Influence of lateral flow on land surface fluxes in southeast Australia

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Abstract: Most land surface models (LSMs) used in climate models do not explicitly represent lateral hydrologic connectivity, unlike surface hydrologic models typically used in water management applications. This is because LSMs were primarily developed to model the partitioning of surface fluxes in climate models and use a 1-dimensional representation of surface hydrology to capture the vertical movement of water through the soil column. The assumption is that the lateral flow of water has a negligible influence on surface fluxes at resolutions relevant to climate modelling. With current computational resources, climate modelling resolutions are increasing (finer than 10 km), and LSMs have been rapidly evolving to incorporate finer surface heterogeneity and additional process representations for added skill. There is an emerging understanding that the lateral flow of water can substantially impact regional land surface and lower atmospheric states at finer resolutions (Arnault et al., 2021; Fersch et al., 2020) and is associated with variations in the regional carbon cycle (Norton et al., 2022). Therefore, it is necessary to assess the influence of lateral flow on surface fluxes in Australia to inform the development of high-resolution regional climate models.

In this study, we perform regional land surface simulations at various resolutions over southeast Australia to quantify the impact of including lateral flow, and its variation with increasing model resolution. We use the WRF-Hydro hydrologic modelling system with the NoahMP land model (Gochis et al., 2020) for the simulations, calibrated to streamflow observations in the region. The modelling system represents the feedback of overland and shallow subsurface lateral flow to soil moisture and surface fluxes of the LSM, and we study the influence of these processes at resolutions of 1 to 10 km. Preliminary results indicate that the lateral redistribution of water results in wetter conditions of up to 15% in low lying areas primarily in spring and summer. Our results suggest that lateral flow has the potential to influence land-atmosphere interactions and vegetation responses to hydrologic extremes in this region, which need to be explored.

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