

# I-DUST 2010 Session A : Geophysics 1

## ORGANISATION OF THE FLOWS IN THE UNSATURATED ZONE

### Preliminary results

## FONTAINE DE VAUCLUSE – LSBB KARST SYSTEM, South-East of France



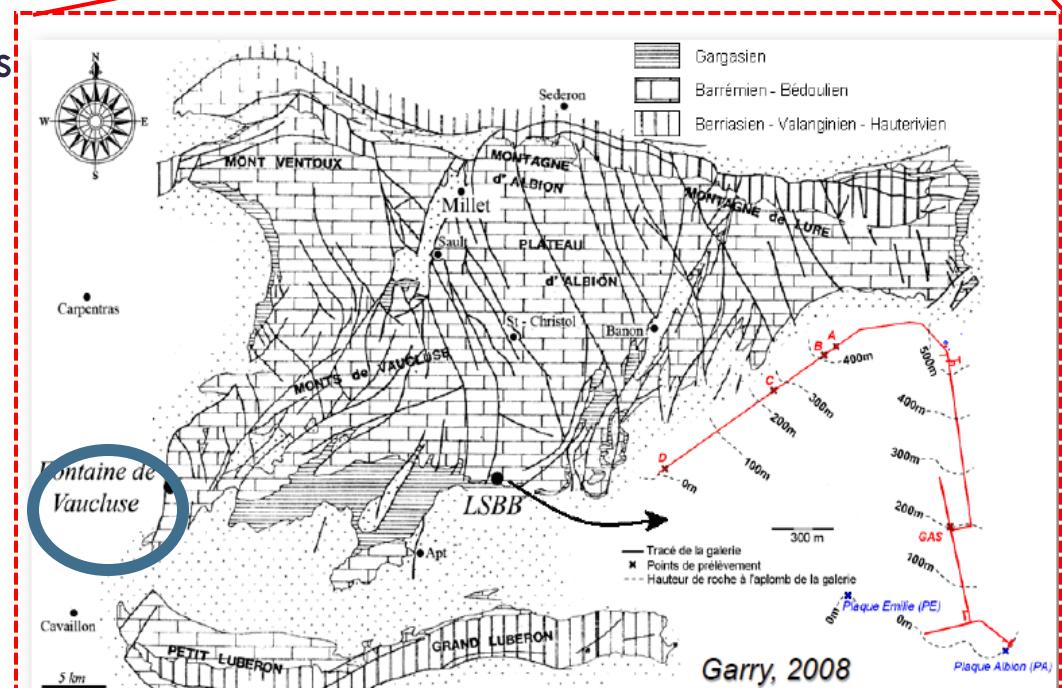
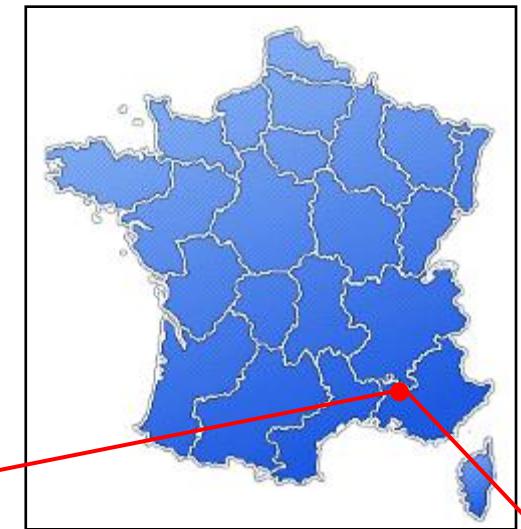
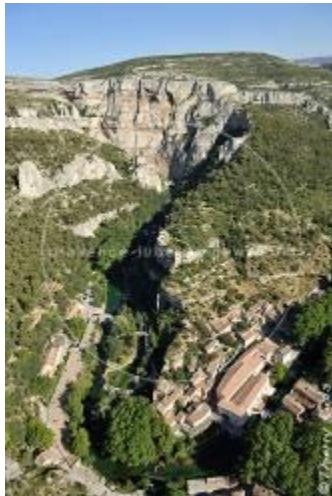
**Aurore PERINEAU, Christophe EMBLANCH, Charles DANQUIGNY**

**[aurore.perineau@etd.univ-avignon.fr](mailto:aurore.perineau@etd.univ-avignon.fr)**  
(UMR EMMAH INRA UAPV)

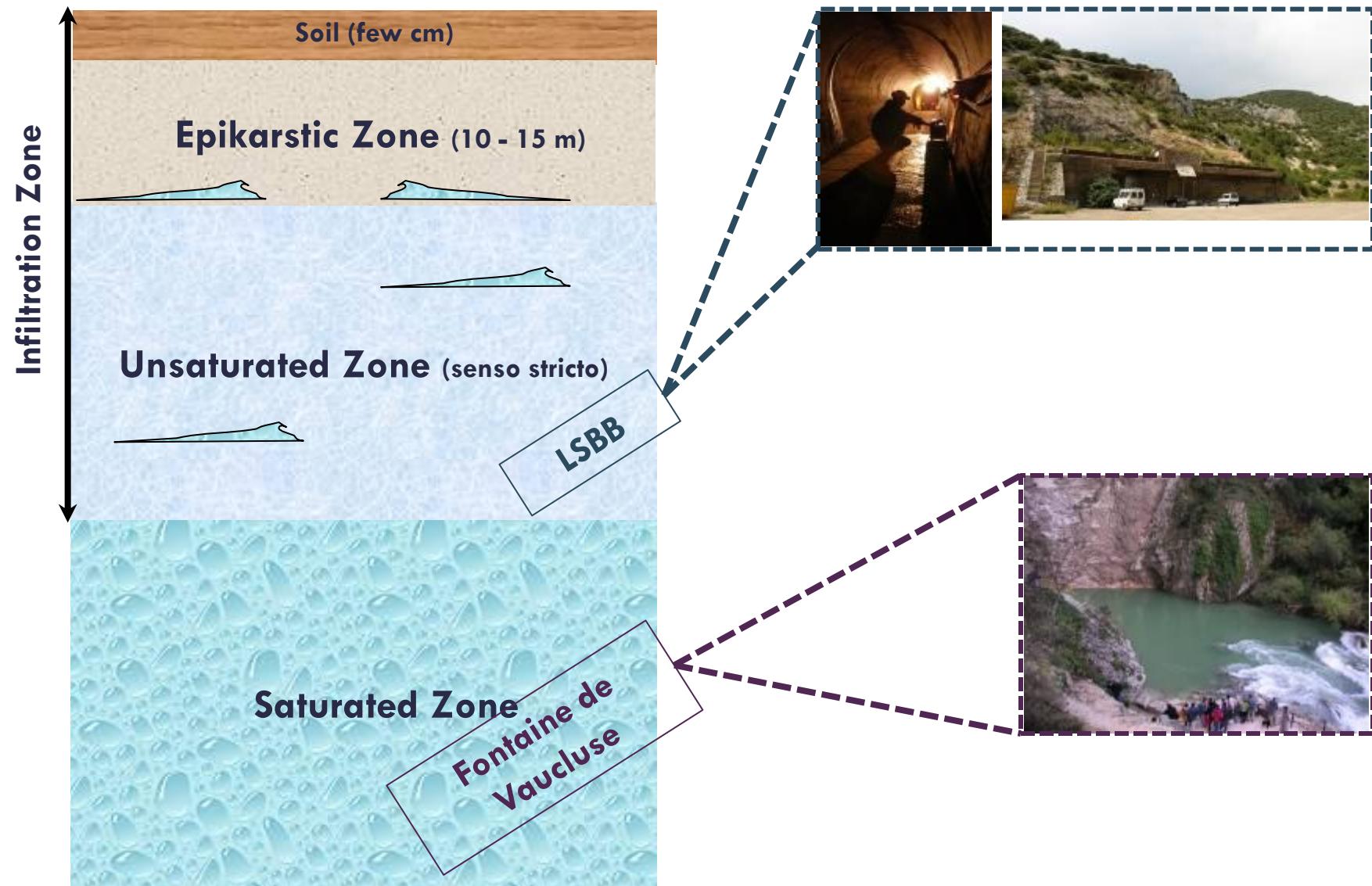
# RESEARCH AREA

## Fontaine de Vaucluse

- Location : South-East of France
- Karst aquifer
- Catchment area ~ 1 130 km<sup>2</sup>
- Unsaturated Zone ~ 800 m thick
- Saturated zone > 300 m thick
- Mean discharge flow rate ~ 19 m<sup>3</sup>/s  
(between 1970 and 2006)



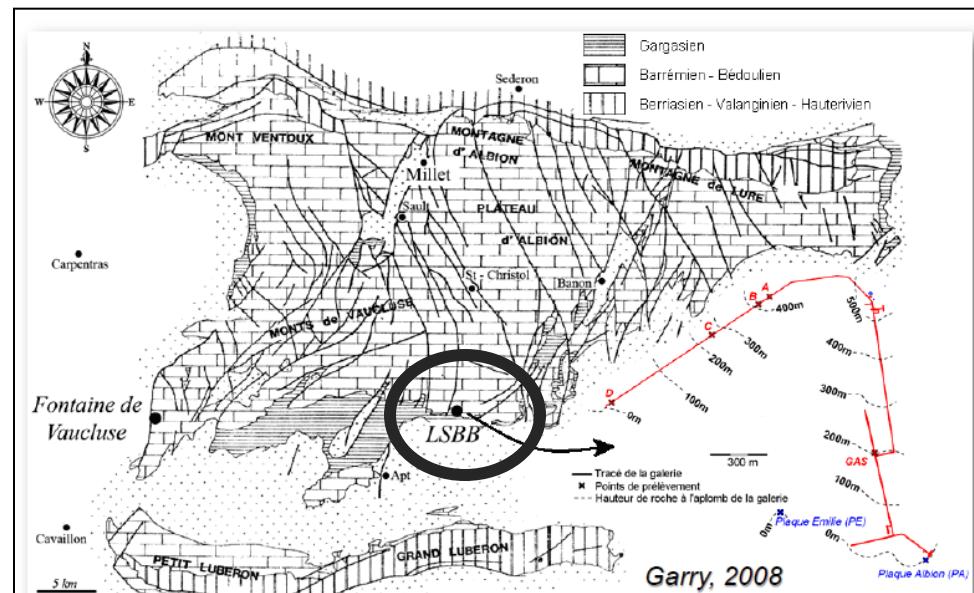
# Fontaine de Vaucluse



# Low-noise Inter-Disciplinary Underground Laboratory Science & Technology, Rustrel



- Drilled in the unsaturated zone:  
random intersection between gallery and karstic drains
- Surface                           ~ 12 000 m<sup>2</sup>,
- Length                           ~ 3.7 Km
- Mean altitude                   ~ 700 m,
- Depth                           ~ 30 to 500 m



# RESEARCH AREA

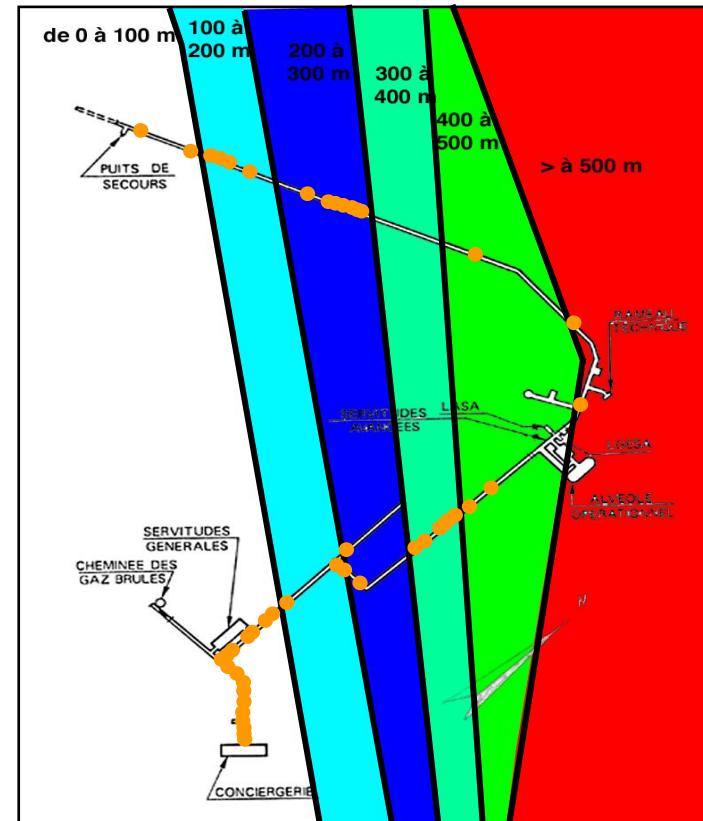
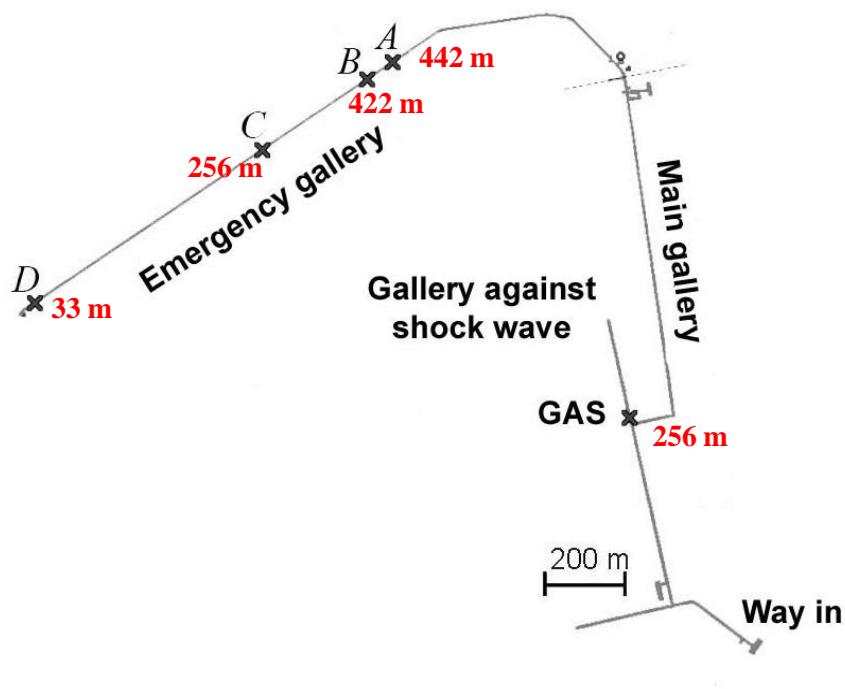
## Low-noise Inter-Disciplinary Underground Laboratory Science & Technology, Rustrel

4 permanent flows  
since **2002, February**

1 temporary flow  
since **2002, may**

+ 48 temporary flows  
since **2008, october**

+ 8 temporary flows  
since **2009, december**



**61 flows detected and sampled**

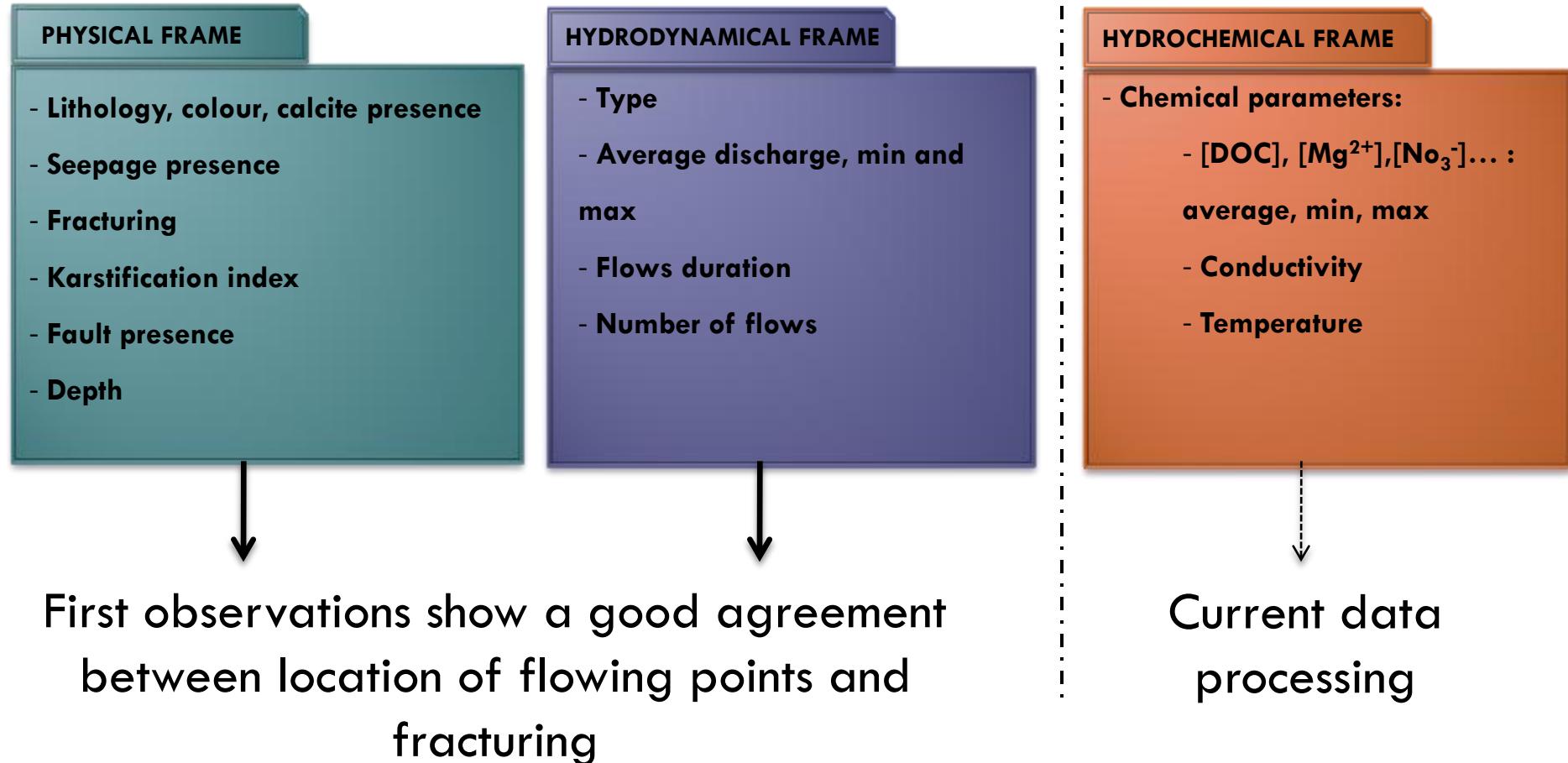
## Low-noise Inter-Disciplinary Underground Laboratory Science & Technology, Rustrel

- **Sampling:**

- More than 7 hydrological cycles (> 4500 samples)
- Field data:
  - pH
  - Conductivity
  - Temperature
  - Discharge
- Laboratory chemical analysis:
  - Major ions quantification
  - Dissolved Organic Carbon
  - Isotope:  $^{18}\text{O}$

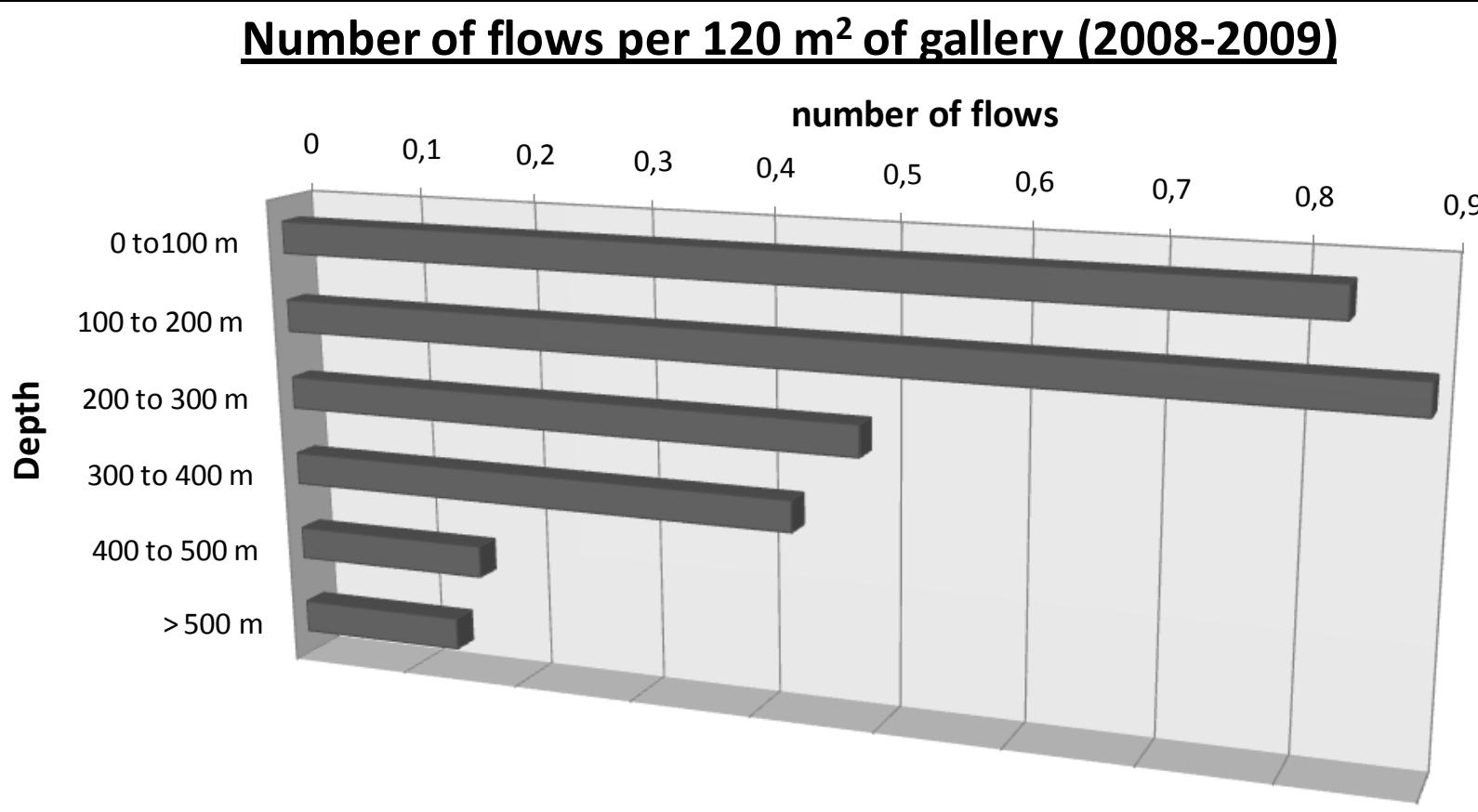
# RESEARCH AREA

## Low-noise Inter-Disciplinary Underground Laboratory Science & Technology, Rustrel



## Results about hydrodynamics data

### Number of flows per 120 m<sup>2</sup> of gallery (2008-2009)

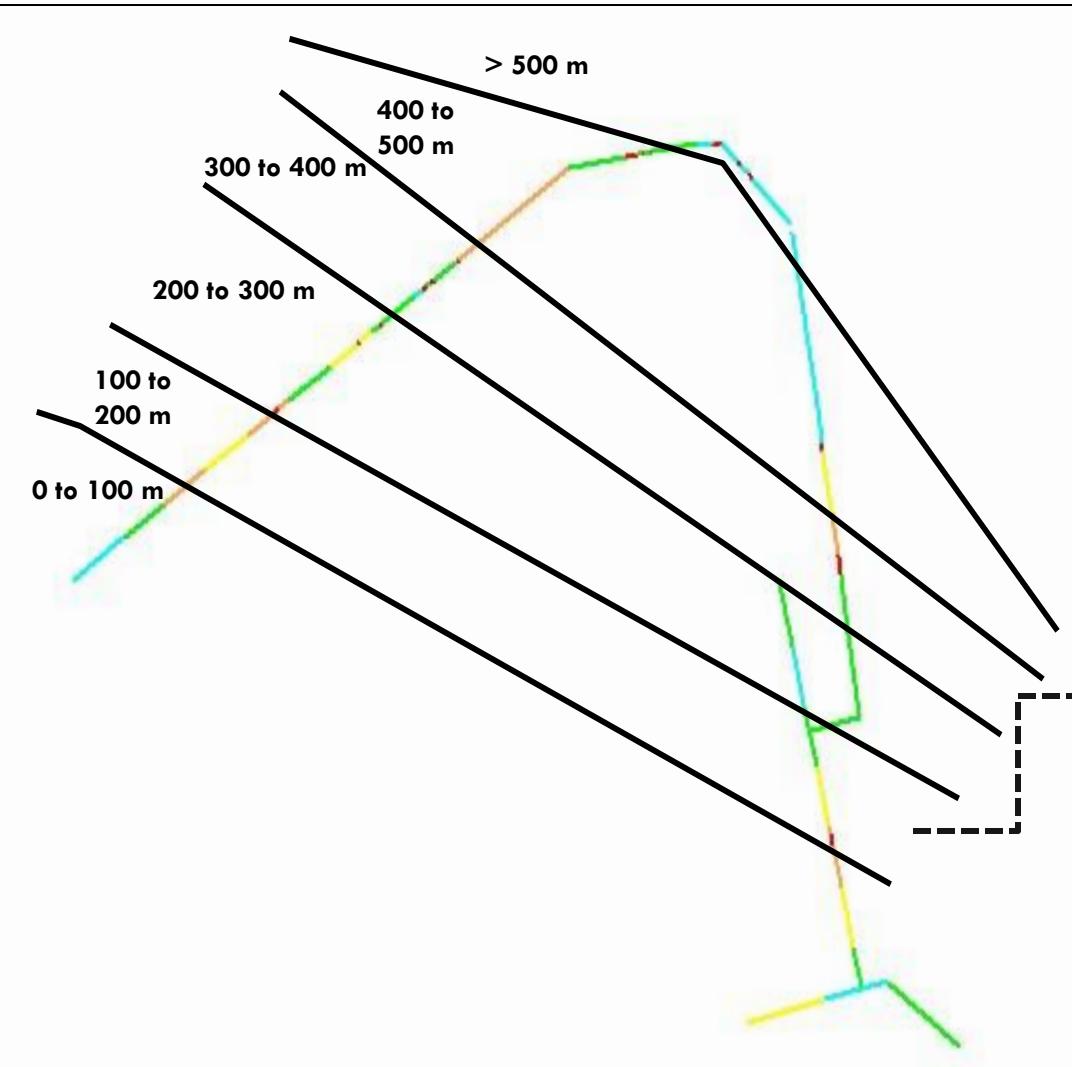


## 3 hypothesis:

- Representativeness of the sampling?
- Hierarchical organisation of the flows is a function of the depth
- 400 to > 500 m area: little fractured area (military strategic requirement)

# Results about hydrodynamics data

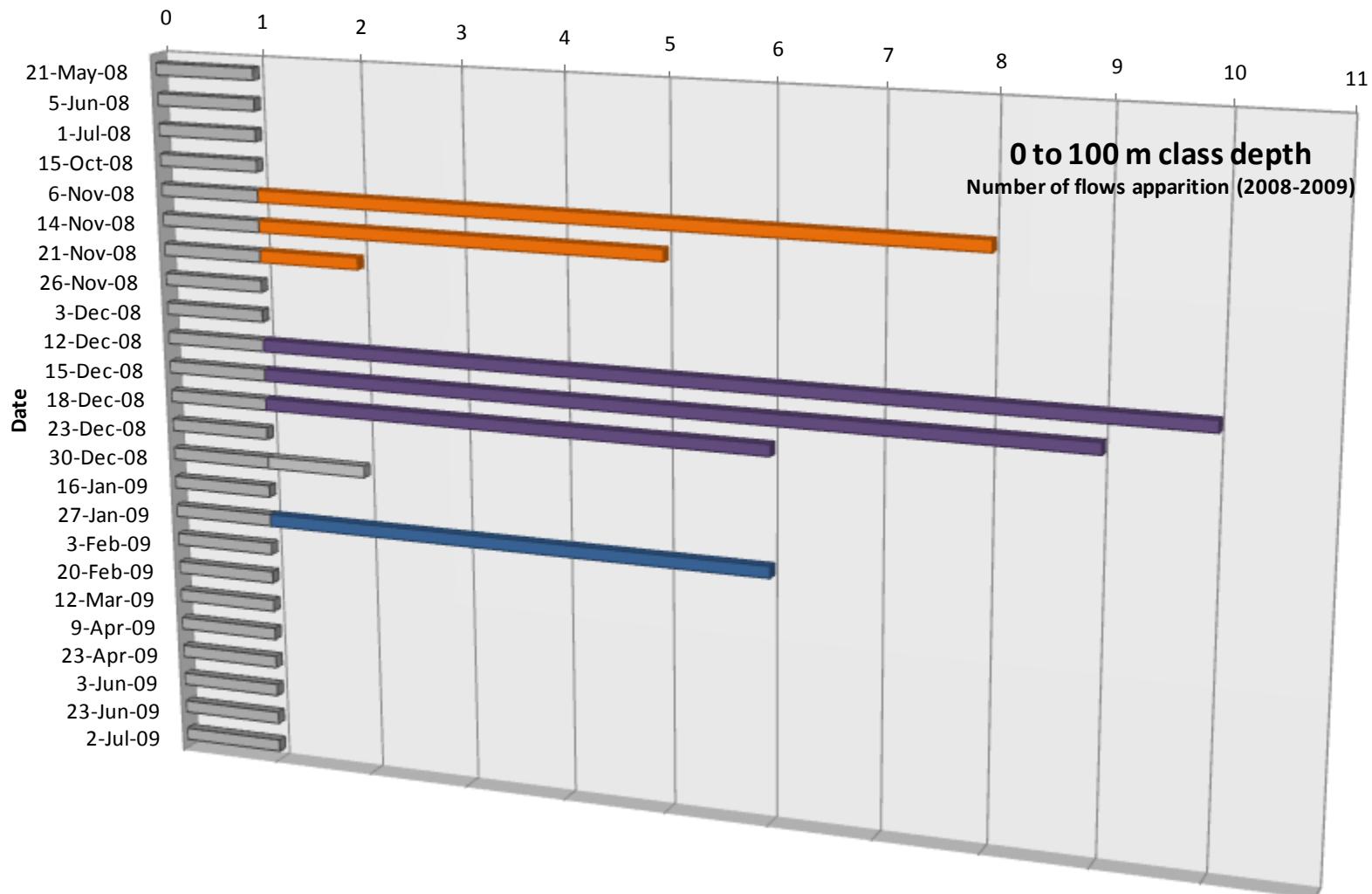
Can the sampling be representative?



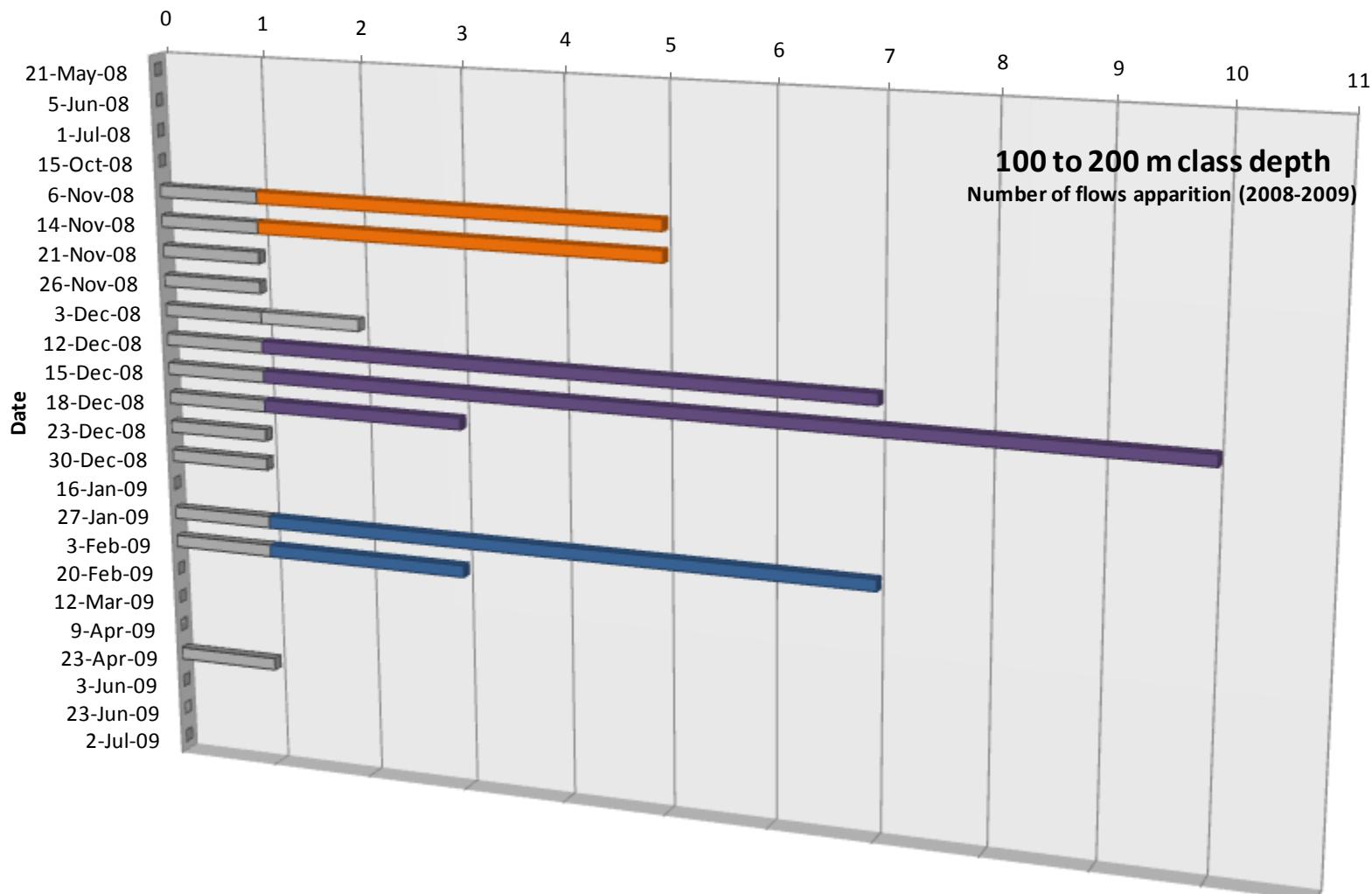
	0 -100 m	100-200 m	200 - 300 m	300 - 400 m	> 400 m
total flow rate (l/min)	20.96	50.17	26.06	13.98	34.34
surface %	24.00	15.70	14.50	14.00	31.80
flow rate per surface unit	0.87	3.20	1.80	1.00	1.08

(2008-2009)

- crushed area
- 35 to 45 faults/100 m
- 25 to 35 faults/100 m
- 15 to 25 faults/100 m
- 5 to 15 faults/100 m

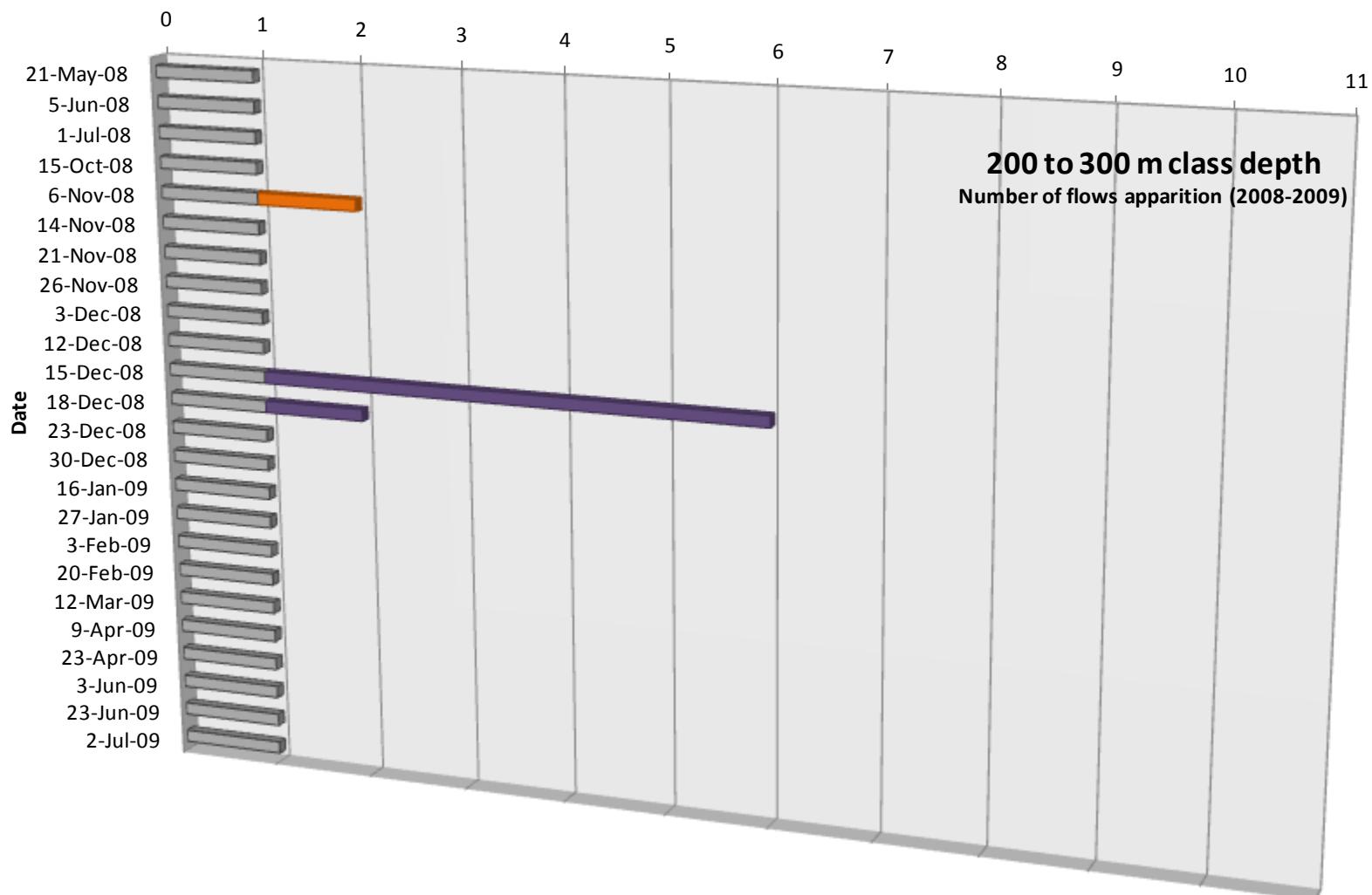


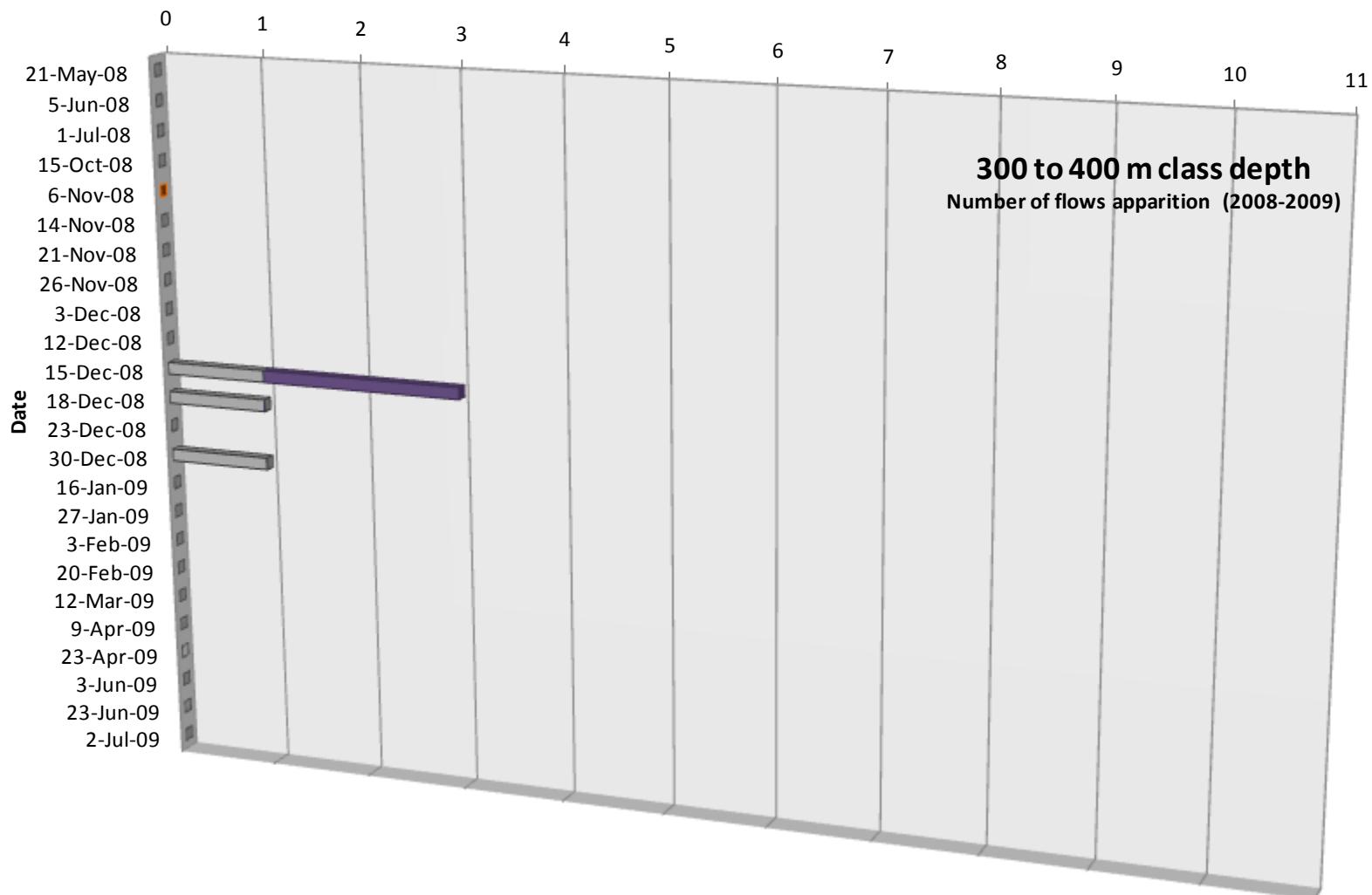
Infiltration Front in the system : qualitative approach



# PRELIMINARY RESULTS

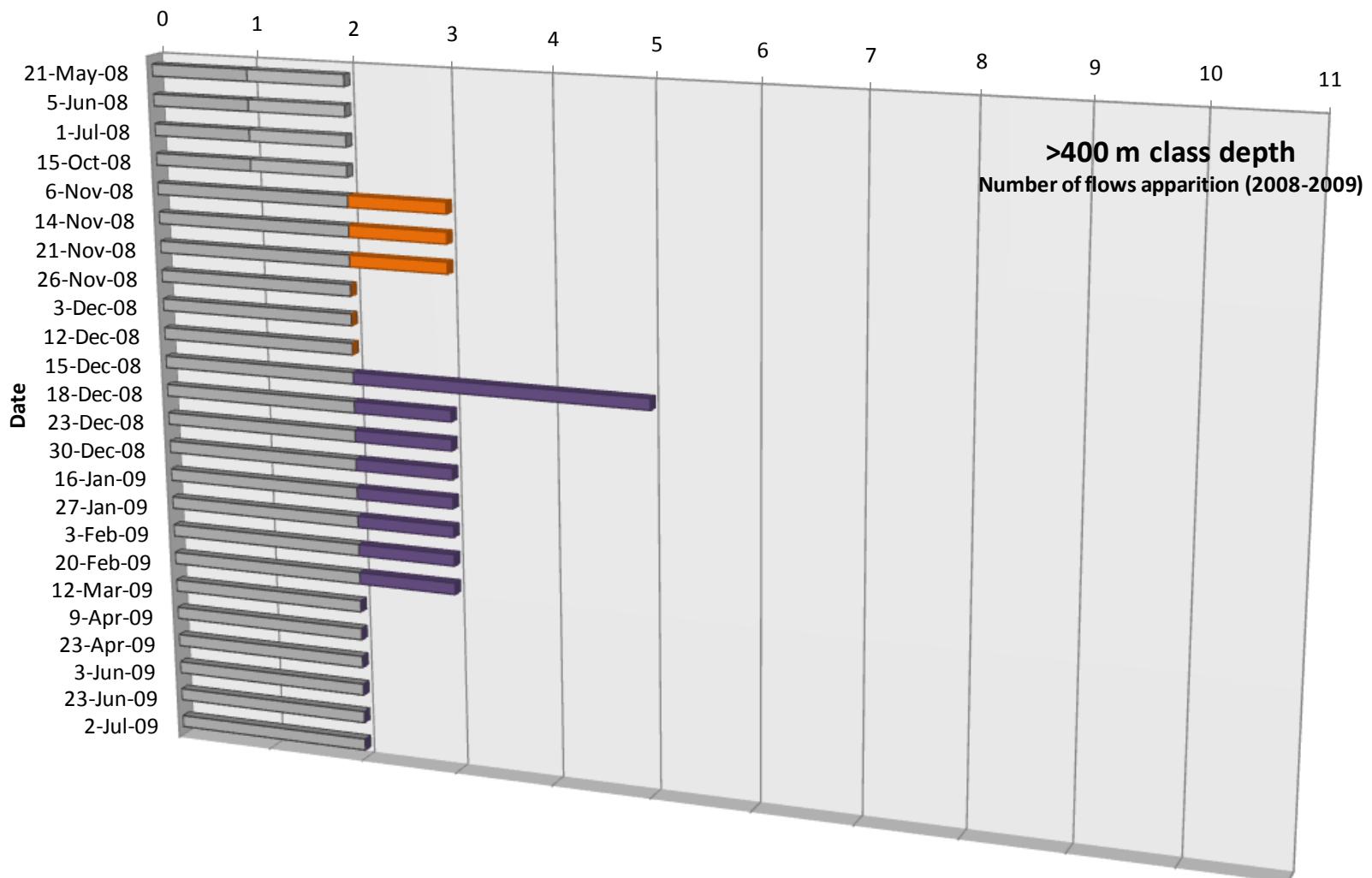
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# PRELIMINARY RESULTS

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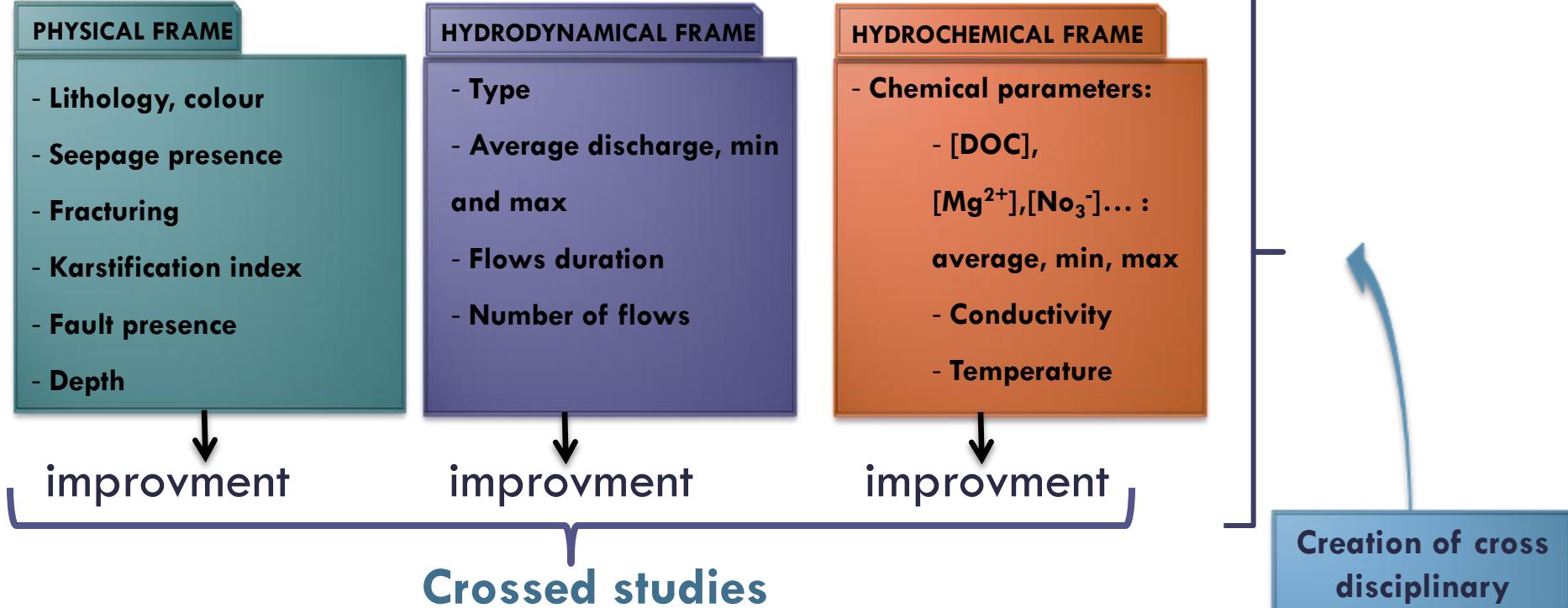
## Hydrodynamic of flows : quantitative approach

range (m)	0 - 100	100 - 200	200 - 300	300 - 400	> 400
total flow rate (l/min)	21.0	50.2	26.1	14.0	34.3
number of flows	20	14	7	6	5
ratio	1.05	3.58	3.72	2.33	6.87

## Conclusions

- **Sampling is « representative »**
  - Number of flows per surface unit is quite homogeneous
  - Explanation of its variability with physical frame
- **Flows organisation**
  - Spatial distribution of points
  - Flows clustering with « depth »
  - Flow rate scattering with « depth »
- **Discussion: Can depth be the key parameter?**
  - Variation of other parameters, e.g. density of fracturation,
    - within the classification?
    - vs. depth?

## To go forward:



- Seismic and electromagnetic imaging methods
- New statistical approaches, “mathematical”