Predictability of fossil fuel CO_2 from air quality emissions

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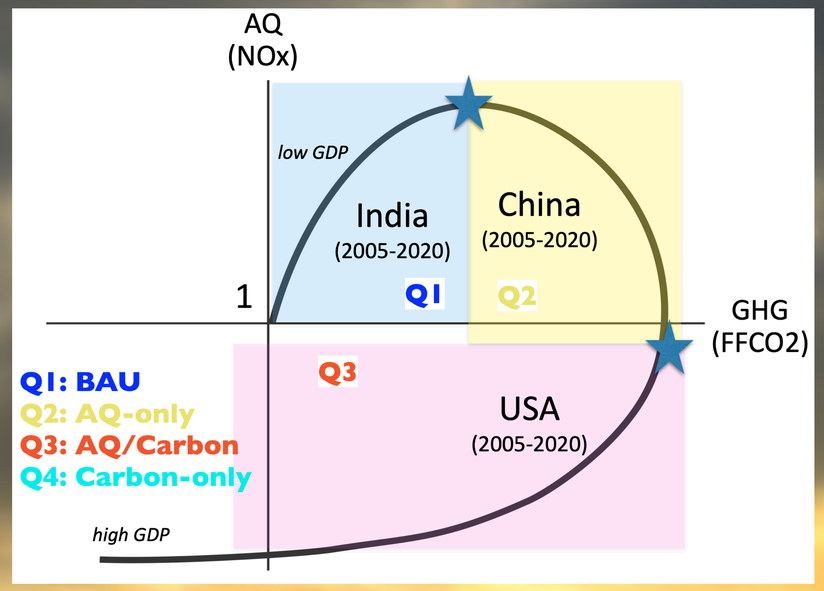
Q1. How does air quality (AQ) info help global $FFCO_2$ estimates?

Q2. How will changes in AQ mitigation impact carbon emissions?

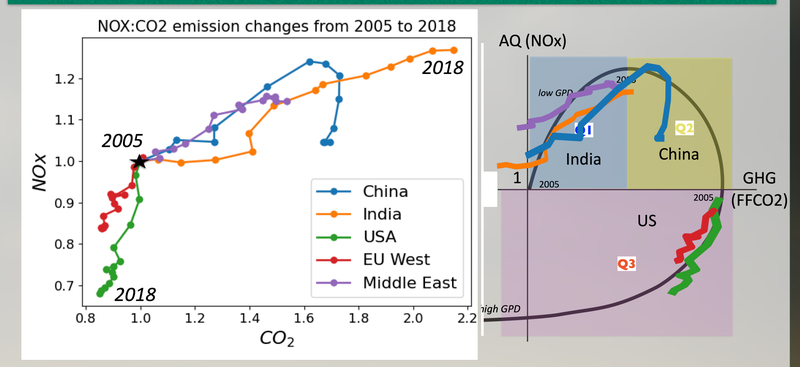
Summary

- Quantifying the coevolution of GHG gases and air quality pollutants can provide insight into underlying anthropogenic processes enabling predictions of their emission trajectories.
- We classify the dynamics of historic emissions in terms of a modified *Environmental Kuznets Curve (MEKC)*, which postulates the coevolution of $FFCO_2$ and NOx emissions as a function of economic development.
- The MEKC broadly captures the historic $FFCO_2$-NOx dynamical regimes as well as IPCC scenarios.
- Given these dynamics, we find the predictive skill of $FFCO_2$ given NOx emissions constrained by satellite data is less than 2% error at one-year lags for many countries and less than 10% for 4-year lags.

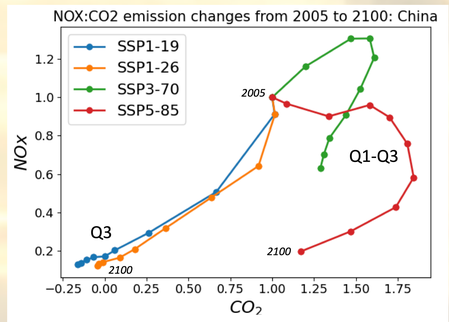


Modified Environmental Kuznets Curve (MEKC) *combines GHG and AQ emissions wrt GDP into a single graph*

Countries are at different points along the MEKC trajectory



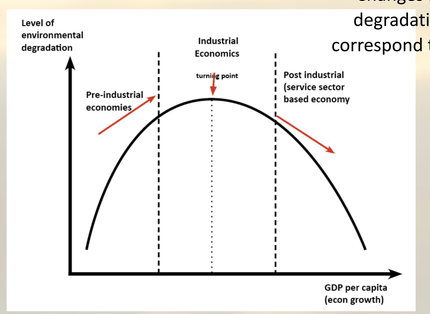
Future perspective of emission trajectory



Shared Socioeconomic Pathways (SSPs)

- Most of the predicted changes can be described by the MEKC.
- To achieve the socio-economic level considered in the optimistic scenarios (SSP1), substantial socio-economic/ technological developments would be required.

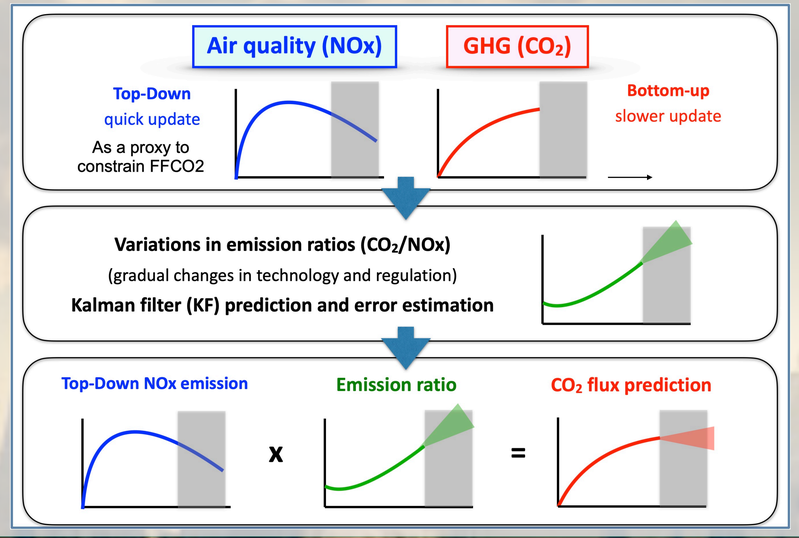
Changes in environmental degradation/improvement correspond to economic growth



Environmental Kuznets Curve (EKC)

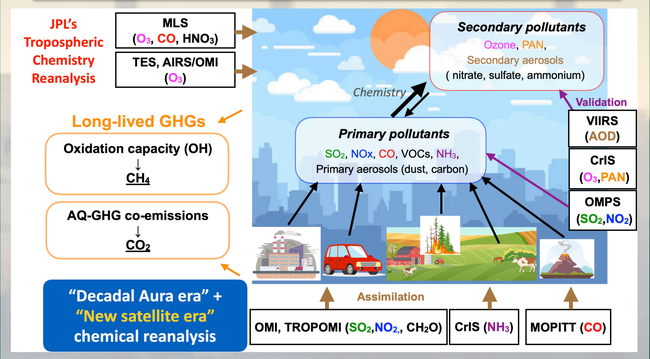
(for which Kuznets won the Nobel Prize in 1971)

Does knowing MEKC trajectory give us predictive skill in CO_2?



CO_2 flux prediction with Kalman Filter using top-down NOx emissions

Satellite-based emission estimations



- The MEKC is an important framework for understanding the co-evolution of AQ and carbon emissions in the context of large-scale macroeconomic growth. Comparing different countries at equivalent GDP could provide insight into their near-term trajectory. City-level MEKC will be evaluated.
- The proposed framework in conjunction with an increasing satellite constellation, including TEMPO, CO2M, GOSAT-GW, will provide valuable guidance to emission scenario development and evaluation at time-scales relevant to international assessments such as the Global Stocktake.
- The MEKC concept is a useful interpretive framework for both bottom-up and top-down approaches. Top-down approaches can provide low-latency information, especially for point-urban sources, whereas our predictions could help provide AQ-informed priors. Over larger scales, our approach can help partition net carbon fluxes and support attribution.

Remarks

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