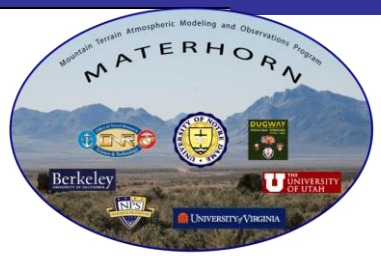
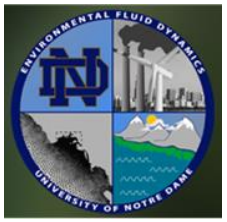




Observations of flow and turbulence in complex terrain during evening transition

S. Di Sabatino *(1,2), L. Leo (1), H.J.S. Fernando(1), A. Grachev (1,3), R. Dimitrova (1,4), Z. Silver (1), R. Quarta (1,2), T. Zsedrovits (1,5), T. Pratt(6) Zi Lin(6), D. Zajic (7), J. Pace (7), E. Pardyjak(8), D. Jensen(8), S. Hoch(9)*

(1) University of Notre Dame, Dept Civil and Environmental Engineering and Earth Sciences, Notre Dame, IN, USA
(2) University of Salento, Department of Biological and Environmental Sciences and Technologies, Lecce, Italy
(3) NOAA ESRL / University of Colorado CIRES, Boulder (CO), USA
(4) National Institute of Geophysics, Geodesy and Geography, Bulgarian Academy of Sciences, Bulgaria
(5) Pazmany Peter Catholic University, Faculty of Information Technology, Hungary
(6) University of Notre Dame, Dept Electrical Engineering, Notre Dame, IN, USA
(7) Meteorology Division, West Desert Test Center, Dugway Proving Ground, Dugway, UT, USA
(8) University of Utah, Dept Mechanical Engineering, Salt Lake City, UT, USA
(9) University of Utah, Dept of Atmospheric Sciences, Salt Lake City, UT, USA

MOTIVATION

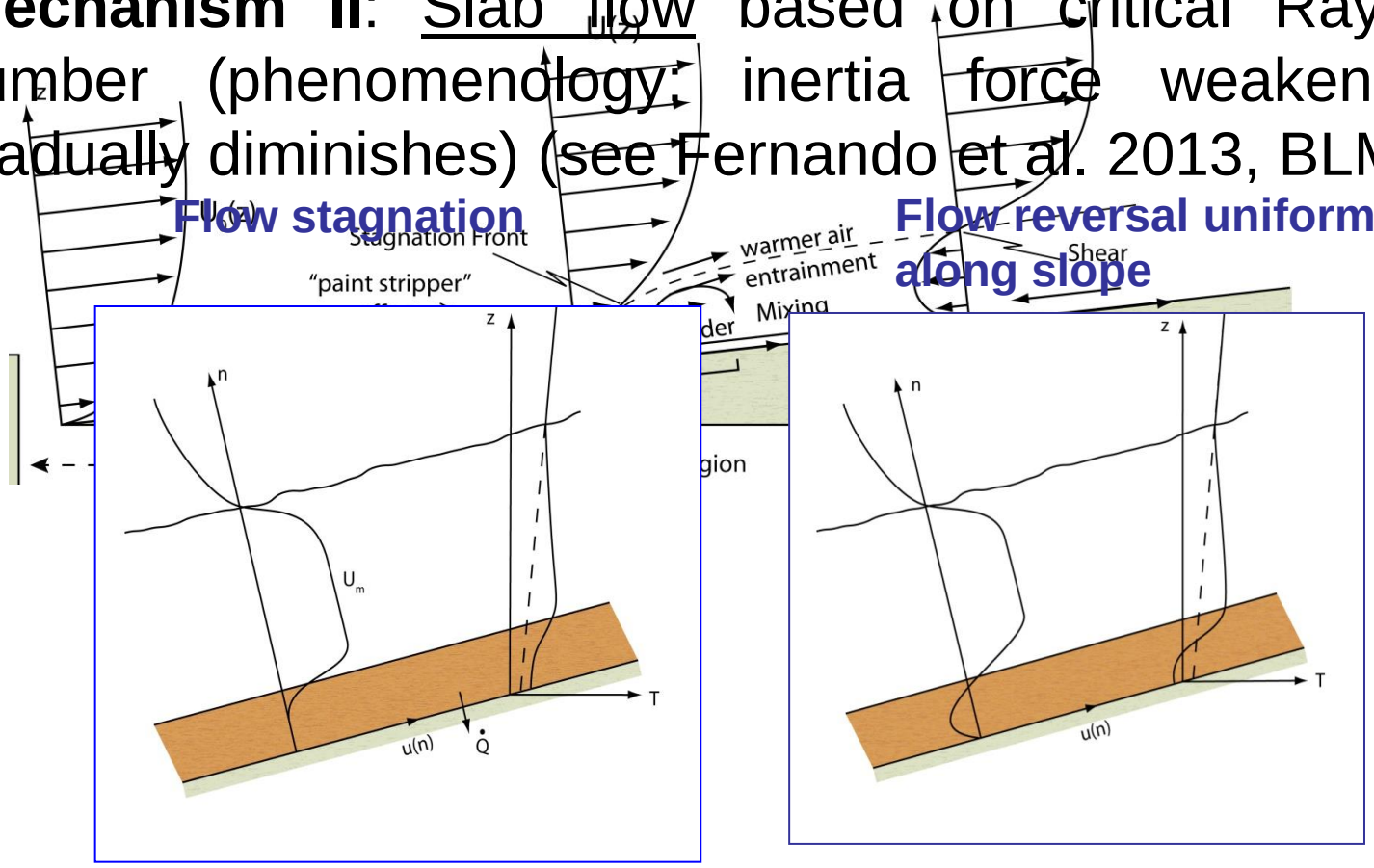
- Evening transitions – more complex than hypthesized to date i.e. front or slab flow? Non- local vs local phenomenon?
- Slope vs valley – what time scales are involved?
- Mesoscale models: evening transitions are well captured?

- Need for improved parameterizations in mesoscale models?

EVENING TRANSITION - PARADIGM

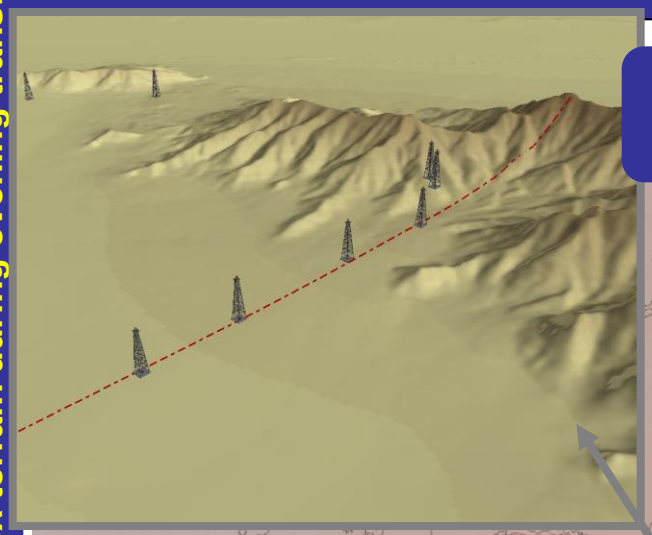
Mechanism I: Transitional front (following a balance between buoyancy and inertial forces) (see Hunt et al. 2003, JAS)

Mechanism II: Slab flow based on critical Rayleigh number (phenomenology: inertia force weakens; T gradually diminishes) (see Fernando et al. 2013, BLM)



THE SITE

Observations of flow and turbulence in complex terrain during evening trans.



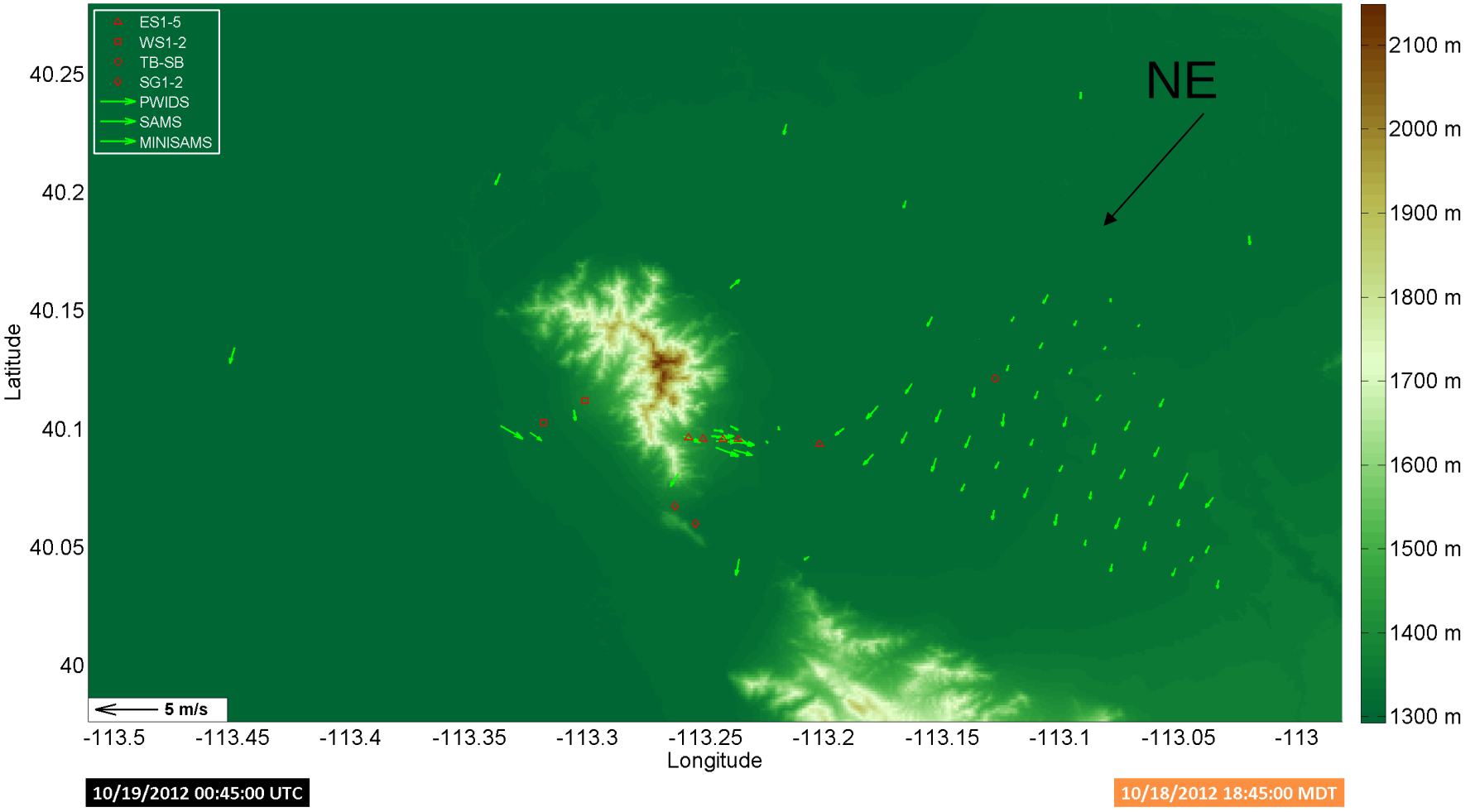
DATA: IOP 8 (Fall Campaign)

IOP Number: IOP 8
IOP Type: Quiescent
Start (MDT): 10/18/2012 5:00 AM
End (MDT): 10/19/2012 12:00 (NOON)
SUNSET (MDT): 06:42 PM -

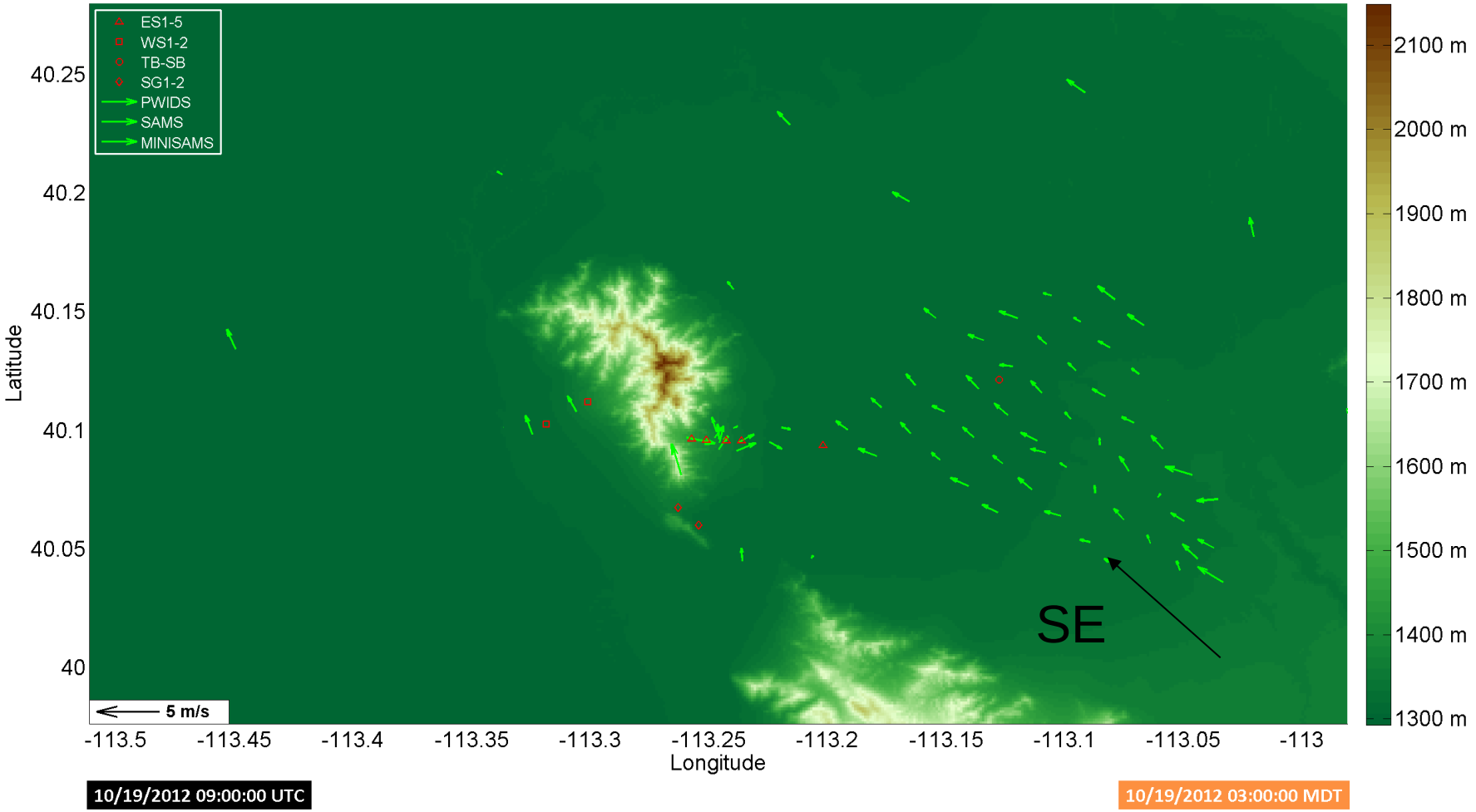
Start (UTC): 10/18/2012 11:00
End (UTC): 10/19/2012 18:00

Tethered Balloon: Playa, Sage Brush, North Playa
Radio Sounding: SLTEST, North Playa, Sage Brush
Flights: Twin Otter

FLOW PATTERNS AROUND SUNSET

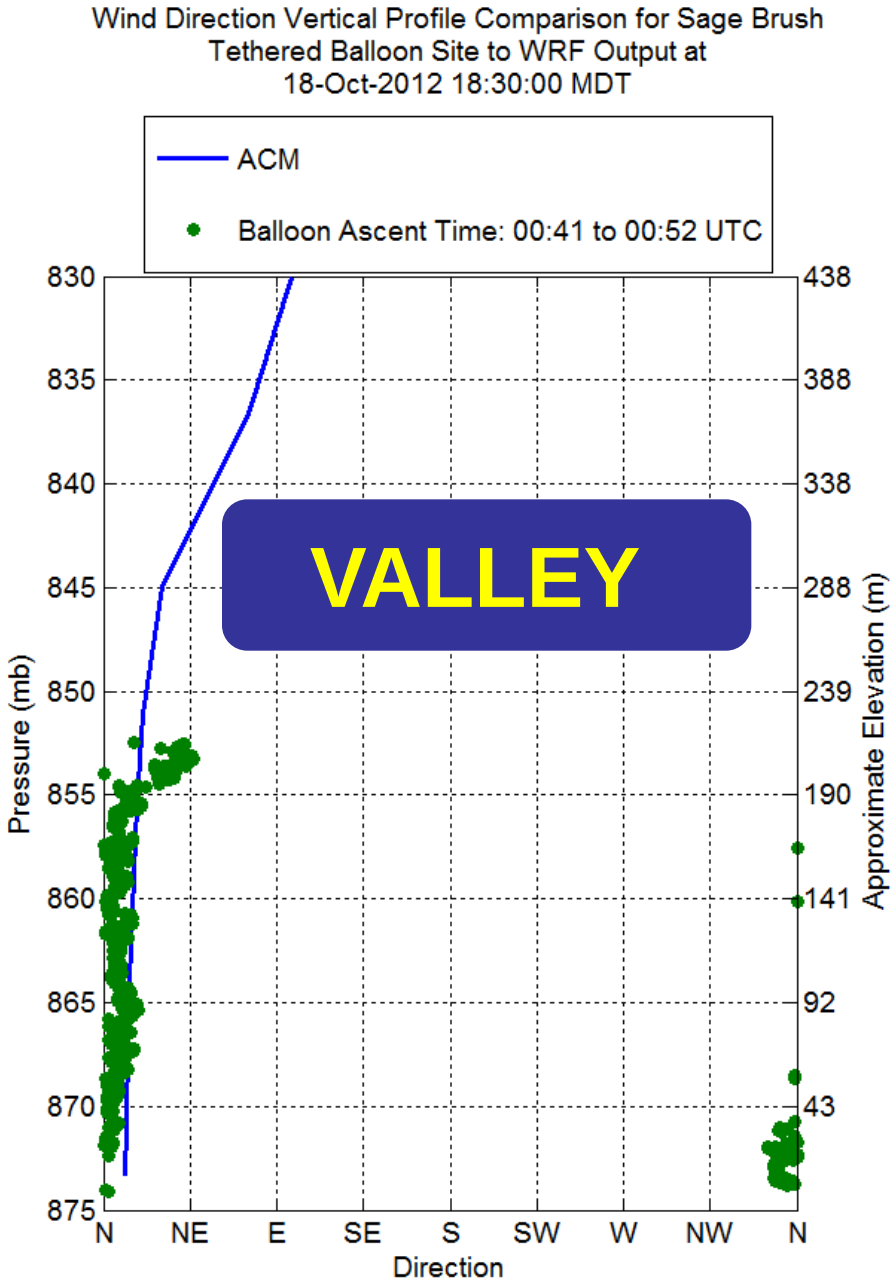


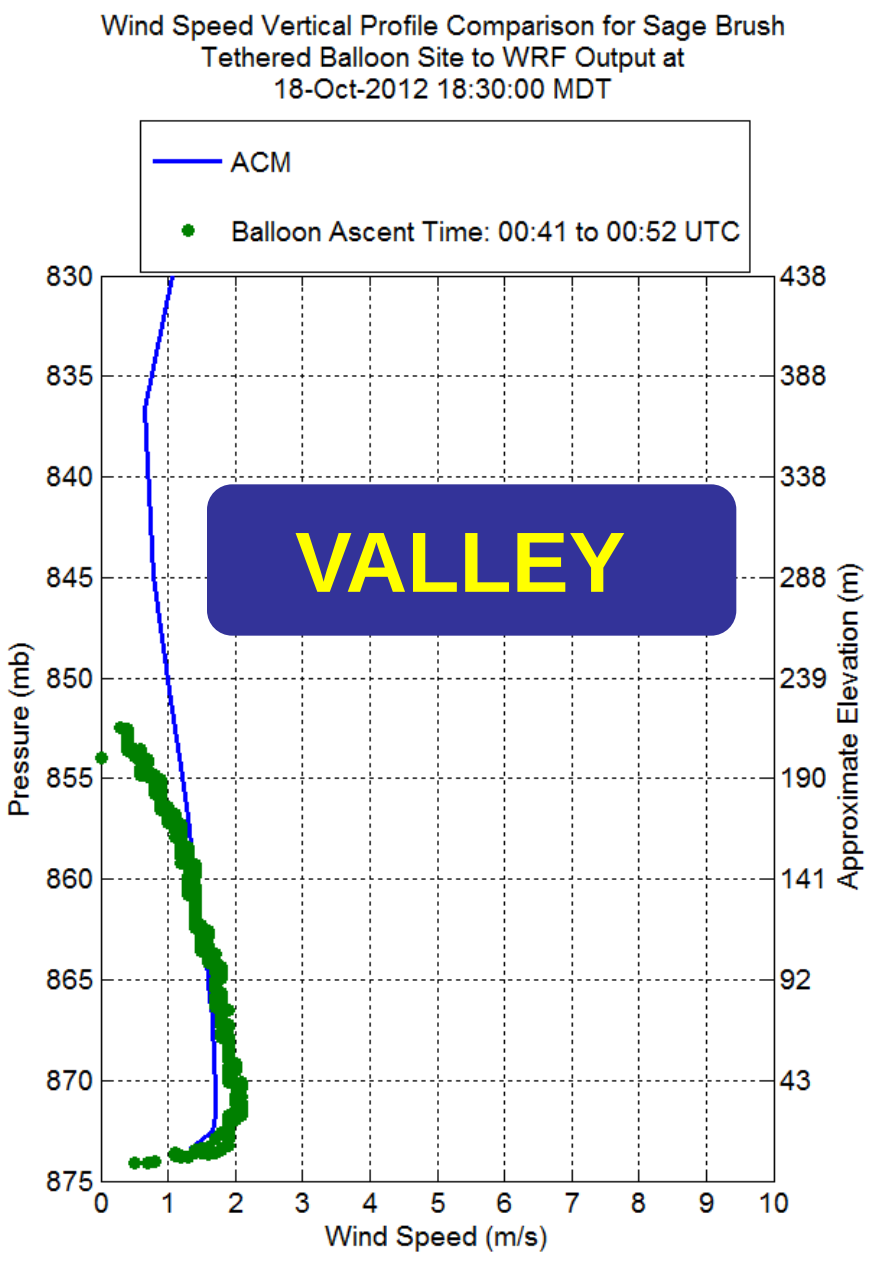
FLOW PATTERNS DURING NIGHT



Observations of flow and turbulence in complex terrain during evening trans.

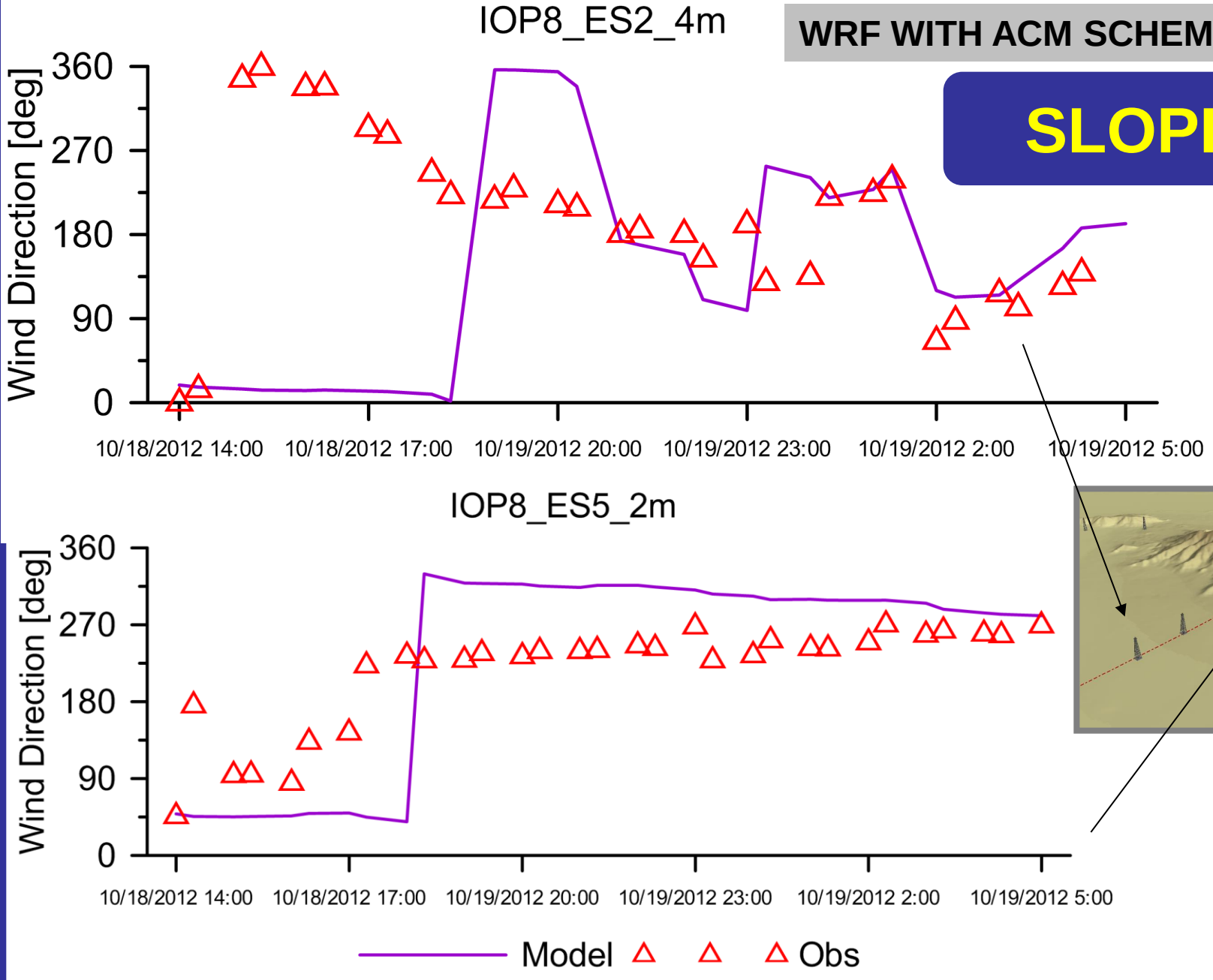
WRF WITH ACM SCHEME

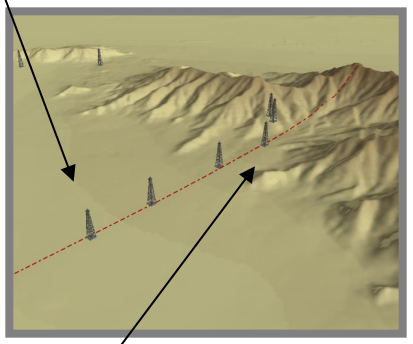




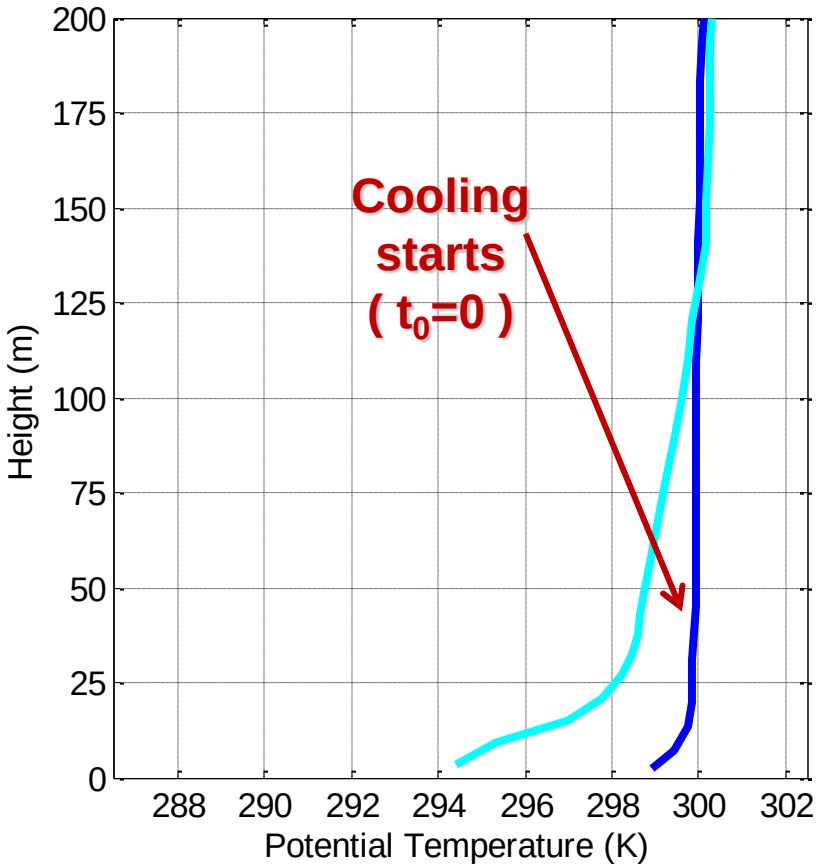
WRF WITH ACM SCHEME

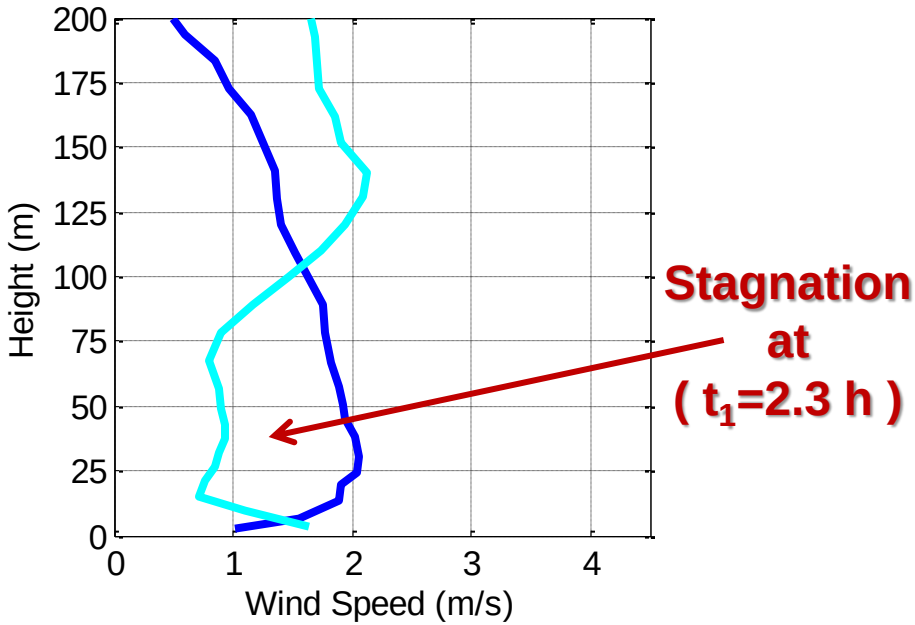
SLOPE

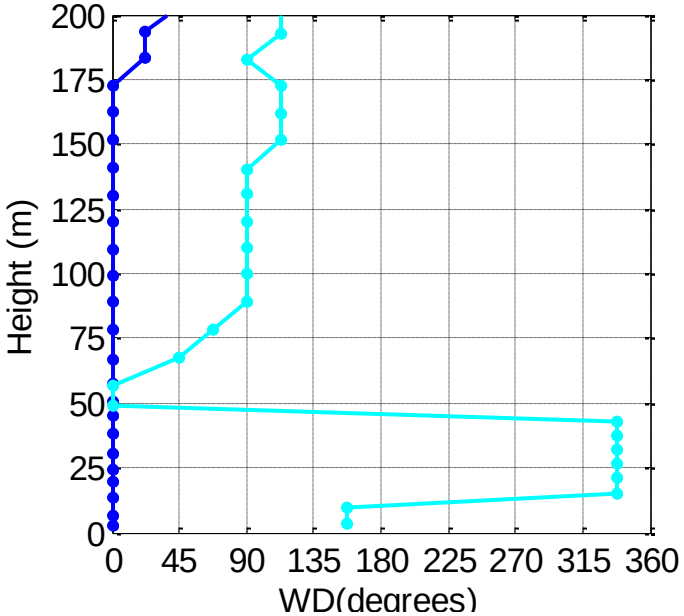




Observations of flow and turbulence in complex terrain during evening trans.







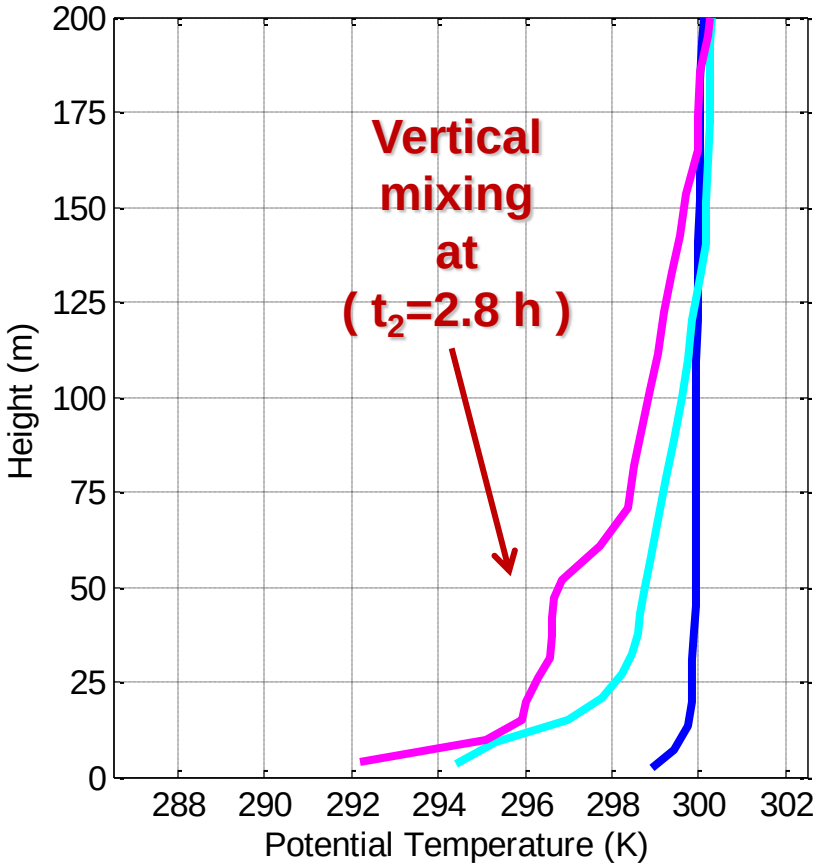
VALLEY

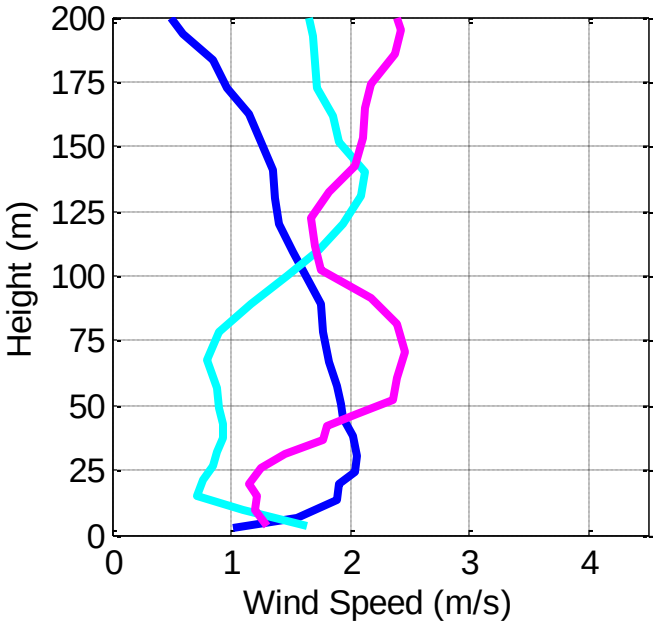
0041-0052
0257-0316

18:41 -18:52 MDT

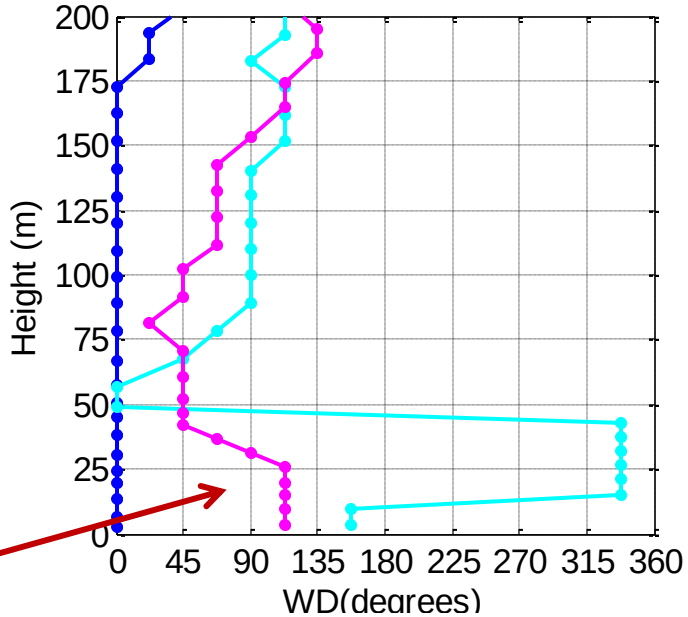
20:57 -21:16 MDT

Observations of flow and turbulence in complex terrain during evening trans.





Stagnation at (t_1=2.3 h)



18:41 -18:52 MDT

20:57 -21:16 MDT

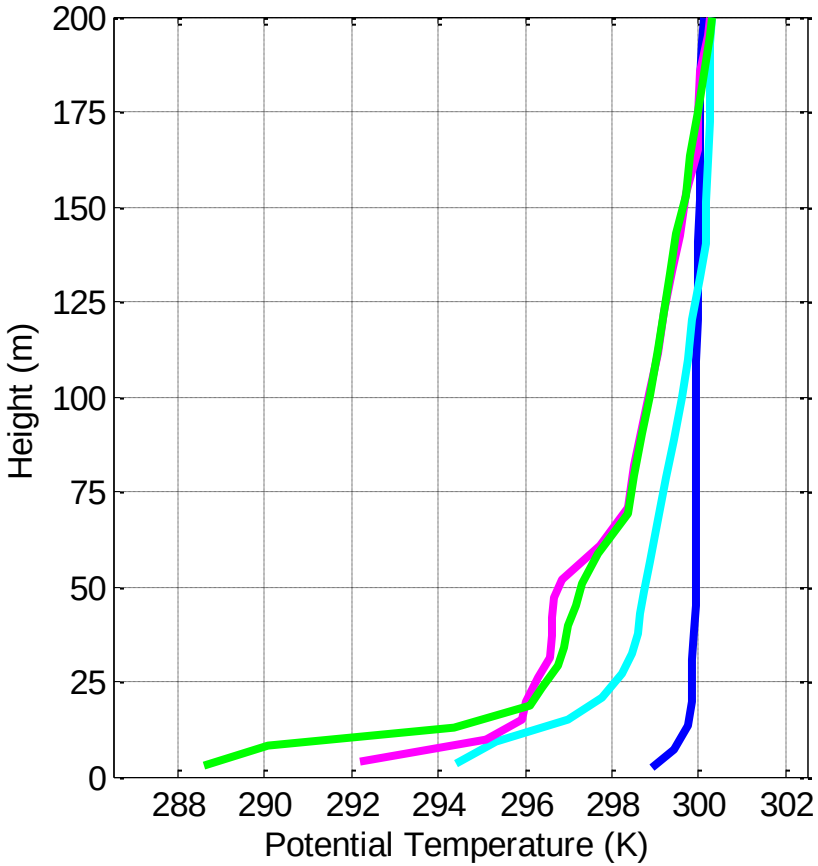
21:29 -21:54 MDT

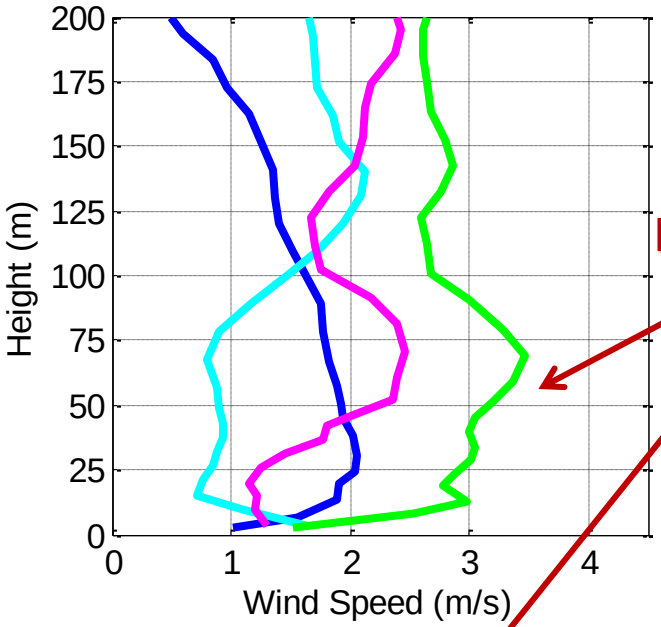
0041-0052

0257-0316

0329-0354

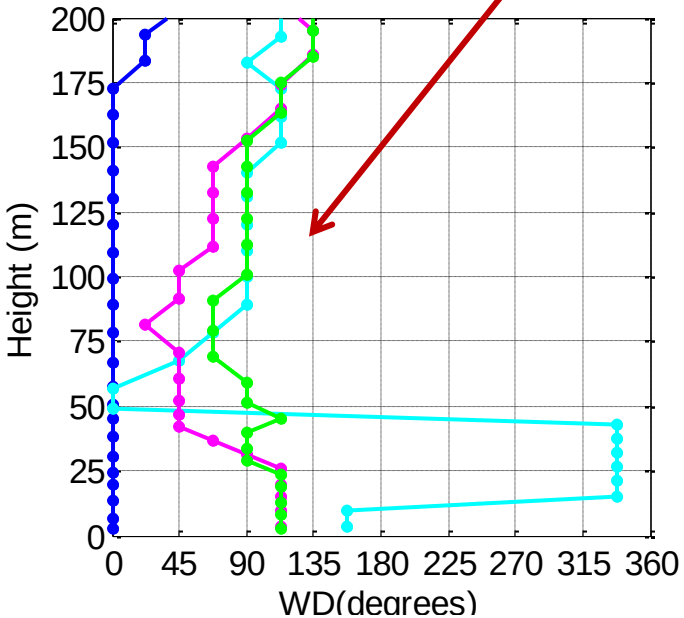
Flow starts reversing (t_2=2.8 h)





Downvalley flow

(t_3= 3.3 h)



18:41 -18:52 MDT

20:57 -21:16 MDT

21:29 -21:54 MDT

22:03 -22:28 MDT

0041-0052

0257-0316

0329-0354

0403-0428

1) Evening transition observed at Sagebrush resembles "somewhat" the front mechanism of Hunt et al. (2002) although no strong evidence of front propagation

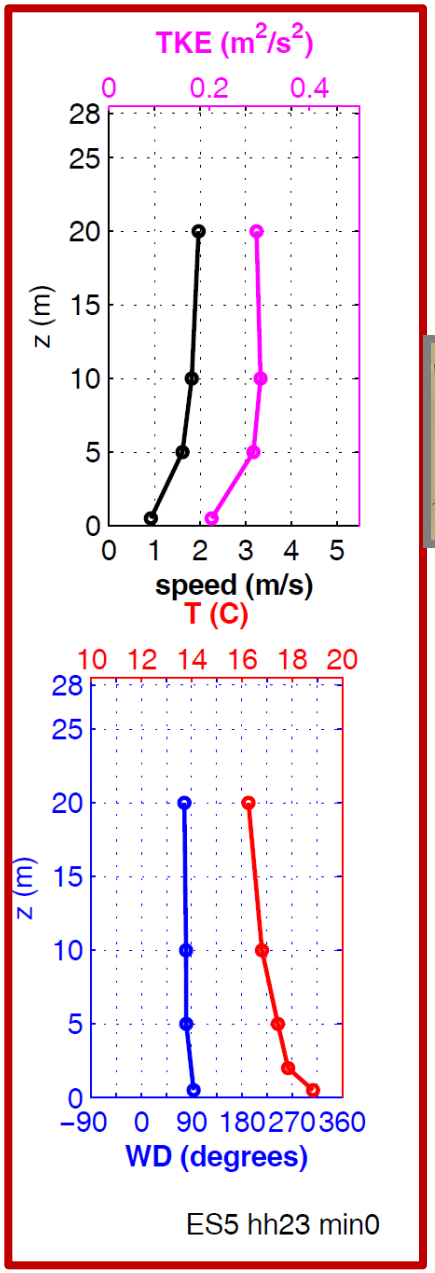
2) Good agreement in the time delay of the evening transition

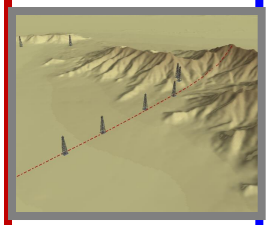
T_d(observed) = 3.3 hours

T_d (theory)= 3.2 hours (Brazel et al., 2005)

EAST SLOPE (EVENING)

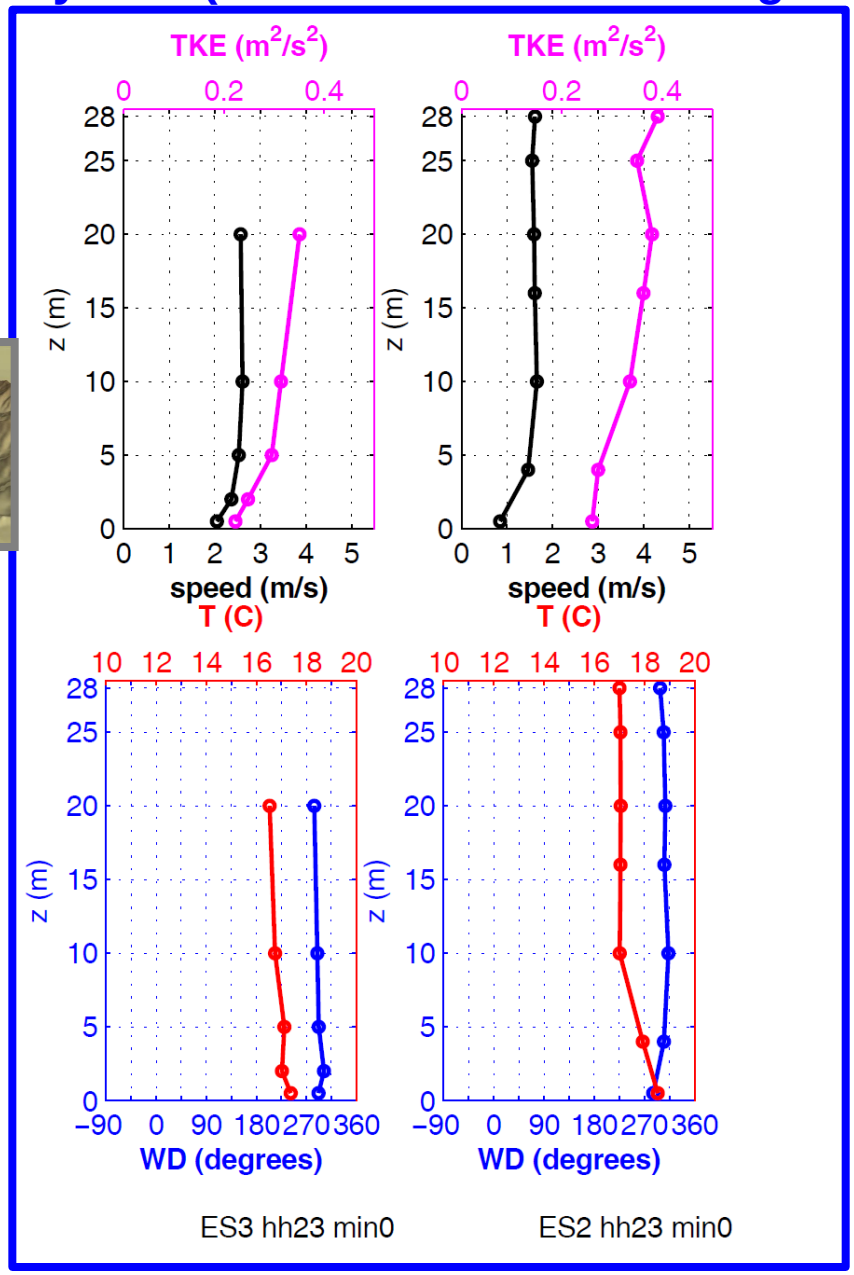
Slope Flow

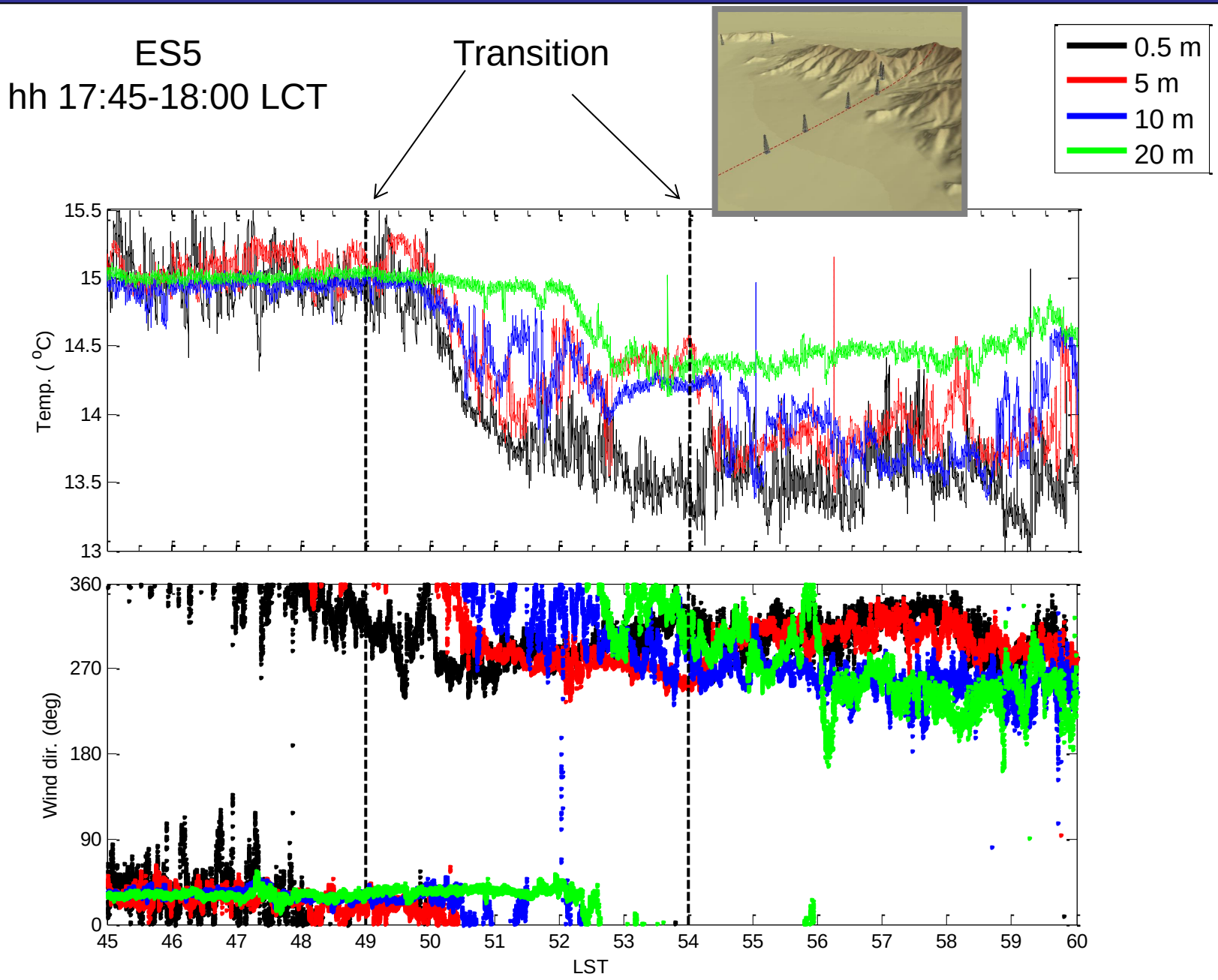




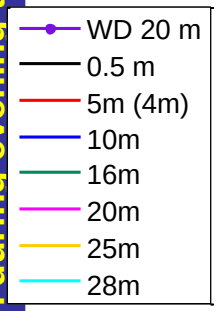
hh :17:00
local time

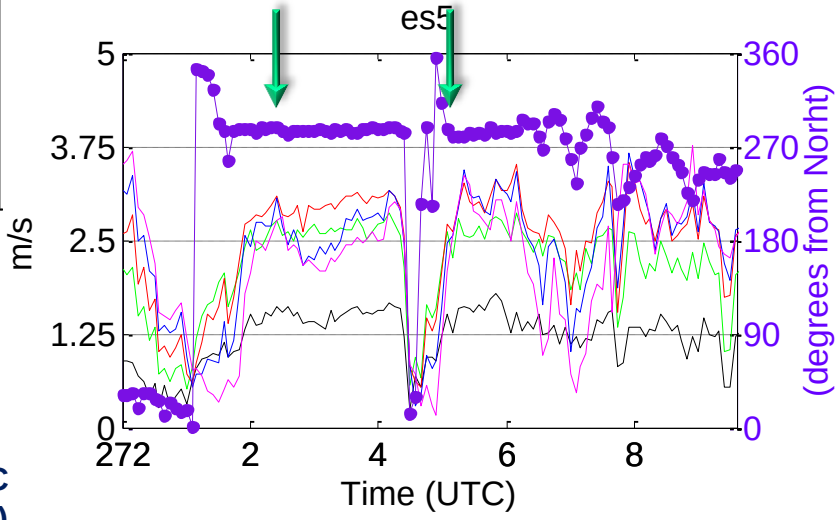
Valley flow (same as observed at sagebrush)

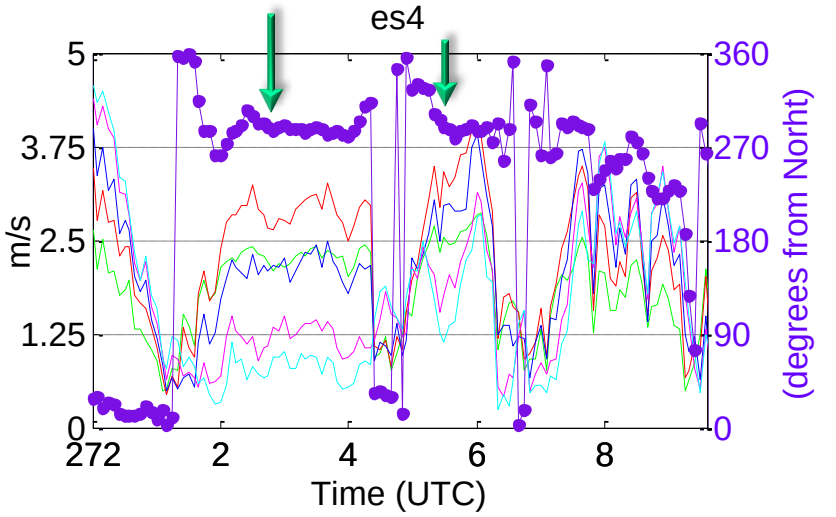



ES5
hh 17:45-18:00 LCT
Transition
0.5 m
5 m
10 m
20 m
Temp. (°C)
15.5
15
14.5
14
13.5
13
Wind dir. (deg)
360
270
180
90
0
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60
LST

Observations of flow and turbulence in complex terrain during evening trans.

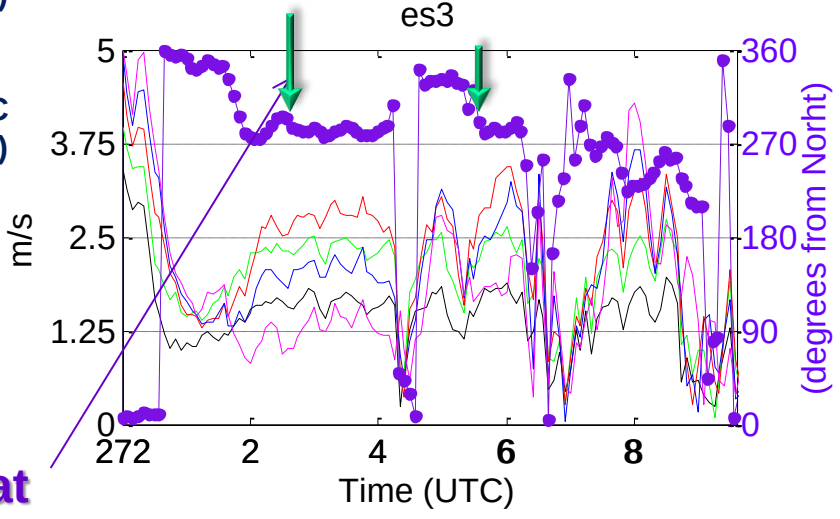


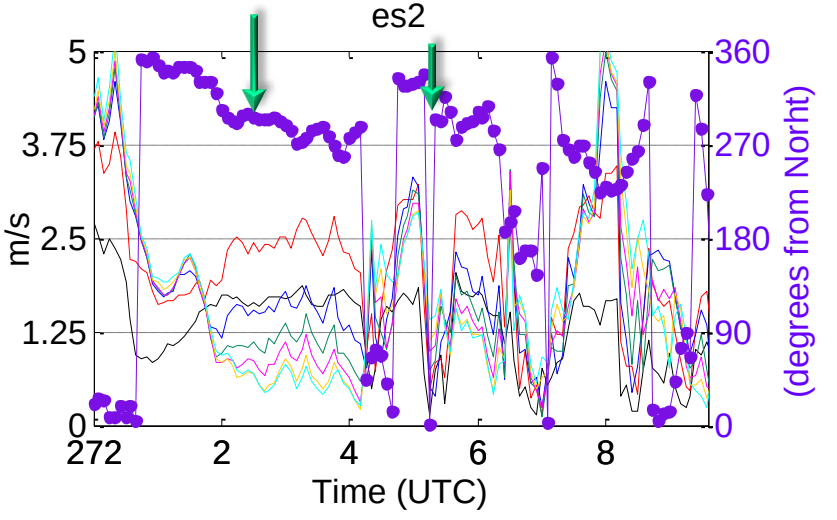




Sunset
01:17 UTC
(19:17 LC)

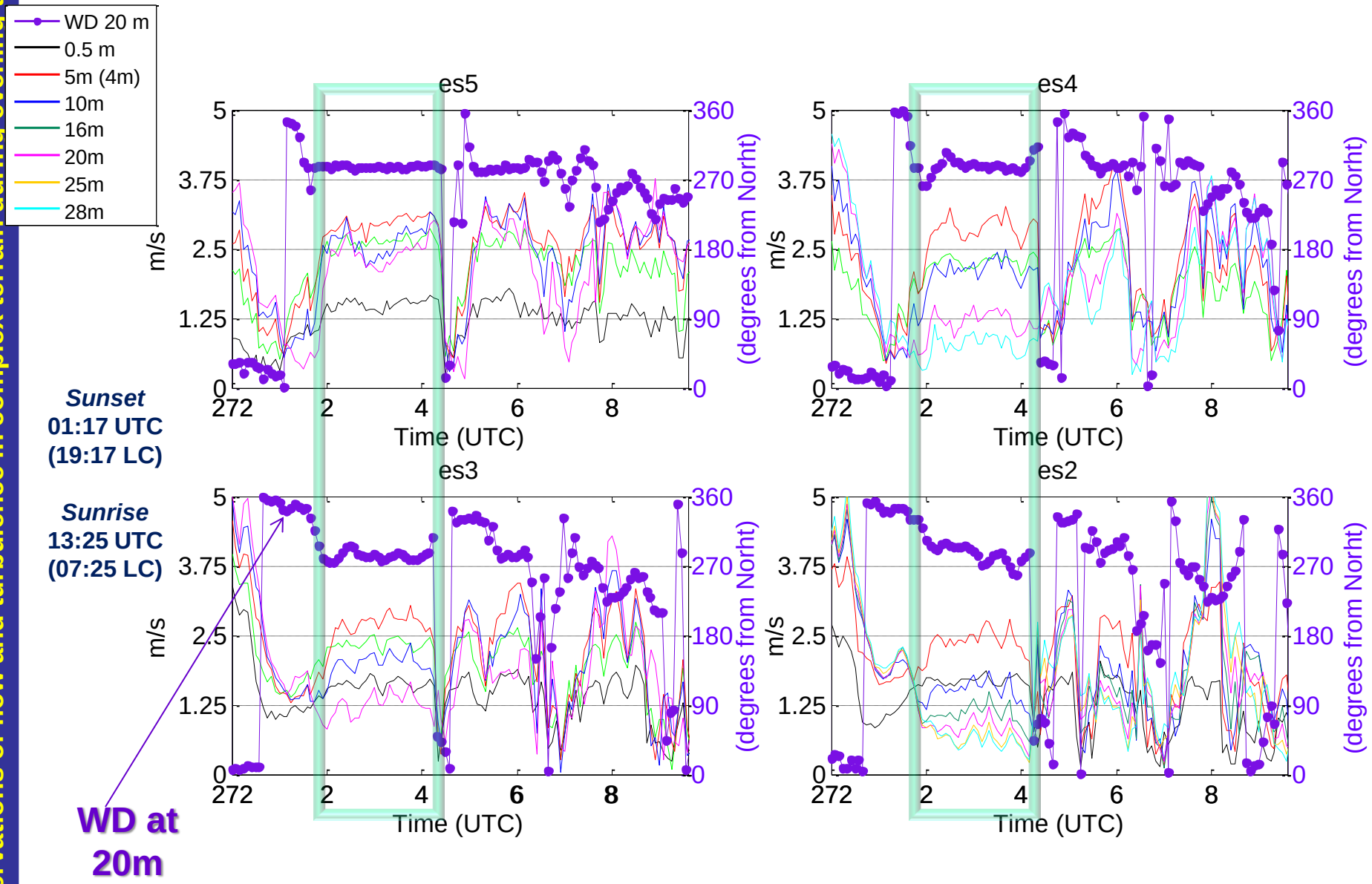
Sunrise
13:25 UTC
(07:25 LC)

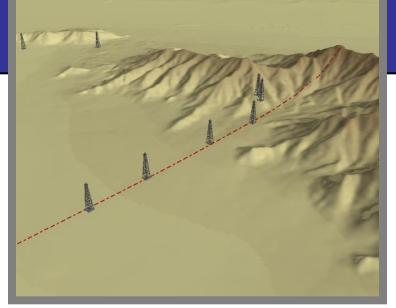




WD at 20m

Observations of flow and turbulence in complex terrain during evening trans.





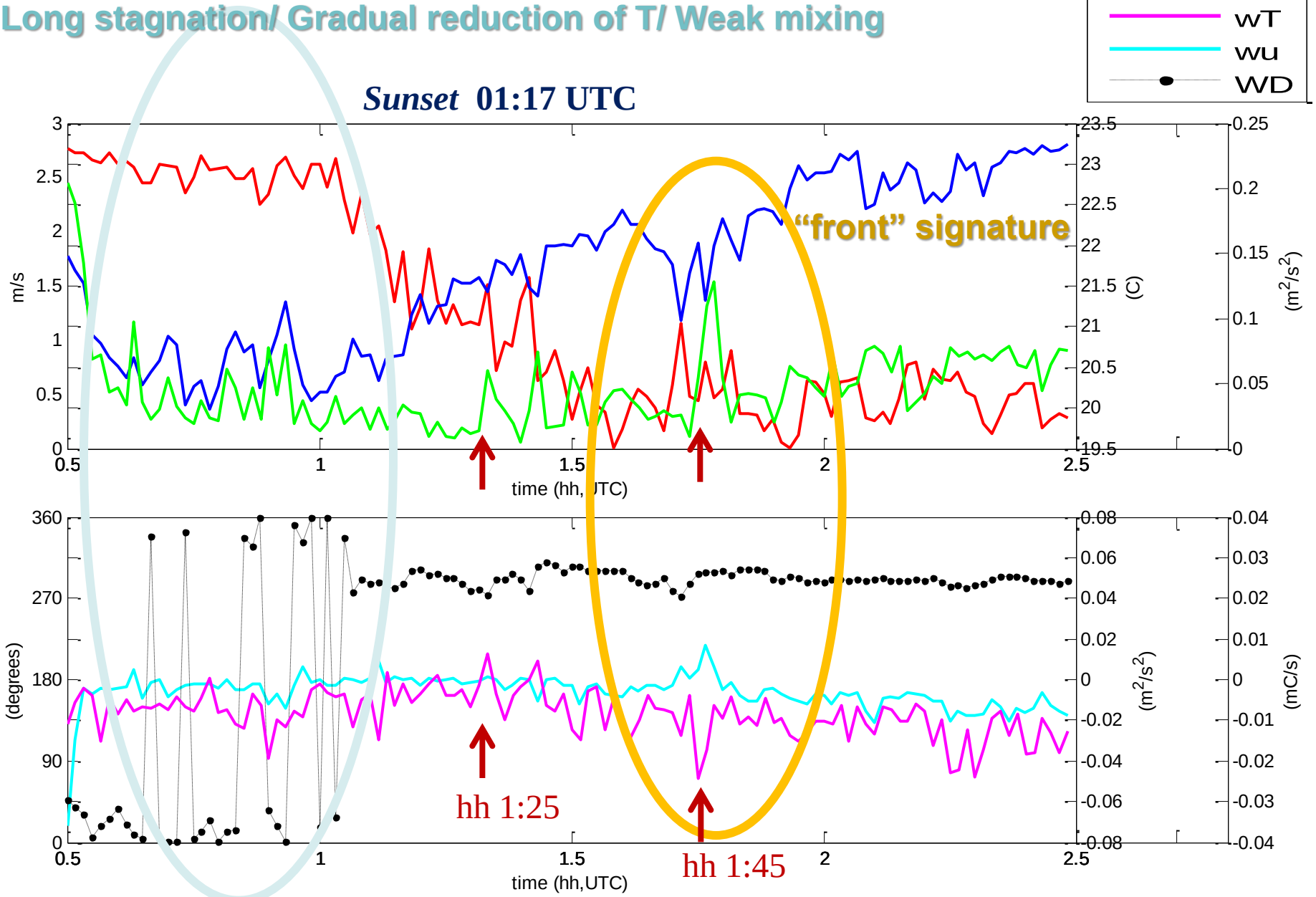
Es5 – 2m level – 1 min avg

***Sunset* 01:17 UTC**

Observations of flow and turbulence in complex terrain during evening trans.

Es5 – 2m level – 1 min avg

Long stagnation/ Gradual reduction of T/ Weak mixing

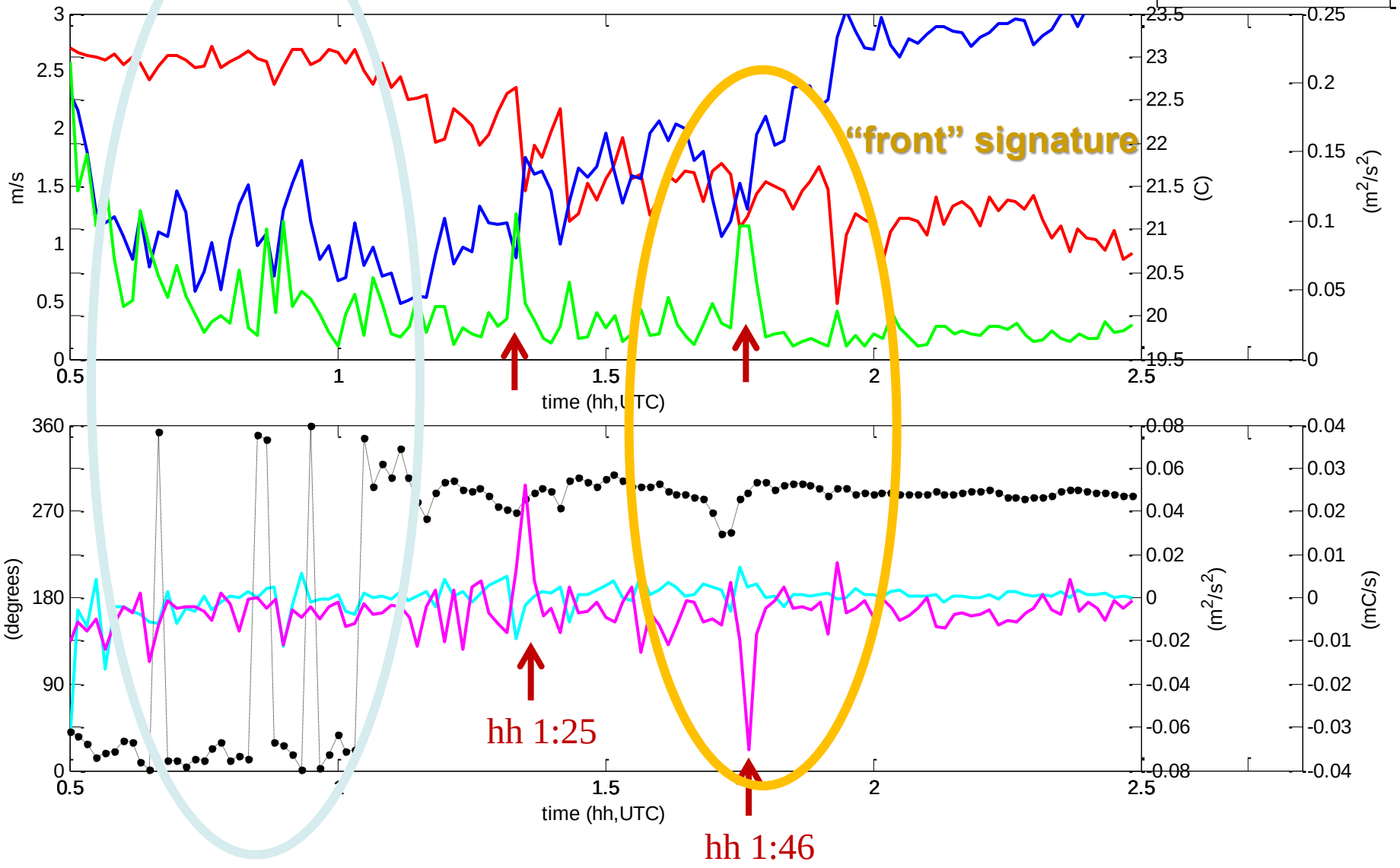


Observations of flow and turbulence in complex terrain during evening trans.

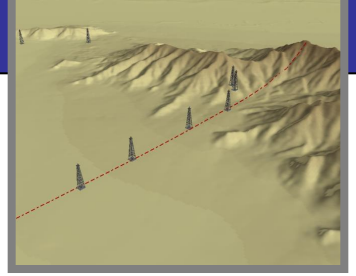
Es5 – 5 m level – 1 min avg

Long stagnation/ Gradual reduction of T/ Weak mixing

***Sunset* 01:17 UTC**

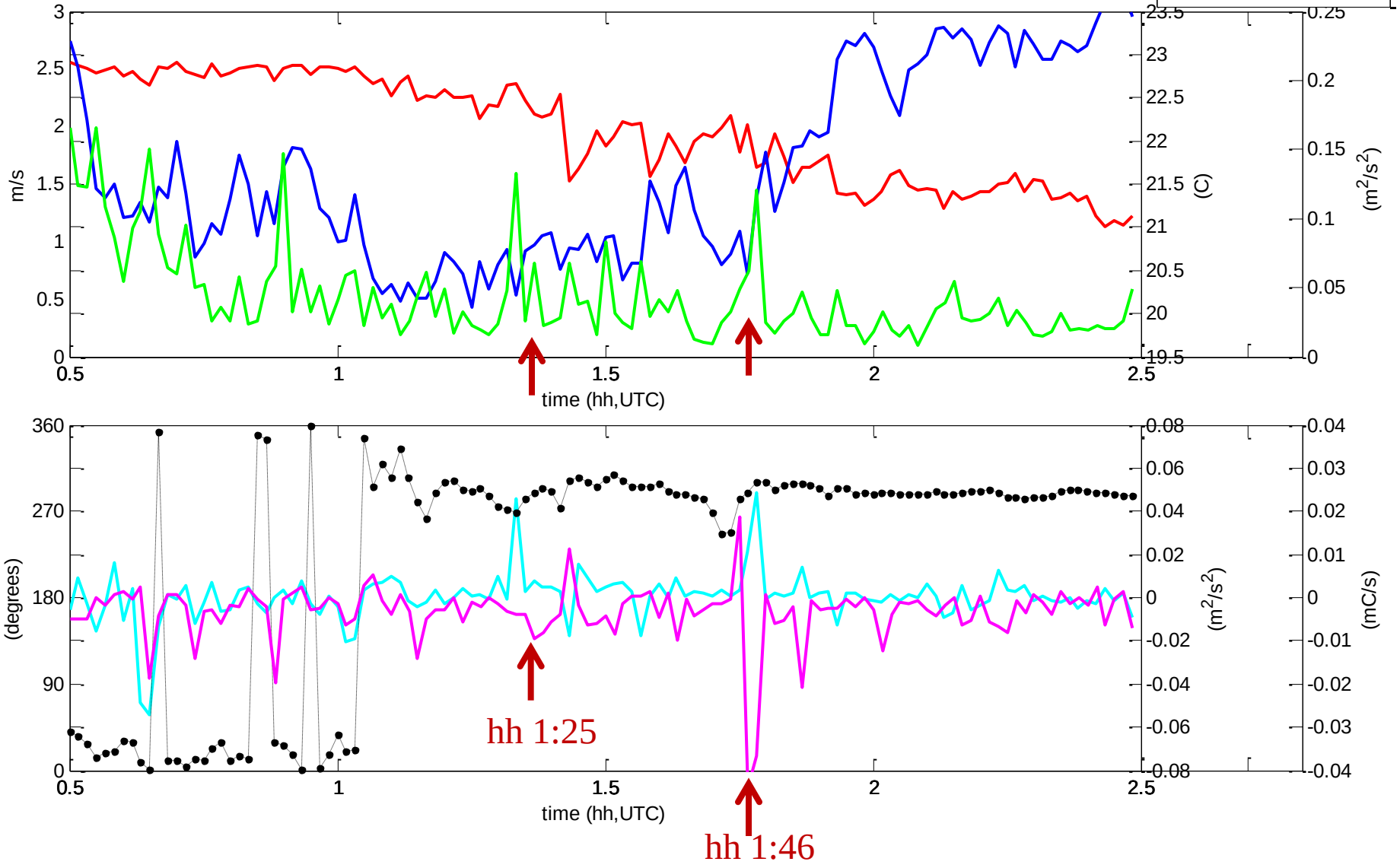


Observations of flow and turbulence in complex terrain during evening trans.



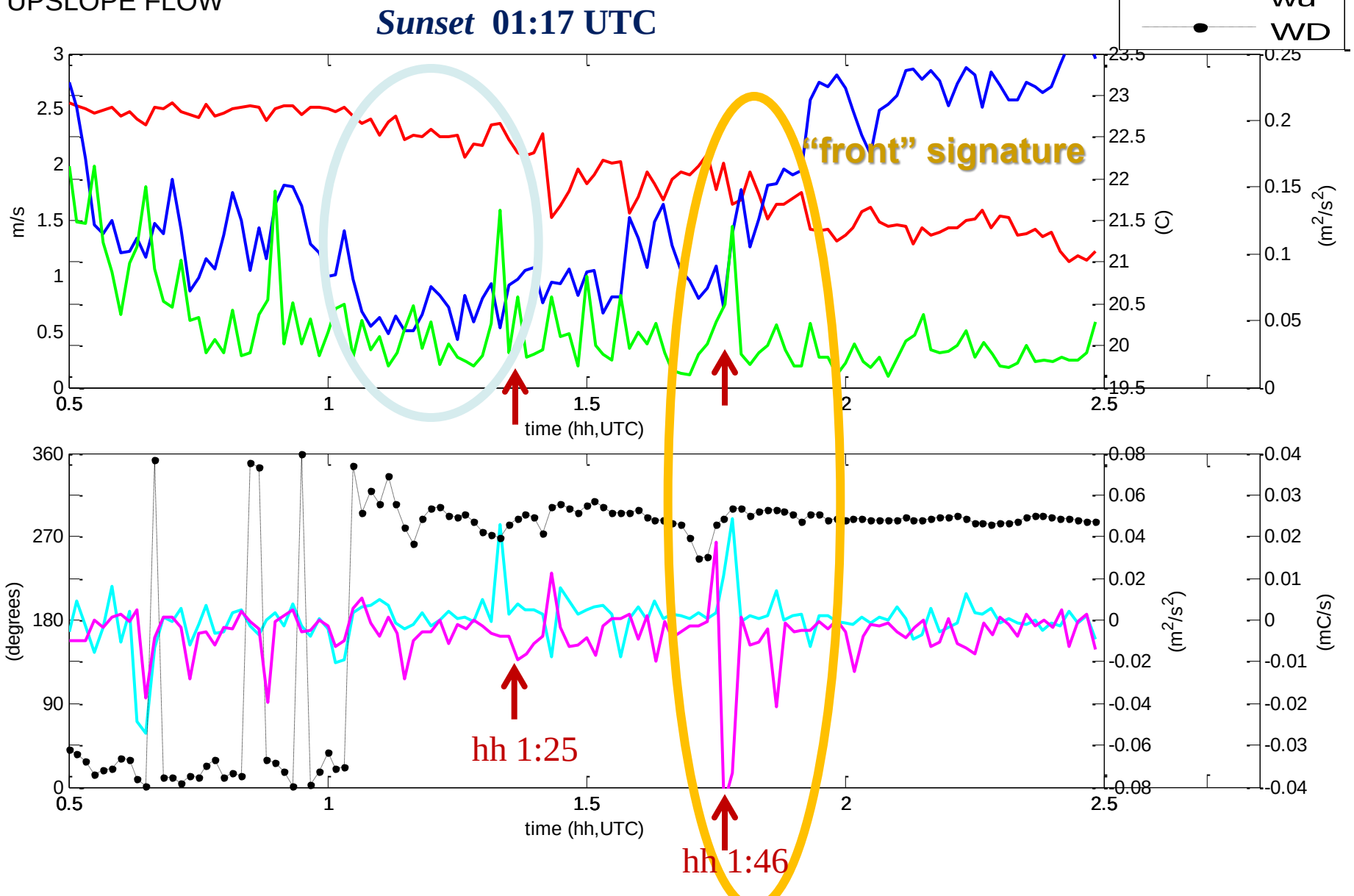
Es5 – 10 m level – 1 min avg

***Sunset* 01:17 UTC**

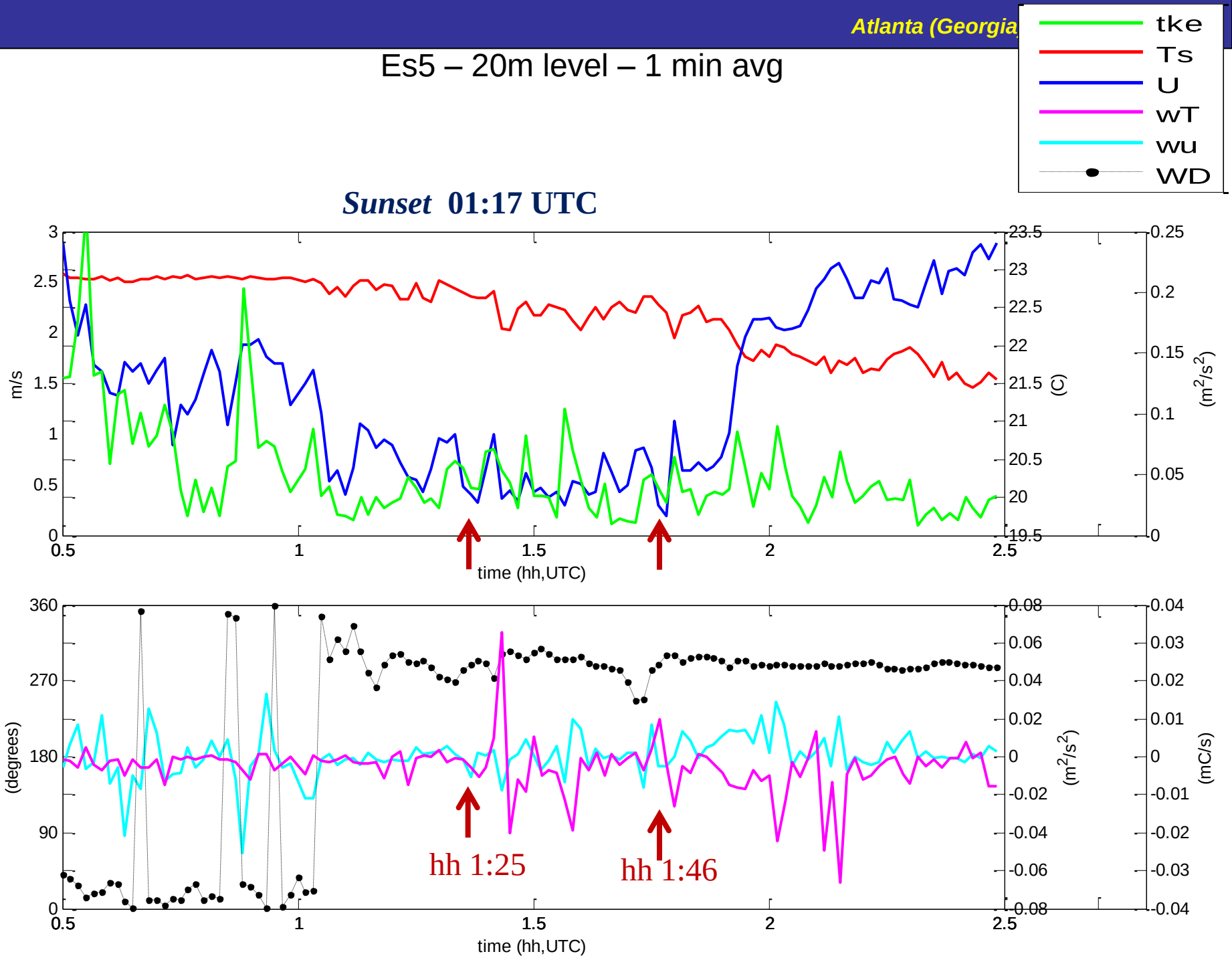


Es5 – 10m level – 1 min avg

INTERFACE – STILL RESIDUAL OF UPSLOPE FLOW



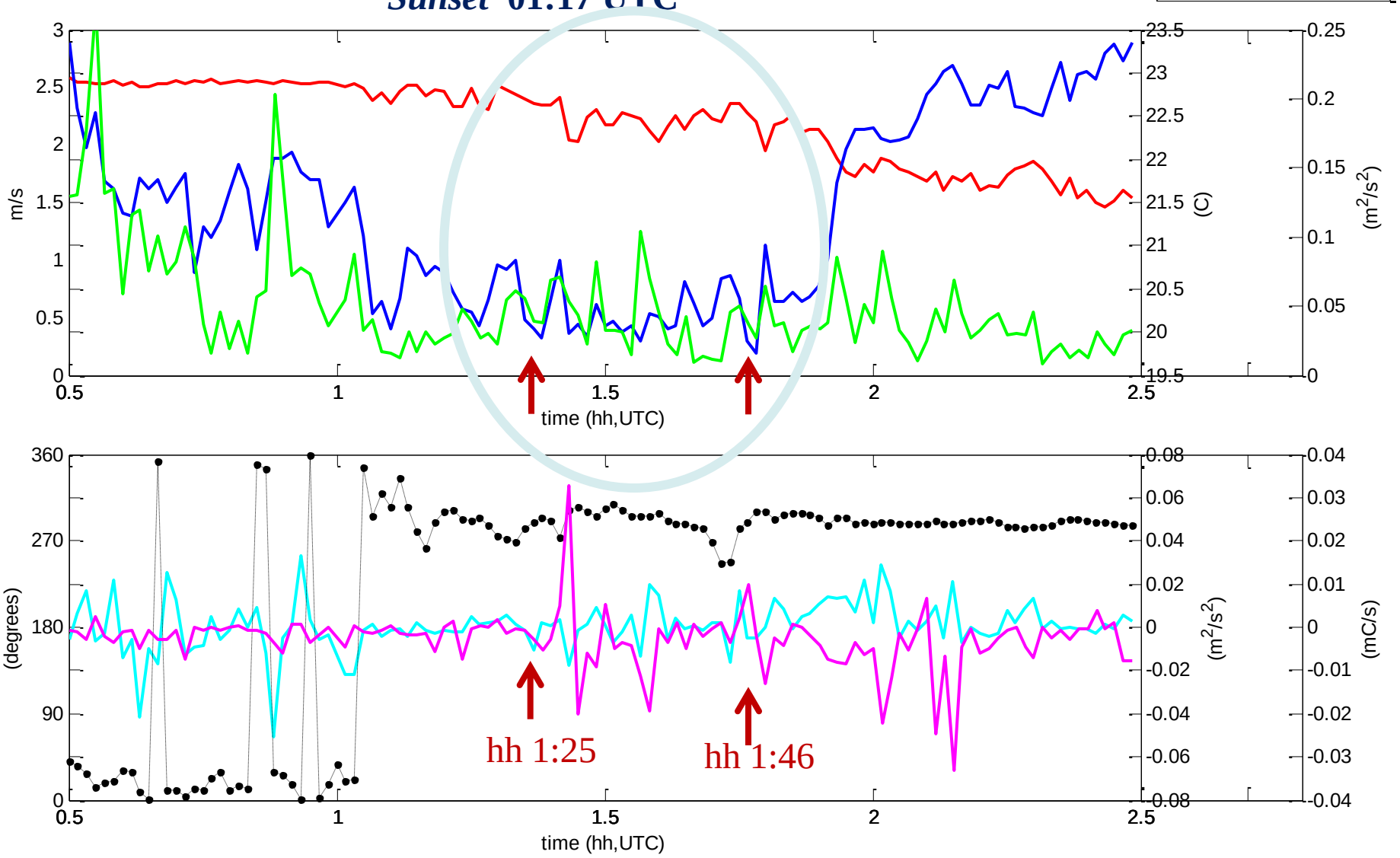
Es5 – 20m level – 1 min avg



Observations of flow and turbulence in complex terrain during evening trans.

Es5 – 20 m level – 1 min avg

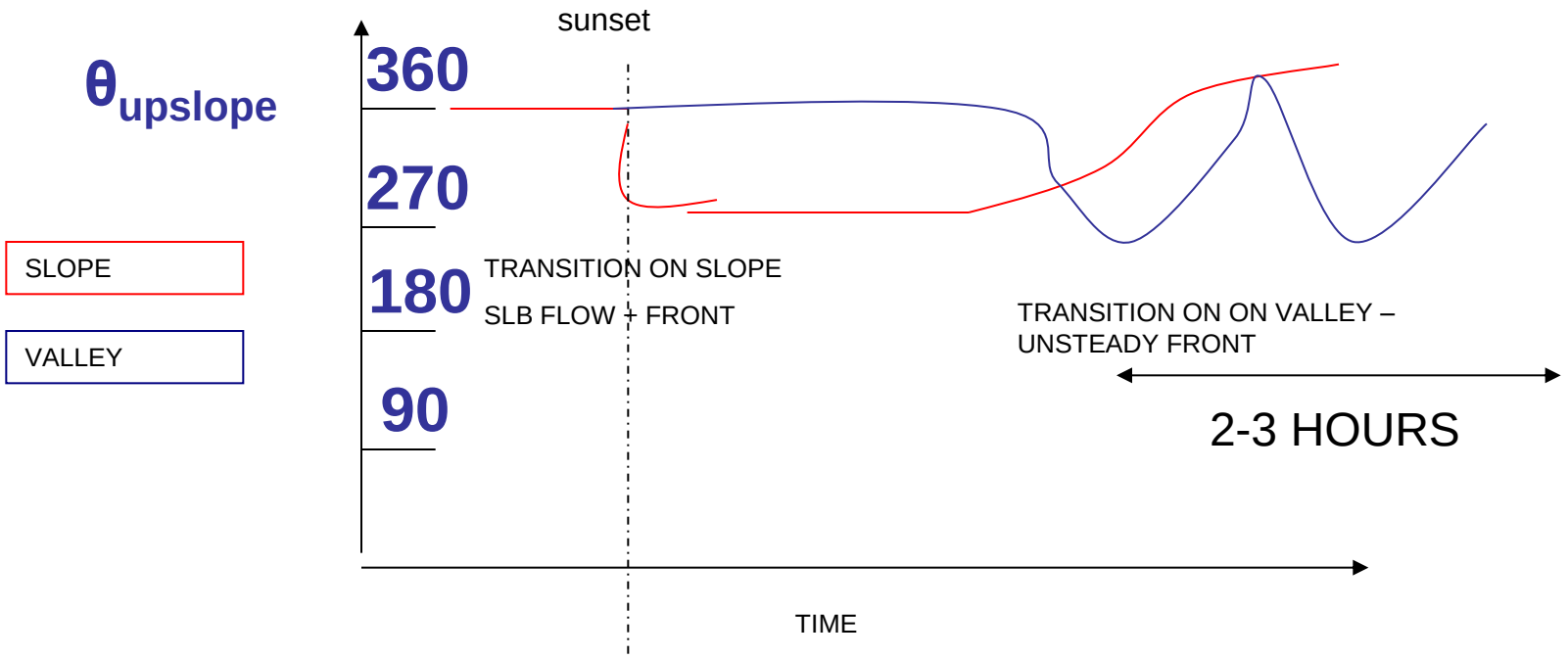
Long stagnation/ Gradual reduction of T – MORE MIXING BUT NOT A FRONT



CONCLUSIONS

COMPLEX EVENING TRANSITIONS SCENARIOS: EVIDENCE OF COEXISTENCE OF MULTIPLE MECHANISMS (ON SLOPE AND VALLEY)

DIFFERENT TIME SCALES FOR VALLEY AND SLOPE



Acknowledgments

This research was funded by the Office of Naval Research Award # N00014-11-1-0709, Mountain Terrain Atmospheric Modeling and Observations (MATERHORN) Program. Additional support for the Twin Otter was provided by the Environmental Sciences group at the Army Research Office (ARO).