Emergence and diffusion of HPAI (H5N1) in Thailand (2004-2008)

***ANR* ECOFLU Project**
***AiRD* ARDIGRIP Project**

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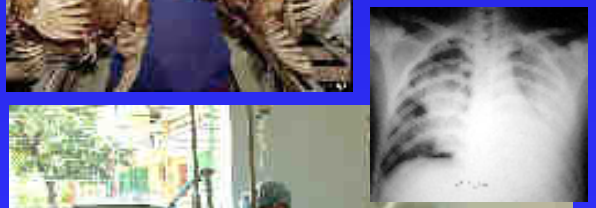
H5N1 Avian Influenza in Thailand



Dr Tran Tinh Hien

Presentation summary

Introduction

- Emergence and diffusion : many interrogations and hypothesis
- Methodology : Spatio-temporal analysis and GIS
- Projects granted (ANR, AiRD)

Data and methods

- Retrospective data
- Spatio-temporal emergence and diffusion reconstruction
- Spatial statistics
- Environmental correlations

Results

- Mapping
- Emergence
- Diffusion

Introduction

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Mapping
Emergence
Diffusion

Retrospective data analysis

Spatial analysis of retrospective data

► Finding factors and cofactors of emergence and diffusion processes of HPAI infection (farm level), using spatial location of infected farms and spatial relationship between infected farms

► Finding ecological and environmental characteristics or conditions of infected farms, in emergence and diffusion processes

Emergence, diffusion, extinction

Emergence

- Presence and persistence of the virus in environment ?
- Reservoirs and vectors: birds, snails, insects ?
- Silent phase ?
- Climate ? Vegetation ? Others ?
- Human behaviors, poultry trade, transportation system ?

Diffusion

- Wild fauna ?
- Agricultural practices
- Human and social behaviors, poultry trade, transportation system ?

Extinction and re-emergence

- Surveillance system evaluation, comparison with other countries ?

HPAI (H5N1) in Thailand: spatial analysis

Characterization of temporal and spatial patterns of diffusion for H5N1 infection in poultry

Randomness pattern ?
Correlation and probabilities for geographical factors ?
Cluster detection ? Cluster movement ?
Emergence definition and detection ?
Attraction/infectious pattern ?

Analysis of the evolution for AI foci in time and space

Speed, distances ?
Diffusion pattern (radial, waves, translation,…) ?

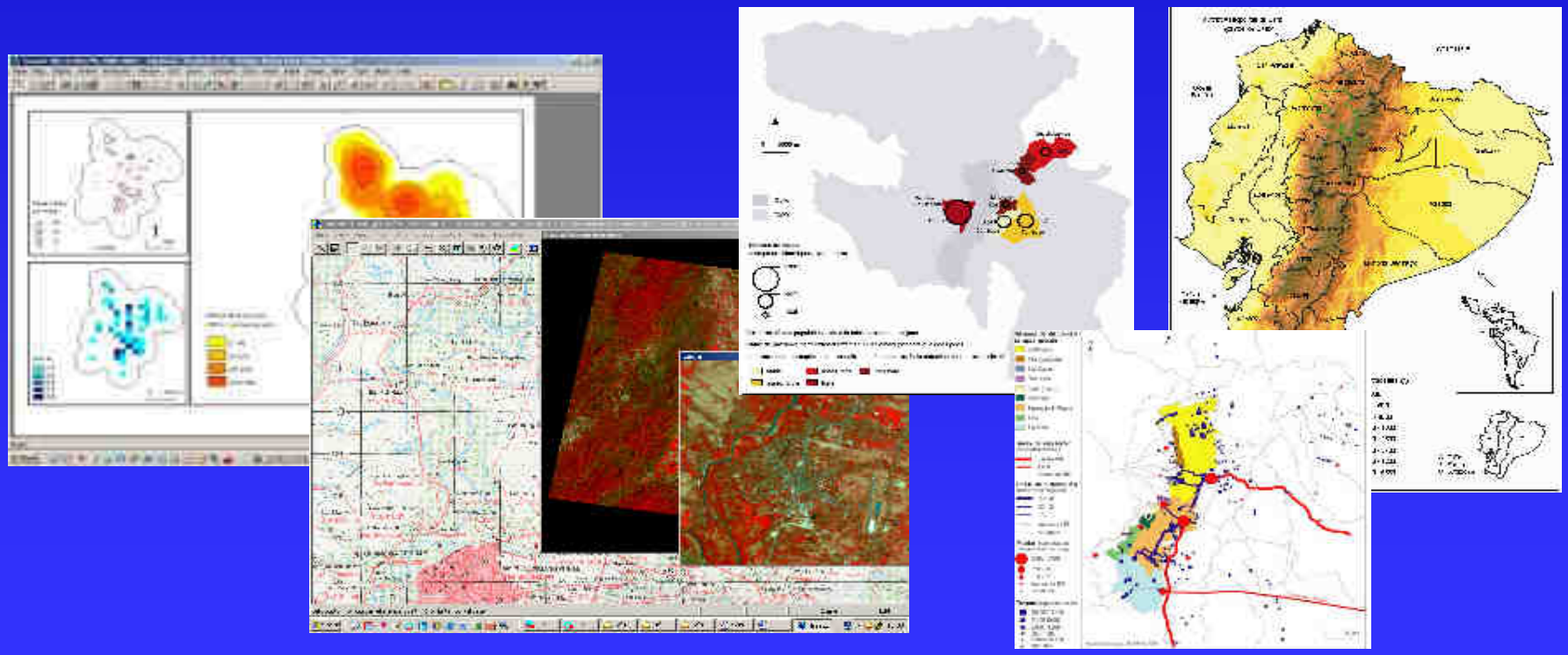
Witch geographical scale is the most appropriate for this study (district, sub-district, villages, farms) ?

A full GIS software for research and development

SavGIS

IRD
Institut de recherche pour le développement

Free download at www.savgis.org



Spatial Database management • Spatial queries • Spatial analysis • Geostatistics • Interpolations • Remote sensing • Cartography • Network analysis and Operation Research • 3D • Georeferencing • Digitalization • and more…

SavGIS

Funded Project

ECOFLU

Influenza Virus Ecology

Avian Influenza Virus in environment
Emergence and persistence conditions analysis to improve surveillance network
Project ANR 06 SEST 12 (2007-2009)

ARDIGRIP

Avian Influenza Emergence and Diffusion Modeling and Simulation

Modeling and Simulation:
Using characteristics of all entities (virus, animals, reservoirs, vectors , humans) and environmental real conditions to model emergence and transmission risk
Computer Science and Artificial Intelligence:
Developing spatial stochastic multi-agent modeling techniques in GIS
Project AIRD (2008-2010)

Data and Methods

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HPAI (H5N1) in poultry : epidemiological data source

► All surveillance and epidemiological data come from DLD (Department of Livestock Development, Ministry of Agriculture, Thailand)

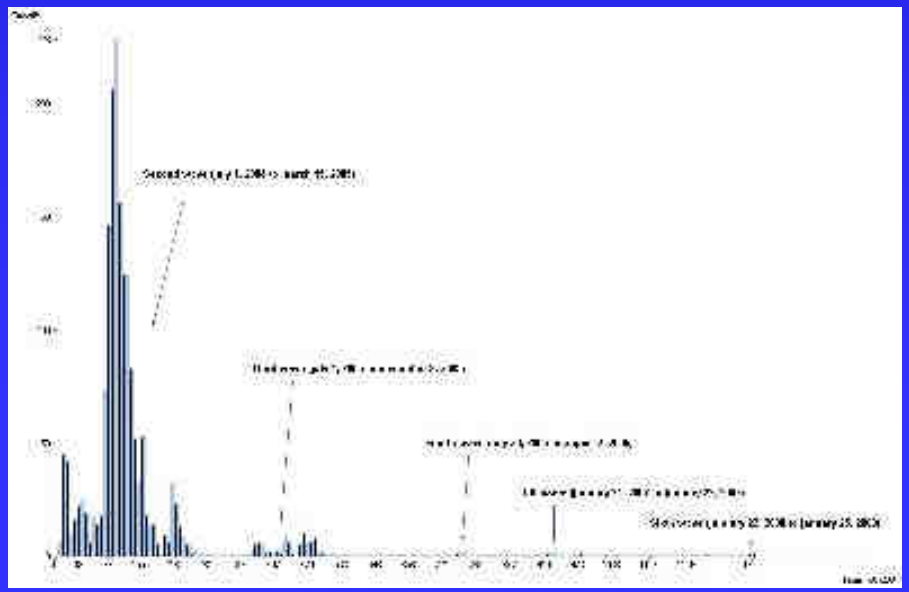
► DLD is in charge of the surveillance, laboratory tests, and information management for diseases in livestock

► Information is collected but not ready to use in GIS (no codification, no co-ordinates, quality of data is unknown). From July 2004 to January 2008, data available on the website of DLD, in Thai language

HPAI (H5N1) retrospective in Thailand

- Detected in Thailand in January 2004, after China, Japan, Korea, Vietnam, Laos, Cambodia, and disappear in April 2004 (first wave).
- Re-emerge in July 2004, until march 2005 (second wave).
- Re-emerge in July 2005, at very low level (third wave), until November 2005
- Only 3 foci in 2006 (July, August)
- Only 2 foci in 2007 (January)
- Only 4 foci in 2008 (January, December)

Total: 1805 confirmed foci



Thailand GIS database

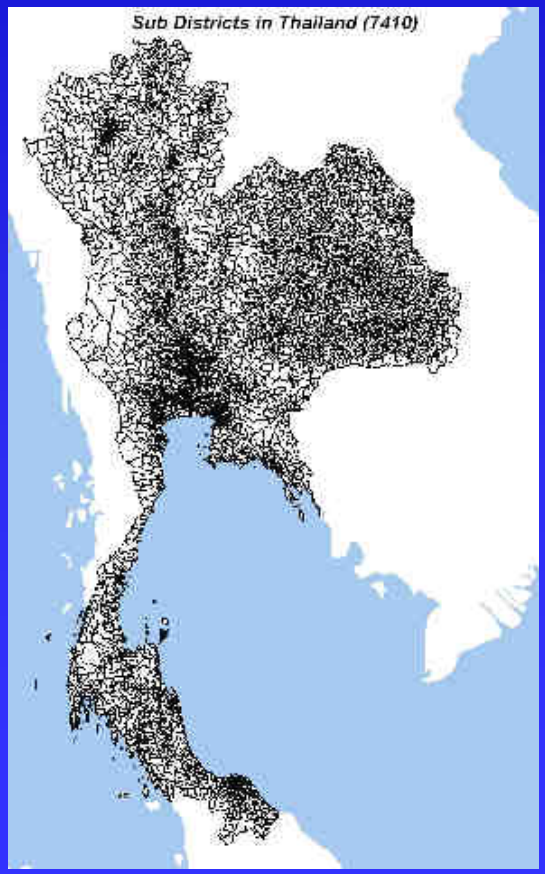
Large scale environmental GIS geodatabase, using aerial pictures, remote sensing, maps, geographical databases

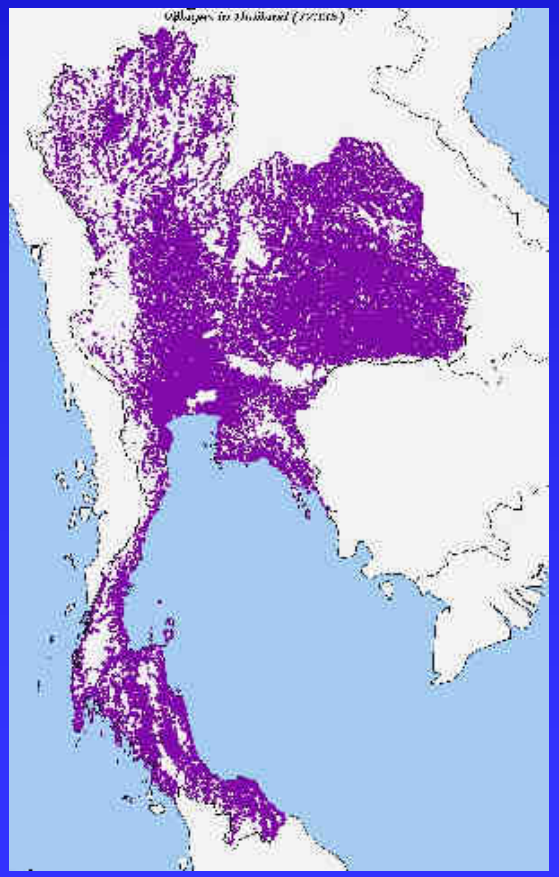
- *Land use*
- *Climate*
- *Topography*
- *Urbanizations, markets*
- *Water bodies*
- *Forest areas*
- *Infrastructure (road networks, migrations, etc.)*
- *Demography and socio-economic data (densities, behaviours)*
- *Etc.*

Thailand GIS database: example

- Administrative boundaries: districts, sub-districts, villages

Exact farm locations are not available for whole country

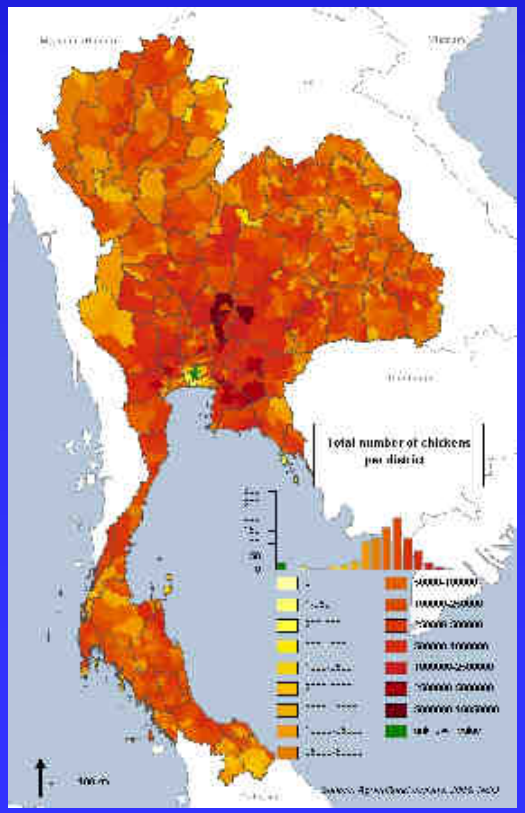


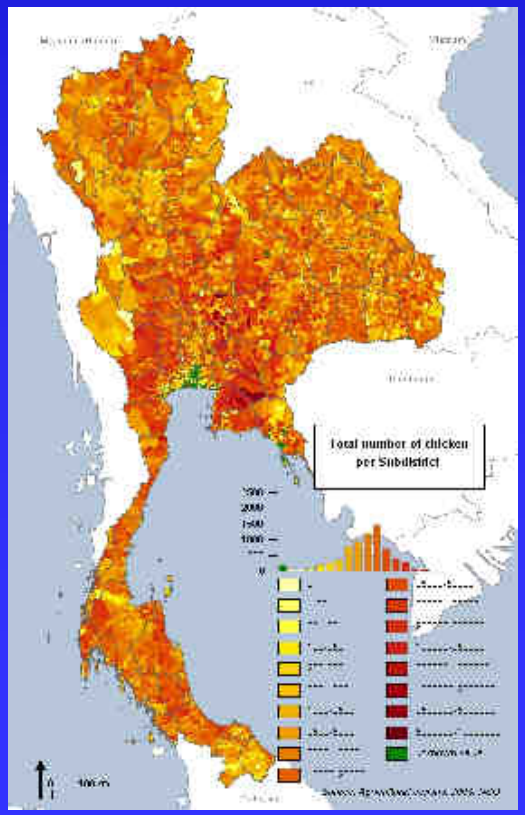


Thailand GIS database: example

► Agricultural statistics data are available from DLD and from NSO (National Statistic Office, Ministry of Interior)

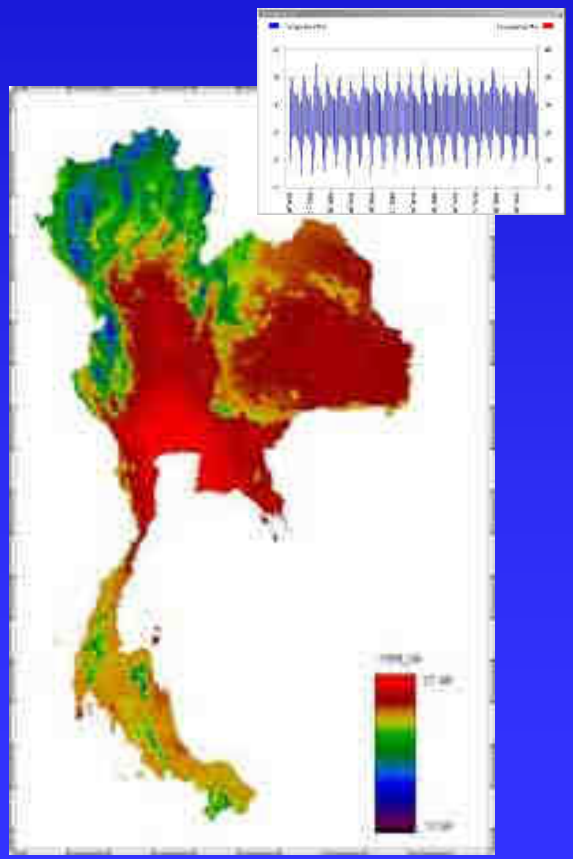
Agricultural census data: year 2003. No backyard farm data available.

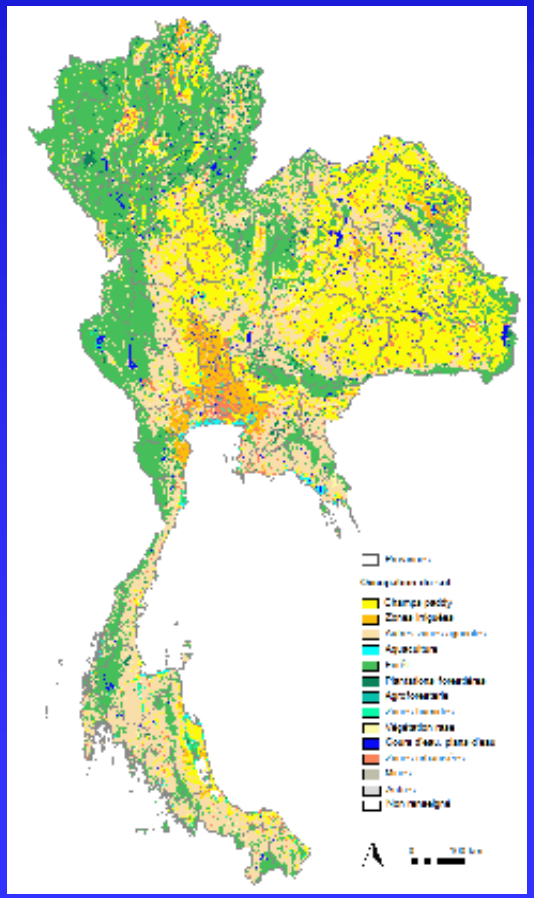


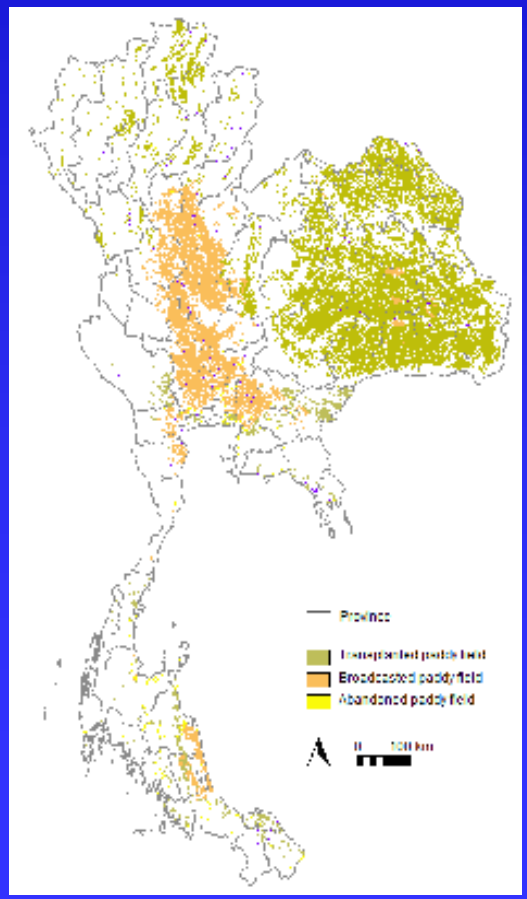


Thailand GIS database: example

Climatic data (for stations), Land use data (from 30 m resolution Landsat 5)







Retrospective spatio-temporal analysis

From retrospective data :

- Extracting the Emergence (index cases)

  Emergence cases are statistically independent one from each other, allowing statistical analysis with environmental conditions

  - Analyzing the randomness of the spatial distribution
  - Analyzing correlations with environmental factors

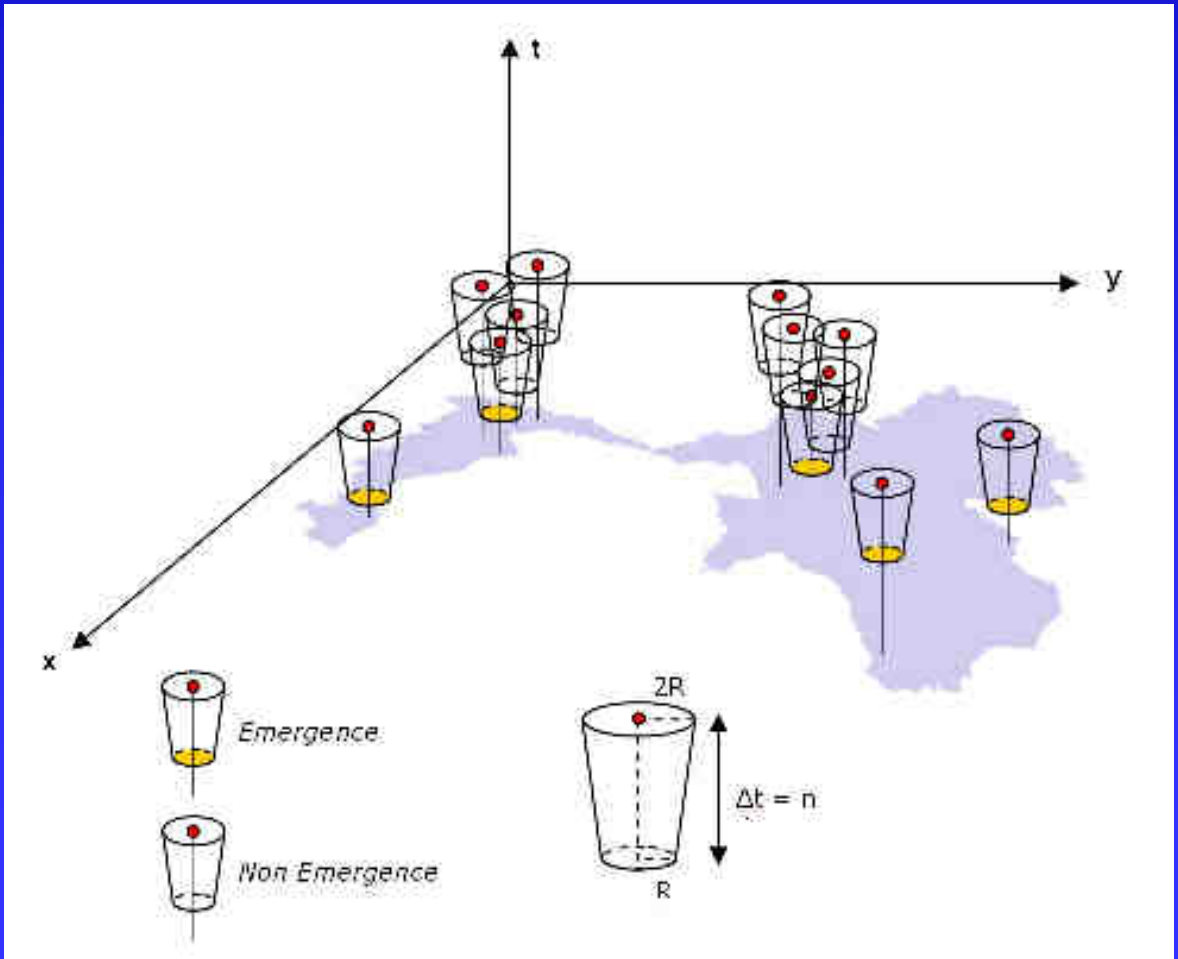
- Rebuilding the Diffusion process

  Assumptions must be made in order to link events for spatio-temporal analysis

  - Pattern of diffusion : Clusters, spatio-temporal characteristics

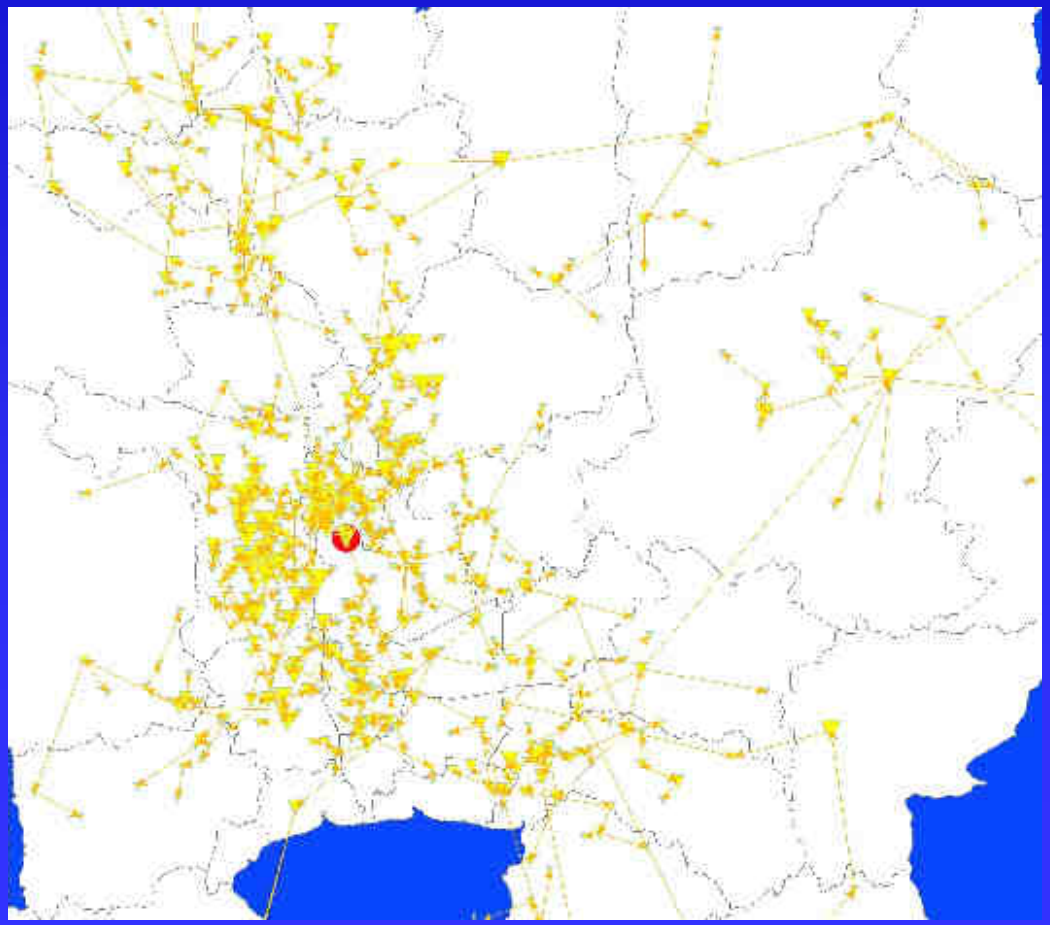
Emergence criteria

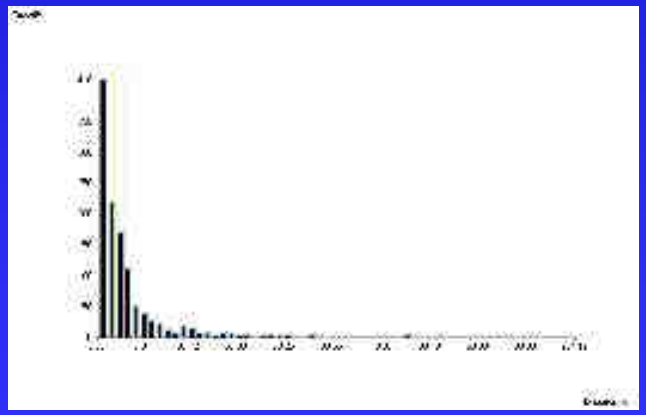
Criteria for emergence: time and distance between infected locations



Diffusion criteria

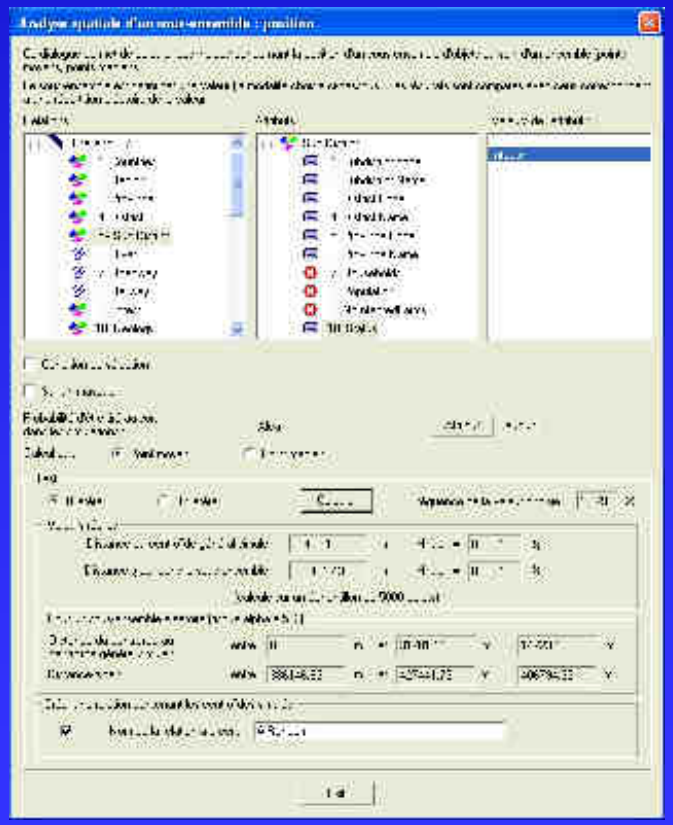
Criteria for linking two events: time and distance, in a backward reseach

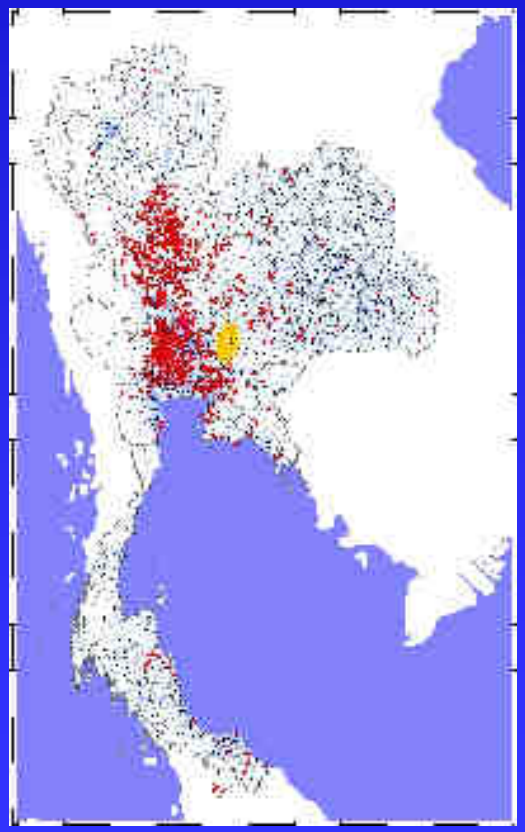


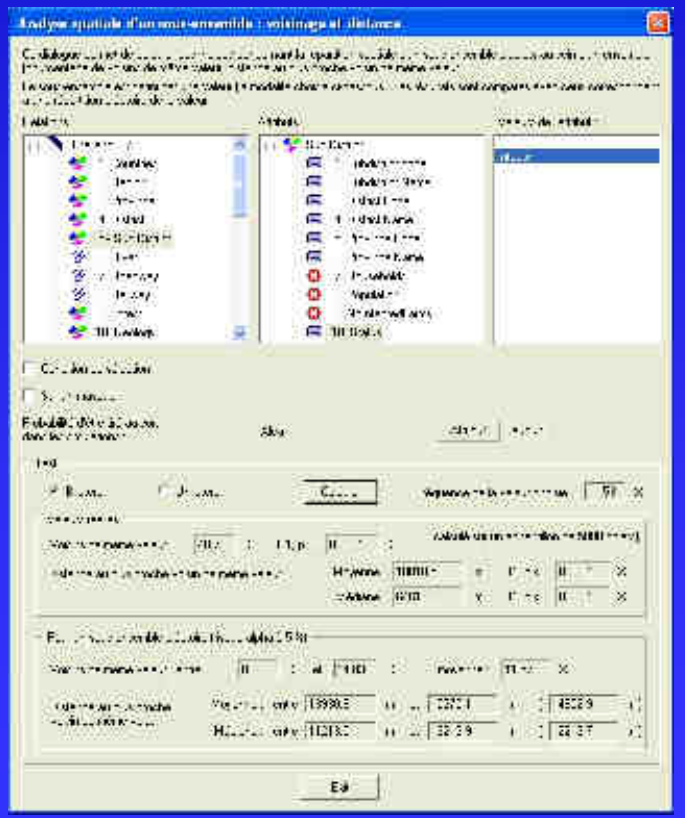


Point pattern spatial analysis

Testing spatial randomness of infected farms, with MC simulations, with attribute weight (number of holdings, number of birds)

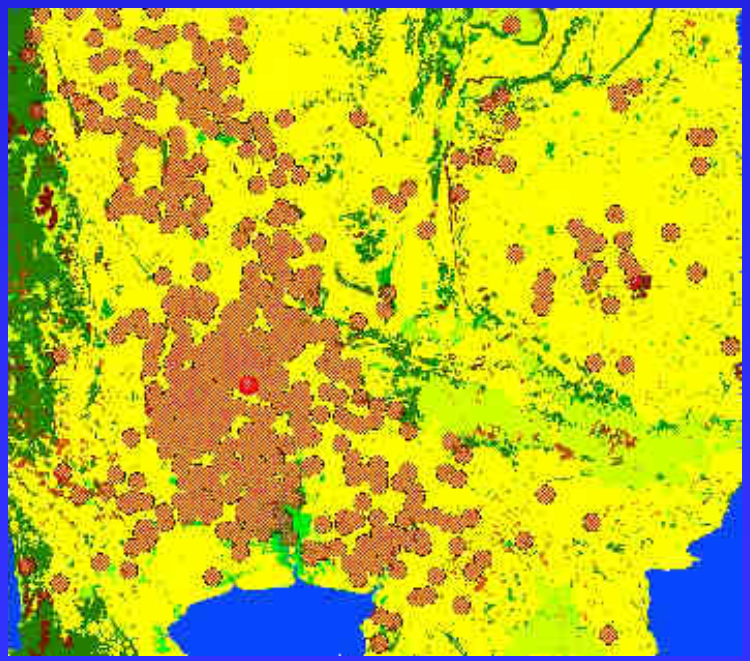


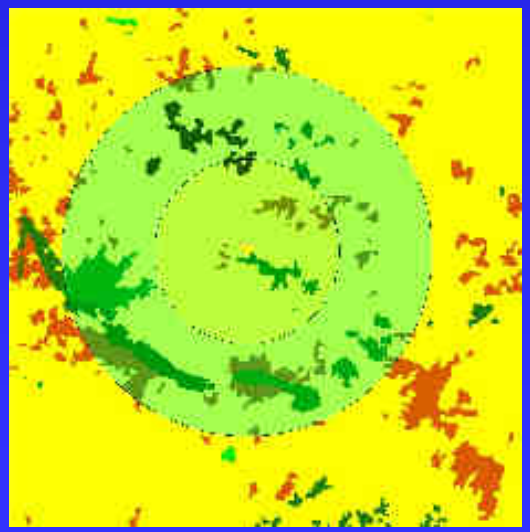




Environmental correlations

- Testing correlation, with MC simulations, between land use percentage of a value in a radius, and presence of an emergence
- Testing correlation, with MC simulations, between farm characteristics and emergence





Spatio-temporal analysis limitations

- Accuracy of declaration (in space, in time)
- No declaration
- Variability: 73000 villages, 9000 sub-districts, only 1805 cases, and less than 60 emergences
- Retrospective analysis is difficult: many hypothesis must be done

Spatial integration in larger areas can be used in order to reduce the random variability, but the integration increase the variance for the environmental variables in the clusters

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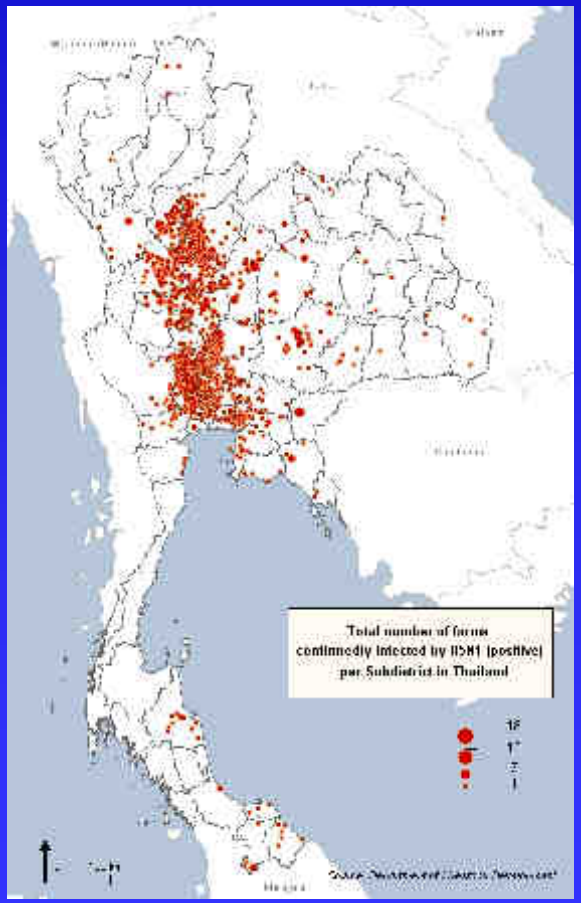
HPAI (H5N1) in Thailand : mapping

Mapping Avian Influenza in Thailand:

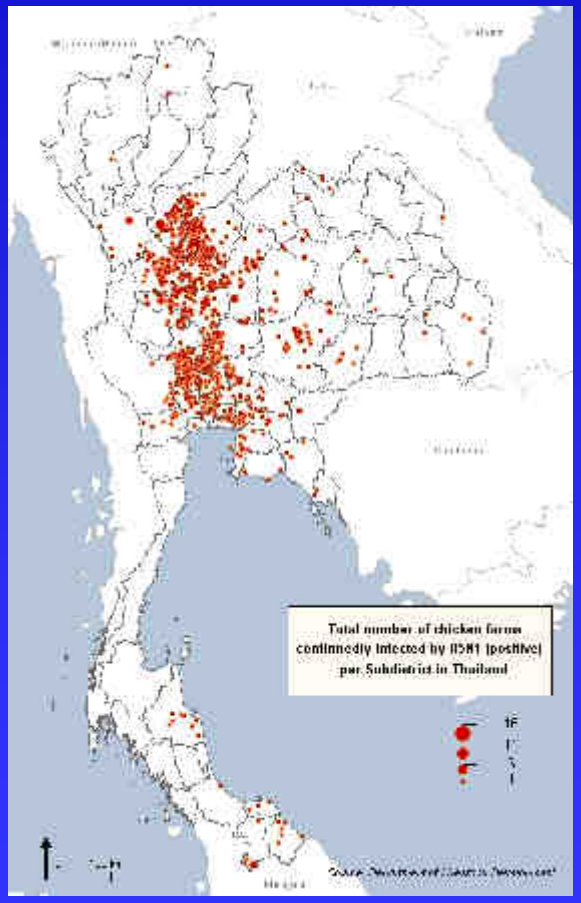
- Foci: all, by poultry type, by date (by week), by scale (district, subdistrict)
- Incidence
- Agricultural census for poultry farms
- Emergence

website : http:/www/star.ait.ac.th/~souris/HPAI

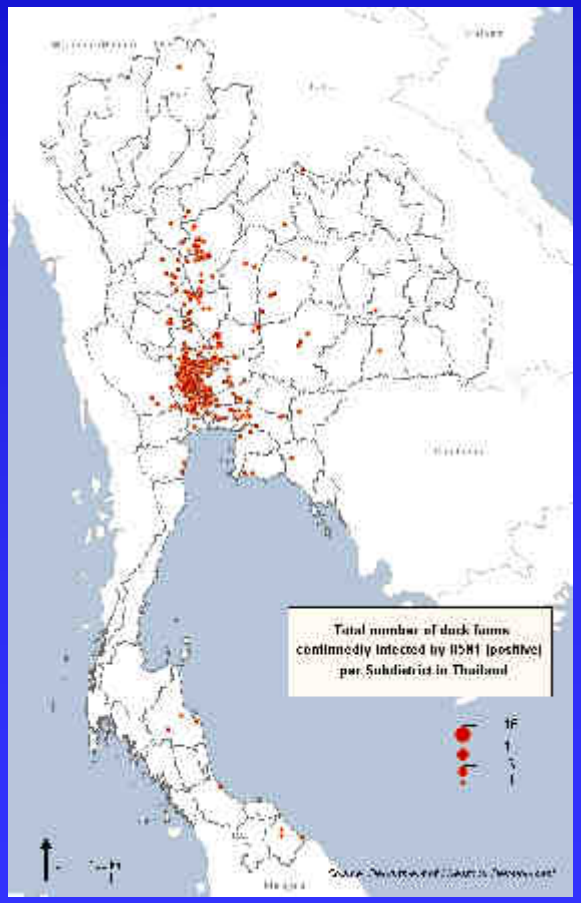
HPAI (H5N1) in Thailand: mapping (example)



Infected Farms, Total

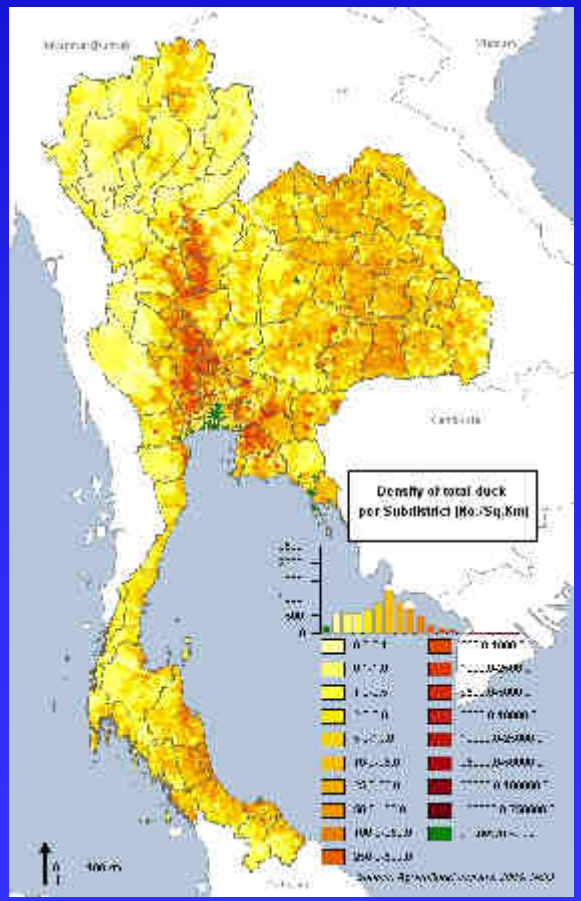


Infected Chicken Farms

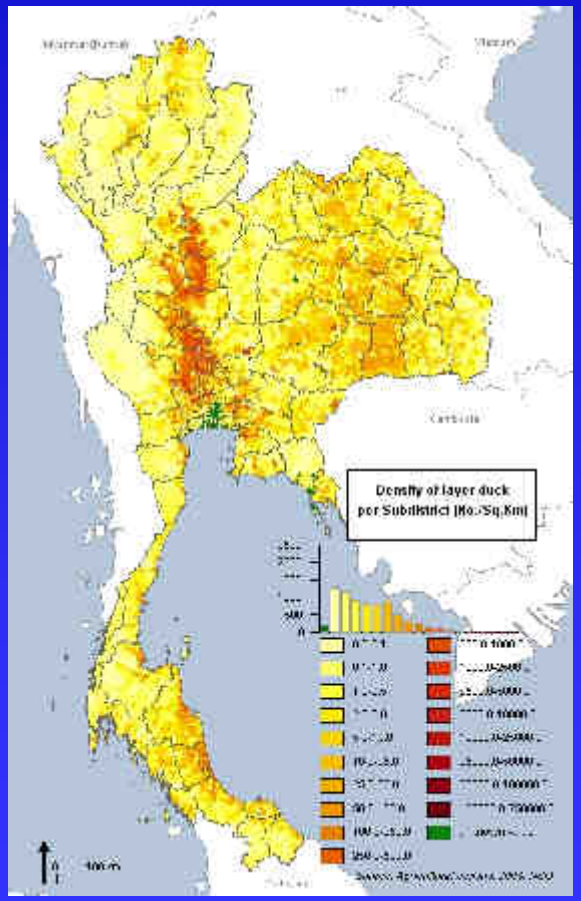


Infected Duck Farms

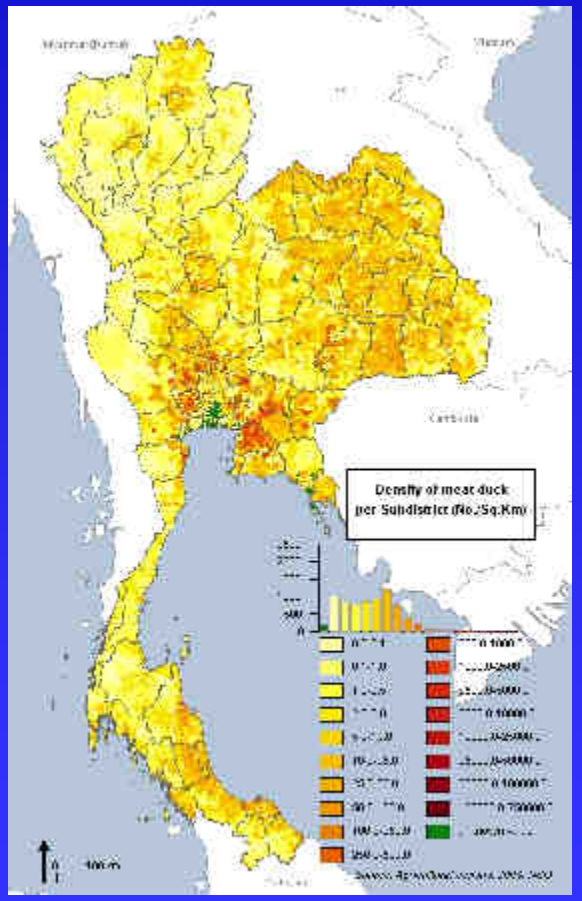
HPAI (H5N1) in Thailand: mapping (example)



Density of Duck

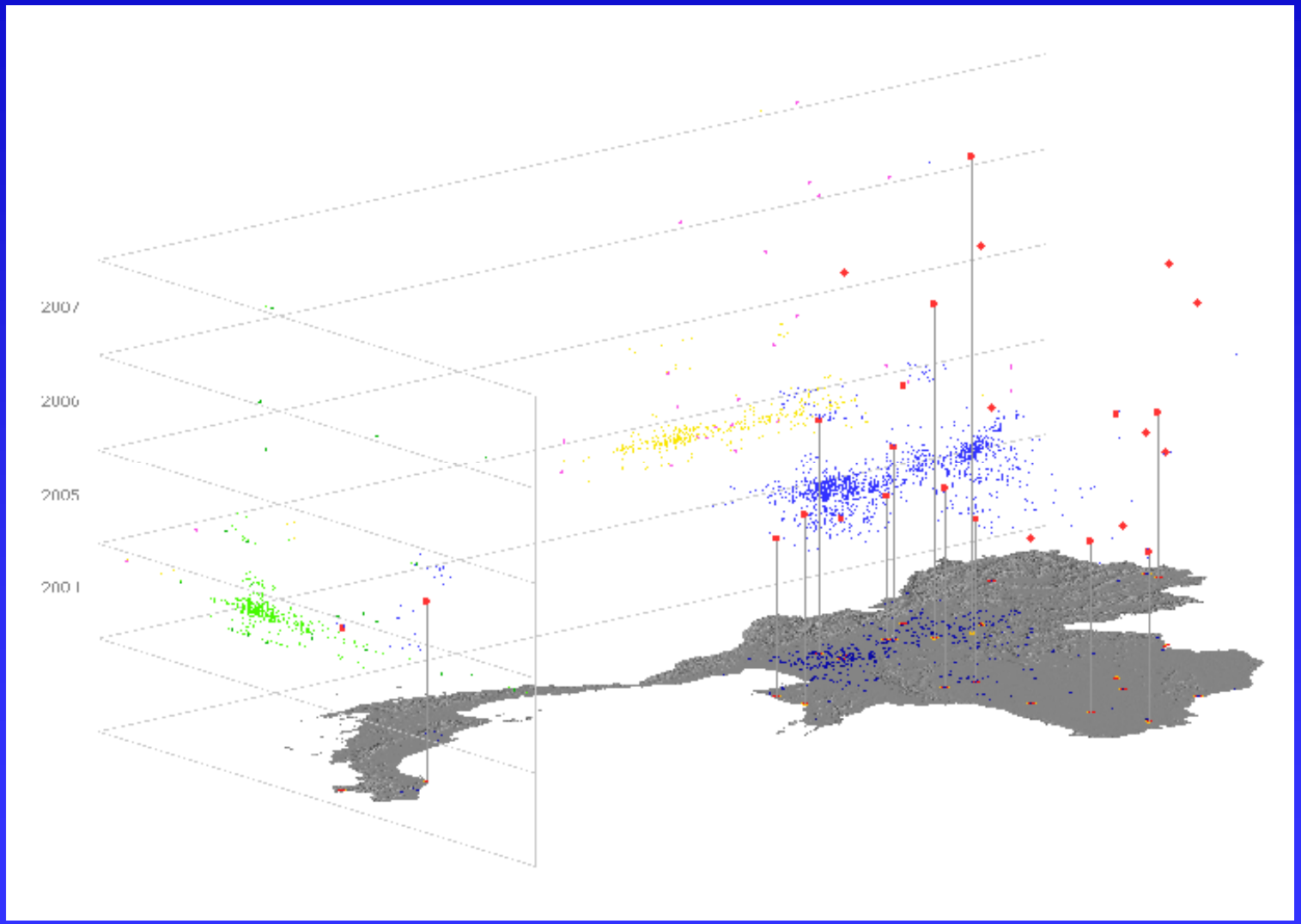


Density of Layer Duck



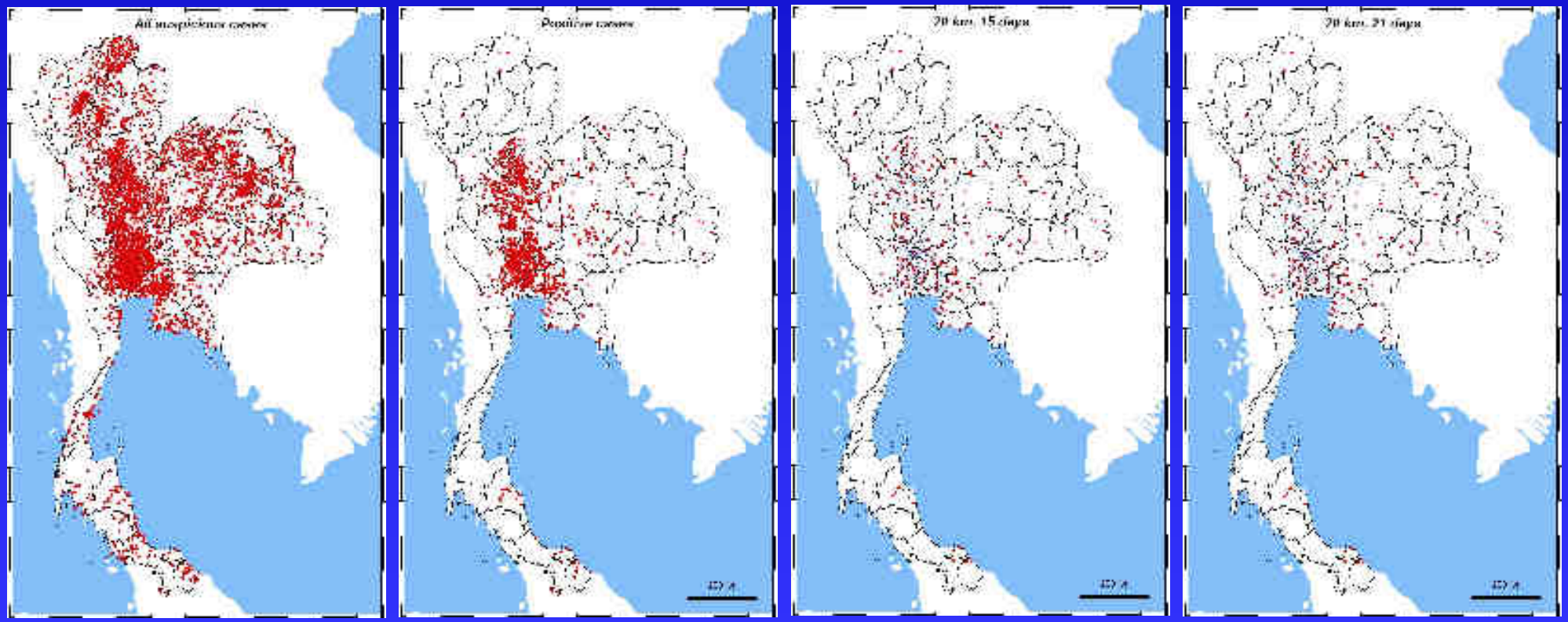
Density of Meat Duck

HPAI (H5N1) in Thailand : mapping (example)



HPAI (H5N1) emergence

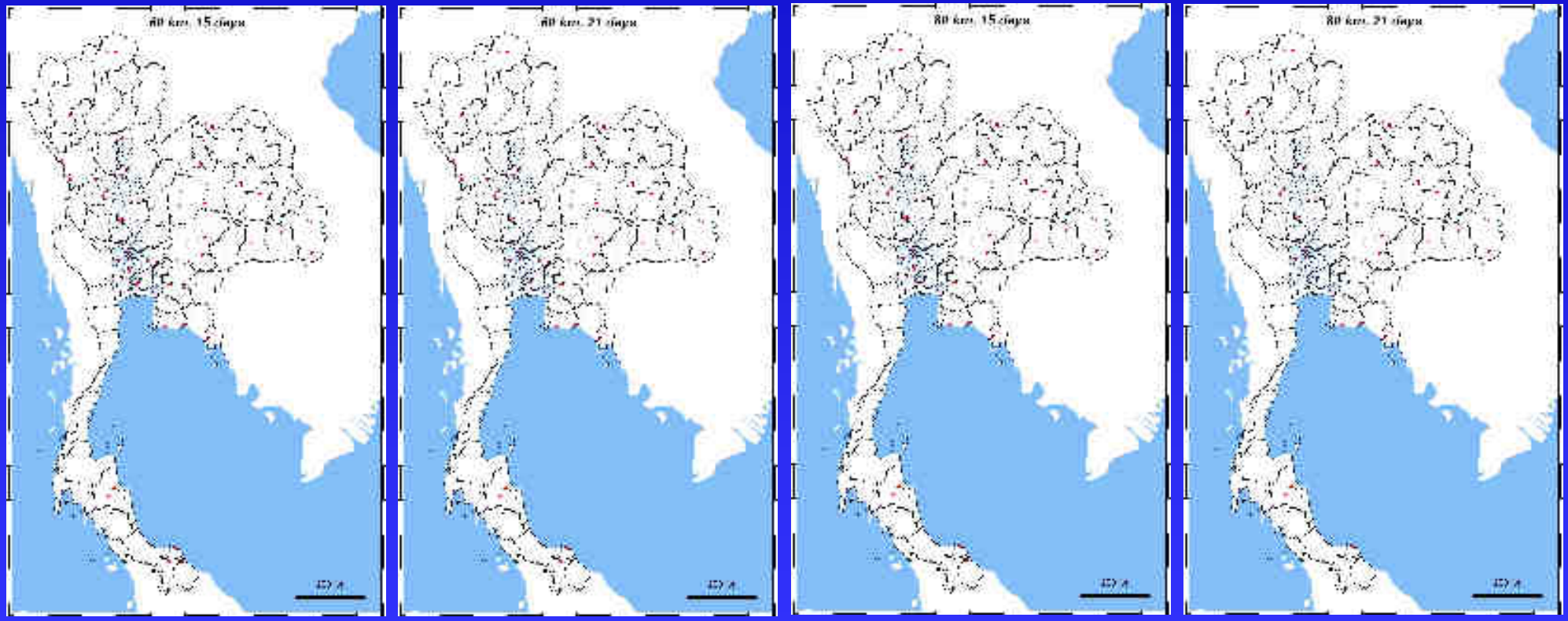
Criteria for emergence: time and distance between foci



At sub-district level, no clusters for emergence locations: clustering may be given by contagious process, not environmental factors.

HPAI (H5N1) emergence

Criteria for emergence: time and distance between foci



Are migratory birds or free-range ducks involved in emergence ?

HPAI (H5N1) emergence

Criteria for emergence: time and distance between foci

Number of cases selected as emergence, as a function of radius distance (V) and elapsed past time without cases (T)

	V														
	10	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**100**	**150**	**200**	**300**	**400**	**500**
T															
7	687	389	256	185	142	115	87	75	61	55	35	28	18	13	11
14	**555**	**318**	**195**	**133**	**102**	**78**	**62**	**54**	**48**	**41**	**27**	**21**	**12**	**8**	**5**
21	489	291	176	118	89	72	54	46	40	34	22	16	15	7	4
28	**446**	**262**	**152**	**100**	**77**	**60**	**48**	**39**	**36**	**32**	**22**	**16**	**11**	**5**	**4**
60	525	237	131	86	67	52	42	36	31	27	16	15	8	7	4
90	**504**	**236**	**129**	**84**	**68**	**52**	**42**	**33**	**31**	**27**	**16**	**14**	**8**	**7**	**4**

Parameters values are expressed as: T = time by days and V= distance in kilometers

HPAI (H5N1) emergence

Criteria for emergence: time and distance between foci

Geostatistical test: frequency of same value neighbors (risk α = 0.1 %)

	V														
	10	20	30	40	50	60	70	80	90	100	150	200	300	400	500
T															
7	H1	H1	H1	H1	H1	H1	H1	H1	H1	H1	H1	H1	H0	H0	H0
14	H1	H1	H1	H1	H1	H1	H1	H0	H0	H0	H1	H1	H0	H0	H0
21	H1	H1	H1	H1	H1	H1	H1	H0	H0	H0	H0	H1	H1	H0	H0
28	H1	H1	H1	H1	H1	H1	H0	H0	H0	H0	H1	H1	H0	H0	H0

Parameters values are expressed as: T = time by days and V= distance in kilometers

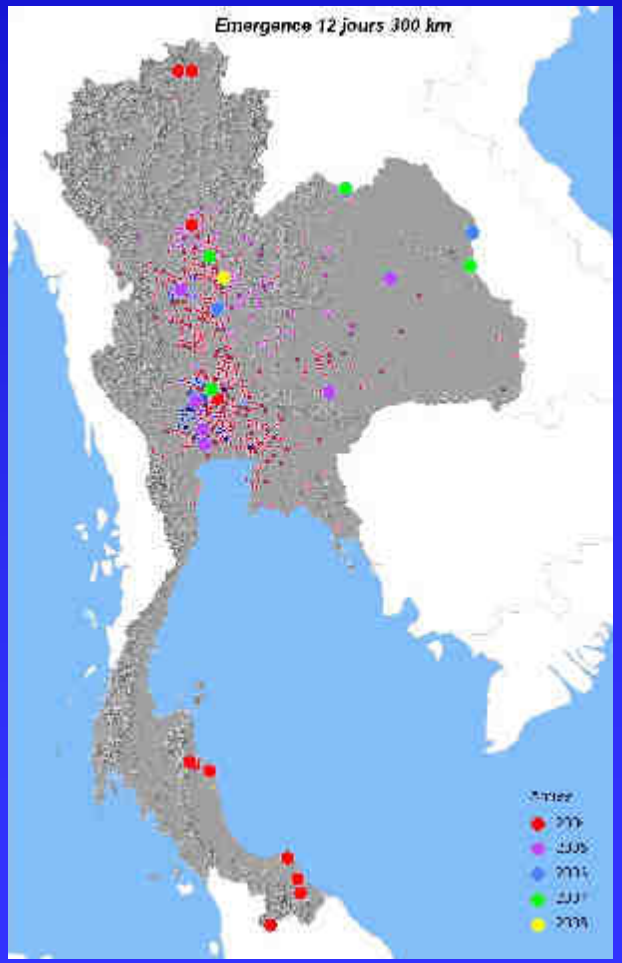
HPAI (H5N1) exposure factors (emergent vs non emergent)

Exposure factor: type of poultry in emergent vs. non-emergent farms (V=60 km, T=21 days, 72 farms)

Type of poultry	Emergent farms (%)	Non-Emergent farms (%)	p-value (%)
Batam Cock	1.6	0.5 ± 0.9	15 (H0)
Domestic Chicken	59.2	55.3 ± 6.2	24 (H0)
Domestic Duck	1.6	1.1 ± 1.3	36 (H0)
Egg Chicken	10.9	4.4 ± 2.5	0.5 (H1)
Egg Duck	4.7	15.6 ± 4.2	0.7 (H1)
Farm Chicken	9.4	4.9 ± 2.6	4.9 (H1)
Farm Duck	3.2	7.6 ± 3	8.1 (H0)
Farm Francolin	3.2	2.2 ± 1.8	30 (H0)
Fighting Cock	3.2	2.7 ± 2	42 (H0)
Free range duck	1.6	1.1 ± 1.5	47 (H0)
Goose	0	0.8 ± 1	23 (H0)
Mandarin Duck	1.6	2.5 ± 1.9	30 (H0)
Turkey	0	0.2 ± 0.6	34 (H0)

HPAI (H5N1) diffusion

Criteria for diffusion: time and distance between foci

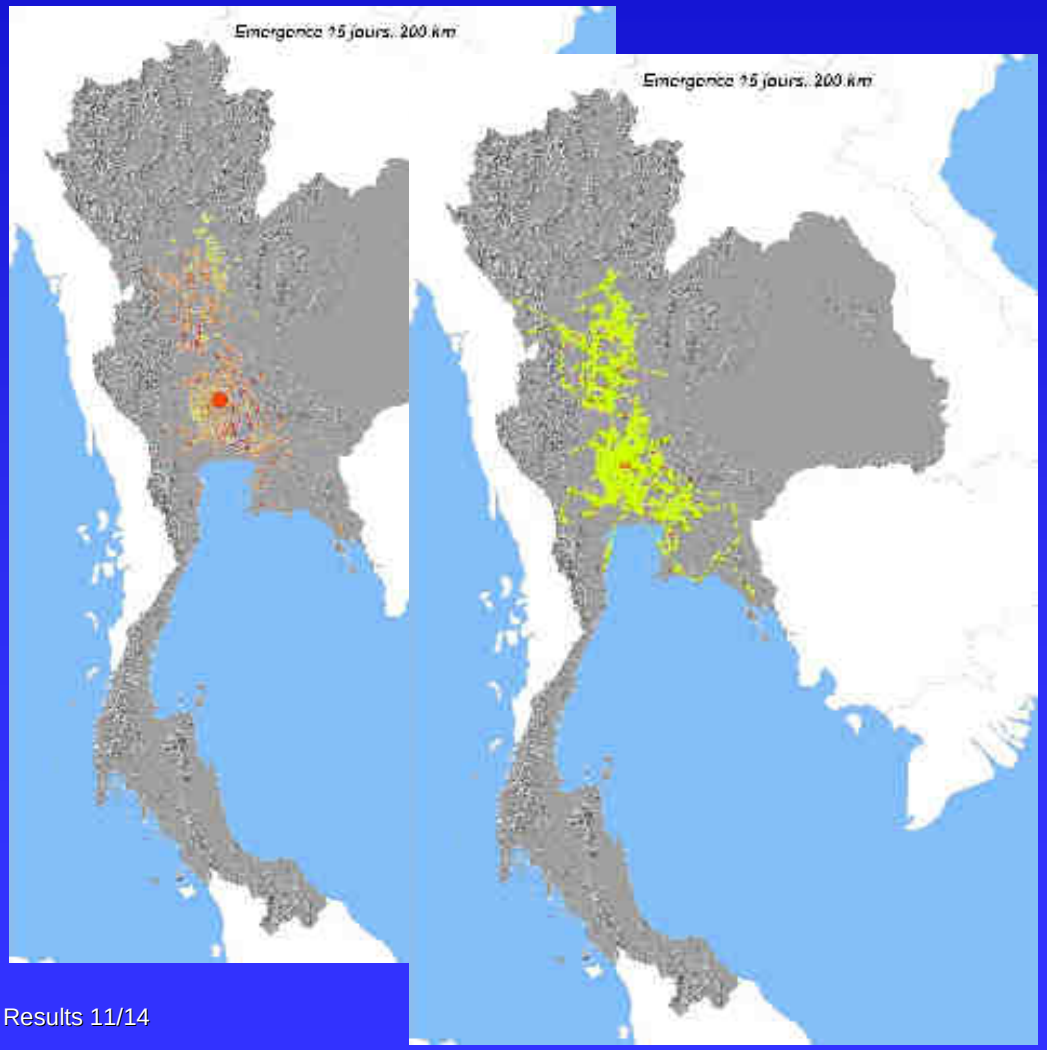


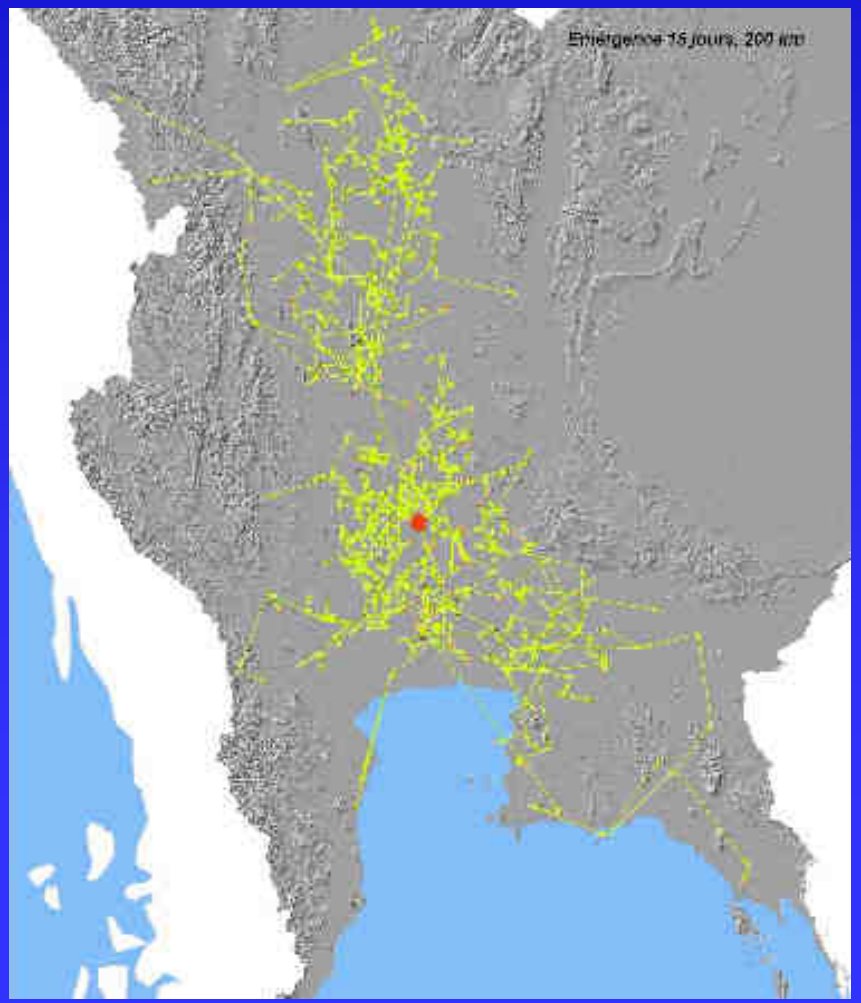
1350 foci from the first one (total 1805)

205 foci from the second one (total 1805)

HPAI (H5N1) diffusion

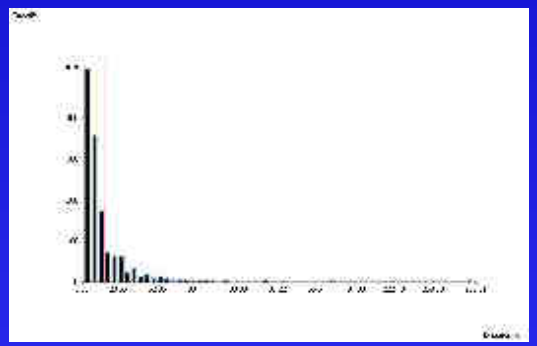
Criteria for diffusion: time and distance between foci

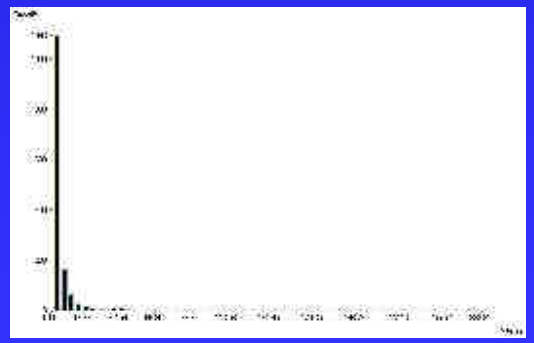


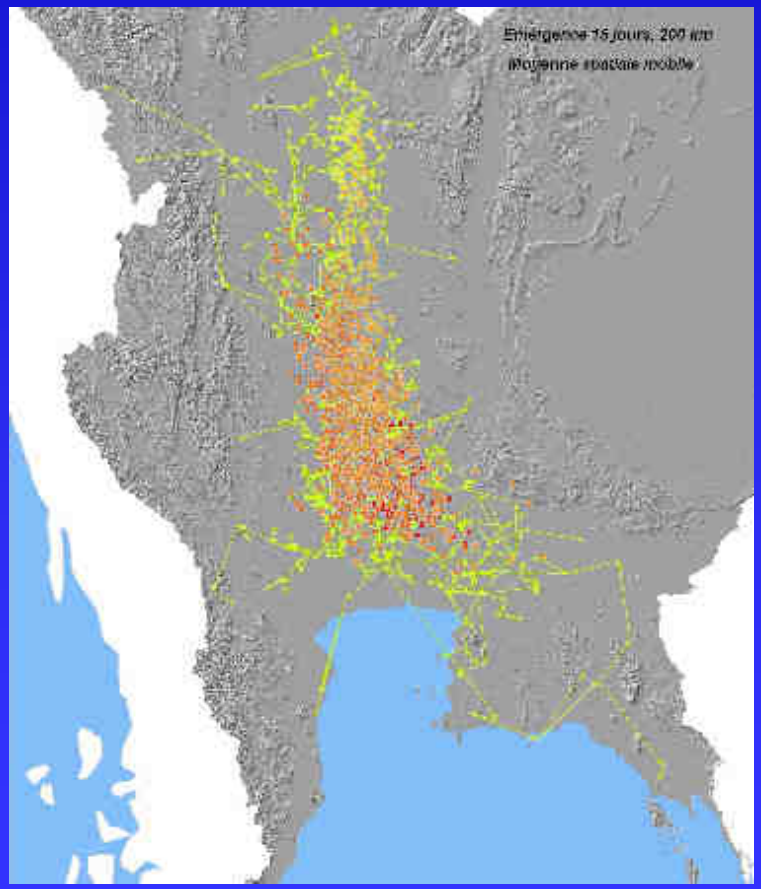


HPAI (H5N1) diffusion

First wave (2004) characteristics: distance, speed, jumps, patterns







HPAI (H5N1) emergence and diffusion: results

► in each waves, no time interruption of more than 8 days: few independent clusters. No global randomness, but clustered pattern due to local diffusion.

► Random spatial pattern for emergence

► No relationship between emergence foci and land use (in a 5 km radius)

Conclusions

- Emergence is spatially random, not predictable
- Only few index cases responsible of each HPAI epidemics wave and, at subdistrict level, no geographical locations or environmental conditions can be highlighted in the risk of emergence.
- Surveillance on HPAI must focus on dissemination, more than on migrating birds or wild fauna control: local farm to farm transmission, long distance jumps from human agro-commercial practices, and cross-border trade.

Thank you

Marc Souris, 2008