



Introduction

In the process of verification whether a given detection can be caused by an event like a nuclear explosion, the knowledge about civil sources like nuclear power plants or isotope production facilities is extremely important because they contribute to the background signal. To estimate the xenon background the Atmospheric Transport Modelling (ATM) results were combined with Xe-133 observations for the full year of 2014. This study shows the monthly changes in the Xe-133 background for 3 IMS stations: JPX38 in Takasaki, Japan, USX77 in Wake Island and USX79 in Oahu, Hawaii (see Figure 1). It is demonstrated that Nuclear Power Plants (NPPs) emissions can significantly contribute to the Xe-133 measurements even at remote locations like IMS stations USX77 in Wake Island or USX79 in Oahu, Hawaii.

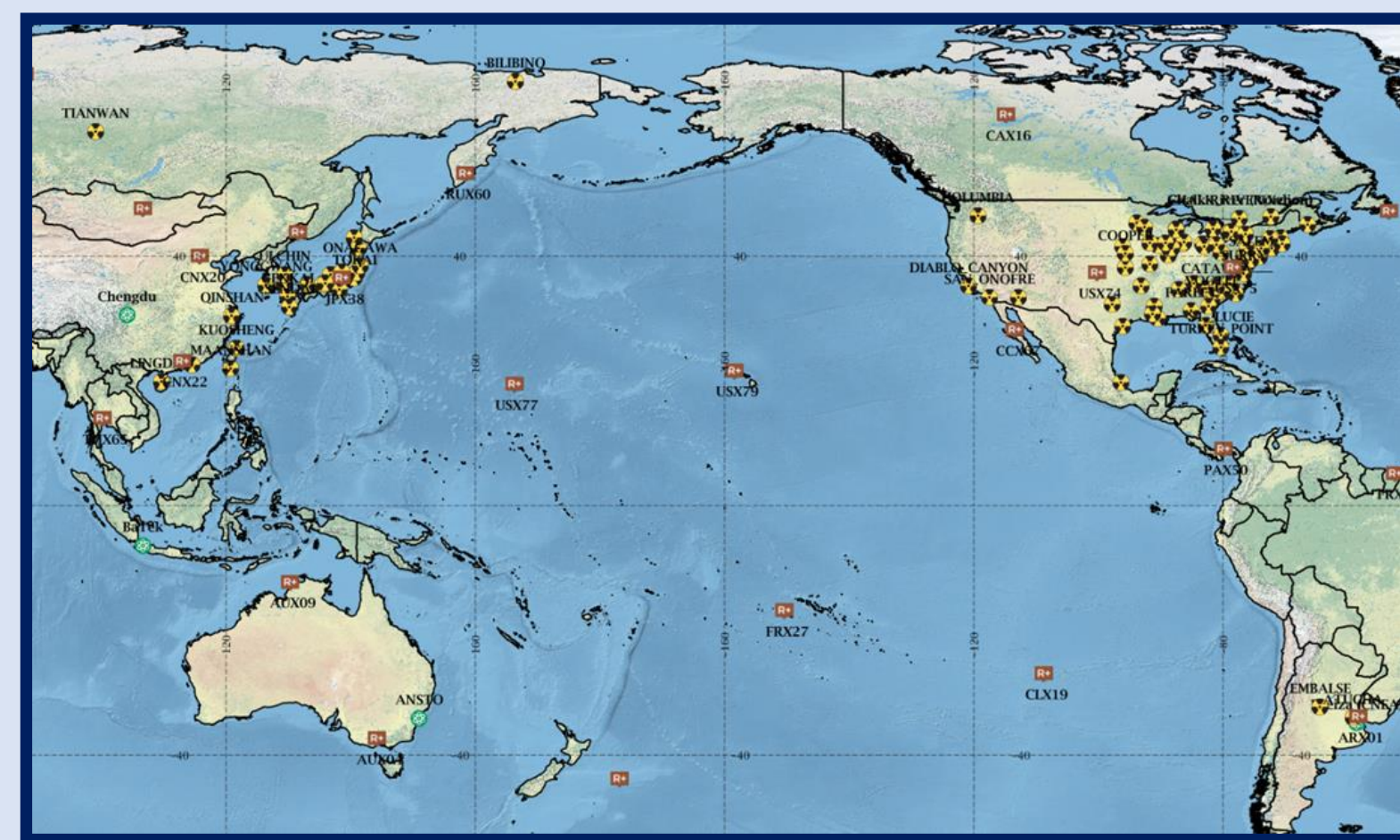


Figure 1. Map showing location of IMS stations: JPX38 in Takasaki (Japan), USX77 in Wake Island and USX79 in Oahu (Hawaii).

The effect of NPPs emissions observed at USX77 & USX79

It is interesting to note that the effect of NPPs emissions is not only observed at the station JPX38 which as Figure 1 demonstrates is surrounded by NPPs, but also at the remote IMS stations USX77 and USX79. The number of detections observed at these stations is relatively small, larger at USX79 than USX77. It turns out that in summer time, the contributing sources as indicated by ATM (backward modelling) using as the meteorological input ECMWF and NCEP data, are only NPPs.

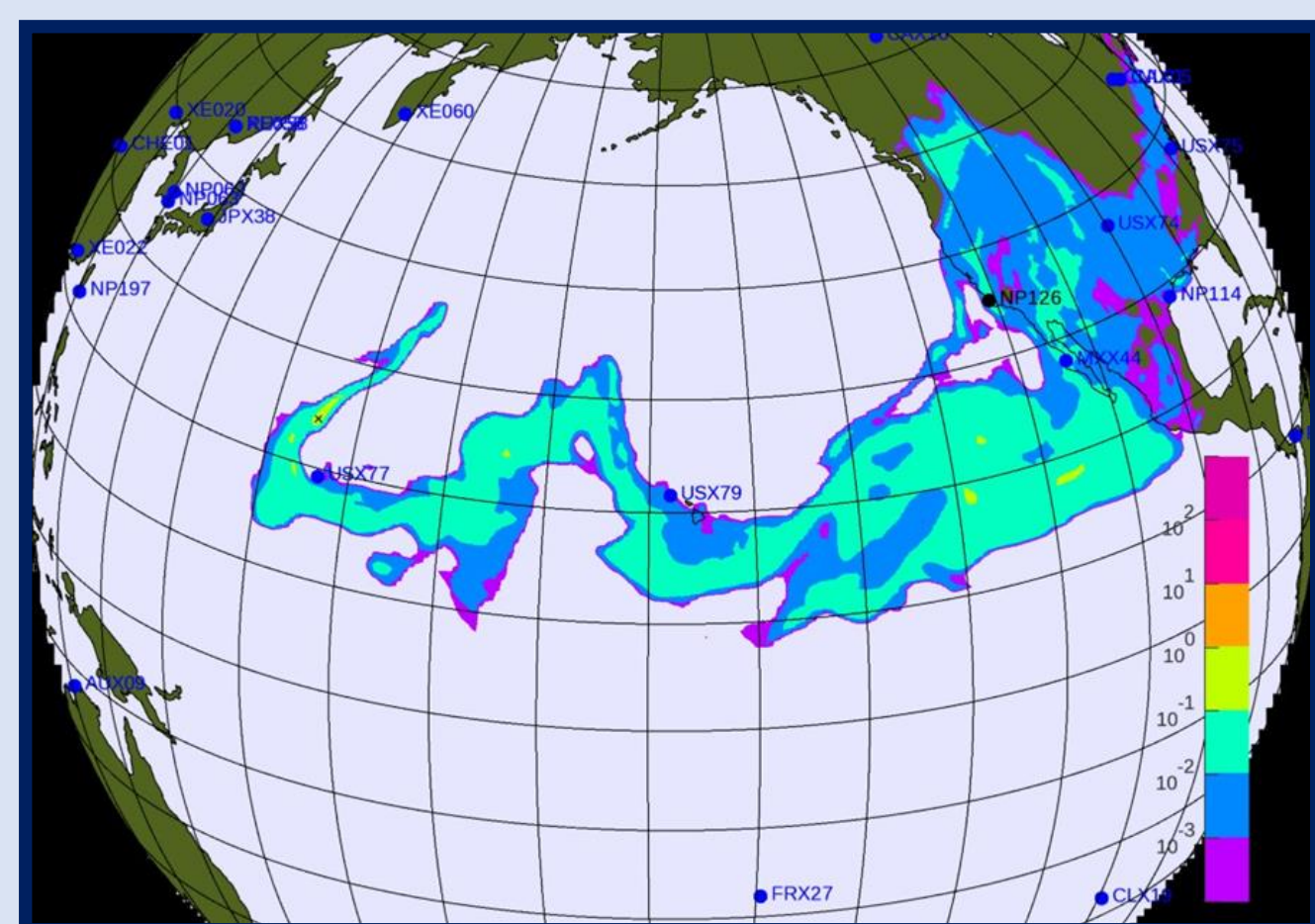


Figure 2. **Left Panel:** Example of air mass trajectory. Plume released on 10 July 2014 from NPP Diablo Canyon arrives at USX79 on 18 July and 4 days later at USX77. **Right Panel:** Number of detections in a given month as indicated by ATM results. The agreement between NCEP and ECMWF data is highlighted in red.

Contribution from nearby and remote sources as seen by IMS stations in the Pacific Ocean

To estimate the contribution from the major Medical Isotope Production Facilities (MIPFs) and from NPPs which were operational in 2014 (IAEA, 2015), the ATM results in the backward mode were used. The daily values of Xe-133 released from facilities are the best estimate from literature. In case of IRE (Belgium) and CNL (Canada), the real daily emission values were used. Figure 3 illustrates the results. Since the number of NPPs is very large, the cumulative effect is indicated and labelled as NPPs. It is evident that independently of the season, NPPs are the main source of Xe-133 emissions contributing to the potential detections.

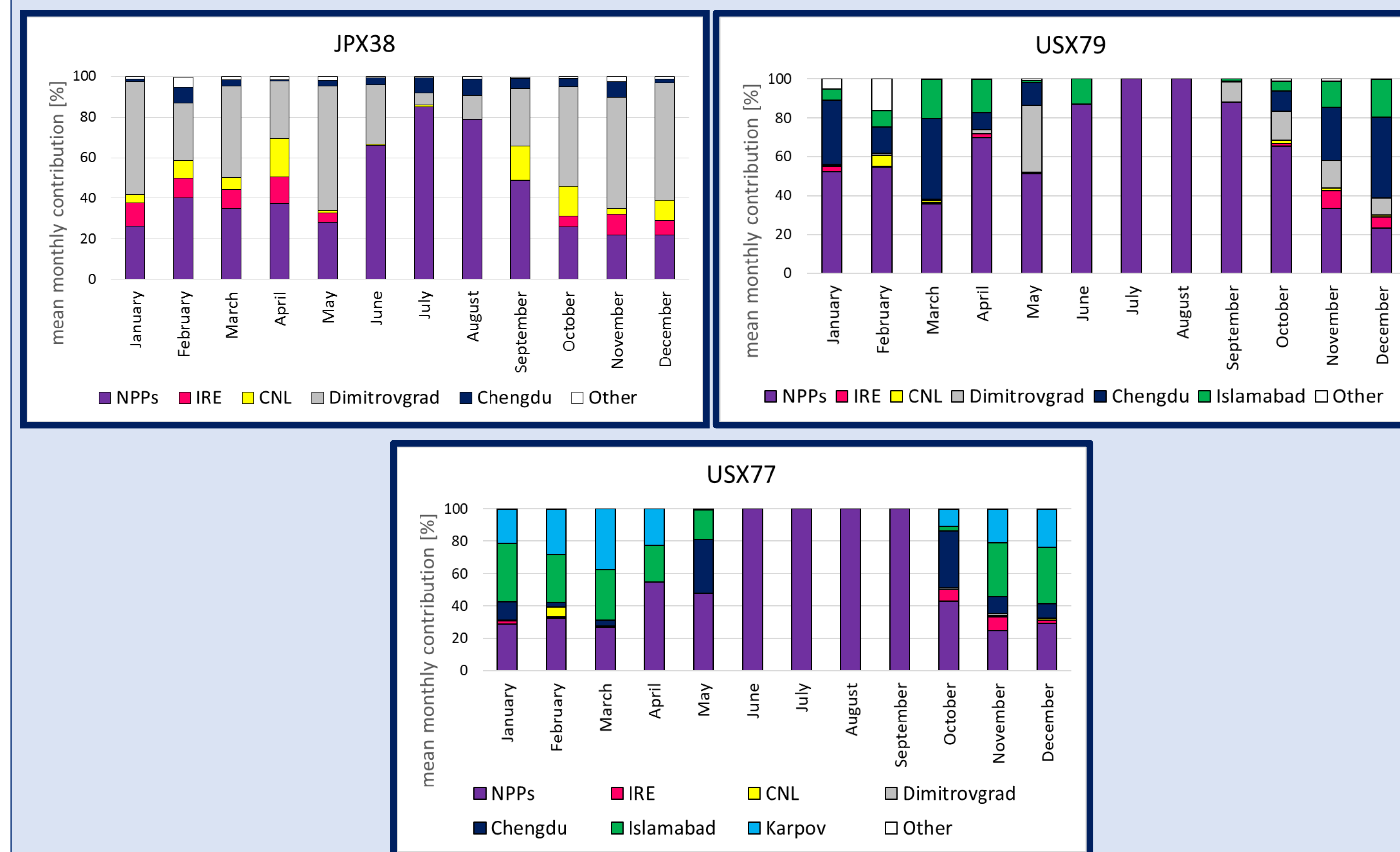


Figure 3. Mean monthly contribution of Xe-133 emissions from individual sources as observed at IMS stations. It is assumed that all facilities operate continuously on a daily basis. The results are based on operationally produced ATM results (backward modelling) using meteorological data from ECMWF.

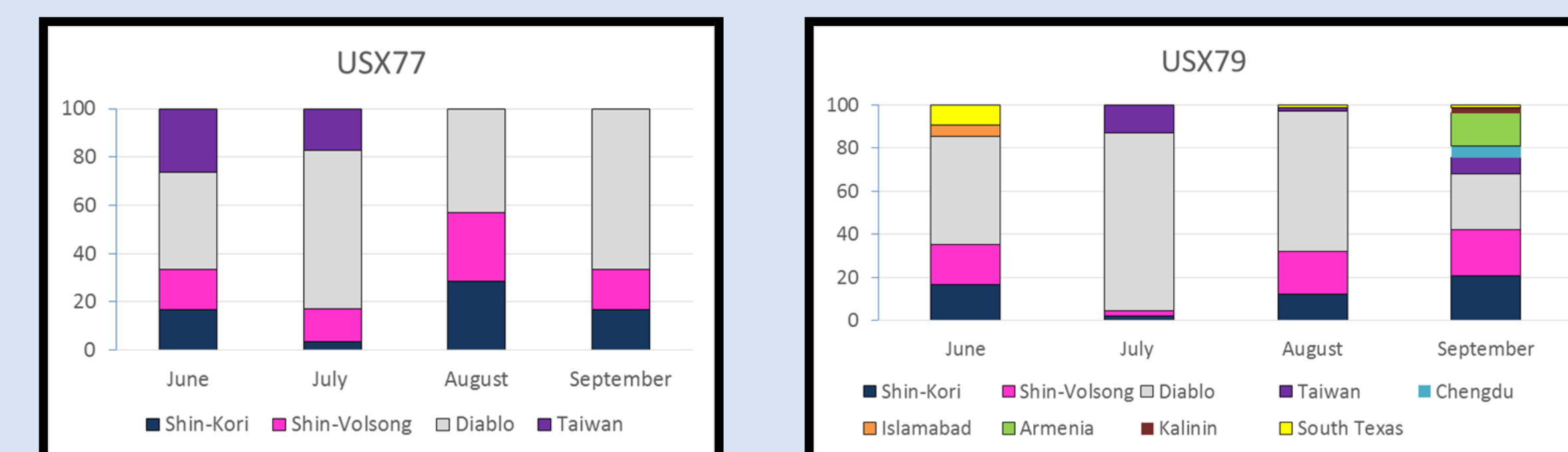


Figure 4. Monthly contribution from individual sources to the number of potential detections at 2 IMS stations: USX77 and USX79. It is assumed that all facilities operate continuously on a daily basis. The results are based on a series of 14 day forward simulations with ECMWF data, released daily in the period 15 May to 30 September 2014 from all contributing facilities.

Contribution from NPPs as seen at USX77 & USX79

It is interesting to note that during summer time the main contribution to the Xe-133 emissions measured at JPX38, USX79 and USX77 come from NPPs (see Figure 3). Moreover, between June and September, Xe-133 observed at USX77 and USX79 seems to be exclusively associated with NPPs, and the most frequently observed contribution at both IMS stations comes from NPP Diablo Canyon (see Figure 4). As Figure 2 (Left Panel) demonstrates the plume released from one facility may be observed at both stations.

To check if the order of magnitude between measured and simulated values agrees, the total monthly activity concentrations of Xe-133 measured at the station were compared to the simulated values for the same period of time using ATM. The simulated values are presented in the form of maps of activity concentration for the Region of Interest (ROI) which includes both IMS stations but also the adjacent area just to have a broader overview. Figure 5 reveals that for the cumulative monthly values, the simulated values are lower than the measured values, approximately by one order of magnitude. One of the possible explanations is that the assumption of continuous operation (instead of pulses) leads to such discrepancies. It is also possible that there are other unknown sources not included in this study.

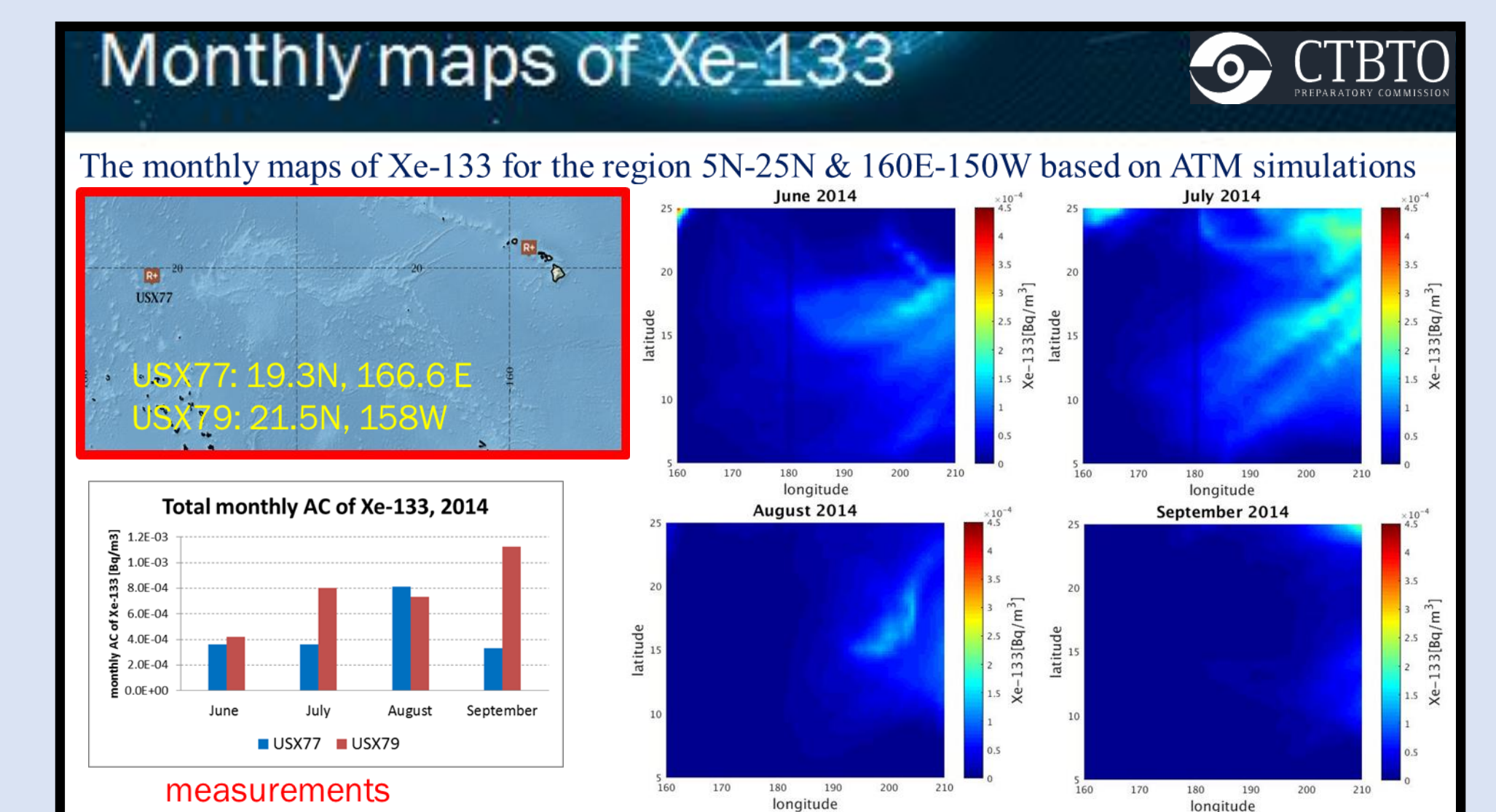


Figure 5. Monthly maps of Xe-133 emissions as predicted by ATM simulations.

Concluding remarks

- Knowledge about contributing sources is crucial in estimating the xenon background.
- Detections observed at IMS stations JPX38, USX79 and USX77 in many cases are caused by multiple sources. Even if each single NPP will contribute with a very low value, a combination of many weak sources leads to a measurable result. Therefore Xe-133 can be detected even at remote locations like USX77 or USX79.

References

- IAEA, 2015. Power Reactor Information System. International Atomic Energy Agency.
- Kalinowski M. (T2.4-P27) Global radioxenon emission inventory for 2014 by normal operational releases from Nuclear Power Plants and Medical Isotope Production Facilities.