

Paper 16.6

Lagrangian Analysis of passive tracers dispersion in a confined convective flow

by

Stefania Espa*, Giorgio Querzoli**

*Dipartimento di Idraulica, Trasporti e Strade
Università "La Sapienza", Via Eudossiana 18, 00184-Roma, Italy

**Dipartimento di Ingegneria del Territorio
Università di Cagliari, P.zza d'Armi, 1 90123-Cagliari, Italy

ABSTRACT

Lagrangian motion in a quasi-two dimensional time dependent, convective flow is studied at different Rayleigh numbers (Ra). Convective motion is generated in a rectangular tank by a linear heat source placed 0.4 cm above the lower surface of the tank. Lagrangian trajectories (Fig.1) have been evaluated using PTV technique. An intermediate regime characterised by an almost periodic Eulerian flow is observed. The flow consists mainly of two counter-rotating rolls divided by an ascending thermal plume above the heat source. The upper end of the plume oscillates horizontally with a frequency which increases with Ra . It is known that Lagrangian motion of particles in a time-dependent flow can be very complex due to chaotic advection even if the Eulerian flow is laminar and regular in an Eulerian viewpoint (?). As a matter of fact, the non-autonomous one-degree of freedom Hamiltonian system of the equation of motion can not be trivially integrable. Dispersion phenomena occurring in the tank are investigated in a Lagrangian framework by using different statistics on particle displacements. One particle and two particle approaches have been considered. The classical way of looking at diffusive properties by computing average separation at fixed time is compared with an alternative measure known as *Finite Size Lyapunov Exponent* (FSLE) consisting in the evaluation of average separation time at fixed scale. The impact of an increasing forcing on the system and the corresponding dependence of Lagrangian statistics on Ra have been investigated varying this parameter by increasing the power supplied to the heat source (Table I).

The obtained results can be generalised to many geophysical problems allowing us to discuss about the right way of describing spreading of pollutants in closed basins characterised by a not sharp separation between the scale of the velocity field and the dimension of the domain.

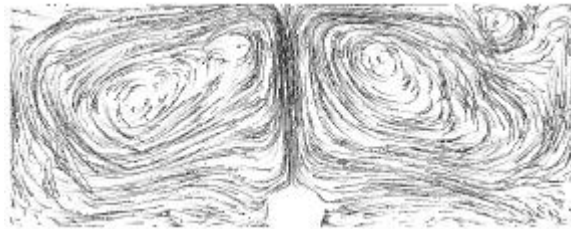


Figure1 Recognised trajectories during 100 frames of their evolution

Table I Parameters related to the performed runs.

| $Q(W/m)$ | $\alpha(m^3/^\circ C)$ | $u(m^2/s)$ | $k(m^2/s)$ | $I(J/m \cdot s \cdot ^\circ C)$ | Ra | $Ra Pr$ |
|--------------------|------------------------|-----------------------|-----------------------|---------------------------------|--------------------|---------|
| 0.96×10^1 | 2.53×10^{-4} | 8.85×10^{-1} | 1.44×10^{-1} | 6.03×10^{-1} | 6.87×10^1 | 6.14 |
| 1.44×10^1 | 2.60×10^{-4} | 8.83×10^{-1} | 1.44×10^{-1} | 6.03×10^{-1} | 1.03×10^8 | 6.13 |
| 3.36×10^1 | 2.58×10^{-4} | 8.87×10^{-1} | 1.44×10^{-1} | 6.02×10^{-1} | 2.39×10^8 | 6.16 |
| 7.93×10^1 | 2.65×10^{-4} | 8.72×10^{-1} | 1.44×10^{-1} | 6.04×10^{-1} | 5.96×10^8 | 6.04 |
| 1.17×10^2 | 2.32×10^{-4} | 9.44×10^{-1} | 1.42×10^{-1} | 5.98×10^{-1} | 7.19×10^8 | 6.61 |
| 2.15×10^2 | 2.81×10^{-4} | 8.38×10^{-1} | 1.42×10^{-1} | 6.06×10^{-1} | 1.74×10^9 | 5.77 |
| 2.80×10^2 | 2.72×10^{-4} | 8.56×10^{-1} | 1.44×10^{-1} | 6.05×10^{-1} | 2.17×10^8 | 5.92 |