5 REMOTE SENSING PAPERS

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THE WEATHER RADAR NETWORK - ANOTHER MONITORING DEVICE FOR BIRD ACTIVITY

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Summary

Monitoring of bird migration for the purpose of low level birdstrike warnings (BIRDTAM) requires an area wide radar observation network. Besides air traffic control and air defence radar systems, a new network of c-band weather radar systems has been implemented in many European countries, providing continuous three-dimensional volume clutter scans of the atmosphere. Within the variety of operationally available products there are some, that implicitly contain bird activity information. The difficulty however is, that a complete analysis of the meteorological information has to be done, in order to eliminate weather echoes, ground clutter and anomalous propagation clutter.
An example of a typical interesting situation is presented. It demonstrates how to deal with the information and how to extract bird activity. Further efforts on the study of the potentials of new radar networks seem to be worthwhile.

Keywords: Migration, Remote Control, Radar, Electronic Detection, Warning Systems.

Introduction

The necessity and advantages of bird migration observation by radar for bird strike prevention are well acknowledged and do not need to be discussed [1]- Although often requested, there are no operational bird radar systems for the only task of bird observation. Even big airports are still frightened by the high costs for running such a bird radar. As far as there is no optimal solution one has to use other operational radar systems and adapt them to our special task. Different approaches have been worked out and are in use to provide bird strike warnings to air traffic [3].The aim of our effort should be a global monitoring network (2].
So far the most suitable monitoring device are surveillance air traffic or air defence radar systems. Since computer technology and data handling has improved enormously, there are now more radar systems and radar networks that should be examined towards its abilities for bird activity monitoring. Of course, they are all optimised for their special tasks and in the first instance they do not show birds on their displays. But there is a good chance to use the systems for our purposes as well, because the sensors (antennas) have become more sensitive and do detect birds.

Modern radar systems are meanwhile dominated by their software, whereas older systems, which are also still in use are dominated by their electronic hardware. This circumstance makes it more easy to configure an additional task on the same system.

The Weather Radar Network

Besides the flight safety radar network a weather radar network has been implemented in many parts of the world during the last years [4]. Europe is meanwhile almost completely covered by weather radar systems. In Germany for instance, there are now 15 weather radars (Fig.: 1) and they are in conjunction with the radar stations of the neighbouring countries. Each radar is continuously scanning with a range of 100 km, resulting in a complete run each 15 minutes. The data of every station are transferred into a rectangular three-dimensional grid and a variety of products are submitted to the Central Office of the German Weather Service (DWD) in Offenbach where all the radar information, national and international, is processed and combined to a composit view. These Products are then distributed and are available via the World Meteorological Organization - Global Telecommunication Network.
There are a number of products. Most of them view calculated meteorological parameter and are not interesting for our purpose. Besides those, single-radar, as well as national composite and international composite three-dimensional volume scan reflectivity distribution charts are available, which are ground clutter suppressed. There are also unfiltered radar reflectivity charts of local stations available. However latter one is not yet available in the German Military Geophysical Office.

Technical Details

The weather radar systems that are in use in Germany are operating in C-Band (5 cm wavelength) with emitter frequency of about 5600 MHz and a peak power of 250 kW per pulse. The pulse repetition frequency ranges between 600 and 1200 Hz. The beam width angle of the antenna is approximately 1°. There are older non doppler and new doppler radar combined in the network, due to historical reasons. The differences are in the emitter/receiver parts of the systems. However signal processing is the same for both, Clutter suppression is done either by clutter maps and more recently by statistical filter methods [S].

Clutter Processing

As the weather radar's primary task is the detection of hydrometeors [6], all other targets are suppressed during signal filtering as far as possible. These unliked targets are mainly from ground echos, which can occur in varying amounts, due to the propagation properties of the atmosphere. Under certain meteorological conditions the radar beam is bent towards the earth's surface, known as superrefraction, resulting in an enormous amount of ground clutter. This anomalous propagation conditions usually occur in the Mid Latitudes during high pressure weather situations with strong vertical temperature and moisture gradients. Such conditions can be computed and visualized in ray-propagation-diagrams (Fig.:2).

There are several techniques for clutter suppression for weather radar systems in use:

Static Clutter File

From a long series of recordings, those echoes are selected, which are on the same spot most of the time and are subtracted from the actual observation file. This method is simple and often used. But it does not take into account, that clutter is a dynamic feature, varying in space and time.

Multi-temporal Image Processing

This is a variation of the static clutter file method. Instead of a long series, the static clutter is extracted from a recent time interval before the actual observation. A modified version of this method is used by the German Weather Service. The disadvantage of it is, that stationary rain cells and in a consequence stationary soaring birds are suppressed as well.

Dynamic Clutter File

Another improvement of the static clutter file is the use and combination of secondary information, such as wind direction and wind speed. In order to filter out anomalous propagation, all clutter is removed that is not moving with the wind vector. This method is not used in Germany.

Decision Tree Filter

In Switzerland a method is used, which uses a_ logic algorithm for the identification of clutter. Some of the criteria are closely connected to the radar electronics, some use the propagation properties and one is based on the history of the clutter. In Germany a similar method is being tested at the moment.
As a consequence, it can be stated, that clutter suppression is less strongly carried out compared with air traffic control or air defence radars. Otherwise the meteorological information would diminish too much. For this reason there is still a good opportunity for large birds, bird flocks and big concentrations of insects to be detected by the radar as well as hydrometeors.

Weather Radar Display

Since about one year, the Biology Section of the German Military Geophysical Office has been equiped with a computer system and a data connection to the weather radar network. During this time first experiences could be gathered with the provided radar information.

The equipment consists of a UNIX based workstation forming the Geophysical Information System Terminal of the German Military Geophysical Service linked to a satellite communication system for online actual weather and other geophysical information. The weather information allows a continuous complete view on the atmospheric conditions. Additionally there are various specific methods available that use the basic actual information and extract sophisticated computed and numerical forecast products. The weather radar information is handled in a subsystem for the visualisation of echo plots. The weather radar network products, that are mentioned earlier can be combined for loop displays. A zoom function makes it possible to display the information also in small scale three dimensional views, overlayed on a geographical reference map. The echo plot files can be stored on tape for later analysis.

Bird Monitoring Example

A typical example of the features that could be observed several times in the past is presented as follows:

In the early morning of the 11.05.98 the weather situation showed clear sky conditions under high pressure influence over Germany, as can be seen from the satellite and metorological observations (Fig.:3 and 4). The vertical sounding showed typical temperature inversions, giving slight indications to ‚ana-prop"conditions. But the exact calculation of the radarbeams did not reveal such strong superrefraction or even trapping (Fig.: 5) of the radar beam. However over northern lowlands of Germany and the Netherlands there was an enormous amount of clutter in the composit radar pictures (Fig.: 6) throughout the early morning hours from just before sunrise on. The echo intensities varied throughout the entire scale, fluctuating on the same spot when visualising a radar loop. A closer look at the hight values of maximum echoes in south/north and west/east direction show a rise of the echoes with increasing distance from a selected single radar station (Fig.: 7) which indicates that there will be a certain amount of superrefraction, causing a hight error effect, that increases with distance.

The absence of hydrometeors and the absence of trapping indicates, that something else must have caused the enormous amount of echoes, although being ground clutter filtered. The time of day of course is very typical for high bird activity. The species which might have caused the echoes could be swifts and swallows. The fluctuation of the echo intensities is likely to be caused by the variation of bird concentration in the specific volumes of air. Unlike the air traffic or air defence radar display or the well known time exposure of the radar screen, the volume echo display of the weather radar shows an overall target in the volume as the radarbeam passes and displays its intensity.

Limitations
An important difference between the well known techniques of radar ornithology and the observation of bird echoes with weather radars is, that one cannot trace bird movements/migrations in the form of flight tracks. What can be seen, is an instantaneous overall bird activity in a volume of air. It is difficult to distinguish between ground clutter and bird activity in volumes close to the surface, when there are anomalous propagation conditions in the atmospheric boundary layer. Similarly it is difficult to distinguish bird activity and weather in areas where both can occur, The resolution scale is at maximum 1km3. The interpretation in the sense of bird observation is only possible if the complete meteorological background is available and considered.

Conclusions
The experience of about one year of sporadic observation of weather radar images from the point of a radar-birdwatcher allows some first conclusions:

- There are indications, that bird activity can be seen in weather radar images.
- Weather radarsystems provide continuous three-dimensional clutter information.
- Operational products are quite easy to obtain via national weather services.
- Interpretation is difficult and problems arise when anomalous propagation occurs.
- Interpretation is only possible, when the meteorological situation is considered as well in the same intense way.

References

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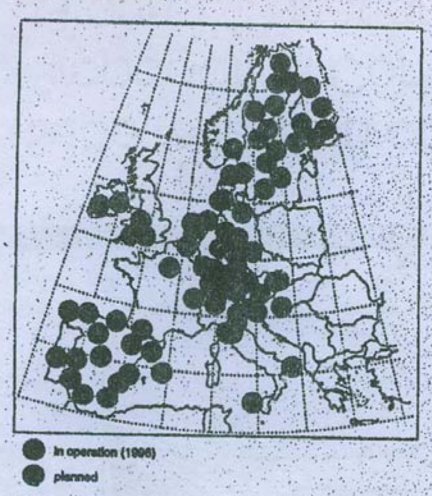

FIG. 2. Doppler weather radars in Europe used for operational services and for research. The circles indicate a radius of 100 km, which is the typical quantitative range to which radars in Europe are used to make measurements of precipitation. Often Doppler measurements are used up to 120 km, whereas reflectivity measurements are evaluated up to 230 km.

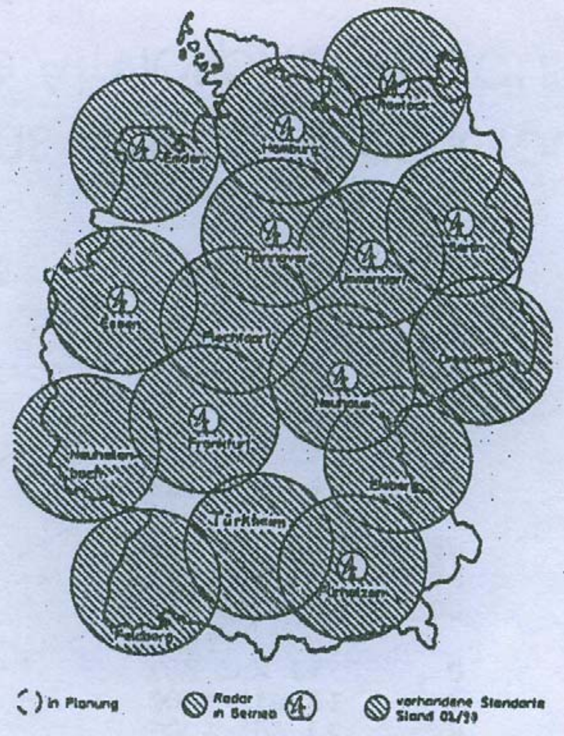

Figure 1: European Doppler Weather Radar Stations and German Weather Radar Network.

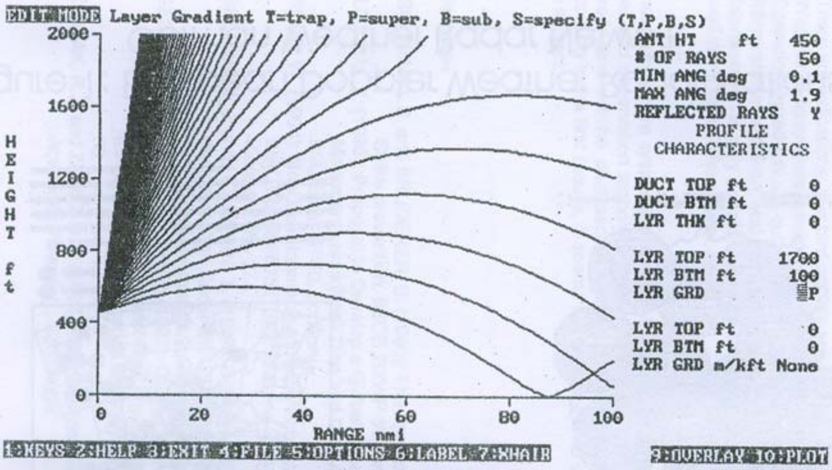

Figure 2: Superrefraction of Radarbeams due to Anomalous Propagation Conditions of the Atmosphere, Causing Ground Clutter and Hight Errors

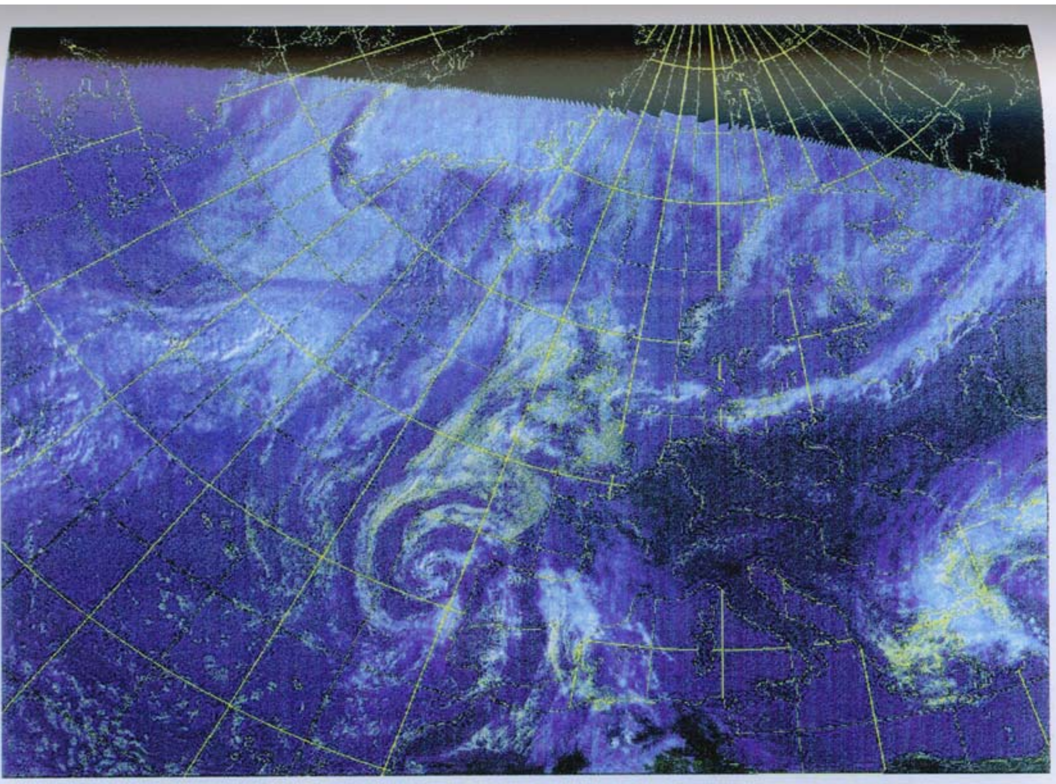

Figure 3: Satellite Image from 11.05.98/06 UTC

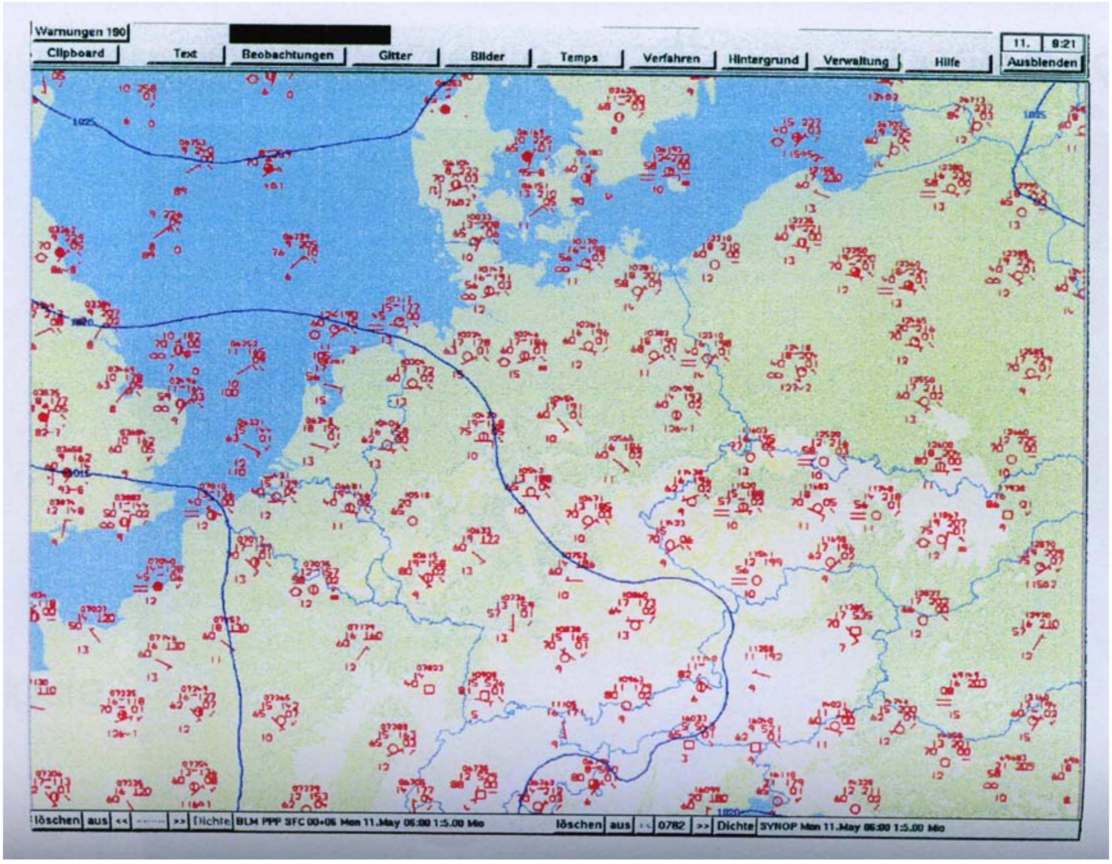

Figure 4: Synoptic Weather Observations from 11.05.98/06 UTC

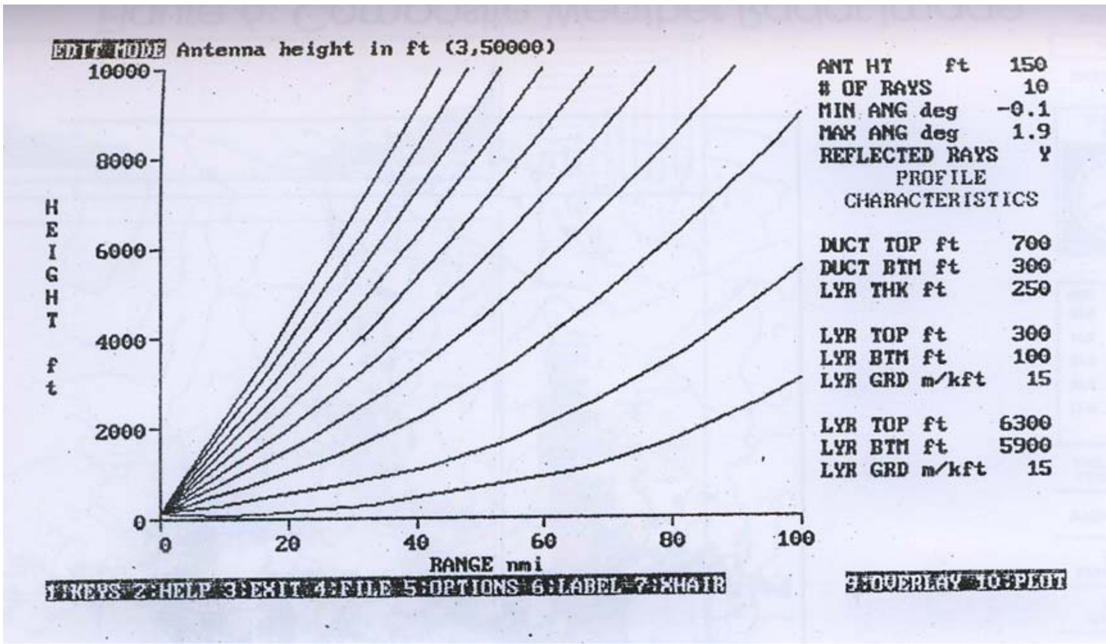

Figure 5: Propagation of Radarbeam According to Atmospheric Conditions over Northern Germany at 11.05.98/06 UTC

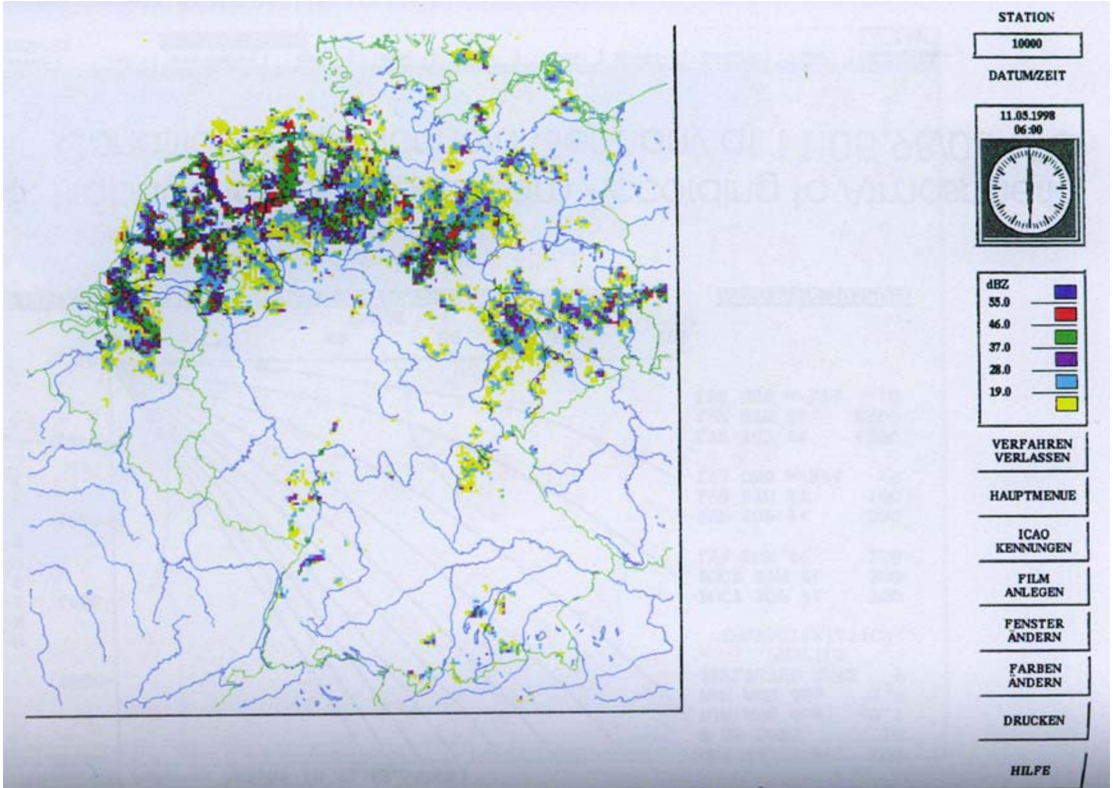

Figure 6: Composite Weather Radar Image

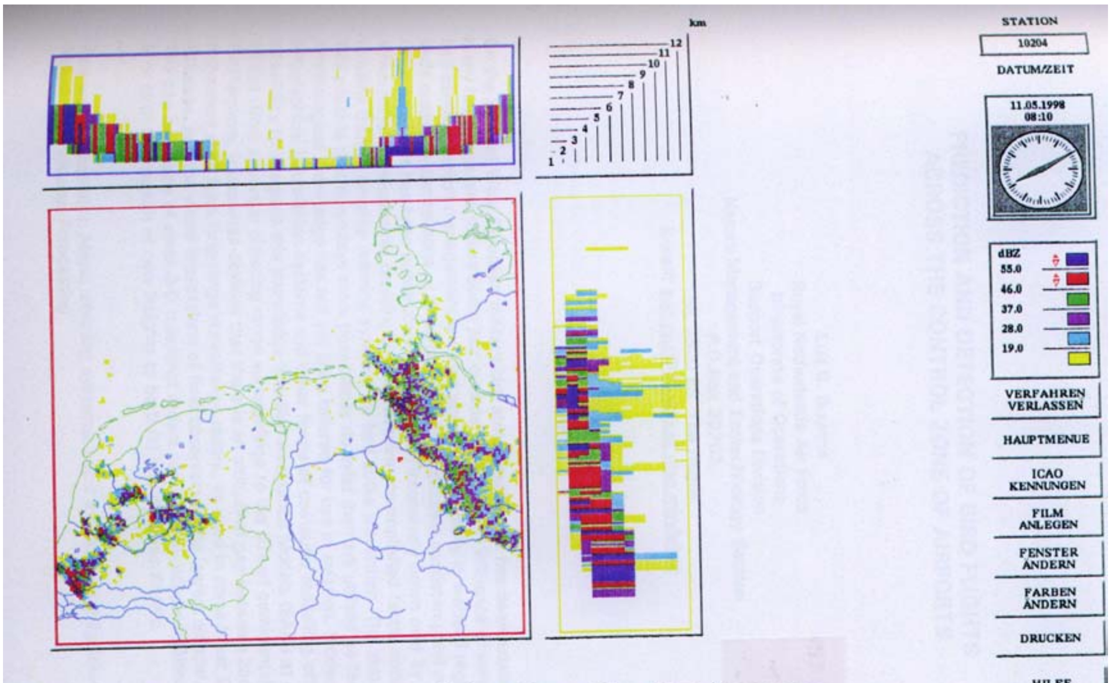

Figure 7: Single Station Weather Radar Image
with Maximum Intensities per Direction