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# Phenomenology of a bubble plume From the leak of an underwater storage tank to the seawater surface

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## Context and Objectives

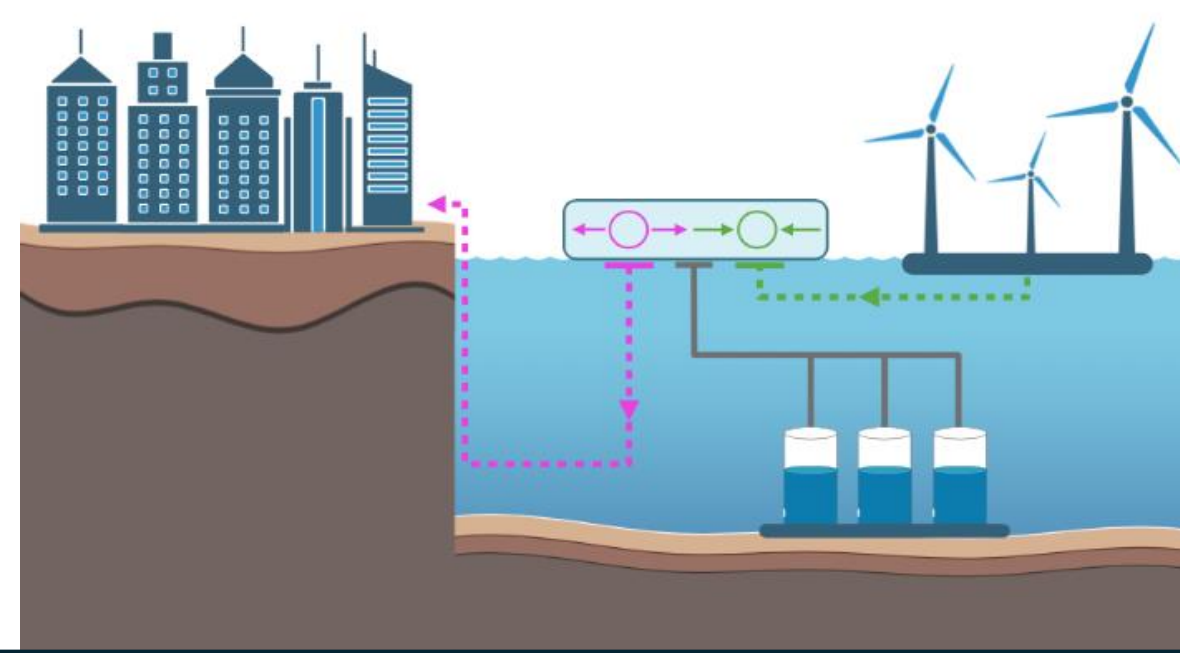
Helping designing an underwater compressed air energy storage system (UWCAES)

- Predicting the impacts induced by a massive leak of compressed air into seawater
- Implementing a suitable risk analysis study

## Application

UWCAES system configuration

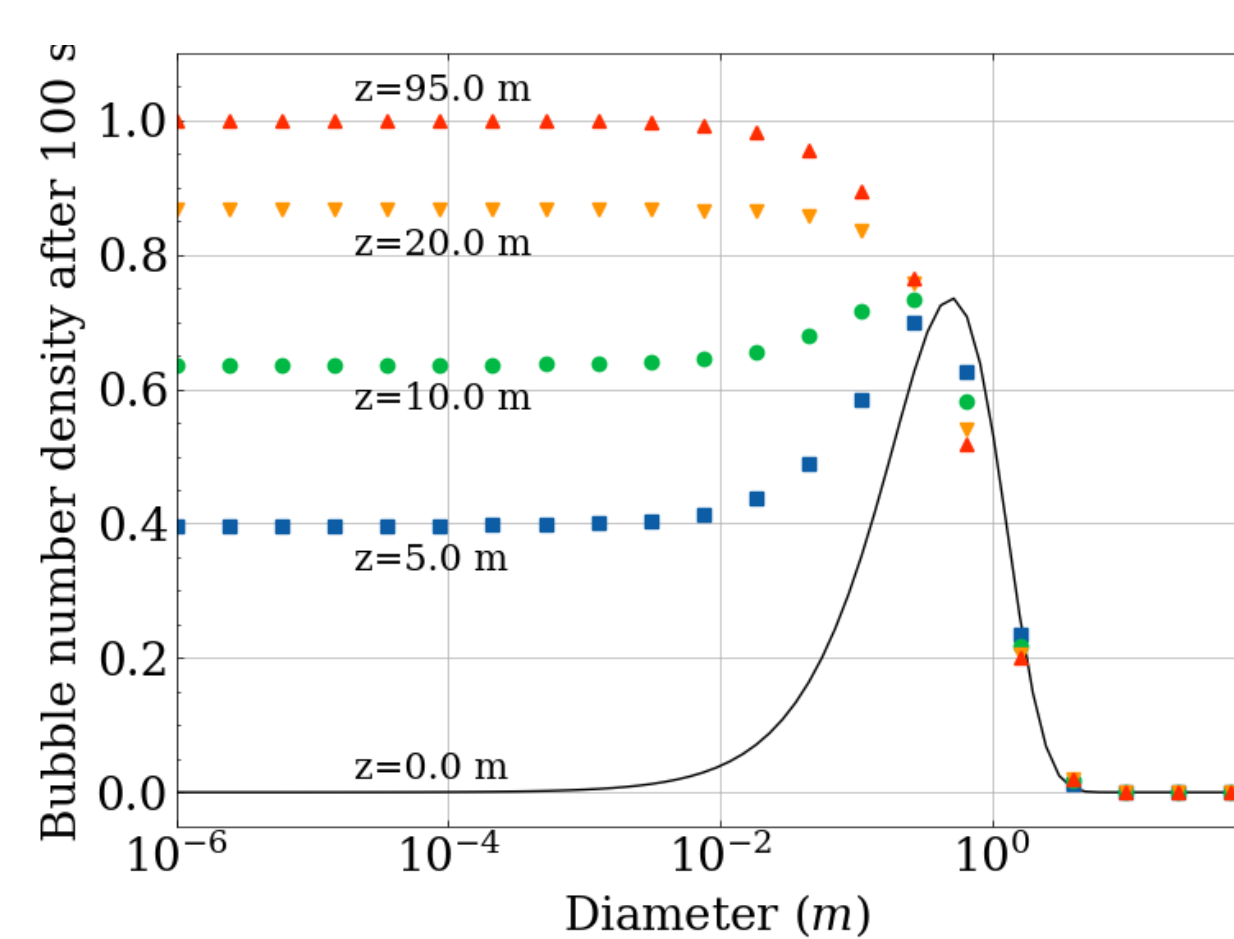
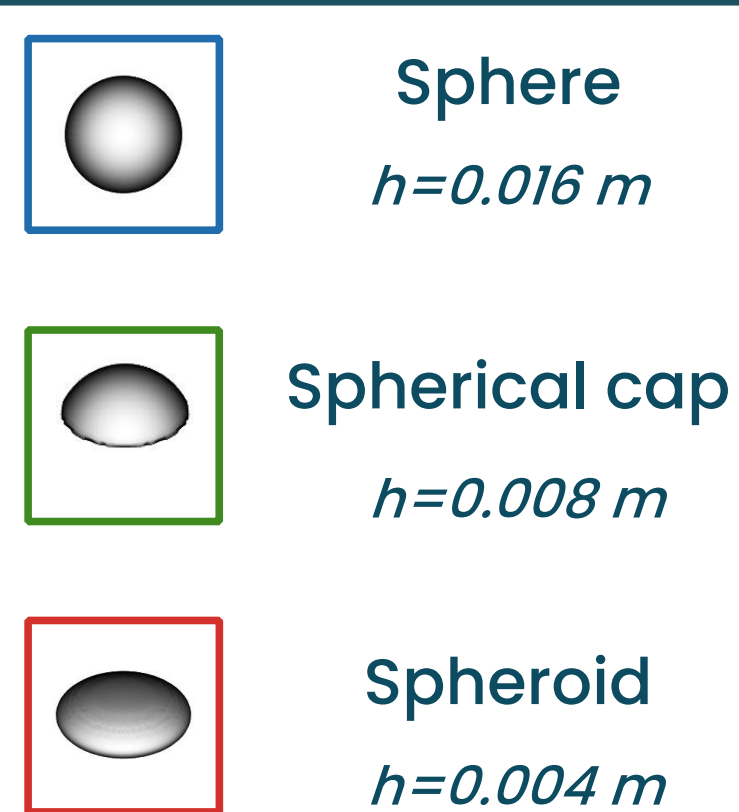
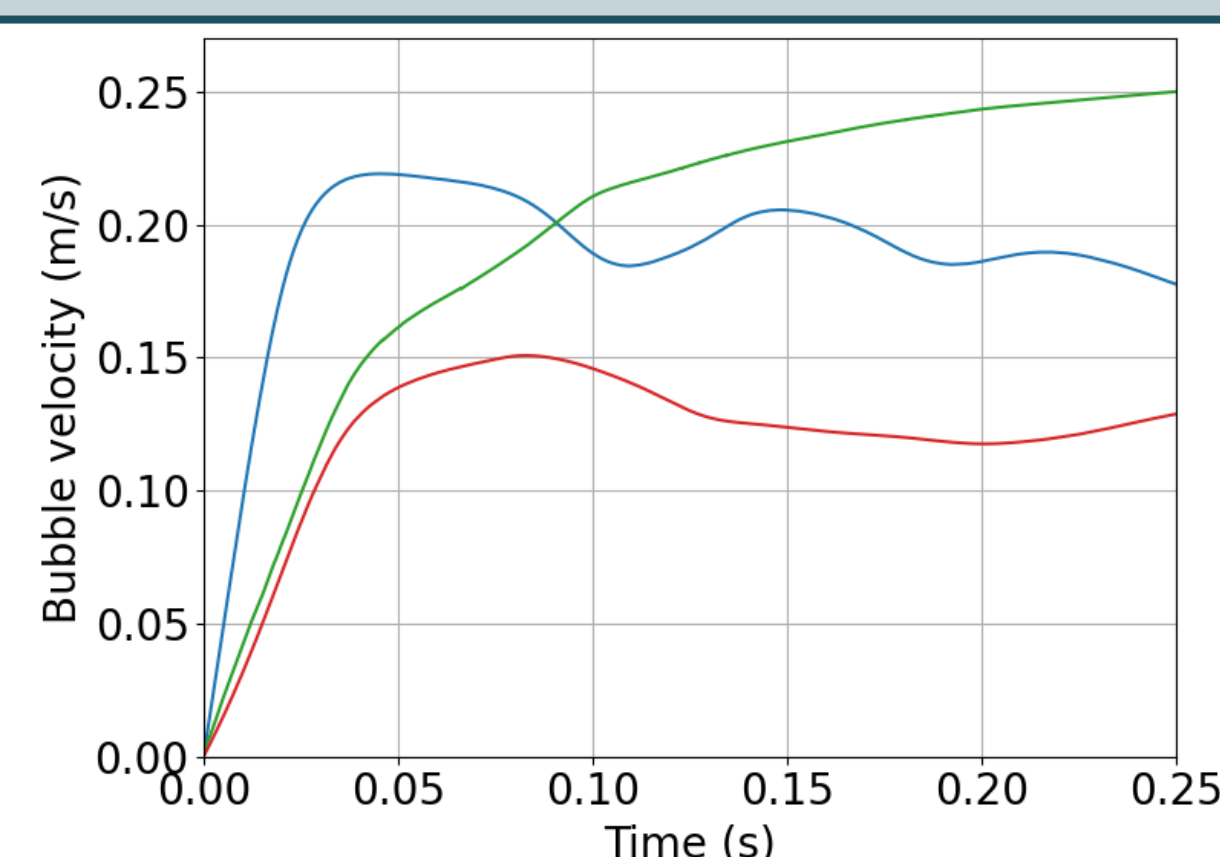
- Submerged at 200 m depth
- Cylinder tank initially filled with 15 000 kg of compressed air
- Leak orifice of 30 cm diameter



## Results

- A. Tank empties in less than 4 minutes  
Initial gas flow rate is 136 kg/s → Jetting flow regime
- Leak behaviour depends on tank dimension

- B1. Gas density has no effect on bubble dynamics  
Dynamics is driven by bubble height  $h$
- Initial shape influences bubble velocity

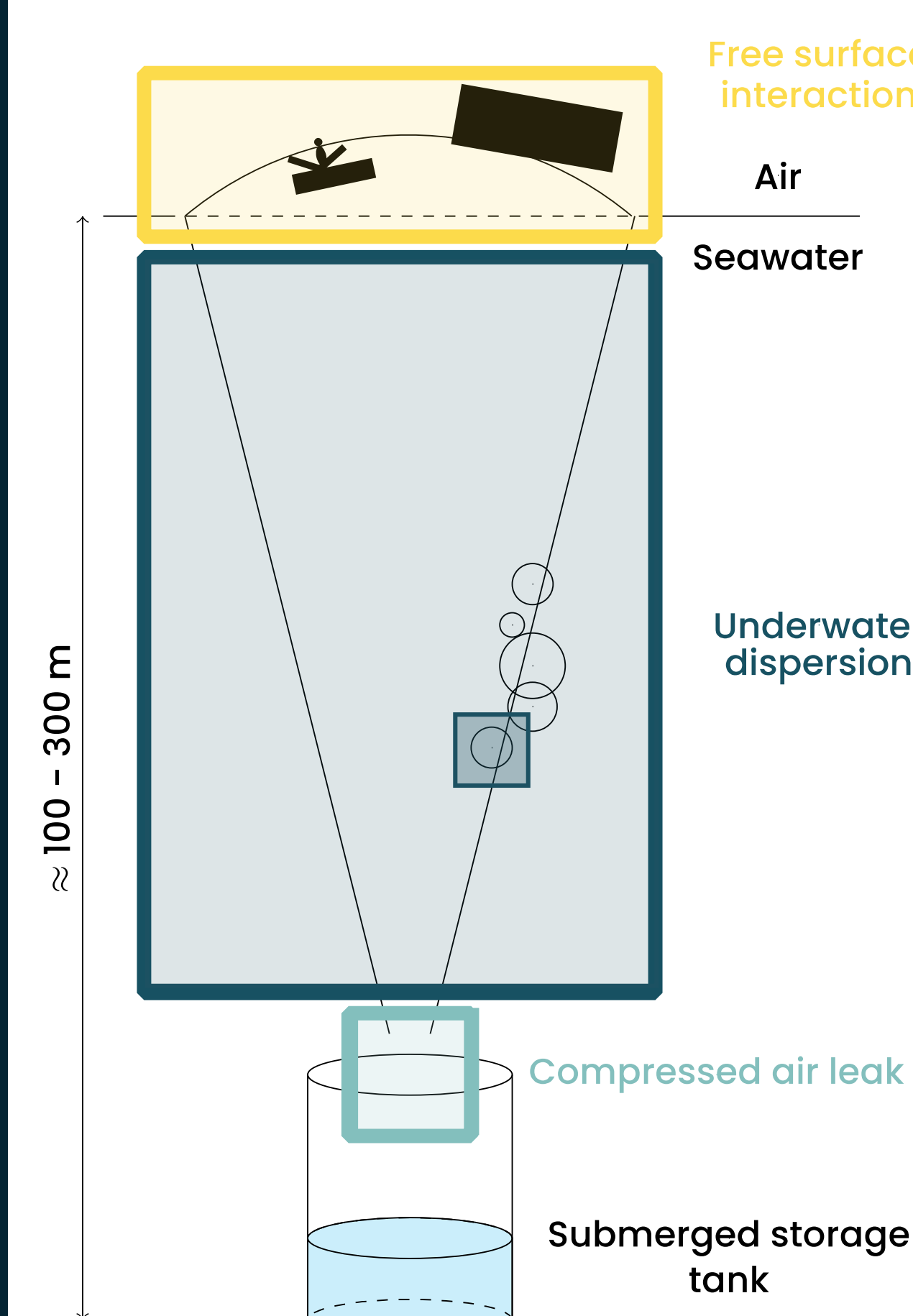


- B2. Expansion rate is negligible compared with bubble rise velocity  
Bubbles increase in number but decrease in size
- Fragmentation prevails over coalescence and expansion

- C. Seawater surface fountain is 1 m high and 42 m wide
- Fountain width increases with immersion depth

## Method

Different scales ...



... Different tools

C. Correlation for the sea surface flux [3]

B2. Population balance model of the bubble plume [2]

B1. DNS of single rising bubbles

A. Mathematical modelling of the gas flow rate [1]

## Conclusion and Perspectives

Using multiple tools to study an air bubble plume offers a deeper insight into its dynamics.

Greater accuracy could be achieved by considering the interaction between plume and seawater

DNS have been realized with in-house code ARCHER



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- [2] Solsvik, J., Jakobsen, H. A. (2015) « The Foundation of the Population Balance Equation : A Review ». Journal of Dispersion Science and Technology, 36:4, 510-520
- [3] Friedl, M. J., Fanneløp, T. K. (2000) « Bubble plumes and their interaction with the water surface ». Applied Ocean Research, 22, 2