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New metrics for permafrost model validation

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Meteorological data from Arctic regions are historically scarce, due principally to their remote and inhospitable nature, and therefore, decreased human habitation compared with more temperature environments. Simulating the future climate of these regions has become a problem of significant importance, as recent projections indicate a high degree of sensitivity to forecasted increases in temperature, as well as the possibility of strong positive feedbacks to the climate system. For these climate projections to be properly constrained, they must be validated through comparison with relevant climate observables in a past time frame. Active layer thickness (ALT) has become a key descriptor of the state of permafrost, in both observation and simulation. As such, it is an ideal metric for model validation as well. Concerted effort to create a database of ALT measurements in Arctic regions culminated in the inception of the Circumpolar Active Layer Measurement (CALM) project over 20 years ago. This paper examines in detail the utility of Alaskan CALM data as a model validation tool. Derivation of ALT data from soil temperature stations and boreholes is also examined, as well as forced numerical modelling of soil temperatures by surface air temperature (SAT) and ground surface temperature (GST). Results indicate that existing individual or repeated borehole temperature logs are generally unsuitable for deriving ALT because of coarse vertical resolution, and failing to capture the exact timing of maximum annual thaw. However, because of their systematic temporal resolution, and comparatively fine vertical resolution, daily soil temperature data compare favourably with the ALT measurements from CALM data. Numerical simulation of subsurface temperatures also agree well with CALM data if forced by GST; results from SAT-forced simulations are less straightforward due to coupling processes, such as snow cover, that complicate heat conduction at the ground surface.