A case study of the nocturnal boundary layer on a slope at the foot of a desert mountain

Manuela Lehner

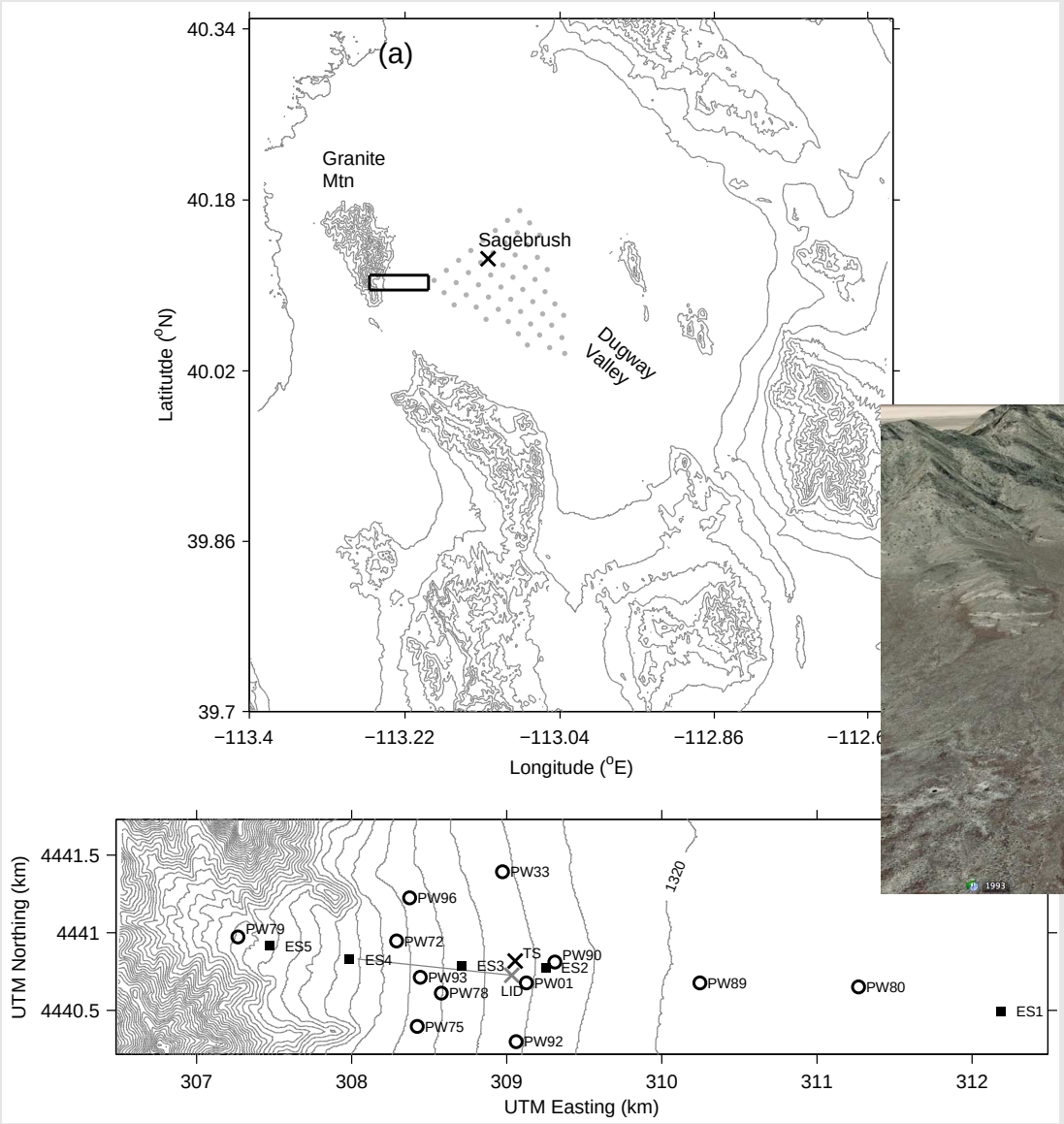
C. David Whiteman, Sebastian W. Hoch, Derek Jensen, Eric R. Pardyjak, Laura S. Leo, Silvana Di Sabatino, and Harindra J. S. Fernando

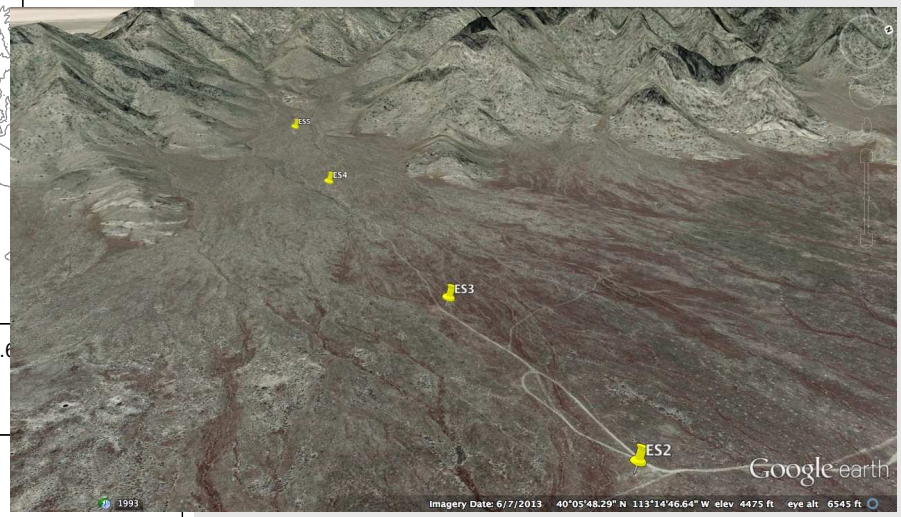
submitted to Journal of Applied Meteorology and Climatology

Case study: Spring IOP 4

- Spring IOP 4:
  11–12 May 2013
- Quiescent, clear-sky conditions
- Tethered-balloon soundings on the east slope

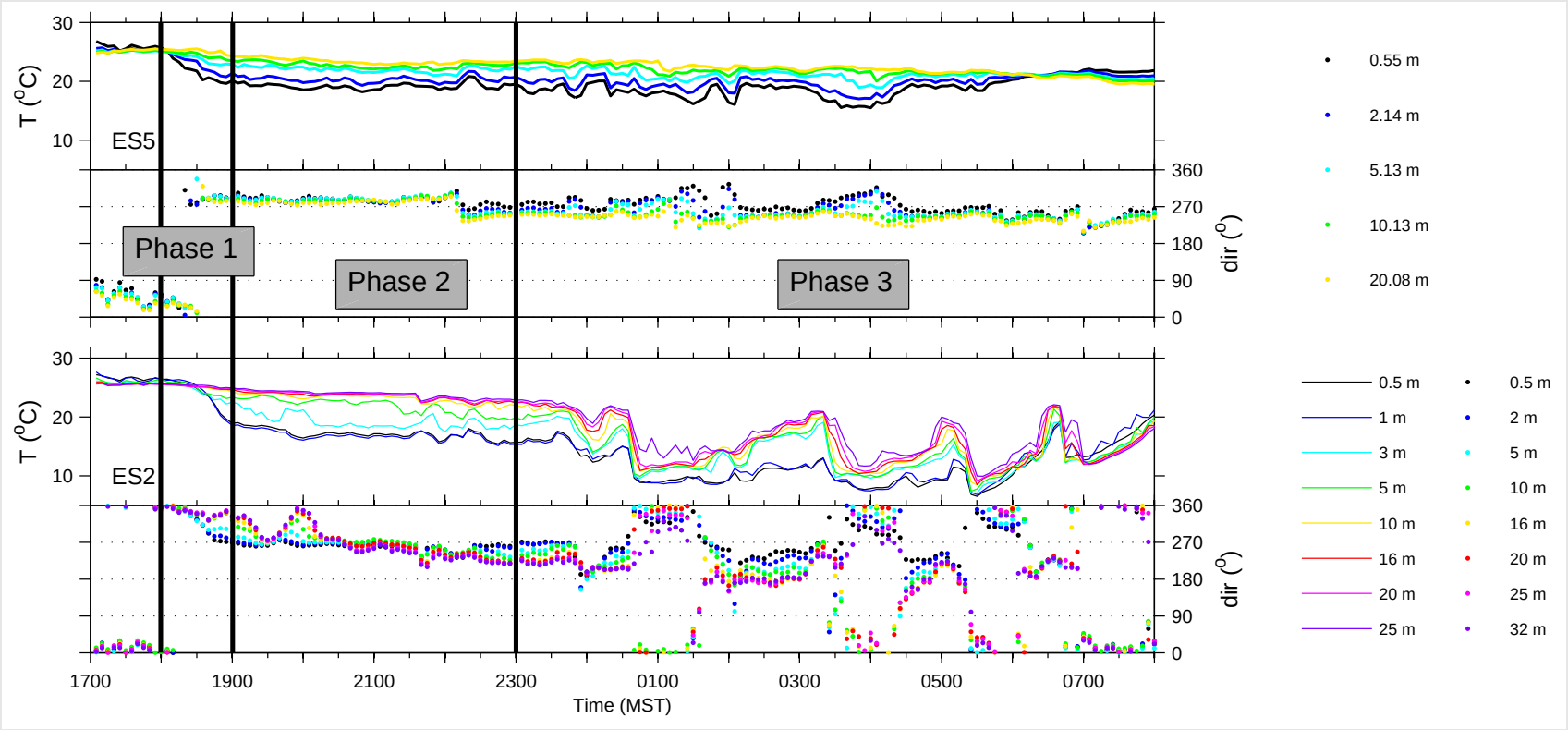
Case study: Spring IOP 4



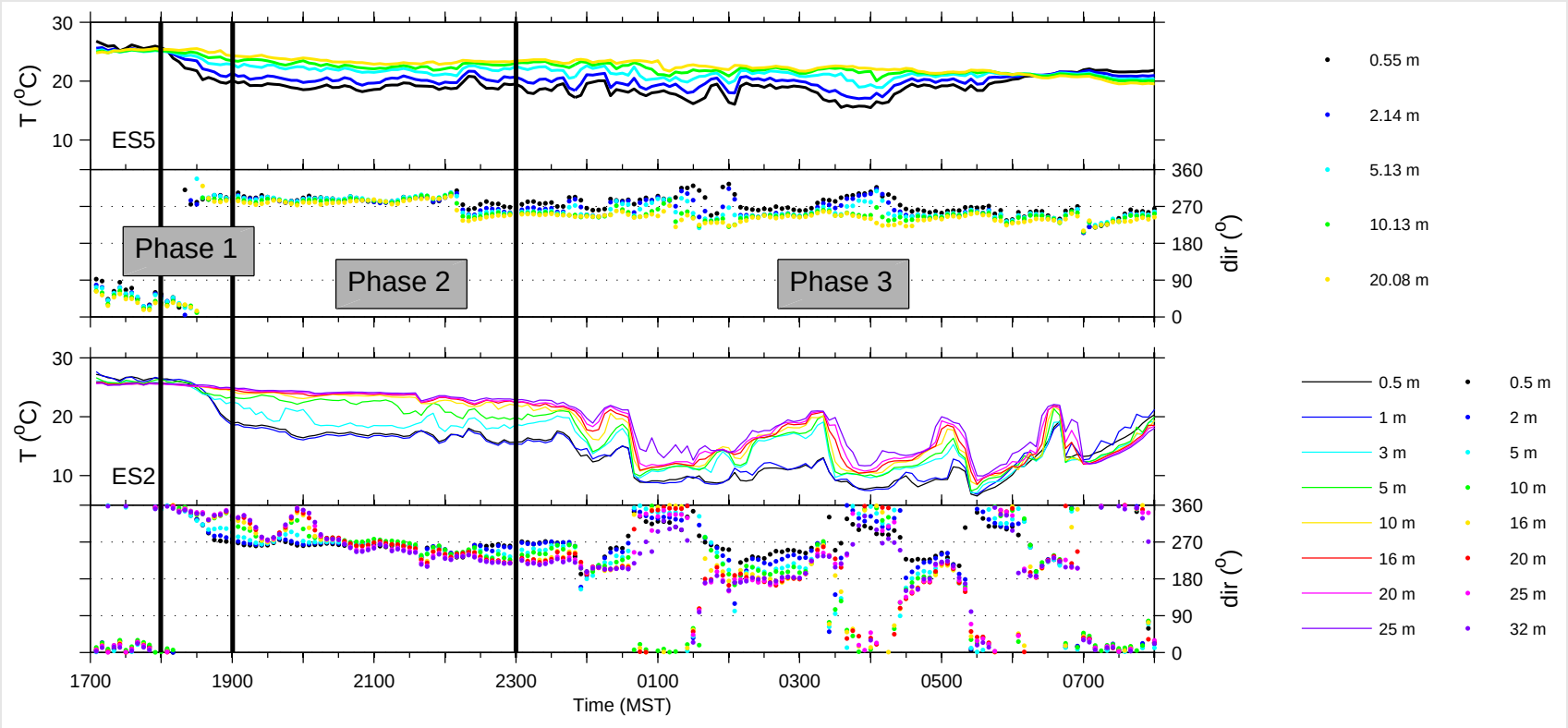


- East slope of Granite Mountain

IOP 4 Overview



IOP 4 Overview

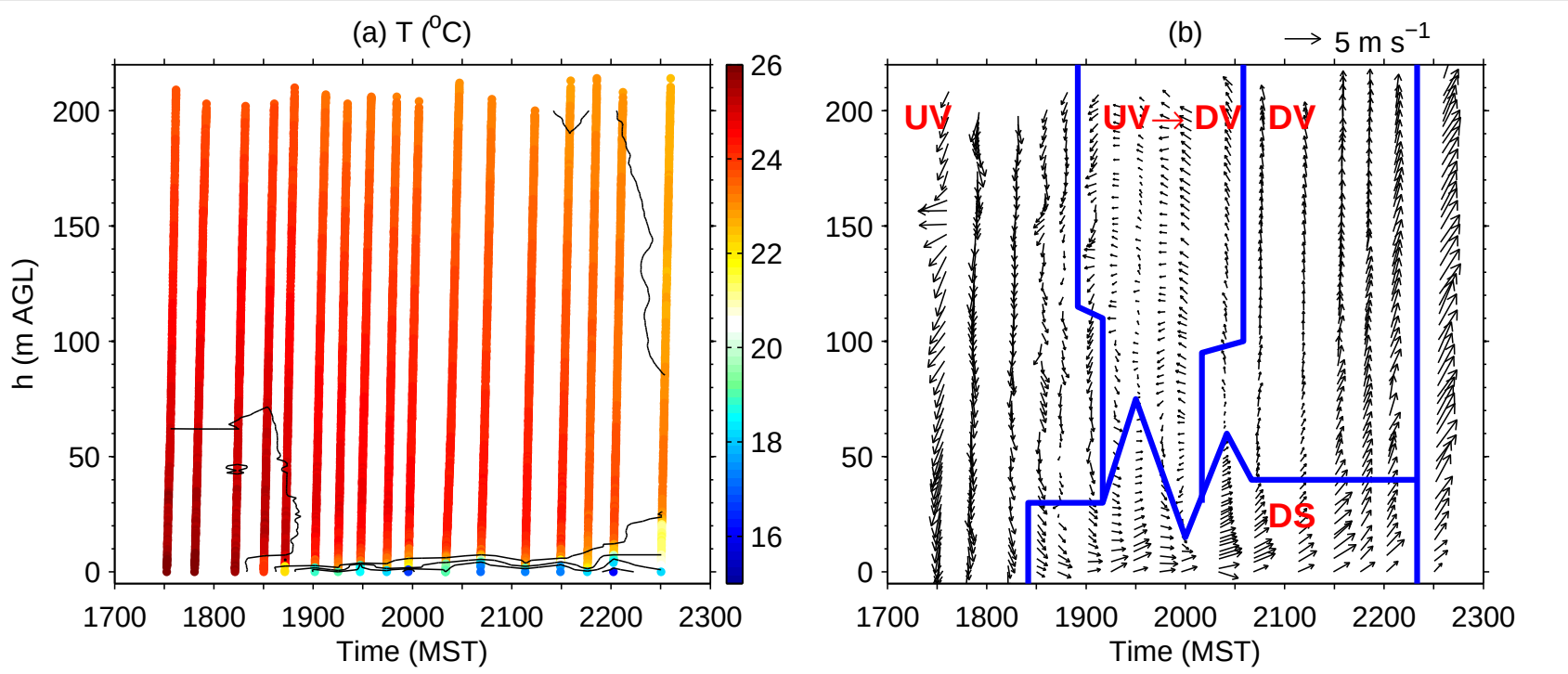


Phase 1

Evening flow transition

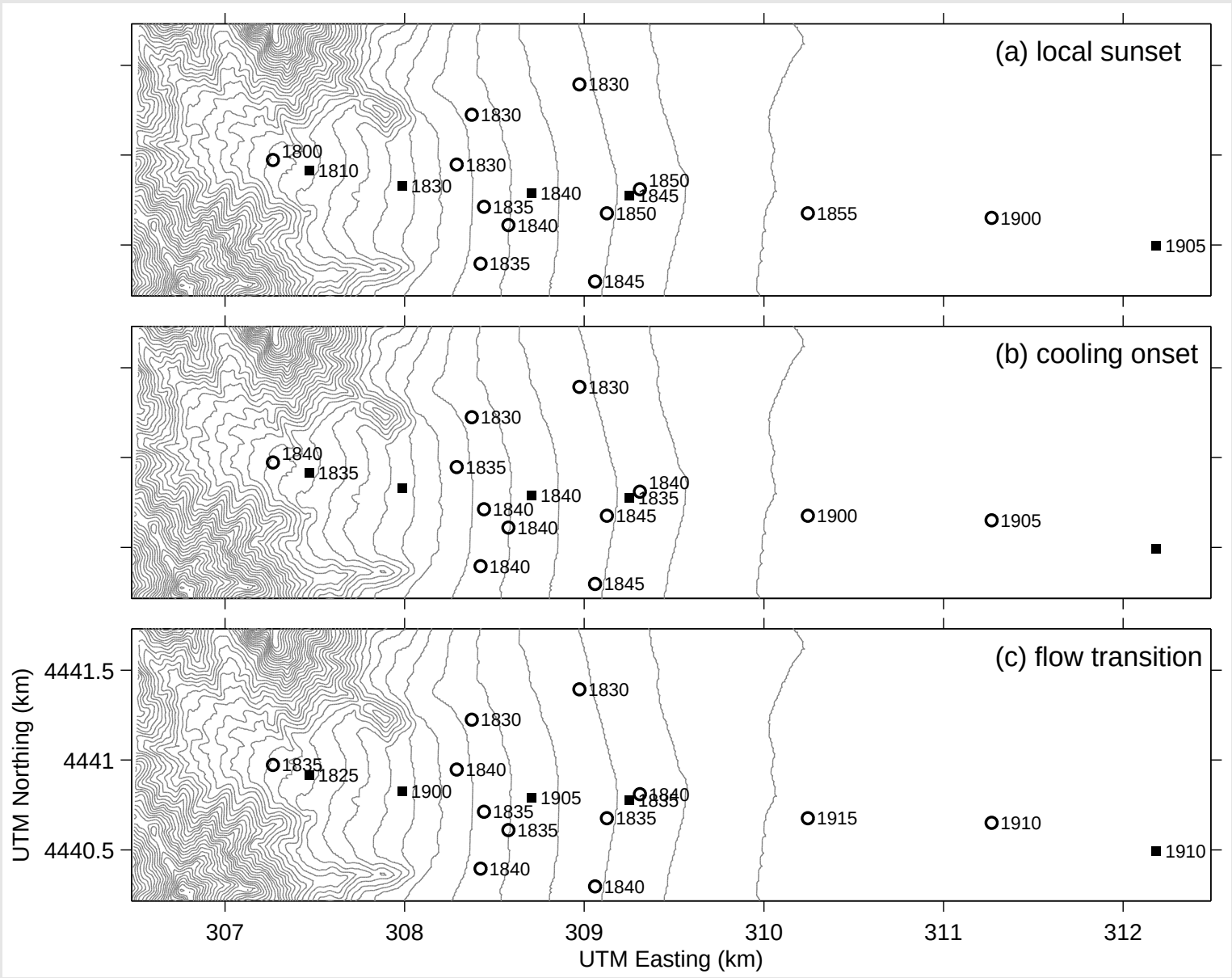
Evening flow transition

Tethered-balloon soundings



UV ··· up-valley
DV ··· down-valley
DS ··· downslope

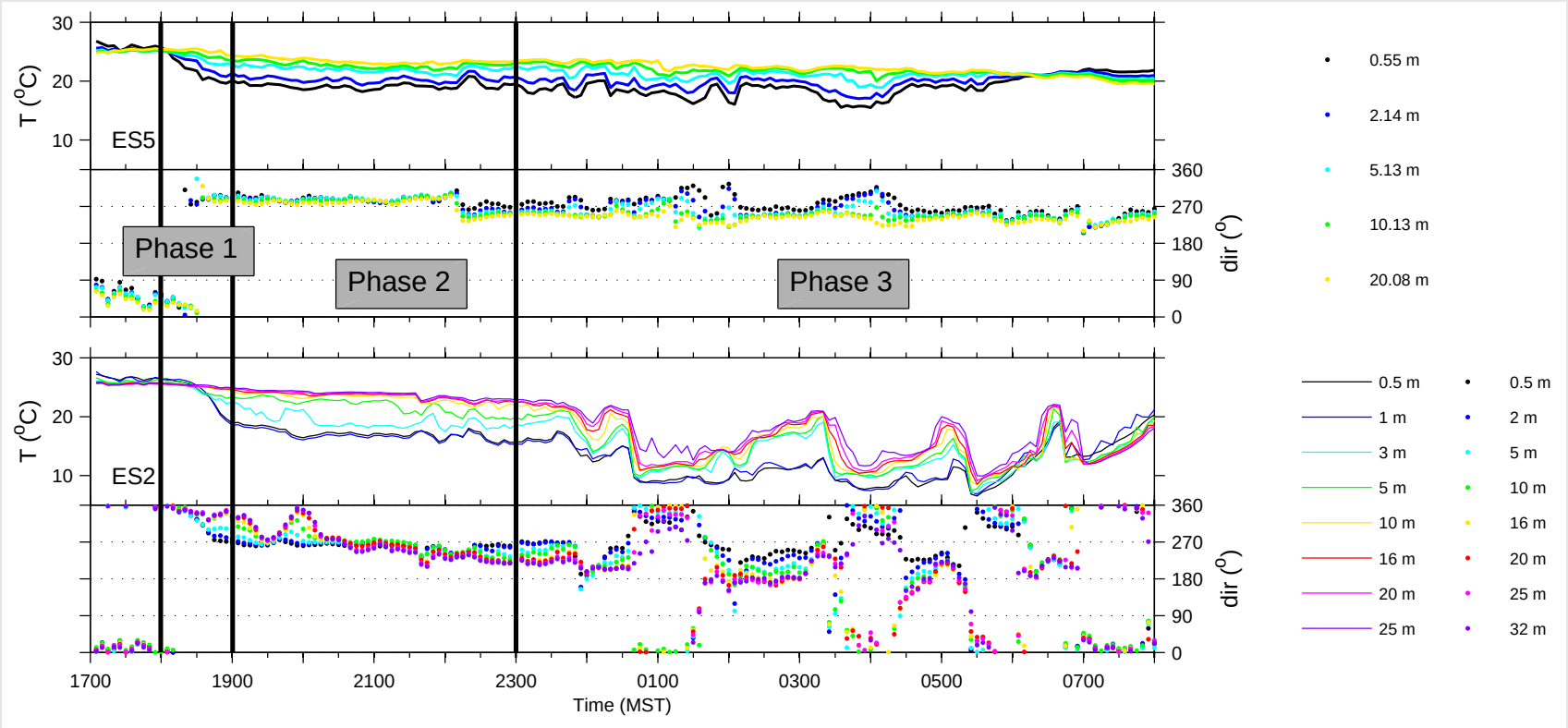
Evening flow transition



Evening flow transition

- The shadow propagated down the sidewall from northwest to southeast.
- The strongest temperature decrease occurred shortly after the shadow passed each site.
- The transition from upslope/up-valley winds to downslope winds followed the propagation of the shadow down the slope.
- Differences between the upper and lower parts of the slope:
  - Upper part: weakening and stagnating upslope winds before the onset and increase of downslope winds.
  - Lower part: gradual counter-clockwise turning of the weakening up-valley winds to a downslope direction.

IOP 4 Overview



Phase 2

Undisturbed nocturnal slope-boundary layer

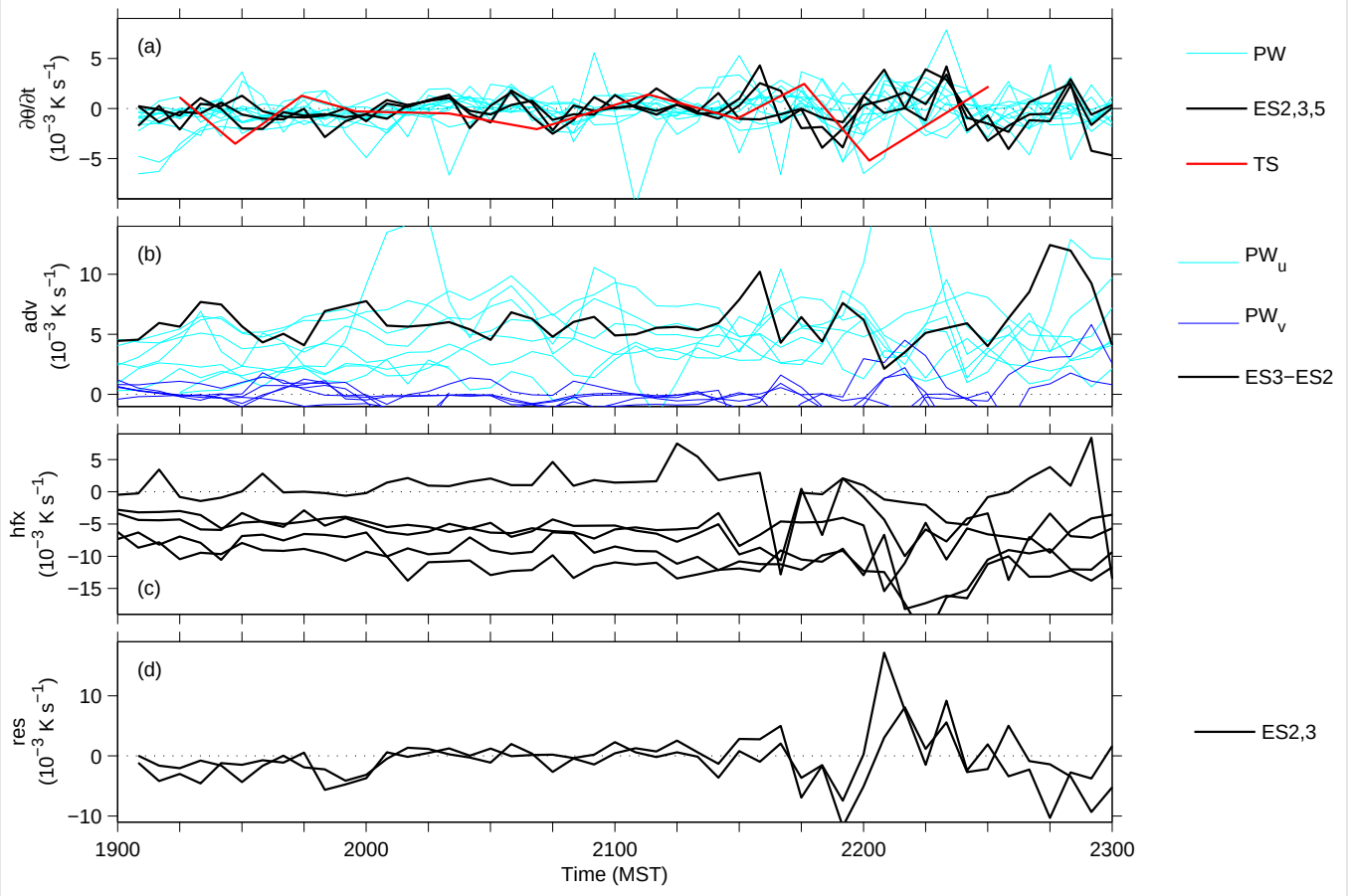
Near-surface heat budget

$\frac{\partial \theta}{\partial t}$

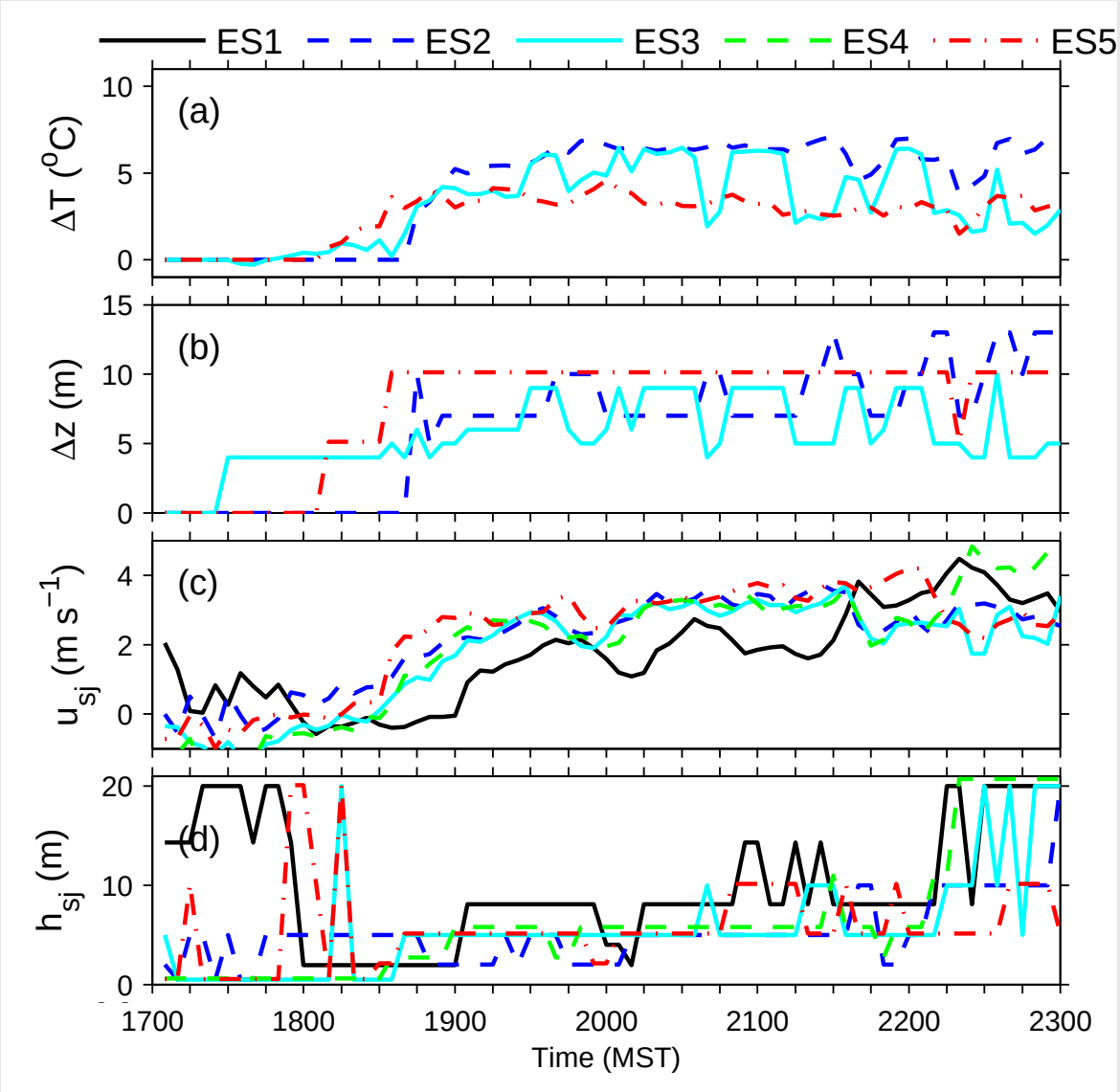
advection (along-slope, cross-slope)

heat flux

residual



Downslope-flow characteristics



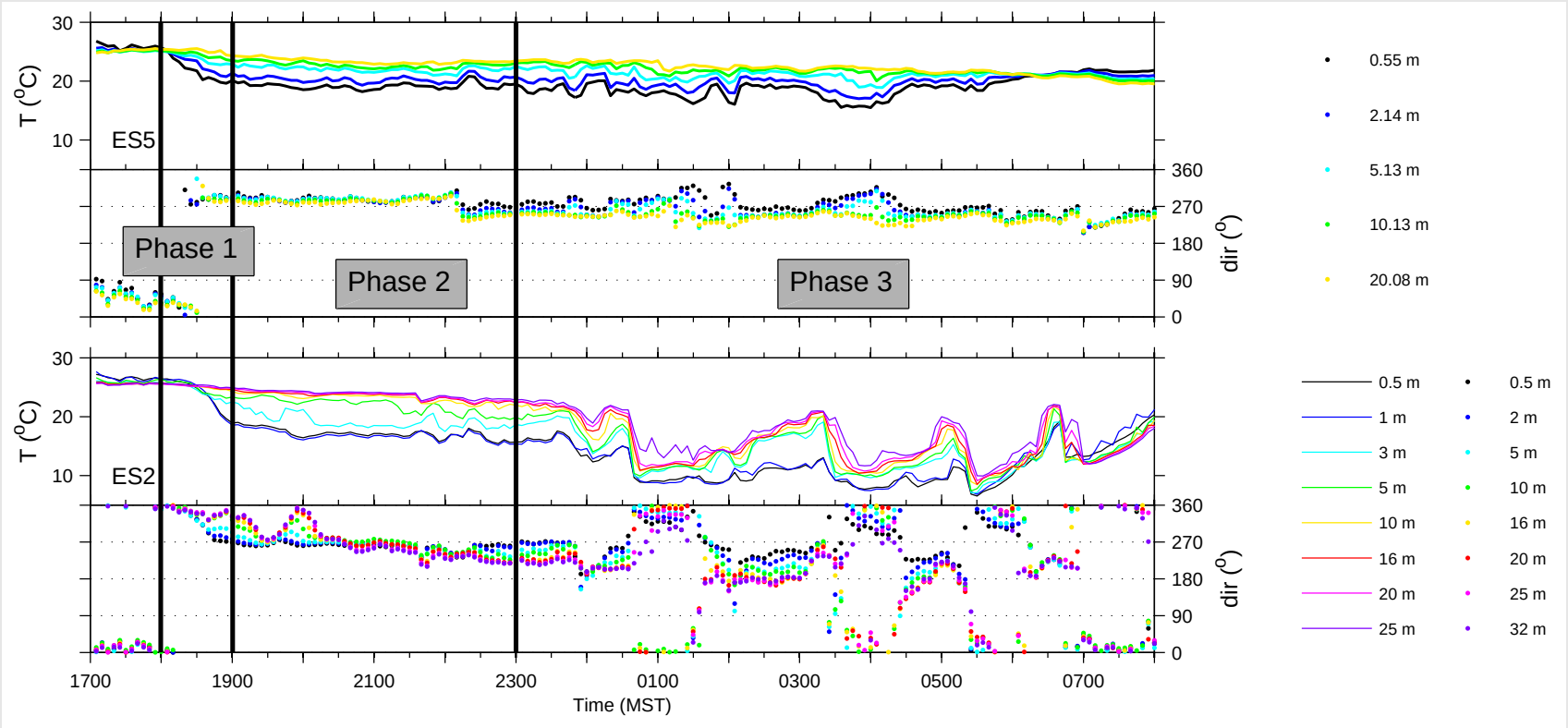
Inversion strength

Inversion depth

Jet maximum speed

Jet maximum height

IOP 4 Overview

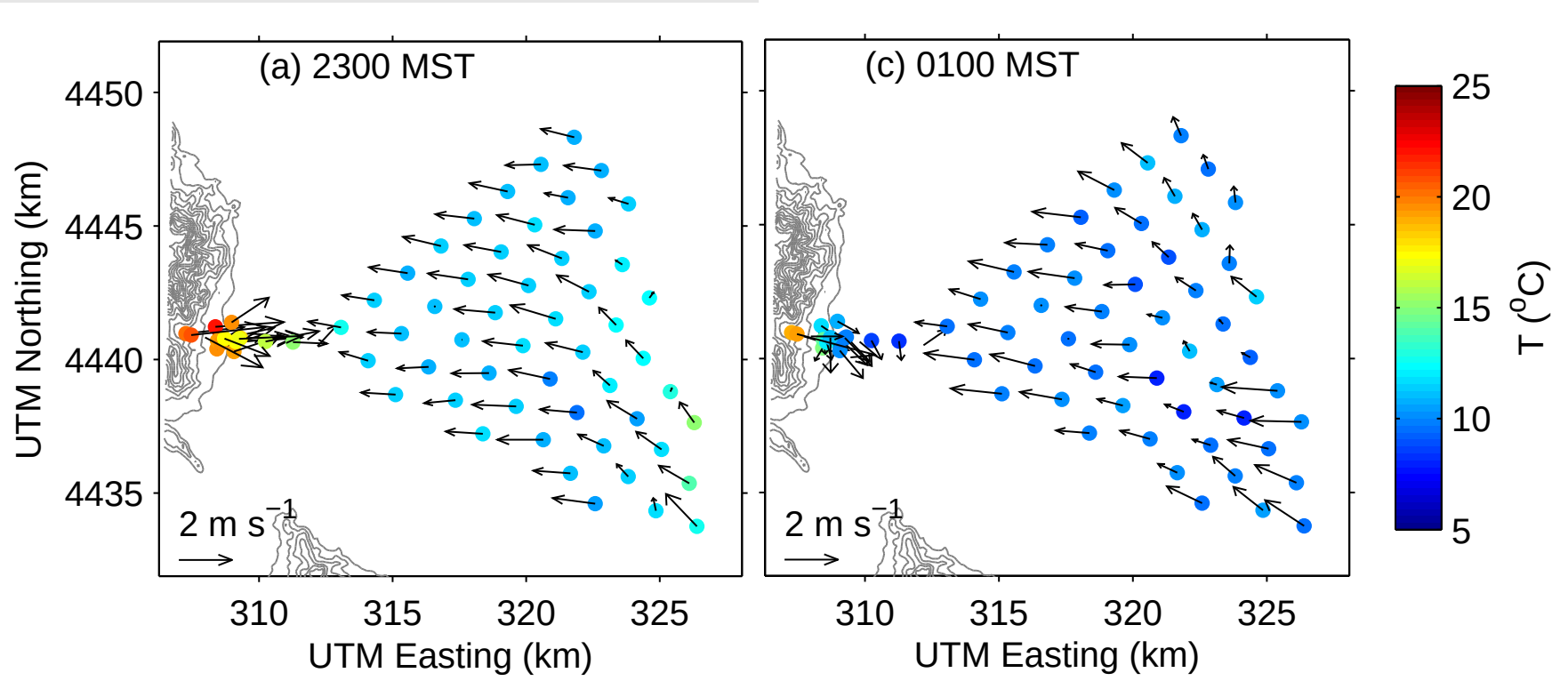


Phase 3

Sloshing valley inversion

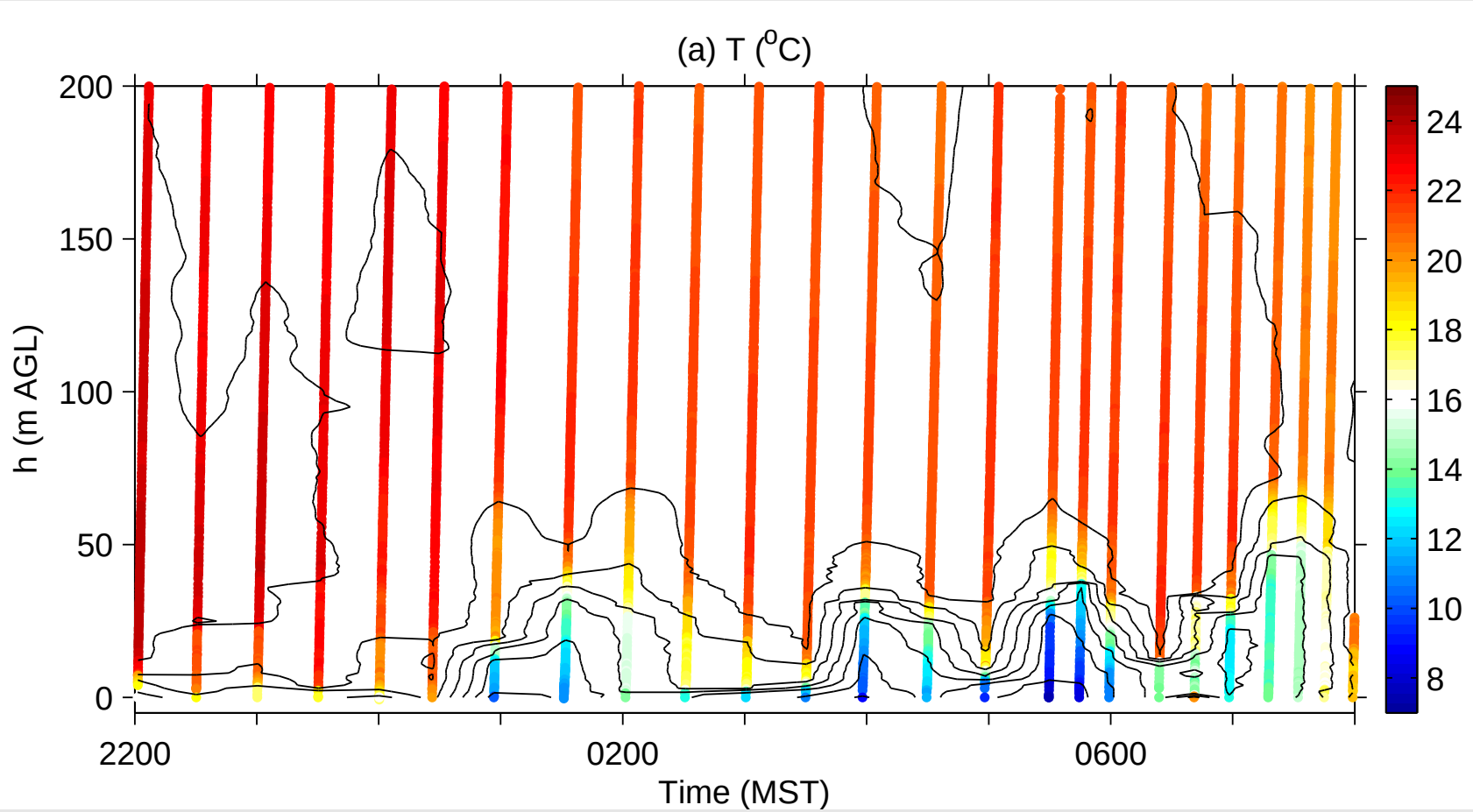
Sloshing valley inversion

Slope immersed in cold air as the valley inversion pushed up the slope.

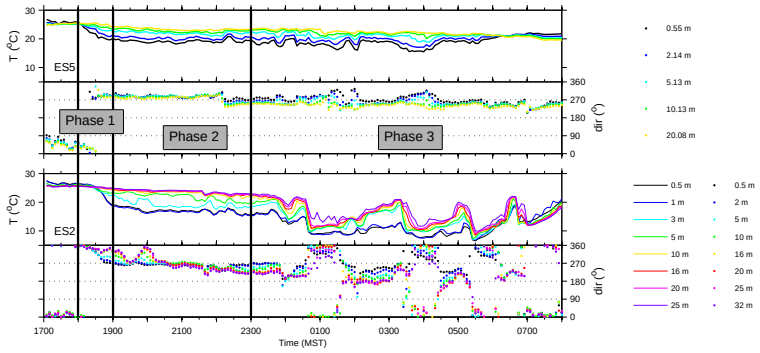


Sloshing valley inversion

Tethered-balloon soundings

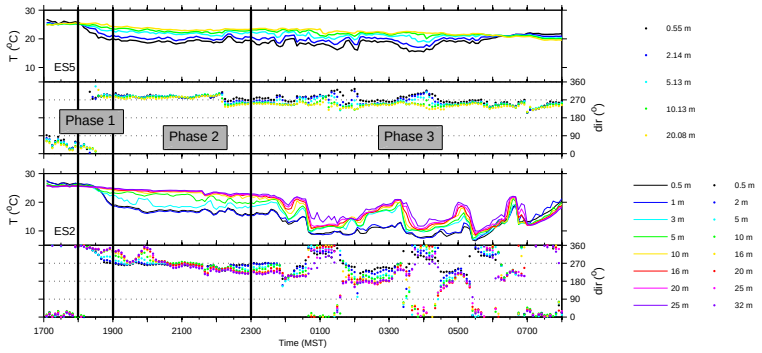


Summary



Three distinct periods:

1. Evening flow transition
2. Undisturbed nocturnal slope-boundary layer
3. Sloshing valley inversion



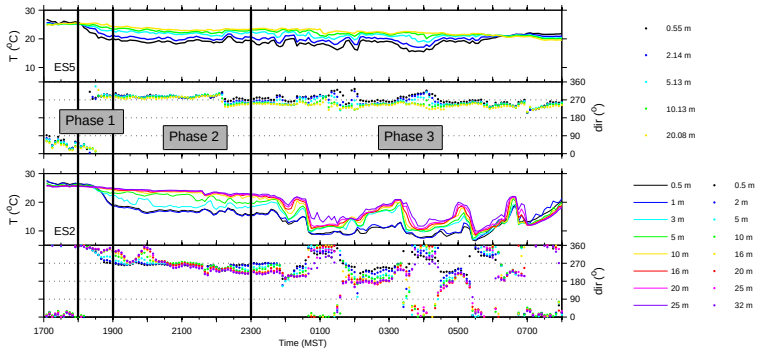
Three distinct periods:

1. Evening flow transition
2. Undisturbed nocturnal slope-boundary layer
3. Sloshing valley inversion

Phase 1

- Shadow propagates down the east-facing sidewall.
- Transition from upslope to downslope winds follows the shadow propagation down the slope.

Summary



Three distinct periods:

1. Evening flow transition
2. Undisturbed nocturnal slope-boundary layer
3. Sloshing valley inversion

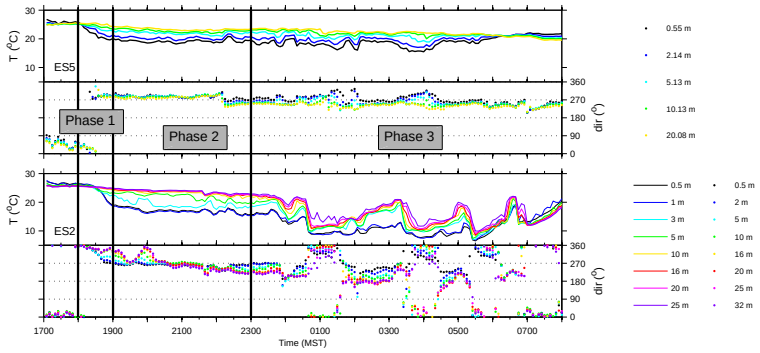
Phase 1

- Shadow propagates down the east-facing sidewall.
- Transition from upslope to downslope winds follows the shadow propagation down the slope.

Phase 2

- Near-surface temperatures remained almost constant (balance between along-slope advection and heat-flux divergence).
- Three small disturbances affected temperature and wind fields.

Summary



Three distinct periods:

1. Evening flow transition
2. Undisturbed nocturnal slope-boundary layer
3. Sloshing valley inversion

Phase 1

- Shadow propagates down the east-facing sidewall.
- Transition from upslope to downslope winds follows the shadow propagation down the slope.

Phase 2

- Near-surface temperatures remained almost constant (balance between along-slope advection and heat-flux divergence).
- Three small disturbances affected temperature and wind fields.

Phase 3

- Valley inversion repeatedly pushes up the slope and retreats again producing large temperature oscillations over the slope.