

Characteristics of radar observed hail storms in Germany

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HD(CP)²

High definition clouds and precipitation
for advancing climate prediction

Large hail event in Bonn

2015-07-05

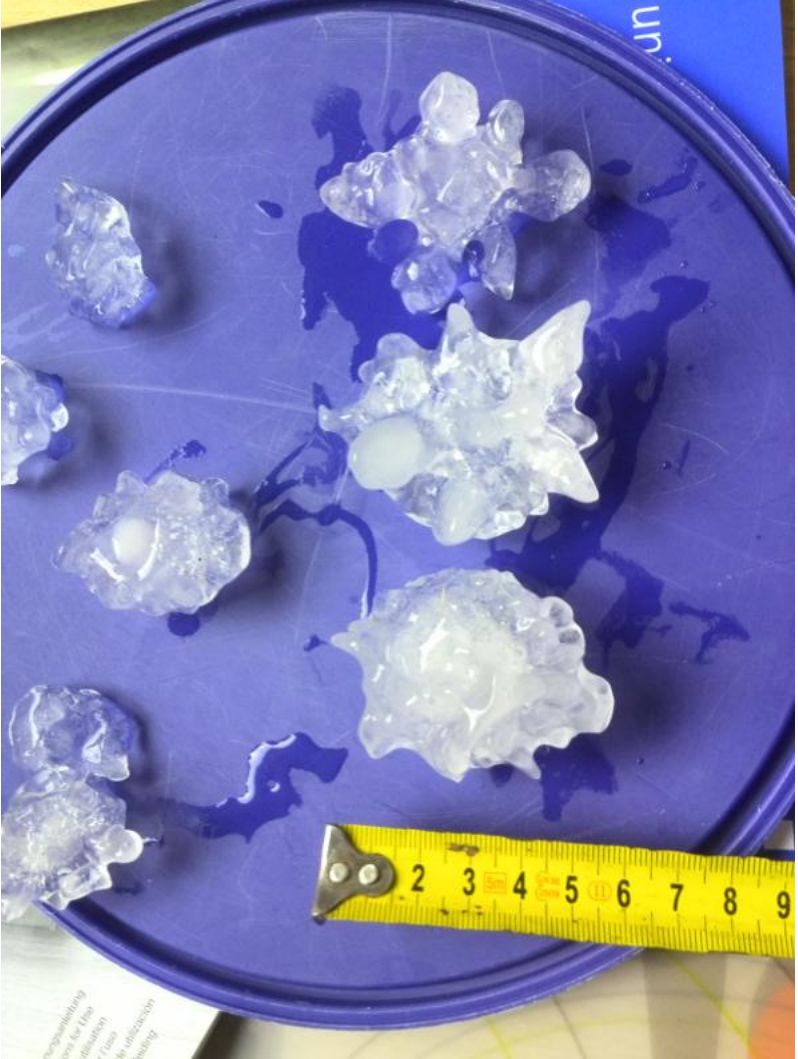
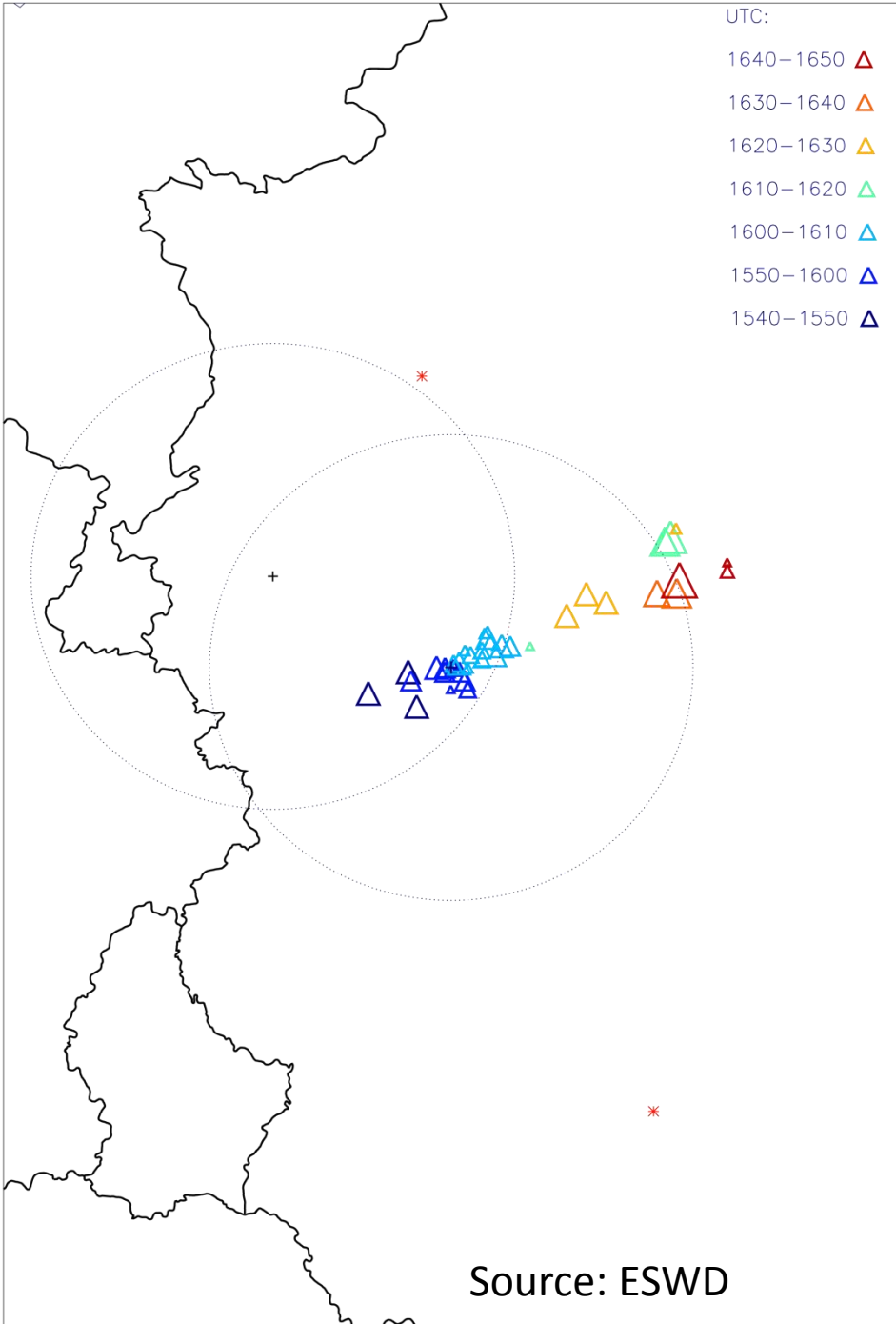


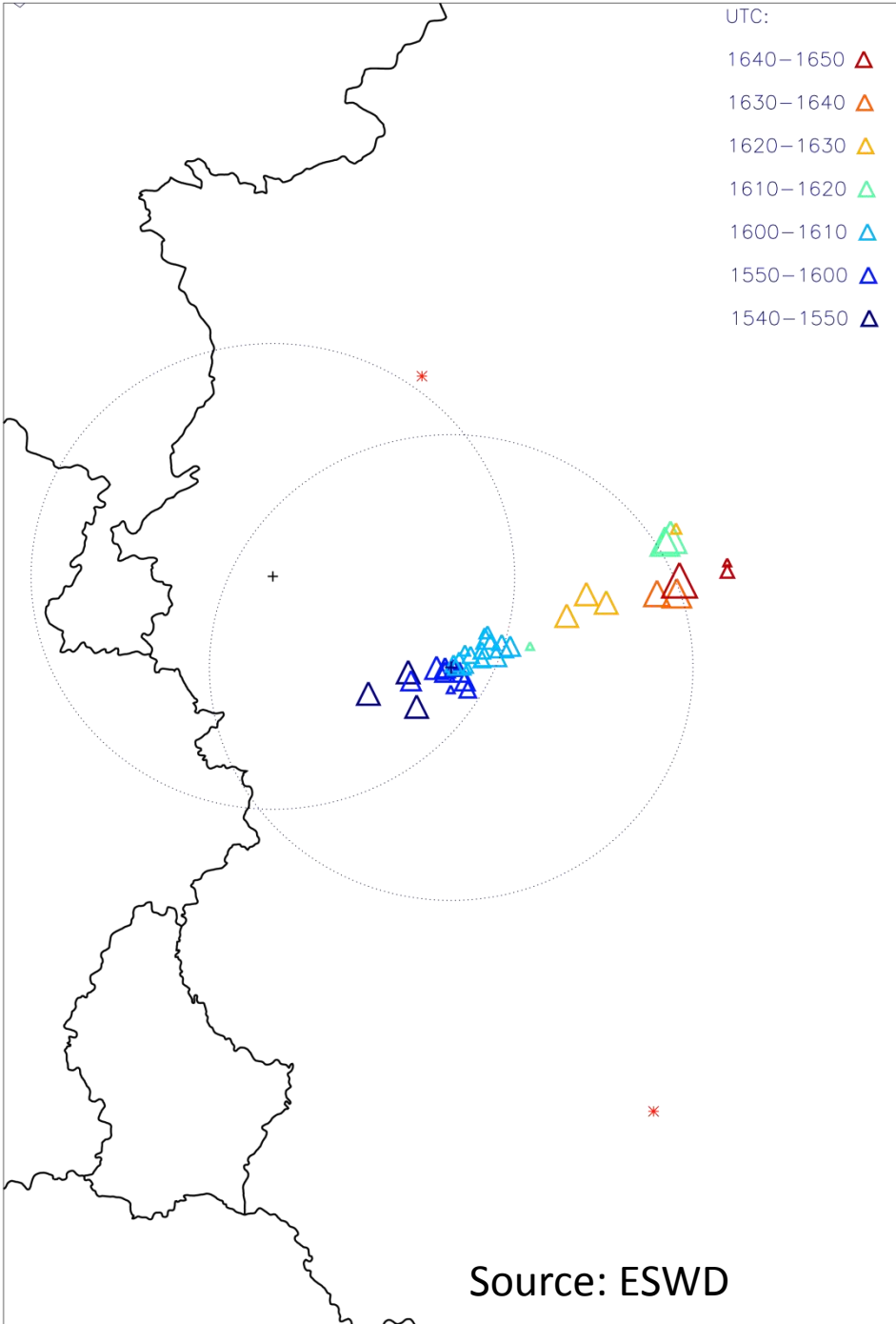
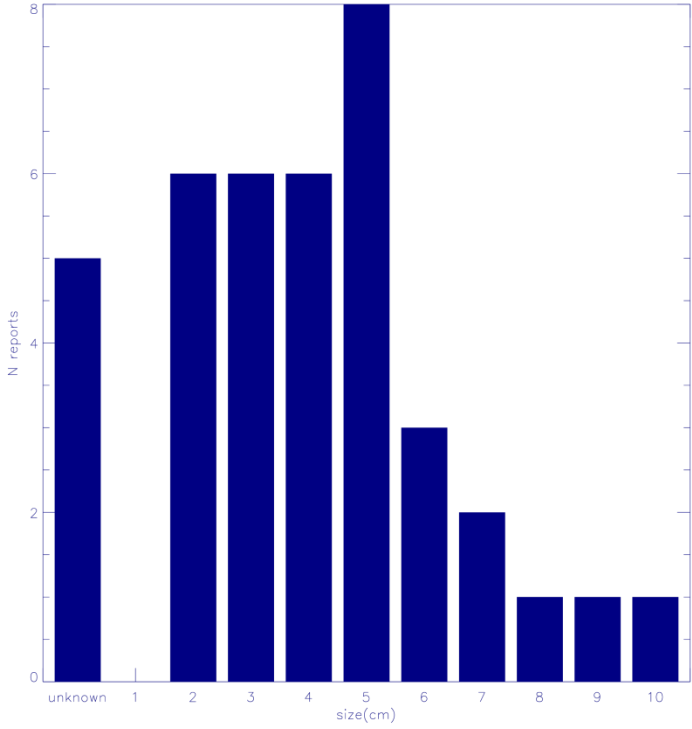
Photo by Kai Mühlbauer



Large hail event in Bonn

- 39 hail reports in the Bonn area
- Sizes range from 2 to 10.5 cm

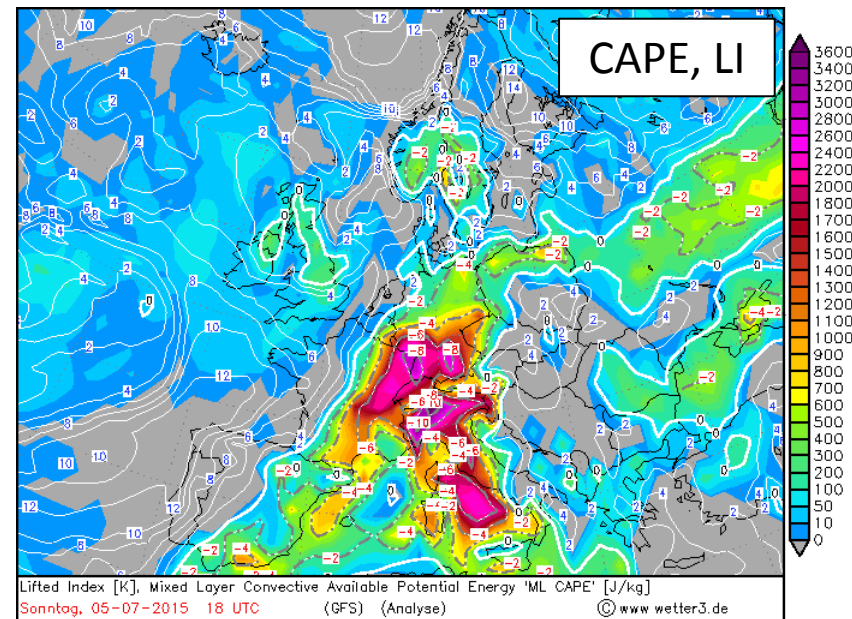
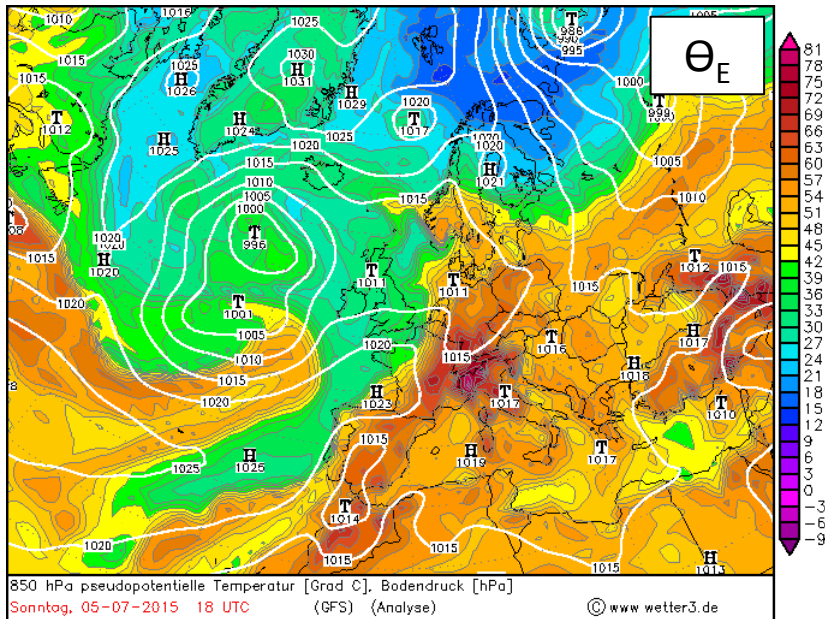
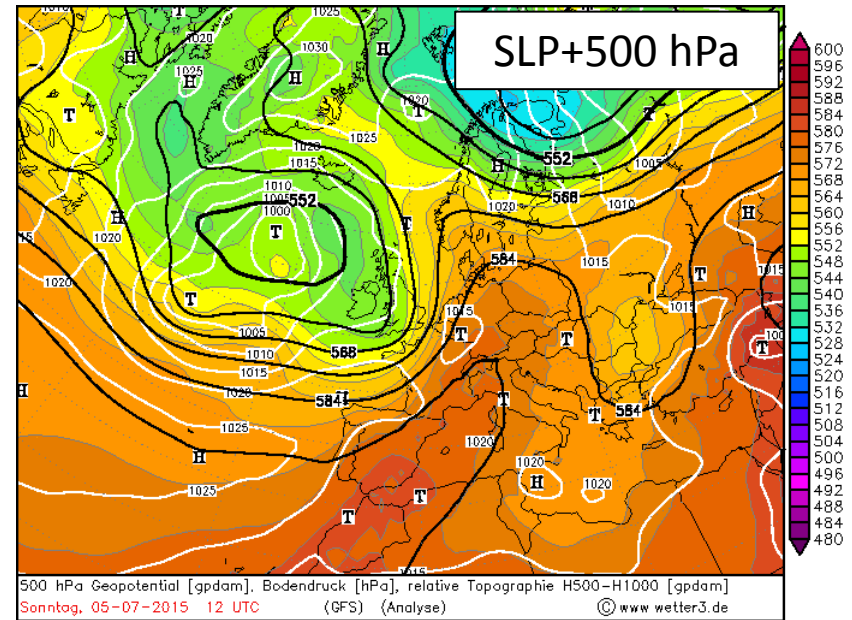
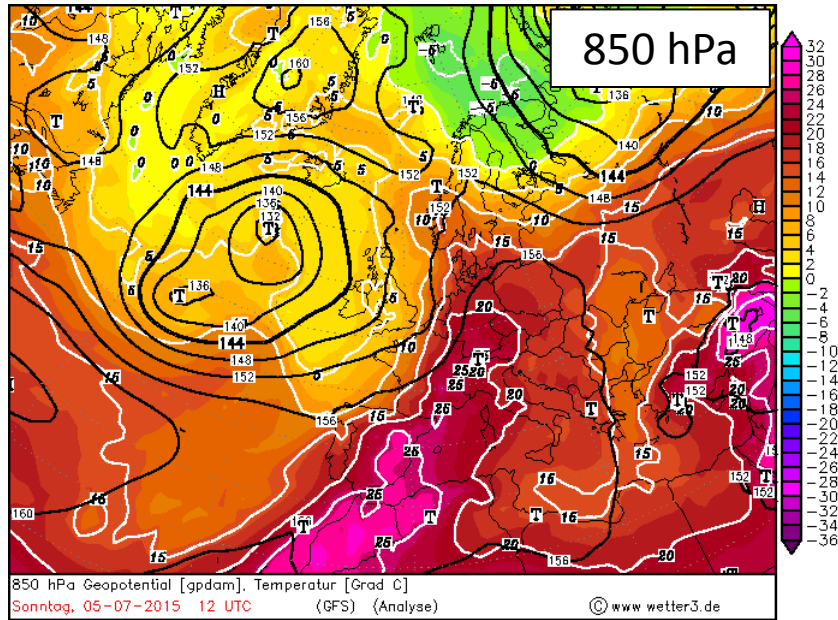
Hail size distribution according to reports



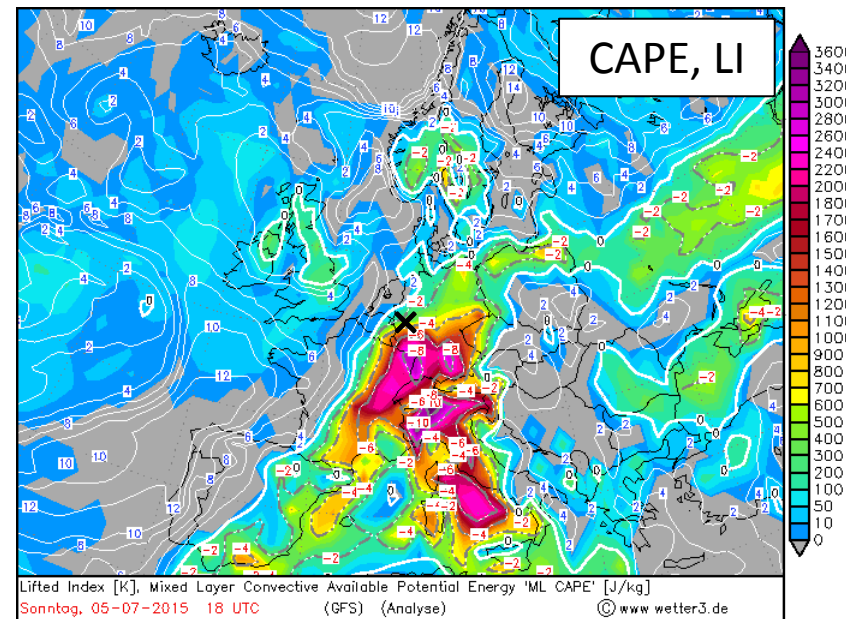
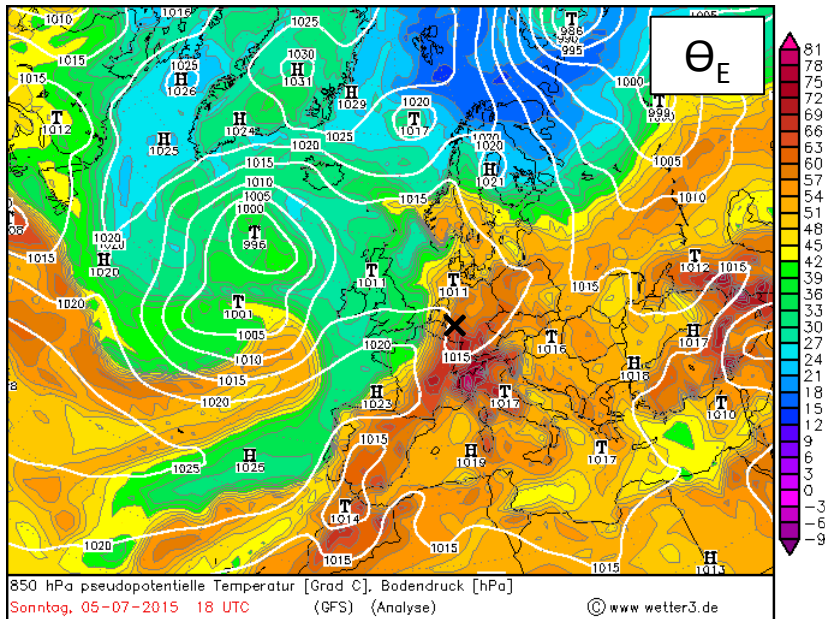
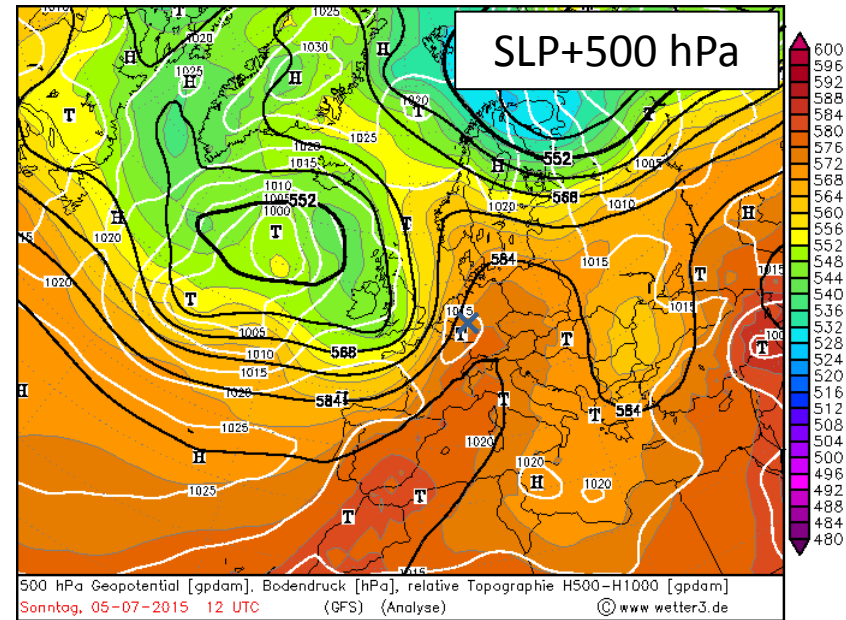
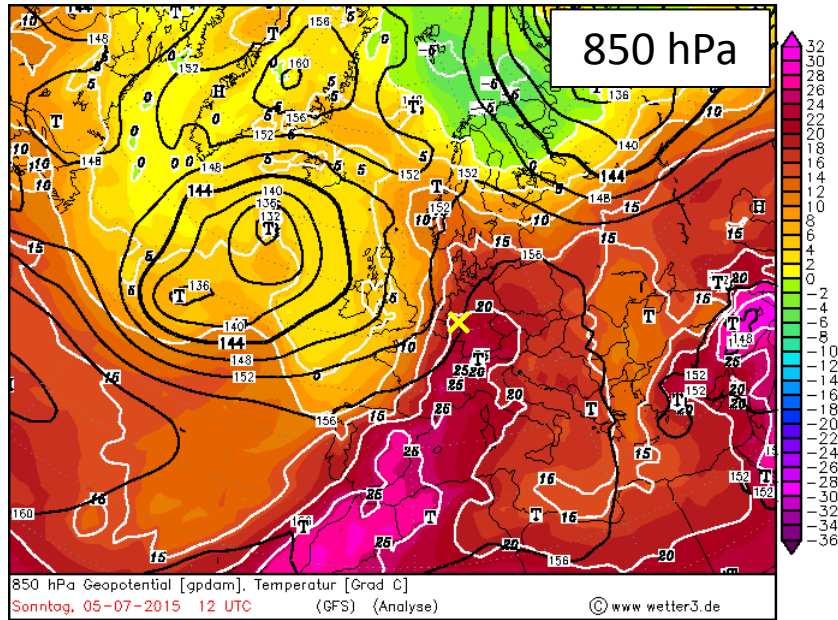
Outline

- Meteorological setup
- Attenuation and differential attenuation correction
- Evolution in PPIs of base reflectivity
- Distinct storm features
- Lifecycle
- Summary

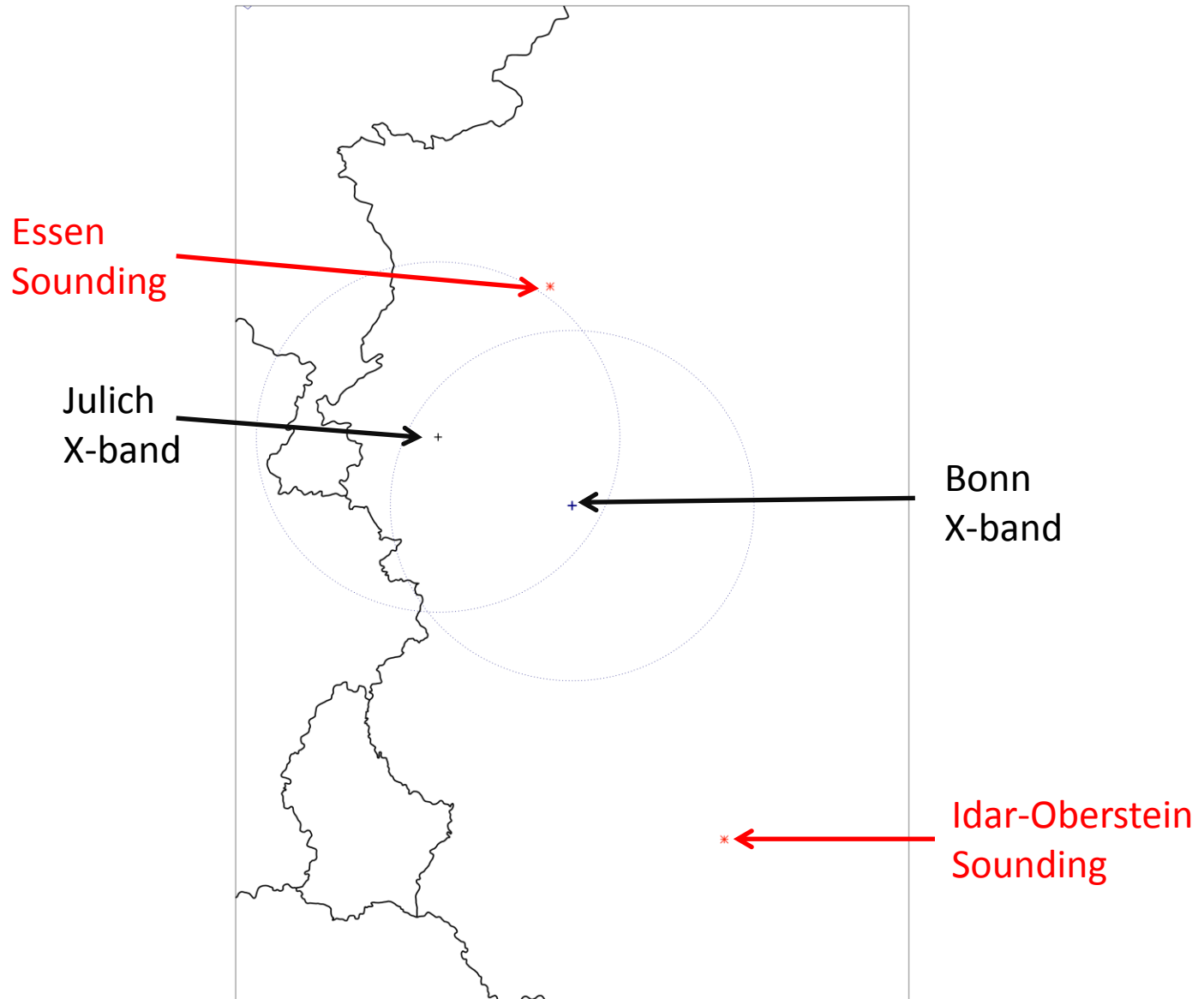
Meteorological Setup



Meteorological Setup

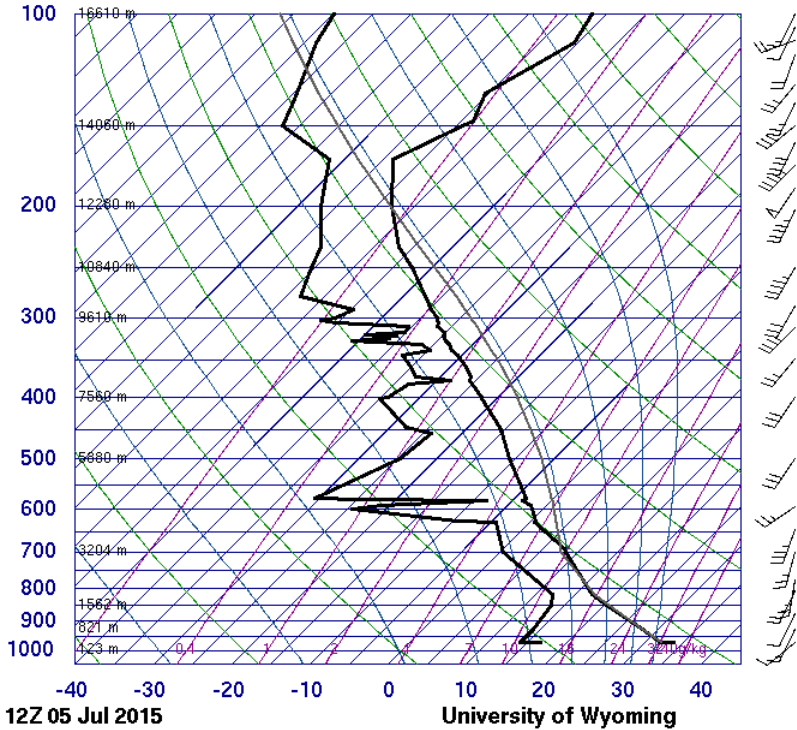


Meteorological Setup



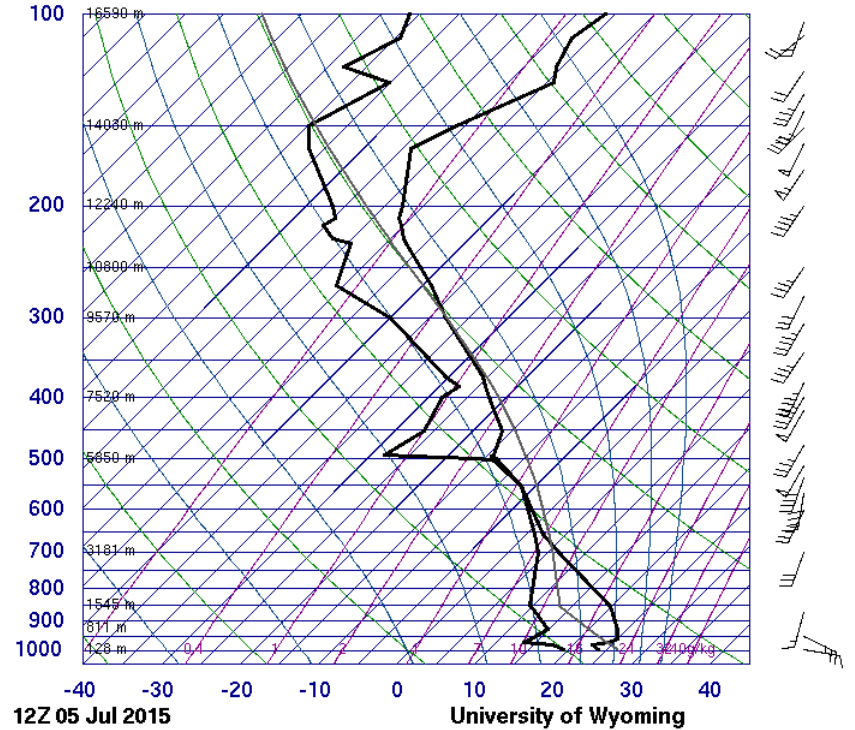
Meteorological Setup

10618 ETGI Idar-Oberstein



SLAT 49.70
SLON 7.33
SELV 377.0
SHOW -4.82
LIFT -4.15
LFTV -4.75
SWET 337.2
KINX 36.50
CTOT 24.10
VTOT 31.10
TOTL 55.20
CAPE 1227.
CAPV 1337.
CINS -48.0
CINV -26.9
EGLV 201.5
EGTV 201.4
LFCT 680.5
LFCV 701.4
BRCH 72.43
BRCV 78.92
LCLT 283.6
LCLP 750.6
MLTH 307.9
MLMR 10.78
THCK 5757.
PWAT 34.14

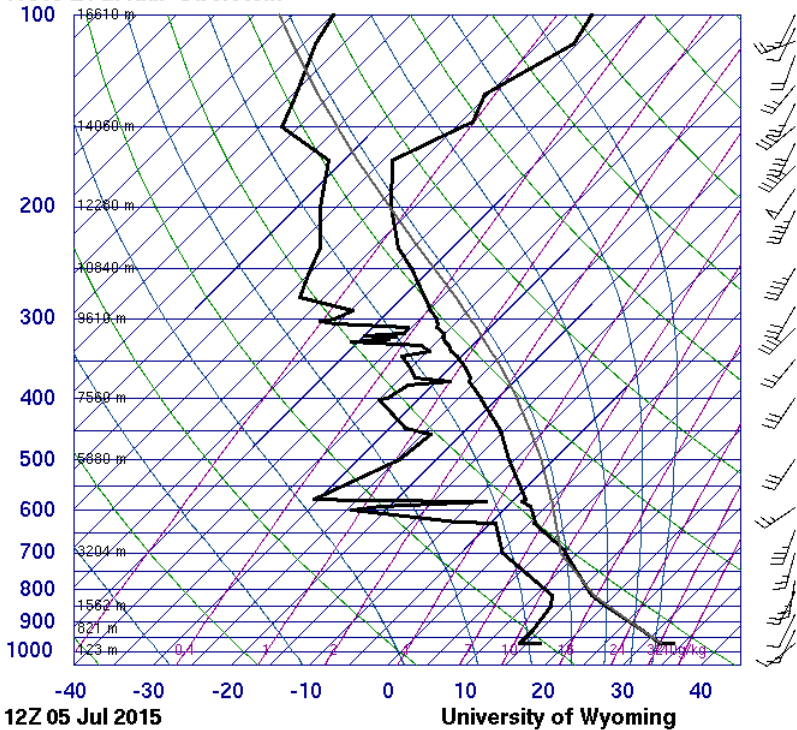
10410 EDZE Essen



SLAT 51.40
SLON 6.97
SELV 147.0
SHOW -3.96
LIFT -4.04
LFTV -4.31
SWET 391.3
KINX 40.10
CTOT 23.10
VTOT 33.10
TOTL 56.20
CAPE 340.2
CAPV 376.0
CINS -34.2
CINV -318.
EGLV 295.4
EGTV 294.4
LFCT 678.7
LFCV 682.6
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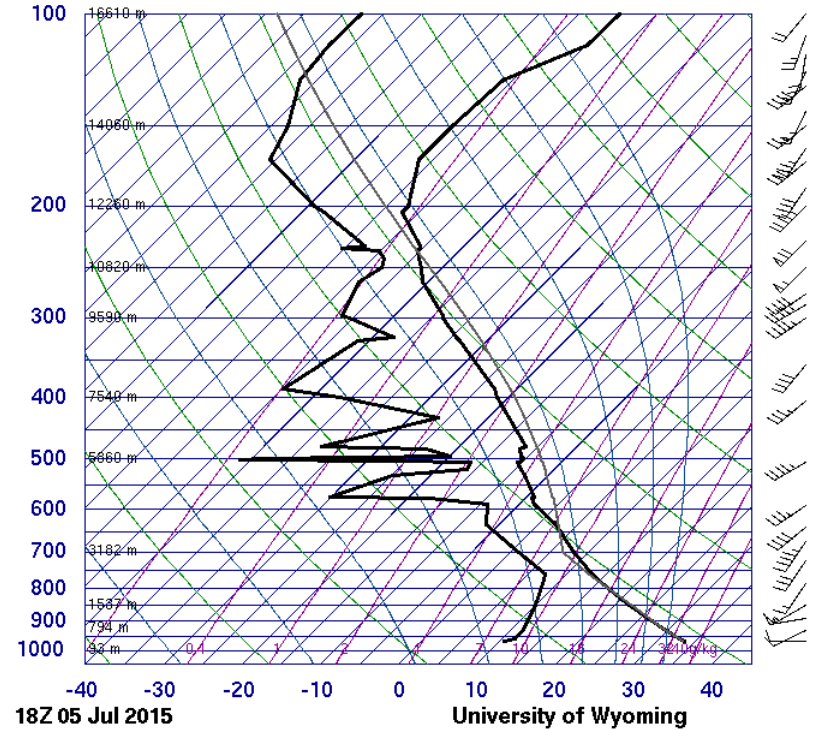
Meteorological Setup

10618 ETGI Idar-Oberstein



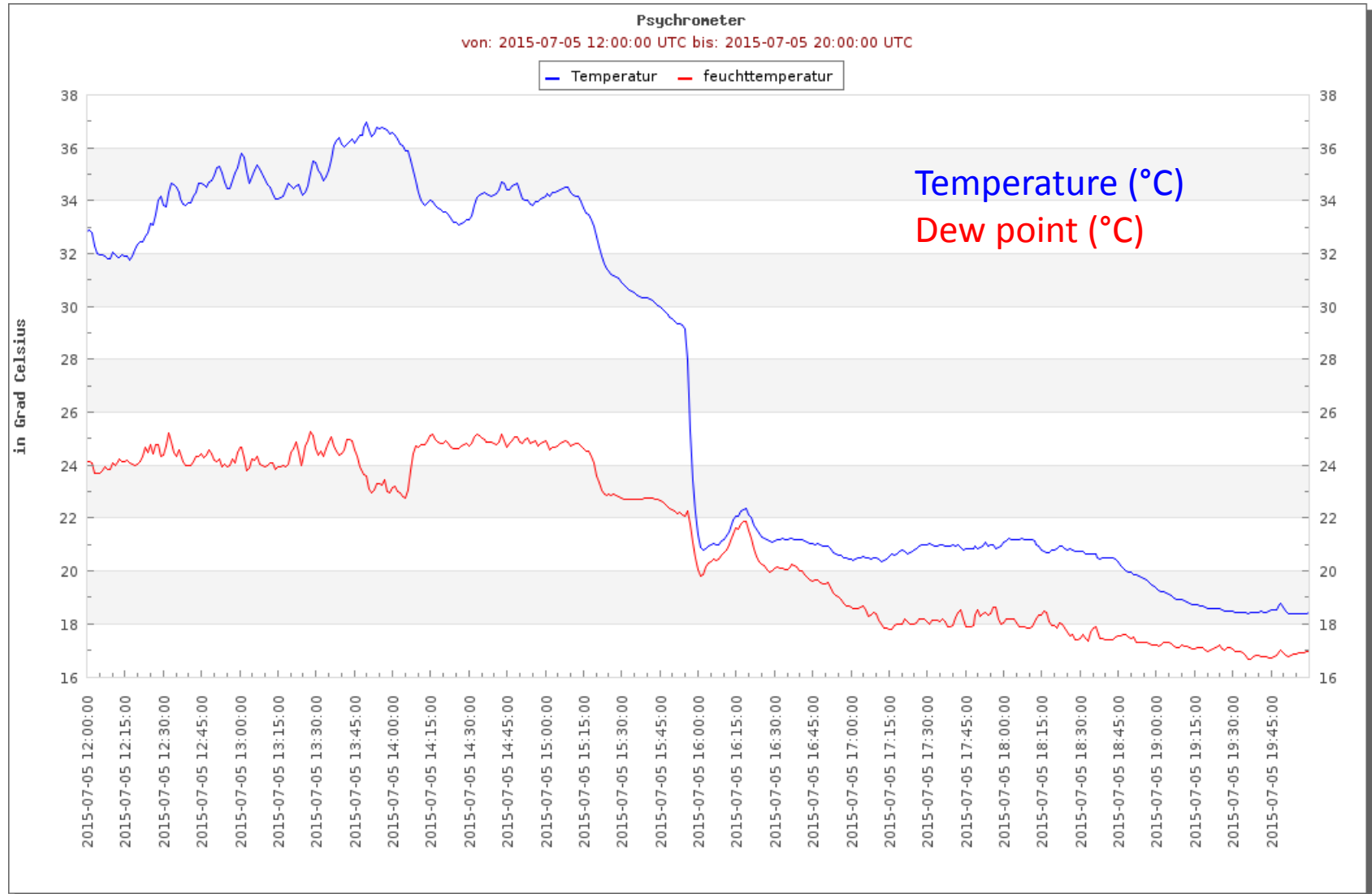
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 LIFT -4.15
 LFTV -4.75
 SWET 337.2
 KINX 36.50
 CTOT 24.10
 VTOT 31.10
 TOTL 55.20
 CAPE 122.7
 CAPV 133.7
 CINS -48.0
 CINV -26.9
 EQLV 201.5
 EQTV 201.4
 LFCT 680.5
 LFCV 701.4
 BRCH 72.43
 BRCV 78.92
 LCLT 283.6
 LCLP 750.6
 MLTH 307.9
 MLMR 10.78
 THCK 575.7
 PWAT 34.14

10618 ETGI Idar-Oberstein



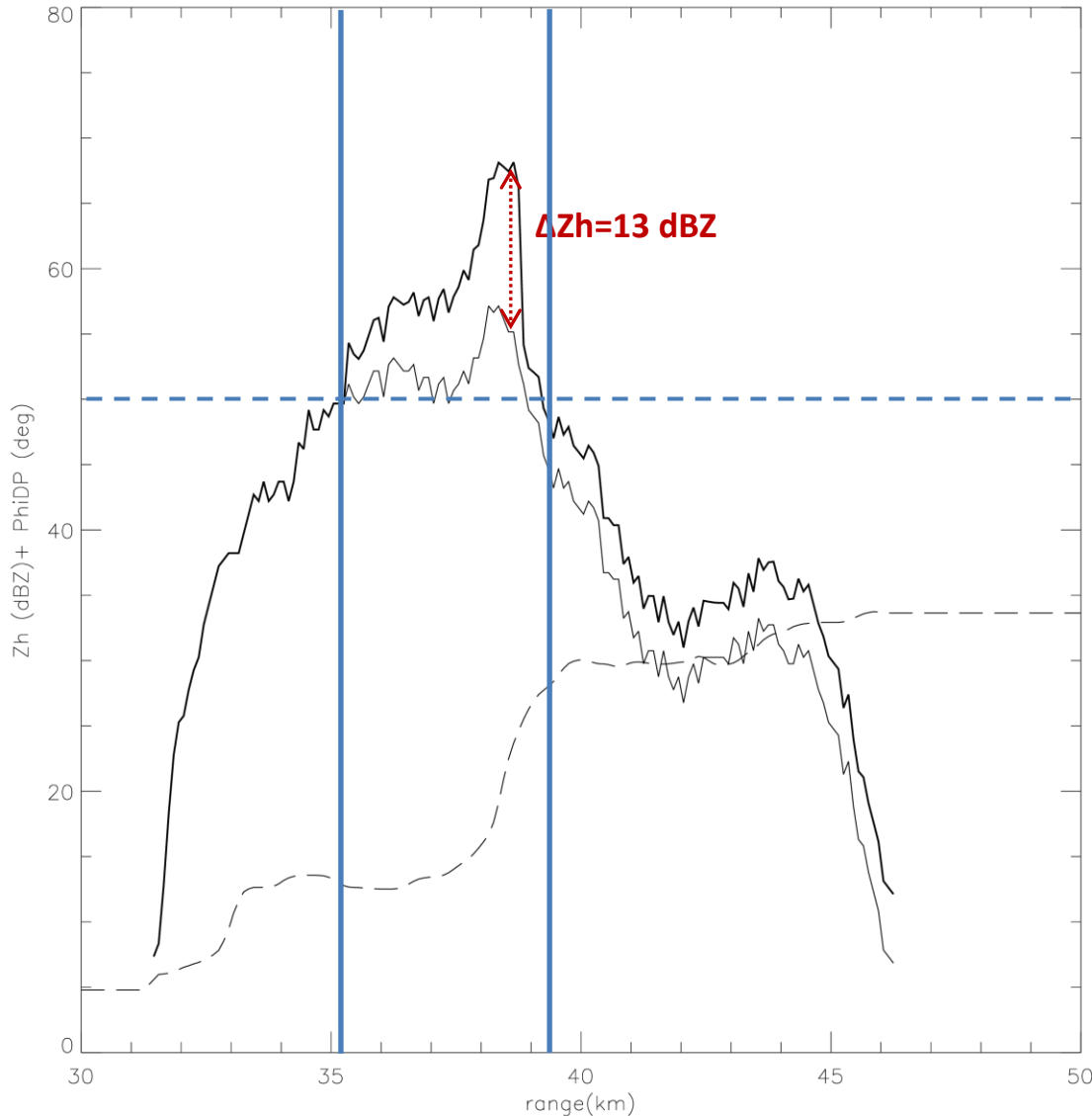
SLAT 49.70
 SLON 7.33
 SELV 377.0
 SHOW -2.32
 LIFT -2.39
 LFTV -3.05
 SWET 269.7
 KINX 35.30
 CTOT 20.30
 VTOT 32.30
 TOTL 52.60
 CAPE 630.8
 CAPV 719.8
 CINS -41.0
 CINV -22.6
 EQLV 236.7
 EQTV 236.6
 LFCT 647.9
 LFCV 671.3
 BRCH 14.67
 BRCV 16.74
 LCLT 280.3
 LCLP 708.4
 MLTH 309.4
 MLMR 9.12
 THCK 576.7
 PWAT 30.62

Meteorological Setup



Attenuation Correction

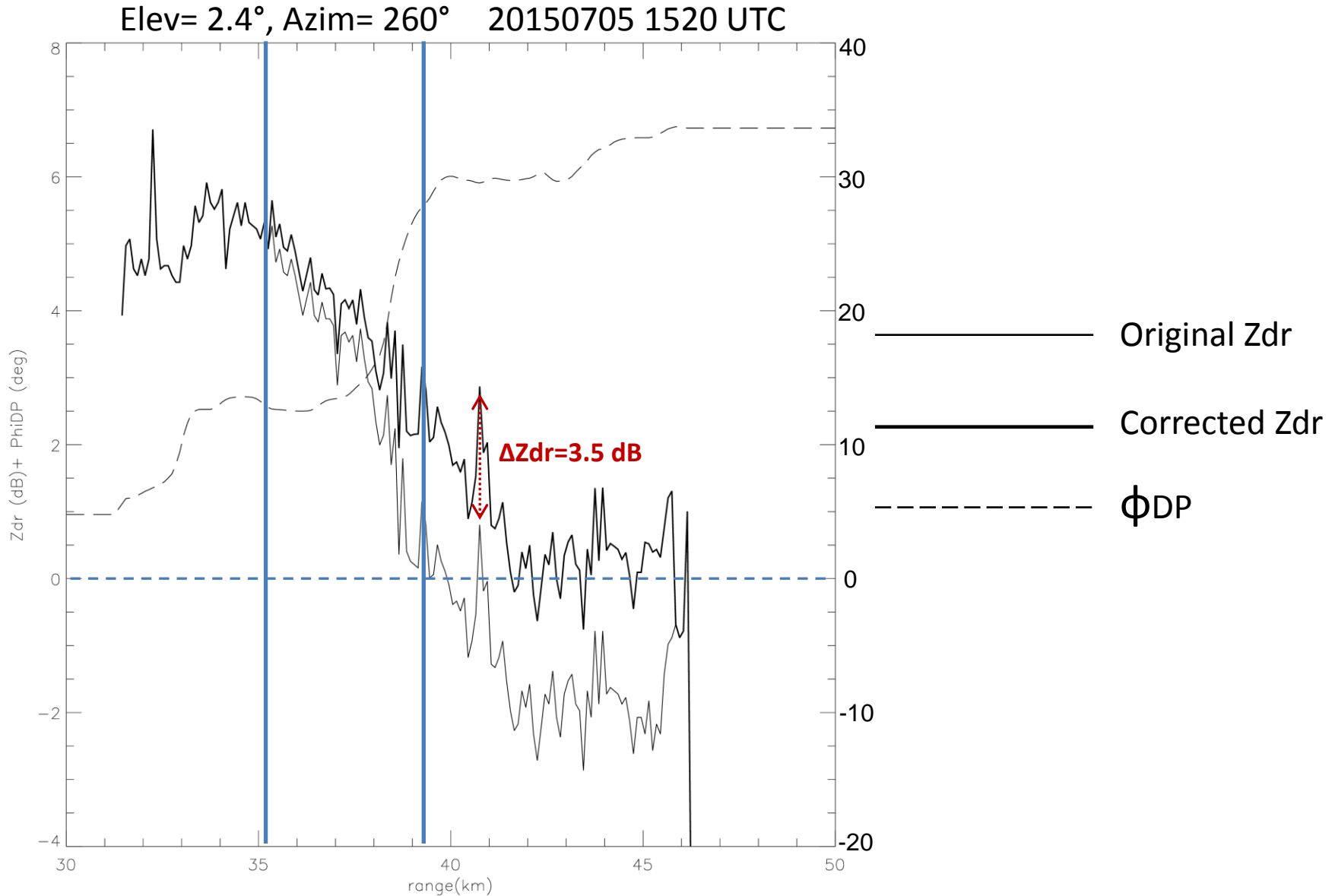
Elev= 2.4°, Azim= 260° 20150705 1520 UTC



Attenuation correction using the “hot spot” method for hail (Ryzhkov et al 2013).

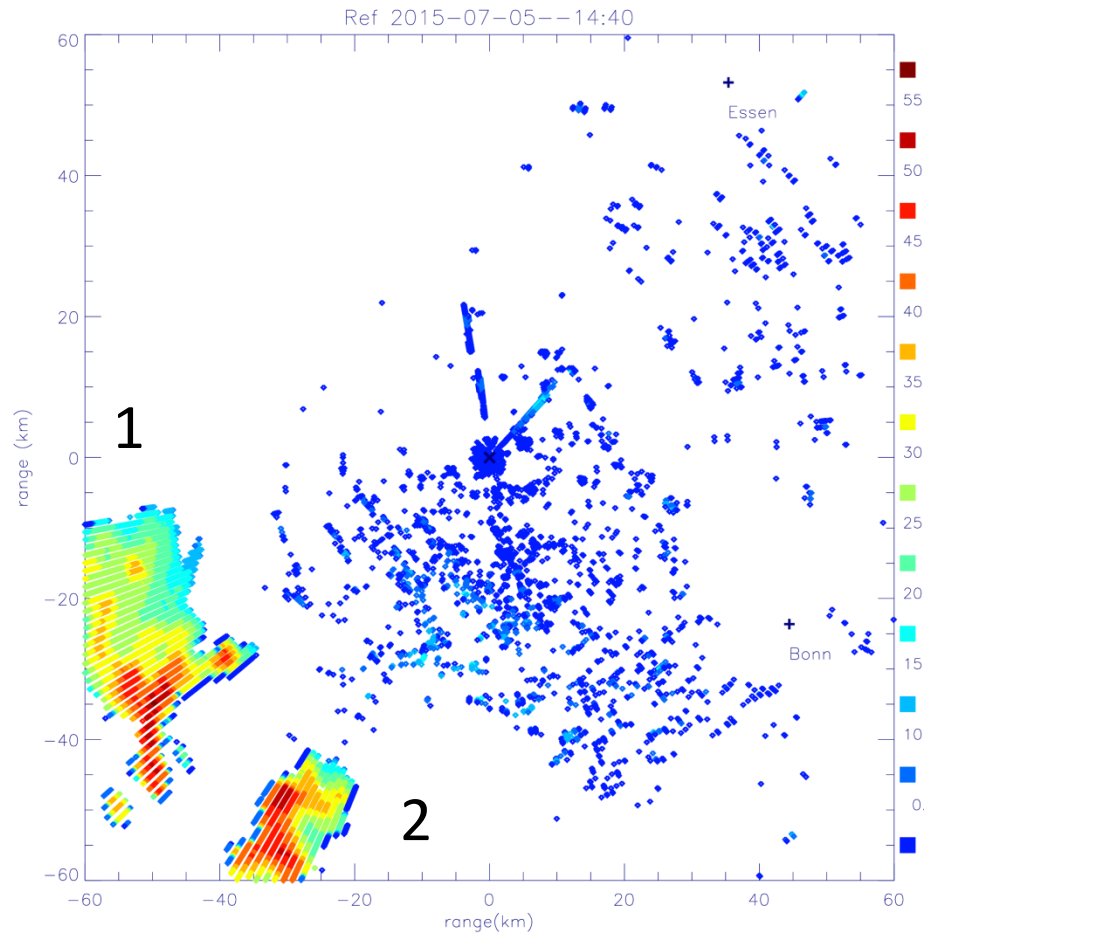
- Original Zh
- Corrected Zh
- Φ_{DP}

Differential Attenuation Correction



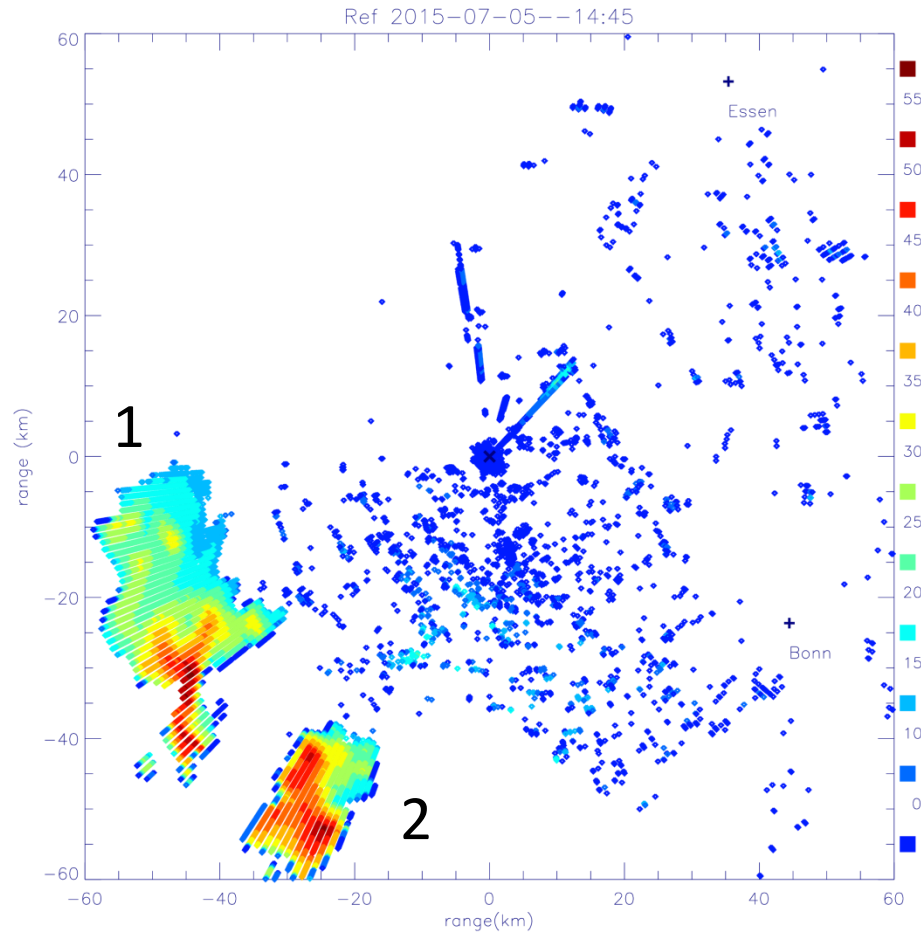
Development of the hail cell

PPI scan of Zh at 1.5° elevation



Development of the hail cell

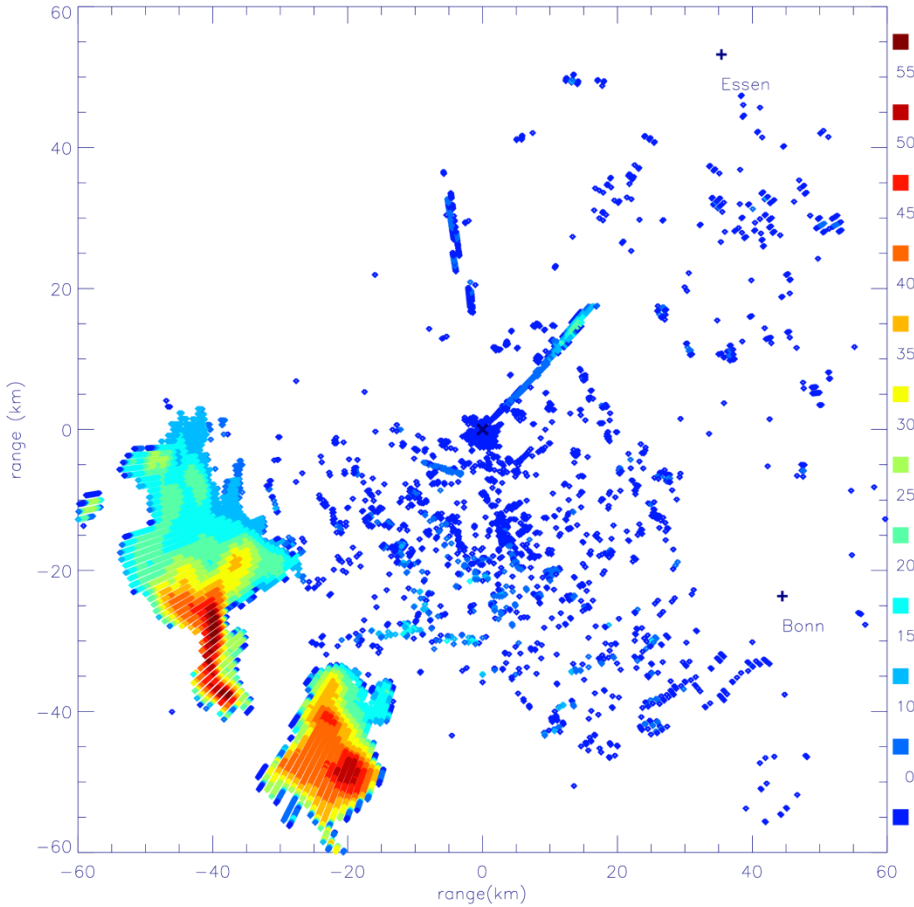
PPI scan of Zh at 1.5° elevation



Development of the hail cell

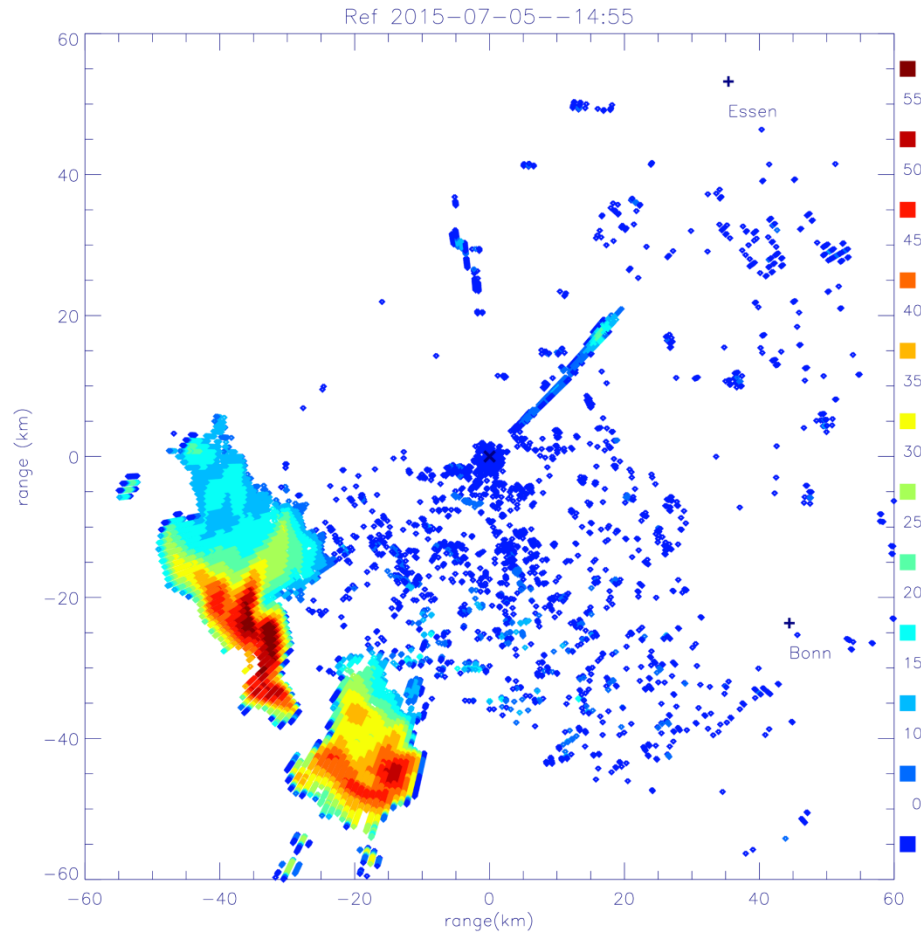
PPI scan of Zh at 1.5° elevation

Ref 2015-07-05--14:50



Development of the hail cell

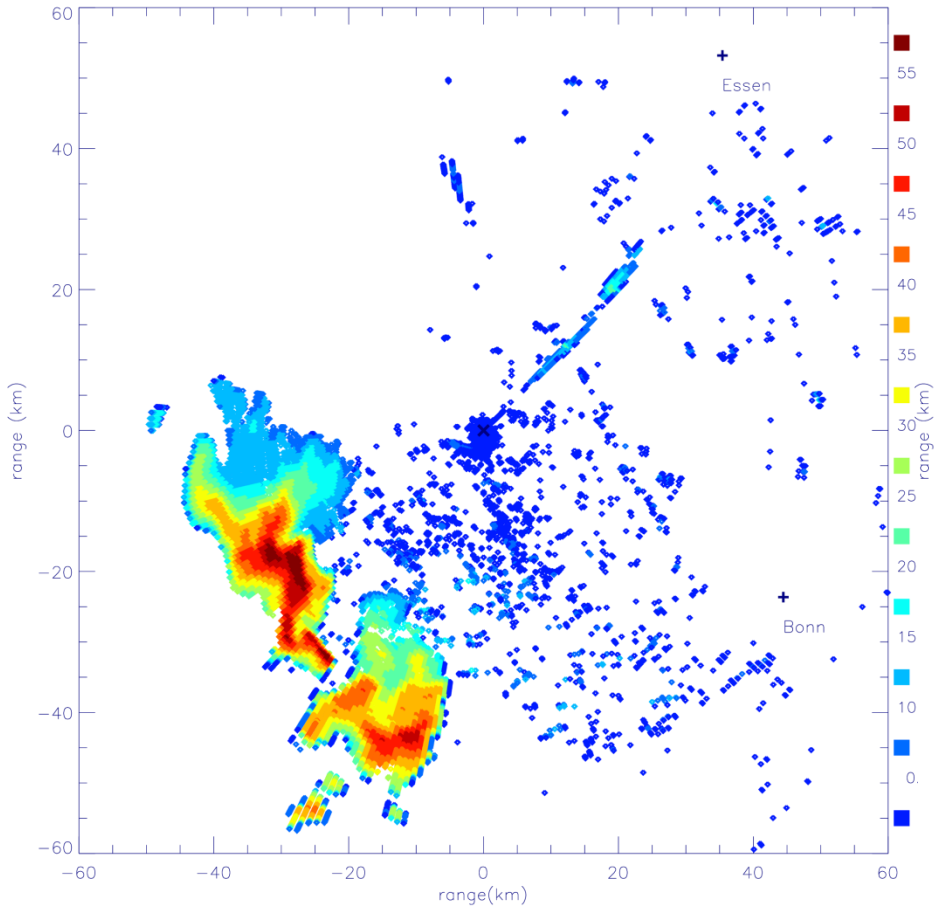
PPI scan of Zh at 1.5° elevation



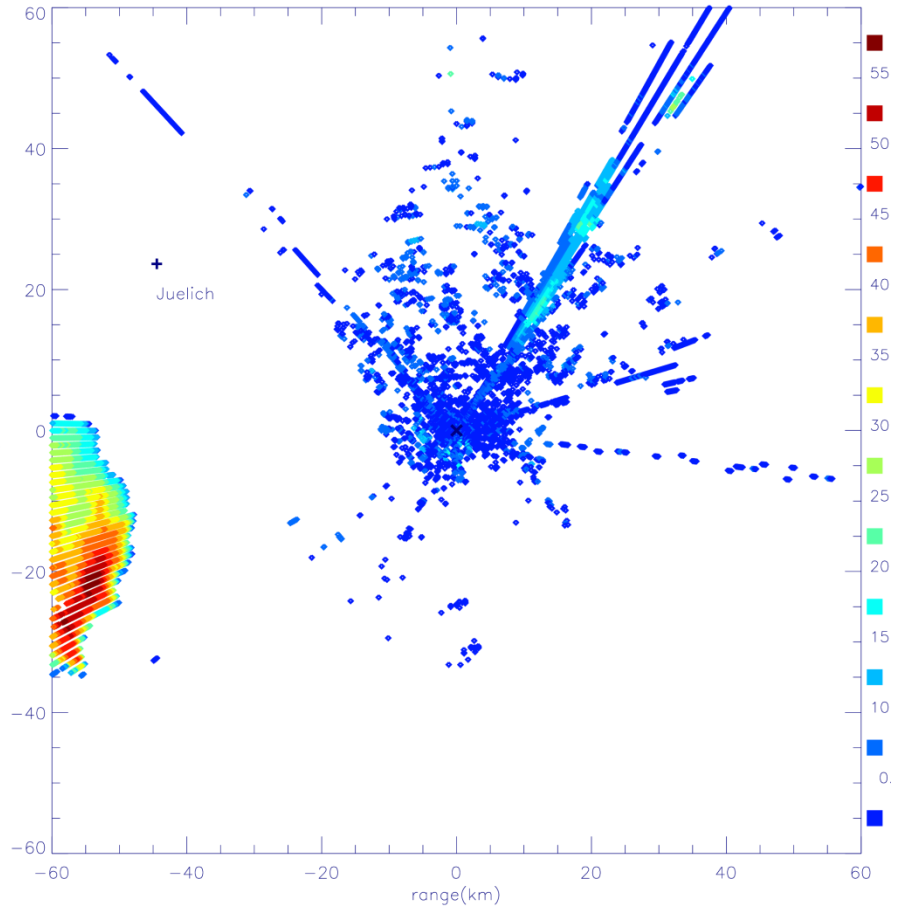
Development of the hail cell

PPI scan of Zh at 1.5° elevation

Ref 2015-07-05--15:00



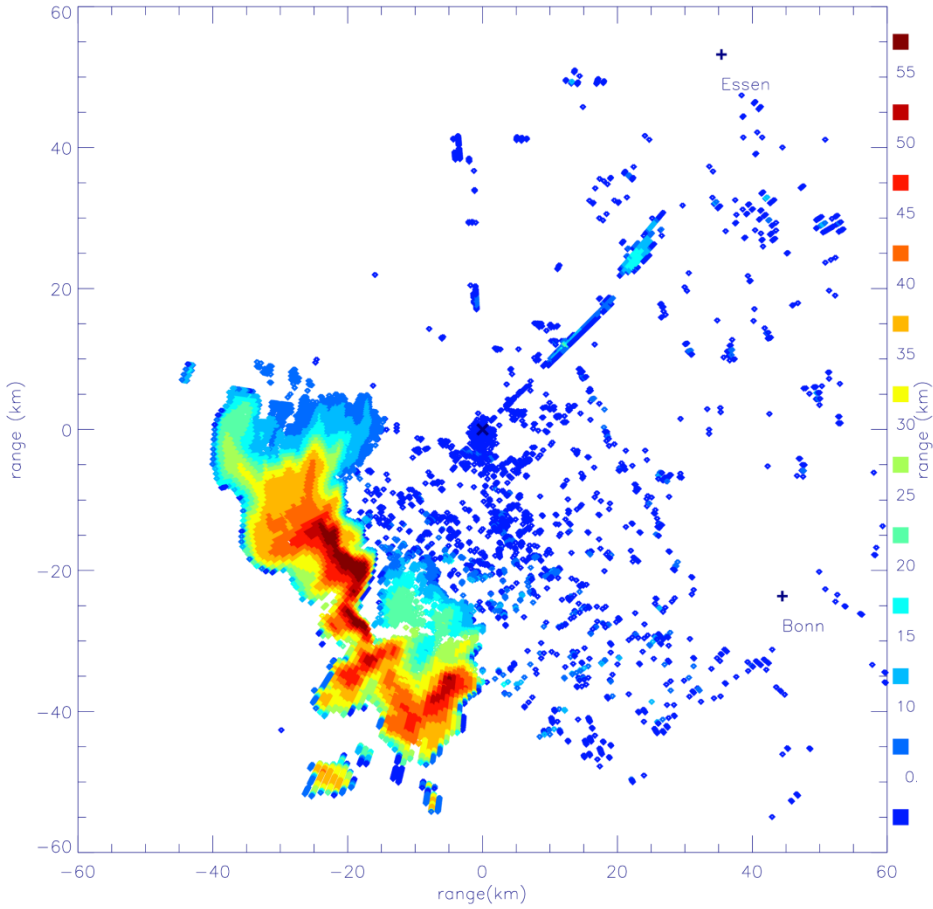
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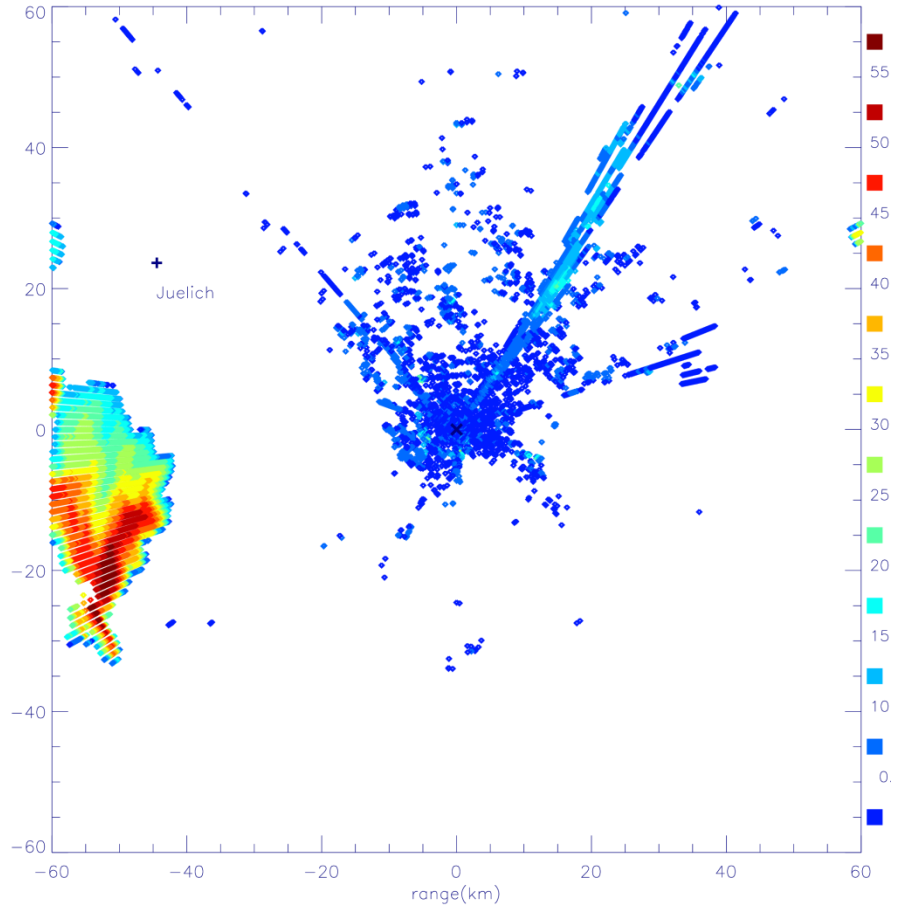
Development of the hail cell

PPI scan of Zh at 1.5° elevation

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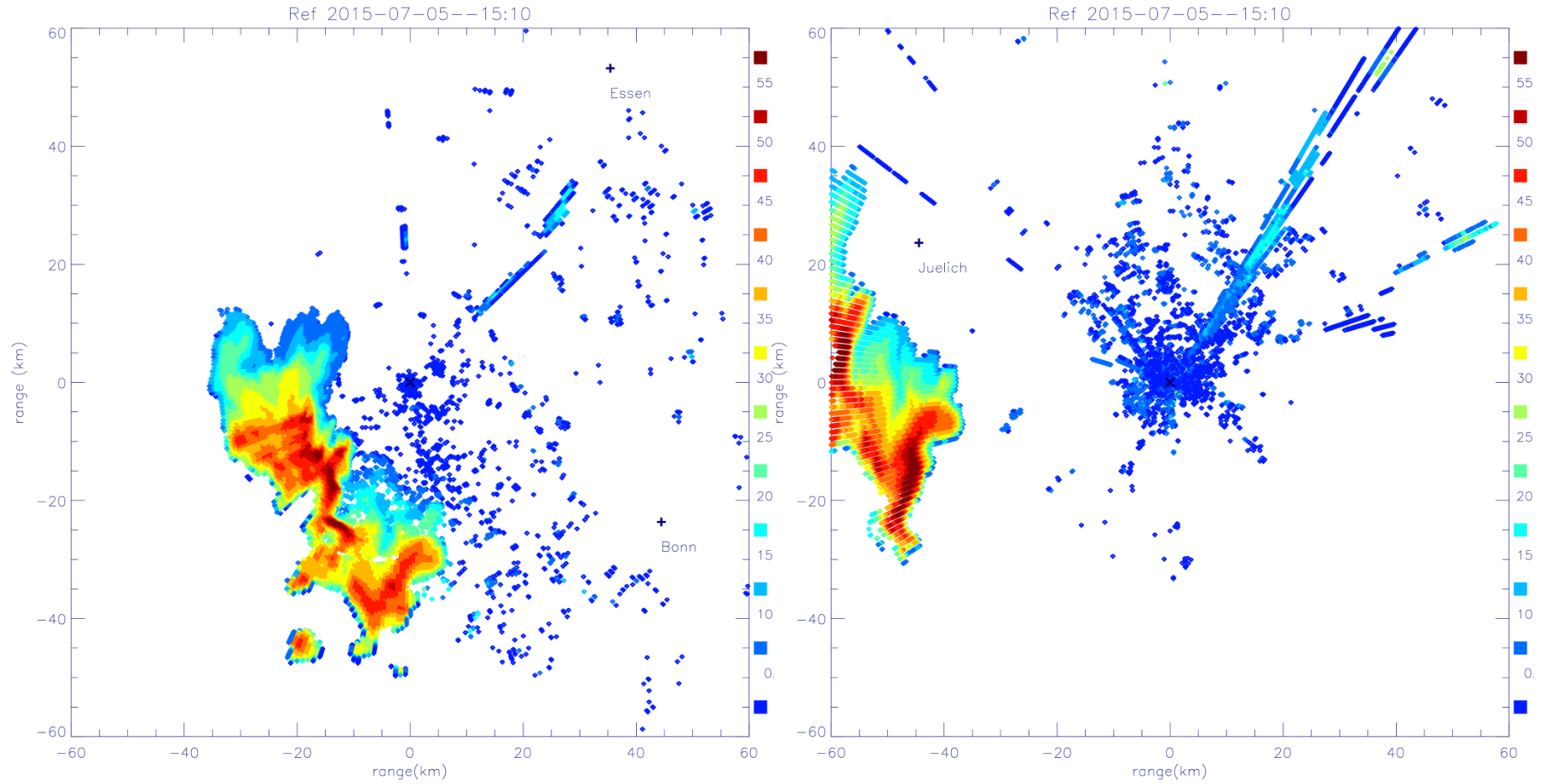


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Development of the hail cell

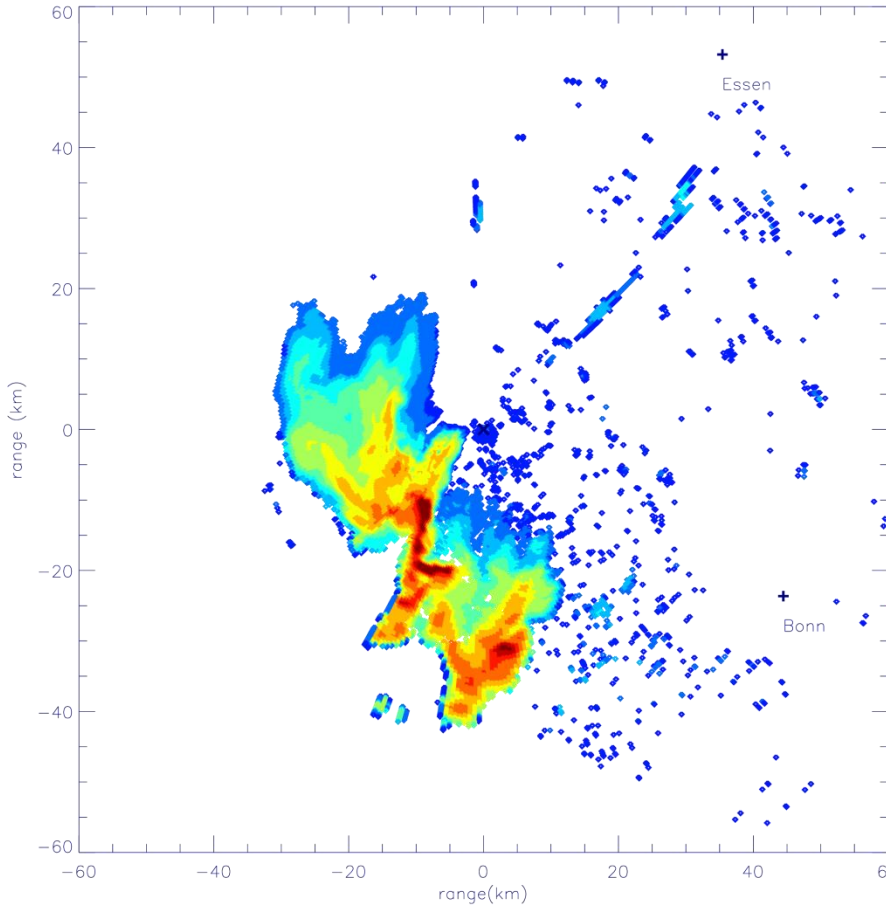
PPI scan of Zh at 1.5° elevation



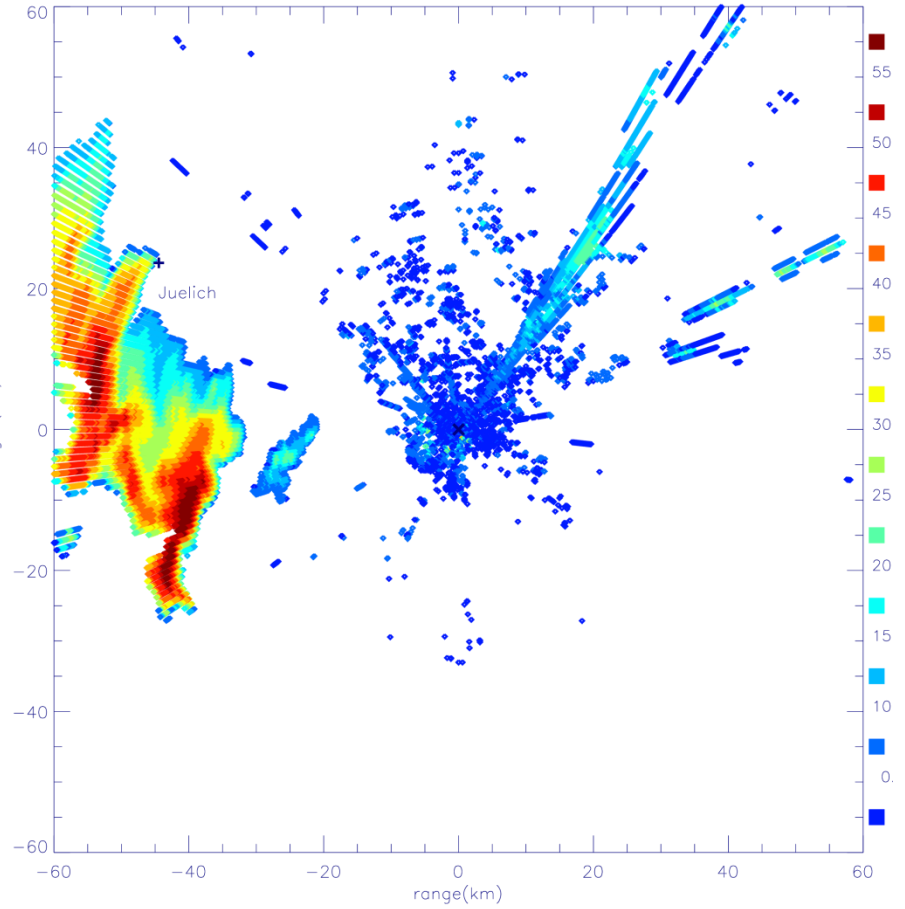
Development of the hail cell

PPI scan of Zh at 1.5° elevation

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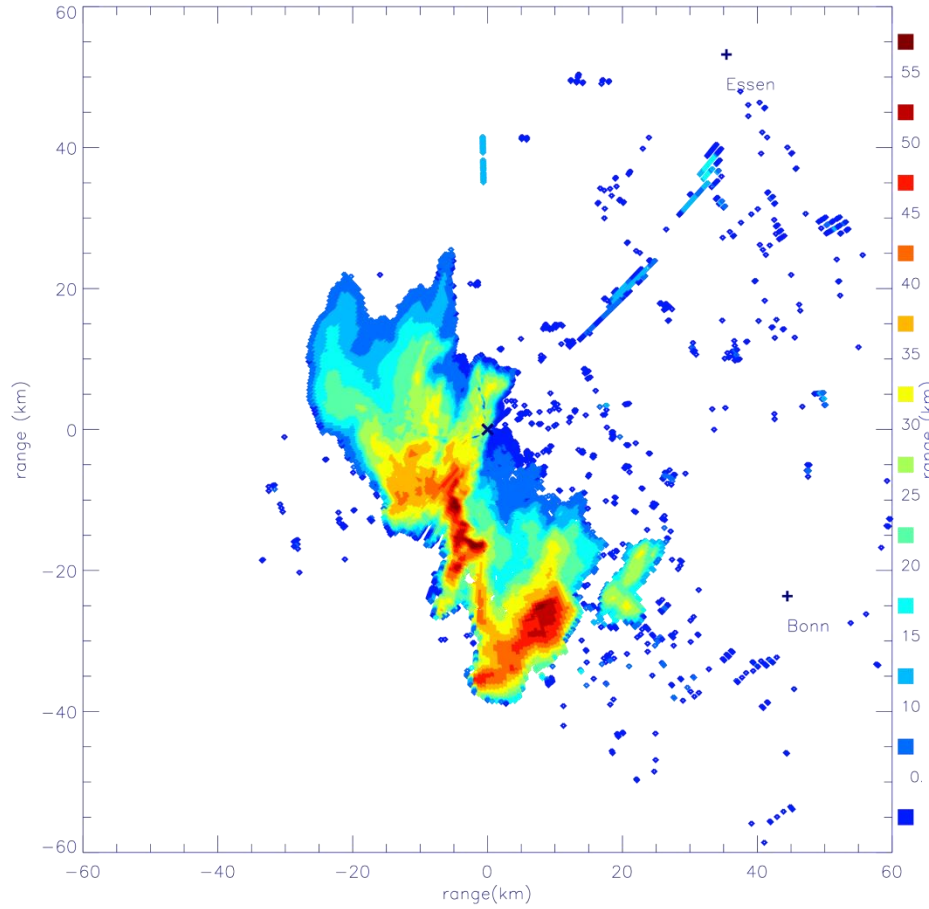
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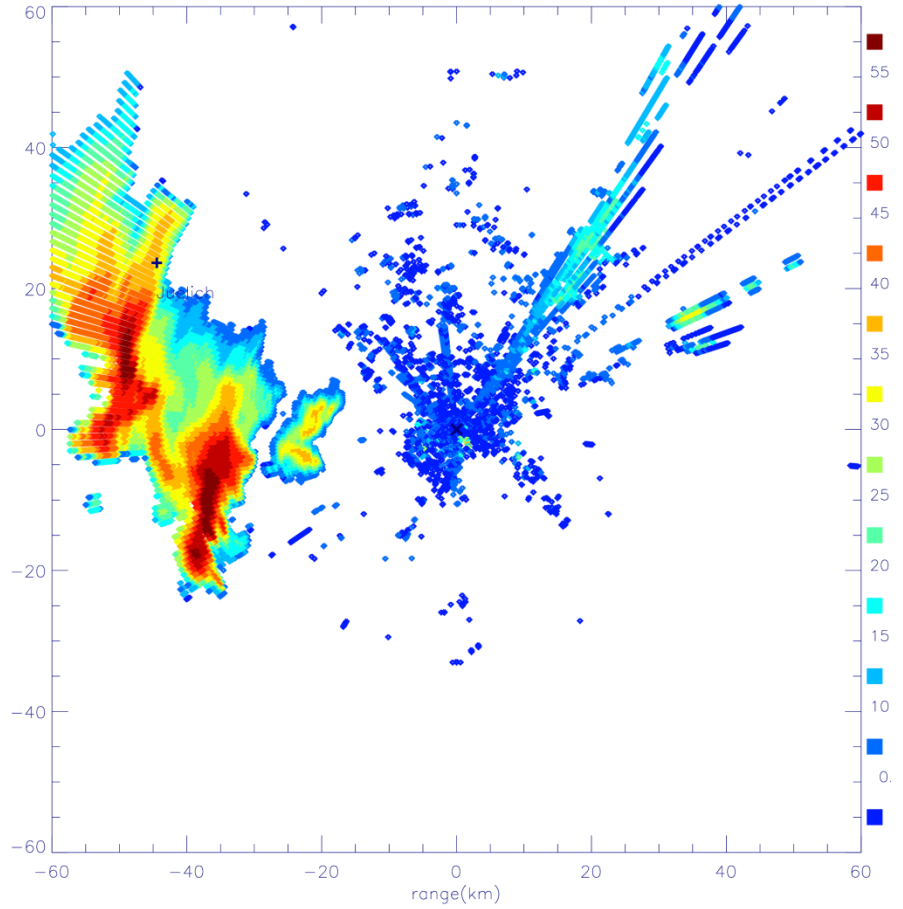
Development of the hail cell

PPI scan of Zh at 1.5° elevation

Ref 2015-07-05--15:20



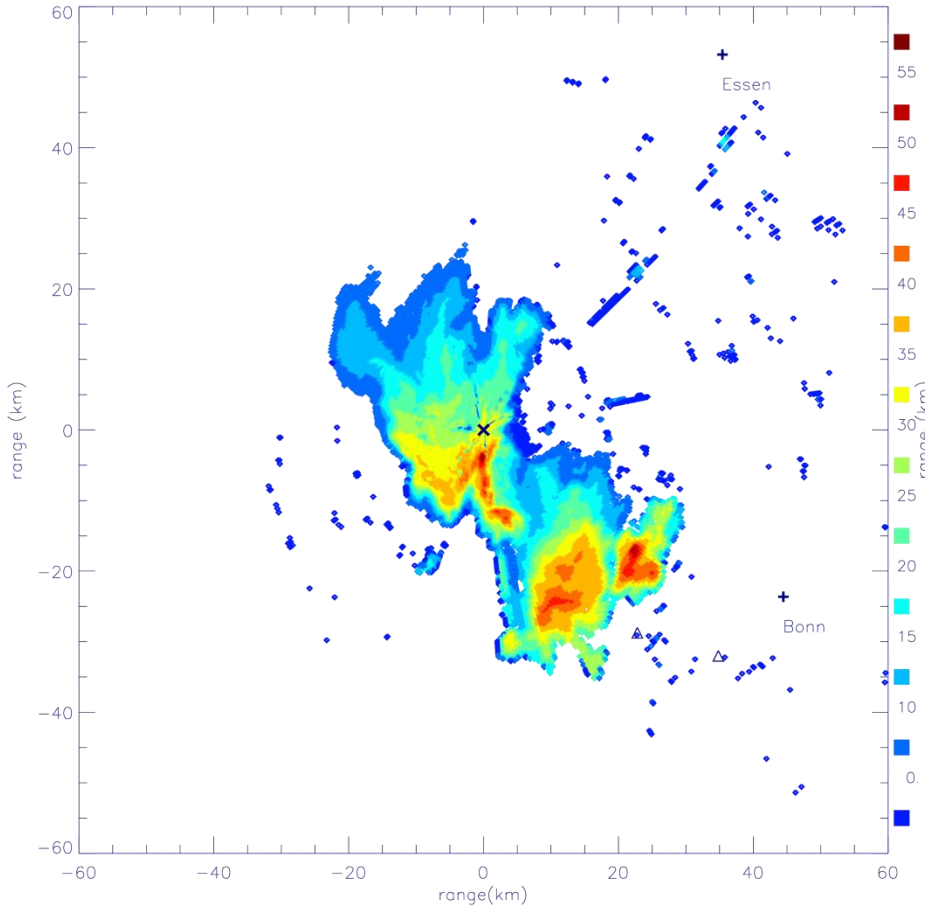
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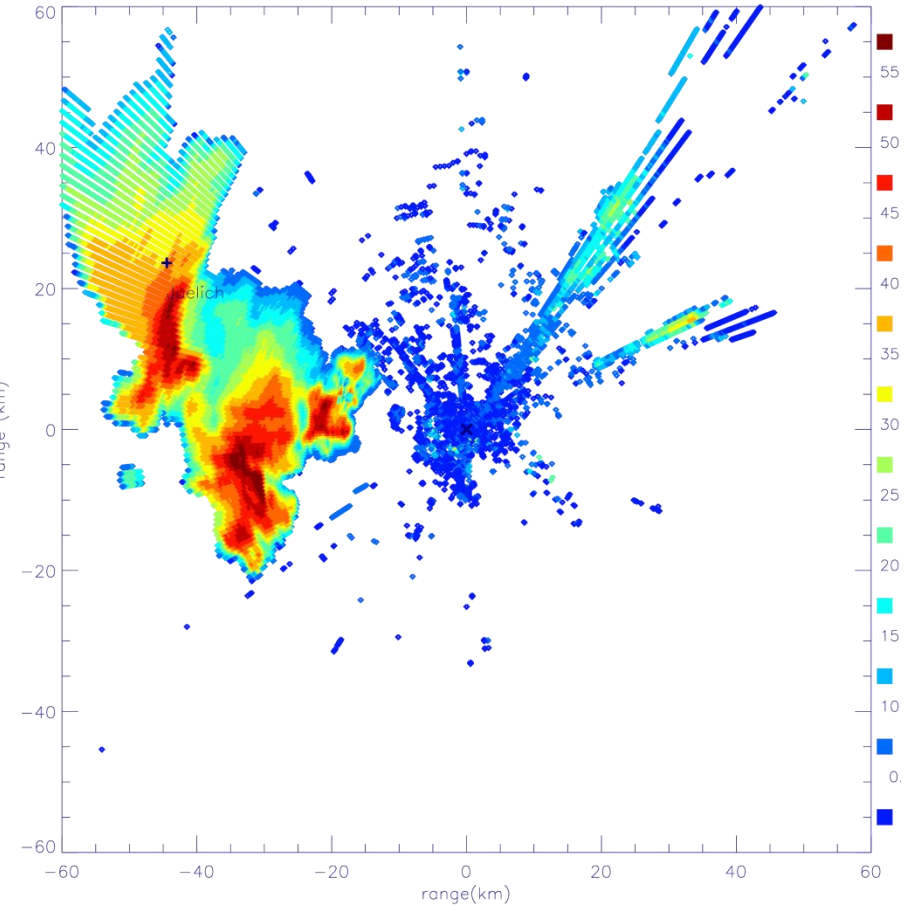
Development of the hail cell

PPI scan of Zh at 1.5° elevation

Ref 2015-07-05--15:25



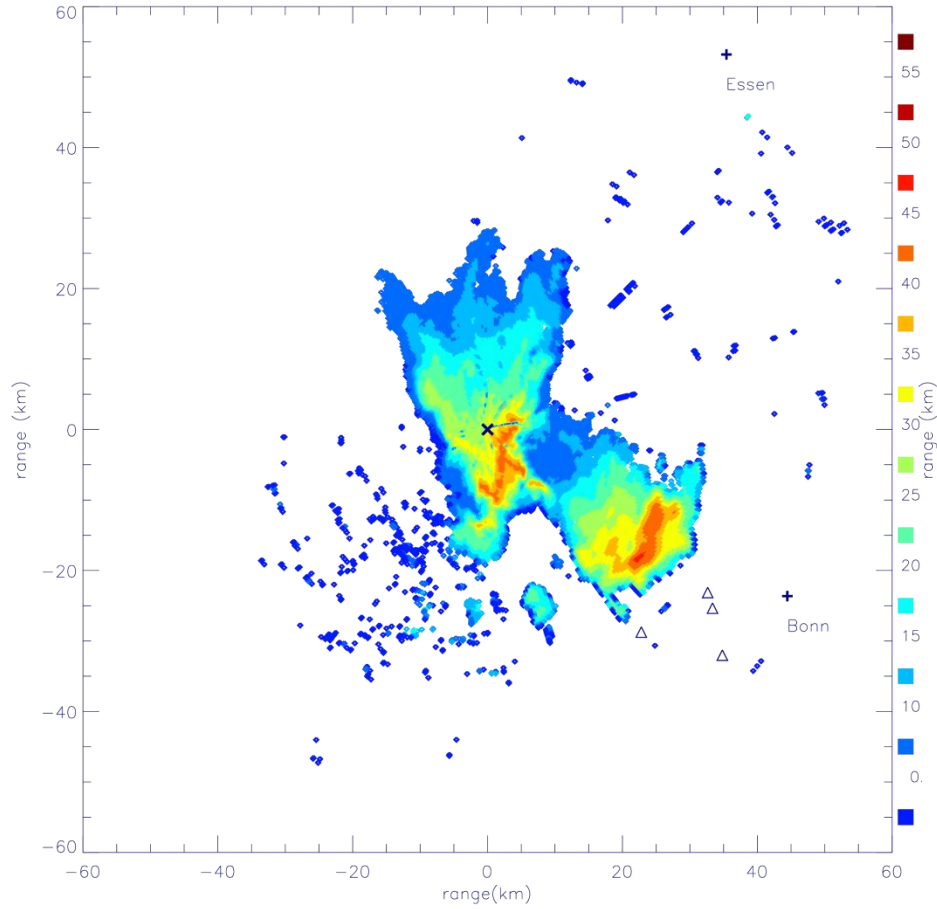
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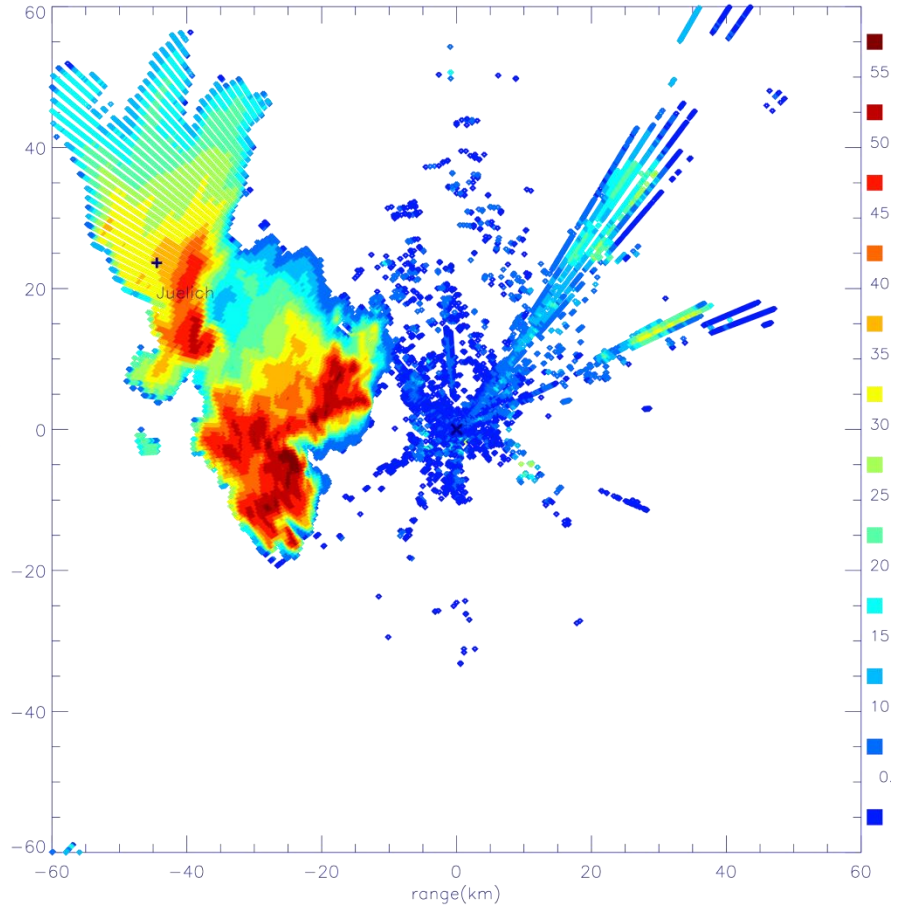
Development of the hail cell

PPI scan of Zh at 1.5° elevation

Ref 2015-07-05--15:30

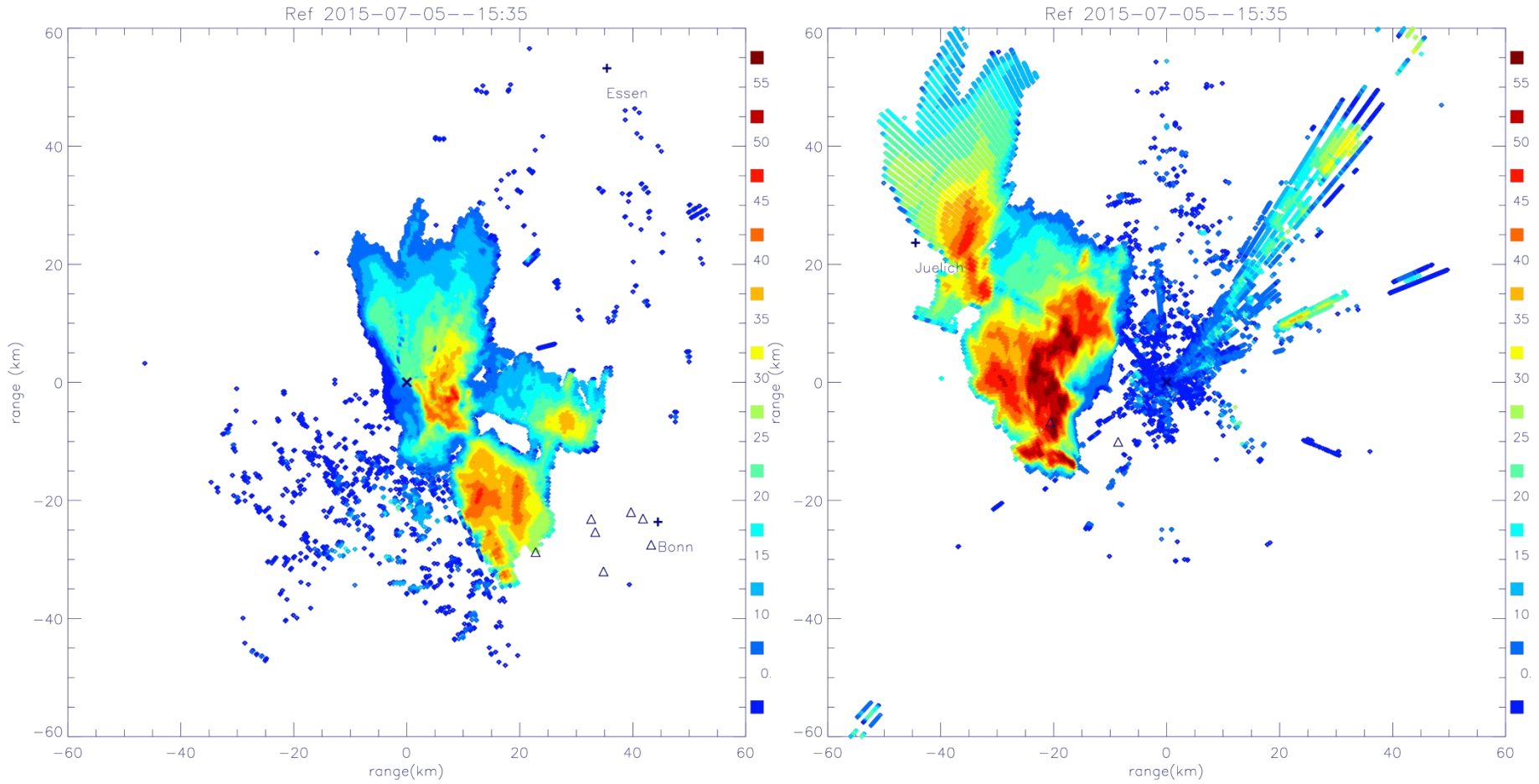


Ref 2015-07-05--15:30



Development of the hail cell

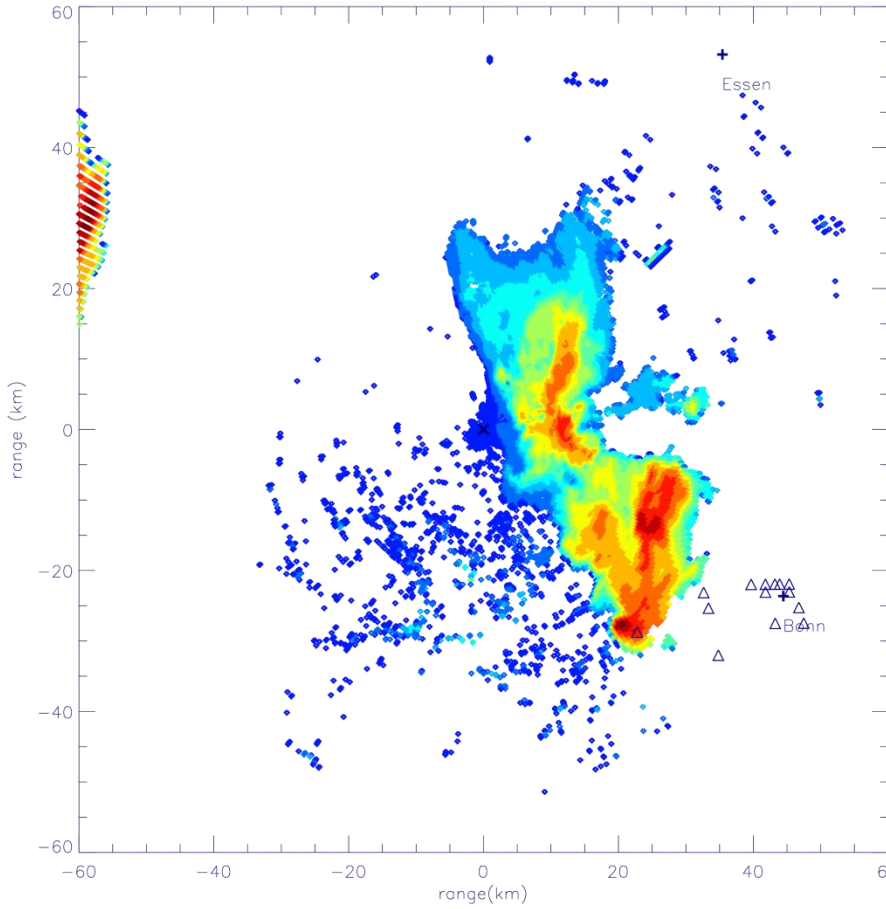
PPI scan of Zh at 1.5° elevation



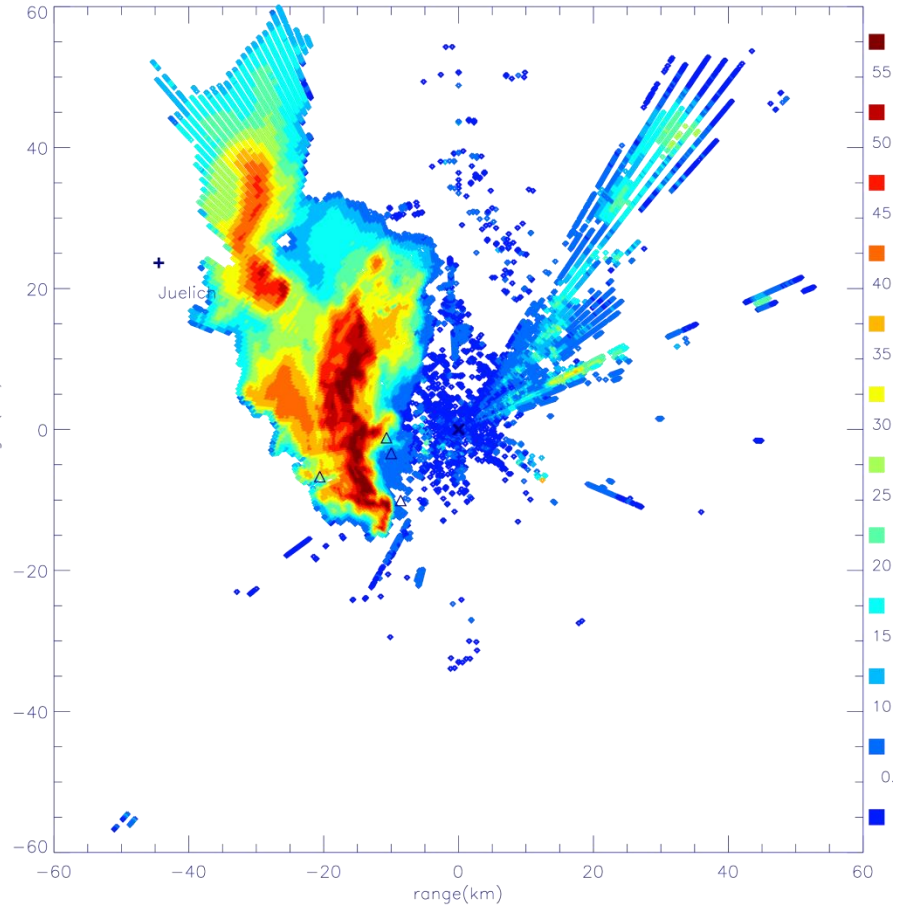
Development of the hail cell

PPI scan of Zh at 1.5° elevation

Ref 2015-07-05--15:40



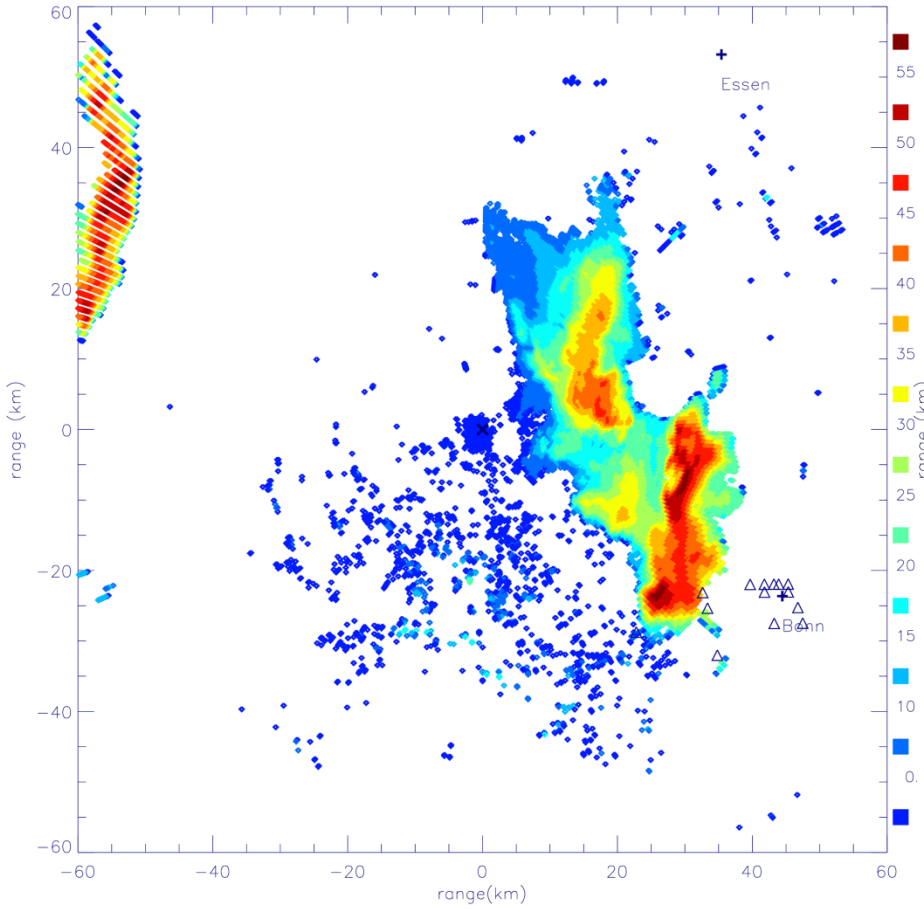
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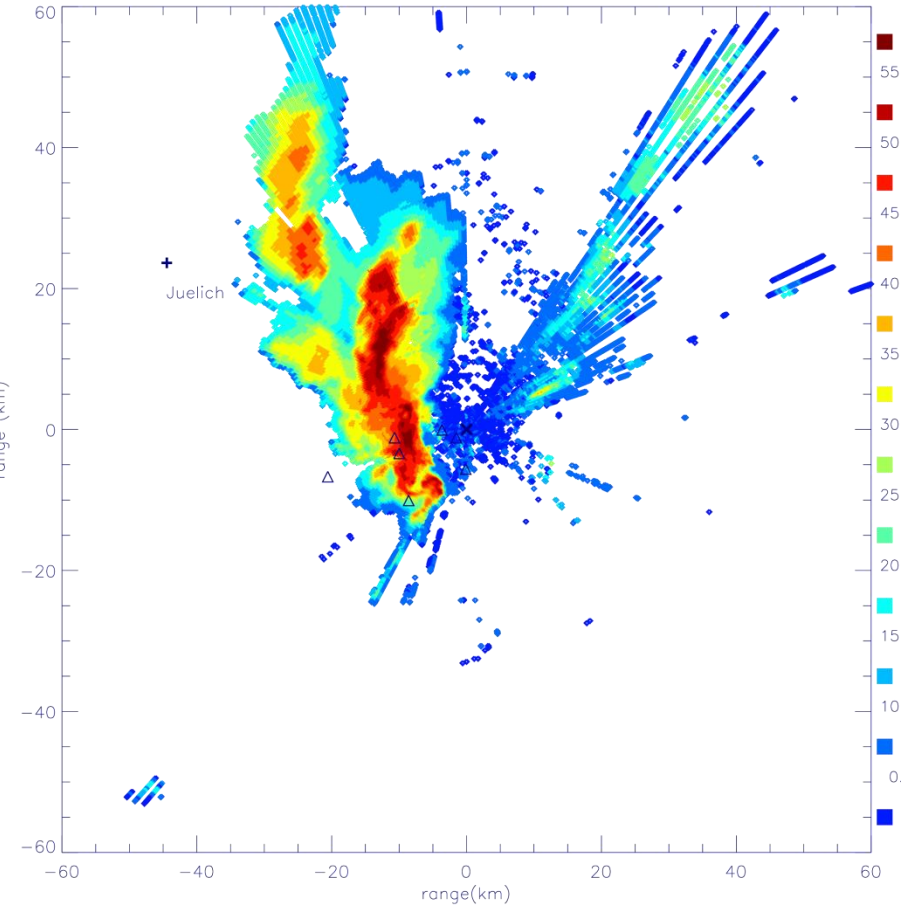
Development of the hail cell

PPI scan of Zh at 1.5° elevation

Ref 2015-07-05--15:45

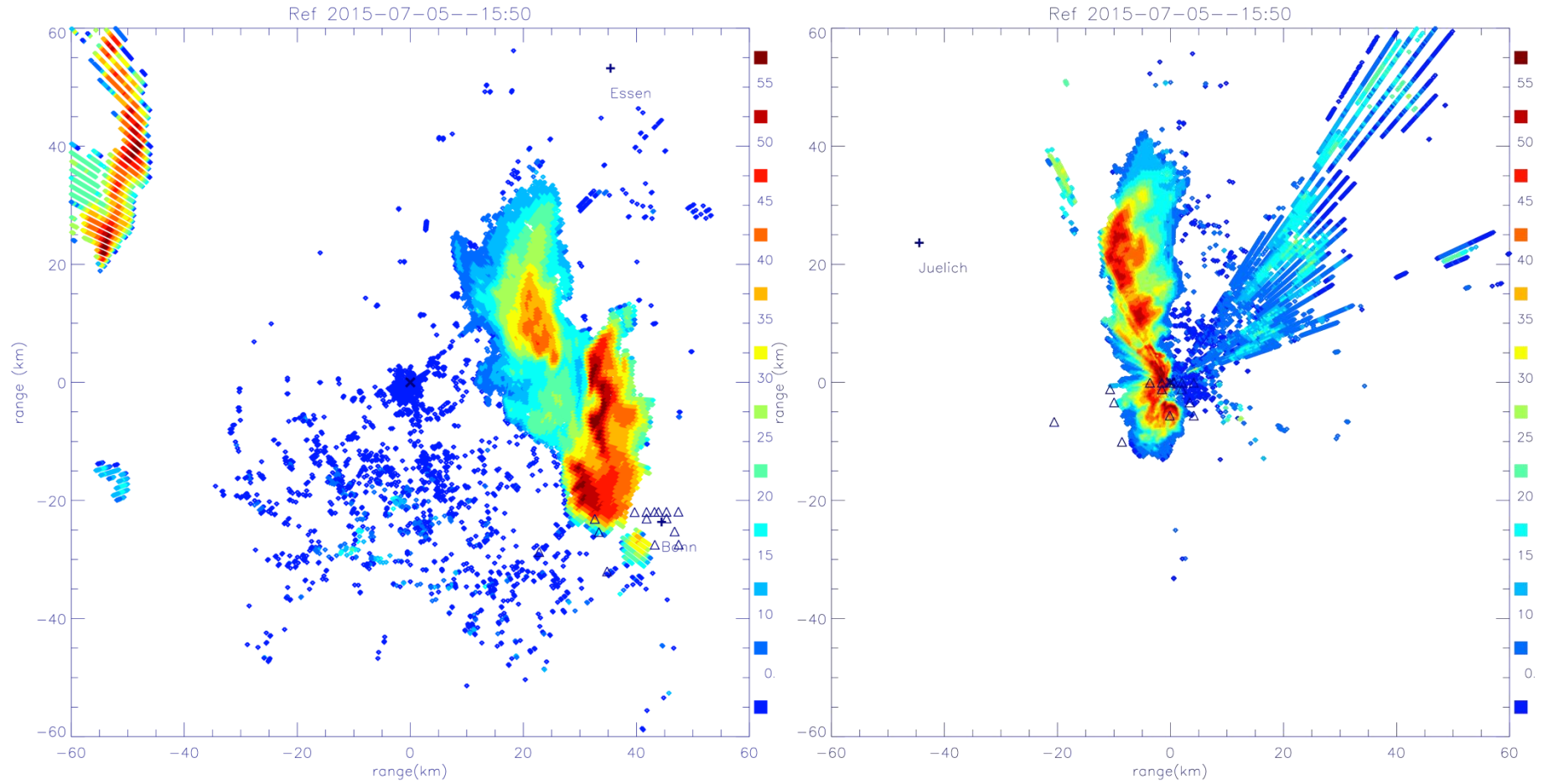


Ref 2015-07-05--15:45



Development of the hail cell

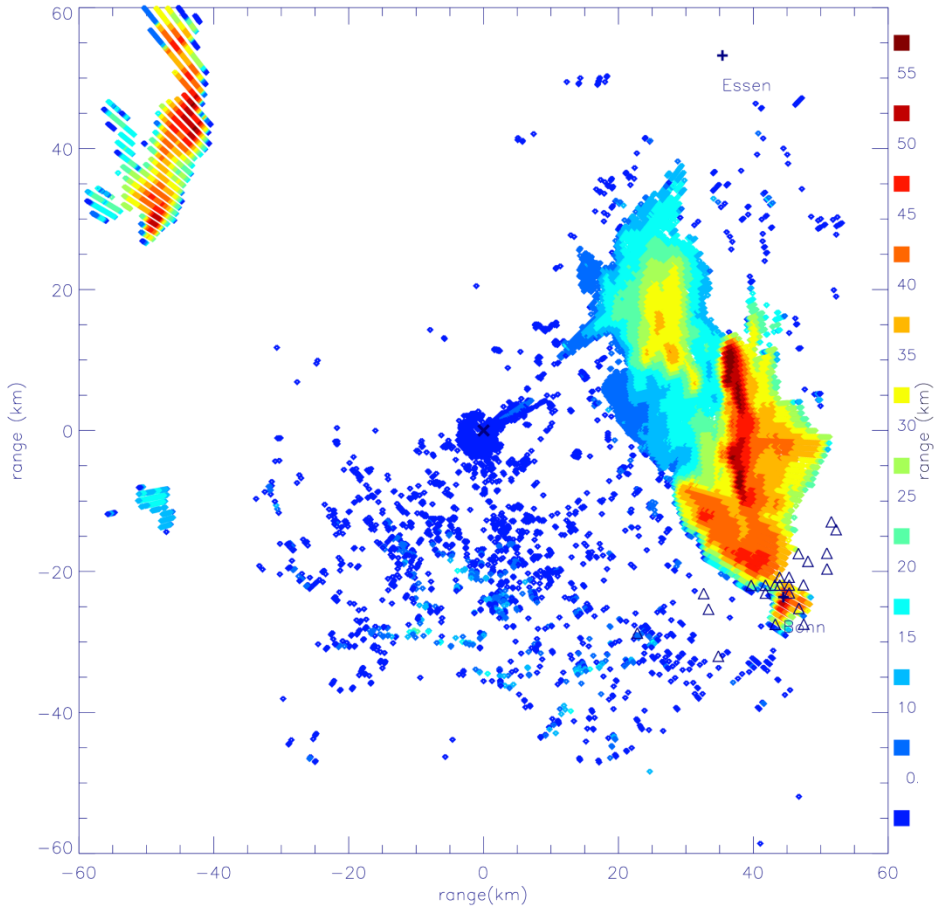
PPI scan of Zh at 1.5° elevation



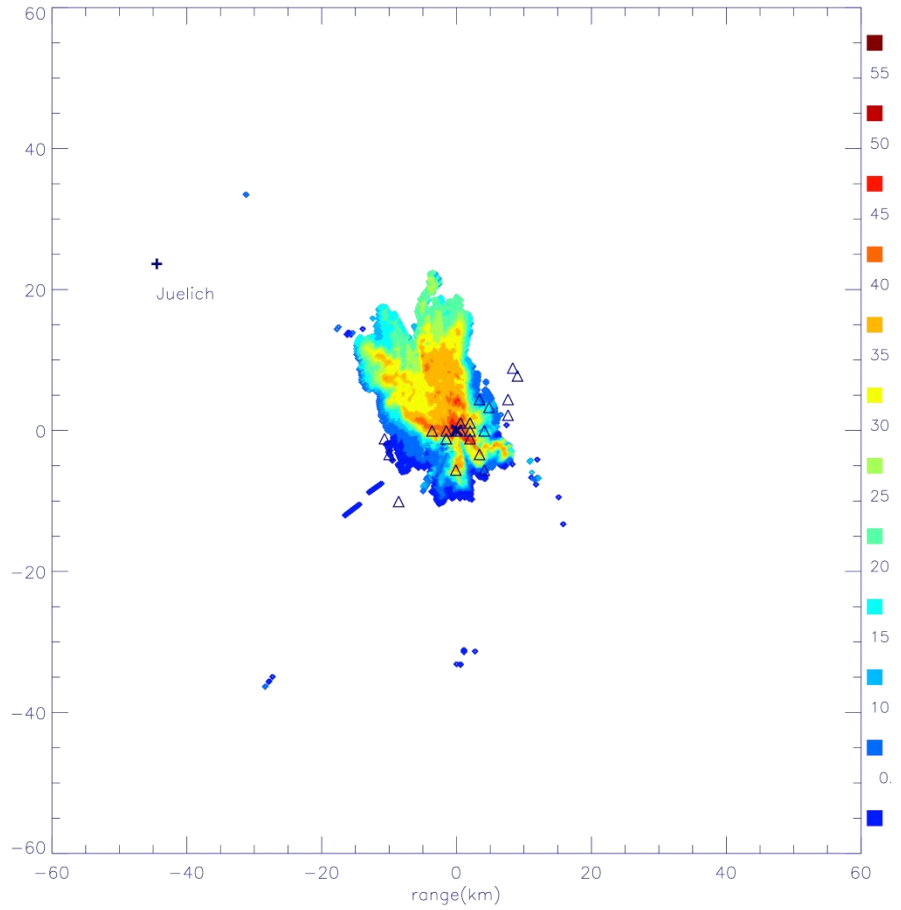
Development of the hail cell

PPI scan of Zh at 1.5° elevation

Ref 2015-07-05--15:55



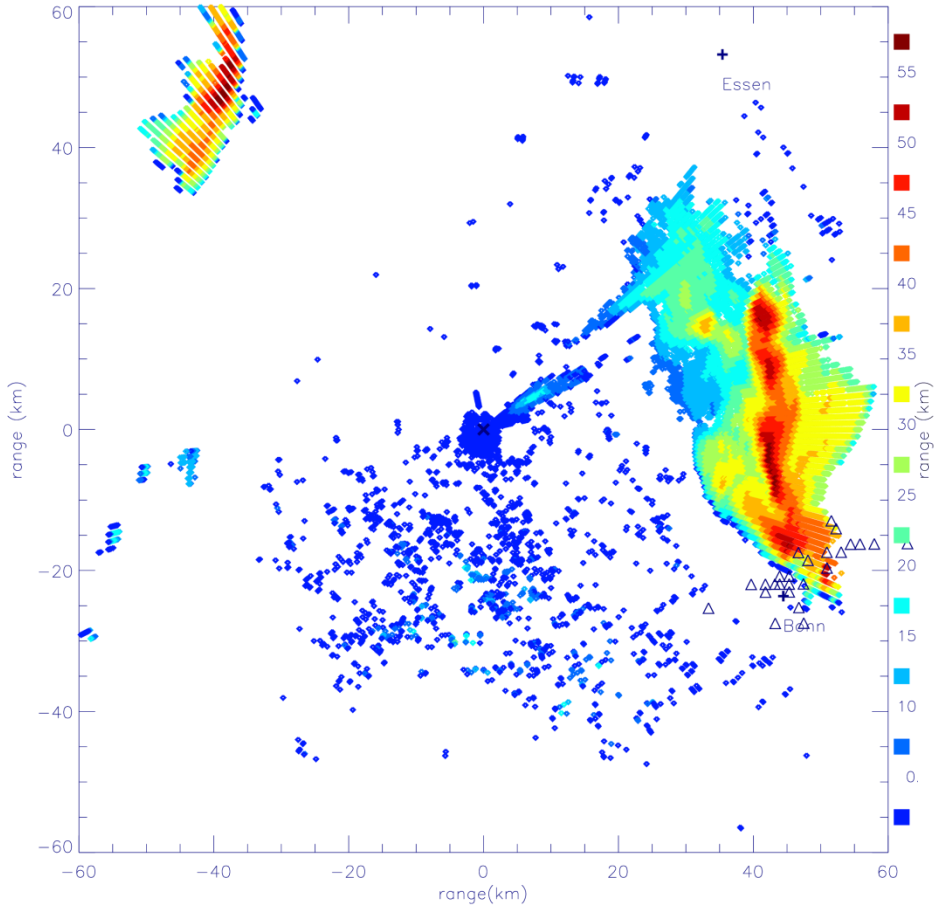
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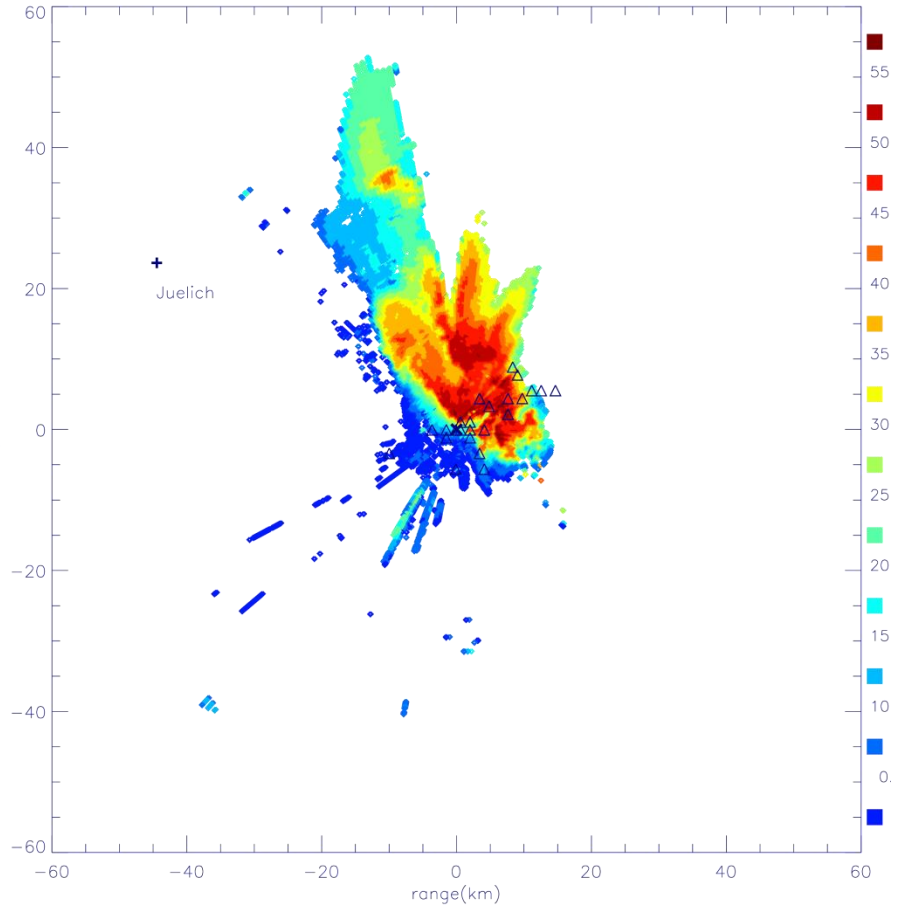
Development of the hail cell

PPI scan of Zh at 1.5° elevation

Ref 2015-07-05--16:00

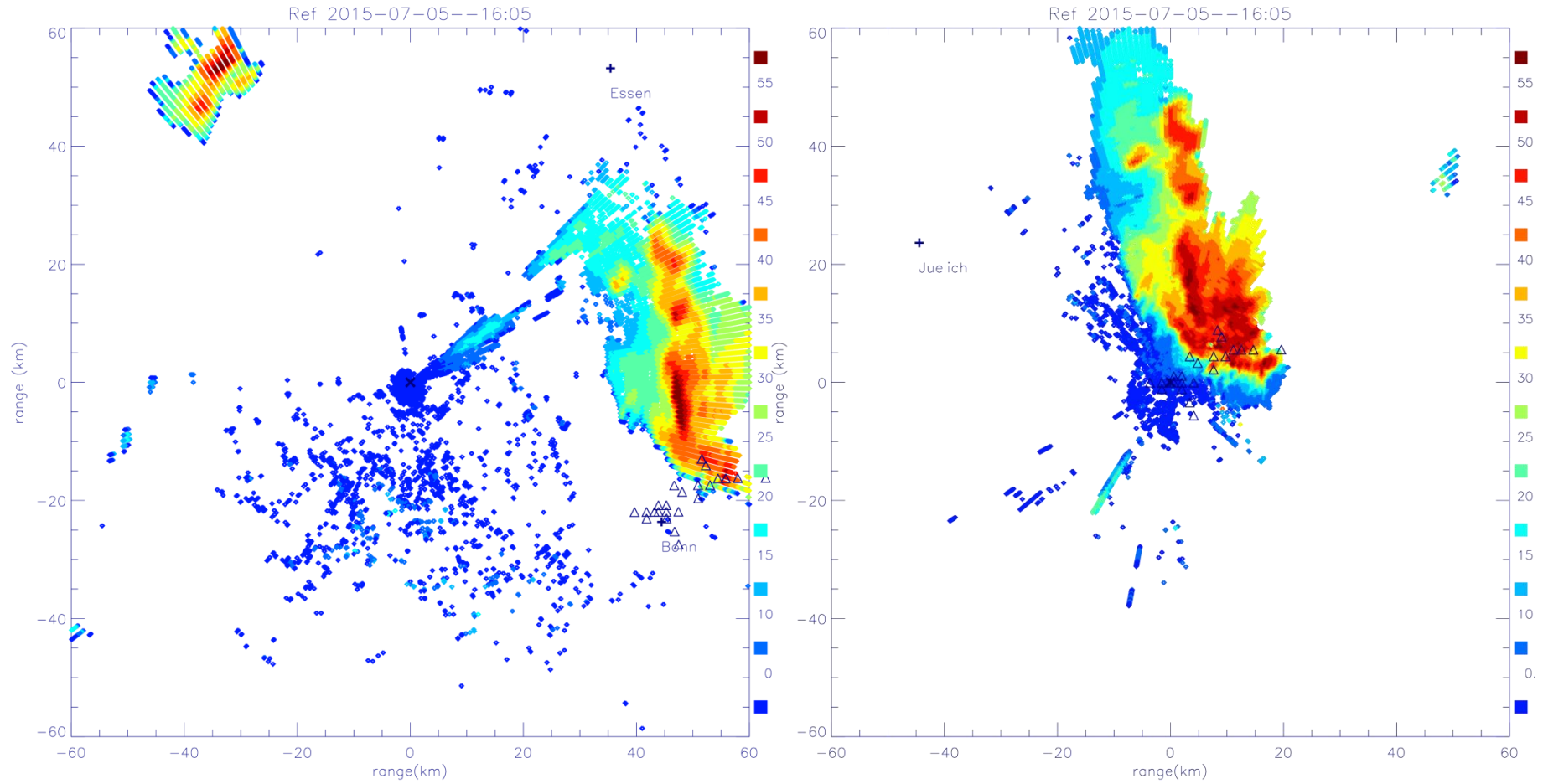


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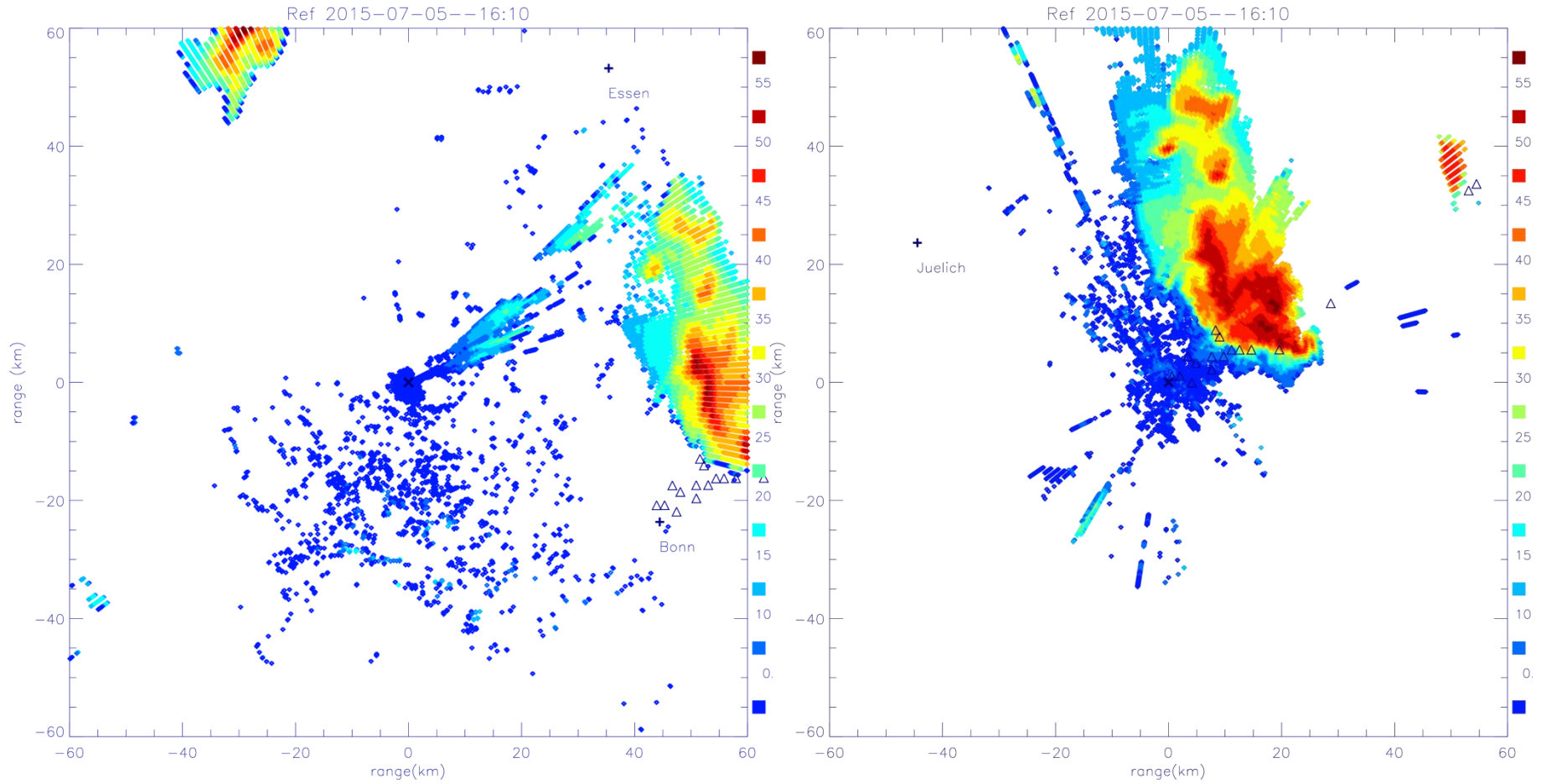
Development of the hail cell

PPI scan of Zh at 1.5° elevation



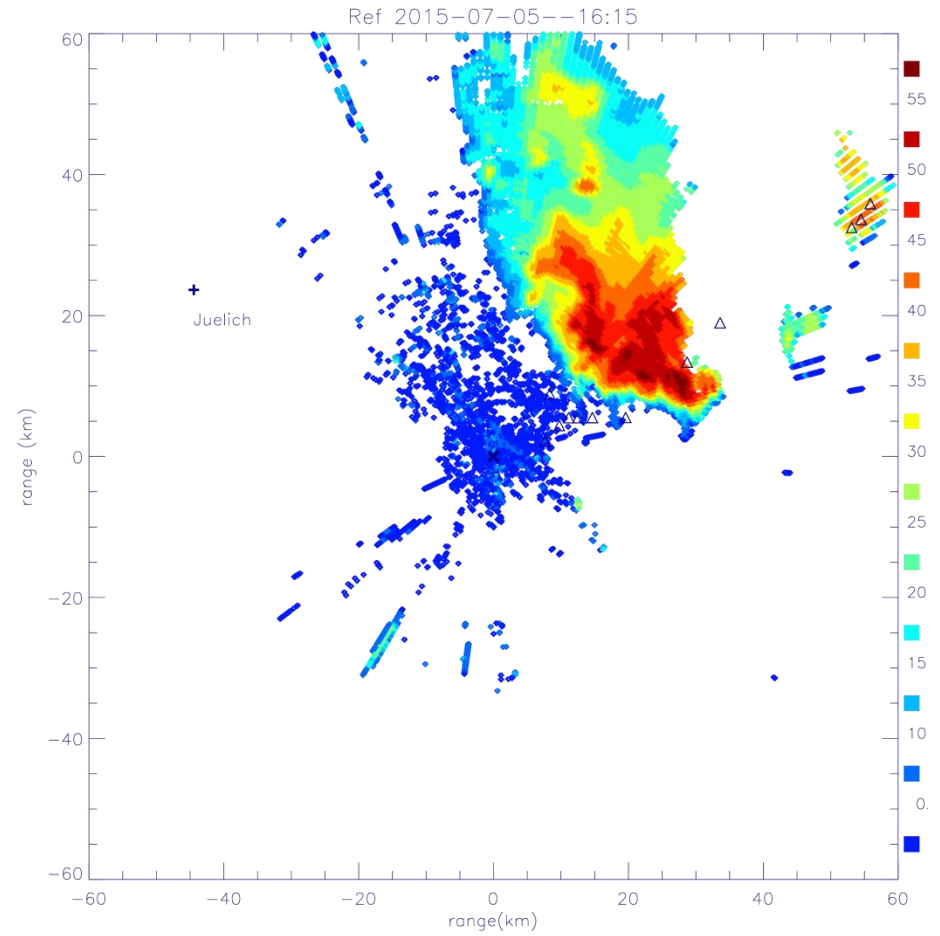
Development of the hail cell

PPI scan of Zh at 1.5° elevation



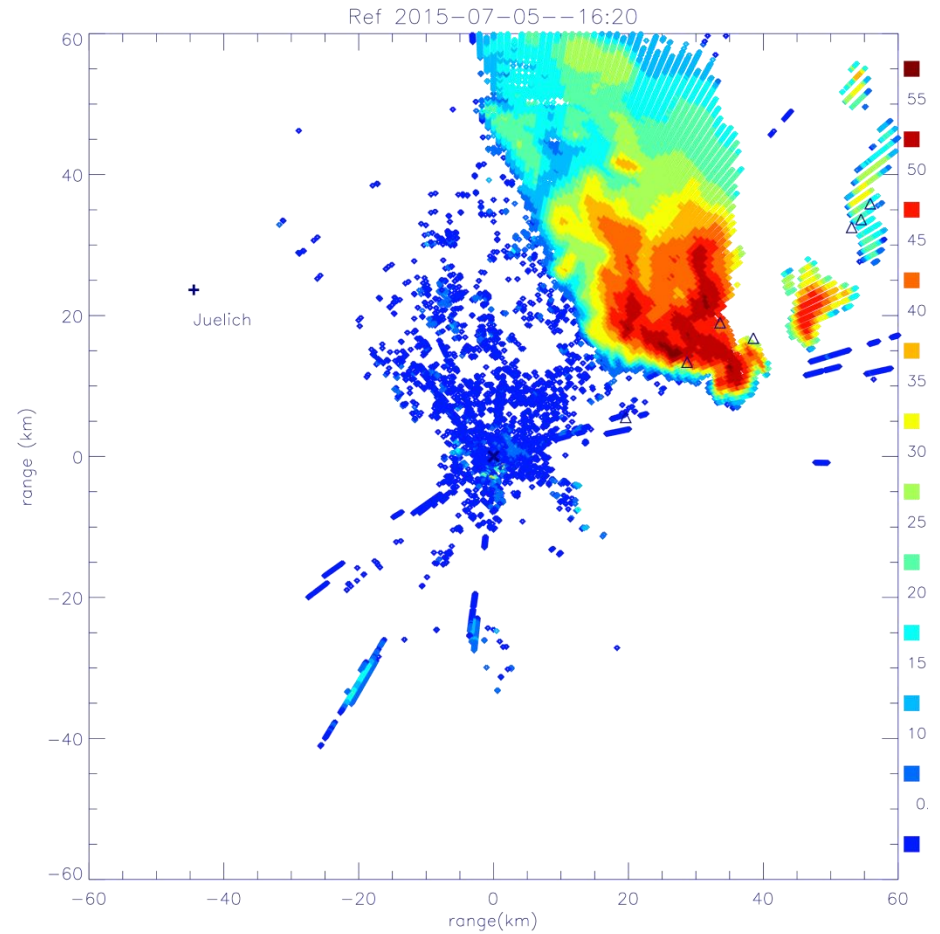
Development of the hail cell

PPI scan of Zh at 1.5° elevation



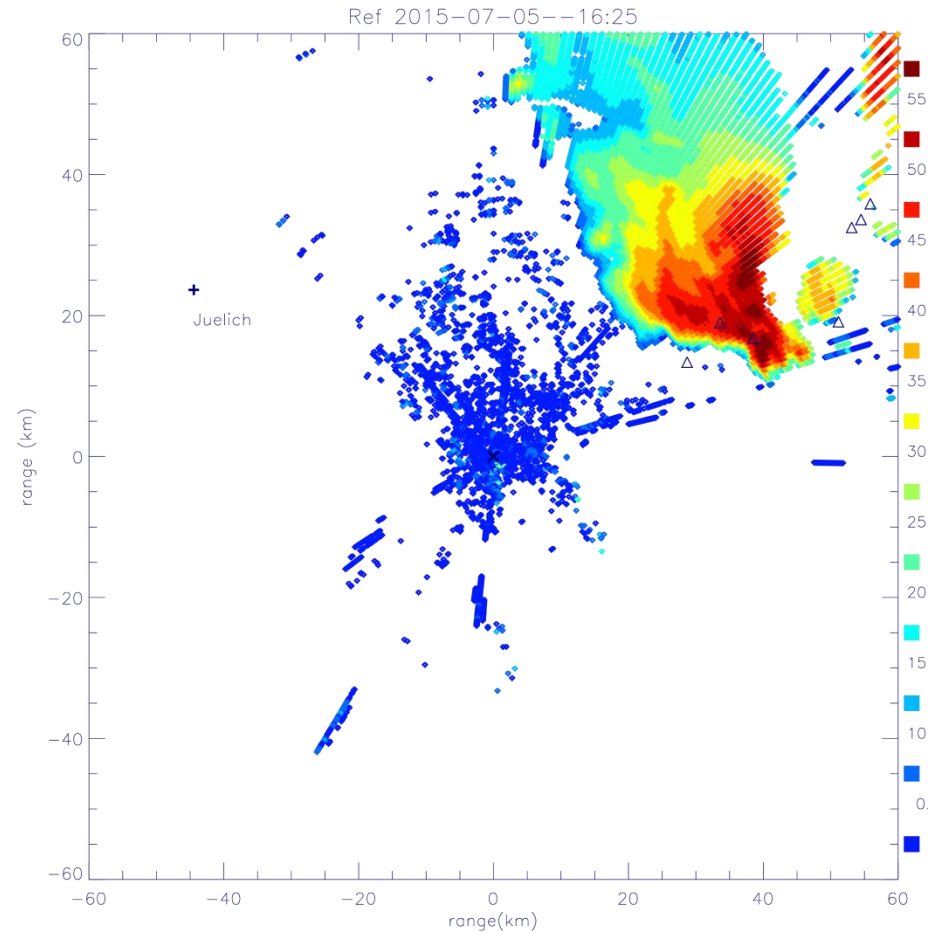
Development of the hail cell

PPI scan of Zh at 1.5° elevation



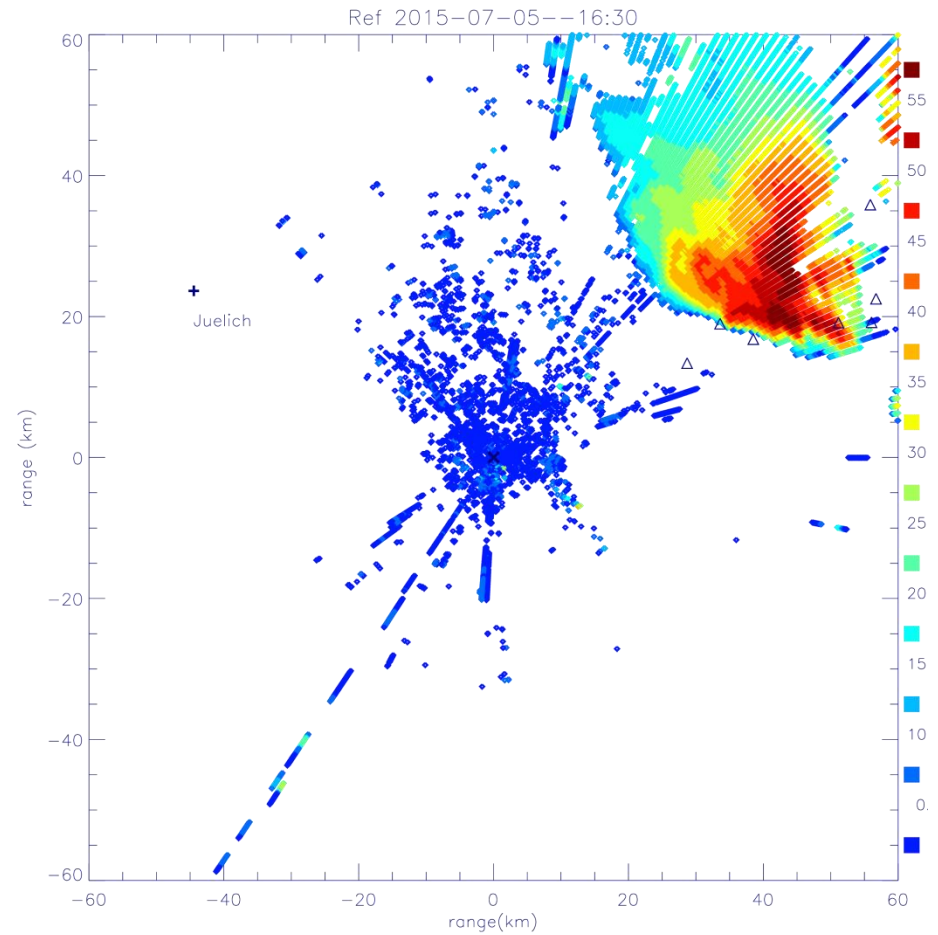
Development of the hail cell

PPI scan of Zh at 1.5° elevation



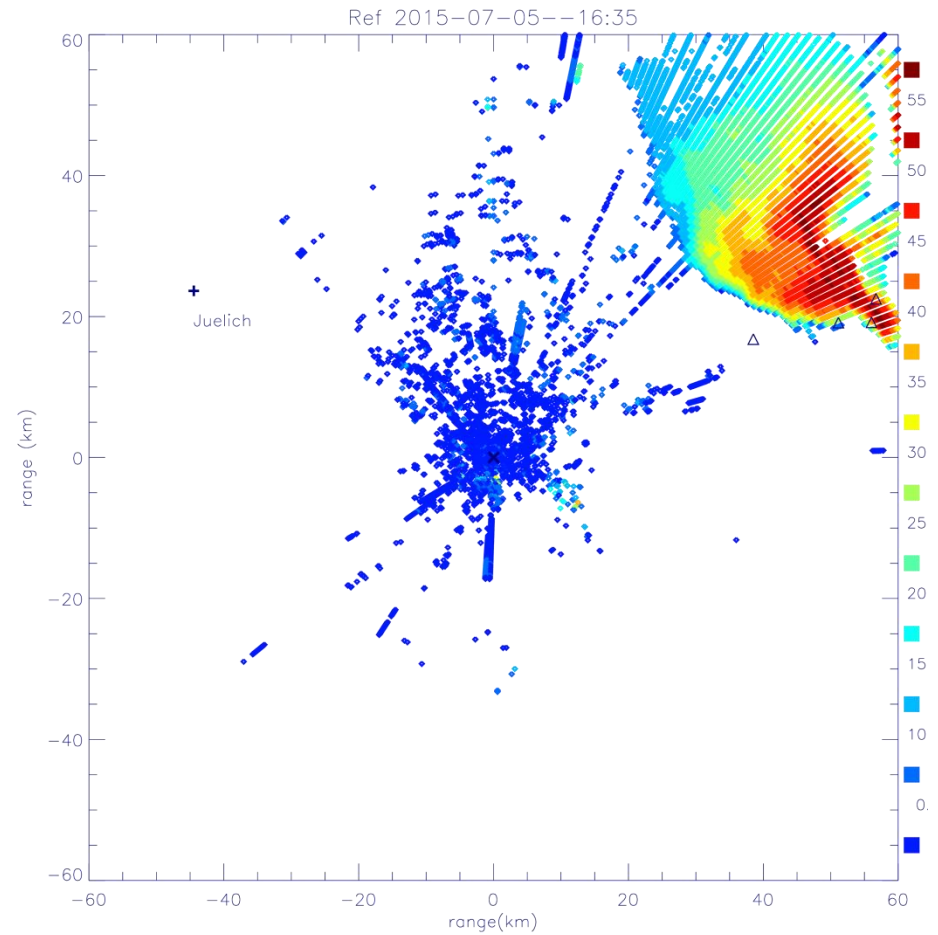
Development of the hail cell

PPI scan of Zh at 1.5° elevation



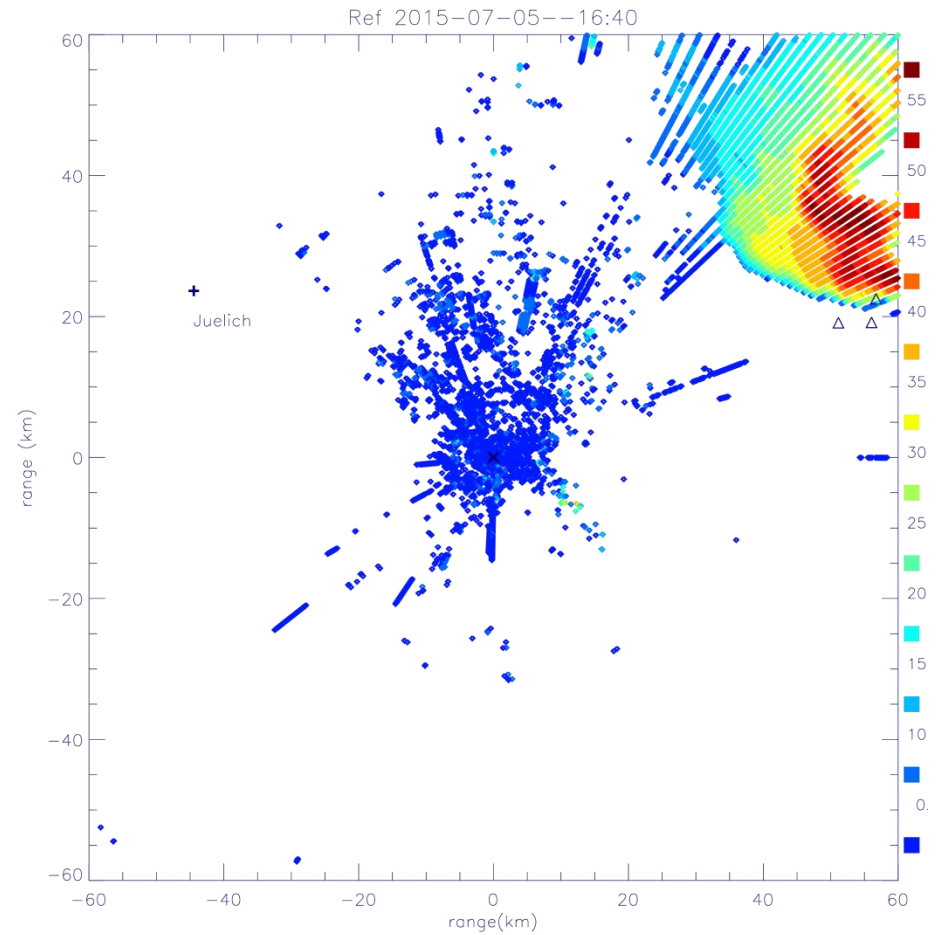
Development of the hail cell

PPI scan of Zh at 1.5° elevation



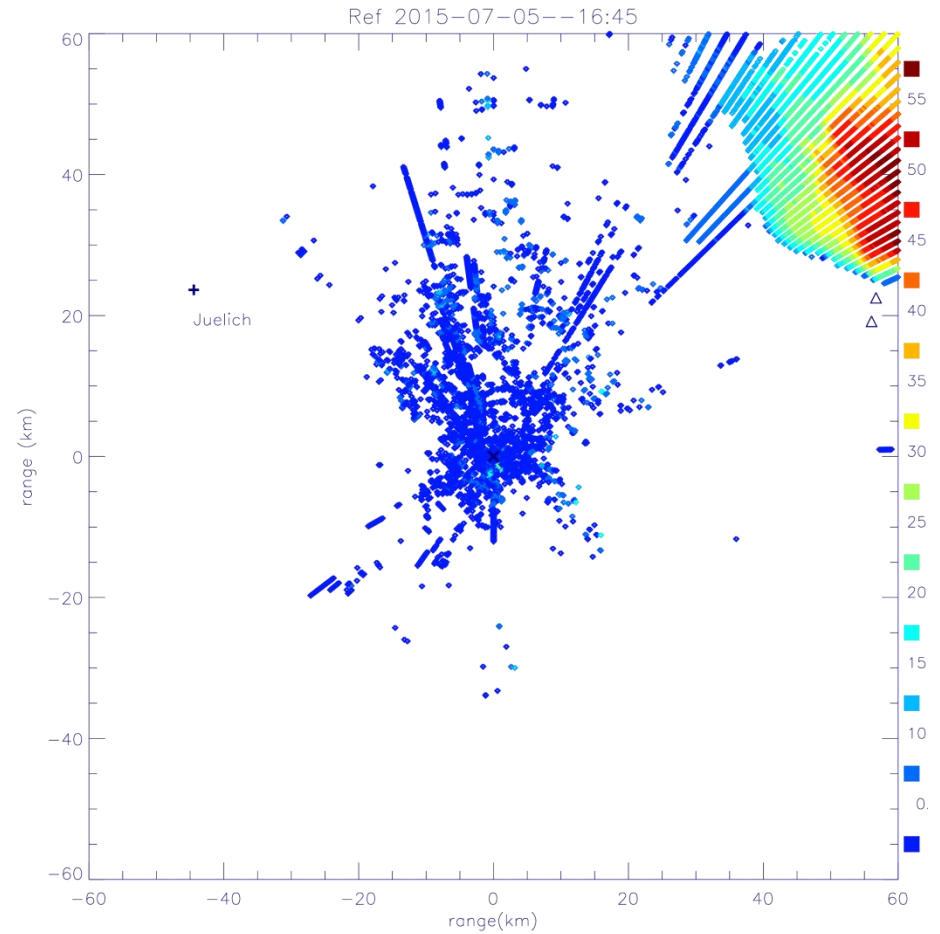
Development of the hail cell

PPI scan of Zh at 1.5° elevation

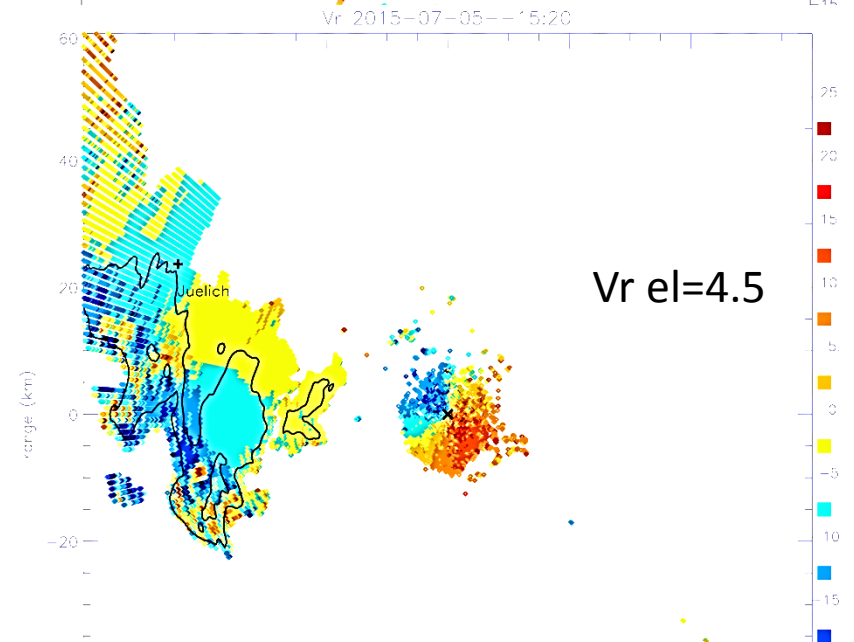
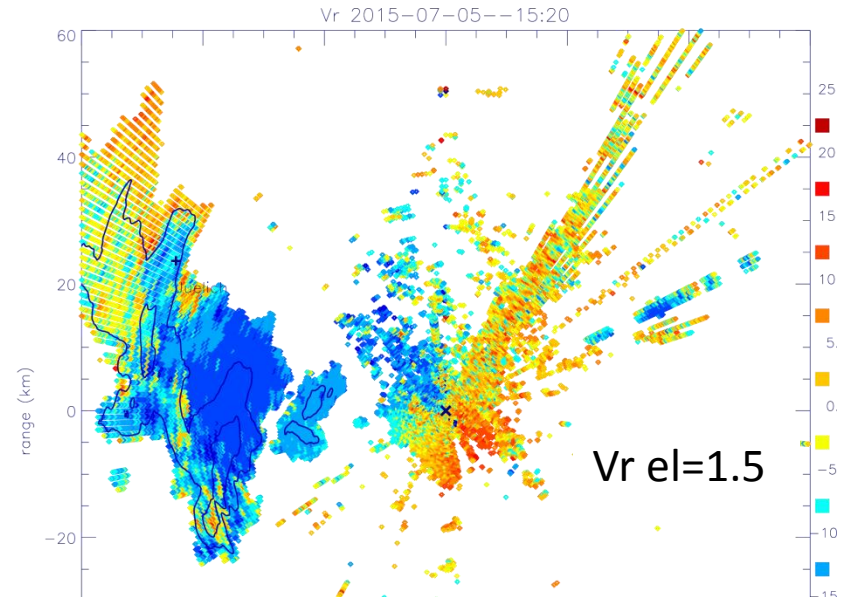
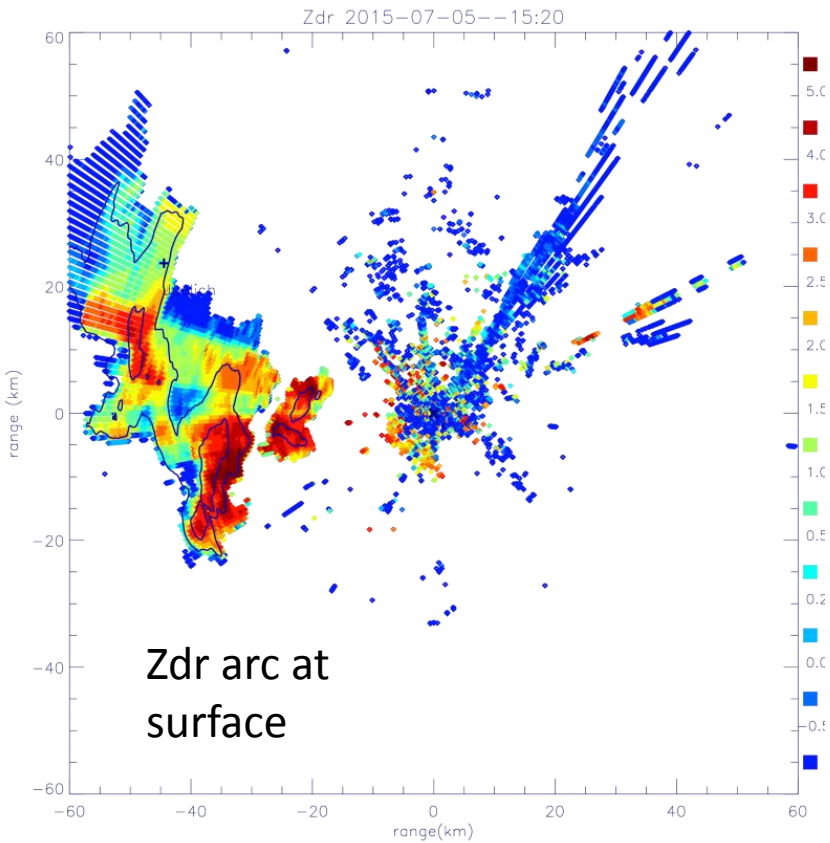


Development of the hail cell

PPI scan of Zh at 1.5° elevation

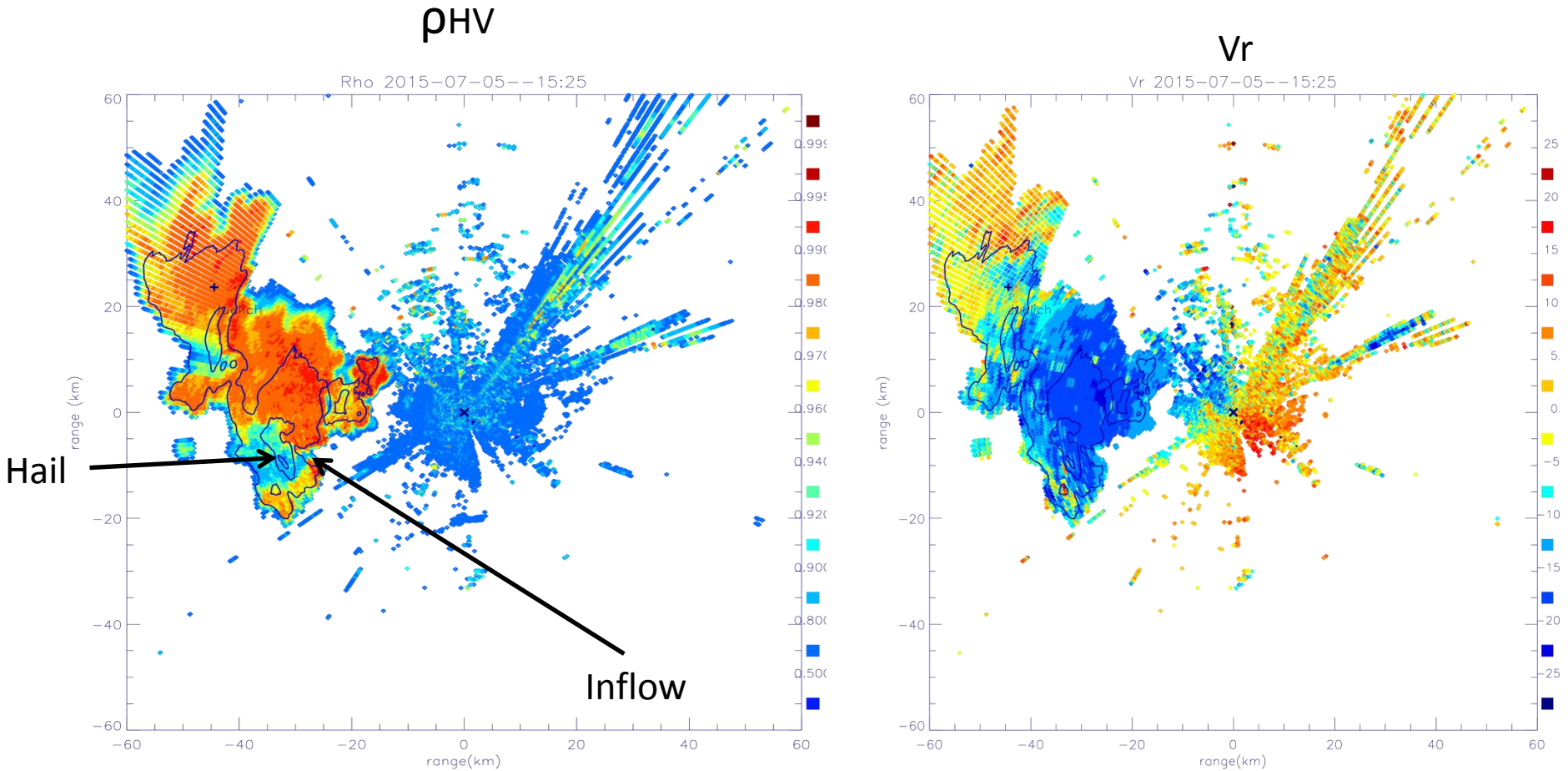


Distinct storm features



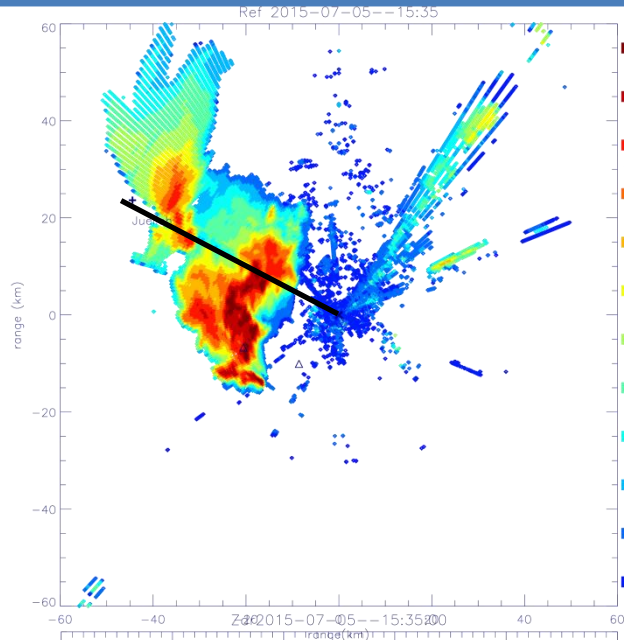
Size sorting: small and large drops are separated due to low level wind shear.

Distinct storm features

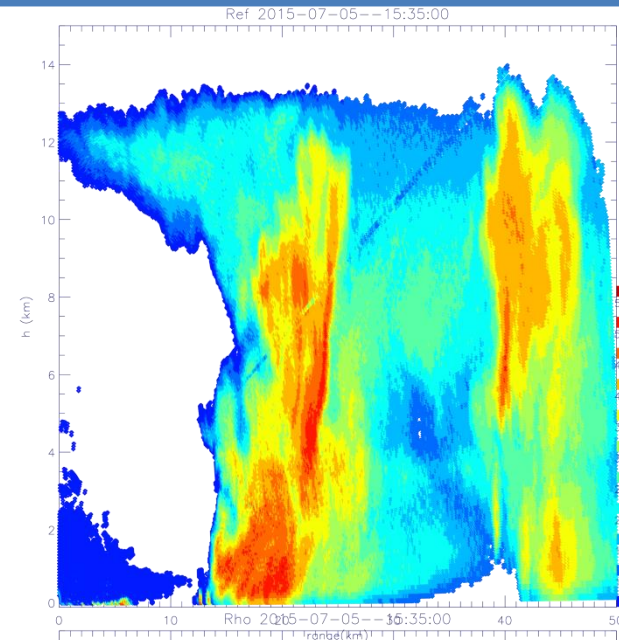


Distinct storm features

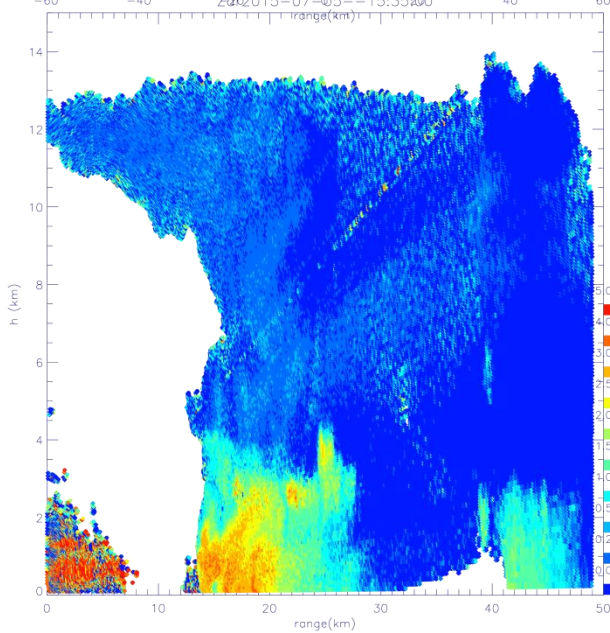
ρ_{hv}



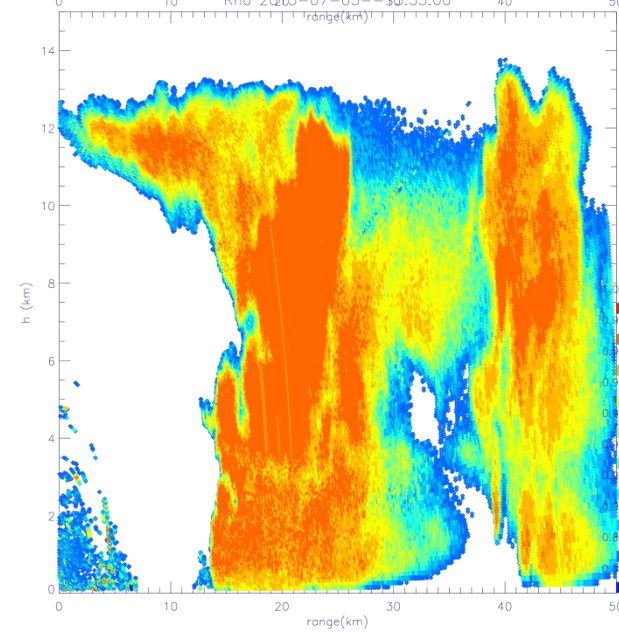
Zh



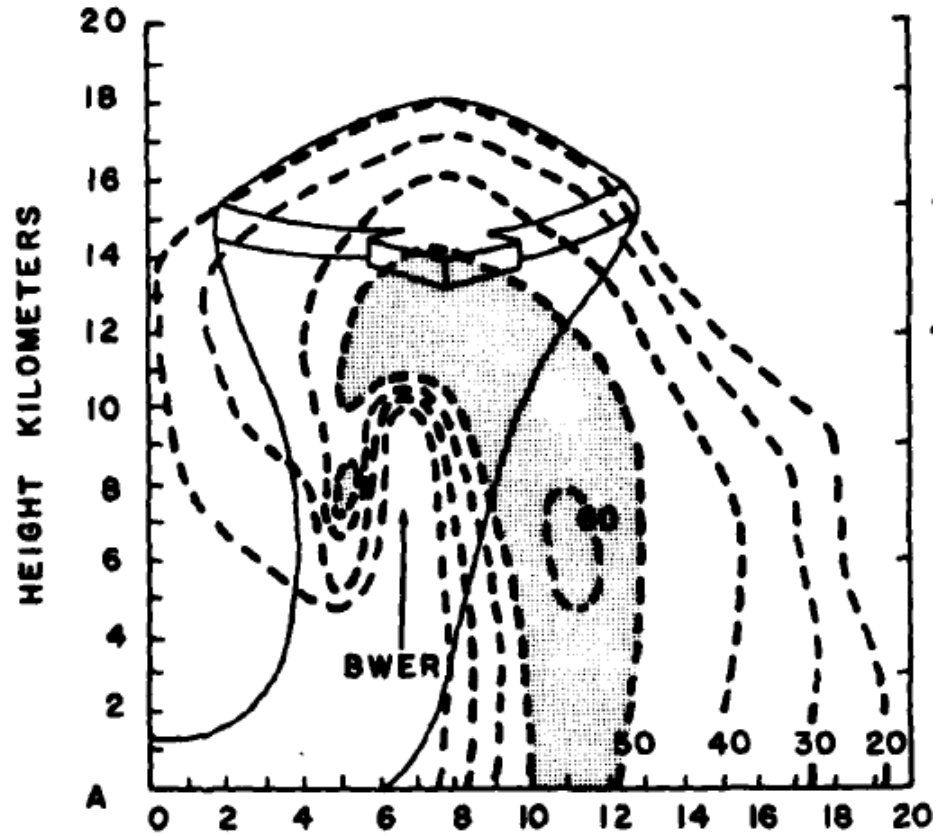
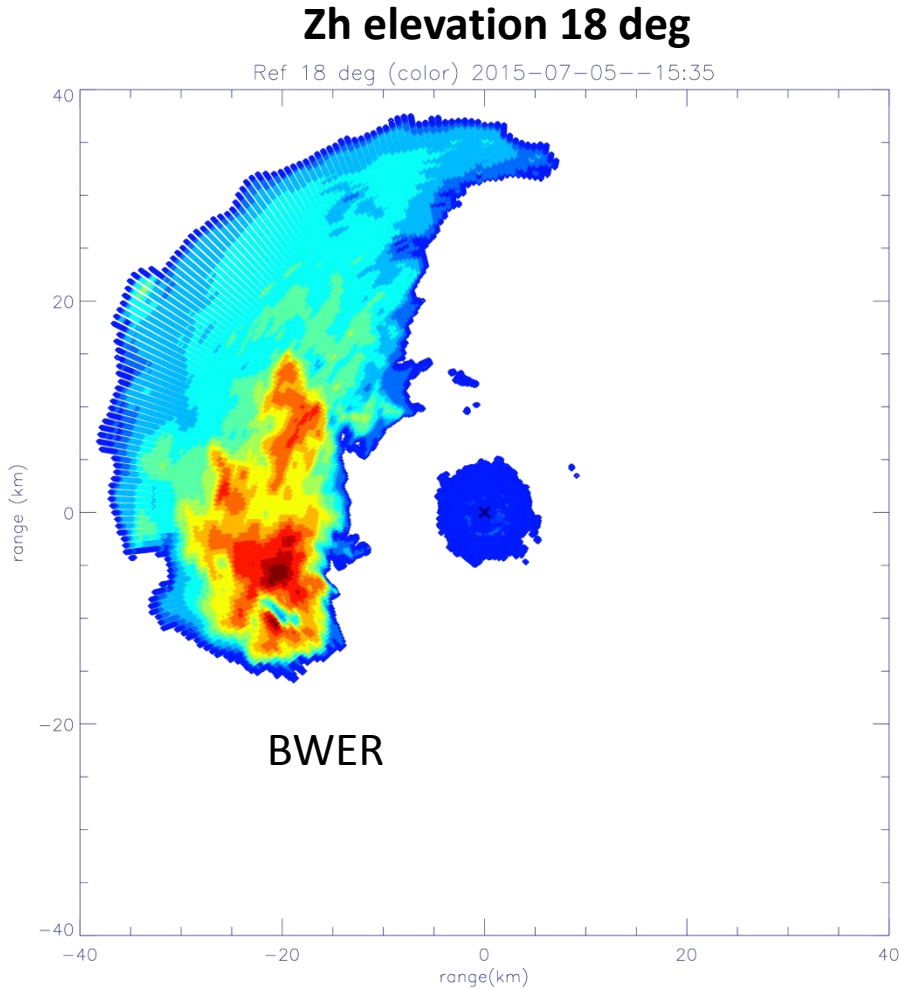
Zdr



ρ_{hv}



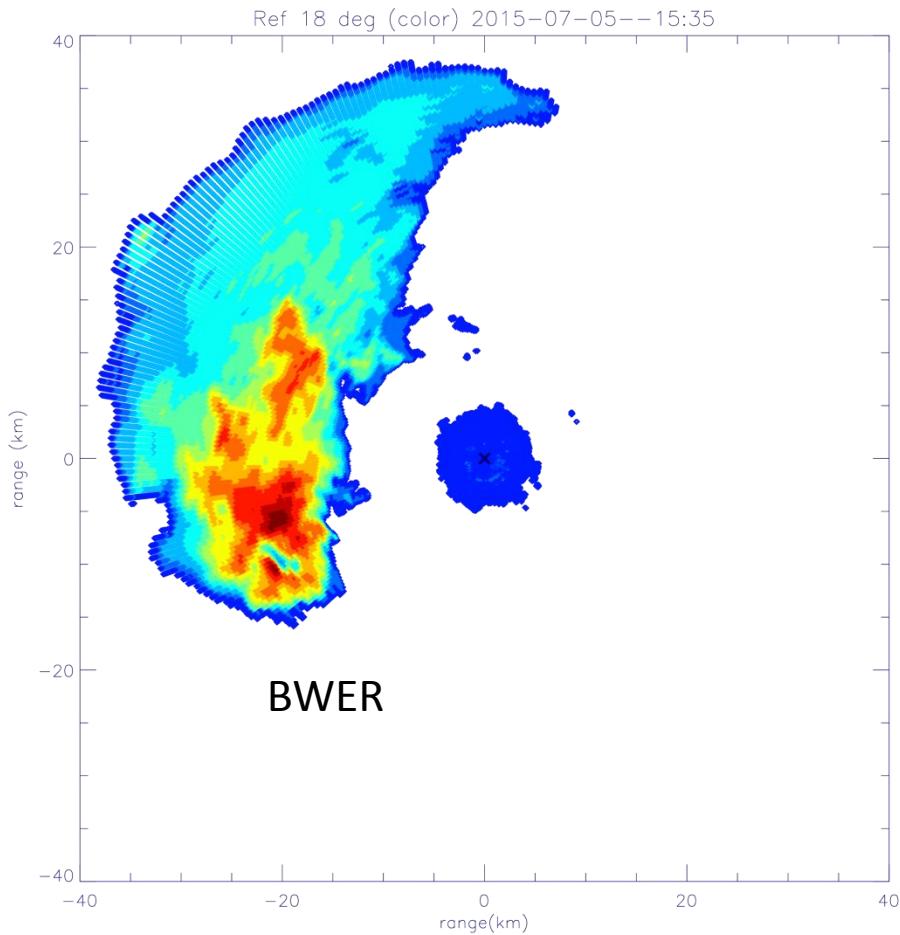
Distinct storm features



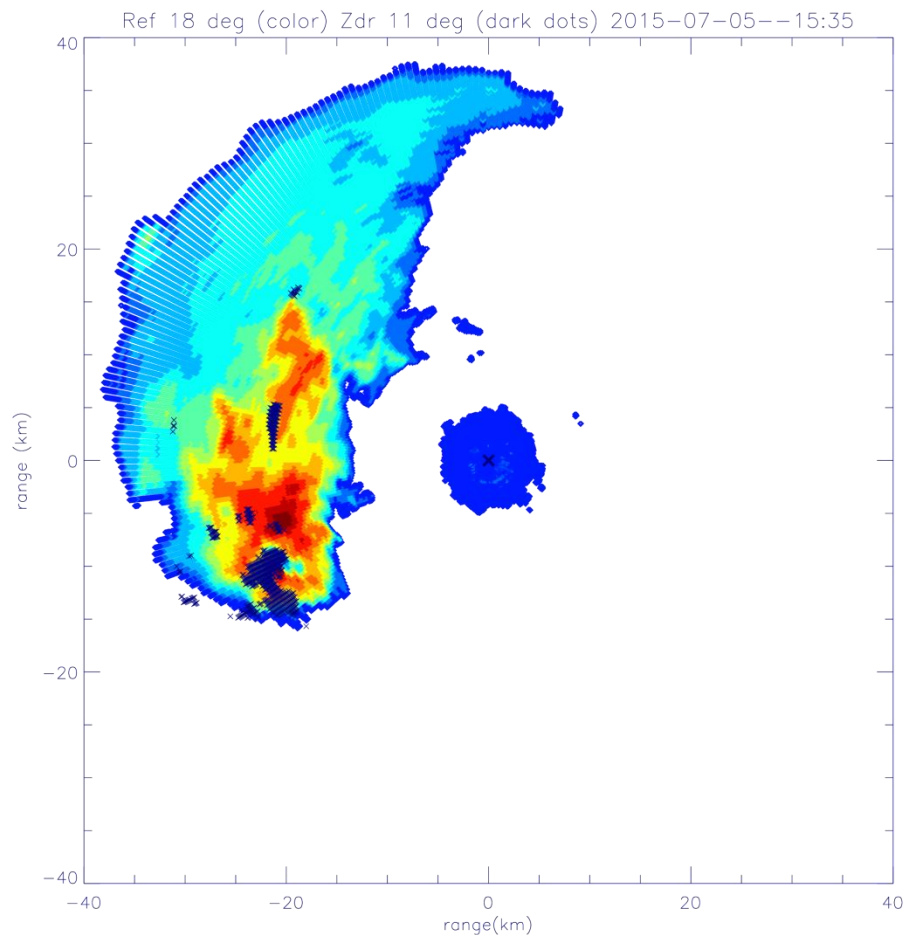
Center of the BWER at an altitude of 7.5km

Distinct storm features

Zh elevation 18 deg



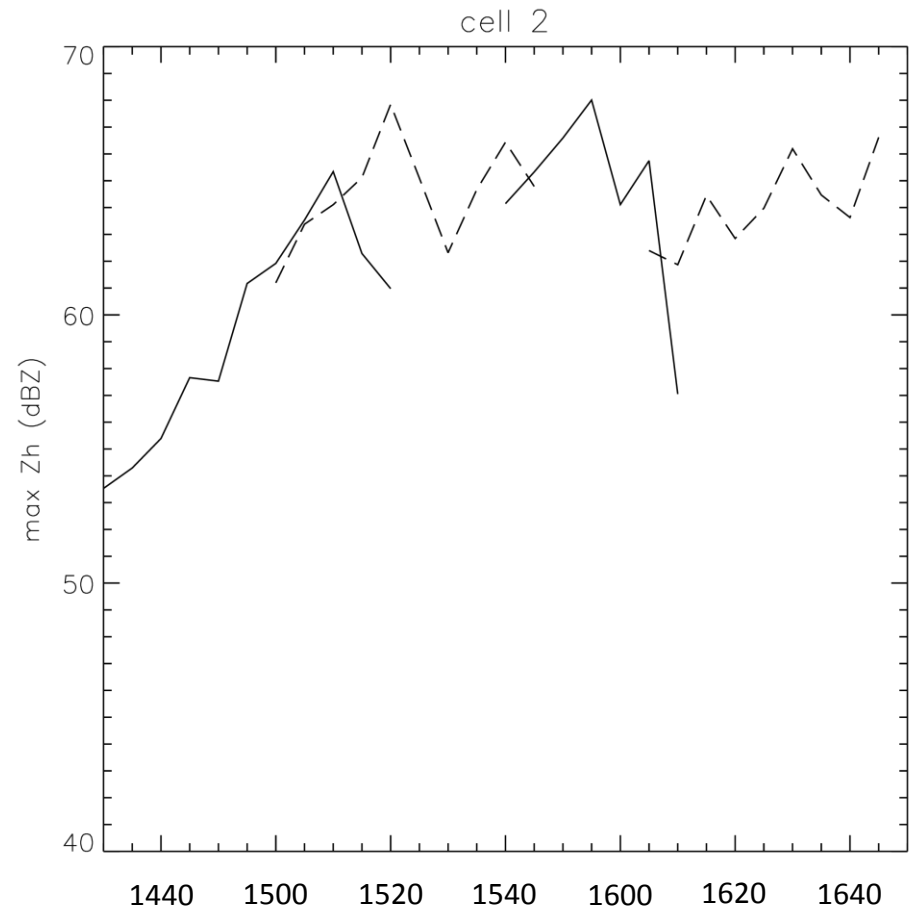
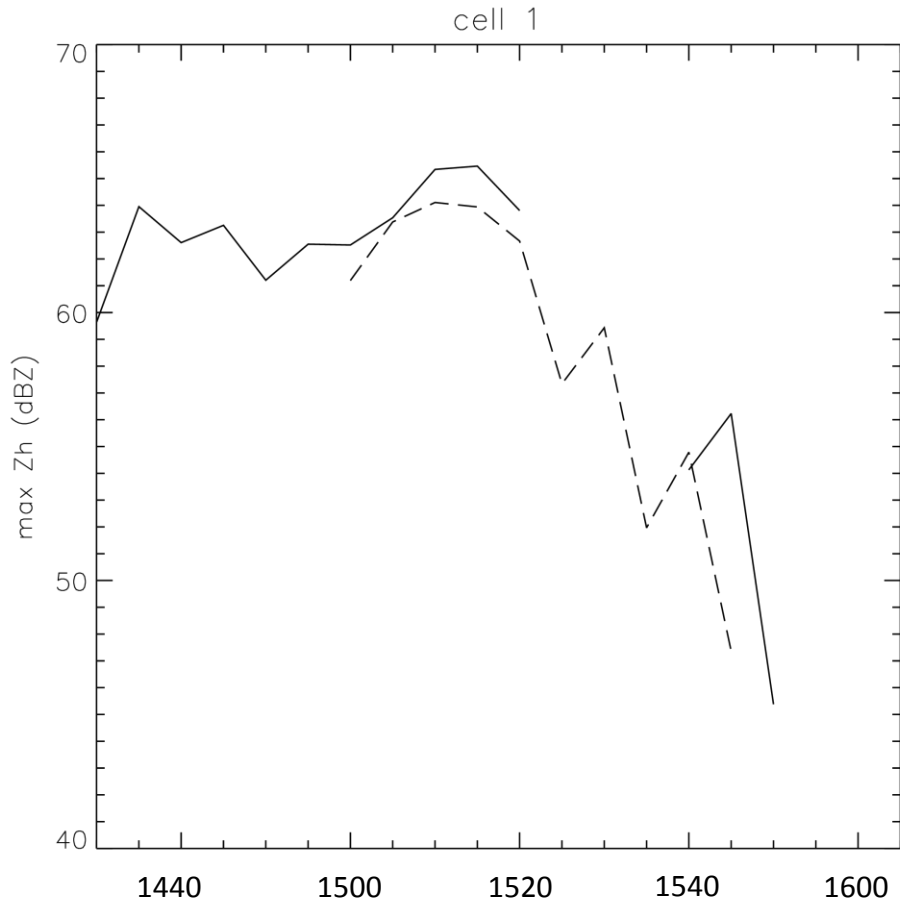
Dark dots: Zdr>1 dB elev=11 deg



Center of the BWER at an altitude of 7.5km

Altitude of Zdr column at 4.5km

Time evolution of max Zh

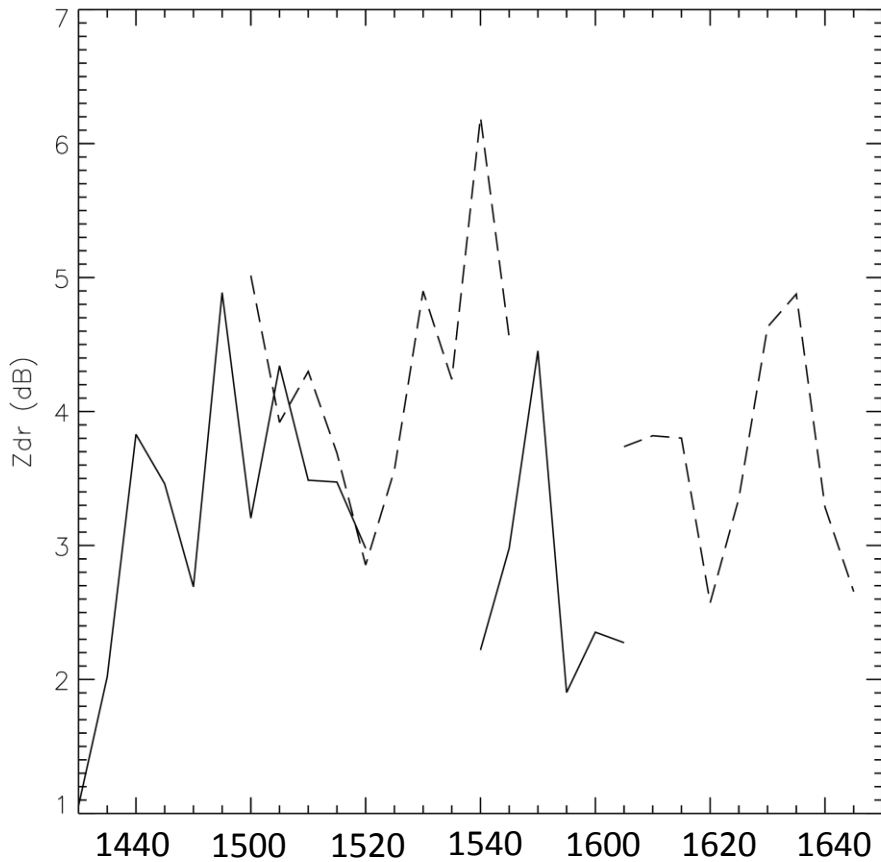


— Julich radar
- - - Bonn radar

Time evolution of max Zdr

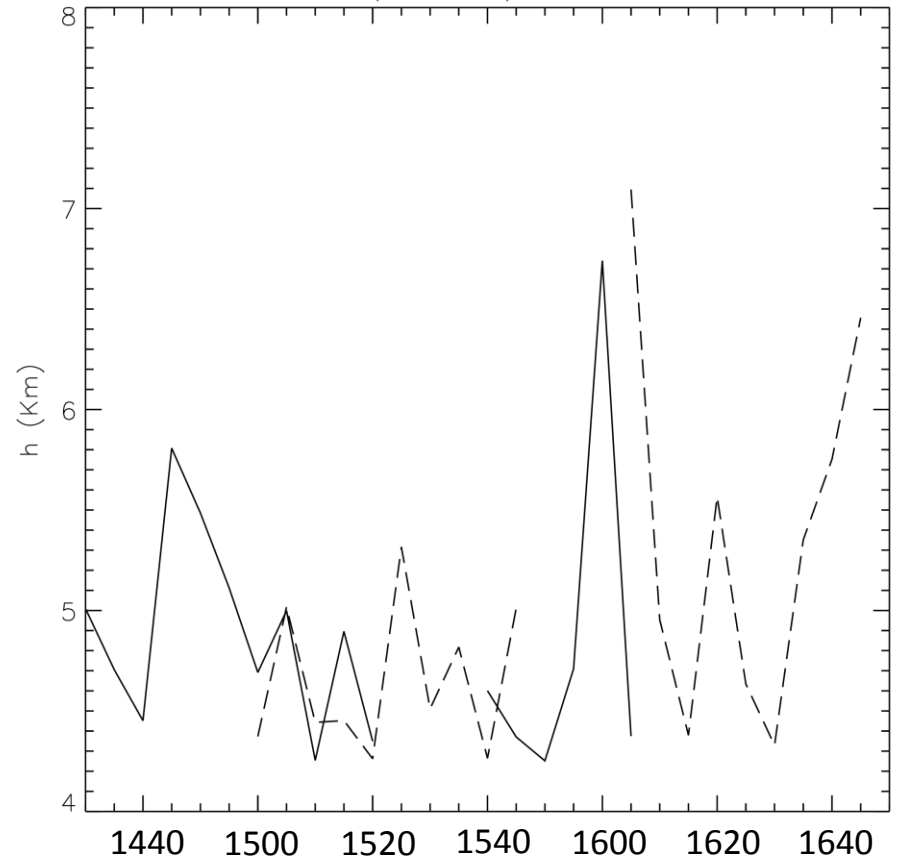
Max Zdr in the Zdr column (above 4.25km)

cell 2



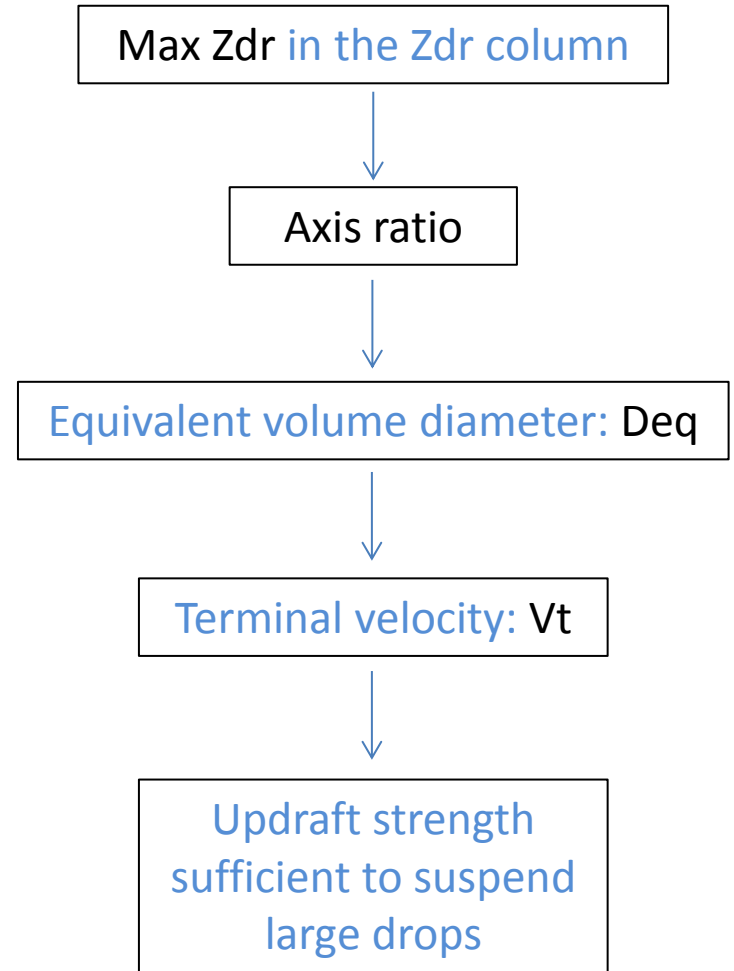
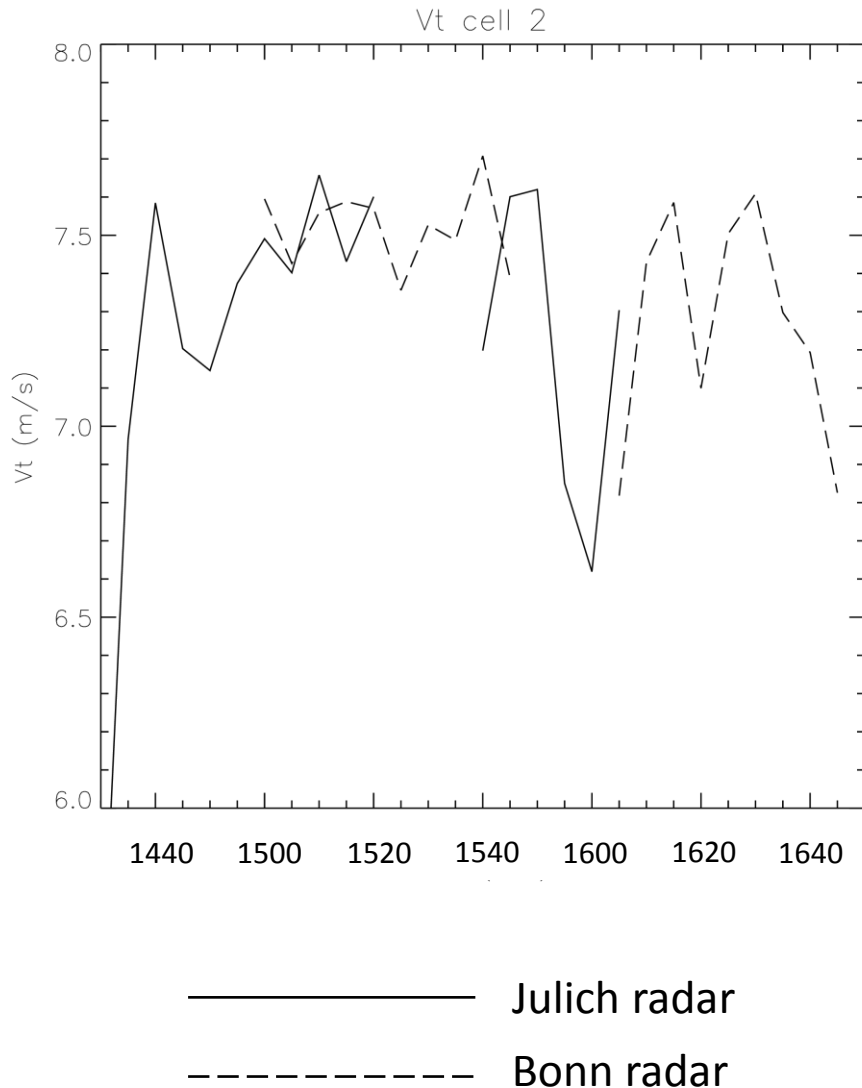
Altitude corresponding to Zdr max

$h(\text{Zdrmax})$ cell 2



———— Julich radar
----- Bonn radar

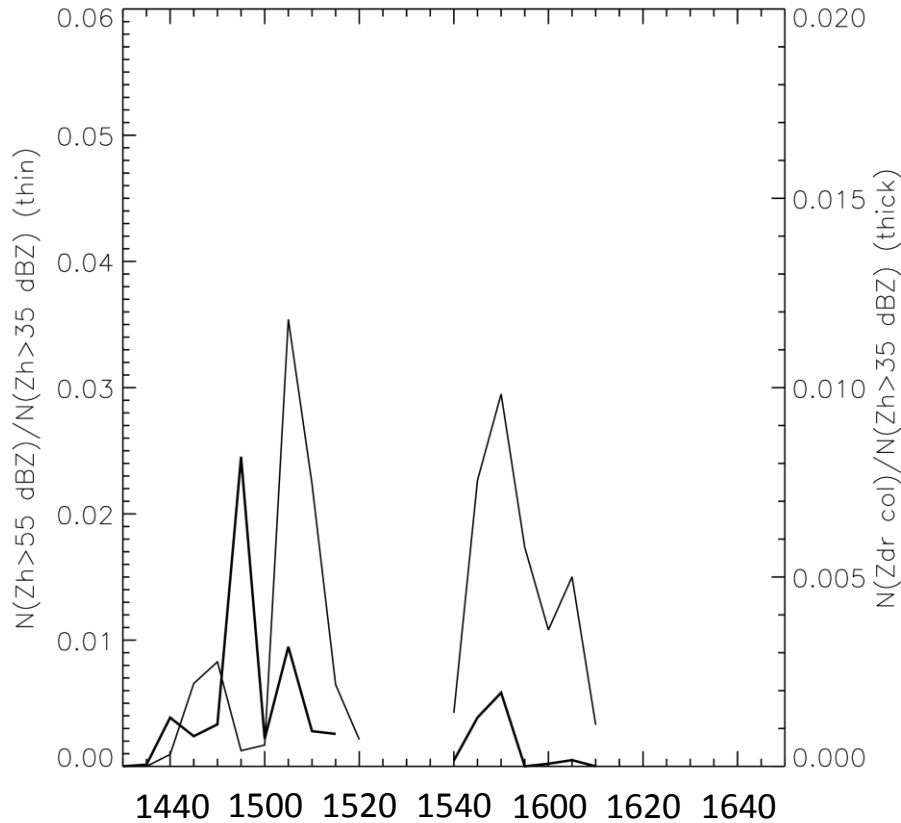
Time evolution of max updraft speed



Zdr Columns and hail

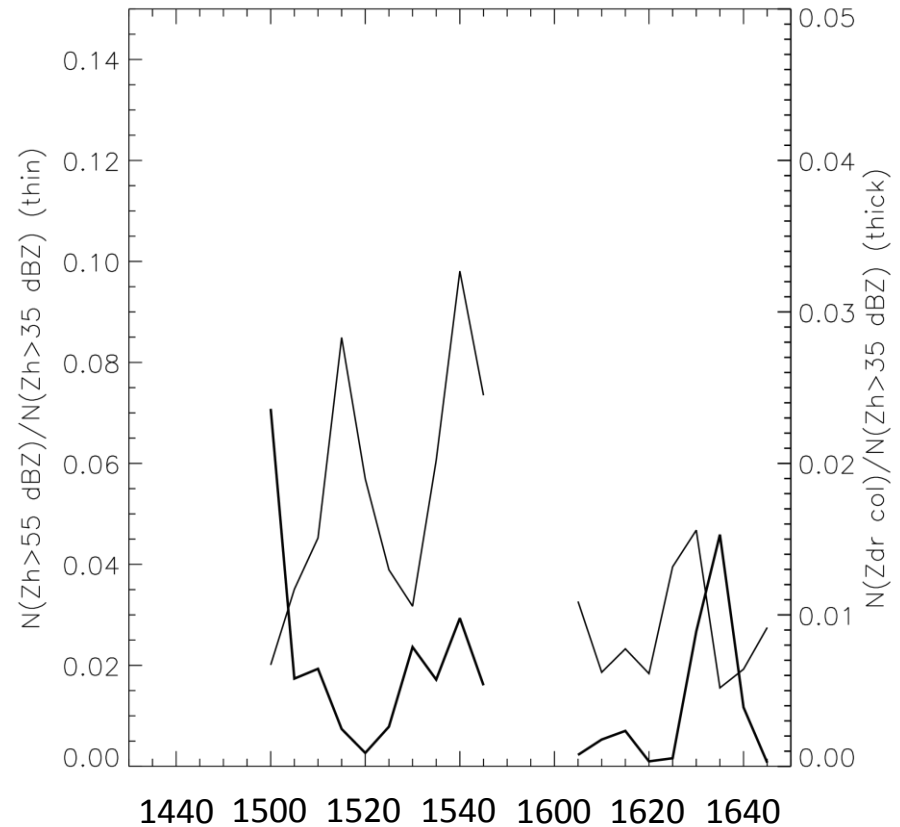
Jülich radar

cell 2



Bonn radar

cell 2

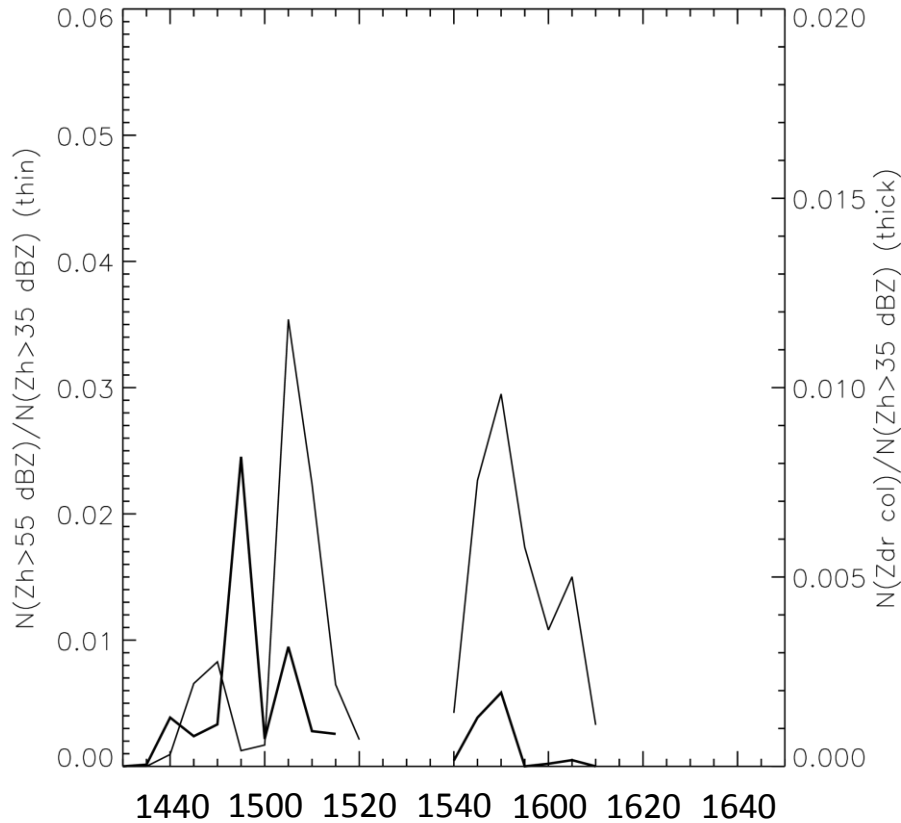


- N $Z_h > 55$ (proxy for Hail)
- N Zdr column

Zdr Columns and hail

Jülich radar

cell 2

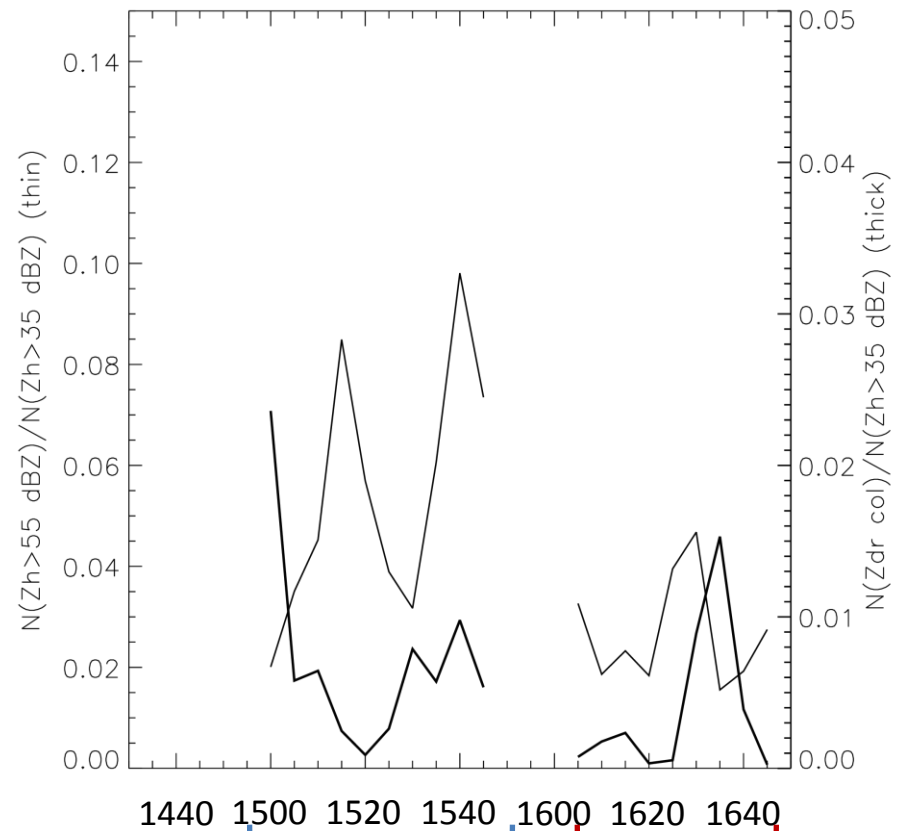


Corr 10 min
lag= 0.78

Corr
no lag= 0.81

Bonn radar

cell 2



Corr 15 min
lag= 0.28

Corr -5 min
lag= 0.82

Summary

- Supercell formed in unstable conditions producing **large hail near Bonn**
- **Strong attenuation** and **differential attenuation** required correction techniques based on the detection of “hot spots”
- The supercell lasted **more than 2 hours**, and moved away from the radar domain while still very intense
- Evidence of **strong updrafts** from elevated **BWER** and **Zdr column**, colocated.
- **Updraft strength** was about **7 m/s** and persisted throughout the observation time, consistent with the track of hail reports.
- Growth of **Zdr columns** seem to **precede hail** at low levels only in the earlier times of observations.
- The **2 radars** show in general good **agreement**.