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Modeled Active-Layer Depth and its Annual Timing along the Qinghai-Xizang Railroad on the Tibetan Plateau

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The soil thermal regime of the Tibetan Plateau is modeled by applying a one-dimensional heat transfer model with phase change. The two main forcing parameters are surface air temperature and snow depth. Air temperature is from the ERA-40 reanalysis, and snow depth is derived from snow-water equivalents from passive microwave satellite data, in combination with climatological daily snow density. Soil bulk density as well as the concentrations of fine and coarse-grained soils are obtained from the SoilData System of the IGBP-DIS. Daily fields of soil temperature are simulated, ranging from the soil surface down to 30 m depth, with a horizontal grid cell resolution of 25 km x 25 km. Soil moisture does not exist as spatial fields at different depths, so results are presented for three different standard soil moisture regimes. The active-layer trend analysis is based on daily fields of thaw depth for the 22-year period January 1980 through December 2001. Positive active-layer depth trends for all Tibetan permafrost regions are simulated in response to positive trends in air temperature, with the strongest warming trend (+1.38 cm/year) for the Northern Tibetan Plateau. Discontinuous permafrost regions within the model domain reveal a significant warming trend of +1.23 cm/year, and sporadic/isolated permafrost regions a trend of +0.66 cm/year. Trends are virtually independent of soil moisture content. The Day of Year when the active-layer depth is reached (in general between early September and mid October, depending on the region) is subject to strong interannual variation of up to three weeks, and reveals mostly insignificant trends. As an application, simulated active-layer deepening and interannual variability is analyzed along the tracks of the Qinghai-Tibet railroad line that is presently under construction through discontinuous permafrost at altitudes of more than 4000 m.