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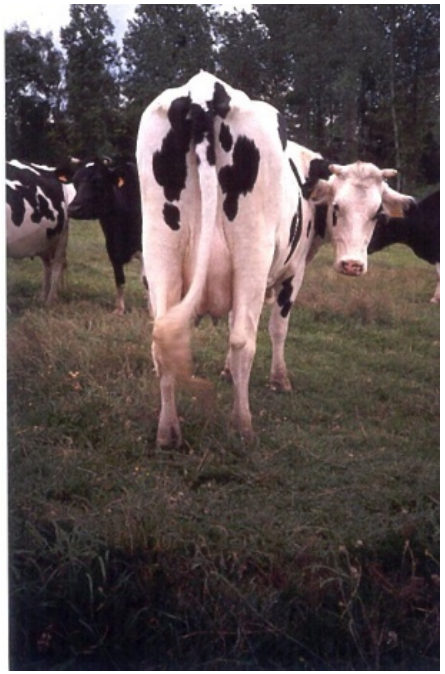
Surveillance of emerging diseases in cattle based on reproduction data

C. Fourichon[1], A. Marceau[1], T. Lesuffleur[1], A. Madouasse[1], A. Lehebel[1], Y. van der Stede[2], G. van Schaik[3]

[1]*ONIRIS – INRA, Nantes, France*
[2]*CODA-CERVA, Brussels, Belgium*
[3]*GD Animal Health Service, Deventer, The Netherlands*

Available data for syndromic surveillance

- **Reproduction data for dairy cattle**
  - **Dates of AI**
  - **Dates of calving**
- **High coverage**
- **Continuity in time**



- **Use for Identification + Payment + Pedigree → Reliability**

Basis & Hypothesis of the project

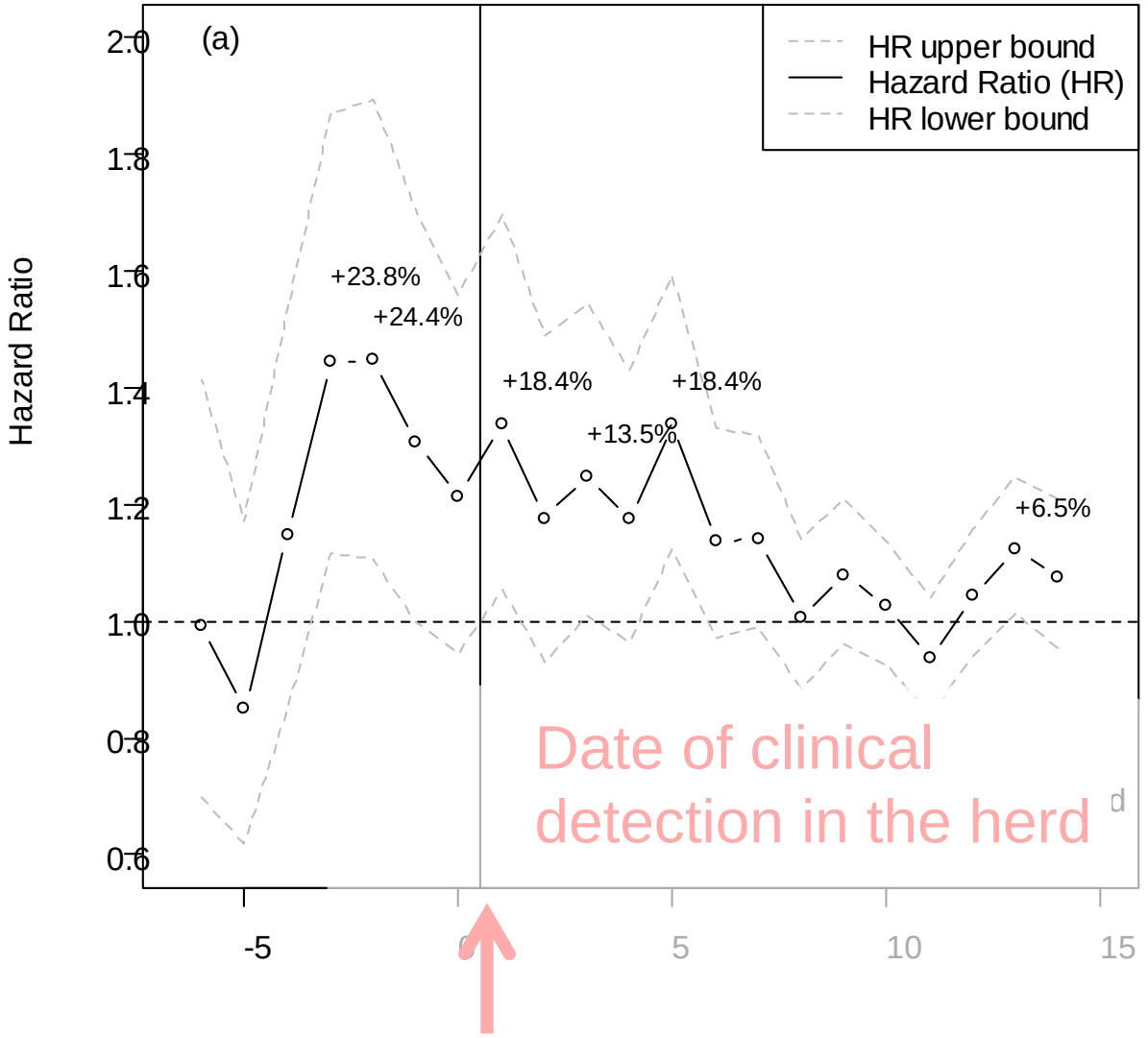
Infectious diseases can impair reproduction

- **e.g. BTV**

→ **return-to-service**

→ abortions

Can an increase in reproduction disorders be used to early detect a disease emergence?



Objectives

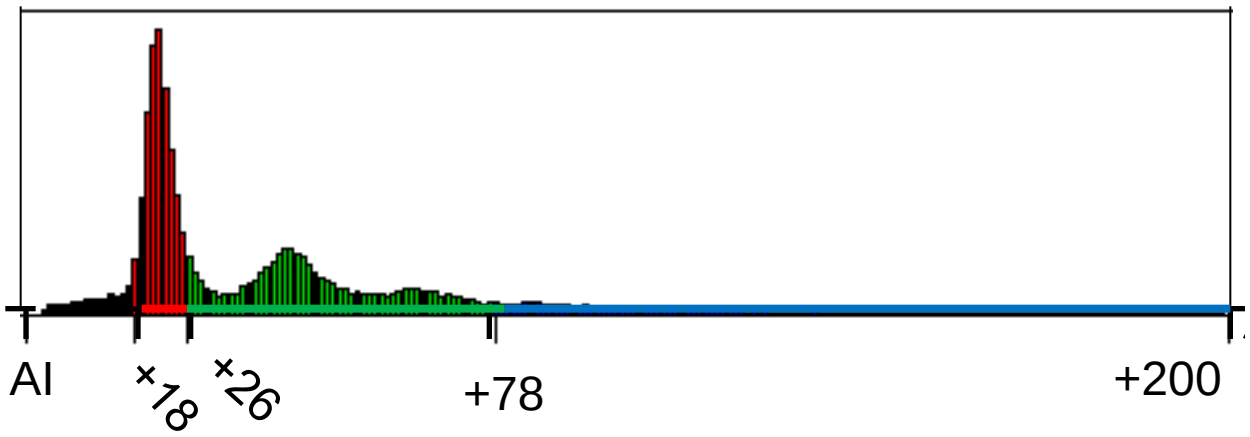
1. **To develop and evaluate indicators of health disorders based on reproduction data for early detection of emerging diseases**

2. **To evaluate the performances of modelling approaches for surveillance**
   - **Ability to detect an emergence**
   - **Timeliness: early detection**
   - **Reduced number of false alarms**

Using emergence of BTV in 2007-2008 in France as a case

Definition of five complementary indicators

Frequency of the intervals between 1st AI and return-to-service



- *Fertility disorders*
- *Early embryonic death*

1

- *Fertility disorders*
- *Late embryonic death*

2

- *Fetal death*
- *Abortion*

3

Computing time series for each indicator

For indicator 1 to 5: daily rates of occurrence

- **Separately in cows and in heifers**

$$\frac{\text{Number of events in cows/heifers that day}}{\text{Number of cows/heifers at risk that day}}$$

Cow/heifers at risk:

- **Present in the herd**
- **In the ad hoc interval for the indicator**
- **Not censored (by a return or calving since AI)**

Forecasting and measures of differences

History based prediction

Time-series statistical modelling

- ARMA
- EWMA
- Farrington algorithm
- Trigonometric regression over time
- Logistic model with covariates on cow characteristics

Differences

- **Confidence interval of the prediction**
- **CUSUM: cumulative difference observed-predicted**

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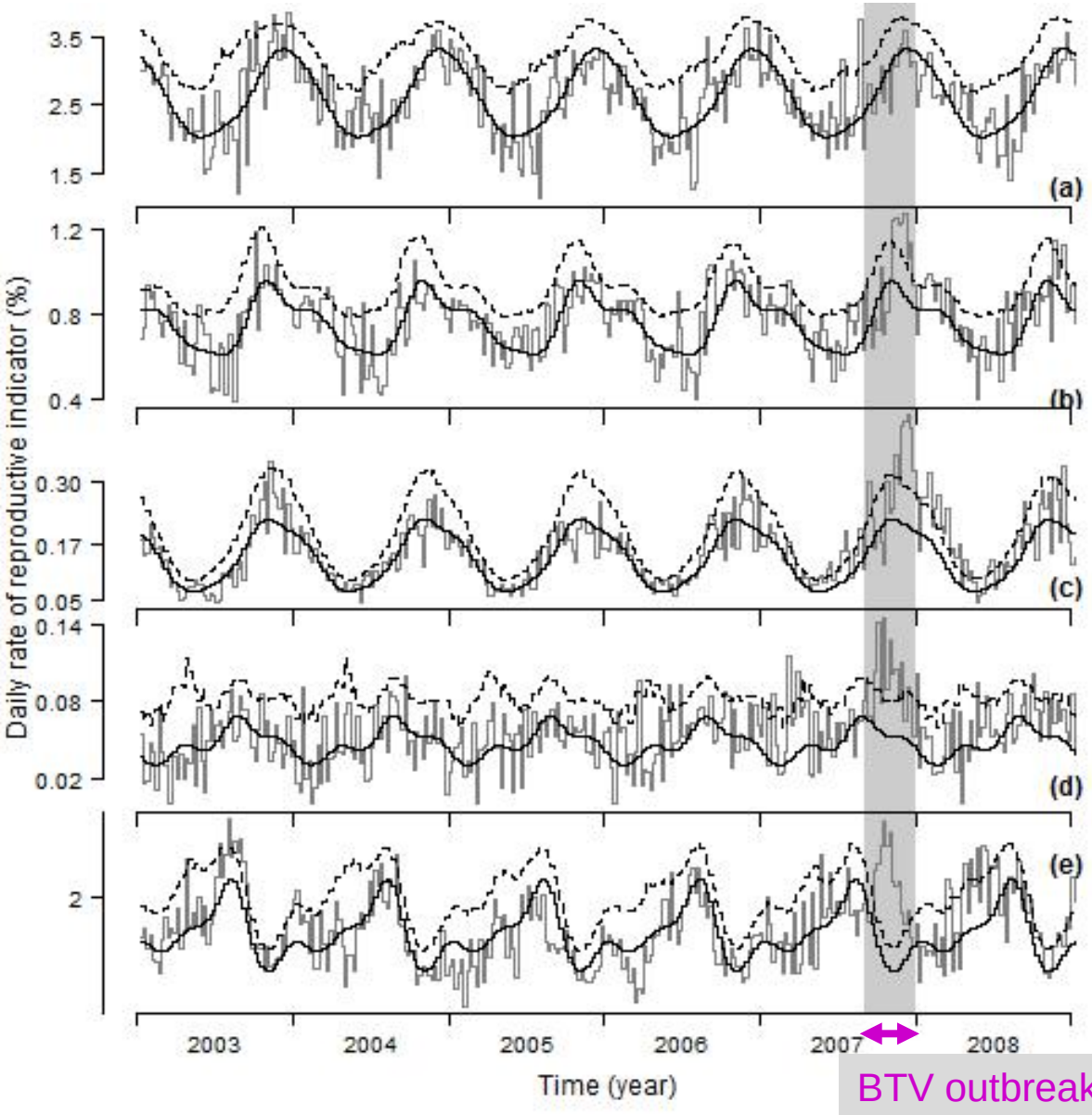
Results: variations in indicators over time

Example in one district infected in 2007 (Meuse)

Observed

Predicted

Upper bound of 95%CI



1 3-week r-t-s

2 delayed r-t-s

3 very late r-t-s

4 premature calving

5 short gestation

BTV outbreak in the district

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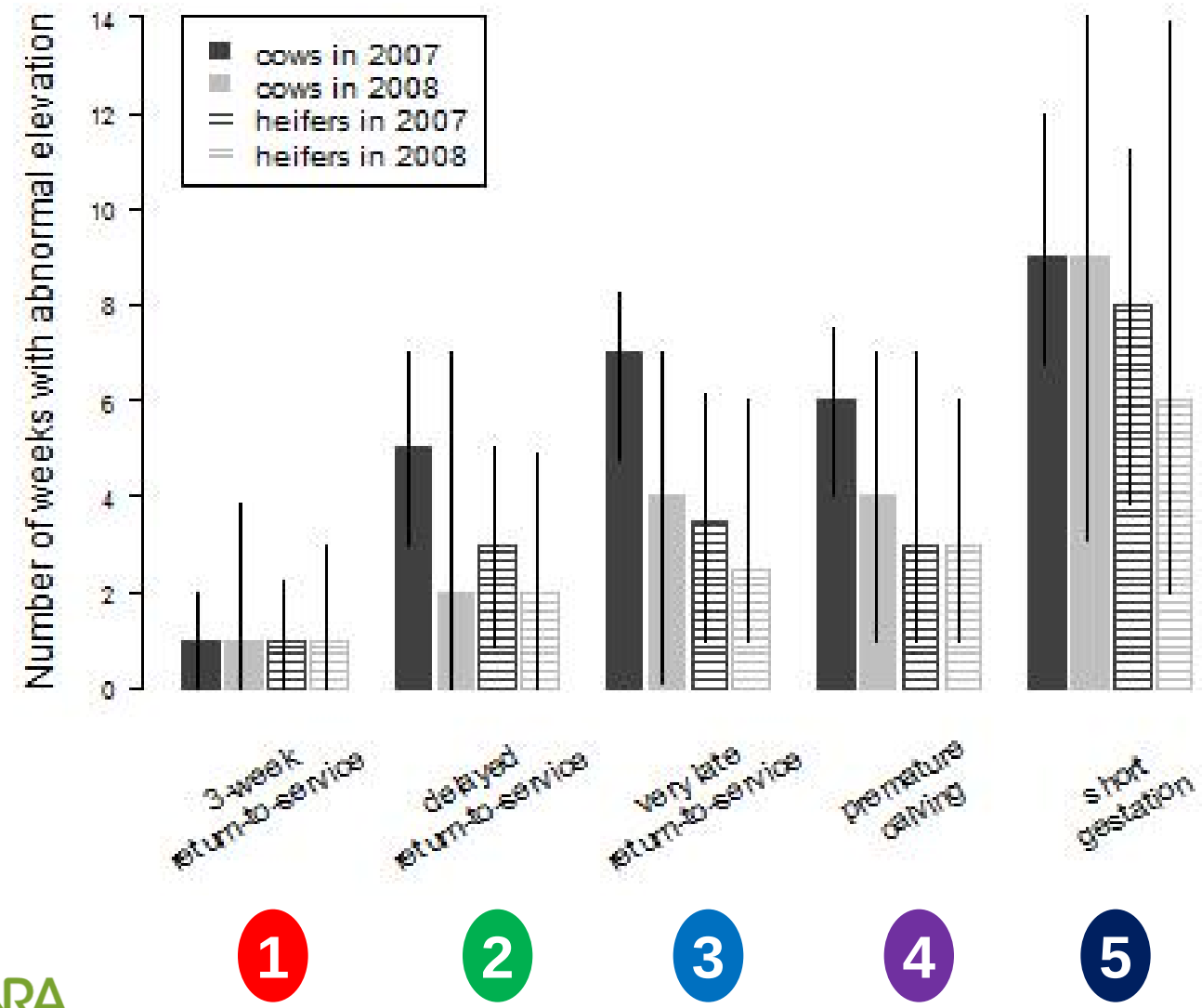
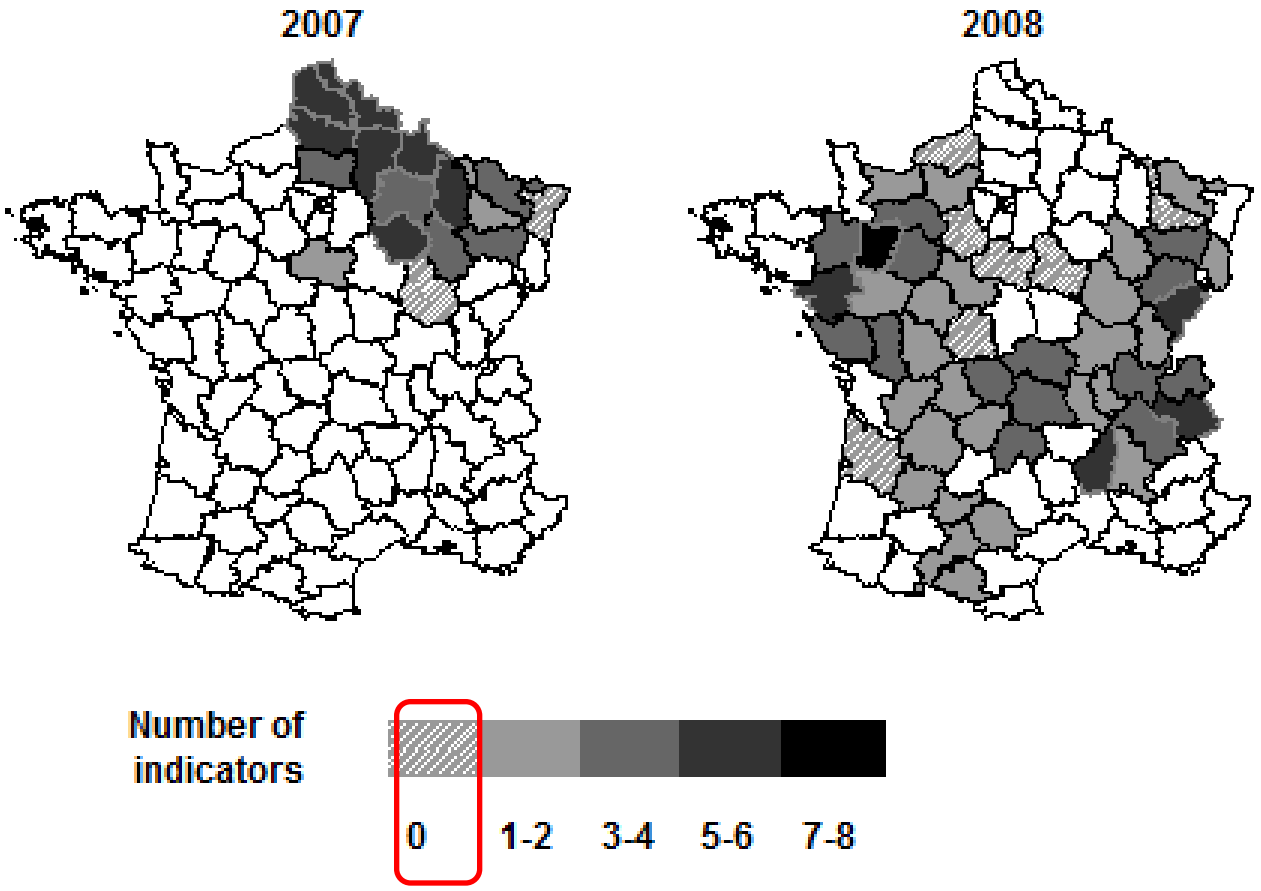
Results: duration of « high » difference

#weeks >95%CI during the BTV outbreak (median)



Results: combined indicators per district

indicators with elevation >3 weeks per district



District not infected or #herds <100

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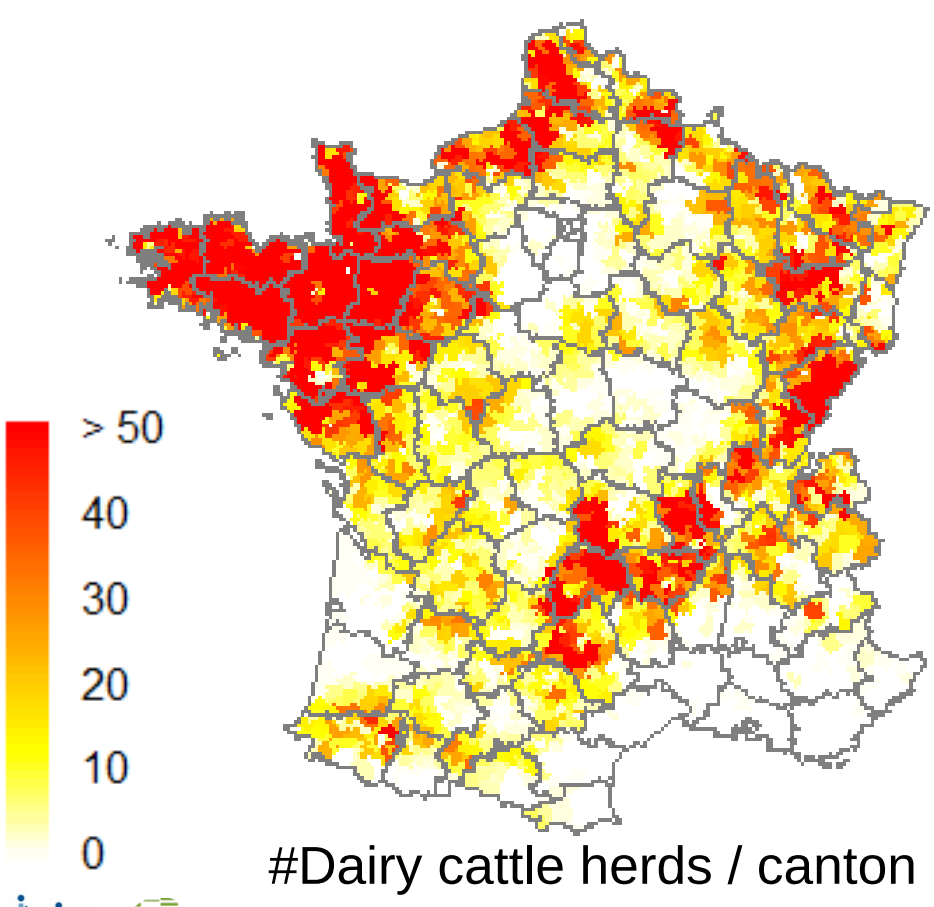
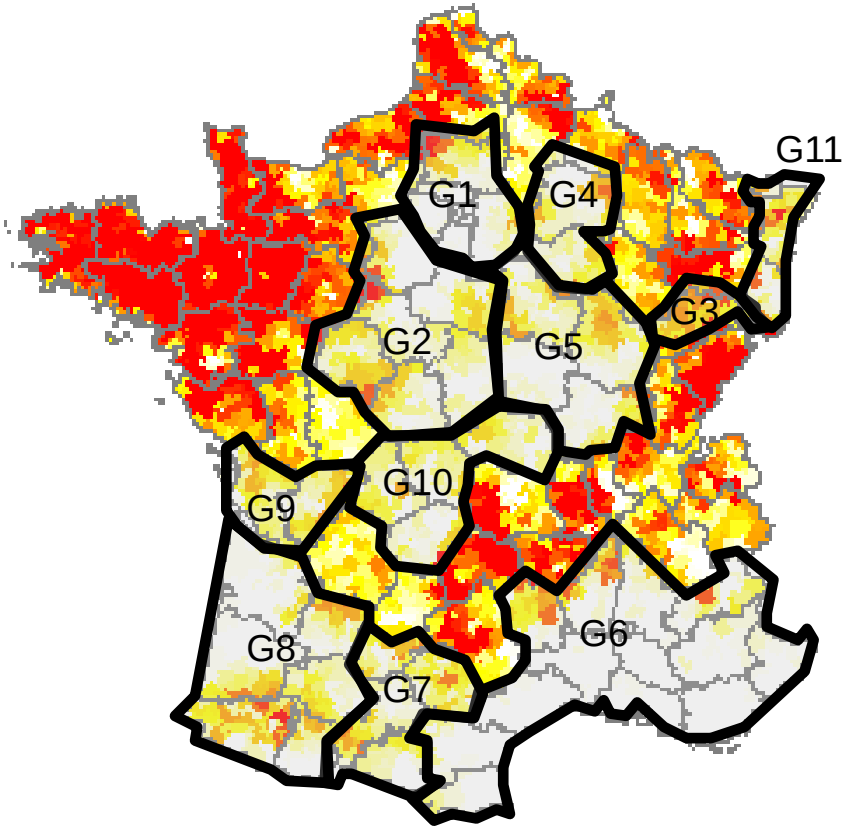
Automatic detection of elevations

Heterogenous distribution of dairy cattle herds

Data driven grouping:
#herds > 500
in each spatial unit



#Dairy cattle herds / canton



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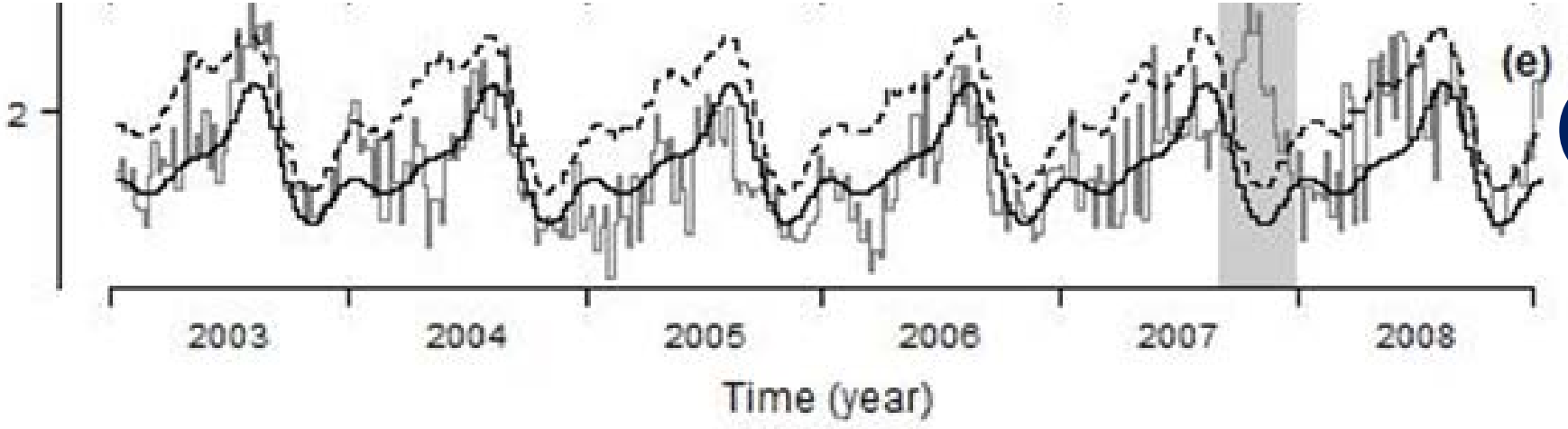
Automatic detection of elevations: CUSUM

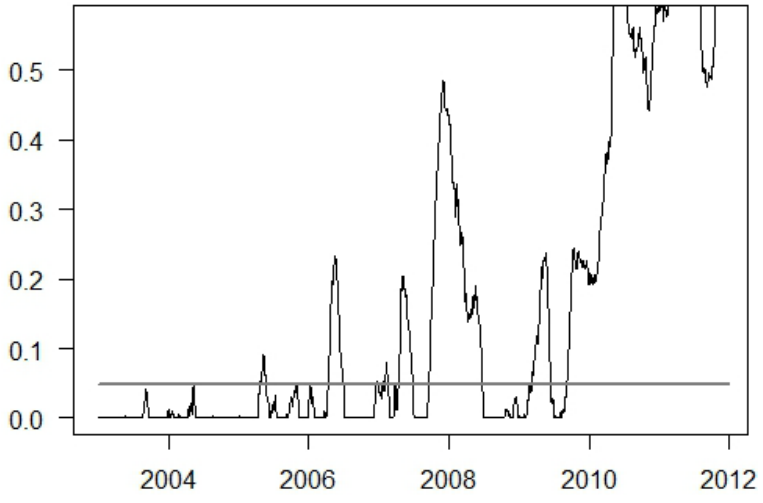
Calculation of a CUSUM in each district



5

$$Cusum(t) = \max\left\{0, Cusum(t-1) + (Y_t - \hat{Y}_t - k)\right\}$$

Cumulative sum



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Results: ability to detect an infected district

“Sensitivity” at the district level

In districts with final prevalence > 10%

Number of automatically detected districts

	1	2	3	4	5	#districts
2007	0	9	10	5	10	12
2008	1	6	9	4	25	26

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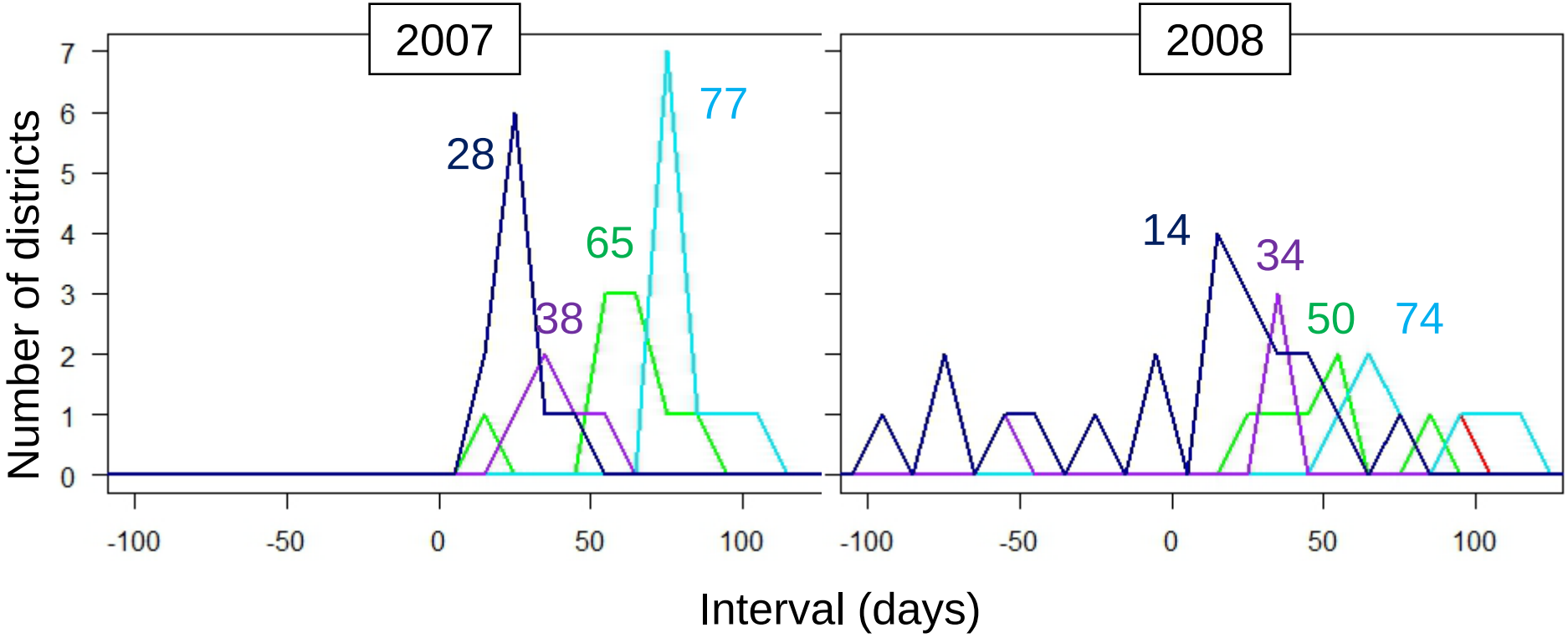
Results: Timeliness

Precocity of the detection

In districts with final prevalence > 10% (at the end of the vector season)

Interval between 1st clinical notification and 1st alarm in the district (median)



5 4 2 3 1

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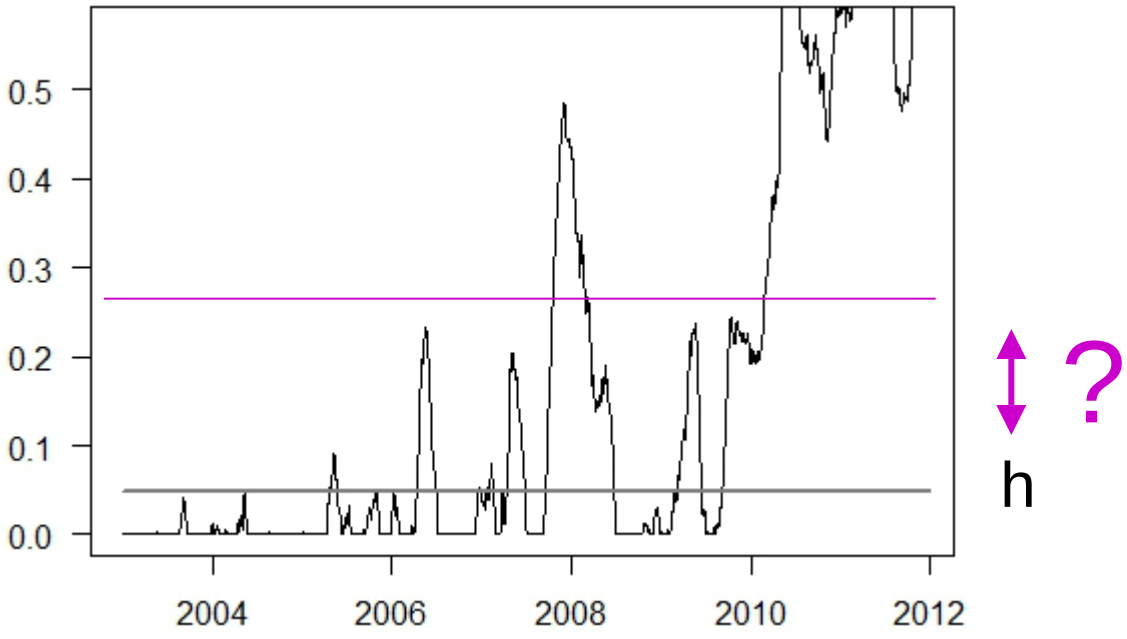
CUSUM: effect of the threshold h

Example: short gestation in one district

Cumulative sum

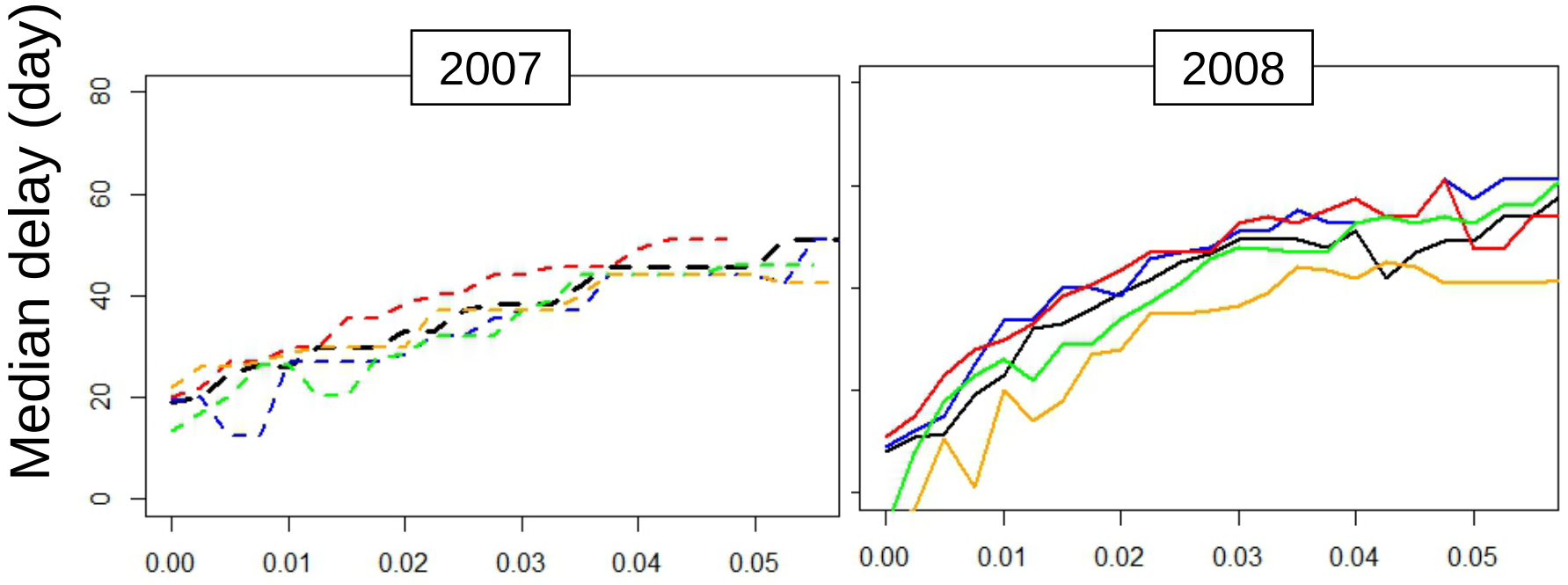


Time (years)

Results: h threshold and timeliness

Interval from clinical notification to detection

In districts with final prevalence > 10%

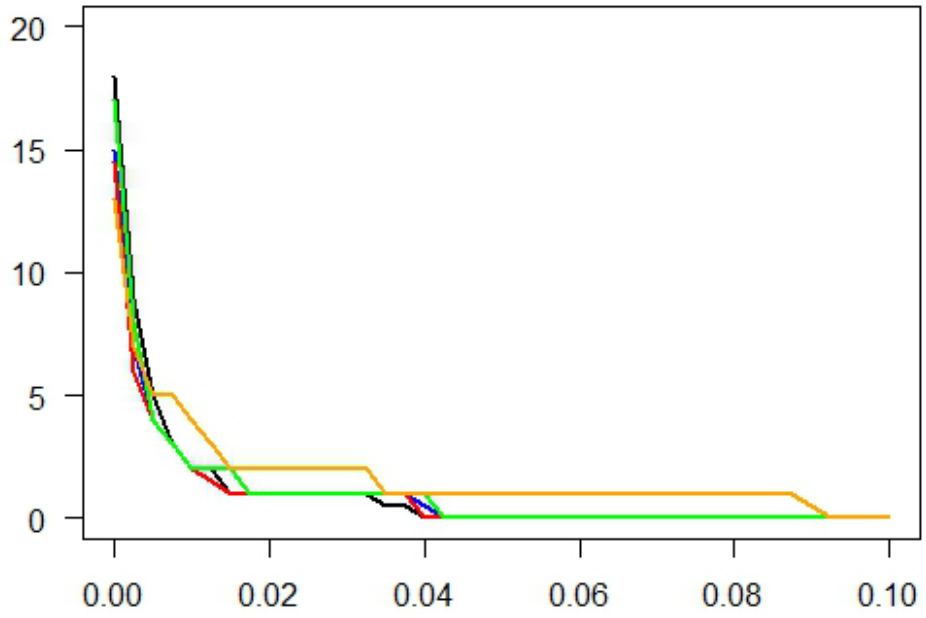


Results: h threshold and specificity

Number of false alarms

All districts

Median number of alarms



Covariate model
ARMA
EWMA
Temporal regression
Farrington

Conclusions

Relevance and effectiveness of 4 indicators out of 5 to detect BTV outbreaks

- **3 = previously demonstrated effects of BTV**
- **early gestation = biological mechanism unknown**
  - **Fever? (extension to a number of diseases)**

No difference between statistical models for prediction → simplicity

Choice of the h threshold → decision-maker's priorities between Se, Sp and timeliness

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Conclusions

Reproduction data are of interest for syndromic surveillance

Preferably combine several indicators to detect « multiple » signals

- **Interpretation of alarms**

If one indicator only : the most reactive one = « short gestations »

Acknowledgements

Project team

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- **CODA-CERVA, Brussels, Belgium**
- **GD Animal Health Service, Deventer, The Netherlands**

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Data

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Thanks for your attention!

christine.fourichon@oniris-nantes.fr