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Precise measurement of atmospheric helium isotopes

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Several recent papers have addressed the question of whether the atmospheric ^{3}He/^{4}He ratio is decreasing with time. Sano et al. measured the ^{3}He/^{4}He ratio of air samples collected over a 10-year period at various sites in Japan and claimed an apparent 1-2% decrease in the ratio. Lupton and Graham reported a slope of +0.009±0.043 %/year (2σ) for the time rate of atmospheric ^{3}He/^{4}He change (TROC) based on the Pacific marine air collected over a 17-year period. Pierson-Wickman et al. measured ^{3}He/^{4}He ratios of air trapped in historical metallurgical slag in an attempt to study secular variation of the ratio. Taking into account of data, they proposed a TROC of -0.014±0.007 %/year. Recently Lupton and Evans reported that a TROC could be between -0.0102 and +0.0019 %/year, which corresponds to a 0.3% decrease at the most in the air ^{3}He/^{4}He over the past 3 decades. Even though many efforts have been devoted to secular variation of air helium, the change of atmospheric ^{3}He/^{4}He ratio with latitude and longitude have not been assessed since the pioneer work of Mamyrin et al. We have developed an analytical system to measure atmospheric ^{3}He/^{4}He ratios precisely by using a static vacuum operation mass spectrometer and an ultrahigh-vacuum purification line. Repeated analysis of a sample calibrated against a standard shows the precision of about 0.2% error margin (2σ). This system has been applied to the evaluation of ^{3}He/^{4}He ratio of He Standard of Japan (HESJ), and to the assessment of atmospheric variation of latitude. Observed ^{3}He/^{4}He ratio of HESJ, 20.405±0.040 R_{air} (2σ) agrees well with the value of 20.408±0.044 R_{air} by Lupton and Evans, but is smaller than the recommended value of 20.63±0.10 R_{air} in a literature. Air samples collected from 45˚N to 20˚N in the Far East show a slight decrease of ^{3}He/^{4}He ratio with latitude. Even though the variation is attributable to an experimental artifact, it may not preclude the possibility that the anthropogenic release of crustal ^{4}He

is significant in the high latitude region of the northern hemisphere.