

**Joint Short Range Wireless and Wireless Sensing SIGs  
“Sensing from Radio”**

## **Utilising Throaway Data for Sensing Applications**

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or

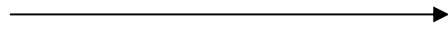
# Research projects at University of Colorado

- Measuring Snow Depth with GPS Receivers.
- Sensing vegetation growth with reflected GPS signals.
- Use of GPS receivers as a soil moisture network for water cycle studies.

# The concept

- Using waste data from the GPS.
- When a wave leaves a GPS satellite heading for a receiver, not all of it reaches the antenna directly. Some of it bounces off the ground around the actual antenna.
- This “multipath” signal could yield valuable information about the surfaces it’s hitting.

# The concept



**Low cost**

**Less development time**

**Enable completely new applications**

**“Sensing vegetation growth with reflected GPS signals”, Small, Eric E.; Larson, Kristine M.; Braun, John J. Geophysical Research Letters, Volume 37, Issue 12.**

# Sensing vegetation growth with reflected GPS signals

- The results of this project show that GPS multipath is sensitive to plant growth in vegetation types that together cover a majority of the Earth's land surface, including cropland, grassland and shrubland.
- These are environments where optical remote sensing data is complicated by soil reflection, so the information provided by microwave remote sensing is particularly useful.

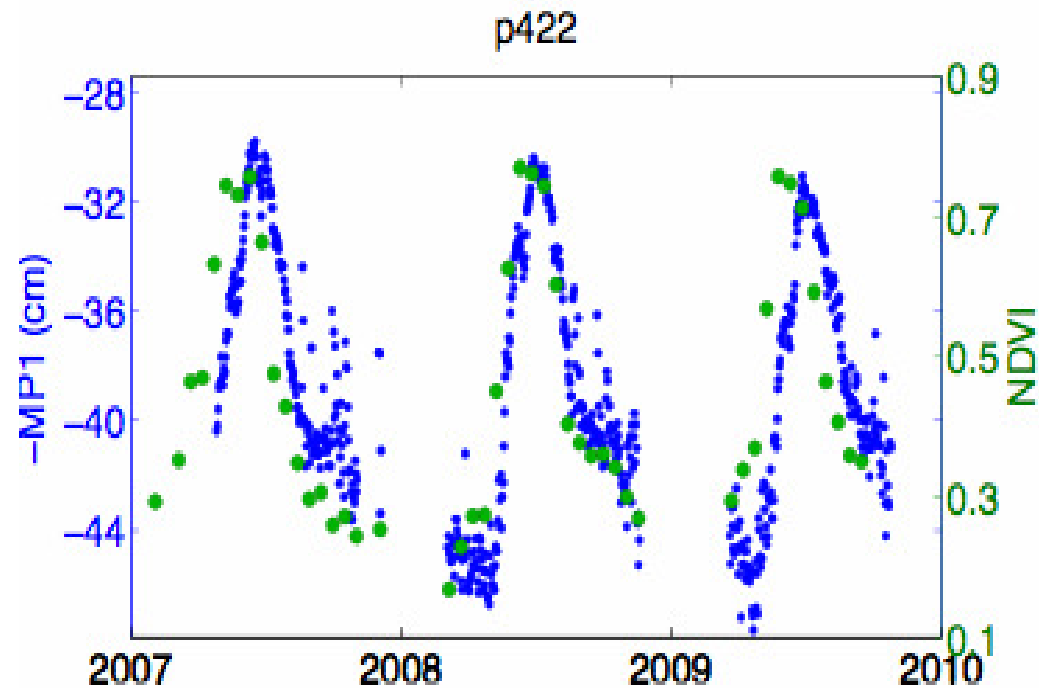
# Sensing vegetation growth with reflected GPS signals

- In this project GPS multipath amplitude variations can be used to estimate biophysical parameters. The dataset is from continuously operating GPS sites that were primarily installed for geophysical studies.



- As vegetation grows, reflected GPS signals are reduced.

# Sensing vegetation growth with reflected GPS signals



# Use of GPS receivers as a soil moisture network for water cycle studies

- Larson, K.M., E.E. Small, E. Gutmann, A. Bilich, J. Braun, V. Zavorotny, Use of GPS receivers as a soil moisture network for water cycle studies, *Geophys. Res. Lett.*, 35, L24405, doi:10.1029/2008GL036013, 2008.

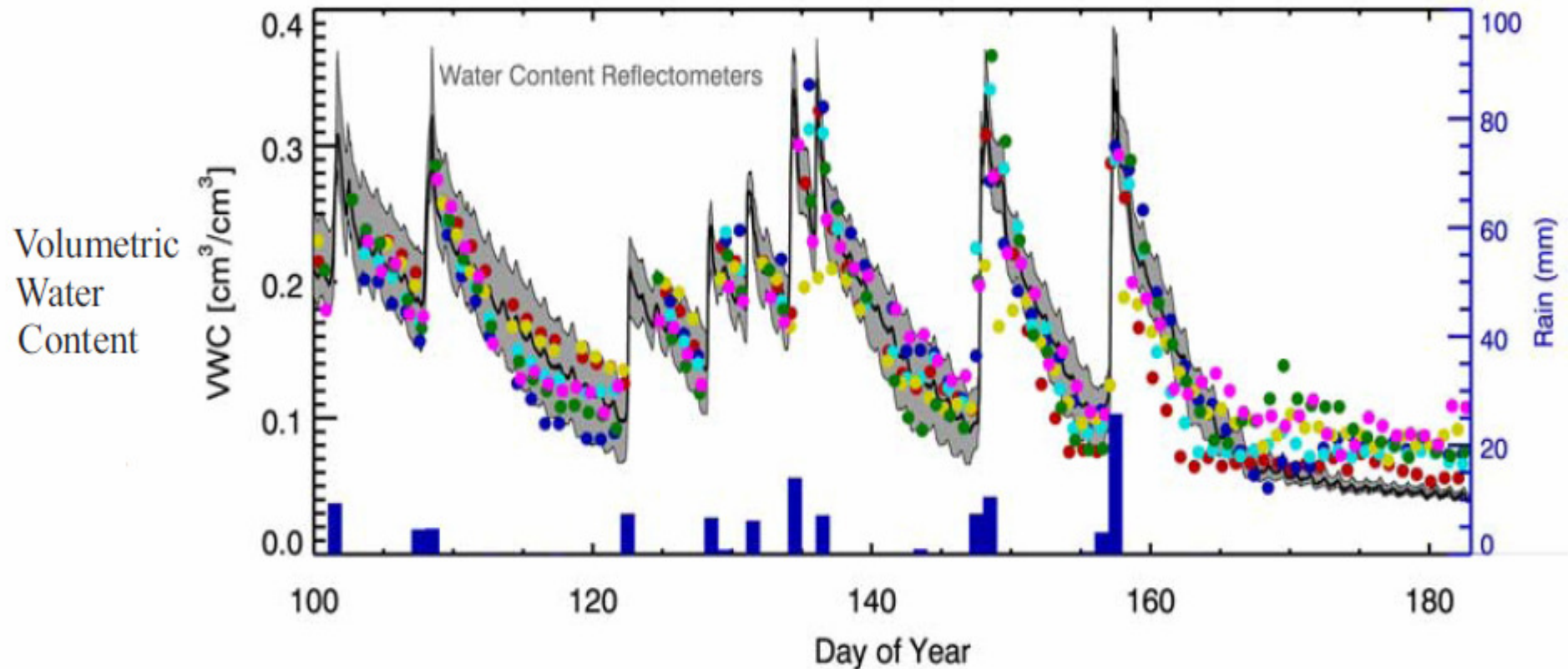
# Use of GPS receivers as a soil moisture network for water cycle studies

To date, a global soil moisture dataset that fulfills the needs of the hydrology and climate communities does not exist.

Recently, it has been shown that high-precision GPS receivers can be used to estimate fluctuations in near surface soil moisture over an area of ~1000 sq. meters.



# Use of GPS receivers as a soil moisture network for water cycle studies



Variation in VWC from multiple GPS satellites and water content reflectometers (WCR). The range of the five WCRs The daily precipitation totals are in blue. GPS measurements are only shown on days when there was no snow and the daily average temperature was above 3°C.

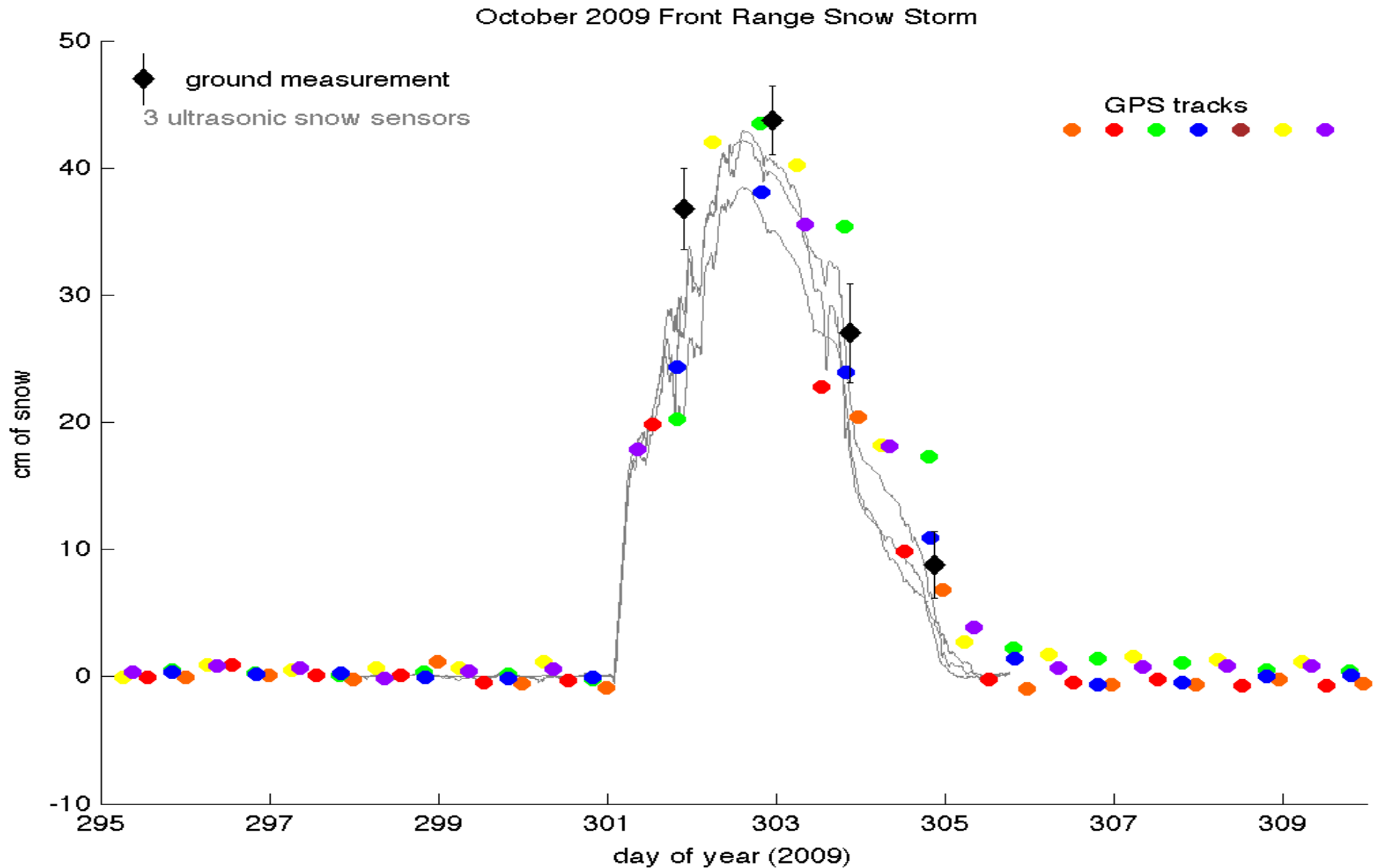
# Measuring Snow Depth with GPS Receivers

Larson, K.M., E. Gutmann, V. Zavorotny, J. Braun, M. Williams, and F. Nievinski, Can We Measure Snow Depth with GPS Receivers?, *Geophys. Res. Lett.*, 36, L17502, doi:10.1029/2009GL039430,2009.

# Measuring Snow Depth with GPS Receivers

- The GPS data are available on a daily basis from network of existing GPS sites, and therefore are particularly useful for validation of remote sensing products.





***GPS estimates of snow depth compared with ultrasonic snow depth sensors and ground measurements (people using a meter-stick).***