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High Resolution WRF Modeling for MATERHORN Field Campaign

UNIVERSITY OF NOTRE DAME

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Abstract:

The Weather Research and Forecasting (WRF) model was used for high resolution simulation of flow around Granite Mountain Atmospheric Sciences Testbed during MATERHORN field campaigns (www.nd.edu/~dynamics/materhorn). The aim was to provide guidance for instrument siting and map possible flow structures emanating from topographic and thermal inhomogeneities. Intriguing flow features were noted: short-lived nature of down-slope and down-valley flows due to mutual interactions between multiple nocturnal flows, drainage of cold pools between basins through sills that separate them, channelized flow expanding into nearby cold pools forming intrusions, critical (stagnation, convergence and divergence) points due to flow interactions, flow separation and wake vortices in the presence of synoptic winds, and interaction between synoptic and thermally driven flow that modifies both. The performance of the model was evaluated by comparing model predictions with observations from the two MATERHORN field campaigns (October 2012 and May 2013).

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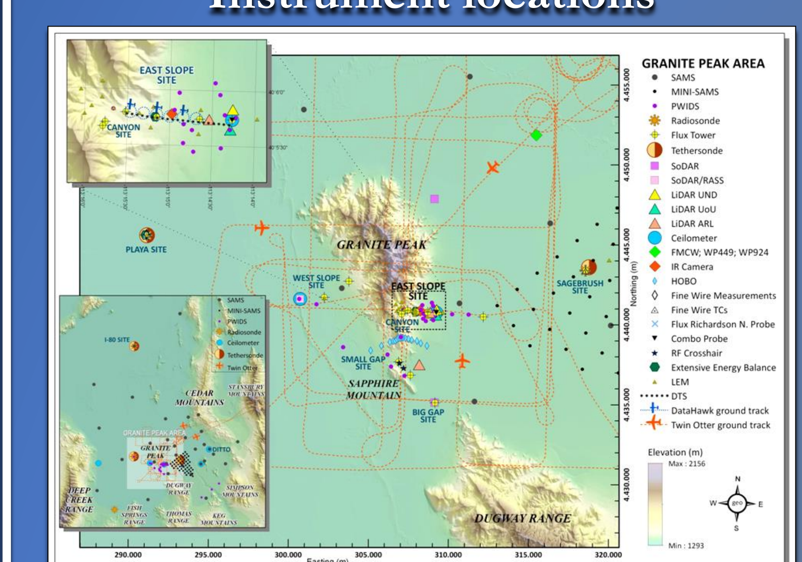
Mountain Terrain Atmospheric Modeling and Observations Program

Instrument locations

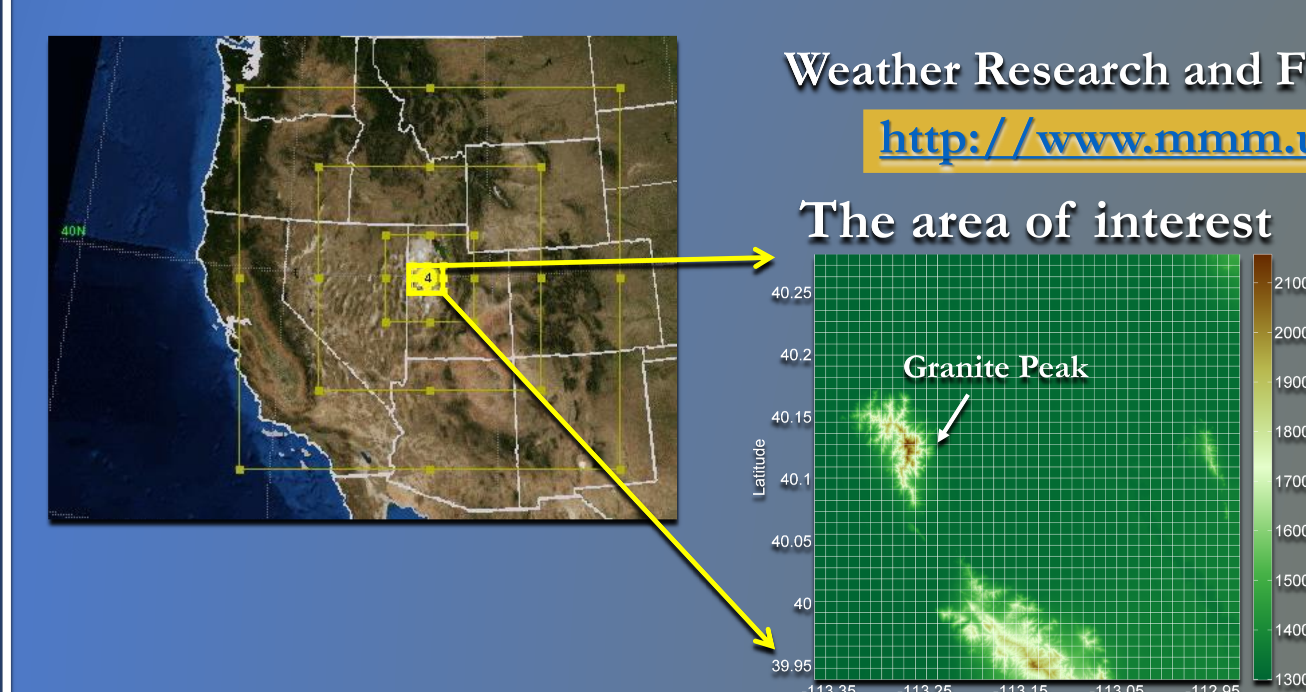


Down-slope flow and valley flow interaction

Weather Research and Forecasting Model (WRF)

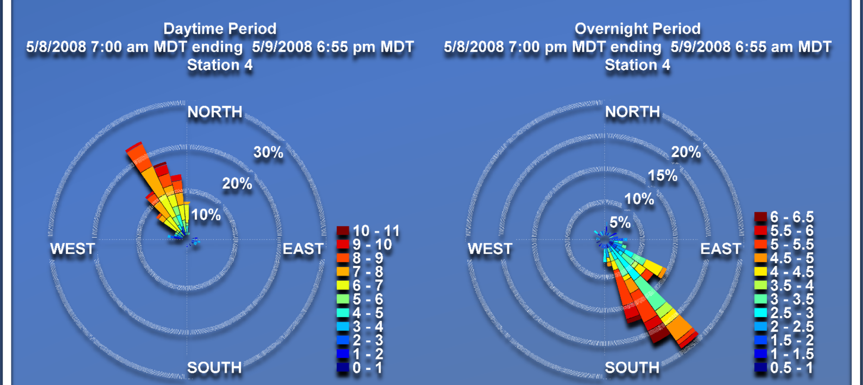
http://www.mmm.ucar.edu/wrf/users/

The area of interest



Modeling Domains:
Lambert projection
Utah (113°W, 40°N);
Two-way nested
(64, 16, 4, 1km);
Vertical levels: 48

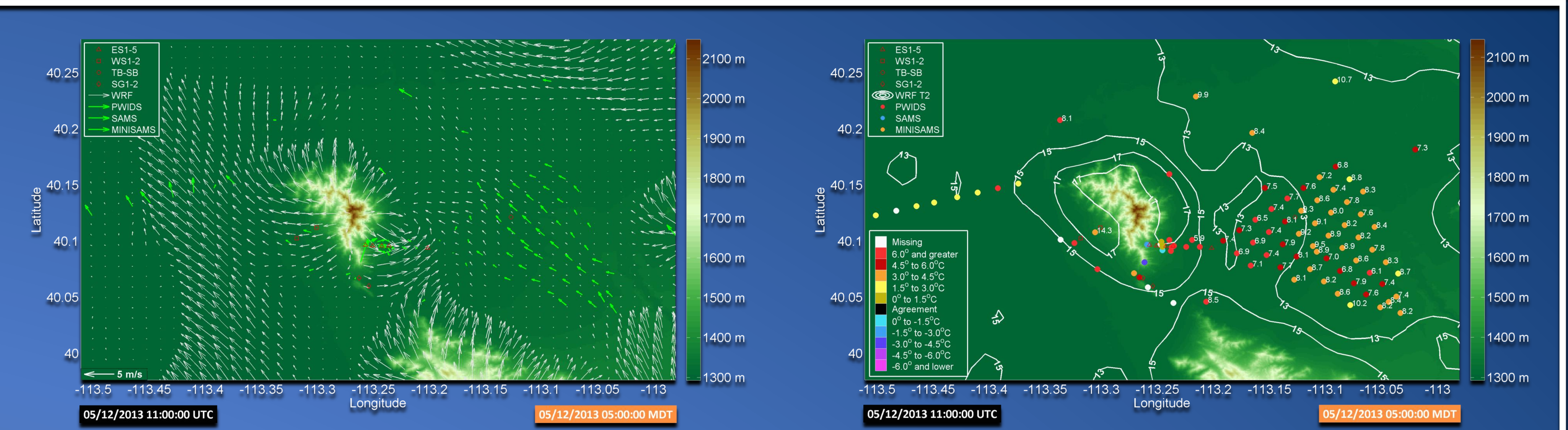
In the planning stage of the second field campaign wind roses were used to determine the predominant wind direction during the day and night.



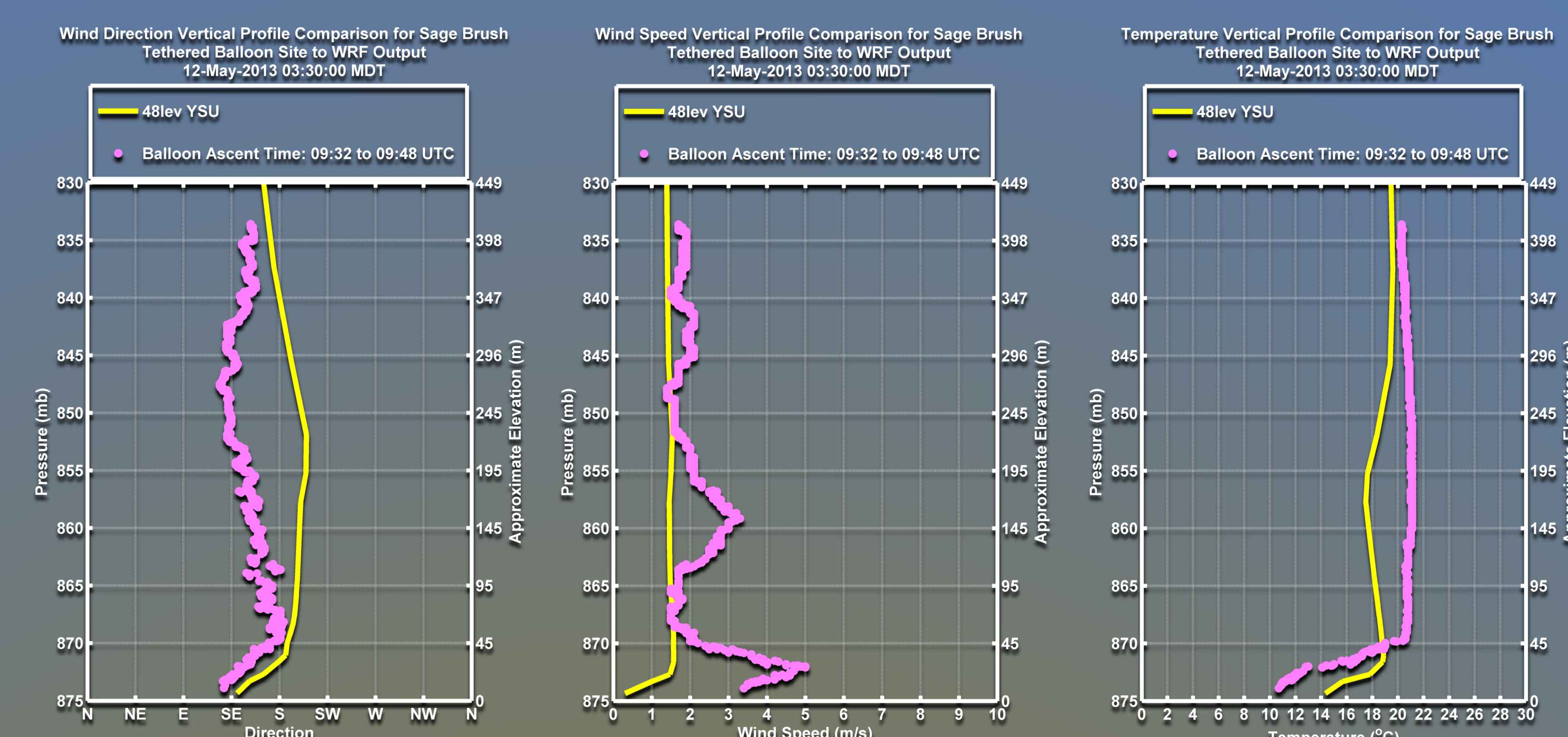
Wind vectors and temperature at 2 meters for the 1 km domain at 5:00 AM (MDT)

White vectors and contours: WRF

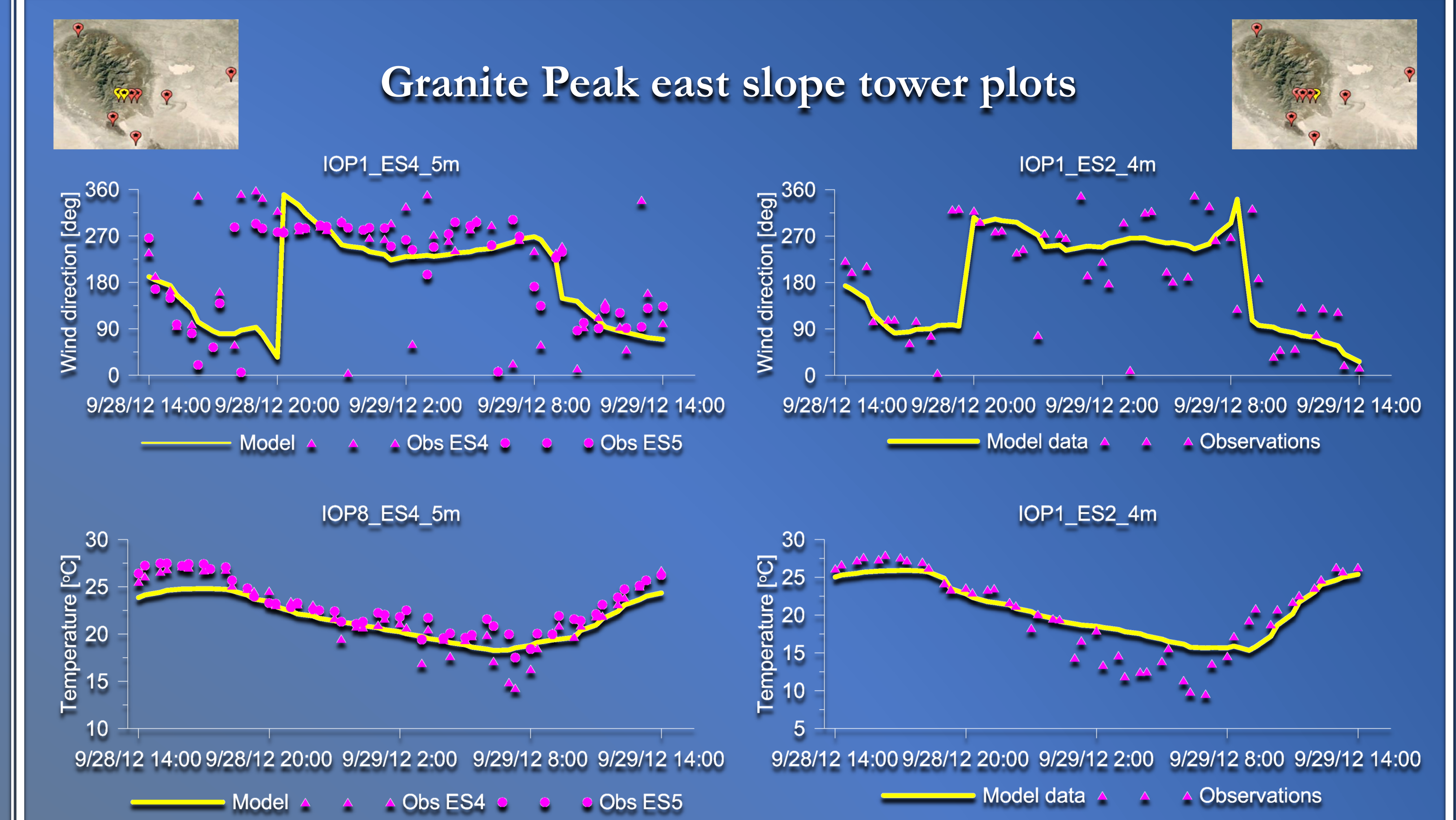
Green vectors:
- Surface Atmospheric Measurement Systems (SAMS)
- MiniSAMS
- Portable Weather Instrumentation Data Systems (PWIDs)



Vertical tethered balloon profile comparison at 3:30 AM (MDT) for the Sagebrush site located in the valley



Granite Peak east slope tower plots



Two field campaigns were conducted each consisting of 10 Intense Observations Periods (IOP). WRF model simulations have been performed for all of the IOPs

IOP - Fall	Start (MDT)	End (MDT)	Start (UTC)	End (UTC)	Classification	Wind speed
IOP0	9/25/2012 14:00	9/26/2012 14:00	9/25/2012 20:00	9/26/2012 20:00	Quiescent	<5m/s
IOP1	9/28/2012 14:00	9/29/2012 14:00	9/28/2012 20:00	9/29/2012 20:00	Quiescent	<5m/s
IOP2	10/1/2012 14:00	10/2/2012 14:00	10/1/2012 20:00	10/1/2012 20:00	Quiescent	<5m/s
IOP3	10/3/2012 2:00	10/4/2012 2:00	10/3/2012 8:00	10/4/2012 8:00	Transitional	front
IOP4	10/6/2012 14:00	10/7/2012 14:00	10/6/2012 20:00	10/7/2012 20:00	Moderate	5 m/s – 10 m/s
IOP5	10/9/2012 14:00	10/10/2012 14:00	10/9/2012 20:00	10/10/2012 20:00	Moderate / Quiescent	front
IOP6	10/14/2012 2:00	10/15/2012 2:00	10/14/2012 8:00	10/15/2012 8:00	Quiescent	<5m/s
IOP7	10/17/2012 12:00	10/17/2012 20:00	10/17/2012 18:00	10/18/2012 2:00	Moderate / Quiescent	5 m/s – 10 m/s
IOP8	10/18/2012 5:00	10/19/2012 12:00	10/18/2012 11:00	10/19/2012 18:00	Quiescent	<5m/s
IOP9	10/20/2012 14:00	10/21/2012 14:00	10/20/2012 20:00	10/21/2012 20:00	Moderate	5 m/s – 10 m/s

IOP - Spring	Start (MDT)	End (MDT)	Start (UTC)	End (UTC)	Classification	Wind speed
IOP1	5/1/2013 14:00	5/2/2013 14:00	5/1/2013 20:00	5/2/2013 20:00	Moderate / Quiescent	<5 m/s – 10 m/s
IOP2	5/4/2013 14:00	5/5/2013 14:00	5/4/2013 20:00	5/5/2013 20:00	Moderate	5 m/s – 10 m/s
IOP3	5/7/2013 5:00	5/7/2013 17:00	5/7/2013 11:00	5/7/2013 23:00	Moderate	5 m/s – 10 m/s
IOP4	5/11/2013 14:00	5/12/2013 14:00	5/11/2013 20:00	5/12/2013 20:00	Quiescent	<5m/s
IOP5	5/13/2013 12:00	5/14/2013 12:00	5/13/2013 18:00	5/14/2013 18:00	Moderate / Transitional	5 m/s – 10 m/s
IOP6	5/16/2013 12:00	5/17/2013 12:00	5/16/2013 18:00	5/17/2013 18:00	Moderate / Transitional	5 m/s – 10 m/s
IOP7	5/20/2013 17:15	5/21/2013 14:00	5/20/2013 23:15	5/21/2013 20:00	Sandwich Quiescent	<5m/s
IOP8	5/22/2013 14:00	5/23/2013 14:00	5/22/2013 20:00	5/23/2013 20:00	Moderate	5 m/s – 10 m/s
IOP9	5/25/2013 10:00	5/26/2013 10:00	5/25/2013 16:00	5/26/2013 16:00	Moderate	5 m/s – 10 m/s
IOP10	5/30/2013 14:00	5/31/2013 10:00	5/30/2013 20:00	5/31/2013 16:00	Moderate	5 m/s – 10 m/s

Model – Observation statistical correlation results calculated using 77 total stations located within the 1km domain

		Quiescent						Moderate					
		MB	NMB	ME	NME	RMSE	IA	MB	NMB	ME	NME	RMSE	IA
Temperature	48 levels	1.47	10.36	3.26	22.92	6.54	0.82	-0.75	-3.78	1.84	9.28	6.70	0.73
	35 levels	2.23	15.68	4.28	30.15	7.31	0.76	-1.38	-6.96	2.34	11.82	6.89	0.71
Wind speed	48 levels	-0.21	-8.46	1.29	51.28	1.65	0.68	0.37	8.31	1.62	36.68	2.04	0.80
	35 levels	0.58	22.97	1.69	67.11	2.16	0.61	0.12	2.80	1.82	41.23	2.25	0.79
Wind direction	48 levels	-4.31	-2.55	74.85	44.23	110.27	0.56	-1.07	-0.48	73.07	32.70	115.09	0.58
	35 levels	-13.18	-7.79	76.40	45.15	112.64	0.52	-8.48	-3.80	77.46	34.66	118.78	0.58

Conclusions

- WRF is capable of capturing local thermal circulation in general (the slope flow better than the interaction area)
- Collisions occurred between slope and valley flows (and produced short ephemeral turbulence events)
- Near surface jets were not well captured (Boundary layer and surface schemes need to be improved)
- The existing parameterizations in mesoscale models cannot capture vigorous transient episodes, which can play a significant role in determining the flow patterns

Computational Resources

This research was supported in part by the Notre Dame Center for Research Computing through [CRC resources].