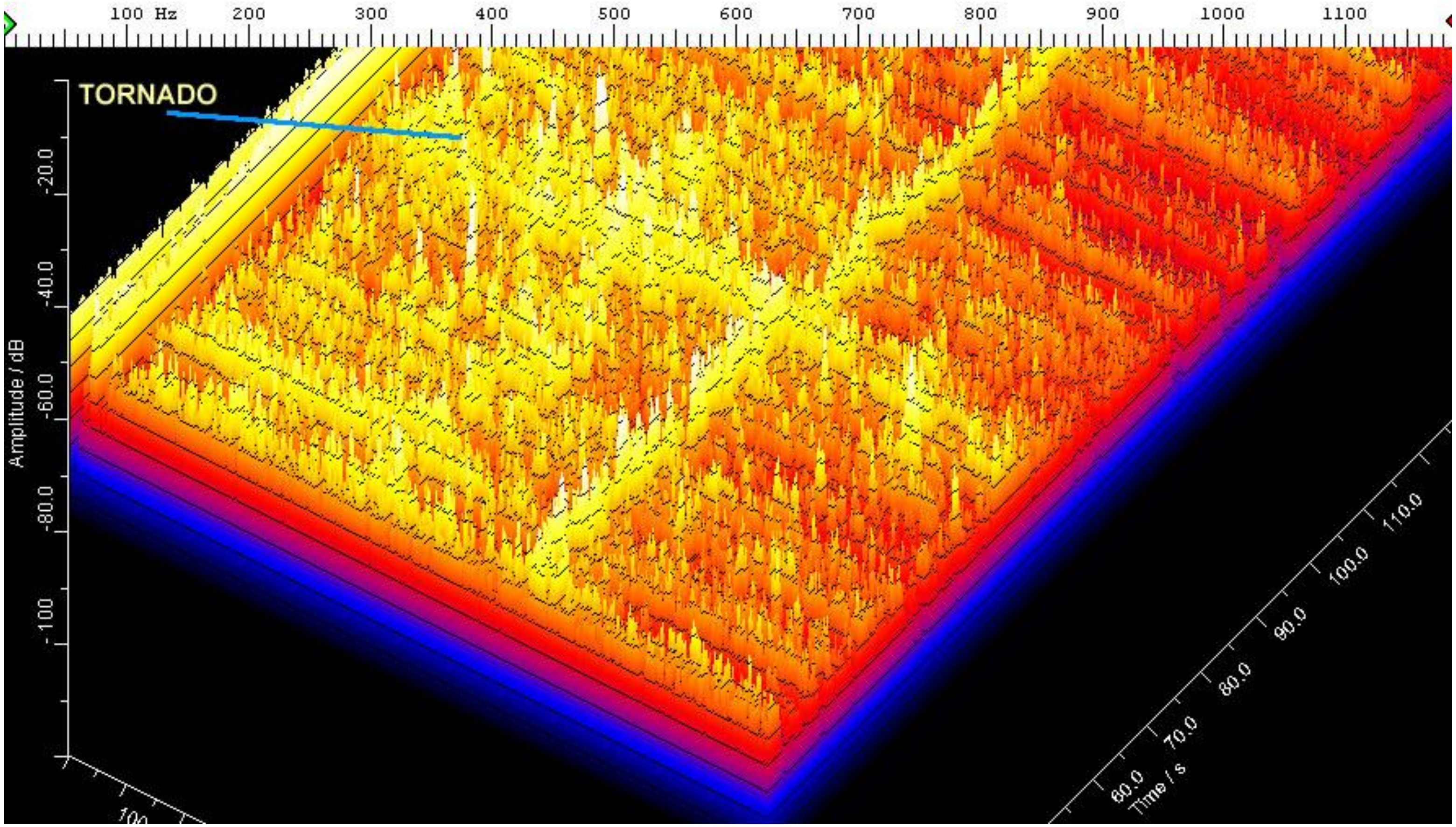




Glenda Project – Remote Sensing – Application

EM Field Mapping

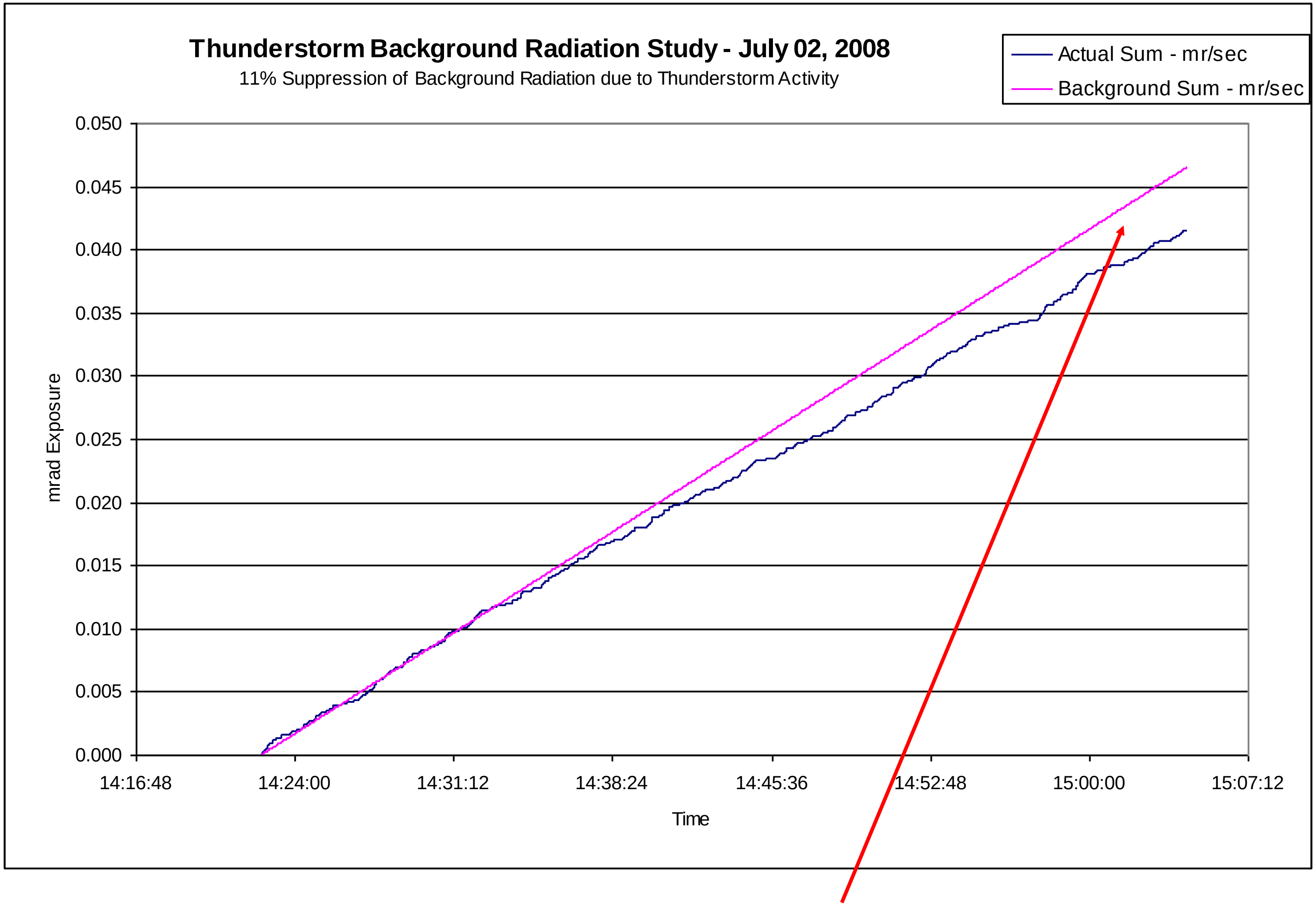
Combining Glenda computing and sensors allows the capability for advanced analysis and detection. Shown below is a 3D Electromagnetic Field (EMF) analysis of a tornado from a three-second data capture. The circular effects of the funnel are easily visible and provide a snapshot of the electrical activity around a tornado.



Glenda Project – Remote Sensing – Application

Gamma Radiation Studies

Data collection capability of Gamma Ray Radiation during Thunderstorms



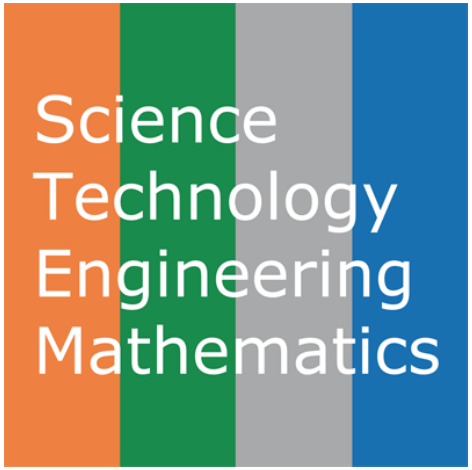
During this extensive tunderstorm, lightning suppressed the “background” gamma radiation count by 11 percent

Glenda Project – Educational Outreach

Over many years, the Glenda Project has developed strong local community ties with educational and governmental groups ranging from the National Weather Service and museums to local schools.

The Glenda Project provides mentorship support to the National Associate of Rocketry "The American Rocketry Challenge " (TARC), and the NASA Student Launch Initiative (SLI), involving high school and college student designed and launched payloads.

Glenda is also involved with the Science, Technology, Engineering, and Mathematics (STEM) programs at several local schools, since Glenda operations involve directly applying STEM skills from a variety of disciplines.



THE AMERICAN ROCKETRY CHALLENGE

Glenda Project – Educational Outreach

April 2018 – Museum of Flight, Seattle, WA – "NASA Climate Night"

August 2017 – Museum of Flight, Seattle, WA – STEM "Science Fest"

June 2013 – NWS Pendleton, Oregon Open House

February 2019 – Edmonds, WA – Westgate Elementary School "Science Night"

Glenda Project – Educational Outreach

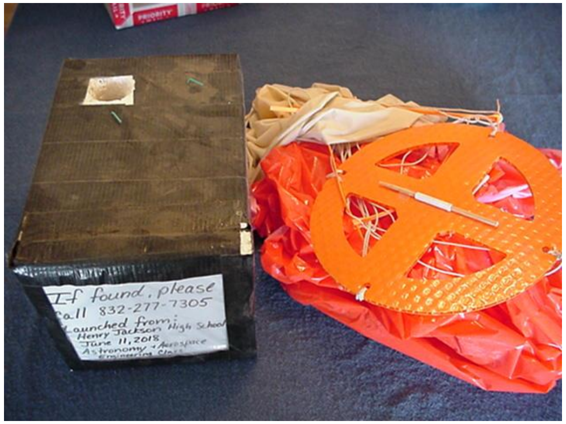
Henry Jackson High School – Mill Creek, WA – 2018 - Multiple Balloon Launches

On June 11, 2018, the Glenda Project supported the launch of three student-developed payloads from the Henry Jackson High School in Mill Creek, WA. The students provided the payloads, while the Glenda Project provided the balloons, parachutes, helium, and ground support.

The payloads flew across almost the entire state. Launched from western Washington, they landed on the Washington/Idaho border. Two of the three payloads were successfully recovered. Photos from the flights are shown below and on the following slide.

A Successful Launch

Henry Jackson High School – From the Balloon



A Successful Recovery

Glenda Project – Educational Outreach

Henry Jackson High School – Mill Creek, WA – 2018 - Multiple Balloon Launches

Two of the payloads carried video cameras. One only captured clouds, while the other reached an altitude of around 20,000 feet before its batteries ran down. As the balloon rotated, it successfully captured views of Mt. Rainier, Mt. Baker, Mt. St. Helens, and the Olympic Mountain Range.

Mount Rainier

Mount St. Helens

Mount Baker

Olympic Mountain Range

Puget Sound

Glenda Project – Educational Outreach

Henry Jackson High School – Mill Creek, WA – June 3, 2019, High Altitude Balloon Launch

For 2019, the students decided to launch a larger single balloon rather than three smaller ones. The Glenda project provided the balloon, the supporting balloon-launching equipment, and associated launch-related hardware.

A single 600-gram balloon with 110 cubic feet of helium carried aloft three payloads. Two payloads were video cameras: one was pointed horizontally, and the other was pointed downward. The third payload was a Glenda-provided RS-92 radiosonde with GPS tracking and active temperature, relative humidity, and barometric pressure sensors.

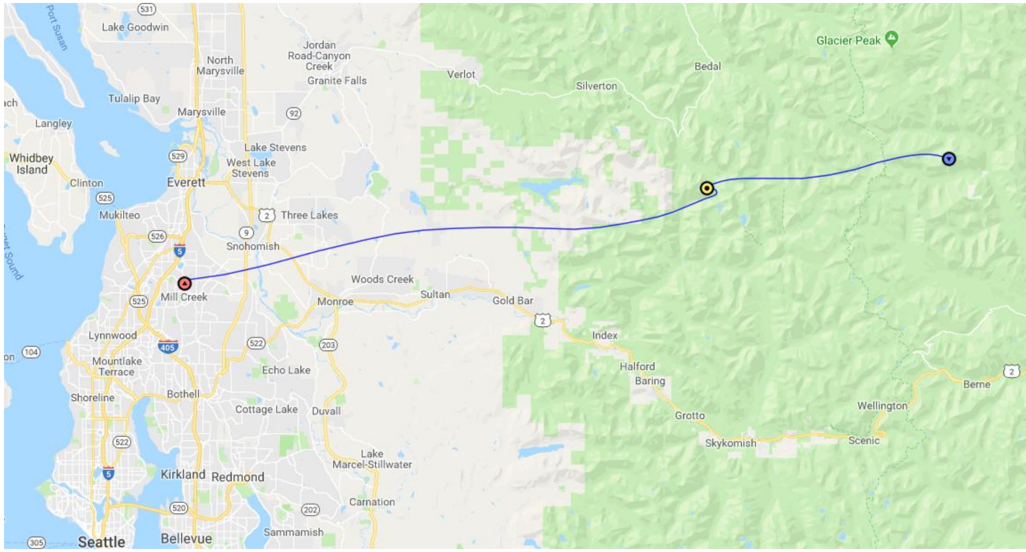
The launch was successful, even though the radiosonde bounced off the ground upon take-off, damaging the relative humidity sensor. All other sensors remained intact.

Based on the GPS coordinates transmitted back from the payload, the balloon landed near Skycomish/Glacier Peak in the Henry Jackson Wilderness area. Although local climbers searched for the payloads, they were not recovered.

Glenda Project – Educational Outreach

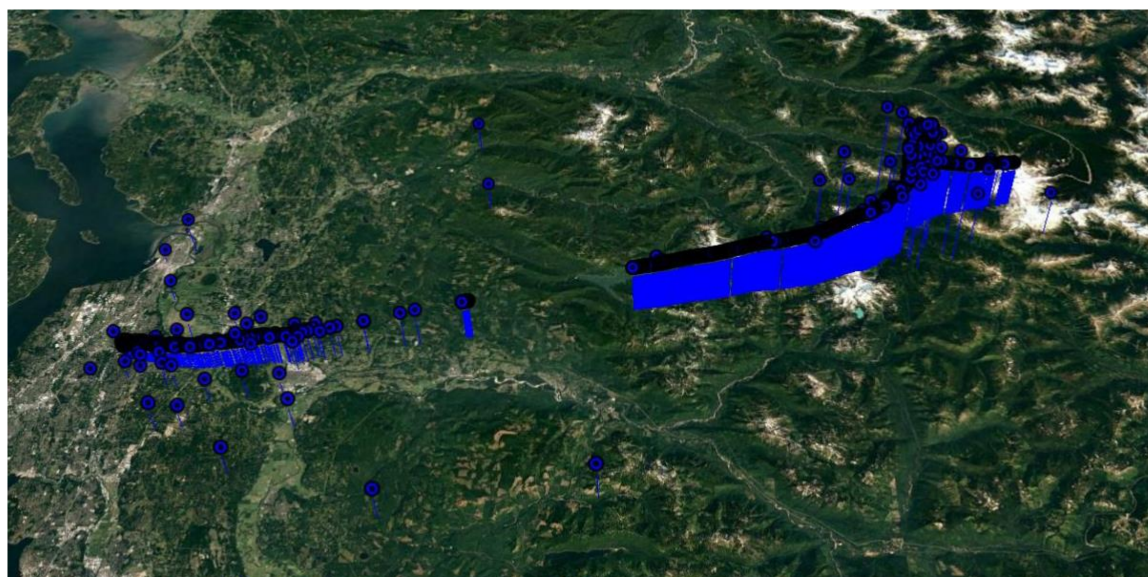
Henry Jackson High School – Mill Creek, WA – June 3, 2019 High Altitude Balloon Launch

Flight Trajectory Performance



Projected Flight Simulation

Actual Flight Path

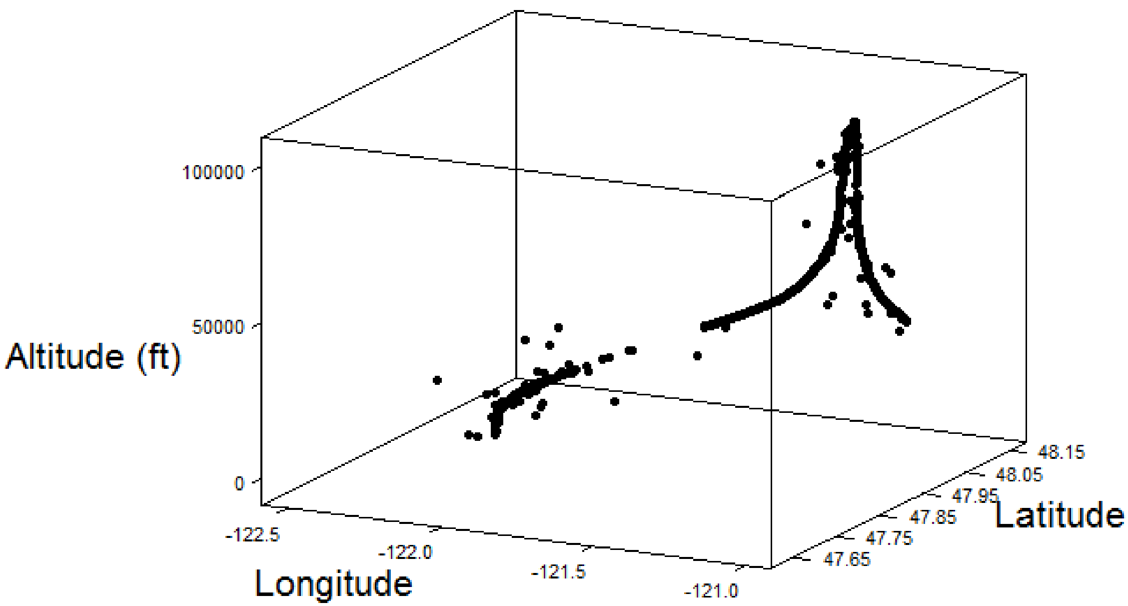


The actual flight path closely followed the projected flight simulation, which further proves the integrity of the data modeling process.

Glenda Project – Educational Outreach

Henry Jackson High School – Mill Creek, WA – June 3, 2019 – High Altitude Balloon Launch

Flight Data – GPS Positioning Telemetry – Altitude Exceeded 100,000 feet



1	Date / Time	Lattitude	Longitude	Altitude (m)	Altitude (ft)	Reference Line
3483	21:46:03	48.0386	-121.2611	30423.880	99820.750	12039
3484	21:46:04	48.0386	-121.2609	30435.644	99859.348	12040
3485	21:46:05	48.0387	-121.2609	30442.513	99881.885	12041
3486	21:46:06	48.0387	-121.2608	30451.263	99910.594	12042
3487	21:46:07	48.0387	-121.2608	30456.555	99927.957	12043
3488	21:46:08	48.0386	-121.2606	30465.534	99957.417	12044
3489	21:46:09	48.0386	-121.2605	30469.020	99968.855	12045
3490	21:46:10	48.0384	-121.2605	30473.356	99983.081	12046
3491	21:46:11	48.0384	-121.2603	30485.139	100021.741	12047
3492	21:46:12	48.0384	-121.2603	30488.846	100033.904	12048
3493	21:46:13	48.0384	-121.2601	30499.196	100067.862	12049
3494	21:46:14	48.0386	-121.2600	30506.199	100090.839	12050
3495	21:46:15	48.0041	-121.2318	30509.424	100101.420	12051
3496	21:46:16	48.0387	-121.2600	30520.586	100138.043	12052
3497	21:46:17	48.0391	-121.2601	30529.794	100168.254	12053
3498	21:46:18	48.0385	-121.2599	30532.671	100177.694	12054
3499	21:46:19	48.0384	-121.2597	30545.055	100218.325	12055
3500	21:46:20	48.0383	-121.2595	30556.141	100254.699	12056
3501	21:46:21	48.0383	-121.2595	30552.546	100242.903	12057
3502	21:46:22	48.0383	-121.2593	30565.250	100284.585	12058
3503	21:46:23	48.0384	-121.2593	30565.477	100285.330	12059
3504	21:46:24	48.0385	-121.2593	30576.997	100323.127	12060
3505	21:46:25	48.0378	-121.2644	30582.885	100342.446	12061
3506	21:46:32	48.0394	-121.2601	30502.930	100080.113	12064
3507	21:46:33	48.0385	-121.2611	30258.114	99276.872	12065
3508	21:46:34	48.0385	-121.2603	30301.880	99420.468	12066
3509	21:46:35	48.0385	-121.2596	30312.366	99454.873	12067
3510	21:46:36	48.0384	-121.2609	30073.354	98670.674	12068
3511	21:46:37	48.0385	-121.2604	30071.926	98665.989	12069
3512	21:46:39	48.0384	-121.2589	29892.959	98078.798	12070
3513	21:46:40	48.0384	-121.2584	29879.866	98035.840	12071
3514	21:46:41	48.0384	-121.2585	29792.371	97748.769	12072
3515	21:46:42	48.0384	-121.2580	29790.284	97741.922	12073
3516	21:46:43	48.0384	-121.2574	29804.855	97789.729	12074
3517	21:46:45	48.0386	-121.2569	29754.398	97624.180	12076
3518	21:46:46	48.0386	-121.2575	29602.582	97126.072	12077
3519	21:46:47	48.0386	-121.2572	29578.844	97048.187	12078
3520	21:46:48	48.0387	-121.2571	29545.067	96937.365	12079
3521	21:46:49	48.0387	-121.2570	29508.707	96818.068	12080
3522	21:46:50	48.0387	-121.2575	29387.567	96420.607	12081
3523	21:46:51	48.0387	-121.2571	29393.009	96438.463	12082
3524	21:46:52	48.0387	-121.2576	29291.911	96106.760	12083
3525	21:46:53	48.0387	-121.2576	29244.321	95950.617	12084
3526	21:46:54	48.0388	-121.2571	29283.757	96080.007	12085

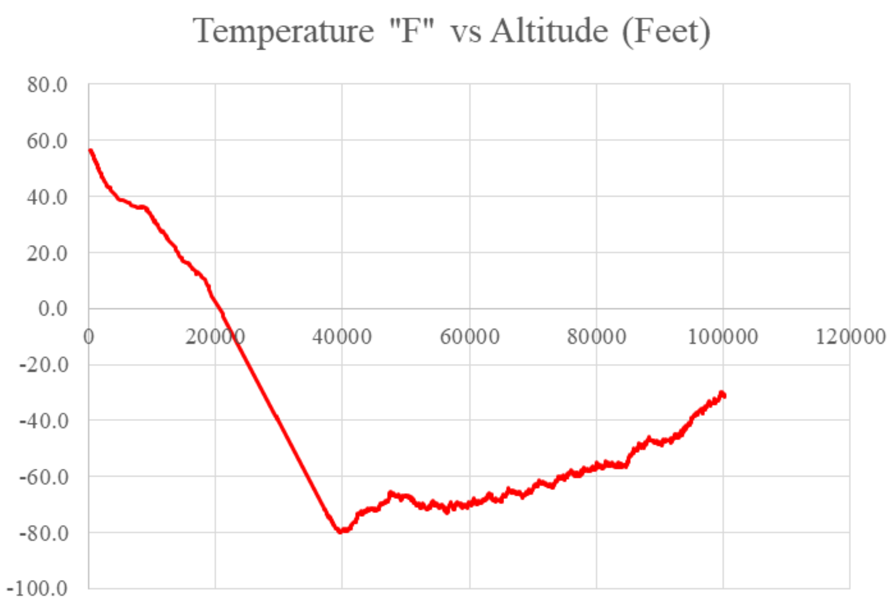
The significant difference between the 2018 and 2019 Jackson H.S. launches was the addition of live-feed transmitted flight telemetry. The live feed transmitted flight data streams of the payload's position via GPS, as well as capturing and transmitting temperature and barometric (atmospheric) pressure data to the ground receiver station, where they were recorded and presented in real time.

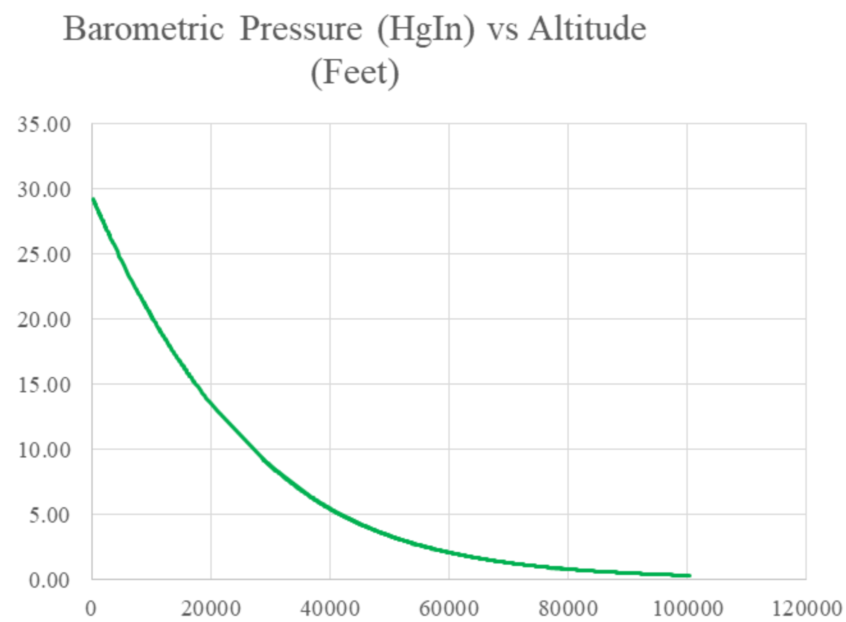
16 seconds over 100,000 feet

Glenda Project – Educational Outreach

Henry Jackson High School – Mill Creek, WA – June 3, 2019, High-Altitude Balloon Launch

Flight Data – Temperature and Barometric (Atmospheric) Pressure





-80 Degrees F at 40,000 feet

0.31" of Mercury (Barometric Pressure) at 100,253 feet

The onboard Temperature and Pressure Sensors detected and transmitted close to a 140-degree temperature drop from near 60 degrees F at launch to -80 degrees F at altitude. Atmospheric pressure levels varied from near normal at launch to an almost vacuum at altitude.

Next Steps

While this flight was an amazing success, reaching an altitude of over 100,000 feet and returning viable positioning and environmental data, it highlights the distinction between "active," and "passive" payloads.

"Active" payloads transmit their data to a ground station. While this process is more complex, the payload can be expended without loss of data. "Passive" payloads are much simpler to operate and are often much less expensive. However, they do have to be recovered to retrieve their data.

While the High Altitude Science (HAS) commercial balloon performed flawlessly, its fill neck diameter is smaller than the "standard" Kaymont balloons used by NWS/NASA/DoD. This additional requirement now has driven the creation of a new balloon fill system configured for HAS balloons. In a parallel effort, our existing balloon fill system was updated with these new system upgrades.

This flight has shown how far the Glenda Project has come, in a very short time, in the launch and data collection arena, for high-altitude payloads.

Flights above 100,000 feet are planned with even more diverse payloads and with advanced radiosondes.

In Conclusion

The Glenda Project is a highly mobile data collection system designed to place instrument packages into areas previously considered to be too hazardous or inaccessible using traditional platforms such as aircraft, helicopters, kites, etc.

The operational Glenda Project shows the differences among Hollywood “fiction,” “Reality Television” publicity stunts, and engineering “fact,” mapping everything from local environments to a tornadic funnel with a full mission suite of sensors and cameras.

We have achieved multiple storm intercepts, deployed a wireless long range ground station network with Sigma Theta capability, and built sustaining relationships with emergency managers and first responders.

An operational balloon deployment capability for applications where booster launches are not feasible is now in place, and we continue to expand the flight envelope of our sensors and ground stations.

The Glenda Project Team is up to the task.