PF7) # An Integrated Emission Model of Greenhouse Gases to Assess Regional Climate Change

Yun Seob Moon · Sung Nam Oh · Myung Suk Hyun
National Research Lab., Meteorological Research Institute, KMA,
Seoul, Korea

I. Introduction

Greenhouse gases (GHGs) such as carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), chlorofluorocarbons (CFCs), sulphur hexafluoride (SF_6), together with water vapour (H_2O) and ozone play an important role in determining the earth's climate. The primary cause of the enhancement of GHGs is the global use of fossil fuels to generate heat, power, and electricity for a growing world population, as well as the changes in the land use, especially for agriculture. In addition, biomass burning and biofuel emissions play major roles in the GHG emissions in the Asian region because they produce large amounts of carbon monoxide (CO), nonmethane volatile organic compounds (NMVOC), black carbon(BC) and other gases. Recently. in springtime, monthly averaged biomass burning CO emissions was shown high in Southeast Asia, South Asia, and southern China from Measurement of Pollution in the Troposphere (MOPITT) and Total Ozone Mapping Spectrometer (TOMS) satellites. Tropospheric ozone also (which amounts to about 10% of the total ozone content) is the fourth significant GHG. Changes in stratospheric and tropospheric ozone contribute differently to climate change and have different effects on humans and ecosystem (Low, 1998).

The aim of this study is to summarize an integrated emission model of GHGs about the relative importance of feedbacks in the biosphere and climate system. We are also to estimate the GHG concentrations using the integrated emission model in East, Southeast and South Asia including the Korean Peninsula as the emission data set of regional or global climate models.

2. An integrated emission model of greenhouse gases

The emission model includes the trace gases such as CO_2, CH_4, CO, N_2O, CFC-11 and CFC-12. The emission modules current global, annual estimates of historical emissions have been incorporated for the period 1900 to 1985. For the period 1985 to 2100 four sets of scenarios were chosen. The underlying scenario assumptions are based on a study of the different sources of trace gas emissions grouped as: nature, energy, agriculture and industry.

The emission modules provide the input for the concentration module. the emission and concentration of CO_2 is linked to an ocean module, and a deforestation module, together reflecting the carbon cycle. Atmospheric CO_2 concentration is then modelled according to the following equation:

$$pCO_2(t) = pCO_2(t-1) + \int_{t-1}^{t} [ATMCF*(FSEM(x) + OCEA(x) - TNEP(x) + THDIST(x))]dx \qquad (1)$$

where $pCO_2(t)$ is the atmospheric CO_2 concentration at time t, $pCO_2(0)$ is the initial CO_2 concentration at time t=0, $ATMCF$ is the factor that converts emissions of CO_2 into concentrations, $FSEM(t)$ is the fossil fuel combustion flux at time t (in GtC/yr), $OCEA(t)$ is the flux from oceanic mixed layers to the atmosphere (in GtC/yr), $TNEP(t)$, the carbon flux by total net ecosystem production (in GtC/yr), and $THDIST(t)$ is the total carbon flux of CO_2 due to human disturbance.

The structure of the greenhouse trace gases of CH_4, CO, N_2O, CFC-11 and CFC-12 is quite different from that of CO_2. Generally, these trace gas concentrations are expressed as:

$$pX(t) = pX(t-1) + \int_{t-1}^{t} (convfX*emX(x) - remvlX*pX(x-\triangle x))dx \qquad (2)$$

where $pX(t)$ is the tropospheric concentration of a trace gas at time t (in ppb), $emX(t)$ is the global emission of a trace gases at time t (in Tgy^{-1}), $convfX$ is the conversion factor of trace gas X (in ppb Tg^{-1}), and $remvlX$ is the removal rate of trace gas X (in y^{-1}).

The concentration of methane is derived from the global CH_4-CO-OH cycle by simulating the main atmospheric chemical processes influencing the global concentrations of these trace gases. The removal rates of CH_4 and CO rate determined by the uptake, transport and oxidation rates of these gases, the latter being dependent on the OH concentration.

For CFCs the removal rate is supposed to be inversely proportional to the atmospheric lifetime, which is assumed to be constant. Finally nitrous oxide concentrations are computed from emissions by taking a constant atmospheric lifetime into account.

The total changes in radiative forcing ($\triangle Q_{tot}$) resulting from concentration change of CO_2, CH_4, N_2O, CFC-11 and CFC-12 is modelled according to the following equation:

$$\triangle Q_{tot} = a \cdot ln(pCO_2/pCO_2(0)) + b \cdot (\sqrt{pCH_4} - \sqrt{pCH_4(0)}) + c \cdot ((\sqrt{pN_2O} - \sqrt{pN_2O(0)})$$
$$+ d \cdot pCFC\text{-}11 + e \cdot pCFC\text{-}12 \qquad (3)$$

where pX is the concentrations of CO_2, CH_4, N_2O, CFC-11 and CFC-12, and $pX(0)$ is the initial concentrations. The total changes in radiative forcing of CO_2, at Anmyeon and Jeju from 1990 to 2001 is 0.2 to 0.7 W/m^2.

3. Conclusions

We established the integrated emission model to assess the GHG emissions. The future climate change will depend on the emissions of trace gases and aerosols. Growth in fossil fuel use, the adoption of alternative energy sources, the rate of deforestation, Asian dust events and desertification, and policy measures will strongly affect future emission pathways. Therefore, we need to reduce uncertainties of the emissions of aerosols, GHGs and other trace gases, together with the feedback mechanisms of these future emission levels.

Reference

Low, P. S.(1998) Tropospheric ozone: The missing GHG in the UNFCCC equation, Linkages journal, 3, N4, 32-34.