INSTITUTO DE DEFESA QBRN

SnT 2019

CTBT: SCIENCE AND TECHNOLOGY CONFERENCE

Cap QEM Carlos Eduardo Santos BONFIM
Brazilian Army - IDQBRN

24 June 2019

CAMPUS

IDQBRN- Instituto de Defesa Química, Biológica, Radiológica e Nuclear *(Chemical, Biological, Radiological and Nuclear Defense Institute)*

Fig. 2. Chemical, Biological, Radiological and Nuclear Defense Institute.

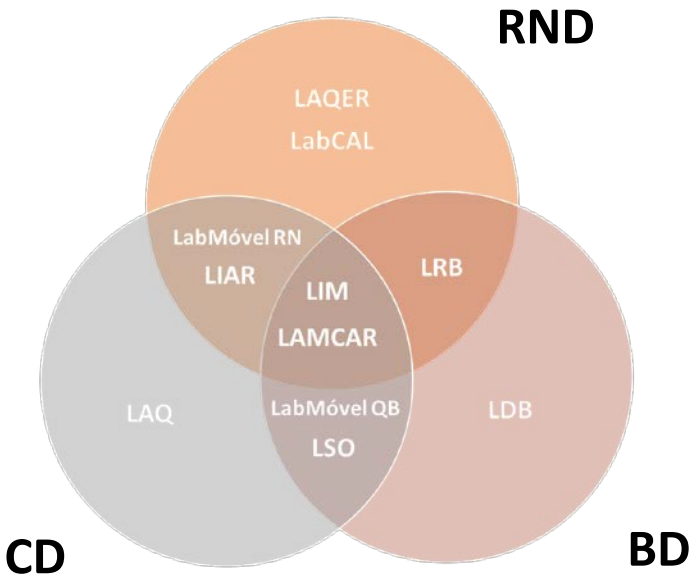
LOCALIZATION

CTEx- Centro Tecnológico do Exército *(Brazilian Technological Army Center)*

Fig. 1. Brazilian Technological Army Center and IDQBRN.

OBJECTIVE

- **Research and development of Defense Products in the area of CBRN defense.**



CD	BD	RND
Chemical Analysis Laboratory	Biological Defence Laboratory	Radiobiology Laboratory
Organic Sysnthesis Laboratory		Irradiation of Materials Laboratory
Chemical and Biological Mobile Laboratory		Identification of Radiological Agents Laboratory
Consequence Modeling and Risk Analysis Laboratory		Calibration of Radiation Monitors Laboratory
		Quality Verification of Radiological Equipment Laboratory
		Radiological and Nuclear Mobile Laboratory

OBJECTIVE

- Application of Computational Fluid Dynamic in the atmospheric dispersion of radionuclides at Fukushima disaster.

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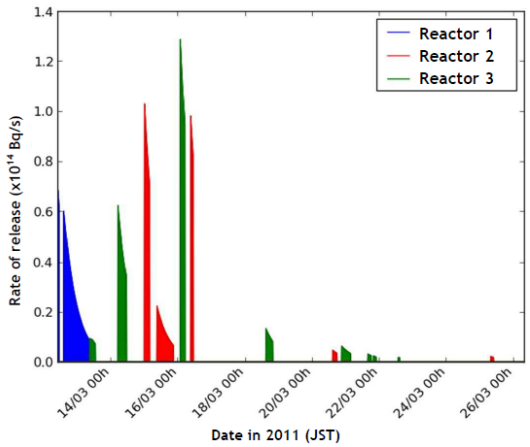
Brazilian Army Institute of Chemical, Biological, Radiological and Nuclear Defense (IDQBRN)

FUKUSHIMA DISASTER

Fig. 3. Nuclear Meltodown Disaster, BBC Documentary

Fig. 4. Nuclear Meltodown Disaster, BBC Documentary

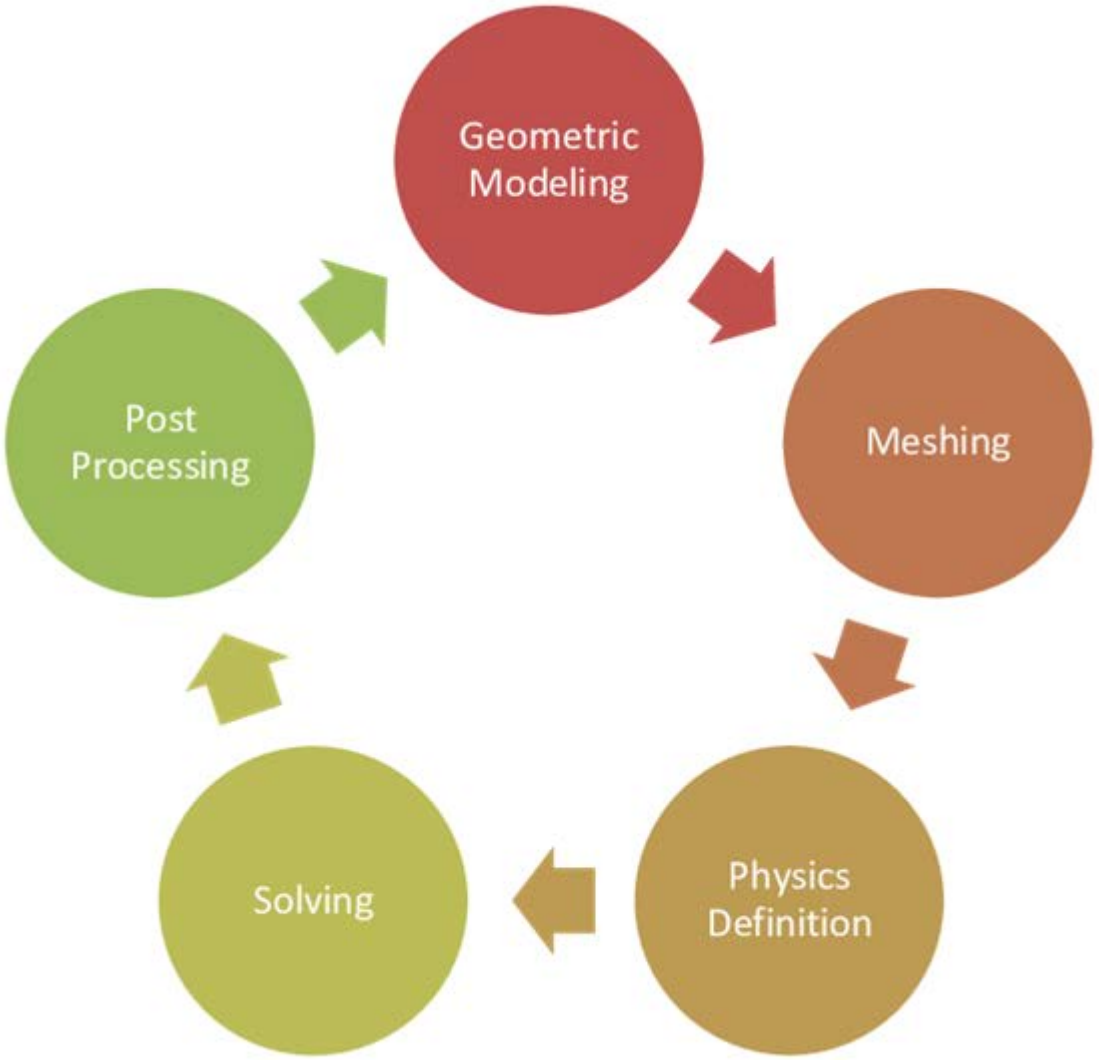
Fig. 5. Understanding the accident of Fukushima Daiichi - Documentary
Institut de Radioprotection et de Sûreté Nucléaire - IRSN



Change in the rate of release per reactor for all radionuclides released into the atmosphere during the Fukushima accident (in blue: reactor 1; in red: reactor 2; in green: reactor 3).

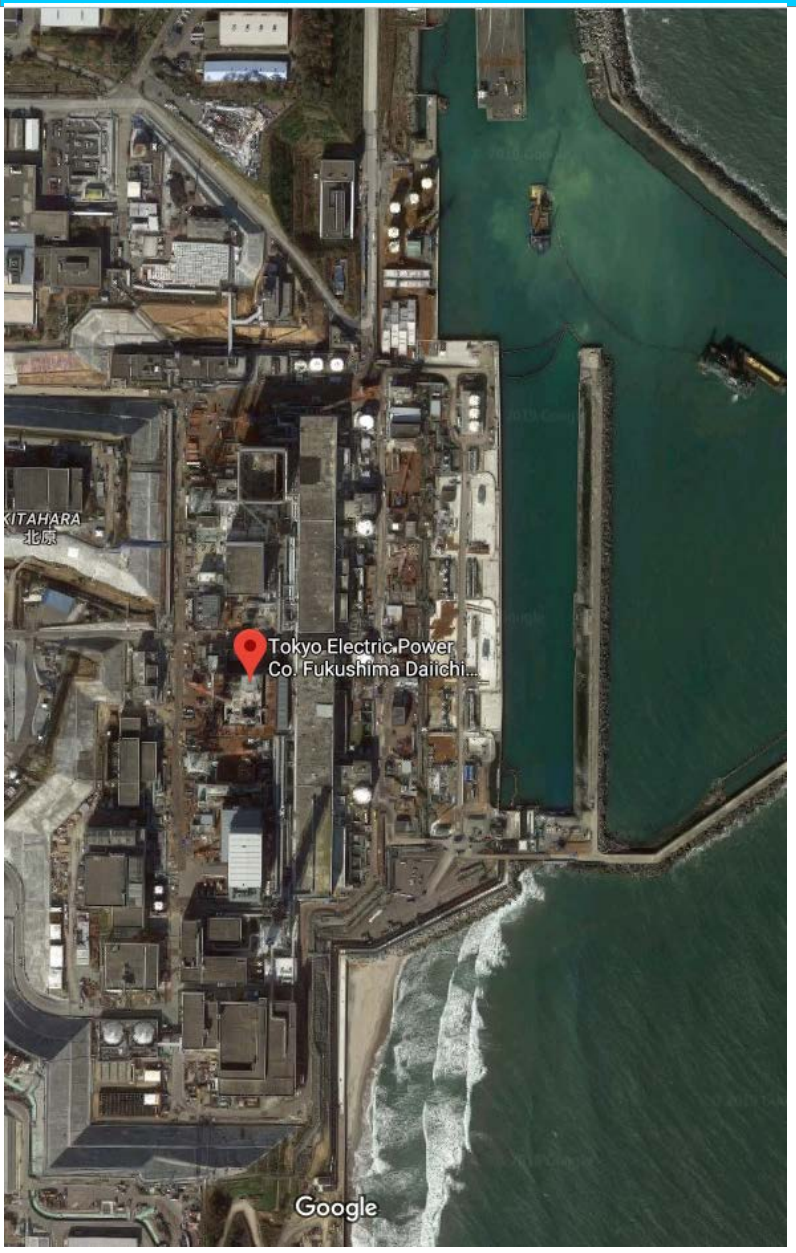
Fig. 6. Summary of the Fukushima accident's impact on the environment in Japan, one year after the accident

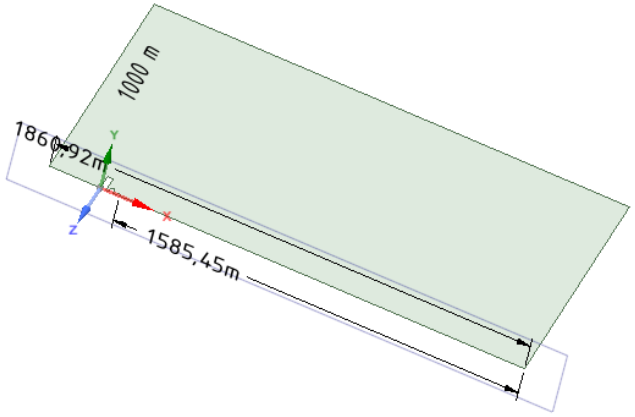
COMPUTATIONAL FLUID DYNAMICS (CFD)



CFD Steps

GEOMETRIC MODELING





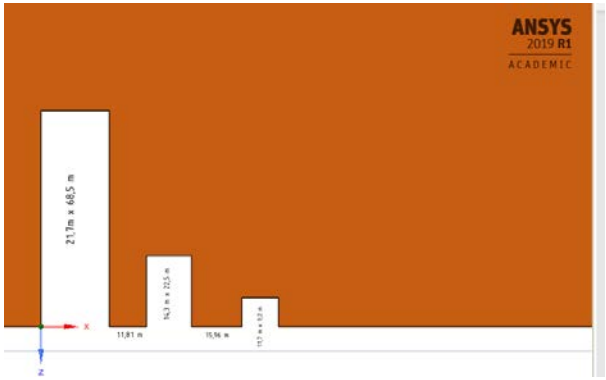
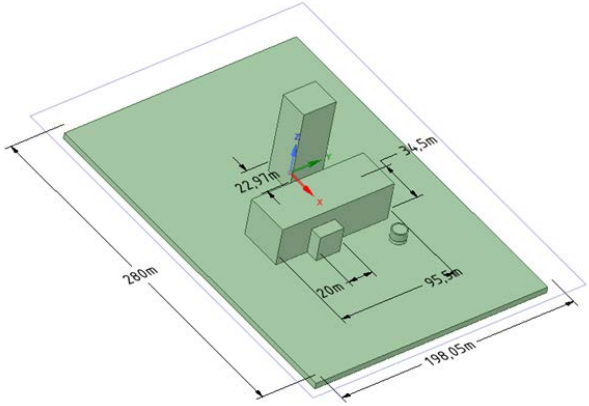


Fig. 7. 2D Geometry with obstacles.



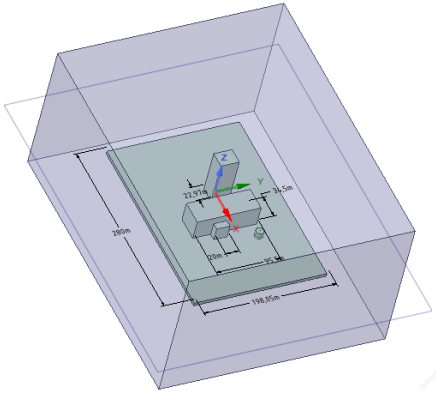


Fig. 8. 3D Geometry with obstacles.

MESHING

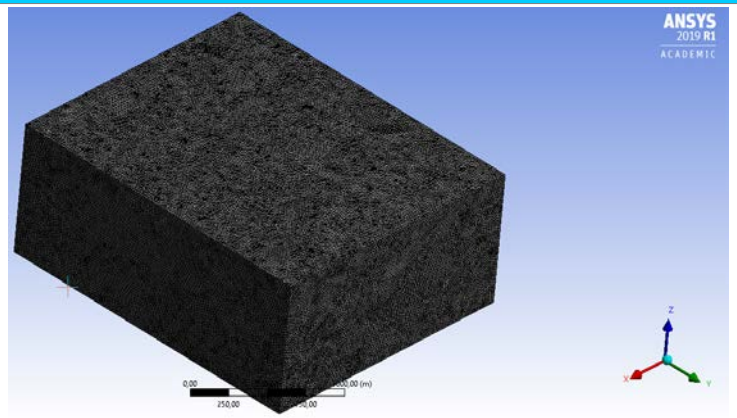


Fig. 9. Enclosure Mesh (7052350 elements).

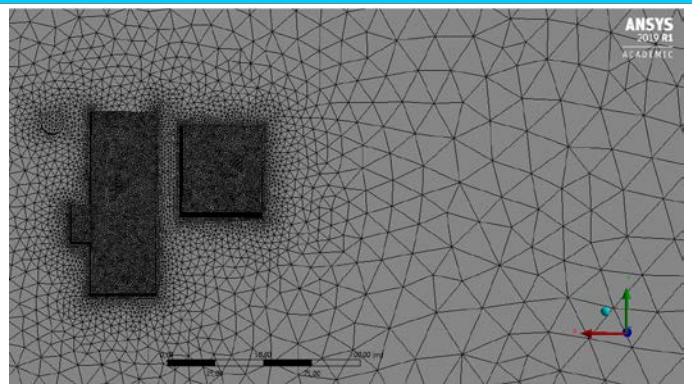


Fig. 10. Plant Mesh.

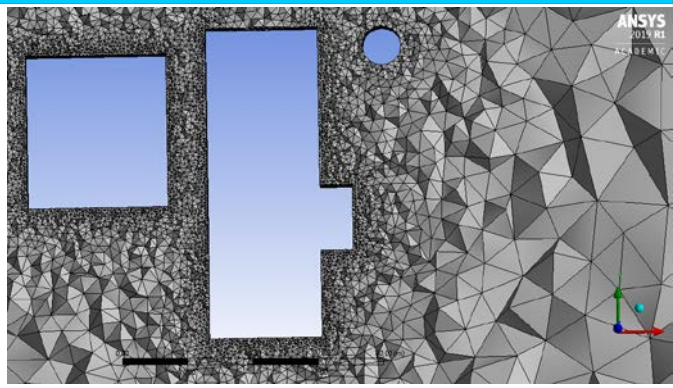


Fig. 11. Plant Mesh recort.

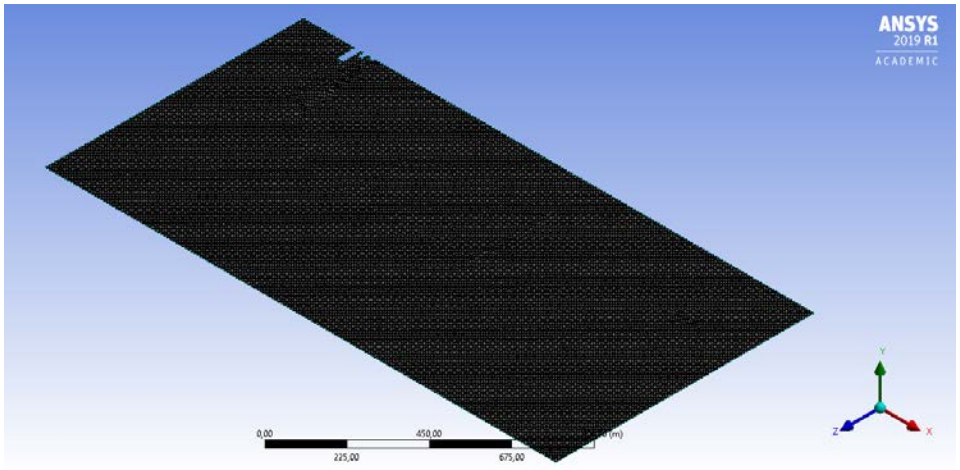


Fig. 12. 2D Mesh Isometric view (123391 elements).

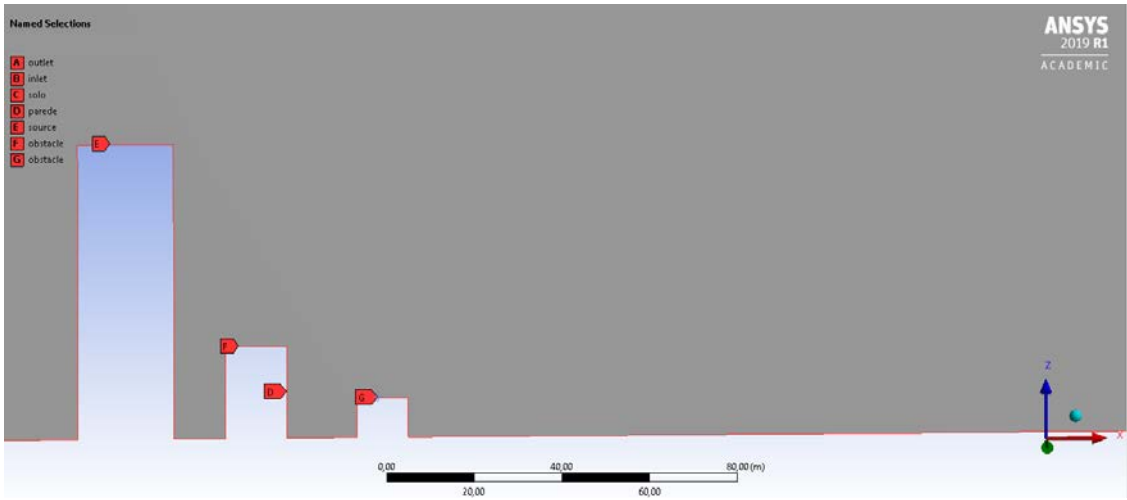


Fig. 13. Named Selection.

PHYSICS DEFINITION

Mesh	**Nodes**	**124158**
	Elements	123937
	Ortoghonal Quality	0.897
Dominium	Fluid	Air at 5º C
	Heat transfer	Energy On
	Turbulence Model	κ - ε
	Rate grothw	1,2
	Kinetic Diffusivity (m^2/s)	10^{-5}
Wind Boundary Condition	Normal velocity	4.3
	Turbulence	5%
Rate Radionuclide	Mass flow inlet rate (Bq/s)	0.6e+15
	Turbulence	5%
Enclosure or Atmpospheric Boundary	Type	Open
	Pressure relative (Pa)	0
Solution Control	Solution	First Order
	RMS	10^{-4}

Tab 1. Boundary condition.

- Validation that was done using the experiment. (BRUSCA et all, 2016)

POST PROCESSING: RESULTS

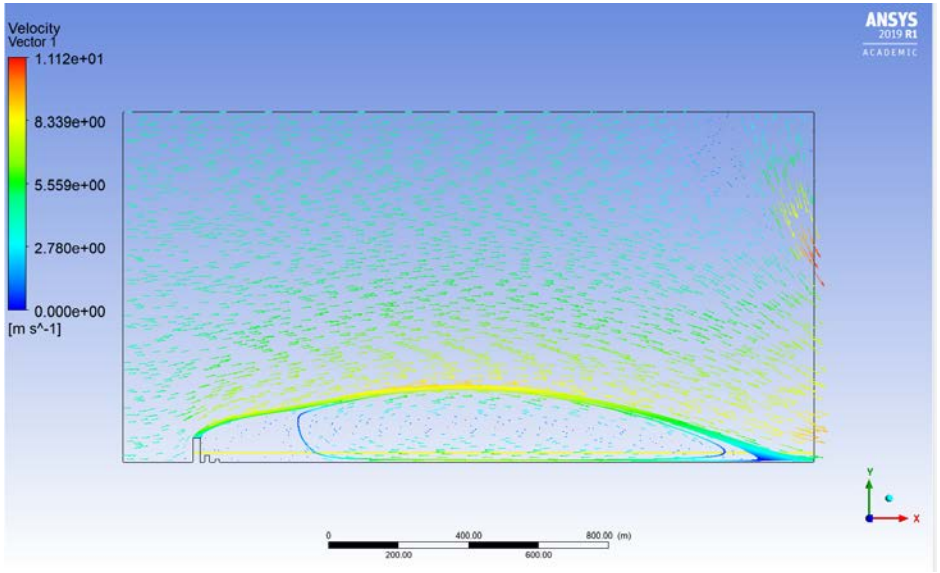


Fig. 14: Air flow velocity around a building, showing the recirculation zone.

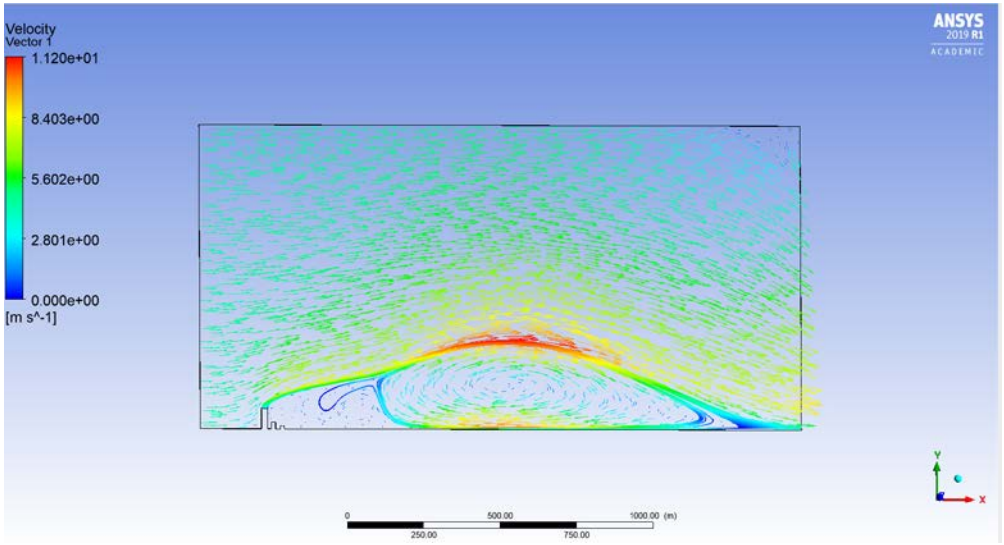


Fig. 15: Transport of radionuclides released to the atmosphere.

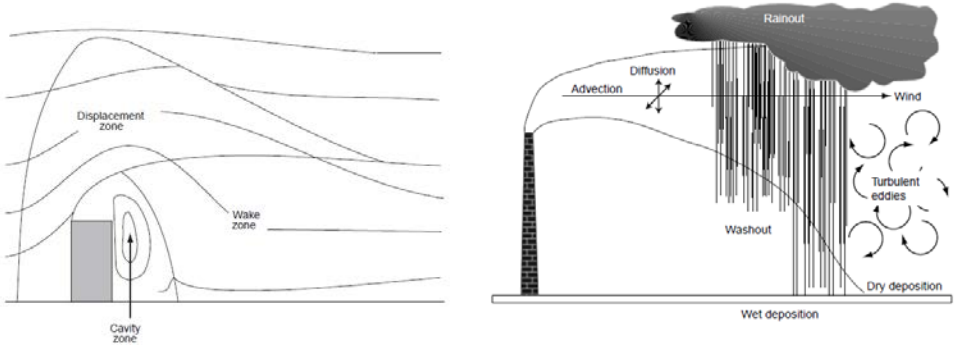


Fig. 16: Air flow aroud a building, showing the three main zones of flow.

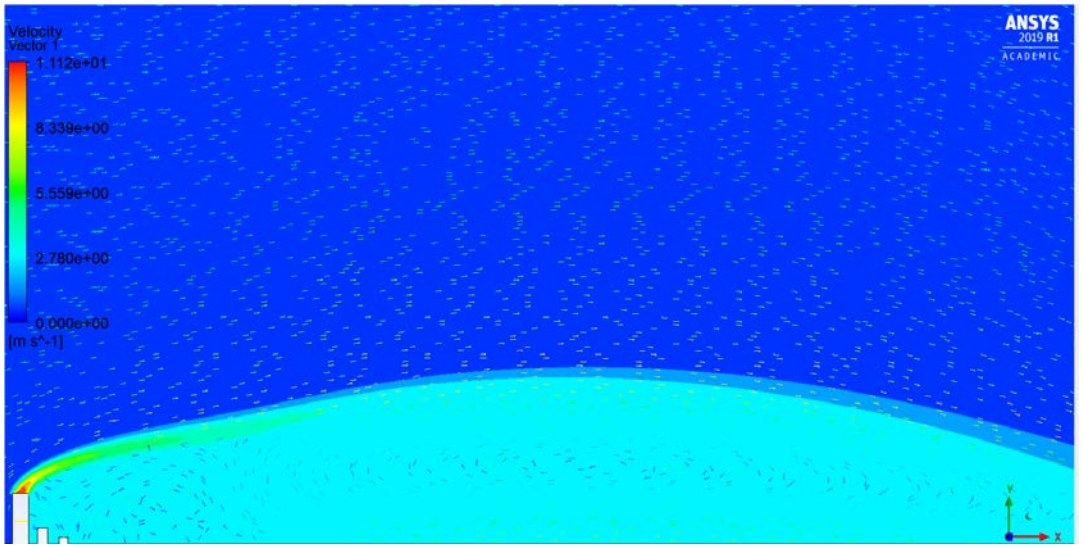


Fig. 17: Air flow velocity around a building, showing the vortex zone.

POST PROCESSING: RESULTS

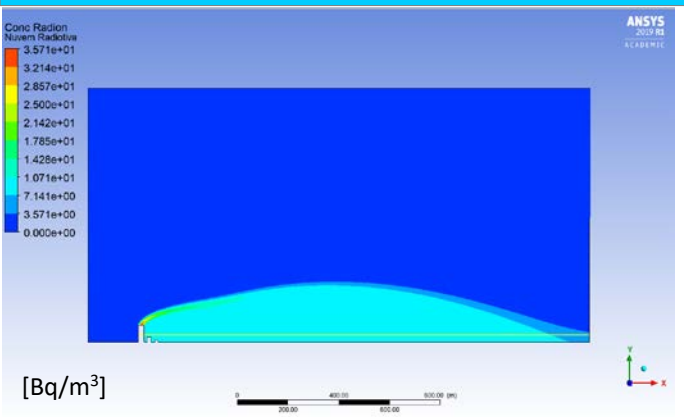


Fig. 18. Radiological cloud.

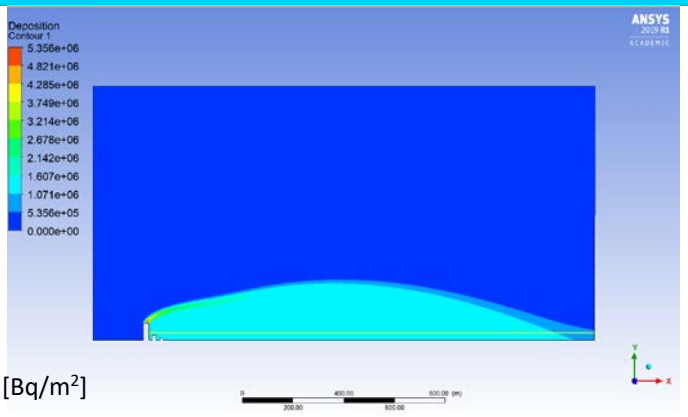


Fig. 19. Radiological cloud ground deposition.

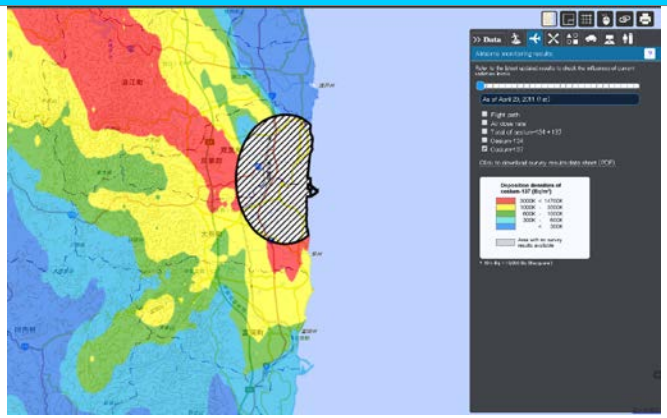


Fig. 20. Deposition densities of Cs-137 (Bq/m^2).

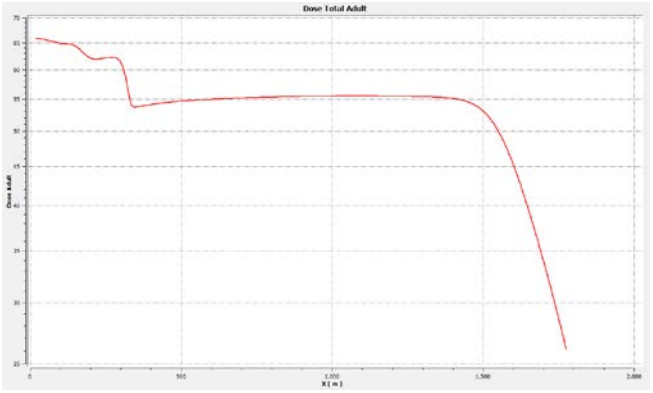


Fig. 21. Level dose for intants.

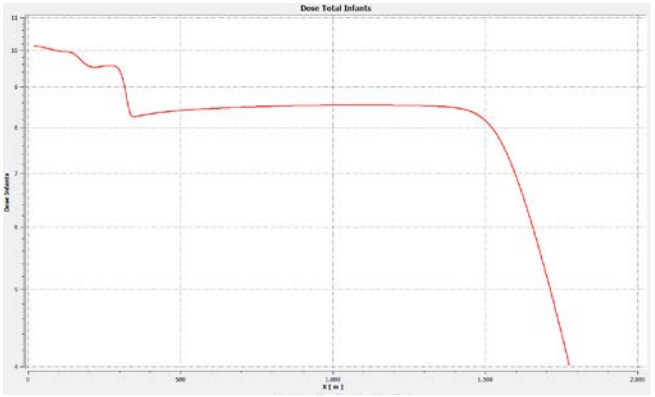


Fig. 22. Level dose for adults.

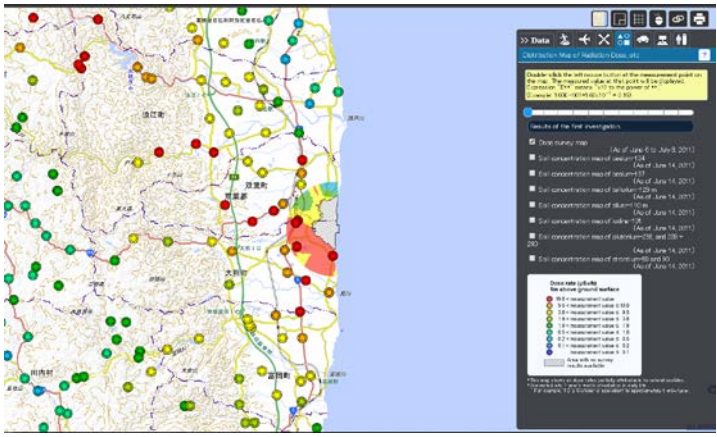


Fig. 23. Level dose for adults.

CONCLUSION

- The use of CFD for the calculation of the atmospheric dispersion allowed a more realistic simulation of the land conditions.
- Featured a greater accuracy than the Gaussian model.
- Brief comparison between the models:

Models	Deposition Cesium 137 Value (KBq/m^2)	Dose
CFD obstacle	5356	65μSv/h
Gaussian Plume without obstacle	3000<x<14700	>19μSv/h

Tab. 2. Comparison between models.

- Future implementations:
  - use of other turbulence models;
  - evaluation of other atmospheric dispersion;
  - study of radionuclide transport in surface waters;
  - study of 3D models using super computers;
  - application in Angra dos Reis Plant;

REFERENCE

- AIEA, Generic Models for Use in Assessing the Impact of Discharges of Radioactive Substances to the Environment, Safety Report Series No.19, Vienna, Austria, 2001.
- Brusca, S., Famoso, F., Lanzafame, R., Mauro, S., Messina, M., & Strano, S. (2016). *PM10 Dispersion Modeling by Means of CFD 3D and Eulerian–Lagrangian Models: Analysis and Comparison with Experiments. Energy Procedia, 101, 329–336.*
- Duarte, Juliana P. – Dispersão atmosférica de radionuclídeos e cálculo de dose devido a queda de embalados de baixo e médino nível de radiação, projeto de graduação em Engenharia Nuclear, UFRJ, Rio de Janeiro, 2013
- CNEN, Coeficientes de Dose para Exposição do Público, Posição Regulatória 3.01/011, Rio de Janeiro, Brasil, 2011.
- CNEN, Diretrizes Básicas de Proteção Radiológica, CNEN-NE-3.01, Rio de Janeiro, Brasil, 2005.
- NRC (US Nuclear Regulatory Commission), Atmospheric Dispersion Models for Potential Accident Consequence Assessments at Nuclear Power Plants, Regulatory Guide 1.145, Washington, EUA, 1983.
- Tokyo Electric Power Company, Inc. , Fukushima Nuclear Accidents, Investigation Report ,2012.
- Tokyo Electric Power Company, Inc. ,Fukushima Nuclear Accident Analysis Report ,2012.
- The CTBTO web Portal, User guide. Available in <https://access.ctbto.org/portal/documents/user_manual.pdf> . Access in 03 fev. 2019
- Secure Web Portal (CTBTO). Available in < https://access.ctbto.org/portal/index.html>. Last access in 10 jun. 2019
- Extension Site of Distribution Map of Radiation Dose. Available in < https://ramap.jmc.or.jp/> Last access in 11 jun. 2019
- Institut de Radioprotection Et de Sûreté Nucléaire. Available in https://www.irsn.fr/FR/Pages/Home.aspx Last access in 10 jun. 2019


Obrigado!
Thank you
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