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Top-down Atmospheric Inventories of CO₂ and CH₄ to Support the Global Stocktakes

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Parties to the Paris Agreement agreed to report GHG emissions and removals to the United Nations Framework Convention on Climate Change (UNFCCC), which will evaluate progress toward the NDCs through Global Stocktakes (GSTs) conducted at five-year intervals, the first of which is scheduled in 2023. National emission reports are based on “bottom-up” inventories of emissions or removals, derived from statistics such as the number tons of coal or barrels of oil delivered to the commercial, residential, industrial or transportation sectors or the number of acres of forest converted to agriculture. These methods can provide accurate estimates for fossil fuel emissions, but are somewhat less reliable for tracking changes in emissions from agriculture, forestry and other land use (AFOLU) or rapid changes in emissions due to disturbance events, such as hurricanes, drought, wildfires, or climate change.

CO₂ and CH₄ emissions and removals can also be estimated using high resolution, time-resolved measurements of their concentrations in the atmosphere. These data are analyzed with atmospheric inverse models to derive the flux distribution needed to match the observed atmospheric concentrations in the presence of the winds. These top-down atmospheric inventories complement bottom-up inventories by providing an integrated constraint on emissions from all sources and removals by all sinks. They are less source specific than bottom-up inventories, but are ideal for tracking rapid changes in large emitters or changes in emissions or uptake by forests, crops or the ocean associated with human activities, severe weather or climate change.

The GHG Task Team of the Joint CEOS/CGMS Working Group on Climate has embarked on an ambitious effort to use available ground-based and space based atmospheric measurements of CO₂ and CH₄ to develop a pilot, top-down atmospheric inventory to support the 2023 GST. CO₂ estimates derived from Orbiting Carbon Observatory-2 (OCO-2) data will be combined with surface CO₂ measurements from the World Meteorological Organization (WMO) Global Atmospheric Watch (GAW) and its partners to construct a CO₂ inventory. CH₄ estimates derived from Greenhouse gases Observing SATellite (GOSAT) and the Copernicus Sentinel 5 Precursor (S5P) data will be combined with ground based GHG data to construct a CH₄ inventory. These inventories will be compared with results from a parallel effort within CEOS to produce space-based bottom-up

inventories for emissions and removals by AFOLU to provide more source specific constraints on emissions and removals.

With the current measurement and modeling capabilities, these pilot inventories may not improve the results delivered by developed nations, where high-quality bottom-up inventories have been produced for decades. They should have greater value in the developing world, where countries have much less experience and resources for developing inventories and/or a much larger fraction of their emissions come from AFOLU. They are also expected to yield much greater insight into the evolution of the natural carbon cycle as it responds to human activities, extreme weather and climate change. The pilot products prepared for the 2023 Global Stocktake will provide the basis for iterative improvements in the products and their delivery to users for future GSTs.

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