First studies with the high-resolution coupled wave current model CWAM and other aspects of the project Sea State Monitor

Jens Kieser, Thomas Bruns
German Meteorological Service (Deutscher Wetterdienst, DWD)
Anja Lindenthal, Frank Janssen, Thorger Brüning
German Maritime and Hydrographic Agency (Bundesamt für Seeschifffahrt und Hydrographie, BSH)
Arno Behrens
Helmholtz-Zentrum Geesthacht (HZG)
Xiao-Ming Li, Susanne Lehner, Andrey Pleskachevsky
German Aerospace Center (Deutsches Zentrum für Luft- und Raumfahrt, DLR)
Structure of the presentation:

• Motivation and intention of the project "Sea State Monitor"

• Model development
  → CWAM

• Model validation
  → using in-situ measurements
  → using TerraSAR-X

• The influence of currents and water depth on sea state

• Summary, conclusions, and outlook
Motivation and intention:

DWD: operational sea state forecast using global and regional wave forecast models (e.g. GWAM, EWAM).

BSH: operational sea current and water level prediction using ocean circulation models (e.g. BSH CMOD, HBM).

Users of forecasts:

e.g. commercial shipping, recreational craft, coastal protection, offshore industry
Motivation and intention:

Offshore industry is very active in German coastal waters.

They need very exact forecast in the range of low and moderate wave heights.
Motivation and intention:

Offshore industry operates in sea areas with complex topography and strong currents, where conventional prediction exhibits significant uncertainties.

Planned or existing wind farms within the German Bight

Typical shipping routes of the offshore industry within the German Bight
**Motivation and intention:**

improvement of the operational sea state, sea current, and sea height forecast for the German coastal waters

**Main parts of the project:**

- development of the high-resolution, coupled wave current model CWAM for the German Bight and the western Baltic Sea
- development of algorithms in order to derive meteo-marine parameters from radar satellite observations
- creation of new forecast products combining model and satellite data
Coastal Wave Model (CWAM)  
**NEW!**
- wind input from COSMO-EU,
- spectral resolution: 36 directions, 30 frequencies
- increment longitude: 0.01389°
- increment latitude: 0.00833°
- coupled with the ocean circulation model (HBM) that provides current and water depth

European Wave Model (EWAM)  
**CONVENTIONAL**
- increment longitude: 0.1°
- increment latitude: 0.05°

First studies with the high-resolution wave current model CWAM …, Jens.Kieser@dwd.de, Banff, 2013-10-31
Comparison between CWAM, EWAM, and in situ measurements at two positions within the German Bight

Significant wave height

In situ observation, EWAM, CWAM

First studies with the high-resolution wave current model CWAM …, Jens.Kieser@dwd.de, Banff, 2013-10-31
First studies with the high-resolution wave current model CWAM …, Jens.Kieser@dwd.de, Banff, 2013-10-31

comparison model vs in situ measurements:
comparison model vs in situ measurements:

significant wave height at buoy position close south of the island Helgoland

EWAM: European Wave Model
First studies with the high-resolution wave-current model CWAM …, Jens.Kieser@dwd.de, Banff, 2013-10-31

Comparison model vs in situ measurements:

Significant wave height at buoy position close south of the island Helgoland
comparison model vs in situ measurements:
significant wave height at buoy position close south of the island Helgoland

EWAM: European Wave Model

Helgol.BuoyS correlation coeff. 0.951608 scatter index 0.313087

CWAMN: fixed depth, no current

Helgol.BuoyS correlation coeff. 0.957344 scatter index 0.218326

CWAMC: variable depth, current

Helgol.BuoyS correlation coeff. 0.956081 scatter index 0.229603
comparison model vs in situ measurements:

significant wave height at offshore research platform FINO 1*

(* The FINO project is promoted by the German Federal Ministry for Environment, Nature Conservation, and Nuclear Safety and by the Projektträger Jülich.)

EWAM: European Wave Model

CWAMN: fixed depth, no current

CWAMC: variable depth, current

First studies with the high-resolution wave current model CWAM …, Jens.Kieser@dwd.de, Banff, 2013-10-31
Comparison of TerraSAR-X (satellite) observations with CWAM results:

Significant wave height computed by CWAM and derived from high-resolution TerraSAR-X observation using XWAVE algorithm (Bruck and Lehner 2012)
influence of water depth and current on the wave height:
influence of water depth and current on the wave height:

**significant wave height**

**water depth relative to reference depth**

**current**
influence of water depth and current on the wave height:

**significant wave height**

**water depth relative to reference depth**

**current**

First studies with the high-resolution wave current model CWAM ..., Jens.Kieser@dwd.de, Banff, 2013-10-31
influence of water depth and current on the wave height:

significant wave height

water depth relative to reference depth

First studies with the high-resolution wave current model CWAM ..., Jens.Kieser@dwd.de, Banff, 2013-10-31
influence of water depth and current on the wave height:

**significant wave height**

**water depth relative to reference depth**

**influence of sea height and current on swh**

2013_06_01_12+11h

**influence of current on swh**

2013_06_01_12+11h

**current speed and direction**

2013_06_01_12+11h
Summary and conclusions:

• CWAM has been developed

• Comparison with buoy measurements shows:
  → general improvement of wave height prediction due to higher model resolution and more detailed representation of topography

• First studies indicate:
  → potential improvements in near shore areas when time varying water depth and currents are taken into account
  → effects of currents are highly localized, but affected areas are highly frequented by offshore industry (main beneficiary of improved forecasts)
First studies with the high-resolution wave-current model CWAM …, Jens.Kieser@dwd.de, Banff, 2013-10-31

**Outlook:**

- Interactive coupling of CWAM and the ocean circulation model HBM
- Extension of the operational forecast time range to 48 or 72 hours
- Refinement of algorithms to derive meteo-marine parameters from TerraSAR-X satellite measurements
- Validation of model results with space-borne SAR data covering large areas
THANK YOU
Scatter Index as used by Ris et al. 1999:

\[ SI = \frac{\text{rms}_{\text{error}}}{X} \]

\[ \text{rms}_{\text{error}} = \sqrt{\frac{1}{N} \cdot \sum_{N}(X_n - Y_n)^2} \]

- \( X_n \): observed values
- \( Y_n \): computed values
- \( N \): number of observations
- \( X \): averaged observed value