Spatiotemporal characteristics of pandemic influenza

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Data Sources

Disease / health data

- Swedish Society for Medical Doctors (influenza, 1889–90)
- Royal Medical Board (influenza, 1957–58)
- Swedish Institute for Communicable Disease Control (influenza, 2009–10)
- Swedish Board of Agriculture (salmonella infections, 1993–2010)

Demographic / socioeconomic data

- Parish populations (1571, 1890, unpublished, Prof. Andersson-Palm, Gothenburg)
- Statistics Sweden
- Demographic Data Base (Umeå University)
- Teleadress

Environmental data

- Swedish Meteorological and Hydrological Institute (meteorological data, 1957–58)

Other data sources

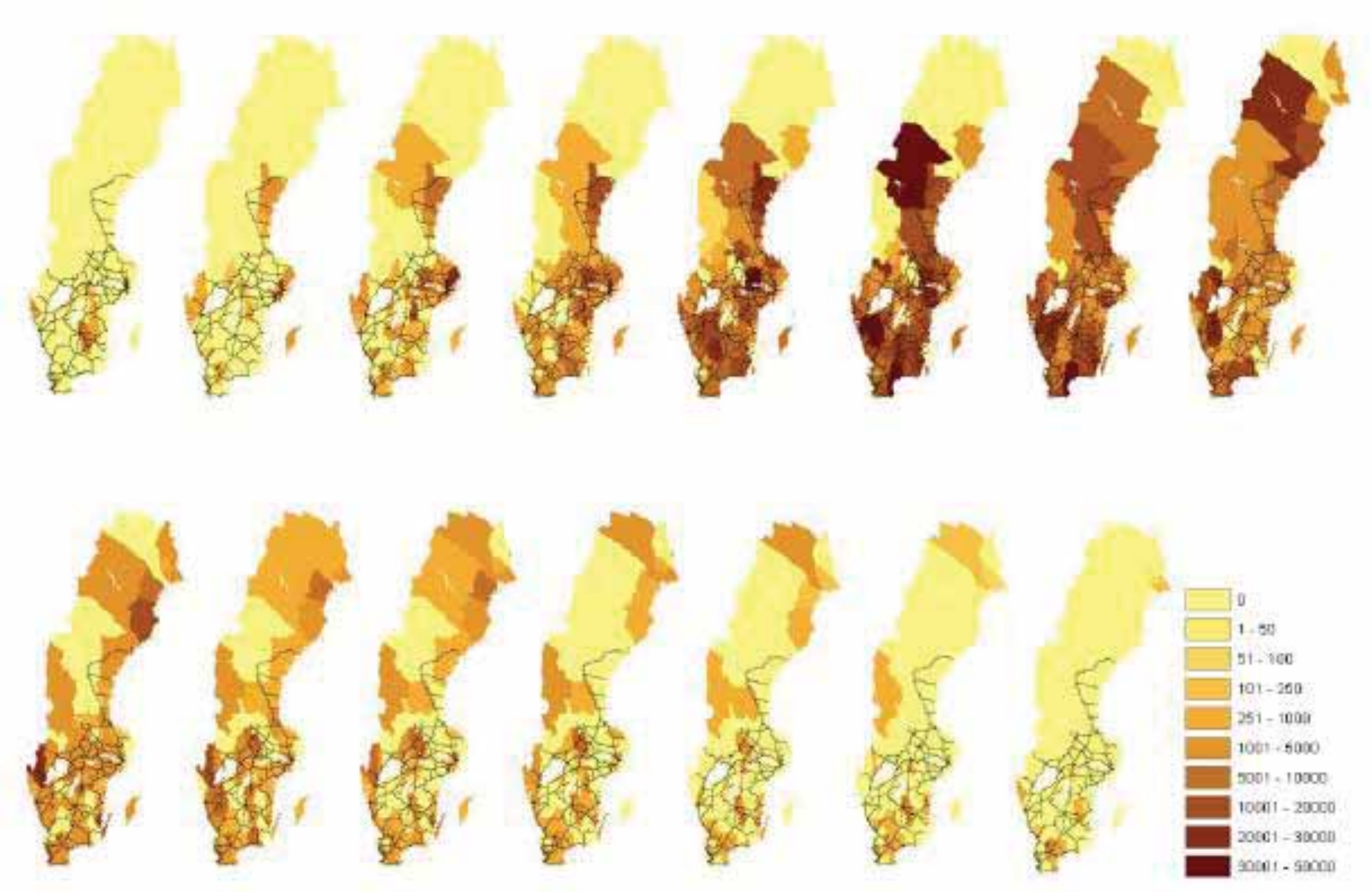
- Swedish railroad map, 1890 (map)
- Swedish water bodies (map)

Background

- Early understanding of factors determining spread
  - Optimal distribution of measures for mitigation of consequences
- Old pandemics – new knowledge

Russian Influenza 1889-1890

The Russian influenza in Sweden in 1889-90



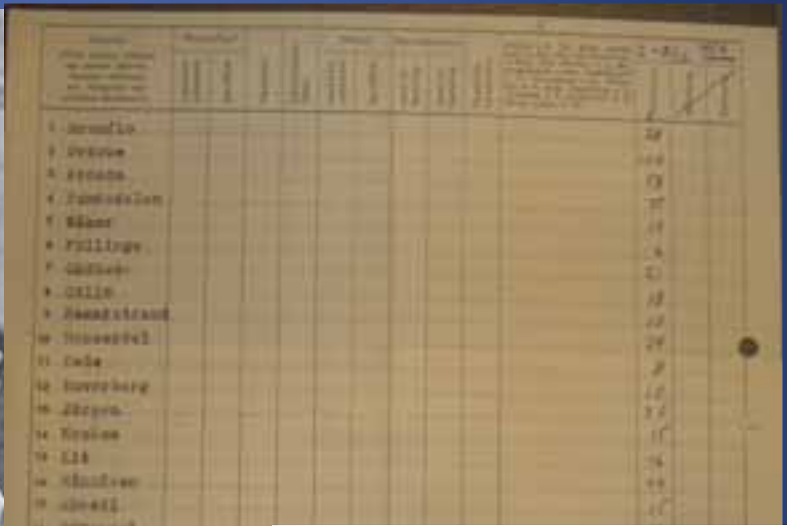
Asian Influenza 1957-1958

A(H1N1)pdm09 (Swine Flu) 2009-2010

Methods

- Data acquisition and preparation
- Geocoding
- Study of climate factors (Asian Influenza)
- Study of duration of epidemic periods and spatial distribution of peaking week
- Spatiotemporal Visualization
  - Geographic Weighted Mean (GWM)
  - Moran's I and Ripley's K-function

Data acquisition, preparation and geocoding



Climate factors (Asian Influenza)

- Mean temperature and precipitation/week
- 8 major cities with weather stations
- Trend lines least squares regression
- z-scores for temperature, precipitation and number of cases
  - (observation-mean value)/standard deviation
- Interpolation of weather data for all locations with diagnosed influenza cases

Duration of epidemic periods and spatial distribution of peaking week

- z-scores
- Slope for start and end of pandemic period
- Peaking week for each municipality
- Moran’s I
- Spatial correlation latitude and peaking week

Spatiotemporal Visualization

- Incidence per municipality (cumulative number of cases per week divided by number of inhabitants)
- GWM for weekly incidence

$$\overline{X}_w = \frac{\sum_{i=1}^{n} w_i x_i}{\sum_{i=1}^{n} w_i}, \quad \overline{Y}_w = \frac{\sum_{i=1}^{n} w_i y_i}{\sum_{i=1}^{n} w_i} \qquad (1)\ ,$$

where $\mathbf{w}_i$ is the incidence at municipality i

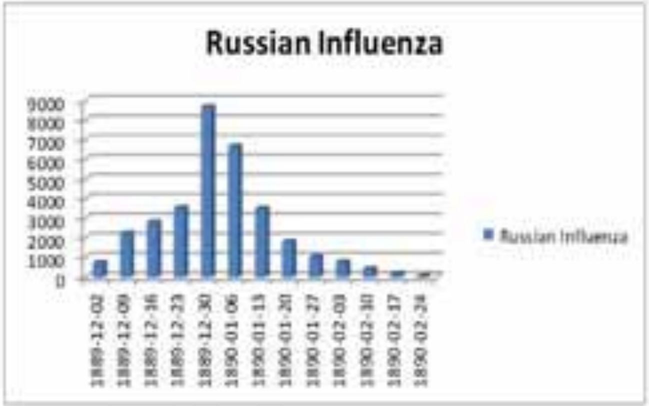
Results

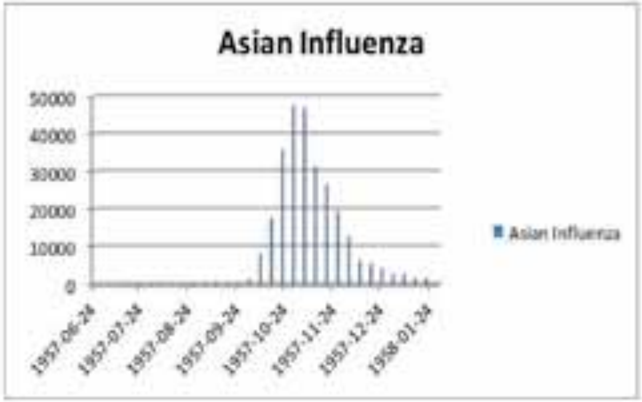
- Russian Influenza
- Asian influenza
  - Spatiotemporal propagation
  - Climate observations
- A(H1N1)pdm09
- GWM for incidence

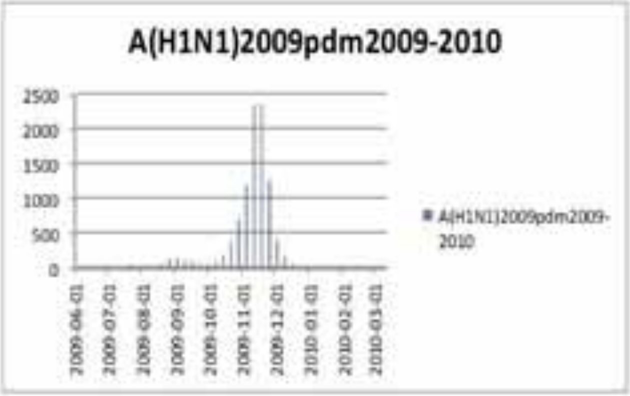
Pandemic	Total number of cases	Cases within 10 weeks epidemic period				Total number of weeks
		Number	%	Mean	STDV	
Russian Influenza	32,642	32,366	99.2	2511	21	13
Asian Influenza	276,537	250,518	90.6	8921	297	30
A(H1N1)pdm09	10,077	9,203	89.5	252	6	40

Results

Temporal Spread

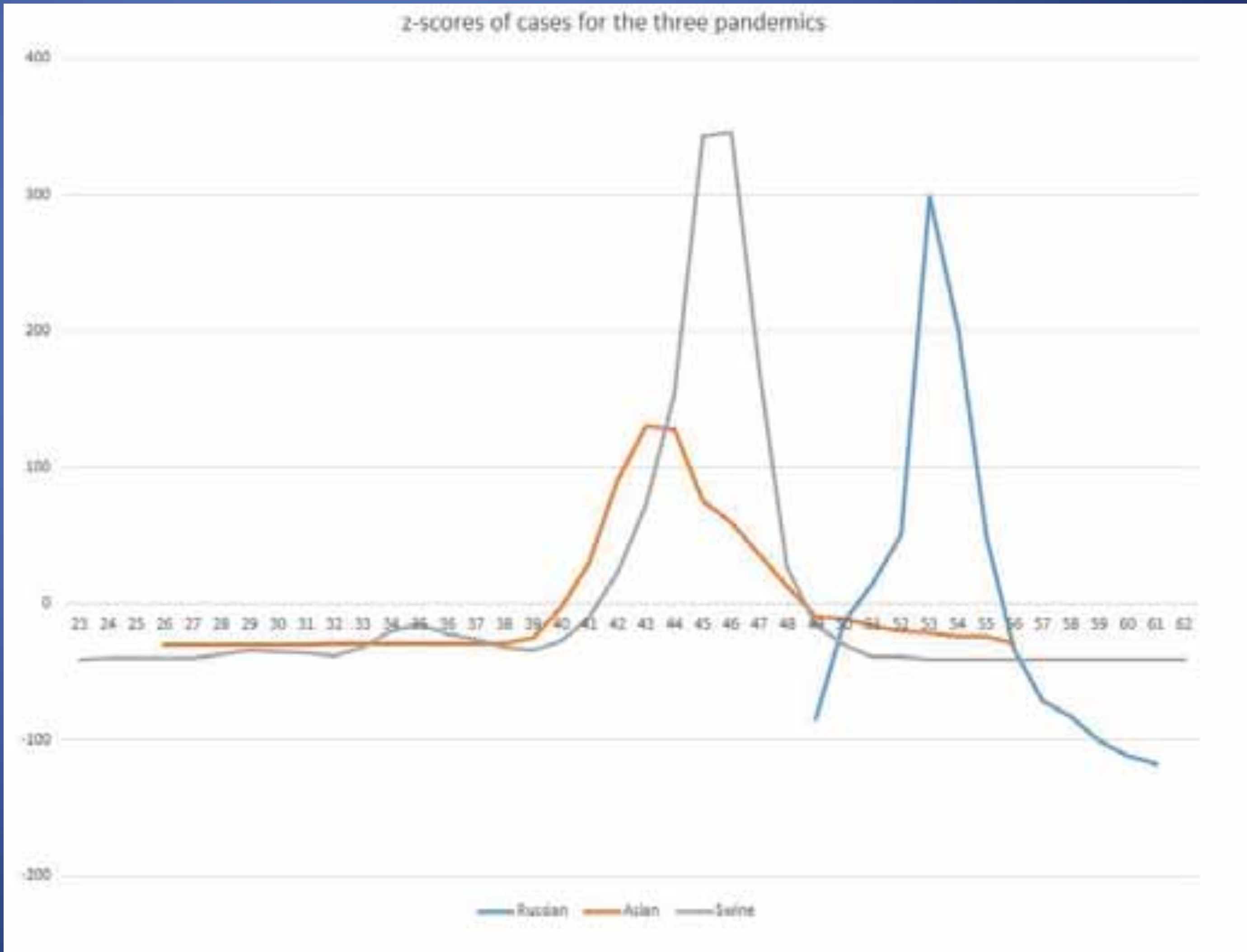






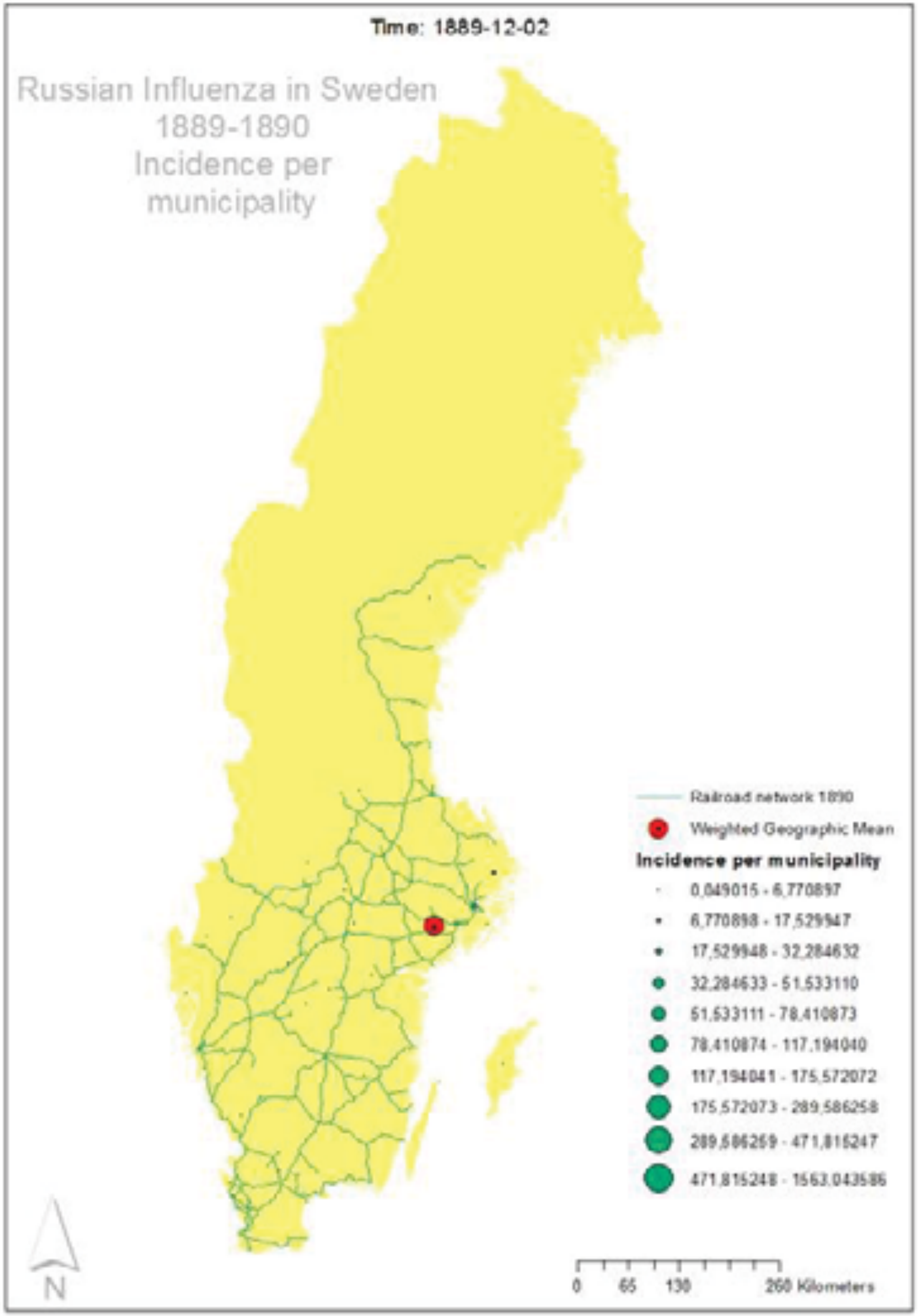
Results

z-scores of temporal spread



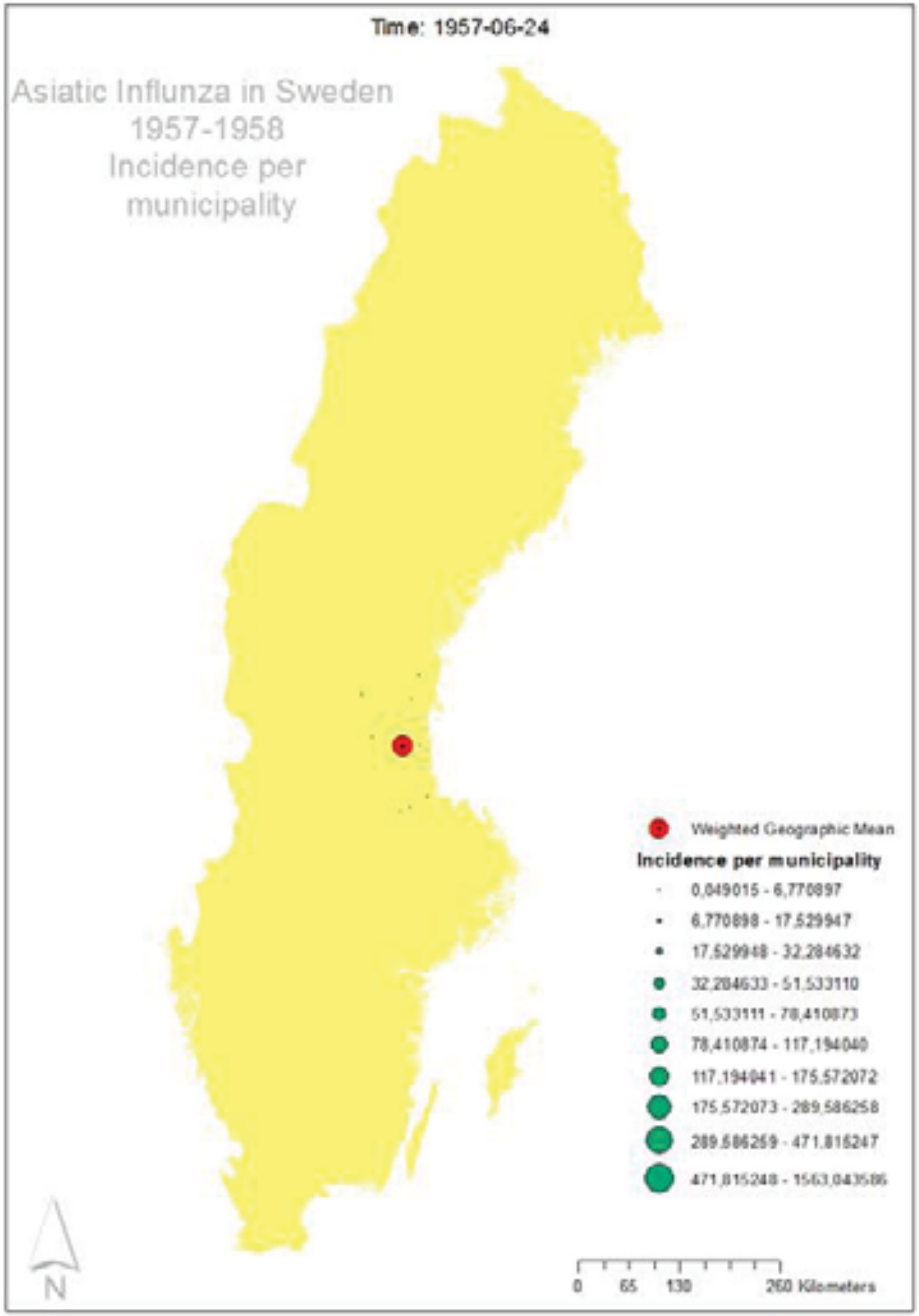
Results

Russian Influenza

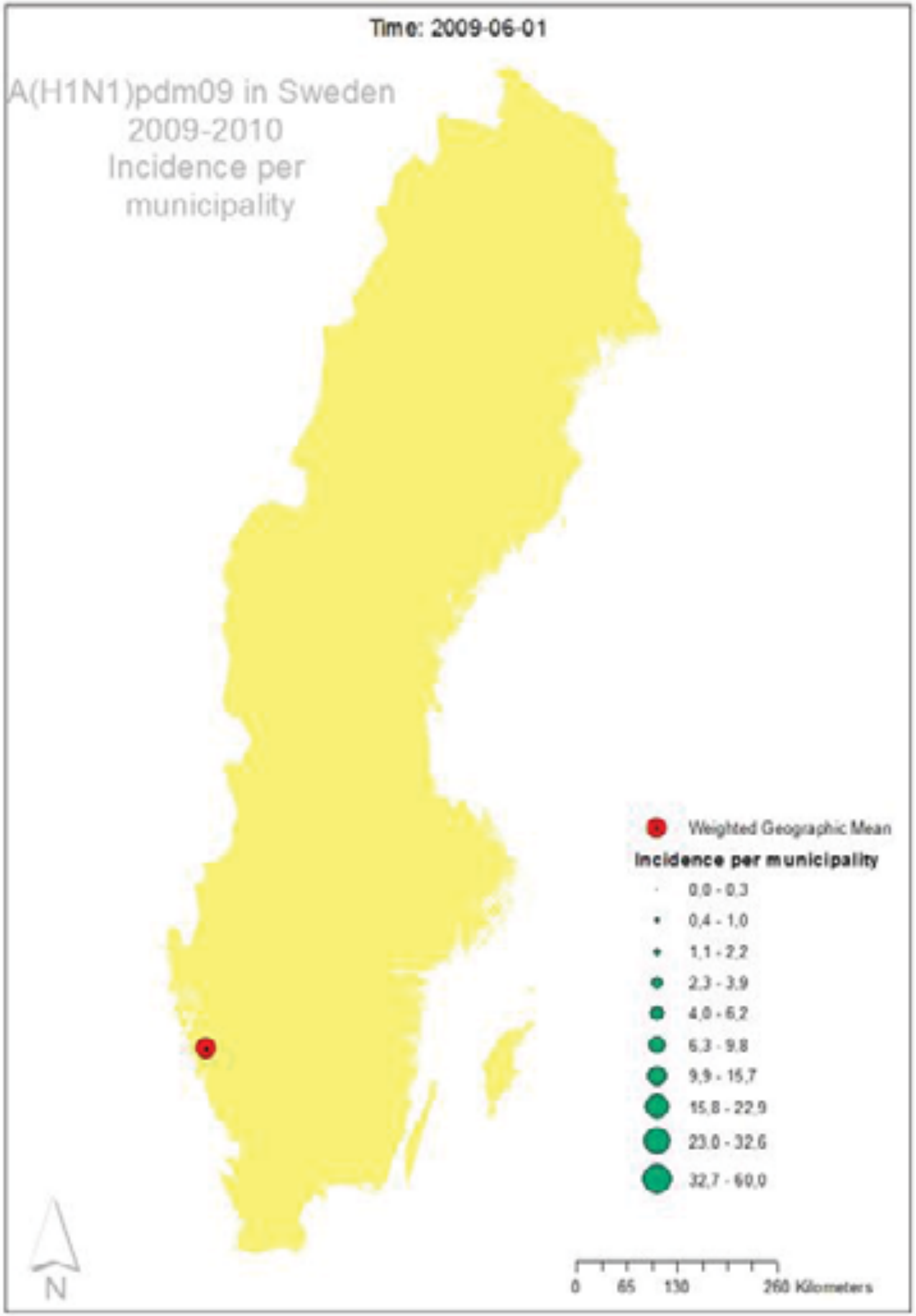


Results

Asian Influenza



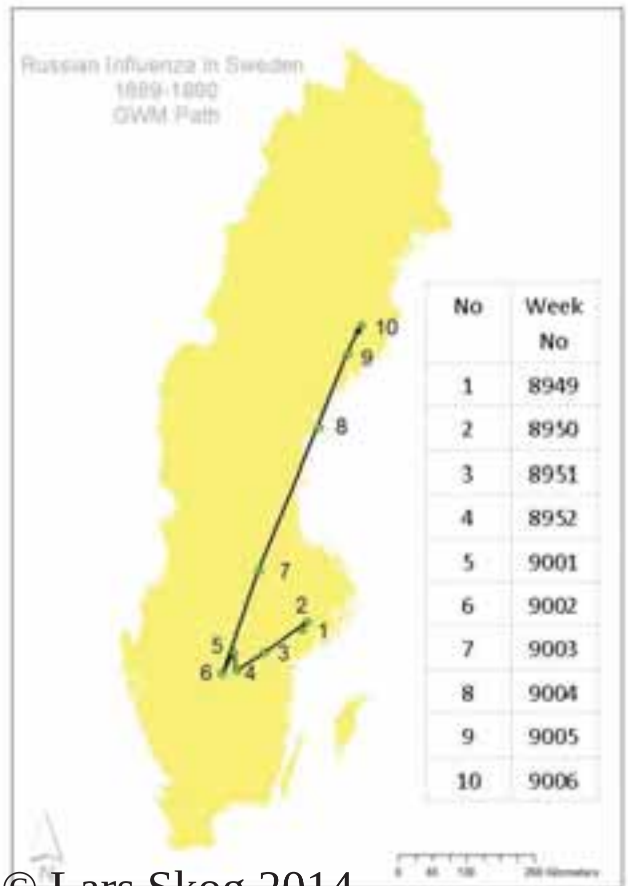
Results
A(H1N1)pdm09

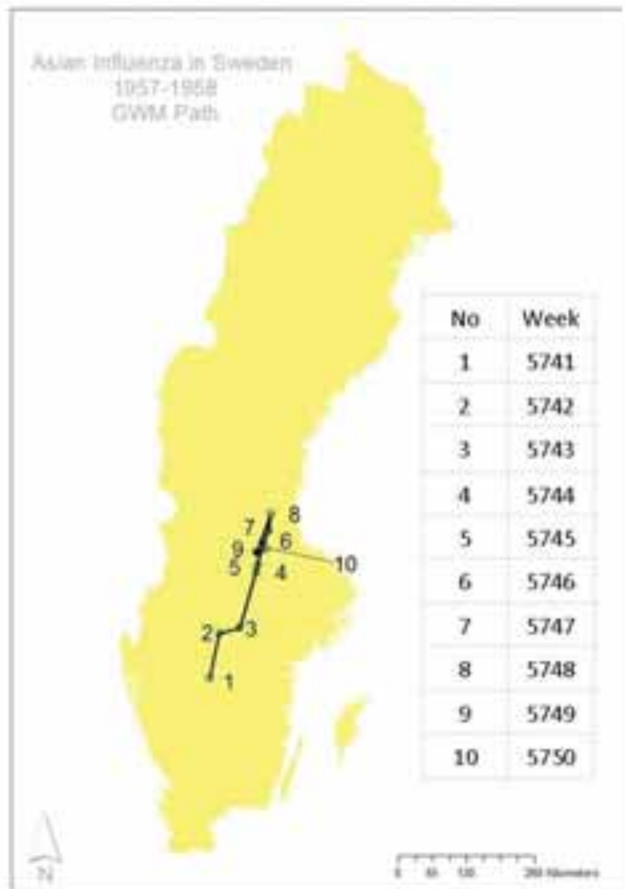


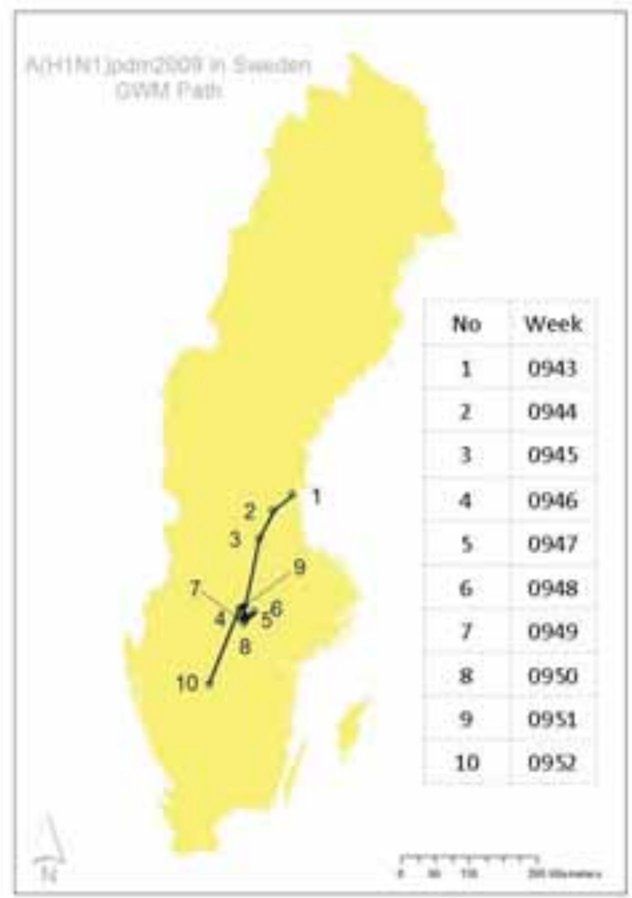
Results

Geographically weighted mean in tim

Directions of GWM during epidemic period		
Pandemic	Compass angle of resulting vector	Average length of vector (km)
Russian	14	109
Asian	29	50
A(H1N1)pdm09	205	59



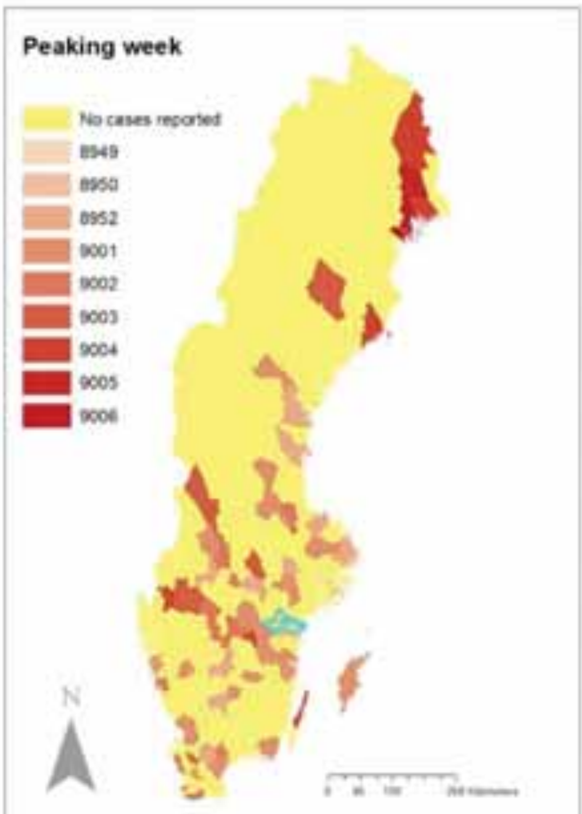




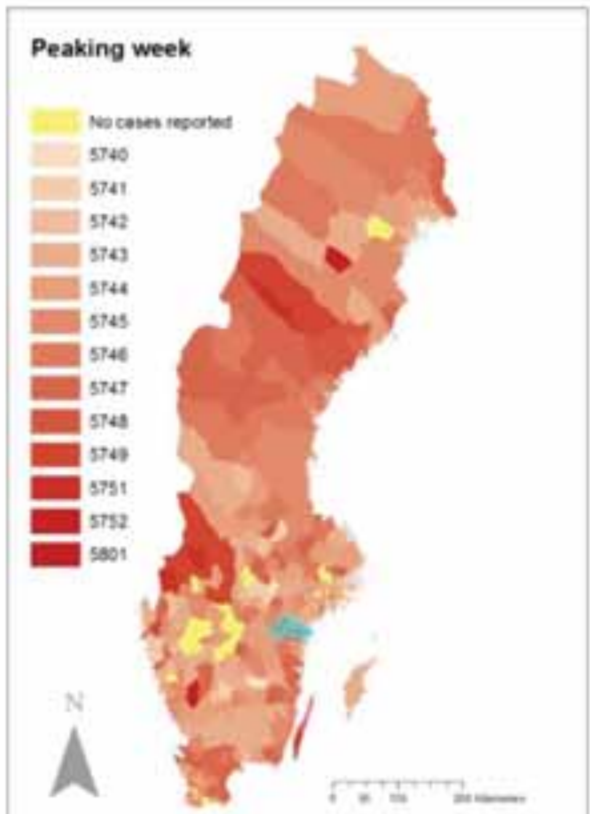
Results

Peaking week

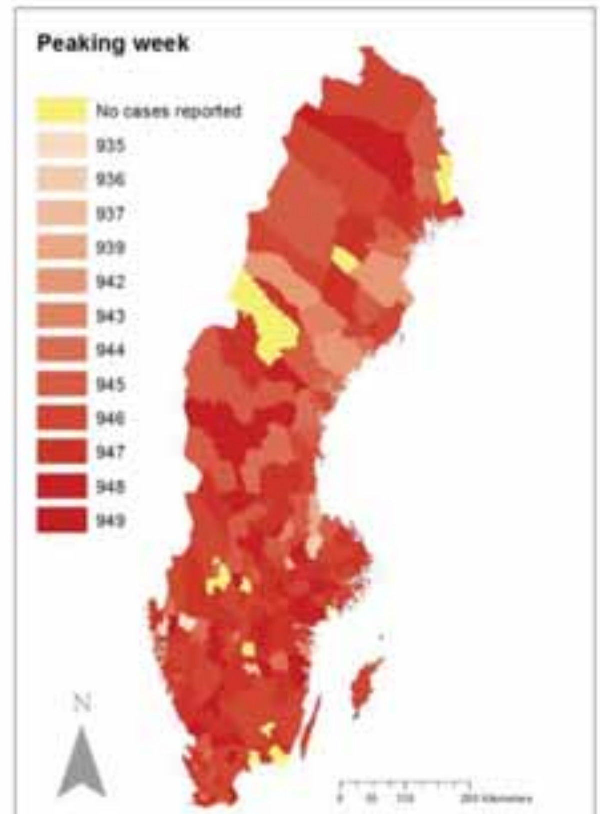
Russian Influenza 1889-1890



Asian Influenza 1957-1958

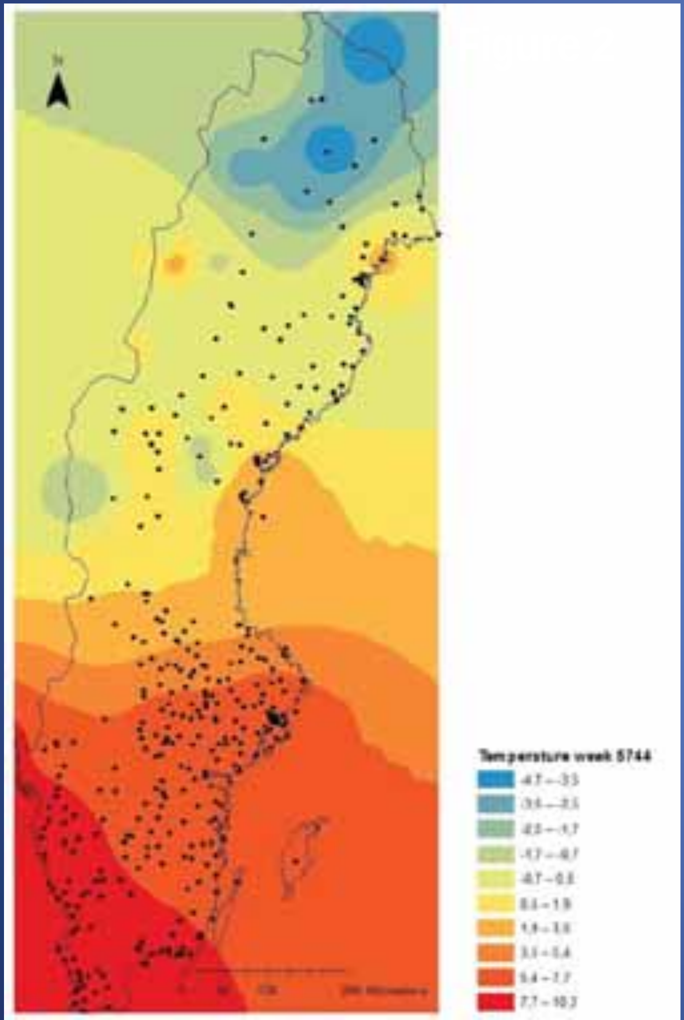


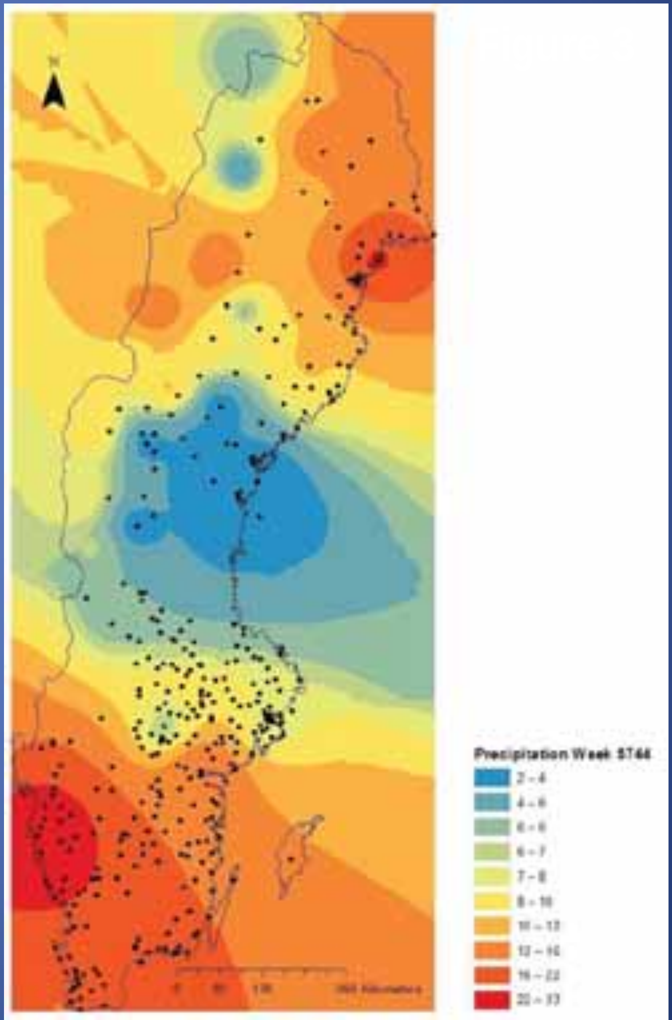
A(H1N1)pdm09



Results

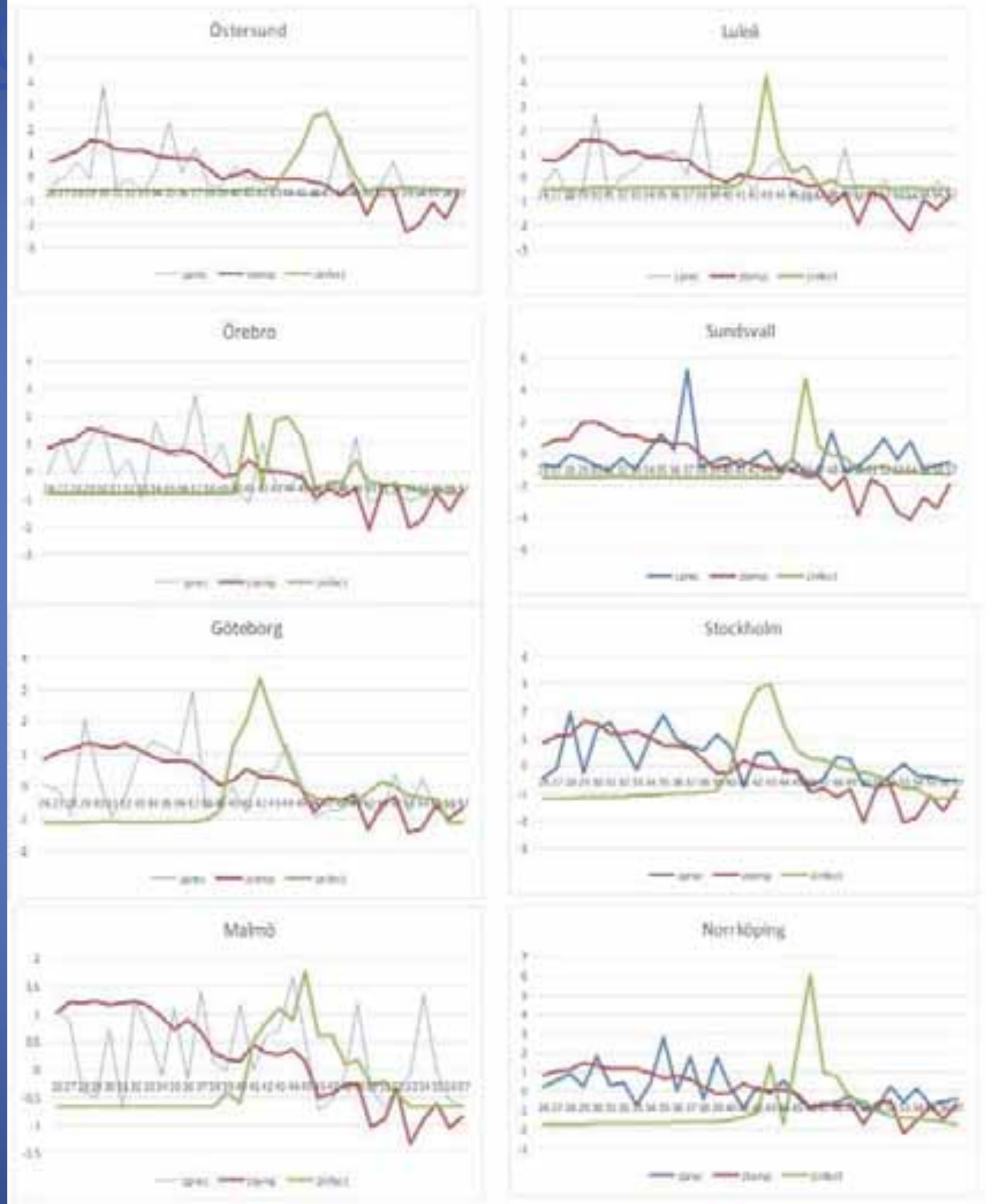
Climate observations





Results..\Bilder\

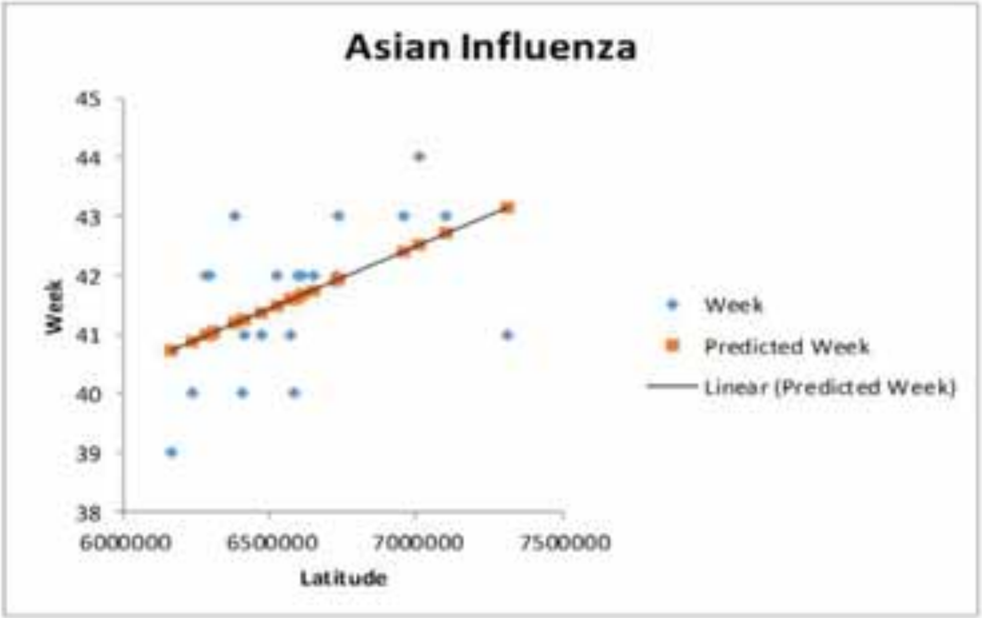
Falling temperature prior to onset of peaking period

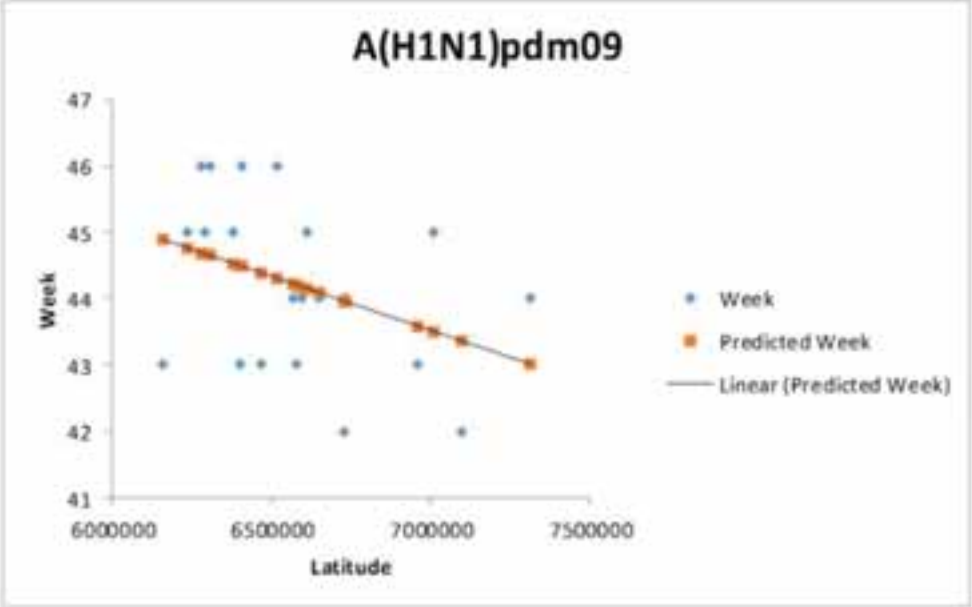


Results

Peaking period and latitude

Time for onset of peaking period vs latitude for county capitals for the Asian Influenza and the A(H1N1)pdm09





Discussion

- Quality of data; ILI vs laboratory tests
- Interventions
- Incidence and peaking period
- Climate

Conclusions

- Each pandemic had an epidemic period of approximately 10 weeks
- The weekly geographic weighted mean (GWM) of the incidence of the Russian and the Asian Influenza pandemics is mainly moving along a line from southwest to northeast. The weekly GWM for the A(H1N1)pdm09 influenza pandemic moved in the opposite direction, but along a line parallel to the one above
- The epidemic period of the Asian Influenza was preceded by falling temperatures
- The power of spatiotemporal analysis and modeling has been clearly demonstrated and epidemiologists have been given new information to be used in the development of new models for preparedness, prediction and analysis

Thank you for listening!

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