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Possible contamination of Ukraine and neighboring countries by Cs-137 due to a hypothetical accident at the Zaporizhzhia NPP as a consequence of the Russian aggression

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The Zaporizhzhia nuclear power plant (ZNPP) has been occupied by Russian aggressors since March 4, 2022. Its proximity to the combat zone results in a real risk of an accident with radioactivity emissions. There have been a number of blackouts at ZNPP (the most recent one was reported on December 2, 2023, lasting for approximately 5 hours), which could potentially lead to an accident with a scenario similar to that of the 2011 Fukushima Daiichi NPP disaster. The objective of this research is to assess possible contamination of the territory of Ukraine and neighboring countries by Cs-137, emitted in a hypothetical accident at ZNPP, depending on weather patterns usually observed over the domain. The assessment is based on numerical simulations of atmospheric transport, dispersion and deposition processes.

In order to obtain an input meteorology for the dispersion/deposition simulations, we chose 37 typical weather patterns out of 153 that were objectively identified in the domain during 2018-2020. Our selection aimed to keep seasonal and frequency distribution of the patterns in the sampled population. Generally, the selected patterns included 22 cyclonic, 12 anticyclonic, and 3 situations of western transport. Their mean duration was approximately 6 days. 3D meteorological data for the selected weather patterns were generated by means of the WRF v4.3 meteorological model based on ERA5 reanalysis data.

The source term parameterization was based on freely available information published in scientific papers, reports etc. Several Cs-137 emission scenarios were considered by varying an emitted fraction of the total core inventory (50% and 3.43%) and a period of time when the source was active (24, 32, and 40 hours). The dispersion/deposition calculations were performed with the CALPUFF v6 and HYSPLIT v5.2.3 atmospheric dispersion models. Using these two models, which implement different computation algorithms, allowed us to perform the verification of the computed results.

Our calculations showed that a hypothetical accident with the most conservative emission scenario (emitted 50% of the total core inventory) could lead to significant contamination of not only the territory of Ukraine but also neighboring countries. Generally, depending on the weather

pattern, from 10 to 80% of the emitted Cs-137 could be deposited on the territory of Ukraine. The reduction of the total emission obviously leads to decreased absolute values of the contamination, however the fractions of deposited in Ukraine Cs-137 stay unchanged for each weather pattern.

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