Automatic hazard level estimation of convective storms using emergency data

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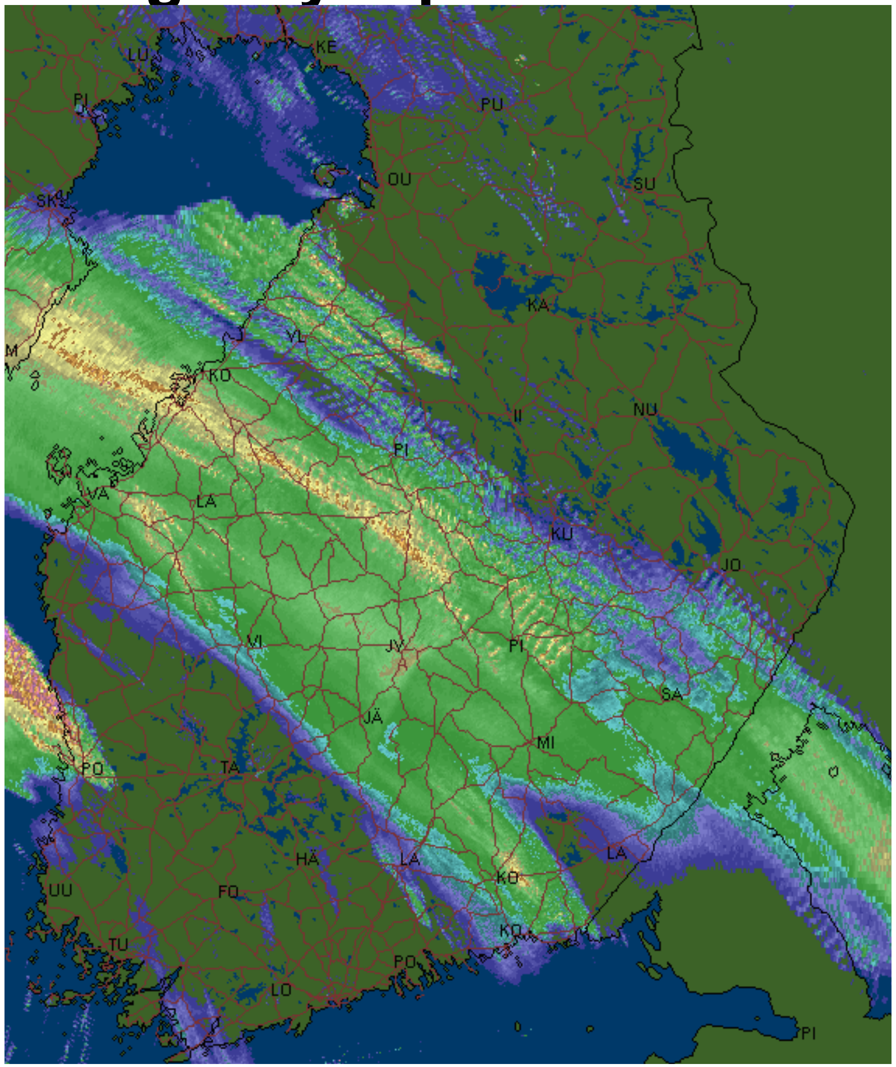
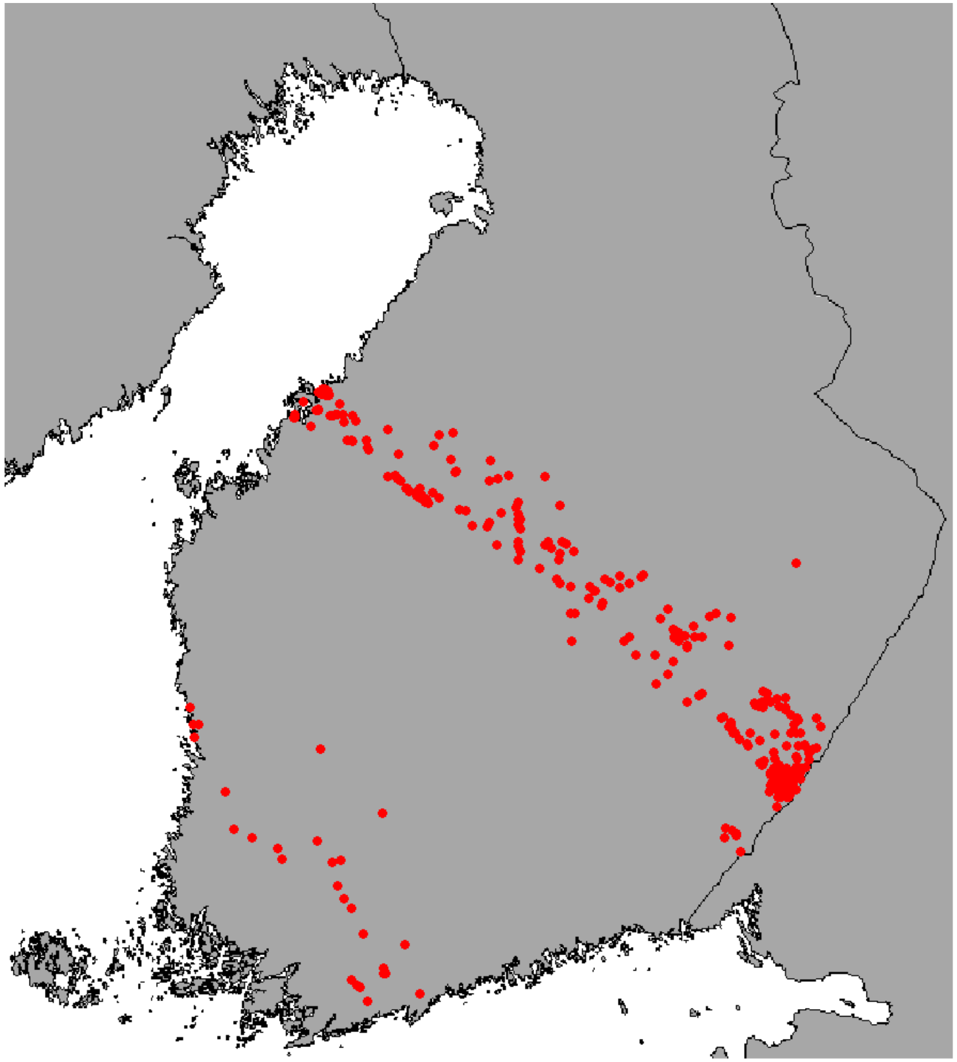
Background

- **Finnish municipal emergency centers were combined into a nationwide center in 2001 – 2005**
  - The time of the report, the exact event location, the classification of the emergency type are available in real time
- **New largely unused source of information**
  - Disasters caused by lightning, heavy precipitation, strong wind etc.
- **Need for algorithms that utilize emergency data in nowcasting and warning products**

Emergency other data sources

- **MCS on 29.7.2010: 6h radar based rainfall accumulation vs. emergency report data**

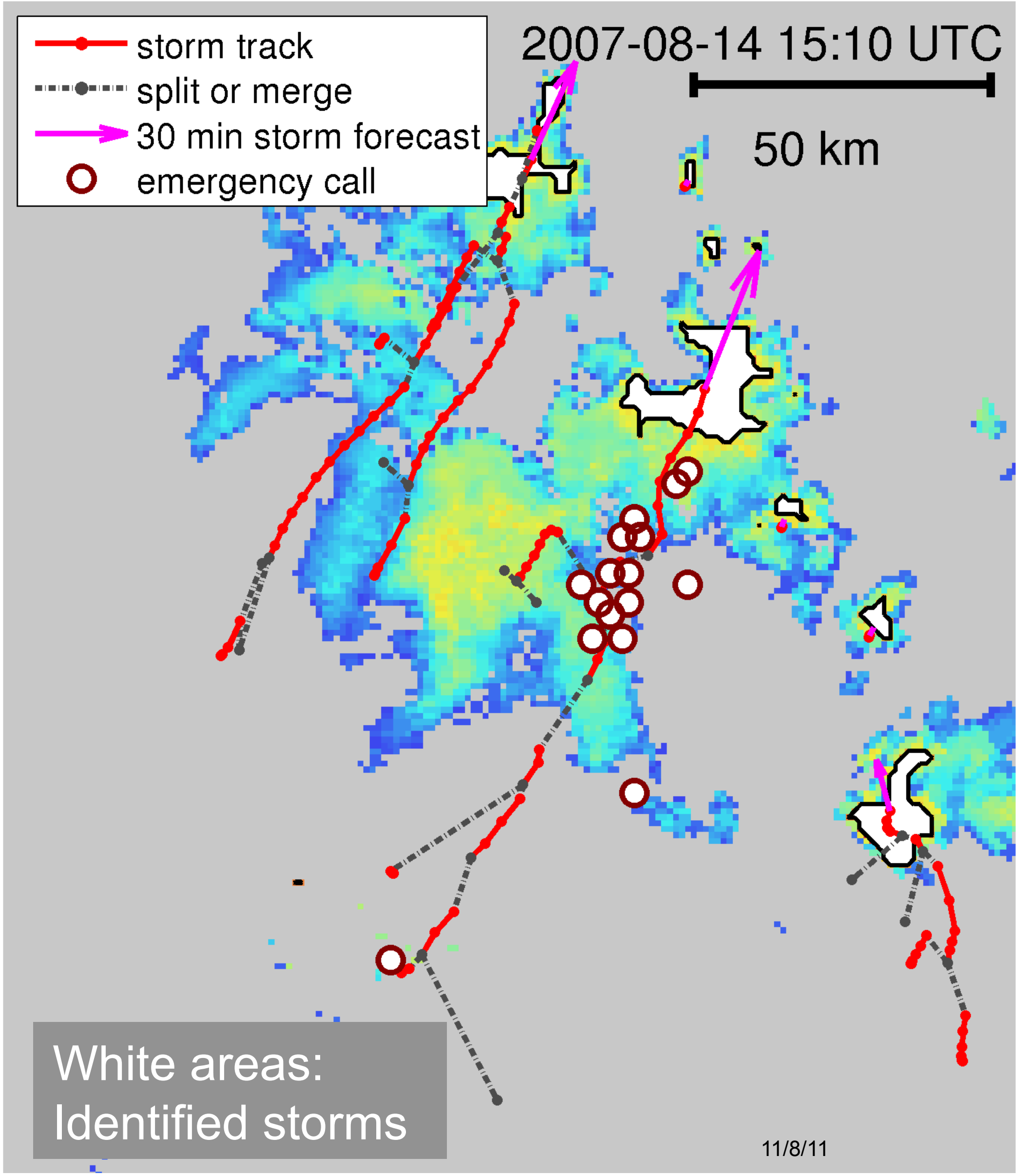




Object oriented convective storm tracking

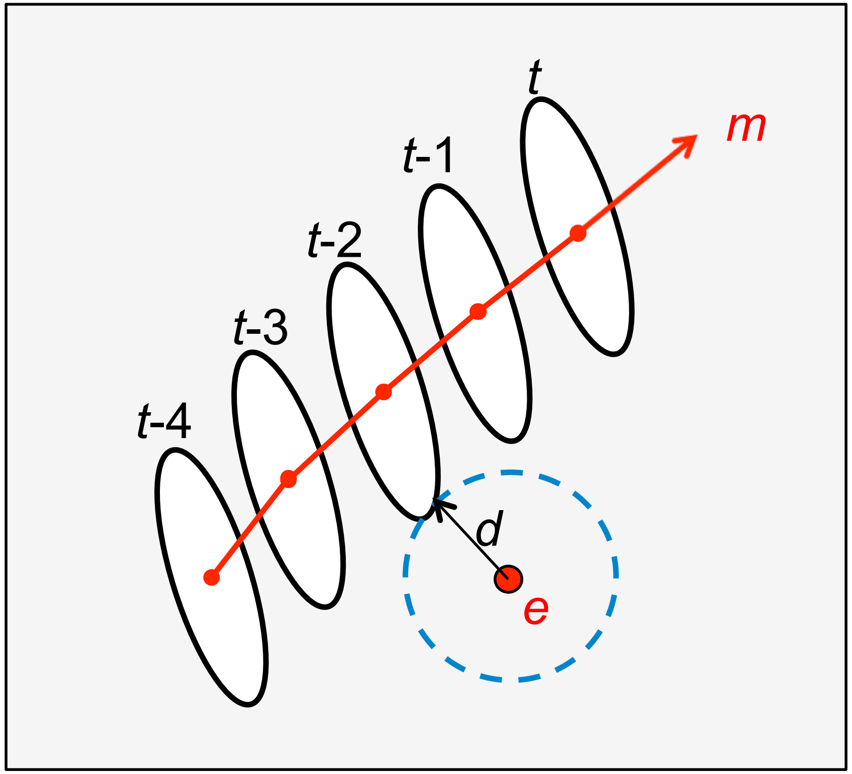
- **A natural way for severe weather nowcasting and for constructing warning products**

- **Objects can be supplemented with various attributes, e.g., age, intensity or the *amount of disasters they have possibly caused***



Attaching emergency event information to convective storm objects

- **The *relatedness*** $r(e,m)$**:**
  - Describes how much an emergency event e is related to a convective storm track m
    - $r(e,m)$ is a function of the minimum distance $d(e,m)$
      - $d(e,m) = 0 \rightarrow r(e,m) = 1$
      - $d(e,m) = \infty \rightarrow r(e,m) = 0$
  - It is computed between each storm track and emergency report



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Attaching emergency event information to convective storm objects

- **To preserve the past relatedness information in convective cell tracks, individual relatedness values are converted to *hazard level* values**
  - The current hazard level $h(m,t)$ for the mth convetive storm track at time t is computed recursively using:
    - Previous hazard level value $h(m,t\text{-}1)$
    - Sum of current relatedness values
  - Moreover, the hazard level is weighted with:
    - Population density information
    - Hypothetical emergency report delay

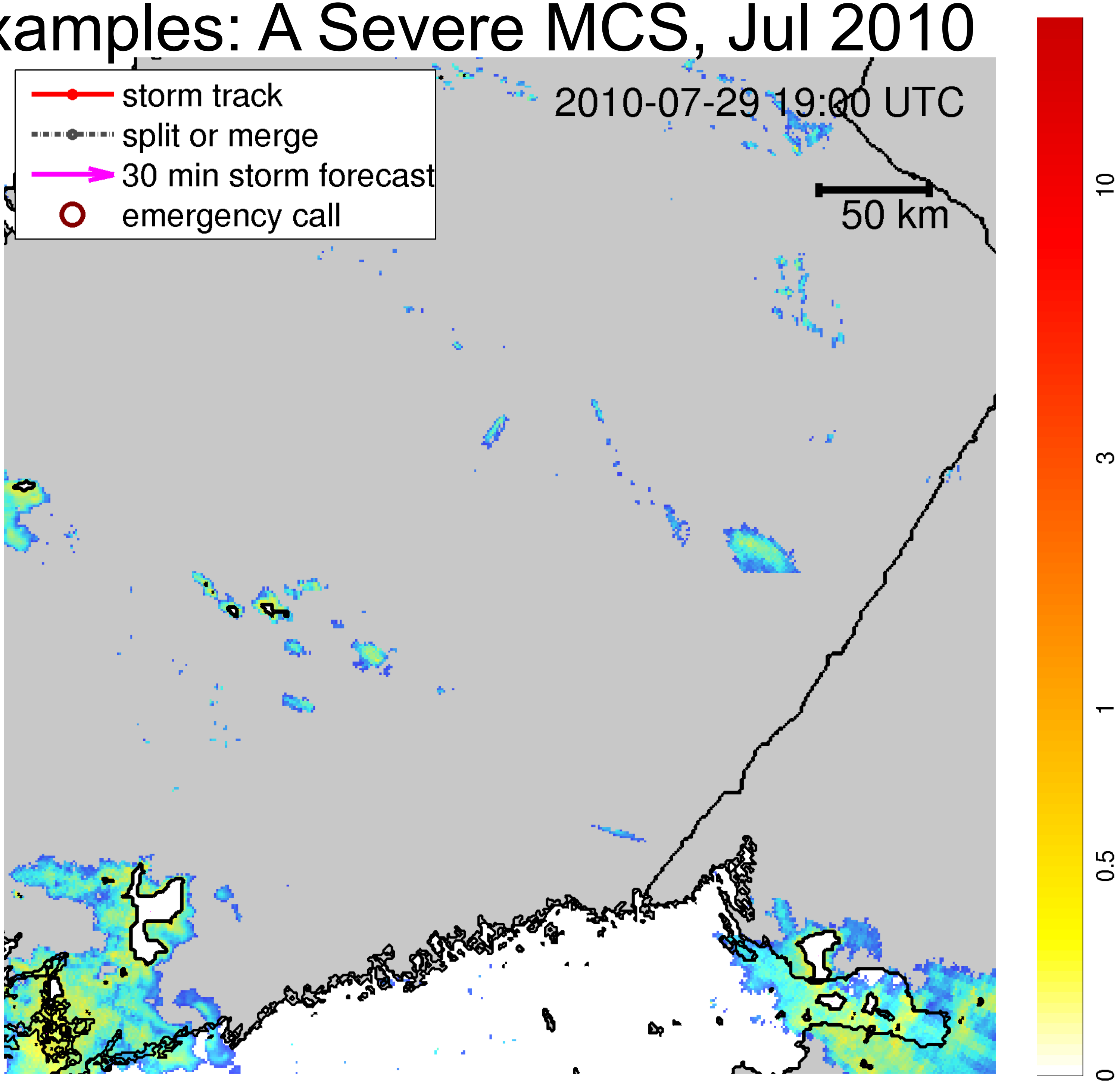
Attaching emergency event information to convective storm objects

- **The recursive equation for hazard level computation**

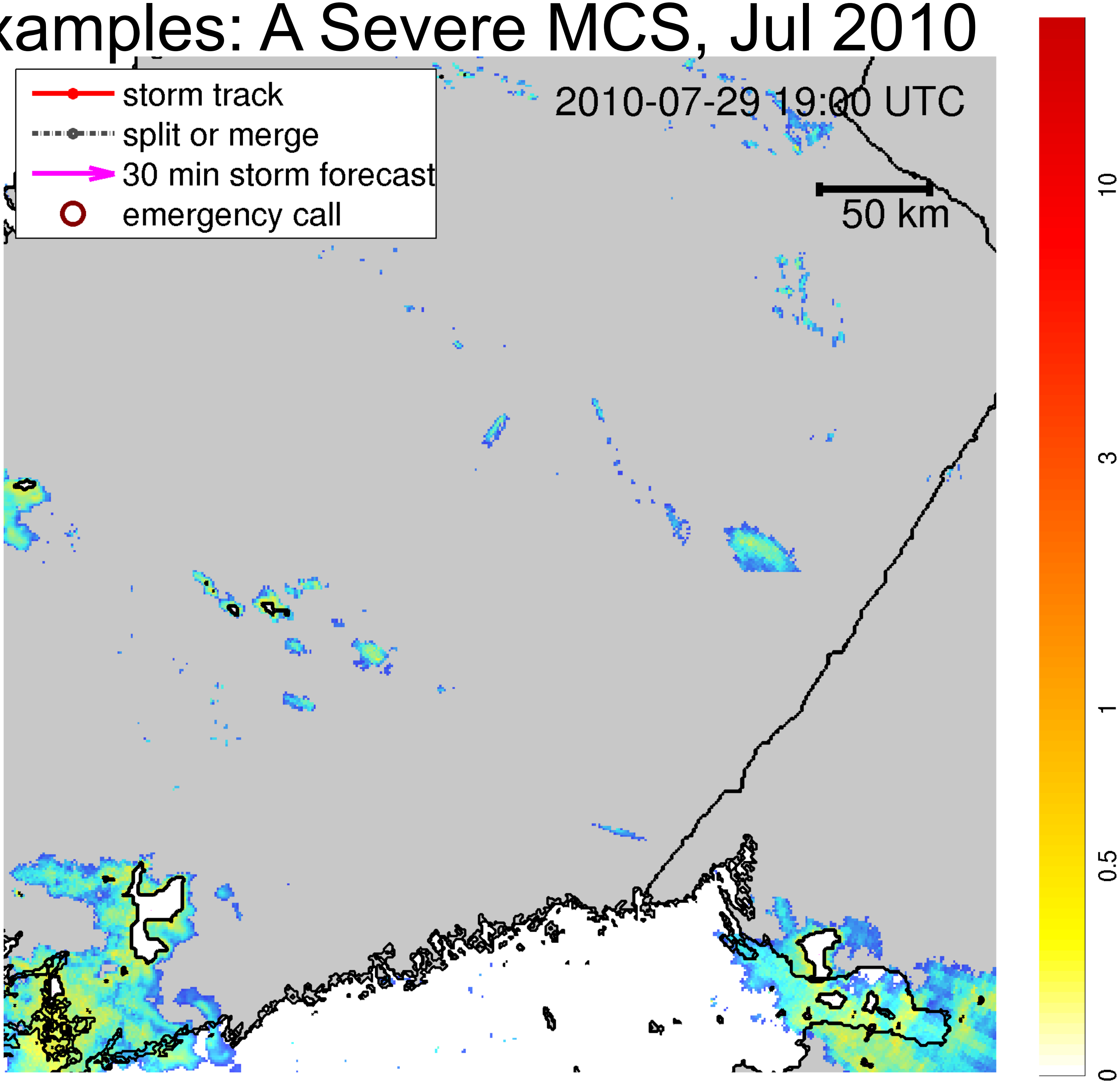
$$h(m,t) = \lambda h(m,t-1) + \sum_i \Theta^{\infty(t - em_{i,t})}\, w(e_{i,t})\, (\ldots)$$

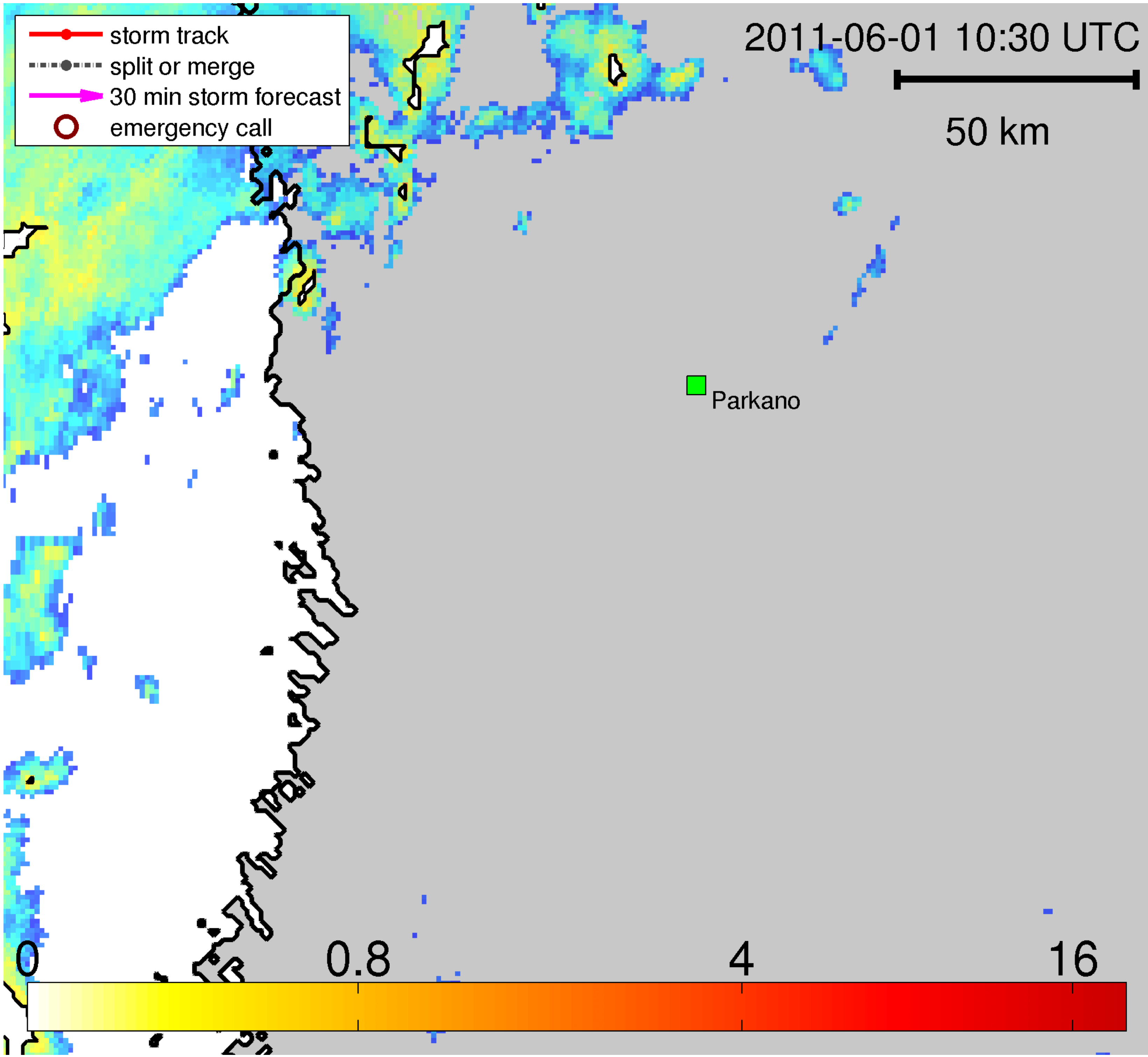
- λ is the forgetting factor $0 < \lambda < 1$,
  - Describes how fast the hazard level decays
- $w(e_{i,t})$ is population density dependent weight
- $\Theta^{\infty(t - em_{i,t})}$ is the delay scaling.
  - Delayed emergency events have smaller impact on the hazard level

Case examples: A Severe MCS, Jul 2010



Case examples: A Severe MCS, Jul 2010




storm track
split or merge
30 min storm forecast
emergency call
2011-06-01 10:30 UTC
50 km
Parkano
0
0.8
4
16

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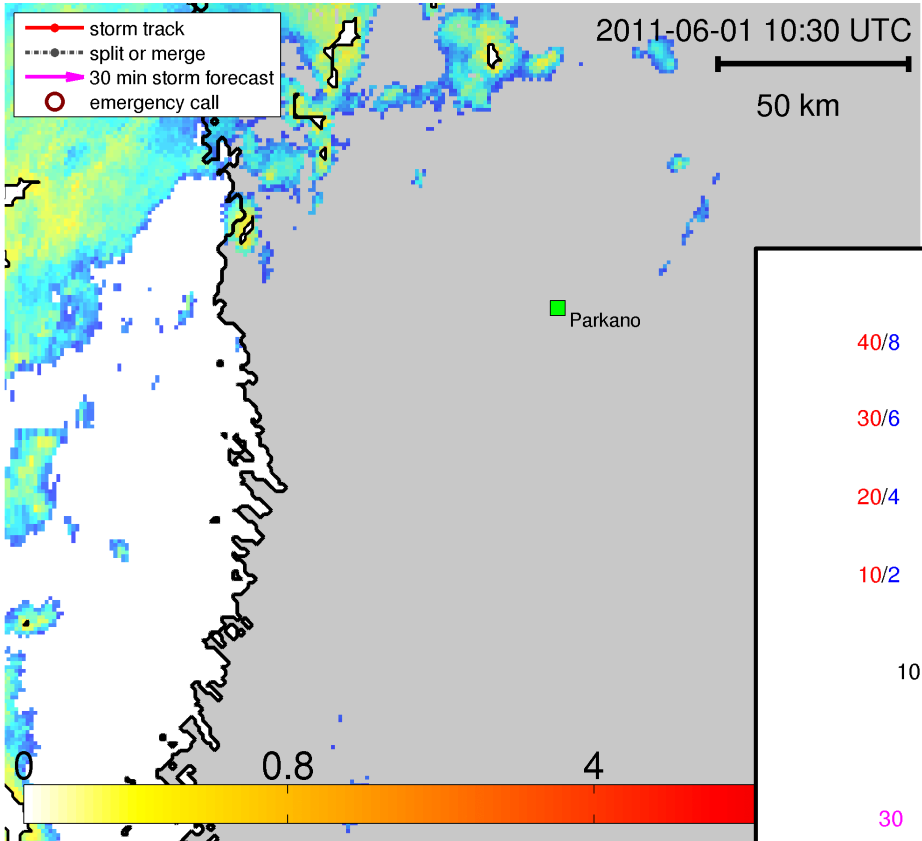
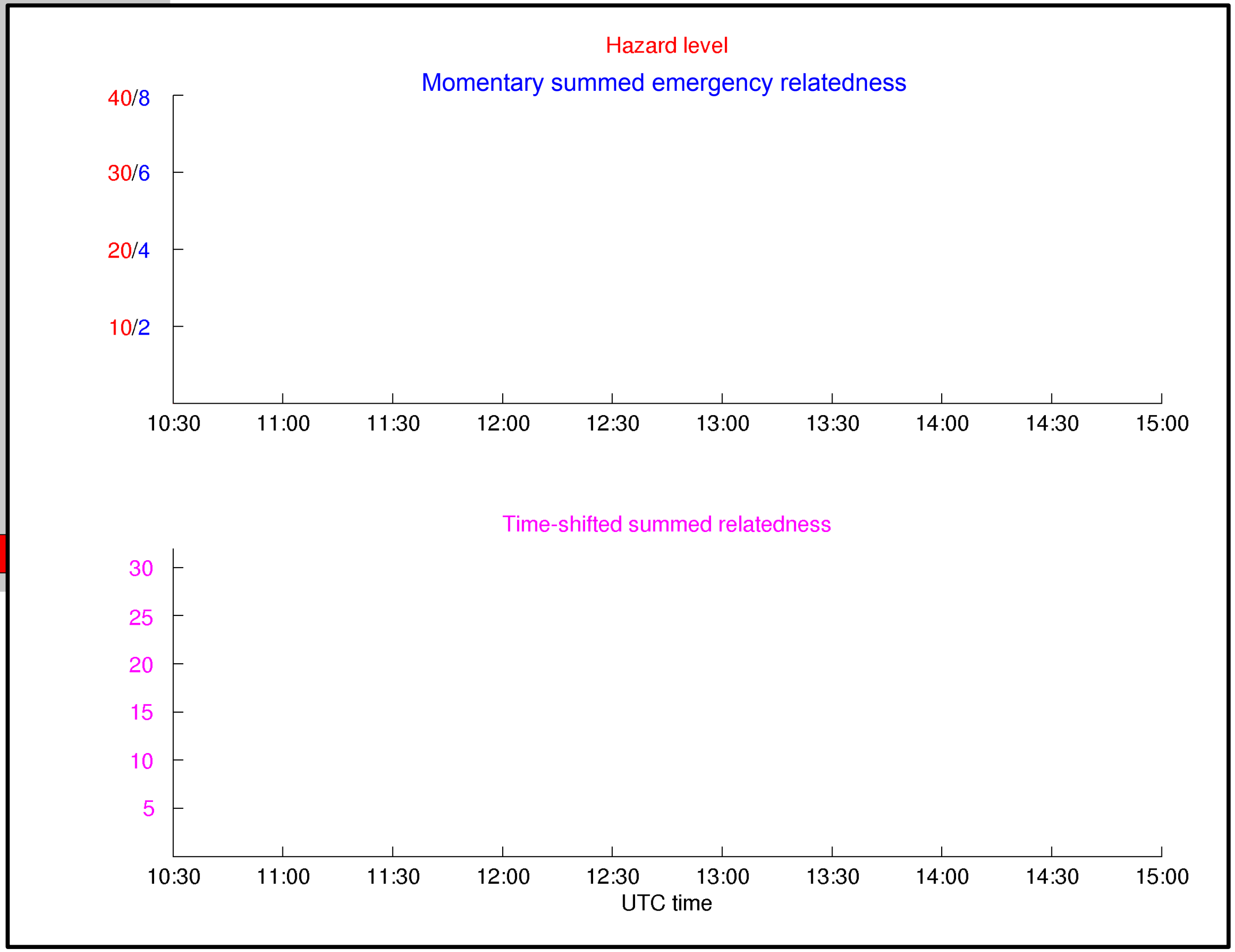
Hazard level information as time series



- Emergency information as time series separately for each tracked storm



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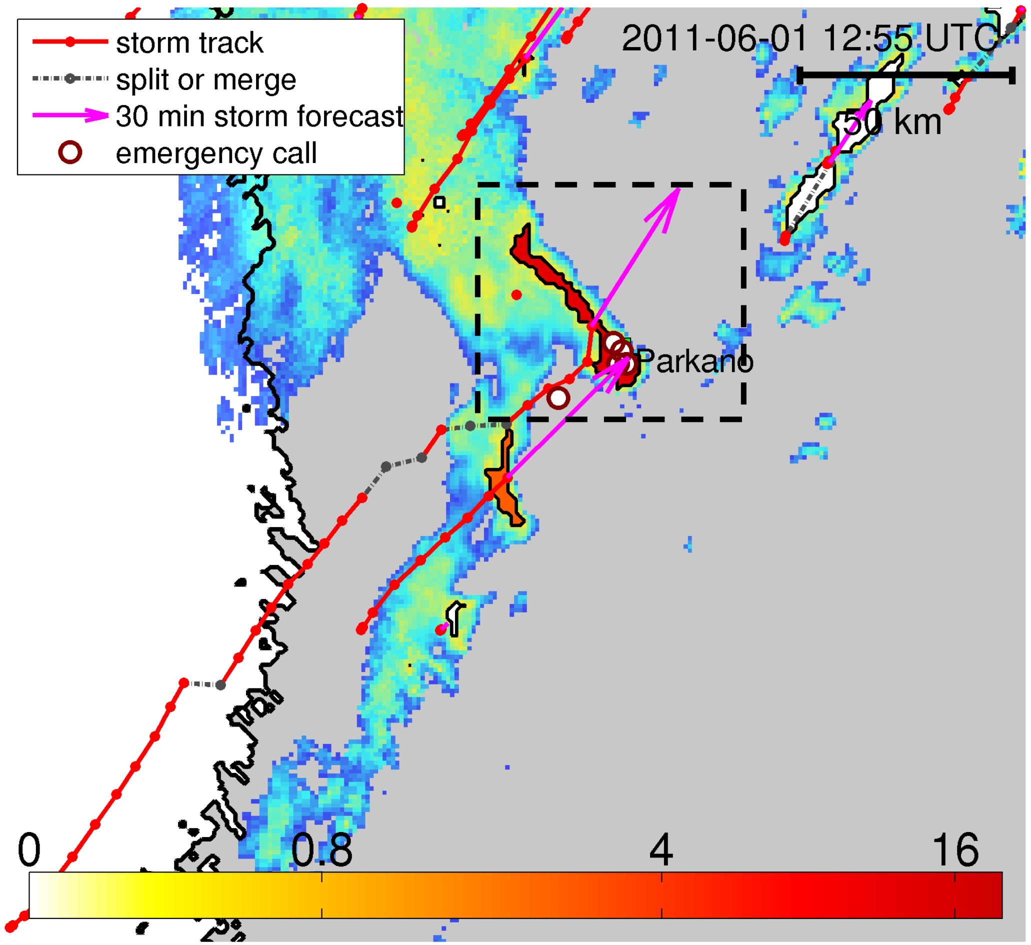
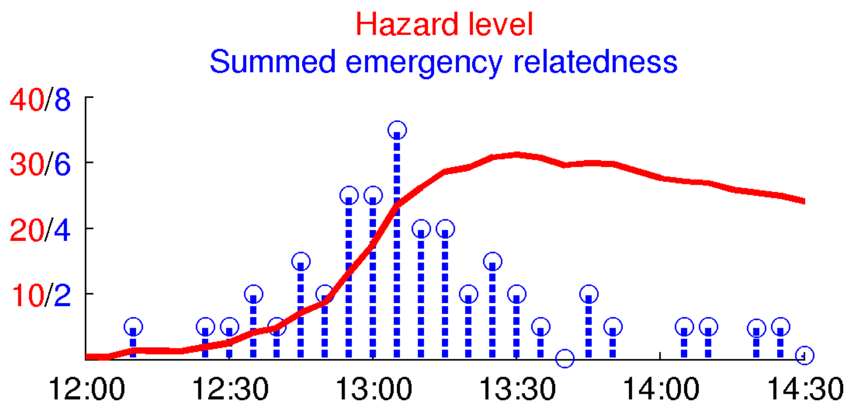
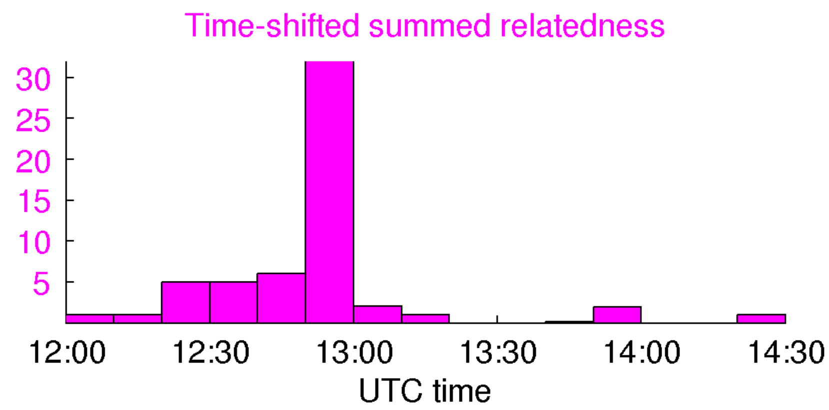
Hazard level information as time series







Conclusions

- **Emergency report data is a promising additional source of information for object oriented weather forecasting and for creating severe weather warning products**

- **Hazard level can be expressed practically with a color coding of storm cells without burdening the forecasters with excess information**

Conclusions

- **The algorithm exemplifies how tracked convective storms can be supplemented with novel information sources**
  - In the future, we could supplement convective storms with other unused information sources with high spatial and temporal accuracy:
    - Real time outage information from power transmission companies
    - On-line reports from storm chasers
    - Social media information

Population density weighting

- **Population density weighting is necessary, since the intensity of the report flow depends strongly on population density**
  - At median population density, the weight for an emergency report is 1
  - At sparsely populated areas the weight is approximately 10 times more than at densely populated areas