Howard University – Beltsville Site Report

4th GRUAN Implementation-Coordination Meeting
Tokyo, Japan
3-10 March 2012

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

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

Acknowledgment:
NASA, NOAA, NOAA/NCDC; NOAA Center for Atmospheric Studies

Outline

- **Summary of GRUAN activities**

- **GRUAN-related facility updates**
  - ALVICE: *Mobile Lidar Laboratory*
  - Ground Site activities update
- **Analysis/Techniques**
  - Data/Trends contribution in brief
  - Raman lidar Calibration/Diagnostics
- **Collaborations**
  - NWS Collaboration
  - Satellite related work

GRUAN

Summary of activities

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We have funding from NASA/NOAA to prepare for implementation
- Covered initial instrumentation; Site preparation and training

Beltsville Sounding Data, 2011 Statistics.
- RS92 soundings: 81- RS92 ➔ *>1/week*
- ozone soundings: 40 - EN-SCI Z1 model ECC Ozone- GPS

Beltsville GRUAN data submission
- RSLAUNCH initial setup is done will soon complete data submissions

Sonde Capability:
- CFH: Periodic launches continue_WAVES-2011
- NOAA funding will be used exclusively CFH.

NWS-Beltsville Collaboration
-LMS/RS92-CFH work continues. Summer 2012 IOP.
-GRUAN contribution is discussed

Other: Involved in GATANDOR, Trend analysis, others tasks, WCRP etc.

GRUAN-use Facility Update/IOP

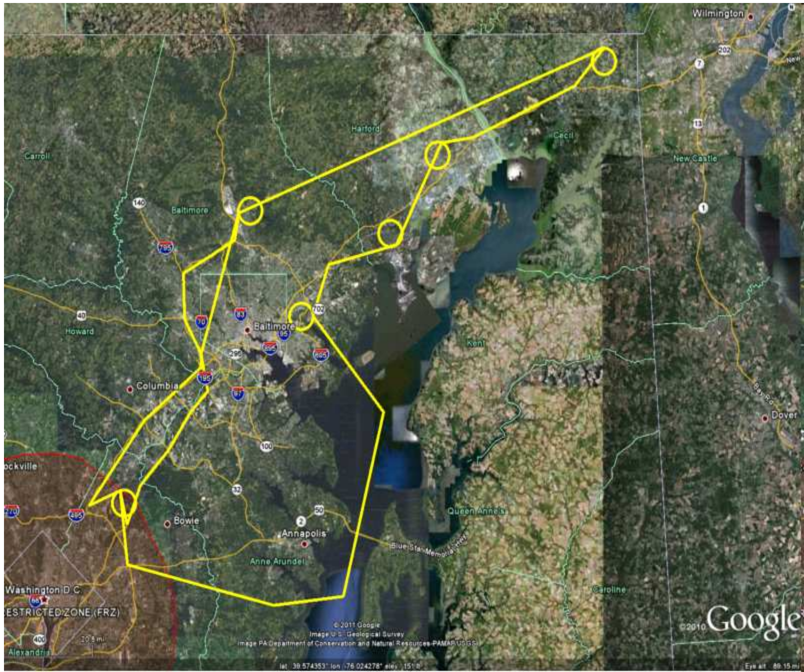
- Beltsville: *Ground site*
  - Multi-Sonde capability:
    - *Acquired ground stations from the following vendors InterMet, RS92, CFH, Modem, LMS, and GRAW*
  - MPL-like 24/7 lidar + Ceilometer
  - Reference HURL Raman calibration work continued
  - MWR profilers (operating 2 similar design for comparison.
    - Data submitted to MWRnet

<u>*IOPs:*</u>

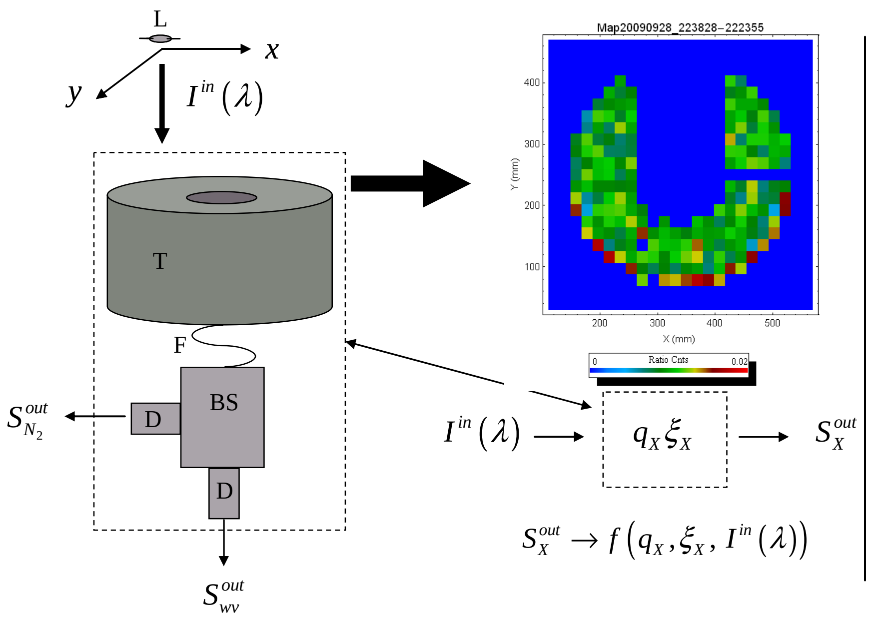
–WAVES_2011 (March – April, 2011)

–DISCOVER-AQ

- *Relate column observations to surface conditions*
- *Improved understanding of diurnal variability as it influences the interpretation of satellite observations*
- *Improved interpretation of satellite observations in regions of steep gradients*



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



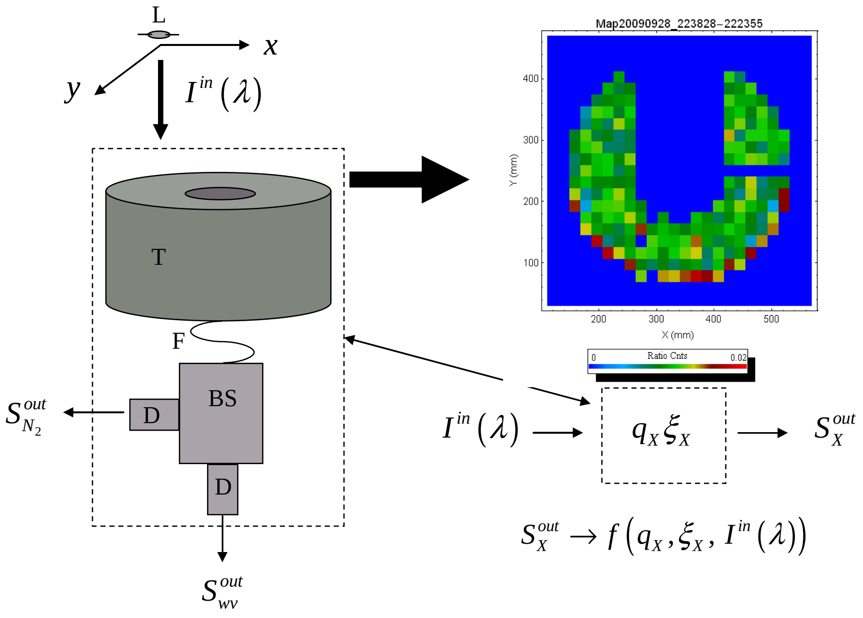
- The water vapor mixing ratio calibration factor C_R depends on the optical efficiency (κ), the differential scattering cross sections (dσ/dΩ) and the band pass filter shape (ε)
- One determines an overall efficiency by comparing the Mapping Experiment throughput of the N_2 channel to the throughput of the *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: (ΔFWHM < 0.01 nm, $\Delta\lambda_o$ < 0.02 nm, & Baseline Offset < 0.5%**

1st principle calibration/diagnostics for Lidar Systems – Update.



Ignoring cross section errors, one can obtain 3% relative uncertainty in *CR* with careful optical filter characterization.

Student work.

Current Efforts

- Transfer to NASA GSFC ALVICE Raman Lidar
- Determination of Water Vapor Mixing Ratio Calibration Factor
- Determination of System Gluing Coefficients for Licel Transient Recorders
- Determination of the Raman System Overlap function for HURL
- Investigation of Temperature calibration constant for a Raman temperature measurements

Reference: A Lamp Mapping Technique for Independent Determination of the Water Vapor Mixing Ratio Calibration Factor for a Raman Lidar System, D. D. Venable, D. N. Whiteman, M. N. Calhoun, A. O. Dirisu, R. M. Connell, E. Landulfo, ***Applied Optics***, 50, pp. 4622-4632 (2011)

Update: GRUAN-use Facility and IOP

- **ALVICE:** ***Mobile "GRUAN Site" Laboratory***
  - Raman water vapor, aerosol, cloud lidar
  - RS92, iMet and CFH launch capability
  - GPS total column water (SuomiNet)
  - THRef Surface reference measurements with sonde ventilation capability
  - calibration lamp technique enabled.

- **Upcoming Campaigns**:
  - WAVES_2011 University of Western Ontario (May – June, 2012)
    - *Intercomparisons with Purple Crow Raman Lidar (Canada)*
  - First principles calibration effort for ALVICE Lidar
    - *Student Monique Walker transferred from HURL to ALVICE*
    - *Can test alignment, overlap, etc.*

Updates on analysis

- Water Vapor Trend Detection Analysis in the **UT**
  - High natural variability in UT water vapor implies Trend detection in UT relatively insensitive to random errors in measurements
    - *High random error can hide small systematic errors so procedures adopted should attempt to randomized known sources of systematic errors, if possible. - Tom Gardiner presentation*
  - To decrease time to detect trend, much more efficient to increase the *frequency* of measurement than the *accuracy* of measurement.
  - Quality profile extending in to UT every *3-4 days* is a good compromise between efficiency of detection and level of effort.

Reference: Whiteman, D. N., K. C. Vermeesch, L. D. Oman, and E. C. Weatherhead (2011), The relative importance of random error and observation frequency in detecting trends in upper tropospheric water vapor, J. Geophys. Res., 116, D21118, doi:10.1029/2011JD016610.

Updates on analysis

- MOHAVE 2009 Analysis update
  - Wet bias developed in Raman lidar due to deposition of *biological material* on receiver during campaign.
  - Correction technique developed and applied consistent with the GUM
    - *"It is assumed that … measurement has been corrected for all recognized significant systematic effects and that every effort has been made to identify such effects."*

– ***Recommendations for GRUAN Raman Lidars:***

- Not sufficient to ensure bias free results. On-going data quality protocols are needed (*e.g. Window should be washed regularly, coverings, etc).*
- *Data analysis should include checks for the existence of biases.*
- *Corrections should be applied when the biases are significant, with uncertainty of the correction accounted for, consistent with recommendations of the GUM*

References: *Whiteman et al., "Correction technique for raman water vapor lidar signal dependent bias and suitability for water vapor trend monitoring in the upper troposphere." Under discussion at AMTD.*

NWS Collaboration

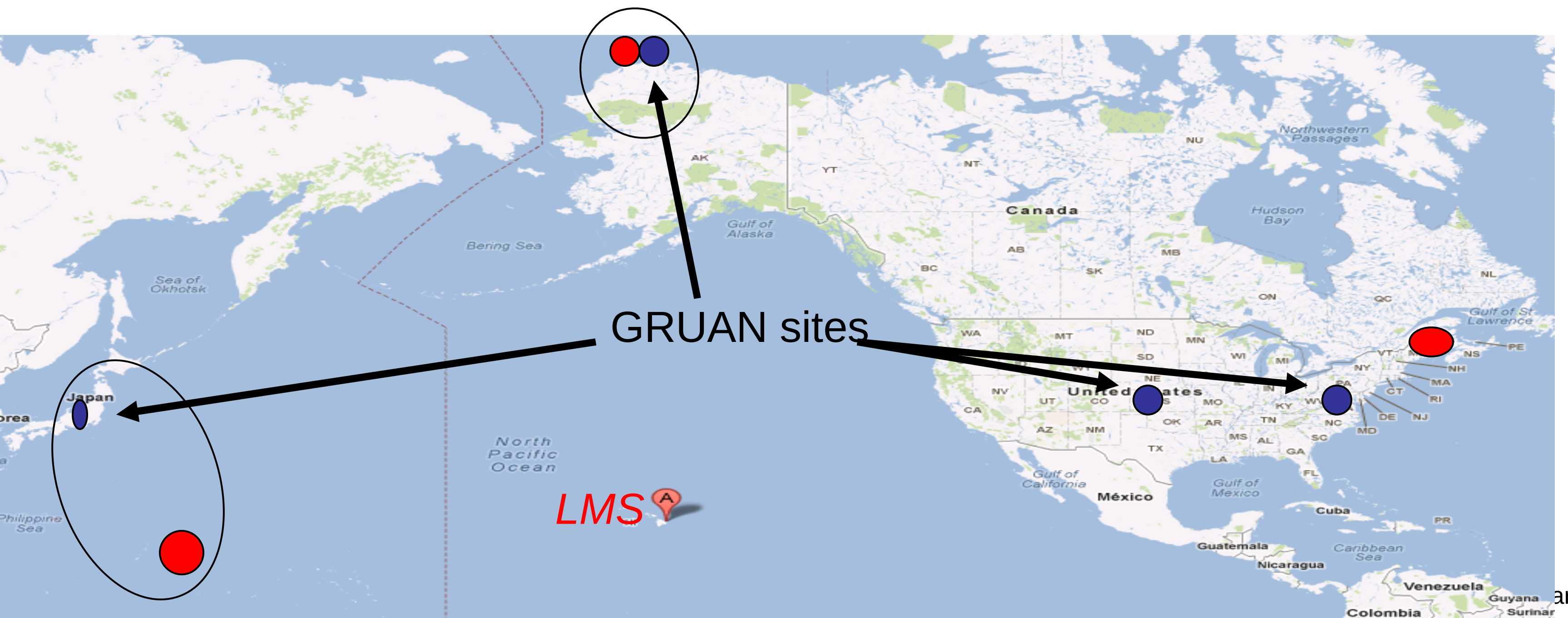
NWS - Howard collaborations: 2012

- ***Continue work and refine the "consensus reference work***
  - *Technique dev/enhancement and expansion*
  - *This may interest the GRUAN/GATNDOR group.*
- ***LMS-ground station operations***
  - *Work will include SW analysis and Multi-thermistor issues (SW analysis tools, solar correction on SW/LMS, etc)*
  - *radiation flux on a sonde – exploring the idea*
  - *Multi-package flights (planning for RS92, LMS, CFH)*
- ***Other***
  - *Mini-DIAL Test – NCAR/Montana*
    - *24/7 DIAL water vapor and aerosol for low $ (Potential game changer)*
  - *Thermodynamic Profiling Technology report (NAS/NSF/NOAA) report completed with several recommendations pertinent for GRUAN.*

Possible GRUAN related -NWS-Howard Collaboration

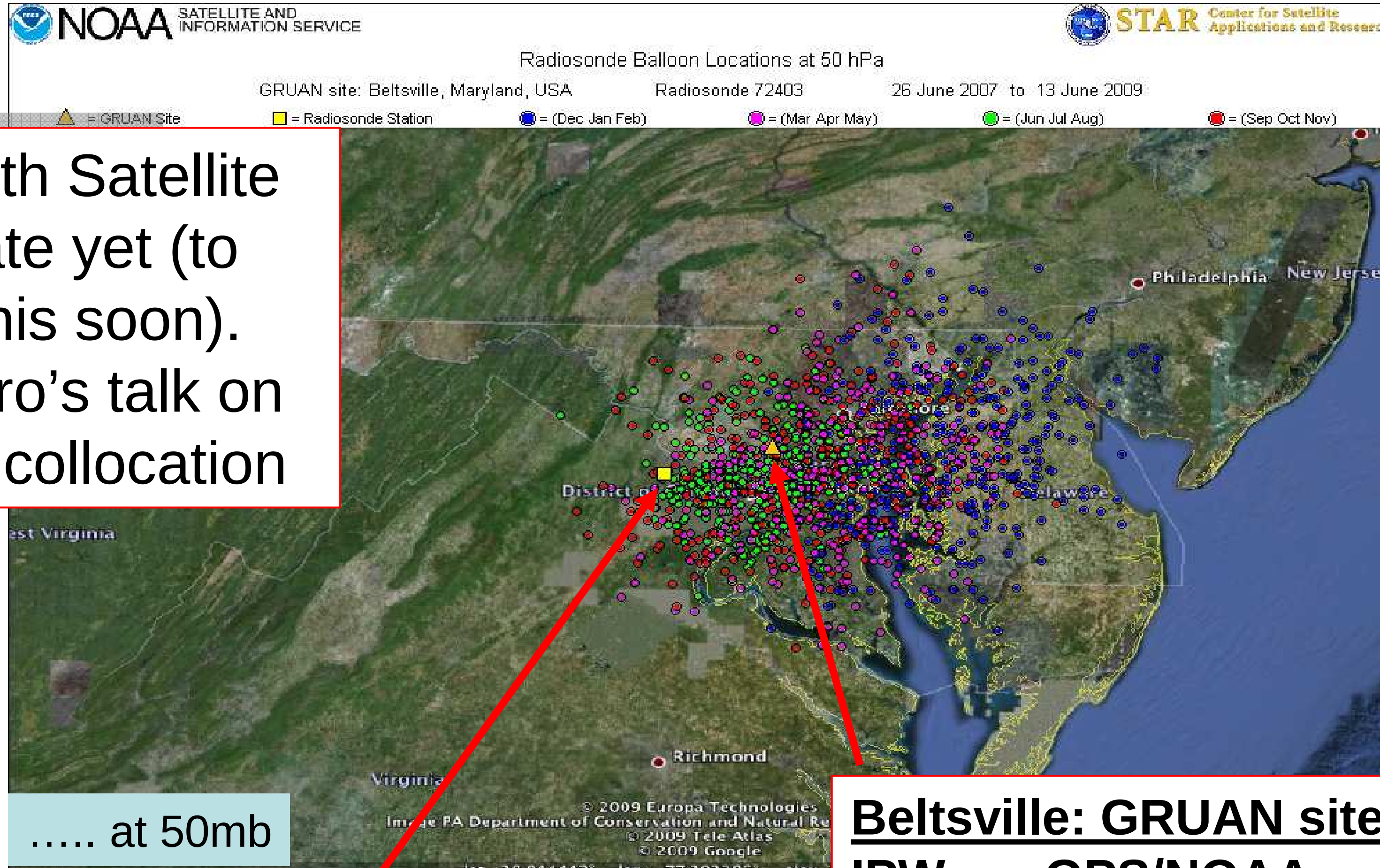
Possible NWS-Howard Collaborations:2012

- ***NWS and RS92:*** sites (6) will be launching RS92 in NWS.
    - *Caribou, Main; Barrow, Alaska; Guam, Sterling, VA*
    - *Data continuity study using the 2005 RadCor table.*
    - *Uses NWS ground system and not DigiCora.*
- Hilo, will be LMS and is in continuity study.
- GRUAN – NWS collaborations



Update:

Satellite Collaboration (Tony)
Co-location (Allesandro Fasso)



- Update with Satellite
  - No update yet (to restart this soon).
- Allessandro's talk on Friday for collocation

….. at 50mb

<u>Sterling: NOAA/NWS Site</u>
IPW: GPS/NOAA
Sonde: RRS (Routine)

<u>Beltsville: GRUAN site</u>
IPW: GPS/NOAA
MWR: 2 & 39 Channel
Sonde: RS92, CFH
Raman: HURL/ALVICE

Collaboration with Satellite

(See Tony Reale's discussion)

Plan

- 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 (IASI (1030), N19 (1330), N18 (0730), AIRS (1330)?, COSMIC?) 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 to other sites.

GRUAN UPDATE: *Wind comparisons continues*

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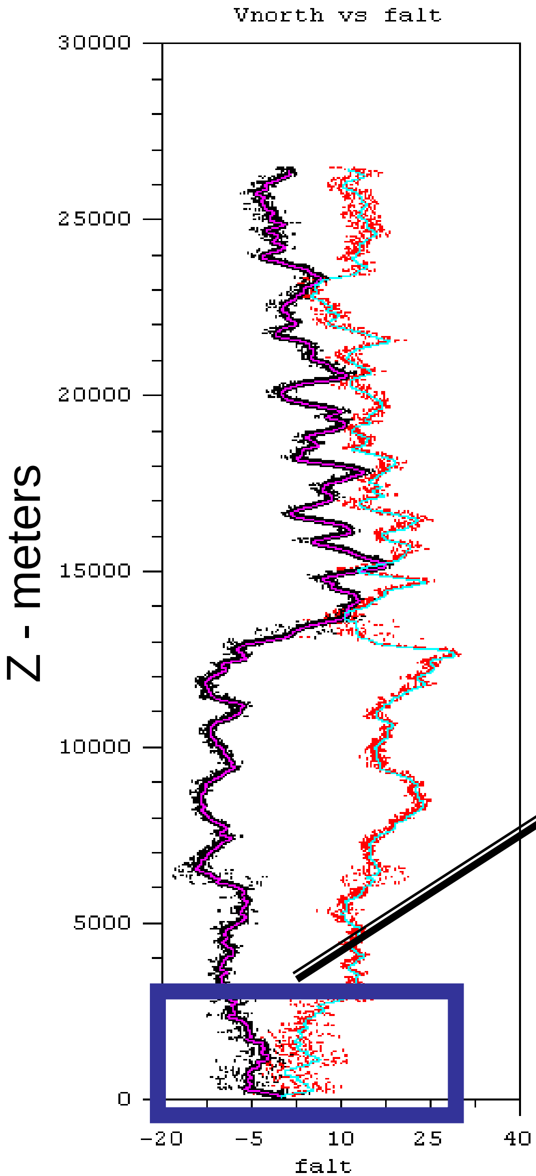
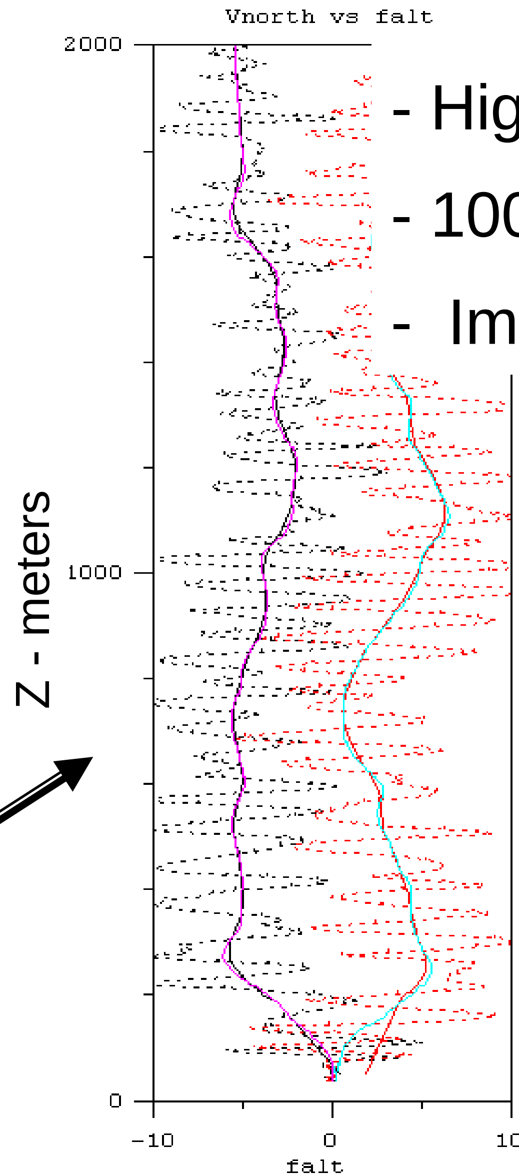
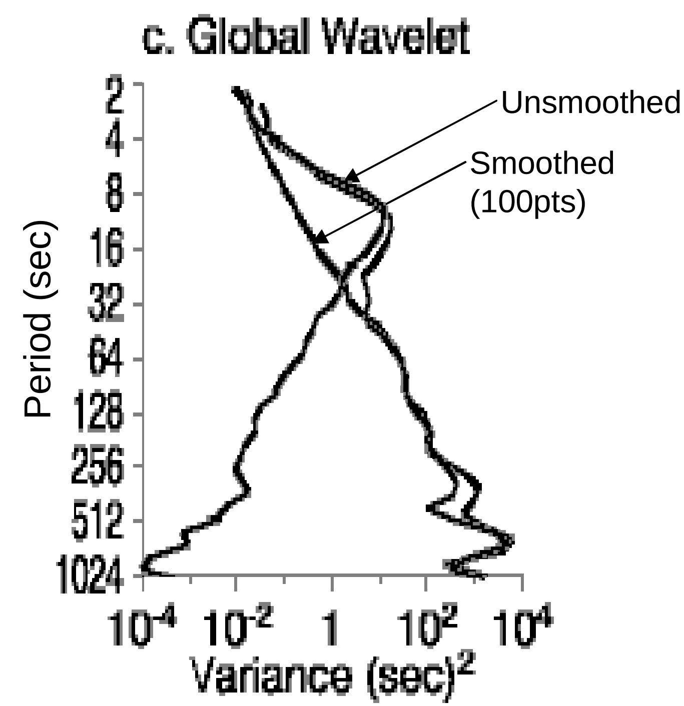
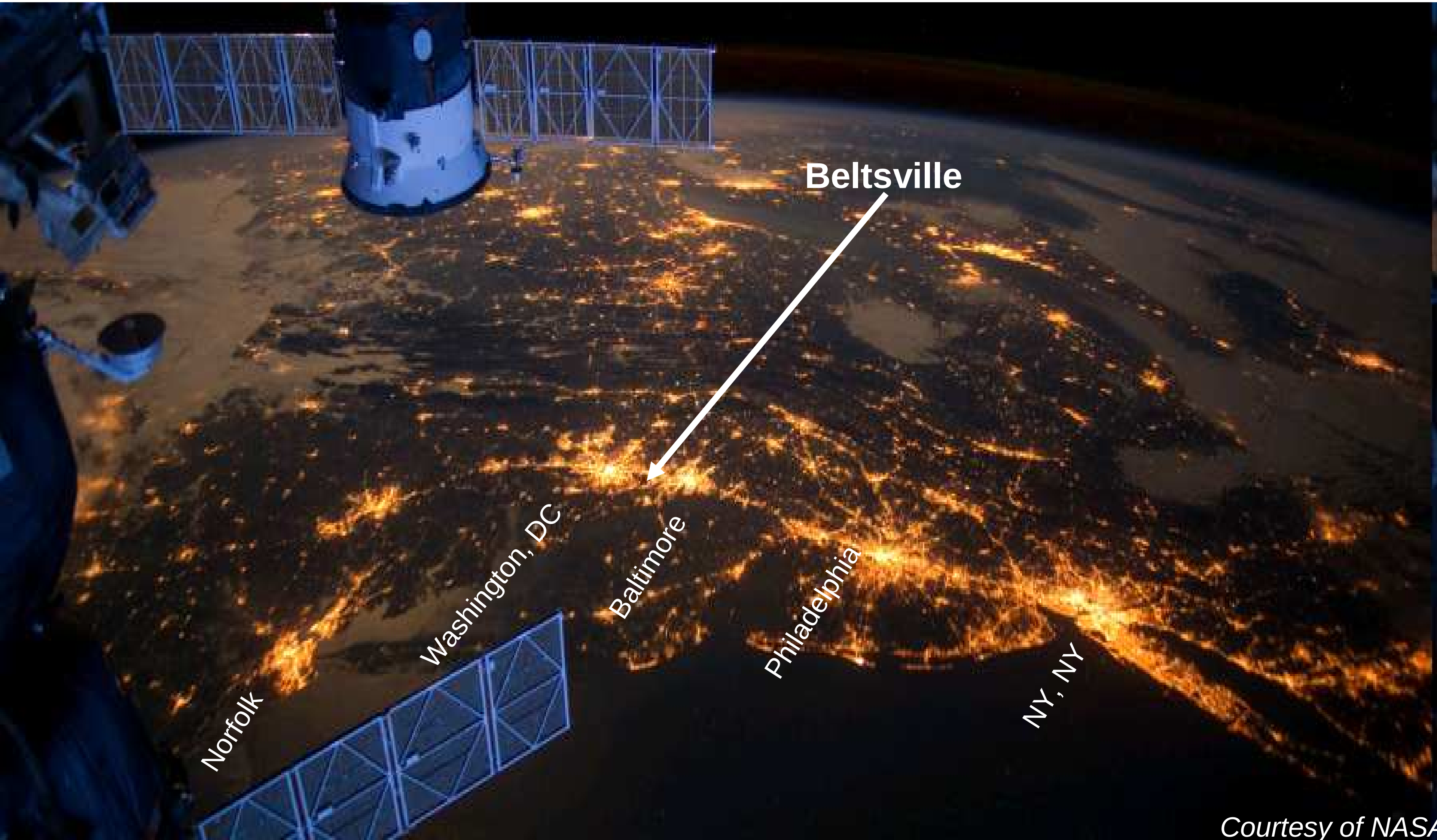




- Highly variable < 2km region
- 100pts smooth may be overkill
- Implications to lidar winds?



END – Thank you.



Courtesy of NASA