ASEN 6519. Lidar Remote Sensing

HWK Report #3. Wind Lidar Technology

Please write a HWK report on wind lidars using the following reading materials:

1) Our lecture notes (#19 to #24) on wind lidars, including Sara's two lectures and NOAA field trip visit on April 6, 2007
2) A short chapter "Doppler Wind Lidar" by Christian Werner "WindLidarChapter.pdf" at the class wesite.
3) Chapter 7 "Wind Lidar" in textbook "Laser Remote Sensing" (for coherent detection wind lidar and direct detection wind lidar)

A few research papers ("DDLdoubleEdge.pdf", "DDLI2Filter.pdf", and "DDLfringeImaging.pdf") at the class website are not required but for your reference only. In other words, these research papers may provide a better description of technical details when compared to lidar chapters.

In the report, please address the following aspects:

1. There are three major techniques for wind measurements: Direct Motion Detection, Doppler Wind Detection, and Geostrophic Wind Detection. Please summarize the basic principles of the three techniques in your own words, and give equations or figures if necessary. Please also describe the application range or areas of each technique.
2. Wind is a vector while temperature is a scalar. Thus, the main question is how to a determine vector wind. Please describe the principles of ideal vector wind measurement, VAD technique, and DBS technique. Give equations or figures if necessary. *In Dr. Qian Wu's FPI tutorial talk, his FPI at Resolute Bay is pointing to east, west, and zenith sequentially. Could you explain why? How does he determine zero wind point?*
3. Direct Motion Detection technique has three major approaches: crosswind determination by pattern correlation, LTV, and LDV. Please explain the measurement principles for each of the technique. Give equations or figures if necessary. *Recently, in determining gravity wave phase speed from lidar data, we found maximizing the cross correlation between sequential profiles is a good quantitative way. Could you explain how it works?*
4. In Doppler wind technique, why do we use 1 time of Doppler shift in the Doppler-broadened absorption cross section of resonance fluorescence but use 2 times of Doppler shift in the Doppler-broadened Rayleigh scattering signal? Please derive equations to prove this is right. Please calculate the Doppler width (FWHM) for Fe 372nm absorption line and for the atmosphere (molecular weight is 29) Rayleigh 532nm return at 200 K.
5. Coherent Detection Doppler Wind Lidar: Please describe the measurement principle of CDL based on Sara's lectures and reference Chapter 7. Give equations if necessary. Please describe the HRDL and MOPA lidar systems and explain the wavelength selection (or consideration) basis – why does CDL prefer longer wavelength?
6. Direction Detection Doppler Wind Lidar: DDL is incoherent detection Doppler lidar. DDL has resonance DDL (resonance fluorescence lidar) and non-resonance DDL (many different types, like fringe-imaging DDL, scanning-FPI DDL, FPI-edge-filter DDL, atomic or molecular absorption-edge-filter DDL). What is the major difference between the resonance and non-resonance DDL (*remember the "skirt" description used in the class*)? Please briefly describe the principles of each non-resonance DDL technique and summarize their advantages and disadvantages. Give equations or figures or tables if

necessary. What is the common point in these non-resonance DDLs? *What more approaches could you suggest?*

7. Give a summary of our NOAA field trip (what you learned). What we emphasized in the lidar class is the fundamental spectroscopy, physical measurement principles, lidar equations, laser transmitter design and receiver optics design. These are fundamental principles and solid foundations for lidar technology. However, besides the above, many more aspects must be considered in lidar design for field campaigns like trailer-borne, ship-borne, aircraft-borne or space-borne. Based on NOAA visit and Carl Weimer's guest lecture, please describe the instrument design aspects you would consider or concern if you were in charge of such a campaign. Your wild or crazy ideas are encouraged.