



Leibniz
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Uncertainty Analysis of Thunderstorm Nowcasts for Utilization in Aircraft Routing

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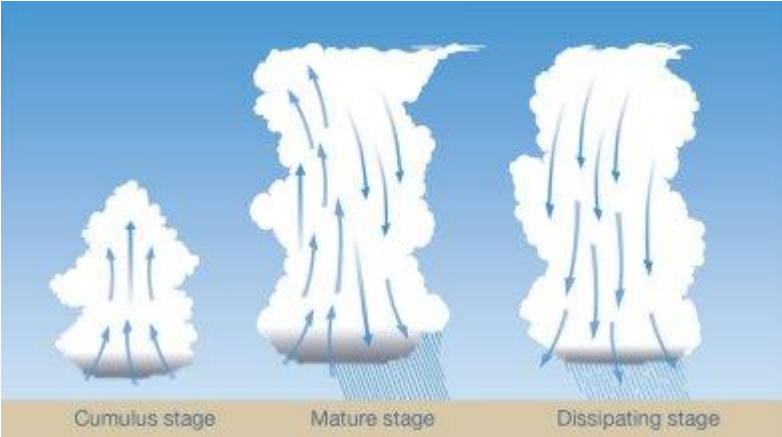
25. November 2014 – 4th SESAR Innovation Days

Outline

- Thunderstorms, motivation and nowcast data used
- Methodology and results of the uncertainty analysis
- Application in weather avoidance routing

Thunderstorms

- Small scale phenomena
 - cell diameter: 5 - 50 km
 - life time: 20 - 60 min
- After generation: further life cycle and movement is in principal predictable

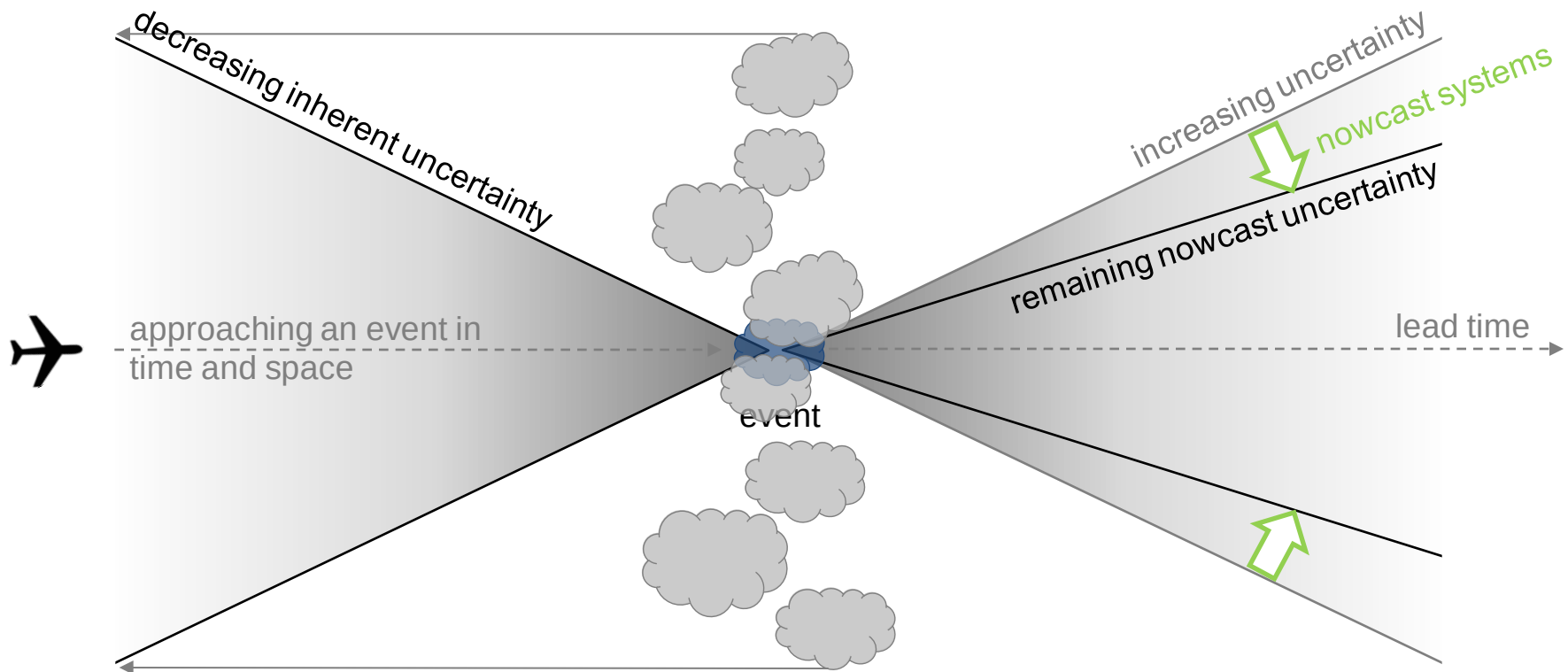


Source: http://www.bom.gov.au/storm_spotters/handbook/thunderstorms.shtml
- Prediction of onset?
 - generation mechanisms need to be forecasted:
 - deterministic components: orography, surface convergence lines
 - stochastic components: gravity waves, temperature inhomogeneities

└─→ not predictable!

UNCERTAINTY

Motivation



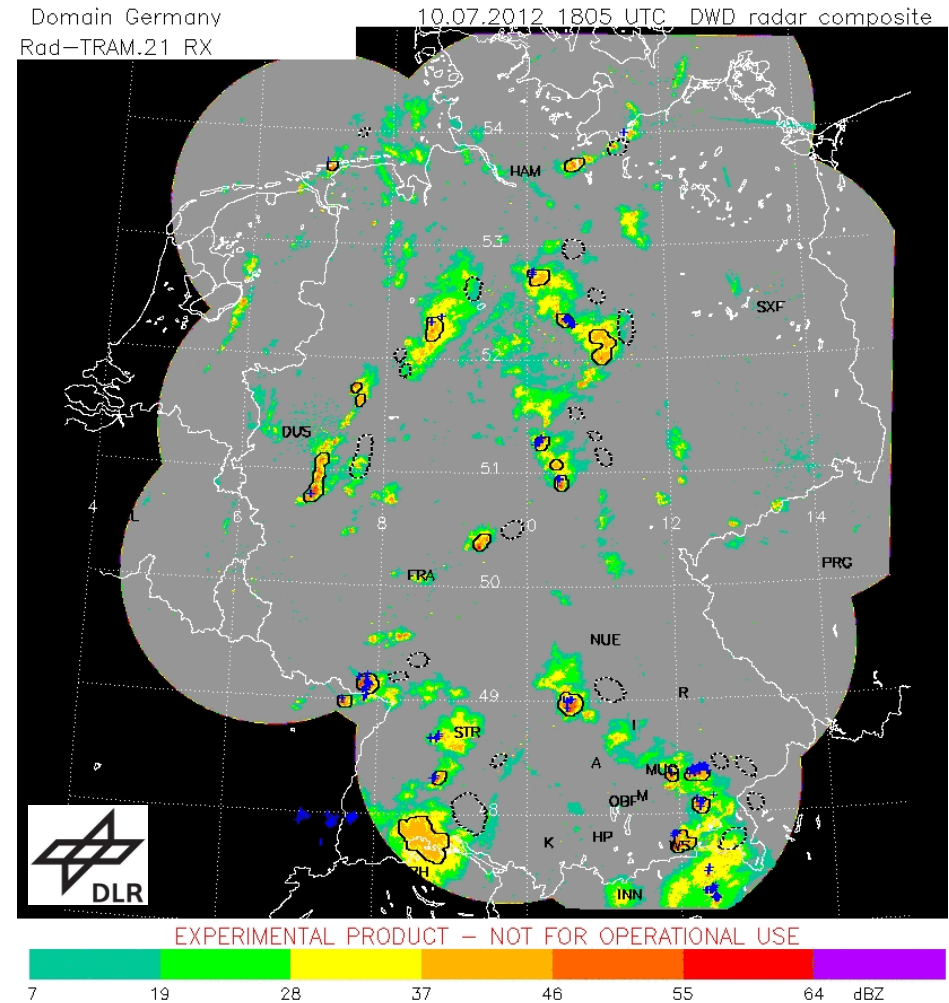
Rad-TRAM nowcast system

Radar Tracking and Monitoring

- Based on radar composite with timely resolution of 5 minutes
- object-based (> 37 dBZ)
- Pyramidal image matcher
 - displacement
 - life cycle: growth and decay of cells

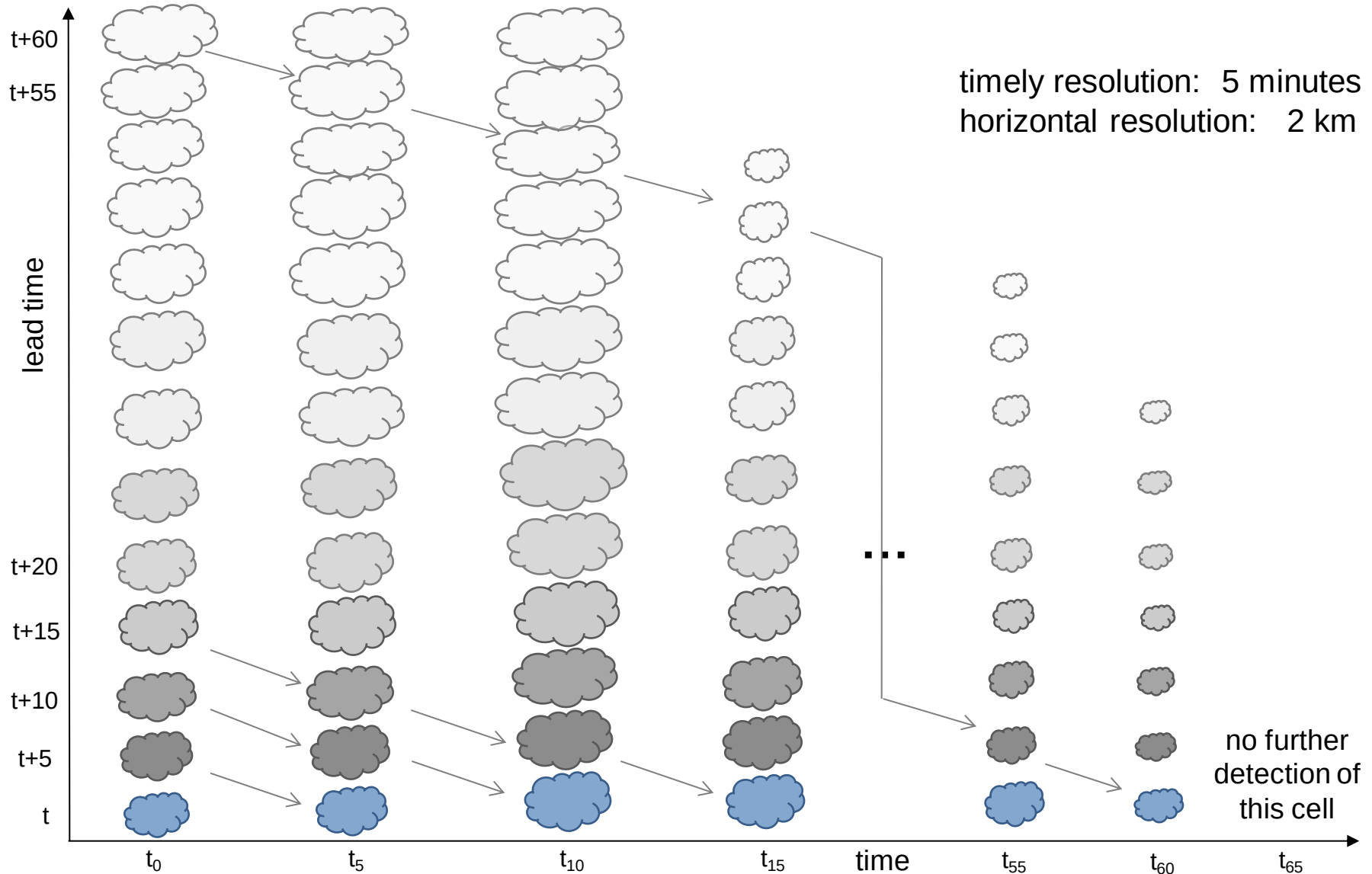
Further information:

Tafferner, A., C. Forster, 2012: Weather Nowcasting and Short Term Forecasting, in Atmospheric Physics, U. Schumann (ed.), Springer Verlag



Source: <http://www.pa.op.dlr.de/MUCSOMMER/2012/>

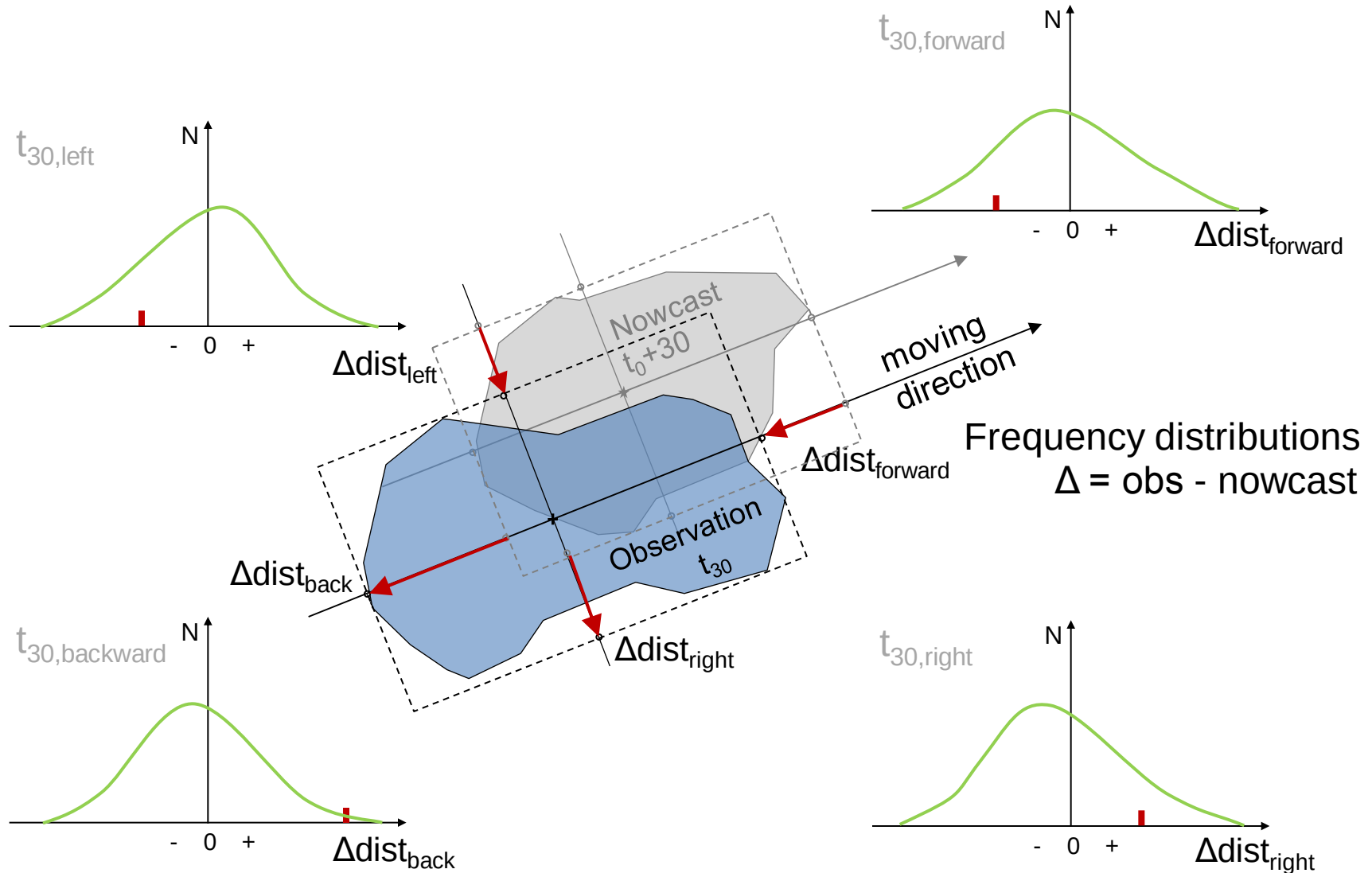
Rad-TRAM nowcasts



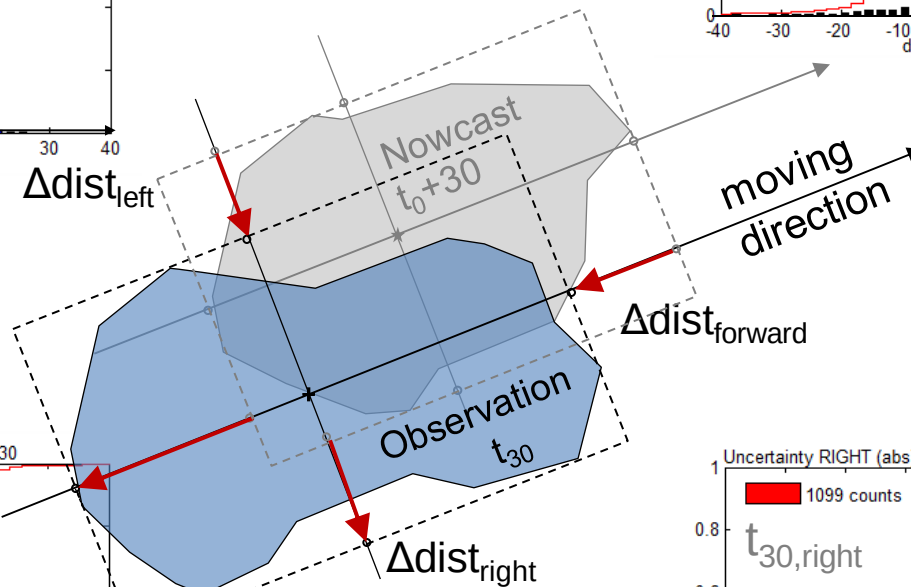
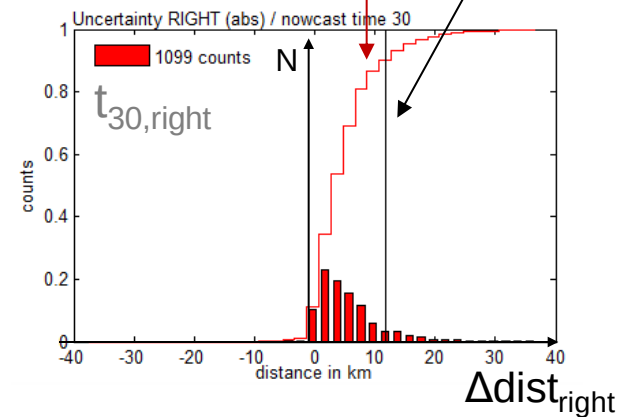
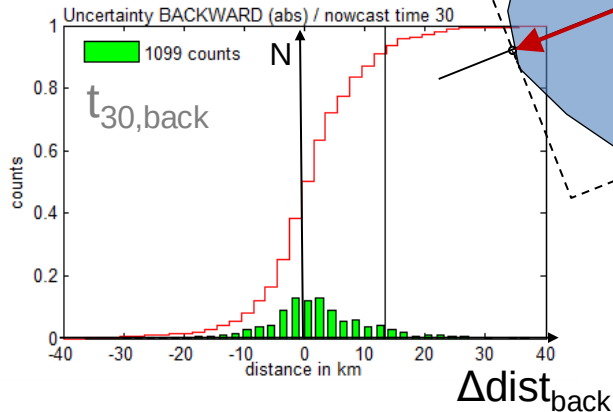
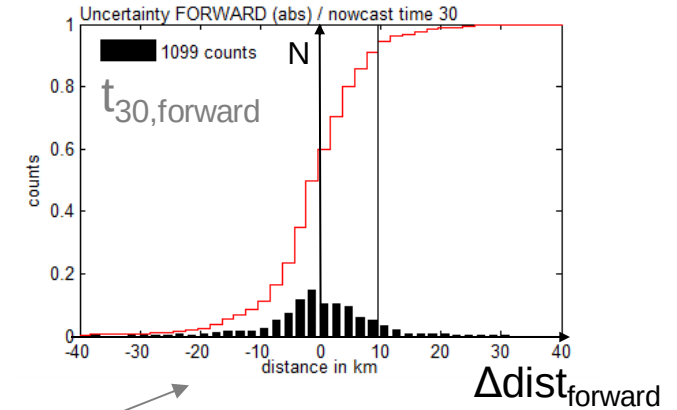
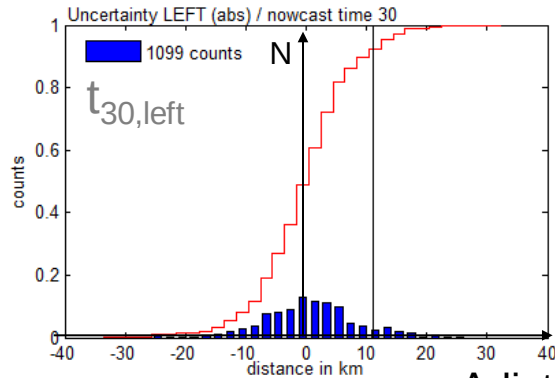
Nowcast uncertainty determination

METHODOLOGY & RESULTS

Methodology



Results 20120715

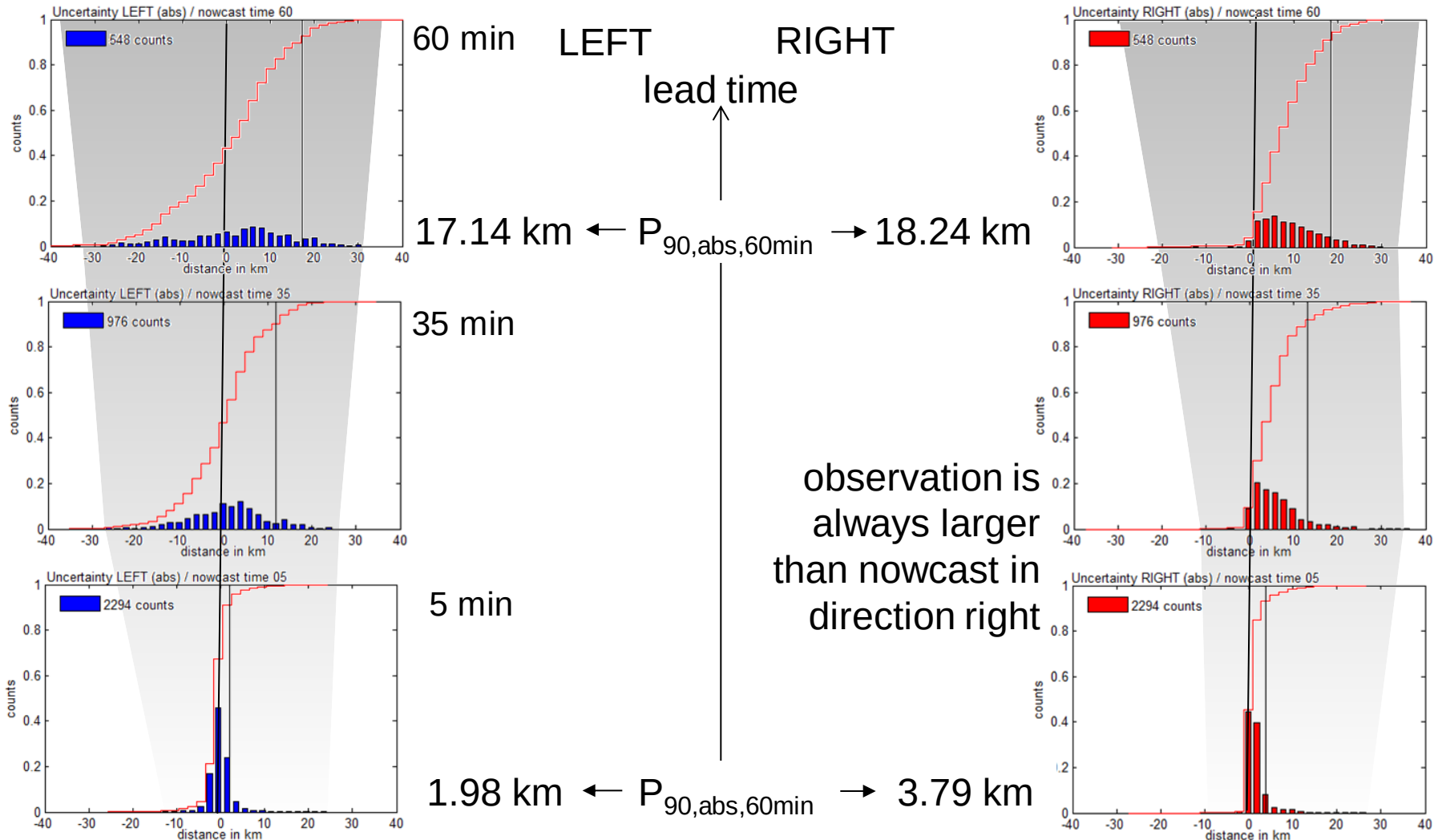


Cumulative
distribution function

90th percentile

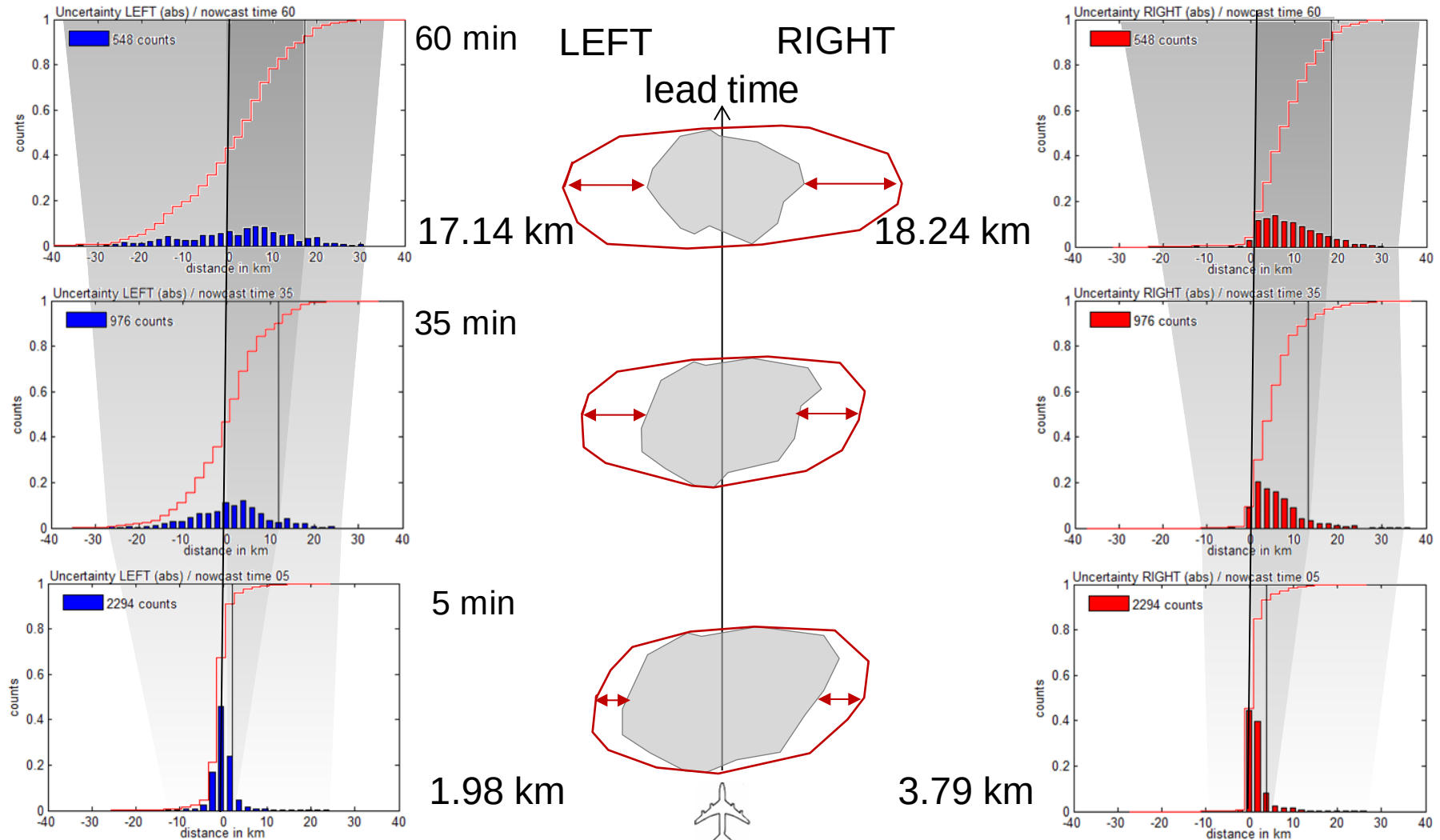
Increase of uncertainty with lead time

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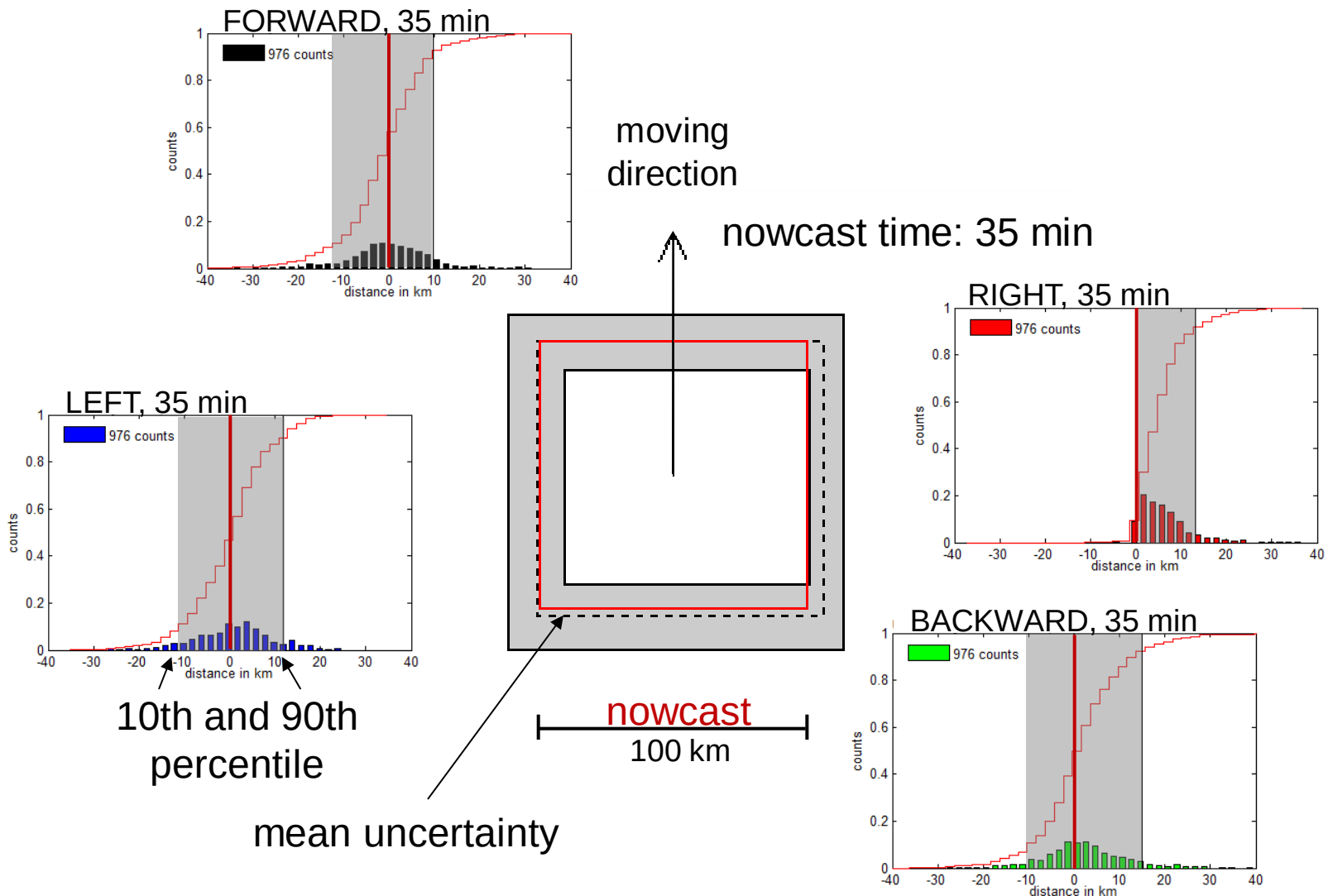
Increase of uncertainty with lead time

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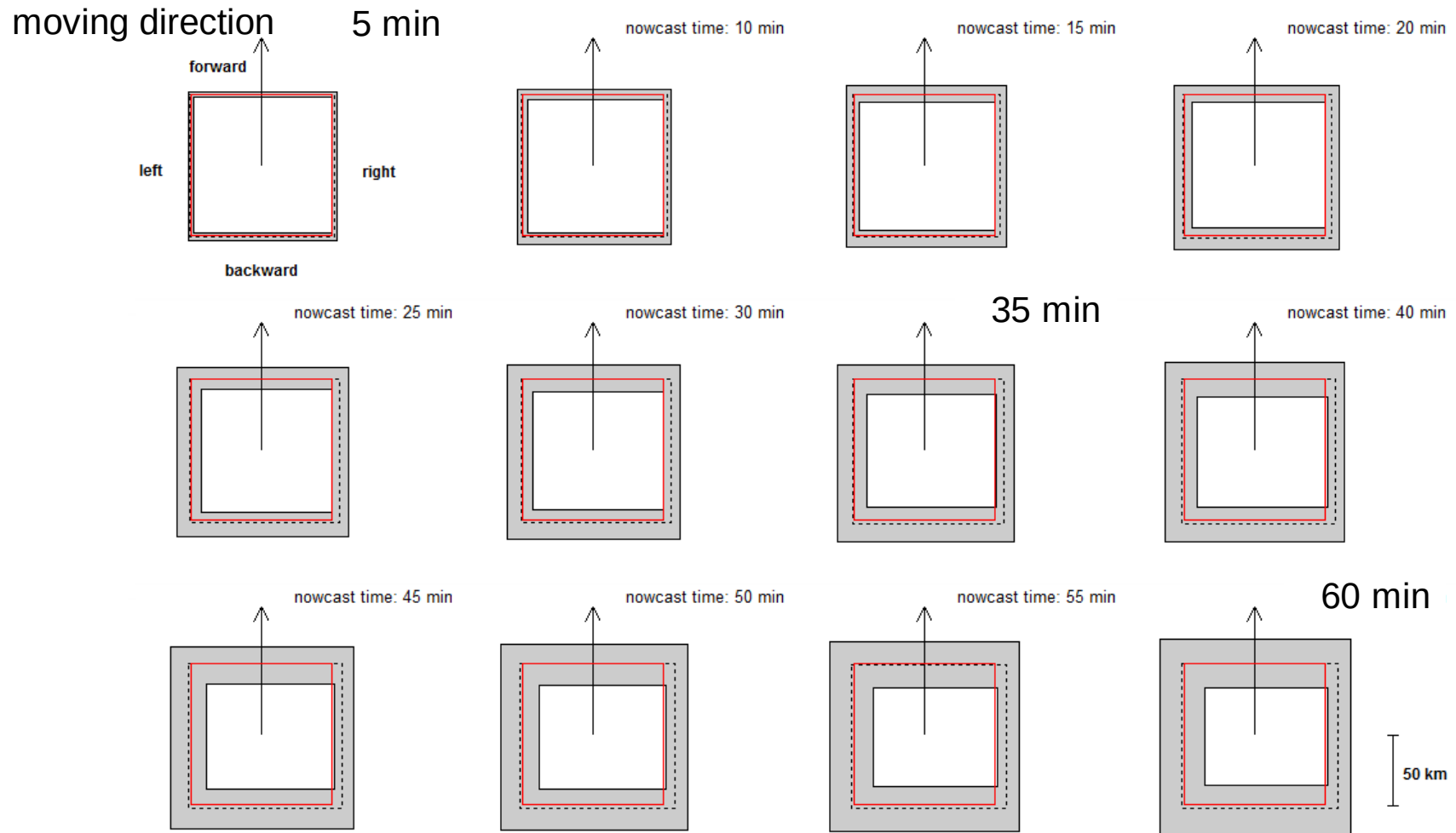
80% intervals in all directions

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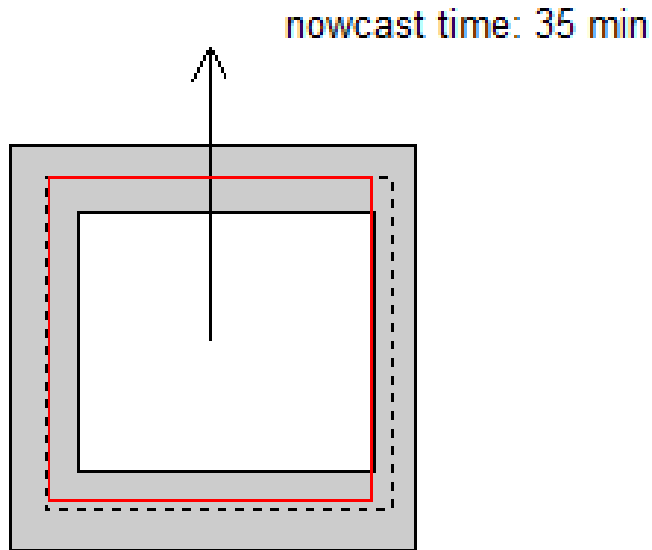
80 % intervals in all directions

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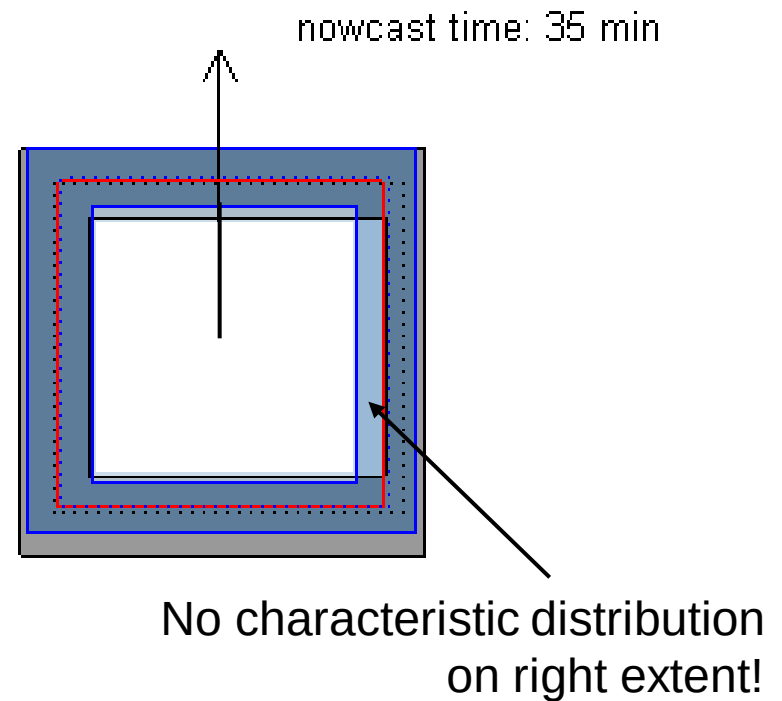


Differing results for different days/situations

July 15th, 2012

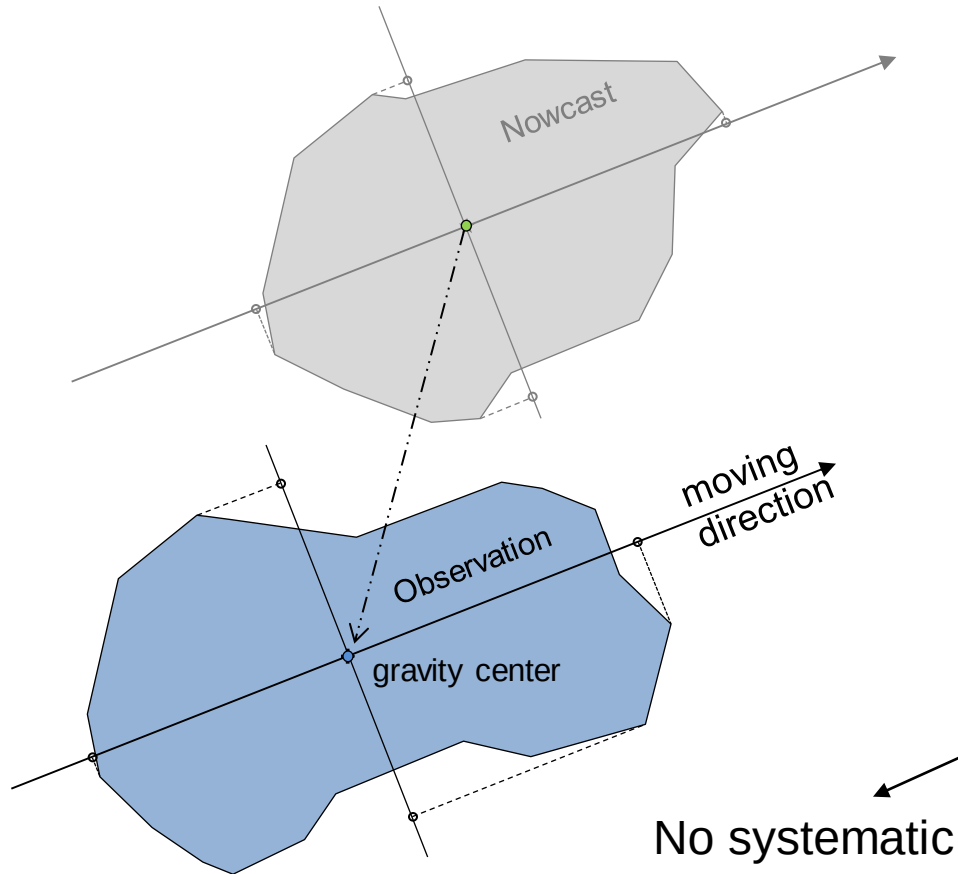


July 15th & 10th, 2012

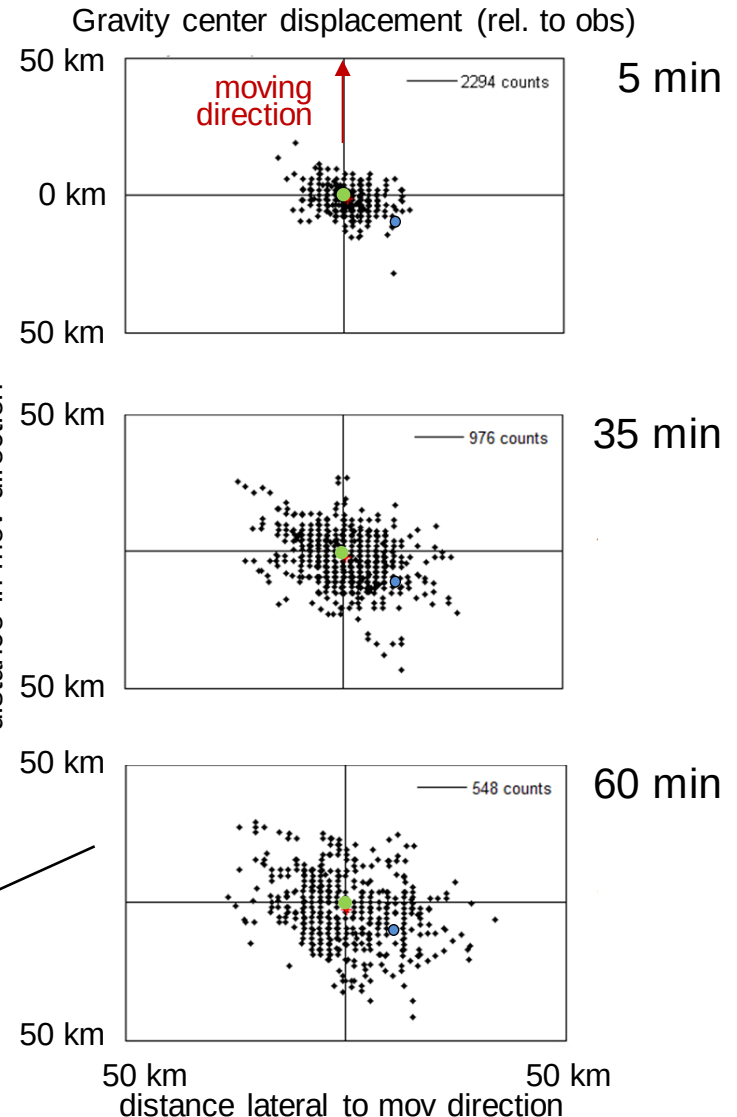


Separate uncertainty analysis – propagation error

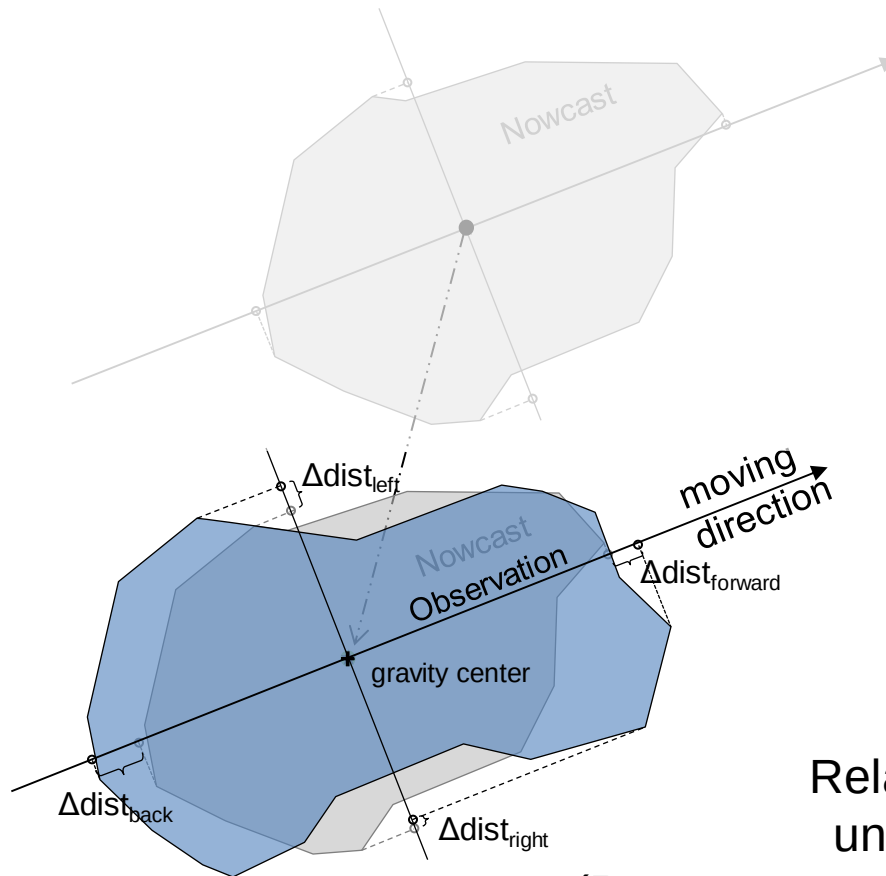
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No systematic
misplacement!

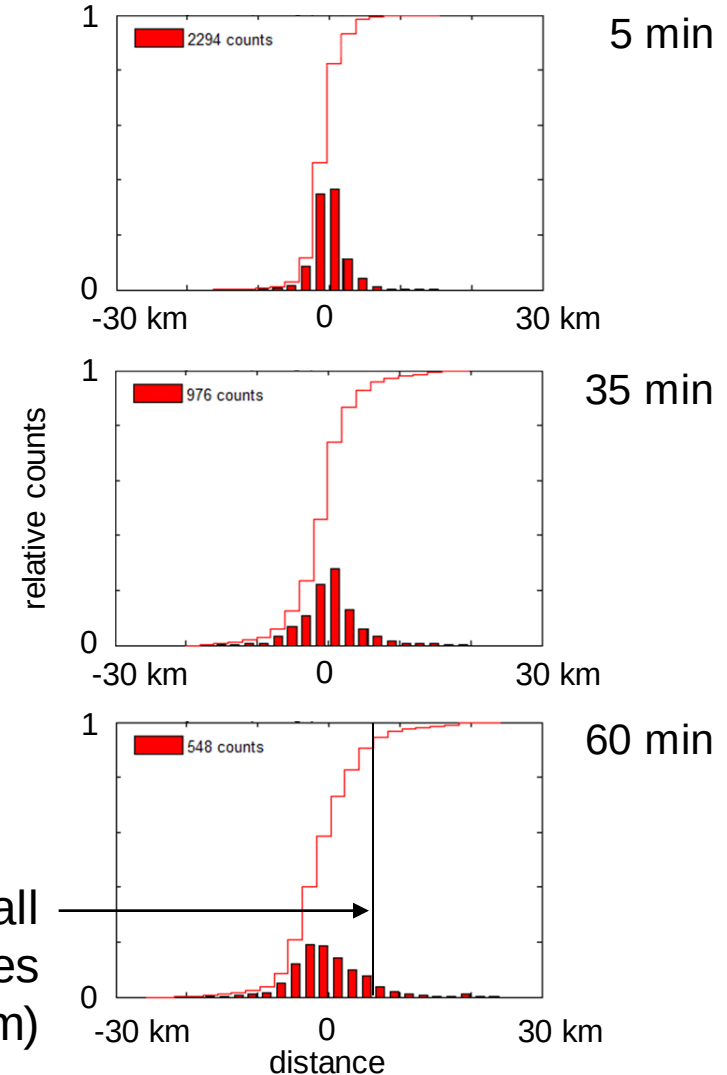


Separate uncertainty analysis – extension error



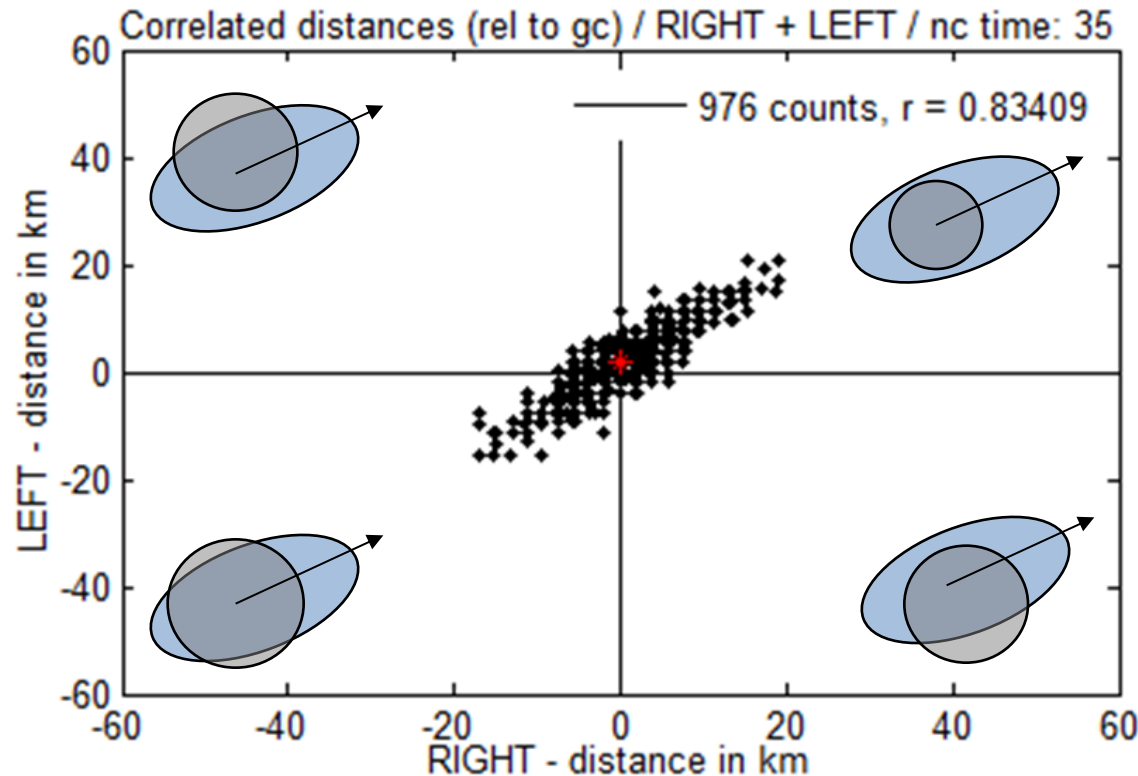
Relative small
uncertainties
($P_{90,rel,right,60min} = 5.87 \text{ km}$)

Extension difference in direction RIGHT

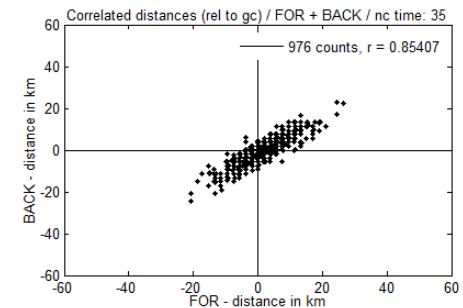


Correlated distances in separate analysis

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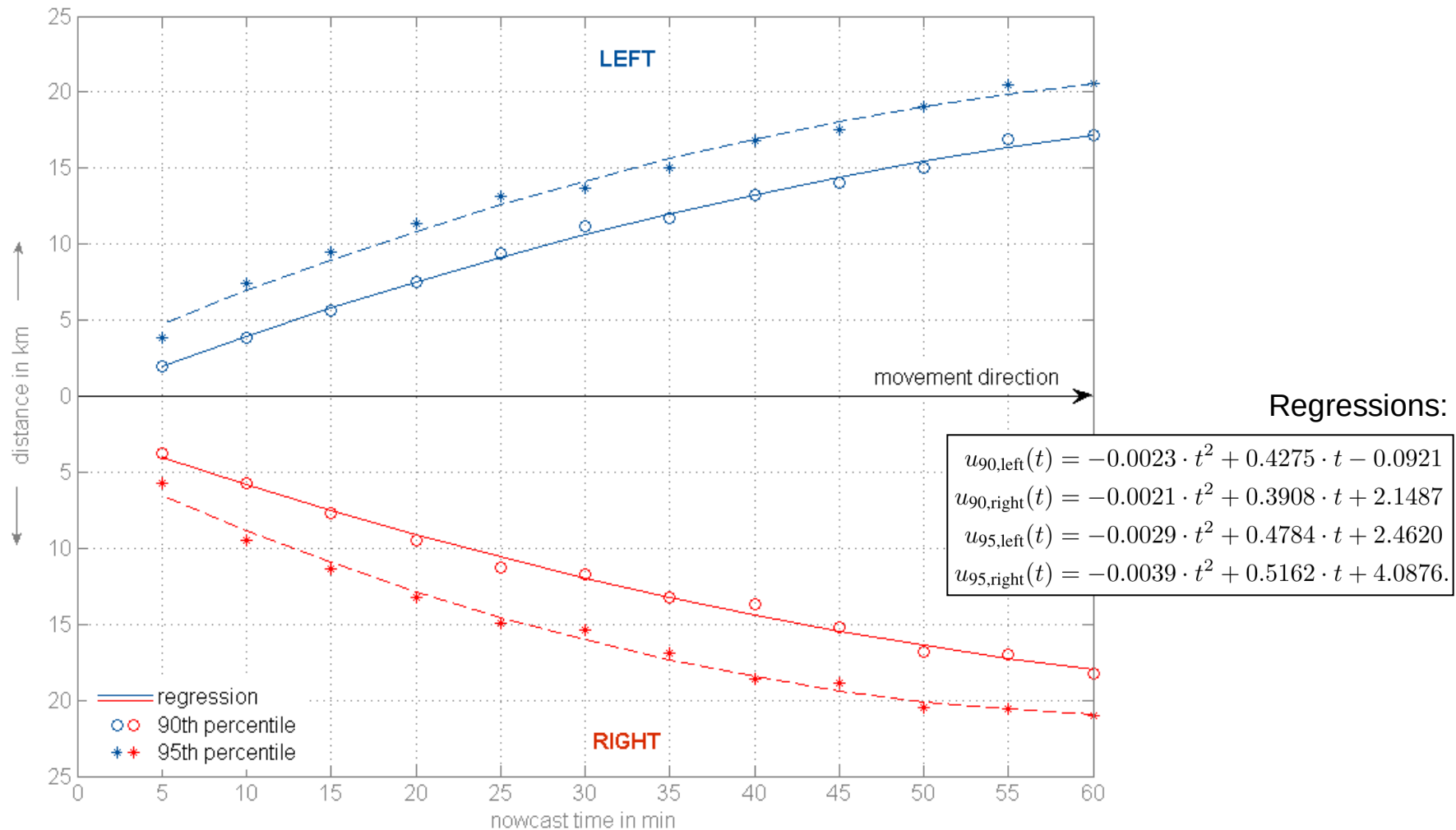
→ Regular growth or shrinkage on both sides



Equivalent correlation
between FORWARD and
BACKWARD deviations

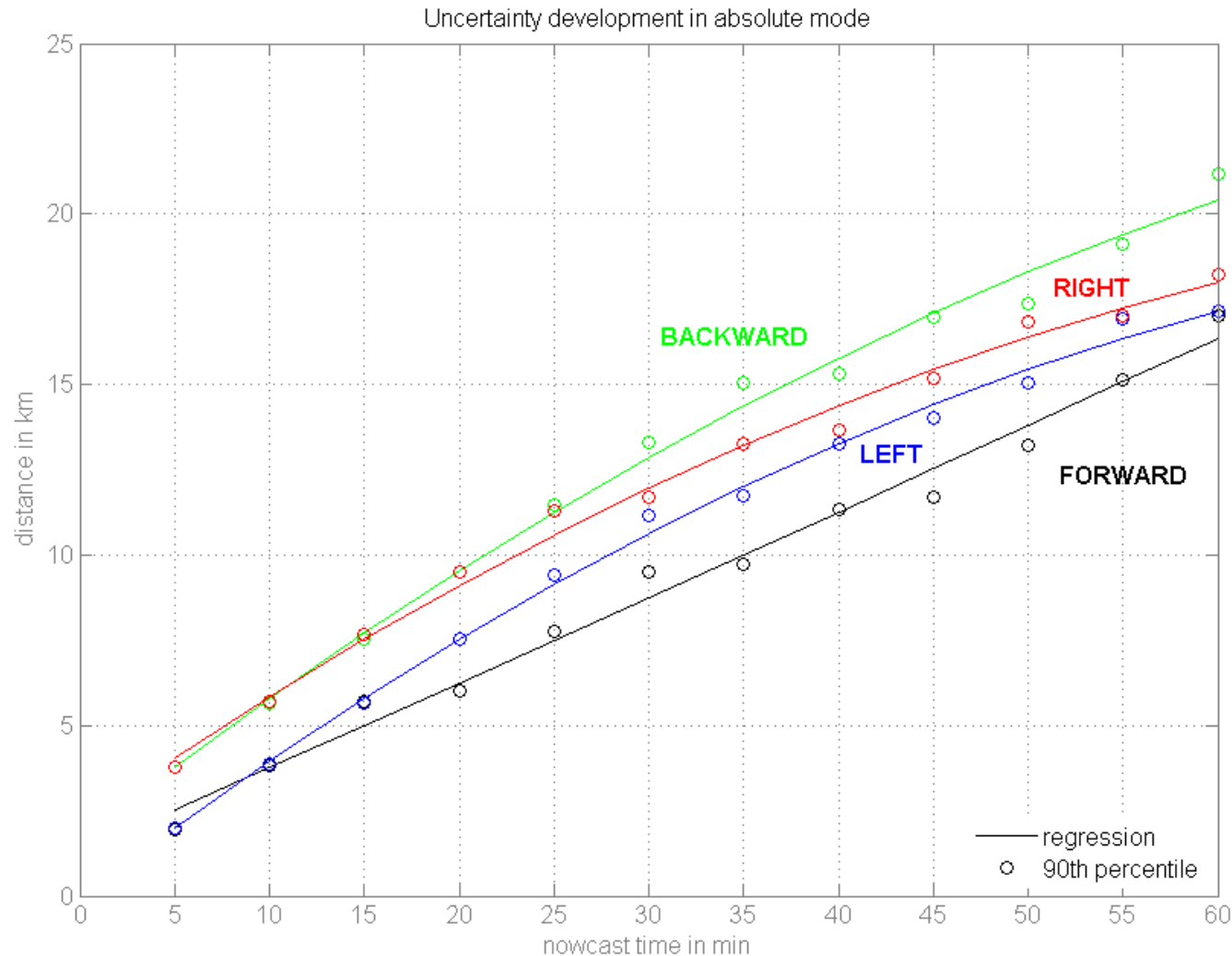
Integrated uncertainty development

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Integrated uncertainty development

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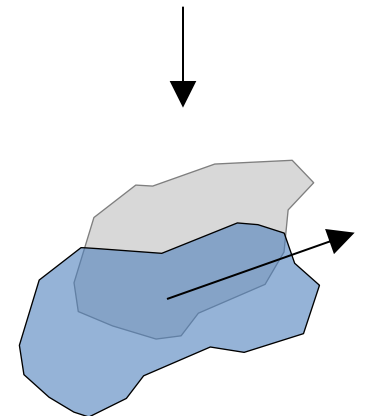


Larger 90th
percentiles
for directions

BACKWARD

and

RIGHT

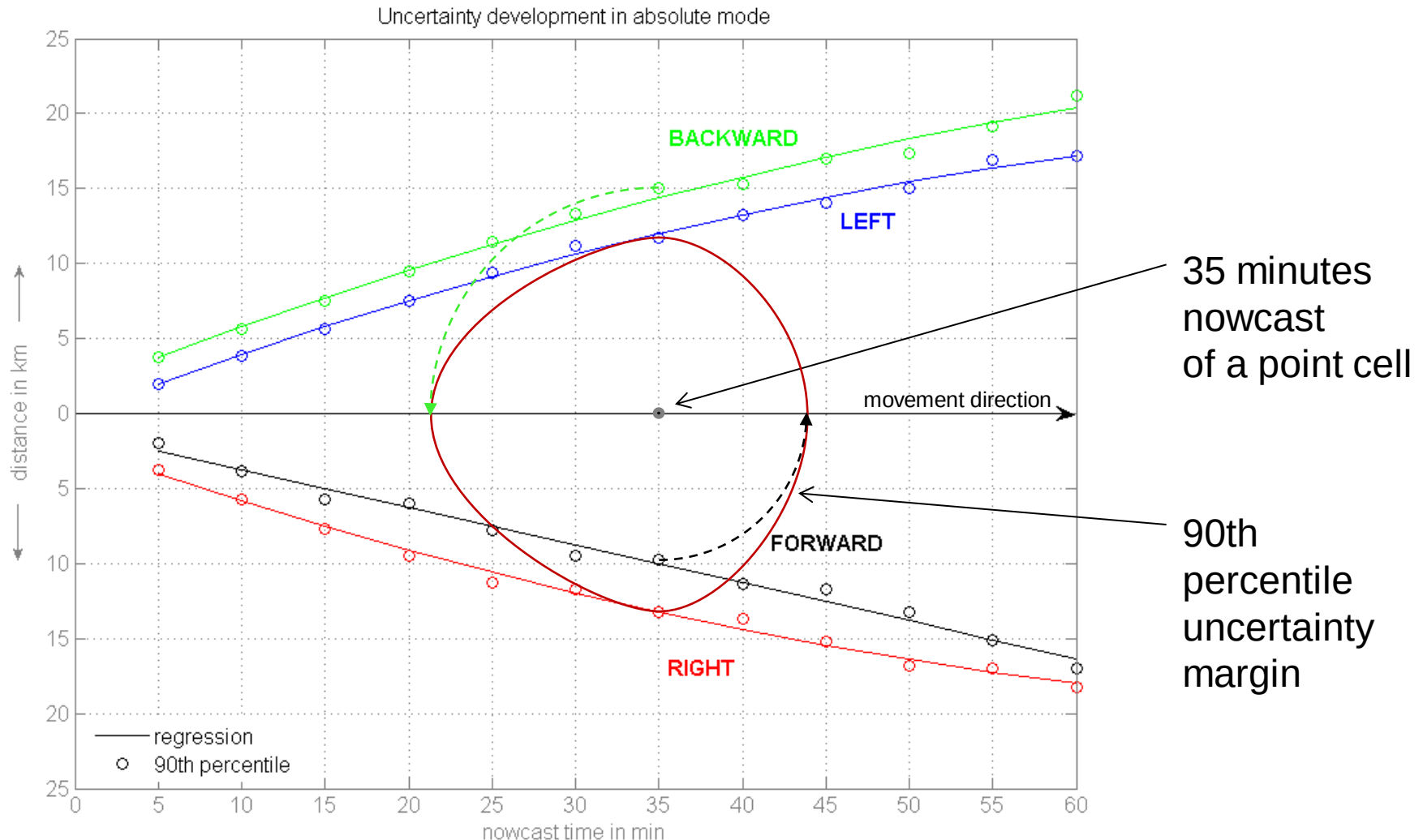


Nowcast uncertainty determination

APPLICATION IN WEATHER AVOIDANCE ROUTING

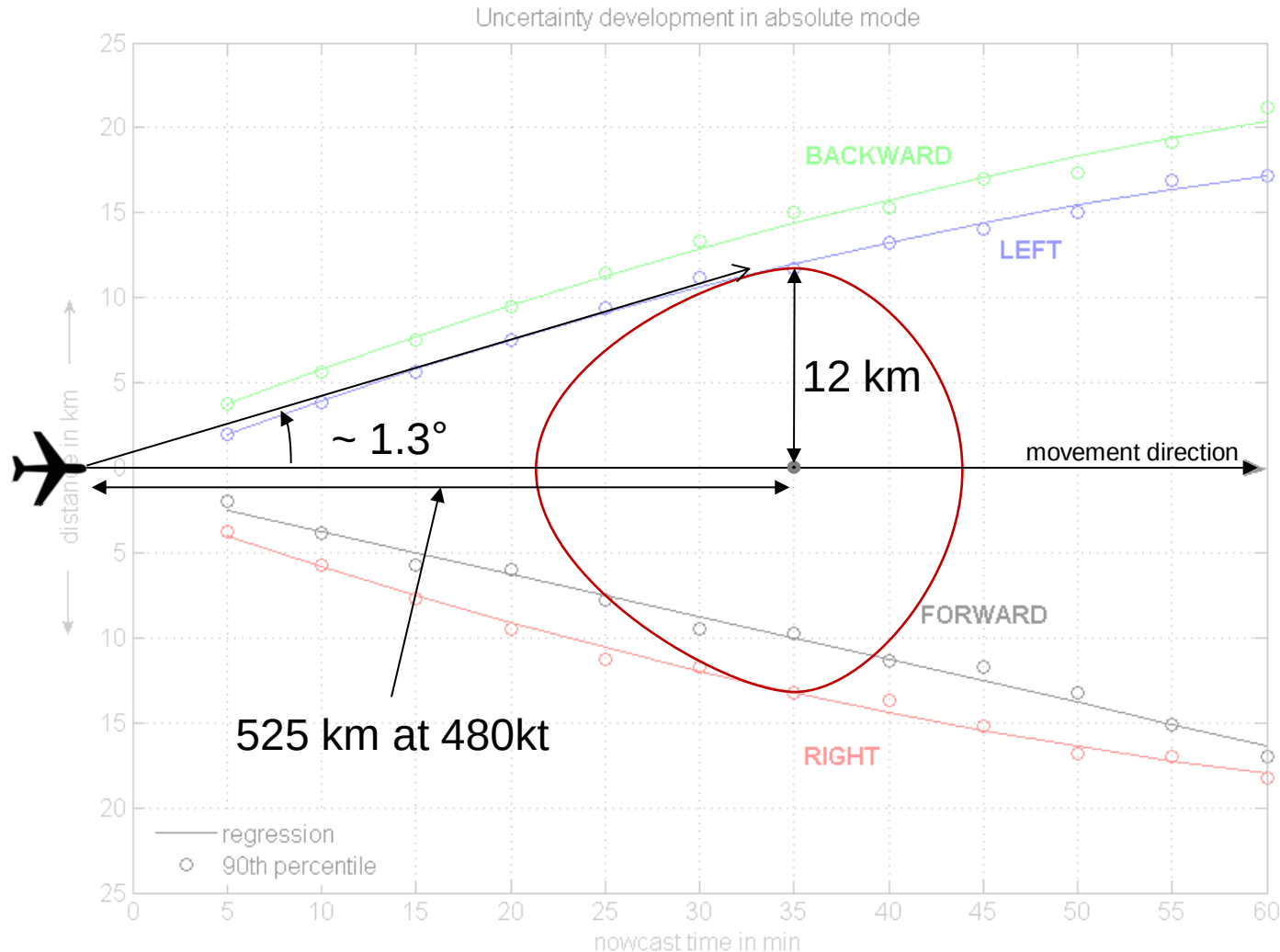
Add uncertainty margin around a nowcast

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Add uncertainty margin around a nowcast

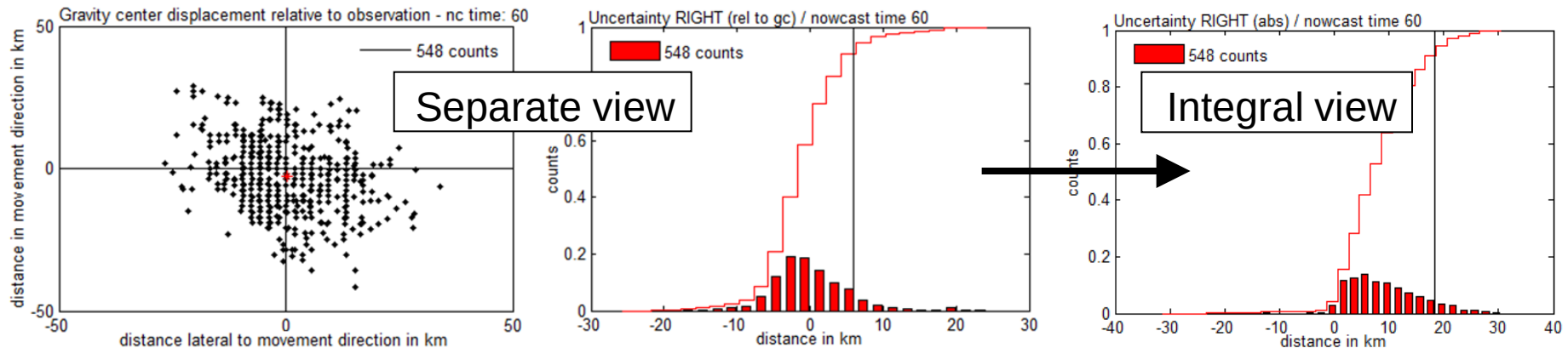
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Additional heading change to that forced by the nowcasted cells extent.

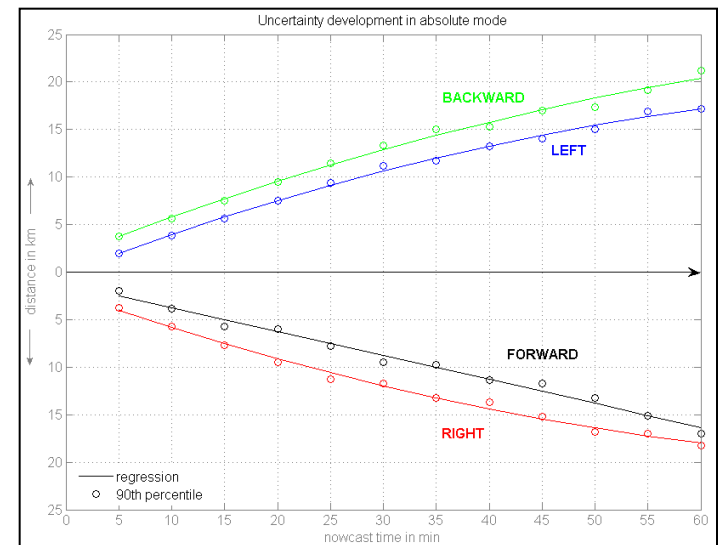
Conclusion I

- Spatial uncertainty determination method of nowcast cells considering extent and displacement
 - Isotropic behavior for both components
 - BUT: integrated uncertainty shows characteristic features



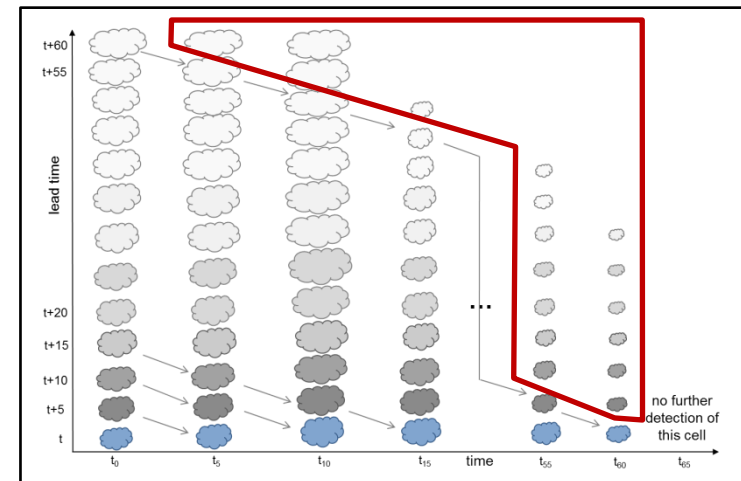
Conclusion II

- Spatial uncertainty determination method of nowcast cells considering extent and displacement
 - Isotropic behavior for both components
 - BUT: integrated uncertainty shows characteristic features
- Quantified rate of increasing uncertainty with lead time



Conclusion

- Spatial uncertainty determination method of nowcast cells considering extent and displacement
 - Isotropic behavior for both components
 - BUT: integrated uncertainty shows characteristic features
- Quantified rate of increasing uncertainty with lead time
- Uncertainty is even higher due to
 - new, not yet nowcasted cells
 - Other not yet considered statistics
 - dissipating cells
 - merged/splitted cells
- Further analyses on different thunderstorm situations



THANK YOU

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