SENSITIVITY OF SPRAY AND CALPUFF MODELS TO SOURCE CHARACTERISTICS WHEN SIMULATING DISPERSION FROM FIRES

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The application of dispersion modelling for the evaluation of pollutant dispersion from an incidental fire is particularly challenging, due to the high uncertainties associated with the characterization of the source term. Two dispersion models, i.e. CALPUFF and SPRAY, are compared by changing the source term parameters within an estimated uncertainty range.

Materials and methods

Case study description

The proposed case study regards an hypothetical incidental fire in an oil refinery. The event is supposed to involve a combustion of diesel fuel and lasts 3 hours. To optimize the choice of the geographic area to be considered, weather data showing the plume direction should be taken into account. For the selected case-study a rectangular domain that follows the trend of the plume is identified. According to this, the source is located at the north-eastern limit of the domain. Also, some discrete receptors are chosen in places (e.g. hospital, school, city hall) that are considered of particular interest to estimate the pollutant concentration resulting from the incidental fire.

The choice of the two models (CALPUFF and SPRAY) to be investigated was based on the study of the scientific literature. Both models comprise specific tools for modelling fires.

Definition of emission scenarios

A "base-case" is defined by assuming a set of reasonable source term parameters. Thus, alternative emission scenarios were investigated by changing the most critical source parameters, i.e. source area and height. Another parameter that is investigated is the modelled source types: for both CALPUFF and SPRAY, the fire is modelled by applying the specific source type (buoyant area source for CALPUFF, and fire for SPRAY) and then compared with the point source, using the same physical input parameters, reported below as "Base case". Particulate matter (PM) is chosen as target species, applying a suitable emission factor.

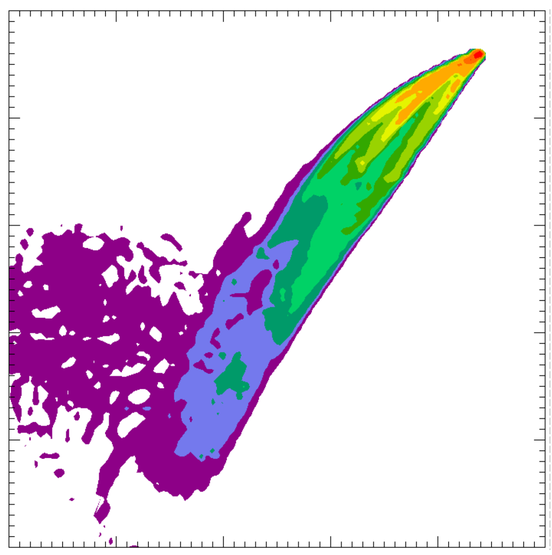
Scenario	A (m^2)	T (K)	H (m)	Quantity (ton)	v ($m\ s^{-1}$)	ER PM ($g\ s^{-1}$)
BASE	20	1373	15	11.2	8.16	51.852
A1	*100*	1373	15	11.2	6.21	51.852
A2	*10*	1373	15	11.2	9.17	51.852
H1	20	1373	*20*	11.2	8.16	51.852

Results and conclusions

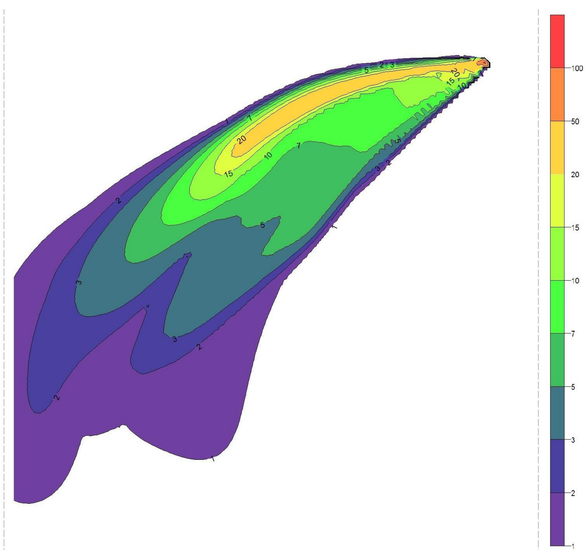
As an example of the results of the simulations, the maps here reported show the maximum 1-hour PM concentration values resulting from the base-case simulation in function of the different source types considered. Due to the different wind field elaborated from the two meteo data processors (SWIFT for SPRAY, CALMET for CALPUFF), the sensitive receptor with the maximum ground concentration, which have been considered for the numerical comparison were different for the two models. A deeper investigation for the comparison of the two models was made by evaluating the maximum 1-hour concentration values as a function of the distance from the source along the main direction of the plume. The results are reported below: close to the source, a significant difference between the different types of sources modelled is observed, because of the to different plume rise computation. On the contrary, for the same type of source (i.e. point vs. fire), the results of the two models are comparable.

The next table shows a comparison of the results obtained for the different emissive scenarios in terms of variability (%) of the maximum PM concentration values resulting at the selected receptors compared to the base-case.

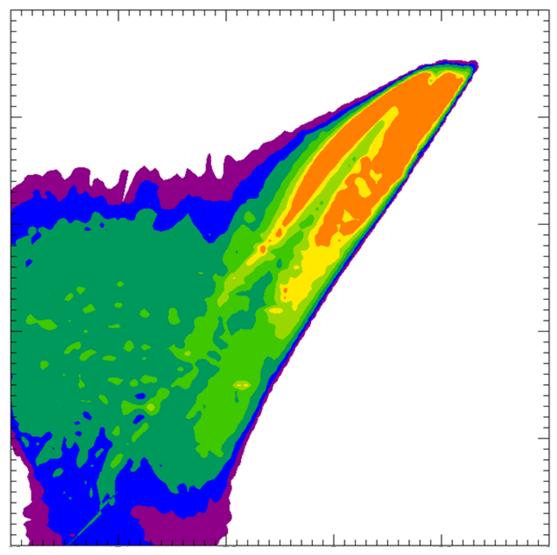
SPRAY - FIRE SOURCE



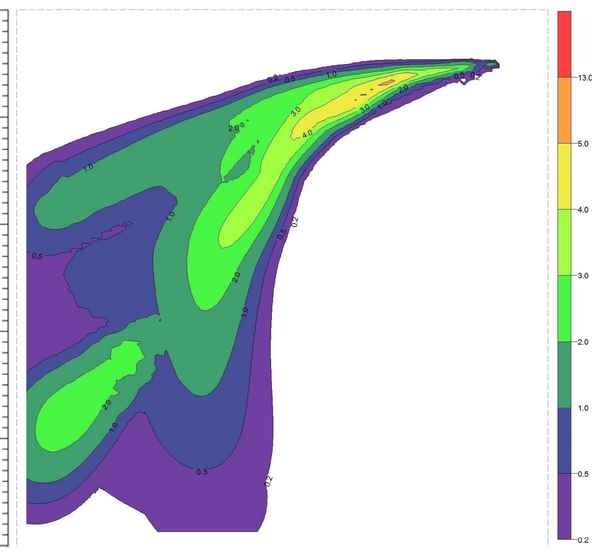
CALPUFF - BUOYANT SOURCE

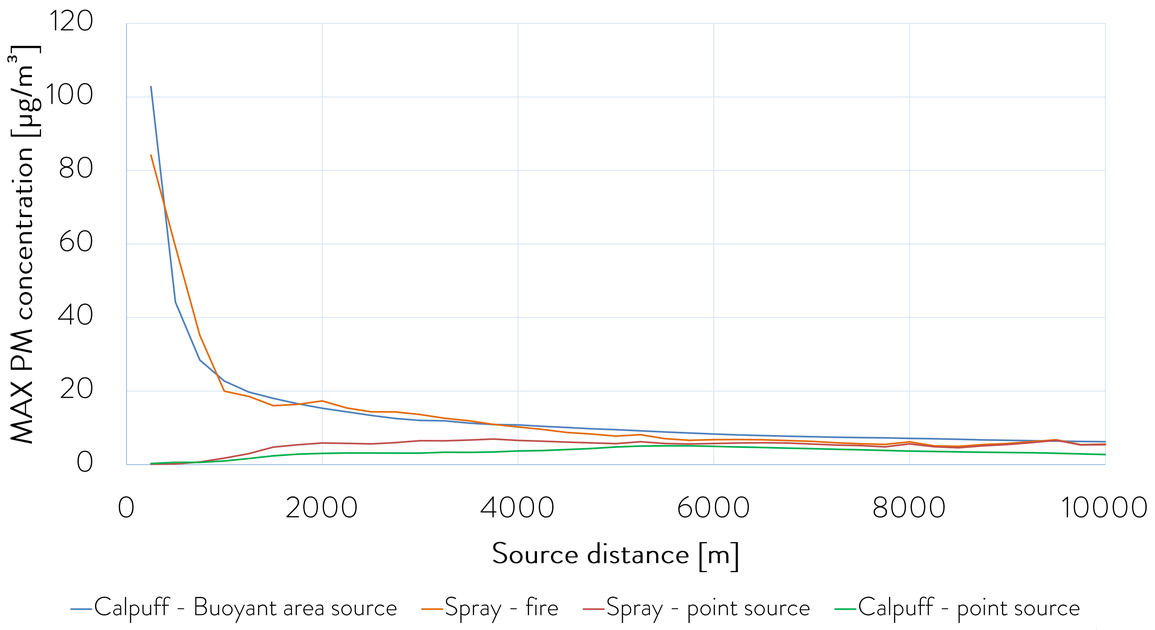


SPRAY - POINT SOURCE



CALPUFF - POINT SOURCE





CALPUFF - Buoyant Area				SPRAY - Point				SPRAY - Fire		
Rec.	A1	A2	H1	Rec.	A1	A2	H1	A1	A2	H1
1	-48%	42%	-17%	7	-52%	48%	1%	10%	-1%	-22%
2	-62%	8%	-1%	8	-25%	8%	0%	2%	-2%	3%
3	-41%	39%	-5%	9	-64%	51%	14%	3%	0%	0%
4	33%	-53%	4%	10	-39%	25%	11%	2%	1%	2%
5	-67%	74%	-7%	11	-39%	23%	3%	1%	0%	0%
6	-46%	21%	3%	12	-60%	50%	17%	1%	0%	-1%

For CALPUFF and SPRAY – point source, the parameter that most affects the model outputs in terms of ground concentration on selected receptors is the source area. By considering the extreme values of the defined uncertainty range (10 m^2 - 100 m^2), the pollutant ground concentrations on some receptors vary up to +/- 60%. On the other hand, if the SPRAY model is applied with the specific fire source option, then the modelled concentrations, varying area source parameter in the same range, result almost independent from this parameter. Although this can be explained from a mathematical point of view, the problem remains open of choosing case by case the option that best approximates the real behavior of the incidental source under investigation.