Stochastic Detection Time Concept

and its Economic Implications

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Outline

1. Kyoto protocol and detection of emissions

2. Uncertainty (Variability) matters

3. Practical Example: Long time data series

4. Variability of emissions: “fast” and “slow” systems

5. Emission signal detectability: stochastic detection techniques

6. Economic value of stochastic detection:

   a. carbon trading markets
   b. insurance of carbon credits transactions

Kyoto protocol and detection of emissions

Kyoto –
binding commitments to limit or reduce the emissions of six GHGs or groups of gases (CO_2, CH_4, N_2O, HFCs, PFCs, and SF_6).

Each Party of the protocol calculates how much of gases its country emits by adding together estimates/reported emissions from individual sources.

Often estimated/reported emissions are inaccurate:
M. Gillenwater & F. Sussman & J. Cohen: Practical Policy Applications of Uncertainty Analysis for National Greenhouse Gas Inventories.

In many countries, agreed emission changes are smaller than their underlying uncertainty.

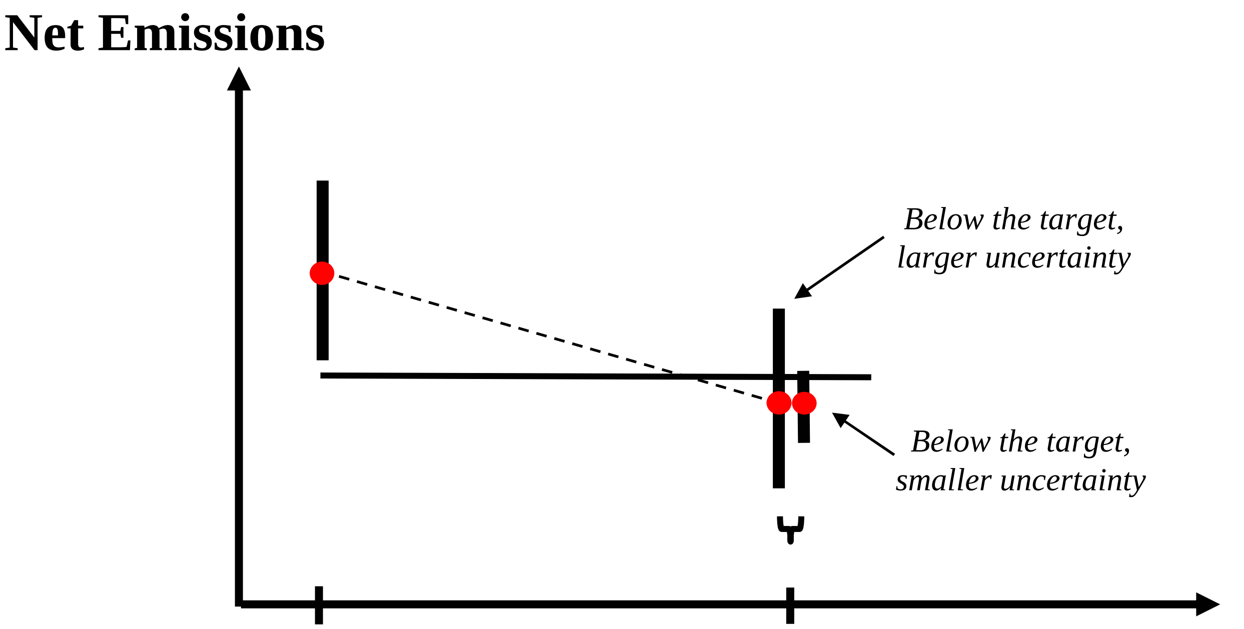
In IPCC practice, emission/emission changes are reported, but without rigorous signal detection

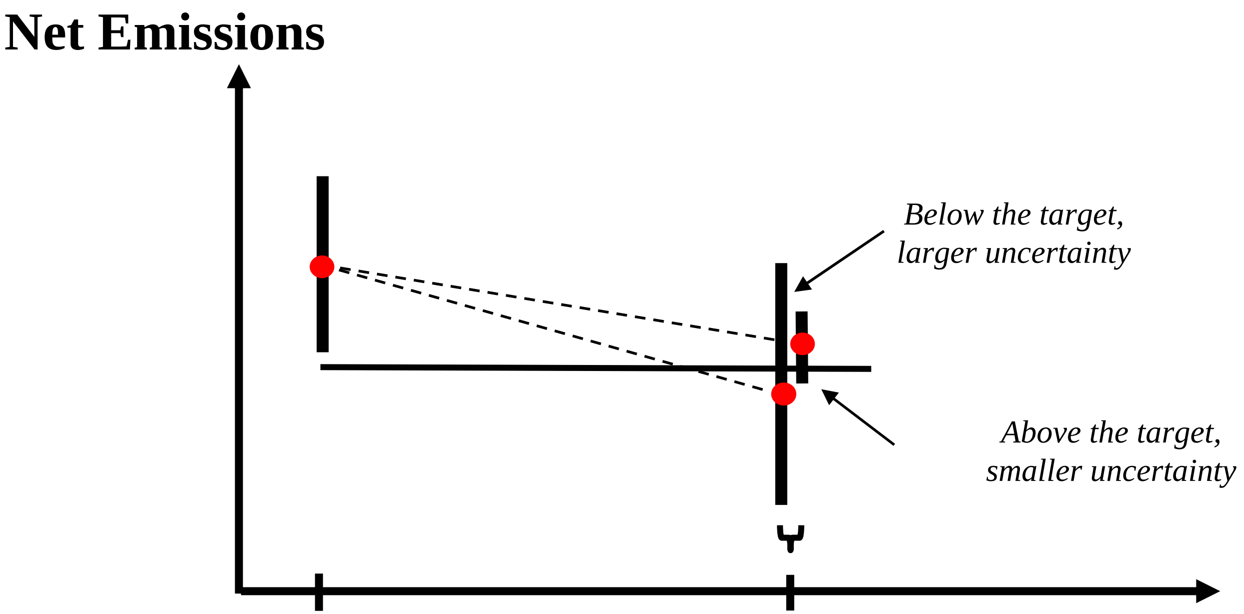
The KP requires that net <u>emission changes</u> be “verified” on the spatial scale of countries by the time of commitment, relative to a specified base year.

The key questions:

1. Whether reported emissions outstrip uncertainty and can be “verified/detected” ?
2. What percentage of all possible emissions can be detected within a given time ?

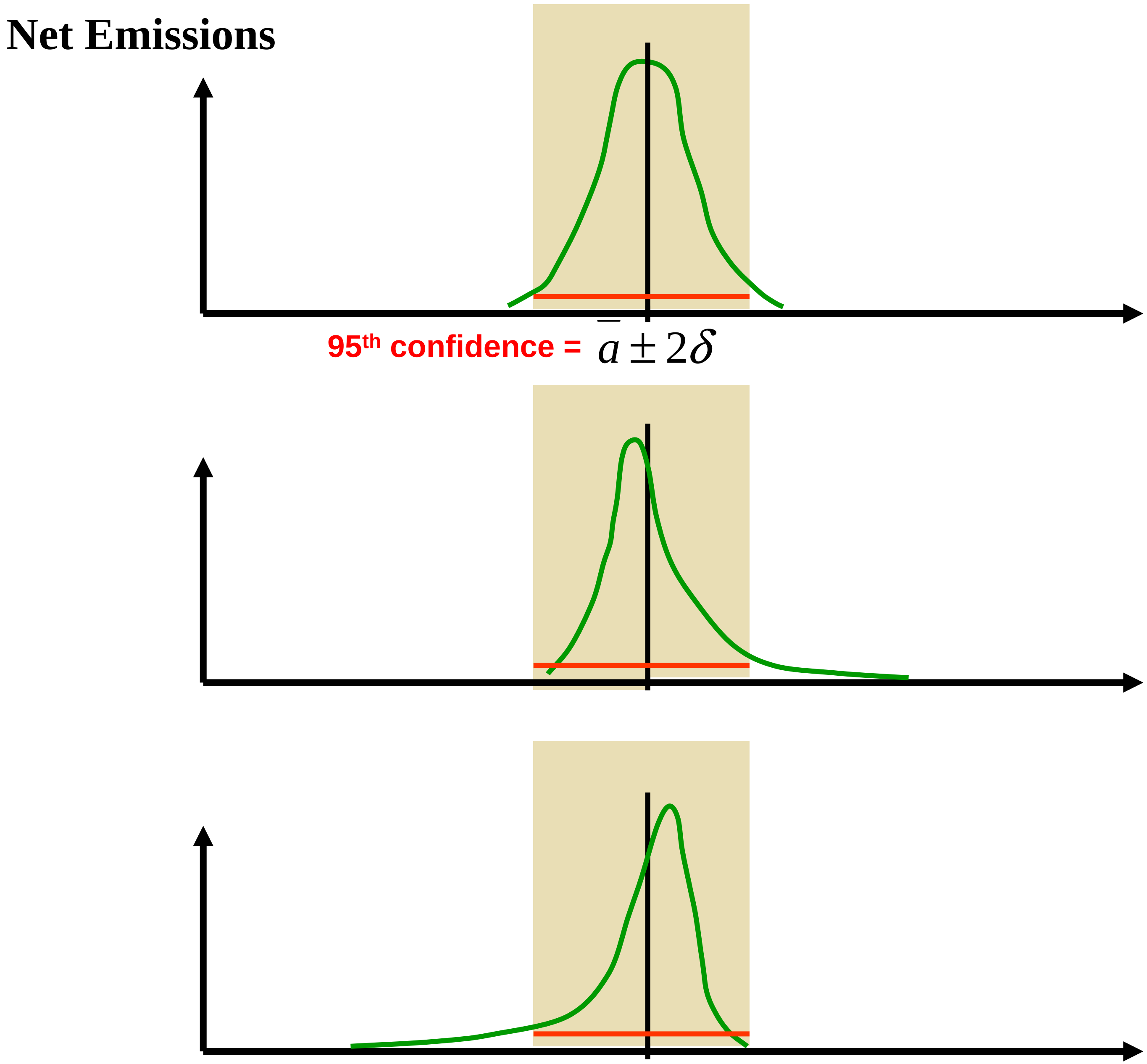
Uncertainty (variability) matters



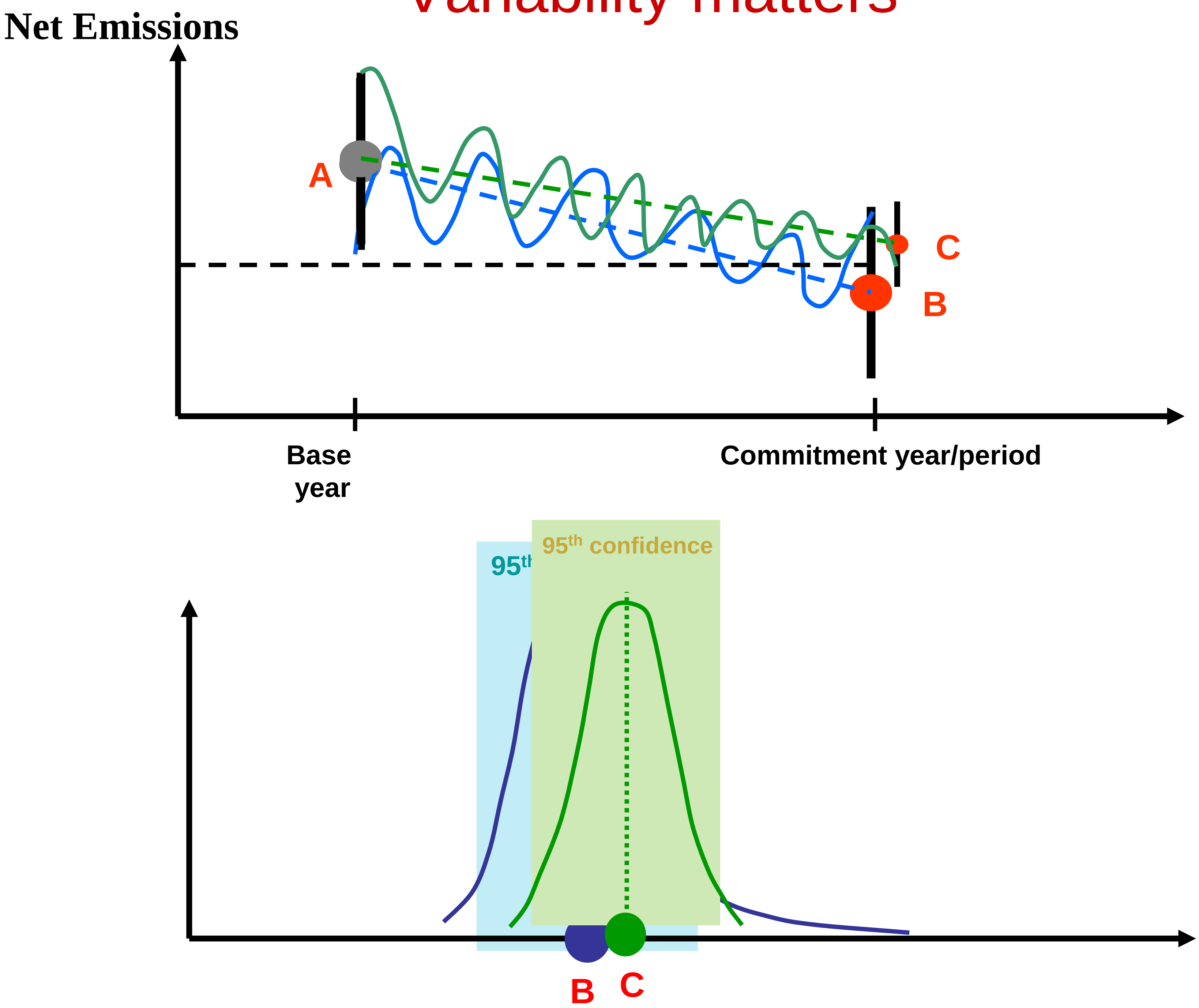


Source: *M. Jonas et. al.*

Variability matters



Variability matters



Practical examples

Longer data time series on **FF**, **LUC** and **OU** taken from global carbon budget:

http://lgmacweb.env.uea.ac.uk/lequere/co2/carbon_budget.htm

Fossil Fuel Emissions (FF) are estimated from data on the global consumption of coal, oil, and natural gas.

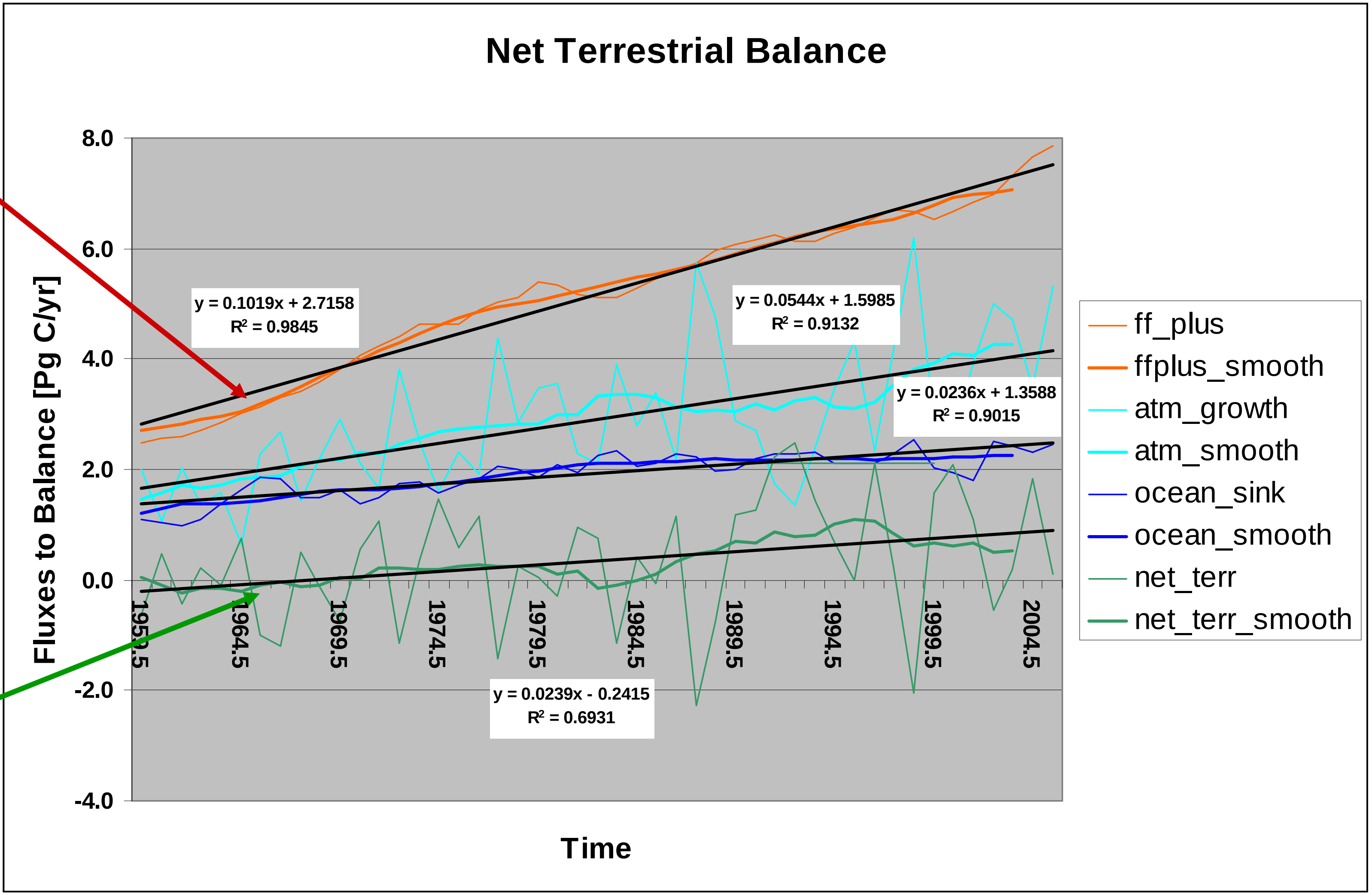
The **Land Use Change (LUC)** are estimated using a bookkeeping model updated in August 2006 using revised data from the FAO of the United Nations.

The mean **Ocean Uptake (OU)** for 1959-2005 is estimated using an ocean general model forced by observed atmospheric conditions of weather and CO2 concentration.

The **terrestrial uptake** is estimated as a residual of all the sources minus the ocean uptake and atmosphere increase ***(Assessment Report 4, WG 1, Ch. 7, 2007, p. 519)*****.**

Variability of emissions: “fast” and “slow” emissions dynamics

Fossil Fuels: strong dynamics, small variability

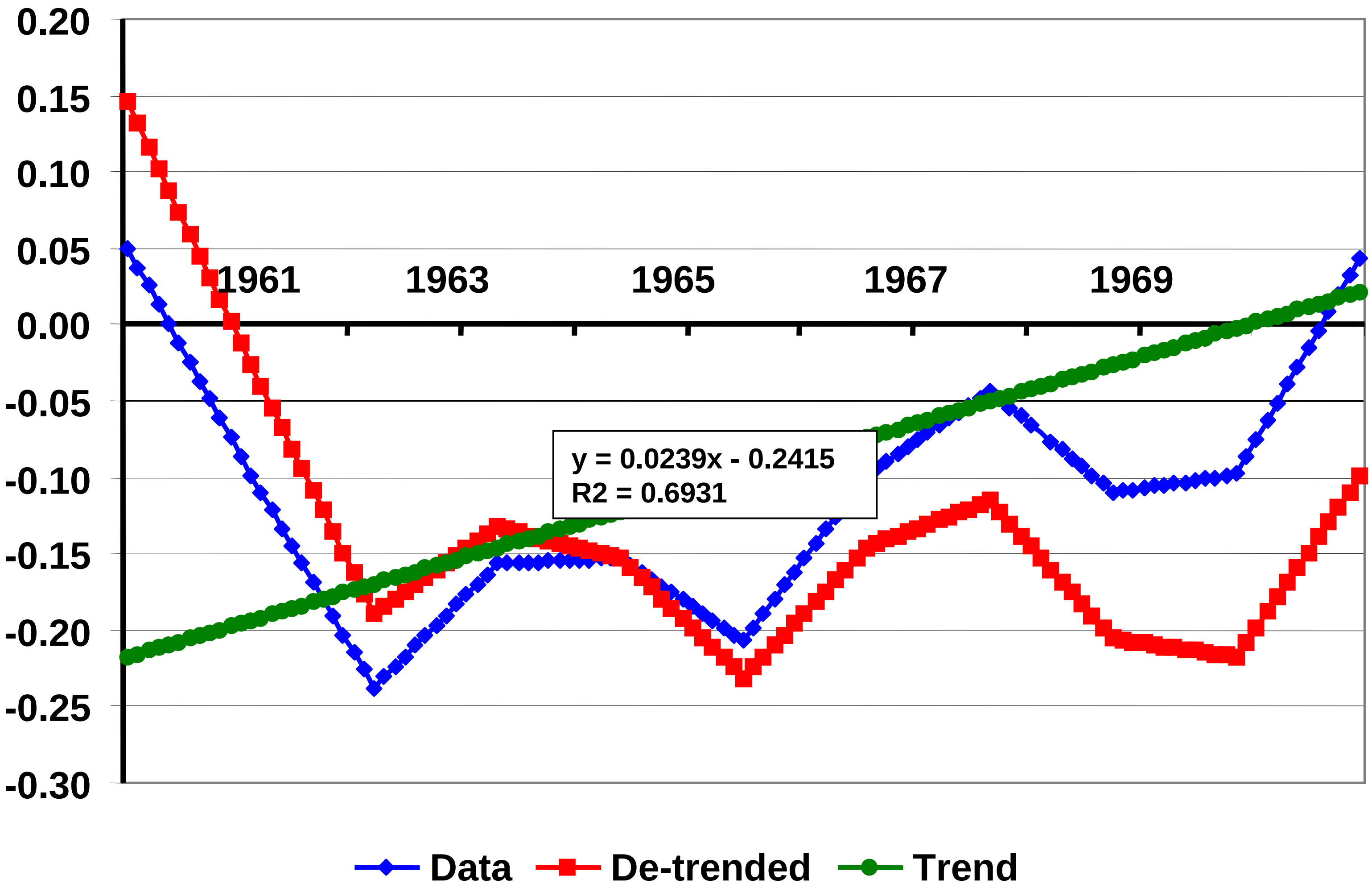


Net terrestrial: slow dynamics, large variability

http://lgmacweb.env.uea.ac.uk/lequere/co2/carbon_budget.htm

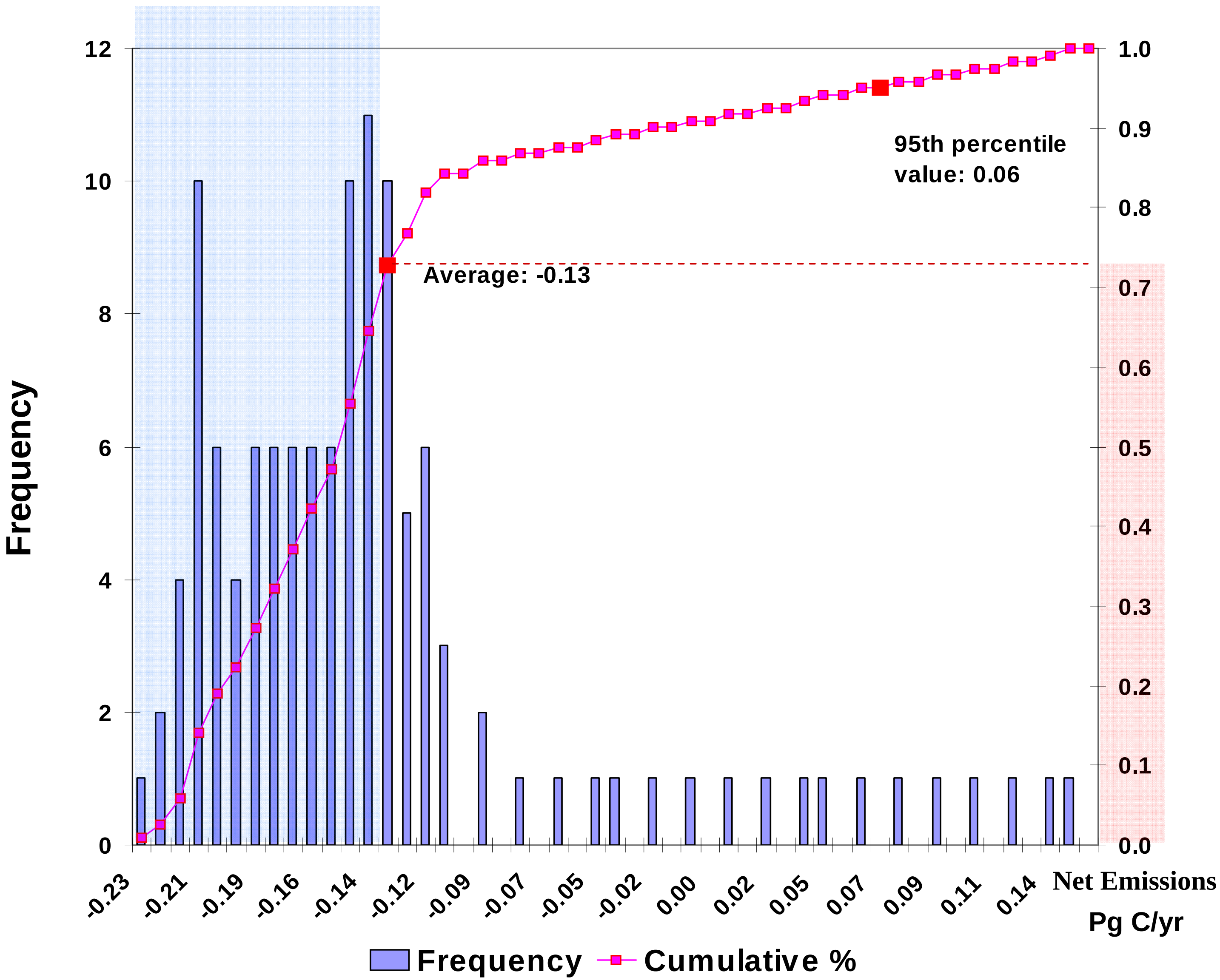
Data series

Net Emissions

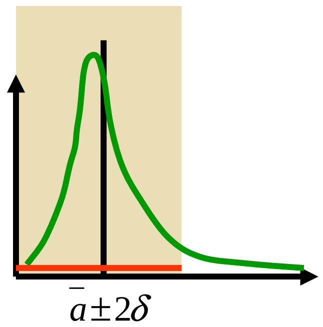


Slow dynamics vs large variability:

Net terrestrial uptake, 1960-1970

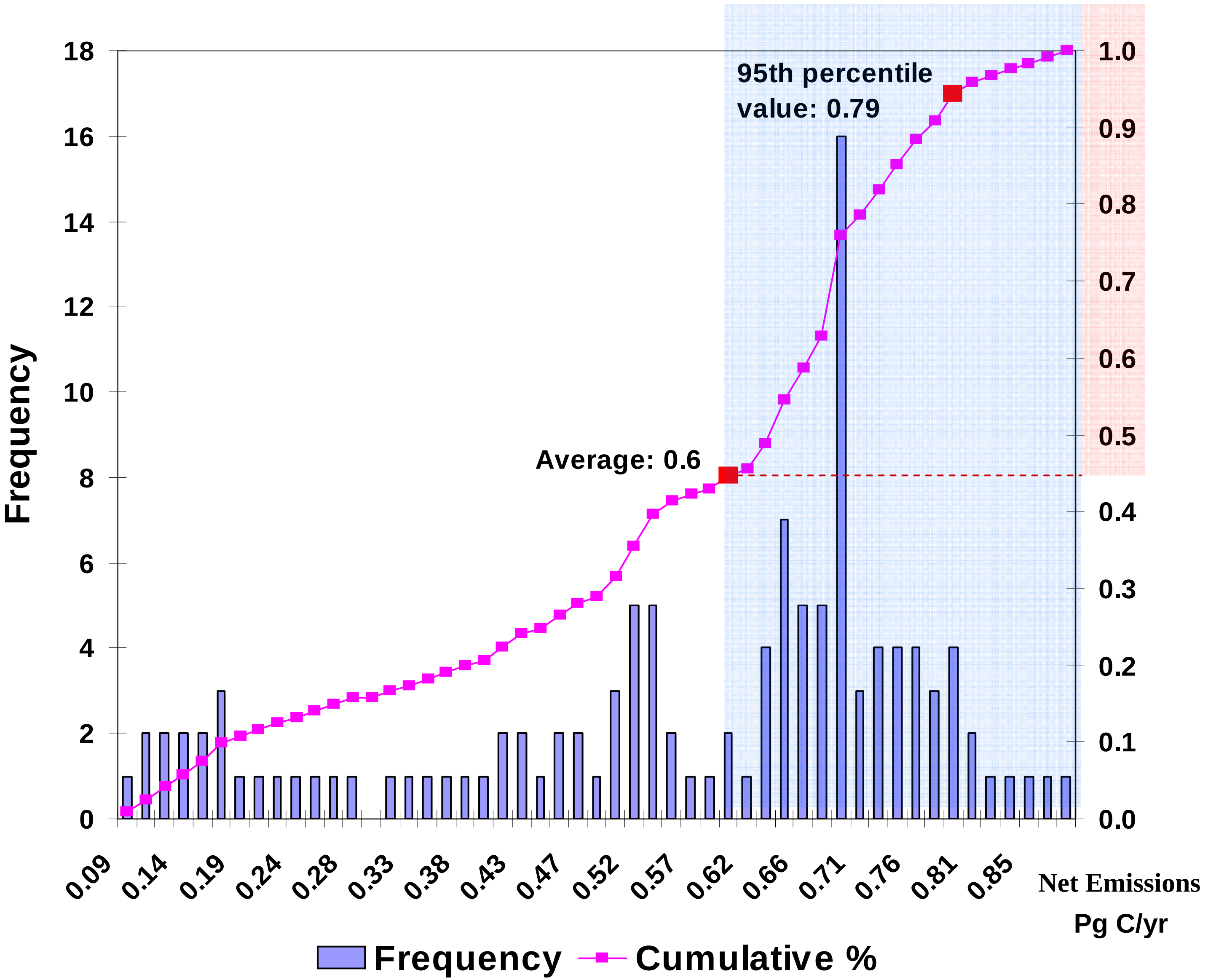


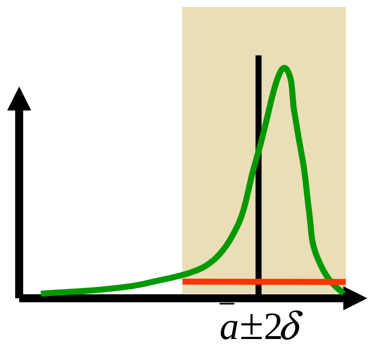
More emissions below average !



Slow dynamics vs large variability:

Net terrestrial uptake, 1985-1995

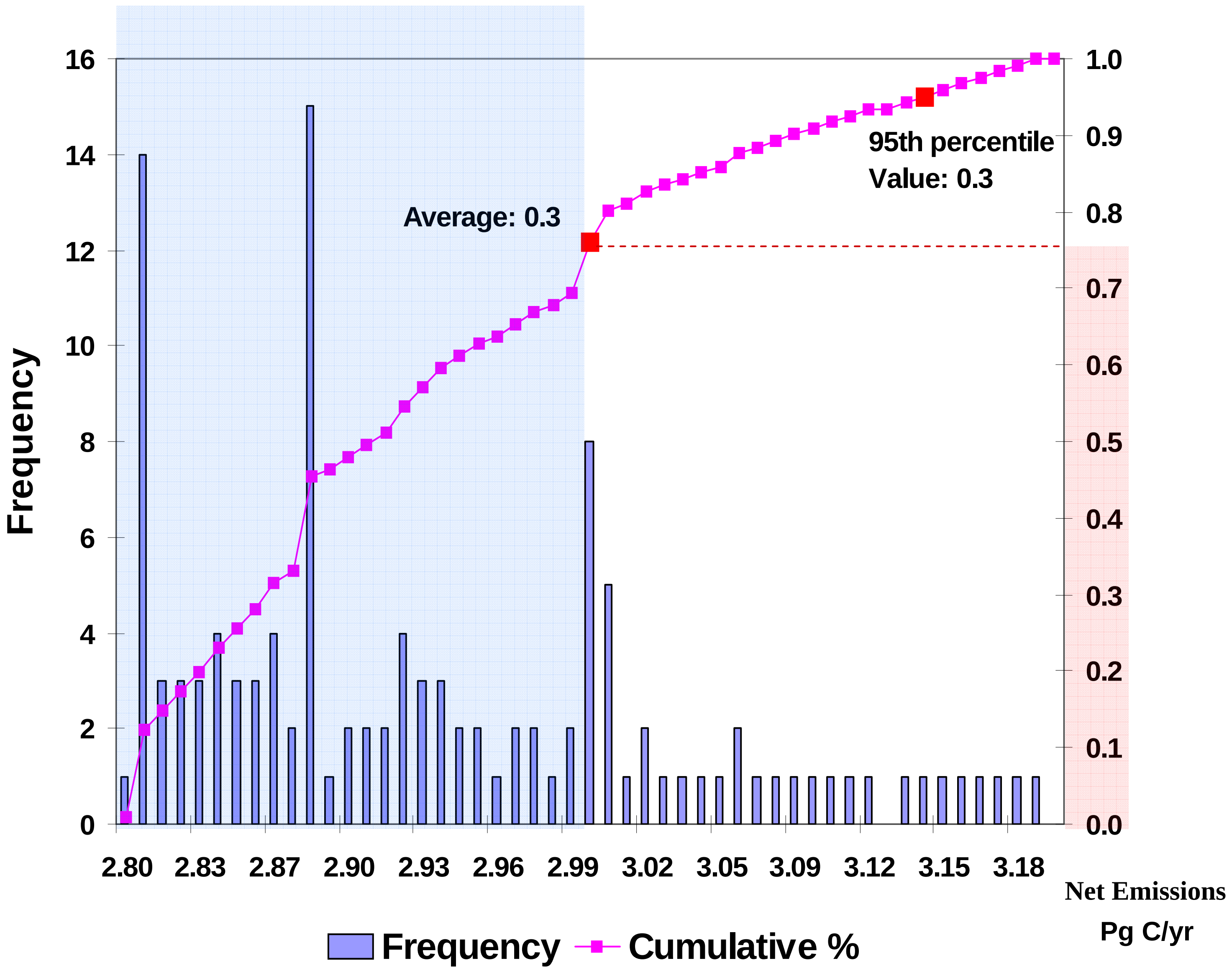


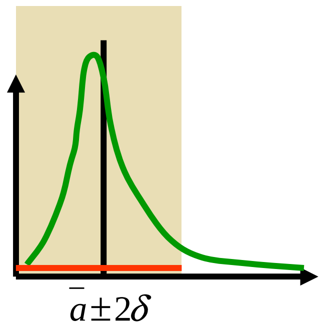


More emissions above average !

Fast dynamics vs small variability:

Fossil fuel emissions, 1960-1970





More emissions below average !

Fast dynamics vs small variability:

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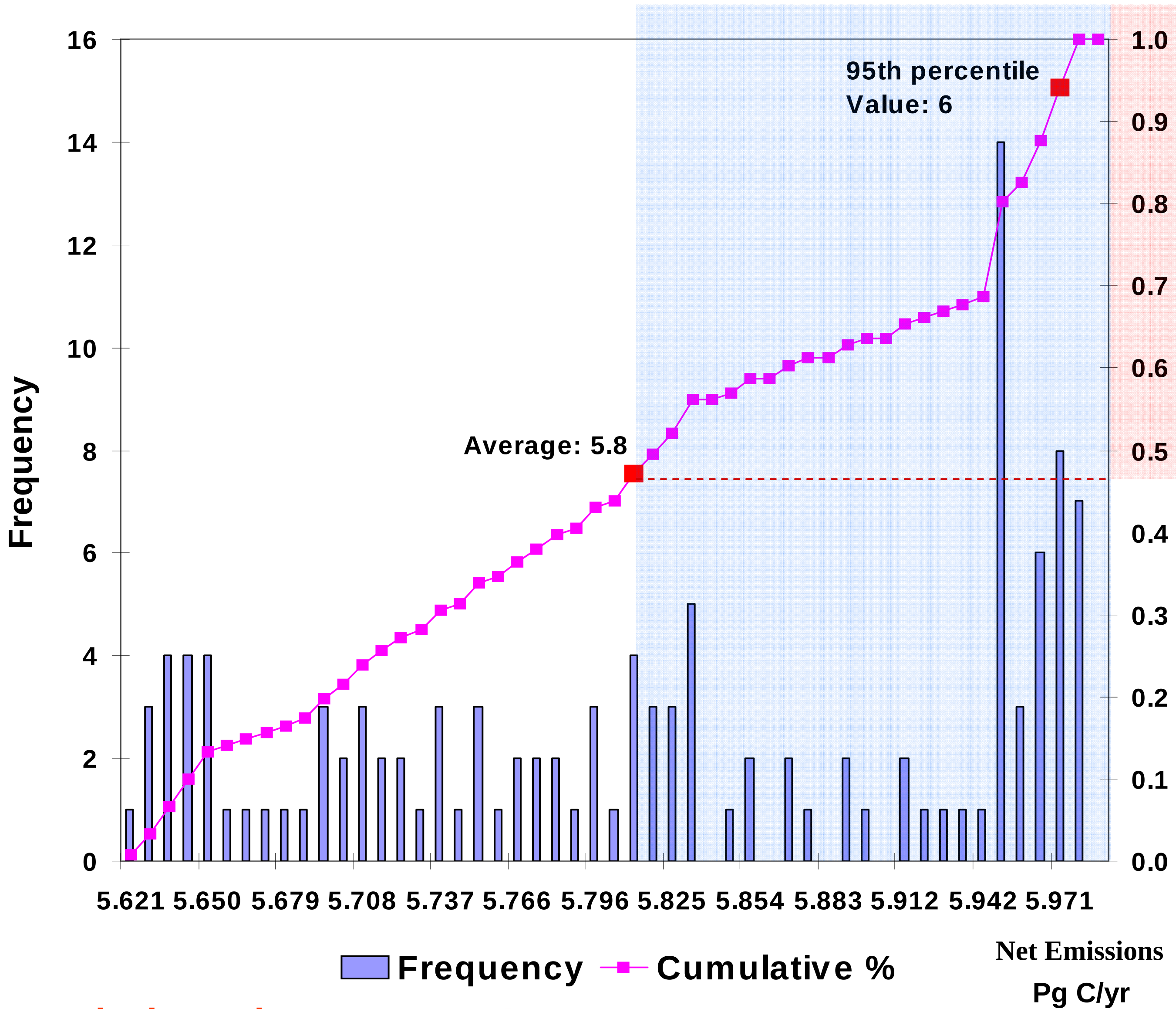
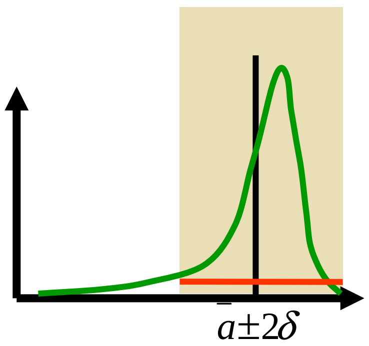




More emissions above average !

The need for “detection” of emission shapes

1. In 1960 to 1970, the terrestrial system was mostly a sink.

2. Average flow -0.13. Higher likelihood of flows larger than average.

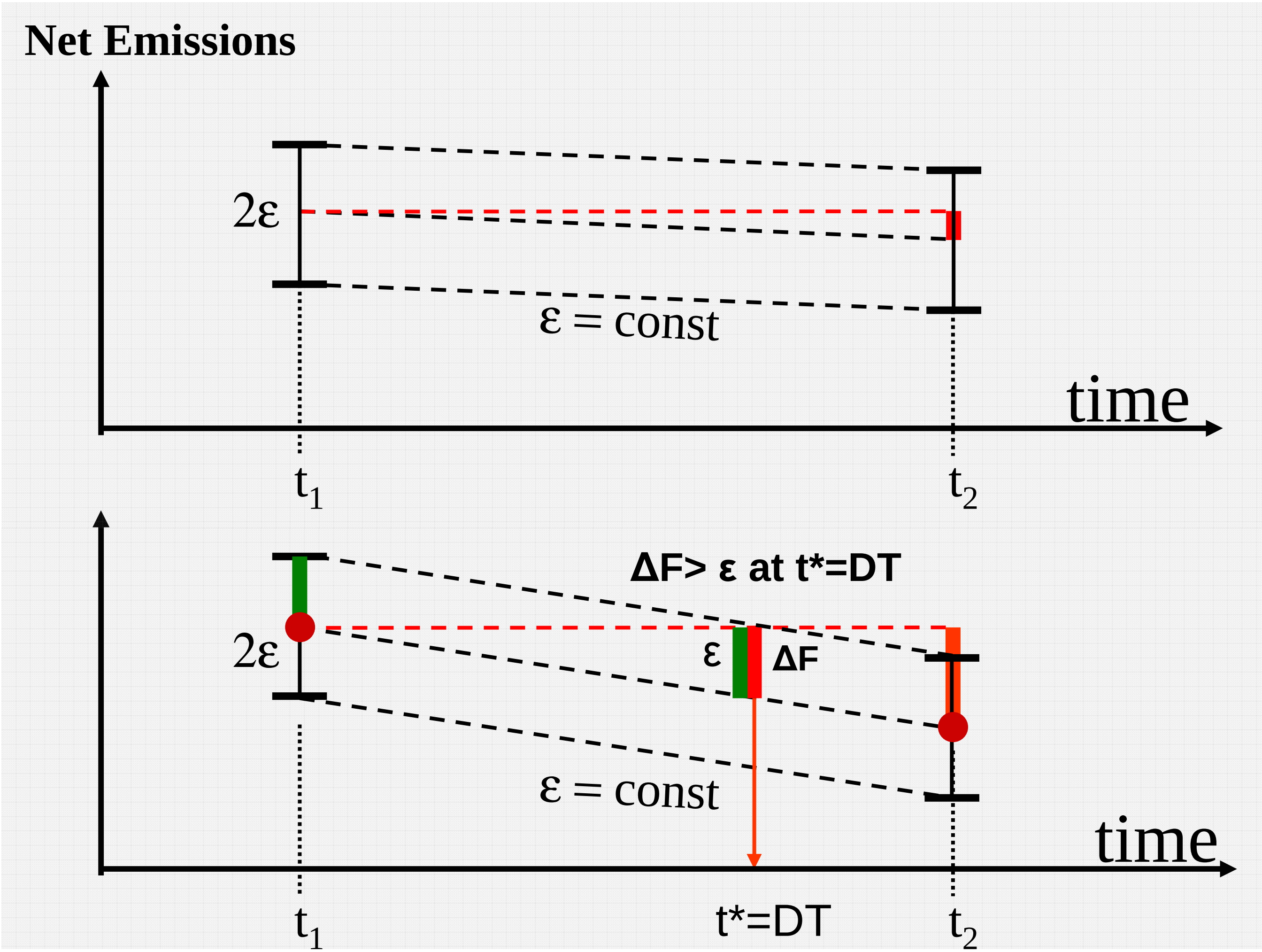
3. More of probability mass below average

4. In 1985 to 1995, it turned to source. Average flow 0.6.

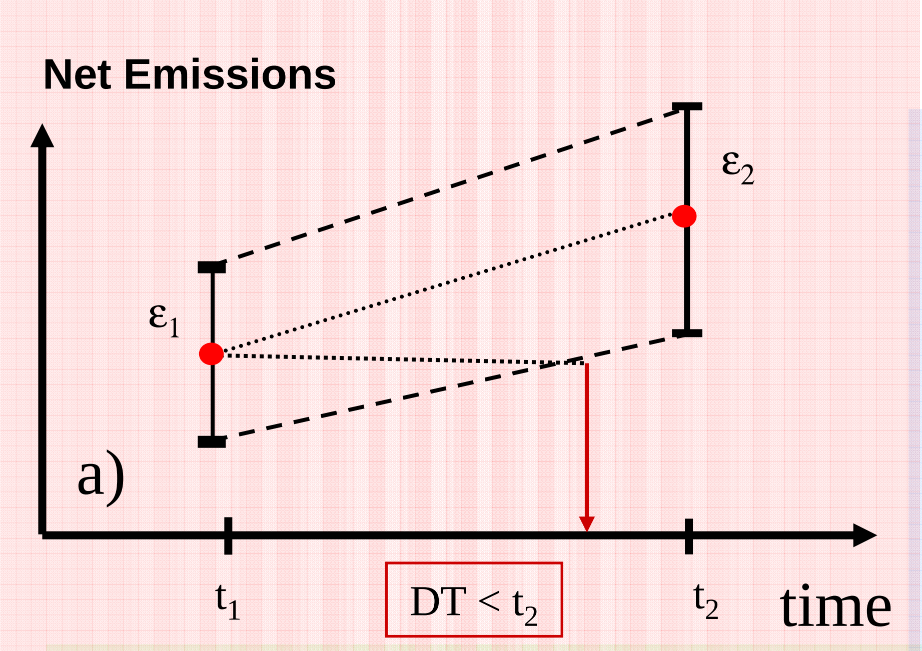
5. More of probability mass above average.

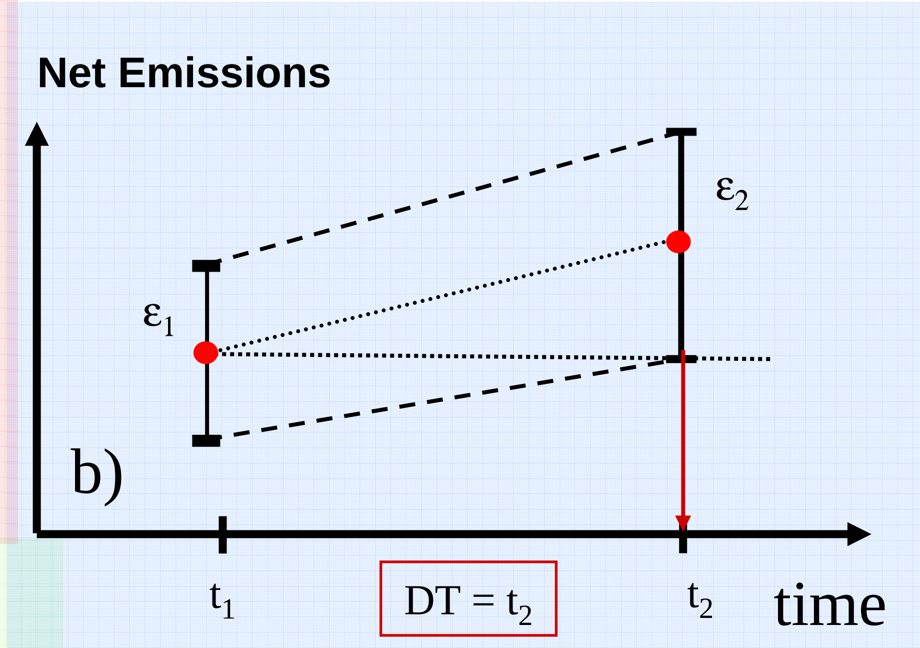
Emission signal: detectability

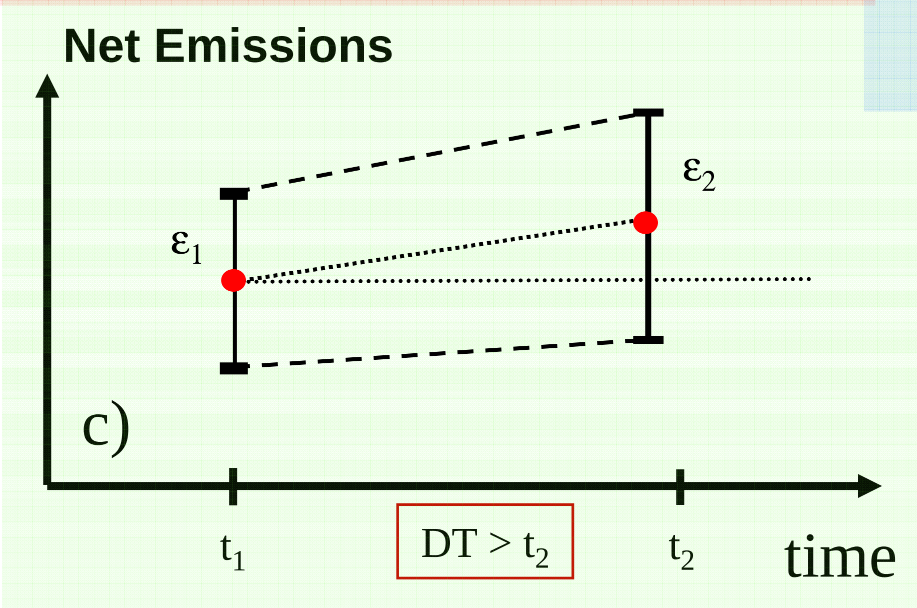
Detect time when emission outstrips the uncertainty represented by a symmetrical interval



Emission signal: detectability

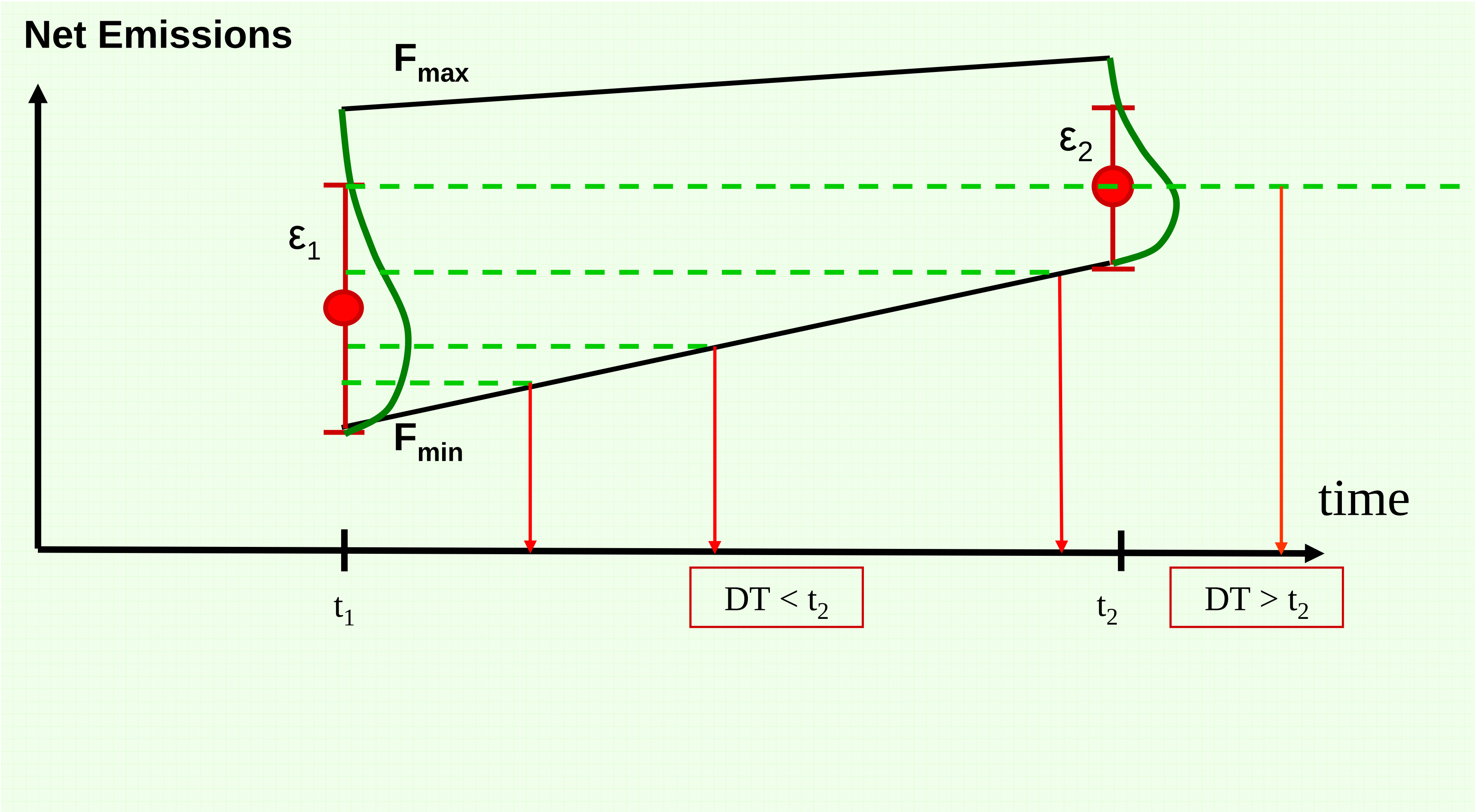






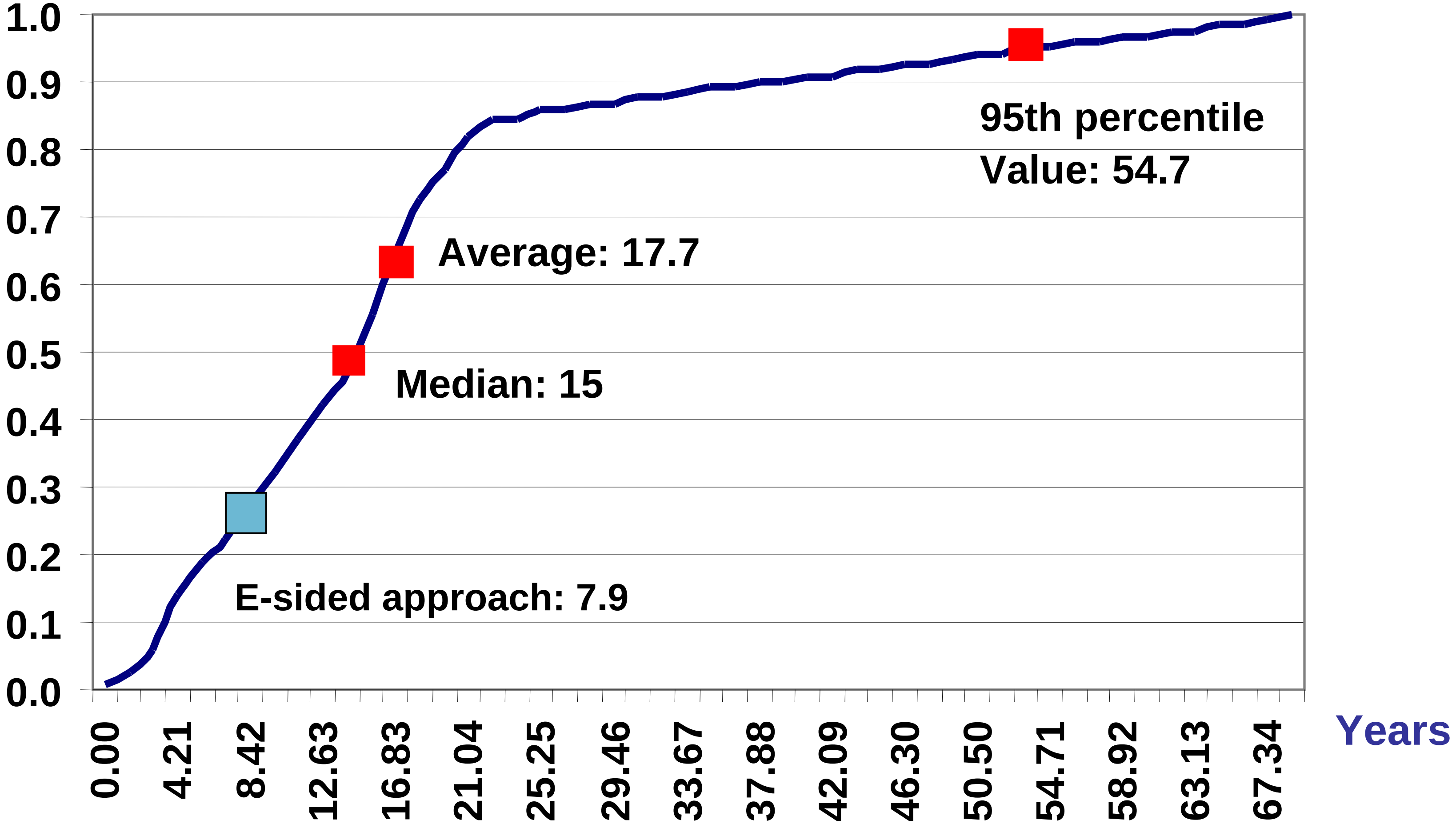
$$\Delta t > \frac{\varepsilon(t_1)}{2\left|\frac{dF_{net}}{dt}\right|_{t_1} - \left(\frac{d\varepsilon}{dt}\right)_{t_1}}$$

Stochastic detection of emission signal



E-sided vs stochastic detection, slow dynamics and large variability:

Net terrestrial uptake, 1965 – 1985



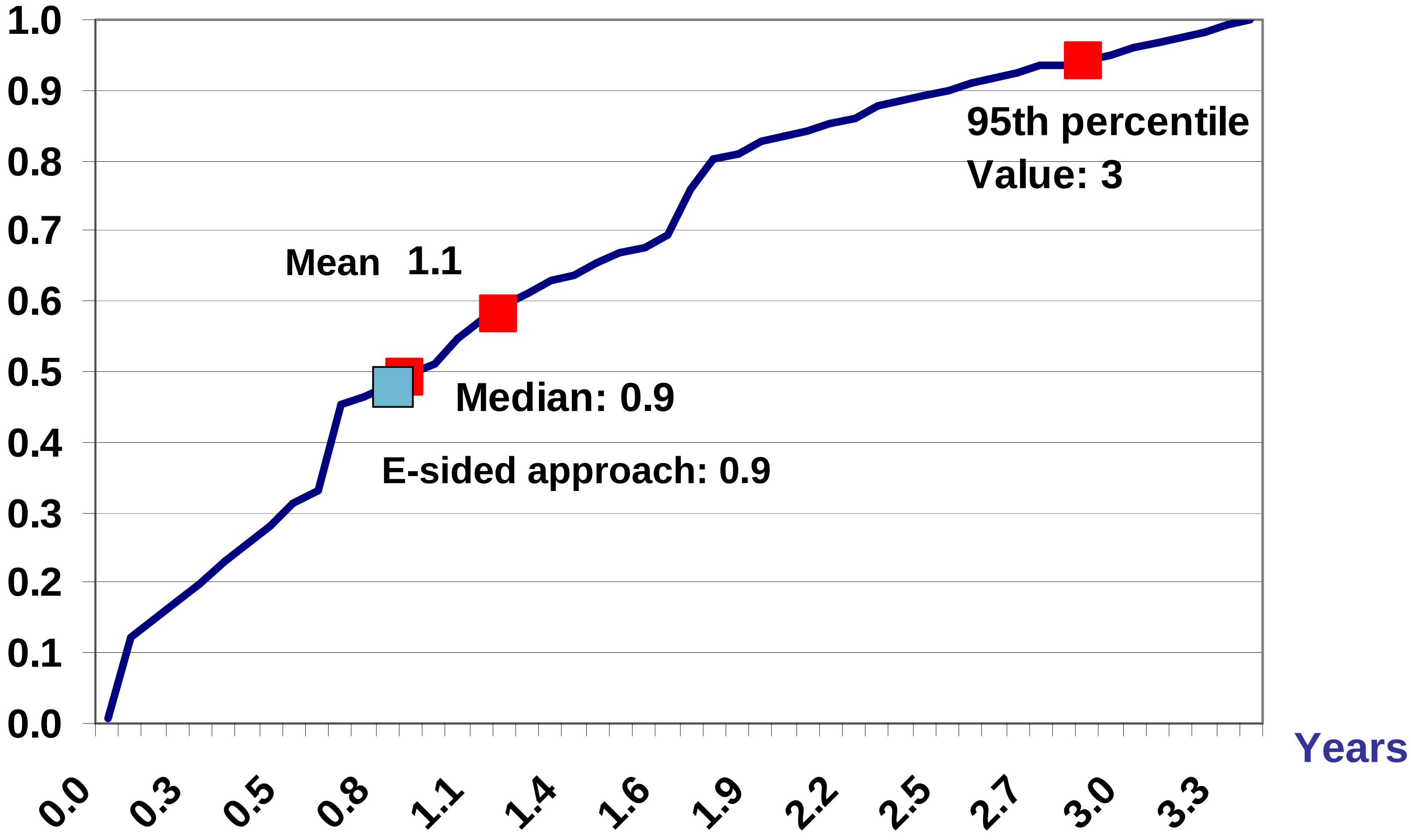
E-sided vs stochastic detection, slow dynamics and large variability:

Net terrestrial uptake, 1965 – 1985

Example 1.	1965–1985	
$F(t_1)$	-0.13	Pg C yr-1
$F(t_2)$	0.18	Pg C yr-1
$\varepsilon(t_1)$	0.16	Pg C yr-1
$\varepsilon(t_2)$	0.39	Pg C yr-1
dt	20	Pg C yr-1
$d\varepsilon=\varepsilon(t_2)-\varepsilon(t_1)$	0.23	Pg C yr-1
$\lvert dF_{net}\rvert=\lvert F(t_2)-F(t_1)\rvert$	0.32	Pg C yr-1
VT	7.9	yr

E-sided vs stochastic detection, fast dynamics vs small variability:

Fossil fuel emissions, 1965 – 1985



Economic implications of stochastic detection techniques

1. Emissions are tradable commodities.

2. Variability of emissions is a key element for pricing commodities

   2.a. Inclusion of various systems (forestry and land use CDMs) in carbon trading market: *Carbon Market Europe, 21, 2006. (Available on request)*

   2.b. Slow dynamic systems (forestry, land use) long response times.

   2.c. The “must” for an appropriate emission detection technique - affects prices.

3. Stochastic detection: what share of possible emissions is detectable within a given time interval.

4. Clean Development Mechanisms (CDM), Joint Implementation (JI) projects.

5. SwissRe and emission trading insurance: emissions uncertainties.

   http://www.swissre.com/pws/transactions.html

6. Insurance of “skewed” risks of emissions trading is similar to Catastrophic risks insurance.

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Conclusions

Stochastic detection technique:

Percentage of possible emissions detectable within a given time

Contrary to e-sided, captures variability of emissions

Applicable for/to evaluation of carbon related financial instruments

(emission trading, investments, Kyoto related mechanisms)

Further research:

Development of specific risk-adjusted pricing procedures for carbon-related products

Detection/analysis of emission outliers

Integrated modeling for the analysis of potential emission trajectories