Technical Note 2

Probabilistic Emissions Scenarios

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We provide a set of 3 emissions scenarios with known probability characteristics generated using an uncertainty technique known as the deterministic equivalent modeling method (DEMM). The approach and scenarios are described in more detail in Webster et al., 2001a.

Emissions of CO2, CH4, N2O, SF6, PFC, HFC, NOX, SOX, CO, NMVOC, NH3 and carbonaceous particulates from 1995 through 2100 at 5 year intervals are provided on a 1° by 1° latitude-longitude grid. The scenarios were generated using the MIT Emissions Prediction and Policy Analysis (EPPA) model described in detail in Babiker, et al., 2001. (For published applications see Babiker et al., 2000a,b.)

The emssions values were downscaled from aggregated EPPA regions using population as weights. A graphical presentation of these data at the global level is given in Reilly et al., 2000. This presentation (available as a (420 kB) PowerPoint file) includes a comparison of these scenarios to those presented in the IPCC Special Report on Emissions Scenarios and the atmospheric and climatic results of running the MIT IGSM (Prinn et al., 1999; Mayer et al., 2000; Wang et al., 1998) with both the SRES scenarios and the 3 scenarios we provide.

Briefly, the DEMM approach requires distributions for uncertain parameter inputs and then uses a statistical sampling technique to generate parameter sets. The full model (EPPA) is run with these parameter sets and then an nth order polynomial is fit to the outcomes of interest. A Monte Carlo analysis of 10,000 runs was then conducted, again using the input distributions, but simulating the polynomial fit rather than the underlying complex model to limit computation requirements. We then select parameter sets and using the underlying complex model to produce scenarios with a known probability for the outcomes of interest. DEMM has been applied to other components of our Integrated Global Systems Model (IGSM) elsewhere (Webster & Sokolov, 1998, 2000).

The 3 scenarios available here were selected as follows: We chose parameter sets that produced the median (50 percentile value) and 97.5 percentile value (upper) and 2.5 percentile value (lower) limit for CO2 emissions in 2100 (i.e. a range covering 95 percent of the distribution). Conditional on these values, we then chose parameter sets that produced 50 percentile values for each of the other emissions. Conditioning the other emissions on the likelihood of the CO2 emissions scenarios means that emissions of the non-CO2 substances are higher for the scenario conditioned on the 97.5 percentile than on that for the 50 percentile which are, in turn, higher than those conditioned on the 2.5 percentile value scenario of CO2 emissions because of generally positive correlation among emissions of these substances and CO2. This scenario selection design was chosen so that the resulting scenarios are approximately 2.5, 50, 97.5 percentile outcomes yet retain the characteristic that the scenarios for all substances are the result of internally consistent scenarios given the structure of the EPPA model.

Because we have multiple outcomes of interest (emissions of different substances) and there are interactions of these substances in the atmosphere and as they affect climate, the scenarios cannot be strictly interpreted as producing a 2.5, 50, and 97.5 range for climate outcomes (conditioned on 50 percentile value of climate and atmospheric chemistry uncertainties). To do so requires that the Monte Carlo process for the entire earth system model be conducted simultaneously (including the selection of emissions scenarios). Preliminary results of such an exercise are reported in Webster et al. 2001b.

Some important caveats: These scenarios do not include emissions from natural sources or sinks of carbon, other GHGs, or other substances. They include emissions of carbon and other substances from land use change (deforestation) and agriculture (waste burning, livestock, rice production, soils) but do not include carbon sinks due to forest regrowth. Babiker et al. (2001) provides a complete inventory for 1995 for the reference case. Also, note that we include uncertainty in emissions for most of these substances in our base year of 1995. This means that, for a predetermined level of natural emissions and/or uptake, any particular anthropogenic emissions scenario in our set may not be consistent with an observed trend in concentrations of gases in the atmosphere (e.g. CH4, N2O). To be consistent with recent trends in atmospheric concentrations, for example, our high emissions scenario will require a low estimate of net natural emissions of CH4. The range of anthropogenic emissions we project for 1995 is not, in our evaluation, inconsistent with the uncertainty range for natural emissions/sinks for those substances where concentrations data are relatively well-established. For many of the short-lived substances, data on atmospheric concentrations is too poorly known to strongly constrain emissions estimates.

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