Fossils Fuels Ultimate Recovery Appraisal, Clue to Climate Change Modelling
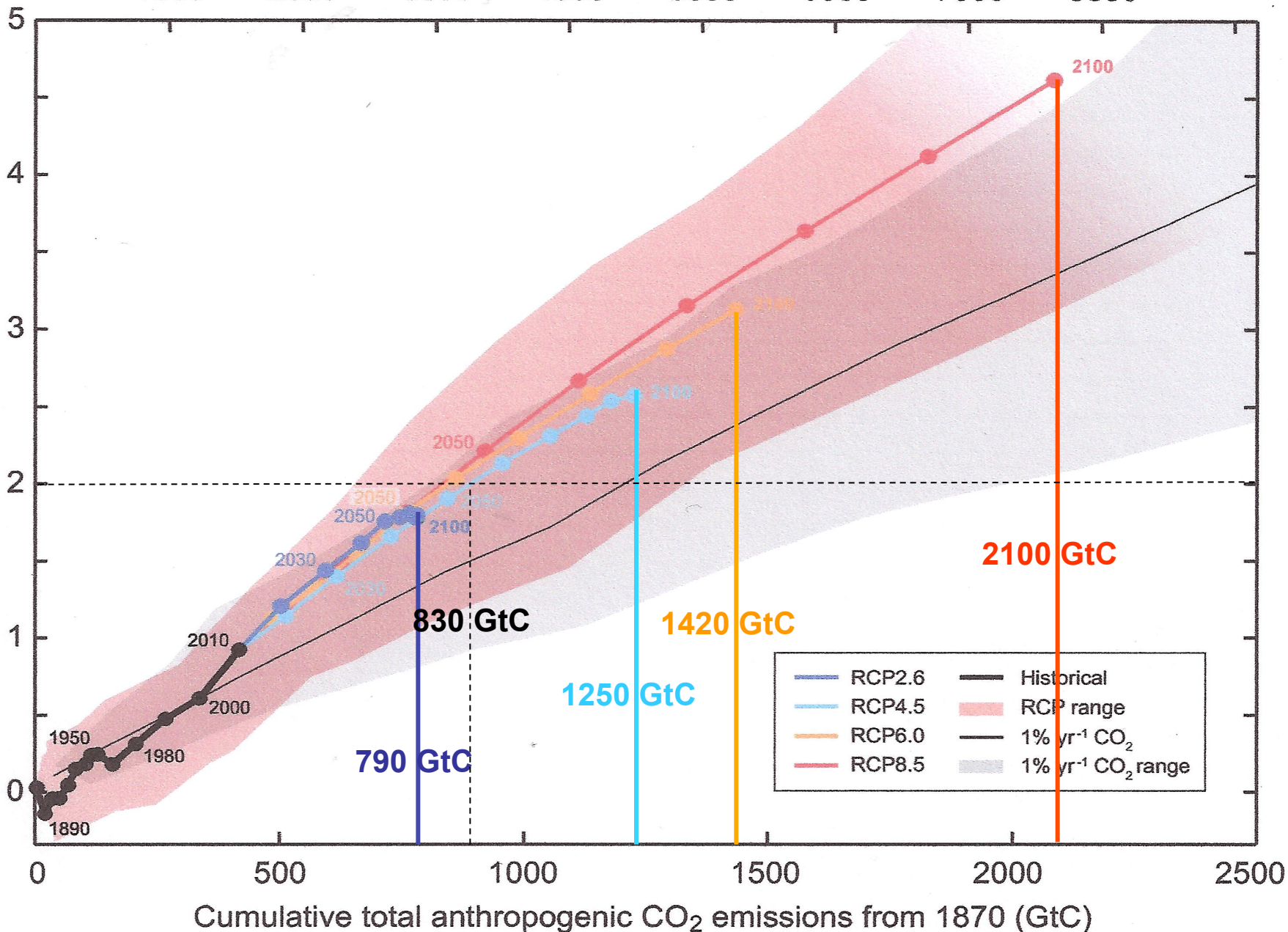
B.Durand* & J.Laherrère**

* *Fossil Fuels Geochemist, former Director of ENS de Géologie*
** *Geophysicist, former Director of Exploration Techniques, Total*

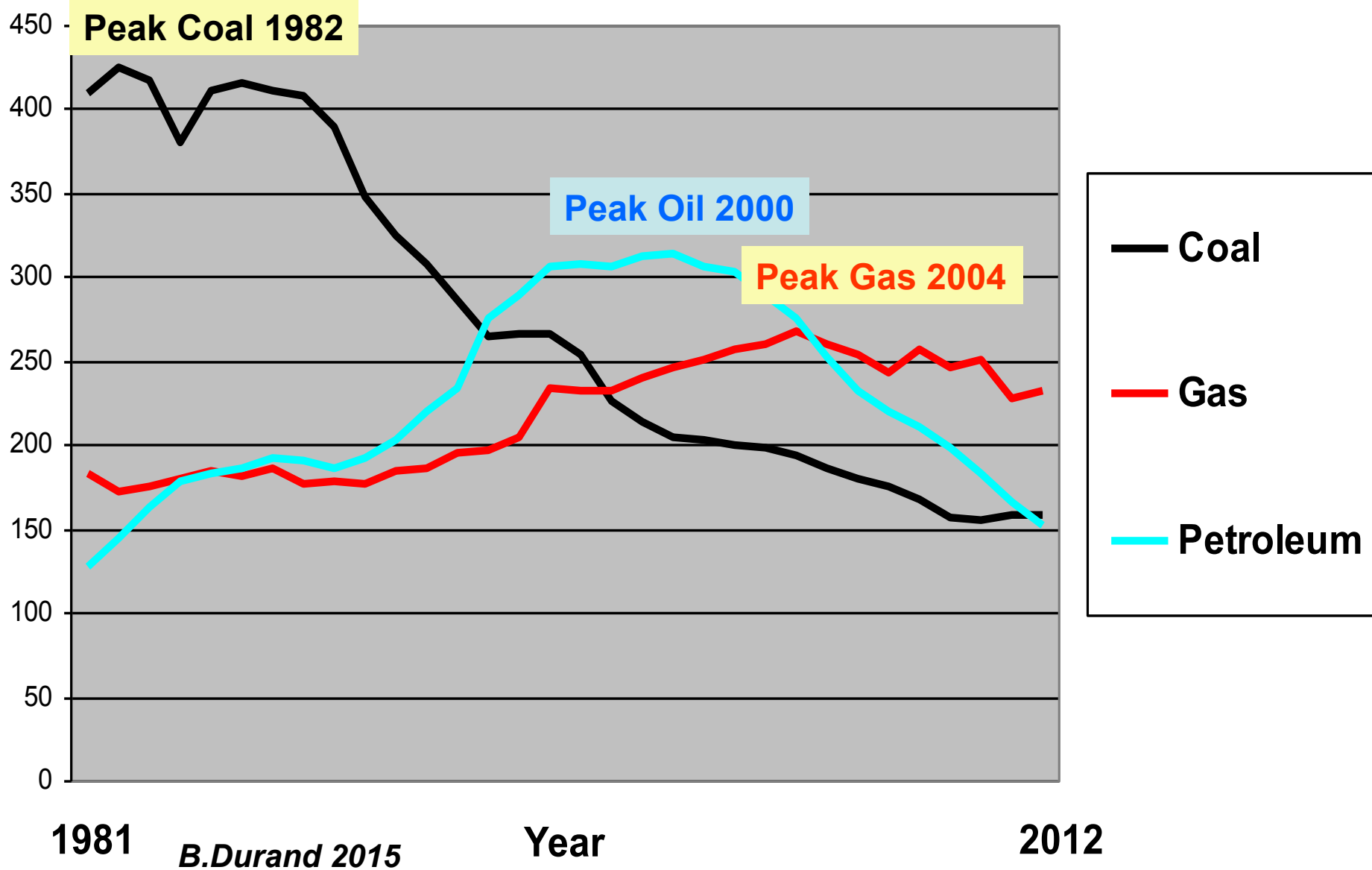Cumulative total anthropogenic CO$_2$ emissions from 1870 (GtCO$_2$)

- **According to ICCP 2013*, temperature increase of the Earth's surface depends nearly linearly on cumulative anthropogenic CO_2 emissions from 1870.**

- **Representative concentration pathways (RCP) scenarios produce, in GtC contained in 1870-2100 CO_2 emissions :**

- **790 GtC for RCP 2,6**   **1250 GtC for RCP 4,5**

- **1420 GtC for RCP 6**   **2100 GtC for RCP 8,5**

- **So as temperature increase from 1870 to 2100 to stay below 2°C, these emissions should not exceed approximately 830 GtC, i.e a little bit more than emissions of RCP 2,6.**

- **Because it makes up 80 % of CO_2 anthropogenic emissions, consumption of fossil fuels should be the main driver of climatic change.**

- ** The Physical Basis, Summary for Policymakers, figure SPM.10*

United Kingdom, fossil fuels productions 1830-2012, Mtoe. (D.Rutledge, E.Mearns, BP)
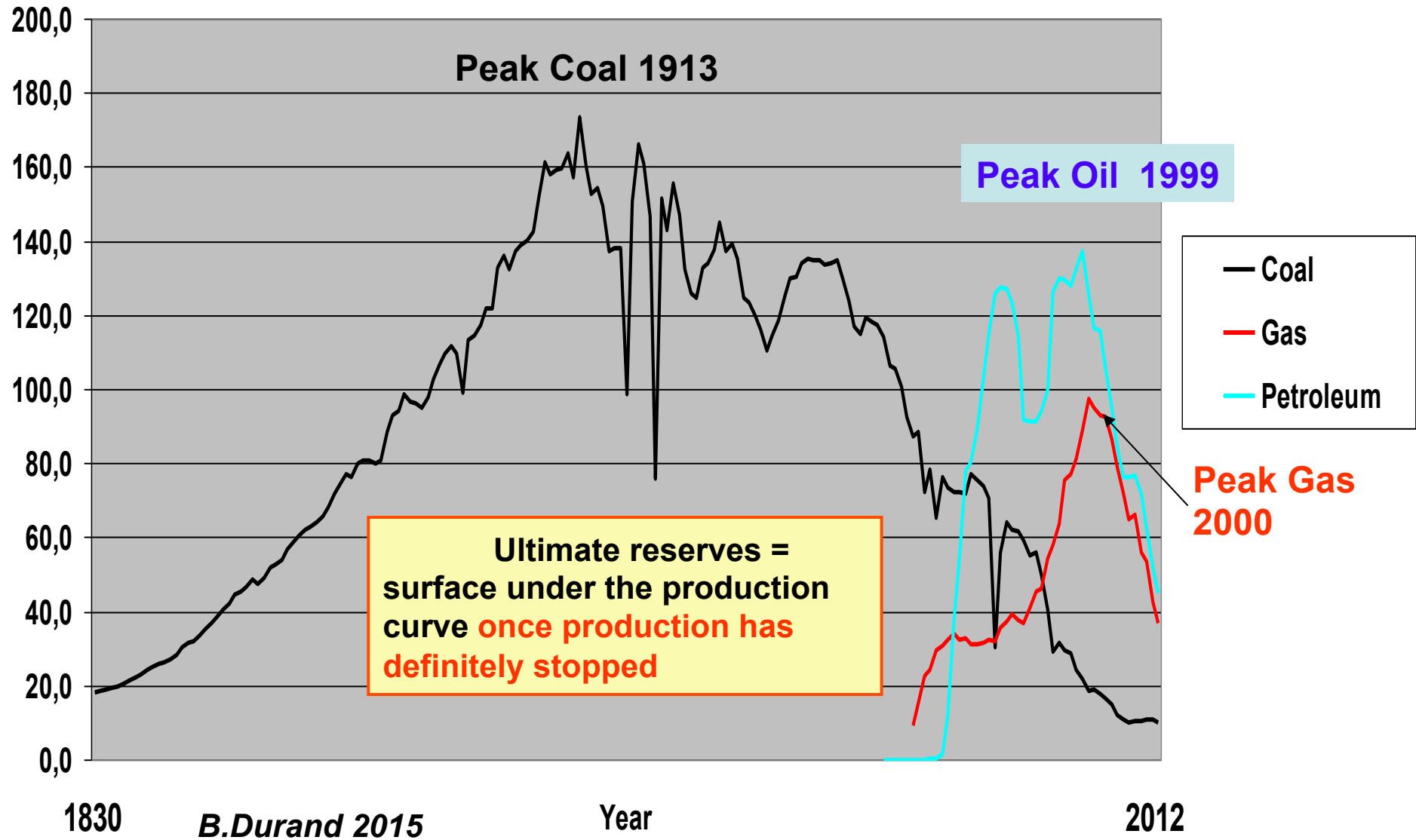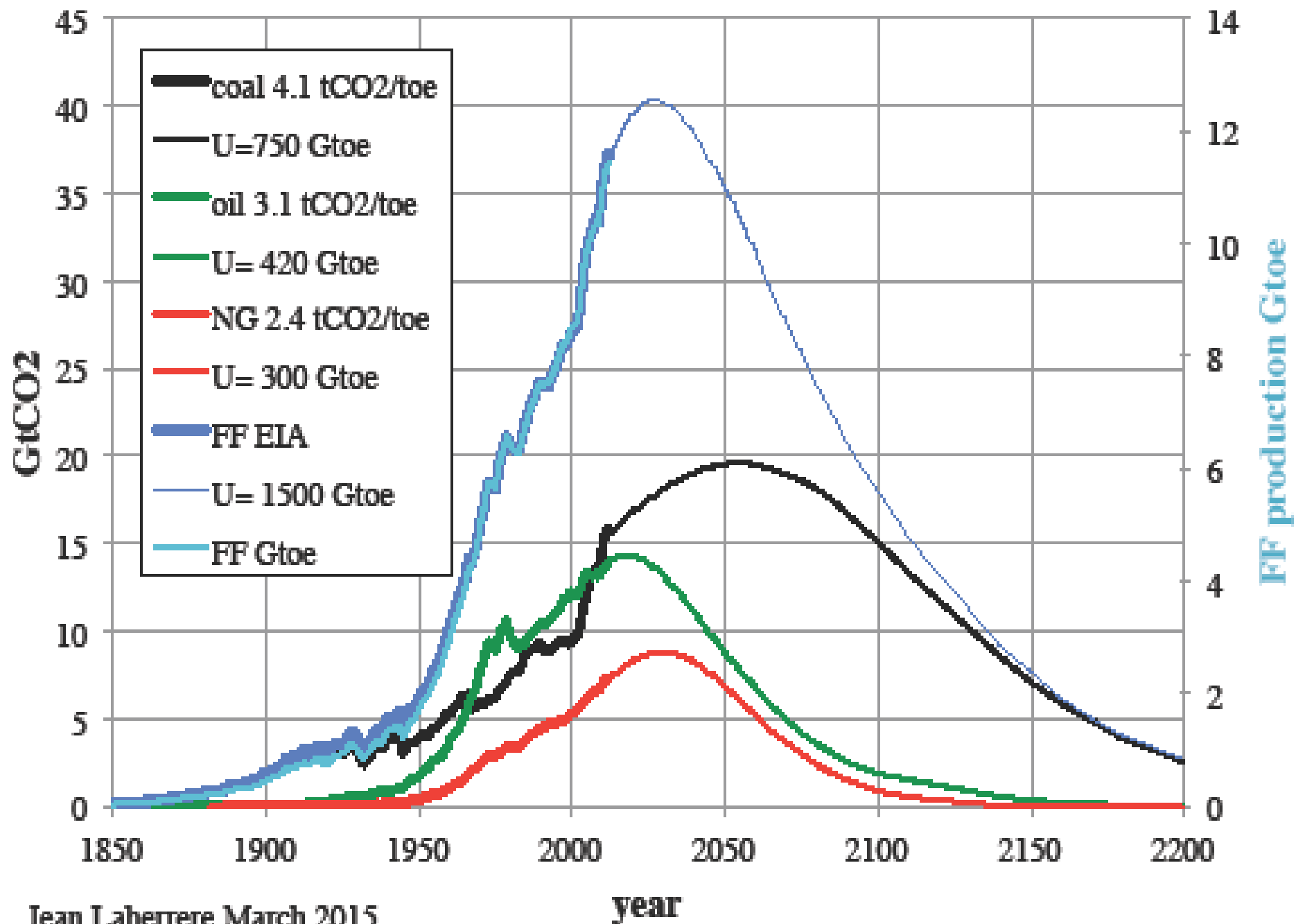
- Since emissions by fossil fuel consumption makes up 80 % of CO_2 anthropogenic sources, it should be, according to ICCP, the main driver of the Earth's surface temperature increase.

- However availability of FF is limited by geology and their production must peak some time.

- Here is the example of United Kingdom:

- All Peaks of fossil fuels indigenous productions have been already largely passed:

- 1913 for coal,

- 1999 for oil,

- 2000 for gas !

EU 28 + Norway: Productions of fossil fuels
from 1981 to 2012, Mtoe. (BP)

Peak Coal 1982

Peak Oil 2000

Peak Gas 2004

Coal

Gas

Petroleum

1981

B.Durand 2015

Year

2012

- **All fossil fuels indigeneous productions have also already peaked in EU 28 +Norway:**
- **- 1982 for coal**
- **- 2000 for oil**
- **- 2004 for gas**

- **Neither technological improvments nor high market prices succeeded in reversing the trend once the peaks passed !**

world fossil fuels CO2 emissions & production toe

Legend:
- coal 4.1 tCO2/toe
- U=750 Gtoe
- oil 3.1 tCO2/toe
- U= 420 Gtoe
- NG 2.4 tCO2/toe
- U= 300 Gtoe
- FF EIA
- U= 1500 Gtoe
- FF Gtoe

Y-axis left: GtCO2
Y-axis right: FF production Gtoe
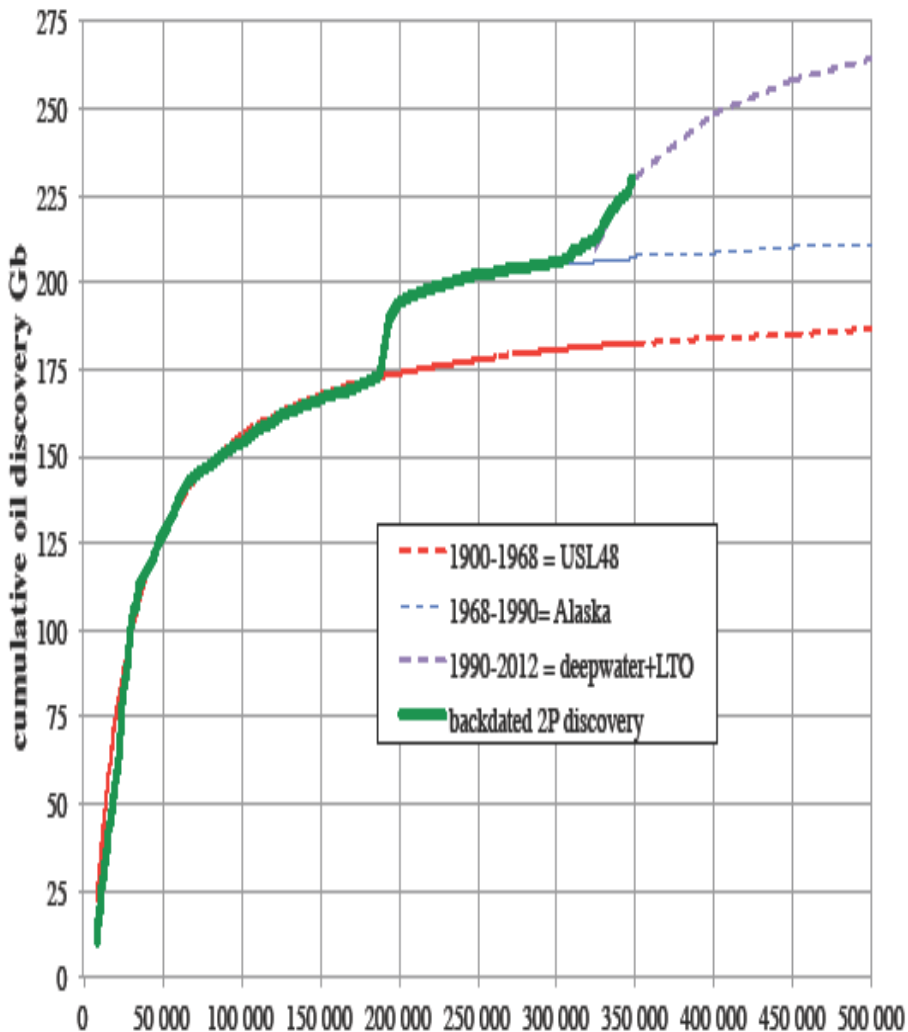X-axis: year

Jean Laherrere March 2015

- **World production of fossil fuels is estimated (see methods) to peak in 2025, largely before the middle of the century:**
- **2020 for oil (total liquids),**
- **2030 for gas,**
- **2050 for coal.**
- **Methods: estimations of ultimates from creaming curves construction of 2 P (technical) reserves and/or Hubbert linearization of productions histories, then the use of logistic curves to predict the productions to come (without above the ground constraints).**
- **This fossil fuels ultimate recovery appraisal can easily be translated in ultimate CO_2 emissions from fossil fuels consumption.**

Methods: examples of creaming curves and of Hubbert's linearization of production
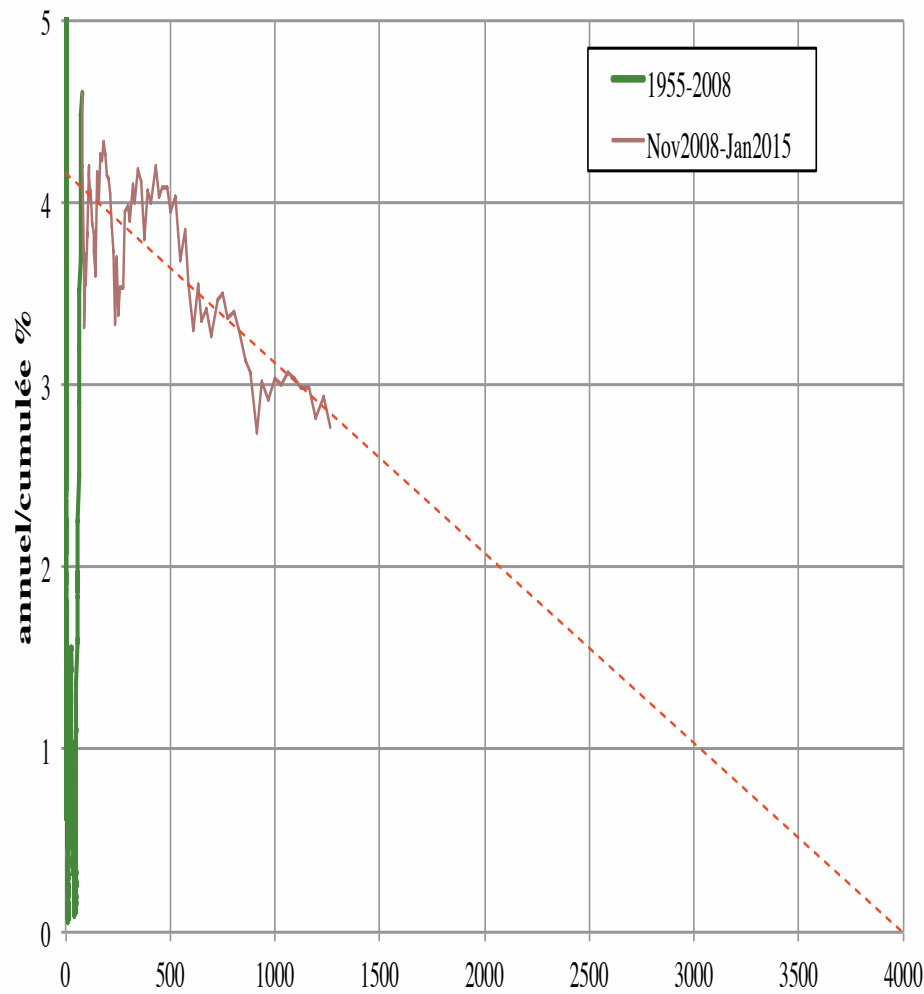

US oil creaming curve 1900-2012 trending to 275 Gb

- - - - 1900-1968 = USL48
- - - - 1968-1990= Alaska
- - - - 1990-2012 = deepwater+LTO
──── backdated 2P discovery

Jean Laherrere Feb 2014

cumulative number of New Field Wildcats

cumulative oil discovery Gb

Bakken North Dakota: linéarisation d'Hubbert de la production de pétrole

──── 1955-2008
──── Nov2008-Jan2015

annuel/cumulée %

Jean Laherrere Mars 2015

production cumulée Mb

monde: production & emissions CO2 cumulées de combustibles fossiles & prévisions

Gtoe (left axis): 0, 250, 500, 750, 1000, 1250, 1500

GtCO2 (right axis): 0, 800, 1600, 2400, 3200, 4000, 4800

1100 GtC

année: 1850, 1900, 1950, 2000, 2050, 2100, 2150, 2200

Jean Laherrere Mars 2015
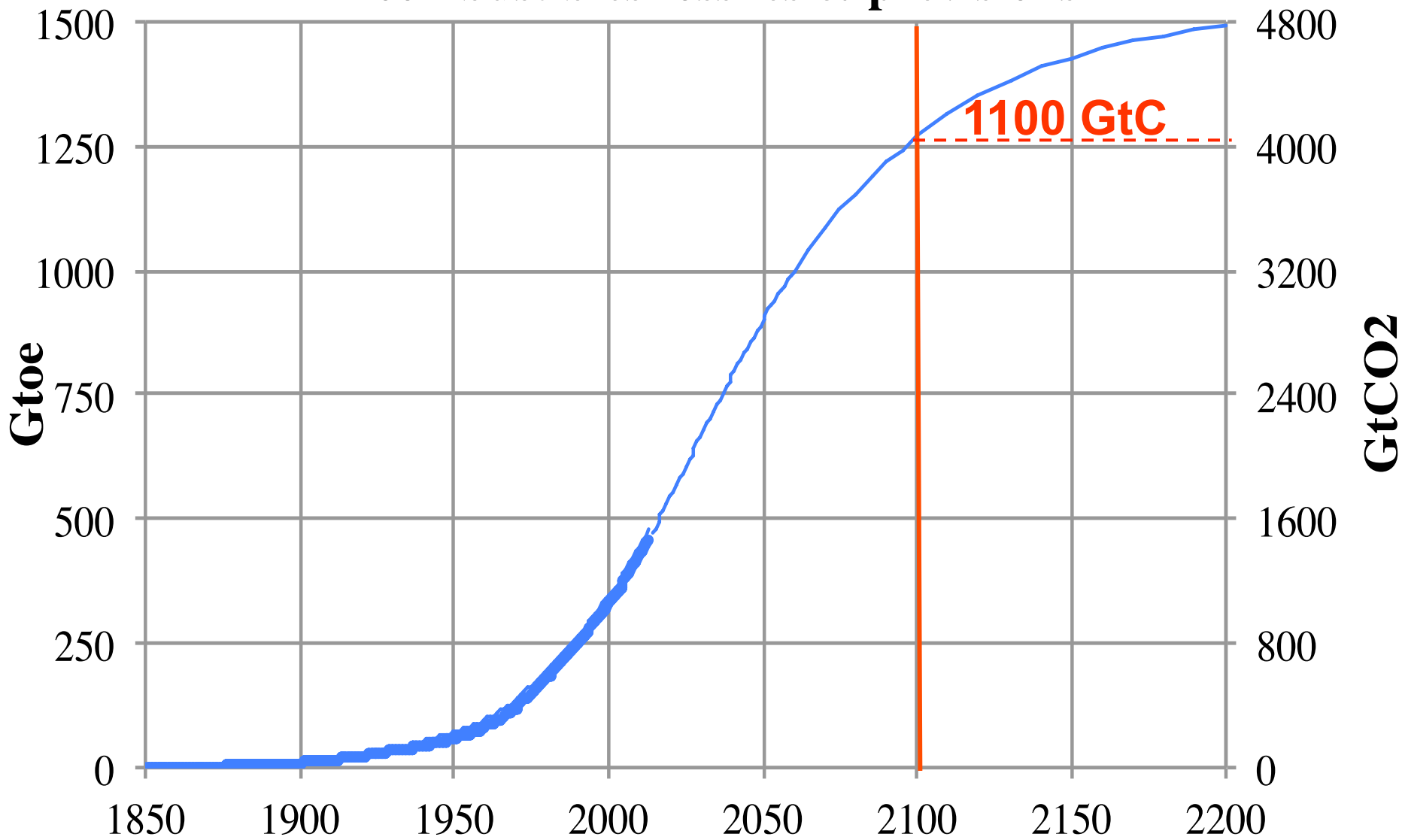
- Best guess for ultimate recovery of fossil fuels is 1500 Gtoe, corresponding to 1300 GtC (4800 GtCO2), whose 1100 GtC would be emitted from 1870 to 2100.

- This is less than fossil fuel emissions of RCP 4,5 (1250 GtC).

CO2 emissions from fossil fuels with IPCC RCP

Legend:
- RCP8.5 FF
- RCP6 FF
- RCP4.5 FF
- RCP3-PD FF
- U= 1500 Gtoe
- FF

Jean Laherrere March 2015
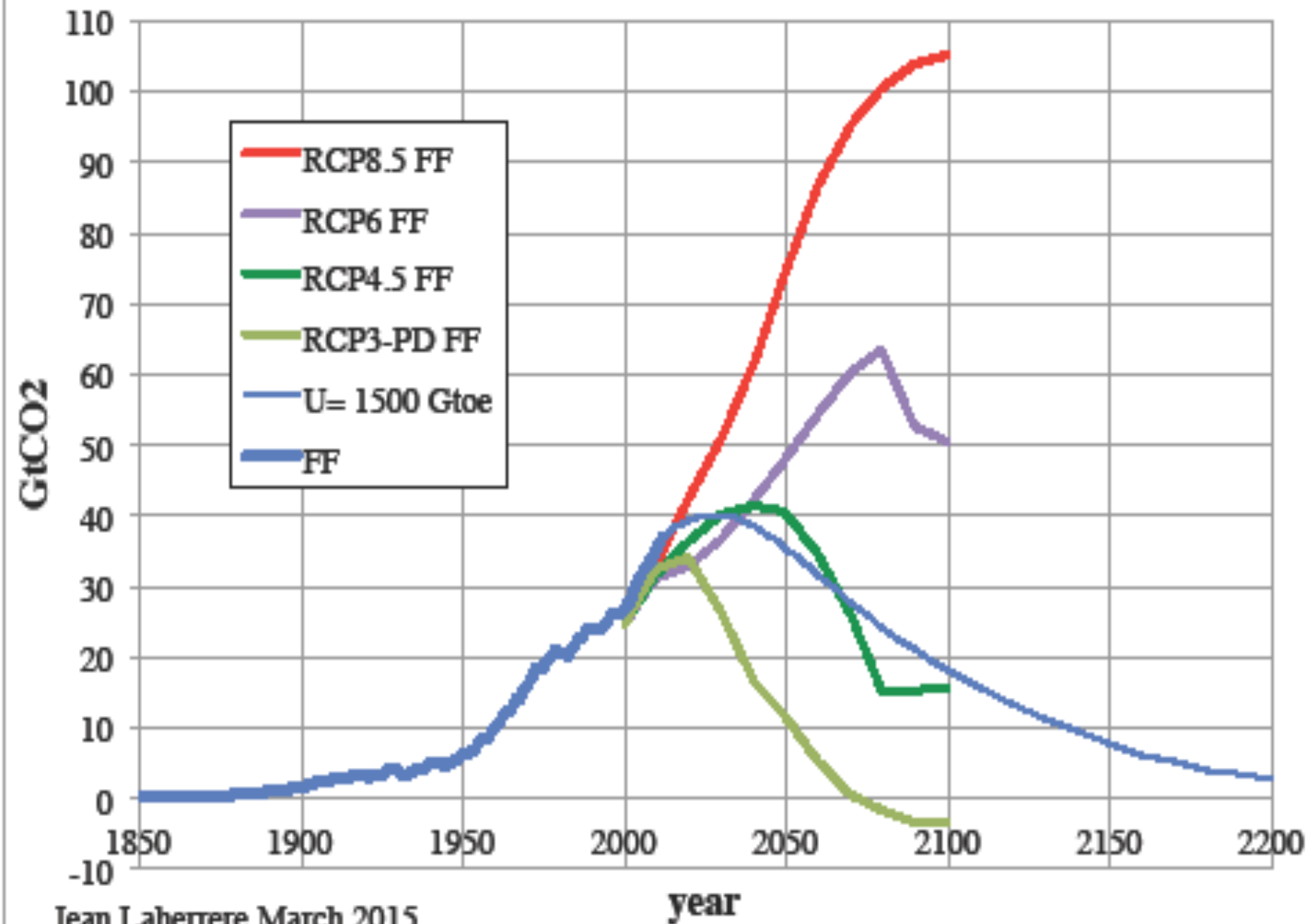
Conclusions

Best guess for fossil fuel emissions from 1870 to 2100 is below prediction of RCP 4,5 for that period and roughly 300 GtC above the 2°C limit.

There is a large uncertainty in these results. Nevertheless RCP 8,5 looks irrelevant and RCP 6 unlikely. The same conclusion was reached by Mohr et al. 2015, Fuel,141, 120-135.

Uncertainty comes mostly from coal ultimate appraisal, and coal will be very soon the main responsible for CO_2 emissions.

- Therefore future of climate, according to ICCP physical modelling, is mostly in the hands of the main coal consuming countries.

See below the 10 main responsibles

**The ten first consumers of coal (in Mtoe) in 2013
and their CO$_2$ emissions (in MtC). (IEA, BP)**

B.Durand 2015