Appendix Meetresultaten

(Het doordringen van golven in een filterlaag)

november 2000

Roland Jansens

R. Jansens
Korvezeestraat 66
2628 DC Delft
tel. nr.: 015-2569076
e-mail: roland66@dds.nl
st. nr.: 9393567

Afstudeercommissie:

Prof. ir. K. d' Angremond
dr. ir. H.L. Fontijn
drs. R. Booij
ir. W.H. Tutuarima
ir. B. Steijn

Inhoudsopgave

Appendix meetresultaten bevat de resultaten van alle metingen, die zijn uitgevoerd tijdens het afstudeerwerk 'Het doordringen van golven in een filterlaag', en is een extra bijlage behorende bij het gelijknamige afstudeerrapport.

1 Meetserie 1, Verloop van de poriesnelheden over de dikte van de filterlaag 1

1.1 Meetserie 1, belastingsgeval A 3

1.1.1 Belastingsgeval A, 1*D_{n50} in filterlaag 3
1.1.2 Belastingsgeval A, 2*D_{n50} in filterlaag 7
1.1.3 Belastingsgeval A, 3*D_{n50} in filterlaag 11
1.1.4 Belastingsgeval A, 4*D_{n50} in filterlaag 15
1.1.5 Belastingsgeval A, 5*D_{n50} in filterlaag 19

1.2 Meetserie 1, belastingsgeval B 23

1.2.1 Belastingsgeval B, 1*D_{n50} in filterlaag 23
1.2.2 Belastingsgeval B, 2*D_{n50} in filterlaag 27
1.2.3 Belastingsgeval B, 3*D_{n50} in filterlaag 31
1.2.4 Belastingsgeval B, 5*D_{n50} in filterlaag 35
1.2.5 Belastingsgeval B, 5*D_{n50} in filterlaag 39

1.3 Meetserie 1, belastingsgeval C 43

1.3.1 Belastingsgeval C, 1*D_{n50} in filterlaag 43
1.3.2 Belastingsgeval C, 2*D_{n50} in filterlaag 47
1.3.3 Belastingsgeval C, 3*D_{n50} in filterlaag 51
1.3.4 Belastingsgeval C, 4*D_{n50} in filterlaag 55
1.3.5 Belastingsgeval C, 5*D_{n50} in filterlaag 59

1.4 Meetserie 1, belastingsgeval D 63

1.4.1 Belastingsgeval D, 1*D_{n50} in filterlaag 63
1.4.2 Belastingsgeval D, 2*D_{n50} in filterlaag 67
1.4.3 Belastingsgeval D, 3*D_{n50} in filterlaag 71
1.4.4 Belastingsgeval D, 4*D_{n50} in filterlaag 75
1.4.5 Belastingsgeval D, 5*D_{n50} in filterlaag 79

2 Meetserie 2, effect verhogen bemonsteringsfrequentie 83

2.1 Meetserie 2, bemonsteringsfrequentie 400 Hz 84

2.2 Meetserie 2, bemonsteringsfrequentie 800 Hz 85

2.3 Powerspectra, horizontale orbitaalsnelheid, 200, 400 en 800 Hz 85

2.4 Powerspectra, horizontale poriesnelheid, 200, 400 en 800 Hz 86

2.5 Powerspectra, verticale poriesnelheid, 200, 400 en 800 Hz 86

3 Meetserie 3, gevoeligheid verschillende oriëntaties meetporie 87

3.1 Gevoeligheid voor verschillende oriëntaties meetporie 87

3.2 Meetserie 3, rotatie 0° 88

3.3 Meetserie 3, rotatie 90° 89

3.4 Meetserie 3, rotatie 180° 90

3.5 Meetserie 3, rotatie 270° 91

4 Meetserie 4, constante golfperiode, variabele golfhoogte 93

5 Meetserie 5, constante golfhoogte, variabele golfperiode 95

6 Meetserie 6, snelheidsmetingen met LDFM boven de filterlaag 97

6.1 Meetserie 6, 2 cm boven filterlaag 98

6.2 Meetserie 6, 4 cm boven filterlaag 99

6.3 Meetserie 6, 6 cm boven filterlaag 100

6.4 Meetserie 6, 8 cm boven filterlaag 101

7 Meetserie 7, snelheidsmetingen zonder filterlaag 103

7.1 Meetserie 7, belastingsgeval Azf 104

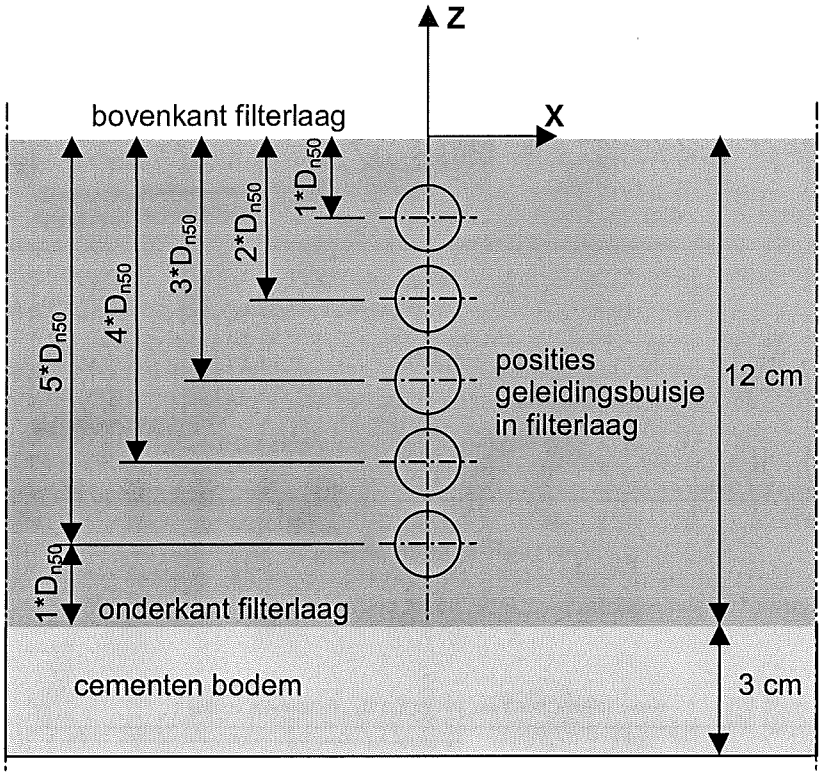
7.2 Meetserie 7, belastingsgeval Bzf 105

7.3 Meetserie 7, belastingsgeval Czf 106

7.4 Meetserie 7, belastingsgeval Dzf 107

1 Meetserie 1, Verloop van de poriesnelheden over de dikte van de filterlaag

De eerste meetserie dient om het verloop van de poriesnelheden over de dikte van de filterlaag in kaart te brengen. Hiertoe zijn de geleidingsbuisjes achtereenvolgens op de in de onderstaande figuur aangegeven posities gesteld, waarna de snelheidsmetingen zijn uitgevoerd.



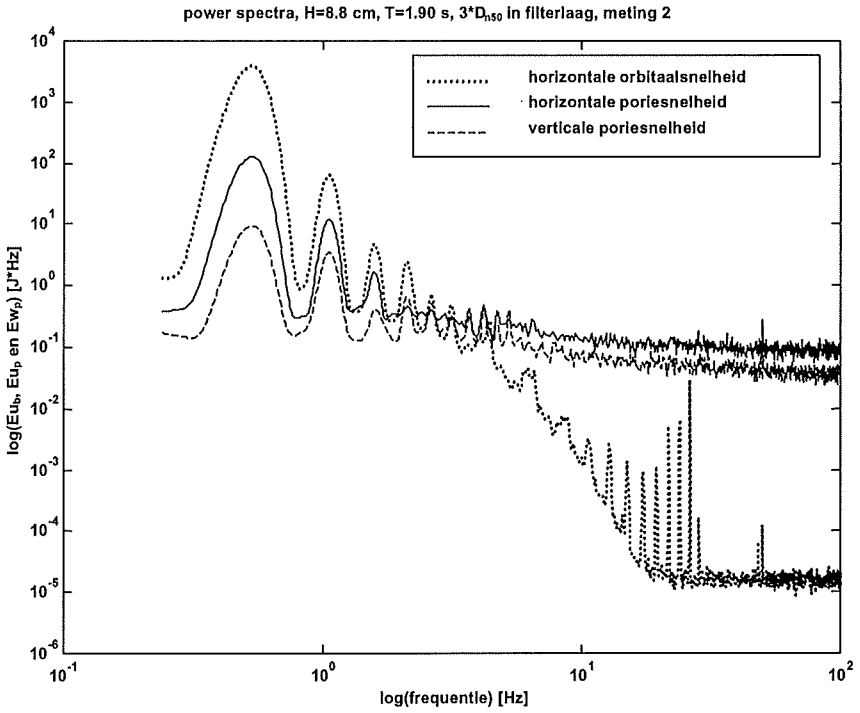
Om de gevoeligheid voor een gewijzigde stenenstapeling te onderzoeken wordt op iedere positie een experiment drie maal herhaald, waarbij de stenenstapeling wordt gewijzigd, maar de oriëntatie van de meetporie exact hetzelfde blijft. Hiernaast is tijdens meetserie 1 op iedere positie een extra meting uitgevoerd, waarbij de meetporie in het horizontale vlak 180° werd gedraaid. Hierdoor is de oriëntatie van de meetporie dus anders dan bij de overige metingen. Deze metingen worden aangeduid als meting 4*. In onderstaande tabel is een aantal gegevens van de verschillende metingen weergegeven.

golfbelasting	golfhoogte [cm]	golfperiode [s]	meetduur [s]	aantal stenen-stapelingen	aantal posities	aantal metingen/ golfbelasting
A	16,7	1,03	110	3(+1)	5	15(+5)
B	8,9	1,33	140	3(+1)	5	15(+5)
C	8,8	1,90	200	3(+1)	5	15(+5)
D	7,9	2,41	250	3(+1)	5	15(+5)
totaal aantal metingen meetserie 1						60(+20)

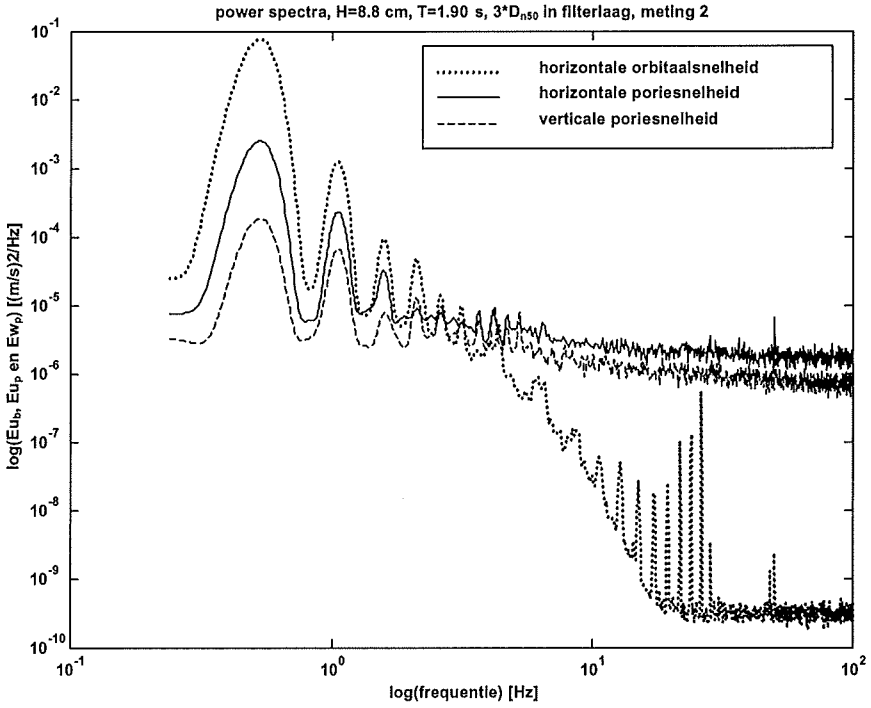
Tijdens meetserie 1 is de bemonsteringsfrequentie 200 Hz voor alle belastingsgevallen. Bij deze meetserie was er geen analoog lowpass-filter tussen de meetapparatuur en de A/D-convertor geplaatst.

Waarschuwing: Bij deze meetserie is de verticale as van de powerspectra verkeerd geschaald en is de verkeerde eenheid aangegeven. Dit kan worden gecorrigeerd door de waarden op de

verticale as door $5*10^{-4}$ te delen, en voor de eenheid $(m/s)^2/Hz$ i.p.v. J*Hz in te vullen. Zie figuur 1 en 2 voor een voorbeeld van verkeerde en goed geschaalde spectra.



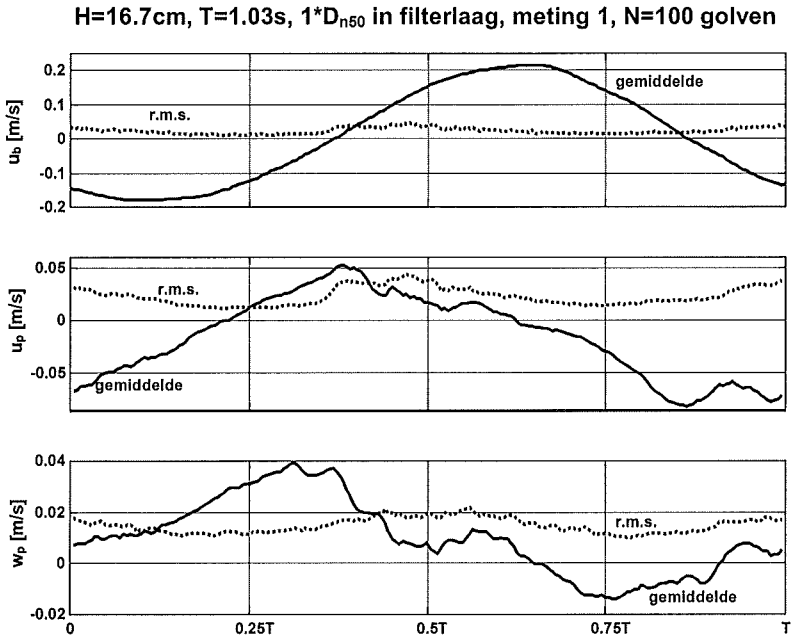
Figuur 1: Powerspectra meetserie 1 met verkeerd geschaalde verticale as



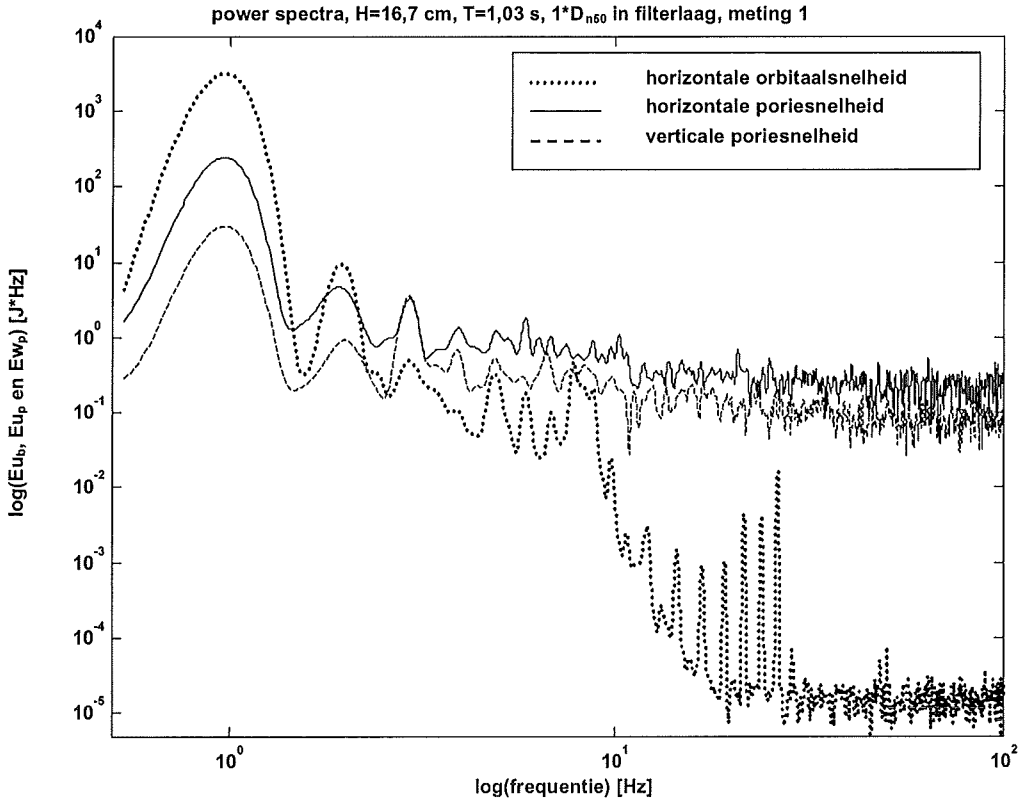
Figuur 2: Powerspectra meetserie 1 met goed geschaalde verticale as

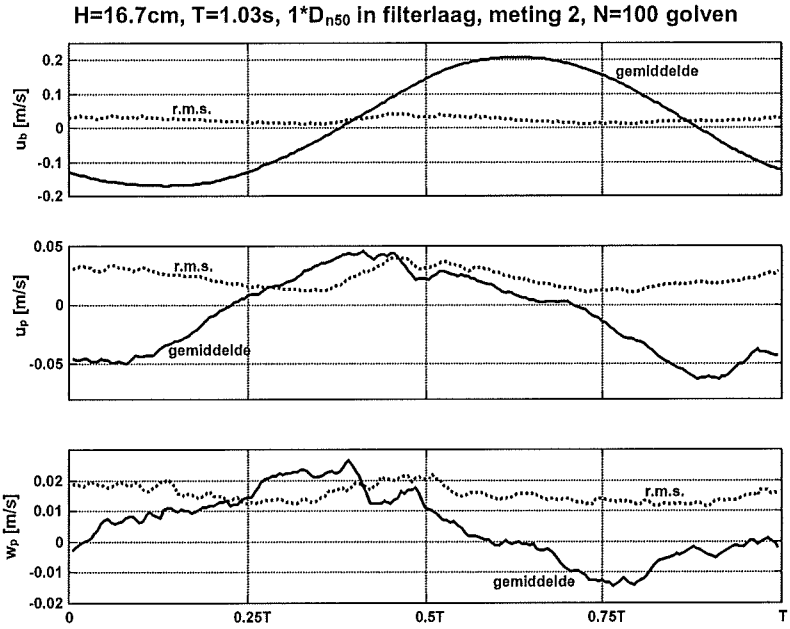
Meetserie 1, belastingsgeval A

1.1.1 Belastingsgeval A, 1*D_{n50} in filterlaag

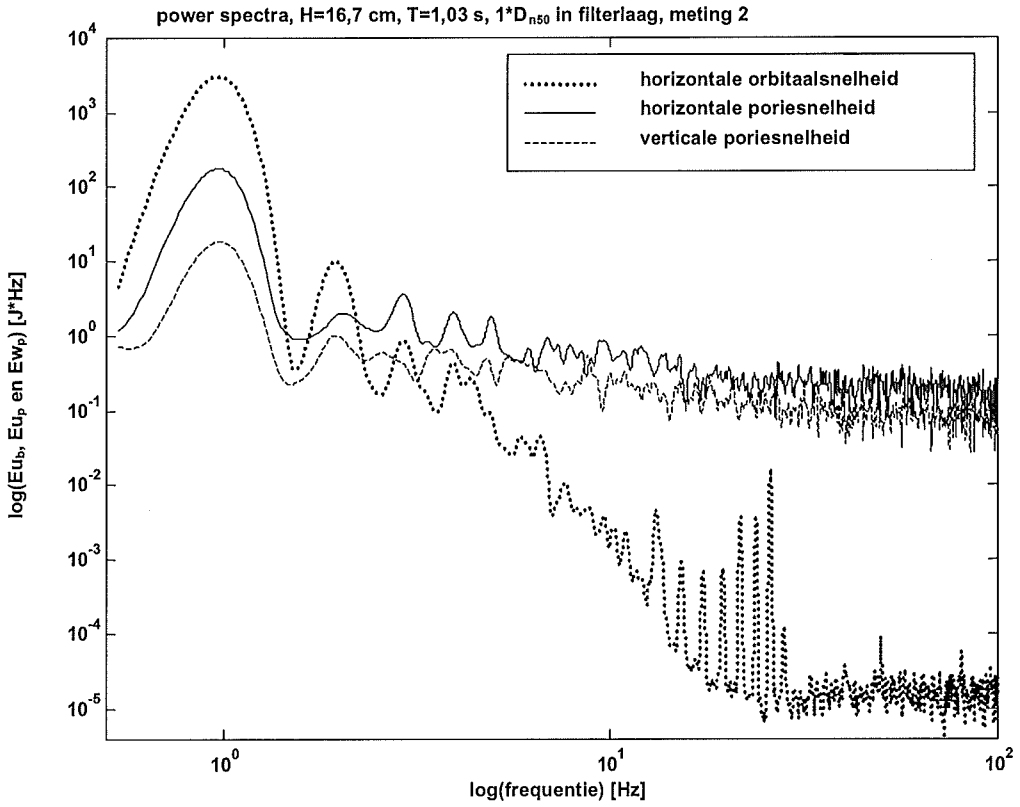


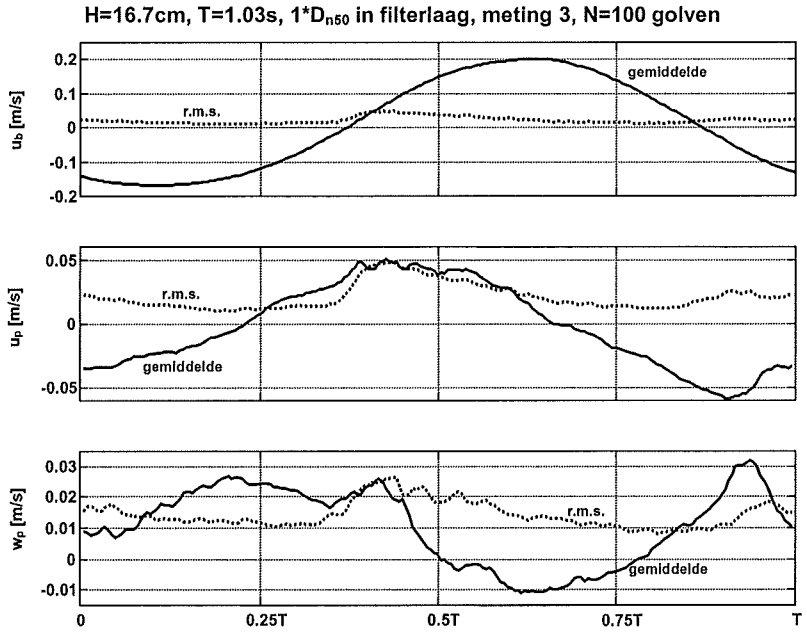
1*D_{n50} in filterlaag, meting 1, H_{gem}= 16,59 cm, Tgem= 1,03 s			
$\hat{u}_b$ [m/s]	0.18 – 0.22	u_b' [m/s]	
$\hat{u}_p$ [m/s]	0.05 – 0.08	u_p' [m/s]	0.01 – 0.05
$\hat{w}_p$ [m/s]	0.015 – 0.040	w_p' [m/s]	0.009 – 0.023



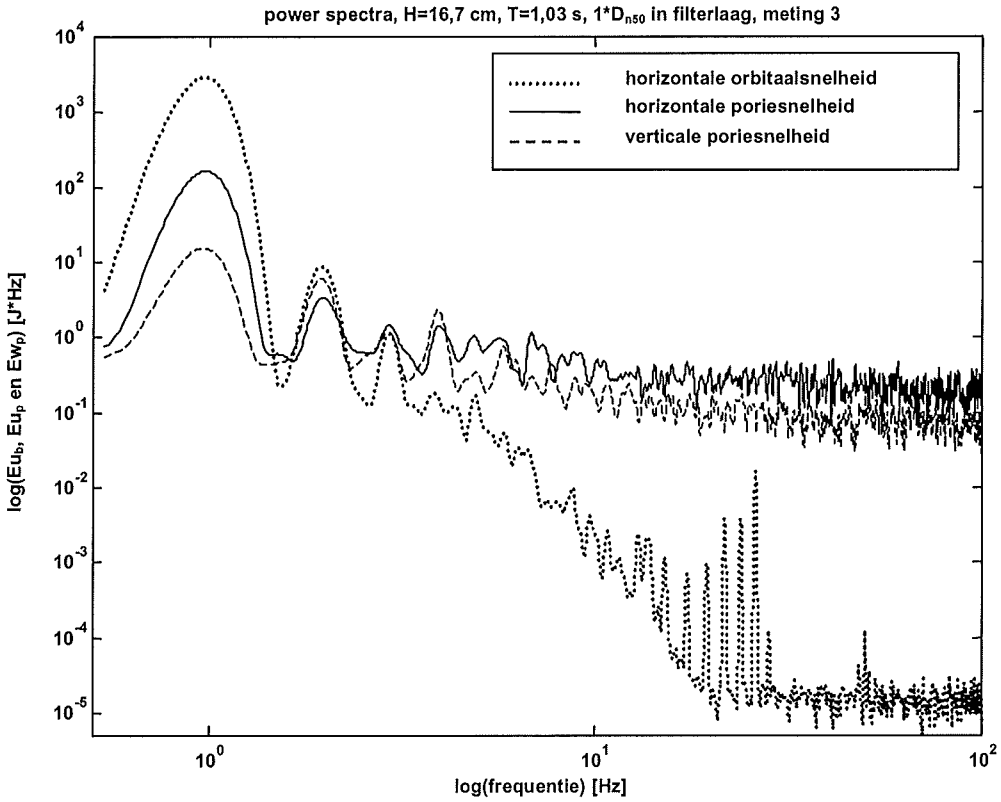


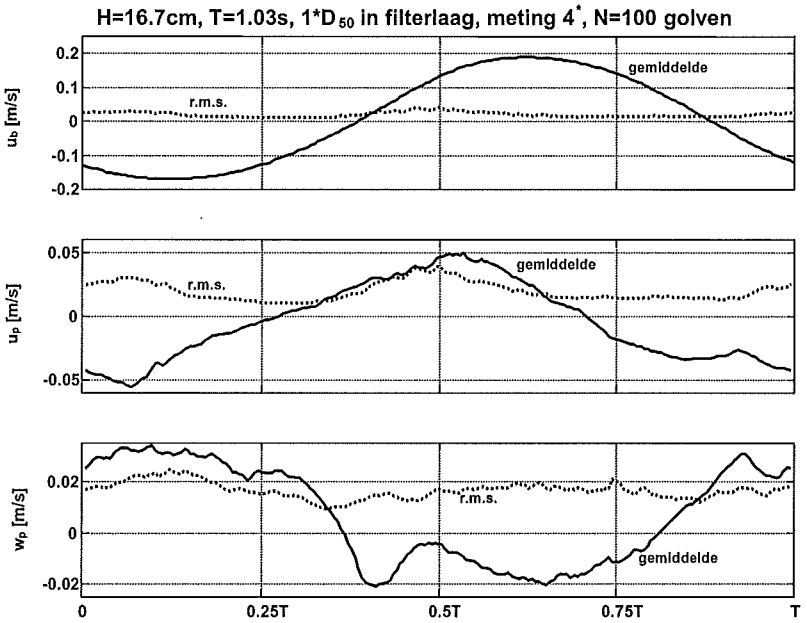
1*D_{n50} in filterlaag, meting 2, H_{gem}= 16,86 cm, Tgem= 1,03 s			
$\hat{u}_b$ [m/s]	0.17 – 0.21	u_b' [m/s]	
$\hat{u}_p$ [m/s]	0.05 – 0.07	u_p' [m/s]	0.01 – 0.04
$\hat{w}_p$ [m/s]	0.015 – 0.028	w_p' [m/s]	0.010 – 0.025



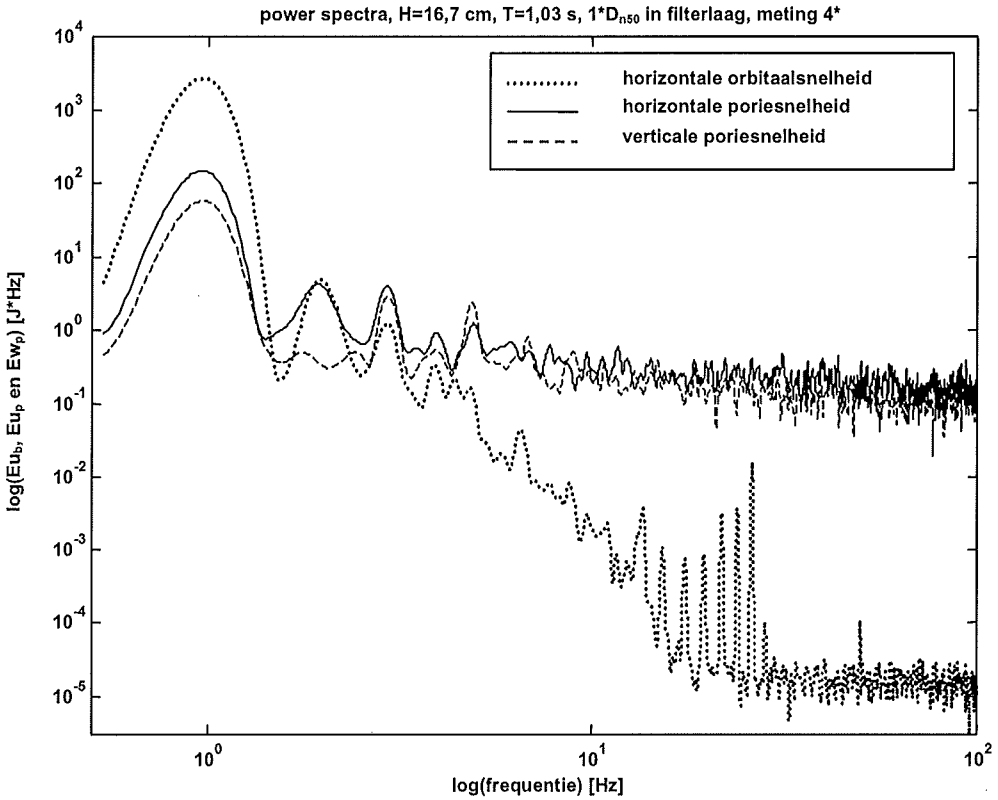


$1*D_{n50}$ in filterlaag, meting 3, H_{gem}= 16,73 cm, Tgem= 1,03 s			
$\hat{u}_b$ [m/s]	0.17 – 0.20	u_b' [m/s]	
$\hat{u}_p$ [m/s]	0.05 – 0.06	u_p' [m/s]	0.01 – 0.05
$\hat{w}_p$ [m/s]	0.012 – 0.033	w_p' [m/s]	0.008 – 0.028

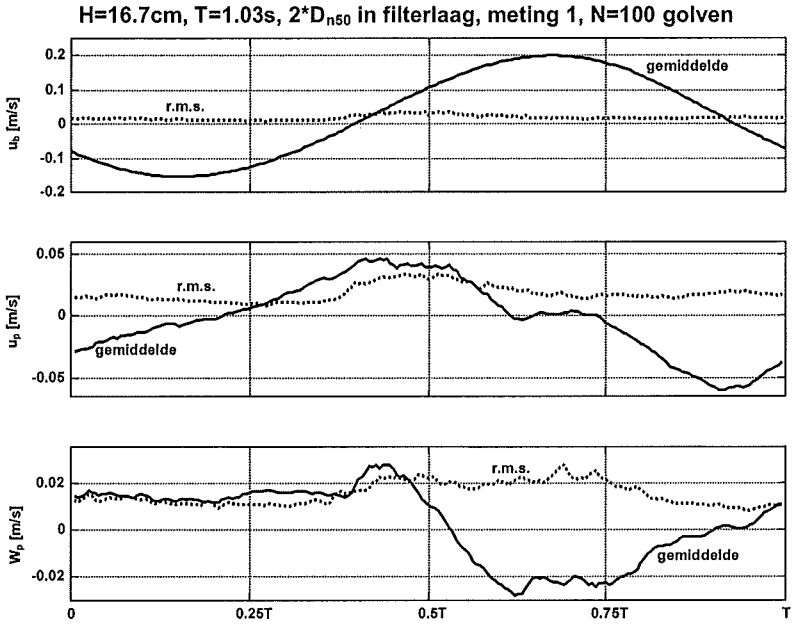




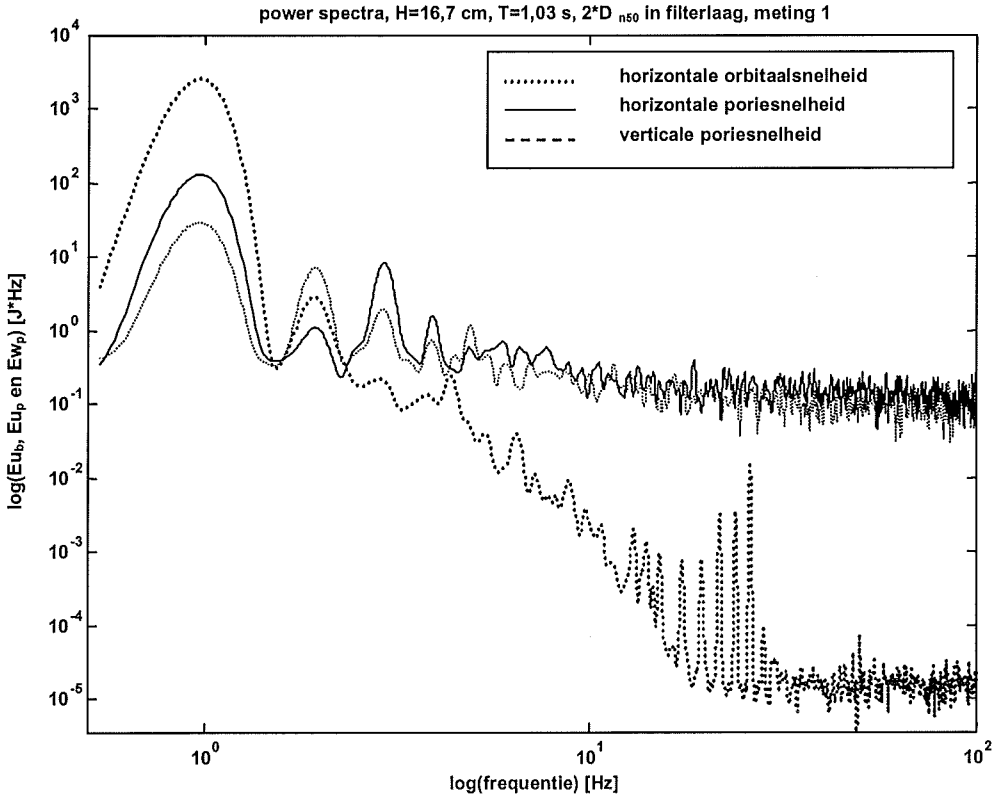
$1*D_{n50}$ in filterlaag, meting 4*, H_{gem}= 16,84 cm, Tgem= 1,03 s			
$\hat{u}_b$ [m/s]	0.17 – 0.19	u_b' [m/s]	
$\hat{u}_p$ [m/s]	0.05 – 0.06	u_p' [m/s]	0.01 – 0.04
$\hat{w}_p$ [m/s]	0.021 – 0.035	w_p' [m/s]	0.009 – 0.026

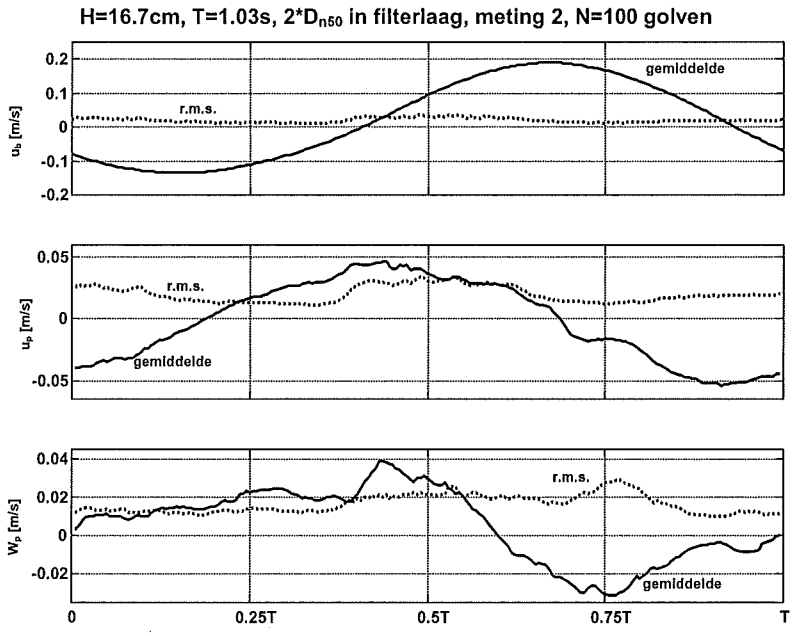


1.1.2 Belastingsgeval A, 2*D_{n50} in filterlaag

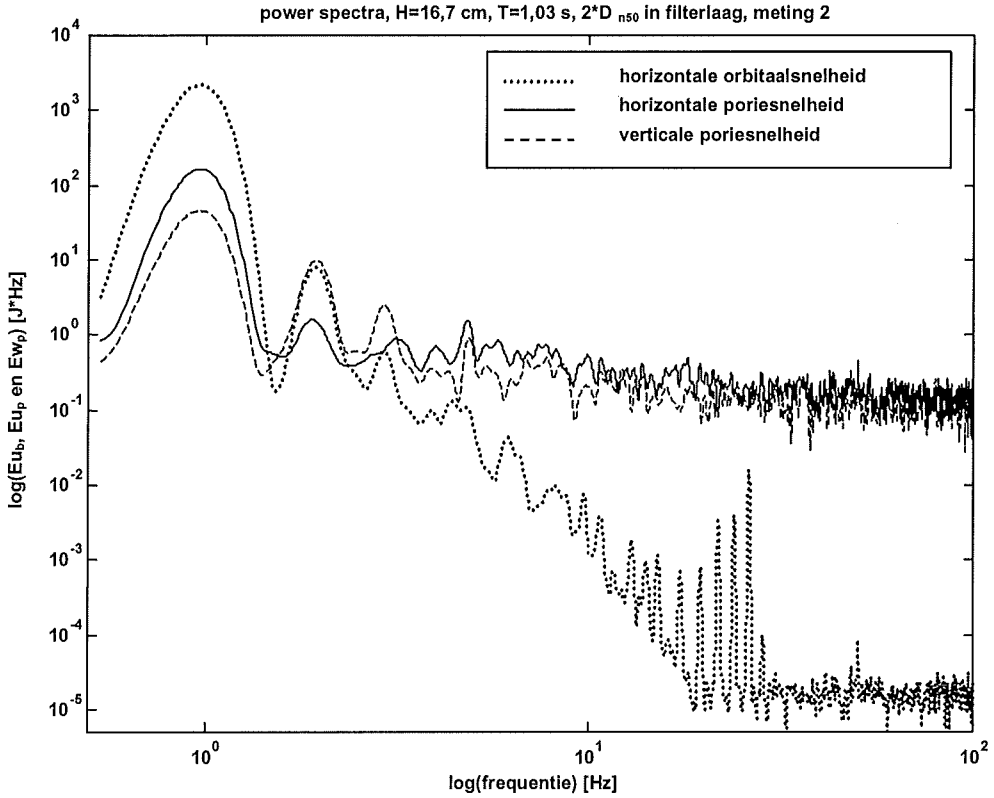


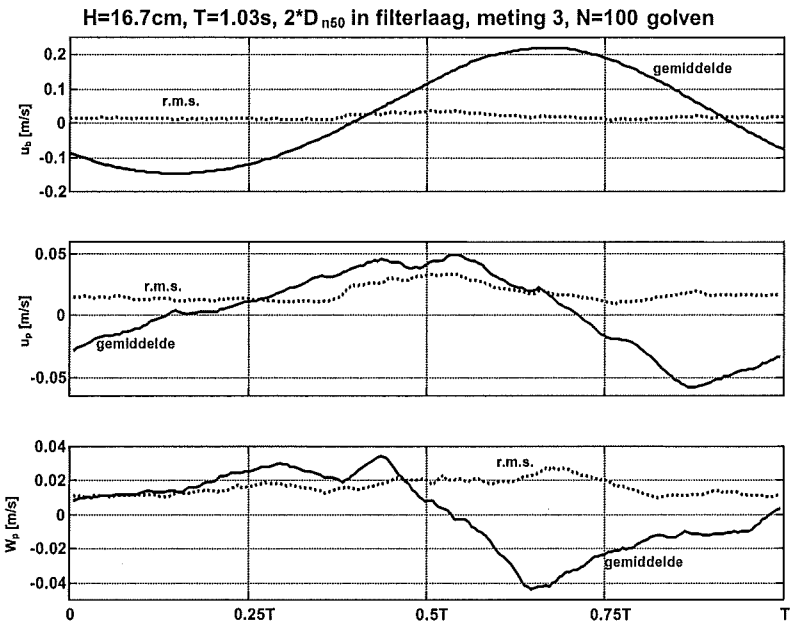
$2*D_{n50}$ in filterlaag, meting 1, H_{gem}= 16,77 cm, Tgem= 1,03 s			
$\hat{u}_b$ [m/s]	0.15 – 0.20	u_b' [m/s]	
$\hat{u}_p$ [m/s]	0.05 – 0.06	u_p' [m/s]	0.0077 – 0.04
$\hat{w}_p$ [m/s]	0.021 – 0.035	w_p' [m/s]	0.007 – 0.029



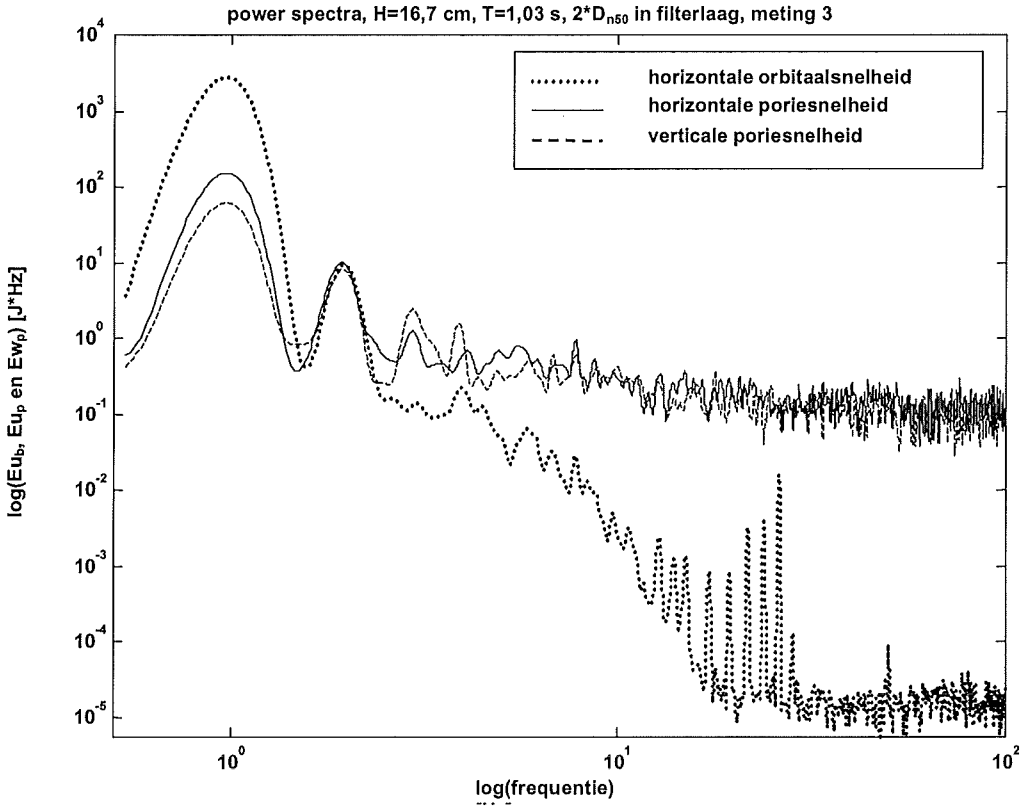


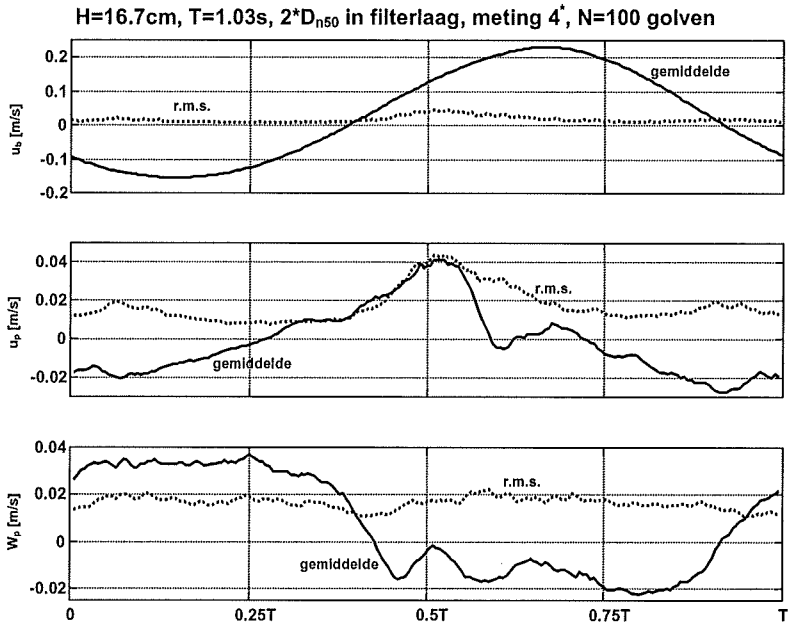
$2*D_{n50}$ in filterlaag, meting 2, H_{gem}= 16,74 cm, Tgem= 1,03 s			
$\hat{u}_b$ [m/s]	0.17 – 0.19	u_b' [m/s]	
$\hat{u}_p$ [m/s]	0.05 – 0.06	u_p' [m/s]	0.01 – 0.04
$\hat{w}_p$ [m/s]	0.033 – 0.040	w_p' [m/s]	0.009 – 0.031



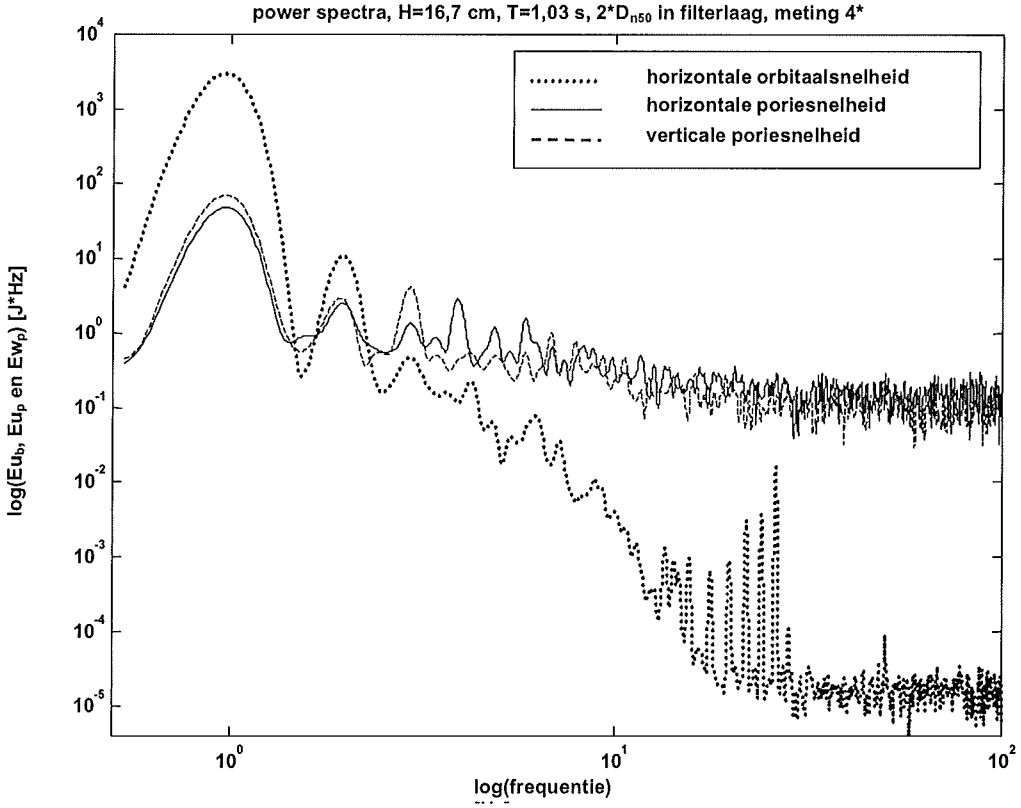


$2*D_{n50}$ in filterlaag, meting 3, H_{gem}= 16,82 cm, Tgem= 1,03 s			
$\hat{u}_b$ [m/s]	0.15 – 0.22	u_b' [m/s]	
$\hat{u}_p$ [m/s]	0.05 – 0.06	u_p' [m/s]	0.01 – 0.04
$\hat{w}_p$ [m/s]	0.035 – 0.045	w_p' [m/s]	0.009 – 0.030

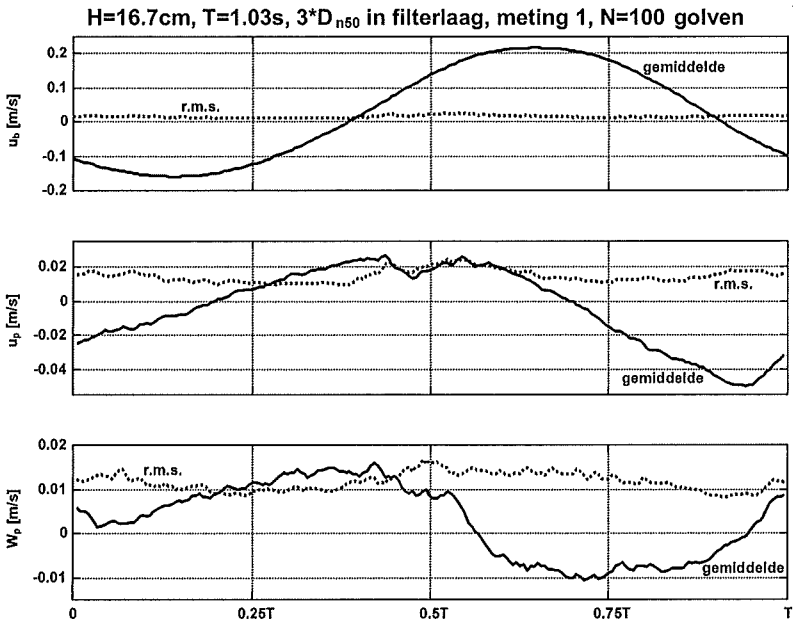




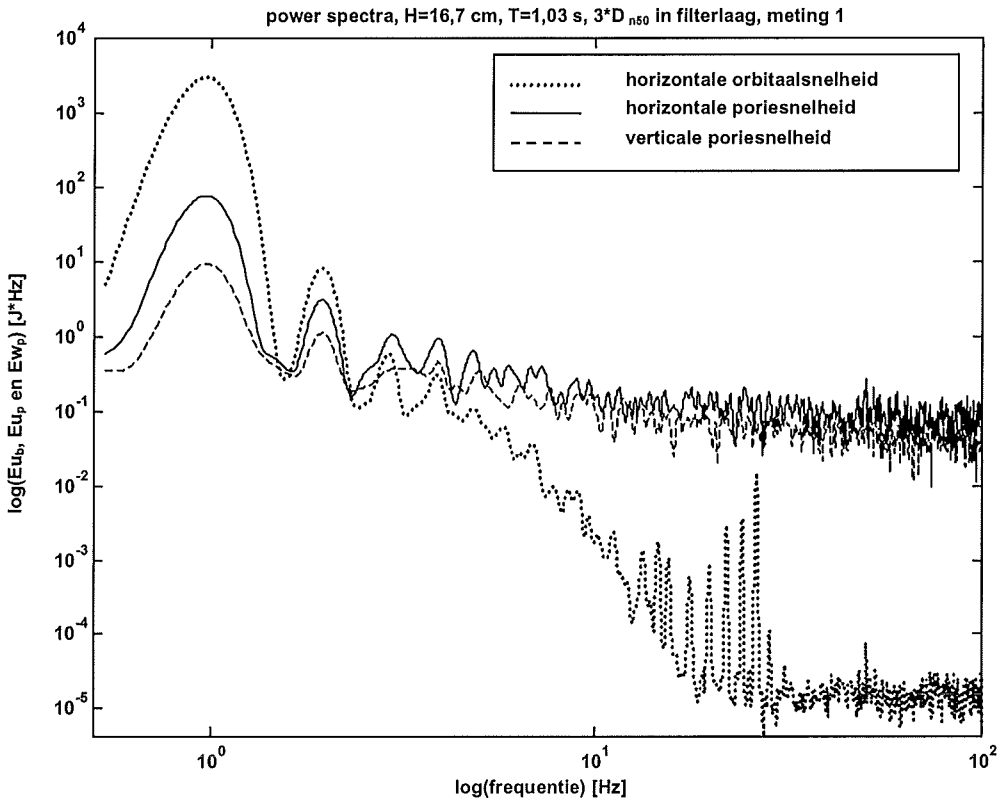
$2*D_{n50}$ in filterlaag, meting 4*, H_{gem}= 16,82 cm, Tgem= 1,03 s			
$\hat{u}_b$ [m/s]	0.15 – 0.23	u_b' [m/s]	
$\hat{u}_p$ [m/s]	0.03 – 0.04	u_p' [m/s]	0.01 – 0.04
$\hat{w}_p$ [m/s]	0.023 – 0.038	w_p' [m/s]	0.009 – 0.024

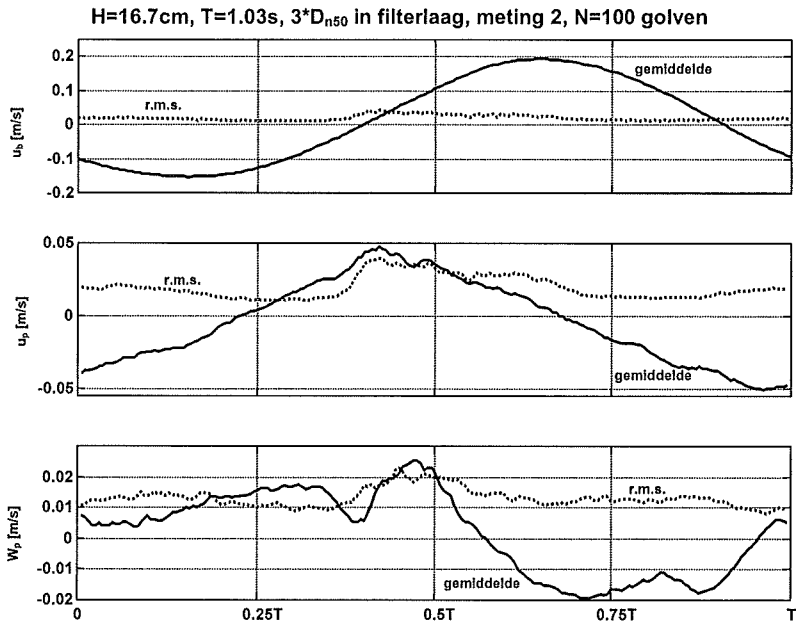


1.1.3 Belastingsgeval A, 3*D_{n50} in filterlaag

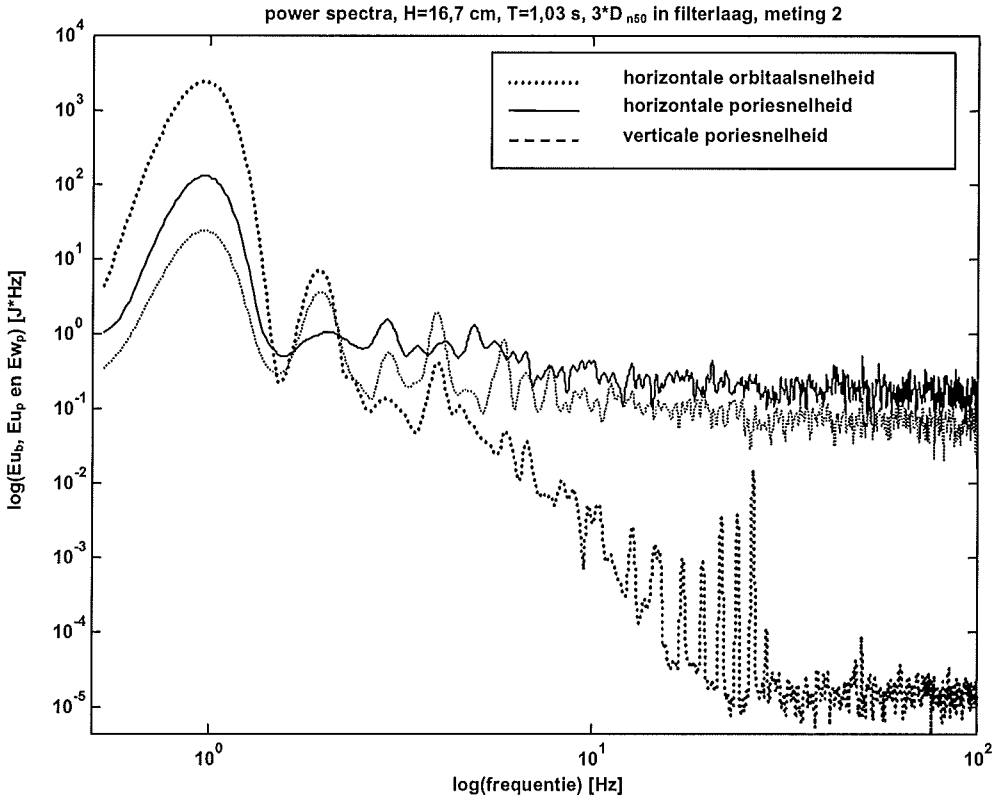


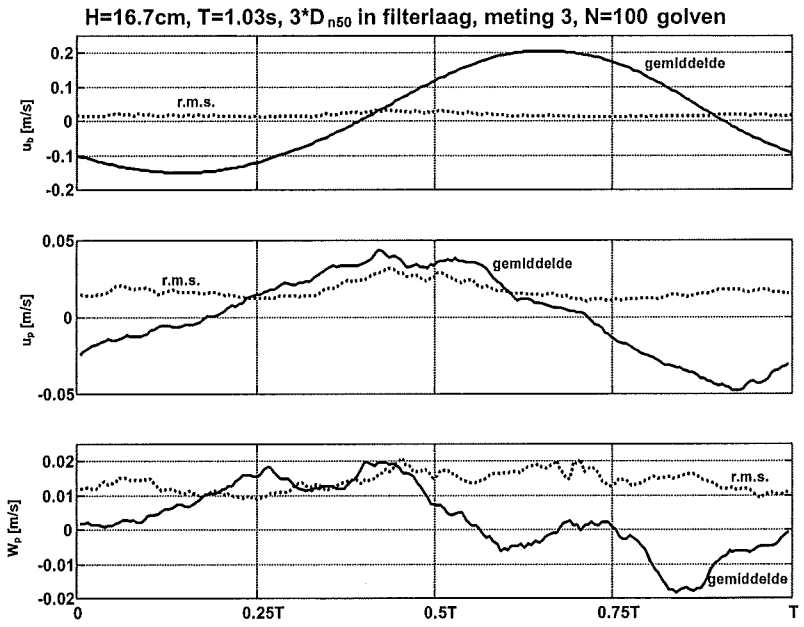
$3*D_{n50}$ in filterlaag, meting 1, H_{gem}= 16,70 cm, Tgem= 1,03 s			
$\hat{u}_b$ [m/s]	0.16 – 0.22	u_b' [m/s]	
$\hat{u}_p$ [m/s]	0.03 – 0.05	u_p' [m/s]	0.01 – 0.03
$\hat{w}_p$ [m/s]	0.011 – 0.016	w_p' [m/s]	0.008 – 0.018



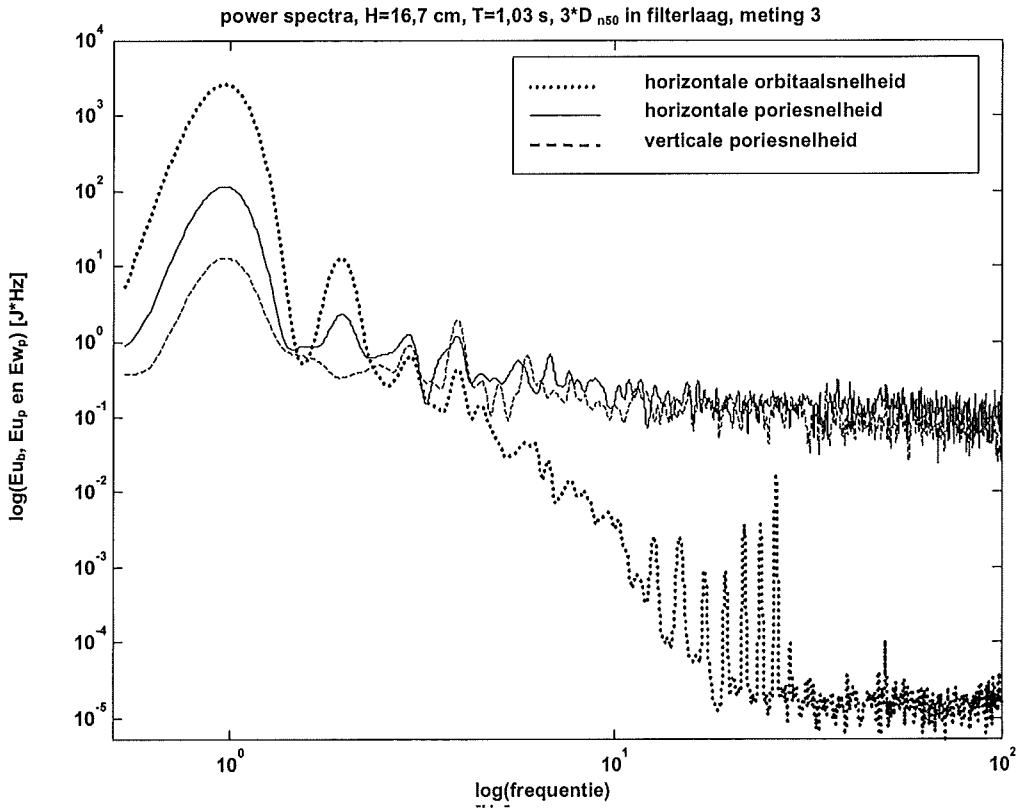


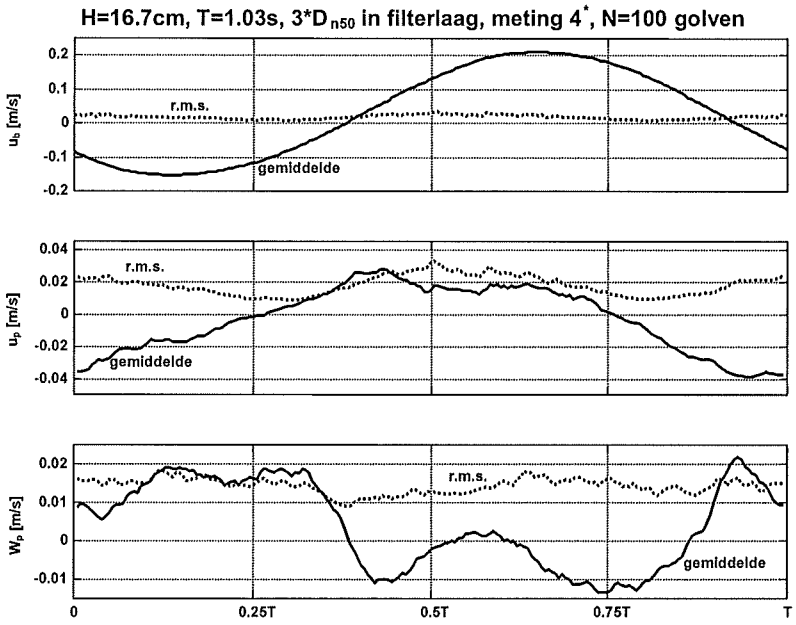
$3*D_{n50}$ in filterlaag, meting 2, H_{gem}= 16,90 cm, Tgem= 1,03 s			
$\hat{u}_b$ [m/s]	0.15 – 0.19	u_b' [m/s]	
$\hat{u}_p$ [m/s]	0.05 – 0.05	u_p' [m/s]	0.01 – 0.04
$\hat{w}_p$ [m/s]	0.020 – 0.028	w_p' [m/s]	0.008 – 0.025



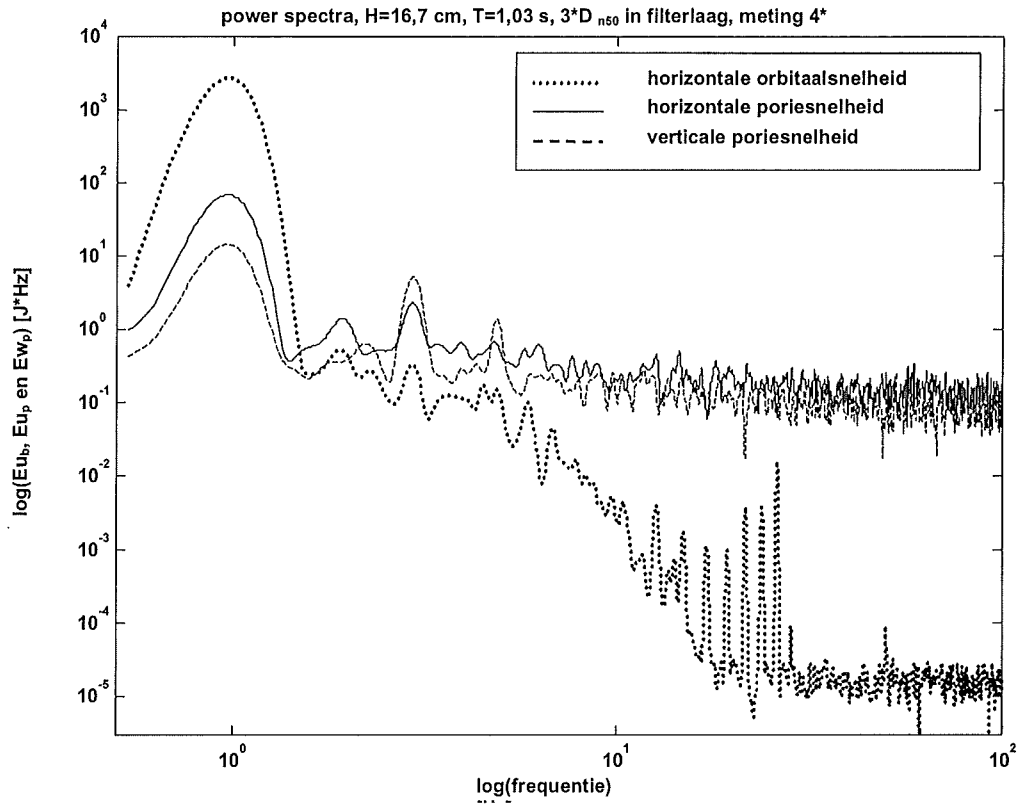


$3*D_{n50}$ in filterlaag, meting 3, H_{gem}= 16,88 cm, T_{gem}= 1,03 s			
$\hat{u}_b$ [m/s]	0.15 – 0.21	u_b' [m/s]	
$\hat{u}_p$ [m/s]	0.05 – 0.05	u_p' [m/s]	0.01 – 0.03
$\hat{w}_p$ [m/s]	0.020 – 0.021	w_p' [m/s]	0.008 – 0.026

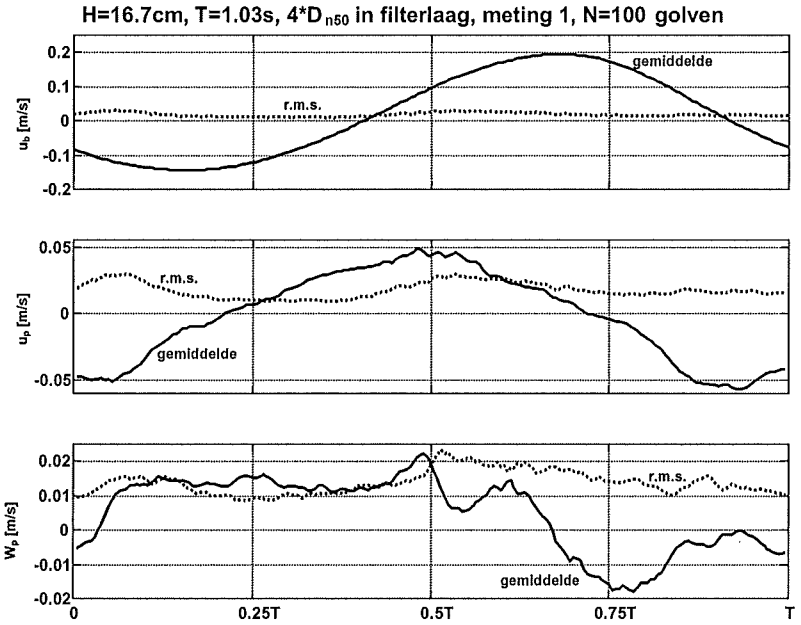




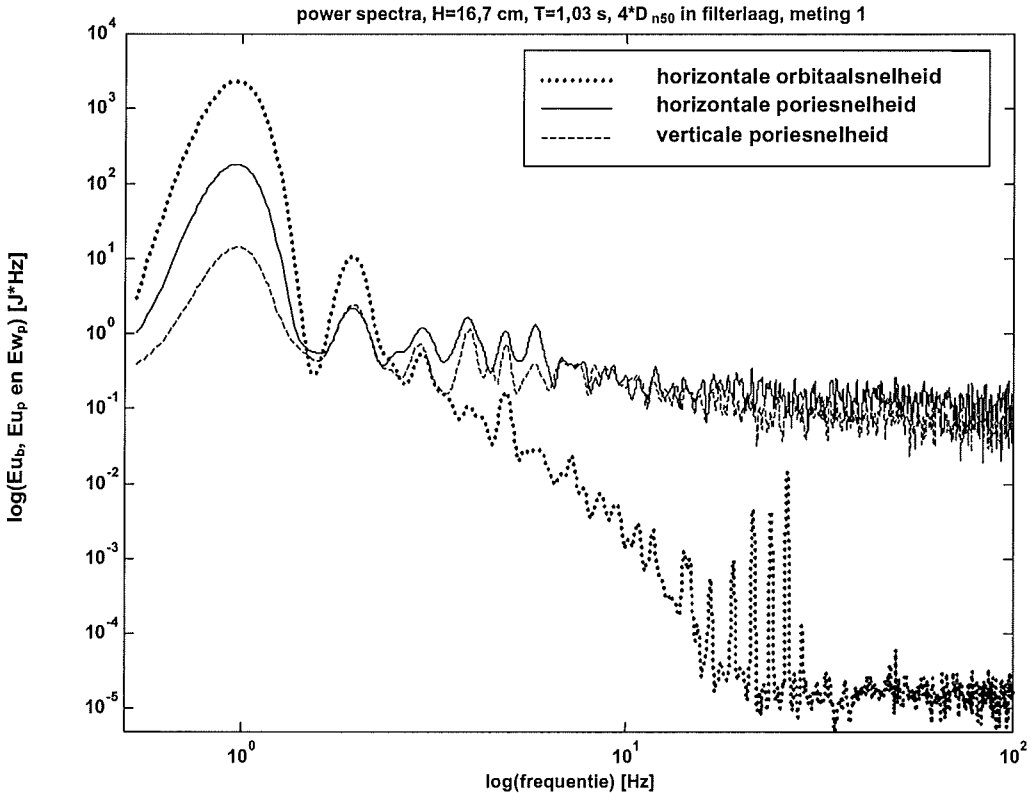
$3*D_{n50}$ in filterlaag, meting 4*, H_{gem}= 16,83 cm, T_{gem}= 1,03 s			
$\hat{u}_b$ [m/s]	0.15 – 0.21	u_b' [m/s]	
$\hat{u}_p$ [m/s]	0.03 – 0.04	u_p' [m/s]	0.01 – 0.03
$\hat{w}_p$ [m/s]	0.015 – 0.023	w_p' [m/s]	0.009 – 0.020

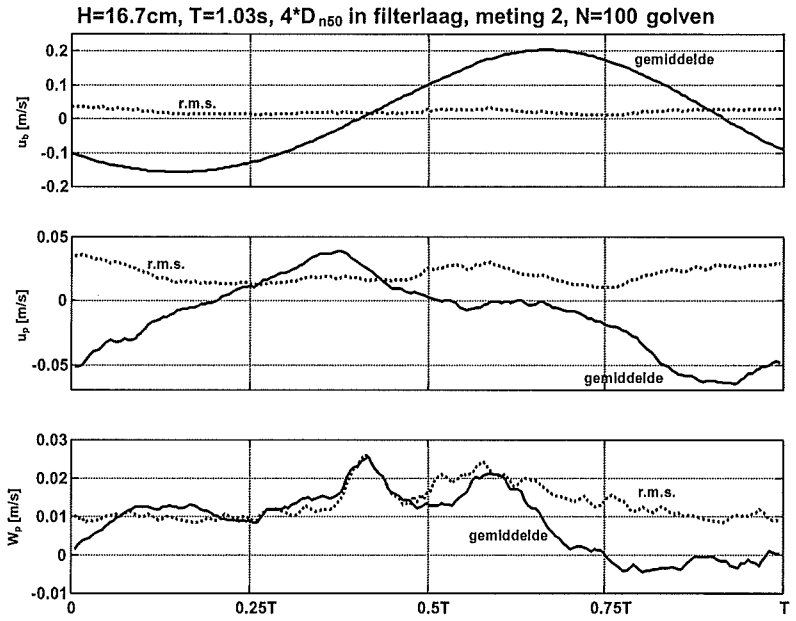


1.1.4 Belastingsgeval A, 4*D_{n50} in filterlaag

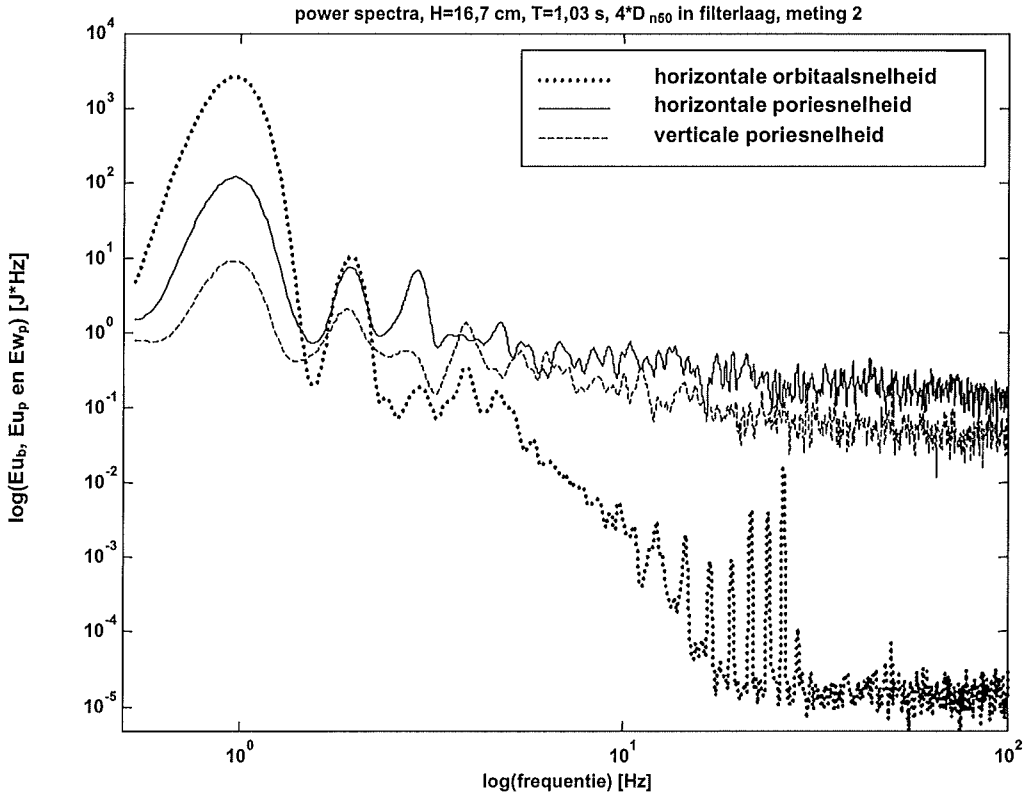


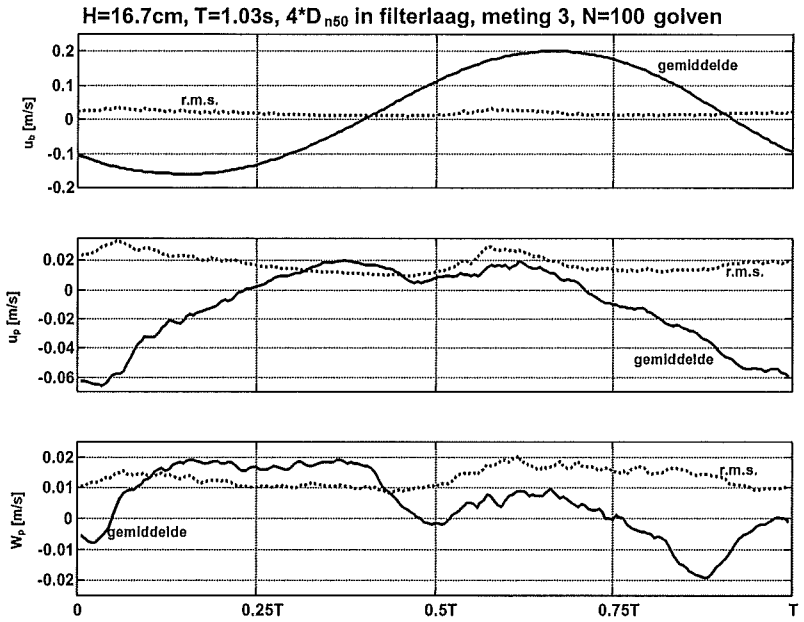
4*D_{n50} in filterlaag, meting 1, H_{gem}= 16,59 cm, T_{gem}= 1,03 s			
$\hat{u}_b$ [m/s]	0.14 – 0.20	u_b' [m/s]	
$\hat{u}_p$ [m/s]	0.05 – 0.06	u_p' [m/s]	0.01 – 0.03
$\hat{w}_p$ [m/s]	0.019 – 0.023	w_p' [m/s]	0.008 – 0.024



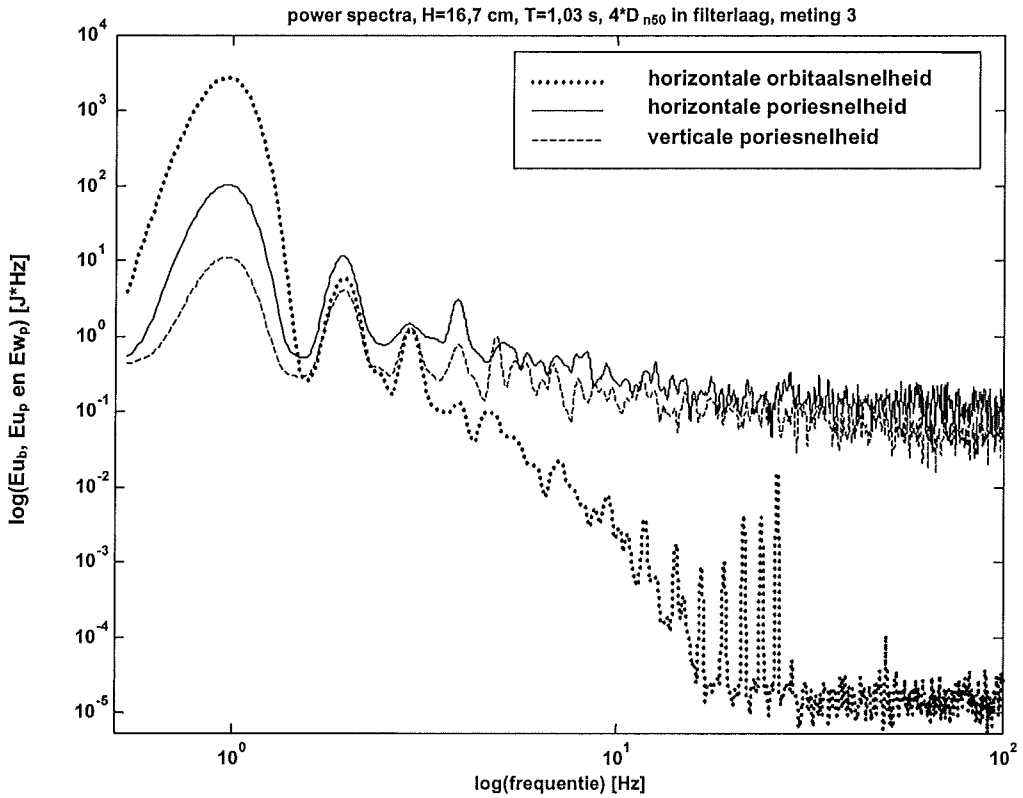


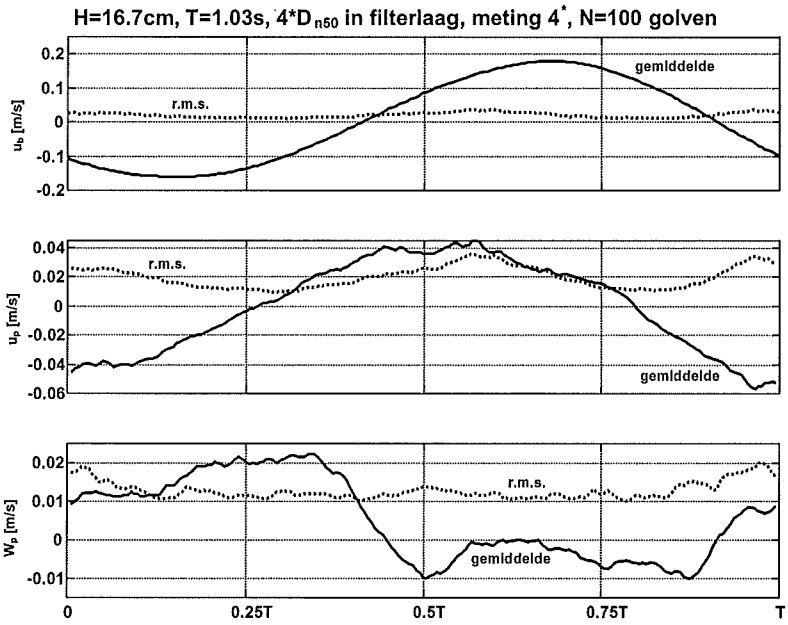
$4*D_{n50}$ in filterlaag, meting 2, H_{gem}= 17,05 cm, T_{gem}= 1,03 s			
$\hat{u}_b$ [m/s]	0.16 – 0.20	u_b' [m/s]	
$\hat{u}_p$ [m/s]	0.04 – 0.07	u_p' [m/s]	0.01 – 0.04
$\hat{w}_p$ [m/s]	0.005 – 0.027	w_p' [m/s]	0.007 – 0.028



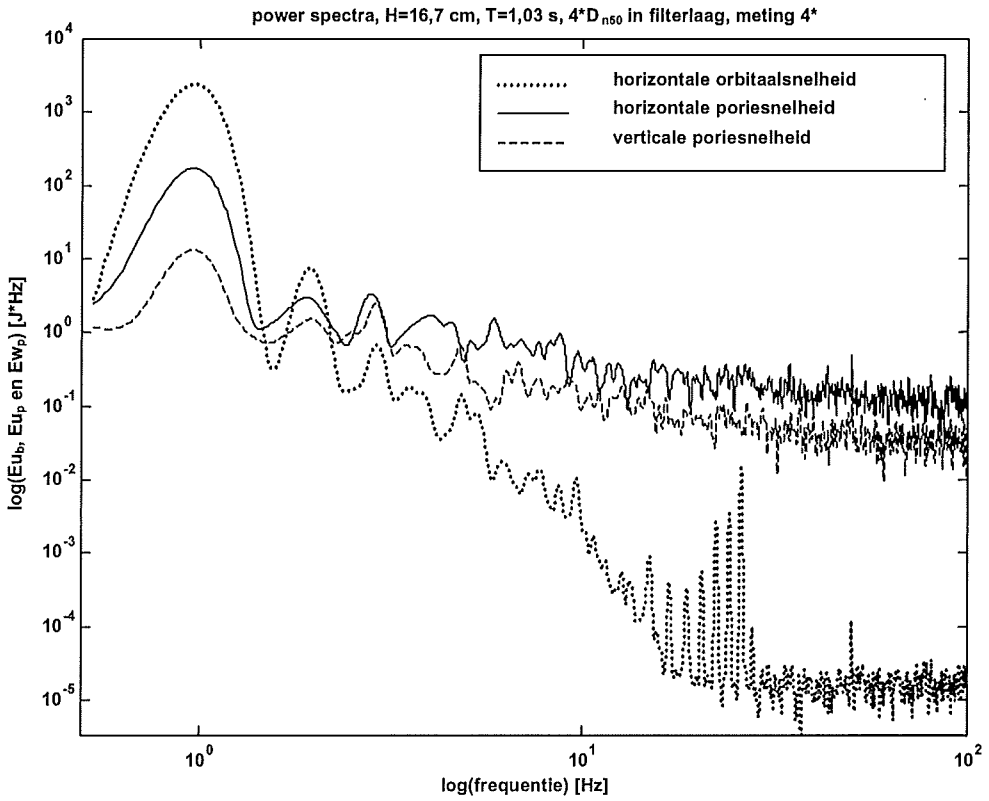


$4*D_{n50}$ in filterlaag, meting 3, H_{gem}= 16,90 cm, T_{gem}= 1,03 s			
$\hat{u}_b$ [m/s]	0.16 – 0.20	u_b' [m/s]	
$\hat{u}_p$ [m/s]	0.02 – 0.07	u_p' [m/s]	0.01 – 0.03
$\hat{w}_p$ [m/s]	0.020 – 0.020	w_p' [m/s]	0.008 – 0.023

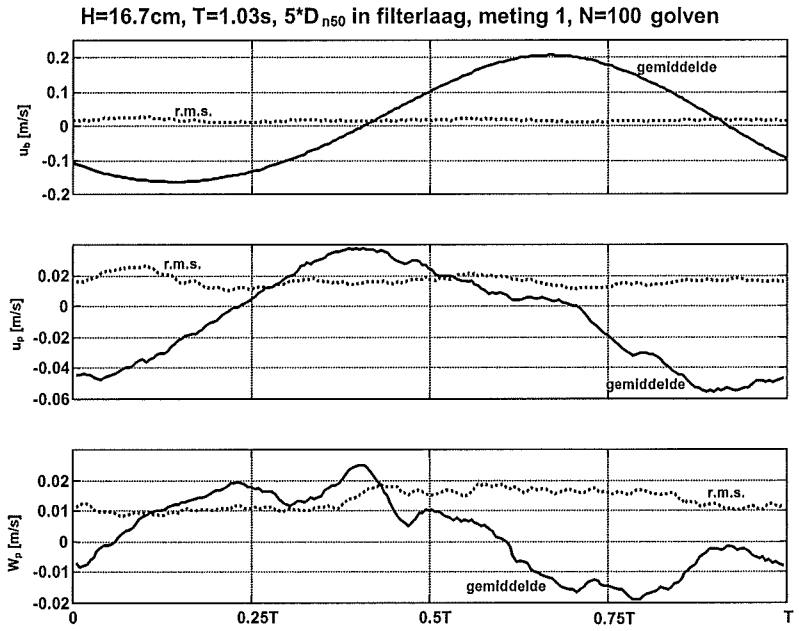




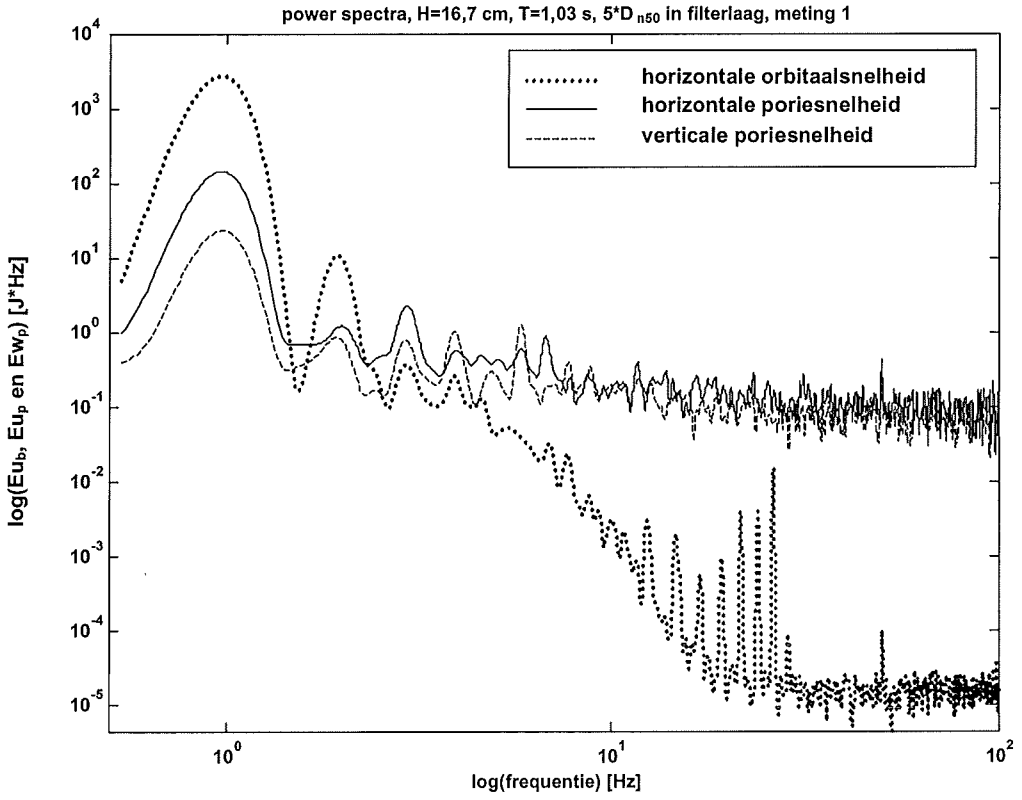
4*D_{n50} in filterlaag, meting 4*, H_{gem}= 16,73 cm, T_{gem}= 1,03 s			
$\hat{u}_b$ [m/s]	0.16 – 0.18	u_b' [m/s]	
$\hat{u}_p$ [m/s]	0.05 – 0.06	u_p' [m/s]	0.01 – 0.04
$\hat{w}_p$ [m/s]	0.010– 0.023	w_p' [m/s]	0.009 – 0.020

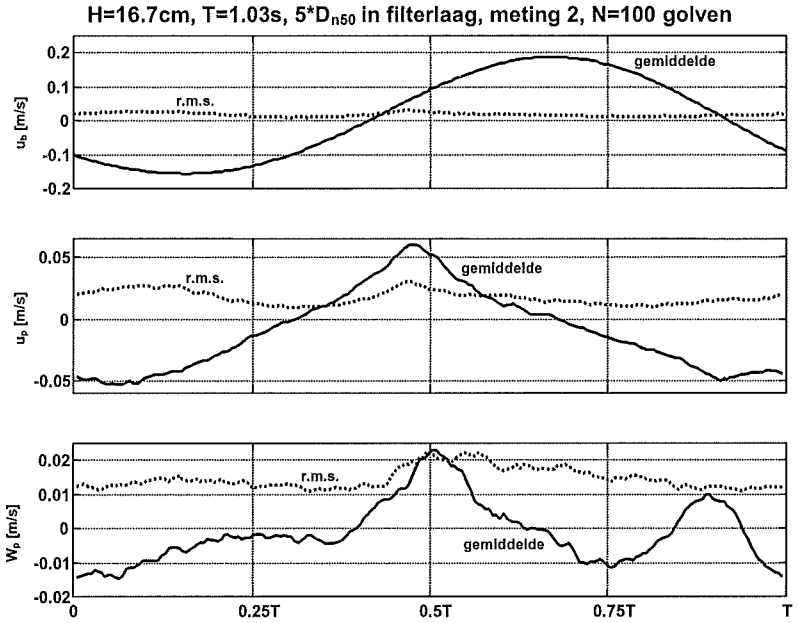


1.1.5 Belastingsgeval A, 5*D_{n50} in filterlaag

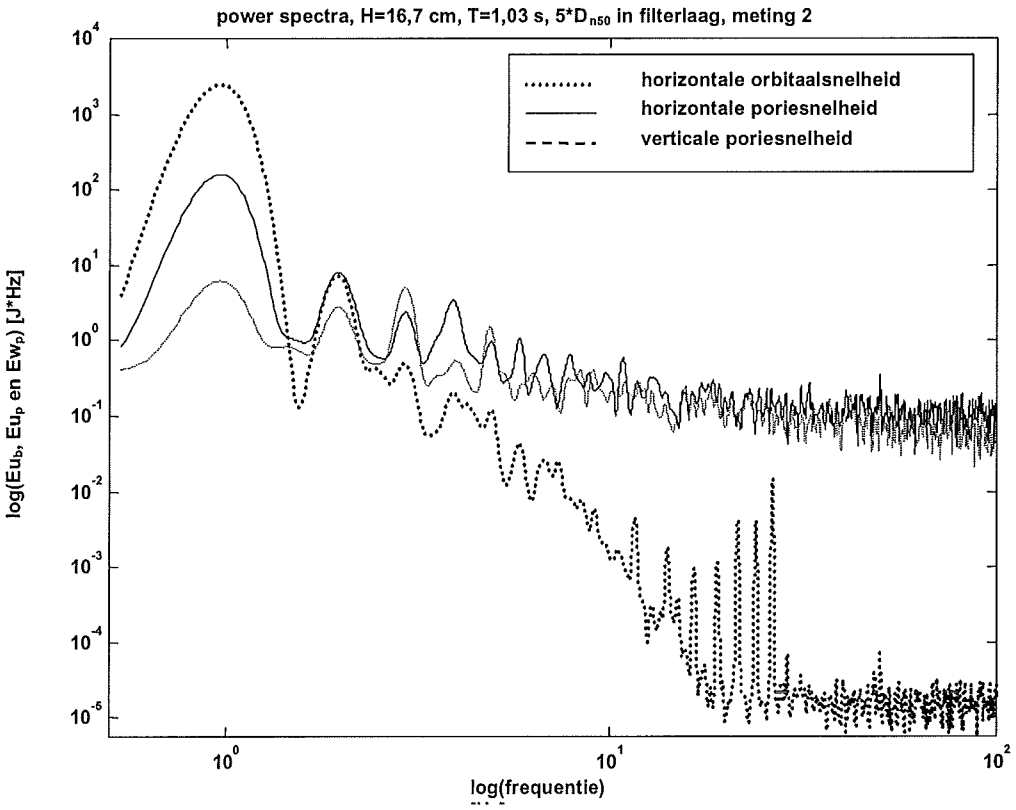


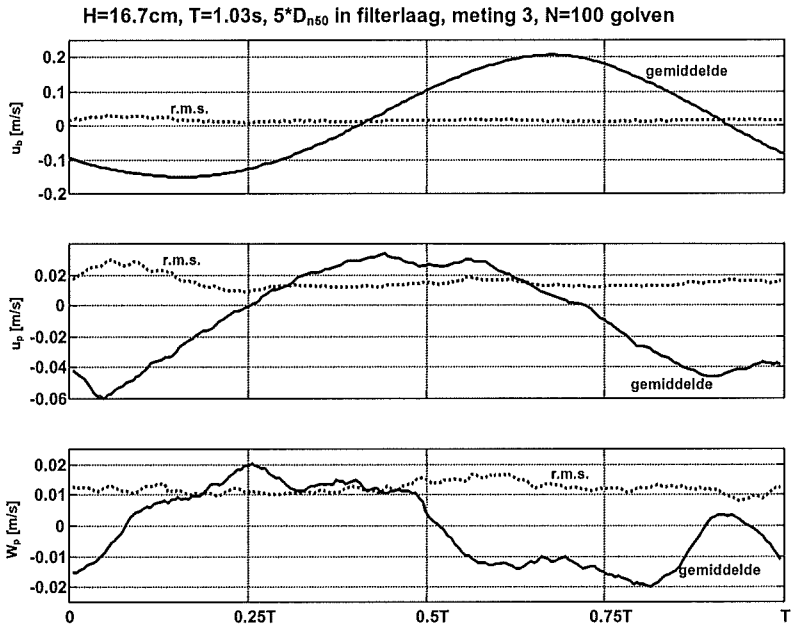
5*D_{n50} in filterlaag, meting 1, H_{gem}= 16,93 cm, T_{gem}= 1,03 s			
$\hat{u}_b$ [m/s]	0.16 – 0.21	u_b' [m/s]	
$\hat{u}_p$ [m/s]	0.04 – 0.06	u_p' [m/s]	0.01 – 0.03
$\hat{w}_p$ [m/s]	0.019 – 0.026	w_p' [m/s]	0.008 – 0.021



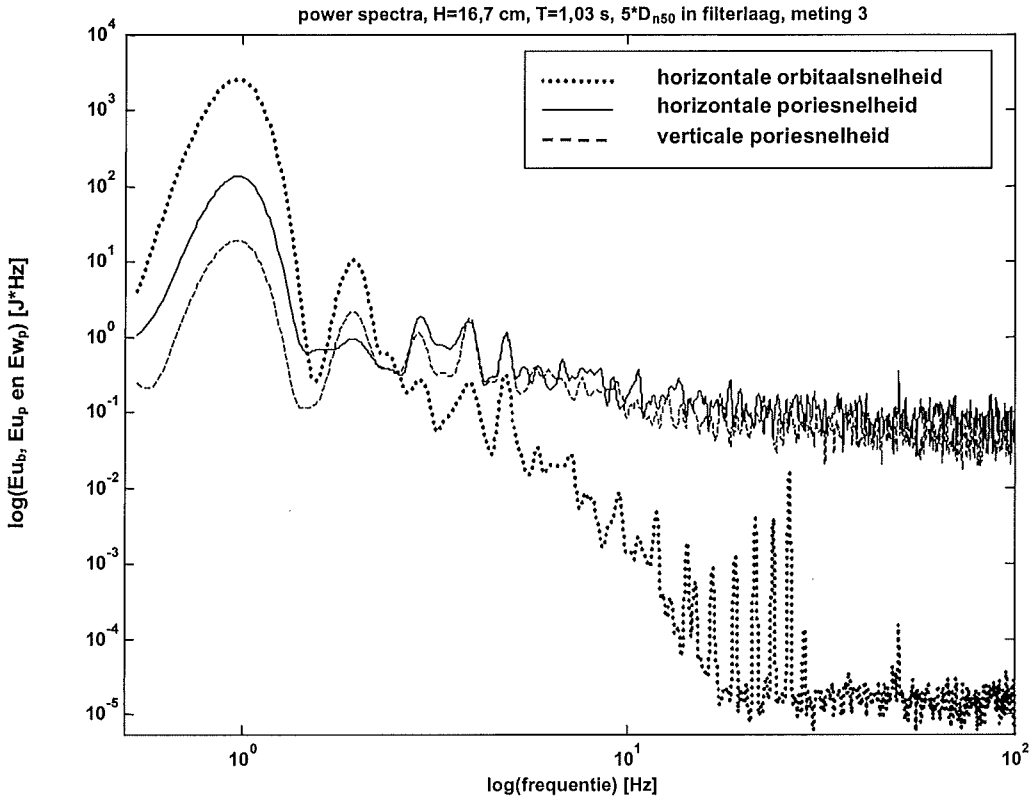


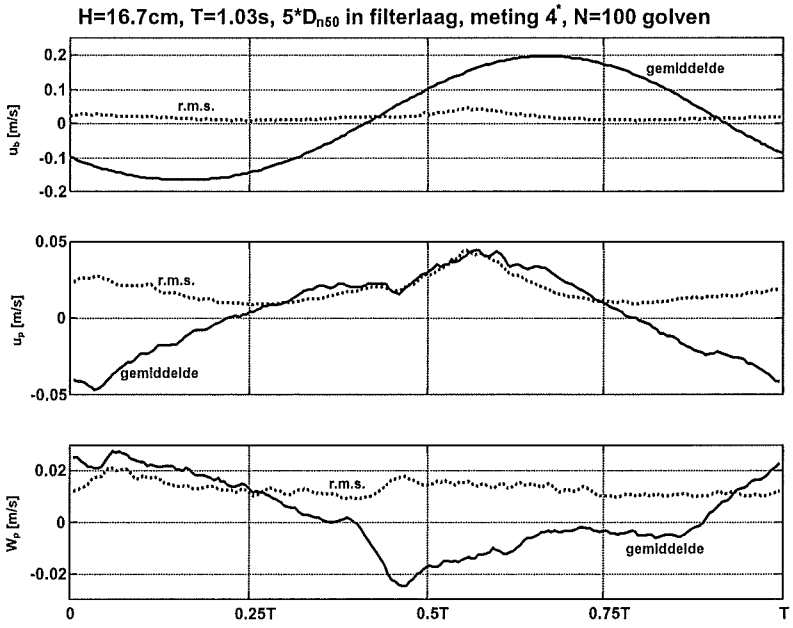
$5*D_{n50}$ in filterlaag, meting 2, H_{gem}= 16,73 cm, T_{gem}= 1,03 s			
$\hat{u}_b$ [m/s]	0.16 – 0.19	u_b' [m/s]	
$\hat{u}_p$ [m/s]	0.06 – 0.06	u_p' [m/s]	0.01 – 0.03
$\hat{w}_p$ [m/s]	0.017 – 0.024	w_p' [m/s]	0.010 – 0.023



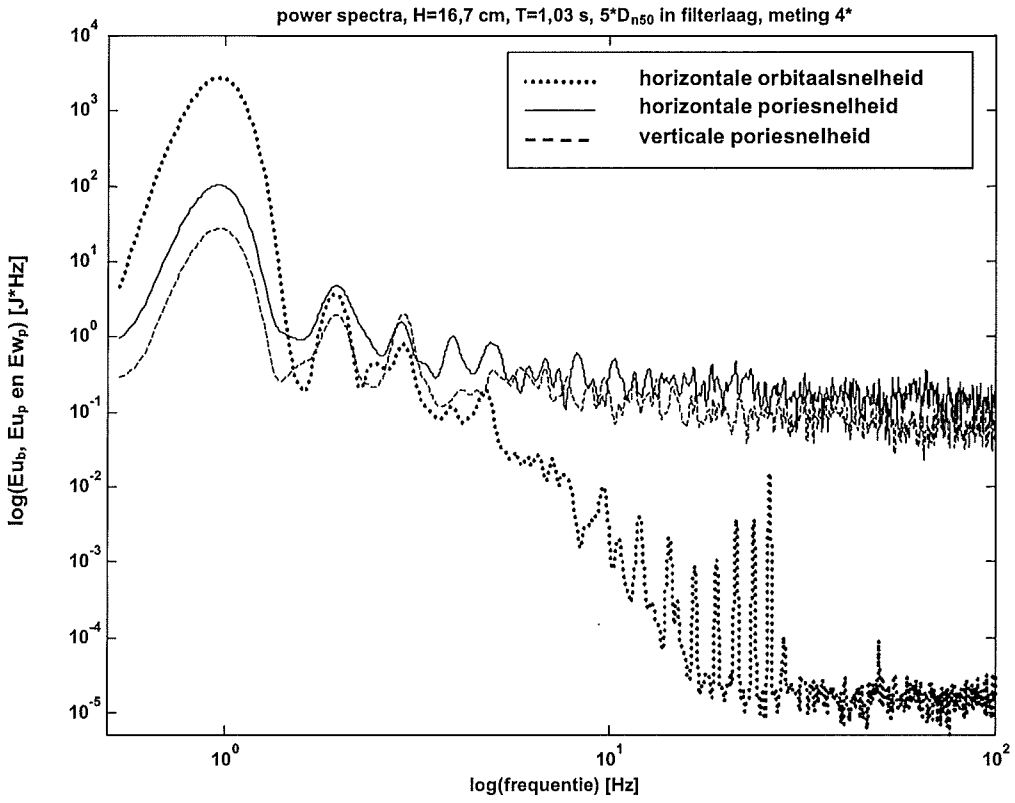


$5*D_{n50}$ in filterlaag, meting 3, H_{gem}= 16,79 cm, T_{gem}= 1,03 s			
$\hat{u}_b$ [m/s]	0.15 – 0.21	u_b' [m/s]	
$\hat{u}_p$ [m/s]	0.03 – 0.06	u_p' [m/s]	0.01 – 0.03
$\hat{w}_p$ [m/s]	0.020 – 0.021	w_p' [m/s]	0.007 – 0.017



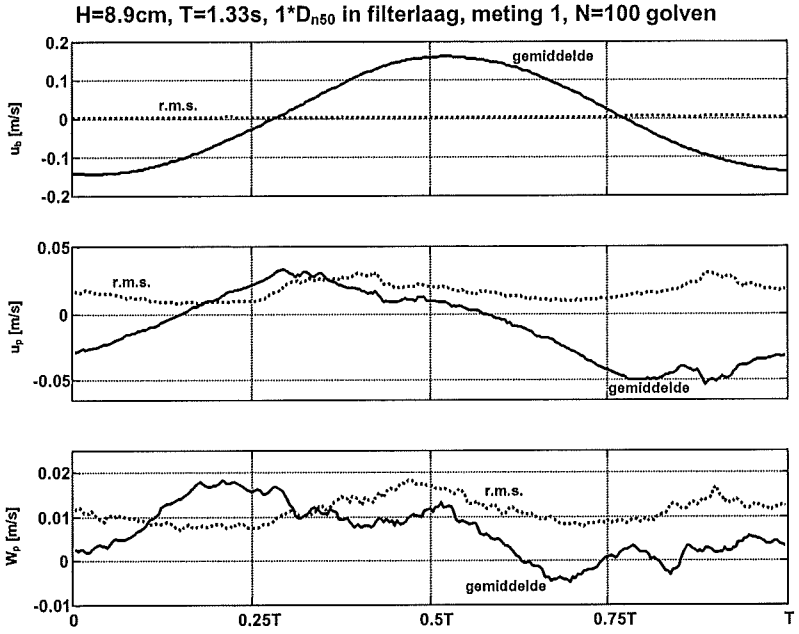


5*D_{n50} in filterlaag, meting 4*, H_{gem}= 16,84 cm, T_{gem}= 1,03 s			
$\hat{u}_b$ [m/s]	0.17 – 0.20	u_b' [m/s]	
$\hat{u}_p$ [m/s]	0.05 – 0.05	u_p' [m/s]	0.01 – 0.05
$\hat{w}_p$ [m/s]	0.026 – 0.029	w_p' [m/s]	0.008 – 0.022

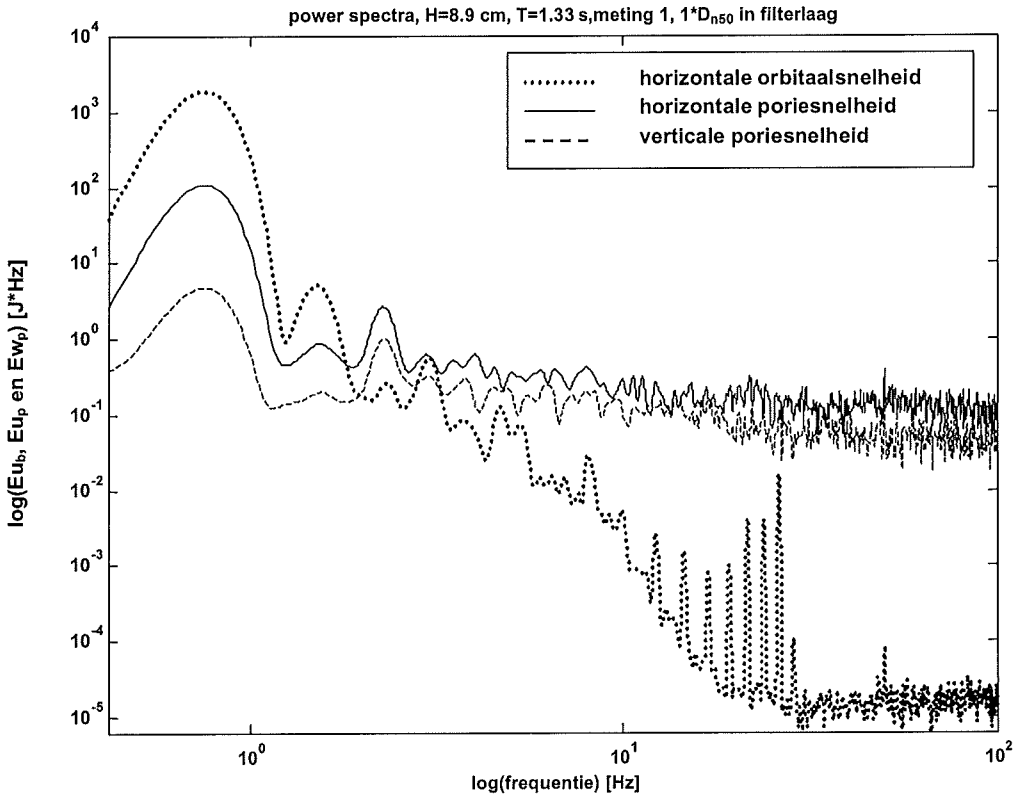


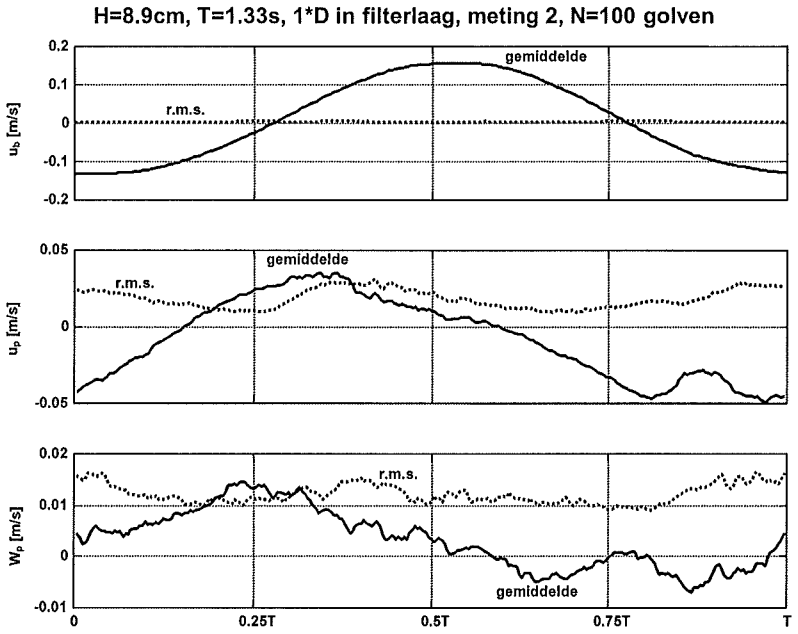
1.2 Meetserie 1, belastingsgeval B

1.2.1 Belastingsgeval B, 1*D_{n50} in filterlaag

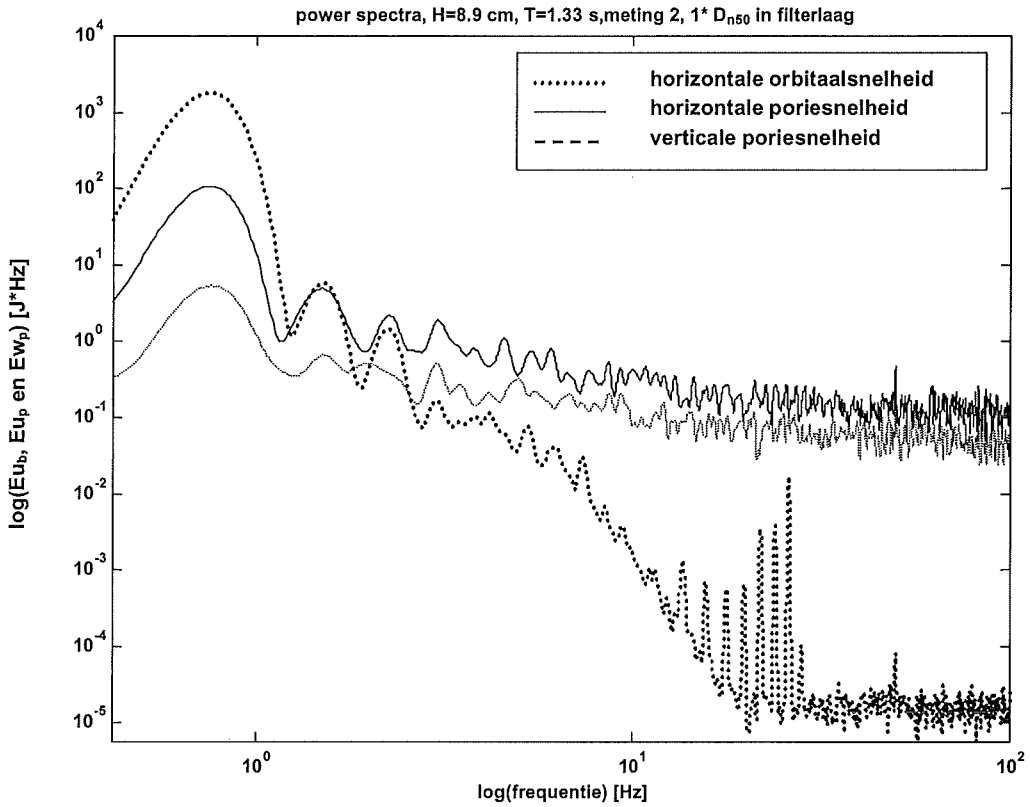


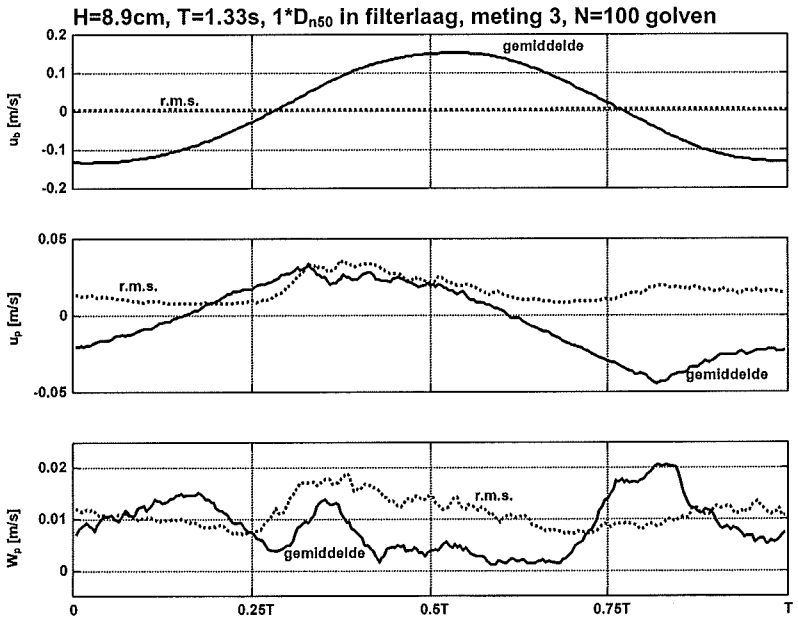
1*D_{n50} in filterlaag, meting 1, H_{gem}= 8,94 cm, T_{gem}= 1,33 s			
$\hat{u}_b$ [m/s]	0.14 – 0.16	u_b' [m/s]	
$\hat{u}_p$ [m/s]	0.03 – 0.05	u_p' [m/s]	0.01 – 0.03
$\hat{w}_p$ [m/s]	0.005 – 0.019	w_p' [m/s]	0.007 – 0.019



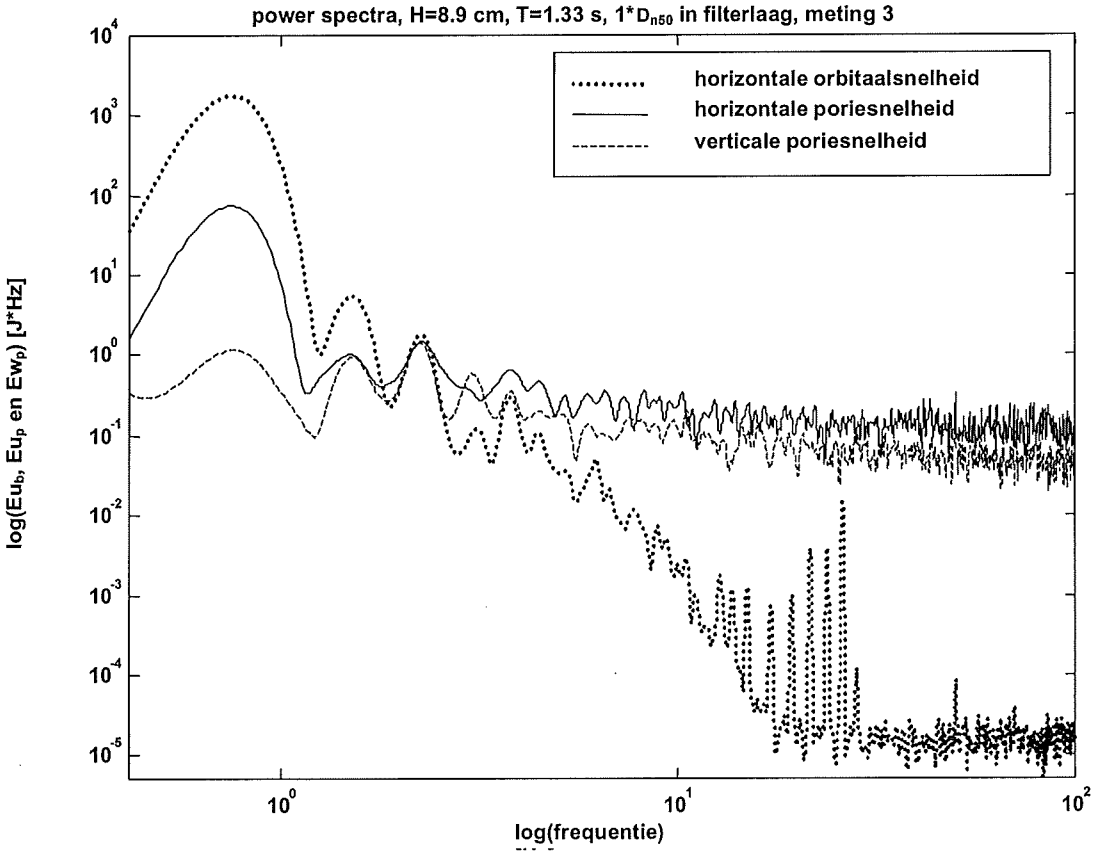


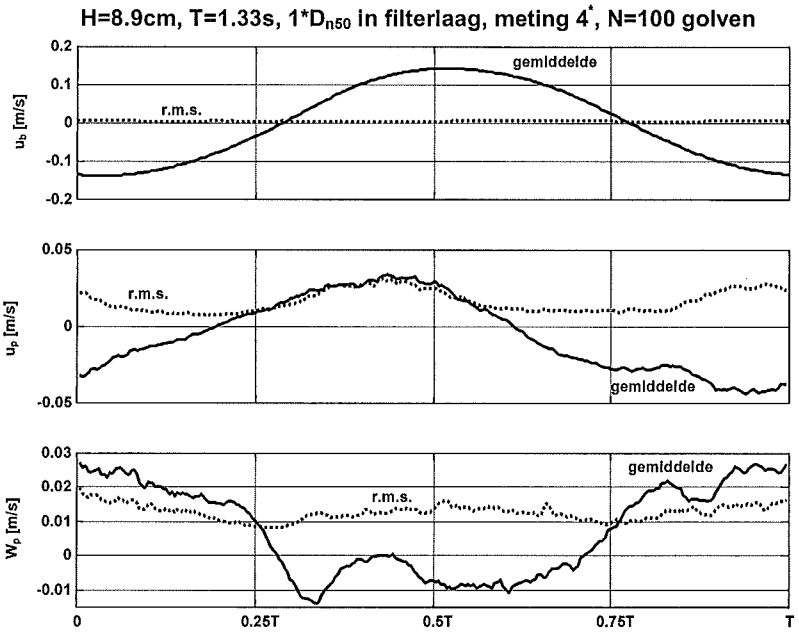
1*D_{n50} in filterlaag, meting 2, H_{gem}= 8,91 cm, T_{gem}= 1,33 s			
$\hat{u}_b$ [m/s]	0.13 – 0.16	u_b' [m/s]	
$\hat{u}_p$ [m/s]	0.04 – 0.05	u_p' [m/s]	0.01 – 0.03
$\hat{w}_p$ [m/s]	0.008 – 0.015	w_p' [m/s]	0.008 – 0.017



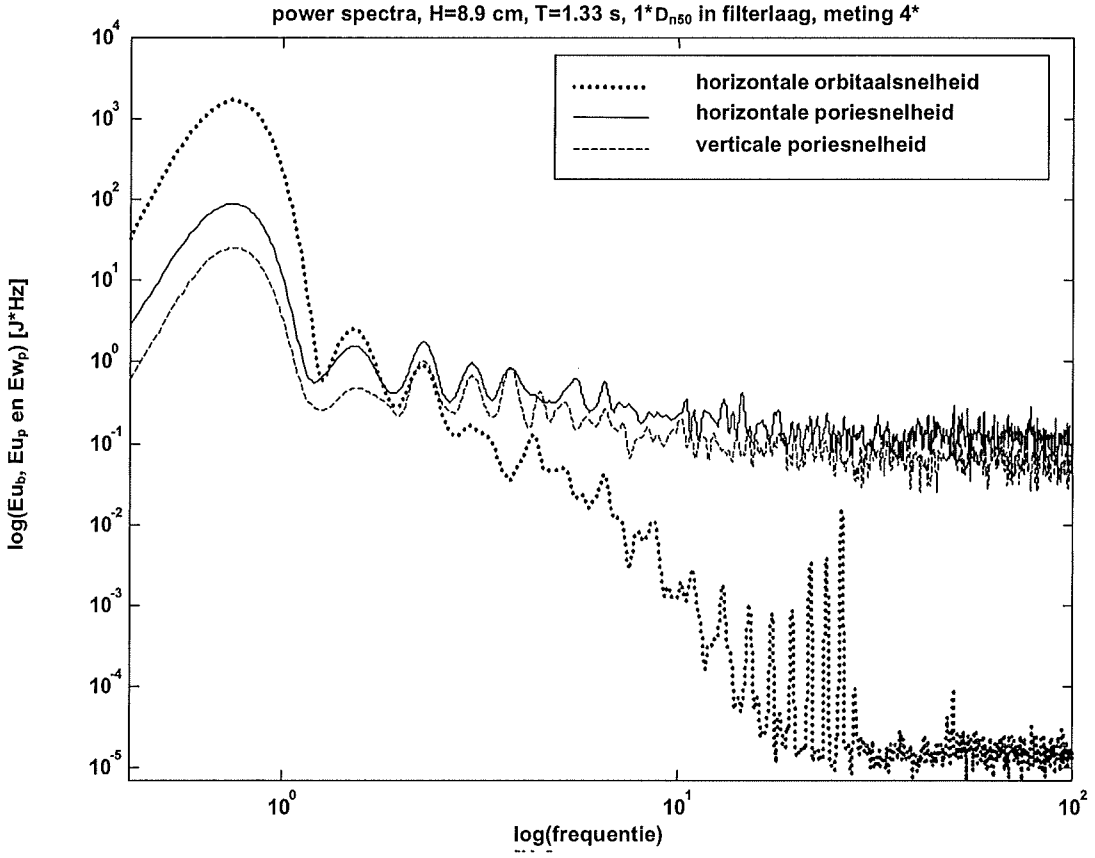


$1*D_{n50}$ in filterlaag, meting 3, H_{gem}= 9,01 cm, T_{gem}= 1,33 s			
$\hat{u}_b$ [m/s]	0.13 – 0.15	u_b' [m/s]	
$\hat{u}_p$ [m/s]	0.03 – 0.05	u_p' [m/s]	0.01 – 0.04
$\hat{w}_p$ [m/s]	0.006 – 0.021	w_p' [m/s]	0.007 – 0.020

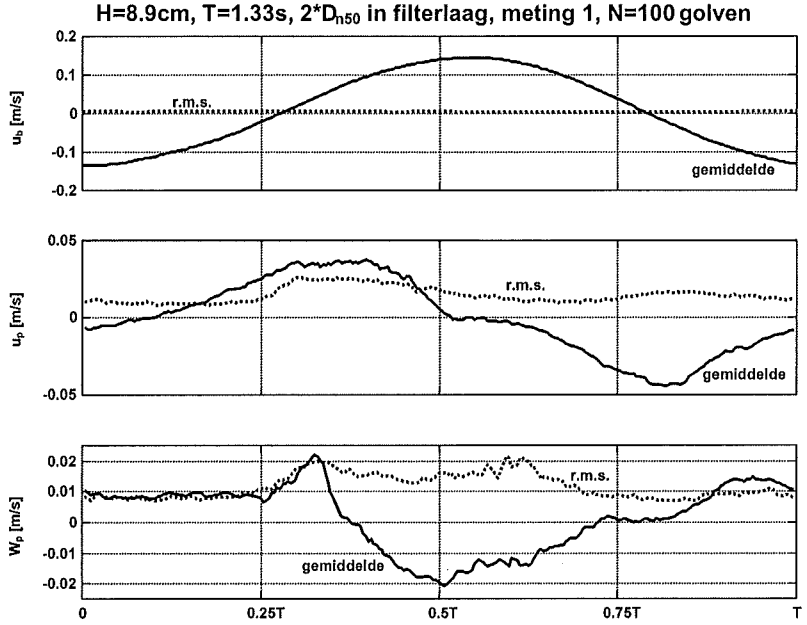




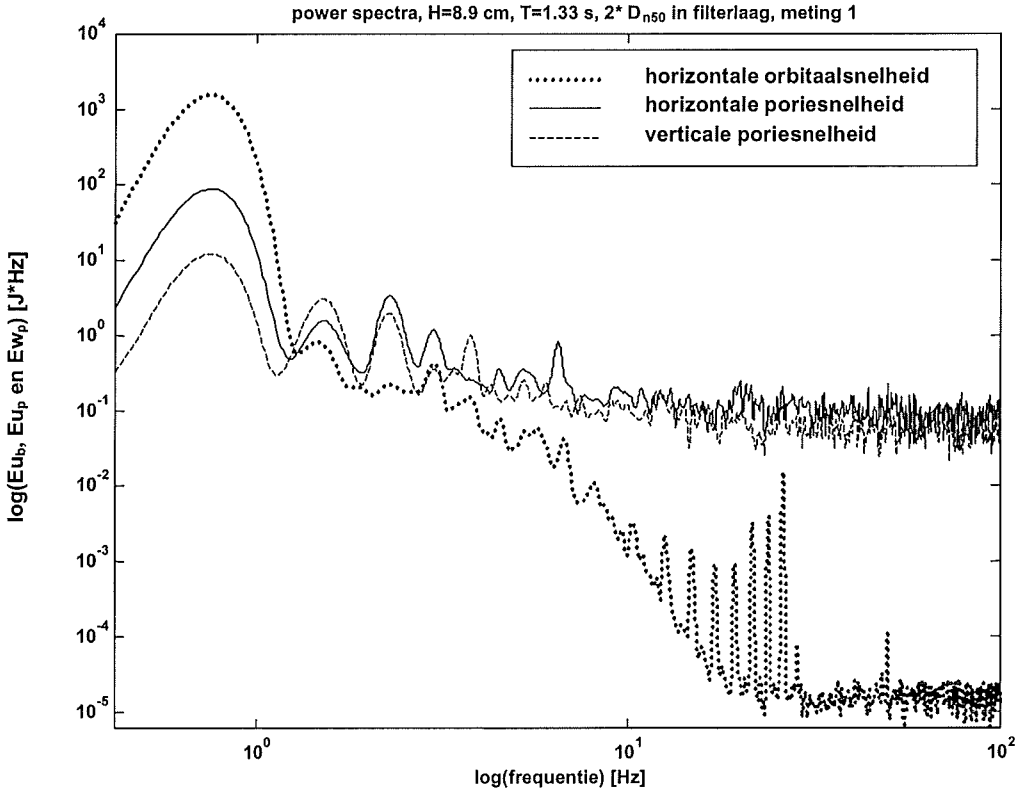
$1*D_{n50}$ in filterlaag, meting 4*, H_{gem}= 8,94 cm, T_{gem}= 1,33 s			
$\hat{u}_b$ [m/s]	0.14 – 0.14	u_b' [m/s]	
$\hat{u}_p$ [m/s]	0.04 – 0.04	u_p' [m/s]	0.01 – 0.03
$\hat{w}_p$ [m/s]	0.015 – 0.029	w_p' [m/s]	0.008 – 0.021

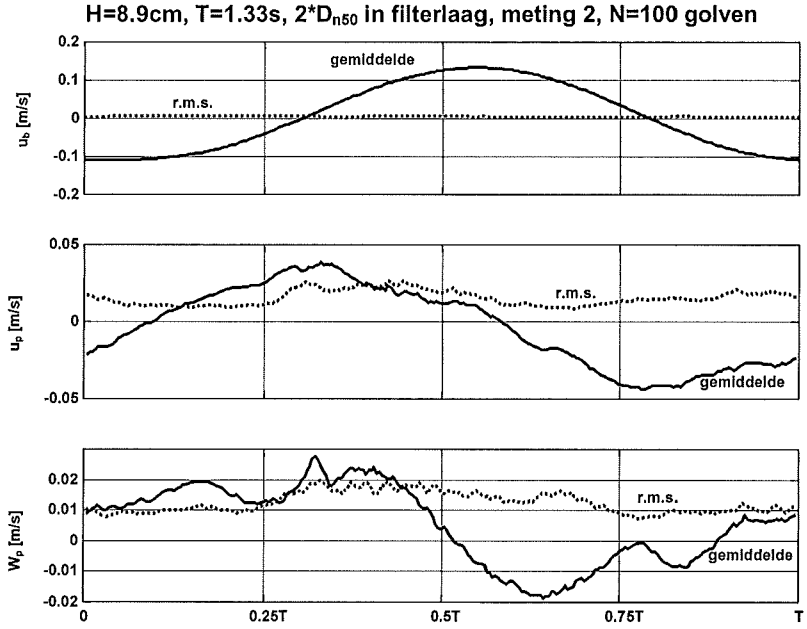


1.2.2 Belastingsgeval B, 2*D_{n50} in filterlaag

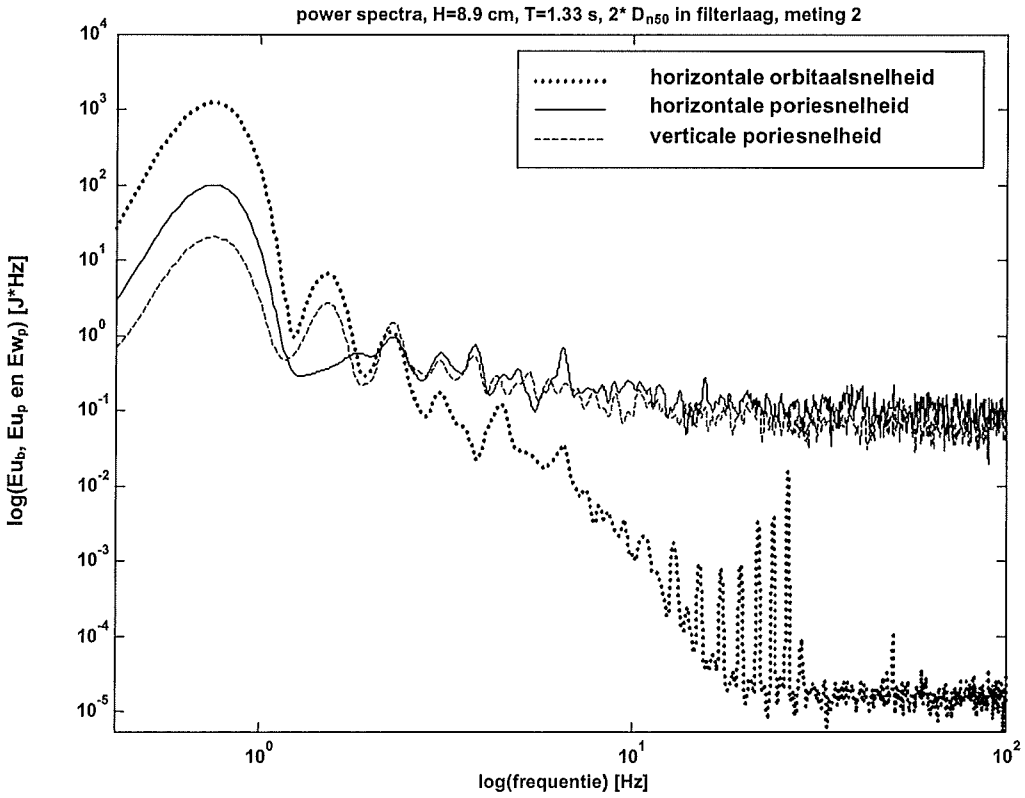


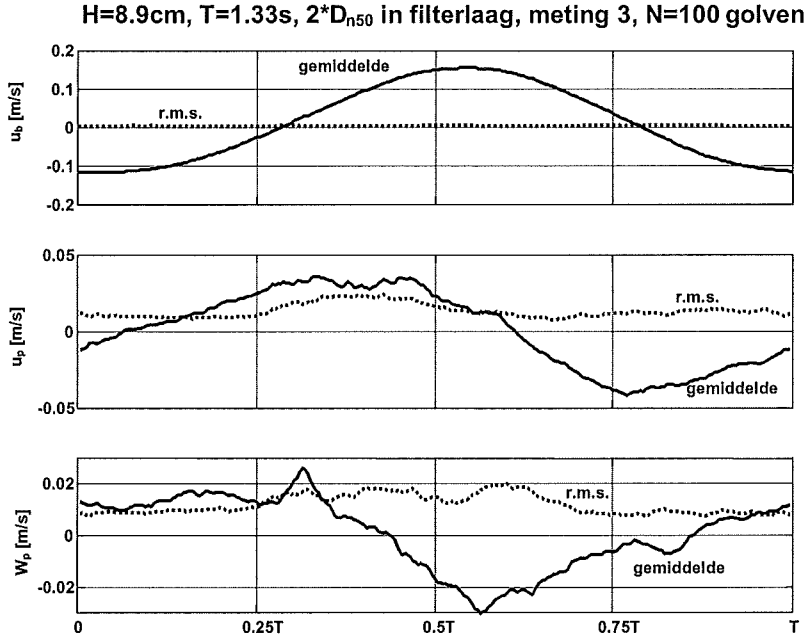
$2*D_{n50}$ in filterlaag, meting 1, H_{gem}= 9,01 cm, T_{gem}= 1,33 s			
$\hat{u}_b$ [m/s]	0.14 – 0.14	u_b' [m/s]	
$\hat{u}_p$ [m/s]	0.04 – 0.05	u_p' [m/s]	0.01 – 0.03
$\hat{w}_p$ [m/s]	0.022 – 0.023	w_p' [m/s]	0.007 – 0.023



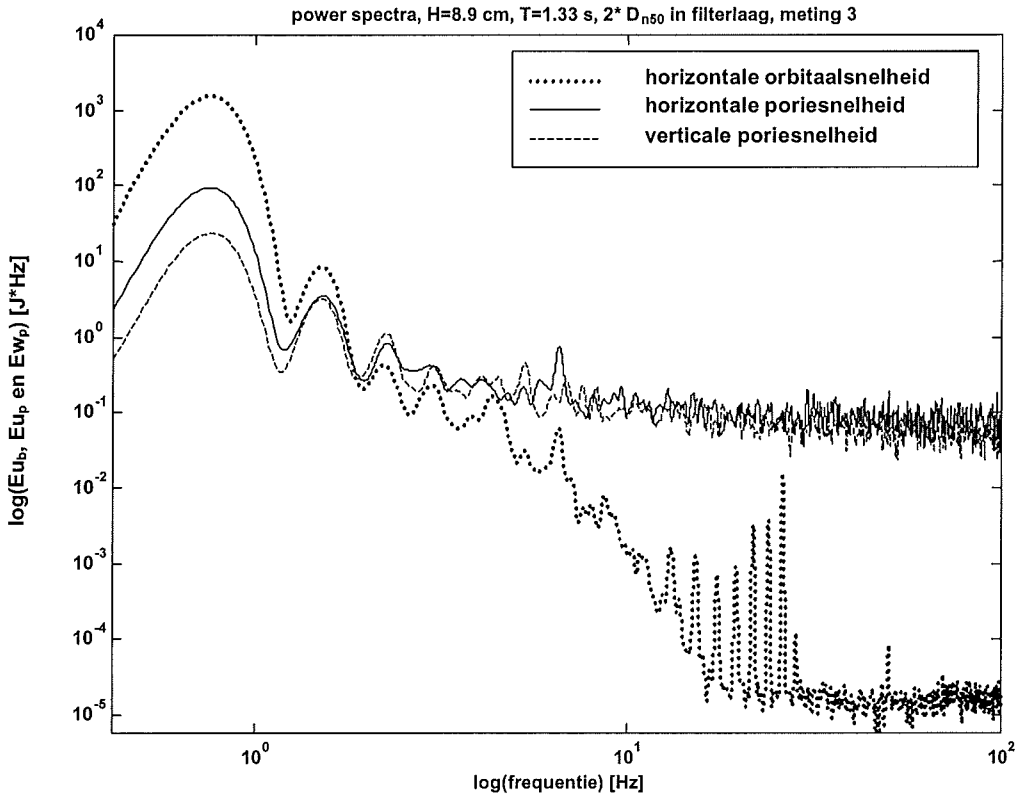


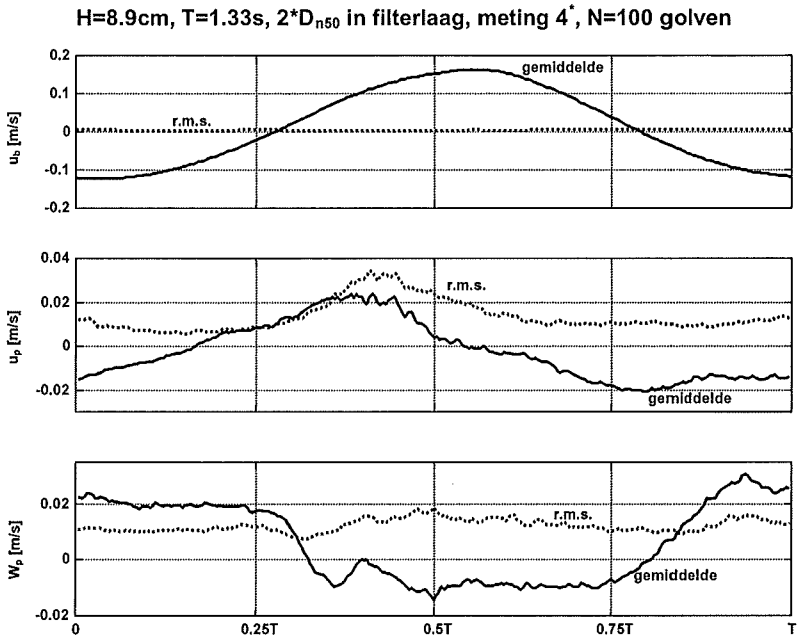
$2*D_{n50}$ in filterlaag, meting 2, H_{gem}= 8,92 cm, T_{gem}= 1,33 s			
$\hat{u}_b$ [m/s]	0.11 – 0.13	u_b' [m/s]	
$\hat{u}_p$ [m/s]	0.04 – 0.04	u_p' [m/s]	0.01 – 0.03
$\hat{w}_p$ [m/s]	0.020 – 0.029	w_p' [m/s]	0.007 – 0.021



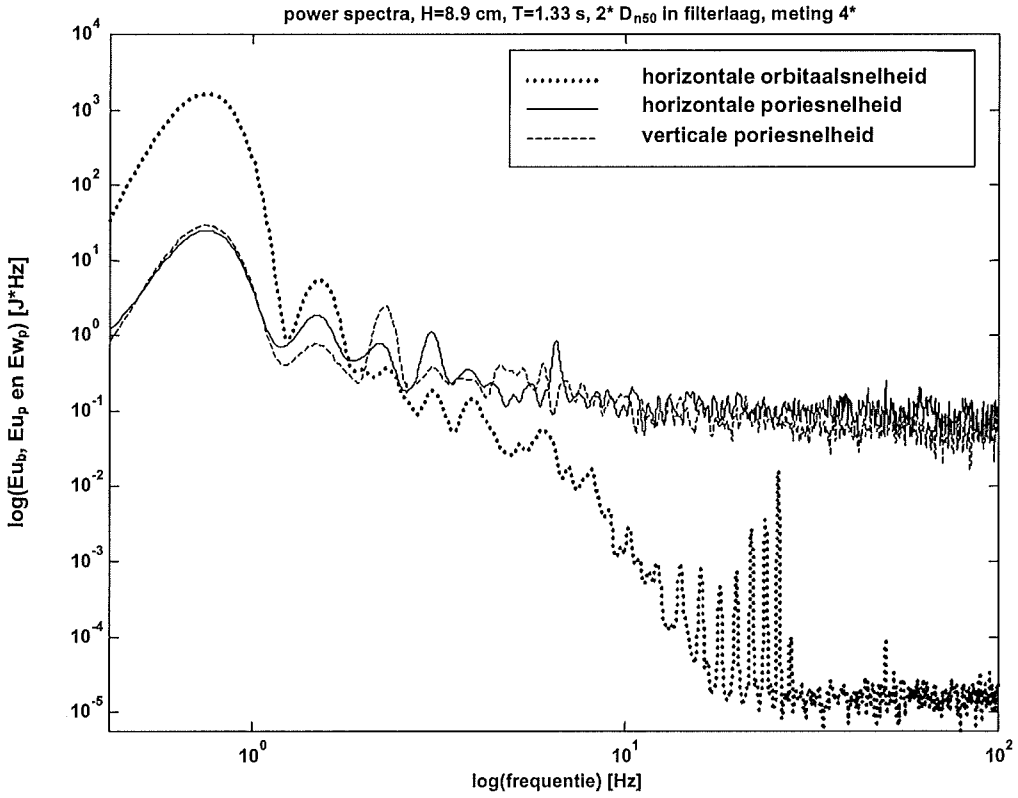


$2*D_{n50}$ in filterlaag, meting 3, H_{gem}= 8,89 cm, T_{gem}= 1,33 s			
$\hat{u}_b$ [m/s]	0.12 – 0.16	u_b' [m/s]	
$\hat{u}_p$ [m/s]	0.04 – 0.04	u_p' [m/s]	0.01 – 0.03
$\hat{w}_p$ [m/s]	0.028 – 0.031	w_p' [m/s]	0.007 – 0.023

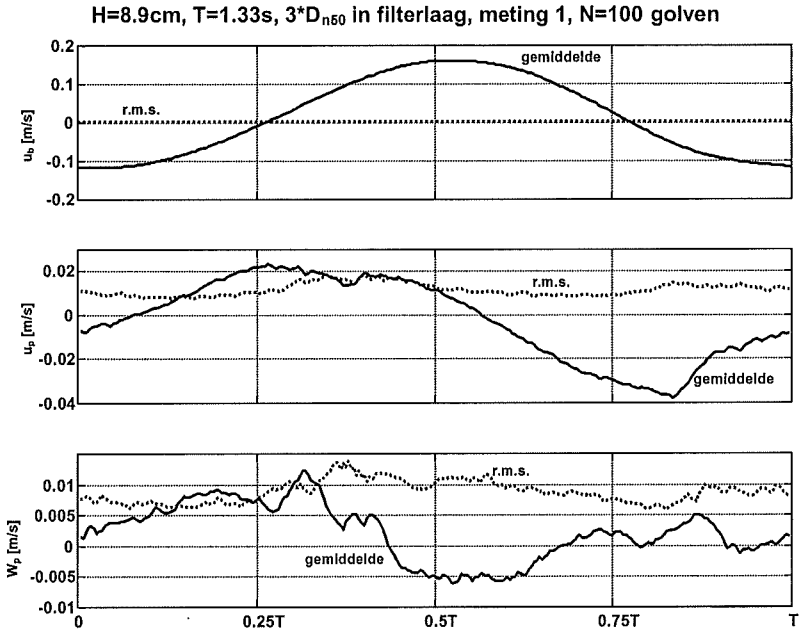




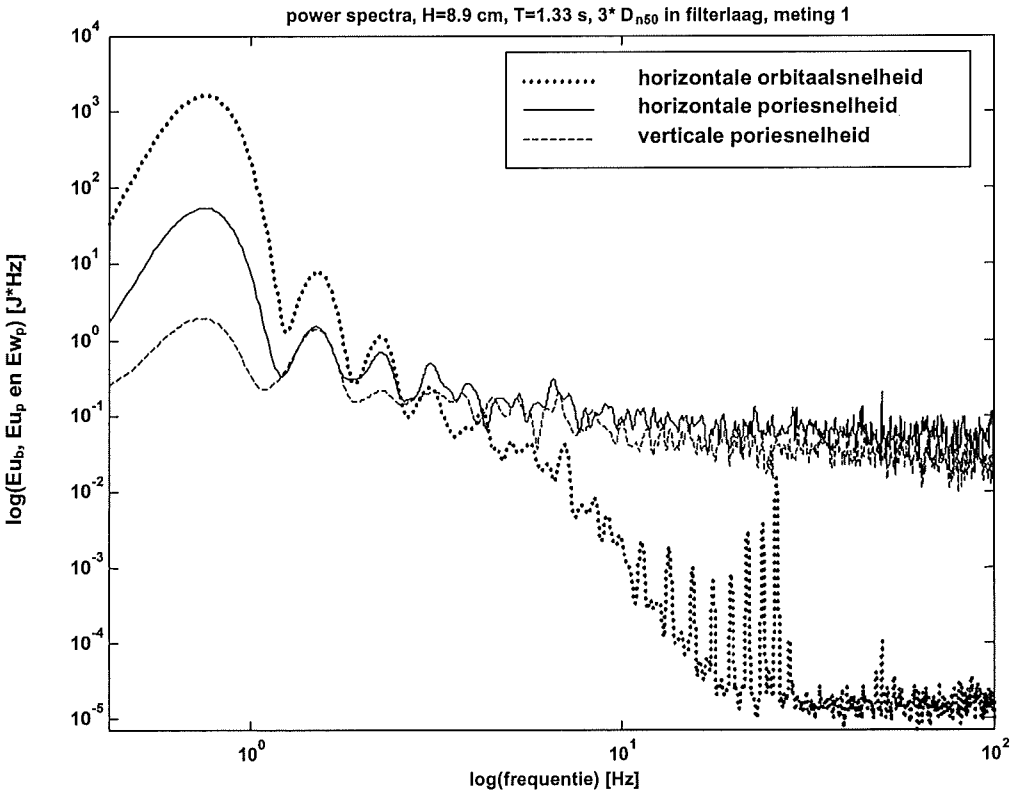
2*D_{n50} in filterlaag, meting 4*, H_{gem}= 8,90 cm, T_{gem}= 1,33 s			
$\hat{u}_b$ [m/s]	0.12 – 0.16	u_b' [m/s]	
$\hat{u}_p$ [m/s]	0.02 – 0.03	u_p' [m/s]	0.01 – 0.04
$\hat{w}_p$ [m/s]	0.015 – 0.033	w_p' [m/s]	0.007 – 0.020

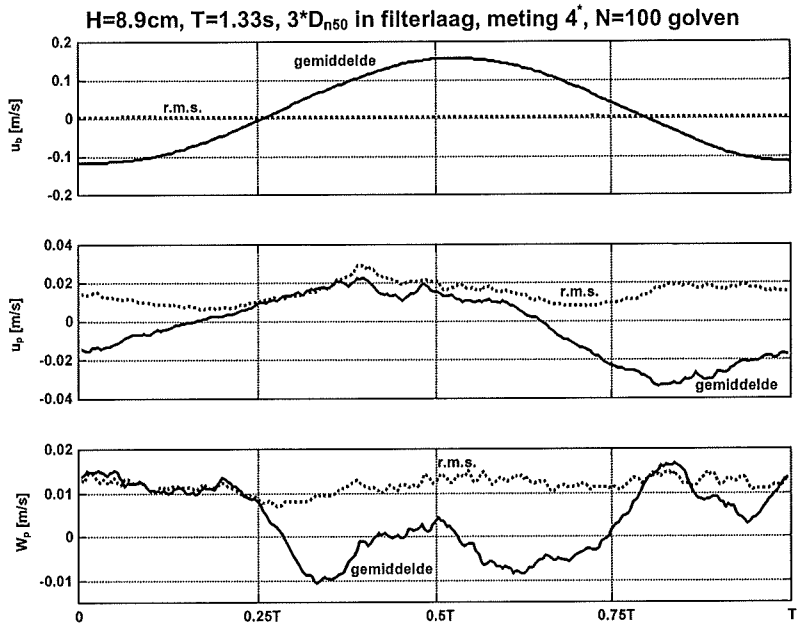


1.2.3 Belastingsgeval B, 3*D_{n50} in filterlaag

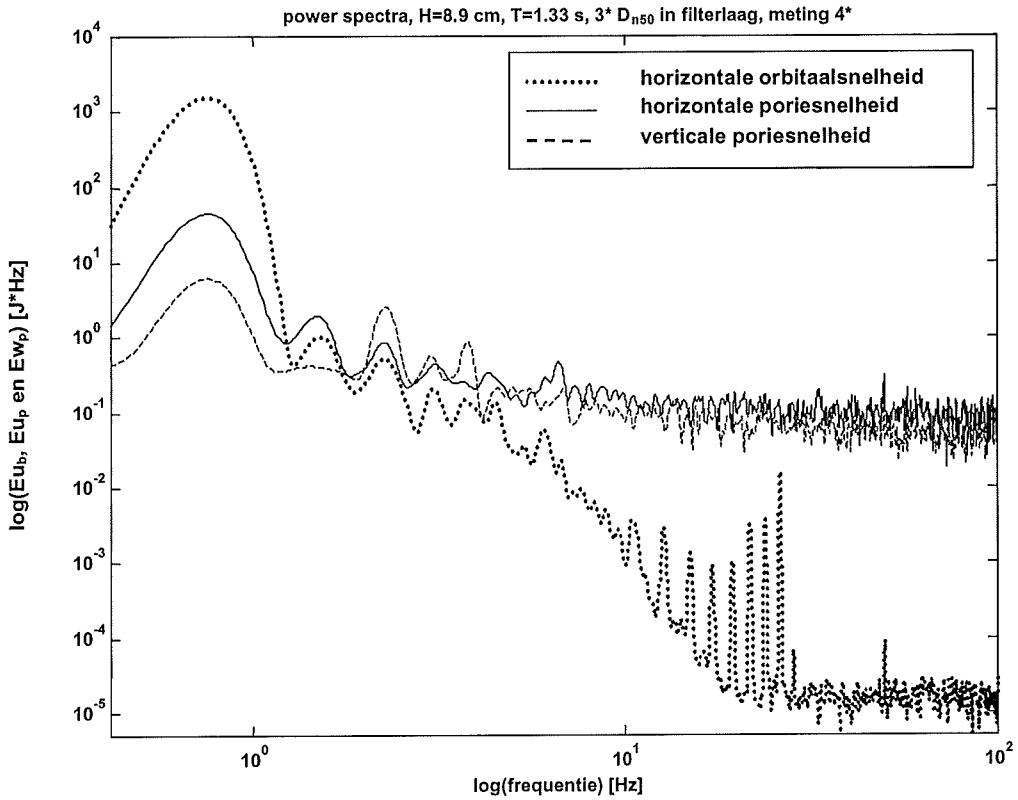


$3*D_{n50}$ in filterlaag, meting 1, H_{gem}= 9,07 cm, T_{gem}= 1,33 s			
$\hat{u}_b$ [m/s]	0.12 – 0.16	u_b' [m/s]	
$\hat{u}_p$ [m/s]	0.02 – 0.04	u_p' [m/s]	0.01 – 0.02
$\hat{w}_p$ [m/s]	0.007 – 0.013	w_p' [m/s]	0.005 – 0.016

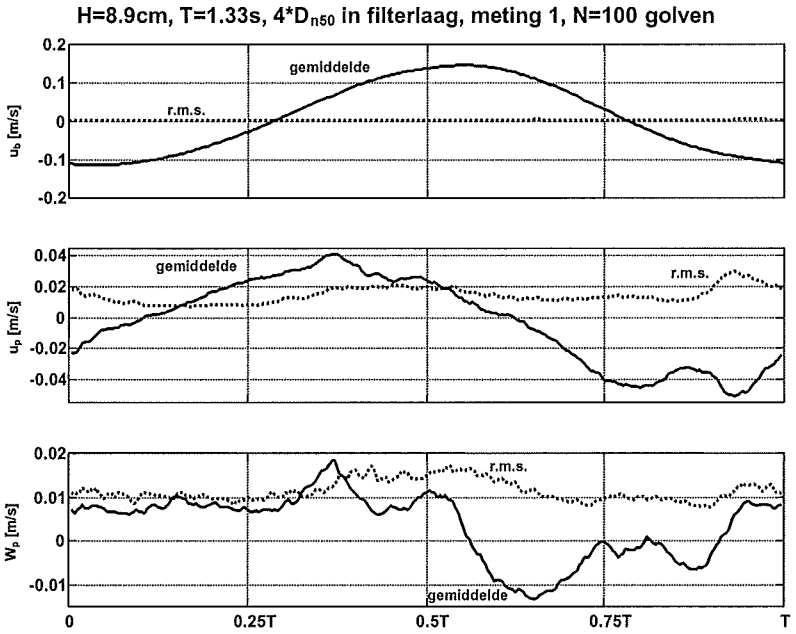




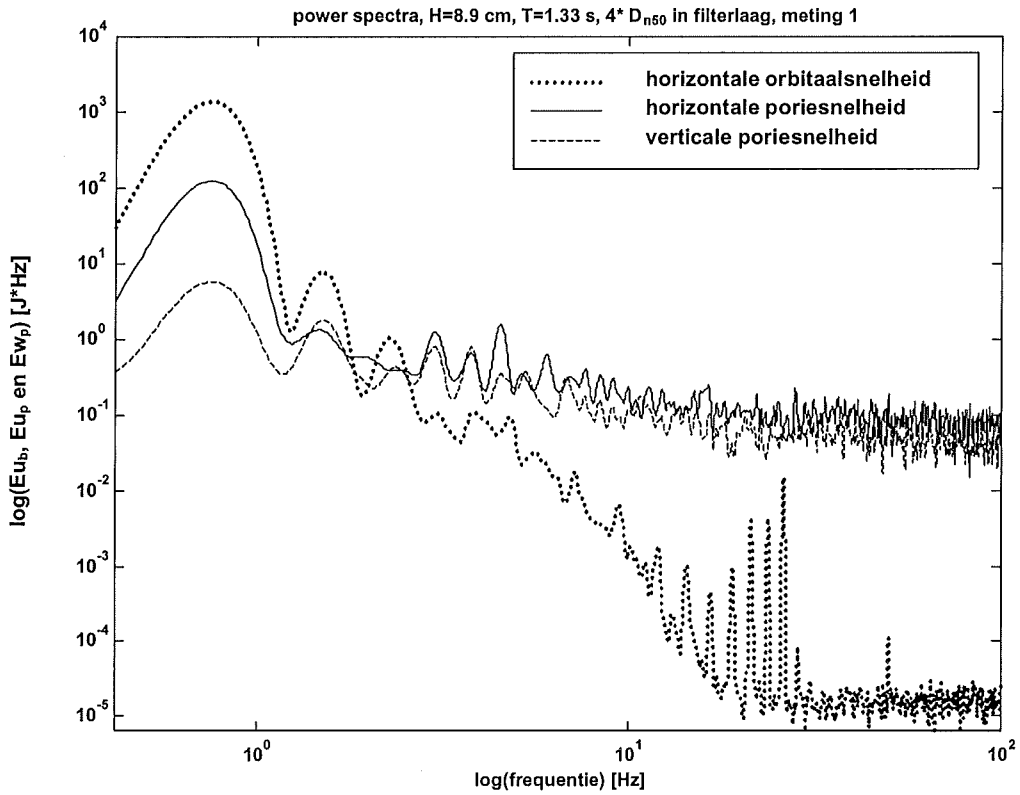
$3*D_{n50}$ in filterlaag, meting 4*, H_{gem}= 8,90 cm, T_{gem}= 1,33 s			
$\hat{u}_b$ [m/s]	0.12 – 0.16	u_b' [m/s]	
$\hat{u}_p$ [m/s]	0.02 – 0.03	u_p' [m/s]	0.01 – 0.03
$\hat{w}_p$ [m/s]	0.011 – 0.017	w_p' [m/s]	0.006 – 0.016

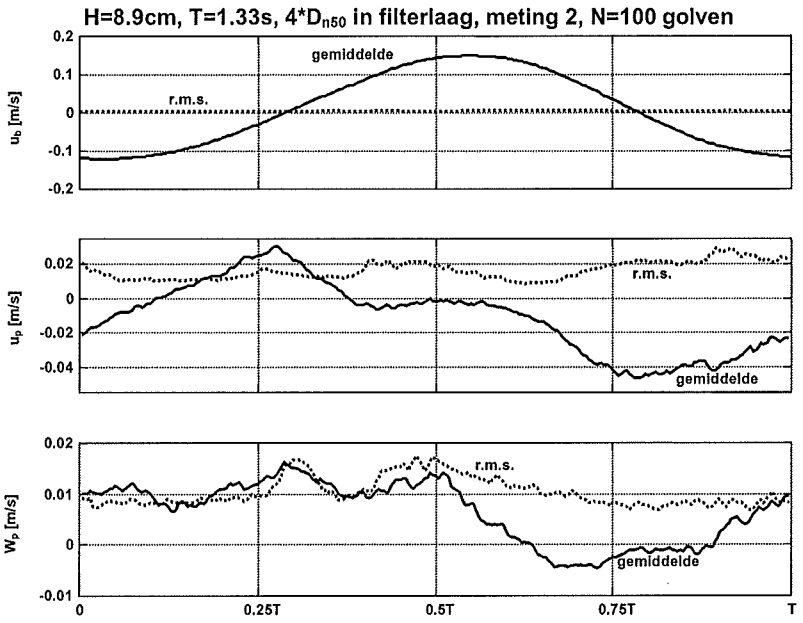


1.2.4 Belastingsgeval B, 5*D_{n50} in filterlaag

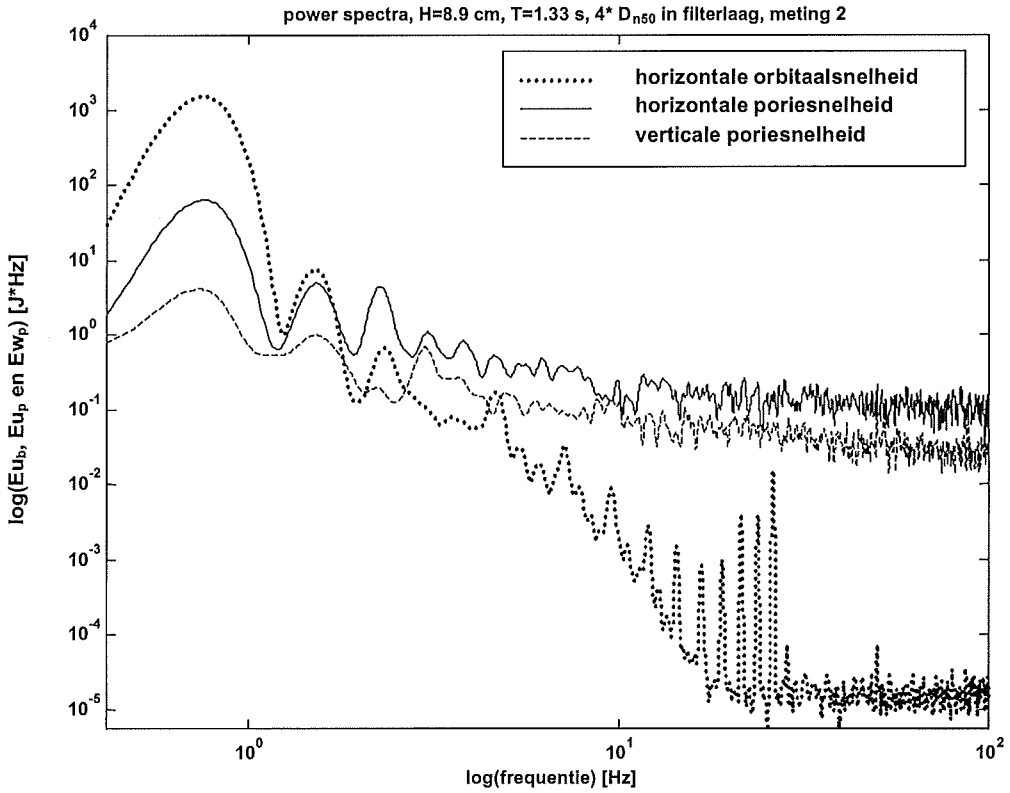


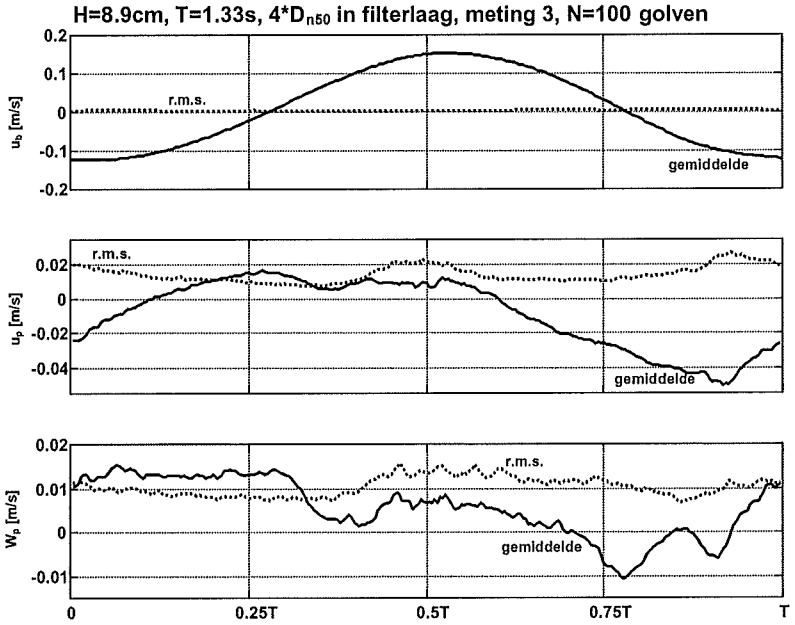
4*D_{n50} in filterlaag, meting 1, H_{gem}= 8,99 cm, T_{gem}= 1,33 s			
$\hat{u}_b$ [m/s]	0.11 – 0.15	u_b' [m/s]	
$\hat{u}_p$ [m/s]	0.04 – 0.05	u_p' [m/s]	0.01 – 0.03
$\hat{w}_p$ [m/s]	0.014 – 0.019	w_p' [m/s]	0.007 – 0.020



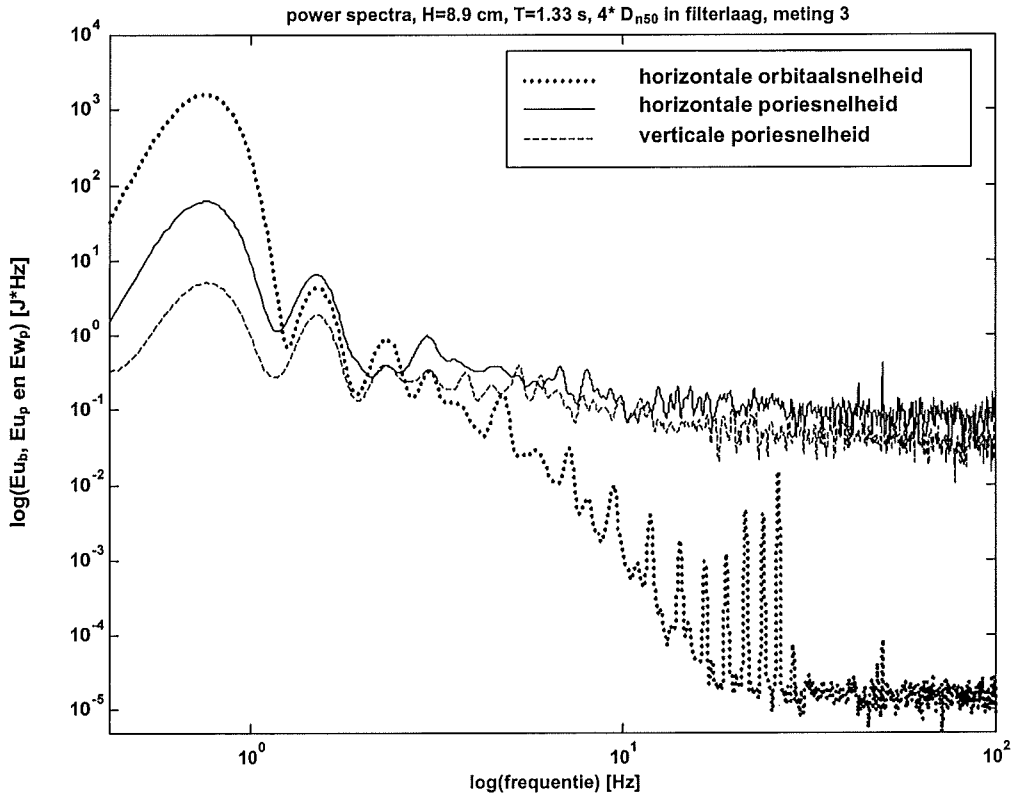


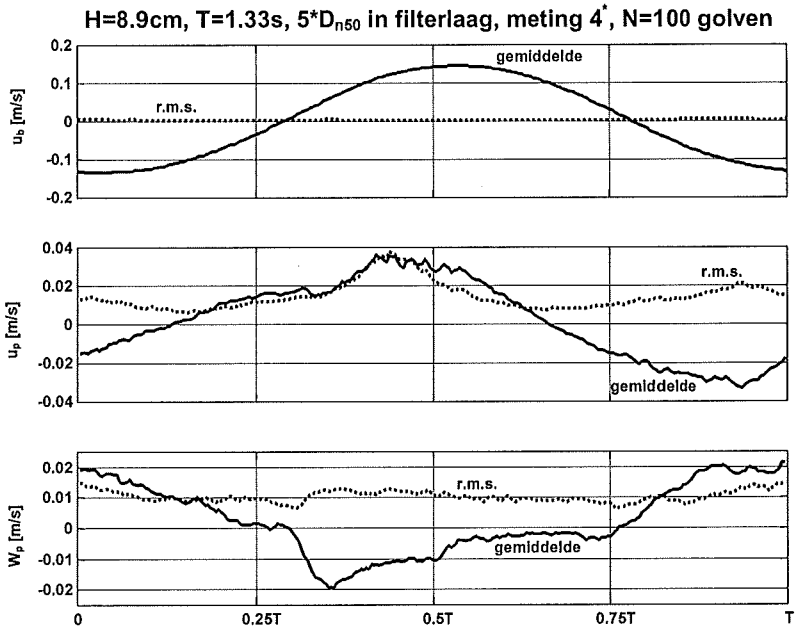
$4*D_{n50}$ in filterlaag, meting 2, H_{gem}= 8,90 cm, T_{gem}= 1,33 s			
$\hat{u}_b$ [m/s]	0.12 – 0.15	u_b' [m/s]	
$\hat{u}_p$ [m/s]	0.03 – 0.05	u_p' [m/s]	0.01 – 0.03
$\hat{w}_p$ [m/s]	0.005 – 0.017	w_p' [m/s]	0.006 – 0.019



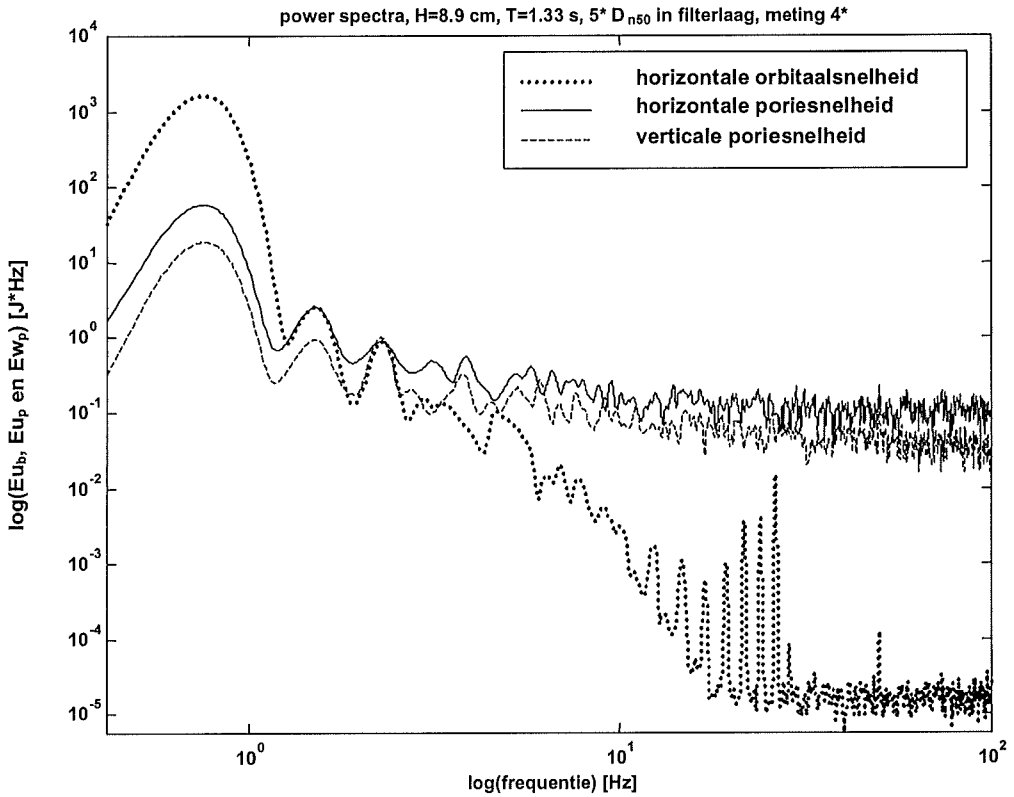


$4*D_{n50}$ in filterlaag, meting 3, H_{gem}= 8,96 cm, T_{gem}= 1,33 s			
$\hat{u}_b$ [m/s]	0.12 – 0.15	u_b' [m/s]	
$\hat{u}_p$ [m/s]	0.02 – 0.05	u_p' [m/s]	0.01 – 0.03
$\hat{w}_p$ [m/s]	0.011 – 0.016	w_p' [m/s]	0.006 – 0.017



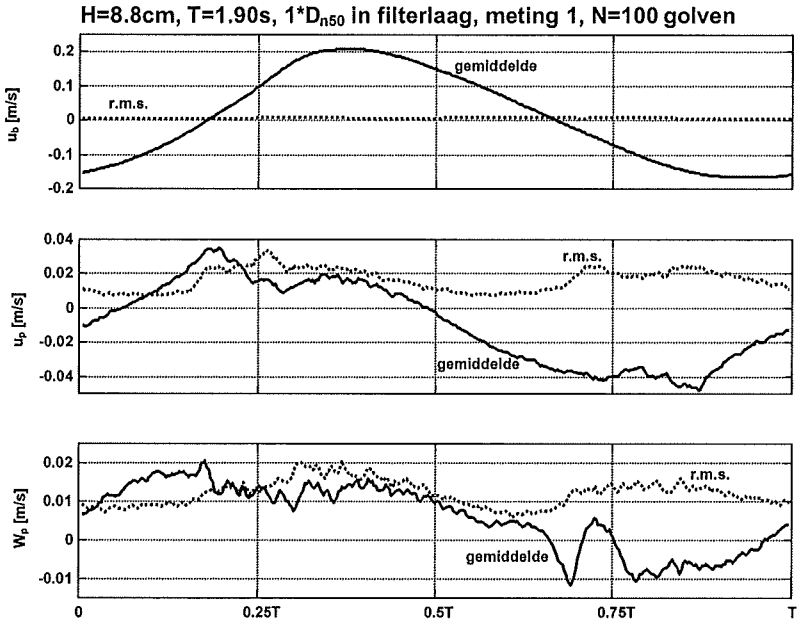


5*D_{n50} in filterlaag, meting 4*, H_{gem}= 8,98 cm, T_{gem}= 1,33 s			
$\hat{u}_b$ [m/s]	0.13 – 0.15	u_b' [m/s]	
$\hat{u}_p$ [m/s]	0.04 – 0.04	u_p' [m/s]	0.01 – 0.04
$\hat{w}_p$ [m/s]	0.021 – 0.022	w_p' [m/s]	0.006 – 0.016

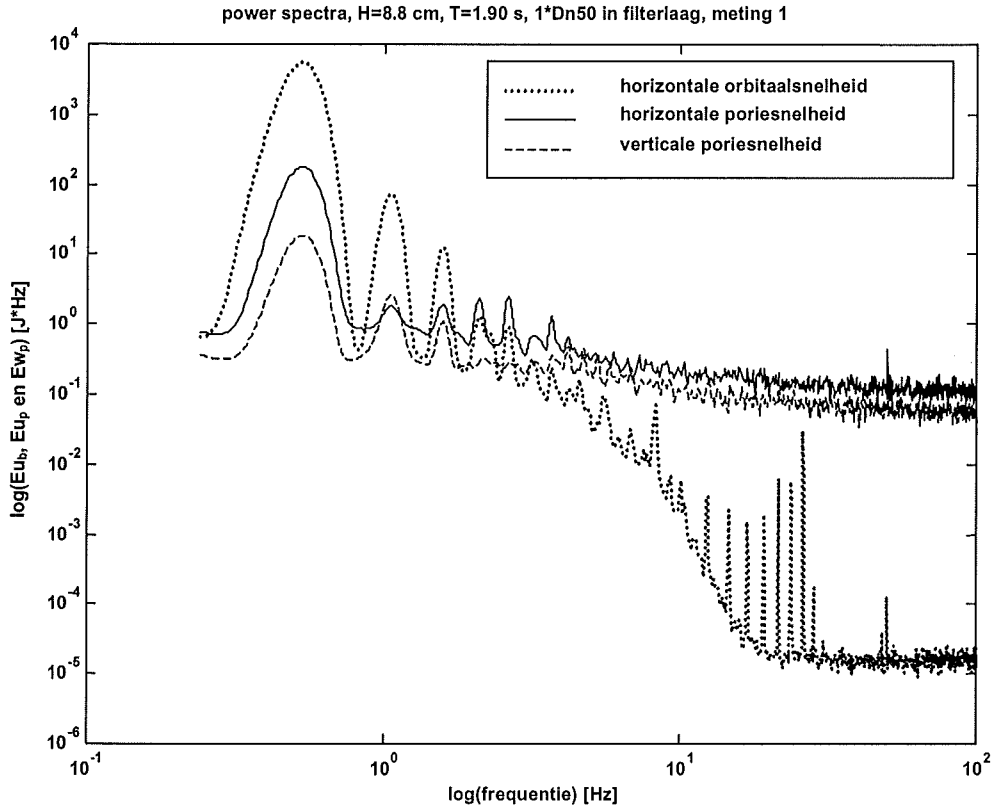


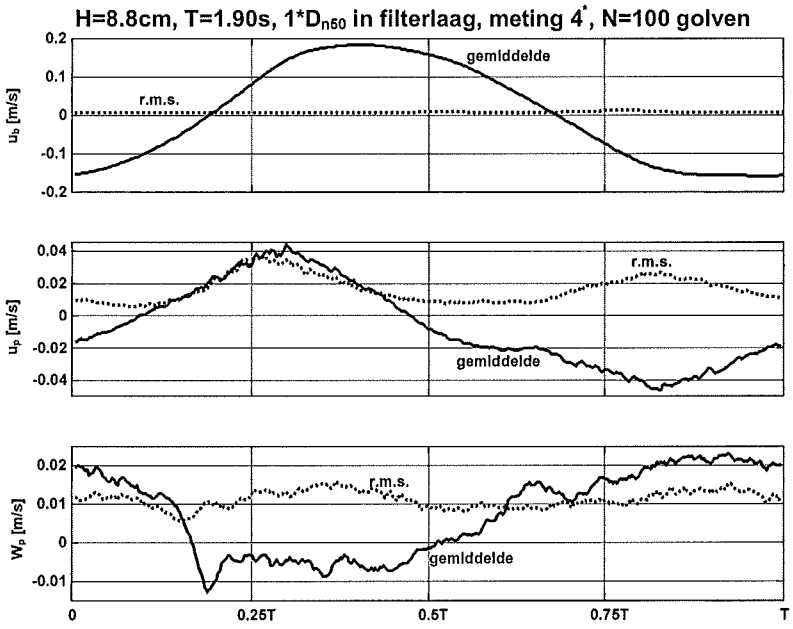
1.3 Meetserie 1, belastingsgeval C

1.3.1 Belastingsgeval C, 1*D_{n50} in filterlaag

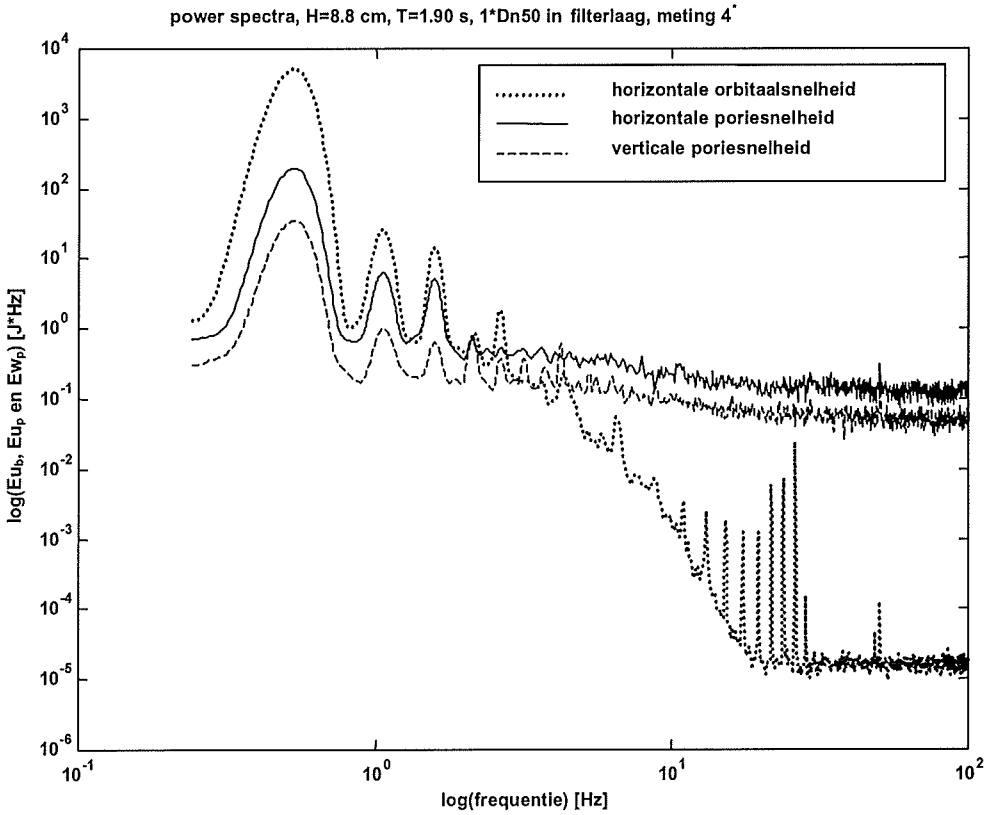


1*D_{n50} in filterlaag, meting 1, H_{gem}= 8,87 cm, T_{gem}= 1,90 s			
$\hat{u}_b$ [m/s]	0.17 – 0.21	u_b' [m/s]	
$\hat{u}_p$ [m/s]	0.04 – 0.05	u_p' [m/s]	0.01 – 0.04
$\hat{w}_p$ [m/s]	0.013 – 0.022	w_p' [m/s]	0.006 – 0.022

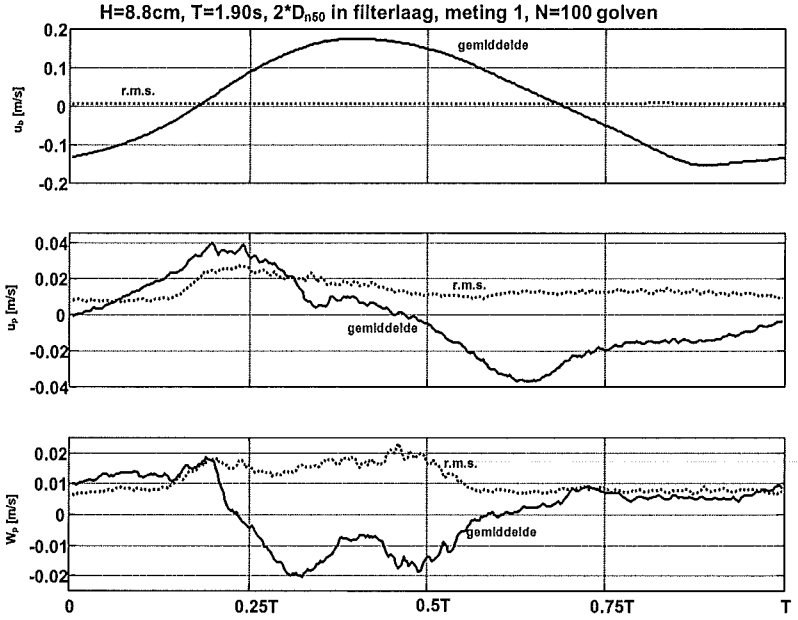




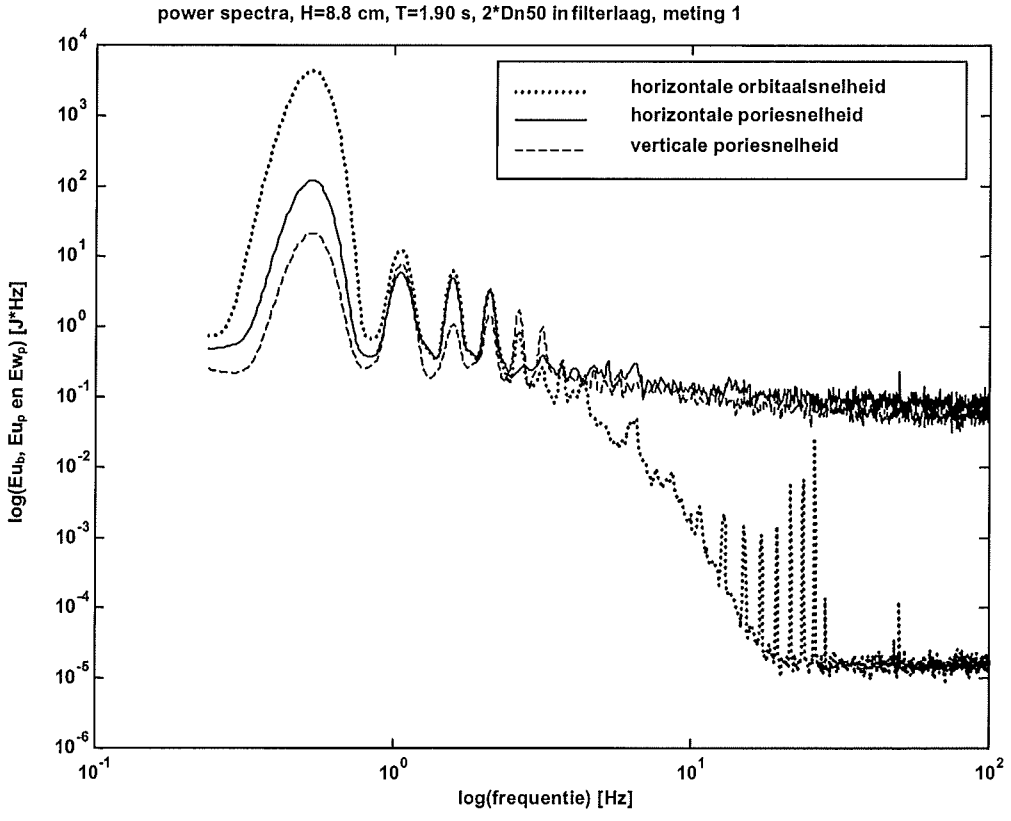
1*D_{n50} in filterlaag, meting 4*, H_{gem}= 9,08 cm, T_{gem}= 1,90 s			
$\hat{u}_b$ [m/s]	0.16 – 0.18	u_b' [m/s]	
$\hat{u}_p$ [m/s]	0.05 – 0.05	u_p' [m/s]	0.01 – 0.04
$\hat{w}_p$ [m/s]	0.013 – 0.024	w_p' [m/s]	0.006 – 0.017

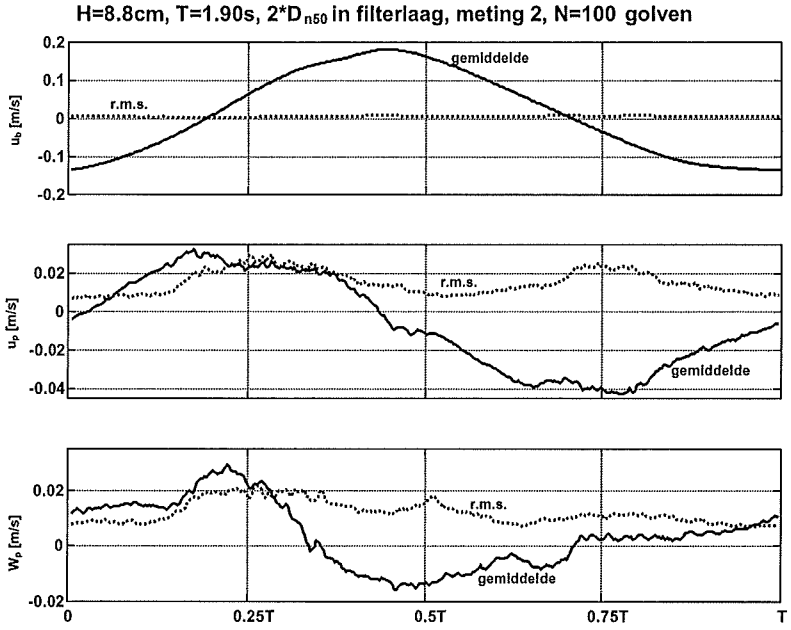


1.3.2 Belastingsgeval C, 2*D_{n50} in filterlaag

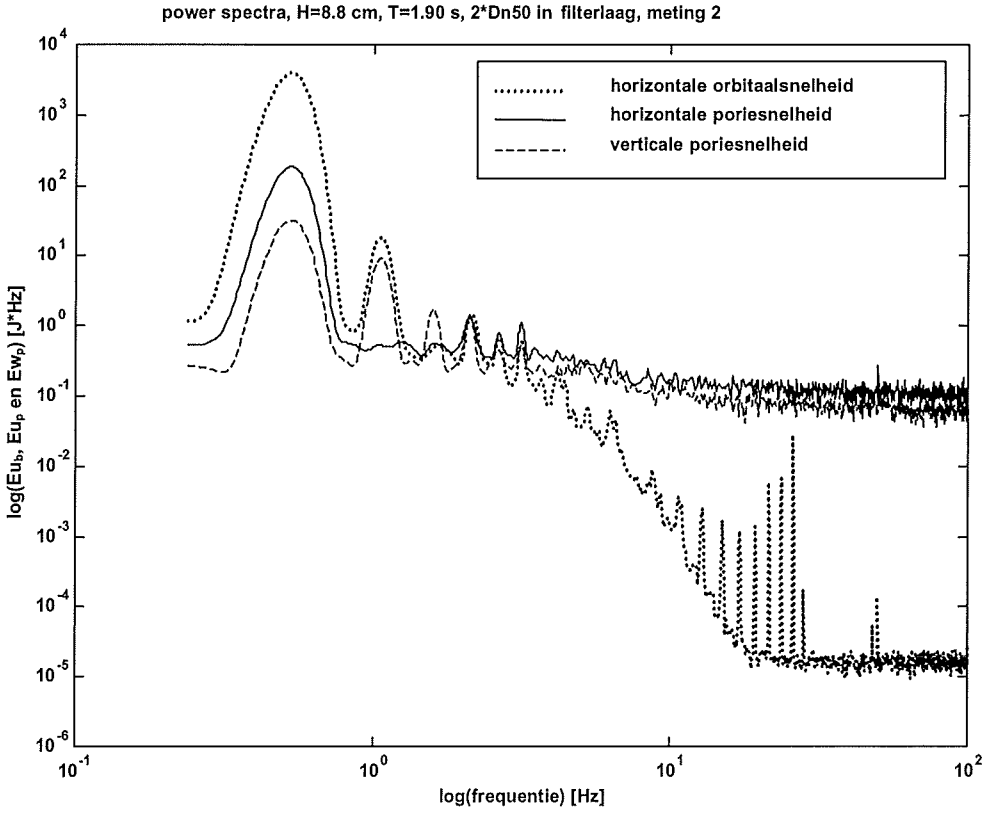


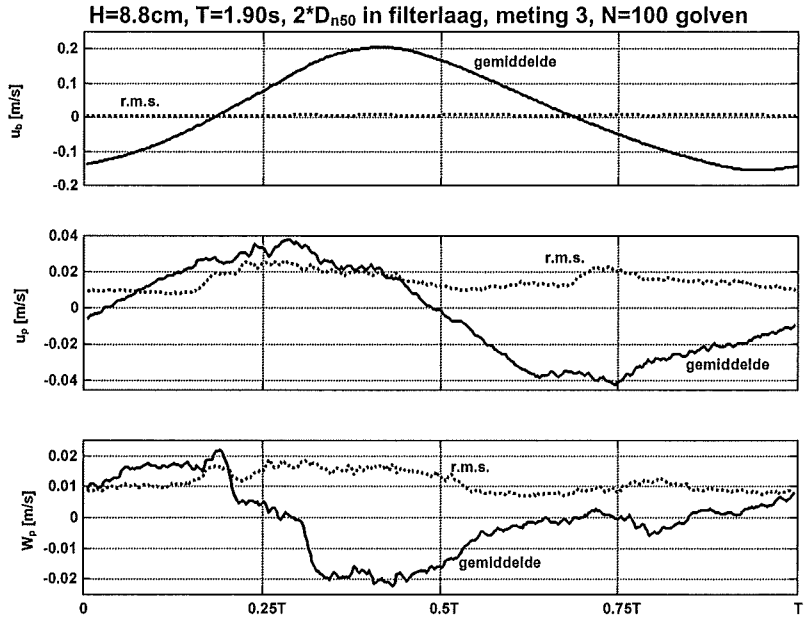
$2*D_{n50}$ in filterlaag, meting 1, H_{gem}= 8,96 cm, T_{gem}= 1,90 s			
$\hat{u}_b$ [m/s]	0.15 – 0.18	u_b' [m/s]	
$\hat{u}_p$ [m/s]	0.04 – 0.04	u_p' [m/s]	0.01 – 0.03
$\hat{w}_p$ [m/s]	0.020 – 0.021	w_p' [m/s]	0.006 – 0.025



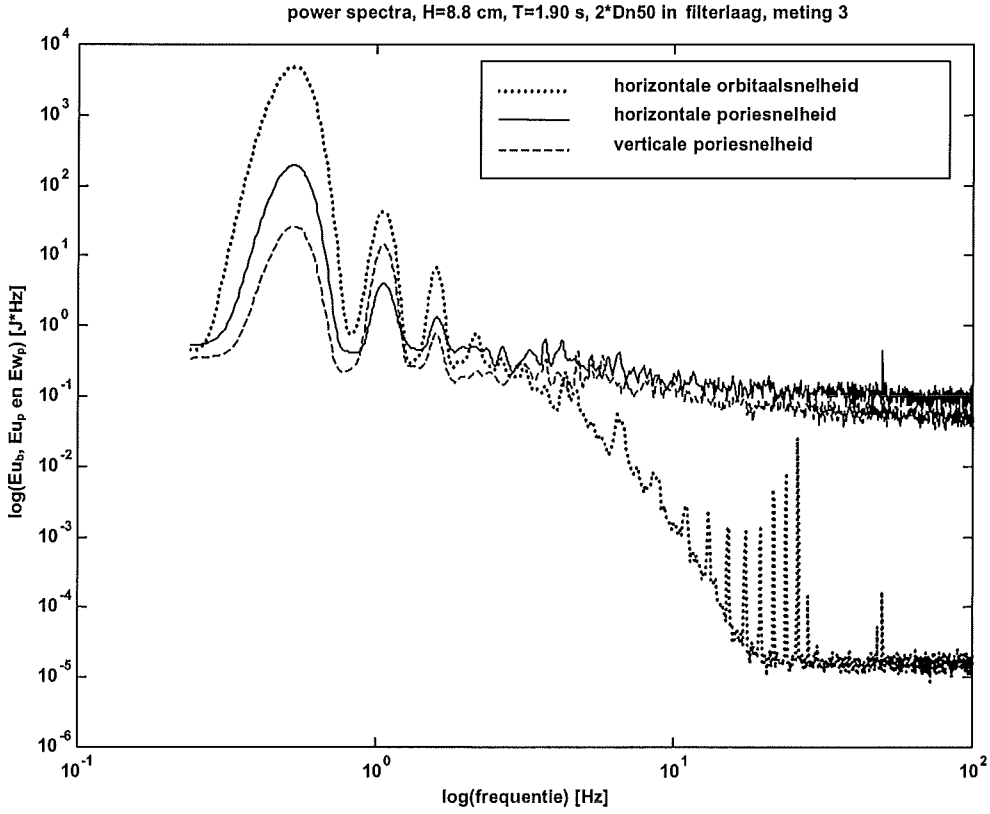


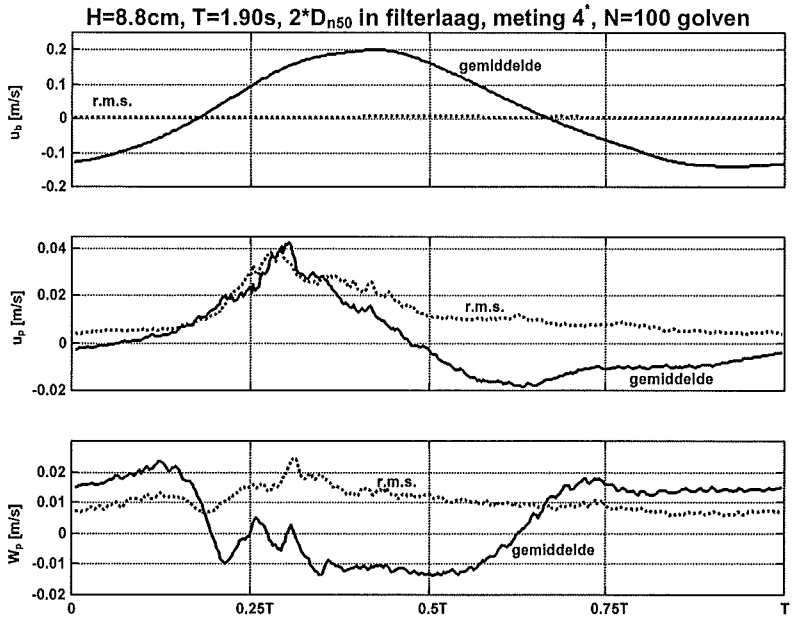
$2*D_{n50}$ in filterlaag, meting 2, H_{gem}= 9,84 cm, T_{gem}= 1,90 s			
$\hat{u}_b$ [m/s]	0.13 – 0.18	u_b' [m/s]	
$\hat{u}_p$ [m/s]	0.03 – 0.04	u_p' [m/s]	0.01 – 0.03
$\hat{w}_p$ [m/s]	0.017 – 0.032	w_p' [m/s]	0.007 – 0.025



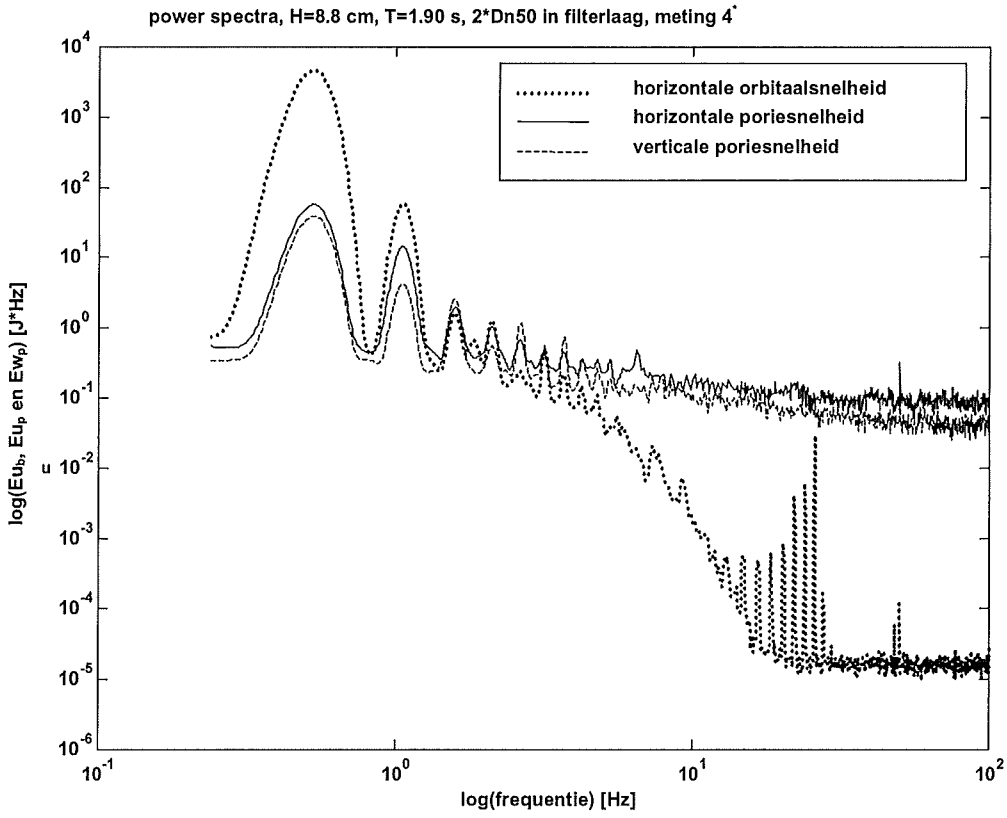


$2*D_{n50}$ in filterlaag, meting 3, H_{gem}= 8,89 cm, T_{gem}= 1,90 s			
$\hat{u}_b$ [m/s]	0.16 – 0.20	u_b' [m/s]	
$\hat{u}_p$ [m/s]	0.04 – 0.04	u_p' [m/s]	0.01 – 0.03
$\hat{w}_p$ [m/s]	0.023 – 0.025	w_p' [m/s]	0.007 – 0.021

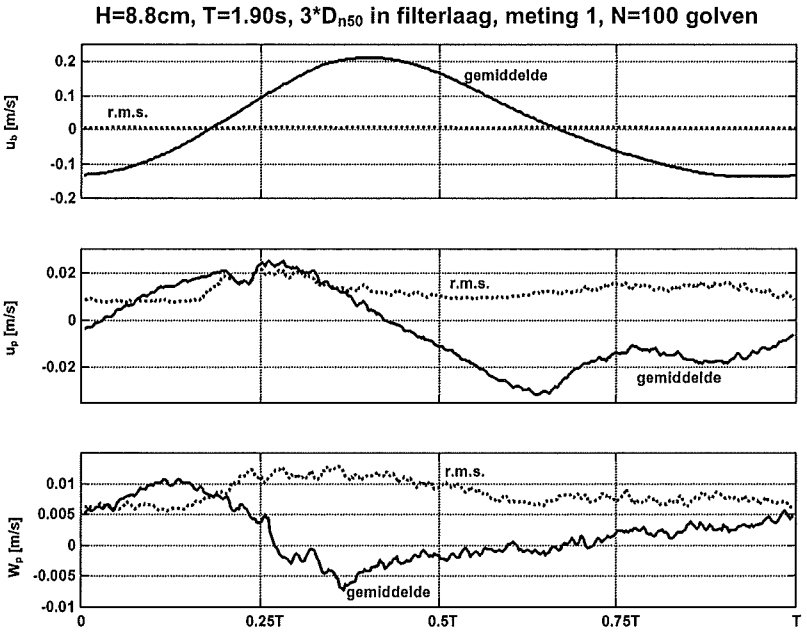




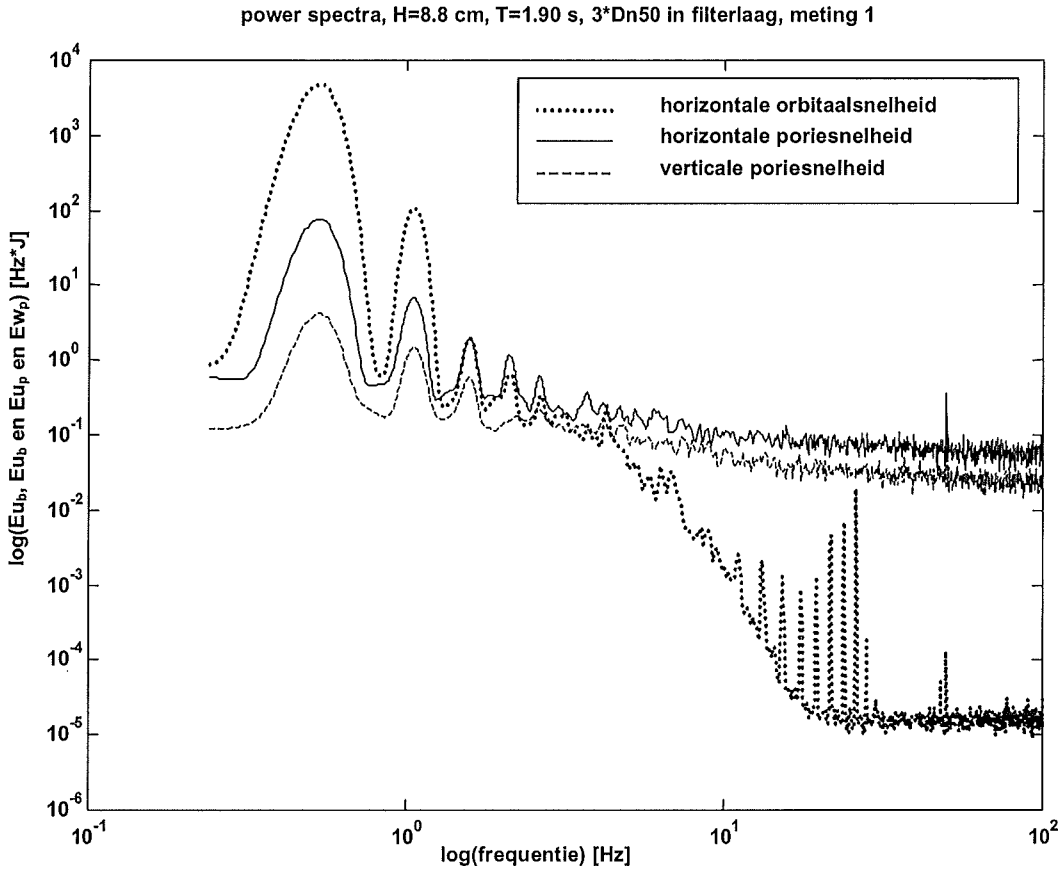
$2*D_{n50}$ in filterlaag, meting 4*, H_{gem}= 8,86 cm, T_{gem}= 1,90 s			
$\hat{u}_b$ [m/s]	0.14 – 0.20	u_b' [m/s]	
$\hat{u}_p$ [m/s]	0.02 – 0.04	u_p' [m/s]	0.01 – 0.04
$\hat{w}_p$ [m/s]	0.015 – 0.024	w_p' [m/s]	0.006 – 0.025

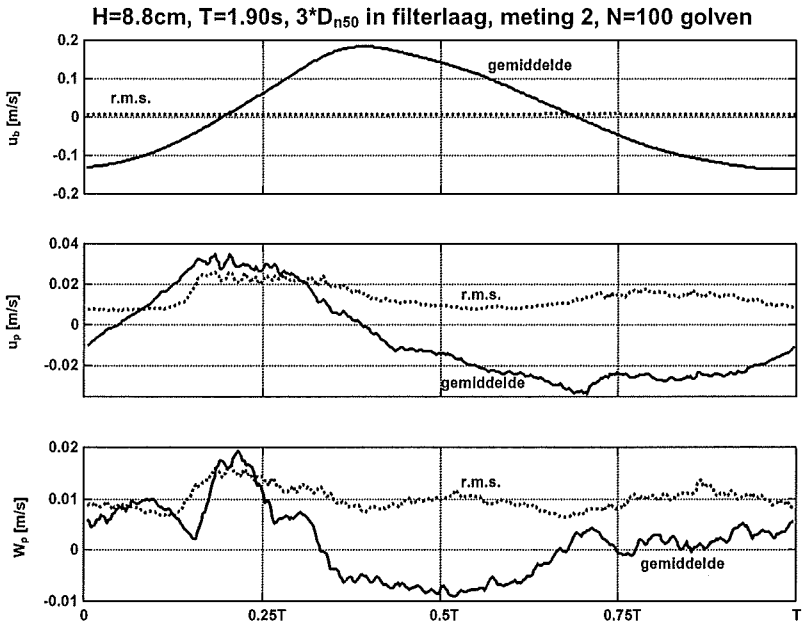


1.3.3 Belastingsgeval C, 3*D_{n50} in filterlaag

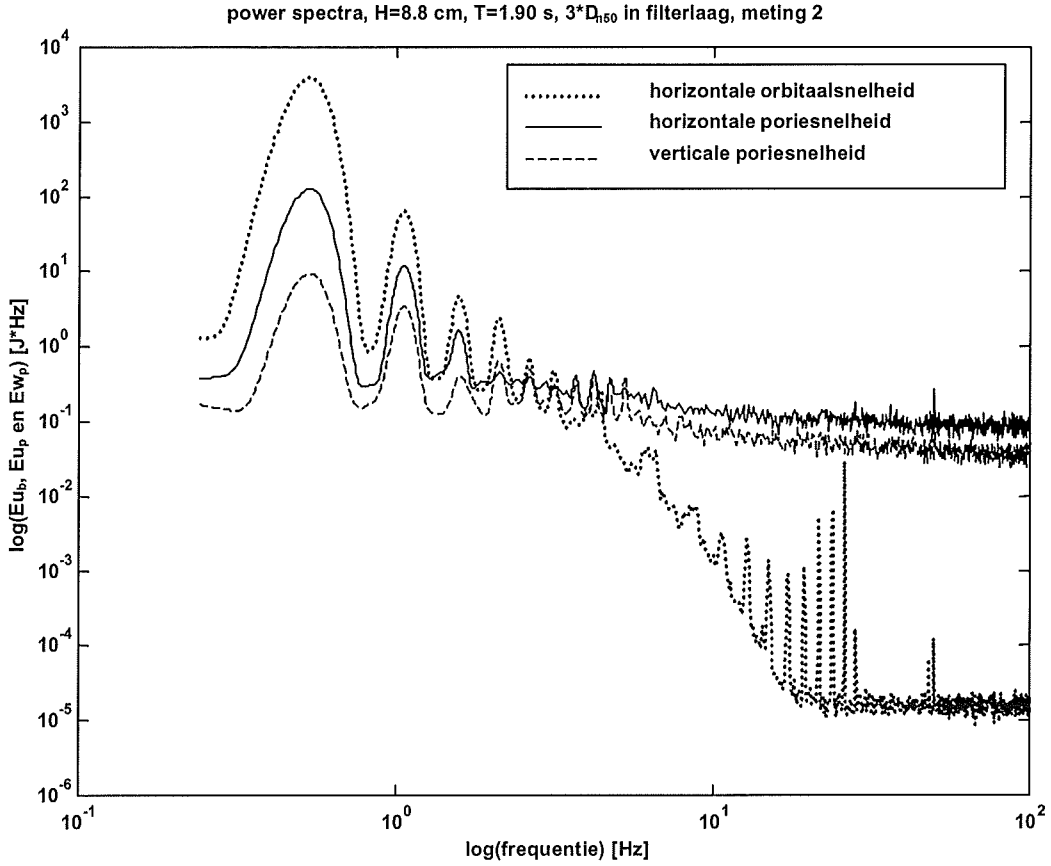


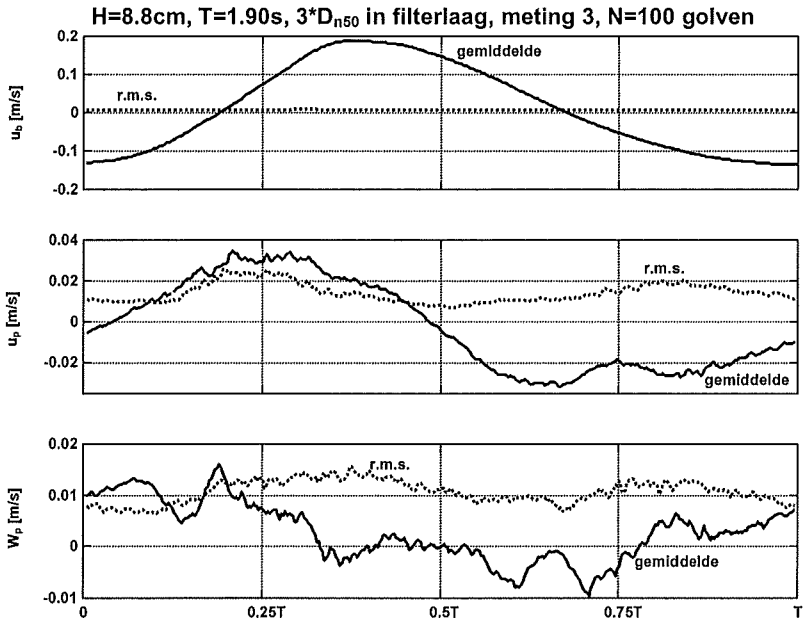
3*D_{n50} in filterlaag, meting 1, H_{gem}= 9,34 cm, T_{gem}= 1,90 s			
$\hat{u}_b$ [m/s]	0.14 – 0.21	u_b' [m/s]	
$\hat{u}_p$ [m/s]	0.03 – 0.03	u_p' [m/s]	0.01 – 0.02
$\hat{w}_p$ [m/s]	0.010 – 0.011	w_p' [m/s]	0.005 – 0.013



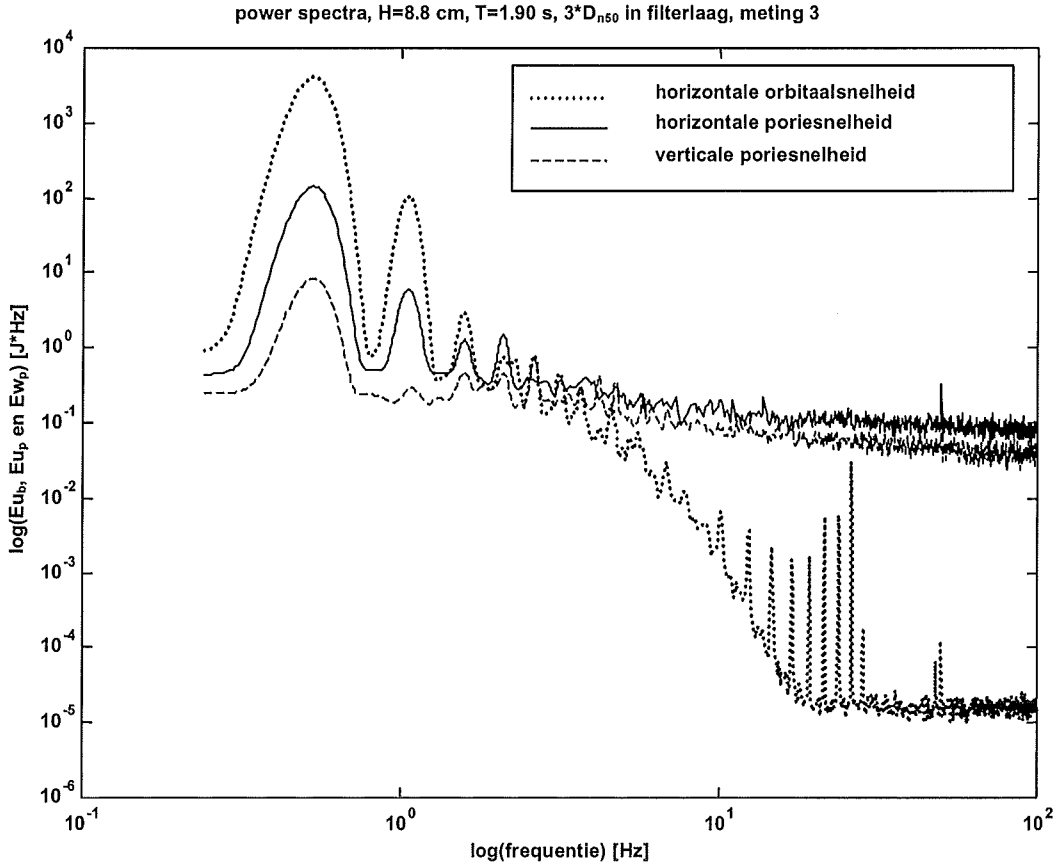


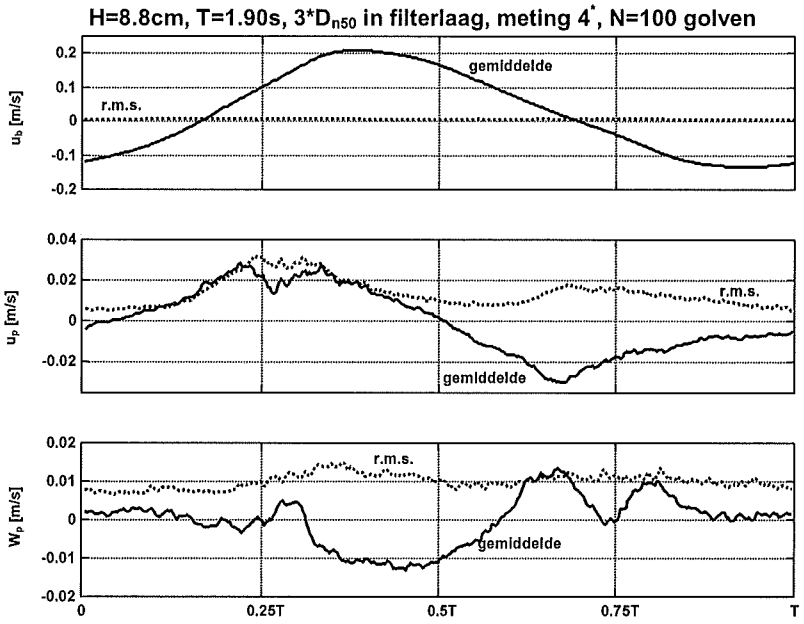
$3*D_{n50}$ in filterlaag, meting 2, H_{gem}= 8.84 cm, T_{gem}= 1,90 s			
$\hat{u}_b$ [m/s]	0.13 – 0.18	u_b' [m/s]	
$\hat{u}_p$ [m/s]	0.04 – 0.04	u_p' [m/s]	0.01 – 0.03
$\hat{w}_p$ [m/s]	0.010 – 0.020	w_p' [m/s]	0.006 – 0.018



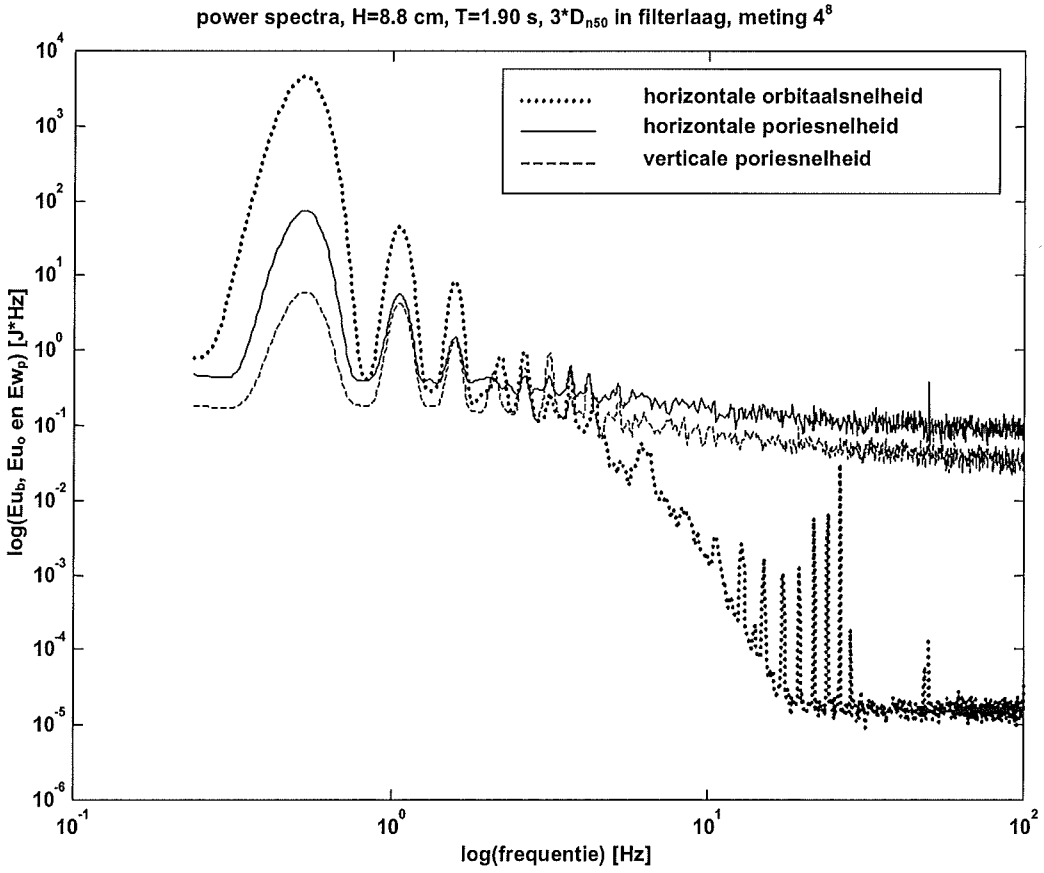


$3*D_{n50}$ in filterlaag, meting 3, H_{gem}= 8,87 cm, T_{gem}= 1,90 s			
$\hat{u}_b$ [m/s]	0.13 – 0.19	u_b' [m/s]	
$\hat{u}_p$ [m/s]	0.03 – 0.04	u_p' [m/s]	0.01 – 0.03
$\hat{w}_p$ [m/s]	0.010 – 0.017	w_p' [m/s]	0.006 – 0.017

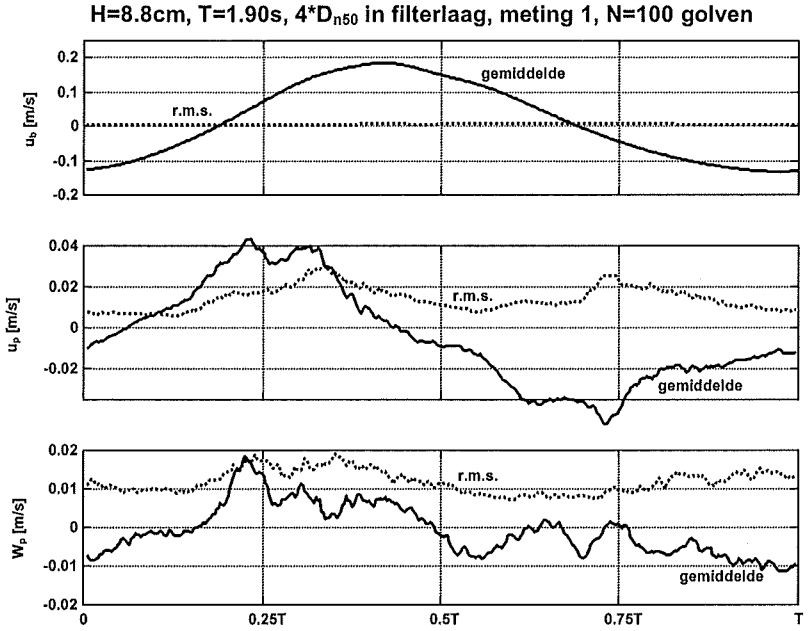




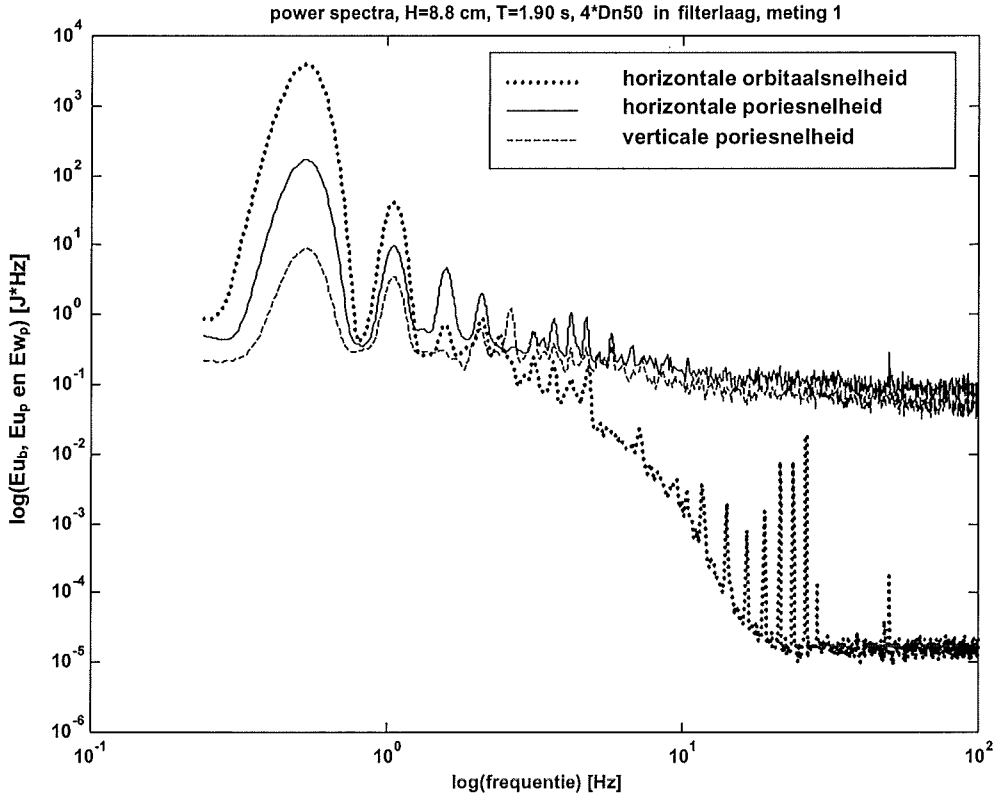
3*D_{n50} in filterlaag, meting 4*, H_{gem}= 9,08 cm, T_{gem}= 1,90 s			
$\hat{u}_b$ [m/s]	0.13 – 0.21	u_b' [m/s]	
$\hat{u}_p$ [m/s]	0.03 – 0.03	u_p' [m/s]	0.01 – 0.04
$\hat{w}_p$ [m/s]	0.014 – 0.015	w_p' [m/s]	0.006 – 0.017

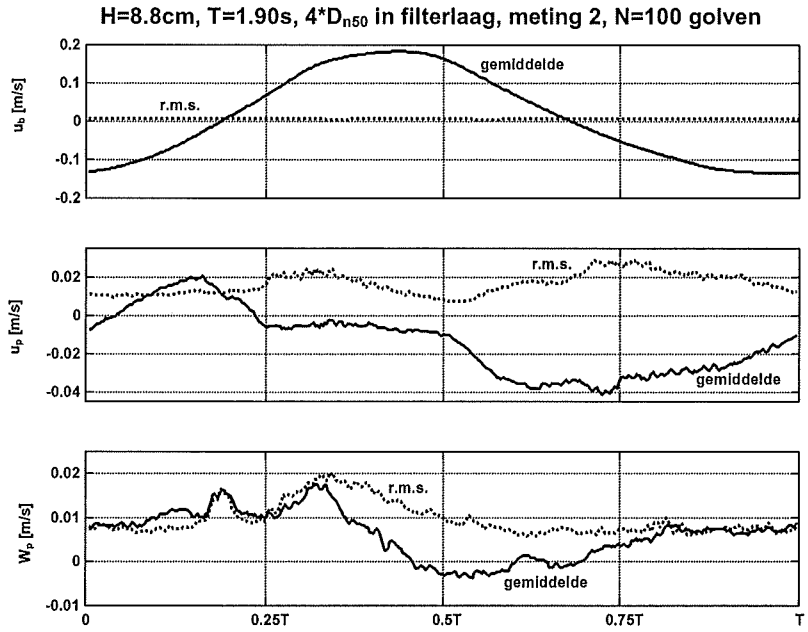


1.3.4 Belastingsgeval C, 4*D_{n50} in filterlaag

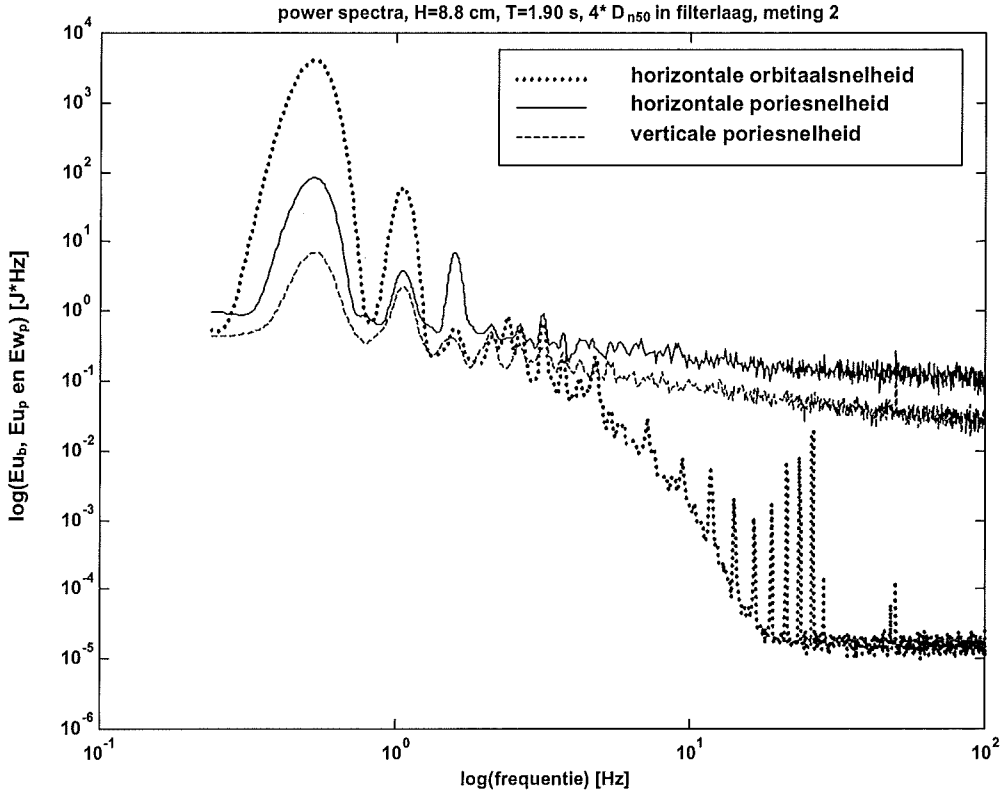


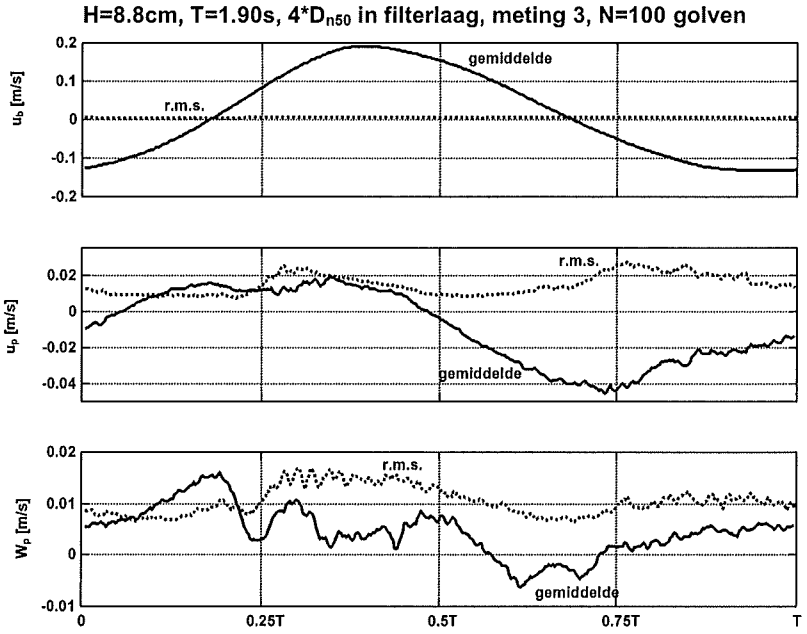
$4*D_{n50}$ in filterlaag, meting 1, H_{gem}= 8,85 cm, T_{gem}= 1,90 s			
$\hat{u}_b$ [m/s]	0.13 – 0.18	u_b' [m/s]	
$\hat{u}_p$ [m/s]	0.04 – 0.05	u_p' [m/s]	0.01 – 0.03
$\hat{w}_p$ [m/s]	0.012 – 0.020	w_p' [m/s]	0.006 – 0.020



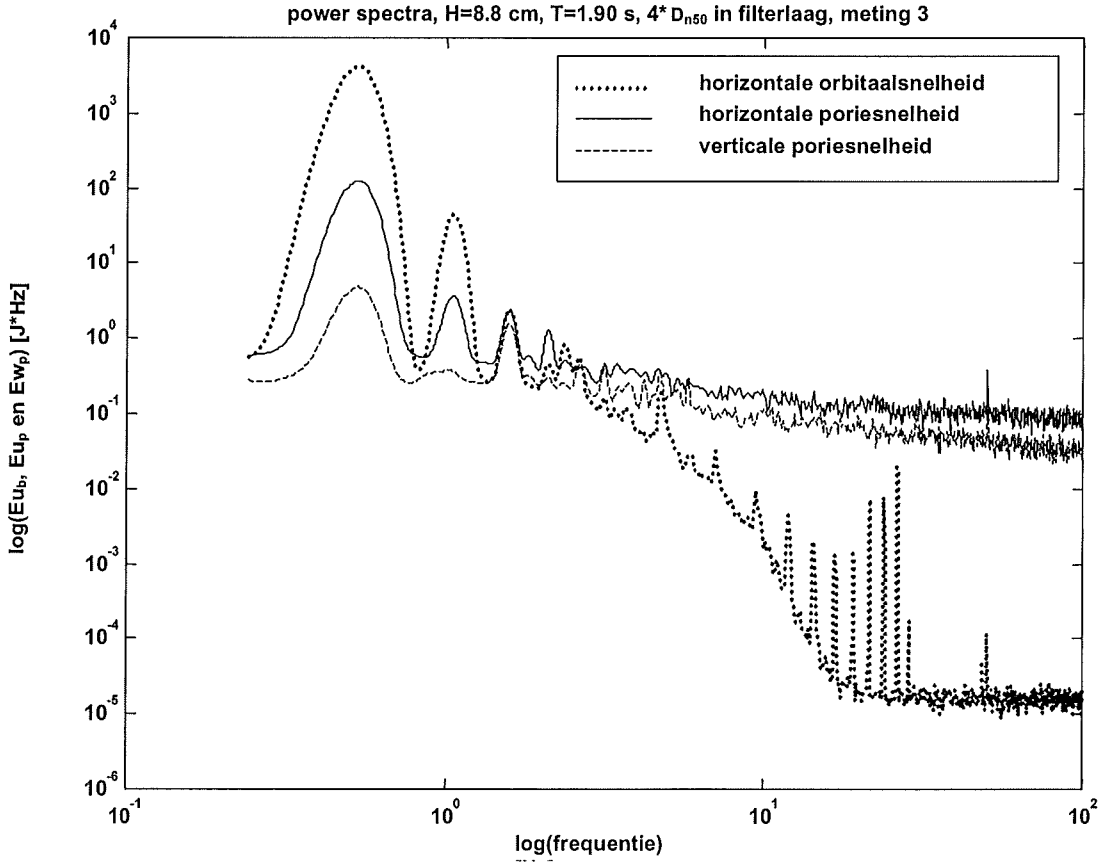


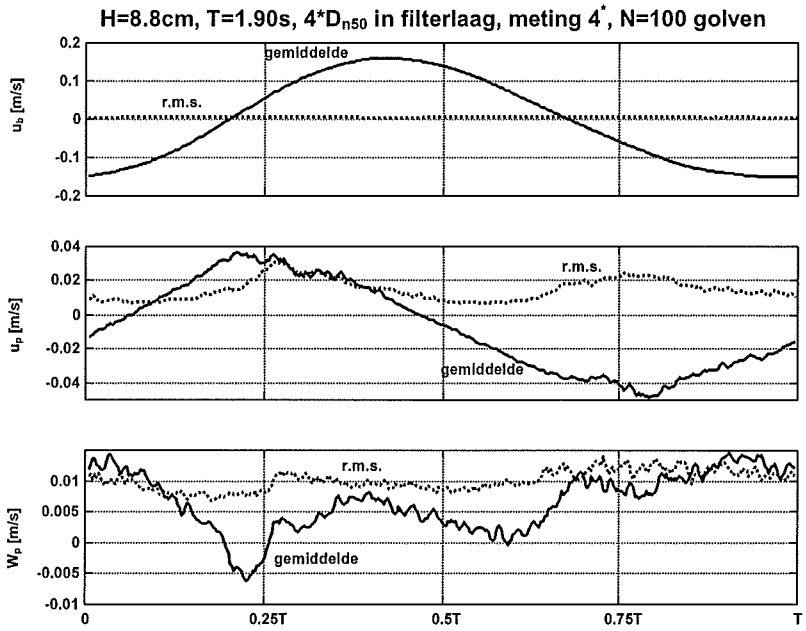
$4*D_{n50}$ in filterlaag, meting 2, H_{gem}= 8,79 cm, T_{gem}= 1,90 s			
$\hat{u}_b$ [m/s]	0.13 – 0.18	u_b' [m/s]	
$\hat{u}_p$ [m/s]	0.02 – 0.04	u_p' [m/s]	0.01 – 0.03
$\hat{w}_p$ [m/s]	0.004 – 0.019	w_p' [m/s]	0.005 – 0.022



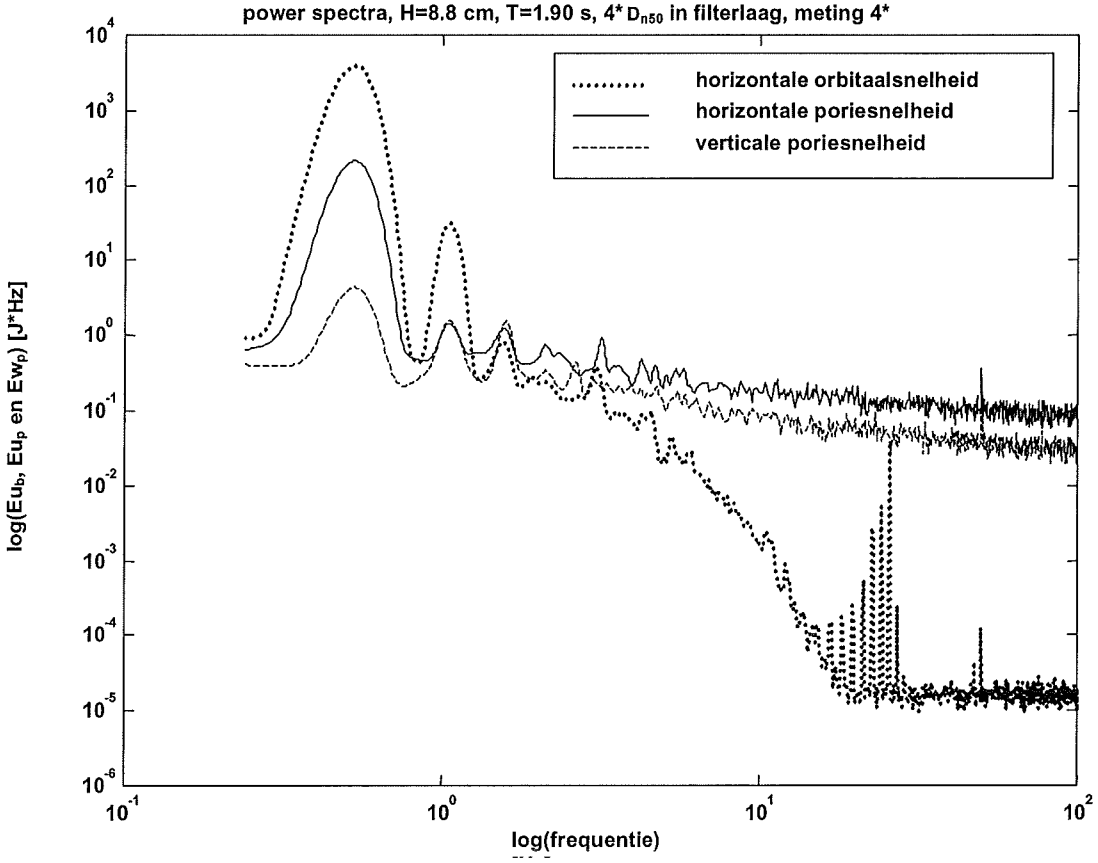


$4*D_{n50}$ in filterlaag, meting 3, H_{gem}= 8,66 cm, T_{gem}= 1,90 s			
$\hat{u}_b$ [m/s]	0.13 – 0.19	u_b' [m/s]	
$\hat{u}_p$ [m/s]	0.02 – 0.05	u_p' [m/s]	0.01 – 0.03
$\hat{w}_p$ [m/s]	0.006 – 0.017	w_p' [m/s]	0.006 – 0.019

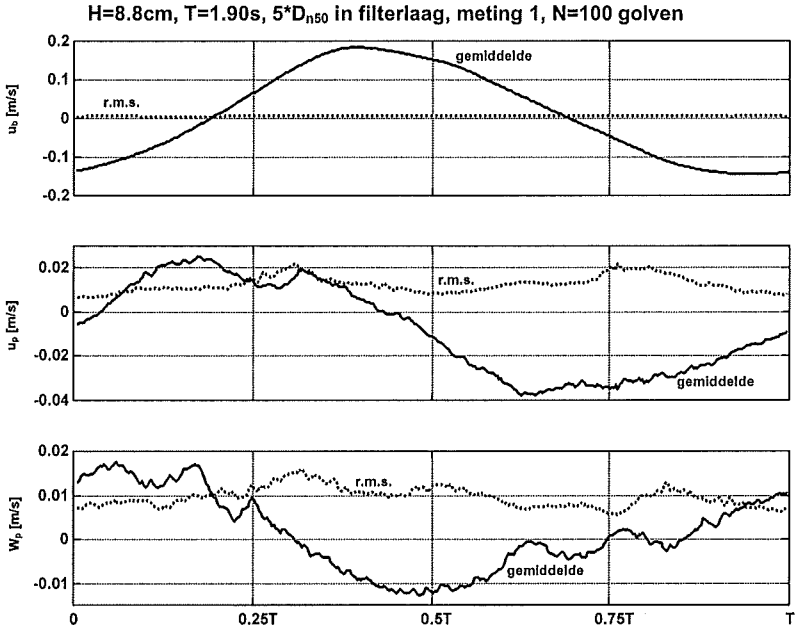




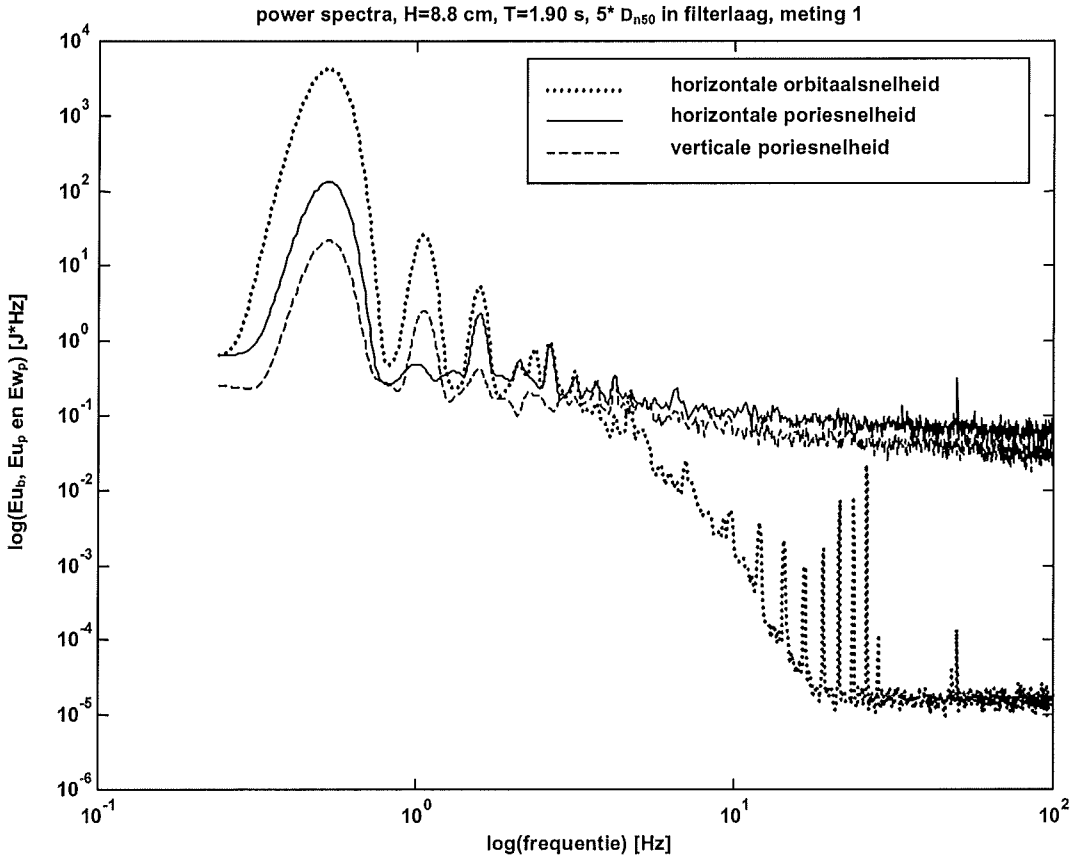
4*D_{n50} in filterlaag, meting 4*, H_{gem}= 8,81 cm, T_{gem}= 1,90 s			
$\hat{u}_b$ [m/s]	0.15 – 0.16	u_b' [m/s]	
$\hat{u}_p$ [m/s]	0.04 – 0.05	u_p' [m/s]	0.01 – 0.03
$\hat{w}_p$ [m/s]	0.007 – 0.016	w_p' [m/s]	0.006 – 0.016

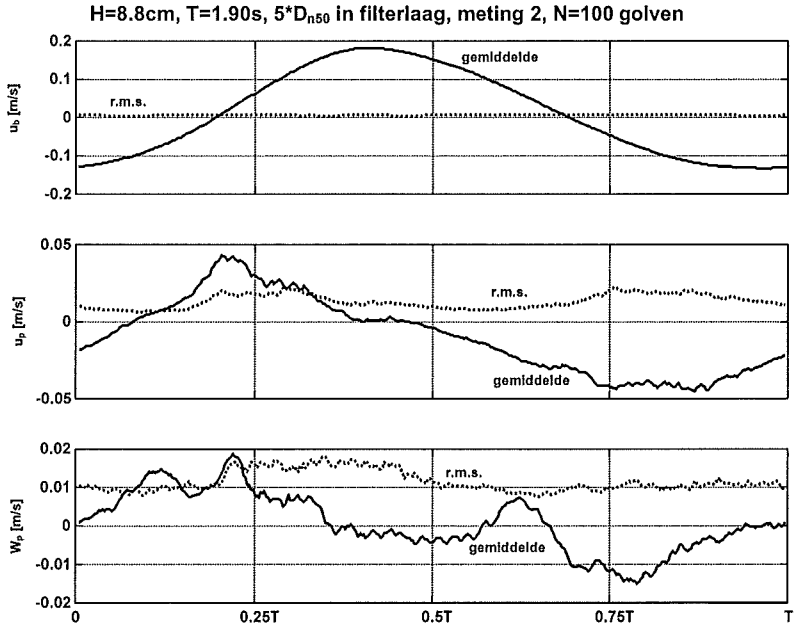


1.3.5 Belastingsgeval C, 5*D_{n50} in filterlaag

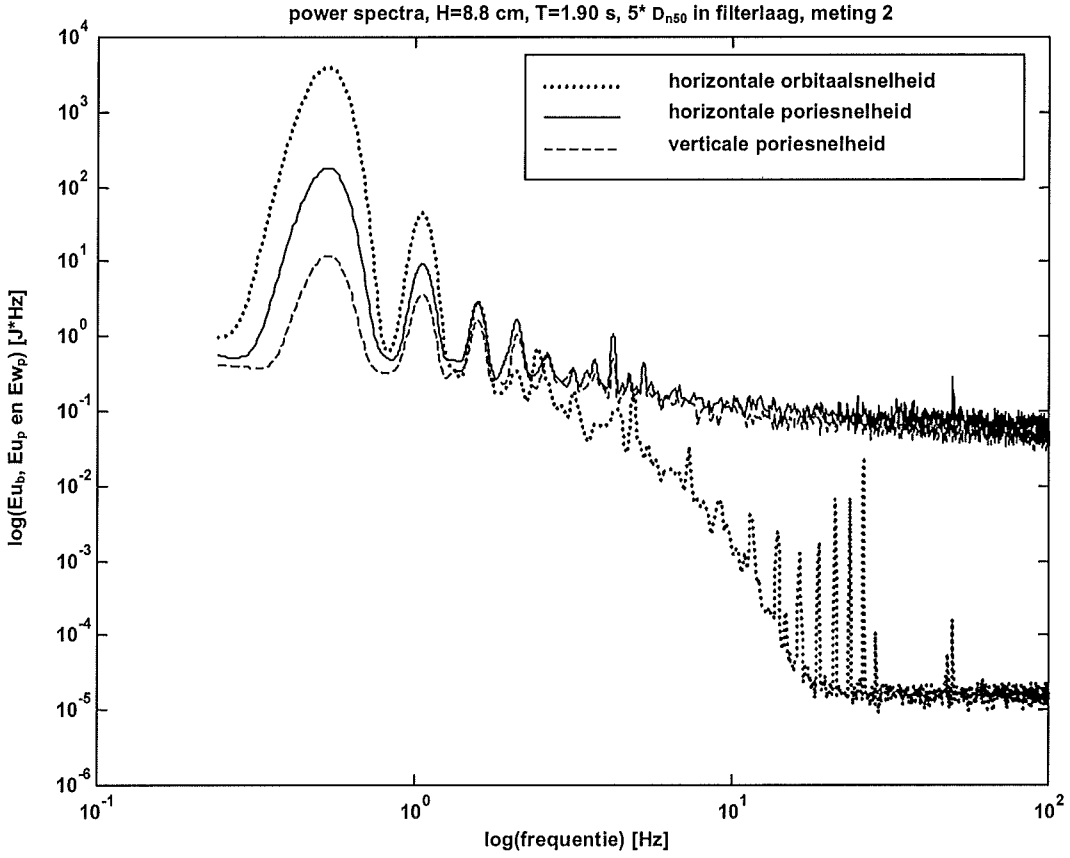


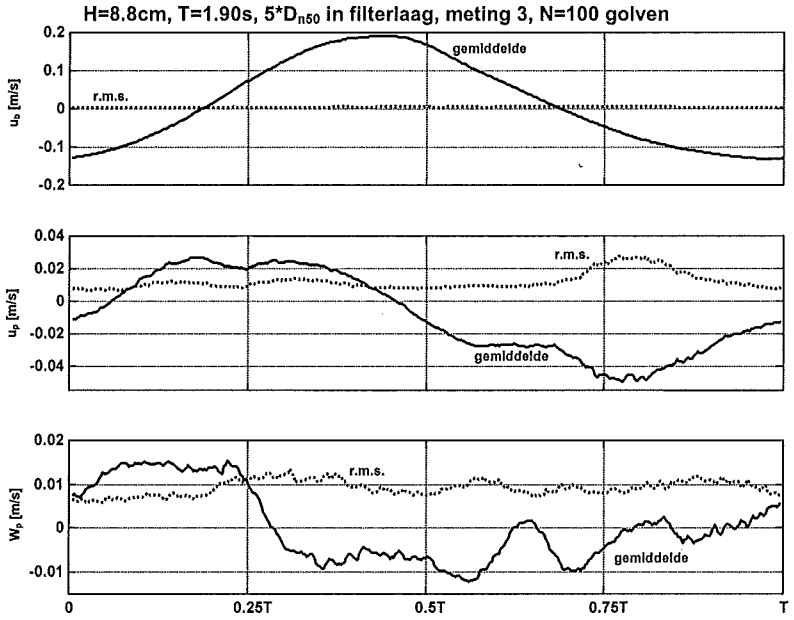
5*D_{n50} in filterlaag, meting 1, H_{gem}= 8,73 cm, T_{gem}= 1,90 s			
$\hat{u}_b$ [m/s]	0.14 – 0.18	u_b' [m/s]	
$\hat{u}_p$ [m/s]	0.03 – 0.04	u_p' [m/s]	0.01 – 0.02
$\hat{w}_p$ [m/s]	0.014 – 0.018	w_p' [m/s]	0.005 – 0.016



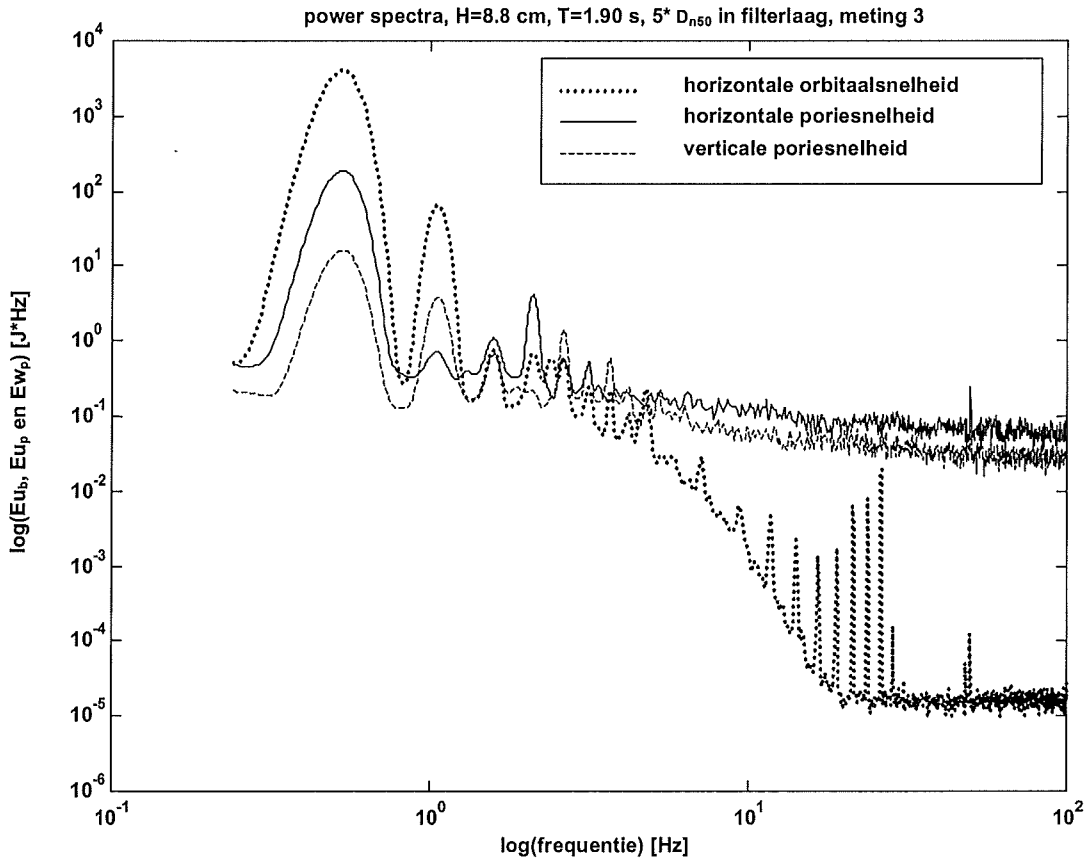


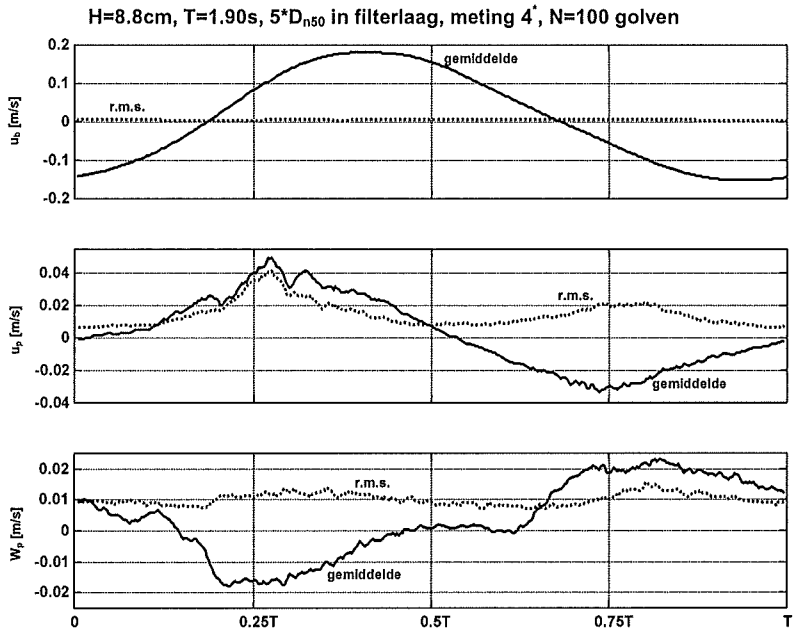
$5*D_{n50}$ in filterlaag, meting 2, H_{gem}= 8,85 cm, T_{gem}= 1,90 s			
$\hat{u}_b$ [m/s]	0.13 – 0.18	u_b' [m/s]	
$\hat{u}_p$ [m/s]	0.05 – 0.05	u_p' [m/s]	0.01 – 0.02
$\hat{w}_p$ [m/s]	0.016 – 0.020	w_p' [m/s]	0.007 – 0.019



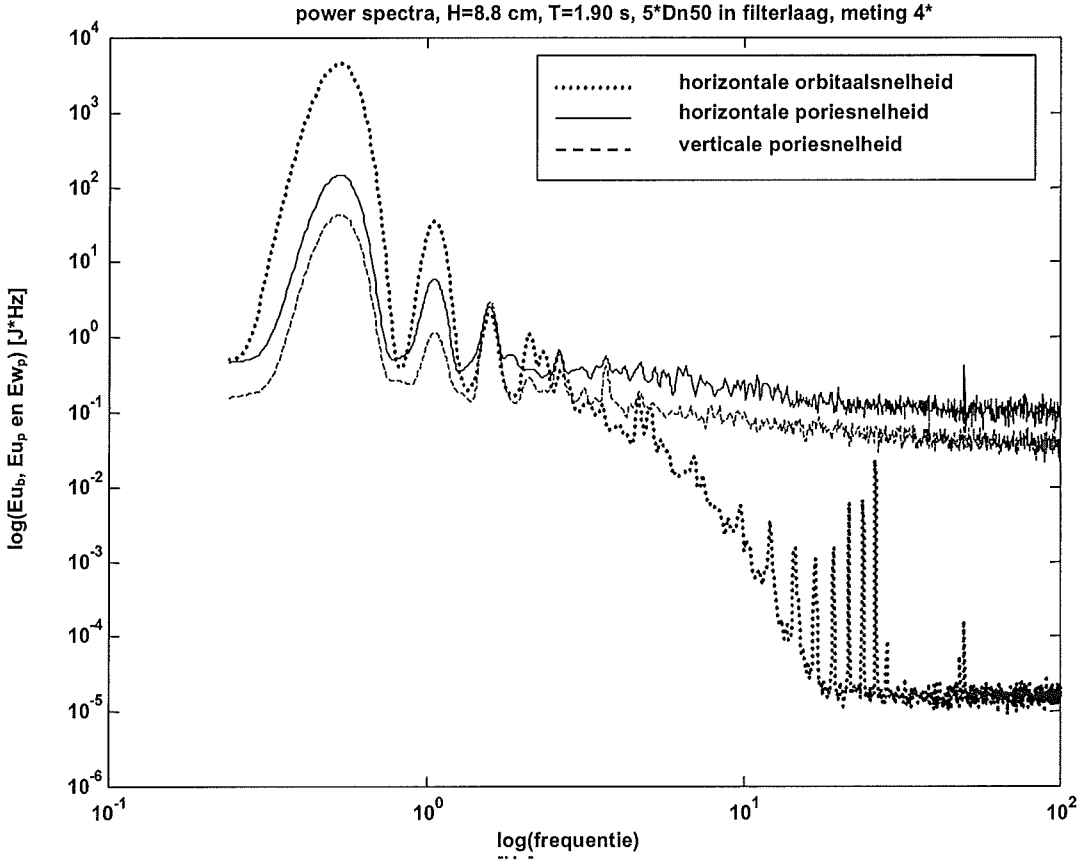


$5*D_{n50}$ in filterlaag, meting 3, H_{gem}= 8,88 cm, T_{gem}= 1,90 s			
$\hat{u}_b$ [m/s]	0.13 – 0.19	u_b' [m/s]	
$\hat{u}_p$ [m/s]	0.03 – 0.05	u_p' [m/s]	0.01 – 0.03
$\hat{w}_p$ [m/s]	0.013 – 0.016	w_p' [m/s]	0.006 – 0.014



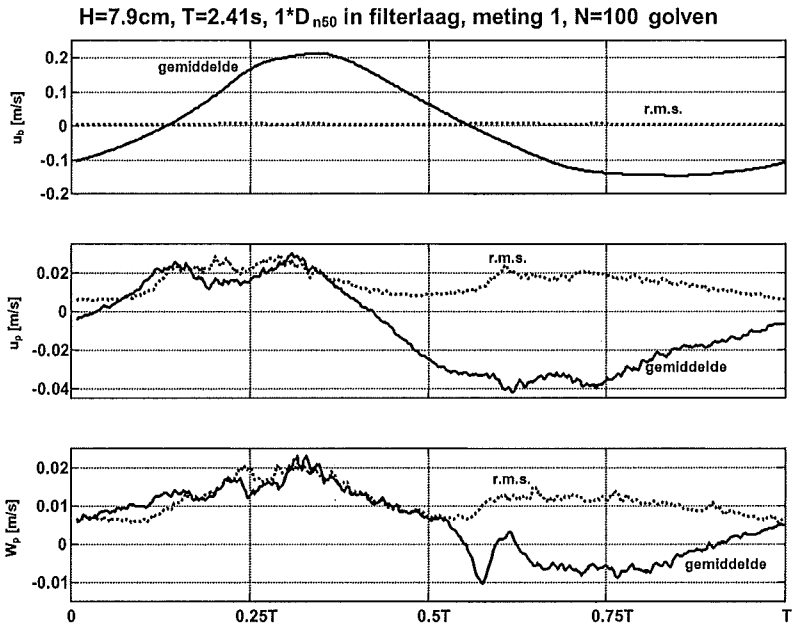


5*D_{n50} in filterlaag, meting 4*, H_{gem}= 8,88 cm, T_{gem}= 1,90 s			
$\hat{u}_b$ [m/s]	0.15 – 0.18	u_b' [m/s]	
$\hat{u}_p$ [m/s]	0.03 – 0.05	u_p' [m/s]	0.01 – 0.04
$\hat{w}_p$ [m/s]	0.019 – 0.026	w_p' [m/s]	0.006 – 0.017

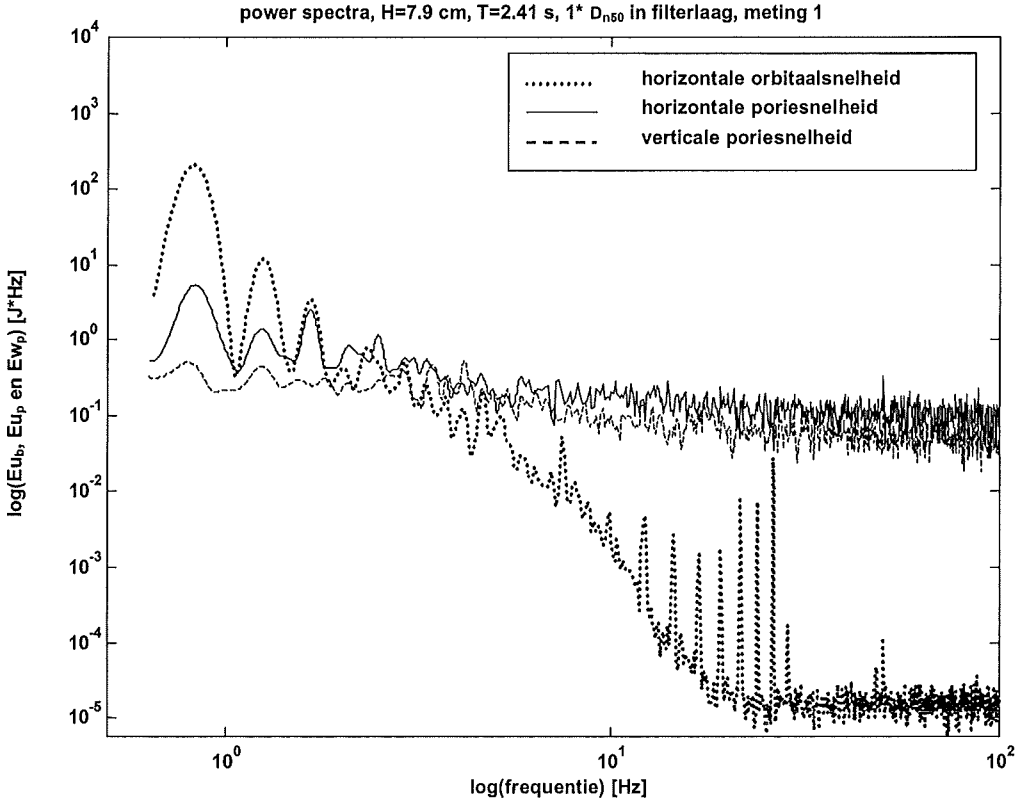


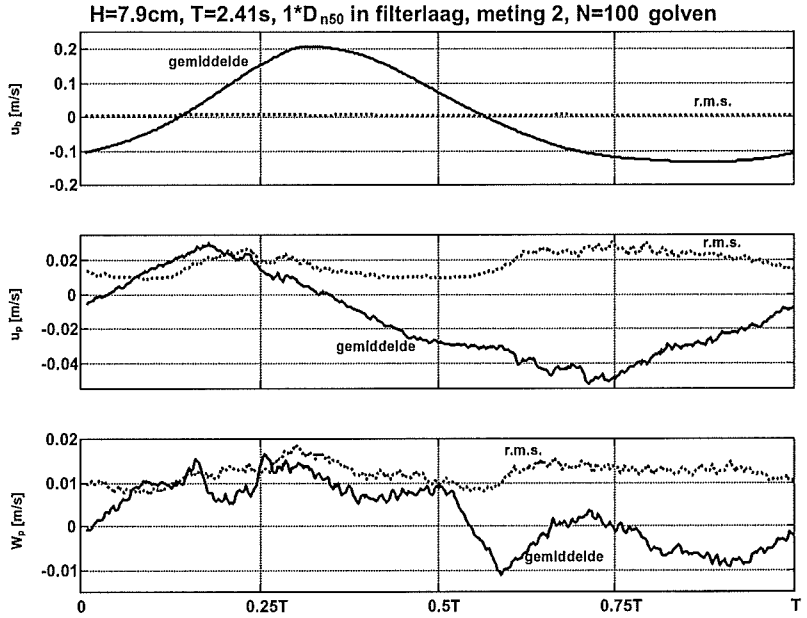
1.4 Meetserie 1, belastingsgeval D

1.4.1 Belastingsgeval D, 1*D_{n50} in filterlaag

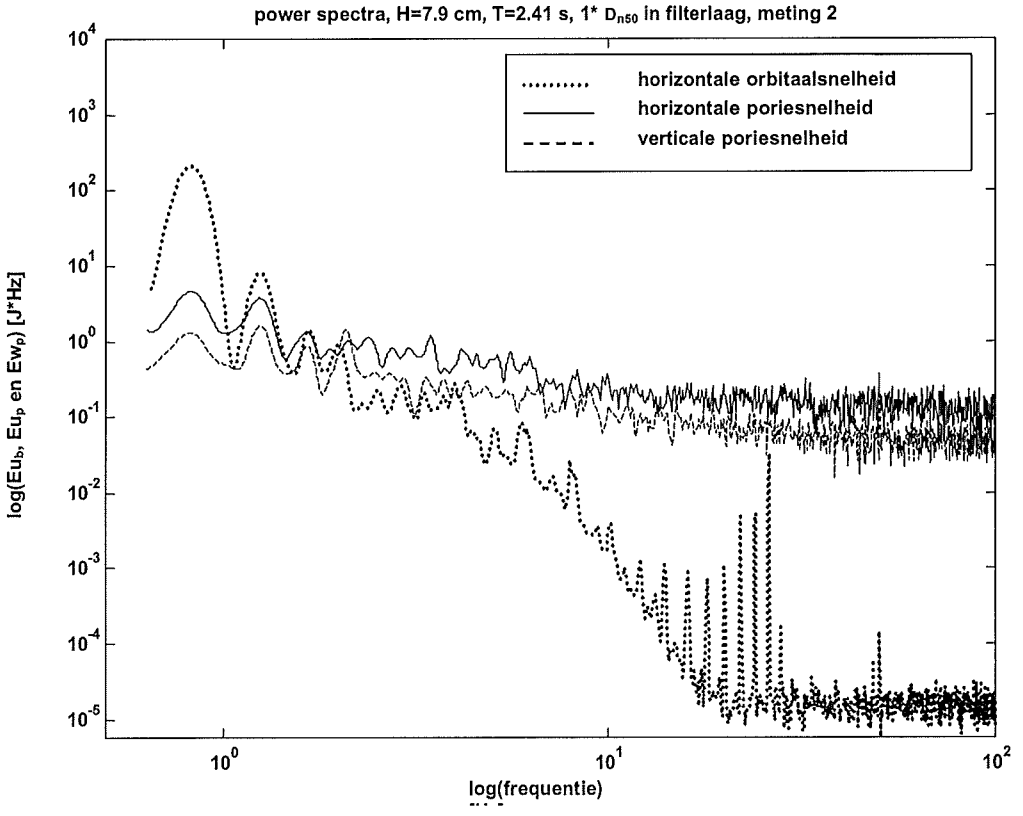


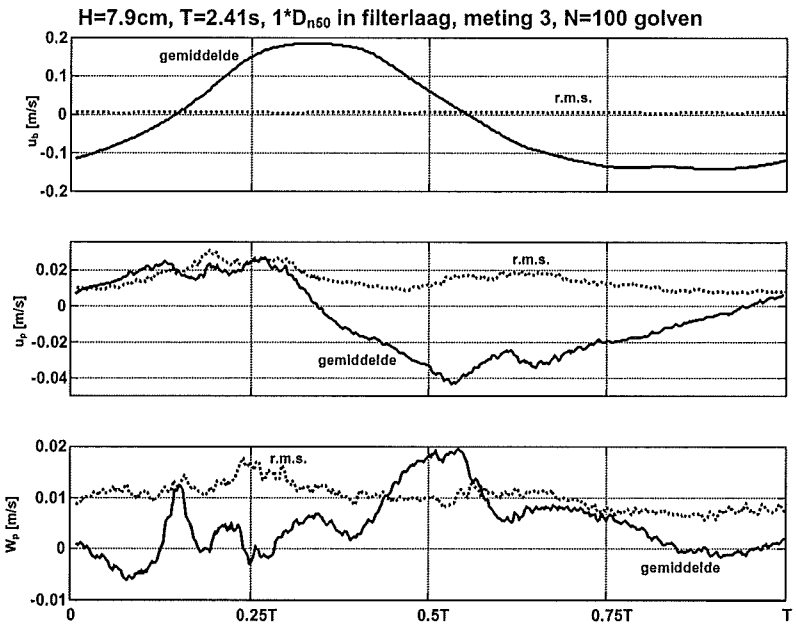
1*D_{n50} in filterlaag, meting 1, H_{gem}= 8,15 cm, T_{gem}= 2,41 s			
$\hat{u}_b$ [m/s]	0.15 – 0.21	u_b' [m/s]	
$\hat{u}_p$ [m/s]	0.03 – 0.04	u_p' [m/s]	0.01 – 0.03
$\hat{w}_p$ [m/s]	0.010– 0.025	w_p' [m/s]	0.005 – 0.023



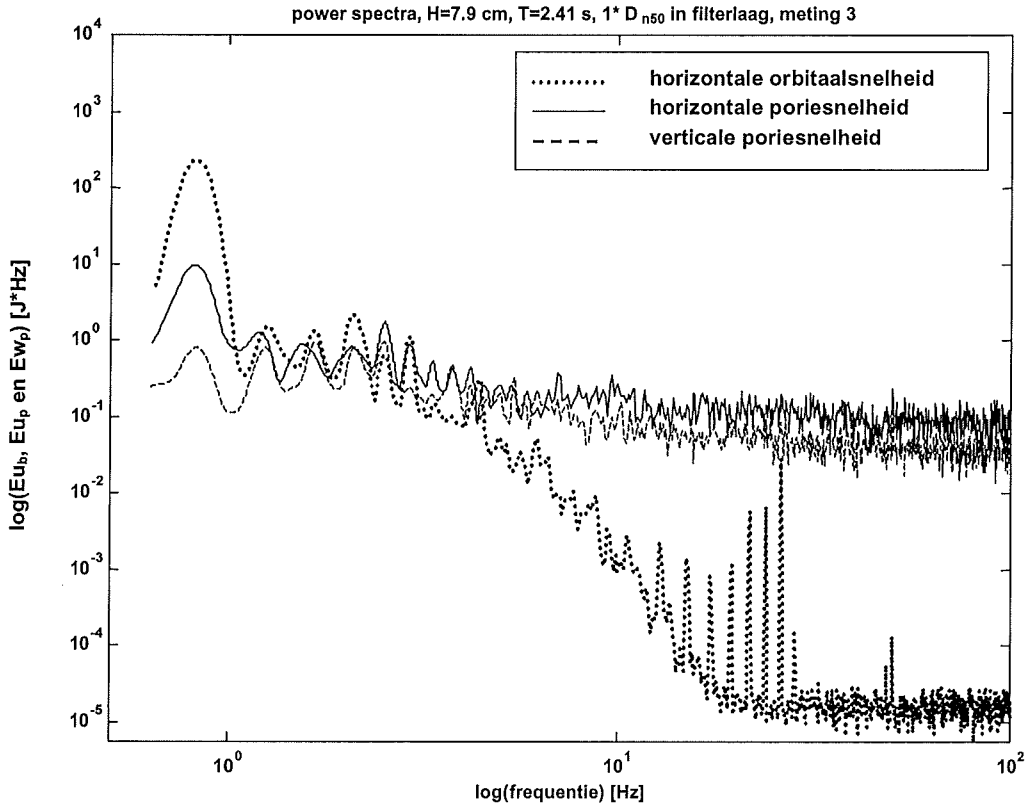


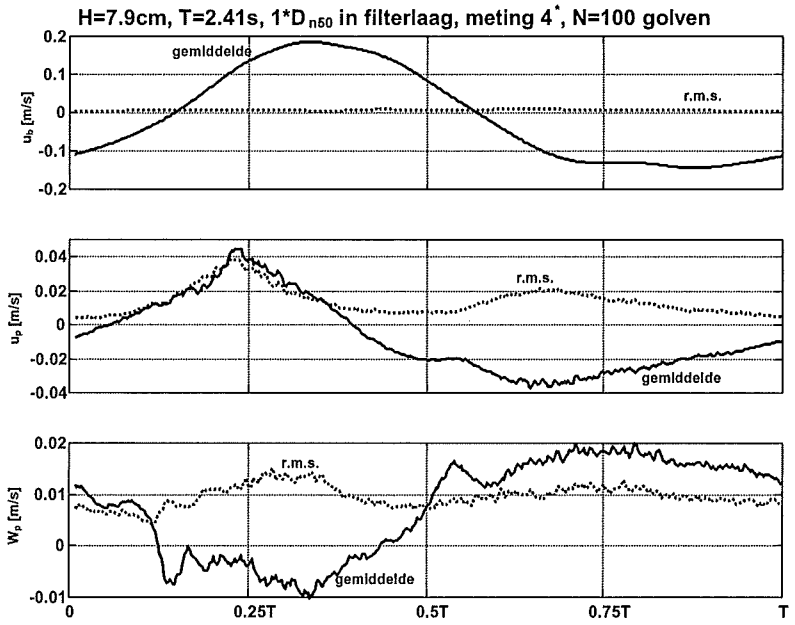
1*D_{n50} in filterlaag, meting 2, H_{gem}= 8,17 cm, T_{gem}= 2,41 s			
$\hat{u}_b$ [m/s]	0.13 – 0.21	u_b' [m/s]	
$\hat{u}_p$ [m/s]	0.03 – 0.04	u_p' [m/s]	0.01 – 0.03
$\hat{w}_p$ [m/s]	0.010 – 0.025	w_p' [m/s]	0.007 – 0.019



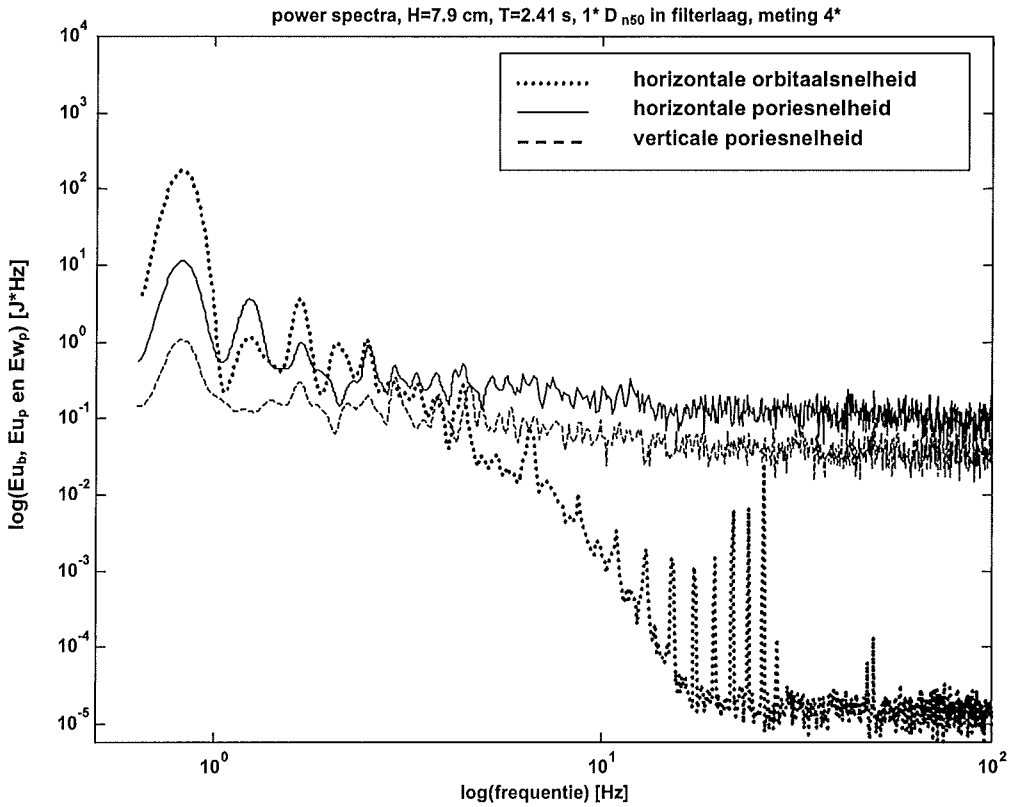


1*D_{n50} in filterlaag, meting 3, H_{gem}= 8,16 cm, T_{gem}= 2,41 s			
$\hat{u}_b$ [m/s]	0.14 – 0.19	u_b' [m/s]	
$\hat{u}_p$ [m/s]	0.03 – 0.05	u_p' [m/s]	0.01 – 0.03
$\hat{w}_p$ [m/s]	0.007 – 0.020	w_p' [m/s]	0.005 – 0.019

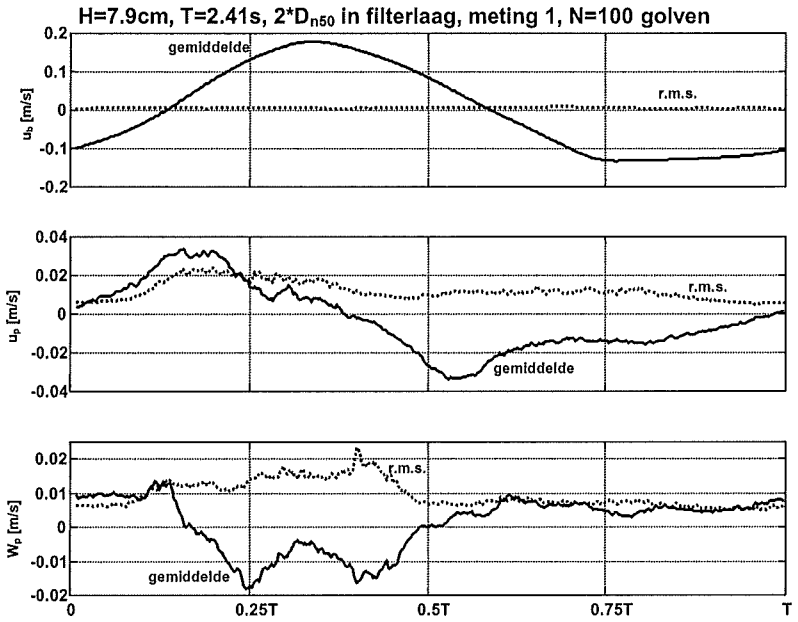




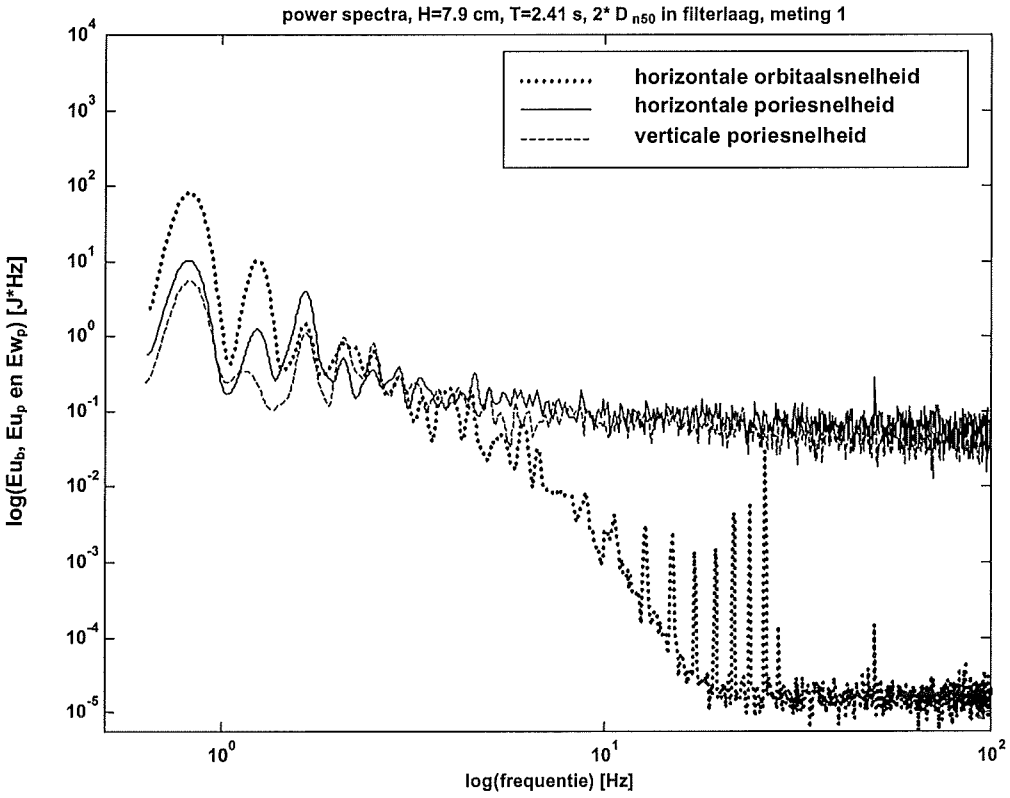
1*D_{n50} in filterlaag, meting 4*, H_{gem}= 8,15 cm, T_{gem}= 2,41 s			
$\hat{u}_b$ [m/s]	0.14 – 0.18	u_b' [m/s]	
$\hat{u}_p$ [m/s]	0.04 – 0.05	u_p' [m/s]	0.01 – 0.04
$\hat{w}_p$ [m/s]	0.011 – 0.022	w_p' [m/s]	0.004 – 0.016

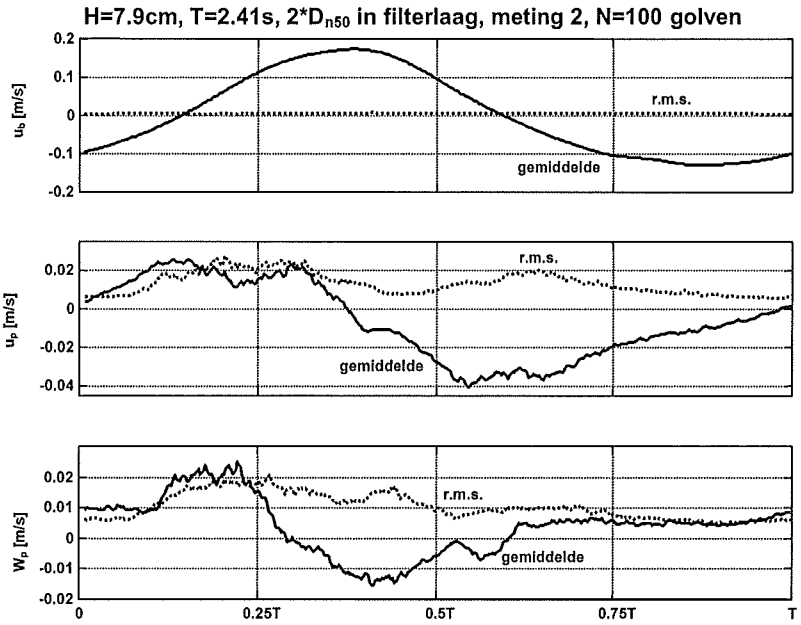


1.4.2 Belastingsgeval D, 2*D_{n50} in filterlaag

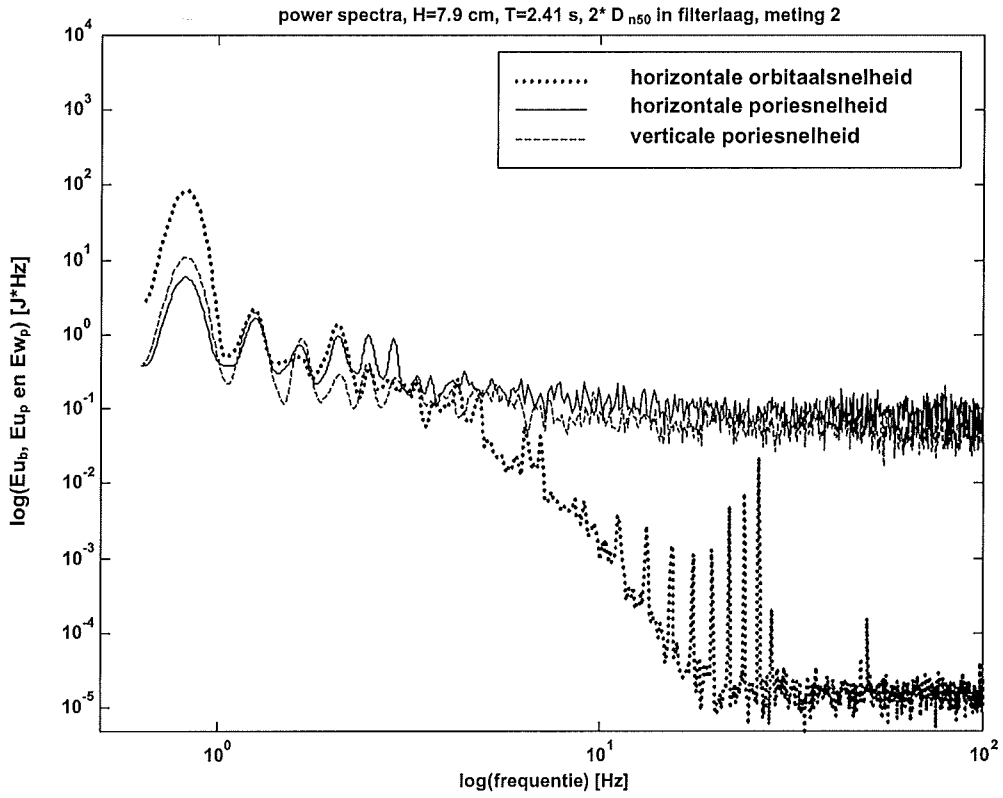


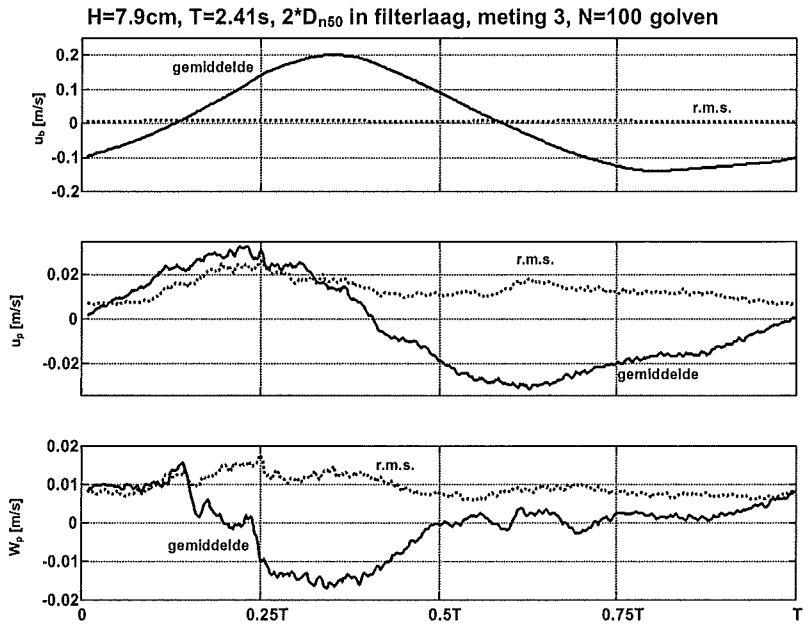
2*D_{n50} in filterlaag, meting 1, H_{gem}= 8,22 cm, T_{gem}= 2,41 s			
$\hat{u}_b$ [m/s]	0.13 – 0.18	u_b' [m/s]	
$\hat{u}_p$ [m/s]	0.03 – 0.04	u_p' [m/s]	0.01 – 0.03
$\hat{w}_p$ [m/s]	0.015 – 0.019	w_p' [m/s]	0.005 – 0.026



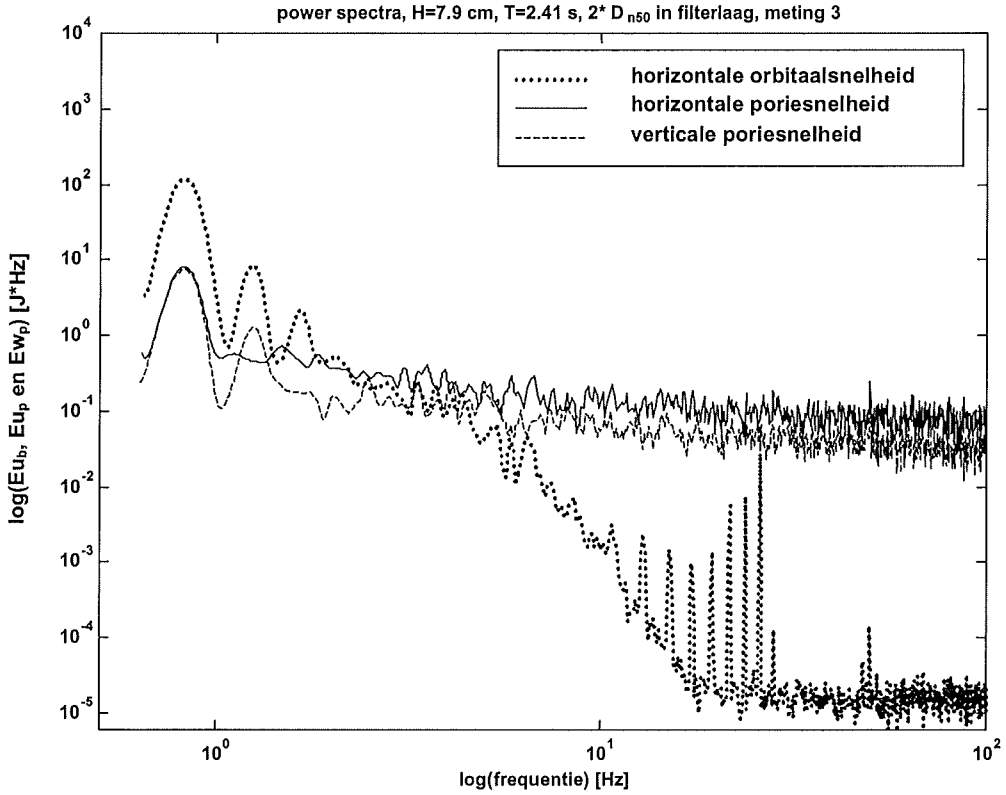


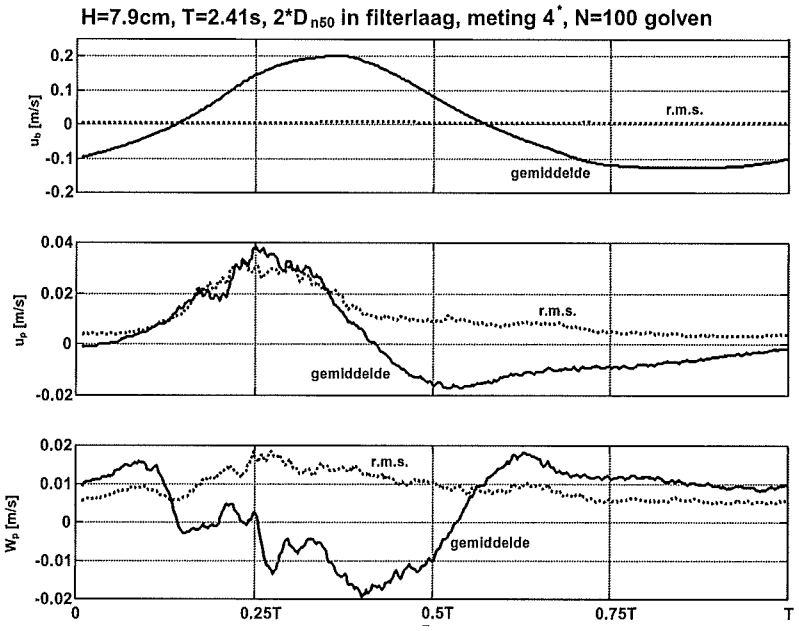
1*D_{n50} in filterlaag, meting 2, H_{gem}= 8,18 cm, T_{gem}= 2,41 s			
$\hat{u}_b$ [m/s]	0.13 – 0.17	u_b' [m/s]	
$\hat{u}_p$ [m/s]	0.03 – 0.04	u_p' [m/s]	0.01 – 0.03
$\hat{w}_p$ [m/s]	0.017 – 0.027	w_p' [m/s]	0.004 – 0.021



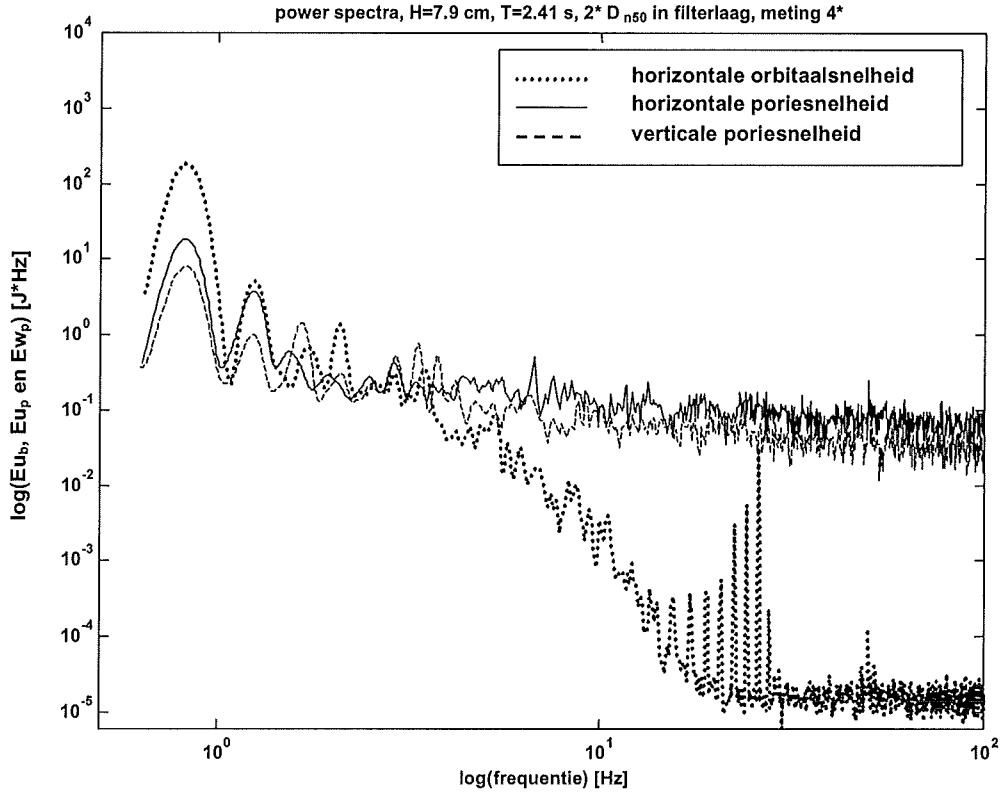


$2*D_{n50}$ in filterlaag, meting 3, H_{gem}= 8,02 cm, T_{gem}= 2,41 s			
$\hat{u}_b$ [m/s]	0.14 – 0.20	u_b' [m/s]	
$\hat{u}_p$ [m/s]	0.03 – 0.04	u_p' [m/s]	0.01 – 0.03
$\hat{w}_p$ [m/s]	0.017 – 0.020	w_p' [m/s]	0.006 – 0.019

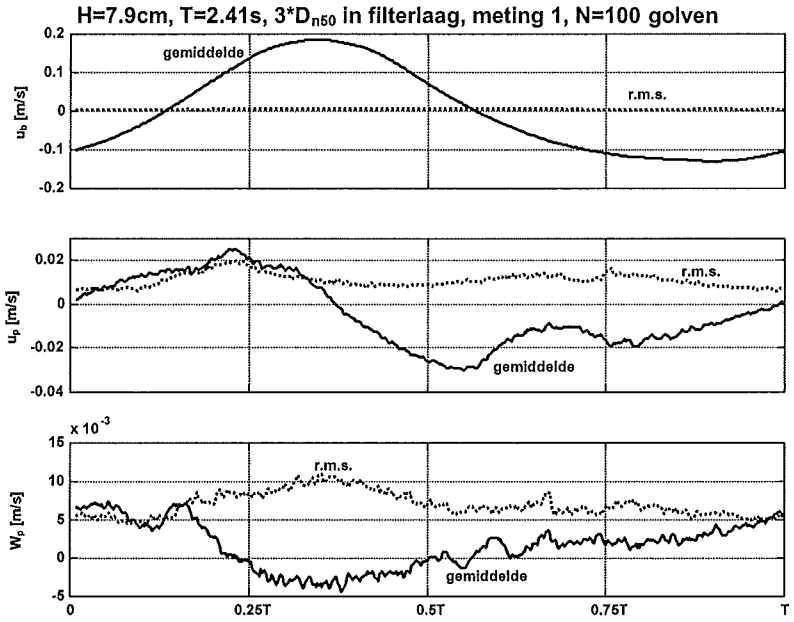




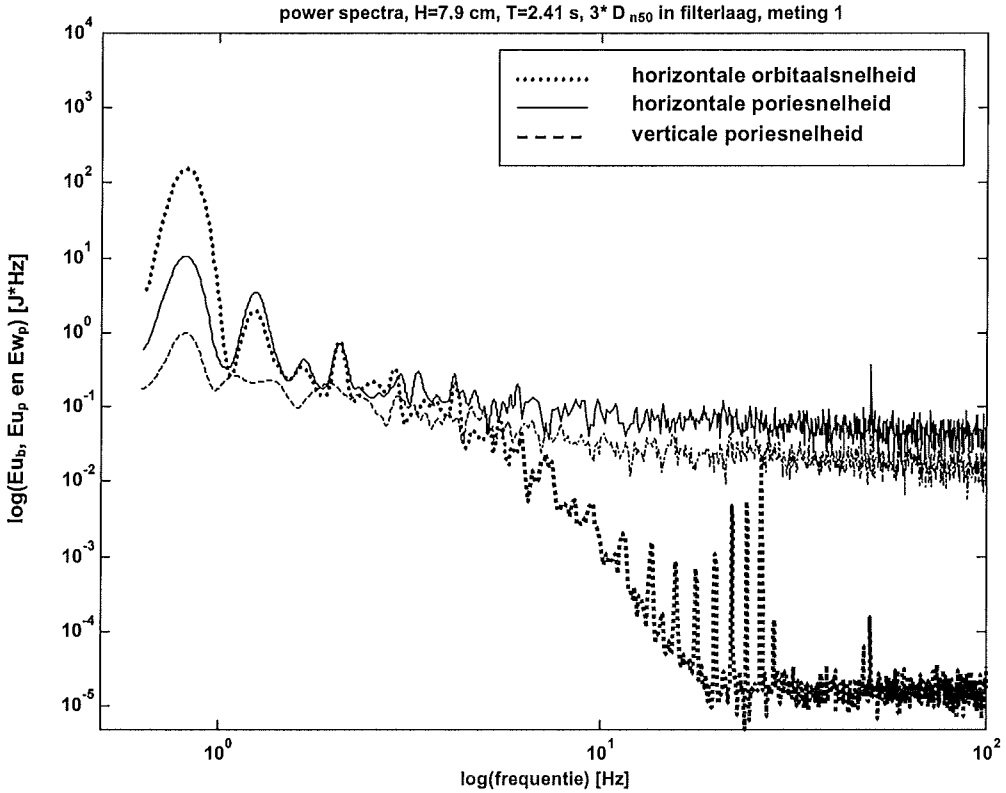
2*D_{n50} in filterlaag, meting 4*, H_{gem}= 8,08 cm, T_{gem}= 2,41 s			
$\hat{u}_b$ [m/s]	0.13 – 0.20	u_b' [m/s]	
$\hat{u}_p$ [m/s]	0.02 – 0.04	u_p' [m/s]	0.01 – 0.03
$\hat{w}_p$ [m/s]	0.019 – 0.021	w_p' [m/s]	0.005 – 0.019

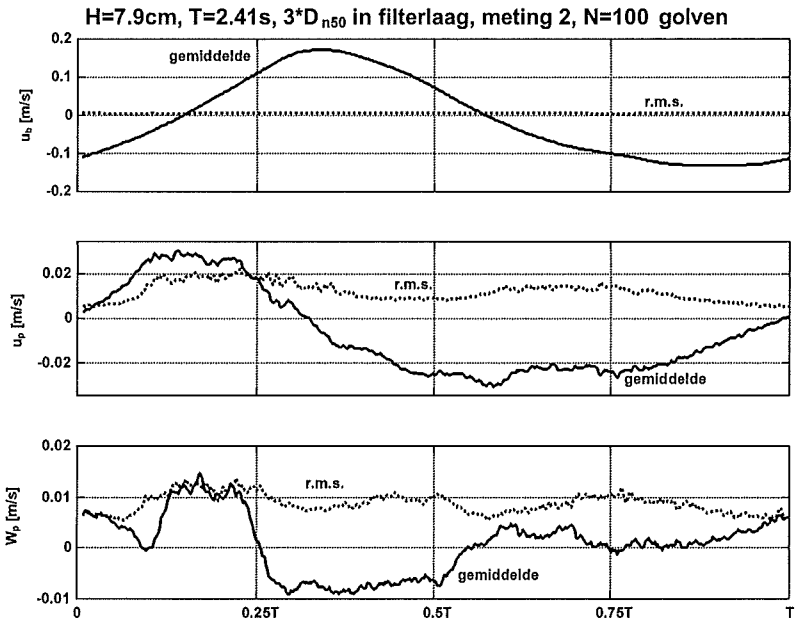


1.4.3 Belastingsgeval D, 3*D_{n50} in filterlaag

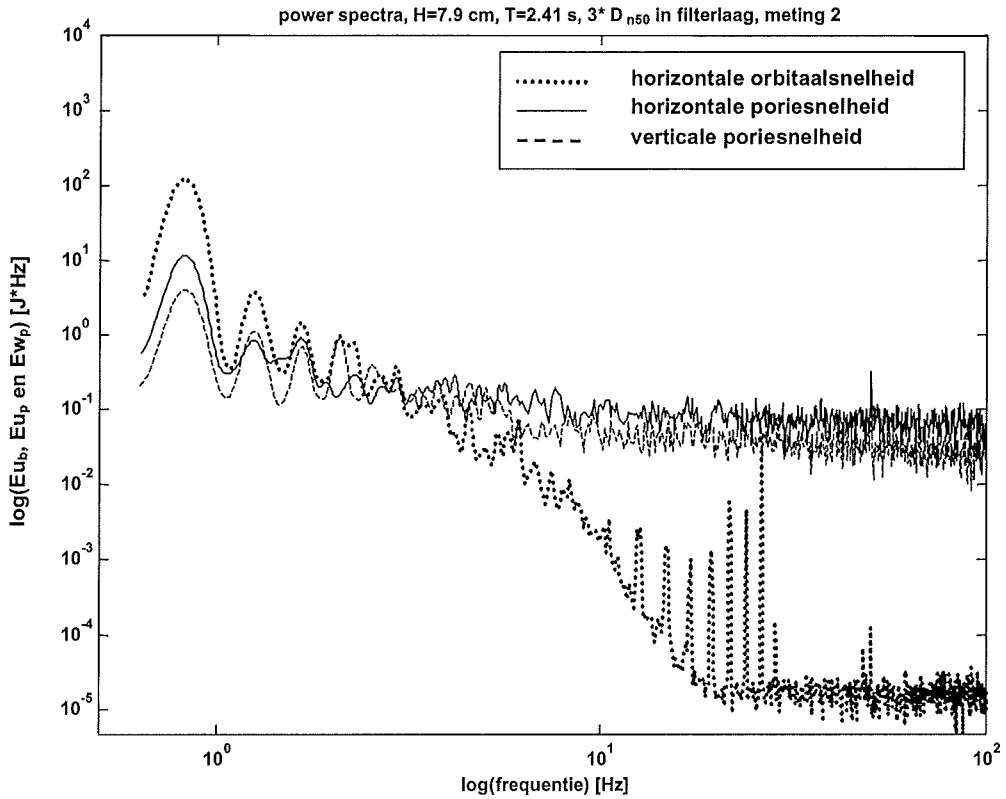


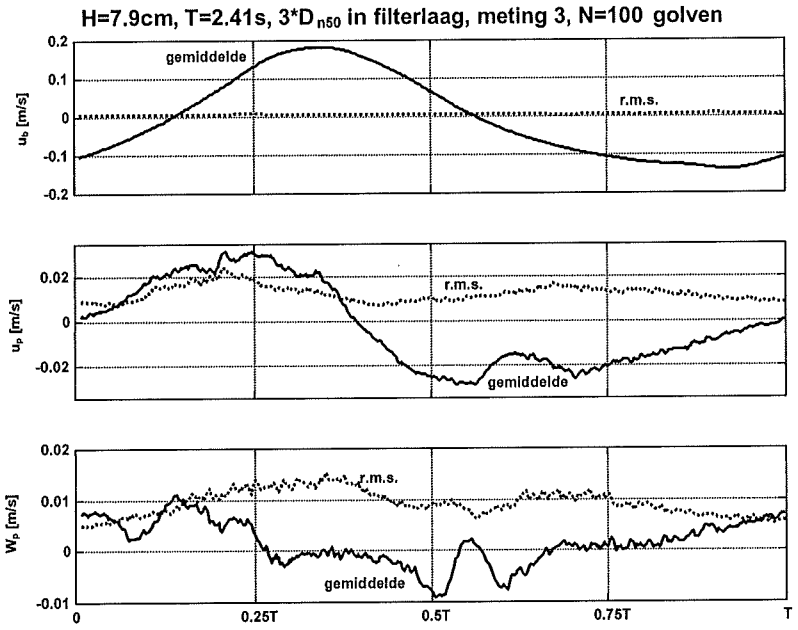
3*D_{n50} in filterlaag, meting 1, H_{gem}= 8,11 cm, T_{gem}= 2,41 s			
$\hat{u}_b$ [m/s]	0.13 – 0.19	u_b' [m/s]	
$\hat{u}_p$ [m/s]	0.03 – 0.03	u_p' [m/s]	0.01 – 0.02
$\hat{w}_p$ [m/s]	0.005 – 0.008	w_p' [m/s]	0.004 – 0.011



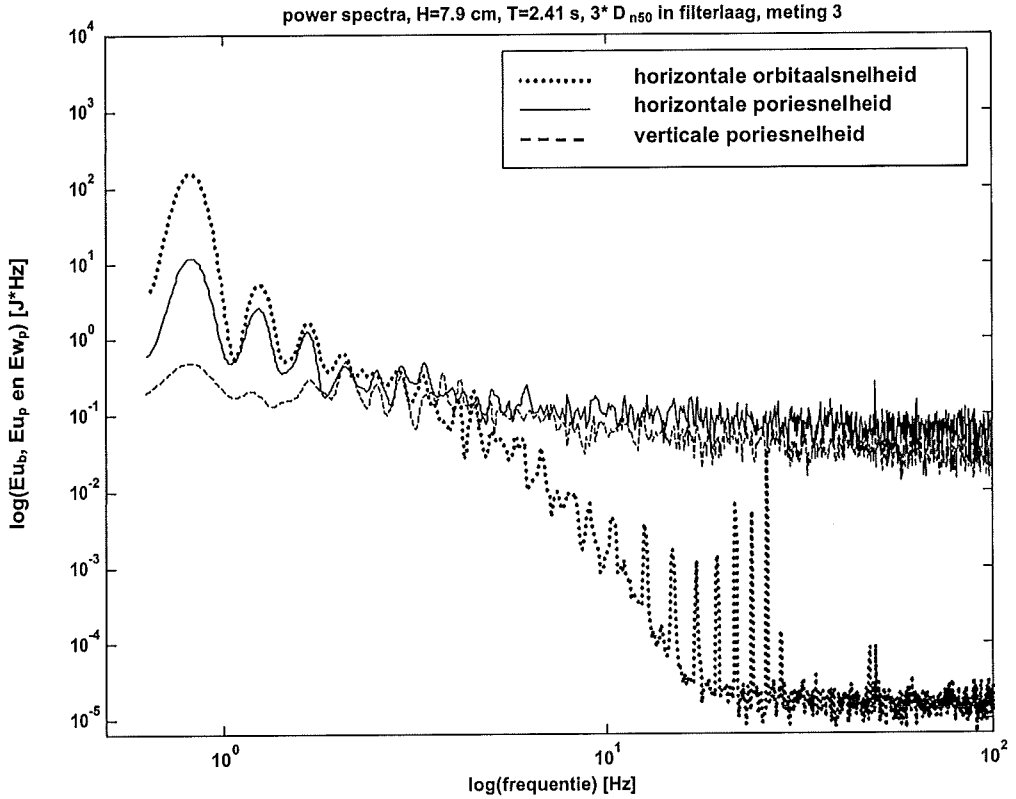


3*D_{n50} in filterlaag, meting 2, H_{gem}= 8,04 cm, T_{gem}= 2,41 s			
$\hat{u}_b$ [m/s]	0.13 – 0.17	u_b' [m/s]	
$\hat{u}_p$ [m/s]	0.03 – 0.03	u_p' [m/s]	0.01 – 0.02
$\hat{w}_p$ [m/s]	0.010 – 0.016	w_p' [m/s]	0.005 – 0.015

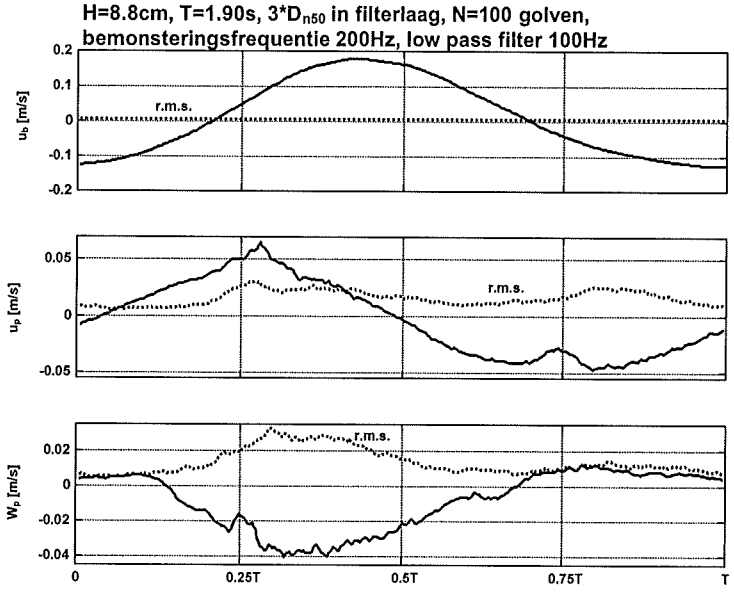




3*D_{n50} in filterlaag, meting 3, H_{gem}= 8,18 cm, T_{gem}= 2,41 s			
$\hat{u}_b$ [m/s]	0.14 – 0.18	u_b' [m/s]	
$\hat{u}_p$ [m/s]	0.03 – 0.03	u_p' [m/s]	0.01 – 0.03
$\hat{w}_p$ [m/s]	0.010 – 0.012	w_p' [m/s]	0.005 – 0.016

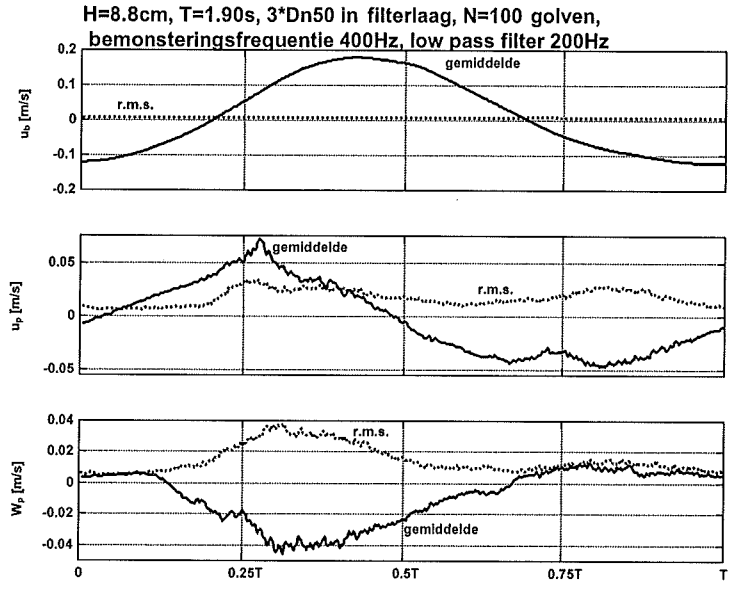


Meetserie 2, bemonsteringsfrequentie 200 Hz



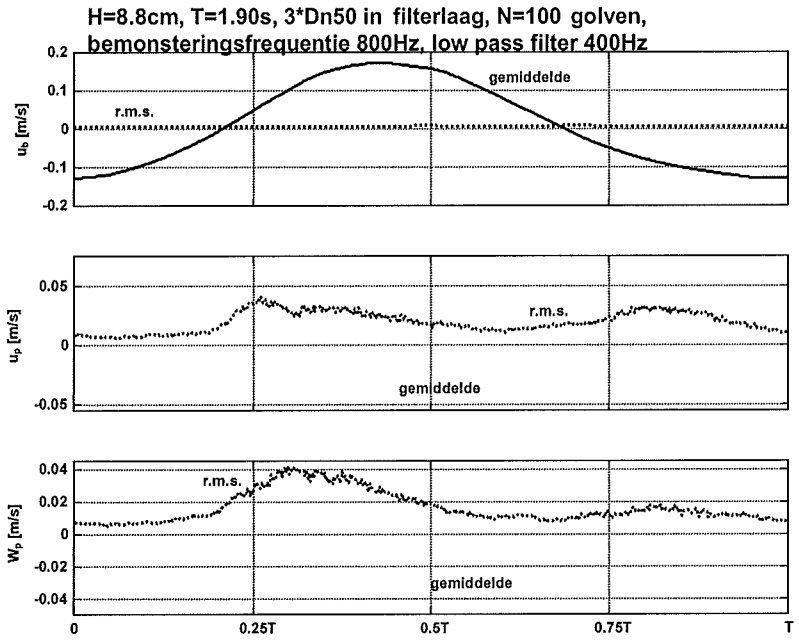
Bemonsteringsfrequentie 200 Hz, H = 8,8 cm, T = 1,90 s			
$\hat{u}_b$ [m/s]	0.18	u_b' [m/s]	
$\hat{u}_p$ [m/s]	0.07	u_p' [m/s]	0.030
$\hat{w}_p$ [m/s]	0.014	w_p' [m/s]	0.033

2.1 Meetserie 2, bemonsteringsfrequentie 400 Hz



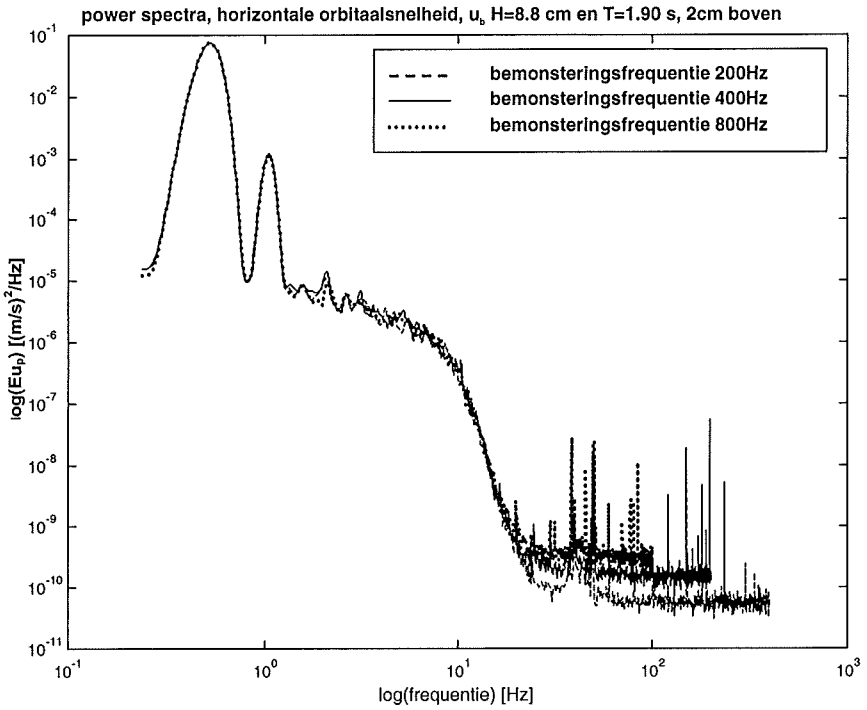
Bemonsteringsfrequentie 400 Hz, H = 8,8 cm, T = 1,90 s			
$\hat{u}_b$ [m/s]	0.18	u_b' [m/s]	
$\hat{u}_p$ [m/s]	0.07	u_p' [m/s]	0.035
$\hat{w}_p$ [m/s]	0.014	w_p' [m/s]	0.038

2.2 Meetserie 2, bemonsteringsfrequentie 800 Hz

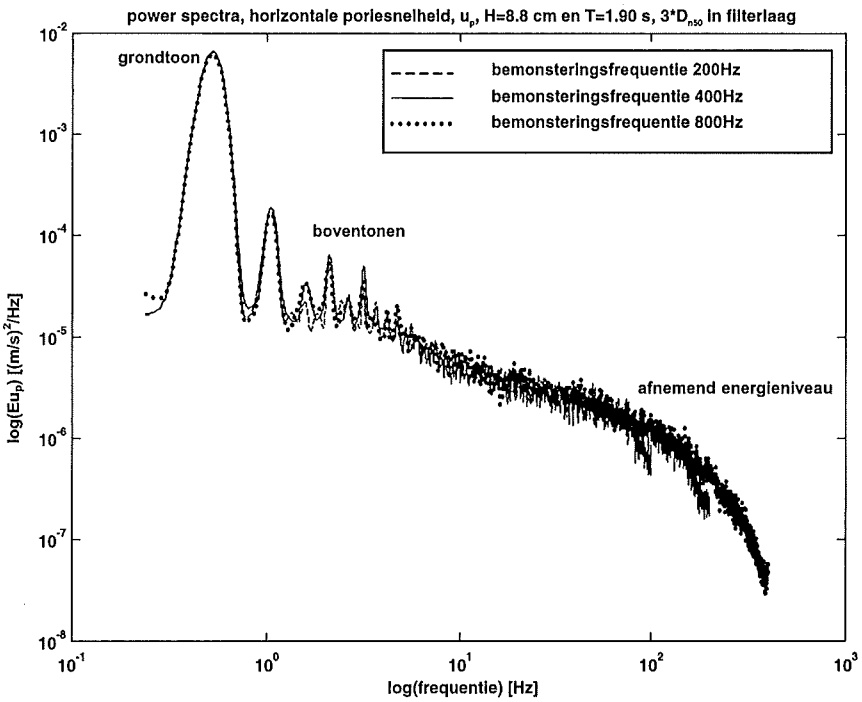


Bemonsteringsfrequentie 800 Hz, H = 8,8 cm, T = 1,90 s			
$\hat{u}_b$ [m/s]	0.18	u_b' [m/s]	
$\hat{u}_p$ [m/s]	0.07	u_p' [m/s]	0.041
$\hat{w}_p$ [m/s]	0.015	w_p' [m/s]	0.044

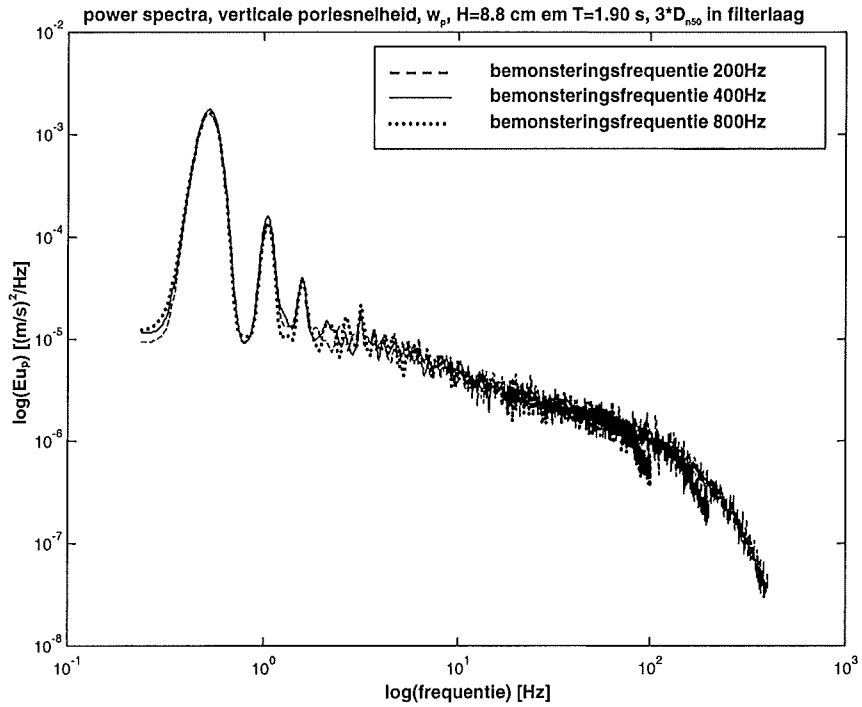
2.3 Powerspectra, horizontale orbitaalsnelheid, 200, 400 en 800 Hz



2.4 Powerspectra, horizontale poriesnelheid, 200, 400 en 800 Hz



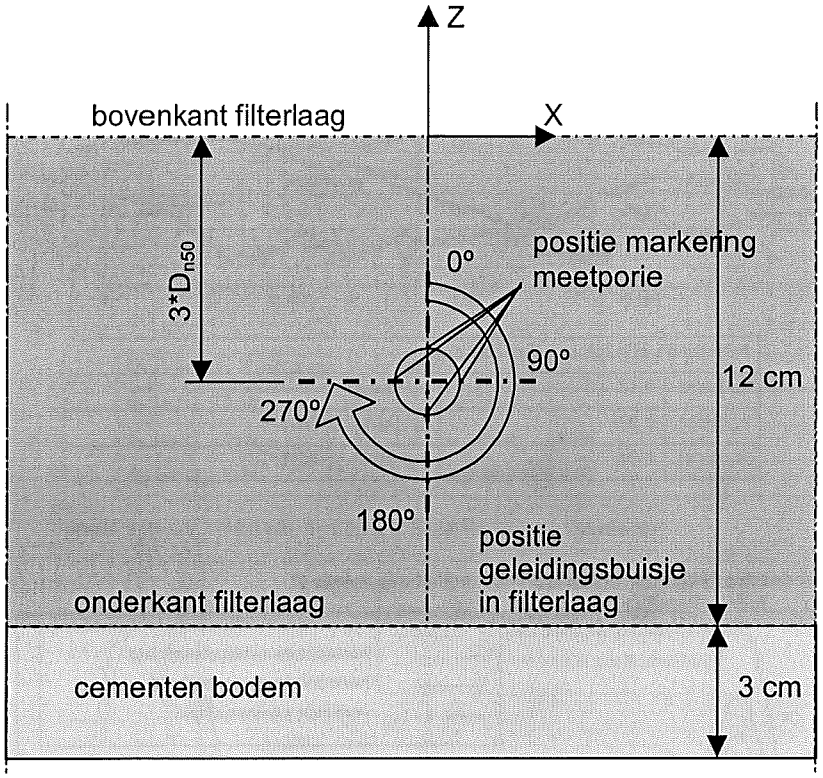
2.5 Powerspectra, verticale poriesnelheid, 200, 400 en 800 Hz



3 Meetserie 3, gevoeligheid verschillende oriëntaties meetporie

3.1 Gevoeligheid voor verschillende oriëntaties meetporie

De derde meetserie dient om het effect van verschillende oriëntaties van de meetporie te onderzoeken. Tijdens *meetserie 1* en *meetserie 2* is de meetporie telkens in dezelfde stand tussen de geleidingsbuisjes geplaatst. Om verschillende oriëntaties te onderzoeken wordt de meetporie om de as van de geleidingsbuisjes geroteerd, waarbij een viertal standen is onderzocht. Bij de eerste meting is de rotatie 0° , hetgeen inhoudt dat de oriëntatie van de meetporie gelijk is aan de oriëntatie in voorgaande experimenten. De meetporie maakt hierna bij iedere opeenvolgende meting een hoekverdraaiing van 90° (zie onderstaande figuur).



Ook bij deze meetserie wordt één belastingsgeval op één positie in de filterlaag te onderzocht, namelijk belastingsgeval C, $3*D_{n50}$ in de filterlaag. In onderstaande tabel is een aantal gegevens van de verschillende metingen weergegeven.

golfbelasting	golfhoogte [cm]	golfperiode [s]	meetduur [s]	rotatie [°]	aantal metingen
C	8,8	1,90	200	0	1
C	8,8	1,90	200	90	1
C	8,8	1,90	200	180	1
C	8,8	1,90	200	270	1
totaal aantal metingen meetserie 3					4

Tijdens meetserie 3 is de bemonsteringsfrequentie 400 Hz voor alle belastingsgevallen. Bij deze meetserie was er een analoog lowpass-filter tussen de meetapparatuur en de A/D-convertor geplaatst.

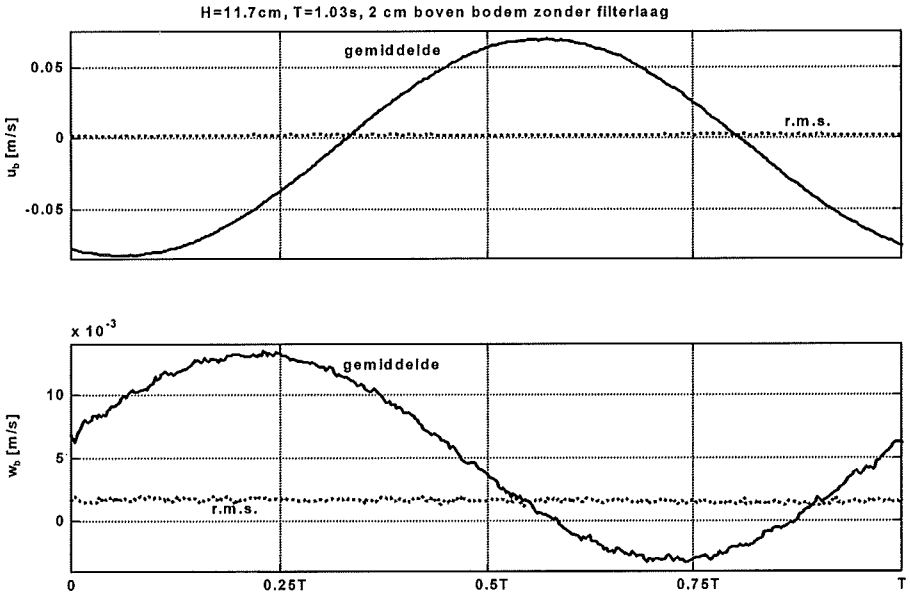
7 Meetserie 7, snelheidsmetingen zonder filterlaag

De zevende meetserie bestaat uit snelheidsmetingen met de LDFM op 2 cm boven de cementen bodem, zonder filterlaag. Halter (1999) heeft voor de situatie zonder filterlaag ook een aantal kritieke golfbelastingen bepaald. Hierbij zijn met een EMS snelheden gemeten op 2 cm boven de bodem. We zijn geïnteresseerd in de overeenkomst tussen de kritieke golfbelastingen met en zonder filterlaag en de grootte van de fluctuaties boven de bodem. Daarom wordt om dezelfde reden als genoemd in de vorige paragraaf de EMS vervangen door de LDFM. In onderstaande tabel is een aantal gegevens van de metingen weergegeven.

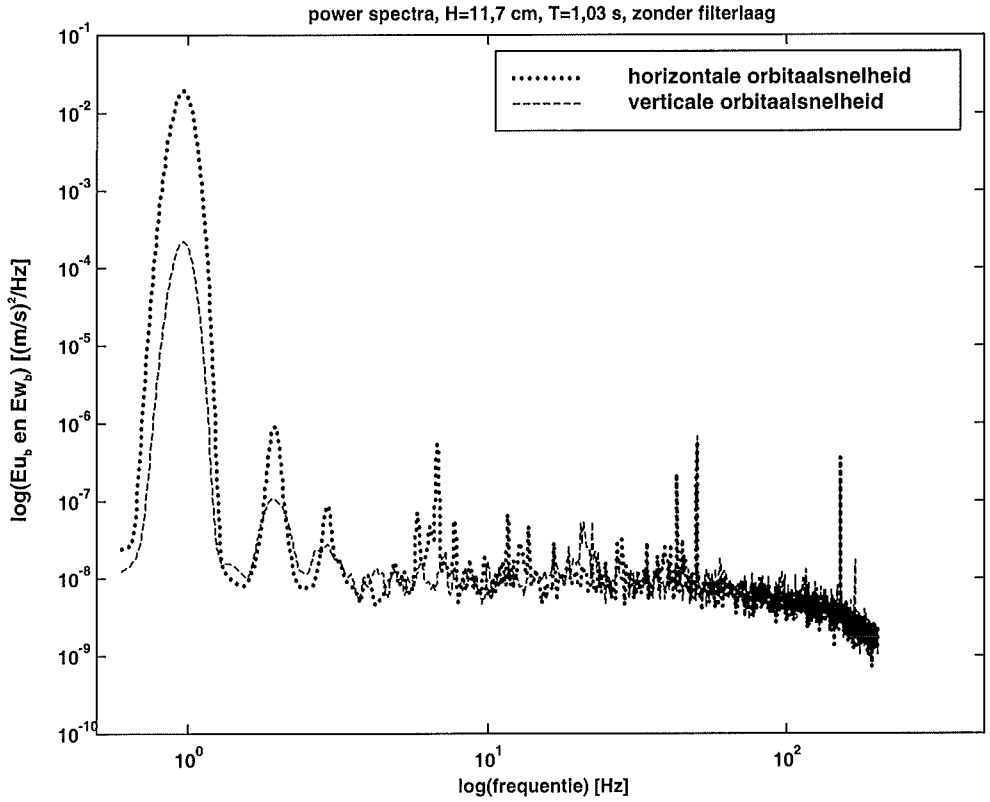
golfbelasting	golfhoogte [cm]	golfperiode [s]	meetduur [s]	aantal metingen
A	11,7	1,03	110	1
B	7,0	1,33	140	1
C	6,3	1,90	200	1
D	5,1	2,41	250	1
totaal aantal metingen meetserie 7				4

Tijdens meetserie 7 is de bemonsteringsfrequentie 400 Hz voor alle belastingsgevallen. Bij deze meetserie was er een analoog lowpass-filter tussen de meetapparatuur en de A/D-convertor geplaatst.

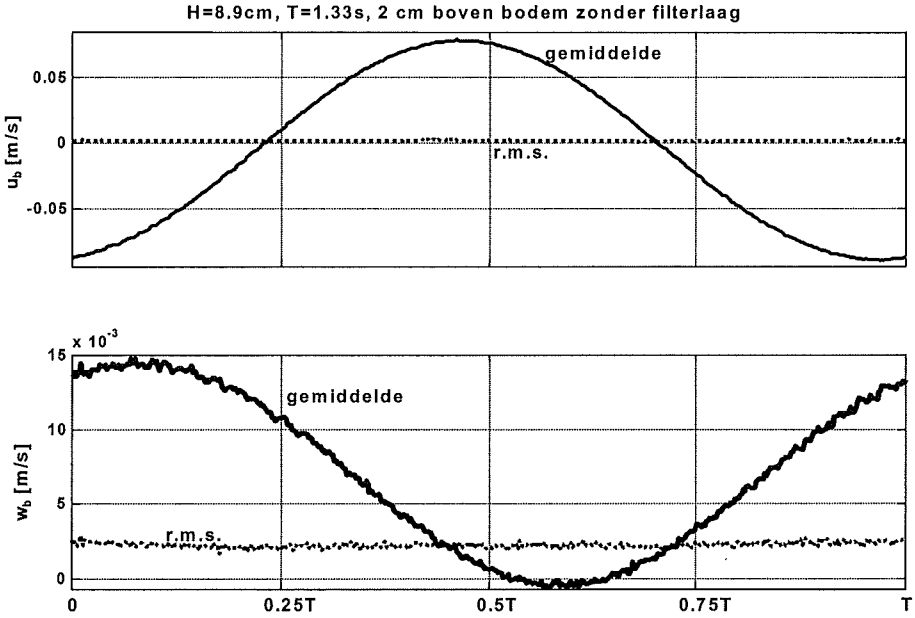
7.1 Meetserie 7, belastingsgeval Azf



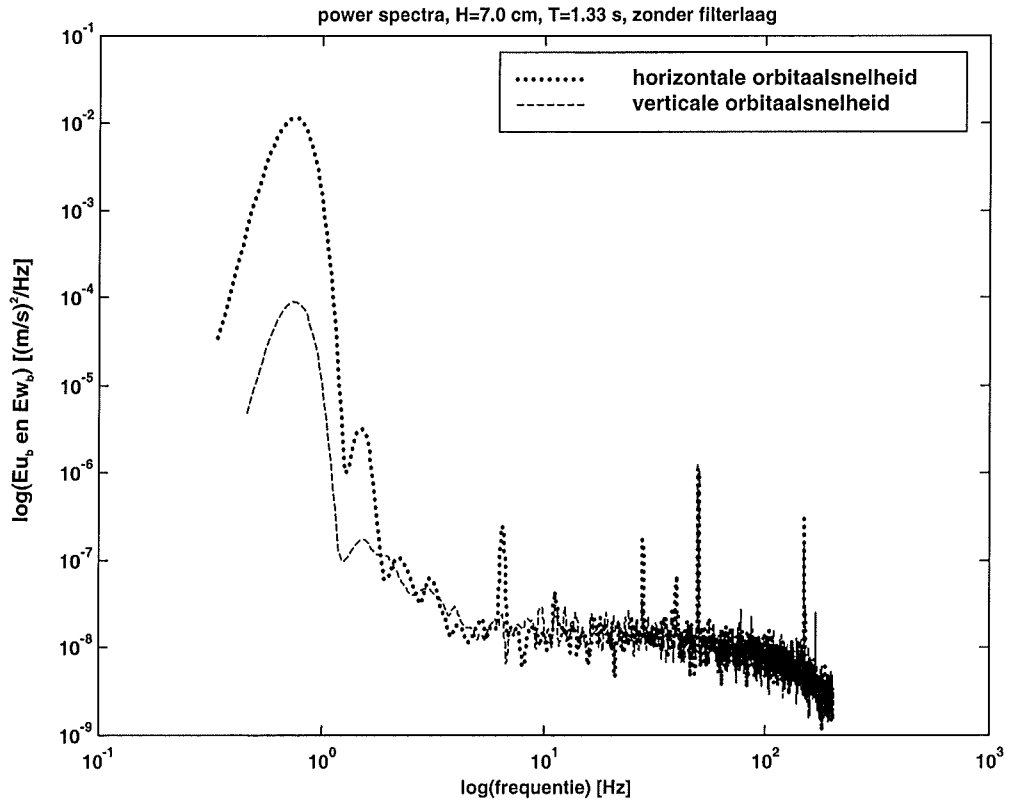
Zonder filterlaag, 2 cm boven bodem , H_{gem}= 16,7 cm, Tgem= 1,03 s			
$\hat{u}_p$ [m/s]	0.07 – 0.08	u_p' [m/s]	0.04
$\hat{w}_p$ [m/s]	0.014	w_p' [m/s]	0.0035



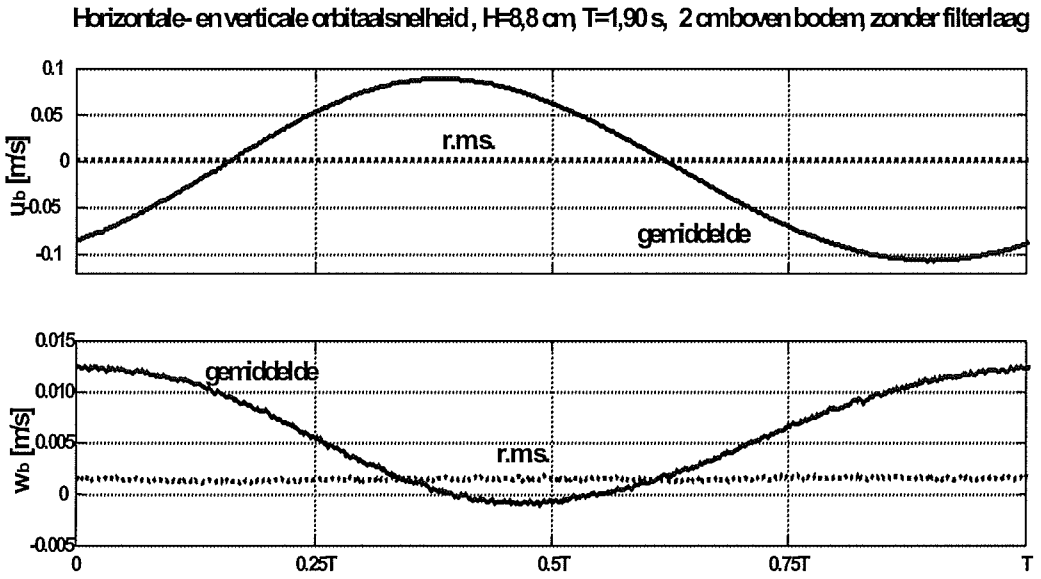
7.2 Meetserie 7, belastingsgeval Bzf



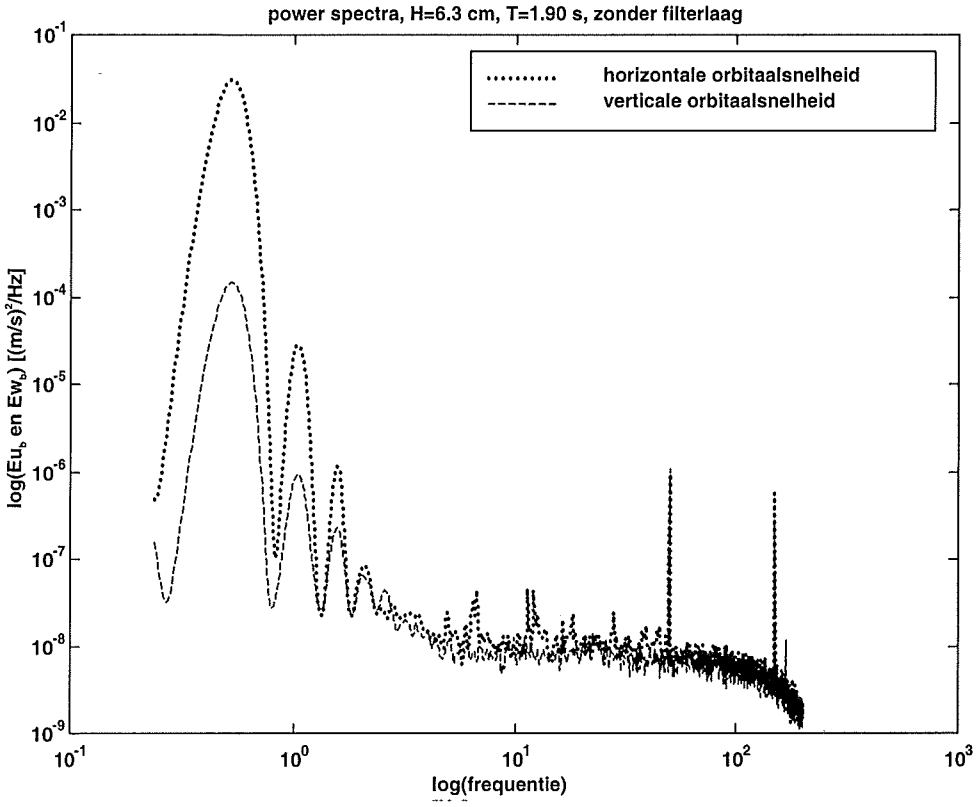
Zonder filterlaag, 2 cm boven bodem , H_{gem}= 8,9 cm, Tgem= 1,33 s			
$\hat{u}_p$ [m/s]	0.08 – 0.09	u_p' [m/s]	0.04
$\hat{w}_p$ [m/s]	0.015	w_p' [m/s]	0.0063



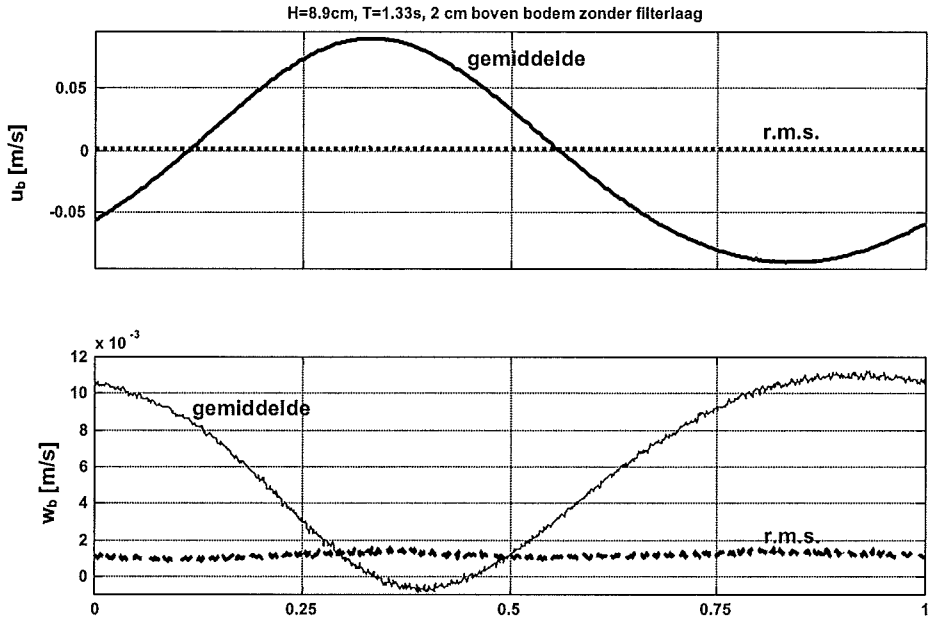
7.3 Meetserie 7, belastingsgeval Czf



Zonder filterlaag, 2 cm boven bodem , H_{gem}= 8,8 cm, Tgem= 1,90 s			
$\hat{u}_p$ [m/s]	0.09 – 0.10	u_p' [m/s]	0.04
$\hat{w}_p$ [m/s]	0.013	w_p' [m/s]	0.0062



7.4 Meetserie 7, belastingsgeval Dzf



Zonder filterlaag, 2 cm boven bodem , H_{gem}= 7,9 cm, Tgem= 2,41 s			
$\hat{u}_p$ [m/s]	0.09	u_p' [m/s]	0.03
$\hat{w}_p$ [m/s]	0.011	w_p' [m/s]	0.0055