ArcGIS for revealing space-time patterns of livestock diseases spread

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- OIE* Regional Reference Laboratory for FMD** for Eastern Europe, Central Asia and Transcaucasia
- OIE Coordinating Center for Diagnosis and Control of Animal Diseases for Eastern Europe, Central Asia and Transcaucasia
- The Center produces biological preparations of high quality for prevention and treatment of animal diseases
- The Centre carries out researches in the framework of various Federal scientific and technical programs as well as international projects

*OIE - Office International des Epizooties  
currently World Organization for Animal Health  http://www.oie.int/

**FMD – Foot-and-Mouth Disease: a viral disease of cloven-hoofed animals causing economic impact by reducing growth and milk production of an affected herd
The Center for Information and Analysis
Reports to the Federal Service for Veterinary and Phytosanitary Surveillance (FSVPS)  http://fsvps.ru/fsvps/iac

• Monitoring of animal disease situation in Russia and in the world
• Disease mapping, modeling and forecasting
• Reporting to OIE
• Risk analysis in export/import operations with animals and food products
• Evaluation of Performance of National Veterinary Service (PVS)
GIS is an important tool in the Center’s activity

• ESRI customer since 2007
• ArcGIS for Desktop + extensions
• ESRI-trained personnel
• Regular participation in ESRI User Conferences (US and CIS)
The main applications of ArcGIS

- Static maps
- Online mapping
- Analytical work
Mapping
FSVPS enquiries on animal diseases in the RF and abroad

Worldwide distribution of African swine fever in 2014 (OIE data)

Wild boar (Sus Scrofa) range and population in the territory of the RF, different data sources
Online mapping
Online mapping

- Since 2016, ArcGIS-online platform is in use for sharing the official information on dangerous animal diseases in Russia
- Web Maps and Web Apps are both used
Online mapping

- Web-map of the “epidemic profile of the RF regions”
- Embedded into FSVPS web-site
Online mapping

- Map series to demonstrate disease / vaccination statuses of the RF regions
- http://arcg.is/2qetJqq (Foot-and-Mouth disease as an example)
Online mapping

- Web apps to show distribution of dangerous animal disease outbreaks
- Available at [http://fsvps.ru/fsvps/iac/rf/](http://fsvps.ru/fsvps/iac/rf/)

- African swine fever
- Foot-and-Mouth disease
- Lumpy skin disease
- Highly pathogenic avian influenza
- Sheep and goat pox
Online mapping

Pros and cons of using ArcGIS online platform

- Available with ArcGIS subscription
- Easy to upload data
- Ready-to-use maps and apps templates

- Lack of customization (symbology, labeling etc… )
- Sourcing data from Excel is challenging
- Slow drawing performance due to remoteness of server

Purchase of ArcGIS for Server is under consideration
Application of Spatial Statistics tools
The most used ArcGIS tools for advanced data analysis

Spatial statistics tools:
- Standard Deviational Ellipse
- Standard Distance
- Mean Center
- Grouping Analysis

Spatial Analyst tools:
- Kernel Density

Space-Time Pattern Mining toolbox:
- Create Space-Time cube
- Visualize space-time cube
Application of ArcGIS tools for revealing spatio-temporal patterns of animal diseases spread

African swine fever (ASF): dangerous viral disease of domestic and wild pigs leading to nearly 100% mortality among infected animals. No vaccine exists: the only control measure is total depopulation of pigs at the affected farm and within high risk zone of a certain radius.

- Revealing spatio-temporal patterns of the disease outbreaks emergence:
  - To predict further disease spread
  - To evaluate effectiveness of control/preventive measures
  - To plan monitoring activity
An example of Spatial Statistics tools application

- ASF outbreaks in Central Russia (2011-2014) were explored by:
  1. Grouping analysis
  2. Standard Deviational Ellipse within each group
An example of Kernel Density tool application

- ASF outbreaks in Eastern Europe (2007 – 2015) were used to create a density surface
- Concentration of outbreaks corresponds to main temporal stages of the disease spread
Application of Space Time Pattern Mining Tools

- Space-time cube (STC) allows detecting patterns of the disease outbreaks clustering through time
  - Reveal areas of increase/decrease of outbreaks’ emergence
  - Reveal locations with re-emerging outbreaks
  - Reveal Hot and Cold spots

- Two categories of patterns can be recognized using STC analysis:
  - Hot/Cold spots and trends of its emergence through time
  - Trends of outbreaks emergence at a particular location
Space-Time Cube

- ASF outbreaks in the Russian Federation (2007 – 2017) were used to create a space-time cube (STC)
- 3D visualization of space-time cells (Bins) with outbreaks
- The Space-Time cube is stored in NetCDF format allowing its further conversion and analysis by additional tools
Emerging Hot/Cold Spots Analysis

• Hot and Cold spots indicate areas where the disease outbreaks tend to emerge
• Patterns of Hot/Cold Spots demonstrate linkage of hot/cold spots to the particular time periods (Consecutive, Persistent, Sporadic, Oscillating etc.)
Trends of Hot/Cold Spots emergence

• Trends of Hot and Cold spots emergence indicate zones of decrease and increase of the epidemic
Trends of outbreaks emergence within particular locations

- Trends of outbreaks emergence demonstrate locations with Up/Down trends of outbreaks emergence.
- Depending on the disease epidemiology, may indicate locations with presence of natural foci or with poor control measures.
Thank you for your attention!
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