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Continuous hourly radon gradient observations at Cabauw, the Netherlands - a review of main features of the 2007-2009 dataset

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We report on results of the first three years of radon time series and radon gradient observations at the Cabauw site in the Netherlands (51.971^{o}N, 4.927^{o}E). Two 1500 L dual flow loop, two filter radon detectors with a sensitivity better than 40 mBq m^{-3} are installed at the site, ensuring that gradients can be defined to the required precision every hour. The inlets are mounted on the main meteorological tower at 20 m and 200 m above ground level. The Cabauw site, located 50 km inland on a polder in an agricultural region, has a simple orography with surface elevations changing by a few metres at most within a 20 km radius. The radon gradient observations are part of our larger program to characterise turbulent mixing processes throughout the lower atmosphere. The two other related measurement projects are the continuous hourly measurements of radon gradients in the surface layer on a 50 m tower at Lucas Heights, Australia (34.053ºS, 150.981ºE; see Chambers et al, this conference), and campaign-style measurements of radon profiles up to altitudes of 4000 m above ground level using light aircraft (see Williams et al., this conference).

We observe well pronounced absolute radon and radon gradient signals at Cabauw, influenced by atmospheric processes occurring on seasonal, synoptic, and diurnal time scales.

Seasonal variability. The lowest radon concentrations were observed in winter and summer, when the dominant air mass fetch was the Atlantic Ocean. In spring and autumn, concentrations were generally high, as the air mass fetch was primarily over western and/or central Europe. Even when the fetch was oceanic during the latter seasons, it was often over the North Sea where radon concentrations are perturbed by land emissions. In autumn, radon concentrations from the mainland European fetch were more than three times larger than the corresponding concentration from the Atlantic/North Sea regions.

Synoptic variability. The radon signal is typically a combination of local and remote influences. Synoptic and diurnal components can be separated by comparing the radon signal at 20 m and 200 m, and by using wind speed as a selecting condition. For most of the data, the diurnal signal is strongly pronounced in the 20 m data, especially when wind speeds are lower than 3 ms^{-1}. In low wind conditions, local influences dominate and the radon signal is predominantly a combination of local source variations and diurnal changes in the local mixing depth. On the other hand, under high wind conditions (> 7 ms^{-1}) the remote signal dominates at both levels, reflecting variations in the radon source function over a wider fetch area, the geographic extent of which is defined by the radon half-life and prevailing wind conditions. The separation of these two signals provides an opportunity to compare subsets of radon time series and gradient observations with a column or regional model and thus evaluate mixing and transport schemes characteristic for the site and the region.

Diurnal variability. Diurnal composite plots show that the 20 m signal is characterized by an early morning maximum and early afternoon minimum, predominantly reflecting changes in the boundary layer mixing depth on this time scale. The amplitude of this cycle ranged from 450 mBq m^{-3} in winter to 1460 mBq m^{-3} in spring. The 200 m Cabauw data exhibited a modest mid-morning maximum, consistent with upward mixing of radon from the surface as the nocturnal inversion breaks down.