# HNS-MS stakeholders meeting

## Session 5 : Modelling HNS behaviour in the marine environment

# The atmospheric dispersion model CHEMADEL

DG-ECHO civil protection funding mechanism
2014 Call for Prevention and Preparedness

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# The atmospheric dispersion model CHEMADEL

Some HNS are evaporators (E) and present a **risk for human health** at surface :

- Operating people/staff on boats
- Helicopter/aircraft pilots
- Civilians on the coast

Goals :

- Cover all natural compartments affected by pollutant
- Provide **a first line information**
- Use of a simple, fast and efficient tool to evaluate the gas concentration

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# The atmospheric dispersion model CHEMADEL

- CHEMADEL : **CHEM**ical **A**tmospheric **D**ispersion mod**EL**
- Simulation of **gas fate** in the atmosphere
- Integration in the decision support system prototype : The HNS-MS far-field model provide a **source term** to CHEMADEL

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# The atmospheric dispersion model CHEMADEL

- Scenario **key parameters** for CHEMADEL:
  - Simulation time
  - Location
  - HNS evaporation rate
  - Environmental conditions for the atmosphere
    - Wind velocities, cloud coverage
  - Options

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# The atmospheric dispersion model CHEMADEL

- Gaussian models
  - Oldest but simplest models, against CFD and integral models
  - It provides the concentration values in the atmosphere depending of elapsed time and distance from source by solving the transport equation :

$$\frac{\partial C}{\partial t} + u\frac{\partial C}{\partial x} + v\frac{\partial C}{\partial y} + w\frac{\partial C}{\partial z} = \frac{\partial}{\partial x}\left[K_x\frac{\partial C}{\partial x}\right] + \frac{\partial}{\partial y}\left[K_y\frac{\partial C}{\partial y}\right] + \frac{\partial}{\partial z}\left[K_z\frac{\partial C}{\partial z}\right] + S + R$$

  - By making assumptions, analytical solutions are obtained for :
    - Punctual instantaneous emission of gas
    - **Punctual long term gas puffs emission**
    - Punctual long term gas plume emission

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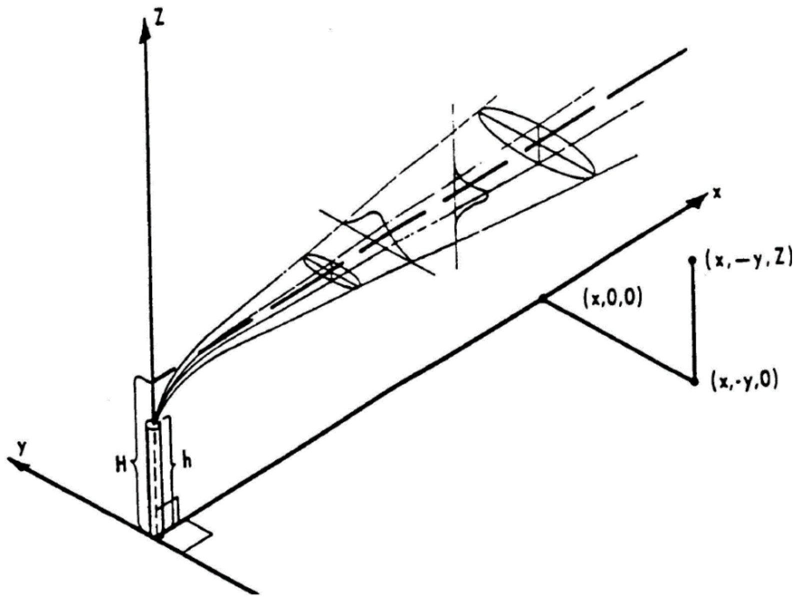
# The atmospheric dispersion model CHEMADEL

- Gaussian models (2)
  - The source term is provided by a flow rate
  - The gas concentration follows a **Gaussian distribution law in space**




Concentration Gaussian profile in a passive gas plume (Turner, 1970)

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# The atmospheric dispersion model CHEMADEL

- Gaussian puff model assumptions
  - Molecular diffusion is negligible
  - Gas is passive or neutral (density close to air, or is very diluted)
  - Gas temperature is similar to atmospheric temperature
  - Turbulence is homogeneous and isotropic
  - Ground is homogenous with a low relief
  - Initial release velocity is considered as null
  - Validity domain : 100m – 10km

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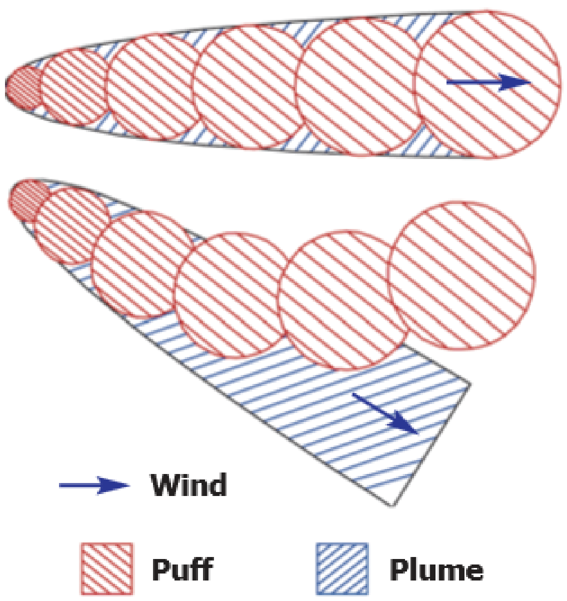
# The atmospheric dispersion model CHEMADEL

- Advantages of the Gaussian puff model
  - Puffs are source-independent
  - Wind field variability (including coastal effects)




Illustrations of Gaussian puff and plume models

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# The atmospheric dispersion model CHEMADEL

- Concentration evaluation at a point (*x*, *y*, *z*)
  - A large number of puffs is necessary to model the continuous release = A puff generated each second
  - Calculated from the summation of all puffs contribution

$$C(x,y,z,t) = \sum_{i=1}^{n} C_i(x,y,z,t_i)$$

$$= \sum_{i=1}^{n} \left( \frac{m_i}{(2\pi)^{2/3}\sigma_{x_i}\sigma_{y_i}\sigma_{z_i}} \right) \times exp\left( -\frac{[x - x_0 - u(t - t_i)]^2}{2\sigma_{x_i}^2} - \frac{[y - y_0 - v(t - t_i)]^2}{2\sigma_{y_i}^2} \right)$$

$$\times \left[ exp\left( -\frac{[z - z_0 - w(t - t_i)]^2}{2\sigma_{z_i}^2} \right) + \alpha\ exp\left( -\frac{[z + z_0 + w(t - t_i)]^2}{2\sigma_{z_i}^2} \right) \right]$$

  - $x_0$, $y_0$, $z_0$ the release location (m), $m_i$ the initial mass (kg), $t$-$t_i$ the *ith* puff age (s), α the ground reflection coefficient , σ standard deviation coefficients (m)

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# The atmospheric dispersion model CHEMADEL

- Standard deviation coefficients
  - Use of the **correlation of Pasquill-Turner**
    - The Pasquill's atmospheric stability classes determined from environmental conditions : wind field, solar insolation and cloud coverage index

| Wind speed | Day | | | Night | |
|---|---|---|---|---|---|
| At 10 meters (m.s-1) | Solar insolation | | | Cloud cover | |
| | Strong | Moderate | Slight | > 50% | < 50% |
| < 2 | A | A - B | B | E | F |
| 2 - 3 | A – B | B | C | E | F |
| 3 - 5 | B | B – C | C | D | E |
| 5 - 6 | C | C – D | D | D | D |
| > 6 | C | D | D | D | D |

| Stability classes | Mark |
|---|---|
| Extremely instable | A |
| Moderately instable | B |
| Instable | C |
| Neutral | D |
| Stable | E |
| Moderately stable | F |
| Extremely stable | G |

Turner and Pasquill stability classes

- Coefficients deduced from empirical relationship based on experimental data

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# The atmospheric dispersion model CHEMADEL

- Output data
  - Generation of netCDF file that contains gas concentration for three elevations : 1m, 10m and 50m

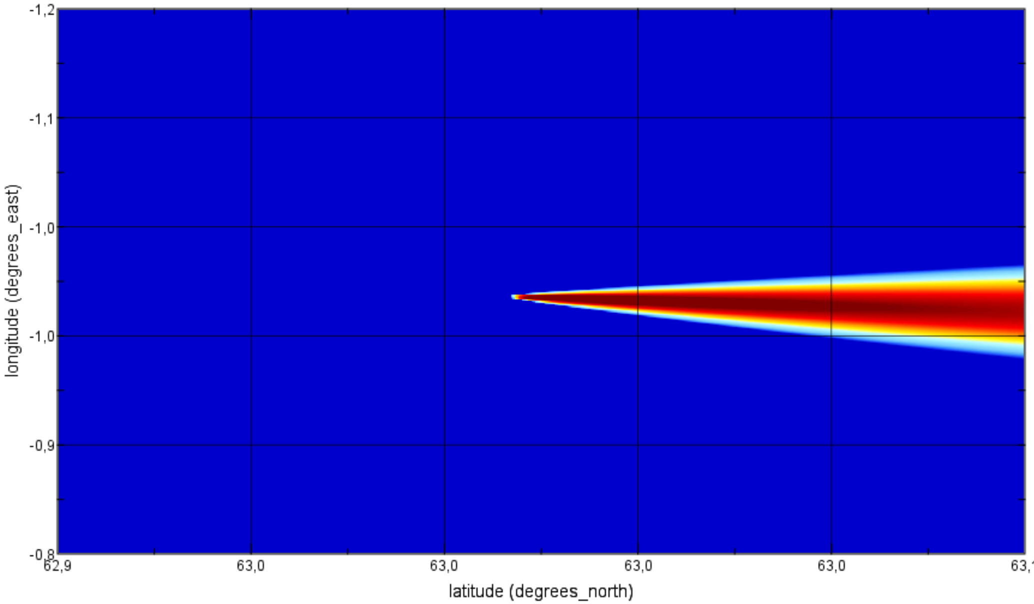


Illustration of gas concentration in the atmosphere (capture from NASA/GISS Panoply)

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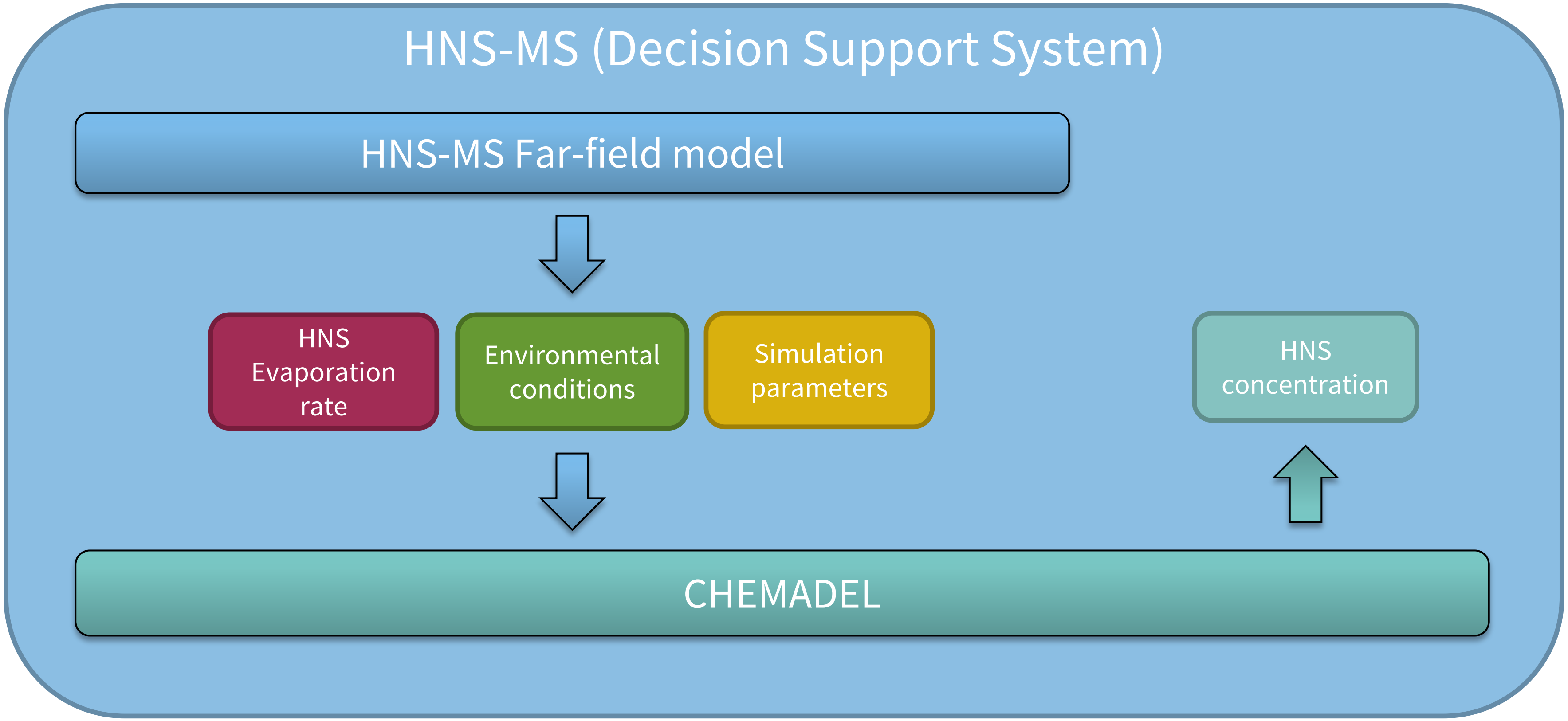
# The atmospheric dispersion model CHEMADEL

- HNS-MS / CHEMADEL models interface



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# The atmospheric dispersion model CHEMADEL

- CHEMADEL technical description:
  - Programming languages : C++, Qt Framework
  - 64 bits executable binary
  - OS : Debian 8 64 bits, Windows 7 64 bits

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# The atmospheric dispersion model CHEMADEL

Thank you for your attention

Any questions ?