Gauging the Potential Climate Change Impacts from WWTP N_2O Emissions

ABSTRACT

N_2O, or nitrous oxide, is a lesser-known but potent greenhouse gas, with over 300x the greenhouse warming potential of carbon dioxide. It is also one of six greenhouse gases recently classified by the U.S. Environmental Protection Agency (EPA) as a pollutant that can be regulated. While the Intergovernmental Panel on Climate Change (IPCC) has included N_2O in its various scenarios for climate change over the next century, one potential anthropogenic source of N_2O has not been included in their projections – namely, N_2O emissions from wastewater treatment plants (WWTPs). For this project, we added new projections for N_2O emissions from WWTPs to the IPCC climate change scenarios, to gauge the potential warming impact from this additional man-made source of N_2O.

BACKGROUND INFORMATION

Over the past two decades, the IPCC has developed several distinct scenarios which project possible climate changes in the 21st century related to greenhouse gas (GHG) emissions. The IPCC scenarios are quite comprehensive, but not all GHG sources have been accounted for – for example, N_2O emissions from WWTPs.

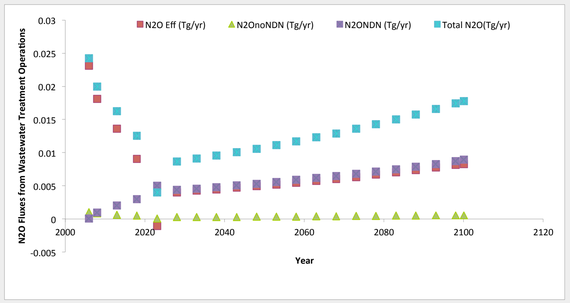

Figure 1. Prof. Chandran's projections for N_2O emissions from WWTP plants in the future, based on measurements from across the U.S. and Europe.

Here in the U.S., the EPA has established regulations regarding the amount of permissible N_2O pollution in the water (effluent) that has passed through a WWTP, but has had little reference for how much N_2O emissions could be expected in a gaseous state, driven off during the water treatment process. Recent research by Prof. Kartik Chandran of Columbia University's Dept. of Earth and Environmental Engineering has shown that the EPA has severely underestimated the potential amount of such emissions. This is a critical problem now, as plans for more stringent N_2O levels in WWTP effluent would likely lead WWTPs to handle the new effluent requirements by the cheapest means available: driving the N_2O off as a gas during water treatment.

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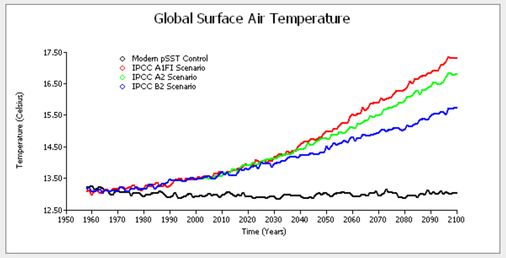
METHODS AND MATERIALS

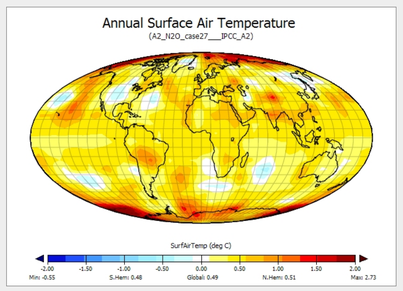
For this project, we added Prof. Chandran's latest estimates of potential N_2O emissions over the course of this century to the N_2O trends used for each of three of the IPCC's climate change scenarios: A1FI, A2 and B2. These estimates made use of Prof. Chandran's on-site measurement of WWTP emissions and new calculations for three emissions factors (EFs) used to scale the overall projections. The estimates were converted from Tg to ppmv for use in a climate model. We then used EdGCM (which contains the NASA/GISS GCM Model II) to run a series of climate simulations, and test whether we could see a measurable impact from the additional N_2O derived from WWTPs.

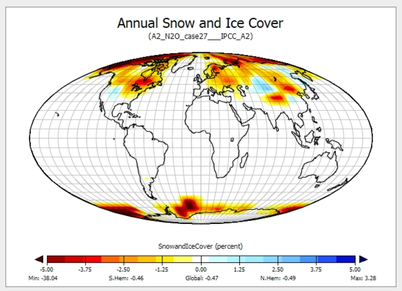
DISCUSSIONS

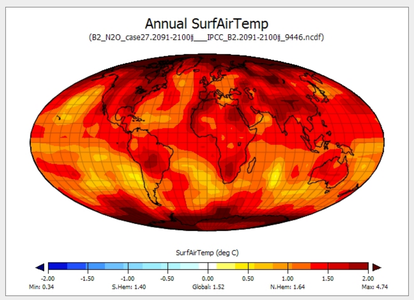
The greatest difference between the "standard" IPCC simulations and our special N_2O projections was the case with the maximum values assigned by Prof. Chandran to all three EFs influencing the amount of N_2O emissions – which are considerably larger than the EFs used by the EPA for their own calculations.

Figure 2. Time series plot of surface air temperatures showing how the GCM responds to various scenarios.









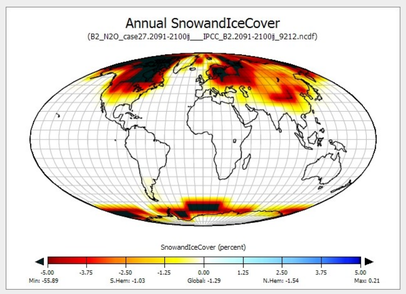


Figure 3. Maps of annual average surface air temperature and annual average snow and ice cover, comparing our climate simulations using the most extreme set of EFs for N_2O against the standard IPCC scenarios A2 and B2. Note that in both cases, global temperatures increase, by as much as 1.5 ˚C, and annual snow and ice cover is reduced by several percent in the polar regions. These results suggest that WWTP emissions do in fact have the potential to increase GHG further than originally thought.

CONCLUSIONS

Through the use of cutting-edge data on WWTP N_2O gas emissions and the EdGCM climate model, we were able to identify at least one set of emissions factors that would result in a noticeable increase in GHG warming even beyond that projected by the IPCC for this century. Our initial results will serve as guidelines for further research with higher resolution, coupled ocean-atmosphere GCMs that would provide more detailed information regarding regional climate impacts associated with WWTP N_2O emissions. Ultimately, all the data accumulated will serve to instruct people on the best methods of nitrogen removal at WWTPs, as well as provide a clearer vision of the danger zone of N_2O emission which we must strive to not breach.

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