

# HydroClass™

Separating meteorological and non-meteorological targets in  
Vaisala radar systems

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**VAISALA**

## HydroClass™ – Software for hydrometeor classification

- Uses dual polarization observations
- Utilizes a fuzzy logic approach to identify hydrometeor particles
- Aims to determine the predominant scatter type: rain, hail, snow, graupel and even non-meteorological targets such as insects, chaff and sea clutter
- Runs in real time and can also be used in post-processing

|   |   |       |            |
|---|---|-------|------------|
| 6 |  | Hail  | HydroClass |
| 5 |  | Graup |            |
| 4 |  | Snow  |            |
| 3 |  | WSnow |            |
| 2 |  | Rain  |            |
| 1 |  | NoMet |            |

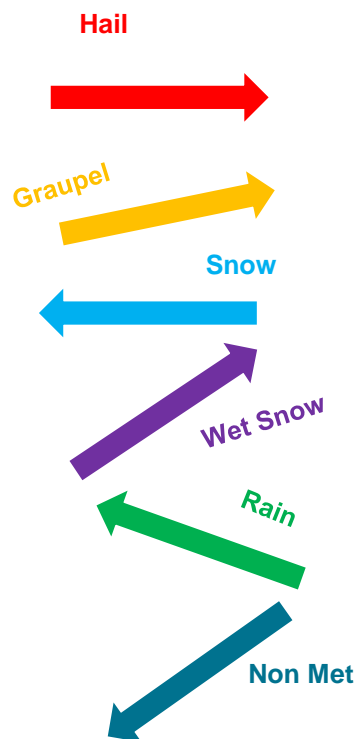


## HydroClass™ – Applications

- Hail detection
- Lightning hazard potential forecasting
- Highway snow removal
- Airport terminal operations
- Rain/snow line demarcation
- Melting height detection
- Military detection of chaff
- Identification of non-meteorological targets
- Improved precipitation forecasting
- Hydrological modeling



## HydroClass™ – Fuzzy logic algorithms



- Is a combination of public classification methods:
  1. **Met – Non-Met classifier:** developed by the National Severe Storms Laboratory (NSSL) as part of the Joint Polarization Experiment (JPOLE) (Ryzhkov et al. 2005)
  2. **Met Classifier:** Hydrometeor classification algorithm developed at Colorado State University (CSU) (Liu et al. 2005)
  3. **Cell Classifier:** A weather pattern classifier of convection and strati-form rain (Waldvogel, 1979)

# HydroClass™ – Classifiers

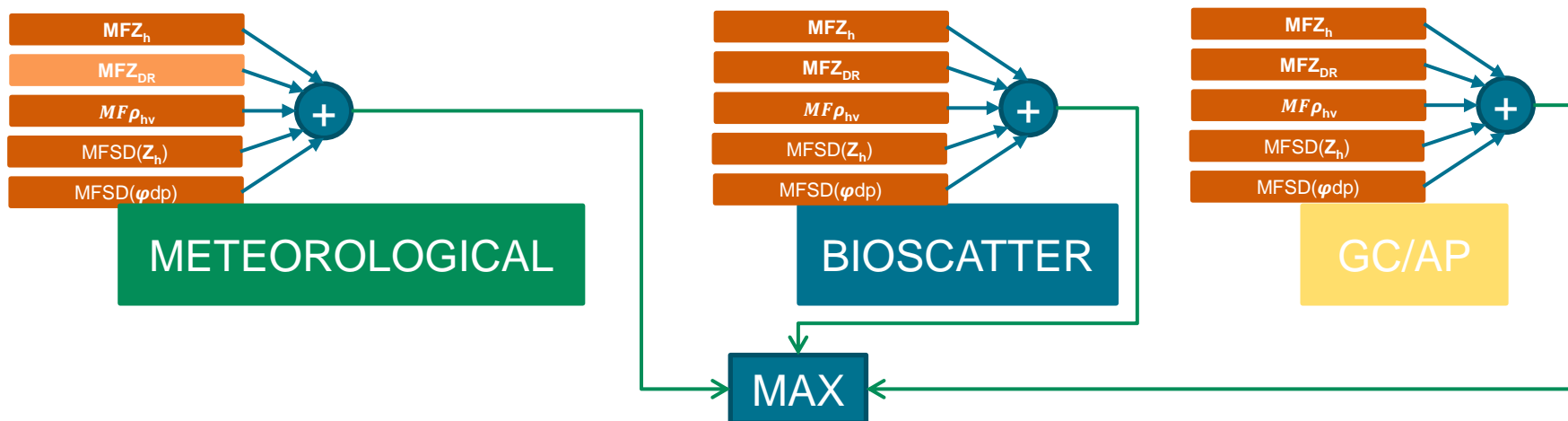
## 1. Pre-classifier (Met – Non-Met classifier):

- Inputs:

Horizontal reflectivity,  $Z_h$ , Differential reflectivity,  $Z_{DR}$ , and Cross-correlation coefficient,  $\rho_{hv}$   
Texture of horizontal reflectivity  $SD(Z_h)$  and differential phase  $SD(\varphi_{dp})$

- Classifier:

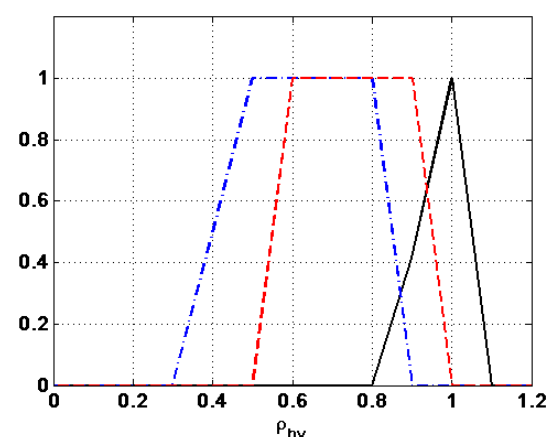
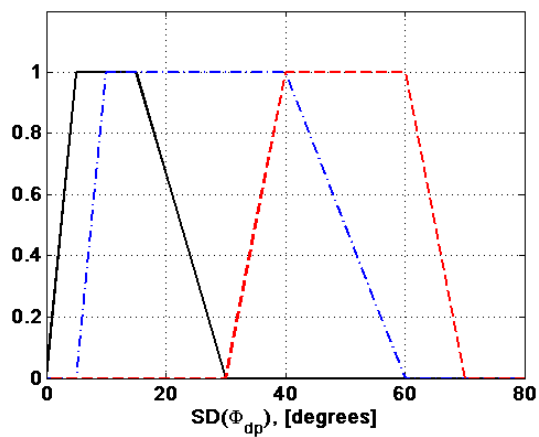
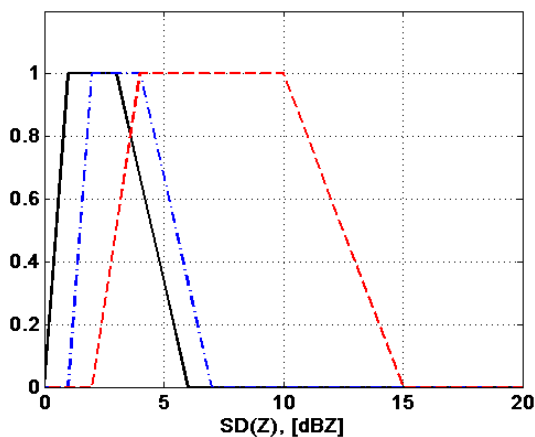
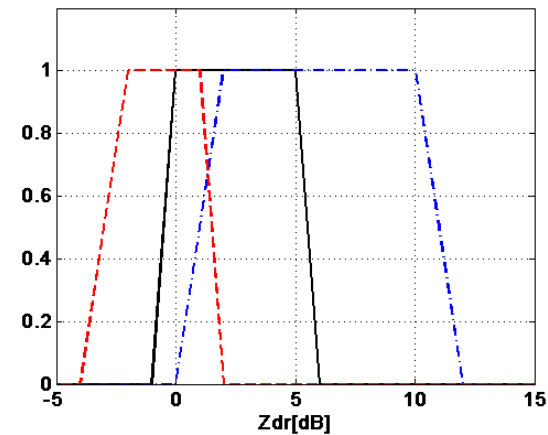
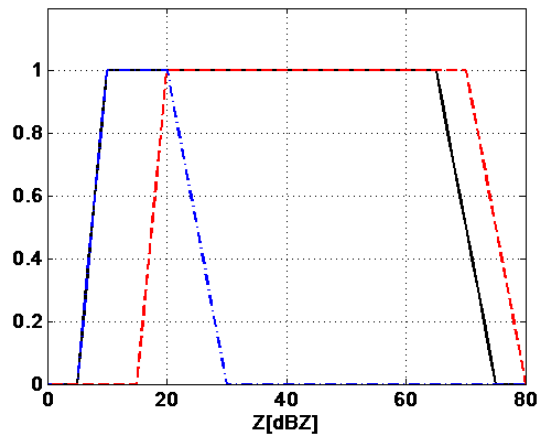
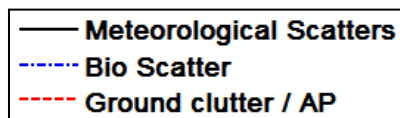
- Trapezoidal membership functions
- One dimensional membership function for  $Z_h$ ,  $\rho_{hv}$ ,  $SD(Z_h)$ ,  $SD(\varphi_{dp})$  and  $Z_{DR}$ ,
- 2 dimensional membership function for met class  $Z_{DR}$



# HydroClass™ – Classifiers

## 1. Pre-classifier (Met – Non-Met classifier):

### Membership functions



# HydroClass™ – Classifiers

## 2. Meteo Classifier (Met - classifier):

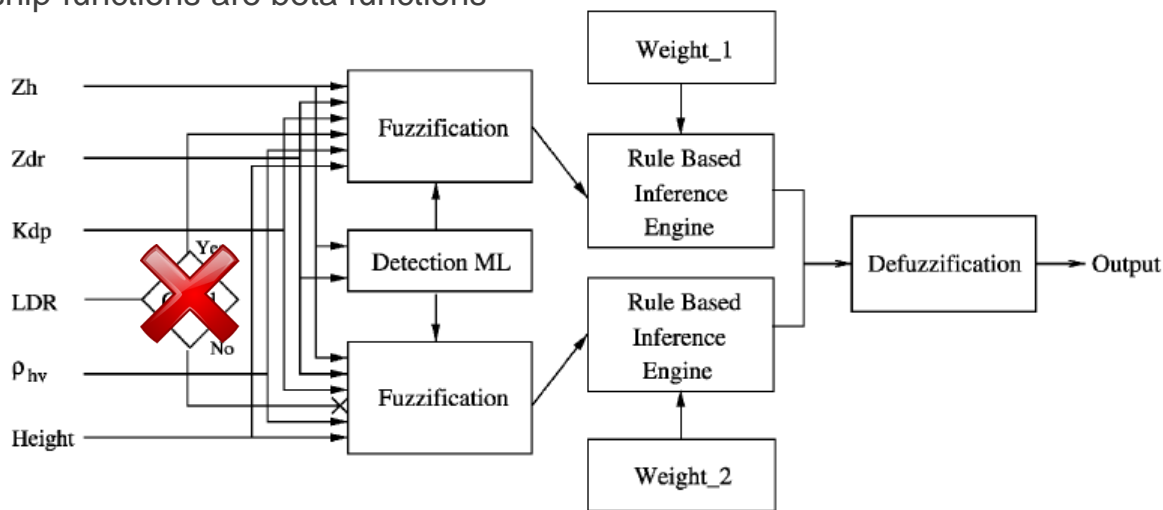
- Inputs:

From those bins classified as Met:

Reflectivity,  $Z_h$  differential reflectivity,  $Z_{DR}$ , specific differential phase,  $K_{dp}$ , cross-correlation coefficient,  $\rho_{hv}$ , observation altitude  $H$ , melting layer height  $MLHGT$

- Classifier:

- Different setting for warm and cold season (Melting layer less than 0)
- Membership functions are beta functions



*Corresponds Fig3 in Liu et al. 2005*

# HydroClass™ – Classifiers

## 2. Meteo Classifier (Met - classifier):

- Classifier:

- Five classes have been defined as the basis for classification in the present implementation: Rain, Wet snow, Dry Snow, Graupel, Hail
- C-band optimization has been performed
- Has been verified comparing measurements with the in-situ airborne observations made with instruments such as 2D cloud particle measurement probe, high volume particle sampler (HVPS) and hail spectrometer (CSU-CHILL)
- Membership functions are beta functions
- Rule strengths (RS) are the following:

$$RS_i(ML>0) = MF_i(Z_h) MF_i(h) * \frac{MF_i(Z_{dr}) + 0.5MF_i(K_{dp}) + 0.5MF_i(\rho_{hv})}{2}$$

$$RS_i(ML<0) = MF_i(Z_h) * \frac{0.7MF_i(Z_{dr}) + 0.3MF_i(K_{dp}) + MF_i(h) + MF_i(\rho_{hv})}{3}$$



## HydroClass™ – Classifiers

### 3. Cell classifier (Hail and convection):

- Inputs:

Reflectivity,  $Z_h$ , observation altitude  $H$

- Classifier:

- The signature of convection is classified using a rule strength of 2 membership functions:
  - Minimal reflectivity required for convection
  - Minimum altitude, with respect to the 0°C isotherm

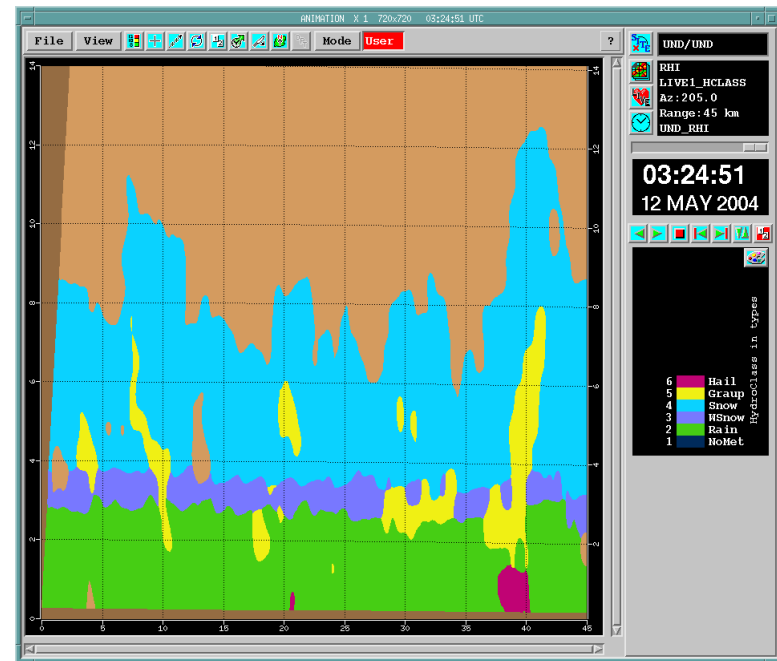
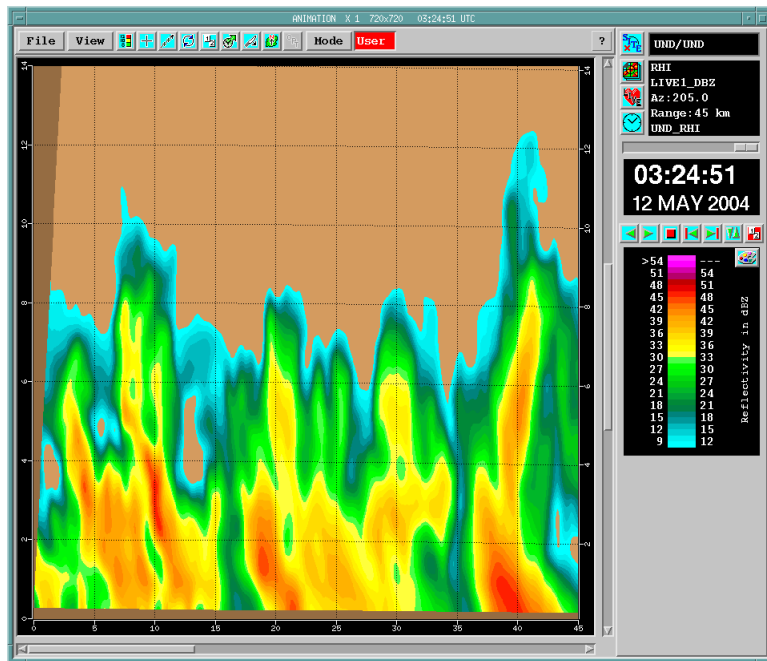


The full rule strength is reached when the reflectivity is 5 dB more than the minimal threshold, and when the height of those reflectivity levels reaches 1 km above the minimum altitude.

# HydroClass™ – Examples

## 12<sup>th</sup> of May 2004 North Dakota US

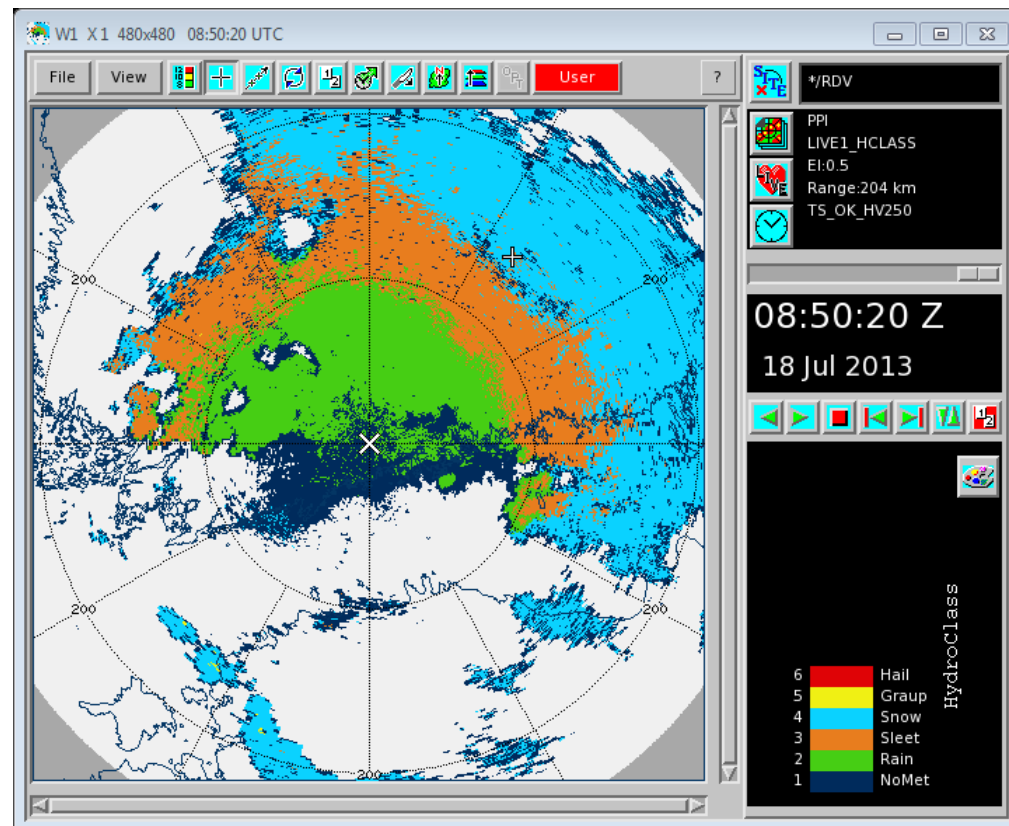
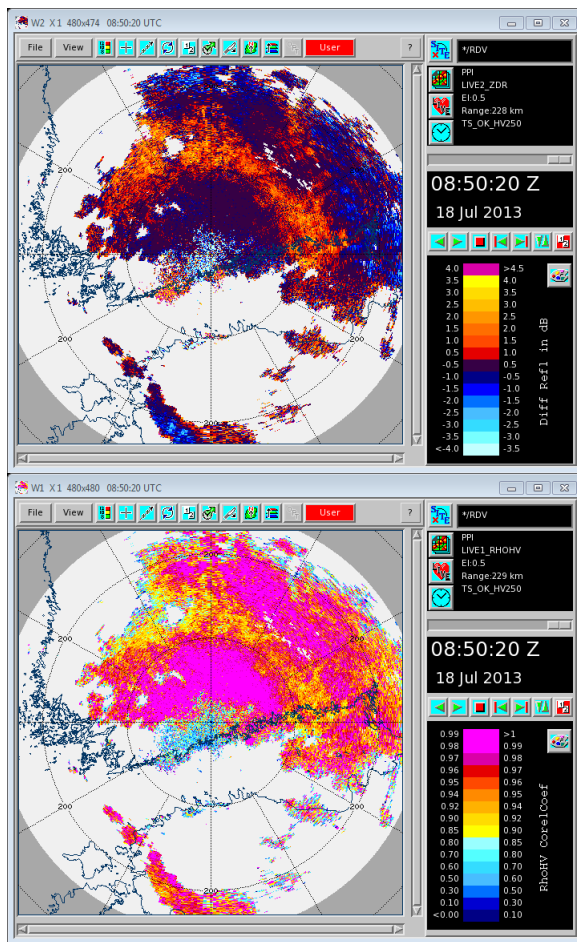
RHI scans through rain and hail producing thunderstorms



# HydroClass™ – Examples

18<sup>th</sup> of July 2013 Helsinki Finland (Kerava Radar)

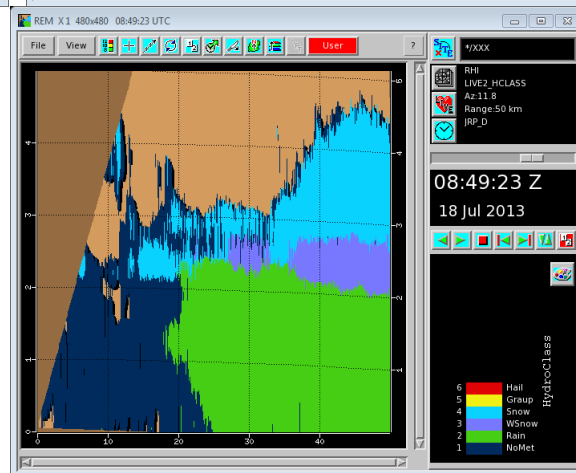
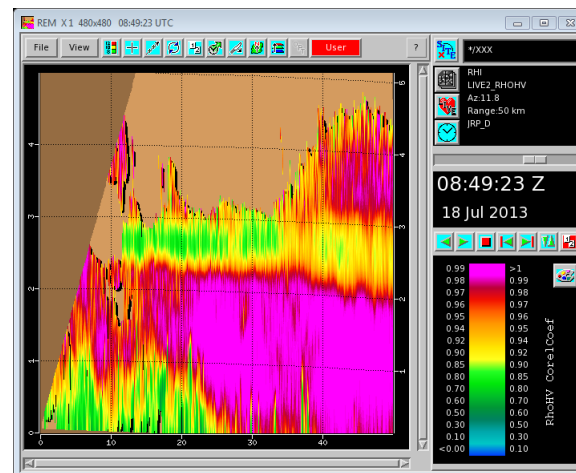
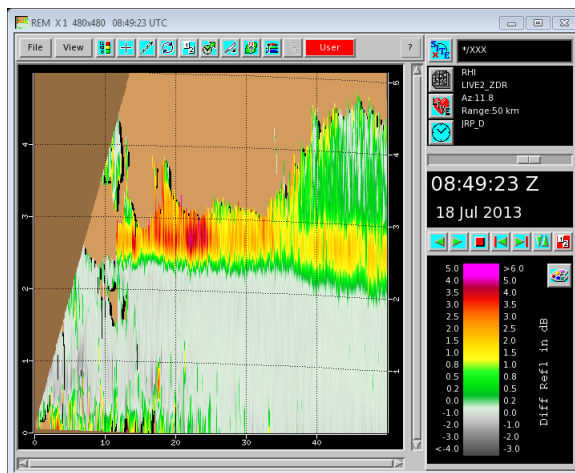
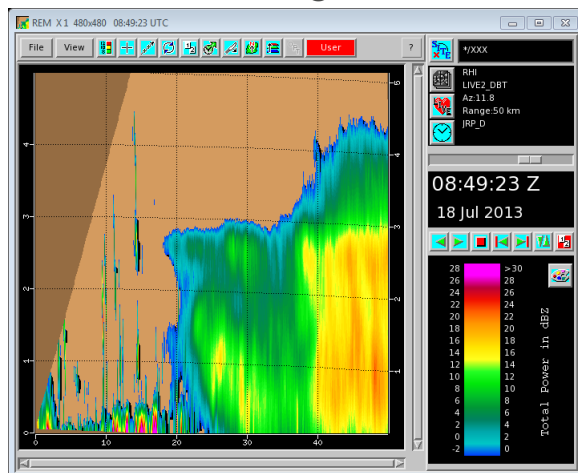
PPI scans through strati-form rain



# HydroClass™ – Examples

18<sup>th</sup> of July 2013 Helsinki Finland (Kumpula Radar) towards Järvenpää (NE)

RHI scans through strati-form rain



## HydroClass™ – Summary

- HydroClass™ is a software which is used to determine predominant scatter type: rain, hail, snow, graupel and even non-meteorological targets such as insects, chaff and sea clutter.
- HydroClass™ is a combination of three public methods:  
**Met – Non Met classifier + Met Classifier + Cell classifier**
- Runs in real time and can also be used in post-processing
- Has been tested and optimized for C-band radars with the collaboration of Colorado State University and University of Helsinki
- Currently a radar-based melting layer detection algorithm is being developed in order to give more consistent information about the melting layer altitude as an input

## HydroClass™ – References

1. Vaisala Oy. 2013 . User's Manual: IRIS™ and RDA Dual Polarization
2. Ryzhkov, A.V., Schuur, T.J., Burgess, D.W., Heinselman, P.L. Giangrande, S.E. and Zrnić, D.S. 2005. *THE JOINT POLARIZATION EXPERIMET Polarimetric Rainfall Measurements and Hydrometeor Classification*. Bulletin American Meteorological Society. Vol 86, 809-824p.
3. Liu, Hongping, V. Chandrasekar, 2000: Classification of Hydrometeors Based on Polarimetric Radar Measurements: Development of Fuzzy Logic and Neuro-Fuzzy Systems, and In Situ Verification. *J. Atmos. Oceanic Technol.*, **17**, 140–16
4. Lim, S., V. Chandrasekar, and V.N. Bringi, 2005: Hydrometeor Classification System Using Dual Polarization Radar Measurements: Model Improvements and In Situ Verification. *IEEE Transactions on Geoscience and Remote Sensing*, 43.4, 792-801.
5. Waldvogel, A., B. Federer, and P. Grimm, 1979: Criteria for the Detection of Hail Cells. *J. of Applied Meteorology*, **18.12**, 1521-1525. See also Foote, G.B. at al ibid.