

PNNL-34338

Core Model Proposal #379:

GCAM-USA non-CO₂ GHG emissions
in industrial and urban processes

June 2023

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U.S. DEPARTMENT
of **ENERGY**

Prepared for the U.S. Department of Energy
under Contract DE-AC05-76RL01830

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PACIFIC NORTHWEST NATIONAL LABORATORY
operated by
BATTELLE
for the
UNITED STATES DEPARTMENT OF ENERGY
under Contract DE-AC05-76RL01830

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Product: Global Change Assessment Model (GCAM)

Institution: Joint Global Change Research Institute (JGCRI)

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Reviewers: Matthew Binsted, Marshall Wise

Date committed: 03 May 2023

IR document number:

Related sector: GCAM-USA, emissions

Type of development: data

Purpose: This core model proposal adds state-level nonCO2 GHG emissions for industrial processes and urban processes sectors in GCAM-USA, which are currently missing from the model.

Description of Changes

CMP #245 was created to generate air pollutant emissions at the state level by introducing state-level industrial processes and urban processed supply sectors. As a consequence, the region-USA level supply sector structures of industrial processes and urban processes were removed. However, the non-CO2 greenhouse gases, namely CH4 and N2O, were still at the region-USA level and were overlooked when the industrial processes and urban processes sectors were deleted at the region-USA level in the GCAM v6 release.

This proposal downscales industrial and urban processes sectors CH4 and N2O **from national to state level**, by leveraging EPA state-level GHG data. Input.emissions were assigned in historical years, and then the same marginal abatement cost (MAC) curve was assigned to all states, copied from the region USA MACs.

1. File changes in gcamdata

Table 1. Level 2 emission files and key assumptions

Chunk name Output name	Sector / Gas	Output Type	Key Assumption
zchunk_L277.ghg_prc_USA.R L277.ghg_prc_USA	industrial processes, urban processes/CH4, N2O	input emissions/output driver (historical emissions)	shared out US total emissions based on state- level GHG emission shares by sector and gas for historical periods.
zchunk_L277.ghg_prc_USA.R L277.MAC_prc_USA	industrial processes, urban processes/CH4, N2O	marginal abatement cost (MAC) curves	copy region USA MACs to all states
zchunk_L277.ghg_prc_USA.R L277.MAC_prc_tc_average_USA	industrial processes, urban processes/CH4, N2O	technological change (TC) for MACs	copy region USA TCs to all states
zchunk_L277.ghg_prc_USA.R L277.MAC_prc_tc_average_USA	industrial processes, urban processes/CH4, N2O	mac.phase.in.time for MACs	copy region USA TCs to all states

2. New xml in configuration

There is one GHG emission file ([ind_urb_processing_sectors_USA.xml](#)) added in the configuration file for GCAM-USA.

New XMLs

```
<Value name =  
"ghg_usa">../input/gcamdata/xml/ind_urb_proc_ghg_emissions_USA.xml</Value>
```

Note that this xml needs to be read after the [ind_urb_processing_sectors_USA.xml](#), as the state-level supplysector structures need to be created first. Therefore, the updated order for GCAM-USA emissions input files is as below:

New XMLs

```
<!--nonGHG EMISSIONS USA-->  
    <Value name =  
"bld_emiss_USA">../input/gcamdata/xml/bld_emissions_USA.xml</Value>  
    <Value name =  
"othertrn_emiss_USA">../input/gcamdata/xml/othertrn_emissions_USA.xml</Value>  
    <Value name =  
"indenergy_emiss_USA">../input/gcamdata/xml/indenergy_emissions_USA.xml</Value>  
    <Value name =  
"elc_emiss_USA">../input/gcamdata/xml/elc_emissions_USA.xml</Value>  
    <Value name =  
"transport_emiss_USA">../input/gcamdata/xml/transport_emissions_USA.xml</Value>  
    <Value name =  
"prc_usa">../input/gcamdata/xml/ind_urb_processing_sectors_USA.xml</Value>  
    <Value name =  
"process_emiss_USA">../input/gcamdata/xml/ind_urb_proc_emissions_USA.xml</Value>  
    <Value name =  
"refining_emiss_USA">../input/gcamdata/xml/refinery_emissions_USA.xml</Value>  
  
<!--GHG EMISSIONS USA-->  
    <Value name =  
"ghg_usa">../input/gcamdata/xml/ghg_emissions_USA.xml</Value>  
    <Value name =  
"ghg_usa">../input/gcamdata/xml/elecS_ghg_emissions_water_USA.xml</Value>  
    <Value name =  
"ghg_usa">../input/gcamdata/xml/trn_ghg_emissions_USA.xml</Value>  
    <Value name =  
"ghg_usa">../input/gcamdata/xml/ind_urb_proc_ghg_emissions_USA.xml</Value>
```

Scenarios

Name	Description
Reference	Standard GCAM-USA reference test case
Tax-25	Standard GCAM-USA Tax25 test case

In addition to running GCAM-USA before and after this change, GCAM core was also run to obtain the previously aggregated processes emissions for comparison; these emissions are completely missing the current GCAM-USA.

Validation

1. USA total emissions

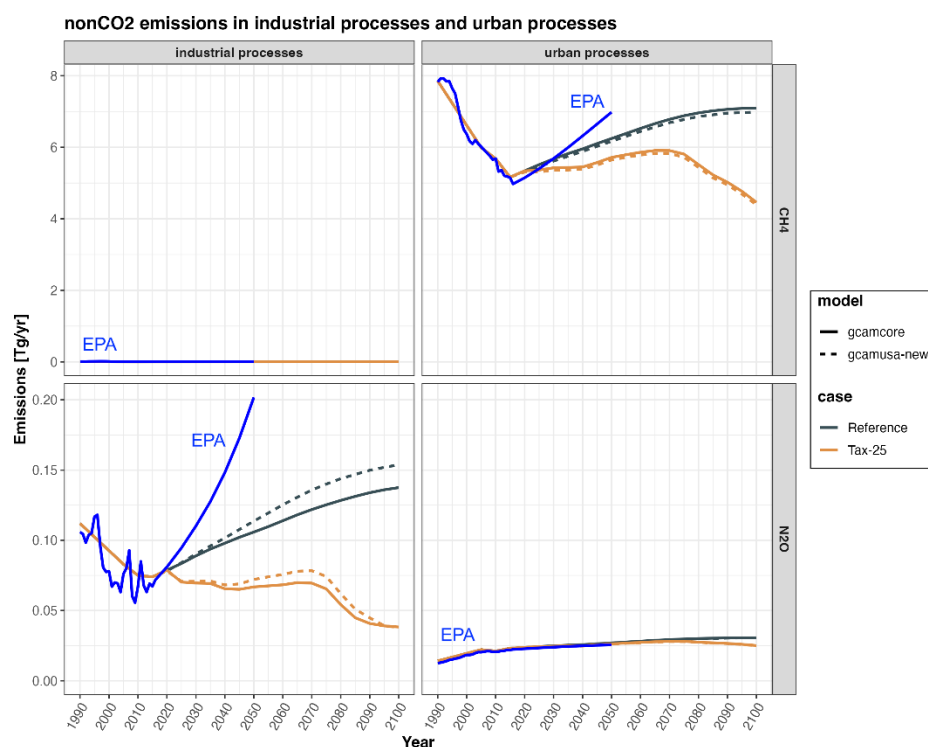


Fig.1 CH4 and N2O emissions in processes sectors, comparing between GCAM core and GCAM-USA new results. Note that for the current GCAM-USA, these sectors are completely missing (neither in region-USA or in states), so this chart shows emissions from the region-USA in the GCAM core runs. EPA data is from the [2019 EPA nonCO2 report](#).

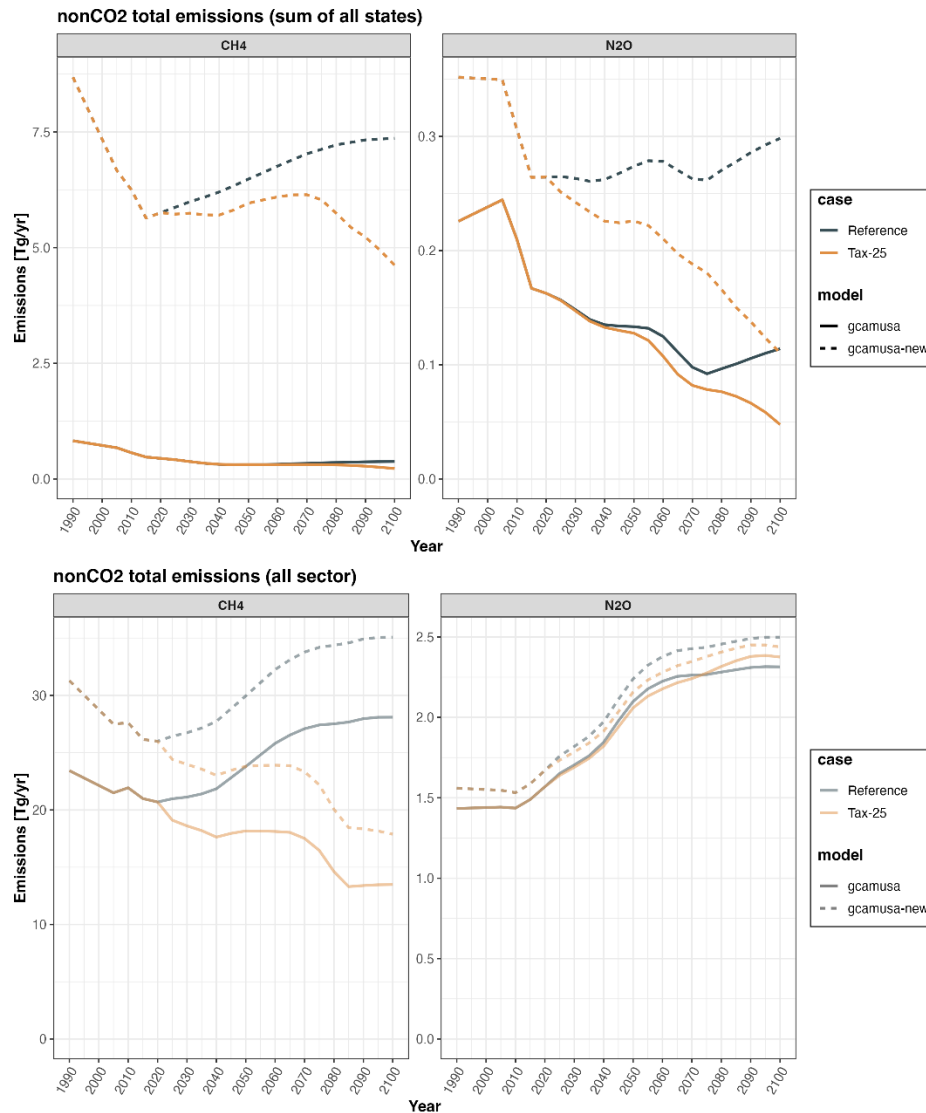


Fig.2 **Top:** Total CH4 and N2O emissions that have been represented at state level (sum of all states). GCAM-USA-new has higher emissions because processes emissions are added back. This figure only includes CH4/N2O emissions that are modeled at the state level (not all CH4/N2O emissions). **Bottom:** Total CH4/N2O emissions in the US from all sectors. With the update, total emissions increased as we now add the missed sectors back. Please note different y-scales from the left figure.

2. Sectoral comparison



Fig.3 CH4 (left) and N2O (right) emissions by sector. Emissions in all other sectors remain the same, except the new sectors added back to GCAM-USA (in blue boxes).

3. State-level comparison

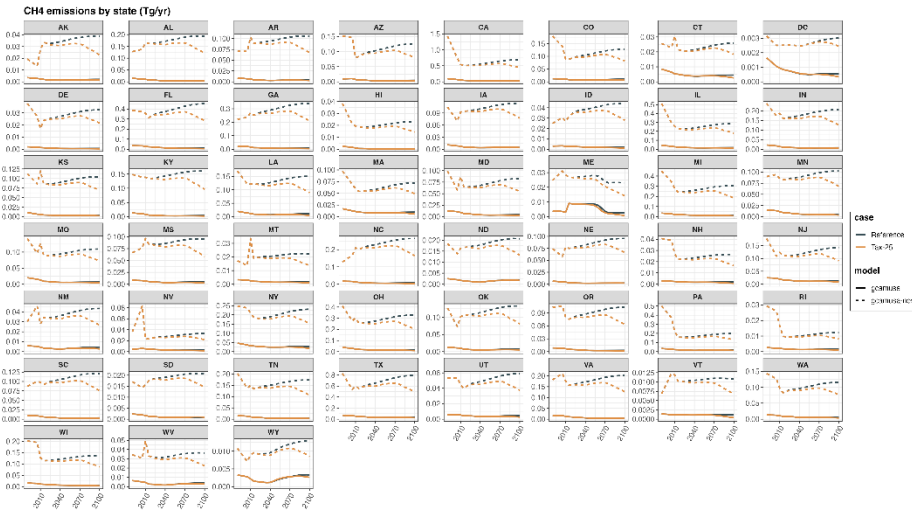


Fig.4 CH4 emissions by state. Emissions are higher in GCAM-USA-new because of the newly added processes emissions.

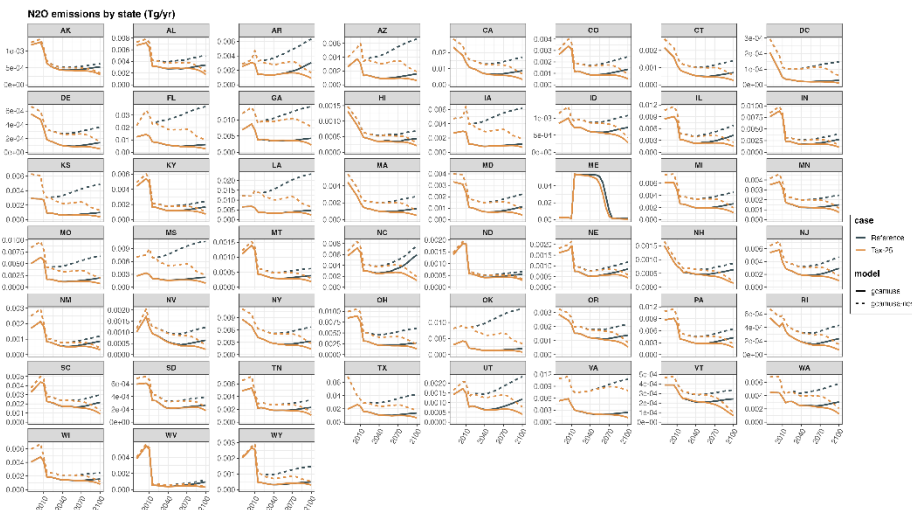


Fig.5 N2O emissions by state. Emissions are higher in GCAM-USA-new because of the newly added processes emissions.

Future work

This proposal is a simple GCAM-USA bugfix for the processes sectors only. However, as part of this proposal, the state-level historical GHG data for all sectors have been included (`GCAM-USA/emissions/EPA_state_ghg_emission_2022.csv`). This data can be used in future work to create emission factors specific to each state for other sectors (such as combustion, resource, and agriculture sectors, see the "source" column of the `EPA_state_ghg_emission_2022_mapping.csv` for a list of detailed EPA sectors), rather than using the same emission factors for all states as currently done for the region-USA for some sectors.

The 2021 EPA State-level Non-CO2 GHG Mitigation Report also includes marginal abatement cost curves for all sectors and gases, in a similar format as the global nonCO2 report, therefore, future work could also develop state-specific MACs for available sectors.

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