UNSD-ESCWA

Training Workshop on Environment Statistics

STATISTICS ON AIR EMISSIONS AND AIR QUALITY

Damascus, 4-8 April 2004

UNEP

MAP

plan bleu

Florence PINTUS
MEDSTAT-Environment II

PLAN BLEU – France

A presentation based on the MED-Env Training on air emissions statistics:

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I. OVERALL ISSUES ON THE AIR POLLUTION IN THE MEDITERRANEAN REGION

II. CALCULATIONS METHODS FOR EMISSIONS INVENTORIES

III. MAJOR INTERNATIONAL PROTOCOLS AND CONVENTIONS

IV. INVENTORIES AND REPORTING

V. UNSD QUESTIONNAIRE ON AIR

I.

OVERALL ISSUES ON THE AIR POLLUTION IN THE MEDITERRANEAN REGION

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MAP

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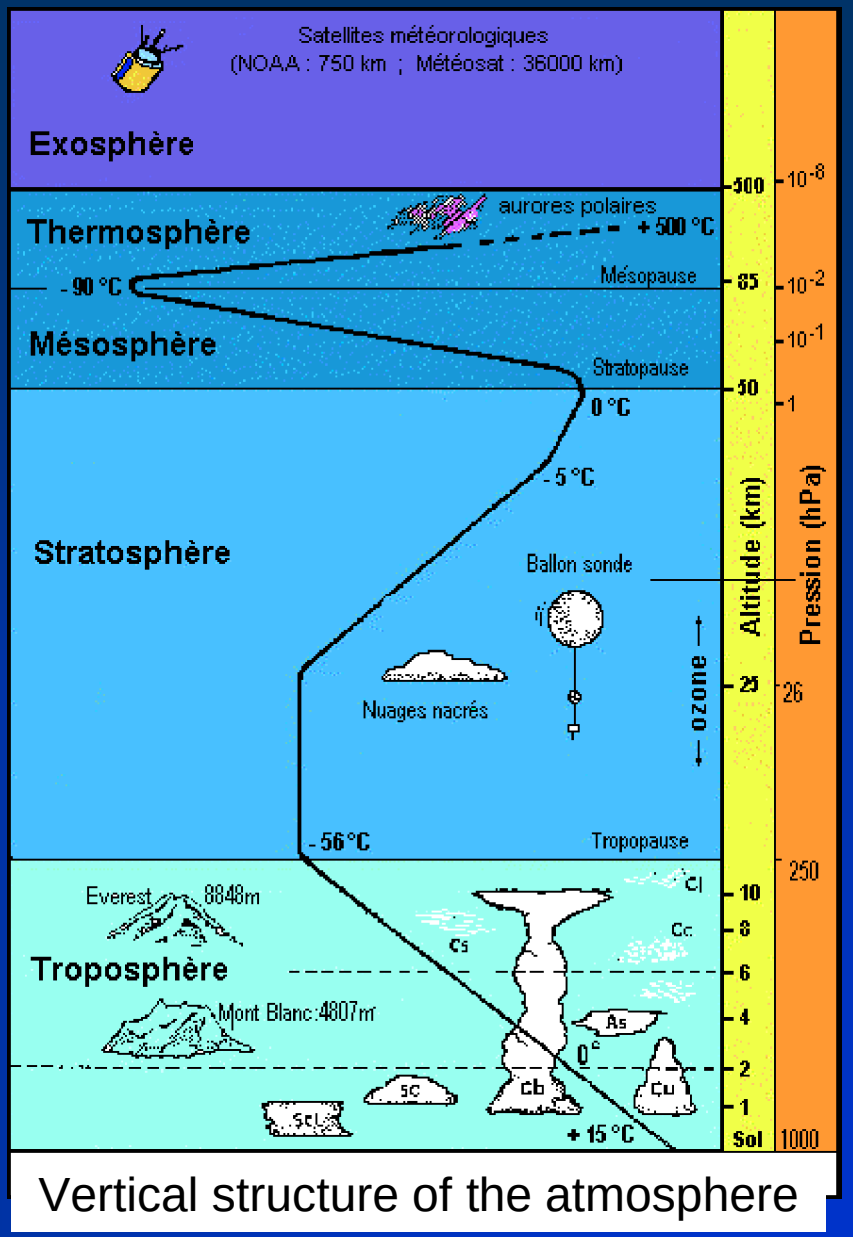
COMPOSITION OF THE ATMOSPHERE (% in volume)

- Nitrogen : 78 %
- Oxygen : 21%
- Argon : 0.93 %
- Carbon dioxide : 0.035 %
- Neon, Helium, Krypton, Hydrogen

« Good ozone » at 25 km altitude

« Bad ozone » in the lower troposphere



Vertical structure of the atmosphere

According to Météo-France

ORIGINE OF THE POLLUTANTS

- Energy activities:
  - * fuel combustion
  - * fugitive fuels
- Industrial processes
- Solvents
- Agriculture
- Others

SOURCES OF POLLUTANTS

- power plants
- refineries
- incinerators
- factories
- domestic households
- cars and other vehicles
- animals and humans
- fossil fuel extraction and production sites
- offices and public buildings
- trees and other vegetation
- distribution pipelines
- fertilised land
- land with biological decay.

MAIN POLLUTANTS

- § CO2 : carbon dioxid
- § Sox: sulphur oxides
- § Nox : nitrogen oxides
- § VOC: volatile organic compounds
- § Particulates (PM)
- § CH4: methane

OTHER POLLUTANTS

- Halogenated molecules : (HF, HCl…)
- Halogenated hydrocarbons : CFC, HFC,PFC…)
- Sulphur hexafluoride : SF6
- Heavy metals : Hg, Pb, As, Cd, (Cr, Cu, Ni, Se, Zn)
- Persistant Organic Pollutants (POP) : PAH
  Dioxines, hexachlorobenzen, PCB
- Odours, etc…

Ozone (O3) is not emitted by any anthropic process.

CHEMICAL PROCESS: example of combustion

Fuels are made of C → CO2

But also
S → SOx (SO2 + SO3)
N → NOx (NO + NO2) et N20
H → H2O
Cl → HCl
minerals → ashes (not transformed)

FUELS

Fuels			
Type	**PCI (MJ / kg)**	**Sulfur content (%)**	**Carbon atomes**
Waste	5 à 9	?	?
Wood	10 à 14	?	n X 6
Lignit	12 à 20	very fluctuant	?
Coal	around 26	0,3 à 8	?
Oil coke	32	2 à 6	1OO ?
Heavy fuel	40	4 / 2 / 1 / 0,5	25 à 100
Domestic fuel	42	< 0,2	10 à 20
Diesel	42	< 0,05	10 à 20
Jet fuel	42	< 0,05	12
(Naphta)			6 à 10
Gasoline	44	< 0,05	4 à 10
LPG (Propane, Butane)	46	0	3 à 4
(Ethane)		0	2
Natural gas (methane)	50	0	1
Hydrogen	120	0	0

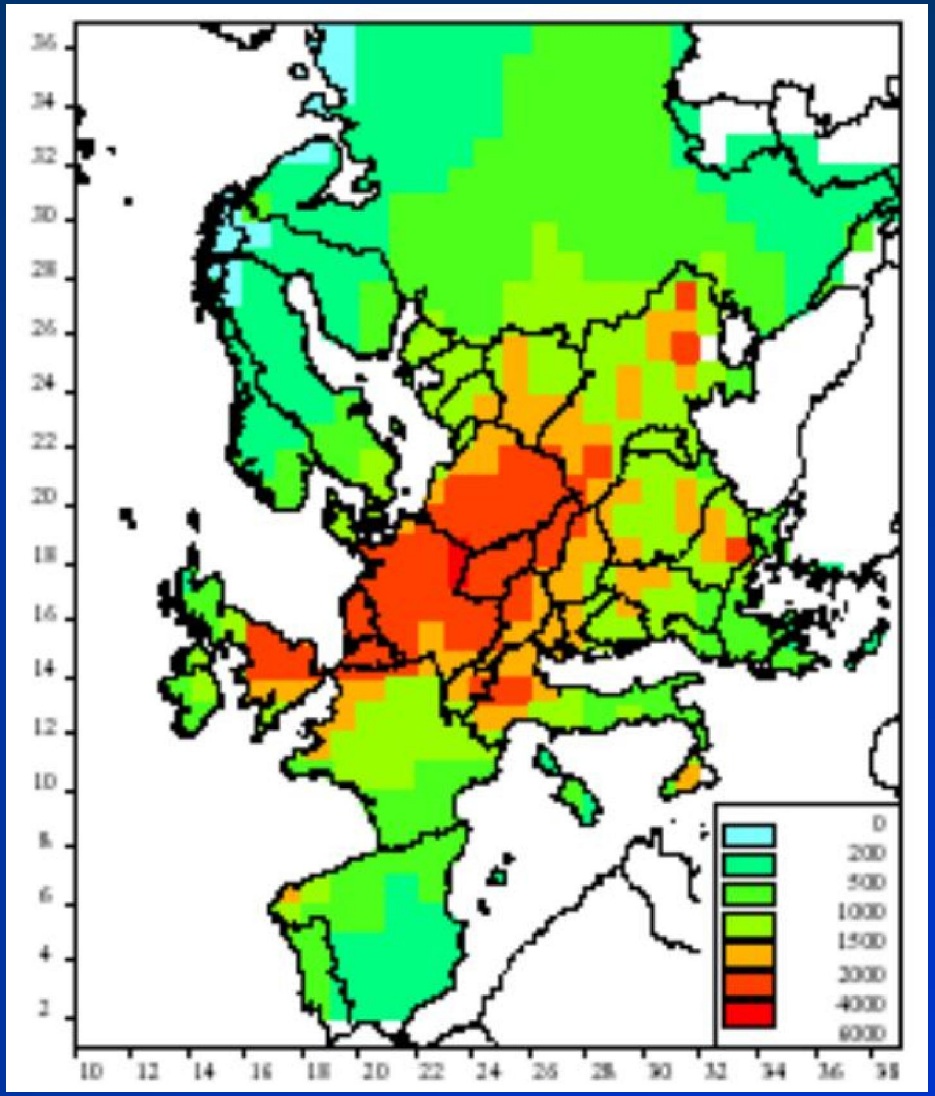
INDUSTRIAL PROCESSES

For more information about industrial processes, have a look on the website :

http://www.jrc.es/pub/english.cgi/0/733169

IMPACTS : SOIL ACIDIFICATION

Soil acidification



IMPACTS : SOIL ACIDIFICATION

As early as 1976, the UNECE became aware of the problem and elaborated a strategy.

Implementation of this strategy required to account:

- **emissions**
- **atmospheric transfers**
- **depositions and concentrations of pollutants**
- **soil, waters and vegetation sensibility**
- **technical means for controling emissions**
- **costs of these means**

IMPACTS : OZONE LAYER DESTRUCTION

Perturbation of the natural cycle « production – destruction » of ozone due to the introduction by human activities of Volatile Organic Compounds (VOC) and nitrogen oxides (NOx)

The whole of chemical reactions forms a fully non linear system. Thousands of reactions and compounds. Each reaction has its own speed and its own equilibrium constant.

IMPACTS : OZONE LAYER DESTRUCTION

Due to the high stability of the stratosphere, molecules injected at ground level reach the ozone layer after some ten years travel. Responsibles: chlorinated or bromated molecules very stable with a very long life

CFC : chlorofluorocarbons (Fréons and Halons)

CCl4, méthyle bromide

Refrigeration, sprays, pesticides, foams, solvents, industrial cleaners, etc…

IMPACTS : OZONE LAYER DESTRUCTION

Substitution by other products :

HCFC less stable (1st generation)

HFC without chlorine (2nd generation)

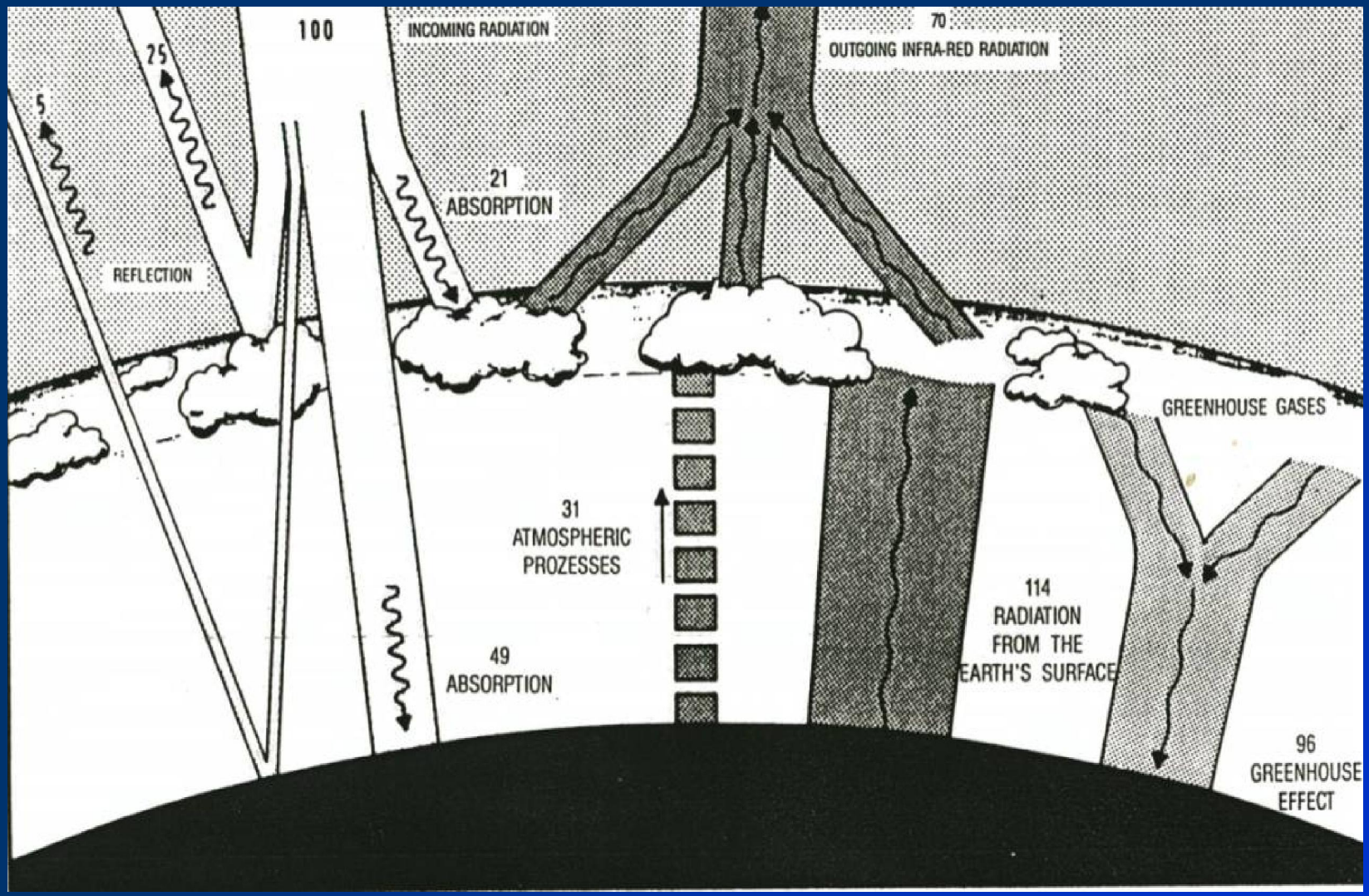
IMPACTS : GREENHOUSE EFFECT

The greenhouse effect exist in natural conditions due to radiative properties of the system Ground – Atmosphere. Without this natural phenomenon, earth surface temperature would be – 18 °C.

But due :
- to absorption of solar radiations temperature is raising,
- to many complex chemical reactions implying Nox,VOC etc, urban pollution is increasing fast:

- **Local and regional pollution with pics in peri-urban areas**
- **Peaks of O3: over 300 micro-grammes**
- **Increase of background O3 concentrations**

IMPACTS : GREENHOUSE EFFECT



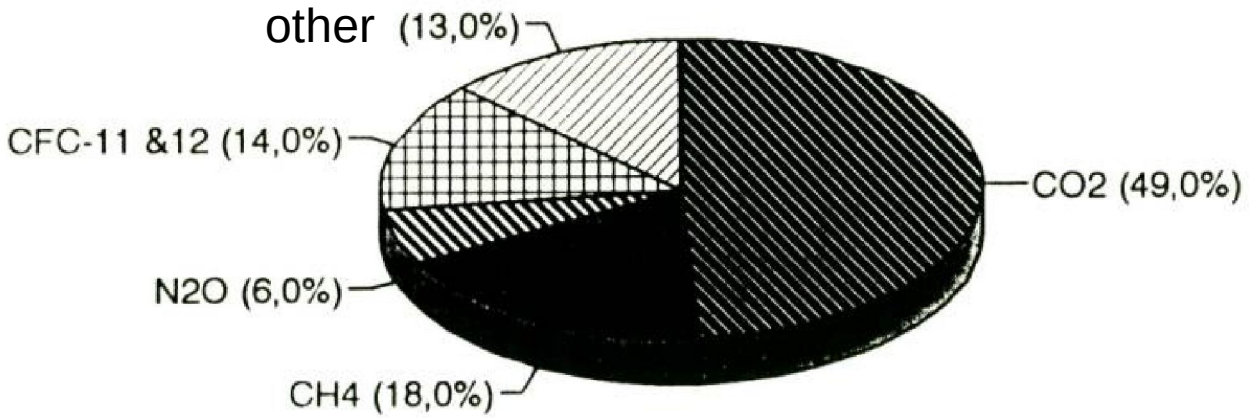
IMPACTS : GREENHOUSE EFFECT

Absorption of infra-red radiation depends on the nature of molecules

Index of “Global Warming Potential“ (GWP) with a base 1 for CO2

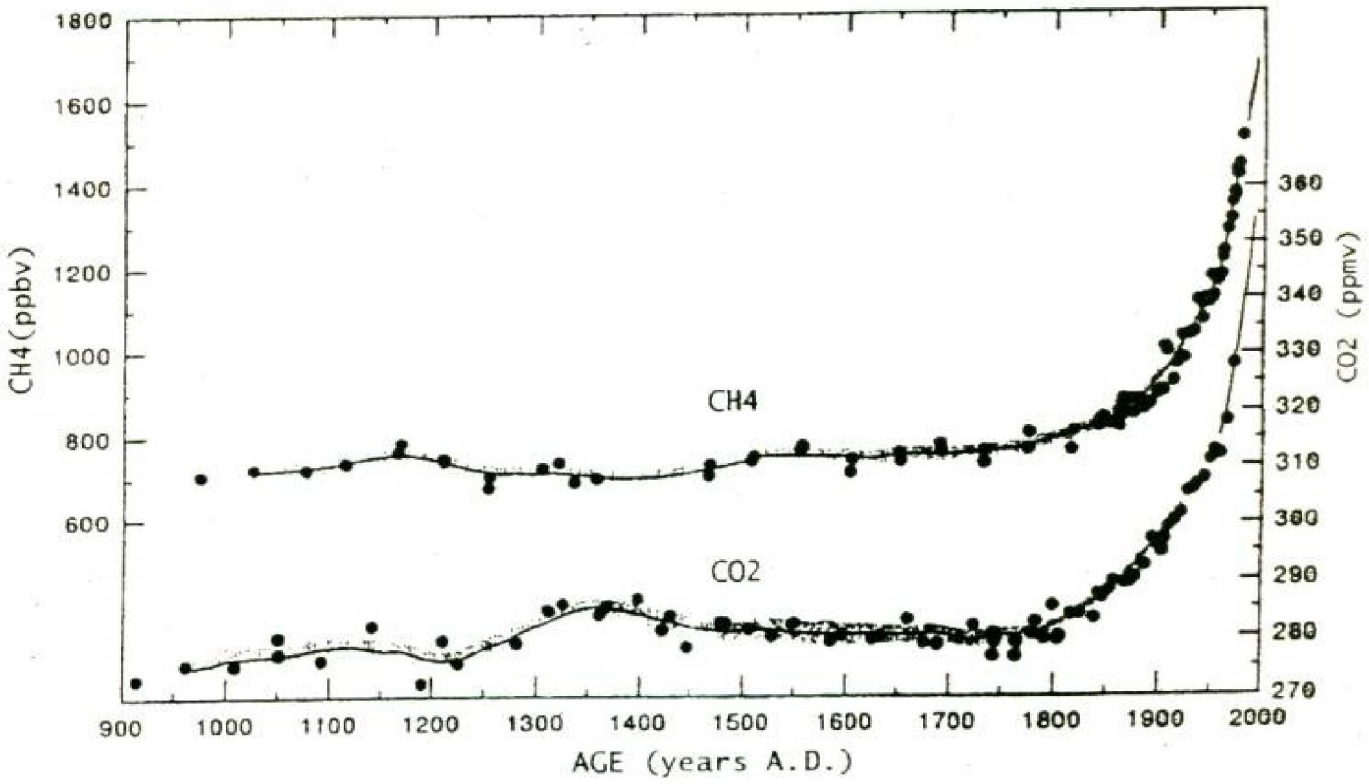
IMPACTS : GREENHOUSE EFFECT

Contribution to the GHG effect during the 80's



Values estimated based on concentration changes

IMPACTS : GREENHOUSE EFFECT



Source : lettre pigb.france

Evolution of the CO2 and CH4 content according to the analysis of the bubbles of air contained in the ice

IMPACTS : HEALTH EFFECTS

Effects on human health (a man breathes 15 m3 of air per day) :

- Directly by action on organism
- Undirectly by modification of our environment (case of CO2, of N20, of odours)

IMPACTS : HEALTH EFFECTS

Short term effects difficult to prouve the harmfulness of each pollutant

- SO2 : inflammation of bronchia (deterioration of respiratory fonctions, cough). Heart and lung desease.
- NOx : irritant for bronchia. Risk for asthmatic people.
- CO : dizziness, heart troubles, asphyxia.
- Ozone : reduce the respiratory fonction. Eye, bronchia and throat irritation.
- Fine PM : mechanical effects and chemical harmfulness.
- Respiratory and cardiovascular desease.

IMPACTS : HEALTH EFFECTS

Long term effects more difficult to assess than short term effects.

- Average concentrations generally low
- Effects can be confused with other effects
- Epidemiological assessments (comparisons either in time or in space and serious statistical treatment)
- Experimental assessments (animals and extrapolation to human)
- In vitro assessments (physiopathological mechanisms at cell level)

II.

CALCULATION METHODS

KNOWLEDGE OF EMISSIONS

1. DIRECT MEASUREMENT

- Extraction of pollutants outside of the gaseous flux
- Transfer of pollutants from the flux to a measuring or analysis device
- Mesure or analysis (including calibration)

2. BASIC MODEL FOR EMISSION ESTIMATES

based on the product of (at least) two variables : emission factors and another parameter (fuel burnt or activity…)

3. INPUT / OUTPUT BALANCE OF A PROCESS

(Solvents, heavy metals, etc…)

Method at first sight simple nevertheless misleading in some cases

EMISSION INVENTORY

The basic model for an emission estimate is the product of (at least) two variables, for example:

- **an activity statistic and a typical average emission factor for the activity,**
- **an annual fuel consumption and an emission factor in grams of pollutants per ton of fuel**
- **an emission measurement over a period of time and the number of such periods emissions occurred in the required estimation period.**

Emissions from road traffic :

More Complex Method

- Fuel consumption :
  - per fuel type
  - per vehicle category
- Vehicle stock
- Number of vehicles per vehicle category
- Age distribution of the vehicle stock

Driving conditions:
- Annual mileage per vehicle class
- Annual mileage per road class
- Average speed of vehicles

Emission factors
.Per vehicle class
.Per production year
.Per road class (average speed)

Other parameters
.Fuel properties
.Climatic conditions

Calculation of annual emissions of all pollutants for all CORINAIR road traffic source categories

EMISSION INVENTORY

- Road Transport (schematic only – actual calculations are more complex)

$$E = \sum_{T} \left\{ \sum_{T,|R} \left(F_{T,R} \times V_{T,R} \right) + \sum_{T} \left(\frac{\sum_{R} V_{T,R}}{L_T} \times C_T \times S \right) \right\}$$

- E = Emissions of a single pollutant in one year
  - T= technology of vehicle
  - R = road type
  - F = Emission Factor
  - V = Vehicle Kilometres
  - L = Average Trip Length
  - C = Cold Start Emissions
  - S = Fraction of starts that are cold

SNAP: Selected Nomenclature for sources of Air Pollution

- developed as part of the CORINAIR project for distinguishing emission source sectors, sub-sectors and activities.
- Take note of the difference between a technical nomenclature (SNAP 97) and a socio-economical nomenclature (for instance ISIC)

SNAP

Group 1:

Combustion in energy and transformation industries

Access to chapters

SNAP	Name of SNAP/CORINAIR Activity	NFR 1	CRF/IPCC classification	
01	**COMBUSTION IN ENERGY AND TRANSFORMATION INDUSTRIES**			
0101	Public power	1a	.	.
010101	Combustion plants > = 300 MW (boilers)	1a	1A1a	Electricity and heat production
010102	Combustion plants > = 50 and < 300 MW (boilers)	1a	1A1a	Electricity and heat production
010103	Combustion plants < 50 MW (boilers)	1a	1A1a	Electricity and heat production
010104	Gas turbines	1a	1A1a	Electricity and heat production
010105	Stationary engines	1a	1A1a	Electricity and heat production
0102	District heating plants	1a	.	.
010201	Combustion plants > = 300 MW (boilers)	1a	1A1a	Electricity and heat production
010202	Combustion plants > = 50 MW and < 300 MW (boilers)	1a	1A1a	Electricity and heat production
010203	Combustion plants < 50 MW (boilers)	1a	1A1a	Electricity and heat production
010204	Gas turbines	1a	1A1a	Electricity and heat production
010205	Stationary engines	1a	1A1a	Electricity and heat production
0103	Petroleum refining plants	1b	.	.
010301	Combustion plants > = 300 MW (boilers)	1b	1A1b	Petroleum refining
010302	Combustion plants > = 50 MW and < 300 MW (boilers)	1b	1A1b	Petroleum refining
010303	Combustion plants < 50 MW (boilers)	1b	1A1b	Petroleum refining

III.

MAIN INTERNATIONAL PROTOCOLS

AND CONVENTIONS

THREE CONVENTIONS : THREE INVENTORIES

VIENNA CONVENTION 1987 ON OZONE LAYER PROTECTION

GENEVA CONVENTION 1991 ON LONG RANGE TRANSPORT AIR POLLUTION (CLRTAP)

RIO CONVENTION 1992 ON CLIMATE CHANGE

VIENNA CONVENTION

Many protocoles and amendments…

- **Montreal protocole (1987)**
- **Beijing amendment (1999)**

Pollutants : organic molecules with Cl and F

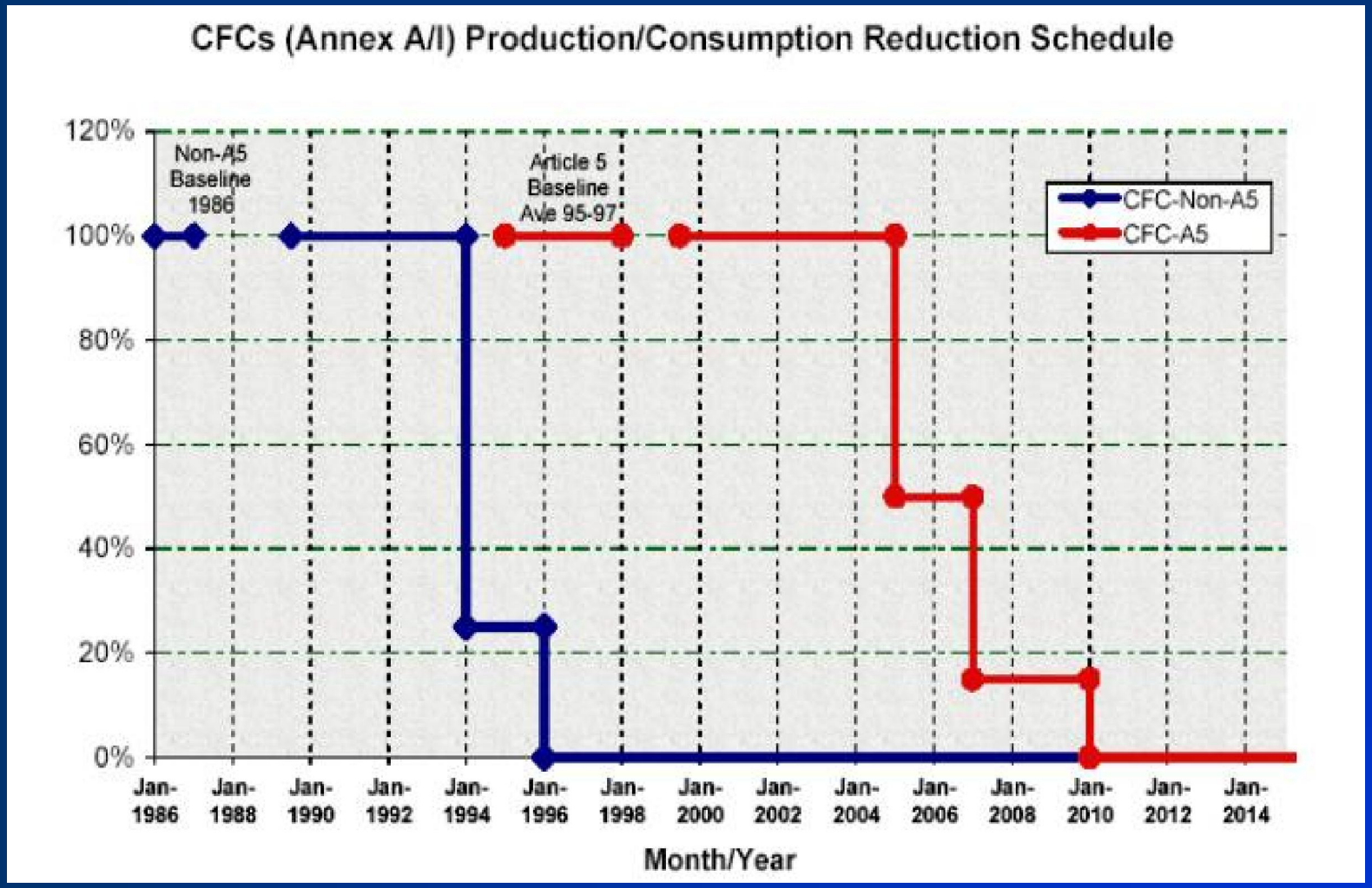
Periodicity : annually

Geographical zone : one country

Activities : in principle all activities, in fact only the most relevant

VIENNA CONVENTION

Group I: Chlorofluorocarbons (CFC-11, CFC-12, CFC-113, CFC-114 and CFC-115)
Applicable to production and consumption Non-Article 5(1) Parties Article 5(1) Parties



VIENNA CONVENTION

Documentation:

Handbook on data reporting under the Montreal protocol available on the Web site **:**
http://www.unep.org/ozone/pdfs/Handbook-on-Data-Report-from-UNEP-TIE.pdf

For worksheets and instructions **:**
www.unep.org/ozone/data-reporting-tools.shtml

GENEVA CONVENTION

UN-ECE = United Nations Economic Commission for Europe

Convention on Long Range Transport of Air Pollution (CLRTAP)

Many protocols :

- **emission reduction ratio**
- **emission ceiling to be respected in a precise delay**

GENEVA CONVENTION: PROTOCOLS

Helsinki: SO2 emissions reduction (1985)
Sofia: NOx emissions reduction (1988)
Genève: COV emissions reduction (1991)
Oslo: SO2 emissions reduction (1994)
Aarhus: heavy metals and COP emissions (1998)
Göthenburg: ceiling emissions for SO2, NOx, COV et NH3 (1999)

The Gothenburg protocol is the first one to be the result of a "technico – economico –geographical" optimisation at the european scale

GENEVA CONVENTION: DATA REQUIRED

Pollutants : SO2, NOx, VOC, NH3 (PM), CO, Heavy metals, POP, Particulates

- § Parties are invited to also report emissions of more detailed sub-sectors (SNAP level 2).
- § Parties are also required to provide EMEP periodically with emission data within grid elements of 50km x 50km, as defined by EMEP and known as the EMEP grid.
- § Parties should use the EMEP/CORINAIR Atmospheric Emission Inventory Guidebook

GENEVA CONVENTION

Geographical coverage : Europe up to Oural
Including USA and Canada

Where to find information ?

Atmospheric Emission Inventory Guidebook
3 rd edition October 2002 update
http://reports.eea.eu.int/EMEPCORINAIR3/en/

CLIMATE CHANGE CONVENTION (UNFCCC)

Parties of the Annexe I :

26 industrialised countries **:** UE + Australia, Canada, USA, Iceland, Japan, Liechtenstein, Monaco, Norway, New-Zealand, Switzerland, Turkey
14 european countries in transition as Russia
European Union (regional integration)

Countries of Annexe II :

24 highly industrialised countries **(same as mentioned above without Monaco and Liechtenstein) +** UE
Countries of annexe II have to supply financial and technological support to underdeveloped countries

CLIMATE CHANGE CONVENTION (UNFCCC)

Kyoto Protocol (1997) :

- GHG emission limitation up to 2008 – 2012 with regard to 1990 (developped countries annex I)
- Emission inventory and National Communications
- Flexibility mechanisms (emission trading system, Mechanism for Clean development, Join application)

CLIMATE CHANGE CONVENTION (UNFCCC)

Pollutants Direct GHG

CO2	Carbon dioxide	HFC's	Hydrofluorocarbons
CH4	Methane	PFC's	Perfluorocarbons
N2O	Nitrous oxide	SF6	Sulphur hexafluoride

Undirect GHG

SO2	Sulphur dioxide
NOx	Nitrogen oxide (NO) + Nitrogen dioxide (NO2)
CO	Carbone monoxide
NMVOC	Non-Methane Volatile organic Compounds

EMISSION INVENTORY IS THE CORNER - STONE OF THE CONVENTION.

Reporting format : CRF/IPCC

THREE CONVENTIONS: Summary

R.BOUSCAREN — EMISSION INVENTORY SYNTHESIS TABLE — 17/01/2004

CONVENTION	OBJECTIVE	MAIN PROTOCOLE	SPONSOR	POLLUTANTS	INVENTORY	DATE	GEOGR EXTENSION	DEFINITION	PERIODICITY	REPORTING FORMAT
VIENNE	Ozone layer	Montreal	UN	CFC's, etc...	Production Consumption	1987	World	Each country	Yearly	
			EC EEA	SO2, NOx, VOC, NH3, PM	EMEP/CORINAIR	1985	EU (15)	Each country	Yearly	NFR
GENEVE	LRTAP	Gothenburg	UN-ECE EMEP	SO2, NOx, VOC NH3, PM, HM's, POP's, etc ...	EMEP/CORINAIR EMEP/CORINAIR	1990	Large Europe Large Europe	Each country 50x50 km	Yearly Every 5 years	NRF
RIO	Climatic change	Kyoto	UN	CO2, CH4, N2O other GHG's	UNFCCC/IPCC	1995	World	Each country	Yearly	CRF

UNEP

MAP

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IV.

INVENTORIES AND REPORTING

INVENTORIES: PURPOSES

- § inform the policy makers and the public
- § define environmental priorities and identify the activities and actors responsible for the problems
- § set explicit objectives and constraints
- § assess the potential environmental impacts and implications of different strategies and plans
- § evaluate the environmental costs and benefits of different policies

INVENTORIES: PURPOSES (2)

- monitor the state of the environment to check that targets are being achieved
- monitor policy action to ensure that it is having the desired effects
- ensure that those responsible for implementing the policies are complying with their obligations.

CORINAIR

- This project started in 1986 with the objective of compiling a co-ordinated inventory of atmospheric emissions from the 12 Member States of the Community in 1985 (CORINAIR 1985).
- Covered three pollutants SO_2, NO_x, and VOC (total volatile organic compounds)
- Updated in 1991 : in co-operation with EMEP and IPCC-OECD to assist in the preparation of inventories required under the Long Range Transboundary Air Pollution (LRTAP) Convention and the Framework Climate Change Convention (FCCC) respectively.

CORINAIR : SCOPE

The CORINAIR90 system was made available to :

- the 12 member states of the European Community in 1990: Belgium, Denmark, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain and United Kingdom
- 5 EFTA countries: Austria, Finland, Norway, Sweden and Switzerland
- 3 Baltic States: Estonia, Latvia and Lithuania
- 9 Central and Eastern European countries: Albania, Bulgaria, Croatia, Czech Republic, Hungary, Poland, Romania, Slovakia and Slovenia
- Russia.

CORINAIR : EMEP

The Cooperative Programme for Monitoring and Evaluation of the Long Range Transmission of Air Pollutants in Europe (EMEP) formed by a Protocol under the Long Range Transboundary Air Pollution Convention has arranged a series of workshops on Emission Inventory Techniques to develop guidelines for estimation and reporting of emission data forSOx, NOx, NMVOCs, CH4, NH3 and CO under the Convention.

The EMEP/CORINAIR Atmospheric Emission Inventory Guidebook

INTRODUCTION : Emissions and Emission Inventories

International Requirements for Emission Inventories
- 2.1 Long Range Transboundary Air Pollution Convention
- 2.2 United Nations Framework Convention on Climate Change
- 2.3 Amended Council Decision 99/296/EC on a Monitoring Mechanism of Community CO2 and other Greenhouse Gas Emissions

Atmospheric Emission Inventory Methodology
- 3.1 OECD/MAP Project
- 3.2 The DGXI Inventory
- 3.3 CORINE and the EEA Task Force
- 3.4 EMEP
- 3.5 The IPCC/OECD Programme on National Greenhouse Gas Inventories

Multi-media Integrated Inventories
The European Environment Agency

The EMEP/CORINAIR Atmospheric Emission Inventory Guidebook

TASK FORCE ON EMISSION INVENTORIES AND PROJECTIONS

Guidebook Specification

Guidebook Format

Tasks for the Expert Panels

GLOSSARY

The EMEP/CORINAIR Atmospheric Emission Inventory Guidebook

PART B GENERAL METHODOLOGY CHAPTERS
CORINAIR nomenclatures
Correspondence between SNAP97 and IPCC96 source categories
Correspondence between IPCC96 source categories and SNAP97
CORINAIR 1990 summary of emissions
CORINAIR 1990 - Top 30 activities (28 countries)
CORINAIR 1996 summary by activity for some countries
Emission projections
Good Practice Guidance for CLRTAP Emission Inventories
Estimation of PAH Emissions
Products containing mercury
Electrical equipment (electrical equipment containing PCBs)
Bibliography

The EMEP/CORINAIR Atmospheric Emission Inventory Guidebook

INDEX TO METHODOLOGY CHAPTERS ORDERED BY SNAP97 ACTIVITY

Group 1 Combustion in energy and transformation industries
Group 2 Non-industrial combustion plants
Group 3 Combustion in manufacturing industry
Group 4 Production processes
Group 5 Extraction & distribution of fossil fuels and geothermal energy
Group 6 Solvent and other product use
Group 7 Road transport
Group 8 Other mobile sources and machinery
Group 9 Waste treatment and disposal
Group 10 Agriculture
Group 11 Other sources and sinks

PART C ANNEXES

Expert Panels

IPCC/OECD/IEA PROGRAMME ON NATIONAL GREENHOUSE GAS INVENTORIES

- In February 1991 the OECD held a workshop in Paris on greenhouse gas emission inventory methodology to consider the OECD report 'Estimation of Greenhouse Gas Emissions and Sinks' (Background Report). The workshop produced (OECD, 1991) consensus on:
- a basic methodology document as the best available starting point for work on consistent national emission estimates and
- a proposed plan for a two-year programme of work to improve and disseminate the inventory methodology.

IPCC

- IPCC subsequently adopted the Work Programme with support from OECD and IEA and recognised that method development effort should (IPCC, 1992):
- build on available information both best available scientific data from ongoing research and currently available inventories and methods
- provide a simple default method accessible to all participating countries while allowing more detailed methods to those countries which have more extensive capabilities
- have careful documentation and review procedures to ensure consistency and transparency of results.

IPCC GUIDELINES

- Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories (“IPCC Guidelines”).
- IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories
- Parties may use different methods (“tiers”), using more detailed approaches for “key sectors”
- Parties can also use national methodologies which they consider better able to reflect their national situation provided that these methodologies are compatible with the IPCC Guidelines and are well documented

IPCC MAIN SECTORS FOR REPORTING EMISSIONS AND REMOVALS :

- All Energy (Combustion + Fugitive)
- Industrial Processes
- Solvent and other Product Use
- Agriculture
- Land Use Change and Forestry
- Waste

COMPATIBILITY

- the European Environment Agency has been working closely with the IPCC/OECD/IEA to ensure compatibility between
  - the joint EMEP/CORINAIR Atmospheric Emission Inventory Guidebook and reporting formats and
  - the IPCC Guidelines and reporting formats.
- the revised SNAP97, distributed in 1998 is fully in line with the 1996 Revised IPCC Guidelines.

REPORTING REQUIREMENTS

NFR: Nomenclature For Reporting

§ Reporting format that provides a mapping between SNAP and UNFCCC reporting formats

CRF: Common Reporting Format

§ A reporting Format – tables supplied by UNFCCC

§ Compatible with Inventories compiled using SNAP

§ Compatible with NFR

§ Detailed and needs careful completion!

INVENTORIES QUALITY

- Comparability
- Completeness
- Consistency
- Transparency
- Accuracy
- Timeliness

INVENTORIES AND REPORTING

Documentation

Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories (3 volumes) (The Reporting Instructions - The Workbook - The Reference Manual)

Good Practice Guidance and Uncertainty Management Corrigendum (GPGAUM-Corr.2001.01, 15 june 2001)

Available on the site : **http://www.ipcc-nggip.iges.or.jp/public**

Database on Greenhouse Gas Emission Factors (IPCC – EFDB) User Manual for Web application Version 1.00 (19 septembre 2003)

Annex to the User Manual Guidance on the “properties” field Version A-1.00 (19 septembre 2003)

Available on the site : http://ipcc-nggip.iges.or.jp/EFDB

V.

UNSD QUESTIONNAIRE ON AIR

UNSD QUESTIONNAIRE ON AIR

- TABLE OF CONTENT
- SO2 EMISSIONS
- LEAD EMISSIONS
- [SO2] CONCENTRATION