Quantifying uncertainties in the Atmospheric Modelling (ATM) simulations resulting from different emission time resolution

SnT 2019
CTBT: SCIENCE AND TECHNOLOGY CONFERENCE

T4.4-P10

CTBTO PREPARATORY COMMISSION

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Introduction

The International Monitoring System (IMS) developed by the Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO) is a global system of monitoring stations, using four complementary technologies: seismic, hydroacoustic, infrasound and radionuclide. The radionuclide network comprises 80 stations, of which more than 60 are certified. The aim of radionuclide stations is a global monitoring of radioactive aerosols and radioactive noble gases supported by the atmospheric transport modelling (ATM) to allow detected radioactivity to be attributed to a source.

Recent studies suggest that the ATM performance using different emission time resolutions is not significantly different. The availability of emission data for IRE (Belgium) and ANSTO (Australia) for the full year of 2014, gave an opportunity to verify the aforementioned statement for different atmospheric conditions. For the purpose of this study, the simulated activity concentrations of Xe-133, calculated using three different emission time resolutions (daily, half-daily and 3 hours), were compared with the available measurements collected by the IMS noble gas stations (see Figure 1) influenced by these facilities.

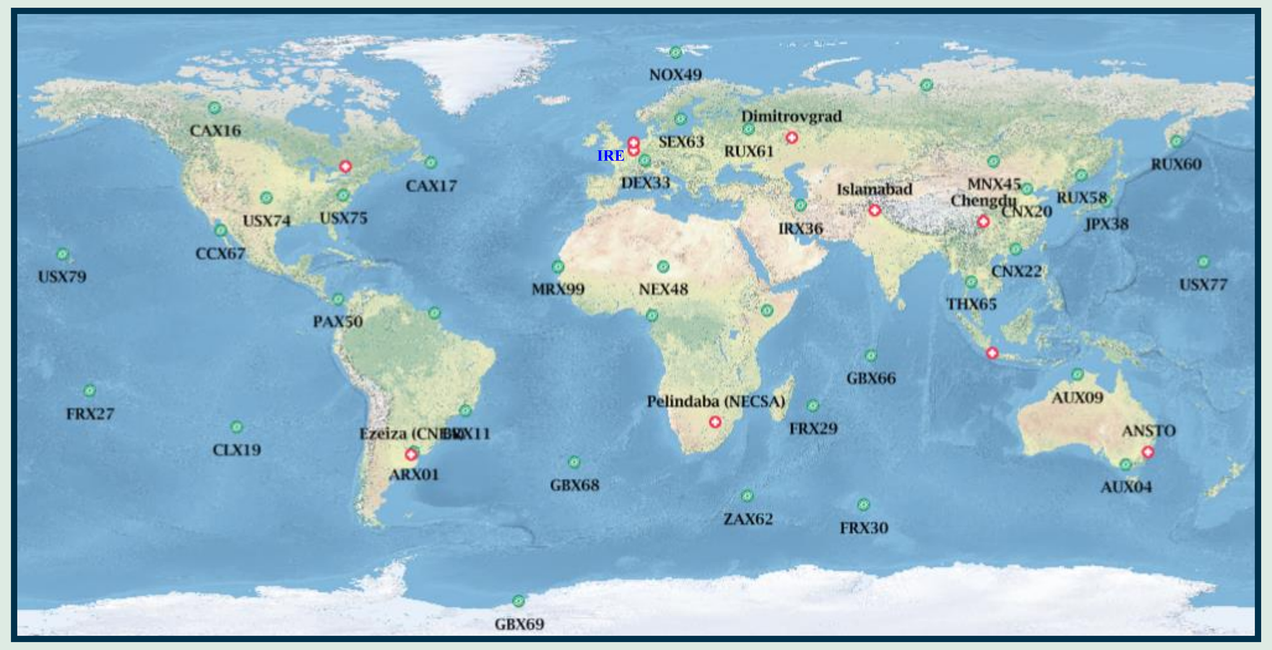

Figure 1. Map showing location of all noble gas IMS stations. Red dots indicate the location of major isotope production facilities (IPF).

Methodology

To investigate the transport of noble gases, the Provisional Technical Secretariat (PTS) operates an Atmospheric Transport Modelling (ATM) system based on the Lagrangian Particle Dispersion Model FLEXPART (Stohl et al., 2005). This model is designed for calculating the long-range and mesoscale dispersion of air pollution. The PTS uses FLEXPART in backward mode to compute daily Source-Receptor-Sensitivity (SRS) fields for all radionuclide measurement locations .

For the purpose of this study, the emission values provided by medical facilities IRE and ANSTO were accumulated into 3-hourly, half-daily and daily time resolution. Next, using the Continuously Emitting Sources (CES) functionality in Web-Grape (Web connected Graphics Engine (CTBTO, 2018)) and the operationally produced SRS fields, the predicted concentrations for all noble gas stations were estimated for the period January to December 2014.

Improvements in ATM results due to real emission data

The availability of emission data for IRE (Belgium) and ANSTO (Australia) provided an opportunity to verify whether ATM simulations using the "real" emission data as an input will be much more accurate than using a constant value known from literature. This comparison was done for two IMS stations in the Northern Hemisphere: DEX33 and SEX63 and two IMS stations in the Southern Hemisphere: AUX09 and NZX46. For each selected IMS noble gas station, the activity concentration (AC) estimated using daily emission time resolution and using a constant value from literature were compared to the measurements. In the next step a difference between the absolute values of the relative errors was estimated for each station and each sample. Figure 2 illustrates the results. Please note that the negative numbers indicate the improvement in ATM simulations resulting from using emission data. For DEX33 and SEX63, the number of samples for which such an improvement is observed, expressed in %, is 63% and 69%, respectively. In case of IMS stations located in the Southern Hemisphere this improvement is more significant: 77% for NZX46 and 97% for AUX09.

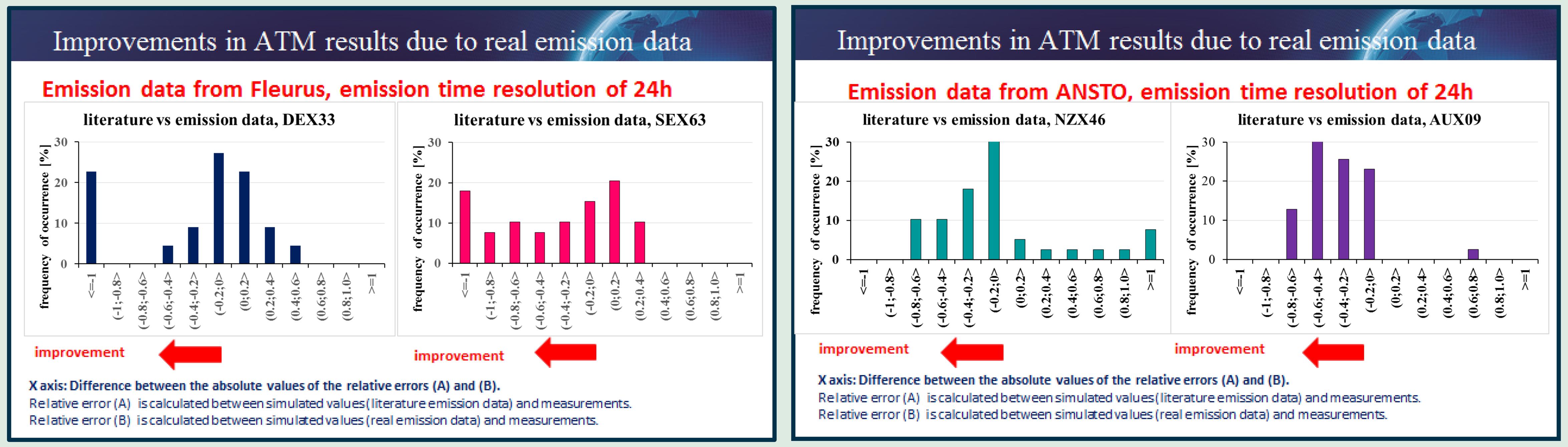

*Figure 2. Improvement resulting from using the real emission data instead of a constant values known from literature. Emission data from IRE (Fleurus) (**Left Panel**), and ANSTO (**Right Panel**).*

Influence of contributing sources on the quality of the ATM simulations

Knowledge about contributing sources is necessary to produce high quality simulations. To observe the added value of the real emission data, ideally, the selected samples should be associated only with a given medical facility, i.e. either IRE or ANSTO. However, this task would be very challenging, especially for DEX33 and SEX63. Figure 3 illustrates that the higher the percentage contribution from other sources, the higher the relative difference between simulated values and measurements, independently of the emission time resolution.

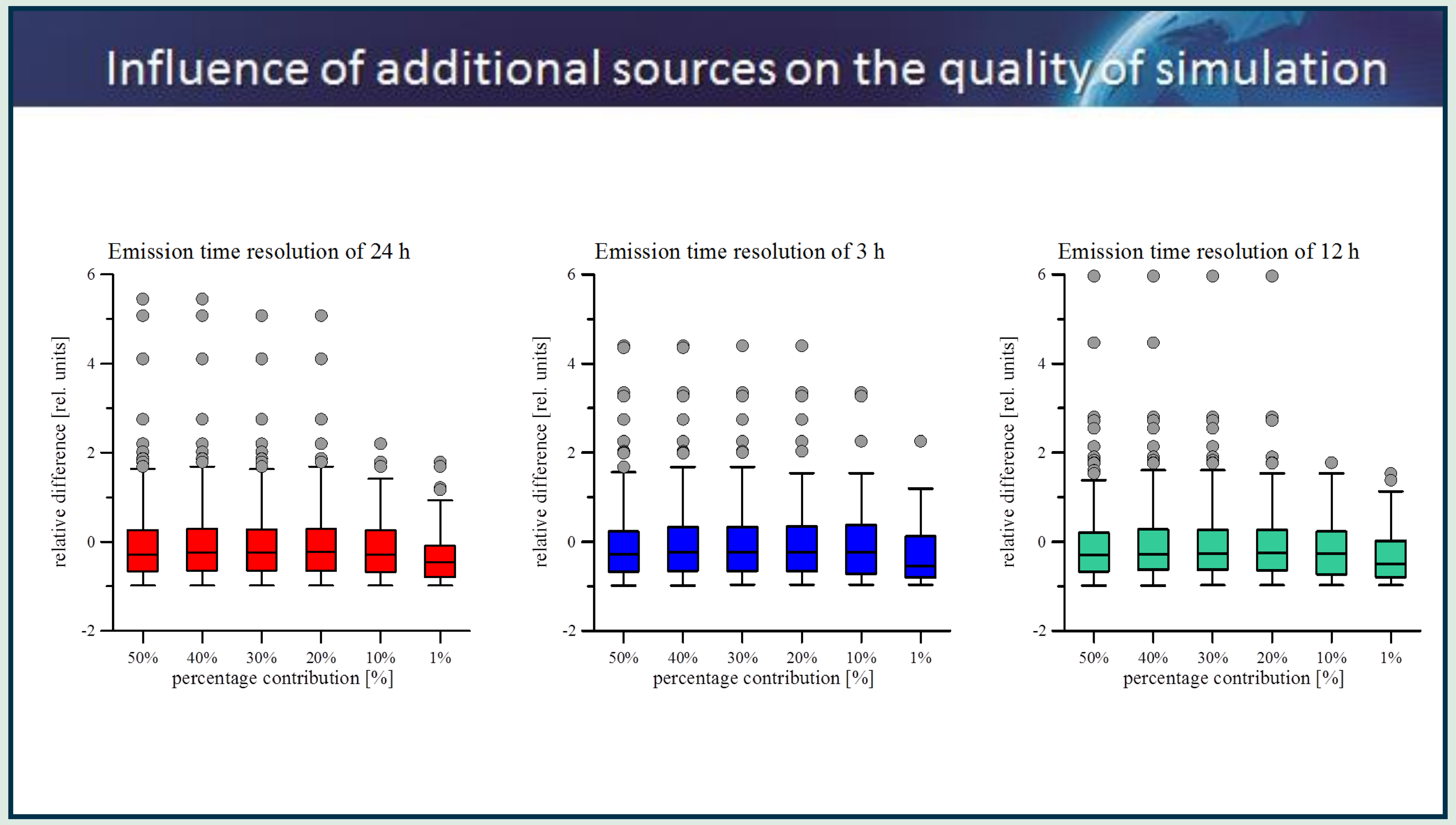

Figure 3. Influence of contributing sources on the accuracy of simulated results. Results for DEX33, SEX63, NZX46 and AUZ09 are combined.

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Influence of higher emission time resolution on ATM simulations

To verify whether a higher emission time resolution will have an influence on the accuracy of the simulated results, the activity concentration estimated using 3h emission time resolution and 24h emission time resolution were compared to the respective measurements. In the next step, the difference between the absolute values of their relative errors was found. The similar exercise was repeated for 12h emission time resolution. Figure 4 demonstrates the results. Please note that the negative numbers indicate the improvement in ATM simulations resulting from using higher emission data i.e. 3h over 24h or 12h over 24h. The most significant improvement is noted for the IMS station SEX63 and concerns about 56% of data.

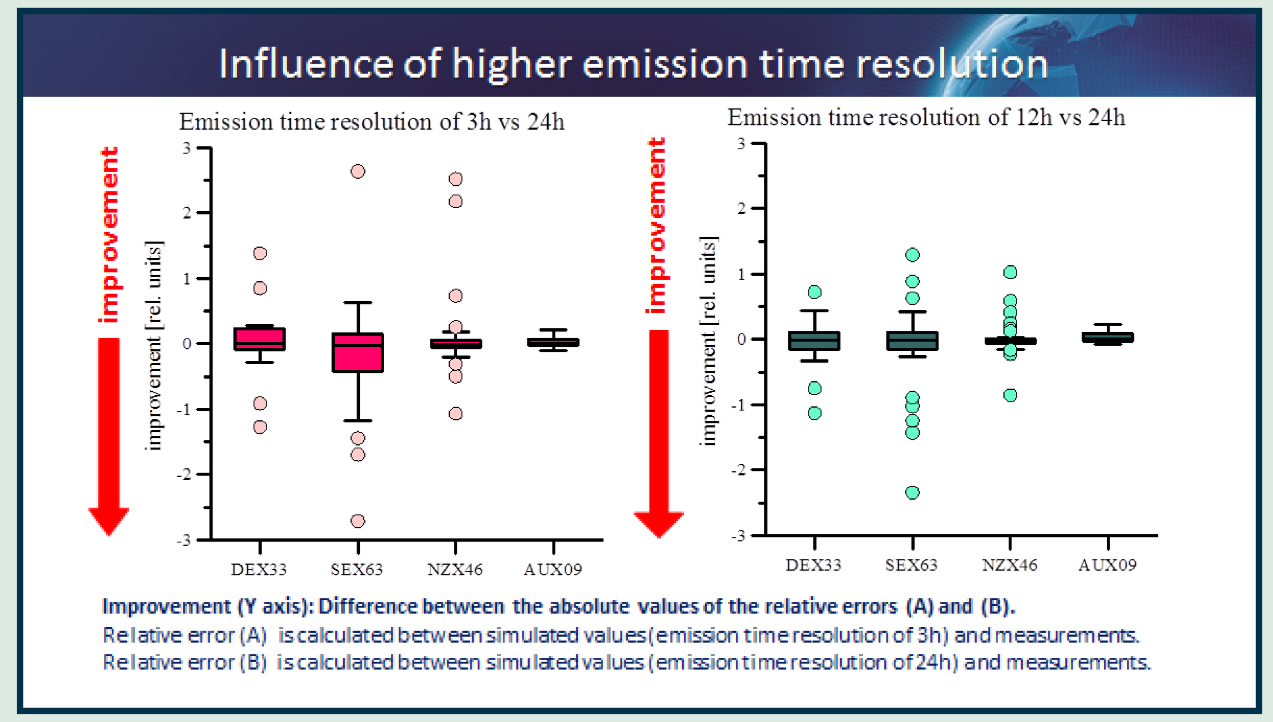

*Figure 4. Influence of the higher emission time resolution on the accuracy of simulations. The negative values indicate the benefit (improvement) of using 3h emission time resolution (**Left Panel**) and 12h emission time resolution (**Right Panel**) over 24h emission time resolution.*

Concluding remarks

It is demonstrated that using the emission data instead of constant values known from literature will lead to the improvement of the ATM simulations. This effect is more noticeable for the IMS stations located in the Southern Hemisphere (more than 77% of all data) than in the Northern Hemisphere (more than 63% of all data).

The improvement related to higher emission time resolution is less obvious. The most significant improvement is noted for the IMS station SEX63 and concerns about 56% of data.

References

CTBTO Preparatory Commission, 2018. International Data Centre (IDC): WEB-Grape 1.8, Software User Manual, Vienna, Austria. pp. 181.

Stohl, A., Forster, C., Frank, A., Seibert, P., Wotawa, C.G., 2005. *Technical note: the Lagrangian particle dispersion model FLEXPART version 6.2*. Atmos. Chem. Phys. 5, 2461-2474.