Technological Innovations in Meteorology

Date 6th February 2014

CONTENT

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Weather Services

Providing Weather services includes

- Measurement of Meteorological parameters at well distributed places with accurate instrumentation which includes AWS having accurate meteorological sensors and data loggers, Weather radars, GPS based IWV measurements and many other modern techniques.
- Developing, continuously verifying and modifying the weather models (Numerical weather prediction).
- Use the effective models to do Weather forecasting(short term, medium term and long term forecasting)
- Use the Weather data and Geospatial data to make intelligent information in GIS compatible format
- Disseminating the Weather data and forecast to various users in different formats as desired for a particular user/application

Hexagon’s contribution in Weather Services

- Turnkey solution for estimating Integrated Precipitable Water Vapour (IPWV) content in the atmosphere.
- Integrated solutions in the field of Micrometeorological measurements.
- Automatic Weather Stations
- Data loggers and high end meteorological sensors

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GPS Meteorology

- **Why is it important to determine Integrated Precipitable Water Vapor (IPWV)?**

• Water vapor is the main driver of atmospheric events.

• Significant changes in the horizontal and vertical distribution of water vapor can occur rapidly during active weather.

• Improved short-term moisture observations mean improved forecasts of precipitation and severe weather developments.

•Such forecasts impact decisions related to transportation, safety, agriculture, commerce, reservoirs, and flood mitigation projects.

•Concerned agencies in the India include IMD, Department of Science and Technology, Ministry of Agriculture, Disaster Management group.

GPS Meteorology

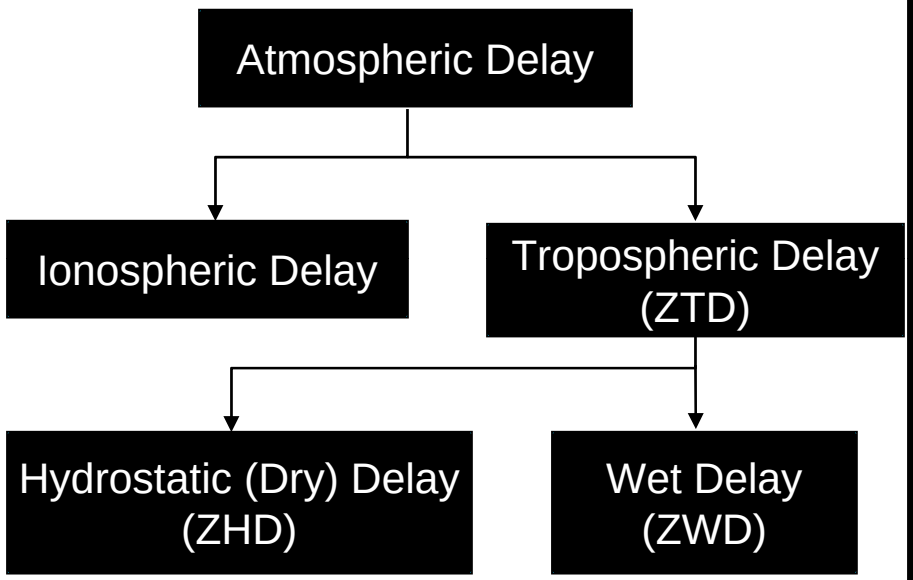
- **What is the advantage of GPS-MET versus conventional methods to determine water vapor in the atmosphere?**

• Most moisture observations are made with weather balloons that are launched twice daily.

• Radiosondes are launched every day around the country. This is an expensive process and cannot provide data under severe weather conditions.

• GPS-based Meteorology is an all-weather system that is both cost effective and reliable.

GPS Meteorology Concept



How do we calculate IPWV?

- Dry delay (ZHD) is a result of the total mass of the atmosphere. Wet delay is caused by the total amount of water vapor (IPWV) along the GPS signal path.
- To calculate the delay, first the dry delay (ZHD) is calculated from surface measurements. Then dry delay is subtracted from the tropospheric delay (ZTD), yielding zenith wet delay (ZWD). The wet signal delay maps into IPWV via a mapping function that is almost proportional to the mean vapor pressure weighted temperature of the atmosphere.

Current observation systems can determine the amount of moisture in the atmosphere with an accuracy of 3 to 5 mm. The goal of GPS-MET is to determine the moisture at the 1 mm level. This can be achieved with appropriate meteorological instrumentation and analysis.

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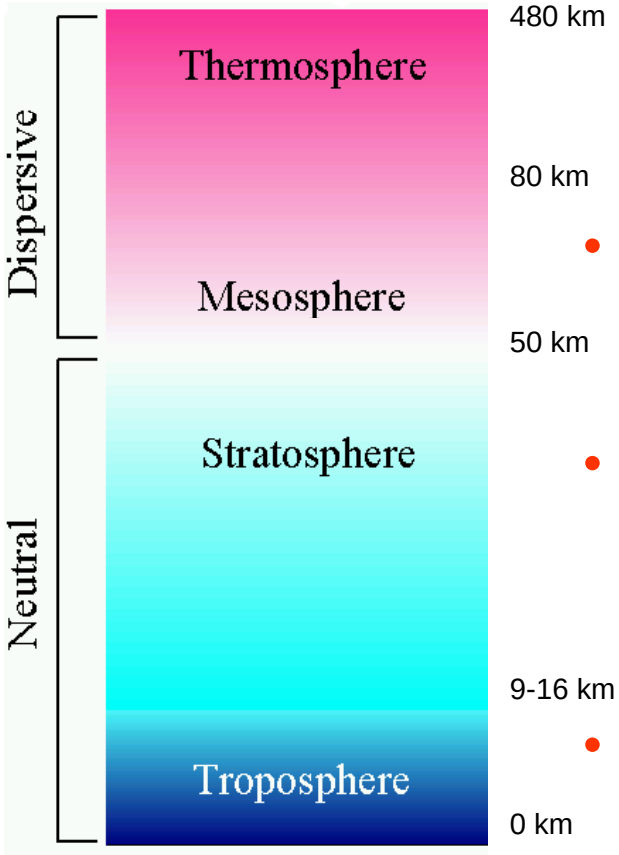
How Does the Atmosphere Effect the GPS Signal?



- The largest signal delays come from the ionosphere, the region of charged particles between 50 and 500 kilometers above the Earth's surface.
- Since the ionosphere is a dispersive medium, the propagation velocity of radio waves is frequency dependent.
- If you form a linear combination of L1 & L2 (called L3), and you use L3 to calculate your distances, you can virtually eliminate the ionosphere as a source of POS/NAV error.
- But if you measure the difference in arrival time of L1 and L2, you can estimate the total electron plasma density (TEC) of the ionosphere for Space Weather Forecasting, since TEC is a tracer for geomagnetic activity.

$$TEC \propto \frac{1}{f}$$

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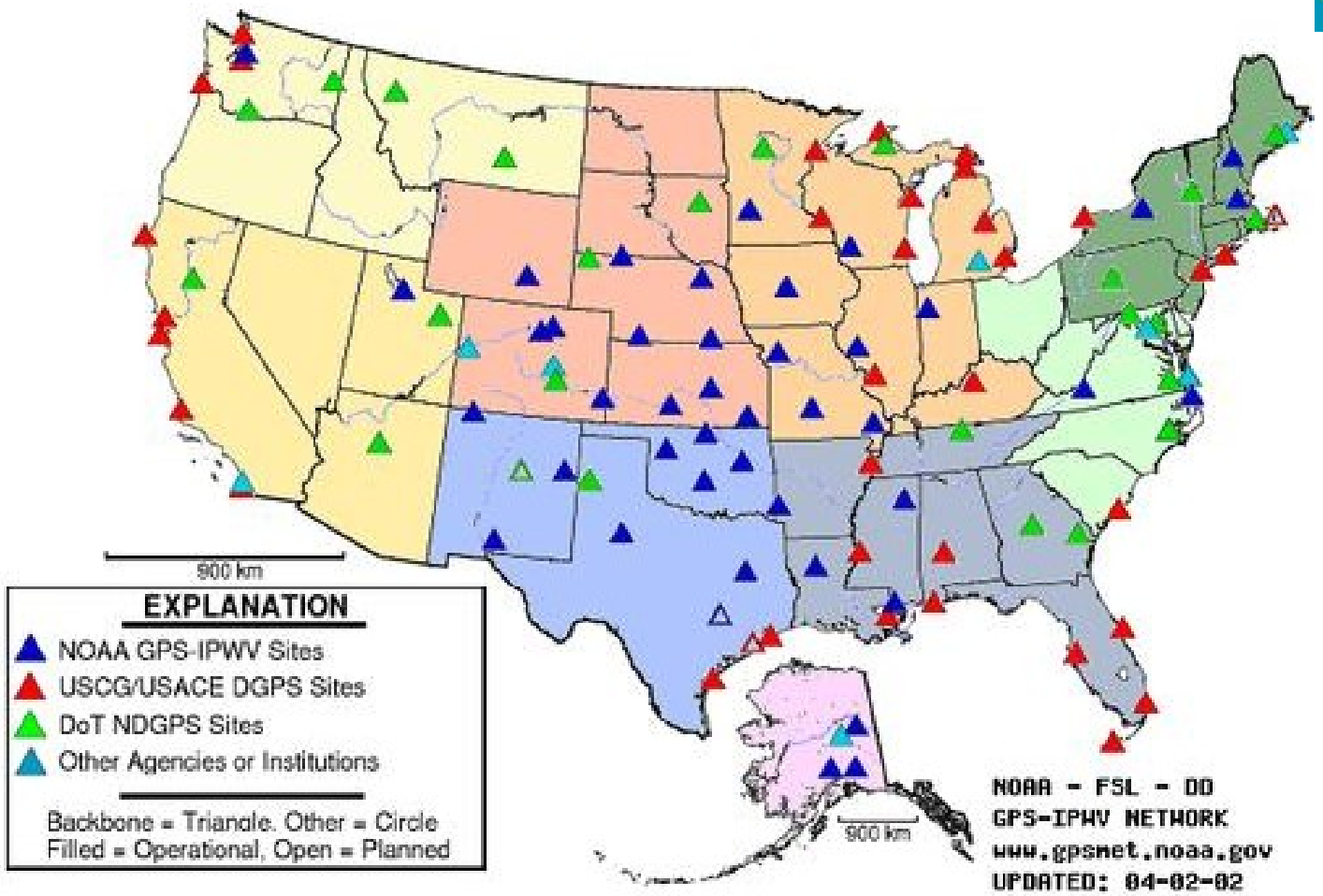
Current GPS Networks

- The promise of GPS Meteorology to improve short-term weather forecasts has attracted world-wide attention.
- The initial goal for most GPS networks was geodetic applications. Over time, as GPS-MET techniques were refined, many of these networks started co-locating a MET package with GPS receivers.
- A number of networks are in operation to focus on GPS-Meteorology including the USA, Germany and Japan.
- Indian Meteorological Department have already tested the system in last 6 years with 5 systems and is in process of increasing the network.

Current GPS Networks



- **NOAA's demonstration network has proven feasibility and is currently in operational use with around 400 stations.**

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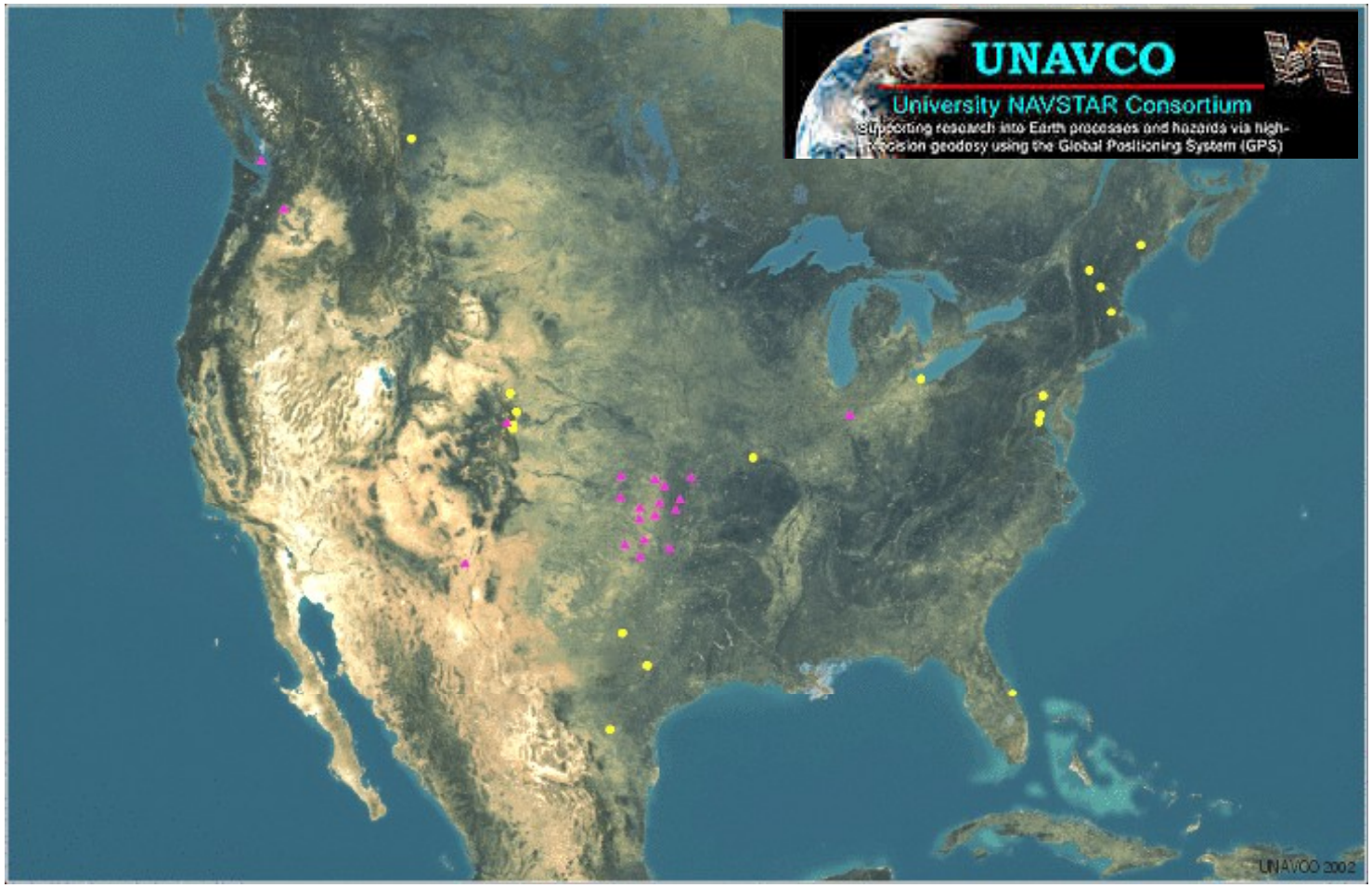
Current GPS Networks



- **SuomiNet has also proven feasibility.**

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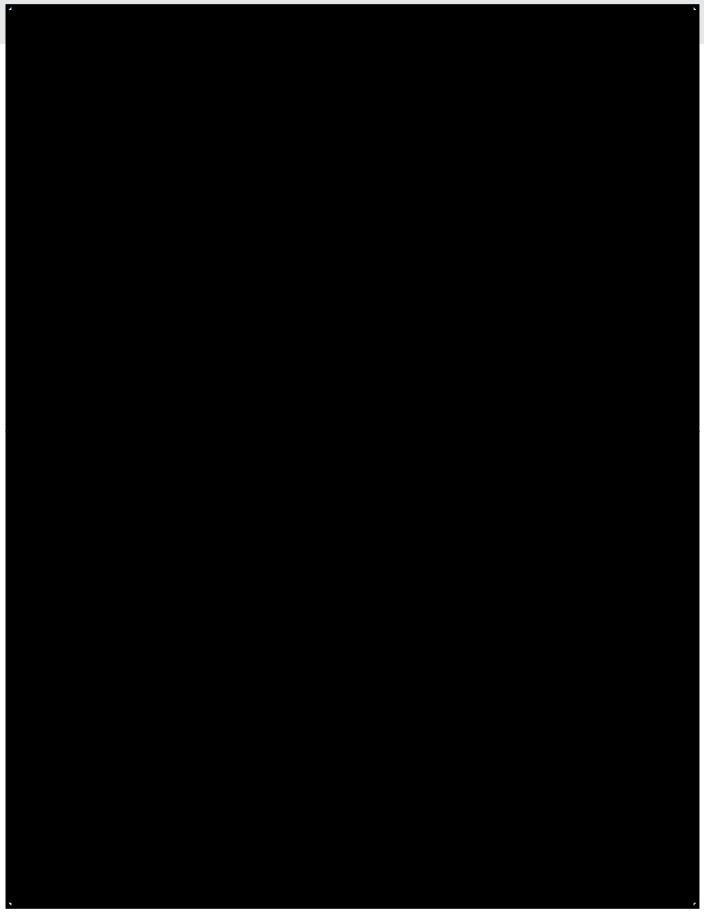
Current GPS Networks

Concerned Organizations in Japan:

- **Universities**
- **Geographical Survey Institute**
- **Japan Meteorological Agency**
- **National Astronomical Observatory**
- **Japanese Meteorological Research Institute**

- **The GPS-MET project was launched in Japan in 1997 to use the existing geodetic GPS network.**
- **Japan has the most dense GPS network in the world with around 1,000 stations and an average spacing of 30 Km.**
- **For Integrated Precipitable Water Vapor calculations, the required density is 100 Km.**

Current GPS Networks



- **Germany has a government operated GPS network of 200 stations with 50 Km spacing.**
- **The network has been used for flash flood monitoring.**

Current GPS Meteorology Applications

- Near Real Time Weather Forecasts
- Flash Flood Monitoring
- Long-Term Weather Studies

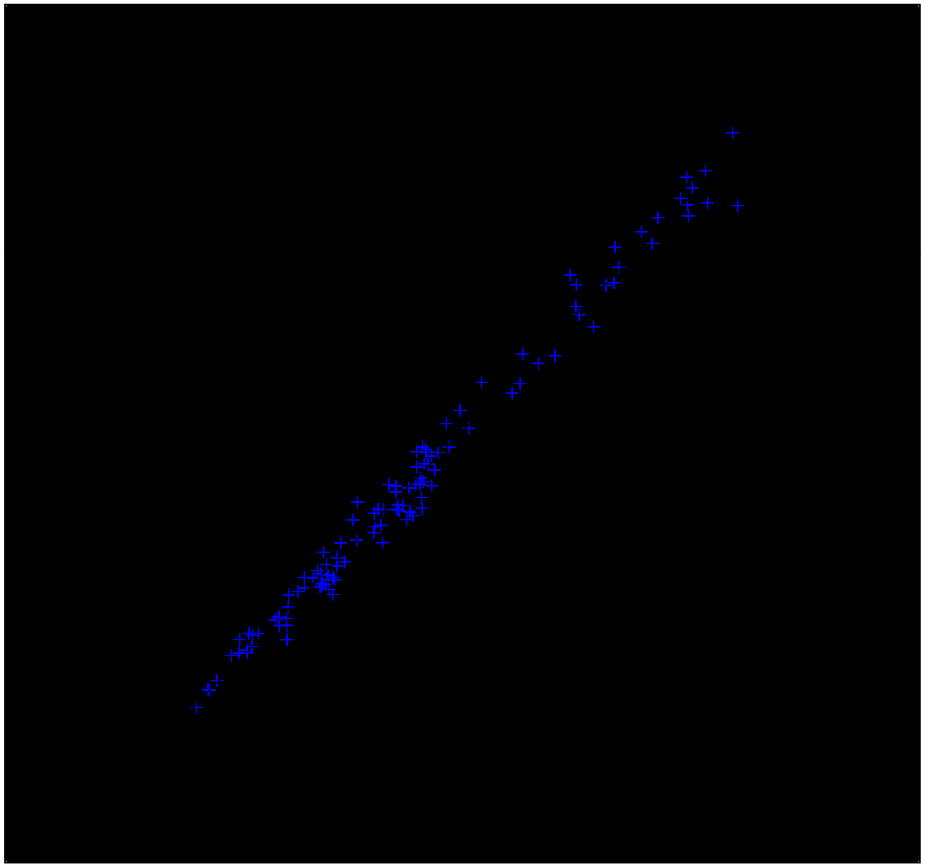
GPS Meteorology has the following present and future advantages:

- Gives near real time weather forecasts.
- Delivers weather information in active weather when conventional systems are not effective.
- Provides the total amount of Integrated Precipitable Water Vapor above zenith.

How Accurate is GPS IPW?

2000 ARM WVIOP PWV Summary

GPS vs. Sondes



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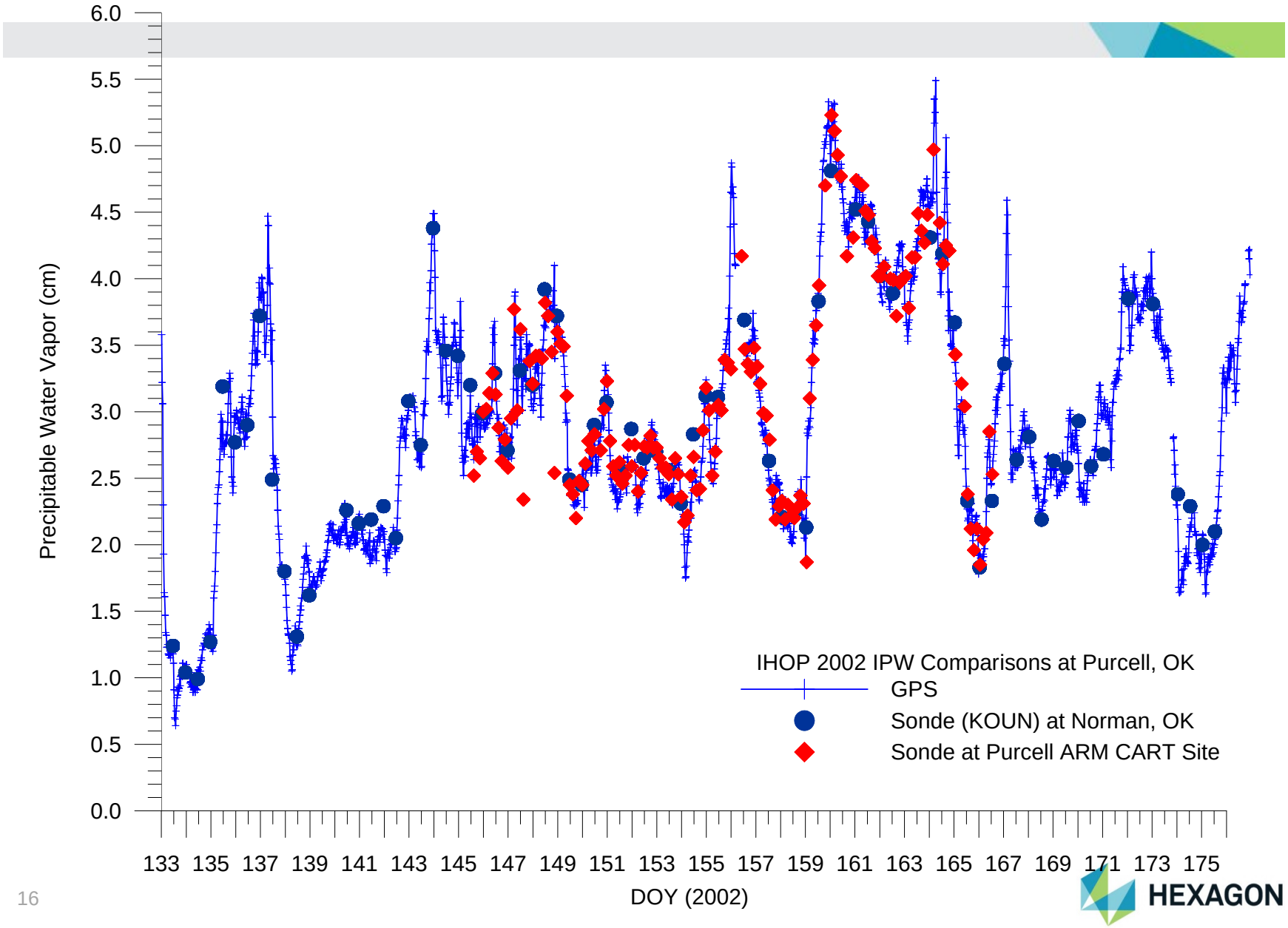
GPS & Radiosonde Comparisons



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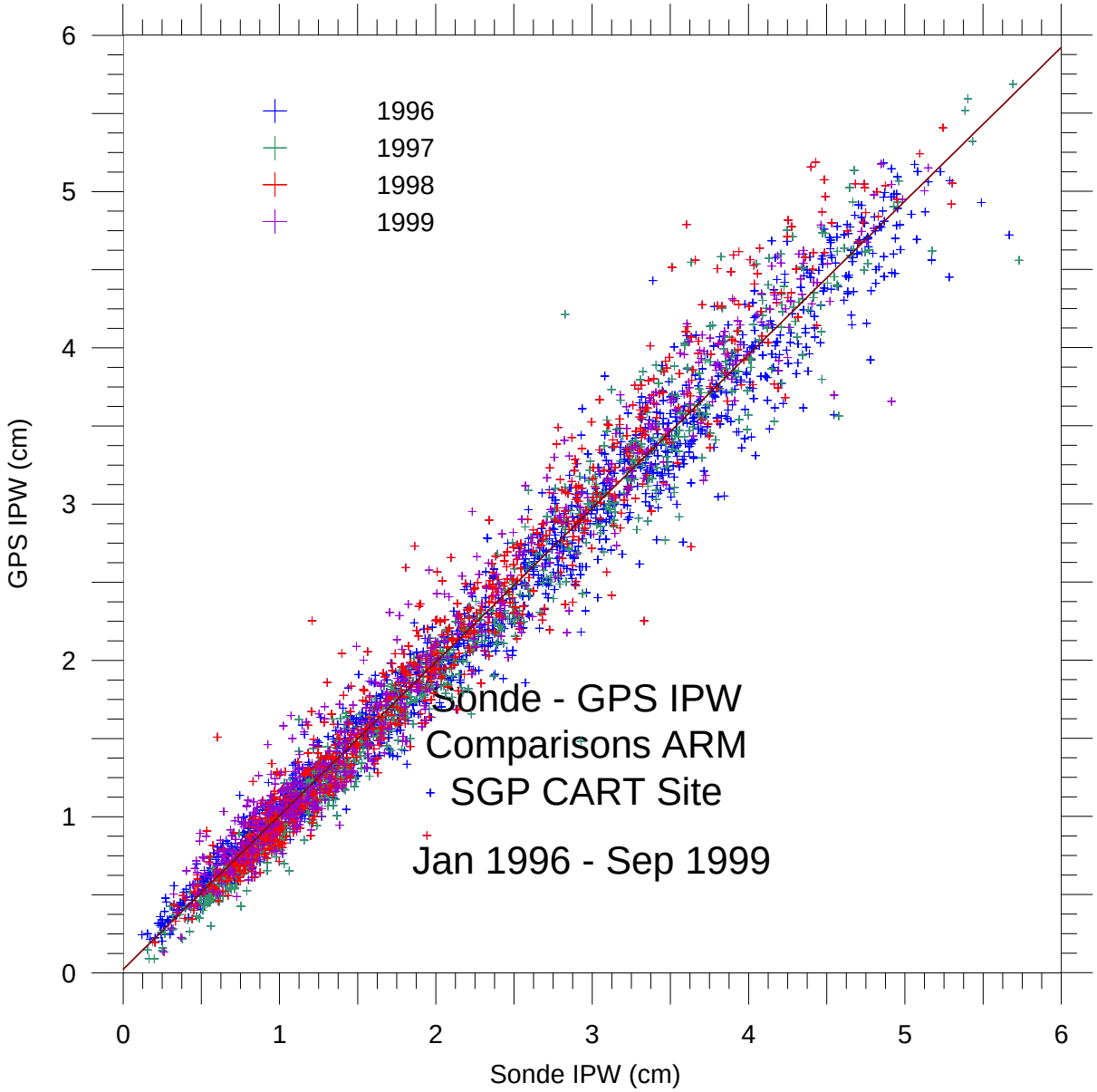
Long-Term Comparison of GPS and Rawinsondes



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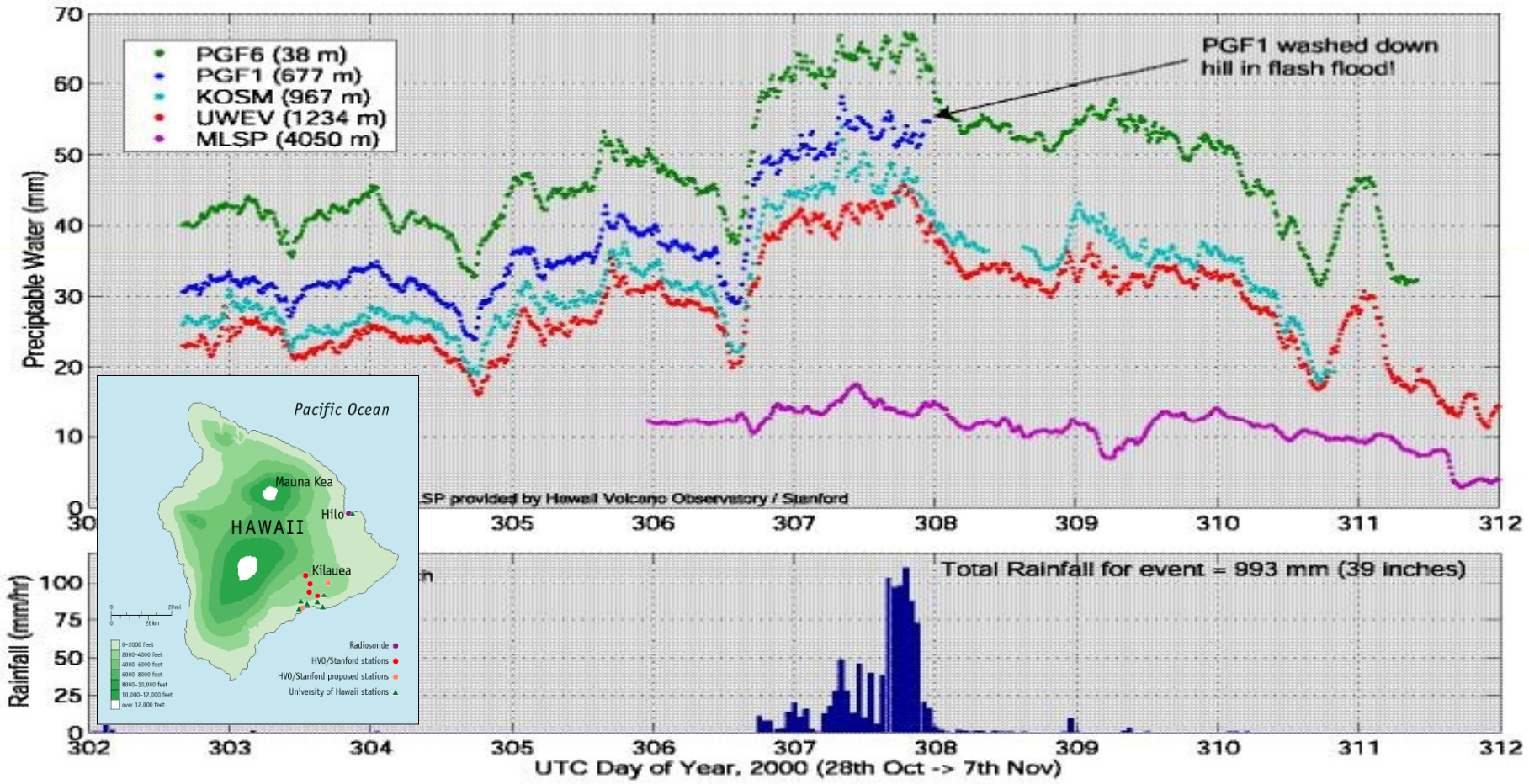
PWV vs actual Rainfall



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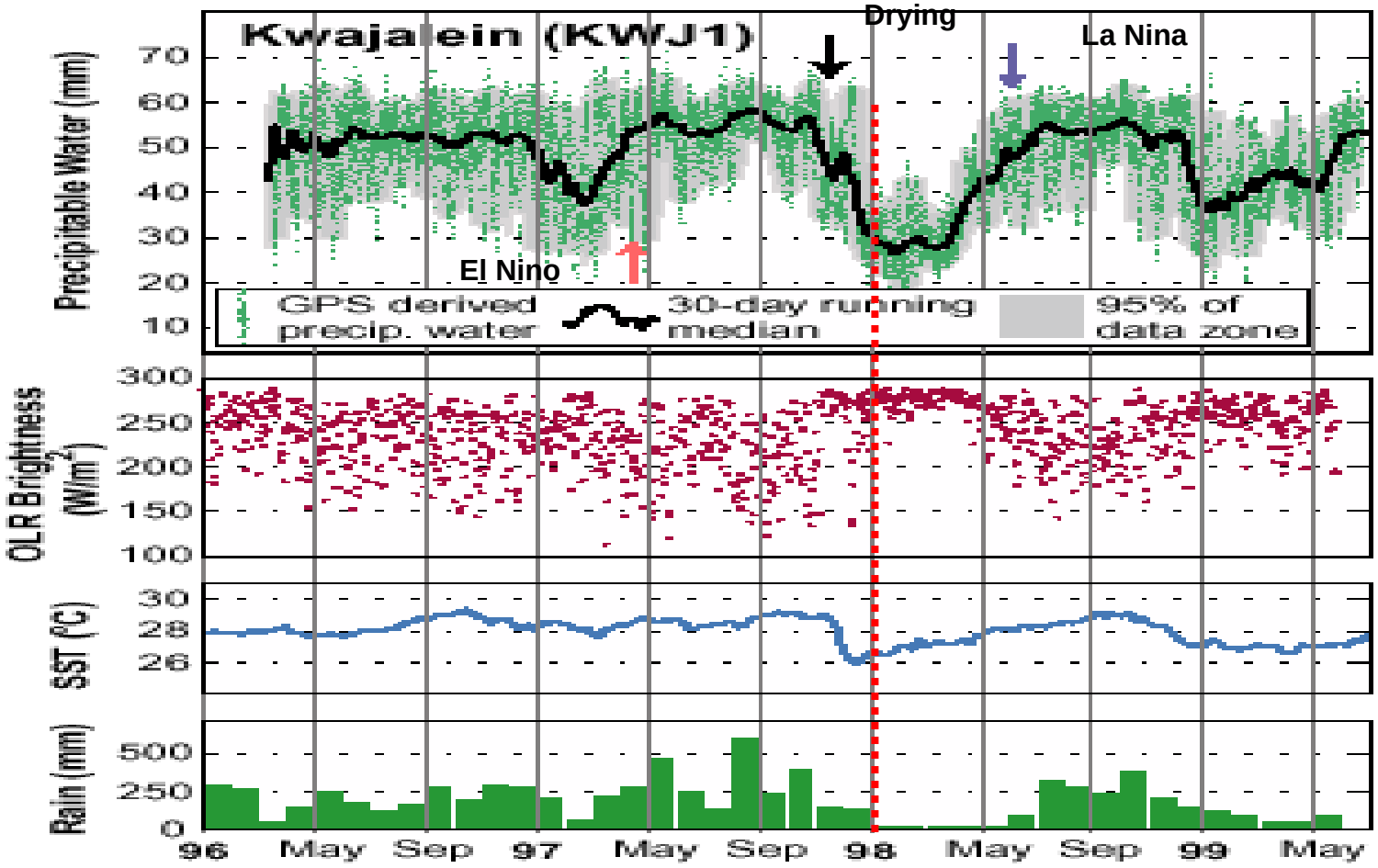
IPWV vs actual Rainfall



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Real-Time GPS Meteorology

Project for

IMD

MADE TO MEASURE

NOAA Forecast Systems Laboratory
325 Broadway R/FS3
Boulder CO 80305

http://gpsmet.noaa.gov

FORECAST SYSTEMS LABORATORY
BOULDER, COLORADO

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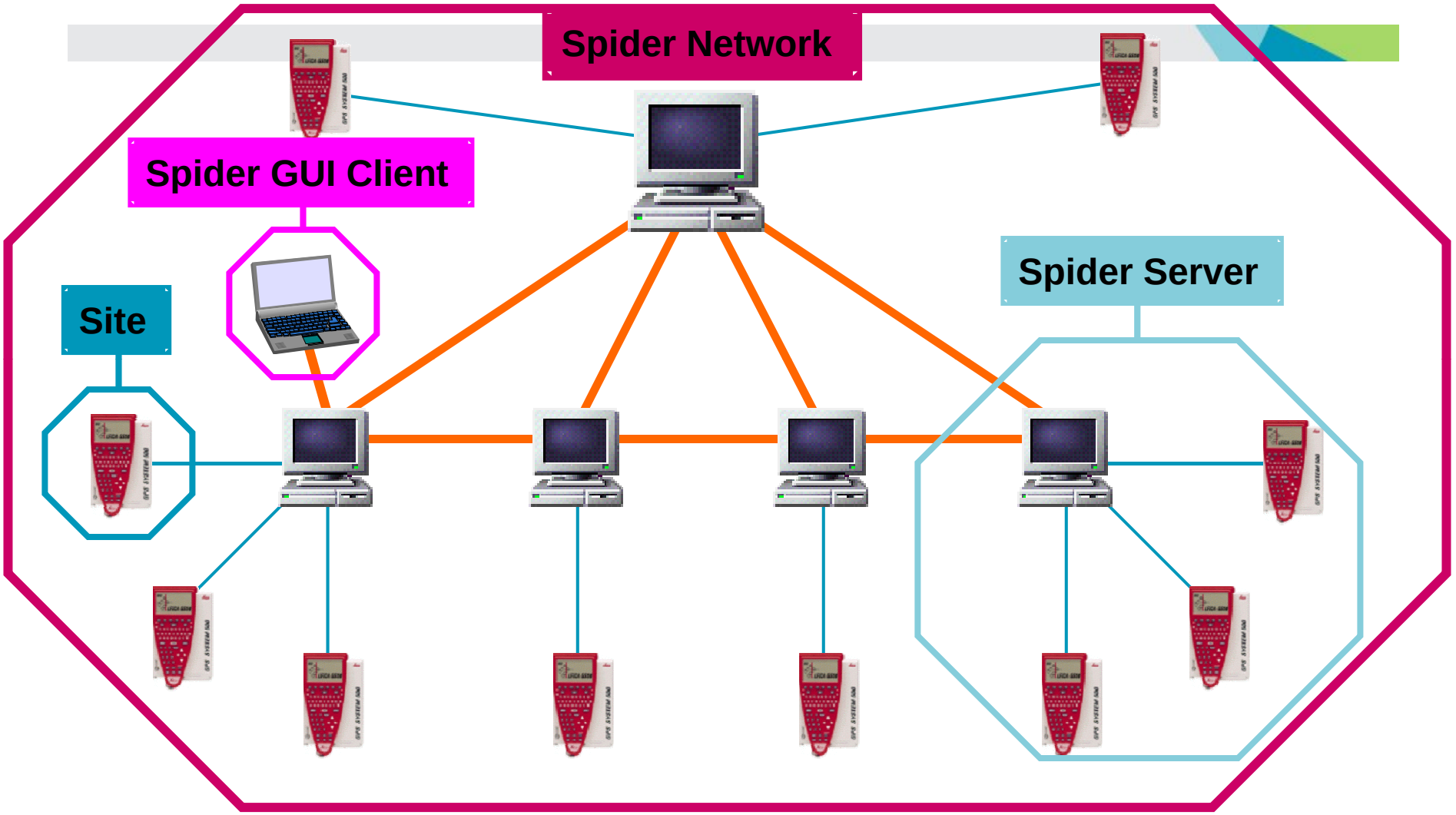
Reference station Network



Computer - GPS Sensor
Transfer of Data
Sensor Configuration
Status Info from Sensor

Computer - Computer
Transfer Database Information
Sever / Client connection

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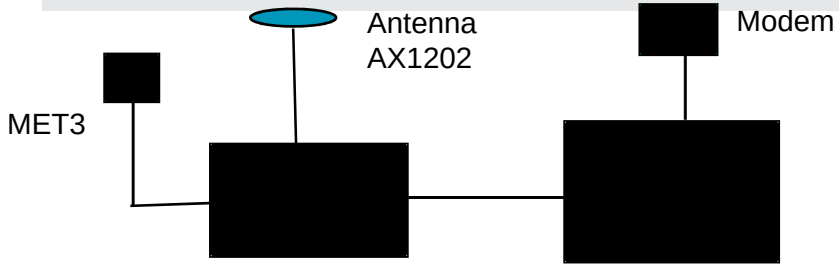
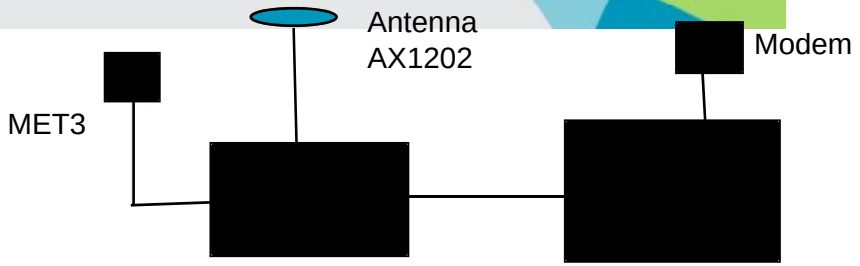
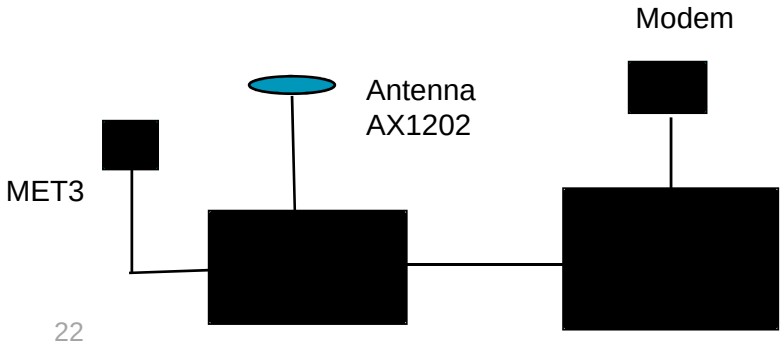
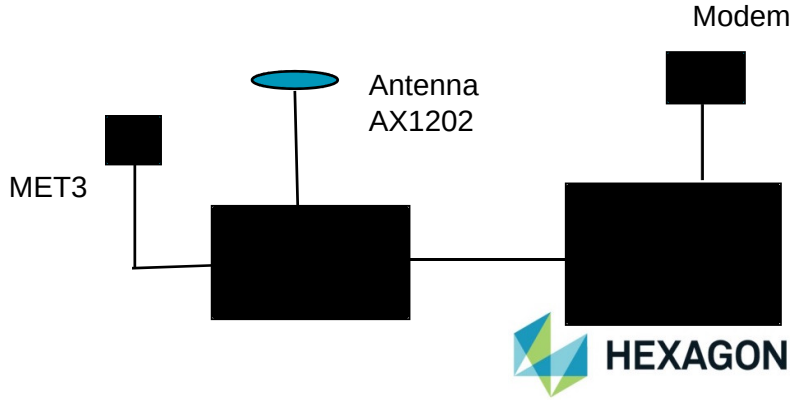
BLOCK DIAGRAM









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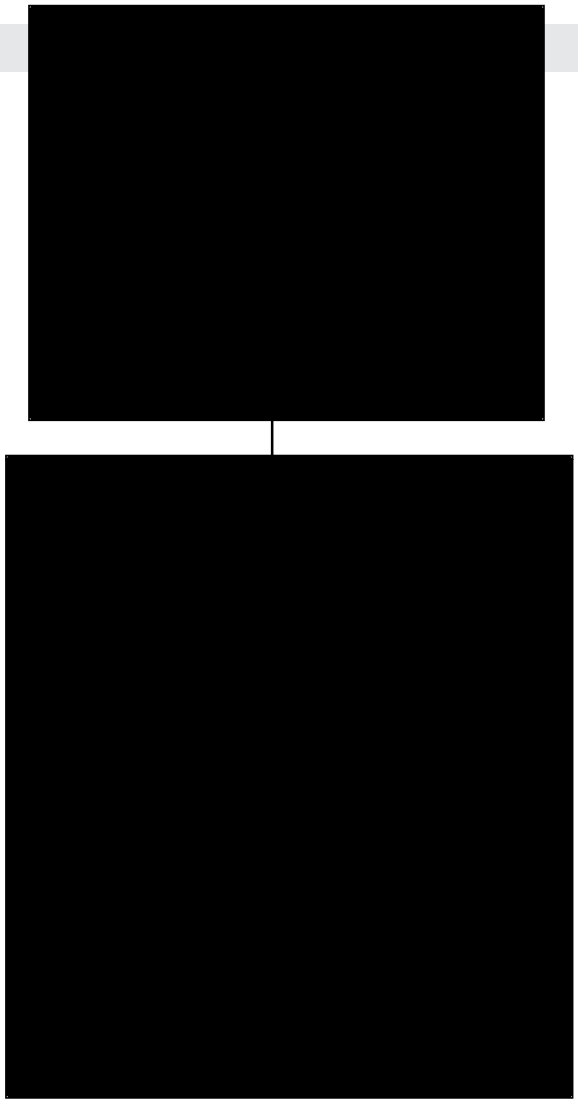
BLOCK DIAGRAM



SITE PC

CENTRAL
PROCESSING CENTER

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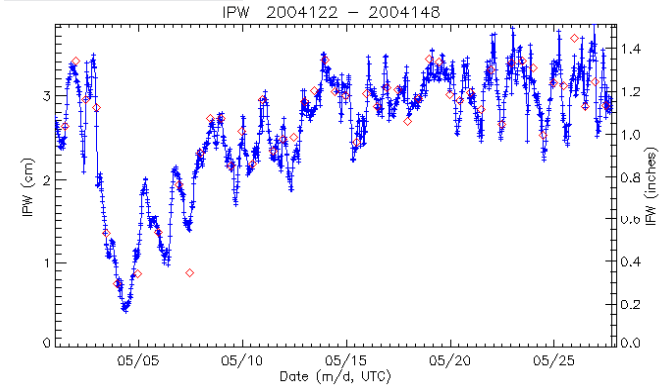
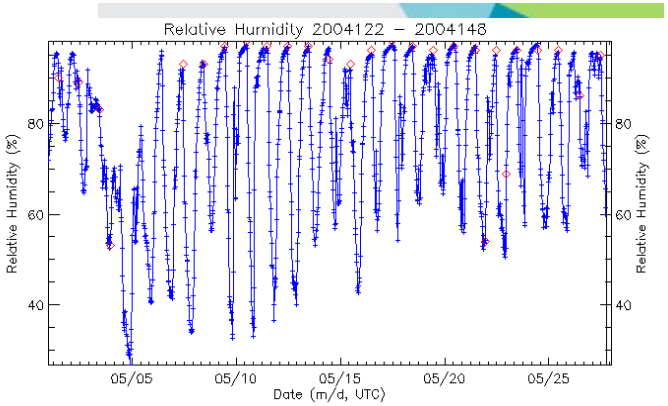
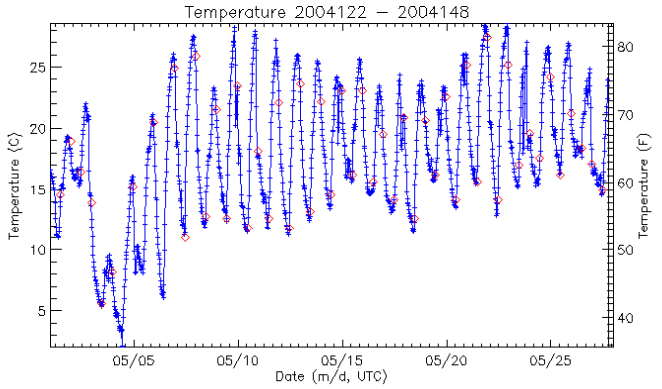
Standard GPS-Met NRT Products

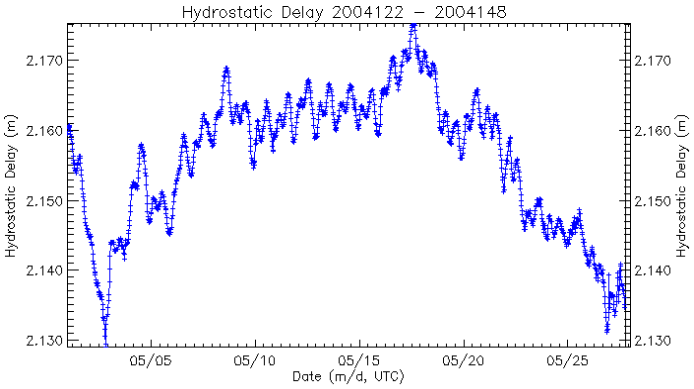


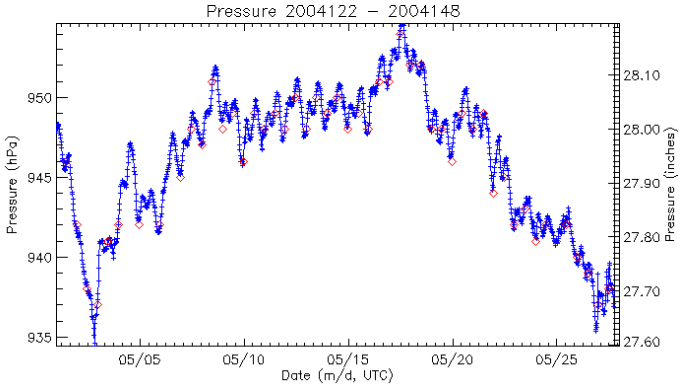


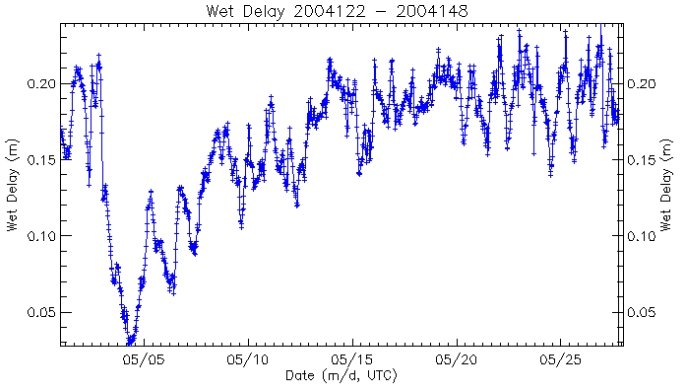


Blacksburg, VA

◇ Data from RNK UA Site







Automatic Weather Station

Basic Automatic Weather Station is shown in above picture.

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Micrometeorology Tower

50 meter tower based Micrometeorology Station is shown in above picture.

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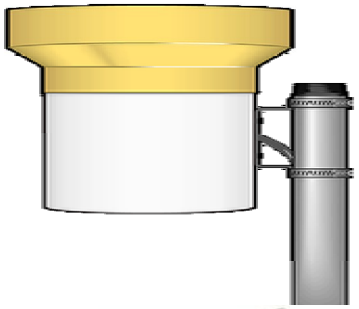
AWS components

- Data Acquisition System/ Data Loggers
- Air Temperature & Relative Humidity Sensor
- Wind Speed & Wind Direction Sensor
- Rain Gauge Sensor
- Solar Radiation Sensor
- Barometric Pressure Sensor
- And many more



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Advanced Equipment

- Ceilometer: for Cloud Height Measurement on LIDAR Principal.

- Present Weather Sensor: for measurement of different parameters of precipitation Like, particle size, velocity, Intensity and precipitation type.

- Doppler Weather Radar

Thank You

Please visit Booth number 7

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