# Model evaluation with polarimetric Radar and with Lidar

## DLR – LMU Contributions to QUEST

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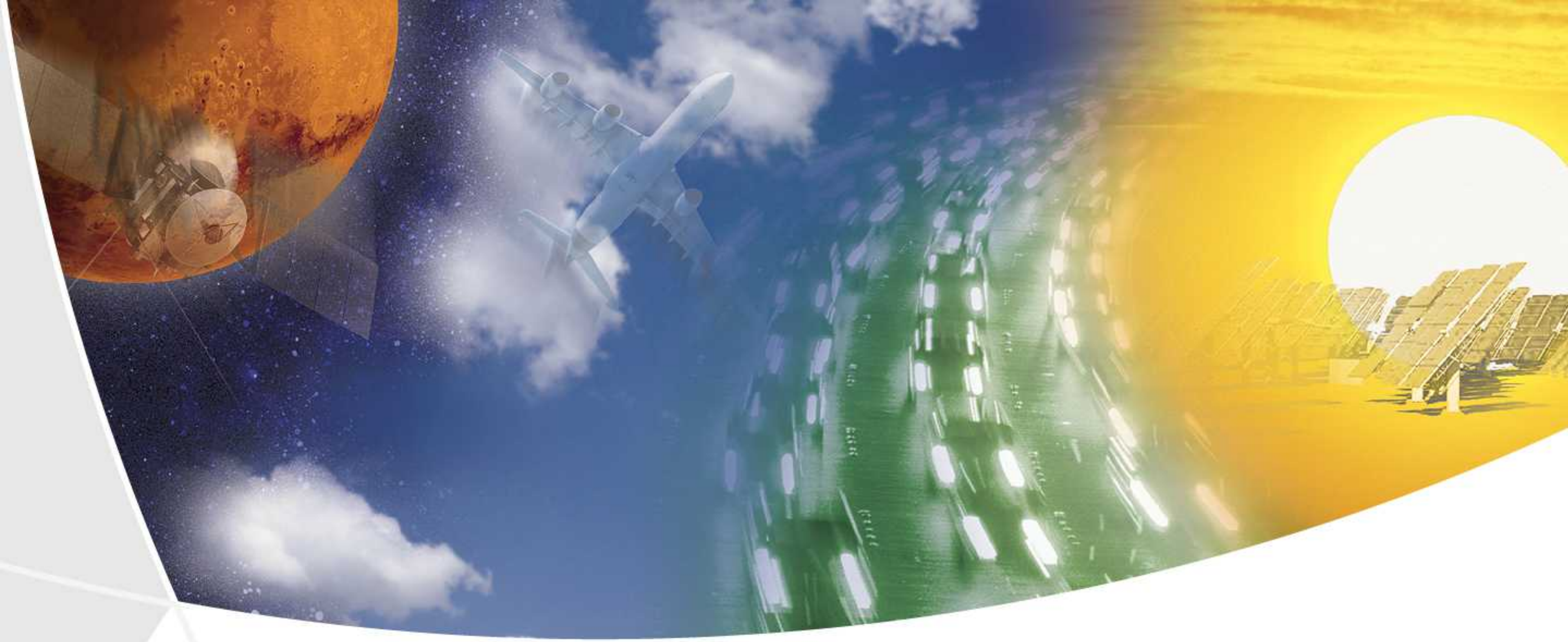

# Precipitation forecast evaluation by polarimetric radar


**Monika Pfeife**

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DLR Deutsches Zentrum für Luft- und Raumfahrt e.V. in der Helmholtz-Gemeinschaft

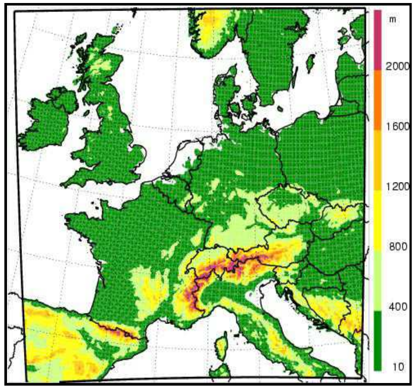
Deutsche Forschungsgemeinschaft DFG

PQP Praecipitationis Quantitativae Praedictio

Institut für Physik der Atmosphäre

# Synthetic Polarimetric Radar: **SynPolRad**


?




Reflectivity, LDR, ZDR

Polar Coordinates

Specific water content of hydrometeors

Model Grid

**Polarimetric Radar Forward Operator: SynPolRad**

Reflectivity, LDR, ZDR,

Model Grid

Synthetic Reflectivity, LDR, ZDR,

Model Grid

## Link Mesoscale Model - SynPolRad

**Output parameters of the mesoscale model**

Bulk water quantities of cloud ice and water, rain, snow and graupel

↓ For every hydrometeor type

Assumed DSD

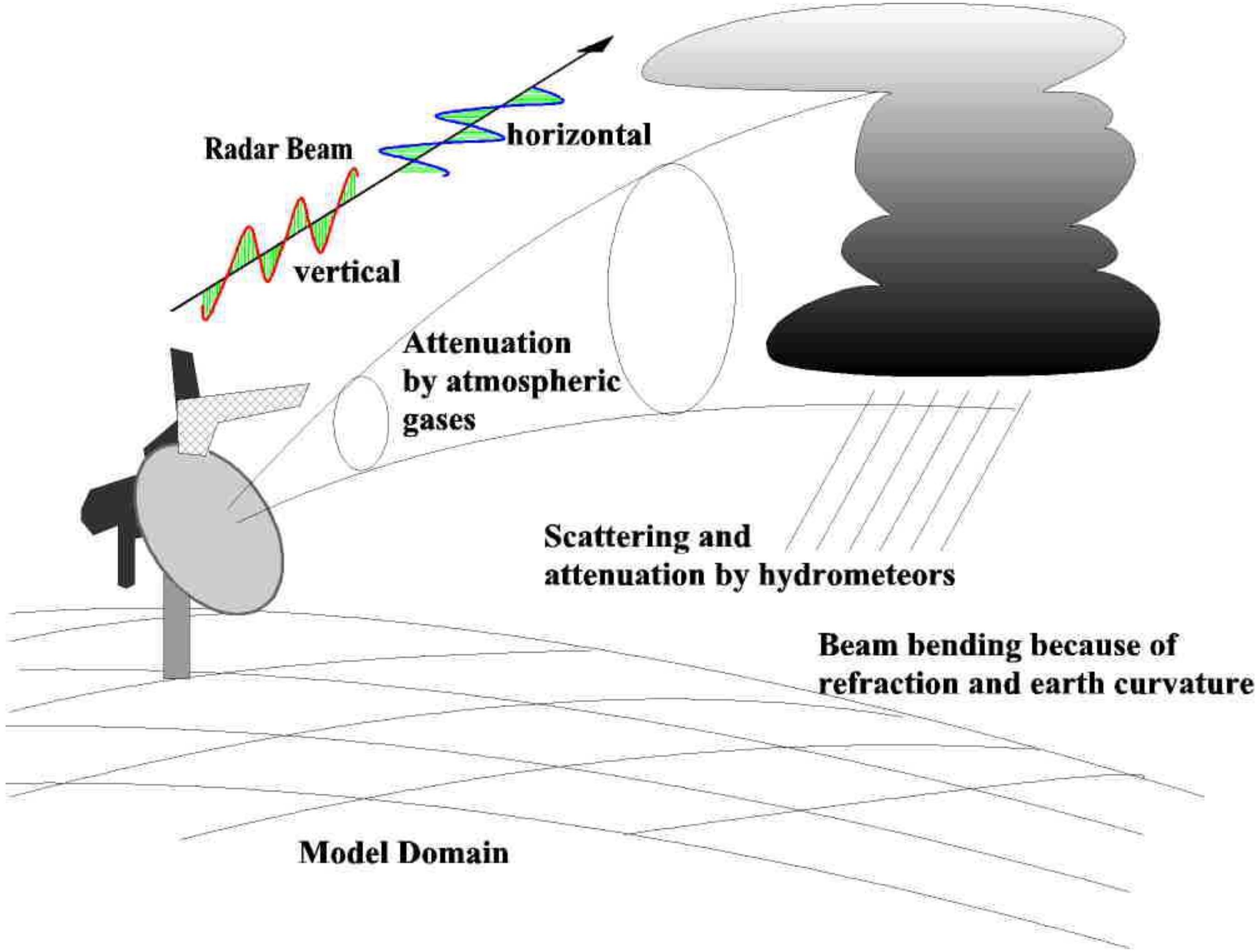
Free Parameters

| DSD (Do, No) | Density | Waterportion in melting ice | Shape | Falling behaviour (canting angle) |
|---|---|---|---|---|

**Input parameters of SynPolRad**

**Reflectivity** ← **Dielectric Constant** → **LDR, ZDR**

# Beam propagation and attenuation



# Stratiform Case: 5th of July 2005

Comparison of LMK

Version 3.16 and 3.17 :

2 component scheme

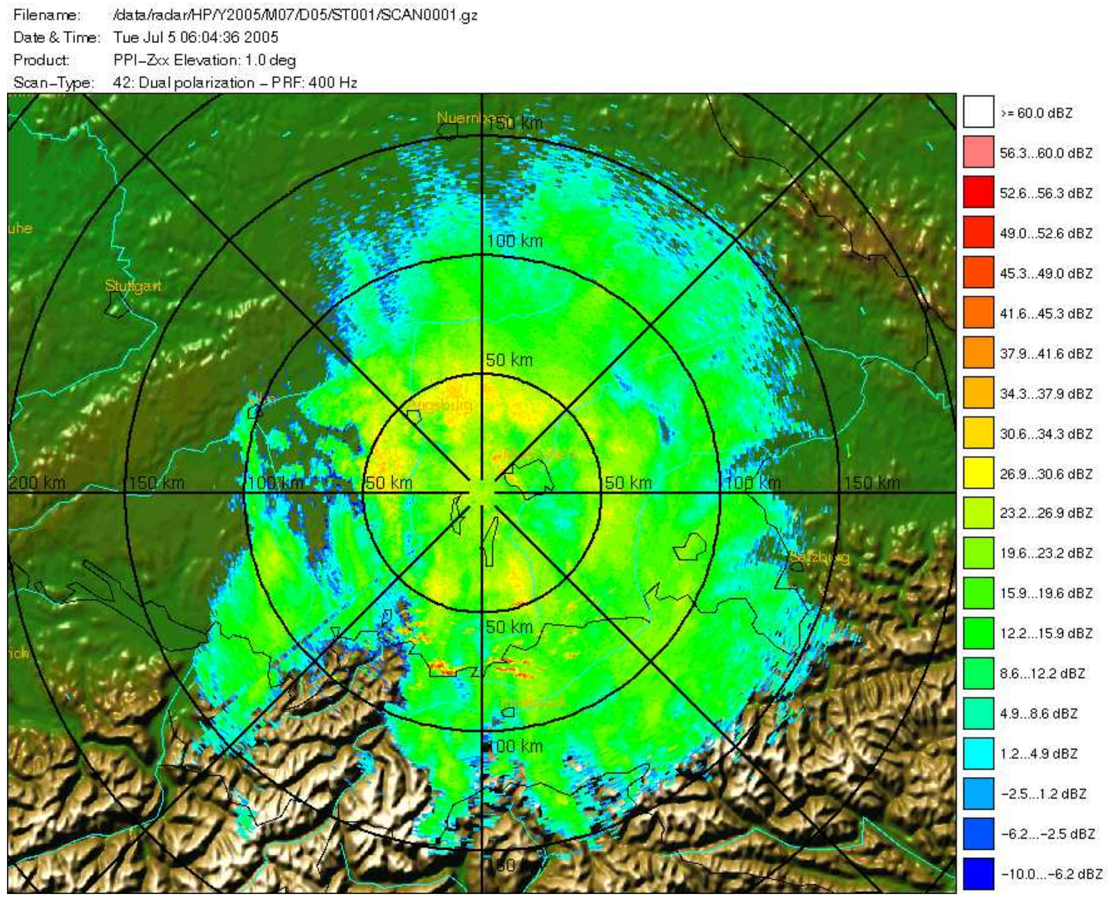
(rain, snow)

3 component scheme

(rain, snow, graupel)

Thompson (MM5)

(rain, snow, graupel)

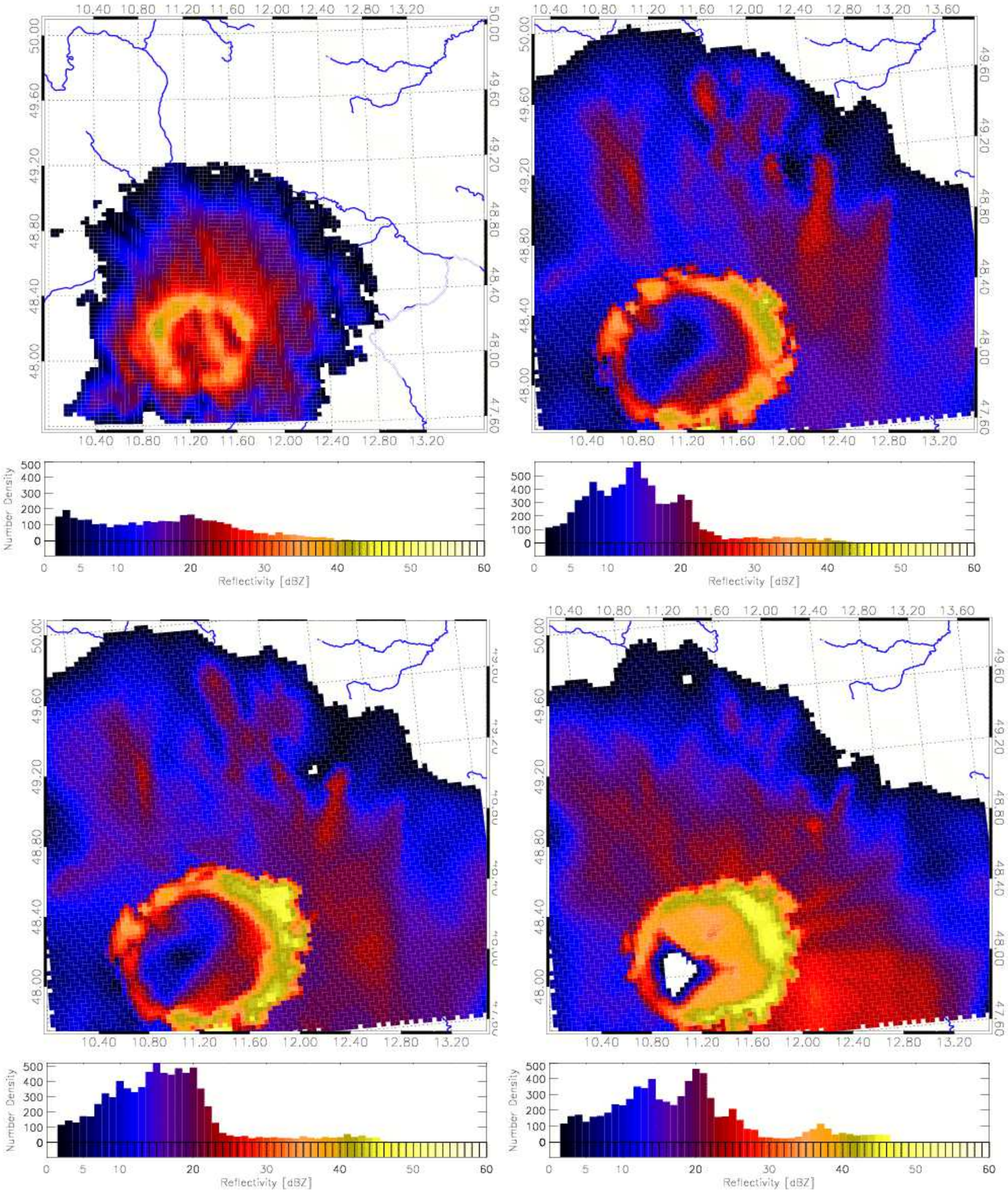


# 8 UTC

Poldirad

PPI Scan

2° Elev.




LMK 3.17:

2 comp.

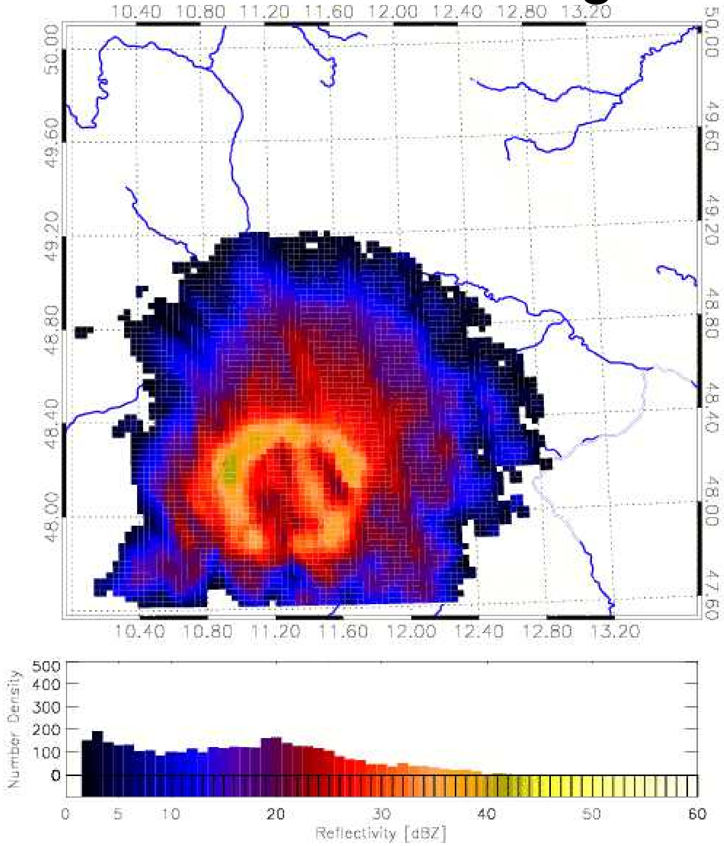
LMK 3.17:

3 comp.

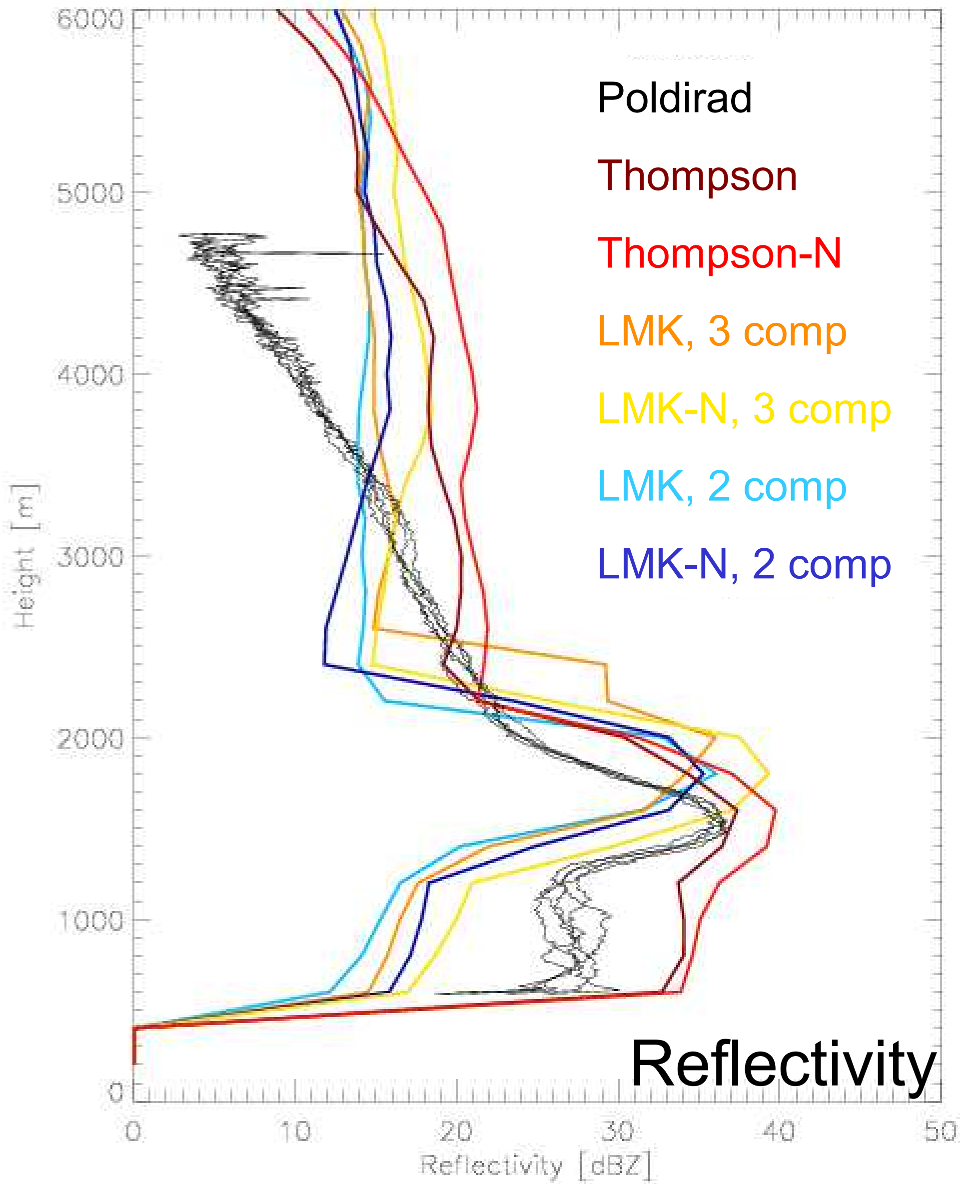
LMK 3.17:
Thompson
Scheme

# 8 UTC: 2° PPI Scan

Mean over azimuth angles

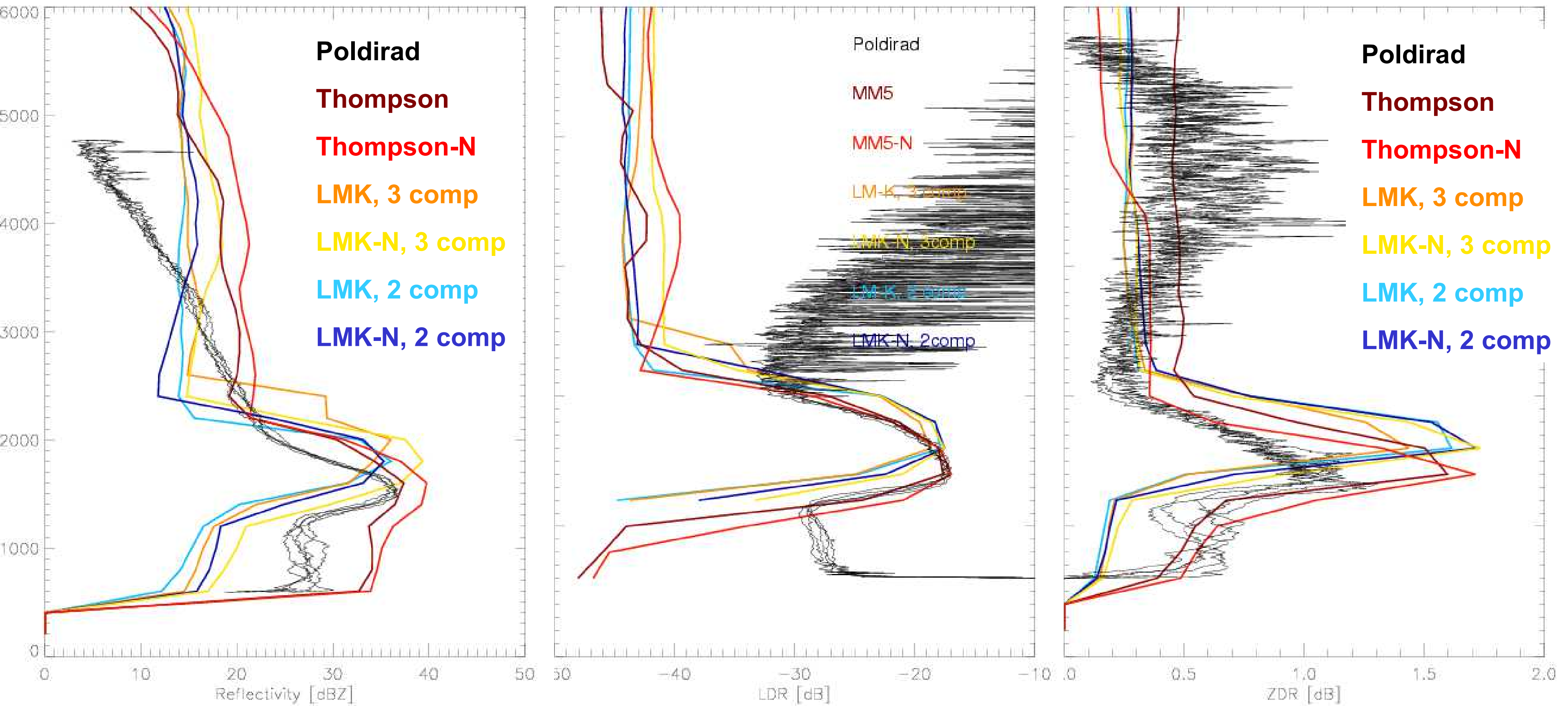



Poldirad 2° PPI Scan



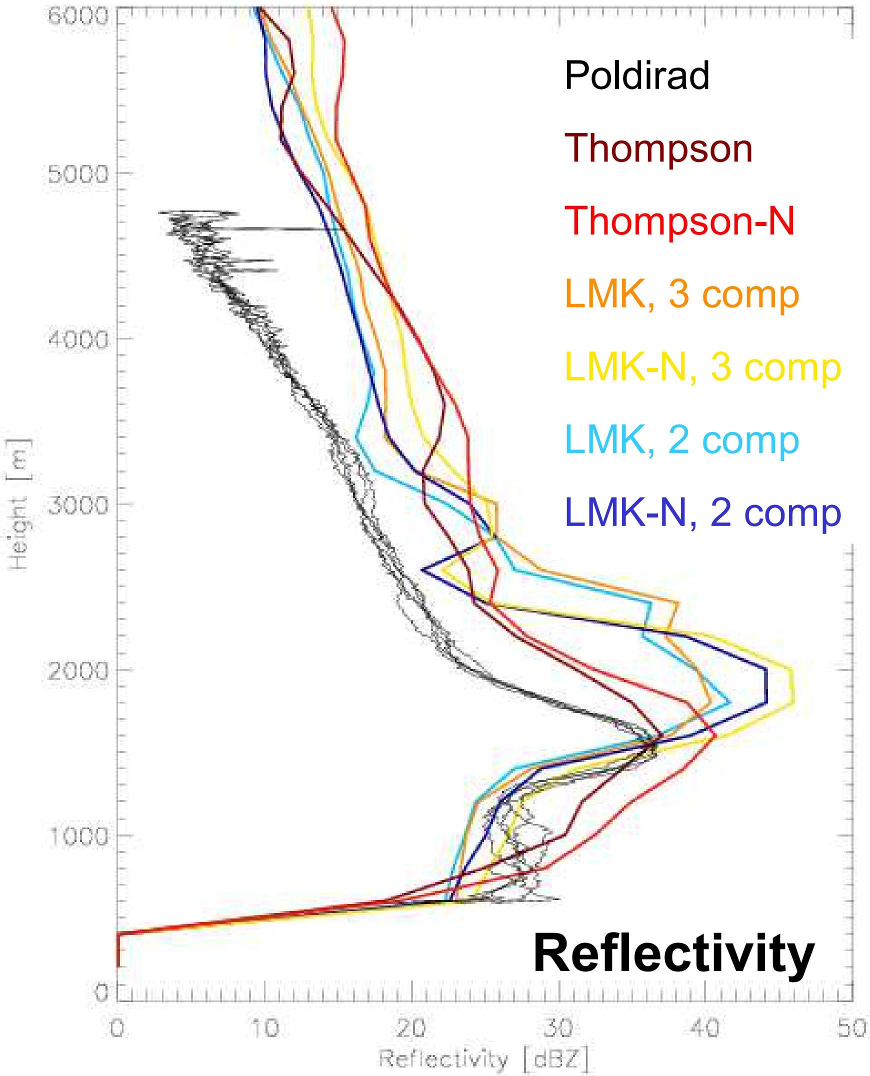

Reflectivity

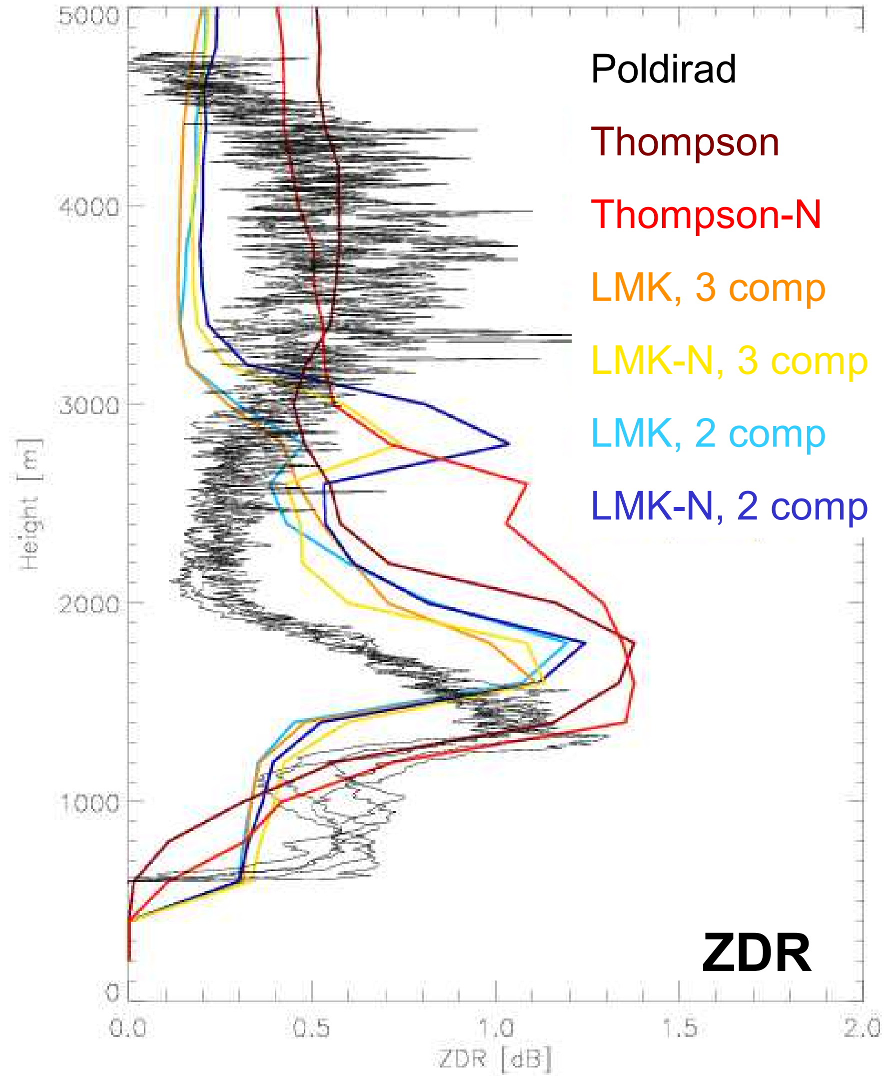
# 8 UTC: 2° PPI Scan - Mean over azimuth angles




**Reflectivity [dBZ]** **LDR [dB]** **ZDR [dB]**

# 6 UTC : 2° PPI Scan - Mean over azimuth angles

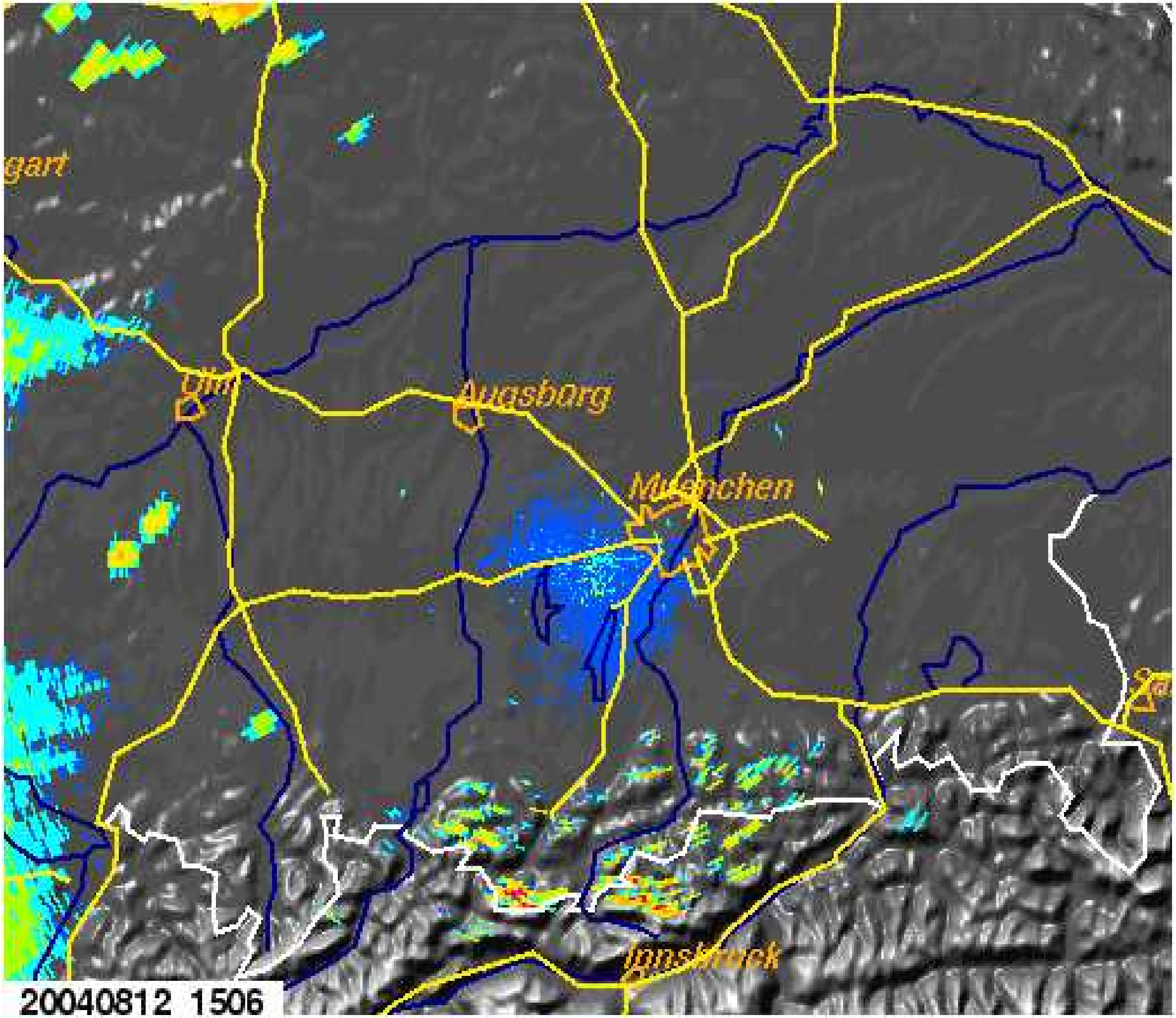


# Convective Case: 12th August 2004, 15 to 20 UTC

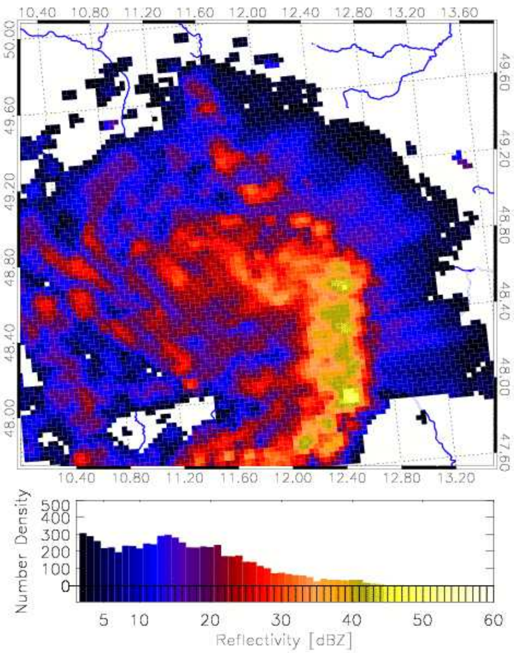
**LMK 3.16:**

- 2 component
- 3 component
- Thompson

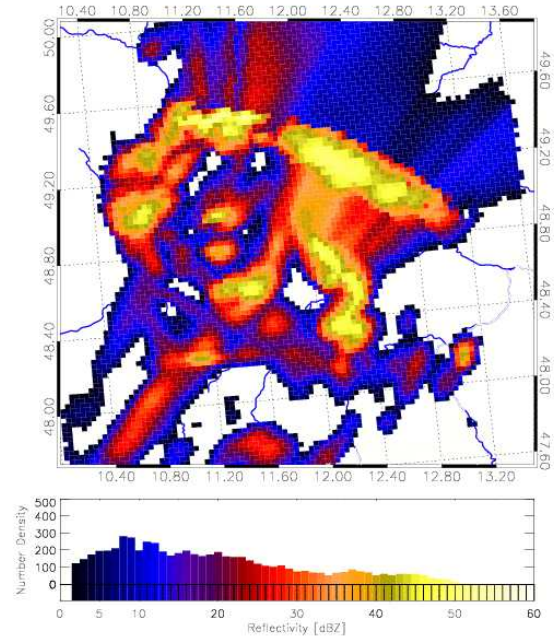


# LMK 3.16: 19:00 UTC

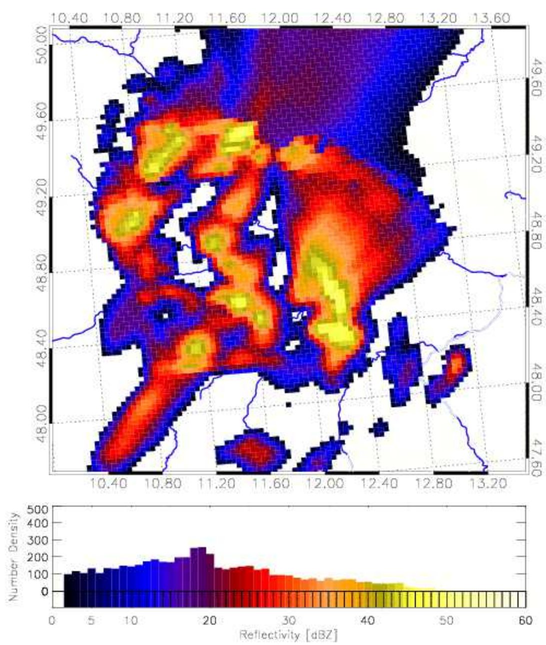
Poldirad



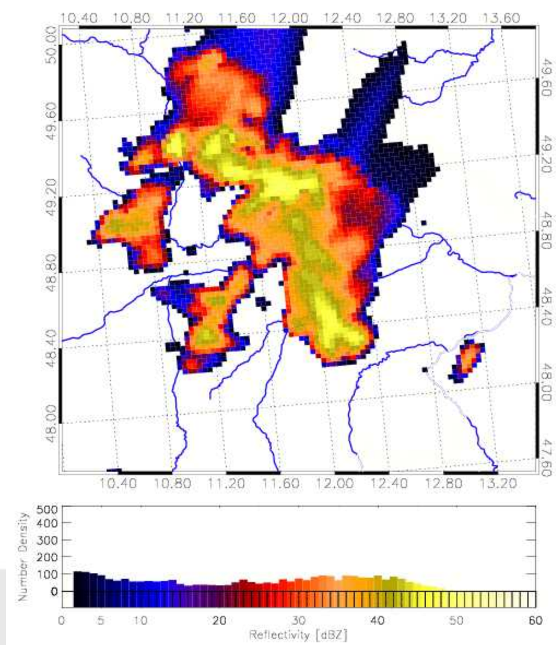

LMK: 2 comp




LMK: 3 comp.

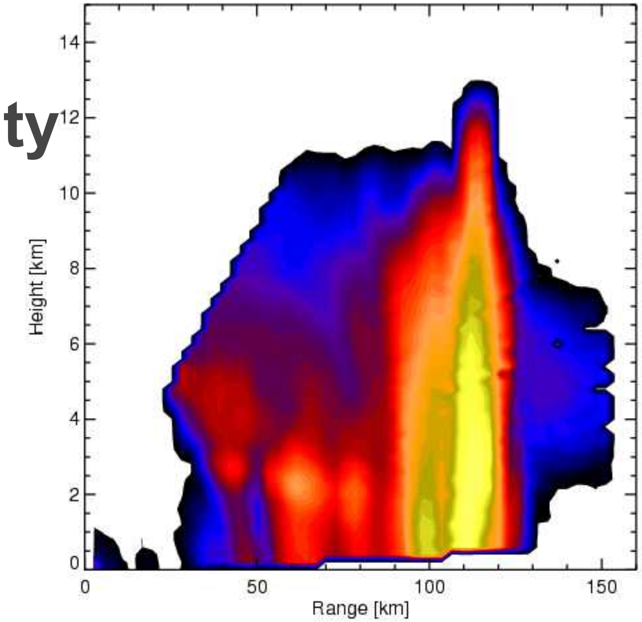


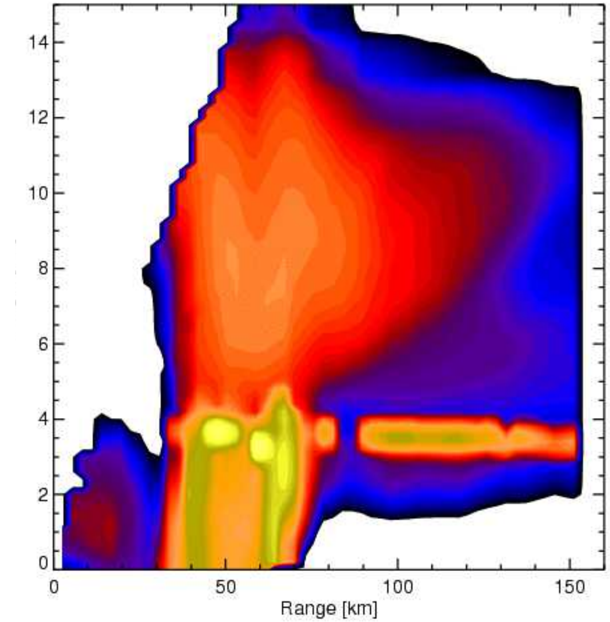

LMK: Thompson



# RHI Reflectivity

Poldirad
19:23 UTC



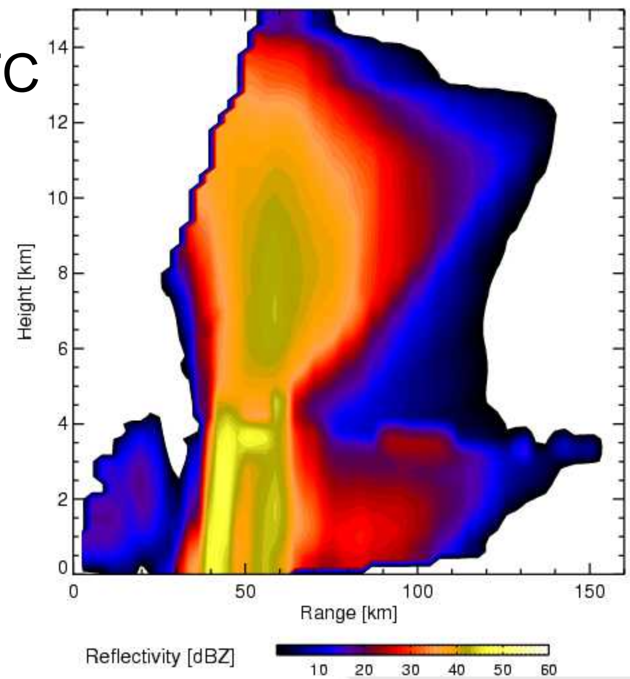



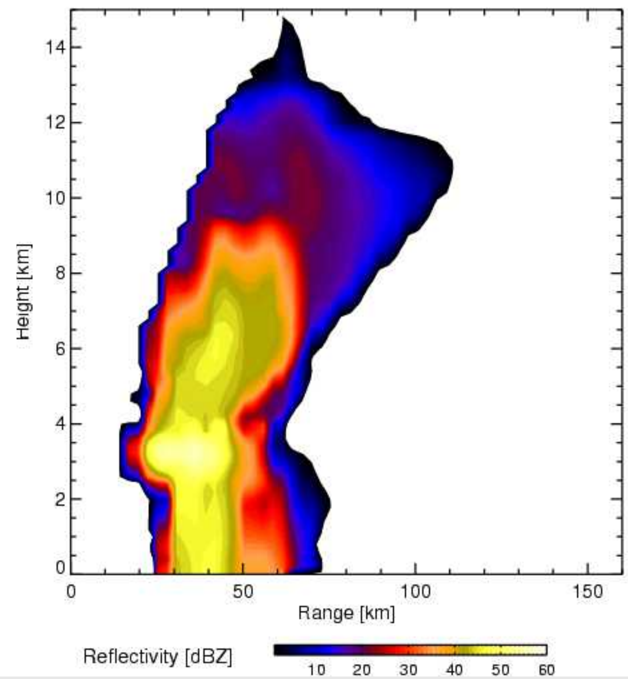

LMK: 19 UTC

2 comp

LMK: 19 UTC

3 comp.

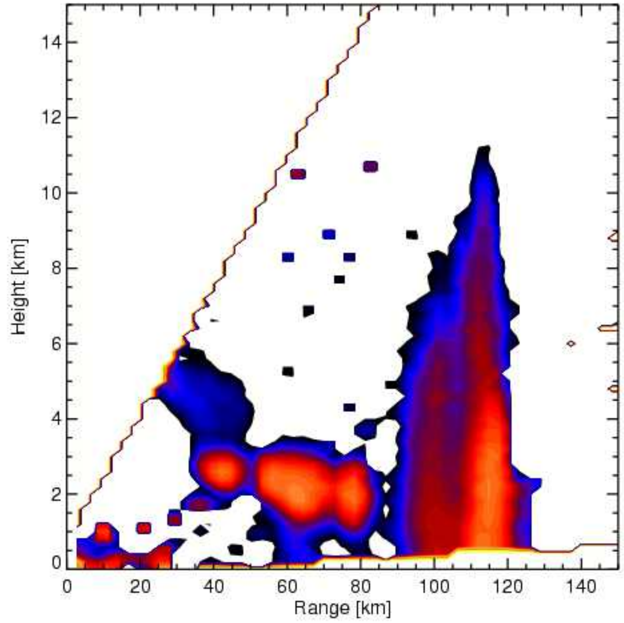


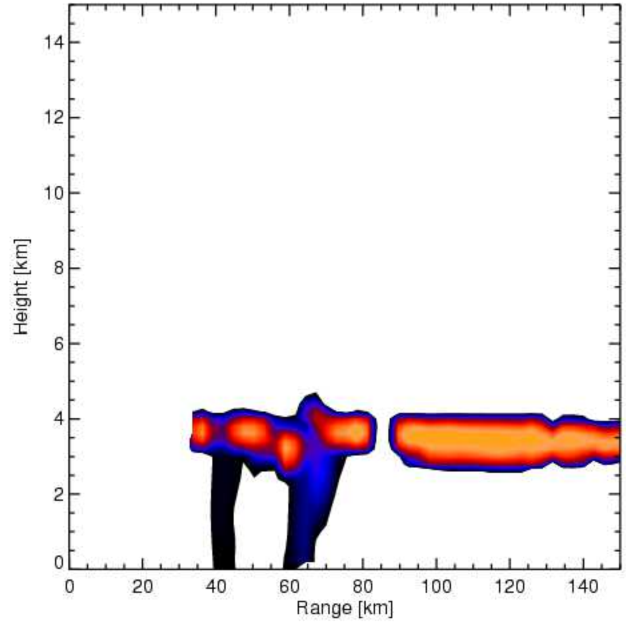




LMK:19 UTC
Thompson

# LDR

Poldirad 19:23 UTC



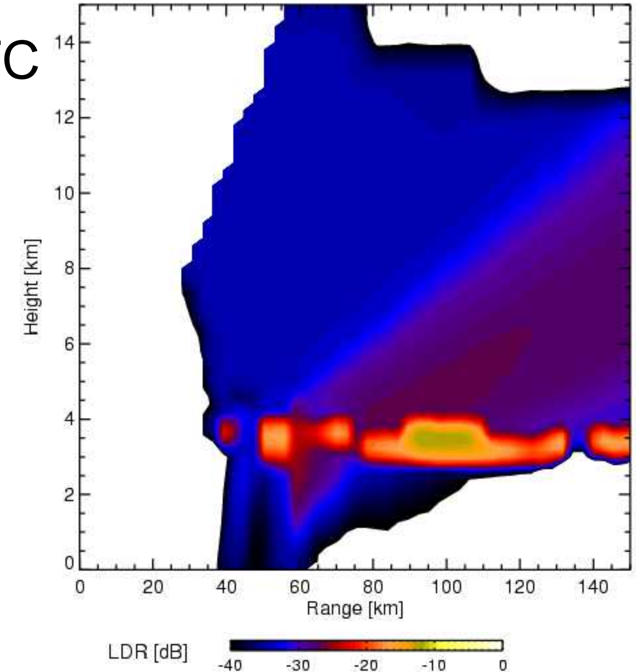



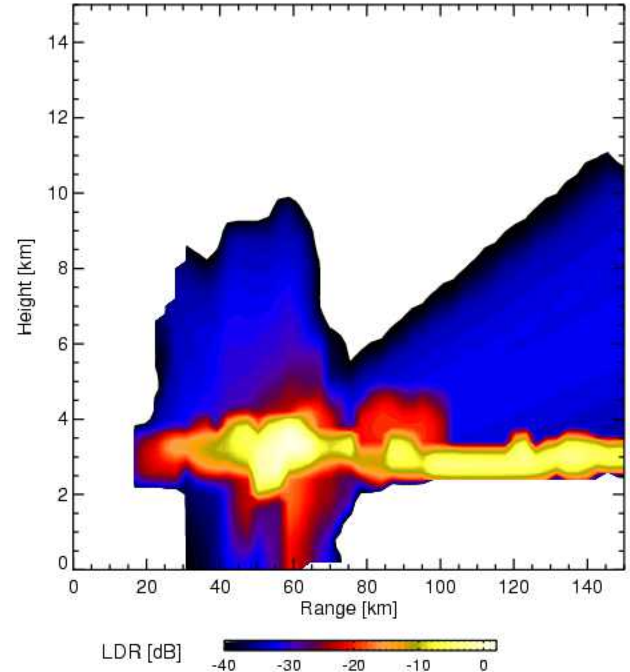

LMK 19 UTC

2 comp.

LMK 19 UTC

3 comp.




LMK 19 UTC

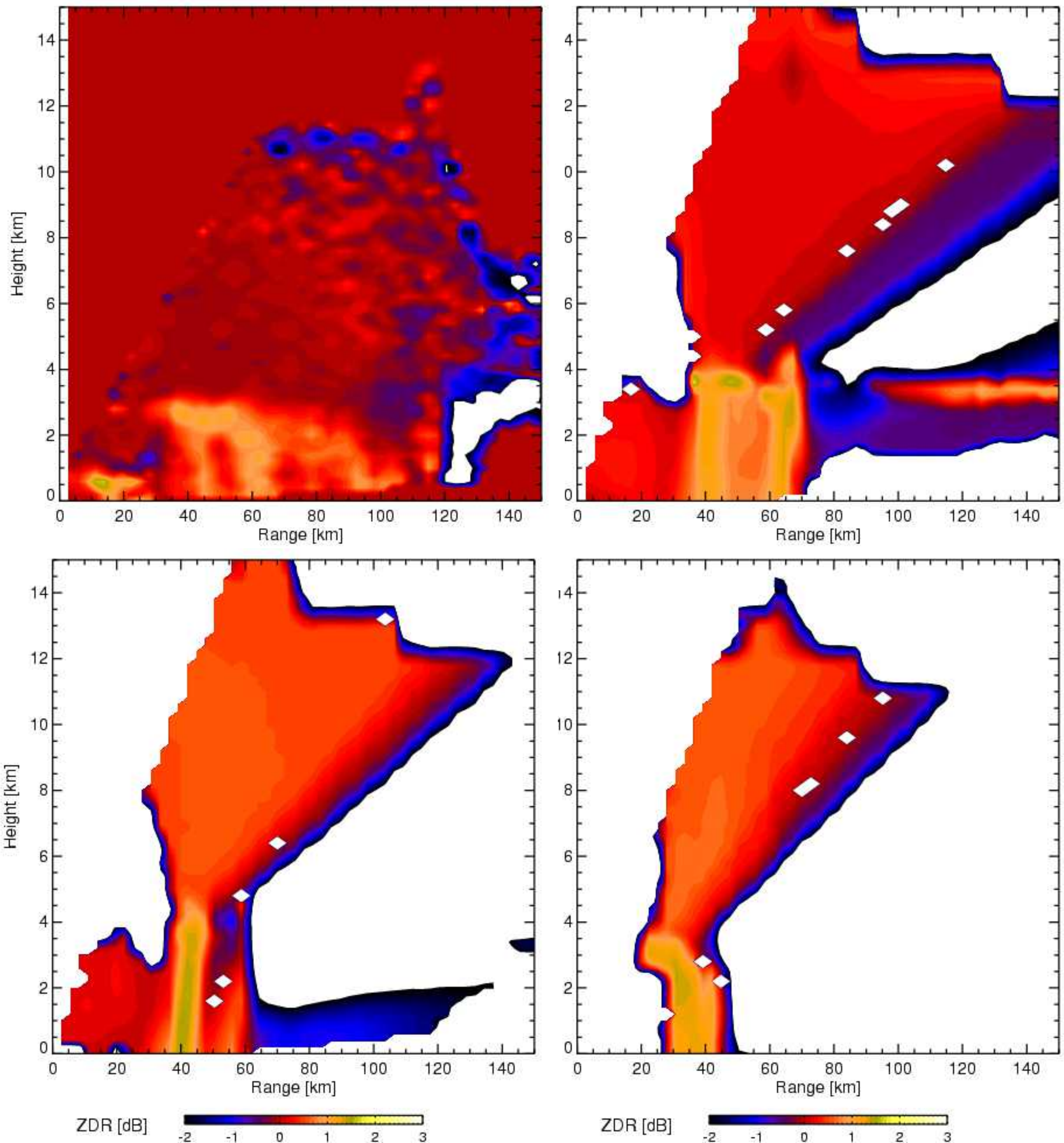
Thompson

scheme

# ZDR

Poldirad
19:23 UTC

LMK 19 UTC
2 comp.

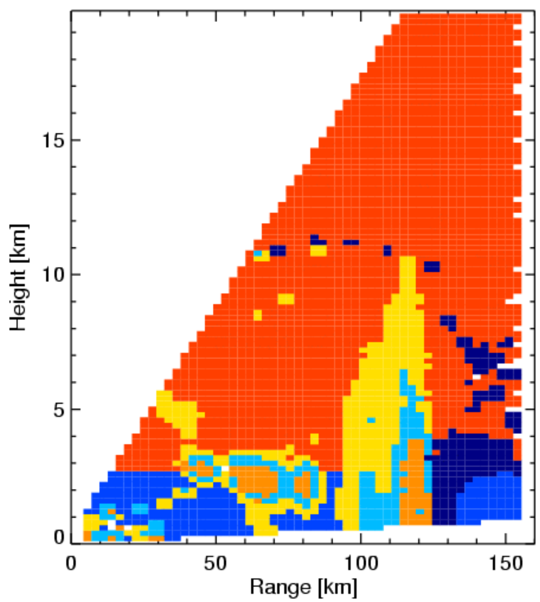



LMK 19 UTC
3 comp.

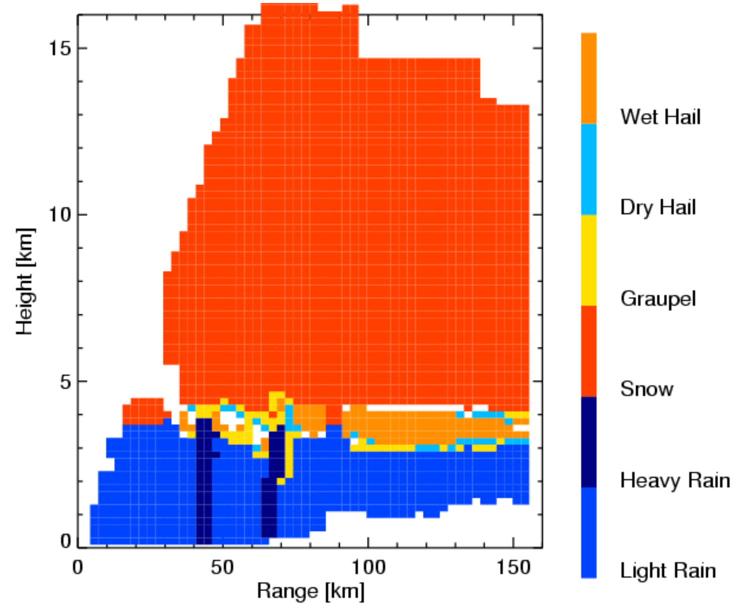
LMK 19 UTC
Thompson

# Hydrometeor Classification (Höller et al. 1994)

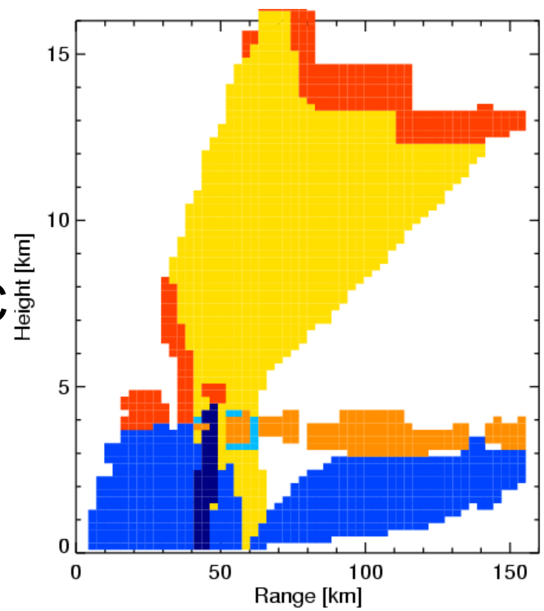
Poldirad
19:23 UTC



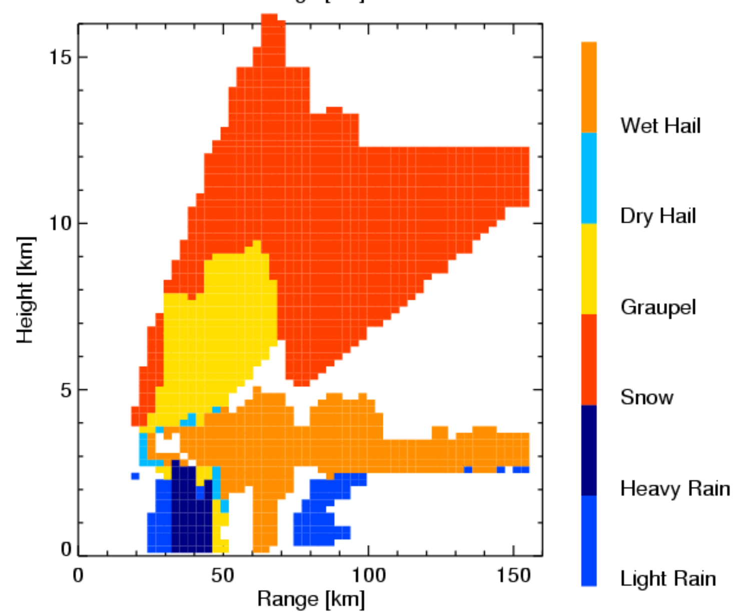

LMK
19 UTC
2 comp.




LMK 19 UTC
3 comp.




LMK
19 UTC
Thompson



# Conclusions

**SynPolRad provides a novel tool to validate cloud microphysics.**

**Stratiform Event:**

- The Thompson scheme overestimates reflectivities in rain, while the ZDR is well represented.

  => The number of large drops is well simulated, but the total water amount is too high.
- The LMK schemes represent reflectivity in rain well, but underestimate ZDR.

  => The number of large drops is too small in comparison to the total water amount.

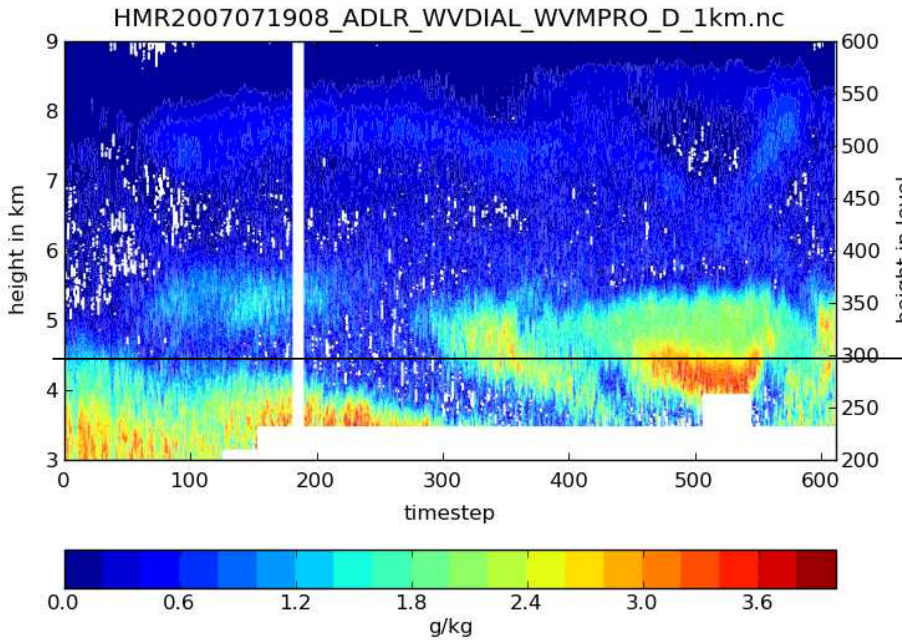
**Convective Event**

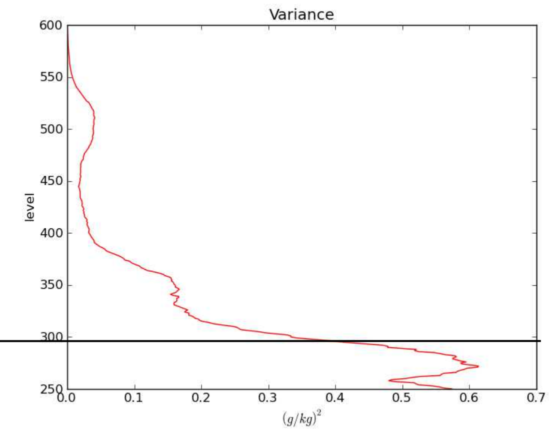
- The LMK 2 component scheme represents the stratiform part of the convective system in the snow, bright band and rain well. The reflectivities in the convective cell and LDR values are underrepresented due to the lack of heavier ice species.
- The LMK 3 component scheme underestimates the reflectivities and LDR within the convective cell. The classification scheme shows, that the ice phase is dominated by graupel, but almost no snow is present.
- The Thompson scheme captures well the distribution of graupel and snow in the ice phase, but strongly overestimates the reflectivity and LDR in the bright band.
- No model captures the hail with high values of reflectivity and LDR down to the ground.

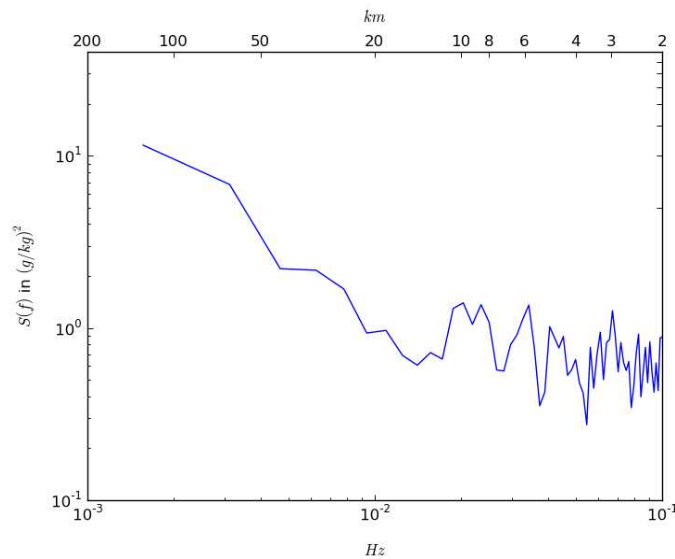
# From QUEST to HALO

| QUEST<br>Quantitative Evaluation of Regional Precipitation Forecasts using Multi-Dimensional Remote Sensing Observations | HALO-LIDAR<br>High Altitude and Long Range Research Aircraft |
|---|---|
| • **Evaluate quantitative precipitation forecasts**<br>- Spatial-temporal structure of water<br>- Sub-grid variability<br><br>• **Data base of ground-based and satellite remote sensing observations**<br><br>• **Investigate the process chain from water vapour to precipitation at the ground** | • **Cooperation between DLR and MIM**<br>- DLR: Christoph Kiemle, Post Doc<br>- MIM: Prof. Dr. G. Craig, L. Fischer (PhD)<br>- Duration 36 month (2nd period of the SPP 1294)<br><br>• **Why LIDAR?**<br>- Direct measurement of model variables<br>- High resolution, high accuracy<br><br>• **Topic**<br>- Combined airborne lidar measurements of moisture transport and cirrus properties<br><br>• **Aims**<br>- Develop methods for analysing physically relevant quantities based on data from lidars<br>- Model data will be exploited to quantify uncertainties due to atmospheric variability |

# Example of First Results




**Analysis of Lidar water vapor observations**:

- High-resolution Lidar data shows fluctuations and structures in humidity field
- Potentially important for convection-permitting models and stochastic parameterisation
- Need to characterise variability statistically and evaluate model



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# Model evaluation with polarimetric Radar and with Lidar

- Polarimetric Radar data allows evaluation of hidden aspects of precipitation physics, e.g. size distribution and particle form

- High-resolution lidar will allow(?) evaluation of variability near (above and below) model truncation