COMPARACIÓN DE MODELOS DE DISPERSIÓN EN LA SIMULACIÓN DE LOS OLORES: UN CASO DE ESTUDIO SOBRE PLANTAS DE DEPURACIÓN DE AGUAS RESIDUALES

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IN THE WORLD. SUEZ AIR & CLIMATE DIVISION

7.5 billion €
of revenue

66 M
people supplied with drinking water worldwide

More than 33 M
people benefiting from sanitation services provided by SUEZ

3.6 TWh
energy produced from waste and wastewater

3.8 Mt CO_2
avoided

9
technical and innovation centers and R&D centers in Europe and Asia

150
researchers acting every day to innovate

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inter-comparison models: AERMOD/CALPUFF/GRAL/PMSS

El estudio presentado tiene como **objetivo principal analizar el comportamiento de 4 modelos de dispersión** atmosférica: 1 modelo **gaussiano**, un modelo de **Puffs** (PuM), y 2 **modelos de partículas lagrangianos** (LPM) en una simulación mensual a partir de las emisiones reales de un planta depuradora de aguas residuales en España.

OWNER	DESCRIPTION
EPA United States Environmental Protection Agency	**AERMOD: Modelo de dispersión recomendado por la EPA. Modelo gaussiano en estado estacionario.**
Lakes Software	**CALPUFF** es un modelo lagrangiano, multicapa, multiespecie, de estado no estacionario. Es un modelo lagrangiano de PUFF.
GRAL	**GRAL** es un modelo Lagrangiano de partículas. Ha sido diseñado para reproducir campos de concentración 3D de contaminantes (pasivos) a muy alta resolución, bajo complejas configuraciones topográficas y de construcción.
suez	**PMSS, Parallel Micro-SWIFT-SPRAY (Moussafir et al., 2004 y 2007), es un modelo Lagrangiano de partículas de modelización para calcular transporte y la dispersión capaz de tener en cuenta la presencia de obstáculos (edificios, etc).**

Some model properties (AERMOD/CALPUFF/GRAL/PMSS)

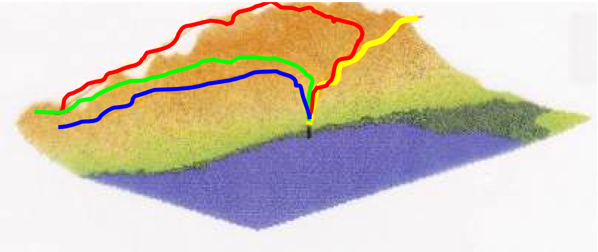
Model	CALPUFF	AERMOD	GRAL	PMSS
Definition	Lagrangian **puff** model	Gaussian model	Lagrangian **particle** model	Lagrangian **particle** model
Transport	Lagrangian	Gaussian	Lagrangian	Lagrangian
Dispersion	**Gaussian**	**Gaussian**	**Lagrangian**	**Lagrangian**
Trajectories (per emission time step)	**1**	**-**	**many**	**many**
Space resolution	**> 90 m**	**> 90 m**	**Even < 5 m**	**Even < 5 m**
Time resolution	Even < 15 min	Even < 1 hour	Even < 1 hour	Even < 15 min
EPA Guidelines*	“Alternative” since 2017 (after almost 10 years of evaluation process)*	Regulatory model EPA Guidelines	Not on any EPA list but “alternative” **in the spirit.** Included in Model Documentation System (MDS)	Not on any EPA list but “alternative” **in the spirit.** Included in Model Documentation System (MDS)
Building downwash	Yes	Yes	Yes	Yes
Microscale (building effects)	**No**	**No**	Yes	Yes

*** It is also important to note that the use of CALPUFF in the near-field as an alternative model for situations involving complex terrain and complex winds is not changed by removal of CALPUFF as a preferred model in appendix A of EPA Guidelines**. The EPA recognizes that AERMOD, as a Gaussian plume dispersion model, may be limited in its ability to appropriately address such situations, and that CALPUFF or other Lagrangian model may be more suitable, so we continue to provide the flexibility of alternative model approvals (as has been in place since the 2003 revisions to the Guideline).”

Focusing on Lagrangian Models

The two modeling approaches (Particles vs Puff) are referred to as "Lagrangian". In this approach, the trajectory of a portion of a pollutant plume is not solved in the observer's reference system, but in the reference system constrained to the portion of the plume itself.

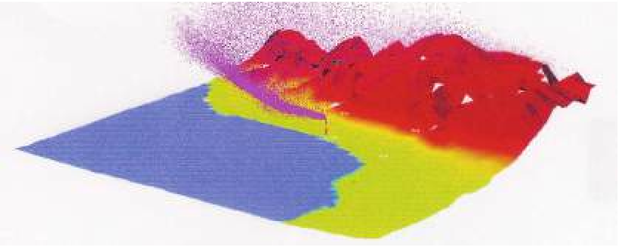
Trajectorie/Puff (CALPUFF – SCIPUFF)



CALPUFF IS A PUFF MODEL : GAUSSIAN FORMULATION (1 TRAJECTORY), VERY FAR FROM THE REAL WORLD

In the case of a **PuM**, the cloud of polluted air expands gradually with time according to the prescribed "expansion rate" and a Gaussian dispersion shape.

Particles (SPRAY – Flexpart – Lapmod - GRAL)



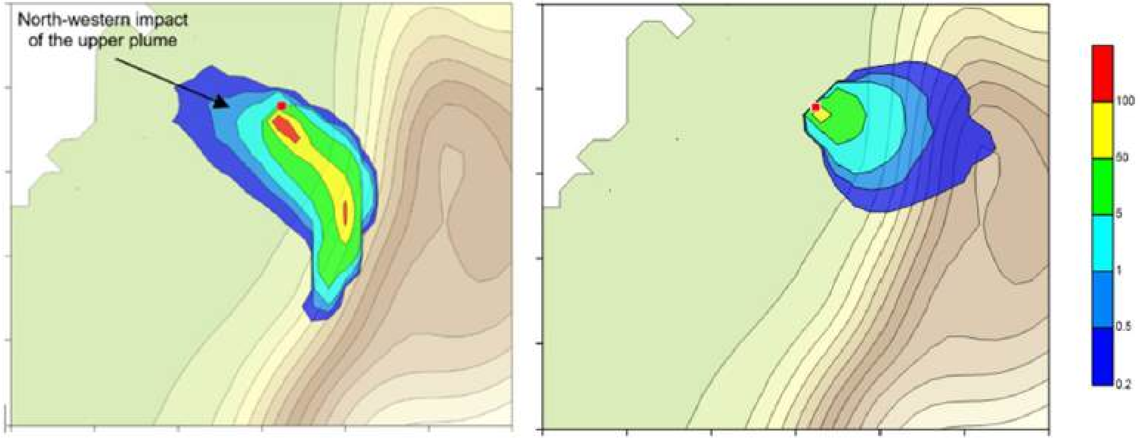
PMSS IS A PARTICLE MODEL : MANY TRAJECTORIES, CONSIDERS THE INHOMOGENEOUS NATURE OF ATMOSPHERIC TURBULENCE IN 3 DIMENSIONS.

In the **LPM** (Lagrangian Particle Model), independent solutions are given instead for a large portion of the points of the plume cross-section, the "particles".

Dispersion in complex terrain for ground sources (odor impact)

PMSS : CORRECT DESCRIPTION OF DISPERSION IN COMPLEX TERRAIN FOR GROUND SOURCES

CALPUFF : INCOHERENT DESCRIPTION OF DISPERSION IN COMPLEX TERRAIN FOR GROUND SOURCES



Nanni, A.; Tinarelli, G.; Solisio, C.; Pozzi, C. **Comparison between Puff and Lagrangian Particle Dispersion Models at a Complex and Coastal Site**. *Atmosphere* **2022**, *13*, 508. https://doi.org/10.3390/atmos13040508

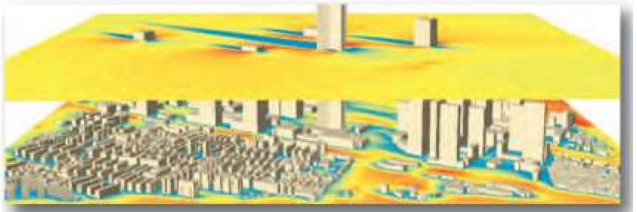
Parallelization

CALPUFF (1 TRAJECTORY) : NO PARALLELIZATION

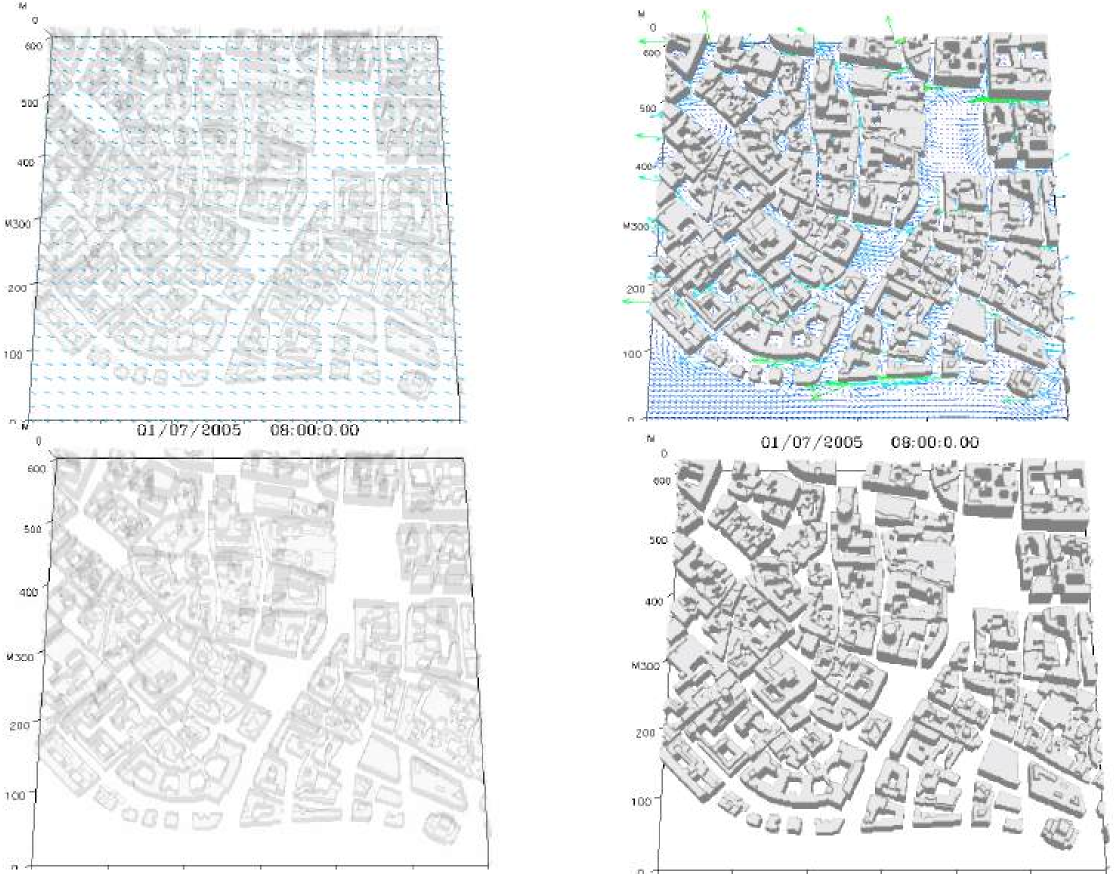
PMSS : EACH PARTICLE FOLLOWS A PATH. TWO WAYS : BY DOMAIN TILE AND SOURCE GROUP

The possibility to parallelize a code allows to push it a very high level and for real time application or massive case study such as a urban domain taking into account street canyons and high resolution.

PMSS CAN REACH VERY HIGH SPATIAL RESOLUTION (< 5 M) AND CONSIDER THE BUILDINGS EFFECT (MICRO SCALE APPLICATIONS), NOT POSSIBLE WITH CALPUFF (RECOMMENDED > 90 M BY EPA).



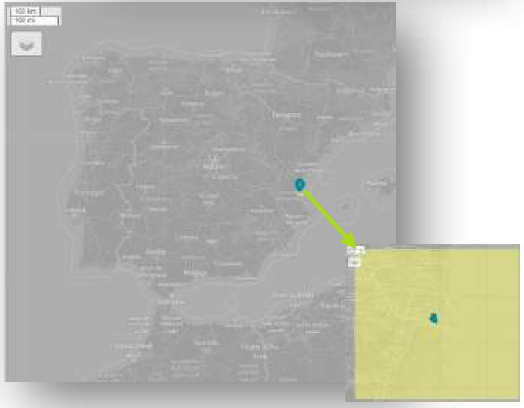
Why do we need microscale models?



Overview of the study

4 models were intercompared for the real study case of a **WWTP in a city - SE Spain**, taking into account point and area emission sources **(> 40 sources, point and areas**):

- Intercompared Models: **PMSS (LPM), GRAL (LPM), CALPUFF (PuM) and AERMOD (Gaussian)**.
- Domain: 20x20 km, **100 m spatial resolution.**
- **Same data input for all models**: Corine Land Use, SRTM topography, meteorological data from WRF.
- Obstacles and building downwash effects **were <u>not</u> considered**.
- Pollutants emitted: **Odor**
- **One month of meteorological data**: (**3 km horizontal resolution / hourly outputs** for April 2024).



Results: Time consumption for the exercise

INPUT DATA (PRE-PROCESSING)

Data	Time spent (hours)		
	Calpuff (Lakes UI)	PMSS	GRAL
Topography	0	1	1
Landuse	0	0,5	0,5
Weather	0,5	4	4
Species	0,1	0,5	0,5
Receptors	0,1	0,1	0,1
Emissions	0,25	0,5	0,5
TOTAL (HOURS)	**0,95**	**6,6**	**6,6**

MODELING

Data	CALPUFF	PMSS	GRAL
Number of processors	1	24	28
Execution time	83h33 min	5h33min	10h43min

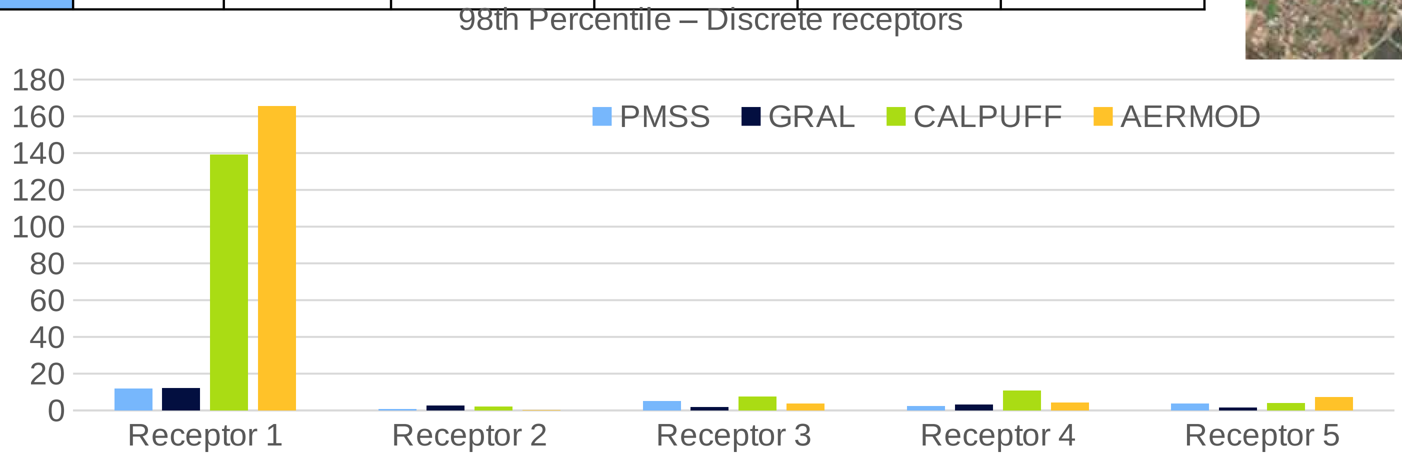
	CALPUFF	PMSS	GRAL
TOTAL	**84h28min**	**13h03min**	17h03min

Best

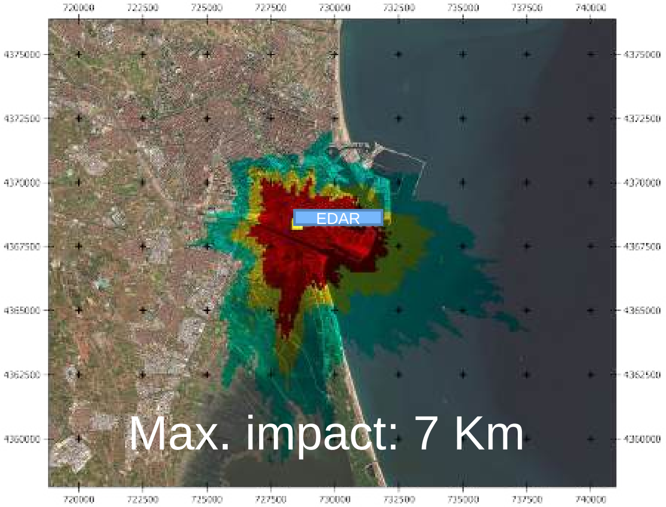
Poorest

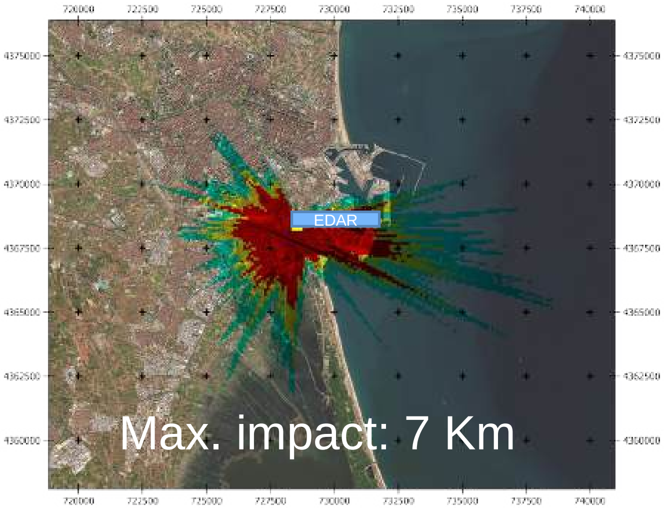
Odour concentration P98 results – Discrete rec

			Odour concentration (uO/m³) – P98			
Point	XPOSIT (km)	YPOSIT (km)	CALPUFF	PMSS	GRAL	AERMOD
Receptor 1	728.85999	4368.2002	**139**	12	12	**165**
Receptor 2	729.70697	4370.33984	2	1	2	0
Receptor 3	727.55103	4369.56006	8	5	2	4
Receptor 4	729.401	4367.16992	11	2	3	4
Receptor 5	727.21899	4367.7002	4	4	1	7



Results


EDAR
Max. impact: 7 Km
CALPUFF MODEL
Legend
P98 Hourly ODOR
uO/m³
<= 1.5
1.5 - 3
3 - 5
> 5


EDAR
Max. impact: 7 Km
AERMOD MODEL
Legend
P98 Hourly ODOR
uO/m³
<= 1.5
1.5 - 3
3 - 5
> 5


EDAR
Max. impact: 3 Km
PMSS MODEL
Legend
P98 Hourly ODOR
uO/m³
<= 1.5
1.5 - 3
3 - 5
> 5


EDAR
Max. impact: 3 Km
GRAL MODEL
Legend
P98 Hourly ODOR
uO/m³
<= 1.5
1.5 - 3
3 - 5
> 5

CONCLUSIONS

Conclusiones

Las similitudes en los resultados entre las soluciones gaussiana y **PuM** (AERMOD/CALPUFF) y **LPM** (PMSS/GRAL) demuestran **una clara diferencia entre ambas soluciones**.

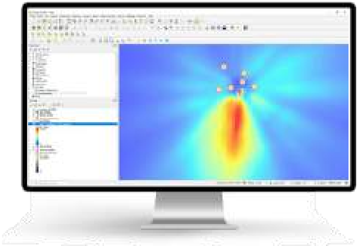
Los PuM tiene una interacción limitada con el terreno para fuentes volumétricas: En el caso de una fuente volumétrica fría a nivel del suelo, **los PuM no muestran prácticamente ninguna interacción con el terreno complejo**. Esto puede llevar **a concentraciones calculadas más altas a largas distancias**.

El PuM puede sobrestimar el impacto en el primer obstáculo: En el caso de una fuente puntual alta y caliente, el PuM tiende a exagerar el impacto en el primer obstáculo significativo que encuentra y a descuidar la presencia de obstáculos posteriores igualmente importantes.

LMP puede considerar los efectos de los edificios (sólo en microescala), determinando de un modo más realista la dispersión.

Se recomienda utilizar modelos de dispersión más avanzados como el LPM al estudiar los impactos atmosféricos a corto y largo plazo de las emisiones de contaminantes del aire fugitivos a nivel del suelo y, en terrenos complejos

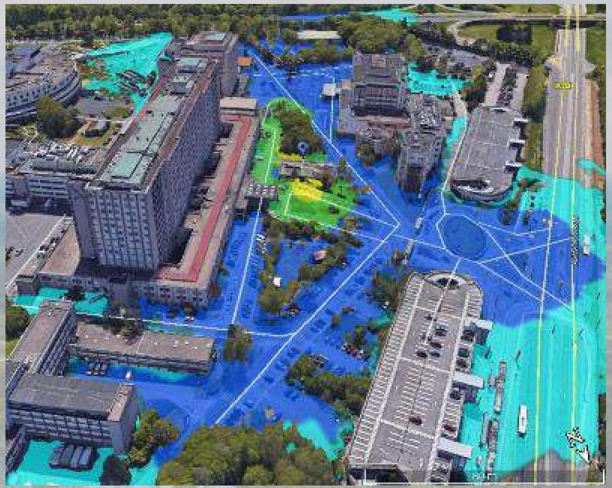
PMSS - Industry

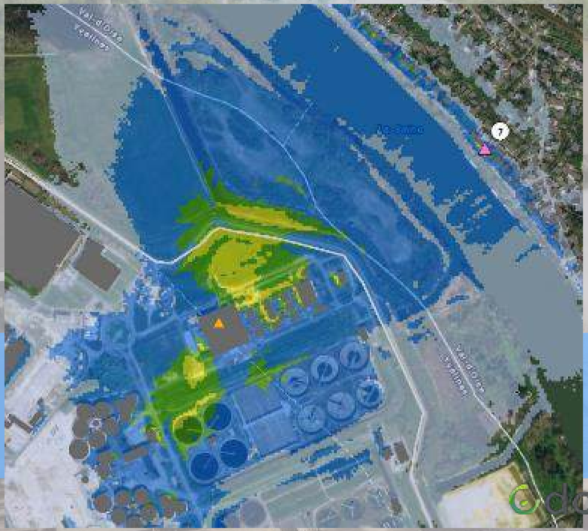


- ✓ Regulatory Compliance Air Quality
- Conducting air quality impact assessments

- ✓ Regulatory Compliance Odors
- Odour impact studies on air quality. Olfactometry Lab 13725

- ✓ Radiological impact study
- Estimating environmental concentrations of radionuclides
- Estimation of effective doses of exposure by irradiation, inhalation and ingestion





AirAdvanced® MAP

MAPPING
of the impact of the industrial site on air quality and health

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THANK YOU!!!

David Cartelle

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