Introduction to CLEWs

Hands-on lecture 10: Climate Change and Greenhouse Gas Emissions

V2.0

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Tags: CLEWs; Climate; Land; Energy; Water; Systems Modelling; Integrated; Policy Coherence; Installation; Hands-on; Climate Compatible Growth; Open Source; Teaching Kit.

Useful links:

1) Energy Modelling Community (EMC) Discourse Forum – please use this for any CLEWs-related discussions, especially troubleshooting queries!
2) EMC LinkedIn.
3) CCG YouTube.
4) Hands-on Solutions can be found here.

Pre-requisites:

1) Successful completion of all the activities under Hands-on Lecture 9.

Learning outcomes

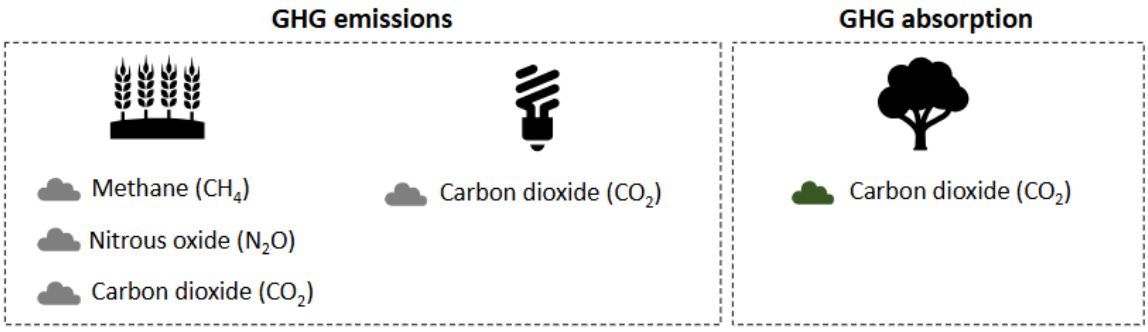
The previous activities focused on building an integrated model of energy, water, and land-use systems. The activities here focus on representing the fourth and final aspect of CLEWs: **Climate**.

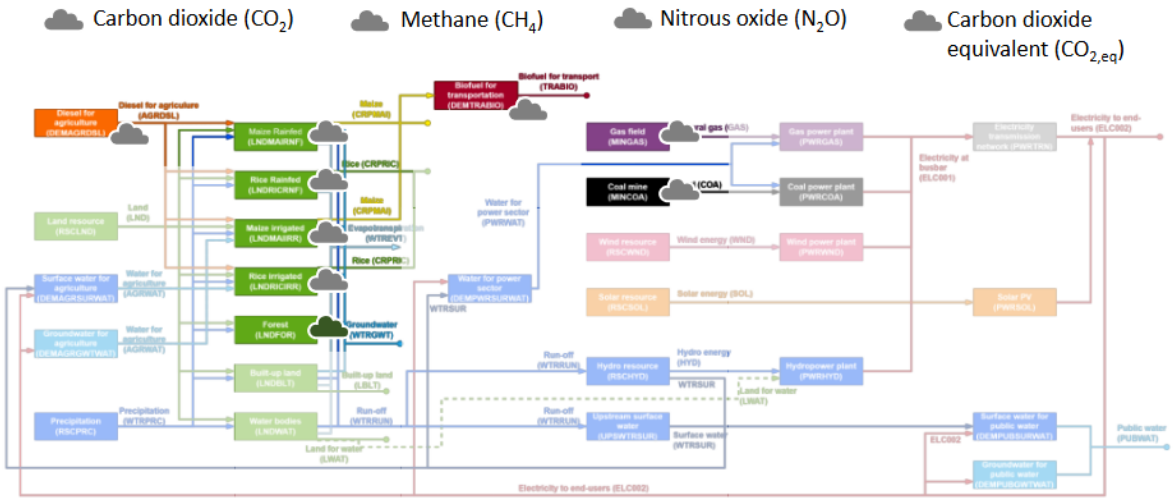
By the end of this Hands-on, you will be able to:

1) Quantify the level of emissions from different fuel sources in a model setting
2) Compare the level of emissions from different sectors in a model setting
3) Interpret the extent of emissions in the CLEWs systems and their potential impact

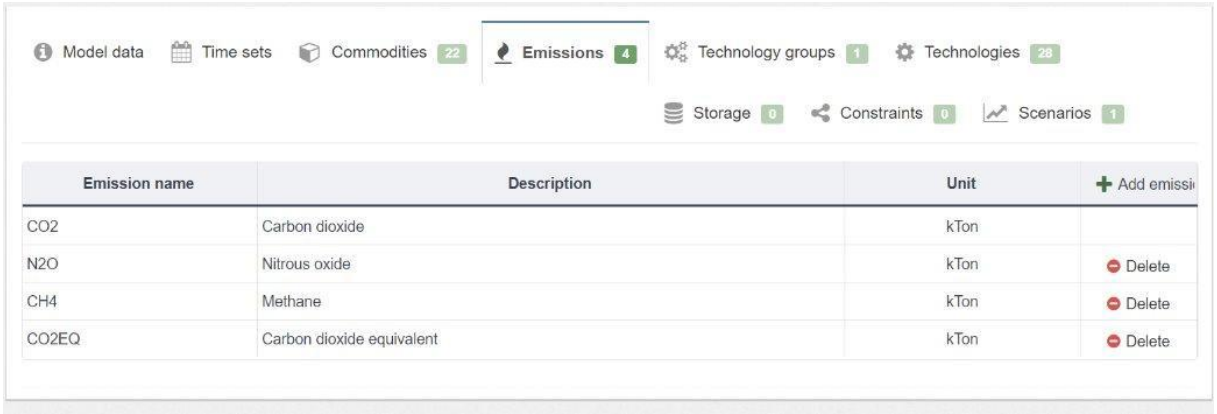
Activity 1 – Impacts ON climate: Adding emissions to the energy and agriculture sectors

Before you start, copy the model from the previous Hands-on.





1. In "**Configure model**", go to the tab "**Emissions**" and create these four emissions:
   - **CO2**, Carbon dioxide, kTon
   - **N2O**, Nitrous oxide, kTon
   - **CH4**, Methane, kTon
   - **CO2EQ**, Carbon dioxide equivalent, kTon



Technology	Description	Emission Activity Ratio
MINCOA	Coal mining	CO2, CO2EQ
MINGAS	Gas field	CO2, CO2EQ
DEMAGRDSL	Agriculture diesel demand	CO2, CO2EQ
DEMTRABIO	Transport biofuel demand	CO2, CO2EQ
LNDMAIRNF	Rainfed maize cultivation	N2O, CO2EQ
LNDRICRNF	Rainfed rice cultivation	CH4, CO2EQ
LNDMAIIRR	Irrigated maize cultivation	N2O, CO2EQ
LNDRICIRR	Irrigated rice cultivation	CH4, CO2EQ
LNDFOR	Forest	CO2, CO2EQ

2. Now, assign the emissions to the technologies. Go to "**Configure model**" and the tab "**Technologies**" and assign emissions as indicated in the table below. Make sure to update the model once you have done this.
3. Go to "**Data entry**" and search for the parameter "**Emission Activity Ratio"** and add the values in the table below for the respective technologies and emissions. Make sure you "Save data" and "Update Model" to save your edits.

Technology	Description	Emission Activity Ratio (kton emission/activity unit) 2020-2035			
		CO2	N2O	CH4	CO2EQ*
MINCOA	Coal mining	96.1	-	-	96.5
MINGAS	Gas field	56.1	-	-	56.2
DEMAGRDSL	Agriculture diesel demand	73.3	-	-	73.6
DEMTRABIO	Transport biofuel demand	70.8	-	-	72.8
LNDMAIRNF	Rainfed maize cultivation	-	0.2	-	102.0
LNDRICRNF	Rainfed rice cultivation	-	-	6.0	162.5
LNDMAIIRR	Irrigated maize cultivation	-	0.4	-	139.0
LNDRICIRR	Irrigated rice cultivation	-	-	8.3	223.1
LNDFOR	Forest	-14.4	-	-	-14.4

* Note that CO2EQ values for energy technologies consider marginal emissions of N2O and CH4 which multiplied by the GWP result in differences with CO2 emissions in the 3rd or 4th decimals.

4. **Run the model of Activity 1 and interpret the results of emissions of selected technologies from different sectors**. For the following you should follow the same process of filtering for commodity and tech description. There are an abundance of results you can view, which are listed below:

1) **Annual Technology Emission By Mode**: This shows the number of emissions produced by a technology.
    i) Visualise the results of CO2EQ emissions for all technologies with assigned emissions – commodity in filters and tech desc in columns.
    ii) Visualise the results of CO2EQ emissions for emitting technologies (excluding forests).
    iii) Visualise the results of CO2EQ for only forests.
    iv) Visualise the results for the separate GHGs (i.e., CO2, CH4, N2O).
    v) Visualise the results for all emissions for all crops – you might see this one
    vi) Visualise the results for the separate GHGs (i.e., CO2EQ, CH4, and N2O) for the cropland technologies.
    vii) Visualise the results for the separate GHGs (i.e., CH4, N2O, and CO2EQ) for cropland technologies and diesel use in agriculture.
    viii) Visualise the results for biofuel production (CO2 and CO2EQ) and diesel use in agriculture (CO2 and CO2EQ) – include both commodity and tech desc in columns, so the emissions appear separately on the graph.

2) **Production By Technology By Mode:**
    i) Visualise the results for the electricity generation mix. *You can also compare it to the previous exercise (HO9_A4), to see if anything has changed.*

Activity 2 – Impacts ON climate: Representing land use change (LUC) emissions

Estimating the "Emission Activity Change Ratio" parameter value for LNDFOR:

- **Forest biomass carbon per unit of area calculation:**

$$\text{forest biomass carbon per unit area}\left(\frac{ton\ Carbon}{ha}\right) = \text{Carbon fraction in forest biomass}\left(\frac{ton\ dry\ matter}{ha}\right) * \text{Above-ground biomass}\left(\frac{ton\ Carbon}{ton\ dry\ matter}\right) * \left(1 + \text{Ratio below-ground to above-ground biomass}\right)$$

- **"Emission To Activity Change Ratio" parameter for LNDFOR:**

$$\textbf{EACR (LNDFOR)} = -\ \text{forest biomass } CO_2 \text{ per unit area}\left(\frac{Mton\ CO_2}{10^3 km^2}\right) = -\ \text{forest biomass carbon per unit area}\left(\frac{ton\ Carbon}{ha}\right) * 10^{-6}/10^{-5} * 44/12 \left(\frac{g\ CO_2\ .\ mol^{-1}}{g\ C\ .\ mol^{-1}}\right)$$

Conversion of *ton* to *Mton* and *ha* to $10^3 km^2$

- **Forest biomass carbon per unit of area calculation:**

$$\text{forest biomass carbon per unit area}\left(\frac{ton\ Carbon}{ha}\right) = 0.47\ \frac{ton\ dry\ matter}{ha} * 260\ \frac{ton\ Carbon}{ton\ dry\ matter} * (1 + 0.20) = 146\ \frac{ton\ Carbon}{ha}$$

Carbon fraction in forest biomass; Above-ground biomass; Ratio below-ground to above-ground biomass

- **Forest biomass carbon per unit of area:**

$$\textbf{EACR (LNDFOR)} = -\ \text{forest biomass } CO_2 \text{ per unit area}\left(\frac{Mton\ CO_2}{10^3 km^2}\right) =$$

Conversion of *ton* to *Mton* and *ha* to $10^3 km^2$

$$\textbf{EACR (LNDFOR)} = -\ 146\ \left(\frac{ton\ Carbon}{ha}\right) * 10^{-6}/10^{-5} * 44/12 \left(\frac{g\ CO_2\ .\ mol^{-1}}{g\ C\ .\ mol^{-1}}\right)$$

$$\textbf{EACR (LNDFOR)} = -\ 54\ \frac{Mton\ CO_2}{10^3 km^2}$$

The value is negative because it multiplies by the activity change in two consecutive years. IF the area of forests decrease, then the area change will be negative, which multiplied by a negative EACR, results in positive value of emissions due to activity change – corresponding to the release of stored carbon.

1. In "**Data entry**", search for the parameter "**Emission To Activity Change**", and in the technology "**LNDFOR**" and for the emissions CO2 and CO2EQ, introduce the value -54000 for all years in the modelling period. **Click on "Save data" to save your edits.**

Technology	**Emission**	**Emission To Activity Change Ratio**
LNDFOR	CO2	-54000 kTon CO_2 / 10^3 km^2
LNDFOR	CO2EQ	-54000 kTon CO_2EQ / 10^3 km^2

2. **Run the model of HO10 Activity 2** and interpret the results of land use change. In this activity, **the results for the variables below will be explored:**

1) **Emission by Activity Change:** This shows the emissions due to land use change every year.
   a) Visualize the emissions from land use change due to forest land conversion.

2) **Annual Technology Emissions**: This shows the number of emissions by technology plus the Emissions By Activity Change.
   a) Visualize and compare the results of CO2EQ emissions for all technologies with assigned emissions for the two climate activities (HO10_A1 and HO10_A2).

^ You can also view **Annual Technology Emission By Mode;** this graph shows the number of emission(s) by technology each year.
   b) Visualize and compare the CO2EQ emissions for all technologies with assigned emissions for both climate exercises.