HARMONIZATION OF PRACTICES FOR ATMOSPHERIC DISPERSION MODELLING WITHIN THE FRAMEWORK OF RISK ASSESSMENT

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CONTENT

- Context
- Objectives of the French 3D atmospheric dispersion working group
- Methodology and purpose of benchmark cases
  - Sum up of benchmark cases
  - Standardization of input meteorological profile
- Best practices and requirements

Industrial risk management in France

2001, September the 21st: Major explosion in Toulouse (AZF factory)

- 31 deaths
- 2500 injuries

Consequences: Modification of the industrial risk prevention strategy

Circular October 2005: A new legal tool in France to protect people from industrial hazards

→ PPRT ("Plan de Prévention des Risques Technologiques")

- Requirement: prediction of impact area (thermal, overpressure and toxic effects), for potential accidents scenarios
- Consequences: financial and human impact, protection measures to expropriation
- Importance in computing precise safety distance to prevent from people exposure and realistic safety cost

Prediction of safety distances by modelling : current approaches

3 types of phenomena

- Fire
  - Radiation models
  - Integral, Gaussian, 3D approaches for smoke dispersion
- Toxic dispersion
  - Integral, Gaussian, 3D approaches
- Explosion
  - Integral, Gaussian, 3D approaches for vapour dispersion
  - Empirical model

➔ **Atmospheric dispersion modelling appears as a key issue for effect prediction**

➔ **<u>But sometimes huge discrepancies between safety distances</u>**

Objectives of the French tridimensional atmospheric dispersion working group

To create a guideline of best practices for 3D atmospheric dispersion modelling :

→To forecast hazardous consequences within the framework of risk assessment

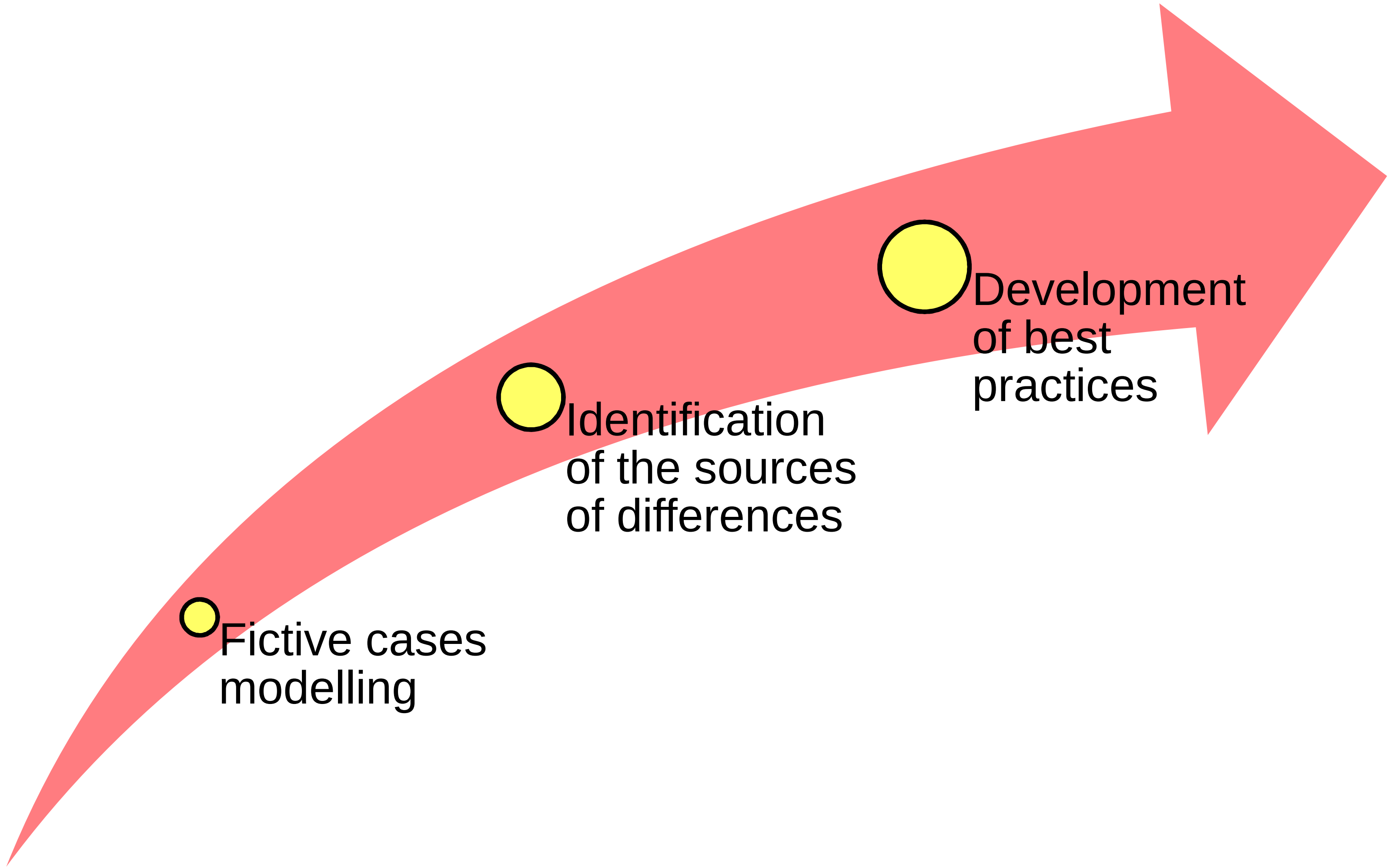
→To harmonize practices and results

→To provide a reading tool for the administration

Participants : Industrialists, Universities, Consulting services, Institutes

Coordination : INERIS

Schematic view on the organisation



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First case: free land atmospheric dispersion

3 different toxic gas releases with 8 bar pressure through 2 inch hole

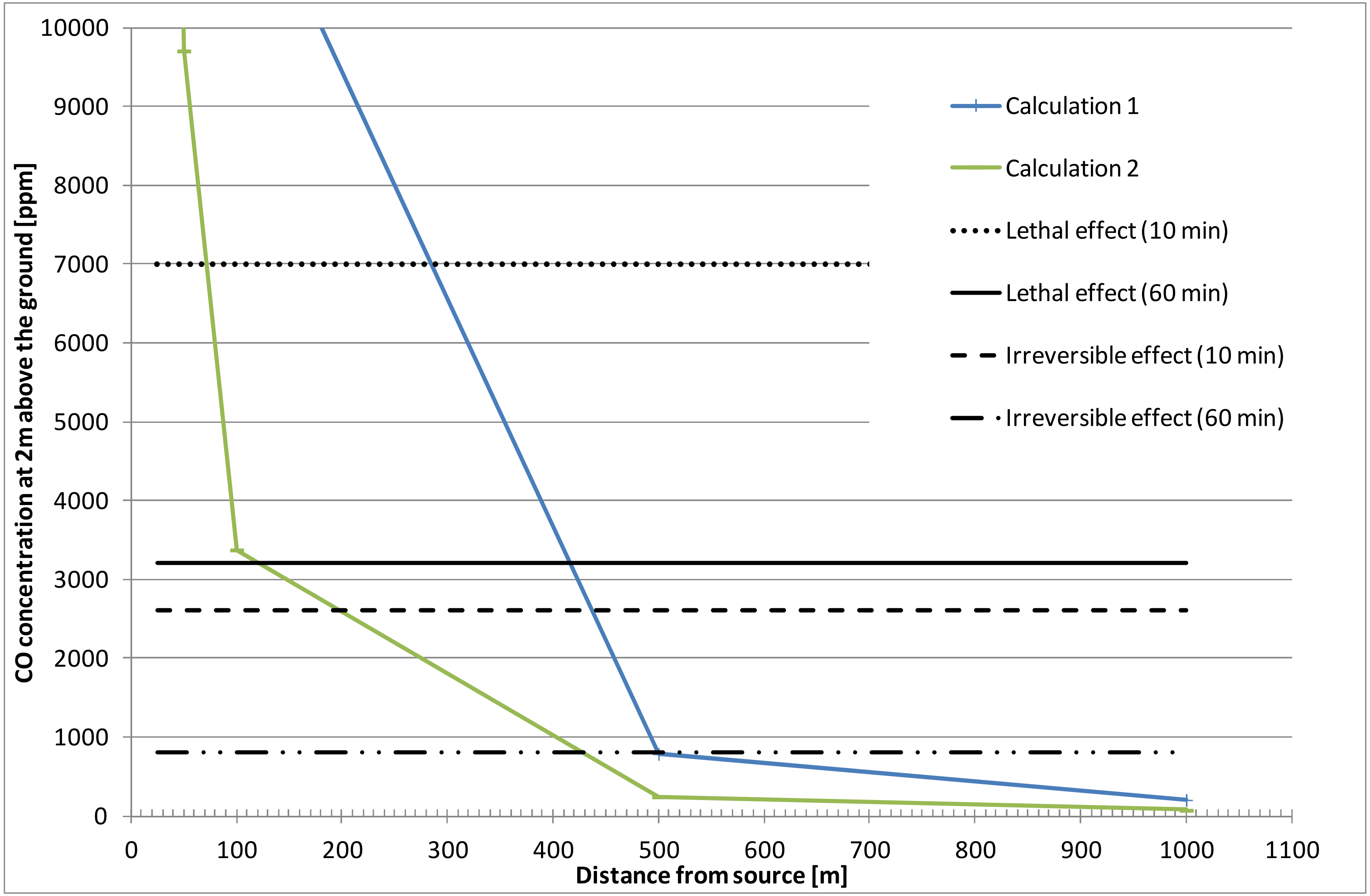
- Heavy: 4.5 kg/s of C_3H_8
- Neutral: 3.6 kg/s of CO
- Light: 2.8 kg/s of NH_3

2 different wind profiles

- Stable: F3
- Neutral: D5

Users are fully free: no constraint on wind representation, turbulence modelling, boundary conditions, source term implementation, etc

First case : some results and analysis



What we have learnt from case 1

4 major factors were identified:

- **Interpretation of wind profile for CFD**
- Turbulence models
- Mesh : cell size
- Source term implementation

Need to standardize the methodology for these 4 issues

Relation between wind profiles and CFD approach

French regulation requires atmospheric conditions as F3 or D5

- But these conditions cannot be translated easily
- For a condition, several profiles are possible

No interpretation rule exists to build profile for CFD models

Great effort in order to establish a consensus

Relation between wind profiles and CFD approach

The proposal is :

- Requirements : Pasquill Class, Wind module u_{zref}, z_0,T_0

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- Requirements : Pasquill Class, Wind module u_{zref}, z_0,T_0

- Method :
  - Relation of Pasquill class and LMO/z_0 within Golder approach

    → **LMO for surface boundary layer profile**

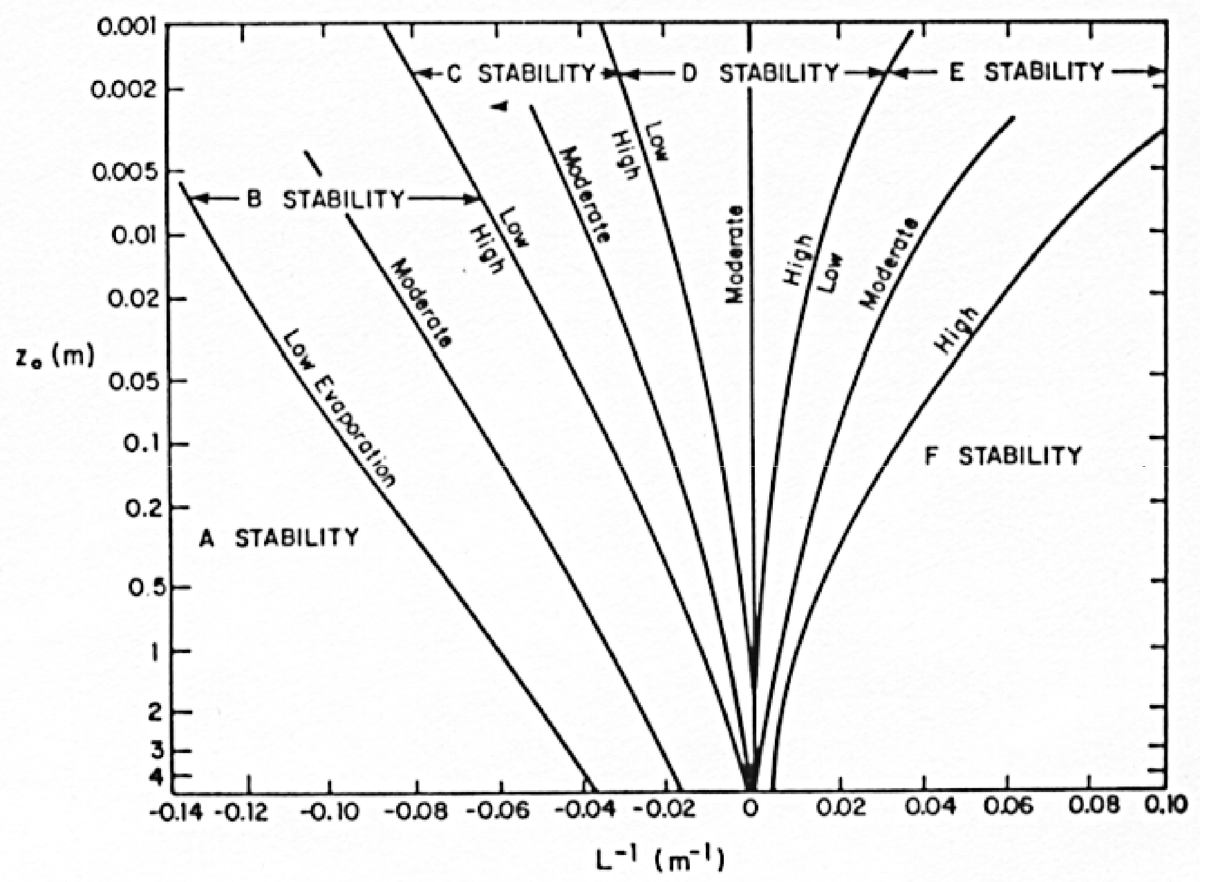
Relation between wind profiles and CFD approach

- Method :

$$\frac{1}{L} = \frac{1}{L_S} \log_{10}\left(\frac{z_0}{z_s}\right)$$

$0.001 \leq z_0 \leq 0.5$

Pasquill stability	L_s(m)	z_s(m)
A	33,162	1117
B	32,258	11,46
C	51,787	1,324
D	∞	Not applicable
E	48,330	1,262
F	31,325	19,36



"Relations among stability parameters in the surface layer"

D. Golder, Boundary-Layer Meteorology 3, 1972.

Relation between wind profiles and CFD approach

The proposal is :

- Requirements : Pasquill Class, Wind module u_{zref}, z_0, T_0

- Method :
  - Relation of Pasquill class and LMO/z_0 within Golder approach
    → LMO for surface boundary layer profile
  - Iterative calculation → u_{*0}
  - Extension within and above surface layer :
    Gryning et al. approach (2007)

Z_i height of the ABL

Case 2 : modelling with obstacles

Some parameters were fixed:

- Wind profiles
- Simpler source term, propane release (45 kg/s)

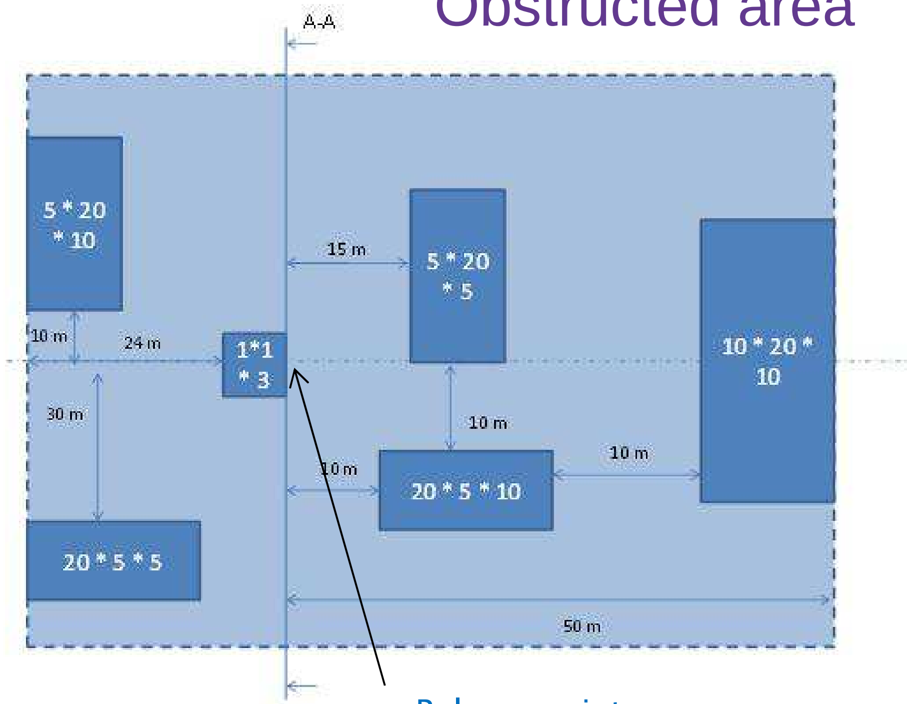
Obstacles were introduced inside the domain

About 12 modellers :

Two main approaches

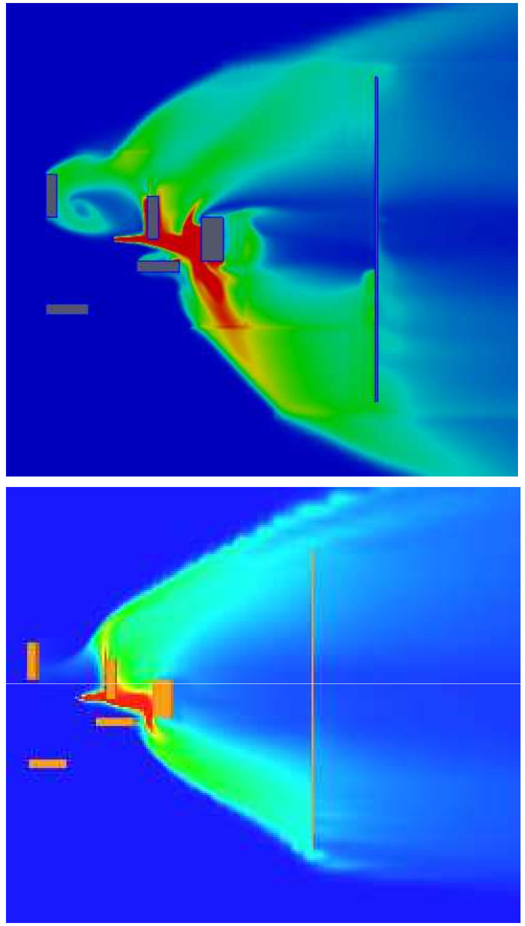
- RANS, mainly k-ε
- LES

Obstructed area



Release point

What we have learnt from case 2



Differences in using similar models

- Buoyancy effects
- Roughness modelling
- Surface or volume source term
- Mesh

Specific work :

- Consideration of turbulence production by buoyancy effects
- Distance upstream first obstacles

Production of a list of best practices (I)

- **Validation procedure**
  - Need for the user to validate the code
  - CFD using requires physical sense for downstream analyse
- **Mesh building**
  - Mesh independence (COST 732)
  - Cell shape
- **Numerical criteria**
  - non dissipative numerical schemes
  - Numerical diffusion ➔ artificial reduction of dangerous area

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Production of a list of best practices (II)

- **Boundary conditions**
  - wind profiles prescribed by the WG
    - correspond to Pasquill classification
  - Boundary conditions position (COST 732)
    - Necessity of a distance upstream first obstacle
    - Distance of the domain roof

- **Wind profile conservation along the domain**
  - Atmospheric turbulence has to be maintained
    - the criteria: F3 at the inlet ➔ F3 at the outlet

- **Turbulence model to take into account specific phenomena**
  - production term due to buoyancy effects

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Concluding comments

Regarding WG

- Simulations with the proposed **best practices** on an experimental case (Kit Fox Field)
- Still some differences but ... Is it worse than other models ?

On CFD use for industrial safety

- A very powerful tool with a lot of input parameters
- And some physical sub models

➔ Requires a high level of physical knowledge for the user

Guideline of Practices Harmonization on CFD use for industrial safety

- Feedback of administration → improvement

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