Review of 222Rn Emissions

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Radon-222 is emitted from all ice-free land surfaces. Ice cover inhibits its emission. Oceans, where its parent material, 226Ra, is in solution emit about two orders of magnitude less 222Rn than continents (Lambert et al., 1982). Negligible amounts are emitted in gas emanating from volcanoes (Lambert et al., 1979). There are no other sources of atmospheric 222Rn.

Turekian et al. (1977) estimated 222Rn flux from continents to be 1.2 atoms cm-2s-1. Lambert et al. (1982) derived an average 222Rn flux of 0.71 atoms cm-2s-1 for the northern, and 0.72 atoms cm-2s-1 for the southern hemisphere. Conen and Robertson (2002) proposed an emissions distribution of 1 atom cm-2s-1 for 60oS to 30oN, declining linearly northwards to 0.2 atoms cm-2s-1 at 70oN. All these values are based on atmospheric 222Rn concentration and 210Pb deposition flux measurements. Based on directly measured 222Rn soil flux and related parameters, Schery and Wasiolek (1998) modelled global 222Rn flux on a 1o x 1o grid and estimated a global average of 1.6 (±0.4) atoms cm-2s-1 with significant regional variations (map can be accessed on Stephen D. Schery's home page: http://www.nmt.edu/~schery/.)

In validating global circulation models (GCM), 222Rn flux is generally assumed to be spatially uniform and 1 atom cm-2s-1 from ice-free land surfaces and zero from oceans. However, including emissions of 0.01 atoms cm-2s-1 from oceans between 60oS and 60oN improved predictions of measured 222Rn concentrations by the GCM NIRE-CTM-96 at remote sites in the South Indian Ocean and Antarctic (Taguchi et al, 2002). For continental emissions Lee and Feichter (1995) concluded that a non-uniform distribution (1 atom cm-2s-1 from 60oS to 60oN; 0.005 atoms cm-2s-1 from 60oN to 70oN) would improve predictions of global transport and deposition of 210Pb, a daughter product of 222Rn. A similar assumption (1 atom cm-2s-1 from 60oS to 60oN; 0.5 atoms cm-2s-1 from 60oN to 70oN) was made in a comparison of scavenging and deposition processes in global models at the WCRP Cambridge Workshop 1995 (Rasch et al., 2000). Predictions by the GCM STOCHEM3 for 222Rn concentrations in the surface layer based on a uniform (1 atom cm-2s-1) and a northwards declining emissions distribution are currently compared to long-term 222Rn concentrations measured at 17 ground based stations around the globe (L.B. Robertson, D.S. Stevenson & F. Conen; University of Edinburgh, in preparation). (Radon concentration data for 1991-1996 at Mauna Loa and Bermudas can be found at http://www.eml.doe.gov/databases/radon/).

In the long term, a reduction of the ice-covered land surface might result in very small increases in global 222Rn emission. However, some of this increase would be offset by increasing sea levels and subsequent submersion of coastal areas.

Regionally, seasonal variations of ± 25% (Schü_ler, 1996, cited in: Levin et al, 1999; Whittlestone et al., 1998) or of a factor of two (Schery & Wasiolek, 1998) have been reported, with largest emissions during summer and smallest emissions in winter.

Important factors affecting 222Rn emission are 226Ra content of the soil (Schery & Wasiolek), precipitation (Ferry et al., 2001), soil moisture (Nazaroff, 1992), water table depth (Conen & Robertson) and soil texture (Dörr & Münnich, 1990).

References

Conen, F. & Robertson, L.B. 2001. Latitudinal distribution of Rn-222 flux from continents. Tellus, 54B, 127-133.

Dörr, H.and Münnich, K.O. 1990. 222Rn flux and soil air concentration profiles in West-Germany. Soil 222Rn as a tracer for gas transport in the unsaturated soil zone. Tellus, 42B, 20-28.

Ferry, C., Beneito, A., Richon, P. & Robe, M.-C. 2001. An automatic device for measuring the effect of meteorological factors on radon-222 flux from soils in the long term. Radiation Protection Dosimetry, 93, 271-274.

Lambert, G., Polian, G., Sanak, J., Ardouin, B., Buisson, A., Jegou, A. & Le Roulley, J.C. 1982. Cycle du radon et de ses descendants: application à l'étude des échanges troposphère-stratosphère. Annales de Géophysique, 38, 497-531.

Lambert, G., Buisson, A., Sanak, J. & Ardouin,. 1979. Modification of the atmospheric polonium 210 to lead 210 ratio by volcanic emissions. Journal of Geophysical Research, 84, 6980-6986.

Lee, H.N. and Feichter, J. 1995. An intercomparison of wet precipitation scavenging schemes and the emission rates of 222Rn for the simulation of global transport and deposition of 210Pb. Journal of Geophysical Research, 100, 23,252-23,270.

Levin, I., Glatzel-Mattheier, H., Marik, T., Cuntz, M. and Schmidt, M. 1999. Verification of German methane emission inventories and their recent changes based on atmospheric observations. Journal of Geophysical Research, 104, 3447-3456.

Nazaroff, 1992. Radon transport from soil to air. Reviews of Geophysics, 30, 137-160.

Rasch, P.J., Feichter, J., Law, K., Mahowald, N., Penner, J., Benkovitz, C., Genthon, C., Giannakopoulos, C., Kasibhatla, P., Koch, D., Levy, H., Maki, T., Prather, M., Roberts, D.L., Roelofs, G.-J., Stevenson, D., Stockwell, Z., Taguchi, S., Kritz M., Chipperfield, M., Baldocchi, D., McMurry, P., Barrie, L., Balkanski, Y., Chatfield, R., Kjellström, E., Lawrence, M., Lee, H.N., Lelieveld, J., Noone, K.J., Seinfeld, J., Stenchikov, G., Schwartz, S., Walcek, C. and Williamson, D. 2000. A comparison of scavenging and deposition processes in global models: results from the WCRP Cambridge Workshop of 1995. Tellus, 52B, 1025-1056.

Taguchi, S., Iida, T & Moriizumi, J. 2002. Evaluation of the atmospheric transport model NIRE-CTM-96 by using radon-222 concentrations. Tellus, 54B, 250-268.

Turekian, K.K., Nozaki, Y. & Benninger, L.K. 1977. Geochemistry of atmospheric radon

and radon products. Annual Review of Earth Planetary Sciences, 5, 227-255.

Schery S.D. & Wasiolek M.A. 1998. Modelling radon flux from the earth's surface. In: Radon and Thoron in the Human Environment, Proceedings of the 7th Tohwa University International Symposium, (eds A. Katase & M. Shimo), pp. 207-217, World Scientific, Singapore.

Whittlestone, S., Zahorowski, W. and Schery, S.D. 1998. Radon flux variability with season and location in Tasmania, Australia. Journal of Radioanalytical and Nuclear Chemistry, 236, 213-217.

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