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Regime transitions in near-surface temperature inversions at the Antarctic: a conceptual model

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A conceptual model is used in combination with observational analysis to understand regime transitions of near surface temperature inversions at night as well as in Arctic conditions. The model combines a surface energy budget with a bulk parameterization for turbulent heat transport. Energy fluxes or feedbacks due to soil and radiative heat transfer are accounted for by a ‘lumped parameter closure’, which represents the ‘coupling strength’ of the system. Observations from Cabauw, Netherlands and Dome C, Antarctica, are analyzed. As expected, inversions are weak for strong winds, whereas large inversions are found under weak wind conditions. However, a sharp transition is found between those regimes, as it occurs within a narrow wind range. This results in a typical, S-shaped dependency. The conceptual model explains why this characteristic must be a robust feature. Differences between the Cabauw and Dome C cases are explained from differences in coupling strength (being weaker in the Antarctic). For comparison, a realistic column model is run. As findings are similar to the simple model and the observational analysis, it suggests generality of the results.

Theoretical analysis reveals that, in the transition zone near the critical wind speed, the response time of the system to perturbations becomes large. As resilience to perturbations becomes weaker, it may explain why, within this wind regime, an increase of scatter is found. Finally, the so-called ‘heat flux duality’ paradox is analyzed. It is explained why numerical simulations with prescribed surface fluxes show a dynamical response different from more realistic, surface-coupled systems.