The effects of using multi-parameter wave criteria for accessing wind turbines in strategic maintenance and logistics models for offshore wind farms

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Outline

"The effects of using multi-parameter wave criteria for accessing wind turbines in strategic maintenance and logistics models for offshore wind farms"

- Motivation – accessibility
- Multi-parameter wave criteria
- The effects in a strategic maintenance and logistics models
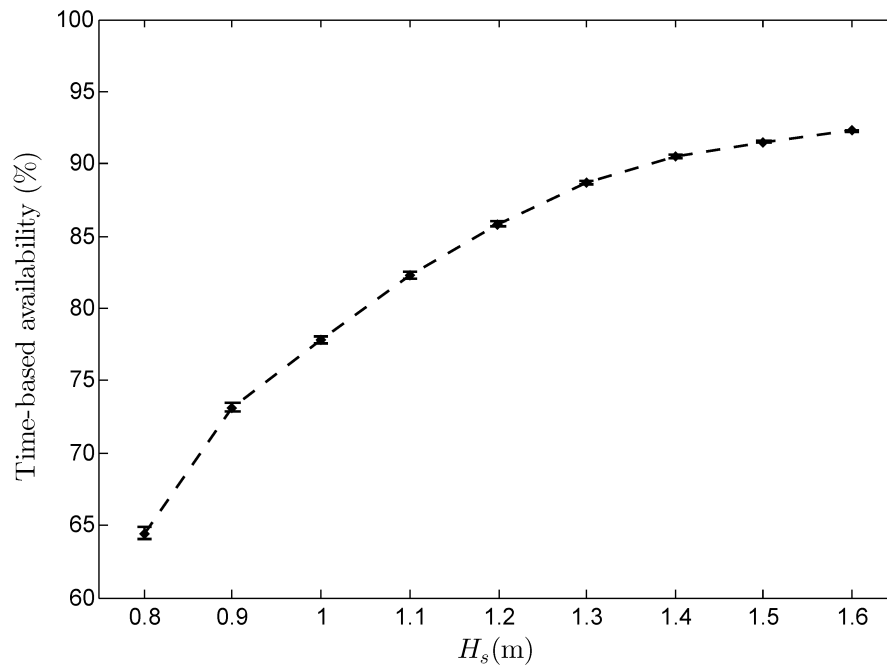- Conclusions

Motivation – accessibility

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Traditional access criterion: Limiting significant wave height (Hs)

Low limiting Hs → low accessibility → low availability of the wind turbines

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Motivation – accessibility

Traditional access criterion: Limiting significant wave height (Hs)

Low limiting Hs → low accessibility → low availability of the wind turbines

Strategic maintenance and logistics models as decision support tools:

- Wants to know what vessels to use
- Wants to use vessels with high accessibility
- Needs to know the value of the limiting Hs

Is a single limiting Hs good enough?

Other weather parameters:

- Wave period

- Relative wave heading

- Current

- Wind speed

- Wind direction

- Visibility

- Swell

- …

Methodology of the work

1. Numerical analysis to calculate multi-parameter wave criteria (including also wave heading and peak wave period)
2. Estimate possible corresponding measures of a single limiting Hs
3. Compare multi-parameter and single-parameter wave criteria for a simulation model
   - NOWIcob: Simulates maintenance activities and related logistics to estimate O&M costs and analyse O&M strategies
4. Compare multi-parameter and single-parameter wave criteria for a optimisation model
   - Finds the optimal vessel fleet size and mix, minimizing O&M costs

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# Objective of the work

What question are we asking?

- *Not* how a given vessel performs in absolute terms
- *Not* how the performance of a given vessel compares with the numbers stated for its limiting significant wave height
- *But* what are the effects of using multi-parameter vs single-parameter wave criteria in strategic maintenance and logistics models
  - How can modelling approaches be compared?
  - Does it matter which approach one uses?
  - Is there any added value of more complex modelling?

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Numerical analysis to calculate wave criteria
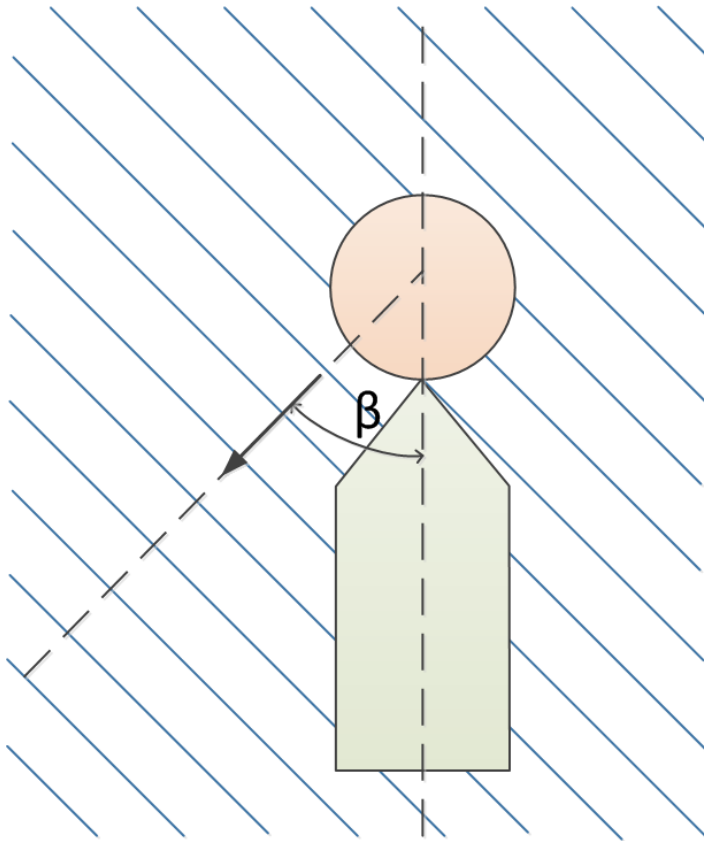
- Crew transfer vessel with bow fender
- Wave conditions:
  - Significant wave height
  - Peak wave period
  - Relative wave heading

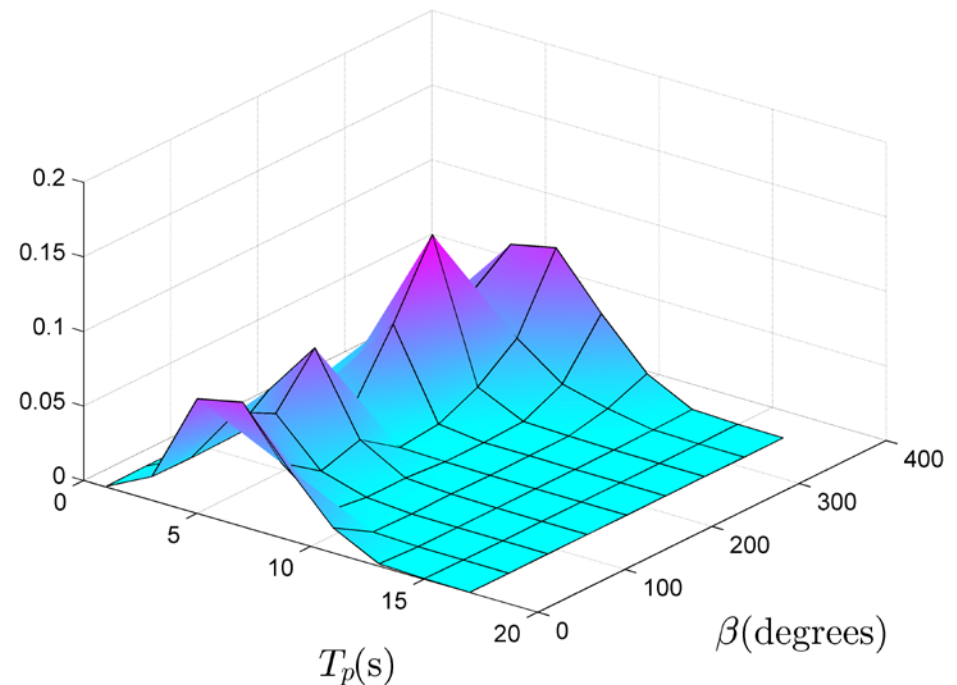- Also modelled: Motion-compensated gangway
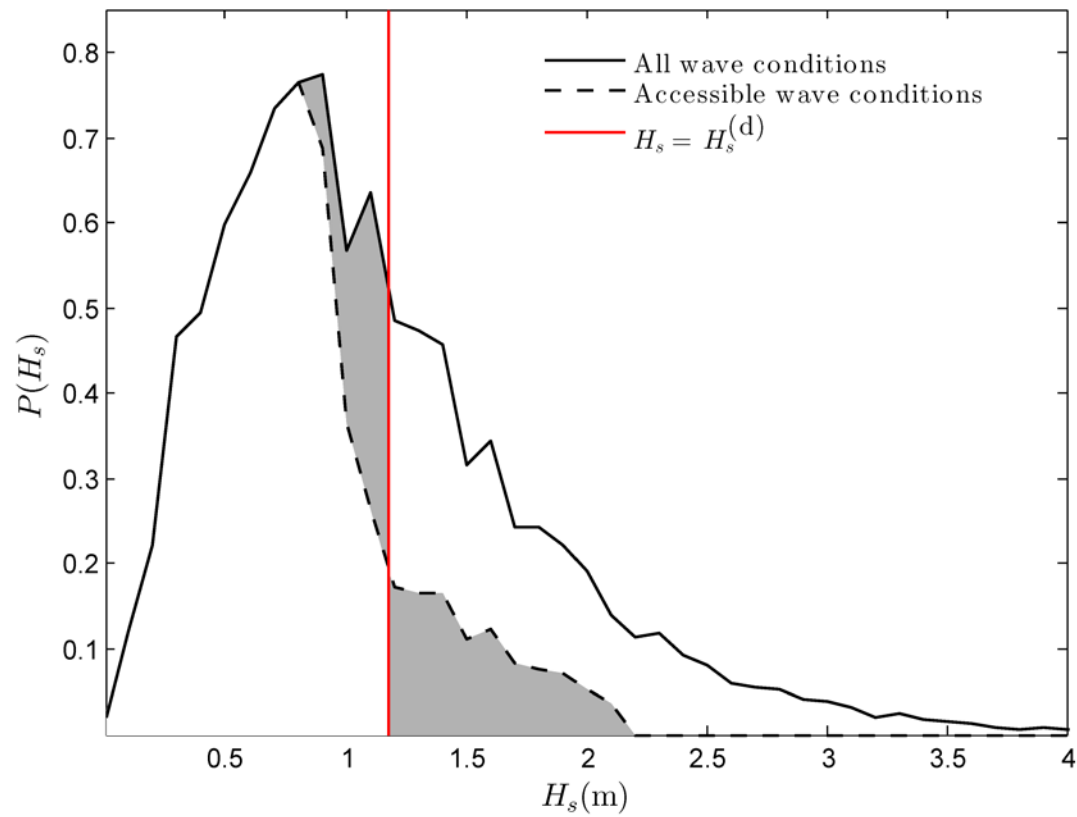
Multi-parameter wave criteria
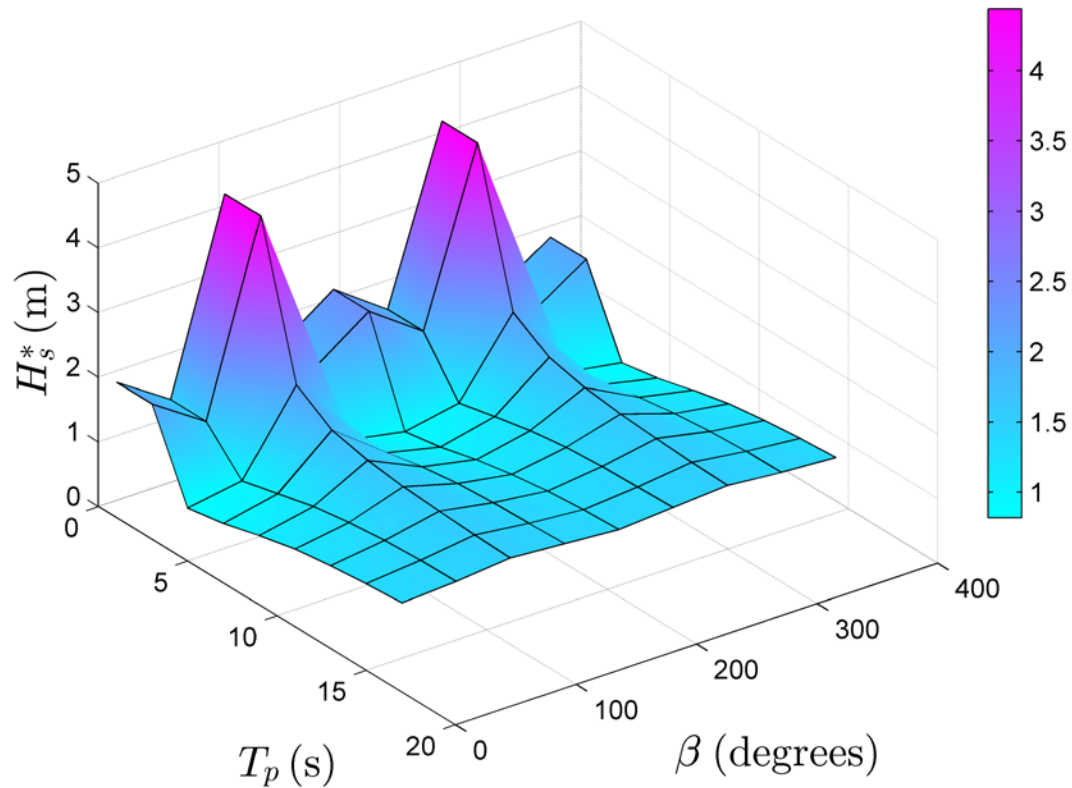
Corresponding single-parameter wave criteria

Possible measures of a single limiting significant wave height:

a) Weighted average
b) Most probable wave conditions
c) Most typical wave conditions
d) Equal average accessibility
e) Most restrictive/limiting value
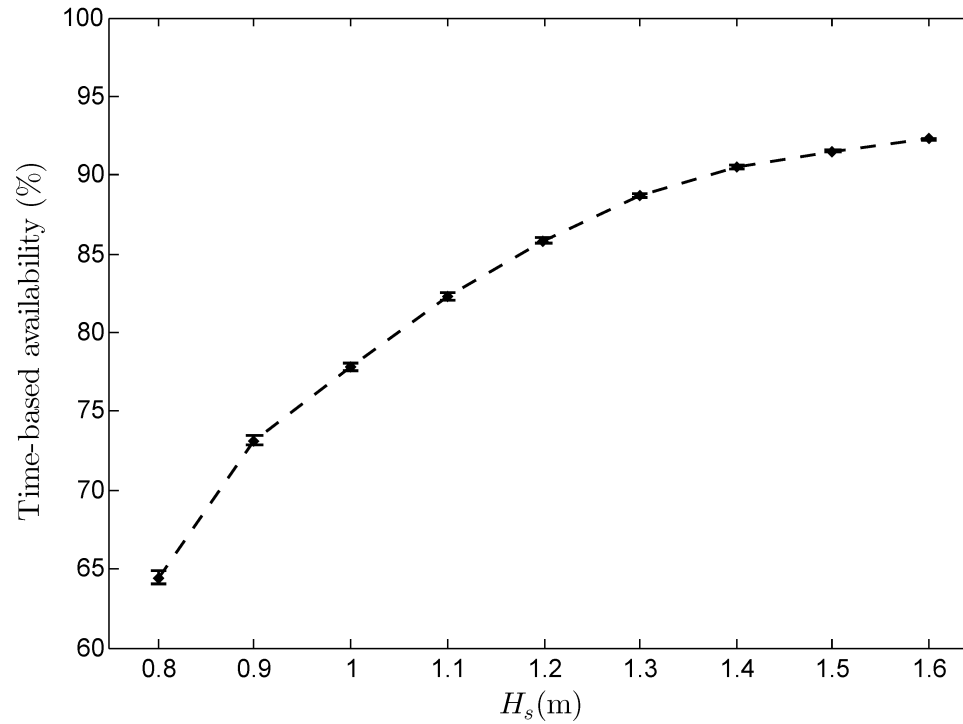
Corresponding single-parameter wave criteria

Corresponding single-parameter wave criteria

Possible measures of a single limiting significant wave height:

a) Weighted average
b) Most probable wave conditions
c) Most typical wave conditions
d) Equal average accessibility
e) Most restrictive/limiting value

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Corresponding single-parameter wave criteria

Possible measures of a single limiting significant wave height:

a) Weighted average   1.513 m
b) Most probable wave conditions   1.11 m
c) Most typical wave conditions   1.030 m
d) Equal average accessibility   1.160 m
e) Most restrictive/limiting value   0.82 m

# Reference case for simulation and optimisation models

- Weather time series with wind speed, peak wave period, wave heading and relative wave height
- Wind farm with 80 turbines 50 km from onshore maintenance base
- Corresponding single-parameter wave criteria
- Vessel fleet fixed to 3 crew transfer vessels for simulation model
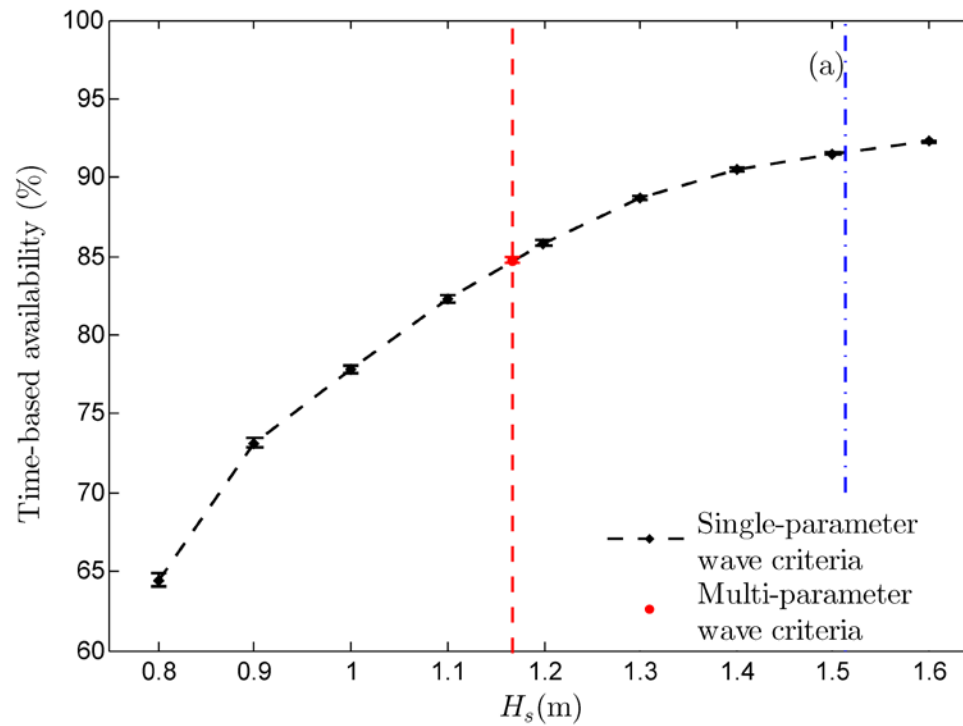- Optimisation model finds the optimal vessel fleet
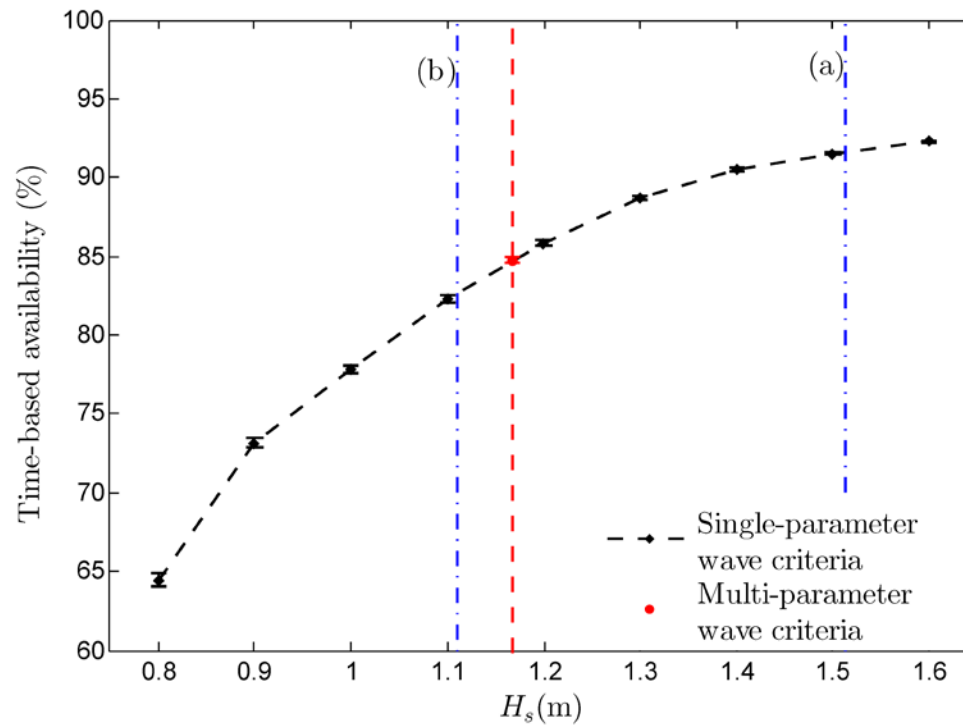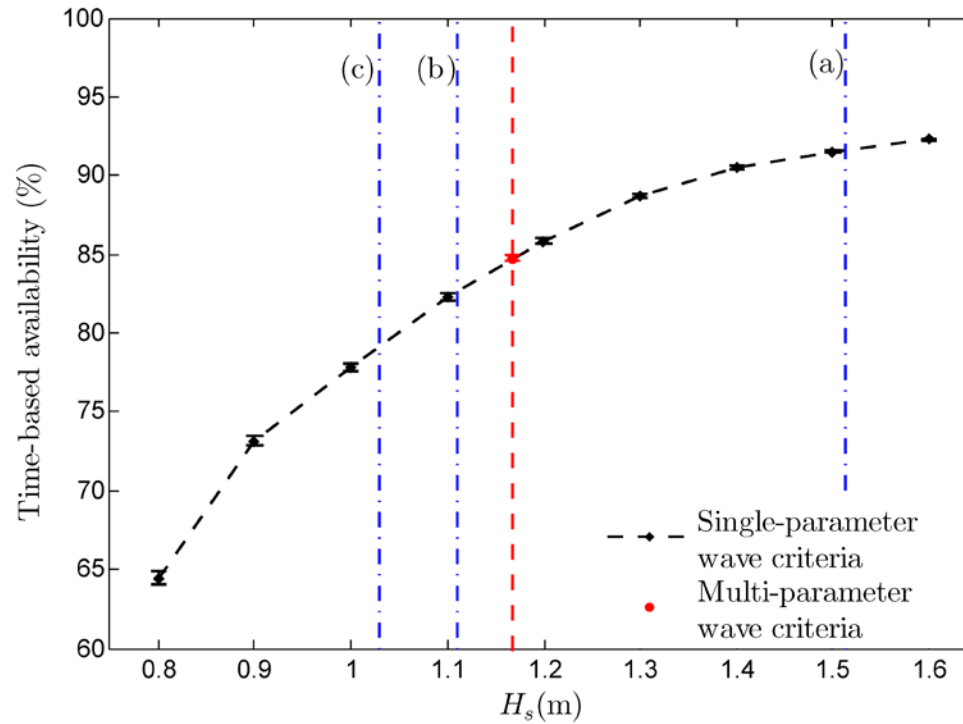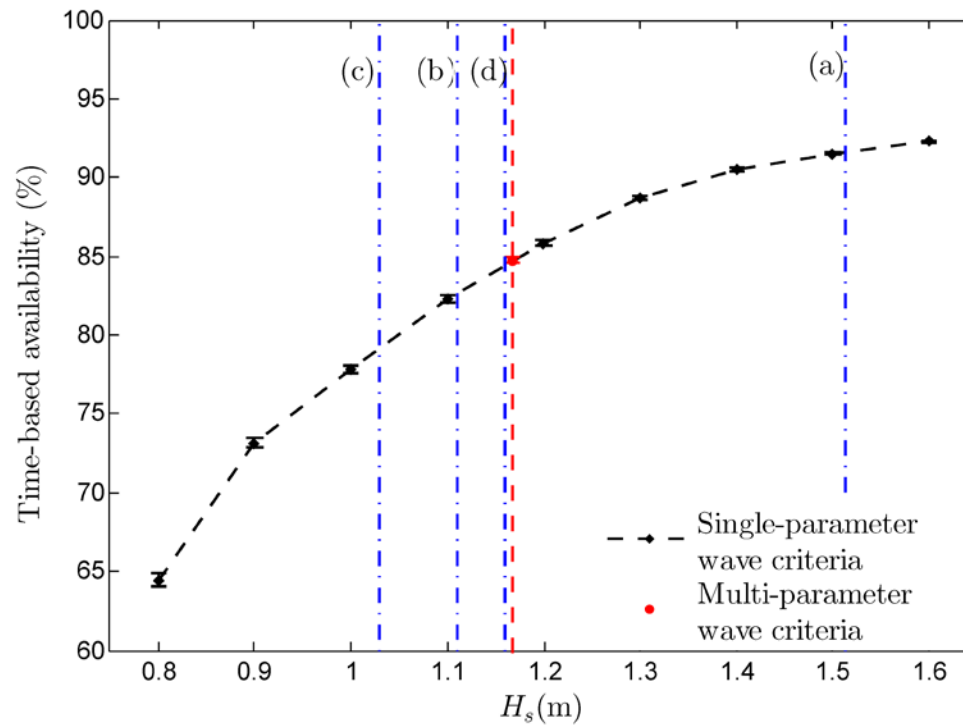
Comparison for the simulation model – availability

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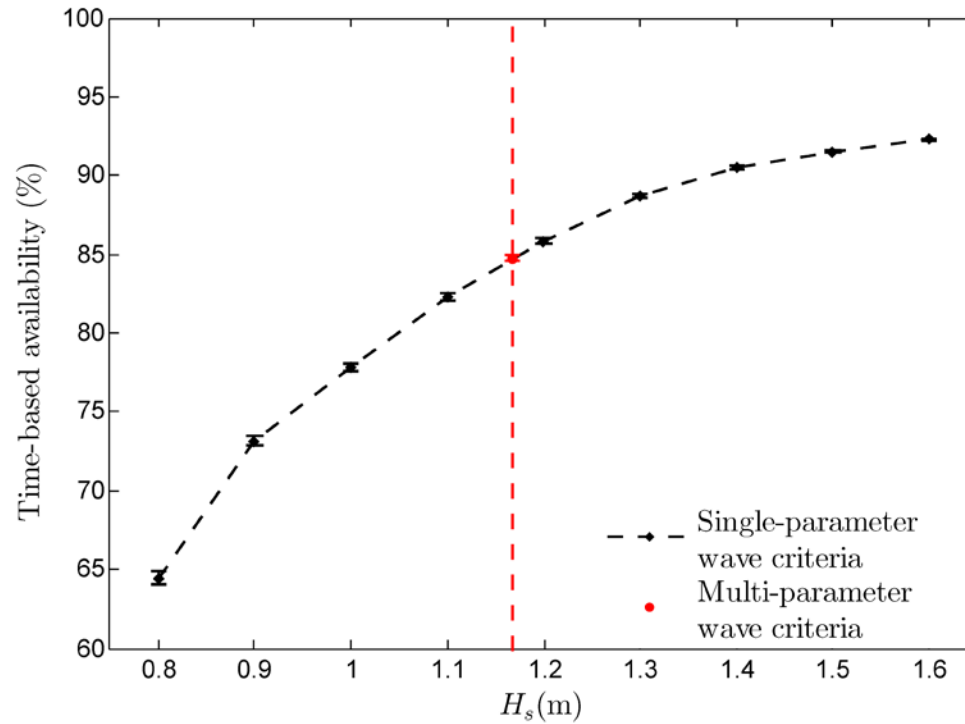
Comparison for the simulation model – availability
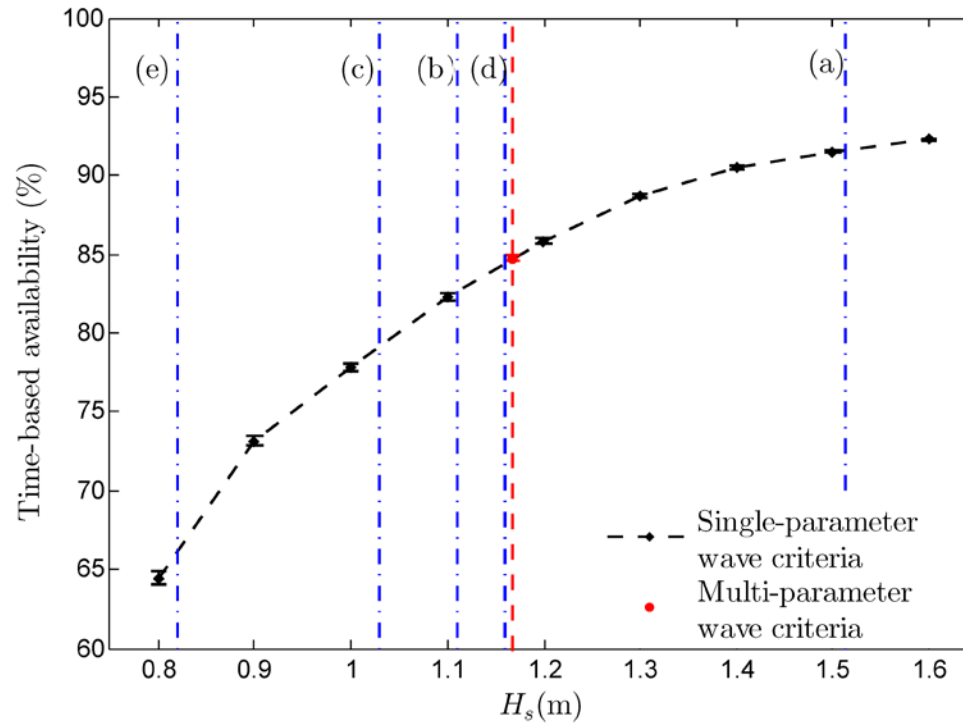
Comparison for the simulation model – availability

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Comparison for the simulation model – availability

Corresponding single-parameter wave criteria

Possible measures of a single limiting significant wave height:

a) Weighted average   1.513 m
b) Most probable wave conditions   1.11 m
c) Most typical wave conditions   1.030 m
d) Equal average accessibility   1.160 m
e) Most restrictive/limiting value 0.82 m

Corresponding single-parameter wave criteria

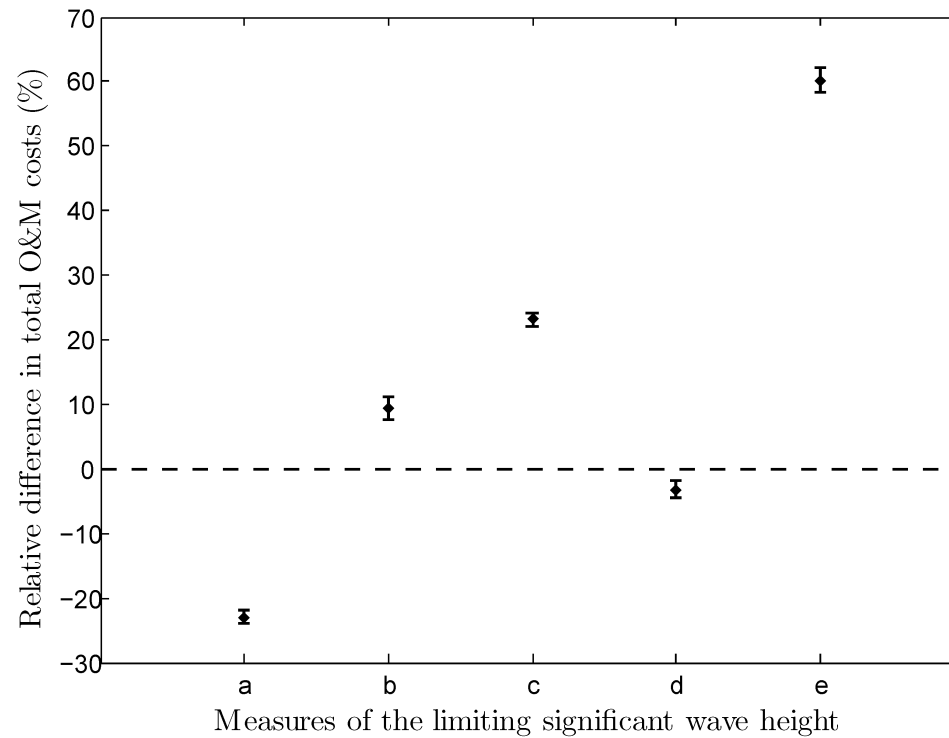Possible measures of a single limiting significant wave height:

a) Weighted average   1.5 m
b) Most probable wave conditions   1.1 m
c) Most typical wave conditions   1.0 m
d) Equal average accessibility   1.2 m
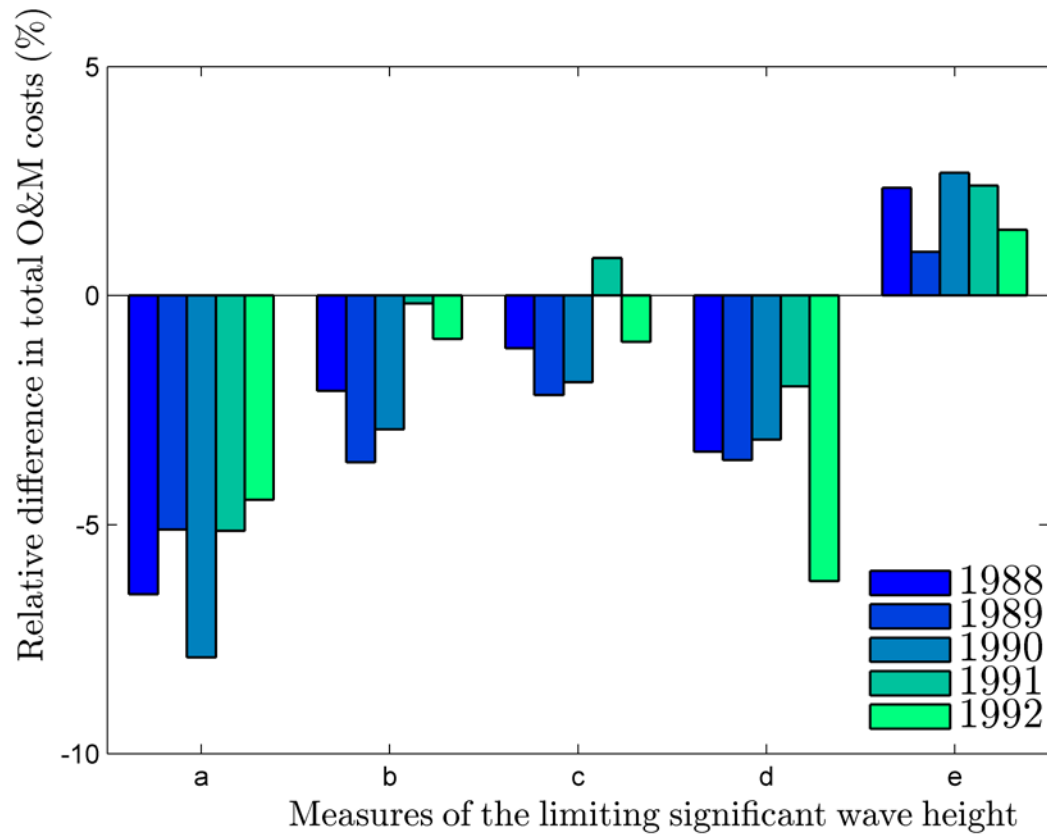e) Most restrictive/limiting value   0.8 m

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Comparison for the simulation model – availability
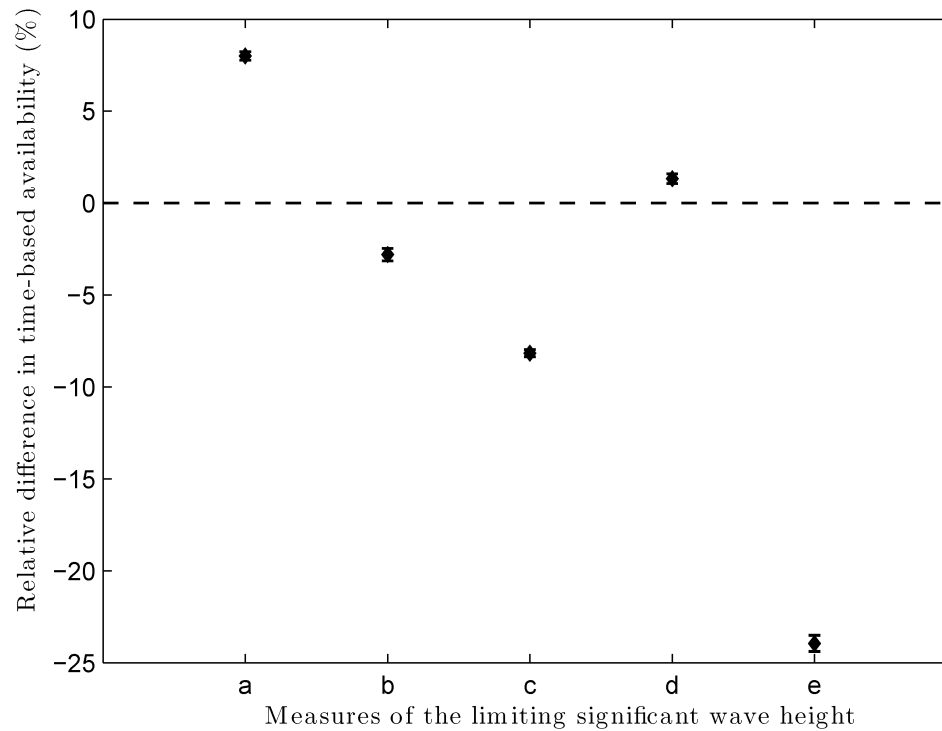
Comparison for the simulation model – O&M costs

Comparison for the optimisation model

Conclusions

- Demonstrated how one may use multi-parameter weather criteria in comparing vessel concepts with strategic maintenance and logistics models
- The difference between multi-parameter and single-parameter wave criteria may be relatively small
- This requires that the single limiting Hs is chosen carefully
- Information from multi-parameter wave criteria and wave conditions useful

- If a single limiting Hs can be used to represent the wave criteria, how is it found?
- Would a single limiting Hs apply for all locations?

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