Response to Reviewer #3:

The reviewer raises a number of interesting points, which we address below and incorporated as minor changes to the manuscript. We also note that major changes have been made to the manuscript in the section describing the CAP tilt (Section 3.5). That portion of the paper has been greatly simplified and much of the math has been removed in favor of a simple representation of the force balance affecting the CAP incline. We have also reduced the total number of figures from 19 down to 15.

1.) The trough passage is linked to the mountain wave in that it generates strong cross barrier flow. As the trough approaches from the NW it induces an ageostrophic down gradient flow above the CAP. The stratified flow crossing the traverse range from south to north generating a mountain wave on the north (e.g. lee slopes) of the mountains. When the trough axis passes (15 UTC) it reverse the along valley pressure gradient, favoring weak northerly flow. The mountain wave is not observed along the north slopes after that time. This transition in the flow aloft is readily apparent in Fig 2. and denotes the end of what we consider the disturbance phase of the CAP evolution.

2.) We propose, in the manuscript, that the northward displacements of the CAP are not only linked to the development of the mountain wave but also relate to adjustments to the regional pressure gradient and wind stress acting on the CAP. The mountain wave and attendant rotor are, as you point out, fixed to the topography and can not alone describe the full evolution of the CAP displacements including the large excursion of the warm front around 06 UTC. I have added a line of text to the manuscript to make this point more clear.

Line 496:

“However since, the mountain wave remains fixed to the topography additional factors must contribute to the larger displacement of the CAP throughout the valley.”

The role of turbulent mixing within the rotor region appears to be two fold. (1) The turbulence within the rotor “tears apart” the isentropes from the stratified flow spilling over the upstream topography (seen as the increase in spacing of the isentropes at the downwind side of the rotor, and (2) disrupts the near surface stratification through strong downward heat flux (w’T’).

3.) Downward turbulent heat flux is in fact observed during the warm frontal passage at one station near the north end of the valley. Values of around -120 W m^-2 were briefly recorded during the jump in near surface temperature.

I have added a line, #675, indicating this:

“ For example during the warm frontal advances downward turbulent heat fluxes of 120 W m-2 were reported associated with the large jumps in surface temperature (not shown).”

However, there is very little useful flux data beyond these measurements during the event, especially considering much of the turbulent mixing is occurring well above the ground within the sheared layers at the top edge of the CAP. For example we do not have reliable measurements of the turbulent heat flux due to the KHW apparent in the ceilometer data.

To address this shortcoming in our observations we have a companion modeling study, which we will be submitting to JAS, examining the turbulent processes that contribute to CAP break up. In that paper we link some of our results to the PCAPS data from IOP-1, but there is not room in the current manuscript to fully treat this topic.

Response to detailed comments:

1.) The phrase “depth collapses” has been changed to “tilt collapses” and pertains the change in the CAP slope due to variations in the dynamic and static forcing which lead to a rapid reduction in the CAP tilt and the propagation of a gravity current through the valley.

2.) We have modified this sentence to make it clearer. It now reads:

“Petkovšek (1992) proposed a semi-analytic model for this process wherein turbulent flow above a CAP progressively erodes downward into the stratified air. In this scenario, the depth of the CAP is progressively reduced, but the strength of the stratification within the capping layer increases in time.”

3.) The locations of the SM stations have been more clearly identified in Fig. 1both with numbering and colors which correspond to the time series data shown later.

4.) The southern string of green dots is not explicitly referenced in the text but do significantly contribute to the surface analyses.

5.) The values in the figure are only the meridional component of the wind. The total wind speed at 2200 m is ~20 m/s. For clarity I have modified the text to talk only about the data shown in the figure, which has a peak speed of 15 m/s.

6.) The top of the CAP is roughly identified as the height of the transition to an adiabatic profile aloft and may also include a low level jet maximum. I have added a line later in the text indicating this:

line 548:

“The CAP top is identified by the transition to an adiabatic profile aloft (Fig. 15a) and the height of the jet maximum in the meridional wind (Fig. 15b).”

7.) SM6 is in the southeastern corner of the valley. I believe the confusion relates to another station ISFS-6 that is further north in the valley. I have modified Fig. 1 to try to make this distinction more clear. I have removed the DAQ station from the figure as it is not relevant to this paper.

8). While turbulent mixing plays a role in the observed CAP evolution we believe that displacement still best describes the processes documented. There are large lateral displacements of the cold-air that result in coherent frontal boundaries moving back and forth through the valley rather than sporadic bursts of wind and warm air, such as in the intermittently turbulent boundary layer. The role of turbulence is more explicitly examined in our subsequent paper, and is somewhat addressed in the previous.

9). We are limited in space as for the number of figures. It was decided to start these panels at 00UTC. The statement on previous line:

“Prior to 0000 UTC, the temperatures in the lowest elevations of the SLC were nearly uniform (not shown).”

Is intended to show that the temperature field at 00 UTC differs from temperature field during the previous hours.

10). The magnitude of the front can be approximated from the difference in temperature between the two ISS sites, which differ in elevation by 13 m and are ~1 KM apart. As the warm front passes over ISS-S the temperature gradient between the sites is ~7K/KM. Similar temperature differences are recorded at other adjacent sites, for example along the Harkers ridge HOBO transects. I have clarified in the text that the frontal magnitude is estimated from adjacent sites.

11.) The location of the upstream sounding is now clearly marked in Fig 1. It is labeled Lehi. It is at the northern edge of the Utah valley near the Jordan Narrows gap through the Traverse Mountains.

12.) Line 467-468 of the text specifies that the lower boundary is a Monin-Obukhov layer for momentum flux while surface sensible and latent heat fluxes are turned off. There is no radiative forcing in the model, so the changes in temperature a purely mechanical.

13.) Following another reviewers comments we have greatly simplified this section of the manuscript and now use a shallow water equation formulation. We have removed the approximation for the momentum flux convergence as it was presented, and now use a simple parameterization with the flow aloft and a drag coefficient to demonstrate that dp/dx within the CAP is sometime in antitriptic balance and proportional to the speed of the flow squared (as in Sun et al. 2013).

14). KSLC is at 1289 m and ISS-S at 1325 m, giving a difference in elevation of 36 m. I have added this to the text in describing the slope between the two sites.

15.) Turbulent mixing is examined in great detail in a forthcoming modeling study, but we lacked the data to resolve most of the mixing within the KHW which generally occurred well above the surface.