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The need for a detection and attribution system for the carbon cycle

Ana Bastos[1], Na Li[1], and István Dunkl[2]
[1]Max Planck Institute for Biogeochemistry, Biogeochemical Integration, Jena, Germany (abastos@bgc-jena.mpg.de)
[2]University of Leipzig, Leipzig, Germany

Climate change is a consequence of the perturbation of the global carbon cycle through emission of CO_2 and other greenhouse gases through fossil fuel burning, large-scale deforestation and other human activities since the industrial revolution. These emissions have been buffered by about 50% by the land and ocean carbon sinks, which have increased in pace with anthropogenic emissions. At the same time, changes in temperature and precipitation patterns and extremes due to climate change influence the efficiency of the land and ocean carbon sinks, so that their efficiency is projected to decline as negative consequences of climate change become more important.

Recent studies have pointed out that the global land carbon sink might be already slowing down and even declining in some regions, e.g., Europe. Understanding to which extent these recent trends are driven by climate change and extremes, policy changes or other factors is key to predict how the land sink will evolve in the coming decades and better constrain the potential for land-based climate change mitigation. However, at time scales of few years to decades, the role of internal climate variability on trends and extremes in climatic drivers of ecosystem carbon cycling cannot be ignored, and may mask or amplify changes in carbon sinks due to anthropogenic activities.

Here, we argue that extending Detection and Attribution (D&A) to the carbon cycle realm is crucially needed to support both climate science and policy assessments. We will discuss a number of conceptual and practical hurdles that make this exercise arguably even more challenging than climate D&A. We further present developments that can open the way towards a D&A for the carbon cycle, including improved quantification of carbon fluxes over land, the progress towards fast-track assessments of carbon flux anomalies following weather extremes, and the use of D&A techniques to study recent trends in the carbon cycle.