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

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Rikke van der Grinten (KNMI/IMAU)
Hans de Vries (KNMI)
Huib de Swart (IMAU)
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:

\[ \tau = \rho_a C_d u^2 \quad \text{Drag coeff. through Charnock relation} \]

\[ u = u_m + u' \quad \langle u' \rangle = 0 \quad \langle u'^2 \rangle = \sigma^2 \]

\[ \langle u^2 \rangle = u_m^2 + \sigma^2 \]

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 $\rightarrow$ 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 multiplying the wind speed by a factor $\sqrt{1 + a \left( \frac{\sigma}{u_{mn}} \right)^2}$.
- When using the approximation $a = 1.7$ in a realistic case gustiness enhances surge levels predicted by WAQUA/DCSM.
Thank you for your attention

Questions?
Angles of the wind
Cross component

\[ \tau = \rho_a C_d \| u_a \| u_a \]

\[ u = \begin{pmatrix} u_m + u' \\ v' \end{pmatrix} \]

\[ \langle \| u \| u \rangle = \left\langle \left( \frac{(u_m + u') \sqrt{(u_m + u')^2 + v'^2}}{v' \sqrt{(u_m + u')^2 + v'^2}} \right) \right\rangle \]