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Radon as a tracer of mixing in terrestrial convective boundary layers

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The vertical distribution of the natural radioactive tracer radon–222 through the atmospheric boundary layer (ABL) is a quantitative indicator of exchange and mixing between the terrestrial surface and the lower atmosphere. Radon is therefore a useful tool in the effort to reduce systematic errors in the representation of boundary layer processes in weather and climate prediction models. We present surface time series and vertical profiles of radon and meteorological quantities in daytime boundary layers over rural inland Australia, obtained during winter and summer field campaigns with samplers based on the ground and mounted on motorized gliders. Cases range from light-wind strong convection to high-wind near-neutral conditions, and from clear skies to moderately developed fair-weather cumulus and stratocumulus. Due to its 3.8-day half–life, radon concentrations in the free atmosphere are constrained to be 1–3 orders of magnitude lower than near-surface values. This ensures that a large radon jump is always maintained between the ABL and the air high above. As a consequence of the "top-down" mixing process, radon displays a range of gradients in the upper mixed layer of the ABL that are sensitive to the degree of exchange (entrainment) across the interface. In the presence of active boundary layer clouds, the venting of air from the sub-cloud layer is strongly enhanced, leading to radon concentrations that remain high within the main part of the cloud layer and only diminish towards its top. Vertical profiles from a number of flight case studies are related to the time series of surface radon concentrations, which exhibit a huge variability in diurnal amplitude between periods of light-wind clear-sky conditions (large amplitude) and high-wind cloudy conditions (small amplitude).