DENSE WEATHER RADAR NETWORK FOR OBSERVATION OF SEVERE STORM IN HELSINKI METROPOLITAN AREA

R. Cremonini[(1)], D. Moisseev[(1)], V. Chandrasekar[(1)(2)], P. J. Rossi[(3)], S. Lautaportti[(1)], L. Rojas[(1)], A. von Lerber[(1)]

(1) University of Helsinki, Department of Physics, Finland
(2) Colorado State University, USA
(3) Finnish Meteorological Institute, Finland

Outline

- Motivations
- Helsinki dense weather radar network
- Weather radar composite over Helsinki
- Severe storm on 2010.08.08
- Conclusions

Motivations

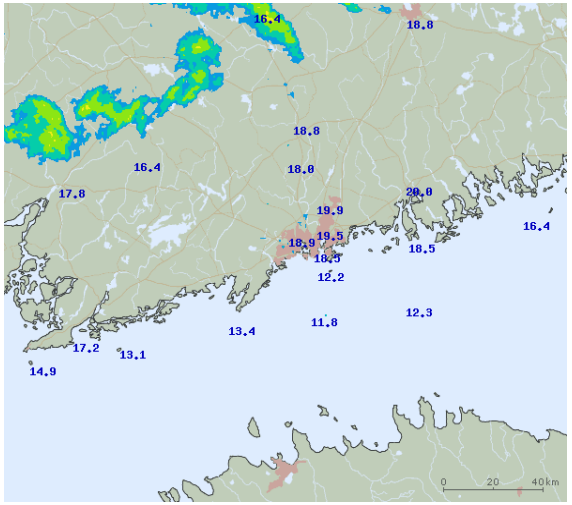
- Population in cities will increase up to nearly 5 billion by 2030 (UN report)
- Rapid, uncontrolled spatial growth and densification increases exposition to natural hazard:
  - Flash floods
  - Heavy snowfalls
  - Heat waves
- Integrated observation approach and systems modeling

Ongoing initiatives in Helsinki

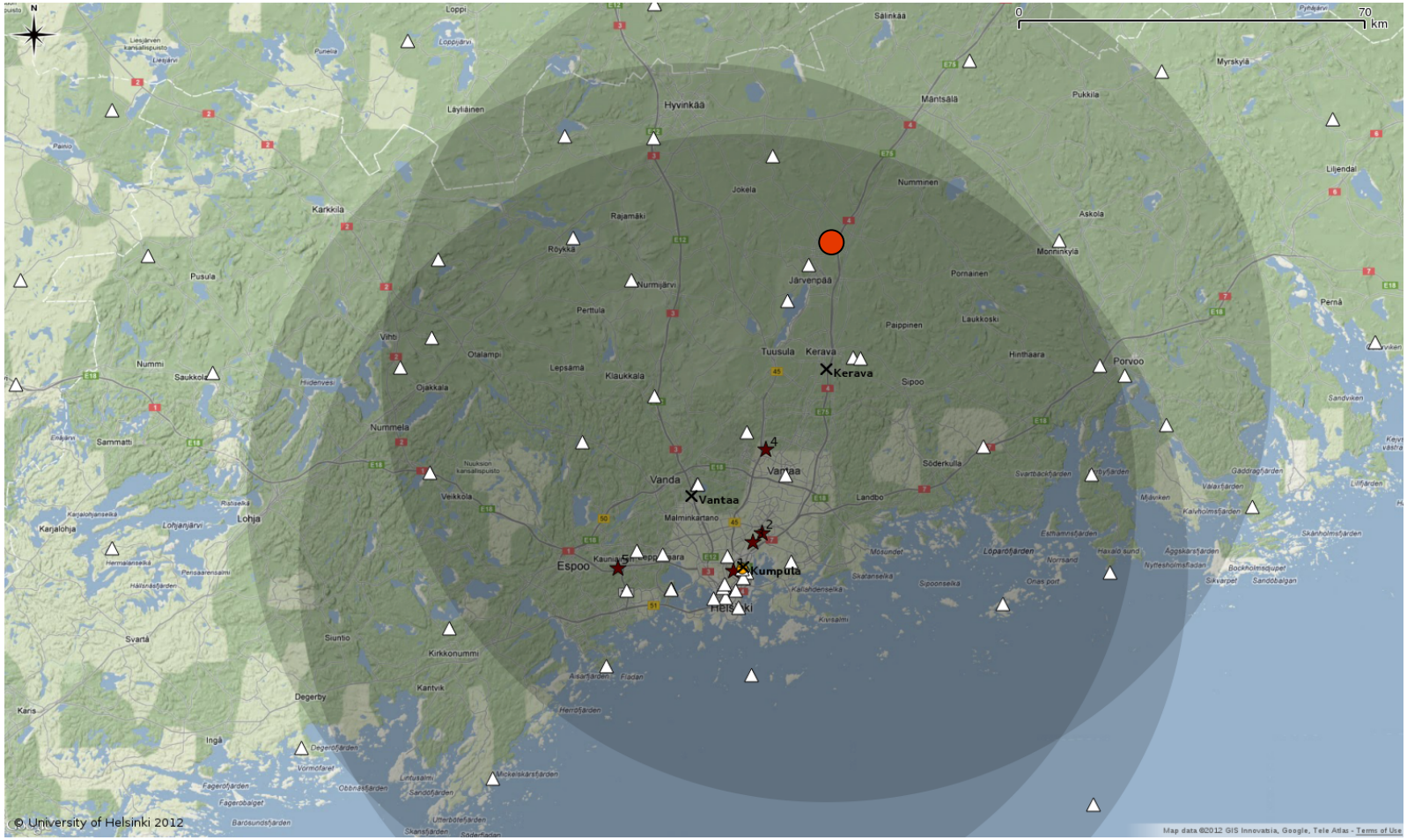
- Helsinki testbed (Koskinen *et al* 2010), http://testbed.fmi.fi
- UrBAN - Urban Boundary-layer Atmosphere Network, http://urban.fmi.fi
- URCA - The quality and quantity of runoff water in relation to land use in urbanized catchment
- PATHWAY - Information technology to accelerated scientific discovery from avalanche of meteorological and environmental data

Meteorological monitoring networks

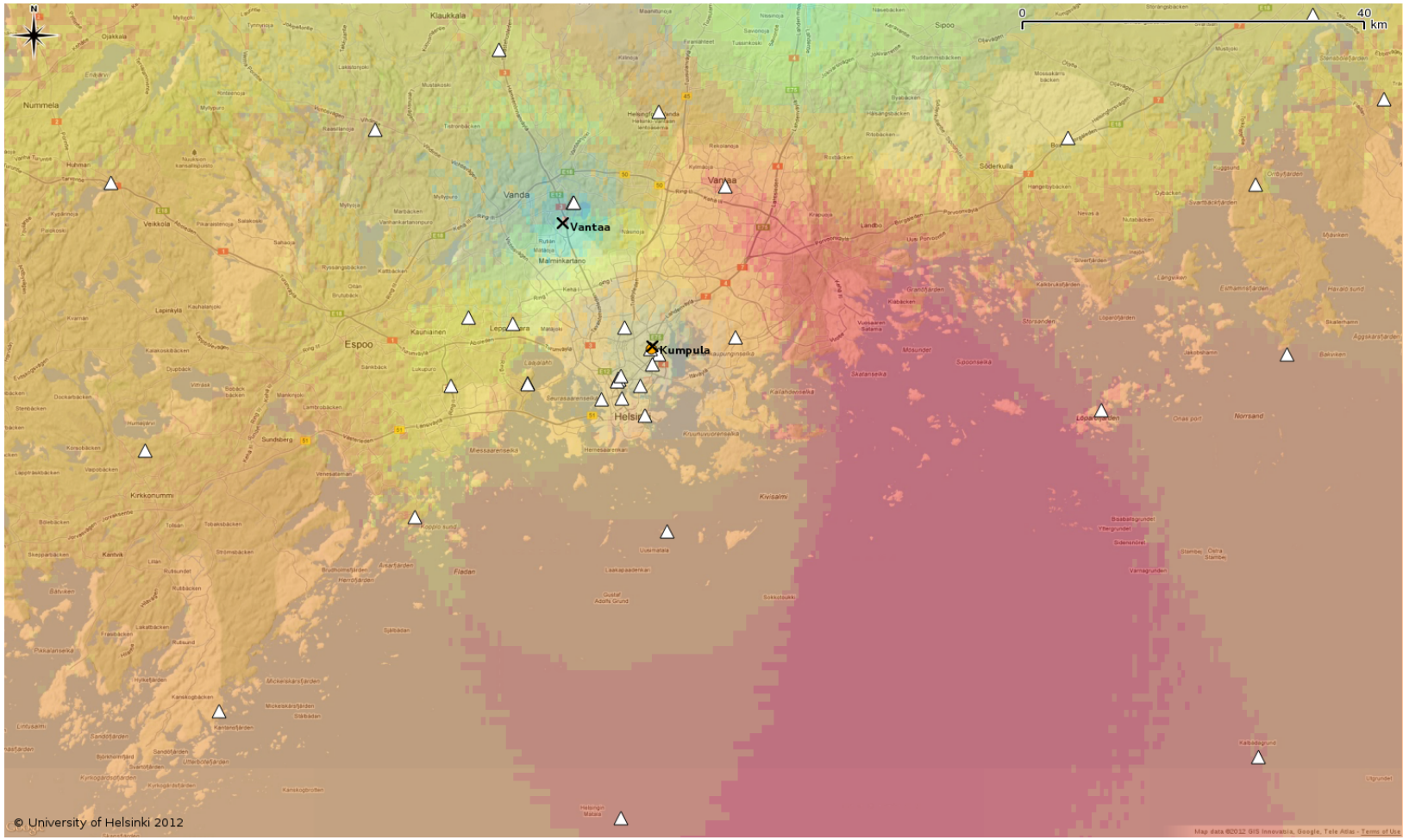
- ~ 50 surface weather stations (FMI and Vaisala)
- 3 C-band polarimetric weather radars: Kerava (Vaisala Oy), Vantaa (FMI), Kumpula (UH)
  - Average distance 16.6 km with meanwhile Vantaa-Kumpula 9.1 km far
  - Large overlapping area
  - High resolution over urban area



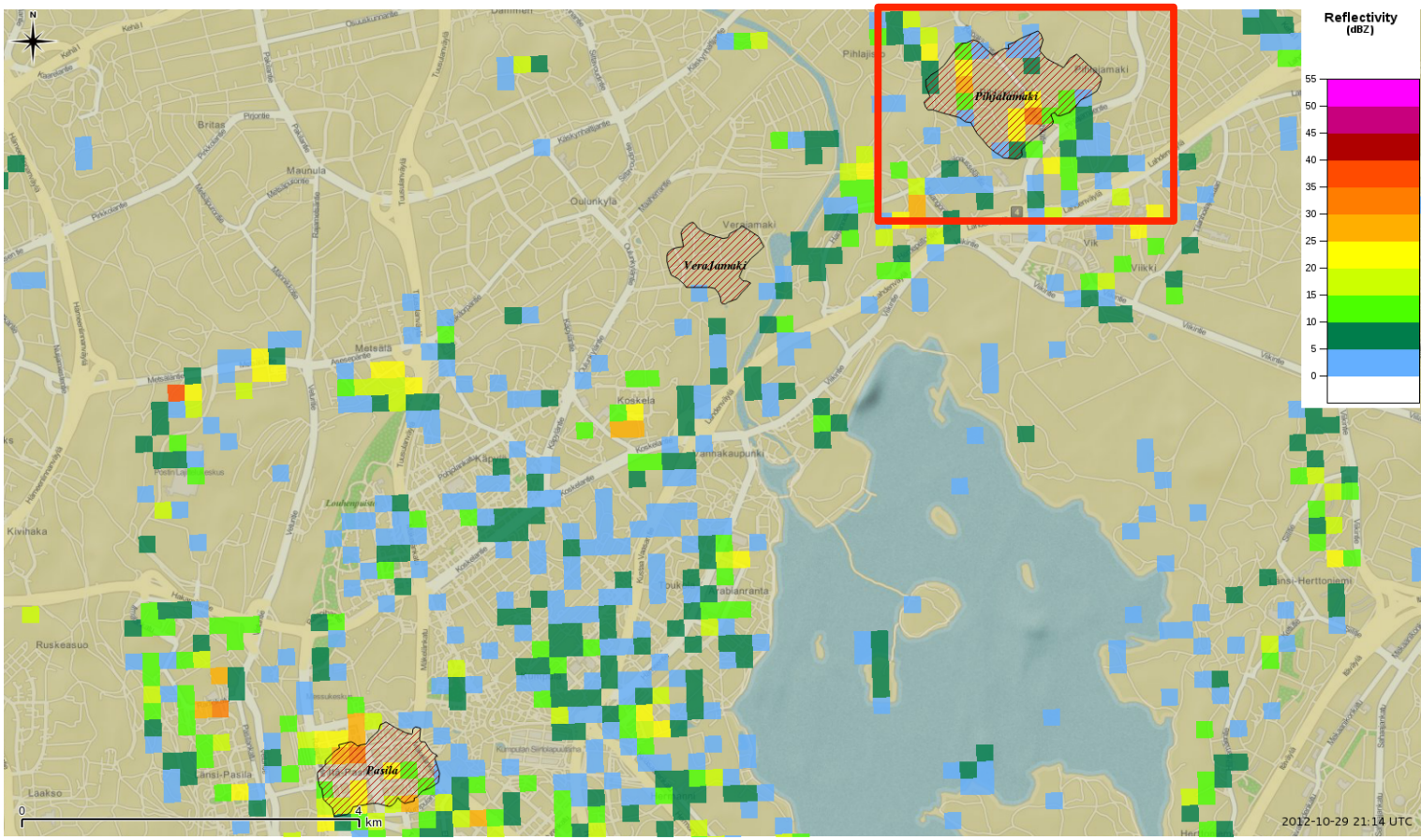
Helsinki next generation testbed



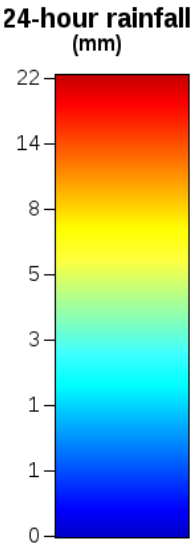
Beams overlap for lowest elevation scan (blue/good – red/excellent)

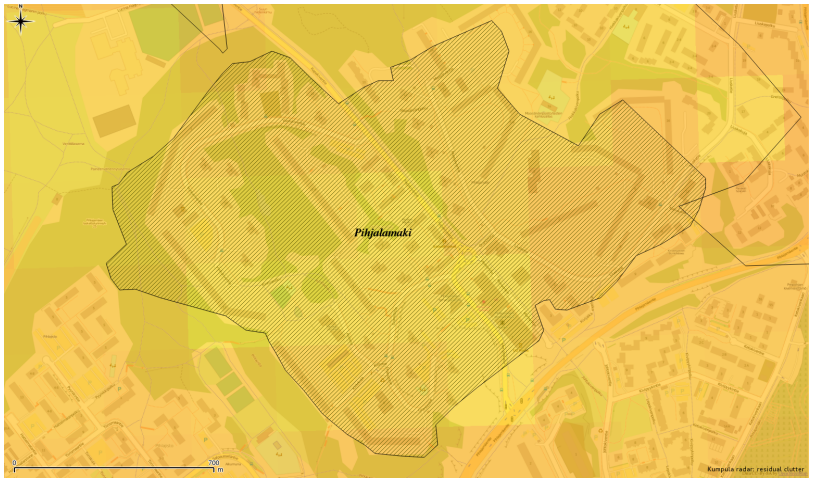


Residual clutter during fair weather

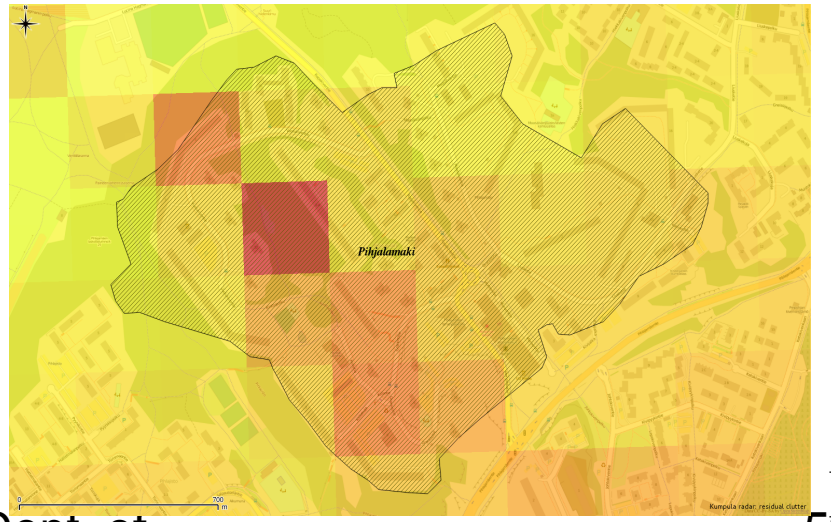


Residual clutter on QPE for the Pihjalamäki catchment



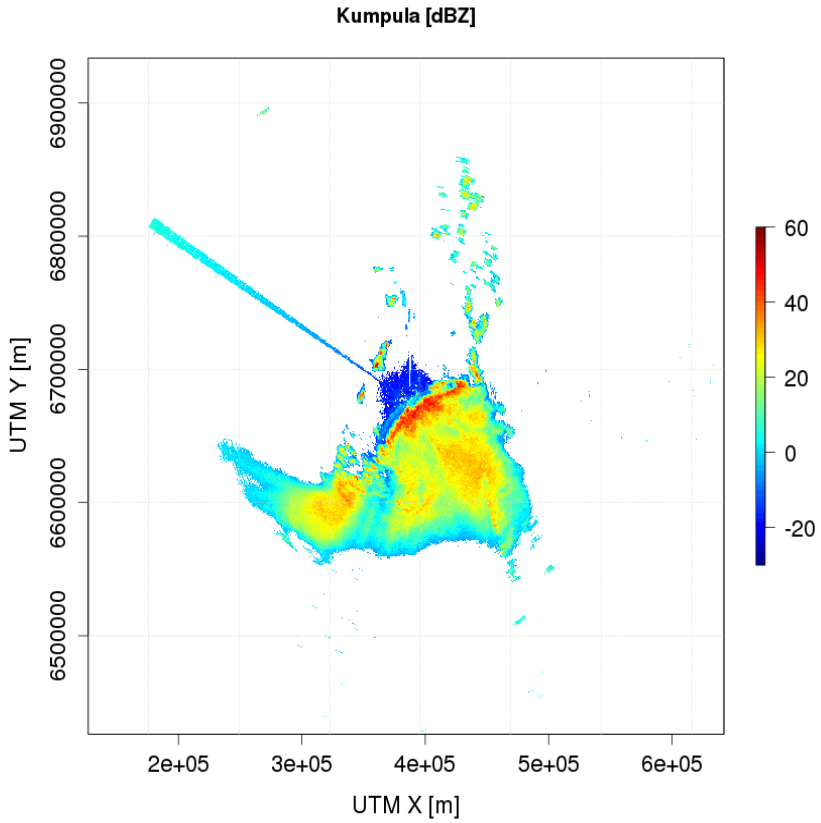


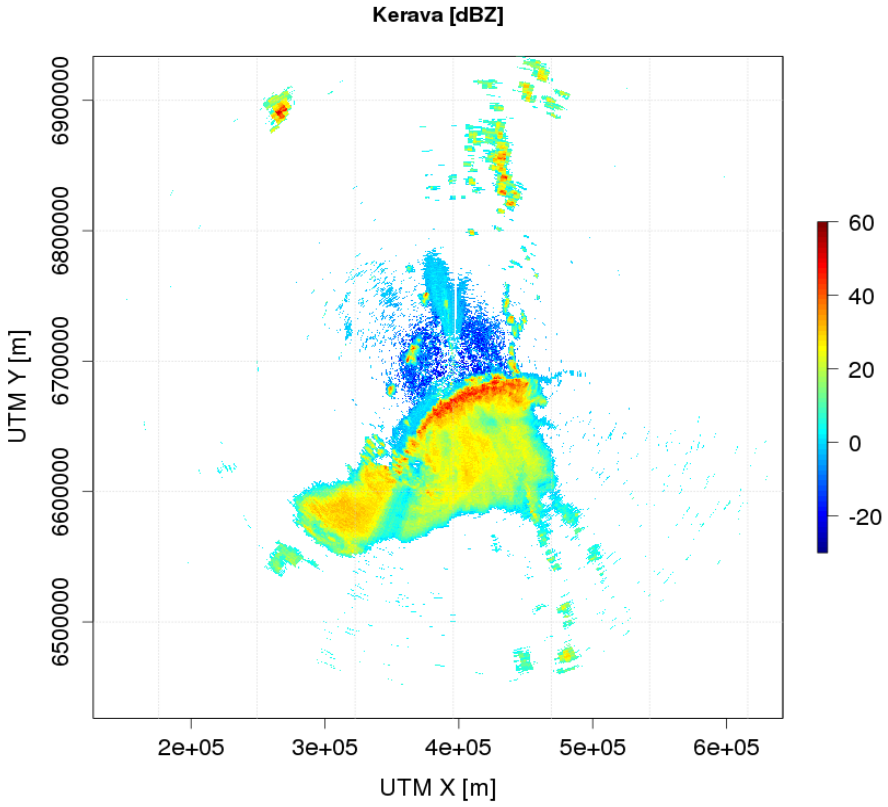
Kerava



Kumpula

8th Aug 2010 18:15 UTC, severe storm in Helsinki



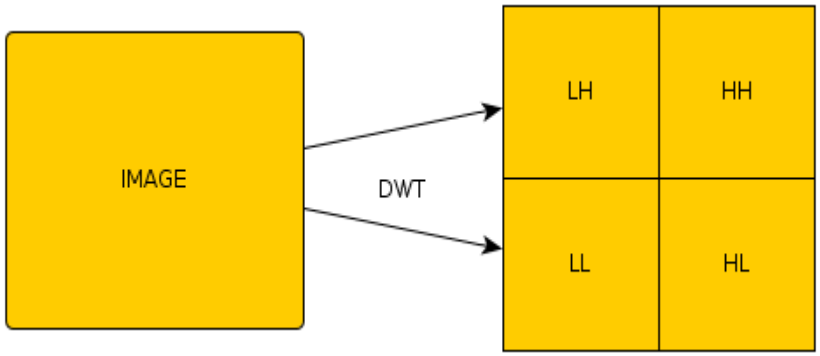


http://www.youtube.com/watch?v=vdhNO6kxhpM

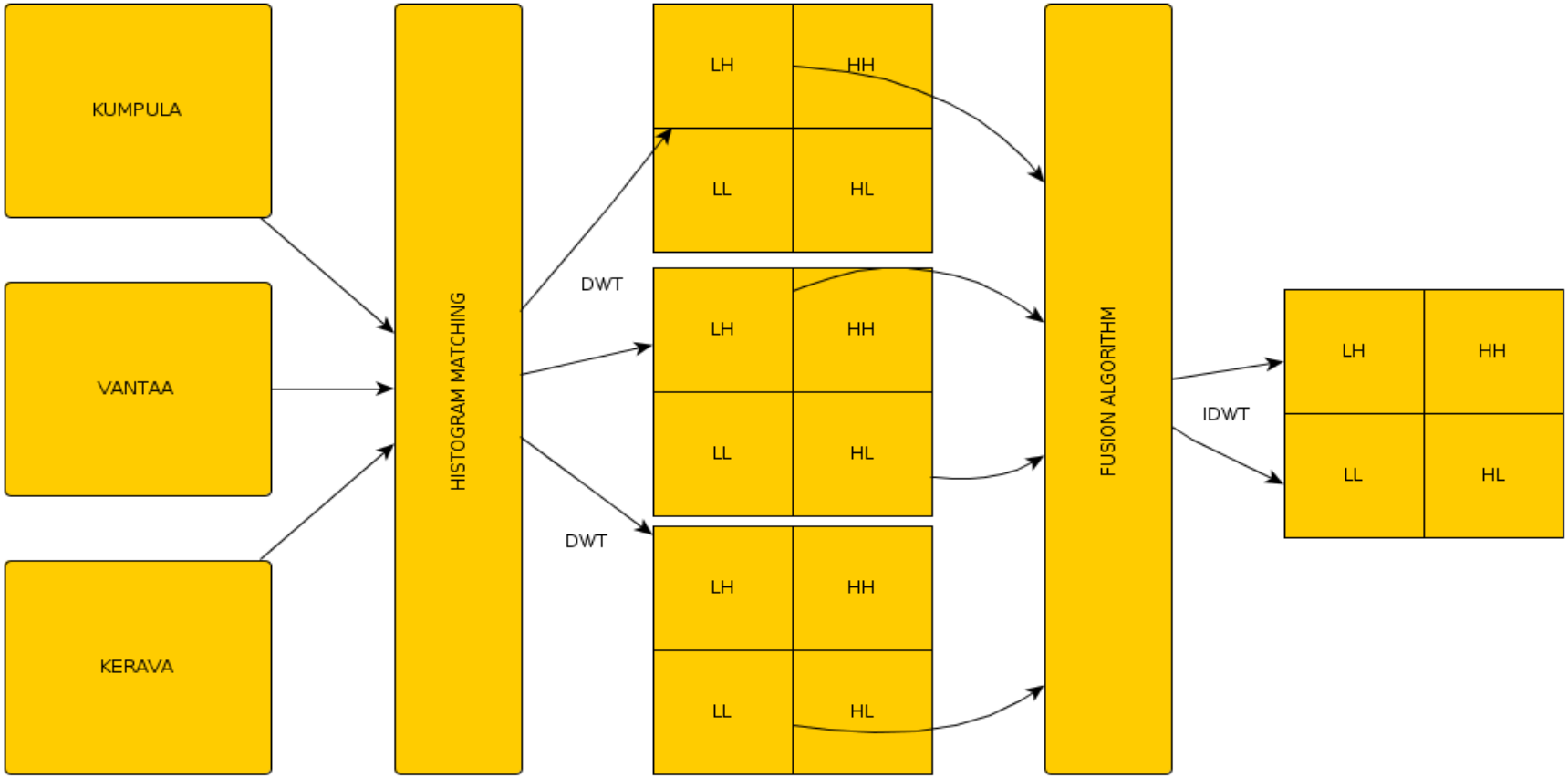
Wavelets decomposition

$$\Psi(t)_{a,b} = \frac{1}{\sqrt{a}} \Psi\left(\frac{t-b}{a}\right) \quad with \ a,b \in R, \quad a > 0$$

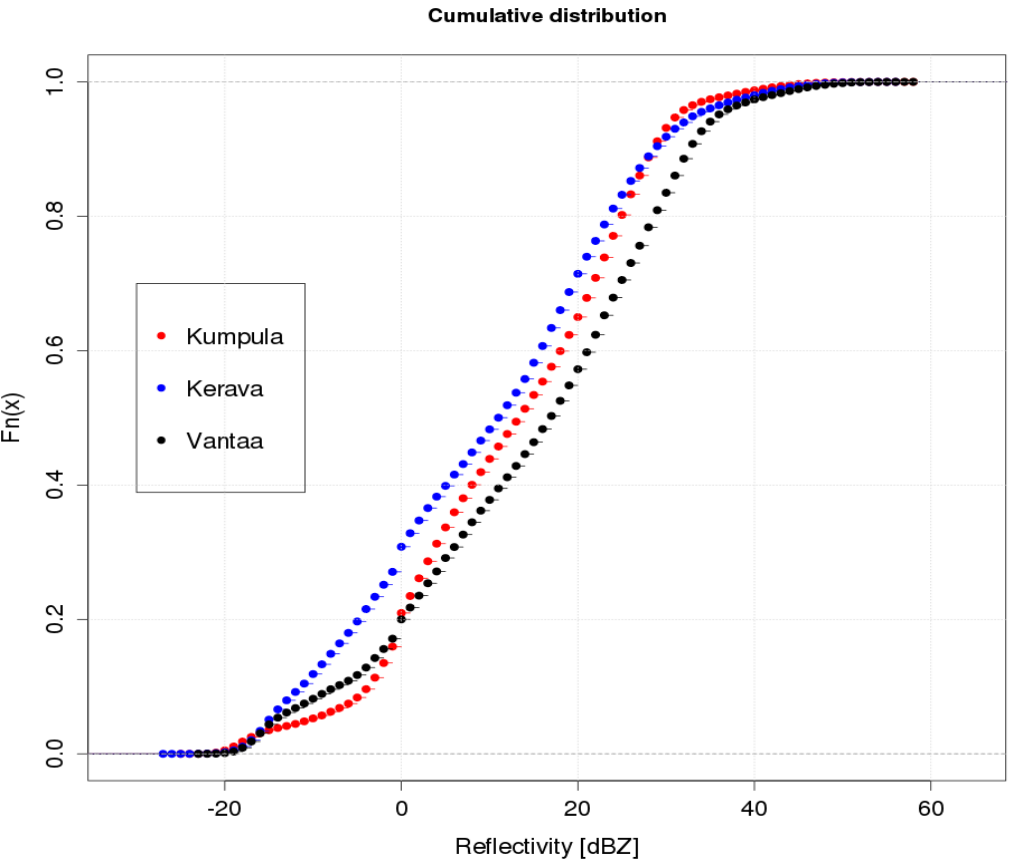
$$I_0 = I_{LL} + I_{HL} +$$

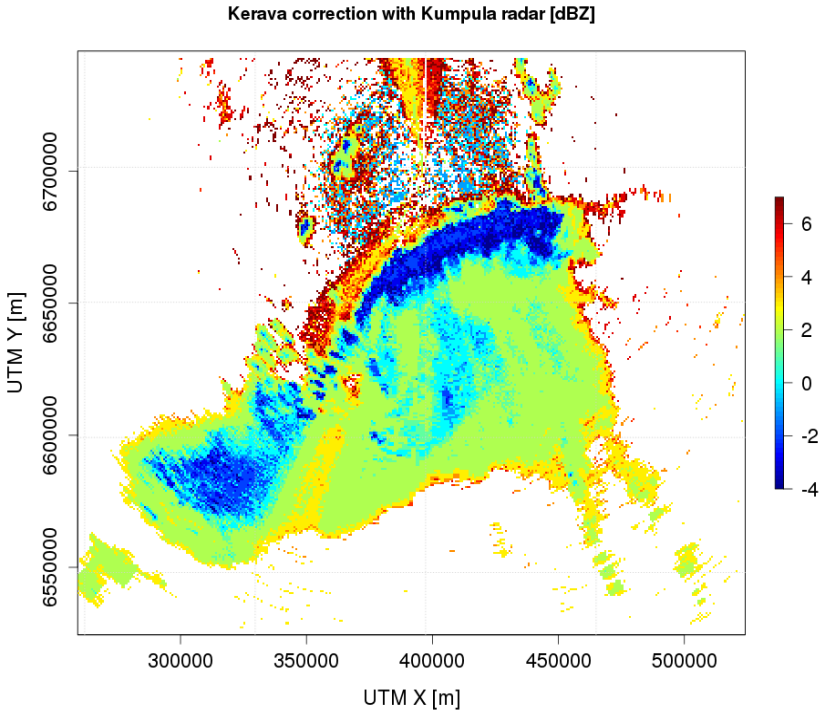


High resolution radar composite using wavelets



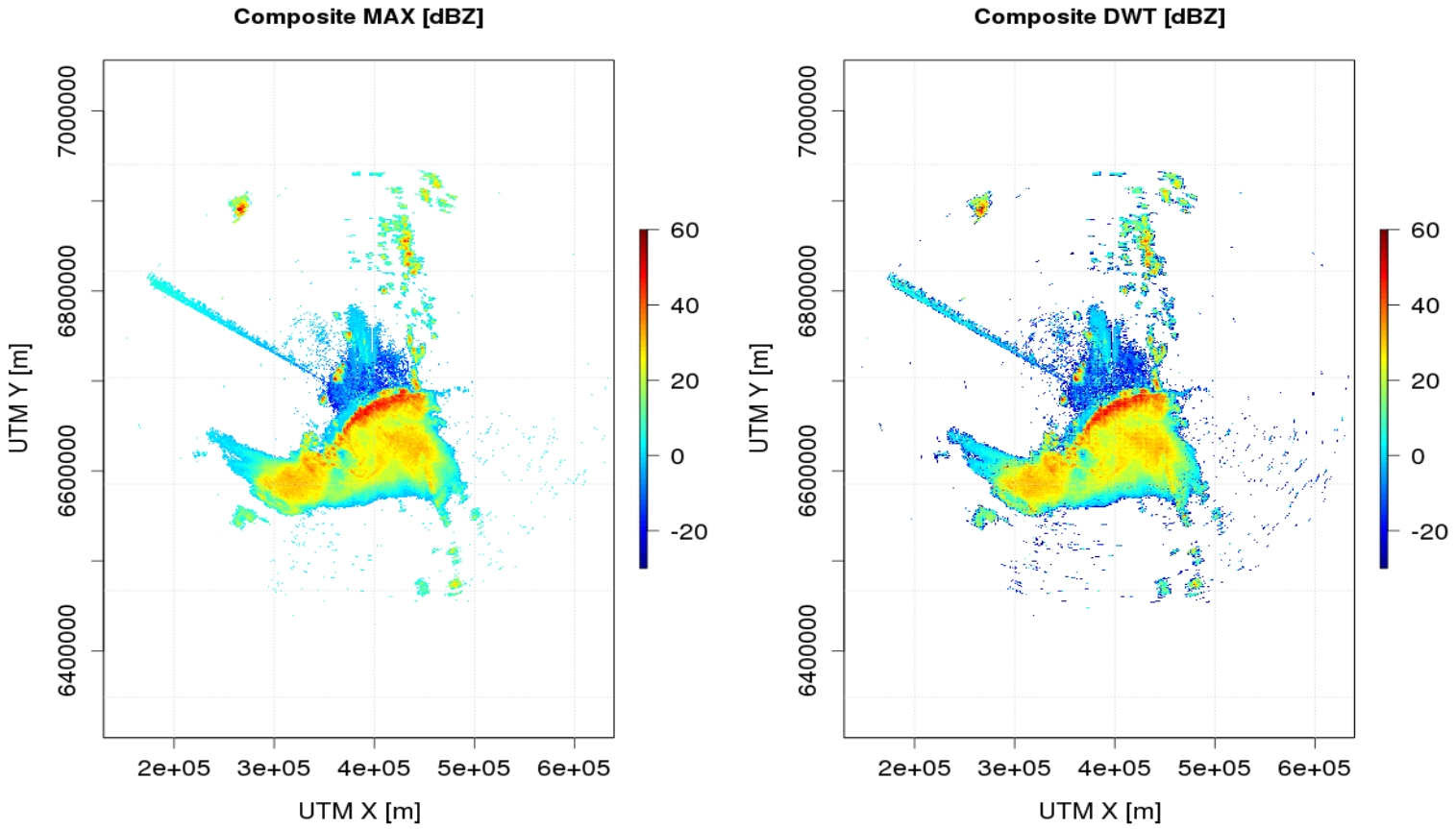
Histogram matching





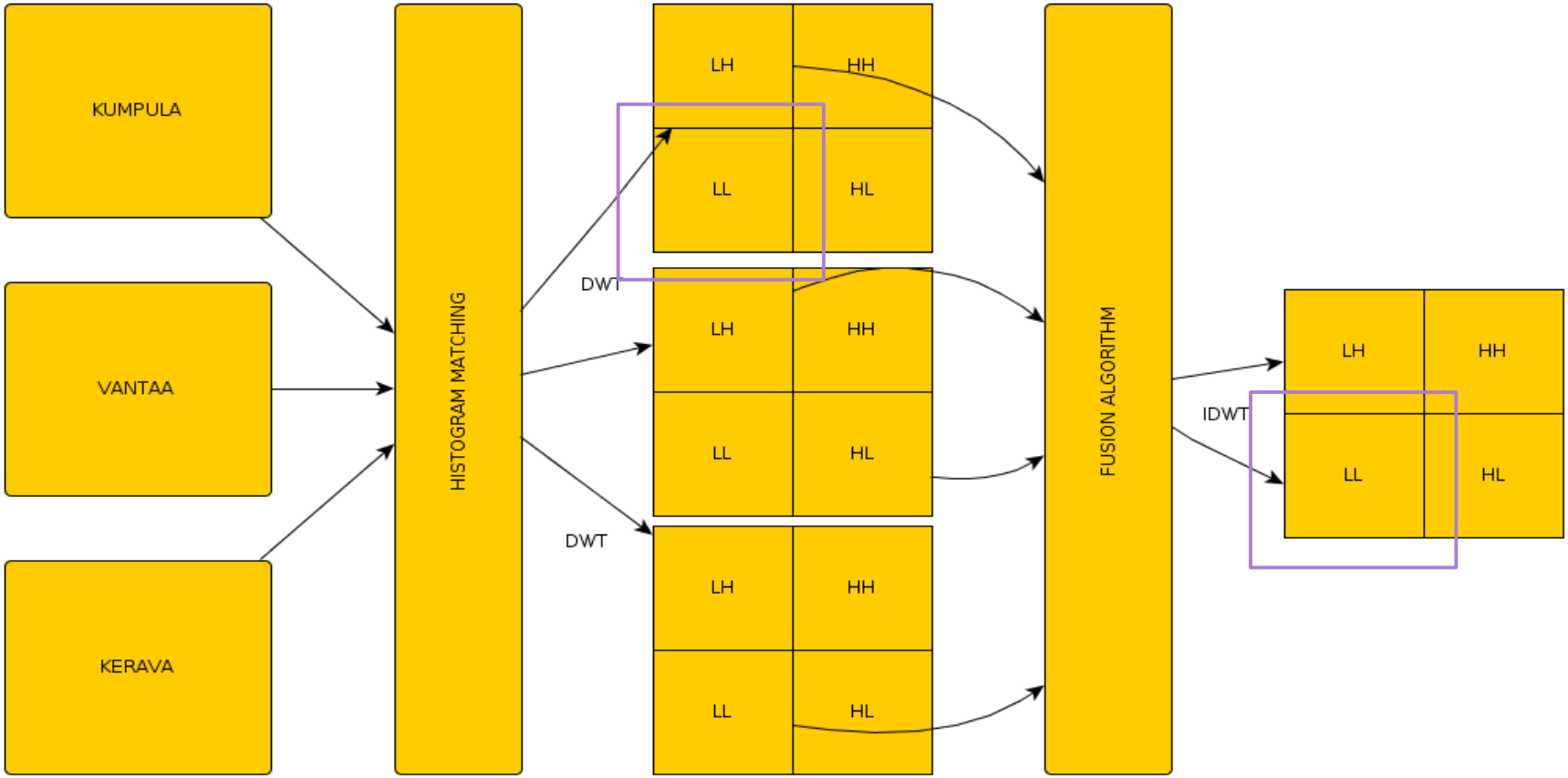
8th Aug 2010 18:15 UTC

Max vs DWT reflectivity composite

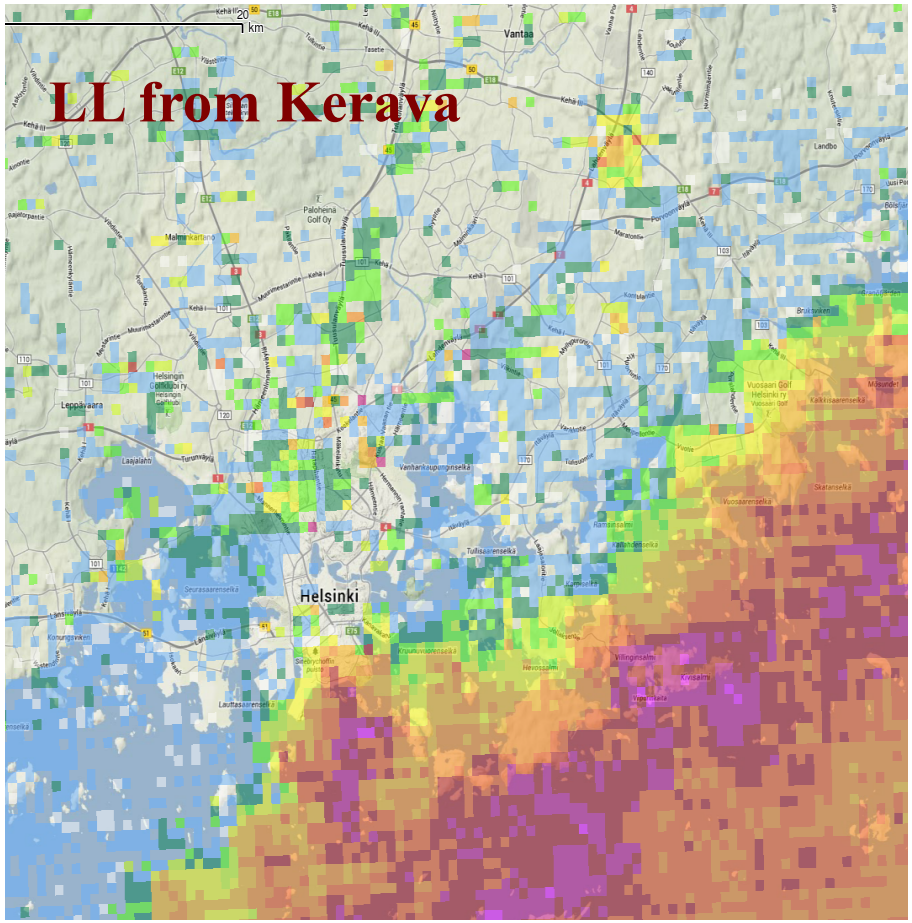


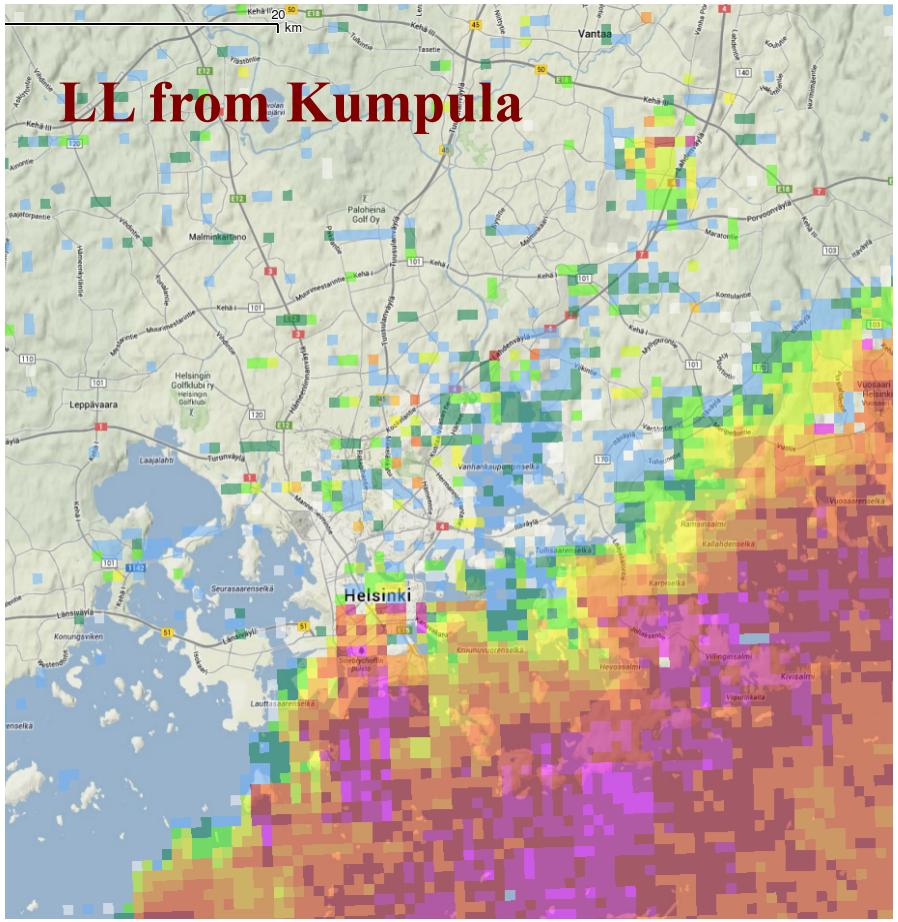
2010.08.08 18:15 UTC

High resolution radar composite using wavelets



LL scales from different radars





Flood ? What flood?

Rain causes flooding in Finland

The wet summer weather goes into overdrive causing severe flooding in parts of Finland.

Published: 14.06.2009 13:40

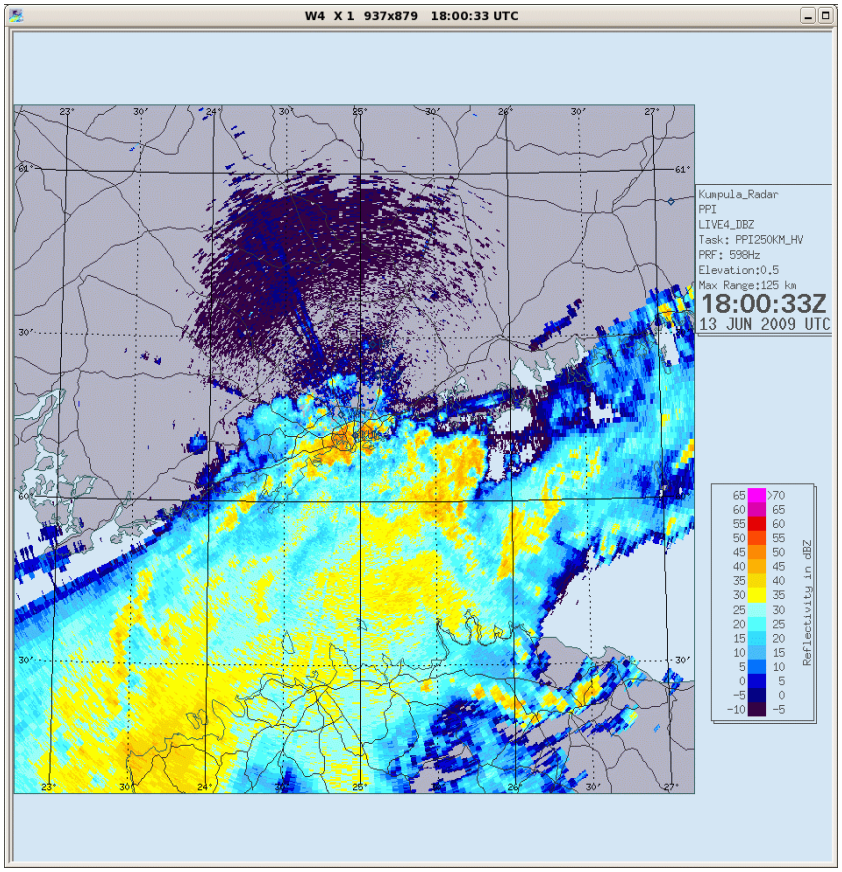
Overnight thunderstorms kept emergency services busy across southern Finland early Sunday, June 14, YLE reports.

In Espoo, heavy rainfall caused damage as flood waters filled cellars.

The most severe damage was at the Iso Omena shopping mall where water from broken pipes caused flooding in various parts of the building.

The emergency service in the western Uusimaa district said damage had occurred in several shopping centers and firefighters had been pumping water out since early morning.

Up to 20 millimeters of rain fell in parts of the Uusimaa district.

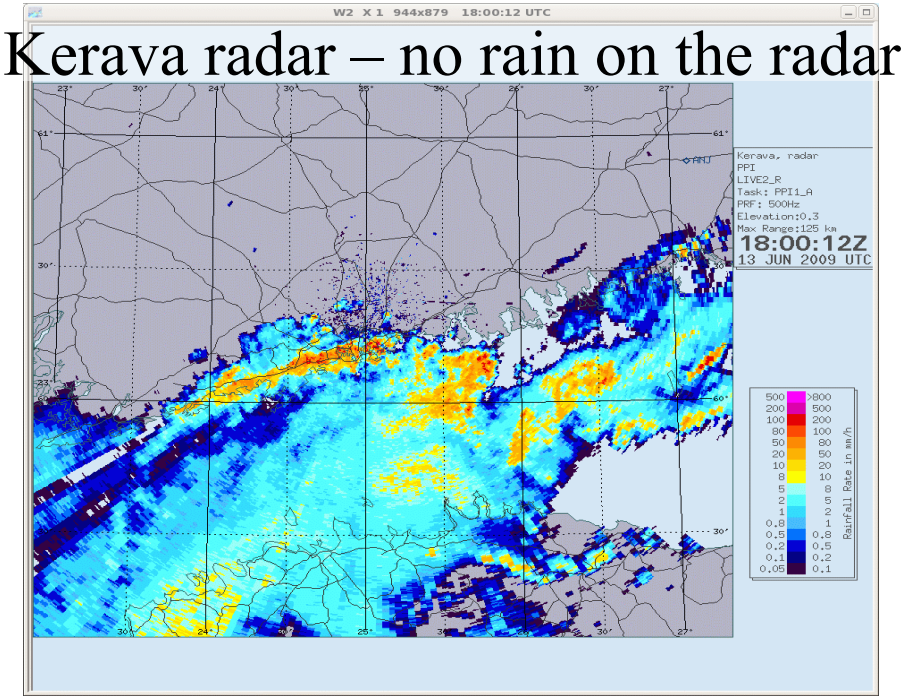


Ground sensors indicate maximum rain intensity of 280 mm/hr at 18.05 UTC in Espoo

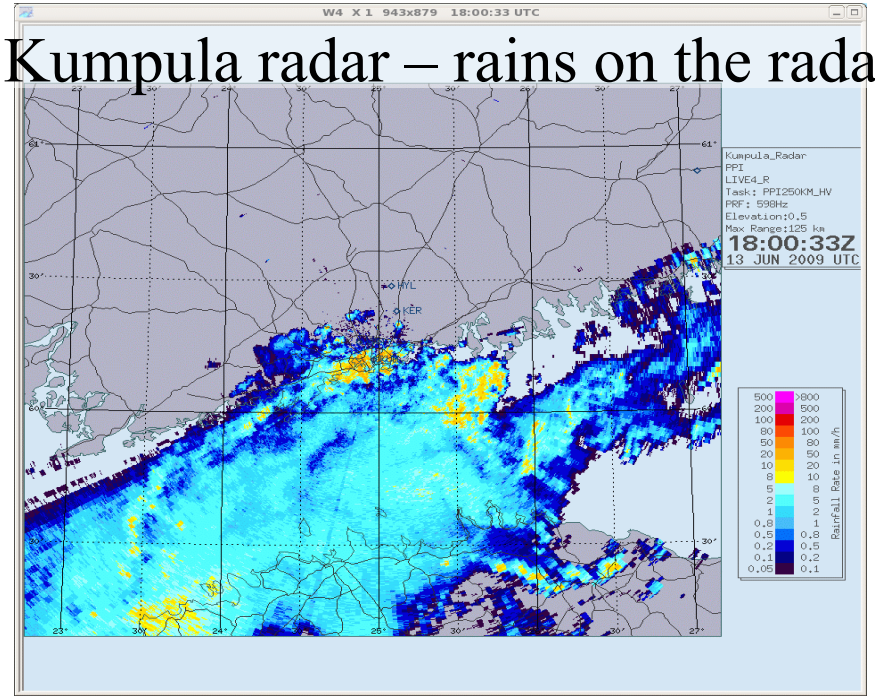
Is radar not aware about situation?

Depending on a view point the picture is different

Kerava radar – no rain on the radar

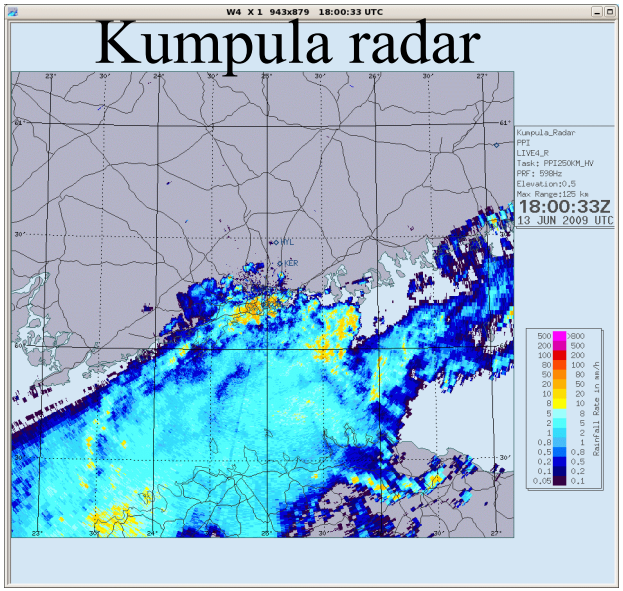


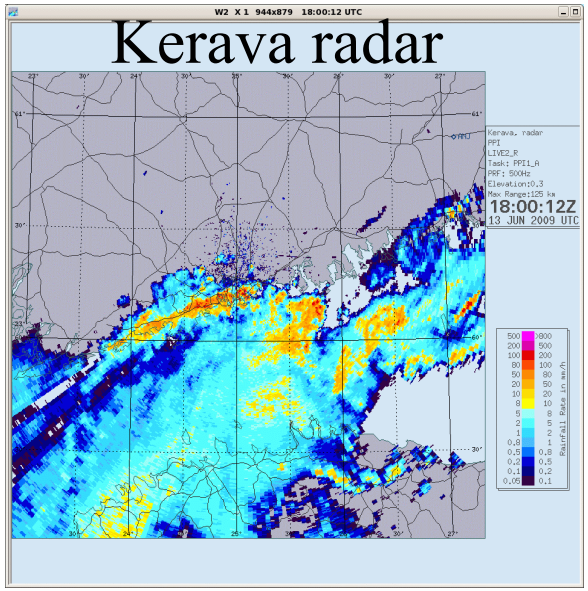
Kumpula radar – rains on the radar

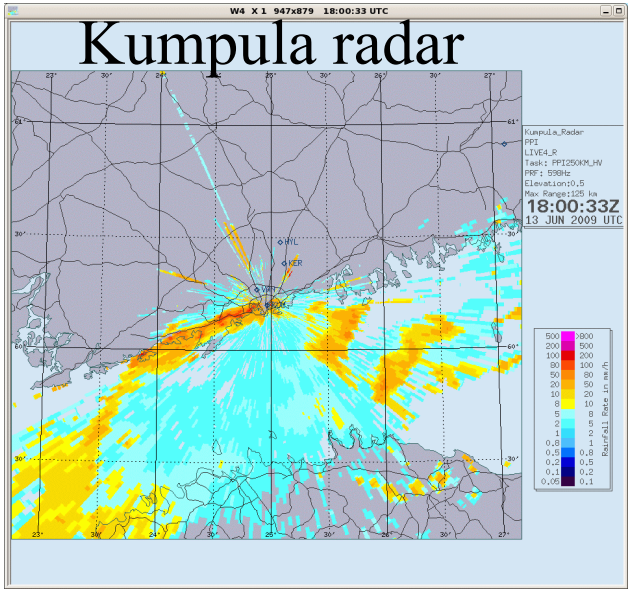


Due to radome and path attenuation Kumpula misses the heavy rainfall

What can we do?
Dual-pol observations

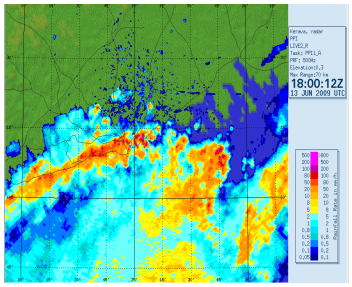


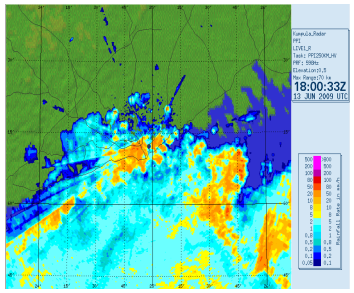


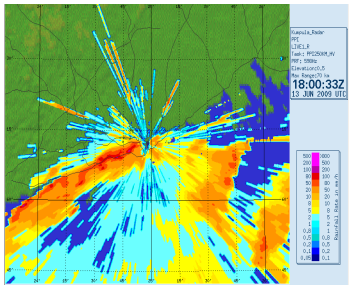


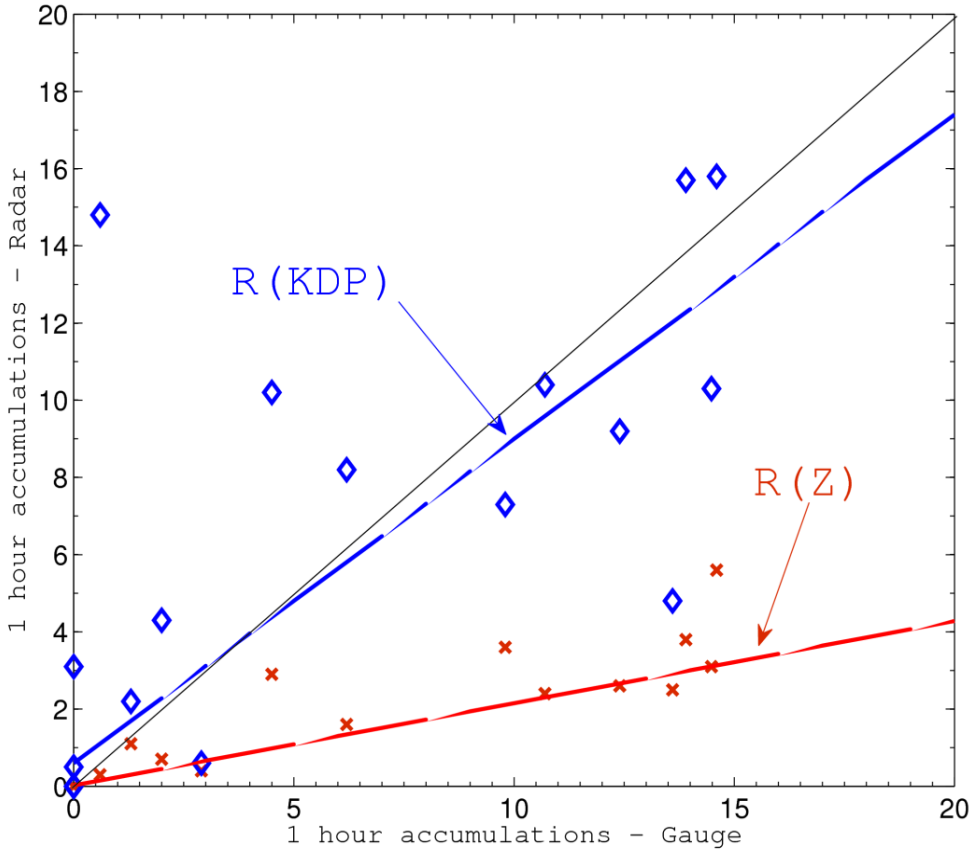
R(Z) R(Z) R(Kdp)

R(Z) estimation is plagued by the attenuation
R(Kdp) is immune









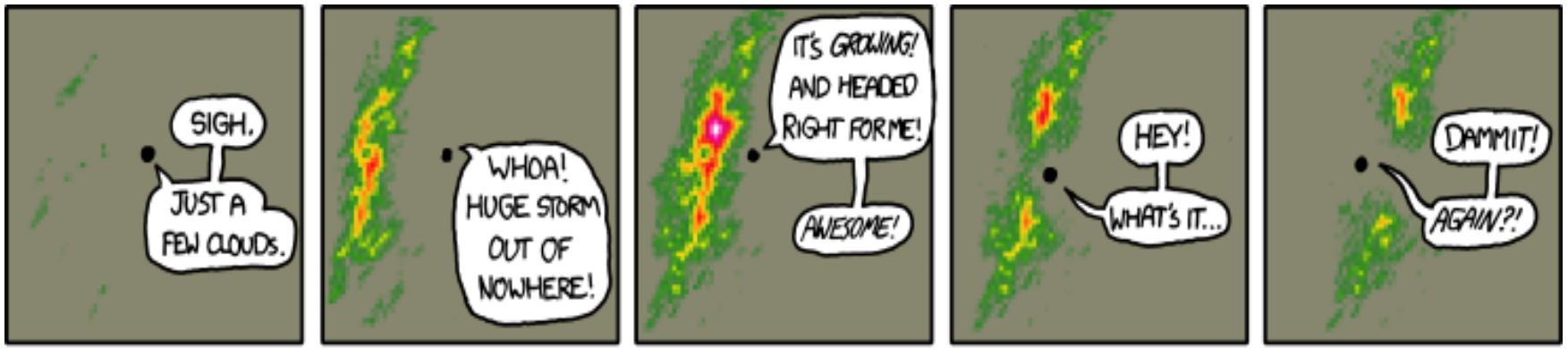
Overall R(KDP) relation performs much better than R(Z). The observed bias using R(KDP) is 0.84, while it is 0.21 for R(Z) based accumulations.

Normalized RMSE is 0.12 for the R(KDP) and 0.21 for the R(Z) accumulations.

Conclusions

- Observing meteorological network in Helsinki metropolitan area is unique
- Improvements in ground **clutter suppression** are needed
- **Polarimetry** is essential for QPE with C-band radar to monitor heavy rain events
- To achieve better spatial and temporal resolutions **dense** radar observations and **specific scanning** tasks are needed (es. CASA)
- Algorithms to handle **time shift** between observations

Thank you!



WHEN THE FOLKS AT THE WEATHER OFFICES SEE YOU REFRESHING THE RADAR TOO OFTEN, THEY START TEASING YOU.