Environment

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Most of the environmental elements of the model are included within other modules, such as Economy and Agriculture. Please see those modules for more information, or click through the links below to learn more about how the IFs model can help environment-related analysis.

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Contents

Structure and Agent System: Environment

System/Subsystem	Environment (e.g. CO2, water)
Organizing Structure	Systemic Accounting

Stocks	Atmospheric carbon Oceanic carbon Forest area Renewable water resources
Flows	Annual Emissions Water Use
Key Aggregate Relationships (illustrative, not comprehensive)	Oceanic absorption of CO2 Global temperatures with CO2
Key Agent-Class Behavior Relationships (illustrative, not comprehensive)	Governments and environmental policies regarding emissions Farmers and water use with agriculture

Dominant Relations: Environment

Environment: Dominant Relations

Atmospheric carbon dioxide is function of emissions from fossil fuel burning. Water use is primarily a function of agricultural sector size (and therefore on irrigation). Forest area is dependent upon the rate of conversion of forest to crop land and grazing area.

For a causal diagram see Environment Flow Charts Overview.

For equations see Environment Equations Overview.

Key dynamics are directly linked to the dominant relations

The energy submodel determines fossil fuel use, and the agricultural model determines agricultural sector size and land conversion patterns. See those models for discussion of dominant patterns and of control parameters.

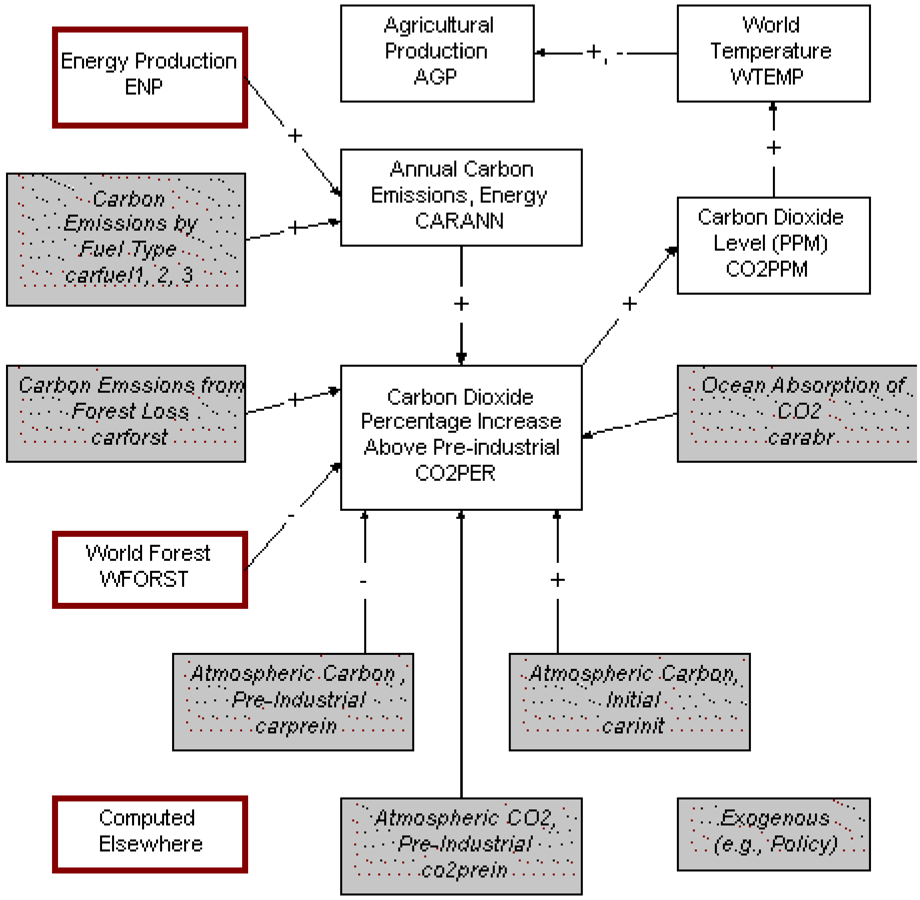
Environment: Selected Added Value

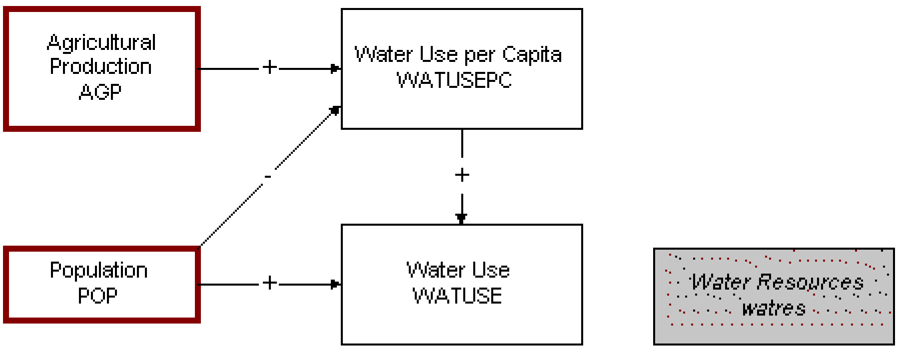
The larger environmental model provides a more extended model of carbon dioxide, including oceanic absorption rates and possible impact of build-up on global temperature and agricultural patterns.

Environment Flow Charts

Overview

Among the most important elements of the "environmental submodel," which is imbedded in the other portions of the model, is the calculation of atmospheric carbon dioxide levels and global warming.





Visual representation of environment submodule

For detail, see the equations on Greenhouse Effect and Climate Change.

To look at deforestation, look at the way in which Agricultural Production leads to changing land use.

Environment Equations

Overview

Many environmental computations take place within the economic module. This is true for topics, such as:

Greenhouse Effect and Climate Change

The beginning point for examining the greenhouse effect is calculation of the percentage increase in atmospheric carbon dioxide (C02PER). This figure is a percentage of the pre#industrial CO2 level, not of the total atmosphere. The model first calculates annual increase in atmospheric carbon from energy use (CARANN) and adds it to a cumulative tracking of carbon (SACARB). That increase depends on global production (WENP) in the fossil fuel categories (oil, gas and coal). The coefficients representing tons of carbon generated per barrel of oil equivalent burned (CARFUELn) multiply those fossil fuel totals (coefficients calculated from the IPCC 1995 report). The oceans and other sinks annually absorb an exogenously specified amount of atmospheric carbon (CARABR) and that retards the accumulation. Deforestation (or reforestation) has an impact via another parameter (CARFORST), the value of which was calculated using deforestation estimates from Vital Signs (Brown, Flavin, and Kane, 1996) and figures for the contribution of deforestation to CO2 emissions from the IPCC. The ultimate value was taken from Mori and Takahaashi (1997: 6). For an understanding of this process and data underlying the parameters see the report of the Intergovernmental Panel on Climate Change (IPCC) and Flavin (1996). See also Repetto and Austin (1997) for an outstanding analysis of models used to investigate climate protection.

Failed to parse (SVG (MathML can be enabled via browser plugin): Invalid response ("Math extension cannot connect to Restbase.") from server "https://wikimedia.org/api/rest_v1/":): {\displaystyle CARANN=WENP_{e-1}*\mathbf{carfuel1}+WENP_{e-2}*\mathbf{carfuel2}+WENP_{e-3}*\mathbf{carfuel3}}

Failed to parse (SVG (MathML can be enabled via browser plugin): Invalid response ("Math extension cannot connect to Restbase.") from server "https://wikimedia.org/api/rest_v1/":): {\displaystyle SACARB=SACARB^{t-1}+CARANN+(WFORST^{t-1}-WFORST)*\mathbf{carforst-carabr}}

where

Failed to parse (SVG (MathML can be enabled via browser plugin): Invalid response ("Math extension cannot connect to Restbase.") from server "https://wikimedia.org/api/rest_v1/":): {\displaystyle SACARB^{t-1}=\mathbf{carinit}}

The percentage increase in atmospheric carbon relative to pre-industrial levels (CO2PER) depends on the accumulated atmospheric level of carbon (billion tons) and the pre-industrial level of carbon in the atmosphere by weight (CARPREIN).

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("Math extension cannot connect to Restbase.") from server "https://wikimedia.org/api/rest_v1/":): {\displaystyle CO2PER=\frac{SACARB-\mathbf{carprein}}{\mathbf{carprein}}*100}

We can calculate the atmospheric level of carbon dioxide in parts per million (CO2PPM) from these figures, if we know the pre-industrial level of carbon dioxide in parts per million (CO2PREIN).

Failed to parse (SVG (MathML can be enabled via browser plugin): Invalid response ("Math extension cannot connect to Restbase.") from server "https://wikimedia.org/api/rest_v1/":): {\displaystyle CO2PPM=\mathbf{co2prein}+\mathbf{co2prein}*\frac{CO2PER}{100}}

We can use a table function to determine the average world temperature (WTEMP) in Centigrade from the atmospheric carbon dioxide level in parts per million (based on figures provided by the IPCC).

Failed to parse (SVG (MathML can be enabled via browser plugin): Invalid response ("Math extension cannot connect to Restbase.") from server "https://wikimedia.org/api/rest_v1/":): {\displaystyle WTEMP=\mathbf{A}nalFunc(CO2PPM)}

Finally, we must compute the increase to overall energy prices (CarTaxEnPriAdd) that carbon taxes cause, because total energy demand will respond to the total price. The increase will depend on the carbon tax per fossil fuel and the production level of fossil fuels in the overall pattern of energy production.

Failed to parse (SVG (MathML can be enabled via browser plugin): Invalid response ("Math extension cannot connect to Restbase.") from server "https://wikimedia.org/api/rest_v1/":): {\displaystyle CarTaxEnPriAdd_r=\frac{\sum^3_{e-1}ENP_{r,e}-\mathbf{carfuel_e}*carbtax_r}{\sum^3_{e-1}ENP_{r,e}}}

Water

IFs calculates the water use per capita (WATUSEPC) and the total water use (WATUSE) for each model region. The biggest water use for most countries is agricultural (on a global basis 65% of freshwater use, according to Postel, 1996: 13). IFs uses a table function that relates change in per capita use to change in agricultural production per capita.

Failed to parse (SVG (MathML can be enabled via browser plugin): Invalid response ("Math extension cannot connect to Restbase.") from server "https://wikimedia.org/api/rest_v1/":): {\displaystyle WATUSEPC_r=WATUSEPC^{t-1}_r*\frac{\mathbf{TF}(\frac{AGP_{r,f-1}}{POP_{\gamma}})}{\mathbf{TF}(\frac{AGP^{t-1}_{r,f-1}}{POP^{t-1}_{\gamma}})}}

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"https://wikimedia.org/api/rest_v1/":): {\displaystyle WATUSE_r=WATUSEPC_r*\frac{POP_r}{1000}}

Advanced Sustainability Analysis

The Advanced Sustainability Analysis (ASA) is a framework developed by the Finland Futures Research Centre (FFRC), and the partial implementation in IFs was in cooperation with the FFRC within the TERRA project. For further information on ASA see: Kaivo-oja, Jari, Jyrki Luukhanen, and Pentti Malaski (2002). "'Methodology for the Analysis of Critical Industrial Ecology Trends: an Advanced Sustainability Analysis of the Finnish Economy' " Turku, Finland: Finland Futures Research Centre.

The ASA builds on resource use or emissions calculations such as those for annual carbon emissions. The implementation in IFs represents four different environmental impact areas:

1. Fossil fuel use
2. Carbon emissions
3. Deforestation
4. Water use

The raw values for each environmental impact are put into the ASA raw value matrix (ASARAW), drawing upon variables from elsewhere in IFs.

Failed to parse (SVG (MathML can be enabled via browser plugin): Invalid response ("Math extension cannot connect to Restbase.") from server "https://wikimedia.org/api/rest_v1/":): {\displaystyle ASARAW_{\gamma,1}=ENP_{\gamma,e-oL}+ENP_{\gamma,e-gas}+ENP_{\gamma,e-coal}}

Failed to parse (SVG (MathML can be enabled via browser plugin): Invalid response ("Math extension cannot connect to Restbase.") from server "https://wikimedia.org/api/rest_v1/":): {\displaystyle ASARAW_{\gamma,2}=CARANN_{\gamma}}

Failed to parse (SVG (MathML can be enabled via browser plugin): Invalid response ("Math extension cannot connect to Restbase.") from server "https://wikimedia.org/api/rest_v1/":): {\displaystyle ASARAW_{\gamma,3}=FOREST^{t-1}_{\gamma}-LD^t_{\gamma,l-Forest}}

Within each area there are four environmental impact views, including the raw impact view shown above. The views are:

1. Raw values of impact (e.g. ASARAW, 2 for raw carbon emissions)
2. Impact per unit of GDP (e.g. ASAGDP, 2 for carbon emissions per unit of GDP)
3. Impact per unit of population (e.g. ASAPOP, 2 for carbon emissions per unit of POP)

4. Impact per member of the labor force (e.g. ASALAB, 2 for carbon emissions per unit of LAB)

The equations below illustrate those for views, using carbon emissions. The other three sets for the other three impact areas would be completely parallel.

Failed to parse (SVG (MathML can be enabled via browser plugin): Invalid response ("Math extension cannot connect to Restbase.") from server "https://wikimedia.org/api/rest_v1/":): {\displaystyle ASARAW_{\gamma,2}=CARANN_{\gamma}}

Failed to parse (SVG (MathML can be enabled via browser plugin): Invalid response ("Math extension cannot connect to Restbase.") from server "https://wikimedia.org/api/rest_v1/":): {\displaystyle ASAGDP_{\gamma,2}=\frac{CARANN_{\gamma}*1000}{GDP_{\gamma}}}

Failed to parse (SVG (MathML can be enabled via browser plugin): Invalid response ("Math extension cannot connect to Restbase.") from server "https://wikimedia.org/api/rest_v1/":): {\displaystyle ASAPOP_{\gamma,2}=\frac{CARANN_{\gamma}*1000}{POP_{\gamma}}}

Failed to parse (SVG (MathML can be enabled via browser plugin): Invalid response ("Math extension cannot connect to Restbase.") from server "https://wikimedia.org/api/rest_v1/":): {\displaystyle ASALAB_{\gamma,2}=\frac{CARANN_{\gamma}*1000}{LAB_{\gamma}}}

In addition, there are calculations within each view of dematerialization over time. Dematerializations are calculated within each impact area (a) relative to raw impact (ASARAWDMAT), to GDP (ASAGDPDMAT), to population (ASAGDPDPOP), and to labor (ASAGDPDMAT)

Failed to parse (SVG (MathML can be enabled via browser plugin): Invalid response ("Math extension cannot connect to Restbase.") from server "https://wikimedia.org/api/rest_v1/":): {\displaystyle ASARAWDMAT_{\gamma,\alpha}=\frac{ASARAW^t_{\gamma,\alpha}-ASARAW^{t-1}_{\gamma,\alpha}}{ASARAW^{t-1}_{\gamma,\alpha}}}

Failed to parse (SVG (MathML can be enabled via browser plugin): Invalid response ("Math extension cannot connect to Restbase.") from server "https://wikimedia.org/api/rest_v1/":): {\displaystyle ASAGDPDMAT_{\gamma,\alpha}=\frac{ASAGDP^t_{\gamma,\alpha}-ASAGDP^{t-1}_{\gamma,\alpha}}{ASAGDP^{t-1}_{\gamma,\alpha}}}

Failed to parse (SVG (MathML can be enabled via browser plugin): Invalid response ("Math extension cannot connect to Restbase.") from server "https://wikimedia.org/api/rest_v1/":): {\displaystyle ASAPOPDMAT_{\gamma,\alpha}=\frac{ASAPOPDMAT^t_{\gamma,\alpha}-ASAPOPDMAT^{t-1}_{\gamma,\alpha}}{ASAPOPDMAT^{t-1}_{\gamma,\alpha}}}

Failed to parse (SVG (MathML can be enabled via browser plugin): Invalid response ("Math extension cannot connect to Restbase.") from server "https://wikimedia.org/api/rest_v1/":): {\displaystyle ASALABDMAT_{\gamma,\alpha}=\frac{ASALAB^t_{\gamma,\alpha}-ASALAB^{t-1}_{\gamma,\alpha}}{ASALAB^{t-1}_{\gamma,\alpha}}}

Gross rebounds are also calculated for the ASA system. They are basically the raw impact times the growth in either GDP, population, or labor.

Failed to parse (SVG (MathML can be enabled via browser plugin): Invalid response ("Math extension cannot connect to Restbase.") from server "https://wikimedia.org/api/rest_v1/":): {\displaystyle ASAGDPGRRB_{\gamma,1}=ASAGDP_{\gamma,\alpha}*(GDP^t_{\gamma}-GDP^{t-1}_{\gamma})/1000}

Failed to parse (SVG (MathML can be enabled via browser plugin): Invalid response ("Math extension cannot connect to Restbase.") from server "https://wikimedia.org/api/rest_v1/":): {\displaystyle ASAPOPGRRB_{\gamma,1}=ASAPOP_{\gamma,\alpha}*(POP^t_{\gamma}-POP^{t-1}_{\gamma})/1000}

Failed to parse (SVG (MathML can be enabled via browser plugin): Invalid response ("Math extension cannot connect to Restbase.") from server "https://wikimedia.org/api/rest_v1/":): {\displaystyle ASALABGRRB_{\gamma,1}=ASALAB_{\gamma,\alpha}*(LAB^t_{\gamma}-LAB^{t-1}_{\gamma})/1000}

Finally, there are three measures of cumulative change created for the display system, once for each of the GDP, population, and labor bases of the system.

Failed to parse (SVG (MathML can be enabled via browser plugin): Invalid response ("Math extension cannot connect to Restbase.") from server "https://wikimedia.org/api/rest_v1/":): {\displaystyle ASAGDPCUMCHG_{\gamma}=\frac{GDP^t_{\gamma}-GDP^{t-1}_{\gamma}}{GDP^{t-1}_{\gamma}}*100}

Failed to parse (SVG (MathML can be enabled via browser plugin): Invalid response ("Math extension cannot connect to Restbase.") from server "https://wikimedia.org/api/rest_v1/":): {\displaystyle ASAPOPCUMCHG_{\gamma}=\frac{POP^t_{\gamma}-POP^{t-1}_{\gamma}}{POP^{t-1}_{\gamma}}*100}

Failed to parse (SVG (MathML can be enabled via browser plugin): Invalid response ("Math extension cannot connect to Restbase.") from server "https://wikimedia.org/api/rest_v1/":): {\displaystyle ASALABCUMCHG_{\gamma}=\frac{LAB^t_{\gamma}-LAB^{t-1}_{\gamma}}{LAB^{t-1}_{\gamma}}*100}

It is recommended that the model user look at the specialized display for ASA in order to see the variables of the ASA system most easily.

Equations on deforestation, however, exist in the agricultural model. See Agricultural Land Use Dynamics.
