## The 2013 Chico Lidar Wind Sensing Experiment: Two-component winds above the reach of typical meteorological masts

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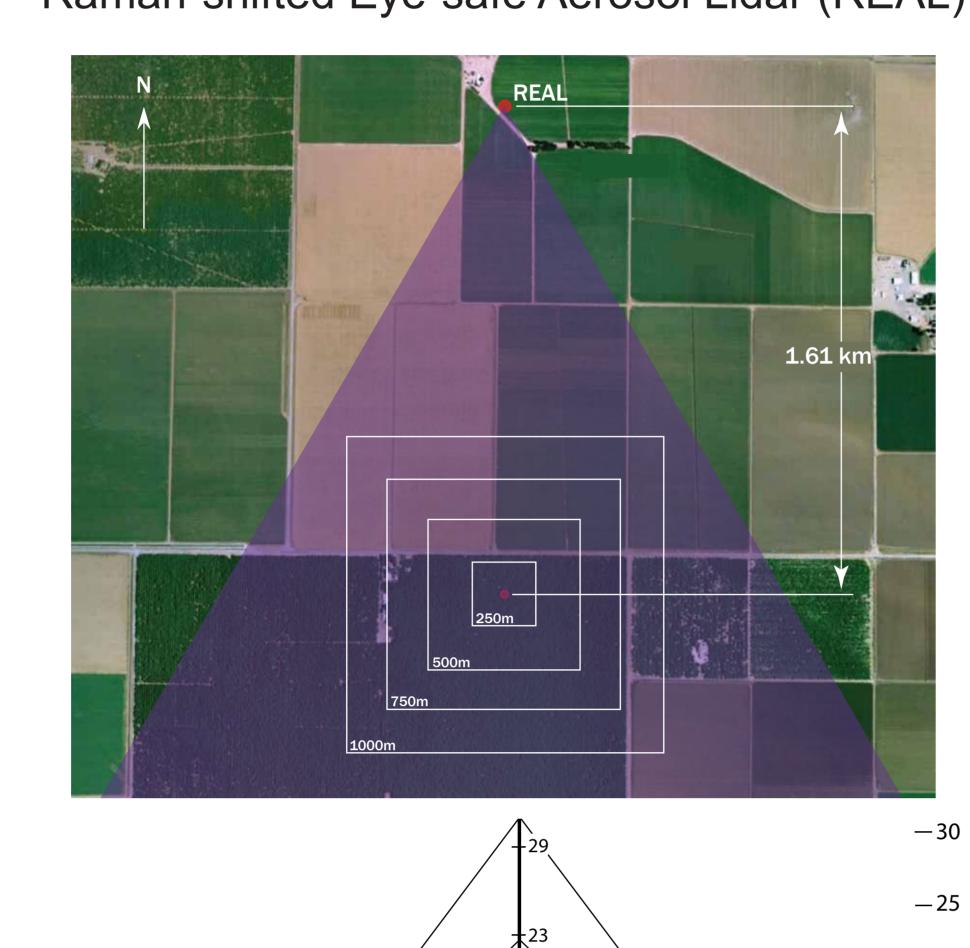
A. Background

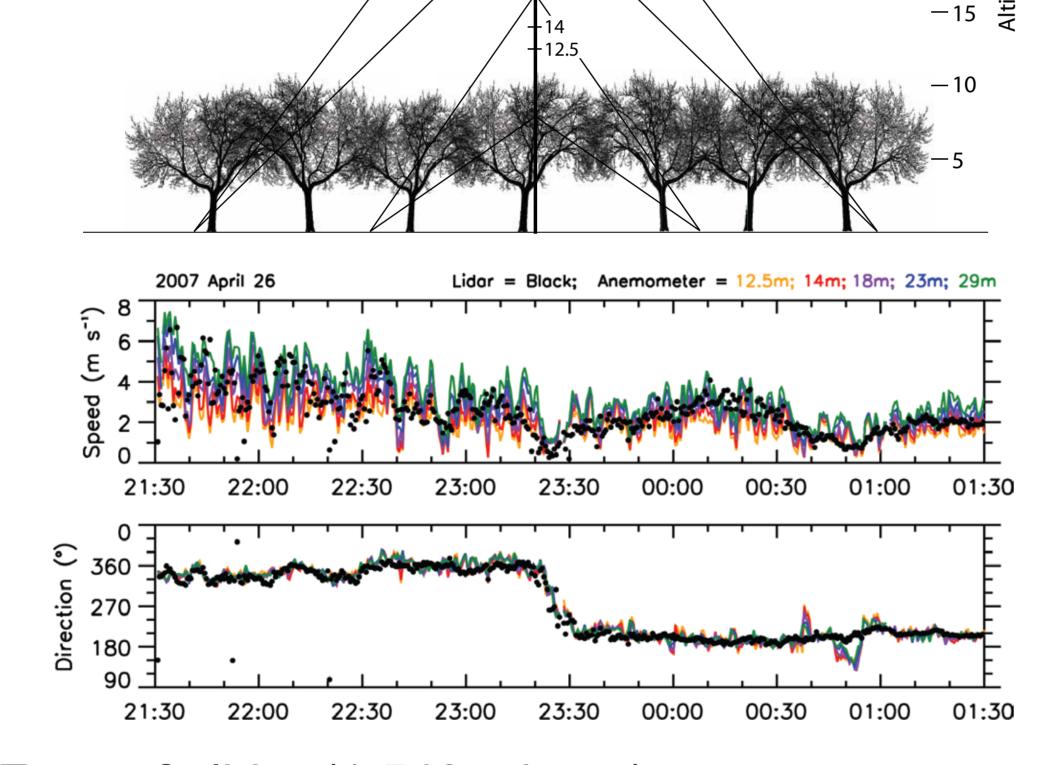
Several experiments have been conducted previously to investigate the potential of using | scanning aerosol lidar and motion estimation algorithms to measure two-component winds (e.g. Eloranta et al. 1975 and Hooper and Eloranta 1986 among others). The most recent experiments to our knowledge were described by Mayor and Elornata (2001) and Mayor et al. (2012). The two sections below highlight the main aspects of those experiments.

# 1997-98, Sheboygan, WI (Lake-ICE) University of Wisconsin Volume Imaging Lidar UW VIL 10 January 1998 14:16 - 14:57 UT Distance east from VIL (km) 4 5 6 7 8 9 10 11 wind speed (m/s)

- Scanning offshore (5 m 15 m ASL)
- Non-eye-safe lidar (1.064 micron)
- No validation of wind vectors
- Compared with LES
- Cross-correlation with moving blocks
- Many cross-correlation functions averaged over time for mean flow
- Described by Mayor and Eloranta (2001)







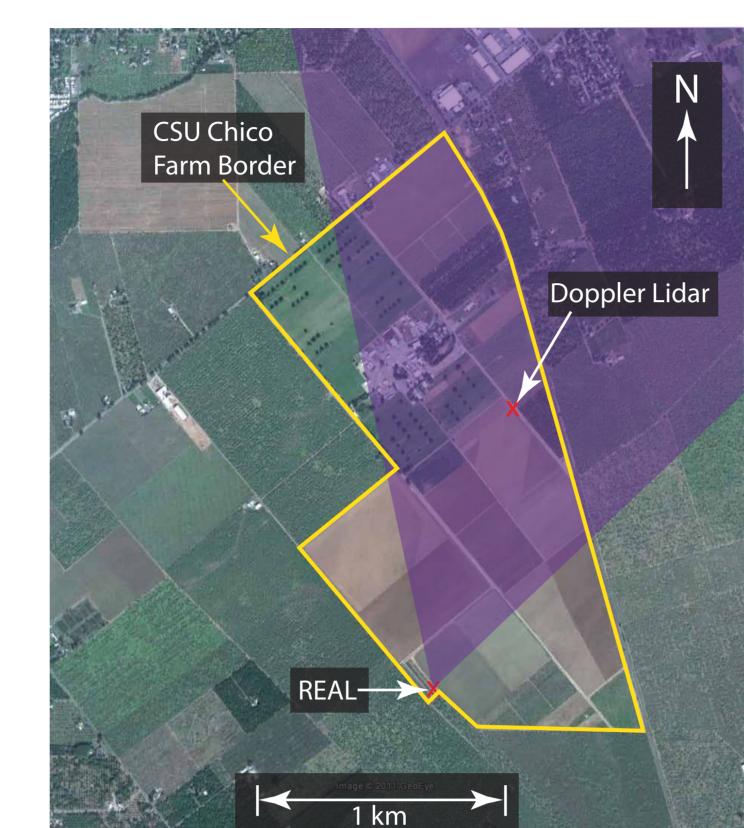
- Eye-safe lidar (1.543 micron)
- Scanning over orchards & fields
- Validation with sonic anemometers from 12.5 m to 29 m AGL (above a 10 m AGL forest canopy)
- Cross-correlation without moving blocks
- 3 month data set
- No averaging of cross-correlation functions
- First attempts with optical flow
- Unstable platform and hard-targets (trees, tower) limited data analysis.
- Described by Mayor et al. (2012)

### C. Current Experiment

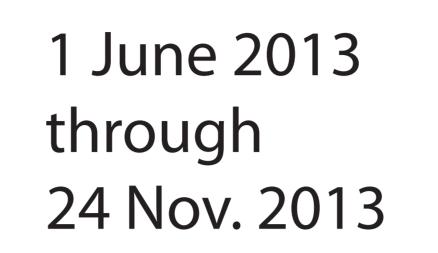
2013, Chico, CA

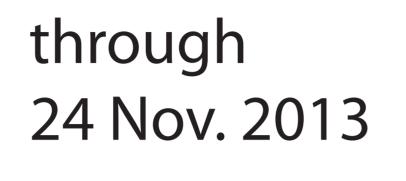
Raman-shifted Eye-safe Aerosol Lidar (REAL)

Phase 1: Time series comparisons

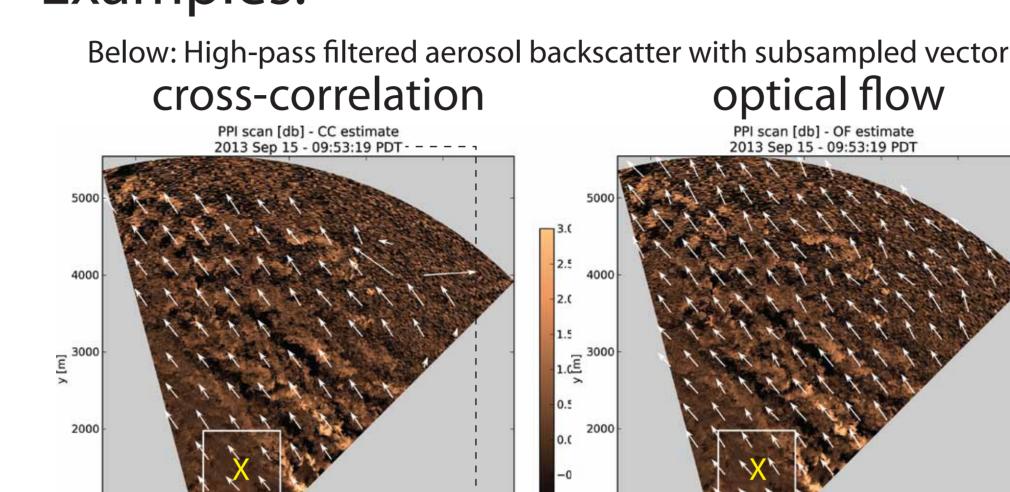


June 2013 through









cross-correlation

3.95 deg. for 100 m AGL at 1.53 km

1.53 km

cross-correlation

optical flow optical flow cross-correlation

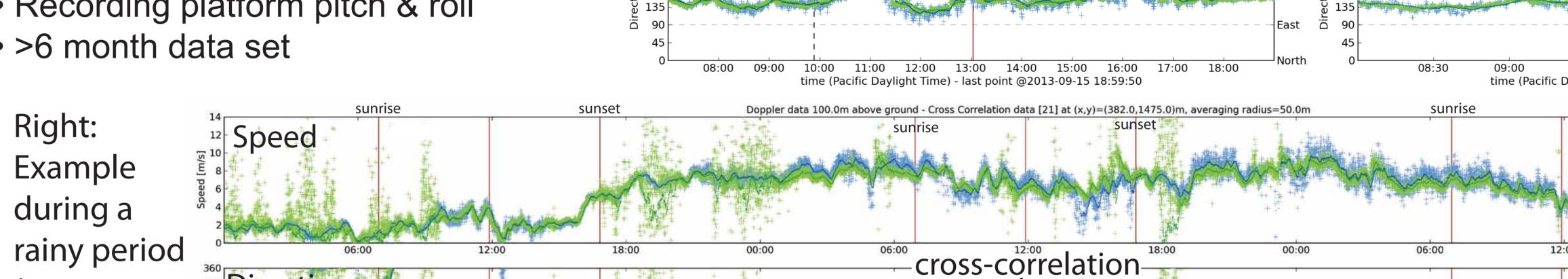
- Eye-safe lidar (1.543 micron) Scanning over orchards & fields Validation with Doppler lidar at
- Cross-correlation with moving blocks
- Wavelet-based optical flow Real-time motion estimation
- Stable platform and no hard-targets
- Recording platform pitch & roll
- >6 month data set

(overcast,

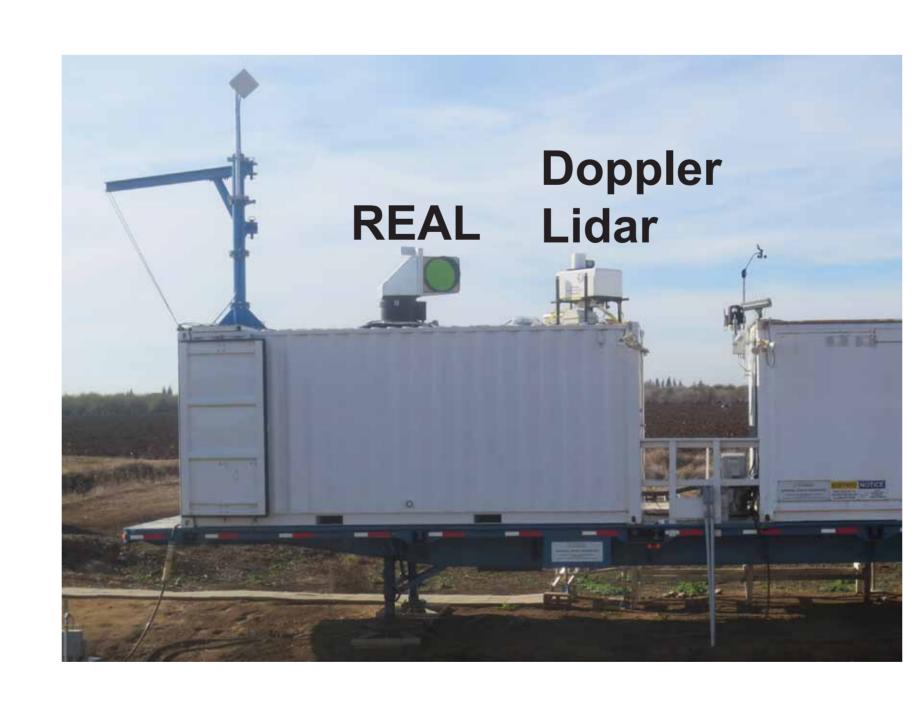
rainy, poor

visibility)

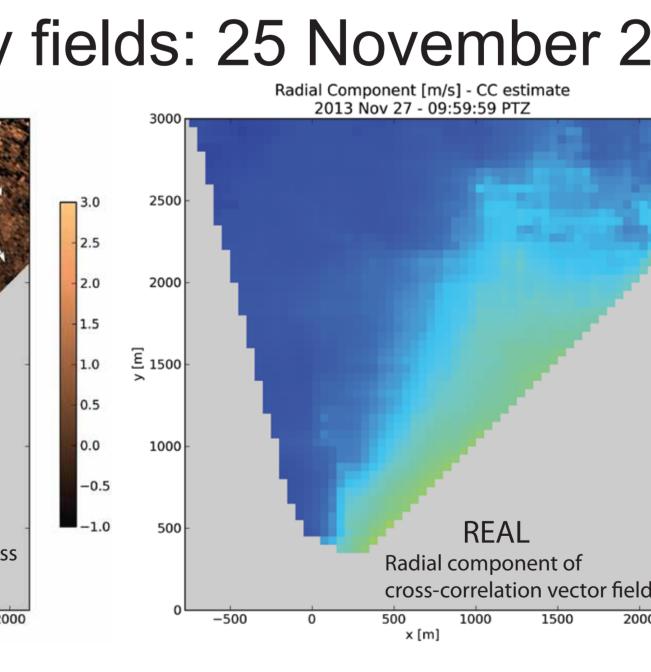
50 - 150 m AGL

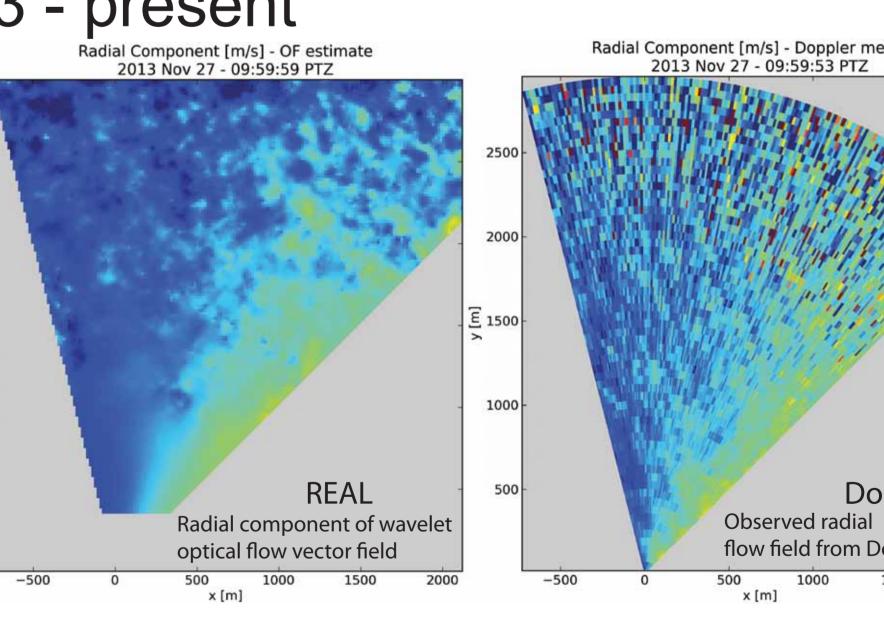


during a windy day (clear, dry, high



Phase 2: Comparison of radial velocity fields: 25 November 2013 - present Wavelet optical flow vectors over high-pas filtered backscatter





Doppler

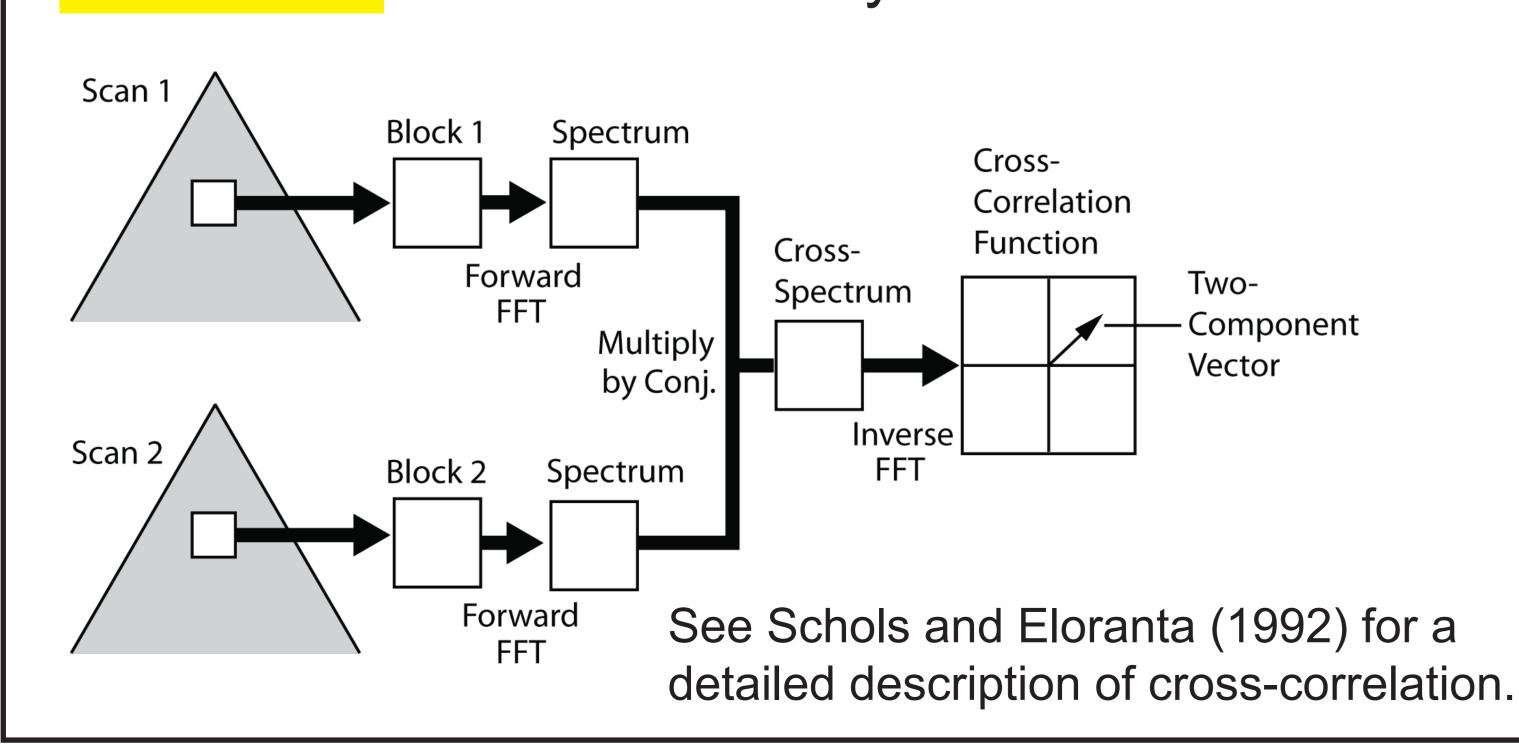
Lidar

Below: Blue points from Doppler lidar. Orange points from REAL.

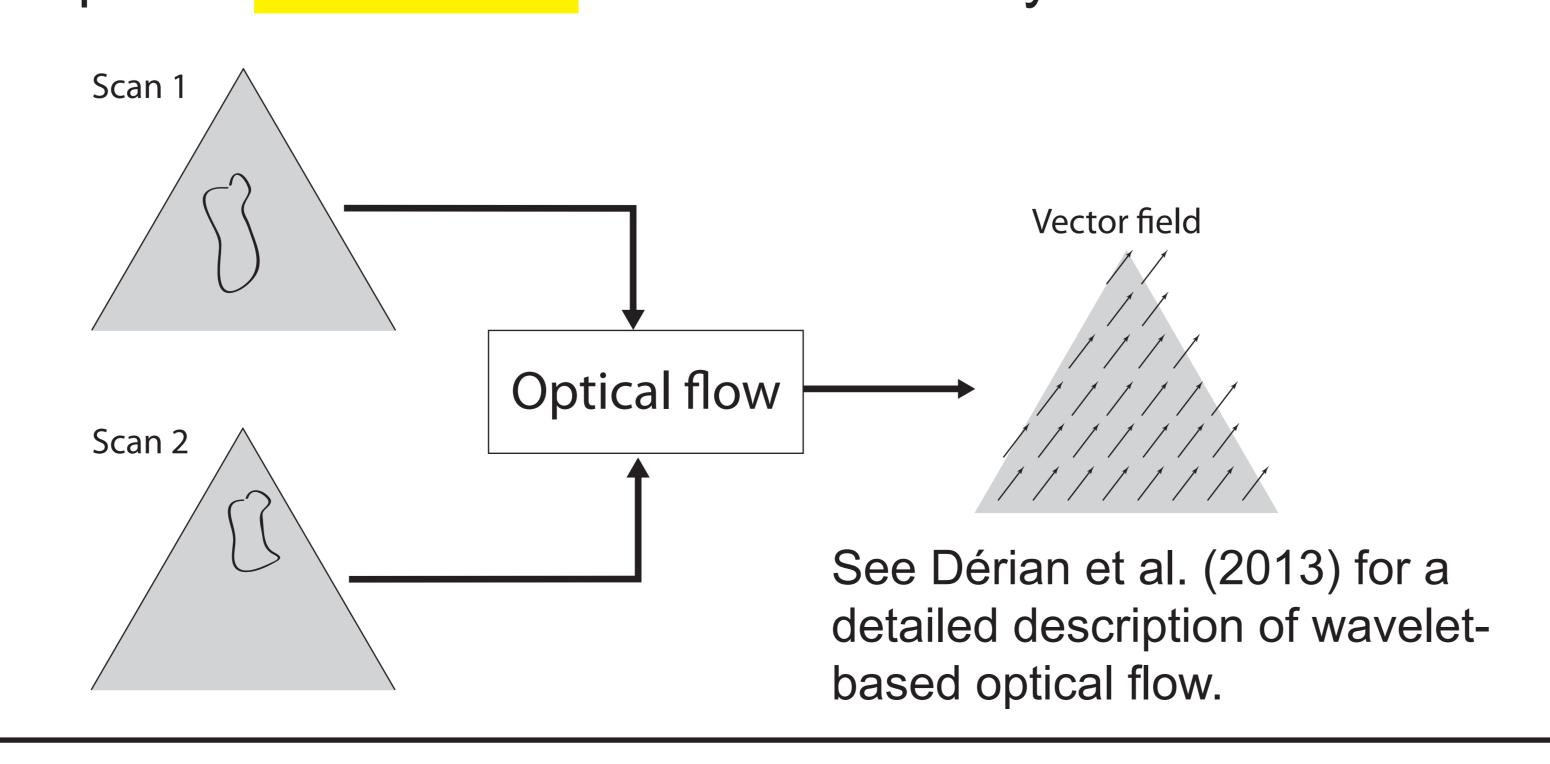
Doppler data 100.0m above ground - Optic Flow data [27] at (x,y)=(382.0,1475.0)m, averaging radius=50.0m

# B. Motion Estimation Algorithms

1. Cross-correlation: For details, please see poster A13G-0311 in this session by Masaki Hamada.



2. Wavelet-based optical flow. For details, please see poster A13G-0303 in this session by Pierre Dérian.



## References

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Dérian, P., P. Héas, C. Herzet and E. Mémin, 2013: Wavelets and Optical Flow Motion Estimation, Numerical Mathematics: Theory, Methods and Applications, **6**, 116-137.

| Eloranta, E. W., J. M. King, and J. A. Weinman, 1975: The determination of wind speeds in the boundary layer by monostatic lidar. J. Appl. Meteor., 14, 1485-

Hooper, W. P. and E. W. Eloranta, 1986: Lidar measurements of wind in the planetary boundary layer: the method, accuracy and results from joint measurements with radiosonde and kytoon. J. Clim. Appl. Meteor., **25**, 990–1001.

Mayor, S. D. and E. W. Eloranta, 2001: Two-dimensional vector wind fields from volume imaging lidar data. *J. Appl. Meteor.*, **40**, 1331–1346.

Mayor, S. D., J. P. Lowe, and C. F. Mauzey, 2012: Two-component horizontal aerosol motion vectors in the atmospheric surface layer from a cross-correlation algorithm applied to elastic backscatter lidar data, *J. Atmos. Ocean. Technol.*, **29**, 1585-1602.

Mayor, S. D. and S. M. Spuler, 2004: Raman-shifted Eye-safe Aerosol Lidar, Appl. Optics, 43, 3915-3924.

Schols, J. L. and E. W. Eloranta, 1992: The calculation of area-averaged vertical profiles of the horizontal wind velocity from volume-imaging lidar data. J. Geophys. Res., 97, 18 395–18 407.