Accuracy standards for Landsat climate data records: an assessment of cloud/shadow masking and topographic normalization over snow-covered surfaces

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Accuracy standards are proposed to guide thematic climate data record (TCDR) development from Landsat TM, ETM+, and OLI/TIRS visible/infrared snow-covered area (SCA) retrievals. Because Landsat's observational timescale now exceeds four decades, and interests in long-term seasonal snow cover monitoring are increasing, efforts to design high quality Landsat snow cover CDR products are timely. While Landsat's acquisition frequency is constrained to every 16 days, concurrent acquisitions by TM and ETM+ during 2000-2011, and now ETM+ and OLI/TIRS from 2013 onwards, guarantees the potential for 8-day SCA retrievals. Based on case studies from western Wyoming, central Idaho, and southwestern Montana, USA, minimum accuracy standards are developed for each image pre-processing algorithm prior to 30-meter SCA retrieval. Using a random sub-sample from 730-processed TM, ETM+, and OLI/TIRS images during discrete peak snow accumulation and snowmelt intervals from 2000-2014, time domain error metrics are derived for cloud saturation, cloud/shadow masking, and topographic normalization. Our results suggest that SCA map accuracy is strongly tied to the ability to minimize cloud/shadow omission errors in particular. If the heritage automated cloud cover assessment (ACCA) algorithm is combined with solar geometry cloud shadow projections, average map accuracy for TM, ETM+, and OLI/TIRS sensors is 95% with a standard deviation of 4% for partially cloudy images. For images with mountainous terrain, local solar illumination is highly variable in time, across space, and each sensor exhibits a distinct wavelength-dependent response to snow-covered surfaces. To reduce observational differences across the Landsat mission, the accuracy of Landsat image pre-processing algorithms must be established before SCA retrieval, and cloud/shadow-masking confidence must increase to guarantee that Landsat TCDRs possess multitemporal consistency and are free from non-climatic biases.

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