Geophysical Research Abstracts, Vol. 8, 05419, 2006
SRef-ID: 1607-7962/gra/EGU06-A-05419

Vertical radon measurements in the boundary layer as a tool for quantifying mixing and exchange processes and evaluation of climate models

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The radioactive noble gas Radon-222 is emitted from terrestrial surfaces at a rate that for practical purposes is horizontally uniform and constant over diurnal timescales. As its only significant sink in the atmosphere is radioactive decay (which is precisely calculable), radon has long been recognised as an excellent passive tracer for continental air, and has been used extensively over the last decade in model evaluation studies of large-scale horizontal transport. Although it has also been recognised that datasets resolving the vertical distribution of radon can add value to studies of tropospheric mixing and deep convective transport, such datasets remain rare. Within the planetary boundary layer, vertically-resolved measurements of radon concentrations can be used to construct direct quantitative measures of the degree of mixing and exchange with the surface and the free atmosphere, and can also be used to improve estimates of regionally-integrated surface fluxes for climatically sensitive gases with complex source and sink functions (e.g. CO_2). The use of radon in boundary layer process and model evaluation studies therefore carries the potential to significantly improve systematic errors in the reproduction of diurnal and seasonal cycles in weather and climate prediction models on a range of scales.

The Australian Nuclear Science and Technology Organisation (ANSTO) is developing and implementing measurement systems for obtaining highly accurate radon concentration profiles throughout the boundary layer and above. A tower-based system for continuous long-term measurement of radon at 2m and 50m has been operational since July 2005 at the ANSTO meteorological tower in Sydney, and a second system

for measurements at 20m and 200m at the Cabauw meteorological site in The Netherlands is currently under construction. Concurrently, a sampling system enabling the measurement of radon concentrations from airborne platforms on a campaign style basis has been developed by ANSTO, and in October 2005 was successfully deployed for the first time on a light aircraft in convective boundary layers over Meningie, South Australia. Together with supporting meteorological and turbulence measurements, these new systems are yielding exciting insights into mixing and exchange processes across the atmospheric surface layer, the nocturnal stable layer, and the convective mixed layer, and are beginning to be used in the evaluation of boundary layer mixing schemes in weather and climate models, as well as in the regional integration of surface fluxes of climatically sensitive gases.