Basic information

In the 1990s, in connection with the completion of the Temelín nuclear power plant, there was an interest to objectively evaluate the impact of plumes, i.e. visible and invisible air currents coming from cooling towers (CT), on the surrounding environment. Unlike chimney-based plumes, CT plumes contain large amount of water, which influences their behaviour, and modelling of this type of plumes must consider this fact. Due to the fact that the Institute of Atmospheric Physics of the CAS had experience with cloud modelling, we started to deal with the modelling of CT plumes and their influence on the surrounding environment.

We developed a model and tools for evaluating the impact of CT plumes on the surrounding microclimate using the following concept:

• A simple mathematical model has been created, which enables to calculate a large amount of cases in a reasonable time for various meteorological data with the aim at processing data from several years.

• The input model data, which describe both the state of the atmosphere and the technical parameters of the CT, should be as simple as possible so that they could be obtained at any given place.

• In addition to the results in the form of specific values, the selected methodology should also provide a quantitative assessment of the reliability of the results.

As a result, we developed a mathematical model CT-PLUME and implemented it into a software. There are different variants of the CT-PLUME model, which differ in the specific purposes for which they have been created. The model itself and its software implementation consist of two basic parts. The first basic part is the model which solves mathematical equations describing evolution and transfer of plumes and calculates the effect of CT on changes in temperature, humidity, and changes in sunlight shading. These results enter other models, which is the second part of the software, which addresses partial effects of CT on specific meteorological phenomena.

Based on the requirements of applicants for studies on the impact of CT plumes on the environment, we are currently able to solve the following tasks:

• Calculation of the effect of CT on ambient temperature and humidity. The results provide any statistical characteristics of the impact for different daily and annual periods. The results can be obtained for diverse areas as well.

• Calculation of the effect of CT on the sunlight shading. The results provide any statistical characteristics of the impact for different daily and annual periods, which can be calculated for diverse areas. The calculations consider the natural shading of the clouds.

• Influence of plumes on precipitation formation. The model considers possible precipitation formation due to plumes, bringing significant humidity into the atmosphere. However, the experience shows that in our conditions, the parameters of CT are not sufficient to cause precipitation to fall to the earth's surface.

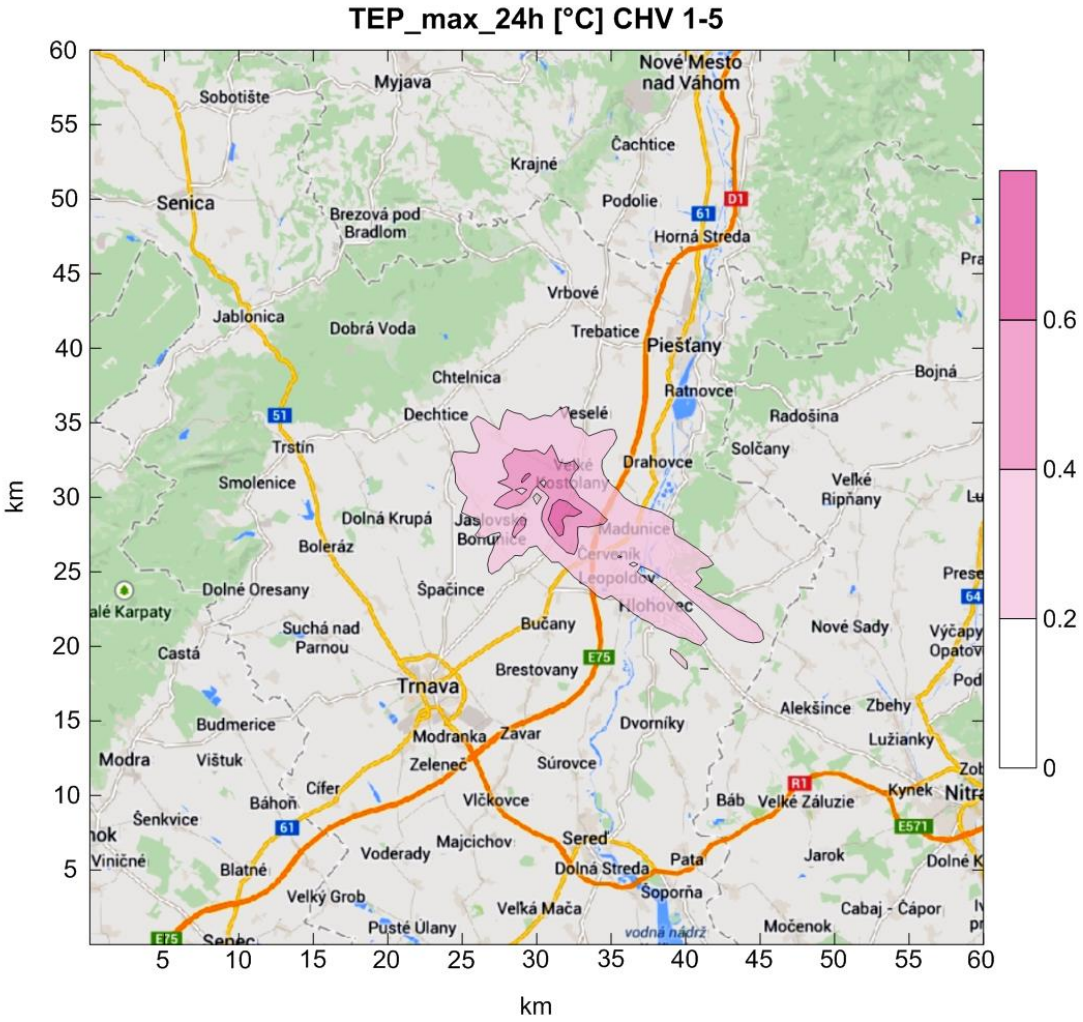
• Transfer of water drops into the surroundings. CT plumes contain small droplets, which are carried by the plume in the air and are further transmitted by the wind and deposited to the ground.

• The probability of fog formation. The fog can result from the emission of warm humid air (plumes) into the atmosphere.

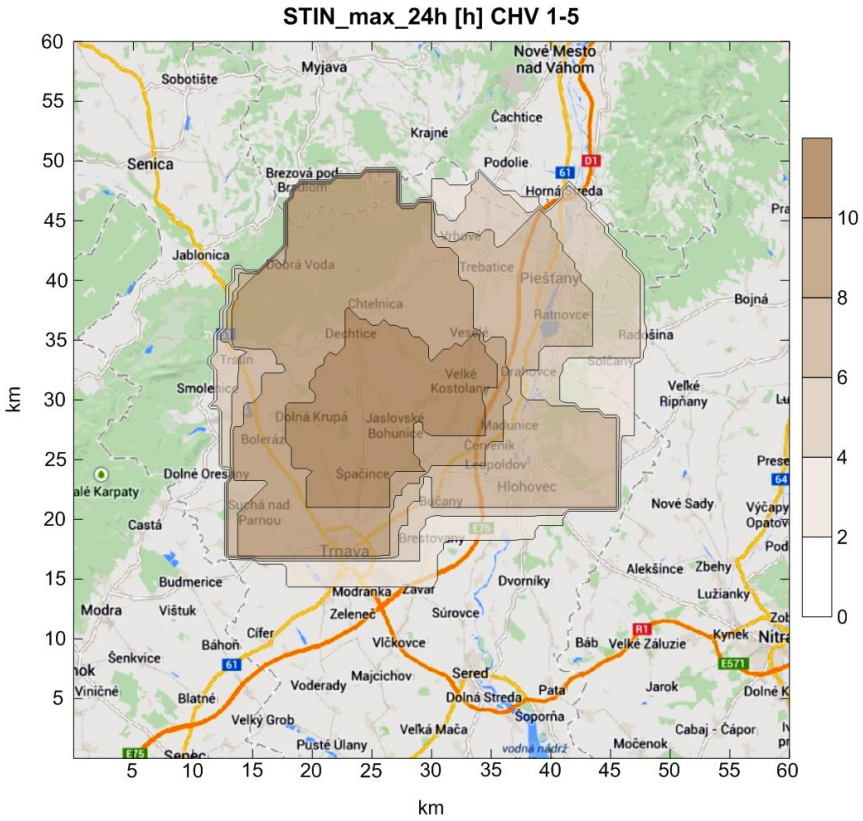
• The probability of icing due to the emission of warm humid air (plumes) into the atmosphere. The formation of icing in the vicinity of CT is a relatively common phenomenon in winter, often under cloudless night sky. The icing is caused by the plume, consisting of warm humid air, gradually cooling and sinking to the ground. If relatively warm humid air touches a frozen surface, then the ice forms from the plume on the surface. This is often observed, for example, on trees near the CT, where the branches are covered by ice due to the plume. This phenomenon is dangerous because it also causes icing on sidewalks and roads, which is risky and can lead to accidents.

Based on different CT configurations and their parameters in the model, it is possible to compare the influence of these configurations on different characteristics and select the most suitable parameters for the client.

Examples of outputs of the CT-PLUME model are in Figures 1-4.



Maximum change in daily temperature (24 h average) caused by CT plumes.



Comparison of old and new CT configurations. The brown area shows the area where the new configuration increases the shading of the earth's surface by at least 1 hour per year.

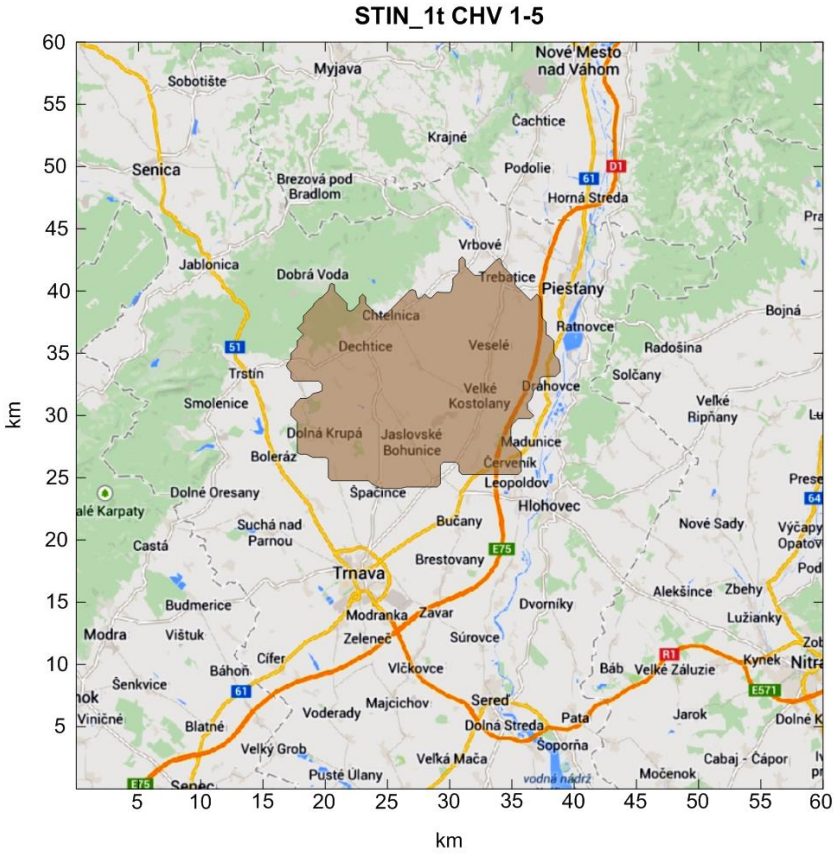
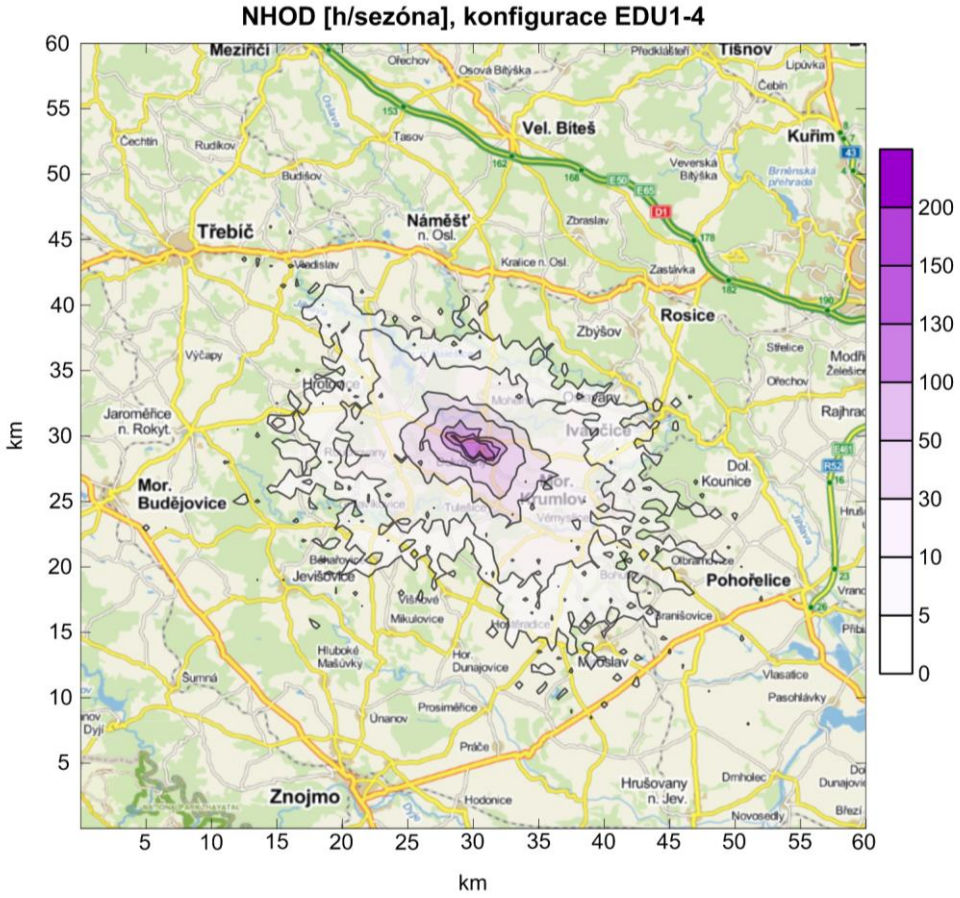


Figure shows areas where the earth's surface might be shaded by plumes.



Area where icing may occur for a shown number of hours per year.