EVALUATION OF WIND LIDARs
(& other INSTRUMENTS)
@ THE HOWARD UNIVERSITY BELTSVILLE RESEARCH SITE

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Outline

- **Motivation**
  - What is NASA’s Interest

- **Standard Wind Measurements: issues**
  - ACARS¹, Radiosondes, Profilers, Lidars

- **Performance of wind lidars – general statistics**
  - Merging molecular & aerosol lidar wind data

- **Summary of Wind data at Beltsville**

¹Aircraft Communications Addressing and Reporting System
Motivation: 3D-Winds in NASA

- NASA Decadal survey
  - 3D-Winds demonstration mission
  - Weather focus

- Satellite winds would yield
  - Factor of 2.1 more vector wind profiles
  - More evenly distributed, including oceans
  - Quality and calibration knowledge
  - Consistent delivery and latency

- The Howard-NASA Beltsville study:
  - Demonstration of molecular and aerosol wind systems
  - Data correlative studies
  - Test commercial system performance

- Direct Detection
  - 24 km, 21 km, 16 km, 12 km, 8 km, 4 km, 1.5 km, 0.5 km
  - Velocity Accuracy: 1, 2, 3, 4 m/s

- Molecular-based (e.g. GLOW)
- Aerosol-based (e.g. Leosphere, Validar, Halo, LMSYSTEM, etc)
Experiment Goals:
- NASA 3D-wind concept
- Compare molecular and aerosol-based Doppler wind retrieval
- Evaluate performance of wind lidars

3-Wind lidars:
- NASA/GSFC: GLOW (molecular)
- NASA/LaRC: VALIDAR (aerosol)
- Leosphere: WLS70 (aerosol)

Wind - Standard:
- Sonde/RS92/CFH (in-situ)
- ACARS – FAA/NWS (in-situ)
- 915 Mhz – MDE Profiler (radar)

Other Instruments Present:
3-Raman lidars, 2-MWR, GPS, 4-types of sondes, and other sensors were also deployed.
All in one: 11 March 2009 case

- General agreement but ...
- A sonde 50km away better correlated than onsite?
- Sonde curves are smooth?

⇒ Require careful processing.
Radiosonde Data: Issues (Contd.)

Post-Burst

- \(~100\) pt running aver. may remove useful data for lidar-comparisons (~10 sec period)

- Highly variable in the PBL

\(\Rightarrow\) layer average statistics preferred
Radiosonde & ACARS: Issues

Sonde Issue: Drift!!

ACARS Issues ...

- Data used are ≤ 50 km from Beltsville
- & within a given profile's aver. time
- Not high res.; ~1 hr to cover the trop.

NB. pilots avoid shear layers ➔ bias

Beltsville: GRUAN site
Sterling: NOAA/NWS Site
915 Profiler: Issues and data quality

- QA “throws the baby with the bath water”
- If no QA data
  - 2-years of sonde data: 2009-2010
  - 83 sonde-profiler data pairs examined
  - 16 revealed significant deviations

Out of the 16 profile differences:
- 44% atmospheric variability
  - near a convergence zone, a shear layer etc
- 38% profiler issues
  - No change in airmass, etc (“Bird” detection)
- 19% were of sonde issues
  - Sonde data processing/smoothing
“standard” data has “problems” ➔ Verify!

… *What general/statistical conclusions do we see between the standard and the lidars?*
GLOW-Sonde comparisons (on-site sondes)

General House Keeping:

- Sonde data interpolated to GLOW resolution
- “# of Points” is GLOW – sonde pairs in that height bin for all available times
- GLOW data is 33min. average

Summary

- aver. diff. is < 3 ms\(^{-1}\) up to 10km or more
- atmospheric part could be as large as ~ 2-3 ms\(^{-1}\) (Bedka et al 2010 at 10km separation)
- agreement is excellent
Despite the issues in the balloon drift

- Excellent correlation.
- less 2.5m/s overall

~ atmospheric variability
Leosphere-Validar-GLOW: 3-Lidars

Aerosol-aerosol systems:
- Same tech.; diff. laser power,
- rms $\sim 1.5$ m/sec
- $r^2 = 0.94$

molecular-aerosol systems:
- $r^2 = 0.84$
- rms $\sim 1.9$
GLOW-VALIDAR correlations are as good as VALIDAR-Leosphere
Molecule-aerosol are as good as aerosol-aerosol systems!!
Example: 24-25 February 2009
Clear Sky 3D-Wind “dual-Component” demonstration

- VALIDAR: < 6km
- GLOW: 2-15km
- Optimum (R² > 0.7) → 4-5km
Summary:
Wind data at Beltsville:

- Profiler (2004)
- Sondes (2004, not regular)
- Tower (~ 2003)
- GLOW (2009)
GLOW Products
- Range resolved scans of radial wind speed
- Vertical Profiles of:
  u,v,w component winds
  wind speed and direction
Coverage: 0.1 to 20 km
Minimum range resolution: 40 m
Accuracy: 0.5 to 2 m/s
Operating wavelength: 355 nm
Thank you
Wind Data Sources

1-Radar:
- 915MHz: operated by Maryland Department of the Environment (MDE)

2-insitu:
- ACARS: Aircraft Communications Addressing and Reporting System
- Radiosonde: Vaisala RS92 on site; LMS-MARK IIA at IAD

The 3-Lidars:
- GLOW: Goddard Lidar Observatory for Winds (GLOW)
- VALIDAR: coherent Doppler wind lidar
- LEOSPHERE: WLS70 wind Lidar (http://www.leosphere.com)

*ACARS and Profiler are available at the Meteorological Assimilation Data Ingest System (MADIS) database http://madis.noaa.gov/madis_acars.html*
Sonde Issues cont’d.
- profiler altitude range is limited (< 3-4km)
  - near the lower limit for the GLOW setup but still does well
- Consistent bias in profiler U, V
  - was heavily affected by “bird” contamination
- relatively large bias in direction, east-west speed
• GLOW-Profiler showed largest RMS differences; had fewer data pairs.

• Profiler operates in the lower tropospheric region, which is not ideal for current GLOW configuration.