The Salut'air-Project: Assessment of European Air Quality in 2050 in the Context of Climate Change

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maîtriser le risque pour un développement durable

TFIAM, 22-23 April 2013, Copenhagen

The Salut’air project

- **Salut’air**
  - Evaluation of strategies mitigating long-range transboundary air pollution in the context of climate change *
- **Funded by the French research programme PRIMEQUAL**
  - financed by the French Ministry for Ecology and ADEME
  - bringing together different scientific communities concerned with air pollution and its impacts
- **Project tasks**
  - downscaling of global climate and chemistry fields to regional scale (Europe)
  - modelling of air pollution scenarios under climate change
  - assessment of impacts on air quality and health in 2050
  - cost-benefit analysis for 2050

=> presentation of preliminary results

* Evaluation des StrAtégies de LUTte contre la pollution de l'AIR à longue distance dans le contexte du changement climatique

Institutes involved

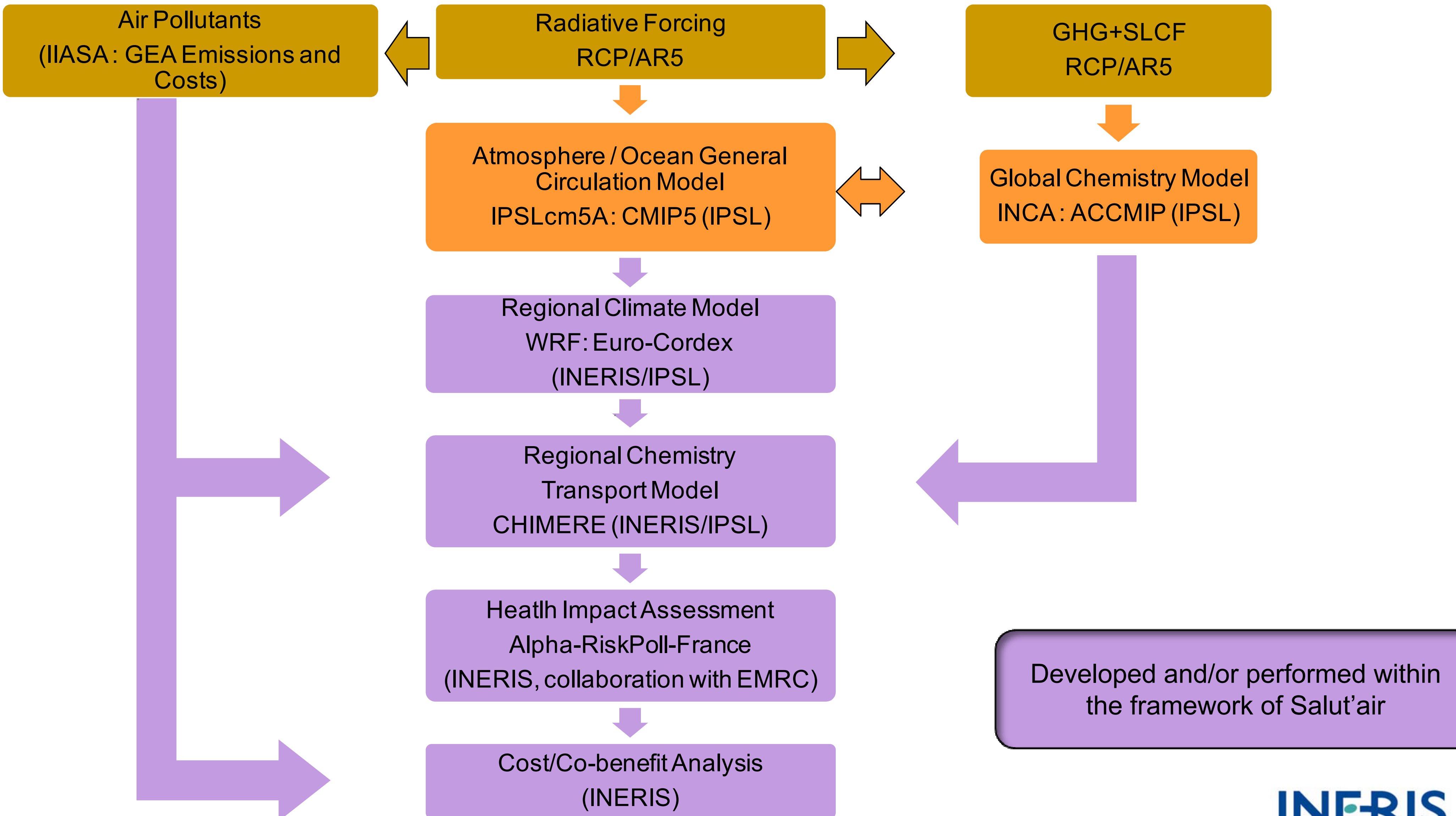
Project partners

- INERIS
  - ➢ Bertrand Bessagnet, Augustin Colette, Frédéric Meleux (MOCA - Atmospheric Modelling and Environmental Mapping Unit)
  - ➢ Simone Schucht (EDEN - Economics and Decision for the Environment Unit)
  - ➢ Laurence Rouïl (DECI – Environmental Modelling and Decision Department)
- Laboratoire des Sciences du Climat et de l'Environnement
  - ➢ Sophie Szopa, Robert Vautard, Gaëlle Clain (LSCE/IPSL/CEA/CNRS)
- Laboratoire de Météorologie Dynamique
  - ➢ Laurent Menut (LMD/IPSL/CNRS)

Further collaboration with

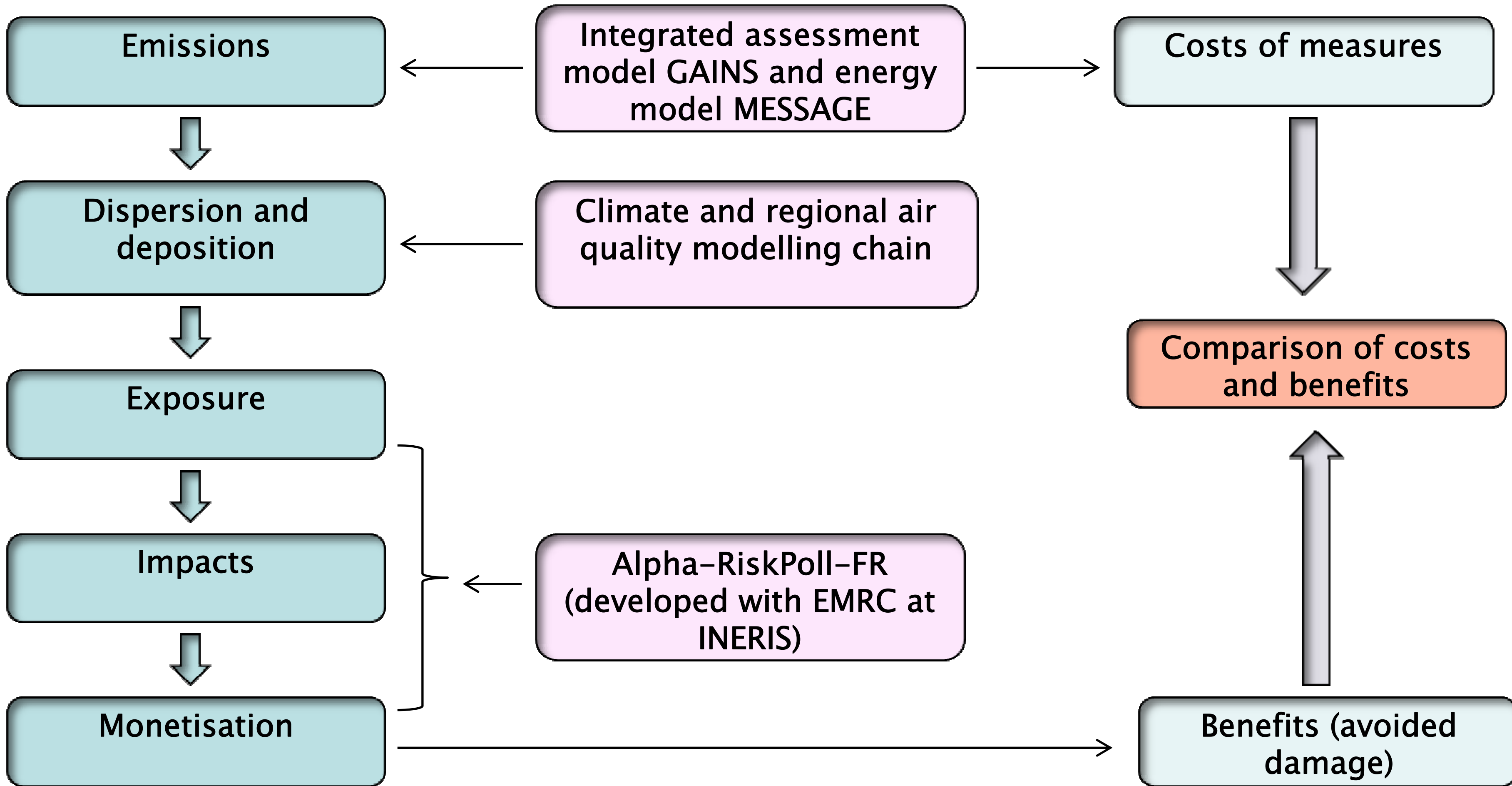
- IIASA
  - ➢ Shilpa Rao, Keywan Riahi, Peter Kolp (ENE – Energy Program)
  - ➢ Zig Klimont, Wolfgang Schöpp (MAG - Mitigation of Air Pollution & Greenhouse Gases)
  - EMRC
  - ➢ Mike Holland

The project setup - regional air quality and climate impact assessment



The modelling chain allowing to compare costs and benefits of emission reduction strategies

Impact pathway approach | Models used | Comparison of costs and benefits



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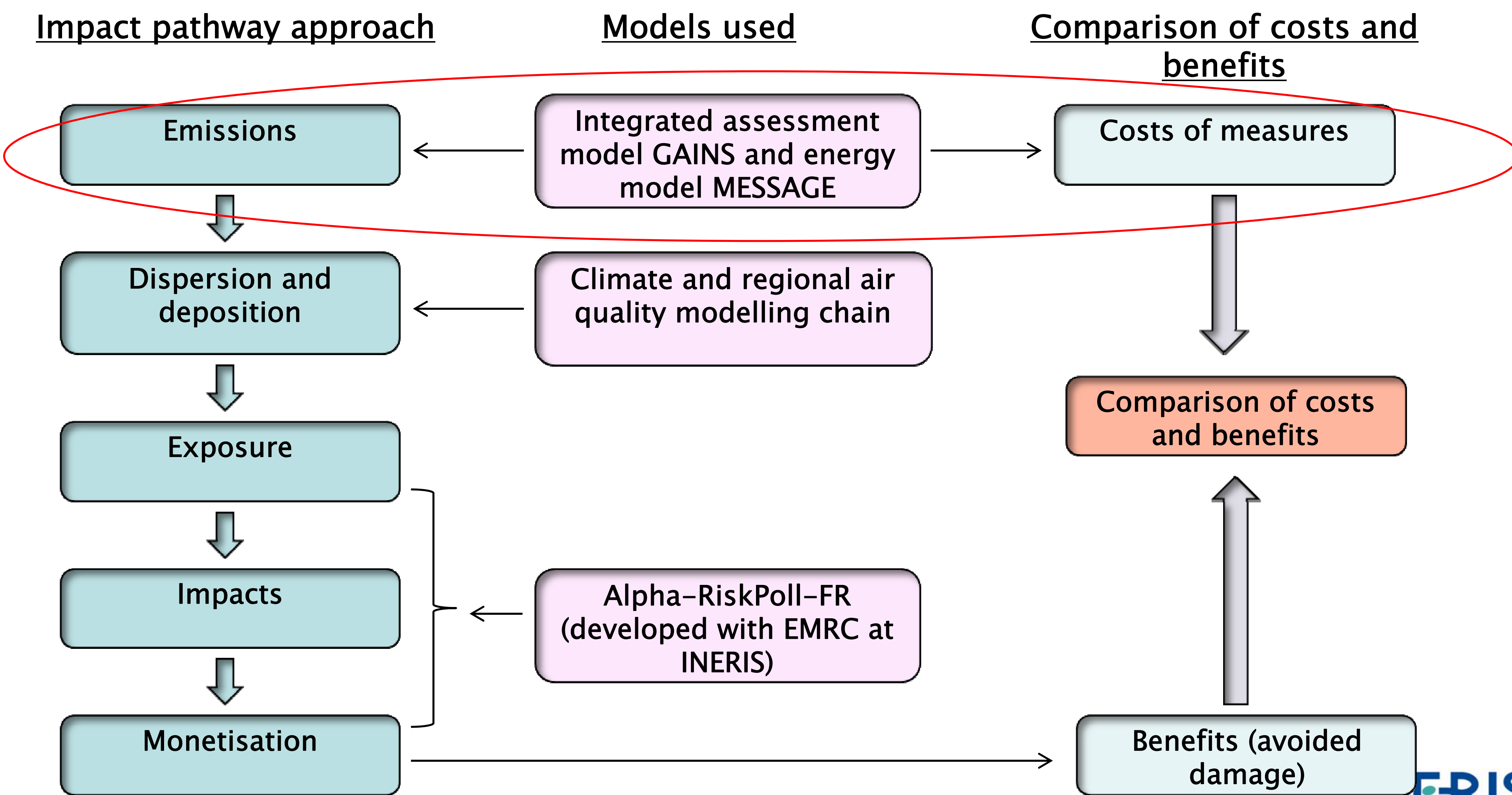


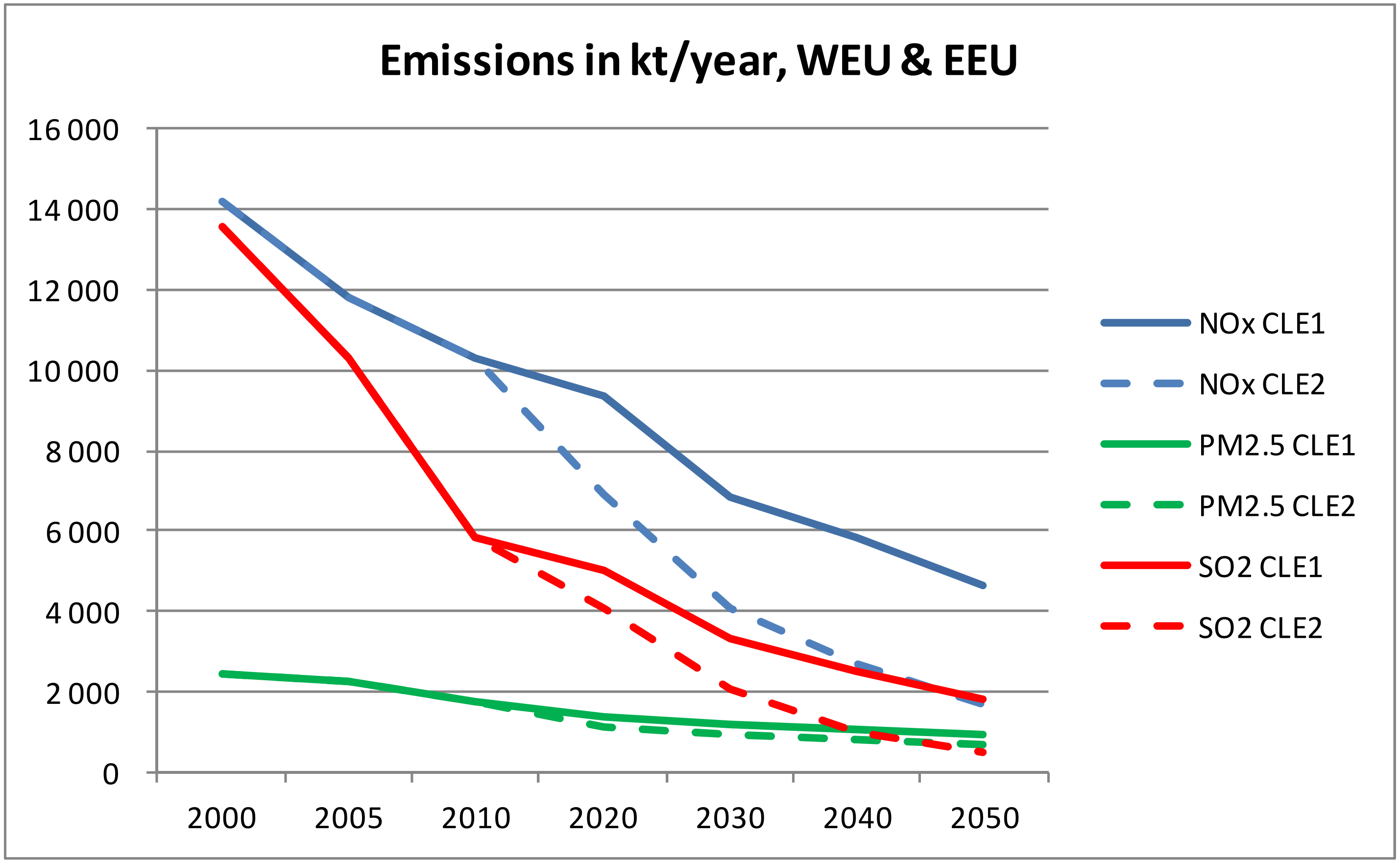
Two emission scenarios from GEA used for AQ and health impact assessment

- Match RCPs in terms of global radiative forcing
- Revised handling of air pollutant emissions
  - detailed assumptions on air pollution abatement in 2030 provided by the integrated assessment model GAINS and fed into the global energy model MESSAGE
- Through collaboration with IIASA access to
  - spatial pollution maps for NOx, VOCs, NH3, SO2, PM2.5, CO, BC and OC
  - global CO2 trajectories for the two climate contexts (REF and MIT)
  - expenditures (investment and O&M costs) for air quality and climate/energy policy
  - data for MESSAGE regions WEU & EEU

Scenarios		**Policies**				**Climate context**
		Air pollution	**Climate change**	**Energy efficiency**	**Energy access**	
CLE-1	**Reference case (climate policy) with current air pollution legislation**	all current and planned air quality legislation implemented by 2030; further improvement of emission factors with economic growth	no climate change policy	annual energy intensity reduction of 1.5% until 2050	no energy access policy; medium improvement in quality of cooking fuels	RCP8.5
CLE-2	**Sustainable climate policy with current air pollution legislation**		limit on temperature change to 2°C in 2100	annual energy intensity reduction of 2.6% until 2050	policies to ensure global access to clean energy by 2060	RCP2.6

GEA: Global Energy assessment, coordinated by IIASA, http://www.iiasa.ac.at/Research/ENE/GEA/index_gea.html
GAINS: Greenhouse gases – Air pollution INteractions and Synergies model (IIASA, MAG team)
MESSAGE: Model for Energy Supply Strategy Alternatives and their General Environmental impact), model selected for producing the AR5 RCP8.5 (IIASA, ENE team)

NOx, SO_2 and $PM_{2.5}$ emissions in kt/year – WEU&EEU



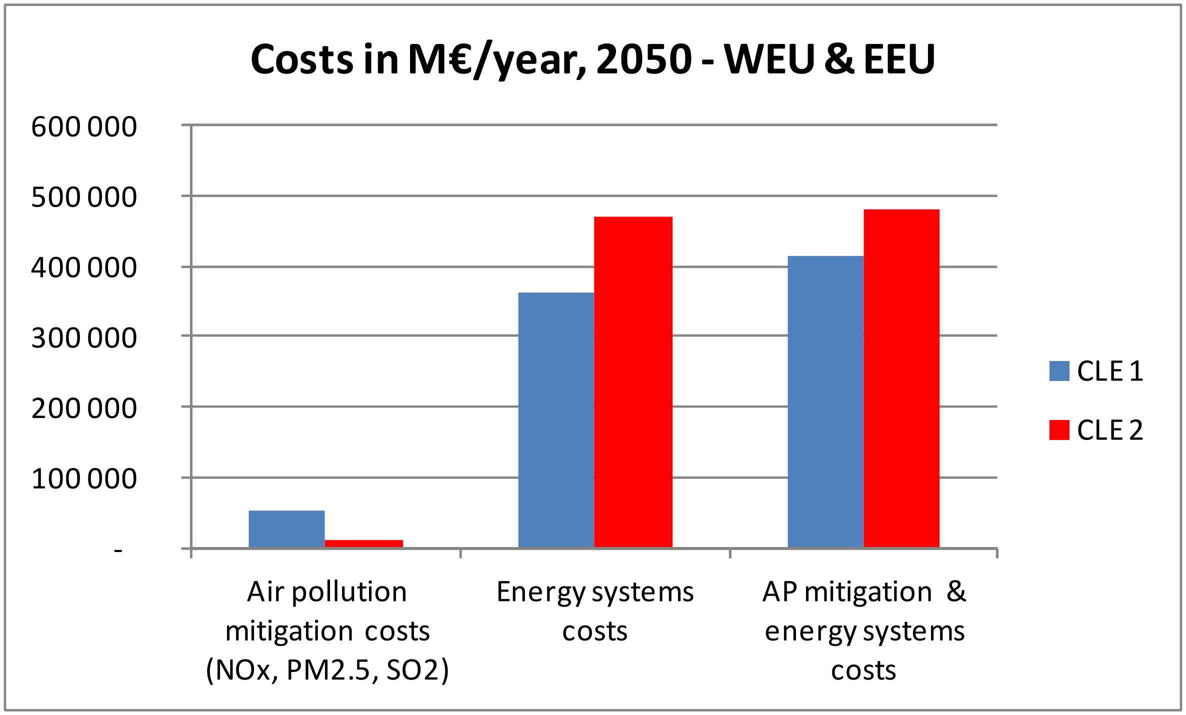
Air pollution policy

- CLE in 2030
- further improvement of emission factors with economic growth until 2050

Climate change policy

- reference scenario (CLE1)
- mitigation scenario (CLE2)

Energy/climate and air pollution mitigation expenditure in the GEA scenarios



MIT (CLE2) relative to REF (CLE1)

Energy costs

- ambitious energy/climate policy increases energy expenditure ≈ 110 billion € (≈30%)
- increase in energy efficiency; reduction in energy demand
- lower investment costs on energy supply side; higher investment costs on energy demand side

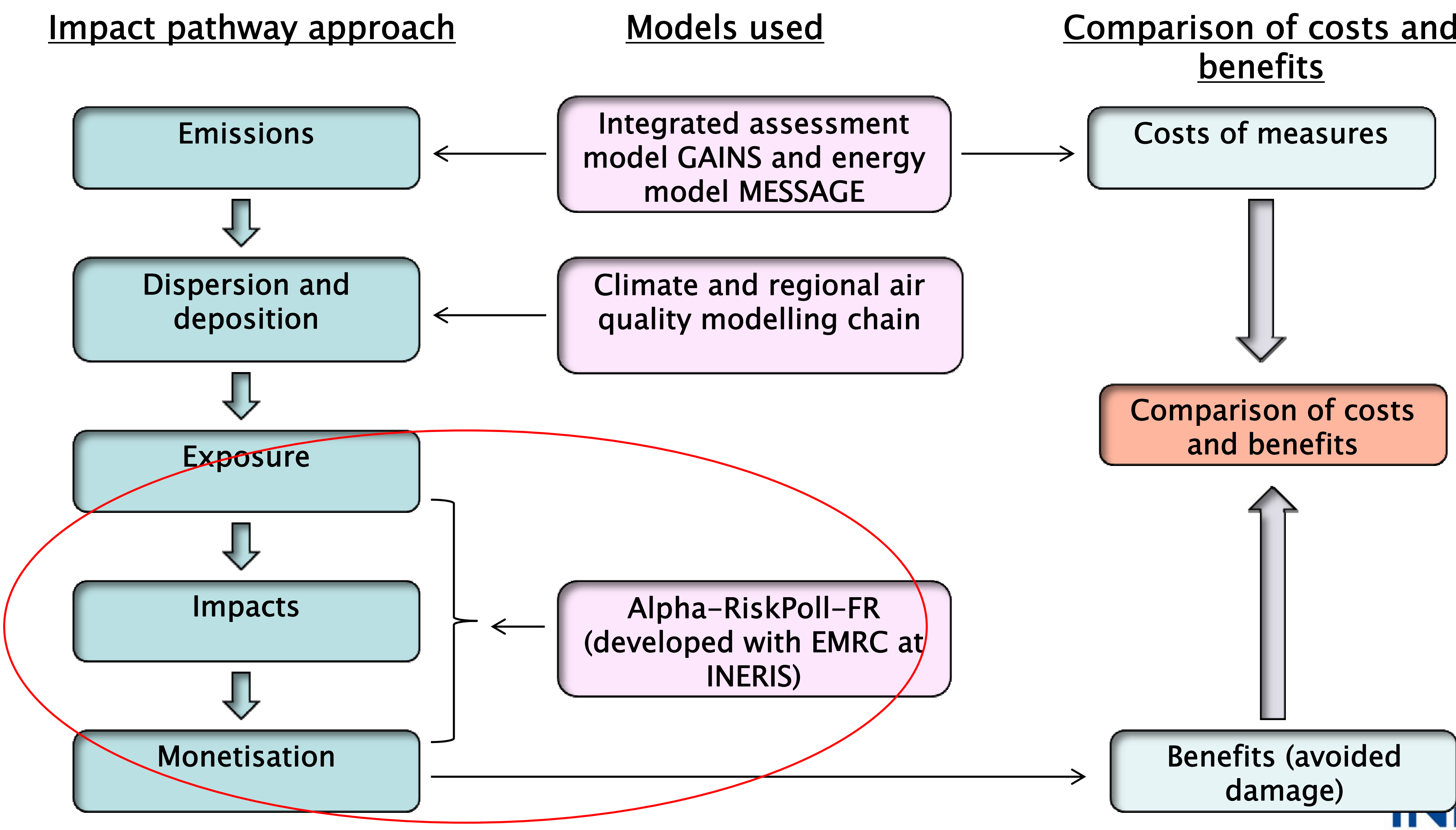
AP costs (NOx, SO_2, $PM_{2.5}$)

- cost savings ≈ 42 billion €
- same air pollution objectives require less emission reduction measures
- structural changes between energy types; reduction of final energy demand

Net aggregate costs

- increase in costs ≈ 65 billion € (decrease for AP costs, increase for energy/climate policy costs)

The modelling chain allowing to compare costs and benefits of emission reduction strategies



Assessment of health impacts from air pollution

- **Implementation of Alpha-RiskPoll-France (ARP-FR) at INERIS**
  - collaboration with Mike Holland (EMRC)
  - ARP-FR designed for taking pollution data generated by CHIMERE model
  - approach coherent with the one used by the EC and UN/ECE
  - impact pathway approach
- **Health effects taken into account**
  - exposure to fine particles
  - exposure to ground level ozone
  - mortality (adults, children)
  - morbidity (different indicators)

Alpha/RiskPoll Models : developed by M. Holland & J. Spadaro, used by AEA & EMRC (for CAFE / CLRTAP)

Indicators and monetary values used to quantify health impacts

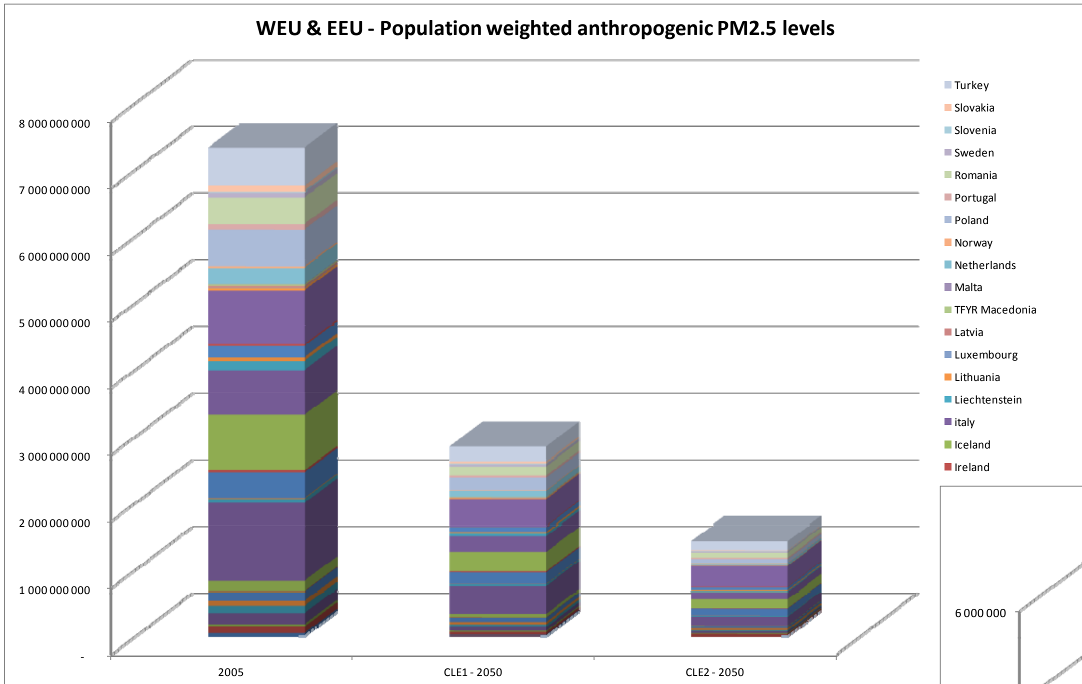
Core indicator

End point	Population	Impact	Pollutant	Exposure metric	Valuation (€, 2005)
Acute Mortality median VOLY	all ages	Premature deaths	O3	SOMO35	57 700
Respiratory Hospital Admissions	over 65 years	Cases	O3	SOMO35	2 220
Minor Restricted Activity Days (MRADs)	15 - 64 years	Days	O3	SOMO35	42
Respiratory medication use	over 20 years	Days	O3	SOMO35	1
Chronic Mortality LYL median VOLY	all ages	Life years lost	PM	PM2.5 annual average	57 700
Infant Mortality median VSL	0-1 years	Premature deaths	PM	PM2.5 annual average	1 635 000
Chronic Bronchitis	over 27 years	Cases	PM	PM2.5 annual average	208 000
Respiratory Hospital Admissions	all ages	Cases	PM	PM2.5 annual average	2 220
Cardiac Hospital Admissions	all ages	Cases	PM	PM2.5 annual average	2 220
Restricted Activity Days (RADs)	15 - 64 years	Days	PM	PM2.5 annual average	92
Respiratory medication use	5-14 years	Days	PM	PM2.5 annual average	1
Respiratory medication use	over 20 years	Days	PM	PM2.5 annual average	1
LRS symptom days	5-14 years	Days	PM	PM2.5 annual average	42
LRS among adults with chronic symptoms	over 15 years	Days	PM	PM2.5 annual average	42

Sensitivity analyses

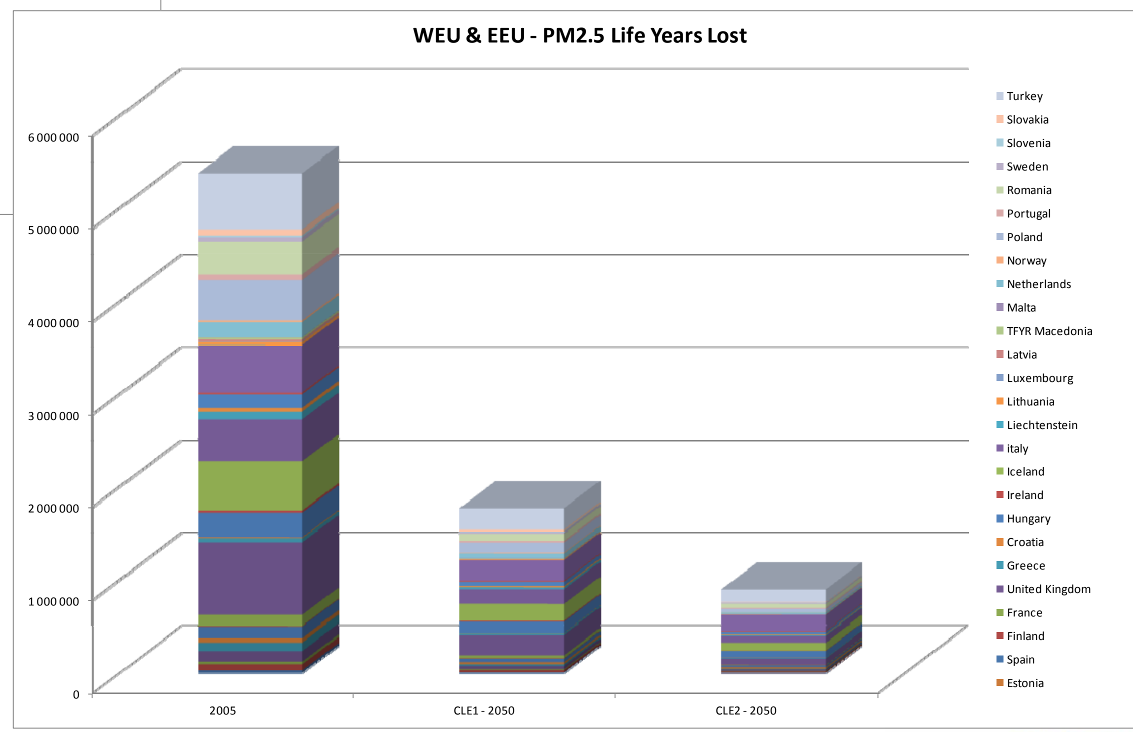
- Ranges for mortality valuation data
  - acute mortality (ozone), chronic mortality (PM), infant mortality (PM)
- Additional indicators for sensitivity analyses
  - ozone: minor restricted activity days; respiratory symptoms
  - $PM_{2.5}$: restricted activity days; asthma consultations ; consultations for upper respiratory diseases

Exposure to fine particles and life years lost from chronic exposure to $PM_{2.5}$



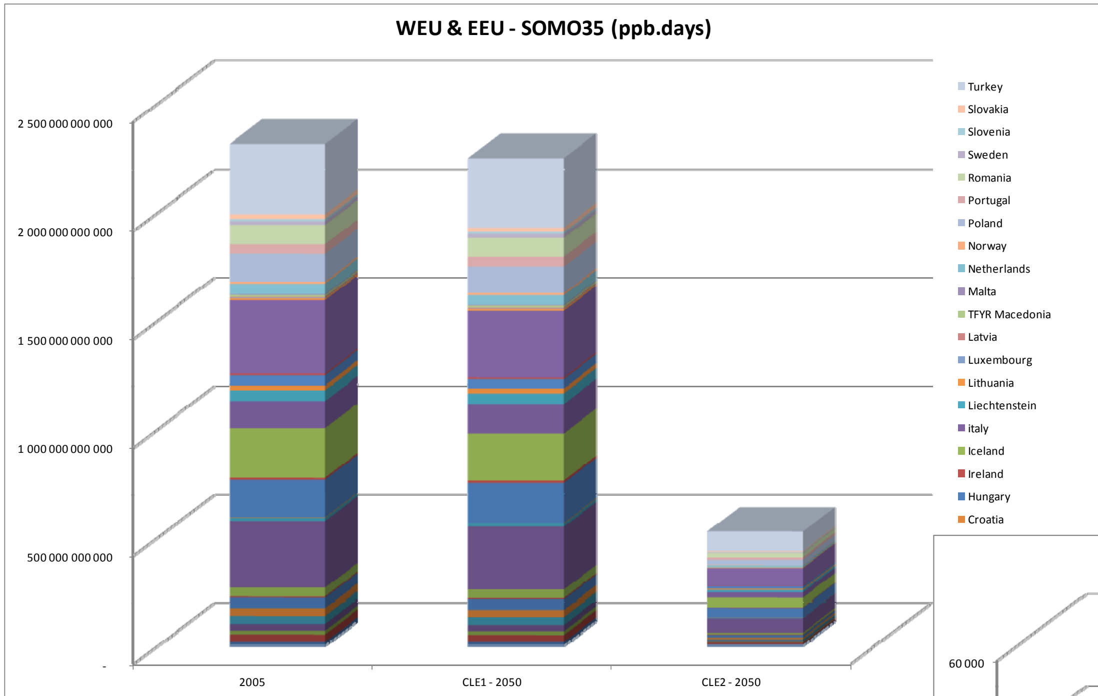
Important reduction in exposure between 2005 and 2050 (CLE 1 vs. 2005) due to atmospheric policy (and despite climate change) ;

Additional reduction brought about by climate policy (CLE 2 vs. CLE 1)



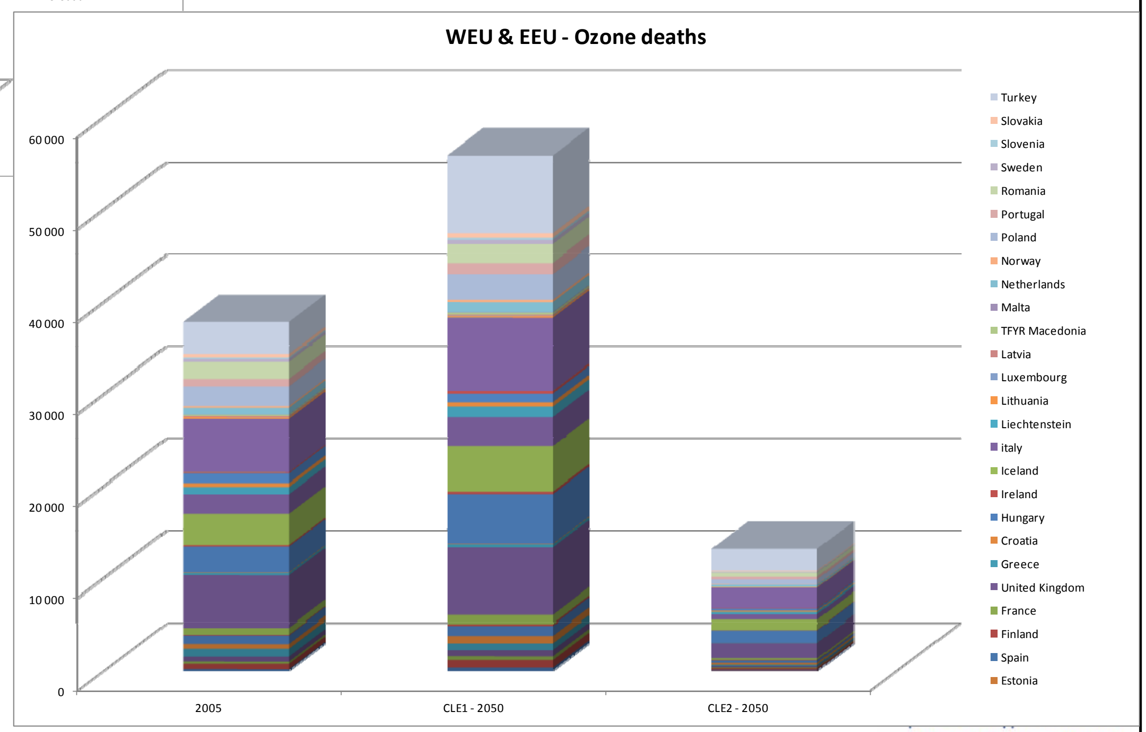
Similar results for Life Years Lost

Exposure to ozone and premature deaths from acute exposure to ozone



Small reduction of exposure between 2005 and 2050 (CLE1 vs. 2005) – effects of atmospheric policy counterbalanced by climate change & hemispheric transport ;

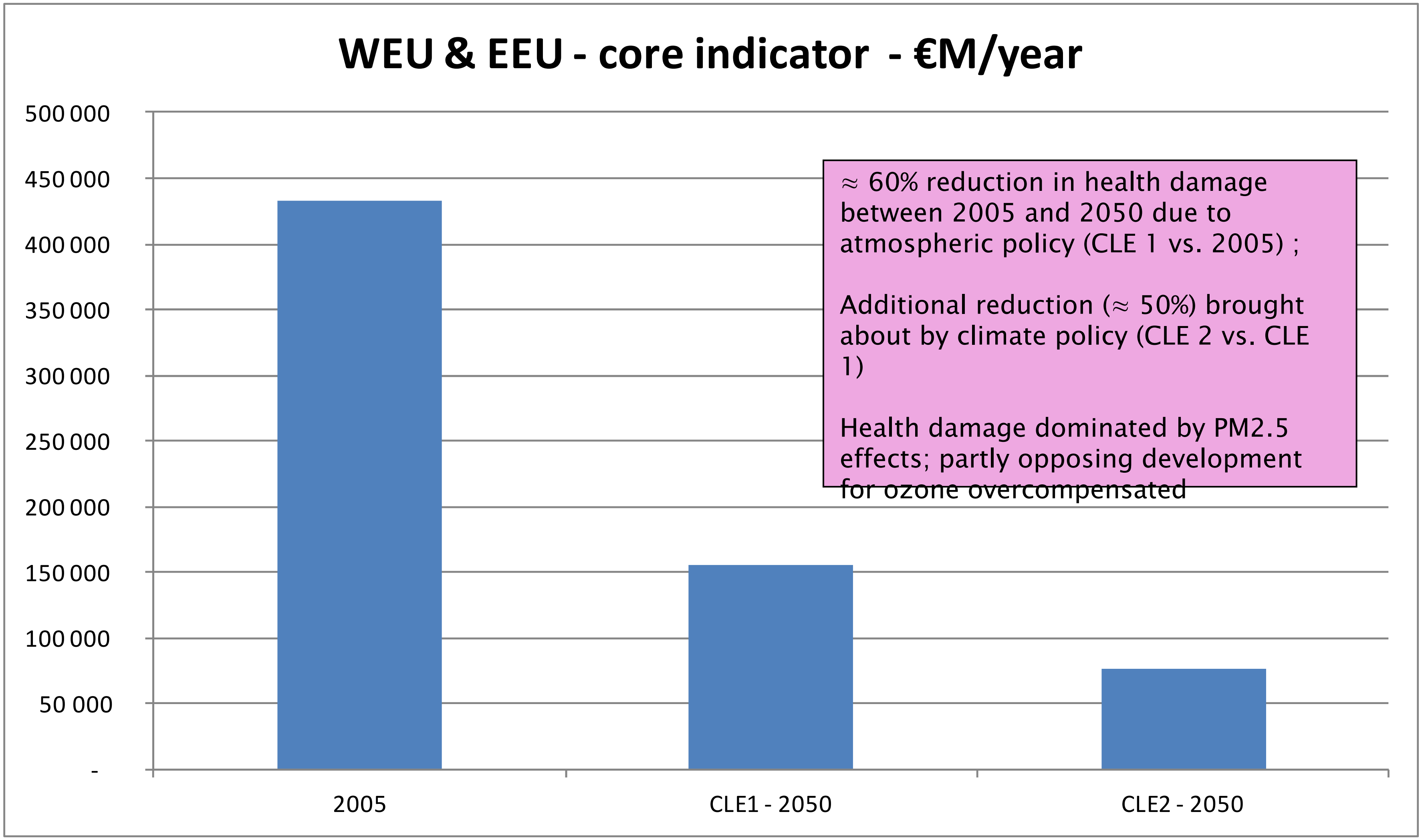
Important reduction brought about by climate policy (CLE 2 vs. CLE 1)



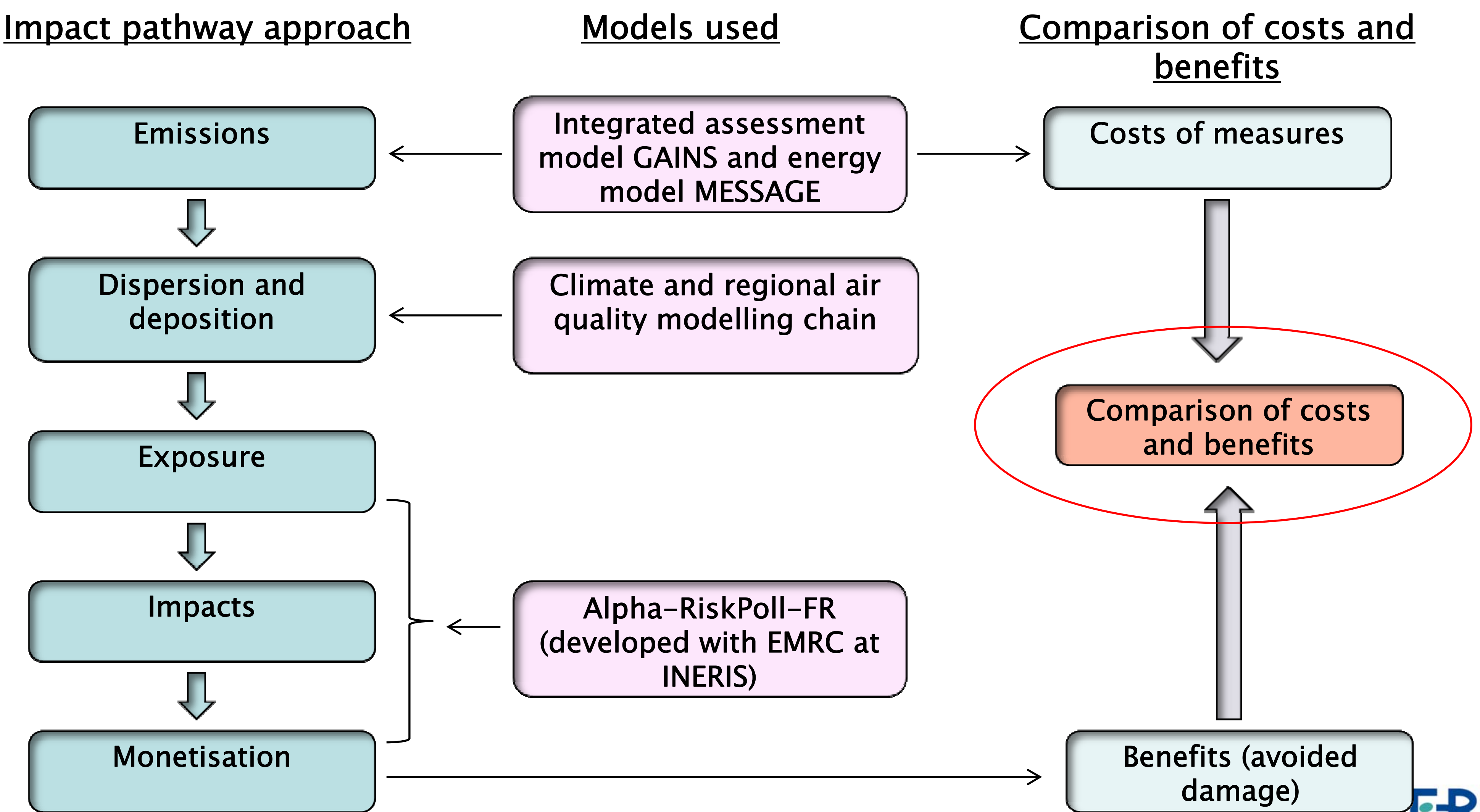
Health effects from ozone increase between 2005 and 2050 (CLE 1 vs. 2005) despite a low reduction in exposure => effect of population increase;

Important reduction brought about by climate policy (CLE 2 vs. CLE 1)

Health damage (monetised)



The modelling chain allowing to compare costs and benefits of emission reduction strategies



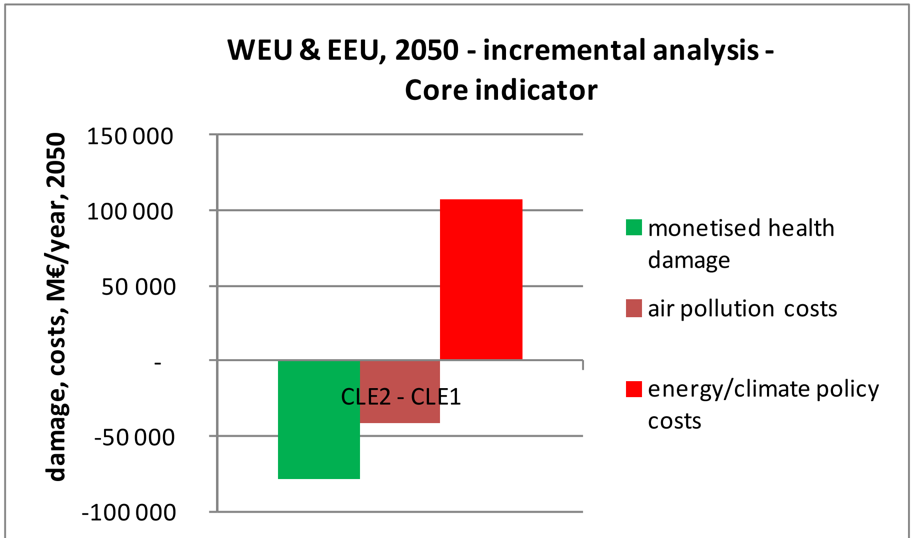
Comparison of costs and benefits of the policies

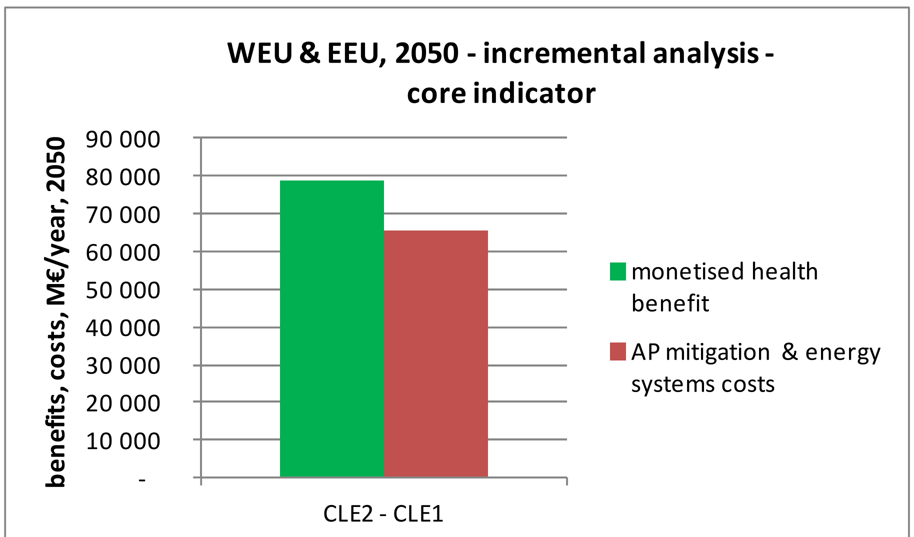
Assessment of the health effects of one air pollution reduction strategy under two climate/energy policy contexts

- No assessment of benefits relative to costs of air pollution policy in monetary terms
  - ➢ we do not have CLE costs in 2005, nor the costs for less ambitious AP policies
- Classical benefit/cost ratio not applicable
  - ➢ requires comparison of air pollution mitigation policies differing in their ambition levels
- Rather a co-benefits/cost ratio
  - ➢ increase of energy/climate policy costs versus decrease of AP policy cost and health damages

=> Preliminary results

Comparison between costs and co-benefits of an ambitious climate policy (incremental analysis)





Moving from the scenario without to the scenario with climate policy

- additional costs for climate/energy measures ≈ 107 billion €/year in 2050
- co-benefits of the energy policy per year in 2050:
  - => air pollution reduction costs decrease relative to the scenario without climate policy (savings ≈ 42 billion €)
  - => avoided health damage (= benefits) from reduced air pollution ≈79 billion €
- co-benefits for the AP policy and for health impacts exceed the additional energy costs
- AP costs only NOx, SO_2, $PM_{2.5}$
- further benefits from the reduction of greenhouse gases not taken into account

Preliminary results

Attribution study to understand what drives the results shown in the maps

- **Analysis of the impact of different processes playing a role in the future evolution of air quality**
  - the global and regional climate
  - air quality mitigation policies (=> emissions)
  - chemical background changes (contribution of long-range AP transport)
- **The question**
  - do regional (European) AP policies attain the expected effects or are these counterbalanced by long-range AP or climate change?
- **Isolation of the contribution of each driving factor to the overall projected change**
  - disentangling the main factors through sensitivity decadal simulations
  - replication of the decadal simulations, keeping two factors constant and varying the third
  - e.g. to investigate the impact of climate change use constant present day AP emissions and boundary conditions but change the climate forcing
  - 12 * 10 runs to analyse the impacts of all drivers

Results of the attribution study

- **Ozone**
  - confirmation of the climate penalty (cf. literature) - not very strong, decreasing in the future
  - a strong penalty (REF) or benefit (MIT) comes from chemical background
  - air pollution policies (emission reductions) are effective
- **$PM_{2.5}$**
  - weak impact of long-range transport
  - air pollution policies (emission reductions) dominate the overall result
  - climate has a negative contribution - weak but statistically significant climate benefit

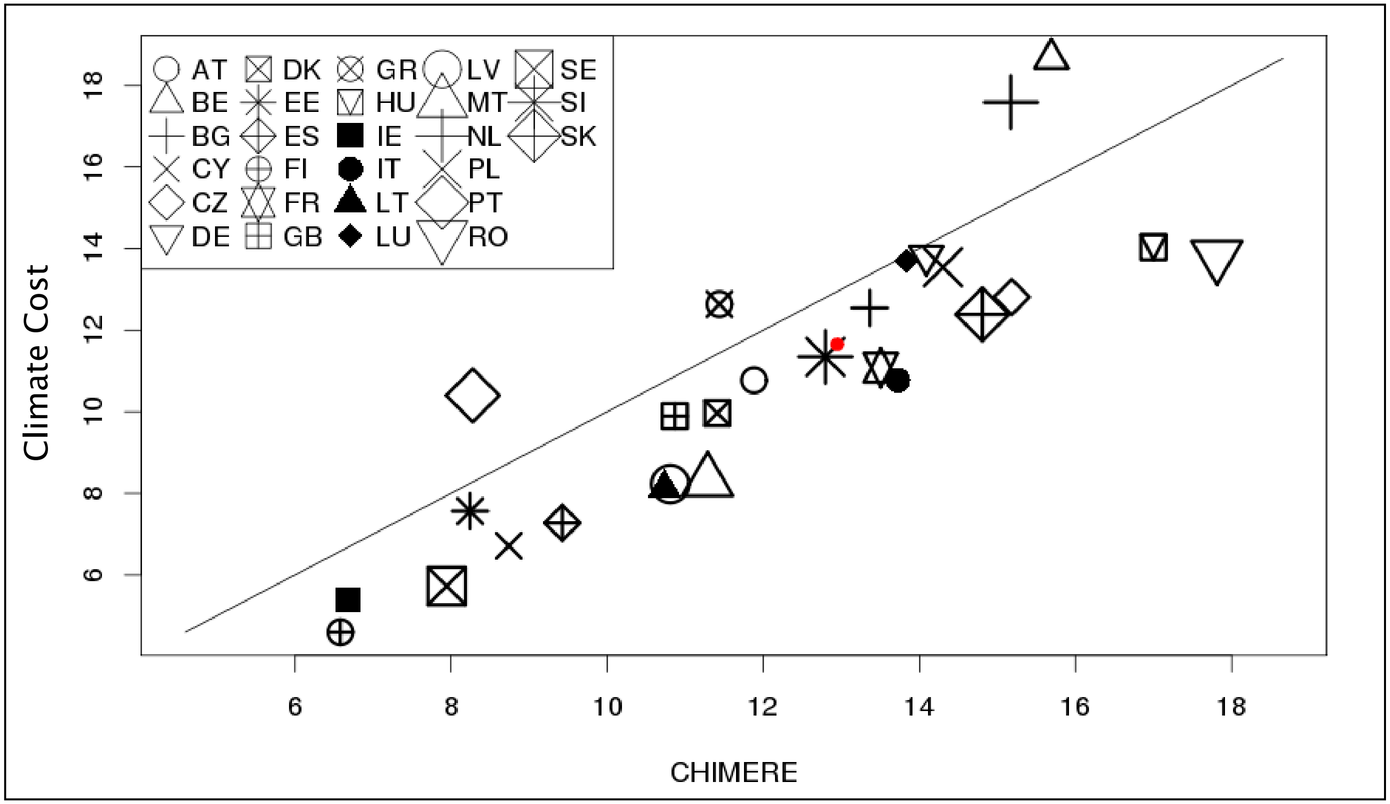
⇒ no consensus in literature on whether climate penalty or benefit for PM (model dependent) - uncertainty

⇒ impact of aerosols on climate change more often analysed than that of climate change on aerosols

⇒ advocates for attribution studies to be done by other modelling teams

⇒ results might be used in health impact assessment/CBA?

Average PM2.5 exposure (2005) per capita from the Climate Cost & Salut'air projects



- CHIMERE exposure slightly higher than Climate Cost exposure
- Possibly due to a PM composition issue

=> CHIMERE might have more natural dust in the $PM_{2.5}$ concentrations than the Climate Cost data

- **Is there natural dust in the Climate Cost project concentrations (GAINS using EMEP SRMs)?**
- **How to deal with this in health impact assessment?**
  - ➢ WHO advice for CBA (NECD): "exclude particles from natural sources as they are not controllable using the measures considered in the setting of emission ceilings" (TSAP Report 10, EMRC)

Summary & conclusions

- **The Salut'air project uses**
  - most recent model runs of global and regional climate and atmospheric chemistry model inter-comparisons under IPCC/AR5
  - up-to-date projections for air pollutants and greenhouse gases
- **The Salut'air analysis found important co-benefits of climate policy for air pollution policy and health impacts**
- **The attribution study disentangling the relative impact on $PM_{2.5}$ and ozone concentrations of climate change, atmospheric policies and chemical background changes**
  - confirmed the climate penalty for ***ozone***; major influence of long-range transport
  - found a weak climate benefit for ***$PM_{2.5}$*** (uncertainty!), and a strong impact of air pollution policies
- **More modelling teams performing attribution studies would be helpful to reduce uncertainty about the climate impact on $PM_{2.5}$**
- **There might be a point in comparing particle composition across different models & analyses**
  - develop a template for modellers to complete?
  - composition of $PM_{2.5}$, origin of emission data, information on scenario development ...

Thank you for your attention!

Publication on the air quality modelling results

A. Colette, B. Bessagnet, R. Vautard, S. Szopa, S. Rao, S. Schucht, Z. Klimont, L. Menut, G. Clain, F. Meleux, and L. Rouïl (2013): 'European atmosphere in 2050, a regional air quality and climate perspective under CMIP5 scenarios', Atmospheric Chemistry and Physics, acp-2013-64.

Acknowledgements

- The ***Salut'AIR*** project supported by the French Ministry in charge of Ecology and ADEME
- The ***Global Energy Assessment*** and specific collaboration with ***IIASA***
- The collaboration on health impact assessment with ***EMRC***
- The EU FP7 ***CityZen*** and ***ATOPICA*** projects
- The ***European Environmental Agency*** through its support to the European Topic Centre on Air Quality and Climate Mitigation
- The ***CCRT*** supercomputing centre

Annex

The project setup - regional air quality and climate impact assessment

Air Pollutants
(IIASA : GEA Emissions and Costs)

- Close collaboration with IIASA
- Implementing air pollutant emission scenarios
- Documentation of scenarios
- Cost analysis

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Radiative Forcing
RCP/AR5

GHG+SLCF
RCP/AR5

Atmosphere / Ocean General Circulation Model
IPSL/CM5A/MR : CMIP5 (IPSL)

- Development of the dynamical regional climate downscaling of the IPSL AOGCM model
- Experimental production of historical and 2 projections
- Operational production of Euro-CORDEX

INERIS LMD

Regional Climate Model
WRF: Euro-Cordex
(INERIS/IPSL)

Regional Chemistry Transport Model
CHIMERE (INERIS/IPSL)

- Adapted to use
  - Climate forcing from RCM
  - Boundary conditions from GCTM
  - Emissions scenarios of IIASA
- Exposure products
  - Relevant for HIA

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Heatlh Impact Assessment
Alpha-RiskPoll-France
(INERIS, collaboration with EMRC)

- Collaboration with M. Holland for the development of a climate-air quality HIA interface
- Monetisation of health impacts

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- Analysis of the cost of AP measures

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alut'air

Cost/Co-benefit Analysis
(INERIS)

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Data for MESSAGE regions WEU & EEU

Western Europe

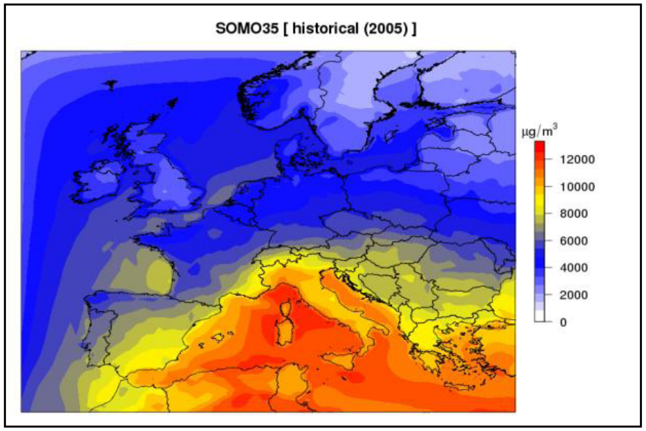
- Andorra, Austria, Azores, Belgium, Canary Islands, Channel Islands, Cyprus, Denmark, Faeroe Islands, Finland, France, Germany, Gibraltar, Greece, Greenland, Iceland, Ireland, Isle of Man, Italy, Liechtenstein, Luxembourg, Madeira, Malta, Monaco, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, United Kingdom

Central & Eastern Europe

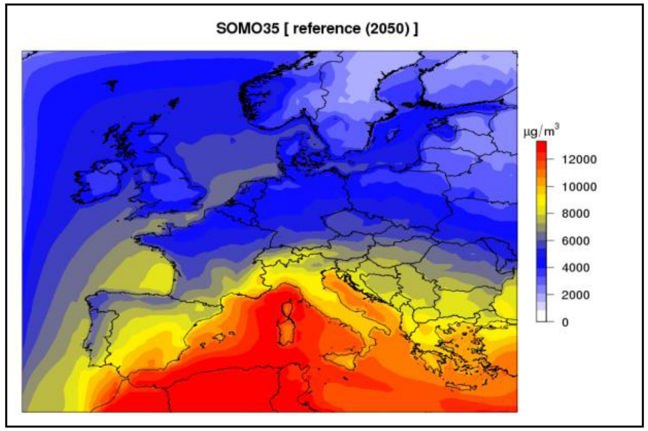
- Albania, Bosnia and Herzegovina, Bulgaria, Croatia, Czech Republic, Estonia, The former Yugoslav Rep. of Macedonia, Latvia, Lithuania, Hungary, Poland, Romania, Slovak Republic, Slovenia, Yugoslavia

O_3 concentrations in Europe - SOMO35 (sum of O3max > 35ppb)

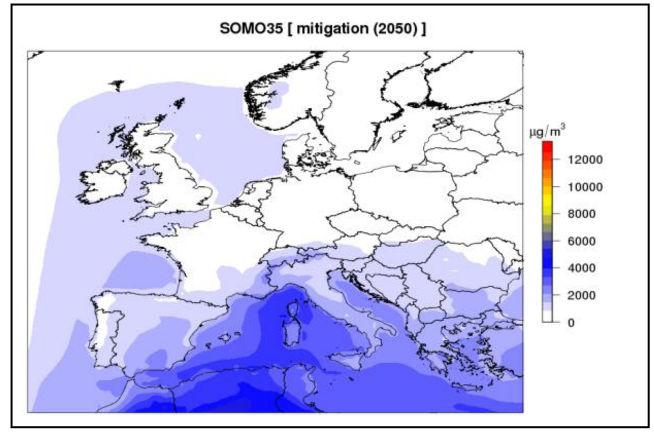
Historic climate model 2005



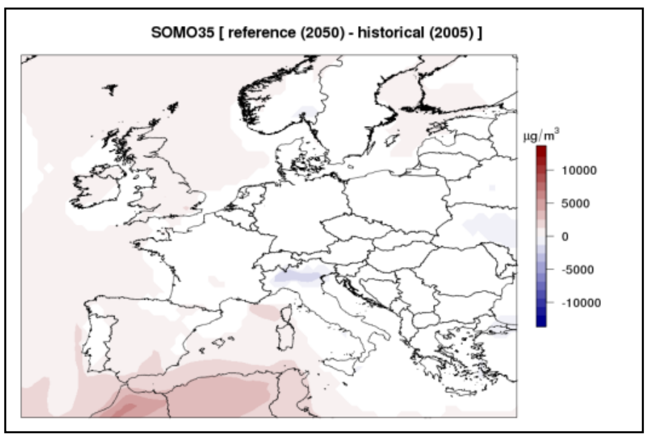
GEA CLE1-REF (~RCP8.5) 2050

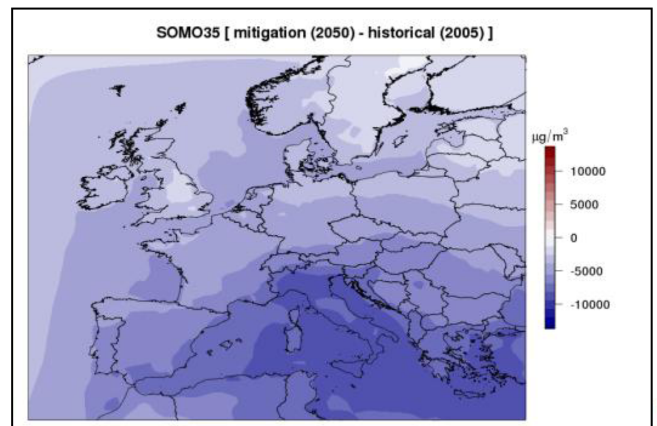


GEA CLE2-MIT (~RCP2.6) 2050



Difference to historic



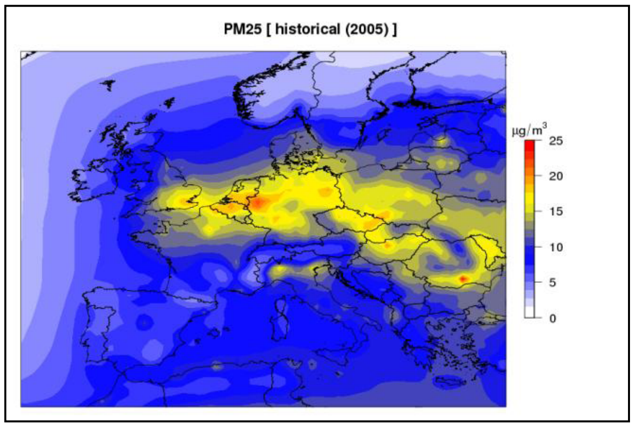


Projections:

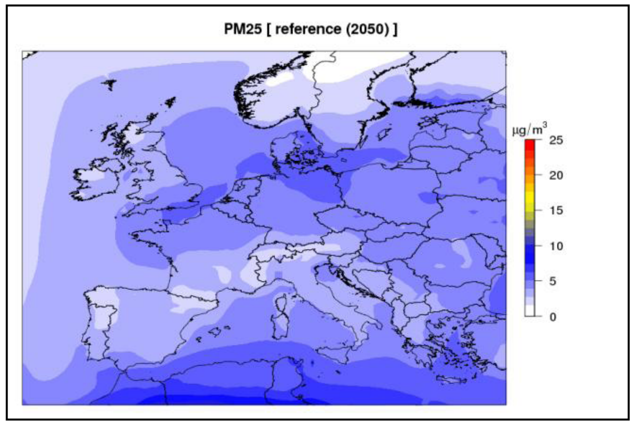
- status quo for CLE1 (climate reference scenario)
  (joint effect of global climate & hemispheric transport => global ozone increases under RCP8.5)
- large decrease for CLE2 (climate mitigation scenario)

$PM_{2.5}$ concentrations in Europe (annual mean)

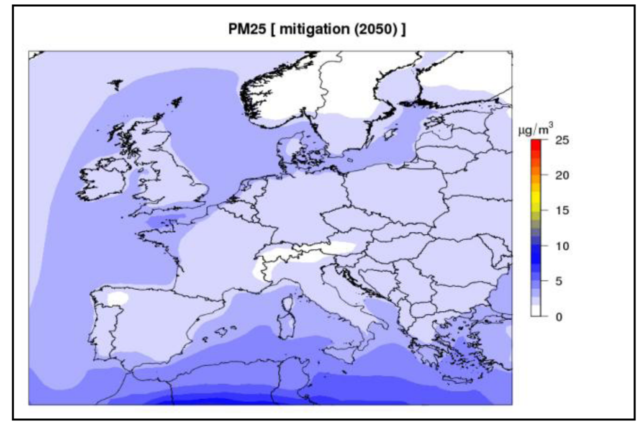
Historic climate model 2005



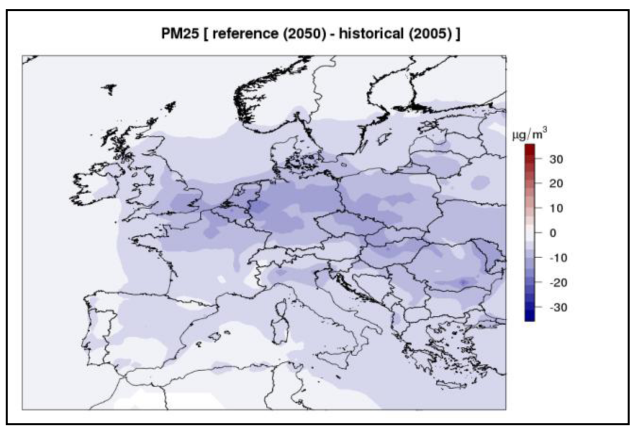
GEA CLE1-REF (~RCP8.5) 2050

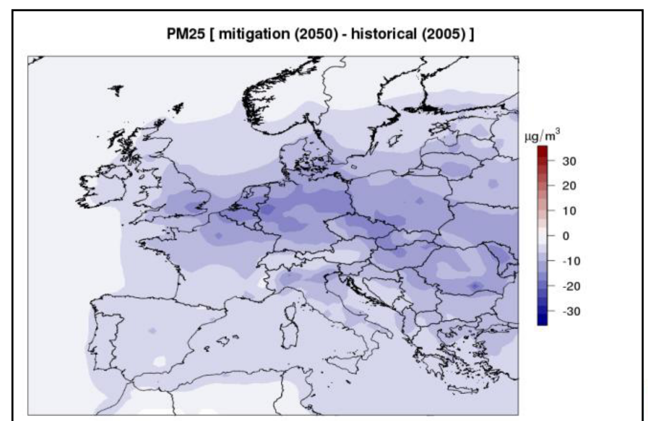


GEA CLE2-MIT (~RCP2.6) 2050



Difference to historic

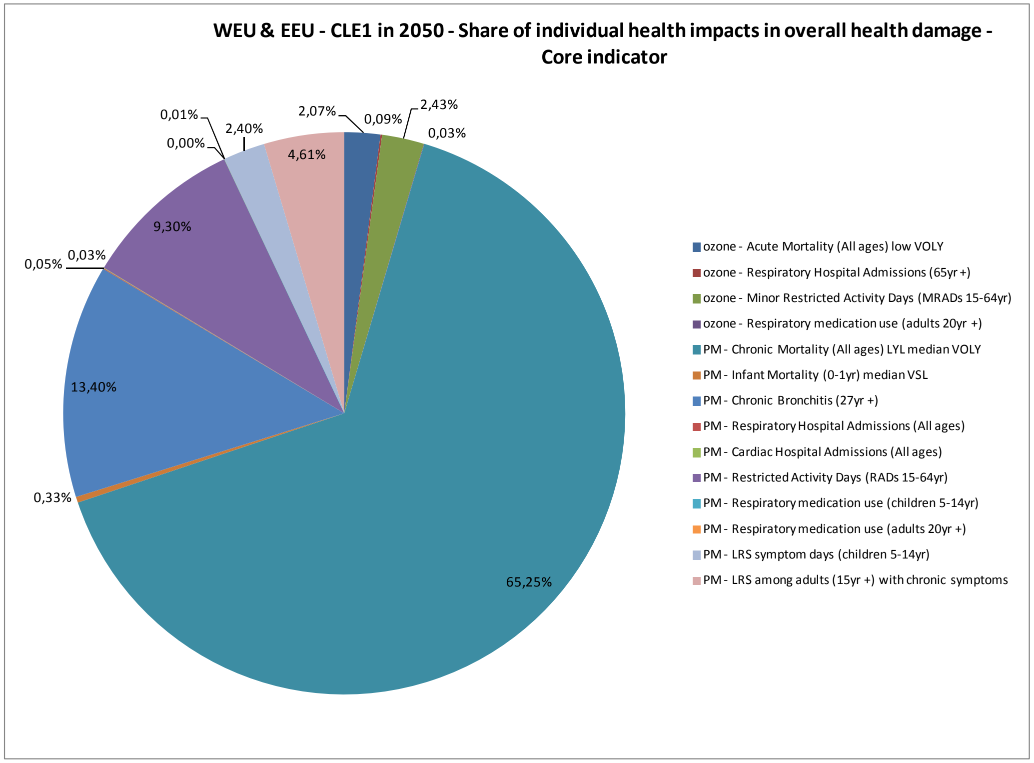




Projections:

- significant decrease under both scenarios

Contribution of different impacts to overall health damage (monetised) in 2050



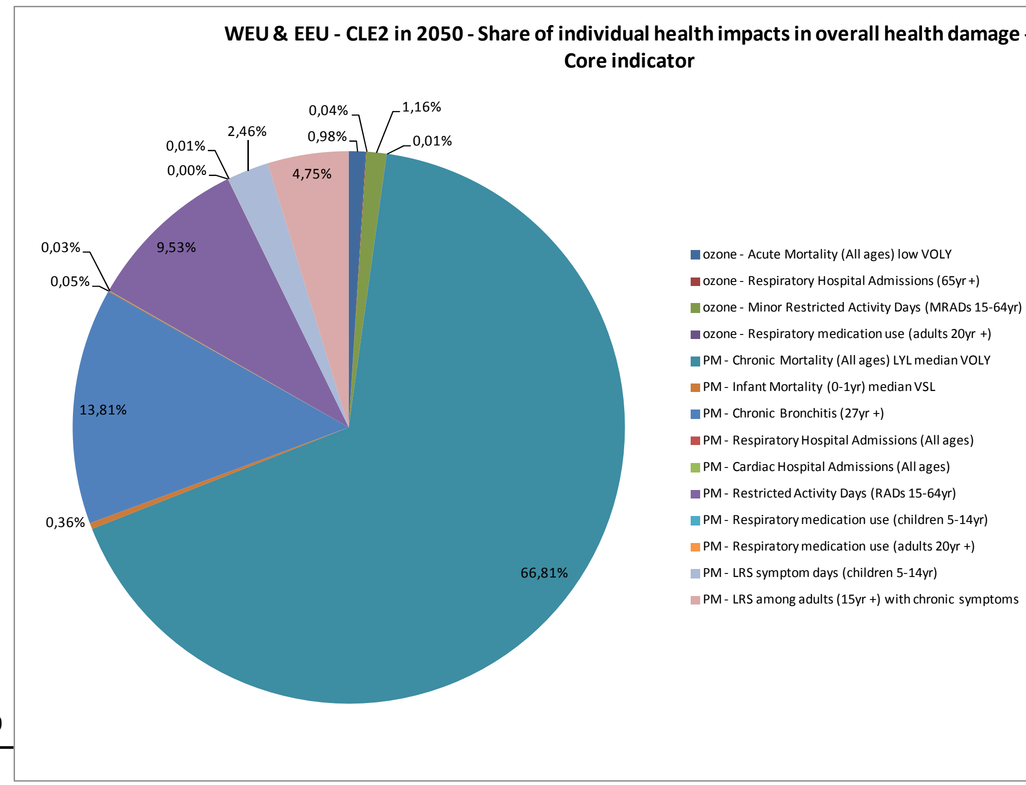
Health costs dominated by PM2.5 effects, especially :

- chronic mortality (≈ 66%)
- chronic bronchitis (≈ 13%)
- restricted activity days (≈ 10%)

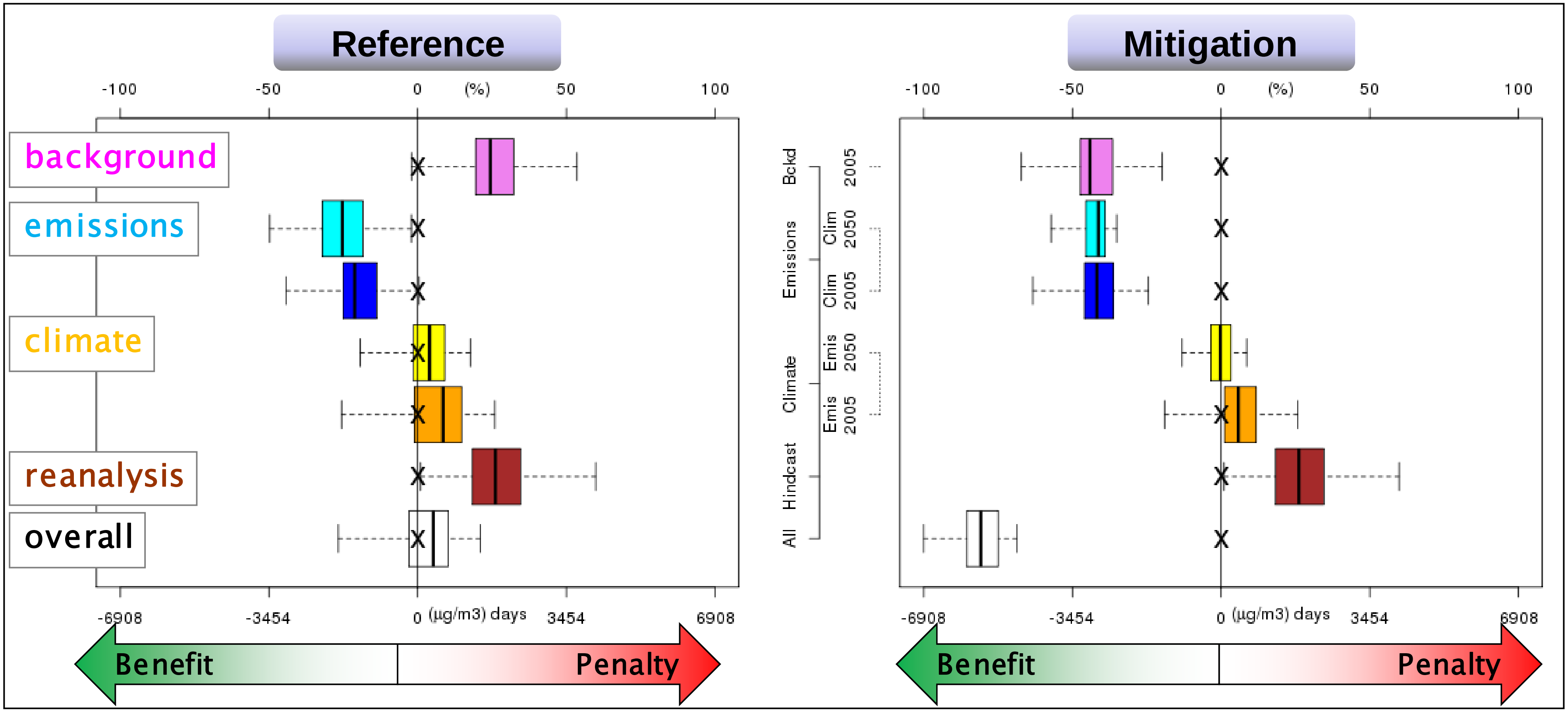
Health costs from ozone amount to:

≈ 1.5 % in 2005
≈ 4.6 % in CLE 1 2050 (=> effect of climate change & long range transport)
≈ 2.1 % in CLE 2 2050 (=> ambitious climate policy)

Model run with climate correction and urban increment (decrement)



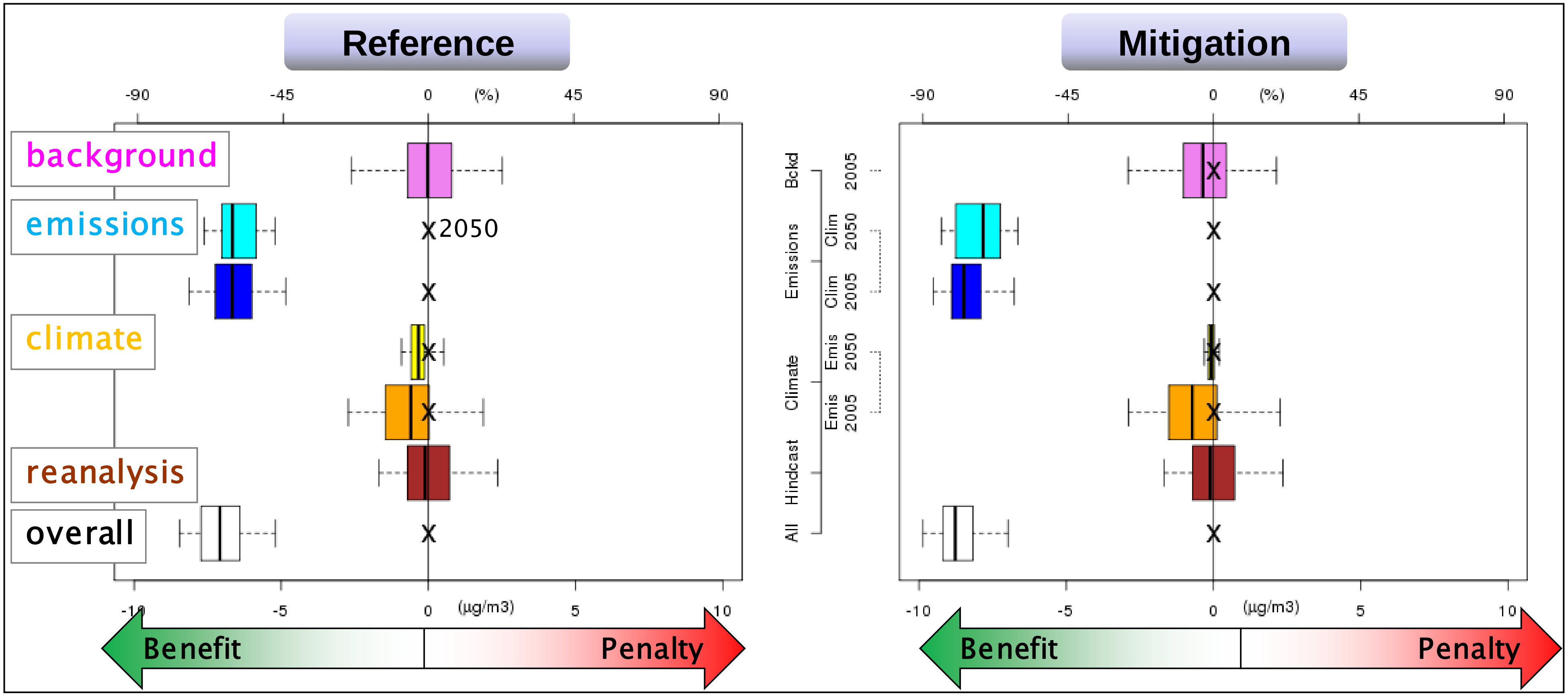
Attribution study for SOMO35



- Climate penalty confirmed, decreasing in the future
- Effective air quality legislation
- Major chemical background penalty (REF)

Source: A. Colette, EGU 2013, session AS3.7, Air pollution modelling

Attribution study for $PM_{2.5}$



- Weak impact of long-range transport
- Air quality legislation dominates
- Slight climate benefit (not robust - cf. literature)

Source: A. Colette, EGU 2013, session AS3.7, Air pollution modelling