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)
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.”
Essential observations:

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

**WG-1 deals with ground-based remote sensing instruments to measure those variables.**
WG1: A variety of

Active instruments

- Lidar
  - 0.3 μm

Passive instruments

- IR-Radiometer
- MW-Radiometer
  - 1 cm
- 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, $\lambda = 62$ cm
Doppler Beam Swinging (DBS)

For a locally linear wind field, i.e.

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

one gets for the radial winds

\( v_r = \bar{v} \cdot \hat{n} \) 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).“


“*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.*


“*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“

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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, $\Delta x = 2.2$ km, $L 60$, Nudging

Effect of CWINDE profiler data assimilation
Impact of wind profiler measurement on COSMO-2 ($\Delta x = 2$ km) model: Aug 19, 2008

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

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

Independent (mobile) wind profiler measurement at Kleindoettingen

System was not assimilated!
Impact of CWINDE profiler data in NWP

Example 2:

OMSZ, Aladin, $\Delta x = 8\text{ km}$, 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
Impact of CWINDE profiler data in NWP

Example 3:

ECMWF model (cycle 29r1), T511 L60, 4D-Var
EUCOS E-SAT OSE study
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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

NOAA Network  
35 WPR @ 404, 449 MHz  
height coverage 0.5 – 16 km

CWINDE  
25 WPR „mixed“

WINDAS (JMA)  
31 WPR @ 1357 MHz  
height coverage 0.4 – 5.5 km
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
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Examples of recent CWINDE gross errors

[Graphs showing data profiles with annotations]

Hardware and software issues with profiler instruments

Data assimilated in UK Model – Operational
COSMO-DE (DWD 2.8 km model) monitoring October 2008: „Good“ BL-profiler

Mean error
(model – Obs)

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

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Courtesy of Stefan Klink, EUCOS
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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
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
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
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 ($\Delta t \sim 30$ min) high-resolution ($\Delta z \sim 100...500$ 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