Geophysical Research Abstracts, Vol. 5, 10627, 2003

MIDDLE-ATMOSPHERIC RESPONSE TO A FUTURE INCREASE IN HUMIDITY CAUSED BY INCREASED METHANE EMISSION

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The response of the middle atmosphere to an increase in humidity arising from a possible future increase in CH_4 is examined in a general circulation model with interactive H_2O and O_3. A chemical parameterization allows the middle-atmospheric H_2O change to evolve naturally from an imposed change in tropospheric CH_4. First, a simulation of the year 2060 using postulated loadings of the radiatively-active gases is compared with a control simulation of the present-day atmosphere. Then, the particular contribution of the CH_4 (and hence H_2O) change to the observed difference is isolated by repeating the 2060 simulation without the projected CH_4 change. Under the IPCC SRES B2 scenario, the middle atmosphere in 2060 cools by up to $\sim$5 K relative to 1995, with the CH_4-derived increase in H_2O accounting for $\sim$10% of the change. The cooling is accompanied by a strengthened general circulation, intensified dynamic heating rates, and a reduction in the mean age of middle-atmospheric air. Around 20% of the increased prevalence of polar stratospheric clouds (PSCs) in 2060 is due to the microphysical effect of the extra H_2O, with the remainder attributable to the reduced vortex temperatures. Although the PSC increase facilitates release of reactive chlorine, this positive impact on chemical O_3 destruction is outweighed by the negative impact of the reduced total chlorine in 2060. Nonetheless, the H_2O increase does make the 2060 Arctic O_3 loss $\sim$15% greater than it would otherwise be.