I

U

A

V
Università Iuav
di Venezia

Implications of uncertainty for transport policy for carbon dioxide

Alessandra La Notte
Stefania Tonin
Silvio Nocera

XVII Conference of SIET, Milano 29 June -1 July

Content

- The context: uncertainty in GHG emissions and its relevance for transport
- The background: review of techniques to deal with uncertainty employing the use-chain model
- The application: Shift-Share Analysis at regional-provincial level implementing the insurance-based approach (by Marland)

Why dealing with transport when we face the issue of air pollutant emissions

The transport sector has the second biggest greenhouse gas emissions in the EU. More than two thirds of transport-related greenhouse gas emissions are from road transport.

Greenhouse gas emissions in other sectors decreased 15% between 1990 and 2007 but emissions from transport increased 36% during the same period.

Since 2008 greenhouse gas emissions from transport have started to decrease. Despite this trend transport emissions were in 2012 still 20.5 % above 1990 levels and would need to fall by 67 % by 2050 in order to meet the 2011 Transport White Paper target reduction of 60% compared to 1990.

[source: EEA]

Why being interested in uncertainty when we face the issue of air pollutant emissions

Emission inventories can be used for a wide variety of decision making purposes

(e.g. development of control strategies for reducing emissions; permit limit determination; emission statements for fee collection purposes; international treaty reporting requirements ; compliance determination; exposure and risk analysis etc.)

Some of the specific questions that decision-makers may ask are:

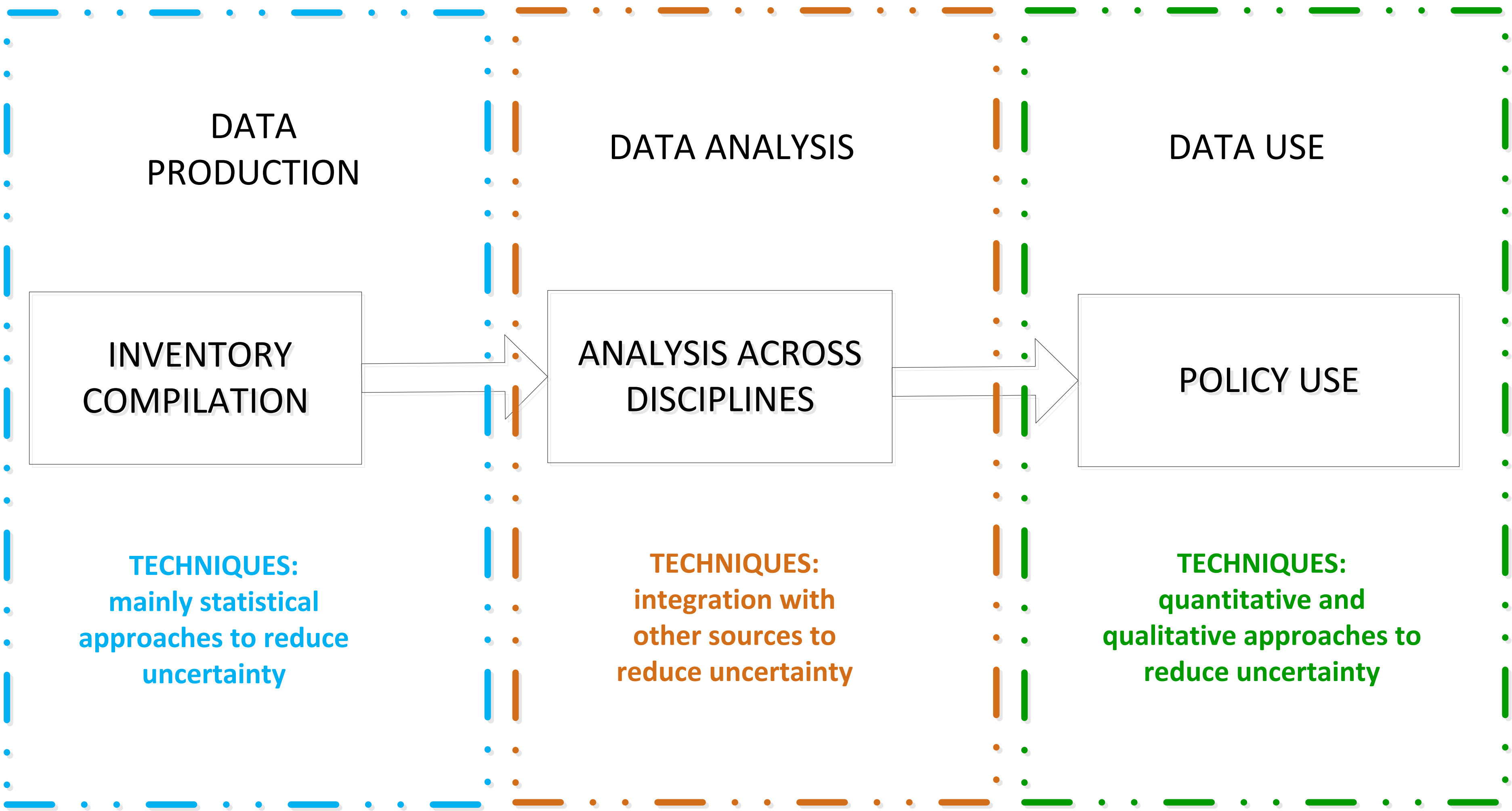
- How well do we know these numbers?
- What is the precision of the estimates?
- How significant are apparent trends over time?
- How effective are proposed control or management strategies?
- …

The causes of uncertainty

Causes of uncertainty	IPCC proposed action to solve uncertainty	Characterization
Lack of knowledge	QA and QC should help avoid this	Scientific
Modelling approach	Statistical validation and expert judgment should help estimating model accuracy and precision	Estimation_model
Shortcomings of available data	Expert judgement can be used to make inference based on analogous data or theoretical consideration	Estimation_model
Lack of representativeness of data		
Insufficient precision	Statistical theory has to play a role in estimating confidence intervals based on variability in the data and sample size	Estimation_paramenter
Systematic errors	Statistics and expert judgment must provide insight about random components; QA/QC must provide insight about systematic components	Estimation_model
Misreporting and misclassification	QA and QC should help avoid this	Scientific and Estimation_model
Missing data	Statistical or judgment base approaches should help because of non-detected measurements or other type of missing data	Estimation_paramenter

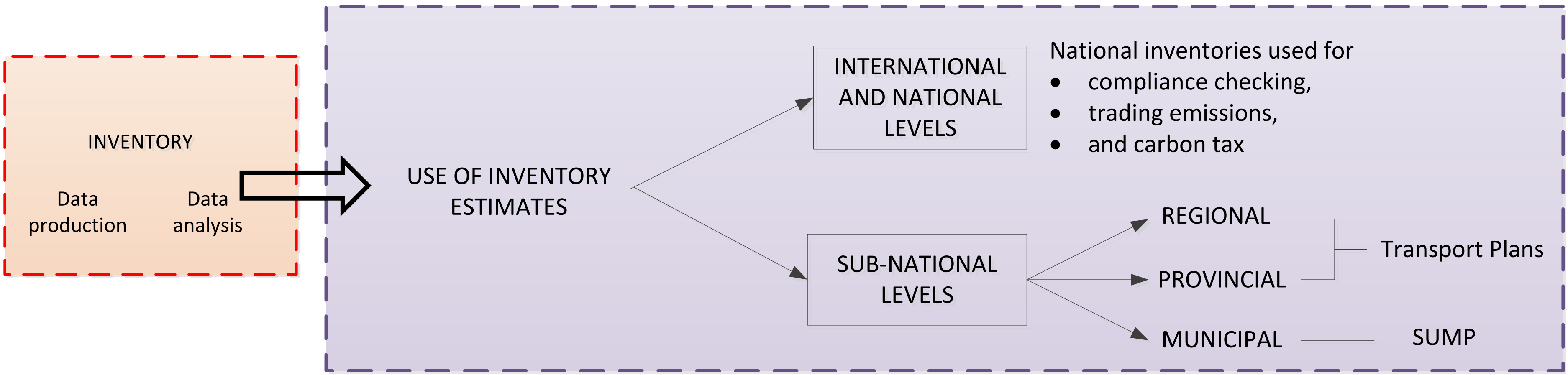
Source: adapted from IPCC (2006)

A model to sort the ways to deal with uncertainty



We call it *use –chain* model

About policy use in Transport



Uncertainty addressed in different disciplines

Causes of uncertainty	Input from other literature	Use-chain feature
Lack of completeness	From producer-based to consumer-based perspective (Caro et al. 2015)	Data use in policy analysis
Modelling approaches	Probability space and equitability constraints (Rodwell et al. 2010)	Data production
	Spatial (correlation) analysis and Time series analysis (Smith et al. 2013)	Data production
Shortcomings of available data	Bayesian approach with informative prior information (Cook 2013)	Data production
	Stratified sample (Moutopoulos and Koutsikopoulos 2014)	Data production
	Adding variable to the model (Punt et al. 2015)	Data production and Data analysis
Lack of representativeness of data	Validation methods: measures VS estimates (Mensink 2000)	Data analysis
Insufficient precision	Target random sampling (Pinto et al. 2014)	Data production
	Count regression models considering other socio-economic indicators (Son et al. 2013)	Data analysis
Systematic errors	Uncertainty study to find out which are the missing variables to be introduced in sampling procedure and models (Hedley et al. 2012; Prechtel et al. 2009	Data production
Misreporting and misclassification	Resample simulation (Moe et al. 2015)	Data production
Missing data	Bayesian approach with informative prior information (Cook 2013)	Data production
	Stratified sample (Moutopoulos and Koutsikopoulos 2014)	Data production
	Adding variable to the model (Punt et al. 2015)	Data production and Data analysis
	Participatory approach (Legay et al. 2015)	Data use in policy analysis

Uncertainty addressed in emissions inventories

Causes of uncertainty	Input from the GHG specific literature	Data use-chain feature
Lack of knowledge	Need for participatory approaches (Nijnik and Pajot, 2014)	Data use in policy analysis
	Decomposition analysis (Rafaj et al. 2014)	Data analysis and data use in policy analysis
Shortcomings of available data	Spatial inventory approach (Bun et al. 2010)	Data production
	Cadastre of GHG emissions (Boychuk and Bun 2014)	Data production & Data analysis
	Spatial inventory approach (Pugliafito et al. 2015)	Data production
Lack of representativeness of data	Fuzzy inference system to solve map overlay (Verstraete 2014)	Data production
	Conditional autoregressive model (Horabik and Nahorski, 2010)	Data production
	Maximum likelihood approach to inference (Horabik and Nahorski, 2014)	Data production
	Insurance approach (Marland et al. 2014)	Data use in policy analysis
Insufficient precision	Prior probability distribution and Bayesian calibration(van Oijen and Thomson 2010)	Data production
	Bottom-up/top-down accounting exercise (Gusti and Jonas 2010)	Data production
	Bottom-up/top-down using inverse modelling (Bergamaschi et al. 2015)	Data production
Systematic errors	Bottom-up/top-down using inverse modelling (Zhang et al. 2015)	Data production
	Bottom-up/top-down using atmospheric measurements (Fairly et al. 2015)	Data production
Misreporting and misclassification	Comparison of different input data for the same variable (Ometto et al., 2014)	Data production
Missing data	Remote sensing input (Verstraeten et al. 2010)	Data production
	Maximum likelihood approach to inference (Horabik and Nahorski, 2014)	Data production

Application

- At what step of the use-chain can this application be referred to?

Data analysis and policy use

- At which administrative level this application takes place?

Sub-national: regional and provincial levels

- What is the policy analysis tool implemented in the application?

Shift-Share Analysis

- What is the technique implemented to reduce uncertainty in emission estimates?

The Insurance Approach (by Marland)

Application steps

- Data collection: Piedmont region emission inventory (EMEP-CORINAIR)
- Uncertainty calculation for each activity and pollutant
- Comparison between data w/o uncertainty and data with uncertainty
- Harmonization between SNAP and NACE classifications
- Shift-share application based on number of employees

Data comparison (2 examples)

Biella _ secondary sector

	MODULO AMBIENTALE									
	CH4	CO	CO2	COV	N20	NH3	NOx	PM10	PM2.5	SO2
REG	107,657.17	6,089.22	15,564.02	27,109.20	2,276.79	1,209.42	21,830.46	785.44	558.87	8,281.56
REGinc	203,505.17	9,375.98	23,672.21	46,169.05	3,001.98	2,103.48	30,070.71	1,129.72	832.51	11,996.89
PROV	2,959.16	73.29	177.06	255.45	6.29	81.35	364.90	32.50	21.31	232.42
PROVinc	5,652.81	115.20	301.58	471.16	11.10	134.85	565.19	56.71	35.70	416.51

Biella _ transport

	MODULO AMBIENTALE									
	CH4	CO	CO2	COV	N20	NH3	NOx	PM10	PM2.5	SO2
REG	288.00	11,215.42	3,902.60	2,518.18	121.09	31.99	29,859.36	4,692.40	1,460.87	48.97
REGinc	488.11	19,219.08	6,628.90	4,302.59	207.52	54.28	50,369.42	8,155.40	2,485.63	86.29
PROV	7.57	363.96	121.45	77.90	3.38	1.08	846.34	169.55	45.21	0.77
PROVinc	12.86	626.26	207.63	133.04	5.79	1.85	1,437.20	295.62	77.29	1.32

Cuneo _ secondary sector

	MODULO AMBIENTALE									
	CH4	CO	CO2	COV	N20	NH3	NOx	PM10	PM2.5	SO2
REG	107,657.17	6,089.22	15,564.02	27,109.20	2,276.79	1,209.42	21,830.46	785.44	558.87	8,281.56
REGinc	203,505.17	9,375.98	23,672.21	46,169.05	3,001.98	2,103.48	30,070.71	1,129.72	832.51	11,996.89
PROV	17,488.18	1,649.34	2,242.85	3,142.84	19.52	250.75	4,279.30	229.83	129.88	674.77
PROVinc	33,236.16	2,513.53	3,524.60	5,432.17	34.82	433.80	5,869.04	292.17	174.84	1,123.86

Cuneo _ transport

	MODULO AMBIENTALE									
	CH4	CO	CO2	COV	N20	NH3	NOx	PM10	PM2.5	SO2
REG	288.00	11,215.42	3,902.60	2,518.18	121.09	31.99	29,859.36	4,692.40	1,460.87	48.97
REGinc	488.11	19,219.08	6,628.90	4,302.59	207.52	54.28	50,369.42	8,155.40	2,485.63	86.29
PROV	29.62	1,372.39	476.15	303.21	14.06	4.18	3,516.55	742.89	177.95	4.47
PROVinc	50.01	2,352.83	809.59	517.19	24.04	7.10	5,940.04	1,294.98	302.91	7.79

What is Shift-Share Analysis

- The basic rationale for decomposition analysis techniques is to spit an identity into its components

- Through SS analysis the role of economic activities can be isolated and the gap b/w emission efficiency in the different sectors explained at different administrative levels

What are the components of Shift-Share Analysis

- The industry mix: describes how specialized the economic system is in some economic activities (when negative the indicator indicates that at the sub-hierarchical level the sectors that employs more workers are less polluting
- The productivity differential: compares the efficiency of a sub-hierarchical level with a superior one (economc activities pollute less than at a higher hierarchical level)
- The allocative component: presents the contribution of the sub-hierarchical levels to economic activity where the higher one shows a higher performance (the sub-hierarchical level is specialized in the economic activity that pollute less)

Industry mix effect	Differential effect	Allocative effect	Policy message
-	-	-	Optimal situation
+	+	+	Worse situation: environmental actions combined with sectoral actions
+	-	-	Sectoral actions to promote environmental friendly sectors; environmental efficiency to be developed in major sectors
-	+	-	Environmental policy to develop environmentally efficient technology in economic sectors
-	-	+	Not efficient combination of industry mix and differential effects. Further investigation on relative impacts
-	+	+	Environmental policy addressing sectoral innovation technology

Source: adapted from Bonazzi et al. 2008

The policy matrix w/o and with uncertainty

CUNEO

Estimates w/o uncertainties

	Xreg	Xprov	Xp-Xr	m	p	a	m+p+a
CH4	0.1798	0.1848	0.0049	-0.0611	0.0950	-0.0290	0.0049
CO	0.0288	0.0319	0.0030	-0.0041	0.0113	-0.0042	0.0030
CO2	0.0324	0.0287	-0.0038	-0.0012	-0.0070	0.0044	-0.0038
COV	0.0494	0.0363	-0.0130	0.0077	-0.0164	-0.0048	-0.0135
N20	0.0040	0.0004	-0.0036	-0.0021	-0.0036	0.0020	-0.0036
NH3	0.0021	0.0027	0.0006	-0.0005	0.0014	-0.0003	0.0006
NOx	0.0861	0.0822	-0.0039	-0.0068	-0.0064	0.0093	-0.0039
PM10	0.0091	0.0103	0.0011	-0.0010	0.0023	-0.0001	0.0011
PM2.5	0.0034	0.0032	-0.0001	-0.0003	0.0001	0.0000	-0.0001
SO2	0.0139	0.0072	-0.0067	-0.0028	-0.0097	0.0057	-0.0067

Estimates with uncertainties

	Xreg	Xprov	Xp-Xr	m	p	a	m+p+a
CH4	0.3398	0.3511	0.0112	-0.1172	0.1900	-0.0615	0.0112
CO	0.0476	0.0513	0.0037	-0.0073	0.0200	-0.0091	0.0037
CO2	0.0505	0.0457	-0.0048	-0.0016	-0.0106	0.0074	-0.0048
COV	0.0841	0.0627	-0.0213	0.0128	-0.0258	-0.0063	-0.0192
N20	0.0053	0.0006	-0.0047	-0.0027	-0.0046	0.0026	-0.0047
NH3	0.0036	0.0047	0.0011	-0.0009	0.0025	-0.0006	0.0011
NOx	0.1340	0.1246	-0.0095	-0.0121	-0.0094	0.0121	-0.0095
PM10	0.0155	0.0167	0.0013	-0.0019	0.0035	-0.0003	0.0013
PM2.5	0.0055	0.0050	-0.0005	-0.0005	0.0000	0.0000	-0.0005
SO2	0.0201	0.0119	-0.0082	-0.0032	-0.0131	0.0081	-0.0082

The policy matrix w/o and with uncertainty

BIELLA

Estimates w/o uncertainties

	Xreg	Xprov	Xp-Xr	m	p	a	m+p+a
CH4	0.1798	0.1099	-0.0699	-0.0758	0.0314	-0.0255	-0.0699
CO	0.0288	0.0162	-0.0126	-0.0145	0.0015	0.0004	-0.0126
CO2	0.0324	0.0111	-0.0214	-0.0169	-0.0092	0.0048	-0.0214
COV	0.0494	0.0124	-0.0370	-0.0237	-0.0252	0.0121	-0.0369
N20	0.0040	0.0004	-0.0036	-0.0023	-0.0035	0.0021	-0.0036
NH3	0.0021	0.0031	0.0010	0.0004	0.0007	-0.0001	0.0010
NOx	0.0861	0.0449	-0.0412	-0.0406	-0.0022	0.0017	-0.0412
PM10	0.0091	0.0075	-0.0016	-0.0042	0.0041	-0.0016	-0.0016
PM2.5	0.0034	0.0025	-0.0009	-0.0015	0.0010	-0.0003	-0.0009
SO2	0.0139	0.0086	-0.0052	-0.0081	-0.0001	0.0029	-0.0052

Estimates with uncertainties

	Xreg	Xprov	Xp-Xr	m	p	a	m+p+a
CH4	0.3398	0.2099	-0.1299	-0.1423	0.0601	-0.0477	-0.1299
CO	0.0476	0.0275	-0.0202	-0.0242	0.0036	0.0003	-0.0202
CO2	0.0505	0.0189	-0.0316	-0.0261	-0.0110	0.0055	-0.0316
COV	0.0841	0.0224	-0.0617	-0.0404	-0.0403	0.0192	-0.0615
N20	0.0053	0.0006	-0.0047	-0.0029	-0.0044	0.0026	-0.0047
NH3	0.0036	0.0051	0.0015	0.0008	0.0008	-0.0001	0.0015
NOx	0.1340	0.0742	-0.0598	-0.0629	0.0031	0.0000	-0.0598
PM10	0.0155	0.0131	-0.0024	-0.0070	0.0075	-0.0029	-0.0024
PM2.5	0.0055	0.0042	-0.0013	-0.0025	0.0018	-0.0006	-0.0013
SO2	0.0201	0.0155	-0.0046	-0.0114	0.0041	0.0027	-0.0046

The policy matrix w/o and with uncertainty

VERCELLI

Estimates w/o uncertainties

	Xreg	Xprov	Xp-Xr	m	p	a	m+p+a
CH4	0.1798	0.0971	-0.0827	-0.0586	-0.0473	0.0232	-0.0827
CO	0.0288	0.0411	0.0123	-0.0114	0.0411	-0.0174	0.0123
CO2	0.0324	0.0546	0.0222	-0.0089	0.0464	-0.0153	0.0222
COV	0.0494	0.0328	-0.0165	-0.0031	-0.0080	-0.0054	-0.0165
N20	0.0040	0.0031	-0.0009	-0.0008	0.0009	-0.0010	-0.0009
NH3	0.0021	0.0045	0.0024	0.0014	0.0005	0.0005	0.0024
NOx	0.0861	0.1172	0.0311	-0.0303	0.1179	-0.0564	0.0311
PM10	0.0091	0.0149	0.0057	-0.0040	0.0178	-0.0081	0.0057
PM2.5	0.0034	0.0047	0.0014	-0.0013	0.0047	-0.0020	0.0014
SO2	0.0139	0.0042	-0.0097	-0.0045	-0.0088	0.0036	-0.0097

Estimates with uncertainties

	Xreg	Xprov	Xp-Xr	m	p	a	m+p+a
CH4	0.3398	0.0475	-0.2923	-0.1172	-0.2832	0.1081	-0.2923
CO	0.0476	0.0187	-0.0289	-0.0073	-0.0262	0.0045	-0.0289
CO2	0.0505	0.0212	-0.0293	-0.0016	-0.0272	-0.0005	-0.0293
COV	0.0841	0.0135	-0.0705	0.0128	-0.0676	-0.0138	-0.0686
N20	0.0053	0.0014	-0.0040	-0.0027	-0.0027	0.0014	-0.0040
NH3	0.0036	0.0021	-0.0015	-0.0009	-0.0007	0.0001	-0.0015
NOx	0.1340	0.0485	-0.0855	-0.0121	-0.0772	0.0039	-0.0855
PM10	0.0155	0.0065	-0.0089	-0.0019	-0.0079	0.0008	-0.0089
PM2.5	0.0055	0.0020	-0.0036	-0.0005	-0.0033	0.0002	-0.0036
SO2	0.0201	0.0018	-0.0183	-0.0032	-0.0182	0.0031	-0.0183

Few comments

- The way to address uncertainty changes according to the purpose of estimates' use
- For data analysis and policy uses a way to proceed is to integrate estimates with additional information and datasets
- Considering uncertainty does affect the message to policy maker and thus the strategy and actions to be implemented

I

U

A

V

Università Iuav
di Venezia

Thank you for your attention

lanotte@iuav.it