



Cosmic ray modulation of infra-red radiation in the atmosphere

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Cosmic rays produce small charged clusters, known as molecular cluster ions, as they pass through the lower atmosphere. Neutral molecular clusters such as dimers and complexes are expected to make a small contribution to the radiative balance, but atmospheric absorption by charged clusters has not hitherto been observed. Here we describe results from an atmospheric experiment where a thermopile filter radiometer tuned to a $9.15\mu\text{m}$ absorption band, already associated with infra-red absorption of molecular cluster ions, was used to monitor changes following events identified by a cosmic ray telescope sensitive to high energy ($>400\text{MeV}$) particles, principally muons at the surface. The change in longwave radiation in this absorption band due to molecular cluster ions is 7 mWm^{-2} for each event recorded by the cosmic ray telescope. The integrated atmospheric energy change for each event is 1.9 Jm^{-2} , whereas the energy density of a typical air shower (40m radius from a 10GeV primary) is estimated to be 10^{-13} Jm^{-2} , representing a direct amplification factor of 10^{12} . This infra-red absorption from molecular cluster-ions is expected to occur continuously and globally, but calculations suggest that it has only a small effect on climate.