Global carbon budget between 1958 and 2008

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English translation corrected by Stephanie Hayes

Note: This activity can follow "Introduction to climate modelling", but it is not necessary.

Introduction

A large amount of the CO_2 that is released into the atmosphere as a result of human activities is absorbed by vegetation and the oceans, thus removing it from the atmosphere. If we know the quantity of CO_2 that is being emitted into the atmosphere, and the quantity that is being absorbed, we can make some predictions about future atmospheric CO_2.

Aims

- To become familiar and work with global carbon budget data: **gross values** (for example, amount of CO_2 absorbed by ocean in billion of carbon tons) **and percentages** (for example, % of CO_2 absorbed by ocean).
- To create graphs to find the best representation of the data to make predictions for the next century.

Activity type: data manipulation and analysis

Previous knowledge required: CO_2 exchanges between atmosphere, oceans and terrestrial vegetation and soils. The release of CO_2 into the atmosphere as a result of human activities, its partial absorption by ocean and terrestrial vegetation and soils.

Cost: none

Materials

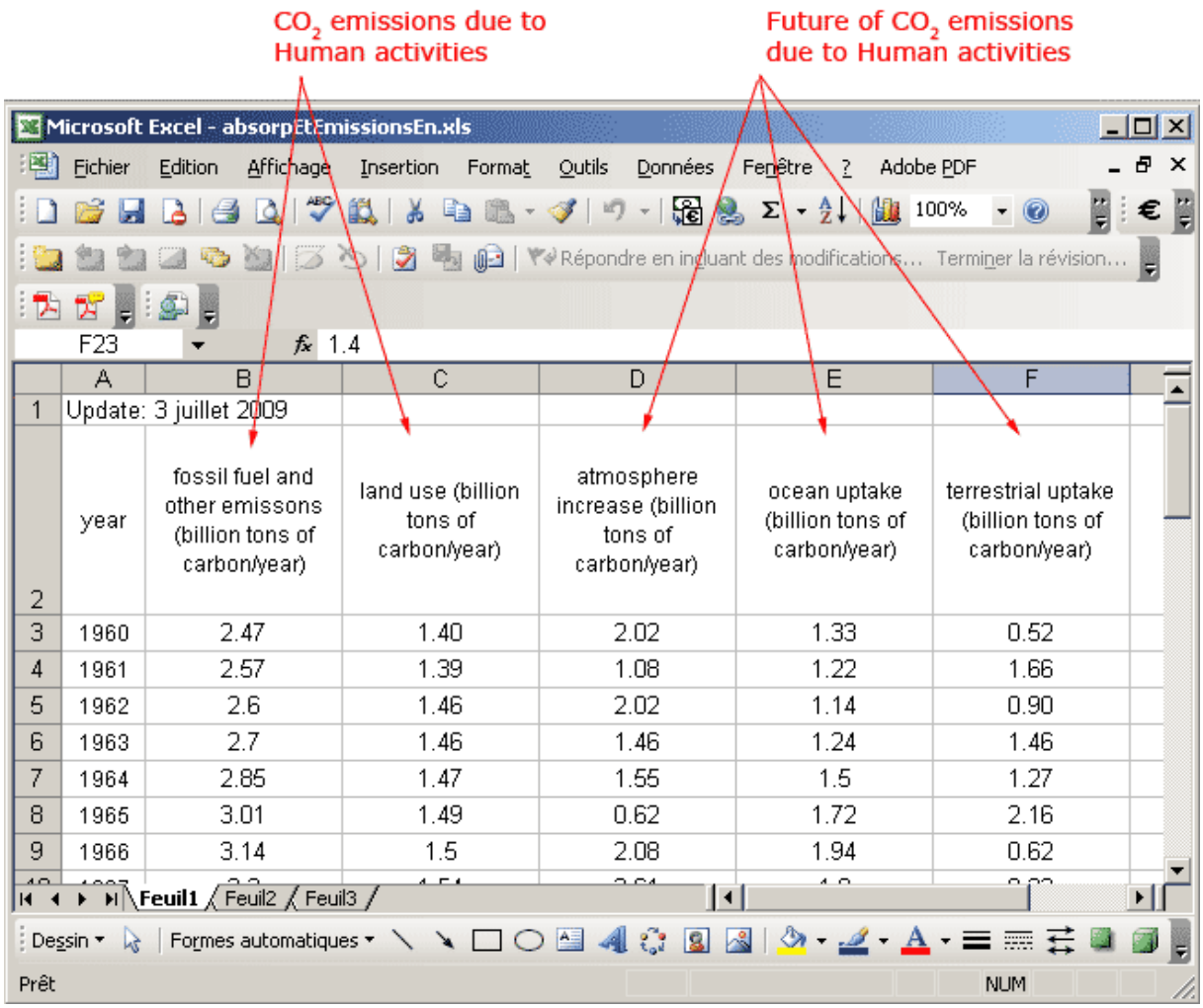
- Computer room: ideally, students work in groups of two.
- Excel file (or openOffice file): **absorpEtEmissionsEn.xls**, download on www.carboschools.org. Or data can be found here: http://lgmacweb.env.uea.ac.uk/lequere/co2/carbon_budget.htm (you will find at this address all explanations for data, but they are also in the file).
- For extra help, download the file **absorpEtEmissionsAvecGrapheEn.xls** where you will find all graphics and calculation.

Part 1

In this first part, graphs are created in order to represent the emissions and absorption data

Procedure

1. Open the Excel file **absorpEtEmissionsEn.xls**



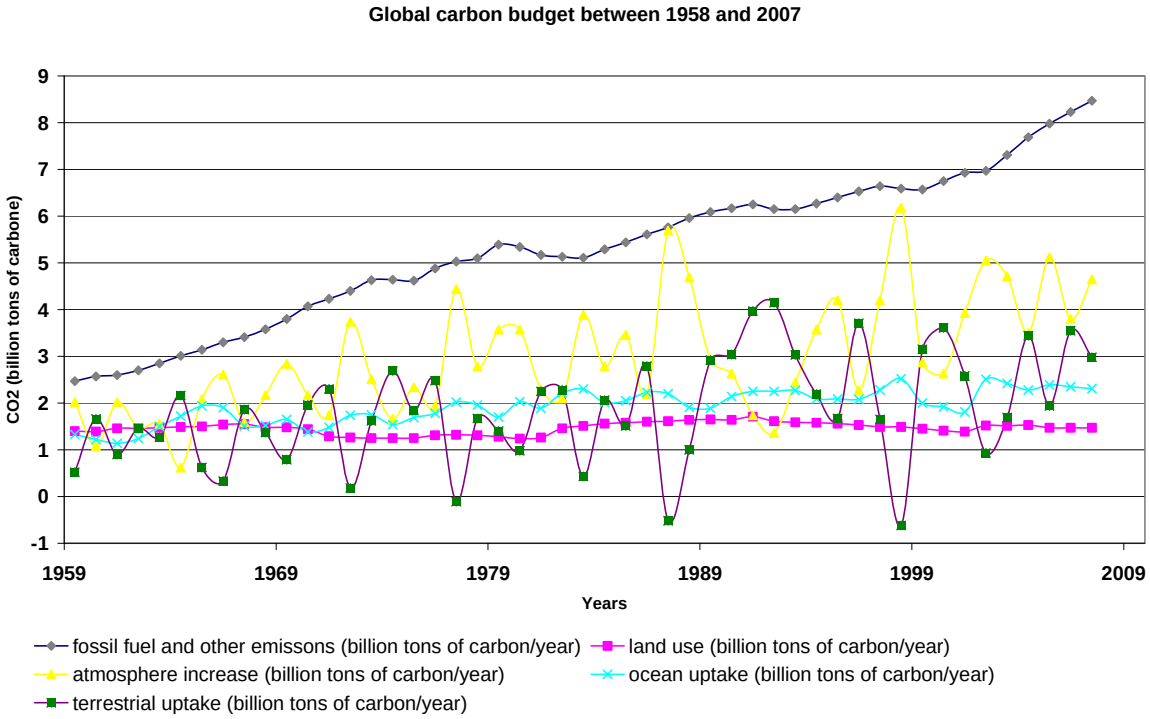
	A	B	C	D	E	F
1	Update: 3 juillet 2009					
2	year	fossil fuel and other emissons (billion tons of carbon/year)	land use (billion tons of carbon/year)	atmosphere increase (billion tons of carbon/year)	ocean uptake (billion tons of carbon/year)	terrestrial uptake (billion tons of carbon/year)
3	1960	2.47	1.40	2.02	1.33	0.52
4	1961	2.57	1.39	1.08	1.22	1.66
5	1962	2.6	1.46	2.02	1.14	0.90
6	1963	2.7	1.46	1.46	1.24	1.46
7	1964	2.85	1.47	1.55	1.5	1.27
8	1965	3.01	1.49	0.62	1.72	2.16
9	1966	3.14	1.5	2.08	1.94	0.62

2. You can create two types of graph to show atmospheric CO_2 emissions and natural absorption (the scatter diagram or the area graph). Try creating both and decide which you think is more appropriate and clearer to represent the data.

Scatter Diagram

- select ALL columns
- click on *Graph Assistant*
- select *Scatter*

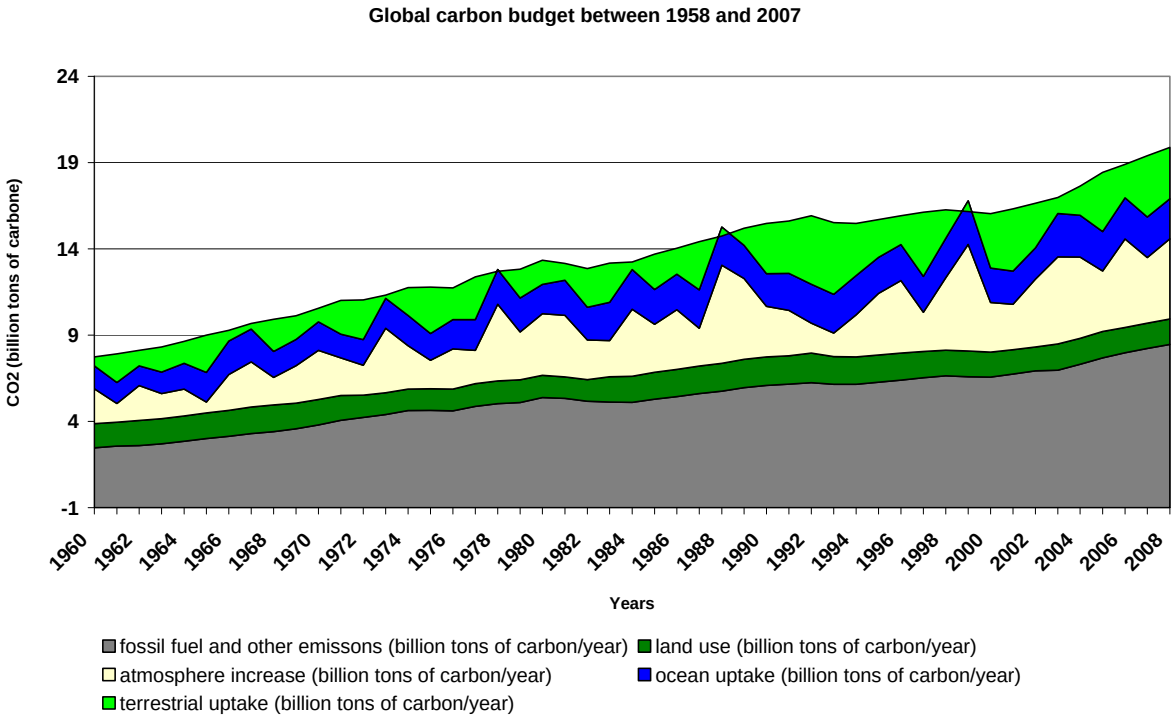
Graphics with all data, with scatter diagram selection



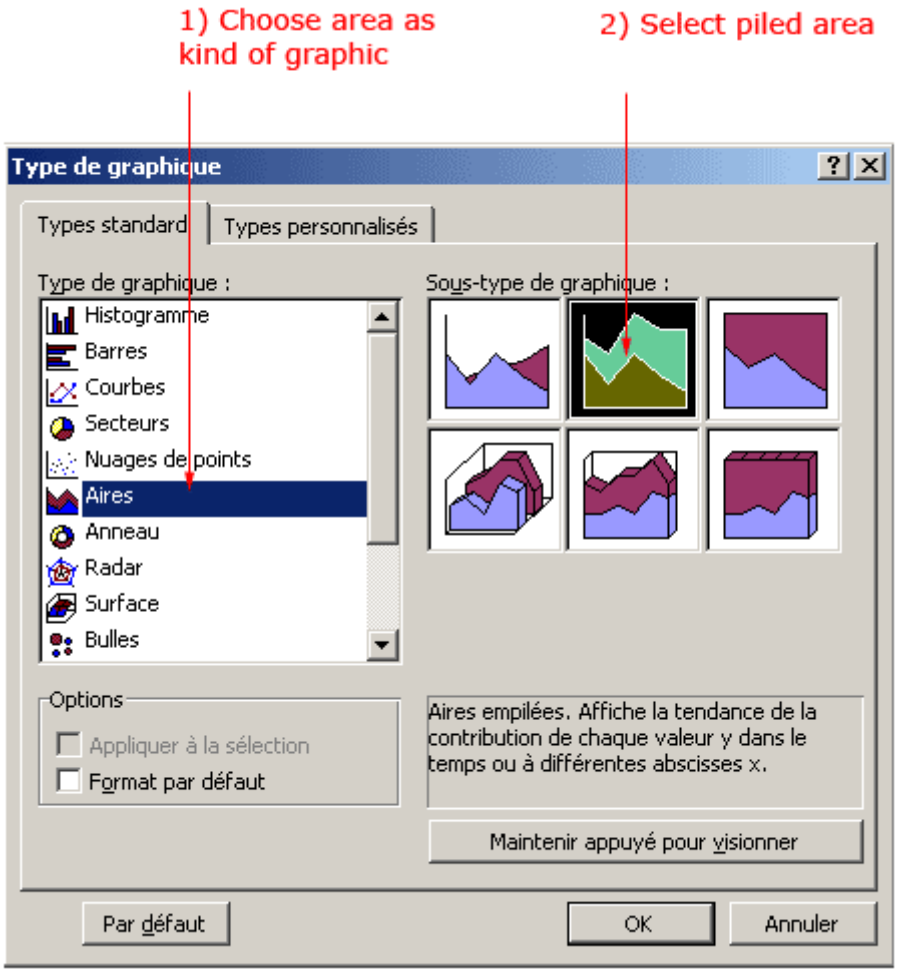
Area Graph

- select ALL columns
- click on *Graph Assistant*
- select *Area*

Graphics with all data, with area selection



Selection of graphic kind (keep this selection for all the activity)



3. Create area graphs to represent a single data type:

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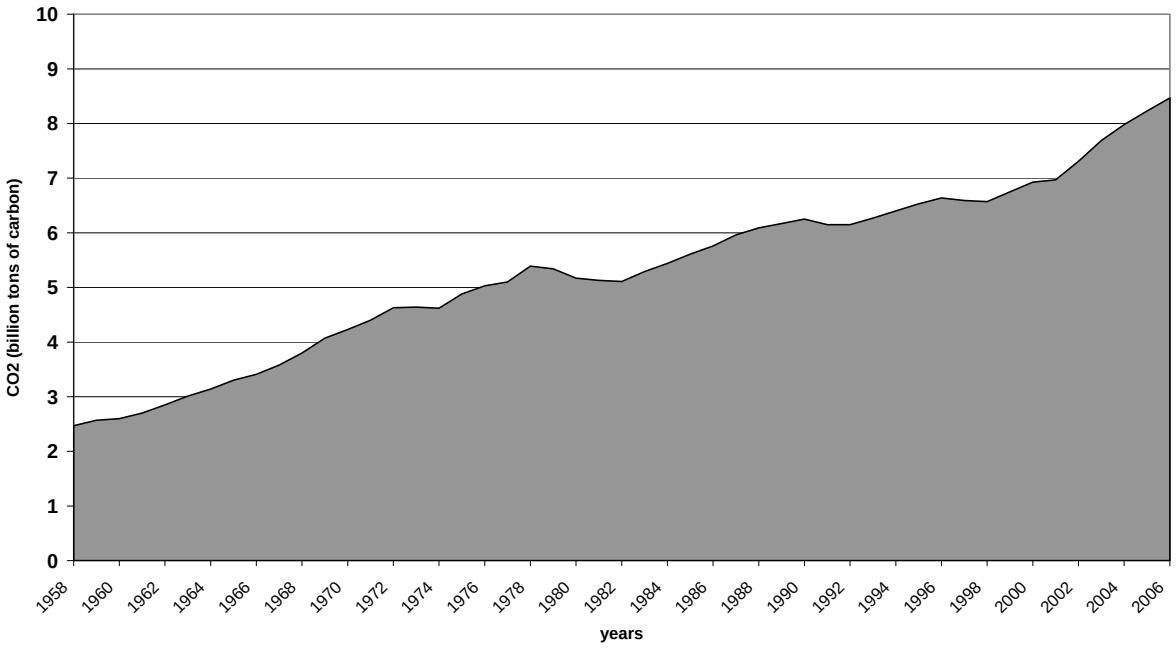
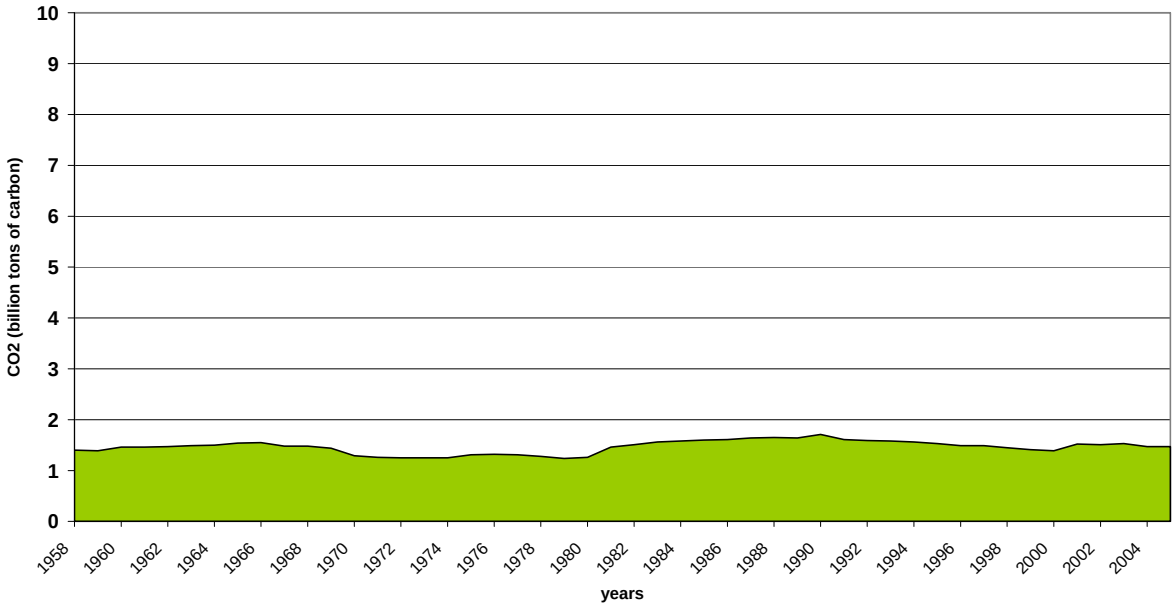
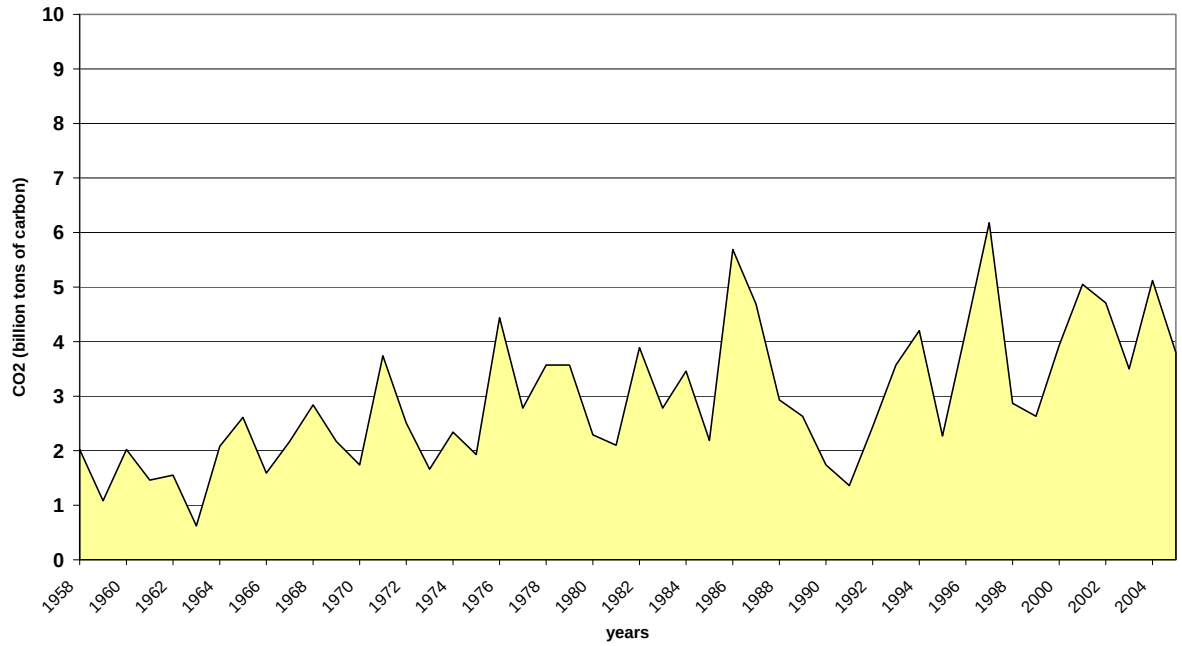
Fossil Fuel and other emissions (billion tons of carbon)



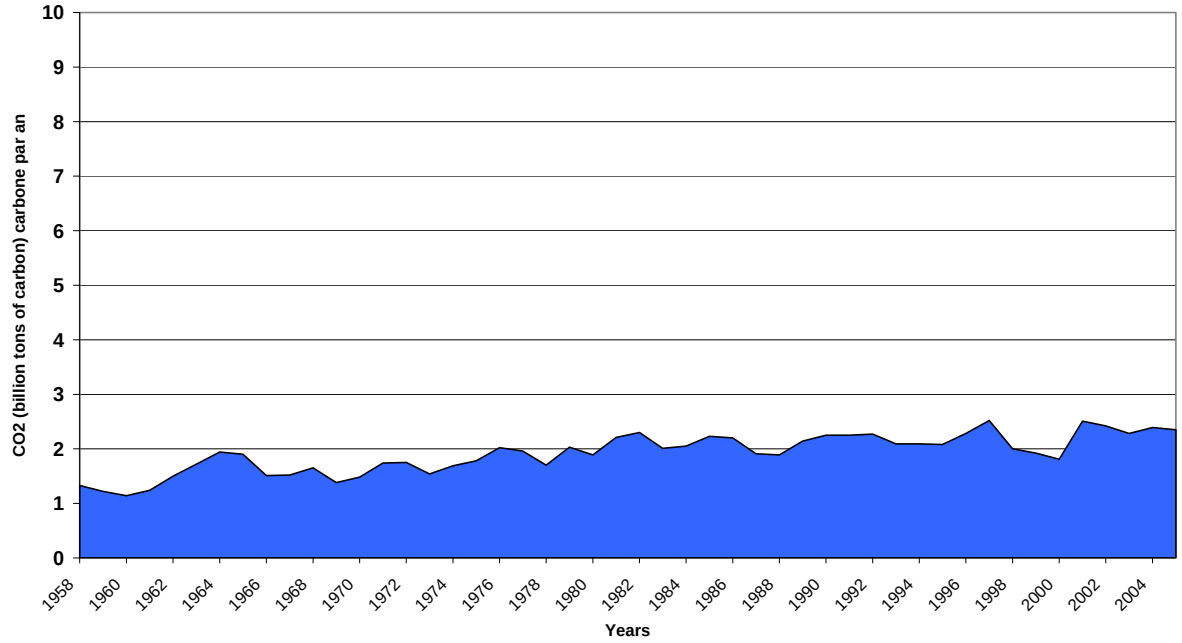
Land use CO_2 emissions (billion tons of carbon)

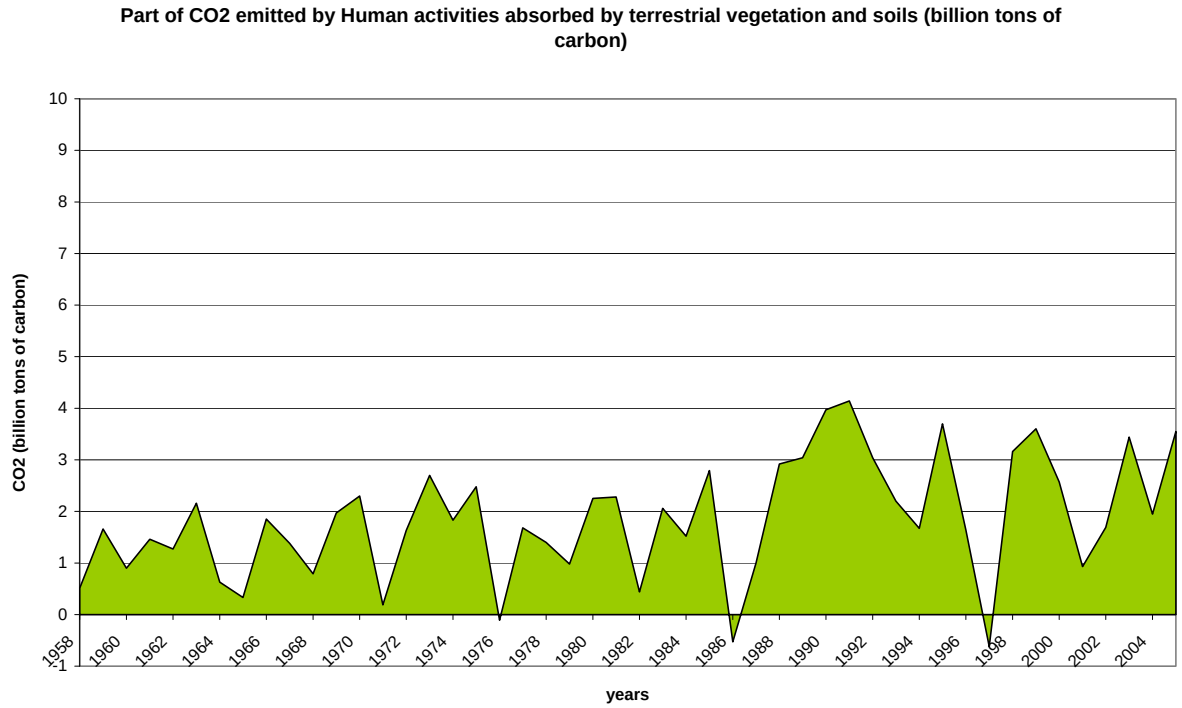


CO_2 emitted by Human activities staying in the atmosphere (billion tons of carbon)



Part of CO_2 emitted by Human activities absorbed by ocean (billion tons of carbon)





4. Describe what you observe in your graphs.

Discussion

We can see then that CO_2 emitted by fossil fuel use is increasing, but that land use emitted CO_2 is in stagnation. We also observe that the CO_2 which remains in the atmosphere (in other words that is NOT absorbed) is increasing, as well as the amount which is absorbed by the oceans and vegetation respectively.

Part 2

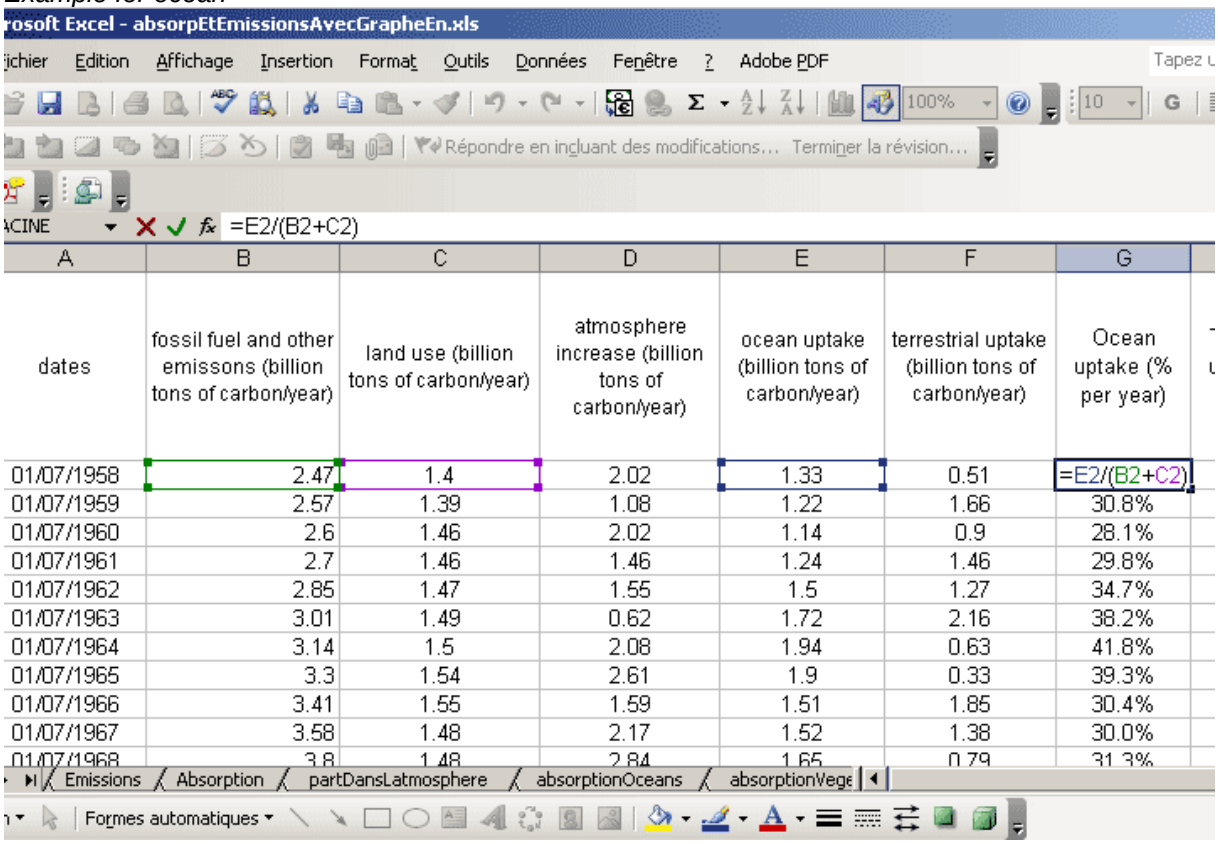
Here we will discover which "compartment" is more efficient at absorbing CO_2: vegetation or oceans? In order to do this our brut values need to be transformed into percentages.

Procedure

1. In your spreadsheet, label three new columns G, H and I, "**Ocean Uptake (%)**", "**Terrestrial Uptake (%)**" and "**Atmosphere Increase (%)**" respectively.

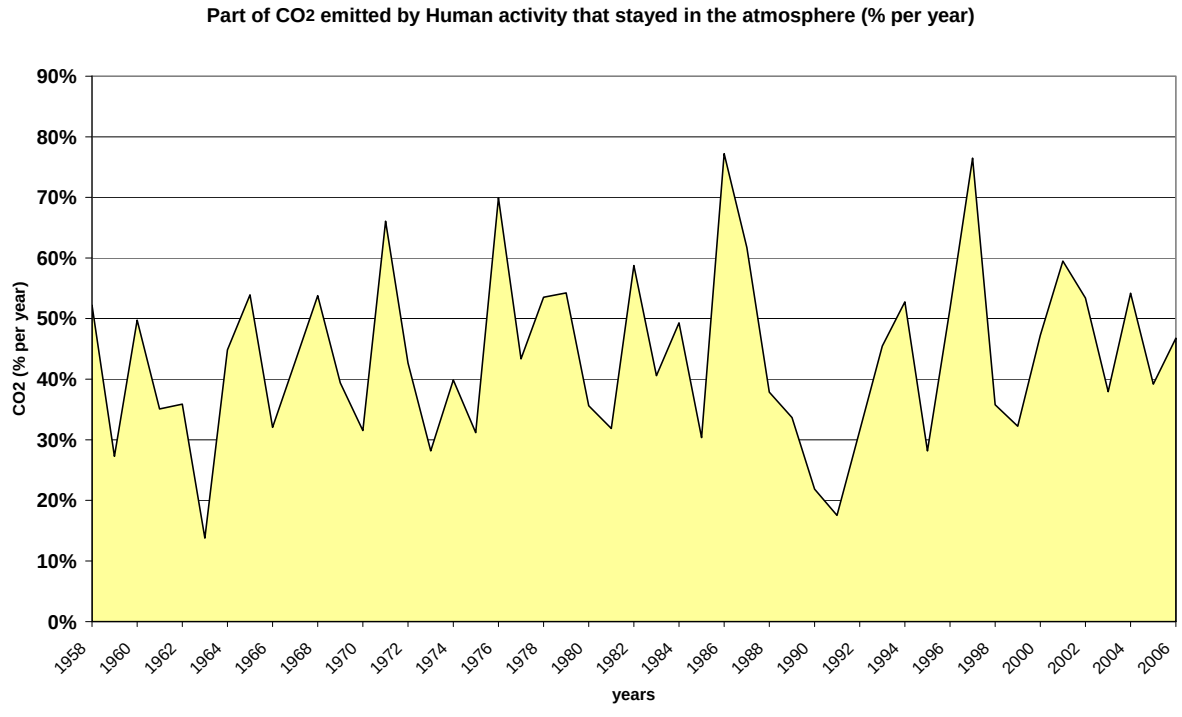
2. Before looking at the example spreadsheet below, find the calculation you must apply in order to transform the values in G, H and I into a percentage of total human emissions (columns B and C).

Example for ocean



dates	fossil fuel and other emissons (billion tons of carbon/year)	land use (billion tons of carbon/year)	atmosphere increase (billion tons of carbon/year)	ocean uptake (billion tons of carbon/year)	terrestrial uptake (billion tons of carbon/year)	Ocean uptake (% per year)
01/07/1958	2.47	1.4	2.02	1.33	0.51	=E2/(B2+C2)
01/07/1959	2.57	1.39	1.08	1.22	1.66	30.8%
01/07/1960	2.6	1.46	2.02	1.14	0.9	28.1%
01/07/1961	2.7	1.46	1.46	1.24	1.46	29.8%
01/07/1962	2.85	1.47	1.55	1.5	1.27	34.7%
01/07/1963	3.01	1.49	0.62	1.72	2.16	38.2%
01/07/1964	3.14	1.5	2.08	1.94	0.63	41.8%
01/07/1965	3.3	1.54	2.61	1.9	0.33	39.3%
01/07/1966	3.41	1.55	1.59	1.51	1.85	30.4%
01/07/1967	3.58	1.48	2.17	1.52	1.38	30.0%
01/07/1968	3.8	1.48	2.84	1.65	0.79	31.3%

3. Now create new area graphs representing the three compartments: Ocean (column G), vegetation (column H) and atmosphere (column I).
4. What do your new graphs tell you?



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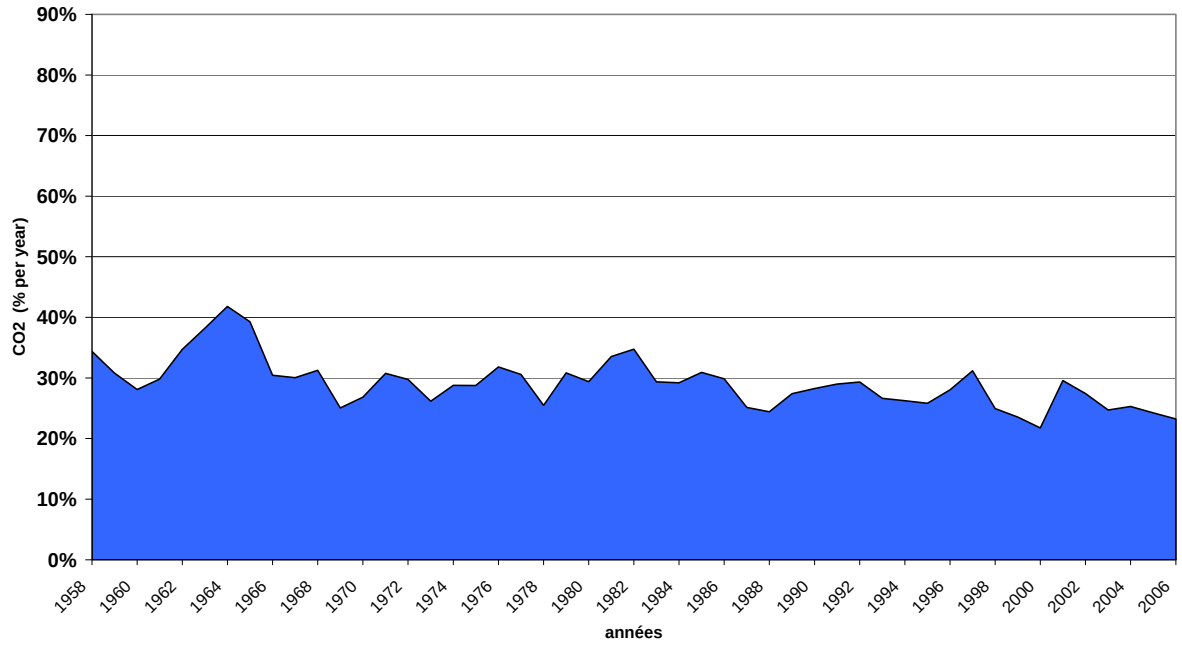
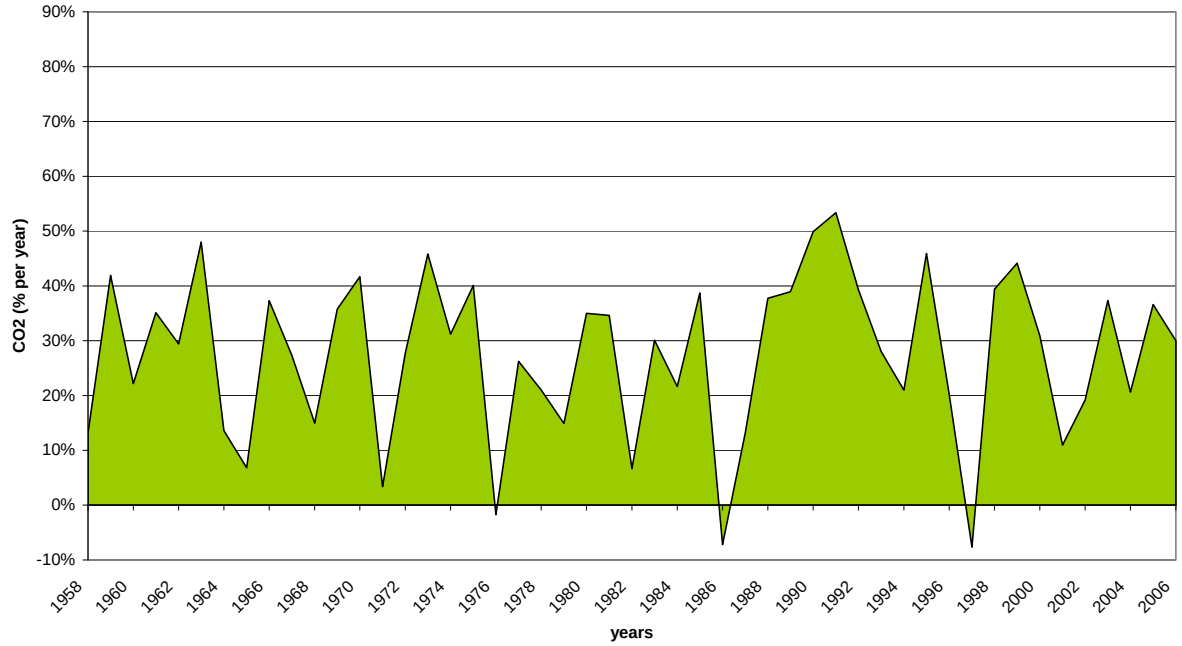
Part of CO2 emitted by Human activities absorbed by ocean (% per year)

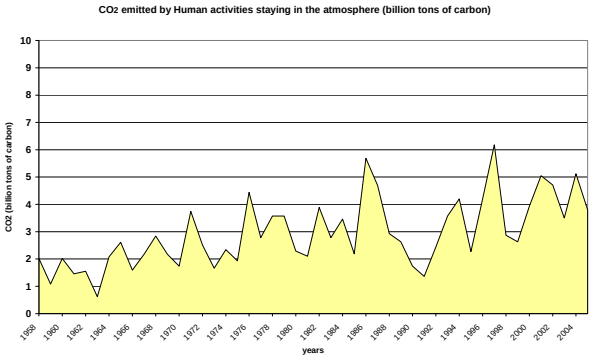


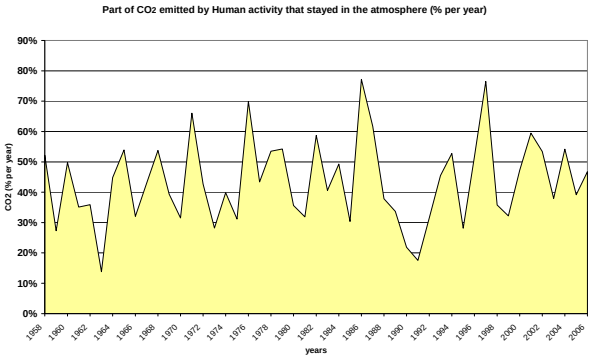
Part of CO_2 emitted by Human activities absorbed by terrestrial vegetation and soils (% per year)



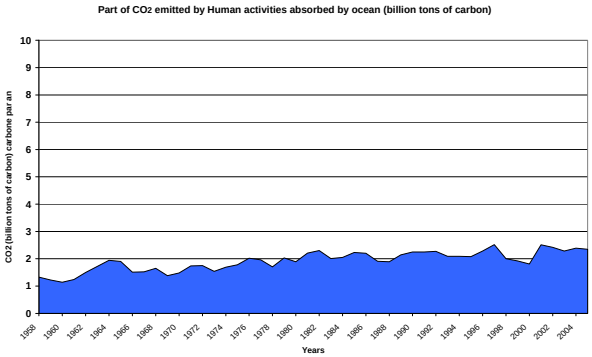
Comparison between brut data (left) and percentage (right) for each compartment.

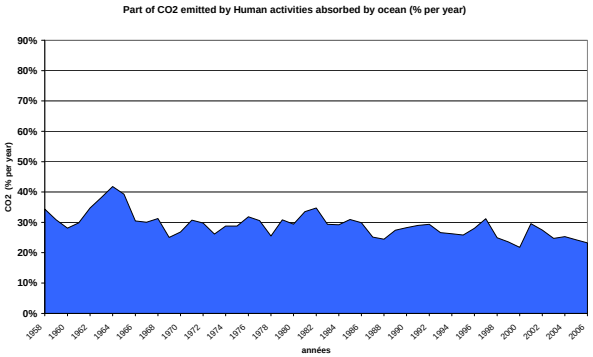
Atmosphere



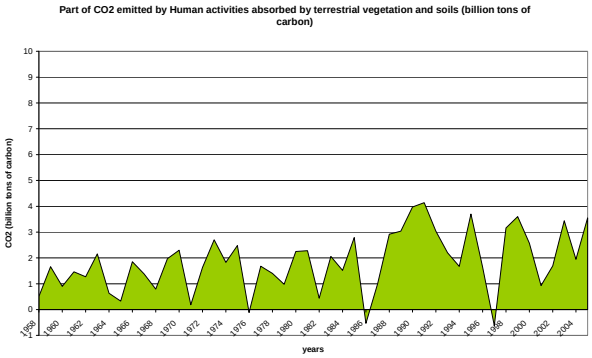


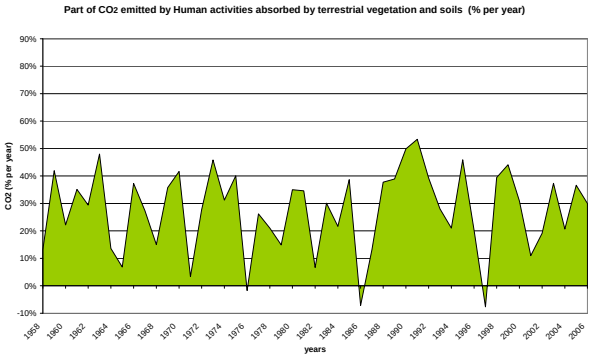
Ocean





Vegetation and soils





Discussion

From the last set of graphs, we can see that the percentage of CO_2 that remains in the atmosphere is increasing. We can link this to the slow decrease that we observe in ocean uptake of atmospheric CO_2.

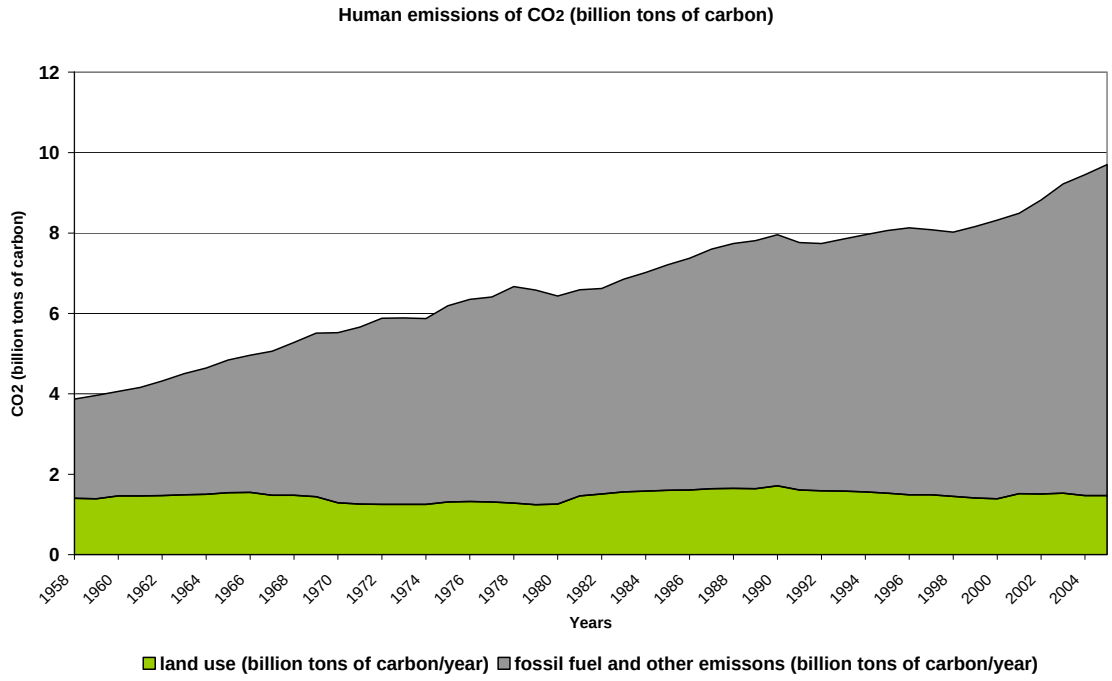
Just by looking at the graphs, we can describe the global carbon budget in these terms: about half of the CO_2 (45%) emitted by humans remains in the atmosphere, while half is absorbed by natural sinks (55%): about half by oceans and half by vegetation.

These values are correct for the twentieth century, but it is thought that they will change during the 21st century when natural sinks will become less efficient.

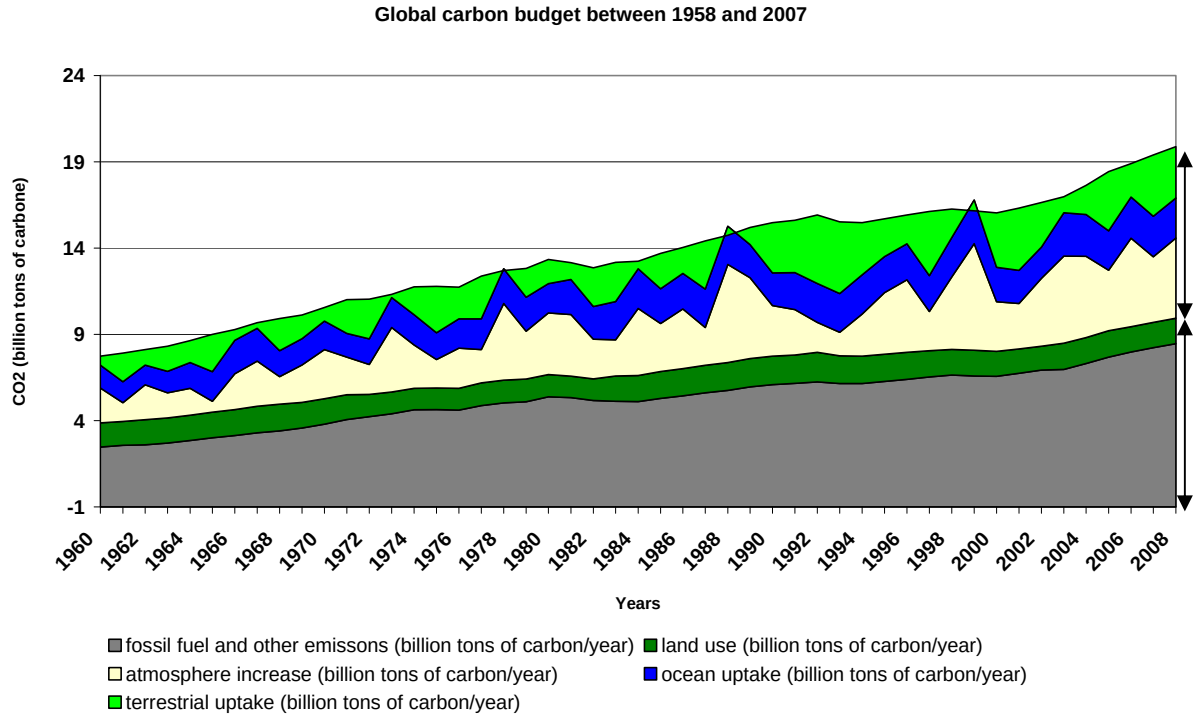
Other graphical representations
We can show in one graph what becomes of human CO_2 emissions each year; in other words, how it is divided up between compartments.

For example, in the first graph below we can see the total human emissions each year, but it does not show us the compartments in which it is absorbed, and this may give us the false impression that all emissions are in the atmosphere. The second graph includes these compartments (atmosphere, vegetation and oceans), thus giving us a more precise picture of what happens to the emissions.

All emissions in one graphic

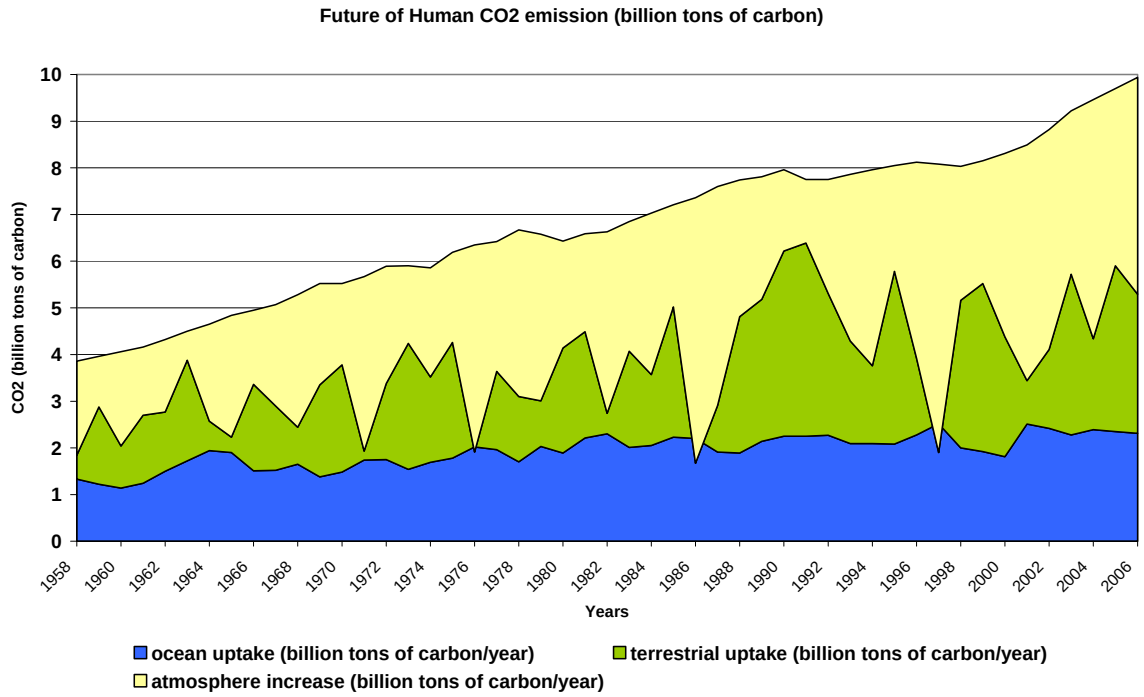


Global carbon budget between 1958 and 2008

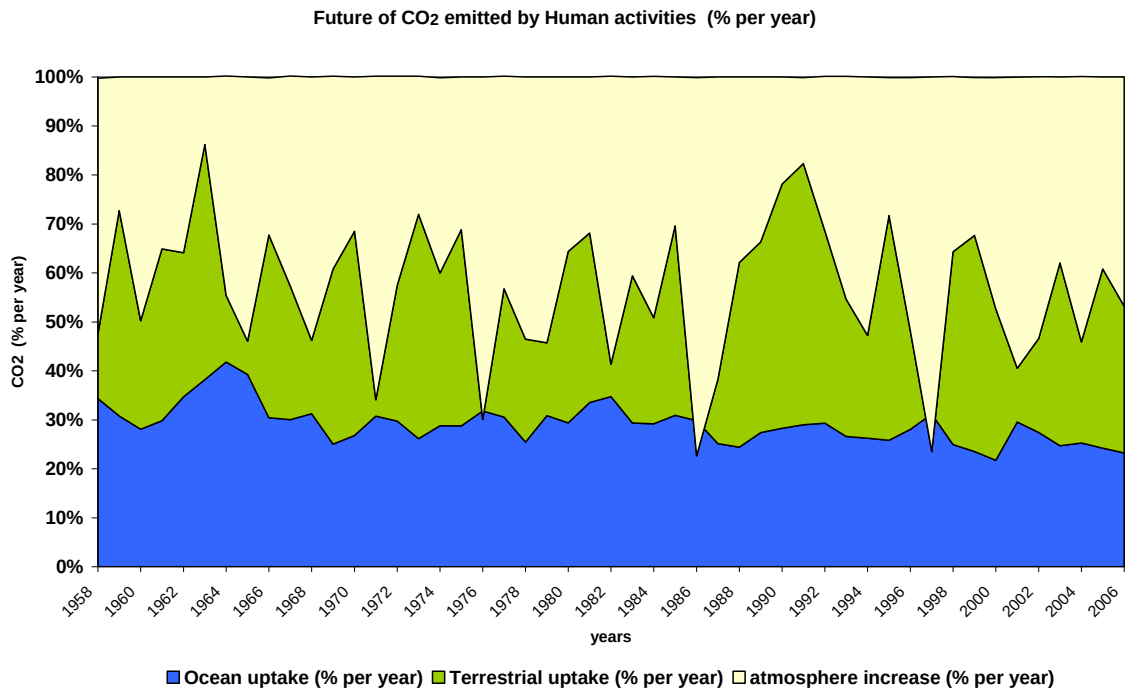


we can see that, for each year, emissions are equal to the future of CO_2 emitted by Human activities (it is evident, by definition, but it is not necessarily clear for the students)

Here are some more graphical representations.
Future of emissions in one graphic



Future of CO_2 emissions in one graphic in percent (sum is 100% because we see the future of all CO_2 emitted)



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