Boundary-layer phenomena in the vicinity of an isolated mountain

A climatography based on an operational high-resolution forecast system

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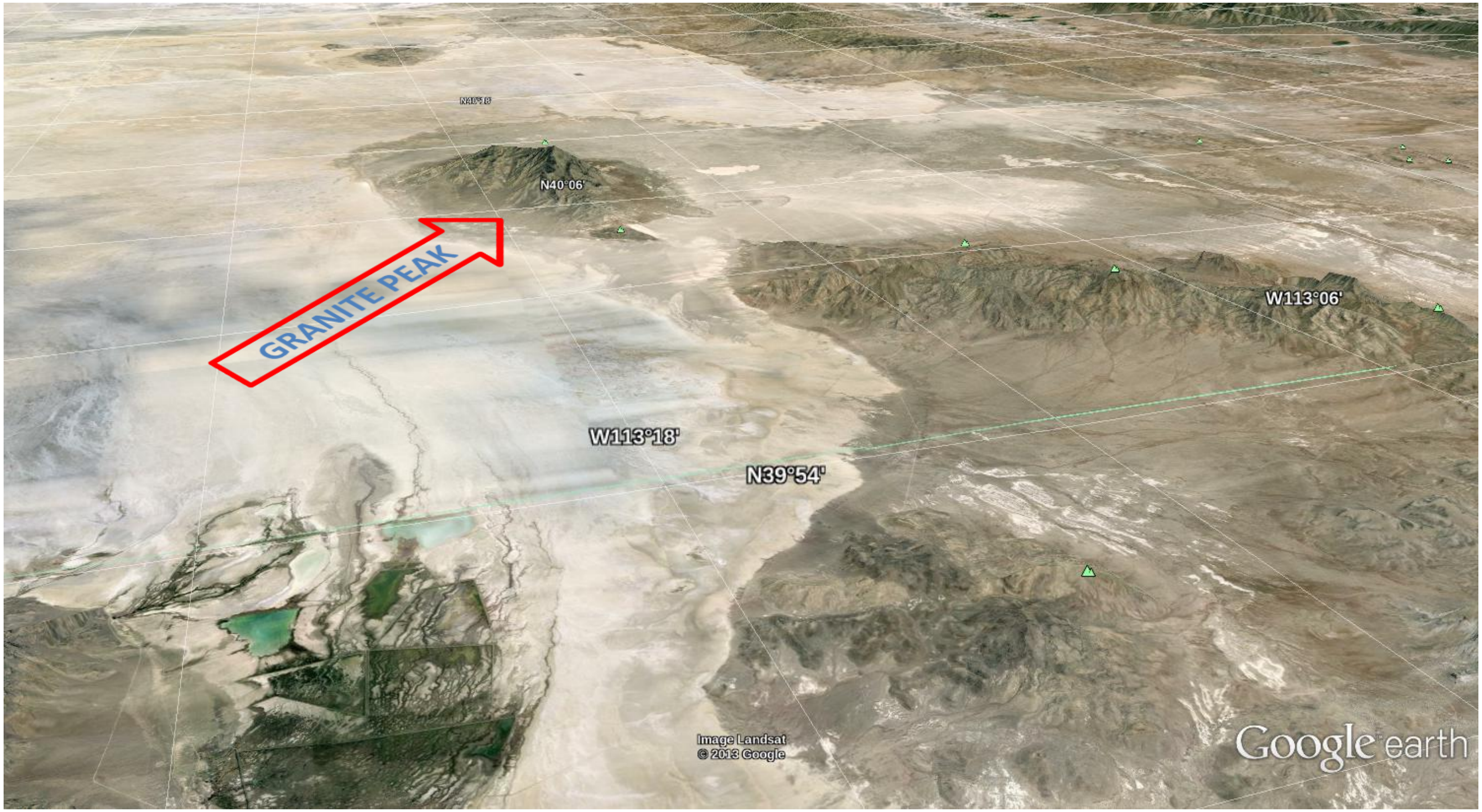
Granite Peak

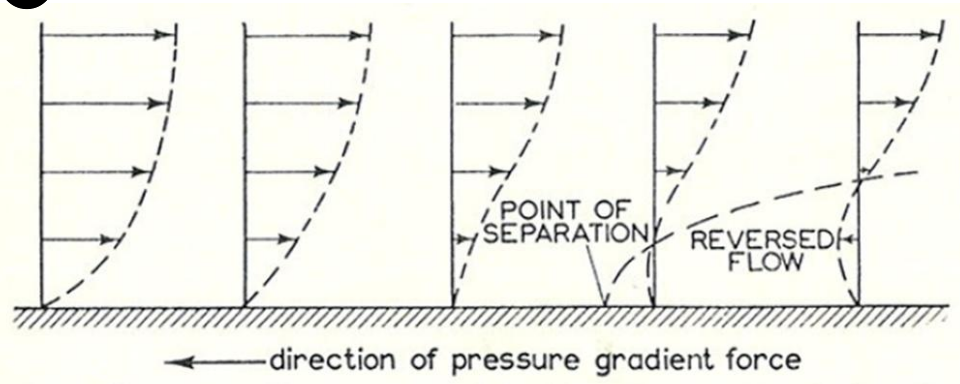
- Granite Peak, Dugway Proving Ground, target area of the MATERHORN-X field campaigns.



Boundary-layer separation (BLS)

❶ Scorer (1957)
❷ Jiang et al. (2007)
❸ Baines (1995)

❶



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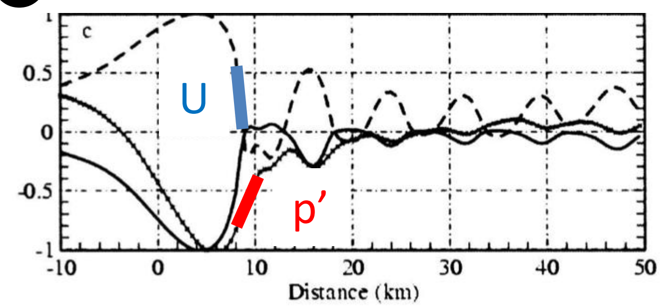
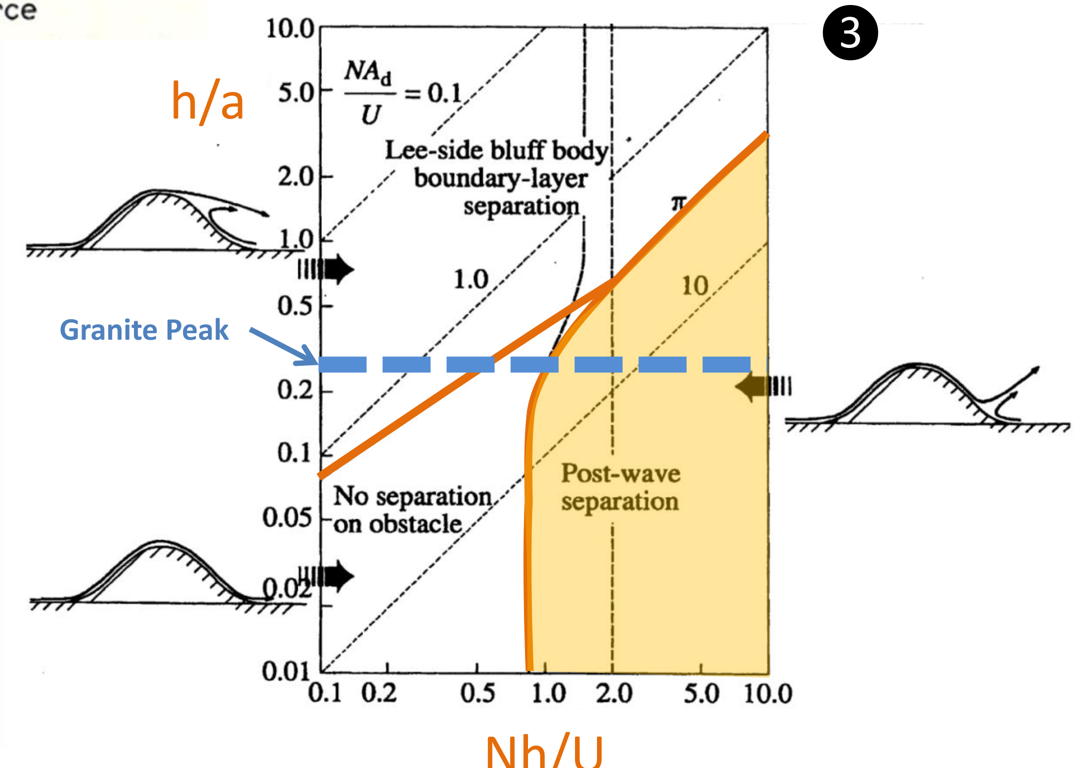


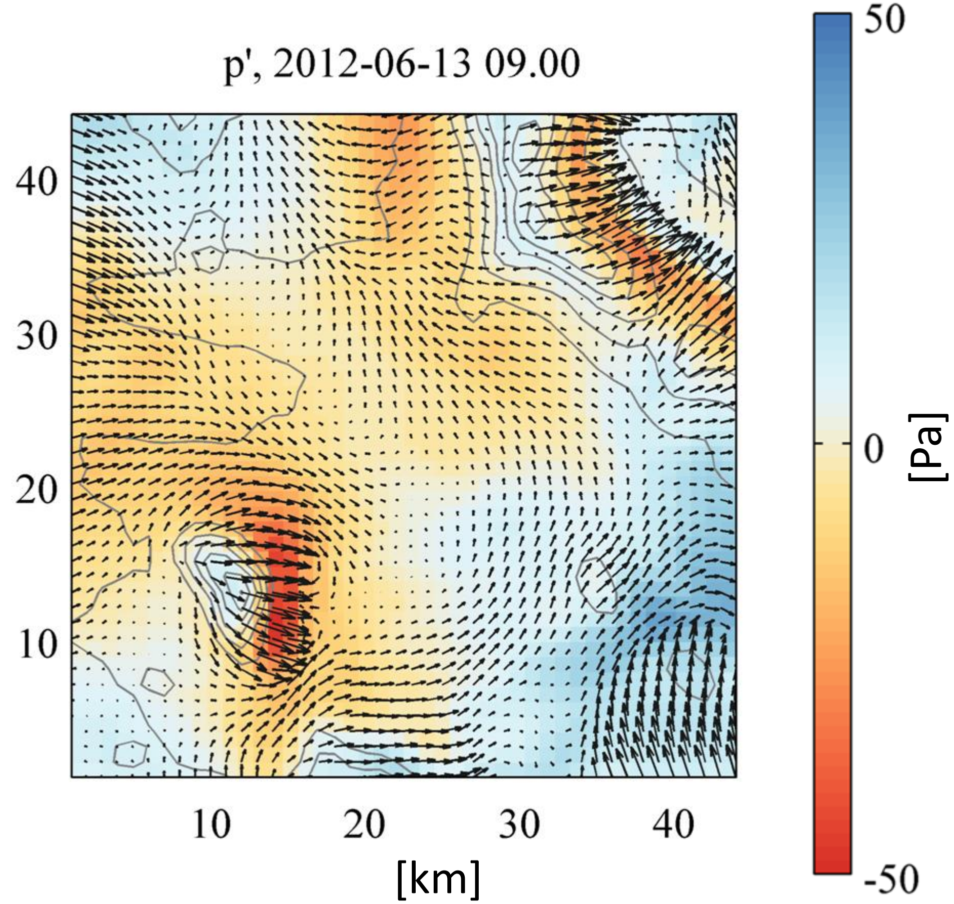
FIG. 2. The plots of the 10-m horizontal wind U_{10}, alongstream surface stress τ_x, and surface pressure perturbation p' as a function of horizontal distance derived from the control run with z_o = 0.01 m and h_m = (a) 300, (b) 350, and (c) 400 m. All three variables are normalized by their maximum values.

❸



4DWX

- Does BLS occur in the lee of Granite Peak? Can Granite Peak help us learn anything new about BLS?
- Look at NWP model output!
- Operational NWP in the area is provided since the 1990s by NCAR-RAL (4DWX, now 1.1-km-resolution WRF runs with observation nudging).



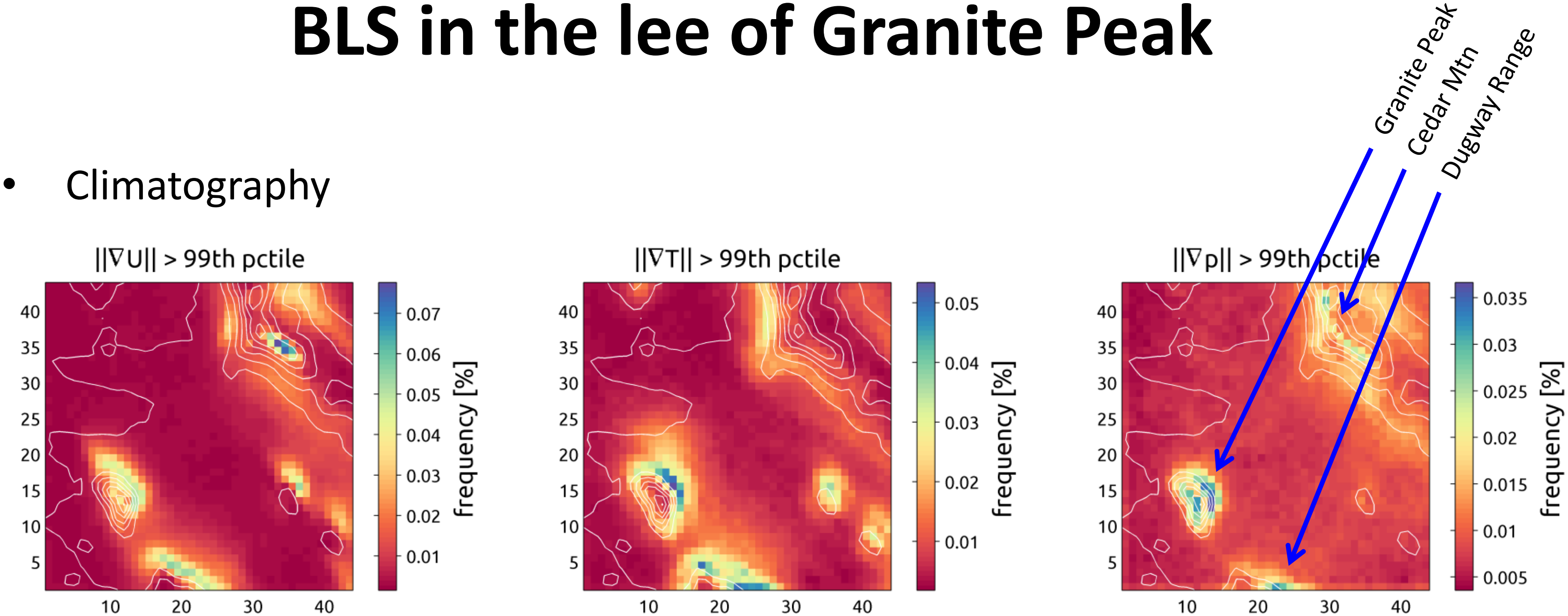
Research question

- What are the scenarios that can lead to BLS in the lee of Granite Peak?
- How to answer:
    1. Use 4DWX output to produce a climatography of surface gradients* of *p*, *T*, wind speed. Period: 2009-2012 (unchanged model settings, hourly output: ~35000 samples).
    2. Identify areas where the strongest gradients occur.
    3. Examine events where the strongest gradients were recorded.

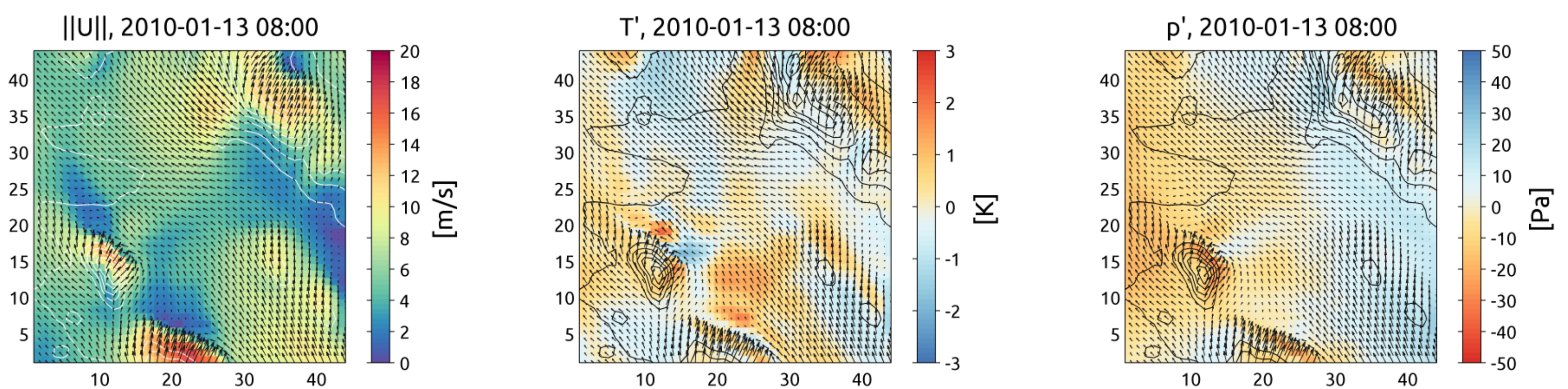
* *p* and *T* have clear altitudinal and seasonal dependencies. In both cases, this low-frequency variability has to be filtered. The resulting filtered fields are free of any altitudinal/seasonal fingerprint and only reflect mesoscale meteorological variability.

BLS in the lee of Granite Peak

- Climatography

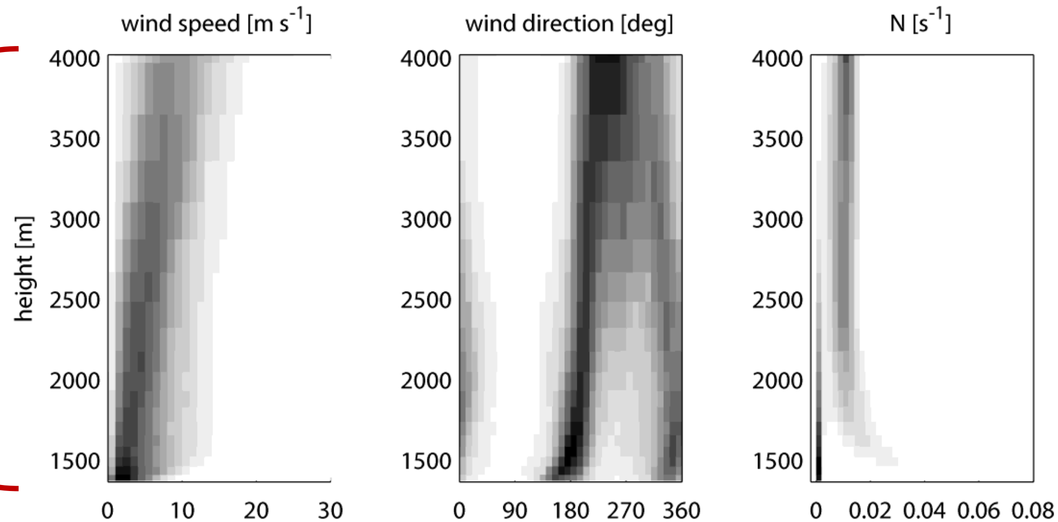


- One case (a typical BLS scenario)

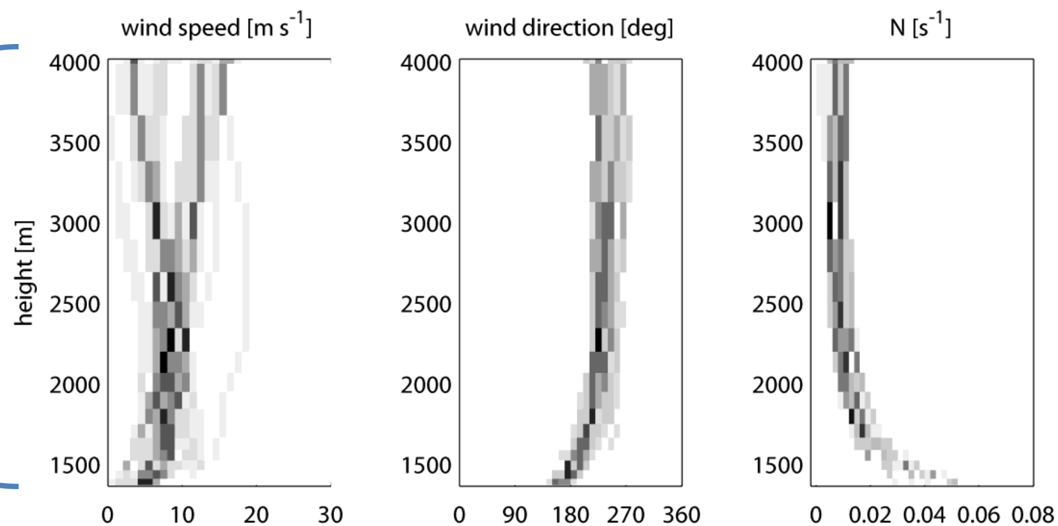


BLS scenario /1

«climate»

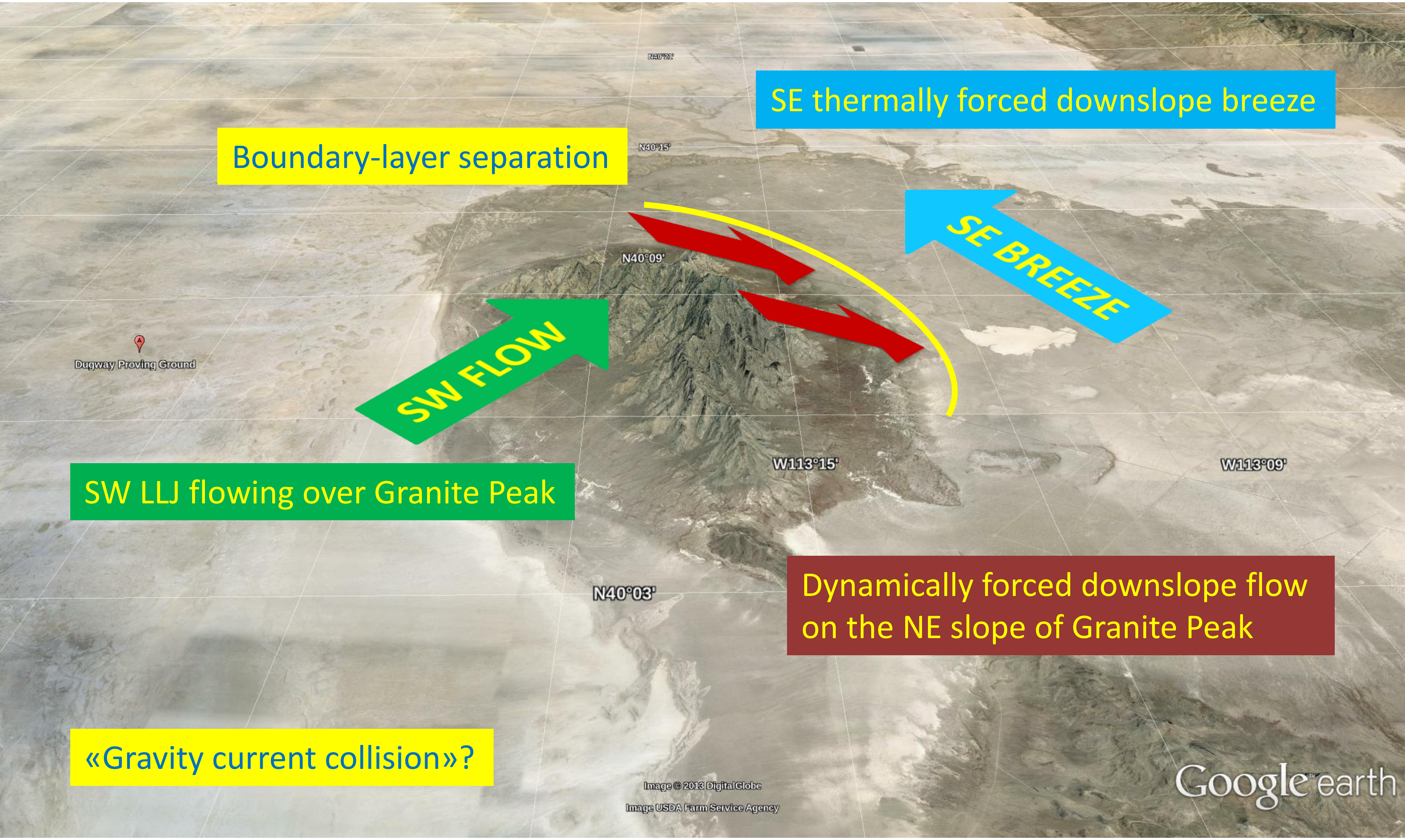


BLS events*



* Those where events included in the right tails of the frequency distributions of $\|\nabla U\|$, $\|\nabla p'\|$ and $\|\nabla T'\|$ are co-located near Granite Peak.

BLS scenario /2



Summary

- 4DWX operational simulations suggest that BLS is a likely event in the lee of Granite Peak (esp. NE slope).
- Most BLS cases are considerably more complex than the simple «2D» picture.
  - Highly transient.
  - Upstream profile with a LLJ (?) and directional shear.
  - Partially blocked flow.
  - Surface cooling.
  - Non-uniform roughness.
- Next step: find evidence of this type of dynamics in the MATERHORN-X measurements.

Thank you for your attention!

Info: new session
AS1.6/NP4.7, Atmospheric processes over complex terrain
at the upcoming EGU General Assembly
Vienna, Austria, 27 April – 02 May 2014
Conveners: Dino Zardi, Stefano Serafin and Ivana Stiperski

http://meetingorganizer.copernicus.org/EGU2014/session/14954

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- ✓ FWF, Austrian Science Fund, grant P-24726 N27 (University of Vienna).

4DWX

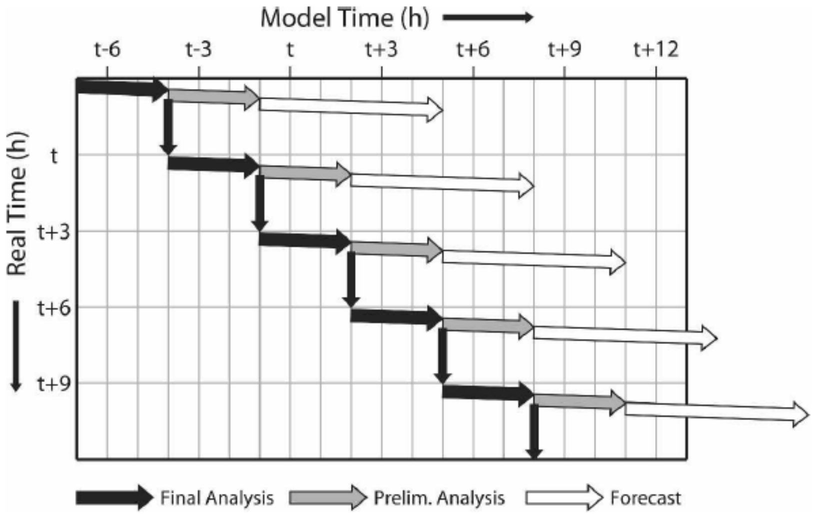

FIG. 3. The data assimilation and forecast cycle. The ordinate axis is wall clock time, and the abscissa is model time (i.e., the time being simulated during the data assimilation or forecast process). The slope of the arrows indicates the elapsed time associated with the model's execution, but the particular slope shown here is not meant to quantitatively indicate model efficiency. An example follows of the 0800 UTC cycle (real-time t on the ordinate = 0800). The cycle starts at 0820 UTC and generates a 3-h final analysis (horizontal black arrow) from 0400 to 0700 UTC in 20–30 min. Then the model writes a restart file (vertical black arrow) for the next cycle (1100 UTC, $t + 3$ on the ordinate) to start with. The model then continues to produce a preliminary analysis and a forecast for the current cycle, where the real time will be about 1110 UTC by the time the forecast (white arrow) terminates at $t + 36$ h.

The Operational Mesogamma-Scale Analysis and Forecast System of the U.S. Army Test and Evaluation Command. Part I: Overview of the Modeling System, the Forecast Products, and How the Products Are Used

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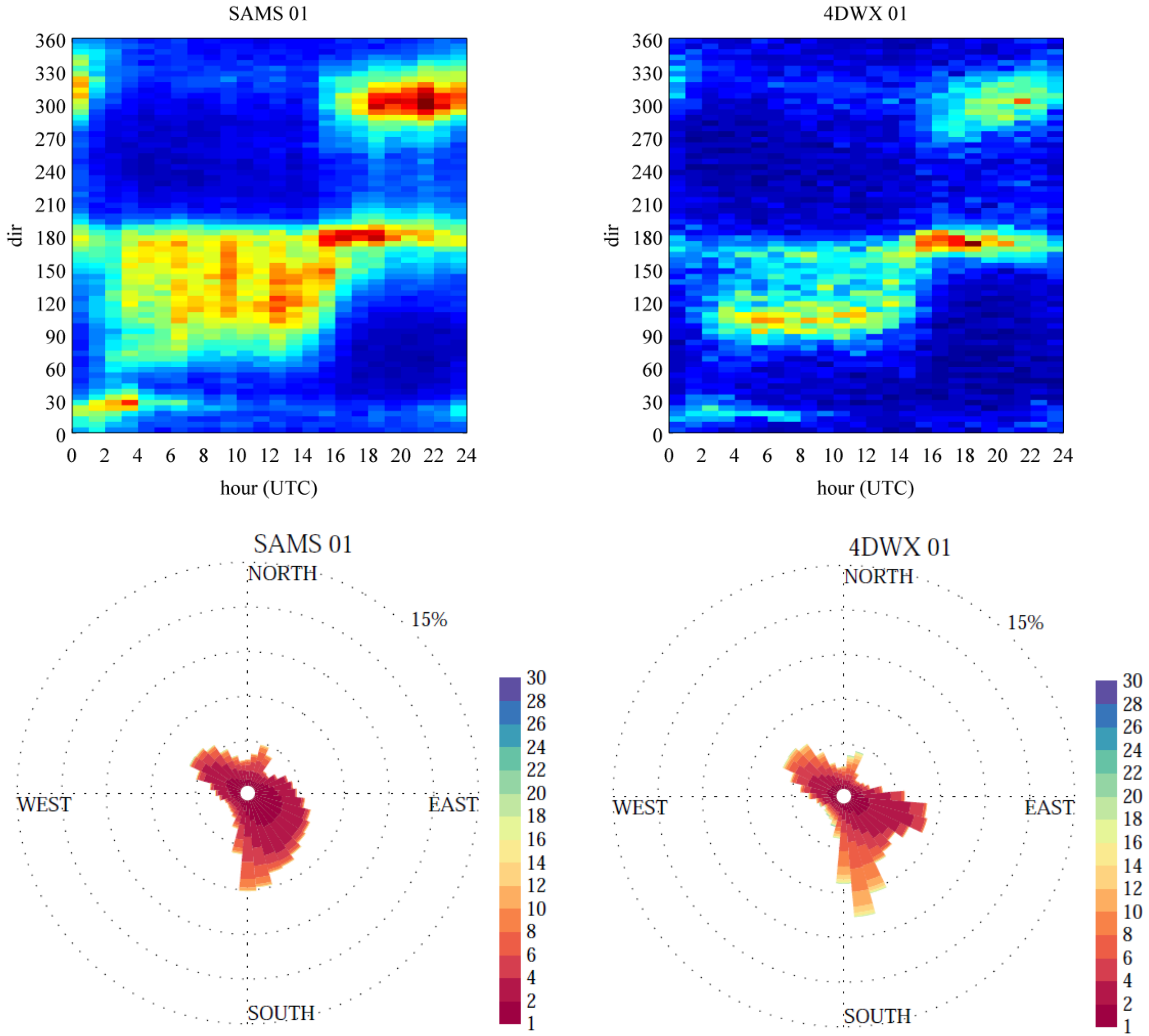
4DWX vs. SAMS observations



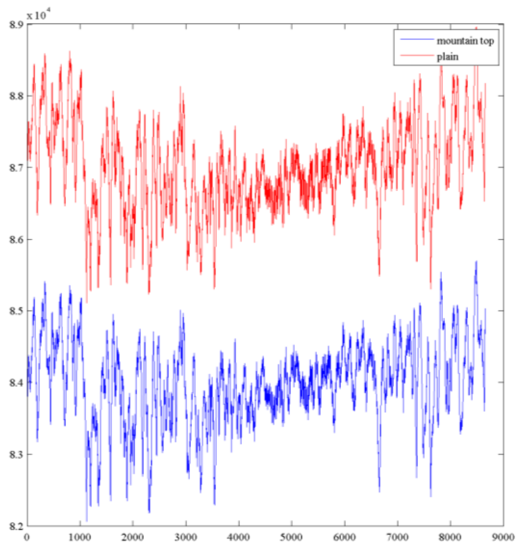
Filtering of *p* and *T* fields

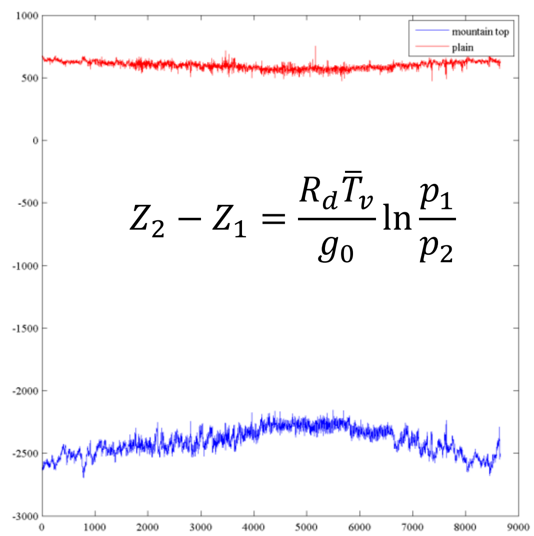
raw series

filtered series

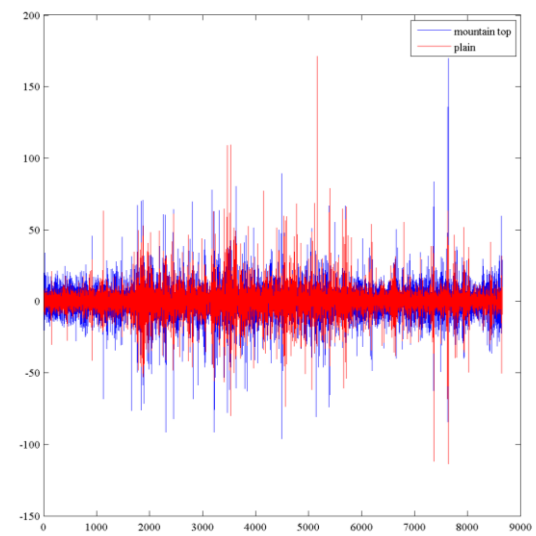
remove regional trend

remove low-frequency variability
(high-pass Lanczos filter)





$$Z_2 - Z_1 = \frac{R_d \overline{T}_v}{g_0} \ln \frac{p_1}{p_2}$$



atmospheric pressure, plain

atmospheric pressure, Granite Peak

2D vs. 3D obstacles