The Human-perturbation of the Global Carbon Cycle and its Management for Climate Protection

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The human perturbation of the carbon cycle is driven by the combustion of fossil fuels and changes in land use and land use intensity. From 1850 to 2011, cumulative C-CO2 emissions from fossil fuels were 373 PgC, were 154 PgC from land use change.

Agriculture is the major source of greenhouse gases to the atmosphere from human activities not accounted in the global C-CO2 budget, and contributing to 10-12% of total anthropogenic ghg emissions. Most emissions are in the form of CH4 and N2O, which are estimated to be 1.4-1.7 PgC-CO2-equivalent (CO2-eq) y-1 for the year 2005.

The global anthropogenic CO2 perturbation leads to the creation of carbon sinks in the ocean and on land. The physical ocean responds to excess atmospheric CO2 through increased air-to-sea fluxes by dissolution of CO2 in surface water given the under-saturation state of the ocean3. The land responds to higher atmospheric CO2 through increased photosynthesis rate and increased water use efficiency, although other drivers such as nitrogen (N) deposition and changes in Land Use and Land Cover Change (LULCC) use and land use intensity also contribute to the current terrestrial sink.

For the period 1850-2011, the natural CO2 sinks removed 304 PgC of the 527 PgC of anthropogenic emissions leading to a cumulative airborne fraction of 58%, the fraction of total anthropogenic emissions remaining in the atmosphere. This fraction, and despite some evidence suggesting a positive trend, has largely remained constant over time resulting from the continue growth in the magnitude of the natural CO2 sinks up to present in response to growing anthropogenic CO2 emissions.

Pathways to climate stabilization require the deployment of a broad base portfolio of efficiency and fossil fuel replacement solutions to curb down greenhouse gases (GHG) emissions. Of the available mitigation portfolios, activities that involve components of the natural and managed carbon cycle are unique in at least two ways. First, there are already large established natural carbon sinks responsible for removing 55% of current anthropogenic carbon dioxide (CO2) emissions. This represents an economic subsidy worth trillions of dollars annually if an equivalent quantity had to be removed through available technologies. Thus, understanding and managing the dynamics of these sinks are of paramount importance. Second, biological mitigation activities require additional human appropriation of the Earth's net primary productivity (NPP) beyond its current use of 24-30%. This requirement places the climate mitigation agenda in direct competition with the agendas for food security, energy security and biodiversity conservation, all with needs for biomass and land in a growing quandary for global sustainable development. Some of the land-based activities with most promising potentials will be discussed in the context of the need for climate stabilization, particularly of stabilization below the safe level of 2degrees C above pre-Industrial.