

Efficient Continuous Mapping in Sensor Networks Using Isolines

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Overview

- Sensor networks, aggregation and timing
- Aggregation by grouping
- Isolines
- Continuous monitoring

Sensor Networks

- Tiny battery powered nodes
- Sensing capabilities
- Wireless communication
- Data collection
- To save energy we aggregate data
- Aggregation requires scheduling
- Not all aggregation is simple

Simple Aggregation

From Childs

Node	Value
20	110

Node	Value
21	150



To Parent

Node	Value
21	150

- Max
- Min
- Total
- Average

Hard Aggregation

From Childs

Node	Value
20	110

Node	Value
21	150



To Parent

Node	Value
20	110
Node	Value
21	150

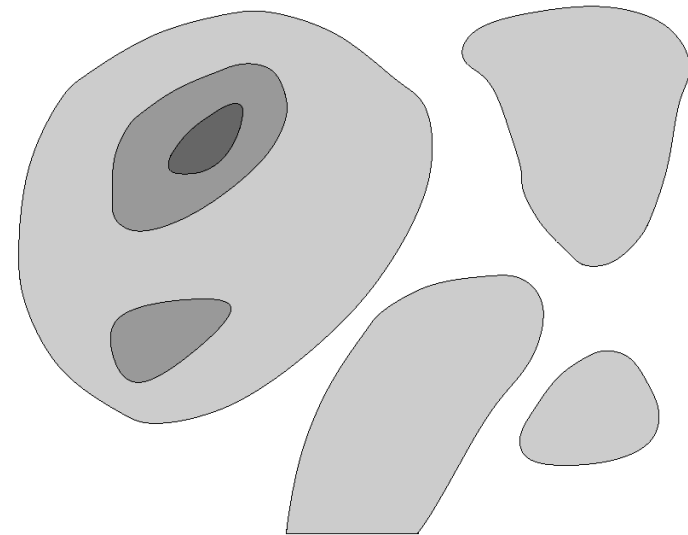
- Mean
- Sort
- Map

Aggregating Data by Grouping

- When to aggregate is not enough for collecting all the data on the network
- We need to exploit the correlation between the data being collected.
- Can we group nodes? How do we determine the grouping? How do we represent them?

Isoclusters: Grouping by Value

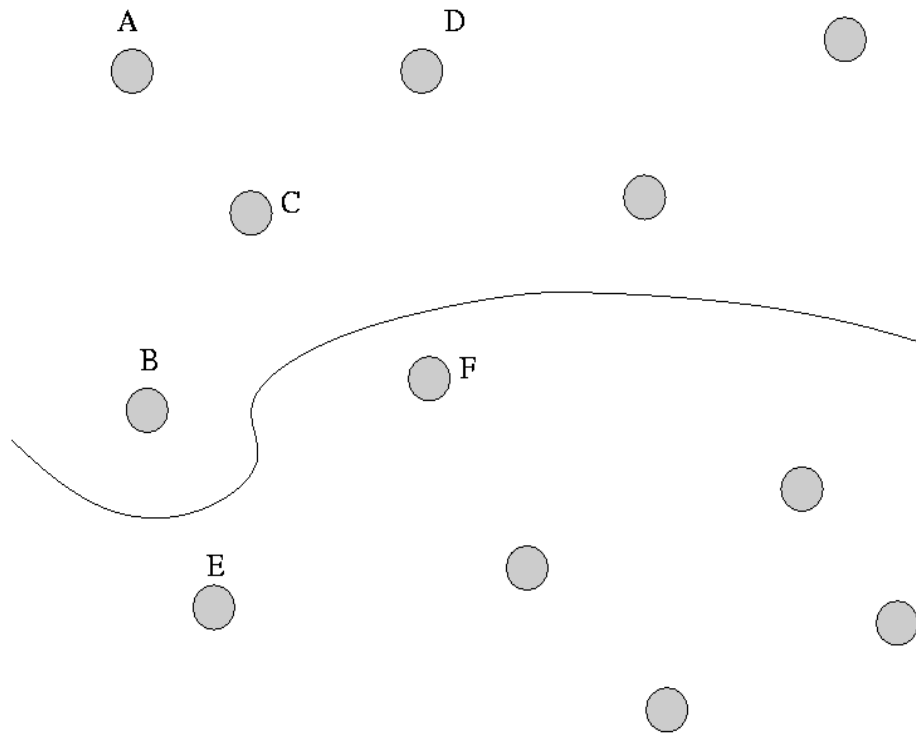
- Group nodes into isoclusters, where all the members have a sensed variable in the same range (i.e. contour maps, isotherms)
- When collecting data we can focus on isolines (isopleths)



Grouping Related Work

- Isobars - (TAG)
 - Divide world into grid
 - Group into discrete polygons and aggregate as reports flow
 - Optimize/Deal with losses by cutting parts from a bounding box.
- E-Scan
 - Aggregate into polygons as data flows through tree
 - Join polygons if close by and if they meet range criteria

Isolines



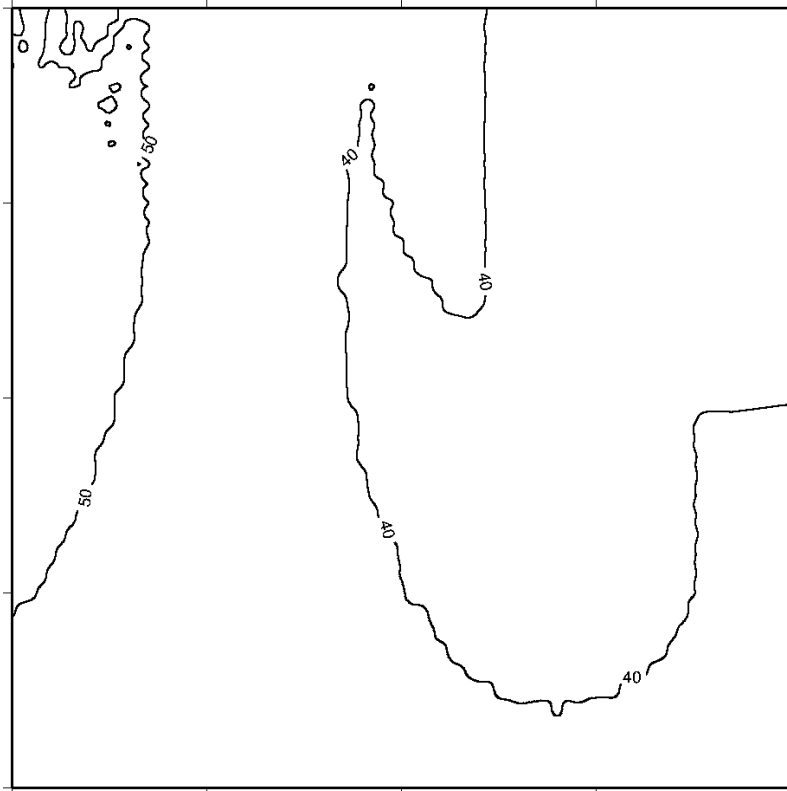
- Isolines are lines which pass through our network and have the same value.
- Nodes detect them by comparing the value they are sensing with their neighbors.
- When nodes detect a nearby isoline they send a report to the data sink.
- Only nodes detecting lines report.

Isocustering Example

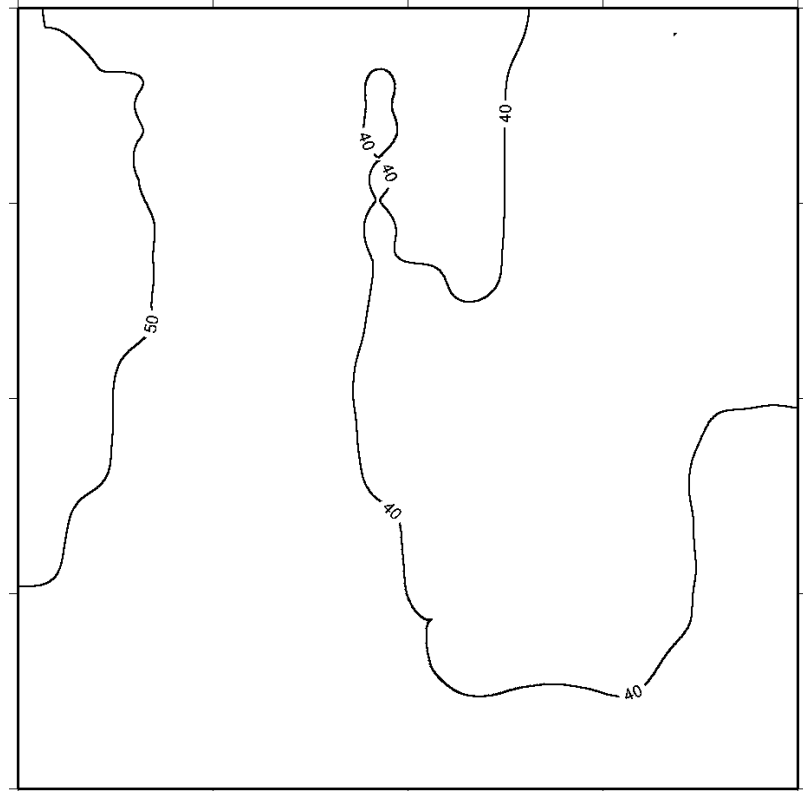
- NS-2, 400 x 400 meter
- 16 x 16 sensor nodes in grid pattern
- 40 meter communication range
- We map reality, no aggregation and isoclusters.
- Isoclusters sends 1/3 of the readings no aggregation sends.
- We map with GMT mapping tools

Isoclustering Example (cont)

Reality

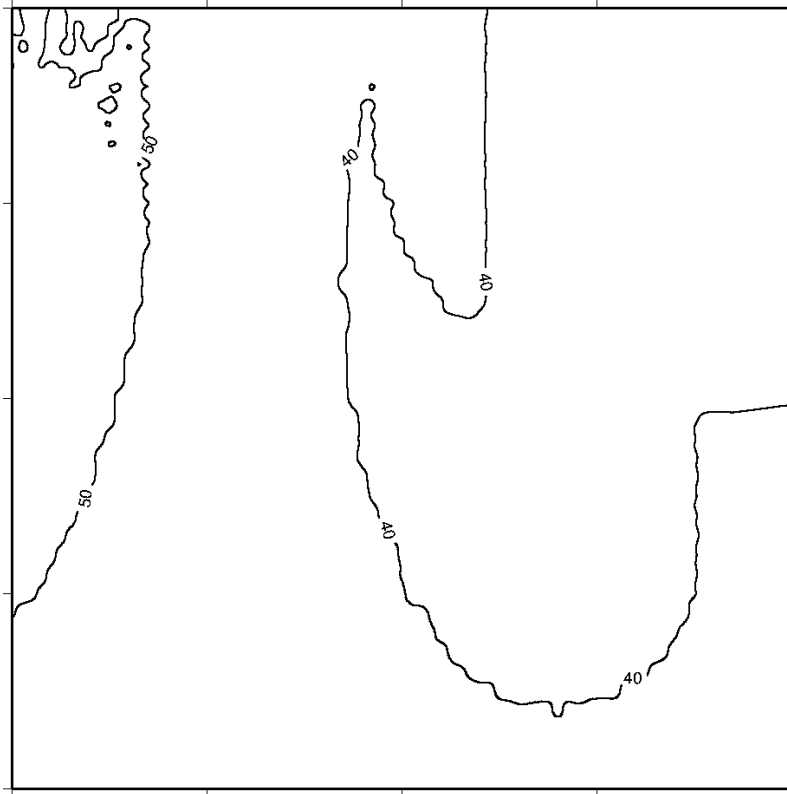


All nodes reporting

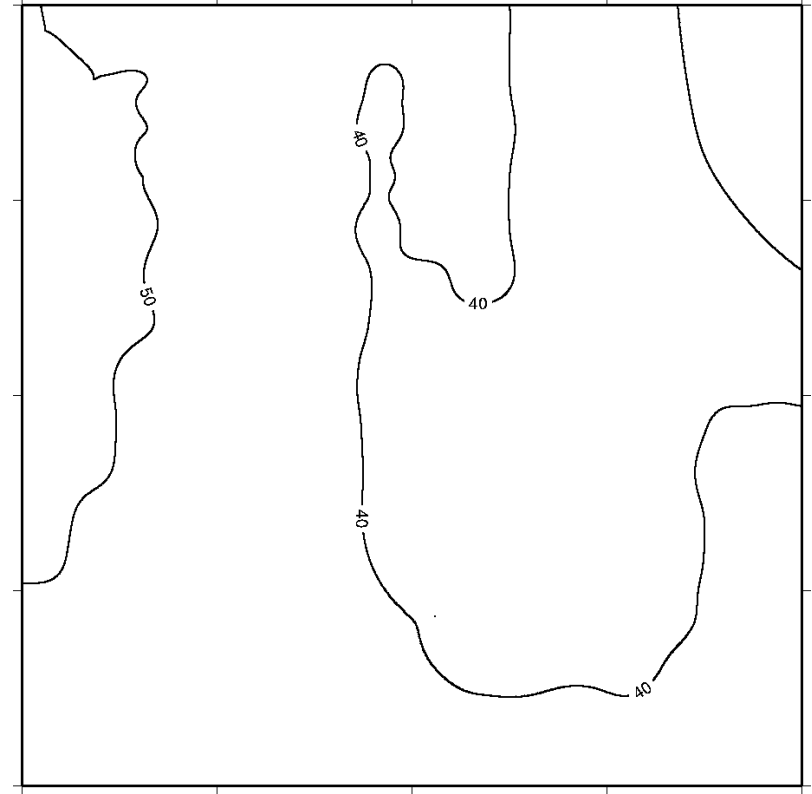


Isoclustering Example (cont)

Reality

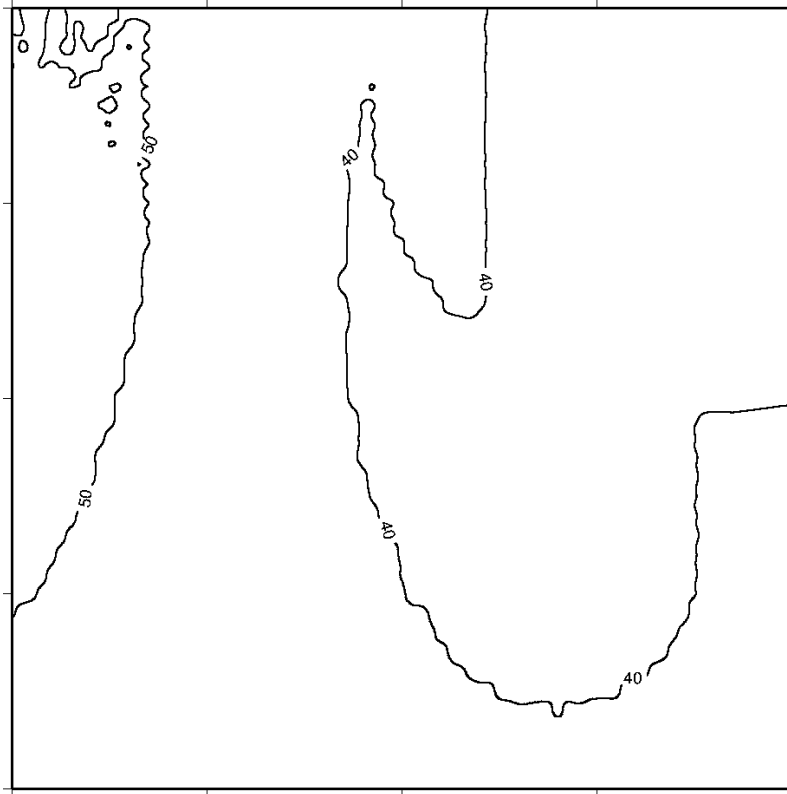


Isoclusters

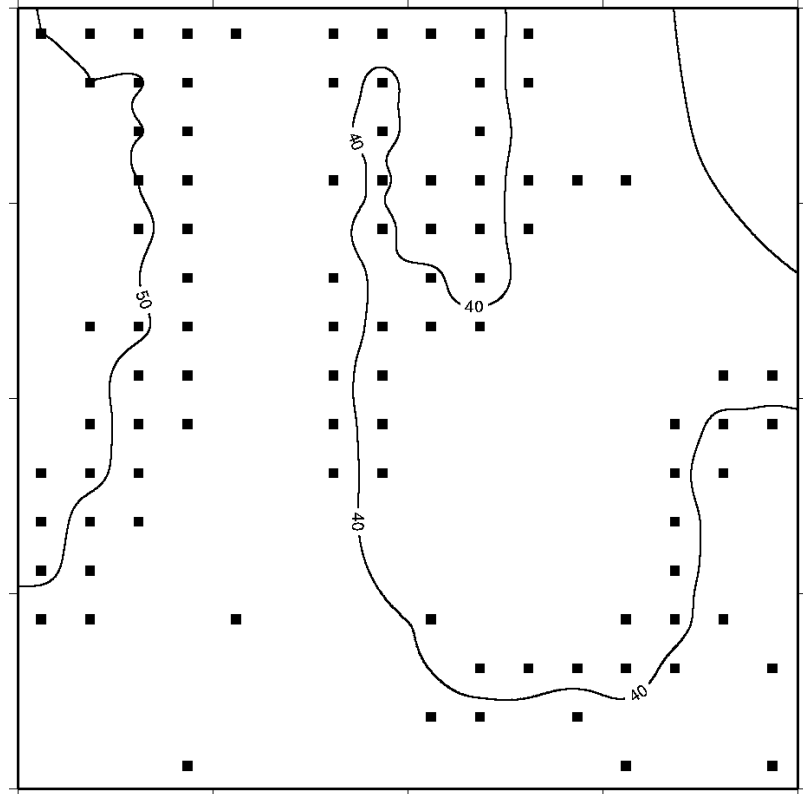


Isoclustering Example (cont)

Reality



Isoclusters + reporting nodes



Continuous Monitoring

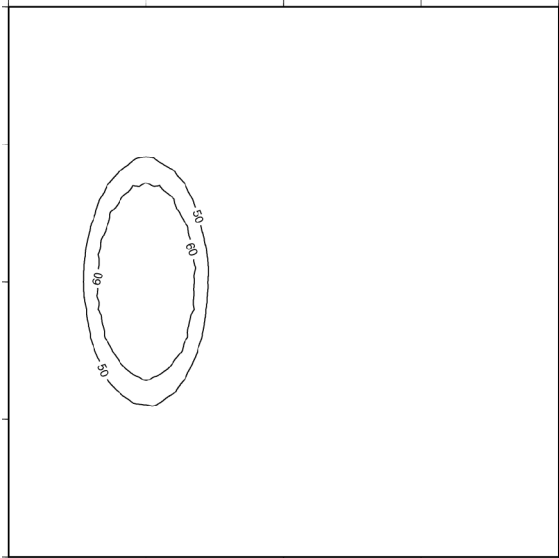
- Real-time data stream
- Data needs to arrive quickly to sink
- Data is collected using isolines
- When nodes detect a new isoline near them they report it.
- If the isoline doesn't change or there is no nearby isoline there is no report.

Continuous Monitoring Simulation

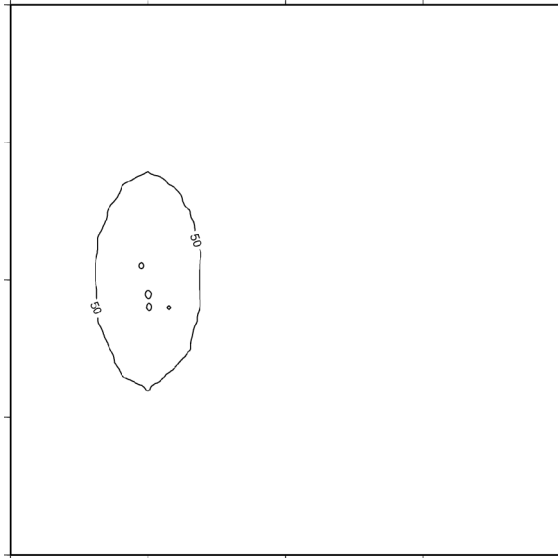
- ns-2 simulator
- 16x16 nodes arranged in a grid
- 400x400m area simulating temperature
- 40m transmission range
- Reality is simulated at 80x40, aggregation done at intervals of 10 deg.
- Simulate 15 seconds of an event
- Scenarios of Hotspot and Front
- Compare with polygon and no aggregation

Hot Spot monitoring: reality

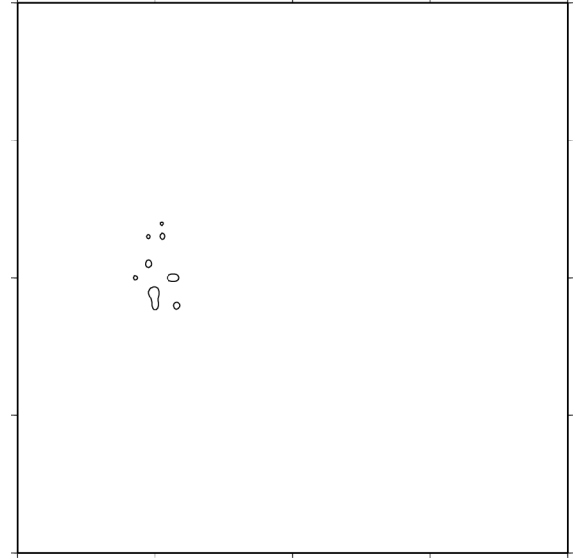
T=4



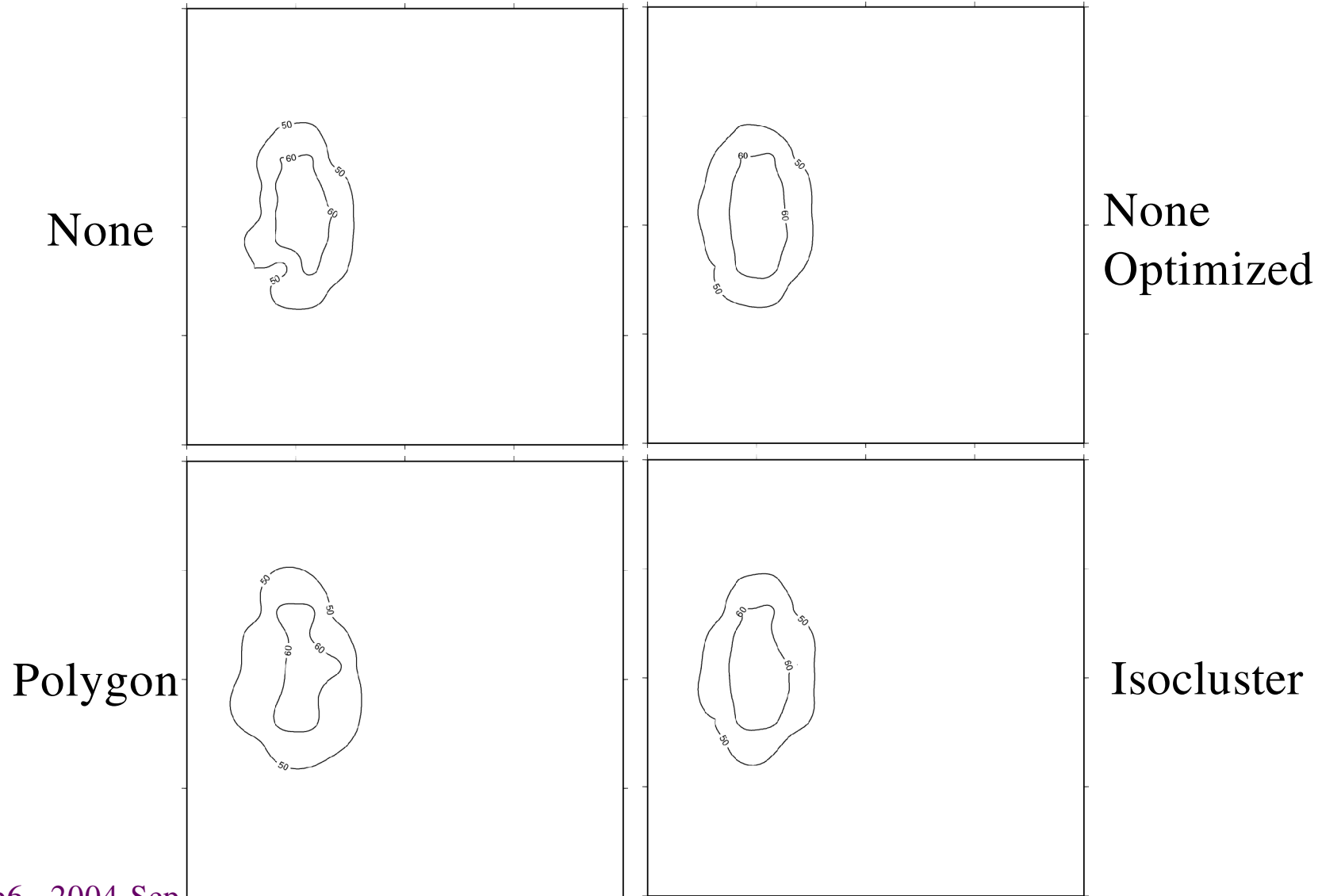
T=7



T=11

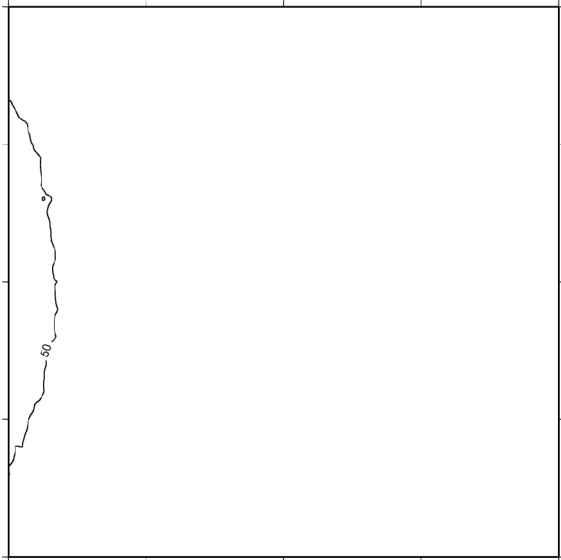


Hot Spot monitoring @ T=4

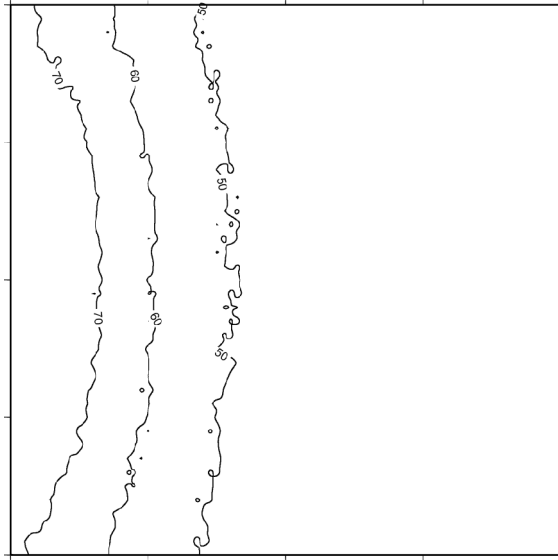


Front monitoring: reality

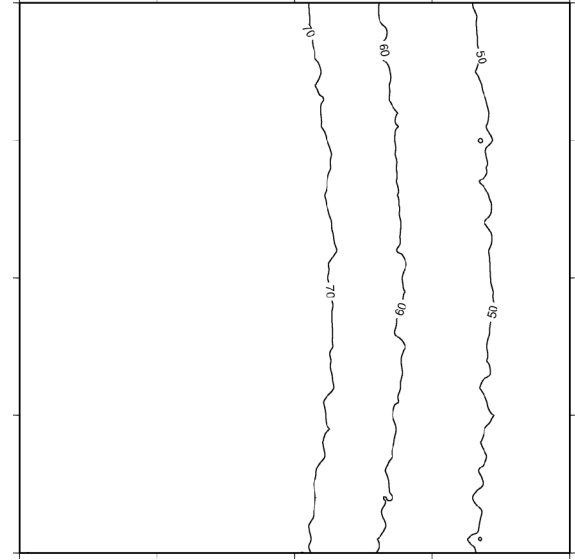
T=4



T=7

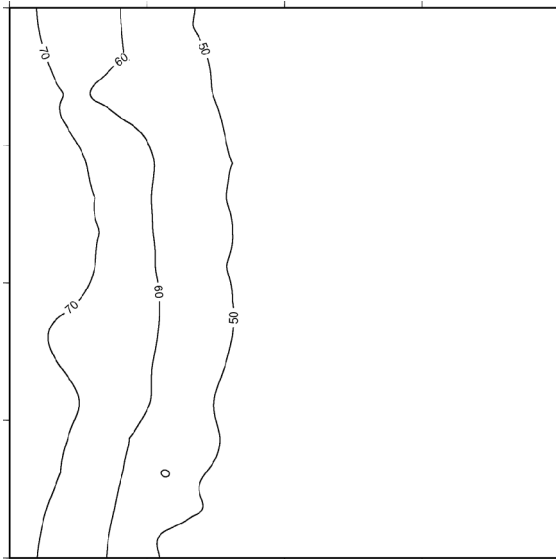


T=11

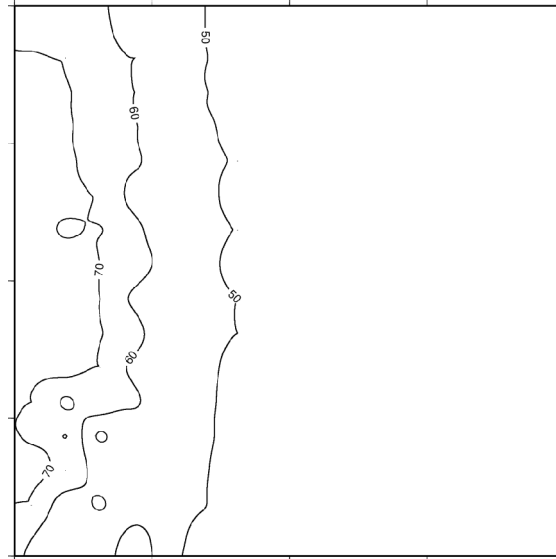


Front monitoring @ T=7

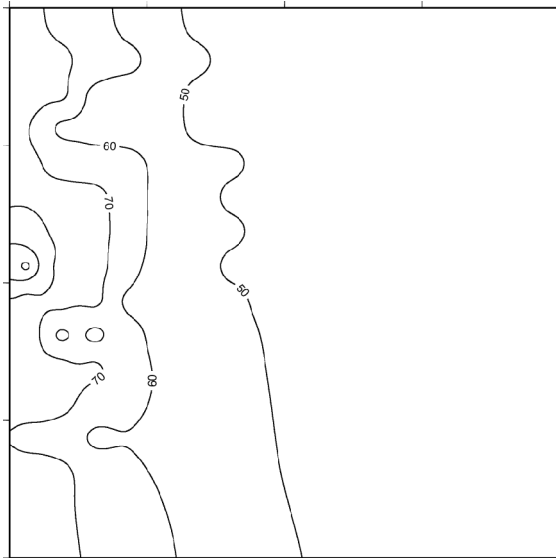
None



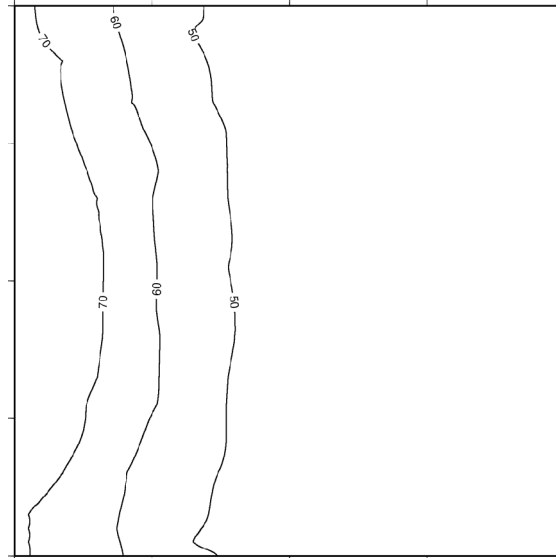
None
Optimized



Polygon



Isocluster



Results

HOT SPOT

	<i>Similarity</i>	<i>KBytes sent</i>
<i>No Agg</i>	98.7	180.0
<i>No Agg opt</i>	98.9	21.1
<i>Polygons</i>	98.1	62.9
<i>Isolines</i>	97.0	15.3

FRONT

	<i>Similarity</i>	<i>KBytes sent</i>
<i>No Agg</i>	93.2	177.1
<i>No Agg opt</i>	89.3	62.1
<i>Polygons</i>	82.4	77.0
<i>Isolines</i>	96.7	55.8

Conclusions

- Isolines are an effective method of aggregating information
- More study needs to be done with respect to the aggregation ranges and environment dynamics.
- Node density also needs to be studied further. We are developing methods to optimize isoline detection in densely monitored areas, relaxing the use of grid placement.

Thank you
Questions?