NASA Science Update

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Earth Science Technology Highlight:

Toward 3D-Winds - Active Optical Investments

Tropospheric Wind Lidar Technology Experiment (TWiLiTE)

UV Direct Detection Molecular Winds
(Gentry, NASA GSFC)

Flew on the ER-2 in 2009 & 2011 and is being configured to fly on the Global Hawk for the Hurricane and Severe Storm Sentinel (HS3) EV-1 Mission in 2014.

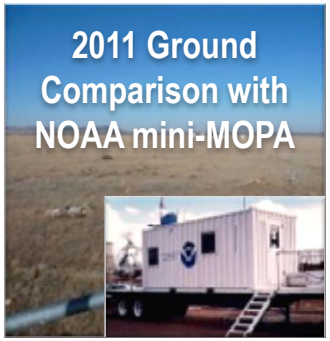
Flew 112 hours over 15 flights on the DC-8 in 2010 in support of the NASA GRIP campaign. Additional flights are planned on the B200.

Doppler Aerosol Wind Lidar (DAWN)

2.0 um Coherent Doppler Aerosol Winds
(Kavaya, NASA LaRC)

Optical Autocovariance Wind Lidar (OAWL)

UV Direct Detection Aerosol & Molecular Winds
(Grund, Ball Aerospace)



Test flights conducted on WB-57 in 2011. Instrument / mission design study for ISS completed in 2012. An Observing System Simulation Experiment (*OSSE*) will complete in 2013.

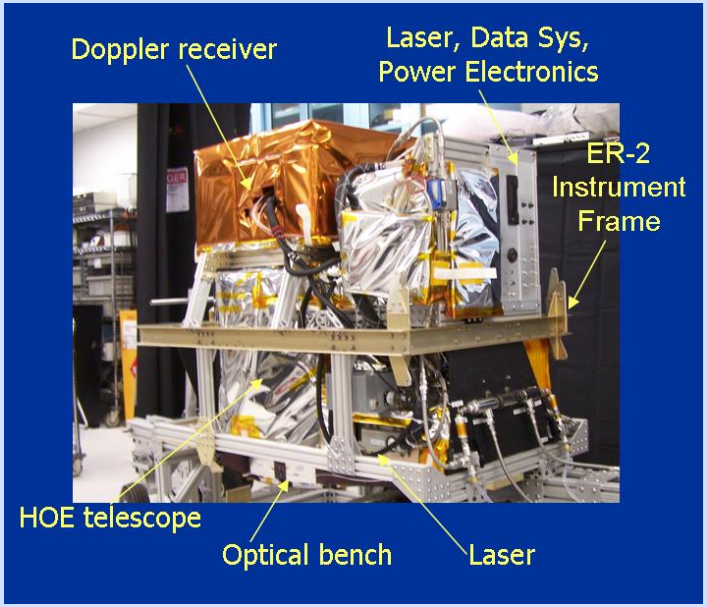
3D-Winds Decadal Survey Mission

Technology Development | Demonstrations / Campaigns | Science Measurements

Tropospheric Wind Lidar Technology Experiment (TWiLiTE) Instrument Incubator Program

PI: Bruce Gentry/GSFC

- The TWiLiTE instrument is a compact, rugged direct detection scanning Doppler lidar designed to measure wind profiles in clear air from 18 km to the surface.
- TWiLiTE operates autonomously on NASA research aircraft (ER-2, DC-8, WB-57, Global Hawk).
- Initial engineering flight tests on the NASA ER-2 in February, 2009 demonstrated autonomous operation of all major systems.
- TWiLiTE has been reconfigured to fly in the NASA Global Hawk as part of the Hurricane and Severe Storm Sentinel Venture Class Mission .



TWiLiTE system configured for ER-2 QBay

Data products	Vertical profiles of u,v wind field from aircraft to surface, clouds permitting
Velocity accuracy (m/s)	< 2.0
Range of regard (km)	0 -18 (ER-2,WB57); 0-12 km (DC-8)
Vertical resolution (km)	0.250 (programmable)
Horizontal integration per LOS (s)	10 s (programmable)
Nadir angle (deg)	45
Scan pattern	8 position conical step-stare (programmable)

TWiLiTE ER-2 Integration
September, 2009

Doppler Aerosol Wind (DAWN) Lidar System

Airborne Instrument Technology Transition (AITT) & Instrument Incubator Program (IIP)

PI: Michael J. Kavaya/NASA LaRC

- The DAWN instrument is:
- Solid-state, compact & rugged for aircraft use
- Designed for the NASA DC-8 and UC-12B
- Pulsed for range resolved wind measurements
- Coherent detection for very accurate winds & high photon efficiency
- 2-micron wavelength for eyesafety & high atmospheric transmission
- Scanning to obtain all 3 components of wind
- 250 mJ pulse energy & 10 Hz pulse rate & 15-cm receiver for excellent aerosol level sensitivity

New Capabilities

- Most powerful coherent Doppler wind lidar for improved combined set of resolution, accuracy, and coverage
- Provides profiles of wind u, v, and w; wind turbulence, and relative aerosol backscatter at 2 microns
- Choice of number of azimuths measured affects horizontal resolution. Planned 5-azimuth scan pattern permits investigation of variability of 3-D wind in measurement volume
- Choice of number of laser shots averaged for line-of-sight wind profile permits trade of coverage vs. horizontal resolution
- Data may be processed multiple ways to provide various trades between vertical resolution, horizontal resolution, and coverage

Data Products	Vertical profiles of u, v, w wind field from aircraft to surface, clouds permitting. Profiles of wind turbulence. Profiles of relative backscatter. Wind spatial variability.
Velocity accuracy (m/s)	< 1-2
Vertical resolution (km)	Selectable, typically 133 m
Horizontal integration per LOS (s)	Selectable, typically 2 s (~460 m)
Nadir Angle (deg)	30
Scan Pattern	5 azimuth angles/pattern (selectable) 1 pattern/13 s (~ 3000 m)
Range of regard (km)	0 – 12 (DC-8 to surface)

DAWN depicted in DC-8

Participated in GRIP flight campaign, Aug-Sept 2010

Ground-Based Hybrid Wind Lidar Demo

- **This intercomparison provided for the first time, the wind speed and direction measurements by coherent and direct detection wind lidars.**
- **Howard University research campus in Beltsville, Maryland was intercomparison site.**
- **VALIDAR arrived on February 17, 2009 and left March 20, 2009.**
- **DAWN transceiver made 180-mile one-way trip to site and back with no measurable change in laser output power or receiver alignment. No optics were adjusted since transceiver left the lab in November 2008.**
- **Lidar ran for continuous stretches of over 3.5 days and unattended at night.**
- **VALIDAR recorded approximately 160-hours of wind data.**

VALIDAR and Wind Sonde Comparison: Wind Profile and direction and RMS Difference

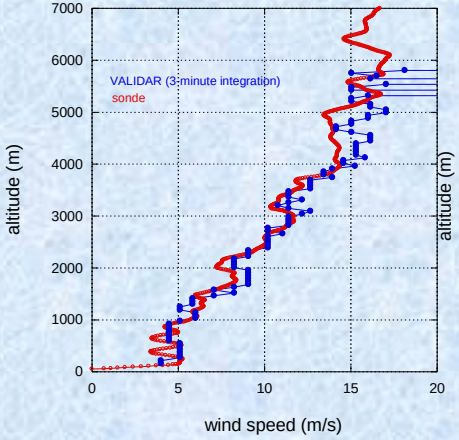


Fig 1 (a)

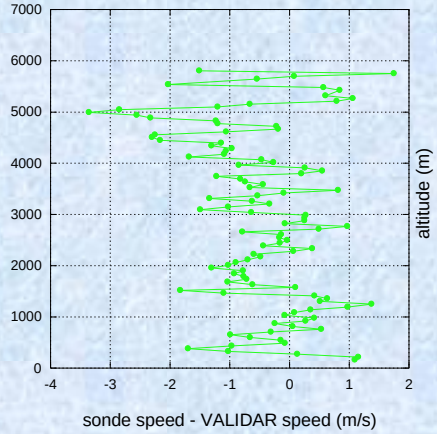


Fig 1 (b)

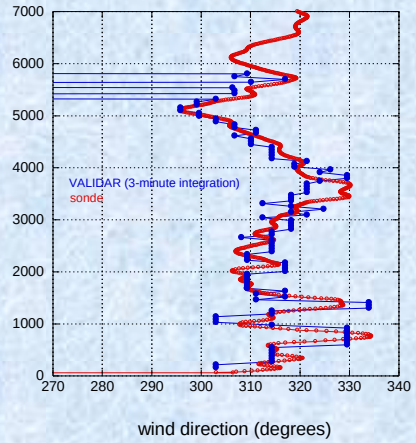


Fig 1 (c)

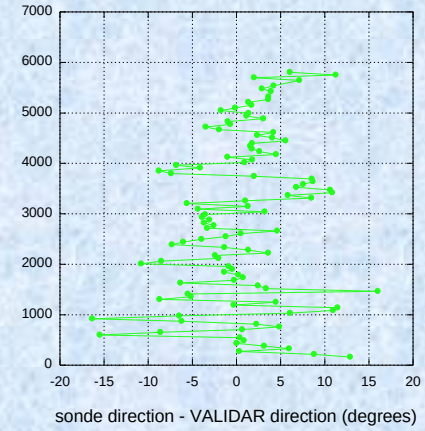
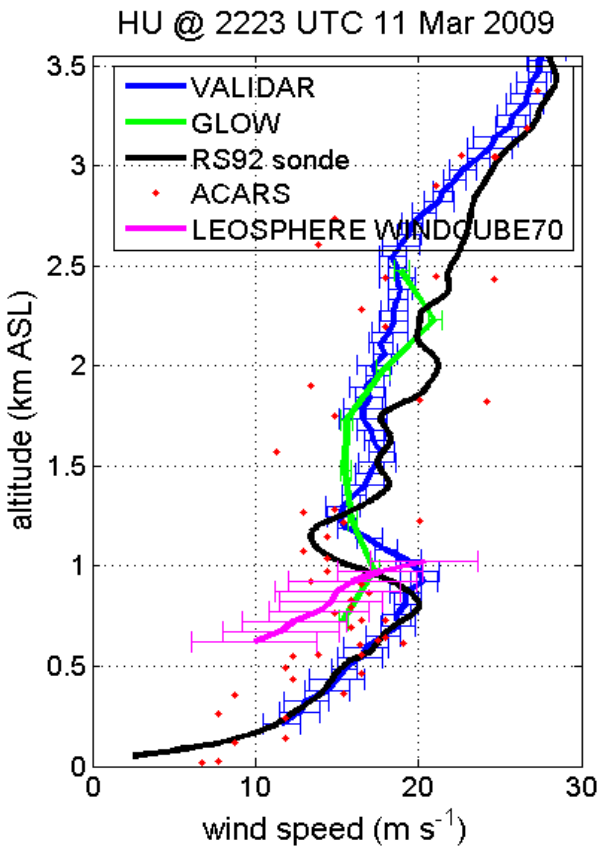
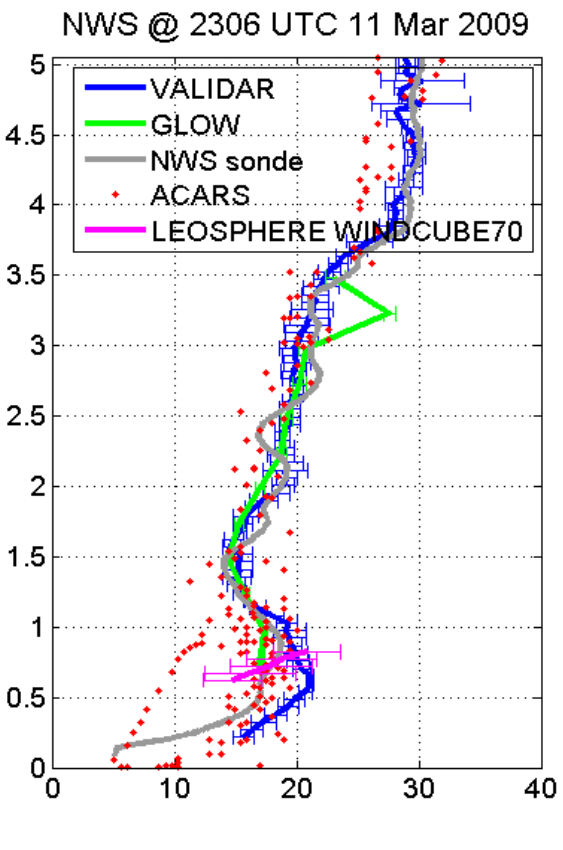


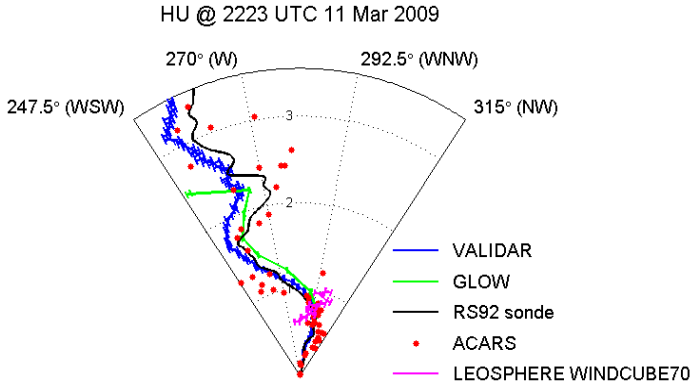
Fig 1 (d)

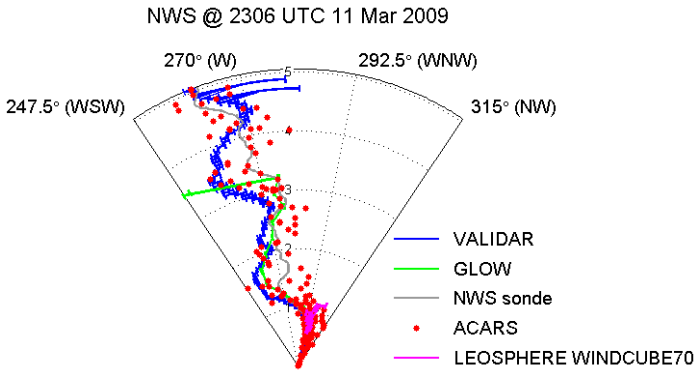
- All data shown above were taken on February 24, 2009, sonde was launched at 17:59 local (Feb. 25, 2009 00:59 UTC)
- Root-mean-square of difference between two sensors for all points shown = 1.06 m/s (Fig 1b)
- Root-mean-square of difference between two sensors for all points shown = 5.78 deg (Fig 1d)

cold front / cloudy case profiles









VALIDAR is averaged for ~30 minutes
LEOSPHERE is averaged for 10 minutes
ACARS is from launch to 1 hour afterward
GLOW is a 33-minute shot average beginning at sonde launch

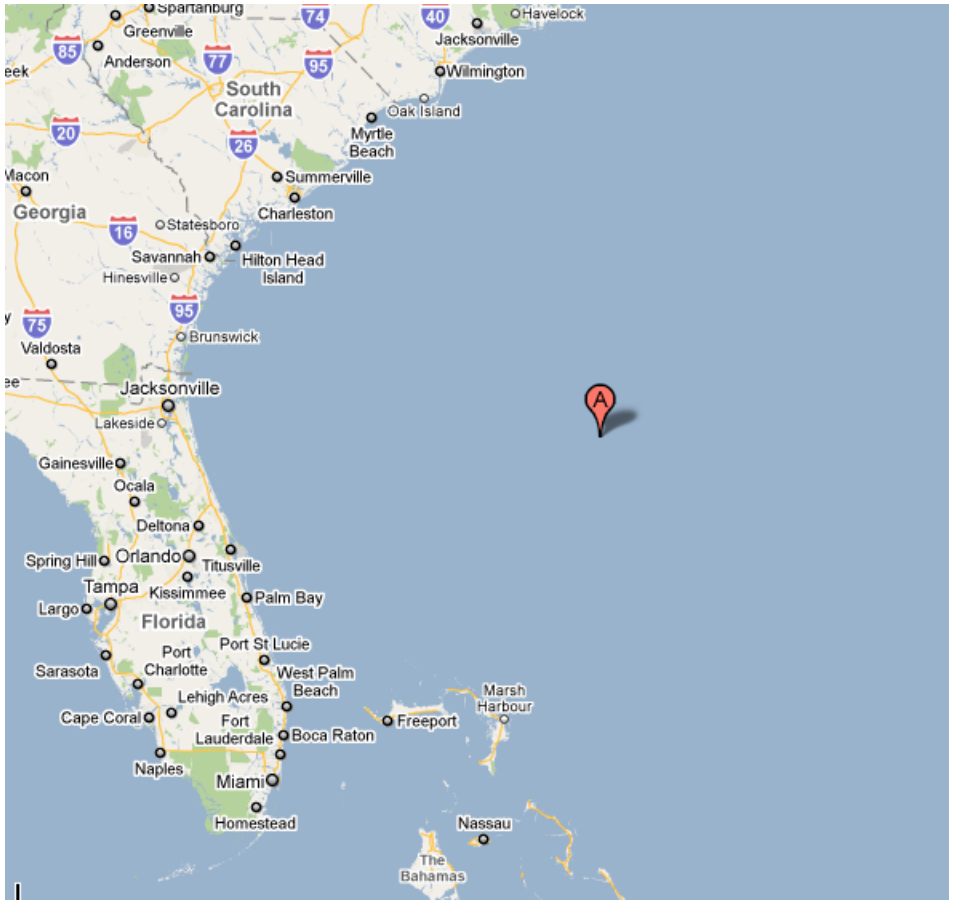
wind direction vs height

	GLOW-VALIDAR	LEOSPHERE WINDCUBE70-VALIDAR
height range (km AGL)	1 – 5 (clear) 1 – 2.5 (cloudy)	0 – 1
r^2 correlation coefficient	0.88 (clear) 0.85 (cloudy)	0.94
regression	y = 0.81x + 2.02 (clear) y = 0.95x + 2.34 (cloudy)	y = 0.84x + 0.94
difference rms	0.945 (clear) 1.783 (cloudy)	1.881

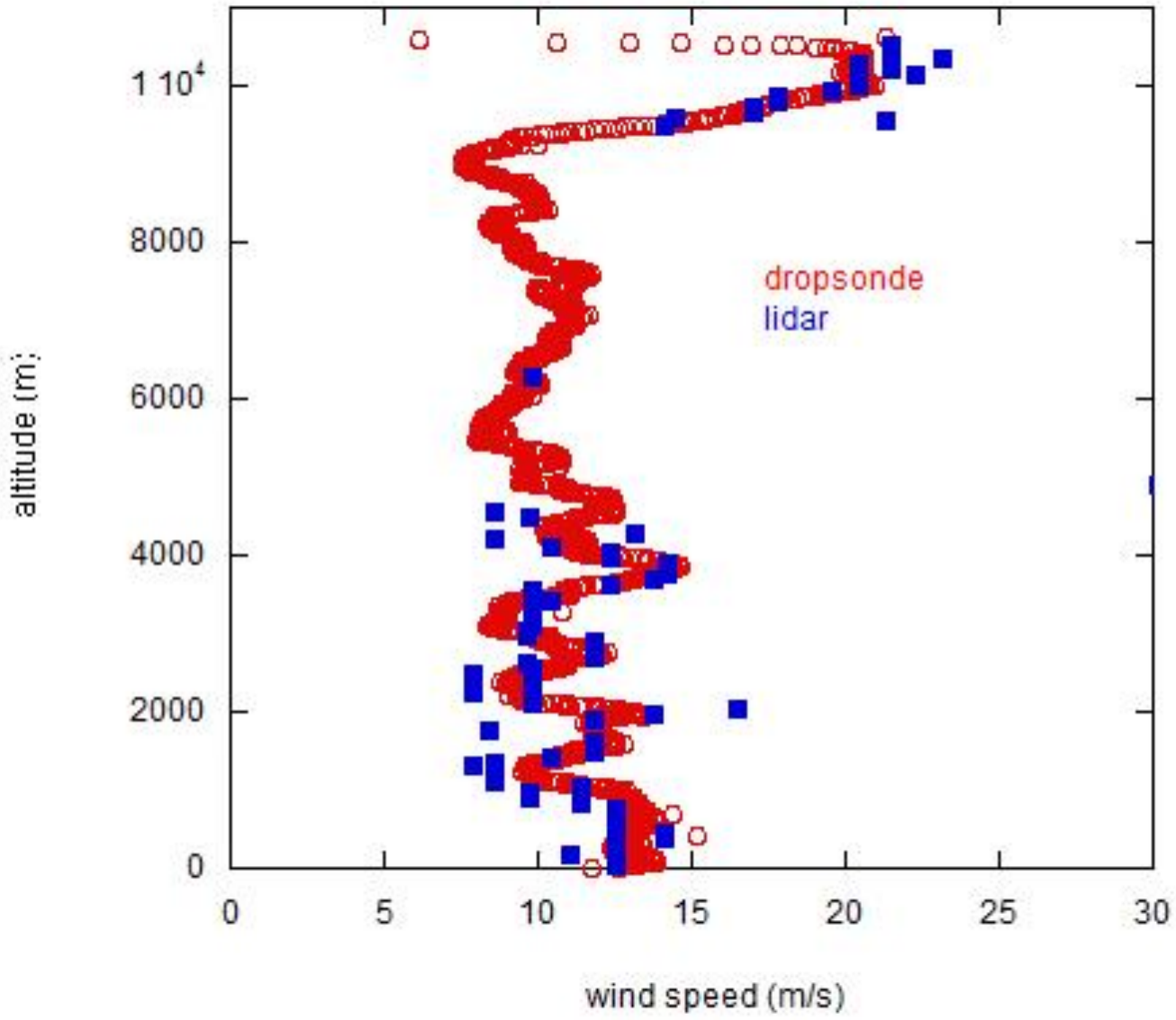
- good agreement with sondes (GLOW average rms difference of 1.68 m s^{-1}, VALIDAR average rms difference of 1.37 m s^{-1}) for 5 cases
- lidar data is smoothed for time-height comparisons using a running average to remove profile-to-profile variability that was affecting results
- ceilometer mask used for GLOW, but not for LEOSHPERE or VALIDAR
- correlation of ~0.9 for all comparisons

Aircraft Location

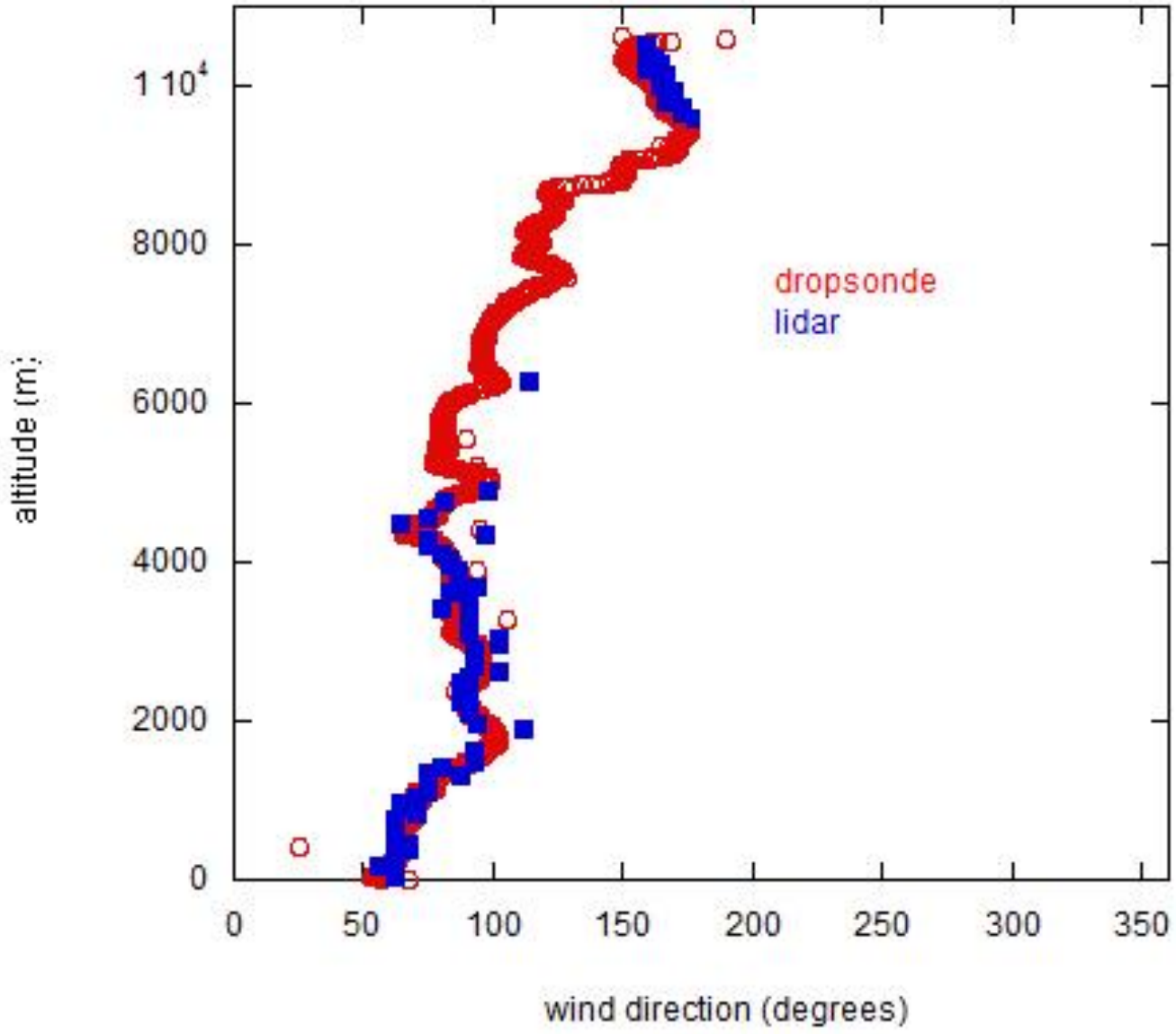
Latitude = 29.956 N
Longitude = 75.753 W
Altitude = 10,609 m over Atlantic Ocean
Speed = 224.57 m/s
Nose Heading = 145.96 degrees
Yaw = 0.23 degrees
Pitch = 1.61 degrees
Roll = 0.20 degrees



Wind Vector Calculation: Speed



Wind Vector Calculation: Direction



Recently Funded ROSES-13 Proposals

Name		Title	Institution
George	Emmitt	Polar Winds: Airborne Doppler Wind Lidar Investigations	Simpson Weather Associates
Bruce	Gentry	Vertically Resolved Wind Study using a Direct-detection lidar	NASA Goddard Space Flight Center
Tiruvalam	Krishnamurti	Planetary Scale Monsoonal 3D Winds linked to the Rapid Arctic Ice Melt	Florida State University
Zhaoxia	Pu	The impact of CYGNSS surface wind observations and 3-D winds on high impact weather forecasting	University of Utah

Near Term Plans

- The launch of ESA's Atmospheric Dynamics Mission (ADM) is scheduled for the middle of 2015. A standing expectation has been that the USA would participate in the Cal/Val of the ADM sensor.

- ESA has enquired about the desirability of conducting a series of prelaunch exercises next spring (2015) that would include joint NASA-ESA airborne DWL flights near Greenland.

Near Term Plans (2)

In preparation for the spring 2015 collaborative effort, we propose to conduct a two week airborne Doppler Wind Lidar (ADWL)mission near the southern tip of Greenland in November of this year (2014). The primary objectives of this mission are as follows:

- Demonstrate the readiness of DAWN (and TWiLiTE tbd) to participate in the joint ESA/NASA exercises in the spring of 2015
- Conduct underflights of currently orbiting sensors to refine techniques for cal/val between a space based lidar and an airborne set of sensors
- Use this opportunity to conduct a subset of the Polar Winds experiments being designed under ROSES13 funding (Emmitt, PI)