Royal Netherlands
Meteorological Institute
Ministry of Transport, Public Works and Water Management

Impact of wind gusts on sea surface height in storm surge situations.

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Wind forcing in WAQUA/DCSM

- Shallow water model for the North Sea: WAQUA/DCSM (v5, res ~ 8 km)
- Forced by hourly averaged winds from HiRLAM
- Drag relation, Charnock relation:

$$\tau = \rho_a C_d u^2$$

Drag coeff. throug Charnock relation

$$u = u_m + u'$$

$$< u' >= 0 \quad < u'^2 >= \sigma^2$$

$$< u^2 >= u_m^2 + \sigma^2$$

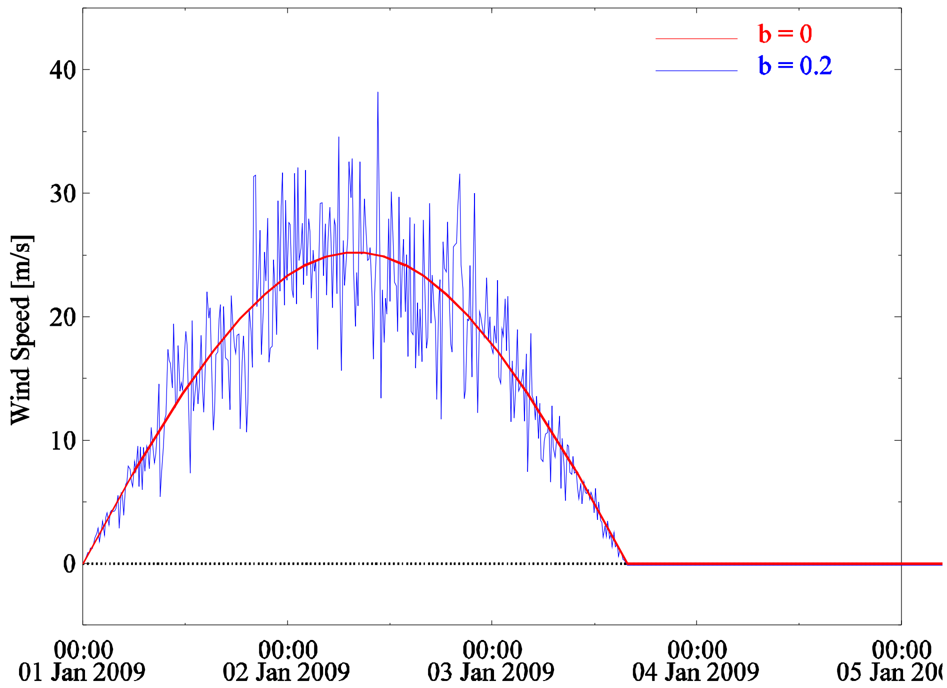
What happens when taking u' not zero? It has an impact on the surge

Monte Carlo experiments in WAQUA

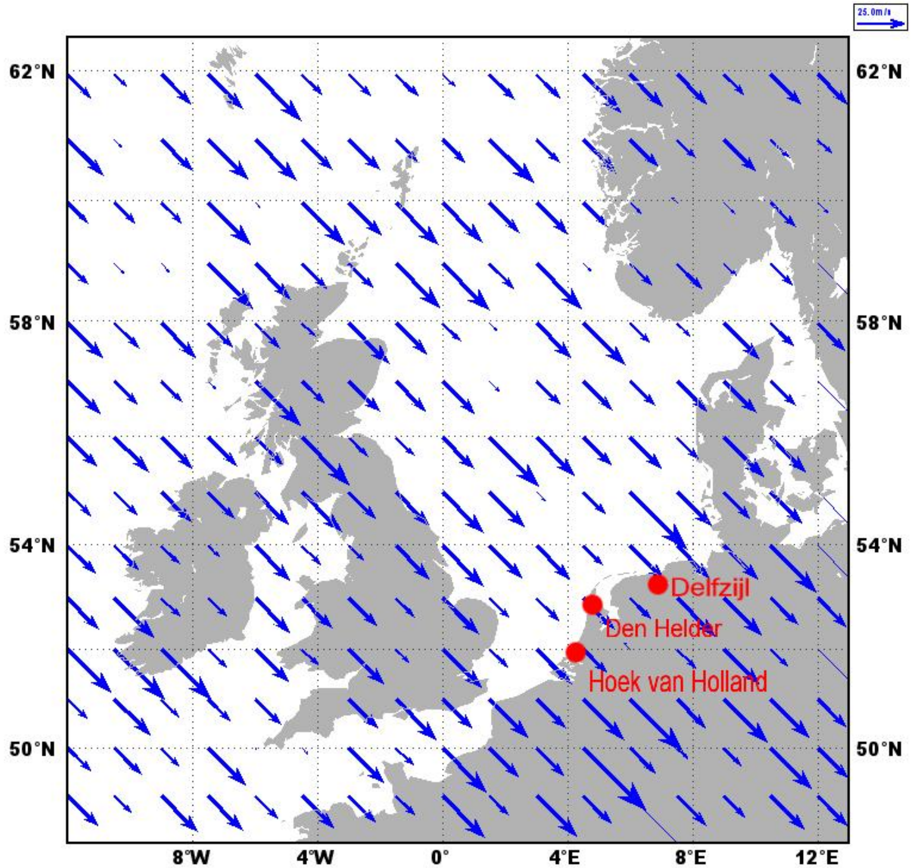
- Forced by theoretical wind field
- Run on the North Sea Domain by WAQUA/DCSM.
- Time step 10 min.
- Mean wind is uniform in space
- Normally distributed random deviations of the wind field:
- $u = u_m + u'$

$$\mu = 0, \quad \sigma = b \cdot u_m$$

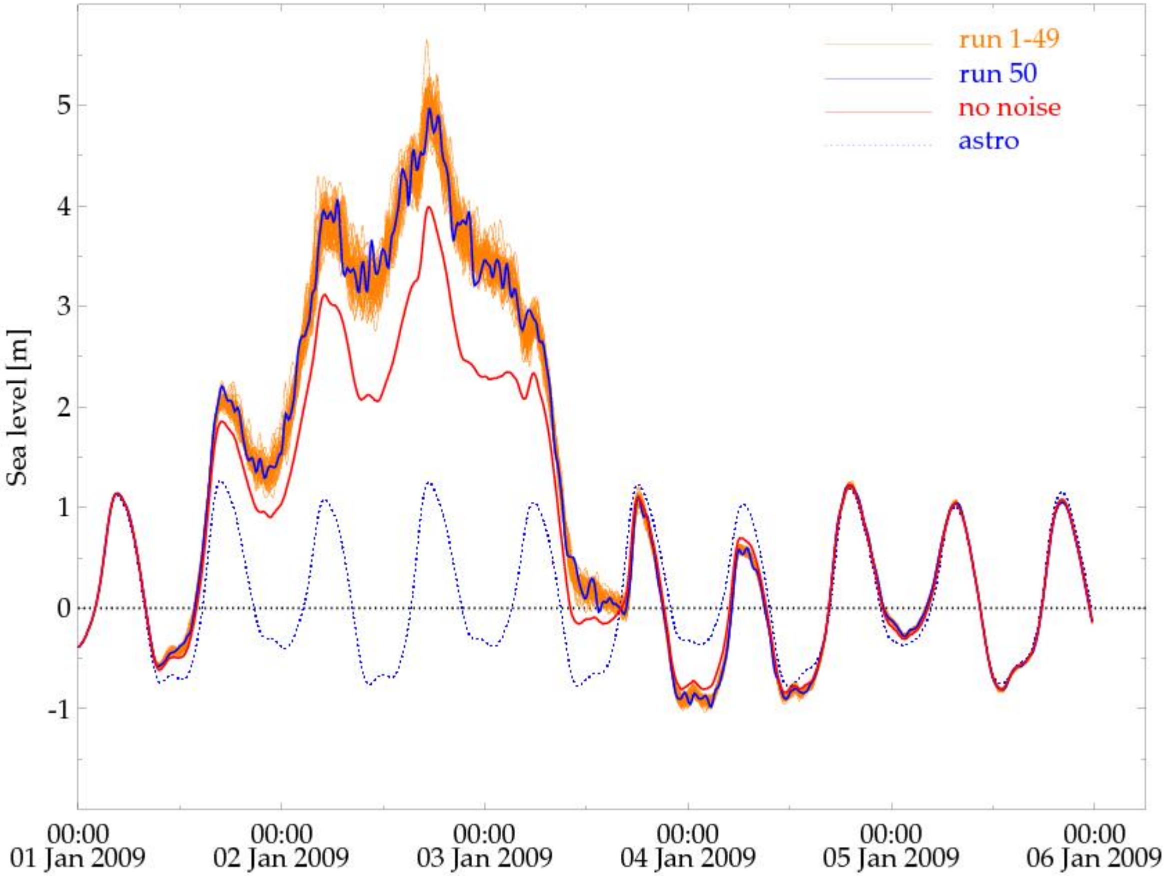
- Cross component zero
- Run on astro tide 1st January 2009



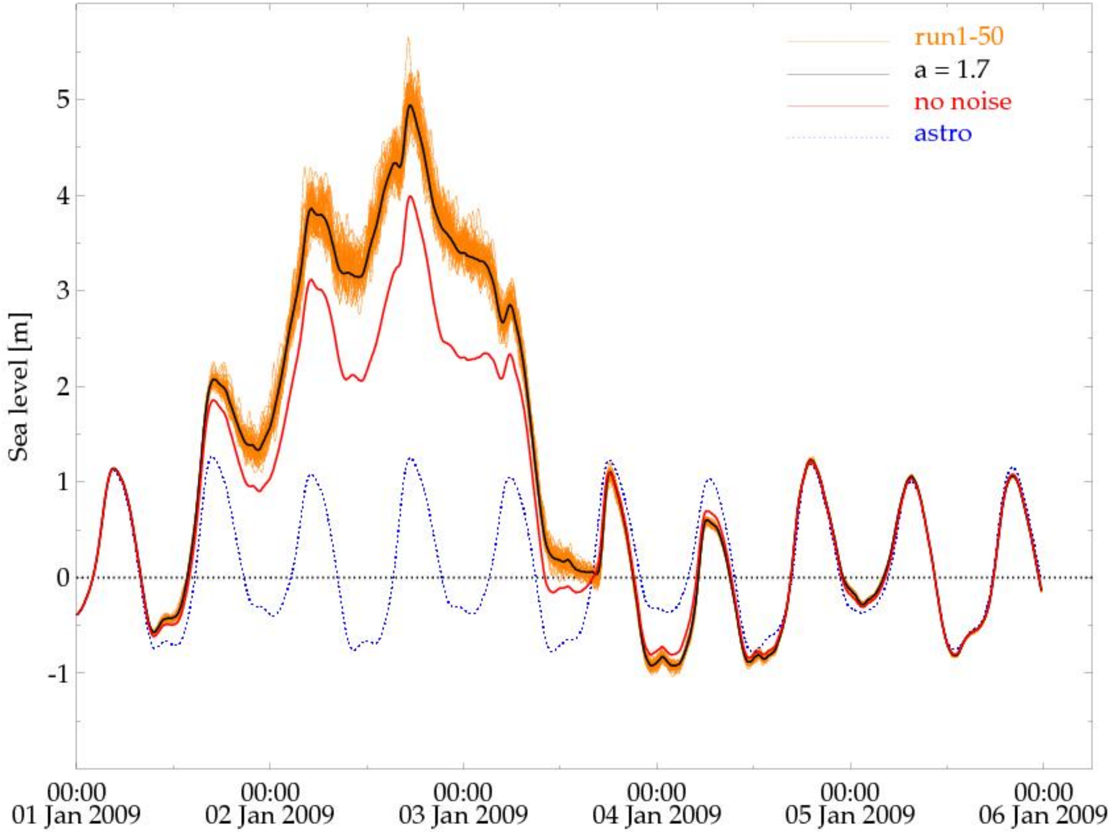
Monte Carlo experiments



Monte Carlo experiments



Monte Carlo experiments

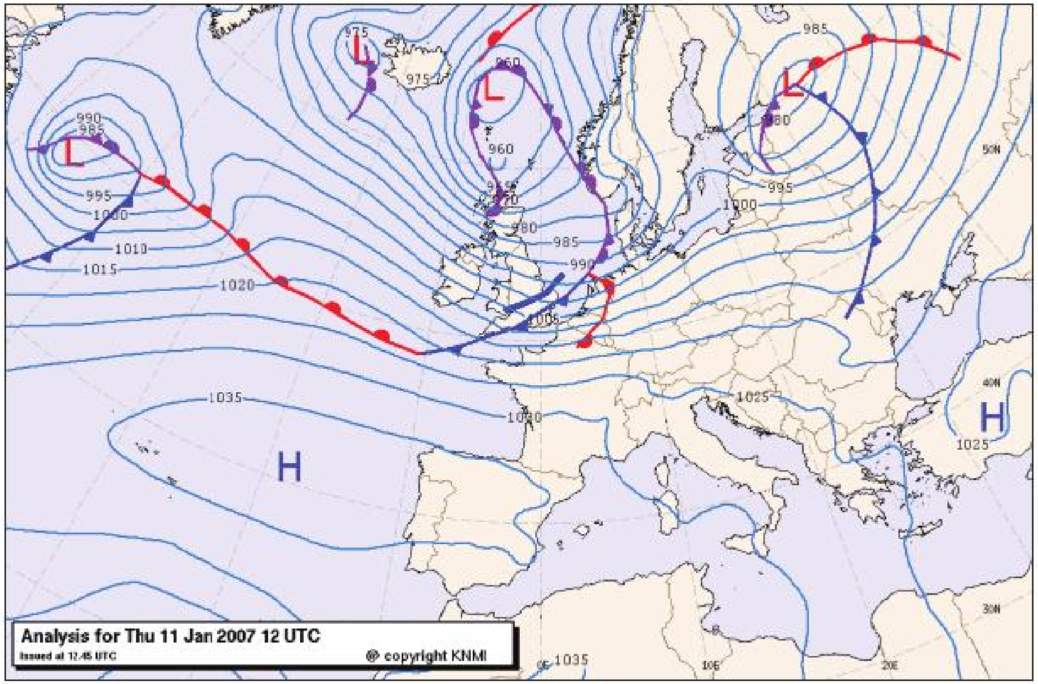


Convenient approximation:

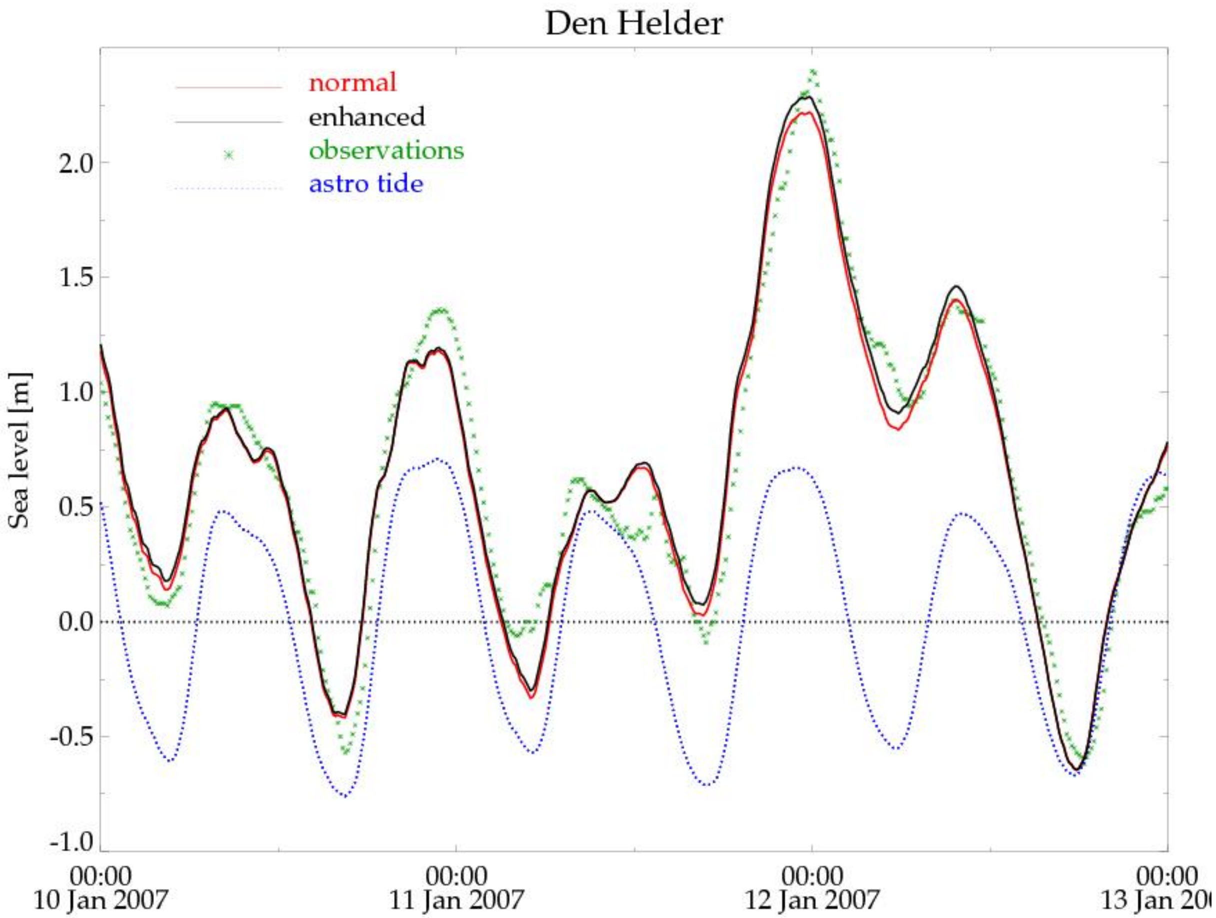
$$u = u_m \sqrt{1 + a\left(\frac{\sigma}{u_m}\right)^2}$$

Realistic case

- Gustiness, pressure and wind field from ECMWF
- Gustiness → Standard deviation of wind:

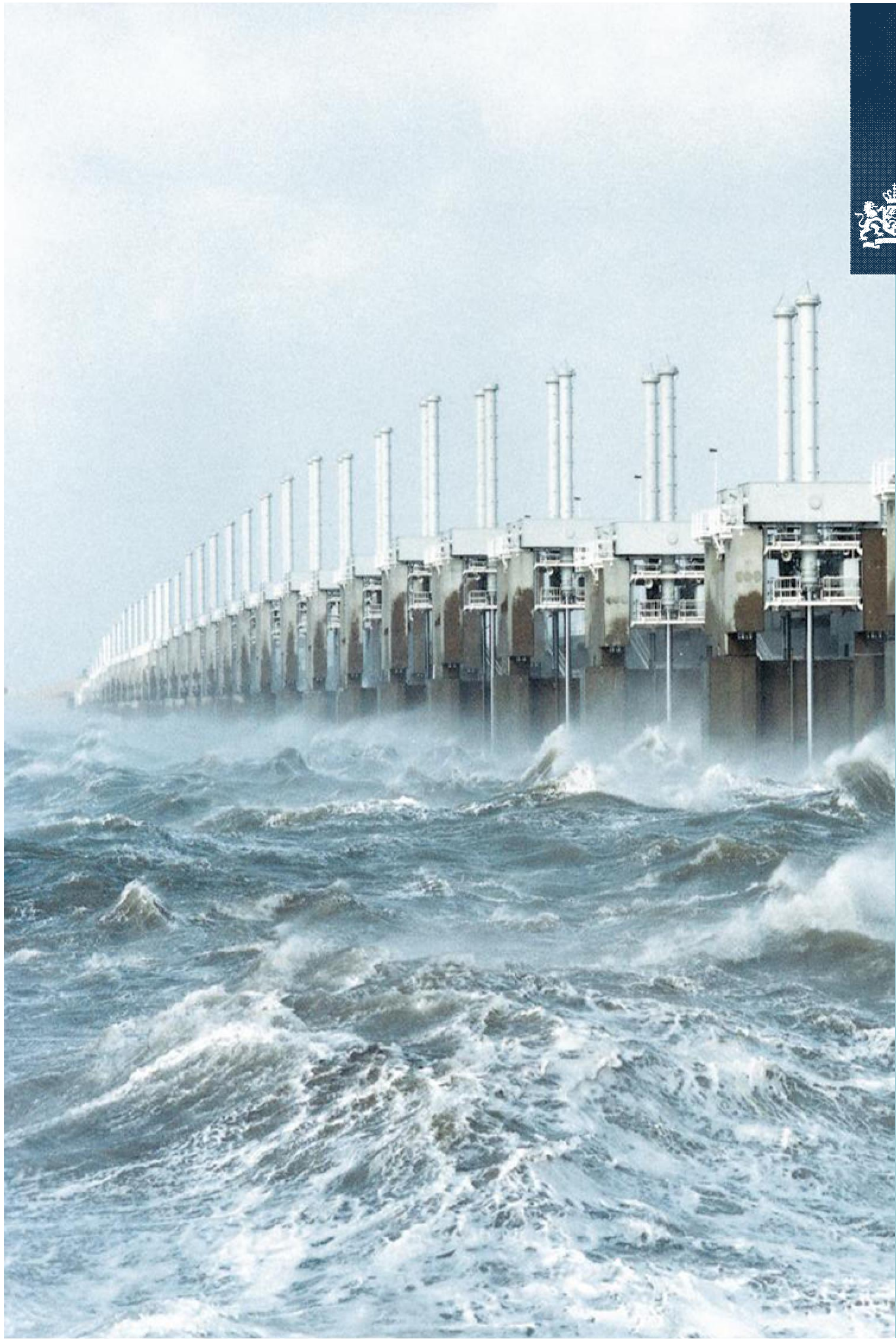


Realistic case



Conclusions

- Gustiness increases the mean stress that is exerted on the sea surface
- This increased wind stress results in enhanced surge levels in case of high gustiness.
- The stress can be approximated by mulitplying the wind speed by a factor $\sqrt{1 + a(\frac{\sigma}{u_m})^2}$
- When using the approximation a = 1.7 in a realistic case gustiness enhances surge levels predicted by WAQUA/DCSM.



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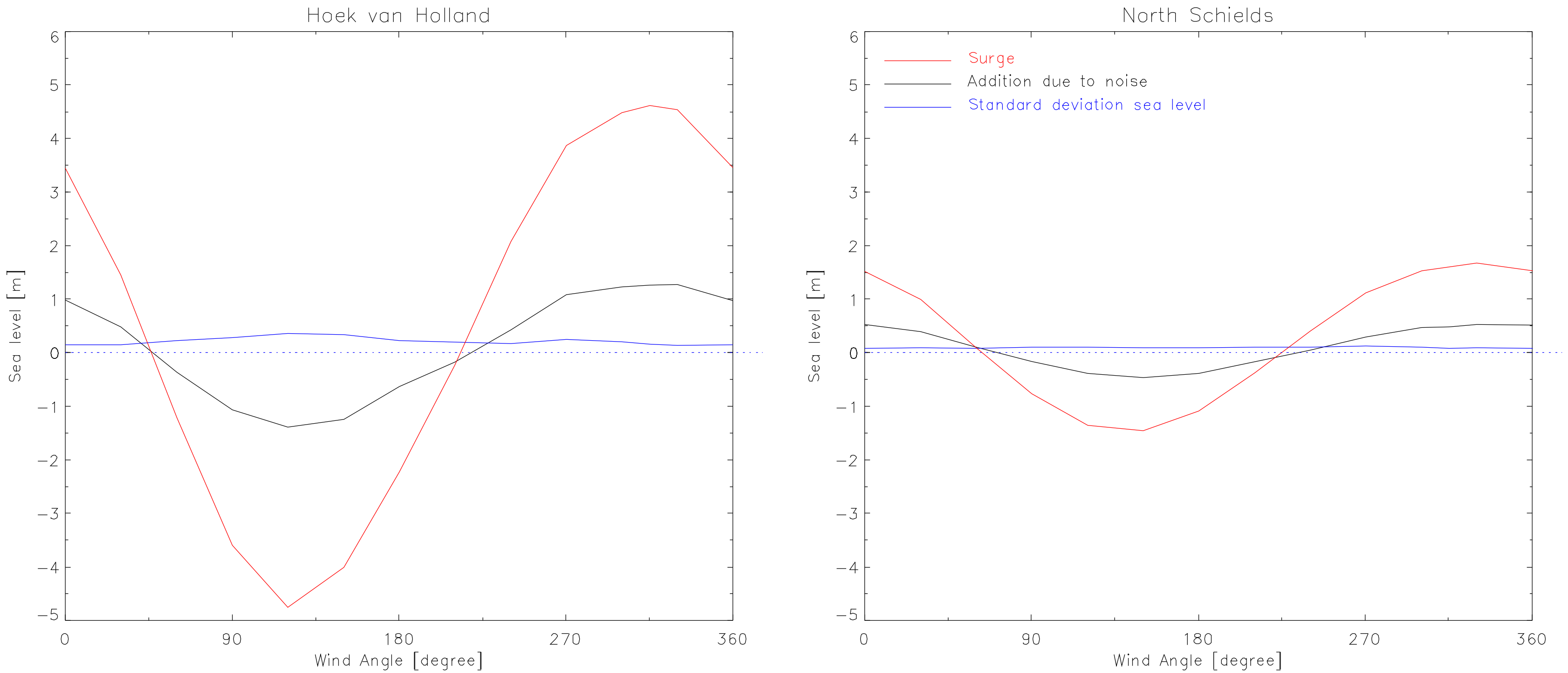
Thank you for your attention

Questions?

Angles of the wind



Cross component

$$\boldsymbol{\tau} = \rho_a C_d \|\boldsymbol{u_a}\| \boldsymbol{u_a} \qquad \boldsymbol{u} = \begin{pmatrix} u_m + u^{'} \\ v^{'} \end{pmatrix}$$

$$< \|\boldsymbol{u}\| \boldsymbol{u} > = \left\langle \begin{pmatrix} (u_m + u^{'})\sqrt{(u_m + u^{'})^2 + v^{'2}} \\ v^{'}\sqrt{(u_m + u^{'})^2 + v^{'2}} \end{pmatrix} \right\rangle$$