



Convective Structures in Clear-Air Echoes seen by a Weather Radar

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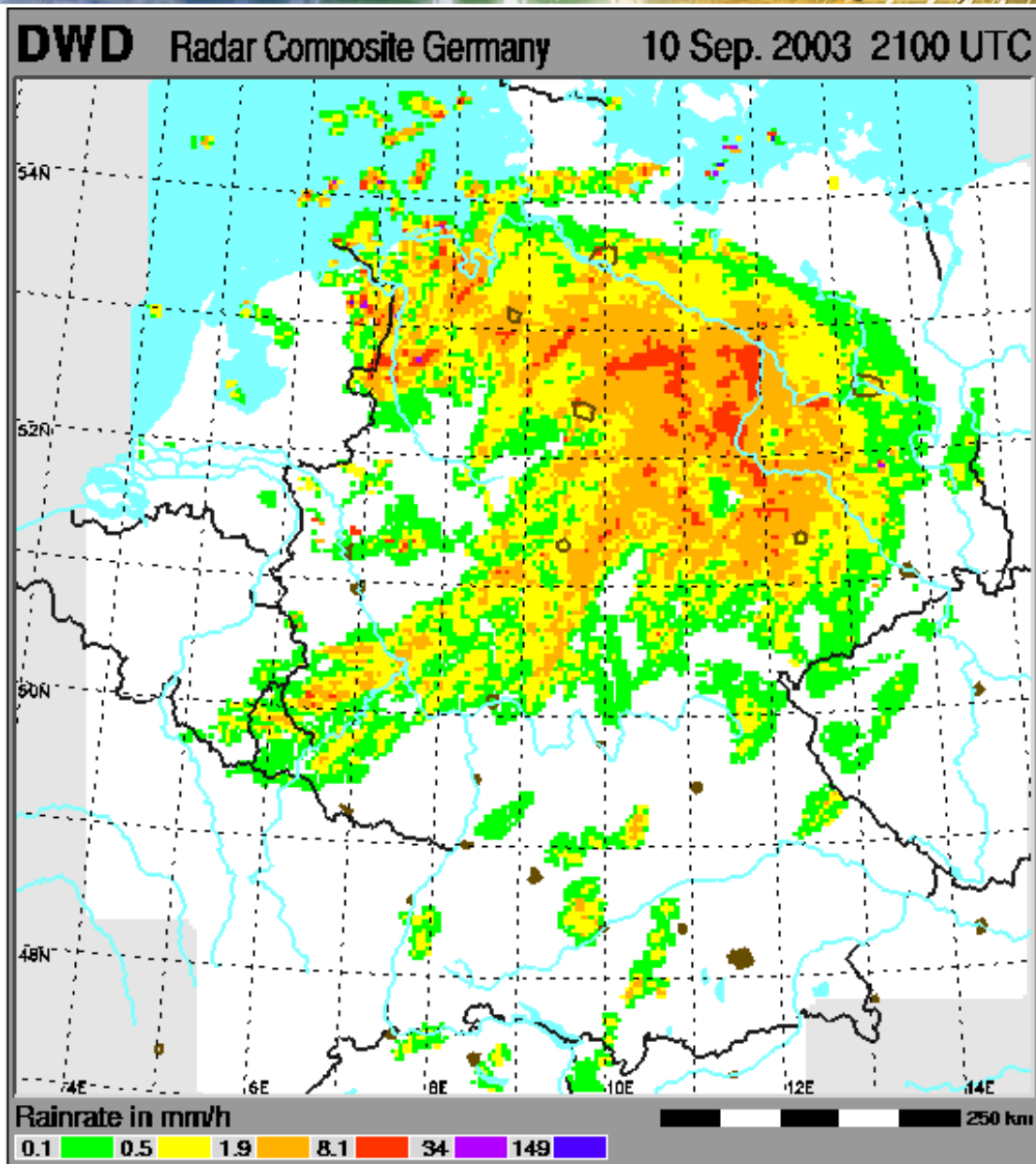
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Weather Radar

Weather radar are normally used to

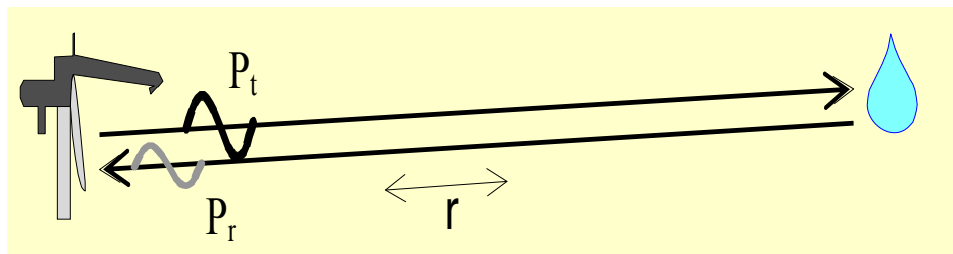
- locate precipitation
- estimate rainfall rate
- apply nowcasting

Advanced radar systems now implemented in Europe, use Doppler and polarization capabilities for improved retrieval algorithms for rain rate estimation and nowcasting.



Some Radar Basics

The radar measures the power of a transmitted electro-magnetic wave packet reflected by a particle:



Radar equation for volume targets:

$$P_r = \frac{\text{Radar constant} \cdot P_t \cdot g^2 \cdot \lambda^2 \cdot \theta_0^2 \cdot h}{1024 \cdot \ln(2) \cdot \pi^2 \cdot r^2} \cdot \sum_{Vol} \sigma_i$$

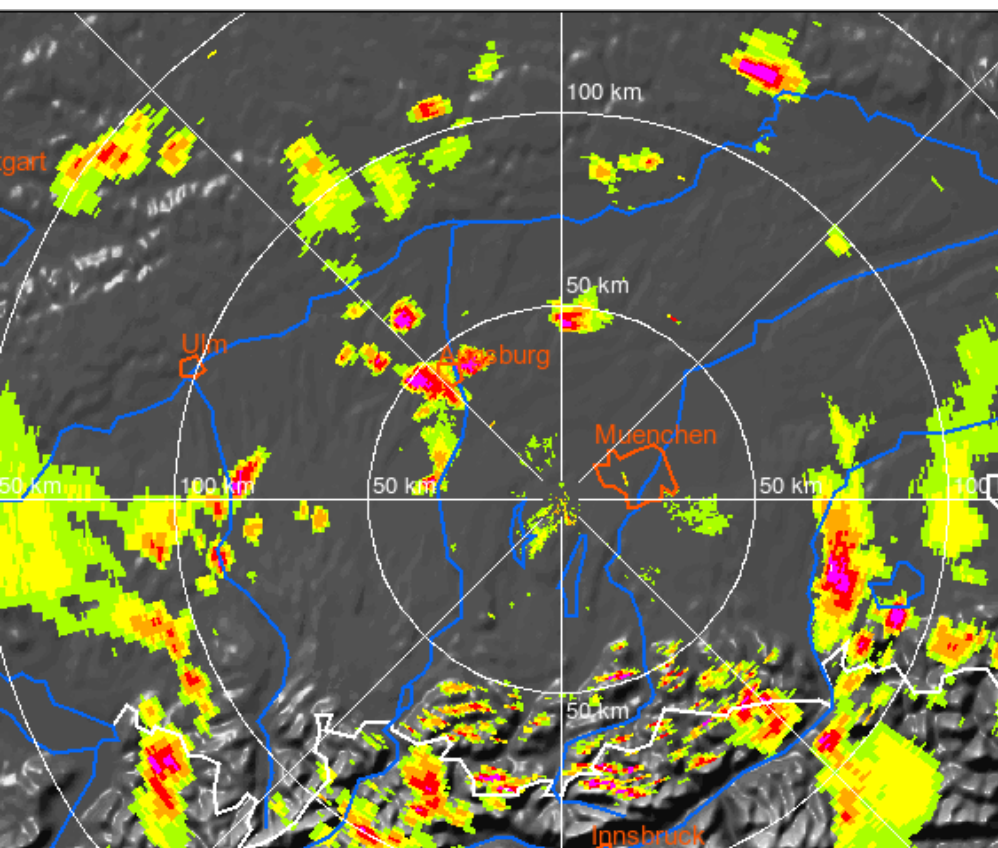
Reflectivity
(sum of the scattering cross-sections)

Particles smaller than the wave length:
(C-Band $\lambda = 5$ cm, $D < 5$ mm) Rayleigh-scatter

$$\sigma_i = \frac{\pi^5}{\lambda^4} |K|^2 D_i^6$$

Reflectivity z:
Unit: $\text{mm}^6 \text{m}^{-3}$
logarithmic
unit: dBZ

Radar Reflectivity



	rain	
dBZ	mm/h	Interpretation
60	338.4	hail
50	66.9	severe rain, hail
40	13.2	strong rain, graupel
30	2.6	rain
20	0.5	light rain
10	0.1	drizzle
0	0.02	1 drop 1 mm per m ³
-10	0.004	1 drop 0.65 mm per m ³

typical sensitivity: -5 dBZ at 50 km range
0 dBZ at 100 km range

cumulus hum.
-30 dBZ



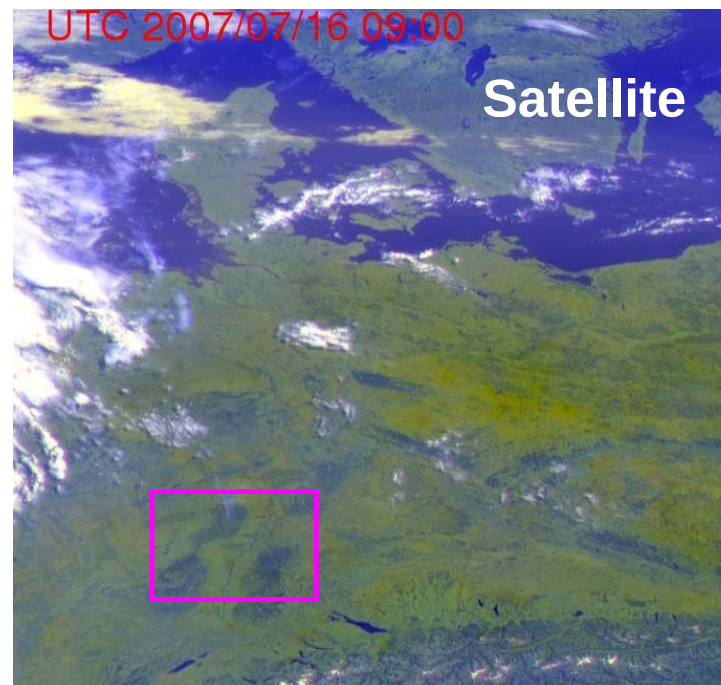
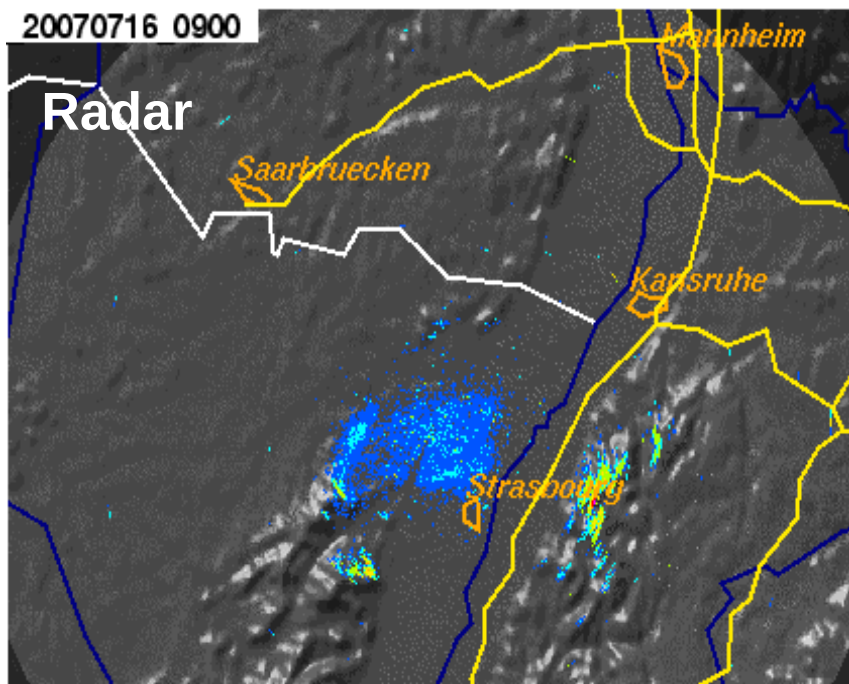
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Clear-Air Echoes ?

- radar echoes from precipitation and cloud free atmosphere (cumulus clouds give $Z \approx -30$ dBZ)
- not ground clutter !!
- what else ??





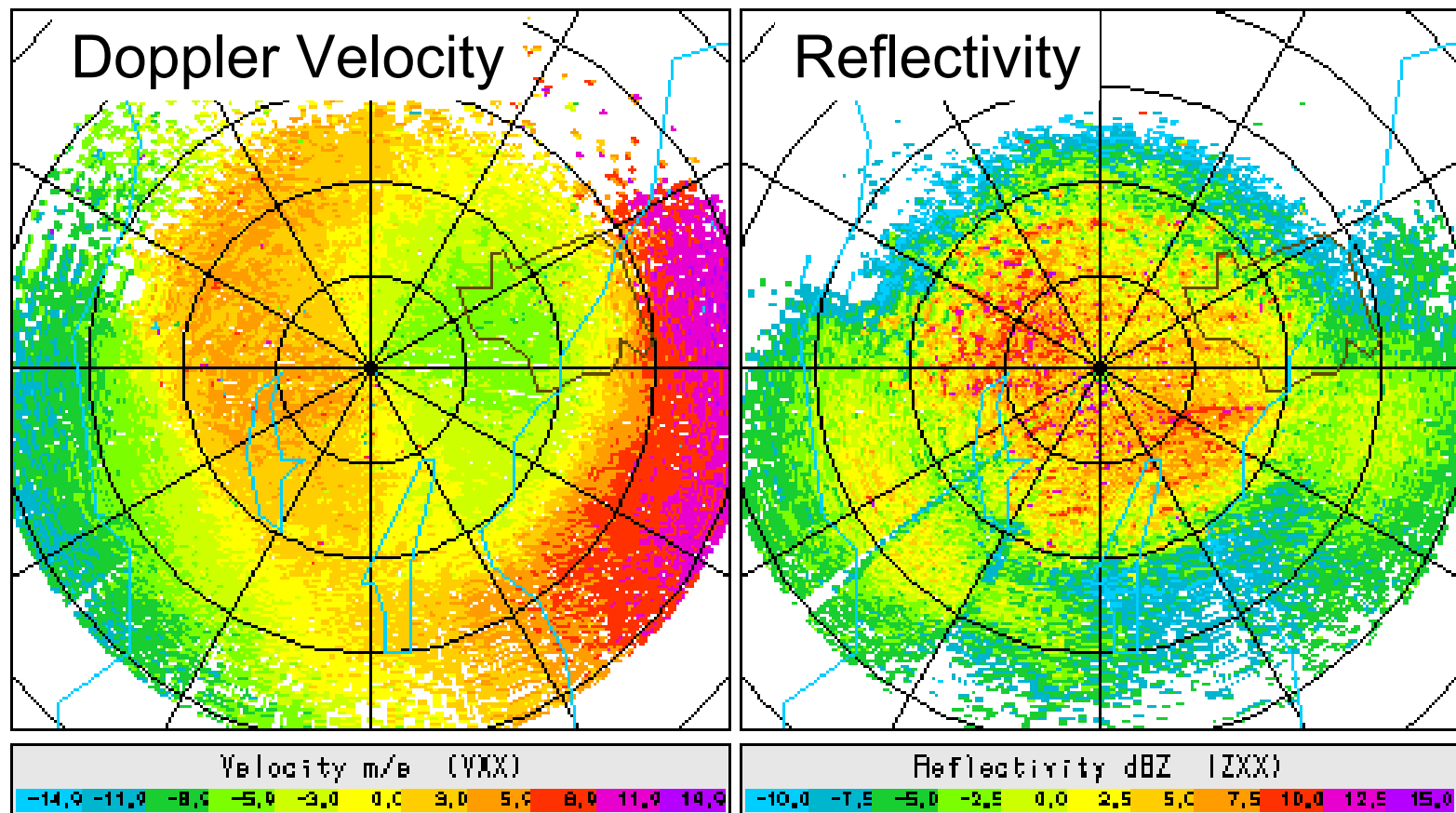
Clear-Air Echoes

Radar meteorologists know two sources for clear-air echoes:

- Bragg scatter
 - strong gradients in refractive index on a scale of $\frac{1}{2} \lambda$
 - (stronger at longer wavelength λ -> wind profilers)
 - need of warm humid air with strong turbulence, possibility to be achieved in summer for C or S band

- small particles like
 - wet large aerosols
 - aerosols are small, would need a very large number
 - insects, birds
 - large (2-4 mm) would need only a few in measurement volume

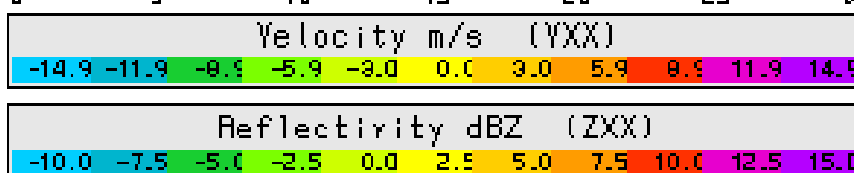
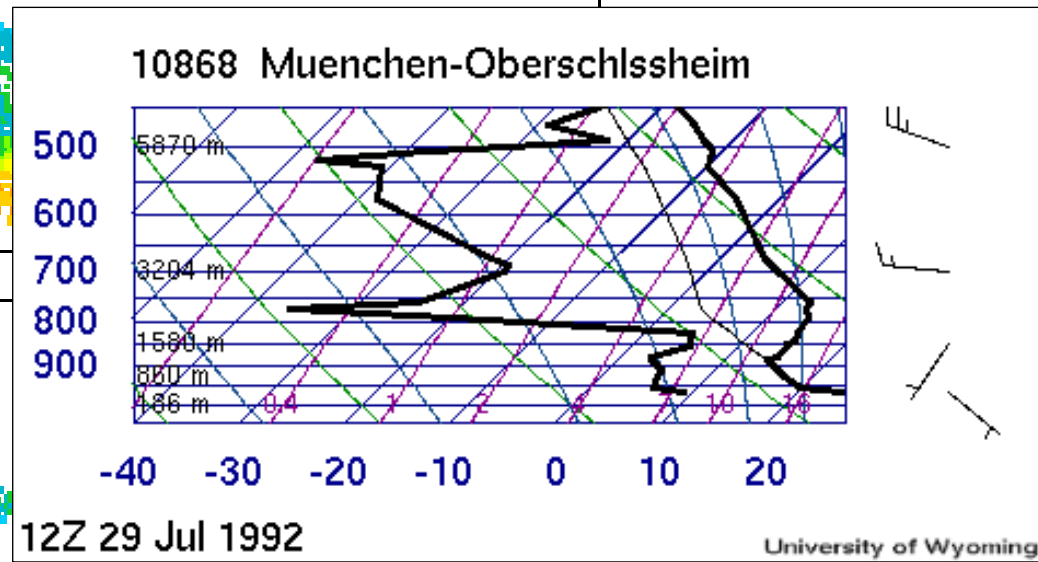
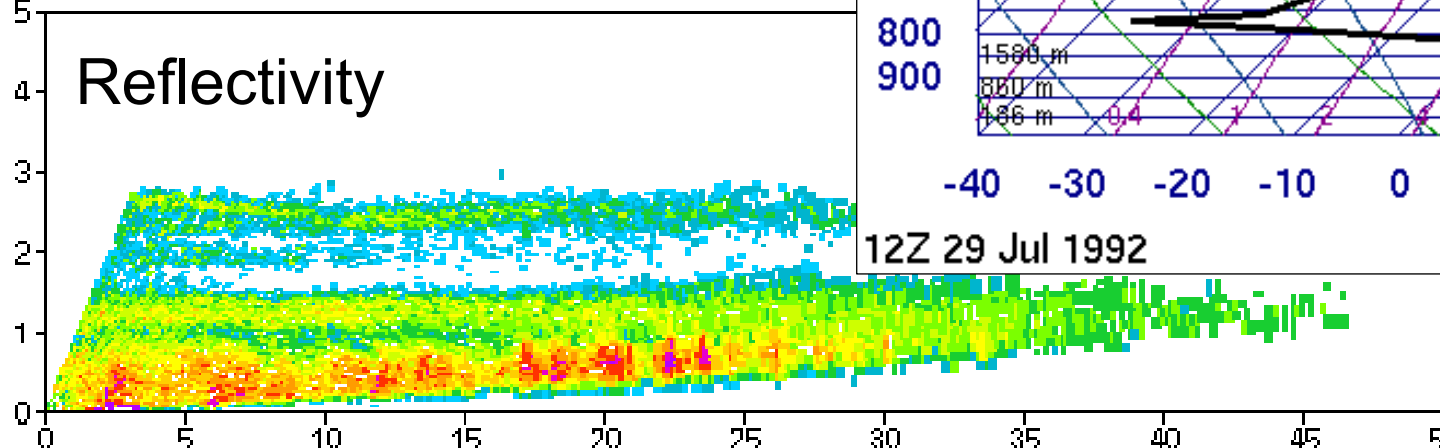
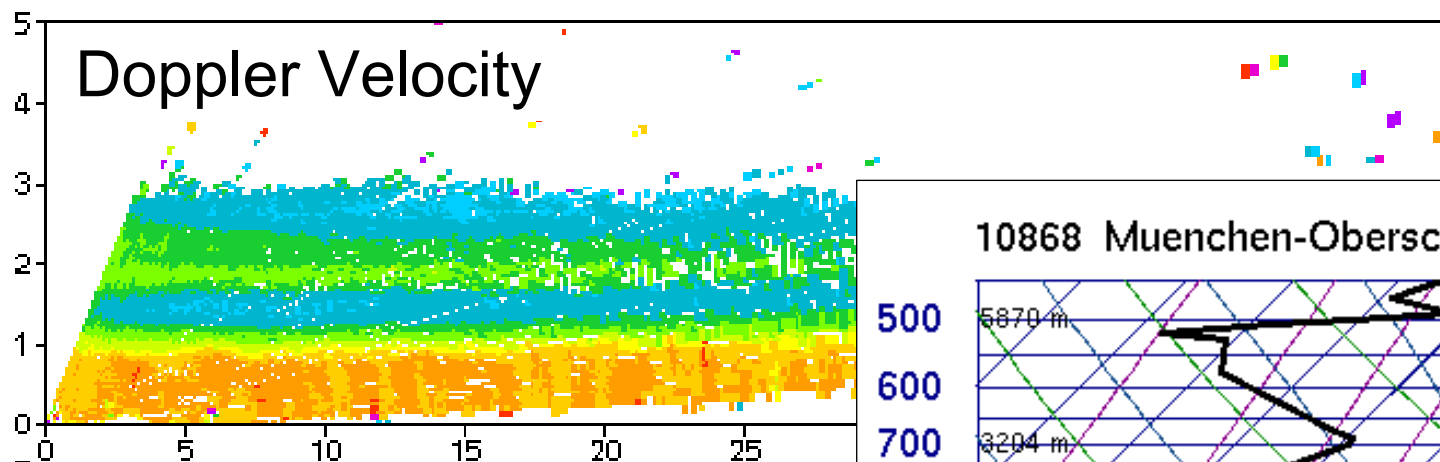
Clear-Air Echoes (horizontal display 40 km range)



29 July 1992 13:26:56
Elevation 2.5 Sweep 1
Map-Id 1992-07-29-010-005 Sig
Tx: hor Rx: hor
PRF 1200 1.0 us Samples 64



Clear-Air Echoes (vertical cross section)

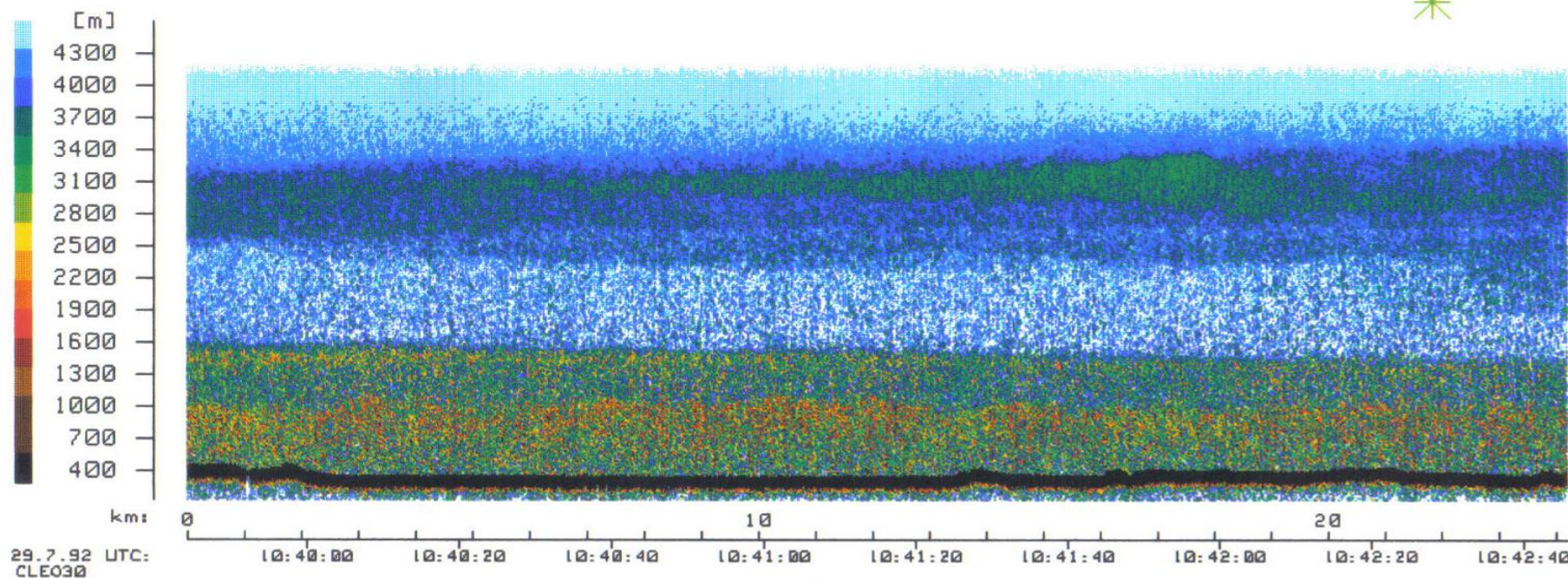


29 July 1992 13:29:15
 Azimuth 268.0 Sweep 1
 Map-Id 1992-07-29-009-027 Sig
 Tx: hor Rx: hor
 PRF 1200 1.0 us Samples 64

Lidar observations for same event

- Lidar observations from aircraft (downward looking)

Aerosol-Rückstreuung Off-Line



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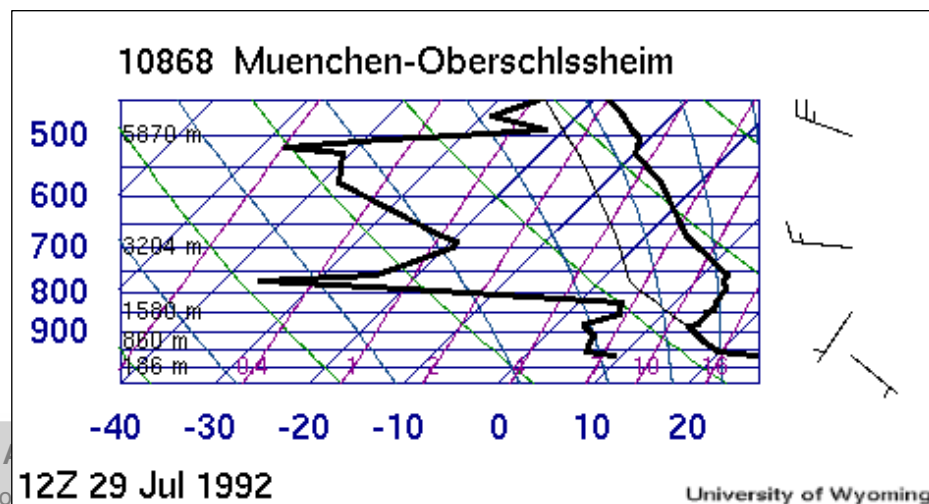
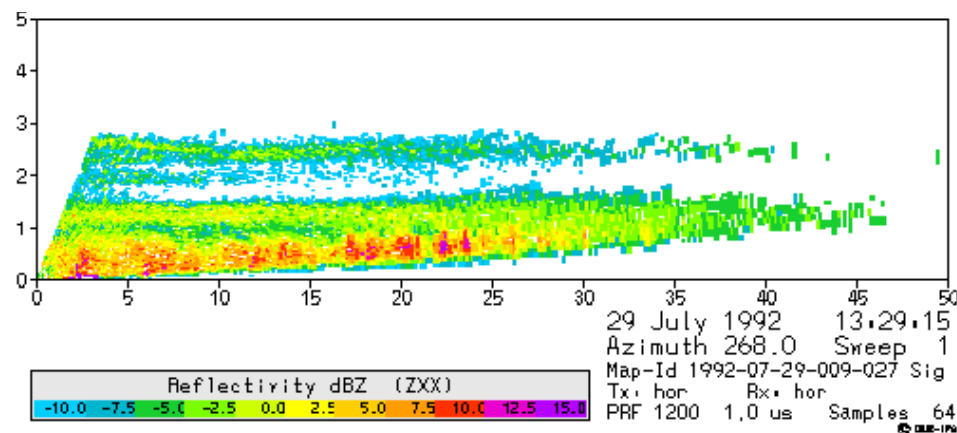
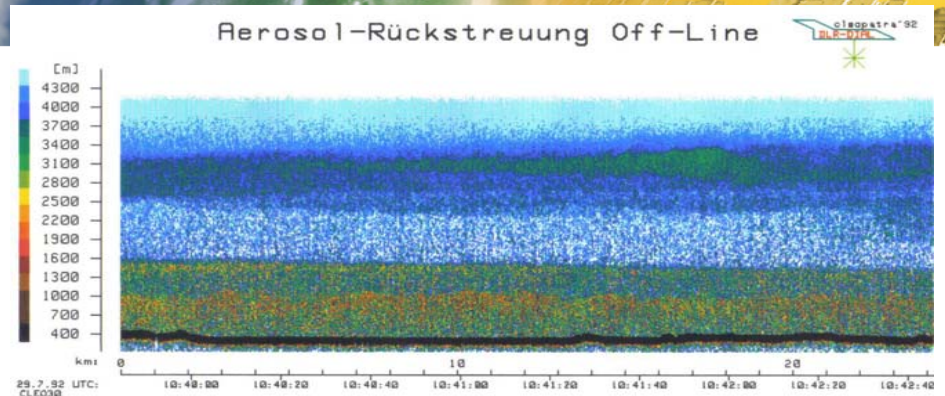
Clear-Air Echoes

similar observations of vertical structure seen by radar, lidar and radio sonde

➤ must be particles !
➤ must be related to vertical humidity/temperature layers !

➤ insects !! ??
- are particles
- present within the convective boundary layer

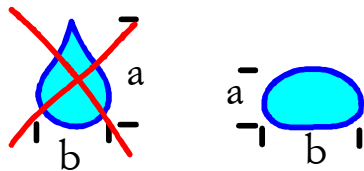
➤ other evidence for insects: polarimetric signature



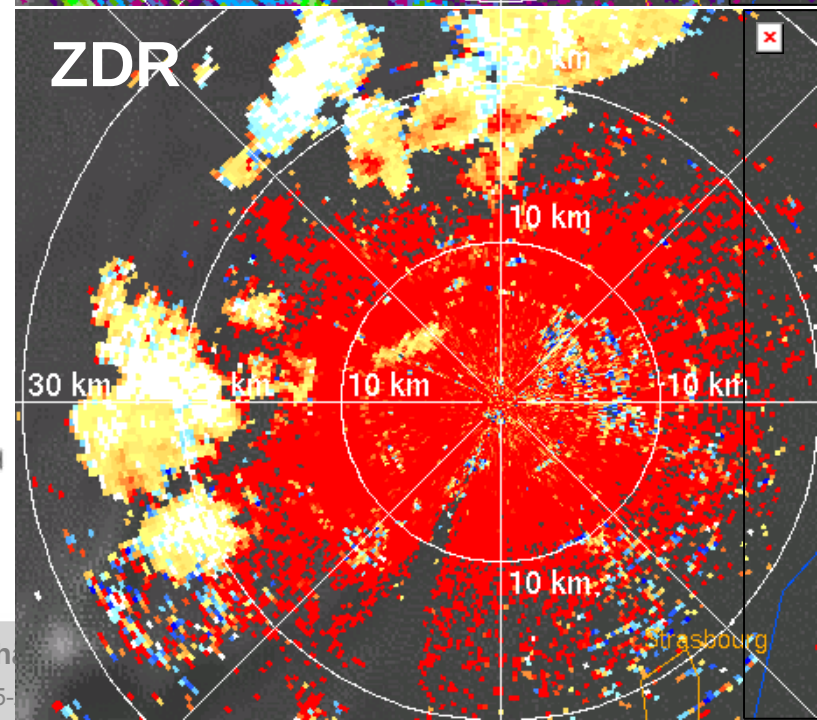
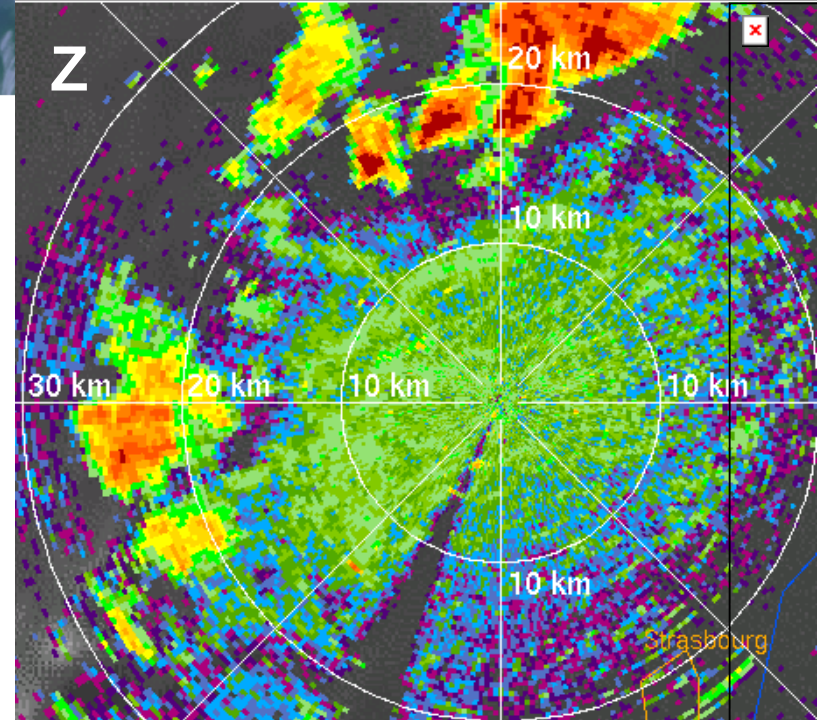
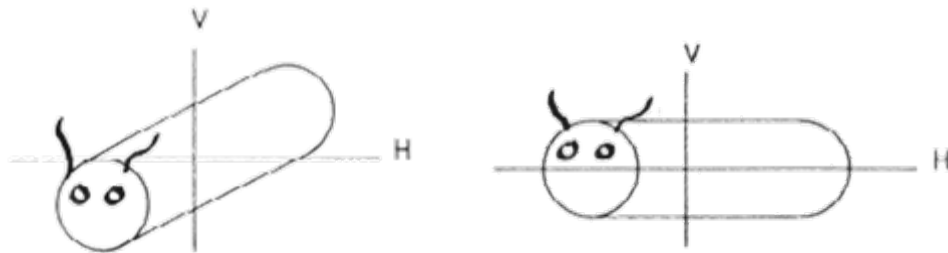
Polarimetric Weather Radar and Insects

➤ Polarimetric weather radar can measure differential reflectivity (ZDR) as a measure of horizontal to vertical axis ratio. Mainly used for rain rate estimation and hydrometeor identification:

➤ Rain: ZDR 0 – 5 dB

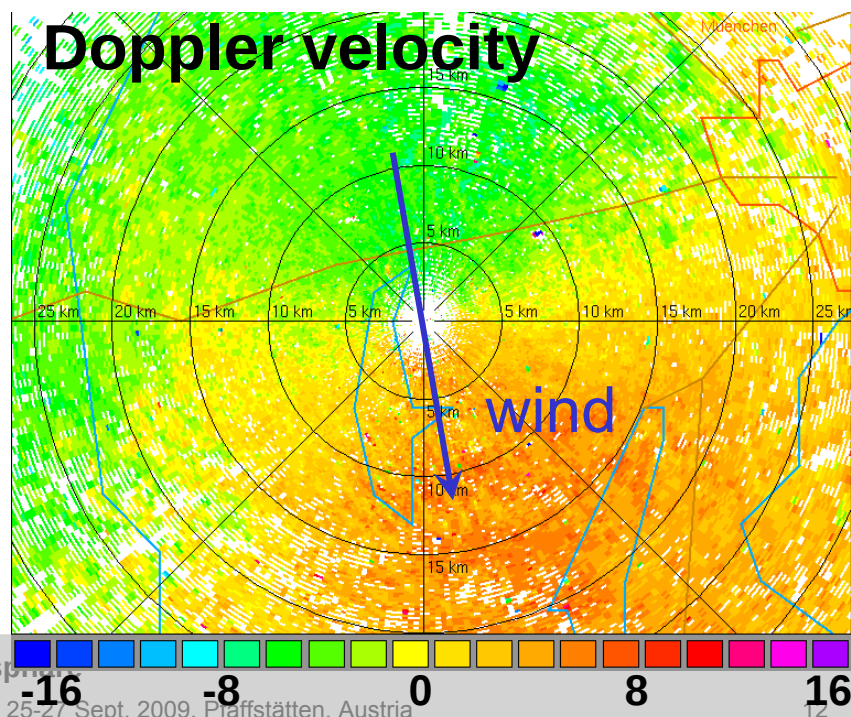
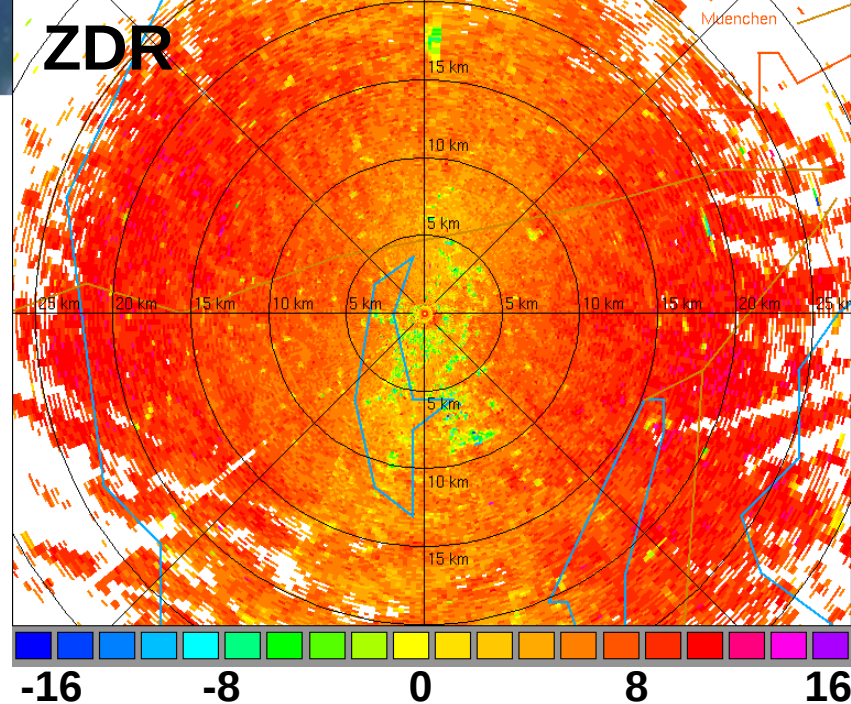


➤ Insects ZDR 5 – 10 dB



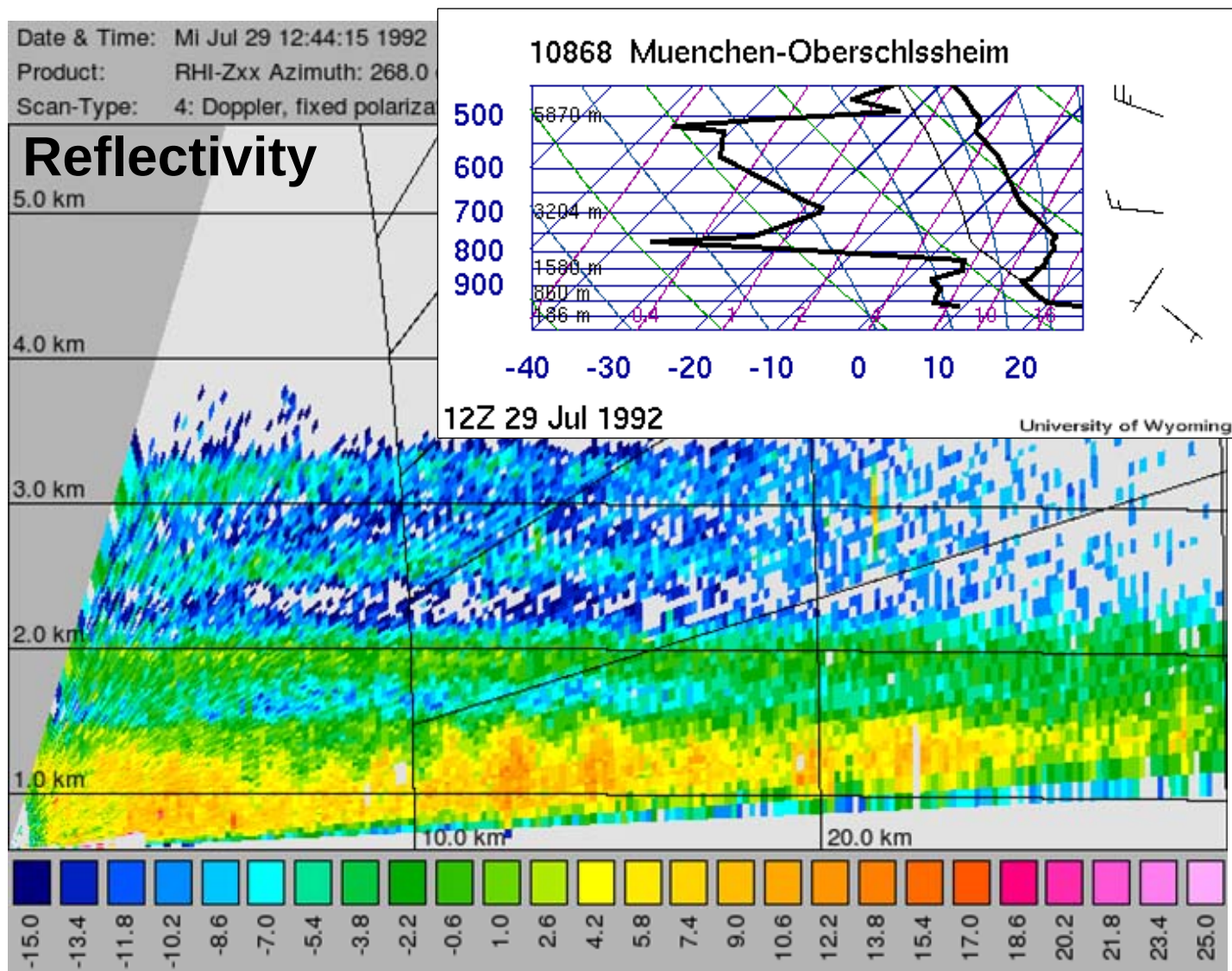
Radar and Insects

- Insects act as passive tracer, small insects do not have the power to fly against wind or convection
- try to avoid humid regions (clouds, sea)
- prefer to see where they are going



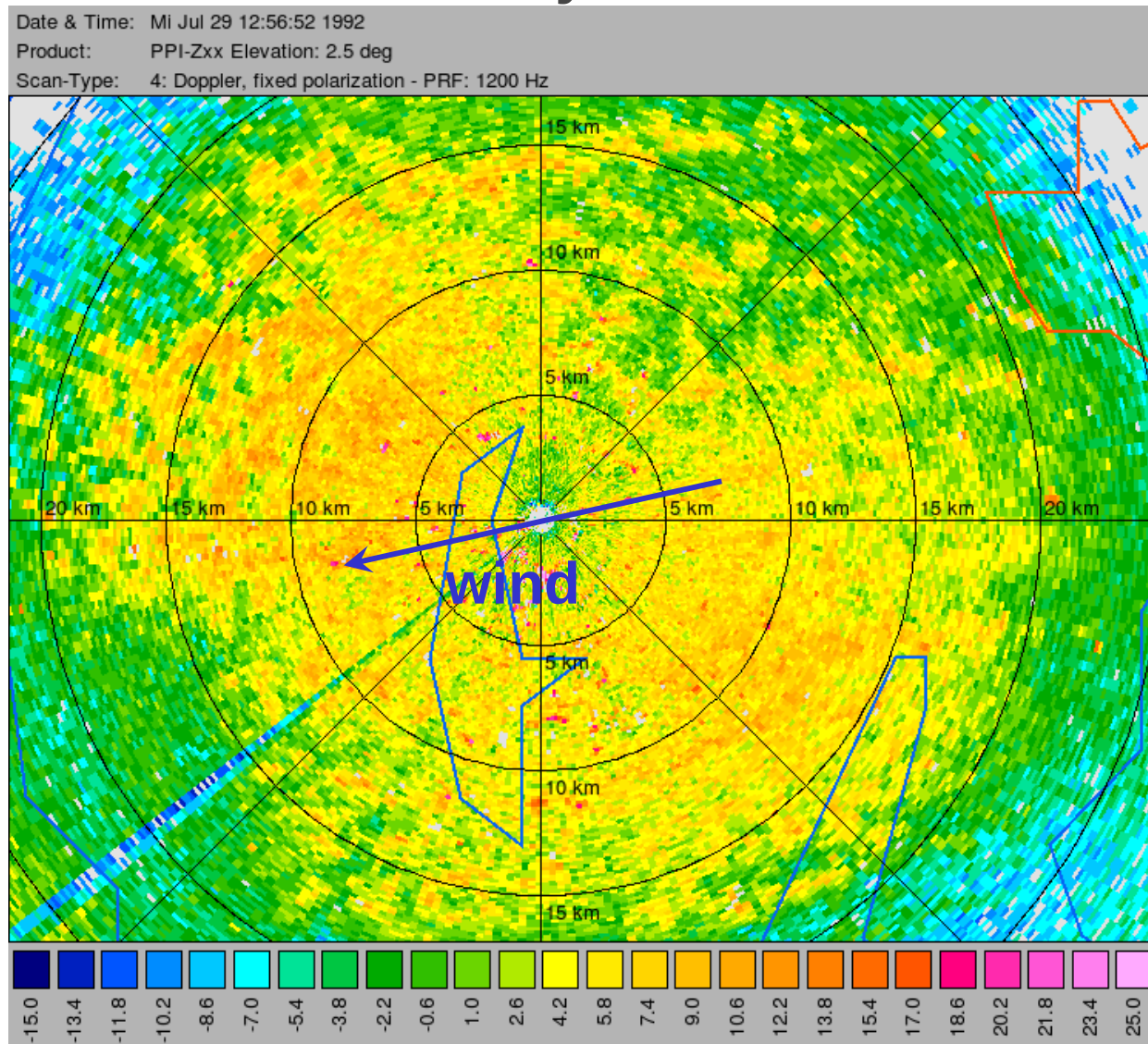
Convective Structures visualized by Insects

➤ vertical plumes



Convective Structures visualized by Insects

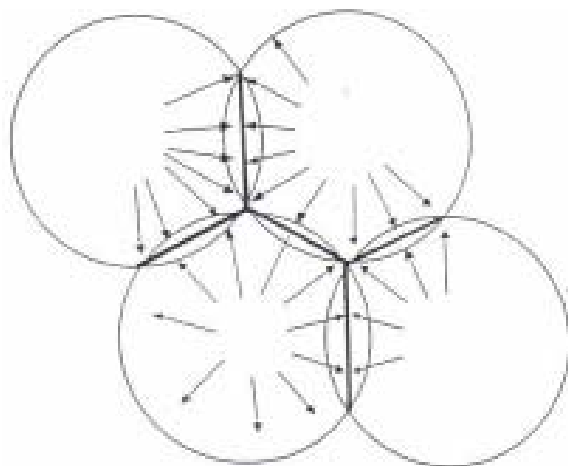
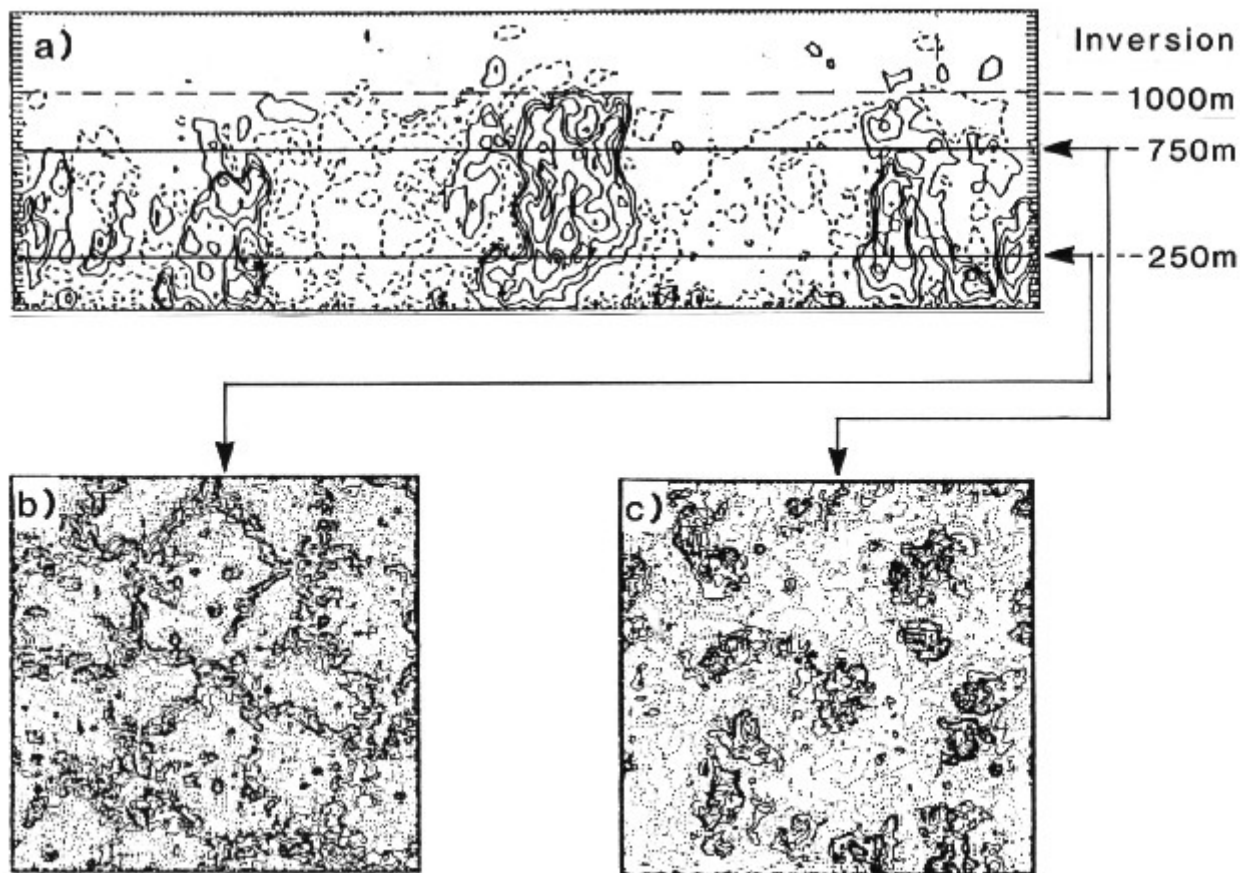
- horizontal alignment of convection





Clear-air Echoes

➤ can we see structures as simulated by Schmidt, 1988 ?



(Schmidt, 1988)

WMO Manual, 1992



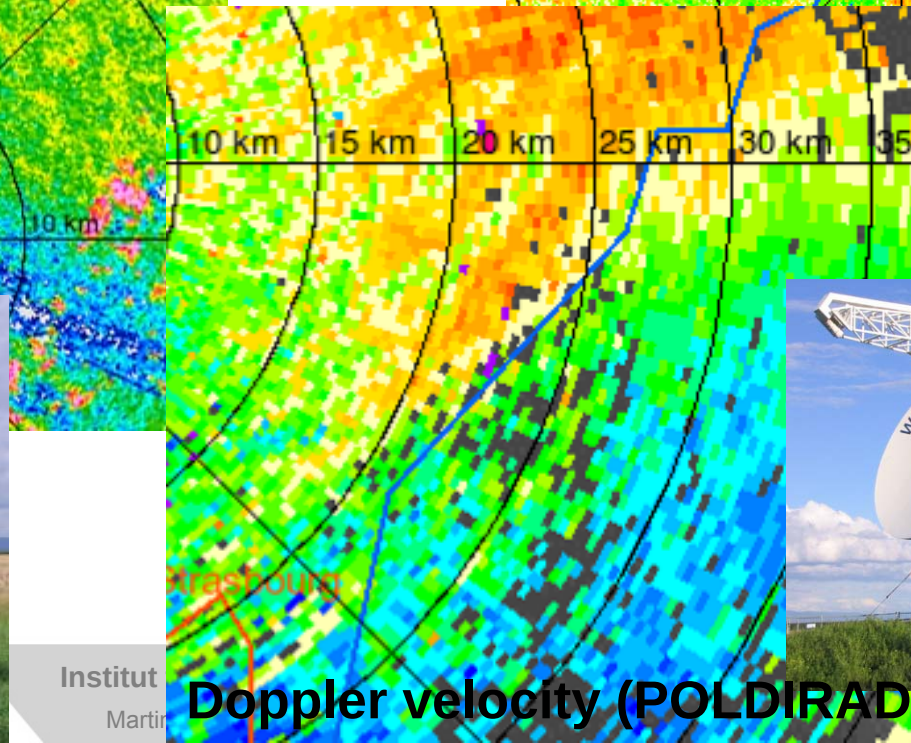
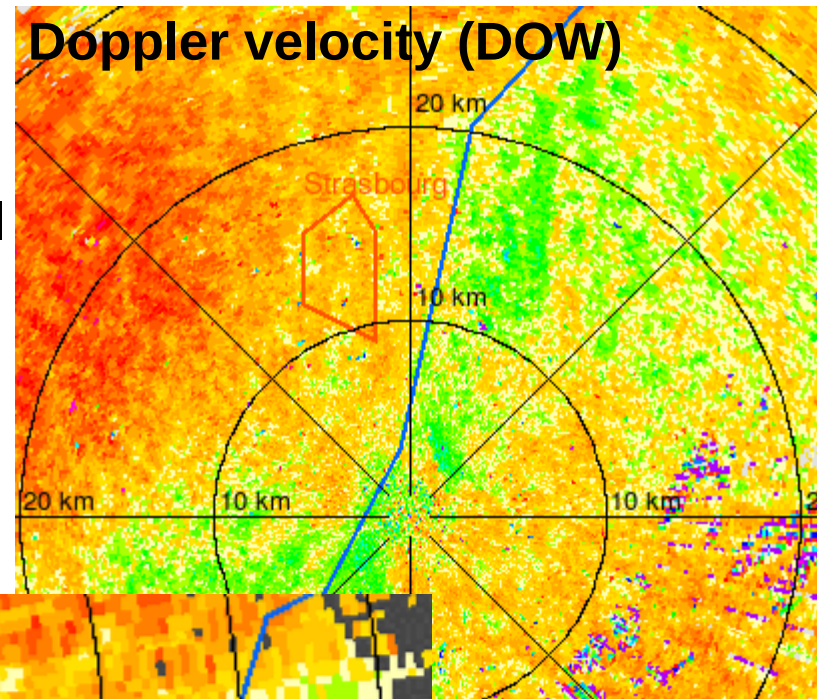
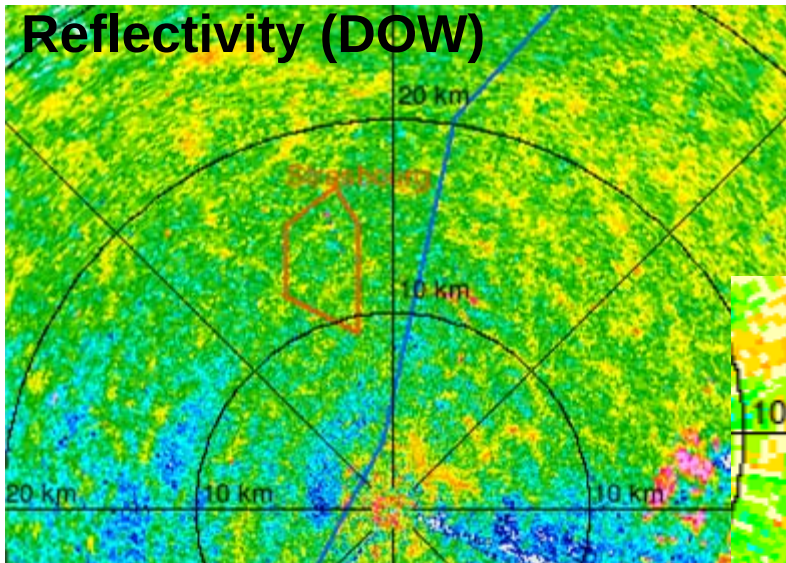
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Clear-Air Echoes 13 July 2007 (COPS campaign)

- Dual-Doppler analysis to get horizontal wind field (to be done).



Summary and Conclusion

- Clear-air echoes from weather radar can give insight in the spatial structure of convection
- Clear-air echoes can be observed throughout the summer time mainly within the boundary layer
- Access to raw data needed, because of reflectivity is well below rain values normally provided by weather services
- Validation by IGC files ?

