MTT Viikki, Helsinki, Finland
April 14, 2014

# *Semantic* disease pressure modelling

Markus Stocker

UNIVERSITY OF
EASTERN FINLAND

# The idea

- Implement disease pressure modelling using Wavellite
- Given sensor data and a disease pressure model
  - Learn about (acute) outbreak situations
  - Of pathogens at agricultural parcels
- Disease pressure modelling useful to farmers
  - Early warning for pathogen outbreaks
  - Implement control measures based on predicted situations

# Materials

- Agricultural parcel data
  - GIS (polygon) data for 41 agricultural parcels
  - Available as ArcGIS shapefile
- Soil weather data
  - For T, RH, WS by one weather station at 15 minutes interval
  - May 1 till August 31, 2013
  - Available as MS Excel document
- The model
  - Physically-based environmental model
  - Pathogen-specific daily and accumulated index
  - (Acute) outbreak situation if index > (75) 50
  - Available as MS Word document

# Wavellite

- Modelling and software framework
- Aimed at situation awareness in environmental monitoring
- Modelling
  - Sensors and their data obtained in measurement
  - Datasets and data derived in computations
  - Situations observed/predicted in monitored environment
- Software
  - Implementation of situation assessment/awareness tasks
  - Assessment is process of achieving situation awareness
- Core types
  - Sensor observation
  - Dataset observation
  - Situation
- Types defined formally and explicitly in ontologies

# Achieved so far

- GIS data
  - Modelled as agricultural parcels, i.e. spatial regions
  - Conversion of ArcGIS data to Wavellite RDF
- Example for Pelto A

```
@prefix mtt: <http://envi.uef.fi/wavellite/mtt#> .
@prefix geo: <http://www.opengis.net/ont/geosparql#> .
@prefix rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#> .
@prefix sf: <http://www.opengis.net/ont/sf> .

mtt:agricultural-parcel-9270503501-A
        rdf:type mtt:AgriculturalParcel .
mtt:agricultural-parcel-9270503501-A
        geo:hasGeometry mtt:795affd6-9216-4cd1-8938-5ff51d2b6076 .
mtt:795affd6-9216-4cd1-8938-5ff51d2b6076>
        rdf:type sf:Polygon .
mtt:795affd6-9216-4cd1-8938-5ff51d2b6076>
        geo:asWKT "POLYGON ((24.37 60.42, ...))"^^geo:wktLiteral .
```

# Achieved so far

- Sensor data
  - Modelled as sensor observations
  - Conversion from Excel document to Wavellite RDF
- Example query

```
select ?time ?value
where {[
    rdf:type woe:SensorObservation ;
    ssn:featureOfInterest matr:Air ;
    ssn:observedProperty quanTemperature:Temperature ;
    ssn:observedBy mtt:weather-station-36-hmp50 ;
    ssn:observationResultTime [ time:inXSDDateTime ?time ] ;
    ssn:observationResult [
        dul:hasRegion [ dul:hasRegionDataValue ?value ]
    ]
]}
```

- Example result

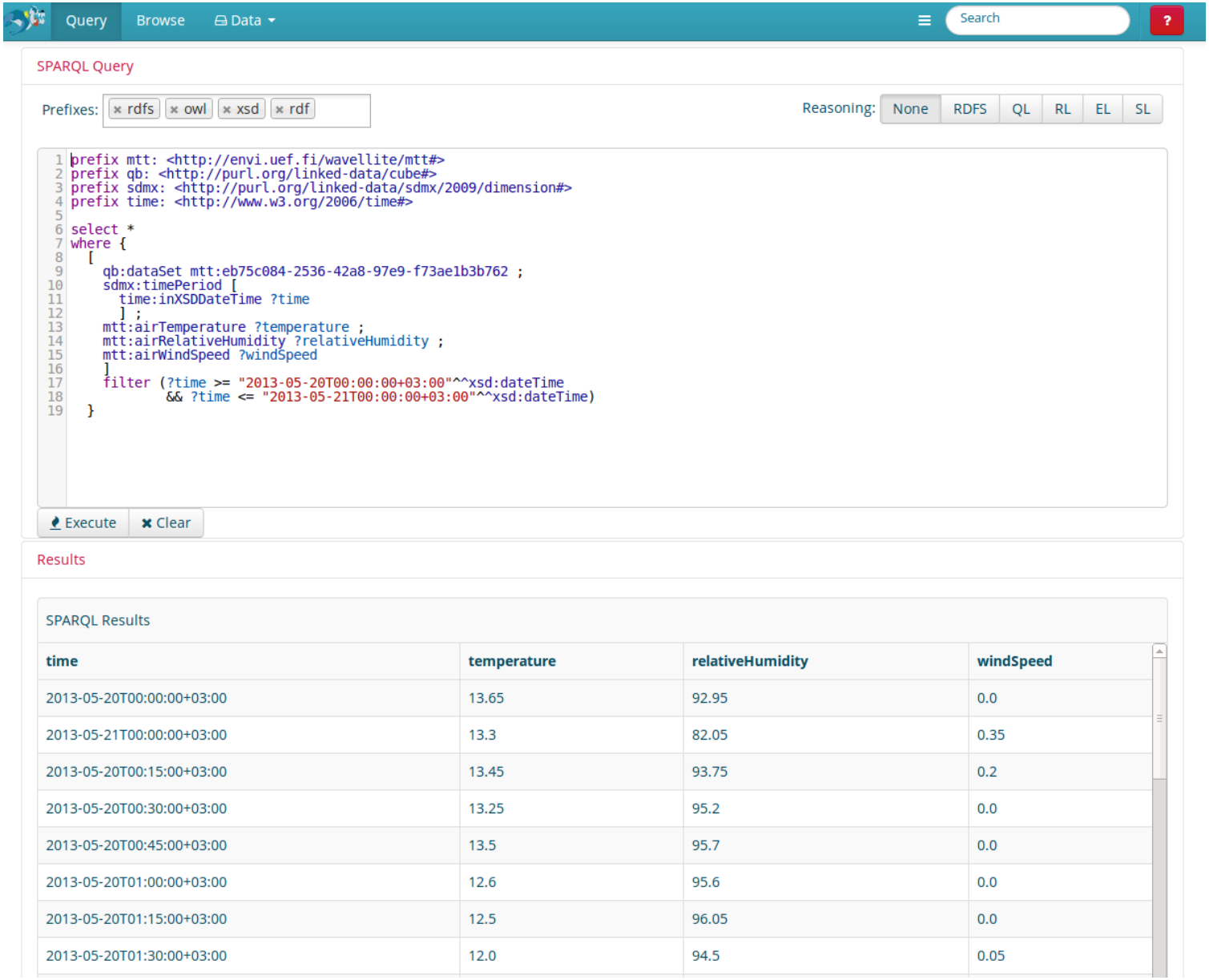
```
?time = 2013-05-01T02:15:00+03:00, ?value = 0.85
```

# Achieved so far

- Dataset for sensor data
  - Basically a “view” on all sensor data
  - Starting point for disease pressure computations
  - Roughly equivalent to original Excel document
- Example query

```
select *
where {[
    qb:dataSet mtt:eb75c084-2536-42a8-97e9-f73ae1b3b762 ;
    sdmx:timePeriod [ time:inXSDDateTime ?time ] ;
    mtt:airTemperature ?temperature ;
    mtt:airRelativeHumidity ?relativeHumidity ;
    mtt:airWindSpeed ?windSpeed
]}
```

- Example result
  - Next slide with Stardog Web Console screenshot


Query
Browse
Data
Search
?
SPARQL Query
Prefixes:
× rdfs
× owl
× xsd
× rdf
Reasoning:
None
RDFS
QL
RL
EL
SL
prefix mtt: <http://envi.uef.fi/wavellite/mtt#>
prefix qb: <http://purl.org/linked-data/cube#>
prefix sdmx: <http://purl.org/linked-data/sdmx/2009/dimension#>
prefix time: <http://www.w3.org/2006/time#>
select *
where {
[
qb:dataSet mtt:eb75c084-2536-42a8-97e9-f73ae1b3b762 ;
sdmx:timePeriod [
time:inXSDDateTime ?time
] ;
mtt:airTemperature ?temperature ;
mtt:airRelativeHumidity ?relativeHumidity ;
mtt:airWindSpeed ?windSpeed
]
filter (?time >= "2013-05-20T00:00:00+03:00"^^xsd:dateTime
&& ?time <= "2013-05-21T00:00:00+03:00"^^xsd:dateTime)
}
Execute
Clear
Results
SPARQL Results
time
temperature
relativeHumidity
windSpeed
2013-05-20T00:00:00+03:00
13.65
92.95
0.0
2013-05-21T00:00:00+03:00
13.3
82.05
0.35
2013-05-20T00:15:00+03:00
13.45
93.75
0.2
2013-05-20T00:30:00+03:00
13.25
95.2
0.0
2013-05-20T00:45:00+03:00
13.5
95.7
0.0
2013-05-20T01:00:00+03:00
12.6
95.6
0.0
2013-05-20T01:15:00+03:00
12.5
96.05
0.0
2013-05-20T01:30:00+03:00
12.0
94.5
0.05

# So far quite trivial

- True, rather boring database tasks
- Just with different technologies
- However,
  - Terminology used in data and queries defined in ontologies
  - Those ontologies ("schemas") are developed by experts
  - Some widely in use (de-facto standard)
  - Aligned to other well-known standards, e.g. OGC
  - Increased interoperability between systems
  - Flexibility of graph data structure and databases
  - Some added goodies, e.g. reasoning
  - Open technologies (W3C recommendations)
  - Everything in RDF (instead of Excel, ArcGIS, ...)
  - One database (Stardog) and one query language (SPARQL)

# Achieved so far

- Disease pressure model implementation
  - Java implementation of disease pressure model description
  - Available as a library (independent software package)
  - Exposes an API to compute daily and accumulated indexes
- Example usage

```
DiseasePressureModel m = new DiseasePressureModel();
m.setPathogen("PyrenophoraTeres");
m.setPrecedingCrop("Wheat");
m.setTillage("Intensive");
m.setCropSusceptibility("Resistant");
m.setAccumulatedRisk(10.0);
m.setTemperature(24.5);
m.setDailyLeafWetnessDuration(11.0);
m.setWindSpeed(2.4);
m.setLeafIsWet(false);
System.out.println("Daily risk: " + m.getDailyRisk());
System.out.println("Accumulated risk: " + m.getAccumulatedRisk());
```

# Achieved so far

- Disease pressure computation
  - For agricultural parcels Pelto A and Pelto C, and
  - Pathogens PyrenophoraTeres and DrechsleraTriticiRepentis
  - Wavellite processing module
    - Uses the dataset for sensor data
    - And the disease pressure model library
    - Computes model parameters (e.g. daily mean T)
    - As well as daily and accumulated indexes
    - For each pathogen and agricultural parcel
    - Represents computation results as dataset observations
    - Persists dataset to store (Stardog)
  - Wavellite situation engine
    - Uses the dataset with accumulated indexes
    - To extract (acute) outbreak situations
    - Represents and persists situations

# Achieved so far

- Situation visualization
  - Use Wavellite browser to visualize outbreak situations
  - Generic JavaScript client for situation visualization
  - Supports timeline and map visualization
  - Some support for filtering (e.g. time interval)
  - RESTful interaction with Wavellite server
  - Available at
    - `http://enviapps.uef.fi/wavellite-browser`
  - Some screenshots ...

Relation

http://envi.uef.fi/wavellite/mtt#outbreakRisk
http://envi.uef.fi/wavellite/mtt#acuteOutbreakRisk

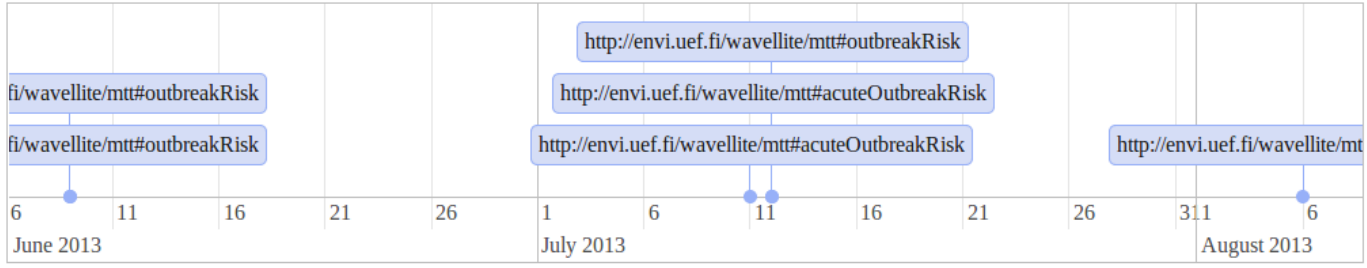
Start date

____-__-__ __:__

End date

____-__-__ __:__

filter




Relation

http://envi.uef.fi/wavellite/mtt#outbreakRisk
http://envi.uef.fi/wavellite/mtt#acuteOutbreakRisk

Start date

2013-07-01 00:00

End date

2013-08-01 00:00

filter

---

**Relation**
http://envi.uef.fi/wavellite/mtt#acuteOutbreakRisk

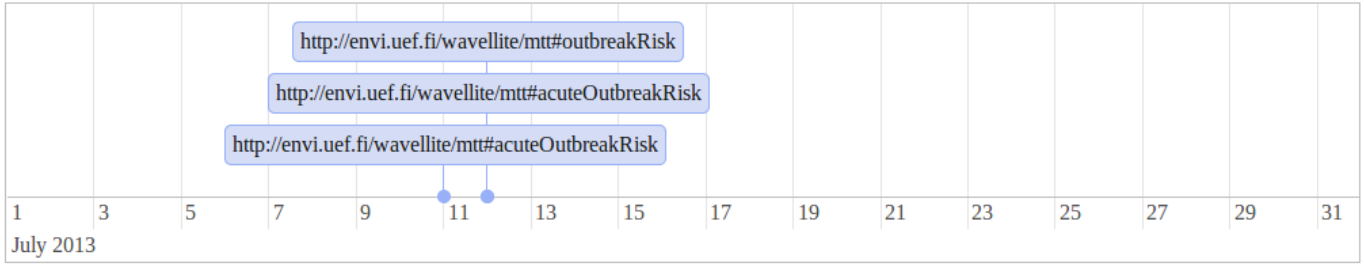
**Value**
Pelto A

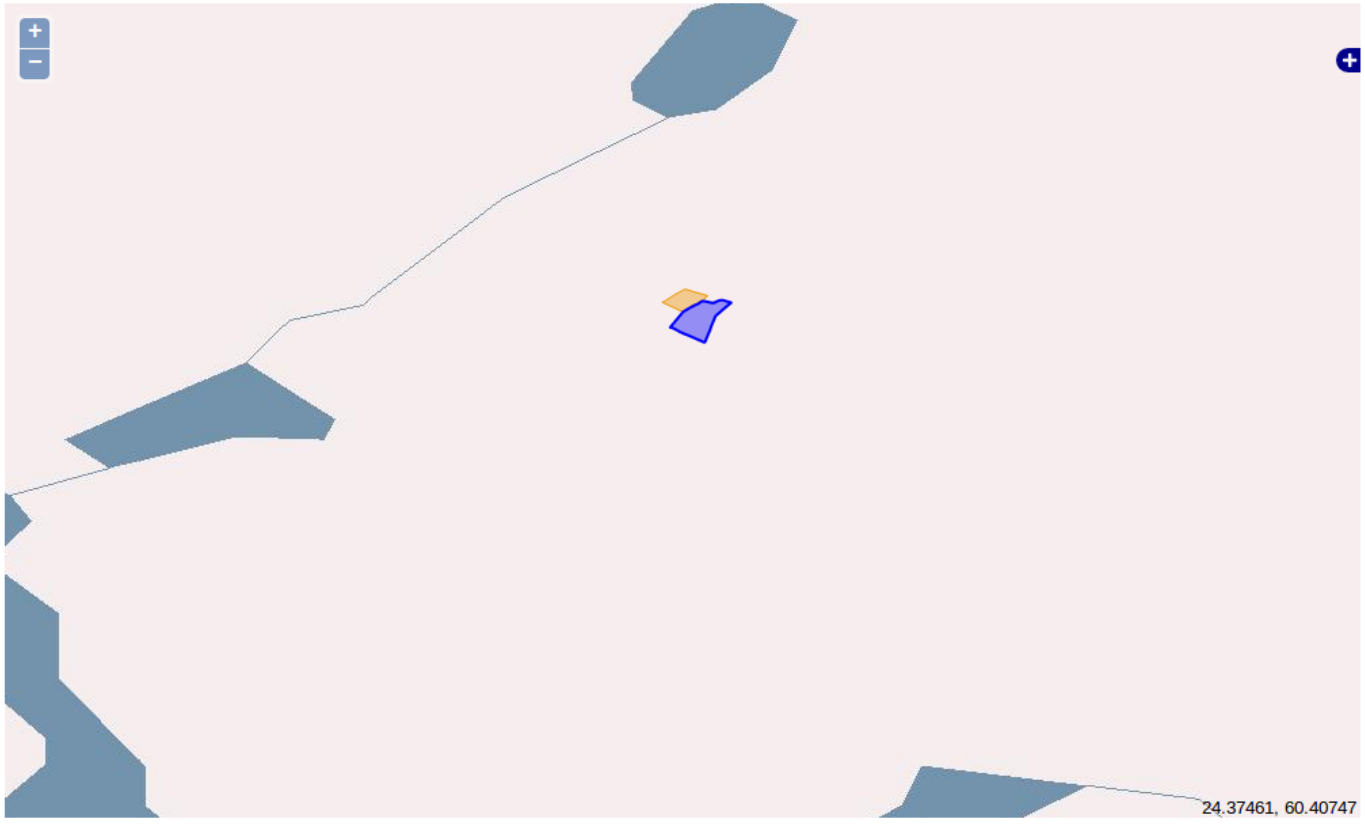
**Value**
DrechsleraTriticiRepentis

**Spatial location**
http://envi.uef.fi/wavellite/mtt#agricultural-parcel-9270503501-A

**Temporal location**
Fri Jul 12 2013 00:00:00 GMT+0300 (EEST)

**Polarity**
True



# To be achieved

- Some refactoring to ontology and program code
- Unit testing of disease pressure model library
- Situation projection
  - Predict outbreak situations, e.g. next week
  - More useful as it gives time to implement control measures
  - Could run in “real” time
  - Some preliminary results using SVR
    - Train SVR models from historical sensor data
    - Use current week data to predict daily values of next week
    - Compute disease pressure using *predicted* values
    - Extract outbreak situations (unchanged)
- Journal article
  - Wavellite article (in addition to & will cite “model article”)
  - Computers and Electronics in Agriculture (JF 2, IF 1.8)
  - Co-authors: Jussi, Hanna, Markku, Mauno, Mikko (sugg.)