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Can We Measure a COVID-19 Related Slowdown in Atmospheric CO_2 Growth? Sensitivity of Total Carbon Column Observations

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The COVID-19 pandemic caused annual CO_2 emission reductions estimated up to -8 % for 2020. This approximately matches reductions required year-on-year to fulfill the Paris agreement. We pursue the question whether related atmospheric concentration changes may be detected by the Total Carbon Column Observing Network (TCCON), and brought into agreement with bottom-up emission-reduction estimates. We present an original mathematical framework to derive annual growth rates from TCCON observations. Our approach guarantees robust results for the non-equidistant (clear-sky) sampling of solar absorption measurements of column-averaged carbon dioxide (XCO_2) and it includes for the first time a mathematically rigorous uncertainty calculation for annual growth rates. The min-max range of TCCON growth rates for 2012-2019 is [2.00, 3.27] ppm/yr with a largest one-year increase of 1.07 ppm/yr for 2015/16 caused by El Niño. Uncertainties are 0.38 [0.28, 0.44] ppm/yr limited by synoptic variability, including a 0.05 ppm/yr contribution from single-measurement precision. TCCON growth rates are linked to a UK Met Office forecast of a COVID-19 related reduction of -0.32 ppm yr^{-2} in 2020 for Mauna Loa. The separation of TCCON-measured growth-rates vs the reference forecast (without COVID-19) is discussed in terms of detection delay. A 0.6 [0.4, 0.7]-yr delay is caused by the impact of synoptic variability on XCO_2, including a »1-month contribution from single-measurement precision. A hindrance for detection of the COVID-19 related growth-rate reduction in 2020 is the ±0.57 ppm/yr uncertainty for the forecasted reference case (without COVID-19). Assuming ongoing growth-rate reductions increasing year-on-year by -0.32 ppm yr^{-2} would allow a discrimination of TCCON measurements vs the unperturbed forecast and its uncertainty – with a 2.4 [2.2, 2.5]-yr delay. Using no forecast but the max-min range of the TCCON-observed growth rates for discrimination only leads to a factor »2 longer delay. Therefore, forecast uncertainties for annual growth rates must be reduced. This requires improved terrestrial ecosystem models and ocean observations to better quantify the land and ocean sinks dominating interannual variability. The paper highlights the results of our first published study based on 4 midlatitude TCCON sites and gives an outlook to our ongoing work including all TCCON sites. TCCON will be a valuable basis to monitor the Paris process in the years to come.

Reference:

Sussmann, R., and Rettinger, M.: Can We Measure a COVID-19-Related Slowdown in Atmospheric CO2 Growth? Sensitivity of Total Carbon Column Observations, Remote Sens., 12, 2387, https://doi.org/10.3390/rs12152387, 2020.