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EDITORIAL

Preface: Special issue on the MATERHORN program and complex terrain flows

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The multiscale/multiphysics character of atmospheric flows in complex terrain are an important part of environmental fluid mechanics and are relevant to a wide range of applications including: air quality, the hydrological cycle, trace gas exchange, energy production, military applications, and agriculture. While many small-scale field, numerical modeling, and laboratory studies have been conducted to address scientific questions related to flows in complex terrain, comprehensive studies, which attempt to use multidisciplinary approaches to bridge gaps in understanding, are far less common. This was one of the goals of the Mountain Terrain Atmospheric Modeling and Observations (MATERHORN) program [3], which was supported by the U.S. Department of Defense through a Multidisciplinary University Research Initiative (MURI). MATERHORN was underpinned by three large-scale field campaigns: two conducted in Utah's West Desert at the U.S. Army Dugway Proving Ground (dubbed MATERHORN-X) that focused on thermal circulations and strong synoptic forcing in a mountainous environment and a third campaign conducted in Heber Valley, Utah (MATERHORN-Fog), which focused on the interaction of mountain-valley circulations and fog processes [5]. In addition to the field campaigns, numerous numerical modeling and several laboratory studies were conducted.

This special issue (SI) communicates results which improve the scientific community's understanding of poorly understood concepts related to environmental fluid mechanics in regions of complex terrain. The SI contains eight manuscripts with an emphasis on results from the MATERHORN program. The SI includes novel field-experiment [1, 4, 6, 7] and laboratory-experiment results [10], as well as high-resolution [9] and mesoscale atmospheric simulation studies [2, 8].

Field studies in the SI cover stable, unstable, and transitional periods. Conry et al. [1] and Goldshmid and Liberzon [4] apply the so-called 'combo-probe' technique, which

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makes use of an artificial neural network technique, to facilitate in situ calibration of hot-film probes allowing for fine-scale turbulence measurements to accurately and efficiently be made outside of the laboratory. Conry et al. [1] use the technique to better understand turbulence mixing processes through the mixing coefficient in a stably stratified environment during MATERHORN, while Goldshmid and Liberzon [4] apply the technique to interrogate turbulence spectra of anabatic flows down to the Kolmogorov scales at a field site in Israel. Nadeau et al. [7] present results on the morning transition from a field experiment conducted in the Swiss Alps. Very few studies have delved into the intricacies of the morning transition in complex terrain due to difficulties associated with observing and analyzing unsteady processes as well as interpreting the various interacting flows. Nadeau et al. [7] present both valley-scale and turbulence results and find that the duration of the morning transition period is highly variable; they hypothesize that this variability is the result of the presence or absence of transport from large-scale eddies. Hang et al. [6] present an in-depth study of the potential temperature variance equation during unstable periods over three different surfaces (two flat and one sloped) during MATERHORN. They found that the turbulent transport term acts as a sink in the near-surface layer at all three locations.

This SI also includes two numerical modeling studies of the MATERHORN field campaign [2, 8] and one focused on using a novel computational technique to study flows in mountainous terrain [9]. Silver et al. [8] use the Weather Research and Forecasting (WRF) model to simulate flow during the MATERHORN campaign at high resolutions to study flow separation and the concept of dividing streamlines in realistic mountainous terrain during stably stratified conditions with strong synoptic forcing. They show that classical methods for identifying dividing streamlines are insufficient for realistic terrain and present a novel software for evaluating dividing streamlines in complex terrain. Duine & De Wekker [2] present an investigation of simulated boundary-layer depths over mountains in the vicinity of the MATERHORN field sites using WRF. Specifically, they studied the impact of grid resolution on boundary-layer depths and found that on fair-weather days the differences between boundary-layer depths simulated using coarse and fine grids can be significant. Wang et al. [9] present results from a large-eddy simulation using a three-dimensional lattice Boltzman model to study stably stratified flow over a two-dimensional ridge for a range of Froude numbers. The technique successfully reproduces complex stably-stratified flow phenomena that are critical to analyzing flow phenomena over mountains such as hydraulic jumps, waves, and rotors.

Finally, the SI includes one laboratory-scale experimental study. Zhong et al. [10] developed a novel and efficient technique for ensemble averaging density fields to remove non-physical noise associated with a lack of alignment between realizations. The method is illustrated using idealized synthetic test cases as well as laboratory experiments of colliding gravity currents, a physical phenomenon that was observed during the MATERHORN field campaign [3].

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