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Interannual variability in the direct radiative climate forcing by global greenhouse gases over the past quarter century: development of an annual greenhouse gas index

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The perturbation to radiative climate forcing which has the largest magnitude and the least scientific uncertainty is the forcing related to changes in long-lived and well mixed greenhouse gases, in particular carbon dioxide, methane, nitrous oxide and the halocarbons (mainly CFCs). All of these gases have been monitored around the world since the 1970's mainly by NOAA's Climate Monitoring and Diagnostics Laboratory (CMDL), in Boulder, Colorado, and its forerunner, the Geophysical Monitoring for Climatic Change (GMCC) program. This paper discusses these observations for the past 26 years, a period when NOAA/CMDL's global network was adequate to form reliable global averages. CMDL operates five baseline climate observatories at Pt. Barrow, Alaska; Mauna Loa, Hawaii; Trinidad Head, California, American Samoa; and South Pole Station, Antarctica, where the concentrations of the greenhouse gases are measured continuously as well as by flask sample. Through several global networks, including the cooperative air flask sampling program at over 50 global sites, both carbon dioxide and other key greenhouse gases are monitored. All air samples from the global cooperative program are analyzed for carbon gas concentrations and isotopic ratios in Boulder. The latter sites are in clean, unpolluted regions such as on seacoasts where the measurements are generally representative of large-scale maritime regions. In addition, air samples are being obtained aboard volunteer commercial ships between the U.S. and New Zealand, between New Zealand and Peru, and between the U.S. and Africa. More recently CMDL has begun to sample the vertical profile of

carbon gases over continents utilizing aircraft and tall communications towers. The data are used to form hemispheric and global average atmospheric mixing ratios and growth rates for the long-lived greenhouse gases. These data will be presented here and analyzed in terms of their changes and the changes in radiative forcing during the 26-year period encompassing 1978 through 2004. The interannual changes in forcing are large and are dominated by changes in the carbon dioxide growth rate. These changes are related to environmental events which must be understood in order to improve projections of future climate. The interannual variation in radiative forcing has been used to develop an annual greenhouse gas index which will be useful in the future as attempts to manage the atmospheric greenhouse gas burden become part of business as usual.