Comparisons Between Large-Eddy Simulations and Lidar Observations of a Land-Breeze Circulation

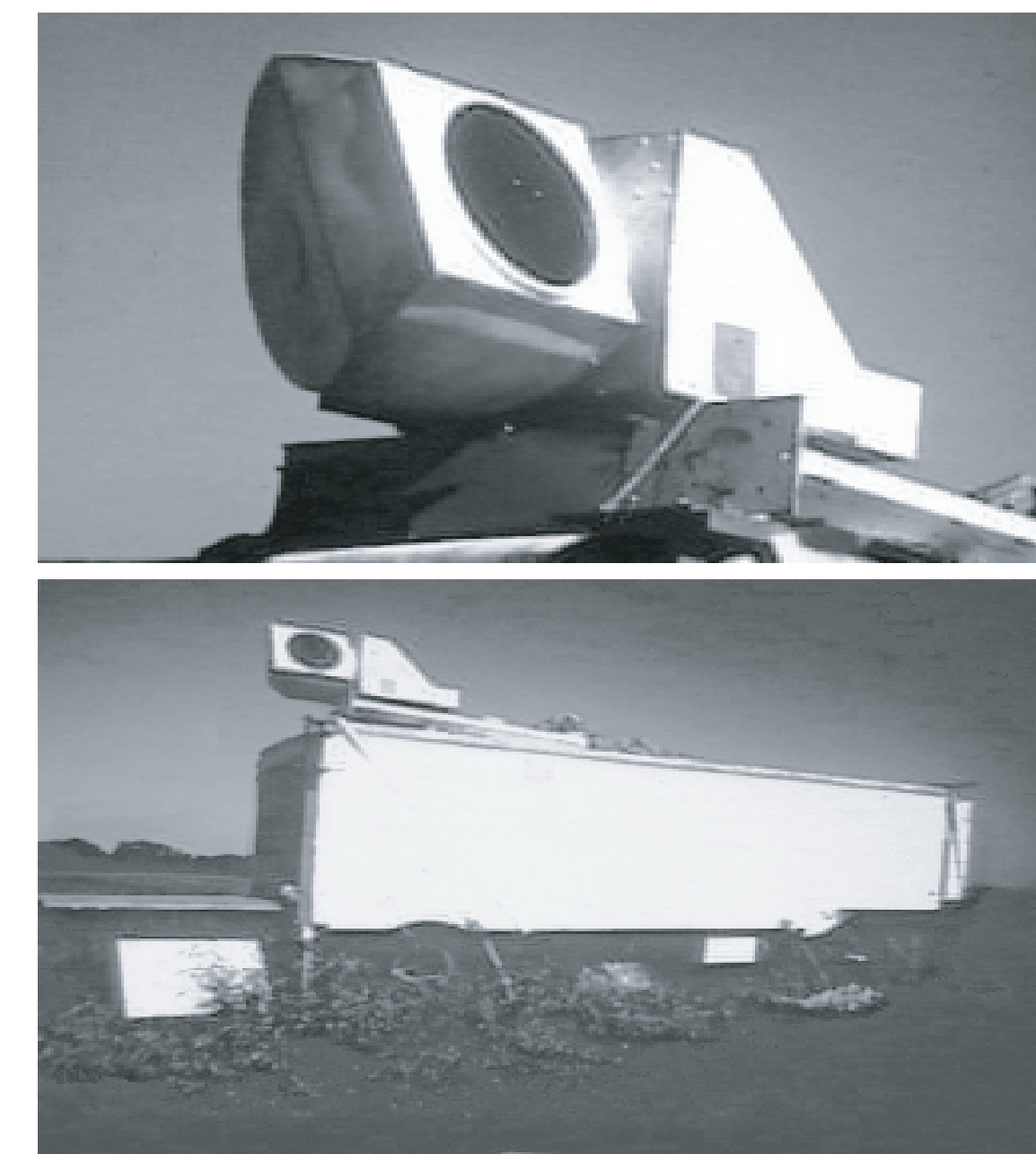## Edwin W. Eloranta, Gijs de Boer, Gregory J. Tripoli
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Introduction

As part of the LAKE-ICE experiment the University of Wisconsin Volume Imaging Lidar (VIL) observed a land-breeze circulation along the western shore of Lake Michigan. During the observation period, a current of cold air from the Wisconsin shore slid under a light south-easterly onshore breeze. Lidar images obtained at 24 second intervals with a range resolution of 15 m provide vivid animations showing advances and retreats of the land-breeze front. Three-dimensional lidar scans also show the classic structure of a density current along with gravity waves forced by the front. The University of Wisconsin Non-Hydrostatic Modeling System (UW-NMS) was applied to simulate these observations in Large-Eddy Simulation mode. Multiply nested model fields of higher and higher resolution provided modeling of both the large-scale forcing and the detailed structure of the land-breeze circulation. The inner grid spacing of 32 m in the horizontal and vertical dimensions provided a good match to the lidar resolution. High resolution topography is also included in the model.

The VIL uses a Nd:YAG laser to transmit 400 mJ pulses at 1.064-micron wavelength at 100 Hz. The VIL resides in a semi-trailer van, employs 0.5 m optics, a beam steering unit, log-amplifier, and real-time displays. Data are stored on write once optical disks.

Transmitter	
Wavelength	1064 nm (Nd:YAG)
Average Power	20 W
Repetition Rate	30 Hz
Receiver	
Telescope Diameter	50 cm
Optical Bandwidth	1 nm
Detector Quantum Efficiency	~35%
Range Resolution	15 m
Maximum Scan Rate	20 degrees/second
Data Rate	~500 MB/h
Length of Data Buffer	16K x 16 bit
Data Acquisition	
Data Acquisition Computer	Heurikon i960
Controlling Computer &	SGI
Real-time Graphics	
Optical Data Storage	Hitatchi 7 GB Disk

In this poster, we present a preliminary comparison between observations from the VIL and output from the UW-NMS.

Synoptic Scale Comparison of Model vs. Analysis for December 21, 1997

UW-NMS MSLP Forecast

1200Z Analysis of MSLP

The VIL in Sheboygan, WI during Lake-ICE. This was taken looking west before dawn. The bright light on the beam steering unit was used to prevent frost formation.
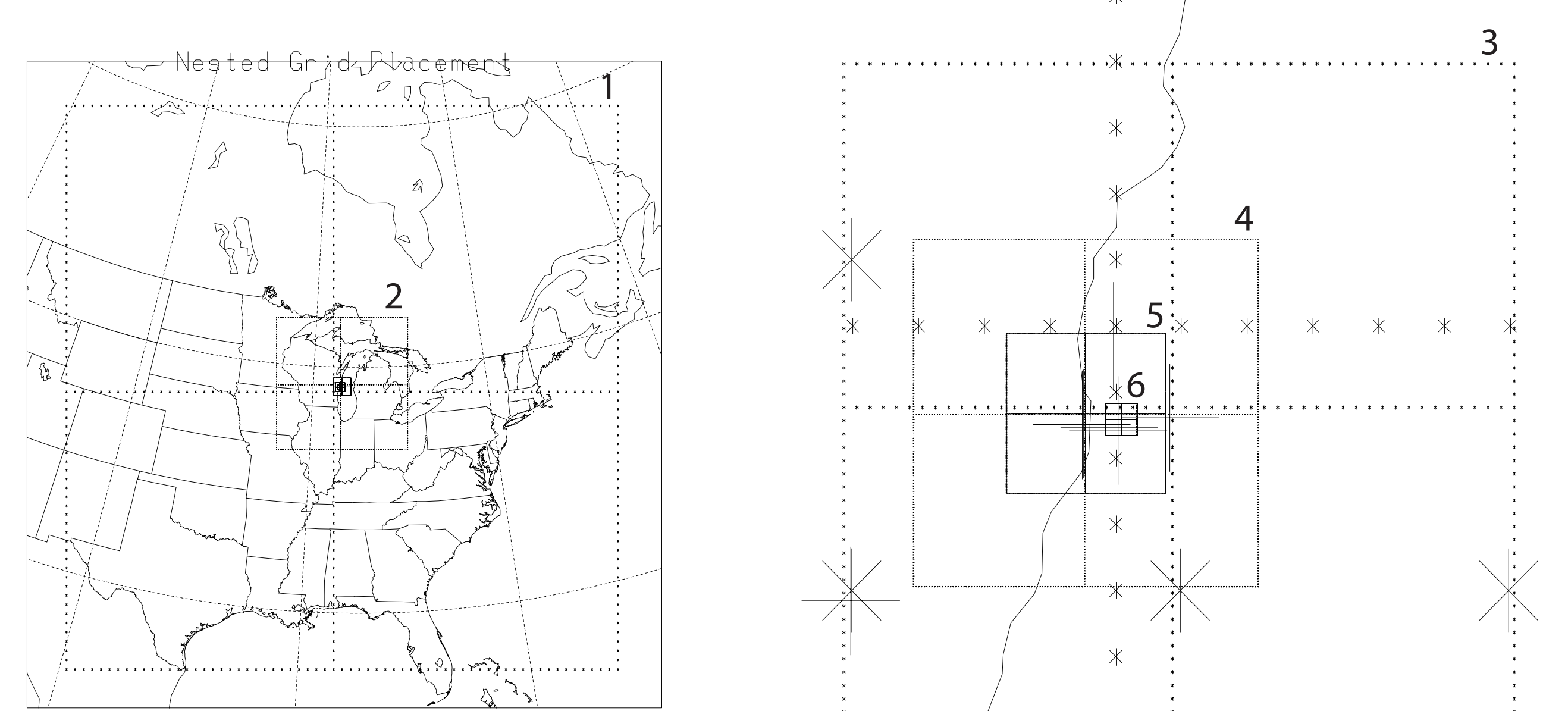
A view from the VIL site, looking towards the southeast. The emissions from the smoke stacks show up in the lidar data, and can be used in future research with the model, to compare to tracers put into the model.

Another view from the VIL site. Note, this is not a photograph of the case being observed, and is merely used to get a feel for the measurement site.
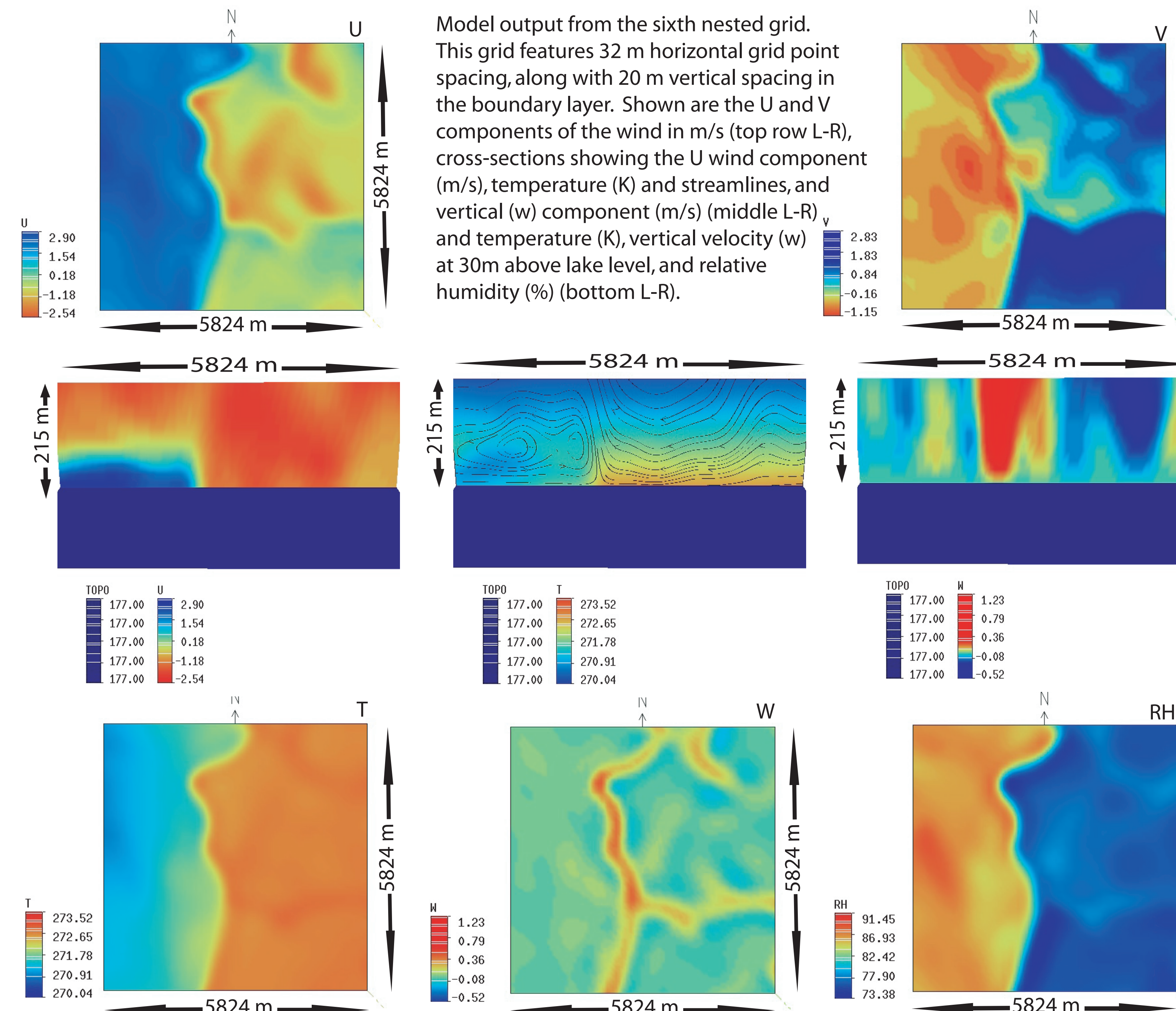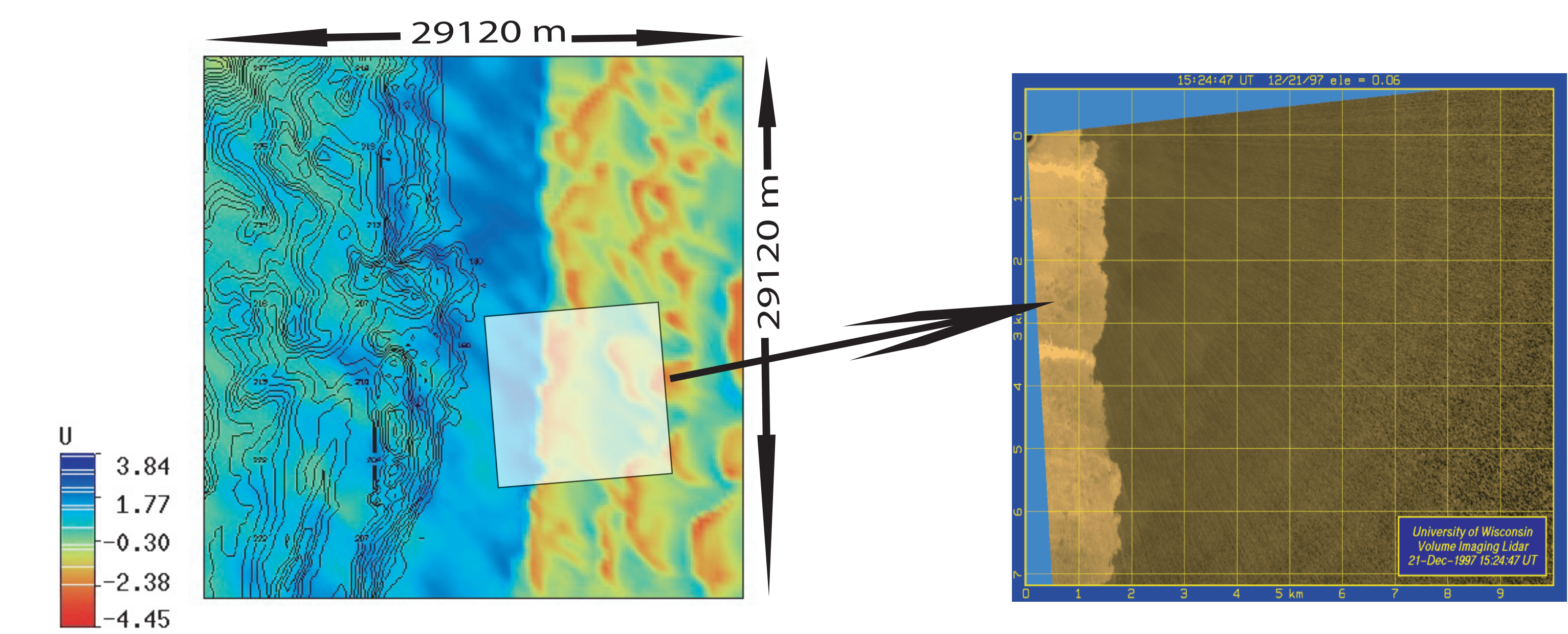
Nest Positions Used in the Simulation

Grid positions used in the simulations of which data is shown here. The left image reveals the entire model domain, with the right image being a more detailed depiction of the third, fourth, fifth and sixth grids. The lidar was located at Sheboygan Point during the LAKE-ICE experiment, which is located approximately in the center of the fifth grid.
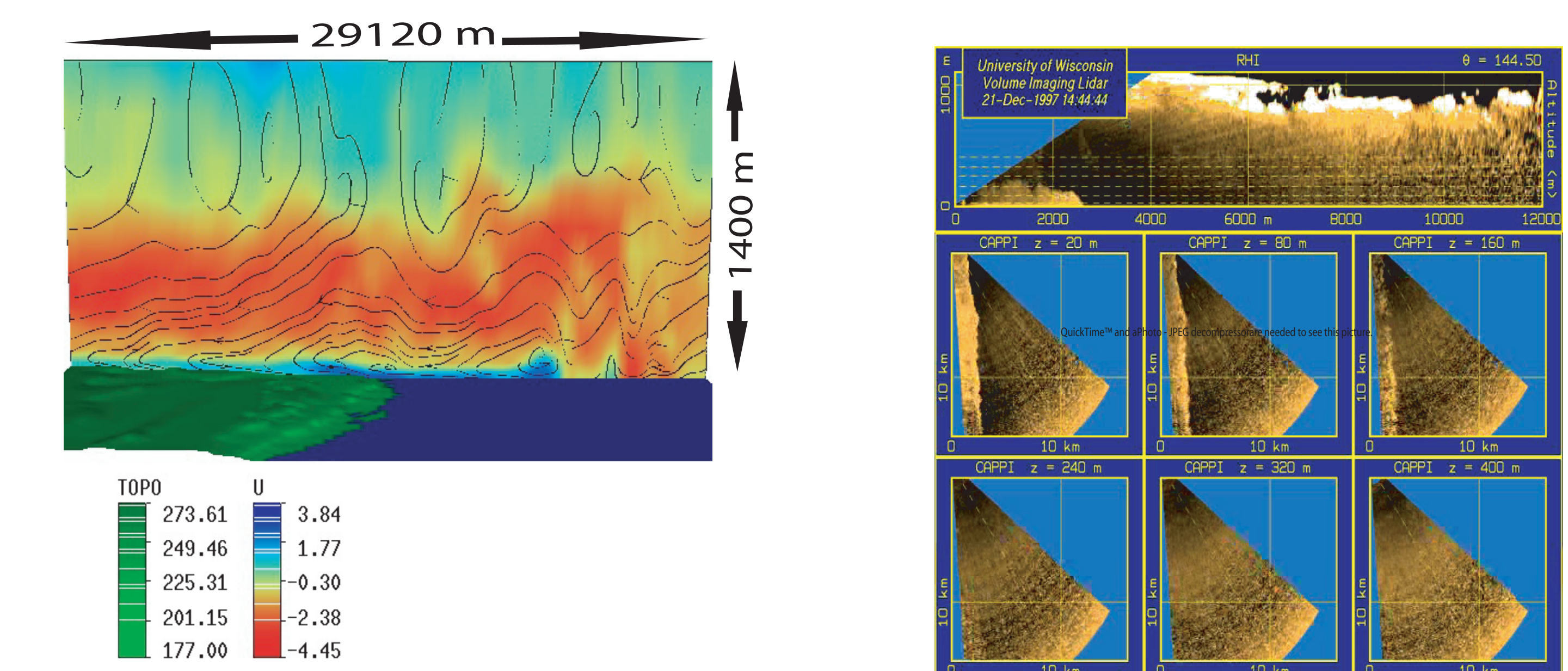
Sixth Grid Model Output

Model output from the sixth nested grid. This grid features 32 m horizontal grid point spacing, along with 20 m vertical spacing in the boundary layer. Shown are the U and V components of the wind in m/s (top row L-R), cross-sections showing the U wind component (m/s), temperature (K) and streamlines, and vertical (w) component (m/s) (middle L-R) and temperature (K), vertical velocity (w) at 30m above lake level, and relative humidity (%) (bottom L-R).
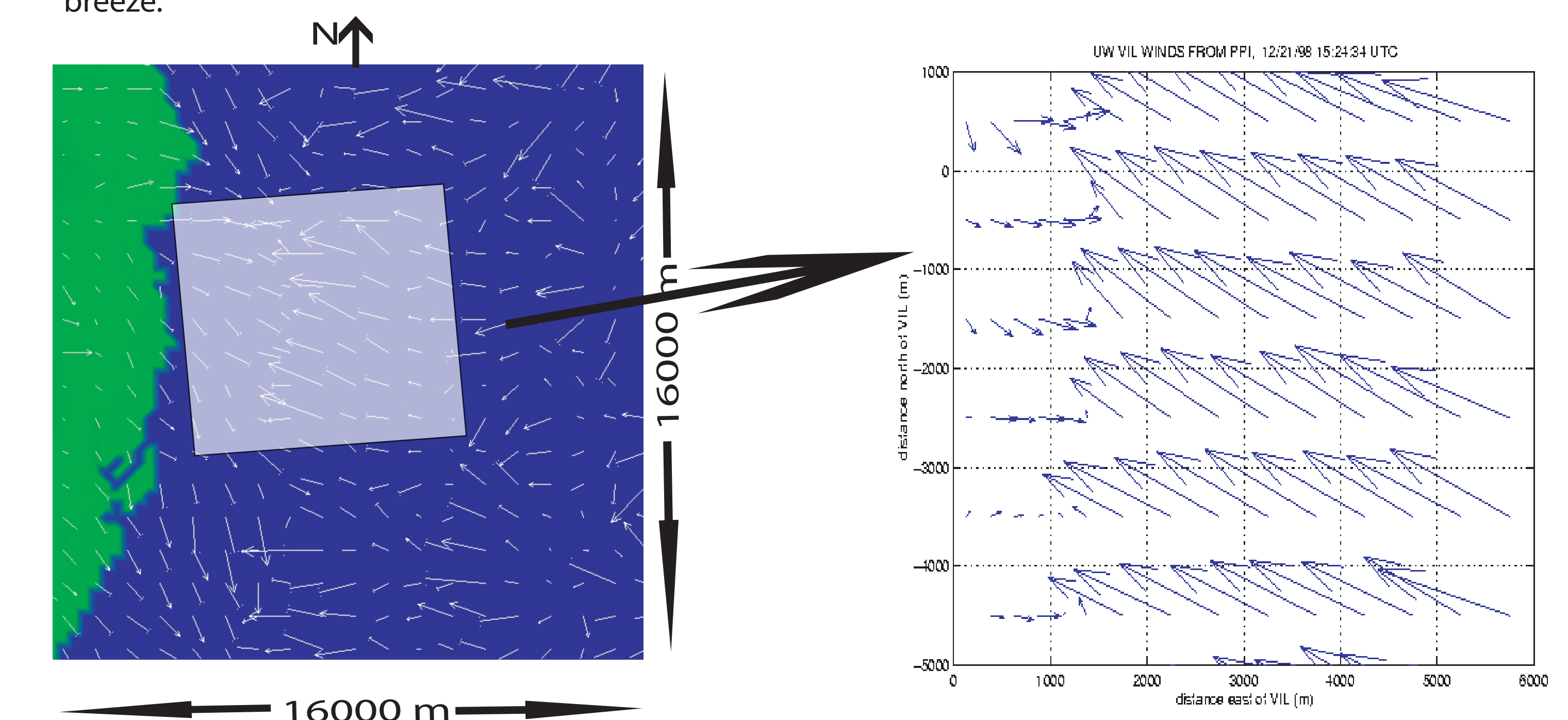

Comparison of Lidar Data to Fifth Grid Model Output

A comparison of the model output U velocities and a PPI scan taken by the lidar. The shaded box indicates approximately what is in the field of the lidar scans.
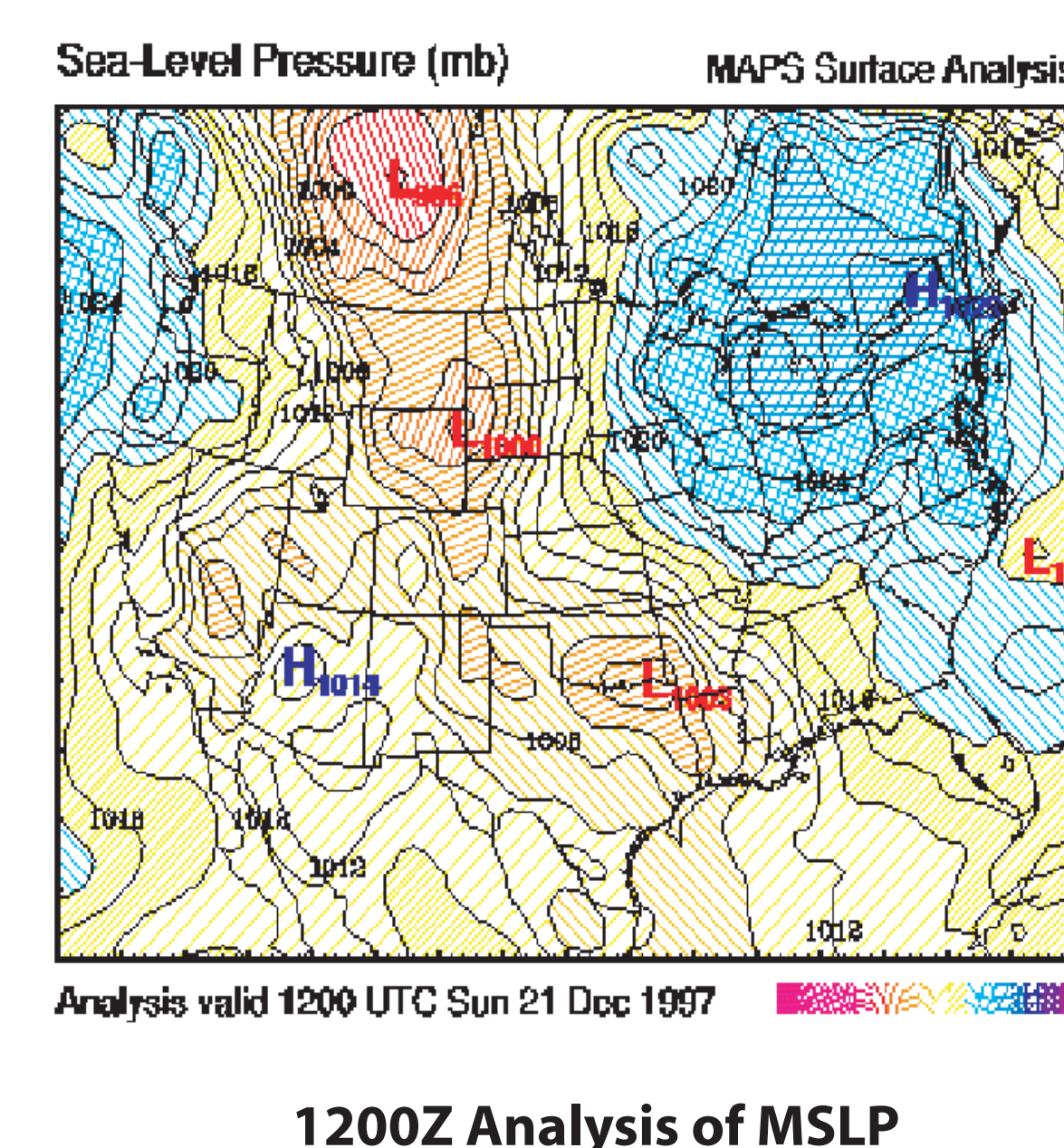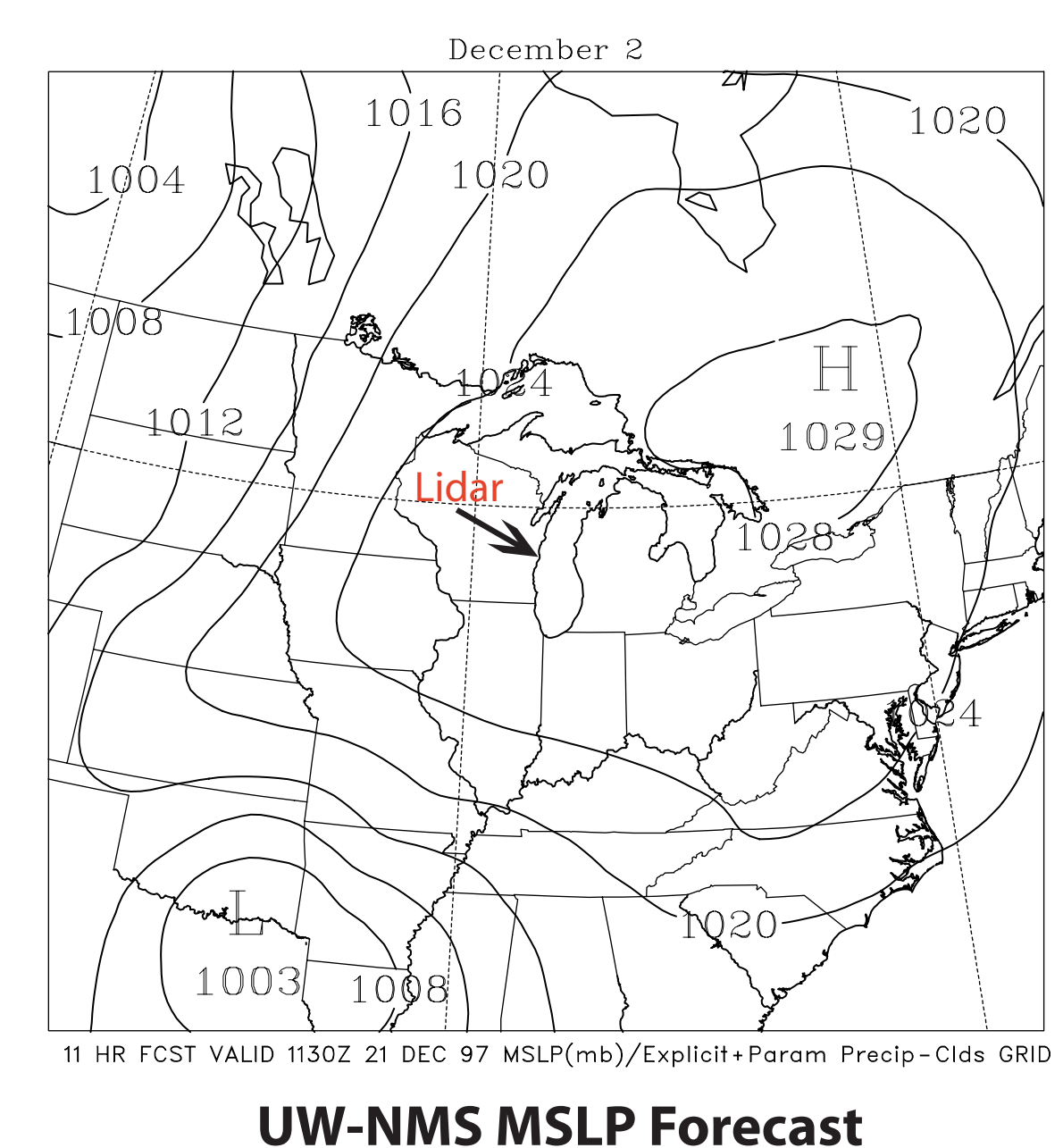

A vertical cross-section of model output streamlines and U-velocity shows the ultra-shallow land-breeze current flowing offshore, as well as the boundary layer. On the right is a RHI scan from the lidar of the land breeze.

A comparison of model derived winds on the fifth grid with a lidar derived average flow over 30 minutes at the front.