

SAWEP Workshop

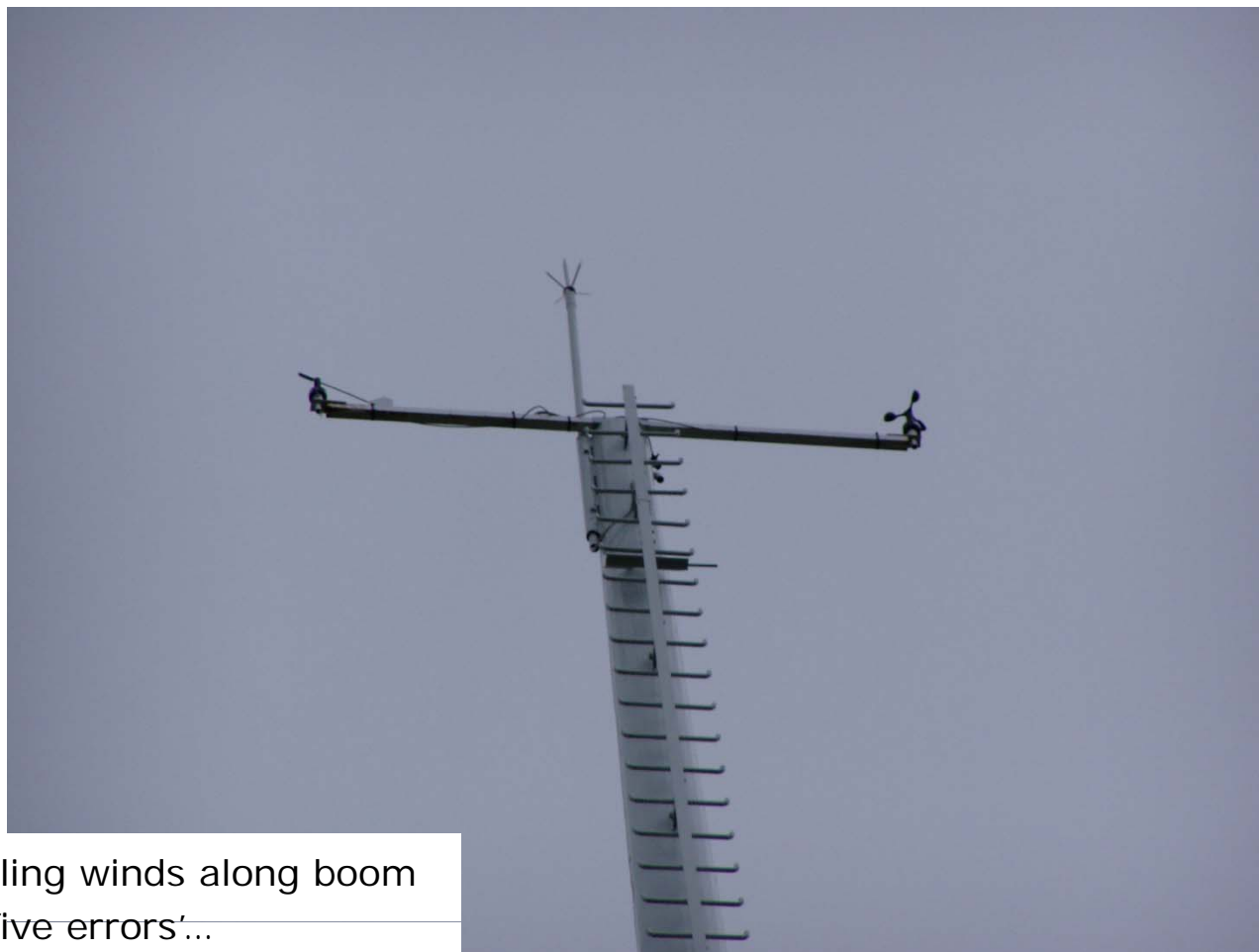
Wind Atlas for South Africa (WASA)



Cape Town, 4th March 2010

Wind measurements and analysis of wind data

Sample met. mast



- Prevailing winds along boom
- Find 'five errors'...

Cup anemometry 1 (2)

- Tower effects (shadow)
 - lightning rod
- Boom and clamp effects
- Anemometer design
 - distance constant (l_0)
 - mech. and elec. construction
- Turbulent biases
 - u -bias $\propto (\sigma_u/U)^2$ (overspeeding)
 - v -bias $\propto (\sigma_v/U)^2$ (DP-'error')
 - w -bias $\propto (\sigma_w/U)^2$ (angular response)
 - stress-bias $\propto \langle uw \rangle / U^2$

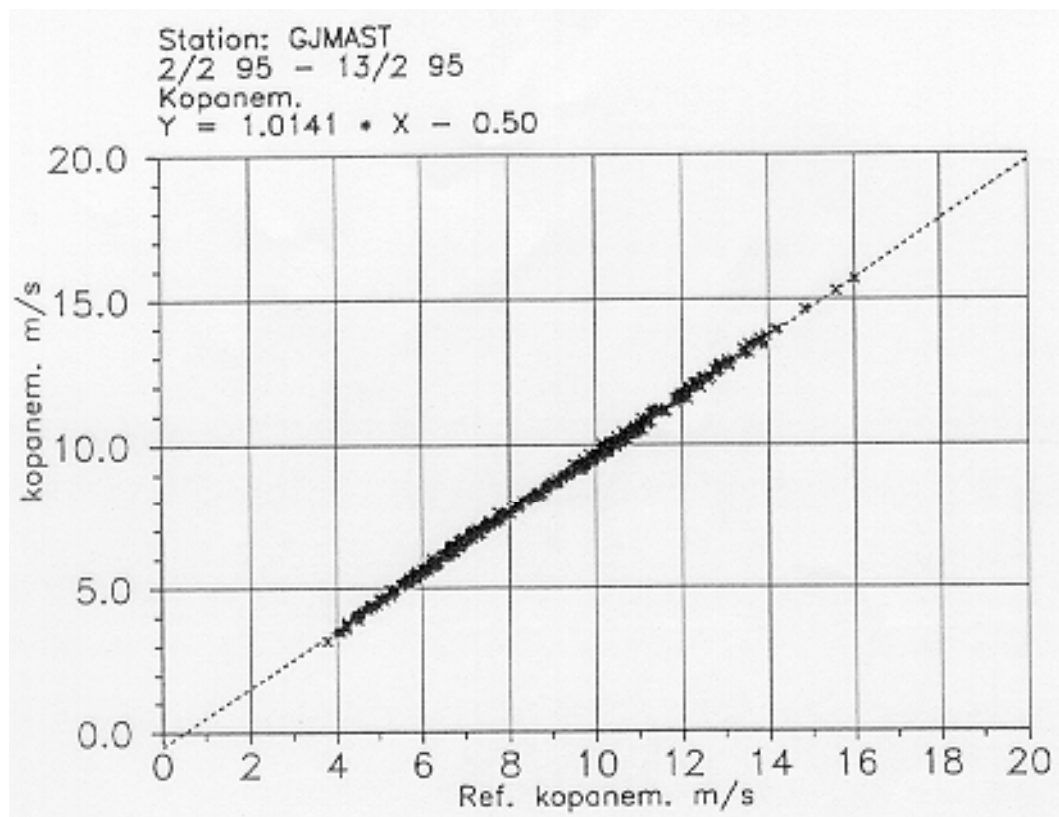


Cup anemometry 2(2)

- Anemometer condition
 - long-term stability of output
 - maintenance/rehabilitation schedule
- Environmental conditions
 - sea spray, salt, dust, insects...
 - icing of instrument
- Calibration procedure
 - wind tunnel calibration ('laminar')
 - atmospheric (in-situ, turbulent)
 - re-calibration at regular intervals
- Anemometer siting

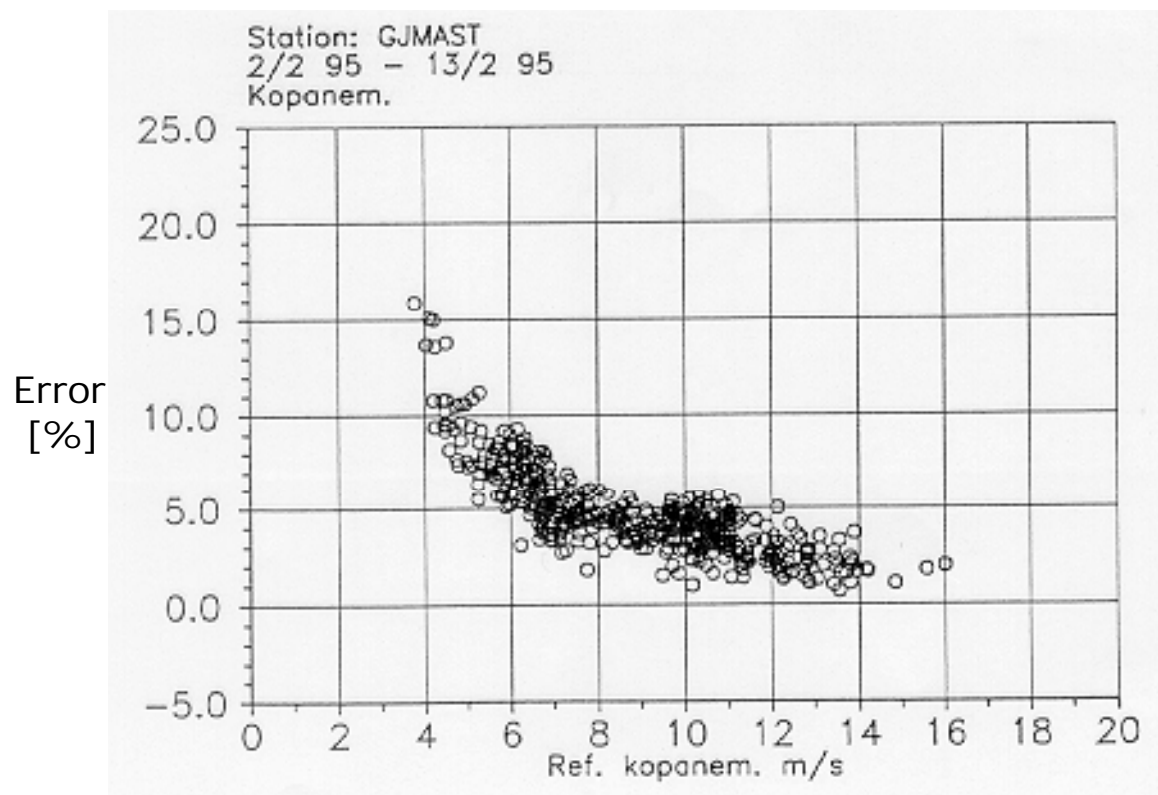


Anemometer calibration 1(2)



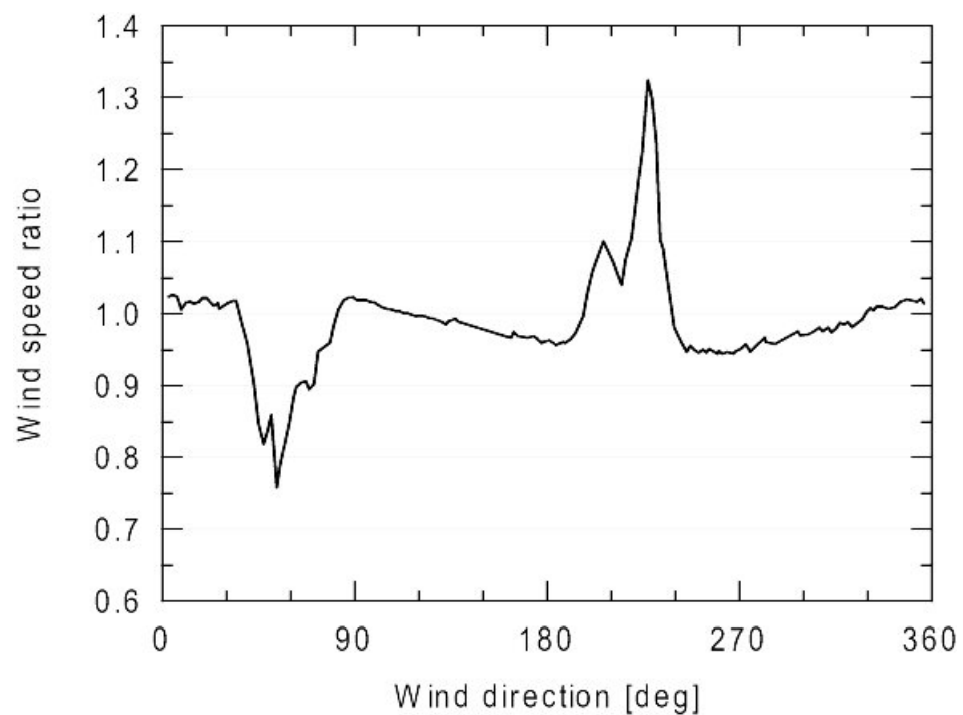
Generic calibration vs. reference anemometer: "looks good"?

Anemometer calibration 2(2)



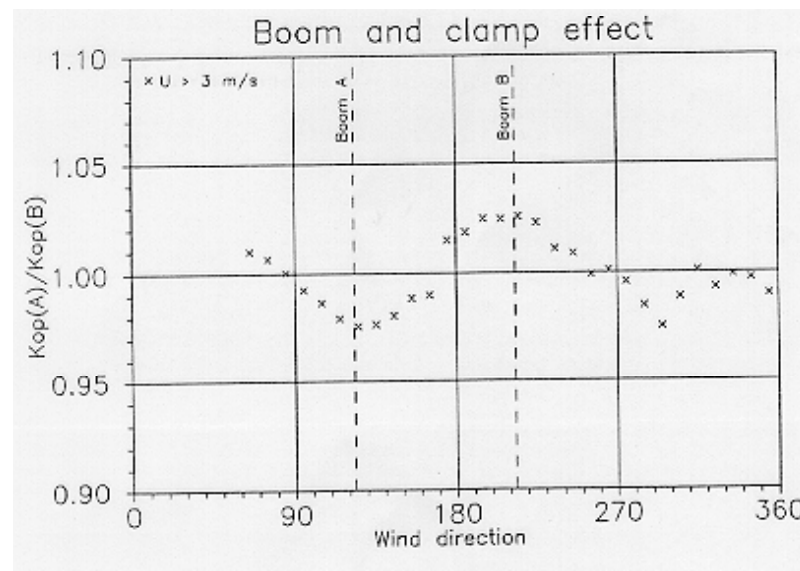
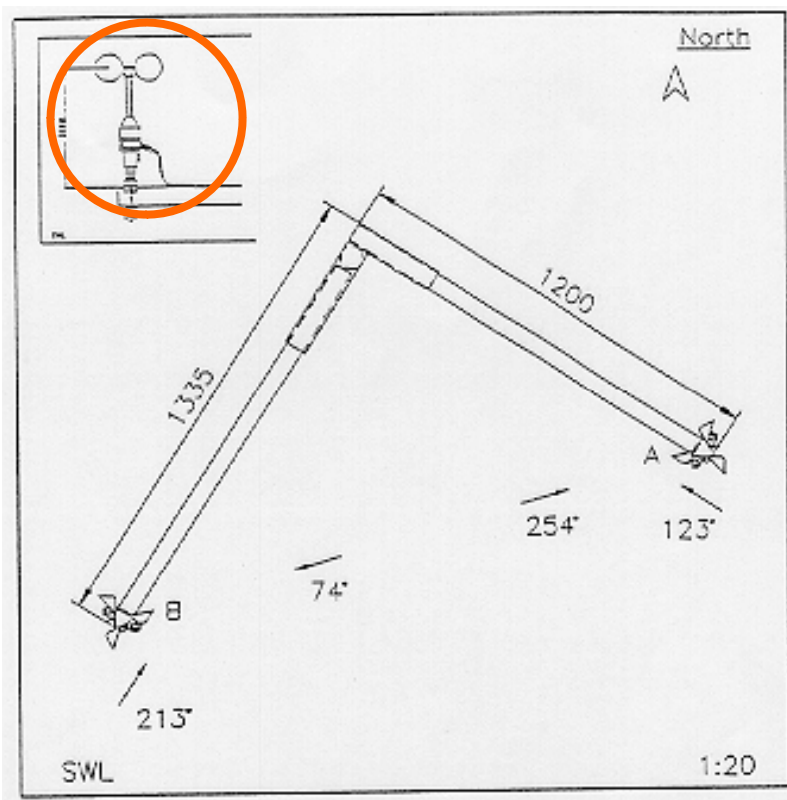
% difference can be significant! Solution: Individual Calibrations

Tower shadow

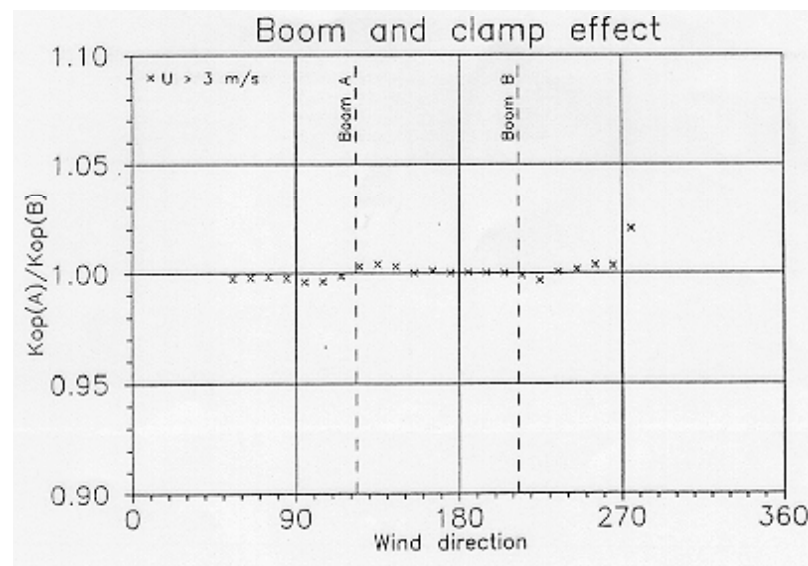
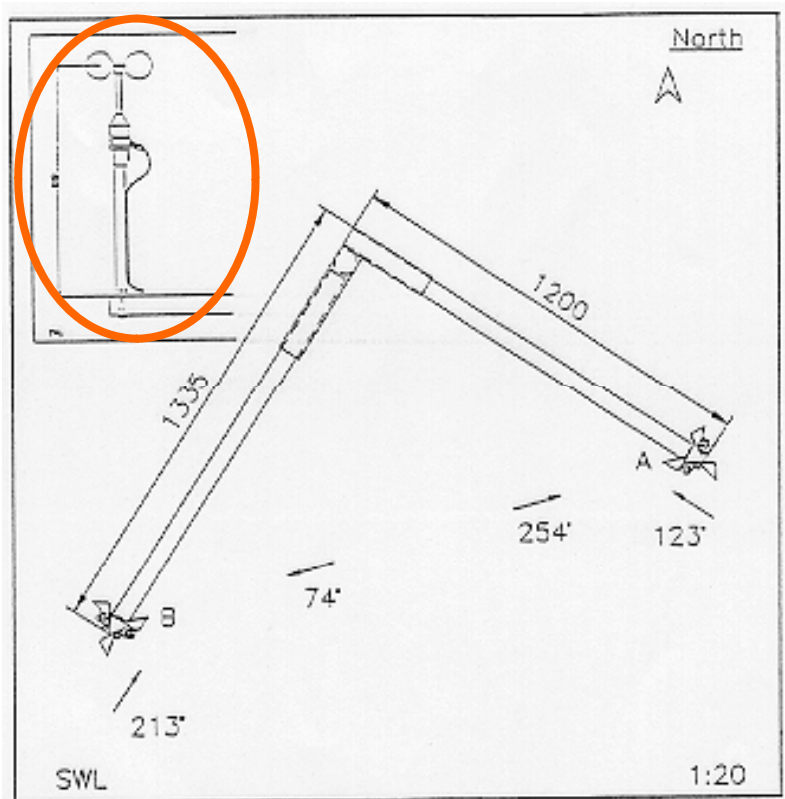


- Triangular lattice tower with side length 1.2 m
- two cups mounted on 2.5-m booms on opposite sides of the tower.

Boom and clamp effect 1 (2)



Boom and clamp effect 2(2)

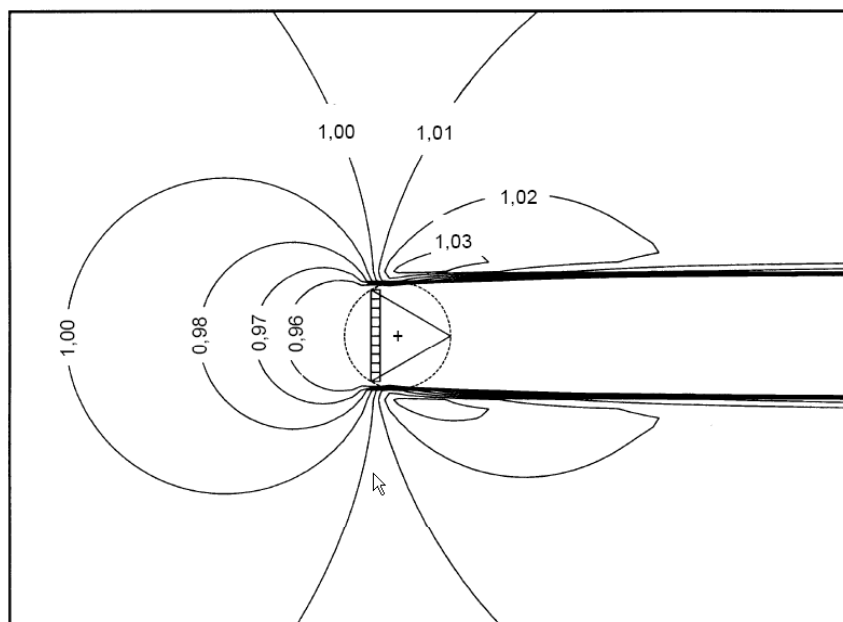


Cup rotor should be > 12-15 boom diameters above boom!

Flow distortion according to IEC 61400-12-1 standard

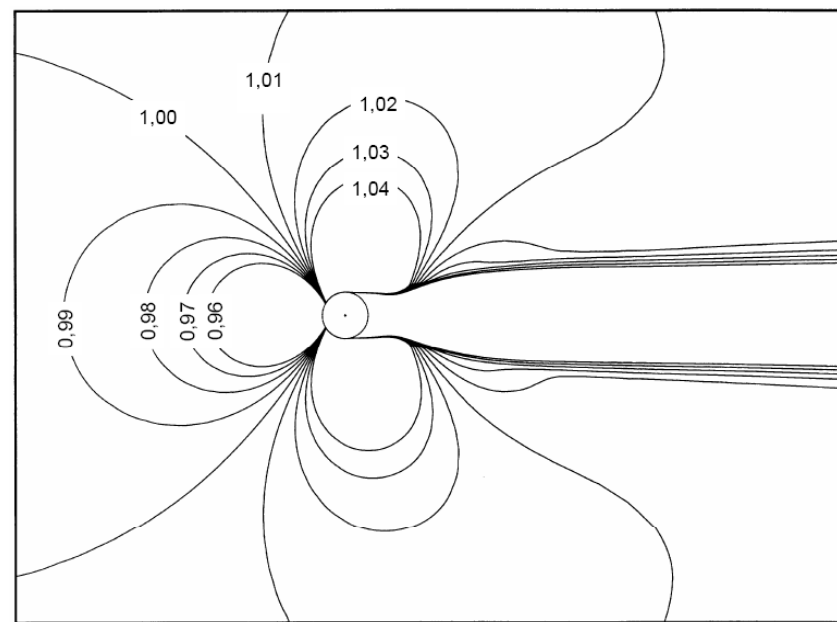
Triangular lattice mast

Optimum boom direction @ 90°

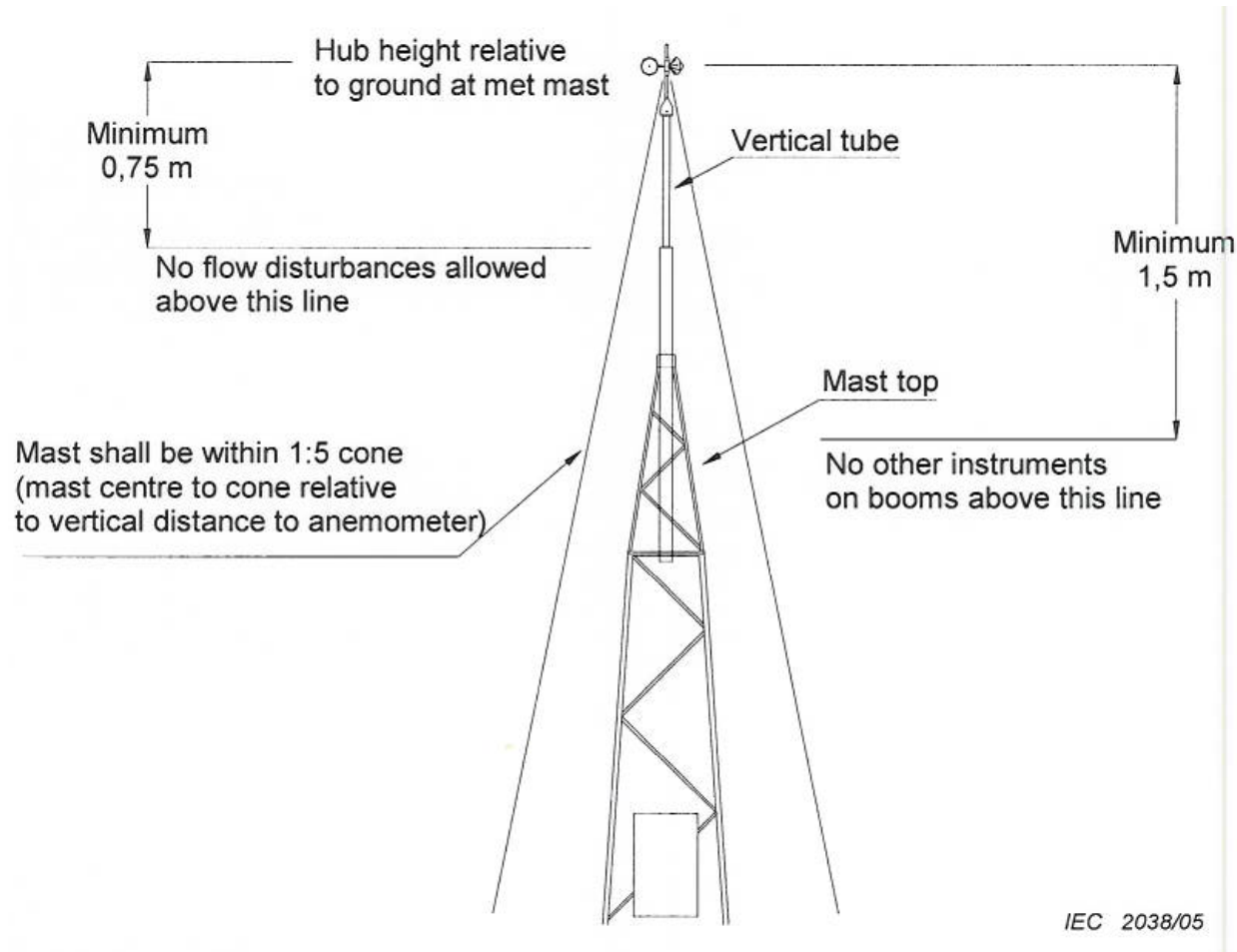


Cylindrical tubular mast

Optimum boom direction @ 45°



Met. mast top arrangement – IEC



Sample met. masts



25-m lattice mast

Risø DTU

National Laboratory for Sustainable Energy



Top-pole



70-m lattice mast

The GIGO principle

- This universal principle for computer models (and many other aspects of life ; -) states:

$$\text{Garbage In} = \text{Garbage Out}$$

or in math terms:

$$\text{Garbage Out} = (\text{Garbage In})^n$$

- Unfortunately, the exponent for wind energy models is:

$$n = 1.5-3$$

- 'Garbage' or not – it's difficult to make accurate, reliable, long-term wind measurements!

... and finally a few rules-of-thumb to remember

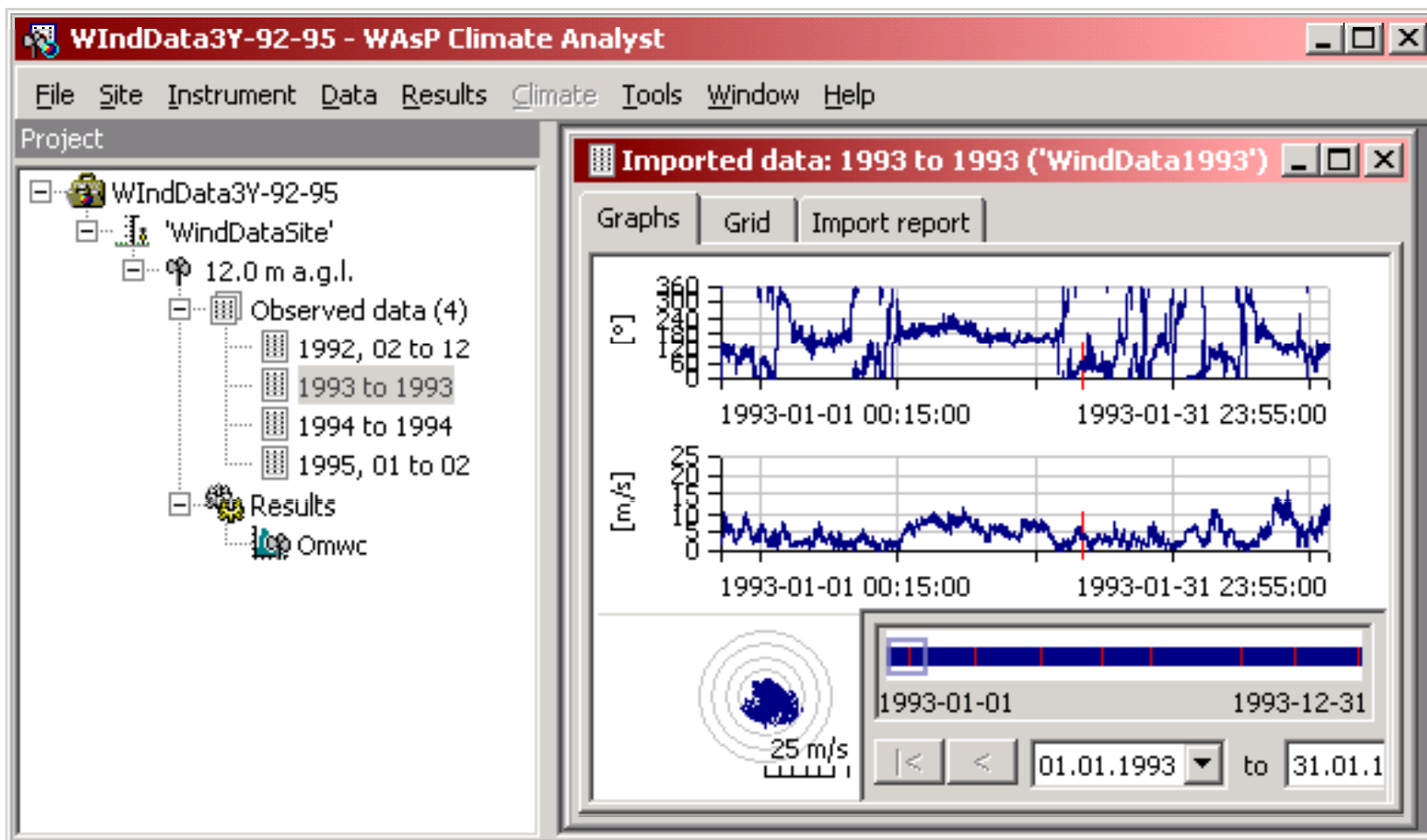
Wind measuring issues

- Cup anemometer rotors should be
> 12-15 boom diameters above boom
- Boom lengths
lattice mast: > 3-5 mast side widths
tubular mast: > 6 mast diameters
- Boom orientation
lattice mast: 45°-90° from prevailing
tubular mast: 45° from prevailing wind
- Uncertainty of wind measurements is
really still 1–3% (or worse)

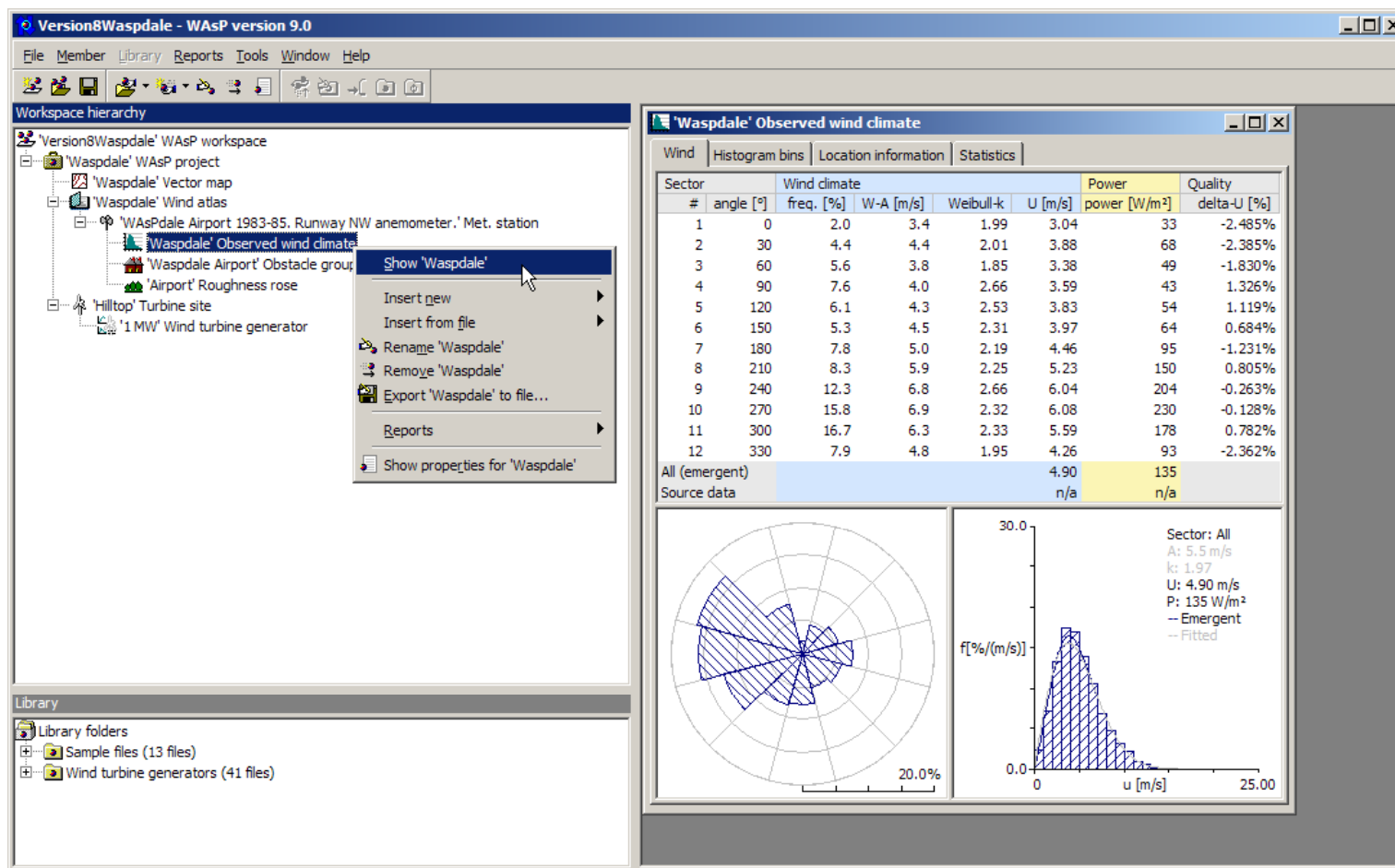
Quality of wind data

- The wind data must be **accurate**
 - equipment design and specifications
 - calibration of sensors (anemometers)
 - careful mounting of sensors on mast
- The wind data must be **representative**
 - data collection for > 1 year
 - data statistics for a number of full years
(no seasonal bias – cut if necessary!)
 - data recovery > 90% (missing data distributed randomly)
 - careful siting of mast (similarity principle)
- The wind data must be **reliable**
 - verification of sensor outputs (QA)
 - O&M (rehabilitation and recalibration)
 - redundant sensors, long-term, wind index, ...

Climate Analyst details (1) – hierarchy



WAsP – the OWC view



The screenshot displays the WAsP software interface. On the left, the 'Workspace hierarchy' shows a tree structure with 'Waspdale' selected. A context menu is open over 'Waspdale', with 'Show Waspdale' highlighted. The main window, titled 'Waspdale' Observed wind climate', contains a table of wind climate data and two charts.

Sector #	angle [°]	freq. [%]	W-A [m/s]	Weibull-k	U [m/s]	power [W/m ²]	Quality delta-U [%]
1	0	2.0	3.4	1.99	3.04	33	-2.485%
2	30	4.4	4.4	2.01	3.88	68	-2.385%
3	60	5.6	3.8	1.85	3.38	49	-1.830%
4	90	7.6	4.0	2.66	3.59	43	1.326%
5	120	6.1	4.3	2.53	3.83	54	1.119%
6	150	5.3	4.5	2.31	3.97	64	0.684%
7	180	7.8	5.0	2.19	4.46	95	-1.231%
8	210	8.3	5.9	2.25	5.23	150	0.805%
9	240	12.3	6.8	2.66	6.04	204	-0.263%
10	270	15.8	6.9	2.32	6.08	230	-0.128%
11	300	16.7	6.3	2.33	5.59	178	0.782%
12	330	7.9	4.8	1.95	4.26	93	-2.362%
All (emergent)						4.90	135
Source data						n/a	n/a

Below the table are two charts: a wind rose on the left and a histogram on the right. The histogram shows frequency f [%/(m/s)] versus wind speed u [m/s]. A legend for the histogram indicates: Sector: All, A: 5.5 m/s, k: 1.97, U: 4.90 m/s, P: 135 W/m², with dashed lines for 'Emergent' and 'Fitted' data.

The OWC file (*.tab, now *.owc)

