Uncertainties & Priorities in Greenhouse Gas Inventories

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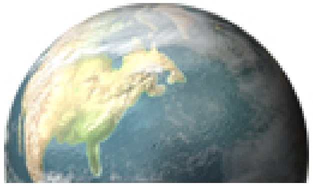
Outline

- Policy perspective
- IPCC Guidelines
- Inventory of U.S. Greenhouse Gas Emissions and Sinks
  - Overview
  - Areas for improvement
- Independent Verification
  - IPCC discussions
  - Gridding
  - Communications
- Key considerations for policy-relevant measurement studies

GHG Data Requirements for Governments

- Why do governments need GHG emissions data?
  - Fundamental for developing, implementing, and assessing policies and programs to reduce emissions
  - EPA can’t wait for perfect information (not an excuse to delay action)
- Data quality requirements
  - **Complete**: cover all anthropogenic sources, exclude natural sources
  - **Consistent**: collected consistently over time to reflect real trends
  - **Transparent**: Stakeholders need to review and understand methodologies
  - **Accuracy/Bias**: Uncertainties can not be eliminated, but should be managed and reduced
  - **Resolution:**
    - Spatial: Important for some applications, but not others, e.g., UN reporting
    - Temporal: International and national reporting is annual
    - Unit/process: Need to connect emissions data to the activities and equipment that cause emissions to be policy and program relevant.



Some GHG sources are suitable for carbon markets

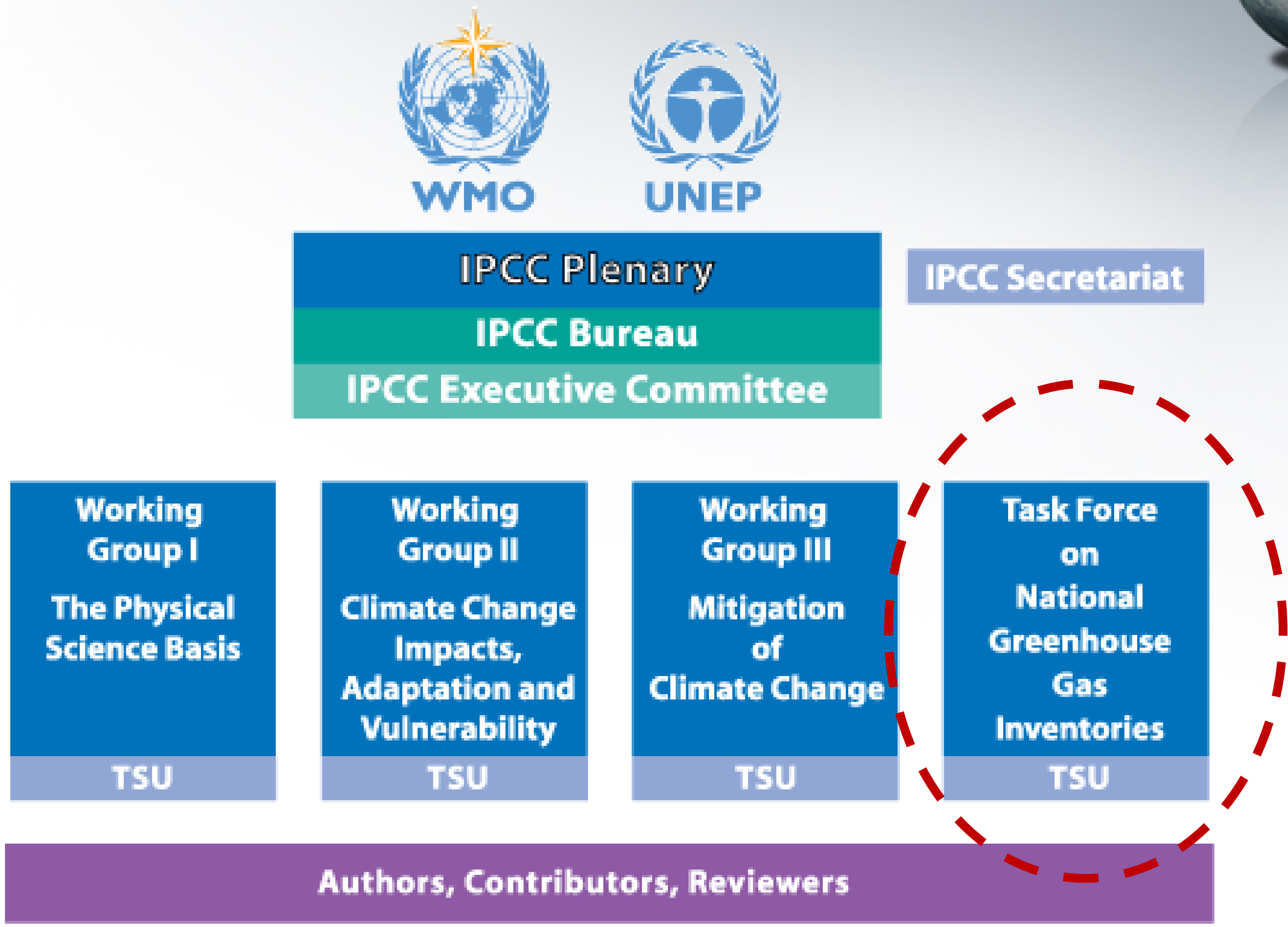
Others are not - (unless you're from NZ)

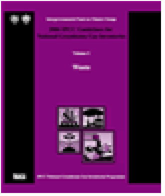
Others are subject to performance standards

Or financial incentives

Others are exceedingly difficult to quantify and may/may not be anthropogenic

IPCC & International Inventory Standards





e IPCC Guidelines (I)

IPCC Good Practice - national inventories contain neither over- nor under-estimates so far as can be judged, and in which uncertainties are reduced as far as practicable.

Key Categories: Have a significant influence on a country's total inventory of greenhouse gases in terms of the absolute level of emissions and removals, the trend in emissions and removals, or uncertainty in emissions and removals. Key Categories should be the priority for countries during inventory resource allocation for data collection, compilation, quality assurance/quality control and reporting

The IPCC Guidelines (II)

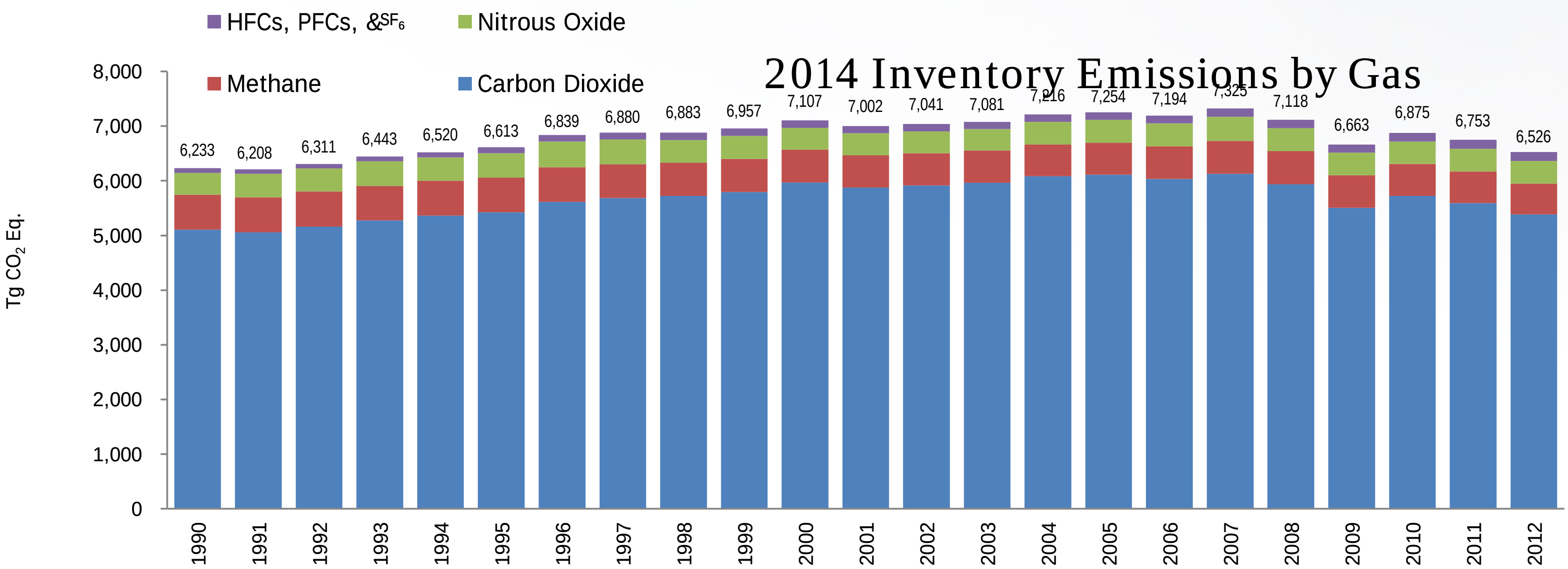
Tiers: The 2006 IPCC Guidelines provide three levels of detail, tier 1 (the default method) to tier 3 (the most detailed method).

- Properly implemented, all tiers are intended to provide unbiased estimates
- Accuracy and precision should, in general, improve from tier 1 to tier 3.
- Tiers allow inventory compilers to use methods consistent with their resources and to focus their efforts on key categories

Uncertainty: The uncertainty analysis characterises the range and likelihood of possible values for the national inventory as a whole as well as for its components. Awareness of the uncertainty of parameters and results provides inventory compilers with insight when evaluating suitable data for the inventory during the data collection and compilation phases. Uncertainty assessment also helps identify the categories that contribute most to the overall uncertainty, which helps the inventory compiler prioritise future inventory improvement

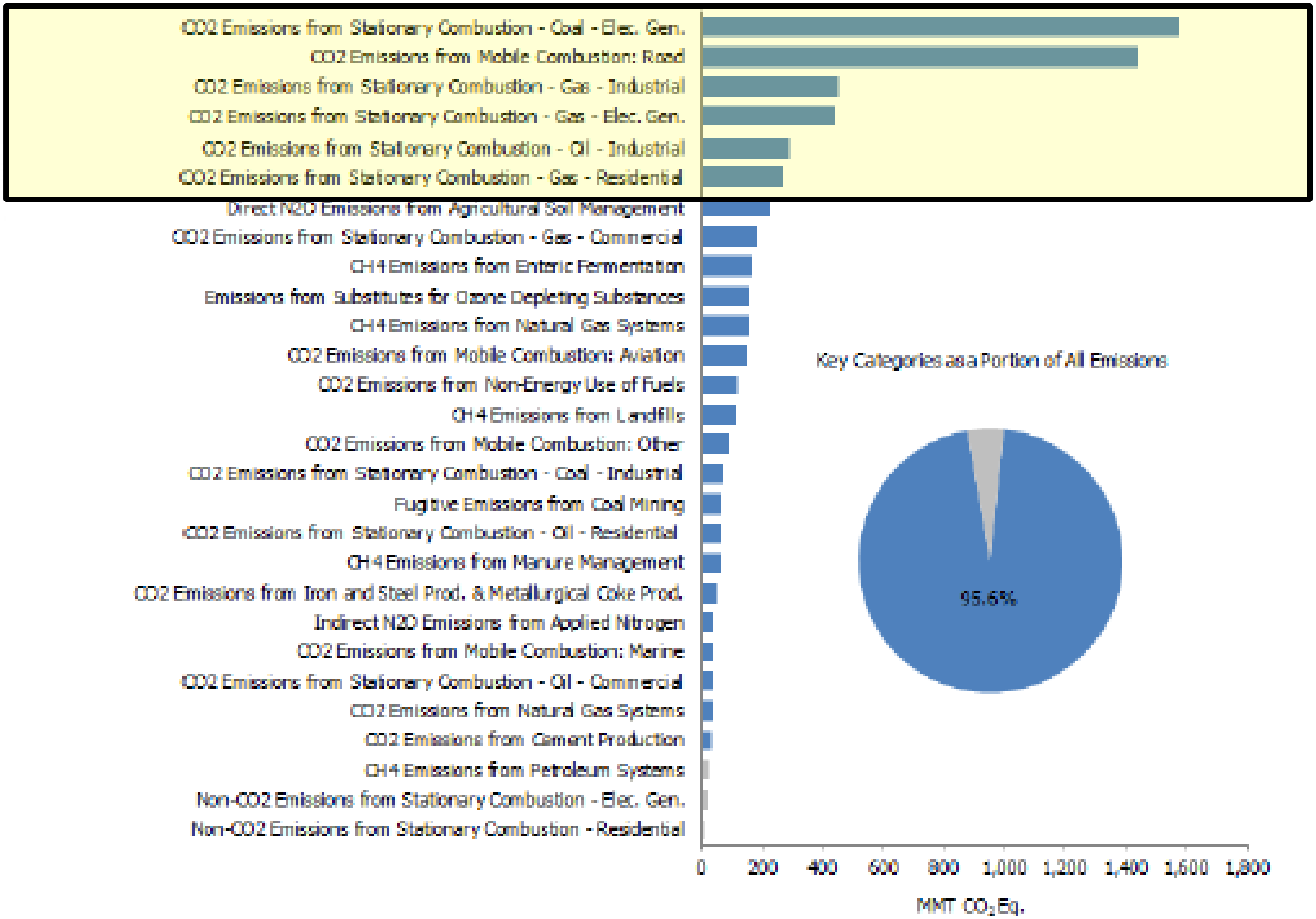
US Inventory Results (April 2014)

- US GHG emissions declined 3.4% from 2011 to 2012
  - Increase of 5% from 1990, decrease of 10% from 2005
- CO_2 from fuel combustion dominate emissions and trends
  - Major contributors to the 2011-2012 decrease in emissions were decrease in energy consumption across all sectors in the U.S. economy, and decreases in carbon intensity for electricity generation

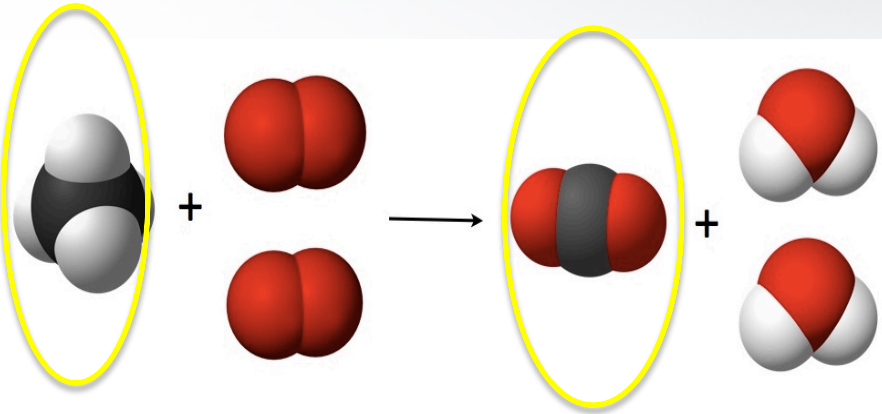


“Key Categories” in the US Inventory

Figure ES-16: 2013 Key Categories



Tracking National Fossil fuel related CO2 emissions



$$CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O$$

Statistics South Africa

The South Africa I know, the home I understand

Statistics Canada Statistique Canada

DESTATIS Statistisches Bundesamt

IBGE Instituto Brasileiro de Geografia e Estatística

eia Independent Statistics & Analysis U.S. Energy Information Administration

Uncertainty estimates for the US Inventory

Table A-290: Quantitative Uncertainty Assessment of Overall National Inventory Emissions (MMT CO_2 Eq. and Percent)

Gas	2013 Emission Estimate[a] (MMT CO_2 Eq.)	Uncertainty Range Relative to Emission Estimate[b] (MMT CO_2 Eq.)		(%)		Mean[c] (MMT CO_2 Eq.)	Standard Deviation[c] (MMT CO_2 Eq.)
		Lower Bound[d]	Upper Bound[d]	Lower Bound	Upper Bound		
CO_2	5,504.8	5,400	5,766	-2%	5%	5,584	95
CH_4[e]	636.3	573	751	-10%	18%	656	45
N_2O[e]	355.2	320	445	-10%	25%	376	32
PFC, HFC, SF_6, and NF_3[e]	171.0	170	190	-1%	11%	180	5
Total	**6,667.2**	**6,584**	**7,008**	**-1%**	**5%**	**6,795**	**110**
Net Emissions (Sources and Sinks)	**5,785.5**	**5,613**	**6,220**	**-3%**	**8%**	**5,916**	**154**

Table 1.5.2 (a & b) 2013 level assessment for New Zealand's key category analysis including LULUCF (a) and excluding LULUCF (b)

(a) IPCC Tier 1 category level assessment – including LULUCF (net emissions): 2013				
IPCC categories	Gas	2013 estimate (kt CO_2-e)	Level assessment (%)	Cumulative total (%)
Land converted to forest land	CO_2	21,403.5	17.770481	17.77048
Enteric fermentation – dairy cattle	CH_4	13,216.3	10.972985	28.74347
Harvested wood products	CO_2	10,295.6	8.5480402	37.29151
Enteric fermentation – sheep	CH_4	9,223.3	7.6577508	44.94926
Transport – road transport – gasoline	CO_2	6936.0	5.7586937	50.70795
Agricultural soils – direct N_2O emissions – urine and dung deposited by grazing animals	N_2O	5,679.4	4.7153871	55.42334
Transport – road transport – diesel oil	CO_2	5,576.9	4.6302853	60.05362
Enteric fermentation – non dairy cattle	CH_4	5,392.4	4.477102	64.53072
Land converted to grassland	CO_2	4,840.4	4.0187977	68.54952
Solid waste disposal	CH_4	4,600.3	3.8194519	72.36897
Energy industries – public electricity and heat production – gaseous fuels	CO_2	3,409.0	2.8303614	75.19934
Forest land remaining forest land	CO_2	2,123.7	1.7632263	76.96256
Metal Industry – iron and steel production	CO_2	1,747.5	1.4508819	78.41344
Energy industries – public electricity and heat production – solid fuels	CO_2	1,615.9	1.3416195	79.75506
Grassland remaining grassland	CO_2	1,559.4	1.2947098	81.04977
Product Uses as Substitutes for ODS – refrigeration and air conditioning	HFCs & PFCs	1,518.5	1.2607521	82.31053
Other Sectors – agriculture/forestry/fishing – liquid fuels	CO_2	1,313.4	1.0904654	83.40099
Manufacturing Industries and Construction – Chemicals – Gaseous Fuels	CO_2	1,295.6	1.0756868	84.47668
Manufacturing Industries and Construction – Food Processing, Beverages and Tobacco – Solid Fuels	CO_2	1,206.3	1.0015444	85.47822
Agricultural soils – direct N_2O emissions – Inorganic N Fertilisers	N_2O	934.6	0.7759624	86.25418
Agricultural soils – indirect N_2O emissions – atmospheric deposition	N_2O	913.9	0.758776	87.01296
Manure management – cattle – dairy cattle	CH_4	896.9	0.7446615	87.75762

“Key Categories” in the New Zealand Inventory

Tracking CO2 from Deforestation

CD REDD II

UN-REDD PROGRAMME

FAO FIAT PANIS

UNDP Empowered lives. Resilient nations.

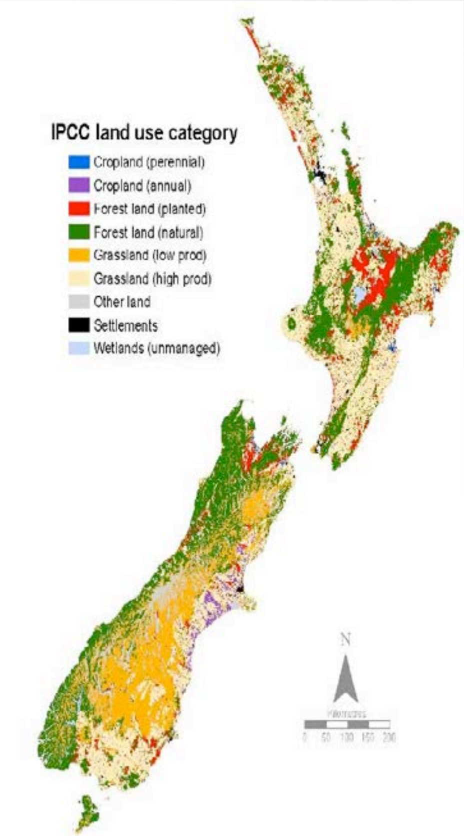
UNEP

SilvaCarbon

THE WOODS HOLE RESEARCH CENTER

FOREST CARBON PARTNERSHIP FACILITY

ipcc INTERGOVERNMENTAL PANEL ON climate change



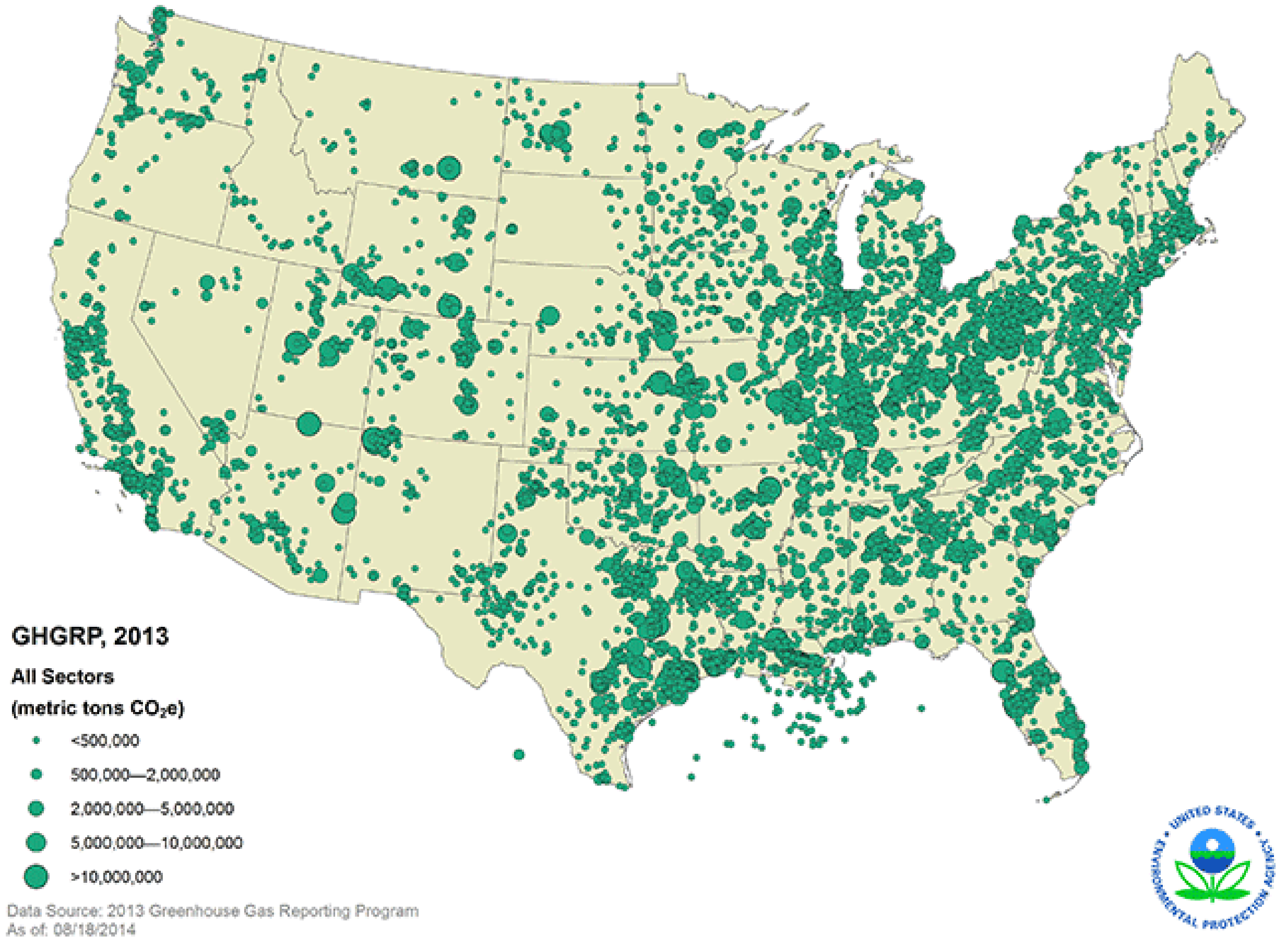
Improving National GHG Inventory Estimates

- Bottom-up calculations require numerous data inputs, some are are more difficult to collect than others (examples):
  - Enteric fermentation: regional and annual differences in animal diets
  - Natural gas: activity data, control practices
  - Landfills: soil oxidation rates, waste composition
  - Coal mining: degasification collection efficiency, ventilation air flow and concentration
  - Manure management: manure handling practices, and methane conversion rates
  - Forest fires: fire intensity, duration etc.
- Many key gaps require “low-tech” or “no-tech” information collection

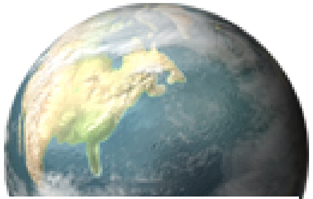
Examples of EPA Work to Improve National GHG Estimates

- Annual Review Processes
- GHGRP integration
  - E.g., Key oil and gas input data available in 2015
- Assessment of external studies and incorporation of new data
  - E.g., API/ANGA data collection
- Engagement with top-down research community
  - Coordination with EPA Office of Research and Development
  - Methane gridding of U.S. GHG Inventory

Geographic Distribution of GHGRP Emissions



EPA GHG Emissions Data Programs

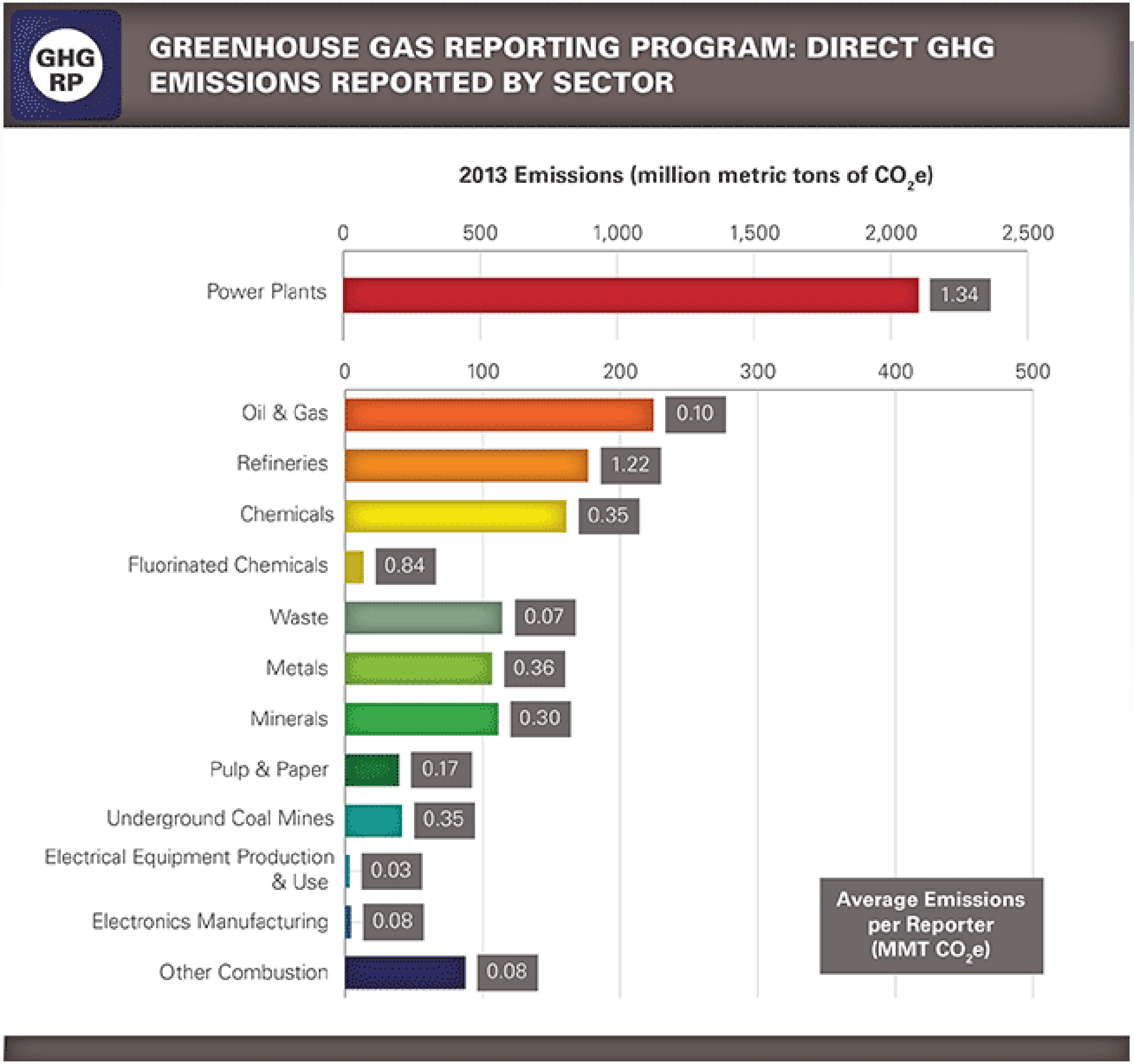


	U.S. GHG Inventory (UN Requirement)	GHG Reporting Program (Facility Reporting by Regulation)
Scale	• National	• Facility

Coverage	• All U.S. anthropogenic emissions
	  • Energy
	  • Industrial Processes
	  • Agriculture and Land Use
	  • Waste
		• ~55% US direct anthropogenic emissions
		• ~30% US indirect anthropogenic emissions (e.g., fuel & chemical suppliers)
		• Over 8,000 facilities
		• Facilities > 25,000 metric tons CO2 equivalent per year
		• Excludes agriculture

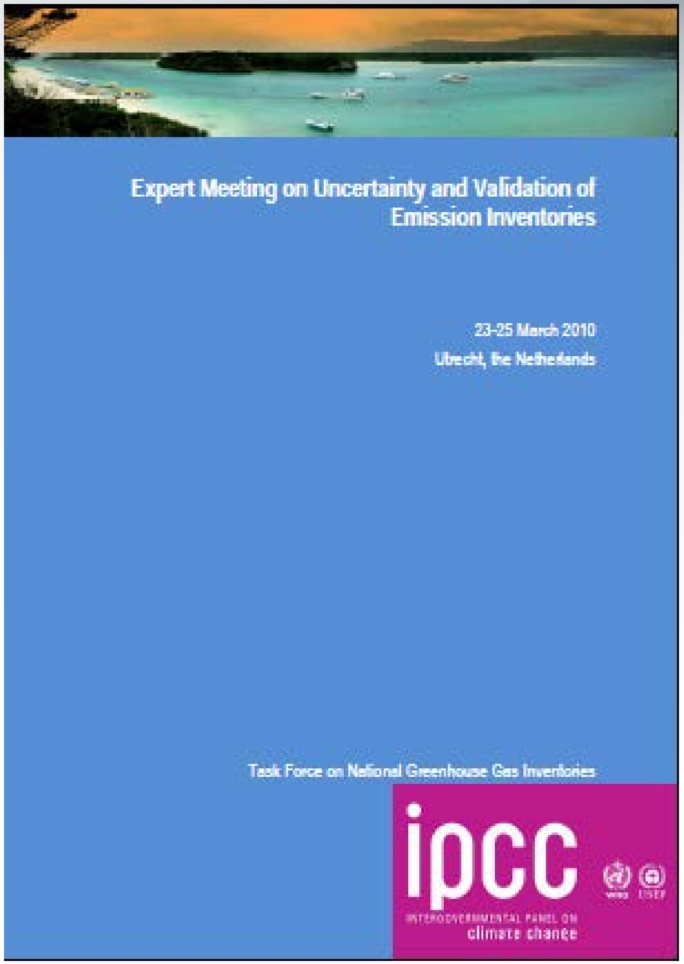
GHGs	• CO_2, CH_4, N_2O, Fluorinated GHGs	• CO_2, CH_4, N_2O, Fluorinated GHGs
Methods	• IPCC higher “tier” • Mix of measurement-based emission factors, models, and GHGRP data	• Mix of continuous, periodic measurements, and sampling • Engineering calculations & emission factors
Time series	• 1990 – present	• Annually, since 2010

Data Reported to GHGRP

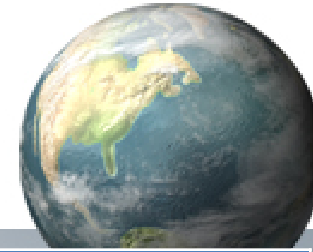


IPCC and independent verification (2010)

- Remote sensing, ambient measurement and inverse modelling techniques have been successfully demonstrated
- They are currently not sufficiently developed to provide comprehensive verification at the required accuracy,
- Much is to be gained from working together, to improve verification techniques as well as gain better understanding of inventory estimates, and of natural emissions and removals.
- The meeting acknowledged that growing international interest in monitoring and verification is increasing the importance of dealing properly with uncertainty and is suggesting new initiatives for emissions inventories that can improve prospects for independent verification.



IPCC recommendations for focus areas



Category/Topic	Challenge
Use of fluorinated gases	Timing of release, new sources & gases
Methane from oil & gas, coal & landfills	Super-emitters, distributed sources, abandoned wells & mines
N2O emissions from soils	Independent measurement of spatial & temporal variability
Forest fires, biomass burning & other disturbances	Identification of area burnt, measurement of N2O & CH4
Carbon capture & storage	Time series of background emission rates for storage sites
Overall inventory totals by gas	Particularly for non-CO2
Peatlands	Diffuse emissions over wide areas are poorly understood
Methane from permafrost melting	Not currently in the IPCC Guidelines
Black carbon & aerosols	Measurements to validate emission estimates at finer temporal and spatial resolutions
Fluxes on coastal oceans	Not included in inventories, but required to calibrate estimates

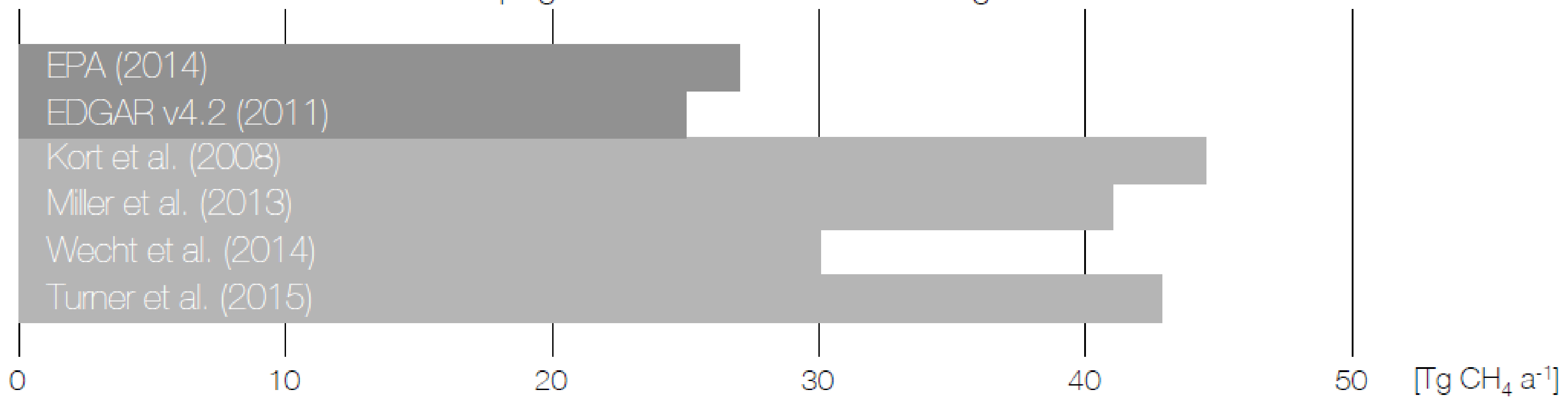
Key considerations for policy-relevant measurement studies

- Top down
  - Using the right bottom up Inventory comparison
    - EDGAR is not U.S. GHG Inventory
    - Seasonal/regional variations are important
    - Natural sources
  - Clearly communicating assumptions and uncertainties
- Bottom up
  - Providing information on activities taking place at the time of measurement and their national/regional representativeness
    - General operating conditions
    - High-emission venting events
    - Controlled versus uncontrolled

Harvard University work on gridding – J.D. Maasakkers

Combining bottom-up & atmospheric information

Top-down studies rely on the EDGAR inventory as prior since gridded data is required to compare to observations



US source attribution based on atmospheric data is currently impossible because of the lack of a high quality gridded bottom-up inventory

Harvard University work on gridding – J.D. Maasakkers

This project: Create an evaluable gridded EPA inventory

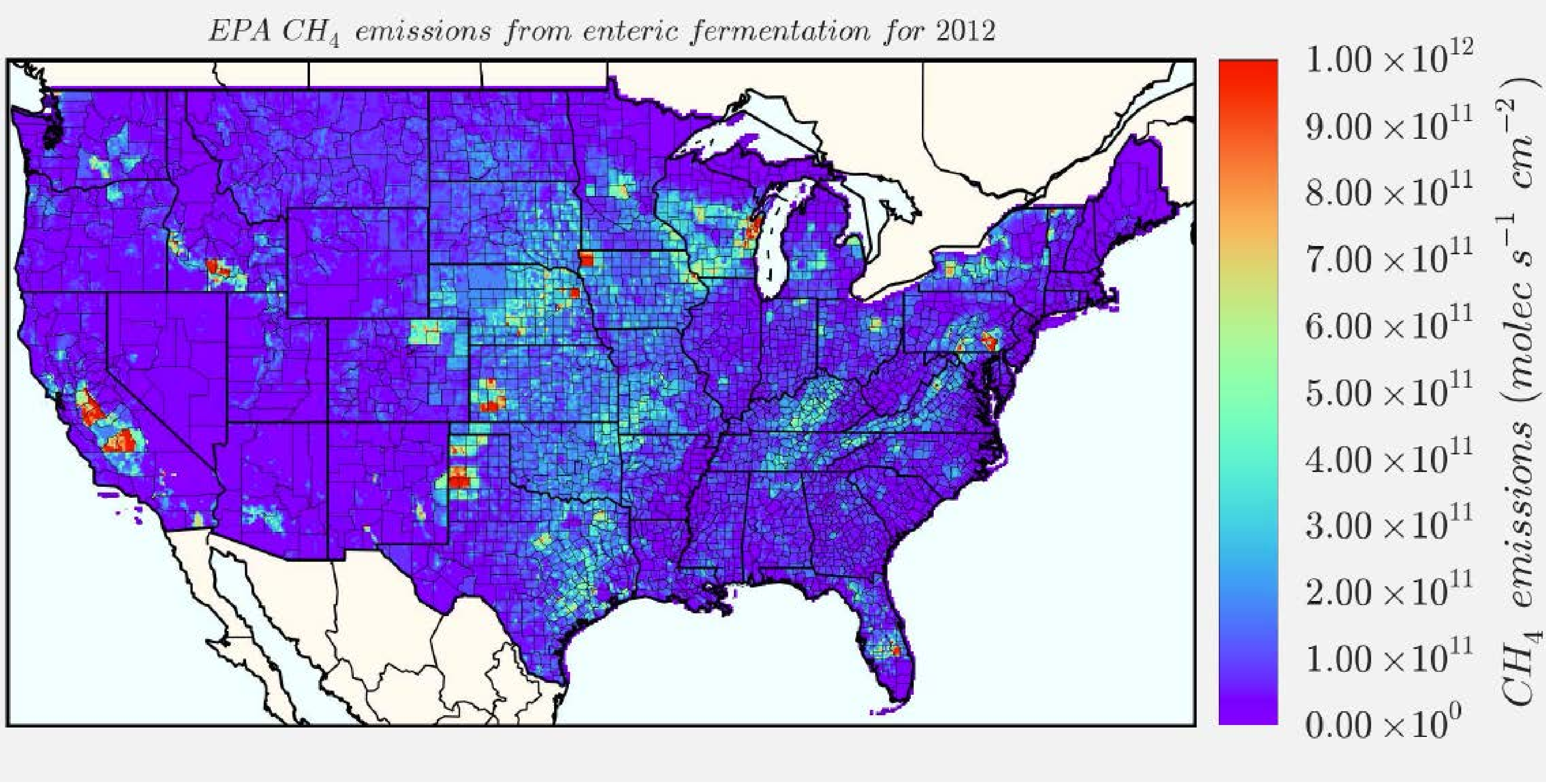
Region-specific EPA emission factors

Spatial allocation on 0.1° x 0.1° grid using national & high resolution datasets

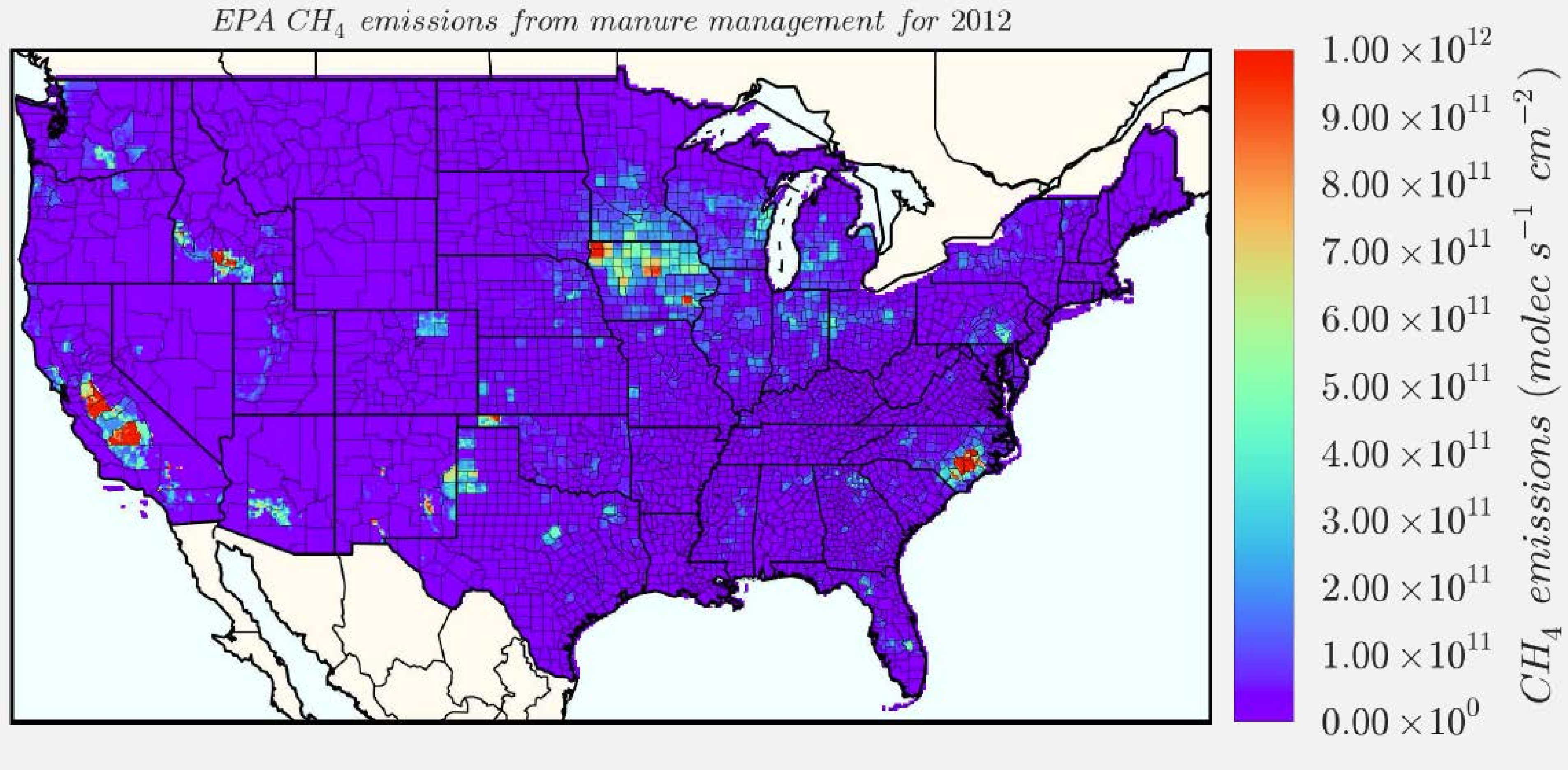
Multiple layers of data for emissions from different processes

Monthly time resolution

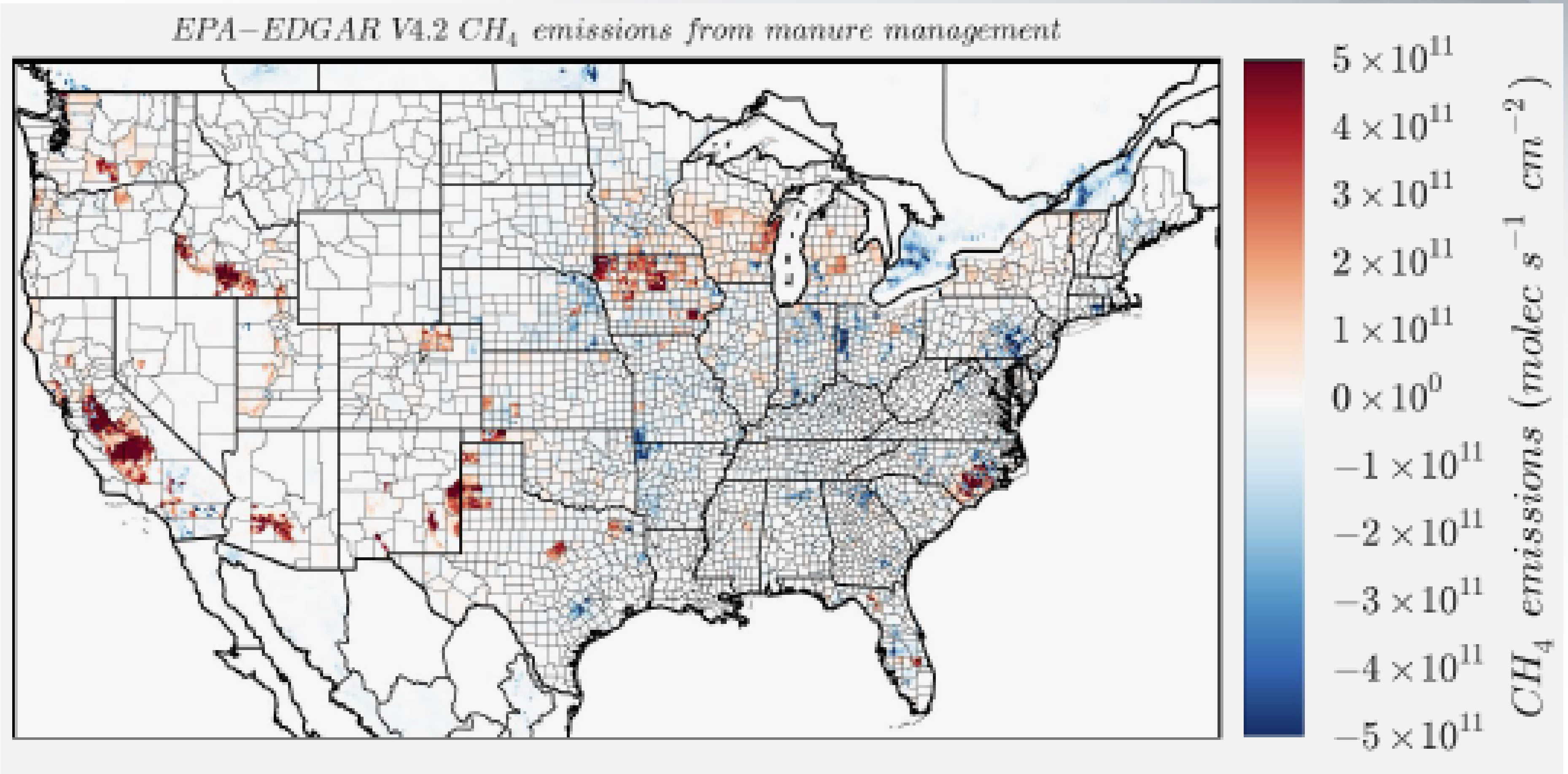
Gridding CH4 – Enteric Fermentation



Gridding CH4 – Manure Management



Gridding CH4 – differences with EDGAR

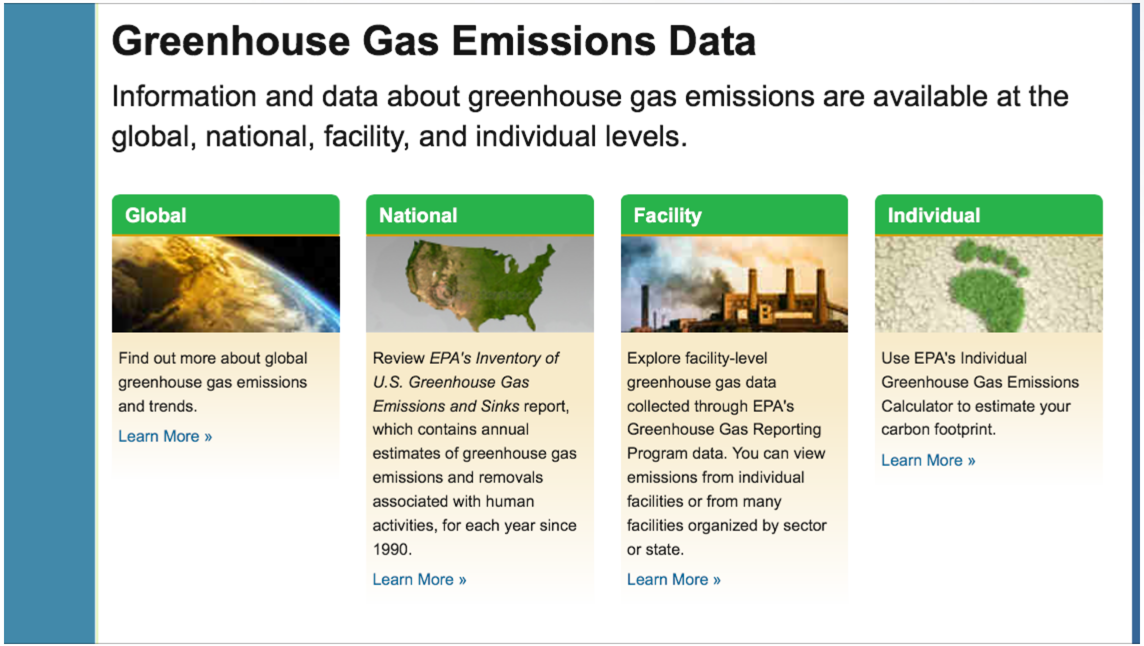


Communicating research results

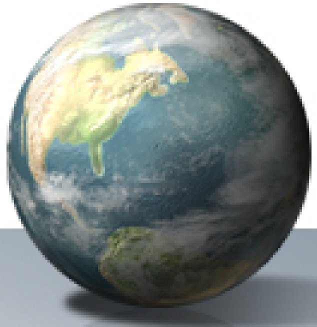
What the media usually say	What studies actually say
“Scientists say EPA numbers are wrong”	“Study results are different from EPA results”
“EPA estimates are highly uncertain”	“Study results also have uncertainty bars”
“EPA needs to fix its data”	“EPA and researchers should work together to try to explain and account for differences”
“Scientists measured the same thing that EPA is estimating”	“We think we measured the same thing, but those natural sources can get in the way….”
“Case closed”	“This is what we can do now, but with X more data points we could do a lot better”

Accessing EPA GHG Data

- U.S. GHG Inventory (National-level data)
  - http://www.epa.gov/climatechange/ghgemissions/usinventoryreport.html
- Facility-Level GHGRP Reporting Data
  - http://www.epa.gov/ghgreporting/



Thank you



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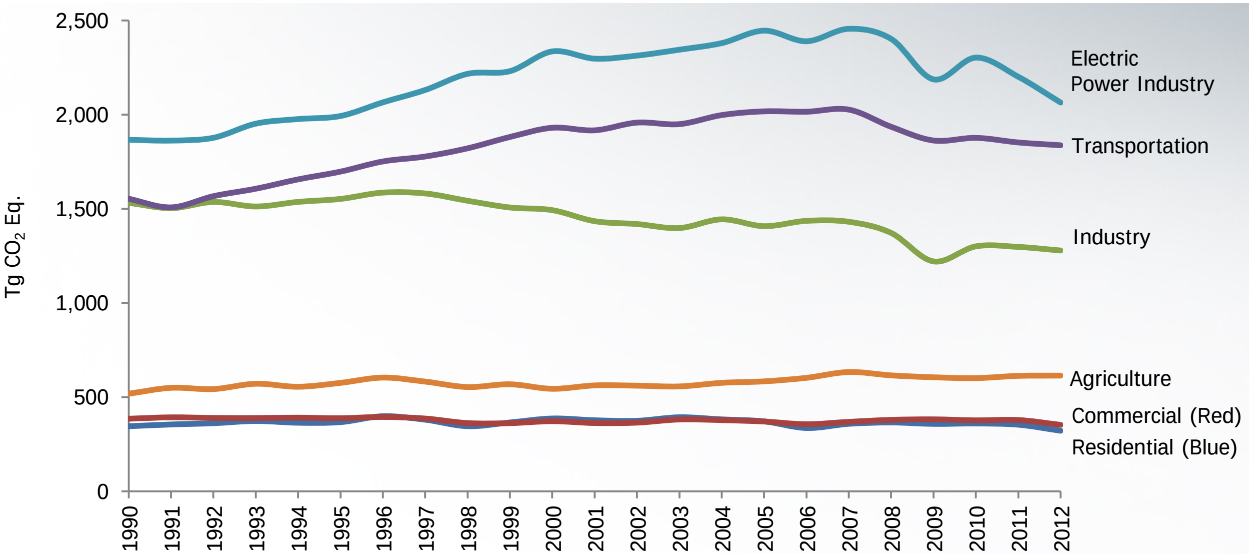
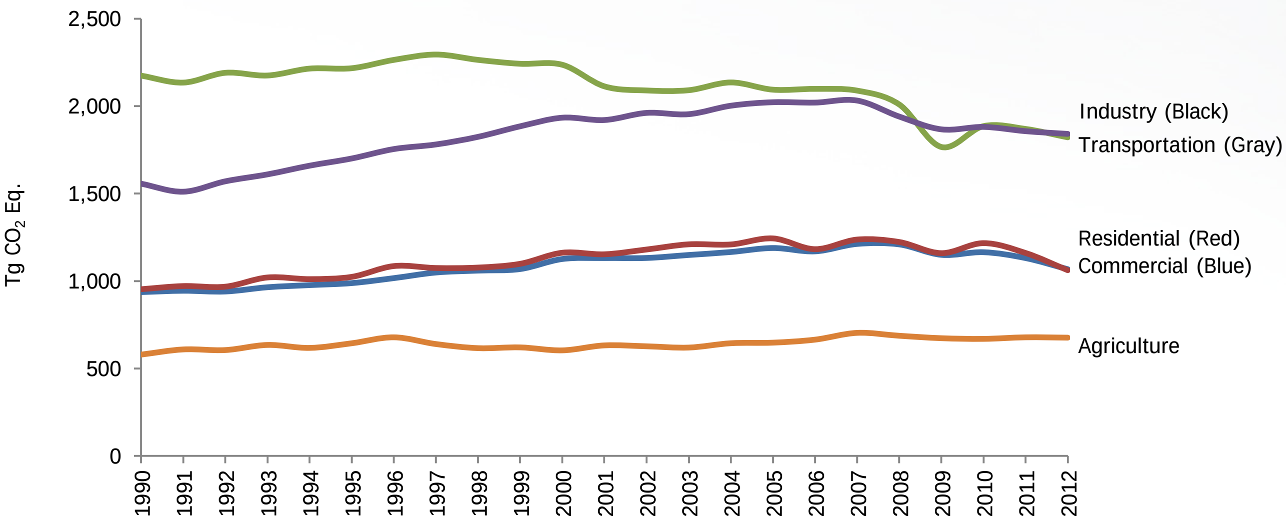
2014 Inventory by Economic Sector



With electric power industry as a separate sector



With electric power industry emissions allocated to other sectors by electricity use

Role of measurement studies in improving inventories

Type of Study	Example	Feedback to inventories
Assessing effectiveness of global efforts to reduce emissions through trends in atmospheric concentrations	IPCC Assessment Reports	• n/a
Independent verification of inventory estimates through inverse modeling	NOAA verification studies	• General conclusions about potential over- and under-estimates • Attribution is a challenge • Limited ability to pinpoint which data inputs need to be improved
Measurement of specific activities, processes and equipment to develop improved emission factors	UT-Austin/EDF studies	• Direct improvements, if measurements are representative • Cost, and access to facilities can be challenging