

461 **Supplementary Information.**

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463 **S1 Diurnal Cycle Analysis**

464 Figure [S1](#) compares cloud and convection metrics between the COSMO-CLM and
465 MPAS simulations. The comparison shows that COSMO-CLM simulates on average
466 more cloud cover at 500 hPa (near the surface) that peaks in the early to mid-morning
467 hours, while MPAS simulates more cloud cover at 400 hPa that peaks in the afternoon
468 (local time is approximately UTC+6; Fig.[S1a](#)). Although only vertically integrated
469 hydrometeors are available, the signal comes from cloud water (Fig.[S1b](#)) rather than
470 ice (not shown). COSMO-CLM shows a somewhat later onset and peak in updrafts
471 on the TP (Fig.[S1c](#)), however convection metrics like convective available potential
472 energy (CAPE) and convective inhibition (CIN) (only available for COSMO-CLM)
473 show exemplary diurnal cycles. Therefore, we hypothesize that the issue is related to
474 the representation of low cloud or cloud microphysics (e.g., autoconversion), which we
475 are currently exploring further in sensitivity studies.

476 **S2 Snow Water Equivalent Analysis**

477 Figure [S2](#) compares simulated snow-water equivalent in the different datasets at GSOD
478 station locations.

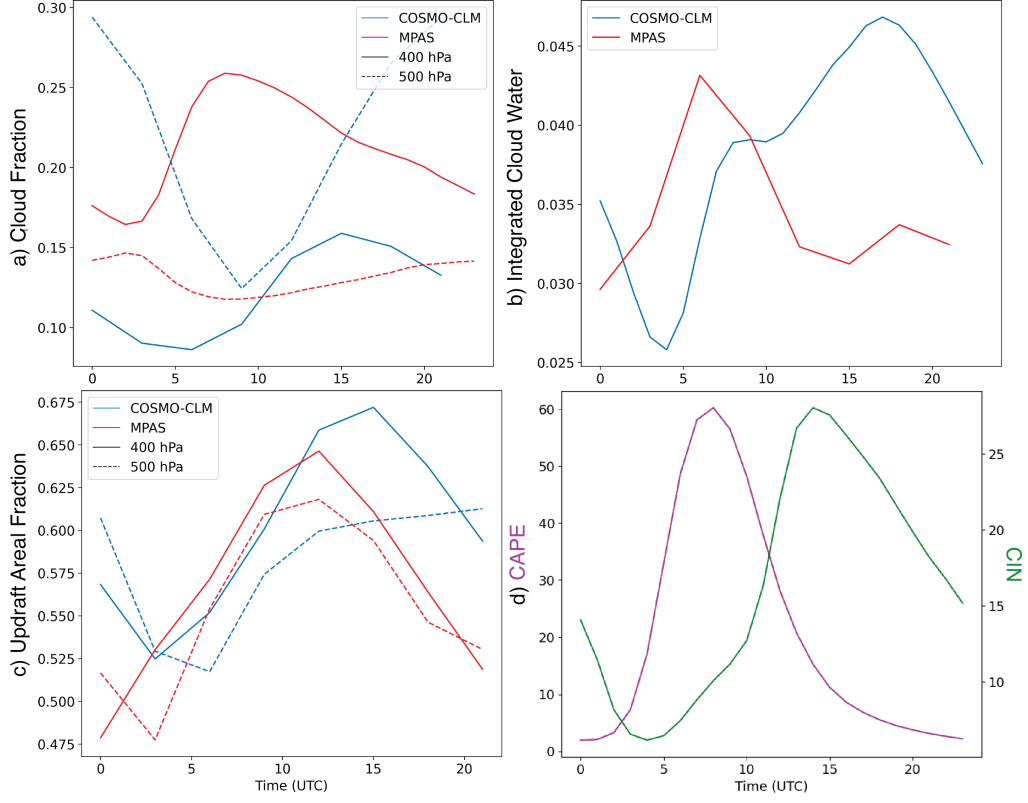


Fig. S1 Diurnal cycle of the following variables, averaged over the JJAS season and above 2800 m on the TP: (a) cloud cover fraction at 500 and 400 hPa; (b) vertically integrated cloud water [$kg m^{-2}$]; (c) updraft areal fraction; and (d) mean surface-layer CAPE and CIN from two simulations, COSMO-CLM and MPAS. All data were area-averaged over the analysis domain and above 2800 m. For the updraft computation, the mean diurnal cycle was first computed and then masked for positive values (data from MPAS were provided as a mean diurnal cycle) and we note that reversing the order of operations did not significantly alter the results in COSMO-CLM.

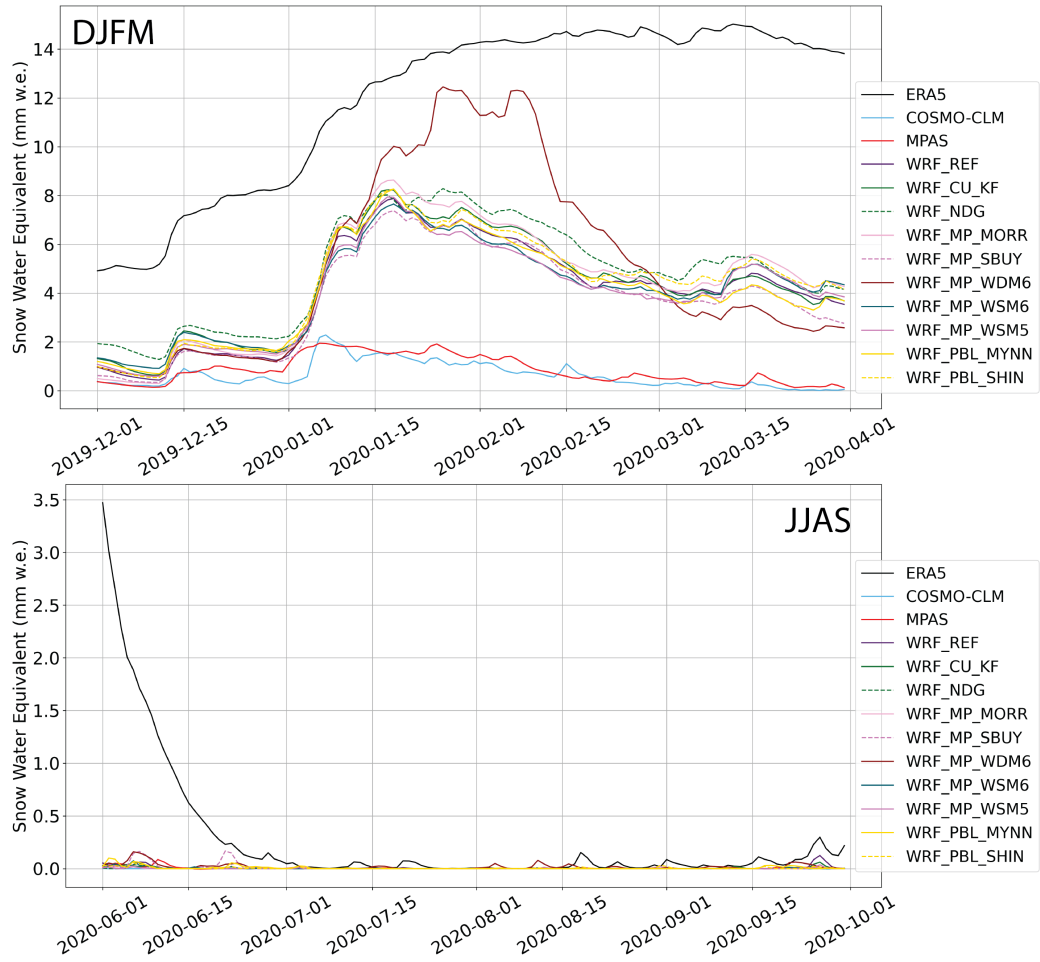


Fig. S2 A time series of simulated daily snow water equivalent [$kg\,m^2$] averaged over all GSOD stations used for the TAS comparison (Fig. 8).