

# Investigating the Advantages of using a Multi-parameter Approach to Derive Automated Snowfall Measurements

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# Objective

- Ultrasonic Snow Depth Sensors (Campbell Sci. SR50) are one of the most commonly used in-situ technologies used to measure Snow Depth (SD) and Snowfall (SF) – differential of SD over time.
- Problem: There are often uncertainties as to why SD changes occurred (blowing snow, etc). – Gregory Tripoli's talk
- Problem: The SR50 SD reading are point-oriented distance-to-target measurements. Therefore using one SR50 measurement may not accurately reflect the changes in SD. – Craig Smith's talk



# Objective

- Working Hypothesis: Using a triple configuration of SR50's, a consensus of changes in SD measurements over time can be used to derive a SF measurement with better confidence in its' accuracy.
- A Geonor Total Precipitation Gauge is used to help verify that observed changes in SD occurred during periods of precipitation.
- This approach should work operationally over short "time scales".



# Overview of the S3-1 Algorithm

- Algorithm methodology similar to NCDC algorithm for Geonor Gauge (Baker et al. 2005).
- Begin at Time step zero
  - Record for each of the 3 SR50's
    - distance to ground measurements.
    - Also record weight of water collected by the Geonor.
  - Place into placeholders
    - SR50hold's.
    - Geonorhold.



# Overview of the S3-1 Algorithm

- Every subsequent 15 minutes
  - Take new reading
    - SR50.
    - Geonor.



# Overview of the S3-1 Algorithm

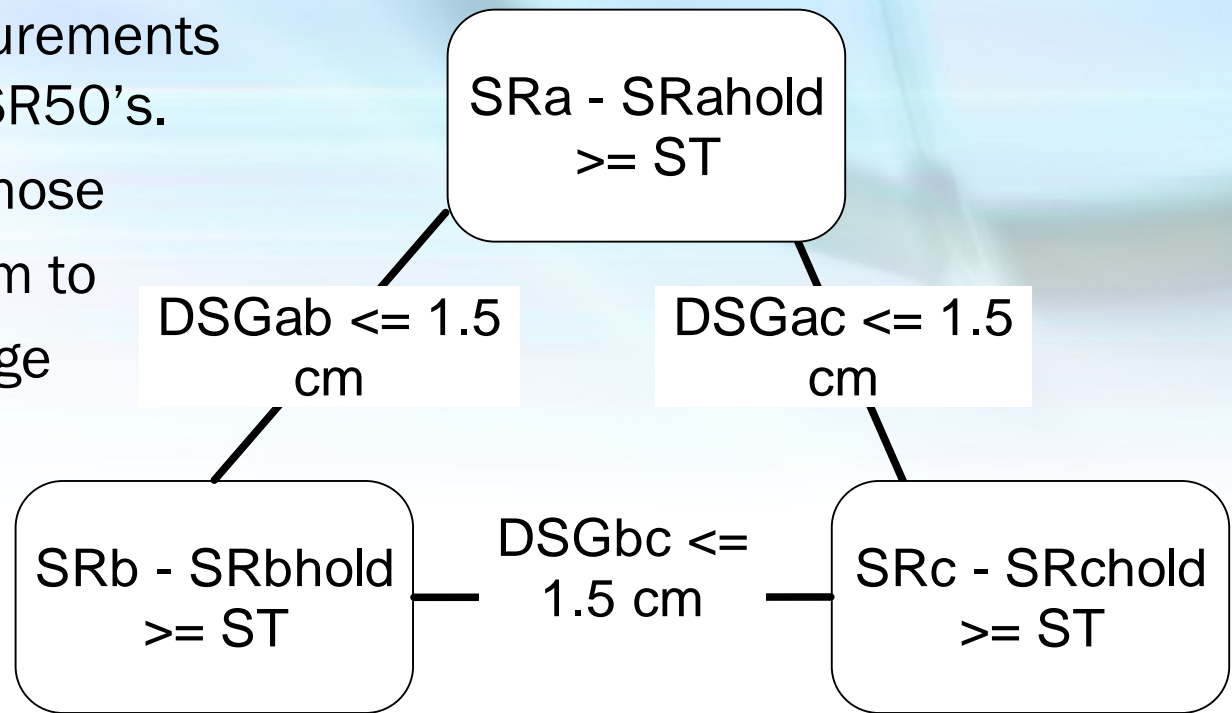
- Check if Snow on Ground (SOG) levels below each SR50 increased by at least 1 cm (Minimum SF Threshold; ST).
  - If at least 2 of 3 SR50's indicate SF then
    - Reset all SR50hold's to current measured values.
  - Check if Geonor Measurement is  $0.2 \text{ mm} > \text{Geonorhold}$ 
    - If Yes then algorithm says SF has occurred.
    - Reset Geonorhold.
    - Begin SF calculation.



# Overview of the S3-1 Algorithm

- Calculate the Difference in  $\Delta$ SOG (DSG) measurements between all three SR50's.
- Use only SR50's whose DSG's are  $\leq 1.5$ cm to construct an average SF value.

This identifies which of the readings are outliers.



# St. John's Airport (CYYT) Test Site



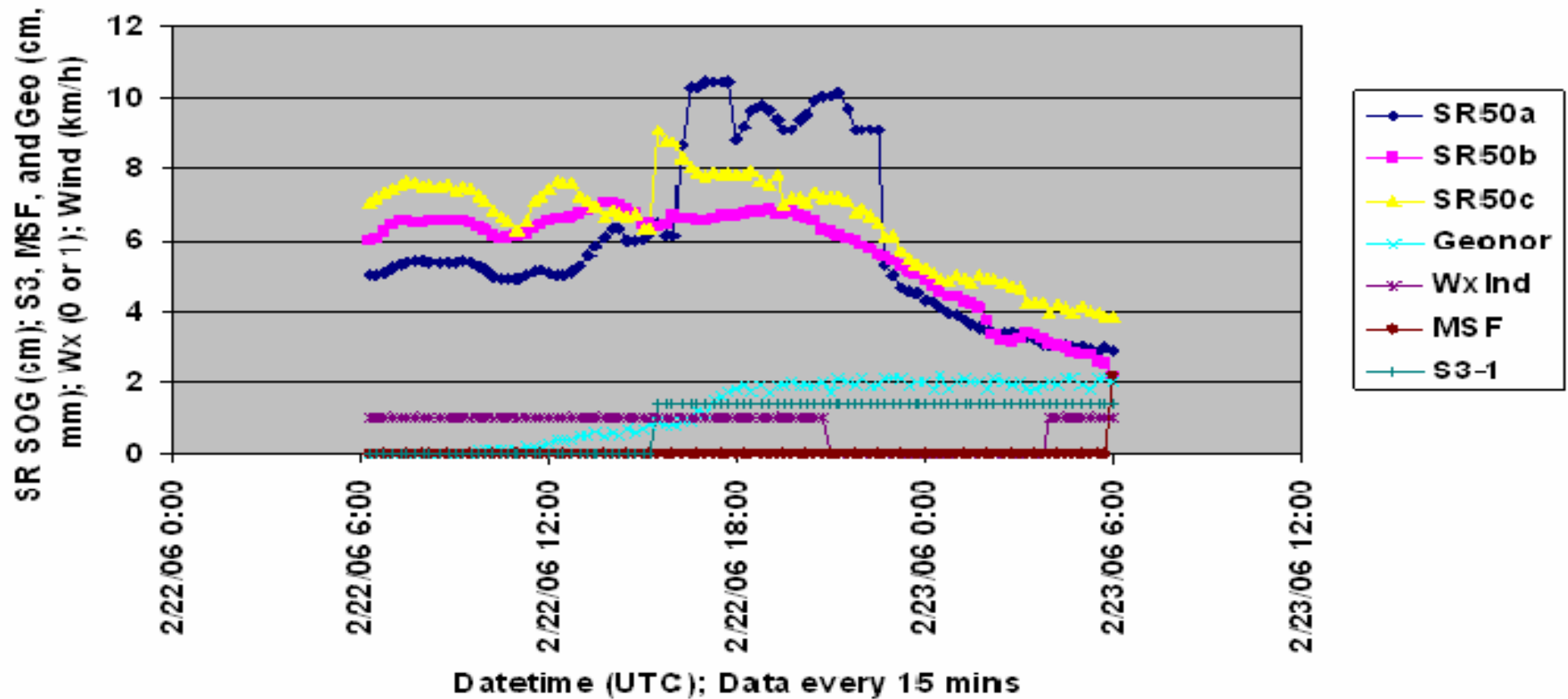
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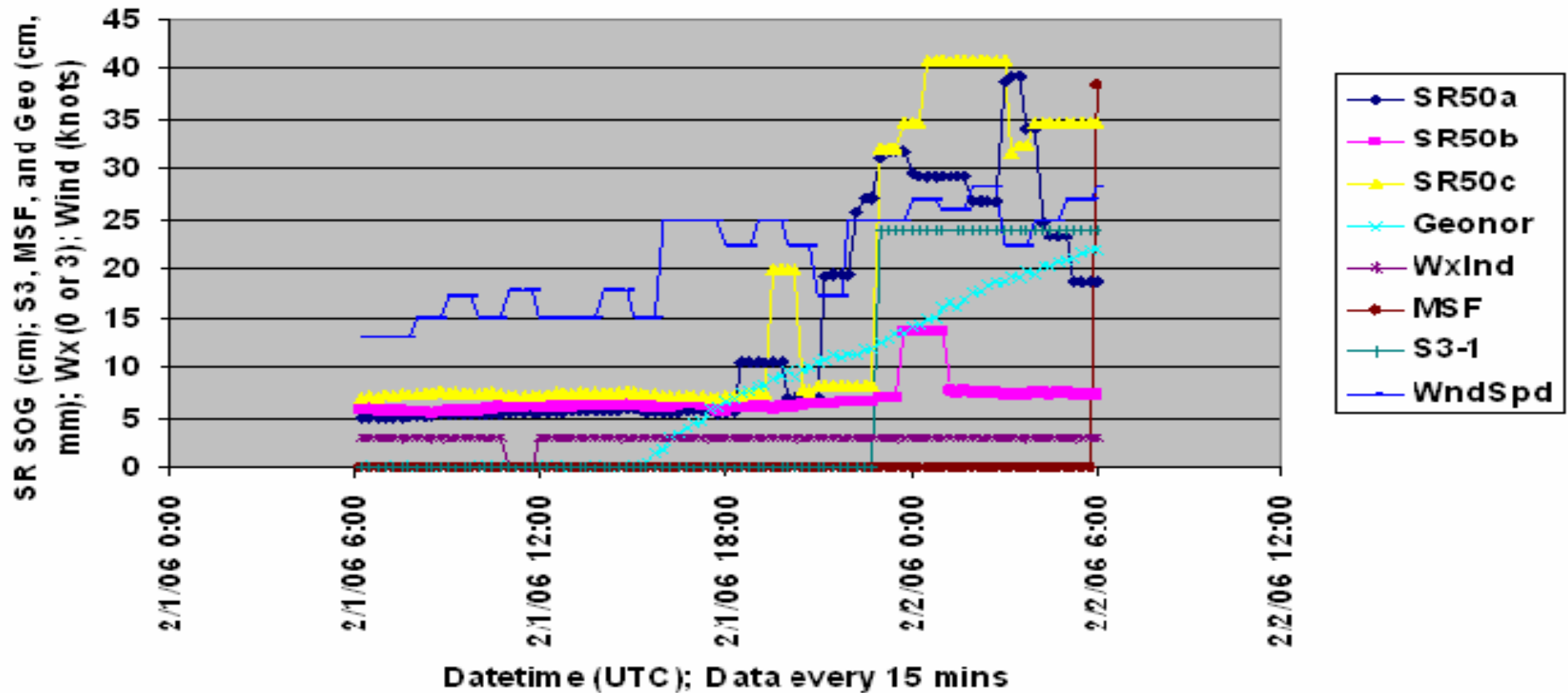
# Light Snowfall Case Study

YYT; 06 UTC 22 Feb 2006 to 06 UTC 23 Feb 2006

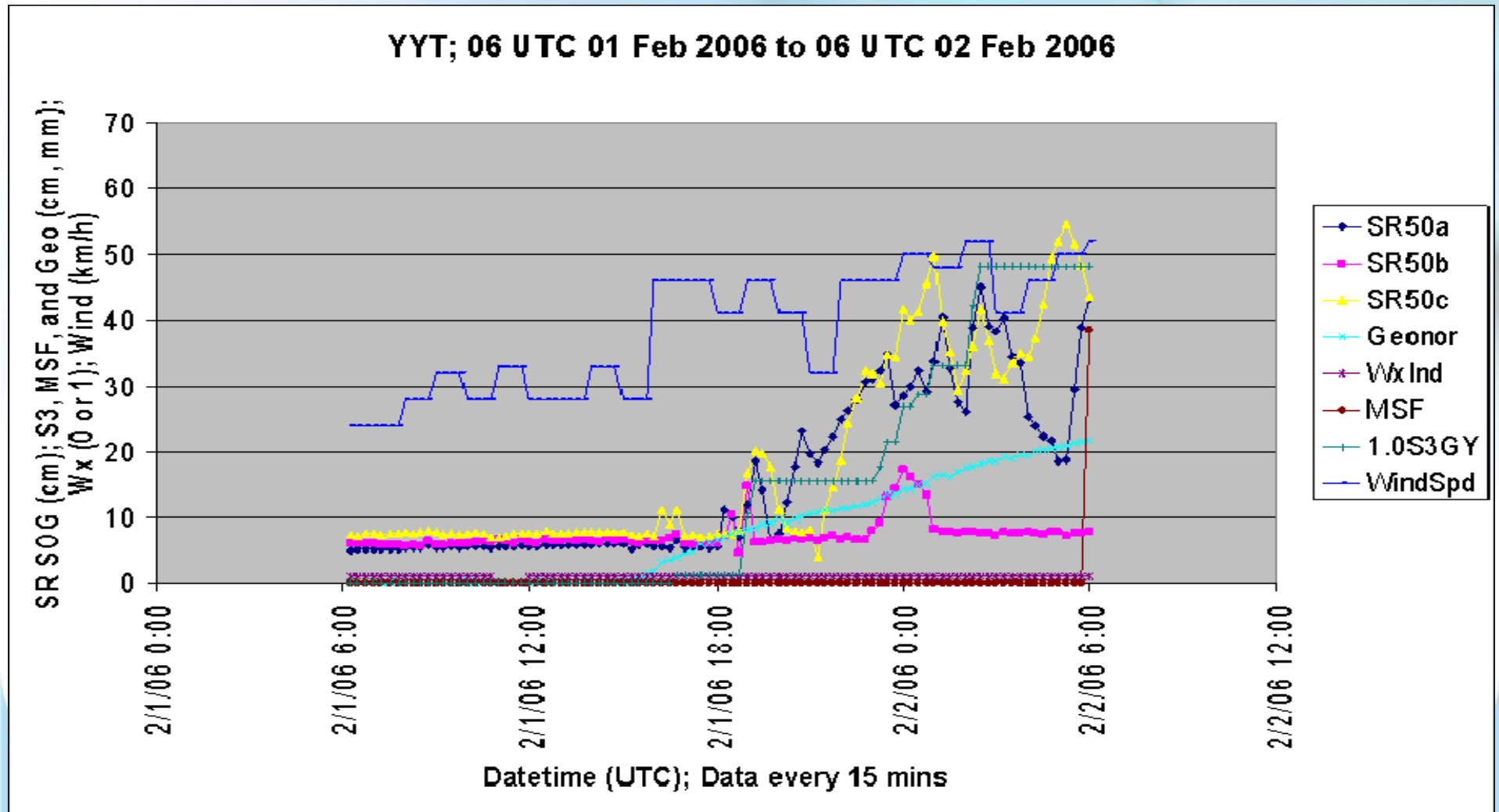


# Heavy Snowfall/High Wind Case Study

YYT; 06 UTC 01 Feb 2006 to 06 UTC 02 Feb 2006

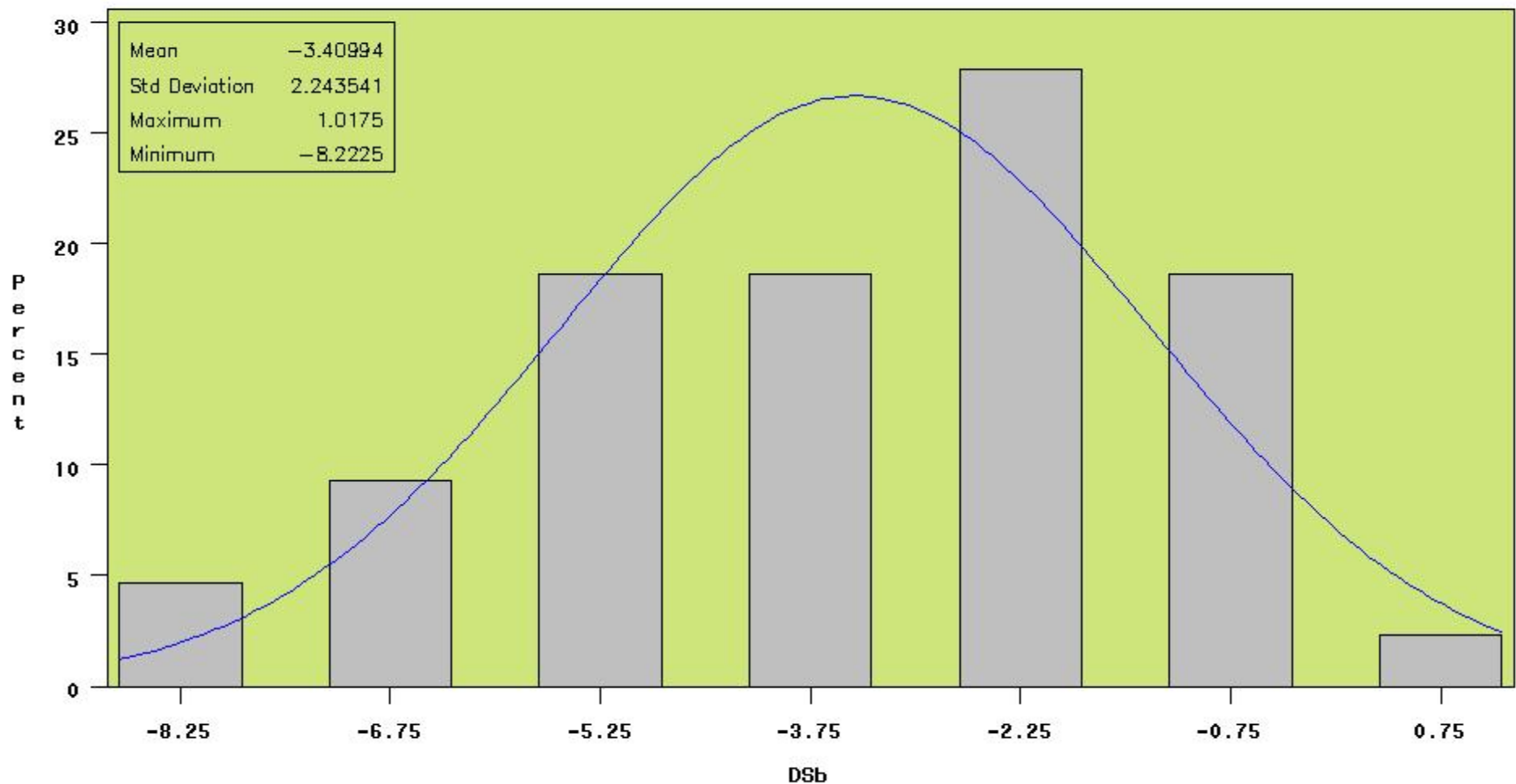


# Same Case Study as previous Slide (no averaging filter applied to SR50 data).



## (Human SD measurements – SR50b measurements). N=64

CYYT Histogram Diff. Human Measured Snowfall vs. SR50b



## CYYT Verification Statistics – 3% FAR

S3-1	CLASS	$\Sigma \frac{ MSF-S3 }{\text{Days (N)}}$	Days (N)
4 Min Av. used	ALL DAYS SF	3.58 5.21	67 45
*****	NO SF	0.24	22
4 Min Av. Not used	ALL N SF	6.62 9.62	67 45
*****	NO SF	0.47	22
SR50a Only (No 4 Min Av.)	ALL DAYS SF NO SF	96.09 128.67 29.44	67 45 22

# CYYT Verification Statistics – 3% FAR

S3-1	CLASS	$\Sigma \frac{ MSF-S3 }{\text{Days (N)}}$	Days (N)
Geonor	ALL DAYS	3.58	67
used	SF	5.21	45
*****	NO SF	0.24	22
Geonor	ALL N	4.46	67
Not used	SF	5.50	45
*****	NO SF	2.20	22

# Length of Model Time Steps used

S3-1	CLASS	$\Sigma \frac{ MSF-S3 }{\text{Days (N)}}$	Days (N)
15 minute	ALL DAYS	3.58	67
Time steps	SF	5.21	45
5 minute	ALL DAYS	3.56	67
Time steps	SF	4.90	45
1 hour	ALL DAYS	4.47	67
Time steps	SF	6.56	45

# Conclusions

- Using a triple configuration of SR50 Ultrasonic sensors statistically produces a more accurate SF value than just using the measurement from a single SR50 instrument.
- Using the Geonor as a precipitation verification check helps to minimize false reports of SF.
- The S3-1 algorithm performs better over shorter time scales (15 minute time steps versus 1 hour), owing to snow redistribution effects.



# Conclusions

- Filtering the SR50 data helps to minimize false reports of snowfall produced by the algorithm which were caused by either snow drift or poor return signals.
- However, filtering the SR50 data can also have the effect of removing the snowfall ‘signal’, and thus result in a less accurate total snowfall measurement.



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# Thank you!