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Estimating the uncertainty in the EU 15's forest sink

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UNFCCC requirement on uncertainty

"Uncertainty **information** is (..) intended (..) to help prioritizing efforts to **improve the accuracy** of inventories in the future and **guide decisions on methodological choice**" (IPCC, 2000)

Uncertainty statistical definition: An uncertainty is a parameter, associated with the result of measurement that characterizes the dispersion of the values that could be reasonably attributed to the measured quantity (e.g., the sample variance or coefficient of variation).

GHG Inventory definition of uncertainty: A general and imprecise term which refers to the lack of certainty (in inventory components) resulting from any causal factor such as unidentified sources and sinks, lack of transparency, etc.

Accuracy: Accuracy is a relative measure of the exactness of an estimate ….. which should be …. systematically neither over nor … …., so far as can be judged, and that uncertainties are reduced so far as is practicable

Methodological choice refers to the methods used to inventory emission/ removal, to identify the key source categories and to en-sure that trends in national emissions are consistently estimated (IPCC, 2000)

Peculiarities of (EU LULUCF) GHG inventory

…a bottom up procedure (summing and aggregating up the estimates provided by the individual MS)

… most disaggregate quantitative data is available on pools/ sources on each LU sub-category (via CRF tables)

… assuming best available estimates provided by the MS (commitments & *bona fides*, EU QA/QC, revision by UNFCCCC, verifications), and

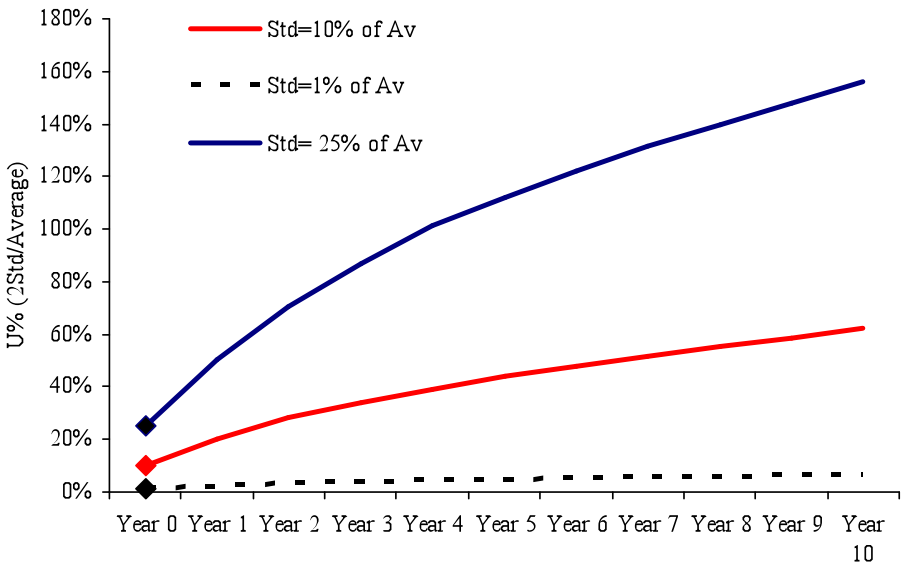
… further assuming that time and space variability specific to LULUCF category is dealt with by the MS

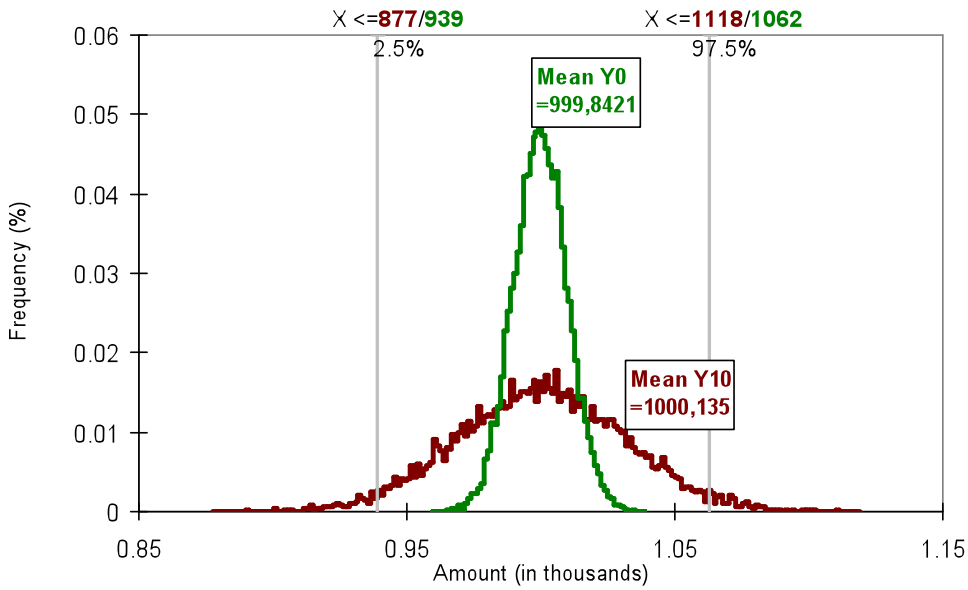
Particularities of LULUCF estimation and uncertainty assessment (1)

- Time consistent within the country, but differences among MS (i.e. definitions and estimation methodologies)
- Estimation based on various datasets and methodologies by MS (i.e. for activity data)
  - Only few basic sources/datasets: NFI, remote sensing, statistics, maps
  - Large variety of underlying methods for datasets/ sources depending on each country (statistical; photointerpretation, mapping & digitization; ground measurements; census; field assessment, etc)
  - GHG computation pathway is different from country to country, as well as the “annual” GHG data computation

Particularities of LULUCF estimation and uncertainty assessment – Activity Data case

- periodic assessment, thus estimates are **intra/extrapolated** or **averaged** or … for non estimated years,
- general filing that "time" issue is still not properly considered in AD's UA





PDFs widens and its shape changes over the projected span and … the uncertainty of smaller initial values is increasing bit faster than for those having high initial value (eg: 2% in Y0 to 6% in Y10)

Particularities of LULUCF estimation and uncertainty assessment – C stock change case

– proxy or easy measurable parameters (no major E/R is directly measured!)

- LULUCF incomplete reporting: missing LUs, pools & sources
- For 5A1 – forest remaining forest land:
    - *omissions* of DOM and SOM pools
        - Reason for doubts on estimates: large differences in reported changes in DOM and SOM pools by neighboring countries (i.e. Belgium, The Netherlands, Germany, France), also SOM-organic soils;
        - Reporting Tier 1 (i.e. Spain, Portugal, Greece) may generate average annually omitted C stock changes of 1.4 th. GgC for DOM (with possible range -2.09 ÷ 7.23 th. GgC) and 5.59 th. GgC for SOM (likely range 0 ÷ 20.06 th. GgC), which represents on average less than 1 % of current net annual 5A1 sink;

– Not transparent data for emissions from disturbances

Particularities of LULUCF estimation and uncertainty assessment (C stock change in 5A1, CO2)

Pool	Annual 5A1 sink shares (%)	Level of the uncertainty of the pools as reported by MS (2Std, %)	Uncertainty of the aggregated pools as reported by MS (2Std, %)	Annual 5A1 aggregated change shares (%)
Biomass - stem	70 %	10%	10-30%	85 %
Biomass - roots	20 %	60%		
Biomass - branches	10 %	60%		
SOM - organic soils	70 %	80%	20-184 %	10 %
SOM - mineral soils	30 %	60%		
DOM - litter	40%	75 %	28-107%	5 %
DOM – dead wood	60%	60 %		
Disturbance (part of Biomass)		100%		

Methods for assessment and quantification of uncertainties (underpinning principles)

- IPCC T1 – error propagation (only for normal distribution!) generates confidence limits for unknown true values,

and

- IPCC T2 – re-sampling techniques (for any type of distribution), generates PDFs for unknown values

Both follow the estimation pathway and allow dis/ aggregation, but second takes easier into account any correlation but rely on the quality of input data

Issues for assessing uncertainty via re-sampling techniques for LULUCF

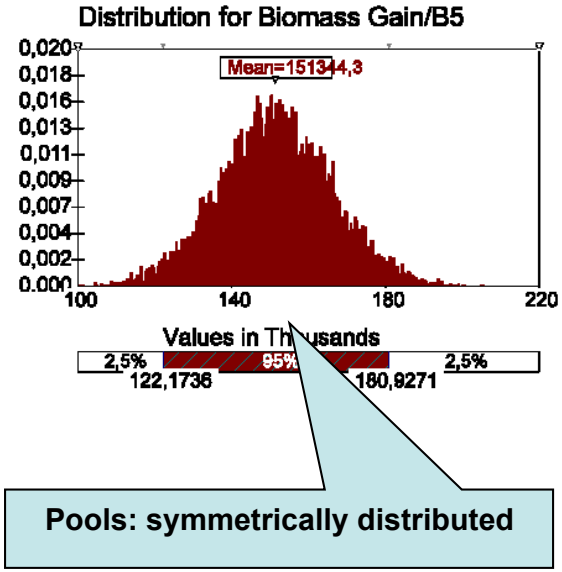
- PDFs shape could be a problem under lack of data for many EF/C stock change factors, with general assumptions:
  - symmetric distributions CO2 both to dis- and aggregated levels
  - asymmetric distributions CH4 & N2O at least at disaggregate levels
- For pure UA the PDF shape may not be very dangerous, but it may heavily affect prediction on lower frequency occurrence events (i.e. target; probability that a certain amount/threshold is reached)
- Uncertainty is simultaneously described by several descriptors (e.g. percentile, median, specific probabilities)
- Easy assessment of versatile or “near nil”, i.e. positive and negative operators, and avoiding indeterminate numbers (eg. division by 0 or infinite U values)
- Easy combination of various GHG (i.e. symmetric /non-symmetric distributions)
- Easier taking into account of time uncertainty
- Sensitivity analysis could be easier performed with appropriate tools

Uncertainty assessment for 1990 and 2008 in EU 15's 5A1 CO2 inventory

- Simple model: excel bookkeeping model for U estimation at EU level
- @Risk, Monte Carlo simulations, 3x10000 runs (<1% change of the monitored estimate)
- Input data is MS inventories C stock change outputs on: Biomass Gain, Biomass Loss, DOM, SOMmin, SOMorg, Disturbance (N.B. not on land sub-categories)
- Input data as normal PDF (CO2 estimate list is complete, any missing uncertainty data as simple average) (data from CRFs, Disturbance computed by JRC tool)

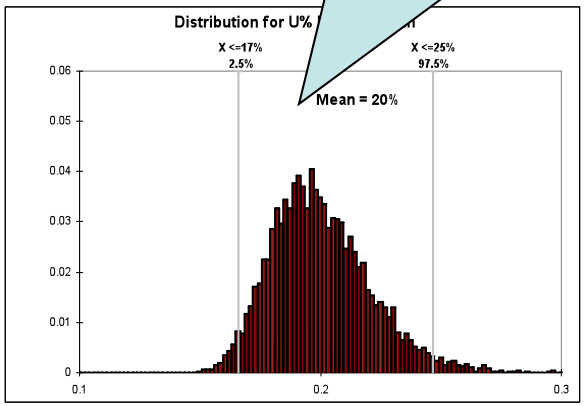
Purpose:

- *assessment of the aggregated uncertainty of 5A1 EU 15's CO2 overall estimate and on individual pools/sources and their trends;*
- *to reveal methodological issues and criticalities in the quantification of uncertainty at EU aggregated level, and eventually,*
- *to set priorities for the GHG inventory improvement from EU perspective*

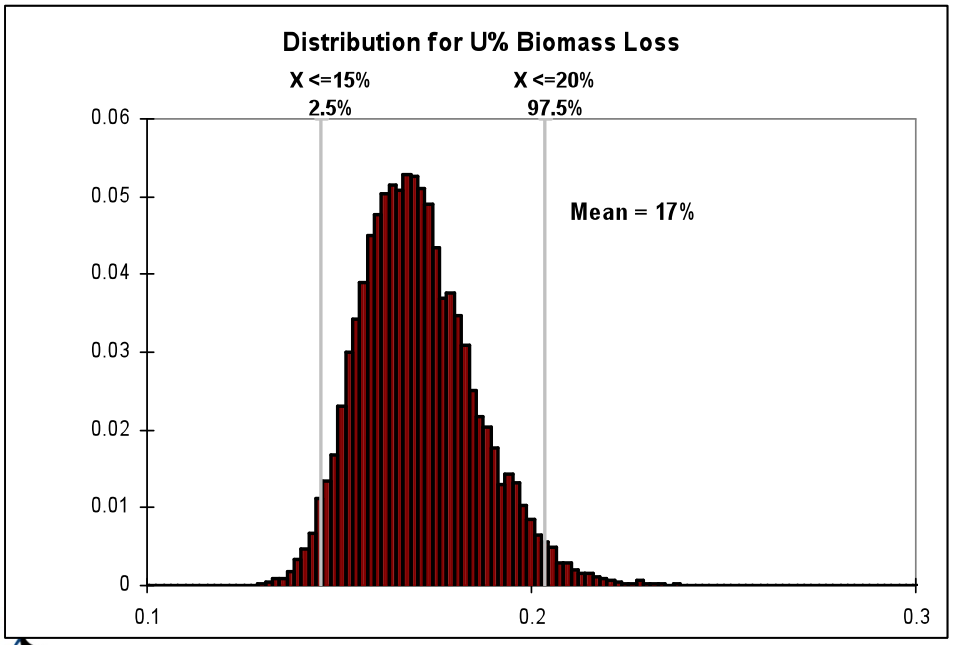


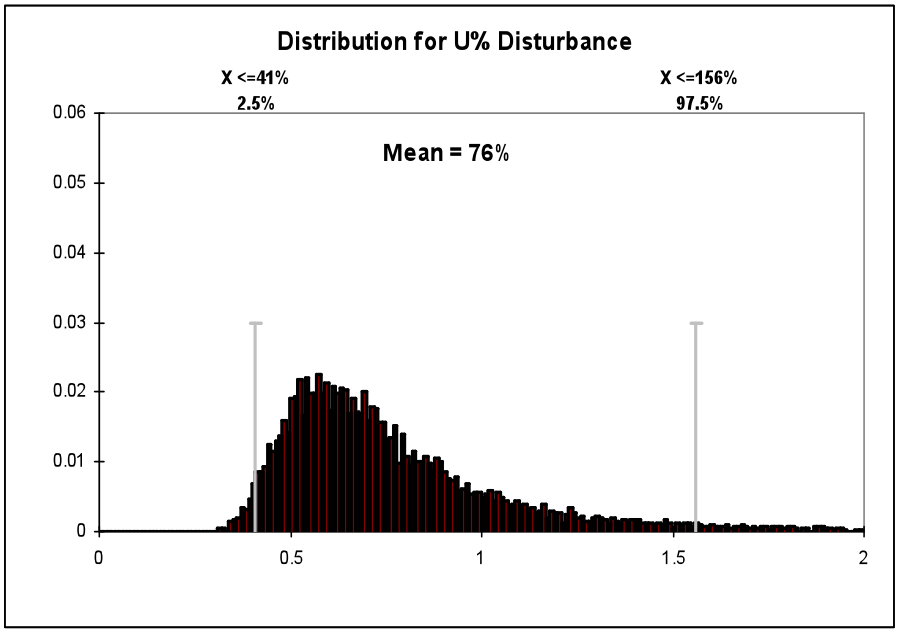
Pools: symmetrically distributed

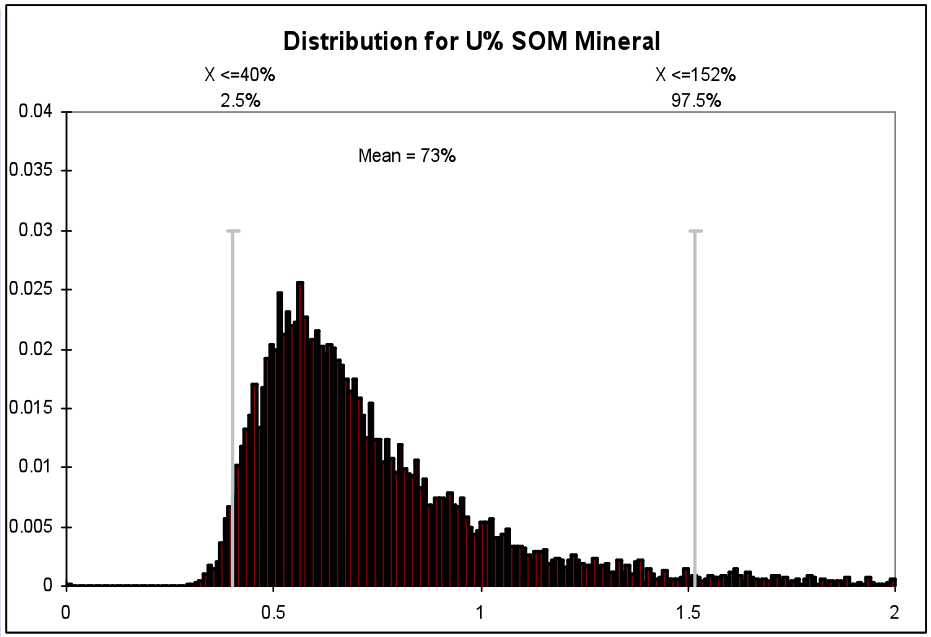
Uncertainty: asymmetrically distributed



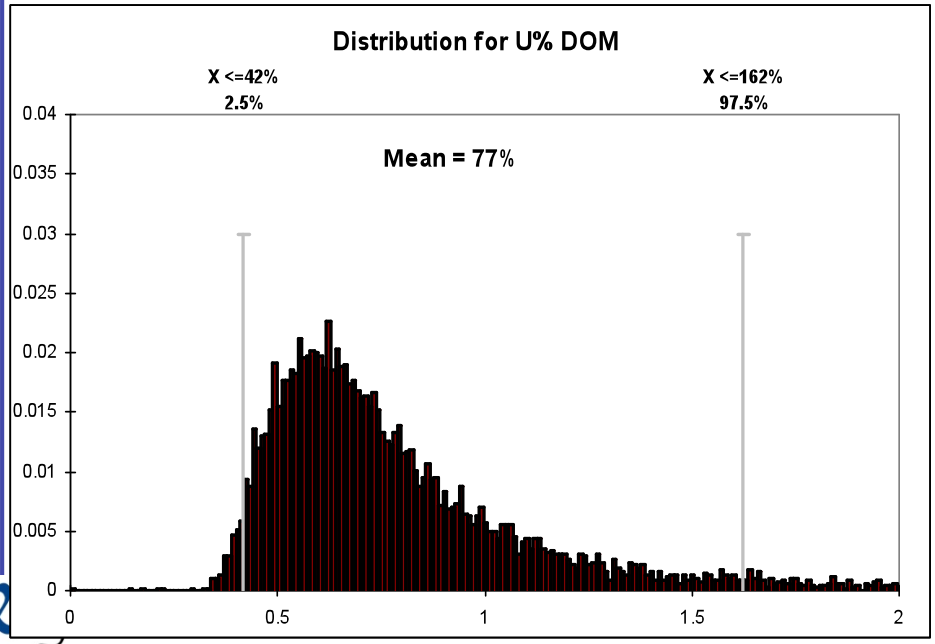
Parameters	Estimated changes in C stock (Gg C)(EU 15) 2008, independent estimates	
	Biomass Gain	Biomass Loss
Most expected	151215	-81124
StdDev	14689	6858

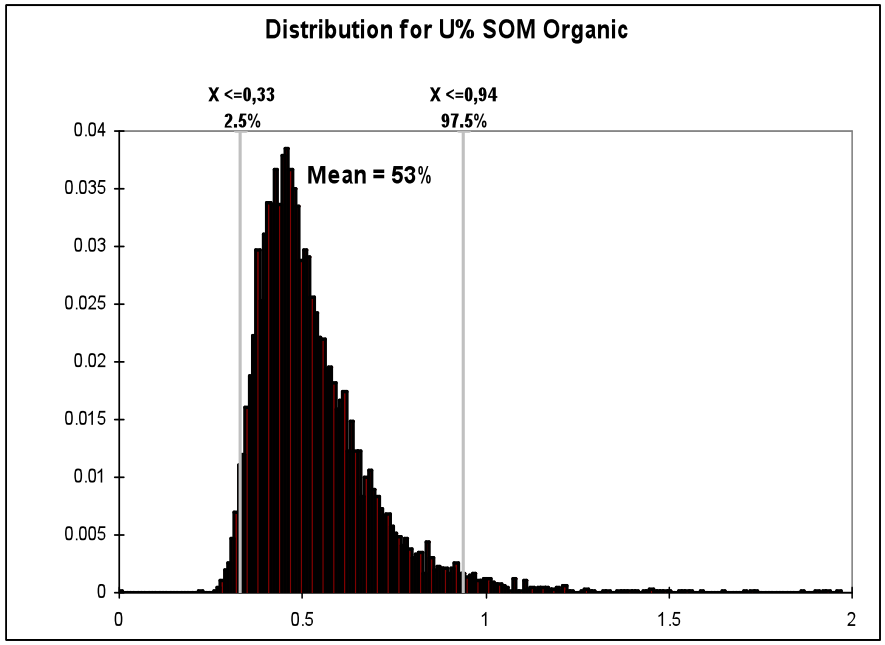






Parameters	Estimated changes in C stock (Gg C)(EU 15) 2008, independent estimates			
	DOM	SOM Mineral	SOM Organic	Actual Disturbances
Most expected	2850	13709	-4321	-1857
StdDev	1015	4561	1083	652

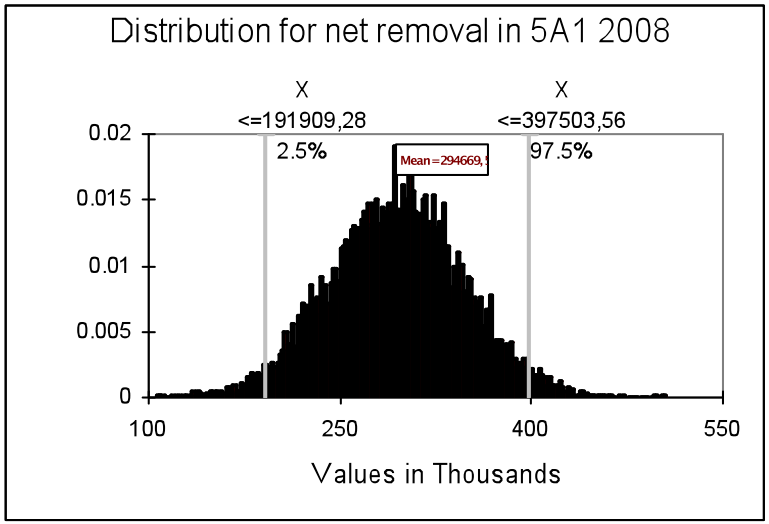


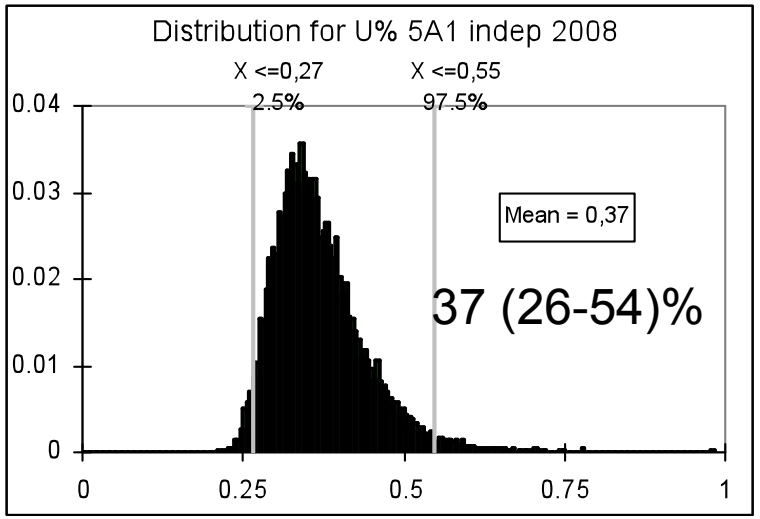


Simply summing up of independent estimates results in lower aggregated uncertainty (as relative/percentage values, while absolute quantity is less than the sum of uncertain inputs)

Eg: 15 MS with 100 % uncertainty in annual removals results in aggregated estimate with only 40 % uncertainty

Parameters	Overall 5A1 net annual removal (gG CO2)
(Most) expected sink	293053
StdDev	52285





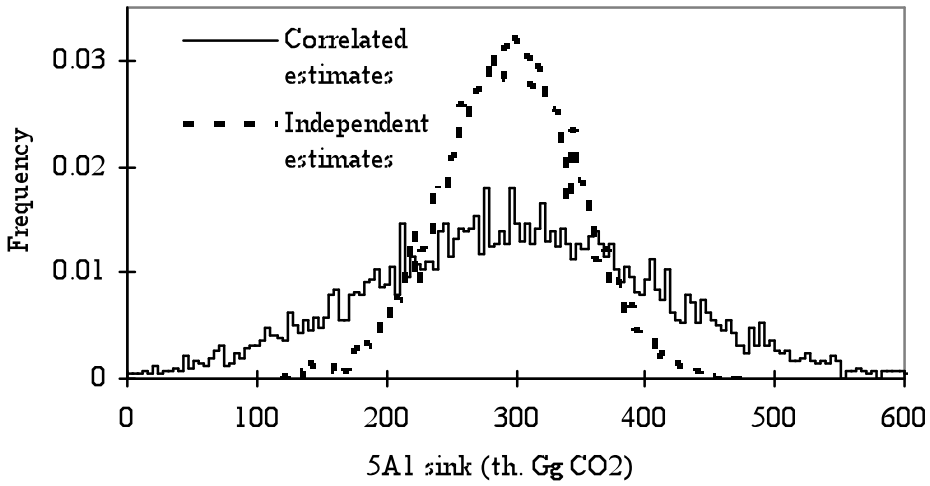
Questions: are the inputs always independent ? is there additional uncertainty over aggregation at EU 15 level?

- Multiple sources of co-variation among MS estimates
  - IPCC default data: BEFs, Root-to-Shoot, CF
  - same allometric equations in trees/stands volume computation
  - “neighboring country” parameters (e.g. EF for organic soils)
  - IPCC default values of uncertainties
  - Tier 1 reporting (“neutral”)

Aggregation of dependent estimates

Case 1) 100 % full correlation on each pool in a year (pool by pool across all MS) results in increasing the overall uncertainty (e.g. MS use default EF):

5A1 total removal (1990 or 2008): 76 (42-240) %



Case 2) 100 % full correlation of pools (pool by pool) across time among all inputs (e.g. MS use EF both in 1990 and 2008) results in increase of the uncertainty

Annual total C stock change in 5A1: 79 (43-280) %, while on individual pools
Biomass Gain: 35 (25-53)%
SOM mineral soils: 105 (100-113)%

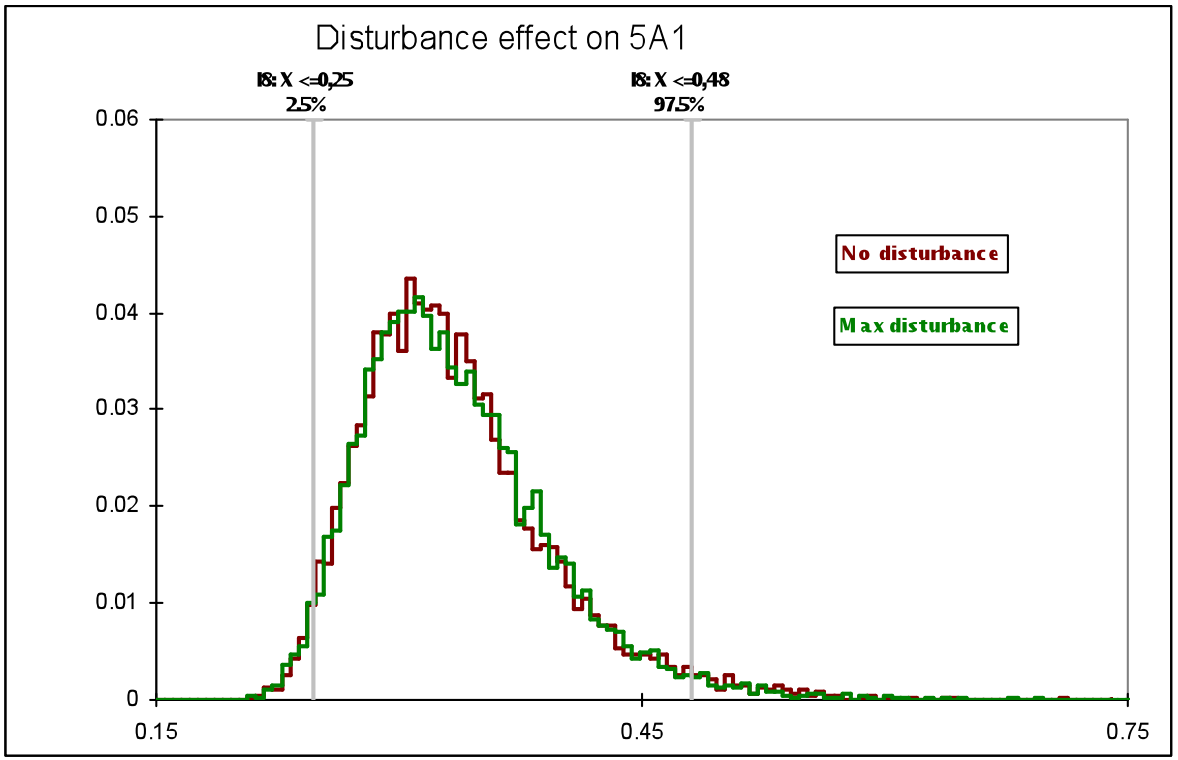
…… ….. …..

This is unrealistic because (at least) new estimates are derived every few years !

Disturbance effect seems low (only forest fire here) !

Annually quantity involved is < 1 % of EU 15 annual C stock change (< 10 th. Gg CO2), it adds up to 2pp to no disturbance uncertainty range, **or**

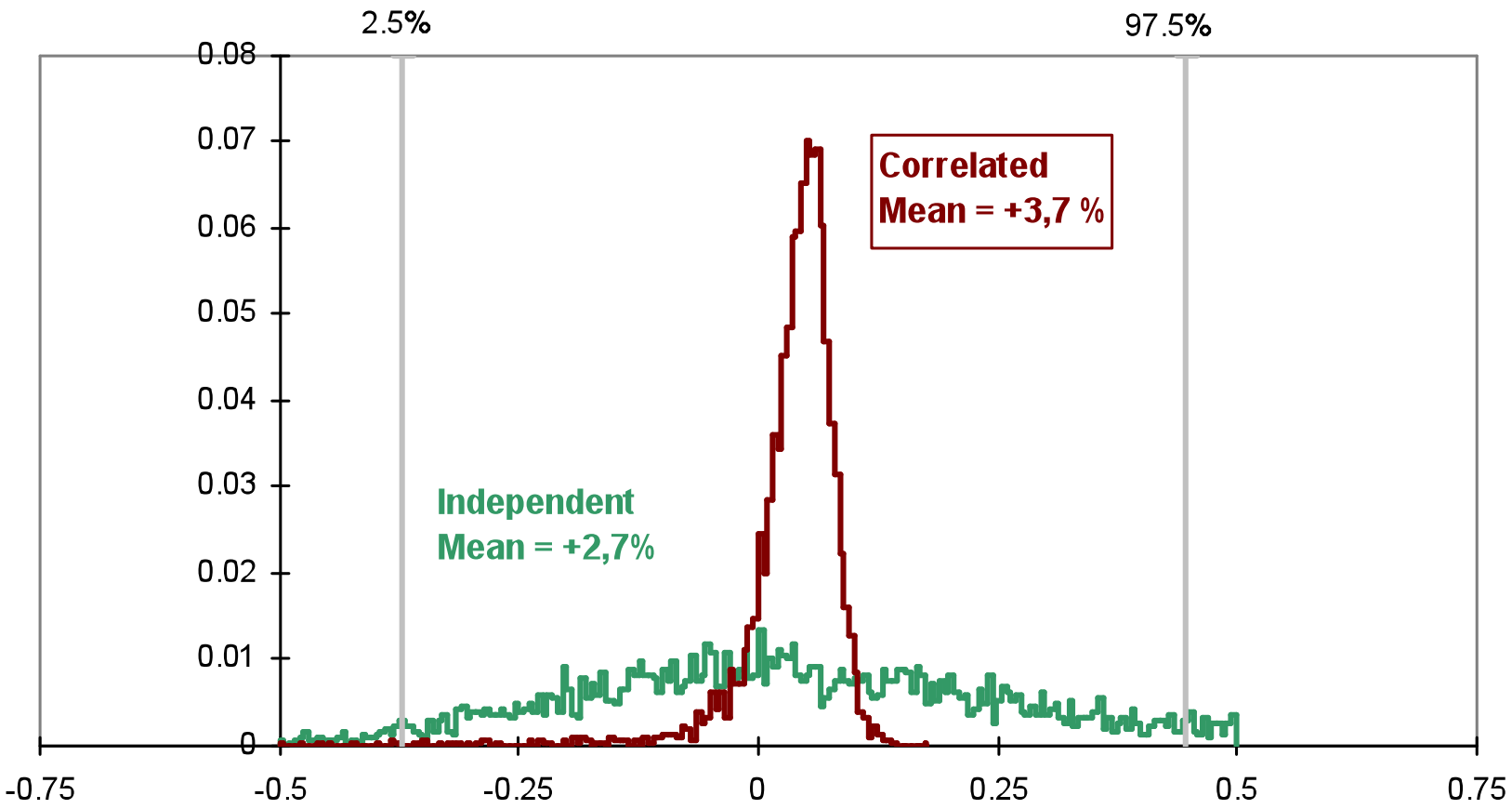
< 7 % of annual EU 15 C stock change (< 22 th. Gg CO2) assuming max of emissions of all fires since 1990 occur in a year, i.e. 2008, it adds up to 2 pp to actual uncertainty range



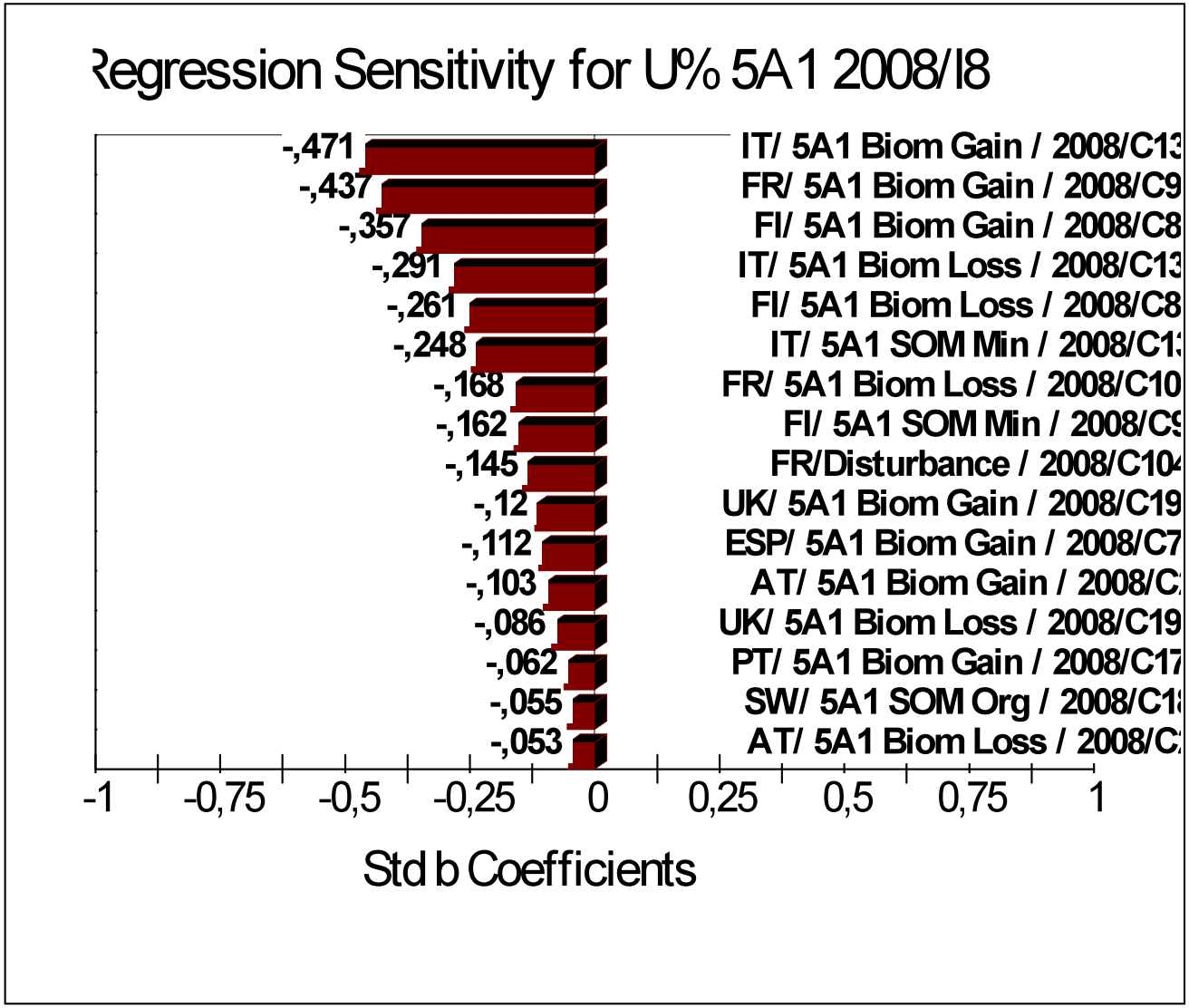
Uncertainty in the trends of aggregated C stock changes

Parameters	Biomass Gain	Biomass Loss	DOM	SOM Mineral	SOM Organic	Distur - bances	Aggregated U% of the trend
INDEPENDENT ESTIMATES							
Most expected 5A1 C stock change (1990-2008)	**1%**	**8%**	**-20%**	**40%**	**-30%**	**-57%**	**4.4%**
Percentile 025	-17%	-15%	-74%	-60%	-69%	-83%	**-35%**
Percentile 975	23%	35%	63%	381%	-53%	-7%	**73%**
100% CORRELATED POOLS							
Most expected 5A1 C stock change (1990-2008)	**1%**	**8%**	**-20%**	**40%**	**-30%**	**-57%**	**4.4%**
Percentile 025	0%	5%	-35%	1%	-35%	-59%	**-6%**
Percentile 975	4%	12%	12%	64%	-25%	-54%	**+10%**

Distribution for U% in 1990-2008 trend of 5A1



Sensitivity analysis for the uncertainty of annual EU 5A1 aggregated C stock change



Can we do it better ? …and conclusions

- Overall ~ 37 %, with
- most uncertain pools are SOM-org; SOM-min and DOM, but as small contributors to EU aggregated C stock change
- main driver of aggregated EU uncertainty is nevertheless the biomass (which is the main contributor to annual C stock change),
- overall aggregated effect of disturbance (i.e. forest fire) is low, still input data to be improved (in NIR ?)
- separation on biomass gain and loss is not always feasible (but should be computed if possible)
- EU MS estimates are rather independent, than correlated
- trend 1990-2008: largely uncertain increasing C stock (so removal)
- uncertainty assessment and QA/QC are tricky as the data type and underlying collection procedure must be clearly understood and transparent, as to also allow verification
- EU is an example of how uncertainty evolves by aggregation at supranational level

- aggregated estimates are less uncertain (Aggregated pools values… ? spatial coverage … ?) – is right the current aggregation in the CRF tables
- quantify, or at least include the uncertainty of “missing emissions” (also for Tier 1 reporting)
- GHG inventory rely on preset rules: is Tier 1 option blocking improved GHG monitoring and further research at various level?

Thank you!