Dispersion of Perfluorocarbon Tracers within the Salt Lake Valley

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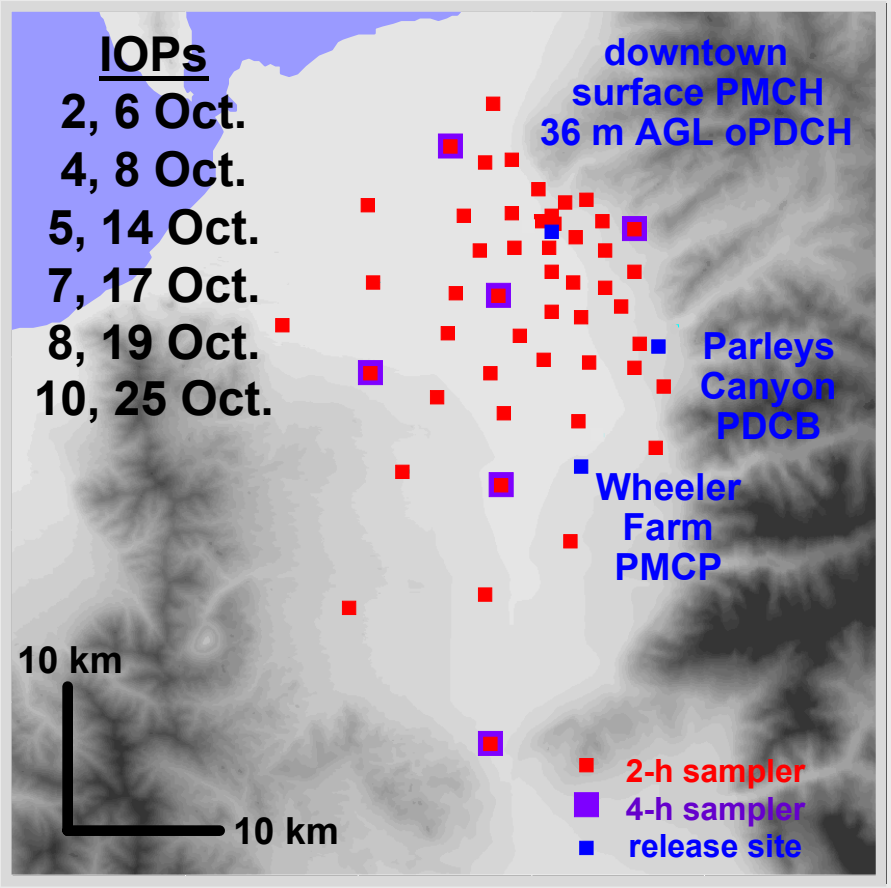
Outline

- overview of PFT experiments
- status of PFT data
- relate PFT data to observed meteorology
- use PFT data to evaluate mesoscale model

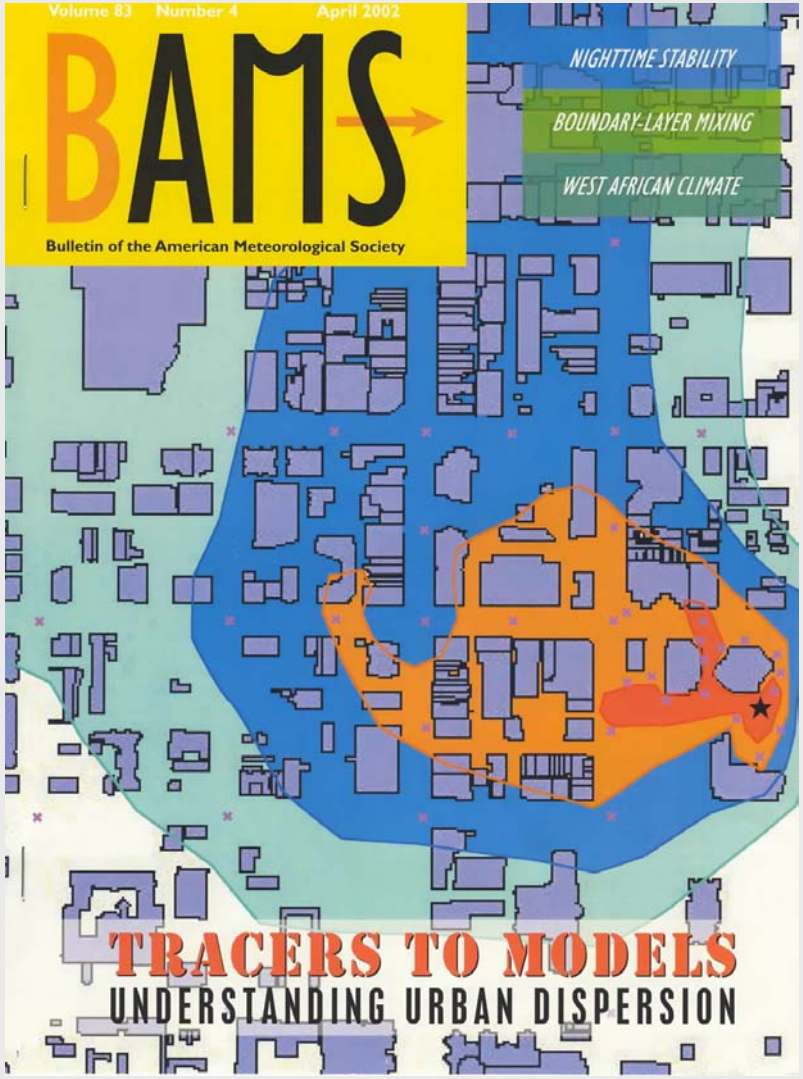
PFT Experiments: A Review

- 6 perfluorocarbon tracer (PFT) experiments
- 50 2-h samplers (22 - 12 MST) and 6 4-h samplers (start at 22 MST)



PFT Experiments: A Review

- CBNP's downtown SF_6 experiments performed in conjunction with VTMX PFT experiments
- combined SF_6 and PFT tracer experiments provided information on dispersion from building (few m) to valley (50 km) spatial scales
- VTMX PFT experimental design also described in Allwine et al., BAMS, 2002



Objective of PFT Experiments

Quantify the effects of vertical transport and mixing processes on scalars (a surrogate for pollutants) by measuring tracer concentrations at surface sites throughout the valley. Most VTMX instrumentation obtained data at specific locations; however, the PFT concentrations reflect the **integrated effect** of transport and mixing within the valley atmosphere

- Are there preferred regions of convergence in the valley?
- What is the vertical extent of mixing of surface releases in the stable boundary layer? Are there differences in upward and downward mixing of tracers?
- How does the interaction of down-valley, down-slope, and canyon flows affect dispersion?
- Are the dispersion patterns among the IOPs different? If so, why?
- What do the tracers reveal about pollutant transport and mixing within the valley atmosphere during night and morning transition periods?

Saga of the PFT Analysis

Series of delays in the analysis of the PFT samples:

- gas chromatograph preparation
- modifications and tests of procedures
- procedures for automatic mass production
- analysis of samples began April 19, 2002

designed to measure parts per quadrillion

Data obtained from BNL:

- experiments 4-6 obtained June 12, revised August 16
- experiments 1-3 obtained August 28, revised September 13

Analyses to ensure quality of the data:

- sample by sample inspection for each site
- samples at same time period compared with meteorology
- 2-h and 4-h sample comparisons
- comparison with CBNP SF_6 and PFT samples

ongoing

not done

Sample Recovery Rate

	Experiment					
	1	2	3	4	5	6
total possible 2-h samples	350	350	300	350	350	300
after equipment failure	90%	90%	90%	96%	96%	95%
after removing "bad" data						
PDCB - Parleys Canyon	80%	79%	84%	0	0	0
PMCP - Wheeler Farm	87%	86%	55%	93%	79%	68%
PMCH - downtown surface	89%	88%	89%	94%	93%	96%
oPCDH - downtown building	85%	84%	87%	93%	92%	94%

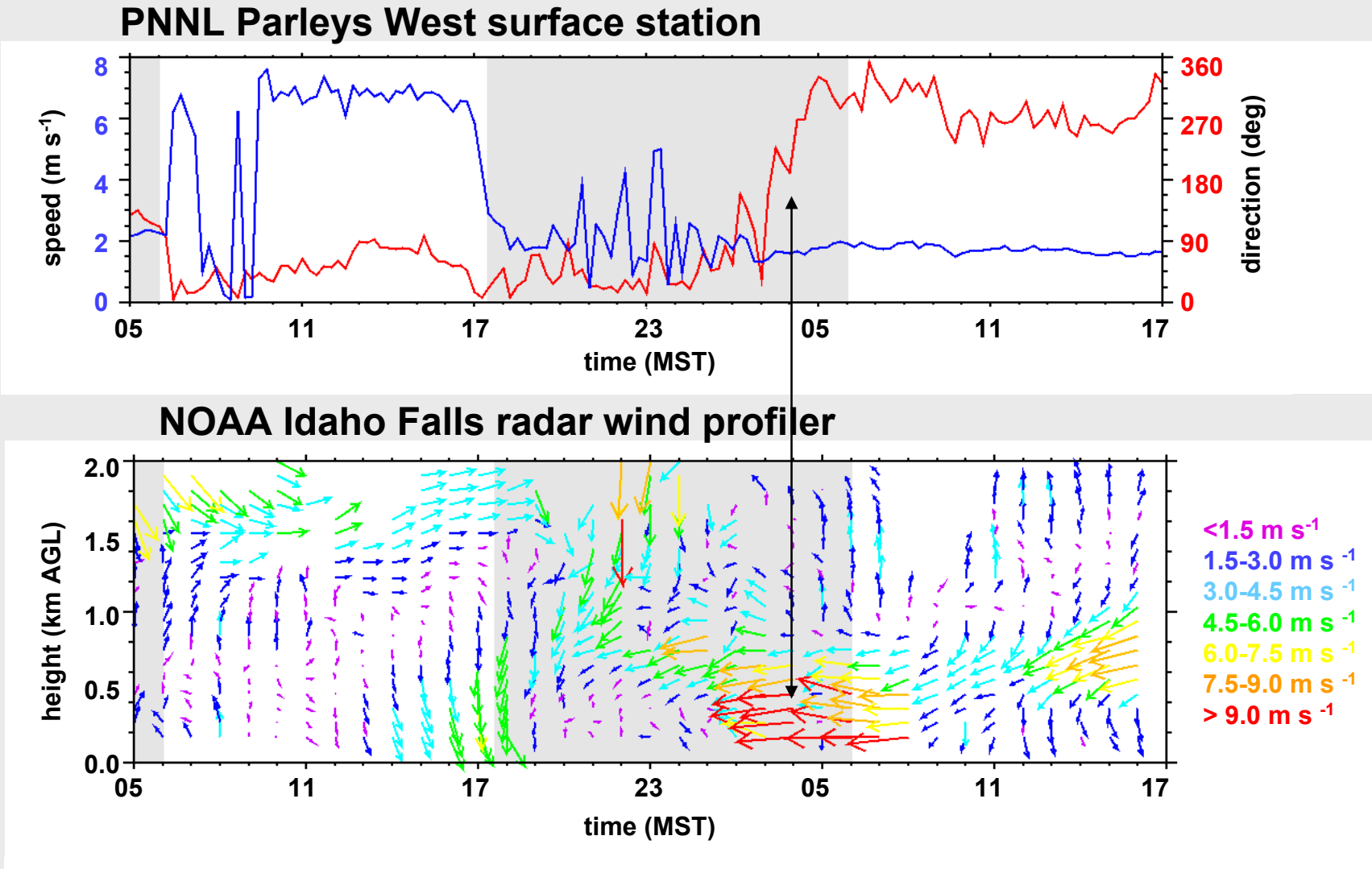
- "bad" data defined as values significantly lower than background and does not include suspicious concentrations > background
- further "re-integration" may bring recovery rate closer to 90% (for experiments 1-3) or 96% (for experiments 4-6)

Bottom Line

- oPDCH - downtown building release: generally good
- PMCH - downtown surface release: generally good, except for intermittent “suspicious” data
- PDCB - Parleys Canyon release: generally good, but no data for experiments 4-6 as a result of contamination after the field campaign
- PMCP - Wheeler Farm release: generally good for experiments 4-6, but lots of “suspicious” data for experiments 1-3

- very useful information obtained, but the amount of good data is much lower than the original experimental design
- all tracers have a number of bad data points (mostly PMCP)
- need to re-examine sampling analysis to 1) determine background concentrations and 2) resolve issues associated with suspicious data (fugitive sources? PFT cylinder leaks? sampling interferences? other issues associate with sample analysis?)

Strong Canyon Outflow: IOP #2



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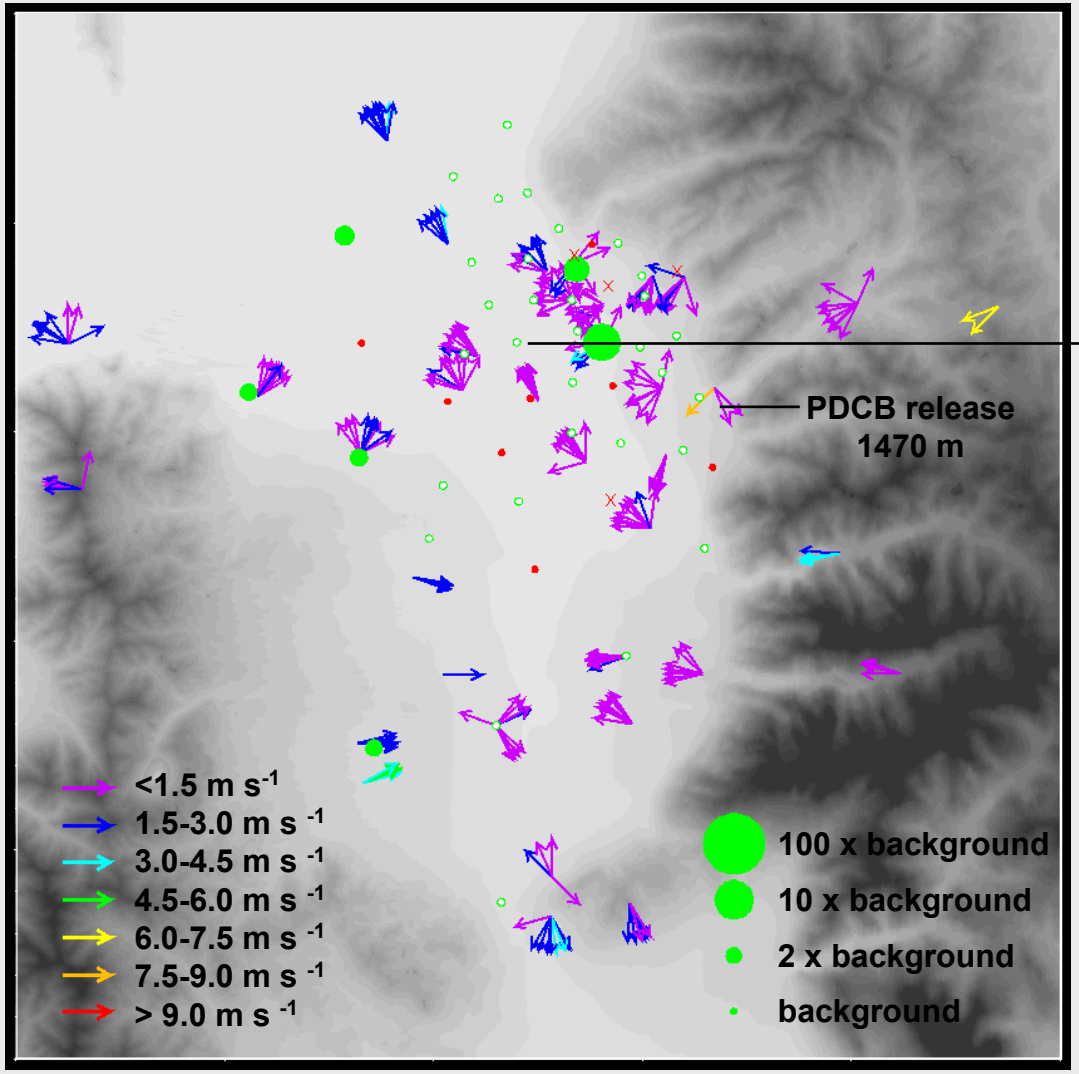
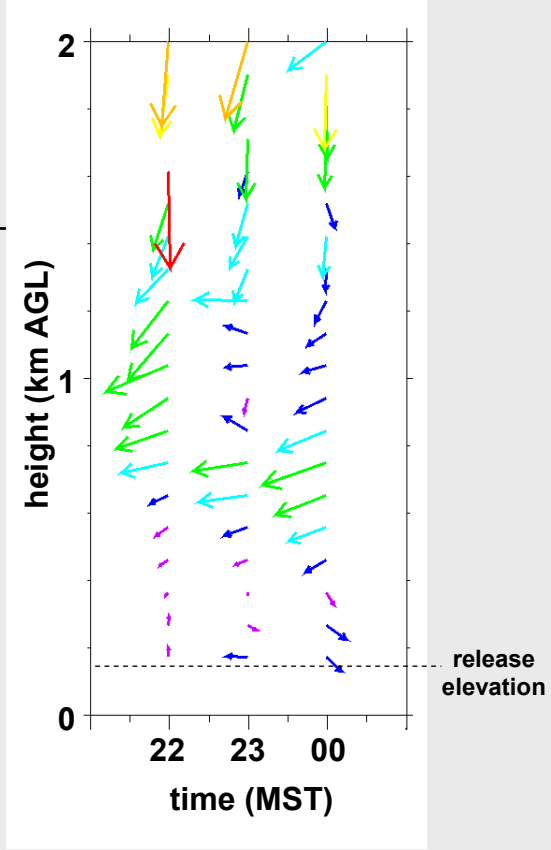


NOAA radar wind profiler



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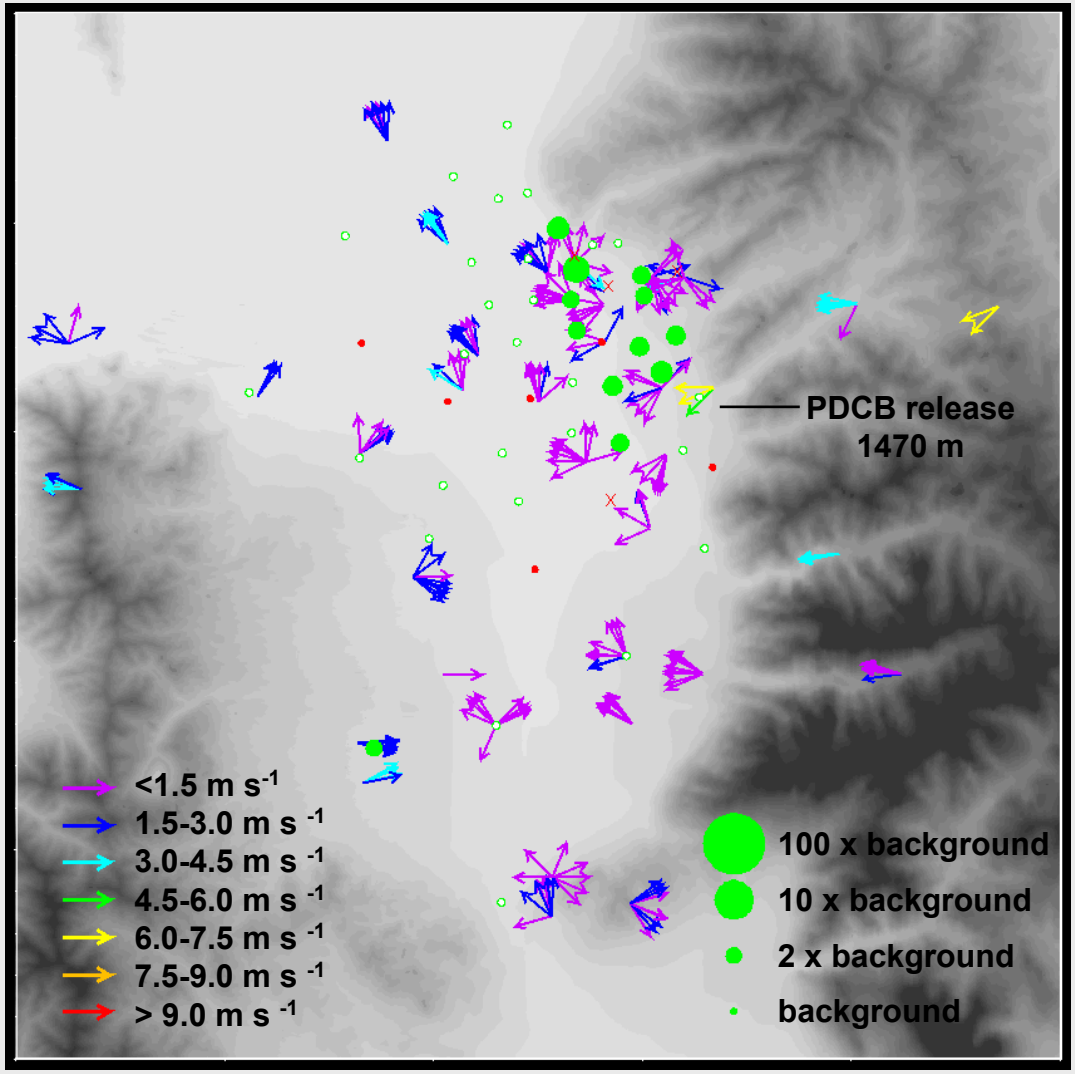

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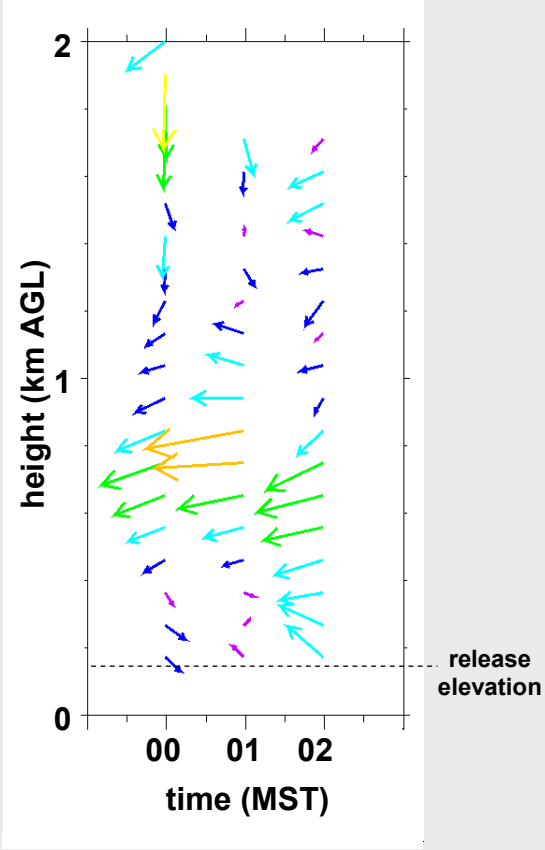

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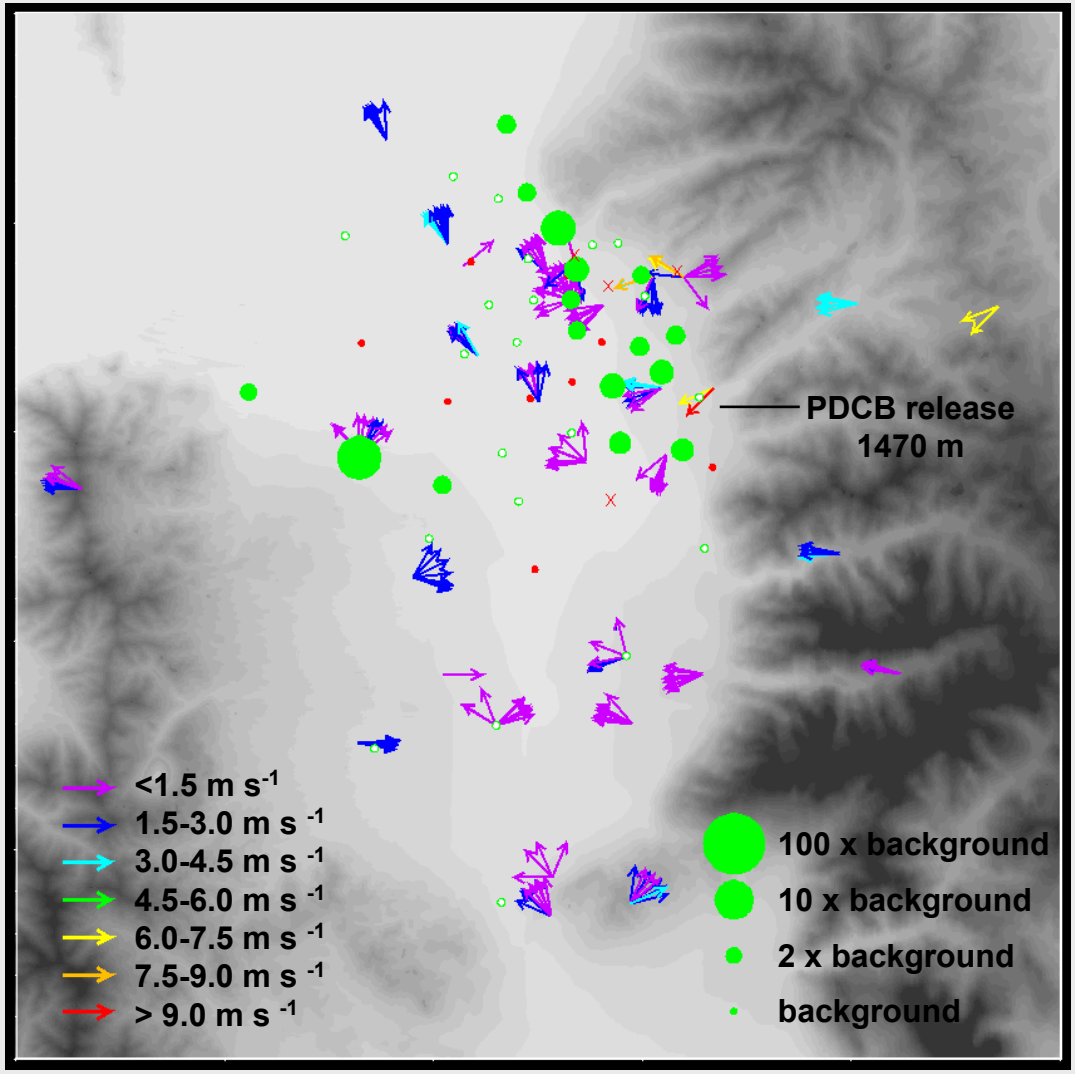

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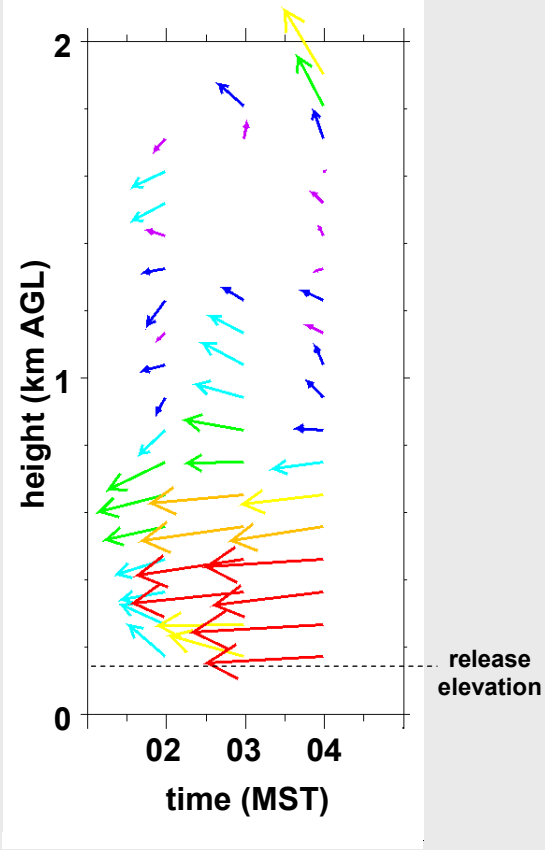

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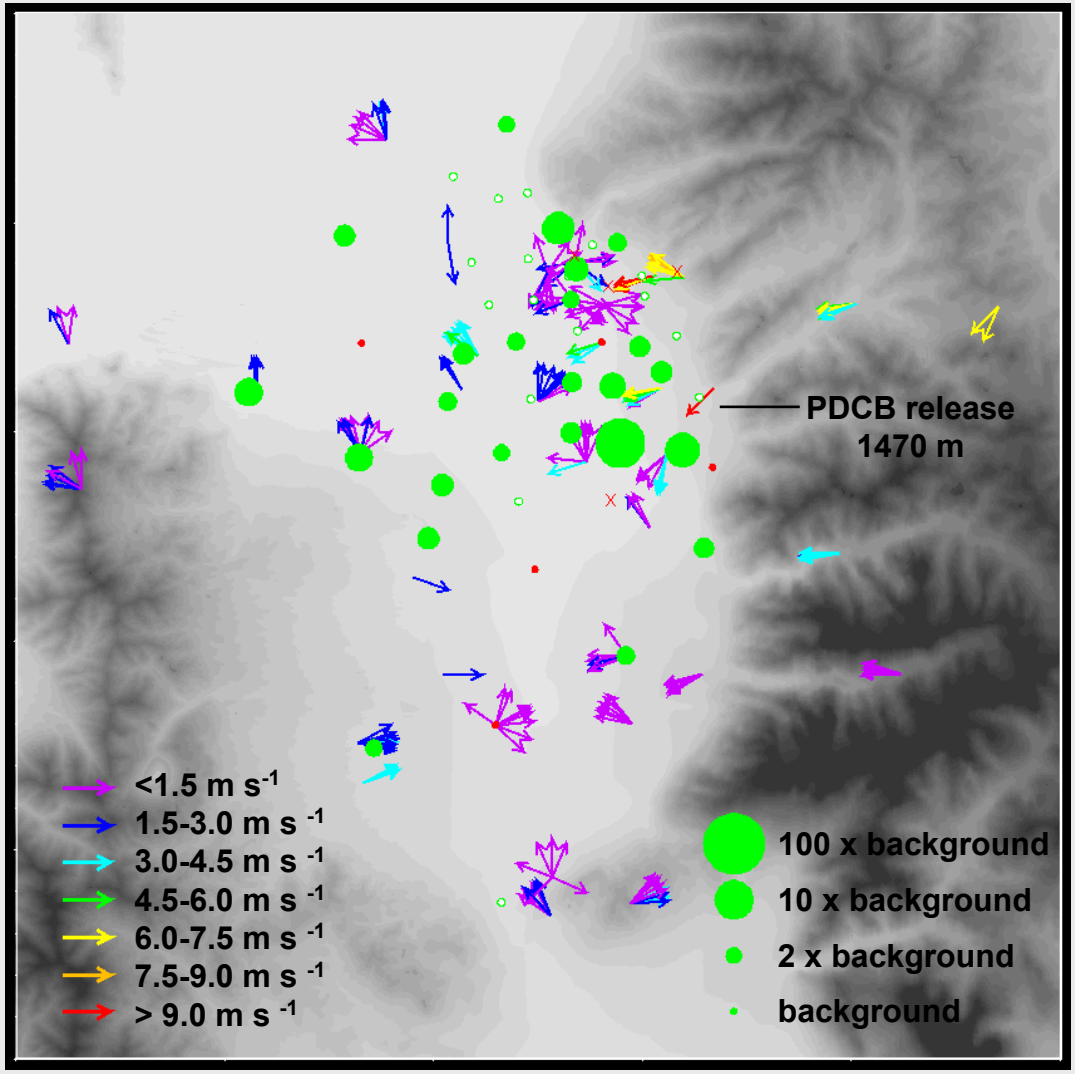

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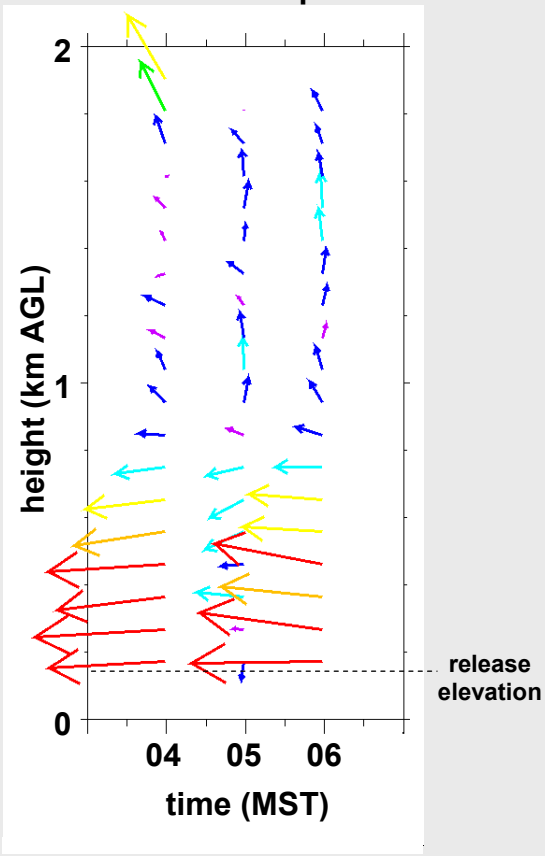

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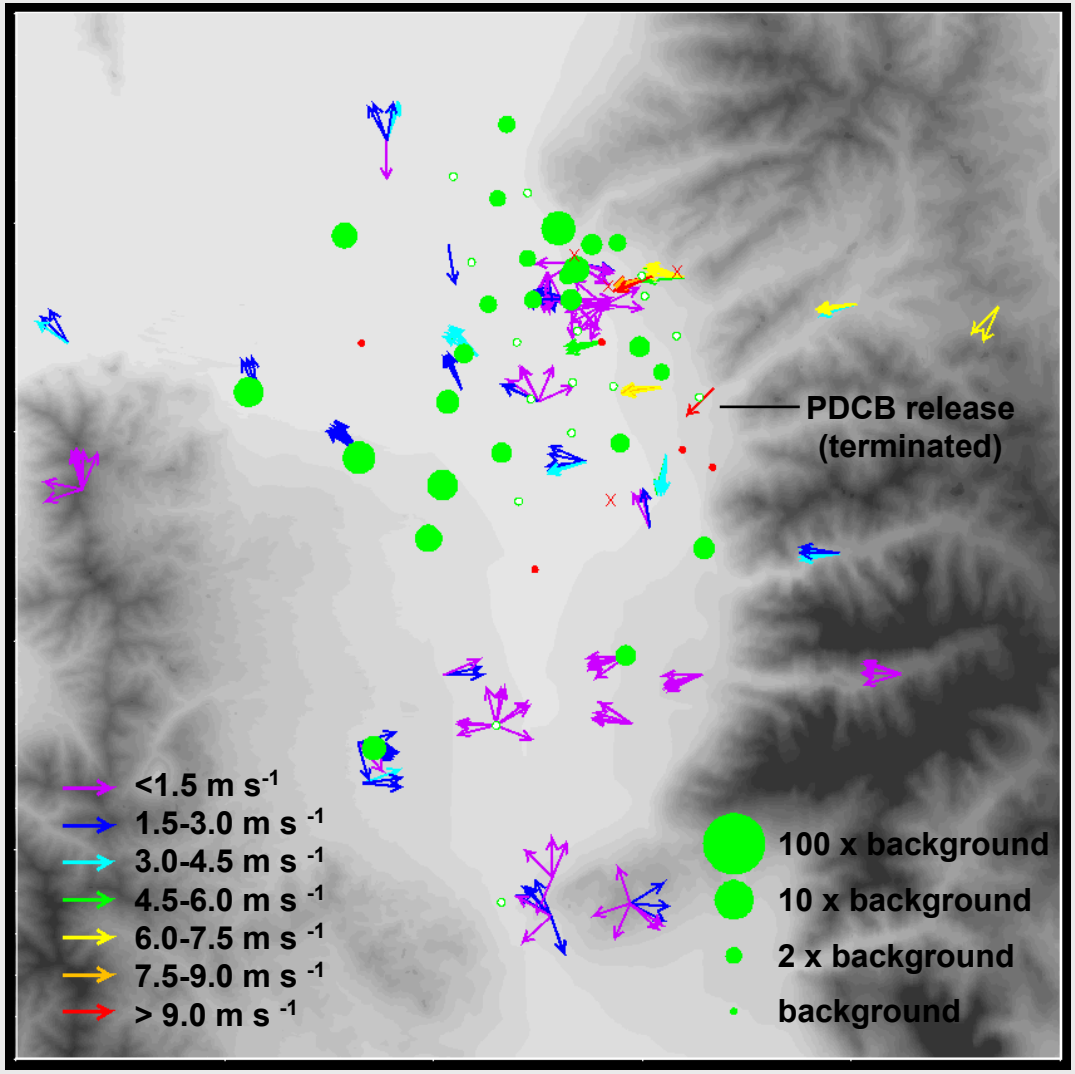

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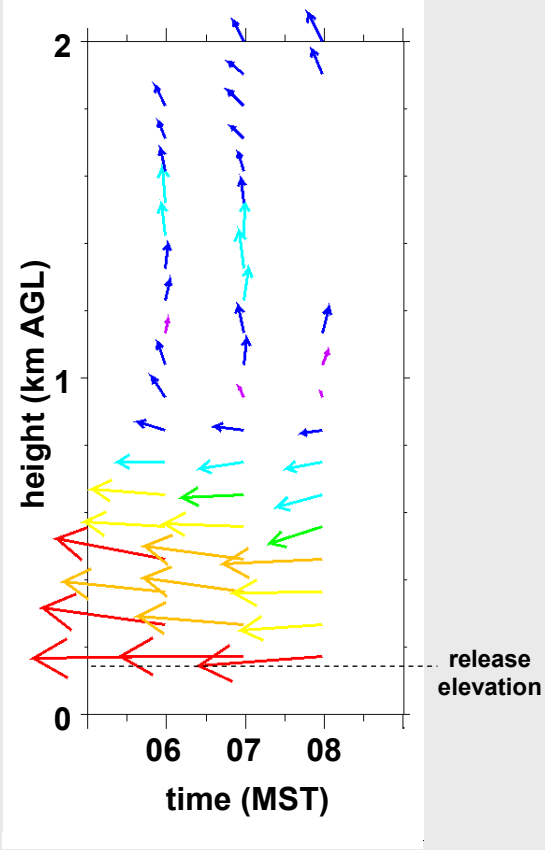

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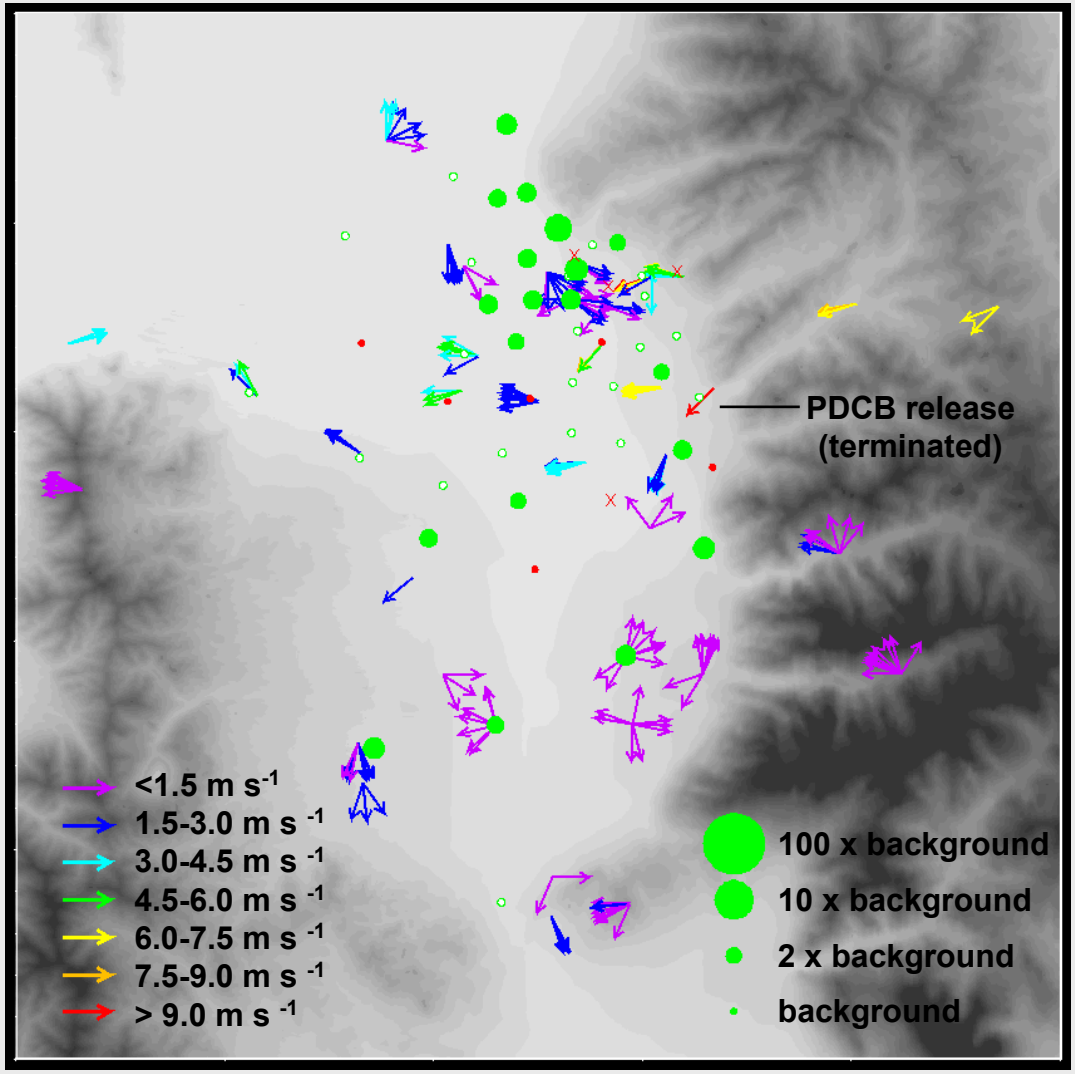

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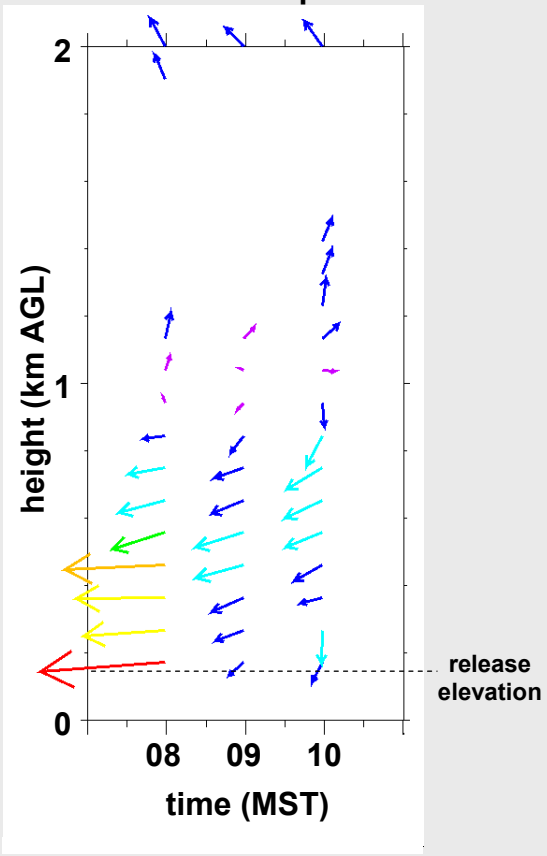

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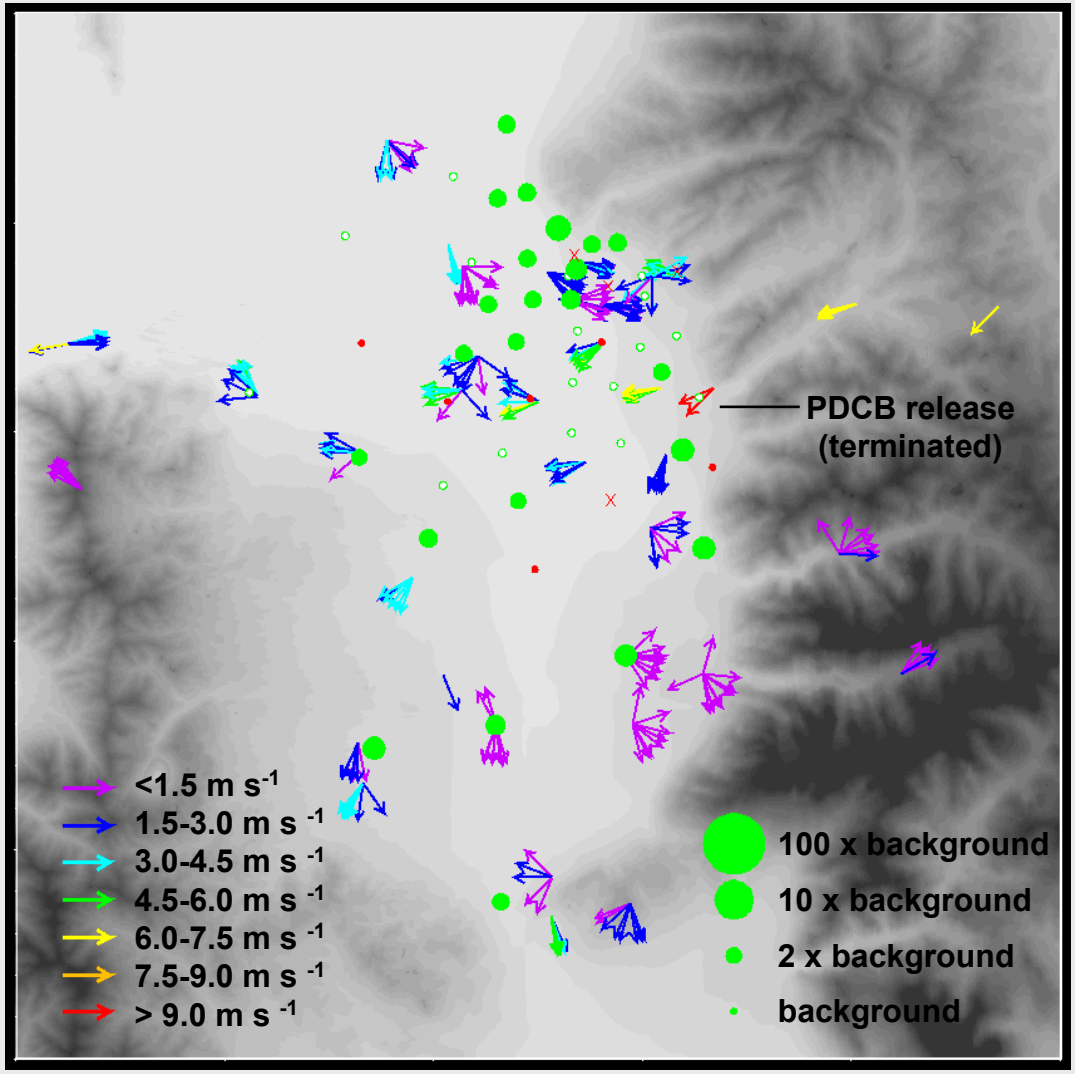

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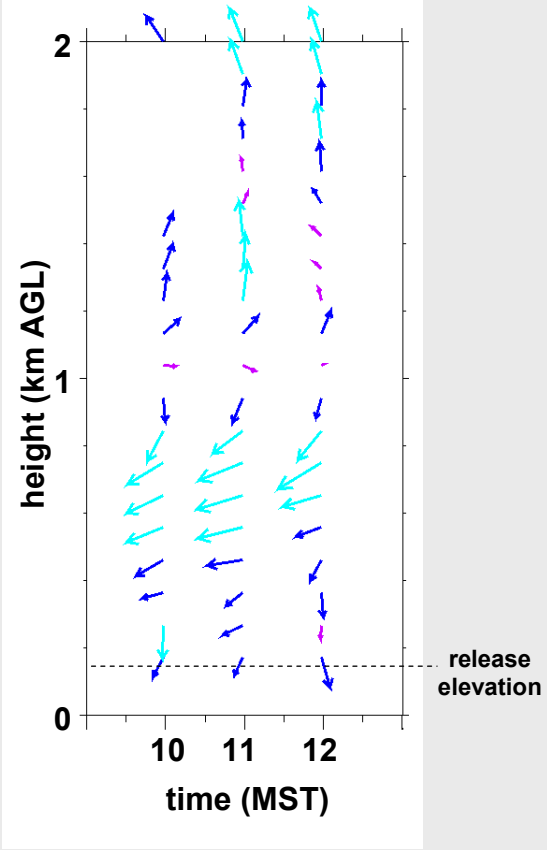

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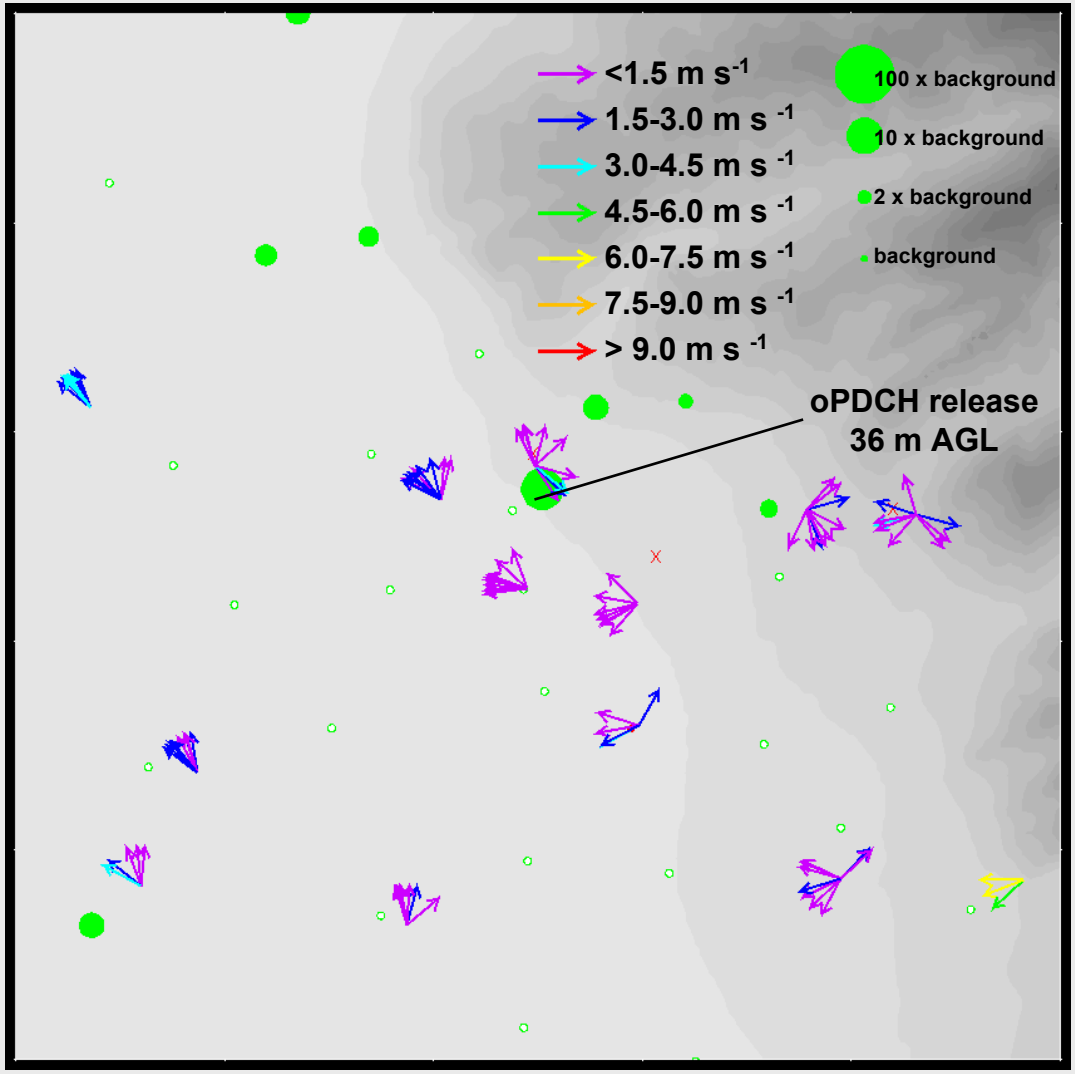

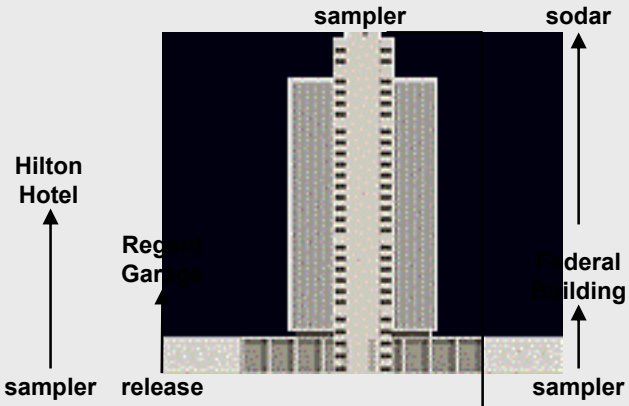

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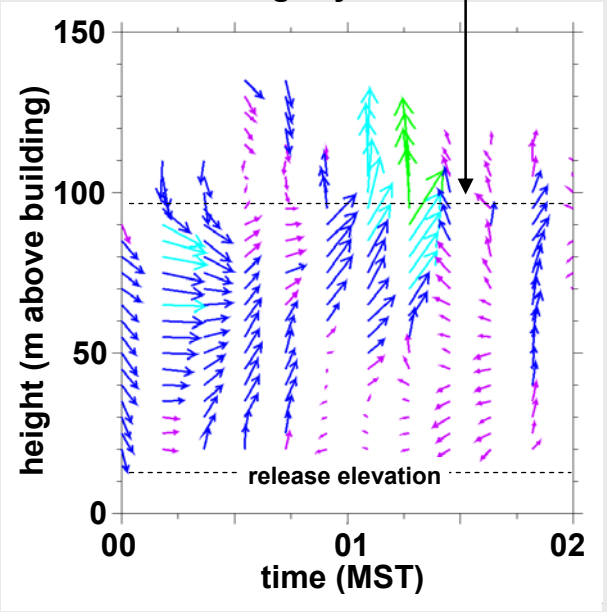

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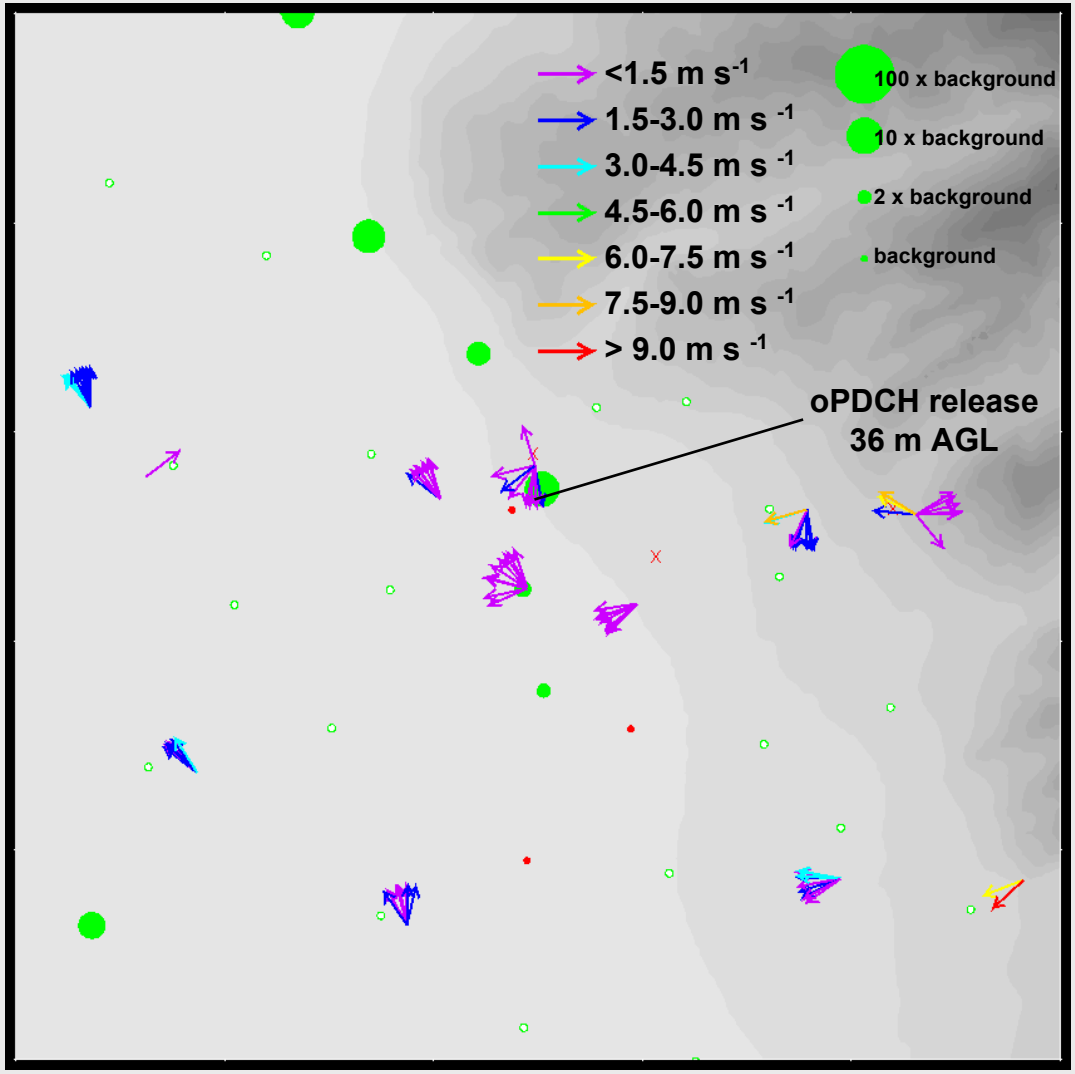

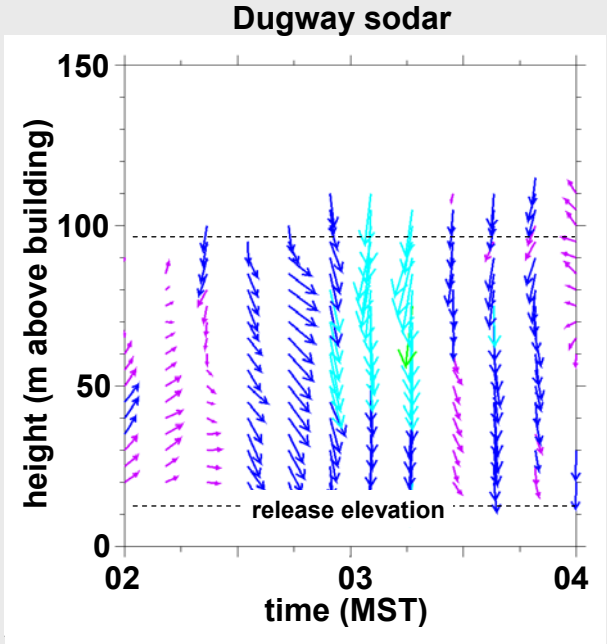

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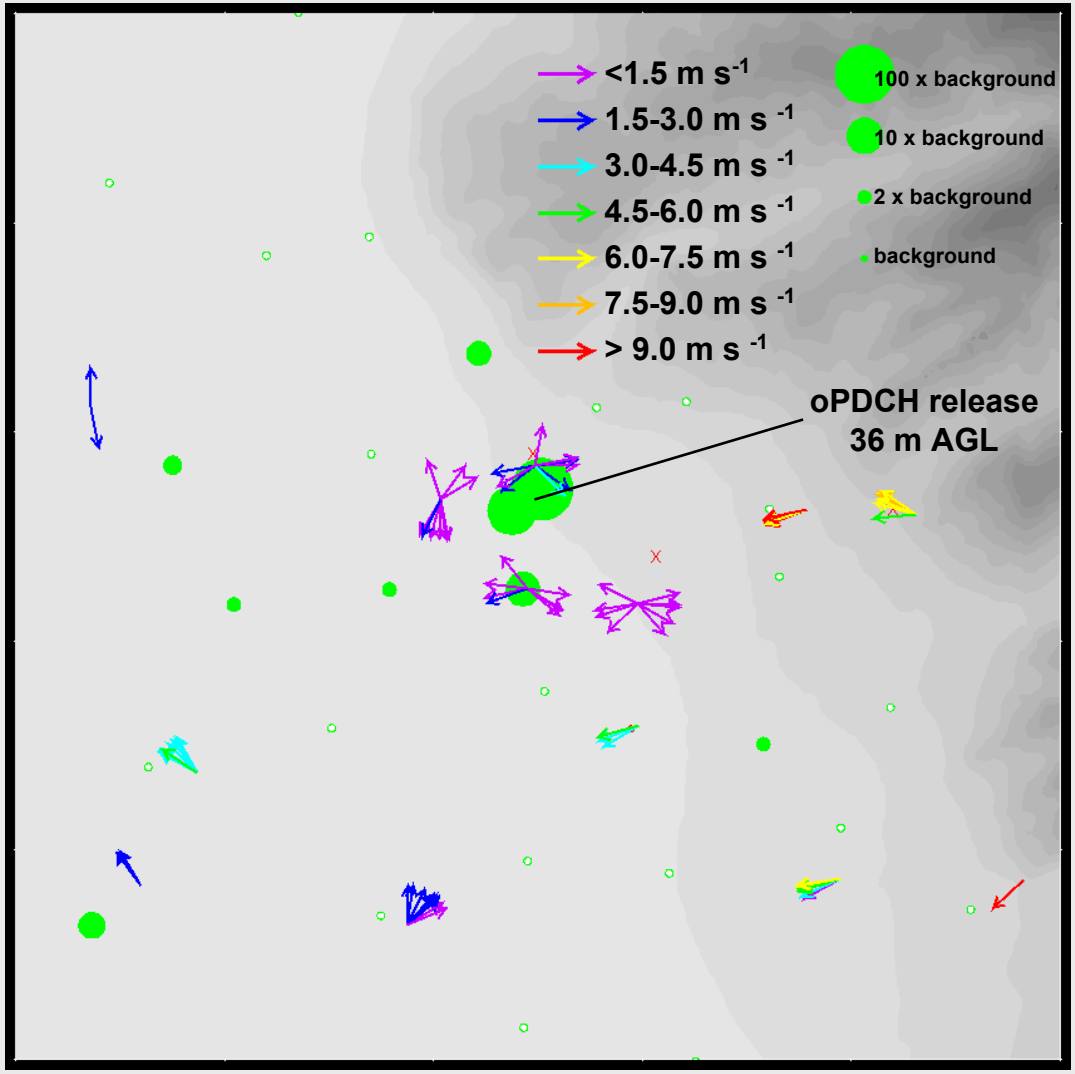

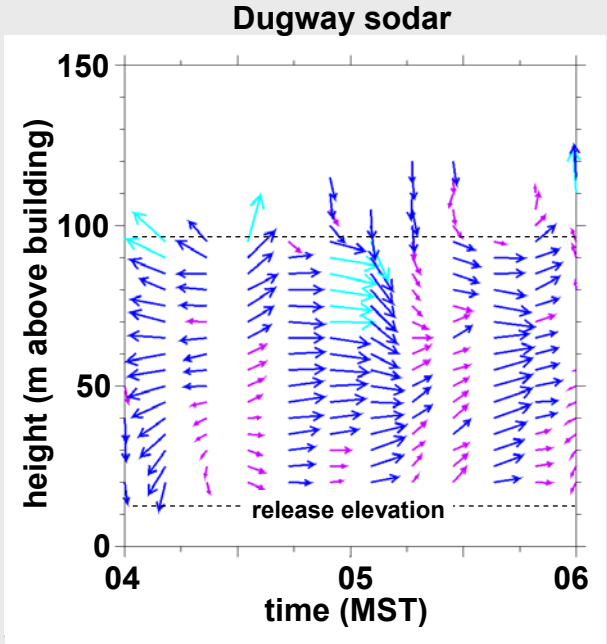

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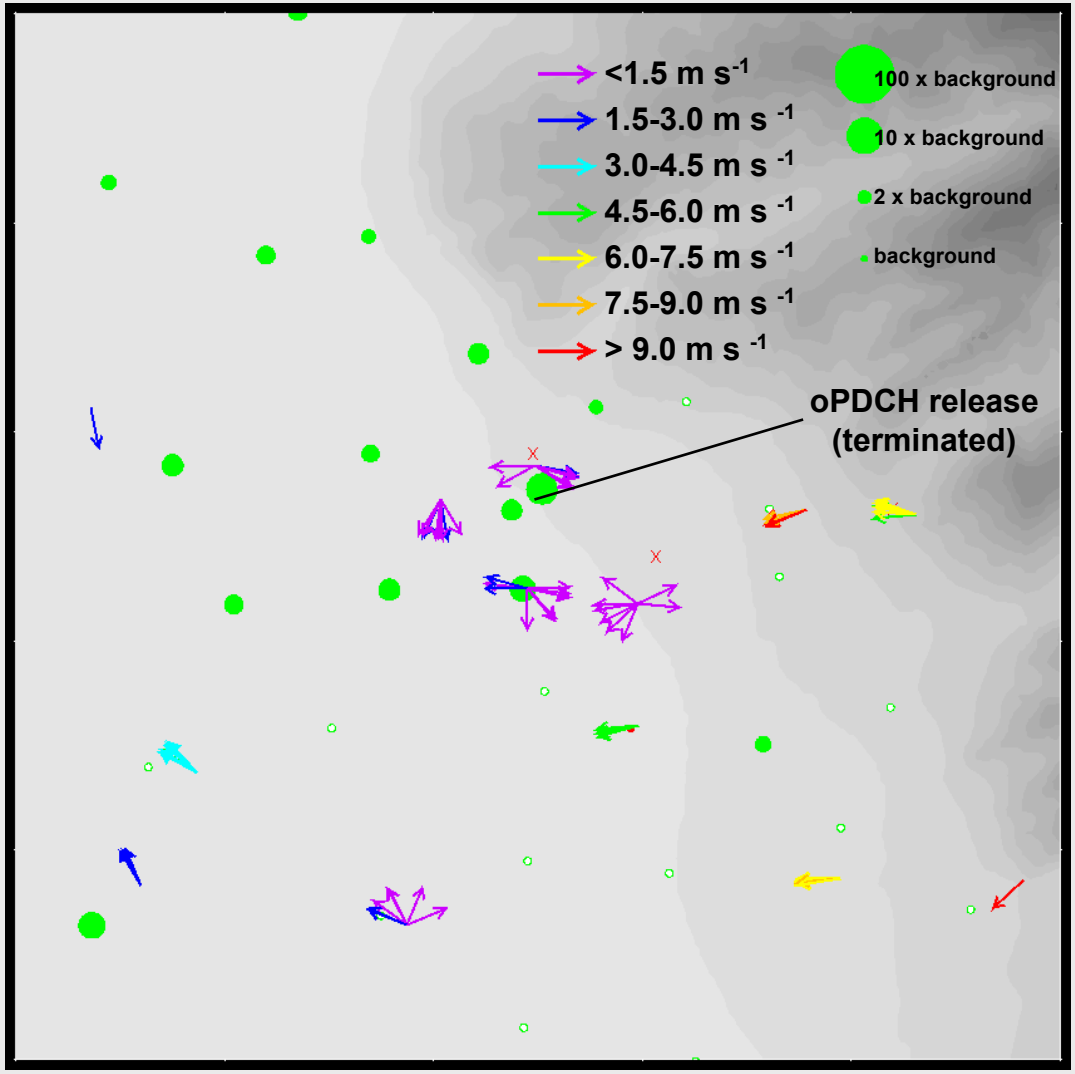

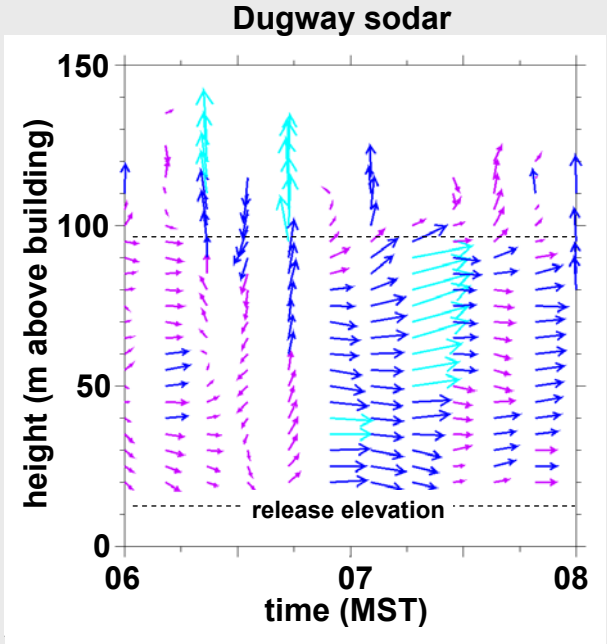

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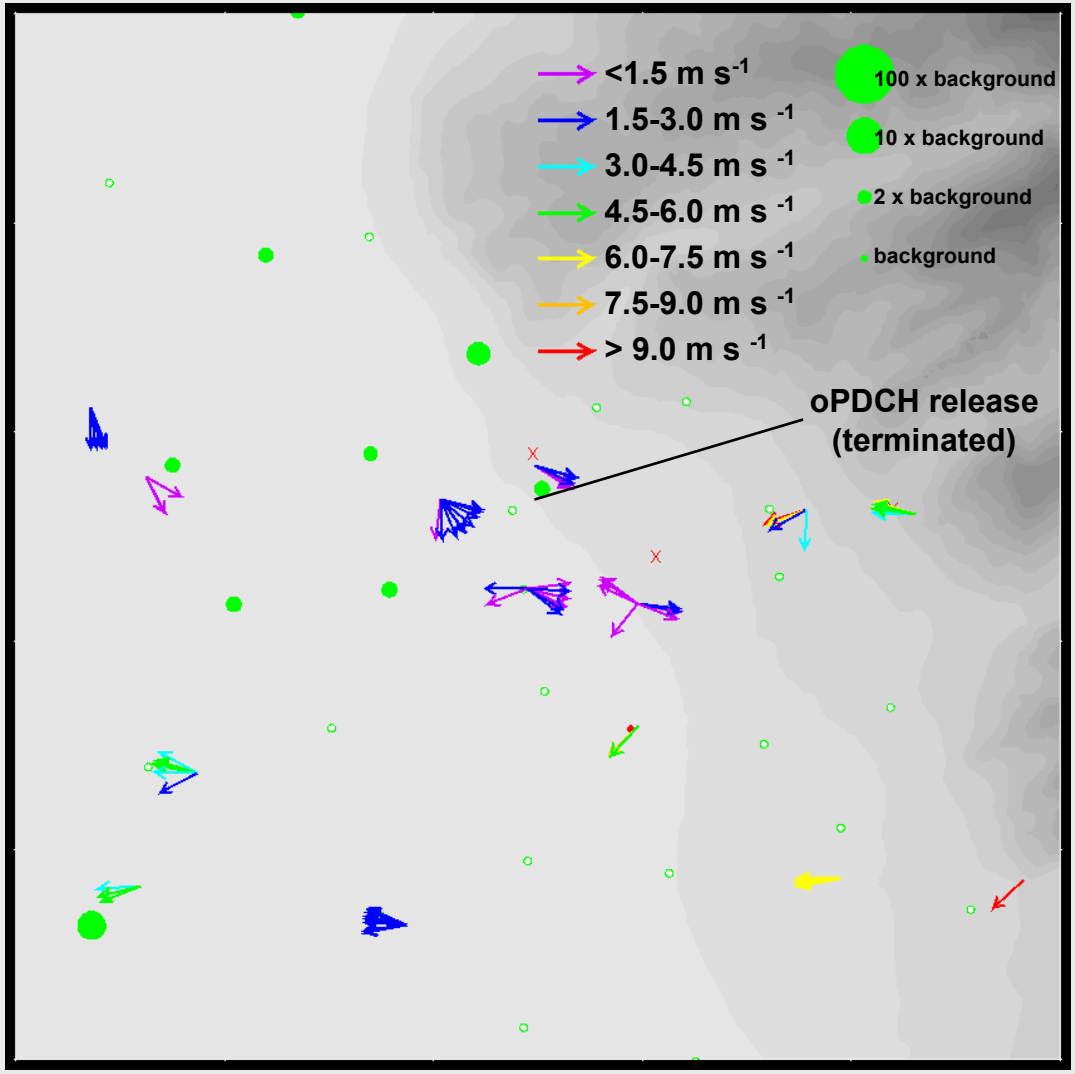
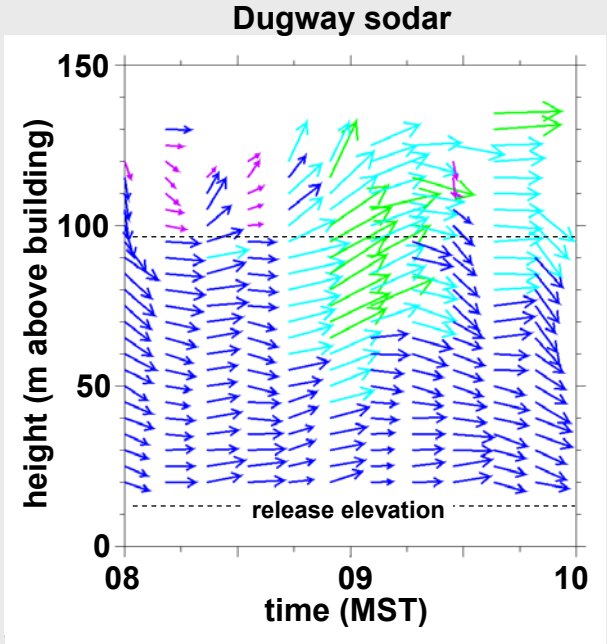
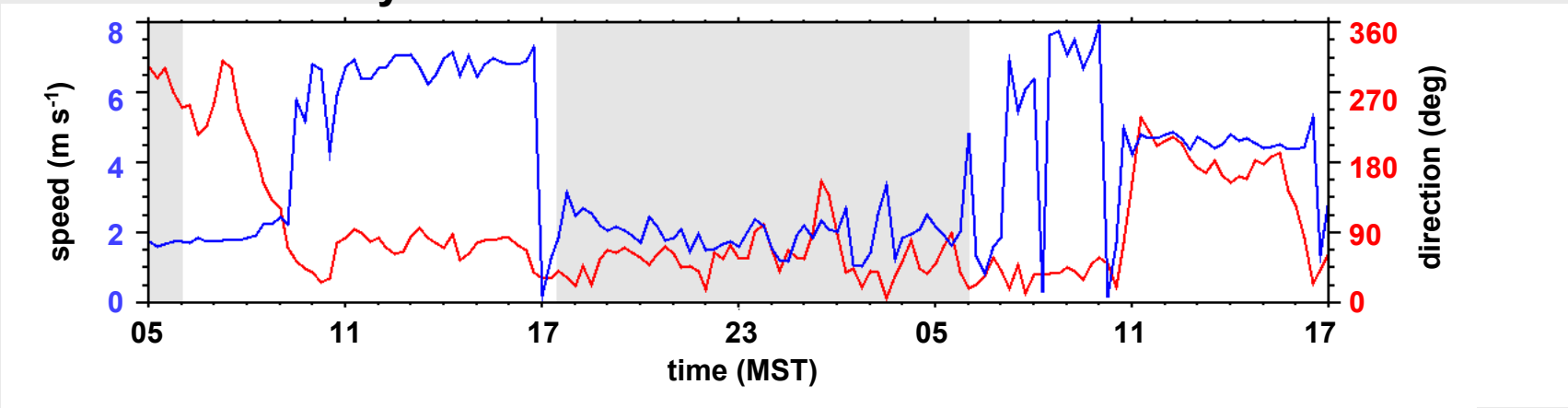


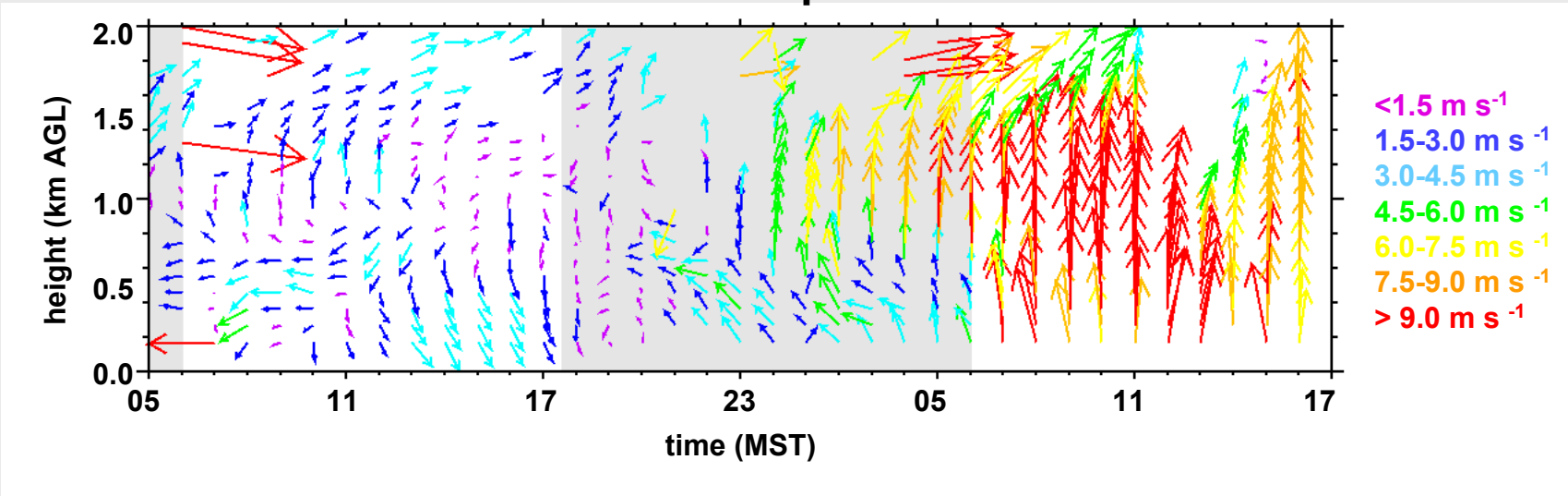


Typical Canyon Outflow: IOP #4

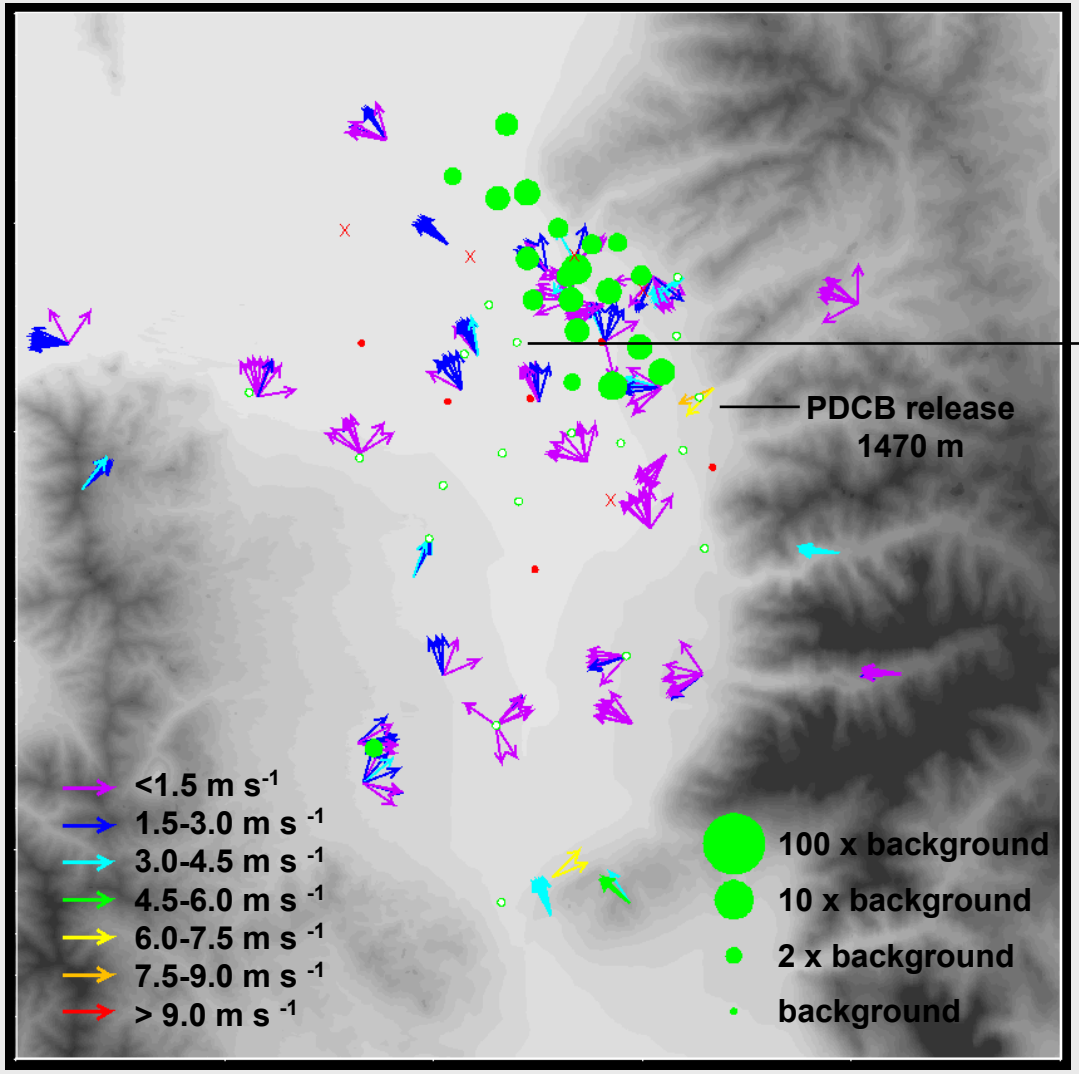
PNNL Parleys West surface station



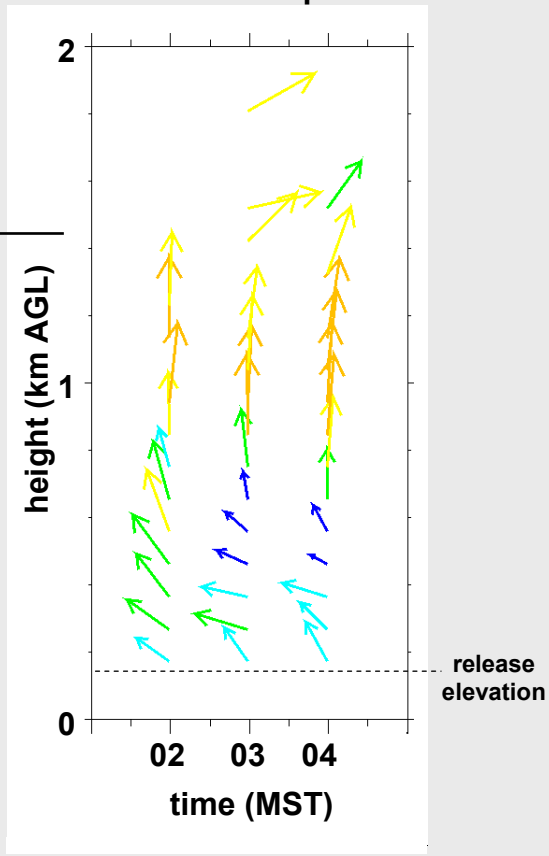
NOAA Idaho Falls radar wind profiler



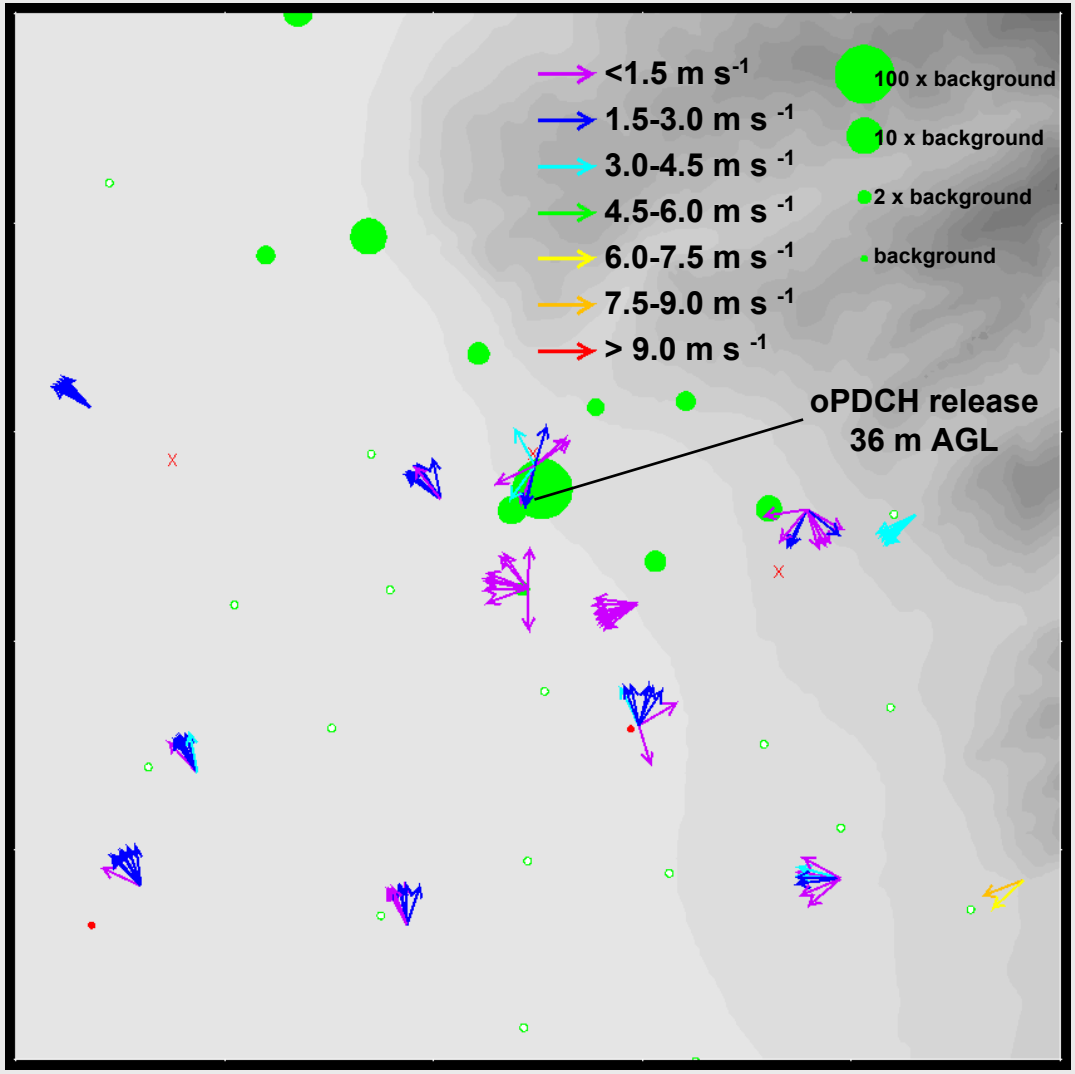
IOP #4: 02-04 MST

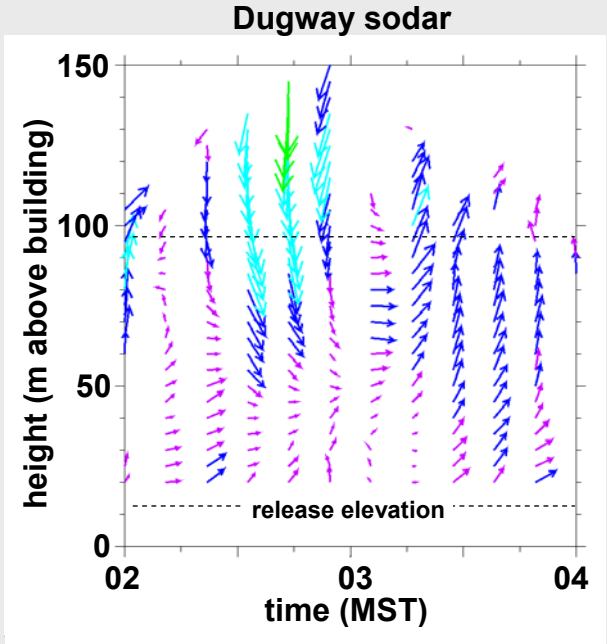


NOAA radar wind profiler



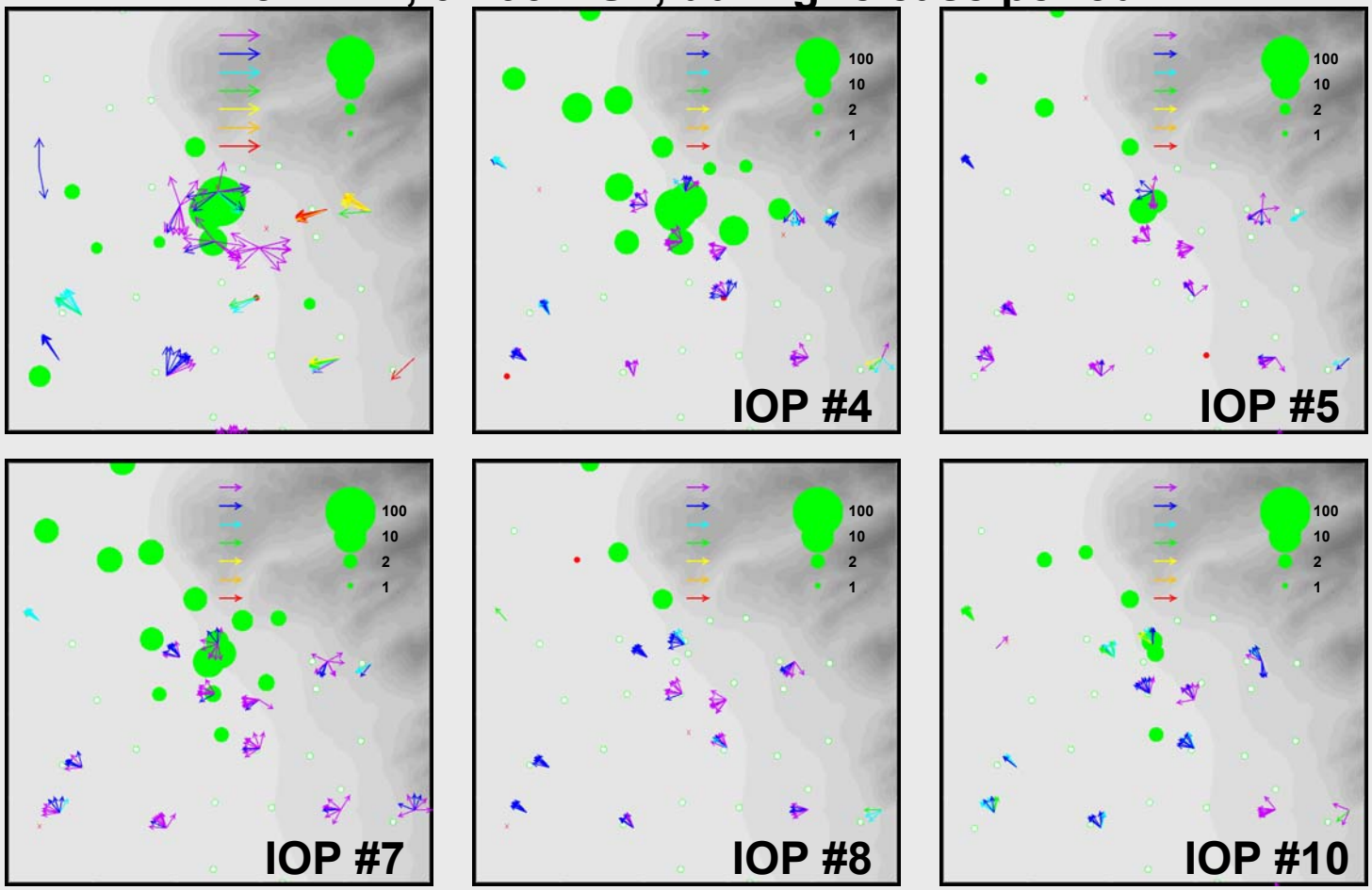
IOP #4: 02-04 MST





Dispersion Patterns

oPDCH, 04-06 MST, during release period



from Doran et al. (BAMS, 2002)

IOPs with well-developed drainage circulations

5 and 8

IOPs modulated by synoptic systems

4 and 7
2
10

- what factors contribute to the different dispersion patterns?

Summary: Data

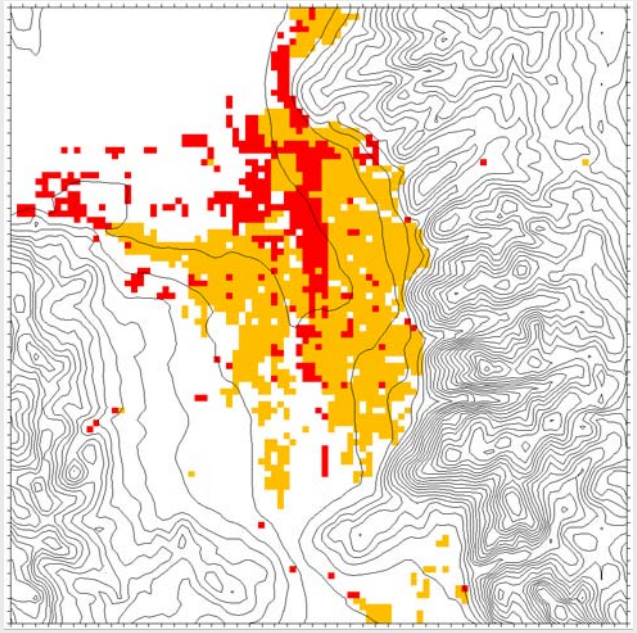
Despite missing data, bad data, suspicious data, the PFT experiments provide very useful information to help quantify the effect of transport and mixing processes within the valley atmosphere. The general findings are:

- **observations suggest cross-valley transport and downward mixing associated with strong canyon outflow; conversely, tracers confined to eastern side of valley during typical canyon outflow conditions**
- **tracer transport to southeastern end of valley - opposite of down-valley flow**
- **a significant portion of the tracer remains over the city during the morning transition period, no matter how windy it was**
- **despite the strong nocturnal stability, the PFTs were well dispersed - plume meandering probably important**
- **during IOPs with well-developed drainage circulations, tracer released from building top remains elevated for some distance before mixing to ground on some; conversely, tracer dispersed over a much wider area during IOPs modulated by synoptic systems**

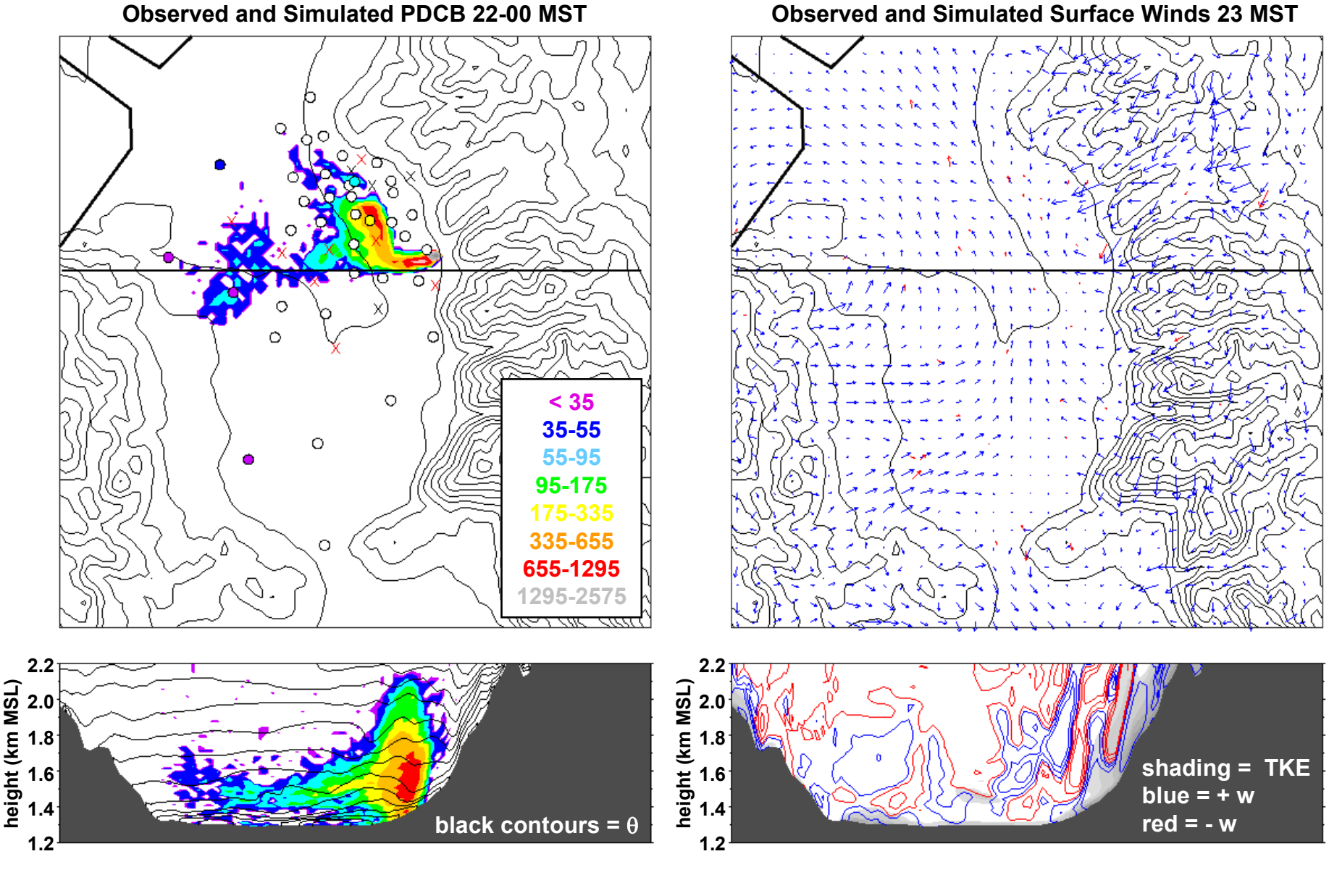
Meteorological Modeling

- use a mesoscale model to simulate nocturnal valley circulations and use a Lagrangian particle dispersion model to mimic PFT transport and mixing
- combine model results and observations to determine processes that affect PFT dispersion

- simulations of all IOPs, except 1 and 9
- nested grids of 45, 15, 5, 1.7 km, and 555 m
- Δz = 15 m at the ground with 48 levels within 2 km of the surface
- without data assimilation
- particles released at 4 tracer sites and during the same time period as PFTs
- particle and PFT concentrations in units of g m^{-3}



IOP #2, Parleys Canyon tracer release



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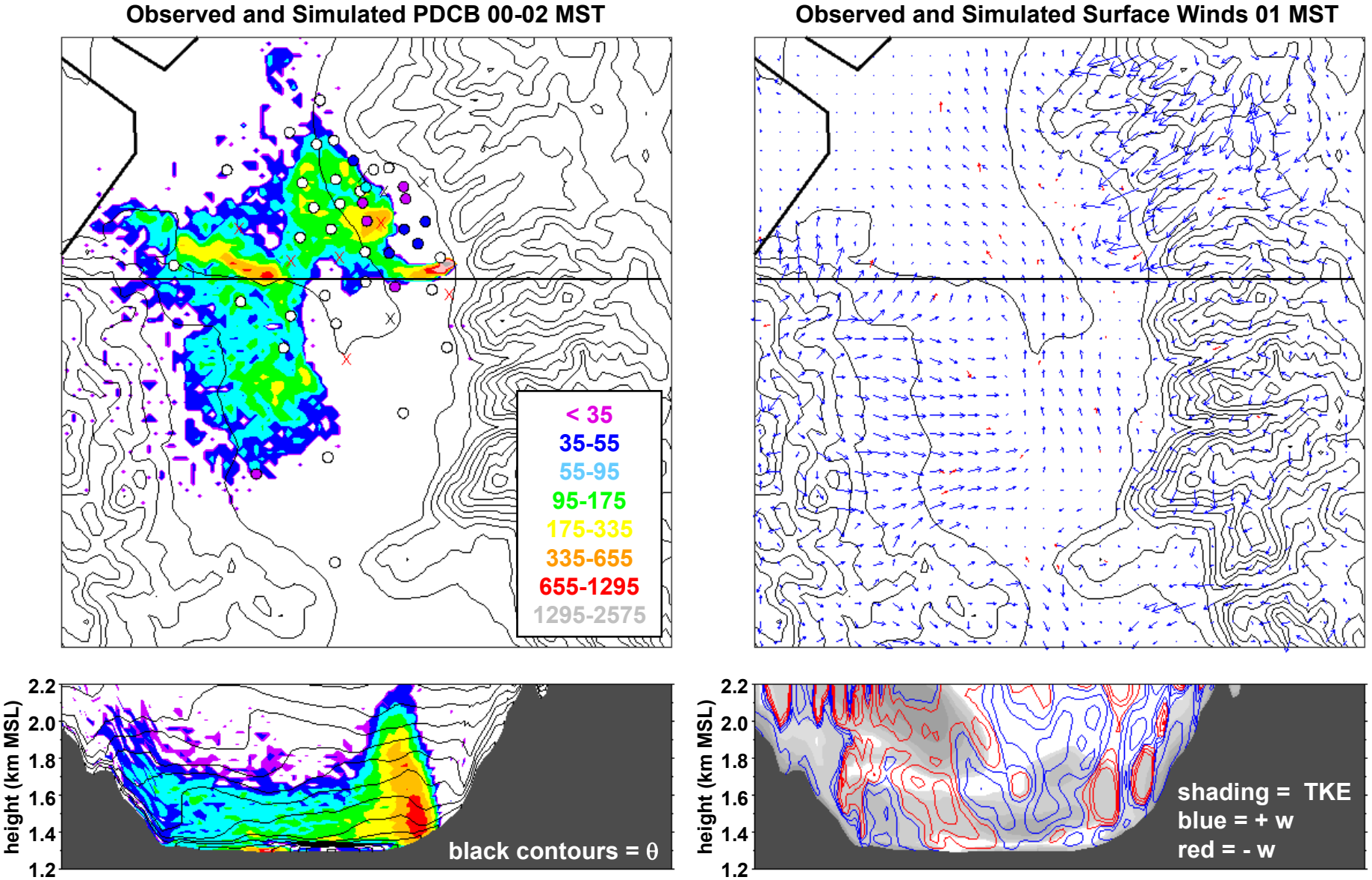
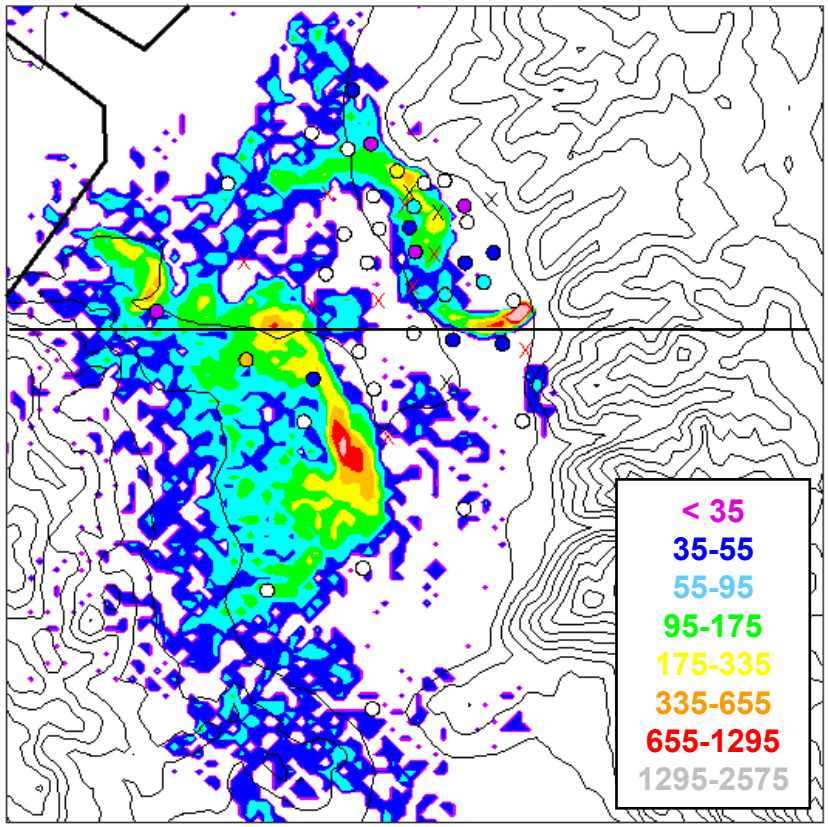
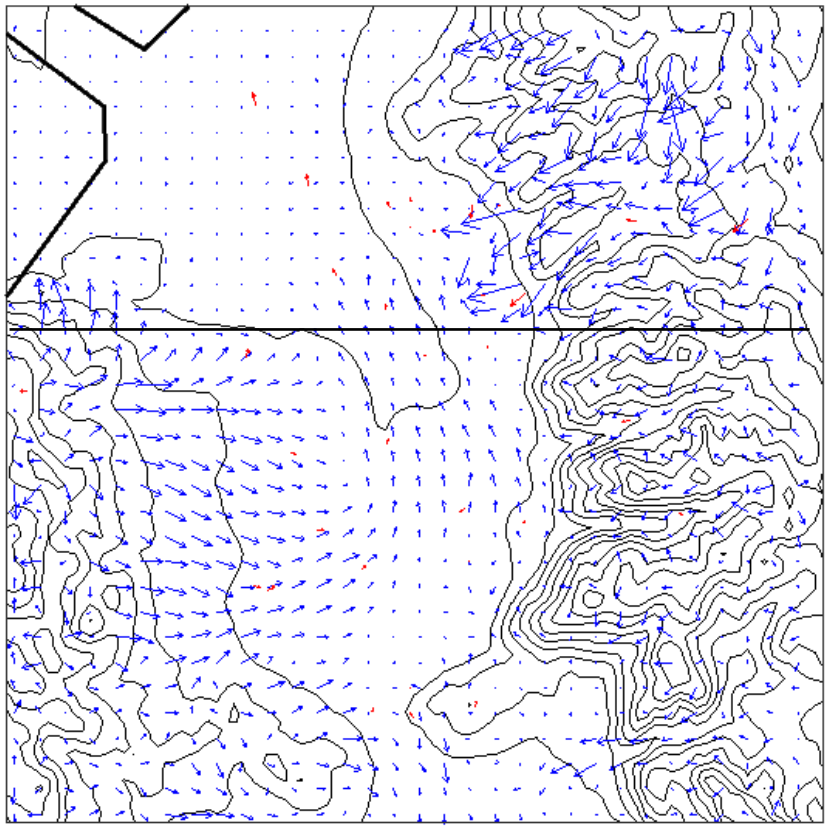


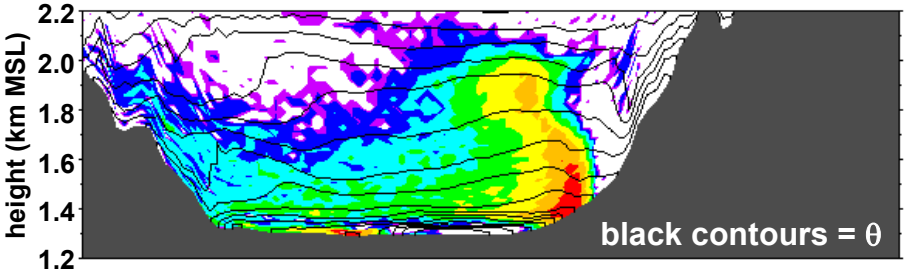
IOP #2, Parleys Canyon tracer release

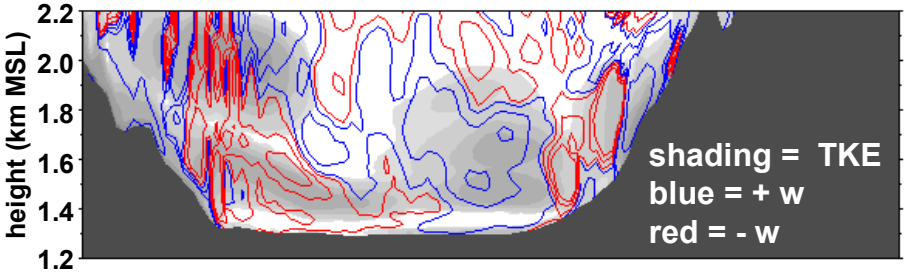
Observed and Simulated PDCB 02-04 MST



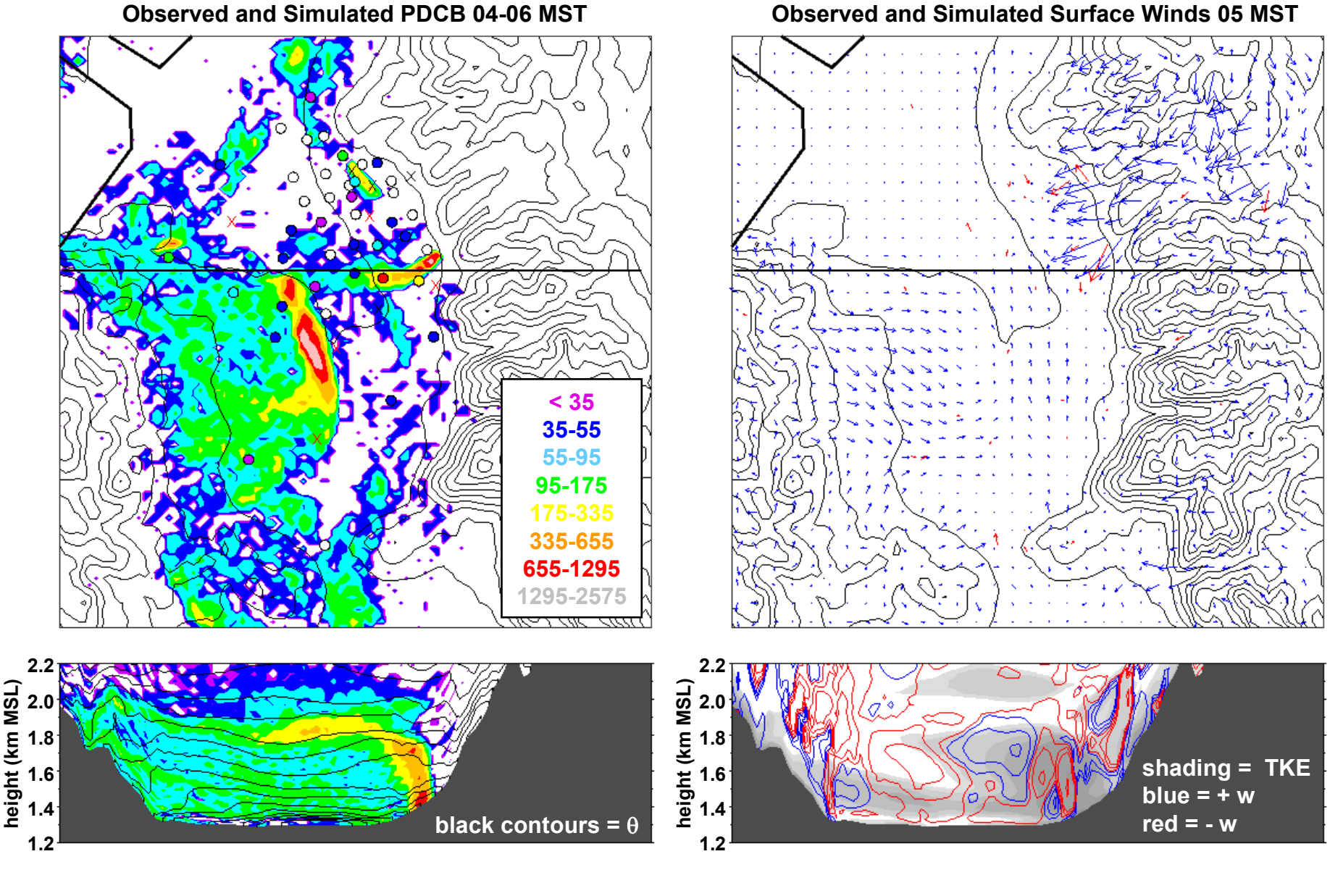
Observed and Simulated Surface Winds 03 MST



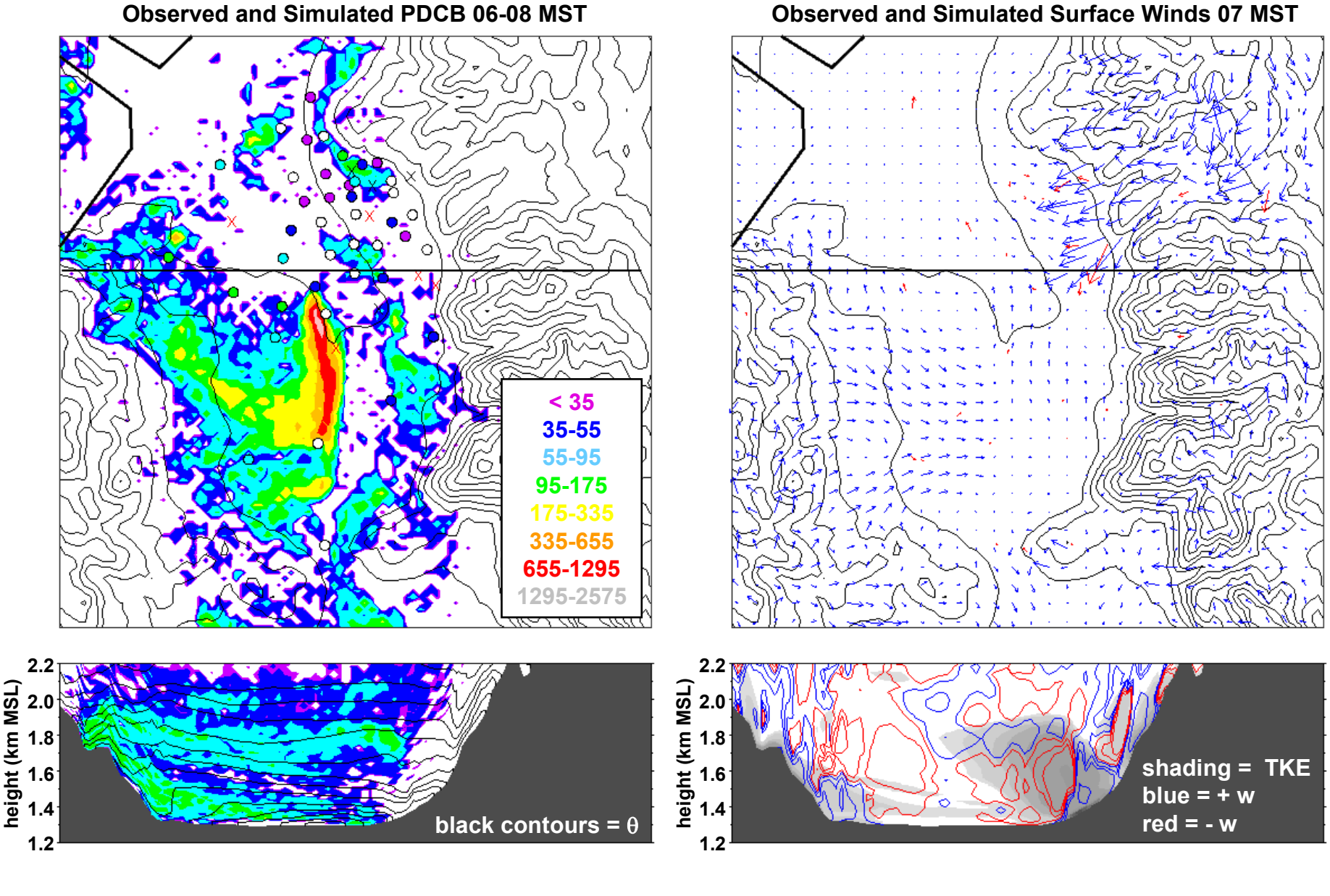




IOP #2, Parleys Canyon tracer release

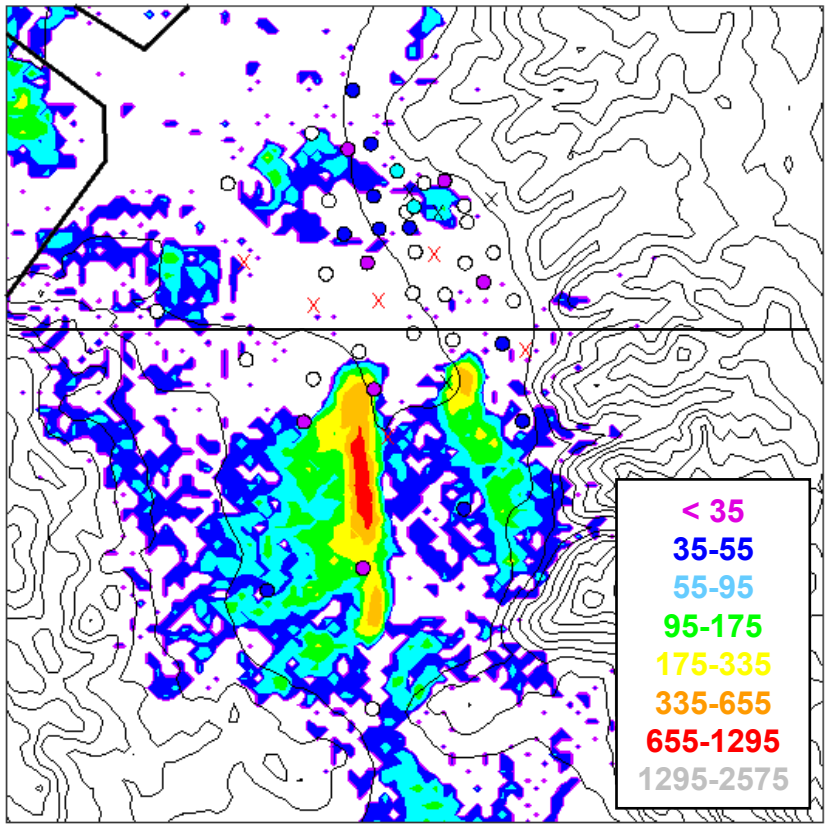


IOP #2, Parleys Canyon tracer release

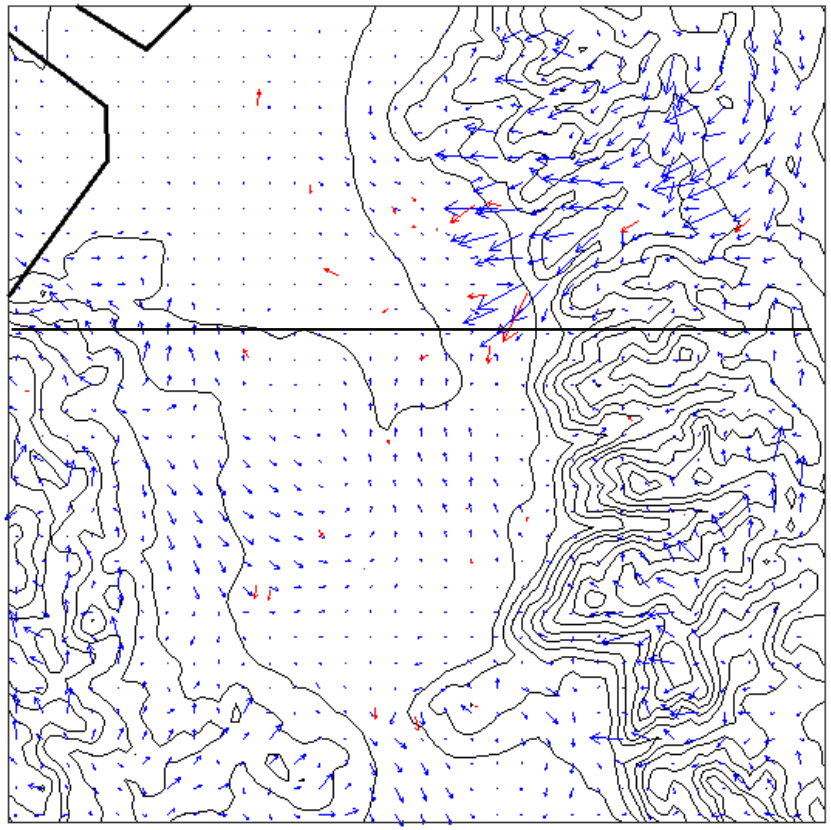


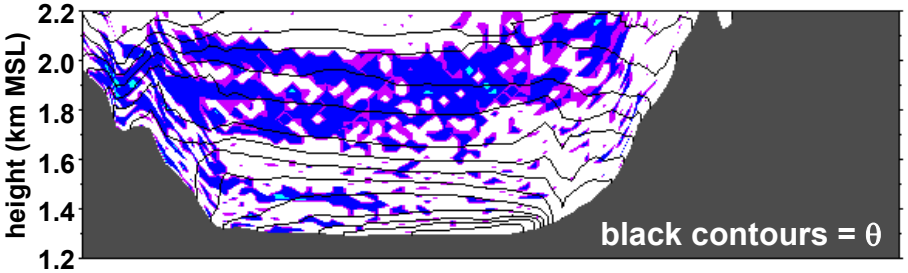
IOP #2, Parleys Canyon tracer release

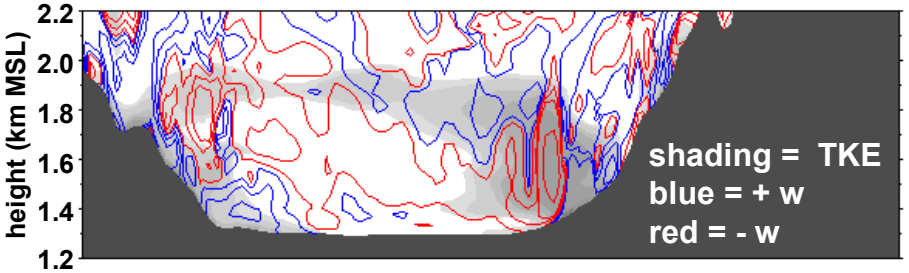
Observed and Simulated PDCB 08-10 MST



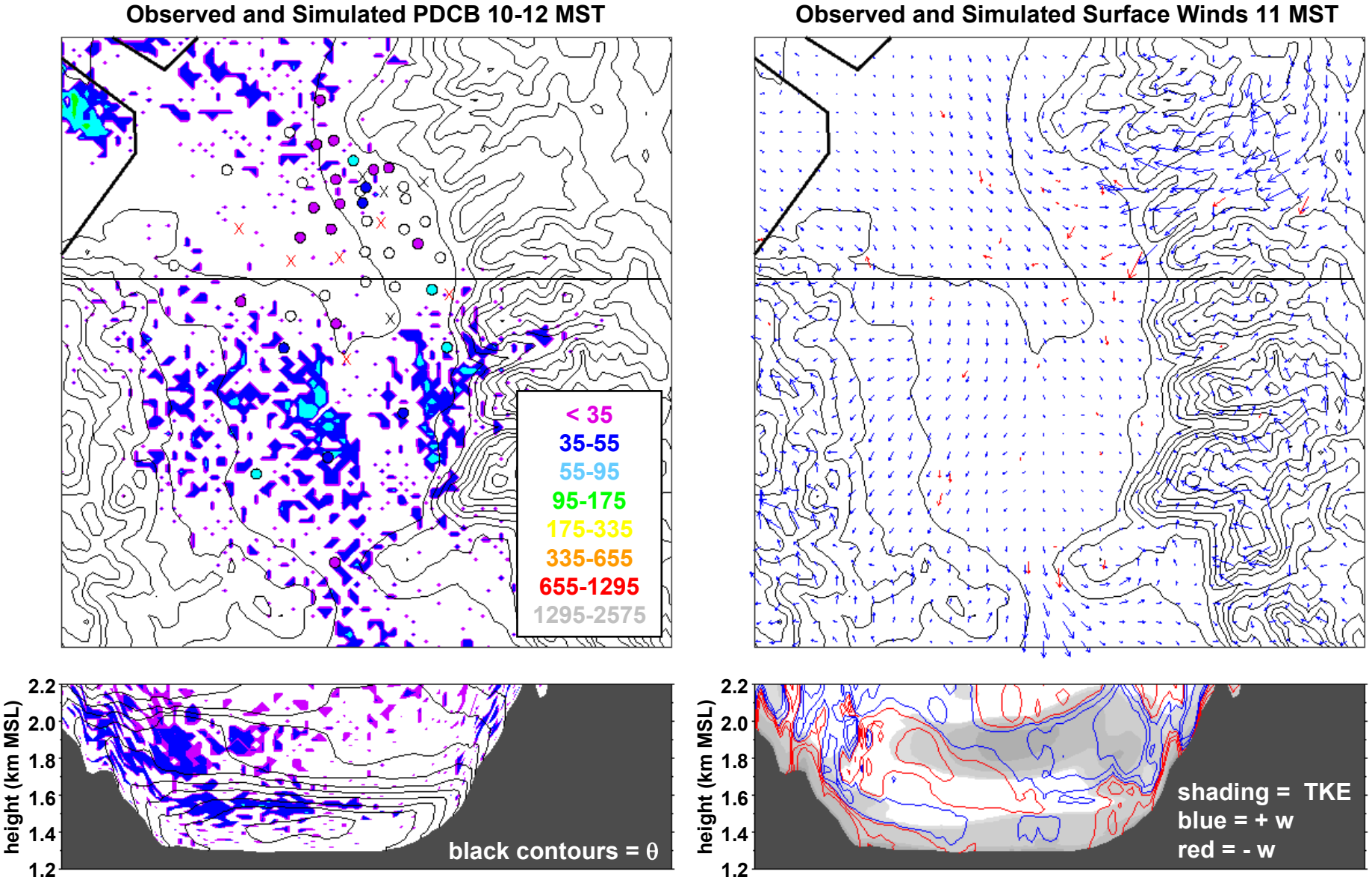
Observed and Simulated Surface Winds 09 MST





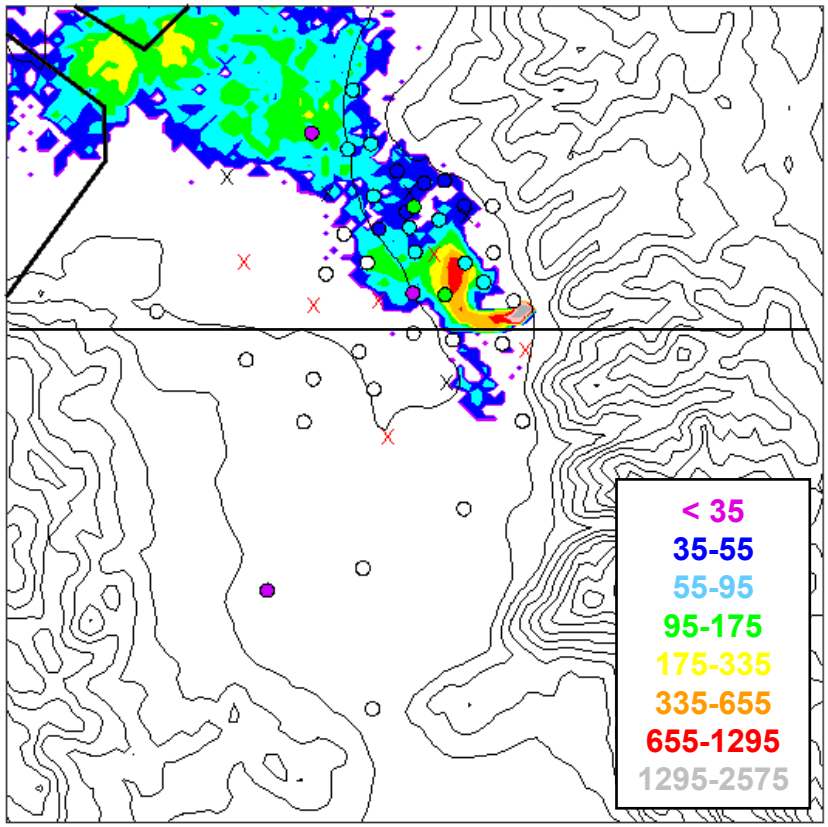


IOP #2, Parleys Canyon tracer release

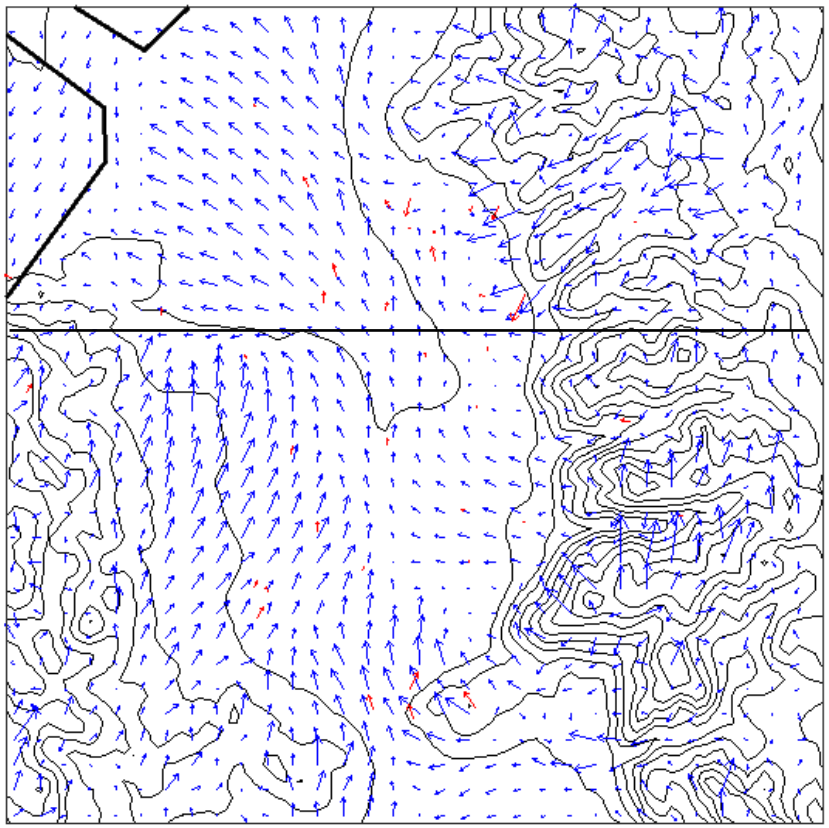


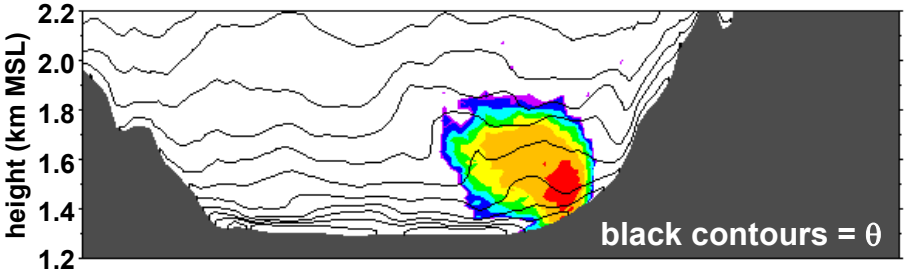
IOP #4, Parleys Canyon tracer release

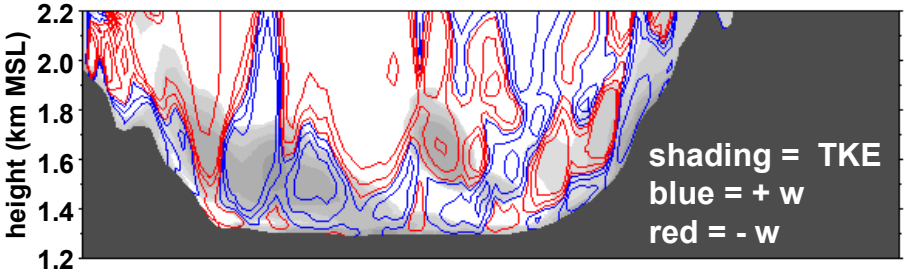
Observed and Simulated PDCB 02-04 MST



Observed and Simulated Surface Winds 03 MST

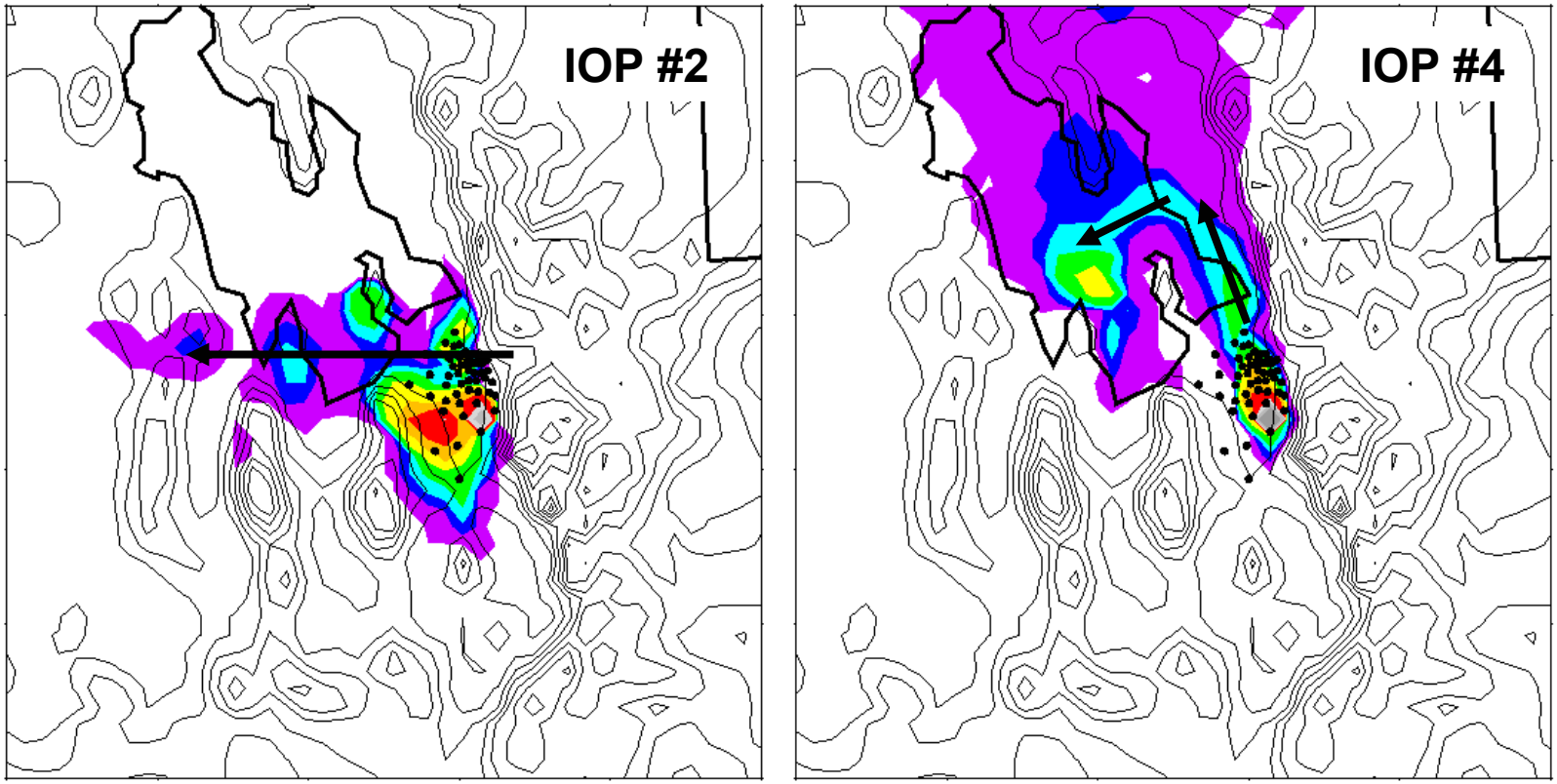






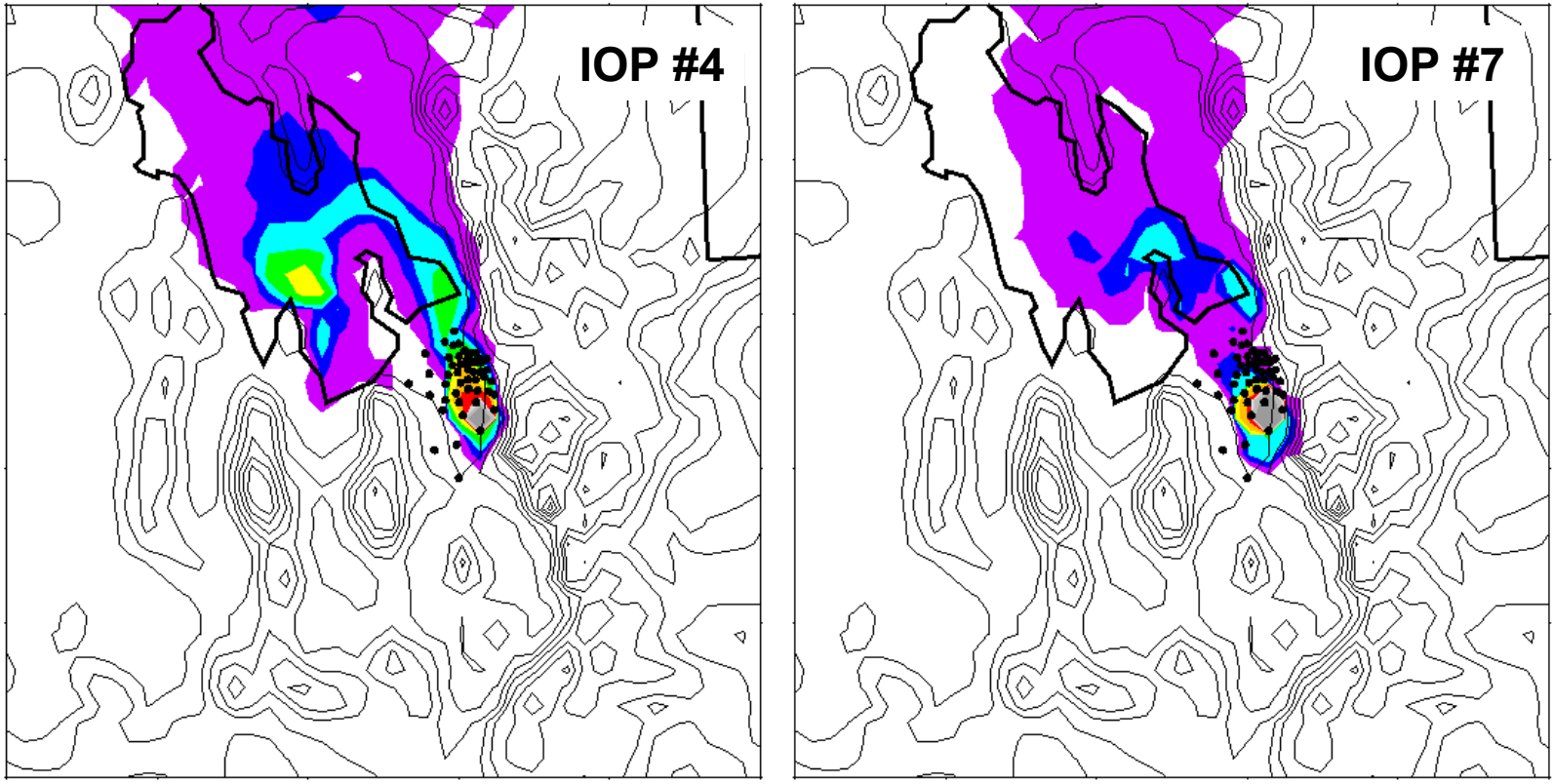
Regional Transport

Simulated PMCP 06 - 08 MST



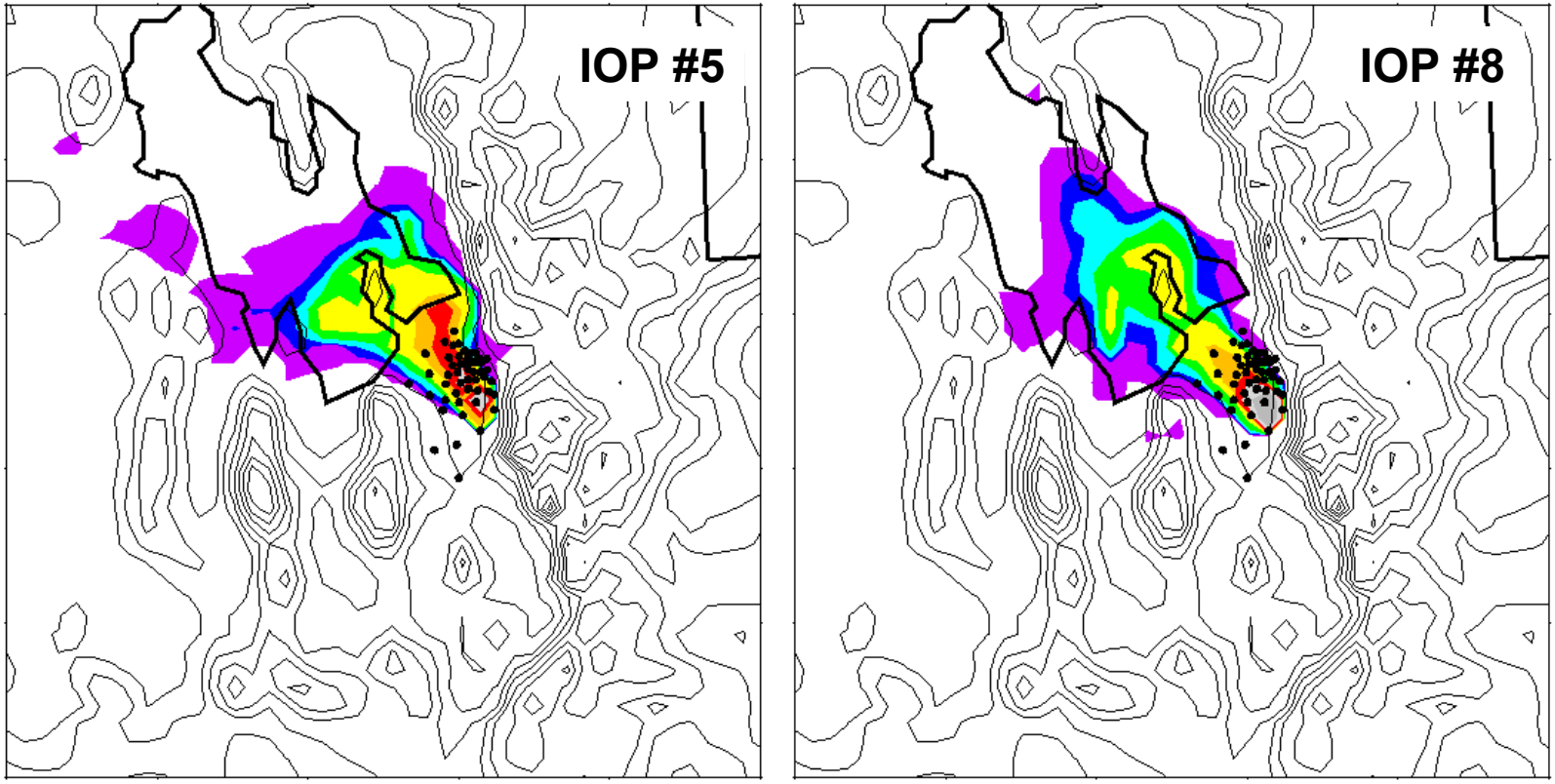
Regional Transport

Simulated PMCP 06 - 08 MST
IOPs Modified by Synoptic Forcing



Regional Transport

Simulated PMCP 06 - 08 MST
IOPs with Well-Developed Drainage Circulations



Summary: Modeling

Simulated PFT dispersion similar in many respects to the observed PFT data. The general findings are:

- **it is encouraging that the magnitude of the observed and simulated PFT concentrations are similar**
- **the model indicates that a significant portion of the PFTs become elevated above the shallow surface stable layer**
- **during IOP #2, transport of PDCB over the shallow surface stable layer and downward mixing over the slopes of the Oquirrh Mountains indicate an overturning of the valley atmosphere when Parleys Canyon outflow is strong**
- **during IOP #4 and later IOPs, tracers confined to eastern side of the valley; southerly down-valley flow blocks transport across the valley**
- **observed and simulated tracer transported to the southeastern end of the valley as a result of horizontal eddies in the valley atmosphere**
- **simulated tracers vented out of the valley during the morning transition period, while observations indicate a significant portion of the tracer remains over the city during the morning transition period**