18-23 July 2017 Grand Mesa DGPS Survey Summary

Introduction

Snow survey transects and snow pits were distributed randomly across the Mesa among various tree classes ranging from treeless to thick forest. While the transect locations were generated using GIS, implementing that sampling scheme on the Mesa injected some inaccuracies on the ground upon implementation. In September 2016, transect start and end points in the field were marked with t-posts and poles. Identical markers were also deployed where needed along transects to act as guides in open areas or guides for the transect line as land cover changed from forest to treeless and vice-versa. In more forested situations, flagging was used on trees to mark the route. Crews placed the markers and flagging using handheld Garmin GPSMAP 64st units with ~3-30 m accuracy, depending on signal and canopy cover. GPS signals are much less reliable under canopy. A number of transects were not marked in September 2016, and those transects were measured in February 2017 using the same Garmin GPS units for navigation.

In February 2017 snow measurements occurred throughout the month along various transects. For the most part, snow pit locations, two per transect, were located 15 m inside each end of the transect and to the north 15 m (E-W oriented transects) or to the west 15 m (N-S oriented transects). Most of the pits were sampled one-two times during the month.

Because transects were placed with less accurate GPS units, getting higher accuracy for transect locations could be used to improve the accuracy and placement of measured snow depths. This is especially true in heavily forested conditions. In July 2017, before the snow stakes were removed permanently, a high accuracy Real-Time-Kinematic (RTK) GPS survey took place to identify SnowEx infrastructure and obtain higher accuracy for transect locations.

Methods

The survey used the same projection and datum as SnowEx Year 1 in Colorado. All coordinates here are reported in UTM Zone 13N, WGS84, using geoid 12 CONUS.

The RTK survey was conducted 18-23 July 2017 on Grand Mesa with the goal of producing as high accuracy horizontal and vertical resolution as feasible given canopy conditions. During each day, a Trimble R8 GNSS base station (Figure 1) would be placed and left running for two hours or more at each base station location. At the base station, a radio antenna was used to broadcast correction data to two rovers deployed within ~6 km of the base station. One rover used was a Trimble R8 (Hiemstra) and the other was a Trimble R10 (Gelvin), both deployed with GNSS antennae and base-station radio antennae to receive corrections.

Figure 1. Over the course of the survey, 11 base stations were deployed and occupied for more than 2 hours and used for real-time kinematic (RTK) surveys all over the Mesa. The goal was to have a nearby base station to the active survey so that satellite information was shared across the base and two rover units.

Starting on the west side of the Mesa and moving to the east, existing stakes were located with handheld GPS units, then surveyed with high-accuracy RTK units placed directly next to the poles. Transects were done in their entirety to measure any stakes that were not documented in the handheld GPS units. Once a stake was reached, it was surveyed. Most of the positions required 5 seconds of occupying time, but in thicker canopy conditions a number of occupations were performed. Multiple survey collections were reduced to their final version by selecting points with higher accuracy that were retained for the final product.

During February, red 2 m long snow pit stakes were often inserted into the snow to mark pit locations so that returning field crews could dig a new pit adjacent to the old pit. A number of these stakes were found in July, and the mid-point of that stake was surveyed.

On Grand Mesa, time lapse cameras and snow stakes (orange poles) were employed in a number of locations, co-located with TLS sites (TLS-A, TLS-D, TLS-F, TLS-J, TLS-K, TLS-L, and TLS-N). For this survey, the naming convention used for the cameras was retained for the location name. Camera locations were surveyed by getting as close to the tree and the camera as possible, but not at the elevation of the camera. Survey heights were taken on the ground elevation. Snow stakes deployed for the cameras were also surveyed and identified with the word "pole" in the name.

Results

Snow Transects. For the 101 transects used, 13 transects had no snow stakes. For the 90 transects with snow stakes, 244 snow survey stakes were surveyed in July 2017 (Figure 2). For each point, a name (transect 1.1, 1.7, etc); location (easting, northing, longitude, and latitude); elevation; horizontal and vertical precision; date and time; stake type (PVC, t-post, both); original easting and northing, and notes are reported in the .csv text file. On average, stake horizontal error was 0.20 m and vertical error was 0.28 m. However, this is due to a number of high-error and leverage sites located in the trees, where satellite signals were difficult to obtain and signal multipathing increased errors. Median horizontal and vertical error was 0.03 and 0.04 m, respectively. The minimum horizontal and vertical error estimated was 0.01 m. The maximum horizontal error was 5.3 m (stake 45.4, in thick trees). Maximum vertical error was 4.96 m at stake 42.7 (also in thick trees). Of all the 244 locations surveyed, 16 have horizontal errors > 1 m and 20 have vertical errors > 1 m. In all cases, these locations represent a substantial leap in accuracy from the original locations.

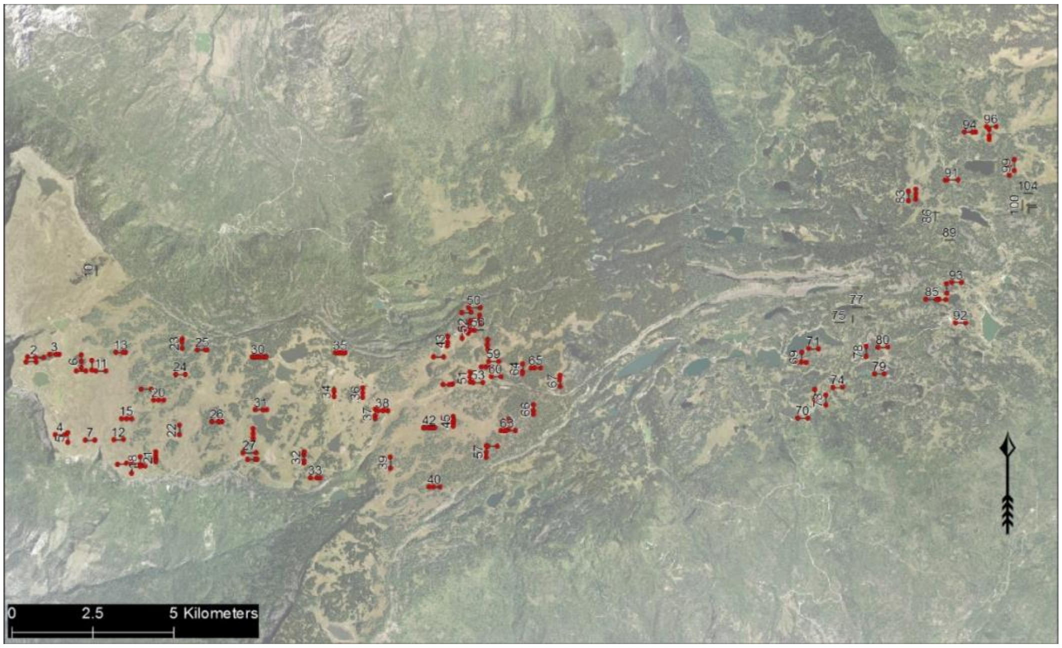

Figure 2. Fence posts and fence posts with white and red PVC markers were used to mark transects and snow observations. All existing markers were surveyed with DGPS RTK surveys in July 2017.

Survey Stakes. Since red stakes were left behind from winter, we were able to located and survey in some of the pit locations the following summer. Overall, 31 red stakes were located on Grand Mesa (Figure 3) in locations near the snow depth transects. Horizontal accuracy is reported as 0.01 m to 2.43 m (Pit 13.1). Vertical accuracy ranges from 0.01 to 2.56 m (Pit 13.1). Median horizontal and vertical accuracies are 0.04 m.

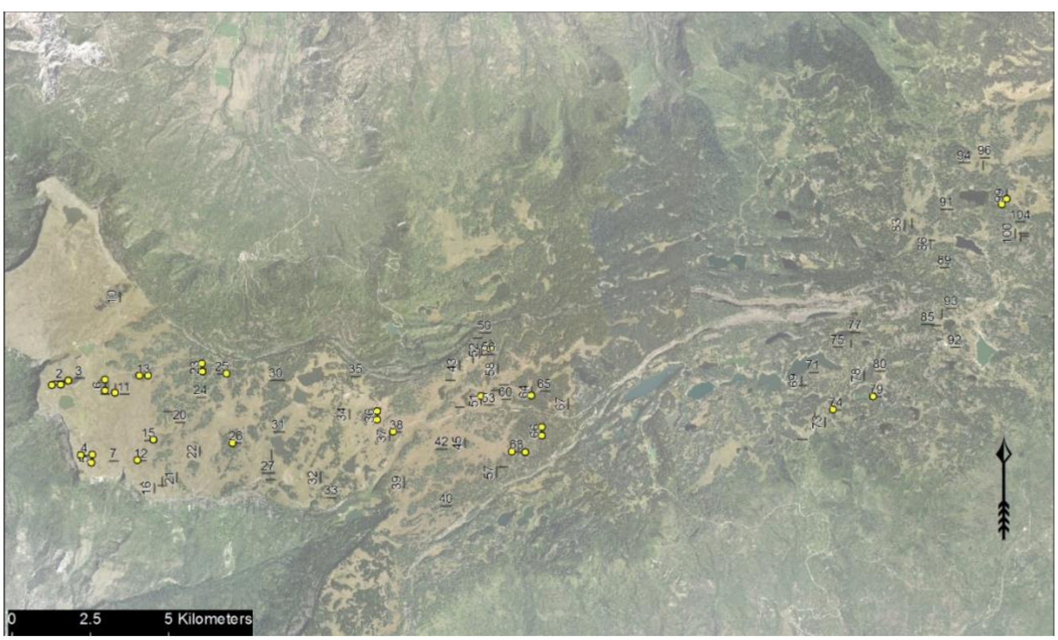

Figure 3. Red poles used to mark winter snow pits were surveyed in the summer as well. Not all were surveyed, and not all pits were marked, but XX poles were located and surveyed on Grand Mesa in July 2017.

Time Lapse Cameras. Thirty-nine time lapse camera features were surveyed on Grand Mesa (Figure 4). Twenty-four cameras were located (see time lapse camera data) and fifteen orange poles used to estimate snow depths from the camera images were also surveyed. Median horizontal accuracies ranged from 0.01 m to 2.47 m (TLS-F3N). Median vertical accuracies were from 0.02 m to 4.17 m (TLS-A2S-Pole). The median horizontal and vertical errors were identical and reported as 0.06 m.

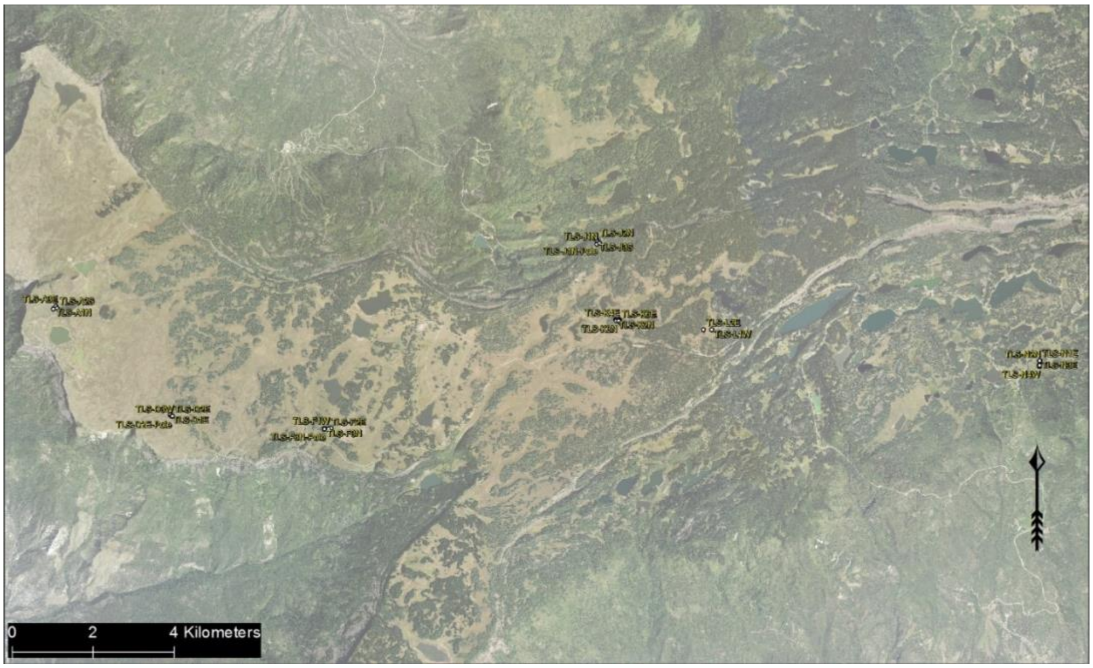

Figure 4. Twenty-four time lapse cameras were distributed on Grand Mesa near and within TLS areas. Fifteen poles were used with the cameras to estimate snow depths. For a description of those data, see the time lapse camera dataset.