# Howard University - Beltsville Site Report

***3rd GRUAN Implementation-Coordination Meeting***
*Queenstown New Zealand*
*28 February - 4 March 2011*

Presented by Belay Demoz
*Howard University, Washington D.C.*

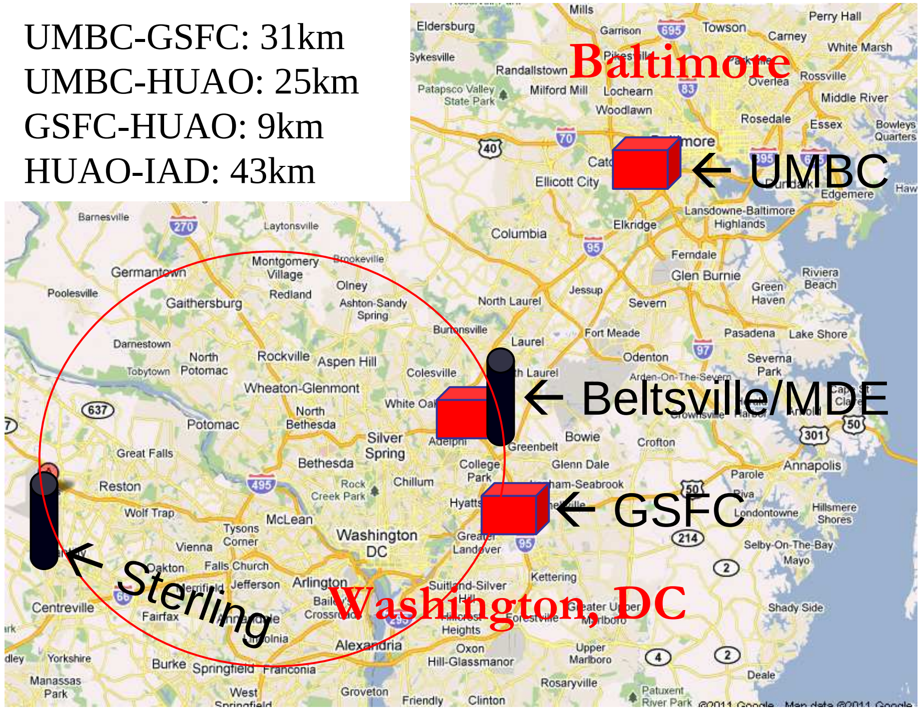
Contributions:
Howard University: D. Venable, E. Joseph,
NASA/GSFC: D. Whiteman, K. Vermeesch
NOAA: J. Facundo (NWS), J. Fitzgibon(NWS); T. Reale (STAR)

Acknowledgment:
*NASA Office of Education: NASA URC at Howard University*
*NASA Atmospheric Composition Program, Earth Science Technology Office - IIP*
*NOAA Center for Atmospheric Studies*

# Howard University Beltsville Campus

*Location and scientific opportunities*

UMBC-GSFC: 31km
UMBC-HUAO: 25km
GSFC-HUAO: 9km
HUAO-IAD: 43km




## *Uniqueness of Site*

- Semi-urban site
- Major Pollution corridor
- Integrate Science and Education
- Extensive instrumentation
- Inter-agency and inter-institute collaboration

# Content

- Routine measurements - 2010
- NDACC workshop: *Update*
- Trend analysis: *Update*
- Facility updates: *Mobile and Ground*
- Raman lidar Calibration: *Lamp calibration*
- GRUAN-NWS: “proximity” studies
  - Satellite
  - Temperature, Humidity, IPW: Preliminary work
- Radiometer and wind study continues

# 2010: Routine Measurements?

***<u>Beltsville is currently NOT Nationally funded for GRUAN operations.</u>***

*We have funding from NASA to prepare for GRUAN implementation and for i<u>nstruments</u> that allow us to satisfy some GRUAN requirements.*

Beltsville Sounding Data, 2010 Statistics. All sondes were ***RS92-SGP with an EN-SCI model ECC Ozone sensor (+ several days of InterMet, a lot of lidar water vapor, and lidar wind work)***

- number of soundings: **72**
- number of days with launches: **34** *(34 weeks?)*
- number of ozone soundings: **22**
- number of days with ozone soundings: **14**

***We are about ready to try out the GRUAN RSLaunch!***

# Updates on activity: Report

- **NDACC Water Vapor Raman Lidar Calibration Workshop**

  *(@ Greenbelt, MD May, 2010. lead: D. Whiteman)*

- **<u>Goal was to review Water vapor profile accuracy needs</u>**
  - Trend detection (D. Whiteman)
  - Satellite Validation (T. Reale)
    - *15% accuracy minimum throughout troposphere*
    - *5% for total column water (* NB: other work indicates higher accuracy required *(~5%) in UTH for forward model validation. (AFWEX: Ferrare, 2003; Whiteman et al. 2006)*
  - Mesoscale meteorology (B. Demoz)
    - *10% with emphasis on the lower to middle troposphere.*
    - *Boundary layer height detection important*

# Update: Trend Analysis

- Based on ARM/SGP analysis of sonde data, maximum likely noise contribution in the UT is ~25% and "years to detect trends" was discussed in ICM3 *(TT3 work for details)*
- Important to *increase the frequency* of measurement than to decrease the instrumental uncertainty

**Years to Detect Trends**

***(see TT3 work for updated Numbers)***

| Freq. | GRUAN sensor | 10% sensor | 15% sensor |
|---|---|---|---|
| Daily | 18 | 18 | 19 |
| Every 4 days | 22 | 23 | 23 |
| Monthly | 36 | 38 | 39 |

- ➔ Lidar can "increase the frequency" by a lot; 1-miute
- ➔ ARM/SGP has data that goes to 1996.
- ➔ Lidar error budgets are "better" understood than sonde
  - ➔ Work is in progress on this.
  - ➔ Desire to incorporate more realistic effects of gaps, recalibrations, etc into trend studies.

# GRUAN-use Facility and IOP

- ALVICE: *Mobile Lidar Laboratory*
  - Raman water vapor, aerosol, cloud lidar
  - RS92 and CFH launch capability, GPS
  - THRef Surface with sonde ventilation capability
  - *Research to establish an absolute, Self calibrated Mobile Raman lidar!*

*Field Trips:*

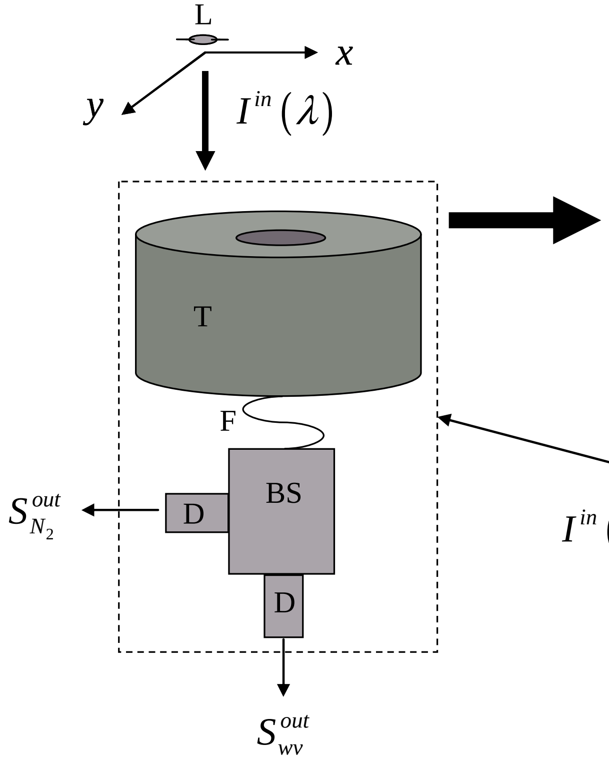
  - MOHAVE_2009 (Oct, 2009)
    - ***http://tmf-lidar.jpl.nasa.gov/campaigns/mohave2009.htm***
    - ***Estimate the capability of the Raman lidar in detecting UTH changes***
  - University of Western Ontario (July – August, 2011)

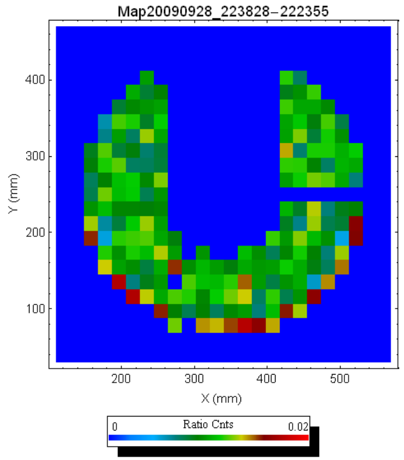
- Beltsville: *Ground site*
  - Multi-Sonde capability: *(InterMet, RS92, CFH, Modem, soon LMS + GRAW)*
  - “DABUL” (MPL-like) 24/7 lidar + Ceilometer
  - Reference HURL Raman calibration work

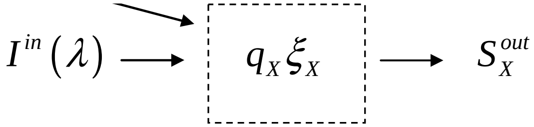
*Upcoming IOPS:*

  - WAVES_2011 (March – April, 2011)
  - Summer BCCSO and DISCOVER-AQ

# Lamp Mapping Technique - Use of a Scanning Standard Lamp Technique for Direct Determination of Water Vapor Mixing Ratio Calibration Factor for HURL




$$S_X^{out} \rightarrow f\left(q_X, \xi_X, I^{in}(\lambda)\right)$$

- Vapor calibration factor $C_R$ depends
  - **Optical efficiency (κ),**
  - **Diff. scattering cross section (dσ/dΩ) and**
  - **Band pass filter shape (ε)**
- Overall efficiency determined by comparing Mapping Experiment throughput of the $N_2$ and *wv* channel.

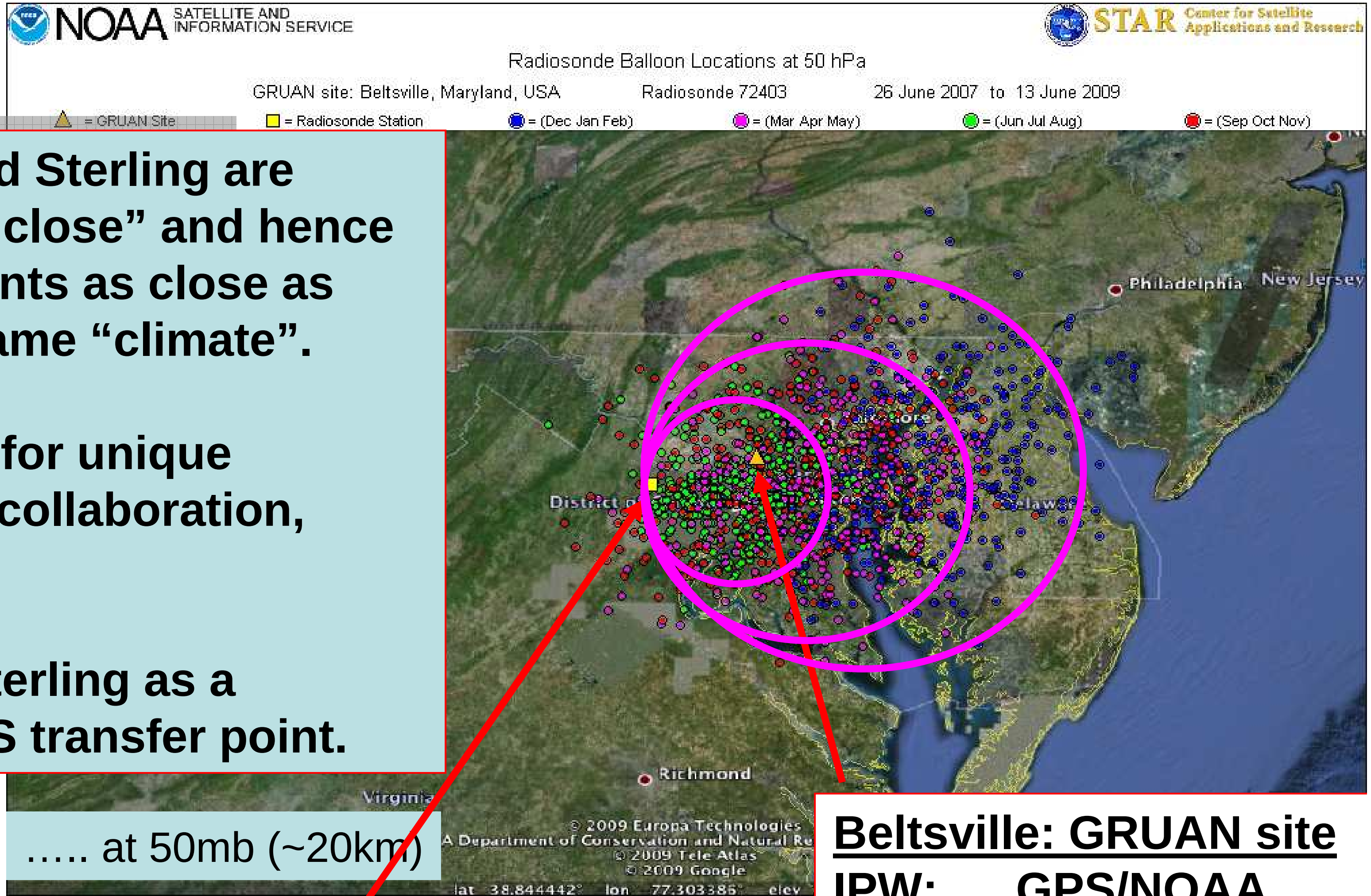
| $C_R$ Mapping Exp | $C_R$ RS92:Lidar |
|---|---|
| 187.8 ± 13.7 g/kg | 192.9 ± 8.7 g/kg |

## Summary

- **Short term repeatability w/ and w/o repositioning of stage better than ~0.2%**
- **Relative error when averaging over full scan is ~1 – 1.5%**
- **Long-term relative error in mean of scanned values ~1 – 1.5 %**
- **Long-term relative error in extreme values for individual cells ~ 2%**
- **Largest error due to 10% uncertainty in cross sections (Penny & Lapp; Avila)**
- **Ignoring cross section errors, one can obtain 3% relative uncertainty in $C_R$ with careful optical filter characterization!!**

# Sterling Balloon drift over Beltsville.

*Courtesy of Tony Reale*




- **Beltsville and Sterling are "sufficiently close" and hence data represents as close as you get to same "climate".**
- **Opportunity for unique interagency collaboration, Education**

**➔Beltsville/Sterling as a GRUAN-NWS transfer point.**

….. at 50mb (~20km)

**<u>Sterling: NOAA/NWS Site</u>**
**IPW: GPS/NOAA**
**Sonde: RRS (2Xday)**

**<u>Beltsville: GRUAN site</u>**
**IPW: GPS/NOAA**
**MWR: 2 & 39 Channel**
**Sonde: GRUAN (Wkly)**
**Raman: HURL/ALVICE**

# Collaboration with Satellite Studies

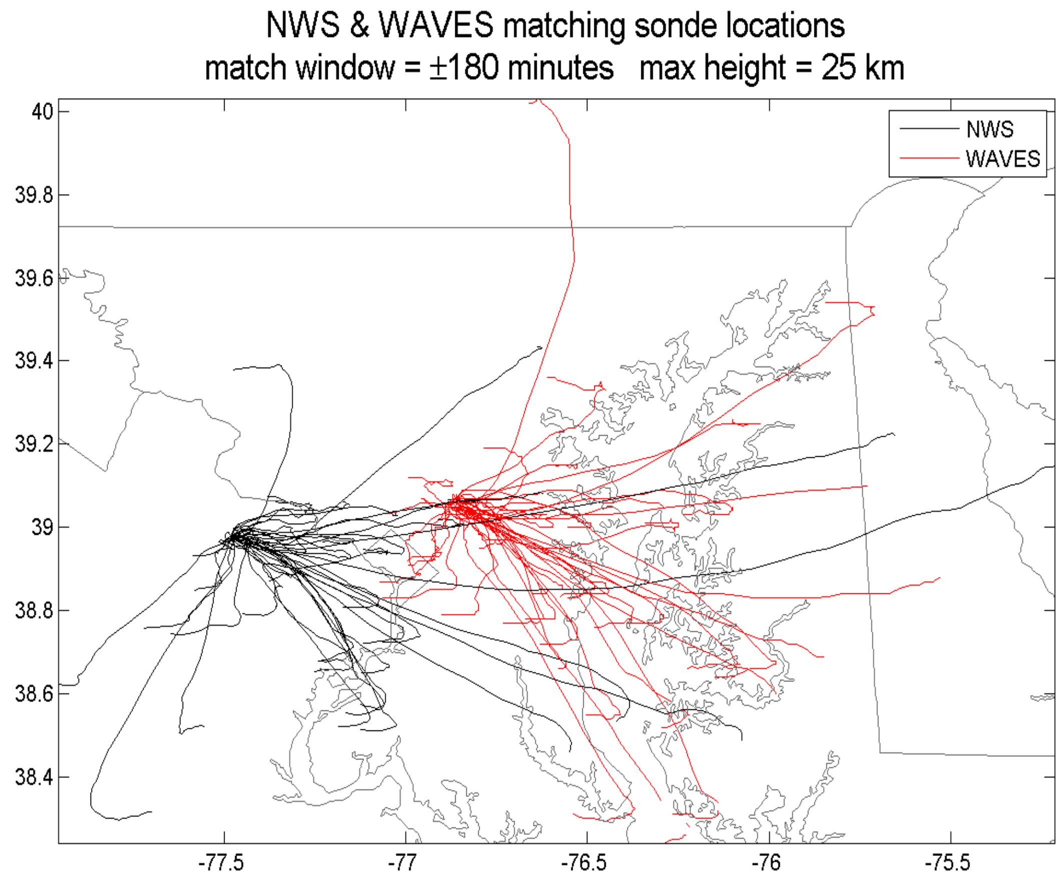
***(in Coordination with Tony Reale)***

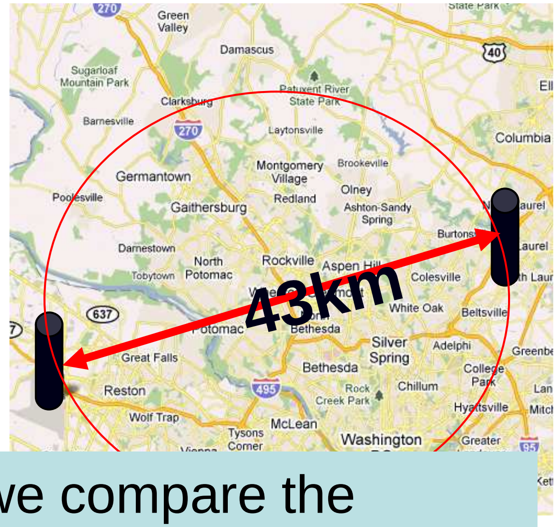
**Plan (evolving):**

- Quantify characteristic baseline differences between sondes (Sterling vs Beltsville) and among selected ancillary measurements at Beltsville and root causes.
- Compare temperature (T) and water vapor mixing ratio (MR) from both sites (sondes); and MWR and Lidar profiles from Beltsville.
- Identify sub-samples of NPROVS collocations of Sterling sonde and respective satellites and compare with matching Beltsville data.
- Characteristic sonde differences converted to MW radiance and respectively compared to respective satellite MW observations.
- “Quantify” Sterling-Beltsville variability and transfer of GRUAN references.

# Sterling/NWS Vs Beltsville

***Next 3 slides are Preliminary work on Sterling and Beltsville sonde/GPS comparisons.***

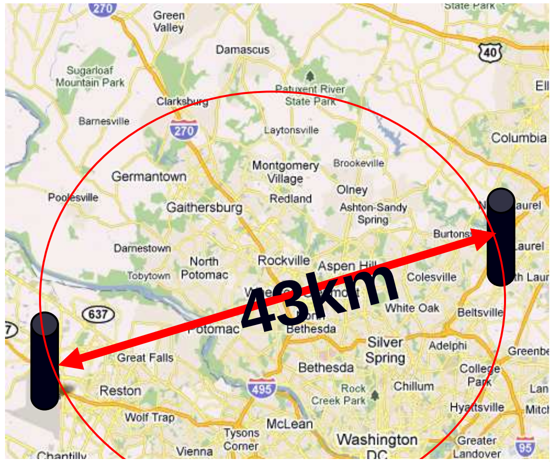



- How do we compare the stations?
- Do we need full overlap of sondes to be useful for comparisons?
- Dual sonde (RS92/RRS) planned.
- Direct comparisons of existing data has started.

- ***This may be useful "next step" in Dian/GATANDOR?***

# Sterling/NWS Vs Beltsville

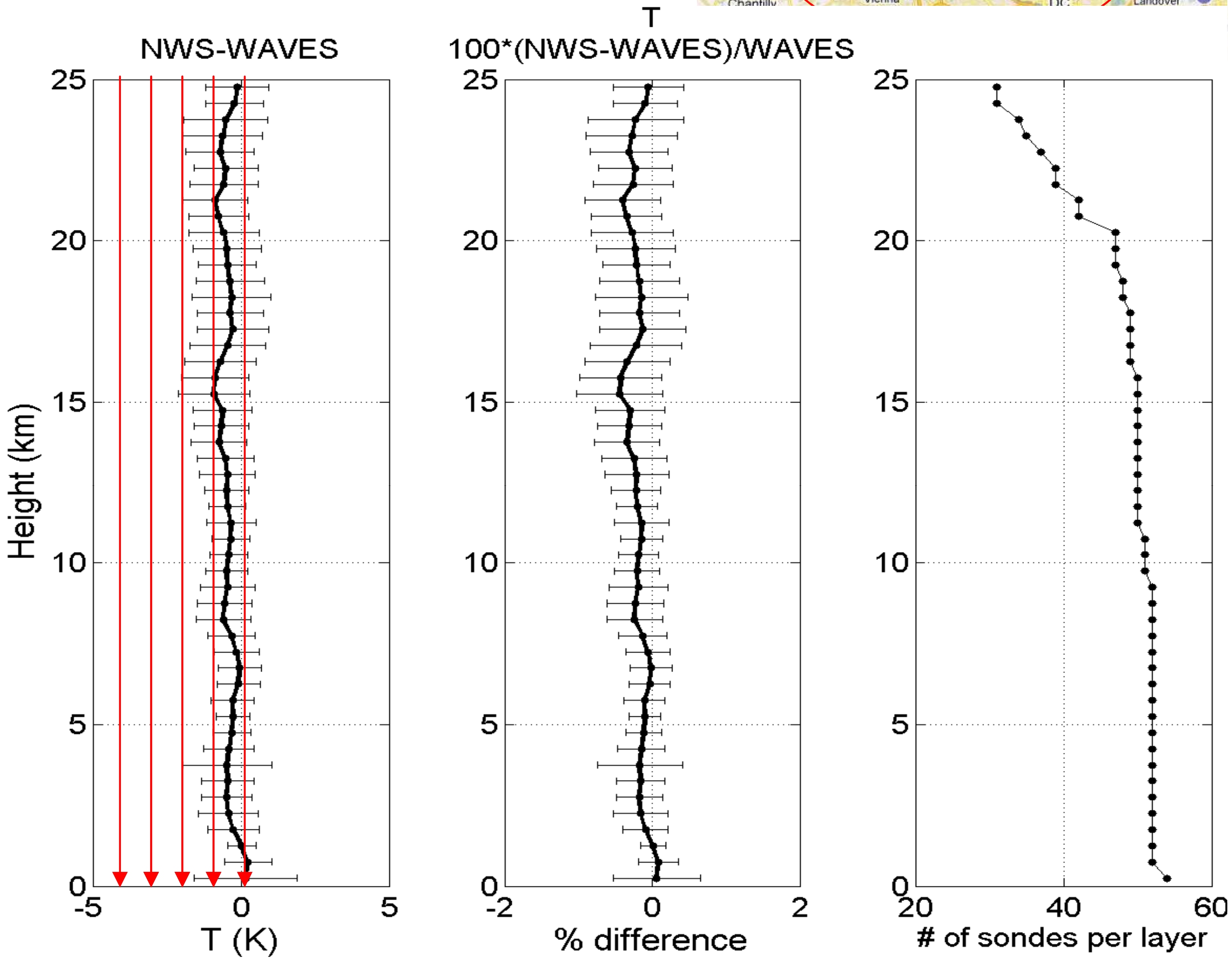



***Temperature Dif.***

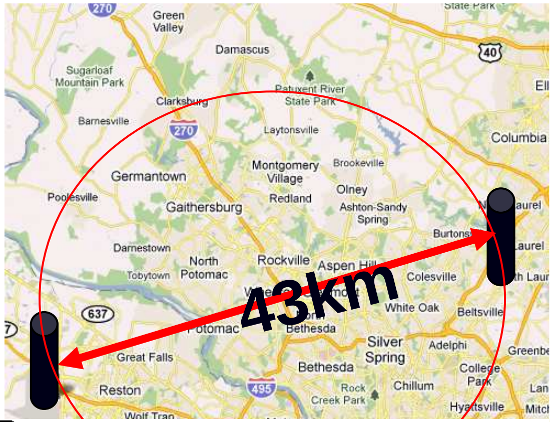
- Different types of sondes at both stations

➔ **Less than 1% diff.**

➔ **Plan to continue to do this by season.**



# Sterling/NWS Vs Beltsville



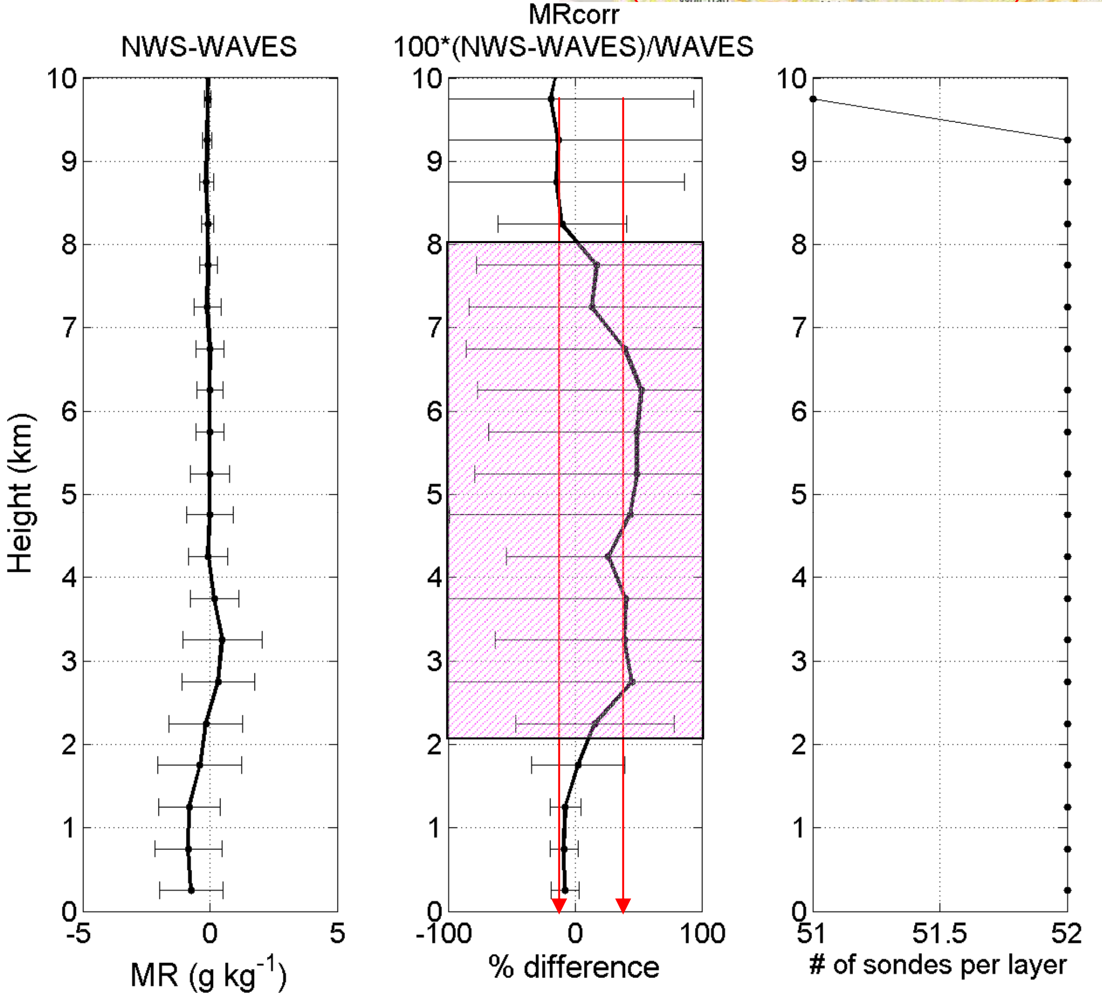

## ***Mixing Ratio Dif.***

- **Diff. types of sondes (RRS vs RS92)**

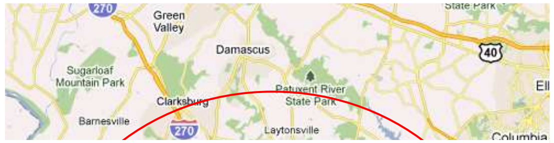
➔ **Diff. of 50% from 2-8km. Note the region we expected.**

➔ **Contribution to IPW is small. "Scaling" may not work.**

➔ **Plan dual sonde (RRS/RS92) flights.**

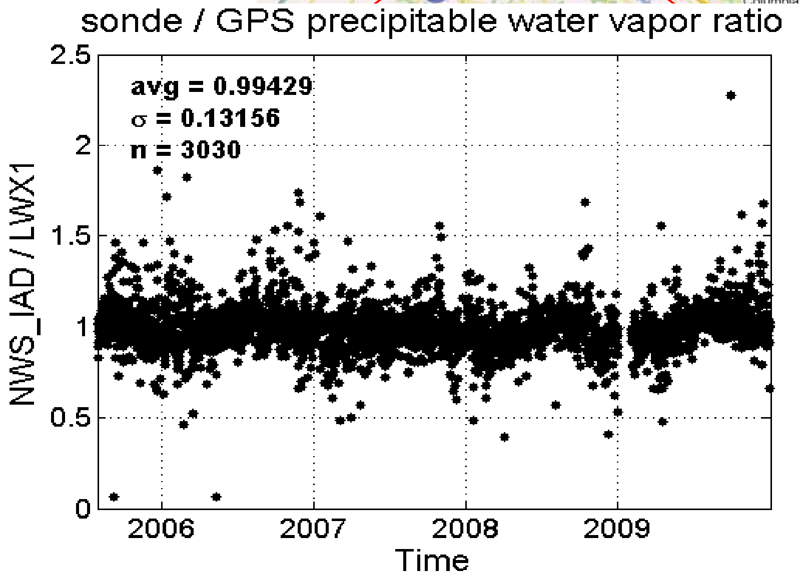


# Sterling/NWS Vs Beltsville

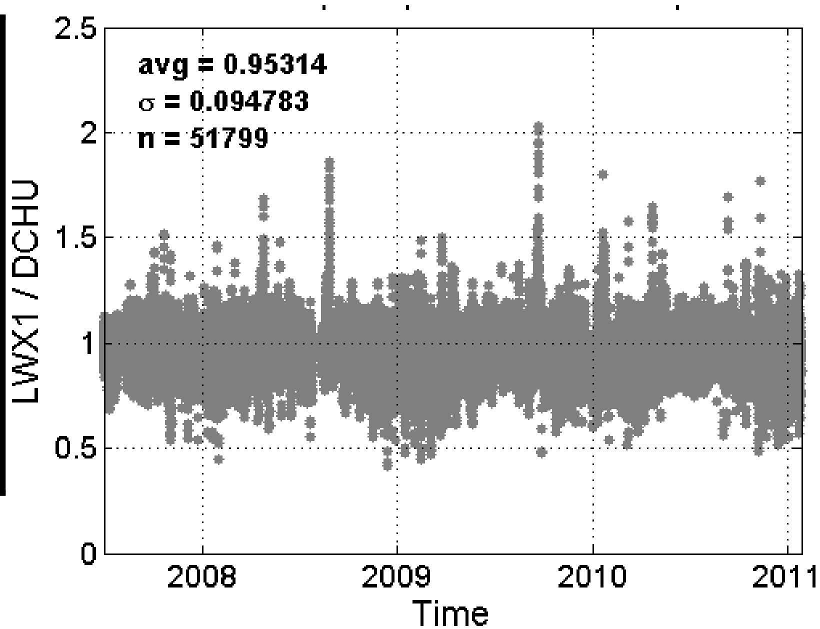



***IPW Comparisons***

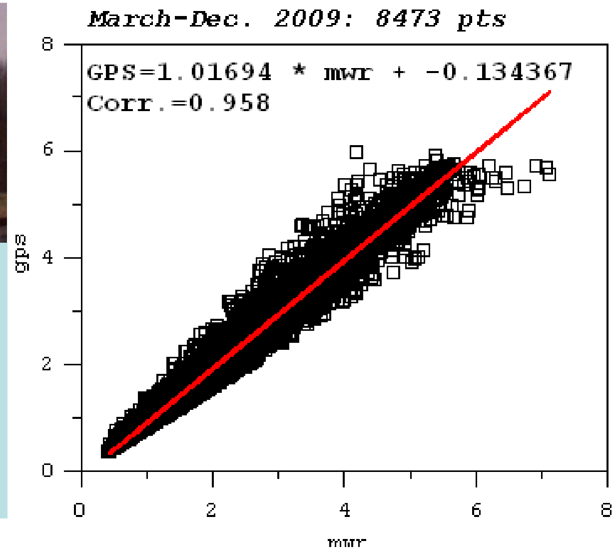
- **GPS-Sonde variations at Sterling are as much as GPS-GPS variations between Sterling and Beltsville.**
  - ***Plan to use GPS IPW to scale mixing ratio profile variations.***



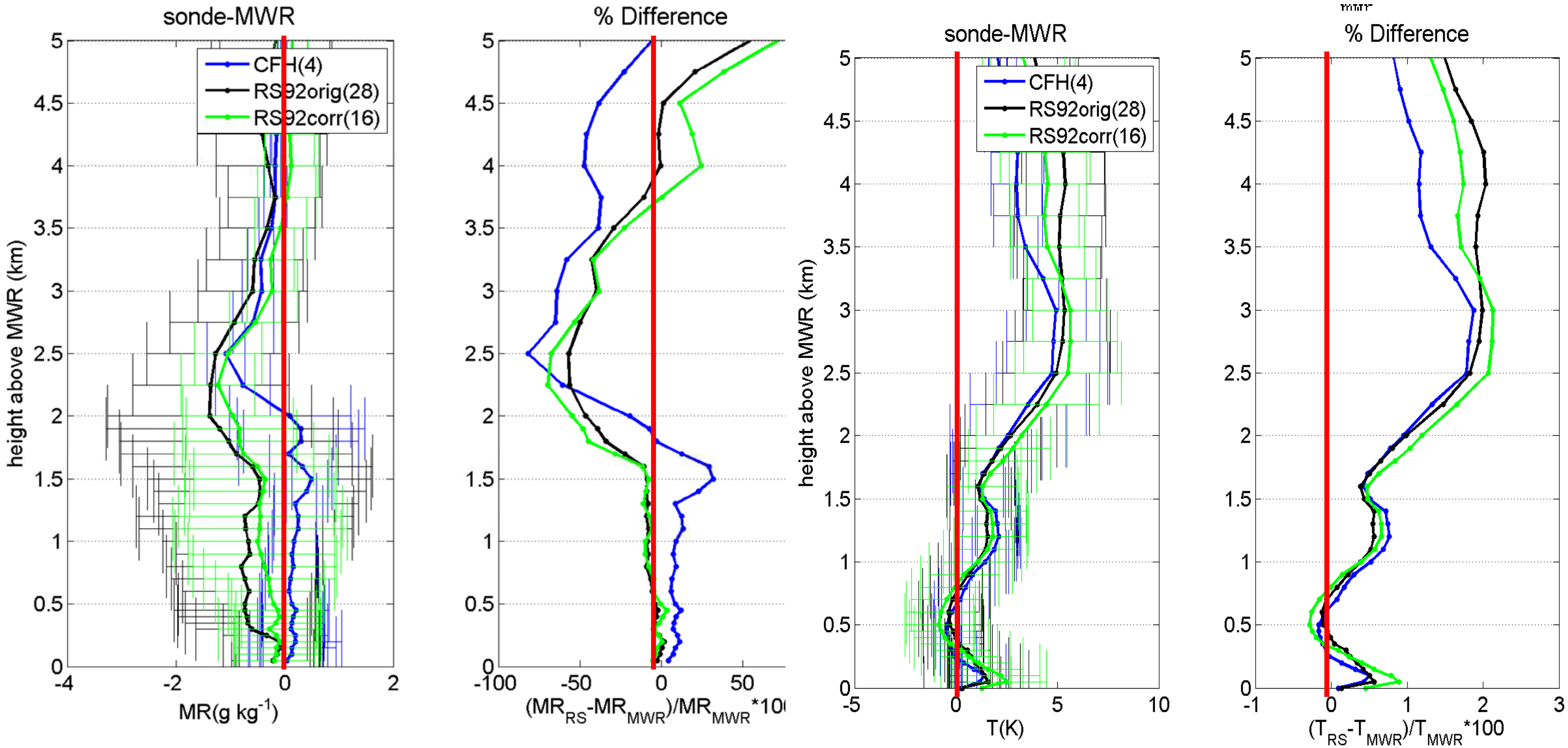

| Ratio | LWX/ DCHU | RRS/ LWX | CFH/ DCHU | RS92Corr/ DCHU |
|---|---|---|---|---|
| Avg. | 0.953 | 0.994 | 1.023 | 0.979 |
| Std. Dev. | 0.094 | 0.132 | 0.085 | 0.099 |
| Pts. | 5179 | 3030 | 18 | 119 |



# Microwave Radiometer Study

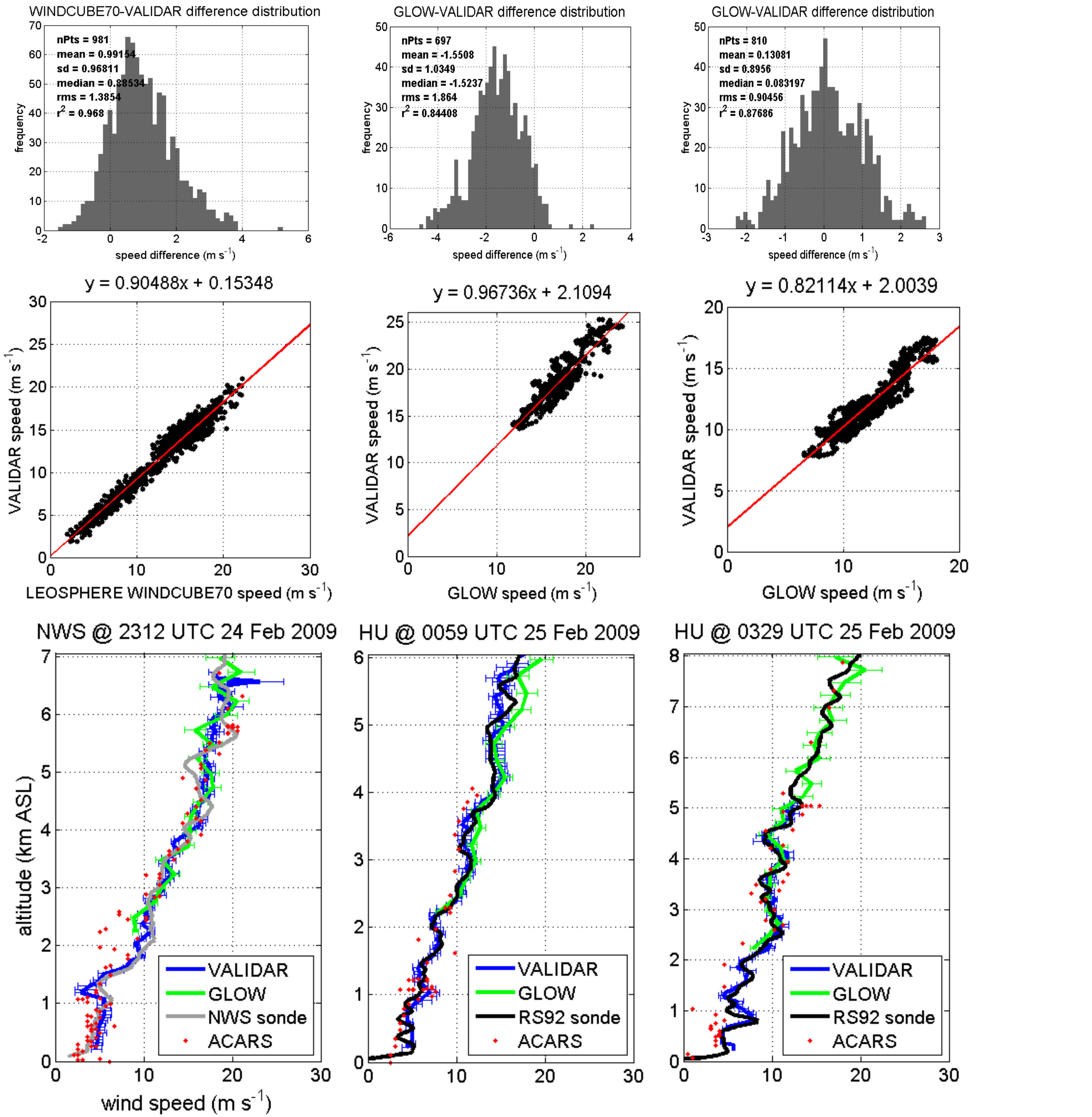



• Started extensive calibration/evaluation of the Microwave radiometer performance against GPS and Sonde.



# Wind IOP Summary @ Beltsville

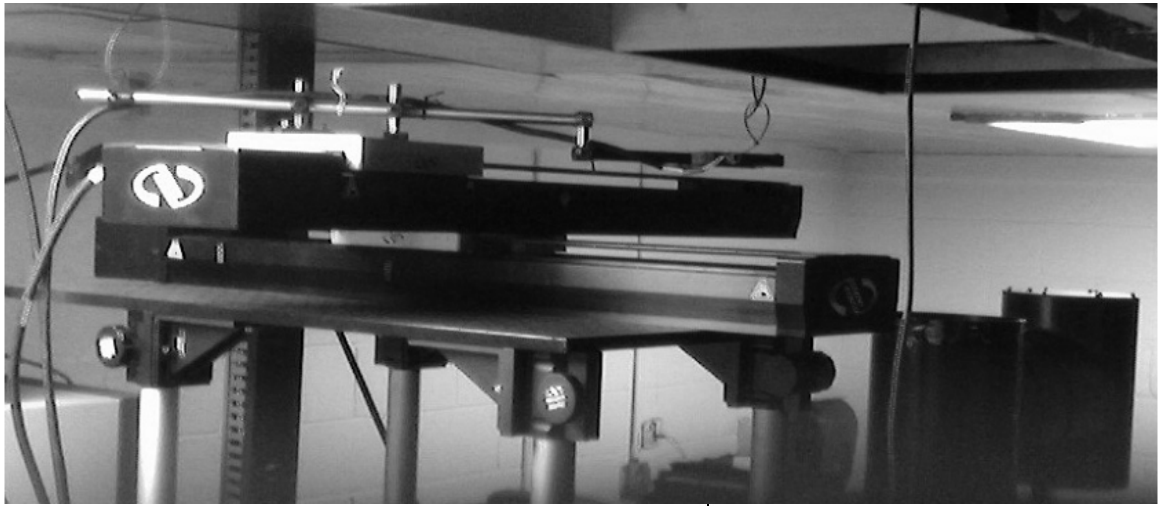
*Analysis of the March 2009 Experiment*



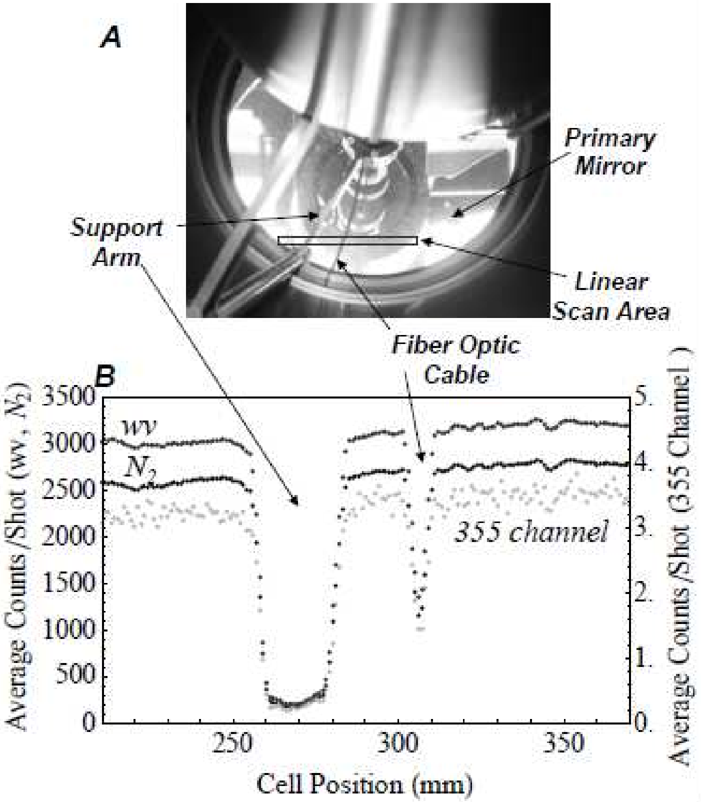
# Summary

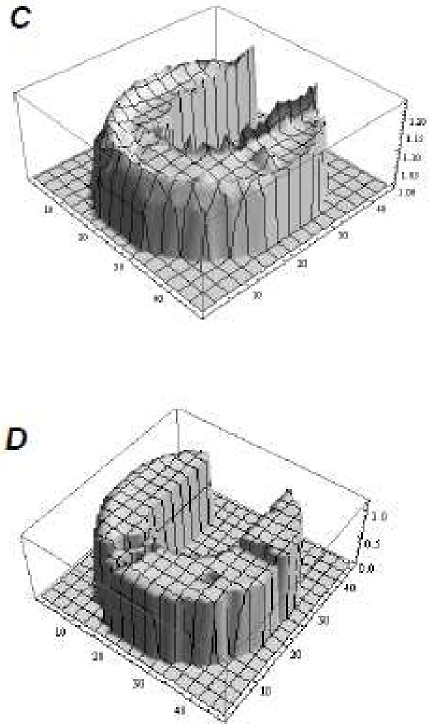
- Continued "weekly" RS92 launch
- Periodic IOP (both lidar, Sonde, MWR/GPS
- Inter-agency co-laboratory
  - *GRUAN-NWS point of "knowledge" transfer*
  - *NDACC- GRUAN related work*
- Researching a Mobile Reference system
- Absolute calibration for HURL Raman lidar
  - *Wiling to transfer the steps*
- Strong Education and training:
- Stat contributing for the GRUAN data
- Not supported by any agency funding (may be unique in GRUAN?)

END



**The Map Experiment xy-positioning stage located in the HURL laboratory above the 16” telescope**

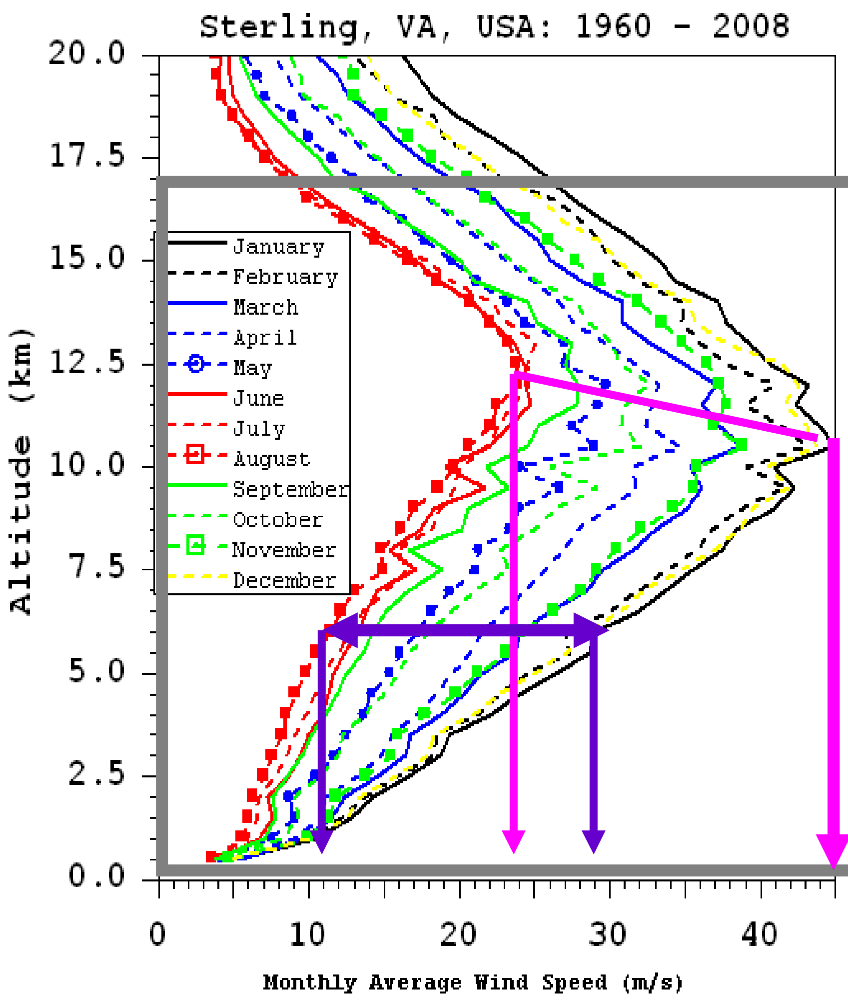


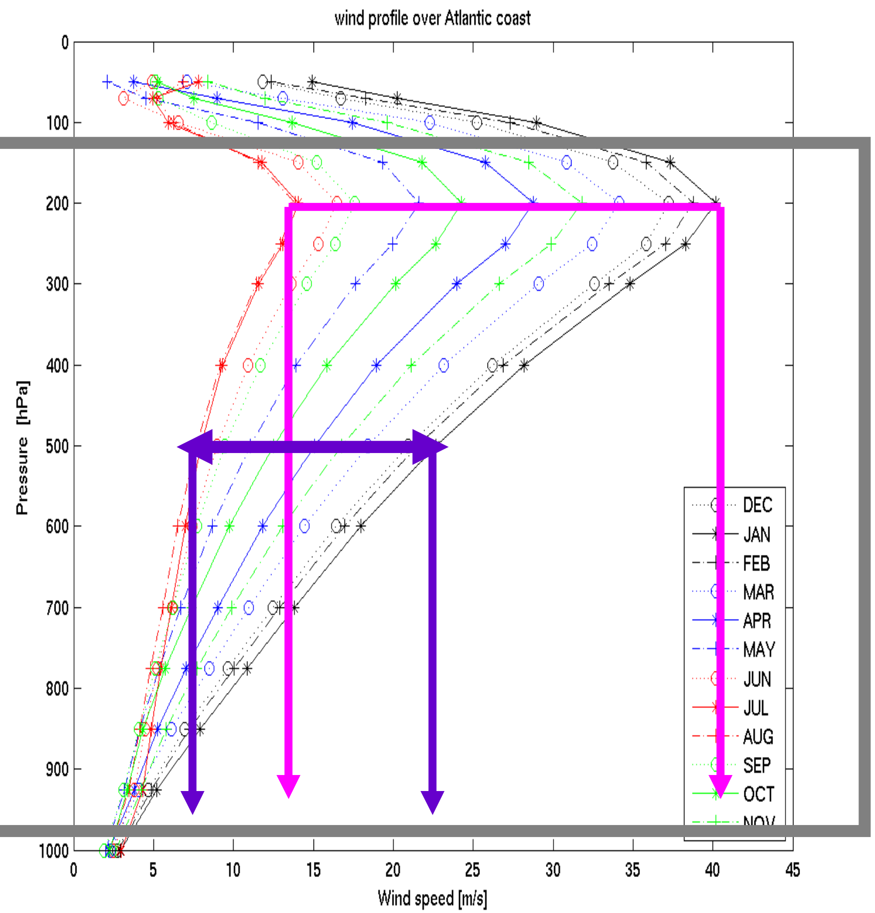




**Mapping results for both linear scans (A,B) and 2D scans (C,D)**

# *From the Howard Univ. Wind Experiment*

## *IAD Sonde – Reanalysis*




**over the East Coast areas of US**
(65W-85W, 25N-50N); ECMWF reanalysis
(1980-1999)

# Regional IPW variability: Beltsville, MD