



An attempt to introduce a resuspension model in MELCOR 1.8.6 for fusion applications

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Content of the presentation

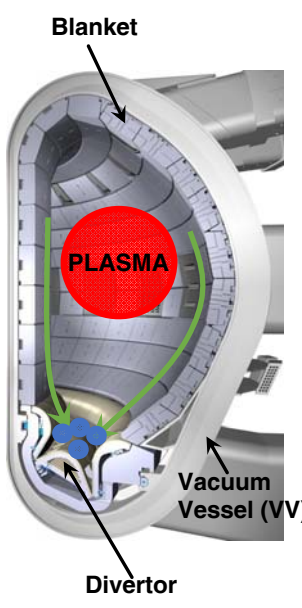


- Introduction – The problem;
- Selection of a resuspension model;
- The “ECART model”;
- Implementation in MELCOR - Limitations;
- Validation;
- Conclusions & Future perspectives.

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Introduction – The problem

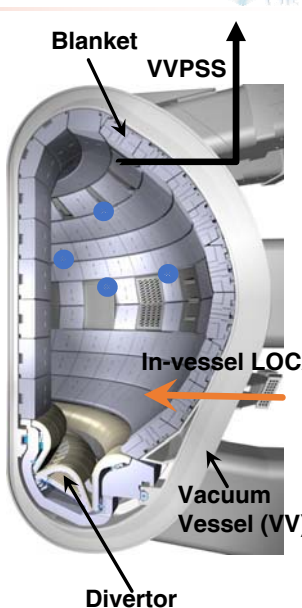
- During normal plasma operation the **erosion** of the "plasma facing components" occurs;
- The **dusts** formed tend to **deposit onto the divertor surface**;
- In case of an **In-vessel LOCA**, these dusts may resuspend;
- **Resuspended dusts may be transported** to the VV Pressure Suppression System (VVPSS);
- Define the **maximum amount of mobilized dust** is an issue of main concern;
- **MELCOR v1.8.6 for fusion applications hasn't a resuspension model**;
- **In MELCOR v2.2 for LWRs a resuspension is implemented (Force Balance Model)**;
- **An attempt to introduce a resuspension model in MELCOR was performed**.



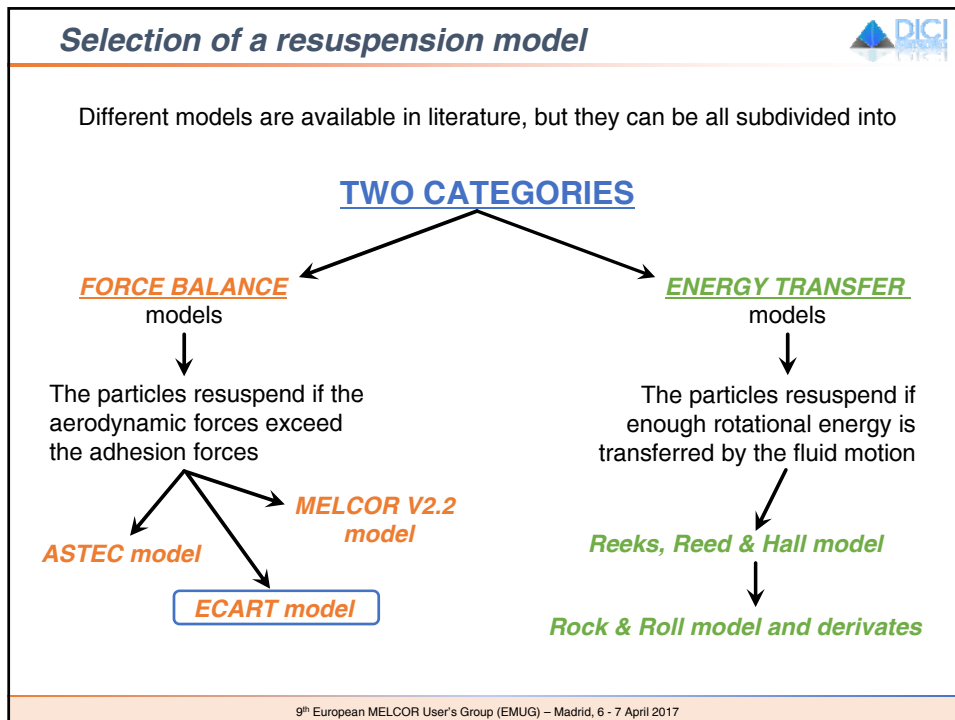
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Introduction – The problem

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The ECART model” DICI

“

- ❖ Why the ECART model?
 - It is **simple**;
 - It was **already validated** for fusion applications.
- ❖ How it works?

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The ECART model

The diagram shows a rough surface with two particles, P₁ and P₂. P₁ is a solid orange circle, and P₂ is a dashed orange circle. A downward arrow from P₁ is labeled F_g. A horizontal arrow from P₁ to P₂ is labeled F_c. A diagonal arrow from P₁ pointing down and to the right is labeled F_a.

Adhesive forces (F_{ad})

F_g	Gravitational
F_c	Cohesive (intermolecular attraction)
F_a	Friction adhesive (sliding and rolling resistance)

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The ECART model

The diagram shows a rough surface with a particle P₁. A flow field with velocity 'm' is shown with green arrows. Blue spirals represent a 'Turbulent burst' above the surface. A 'Laminar sub-layer' is shown below the turbulent burst. A red arrow pointing up from P₁ is labeled F_b. A red arrow pointing right from P₁ is labeled F_a. Green arrows represent drag forces F_d on the surface.

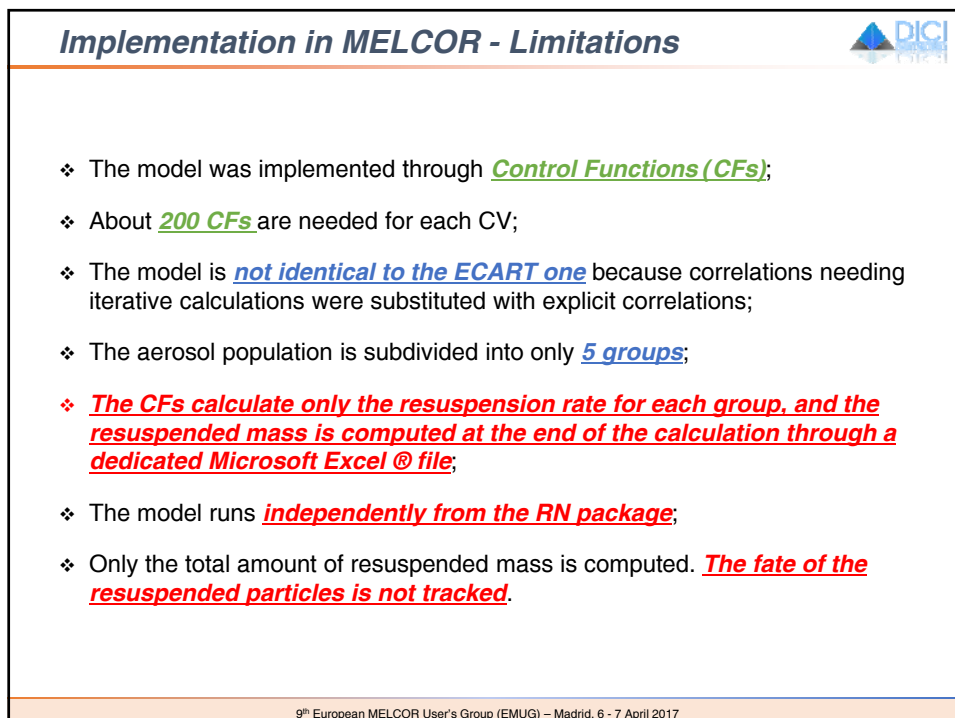
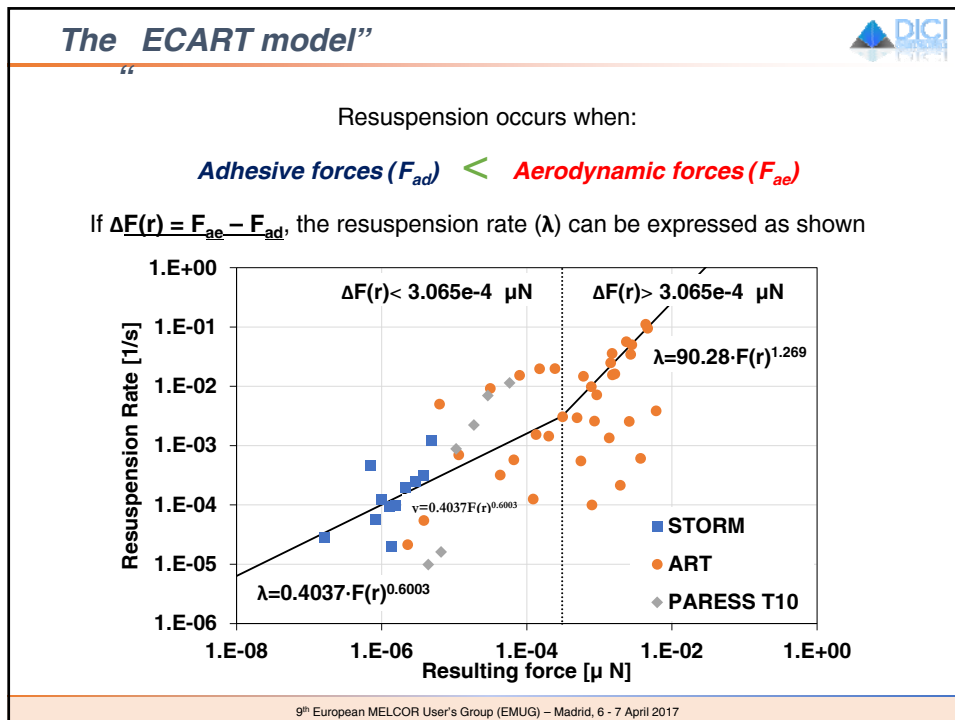
Adhesive forces (F_{ad})

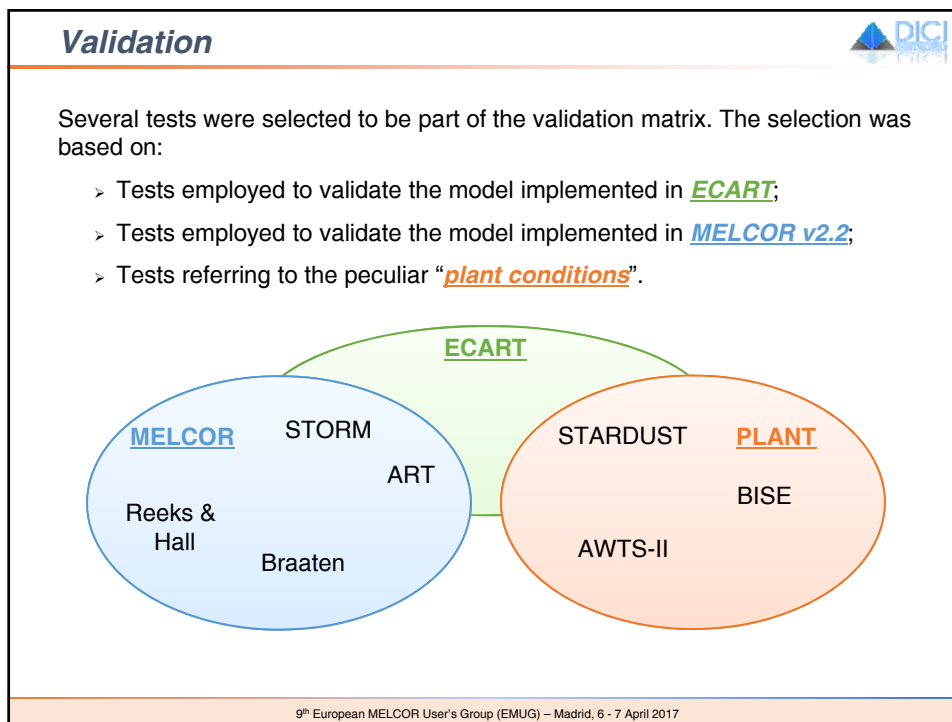
F_g	Gravitational
F_c	Cohesive (intermolecular attraction)
F_a	Friction adhesive (sliding and rolling resistance)


Aerodynamic forces (F_{ae})

F_d	Drag (shear stress on wall)
F_c	Burst (breaking of laminar sub-layer)

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Validation 

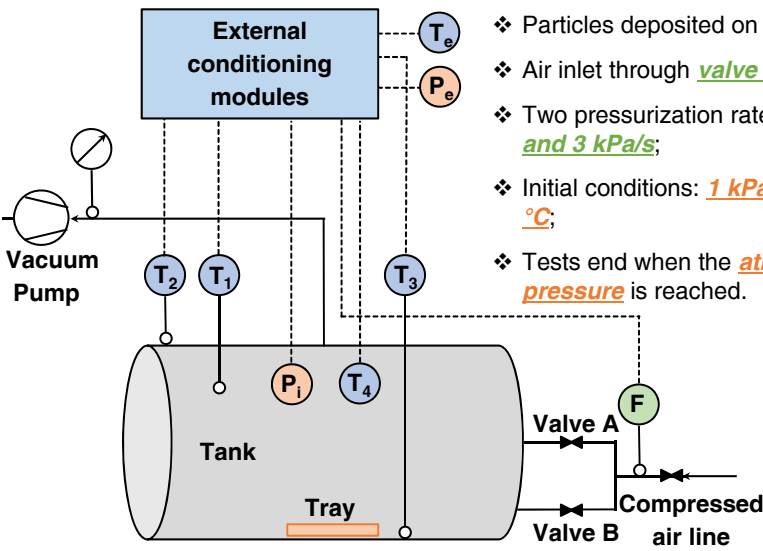
	EC.	MEL.	PL.	N° of tests	Tests characteristics	Ref.
STORM	✓	✓		5	- Atmospheric pressure - Multi-layer deposit	[1] [2] [3]
ART	✓	✓		7	- Atmospheric pressure - Multi-layer deposit	[1] [4]
Reeks & Hall		✓		7	- Atmospheric pressure - Monolayer deposit	[1] [5]
Braaten		✓		141*	- Atmospheric pressure - Monolayer deposit	[1] [5]
STARDUST	✓		✓	41*	- Pressure increasing from 1 kPa to 100 kPa - Multi-layer deposit	[6] [7]
AWTS-II			✓	5	- Pressure below atmospheric one (constant) - Multi-layer deposit	[8]
BISE			✓	30	- Atmospheric pressure - Mono-layer deposit (?)	[9]
TOTAL				236		

* Several tests were executed with the same boundary conditions.

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Validation – STARDUST tests




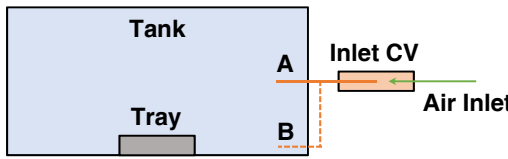


- ❖ *W*, *C*, or *SS* particles;
- ❖ Particles deposited on the *tray*;
- ❖ Air inlet through *valve A or B*;
- ❖ Two pressurization rates: *0.3 kPa/s* and *3 kPa/s*;
- ❖ Initial conditions: *1 kPa* and *110 °C*;
- ❖ Tests end when the *atmospheric pressure* is reached.

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Validation – STARDUST tests






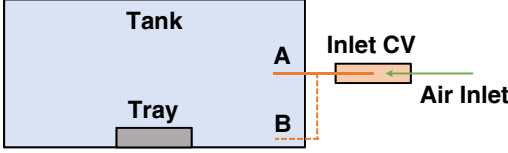
- ❖ *Simple nodalization*;
- ❖ Tank is *adiabatic*;
- ❖ Range of *velocities* impacting the tray calculated through *CFD calculations*;
- ❖ Flow velocity tuned through the *hydraulic diameter of the tank*.

Inlet	Pressurization rate [kPa/s]	Range of velocities impacting the tray [m/s]	Velocities investigated [m/s]
A	0.3	1 – 5	1 – 2.5 – 5
A	3	5 – 10	5 – 7.5 – 10
B	0.3	50 – 100	50 – 75 – 100
B	3	200 – 300	200 – 250 – 300

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Validation – STARDUST tests






- ❖ **Simple nodalization;**
- ❖ Tank is *adiabatic*;
- ❖ Range of *velocities* impacting the tray calculated through *CFD calculations*;
- ❖ Flow velocity tuned through the *hydraulic diameter*.

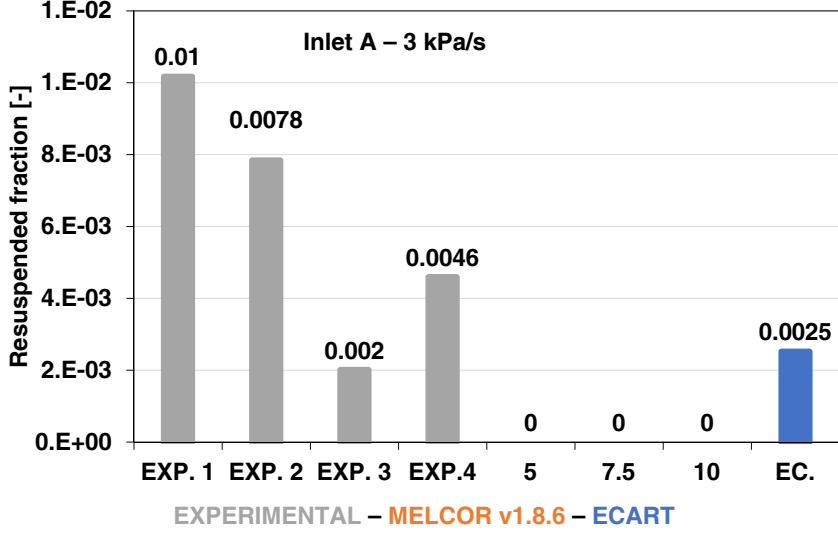
Group	GMD [m]	W mass distribution
1	2.15e-7	0.009
2	3.22e-7	0.104
3	4.30e-7	0.257
4	5.37e-7	0.329
5	6.45e-7	0.300

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Validation – STARDUST tests



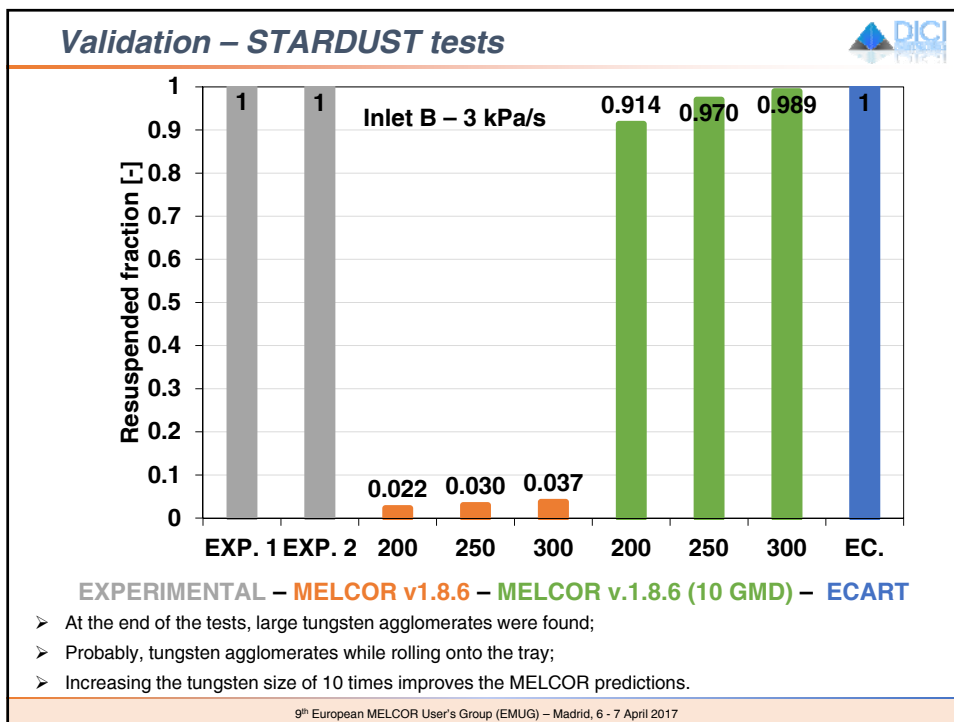
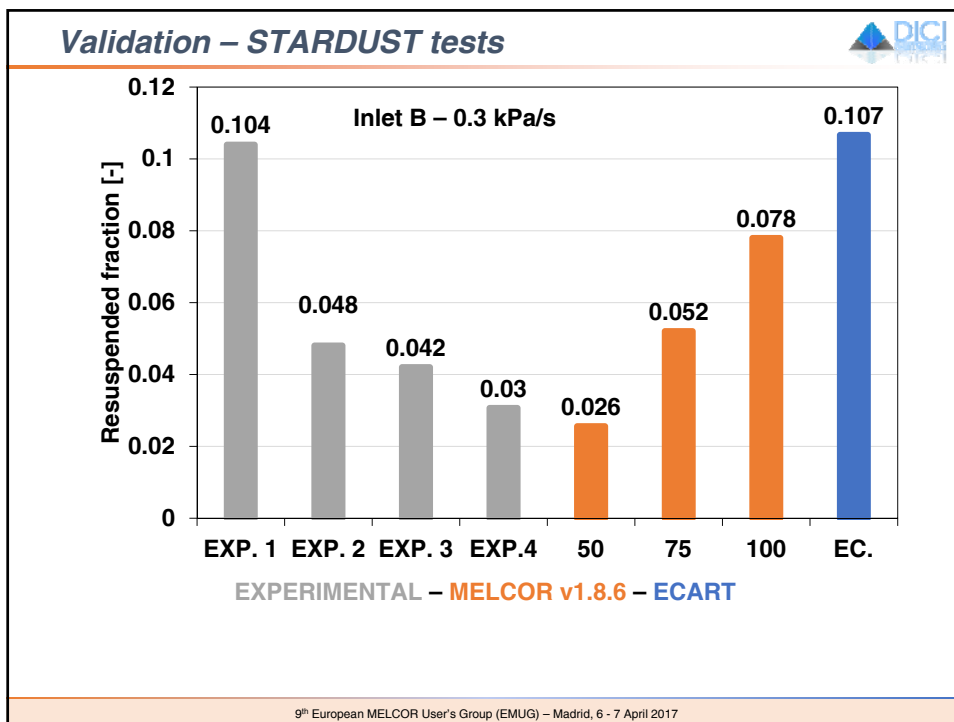
Inlet A – 3 kPa/s



Experiment	Resuspended fraction [-]
EXP. 1	0.01
EXP. 2	0.0078
EXP. 3	0.002
EXP. 4	0.0046
5	0
7.5	0
10	0
EC.	0.0025

EXPERIMENTAL – MELCOR v1.8.6 – ECART

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Conclusions & Future perspectives



- ❖ An attempt to introduce a resuspension model in MELCOR 1.8.6 for fusion applications was shown;
- ❖ The model was derived from the model implemented in the ECART code;
- ❖ The model was implemented by mean of CFs;
- ❖ Small variations were introduced to avoid iterative calculations;
- ❖ The model was validated against several tests;
- ❖ For the STARDUST tests, the model showed a good agreement with the experimental data if only more than the 5% of initial mass is resuspended;
- ❖ For almost all the other validation tests, the model showed conservative estimations.

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Conclusions & Future perspectives



- ❖ Improve the model:
 - Reduce the CFs needed. Some CFs are now employed for diagnostic purposes;
 - Introduce an agglomeration model in function of the “Drag-Burst forces” ratio;
 - Increase the aerosol groups number to 10 (instead of 5);
 - Create CFs for the calculation of the resuspended mass (avoid Microsoft Excel ® file);
 - Coupling with the RN package: Inject the resuspended mass during the time step Δt_n as an aerosol source during the time step Δt_{n+1} ;
 - If needed, further expand the validation matrix.

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