



Koninklijk Nederlands  
Meteorologisch Instituut  
Ministerie van Infrastructuur en Milieu




Deltares  
Enabling Delta Life




## High resolution modelling improves the simulation of extreme winds in the coastal zone

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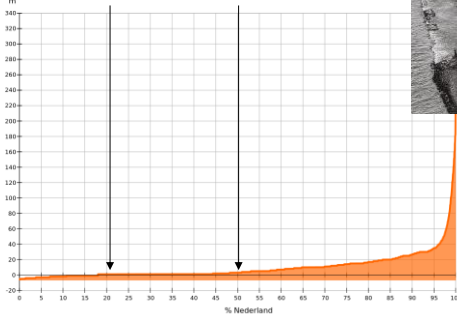
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- Main existential question for the Netherlands: How do we keep our feet dry in the 21st century?




1953  
surge

20% below sea level    50% below 5 m




% Nederland




below sea level  
above sea level

1:1 500 000  
Aankomend Geo informatie en ICT  
Rijkswaterstaat

- Main economic activities are located below sea-level



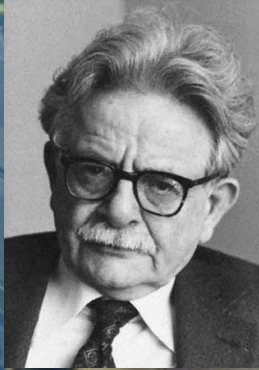
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## Elias Canetti [Nobel Prize literature 1981] on the dyke as the Dutch national symbol in 'Masse und Macht' pg 172 , 173


- Unlike the English who conquered their island and did not wrest it from the sea, the Dutch had to win the land they inhabit from the sea,..... and protect it with dykes. The dykes are the beginning and the end of their national life.
- ....Nowhere else has the feeling of a human wall opposing the sea been so strongly developed.
- The Dutch always had danger on their backs; for them the sea was never entirely subdued. ..Yes, they sailed the seas to the ends of the earth, but even at home it might turn against them.
- And in times of extremity they turned the sea against themselves to keep back the enemy who threatened them.



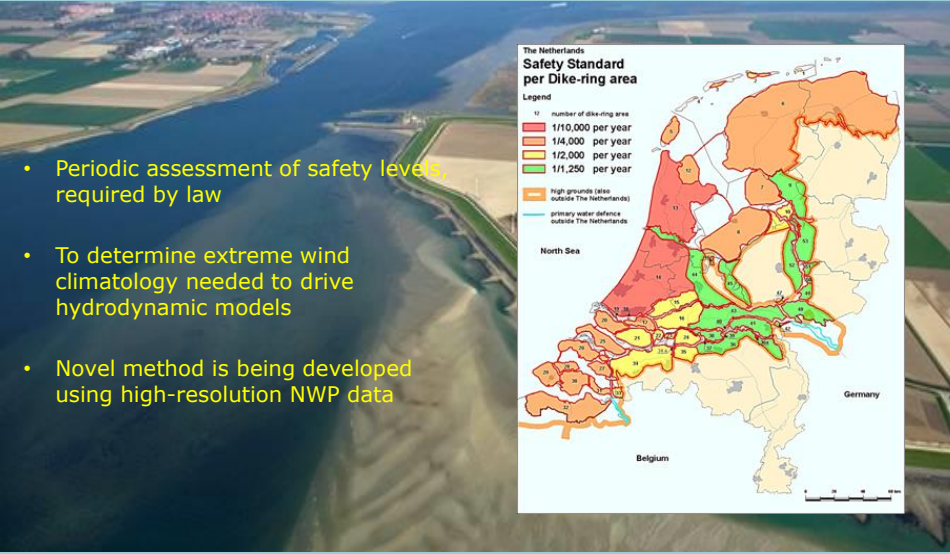
## Introduction | WTI Wind Modelling

### WTI: Wettelijk Toetsings Instrumentarium

### ~~Statutory Testing Framework [for Dyke Protection]



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- Periodic assessment of safety levels, required by law
- To determine extreme wind climatology needed to drive hydrodynamic models
- Novel method is being developed using high-resolution NWP data

**The Netherlands**  
**Safety Standard per Dike-ring area**

**Legend**

12 number of dike-ring area

- 1/10,000 per year
- 1/4,000 per year
- 1/2,000 per year
- 1/1,250 per year

high grounds (also outside The Netherlands)

primary water defence outside The Netherlands

North Sea

Germany

Belgium

0 20 40 km

## Hydraulic Boundary Condition Model Chain

Long-term, high resolution atmospheric model results, calibrated with observations

Time and space evolving  
extreme wind fields+ ass. variables

Wave model / hydrodynamic model

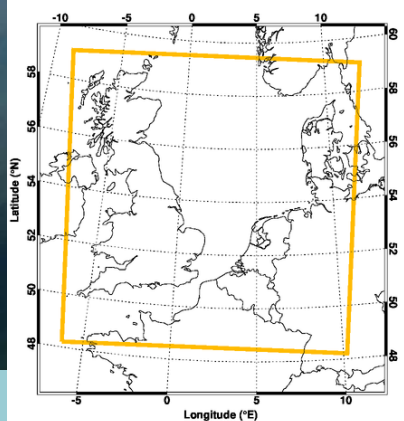
Wave heights / surge levels

Hydraulic boundary conditions

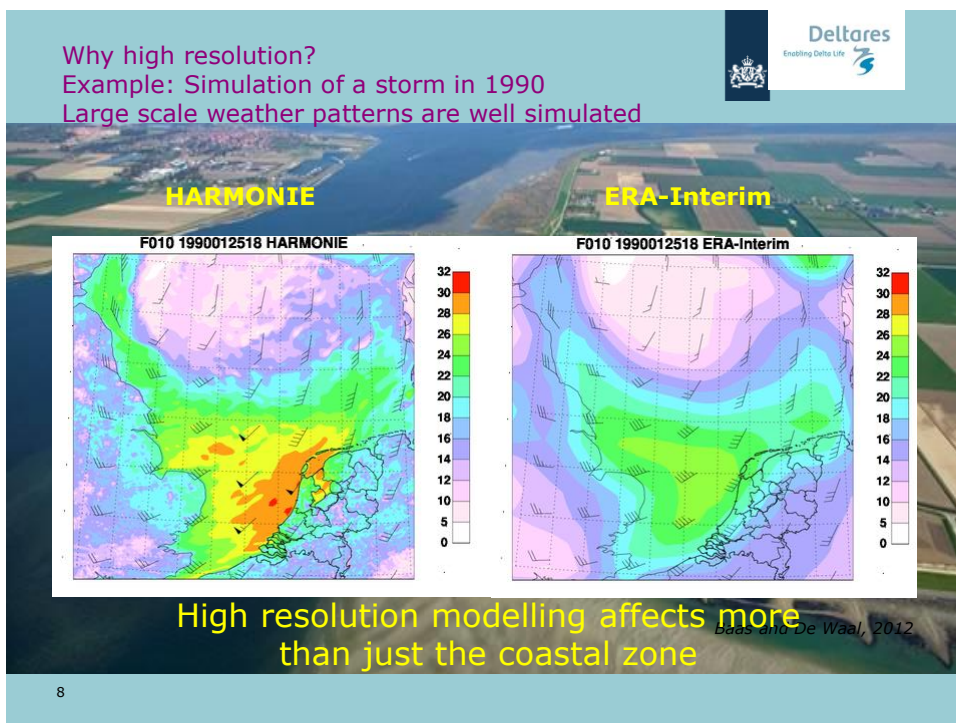
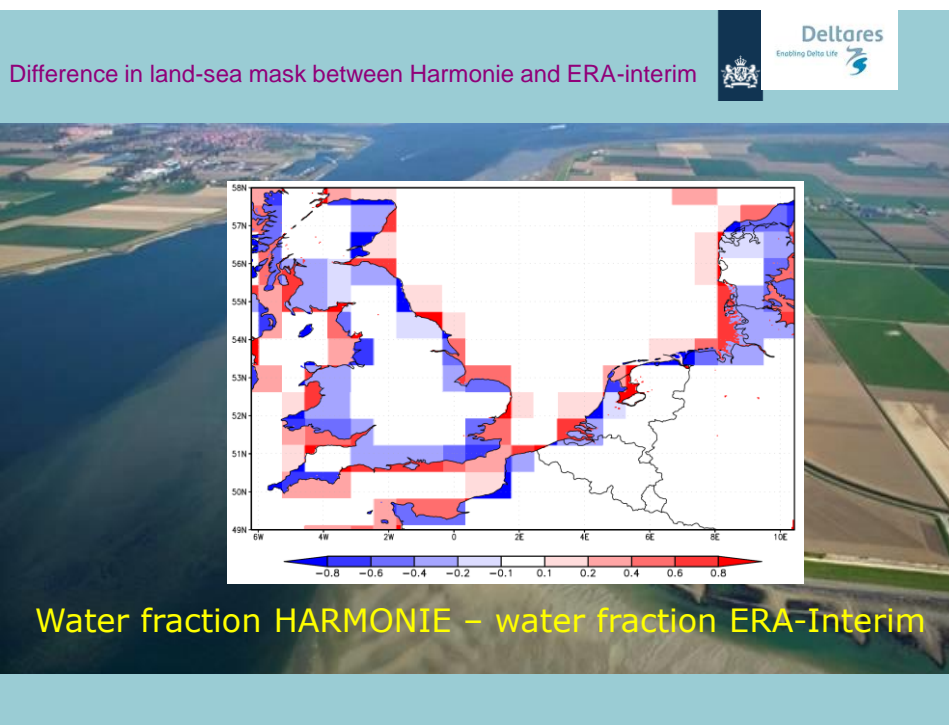
Assessment of water defences

## The HARMONIE model

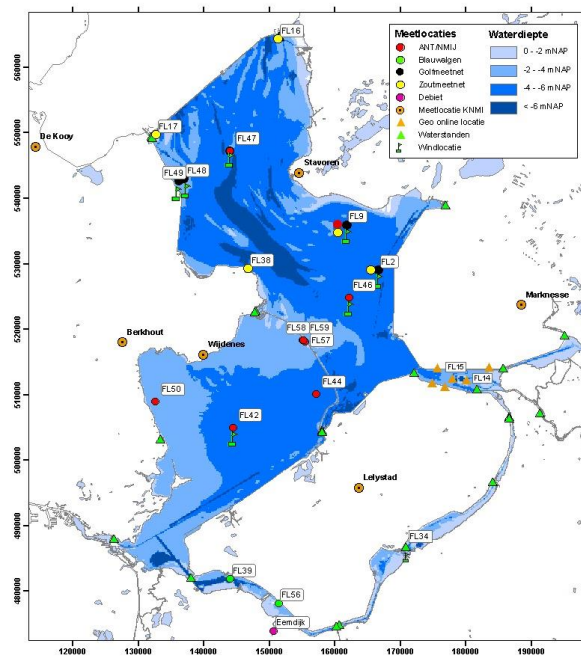
- Operational weather model of the HIRLAM – ALADDIN - consortium
- Grid spacing of 2.5 km
- We use ERA-Interim (ECMWF ~80km) reanalysis as input
  - Observations → ERA-Interim → HARMONIE
- Domain of 489x489x60 grid points:



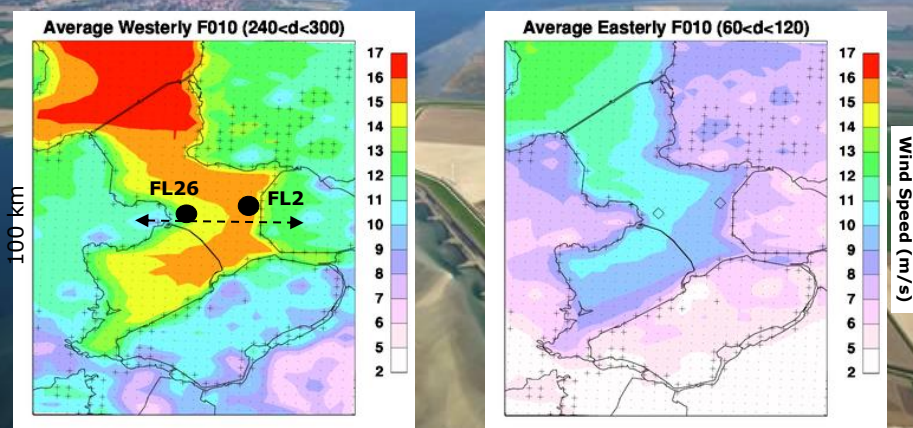




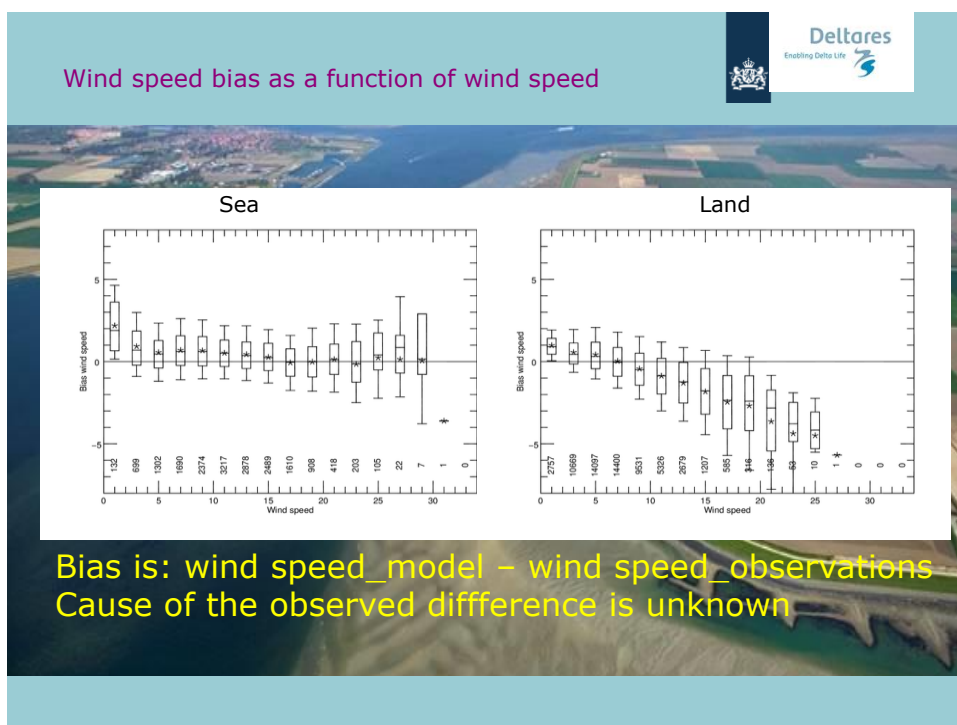
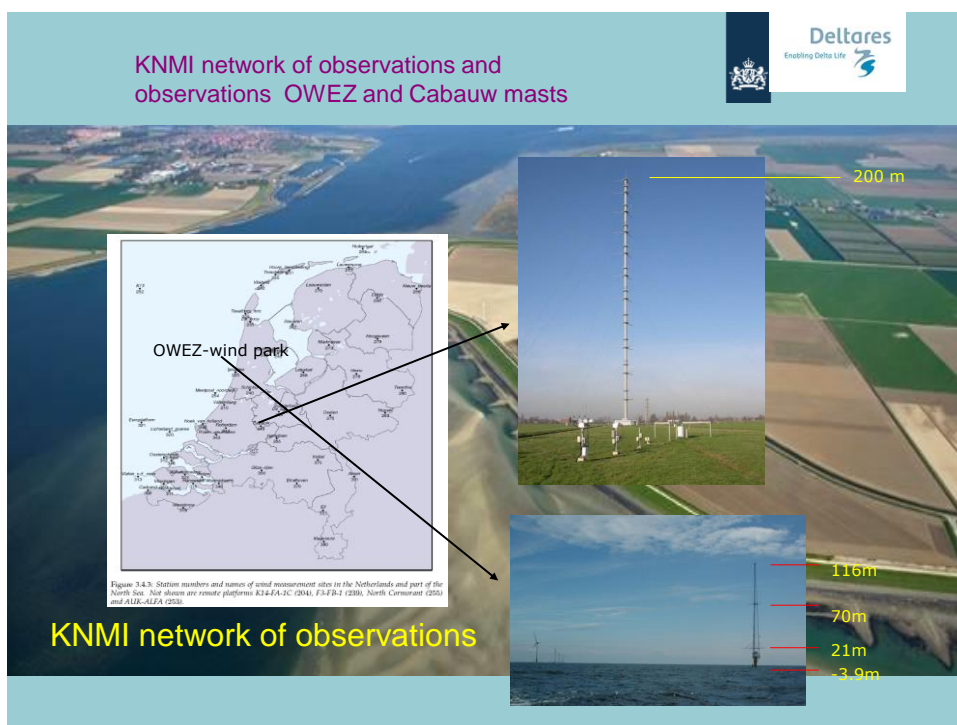
Not only at the coast but also around Lake IJssel is hydraulic load a problem



High resolution affects the simulation of winds in inland waters such as Lake IJssel.

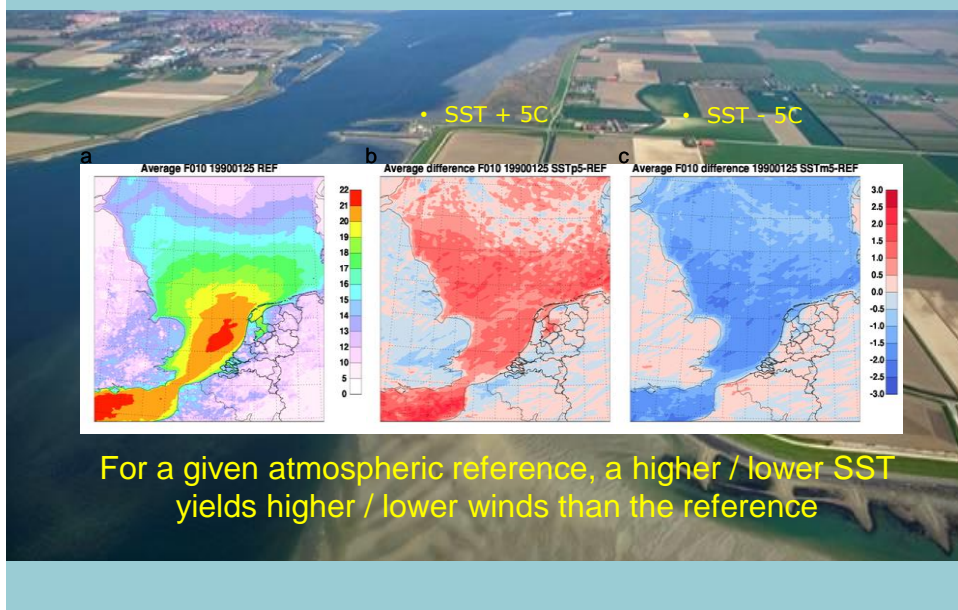


Average wind fields Lake IJssel. Westerlies [left]; easterlies [right]

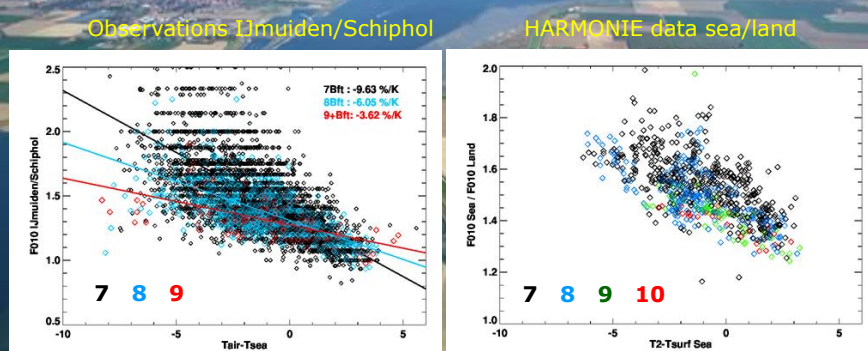




HARMONIE sensitivity test for 25 Jan 1990 storm  
Modify SST to kick the BL stability. What does the wind?



The ratio sea/land of wind speed depends on stability (over sea)



## Prediction of Surge Levels

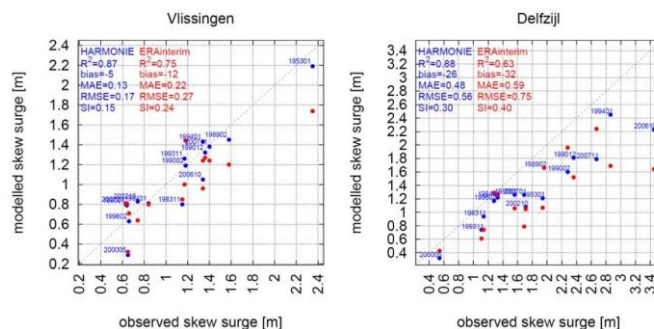


Figure 4.2. Scatter plots of the maximum skew surge at Vlissingen (left) and Delfzijl (right) for the 17 events as modelled by HARMONIE (blue) and ERA (red).

Dynamically downscaled HR model better than ERA. But quality is location dependent.

## Conclusions



- High resolution modelling affects a larger region than just the coastal zone
- High resolution modelling resolves the inland waters such as Lake IJssel
- Stability over sea affects the strength of storms
- Extreme wind speeds over land are underestimated; cause is unknown
- The model is a suitable tool to generate a 30-year wind climatology