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Using robust baseline extraction to examine synoptic-scale variability in European CO2

Alex Resovsky[1], Michel Ramonet[1], Leonard Rivier[1], Sebastien Conil[2], and Gerard Spain[3]
[1]Laboratoire des Sciences du Climat et de l'Environnement, Saint-Aubin, France (alex.resovsky@lsce.ipsl.fr)
[2]ANDRA, Chatenay-Malabry, France (Sebastien.Conil@andra.fr)
[3]National University of Ireland, Galway, Ireland (gerard.spain@nuigalway.ie)

Continuous measurements of long-lived greenhouse gases at ground-based monitoring stations are frequently influenced by regional surface fluxes and atmospheric transport processes, which induce variability at a range of timescales. Dissecting this variability is critical to identifying long-term trends and understanding regional source-sink patterns, but it requires a robust characterization of the underlying signal comprising the background air composition at a given site. Methods of background signal extraction that make use of chemical markers or meteorological filters yield reliable estimates, but often must be adapted for site-specific measurement conditions and data availability. Statistical baseline extraction tools provide a more generally transferable alternative to such methods. Here, we apply one such technique (REBS) to a continuous time series of atmospheric CO_2 readings at Mace Head, Ireland and compare the results to a modeled baseline signal obtained from local wind observations. We then assess REBS' performance at two continental sites within the Integrated Carbon Observation System (ICOS) network at which baseline signals are derived using back-trajectory analyses. Overall, we find that REBS effectively reduces the bias in wintertime baseline estimation relative to other statistical techniques, and thus represents a computationally inexpensive and transferable approach to baseline extraction in atmospheric time series. To investigate one potential application of such an approach, we examine wintertime synoptic-scale CO_2 excursions from the REBS baseline during the period 2015-2019. Our goal is to identify relationships between the timing and strength of such events and to better understand sub-seasonal variability in CO_2 transport over Europe.