Materhorn X: Field studies

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University of Utah

MATTERHORN

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MAT~~T~~ERHORN

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J. Sheldon photo


KUC photo


J. Steenburgh photo
2005 1 20


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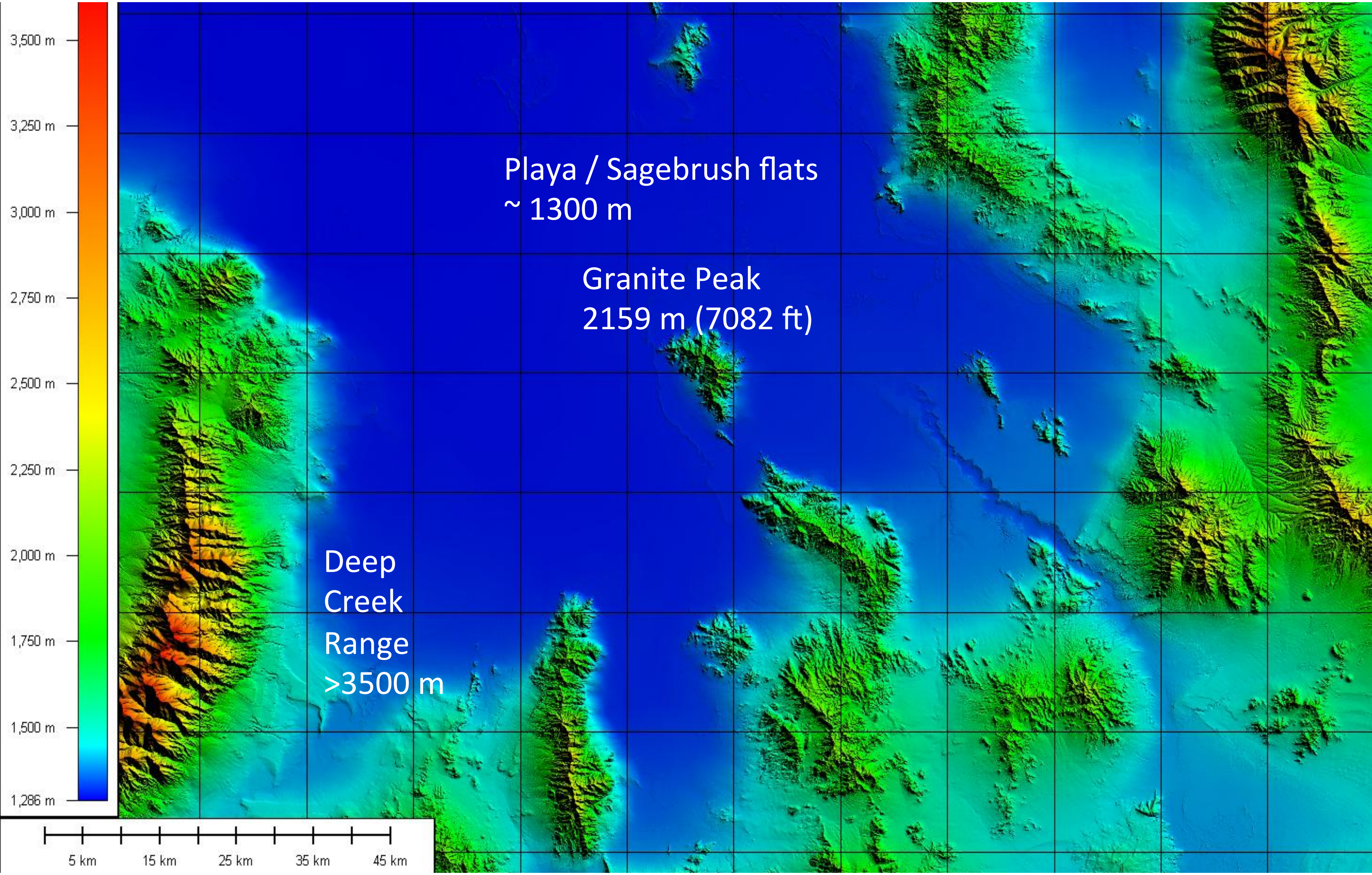
Dugway Proving Ground - Topography



Dugway Proving Ground seen from space

Dugway Topography

Elevations & View from Space

Previous Work

Cold-Air Drainage simulations
Wind field analysis
Slope flow analysis

Planned Work

Extended Flux Sites

Slope Flow Evolution and Interaction

Cold–Air Drainage Model KLAM 21

- Single-layer model
- Predicting depth and the mean wind of a surface based stable layer
- Flow prediction is based on vertically averaged momentum tendency equations.
- Temporal changes in the total heat deficit in the cold air layer heat deficit are calculated from a prescribed local heat loss rate [here 30 W/m^2].

DWD

Berichte des Deutschen Wetterdienstes

227

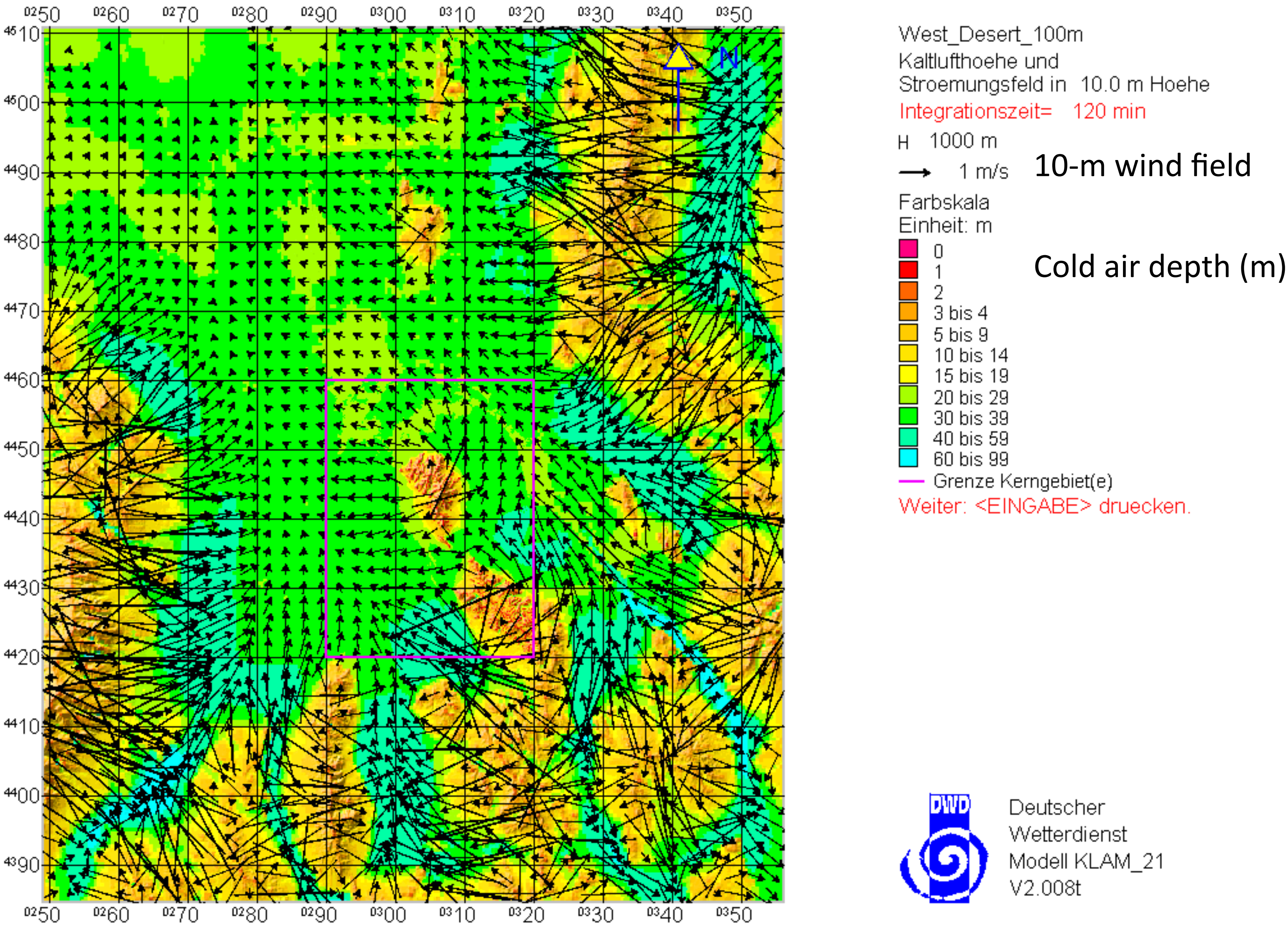
Das Kaltluftabflussmodell KLAM_21
Theoretische Grundlagen, Anwendung und Handhabung des PC-Modells

von
Uwe Sievers

Offenbach am Main 2005
Selbstverlag des Deutschen Wetterdienstes

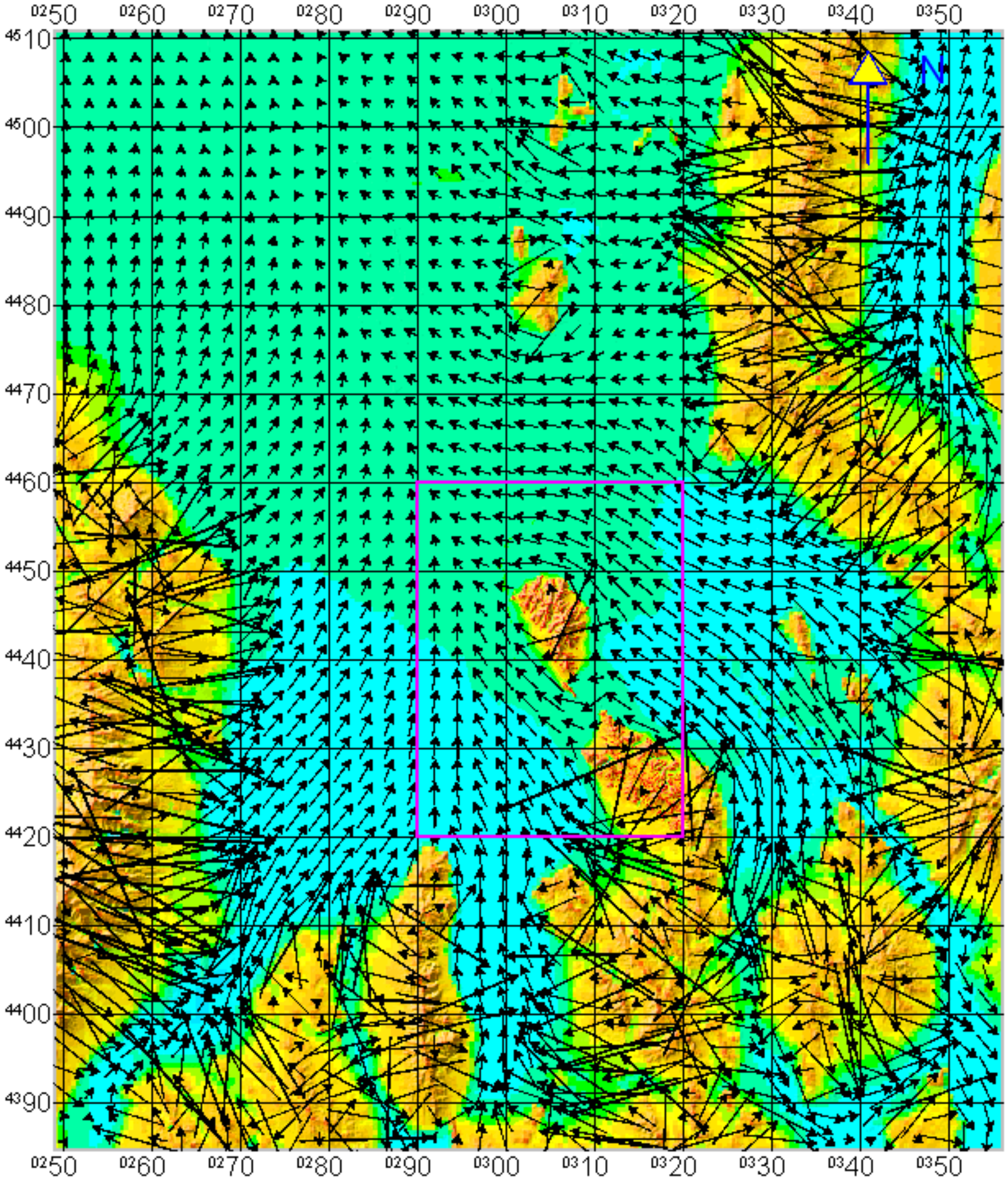
Sievers, U., 2005: Das Kaltluft-Abfluss-Modell KLAM_21. Grundlagen, Anwendungen und Handhabung des PC-Modells. Berichte des Deutschen Wetterdienstes 227. Deutscher Wetterdienst, Offenbach a.M., Germany, 101 pp.

2 hours



West_Desert_100m
Kaltlufthoehe und
Stroemungsfeld in 10.0 m Hoehe
Integrationszeit= 120 min
H 1000 m
1 m/s
10-m wind field
Farbskala
Einheit: m
Cold air depth (m)
0
1
2
3 bis 4
5 bis 9
10 bis 14
15 bis 19
20 bis 29
30 bis 39
40 bis 59
60 bis 99
Grenze Kerngebiet(e)
Weiter: <EINGABE> druecken.
N
0250 0260 0270 0280 0290 0300 0310 0320 0330 0340 0350
4510 4500 4490 4480 4470 4460 4450 4440 4430 4420 4410 4400 4390
Deutscher
Wetterdienst
Modell KLAM_21
V2.008t

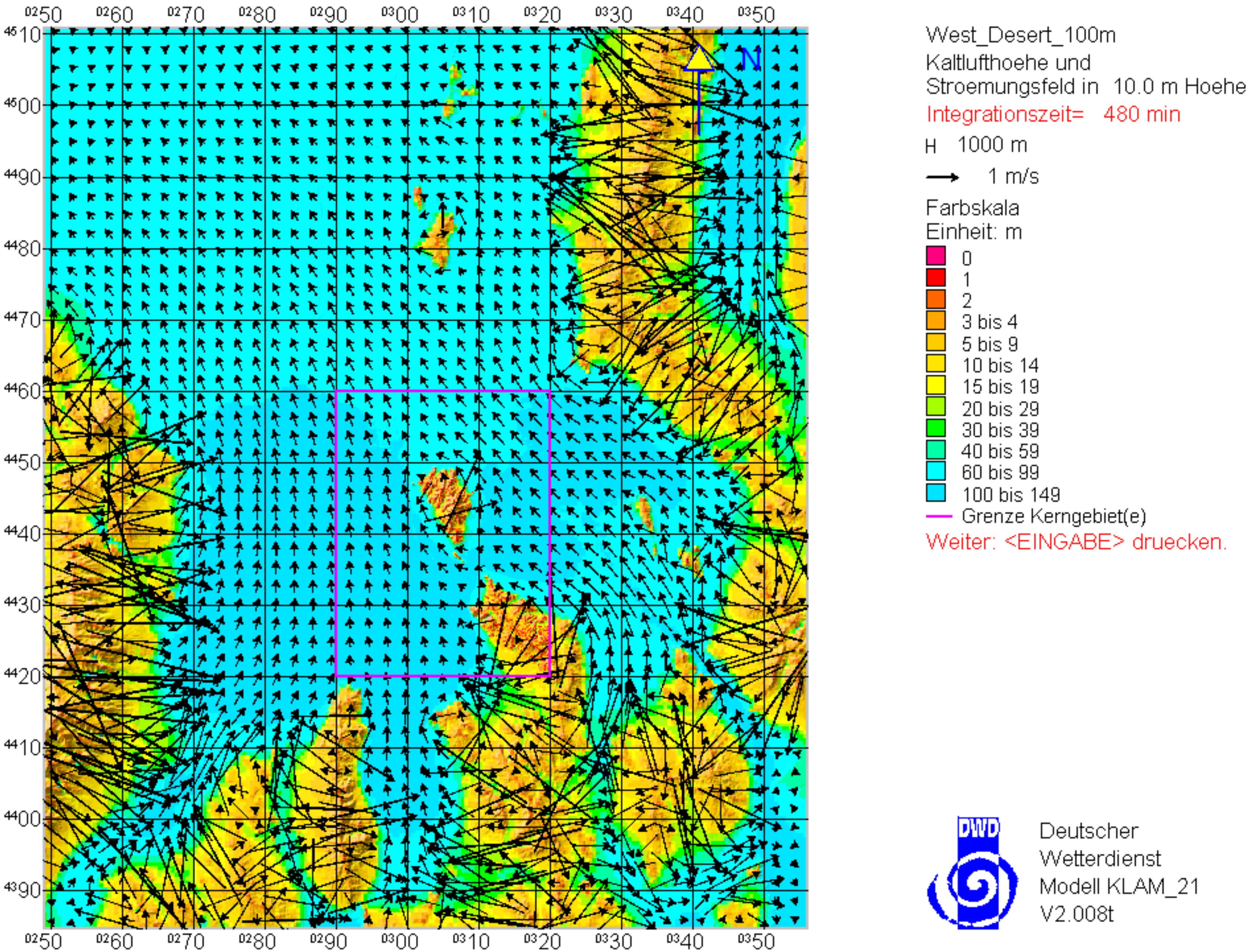
4 hours



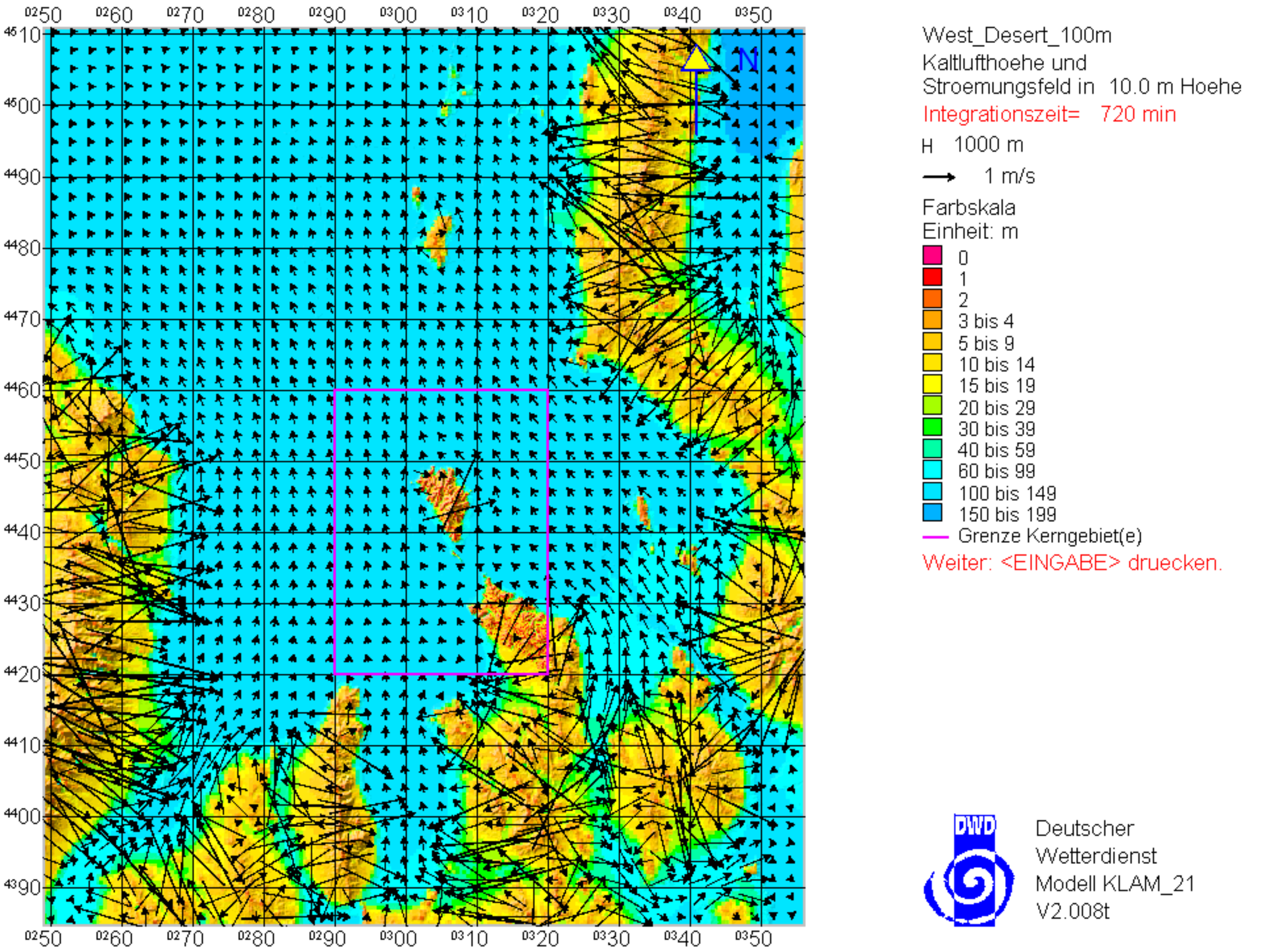
West_Desert_100m
Kaltlufthoehe und
Stroemungsfeld in 10.0 m Hoehe
Integrationszeit= 240 min
H 1000 m
1 m/s
Farbskala
Einheit: m
0
1
2
3 bis 4
5 bis 9
10 bis 14
15 bis 19
20 bis 29
30 bis 39
40 bis 59
60 bis 99
100 bis 149
Grenze Kerngebiet(e)
Weiter: <EINGABE> druecken.

Deutscher
Wetterdienst
Modell KLAM_21
V2.008t

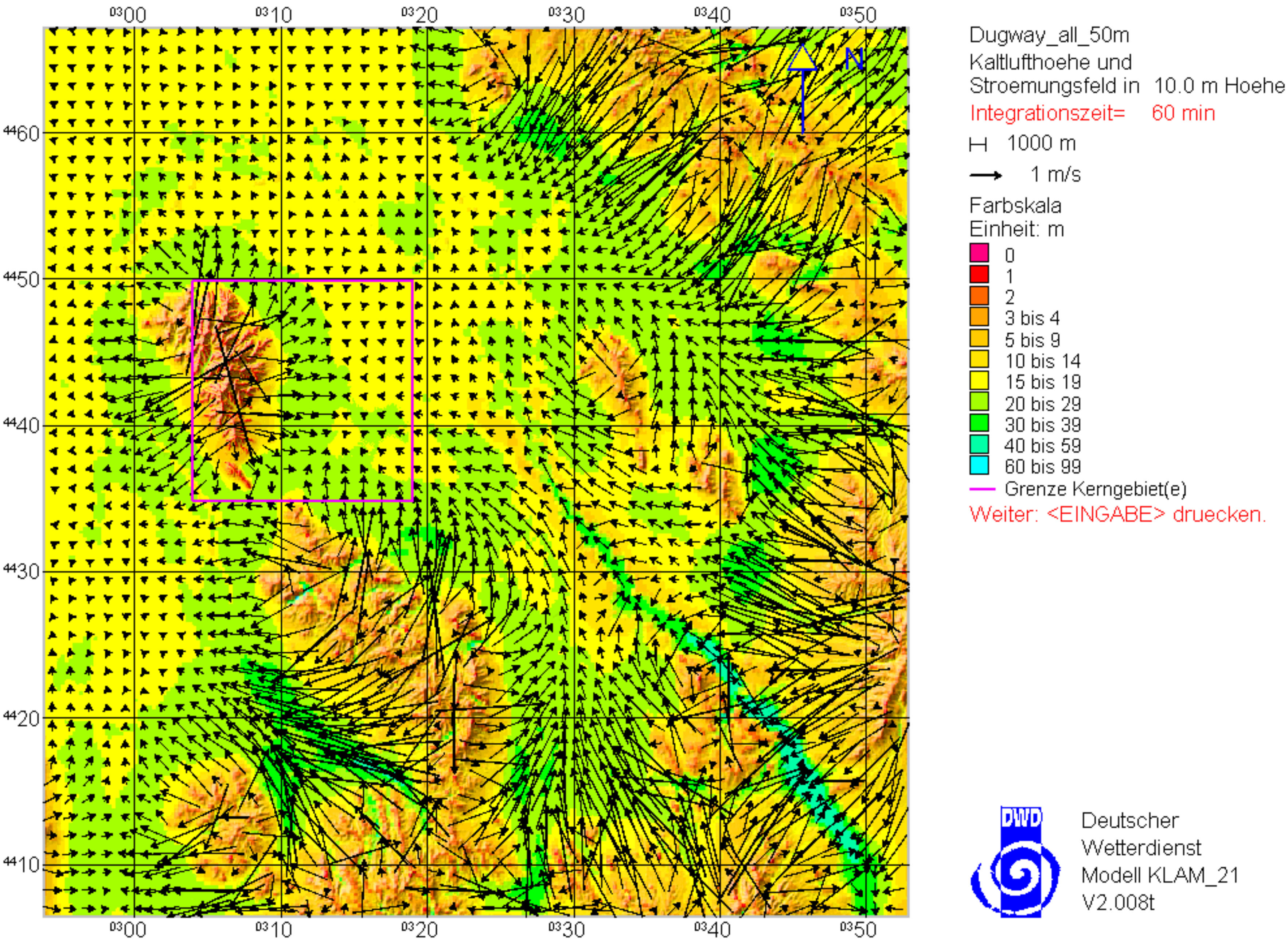
8 hours


West_Desert_100m
Kaltlufthoehe und
Stroemungsfeld in 10.0 m Hoehe
Integrationszeit= 480 min
H 1000 m
1 m/s
Farbskala
Einheit: m
0
1
2
3 bis 4
5 bis 9
10 bis 14
15 bis 19
20 bis 29
30 bis 39
40 bis 59
60 bis 99
100 bis 149
Grenze Kerngebiet(e)
Weiter: <EINGABE> druecken.
N
Deutscher
Wetterdienst
Modell KLAM_21
V2.008t

12 hours

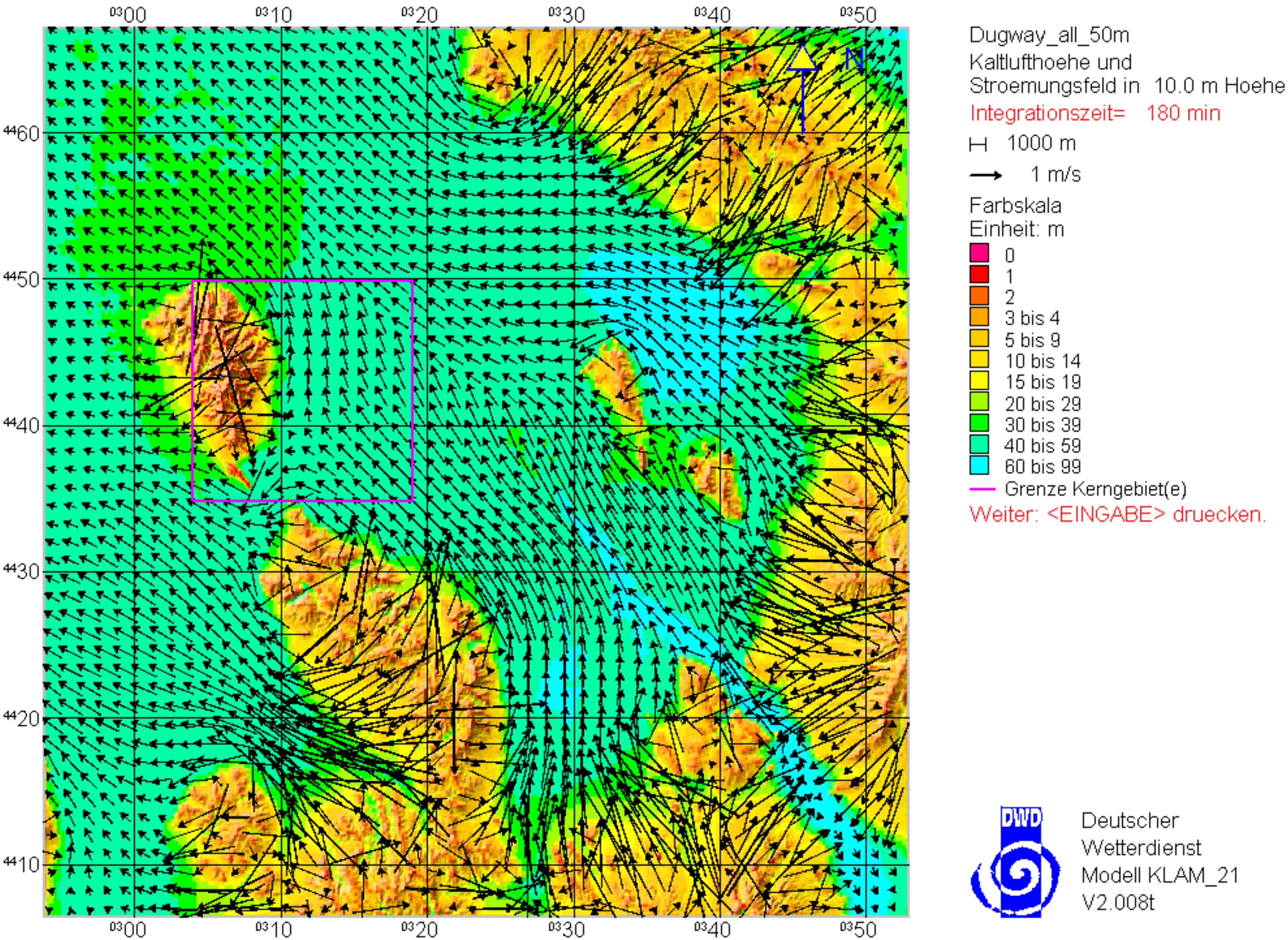

West_Desert_100m
Kaltlufthoehe und
Stroemungsfeld in 10.0 m Hoehe
Integrationszeit= 720 min
H 1000 m
1 m/s
Farbskala
Einheit: m
0
1
2
3 bis 4
5 bis 9
10 bis 14
15 bis 19
20 bis 29
30 bis 39
40 bis 59
60 bis 99
100 bis 149
150 bis 199
Grenze Kerngebiet(e)
Weiter: <EINGABE> druecken.
Deutscher
Wetterdienst
Modell KLAM_21
V2.008t

1 hour

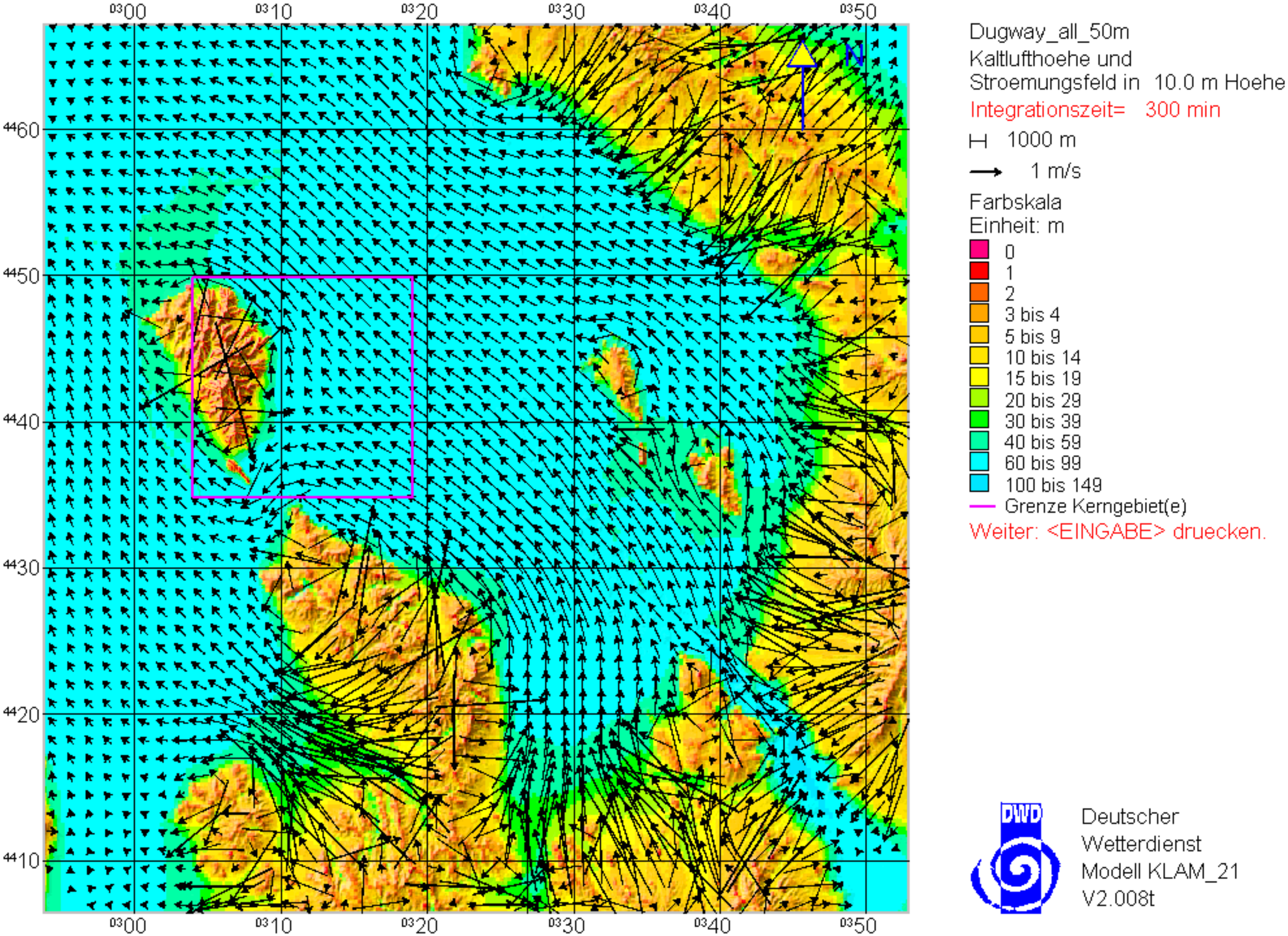


0300
0310
0320
0330
0340
0350
4460
4450
4440
4430
4420
4410
N
Dugway_all_50m
Kaltlufthoehe und
Stroemungsfeld in 10.0 m Hoehe
Integrationszeit= 60 min
1000 m
1 m/s
Farbskala
Einheit: m
0
1
2
3 bis 4
5 bis 9
10 bis 14
15 bis 19
20 bis 29
30 bis 39
40 bis 59
60 bis 99
Grenze Kerngebiet(e)
Weiter: <EINGABE> druecken.
DWD
Deutscher
Wetterdienst
Modell KLAM_21
V2.008t

2 hours

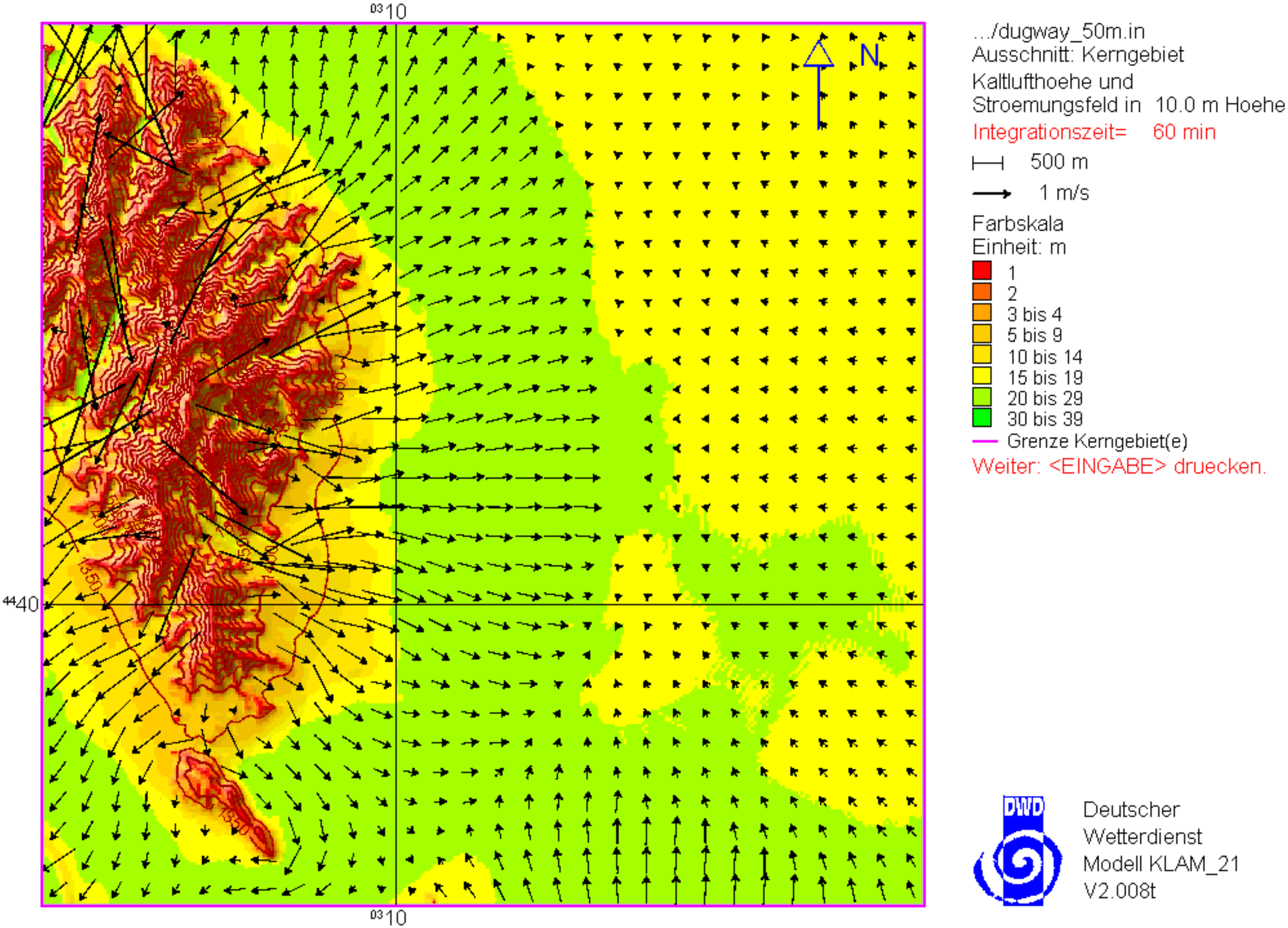

03 00
03 10
03 20
03 30
03 40
03 50
44 60
44 50
44 40
44 30
44 20
44 10
N
Dugway_all_50m
Kaltlufthoehe und
Stroemungsfeld in 10.0 m Hoehe
Integrationszeit= 180 min
1000 m
1 m/s
Farbskala
Einheit: m
0
1
2
3 bis 4
5 bis 9
10 bis 14
15 bis 19
20 bis 29
30 bis 39
40 bis 59
60 bis 99
Grenze Kerngebiet(e)
Weiter: <EINGABE> druecken.
DWD
Deutscher
Wetterdienst
Modell KLAM_21
V2.008t

5 hours



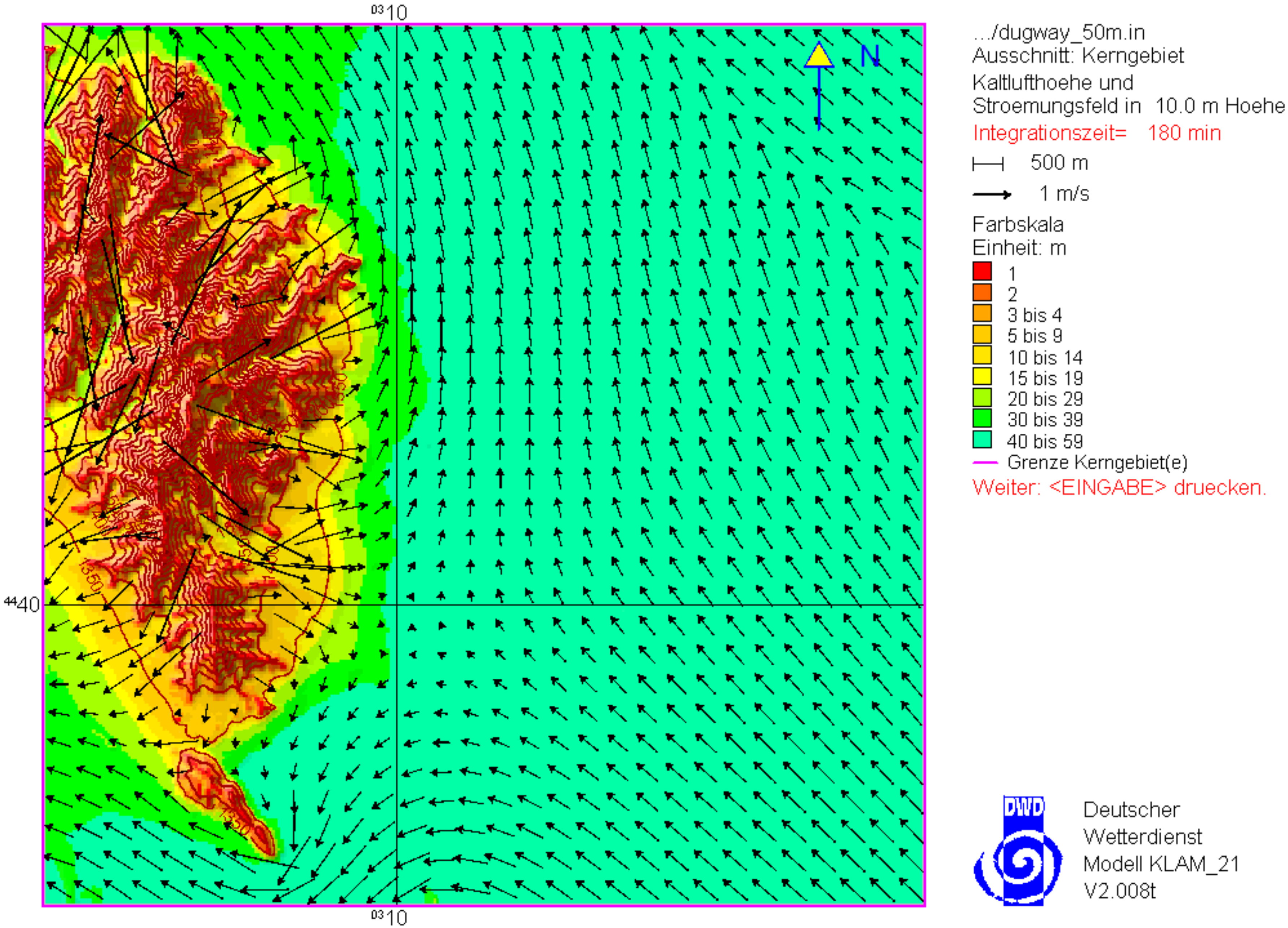
Dugway_all_50m
Kaltlufthoehe und
Stroemungsfeld in 10.0 m Hoehe
Integrationszeit= 300 min
1000 m
1 m/s
Farbskala
Einheit: m
0
1
2
3 bis 4
5 bis 9
10 bis 14
15 bis 19
20 bis 29
30 bis 39
40 bis 59
60 bis 99
100 bis 149
Grenze Kerngebiet(e)
Weiter: <EINGABE> druecken.
N
0300
0310
0320
0330
0340
0350
4460
4450
4440
4430
4420
4410
DWD
Deutscher
Wetterdienst
Modell KLAM_21
V2.008t

1 hour



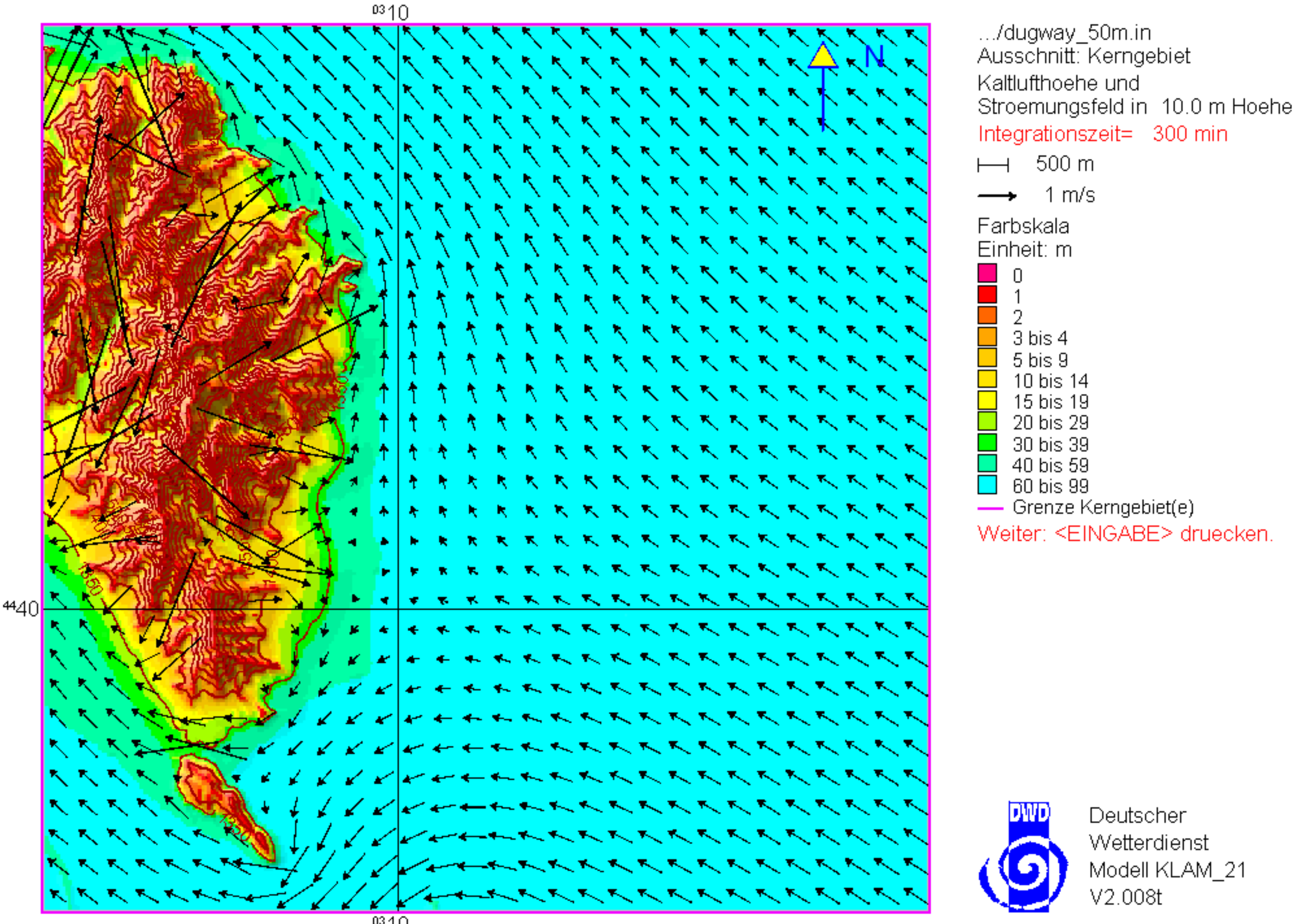
03 10
44 40
N
.../dugway_50m.in
Ausschnitt: Kerngebiet
Kaltlufthoehe und
Stroemungsfeld in 10.0 m Hoehe
Integrationszeit= 60 min
500 m
1 m/s
Farbskala
Einheit: m
1
2
3 bis 4
5 bis 9
10 bis 14
15 bis 19
20 bis 29
30 bis 39
Grenze Kerngebiet(e)
Weiter: <EINGABE> druecken.
DWD
Deutscher
Wetterdienst
Modell KLAM_21
V2.008t

3 hours



0310
4440
N
…/dugway_50m.in
Ausschnitt: Kerngebiet
Kaltlufthoehe und
Stroemungsfeld in 10.0 m Hoehe
Integrationszeit= 180 min
500 m
1 m/s
Farbskala
Einheit: m
1
2
3 bis 4
5 bis 9
10 bis 14
15 bis 19
20 bis 29
30 bis 39
40 bis 59
Grenze Kerngebiet(e)
Weiter: <EINGABE> druecken.
DWD
Deutscher
Wetterdienst
Modell KLAM_21
V2.008t

5 hours

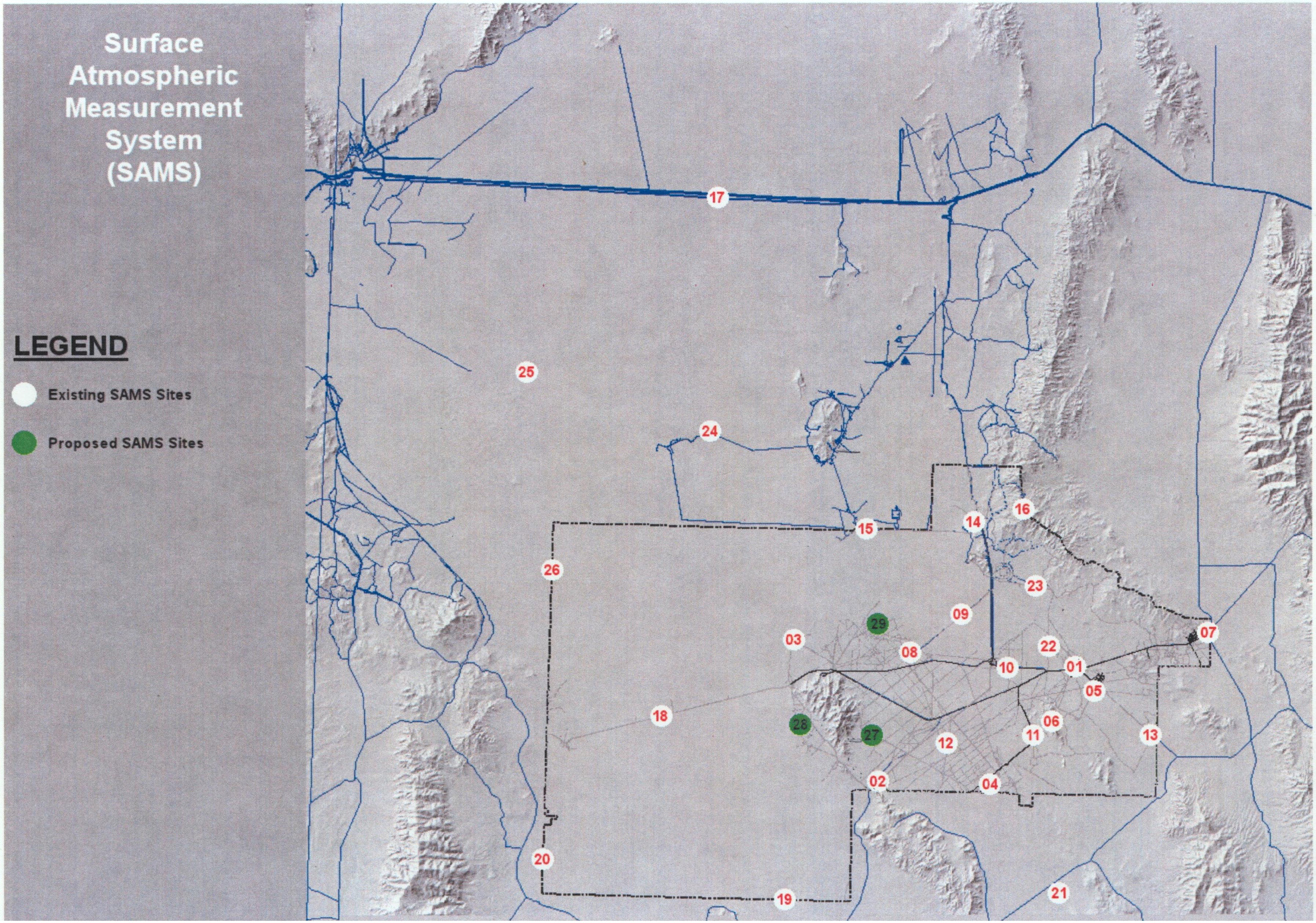


0310
4440
N
.../dugway_50m.in
Ausschnitt: Kerngebiet
Kaltluftthoehe und
Stroemungsfeld in 10.0 m Hoehe
Integrationszeit= 300 min
500 m
1 m/s
Farbskala
Einheit: m
0
1
2
3 bis 4
5 bis 9
10 bis 14
15 bis 19
20 bis 29
30 bis 39
40 bis 59
60 bis 99
Grenze Kerngebiet(e)
Weiter: <EINGABE> druecken.
DWD
Deutscher
Wetterdienst
Modell KLAM_21
V2.008t

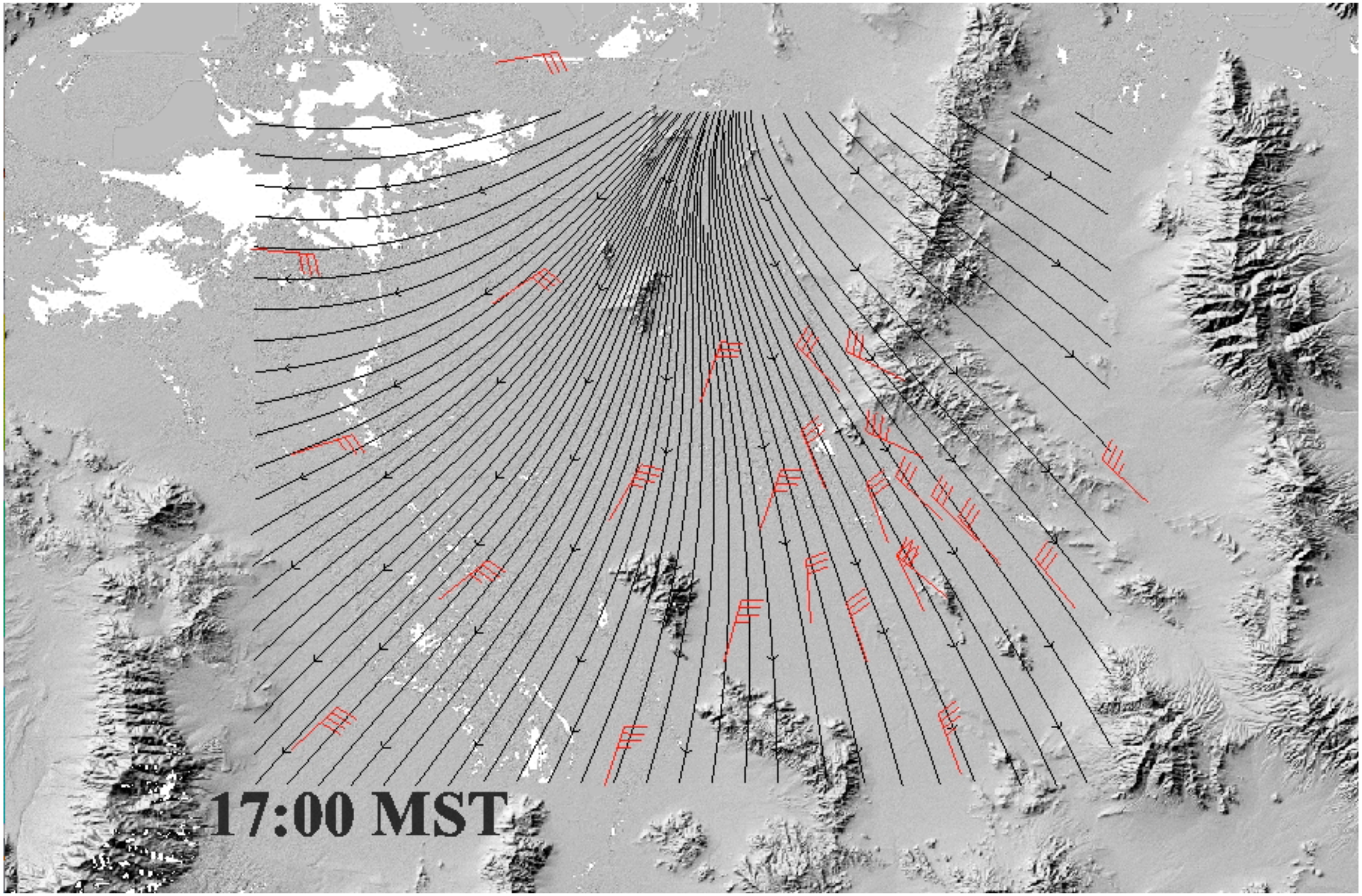
Summary – KLAM 21

- The nocturnal wind field at DGP is strongly influenced by thermally driven flows.
- A homogeneous SE down-valley flow results across the basin east of Granite Peak.
- KLAM 21 produces a cold air layer of ~100 m depth.
- Local drainage flows from Granite Peak interact with the SE down-valley flow.

Wind field evolution over DPG during *undisturbed fair weather days*.
JJA 1998-2008



Fair weather day: 70% of total global radiation, wind speeds < 3 m/s

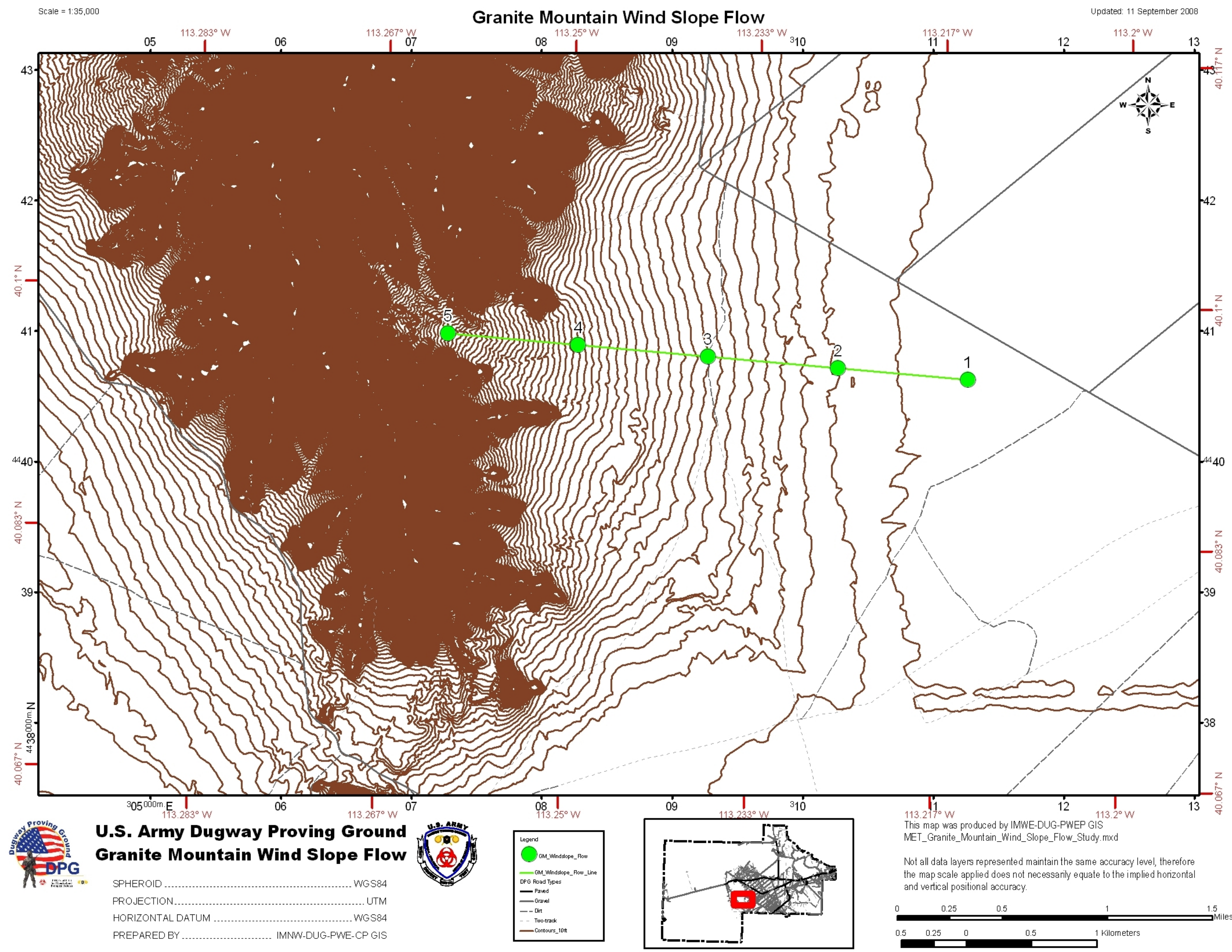


Tippetts, J. M., and C. D. Whiteman, 2010: Fair-weather diurnal wind field in a complex mountainous region. Amer. Meteor. Soc. Annual Meeting 9th Student Conference, 16-17 Jan 2010, Atlanta, GA.

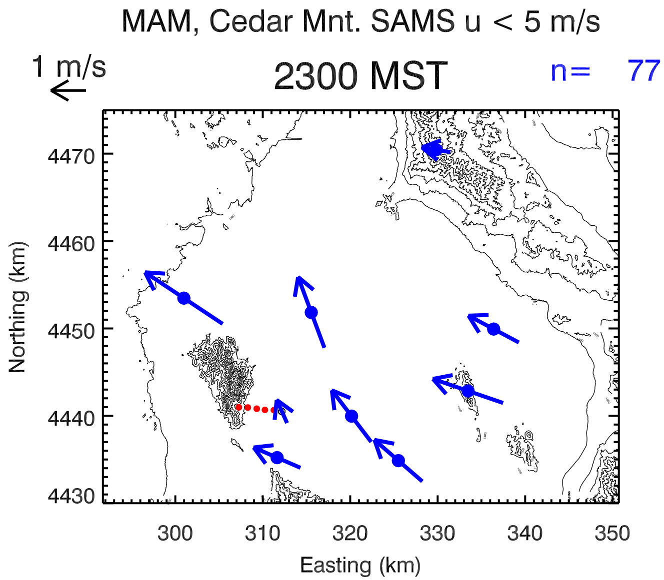
Drainage Flow Experiment

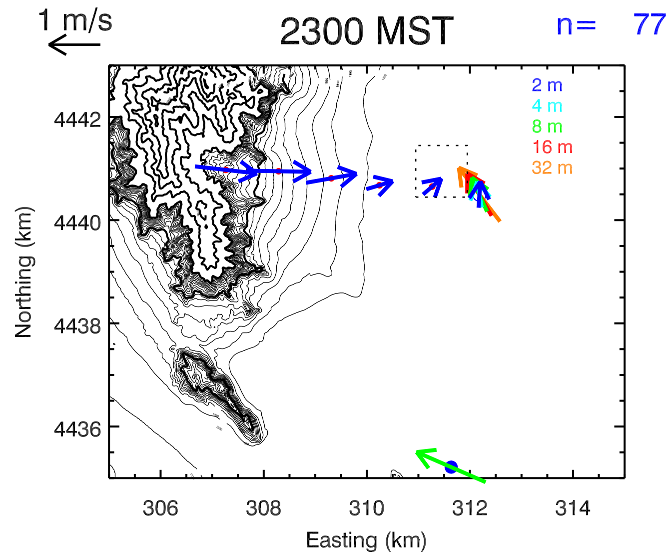
- Experiment designed by Al Astling at DPG
- East slope of Granite Mountain

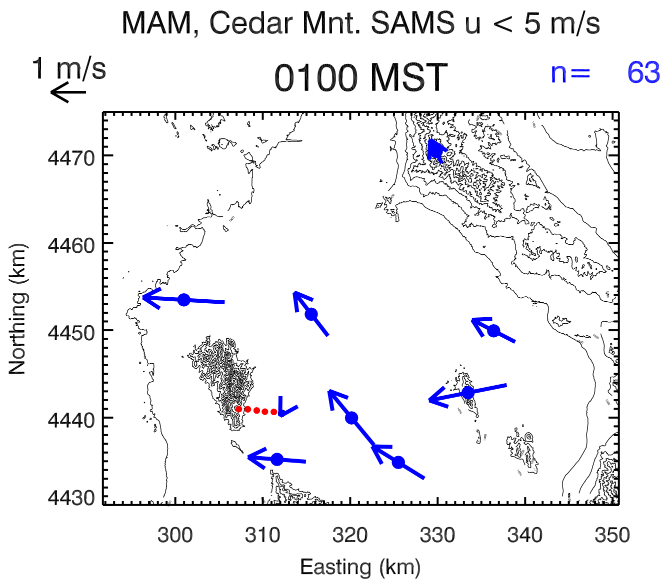
Years 2008-2009
9 SAMS
5 PWIDS
1 32-m tower, 5 levels

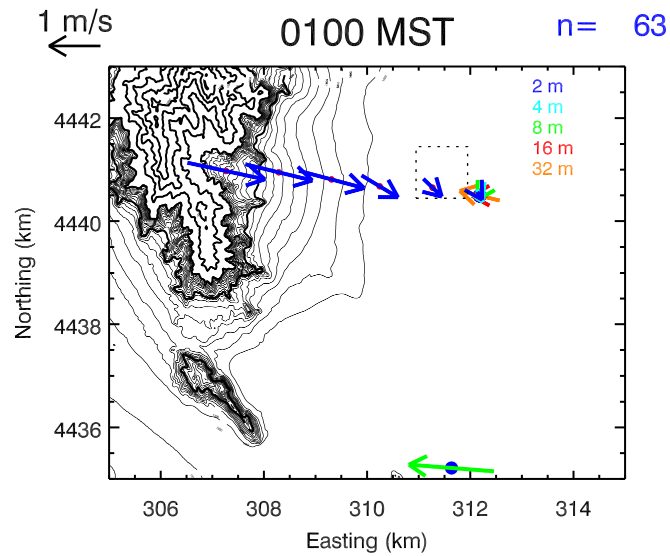


Spring: March-May

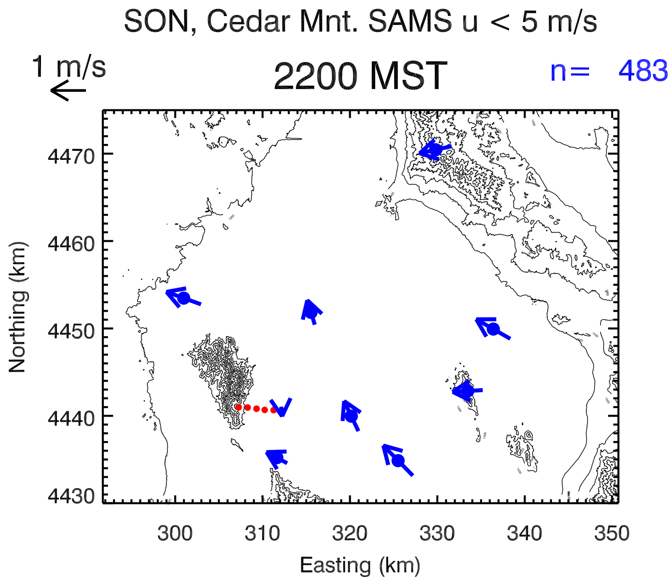


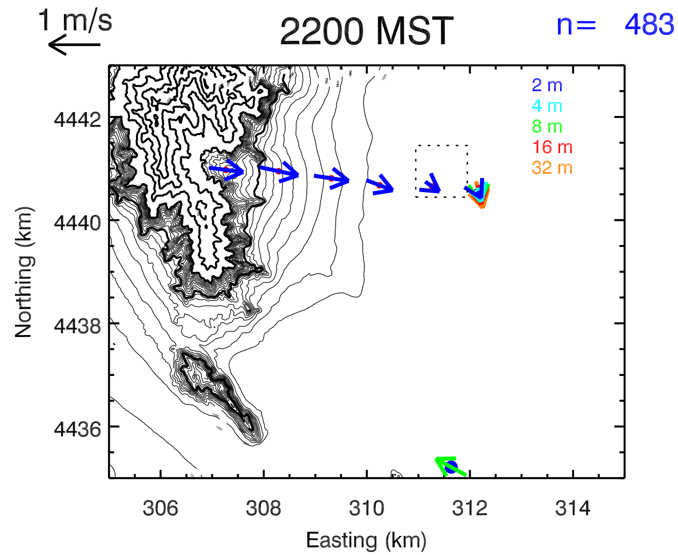


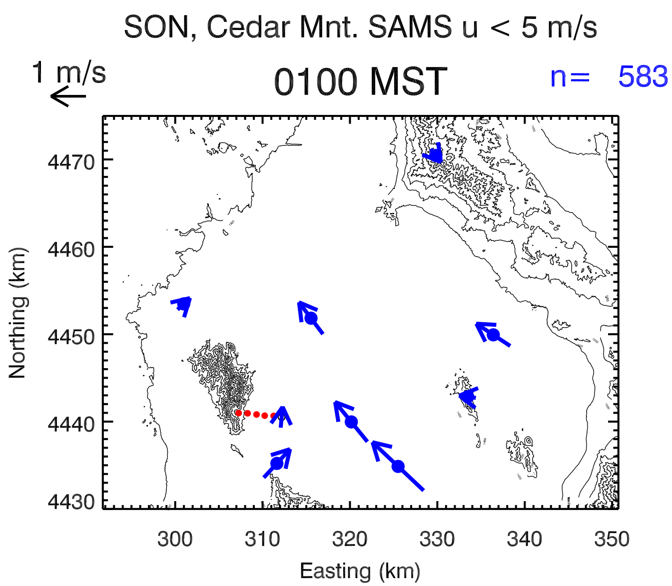


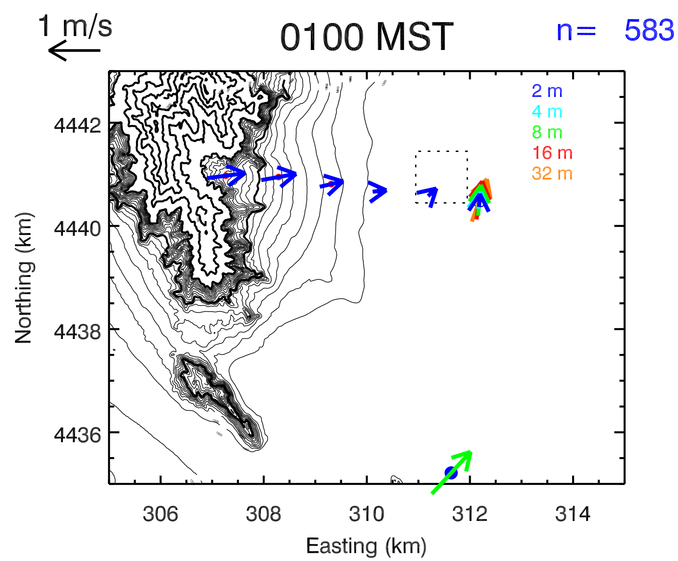


Fall: September-November









Planned Work – MATERHORN-X

Dave Whiteman (Research Professor, University of Utah)
Sebastian Hoch (Assistant Research Professor, University of Utah)
Matt Jeglum (PhD Student, University of Utah)
Leah Campbell (Masters Student, University of Utah

Eric Pardyjak, Jim Steenburgh, Zhaoxia Pu

Research objectives

MATERHORN addresses the interaction of flows of different scales in complex terrain, and their predictability.

Local, thermally driven flows ←→ synoptic scale flows

- What drives the temporal evolution and spatial variability of thermally driven flows in the complex terrain around Granite Peak?
- How do these flows interact with the larger scale flows?
- The collected comprehensive dataset is available for **model validation** and **parameterization development**.

What drives the local circulations ?

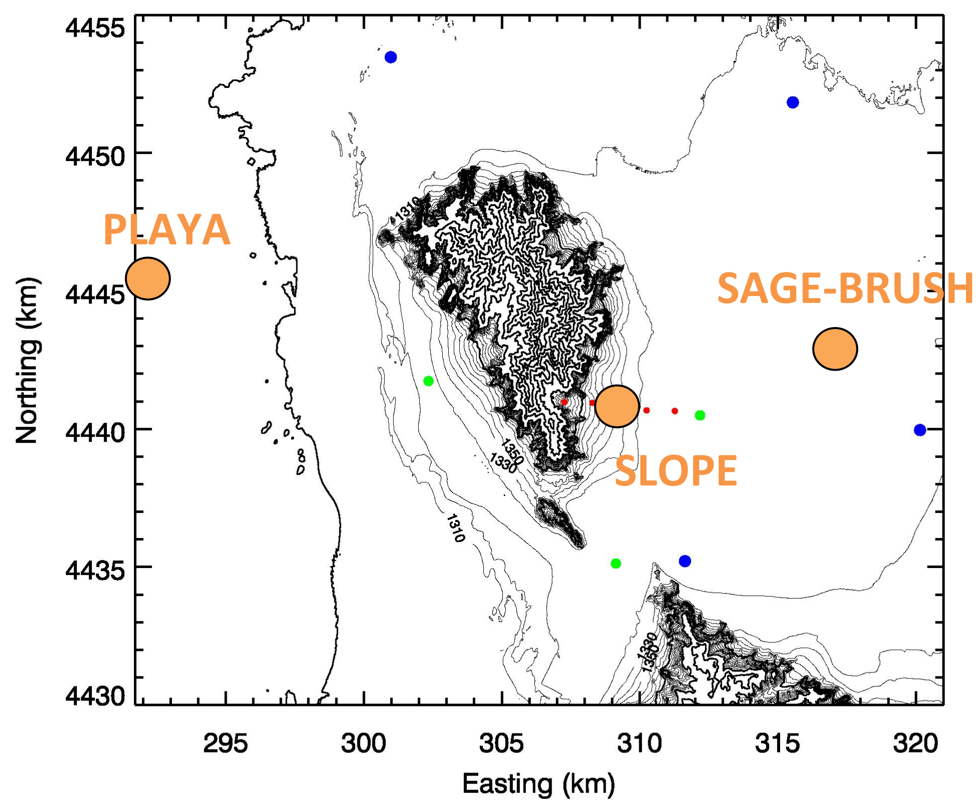
- Energy budget variations
  - Surface Layer development
    - Boundary Layer evolution

Extended Flux Sites (EFS)

- Observe the spatial and temporal variability of surface–atmosphere interactions: Exchange of heat and momentum.
- Dataset for model validation & parameterization development

3 Sites in different locations near Granite Peak:

- *East* and *West* of Granite Peak
- *High* and *low* surface albedos (Playa – Sagebrush)
- *Sloping* site and *flat* terrain



ESF (cont.) - Observations

- Full surface energy budget (SEB)
  - 4-Component radiation budget (SW/LW - IN/OUT)
  - Ground heat flux
  - Latent heat flux
  - Sensible heat flux (2 levels)

- Temperature fine structure (~ 20 thermocouples)
  - Surface Layer evolution
  - Inversion build-up / super-adiabatic sublayers
  - Radiative flux divergence (modeling, supported by TCs)

- Tethersonde observations (Playa & Sage)
  - Boundary Layer evolution & interaction with larger scale flows

Comprehensive dataset collected for:

- Validation of surface parameterizations – Land Surface Models and Initialization
- Data to test Boundary Layer Schemes

Modelers – What data do you need? What would you like to have?

EFS-Playa SITE: A Super EFS (former SLTEST-Site)

Exchange of heat and momentum – a very detailed look.

Extremely homogenous playa surface -
Perfectly suited for micro-meteorological observations

- All terms in the temperature tendency equation will be measured - as a function of height!

- Dataset for Model Validation & development of new parameterizations

See Eric Pardyjak's talk for all the details!

What *are* the local circulations ?

- Slope flows and Valley flows.
  How do these interact?

- Gap flows

- Lake- or Playa Breeze

Granite Peak Slope Experiment

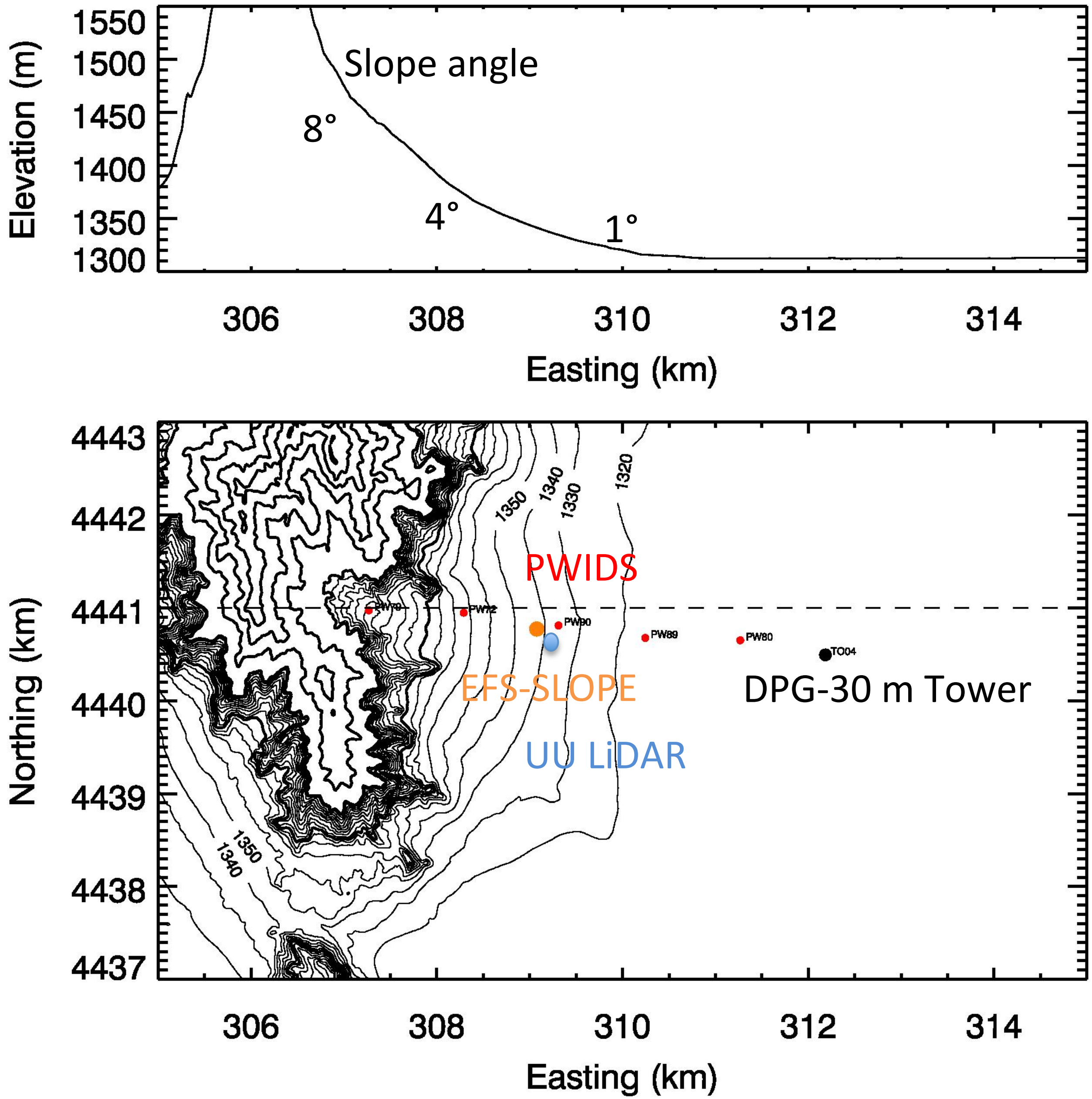
East Slope of Granite Peak

- Slope flow initiation – What are the driving cooling processes (SEB, div H and div R)?
- Slope flow variations (spatial – along slope; temporal)
- Upslope-downslope transition
- Daytime upslope flow, ridge-top convergence
- Interactions with valley flows

PWIDS - DPG photo

30 m Tower DPG photo

1 EFS–SLOPE (10-m tower) - Extended Flux Site + 3rd Sonic
1 DPG 30-m Tower
5(+) PWIDS (DPG Sonics ? – 2 Levels ? – discuss with Dragan)
5-10 IR Surface temperature / Air temperature
UU Halo Photonics Streamline Doppler Wind LiDAR – slope scans



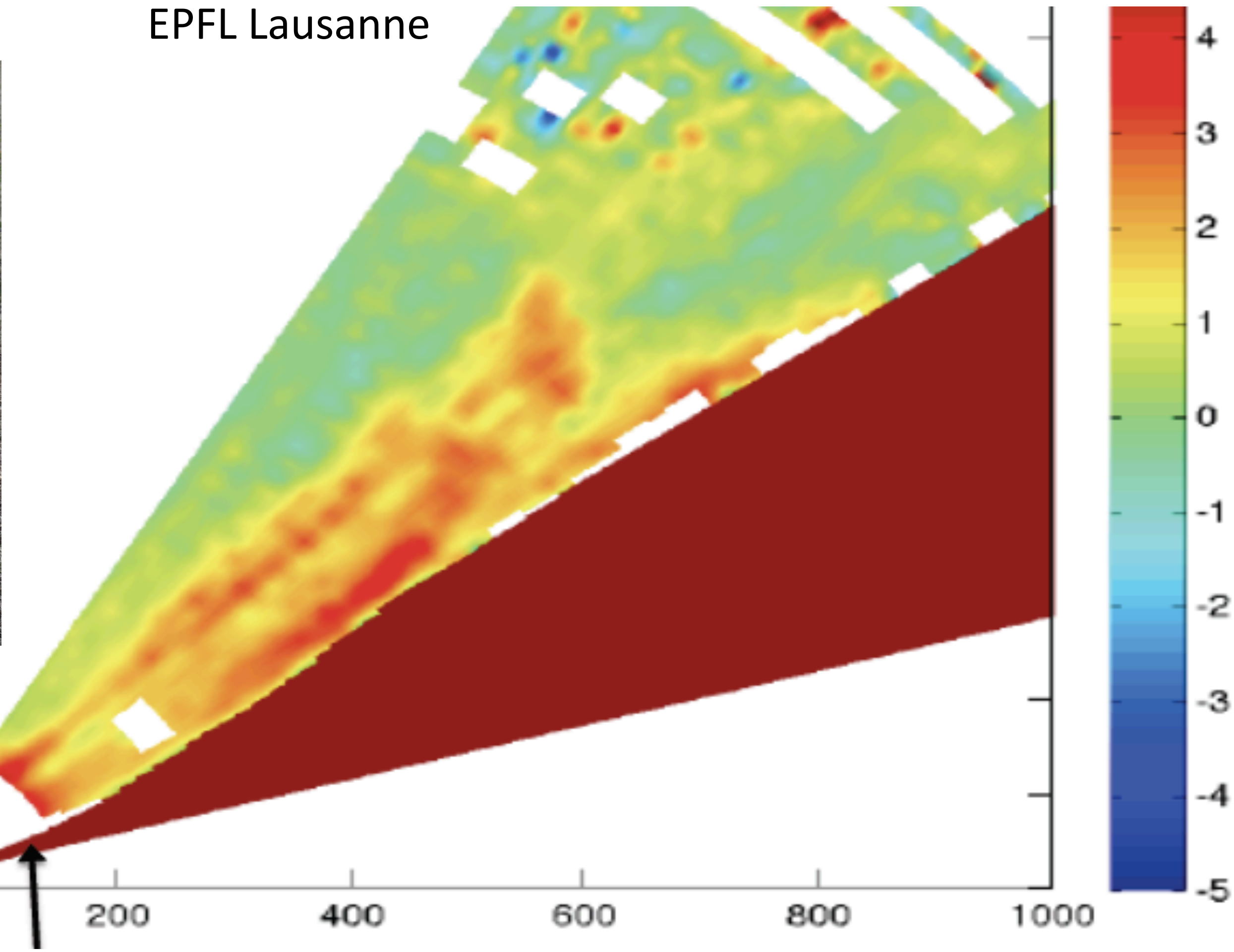
Elevation (m)
1550
1500
1450
1400
1350
1300
Slope angle
8°
4°
1°
306
308
310
312
314
Easting (km)
Northing (km)
4443
4442
4441
4440
4439
4438
4437
1350
1340
1330
1320
PWIDS
PW72
PW90
PW89
PW80
TO04
EFS-SLOPE
DPG-30 m Tower
UU LiDAR
Easting (km)

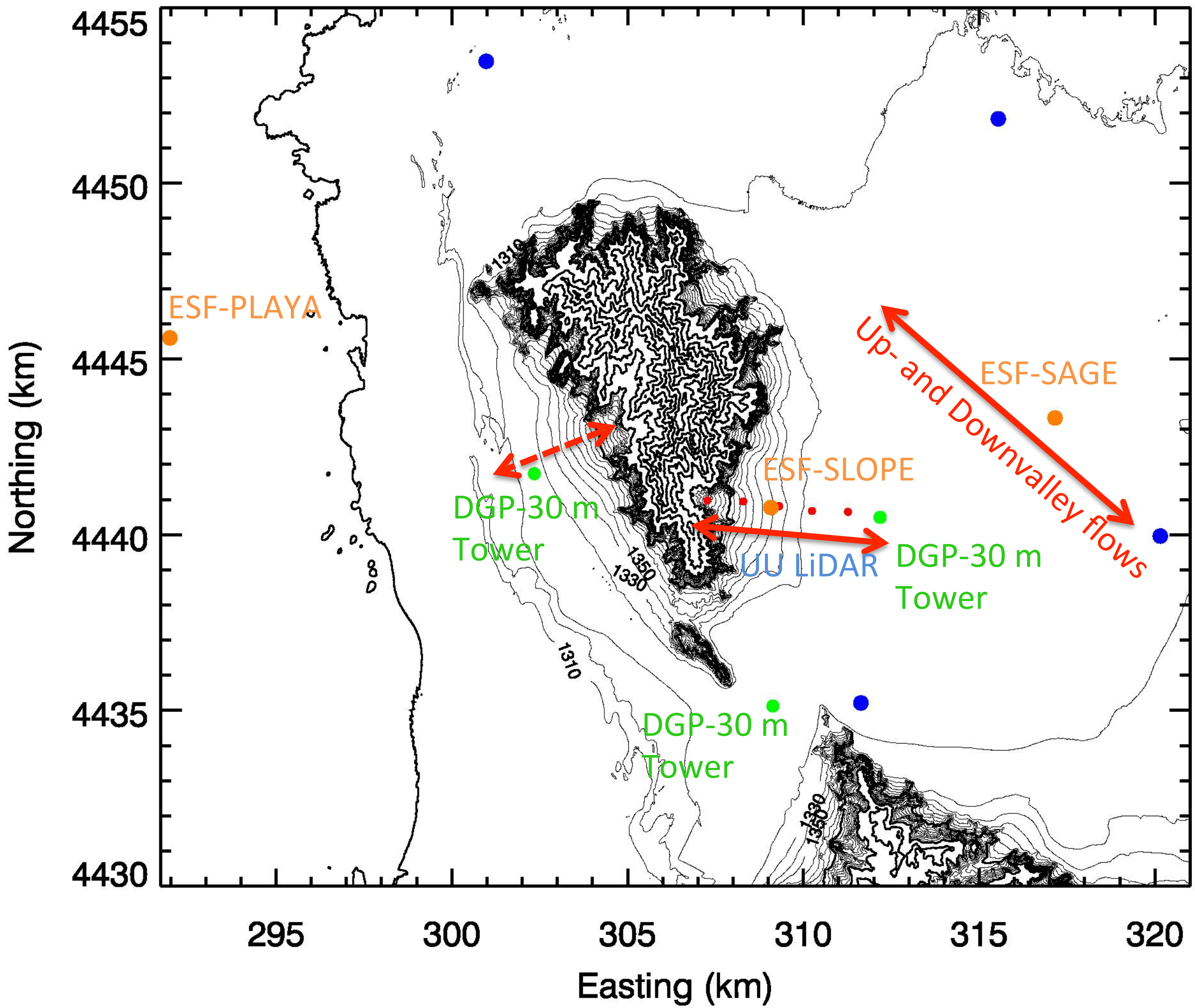
LiDAR observations with UU LiDAR – along-slope scans, range ~100-650 m

University of Utah
Scanning doppler LiDAR

Upslope flows in Val Ferret (CH)
EPFL Lausanne

Radial velocity [m/s]





4455
4450
4445
4440
4435
4430
Northing (km)
295
300
305
310
315
320
Easting (km)
ESF-PLAYA
ESF-SAGE
ESF-SLOPE
Up- and Downvalley flows
DGP-30 m Tower
DGP-30 m Tower
DGP-30 m Tower
UU LiDAR
1310
1330
1350

Flow interactions – with larger-scale flows

- Slope flow - Valley flow interactions
- Gap flows – channeled flows
- Wakes

Tethersonde observations

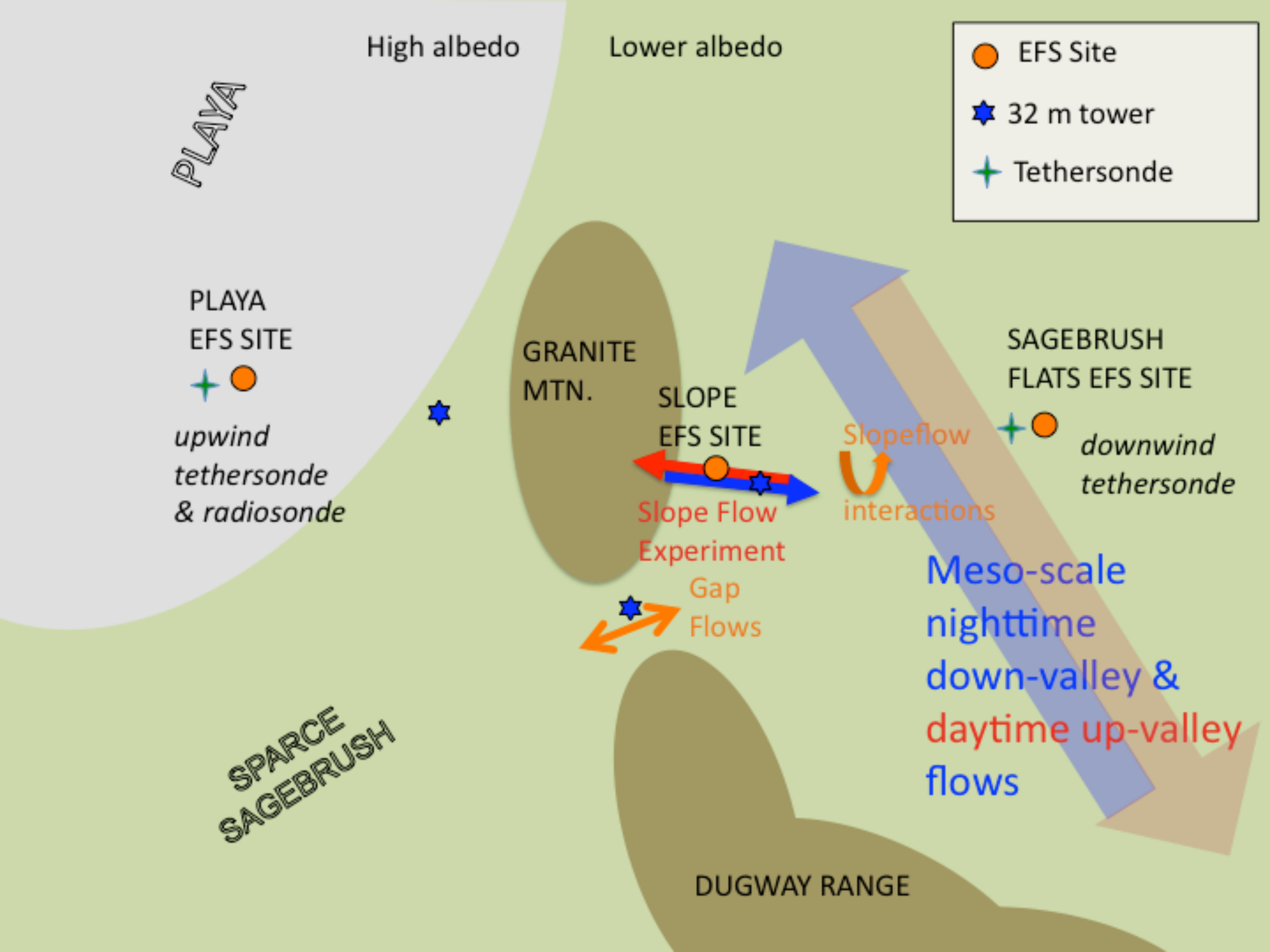
- ESF Playa and ESF Sage
- Boundary Layer Development – interaction between local scale and synoptic scale flows

SoDAR observations

- 2 UU mini-SoDARs – 1 UND SoDARs. – East & West of Granite Peak, Gap

Upper Air Soundings during MATERHORN-X

- 160 sondes budgeted in our project (8 per IOP)
- MATERHORN participants need to plan the radiosonde operation


High albedo
Lower albedo
EFS Site
32 m tower
Tethersonde
PLAYA
PLAYA
EFS SITE
upwind
tethersonde
& radiosonde
GRANITE
MTN.
SLOPE
EFS SITE
Slopeflow
interactions
SAGEBRUSH
FLATS EFS SITE
downwind
tethersonde
Slope Flow
Experiment
Gap
Flows
Meso-scale
nighttime
down-valley &
daytime up-valley
flows
SPARCE
SAGEBRUSH
DUGWAY RANGE