

# From uncertainties on emissions from fossil fuel combustion to climate change

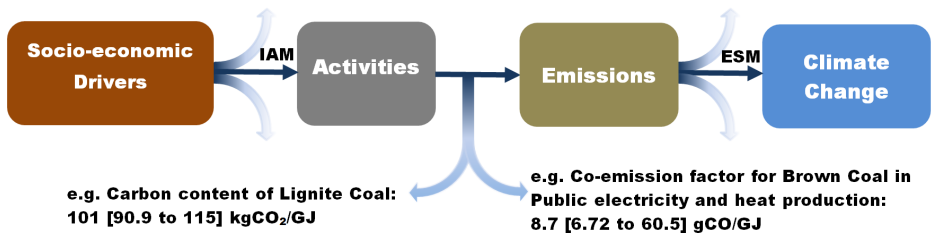
**Yann Quilcaille,**

Gasser T., Ciais P., Lecocq F., Janssens-Maenhout G., Mohr S.,  
Andres R.J. and Bopp L.

LSCE/IPSL & CIRED

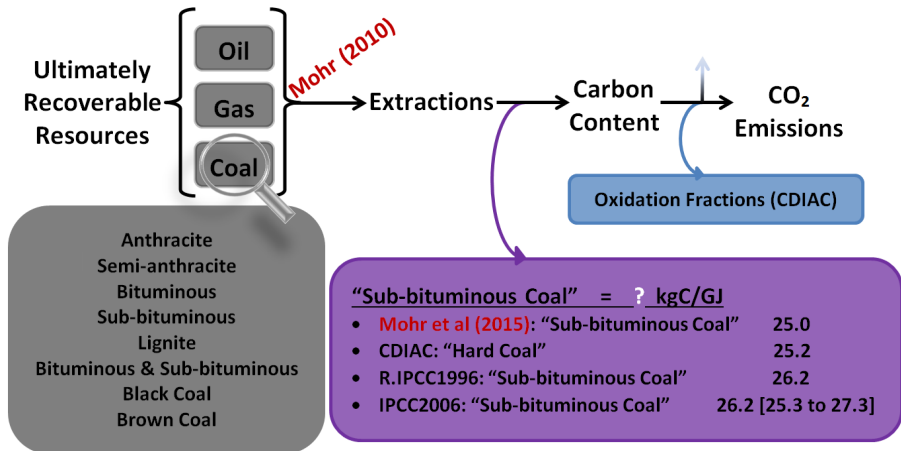
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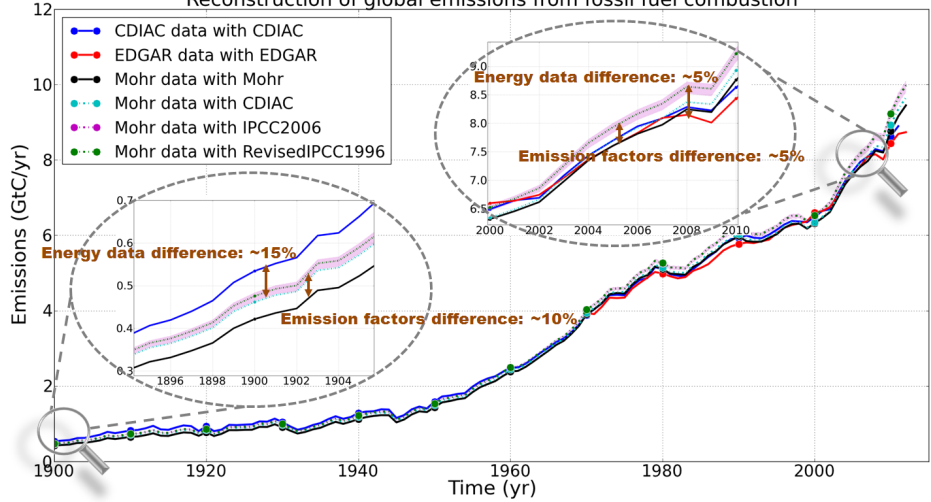
**Objective** : how do the uncertainties on emissions associated to fossil fuel combustion influence the climate change ?

- 1 Evaluation of CO<sub>2</sub> **emissions from fossil fuel combustion**
- 2 Impact on **climate change**
- 3 Evaluation of **co-emissions from fossil fuels**
- 4 Impact on **climate change**

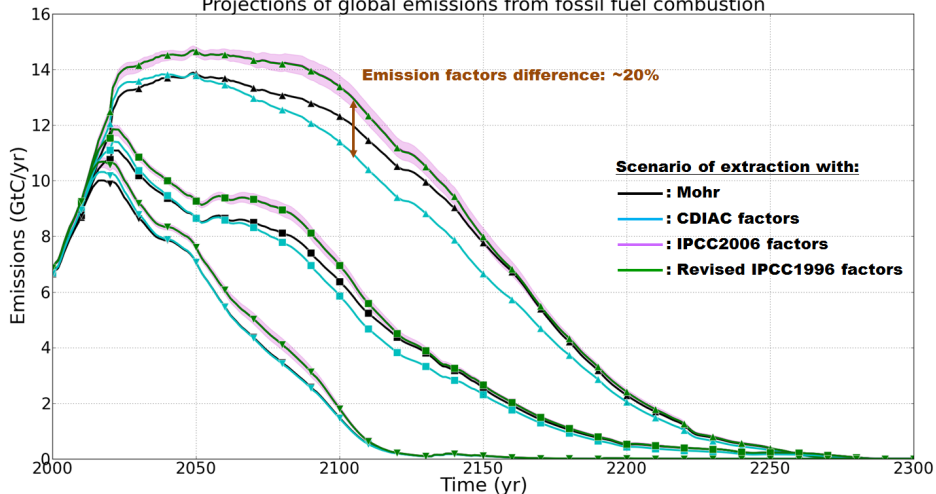


- historical + 3 projections of extraction
  - 4 sets of carbon contents : "Methods"
- compared to the CO<sub>2</sub> inventories of CDIAC and EDGAR

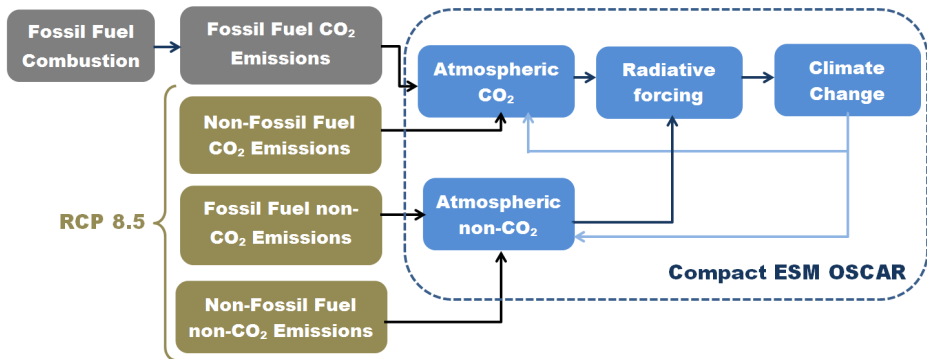
### Reconstruction of global emissions from fossil fuel combustion



## Projections of global emissions from fossil fuel combustion



- ↪ The resources composing a broad category are not depleted at the same rate, but the carbon content of the category is constant
- ↪ Uncertainties due to parameters of non-conventional oils

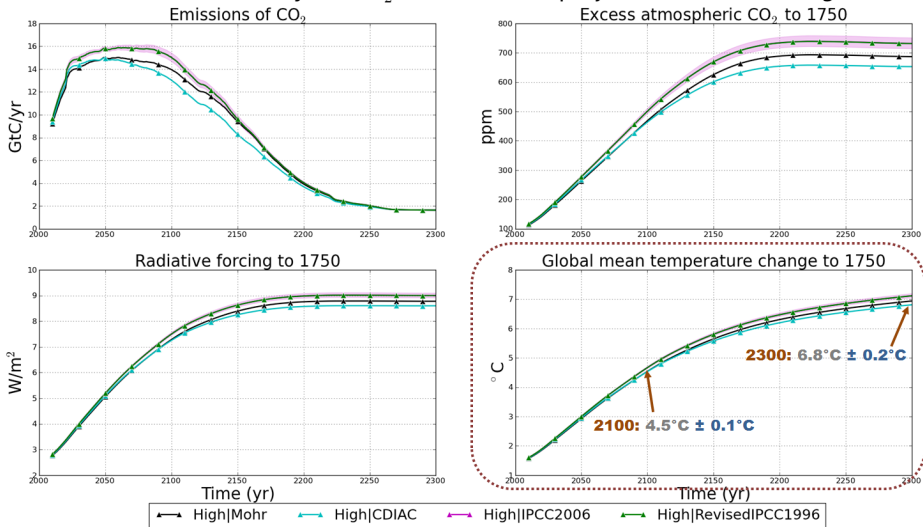


OSCAR :

Gasser (2010) : [tel.archives-ouvertes.fr/tel-01135456](http://tel.archives-ouvertes.fr/tel-01135456)

Li, Gasser et al (2016) : [doi:10.1038/nature17165](https://doi.org/10.1038/nature17165)

# Effect of uncertainty on CO<sub>2</sub> emissions on projected climate change



→ small but significant uncertainty from CO<sub>2</sub> emission factors



**Leaks**

**Fugitive**

**CH<sub>4</sub>, VOC**

**Content**

**N<sub>2</sub>O**

**Incomplete combustion & Combustion process**

**CO, VOC, BC**

**NH<sub>3</sub>**

**NO<sub>x</sub>, SO<sub>2</sub>**

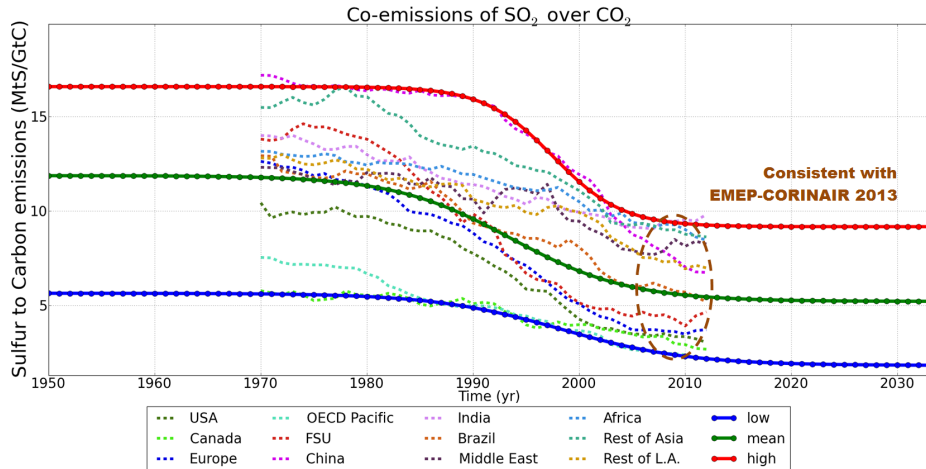
**OC**

**NO<sub>x</sub>**

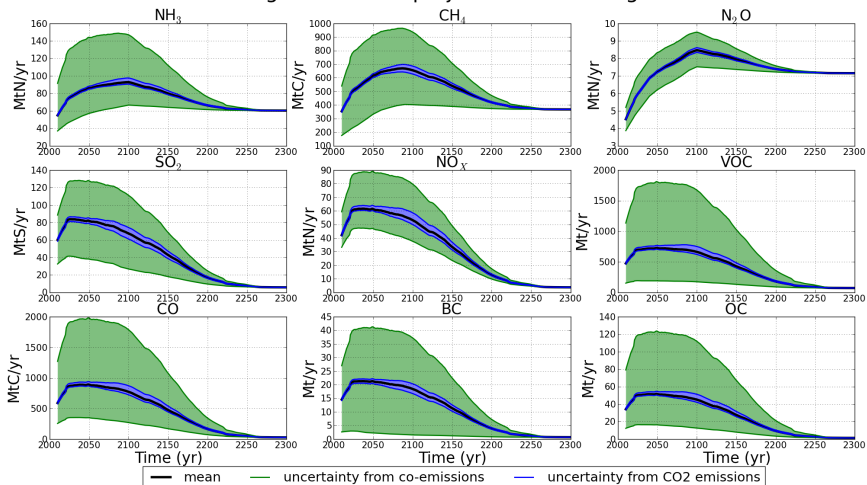


## Principle : co-emission ratios using EDGAR v4.3

- uncertainty from the technology, fuel, operating conditions ,...
- ⇒ **Hypothesis** : Range in 1970-2012 representative of 1700-2300



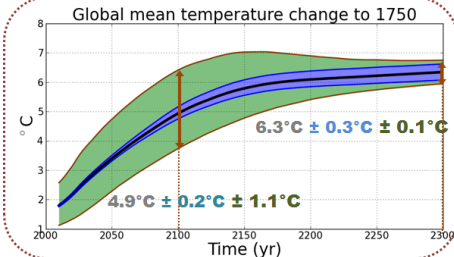
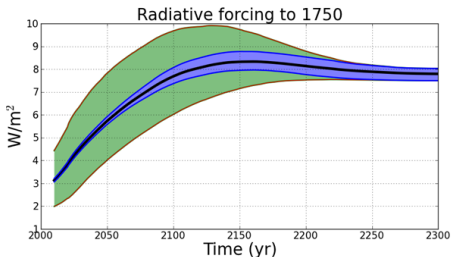
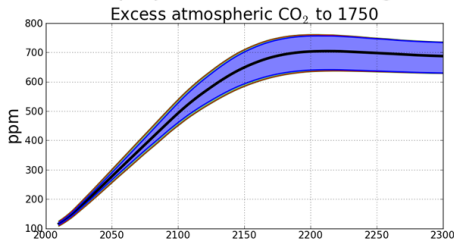
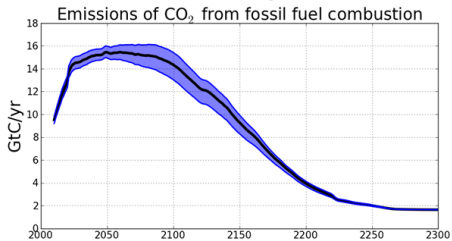
## Emissions on High Resources projection with background RCP8.5



Productions of scenarios **from 1700** : uncertainty in 2010

- Historic emissions close to the mean of trajectories
- Most of the uncertainty from the co-emissions

## Effect of uncertainty on co-emission factors on projected climate change



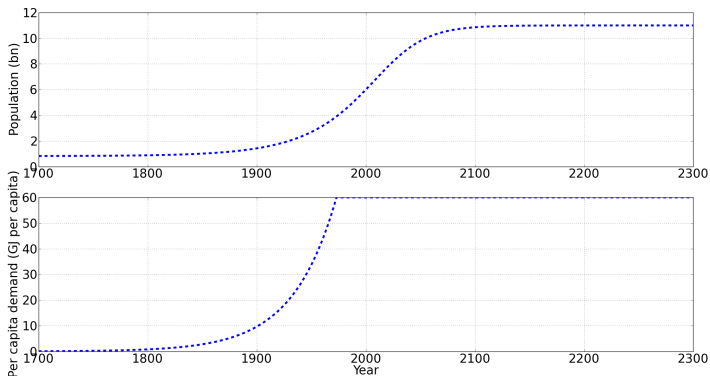
— mean    — uncertainty from co-emissions    — Covariance    — uncertainty from CO<sub>2</sub> emissions

Extraction	2100	CO <sub>2</sub>	non CO <sub>2</sub>	2300	CO <sub>2</sub>	non CO <sub>2</sub>
<b>High</b>	4.9° C	±0.2	±1.1	6.3° C	±0.3	±0.1
<b>Best Guess</b>	4.1° C	±0.2	±0.7	5.0° C	±0.2	±0.1
<b>Low</b>	3.4° C	±0.1	±0.4	4.1° C	±0.1	±0.0

- Decreasing uncertainty from non-CO<sub>2</sub> from fossil fuels
- ↳ Shorter lifetimes for non-CO<sub>2</sub>
- Increasing uncertainty from CO<sub>2</sub> with time and with amount of fossil fuels burnt
- ↳ Accumulation of uncertainties
- ⇒ Uncertainty on co-emission factors dominates the one on CO<sub>2</sub> emissions
- Compared to the uncertainty on climate sensitivity, it represents :
  - 2081-2100 → 45-120%
  - 2281-2300 → 2-8%

- 1 Limited access to information on detailed data (fuel types, carbon contents,...)
- 2 Impact of the categorization : up to  $\pm 0.3^{\circ}\text{C}$
- 3 Impact of the uncertainty on co-emissions : up to  $\pm 1.1^{\circ}\text{C}$
- 4 **How to reduce this uncertainty ?**
  - ⇒ **More frequently updated estimates of factors to account for ongoing technical progress and fuel mix**
- 5 ***Importance for a consistent treatment of co-emitted species from different sectors in IAM***

yann.quilcaille@lsce.ipsl.fr



- Population : stabilization at 11 billions ( $\simeq$  SRES B2)
- Per capita demand : constant from 1973
- Resources available : Low (48 409EJ), Best Guess (75676 EJ), High (141488 EJ)

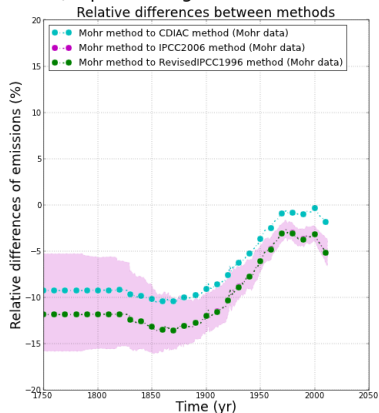
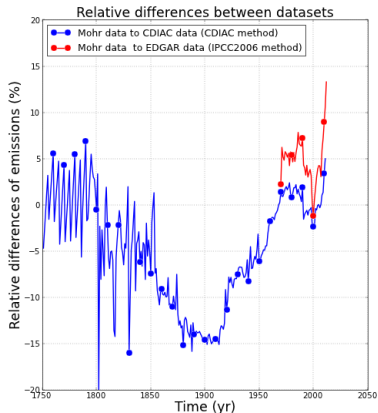
Mohr (2010) : "Projection of world fossil fuel production with supply and demand interactions"

(<http://www.theoil Drum.com/node/6782>)

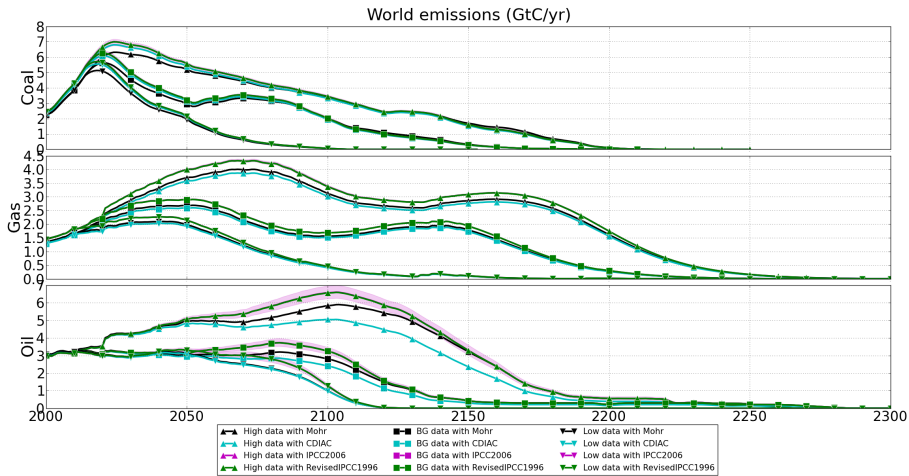
Mohr et al, 2015 : "Projection of world fossil fuels by country" (<http://dx.doi.org/10.1016/j.fuel.2014.10.030>)



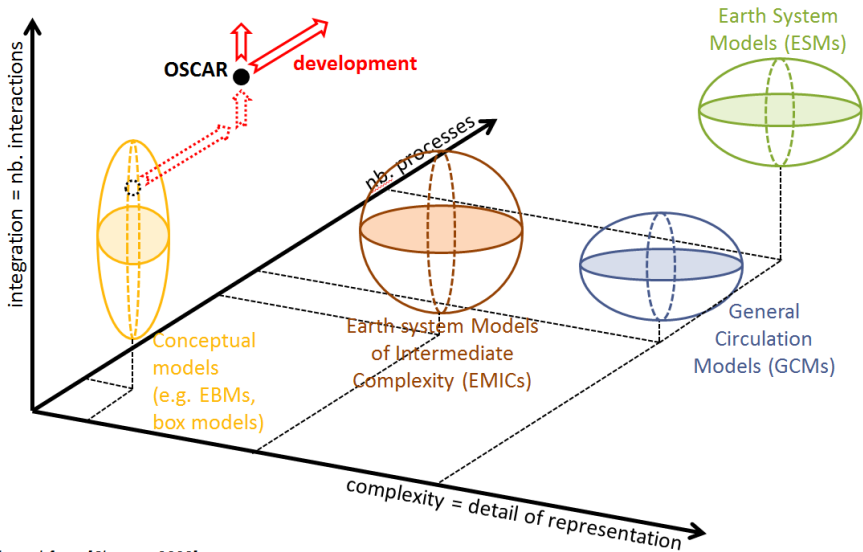
## Relative differences for solids, liquids and gas



- "Data" : CDIAC < Mohr around 1900, up to 15% (from Coal)
- "Data" : EDGAR < Mohr (around 5%)
- "Methods" : IPCC < CDIAC < Mohr, up to 10% (from Gas then Oil)
- "Methods" : CDIAC out of the range for Gas and Coal during 1900-2000







adapted from [Clausen, 2000]

OSCAR is another carbon-cycle box-model, close to MAGICC :

- with regionalized biosphere
- coupled to a regionalized climate impulse response function
- focusing on the integration of the Earth system
- reproducing the behaviours of models of greater degree of spatial representation
- able to combine the sensibilities between modules

OSCAR v2.1, Gasser (2014) : "Attribution regionalise des causes anthropiques du changement climatique"

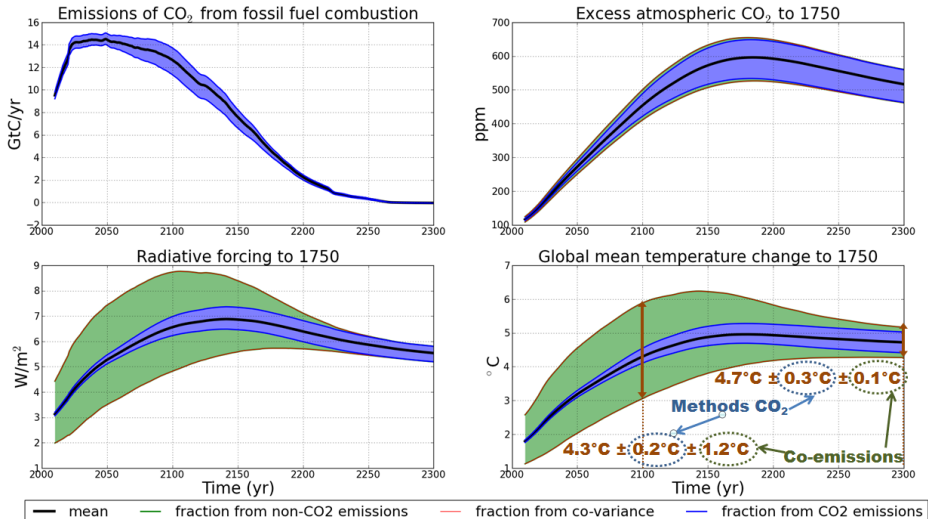
<https://tel.archives-ouvertes.fr/tel-01135456>

Li, Gasser et al (2016) : "The contribution of China's emissions to global climate forcing" (doi :10.1038/nature17165) OSCAR v2.2,

Gasser et al (working paper) : "The compact Earth system model OSCAR v2.2 : description and first results"

- 1 Different estimations of  $\text{CO}_2$  : 6
- 2 Values for each one of 9 gases co-emitted : Low, Mean, High  
↳  $[\text{CH}_4]$  ;  $[\text{BC}]$  ;  $[\text{SO}_2]$  ;  $[\text{N}_2\text{O}]$  ;  $[\text{CO}, \text{VOC}, \text{OC}, \text{NO}_x, \text{NH}_3]$  : 243 trajectories
- 3 Using log-normal distribution from factors to weight each one of the 6 x 243 trajectories
- 4 Evaluating variances from each contribution to scale the 95% range

## Impact on climate on High Resources projection with background RCP2.6



- Shortening the time of development of scenarios
- CM & ESM : uncertainty induced by the climate system
- IAM : identification of the range of different technological, socioeconomic and policy futures that lead a specific RCP.

