



Royal Netherlands
Meteorological Institute
*Ministry of Infrastructure and the
Environment*

Air-Sea Interaction in Extreme Weather Conditions

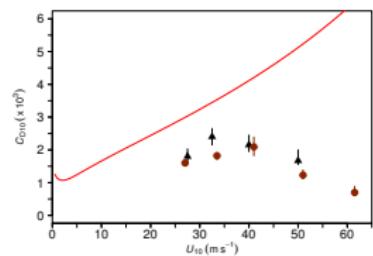
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KNMI, NL



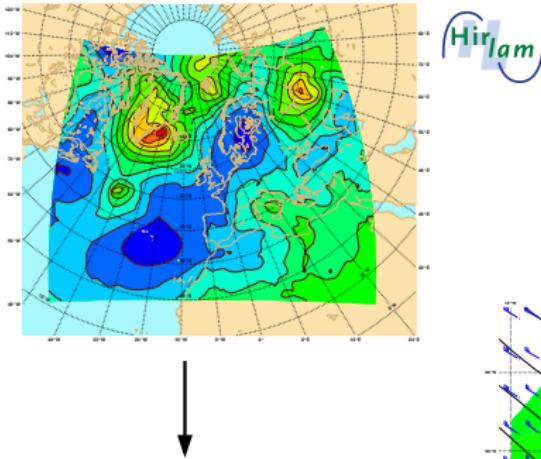
Motivation

- Safety of the coast of the Netherlands for storm surge
- Models not prepared for $U_{10} \gtrsim 30 \text{ m/s}$
- Might occur more frequently in a changed climate
- Investigate alternative drag relation
- Identical in NWP and storm surge model

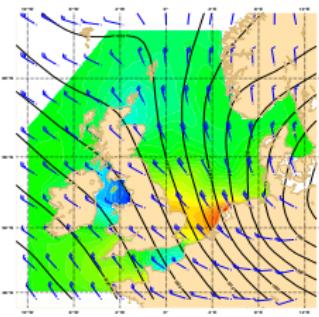




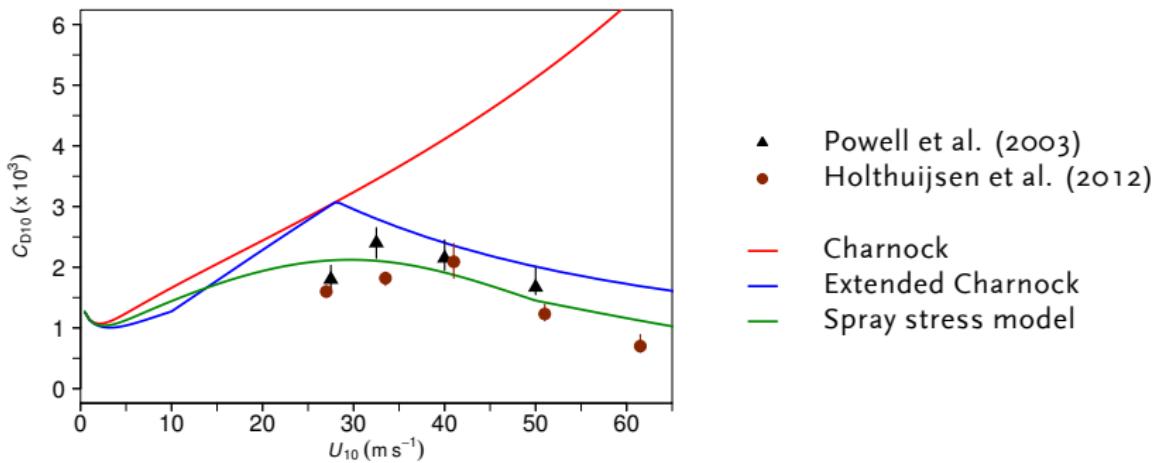
Storm surge forecasts (in the North Sea)



$$\left. \begin{array}{l} \vec{\tau} = \rho_a C_D |\vec{u}_{10}| \vec{u}_{10} \\ p_{msl} \end{array} \right\} \rightarrow$$



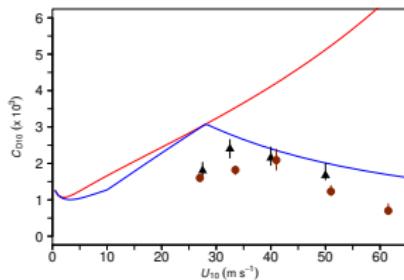
Alternative drag relations





Extended Charnock relation

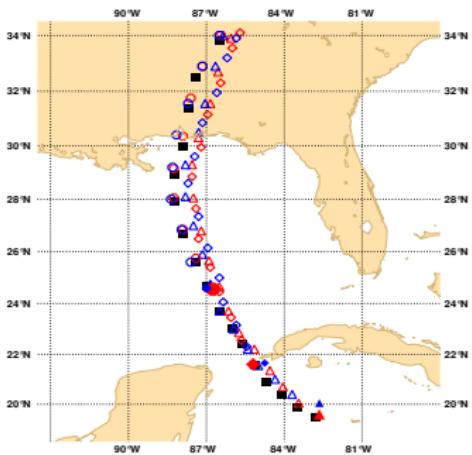
- Include the effect of spray and air-flow separation
- Build into HIRLAM
- Apply in the Gulf of Mexico



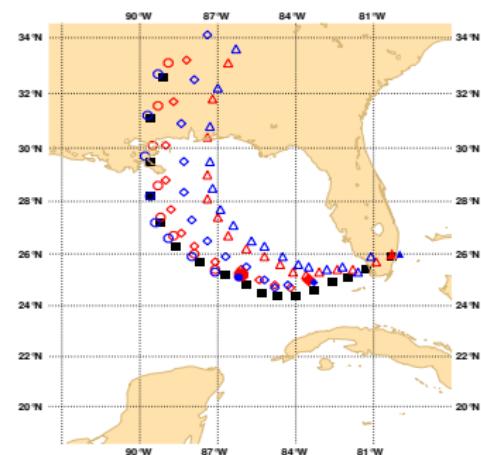


Hurricane tracks

Ivan (2004)



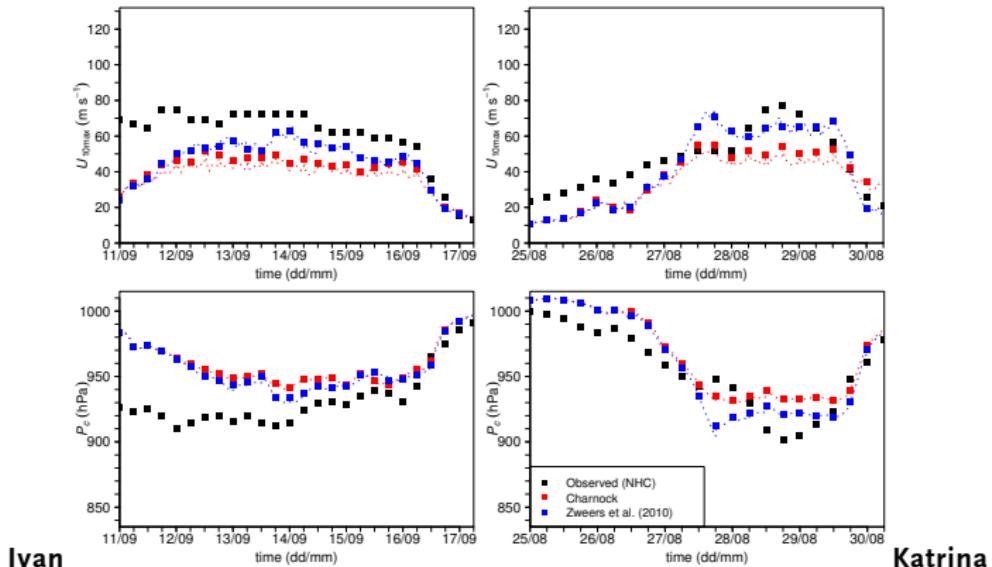
Katrina (2005)



- NHC obs
- ◊ △ Charnock
- ◊ △ New
- ◊ T+48
- ◊ ◊ T+72
- △ △ T+96



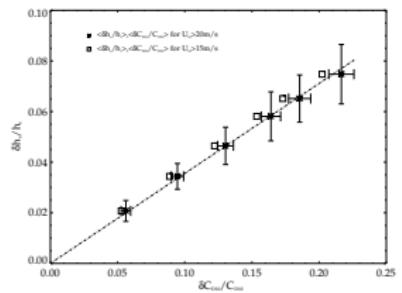
Hurricane intensity





But...

- Lower drag means lower storm surge

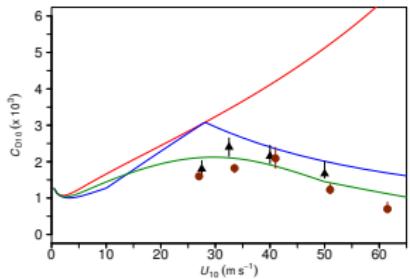


- Exchange of heat and moisture should be larger



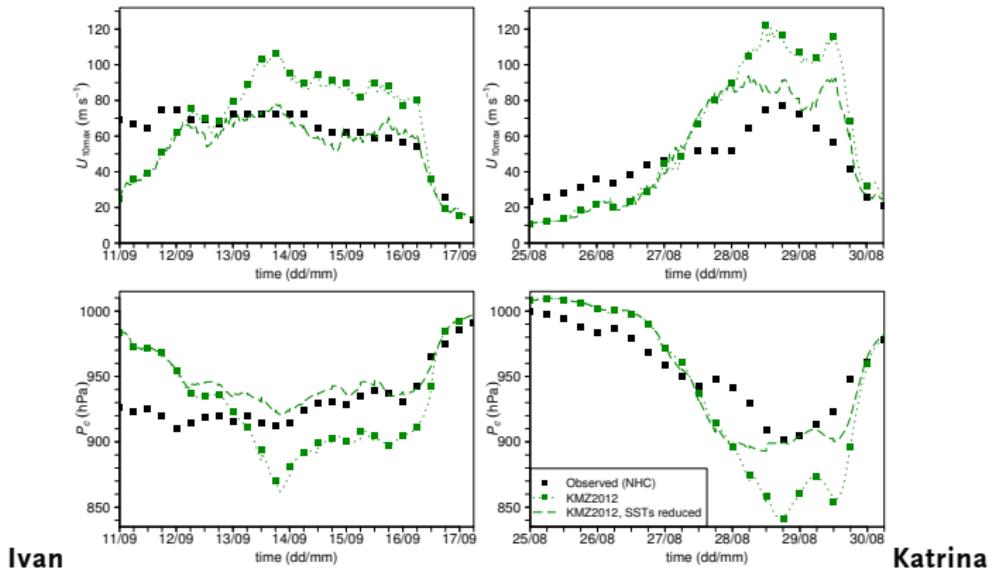
Spray stress model

- Parametrization based on spray stress model
- Enhanced exchange of heat and moisture
- Artificial reduction of SSTs below the storm





Hurricane intensity





Conclusions

- New drag relation produces realistic hurricane wind speed and pressure
- Momentum flux needs also update of heat and moisture fluxes
- Sea surface temperature also plays significant role
- Next step: couple ocean model



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Thank you