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Influence of the background wind on the local soil moisture-precipitation feedback

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The soil moisture - precipitation (SMP) feedback is of key importance for climate and climate change. A positive SMP feedback tends to amplify the hydrological response to external forcings (and thereby fosters precipitation and drought extremes), while a negative SMP feedback tends to moderate the influence of external forcings (and thereby stabilizes the hydrological cycle). The sign of the SMP feedback is poorly constrained by the current literature. Theoretical, modeling and observational studies partly disagree, and have suggested both negative and positive feedback loops. Can wet soil anomalies indeed result in either an increase or a decrease of precipitation (positive or negative SMP feedback, respectively)?

Here we investigate the local SMP feedback using idealized convection-resolving simulations. An idealized simulation strategy is developed, which is able to replicate both signs of the feedback loop, depending on the environmental parameters. The mechanism relies on horizontal soil moisture variations, which may develop and intensify spontaneously. The positive expression of the feedback is associated with the initiation of convection over dry soil patches, but the convective cells then propagate over wet patches, where they strengthen and preferentially precipitate. The negative feedback may occur when the wind profile is too weak to support the propagation of convective features from dry to wet areas. Precipitation is then generally weaker and falls preferentially over dry patches. The results highlight the role of the mid-tropospheric flow in determining the sign of the feedback. A key element of the positive feedback is the exploitation of both low convective inhibition (CIN) over dry patches (for the initiation of convection), and high CAPE over wet patches (for the generation of precipitation).

The results of this study are consistent with previous modeling studies that found a large sensitivity of the SMP feedback with respect to the representation of convection in atmospheric models.