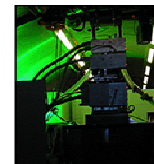
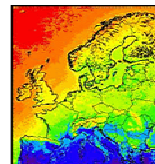
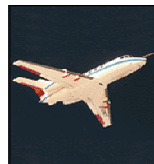
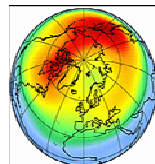
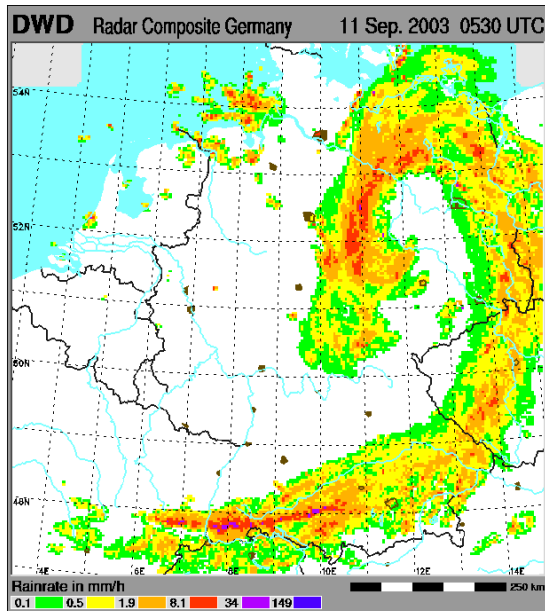


Precipitation radar

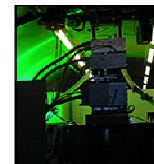
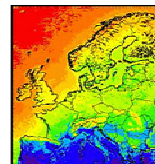
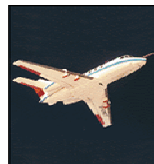
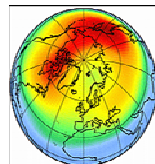
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Germany



~~Weather Precipitation radar~~



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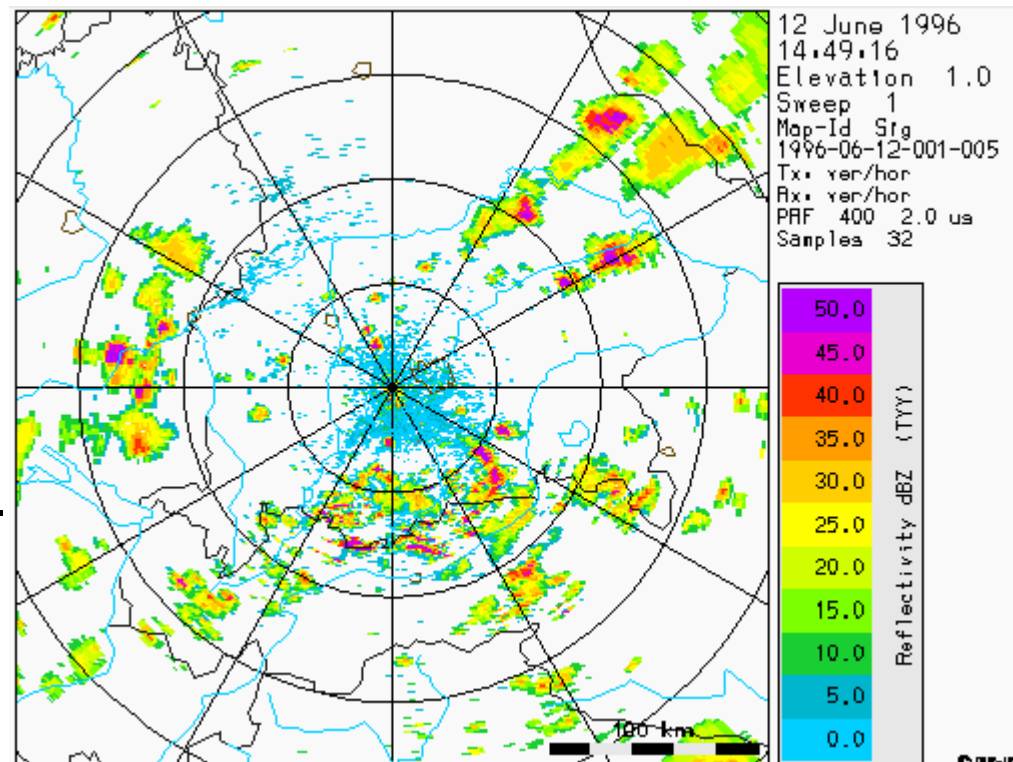


Weather Radar

Weather radar systems are routinely used to sense the 3-D volume of the atmosphere with a resolution of 1-2 km within several minutes up to a range of several hundred kilometres from the radar.

Currently different systems are common:

- **Doppler radars**
reflectivity, Doppler velocity, spectral width.
- **Polarization Doppler radars**
plus:
information on particles
(shape, phase, concentration).



Weather Radar

Weather radar systems use different frequency bands.

- X – band (10 GHz, 3 cm) small (1.5 m), short range, mostly for cities or smaller catchments.
- C – band (5.4 GHz, 5.5 cm) big (4-5 m), medium range, all weather radars in Central Europe.
- S – band (3 GHz, 10 cm) huge (8-10 m), long range, typical in USA and tropics.



Applications of weather radar

Reflectivity:

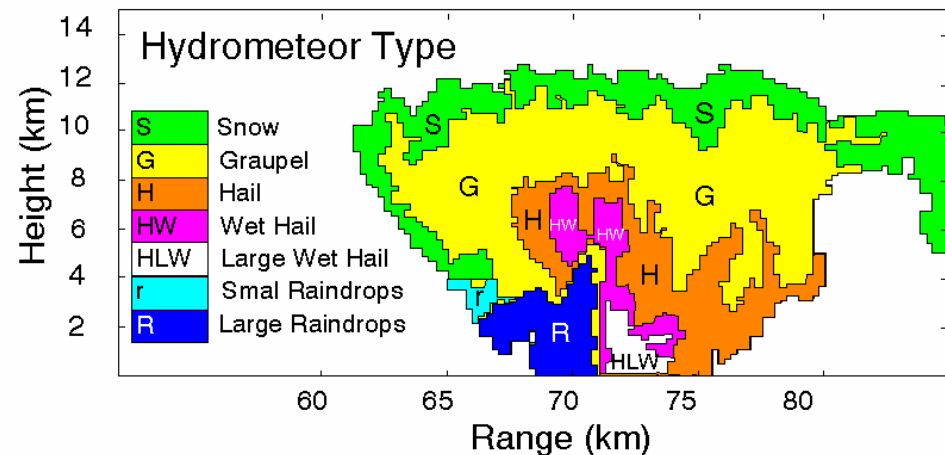
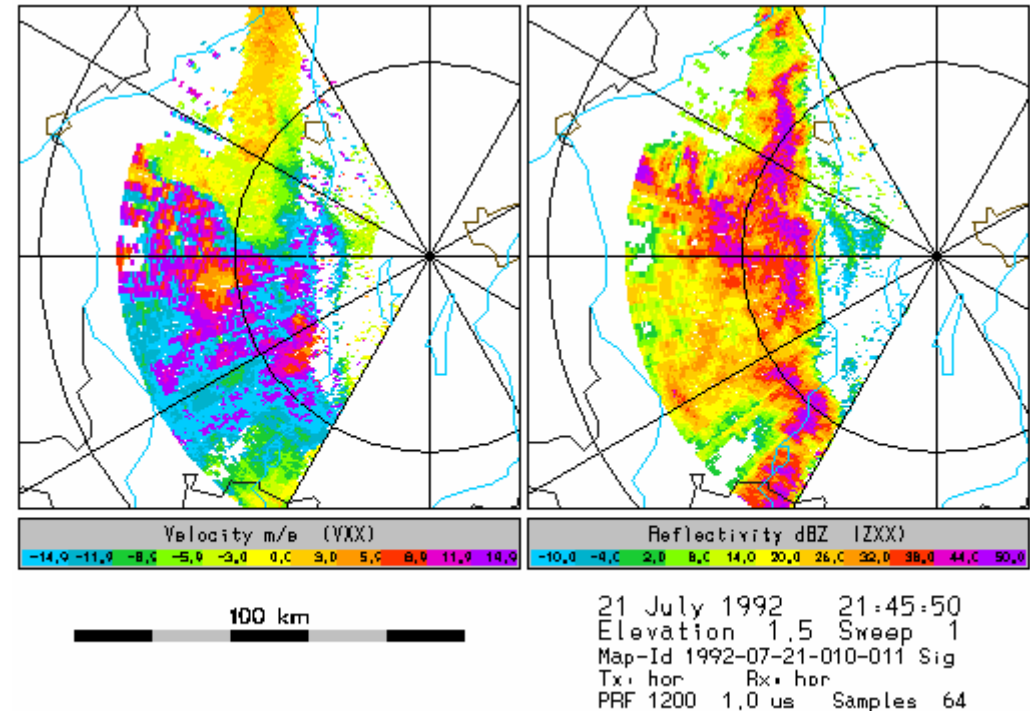
- rain fall rate,
- storm structure.

Doppler velocity:

- flow information,
- wind field,
- Refractive index estimation (so far only for S-band and klystron transmitter).

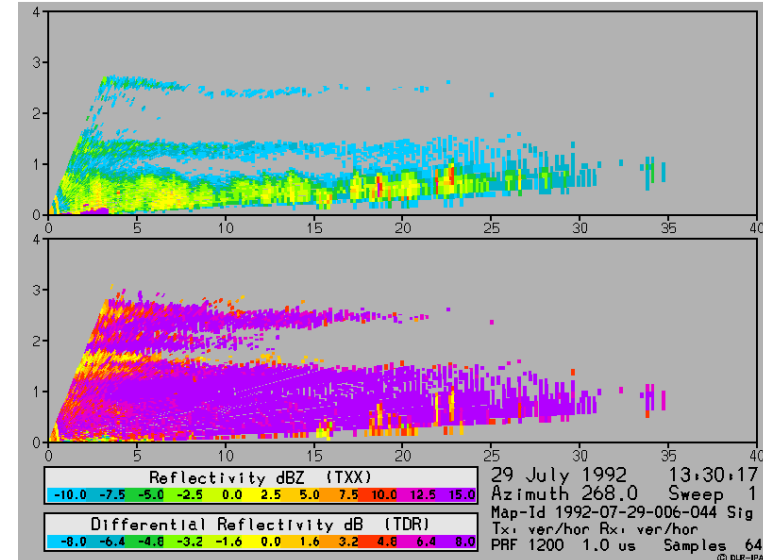
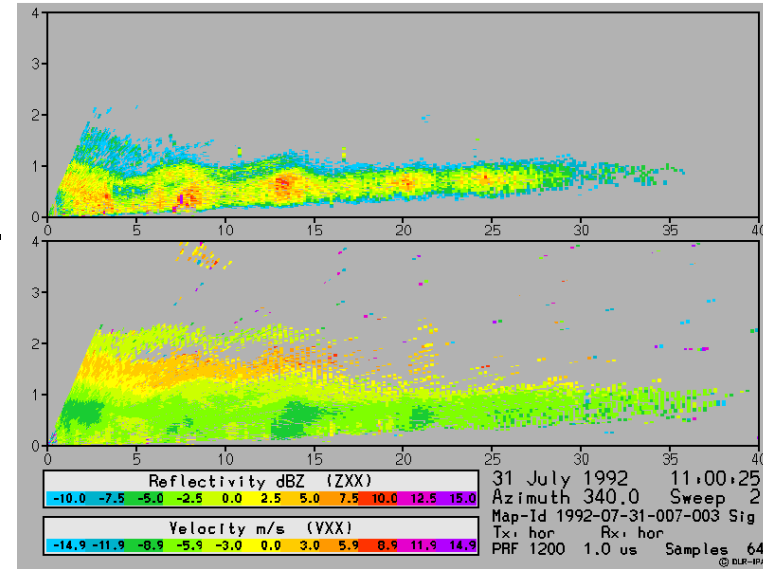
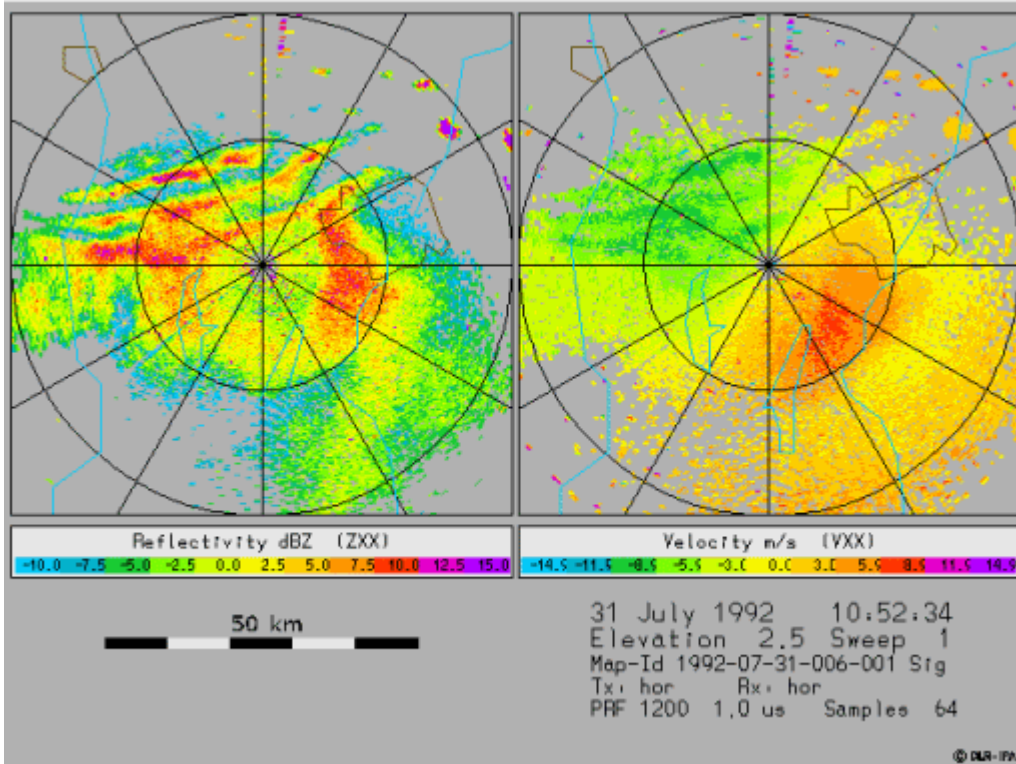
Polarization parameters:

- improved rain rate estimation,
- estimation of RDSD,
- hydrometeor identification.



Not only in rain, but also in “clear-air”

Clear-air scatters in summer up to a range of 50 km, shows convective structures, Scatters are: insects, clouds, Bragg-scatter.



Weather radars in Southern Germany

DWD: 16 C-band operational Doppler radars in Germany.

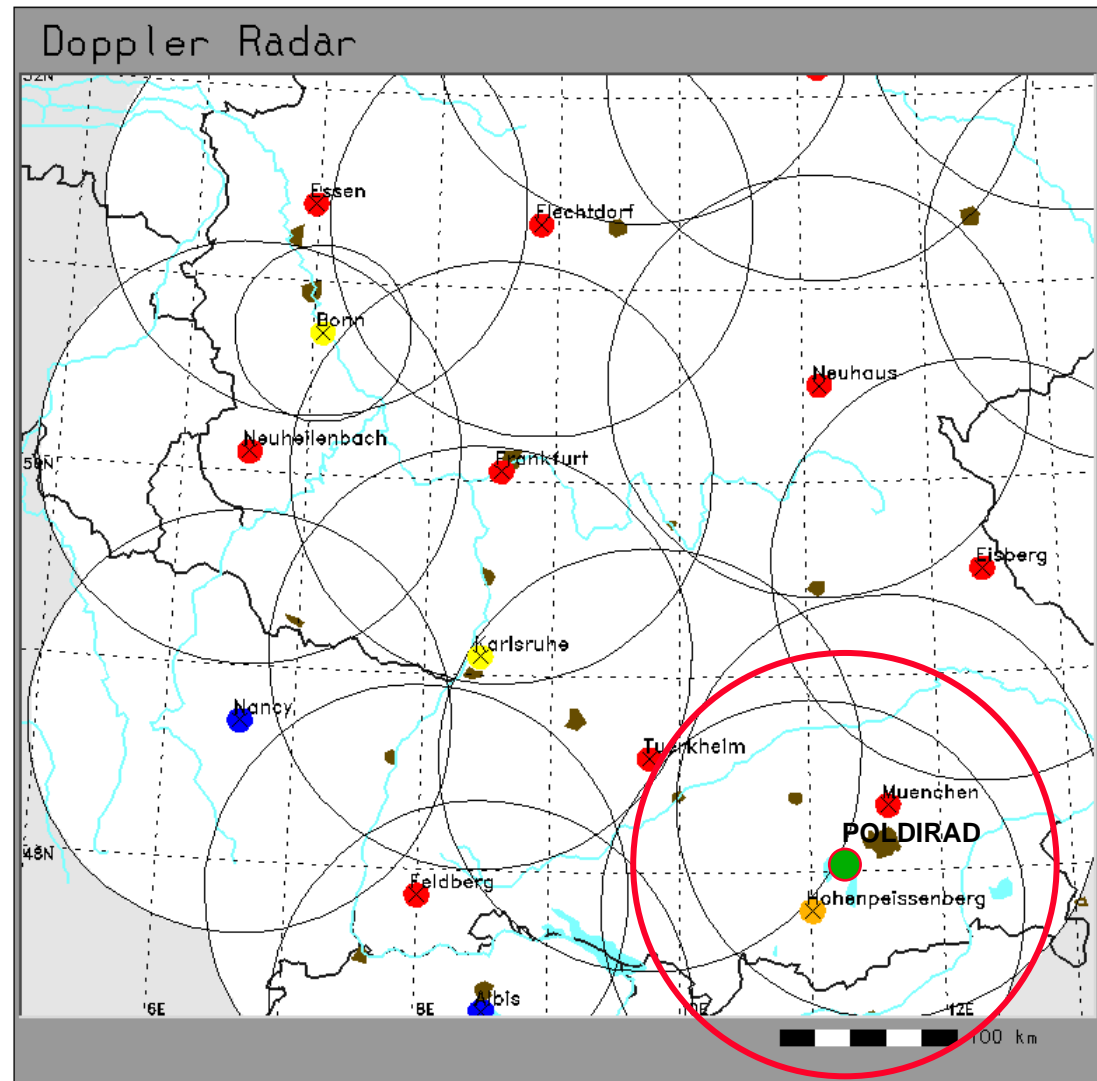
+ DWD research radar at Hohenpeißenberg (polarimetric in 2005),

+ operational C-band radar at Karlsruhe,

+ X-band radar at Bonn (50 km range).

+ C-band at Nancy (France) and Albis (Switzerland).

+ C-band polarimetric DLR Radar POLDIRAD.



120 km range circles

Weather radars in Southern Germany

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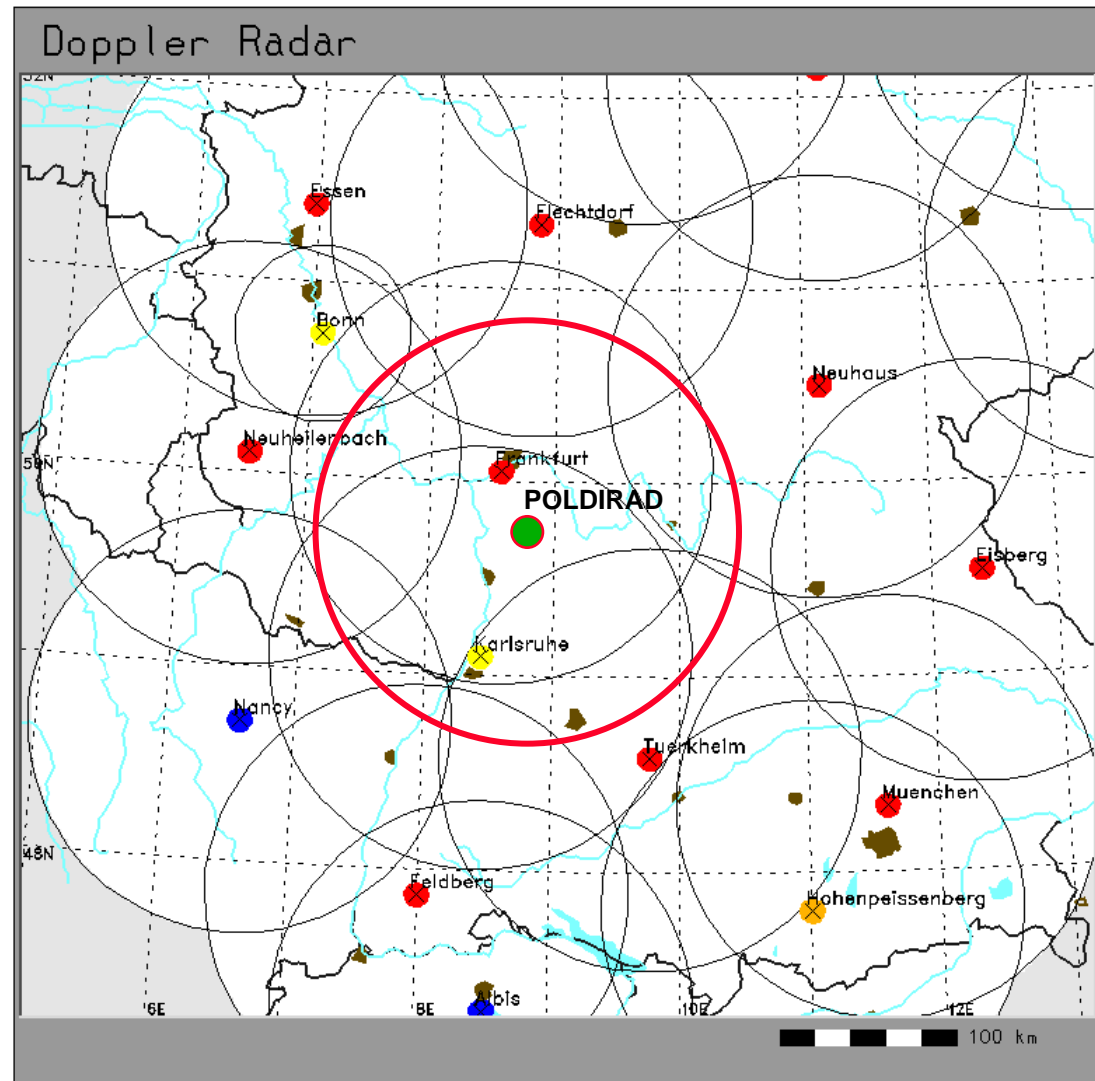
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+ C-band polarimetric DLR Radar POLDIRAD.
Radar is portable.

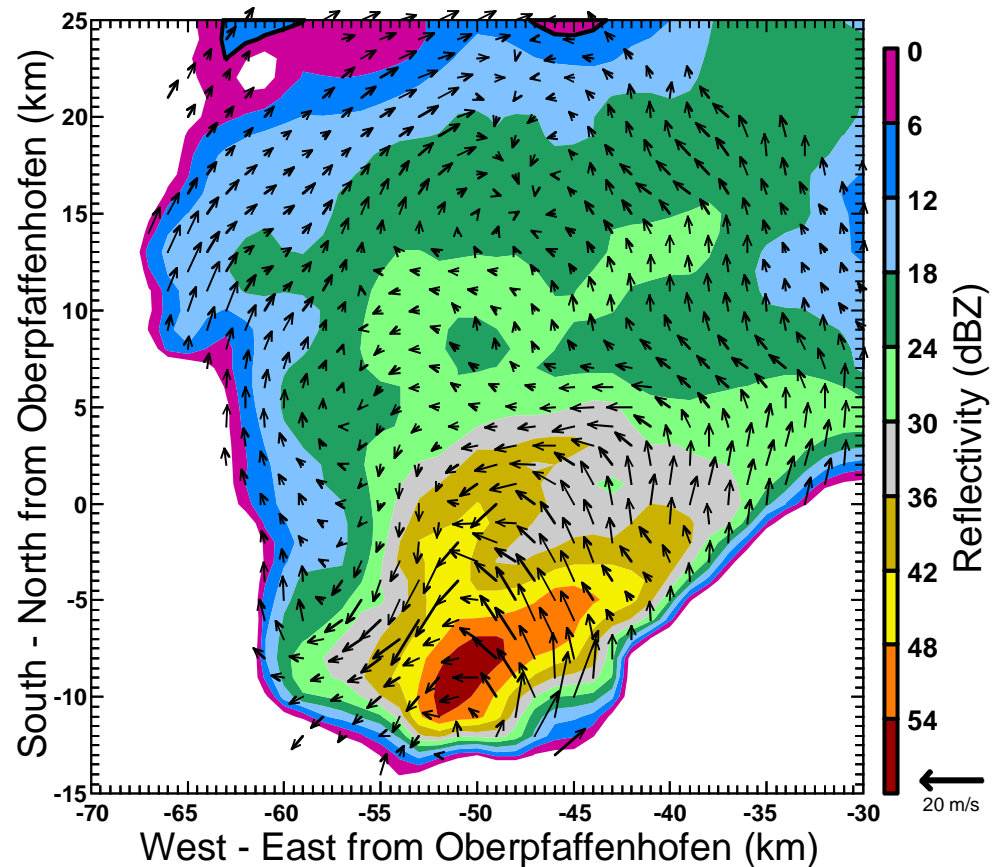
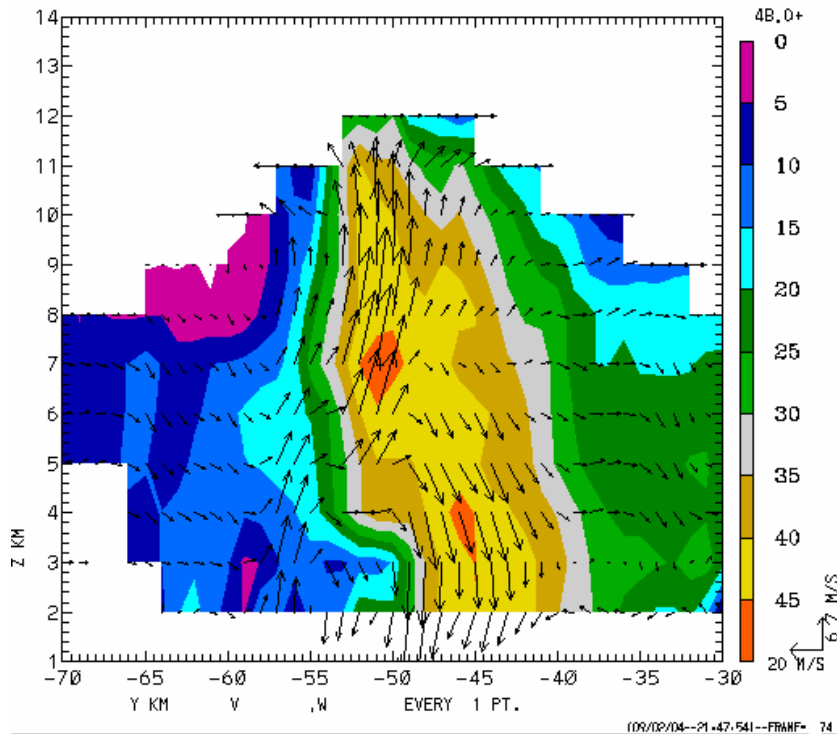


120 km range circles

Multiple Doppler Wind fields

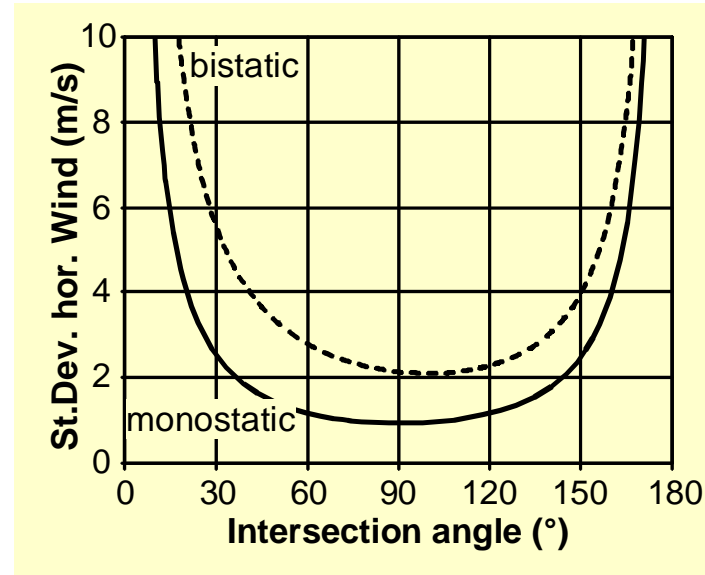
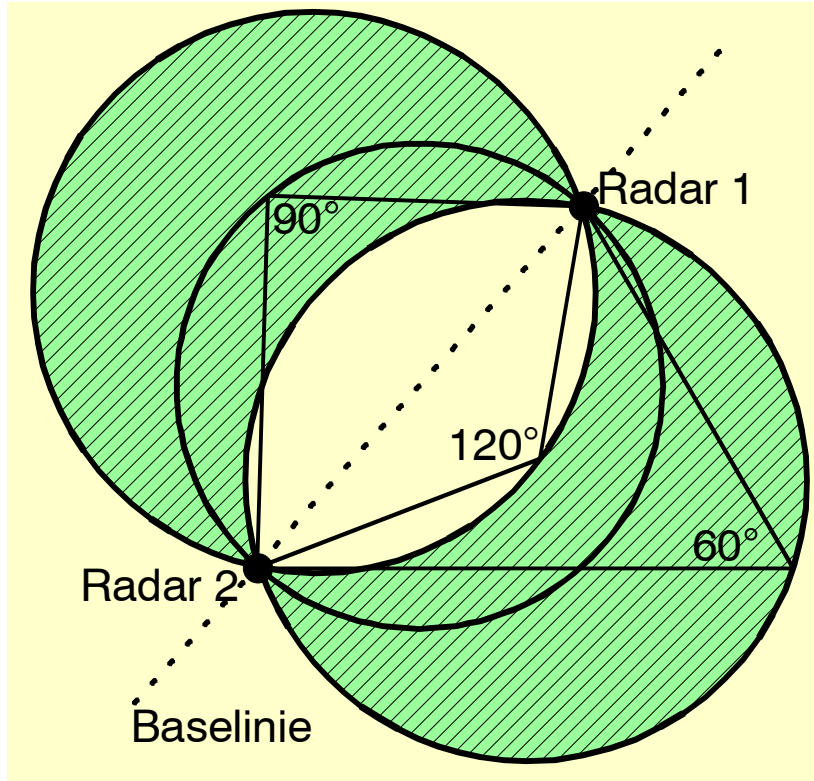
Doppler velocity only gives radial component of wind field.

Doppler measurements with additional radars (monostatic or bistatic) can give the full 3-dimensional wind field.



Dual Doppler Wind fields

Dual-Doppler wind fields are possible as long as the vectors from the two radars intersect at an angle within about 40° to 140° (assuming a maximum uncertainty of 2 m/s).



Horizontal wind vector through direct geometric solution.

Vertical air velocity through integration of horizontal divergence / convergence.

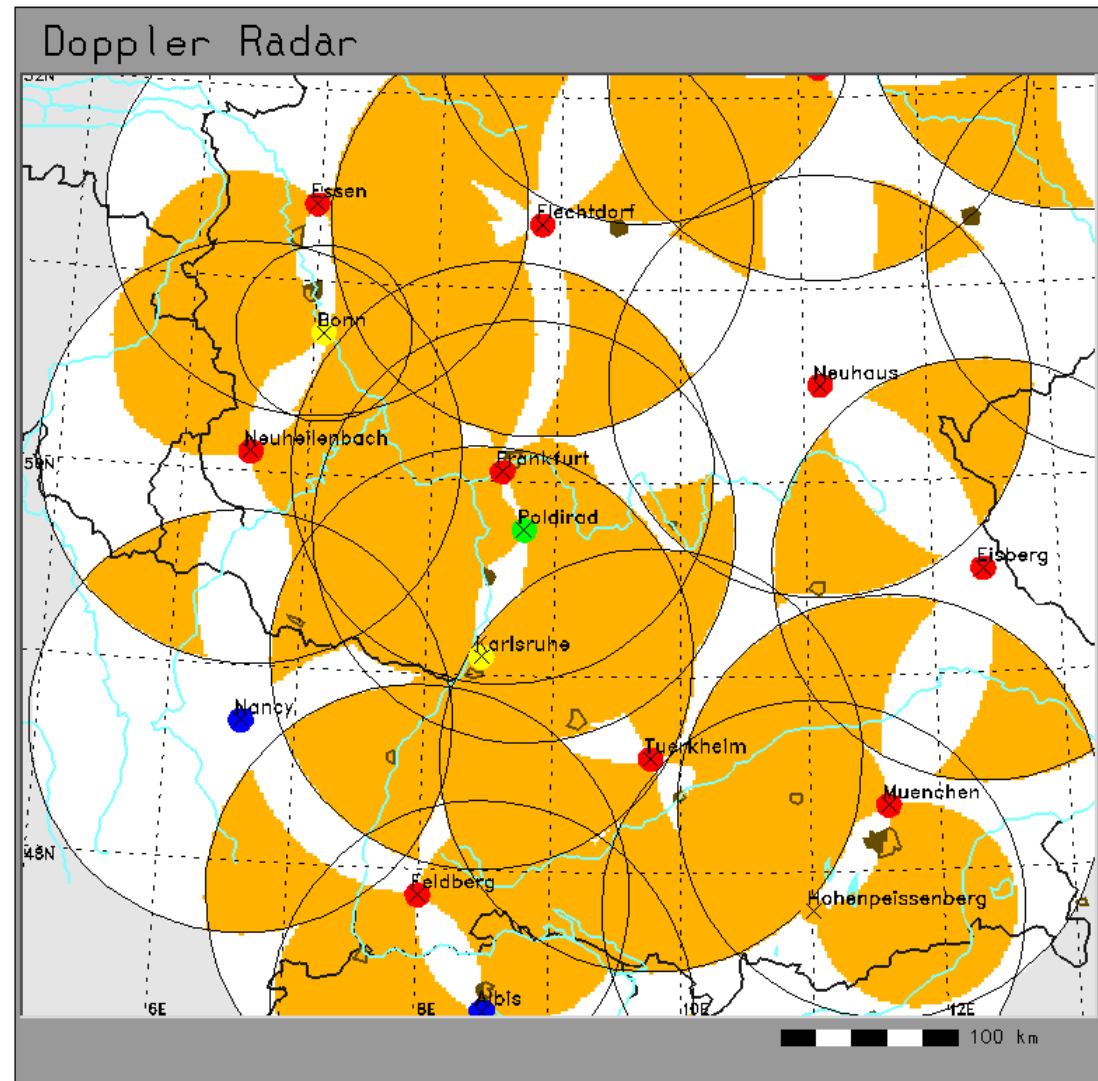
Friedrich & Hagen, 2004, Meteorol. Appl., 11, 155-171.

Multiple Doppler coverage in Southern Germany

Multiple-Doppler with DWD operational radars,
+ other Doppler radars in region,
+ POLDIRAD.

Limitations through large distances between radars.
Lowest usable height can be some kilometres above terrain. Vertical air velocity can only be estimated at short baselines (~30km).

Remaining areas can be covered by single Doppler wind field algorithms.



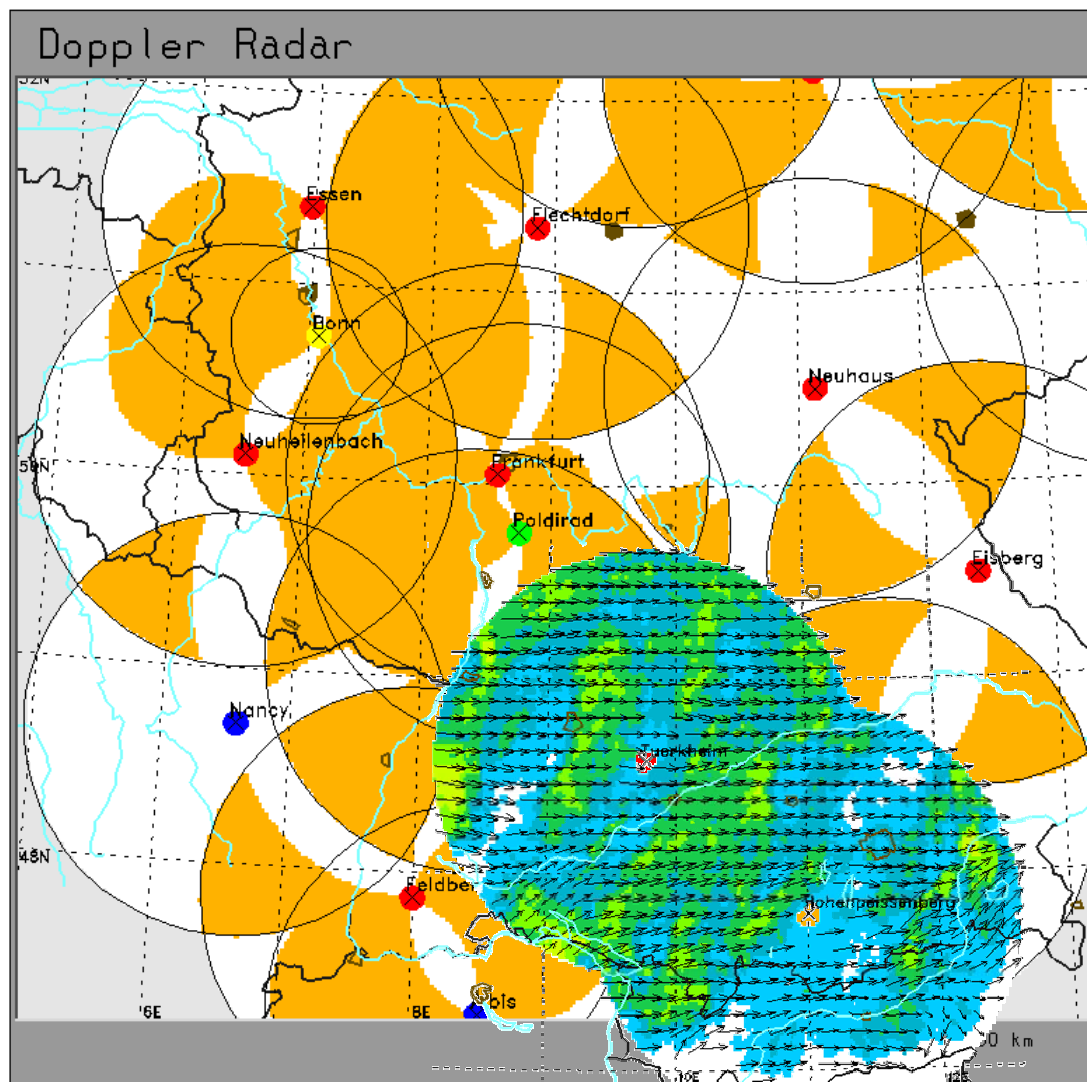
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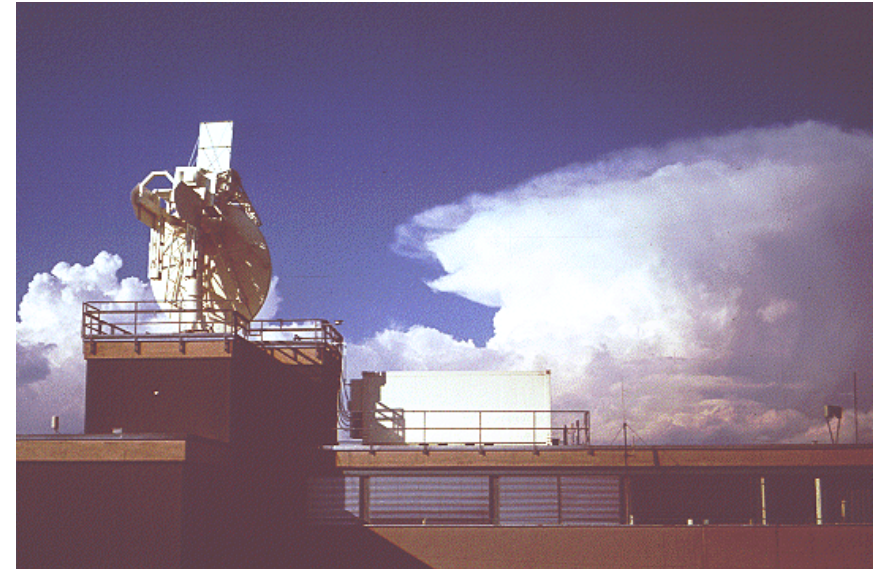
Türkheim – Hohenpeißenberg
2 June 2001 12 UTC.



Summary

Weather radar systems are powerful 4–D observation systems to cover a wide range of atmospheric phenomena (not just rain).

Doppler and polarisation diversity allows for detailed observations of dynamic and microphysical features.



Martin Hagen, COPS Workshop, Hohenheim, Sept. 2004