Science and Energy 2018, Les Houches

Energy and IPCC scenarios

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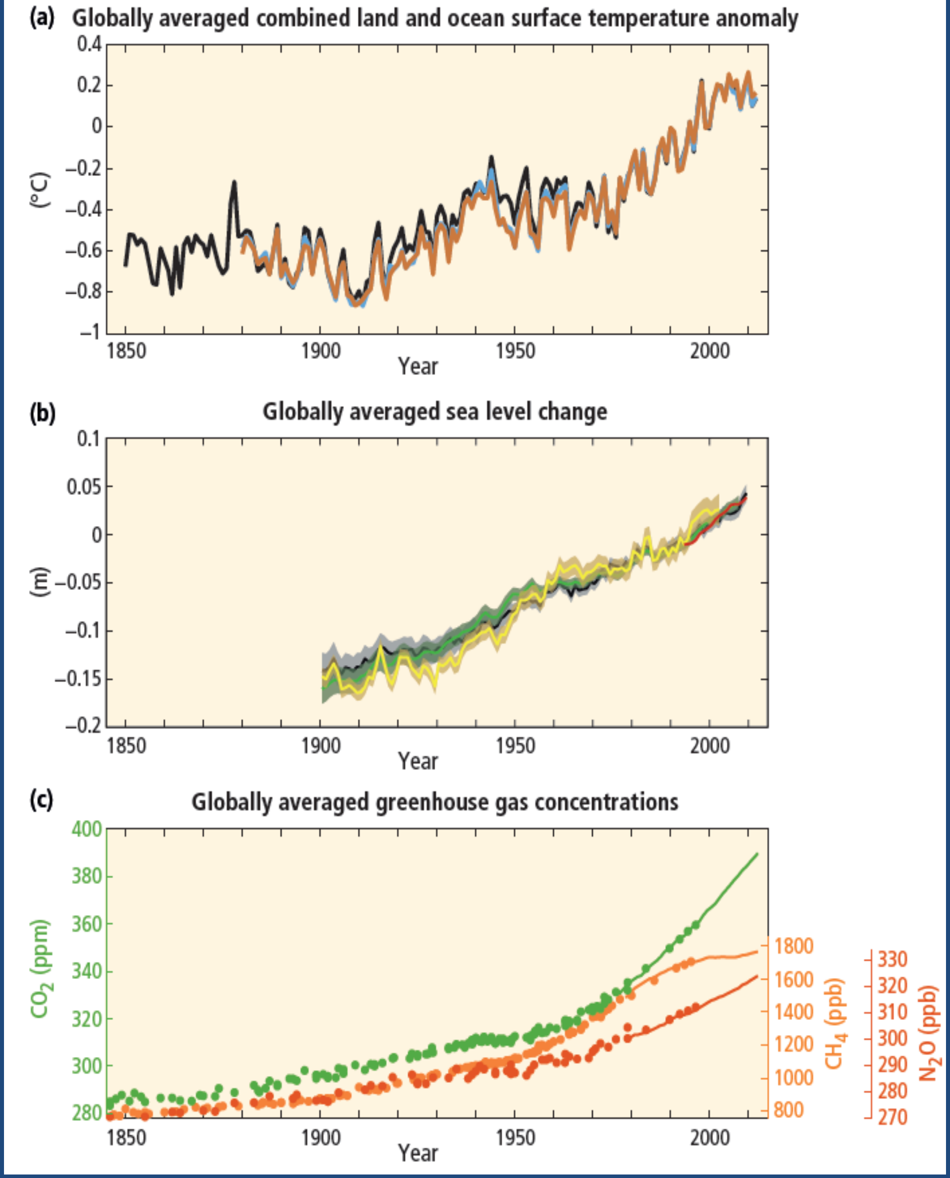
Monday 5 March 2018

Support of presentation by Sarah Amram

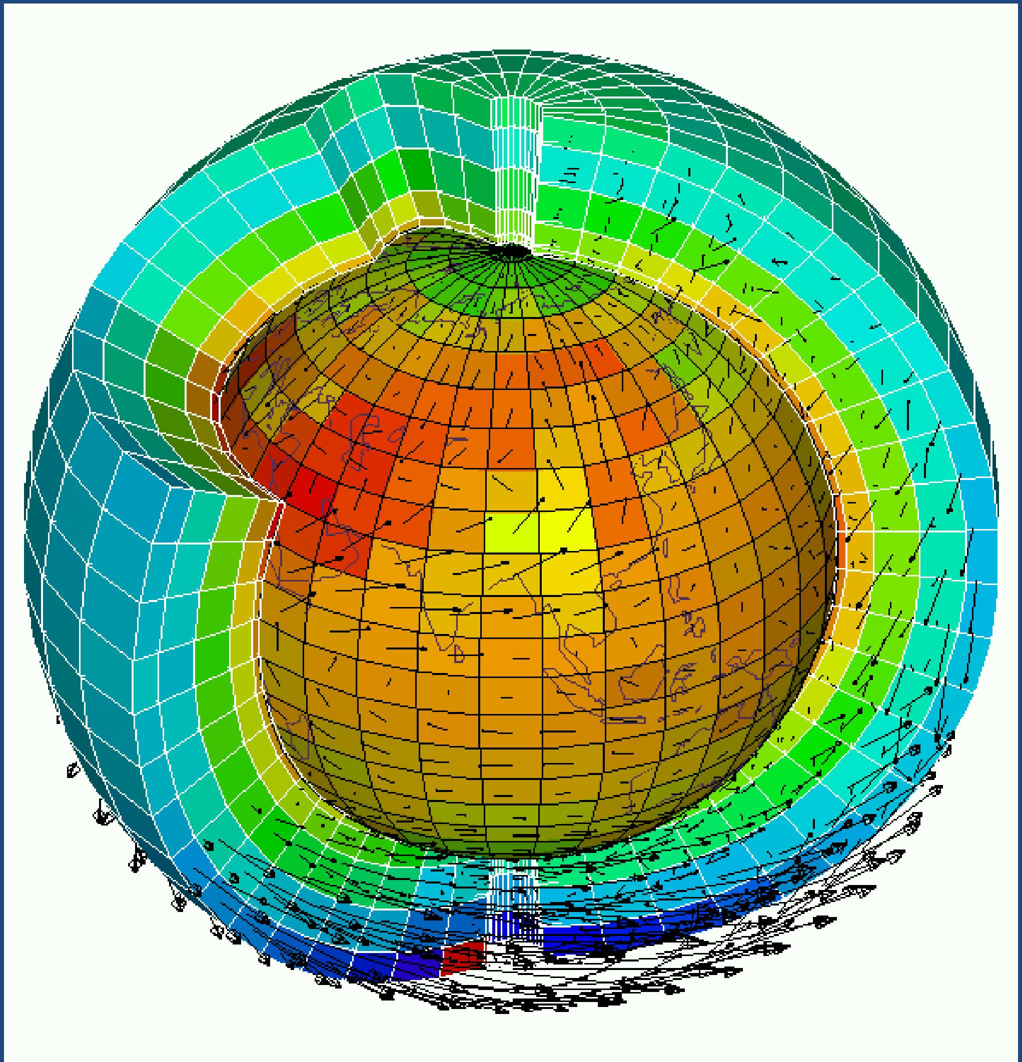
Outline

- Modeling the climate evolution from IPCC scenarios
- Exploring thresholds and non-linearities of Earth system
- Training journalists and communicators to the different impacts of climate change: a new on-line Master formation in French "Understanding the interaction between climate, environment and society " (collaboration ESJ-IPSL-Université Paris-Saclay)
- Increase the citizen education level to better cope with future climate changes
- What about future energy choices?
- What can we learn from the IPCC strategy for a better understanding of energy choices and their impact for the on-going century?

Fig.1 of the "Summary for Policymakers" of the 5th IPCC Report

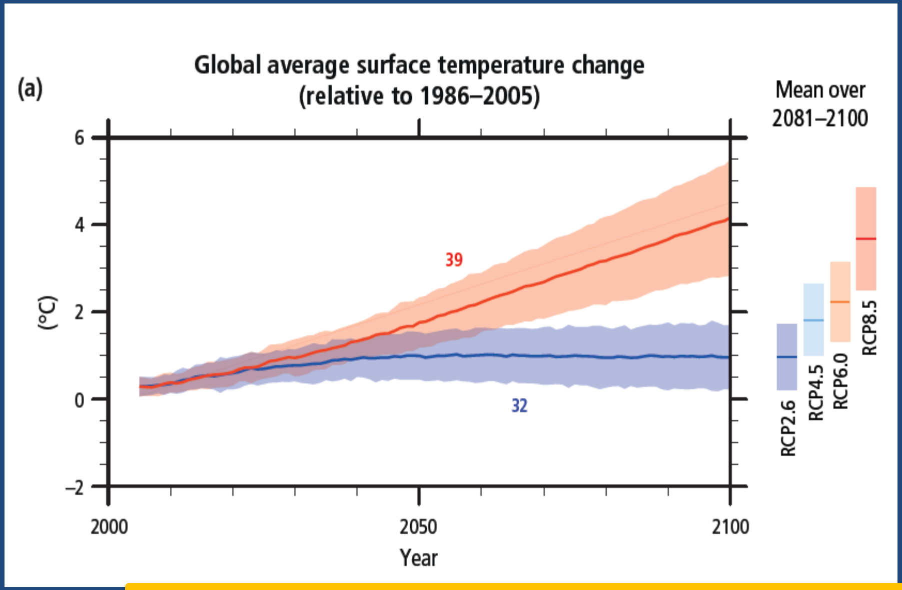


3D climate modeling

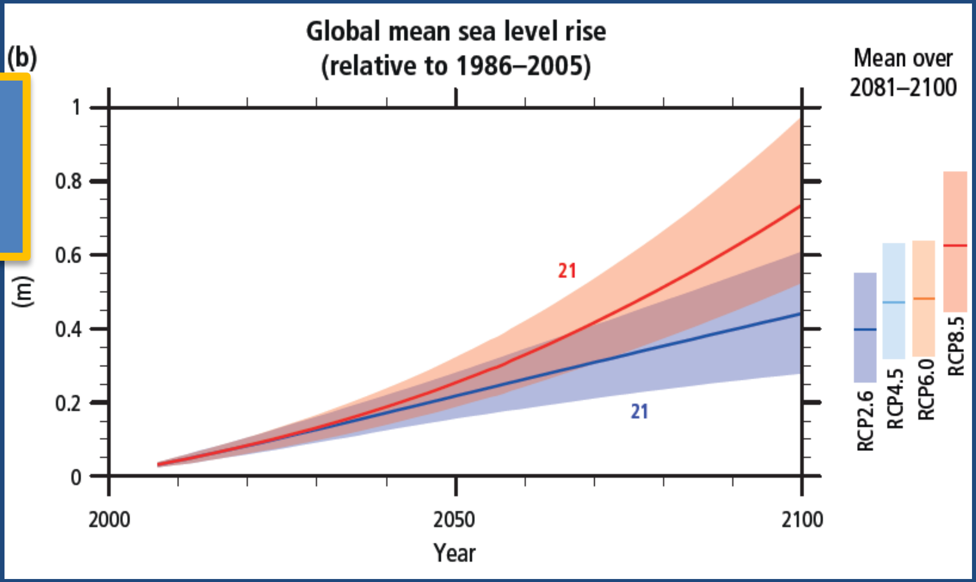


L. Fairhead, LMD/IPSL

Framework



Climate Change 2014, Synthesis Report Summary for Policymakers (Fig SPM.6)



Temperatures and precipitations

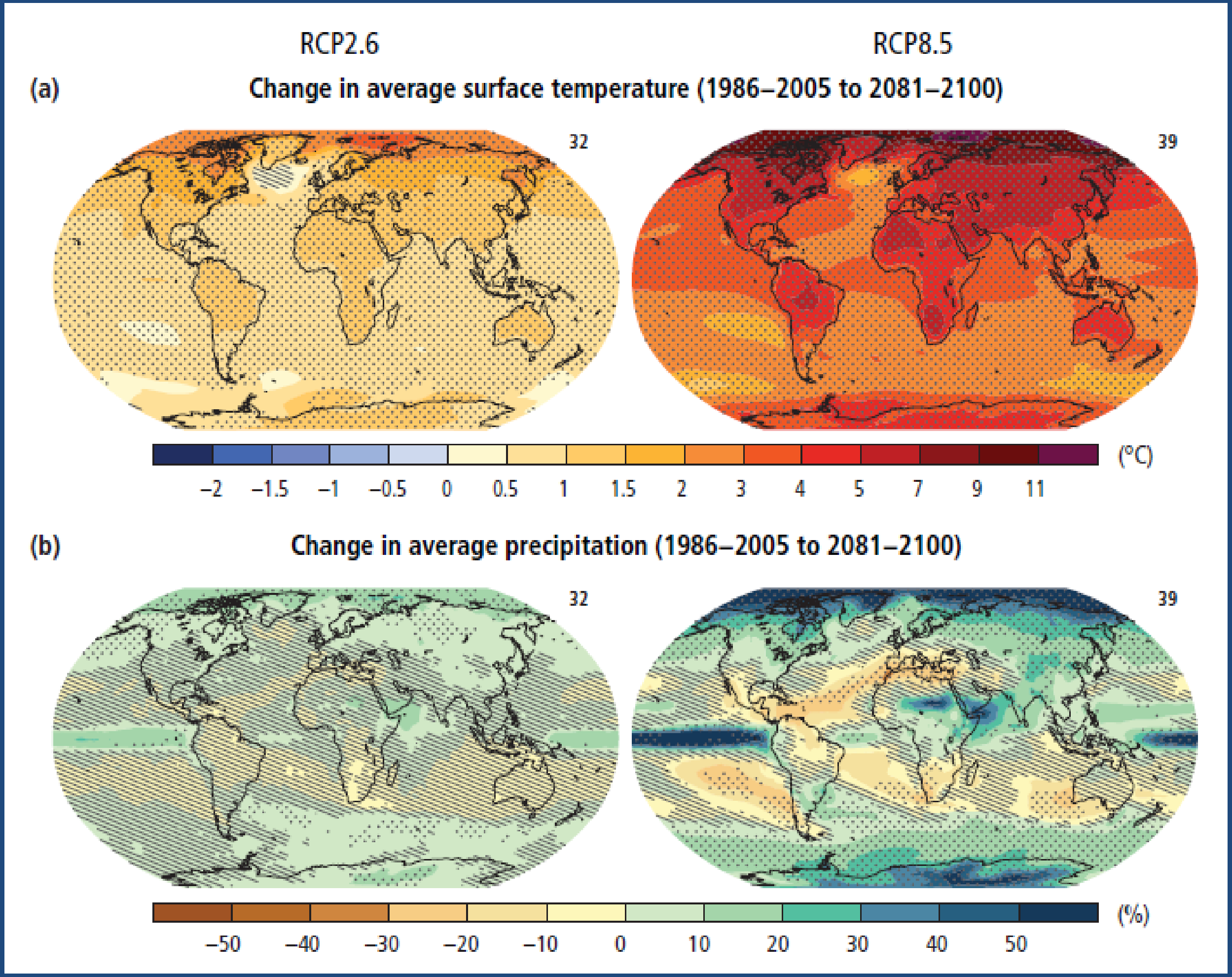
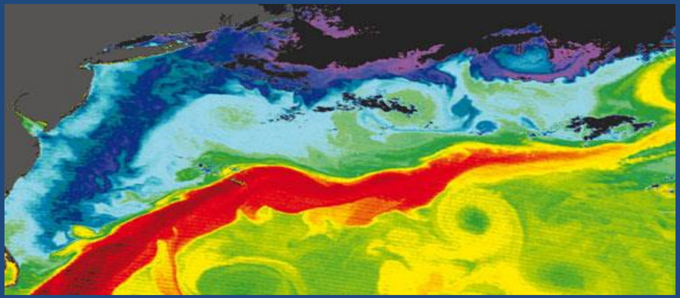


Fig.7 of the "Summary for Policymakers" of the 5th IPCC Report

Breaks, non-linear responses, thresholds…

- Carbon climate interactions
  - CO2 partitioning in different reservoirs
  - Destabilization of existing reservoirs:
    - Permafrost (short term)
    - Methane hydrates (long term)

- Cryosphere and ocean interactions
  - Rapid melting of the ice sheet => freshwater inputs in the ocean
    Deep water formation and meridional ocean circulation changes

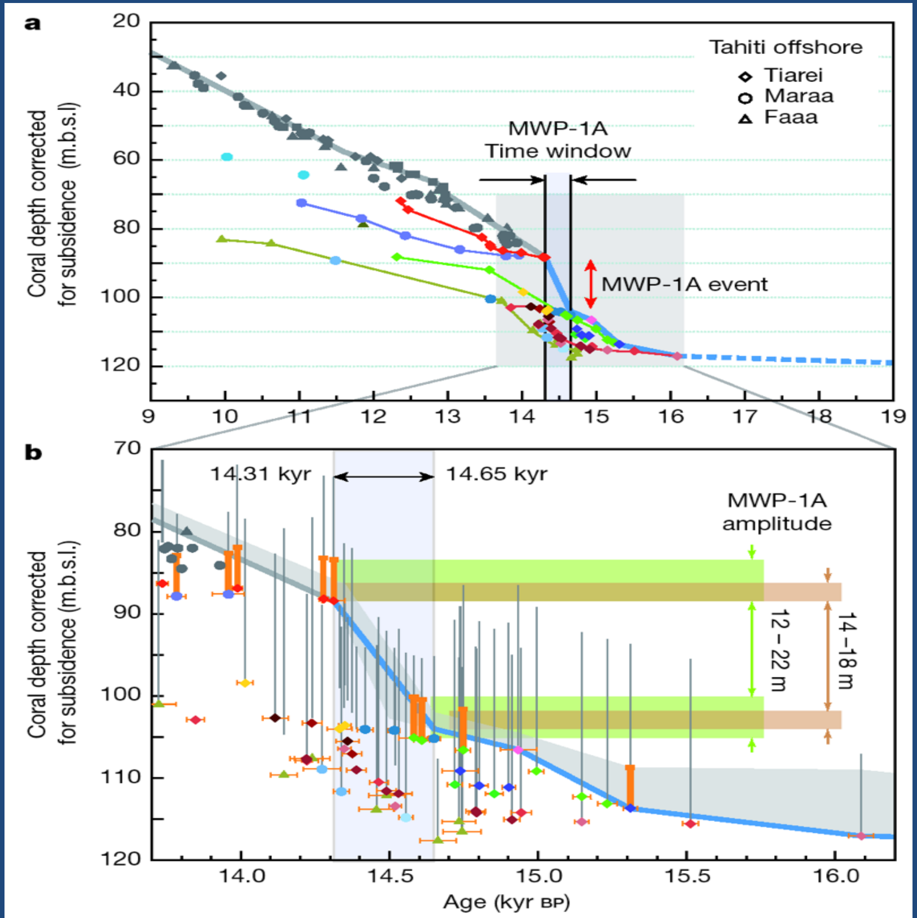


Gulf Stream: temperature pattern; red color shows warm water that decreases in the yellow, green and finally blue areas. P. Minette and B. Evans, University of Miami/MODIS/NASA

Instability I: melt water during deglaciation

Exploring future instabilities annual sea level rise (aslt)

- During the last deglaciation: maximum 37mm/year (melt water) with an annual average rate of 10 mm/year.



- Present day : 3.3 mm/year

- 21st century in RCP 8.5 scenario: around 10 mm/year.

Deschamps et al (Nature 2012)

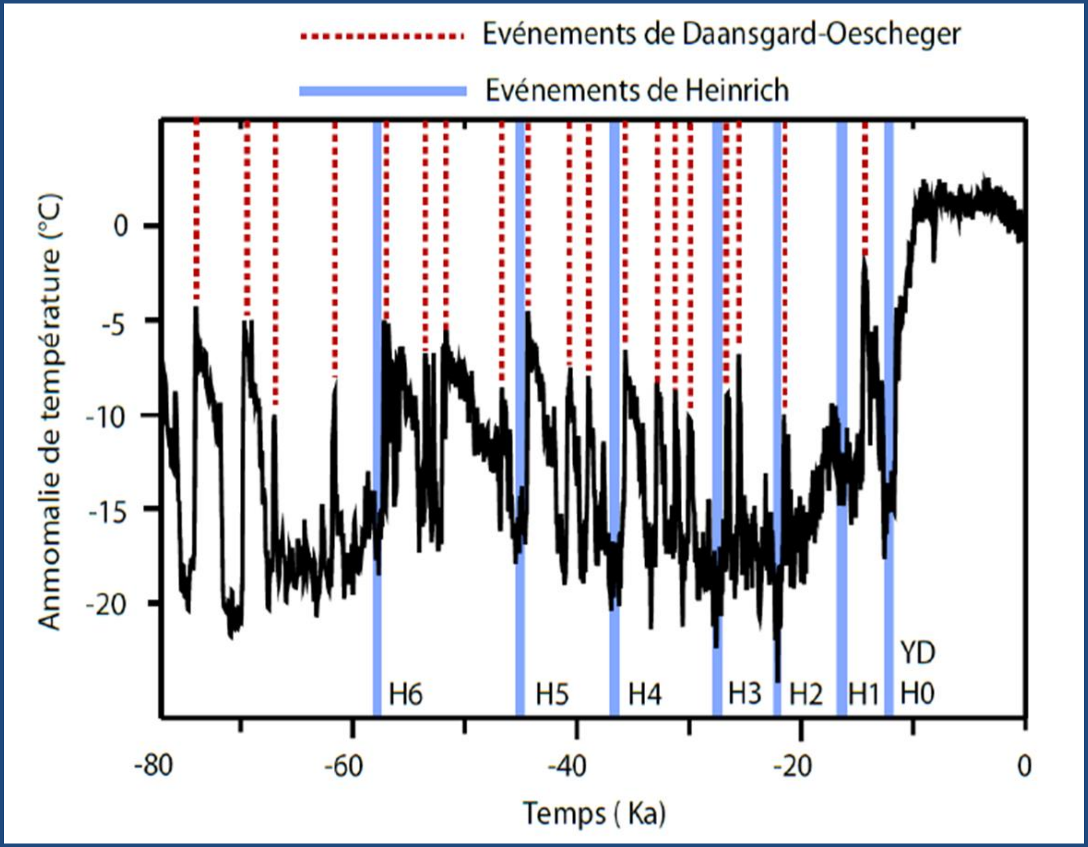
Instability II: Heinrich events

HEINRICH EVENTS

-From 60ky to 15ky very unstable glacial climate.

-Instability of the North America, produced huge quantities of icebergs (Heinrich events)

- ➢ Breakdown of the thermohaline circulation
- ➢ Global climate impact



Instability III: ice shelf

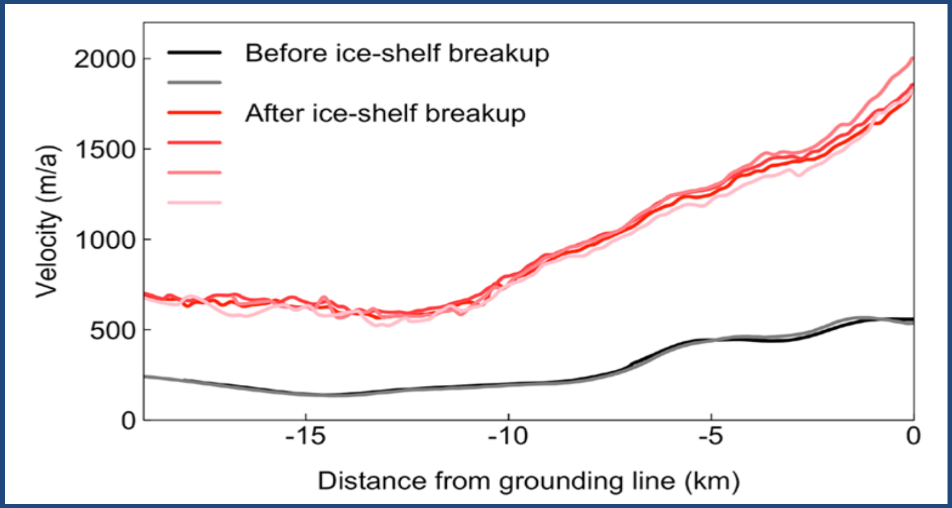
OBSERVATIONS

-During summer 2002, complete melting of the Larsen B Ice shelf.

- No consequence on sea level rise
- Major consequences on the ice sheet dynamics.

-Buttressing effect of the ice shelves on the ice sheet

- large acceleration of ice streams and icebergs which, in contrast, increase the sea level.



Alvarez-Solas et al. “Can recent ice discharges following the Larsen-B ice-shelf collapse be used to infer the driving mechanisms of millennial-scale variations of the Laurentide ice sheet?” The Cryosphere, 6, 687–693, 2012

Methodology/Experimental design

SCENARIOS:

Superimposed to the most realistic scenario of IPCC: RCP 8.5, we add a freshwater corresponding to 0.5 m to 3 meters associated with 3 different scenarios:

1. Partial melting of Greenland ice sheet
2. Partial melting of west Antarctica
3. A mixing of both ice sheets melting

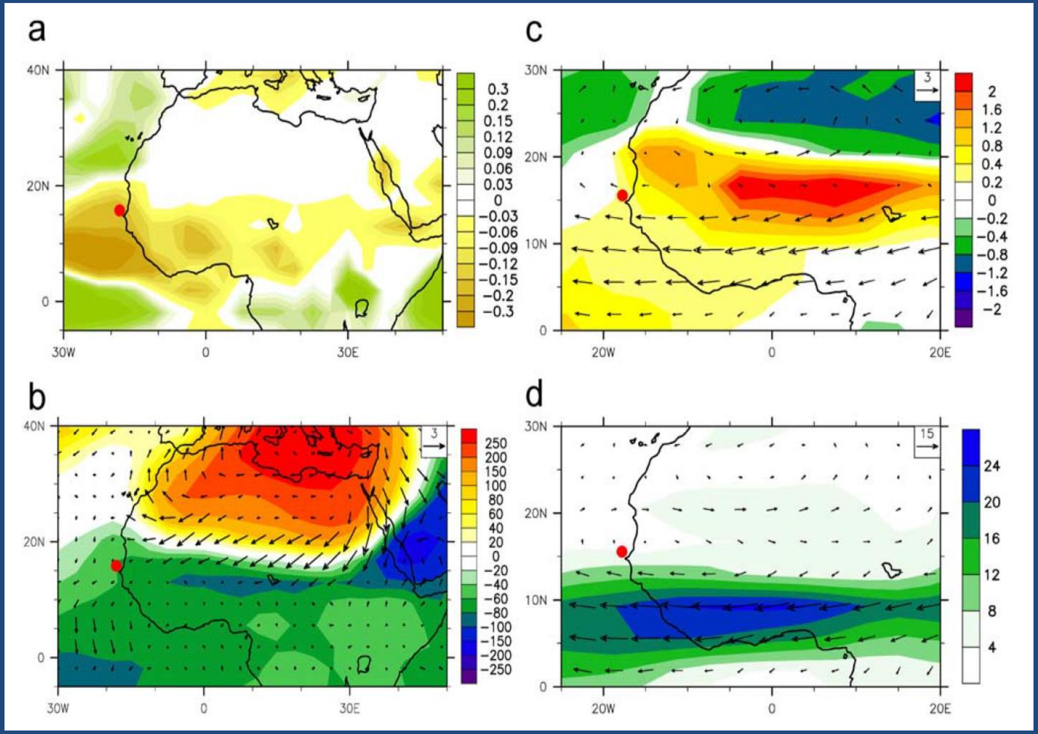
Model used: IPSL AOGCM version 5A
The perturbation superimposed to RCP 8.5 correspond to transient housing experiment with freshwater input corresponding to 0.11 Sv (0.5 m), 0.22 Sv (1 m), 0.34 (1.50) and O,68 SV (3 m).
This perturbation is applied from 2020 to 2070.

We focus here on scenario 1: Greenland ice sheet scenario

Impact of Northern hemisphere ice sheet on tropical dynamics

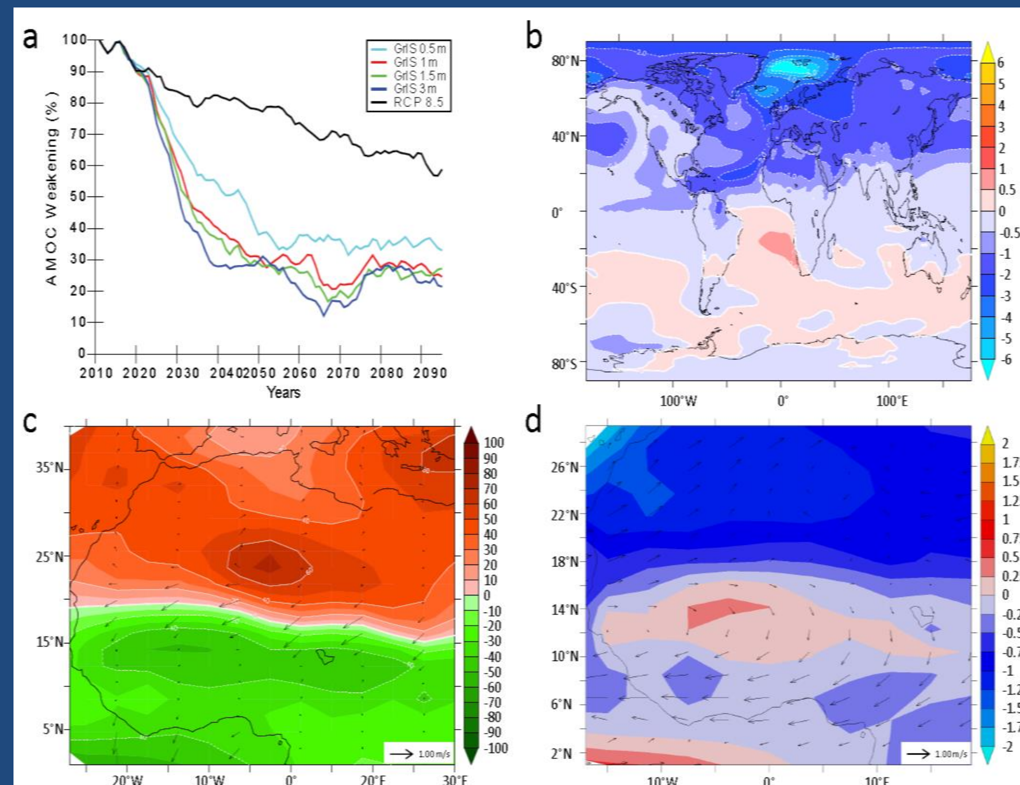
A tribute to pioneering study: Mulitza et al., Paleoceanography, 2008

African climate response to weakening of the AMOC in a CGCM water-hosing experiment. Shown are differences between the climate state with weak AMOC and the state with strong AMOC. The red dot indicates the position of core GeoB9508–5. (a) Annual net precipitation (total precipitation minus evapotranspiration in m a1), (b) summer (JAS) sea level pressure (Pa) and near surface winds (m s1), (c) summer (JAS) surface temperature (C) and winds at 700 hPa (m s1), and (d) summer (JAS) moisture transport at 700 hPa (contours indicate the magnitude of the moisture transport in g kg1 m s1).

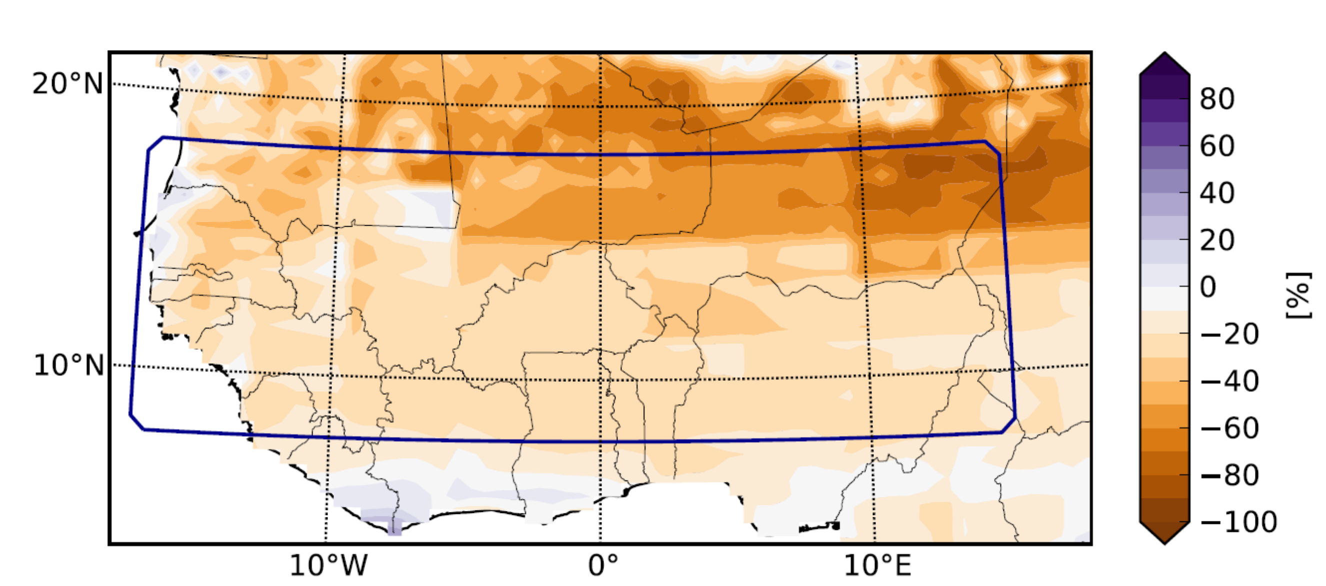


Relationship between freshwater input and tropical atmospheric dynamics

Teleconnection mechanisms linking the Greenland ice sheet melting and the decrease of the Sahelian rainfall. A) AMOC evolution (in % with respect to the present-day values),; B) Mean annual temperature anomaly between the 1.5 m GrIS and the RCP8.5 scenarios averaged over the period 2030-2060; C) Same as B) for the sea-level pressure anomaly; and the 10-m winds (black arrows); D) Same as B) for the mean summer (JJAS) temperature anomaly and the 850 hPa winds (black arrows). *Defrance et al., PNAS, 2017.*



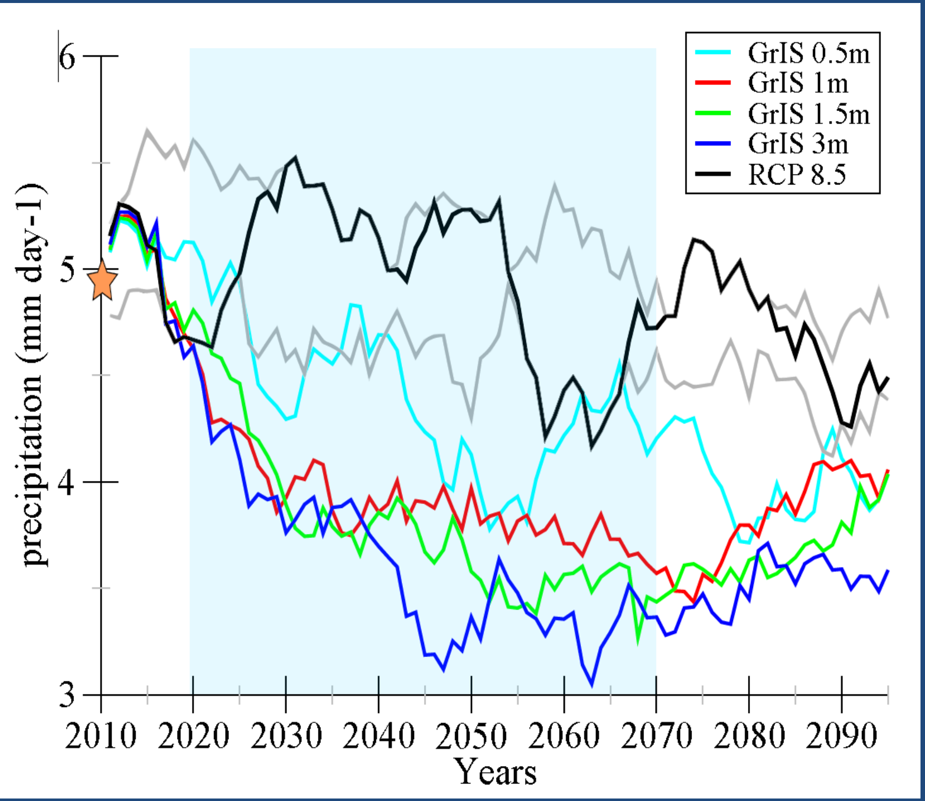
Precipitation changes over Sahel area for 1.5 m experiment



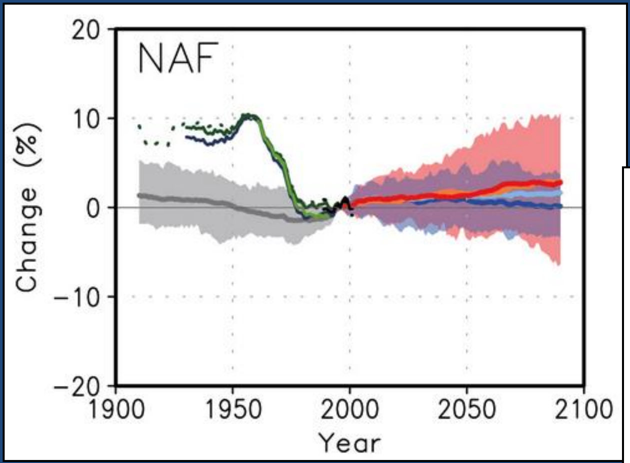
JJAS precipitation anomaly between the 1.5 m GrIS scenario and the RCP 8.5 baseline experiment normalized to the RCP 8.5 values and averaged over 2030-2060. A value of 100 corresponds to a doubling of precipitation and -100 corresponds to zero precipitation. The precipitation values are obtained after applying the statistical method (see Methods). The blue box (8°N-18°N , 17°W-15°E) represents the region under study. *Defrance et al., PNAS, 2017*.

Precipitation evolution over Sahel area for all the housing experiments and the RCP8.5 scenario baseline

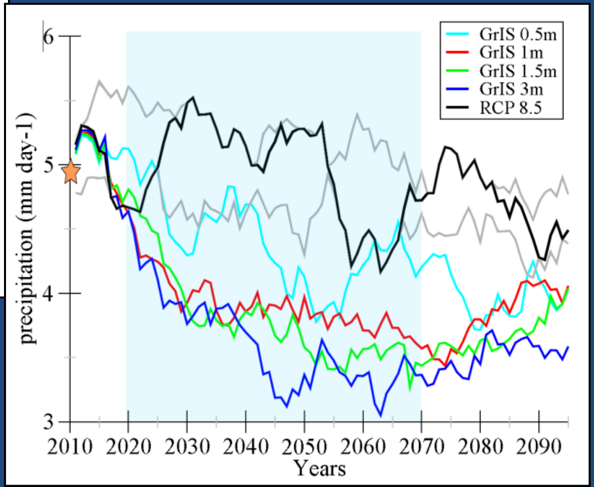
Evolution of JJAS precipitation during the 21st century averaged over the Sahel area (8°N-18°N, 17°W-15°E) for the RCP8.5 and the GrIS scenarios. The orange star indicates the simulated JJAS precipitation over the climatic reference period (1976-2005) deduced from the IPSL-CM5A simulated precipitation (4.96 mm).To illustrate the internal model variability, we considered a 4-member dataset of the RCP8.5 scenario, each member differing in initial conditions. The area delimited by the two grey curves represents the range of model variability deduced from the 4-member dataset. *Defrance et al., PNAS, 2017.*



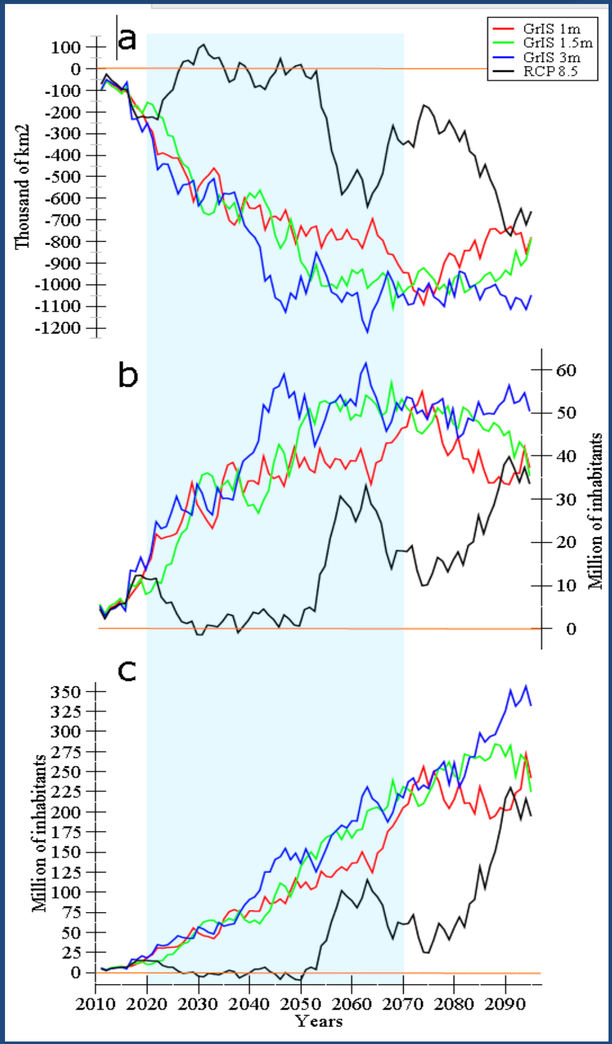
Contrasting IPCC scenarios with our transient experiment in terms of impact on west African monsoon



IPCC simulation
Observations of past and present African monsoon variations (1900-2100) for the different scenarios: (grey 40 models), RCP2.6 (dark blue; 24 models), RCP4.5 (light blue; 34 models), RCP6.0 (orange; 20 models), and RCP8.5 scenarios (red; 32 models). *IPCC WP1 chap, 14*

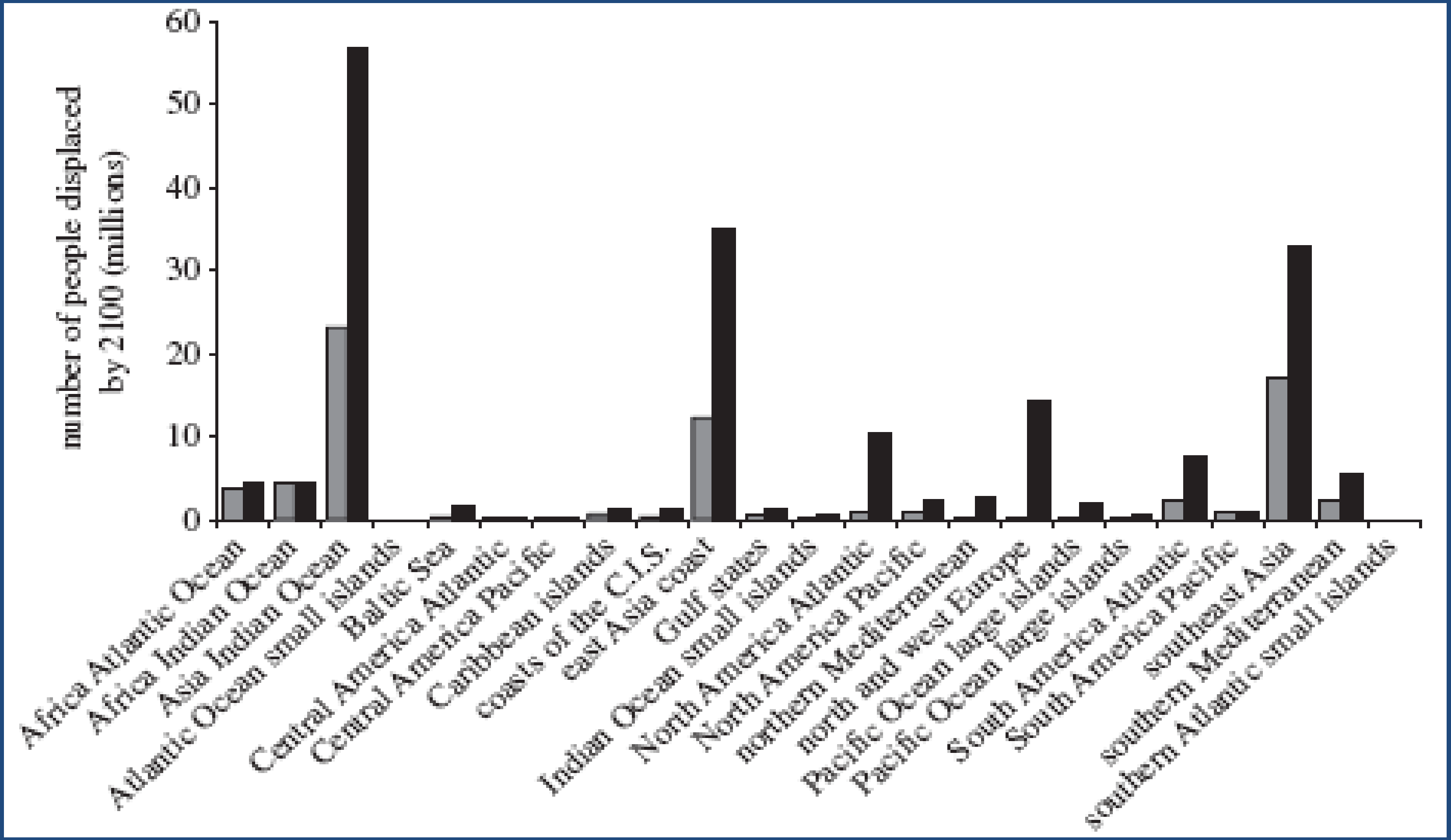


Our housing experiments



Impacts of rainfall change on sorghum cultivation and on population. *Defrance et al., PNAS, 2017.*

The continental migration due to monsoon evolution are superimposed to those due to sea level rise



The distribution of net population displacement over the twenty-first century by region assuming no protection for a 0.5 m (grey bars) and 2.0 m (black bars) rise in sea level. *CIC., Commonwealth of Independent States. Nicholls R J et al. Phil. Trans. R. Soc. A 2011.*

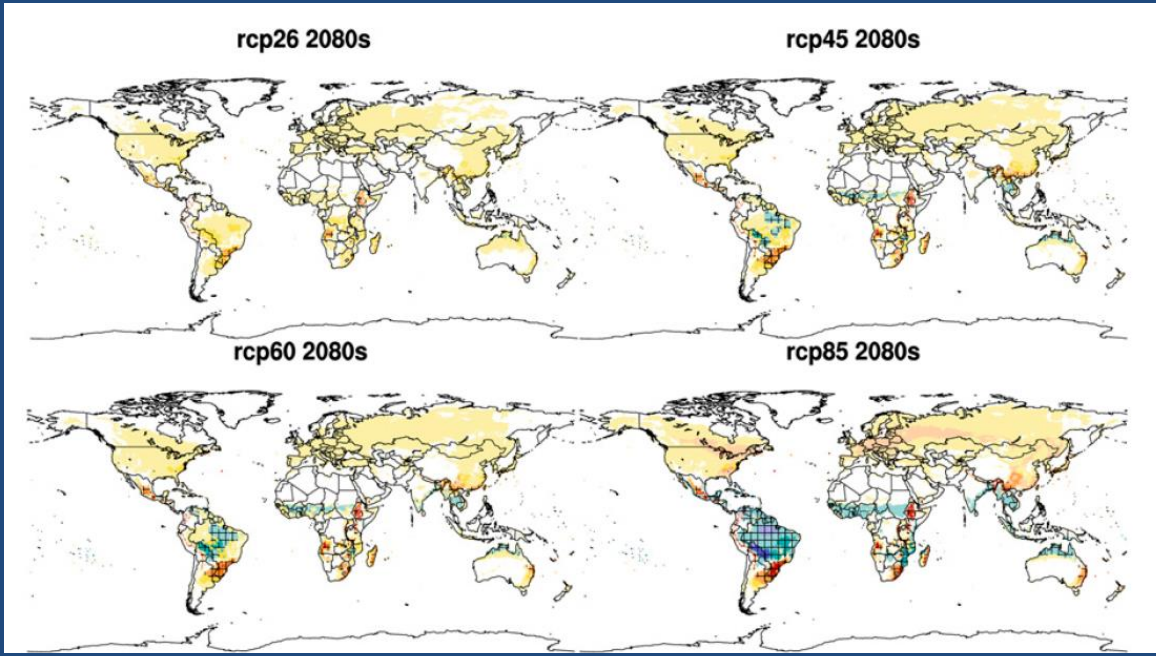
Conclusion

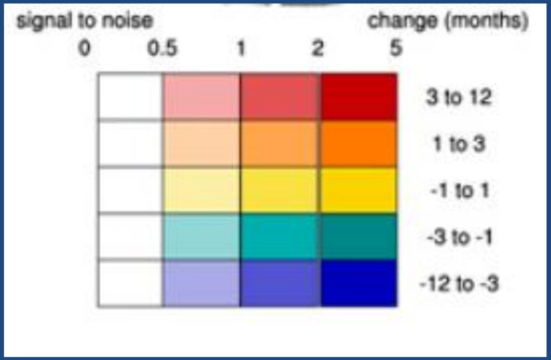
An acceleration of Greenland ice sheet melting could have major impact on western African monsoon and therefore lead to large migration superimposed to costal damage.

Outlook

1. Moreover the rapid partial melting of Greenland will impact a much larger area in the tropics and not only African monsoon
2. It may impact not only human population but also pathogen vectors as Malaria and Zika

Next step, quantifying the changes induced by these housing experiments on the pathogen vector distribution: Malaria, a case study





The effect of climate scenarios on future malaria distribution: changes in LTS. Each map shows the results for a different emission scenario (RCP). The different hues represent change in LTS between 2069–2099 and 1980–2010 for the ensemble mean of the CMIP5 subensemble. The different saturations represent signal-to-noise ratio (μ/Sigma) across the super ensemble (the noise is defined as one SD within the multi-GCM and multimalaria ensemble). The hatched area shows the multimalaria multi-GCM agreement (60% of the models agree on the sign of changes if the simulated absolute changes are above 1 mo of malaria transmission). *Caminade et al., PNAS 2014.*

On-line Master ACCES
Understanding the interaction between climate, environment and society

- *Objectives:*

Give journalists and communication officers the ability to better handle questions linked to climate which are becoming more and more important to society.

- *Participants to this Master will be able to:*
  - Better analyze climatic information
  - Question the environmental, economic, political and societal impacts of climate change
  - Build state-of-art journalistic piece of work with an integrative approach of climatic, environmental and societal approach
  - Characterize and quantify the extent of climate change
  - Explain the functioning of research and especially the way GIEC functions

On-line Master ACCES
Understanding the interaction between climate, environment and society

ESJ-IPSL-univesité Paris-Saclay

UE1 ► Climate evolution, scientific knowledge and the media
Gilles Ramstein, Sylvestre Huet

UE2 ► Impacts of climate change on life
Bruno Lansard, Yves Sciama

UE3 ► Climate change, energy and economy
Patrick Schembri, Patrice Lanoy

UE4 ► Climate change and Regulations
Laurent Neyret, Simon Roger

UE5 ► Climate change and society
Jean-Paul Vanderlinden,Thibault Lescuyer

UE6 ► Thinking climate change
Grégory Quenet, Lise Barnéoud

UE7 ► Climate change and the media
Philippe Bousquet, Yves Renard

UE8 ► Adaptation to climate change
Jean-Paul Vanderlinden

Anthropocene experiment: 1

A big firework

Moreover, the context is cold, with ice cap in each hemisphere

Anthropocene experiment: 2

The population is approximately 7.3 billion in 2015 and will reach approximately 9,3 billion in 2050.
An important part of the world population lives close to costal regions.

World population in 2000

World population in 2050

Energy and IPCC scenarios

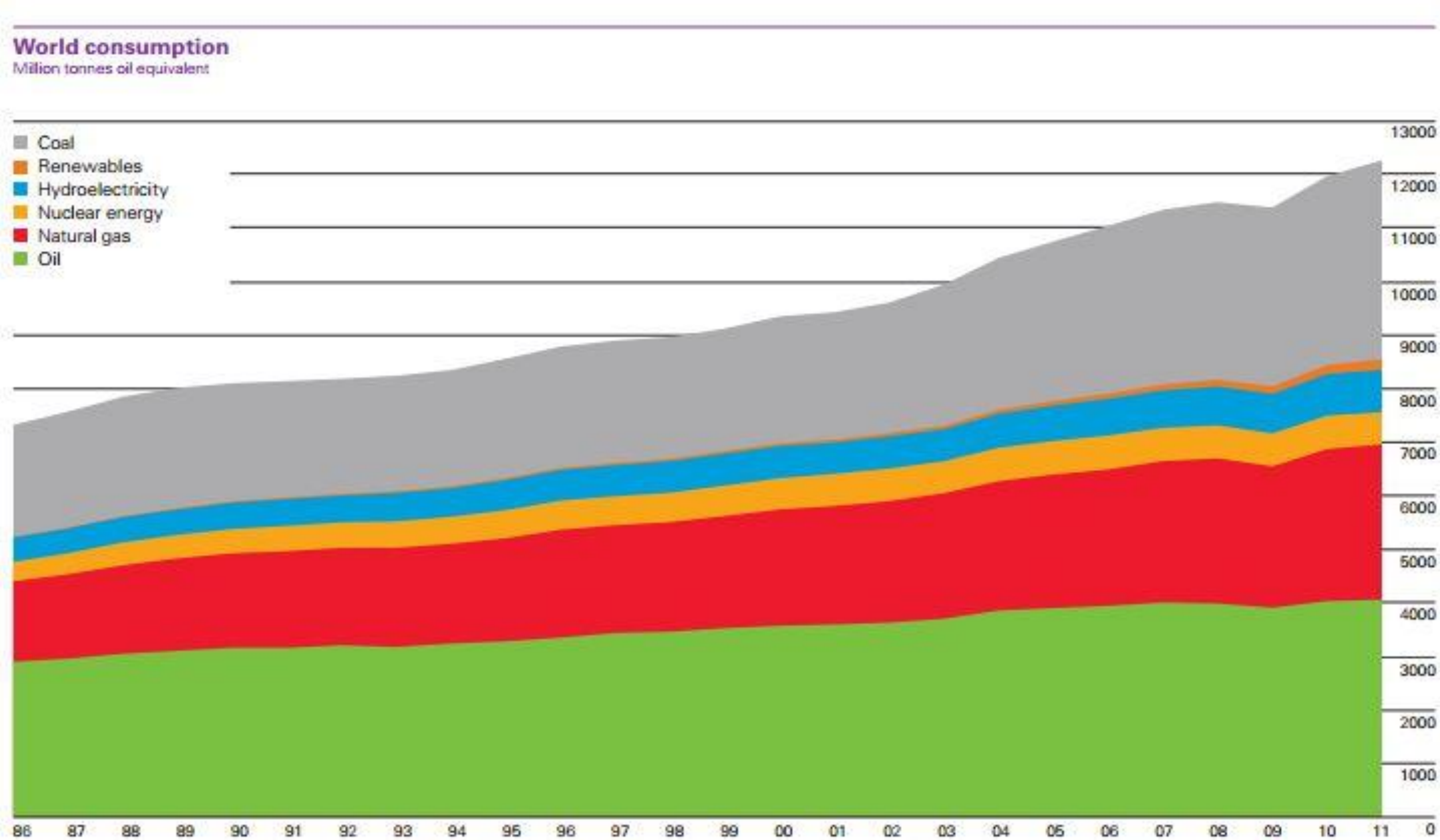
- What about future energy choices ?
- What can we learn from the IPCC strategy for a better understanding of energy choices and their impact for the on-going century?

- This is the result of preliminary discussions with Bernard Tamain, Christophe Goupil, Hervé Bercegol, Jacques Treiner, J.M Jancovici, Mathieu Auzanneau, Didier Pailliard, J.M Bréon... to create a long-term multidisciplinary brain-storming group at LIED on these issues.
- *Merchants of Doubt by Naomi Oreskes and Erik M. Conway*
- Most of the material shown in the next slides comes from Bernard Tamain synthesis of the last IAE report

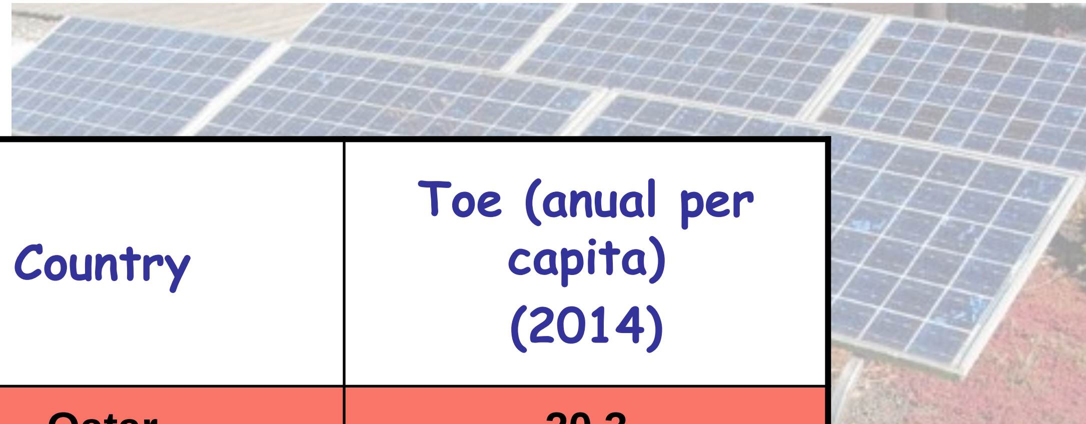
What we have to think about?

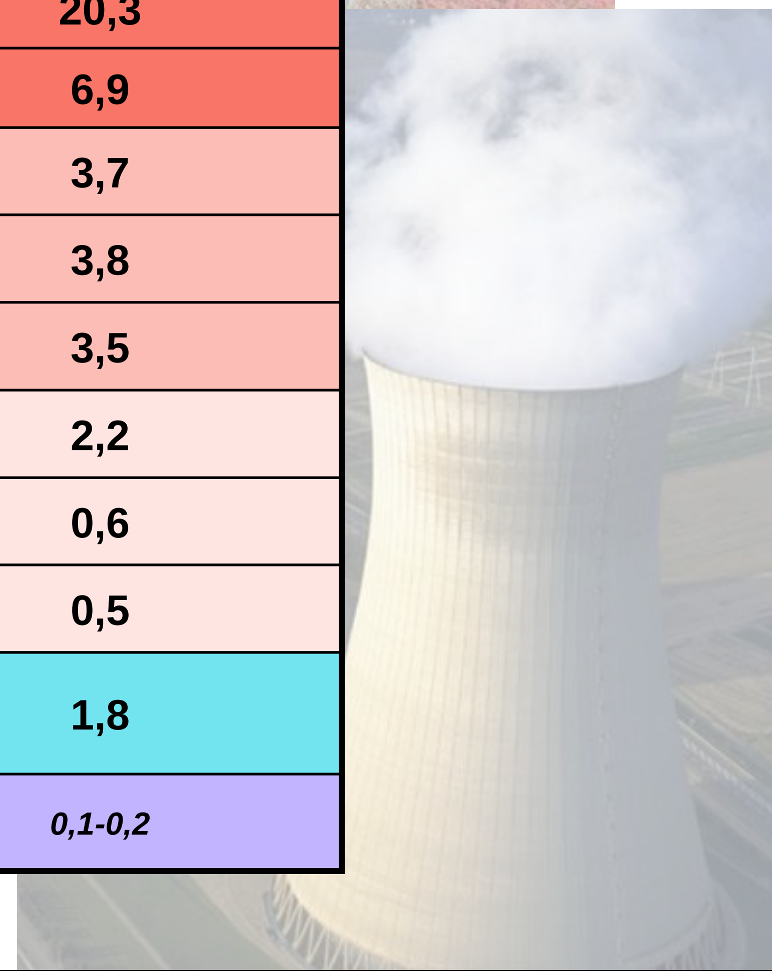
- Global energy demand
- Global electricity demand
- Constraints in terms of adaptation
  - Greenhouse gas reduction
  - fossil ressources limits
  - Wind power/solar intermittency problem

Evolution of global energy consumption



The consumption continues to grow: + 3,5% in 2013;
+ 0,7% in 2015;
+ 0,9% in 2016 for the G20
+ 2,9% in China in 2017





Country	Toe (anual per capita) (2014)
Qatar	**20,3**
USA	**6,9**
France	**3,7**
Germany	**3,8**
Japan	**3,5**
China	**2,2**
India	**0,6**
Ethiopia	**0,5**
World	**1,8**
Human vital minimum	***0,1-0,2***

Which are the plausible evolutions ?

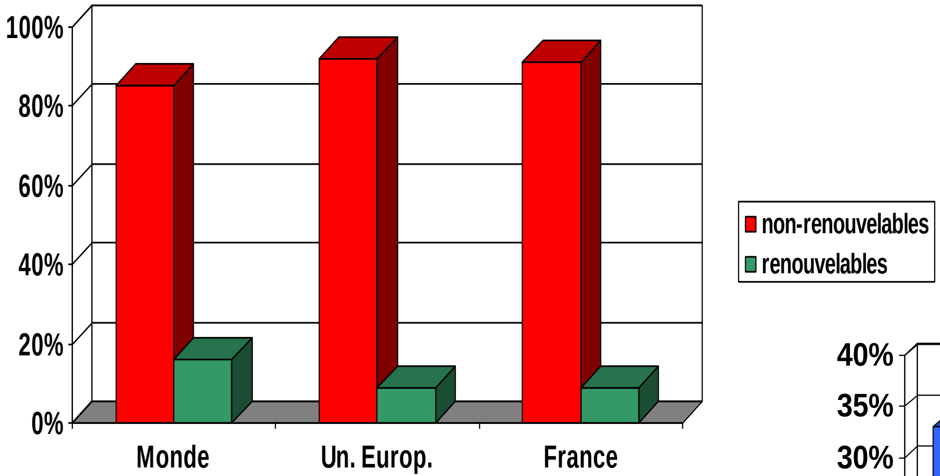
Apart form the consumption reduction necessary in rich countries, a doubling of the global consumption before 2050 is expected :

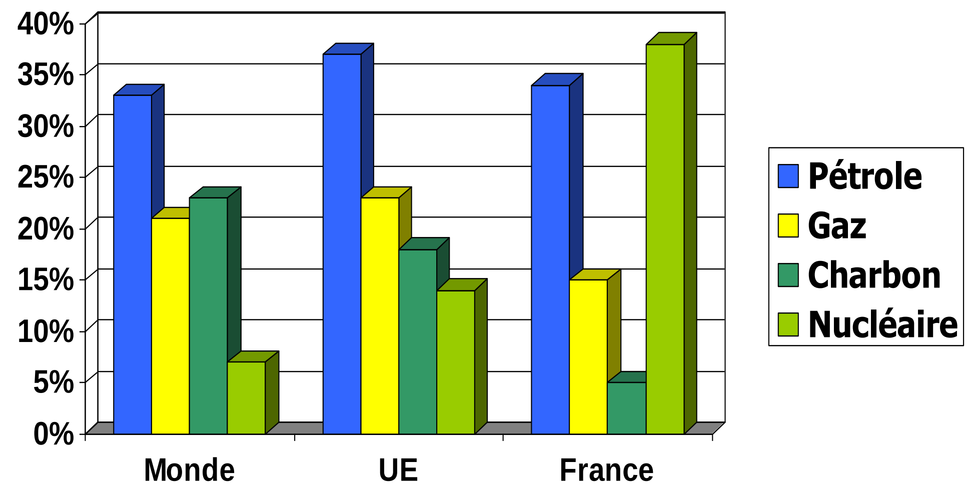
25 billions of toe per year !

Reasons :

- **global population increase**
- **emerging countries development**

Today:

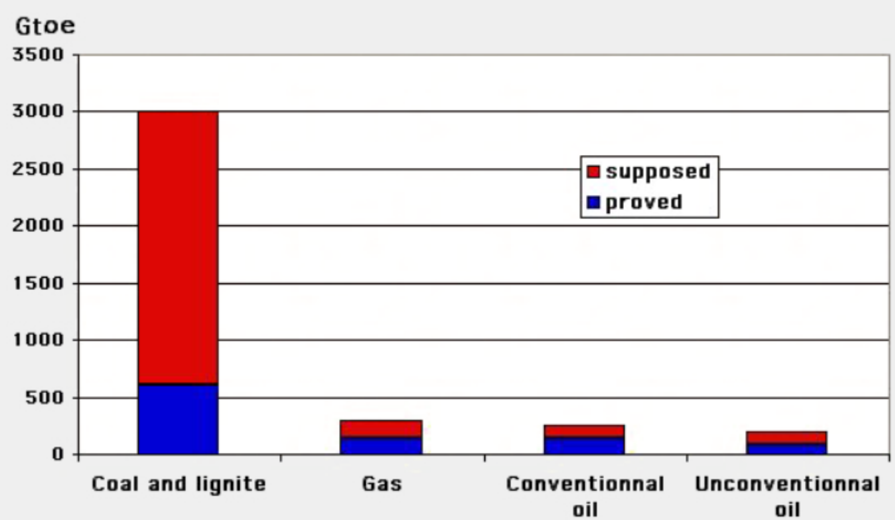




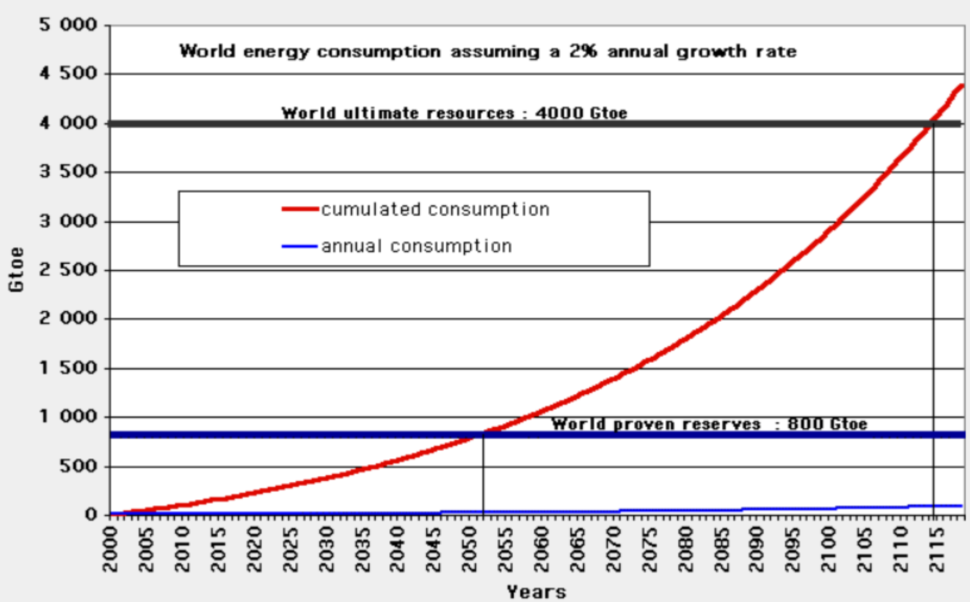
What about the possible scenarios accounting for available resources?

Oil and gas are going to become rare

Source	Oil	Gas	Coal	Nuclear Fission	Nuclear Fusion
Resources (Year of consumption 2000)	Proved 30 years Final 125 years	Proved 80 years Final 220 years	Proved 210 years Final 1400 years	Proved 70 (3000) Final 270 (14000)	Infinite

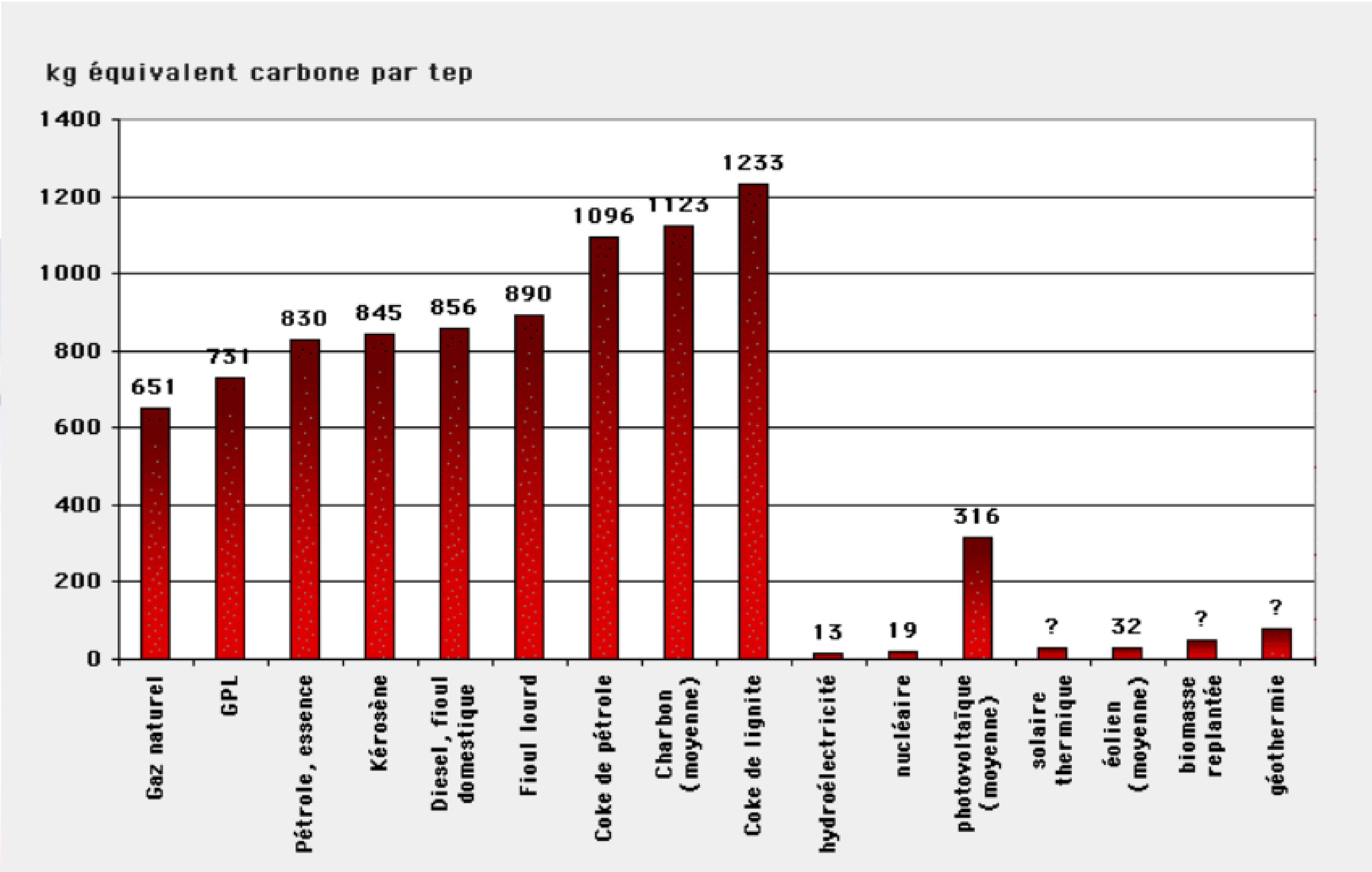


Breakdown of fossil fuel reserves by nature.



Source : Manicore.com

Energies contribution to the greenhouse effect



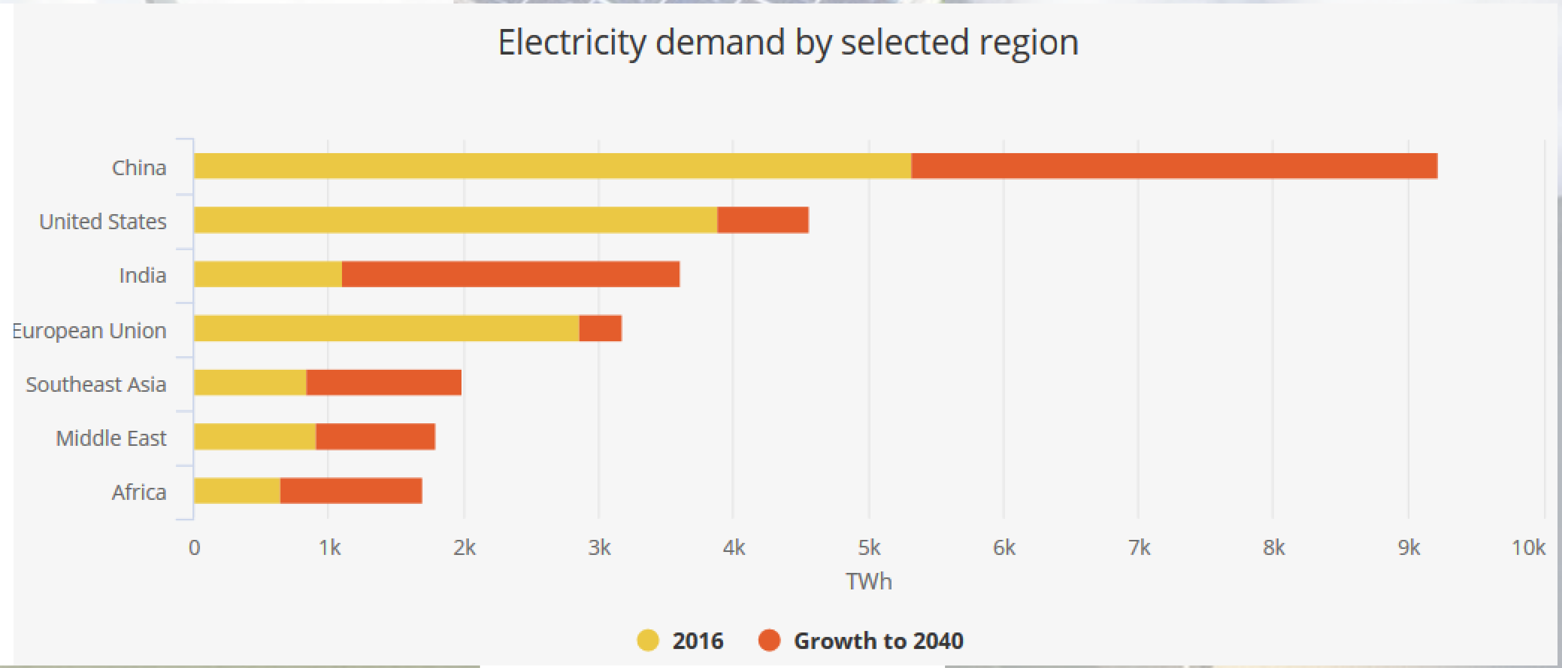
Kg carbon equivalent emitted by tonne oil equivalent when using various energies (1 tonne oil equivalent = 11.600 kWh = 42 billion Joules).Sources: Manicore, ADEME, EDF

Growth demand of global electricity

according to the International Energy Agency (https://www.iea.org/weo2017/)

- electricity: 40% of the growth of final energy consumption in 2040 and 25% of the total final consumption.
- electricity: 40% of the electricity is from renewable origin in 2040

- Transfers towards the electricity of the heating and the transport



How to improve ….

According to the International Energy Agency (https://www.iea.org/weo2017/)

- 40% renewable energies in total energy consumption
- 60% renewable energies in electricity consumption,
- 15% nuclear energy for electricity
- 6% CO_2 emission from fossil energies
- provide access to electricity and energy-saving cooking

Necessary conditions

- Fast decrease of coal consumption
- Decrease of oil consumption after 2025
- Increase of gas contribution by 25%, (+20% in 2030), then stagnation
- Investments in electricity: 2/3 of the 69000G$ invested in energy
- Suppression of subventions to fossil energies
- Role of delocalized renewables sources
- Need for a severe fight against leakage of methane.

….realistic conditions ????

Open questions

- How to build the most possible consensual scenario for a energetic mix for the 21st century allowing for stake holders and citizens what are the major choices and impact of these choices on daily life and environment?

- Many data already exist within IPCC WP3 and IEA as potential basis to begin the brainstorming with?

- Scenarios (energy + economy) of tipping points and precursor

- Needs for education on future energy choices to improve our interaction with policymakers