

Review of manuscript:

Intermittent heat instabilities in an air plume

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General comments

This paper presents a novel plume experiment which dimensions are not the typical ones. The presented experiment is very interesting and original because it is between the laboratory and the real geophysical situations. It is clearly stated by the authors that they experimental results agree with the classical model of Morton et al. (1956). The paper studies the heat instabilities of the plume dynamics which behaviour is not well understood and it is an important topic for industrial and geophysical situations. The authors of this work propose to examine the dynamical behaviour of these instabilities and they clearly show that the instabilities have an intermittent character which is presented by means of different kind of figures. The researchers establish that this dynamics is a universal feature of turbulent plumes in geophysical environments and it could be represented by a smooth spatial function with a global temporal intermittent function. Related to this question, the authors should explain better what is their objective at introduction, at sections 5 and 6 (conclusions). It should be better to introduce a basic description of heat instabilities and intermittency (at introduction). The authors should explain better how their results are important implications for geophysical or industrial situations.

This paper should undergo a minor revision before being considered for publication.

Specific comments

Sub-Section 2.1. The Vincennes quarry

- **Page 2, Lines 23-24.** What is the reason for the temperature increase of about 0.1°C per year? Why it is different from the annual variation (0.8 °C)?
- **Page 2, Lines 29.** You speak about the exceptional conditions of stability. How do you characterize and measure this stability? At this point, I understand that is stable stratified but do you mean that the air of the quarry has a stable stratification or a neutral one?
- **Page 3, Lines 2-5.** You speak about the air exchanges. What is the effect of natural ventilation on stratification of the quarry air?
- Could you also explain in more detail the effect of the quarry walls and ceiling on your experiment and your results?

Sub-Section 2.3. Configuration of the measurement device of the experiment

- **Page 4, Lines 2.** This is the first time you mention the screen (“*and that of the screen*”). Therefore, you must explain here what the screen is. This explanation is written in lines 14-15: “*To study the possible contribution of sideways radiations, a screen was placed around the source in 15 experiments A3, A5-A7 (Table 1)*”. Eliminate these lines and write this explanation in line 2.
- **Page 4, Line 9.** You write that “*Most of the heating experiments (.....) lasted for 24 hours*”. Explain how such 24 hours experiments affect on the stratification of the room. Has the heating source of power 100 W been switched on during the 24 hours experiments or only some hours, minutes? The time that the heating source is on, could it have some effect on the plume behaviour?

Sub-Section 3.1. The horizontal recordings at 1.00 m

- Sensor 7 is symmetrically placed with respect to the sensor 5. Why their measures are different (figure 3, for example).
- **Page 5, Line 9.** You write “*These heat pulses of instability should not be taken as physical drops of air observed at a given time*”. Do you think there is a relation between these pulses and the continuous or intermittent hot air supply (it depends on whether the heat source is turned on all the time).

Sub-Section 3.5. Joint study of the various time series

- **Page 6, Line 21.** Why the threshold is 12 minutes?

Section 4. Averaged temperature profiles

- **Page 7, Line 1.** Change this sentence “*temperature radial profile*” by the following “*radial temperature profile*”.
- **Page 7, Line 13.** Change this sentence.
- **Page 7, Line 17.** How do you calculate the mean of Θ in the section of the plume at the 1-meter altitude because figure 3b does not exist.
- **Page 7, Line 25.** Eliminate the word “*Remark:*”
- **Page 7, Lines 25 to the end of the section 4.** I think that this paragraph could be placed at the beginning of the section as an objective and to clarify the development of the section 4.

Section 5. Some global characteristics of the plume dynamics

- **Page 8, Lines 13-18.** You do not write the values of the sub-index j . For me, it is not clear the meaning of the subscript: does i represent the different sensors and j the different heights? If it is so, I do not understand equation (8). Therefore, does i and j represent the different sensors?
- **Page 8, Lines 13-18.** If equation (9) is an extrapolation of equation (8), you say that at every height z it verifies equation (8) and subscript i is not z . Therefore, the constant parameters a_{ij} are transformed into functions that depend on the radial coordinate. Could you explain and justify better this extrapolation?

Section 6. Discussion and conclusions

- **Page 9, Line 8.** The title of your work is related to instabilities but it is necessary to speak more about it. Could you explain better what kind of

instabilities (already known or new ones) are you studying? What aspects of these instabilities are described and clarified by your experiments?

- Do you think there is some relationship between the instabilities you see/measure and the meandering phenomenon, which appears in geophysical situations under stable conditions?
- **Page 9, Line 30-32.** One of their major contributions is to propose a first order factorization of the spatial and temporal variations. Highlight this aspect and develop it.

Technical comments

- Use units in seconds, not minutes.

Section 1. Introduction.

- **Page 2, Lines 4 to 7.** The text is repeated, it is just the same that at the beginning of the Introduction. You have to eliminate lines 4 to 7.

Section 2.1. Vincennes quarry.

- It would be interesting to add a photograph of the quarry (in Figure 1).

Section 2.2. Temperature measurements. Thermistors. Calibration.

- Change the name of the section (use a phrase, for example “Temperature measurements by thermistors”).
- **Page 3, Line 18.** Change “section II.3” to “section 2.3” because your notation is “2.3 Configuration of the measurement.....”.
- **Page 3, Line 16.** Rewrite the expresión

$$T^I = A + B \ln R + C (\ln R)^2,$$

because the superindex of T is not clear.

Section 3. Results: Temperature fluctuations in the plume.

- **Page 4, Line 18.** Eliminate the notation “ch1, ch2, ... ,ch10” because you do not use it again. Write “by 10 sensors” and add a reference to a figure.
- **Page 4, Line 18.** Why do not you order the names of the experiments: A5a, A5b, A6a, A6b, A7a and A7b? Why do not you mention experiment A4?

Section 3.1. The horizontal recordings at 1.00 m.

- **Page 4, Line 27.** You mention that “Figure 3 shows the ...temperaturefrom 12:00...to 16:00..” but, really, is 14:00.

Section 3.2. The horizontal recordings at 1.50 m.

- Change “section III.1” to “section 3.1” because your notation is “3.1 The horizontal recordings at 1.00 m”.

Section 3.4. AIII device maintained vertically.

- **Page 6, Line 10-11.** Eliminate the definition of t_k ($t_k = t_0 + 20k$) in line 11 and write it in line 10.

Section 3.5. Joint study of the various time series.

- **Page 6, Line 18.** Order the names of the experiments as (A5a, A6a, A7a)

Section 4. Averaged temperature profiles.

- **Page 7, Lines 5-6.** Are necessary the quotation marks at the following phrase: “No velocity scale is provided by the specification of a free convection situation”.
- **Page 7, Line 9.** Change the notation of the upward vertical unit vector to k .
- **Page 7, Lines 17.** Change “m²; from” to “m². From”.
- **Page 7, Lines 17.** Figure 3b does not exist.

Section 5. Some global characteristics of the plume dynamics

- **Page 8, Line 4.** Change “section IV” to “section 4” because your notation is “4. Averaged temperature profiles”.
- **Page 8, Line 18.** Rewrite the sentence. Write “ a_{ij} being (constants) parameters” at the beginning of the phrase. Change the sentence “taking $j = 5$ of the sensor seeing the large variations”.
- **Page 8, Line 19.** Why do you change the coefficient a_{i5} to b ?
- **Page 8, Line 22.** Eliminate the phrase “en bloc” and rewrite the phrase.

Section 6 Discussion and conclusions

- **Page 10, Line 4.** Change the reference (*Hernandez et al., 2015*) to (*Hernandez, 2015*).

References

Revise all the bibliographic references because the following references are not cited in the text:

- Carazzo, G., Girault, F., Aubry, T., Bouquerel, H., and Kaminski, E.: *Laboratory experiments of forced plumes in a density stratified crossflow and implications for volcanic plumes*, *Geoph. Res. Lett.* **41**: 8759–8766, 2014.
- Carazzo, G., Kaminski, E., and Tait S.: *The route to self-similarity in turbulent jets and plumes*. *J. Fluid Mech.* **547**: 137–148, 2006.
- Fischer, H. B., Imberger, J., List, E. J., Koh, R. C. Y., and Brooks N. H.: *Mixing in inland and coastal waters*. *Academia Press, New York, United States*. 483 p., 1979.
- George, W. K. Jr., Alpert, R. L., and Tamanini, F.: *Turbulence measurements in an axisymmetric buoyant plume*. *Int. J. Heat Mass Transfer* **20**(11): 1145–1154, 1977.
- Guyon, E., Hulin, J.-P., Petit, L., and Mitescu, C.D.: *Physical Hydrodynamics (2nd ed.)*. *Oxford University Press, Oxford*, 536 p., 2015.
- Kaminski, E., Tait, S., and Carazzo, G.: *Turbulent entrainment in jets with arbitrary buoyancy*. *J. Fluid Mech.* **526**: 361–376, 2005.
- Morat, P., Le Mouél, J.-L., Poirier, J.-P., and Kossobokov, V.: *Heat and water transport by oscillatory convection in an underground cavity*. *C. R. Acad. Sci. Paris* **328** (1): 1–8, 1999.
- Tritton, D. J.: *Physical Fluid Dynamics*. *Clarendon Press*, 544 p, 1988.

You mention the following reference (Crouzeix et al., 2006) in the text but you write three different papers which have the same reference:

- Crouzeix, C., Le Mouél, J.-L., Perrier, F., Shnirman, M. G., and Blanter E.: *Long-term persistence of the spatial organization of temperature fluctuation lifetime in turbulent air avalanches*. *Phys. Rev. E* **74**, 036308, 2006. Are these the right page?

- Crouzeix, C., Le Mouël, J.-L., Perrier, F., and Richon, P.: *Non-adiabatic boundaries and thermal stratification in a confined volume. Int. J. Heat Mass Transfer* **49**: 1974-1980, 2006.
- Crouzeix, C., Le Mouël, J.-L., Perrier, F., and Richon, P.: *Thermal stratification induced by heating in a non-adiabatic context. Building and Environment* **41** (7): 926–939, 2006.

If you mention the three papers in the text, distinguish them with different references, something like (Carazzo et al., 2006(a), (b), (c)).

Tables

- **Table 1.** Explain the meaning of the signs - and + related to source raised and screen in the table caption.
- **Table 2.** Express all in seconds, not in minutes, as in Table 1.
- **Table 2.** The meaning of the column “ $max(\Delta t)$, s” is not explained in the table caption.

Figures

- **Figure 2.** Explain the meaning of the numbers “1, 2, 3, ...,10” in the table caption. Also explain what is the screen and the meaning of AI, AII, AIII and S. The reason is that when figure 2 is mentioned, these concepts have not yet been explained.
- **Figure 3.** Explain the meaning of “Ch1, Ch2,...Ch10” in the table caption.
- **Figure 6.** Explain the meaning of “T1, T2,...T10” in the table caption. Is T1 the same instrument that Ch1, and so on? If they are, use the same notation in all figures: Ch1 or T1.
- **Figure 8 and 9.** As in Figure 6.
- **Figure 9.** Rewrite the information related to dates and hours (*the periods 2003/04/21 18:54:52-2003/04/21 (upper plate) and 2003/04/22 04:12:52-2003/04/22 05:52:52*) because it is a bit confusing.
- **Figure 13.** Change “A5a, A7a, A6a and A3 experiments” to “A3, A5a, A6a and A7a experiments”.