Estimating Changes in Snow Pack Characteristics at The Aspen Ski Area For The Years 2030 And 2100

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Abstract. We evaluate how climate change resulting from increased greenhouse gas emission may affect the quantity and quality of snow at the Aspen Mountain in the years 2030 and 2100. Snow quantity was evaluated using the Snowmelt Runoff Model (SRM; Martinec, 1975) and snow quality was evaluated using SNTHERM (Jordan, 1991). Climate changes were evaluated using MAGICC/SCENGEN (Wigley, 2004) and the output from 5 GCM's based on which GCMs best simulate present climate patterns. The climate change estimates were run using the relatively mid-range, low, and high greenhouse gas emissions scenarios: A1B, B1, and A1FI. Climate sensitivity (how much global mean temperature would increase for a doubling of CO_2) was set at 3°C. We also tested for climate sensitivities of 1.5 and 4.5°C. We then bracketed potential climate changes by using the mean of the five models, a warm-wet model projection (HadCM2), and a warm-dry model projection (ECHAM3).

The date when snow starts to accumulate is pushed back by six to seven days by 2030 and anywhere from 1.5 to 4.5 weeks by 2100. This is caused by increase in air temperature. Earlier snowfall amounts in the warm-wet scenario melted in October and caused a lag in peak snow depth at the top of the mountain. For mid-winter snows, a 15% increase in snowfall compensates for a 1.5°C increase in air temperature such that there was little change in snow depth. Snow depth in 2030 during spring break showed about a 7-25% decline in the base area, with small decreases near the top of the mountain. However, the onset of the spring avalanche cycle (melt initiation) started earlier by 4-5 days in all model runs. All model runs show skiable snow for all elevations on Aspen Mountain in 2030, but by 2100 this is only true for the B1 scenario. Snow depth goes to almost zero for the base area in 2100 under the A1B emission scenario. In the A1FI scenario, snow depth goes to near zero for the entire lower two-thirds of the mountain. The effect is substantially reduced under the low emissions B1 scenario. In the A1B scenario, even in 2100 with a 4-5°C increase in air temperature, there is little change in overall snow depth in the elevation bands from 9,500 feet to the top of the mountain, compared to current levels. This is true from 10,300 ft and above for the high emission A1FI scenario, which show a more substantial 6-7°C warming. In spite of the reduction in snowpack, snow quality has less than a 20% increase in the density of the top few inches of snow by 2030, which in our judgment does not substantially reduce the quality of the snow. By 2100 densities could be substantially higher.

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