



MACCS Relocation Evaluations for Emergency Preparedness Purposes

Nazarena Lavate, Cristóbal Mulleady and Marcelo Caputo

Nuclear Safety Laboratory – Nuclear Safety Department

Centro Atómico Bariloche – CNEA – Argentina

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- Research Scope and Framework
- Emergency Planning Zones
- MACCS Early Phase Protective Actions
- MACCS Relocation general aspects
- Research Motivation and Objective
- Case Study
- Input Data
- Analysis Tool
- Preliminary Results
- Final Remarks



Research Scope and Framework

- **Scope:**
 - **Research and Exploratory purposes.**
 - **Gain more understanding of MACCS code capabilities.**
- **Framework:**
 - **Emergency Preparedness and Protective Actions Recommendations**
 - **Emergency Planning Zones sizing**
 - **Off-Site Consequences Analysis**
 - **Licensing process.**

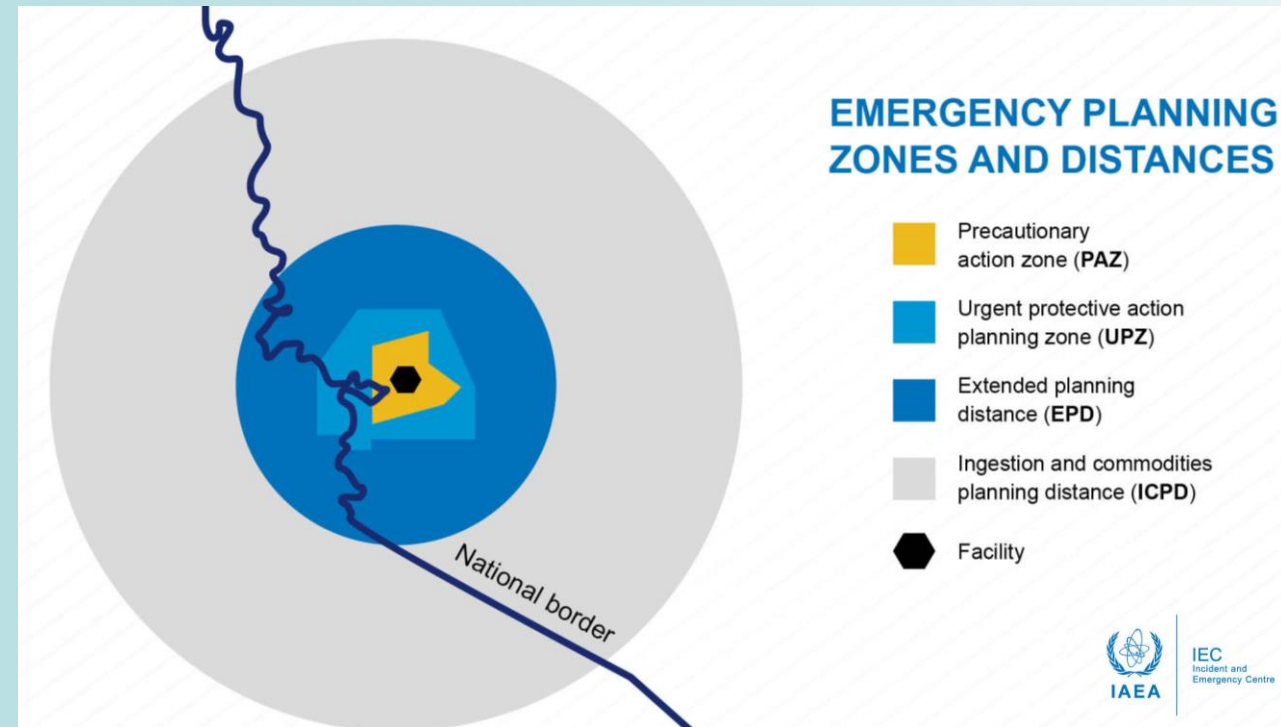


Emergency Planning Zones

- **Emergency Planning Zone (EPZ)**
- **Precautionary Action Zone (PAZ)**
 - ☐ urgent protective actions in order to avoid or to minimize severe deterministic health effects.
- **Urgent Protective Actions Planning Zone (UPZ)**
 - ☐ urgent protective actions in order to reduce as much as possible and justified the risk of stochastic health effects.

$$\text{EPZ} = \text{PAZ} + \text{UPZ}$$

- **Extended Planning Distance (EPD):**
 - ☐ monitoring and assessment of the radiological situation in order to identify areas, within a period of time that would allow the risk of stochastic effects in the areas to be effectively reduced by taking protective actions following a significant radioactive release

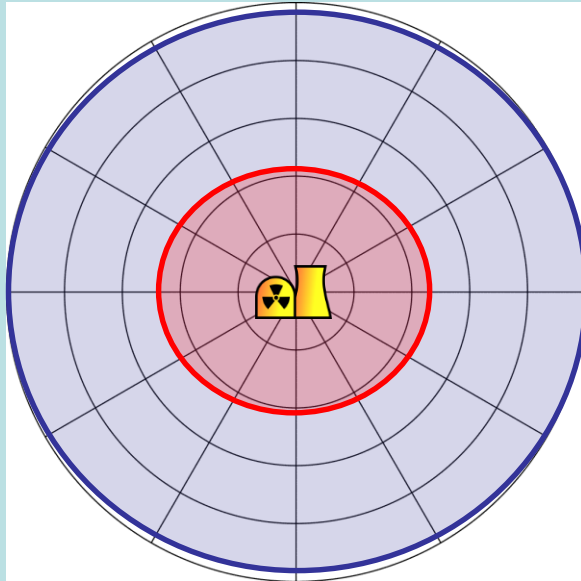


EPR-NPP PUBLIC PROTECTIVE ACTIONS (IAEA – 2013)



MACCS Early Phase Protective Actions

- **Protective actions modeled by MACCS for the Early Phase of the emergency**



■ Shelter/Evacuation Zone:

- RFPNT = Alarm or Plume Arrival.
- Delay to take actions
- Adjusted Shielding Factors
- Adjusted Evacuation velocities

■ Relocation Zone:

- RFPNT = Plume Arrival
- Dose dependent action
- Hot Spot and Normal

- **MACCS early phase relocation model is consistent with an expanded evacuation of areas exceeding a dose criteria beyond the initial evacuation zone.**



MACCS Relocation general aspects

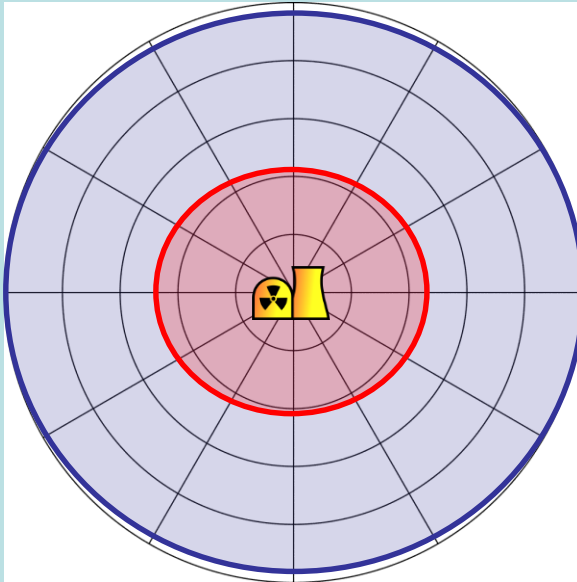
- **Population Relocation is a post-accident protective measure designed to limit radiation exposure from radionuclides deposited on the ground.**
- **The determination of areas requiring relocation would likely be based on dose projections by computer modeling coupled with field measurements.**
- **Relocation would be an informed decision, so it can be implemented in a more selective manner than an immediate evacuation.**
- **Depending on the release characteristics, terrain, weather, and other conditions, some areas could have higher dose rates than the surrounding areas, areas referred to as Hotspots.**
- **Relocation is simulated by MACCS as an expanded evacuation based on dose projections for two alternatives: Normal relocation and Hotspot relocation.**
- **Exposure pathways considered for relocation evaluations are Cloudshine and Inhalation doses during plume passage and projected Groundshine dose and Resuspension inhalation for the duration of the emergency phase.**



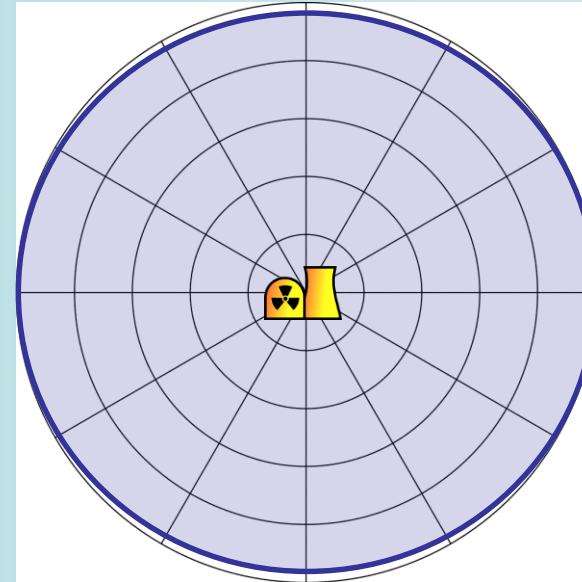
Motivation and Objective

- **Motivation - SMR features regarding EPZ:**
 - **Smaller core radioactive inventory**
 - **More heat transfer per unit heat generation**
 - **Passive Safety Systems**
 - **Slow accident progression**
 - **Lower frequencies of release (LERF)**
 - **Smaller magnitudes of release**
 - **Delay on the releases**
- **Potential reduce of EPZ with benefits such as:**
 - **Sittings closer to populated areas**
 - **Decreased cost of maintaining emergency preparedness**

- **Objective:**
 - **Based on the SMR features regarding EPZ, and in the face of a potential reduction of the EPZ, we postulated an scenario without the need to take immediate evacuation as a protective action. Therefore, the objective of the present work is to analyze the hypothetical scenario where Relocation is the only protective action in place.**



- **Shelter/Evacuation + Relocation**



- **Relocation only**



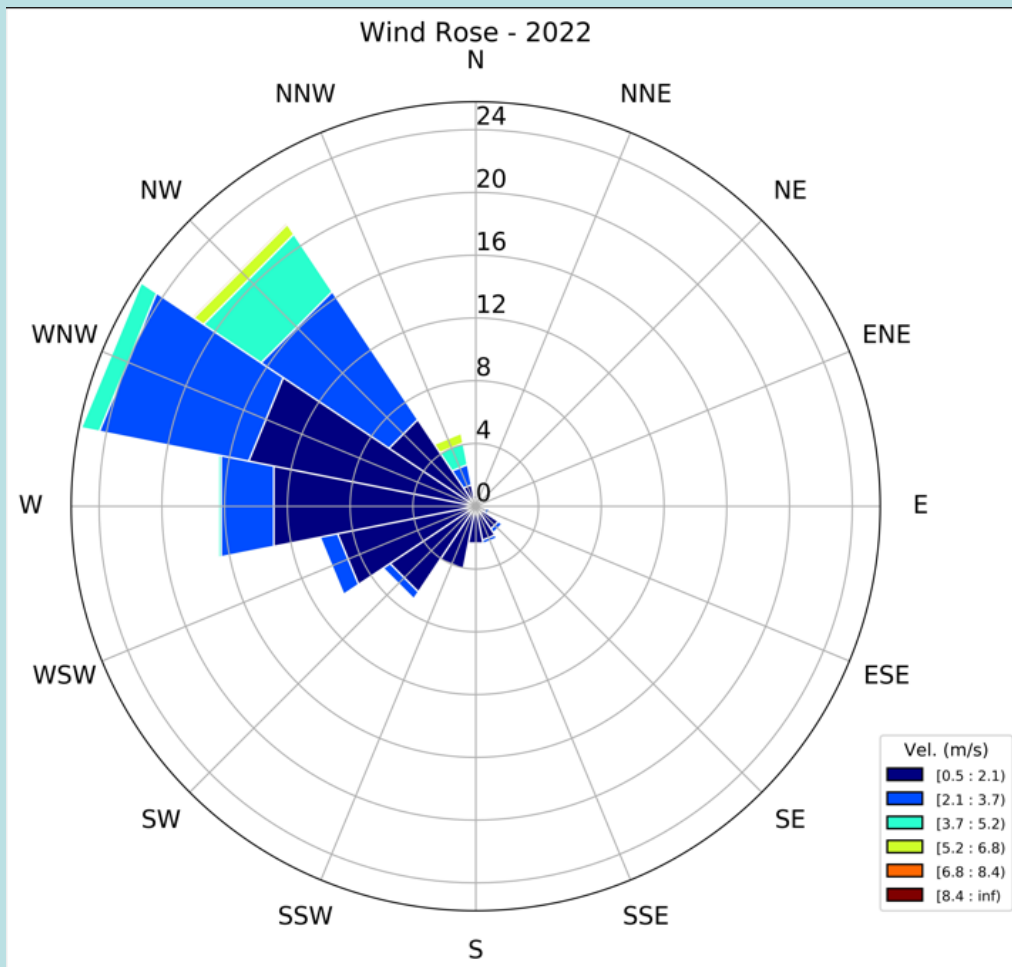
Case Study

- **MACCS input parameters from SOARCA Project Vol. 2 Surry Integrated Analysis.**
- **Source Term: Short Term Station Black Out**
 - **Delay from shutdown: ~ 25 hs**
 - **Release duration: ~ 24 hs**
 - **Release height: 8.4 m**
 - **Core Inventory: Downscaled to a factor of 0.12**
- **Consequence Analysis**
 - **Scope: Early Consequences (EARLY Module)**
 - **Effective Dose: Cloudshine + Inhalation + Groundshine + Resuspension Inhalation**
 - **Dose Conversion Factors: FGR-13**
 - **Critical organ: L-ICRP60ED**
- **Protective actions**
 - **NO Evacuation, only Relocation**
 - **Shielding factors for normal activity**

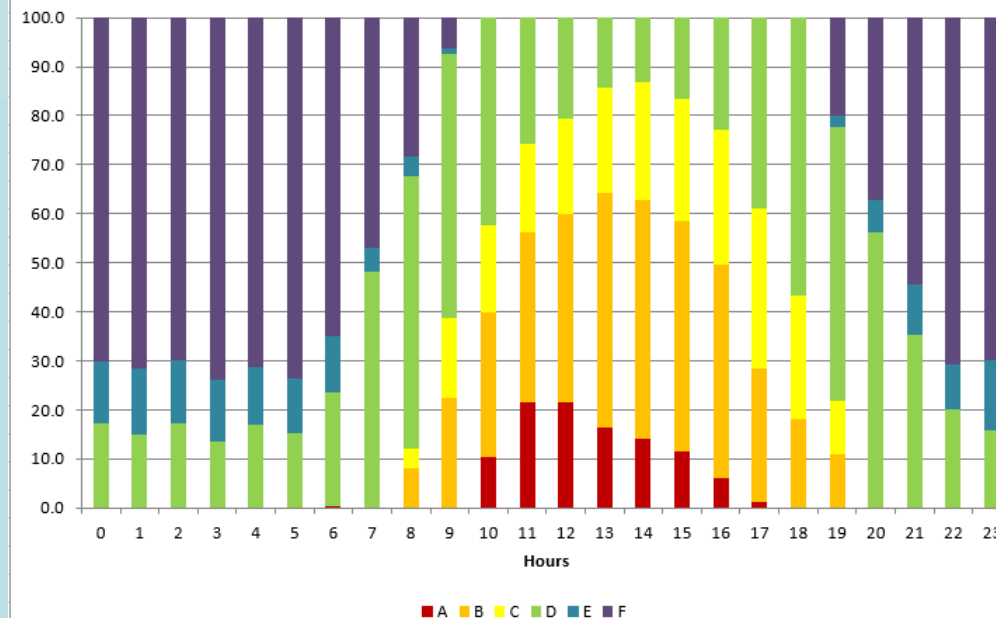


Input Data

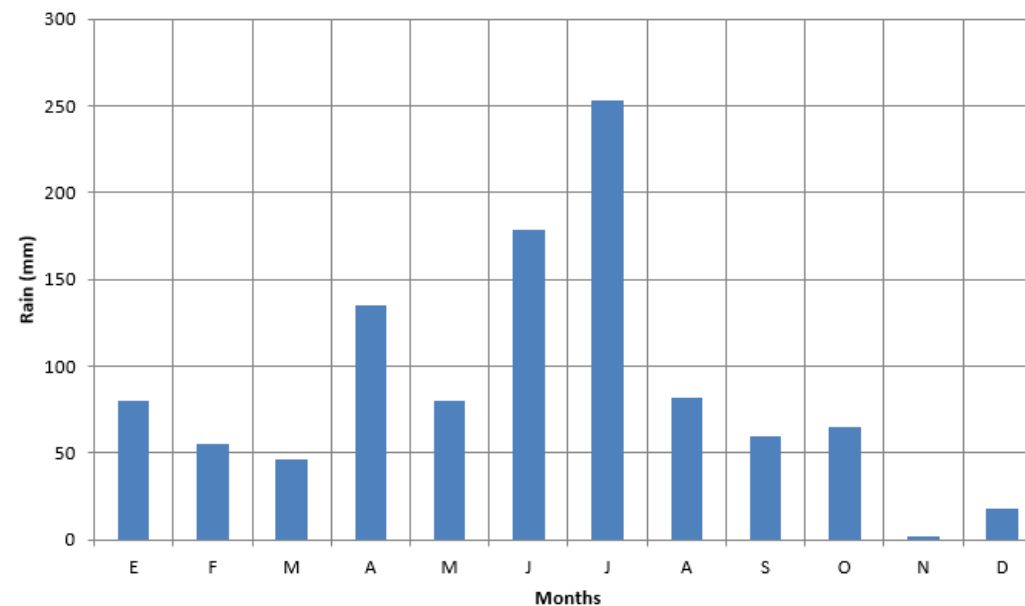
- Met Data:



Pasquill Stability Classes



Monthly rainfall



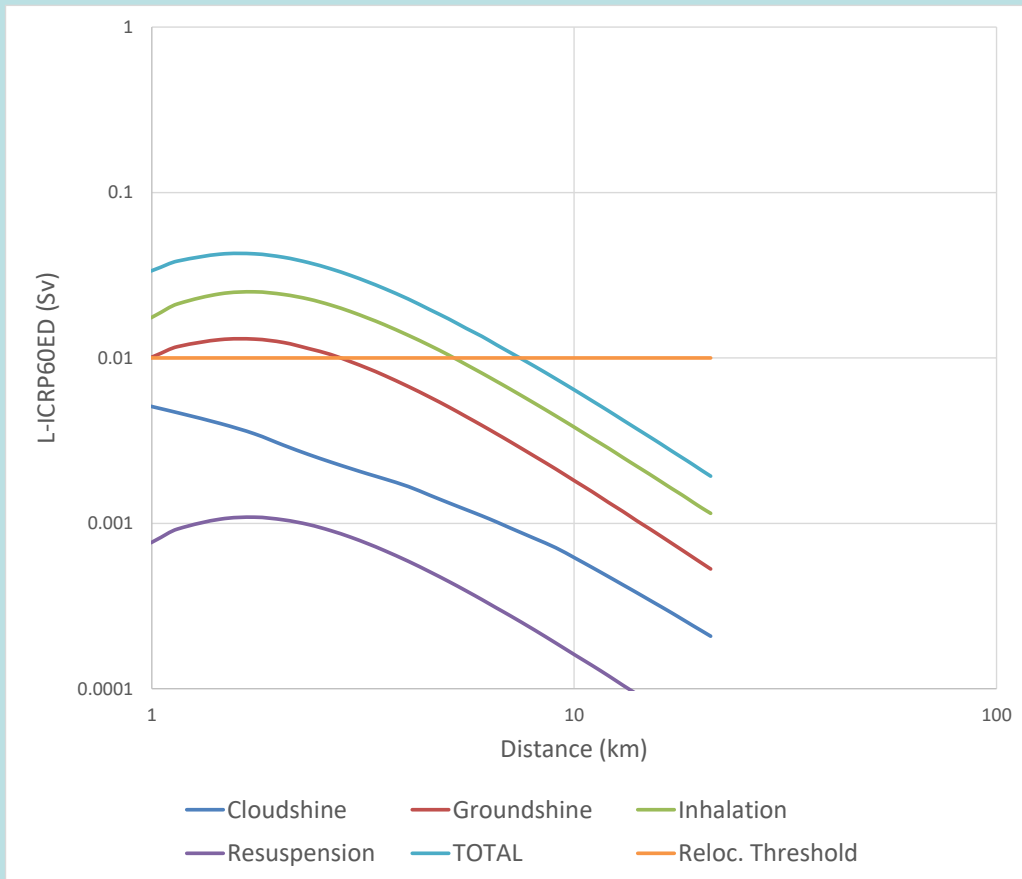


- **MACCS code version 3.10**
 - **Configured to print a binary file which contains all dose values for the target organ for all the spatial grid elements for every trial.**
- **Self developed post processing tool for extracting and analyzing the binary file**
 - **Dose values are extracted and saved in arrays.**

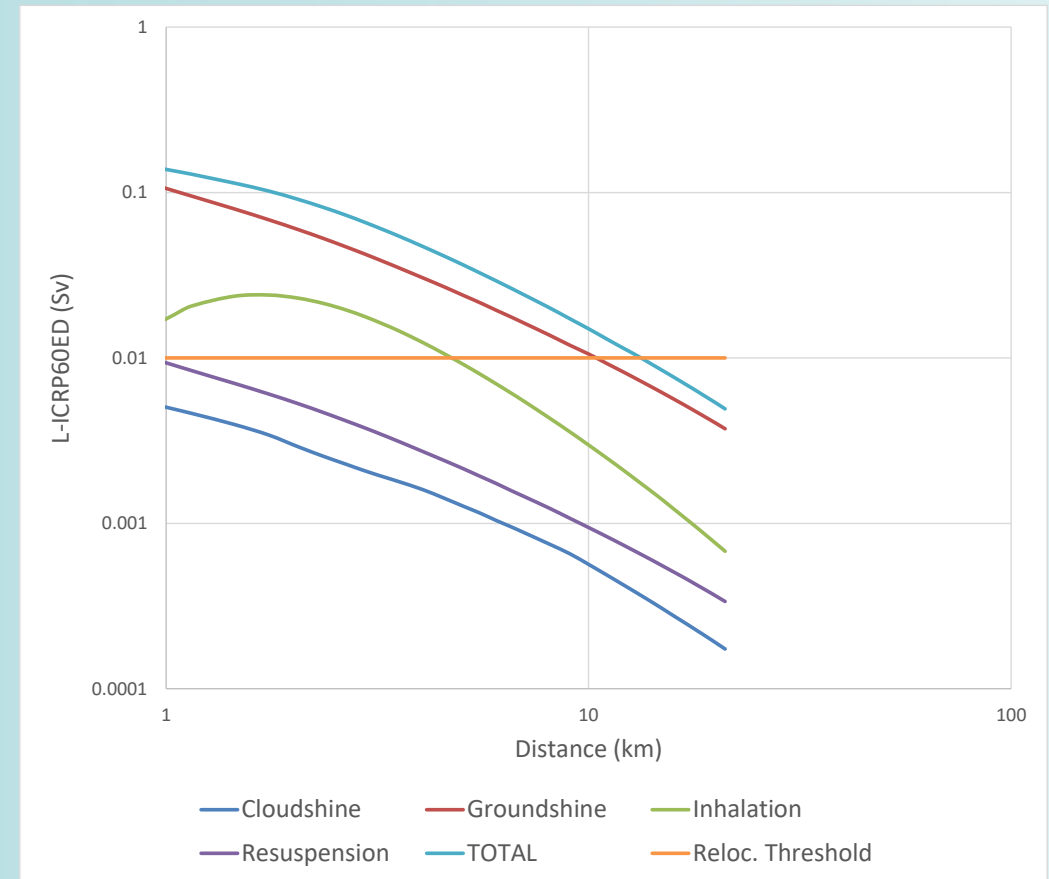


Preliminary Results

- Constant weather simulation (METCOD4) – 7 days dose integration



- Only Dry deposition

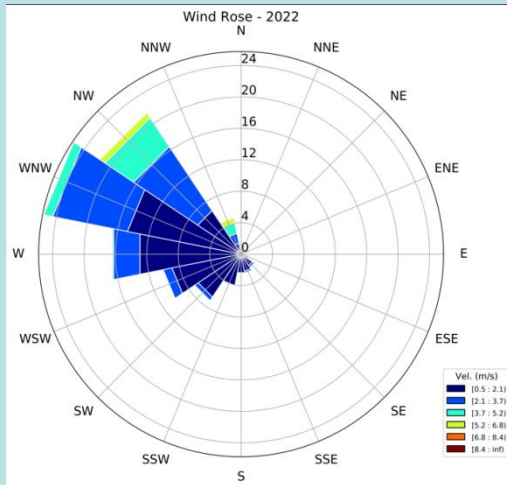
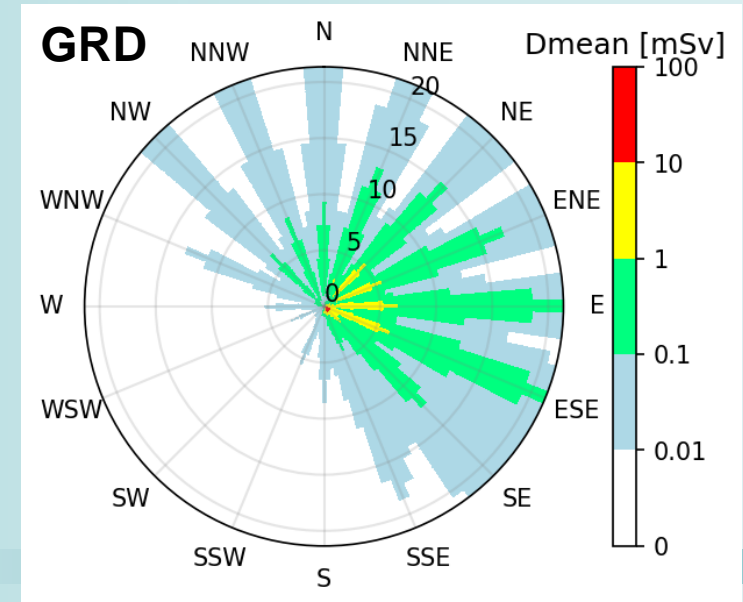
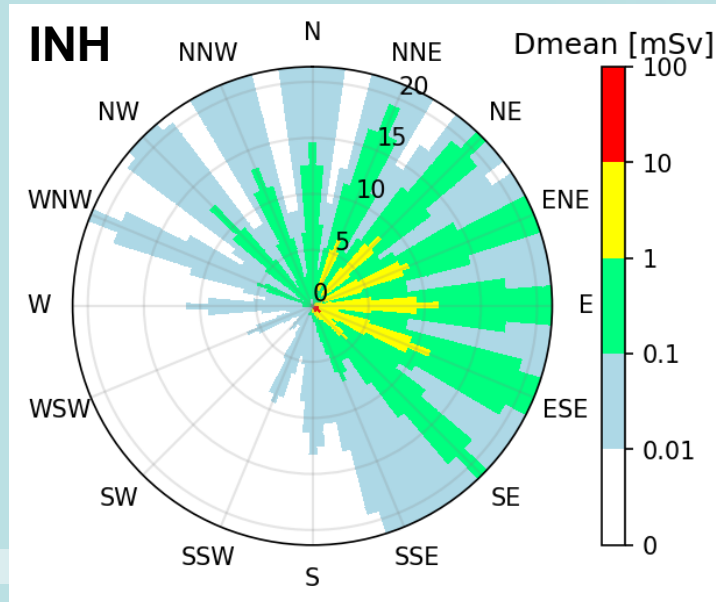
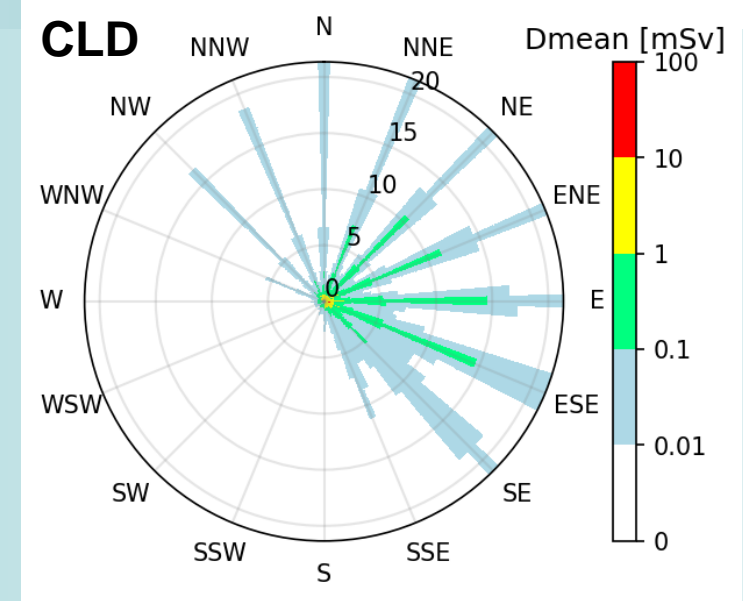
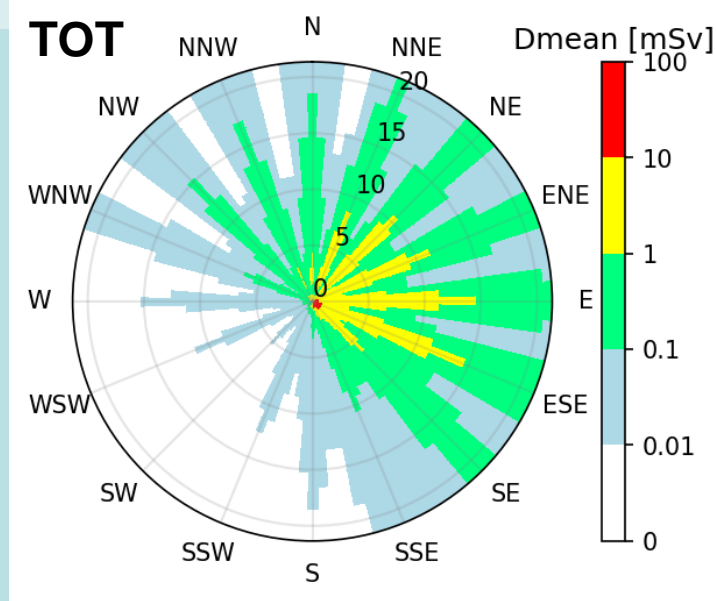


- Dry + Wet deposition



Preliminary Results

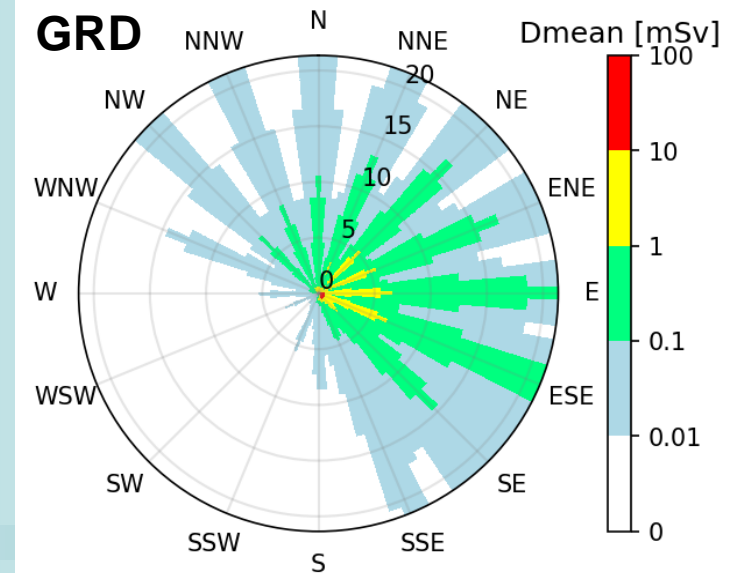
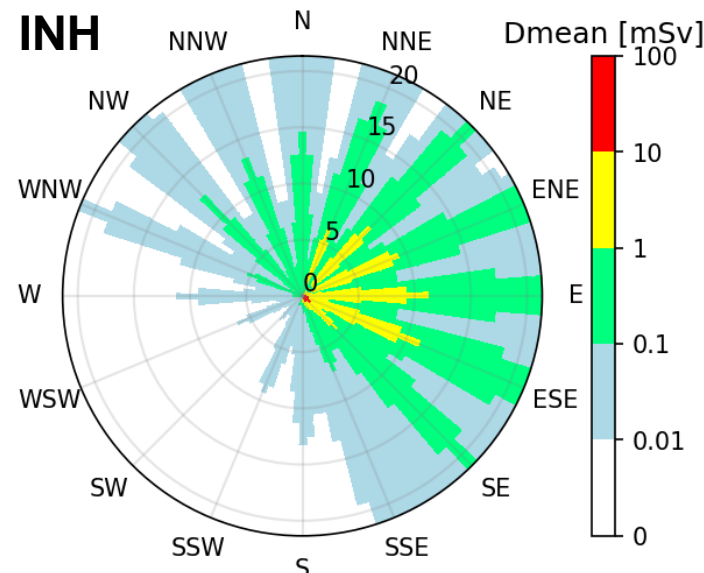
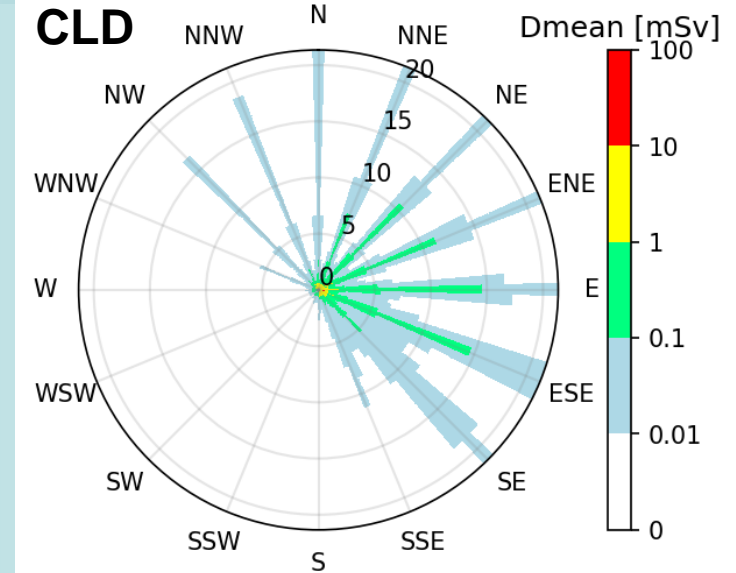
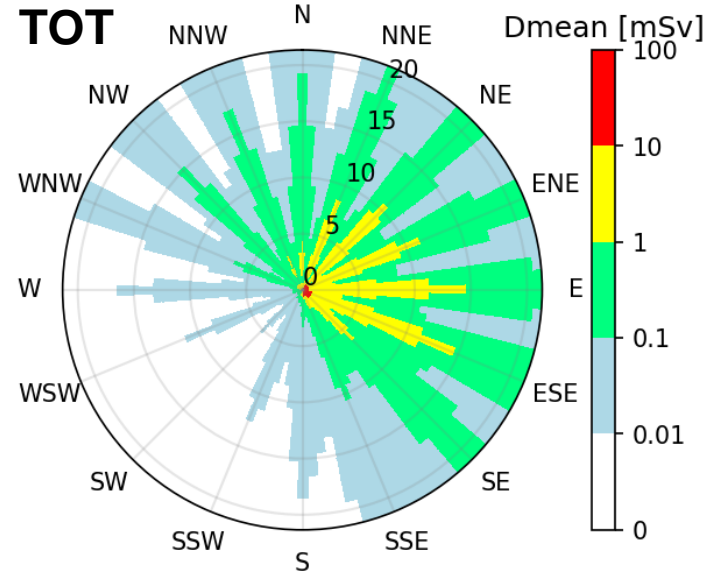
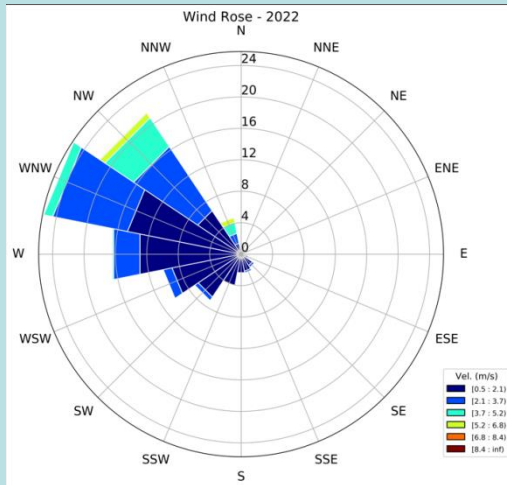
- Only dry deposition
- Real weather data
- 7 days exposure period



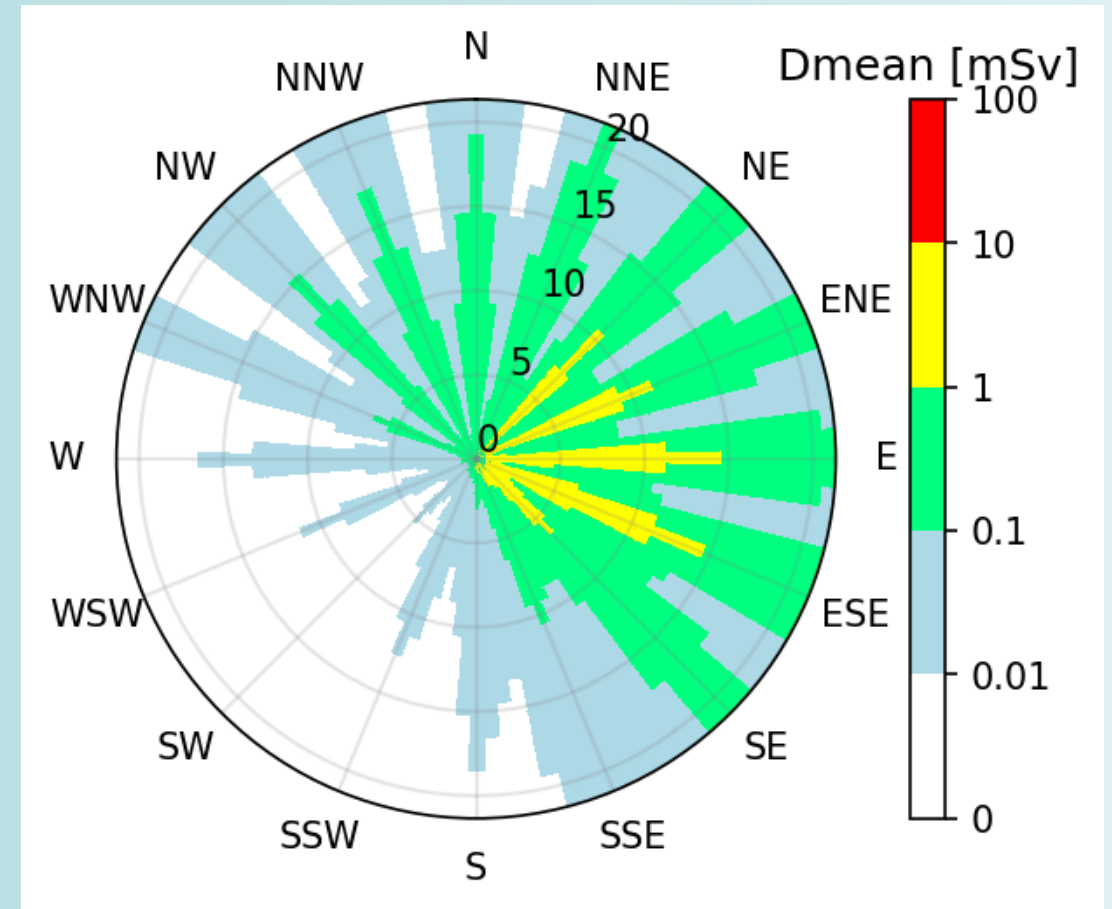
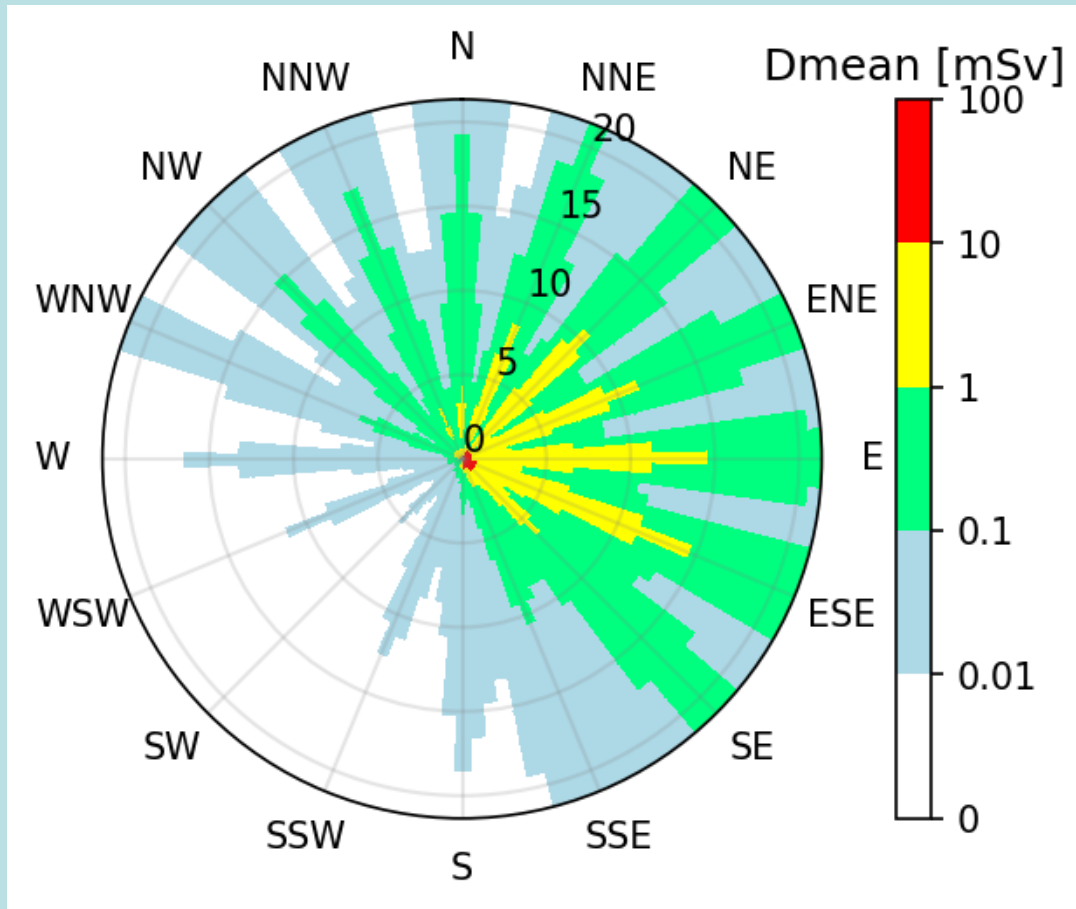


Preliminary Results

- Dry + Wet deposition
- Real weather data
- 7 days exposure period



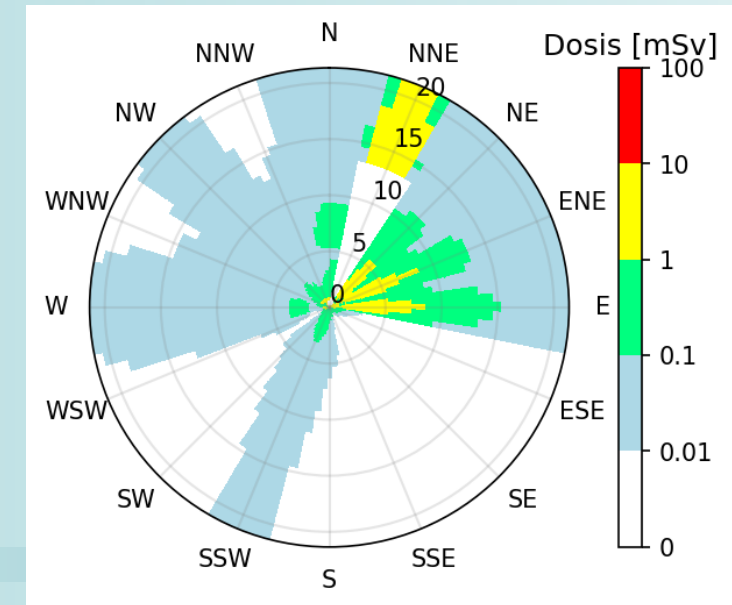
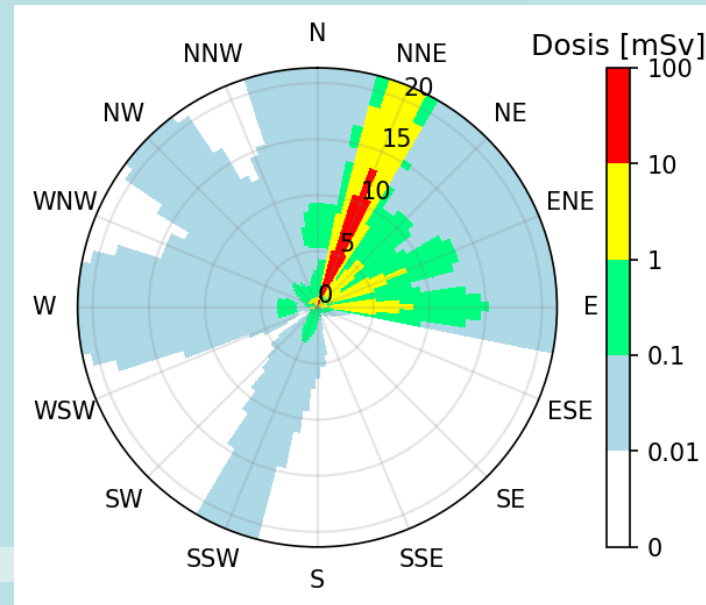
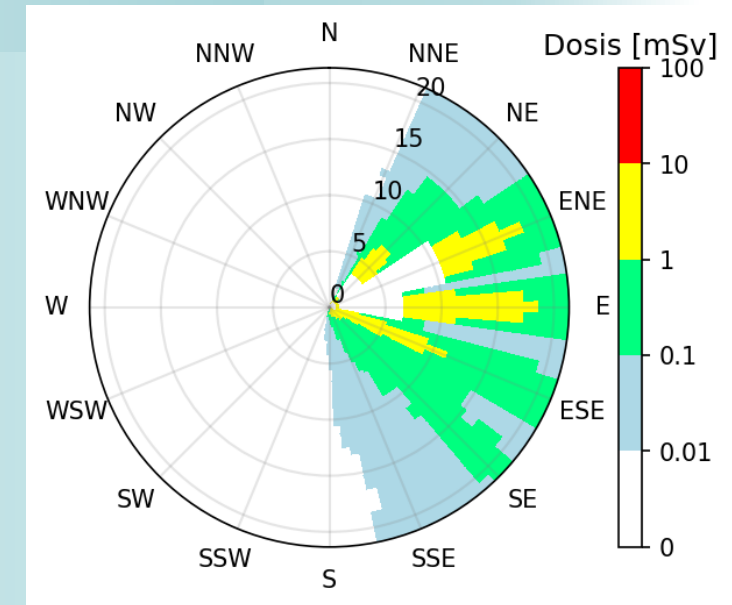
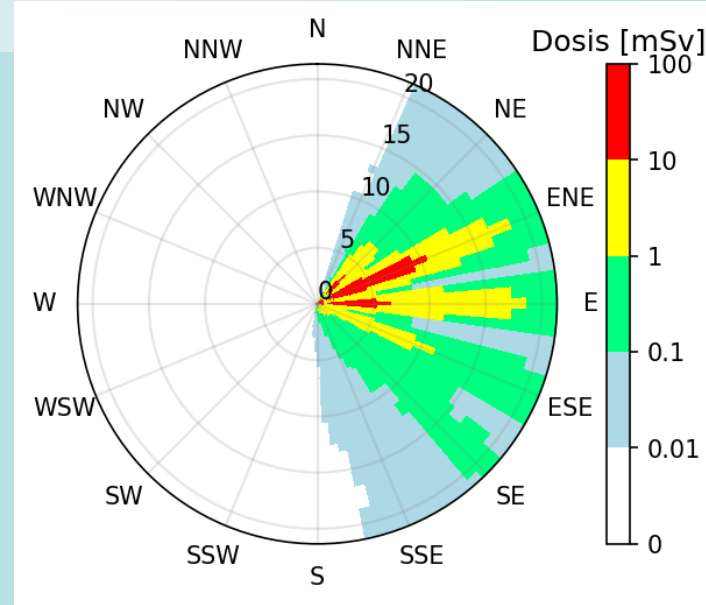
- Relocation impacts on Mean Total Dose spatial distribution for a 7 days exposure period





Preliminary Results

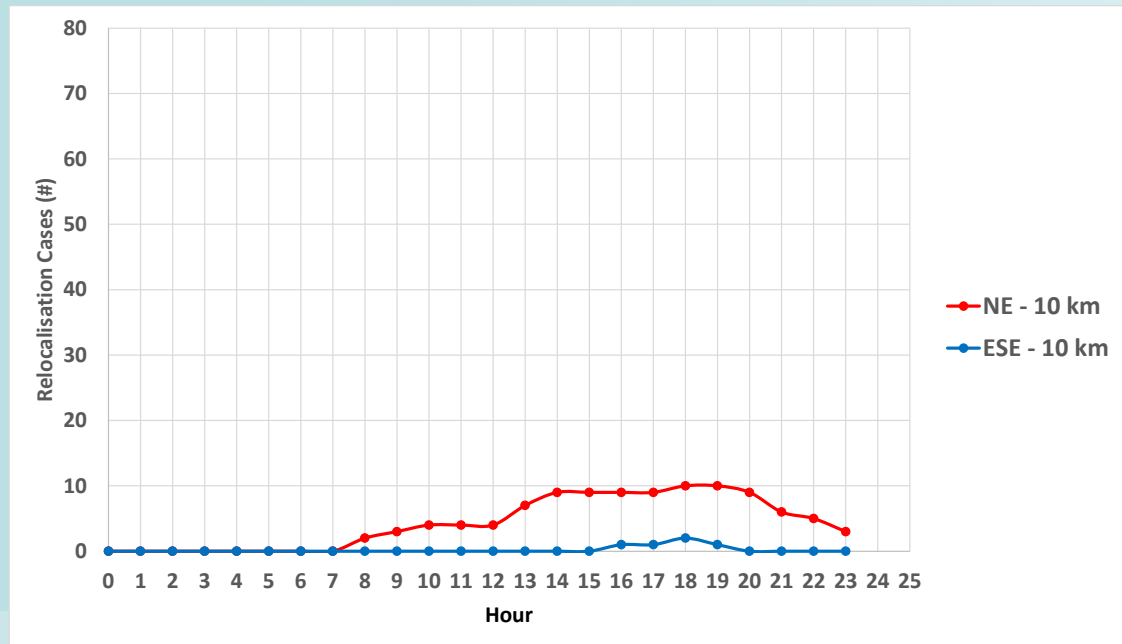
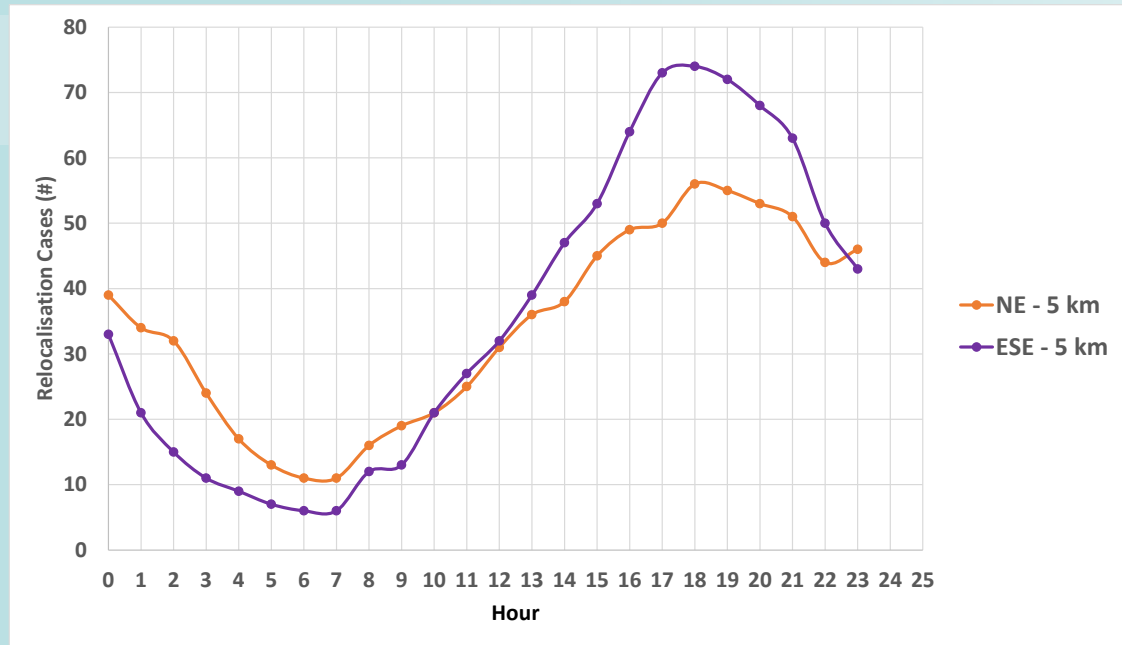
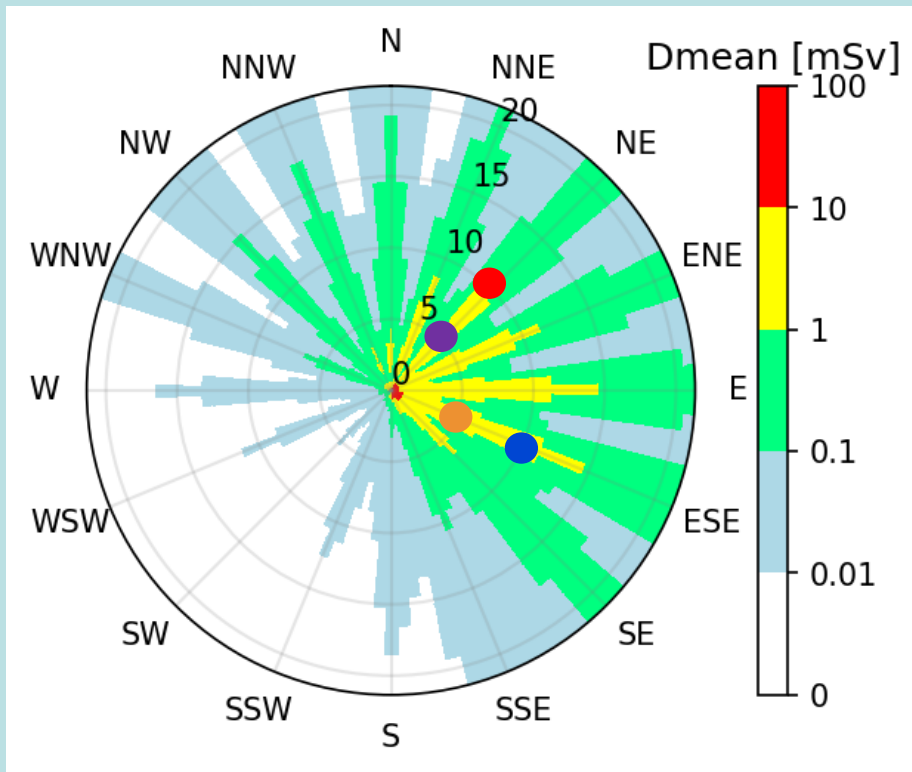
- Relocation impacts on Total Dose for individual trials. 7 days exposure period





Preliminary Results

- Number of relocation cases over all trials for different locations in the spatial grid





Final Remarks

- **Observations and conclusions**
 - **A simple approach with constant meteorology showed that rain enhance significantly exposure by Groundshine pathway as expected. However, results showed that Inhalation due to the passing cloud is a mayor contributor to the total dose, causing early relocation at short distances from the facility.**
 - **Mean dose spatial distribution analysis is useful to put results in perspective. It is consistent with weather data, but it is hardly to see wet deposition and relocation impacts. The results showed that Inhalation is the main contributor to the total dose, something consistent since rainy conditions represent a small fraction of the total weather sequences.**
 - **The analysis of the trials individually showed the impacts of relocation more clearly. The results showed a spatial and even a temporal perspective that could be very useful for Emergency Preparedness applications.**



Final Remarks

- **Next Steps**
 - **Improvements to the Source Term and readjust release characteristics to be more consistent with a SMR reactor.**
 - **Extend exposure period (Early Phase duration), and include the Late Phase for the analysis (incorporate CHRONC Module), but, what would be the dose criteria for relocation in this case?**
 - **Explore combinations of Protective Actions. For example, Shelter + Relocation. This would be possible with MACCS?.**



Final Remarks

- **A very last comment:**
 - **Older MACCS versions have the option to generate a file which contains dose values for the whole spatial grid for every trial.**
 - **At the present we are giving it a great use:**
 - **PSA Level 3 analysis and Individual Radiological Risk with licensing purposes as it is required by or Regulatory Body.**
 - **We are working on coupling MACCS code output with a GIS code, in order to combine dose values with other layers of information.**
 - **And Emergency Preparedness applications as it was showed in this presentation.**



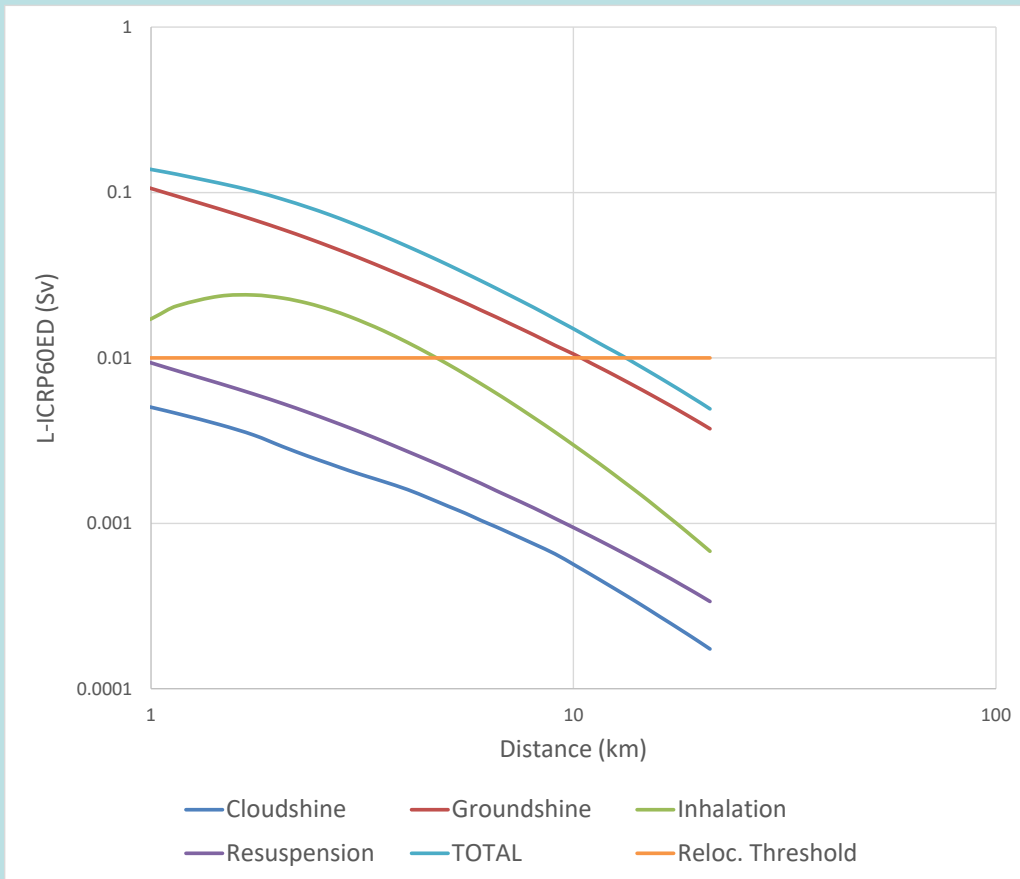
Thank you for your attention!

Cristóbal Mulleady
mulleadyc@cab.cnea.gov.ar

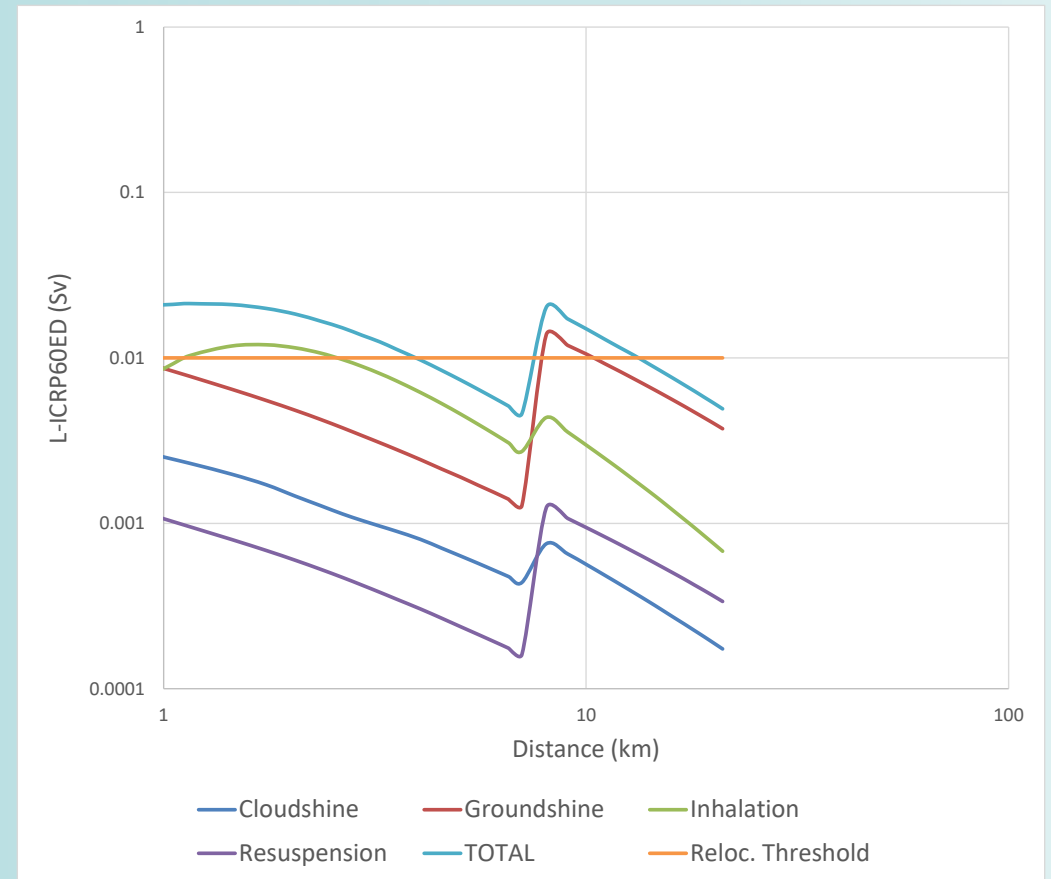
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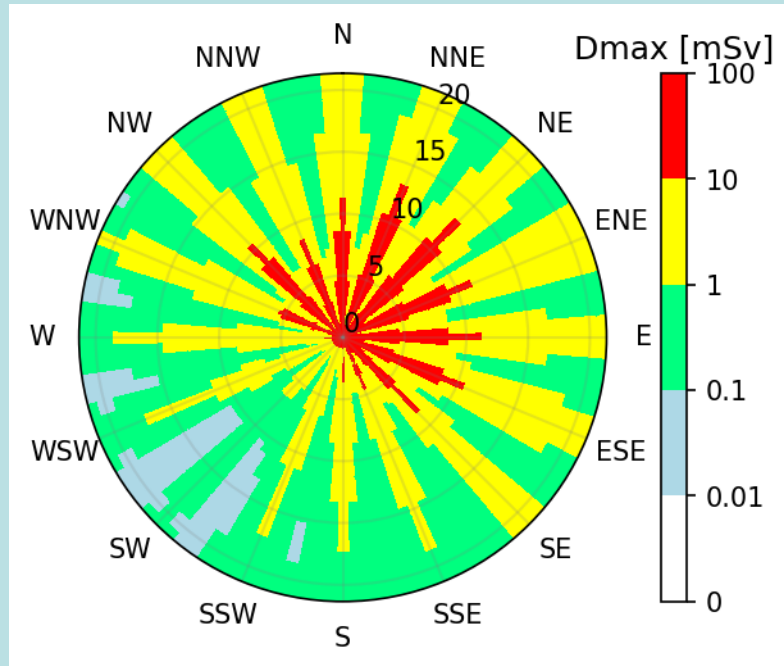


- Dry + Wet deposition

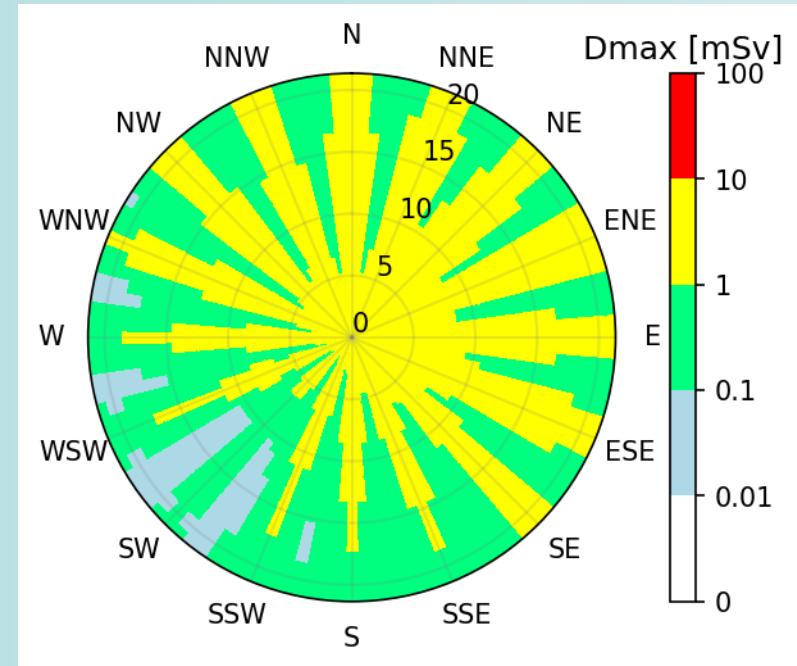


- Relocation after 24 hs

- Max Dose spatial distribution.



- NO Relocation



- Relocation

Response and Planning Zones Sizes

Facility	PAZ	UPZ	FRPD
Category I	3 – 5 km	10 – 25 km	500 – 1000 km
Category II	On-site	0.5 – 2 km	10 – 50 km
Category III	On-site	Not required	Not required

PAZ – Precautionary Action Zone

UPZ – Urgent Protective Planning Zone

FRPD – Food Restrictions Planning Distance



- Hot Spot example

