Optimized significant wave height forecasts and their benefit on the workability at Offshore Wind Farms

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Overview

- Motivation
  - Why improving significant wave height forecasts?
- Methods
  - How to improve the forecasts?
- Data
  - On which information is the work based?
- Results
  - Any improvements for the workability at sea?
- Conclusion
  - What is worth to remember?
- Acknowledgements
  - Where does the money come from?

Motivation

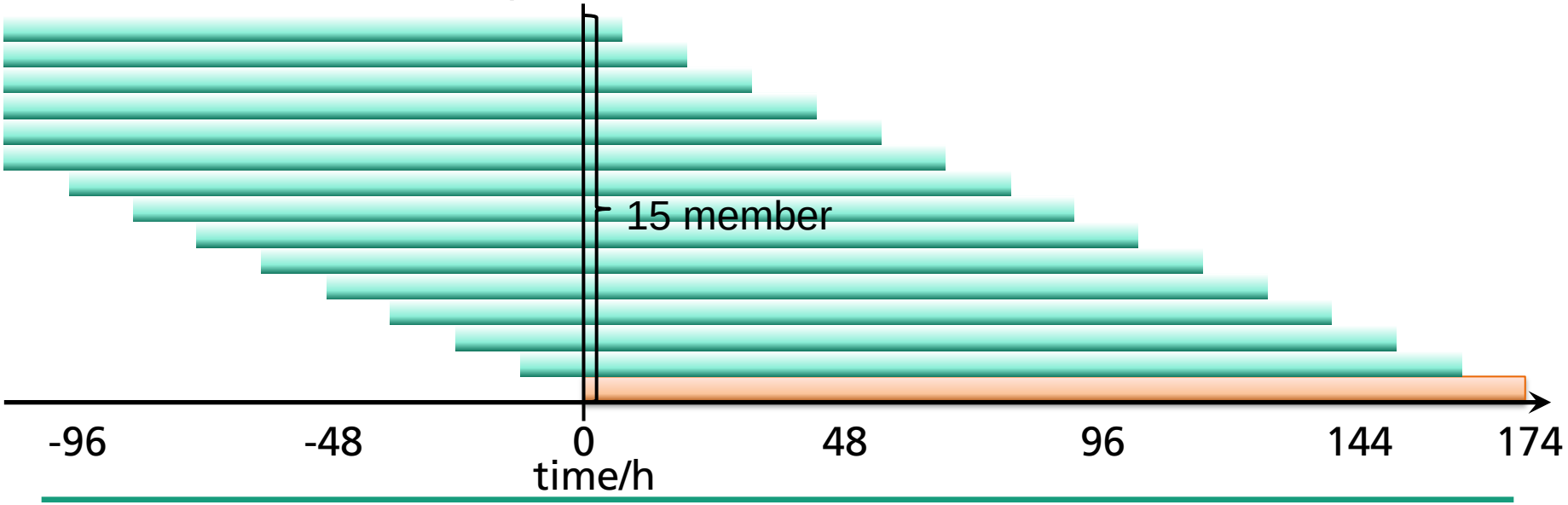
More precise forecasts

- miss less often possible working times
  - overall project is finished in a shorter time
- predict the threshhold values better
  - less operations have to be stopped

➡ reduce the costs of offshore wind energy

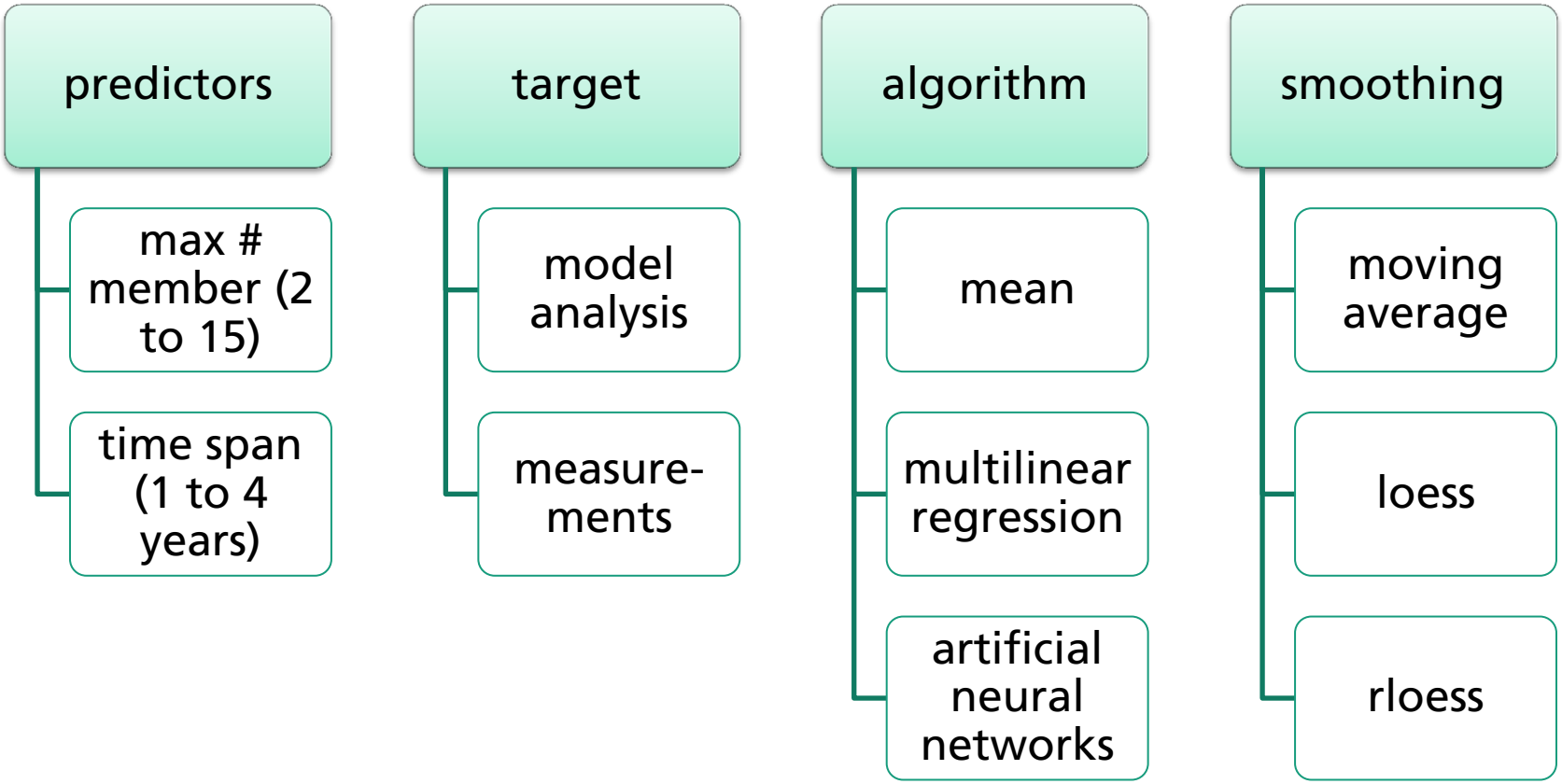
Methods – time-lagged Ensemble (TLE)
basics

- old forecasts have valuable information
- forecasts of only one model
  - updated every 12 hours, forecast lead time 174 hours
  - max. 15 member (up to +6 h)



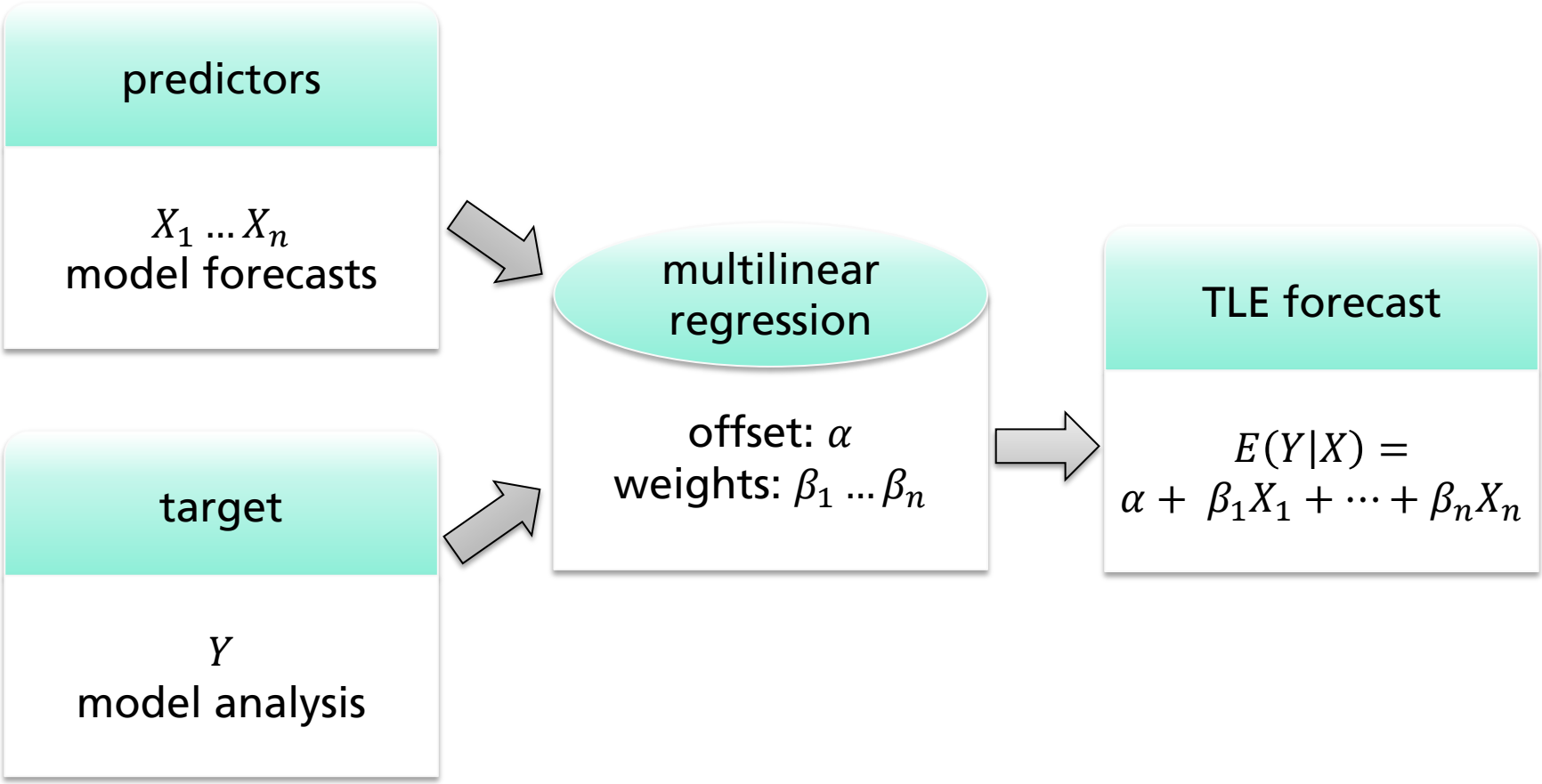
Methods – time-lagged Ensemble (TLE)

examined variations



Methods – time-lagged Ensemble (TLE)

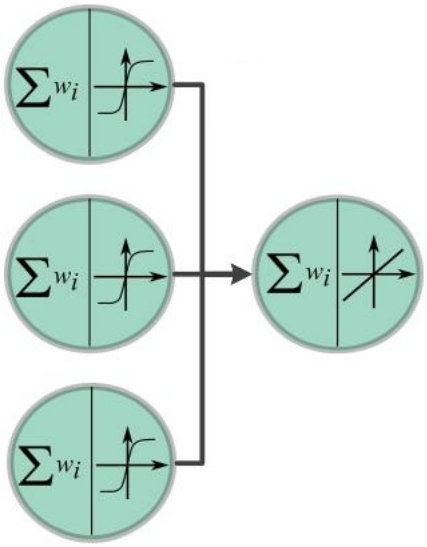
multilinear regression



Methods – time-lagged Ensemble (TLE)
artificial neural networks (ANN)

- Advantages of ANN
  - allow for non-linear relationships
  - hidden dependencies could be catched

- Experimental Setup
  - same inputs and targets as for multilinear regression
  - 1 hidden layer
  - 2 or 3 neurons in the hidden layer



Data

type	name	period	time resolution	spatial resolution
wave model forecast	GSM	10/2005-05/2012	3 h up to +174 h	0.75° x 0.75°
	GWAM	03/2012-01/2013	1 h up to +174 h	0.25° x 0.25°
wave model analysis	GSM	03/2008-05/2012	00, 12 UTC	0.75° x 0.75°
	GWAM	03/2012-01/2013	00, 12 UTC	0.25° x 0.25°
measure-ments	FINO1	10/2005-12/2012	10 min	--
	FINO3	01/2009-12/2012	10 min	--

Results

mean absolute errror of significant wave height in m

location: FINO1

period: 03/2012-12/2012

method	target	best MAE	worst MAE	MAE GWAM
mean	--	0.4338 (3 member)	0.4644	0.4669
multilinear regression	FINO1	0.4060 (9 member)	0.4108	0.4669
multilinear regression	GSM analysis	0.3957 (10 member)	0.3994	0.4669
ANN	FINO1	0.4031 (8 member)	0.4150	0.4669

➡ all TLEs beat direct model output (DMO)!

Results
weather window

- accuracy
  - $\frac{hits+correct\ negatives}{total}$
- hit rate
  - $\frac{hits}{hits+misses}$
- false alarm rate
  - $\frac{false\ alarms}{false\ alarms+correct\ negatives}$

		observed: yes	observed: no
predicted	yes	hits	false alarms
predicted	no	misses	correct negatives

Results
weather window

- definition of event
  - duration: 10 h
  - max. sign. wave height: 1.5 m
- test case
  - location: FINO1
  - period: 03/2012-12/2012
  - forecast horizons: 24-164 h

method	target	accuracy	hit rate	false alarm rate
GWAM (DMO)	--	76.67 %	77.76 %	24.13 %
mean	--	76.95 %	**79.25 %**	24.73 %
multilinear regression	FINO1	**78.37 %**	78.27 %	**21.56 %**

Conclusions

- good improvements of the sign. wave height achieved
  - in terms of MAE
  - with respect to the workability at offshore wind farms
- best method depends on
  - error to be reduced
    - MAE
    - accuracy and false alarm rate
    - hit rate
  - location (not shown)

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Thank you for your attention!

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