Low-tropospheric wind profilers and radio contamination issues

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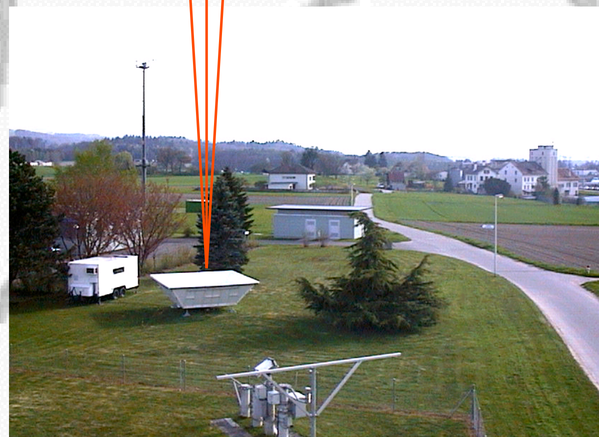
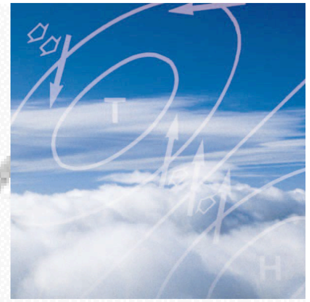
- Wind profiler
  - how it works
  - examples
- Frequency issues





How a remote sensing system works ?

- Ground-based **remote sensing** system, active and passive

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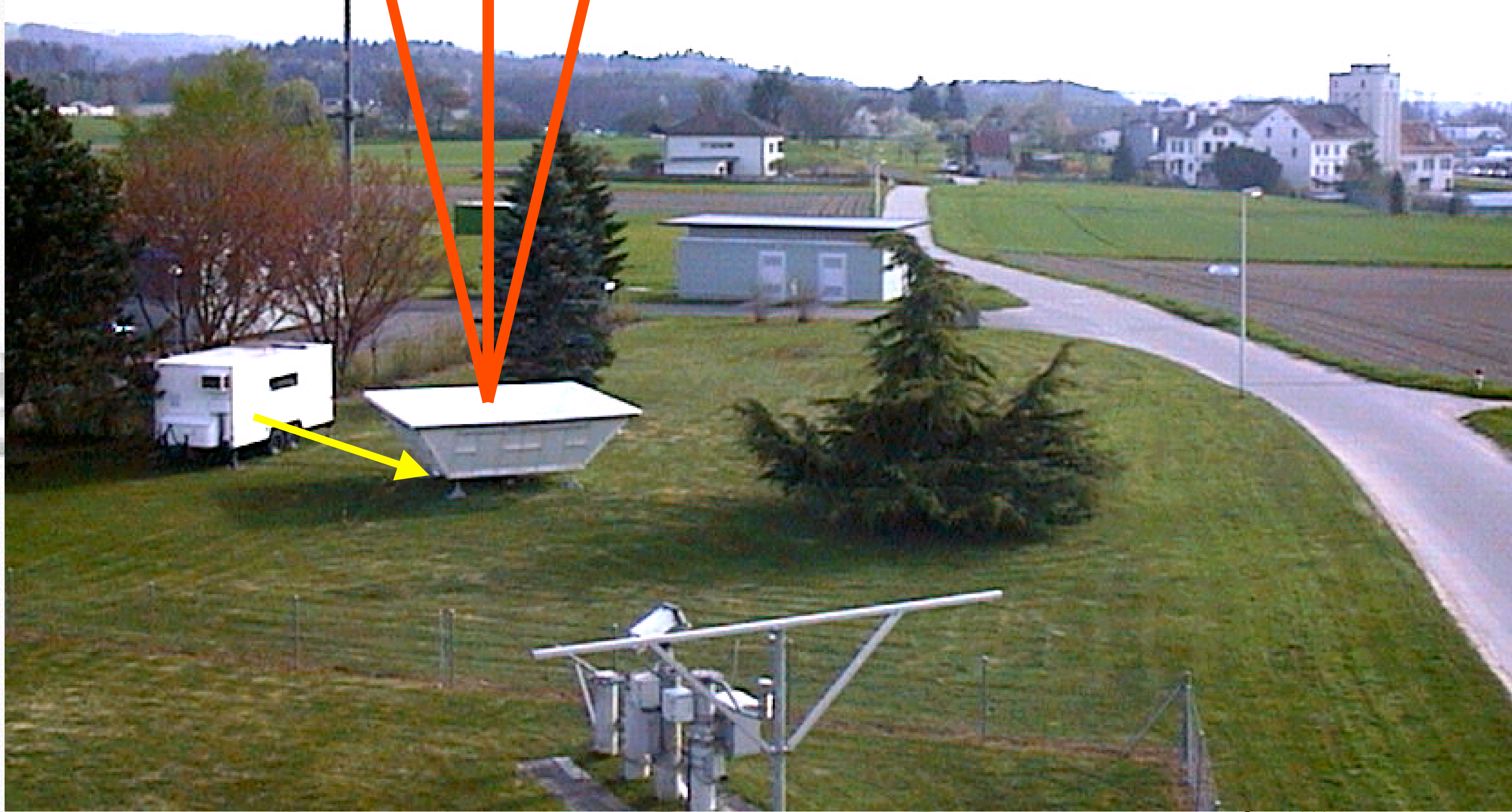
Emission

An electromagnetic pulse is emitted towards the zenith and at least 2 15deg-tilted directions (North and West for ex.)



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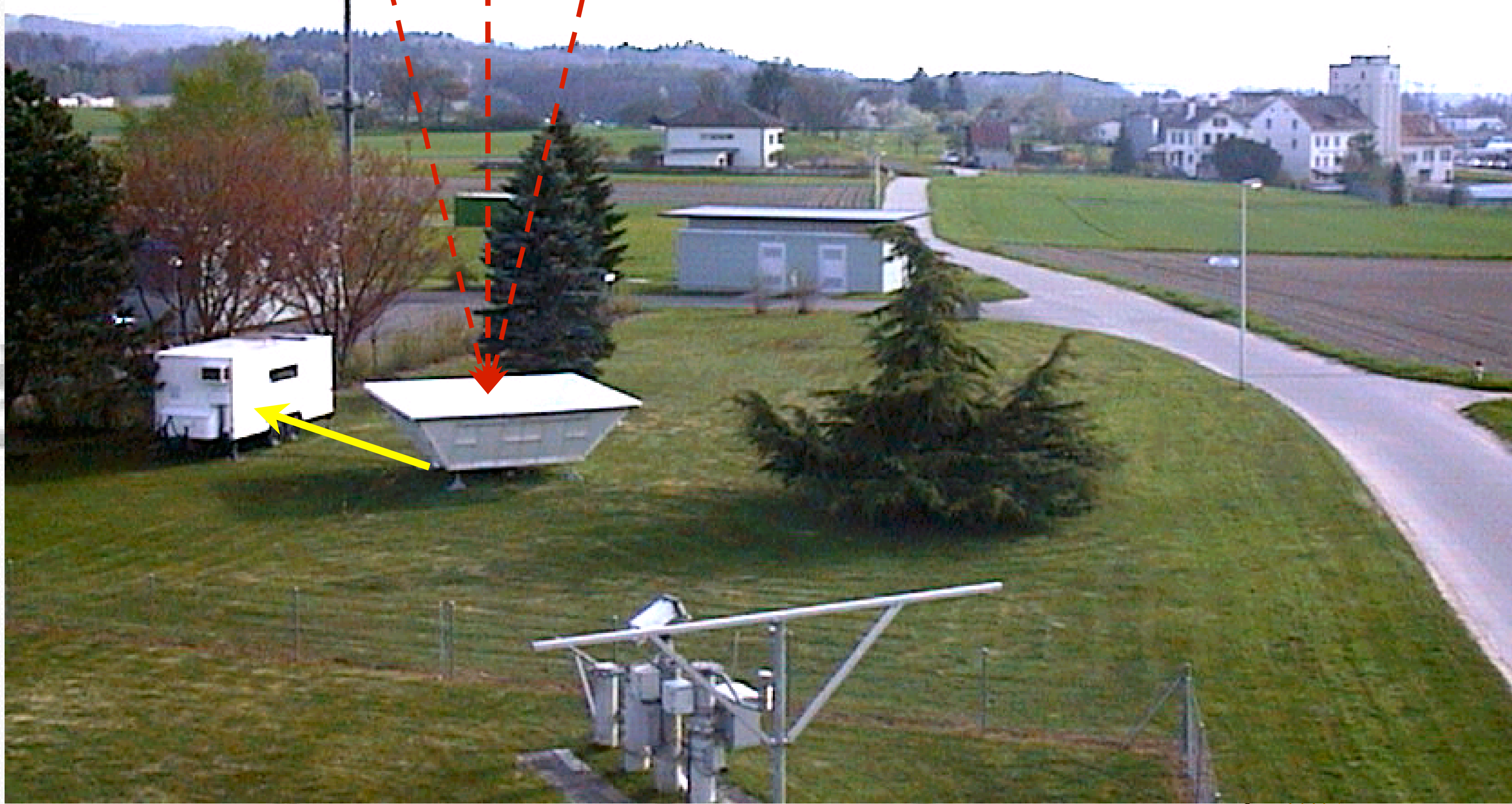
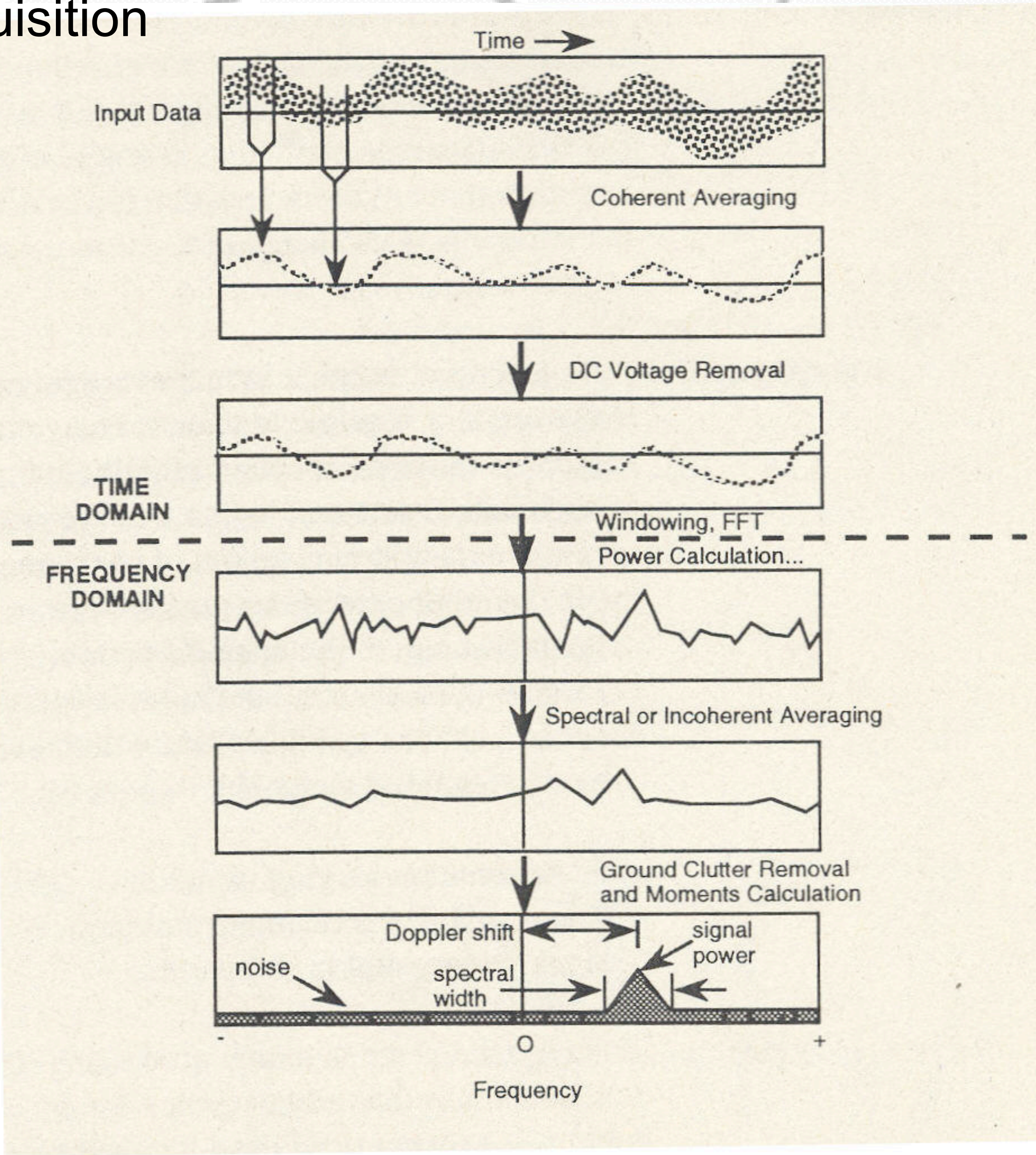
Reception

The intensity of the return signal by the atmosphere depends mainly on the humidity and on the thermal gradients within the atmosphere (C_n^2)



Data acquisition



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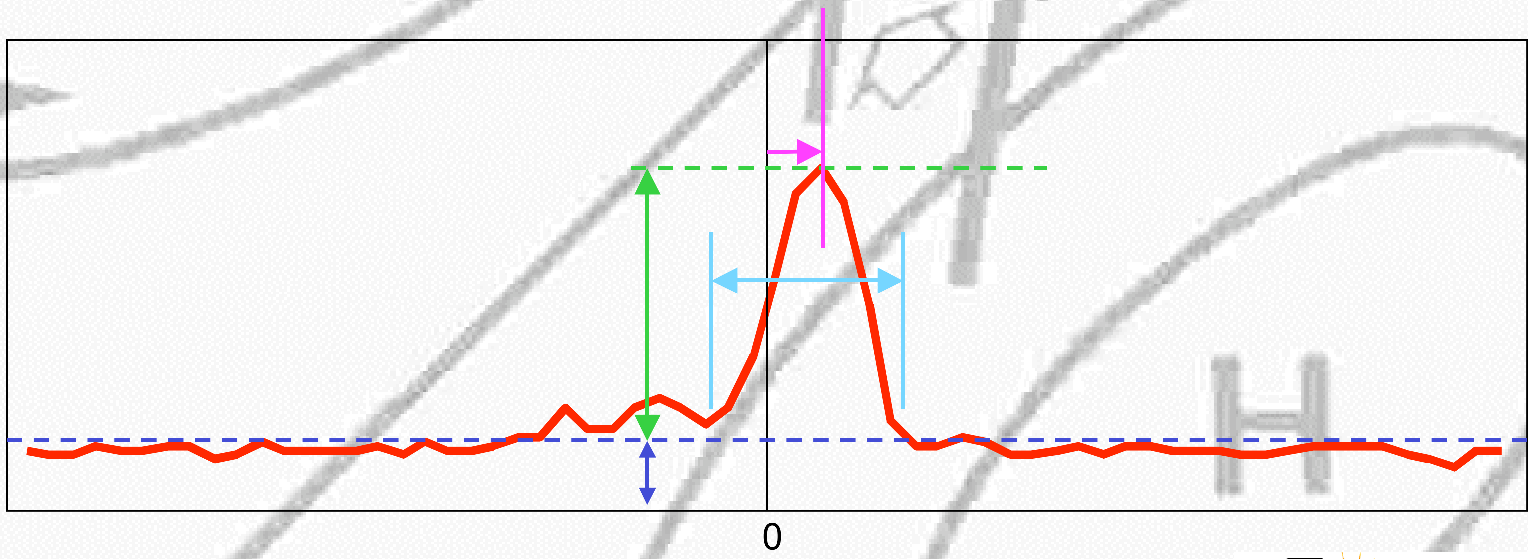
The frequency spectra obtained for each level are characterized by their moments:

- **Doppler shift**
- **Spectral width**
- **Noise level**
- **Signal-to-noise ratio (SNR)**



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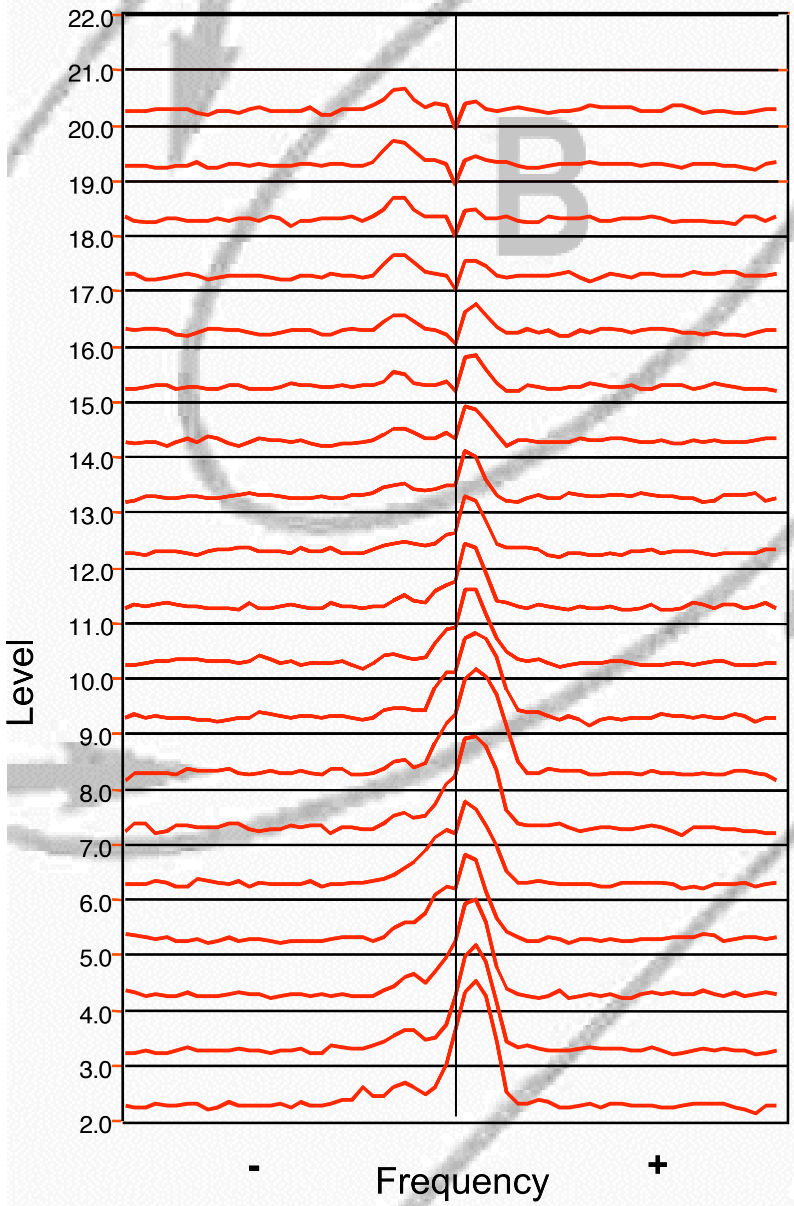
Signal processing



A succession of coherent averaging steps are followed by a Fast Fourier Transform (FFT)

The result is a series of **spectra** defined for each level (heights) and each of the beams

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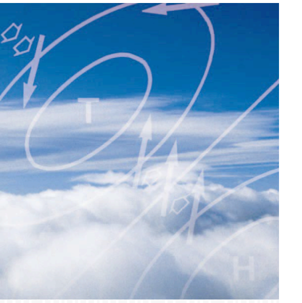

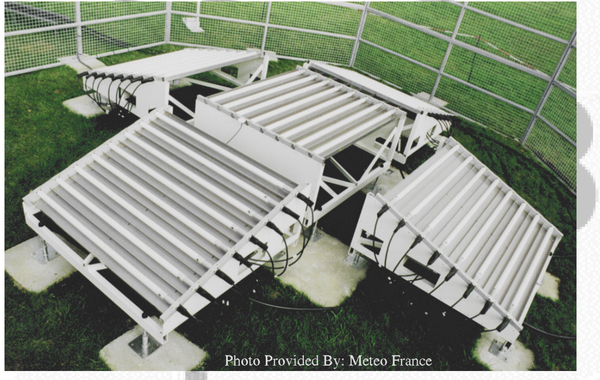

1 GHz systems (Nice)
up to 5km

400 MHz systems (Nordholz)
up to 16km

50 MHz systems (Aberystwyth)
up to 20km

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Performance Characteristics of the Profiler

Frequency	1290 MHz
Bandwidth	
@ 400 nS pulse	2.2 MHz (-3 dB)
@ 700 nS pulse	1.26 MHz (-3 dB)
@ 1400 nS pulse	632 KHz (-3 dB)
@ 2800 nS pulse	316 KHz (-3 dB)
Peak power	500 W
Average power	0.1 - 100 W

Phased Array Antenna

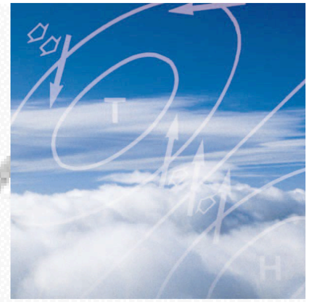
Type	Electrically steerable micropatch phased array formed by typically four 0.9 m x 0.9 m antenna panels
Aperture	Typically 3.35 m²
Direction	Zenith and 15 ° from zenith in four orthogonal directions , 6 degree beams
Gain	-29dBi

Typical Operating Parameters of the Profiler*

Pulse width	0.7 µs
Pulse repetition period	25 µs
Number of spectral points	64
Maximum radial velocity	±10 m/s
Height range (sampled)	120 m to 3 km
Sample spacing	100 m
Averaging time	30 minutes

Typical Performance Specifications of the Profiler

Minimum	
Measurement height:	120 m
Maximum	
Measurement height:	2 to 5 km
Vertical resolution:	
@ 400 nS pulse	60 m
@ 700 nS pulse	100 m
@ 1400 nS pulse	200 m
@ 2800 nS pulse	400 m
Wind speed accuracy:	<1 m/s
Wind direction accuracy:	<10 degrees

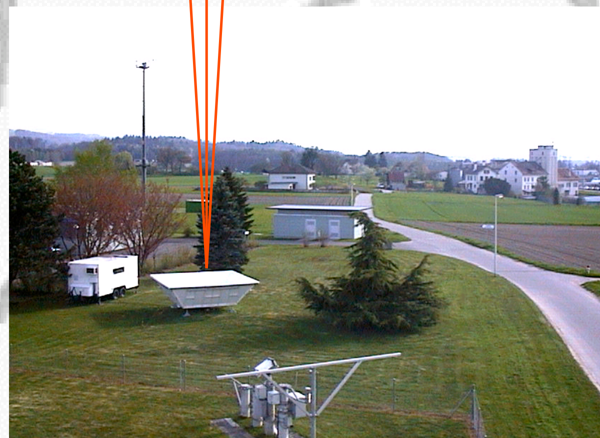


Wind profiler data use, examples

Operational

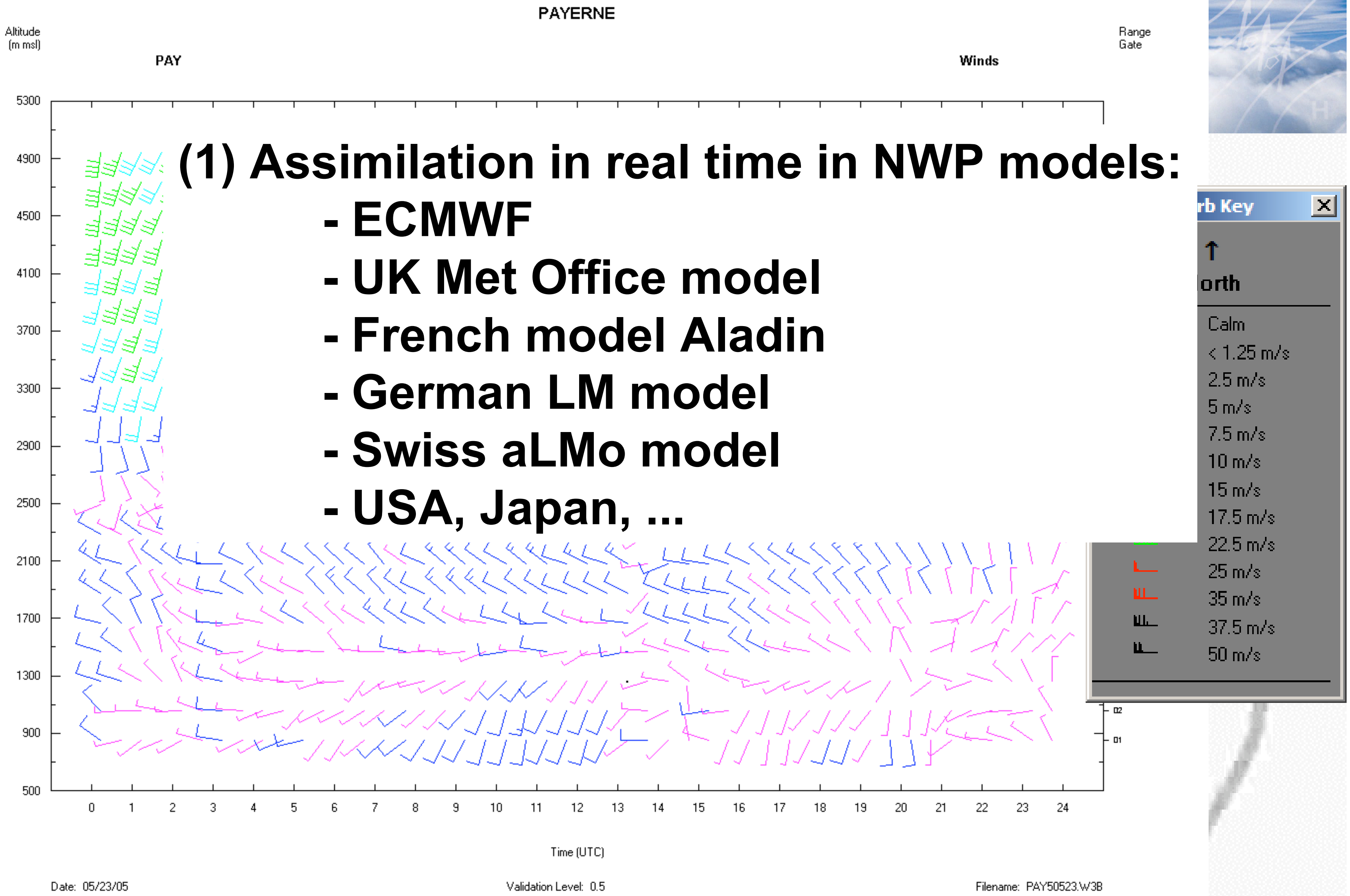
- NWP assimilation
- Weather forecast
- Aeronautics
- surveillance of special installations

- **Research**
  - Urban climatology
  - Complex topography
  - Air pollution



(1) Assimilation in real time in NWP models:

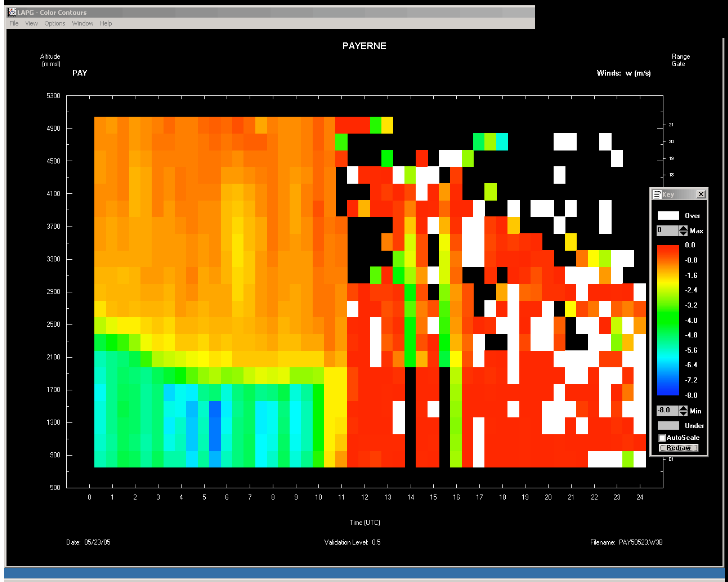
- ECMWF
- UK Met Office model
- French model Aladin
- German LM model
- Swiss aLMo model
- USA, Japan, ...



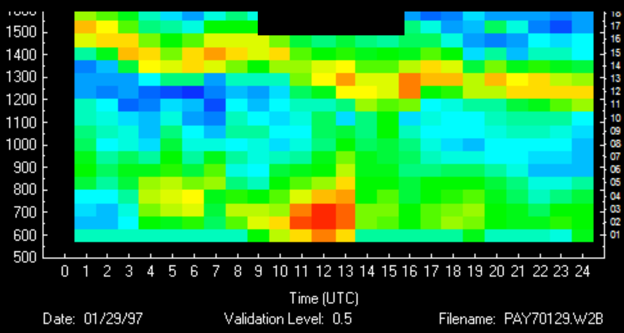
Payerne, 23 May, 2005

(2) Weather forecasting and nowcasting

- winds
- fog limit
- melting level

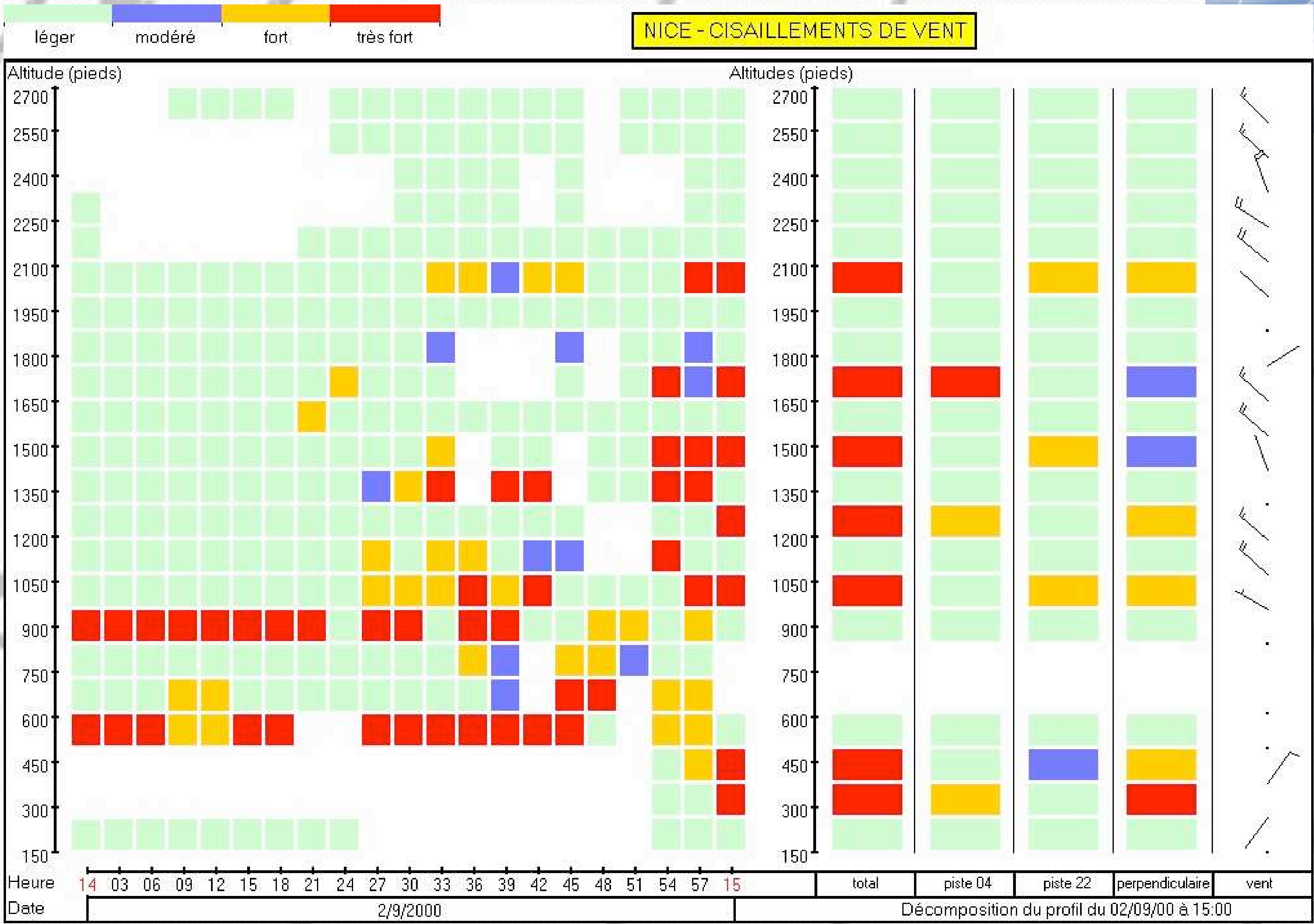


Payerne, 23 May, 2005



Payerne, 29 January, 1997

(3) Aeronautics



From METEO FRANCE

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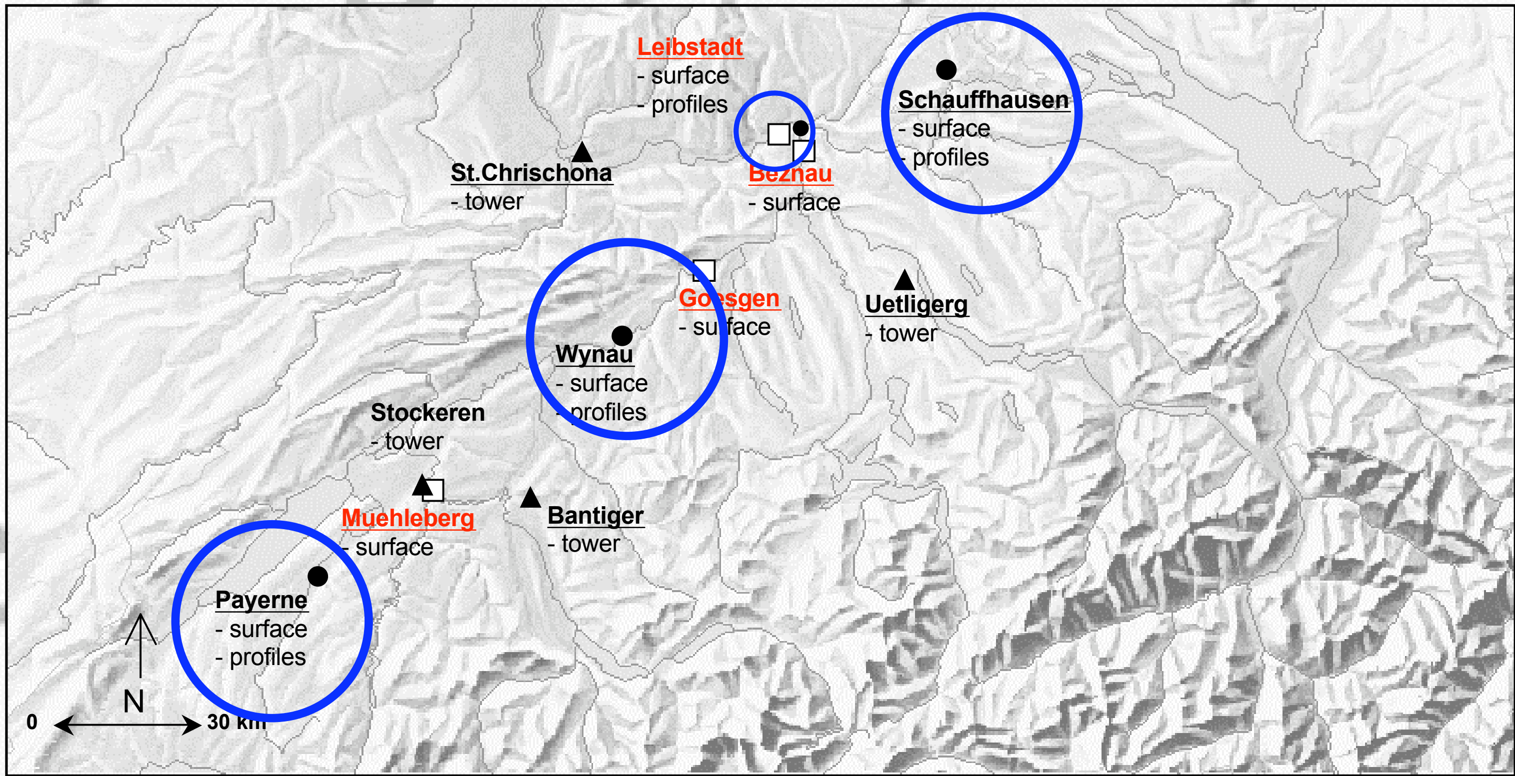
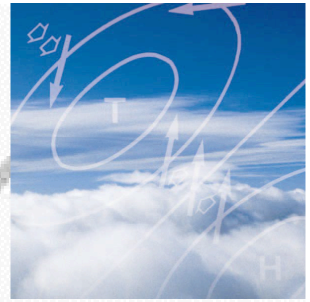
(4) Project for a new network for the surveillance of the Swiss nuclear power plants (including three 1290 MHz wind profilers)

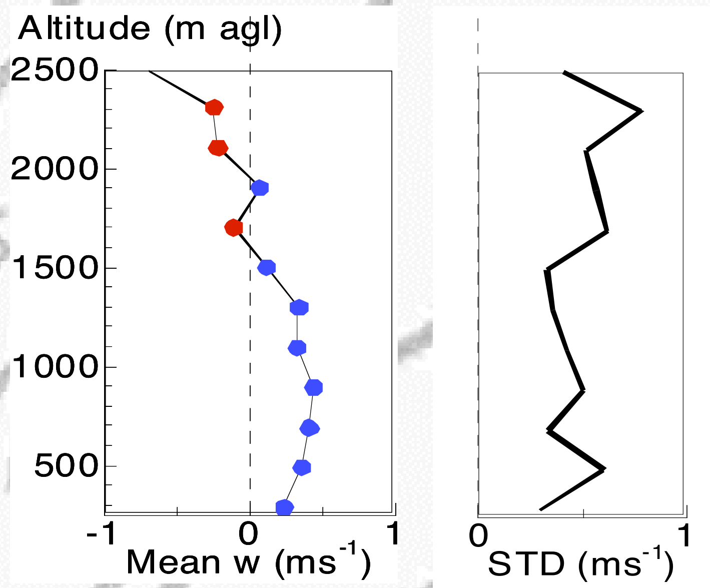


Research



(1) Urban meteorology (BASEL)

Evening (18-00 UTC)



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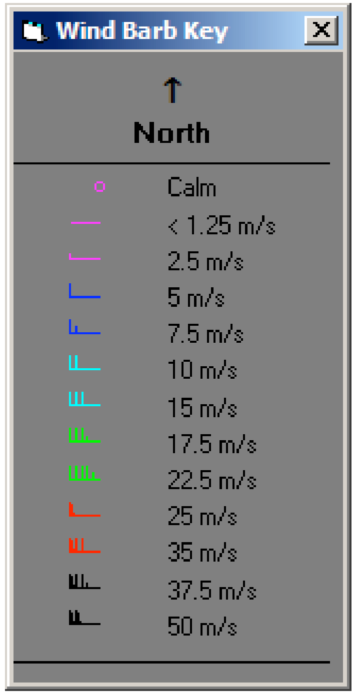
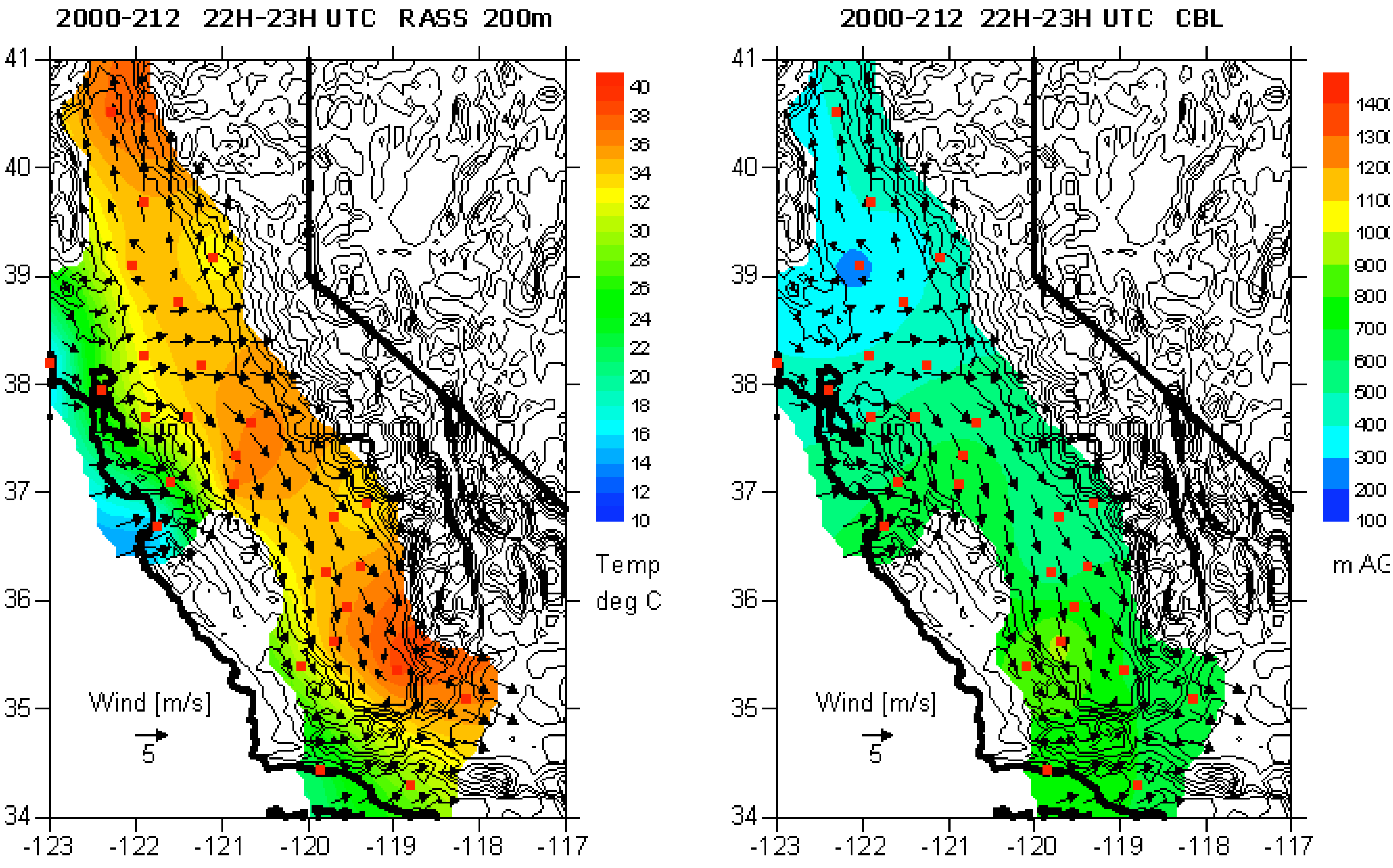
(2) Complex topography (MAP)

6 November, 1999



(3) Air pollution (NOAA/ETL)

13-14 LST



EUMETNET WINPROFII

Setting up of an operational wind profiler network in Europe including thirteen 1290 MHz systems (1 September 2005)

RESOLUTION COM5_5 (WRC_97)
IMPLEMENTATION OF WIND PROFILER RADARS
The World Radiocommunication Conference (Geneva, 1997),

considering

a) that wind profiler radars are vertically_directed Doppler radars exhibiting characteristics similar to radiolocation systems;

b) that wind profiler radars are important meteorological systems used to measure wind direction and speed as a function of altitude;

c) that it is necessary to use frequencies in different ranges in order to have options for different performance and technical characteristics;

d) that, in order to conduct measurements up to a height of 30 km, it is necessary to allocate frequency bands for these radars in the general vicinity of 50 MHz (3 to 30 km), 400 MHz (500 m to about 10 km) and 1000 MHz (100 m to 3 km);

e) that some administrations have either already deployed, or plan to expand their use of, wind profiler radars in operational networks for studies of the atmosphere and to support weather monitoring, forecasting and warning programs;

f) that the ITU radiocommunication study groups have studied the technical and sharing considerations between wind profiler radars and other services allocated in bands near 50 MHz, 400 MHz and 1000 MHz,

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Notes

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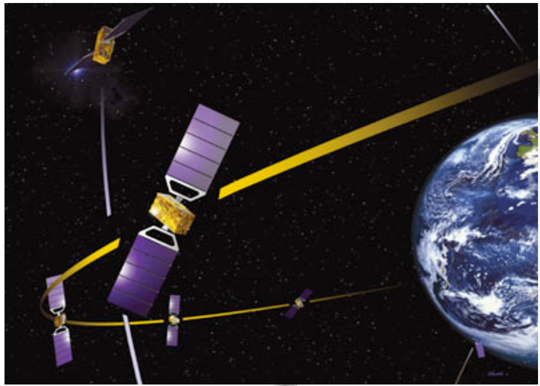
d) 904 - 928 MHz: This band (center frequency 915 MHz) is designated for industrial, scientific and medical (ISM) applications in Region 2 (basically the Americas). In this area, 1 GHz wind profiler radars can be operated here.

e) 1270 - 1295 MHz: In Regions 1 and 3 where the ISM band is not available, or in Region 2 where operation in the ISM band is not feasible, this radiolocation band is available for wind profiler radar operations.

f) 1300 - 1375 MHz: Where neither in the ISM band nor in the radiolocation band operation is feasible, this band may be used for wind profiler radar operations.



Compatibility between GALILEO and wind profiler radars in the 1215-1300Mhz band

GALILEO is the new European Satellite Navigation System

- Satellite deployment 2006-2008, operational 2008, 3 x 10 satellites
- E6 frequency: 1278.75 MHz, B/W: 40 MHz
- E6 power level on the ground -122 dBm

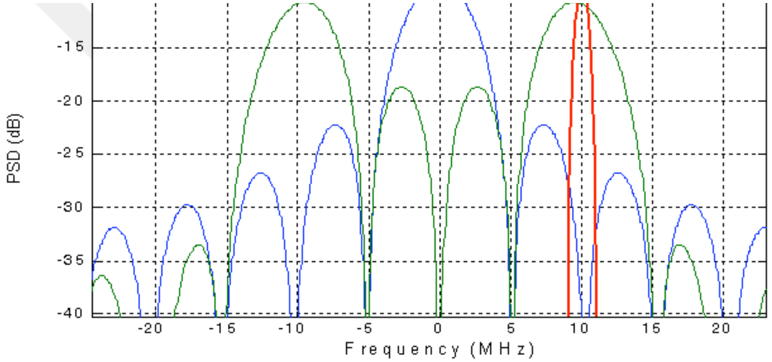


Figure 5-5 Galileo E6 and WPR Spectra

- **How will this signal be seen by wind profiler radars ?**
- **What are the best mitigation options ?**

Various studies in Europe performed within the Electronic Communication Committee (ECC-SE39 working group)

- •Finnisch/Vaisala report
- •Roke Manor report
- •Deutscher Wetterdienst report
- •Meteofrance report

➔final ECC SE39 report with mitigation proposals (in final state)

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(1) Interferences caused by GALILEO

GALILEO signal simulation (DWD)

- No coherent interferences
- Incoherent interferences

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Coherent interferences

(further testing are expected to confirm these results)

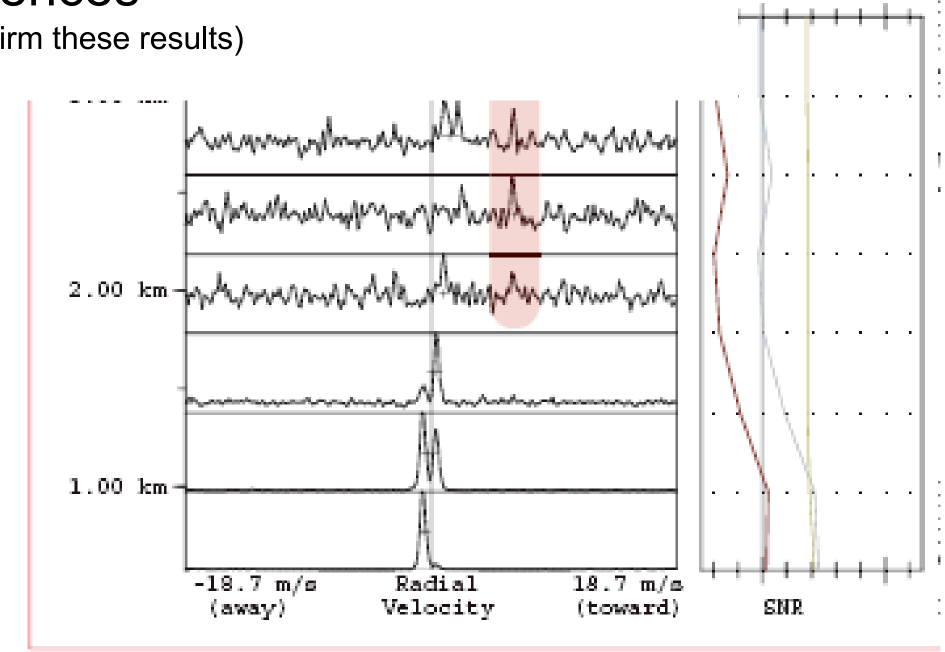

Figure 15: Doppler spectra with a CW signal input at th
and profiler transmitting enabled. The shaded area sho
response to the ingested signal.

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Incoherent interferences

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Doppler spectra and the mathematical effect of the coh
Doppler spectra saved in the radar processor are for vari
a factor of $1/N_{ci}^2$. This is partly compensated by an inc
due to the coherent integration process by a factor of N_c
on the noise level should thus be $N_{ci}/N_{ci}^2 = 1/N_{ci}$. A d
factor of 4 should therefore result in an increase of the n
is actually reflected in the data with a very high accurac

The data obtained show the noise level depending on
should not be observed theoretically. The radar uses a
where the receive bandwidth depends on the pulse-wid
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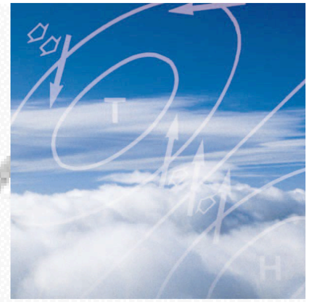
A decrease of the NCI by a factor of 4 should result in an increase of the noise level of 6 dB

(2) Main mitigation options currently in discussion



- a minor frequency shift into GALILEO signal spectral minima (E6 null),
- Increasing the number of beams
- a modification of the beam sequence,
- a major frequency shift of the wind profiler frequency.

In case no mitigation techniques would be efficient, the wind profiler community would recommend a shift of the wind profiler frequencies down to the 0.8 – 1.2 GHz band.

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Summary

- Wind profilers are operational worldwide (Europe, USA, Australia, Japan, ..)
- Wind profilers are providing valuable information for both operational and research applications related to meteorology and climatology
- Low-tropospheric 1GHz systems performance will likely experience minor interference from the new GALILEO system
- Because of the high sensitivity of the wind profiler receiver, new types of contamination can be expected in the near future.

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