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Health impacts of ozone and PM from integrated assessment models: a comparison between national and international analysis

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Abstract

Policies on air pollution, at European level, are regularly based on Integrated Assessment Modeling analysis, aimed at reducing the impact of air pollutants on the environment and the human health. In particular, the RAINS-Europe model, developed by IIASA is the Integrated Assessment Model (IAM) adopted within both the UNECE context (United Nations Economic Commission for Europe), for the analyses concerning the Gothenburg Protocol under the Convention on Long-Range Transboundary Air Pollution (CLRTAP), and the EU framework, as recently used for the review of the NEC directive. The latest NEC scenarios show how, regardless significant differences in terms of emissions among the various scenarios analysed, the impact of $PM_{2,5}$ on human health is quite similar. In this paper, a comparison analysis between the health impact resulting from the latest NEC scenarios, calculated by RAINS_EU, and the impact coming from the same national data, calculated by RAINS_Italy (MINNI Project), at higher resolution (20 km x 20 km), is assessed. The analyses carried out at national level have the added value of being underpinned by the background knowledge of the national experts, very often resulting in a different interpretation of the EU directives effects, compared to the expectations at EU level. (e.g. the IPPC effects on NH3 emissions). Therefore, the national analyses should be ranked like the EU level analyses and the unavoidable differences acquired as a valuable estimation of the uncertainty, intrinsically associated with any modelling exercise. In particular, this analysis allows to highlight the differences in emissions, due to different Control Strategies, and in impact, in terms of Life Expectancy Reduction, due to different calculus resolutions and boundary conditions.

KEY WORDS ï air pollution, emissions scenarios, particulate matter, health impact, integrated assessment modelling, $PM_{2,5}$, Life Expectancy Reduction.

Health Impact Comparison Analysis

The comparison analysis starts from the Impact on Human Health due to PM2,5, as resulting from the 2 scenarios calculated by the RAINS_Europe[1] and the RAINS_Italy[2] models, on the basis of the same national energy and activity levels (fig. 1)

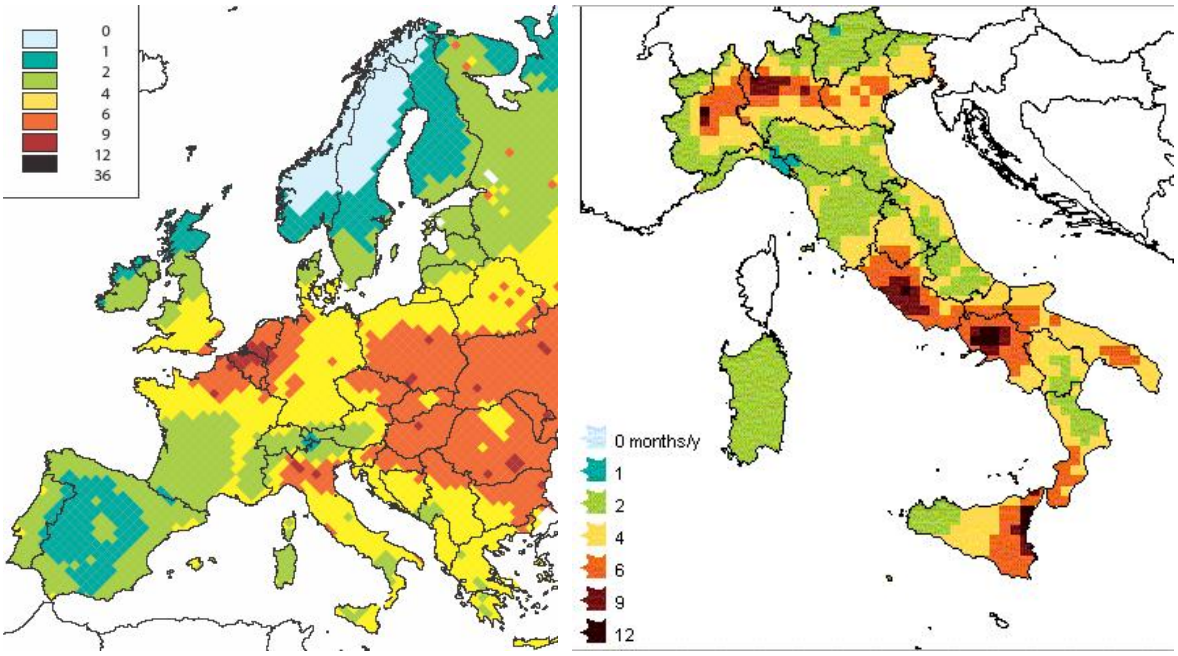


Fig. 1 – Health Impact from PM2,5, in terms of Life Expectancy Reduction (months), calculated at 2020, by RAINS_Europe and RAINS_Italy IAM models, on the basis of national input data, (NEC review process August 2006)

Due to a higher resolution in RAINS_Italy (20km x 20km) than in RAINS_EU (50km x 50km) the higher impact in urban areas is highlighted, although in wide countryside areas RAINS_IT shows lower impact (green areas) than RAINS_EU. On the average values, a 16,6% difference is observed (5,6 RAINS_EU and 4,8 RAINS_IT). The difference is regarded as not too high, considering that the differences between the analyses, discussed below be. RAINS_IT highlights the peak values achieved in the urban areas (> 12 and < 15 months). It should also be considered that the secondary particles are predominant with respect the primary particles; therefore the final impact is less affected by changes in primary PM emissions.

In table 1, the comparison of the Health Impact from ***exposure to ozone*** is reported, for the 2 scenarios, at 2020.

Premature Deaths (2020)	**n**
RAINS_Europe	3796
RAINS_Italy	3956
Difference %	4 %

Table 1 – Premature deaths, at 2020, in Italy, due to exposure of the population to ozone, calculated by RAINS_Europe and RAINS_IT, on the basis of the same national activity levels data.

In this case, a better agreement is observed between the RAINS_EU and the RAINS_IT scenarios, at least in terms of global figures. In fig. 2 the distribution of the premature deaths due to ozone at 2020, calculated by RAINS_IT over the Italian territory, is given. Again peak values are observed in the urban areas.

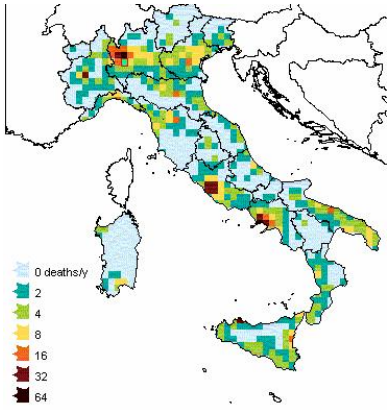
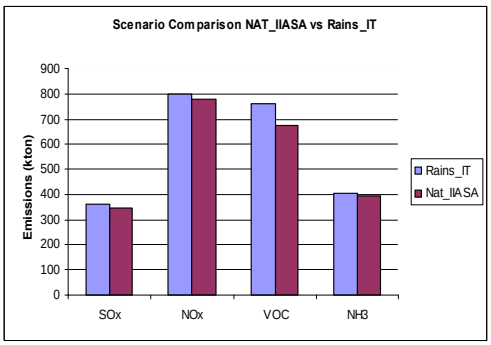


Fig. 2 – Distribution of premature deaths over the Italian territory (n per 20km x 20km cell), at 2020, due to the exposure of the population to ozone, calculated by RAINS_IT

Emission Comparison Analysis

In Fig 3 and associated Table the comparison between the 2 scenarios under analysis is given, in terms of emissions (NEC pollutants), as absolute values (kt) and % difference



2020	Rains_it	RAINS_EU	%
SOx	361.309	345.129	-4.68
NOx	797.744	779.475	-2.34
VOC	758.992	675.665	-12.33
NH3	403.678	396.077	-1.92

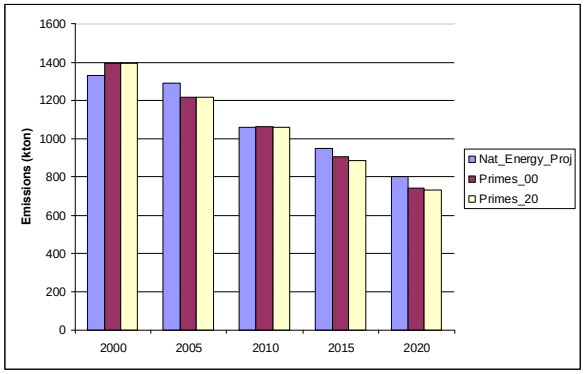
Fig. 3 – Comparison emission scenarios, at 2020, in kt and %, between RAINS_EU and RAINS_IT, on the basis of the same national activity levels data.

The observed differences range between 1,92 % and 12,33 %, as absolute value. Assuming the same activity levels, the reasons for such discrepancies have been identified in:

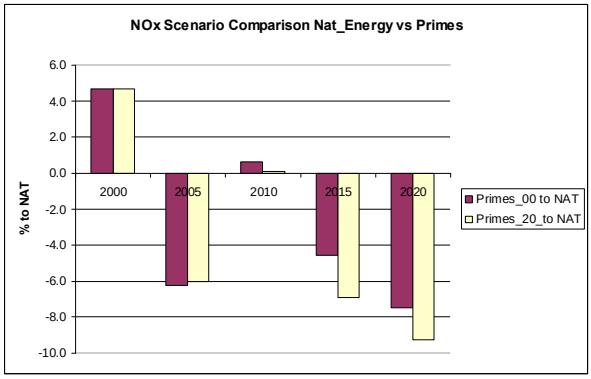
1) Different user interpretation of the technology penetration rates, in the Control Strategy (e.g. VOC scenario, 12.33%)
2) Adoption of country specific EFs in RAINS-IT (NH3)
3) Different source structure in RAINS-EU (Aug 2006) and in RAINS_IT (e.g. bus and trucks are 2 separated sources in RAINS_EU). In the case of the NOx scenarios, the input data are exactly the same and only the source structure is different, resulting in a 2,34 % discrepancy.

Comparison among different energy projections

The discrepancies in emissions are even more evident if the energy projections are different, in the scenarios under analysis. In fig 4, the comparison analysis shows the difference, in terms of absolute emissions and in % (with respect NAT projections), for NOx.



a)



b)

Fig. 4 – a) NOx emission scenarios, resulting by 3 different energy projections (National projections, Primes_00 and Primes_20) b) % difference, Primes vs National

The 2 Primes energy projections assume 0 ú and 20 ú, respectively for CO2 unit cost. It should be noted as, at 2020 (target year for the EU policies), the observed discrepancy is around 9%. The rational for the discrepancies can be identified in the structural differences among the 3 energy projections, per fuel and per sector (e.g. share of petrol/diesel cars).

Introduction of the uncertainty, in the analysis

On the basis of the comparison analyses, reported above, it can be noted that a certain degree of uncertainty can be associated with:

1) *The technology penetration rates, assumed by the user in. the Control Strategy*
2) *Activity levels, especially in energy projections*
3) *The source structure in the RAINS Model*
4) *Some Emission Factors (Country specific)*

In all these cases, the scenarios reported above have provided a first attempt of quantification of such uncertainties, in terms of both input data and output emissions. These uncertaintes are consequentely reflected even in uncertainties on abatement costs (still to be evaluated). Incidentally, any Member State may repeat autonomously this uncertainty analysis, on the basis of the detailed data, made available by IIASA, on their own RAINS_online Web Site [3], by comparing the NAT and Primes scenarios.

Conclusions

The comparison analysis shows how the assessment of the Health Impact, due to the exposure of the Italian population to PM2,5 and Ozone, as calculated in the EU-wide scenario by RAINS_EU and in the national scenario by RAINS_IT, is similar, although RAINS_IT better defines the impact in the urban areas. The comparison analysis on emissions shows greater differences and the reasons have been identified and analyzed. These differences, in terms of input and out data, could be assumed as a first attempt of quantification of the existing uncertainties. Finally, it is proposed that the uncertainties should be carefully taken into accounts, while developing policy analyses and setting targets, due to the fact that the results of different analyses may have significant different consequences, at national level, mainly in terms of national ceilings and, therefore, in terms of related economic impact. Although any methodology to include the uncertainties in the policy development is regarded as premature, at the moment, the above approach could be used at least as starting point for a scientific debate, within the proper contexts.

References

[1] "Baseline scenarios for the revision of the NEC Emission Ceilings Directive" Par 1: Emission Projections and Part 2: Health and environmental impacts" September 2006 Background documents for the Conference on Air Pollution and Greenhouse Gas Emission Projections for 2020, Brussels, September 29, 2006, M. Amann et al. (IIASA)

[2] "The MINNI Project Web Site" – ENEA - www.minni.org

[3] http://www.iiasa.ac.at/rains/ IIASA RAINS web site documentation and online models