Core Model Proposal 375: Miscellaneous Bugfixes

Product: Global Change Analysis Model (GCAM)

Institution: Joint Global Change Research Institute (JGCRI)

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Related sector: energy, agriculture

Type of development: bugfix

Purpose: This Core Model Proposal contains several GCAM 6.0 bugfixes that are not included in CMP 371 and result in modest changes to model results.

Description of Changes

Energy Balance Bugs

The UC Davis transportation database didn't assign any natural gas usage to any vehicle technologies in the Japan region. As a result, the IEA Energy Balances' energy assigned to this sector (which is positive (albeit low) in some years) was used in setting region- and global-level energy balances but wasn't getting assigned to any demands in the model. With global natural gas markets this discrepancy was well within the solution tolerance. Moving to regional natural gas markets (proposal 308) caused calibration failures which were addressed in proposal 308 by relaxing the calibration solution tolerance from 0.001 to 0.002. In this proposal, we fix this bug in the data processing by revising the UCD_trn_data_CORE.csv file to have a nominal amount of natural gas assigned to buses in Japan, and we also readjust the tolerance back to 0.001.

The detailed industry chunks were using the wrong upstream energy balance data, prior to energy-for-water related adjustments to the energy balances. In particular, some of the IEA's reported "Agriculture and Forestry" electricity consumption is assigned to our "irrigation water abstraction" sector, so by using the energy balance data prior to that deduction, this electricity reported under agriculture that we assign to irrigation was effectively getting double counted, with the "other industrial energy use" balancing this out on a regional level. The end result of this fix is shifting some electricity from "agriculture energy use" to "other industrial energy use".

Liquid Limits Fixes

We've added a bio liquids limit to the chemical feedstocks sector that mirrors the industrial feedstocks limitation. We also corrected the industrial feedstocks sector name from "industrial feedstocks” to "other industrial feedstocks", to be consistent with the name changes from the detailed industry proposal. These were causing a lower threshold of crude oil needed in refined liquids pool and causing the constraint to be non-binding.

Removing unused code in LA121.liquids.R

We've removed two unused inputs, `calibrated_techs` and `A21.globaltech_coef` that aren’t used anymore, and also deleted them from the “loading inputs” part, as well as the declared precursors at the end. We also removed the line of code that creates the object `L121.in_EJ_R_TPES_unoil_Yh_temp` which is not subsequently used.

Romania mapping update

Because Romania's 3-digit ISO code changed from "ROM" to "ROU" in 2006, the input data files to gcamdata are mixed in their conventions. We've always handled this individually, re-writing "rou" to "rom" as necessary for agreement with the "iso" column of the country-to-GCAM-region mapping file "iso_GCAM_regID.csv". However, this approach is not ideal, particularly as an increasing portion of data over time uses the newer convention. In this proposal we add a row for "rou" to iso_GCAM_regID, formally recognizing that ISO code as a second one for Romania. Because this switch introduces a duplicate value for Romania in the country_name column, several code files that were using that column required updating. Specifically, the wind data chunks zchunk_L2231.wind_update.R and zchunk_LA120.offshore_wind.R are modified, to use their own mapping file NREL_wind_ctry.csv, in order to translate from country names in external datasets to 3-digit ISO codes.

Food Demand Calculation Fix

There was an inconsistency with how we calculated food demand at low income levels with respect to how they were being calculated in Ambrosia (the offline R package used to fit the food demand parameters). This is corrected in this proposal in the C++, where the food demand calculations occur.

Fix negative profit rates for MiscCropTree in India

This proposal fixes an error that causes occasional model crashes in 2020, with a message about negative profit rates for MiscCropTree in one of several basins in India. The reason for the negative profit rates is two things: one is that MiscCropTree in several basins has a very high N fertilizer input-output coefficient, greater than 0.4 kg of N per kg of crop produced. Second, because a significant portion of the fertilizer in India is produced through partial oil oxidation rather than natural gas steam reforming, its producer prices are higher than most other regions, so the fail-safe that we implement in order to keep agricultural profit rates positive in all ag production technologies is being overcome. The revision here is based on detailed analysis of the data processing responsible for the anomalously high input-output coefficient.

The high input-output coefficients are only seen in basins whose MiscCropTree production consists entirely of nutmeg, which is a spice crop whose yields tend to be a lot lower than other crops that fit this commodity class (e.g., coffee, cacao). In our methods, national fertilizer consumption levels are disaggregated to crops on the basis of detailed inventory data published by the International Fertilizer Industry Association (IFA), but the datasets don't include every crop and country combination, and as such many crop and country combinations have their fertilizer consumption levels assigned based on default area-based fertilizer application levels (i.e., kg N per hectare). Because of the comparatively low yields and an area-based allocation of fertilizer consumption, Nutmeg production in India is getting assigned very high fertilizer input-output coefficient, greater than 0.4 kg of N per harvested kg of nutmeg. Bottom-up data on nutmeg production (e.g., https://indiaagronet.com/indiaagronet/crop%20info/nutmeg.htm) suggests that the IO-coef should be more like 0.1. For plantations whose average yield is about 100 kg/ha (which is about what we see in the historical averages for India), the N application rate would then be about 10 kgN/ha.

This is implemented by effectively modifying the IFA (2002) inventory data within the R code, which manually adds a row for India Nutmeg, assigning a more reasonable initial estimate of the application rate, so that basins where this is the dominant or sole component to MiscCropTree don't get assigned very high input-output coefficients for this commodity class.

New method to run without CCS

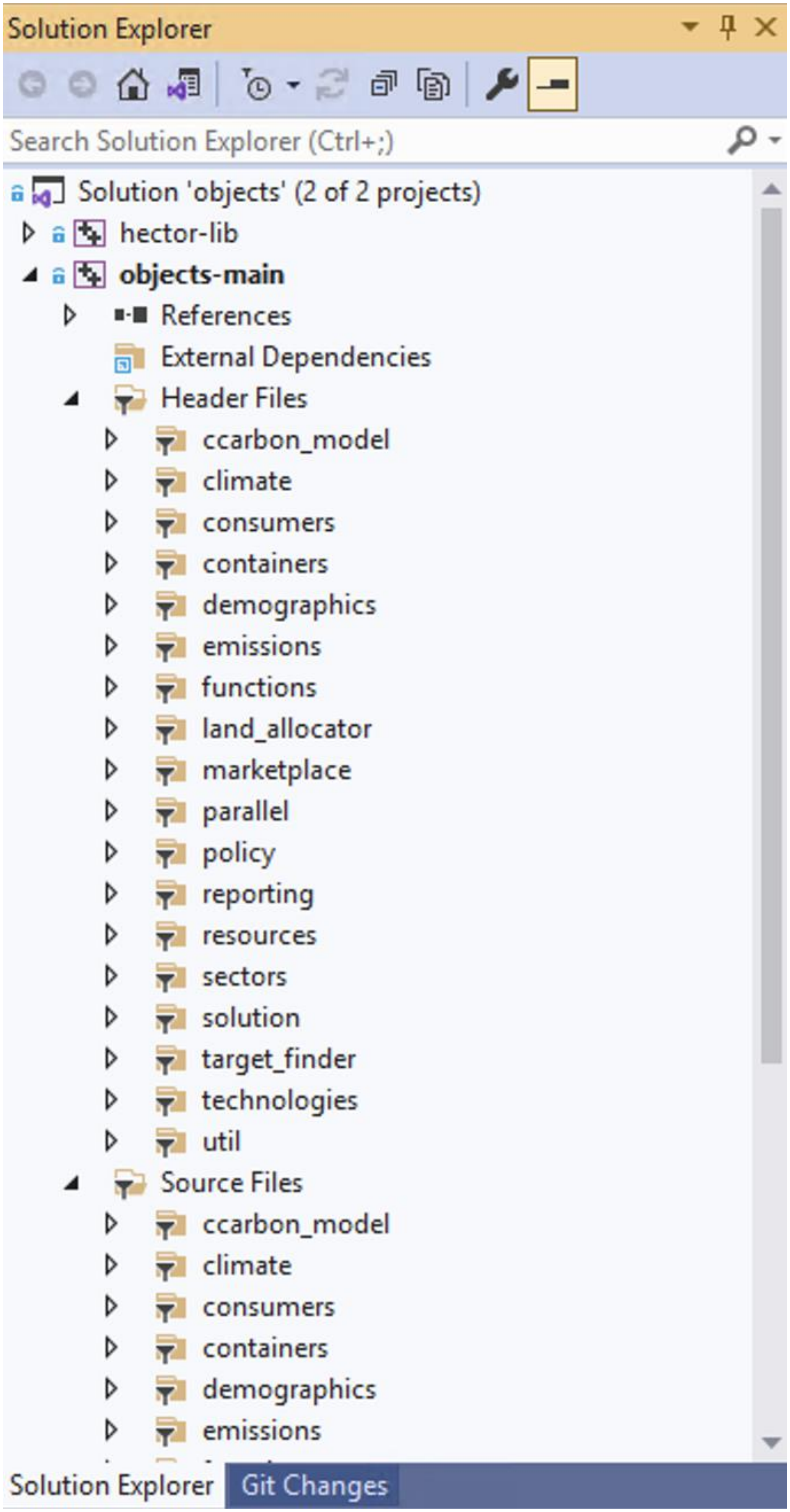
We've run into an issue where when we use `high_cost_ccs.xml` to turn off CCS in the model, we still see small amounts of CCS deployment in the iron and steel and aluminum sectors. To run a scenario with truly no CCS, we've added a new method to the data system which sets CCS technology share-weights to 0. The resulting XML is named "turn_off_ccs.xml".

Updated industrial final energy queries

We've also added the 'district heat' input for industrial energy use to the industrial final energy queries (industry total final energy by region, industry total final energy by service, industry final energy by fuel, industry final energy by service and fuel, and industry final energy by tech and fuel).

Fix Visual Studio project "filters"

The Visual Studio project file got broken somewhere in GCAM 6.0 such that the "folder" structure to organize header/source code files would no longer display from within Visual Studio. Instead, users had to look through a long list of files without organization. Presumably this broke because of manual editing of the project files. This CMP corrects the issue (as verified below), and then re-saves from Visual Studio to ensure everything is consistent with the latest file additions/deletions.


Solution Explorer
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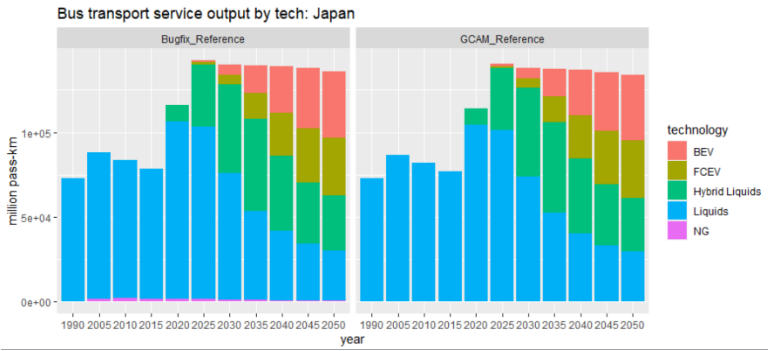
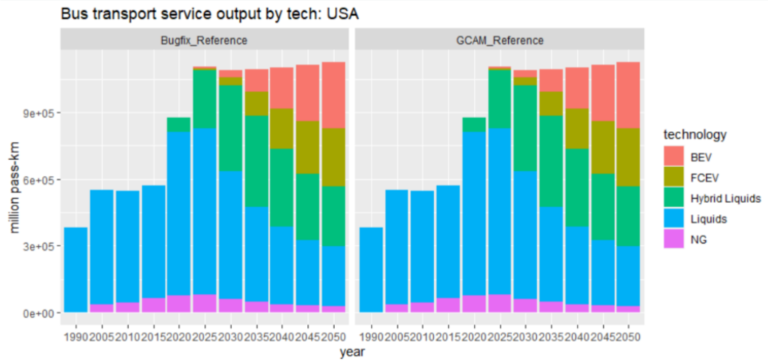
Solution Explorer
Git Changes

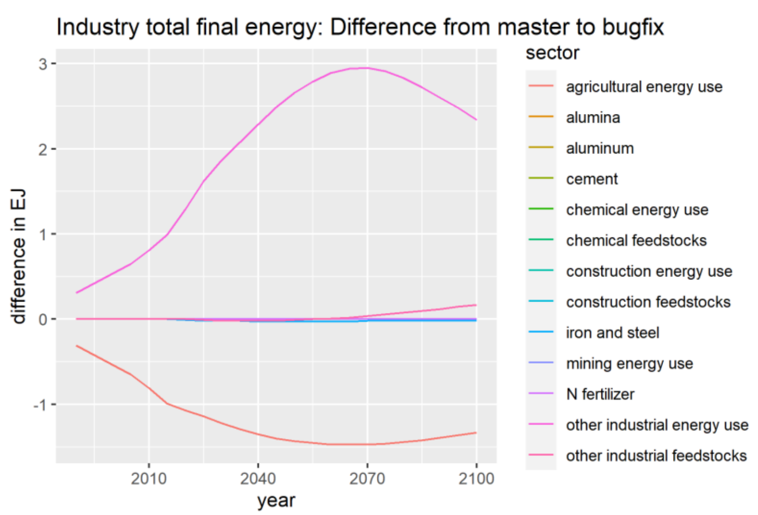
Validation

We now see small amounts of natural gas assigned to buses in Japan in the bugfix branch (Bugfix_Reference) as opposed to the current master (GCAM_Reference). Other regions (U.S. shown as example) do not change.





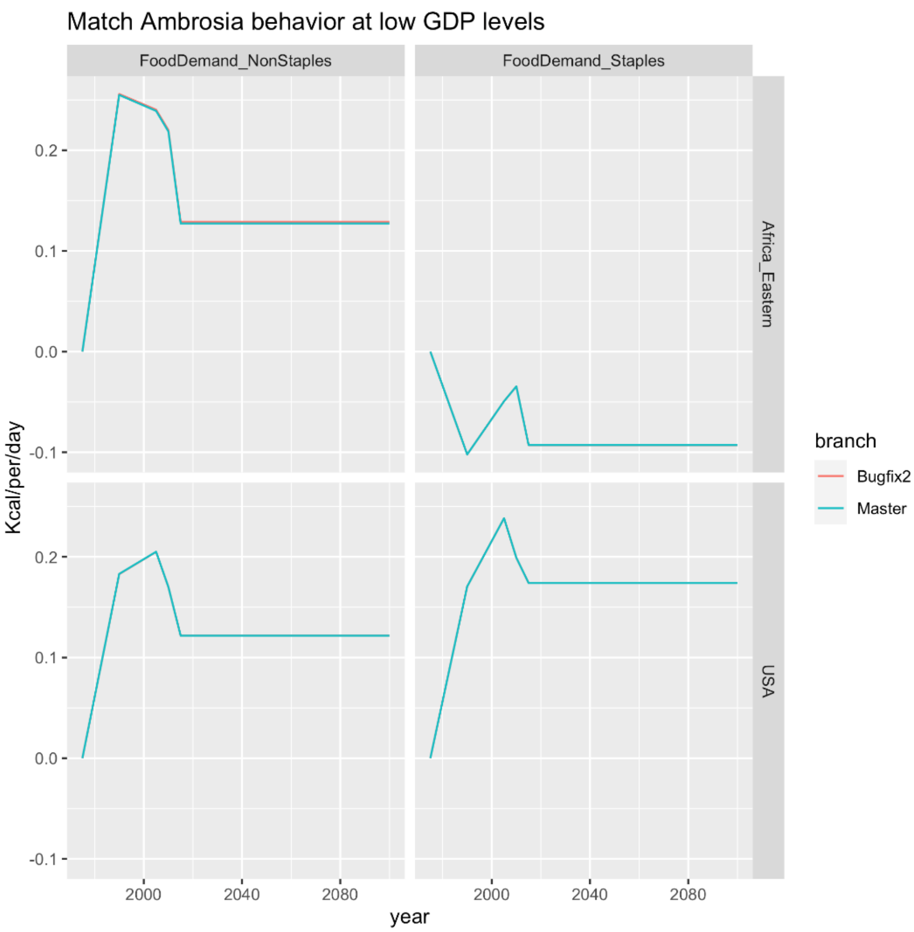
Global industrial final energy shifts from agricultural to other industrial:



No CCS: Shareweight vs High-Cost Approach: We see incredibly small amounts of CCS (they show up as 0 in Model Interface but are slightly positive values) using the high-cost approach. With the shareweight approach, there is truly no CCS in the non-feedstock sectors (as demonstrated by the fact that no CCS technologies even appear for the NoCCS_SW scenario). These results are from a high fixed carbon tax scenario with the different no CCS approaches.

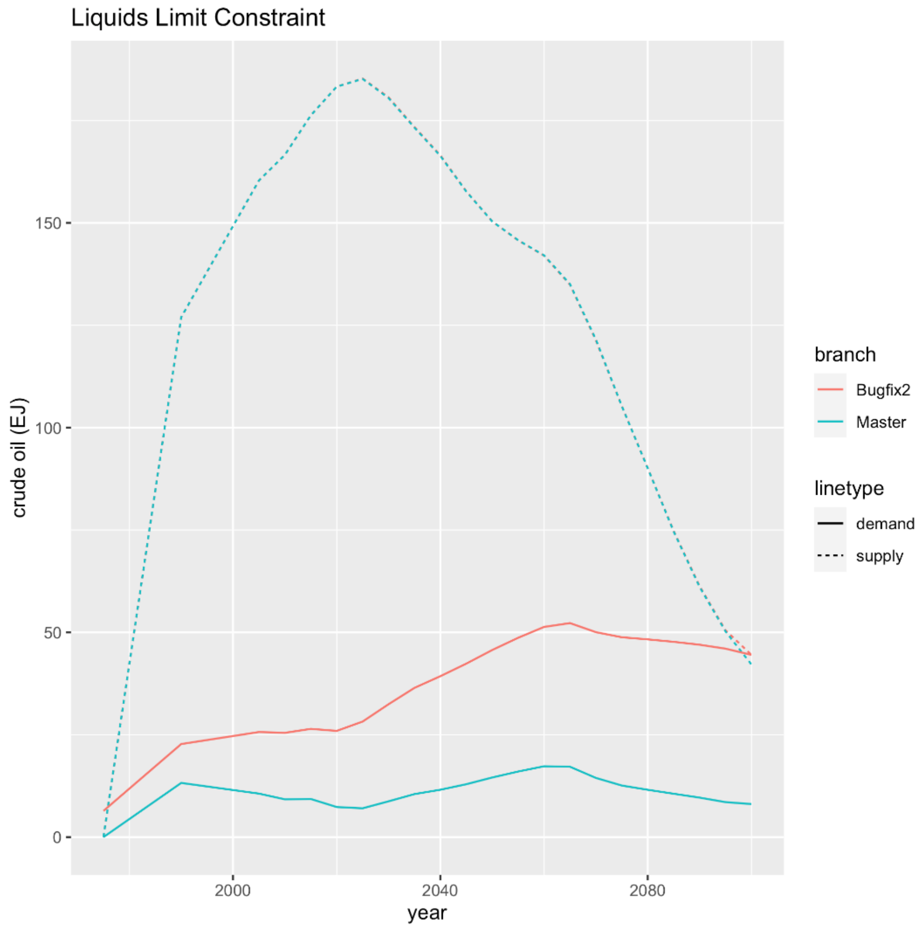
scenario	sector	technology	subsector	1990	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070	2075	2080	2085	2090	2095	2100	Units
HighCost_CCS,d...	H2 central production	coal chemical ...	coal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	MTC
HighCost_CCS,d...	alumina	biomass CCS	biomass	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	MTC
HighCost_CCS,d...	alumina	coal CCS	coal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	MTC
HighCost_CCS,d...	alumina	gas CCS	gas	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	MTC
HighCost_CCS,d...	alumina	refined liquid...	refined liquids	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	MTC
HighCost_CCS,d...	chemical feedstocks	refined liquids	refined liquids	172.527	282.61	322.88	344.17	365.13	390.512	414.495	439.364	463.651	484.317	503.769	519.102	530.414	538.467	542.817	543.613	542.887	539.165	533.732	527.041	518.516	MTC
HighCost_CCS,d...	construction feedstocks	refined liquids	refined liquids	60.795	78.401	76.588	77.291	80.955	84.29	87.344	90.241	92.802	95.162	97.437	99.244	100.783	102.075	103.092	103.848	104.418	104.822	105.11	105.286	105.329	MTC
HighCost_CCS,d...	iron and steel	BLASTFUR CCS	BLASTFUR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	MTC
HighCost_CCS,d...	other industrial feedstocks	refined liquids	refined liquids	60.067	85.938	74.935	75.407	87.319	101.181	115.81	130.725	145.714	160.963	176.465	192.468	208.957	225.466	241.488	256.716	271.317	285.18	298.332	310.678	321.79	MTC
NoCCS_SW,date...	chemical feedstocks	refined liquids	refined liquids	172.527	282.61	322.88	344.17	365.131	390.514	414.494	439.364	463.651	484.317	503.77	519.103	530.415	538.468	542.819	543.615	542.891	539.17	533.738	527.045	518.521	MTC
NoCCS_SW,date...	construction feedstocks	refined liquids	refined liquids	60.795	78.401	76.588	77.291	80.955	84.29	87.344	90.241	92.802	95.162	97.437	99.244	100.783	102.075	103.092	103.848	104.418	104.822	105.11	105.286	105.329	MTC
NoCCS_SW,date...	other industrial feedstocks	refined liquids	refined liquids	60.067	85.938	74.935	75.407	87.319	101.182	115.81	130.725	145.714	160.964	176.465	192.468	208.957	225.466	241.488	256.716	271.316	285.179	298.33	310.673	321.784	MTC

Food Demand Fixes



We can see minor differences in the regional bias calculated (the calibration parameter which takes the slack between modeled food demand and observed). As noted above this only affects values at low GDP values (Africa_Eastern), while others are unaffected (USA).

Bio Liquids Fixes



As expected, we have fixed the accounting of "crude oil demand" by the detailed industry sectors which were missed before. Indeed, in the 2.6 scenario it now binds in 2100.