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Improving Hydrological Models by Applying Air Mass Boundary Identification in a Precipitation Phase Determination Scheme

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Many hydrological models determine precipitation phase using surface weather station data. However, there are a declining number of augmented weather stations reporting manually observed precipitation phases, and a large number of automated observing systems (AOS) which do not report precipitation phase. Automated precipitation phase determination suffers from low accuracy in the precipitation phase transition zone (PPTZ), i.e. temperature range -1˚C to 5˚C where rain, snow and mixed precipitation is possible. Therefore, it is valuable to revisit surface based precipitation phase determination schemes (PPDS) while manual verification is still widely available.

Hydrological and meteorological approaches to PPDS are vastly different. Most hydrological models apply surface meteorological data into one of two main PPDS approaches. The first is a single rain/snow threshold temperature (T_{RS}), the second uses a formula to describe how mixed precipitation phase changes between the threshold temperatures T_S (below this temperature all precipitation is considered snow) and T_R (above this temperature all precipitation is considered rain). However, both approaches ignore the effect of lower tropospheric conditions on surface precipitation phase. An alternative could be to apply a meteorological approach in a hydrological model. Many meteorological approaches rely on weather balloon data to determine initial precipitation phase, and latent heat transfer for the melting or freezing of precipitation falling through the lower troposphere. These approaches can improve hydrological PPDS, but would require additional input data. Therefore, it would be beneficial to link expected lower tropospheric conditions to AOS data already used by the model.

In a single air mass, rising air can be assumed to cool at a steady rate due to a decrease in atmospheric pressure. When two air masses meet, warm air is forced to ascend the more dense cold air. This causes a thin sharp warming (frontal inversion) of air in the vertical profile between the lower cold air mass and the warm air mass above. The warm air forced up often cools to its condensation temperature, becoming the main cause of winter precipitation. A common exception comes with cold air mass boundaries (CAMB) not having a frontal inversion in the vertical profile. Therefore, CAMB precipitation occurs under very different lower tropospheric conditions, than other precipitation.

Changes in continuous hourly AOS temperature and wind could be used to identify different types of surface air mass boundaries. When identified rain and snow observations occurring immediately before CAMB were separated from all other observations, the T_S and T_R values -1˚C, 3˚C respectively, were found to be 1˚C cooler than the T_S and T_R for non-CAMB observations. Analyzing CAMB separately reduced total misclassified precipitation from 7.0% to 5.4% (23% improvement) in the PPTZ. However, this tool only allows a statistically better chance for correct precipitation phase determination; it is incapable of adjustments for deviations from an average vertical temperature lapse rate.