Reforming Traditional Machine Learning Algorithms with Spatio-Temporal Analytics Capability for Big Data

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IBM Analytics

#SAISDS9

Content

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- Spatio-Temporal Exploratory and Modeling (STEM)
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Background
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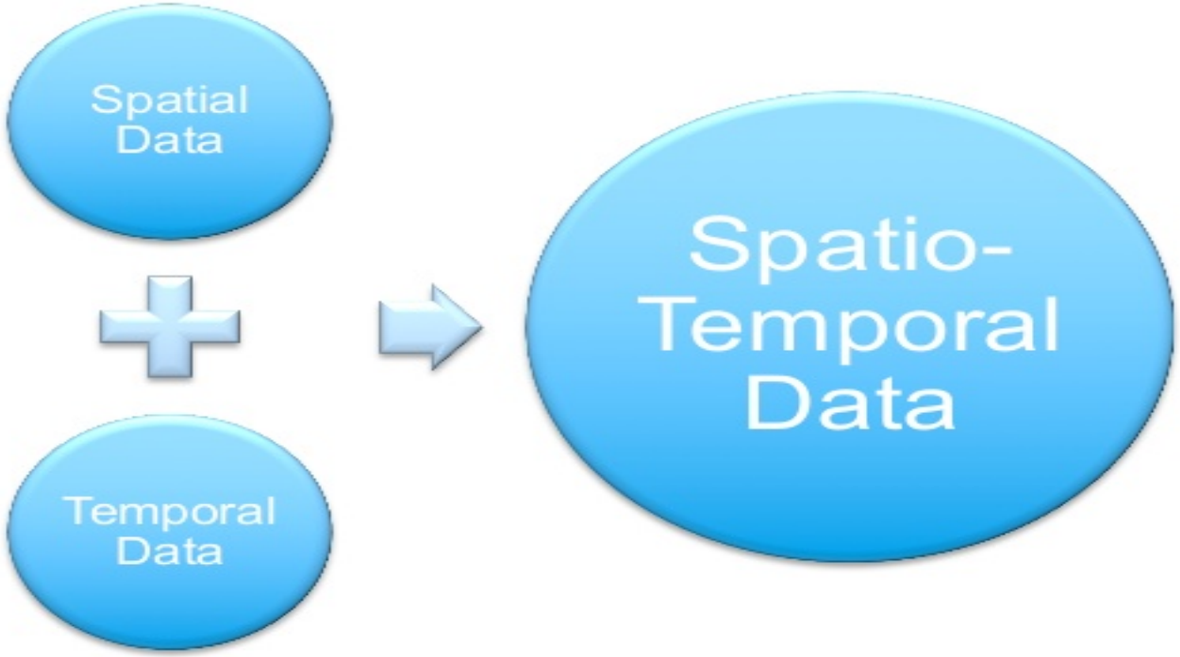
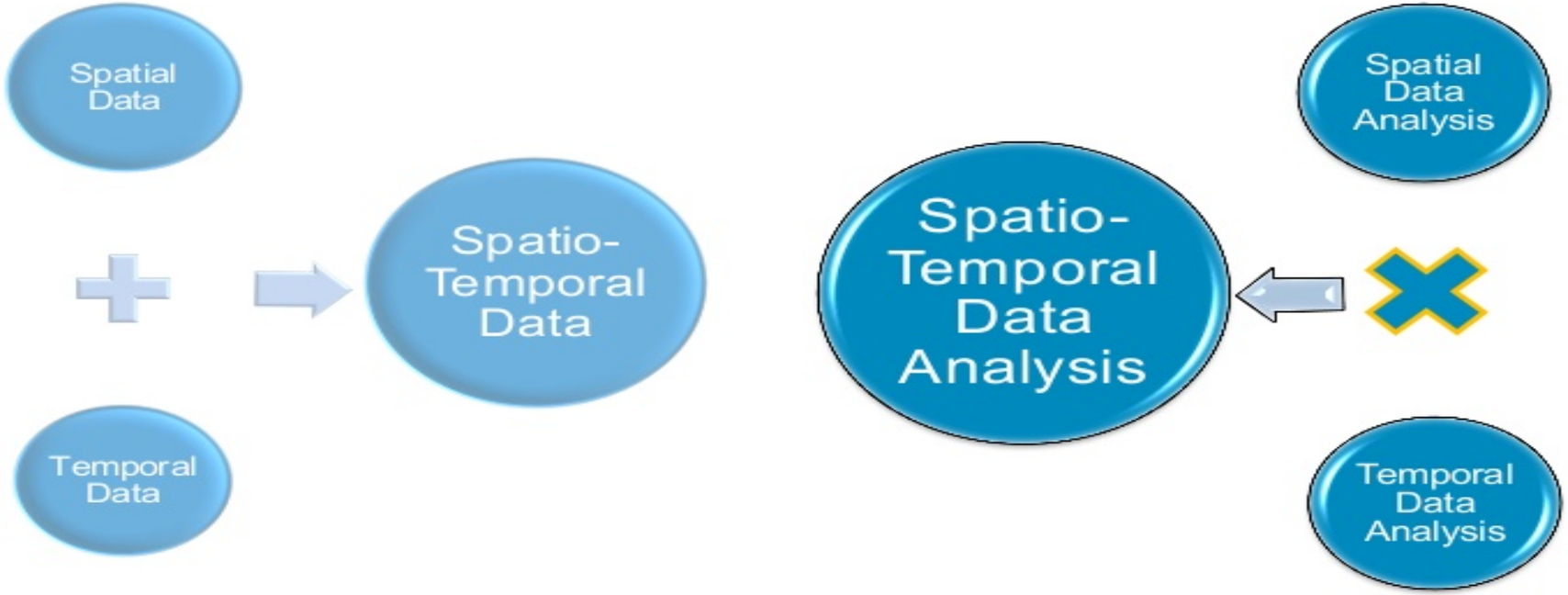
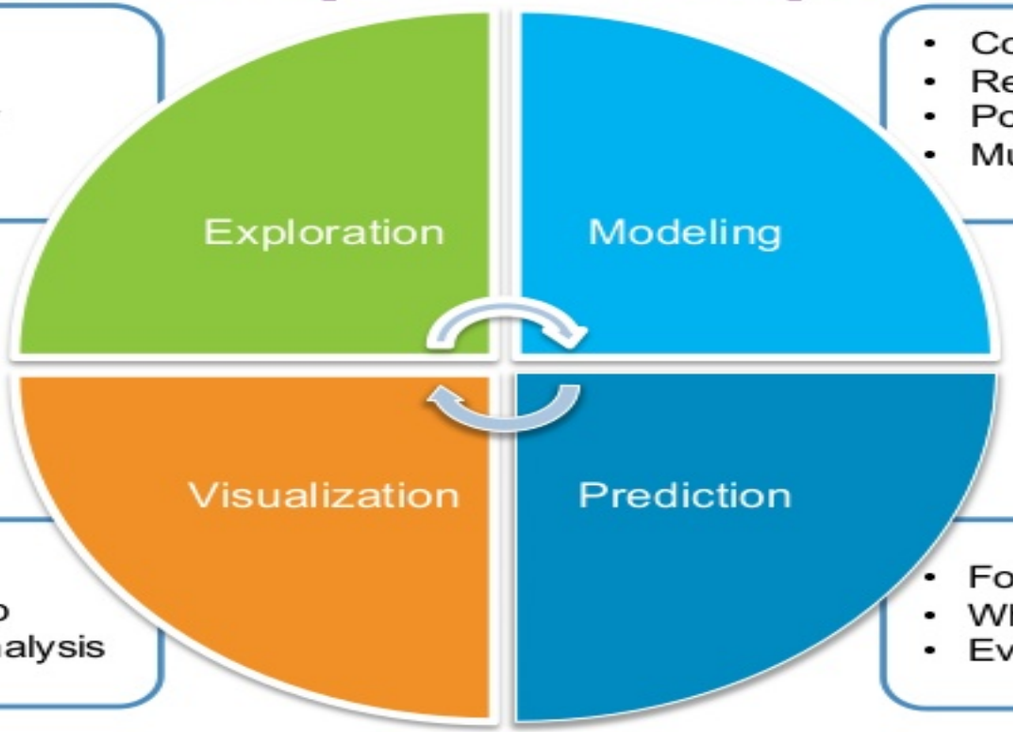


Background
- Spatio-Temporal Data & Analysis



Background
- Analysis Areas for Spatio-Temporal Data

- Association Rule
- Clustering
- Empirical intensity

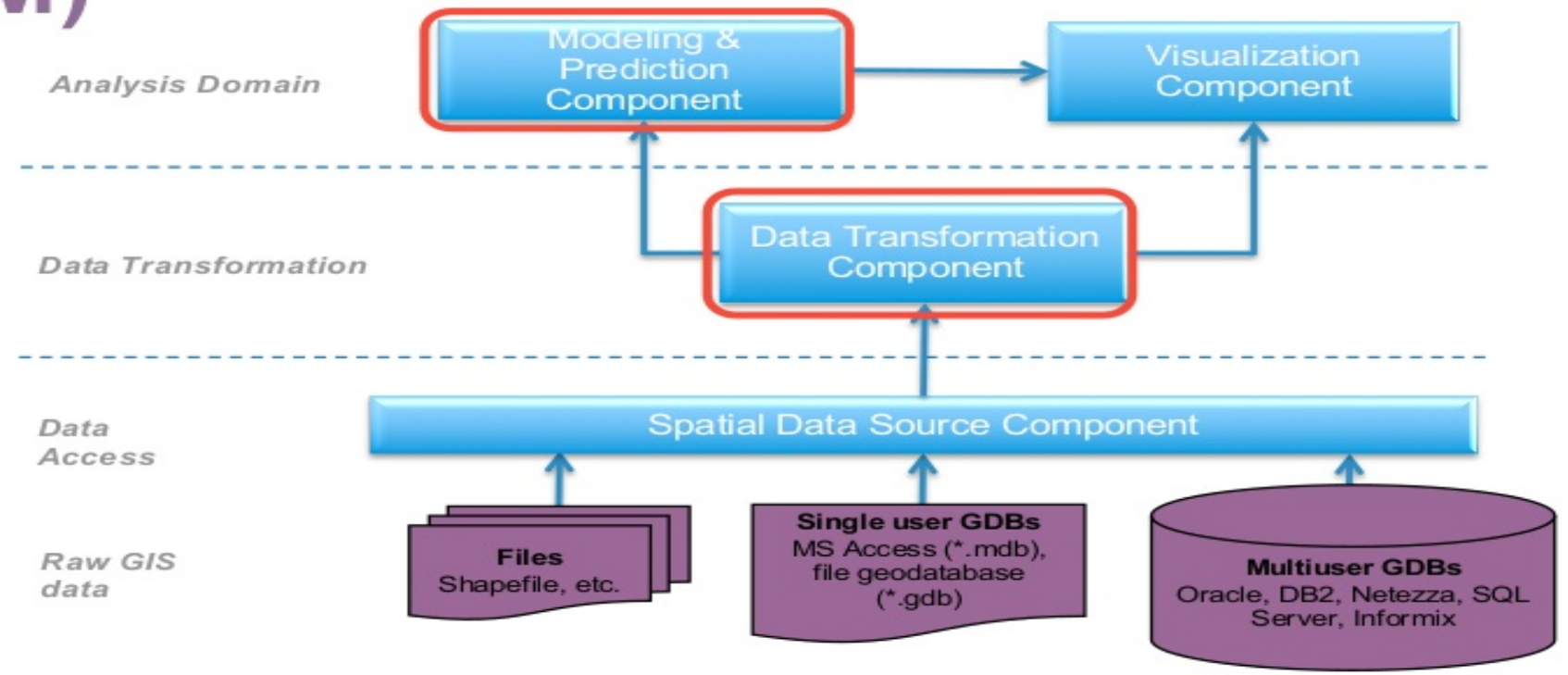


- Correlation modeling
- Regression modeling
- Point process modeling
- Multivariate structural modeling

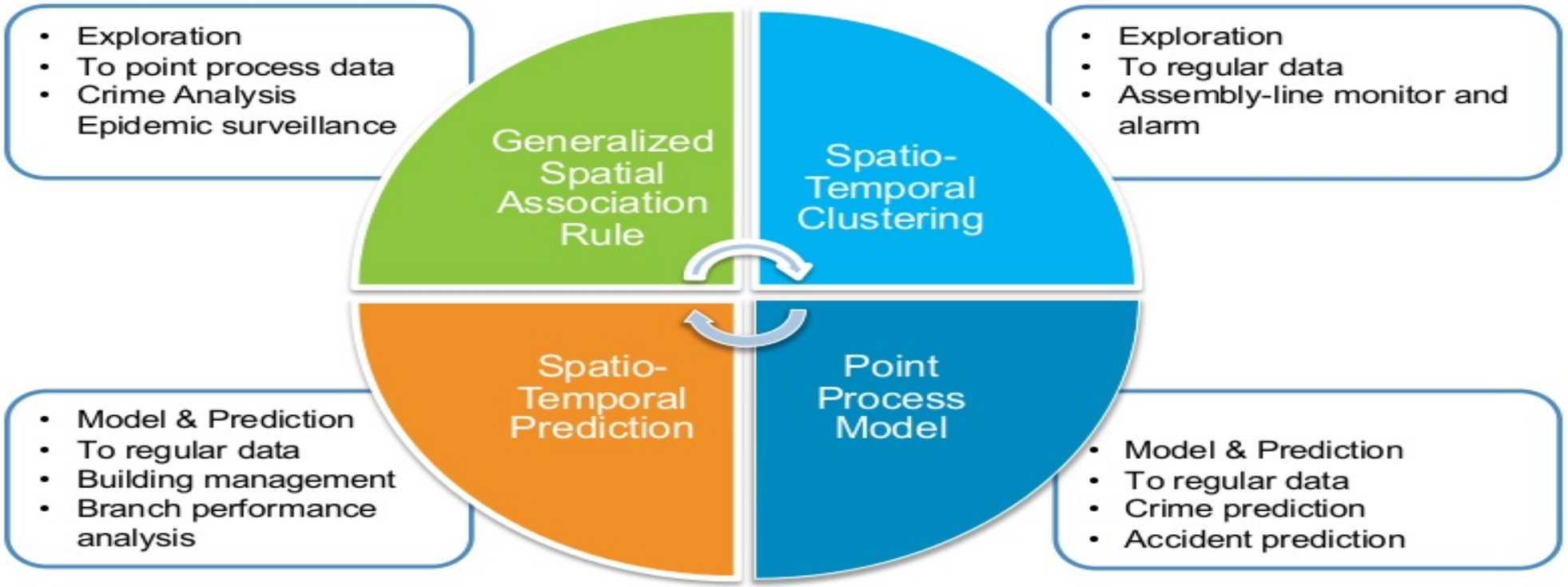
- Objects overlay
- Dynamic heat map
- Visual scenario analysis

- Forecasting & interpolation
- What-if analysis
- Event occurrence alert

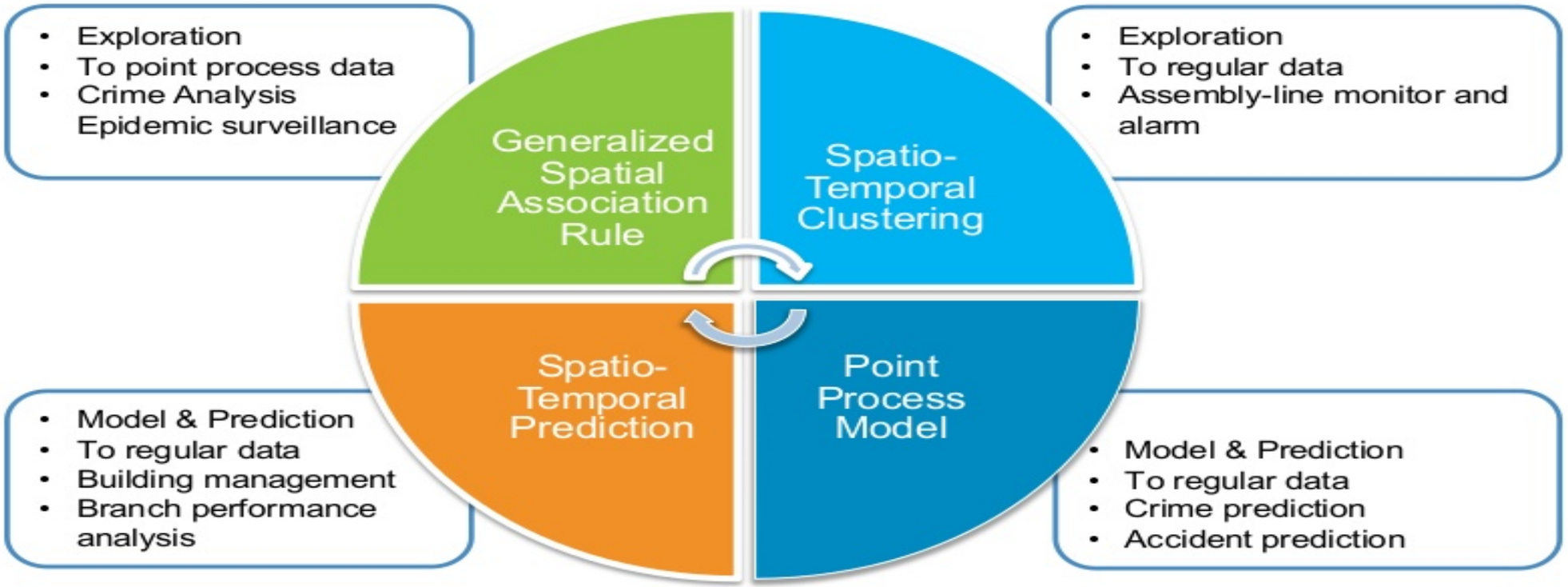
Spatio-Temporal Exploratory and Modeling (STEM)



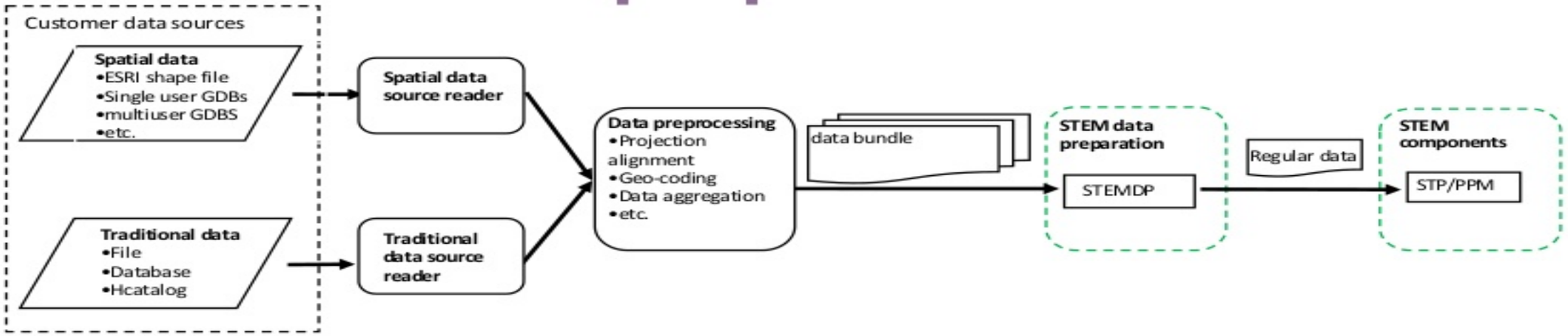
Spatio-Temporal Analysis Suite



Spatio-Temporal Analysis Suite



Work flow of data preparation



- The raw spatial-temporal data from customer involves multiple data sources with different data formats
- STEMDP component
  - Performs the data preparation for STP/PPM
  - Always required before STP/PPM model building
  - Provides the functionality that converts the raw data into regular data that STP/PPM requires
  - Outputs only one regular data source consumable by STP/PPM

Input data of STEM-DP

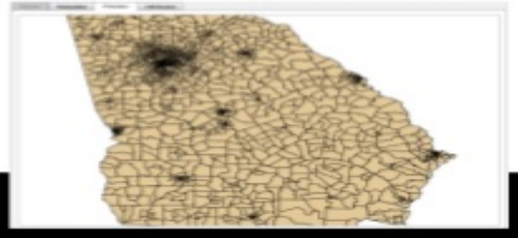
- **Regular data**: A fixed set of spatial locations and equally spaced time stamps common across locations. There is only one case for each location and time stamp combination

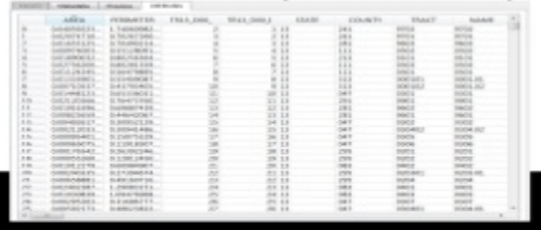
	A	B	C	D	E	F	G	H	I	J
1	longitude	latitude	year	inc	pop	pctw	pctb	pcta	pcth	age
2	-84.431	33.94616	1996	7845.61	181891.1	86.56196	8.80415	3.45804	3.18889	41.3
3	-84.4502	33.92186	1996	9890.284	175523.6	84.40528	10.96279	3.34503	3.24738	34.7
4	-84.4695	33.90059	1996	7375.113	171122.6	82.50816	13.07871	3.0717	3.26355	32.7
5	-84.4522	33.88529	1996	9070.971	160988	83.33412	12.69587	2.67122	3.14153	32.7

- **Point occurrence data**: A list of events labeled by a time stamp and the location of the event

	A	B	C	D
1	year	longitude	latitude	mat_addr
2	1996	-83.23	33.08	301 S WAYNE ST, MILLEDGEVILLE, GA, 31061
3	1996	-83.25	33.11	1900 N COLUMBIA ST, MILLEDGEVILLE, GA, 31061
4	1996	-83.47	33.6	223 N MAIN ST, MADISON, GA, 30650
5	1996	-83.47	33.6	223 N MAIN ST, MADISON, GA, 30650
6	1996	-82.6	31.86	901 S TALLAHASSEE ST, HAZLEHURST, GA, 31539

- **Geospatial layout data**:
  - Required if the regular data or point occurrence data requires the region boundary information
  - Shape files(*.shp and associated *.dbf, *.prj), JSON format, Geo-enabled databases, etc.
  - Convert all of them into unenclosed JSON format that can be used in parallel computing





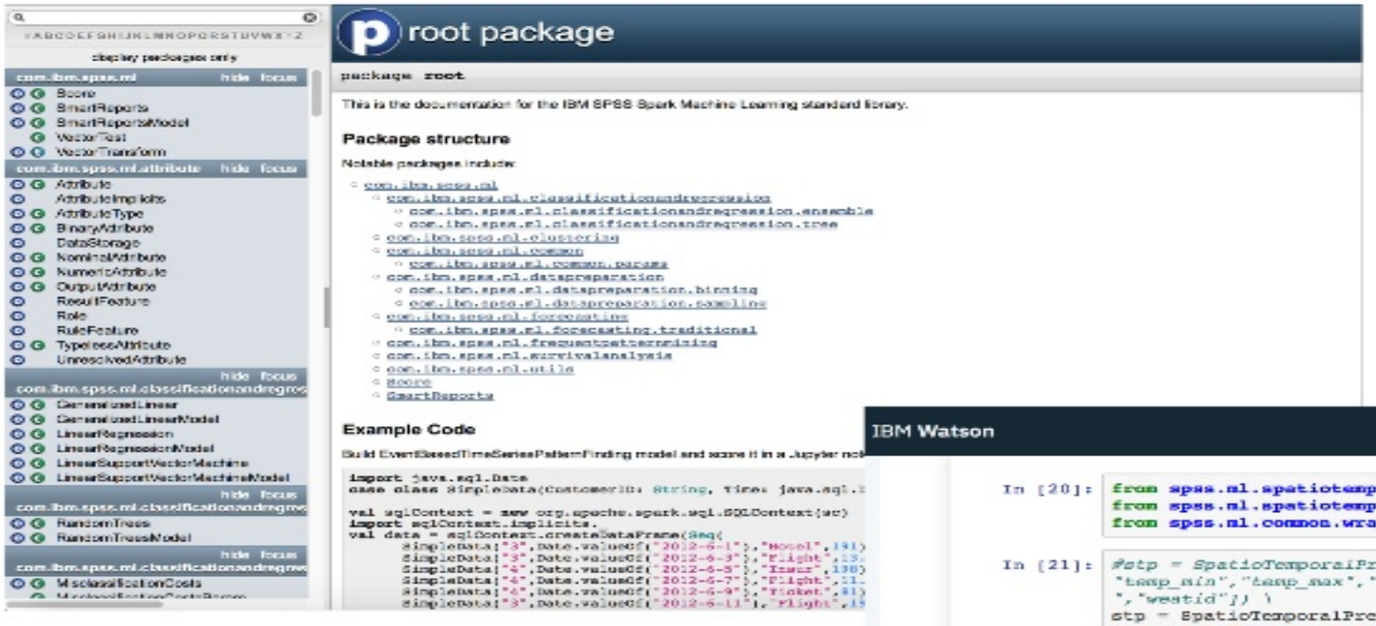
Data transformation in STEM-DP

- **Data transformation for Regular data**
  - Convert timestamp variable into time-index variable
  - Missing records handling

- **Data transformation for Point occurrence data**
  - **For STP:** Perform kernel-density estimation algorithm by using the point occurrence data
  - **For PPM:** Obtain the centroid of each region and compute the event count in the region by using the point occurrence data. The **count** will be a new field for PPM
  - Missing records handling

** Optional inputs depends on the actual scenario*

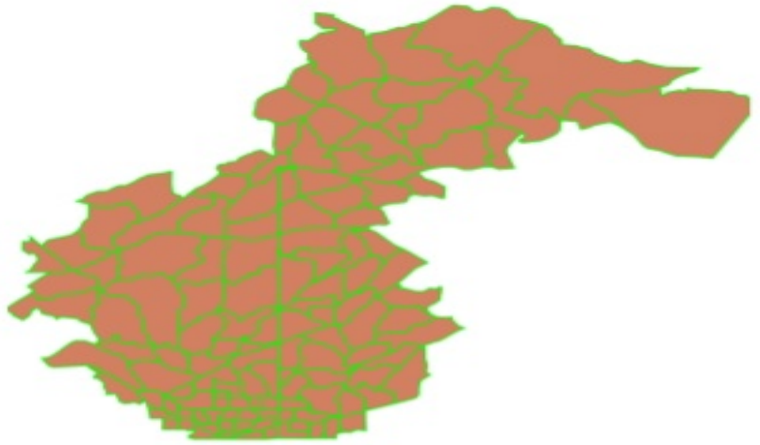
Scala API


root package
package root
This is the documentation for the IBM SPSS Spark Machine Learning standard library.
Package structure
Example Code

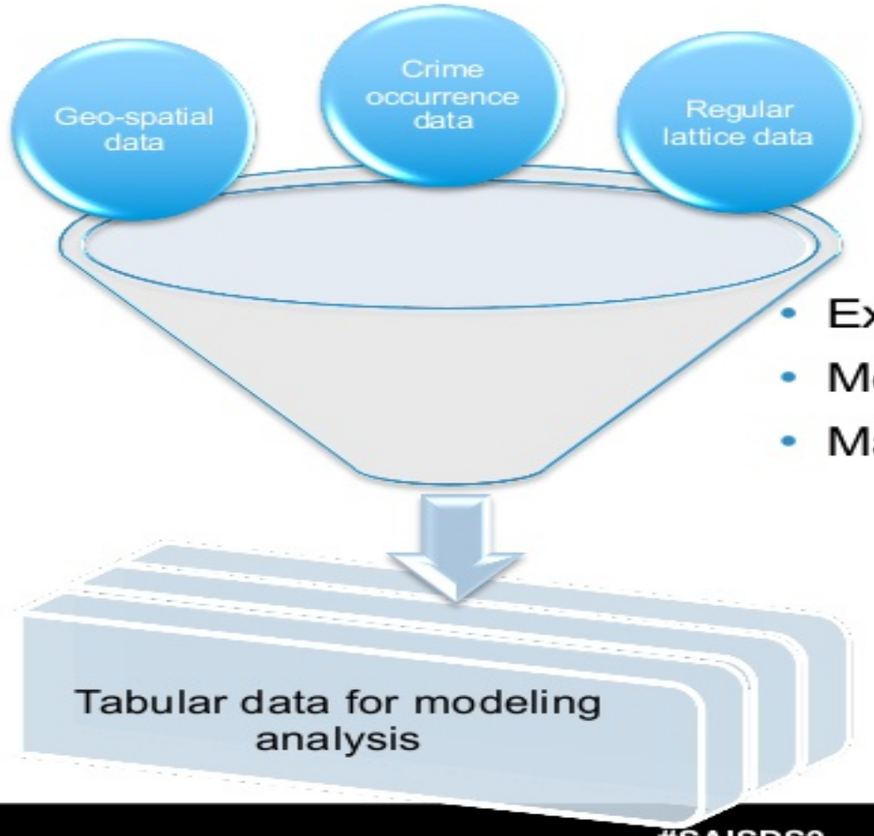

IBM Watson
Log In
Sign Up
In [20]:
from spss.ml.spatiotemporal.spatiotemporalprediction import SpatioTemporalPrediction
from spss.ml.spatiotemporal.spatiotemporalprediction import SpatioTemporalPredictionModel
from spss.ml.common.wrapper import SPSSJavaWrapper
In [21]:
stp = SpatioTemporalPrediction().setTargetField("aqi").setInterceptTrue).setInputFieldList(["temp_min","temp_max","temp_ave","humidity_min","humidity_max","humidity_ave","windid","winpid","westid"]) \
.setLocationFieldList(["Locx","Locy"]).setTimeIndexField("Time") \
.setArLag(1)
model = stp.fit(sdf_model)

Use Case

- Crime Occurrences Modeling and Prediction
  - Police department in a city want to predict crime occurrences of next several months in order to better plan and allocate resources
- Available information for analysis
  - Geo-spatial data defined census tracts of the city
  - Past crime occurrences
    - The time and coordinates of crime event
  - Local demographic profiles
    - population density
    - per capita income
    - ethnic diversity
    - median age
    - male-to-female ratio



Data Preparation



- Extract spatial information
- Merge lattice data
- Map and cumulate point

Prepared Data for Modeling

- Align crime occurrences points with layout, and merge with demographic profiles to get the model ready data for PPM

	A	B	C	D	E	F	G	H	I	J	K
1	Time.Index	Tract.ID	Longtitude	Latitude	Area	log_Popula	log_Incom	Diversity	Age	MFRatio	Counts
2	1	130670303.2	-84.43097	33.94616	0.001159	18.86818	10.41436	-413.322	42	97.189	628
3	1	130670303.2	-84.45015	33.92186	0.000906	19.05783	10.27308	-404.59	35	91.049	161
4	1	130670303.4	-84.46951	33.90059	0.000645	19.39024	10.48969	-406.498	32	104.713	285
5	1	130670303.4	-84.45218	33.88529	0.000418	19.77336	10.38474	-408.388	32	105.296	151
6	1	130670311.1	-84.48765	33.89422	0.000391	19.91062	10.12567	-398.619	32	96.5612	107
7	1	130670312	-84.47668	33.87345	0.000638	19.31286	10.36606	-398.038	34	85.4478	99
8	1	130670312	-84.47881	33.85592	0.000902	18.92945	10.1344	-389.845	34	92.8024	270
9	1	131210001	-84.35463	33.79865	0.000316	20.65016	10.20267	-380.088	40	100.368	94
10	1	131210002	-84.36368	33.79139	0.000285	20.79336	10.17474	-376.83	38	126.696	131
	...		...			...					...

Time dimension: 'time.index' is encoded time point when the aggregated counts are occurs in one time interval

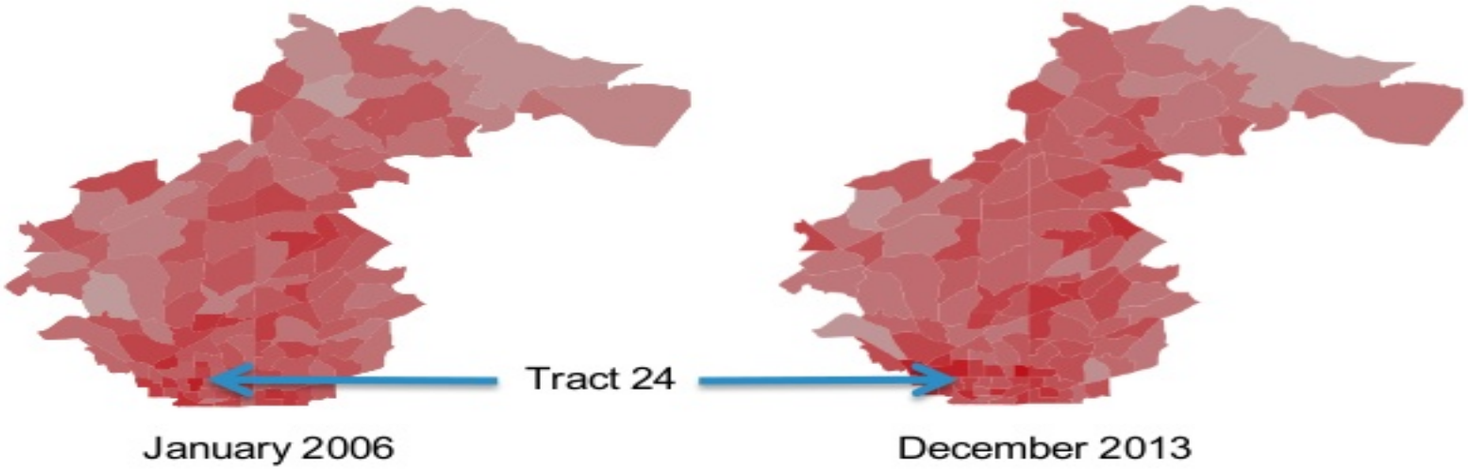
Space dimension: 'Longitude', 'Latitude' are coordinates where the demographic data are belong to

Inputs: There demographic input are the external predictors used in PPM

Target: Crime counts for each area as model building target

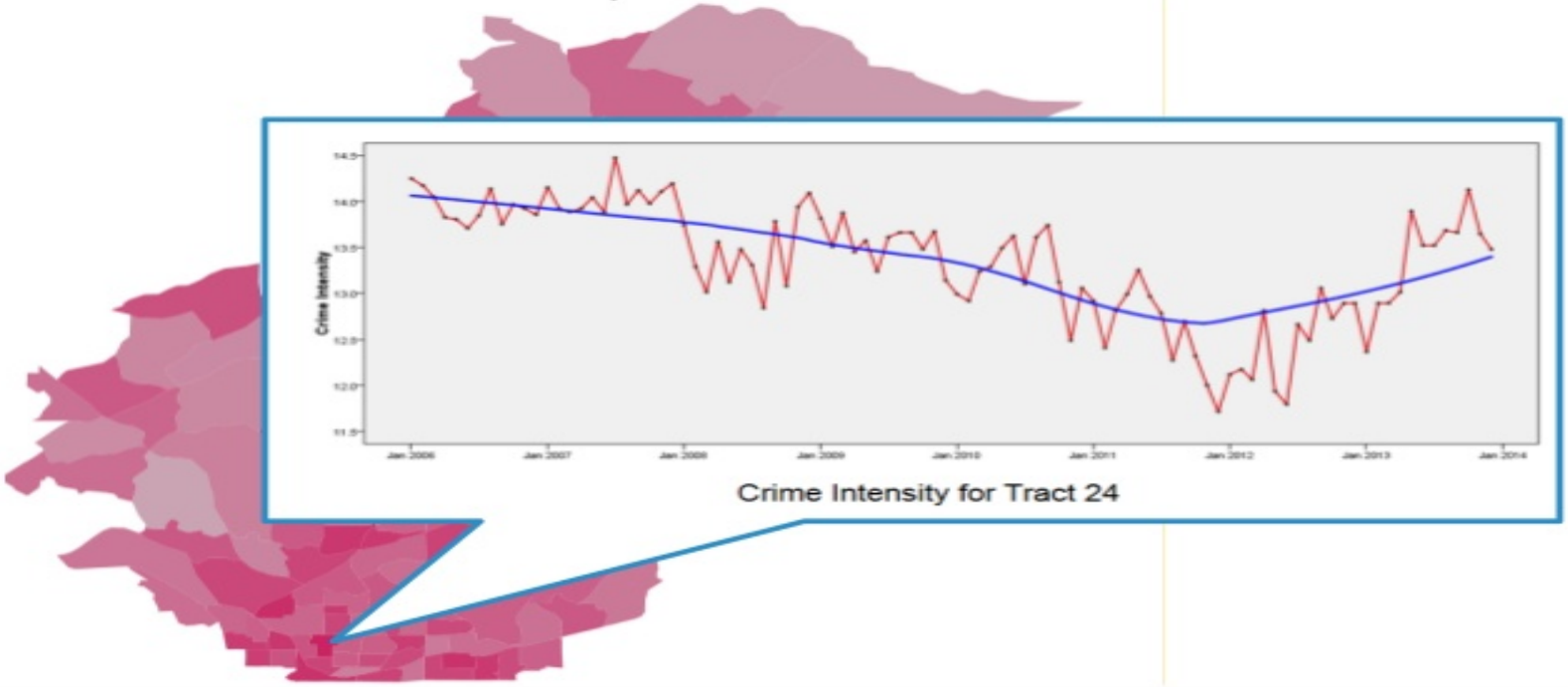
Prepared Data Visualization
- Event occurring intensity

- Intensity is a measure of event counts per unit area



Prepared Data Visualization
- Event occurring trend

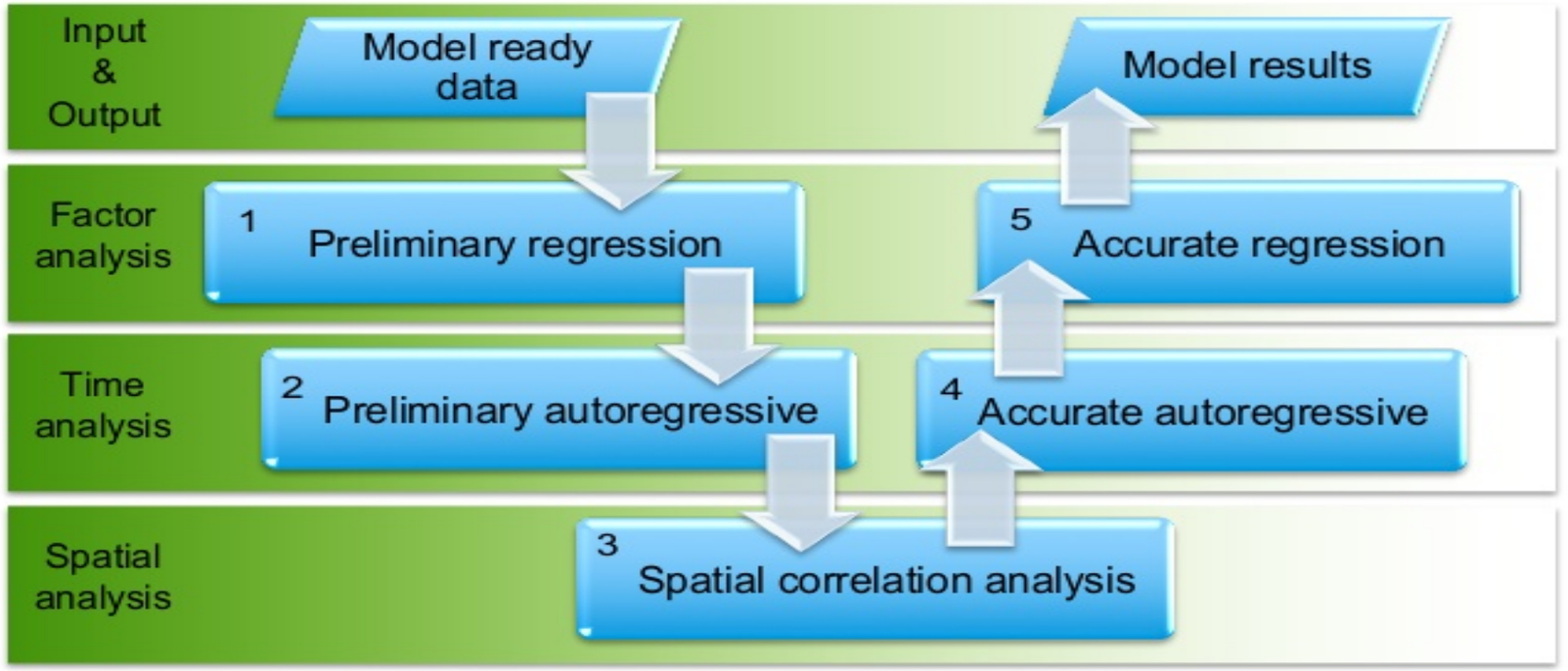
- Intensity is a measure of event counts per unit area



Spatio-Temporal Modeling

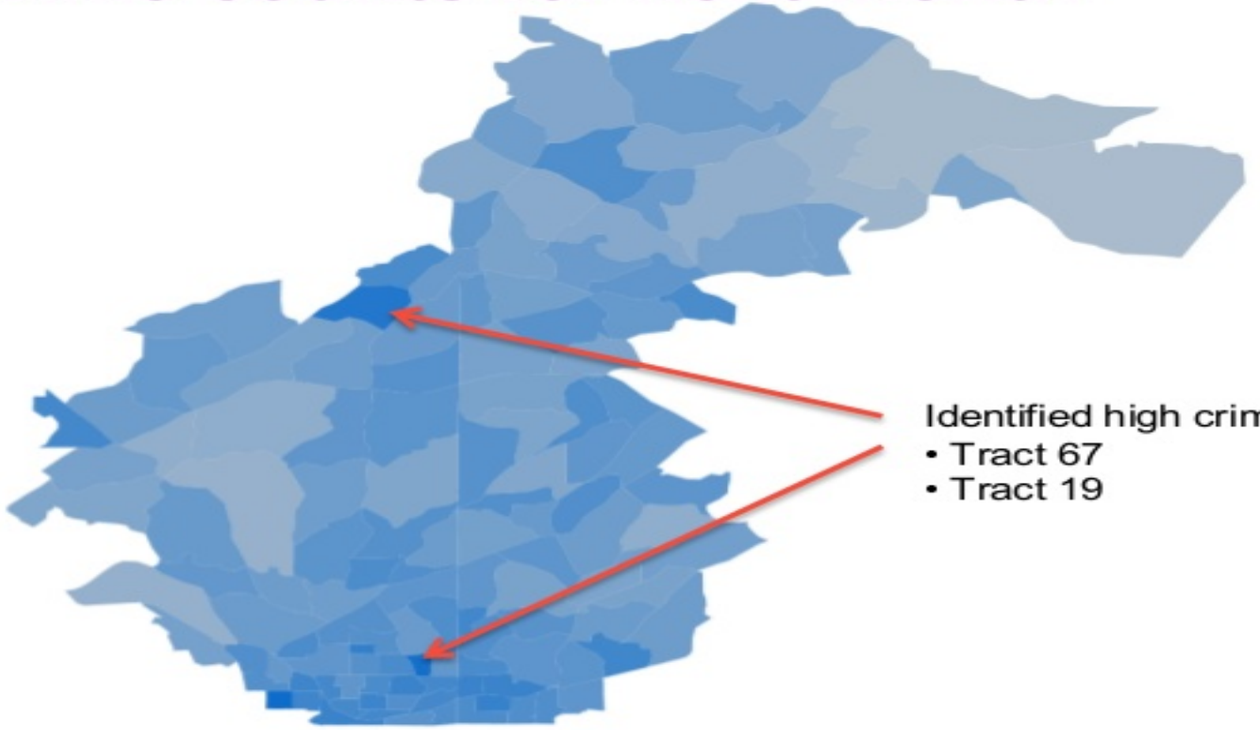
Modeling process including 3 layers to handle different types of information:

- The influence of external factors
- Time-series autocorrelation
- Spatial correlation among all the cities



Prepared Result Visualization

- Predicted crime counts for next month



Identified high crime areas:
- Tract 67
- Tract 19

What-if Scenario Analysis

- Scenario
  - A large sports festival will be held in the city
  - Police department wants to estimate how the crime will increase due to
    - Large influx of people to some areas
    - Fans are mainly adult males

Without the festival

During the festival

Thanks!