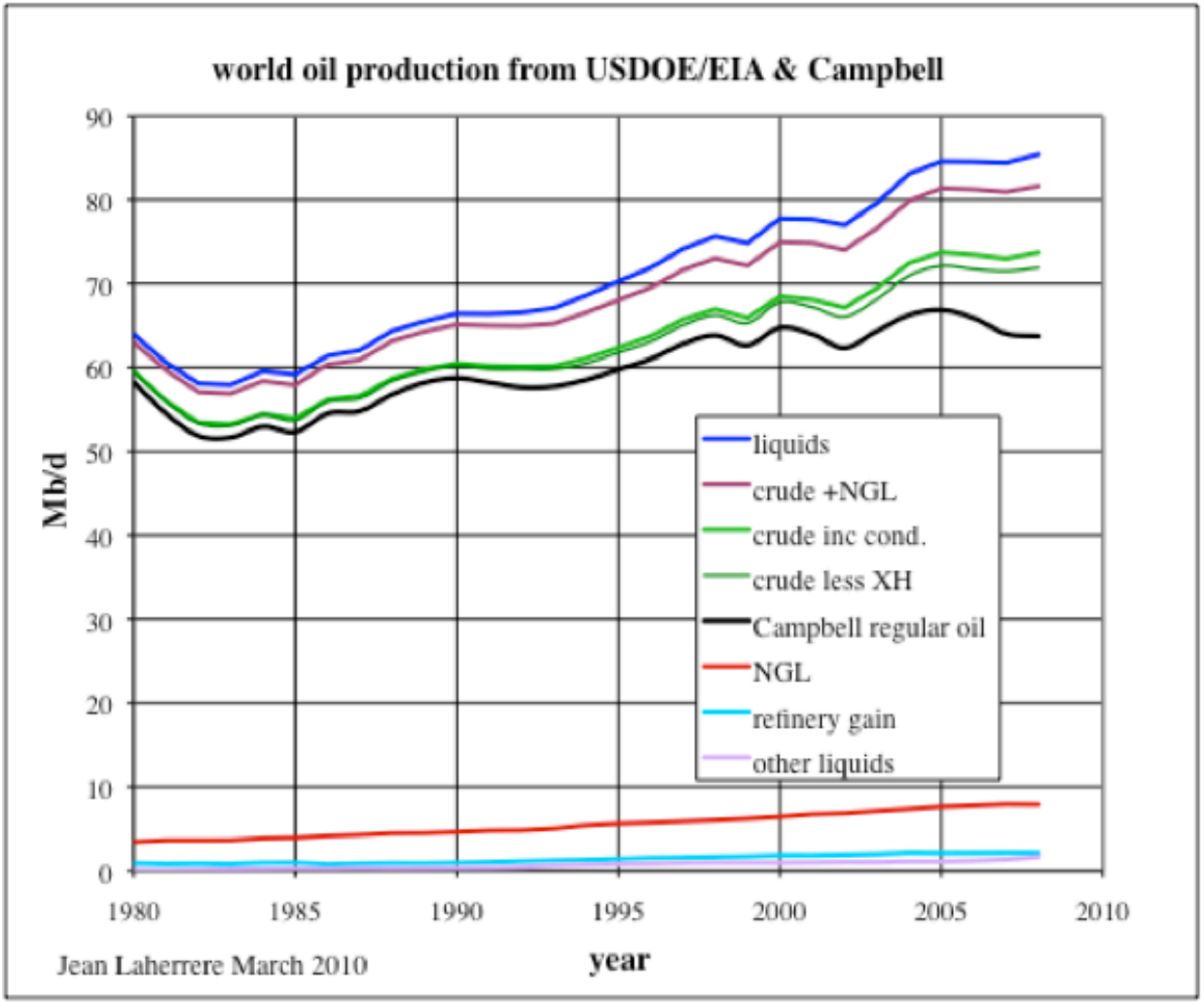
2do SIMPOSIO ASPO ARGENTINA Buenos Aires, 13 de mayo de 2010 “Peak Oil y Seguridad Energética”

Peaks in Argentina, Latin America and the world Jean Laherrere ASPO France

This presentation is based on a long paper available on aspofrance.org site

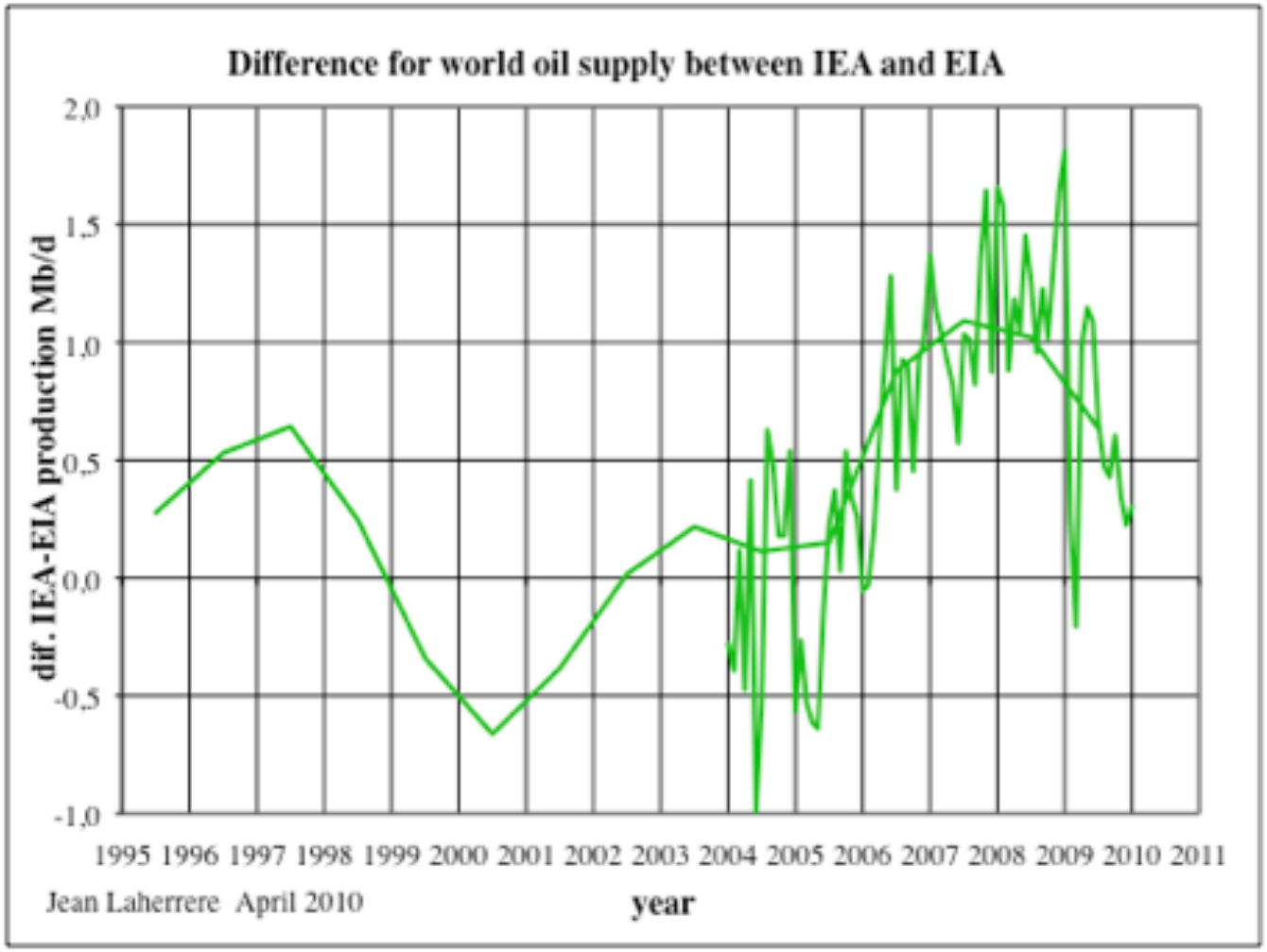
-**World oil peak or bumpy plateau? Oil peak or peak oil?**

Figure 1: world oil production with different definitions



The difference for oil supply between EIA and IEA varies and can reach 1,5 Mb/d and enquiry to those agencies could not precisely explain why,

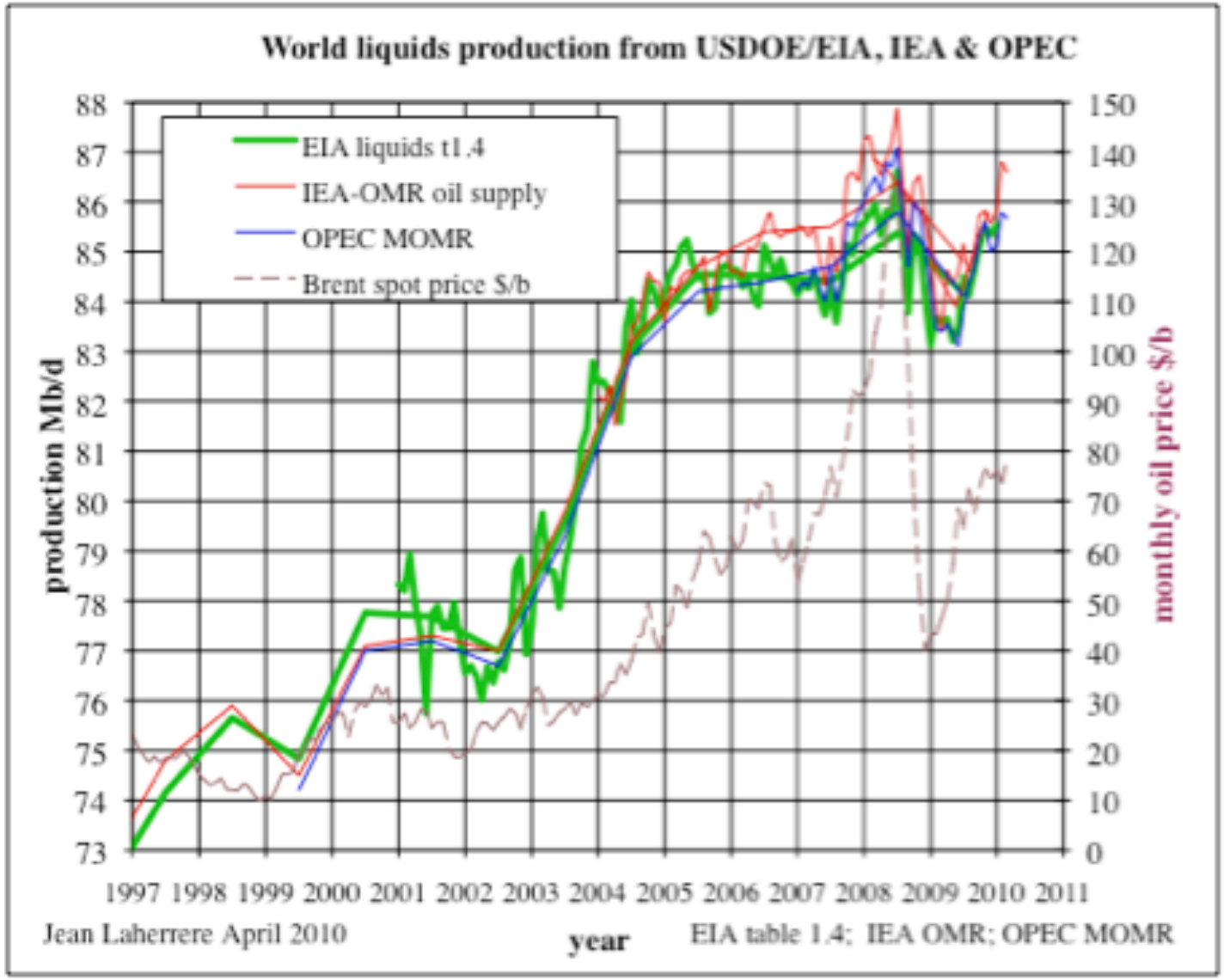
Figure 2: world oil supply: difference between IEA and EIA



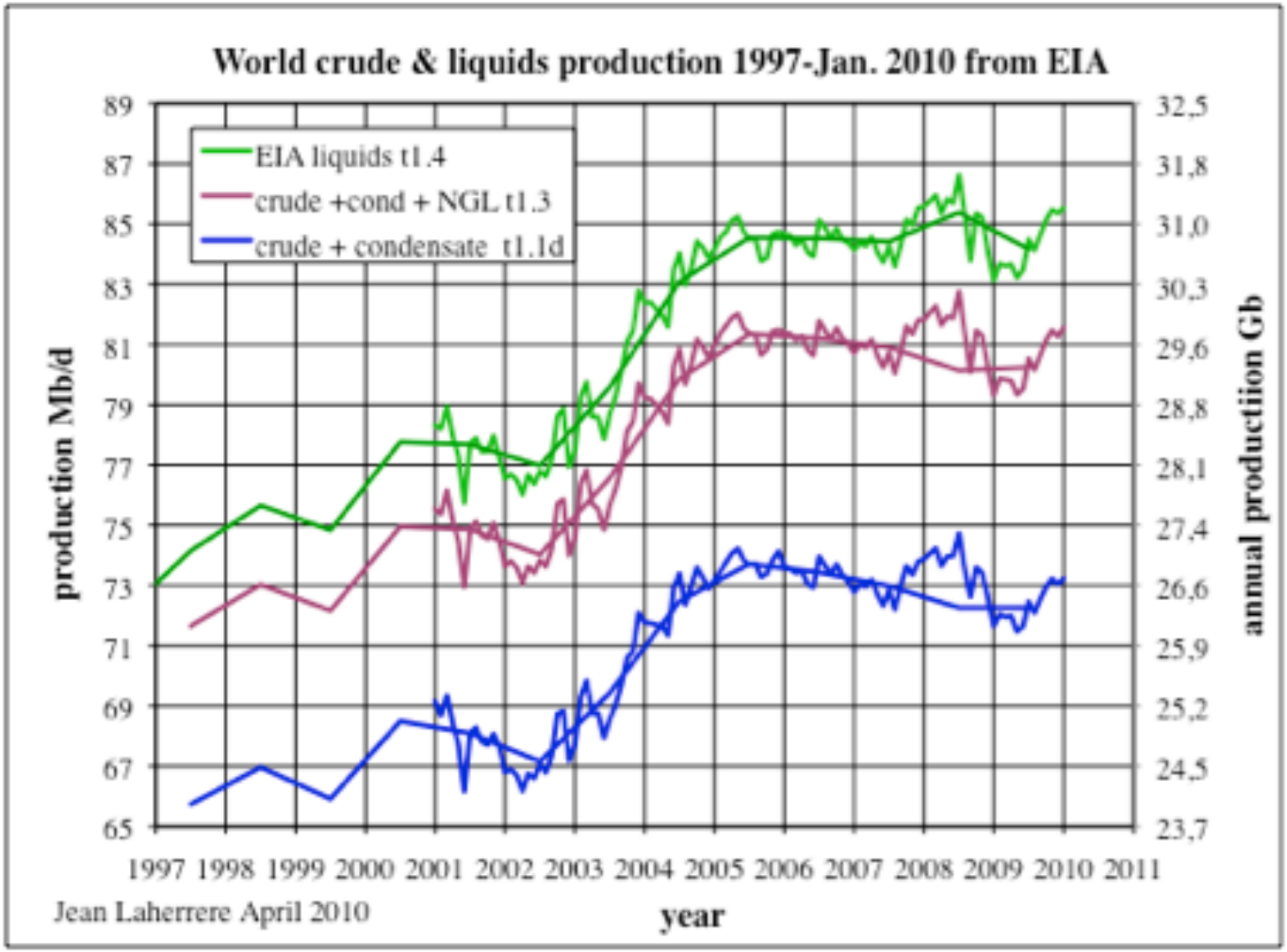
It means that the **accuracy of the world oil supply is about 2 Mb/d (2.5 %).**

Any fluctuation of a bumpy plateau below 2 Mb/d is not significant!

The world liquids monthly and annual production from EIA, IEA and OPEC differs largely.
Figure 3: world oil monthly supply from different sources

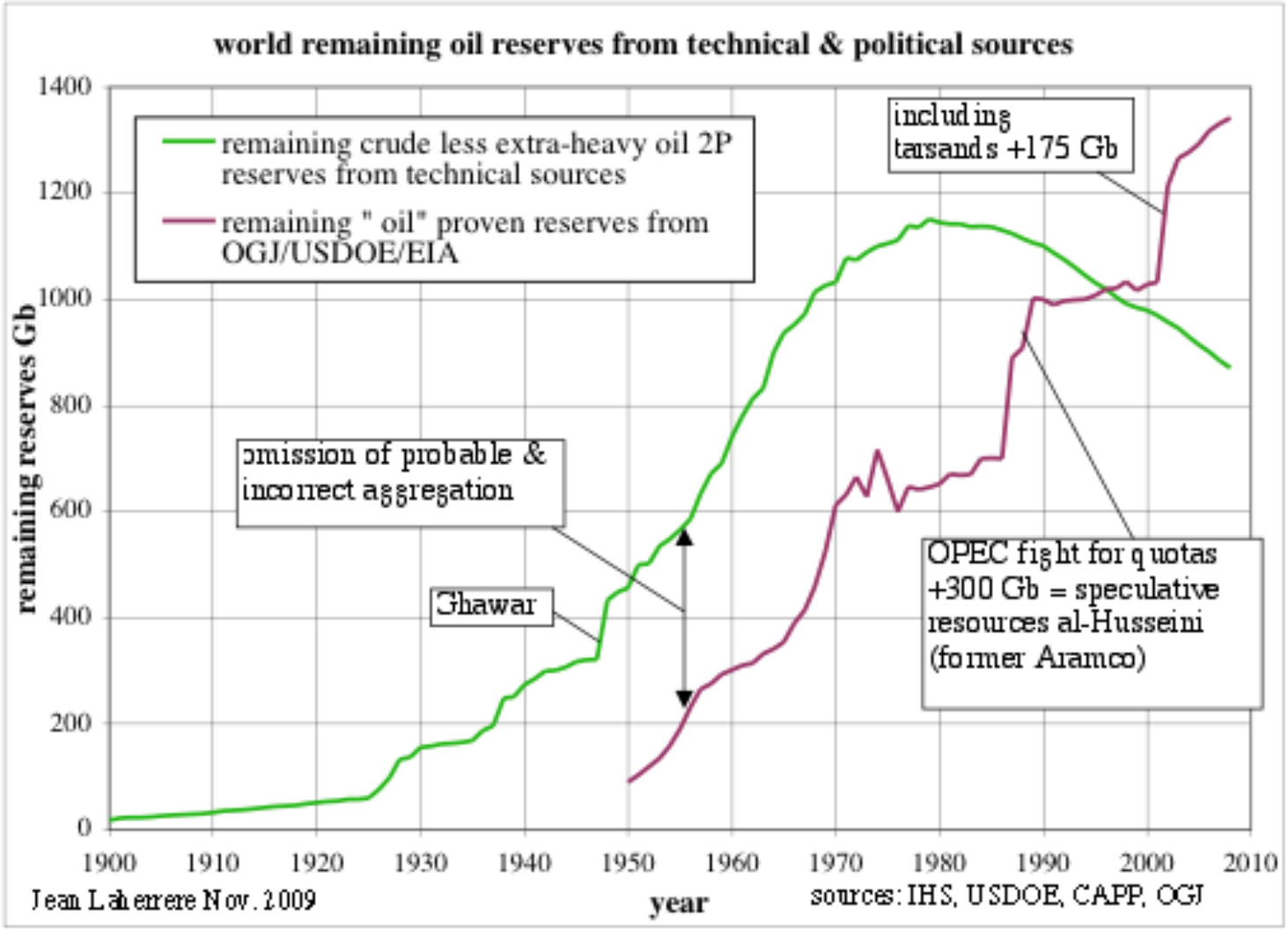


To deal with peak it is necessary to see the evolution from one source, and the best source is EIA.
Figure 4: world liquids and crude oil production from EIA



-**World oil discovery and production** -**Remaining oil reserves**

Figure 5: world remaining reserves from technical (confidential) and political (public) sources



This graph explains why the economists are so optimistic: they only have wrong data, always increasing!

-**Crude les extra-heavy (XH) oil**

Figure 6: world crude less XH oil cumulative discovery & production for U = 2100 Gb

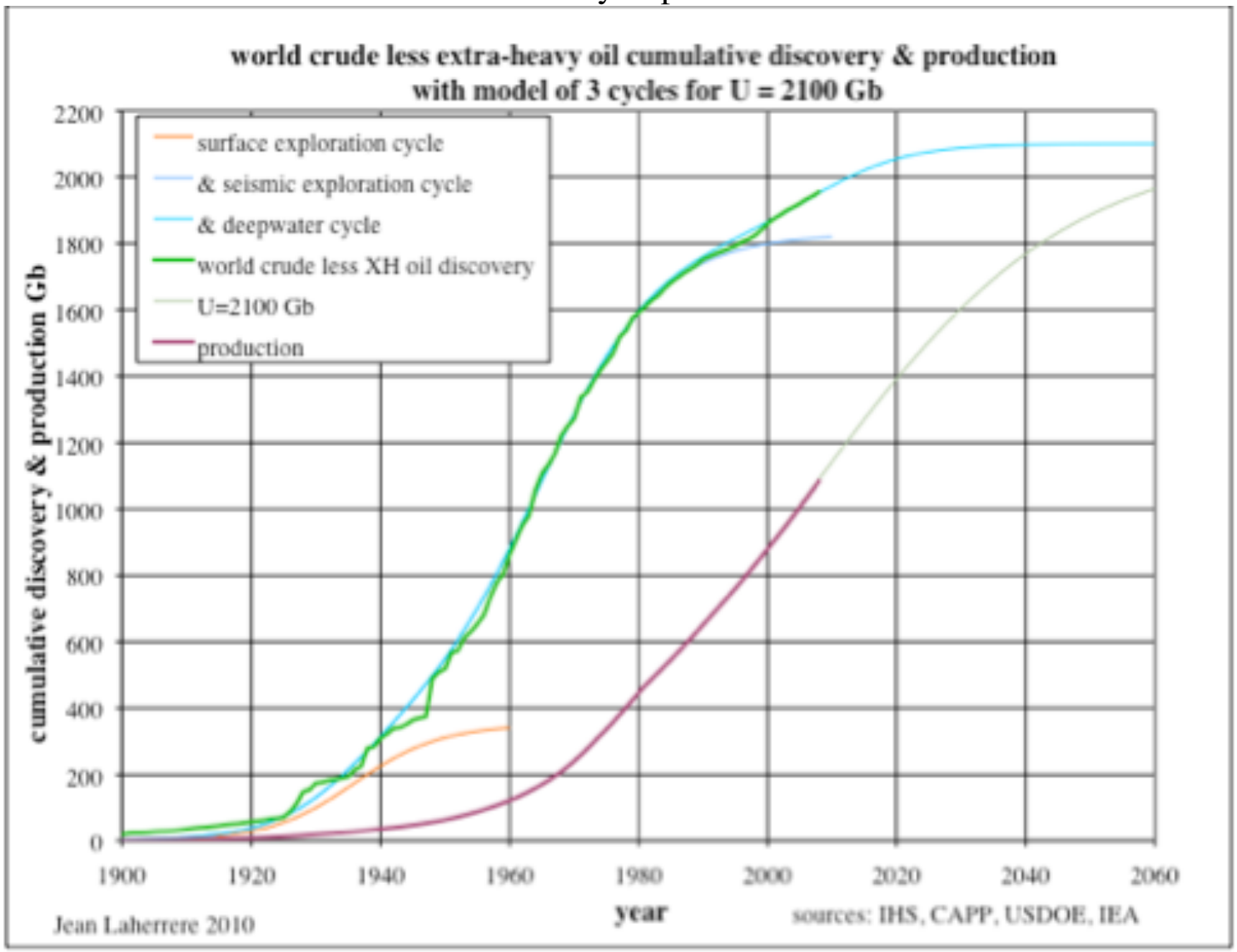
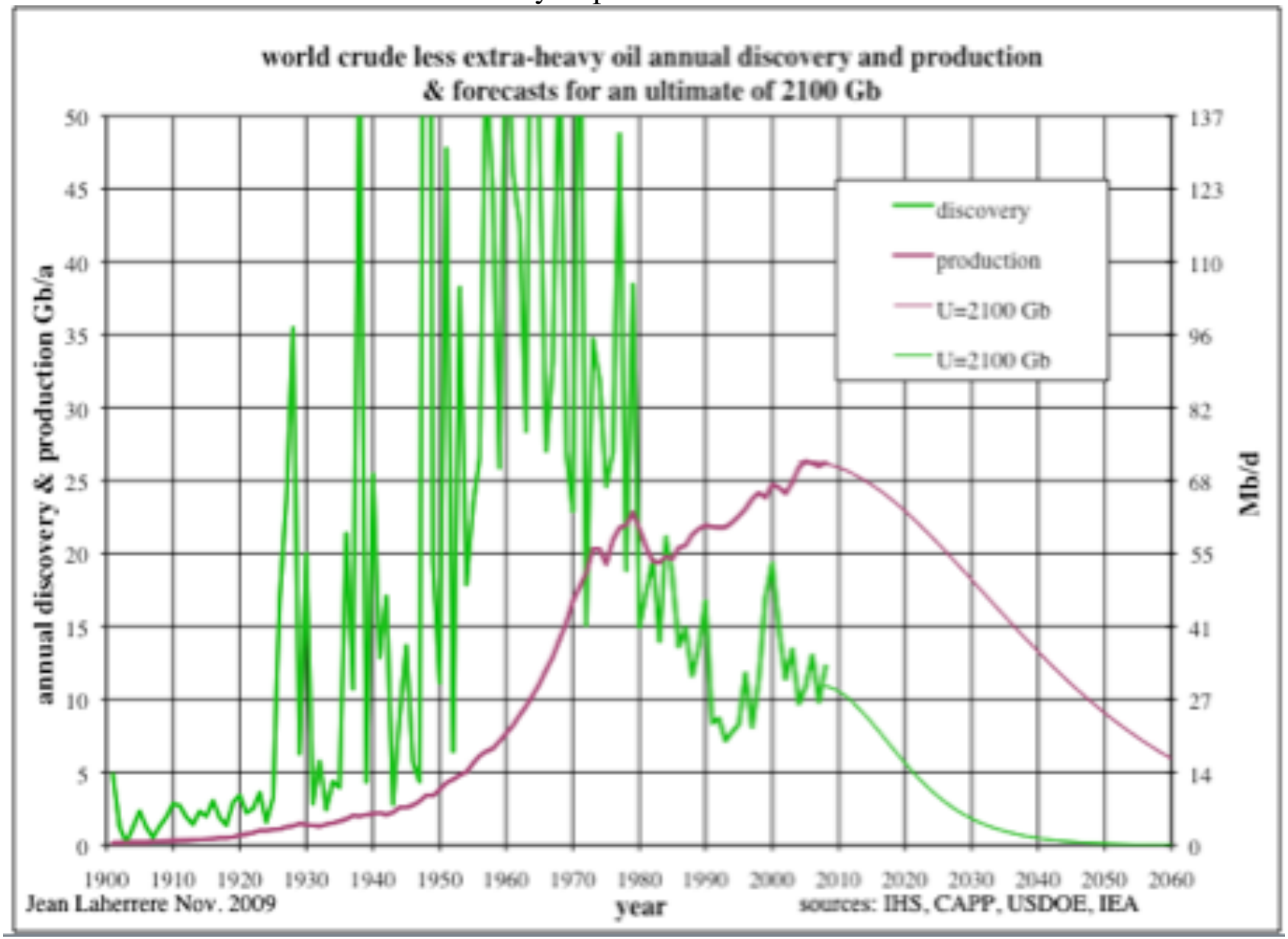
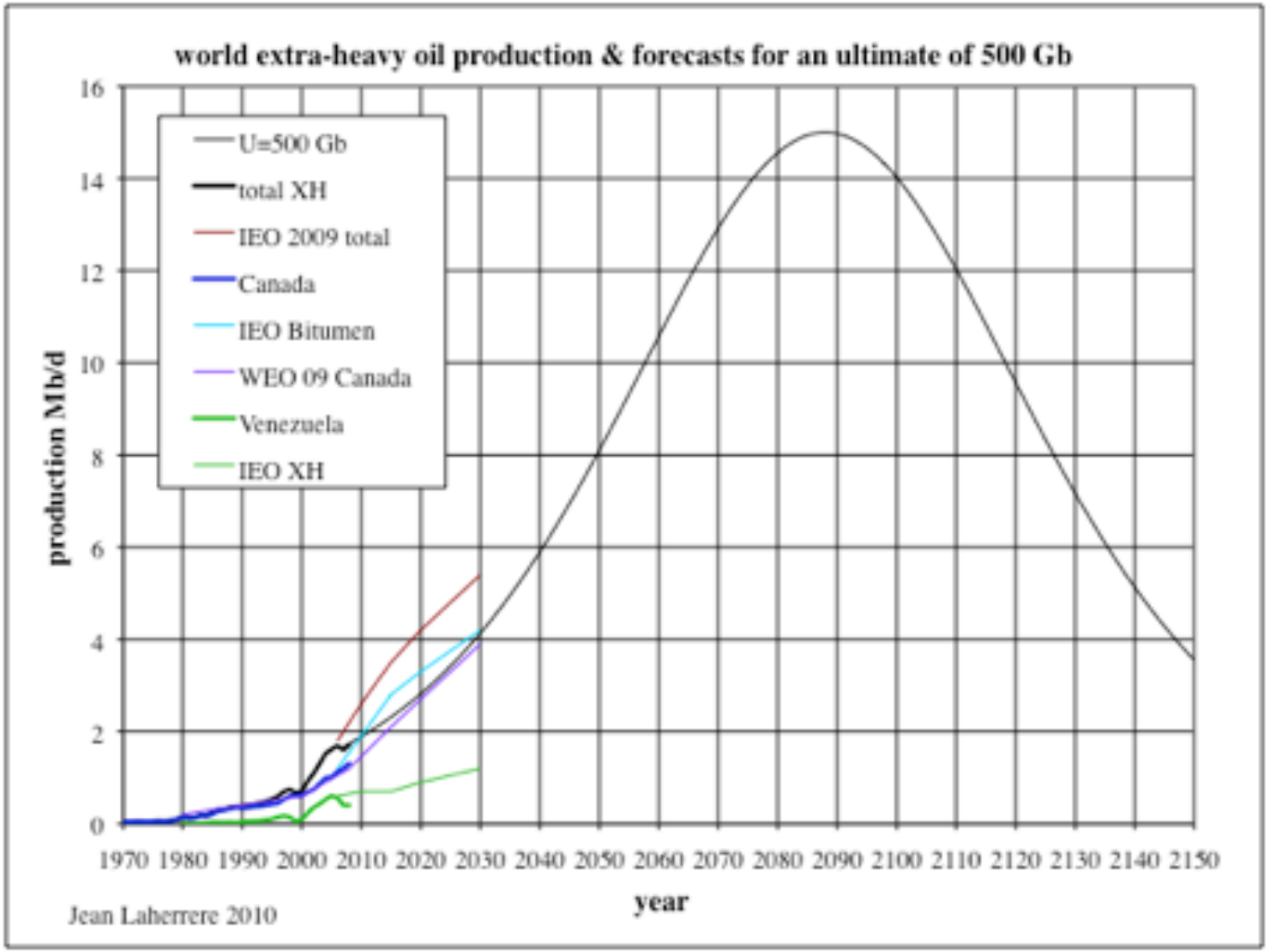


Figure 7: world crude less XH oil annual discovery & production for U = 2100 Gb



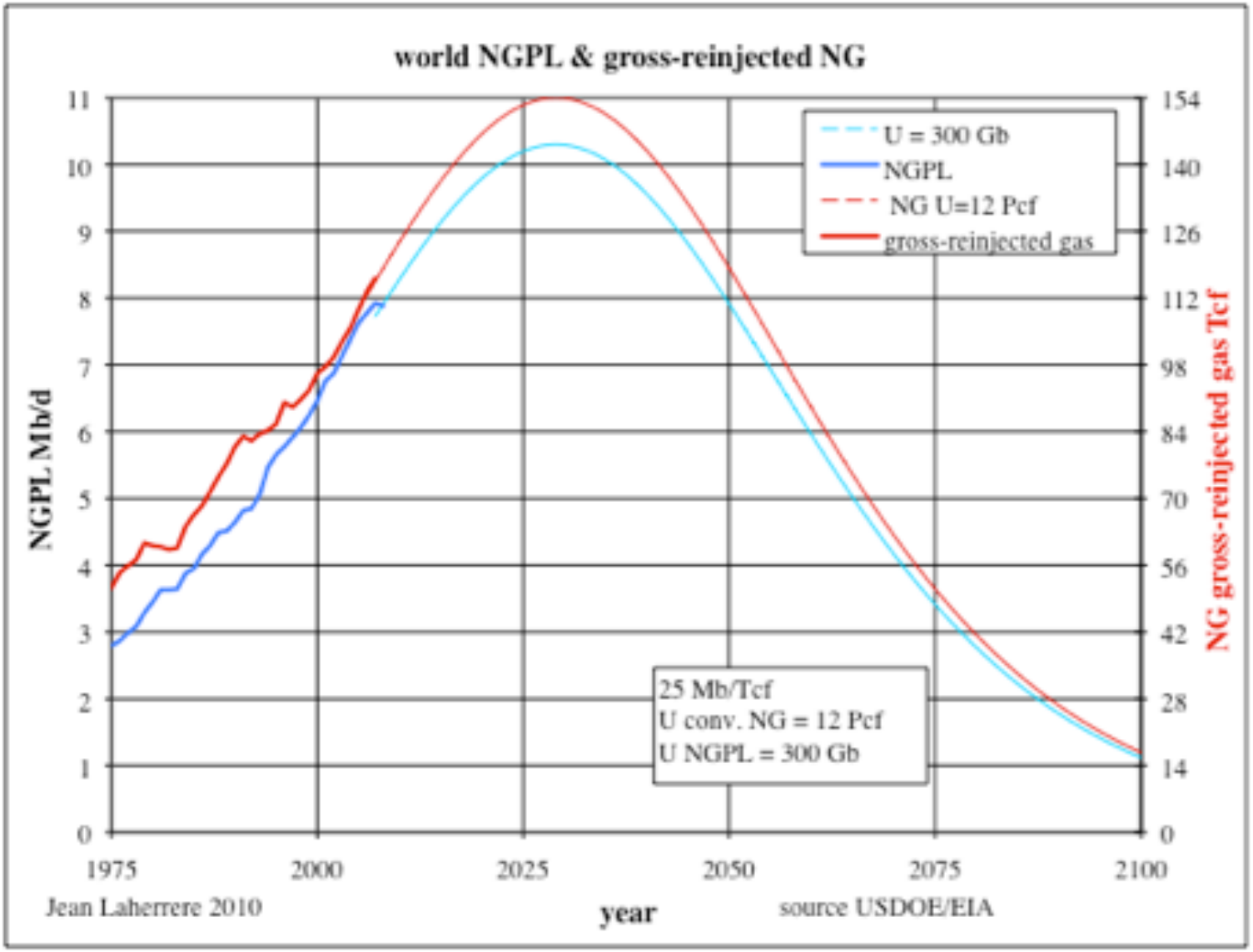
-**Extra-Heavy oil**

Figure 8: world extra-heavy oil production for U = 500 Gb



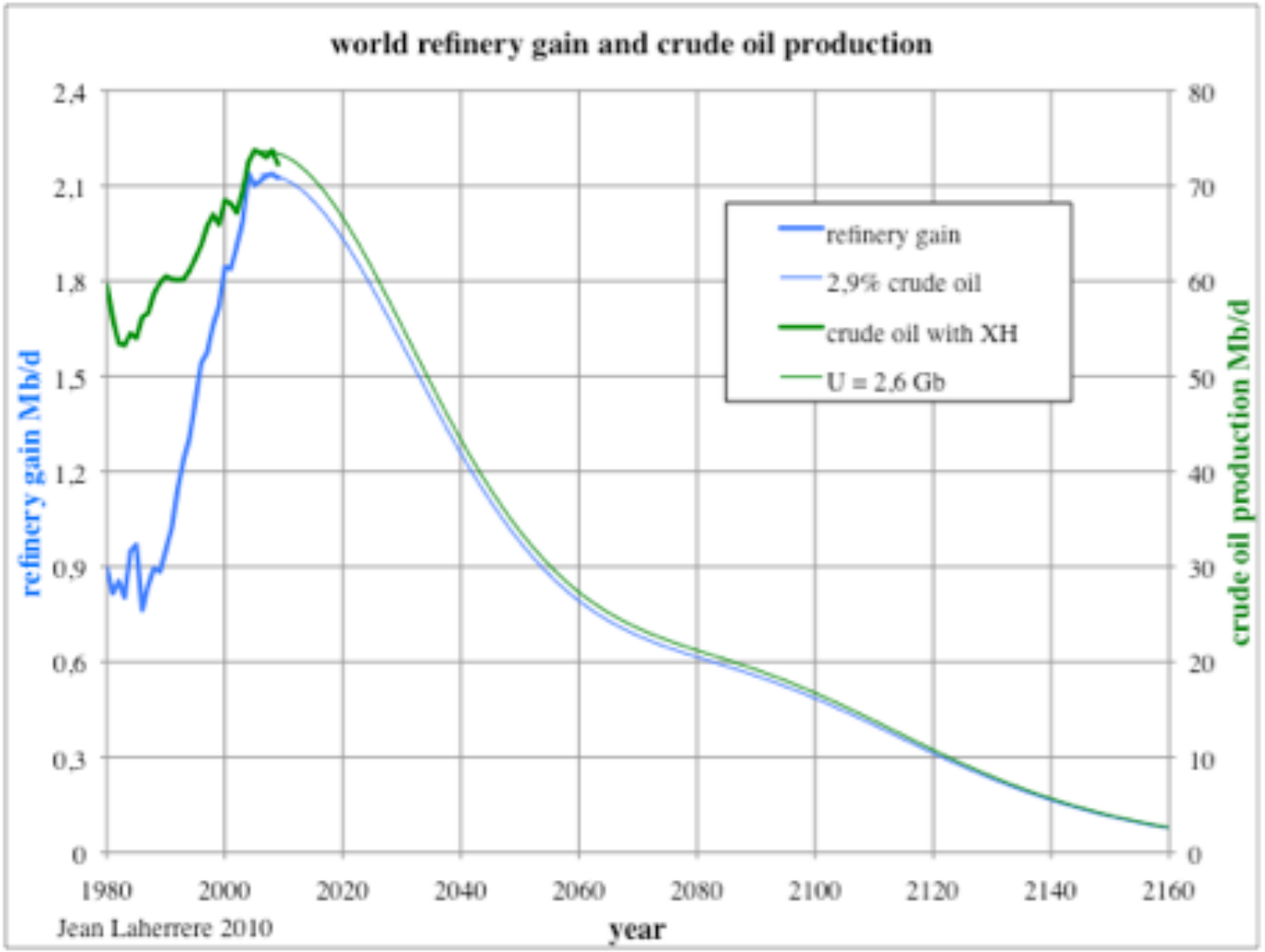
-**Natural gas liquids**

Figure 9: world NGPL production for U= 300 Gb related to NG (gross-reinjected) production



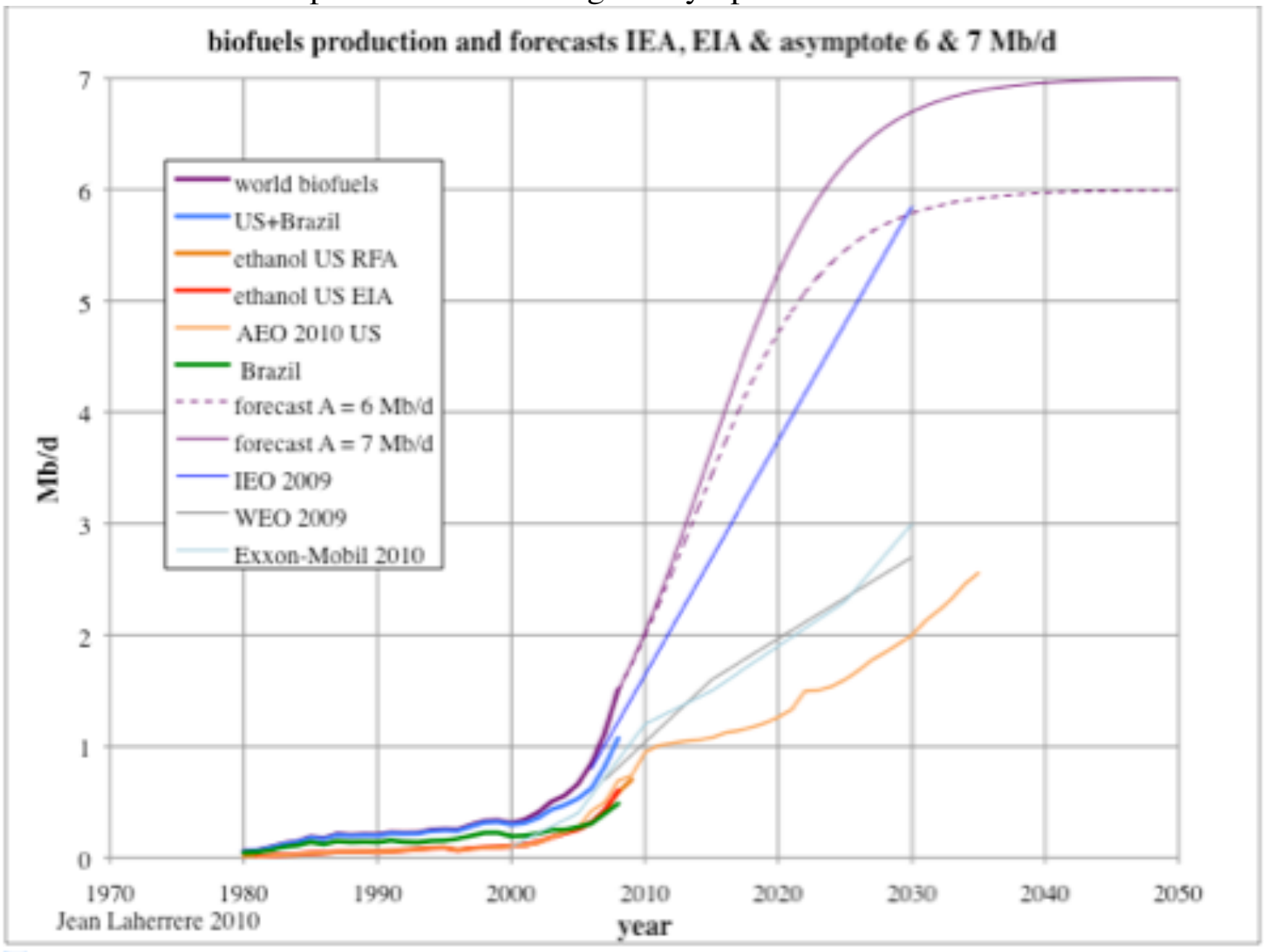
-**Refinery gain**

Figure 10: world refinery gain annual production being 2.9 % of crude including XH production



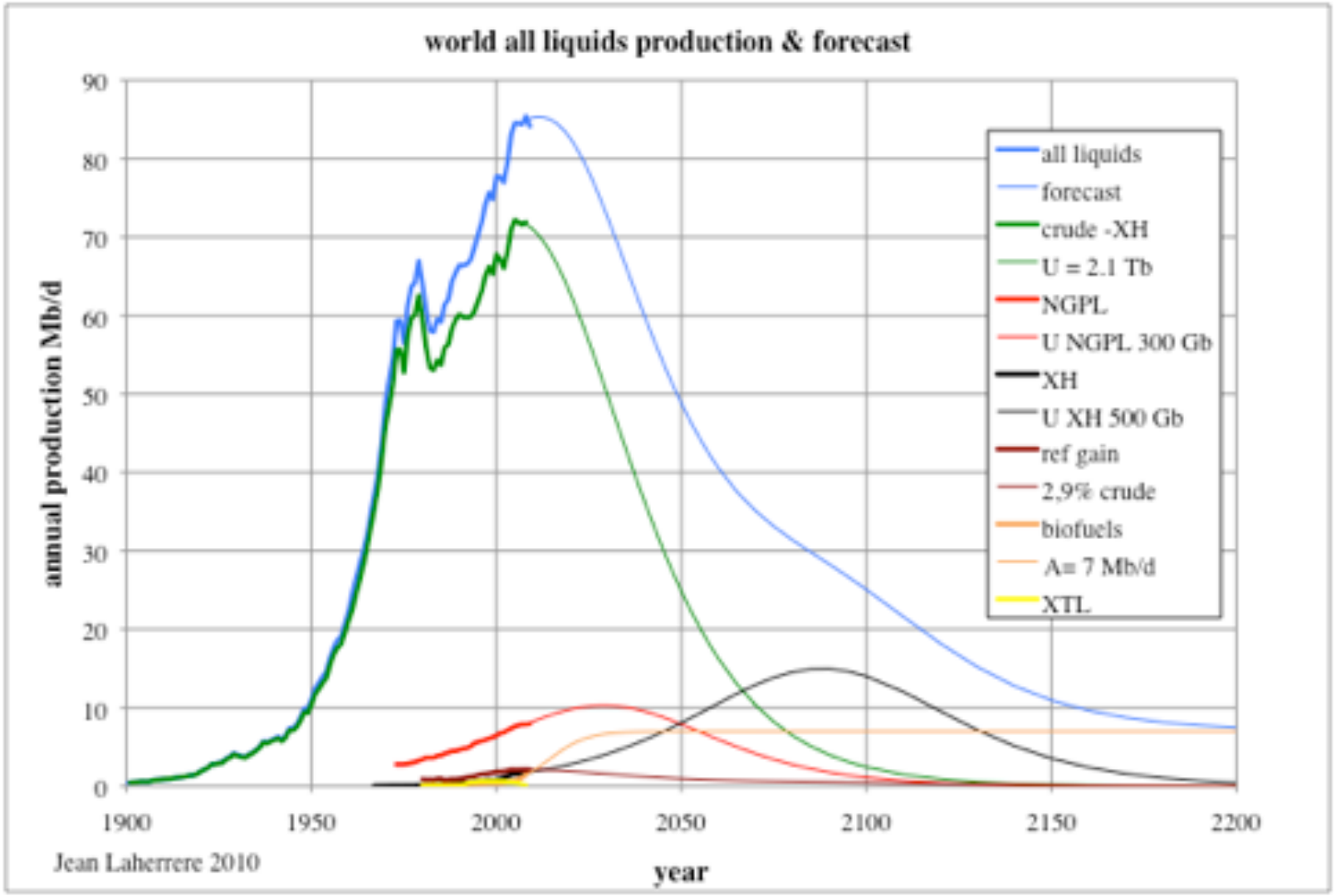
-**Biofuels**

Figure 11: world biofuels annual production assuming an asymptote of 6 & 7 Mb/d

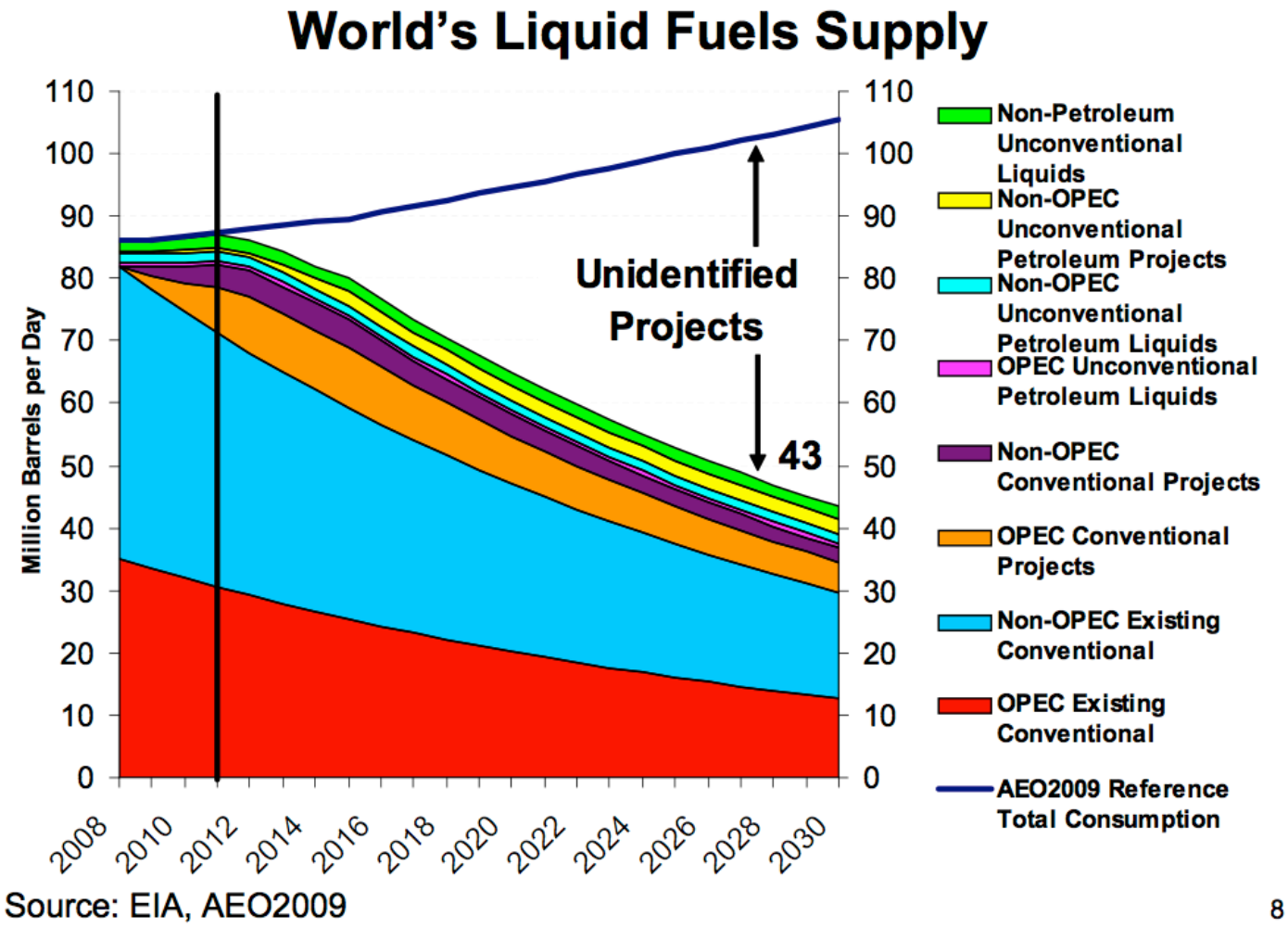


-**All liquids**

Figure 13: world all liquids production and forecast for an ultimate of 3000 Gb + biofuels asymptote at 7 Mb/d, assuming no above ground constraint



My guess for 2030 is 70 Mb/d, but Sweetnam USDOE 2009 forecasts less than 50 Mb/d for the identified projects. The production of the next 10 years will come from presently identified projects
Figure 14: world's liquids supply from USDOE/EIA = Sweetnam 2009



Thunder Horse decline? Deepwater Horizon blow out?

-**USL48 oil discovery & production**

Figure 16: USL48 oil cumulative discovery & production with ultimate 230 Gb

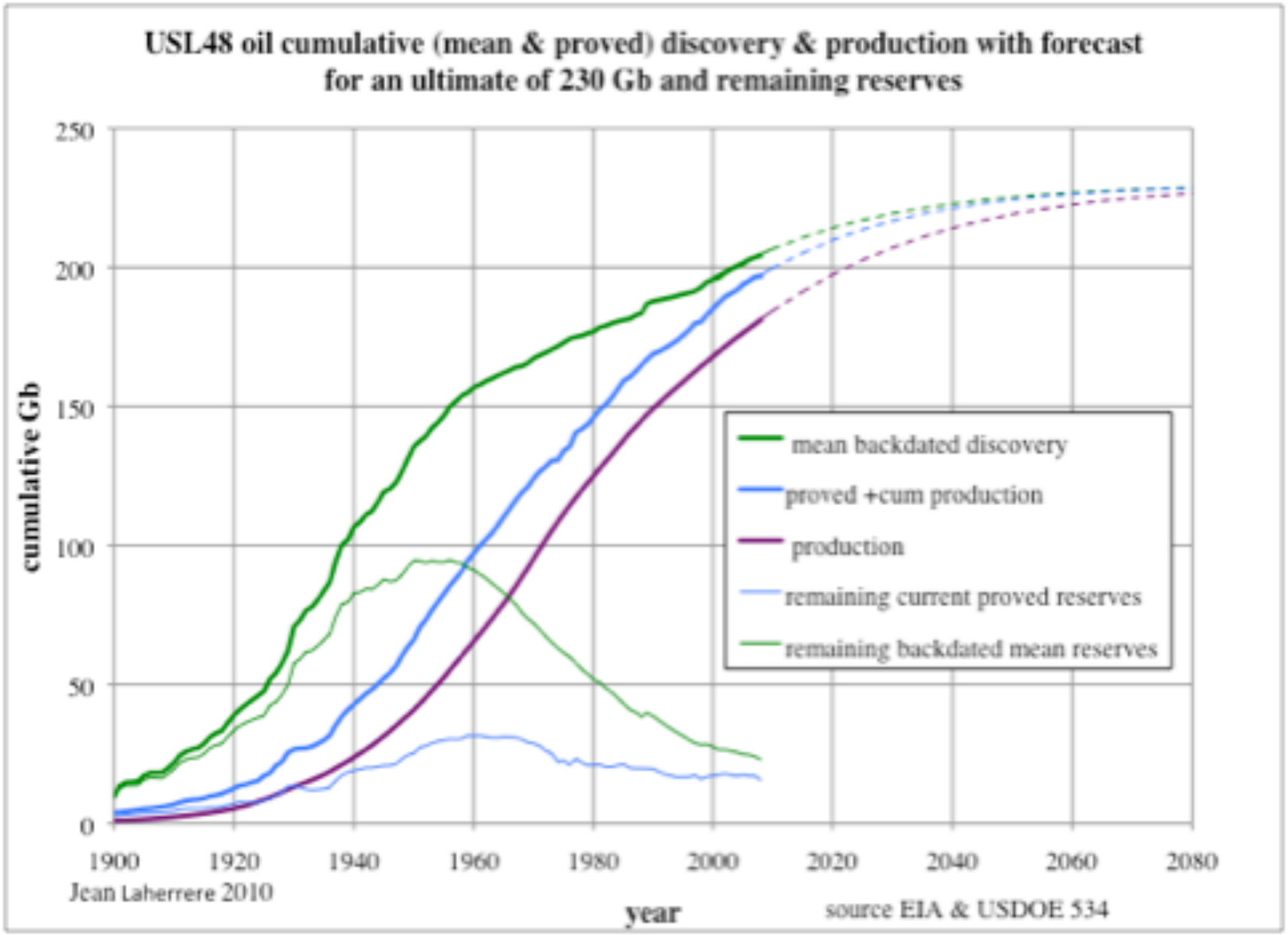
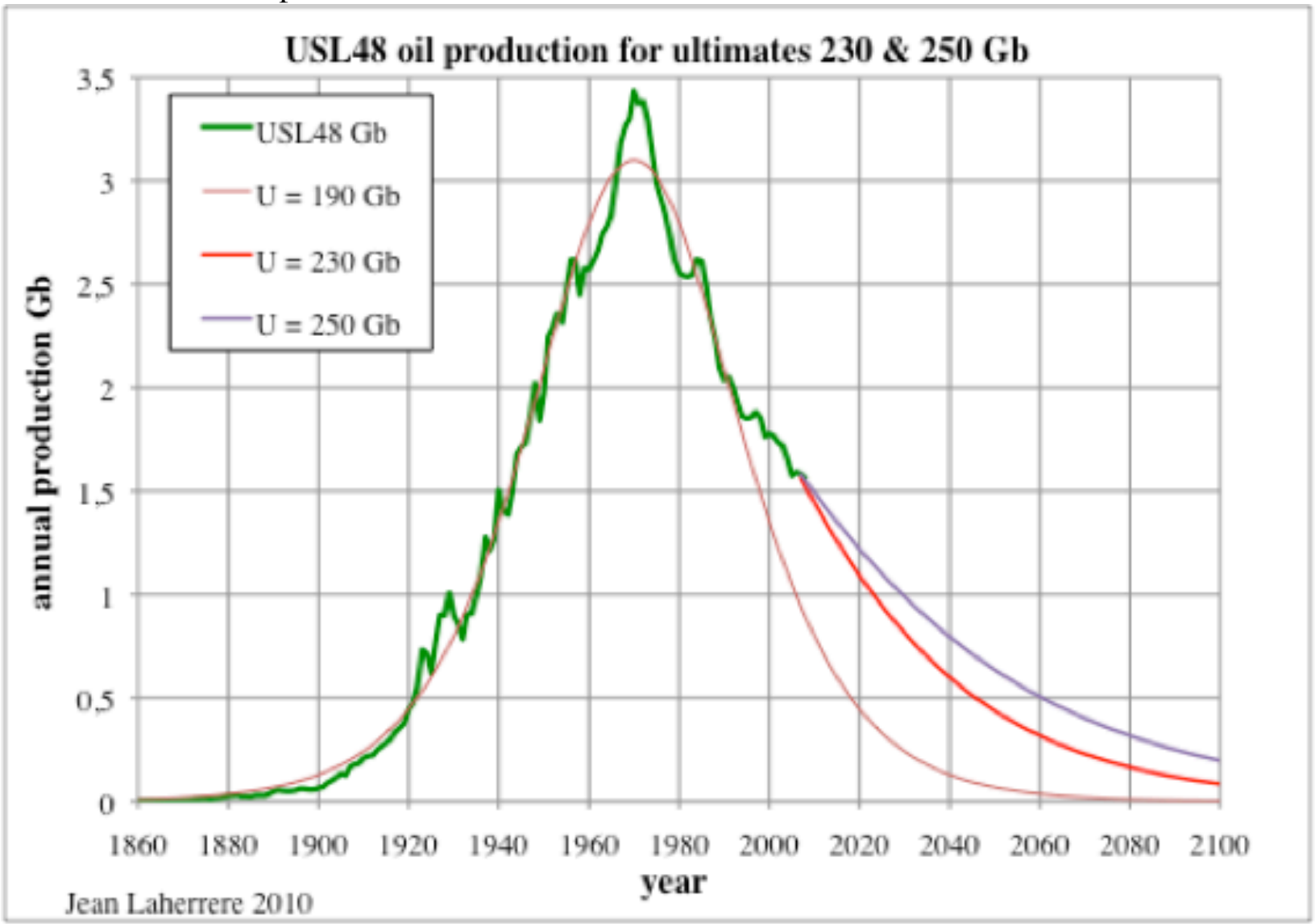


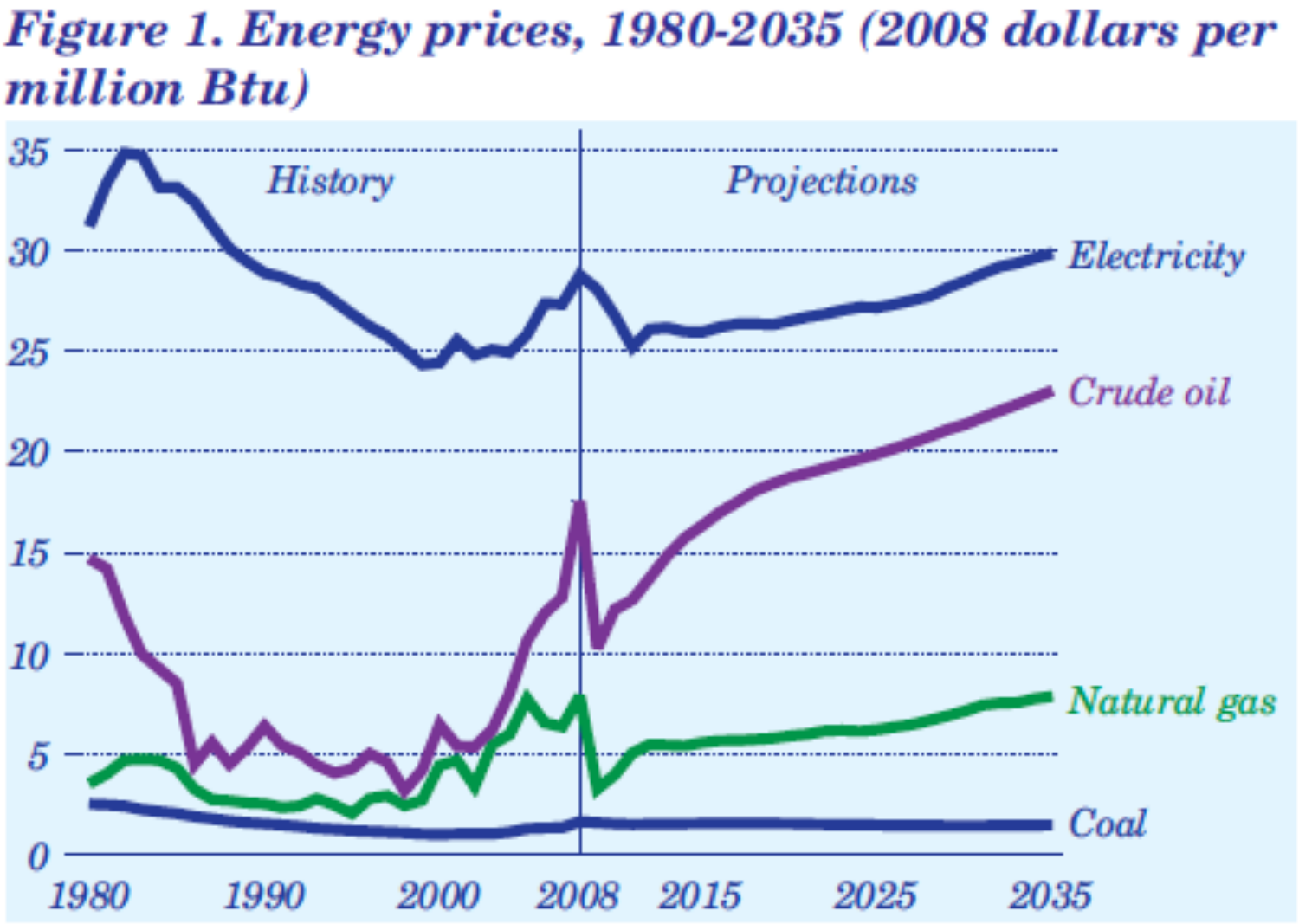
Figure 18: USL48 oil annual production for ultimates 190, 230 & 250 Gb



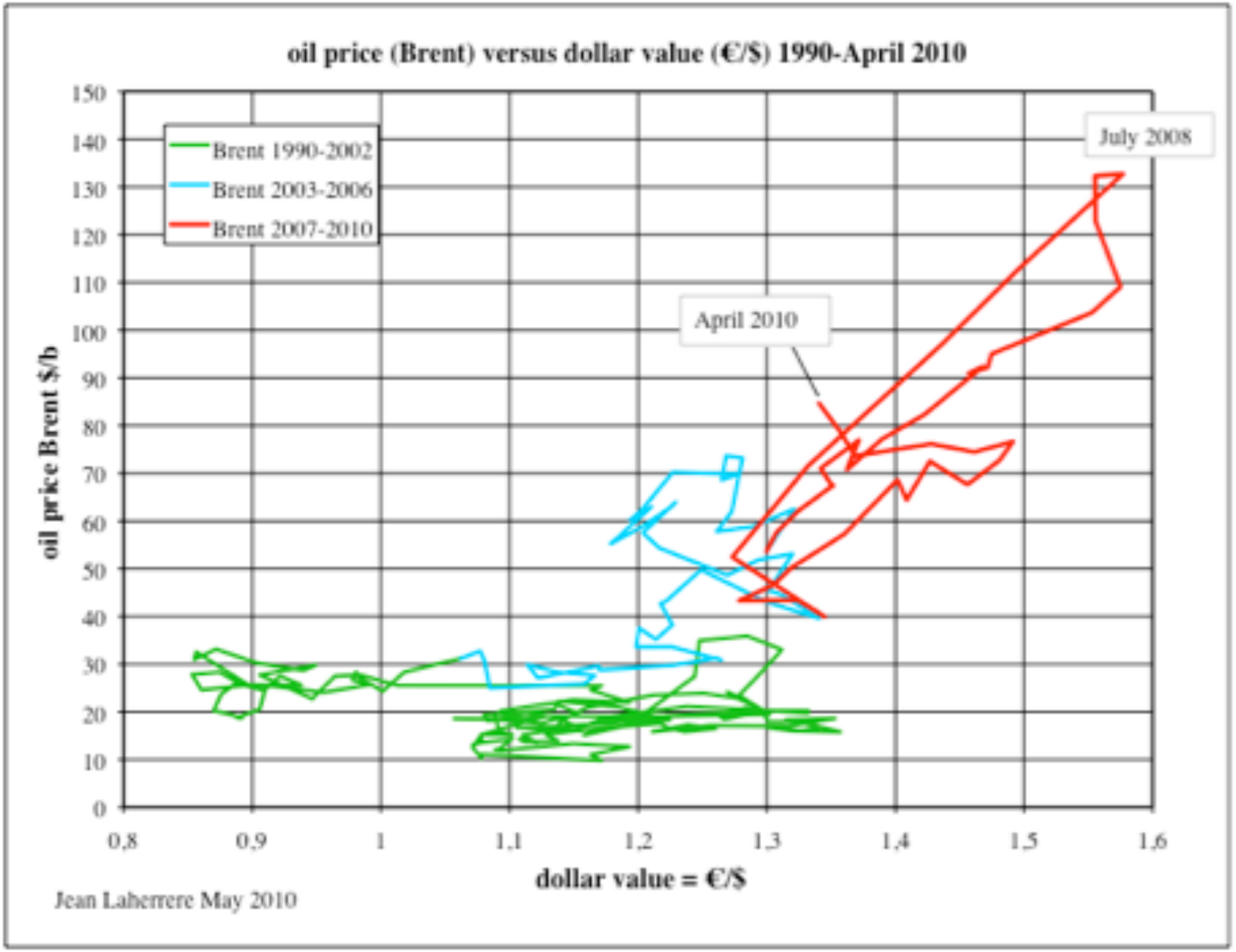
-**Chaotic oil price: peaks and valleys**

EIA had been always wrong in its price forecast!

Figure 20: energy price forecasts from USDOE AEO 2010 in $2008/MBtu



The plot of oil price versus the dollar value (€/$) shows that there is a linear relationship from 2007 to now.
Figure 21: monthly oil price versus dollar = €/$ for the period Jan. 1990-March 2010



-**Natural gas**

Because there is no OGEC and no quotas, the NG reserves are less polluted by politics, only FSU ABC1=3P data need to be corrected.

Figure 22: world natural gas cumulative discovery & production for U= 13 Pcf

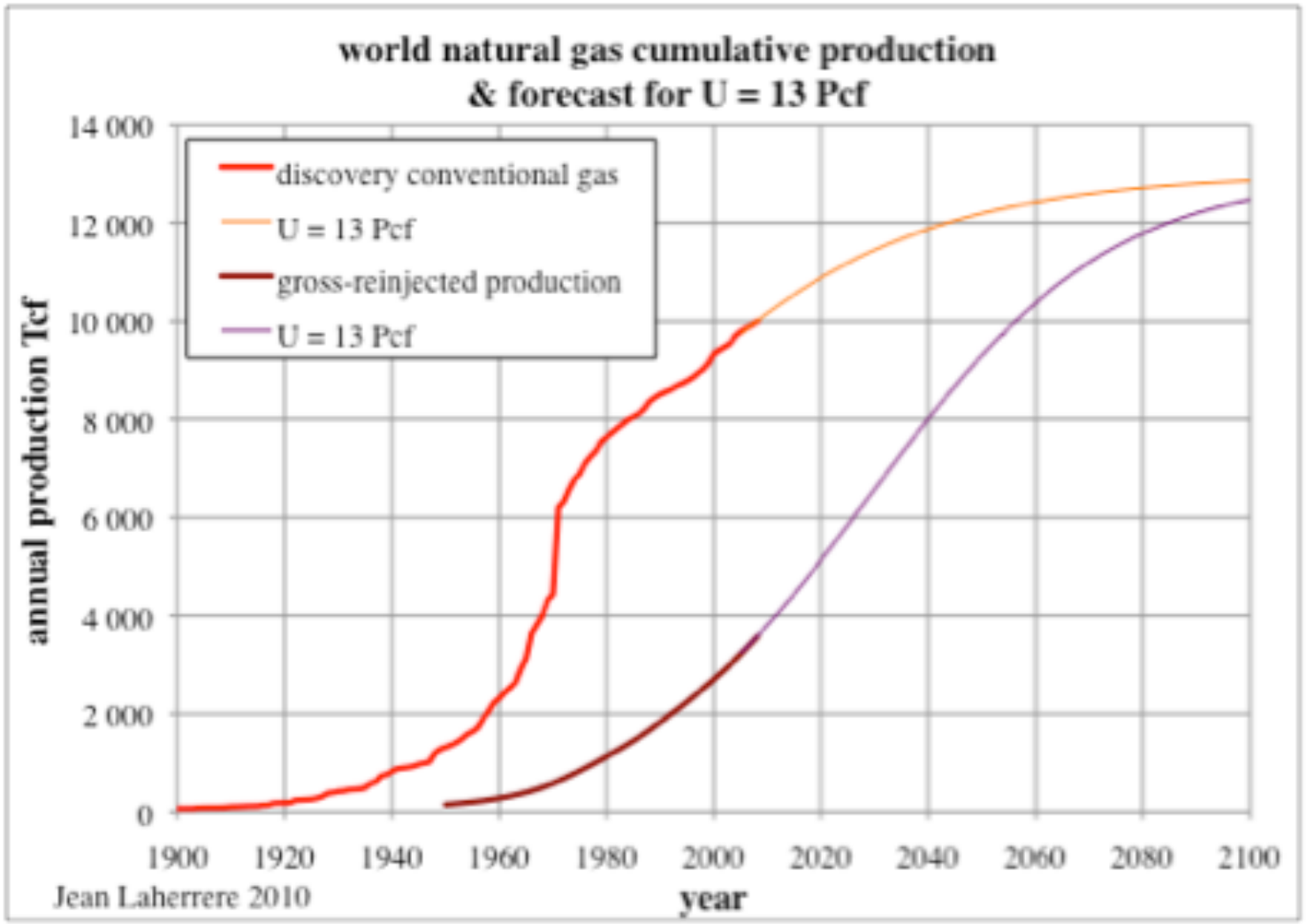
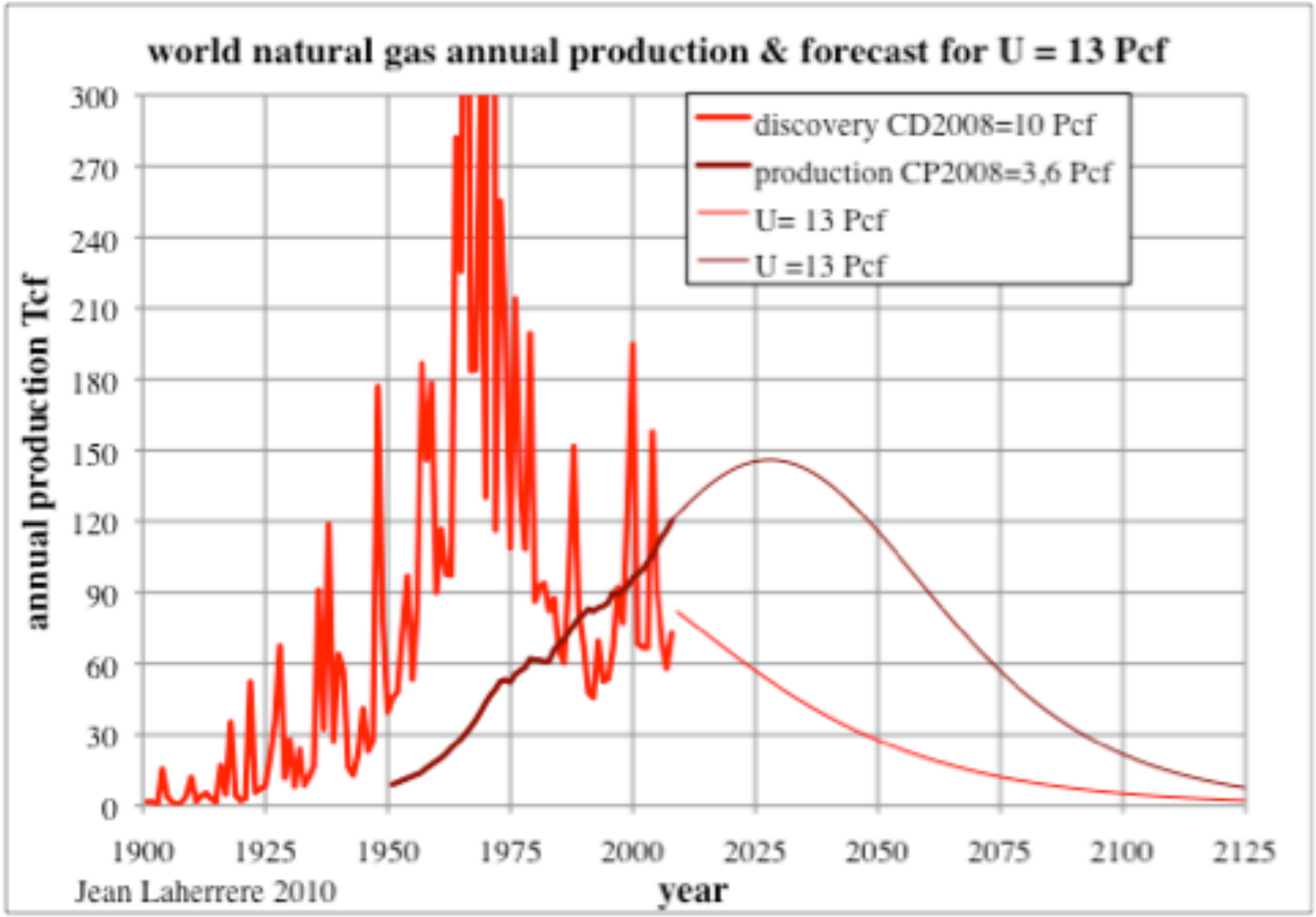


Figure 23: world natural gas annual discovery & production for U= 13 Pcf



-Shale gas

Shale gas is found in source-rock with poor reservoir quality. The first US gas production was in 1820 at Fredonia in New York State from Marcellus shale gas. But shale gas was abandoned when conventional, easy, cheap gas was found.

Shale gas production was recently busted by horizontal wells and hydraulic fracturing, promoted by small independent when gas price went up to more than 10$/kcf. The area of the basins with shale gas is huge (area of the source-rock) and gas is found everywhere in this continuous-type accumulations, but the quality of the reservoir is heterogeneous. Yet most operators assume that good quality reservoir (sweet spot) will prevail in most of the basin, though it is likely not to be the case.
There is disagreement on the economic threshold of shale gas.
Tight gas formerly included in unconventional by EIA is now conventional in AEO 2010, when some gather together tight gas and shale gas!
It appears that transparency is not the goal of many! Confusion helps promotion!

We have to wait a few years to know more about shale gas potential. We have to remember the hopes on CBM potential (now flat) in the 90s, in dissolved gas in geopressured aquifers in the 80s (little production despite resources up to 50 000 Tcf BGR 2003), and tomorrow in the hydrates!

But the main problem of shale gas is the possible pollution of the large injected volume of water with toxic (confidential) products (biocides) in deep aquifers, which can move from faulty (or simply old) wells into shallow drinking aquifers, but it will take some time!
NIMA (Not In My Aquifer) soon could be as strong as NIMBY!.

-**Coal**

Some are reluctant to model unconventional oil & gas, coal and minerals with Hubbert cycles because the ultimates depend on the economic threshold, which depends on price.

But some coal basins are almost depleted and are the best examples of Hubbert linearization trend

-UK coal Figure 25: UK coal Hubbert linearization on the period 1830-2008

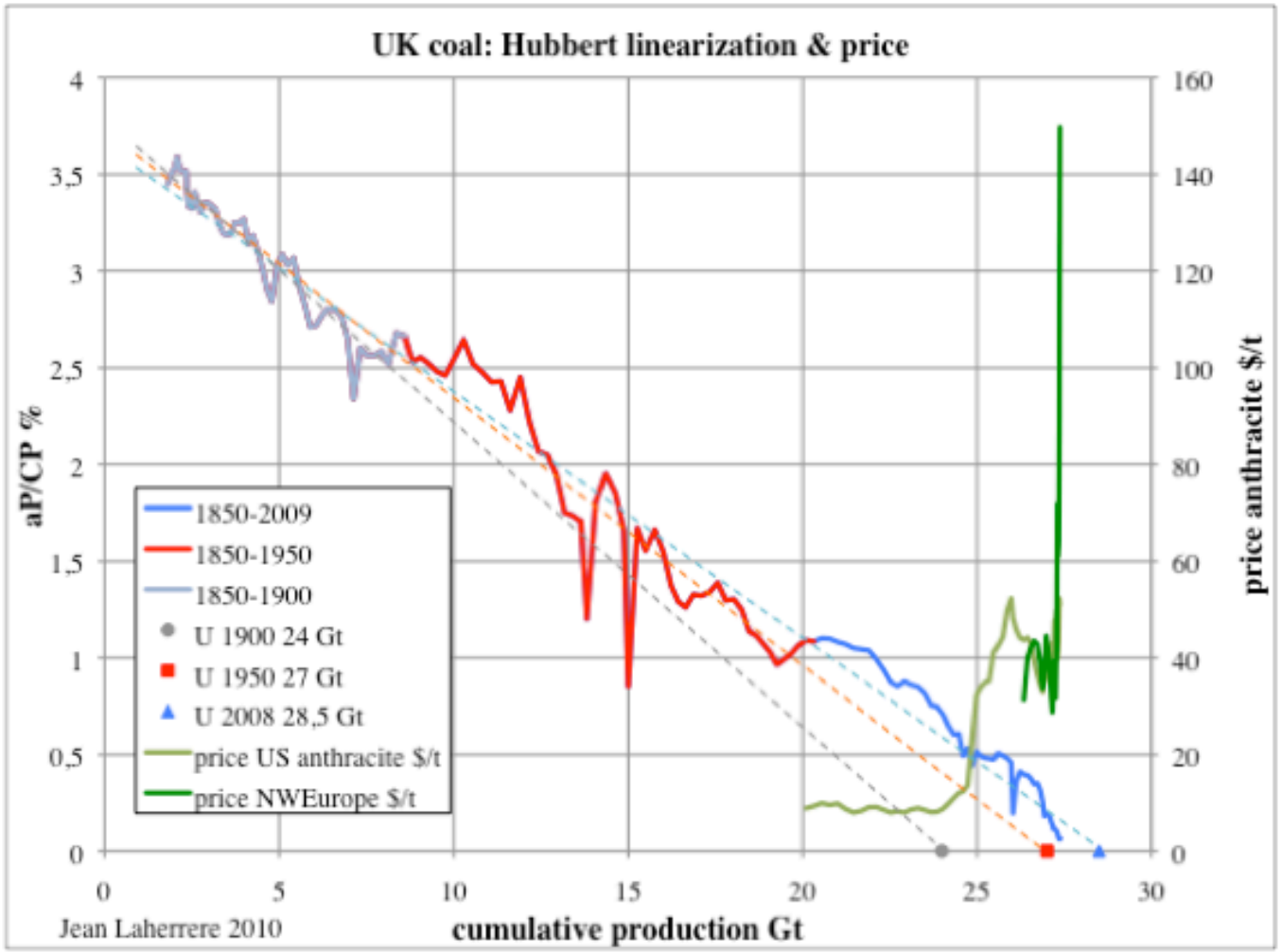
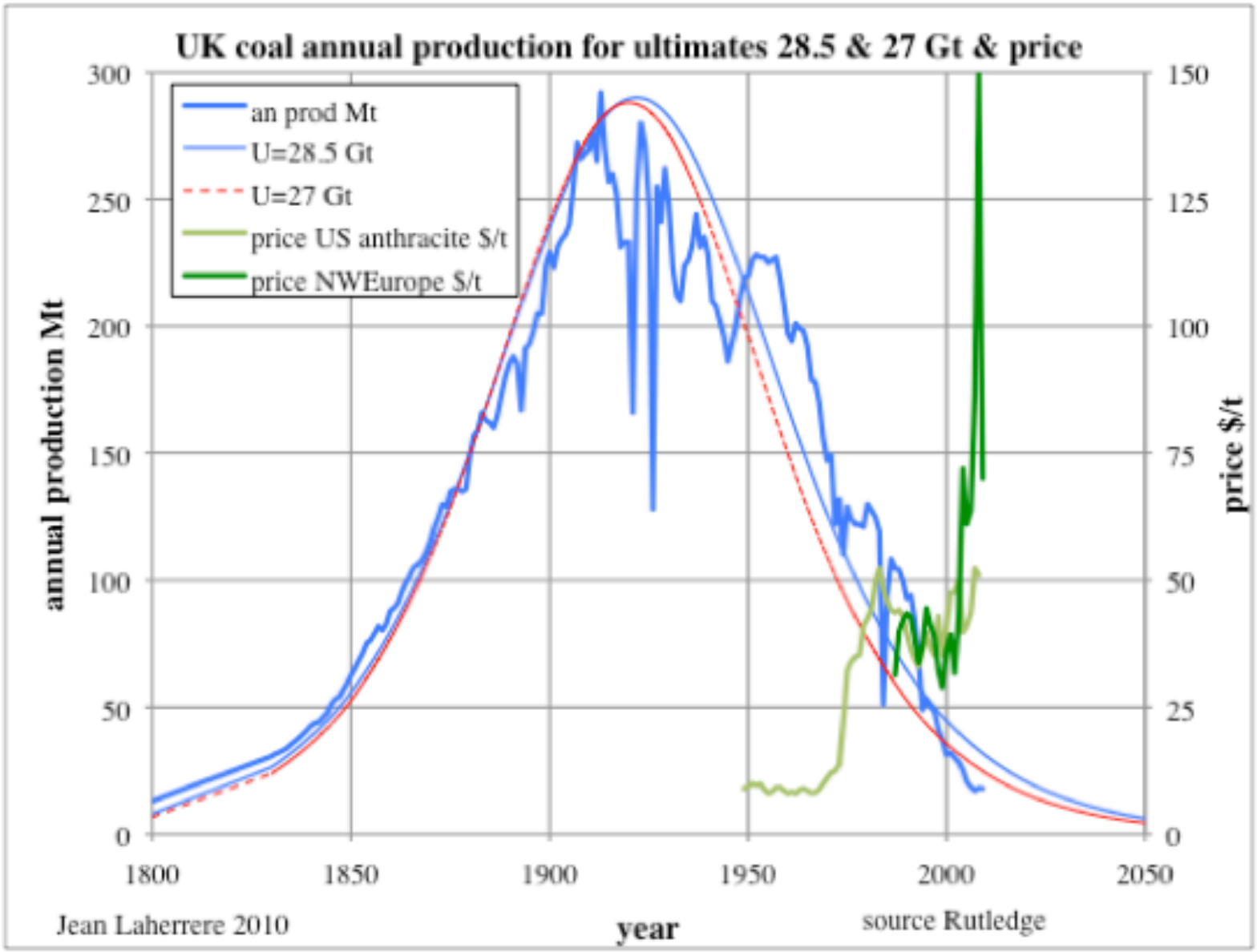


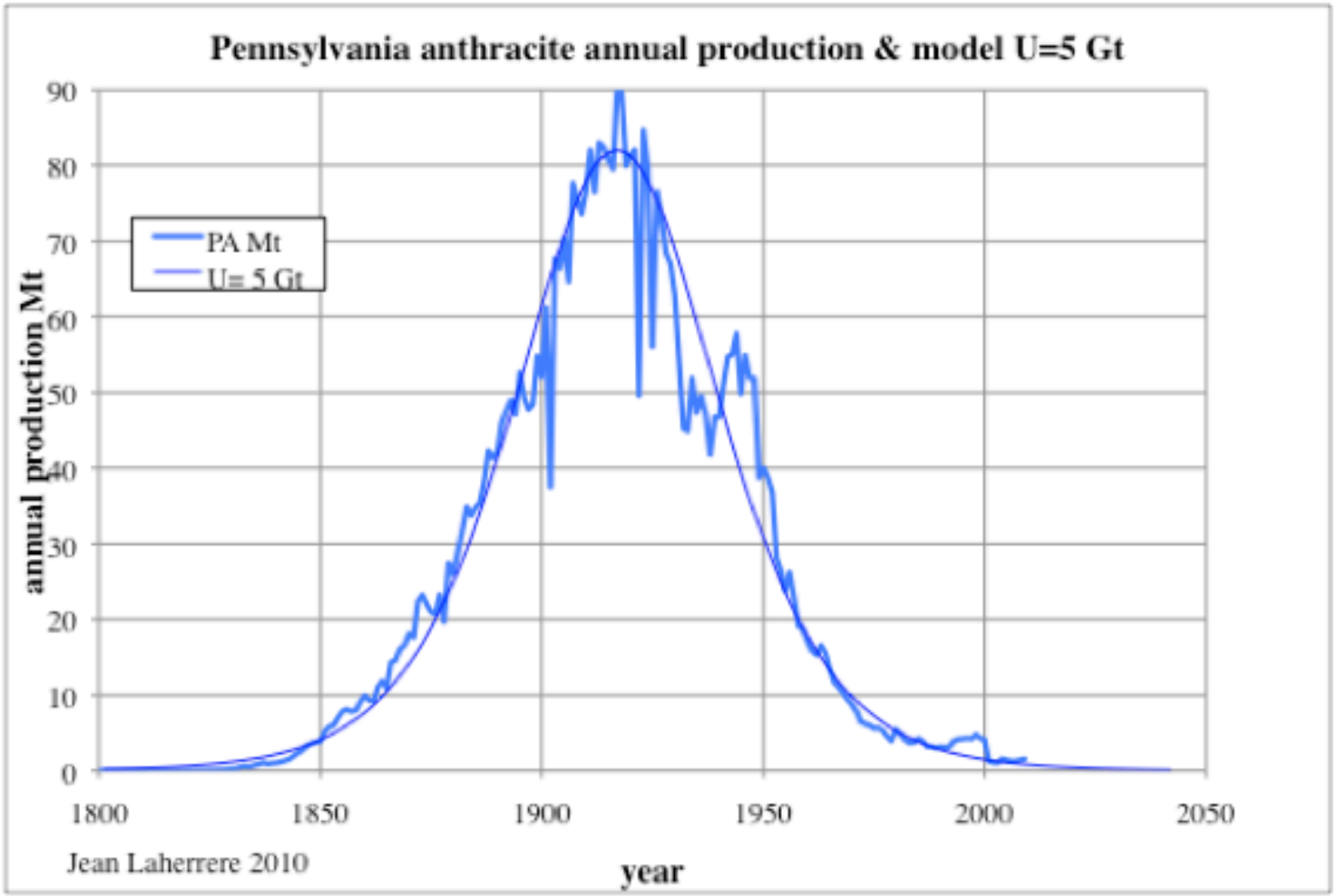
Figure 27: UK coal annual production for ultimates 28.5 & 27 Gt and price



-**US Pennsylvania anthracite**

Pennsylvania anthracite production displays also a near perfect symmetrical pattern, when ignoring the second war. The production is close to exhaustion, confirming the reality of the ultimate.

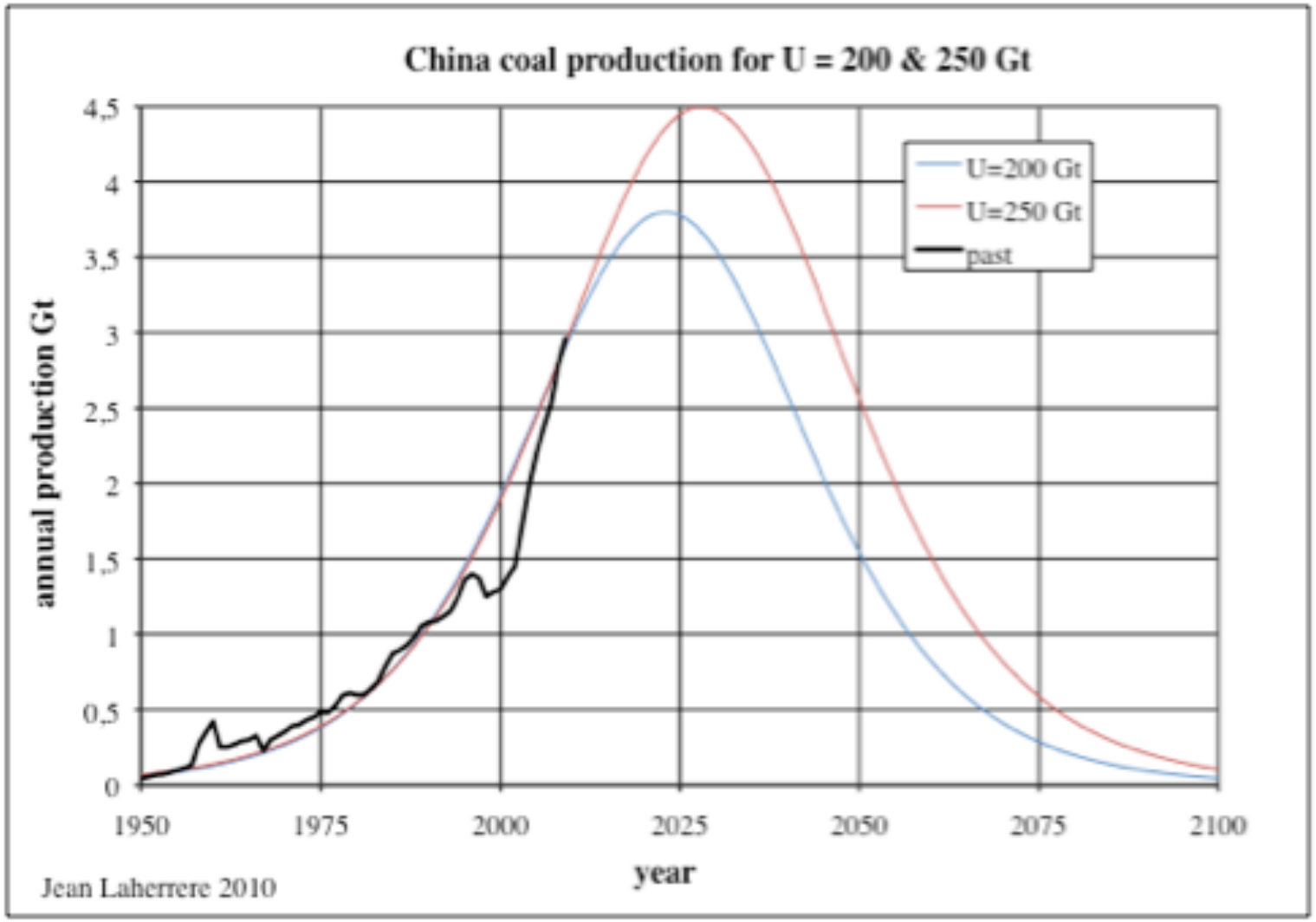
Figure 28: Pennsylvania anthracite production



-**China coal**

China coal annual production could peak around 2025 for an ultimate varying between 200 and 250 Gt, but this estimate is very unreliable!

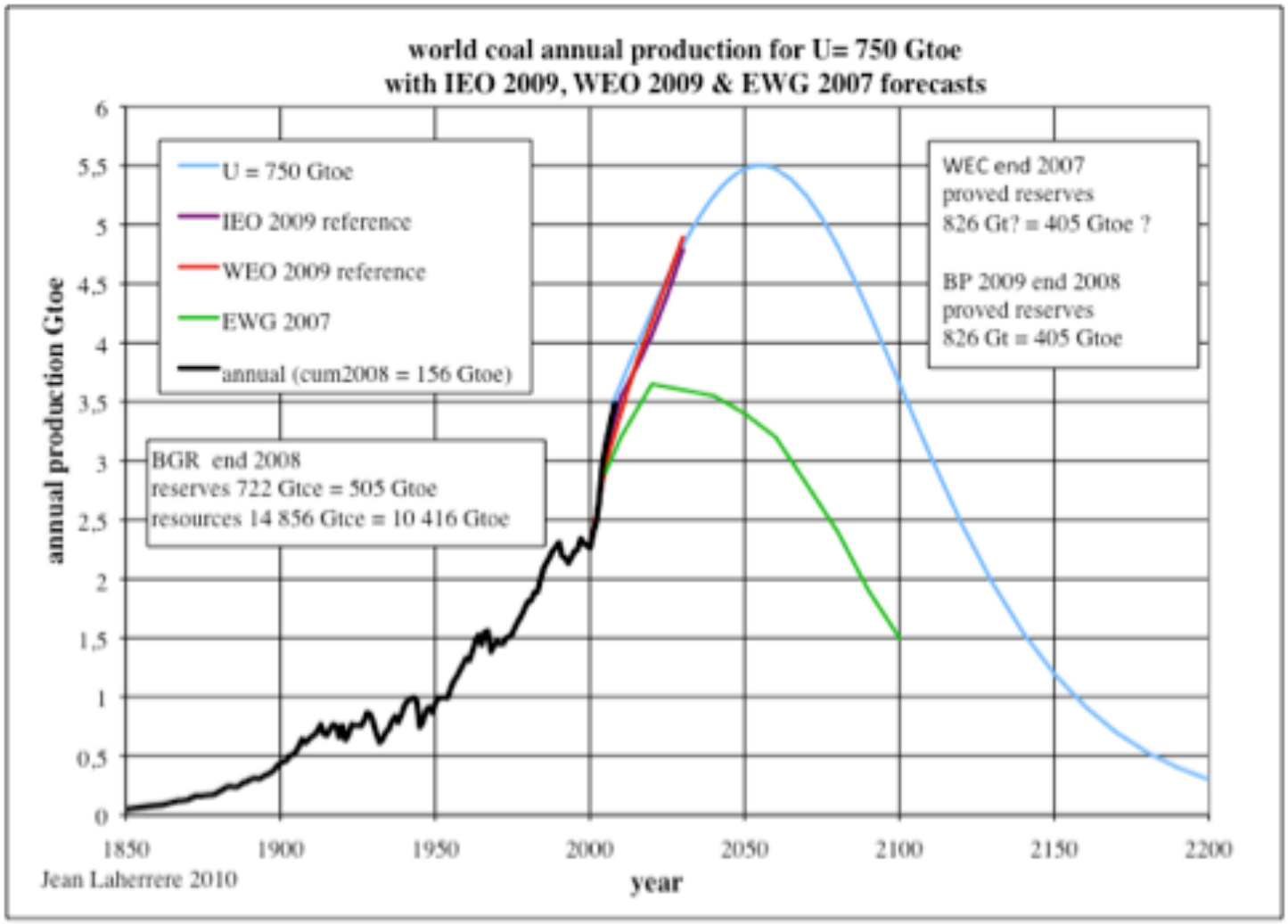
Figure 30: China coal annual production for U = 200 & 250 Gt



-**World coal**

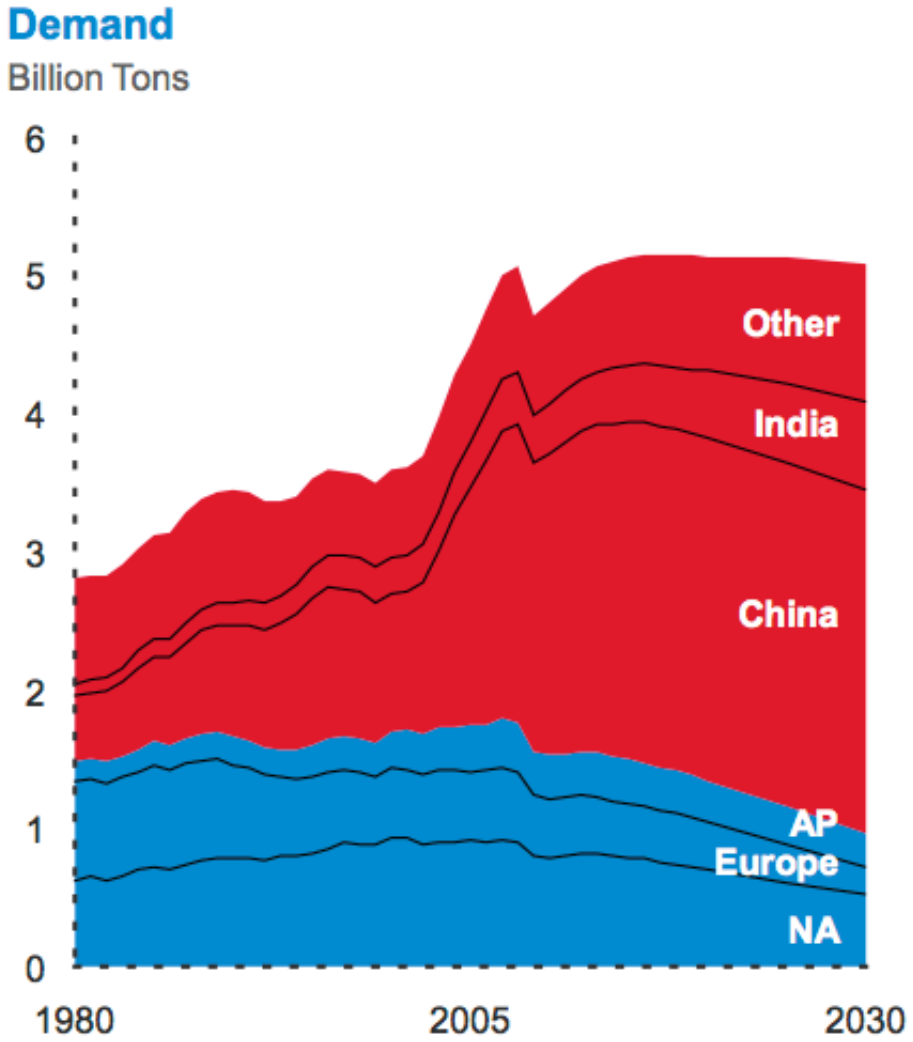
The uncertainty on the world coal ultimate in Gtoe is large, mainly because China. We assume that it could be 750 Gtoe (our last study was taking 600 Gtoe!)

Figure 31: world coal annual production for U = 750 Gtoe



The Energy Watch Group 2007 forecast was lower than EIA & IEA 2009 forecast, but Exxon-Mobil 2010 forecasts a flattening of coal demand from now on!

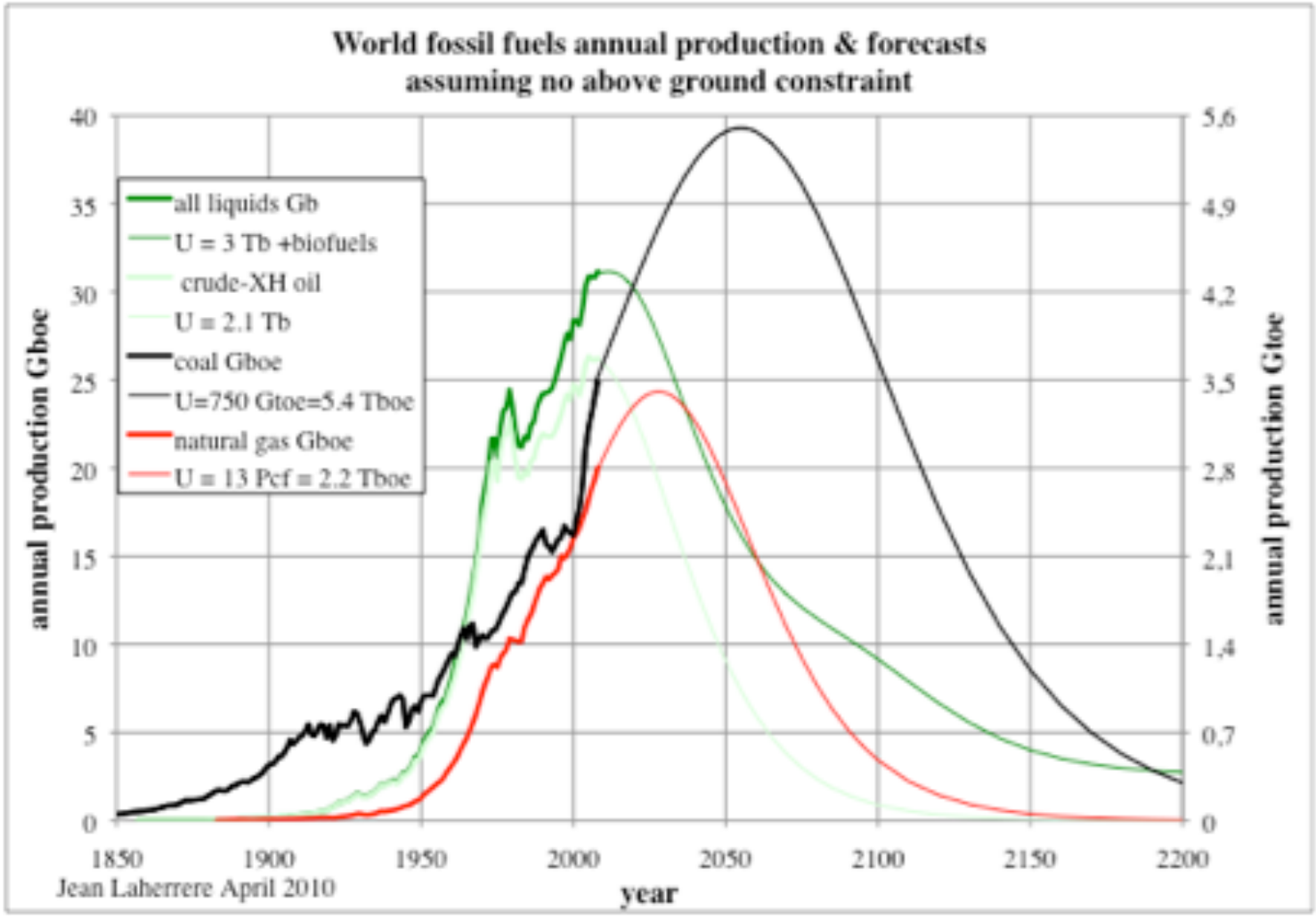
Figure 32: world coal annual demand by Exxon-Mobil (Eizember 2010)



-**Fossil fuels**

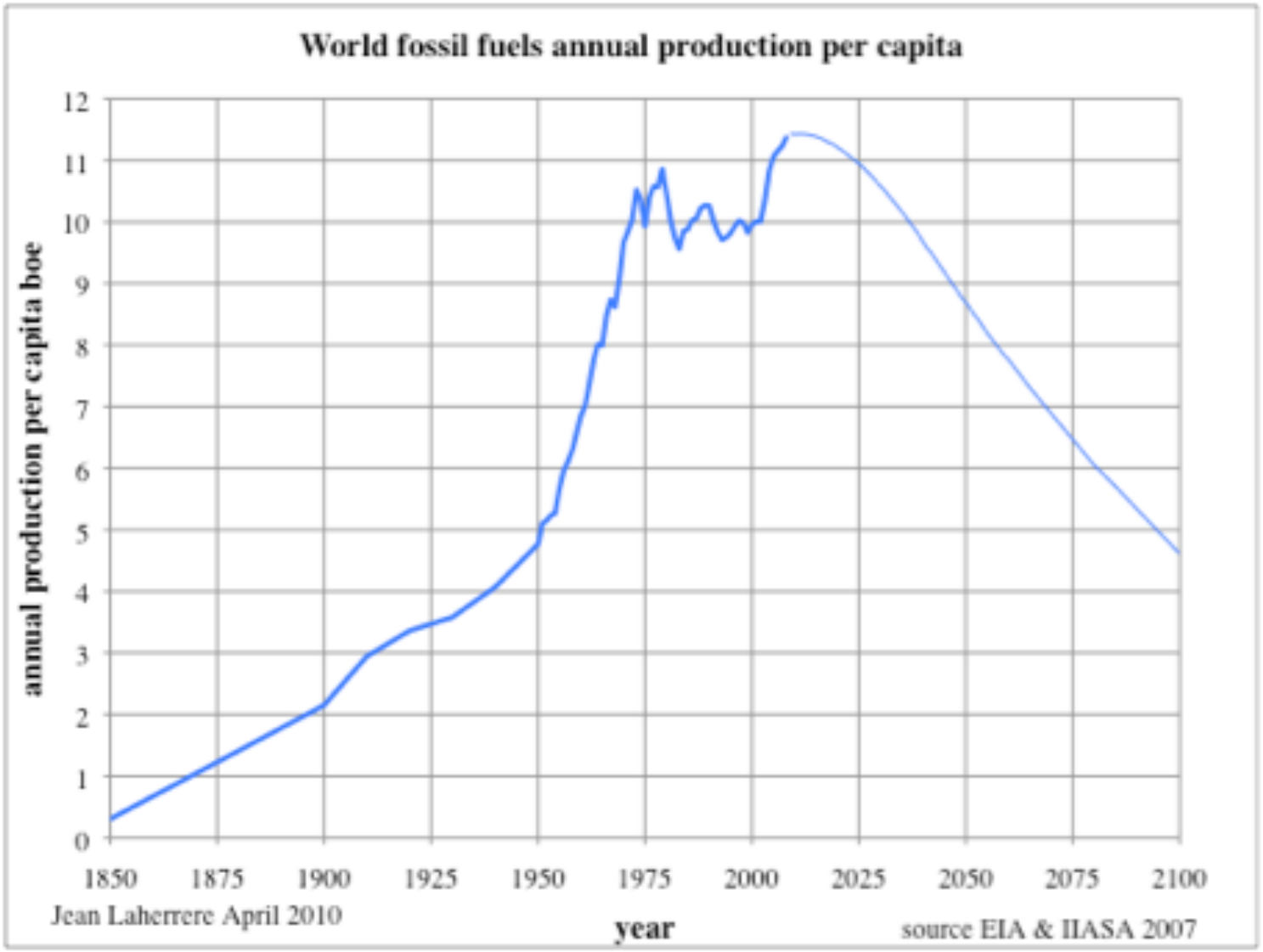
Fossil fuels (assuming ultimates of 750 Gtoe = 5.4 Tboe for coal; 3 Tb + biofuels for all liquids including biofuels; 2.2 Tboe for gas) are modelled assuming no above ground constraint.

Figure 33: world fossil fuels annual production & forecasts (assuming no above ground constraint)



The annual fossil fuels production by capita is displaying a bumpy plateau from 1973 to 2025

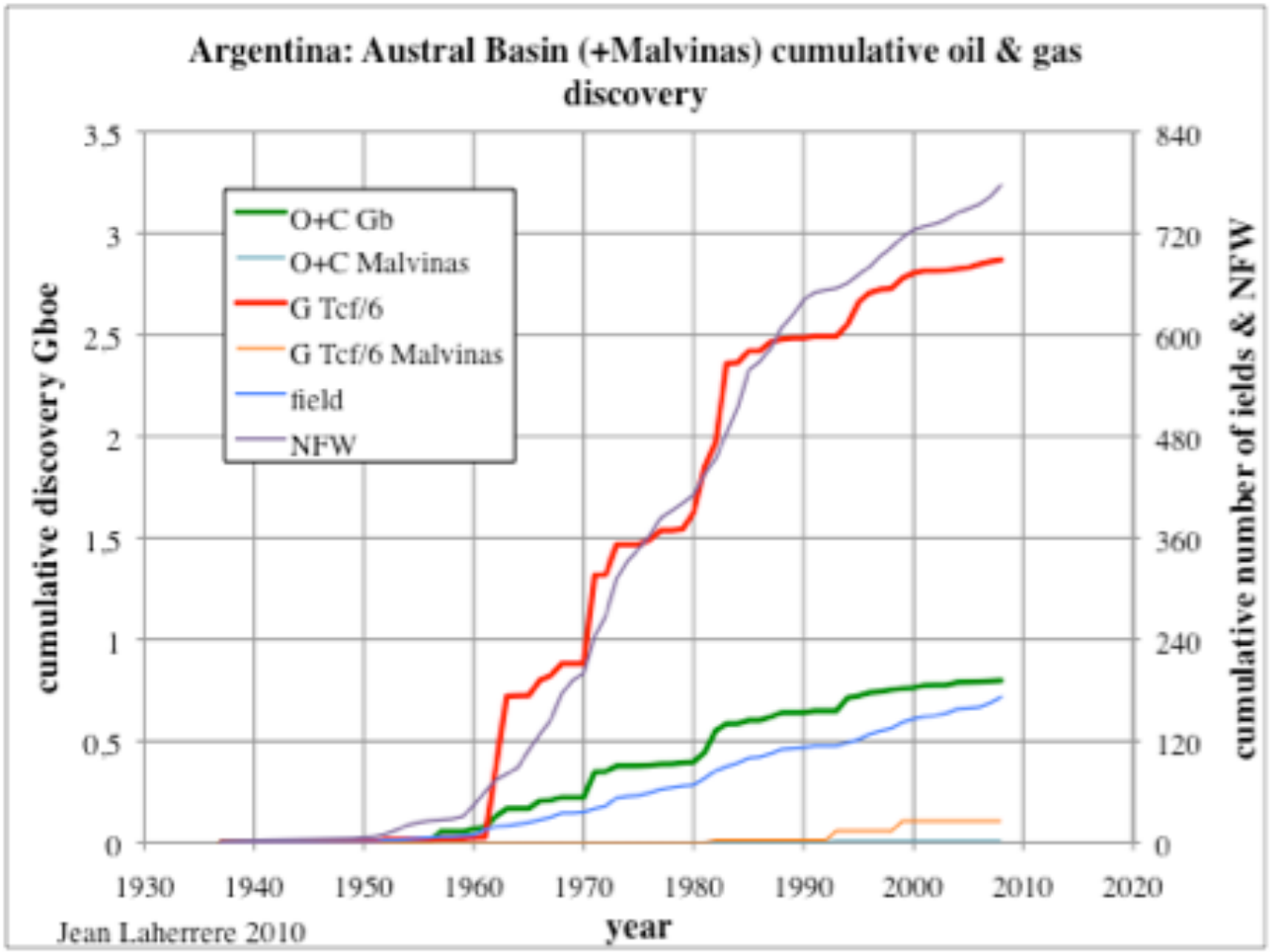
Figure 34: world fossil fuels annual production per capita & forecasts (assuming no above ground constraint)



-**Peaks in Argentina**

-**Oil & gas discovery in Austral Basin & Malvinas**

Figure 36: Austral Basin & Malvinas oil & gas cumulative discovery

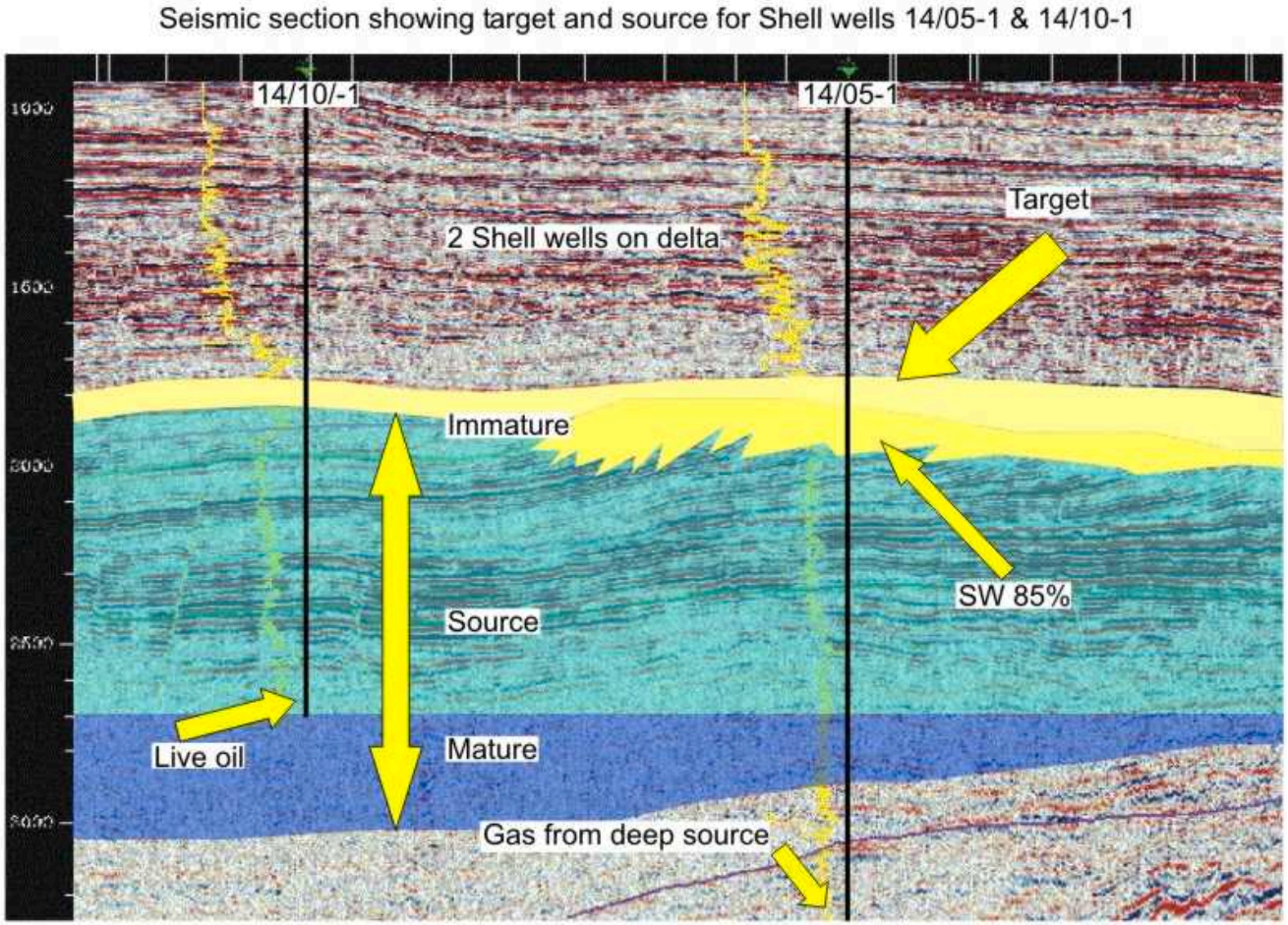


The discovery in the Malvinas (19 NFW) is almost zero for oil and very little for gas.

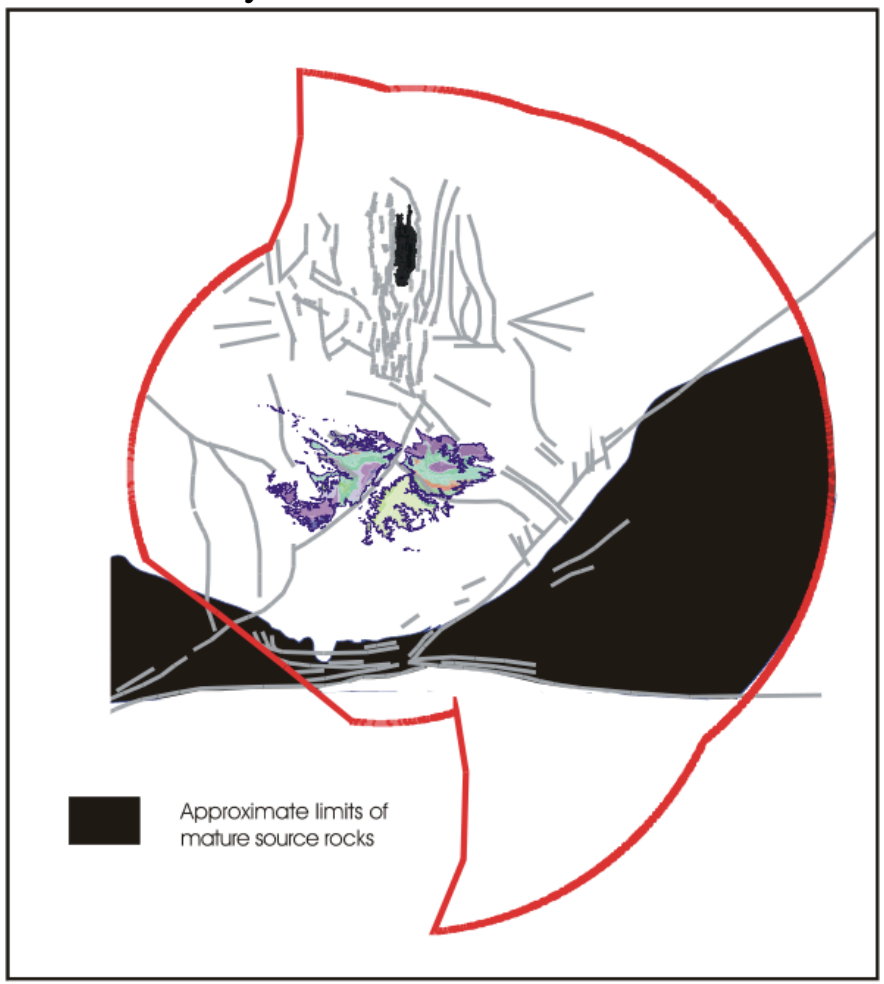
-**Oil & gas discovery in Falklands**

In 1998 six dry holes were drilled in the North Falkland. The dry hole Liz (expected mean reserves 358 Mb with high confidence from Rockhopper) drilled in 2010 was a stratigraphic prospect, showing the lack of good structural leads. The second well Sea Lion(expected mean reserves 170 Mb) is just reported an oil discovery, but located in close proximity to a 1998 Shell oil show well 14/10-1 (sticking to known oil to be sure).

Figure 37: Seismic profile on the two Shell wells drilled in 1998



British Geological Survey 2001 describes the North Falklands as the second richest source rock in the world (100 Gb) ?, but only a very small part of the North Falkland source-rock is mature (deeper than 3000 m).
Figure 38: Falkland: Source-rock maturity from BGS =

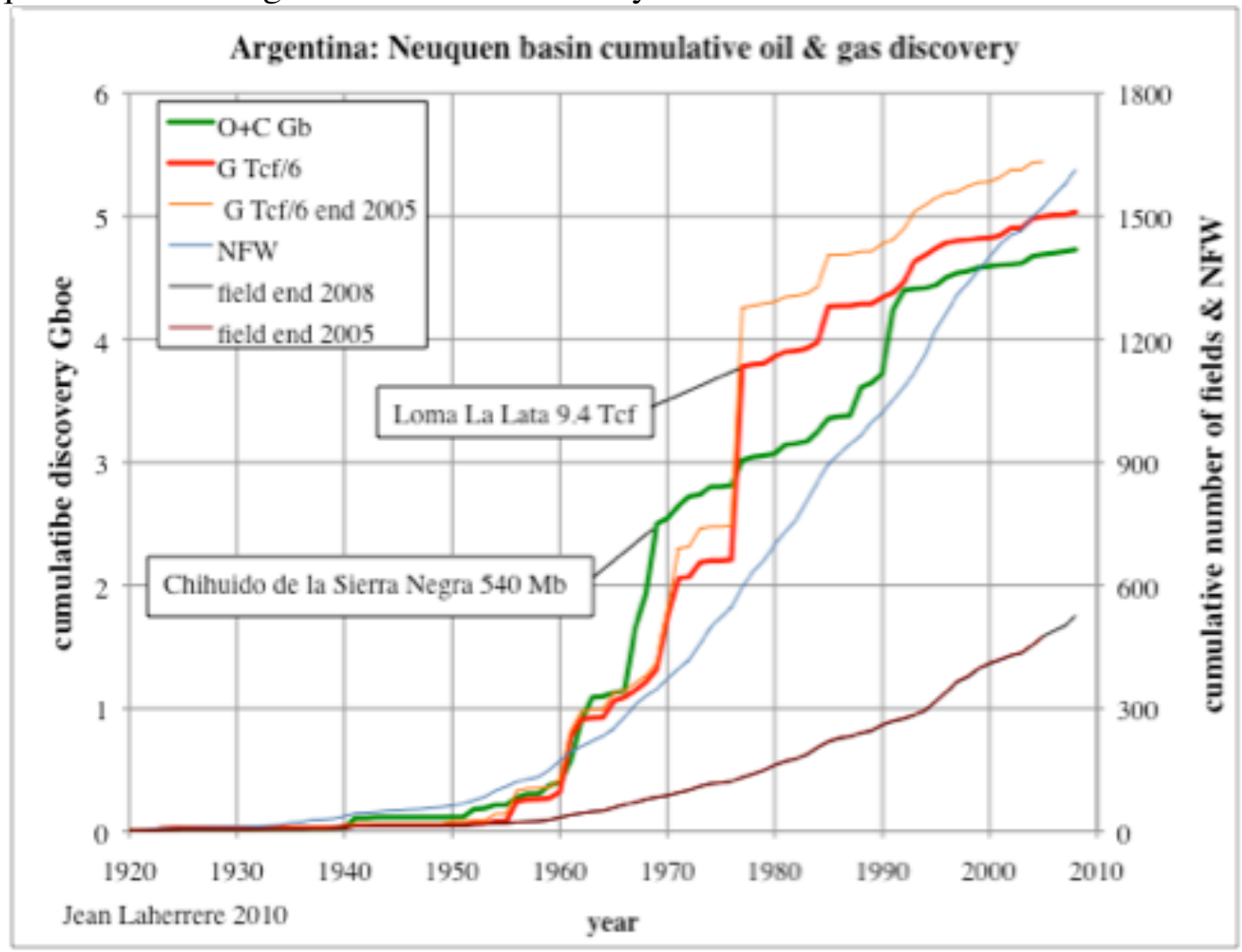


FOGL prospects: Toroa 1.7 Gb & Loligo 3 Gb much too high compared to Austral Basin largest field 112 Mb! It is not the North Sea!

-**Oil & gas discovery in Neuquen**

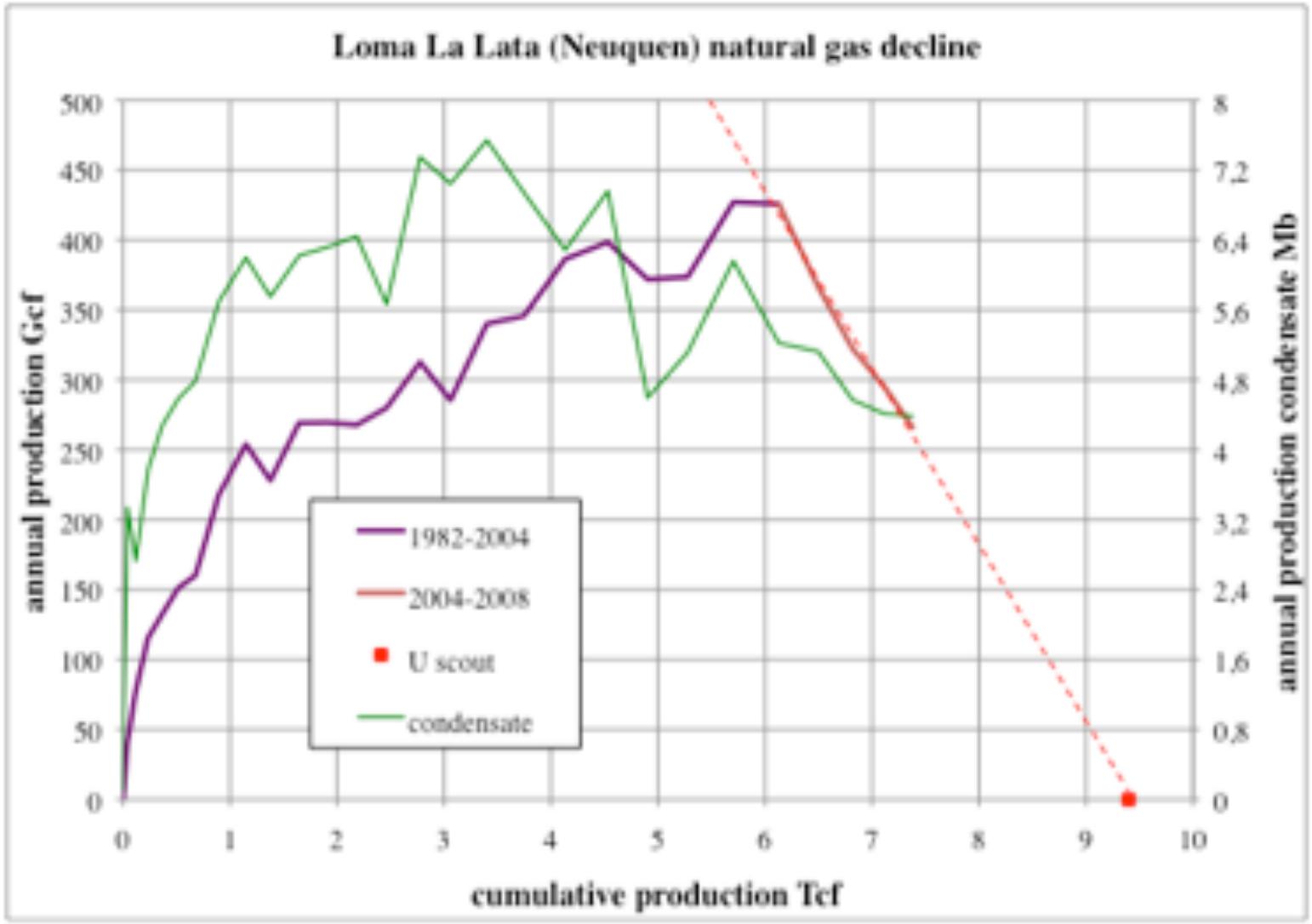
The creaming curve has steps with the discovery of the two large fields: Loma de la Lata gasfield and Chihuido de la Sierra Negra oilfield

Figure 41: Neuquen Basin oil & gas cumulative discovery



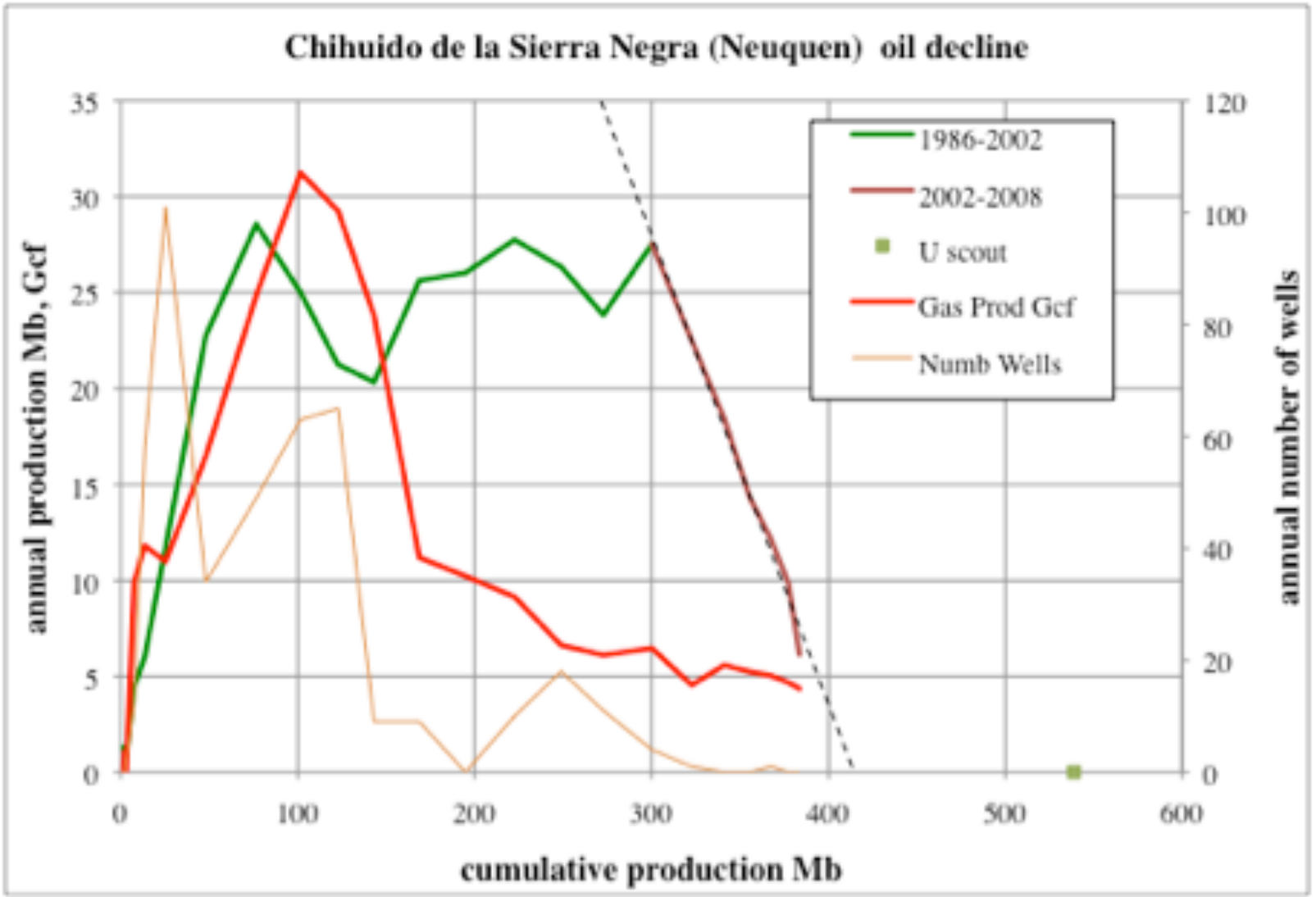
The largest Argentina gasfield Loma de la Lata is declining since 2004 and the ultimate seems to be 9,4 Tcf, as reported by the scout database

Figure 42: Loma de la Lata gas decline



The largest Argentina oilfield Chihuido de la Sierra Negra production declines since 2002 towards an ultimate of 420 Mb much less than the 540 Mb reported by the scout database

Figure 43: Chihuido de la Sierra Negra oil decline



-**Argentina oil & gas discovery and production**

The Argentina creaming curve for oil displays three cycles trending towards an ultimate of 15 Gb, assuming no new cycle (deepwater?). The gas creaming curve trends towards an ultimate of 75 Tcf?

Figure 44: Argentina oil & gas creaming curve and model for ultimates of 15 Gb & 75 Tcf

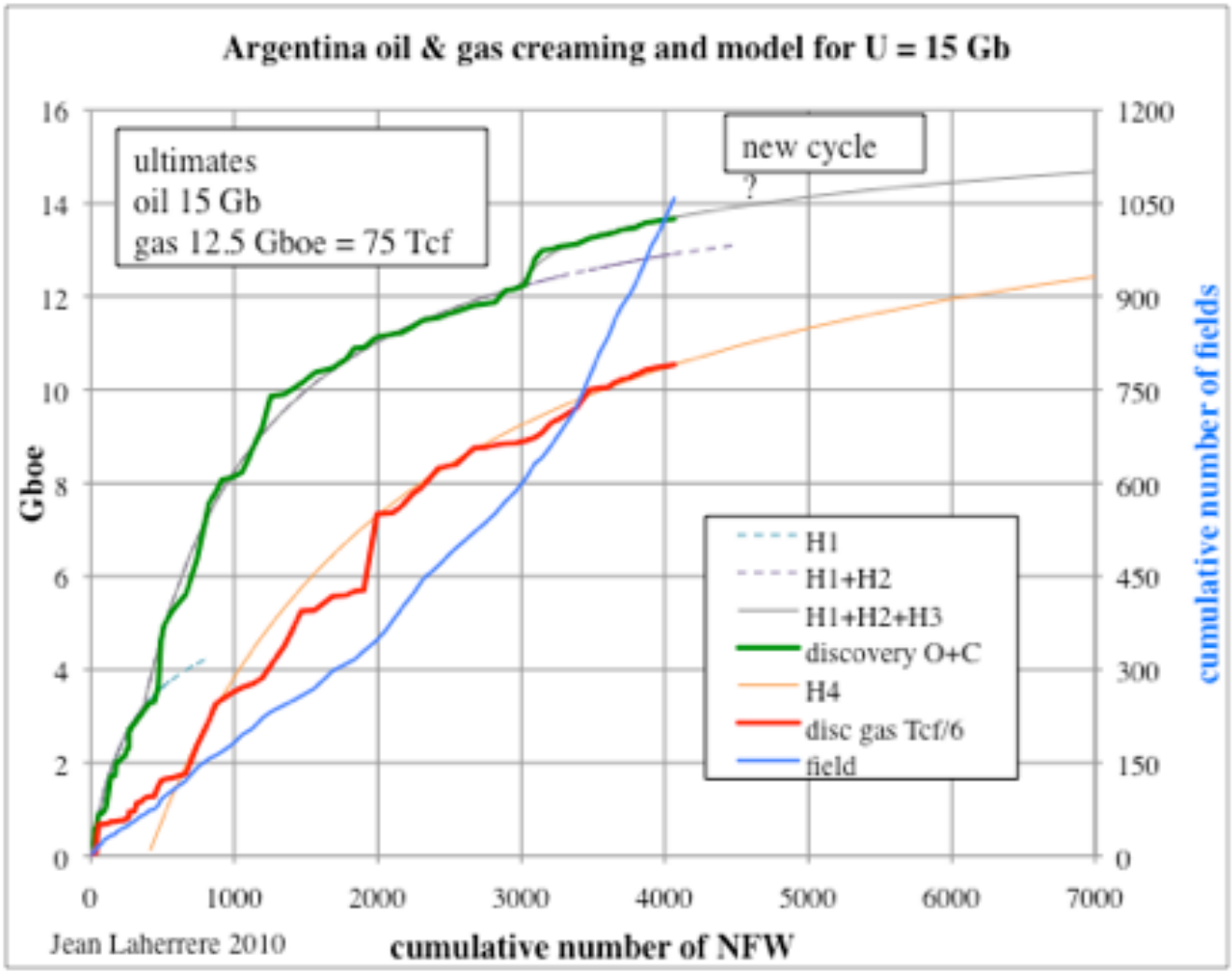


Figure 45: Argentina oil & gas cumulative discovery and production

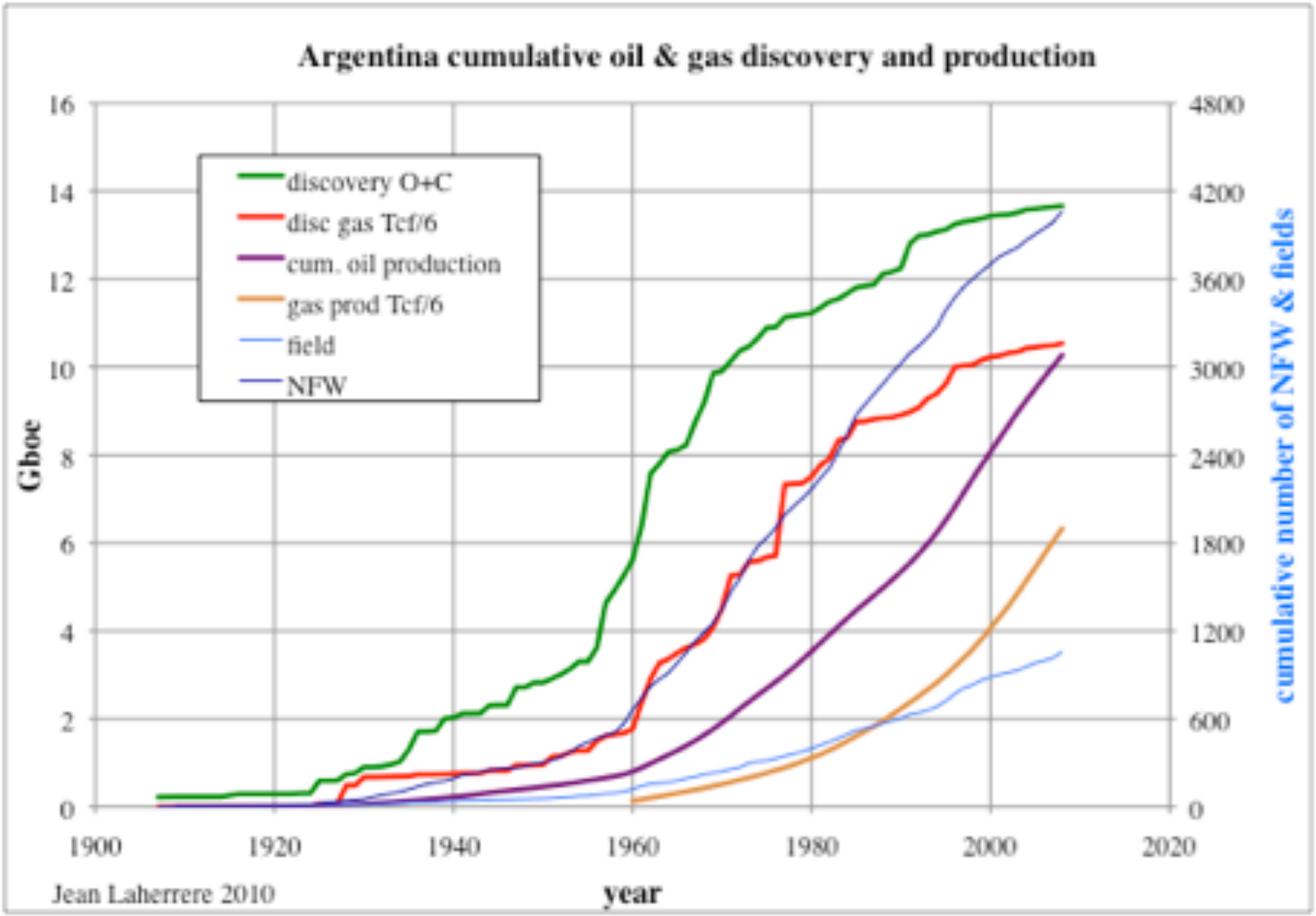


Figure 47: Argentina oil annual production for an ultimate of 14 & 15 Gb

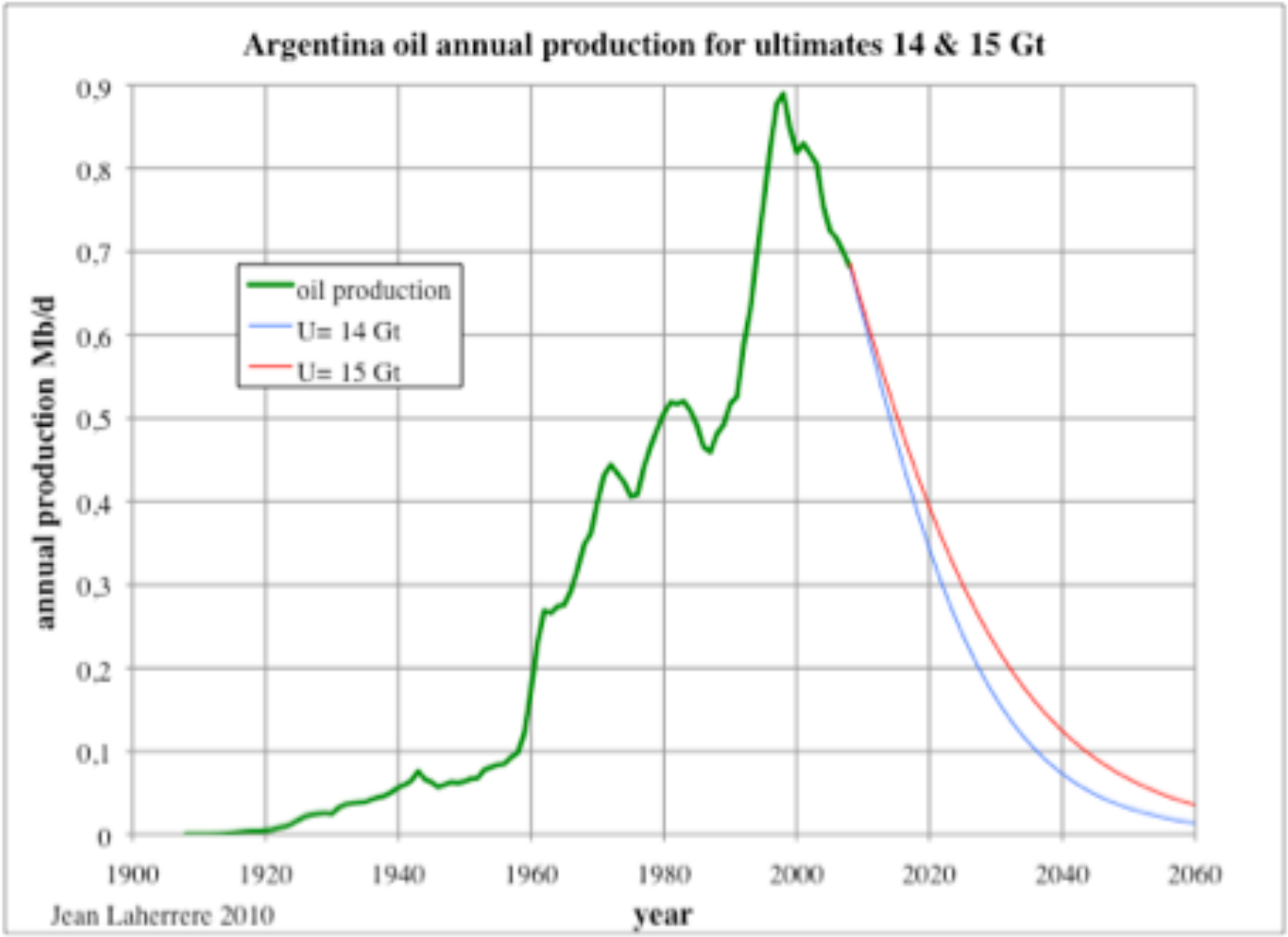


Figure 49: Argentina natural gas annual production for ultimate 75 Tcf

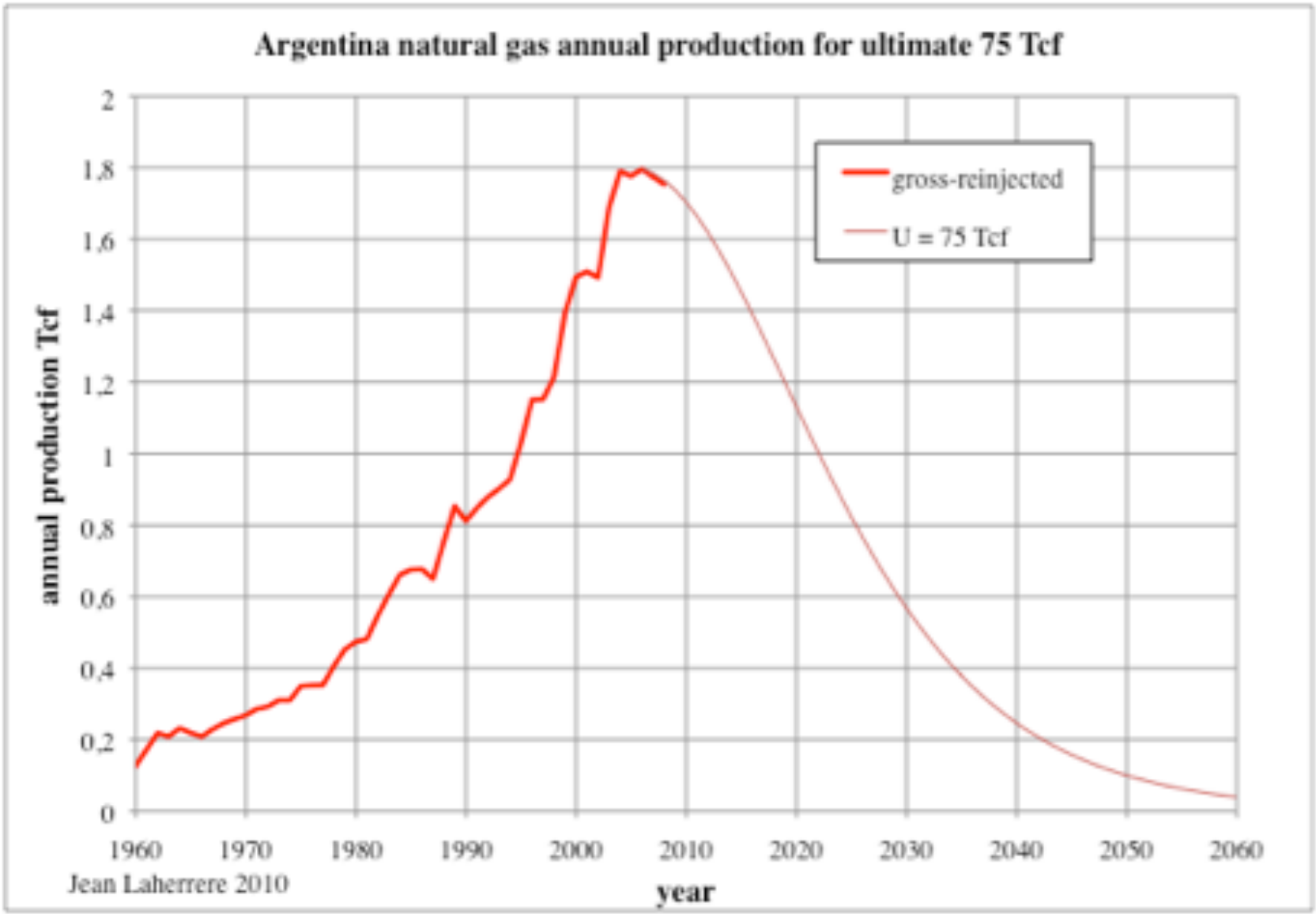
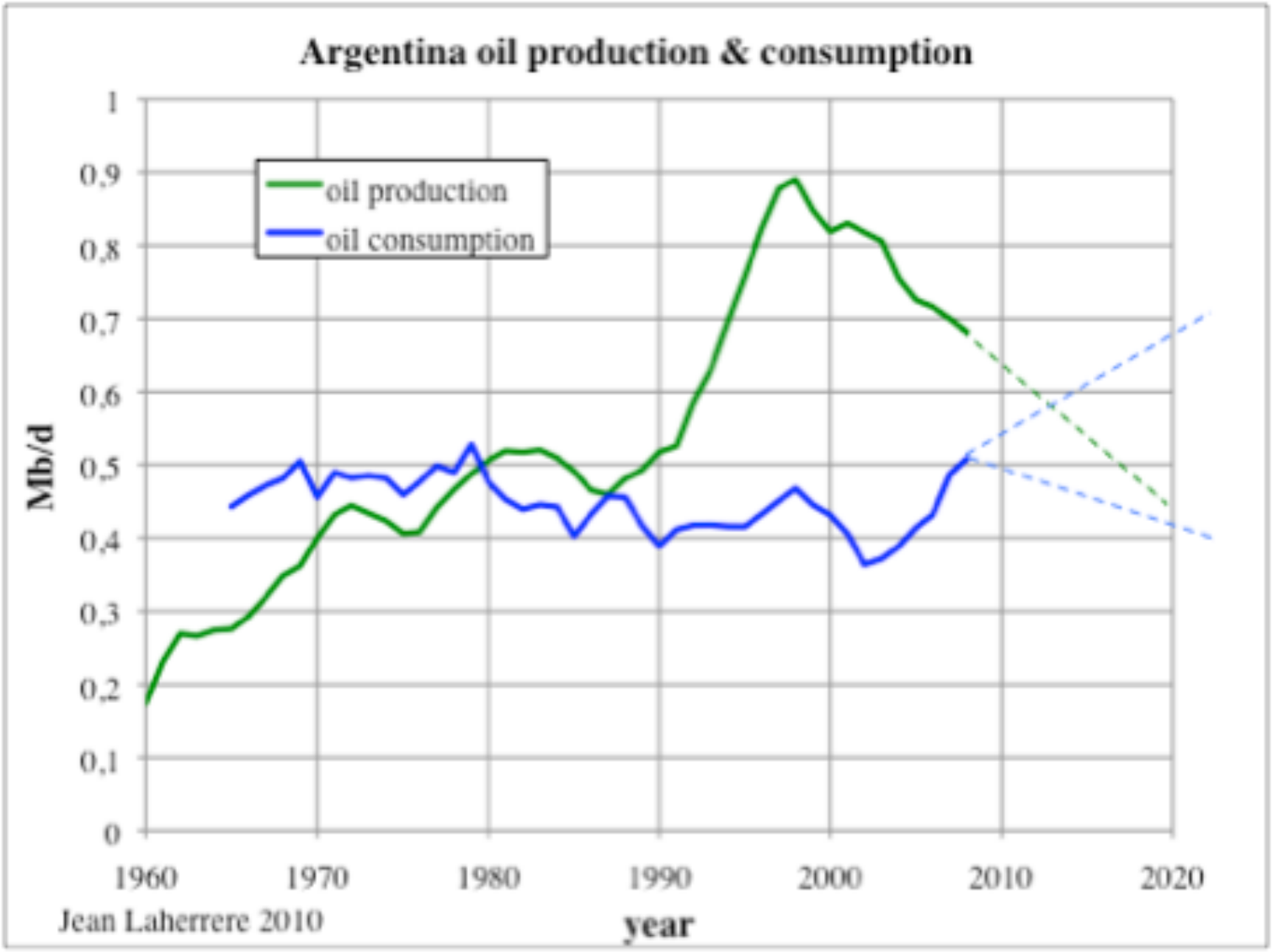


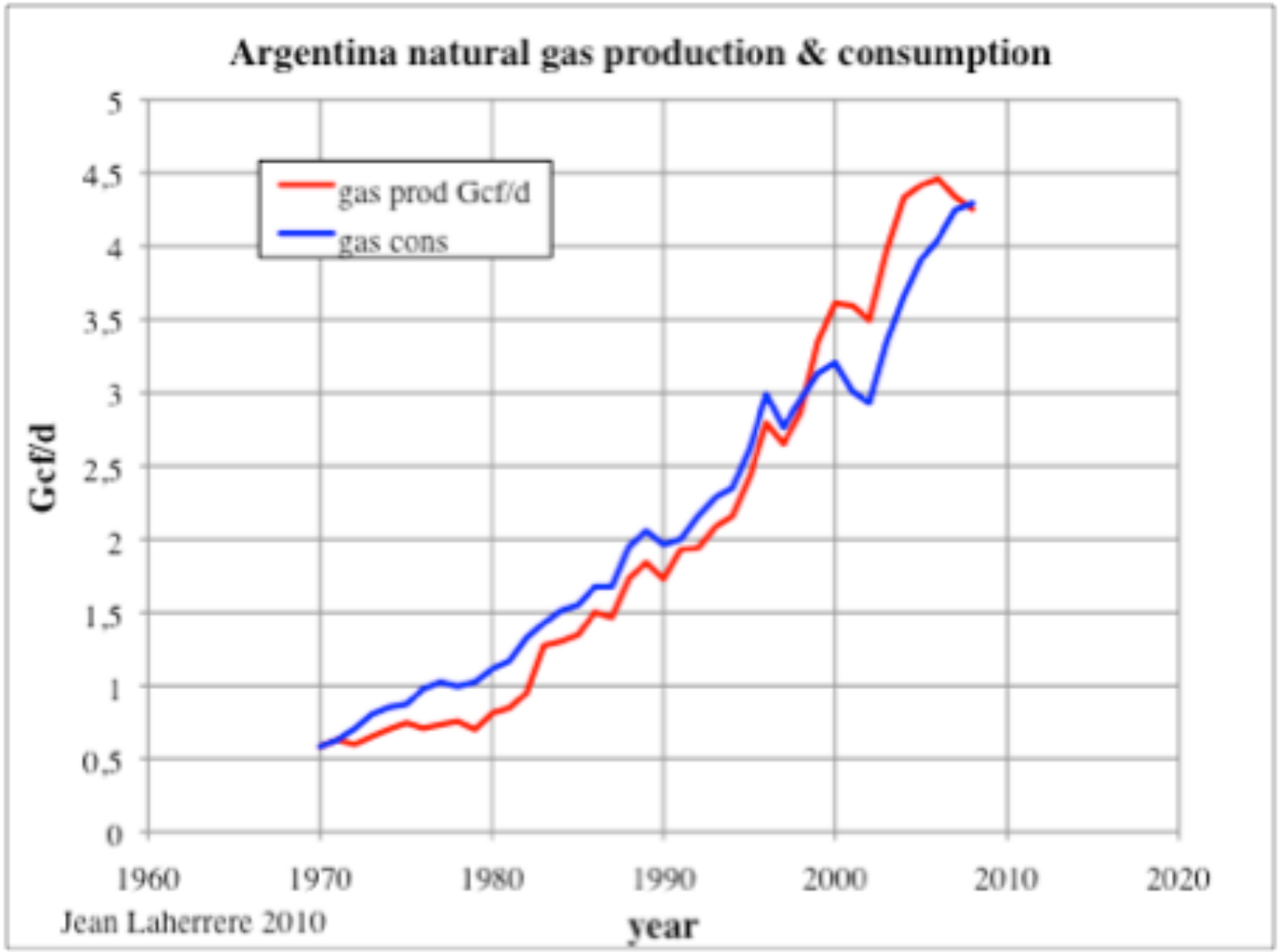
Figure 50: Argentina oil production and consumption



Argentina could be soon obliged to import oil!

Argentina gas consumption has increased with gas production, but since 2008 Argentina has had to import gas.

Figure 51: Argentina natural gas production and consumption



-**Oil peak in Latin America**

Latin America is the second largest crude less XH oil cumulative discovery after the Middle East,

Figure 52: cumulative crude less XH oil corrected discovery by continent

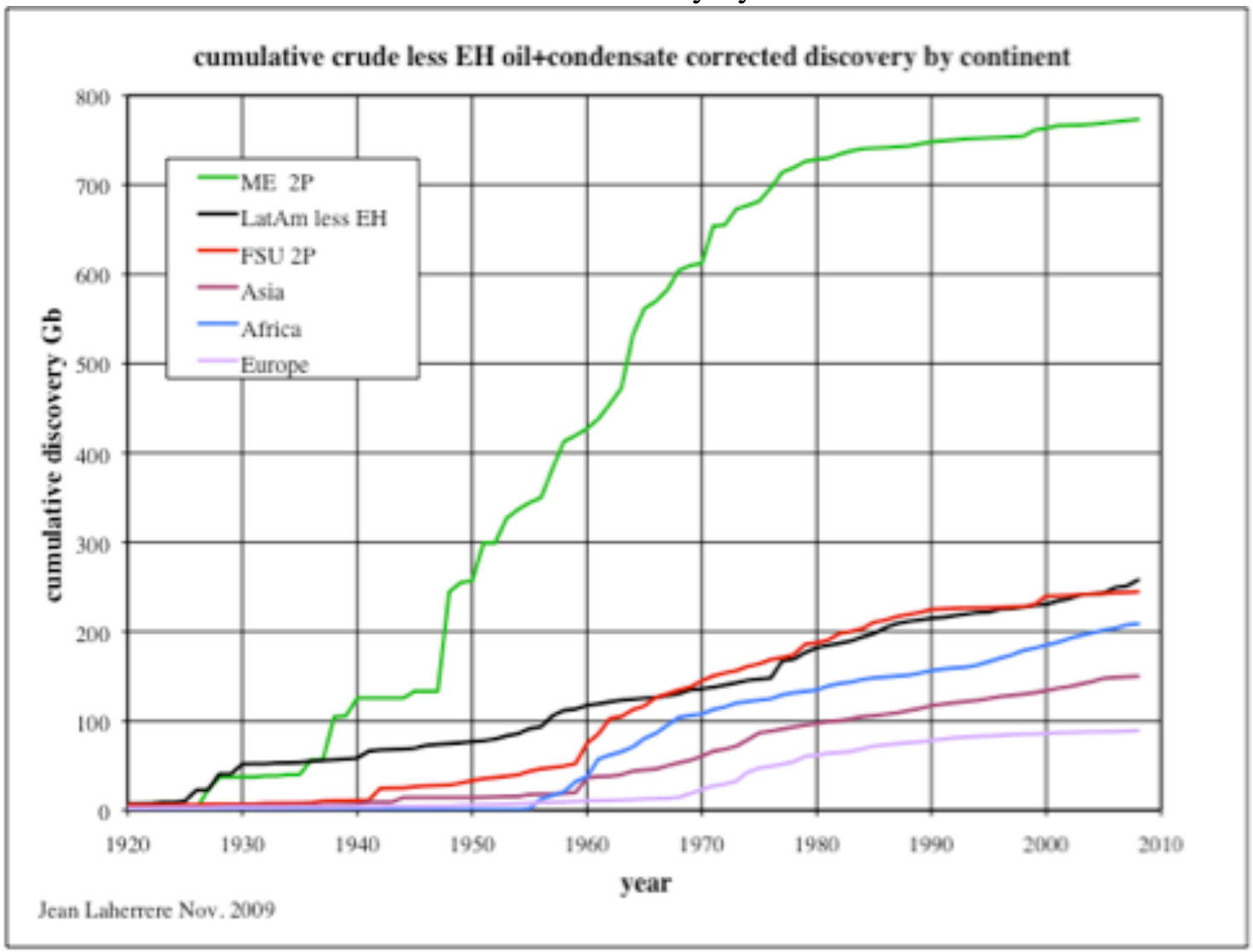
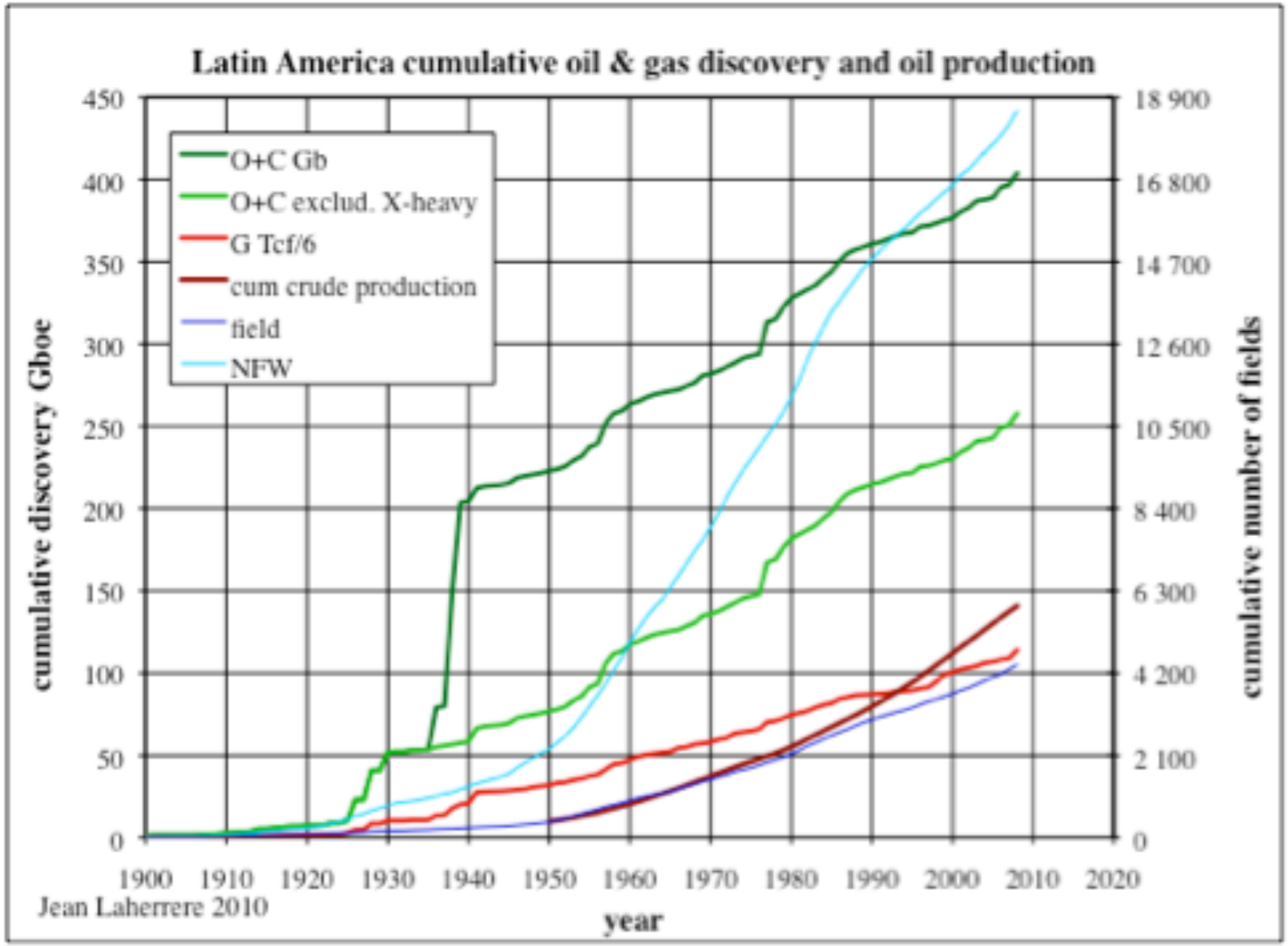
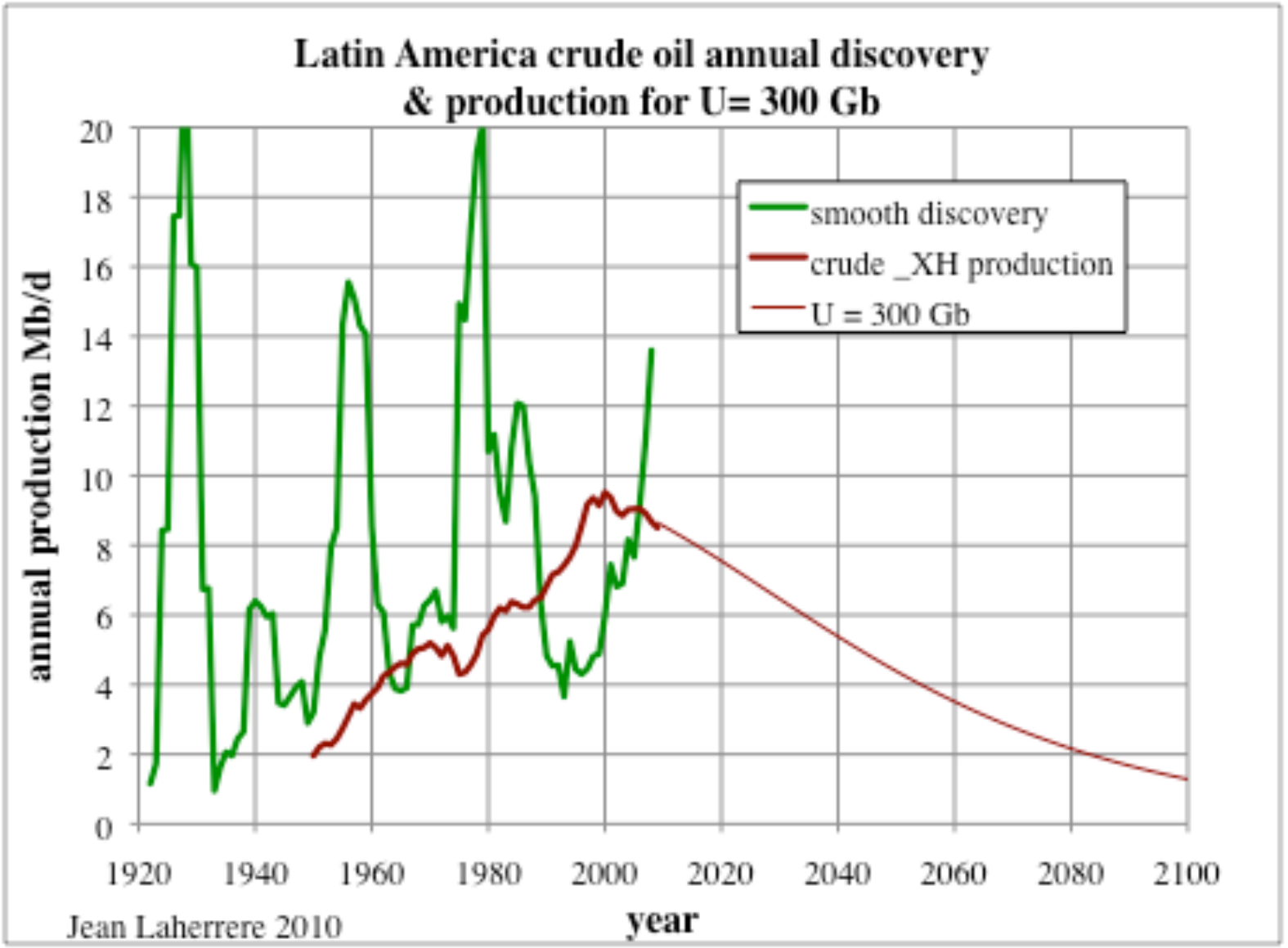


Figure 56: Latin America oil & gas cumulative discovery and oil production

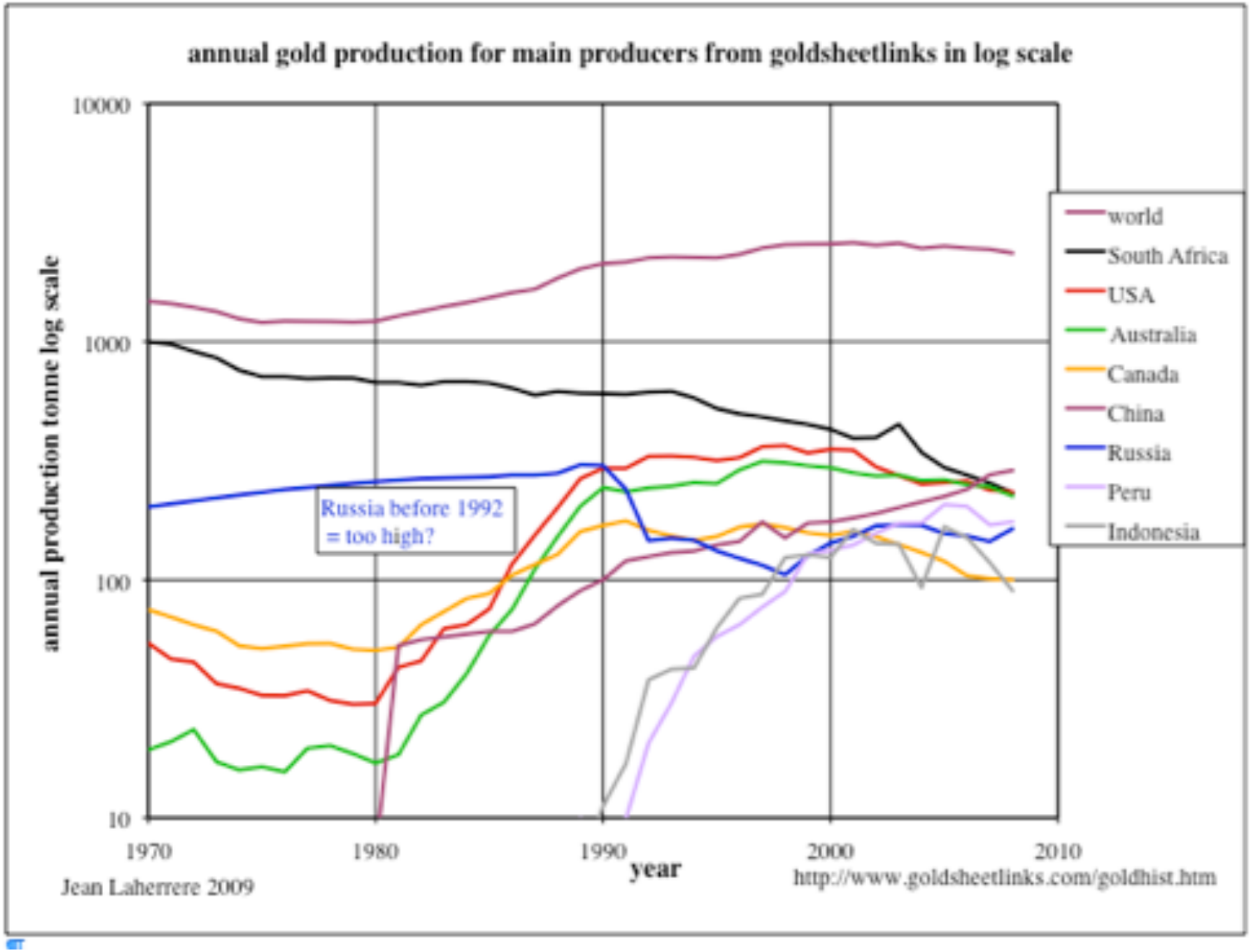


The annual crude –XH oil discovery & production is modelled for an ultimate of 300 Gb.
Figure 57: Latin America crude less XH oil annual discovery & production



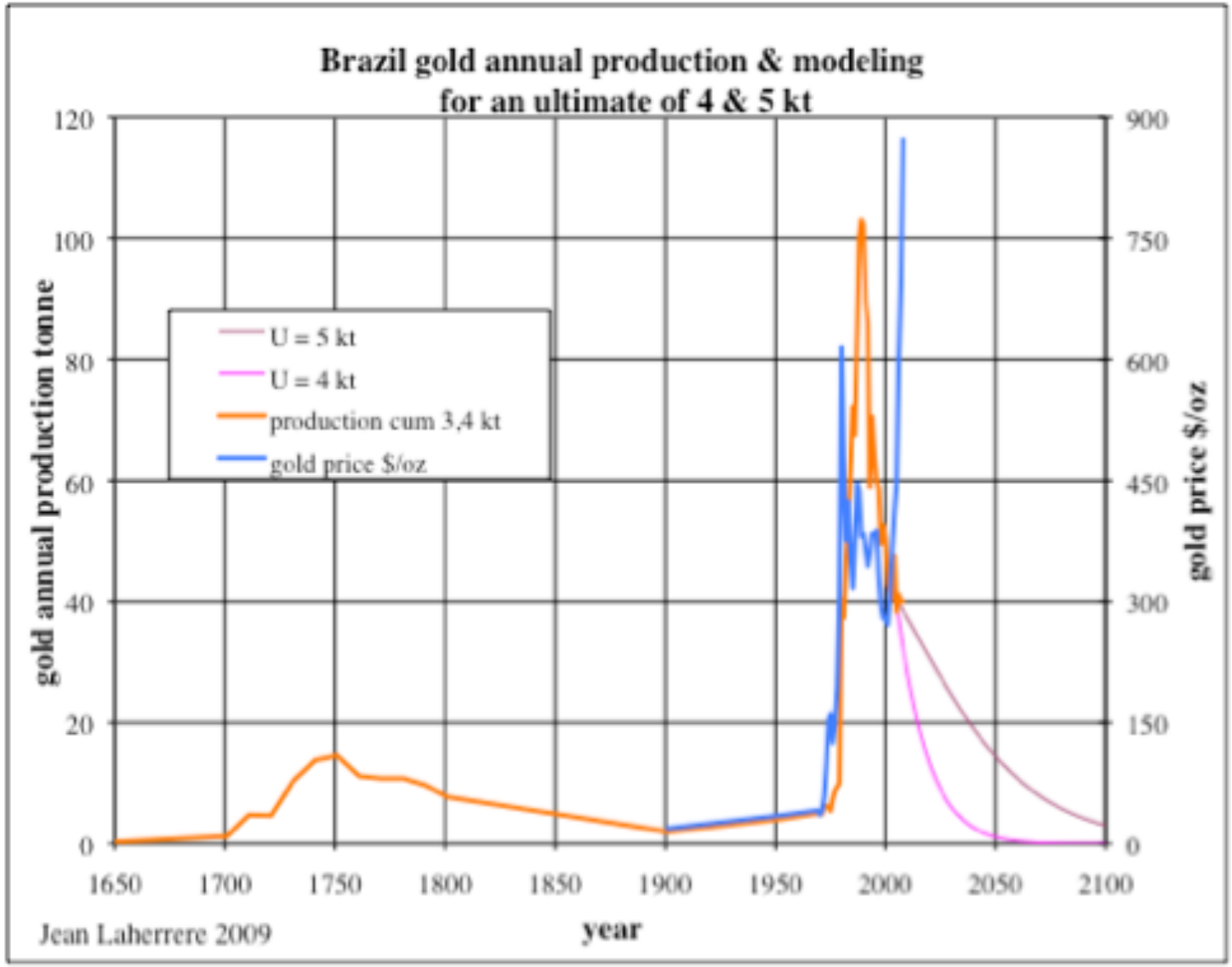
-**Minerals peak** **-Gold peak**

Figure 58: gold annual production for the world & main producers in log scale

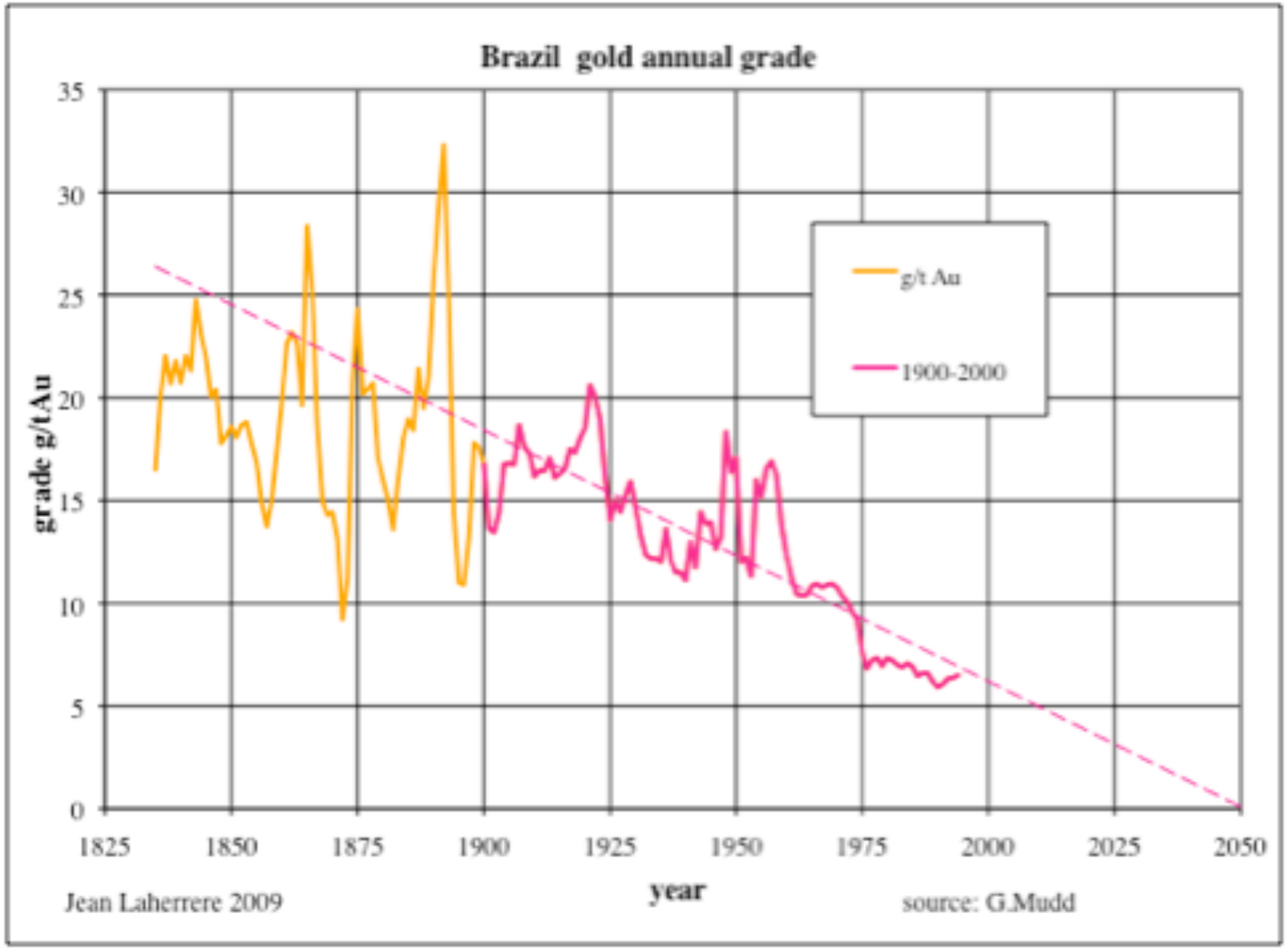


-**Brazil gold**

Figure 59: Brazil annual gold production and modelling for an ultimate of 4 kt & 5 kt



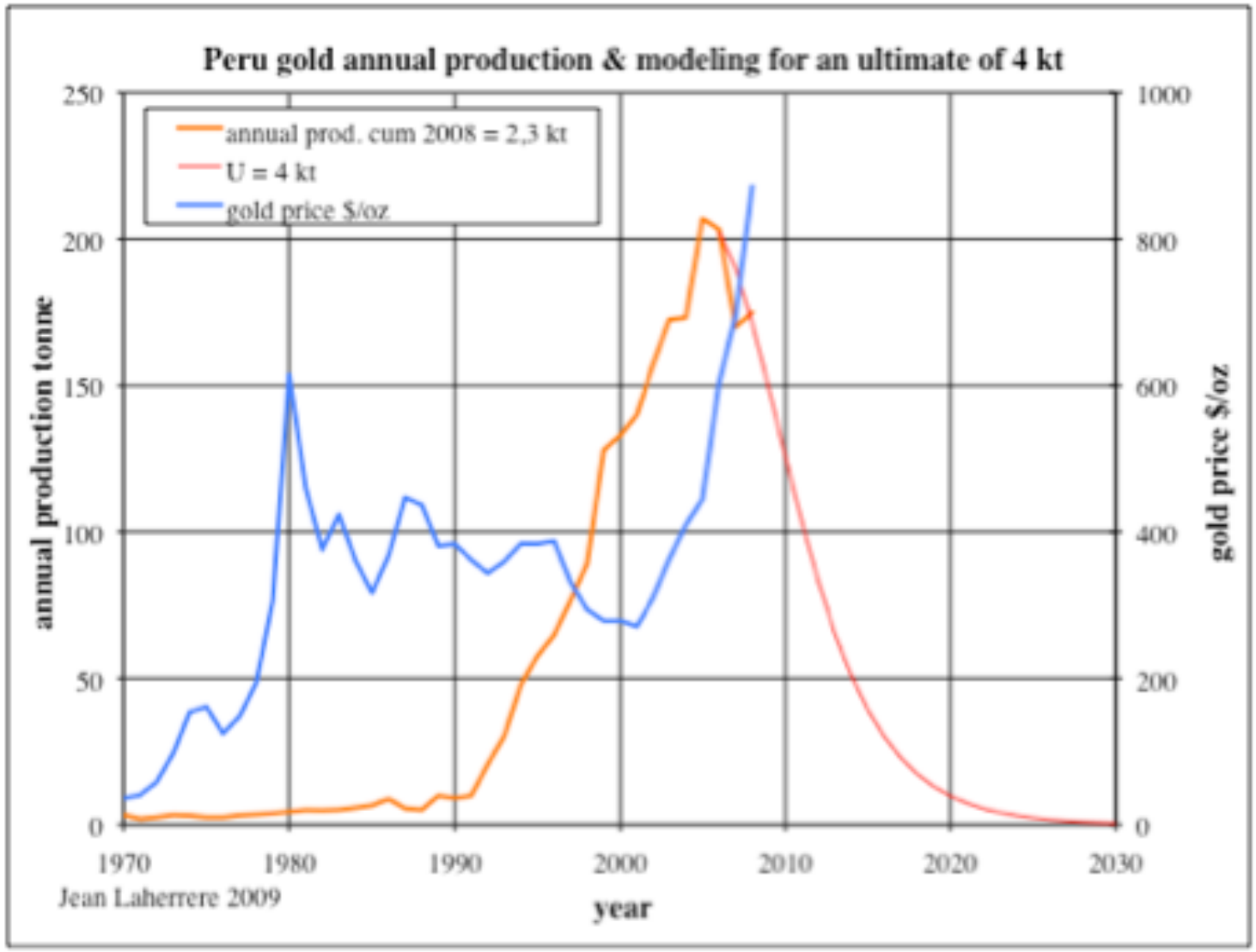
Brazil's gold grade has been declining since 1900 and can be extrapolated towards zero around 2050,
Figure 60: Brazil gold grade



-**Peru gold**

Peru's gold production has peaked in 2005 and will decline until exhaustion around 2025.

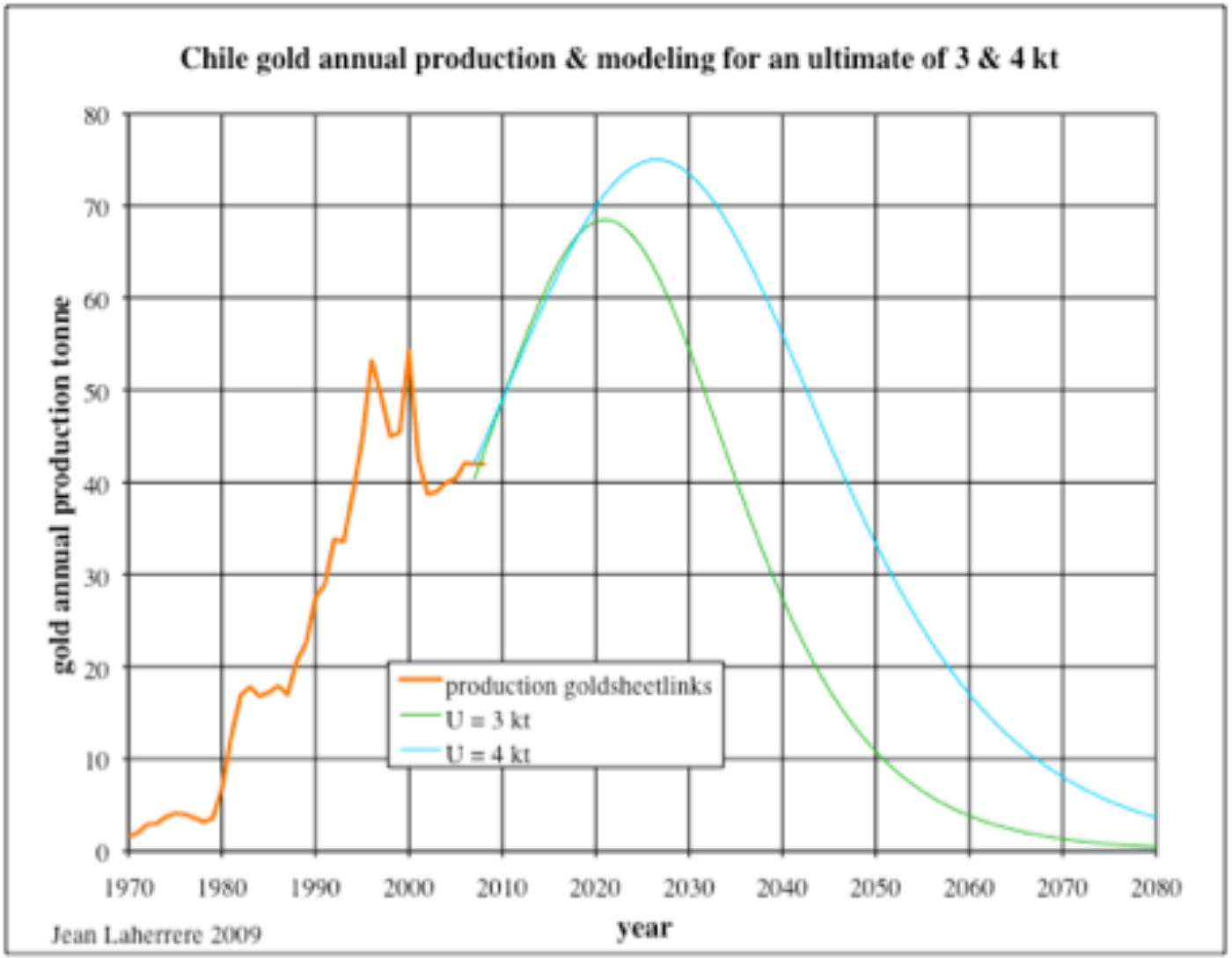
Figure 62: Peru annual gold production & modelling for an ultimate of 4 kt



-**Chile gold**

Chile gold production has peaked at the last of the 1990s, but it will peak again in the 2020s for a higher peak.

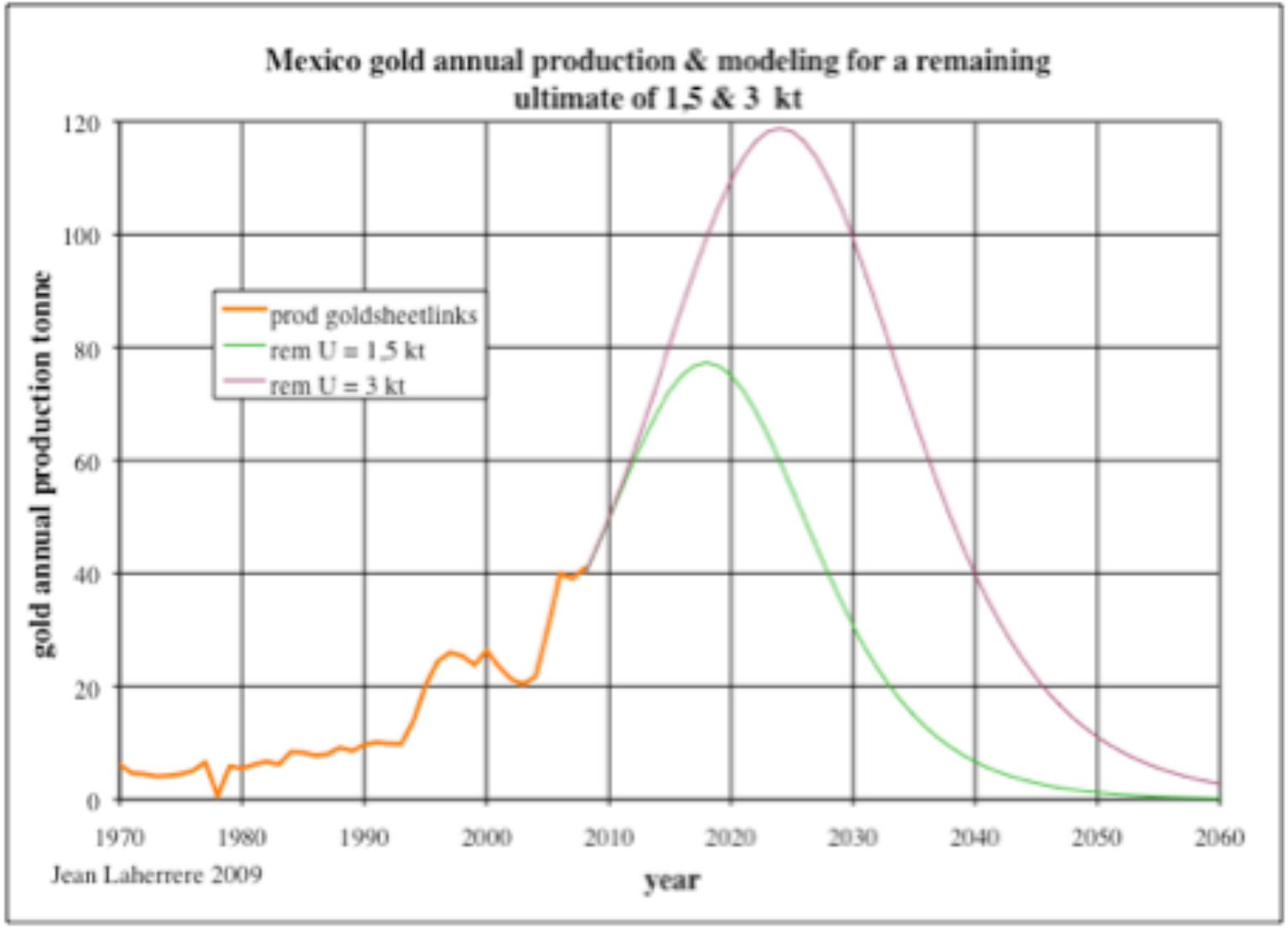
Figure 63: Chile annual gold production & modelling for an ultimate of 3 & 4 kt



-**Mexico gold**

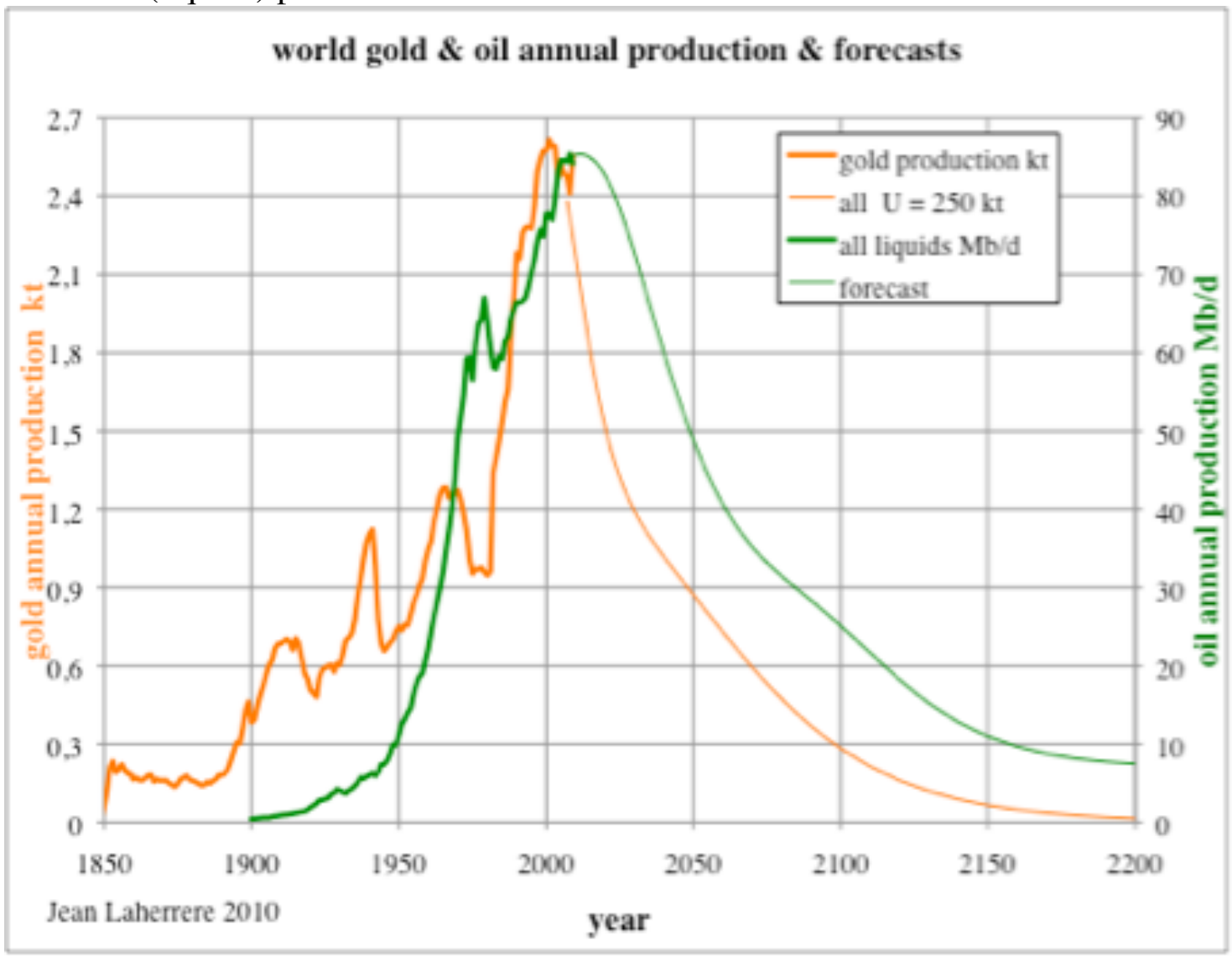
Mexico gold production will peak in the 2020s but the historical data and reserves seem unreliable

Figure 64: Mexico annual gold production & modelling for a remaining ultimate of 1.5 & 3 kt



-**World gold**

Figure 65: gold and oil (liquids) production & forecasts 1800-2200

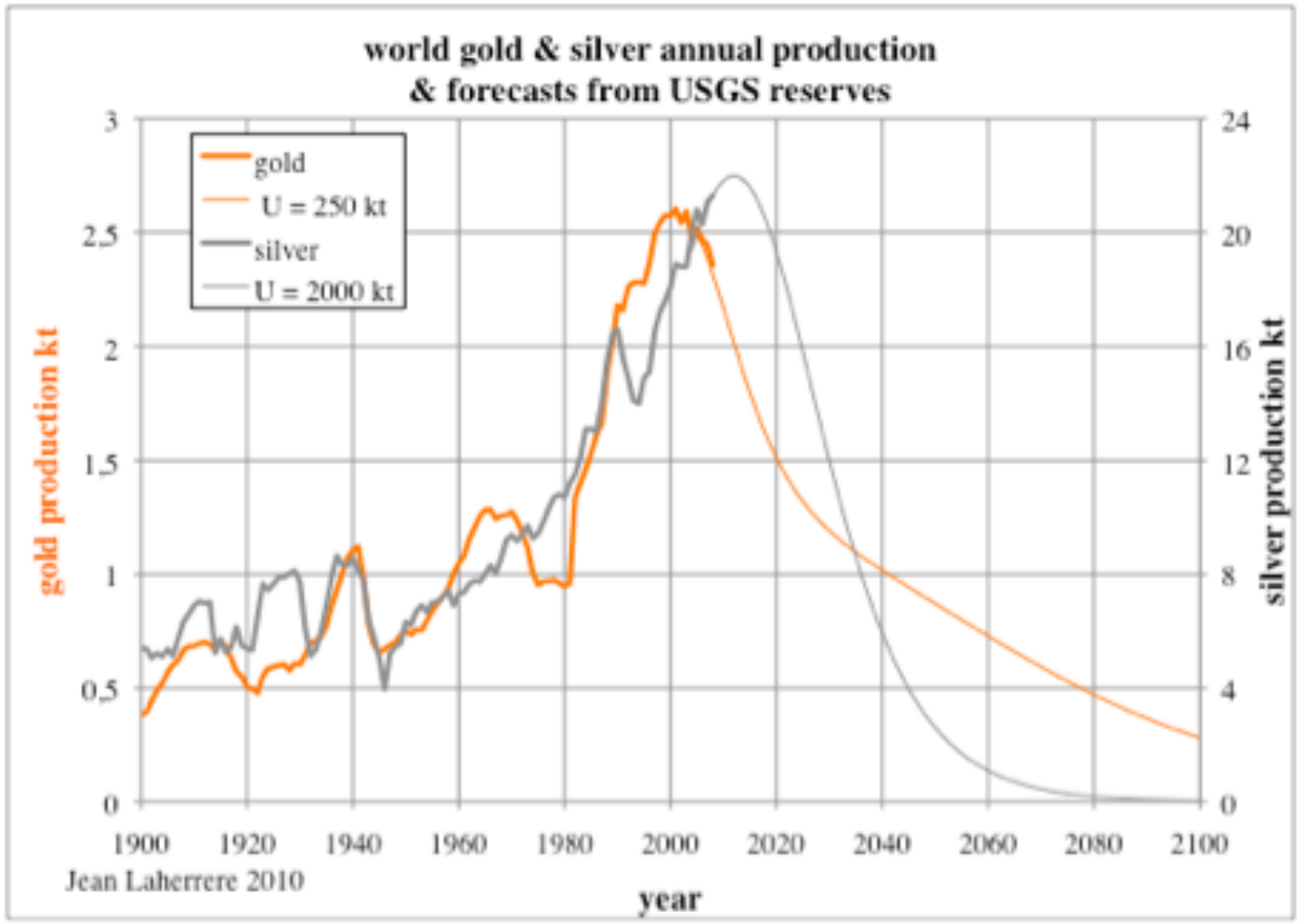


-**Silver peak**

Argentina was wrongly called the country of silver,.

Gold and silver production had similar rise and likely similar decline for the next two decades!

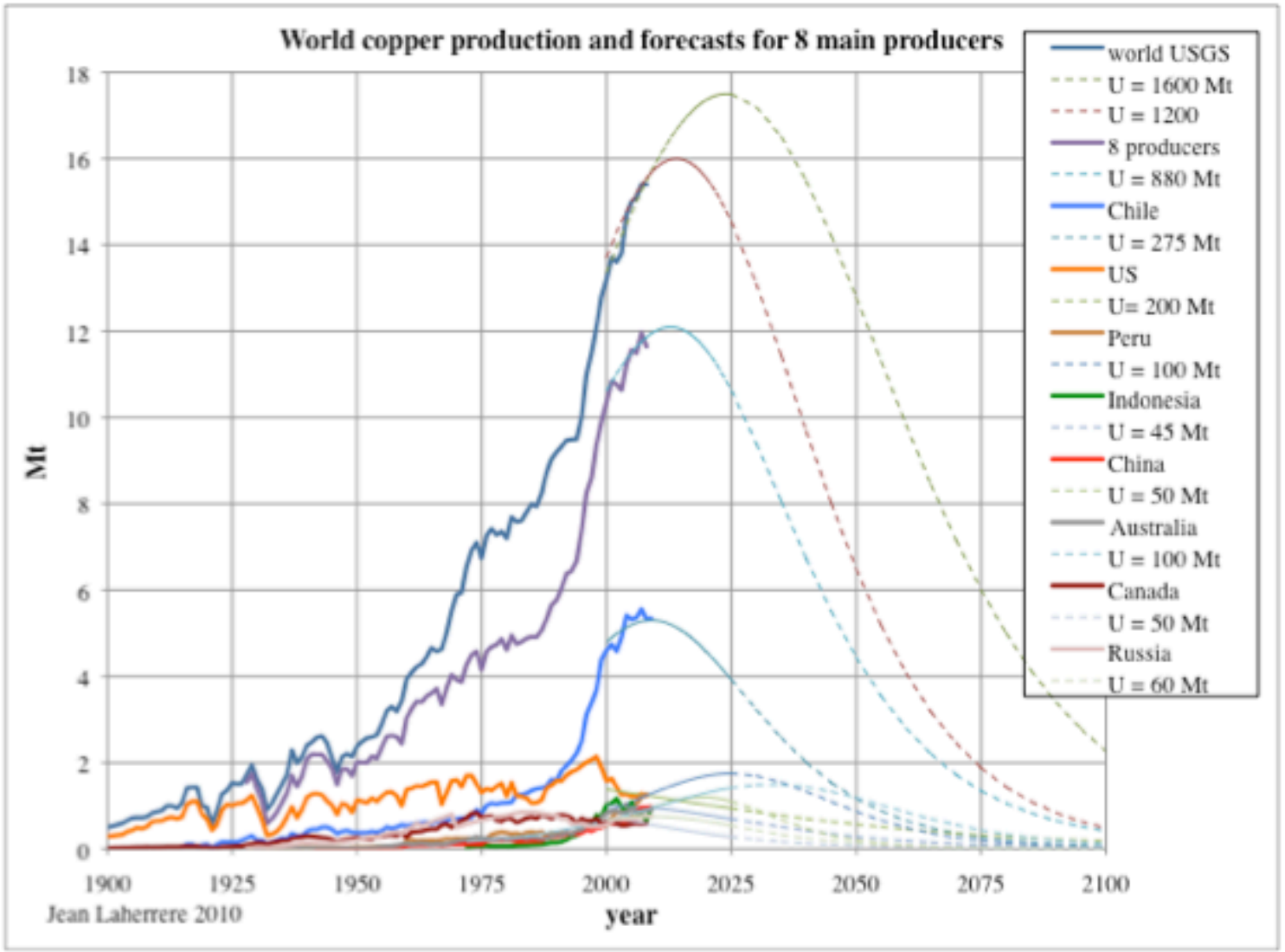
Figure 67: world gold & silver annual production



-**Copper peak**

The world copper production will peak in the 2020s, with Chile being the largest producer peaking in the 2010s

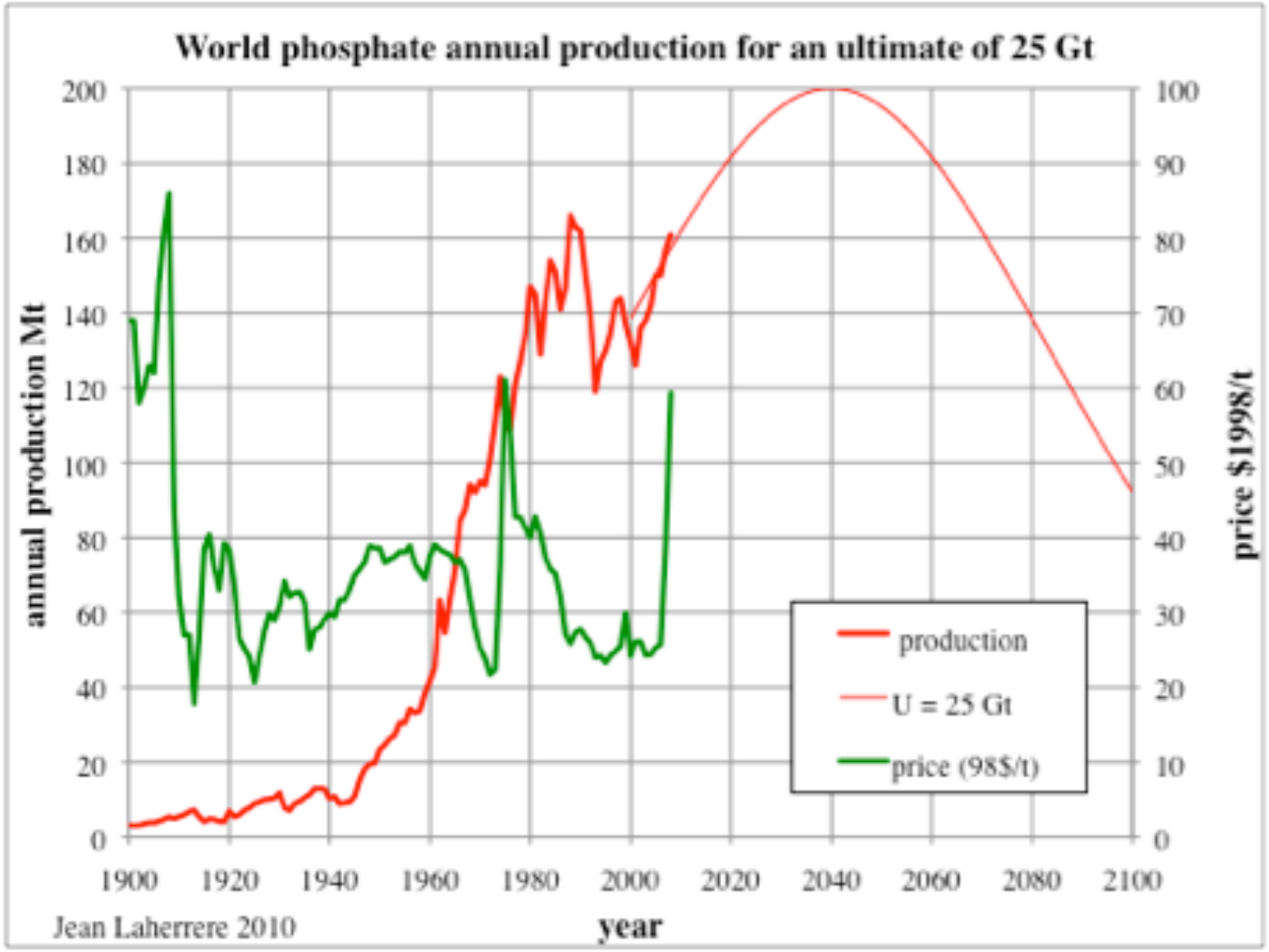
Figure 68: world copper annual production & forecasts for 8 main producers 1900-2100



-**Phosphate peak**

Phosphate is an important mineral for agriculture and its production will peak around 2040

Figure 69: world phosphate annual production & forecast U=25 Gt



-**Population** **-World population**

Many papers have been written on commodity peaks, but few on « population peak »

With Google (April 2010) «peak oil» +2010 3 250 000

«peak gold» +2010 40 000

«peak population» +2010 12 900

Population forecast is mainly estimated by the UN and it is based on fertility rate assumptions = wishful thinking. Figure 70: UN 2003 & 2006 fertility rate assumptions 1950-2150

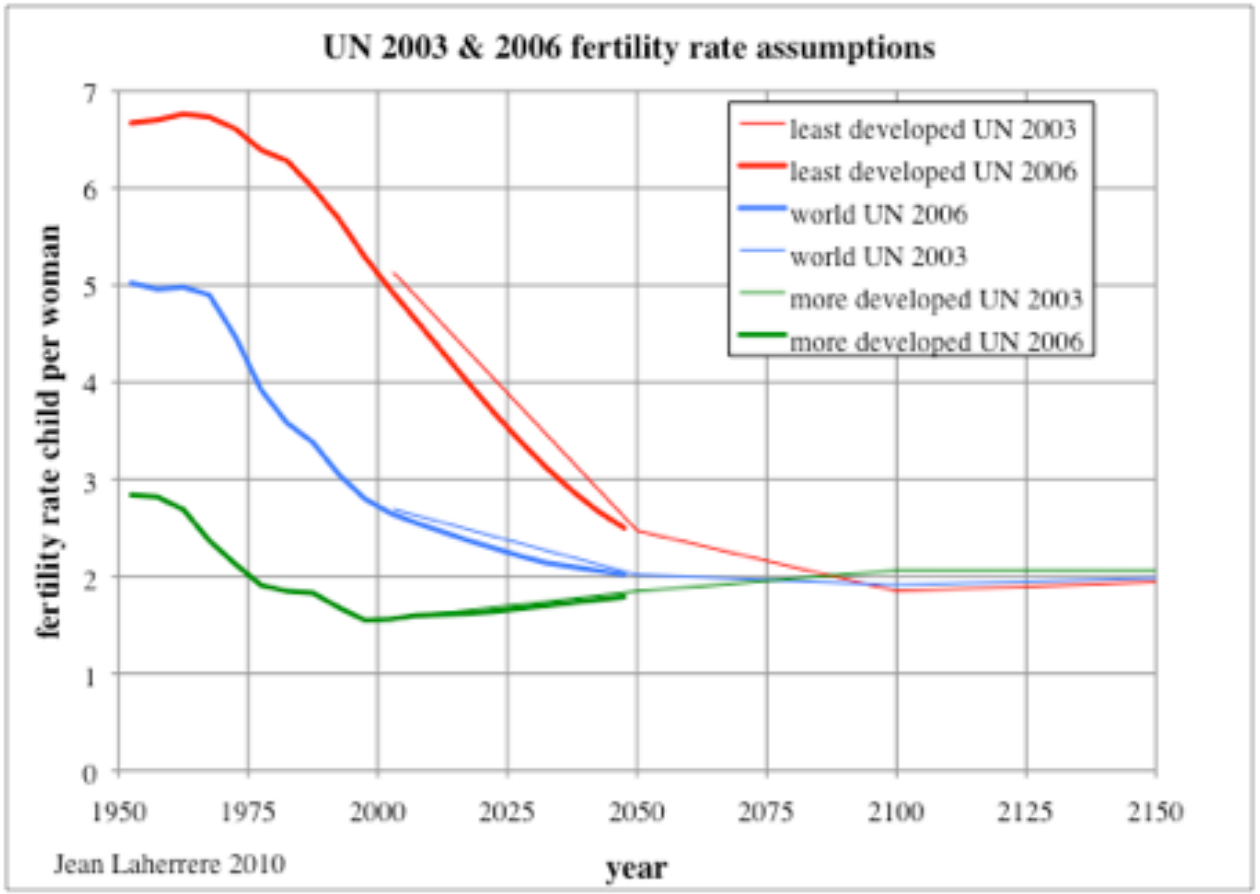


Figure 71: world population forecasts from UN 2004, UN 2008, USCB & IIASA

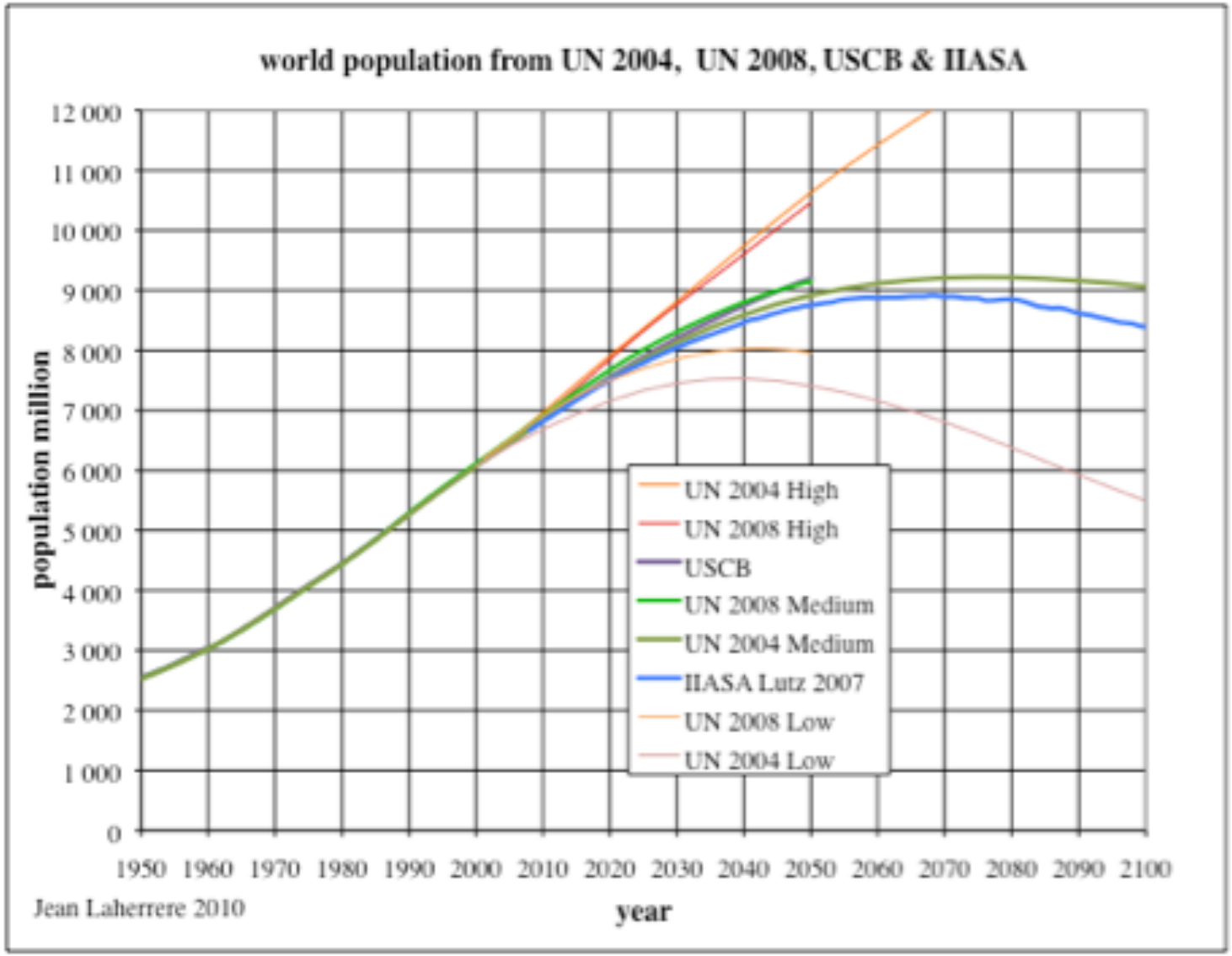


Figure 73: probability of population peak by continent from W.Lutz IIASA 2008

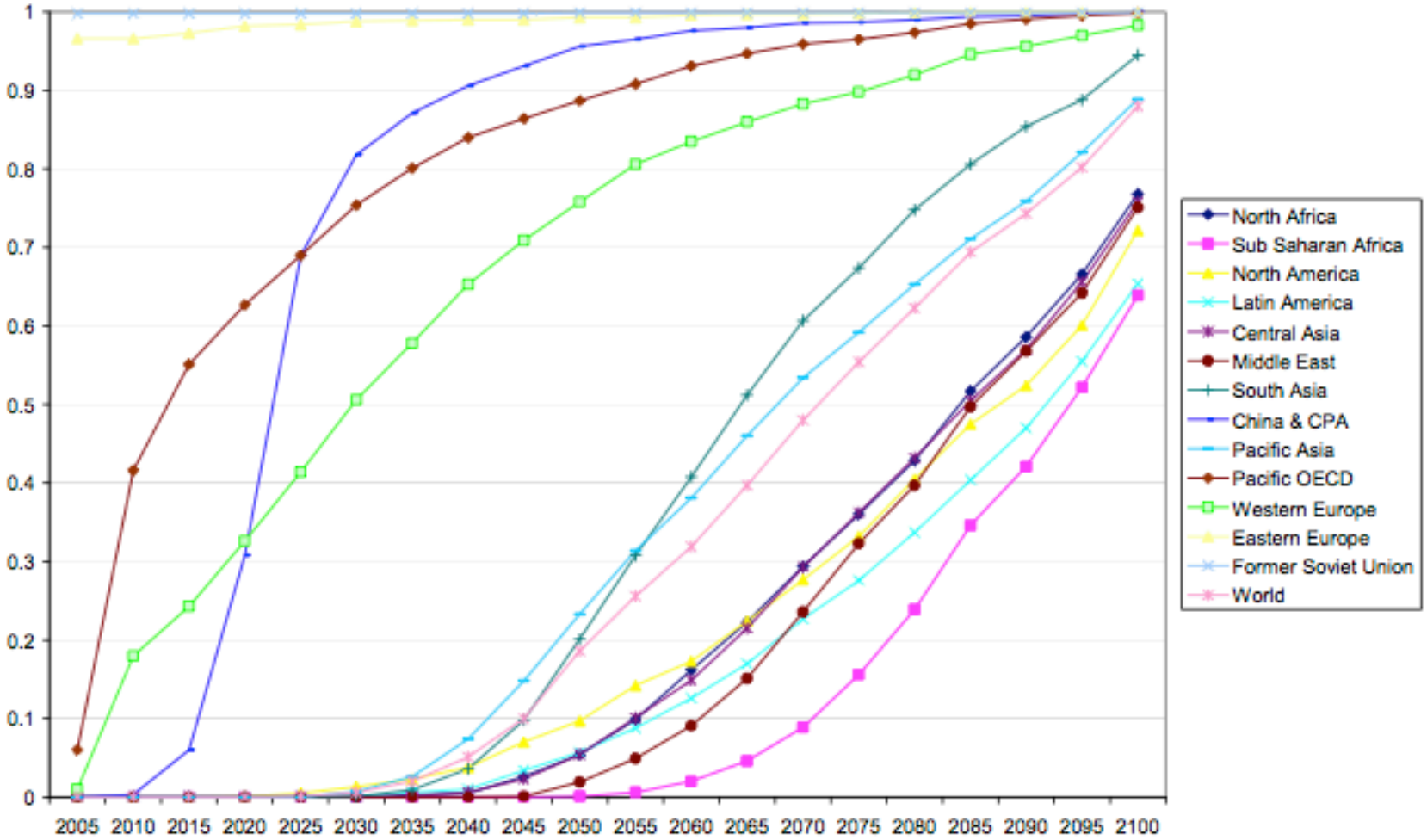
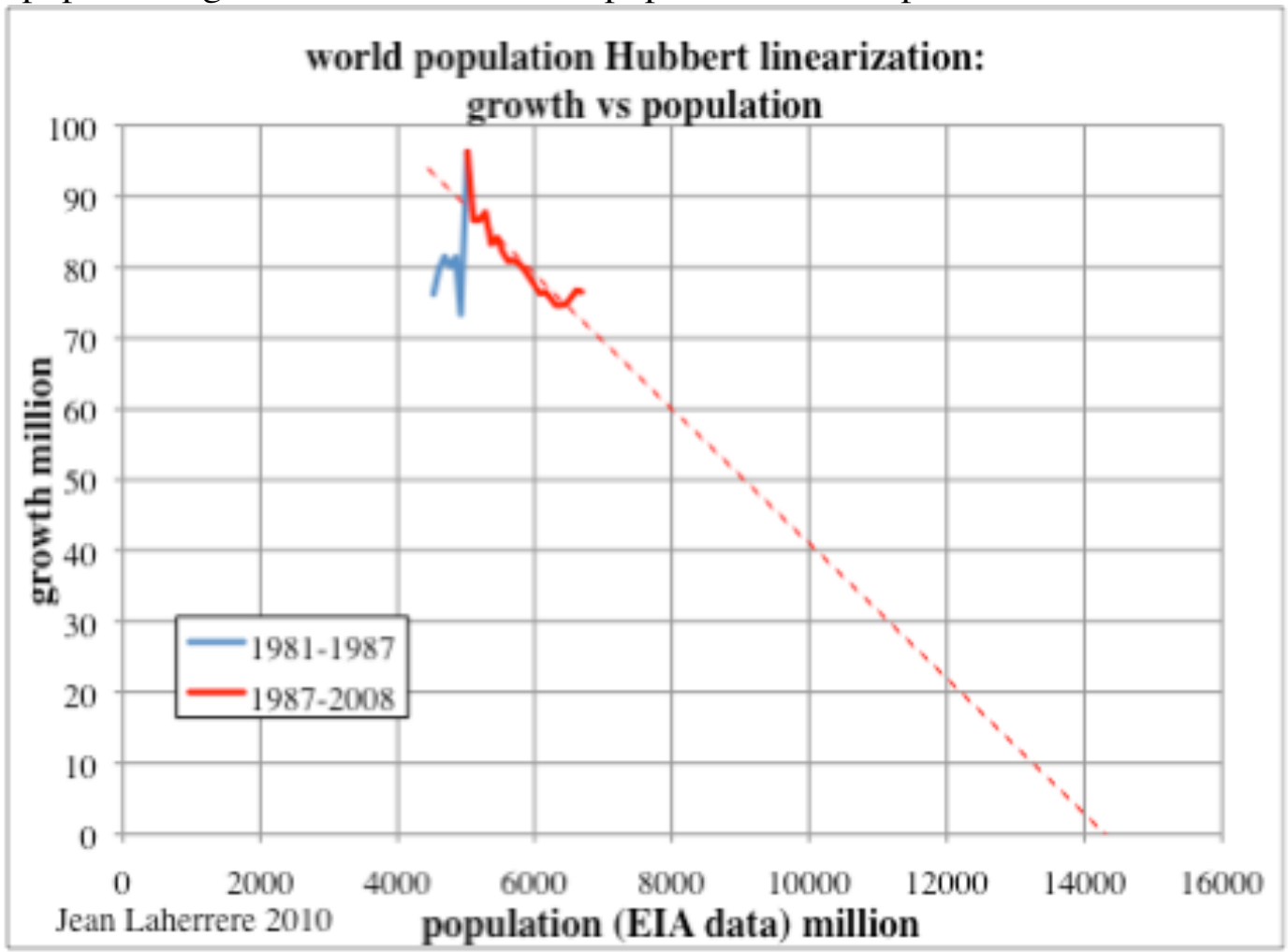
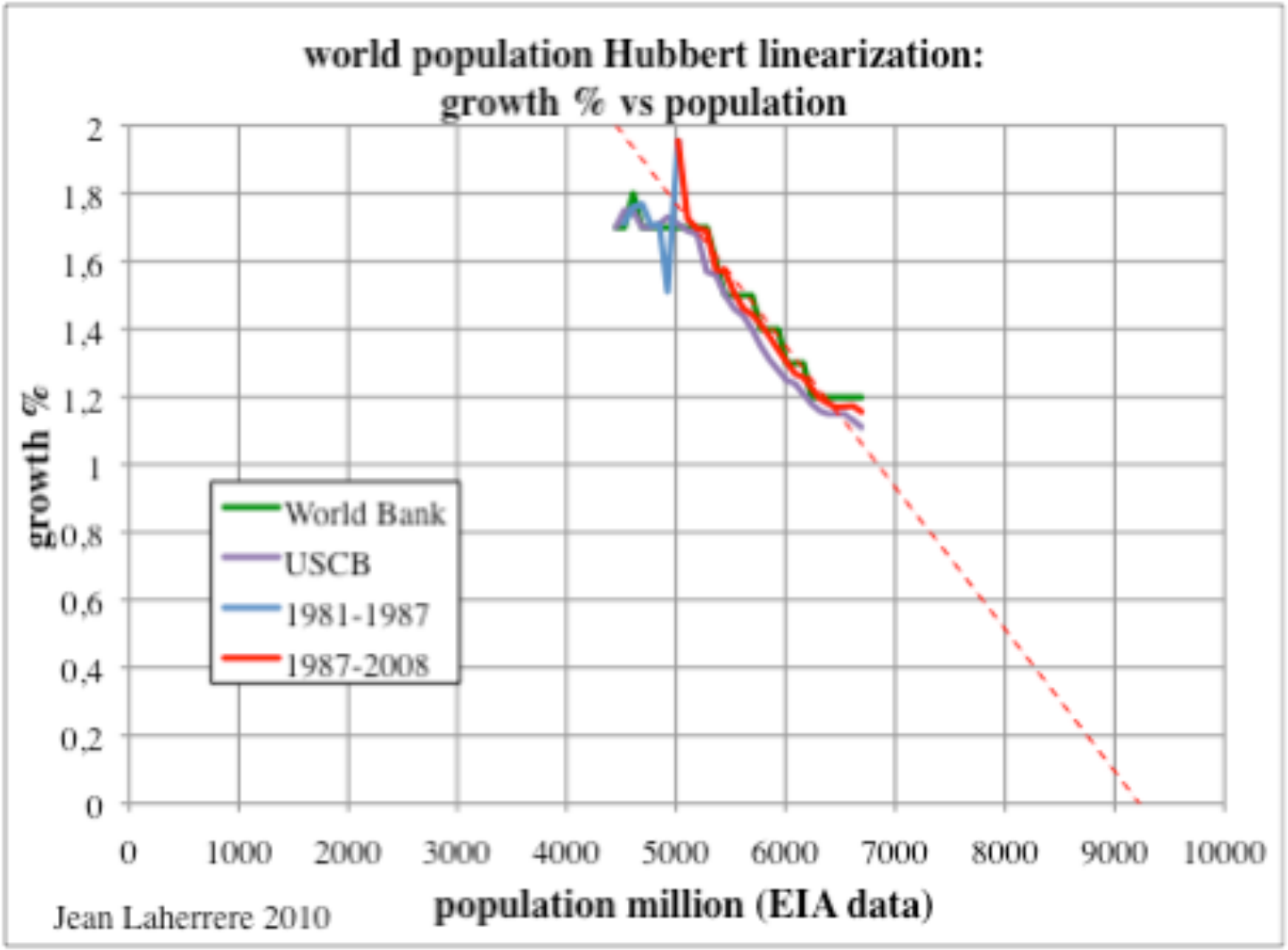


Figure 3. Probability that global and regional populations will reach a peak by the indicated date.

But instead of using assumptions on fertility rates like the UN, the extrapolation of population growth can be used, like it is for commodities (Hubbert linearization).
The growth in million versus population declines linearly since 1987 except the last 4 years and can be extrapolated towards the unrealistic 14 G!
Figure 76: world population growth in million versus population for the period 1981-2008 from EIA data

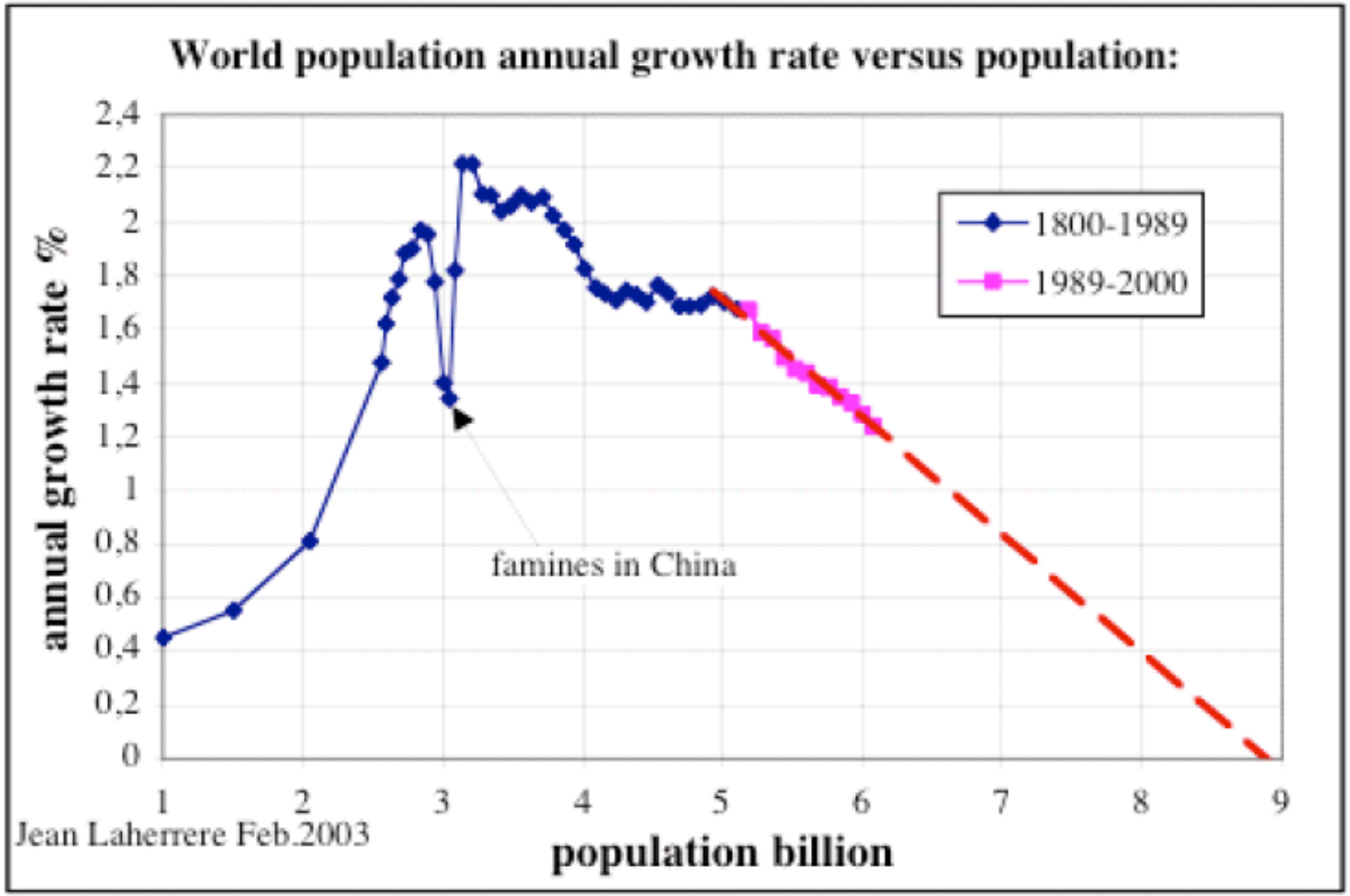


The growth in percentage versus population can be extrapolated since 1987 towards the more realistic 9 G!
But the last year's data make this plot **uncertain**!
Figure 77: world population growth in % versus population for the period 1981-2008 from EIA data



The plot in 2003 for the period 1800-2000 in 2003 looked better and simpler. But linear trend usually does not stay long!

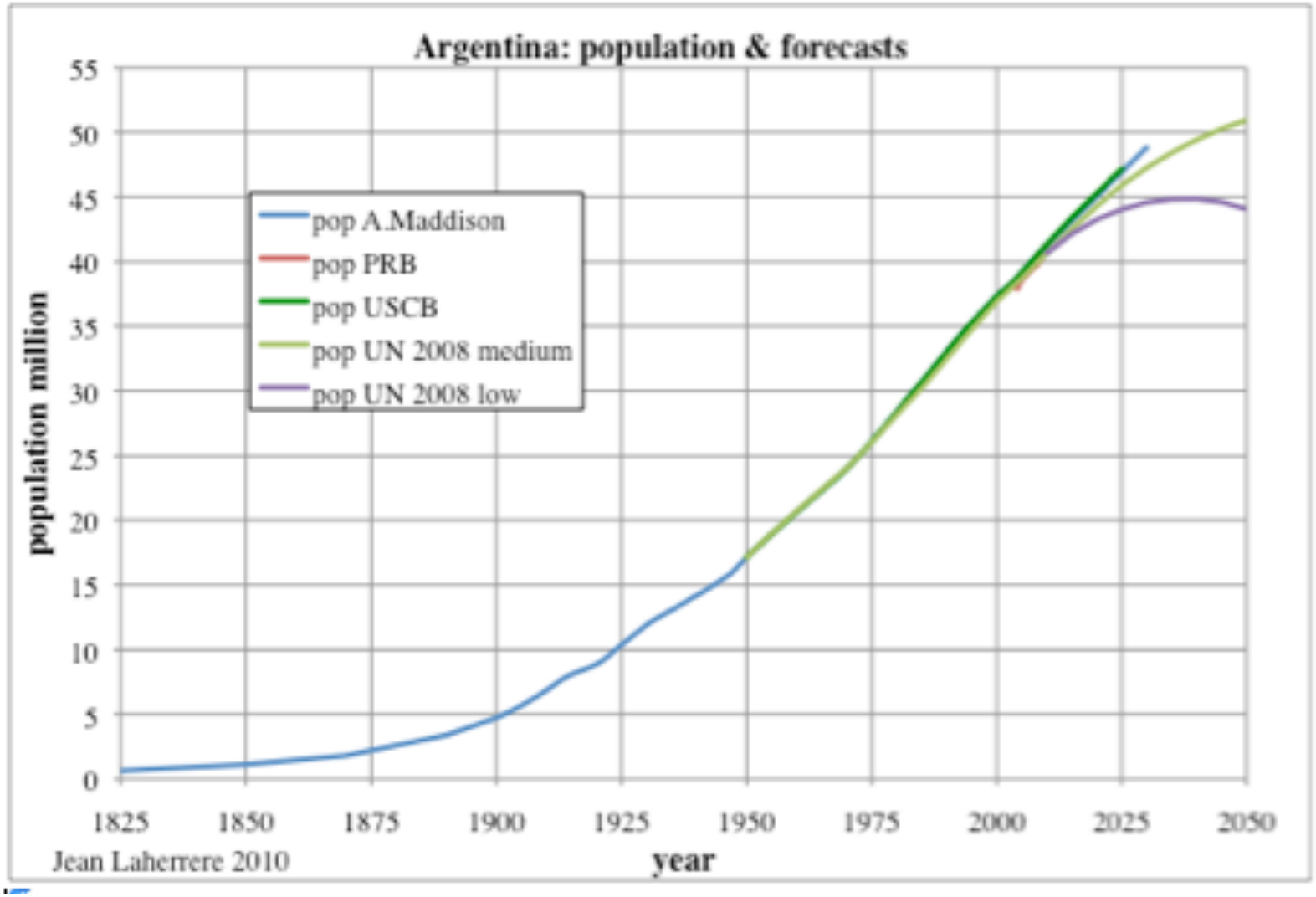
Figure 78: in 2003 world population growth in % versus population for the period 1800-2000



-**Argentina population**

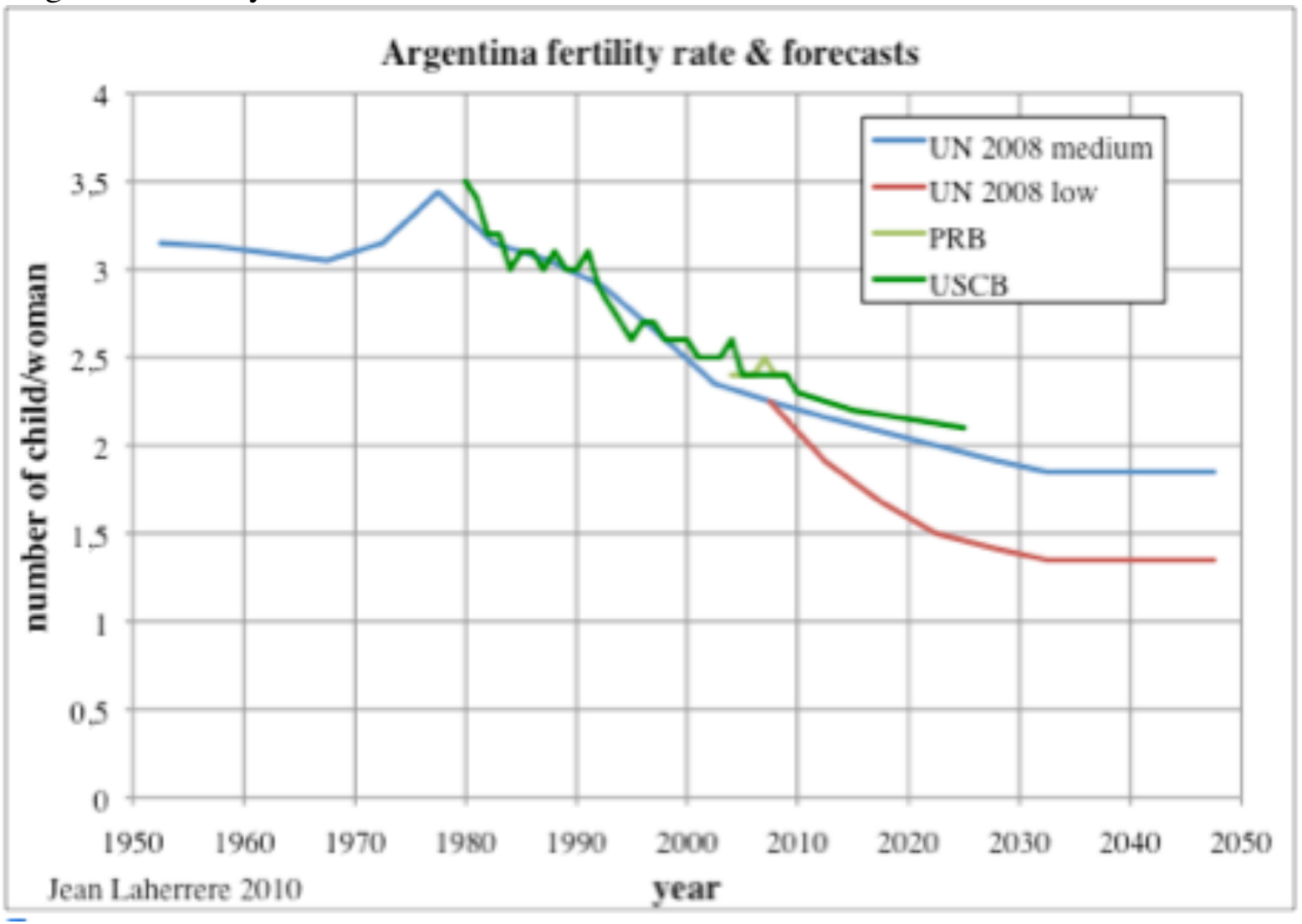
When does Argentina population peak?

Figure 79: Argentina population & forecasts



The Argentina fertility rate has been declining since 1978, but the data is uncertain looking at the discrepancy between PRB and UN data.

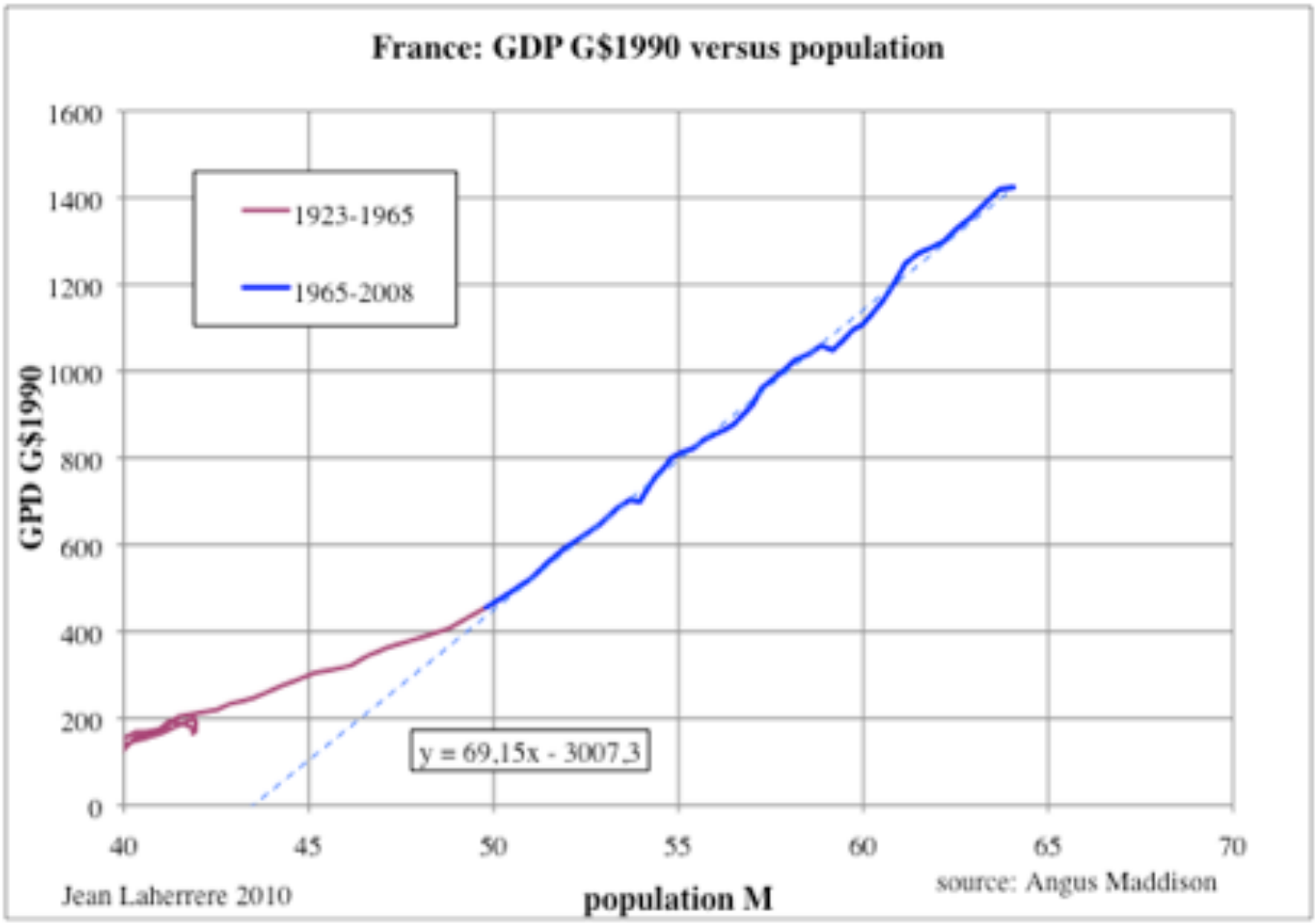
Figure 80: Argentina fertility rate & UN, USCB forecasts



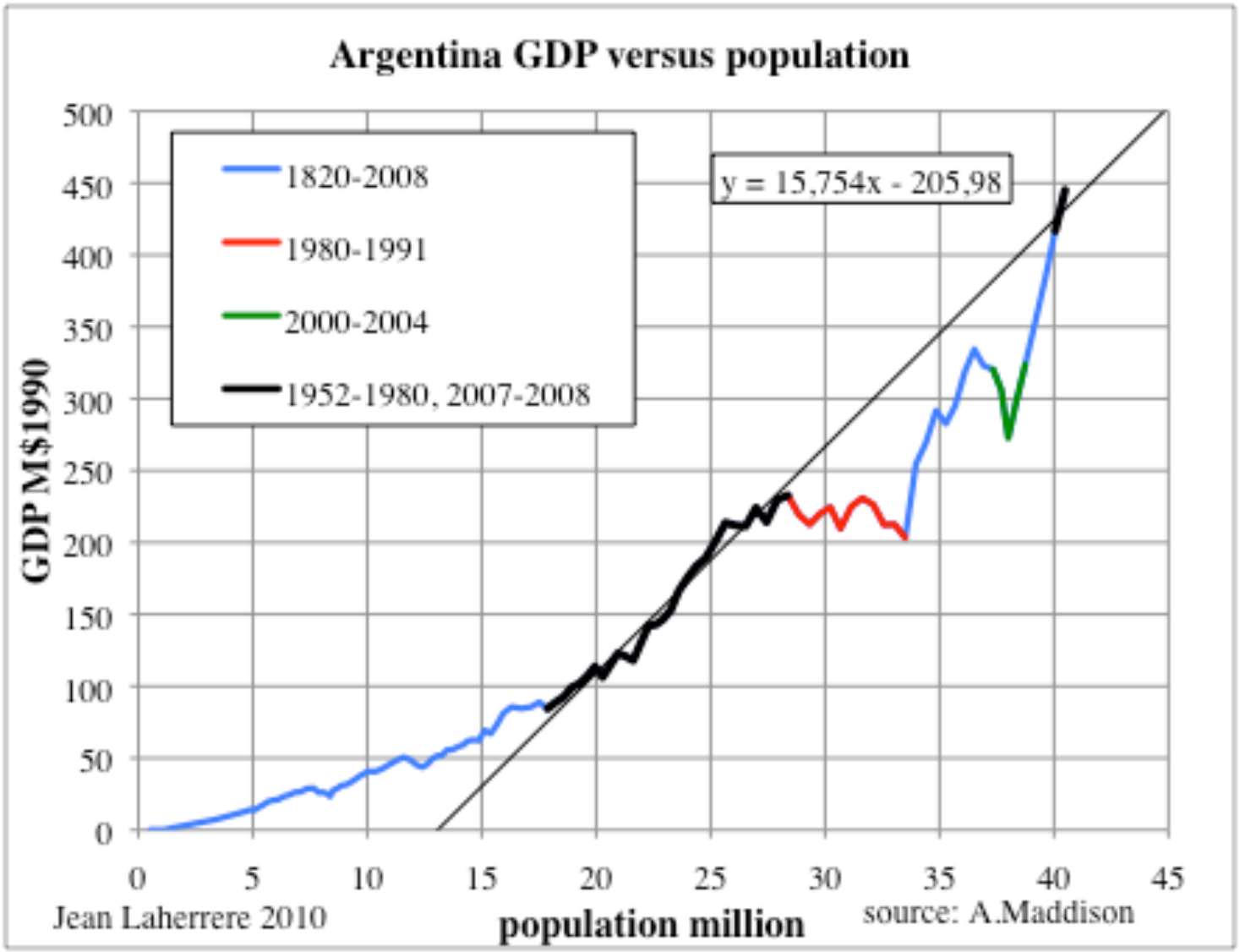
-**Population: GDP and Happiness**

Politicians are judged on the growth of GDP. But GDP represents expenditures and not wealth of the country. It is interesting to find that the plot of GDP versus population displays a linear trend for France, which is surprising the same slope as the US slope for the period 1980-2008

Figure 81: France GPD ($1990) versus population

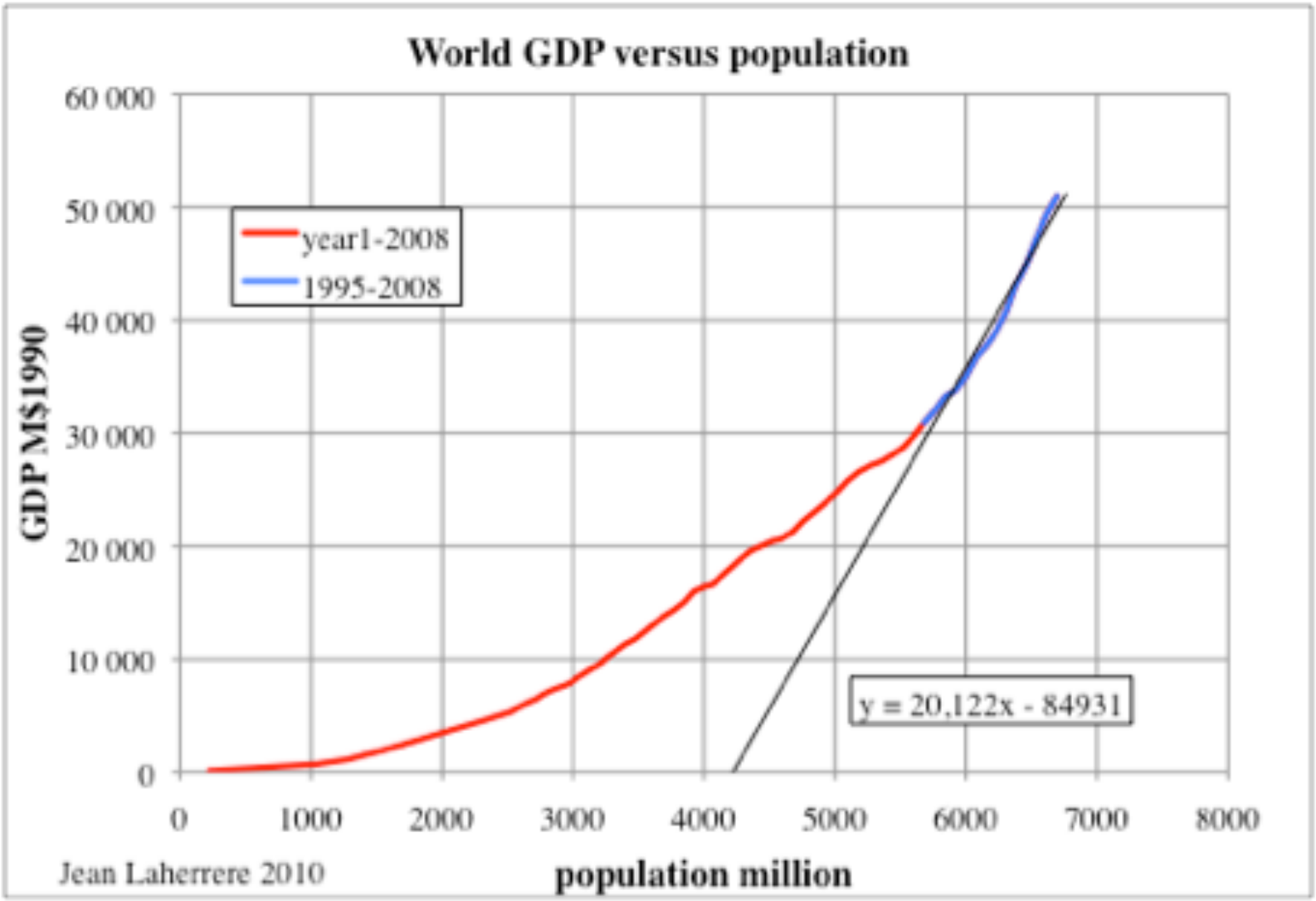


Argentina GDP versus population could display a linear trend when excluding the period from 1980 to 2007
Figure 82: Argentina GPD ($1990) versus population



The world plot is obviously a parabola and the linear trend on the recent years is in fact a tangent to the parabola

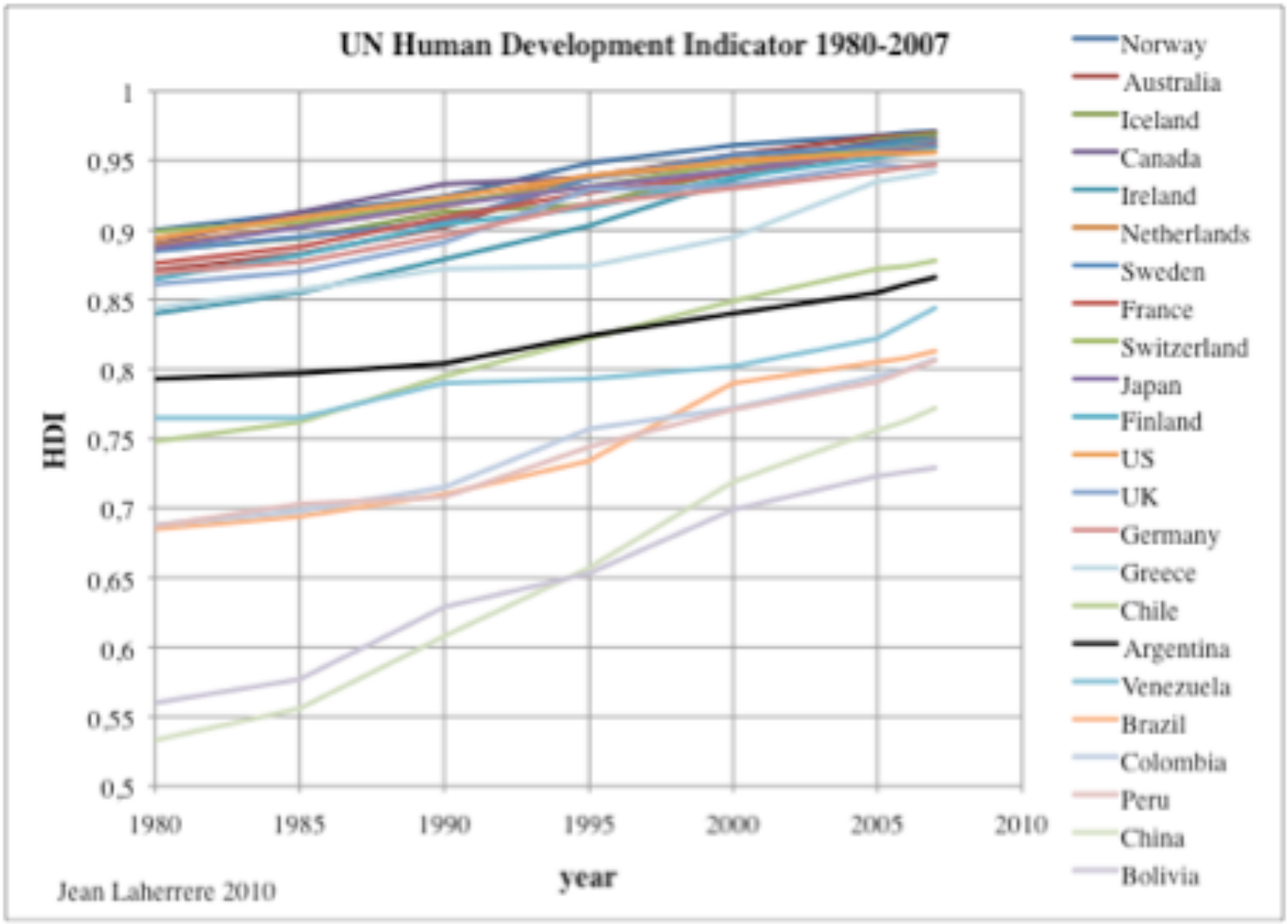
Figure 85: world GPD ($1990) versus population year 1 to 2008



The comparison of the last linear trend of GDP increase per capita in k$2008 is as follows

Country	linear period	k$2008/capita
India	1992-2008	11
Brazil	1965-2008	12
Argentina	1952-1980, 2008	24
world	1995-2008	27
Chile	1985-2008	53
Portugal	1993-2008	95
Australia	1990-2008	95
France	1965-2008	104
US	1980-2008	104
China	2000-2008	114
Canada	1992-2008	117
Holland	1982-2008	131
Switzerland	1995-2008	132
Germany	1990-2005	158
Denmark	1985-2008	174
Norway	1970-2008	189
UK	1970-2008	231
Belgium	1969-2008	261
Italy	1977-2008	351
Spain	1993-2008	569

It is obvious that politicians will continue to favour population growth as long as GDP will be the indicator on which their action is judged.
GDP should be changed and replaced by a well-being and happiness indicator.
Figure 87: UN Human Development Indicator for some countries from 1980 to 2007



Veenhoven (Erasmus University) did a survey on satisfaction with life (scale 1-10) in 146 nations from 2000 to 2009

Rank	Nation	Satisfaction with life scale 0-10
1	Costa Rica	8,5
2	Denmark	8,3
3	Iceland	8,2
4	Switzerland	8
5	Finland	7,9
6	Mexico	7,9
7	Norway	7,9
8	Canada	7,8
9	Panama	7,8
10	Sweden	7,8
11	Australia	7,7
12	Austria	7,7
13	Colombia	7,7
14	Luxembourg	7,7
15	Dominican Republic	7,6
16	Ireland	7,6
17	Netherlands	7,6
18	Brazil	7,5
19	New Zealand	7,4
20	United States	7,4
21	Argentina	7,3

UK was on rank 31 with 7,1 and France was on rank 47 with 6,6

But the New Scientist published a study in 2003 where the happiest countries were Nigeria, Mexico, Venezuela, which have rank 80, 6, 26 in Erasmus study, in total contradiction.
New Scientist found that happiness levels have remained virtually the same in industrialised countries since World War II, although incomes have risen considerably.

It is obvious that measuring happiness is very difficult, too chaotic and without significant change in industrialised countries to be a genuine indicator.
I am afraid that GDP will continue to be used by lack of good substitute, accepted by all.

Statu quo always prevails!

-**Conclusions**

Since centuries, progress was found by going west to new territories.
But today there is no more new land to occupy.

Growth is expected in Business As Usual scenarios.
But constant growth is impossible in a limited world.

Many do not want to change their way of life and deny that peaks are occurring.

We do not like to remember that we are all mortal.
Peak means decline, but decline does not mean death.
We all peak when being adult. We start to realise our decline when, around 45 years old, we need spectacles.
But our life expectancy is then about 35 years, and retirement is a good period of life!
Peaking is not catastrophic, it is only part of life and we have to accept it.

We have to change our way of life and more important our way of thinking.
Instead of pushing consumption and waste, we have to find better ways to consume less and better.

The first thing is to recognize that peaks have occurred and many more are coming.
The best examples are the UK coal peak, the Pennsylvania anthracite peak, the USL48 oil peak, the North Sea oil peak.

Peaks are reality and not theory!