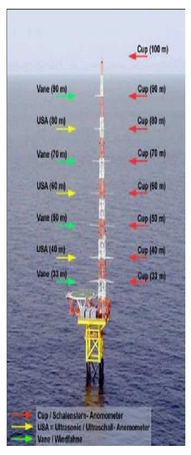
WRF and The Marine Boundary Layer

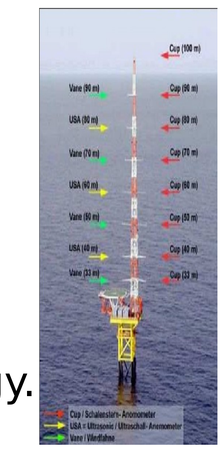
One year run with five different PBL-schemes

PhD-candidate Olav Krogsæter, University of Bergen / StormGeo, olav.krogsaeter@stormgeo.com
Supervisor: Prof. Dr. Joachim Reuder (UiB). Co-supervisor: Dr. Gard Hauge (StormGeo)

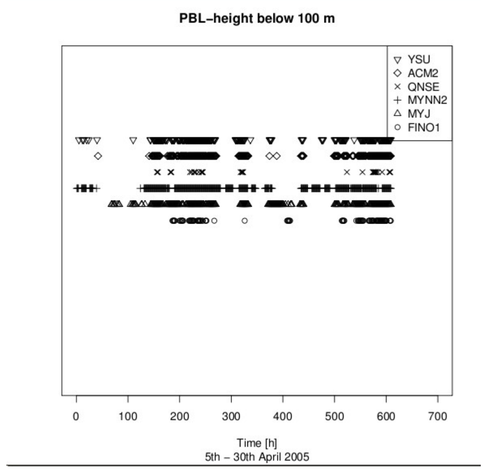


Offshore wind energy is a rapidly growing field worldwide, both in a scientific, engineering, and in an economical point of view. In Europe 150 GW offshore wind projects are already in different planning stages, and at the time of writing 1247 offshore wind turbines are installed and connected to the European power grid.

This study aims to get a better understanding of the processes in the MBL. Of particular interest is the mean wind speed, turbulence, parametrization schemes, and how ocean waves are interacting with the wind field, with application to offshore wind energy. To perform this we have run the WRF3.2.1-model for a whole year with 5 different PBL-schemes: YSU, ACM2, MYJ, MYNN2, and QNSE. This implies almost 700 000 CPU hours. The results are verified against data from the German research platform FINO1 in Southern North Sea. Recently StormGeo has finished the set up of a two-way coupled atm.-wave system, WRF-SWAN, which will be tested during the next months.



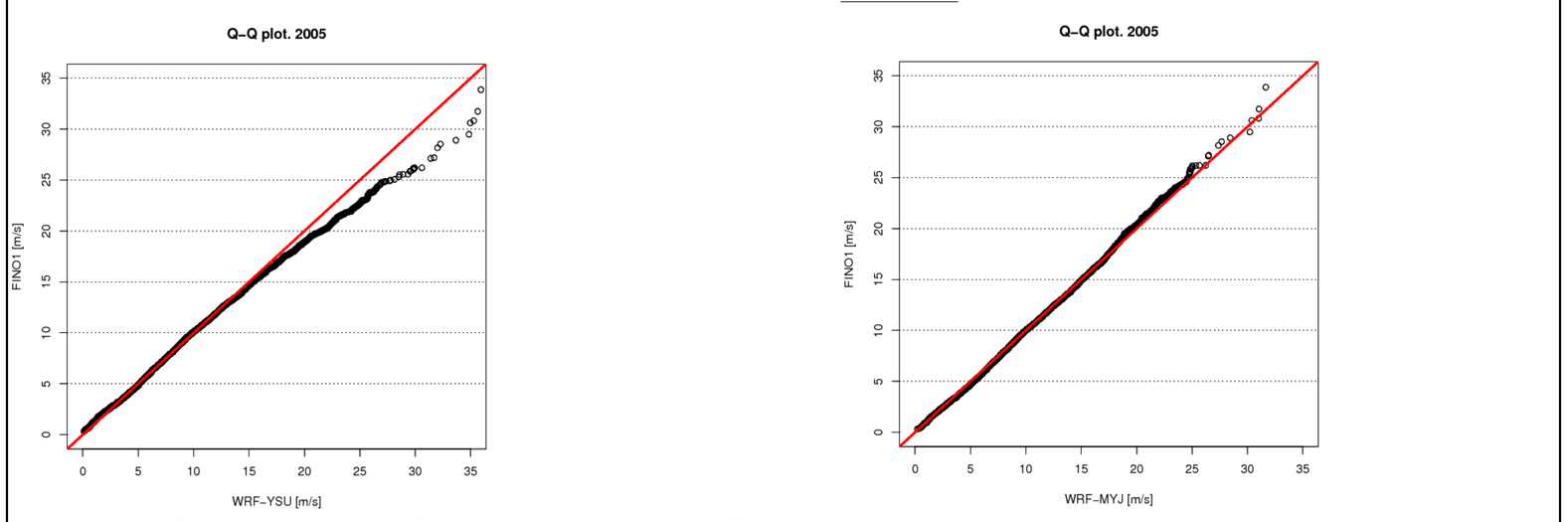
Pbl-height



The Planetary Boundary Layer height varies alot among the different turbulence schemes. It is computed in many different ways, but one common feature is that the PBL-height is too low most of the time compared with observations from FINO1. The exception is the QNSE scheme with far too high boundary layers.

During spring the PBL-height is *below* 100 m 15-20 % of the time. This implies that the use of power laws or the logarithmic wind profile is not valid for longer periods of time.

100 m level wind speed



Examples of QQ-plot for the whole year of 2005 with WRF_YSU scheme (left) and WRF_MYJ scheme (right) compared with FINO1 data. It is clearly seen that the YSU scheme overestimates the wind speed, especially from 15m/s. The MYJ scheme show much better perfomance.

Objective hit Score, OhitS

A method for statistically comparing several model runs with point observations is developed. The OhitS method uses the median, mean error (bias), mean absolute error, standard deviation, and 1st and 3rd quantile of the model variables and observations.

The model statistics closest to the observation statistics gets «# of tested models – 1» points. In this case 4 points, the second best gets 3 points, etc.

Example, Jan.-2005, 100 m level wind speed:

Jan_05							
Wind, 100m	1st Qu	Median	3rd Qu	Mean error	Mean absolute error	Standard deviation	OhitS points
Fino1	12,66	16,68	20,49			5,26	
WRF-YSU	13,02	17,42	22,02	1,15	2,03	6,11	0
WRF-MYJ	12,45	16,88	20,12	-0,15	1,63	5,07	17
WRF-QNSE	12,89	17,04	20,12	0,05	1,70	4,97	14
WRF-MYNN2	12,61	17,36	21,85	0,82	1,91	5,97	10
WRF-ACM2	12,73	16,69	20,17	-0,11	1,61	5,01	21

For Jan-05 we see that the YSU scheme has lowest score compared with the observations on every statistical parameter used in the method, And then get 0 OhitS points. The ACM2 scheme has the best score in three out of six statistical parameters, and is second best for the other three, which gives 4+4+4+3+3+3=21 points in this case.

Summary Ohits points, 2005

	Ohits points
MYJ	175
MYNN2	169
ACM2	160
QNSE	155
YSU	134

The table above show that the MYJ and MYNN2 schemes have the highest score, while the YSU scheme clearly has the lowest score. This applies for 100 m level wind speed.

Ohits score dependencies on PBL-height

PBL-height < 200 m	Ohits points
MYNN2	105
MYJ	95
YSU	89
QNSE	76
ACM2	65

PBL-height > 200 m	Ohits points
ACM2	86
MYJ	64
QNSE	63
MYNN2	58
YSU	34

The different PBL-schemes get different scores depending on PBL-height. The MYJ scheme get high scores *independent* on PBL-height/stratification.