The European Wind Profiler Network CWINDE

Problems and Prospects

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but first.....

a few words about WG-1 (Instrumentation) of COST ES0702 (EG-CLIMET)

COST Action ES0702

Working Group on Instrumentation (WG 1)

From the MoU:

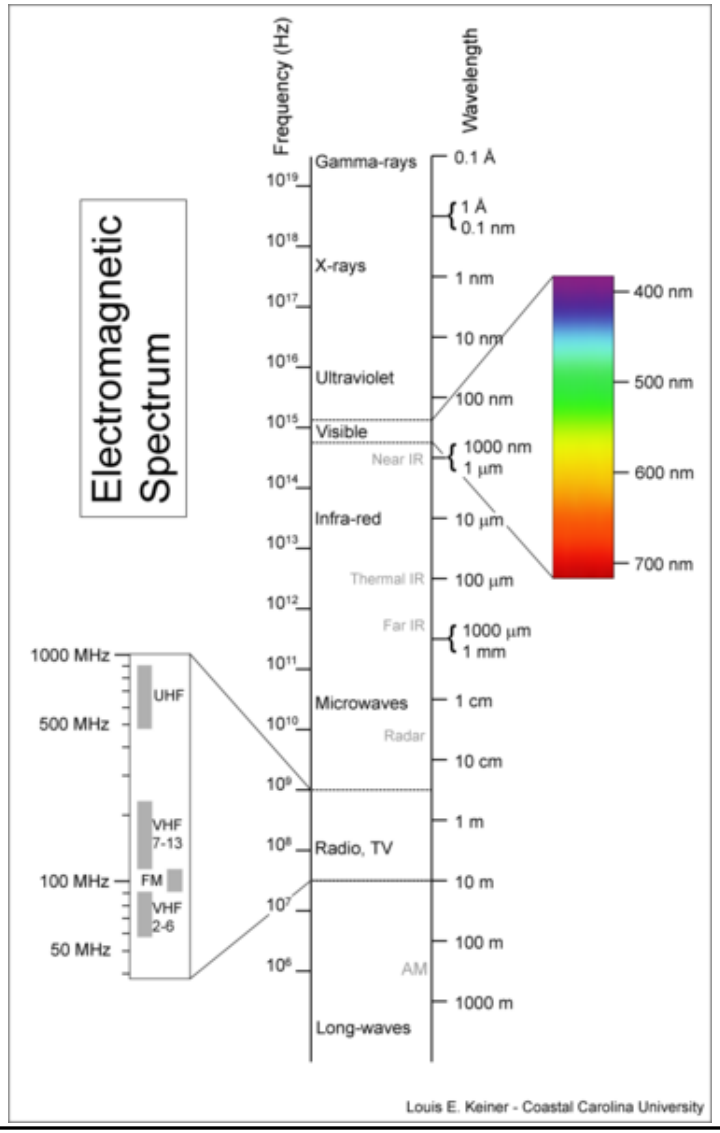
"The main objective of the Action is the specification, development and demonstration of cost-effective ground-based integrated profiling systems suitable for future networks providing essential atmospheric observations for both climate and weather."

COST Action ES0702

Essential observations:

- Temperature
- Wind
- Water vapour
- „Cloud variables“

WG-1 deals with ground-based remote sensing <u>instruments</u> to measure those variables.



WG1: A variety of

Active instruments

Passive instruments

0.3 µm

Lidar

IR-Radiometer

MW-Radiometer

1 cm

Radar

GPS L1

6 m

.... requires different instrument expert groups

WG 1 scope

Survey of the status and current developments of ground based remote sensing systems

- Instrument theory
- International activities (CASA, NGNPN, MPAR, ARM,…)

Evaluation of instruments

- Testing of new instruments (problems, deficiencies,...)
- Error characteristics (instrument error, sampling error)
- Robustness (RF resilience, all-weather capability, stability, manageability, longevity)

Instrument improvements

- Signal processing methods
- Quality control
- Better hardware

Now to the main topic:

CWINDE

The Co-ordinated Wind Profiler Network in Europe

An example of a ground based remote sensing network:

Lessons learned

CWINDE – a result of COST-76

From the executive summary (Nov 2001):

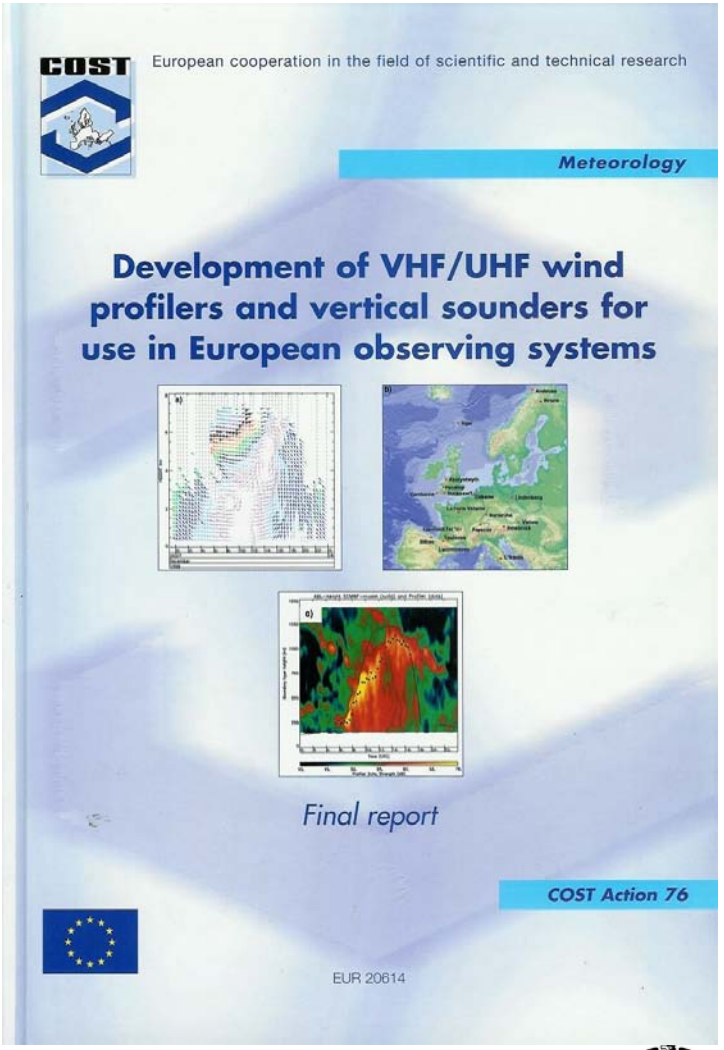
„*COST-76 in general met ist objectives. The time is ripe for the deployment of an operational wind profiler network in Europe. (…)*

A proposal was accepted for the realisation of such a network in the coming years under the EUMETNET umbrella.“

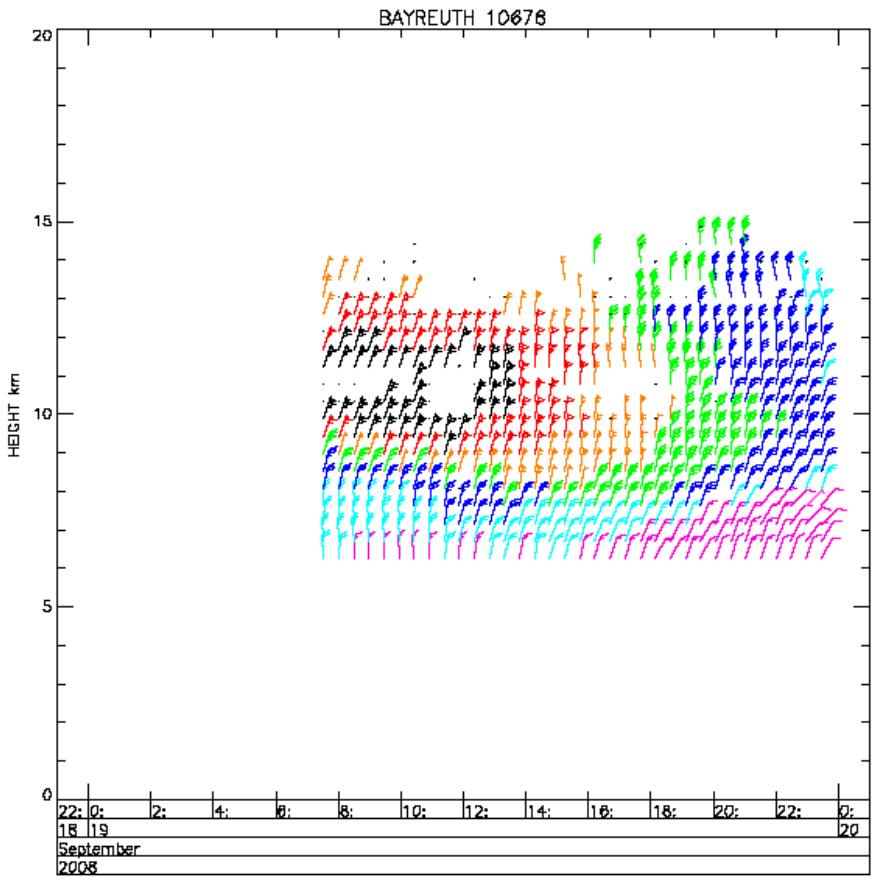
WINPROF I: July 2002 – Dec 2004 (DWD)

WINPROF II: May 2005 – Dec 2008 (UK MetO)

E-WINPROF: 2009 - (?)



Wind profiler: An all-weather Doppler radar for measuring winds



DWD Windprofiler Bayreuth, 19.09.2008, *λ = 62 cm*

Doppler Beam Swinging (DBS)

For a locally linear wind field, i.e.

$$\vec{v}(\vec{r}) = \vec{v}(\vec{r}_0) + \nabla\vec{v}|_{\vec{r}_0} \cdot \vec{\Delta r}$$

one gets for the radial winds

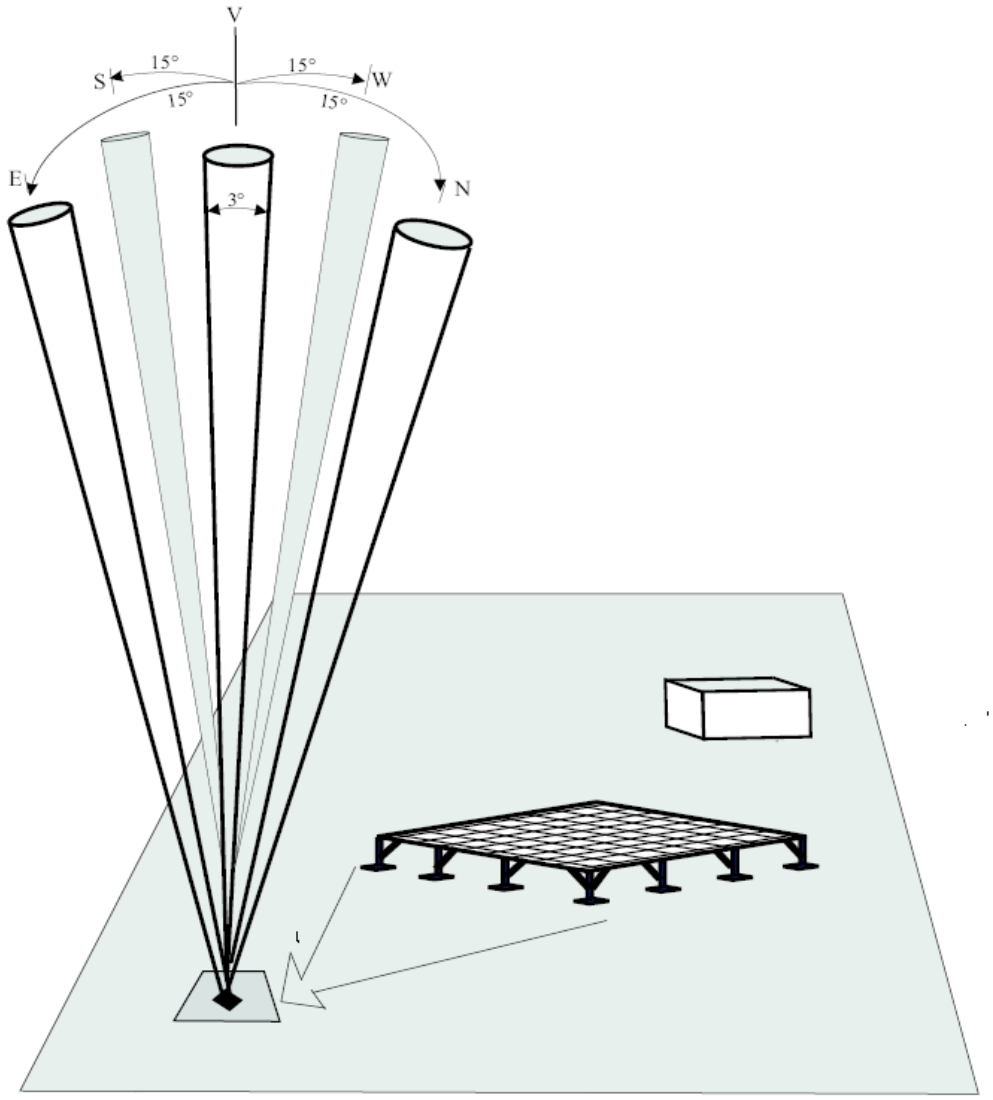
$v_r = \vec{v} \cdot \vec{n}$ at height z:

$$v_{rE} - v_{rW} = 2u_0 \sin(\alpha) + 2\frac{\partial w}{\partial x}\delta x$$

$$v_{rN} - v_{rS} = 2v_0 \sin(\alpha) + 2\frac{\partial w}{\partial y}\delta y$$

where $\delta x = \delta y = z \tan(\alpha) \cos(\alpha)$

DBS assumption: $\frac{\partial w}{\partial x} = \frac{\partial w}{\partial y} = 0$



Importance of wind data for (mesoscale) NWP – a few quotes:

„In the extratropics, wind data are the primary source of information [about the atmospheric flow] *for small horizontal scale features and deep vertical structures (small scales compared to the Rossby radius of deformation).“*

Stoffelen et.al., Bull. Amer. Meteor. Soc. 86, p. 73-87, (2005)

„Model spectra … illustrate the lack of mesoscale observations and assimilation methodologies with which to initialize an NWP forecast model – model spectra are severely deficient in kinetic energy in the mesoscale in forecast initializations.

Skamarock, Mon. Wea. Rev. 132 (2004), p. 3019-3032

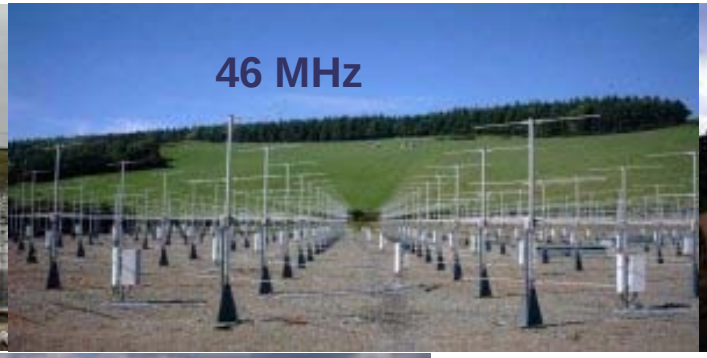
„In the context of storm-scale model initialization .... the horizontal velocity (or stated in another way, the horizontal divergence) should be measured as accurately and completely as possible“

Nascimento and Droegemeier, J. Atmos. Sci. 63 (2006), p. 2246-2268

EUMETNET CWINDE Profiler Network in 2009

http://metscience:sc1ence@www.metoffice.gov.uk/science/specialist/cwinde/

CWINDE Profiler network in 2009 (14 out of 27 systems)



CWINDE is no homogeneous network.... unlike its US and Japanese counterparts

Instruments are diverse: Frequencies, manufacturers, operators,.... :

- Different hardware (beam width, radial resolution)
- Different signal processing and quality control (proprietary software)
- Different sampling: Beam sequence, averaging time
- Operational support and maintenance differs significantly

Error characteristics of individual systems are different !!

Impact of CWINDE profiler data in NWP

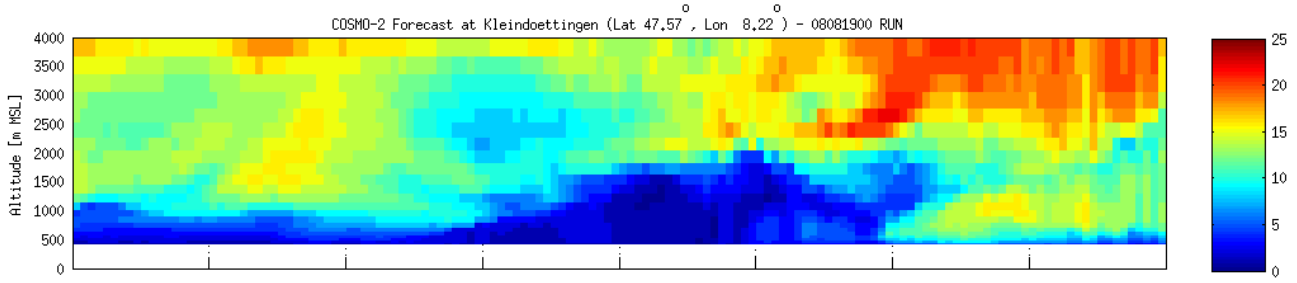
Example 1:

MeteoSwiss COSMO-2, Δx = 2.2 km, L 60, Nudging

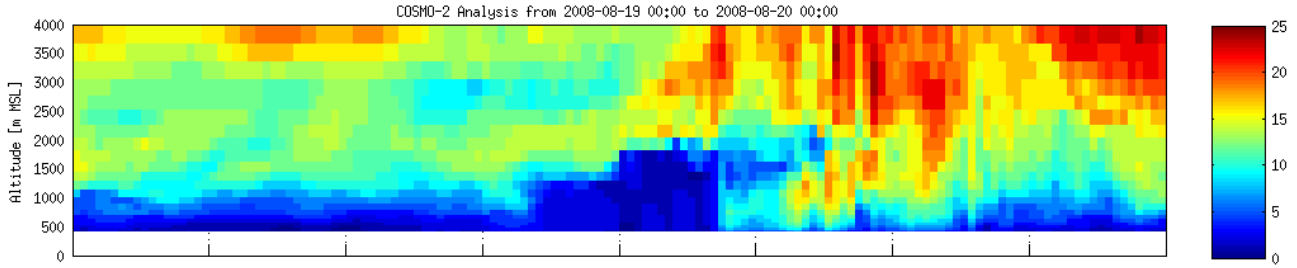
Effect of CWINDE profiler data assimilation

Impact of wind profiler measurement on COSMO-2 (Δx = 2 km) model: Aug 19, 2008

***COSMO-2* WS forecast w/o wind profiler data for Kleindoettingen starting at 00 UTC**

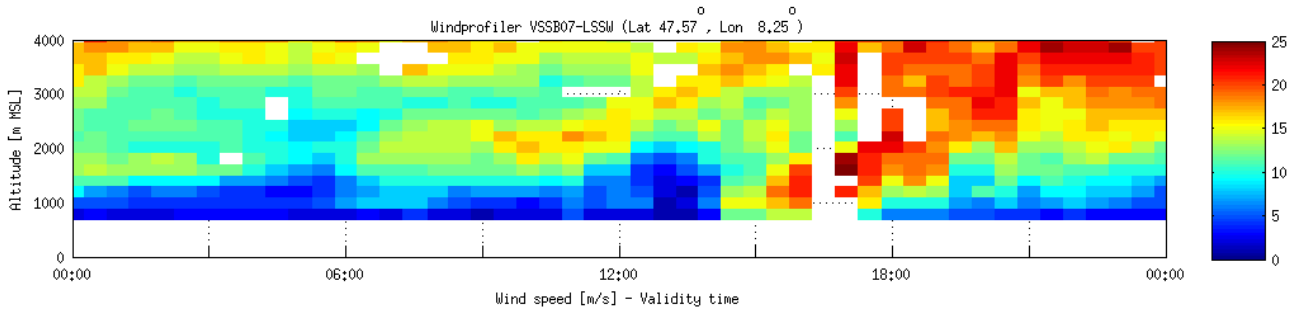


***COSMO-2* WS assmilation cycle for Kleindoettingen using CWINDE profilers**



Independent (mobile) wind profiler measurement at Kleindoettingen

System was not assimilated !



Courtesy of Christophe Hug, MeteoSwiss

Impact of CWINDE profiler data in NWP

Example 2:

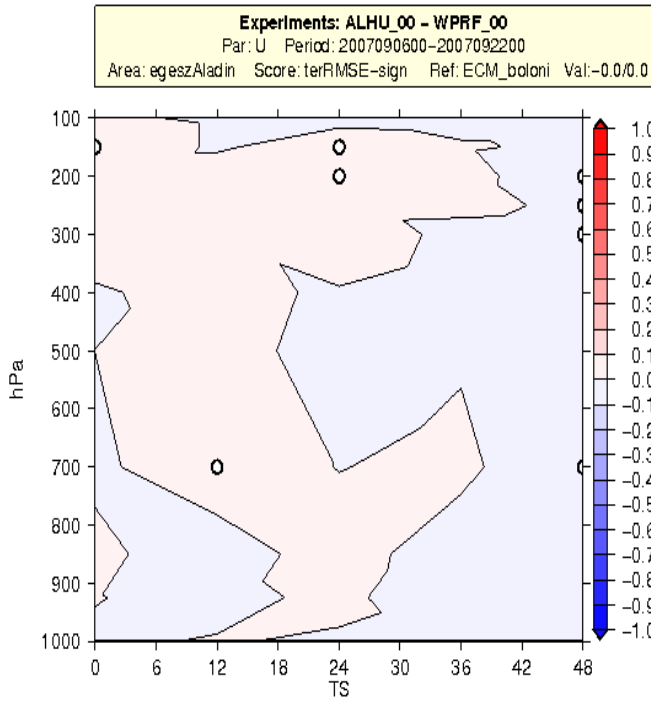
OMSZ, Aladin, Δx = 8 km, L 49, 3D-Var

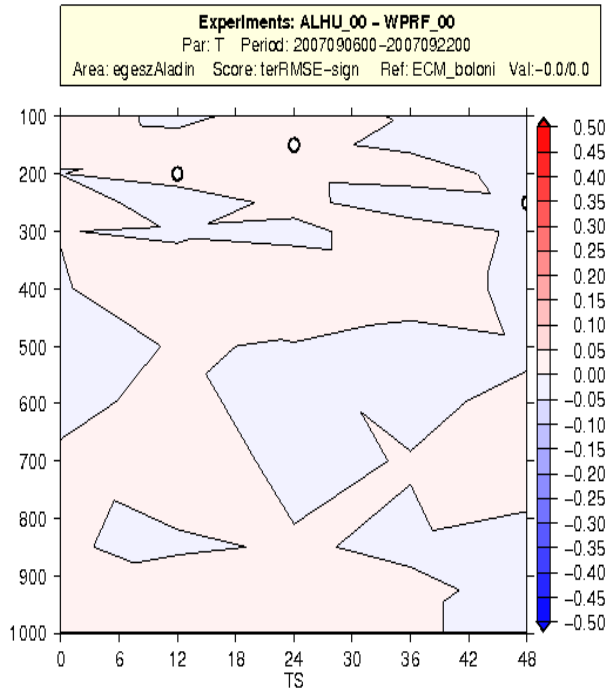
Effect of CWINDE profiler (subset) assimilation

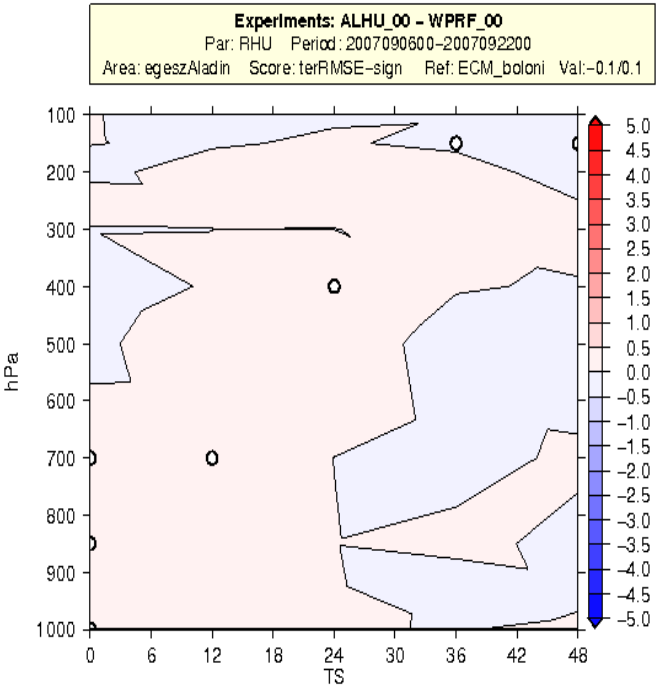
OSE-experiment for a 2 weeks period: 06-22 Sep. 2007

Data: Only the four German 482 MHz wind profiler, whitelisting between 700 and 400 hPa

Verification against ECMWF analysis







Vertical cross section of RMSE differences as function of forecast range. Red indicates improvements

Courtesy of Gergely Bölöni, OMSZ

Impact of CWINDE profiler data in NWP

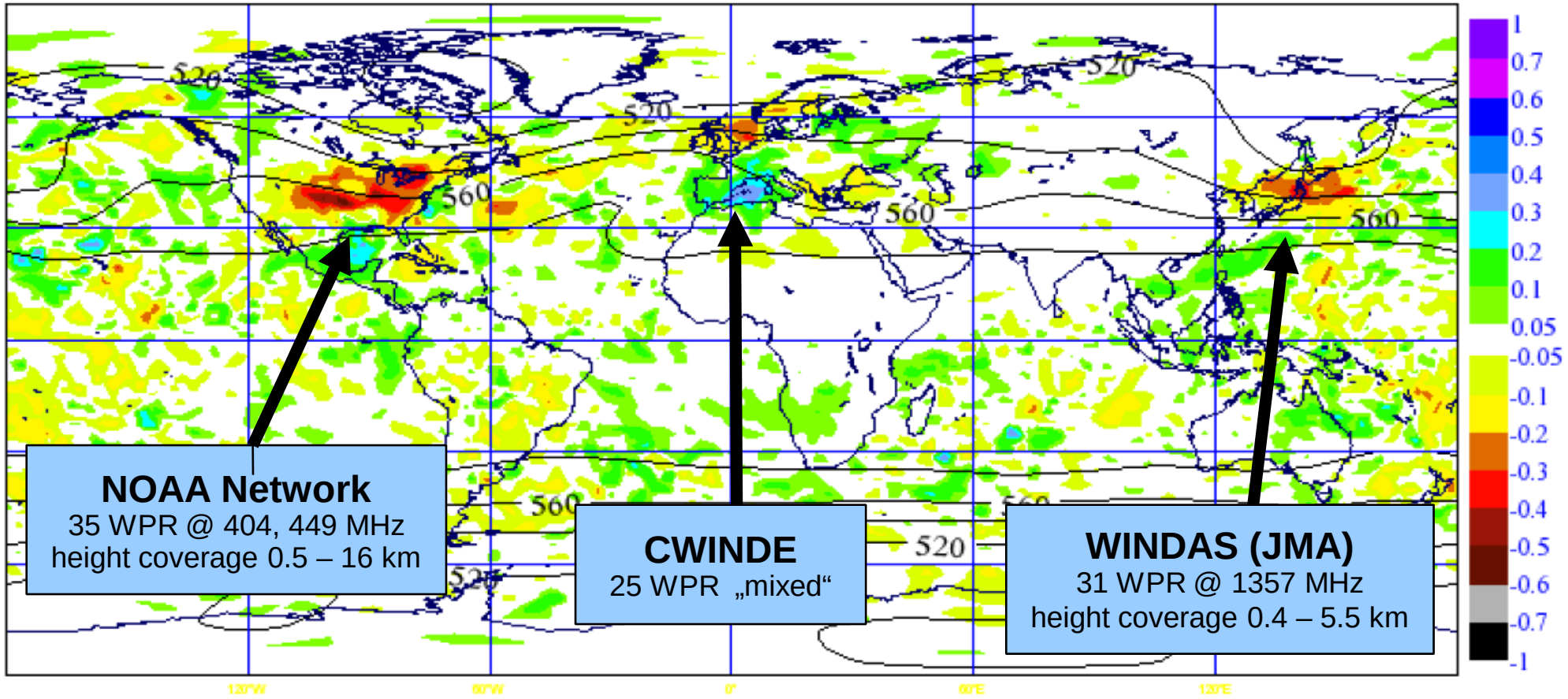
Example 3:

ECMWF model (cycle 29r1), T511 L60, 4D-Var

EUCOS E-SAT OSE study

ECMWF E-SAT Study:

NormDiff in RMS of 500 hPa z fc-Error: RMS(fc_ose – an) – RMS(fc_ref –an)
[Baseline + Windprofiler] – [Baseline], FC + 12 H
Date: 20041214 - 20050125



WMO Workshop on data assimilation (2008)

EUCOS Space-Terrestrial, Conclusions (3)

- Humidity from R/S add very little in terms of scores
  - Noticeable but small impact on relative humidity scores up to day 3
- Impact of wind profilers:
  - Winter impact:
    - → The short range forecasts are improved by the US and japanese profilers
    - → The signal blurs away after day 4-5 and large scale interactions appear
    - → European profilers do not bring much
- In summer, the impact is smaller than during the winter period (in absolute but also relative terms)

Possible reasons for „neutral/negative impact“ of European wind profilers

(1) Observation errors

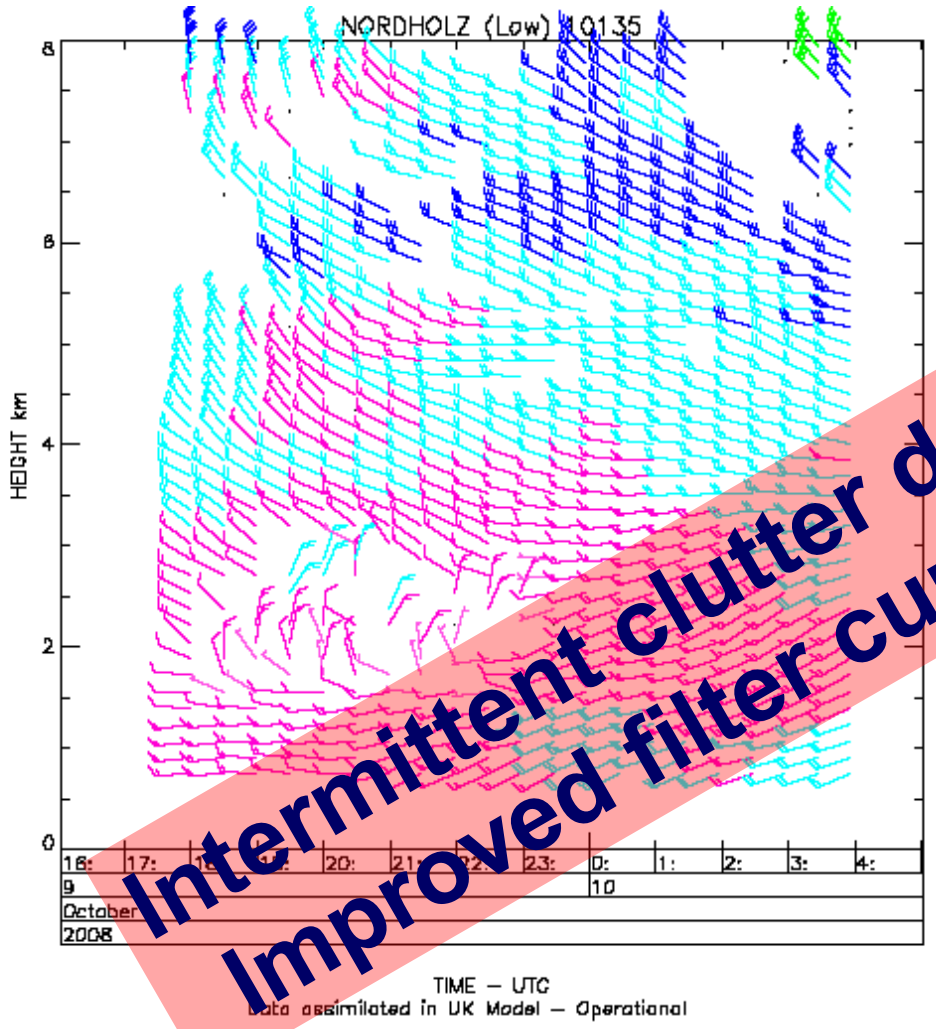
- **Gross errors: „*forcast busts*“ – unfortunately rarely investigated**
- **Systematic errors (bias)**
- **(...)**

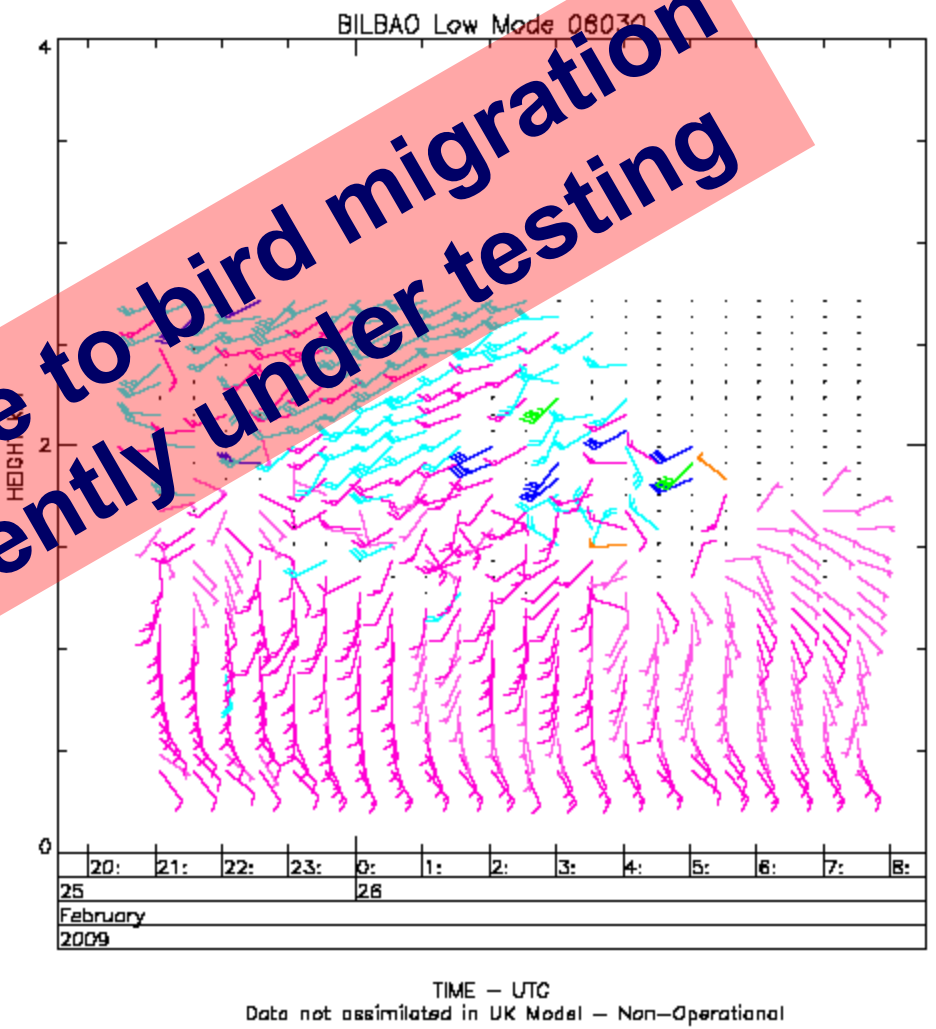
(2) Assimilation problems

- **Assumption of uncorrelated observation errors**
- **Suboptimal use of a very dense in time while very localized network**
- **(...)**

NOAA and JMA network do have positive impact → CWINDE problems due to (1)

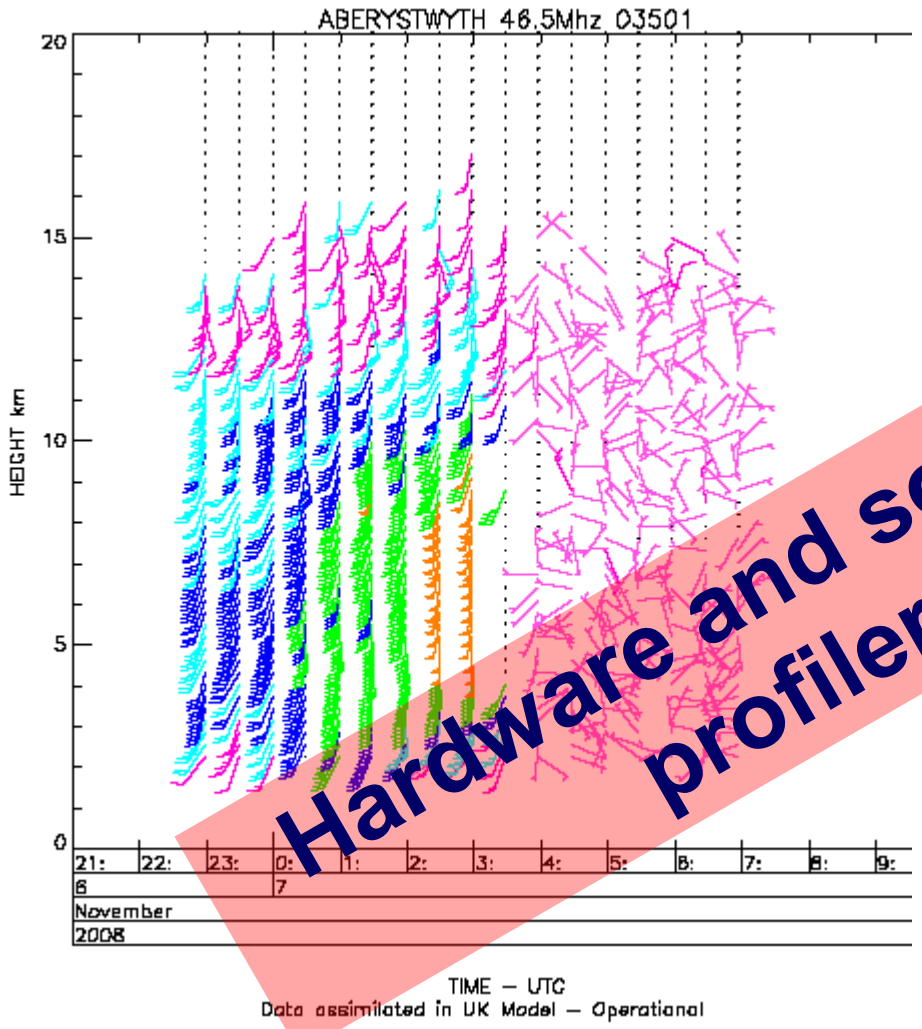
Examples of recent CWINDE (correlated) gross errors

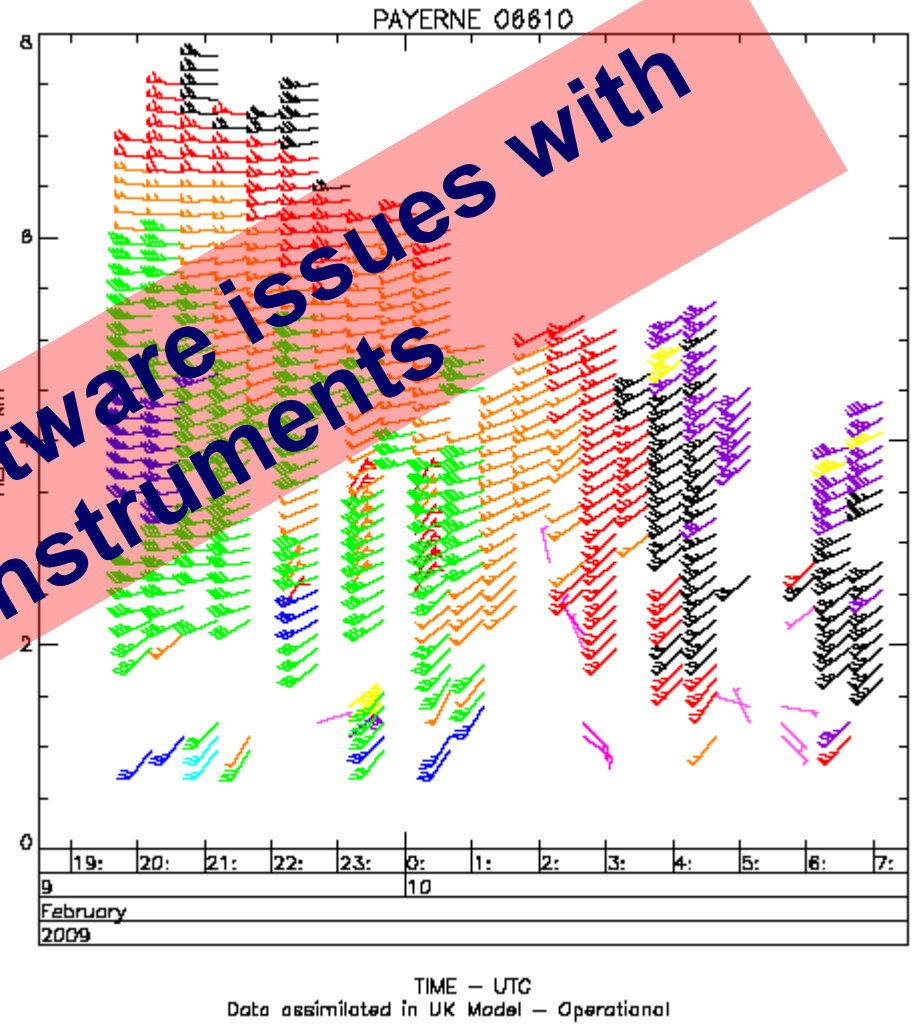




Intermittent clutter due to bird migration
Improved filter currently under testing

Examples of recent CWINDE gross errors



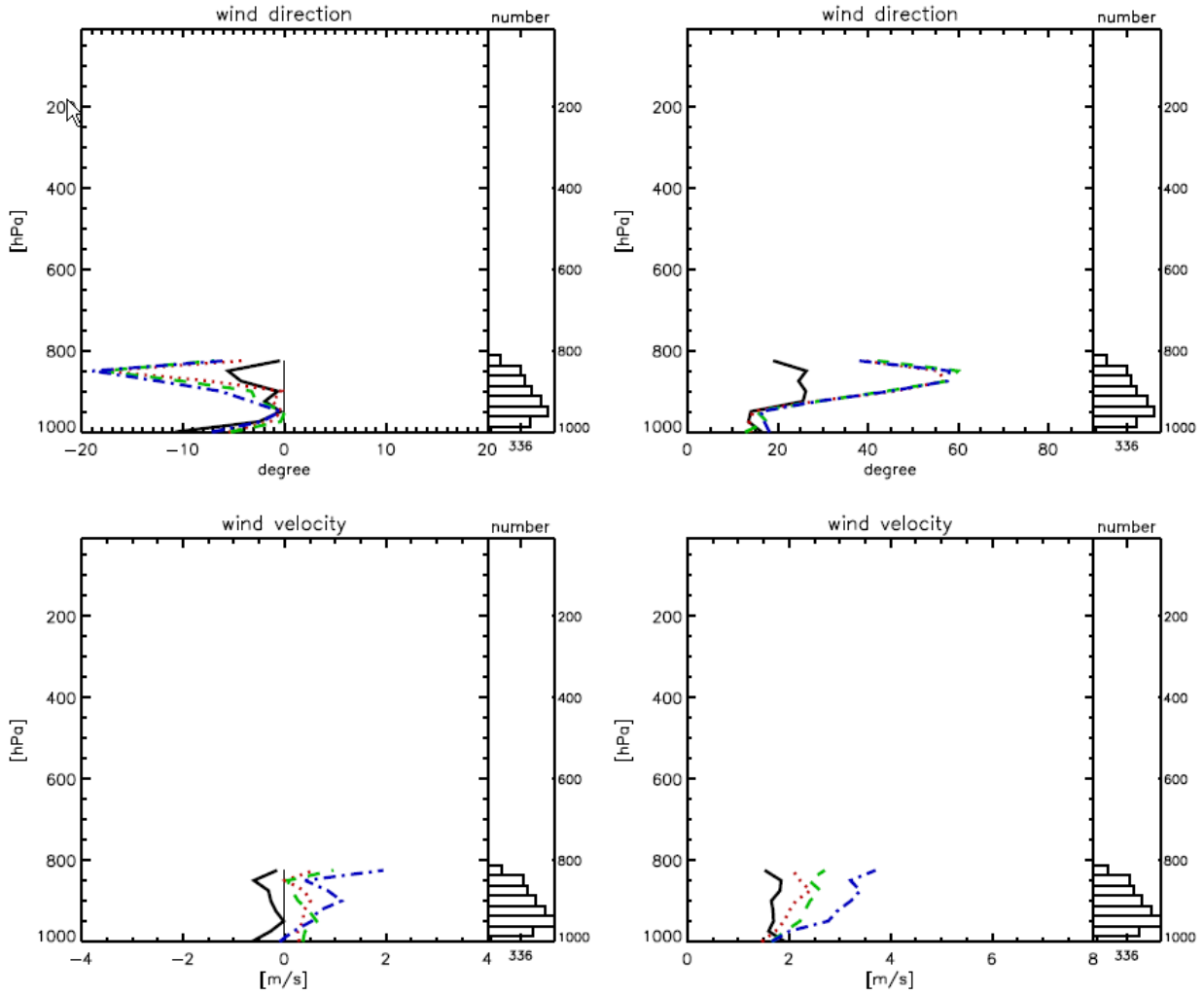


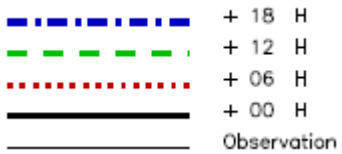
Hardware and software issues with profiler instruments

COSMO-DE (DWD 2.8 km model) monitoring October 2008: „Good“ BL-profiler

Mean error

(model – Obs)



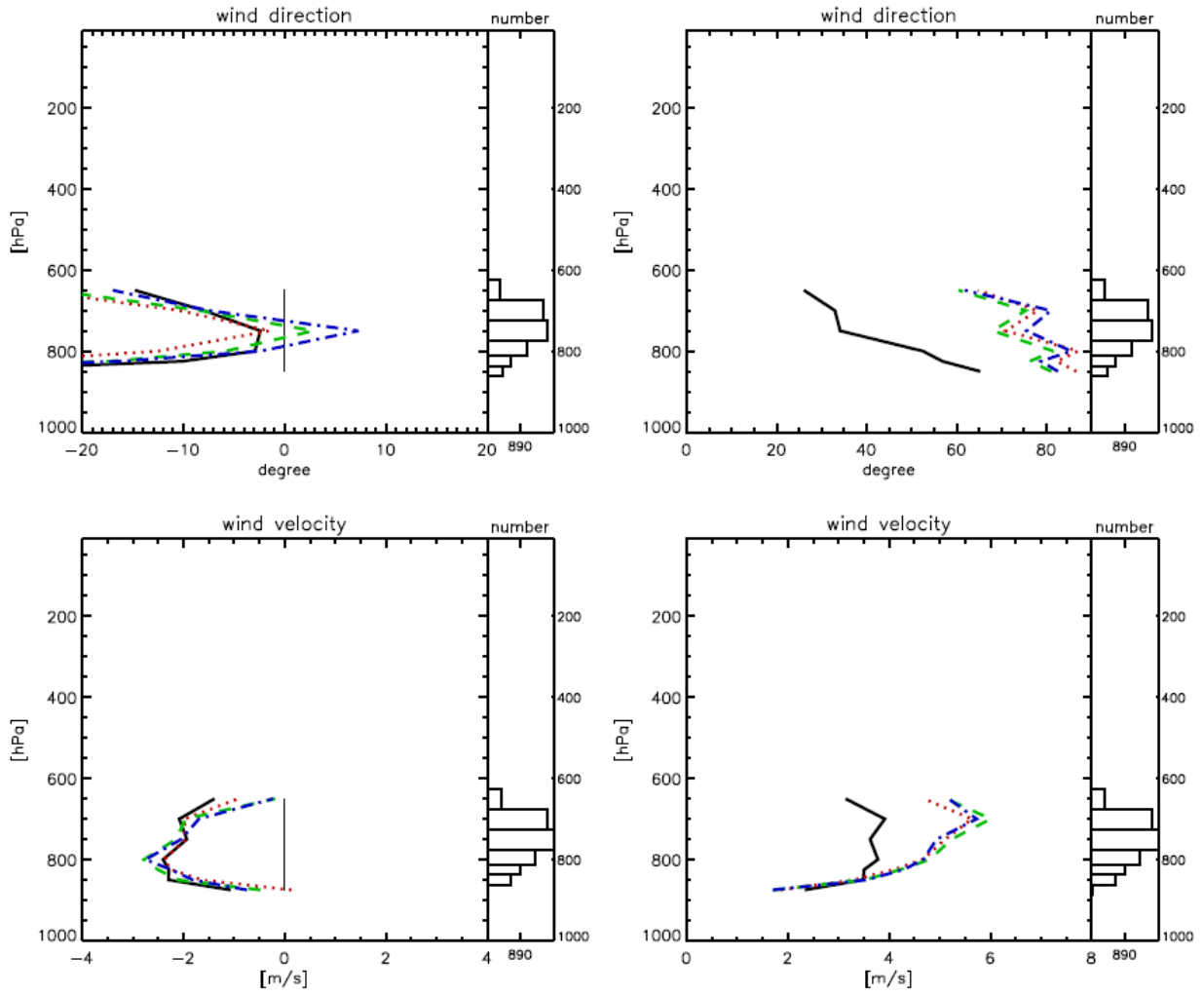


RMS

COSMO-DE (DWD 2.8 km model) monitoring October 2008: „Bad“ BL-profiler

Mean error

(model – Obs)



RMS

Currently, we do not have the resources to operate CWINDE „fully operational“ on a 24h/7d basis....

In contrast to the NOAA and JMA profiler network, CWINDE suffers from...

- Lack of specialized staff to maintain complex instruments
- Lack of centralized monitoring
- Lack of corrective action, once problems are identified

It seems to be rather difficult to get these resources (improved funding):

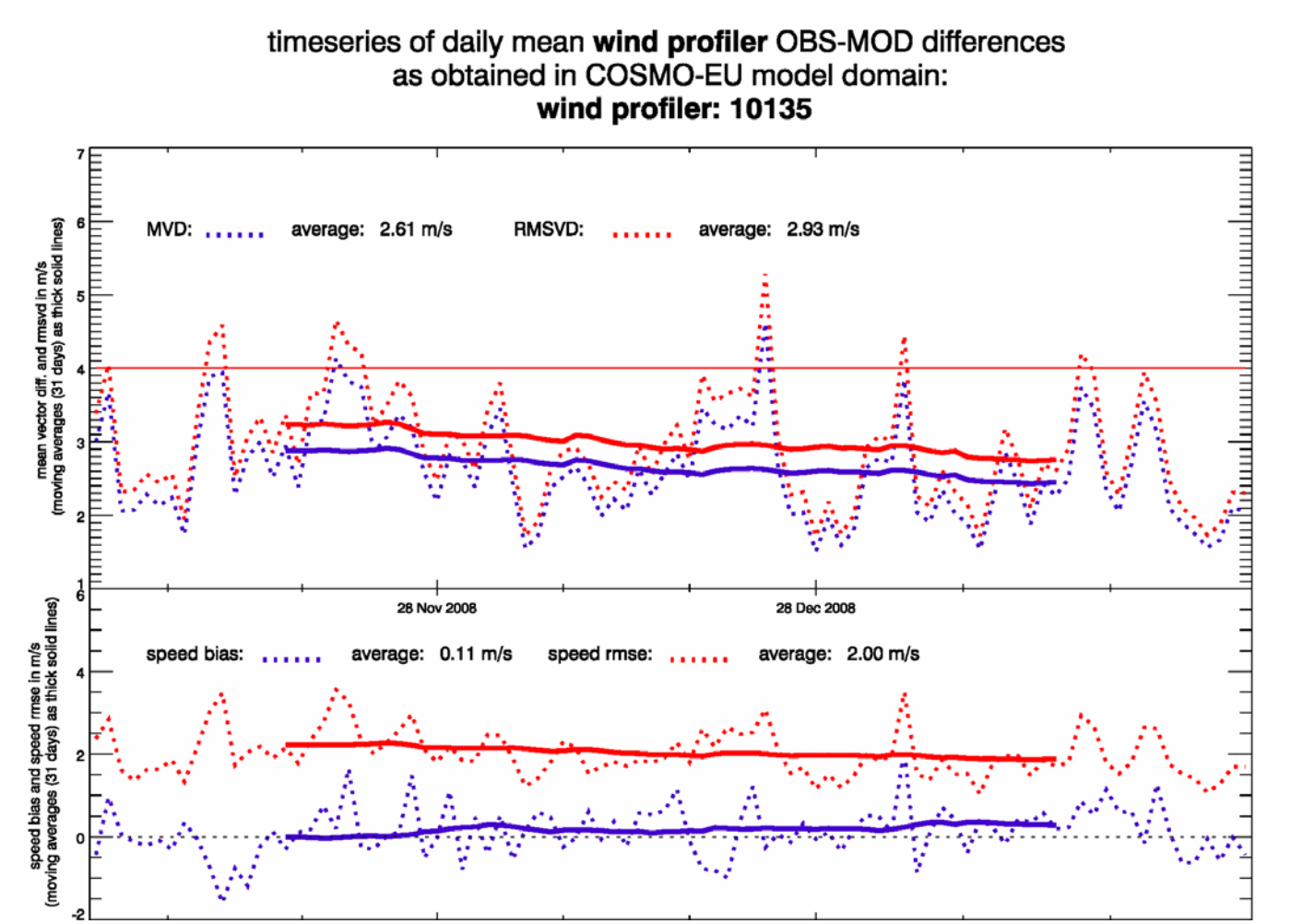
34th EUMETNET COUNCIL MEETING, 16-17 October 2008, Brussels, Belgium:

Decision C34.10
Council approved the continuation of the WINPROF Programme to a new phase with effect from 1st June 2009. Participating Members elected for Option 1 in the proposal (i.e. no increase in funding) until such time as Option 2 becomes affordable to those participating. The UK agreed to continue as RM until the project is handed over to the new RM.

Given more funding, what needs to be done ?

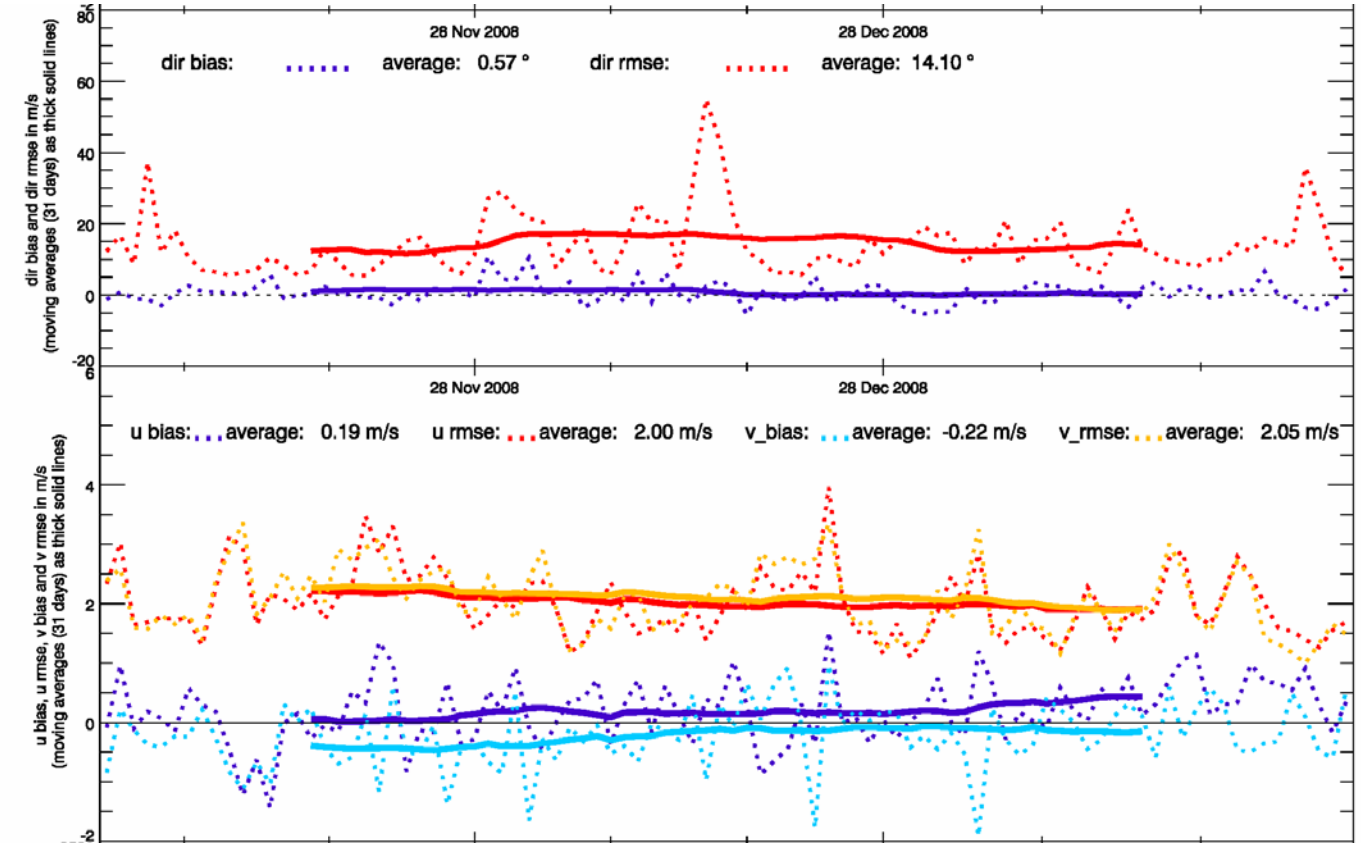
- Development of an improved monitoring (EUCOS)

Already on the way: First results of a future EUCOS monitoring



Courtesy of Stefan Klink, EUCOS

timeseries of daily mean **wind profiler** OBS-MOD differences
as obtained in COSMO-EU model domain:
wind profiler: 10135



Courtesy of Stefan Klink, EUCOS

What needs to be done ?

- Development of an improved monitoring (EUCOS)

- CWINDE needs more technical expertise to:
  - Diagnose and fix problems at the sites
  - Test commercial products and provide feedback to manufacturers

Deutscher Wetterdienst

Wind Profiler Data

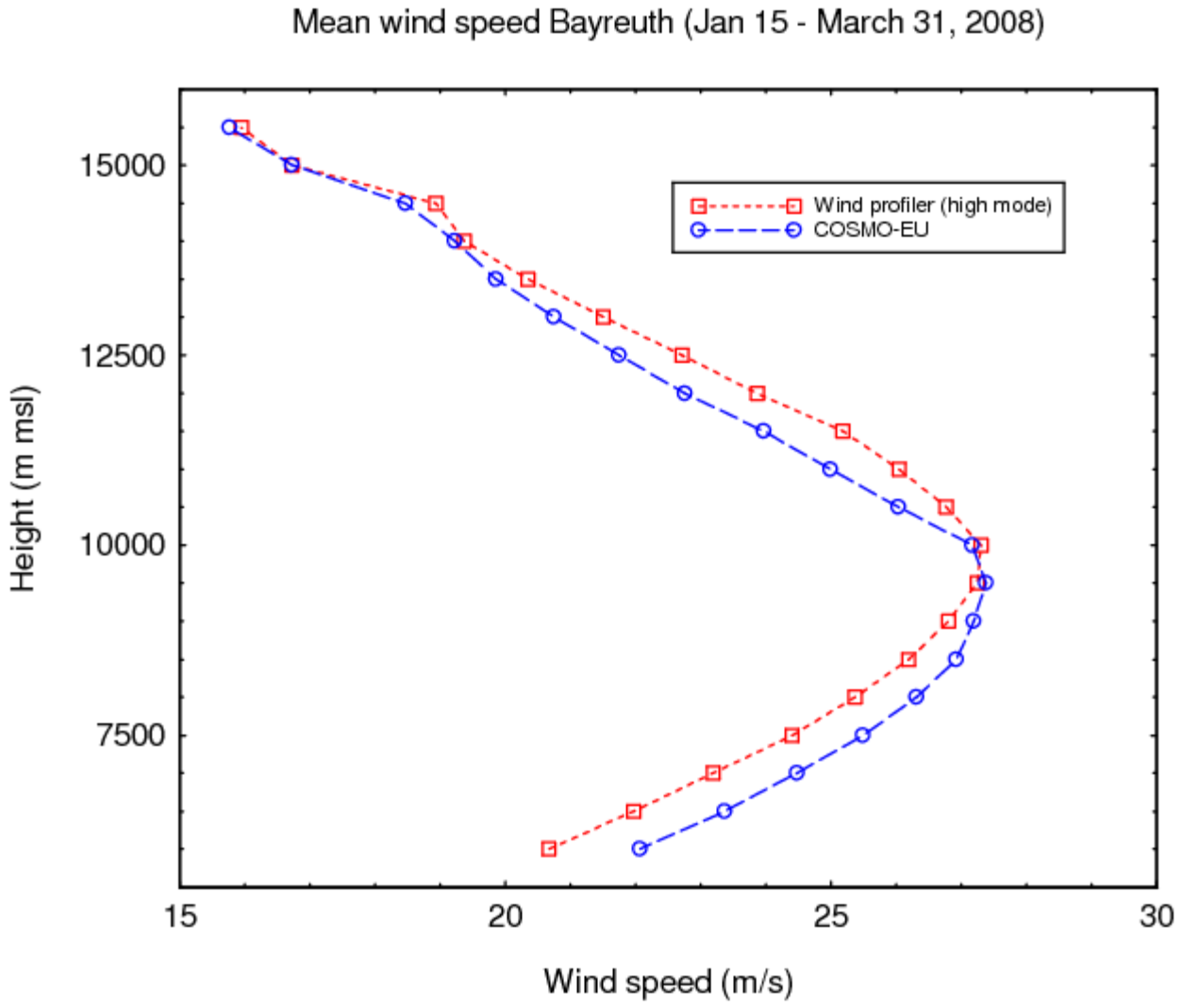
WMO	Profiler site	Type	Frequency *	Assimilated **	Restrictions	Arpege	DWD	ECMWF
02043	Kiruna	MST	30 mins	Yes	Reject above 500hPa and below 700hPa	No	No	No
02999	Helsinki (Malmi)	BL	30 mins	No		No	No	No
03019	South Uist64Mhz(Low Mode)	TROP	30mins	Yes		No	Yes	Yes
03020	South Uist 64Mhz(High Mode)	TROP	30mins	Yes	Reject above 250hPa	Yes	Yes	No
03203	Isle of Man	BL	30 mins	Yes	Reject above 500hPa	Yes	Yes	No
03501	Aberystwyth	MST	30 mins	Yes		No	Yes	Yes
03591	Wattisham	BL	30 mins	Yes	Reject above 500hPa	No	Yes	Yes
03807	Camborne	BL	30 mins	Yes	Reject above 500hPa	Yes	Yes	Yes
03840	Dunkeswell	BL	30 mins	Yes	Reject above 500hPa	No	Yes	Yes
06348	Cabauw	BL	1 hour	Yes		No	Yes	Yes
06610	Payerne	BL	30 mins	Yes	Reject above 400hPa and below 750hPa	Yes	Yes	No
06620	Schaffhausen			Yes		No	No	No
07112	La Ferte Vidame	TROP	1 hour	Yes	Reject below 750 hPa	Yes	Yes	Yes
07453	Clermont Ferrand	TROP	1 hour	Yes	Reject some below 500hPa	No	No	No
07626	Lannemezan	TROP	1 hour	Yes	Reject above 250hPa	Yes	Yes	No
07650	Marignane	BL	30 mins	Yes	Reject above 500hPa and below 950hPa	No	Yes	No
07690	Nice	BL	15 mins	Sep 08		No	No	No
08031	Bilbao	BL	10 mins	Yes	Reject above 600hPa and below 850hPa	No	No	No
10135	Nordholz	TROP	30 mins	Yes	Reject above 150 hPa	Yes	Yes	Yes
10266	Ziegendorf	TROP	30 mins	Yes	Reject above 150 hPa	Yes	Yes	Yes
10391	Lindenberg SODAR	BL	30 mins	Dec 07		No	No	No
10394	Lindenberg 482MHZ	TROP	30 mins	Oct 08		Yes	Yes	Yes
10636	Frankfurt	TROP	15 mins	Yes	Reject above 700hPa and below 950hPa	No	Yes	No
10678	Bayeuth	TROP	30 mins	Yes	Reject above 150 hPa	Yes	Yes	No
11036	Vienna	BL	30 mins	Yes	Reject Below 950hPa	No	No	No
12842	Budapest	BL	15 mins	Yes	Accept some during daytime. Reject above 600hPa and below 950hPa	No	Yes	No
12982	Szeged	BL	15 mins	Yes	Reject above 500hPa and below 950hPa	No	No	No
16228	L'Aquila	BL	1 hour	No		No	No	No
16300	Torino	BL	30 mins	No		No	No	No

ECMWF monitoring helped detecting a systematic error at

Bayreuth (10678):

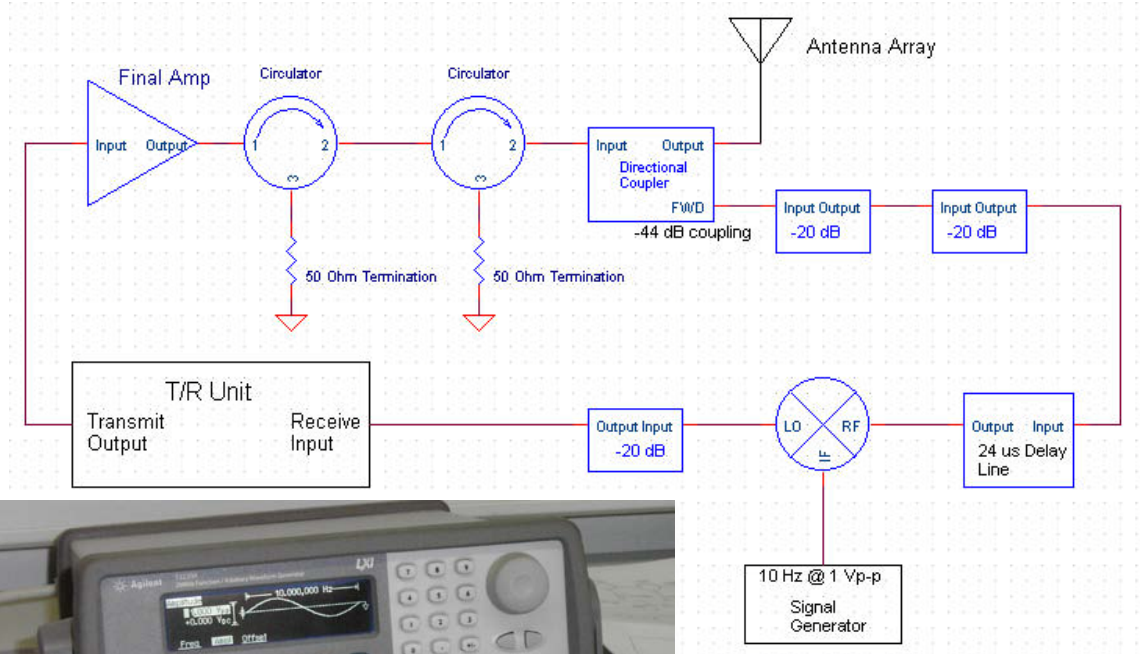
Removed from ECMWF whitelist in March 2008 !

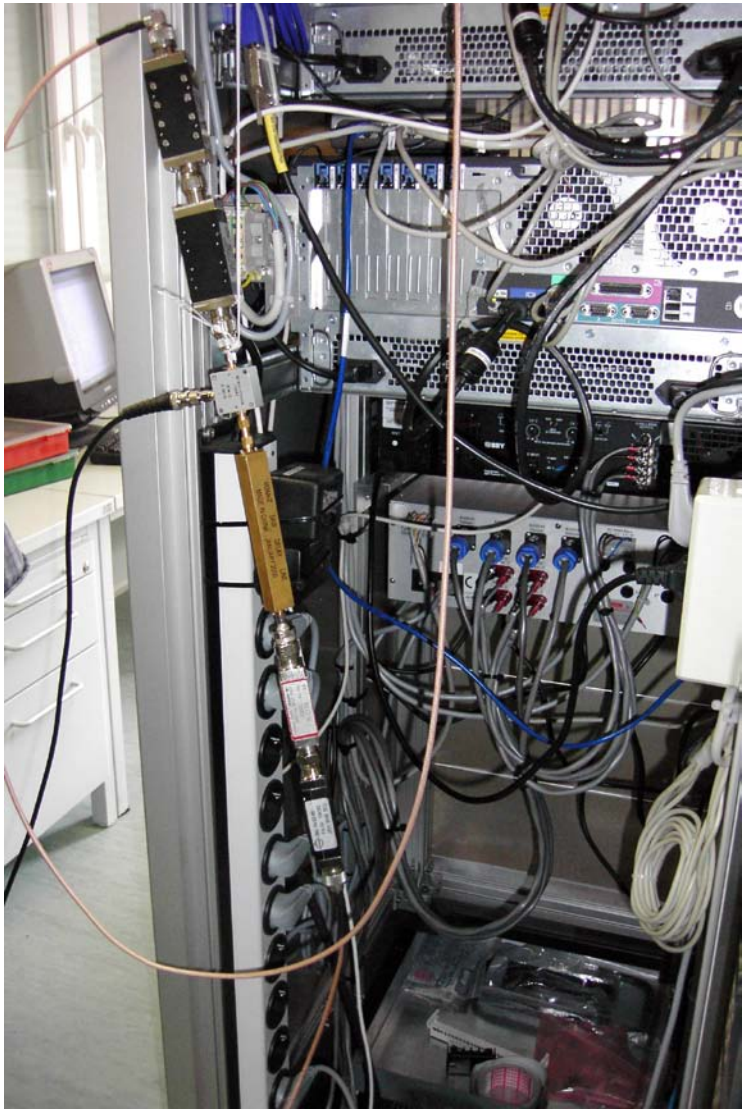
Information obtained at the end of May 2008

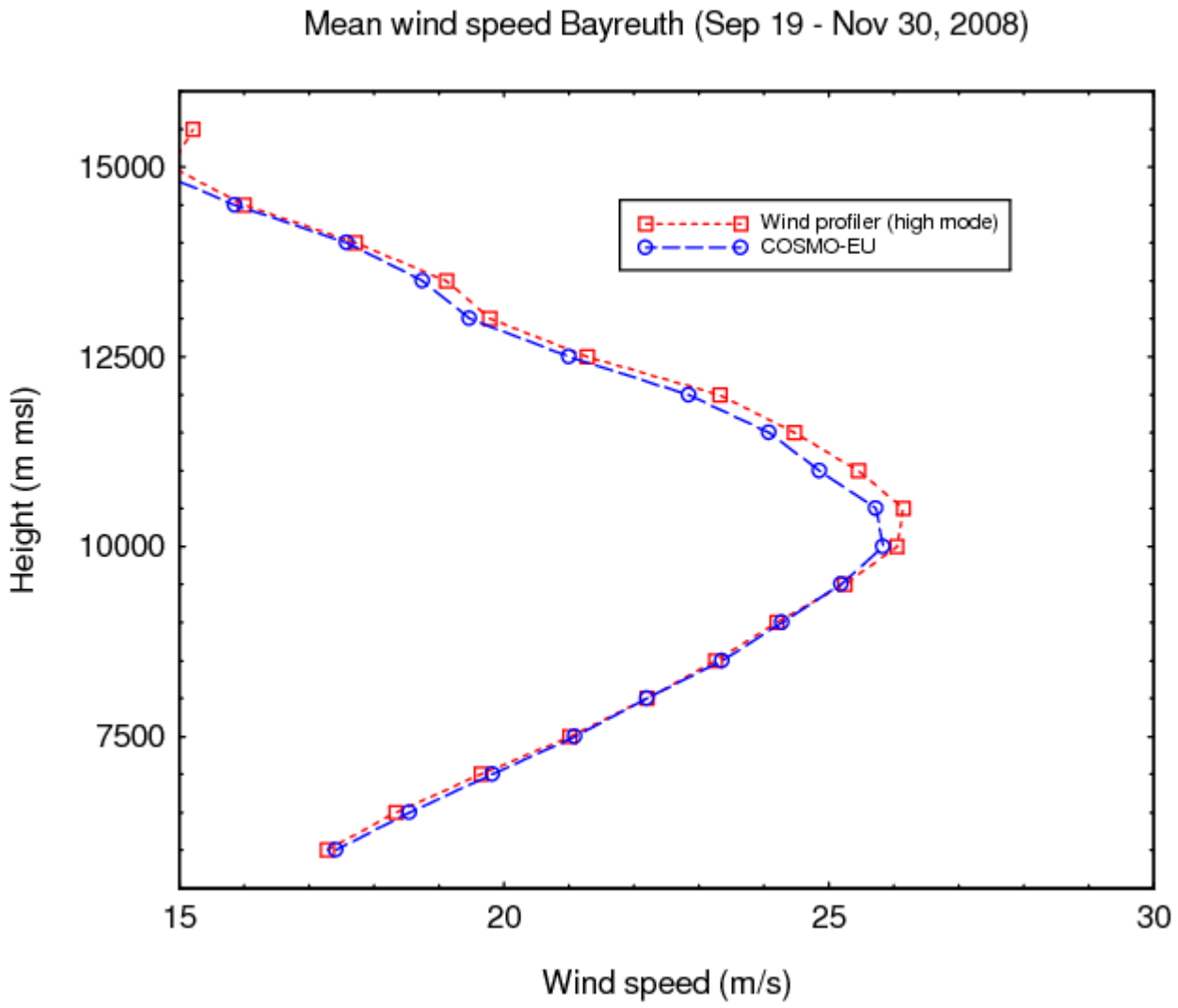

Mean wind speed Bayreuth (Jan 15 - March 31, 2008)
Wind profiler (high mode)
COSMO-EU
Height (m msl)
15000
12500
10000
7500
15
20
25
30
Wind speed (m/s)

Erroneous range calibration, corrected Sep 18

(Group delay of pulse in radar hardware)






Mean wind speed Bayreuth (Sep 19 - Nov 30, 2008)
Wind profiler (high mode)
COSMO-EU
Height (m msl)
15000
12500
10000
7500
15
20
25
30
Wind speed (m/s)

What needs to be done ?

- Development of an improved monitoring (EUCOS)

- CWINDE needs more technical expertise to:
  - Diagnose and fix problems at the sites
  - Test commercial products and provide feedback to manufacturers

- Further development of instrument „Wind profiler radar“: (COST)
  - Improved signal processing and QC
  - Better hardware (antennas)

- Feedback from users:
  - Update of assimilation whitelists / blacklists
  - Joint investigation of negative impact cases

Prospects of CWINDE (E-WINPROF)

A state-of-the-art wind profiler can provide frequent (Δt ~ 30 min) high-resolution (Δz ~ 100...500 m) vertical wind profiles in nearly all-weather conditions with good-quality (Bias u,v < 0.25 m/s, RMS u,v < 2.5 m/s)

„European profilers do not bring much“ – no fundamental reason for that statement, only a matter of funding → „*You get what you pay for*“

Wind profilers are relatively new instruments, quality improvements are quite likely

Existing CWINDE network infrastructure (sites, network hub) – could be a nucleus for a future integrated network (adding other instruments)

Questions and Discussion