Horizon 2020 Societal challenge 5:
Climate action, environment, resource efficiency and raw materials

VERIFY

Observation-based system for monitoring and verification of greenhouse gases

GA number 776810, RIA

Deliverable number (relative in WP)	**D1.5**
Deliverable name:	First ad hoc meeting for networking between national inventory agencies and the scientific community
WP / WP number:	1
Delivery due date:	Month 6 (July 2018)
Actual date of submission:	Month 12 (18/01/2019)
Dissemination level:	Public
Lead beneficiary:	RIVM
Responsible	Paul Ruyssenaars (RIVM)
Contributor(s):	Paul Ruyssenaars (RIVM), Lucia Perugini (CMCC) Dirk Guenther (UBA), Philippe Peylin (CEA/LSCE) and participants to the meeting (see Annex List of participants).
Internal reviewer:	/

1. Changes with respect to the DoA

The deliverable was initially planned at month 6 (M6) of the project. It relies on the achievement of a workshop between the inventory and the observation based scientific communities. Because M6 was in the middle of the summer vacation period for most participants and given the need to find a date with a maximum of available people, the meeting was only hold at month 10.

2. Dissemination and uptake

This report will be uploaded to the internal web-page of the VERIFY project (SharePoint platform), primarily as a means to disseminate the results of the first stakeholder meeting within VERIFY. But part of the workshop results will also be made publically available (http://verify.lsce.ipsl.fr/) to inventory compilers and scientists, as to help shape up discussions on prioritization of the development of methodologies for improving independent verification of greenhouse gas emissions at several scales. The focus of the project is primarily the European scale, but there may be clear interests on other scales such as the global scale - but even regional/local scale.

3. Short Summary of results (<250 words)

A first stakeholder meeting was organized, involving both inventory compilers and scientists, with the main aim to work on the common understanding of emission inventory reporting concepts, definitions, uncertainties, data gaps and ways to deal with those gaps.
This meeting took place in Paris on November 14, 2018 and engaged about 40 experts.
This report is the first one of a series of reports that will be provided along the project: a second one at month 24, and a third and last one at month 48.

4. Evidence of accomplishment

This report is the deliverable D1.5 for VERIFY.

VERIFY is a research project funded by the European Commission under the H2020 program. Grant Agreement number 776810.

Version	Date	Description	Author (Organisation)
V0	18/11/2018	Creation/Writing	Sonia Firion (CEA/LSCE)
V1	04/01/2019	Writing/Formatting/Delivery	Paul Ruyssenaars (RIVM), with contributions of the presenters from the meeting
V1.5	11/01/2019	Review/Writing	Lucia Perugini (CMCC)/ Philippe Peylin (CEA/LSCE)
V2	18/01/2019	Formatting/Delivery on the Participant Portal	Sonia Firion (CEA/LSCE)

VERIFY is a research project funded by the European Commission under the H2020 program. Grant Agreement number 776810.

VERIFY is a research project funded by the European Commission under the H2020 program. Grant Agreement number 776810.

1. Introduction

The main objective of VERIFY's Work Package 1 (WP1) is to assess the current and future needs of inventory institutions and of the international climate process, and to help design the framework of the project's subsequent work packages based on the identified Monitoring Reporting and Verification (MRV) requirements.

To this end, a number of activities and deliverables are defined under WP1 that aim to clarify the needs of the inventory community. WP1 will among others, develop a user requirement document (URD) for a monitoring and verification system of GHGs to be developed by the subsequent work packages. To do this, WP1 will define accuracy, comparability and comprehensiveness targets for the products of such a system, with the aim to serve policy at various temporal and spatial scales. The work package will also provide an overview of approaches used in GHG inventories at the national scale, and of available methods for verification and their gaps and obstacles.

There is a strong need for interaction between inventory agencies and the scientific community working on carbon, methane and nitrogen cycles. To respond to this need the task will develop short and long-term interactions and networking between inventory agencies and the scientific community. Therefore, one of the aims of WP1 under VERIFY, is to guarantee a regular interaction between the inventory agencies and the other Work Packages.

WP1 will especially seek for the interaction with those work packages that are involved in data provision (WP2-4), involving also relevant external experts and scientists. WP1 aims at organising an exchange of knowledge between the partners involved in the consortium as well as the scientific community, with the aim to contribute to achieving the overall objectives of the project. To this end, three joint meetings will be organised with other WPs, providing feedback and enhancing information flows.

This document reports on the first of these joint meetings; held in Paris on 14 November 2018. It summarises the presentations and the key messages.

VERIFY is a research project funded by the European Commission under the H2020 program. Grant Agreement number 776810.

2. Agenda of the first VERIFY network meeting, 14 November 2018, Paris

MORNING SESSION 9:00 – 12:30		
Session 1 - General introduction -		Moderator: Paul Ruyssenaars (RIVM)
9:00-9:10	Workshop introduction	Paul Ruyssenaars
9:10-9:25	Terminology analysis	Lucia Perugini (CMCC)
9:25-9:45	General inventory approach, requirements, uncertainties and needs	Dirk Günther (UBA)
9:45-10:00	Inventory verification, and the use of independent science approaches	Jo House (UoB)
10:00-10:15	Inventory requirements for developing country perspective	Yusuf Serengiel (IUC)
10:15-10:45	Discussion	
10:45-11:15	**COFFEE BREAK**	
Session 2 - Estimation of fossil fuel combustion CO_2 emissions (WP2)		Moderators: Paul Palmer (UoE)/Dirk Günther (UBA)
11:15-11:35	Introduction on inventory approach and guidelines requirements	Anja Kiesow (UBA)
11:35-11:55	potential contribution of WP2 (with a focus on inventory needs)	Hugo Denier van der Gon (TNO)
11:55-12:30	Discussion	
60 min	**LUNCH BREAK**	
AFTERNOON 13:30-17:00 (with coffee break->17:15)		
Session 3 - Terrestrial CO_2 sources and sinks and carbon stocks (WP3)		Moderators: Philippe Ciais CEA/LSCE)/Lucia Perugini (CMCC)
13:30-14:00	Introduction on inventory approach and guidelines requirements	Colas Robert (CITEPA)
14:00-14:20	1 presentation on potential contribution of WP3 (with a focus on inventory needs)	Philippe Peylin (CEA/LSCE)
14:20-14:50	Discussion	
Session 4 - Estimation of all types of CH_4 and N_2O emissions (WP4)		Moderators : Rona Thompson (NILU)/Jean-Pierre Chang (CITEPA)
14:50-15:20	Introduction on inventory approach and guidelines requirements for main sectors for CH_4 and N_2O gases: • Agriculture (10 min) • IPPU (10 min) • Waste (10 min)	AGRI- Eleonora Di Cristofaro (ISPRA) IPPU - Ann Marie Ryan (EPA Ireland) WASTE-Jean-Pierre Chang (CITEPA)
15:30-15:50	1/2 presentations on potential contribution of WP4 (with a focus on inventory needs)	Rona Thompson (NILU)
15:50-16:30	Discussion	
16:30-17:00	**Final considerations and take home messages**	Lucia Perugini (CMCC)/ Dirk Günther (UBA)

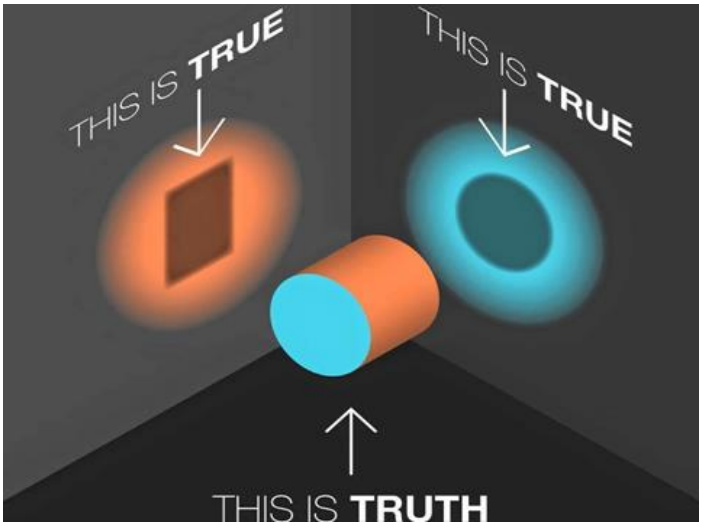
VERIFY is a research project funded by the European Commission under the H2020 program. Grant Agreement number 776810.

3. Report of the Sessions

3.1. Session 1 - General Introduction

3.1.1. Introduction to the meeting (Paul Ruyssenaars, RIVM).

The overall aim of VERIFY aims at improving methodologies and the verification of greenhouse gas emissions. Looking at potential definitions of "verification" at internet, one of the results was: "the process of establishing the truth, accuracy or validity of something".
What is "truth"? This may not always be so clear, and depend on the perspective one is looking at an issue. Following figure (derived from Internet, peterwarski.com) may underpin that.



To put this more in a VERIFY related setting, an article of Tinus Pulles (2018)[1] was quoted, who states that scientists ("true?"), policy makers ("accepted?") and lawyers ("convinced?") all have their own perspective looking at emissions.
In VERIFY, we try to combine these perspectives – both improving the accuracy of inventories & make the results practically applicable for policy makers and stakeholders.

With that in mind, the most important aim of this first stakeholder meeting is to work on the common understanding of emission inventory reporting concepts, definitions, uncertainties, data gaps and ways to deal with those gaps.

3.1.2. Terminology analysis (Lucia Perugini, CMCC).

Short summary of the presentation
Science plays a crucial role in the UNFCCC framework, providing data and methods for GHG estimations and, in the view of the Paris Agreement implementation, serving as "benchmark"

[1] Pulles (2018) Twenty-five years of emission inventorying, Carbon Management, 9:1, 1-5, DOI: 0.1080/17583004.2018.1426970

VERIFY is a research project funded by the European Commission under the H2020 program. Grant Agreement number 776810.

for assessing the collective achievement of the 2°C temperature goal, within the Global Stocktake (GST) process.
On the other hand, the emissions resulting from GHG inventories (GHGIs) provided by Parties under the UNFCCC, and the results from the climate science may be not directly comparable as there are intrinsic differences in scope that should be carefully considered.

The aim of the terminology analysis is to explore issues linked to terminology and definition within each inventory sector, to build a common understanding of the main differences that should lead to a common language to bridge the two communities. The analysis involved directly the inventory agencies within VERIFY, showing that the main terminological issues are related to the LULUCF sector while the other sectors have signaled issues that are more generally linked to different approaches in use between the GHGIs and the climate science such as: system boundaries, temporal and spatial scale, methodologies, emission attribution etc.

To create a common ground for science and inventory frameworks, the deliverable provides the key concepts, terms and approaches in use within the general UNFCCC reporting framework, with an overview of comparability issues between the climate science and GHGIs as reported by the Inventory agencies. The analysis of the terminology problems is provided in details for the LULUCF sector, which was the sector that mostly reported problems linked to the different terms in use. In addition, to increase the understanding of the inventory framework, the main inventory methods and approaches are reported for each sector, describing the main terms in use.

Key messages

- Improve mutual understanding;
- Whenever possible, refer to IPCC GL terminology;
- Careful choice and declaration of the component of the fluxes included or not in the studies;
- Possibility to disaggregate/aggregate components to increase comparability;
- Acknowledging this discrepancy in the land sector is key for the full understanding of the outcome of the GST and the overall balance of emissions and removals.

VERIFY is a research project funded by the European Commission under the H2020 program. Grant Agreement number 776810.

3.1.3. General inventory approach, requirements, uncertainties and needs (Dirk Günther, UBA Germany).

Short summary of the presentation

For national inventories, greenhouse gases are mostly calculated (not measured) on the basis of the (simplified) formula:

$$E = AD * EF$$

Where

AD = activity data;
EF = (gas-specific) emission factor.

The calculation and compilation of national GHG inventories is based on the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (rules for calculations) and the UNFCCC Reporting Guidelines for National Greenhouse Gas Inventories (rules for reporting).
GHG emissions have to be reported in time series on a source category based approach for the categories energy, industrial processes and product use, agriculture, Land-use, Land-use change and forestry and waste. In addition inventories have to follow the quality principles of transparency, accuracy, completeness, coherence and comparability.

A permanent quality control and a verification of results are obligatory. As well as an analysis of the key categories and the uncertainties on a source category base is mandatory. These assessments are analyzed by WP1 on the key categories and gases with the highest uncertainties.
Within the framework of WP1, a survey has been conducted on the methodologies used for emission calculation among all EU MS inventory agencies as well as the participating Inventory agency partners in VERIFY. The aim is to identify methodological weaknesses in the calculation of key categories with high uncertainties were VERFIY can support inventory agencies.

Key messages

- Emissions calculation and inventory compilation is strictly based on source categories;
- CO_2 and the energy & industry sectors have only low uncertainties and a high share of the emissions in EU28 Members states;
- CH_4 and N_2O have rather high uncertainties, in particular in land-based categories (Land Use) and the waste sector. Note that, although both are key categories, the importance of these sectors is limited;
- EU 28 MS use 2006 IPCC Guidelines together with country-specific tools and models in several categories. For some categories this is due to specific weaknesses in the IPCC methodology for the national circumstances, as first results of the survey shows. Once the survey is further elaborated, the results will be made available on the project workspace;

VERIFY is a research project funded by the European Commission under the H2020 program. Grant Agreement number 776810.

- Atmospheric science (measurements) might best help in the fields of land-based emissions and non-CO_2 emissions and of CO_2 emissions on a sub-national (regional/ local) and sub-annual resolution.

3.1.4. Inventory verification, and the use of independent science approaches (Jo House, University of Bristol)

Short summary of the presentation

Several methods have been identified that may help improve the inventories from the science perspective:

- ground measurements (forest inventory, soil carbon);
- flux measurements;
- satellites: land cover, biomass, fire, concentrations, etc.
- process models (e.g. bookkeeping, DGVM, ECOSSE);
- inversions.

An information matrix was introduced, as to help structuring the discussion between inventory compilers and scientists. The development of an information matrix is an attempt to identify weaknesses in the inventories and ways to address these weaknesses from the science perspective. A matrix for the LULUCF sector (to be further elaborated/ filled in) is presented in the table underneath, just as an example. Each sector has its own merits and sector specific methods need to be discussed and developed.

LULUCF	WEAKNESSES IN INVENTORY	INVERSIONS REGIONAL/ NATIONAL/ SUB-NATIONAL	SATELLITE	PROCESS BASED MODELS	GROUND BASED INVENTORY MEASUREMENTS	FLUX MEASUREMENTS
LAND CONVERTED	C stocks, rates of growth/ decomp.	Trends?	AD, biomass emissions	EF, emissions	AD, EF	EF
LAND REMAINING	ditto		Biomass change?	EF, emissions	AD, EF	EF
AGB/BGB						
SOC MINERAL/ Organic DOM						
Wetland CH4						
Anthropogenic biogenic						
Total biogenic		Quantity and trends				

Additionally, a discussion on the discrepancies between different estimates of CO_2 fluxes for the AFOLU sector was made, using recent results. A large part of the differences between the

VERIFY is a research project funded by the European Commission under the H2020 program. Grant Agreement number 776810.

estimates from the "GHG inventories", the "Bookkeeping models" and the "Dynamic global vegetation models" can be explain by differences in the accounting system including or not indirect human induced effects and natural effects.

Key messages

- Some countries (UK, Switzerland) compare the results of inverse modeling with their inventory data, as a means to get insight in the uncertainties in the inventory and for setting priorities for improvement of their inventories. (Also other countries, like the Netherlands are looking into options to introduce this mechanism for inventory improvement).
- Further work within VERIFY on elaborating tables like the one shown above, may be helpful for (discussions on) setting priorities/define areas where further development of methods can really add value;
- Filling in this matrix may help increasing transparency on what the methods can/cannot do.

3.1.5. Inventory requirements from a developing country perspective (Yusuf Serengil, Istanbul University-Cerrahpasa - IUC).

Short summary of the presentation

Inventory cycle is a process that is very similar between developed and developing countries. Major component in this process is the data requirement related to AD and EFs. These data may not be readily available for the developing countries. The data requirements may differ not only based on the development status of the country but also land area and land use dynamics including the forest cover.

National Forest Inventory is the basis of LULUCF sector calculations together with satellite data. One major obstacle for the developing countries is the availability of historic data. Country specific EFs are also problematic in developing countries. They tend to use IPCC default numbers that include large uncertainties. Furthermore, capacity building for the preparation of the greenhouse gas inventories has always been a major issue. On the other hand, most reporting requirements for these countries are not mandatory but rather encouraged. It is expected that the differences in reporting requirements for developed and developing countries will disappear in coming years. The Paris Agreement rulebook is expected to be accepted during COP24 this year; after that we may have a better view on reporting systems.

Key messages

- The developing countries are preparing and submitting GHG reports as a chapter in BUR and NC reports, in accordance with Decision 17/CP.8", "Guidelines for the preparation of national communications from Parties not included in Annex I to the Convention";
- Decision 17/CP.8 mandates that each non-Annex I Party shall, as appropriate and to the extent possible, provide in its national inventory, on a gas-by-gas basis and in units of mass, estimates of anthropogenic emissions of carbon dioxide (CO_2), methane (CH_4) and

VERIFY is a research project funded by the European Commission under the H2020 program. Grant Agreement number 776810.

nitrous oxide (N_2O) by sources and removals by sinks. Non-Annex I Parties are encouraged, as appropriate, to provide information on anthropogenic emissions by sources of hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6). They are encouraged, as appropriate, to report on anthropogenic emission by sources of other greenhouse gases such as carbon monoxide (CO), nitrogen oxides (NOx) and non-methane volatile organic compounds (NMVOCs). Other gases not controlled by the Montreal Protocol, such as sulphur oxides (SOx), included in the IPCC Guidelines, may be included at the discretion of the Parties;

- The GHG reports prepared by the developing countries are not very strict and vary, based on the status of the developing country (small island states, least developed etc.)
- In accordance with the IPCC Guidelines, Parties may use different methods (tiers) included in the Guidelines, giving priority to those methods which are believed to produce the most accurate estimates, depending on national circumstances and the availability of data. As encouraged by the IPCC
- Developing countries are encouraged to use their country-specific and regional emission factors and activity data for key sources or, where these do not exist, to propose plans to develop them in a scientifically sound and consistent manner, provided that they are more accurate than the default data and documented transparently.
- At COP 13, through the Bali Action Plan, Parties agreed on the principle of applying monitoring, reporting and verification (MRV) for developing country Parties, which laid the foundation for the subsequent elaboration of the existing comprehensive MRV framework for developing country Parties. MRV occurs at the international level, but can also be voluntary at the national level. The UNFCCC Secretariat released a new handbook on MRV for developing countries.

VERIFY is a research project funded by the European Commission under the H2020 program. Grant Agreement number 776810.

3.2. Session 2 - Estimation of fossil fuel combustion CO_2 emissions (WP2)

3.2.1. Introduction on inventory approach and guidelines requirements, Anja Kiesow (UBA, Germany)

Short summary of the presentation

The energy sector is, in terms of emissions, the most dominant sector. The sector is largely driven by the energy economy and industry (both stationary) and transport (mobile). The key principles of the calculation of the GHG emission inventories for the energy sector were explained and gave insight from where data for emission factors and activity data are gathered.

Reporting of emissions according to the Common Reporting Format (CRF) is regulated in the Reporting Guidelines by the UNFCCC; the methodologies for estimations on emissions (the calculation) is regulated in the corresponding volumes of the 2006 IPCC Guidelines.
National energy statistics and EU Emission Trading System are reliable data sources of emission factors and activity data. The main conclusion of the presentation is that robust data on CO_2 emissions in the energy sector are available, with recognized emission sources. Hence uncertainties in the energy sector and for CO_2 are relatively low, compared to other sources and gases. Also the TACCC principles are met. Possible contribution by modeling and satellites to further improvement of data quality are rather limited.

Key messages

- LULUCF & Waste sectors (esp. for CH_4 and N_2O) are most uncertain sectors. Atmospheric measurements regarding the LULUCF sector were introduced, but non for the waste sector;
- There are still differences in the terminologies and definition of anthropogenic/biogenic emissions, especially in both mentioned sectors;
- Sectoral “data-driven” ecosystem models may be directly helpful for UNFCCC reporting;
- Uncertainty reporting among countries are inconsistent;
- Reporting and calculation guidelines provided by UNFCCC & IPCC Guidelines are robust – however, a number of parameters used for the estimation can be improved by atmospheric measurements;
- Especially in developing countries, statistical data are lacking. During the meeting there was a plea from IEA not to disregard the quality of energy statistics. Datasets are based more on satellites data and scientific methodologies. Important question may be how to involve developing countries?

VERIFY is a research project funded by the European Commission under the H2020 program. Grant Agreement number 776810.

3.2.2. Possible contributions of WP2 to inventory compiler needs (and vice versa), Hugo Denier van de Gon (TNO).

Short summary of the presentation

The order of importance of GHG emissions from EU countries is generally: HFC ≤ N_2O < CH_4 < CO_2 while the uncertainty order is exactly the opposite. Especially for CO_2 the situation is extreme, with generally over 80% contribution and an estimated uncertainty of ~3%.
The ambition/ability of VERIFY WP2 is not to further reduce this 3% uncertainty.
However, underneath are more complex questions that we need to address such as:

- The increasing use of biomass as a fuel. The question is raised if this is entirely climate neutral;
- How to help cities if they want their local CO_2 emissions and trends quantified for their climate-neutral ambitions?
- How will the uncertainty change when ambitious EU plans for CO_2 reduction towards 2030 are implemented?
- Can we understand the source-sink balance for CO_2 over Europe?
- Will we be able to confirm the trends as reported based on statistics?

VERIFY WP2 intends to support inventory agencies with research developments addressing such questions. For example, more accurate determination of the LULUCF CO_2 fluxes cannot be achieved without better understanding of fossil fuel and biofuel combustion emissions. While reporting guidelines only ask for national scale annual emissions to answer the more detailed and complex questions we need better spatial and temporal disaggregation of the emissions if we attempt to verify these using observations and (inverse) models.
To constrain source sectors we need information on the co-emitted species like NO_x or CO. To inversely calculate fluxes for a certain domain or case study area we need uncertainty information for all components of the system (activity data, emission factors, models, measurements). VERIFY WP2 is working on all these issues and in close cooperation with inventory agencies we may be able to achieve results needed by all involved.

Key messages

- There is no “low hanging fruit” to improve CO_2 inventories and reduce uncertainties but over time inevitable that an atmospheric-based CO_2 assessment supports policy makers in confirming targets are achieved;
- Current uncertainty in National Inventory Reports (NIR) is (very) low, but party defined by methodology in NIR. In time and space, uncertainty is substantially higher;
- Biofuel use is changing rapidly, is it all truly short cycle? Quantification is needed to understand the CO_2 concentrations changes over Europe as it is already ~10% of the emissions and the share is increasing.
- Source – Sink CO_2 in Europe is poorly understood – LULUCF CO_2 is highly uncertain. A complete system addressing all CO_2 fluxes is needed to improve this.

VERIFY is a research project funded by the European Commission under the H2020 program. Grant Agreement number 776810.

- WP2 can provide high-resolution spatial maps to WP1 members if desired for checking or support of (sub) national scale studies. WP2 will do a case study in the Rhine valley area, which will work towards proof of concept.
- WP2 noted (and confirmed by WP1 inventory compilers) that the uncertainty information from the NIRs is not harmonized between countries. WP1 can help WP2 to jointly compile a good overview of sectors and uncertainties for a number of EU countries.
- This is Year 1 of the VERIFY project; more interaction by WP1 and WP2 like the Paris WP1 meeting is needed in the next years to keep the dialogue and ensure both uptake of results and awareness of needs from both sides.

VERIFY is a research project funded by the European Commission under the H2020 program. Grant Agreement number 776810.

3.3. Session 3 - Terrestrial CO_2 sources and sinks and carbon stocks (WP3)

3.3.1. Introduction on inventory approach and guidelines requirements, Colas Robert (CITEPA)

Short summary of the presentation

The first deliverable under WP1 has focused on a (comparison of) terminology applied by GHG inventory experts and scientists. The LULUCF sector (Land-Use, Land-Use Change and Forestry) shows out to be the most complex sector, for several reasons:

- use of areas as activity;
- definition of 'managed land' and 'anthropogenic sources and sinks';
- heterogeneity of land-use data;
- uncertainties regarding the estimates of fluxes and stock change (e.g. soil organic carbon).

Some emissions related to the soil are estimated within the Agriculture Sector. CO_2 emissions from the soil and biomass are included in the LULUCF Sector. Countries apply IPCC 2006 Guidelines and UNFCCC decisions for estimating and reporting this sector in their national inventories. They have to define the managed land, estimate the areas for each land use categories (Forest land, Cropland, Grassland, Settlements, Wetland, Other land) and for sub-categories if relevant, and estimate the annual land-use change matrix between all these categories. This can for example be done using land-use survey statistics or vector-based land-cover change maps. Each country calculates GHG fluxes associated to each land-use category remaining the same; for each transition from one land-use category to another; and for each carbon pool (living biomass (aboveground, belowground), dead biomass (dead wood, litter), soil organic carbon and harvested wood products). This can be done using a "gains & losses" method (often used for forest biomass) or a "stock change" method (which is mostly used).
Overall, hypothesis and datasets used among countries are quite heterogeneous. European projects and activities focus on improving this, in particular in the context of the 529/2013 decision and the 2018/841 regulation, that ensure the improvement of robustness and comparability between EU LULUCF inventories.

Key messages

- The clarification of perimeters (Direct and indirect anthropogenic sources and sinks? Managed forest or total forest? Data temporal extent for estimating land-use change? Urban green spaces taken into account? Cropland soil management and fertilization taken into account? Gross fluxes or net fluxes?) and the definition used (Definition of forest, of grassland?...) are crucial issues in this sector to better ensure comparability and understanding between results of independent research and inventories;
- Due to the high uncertainties of the inventories in this sector, independent estimates are welcome and useful, for example: confirmation of a net sink/net source (e.g. over low-managed forests, over grasslands, etc.); estimation of gross fluxes (e.g.: after a deforestation, after a conversion from grassland/shrubland to cropland…), etc. In

VERIFY is a research project funded by the European Commission under the H2020 program. Grant Agreement number 776810.

addition, other sub-products can be useful, such as clean and consistent land-use change series, etc.

3.3.2. Possible contributions of WP3 to inventory compiler needs (and vice versa), Philippe Peylin (CEA/LSCE).

Short summary of the presentation

The ambition/goal of VERIFY - WP3 is to provide new "observation based" information on the net CO_2 fluxes of land ecosystems, in particular for the LULUCF sector in order to help national reporting and for the global stock take evaluation, especially the European contribution. Although providing national-scale flux estimates (as needed for the inventory agencies) from a combination of bottom-up and top-down approaches remains a scientific challenge, more specific questions can be tackled. Can we provide reliable mean net CO_2 fluxes for the European scale? Can we monitor long-term trend in European CO_2 fluxes? Can we detect the impact of mitigation strategies at the country/European scales? How long would it take to detect these impacts? Is there a consensus on the potentially larger Eastern Europe land carbon sink from observation-based approaches?

These questions will be central in the development of a pre-operational system to monitor CO_2 fluxes in WP3.

Key messages

- The "observation based" estimates of natural CO2 fluxes proposed in WP3 of VERIFY combine both the information from ecosystem models (bottom up approaches) and atmospheric measurements (top down approaches). Atmospheric observations are rarely used alone and crucial a priori information on fine scale spatial and temporal flux distribution is embedded in all top-down approaches;
- Contrary to anthropogenic CO_2 fluxes, the situation with respect to inventory estimates for the LULUCF sector is more favourable: the "observation based" flux estimates will likely provide new information at specific spatial and temporal scales to supports policy makers in confirming their progresses toward specific targets;
- Current uncertainty for the LULUCF sector in National Inventory Reports (NIR) is moderate and the differences in flux estimates with the other scientific community estimates are mainly linked to the definition of sectors and the split between natural and anthropogenic origin;
- Bottom up models cover various approaches from "process-based" to "data-based" models with different strengths depending on the spatial and temporal scale investigated;
- Some ecosystem models follow similar or refined approaches compared to those used in the national reporting: for instance the Bookkeeping model of J. Pongratz (*BLUE*) provides critical information on the legacy effects of all historical land cover / land use changes;
- Top down estimates are likely to bring new and crucial information on the global stock-take and the total continental Europe fluxes (or for large-scale European break down),

VERIFY is a research project funded by the European Commission under the H2020 program. Grant Agreement number 776810.

but the system regional inversion systems are still not mature enough for accurate estimates and the atmospheric in situ observations are too scarce for reliable national estimates;

- The new information will likely concern long-term trends and climate-induced flux anomalies, but yearly mean CO_2 fluxes per country is still a longer term objective for 'observation based' estimates;
- Recent or upcoming observations, like satellite column CO_2 data (from OCO2) are a promising avenue for significant error reductions in the flux estimates, but this is still conditioned to progressed in bias correction of these observations;
- WP3 will provide gridded monthly (up to weekly) flux estimates for Europe but only large scale (space and time) integrated quantities may be useful for National inventory agencies (work to be performed within WP 5-6).
- Given the uncertainties that are still associated to the anthropogenic CO_2 sources (WP2) a complete system addressing the coherence between sources and sinks of CO_2 in Europe is needed to improve the estimates of biogenic emissions. Such a system will be pushed forward in WP2 and WP3.
- More interaction between WP3 and WP1 like in this Paris WP1 meeting is needed in the next years to keep the dialogue and improve the understanding of the strength and weaknesses associated to the different approaches, from both side.

VERIFY is a research project funded by the European Commission under the H2020 program. Grant Agreement number 776810.

3.4. Session 4 - Estimation of all types of CH_4 and N_2O emissions (WP4)

3.4.1. Possible contributions of WP4 to inventory compiler needs (and vice versa).

3.4.1.1. Agriculture - Eleonora Di Cristofaro (ISPRA)

Short summary of the presentation

The presentation includes the description of the IPCC methodology for the estimation of emissions in the Agriculture sector. In particular, the parameters and the equations used for the estimation, according to the Tier 2 methodology, have been presented.
The Common Reporting Format (CRF), containing data related to parameters and emissions, has been shown for each emissions category of the sector. Finally, the analysis of the uncertainty of the emissions estimate, based on the uncertainty values assigned to the activity data and emission factors, according to the IPCC Tier 1 approach, has been briefly described.

Key messages

- Emission reporting requires a variety of detailed information, regarding a number of parameters used in the estimation process that will necessarily have to be considered in the development of new methodological approaches for monitoring greenhouse gas emissions;
- The quantification of CH_4 and N_2O flows, that the VERIFY project aims to achieve, could be explored to be used for the verification of emissions estimates, also considering the difficulty related to the subsequent attribution of the calculated fluxes to the different (sub)sectors and categories;
- The added value of the potential verification exercise could be related to the availability of independent estimates, also considering that agriculture sector is structurally more uncertain than other Inventory sectors, given the high values of combined uncertainty of activity data and emission factors.

3.4.1.2. Industrial Processes and Product Use - Ann Marie Ryan (EPA Ireland)

Short summary of the presentation

The IPPU sector is a relatively small emissions sector, as far as N_2O and CH_4 emissions are concerned. CH_4 emissions of note were not identified in this sector.
There are two main industrial processes which have N_2O emissions: Nitric Acid Production and Adipic Acid Production. The uncertainties of Nitric Acid production are relatively high and dependent on abatement system effectiveness. The Nitric Acid activity data is usually sourced from the ETS data, which has been independently verified. This removes some of the uncertainty.
The emission factors for Adipic Acid are relatively certain, because they are based on stoichiometry of the intended chemical reaction. Uncertainty of activity data may be more of a concern. The uncertainty of Caprolactam Glyoxal and Glycoxylic Acid is high, due to limited available information.

VERIFY is a research project funded by the European Commission under the H2020 program. Grant Agreement number 776810.

N_2O from product uses has low uncertainty as these are well quantified.

Key messages

- As this is not a large industry in Annex 1 countries, it is not a big part of the inventory (approx. 1% of total N_2O emissions). However, countries such as China may have significant Adipic acid production as over half is used as a monomer for the production of nylon and polyurethane.

3.4.1.3. Waste - Jean-Pierre Chang (CITEPA)

Short summary of the presentation

The waste treatment sector is a complex sector. Especially for solid waste disposal, the GHG emitted during a given year not only depend on the activity of waste treatment (in terms of amount of disposed waste and waste composition) for the given year, but also on the disposal activities for many years before. That is reflected in the IPCC 2006 guidelines through a degradation kinetics for CH_4 emissions (that requires data since 1950 in the IPCC tool).

It is important to reflect the actual and complete processes of emissions: e.g. for CH_4 from solid waste disposal, taking into account the possible recovery of CH_4 for energy use and its flaring for security reasons.

In case of energy use of CH_4 from the solid waste disposal (for electricity or heat production), the related combustion emissions are reported in sector Energy (and not waste sector), and the related CO_2 emissions are considered as biomass CO_2 and are not accounted in the national CO_2 total (but other combustion gases are taken into account).

More generally, CO_2 emissions occurring in waste treatment are biogenic CO_2, except CO_2 from incineration of the fossil fraction of waste (plastics, waste oils…). These CO_2 biogenic emissions are not accounted for in the national inventory totals.

Statistics and activity data for the waste sector are generally challenging issues, and the IPCC 2006 guidelines reflect this situation by proposing different options according to the availability of statistics/data on waste.

Key messages

- Because of a complex sector, the need to model biological processes, and the difficulties to get complete and long time series of activity/parameter data, CH_4 emissions from the solid waste disposal is one of the substances/sectors with the highest uncertainties (including NO_2/agriculture soil, CO_2/LULUCF…).

VERIFY is a research project funded by the European Commission under the H2020 program. Grant Agreement number 776810.

3.4.2. Presentation on potential contribution of WP4 (with a focus on inventory needs), Rona Thompson (NILU).

Short summary of the presentation

Top-down approaches (namely, atmospheric inversions) are complementary to inventory estimates in that they reconcile the emissions with observed changes in atmospheric concentrations. In other words, the atmospheric observations place a mass-balance constraint on the total emissions. While top-down approaches have this observation-based constraint for the total emissions, they provide only limited information on the attribution of emissions to different sources. In the case that the sources are separated in space, then high-resolution inversions can provide some constraint on the sources. For CH_4, additional information from the ratios of the stable isotopes of C and H in CH_4 is available and can help distinguish thermogenic (largely fossil fuels), biogenic (such as enteric fermentation and manure management) and pyrogenic (biomass burning) sources. For CH_4 and N_2O, where the uncertainties in the inventories can be very large, atmospheric inversion estimates can be especially helpful. Inversions at high-resolution can also help identify hotspots of emissions and, in the case of N_2O, help verify emission factors.

Key messages

- For CH_4 and N_2O the uncertainties of certain emission sources are extremely large, several hundreds to thousands of percent. However, these emissions in most cases represent only a small fraction of the total emissions.
- For CO_2, most (90%) of the emissions are related to energy production (e.g. coal-fired power plants) and the uncertainties at national and annual level in developed countries are fairly small. On the other hand, atmospheric inversions may help with constraining CO_2 emissions at sub-national and sub-annual level. Inversions can also help constrain the highly uncertain CO_2 emissions associated with land-use change, and the uncertain CH_4 emissions associated with natural gas extraction, storage, and transport.

VERIFY is a research project funded by the European Commission under the H2020 program. Grant Agreement number 776810.

4. Annex: List of Participants

Name	First Name	Organisation
ALBERTI	Carlos	KIT
ANDREW	Robbie	CICERO
ARETS	Eric	Wageningen Environmental Research
BROQUET	Gregoire	LSCE-UVSQ
CHANG	Jean-Pierre	CITEPA
CHEVALLIER	Frederic	CEA LSCE
CIAIS	Philippe	CEA LSCE
DENIER VAN DER GON	Hugo	TNO
DI CRISTOFARO	Eleonora	ISPRA
DOLMAN	Han	VU University Amsterdam
ENGELEN	Richard	ECMWF
FIRION	Sonia	CEA LSCE
FORTEMS-CHEINEY	Audrey	CEA LSCE
GÜENTHER	Dirk	German Environment Agency
HAMMER	Samuel	IUP Heidelberg
HOUSE	Joanna	University of Bristol
JANSSENS-MAENHOUT	Greet	European Commission - JRC
KARSTEN	Ute	ICOS - Lund University
KIESOW	Anja	Umweltbundesamt
KUHNERT	Matthias	University of Aberdeen
MATTION	Fransesco	IEA - Paris
MCGRATH	Matthew	CEA LSCE
MUNTEAN	Marilena	European Commission (EDGAR)
NAIPAL	Victoria	LSCE
PALMER	Paul	University of Edinburgh

VERIFY is a research project funded by the European Commission under the H2020 program. Grant Agreement number 776810.

PERUGINI	Lucia	CMCC
PETER	Björn	IUP Heidelberg
PETERS	Glen	CICERO
PETRESCU	Roxana	VU University Amsterdam
PEYLIN	Philippe	LSCE
PISON	Isabelle	LSCE UVSQ
QUADRELLI	Roberta	IEA - Paris
REIMANN	Stefan	EMPA
ROBERT	Colas	CITEPA
ROSENDAHL	Claudius	IUP Heidelberg
RUYSSENAARS	Paul	RIVM
RYAN	Ann Marie	EPA
THOMPSON	Rona	NILU
TWORKE	Kim	Climate-KIC
WINCKLER	Johannes	LSCE

VERIFY is a research project funded by the European Commission under the H2020 program. Grant Agreement number 776810.