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Global carbon sources and sinks: 2007 update

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The increase in atmospheric carbon dioxide (CO₂) is the single largest human perturbation of the climate system. Its rate of change reflects the balance between human-driven carbon emissions and the dynamics of a number of terrestrial and ocean processes that remove or emit CO₂. It is the long term evolution of this balance that will determine to large extent the speed and magnitude of climate change and the mitigation requirements to stabilize atmospheric CO₂ concentrations at any given level. In this talk, we'll present the most recent trends in global carbon sources and sinks, updated to 2007, with particularly focus on major shifts occurring since 2000. Atmospheric CO₂ growth: Annual mean growth rate of atmospheric CO₂ was 2.2 ppm per year in 2007 (up from 1.8 ppm in 2006), and above the 2.0 ppm average for the period 2000-2007. The average annual mean growth rate for the previous 20 years was about 1.5 ppm per year. This increase brought the atmospheric CO₂ concentration to 383 ppm in 2007, 37% above the concentration at the start of the industrial revolution (about 280 ppm in 1750). The present concentration is the highest during the last 650,000 years and probably during the last 20 million years. [ppm = parts per million]. Emissions from land use change: Land use change was responsible for estimated net emissions of 1.5 PgC per year to the atmosphere. This is largely the difference between CO₂ emissions from deforestation and CO₂ uptake by reforestation. Emissions for 2006 and 2007 were extrapolated from the previous 25-year trend of 1.5 PgC per year. Land use change emissions come almost exclusively from deforestation in tropical countries with an estimated 41% from South and Central America, 43% from South and Southeast Asia, and 17% from Africa. An estimated 160 PgC were emitted to the atmosphere from land use change during the period 1850-2007 [1 Pg = 1 billion tons or 1000 x million tons]. Emissions from fossil fuel and cement: Emissions increased from 6.2 PgC per year in 1990 to 8.5 PgC in 2007, a 38% increase from the Kyoto reference year 1990. The growth rate of emissions was 3.5% per year for the period of 2000-2007, an almost four fold increase from 0.9% per year in 1990-1999. The actual emissions growth rate for 2000-2007 exceeded the highest forecast growth rates for the decade 2000-2010 in the emissions scenarios of the Intergovernmental Panel on Climate Change, Special Report on Emissions Scenarios (IPCC-SRES). This makes current trends in emissions higher than the worst case IPCC-SRES scenario. Fossil fuel and cement emissions released approximately 348 PgC to the atmosphere from 1850 to 2007. Regional fossil fuel emissions: The biggest increase in emissions has taken place in developing countries, largely in China and India, while developed countries have been growing slowly. The largest regional shift was that China passed the U.S. in 2006 to become the largest CO₂ emitter, and India will soon overtake Russia to become the third largest emitter. Currently, more than half of the global emissions come from less developed countries. From a historical perspective, developing countries with 80% of the world's population still account for only 20% of the cumulative emissions since 1751; the poorest countries in the world, with 800 million people, have contributed less than 1% of these cumulative emissions. Carbon intensity of the economy: After decades of improvements, the carbon intensity of the global economy, the carbon emitted per unit of Gross Domestic Product (GDP), was stalled during the period 2003-2005. This change was largely caused by China's rapidly growing share in economic output and carbon emissions. Since 2005 China's energy intensity (which underpins carbon intensity) has decreased (improved) by 1.2% in 2006 and 3.7% in 2007 compared to 2005 levels (according to the National Energy Administration in China). CO₂ removal by natural sinks: Natural land and ocean CO₂ sinks have removed 54% (or 4.8 PgC per year) of all CO₂ emitted from human activities during the period 2000-2007. The size of the natural sinks has grown in proportion to increasing atmospheric CO₂. However, the efficiency of these sinks in removing CO₂ has decreased by 5% over the

last 50 years, and will continue to do so in the future. That is, 50 years ago, for every ton of CO₂ emitted to the atmosphere, natural sinks removed 600 kg. Currently, the sinks are removing only 550 kg for every ton of CO₂ emitted, and this amount is falling. Natural Ocean CO₂ sinks: The global oceanic CO₂ sink removed 25% of all CO₂ emissions for the period 2000-2007, equivalent to an average of 2.3 PgC per year. The size of the CO₂ sink in 2007 was similar to that in the previous year but lower by 0.1 PgC compared to its expected increase from atmospheric CO₂ growth. This was due to the presence of a La Nina event in the equatorial Pacific. The Southern Ocean CO₂ sink was higher in 2007 compared to 2006, consistent with the relatively weak winds and the low Southern Annular Mode (a circumpolar pressure oscillation between Antarctica and southern mid-latitudes). An analysis of the long term trend of the ocean sink shows a slower growth than expected of the CO₂ sink over the last 20 years. Natural Land CO₂ sinks: Terrestrial CO₂ sinks removed 29% of all anthropogenic emissions for the period 2000-2007, equivalent to an average of 2.6 PgC per year. Terrestrial ecosystems removed 2.9 PgC in 2007, down from 3.6 Pg in 2006, largely showing the high year-to-year variability of the sink. An analysis of the long term trend of the terrestrial sink shows a growing size of the CO₂ sink over the last 50 years. Conclusions: Anthropogenic CO₂ emissions have been growing about four times faster since 2000 than during the previous decade, and despite efforts to curb emissions in a number of countries which are signatories of the Kyoto Protocol. Emissions from the combustion of fossil fuel and land use change reached the mark of 10 billion tones of carbon in 2007. Natural CO₂ sinks are growing, but more slowly than atmospheric CO₂, which has been growing at 2 ppm per year since 2000. This is 33% faster than during the previous 20 years. All of these changes characterize a carbon cycle that is generating stronger climate forcing and sooner than expected. Further information: <http://www.globalcarbonproject.org/carbontrends>