# Exploratory Temporal-Spatial Analysis of Influenza Epidemics in France, 1985-2000

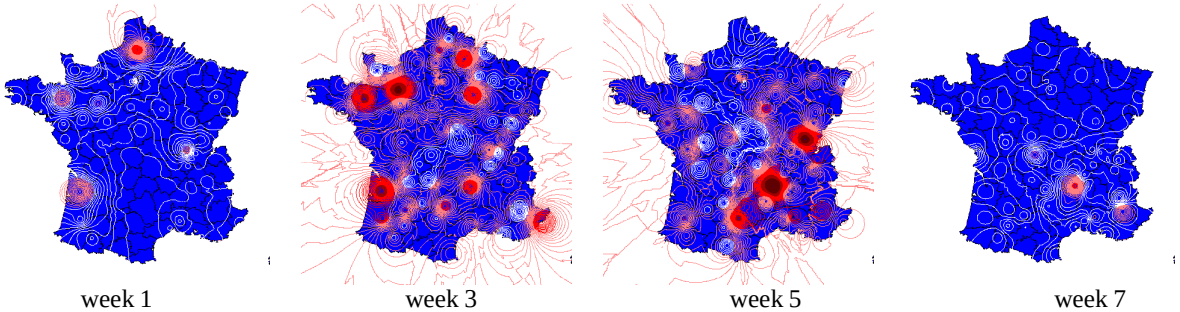
**M.Prou**[1], **A.Long**[2,3], **M.Wilson**[2], **G.Jacquez**[3], **H.Wackernagel**[1], **F.Carrat**[4]

[1]*Ecole des Mines de Paris, Paris, France*
[2]*University of Michigan, USA* [3]*BioMedware, Ann Arbor, Michigan, USA*
[4]*INSERM U1444, Paris, France*

Influenza is the last of the « classic plagues » of the past that has yet to be brought under control. Effective control strategies may ultimately depend on greater understanding of the influenza viruses themselves, but also of the transmission dynamics of viruses. Since 1984 influenza-like morbidity data for France (incidences by week in each of the 94 French departments) has been assembled through the Computer Network for Surveillance of Communicable Diseases. Our objective with these data (incidences by week in each of the 94 French departments) is to better understand the spatial and temporal structure of influenza case dynamics in order to construct predictive models of the space-time path of epidemics once they begin.

## General behavior

The analysis of time series, temporal variograms and incidence maps enabled us to observe the temporal patterns of epidemics in departments, as well as the spatial spread of epidemics. In general, peaks of incidence occur each year in each department, but their beginning, duration, amplitude, and end vary from year to year and from one department to another, with no apparent consistency. It is also difficult to determine the apparent propagation of disease through space: it appears that local foci of transmission occur not exactly at the same time in several places, then they expand and spread to their neighboring areas, before decreasing.




Maps of incidence during the 1988-1989 epidemic (white is lowest, red greatest)

## Correlations between departments

Principal Component Analysis (PCA) and Multidimensional Scaling (MDS) were used to analyze the correlations between departmental time series, especially during epidemics. We observed that groups of departments that were close in PCA or MDS were also geographically close, suggesting that the epidemic behaviors are correlated with their spatial proximity. Furthermore, we also found that very populous but spatially distant cities such as Paris, Strasbourg, and Lyon were similar under PCA or MDS, suggesting that they follow the same trend despite geographic separation. We also measured the time delay between pairs of departments using cross-covariances of time series, and determined that there are “leading” and “following” departments at the scale of one epidemic, but not at the scale of several years.

Results are available on the Web: http://cg.ensmp.fr/~prou