




ANNEX-2 02 Behrens Awi Modeling

## Simulation Module within GITEWS AWI's Contribution



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 Olga Startseva, Eifu Taguchi

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## Institute – in short

- 1980: Institute founded
- State 2005:
  - Budget: 103 Mio. Euro
  - 788 Staff
- Funding:
  - 90% Research State Dept. (BMBF)
  - 8% State of Bremen
  - 1% States Brandenburg and Schleswig-Holstein
  - Third party funding
- Member in Helmholtz-Gemeinschaft



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## Institute – Locations in Germany






Wattenmeerstation Sylt


Biologische Anstalt Helgoland

Alfred-Wegener-Institut für Polar- und Meeresforschung Bremerhaven


Forschungsstelle Potsdam

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## Institute – Research platforms




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## Team



Widodo S. Pranowo

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Sven Harig

Stephan Braune

Alexey Andreoyev


Florian Kiaschka

Olga Startsewa

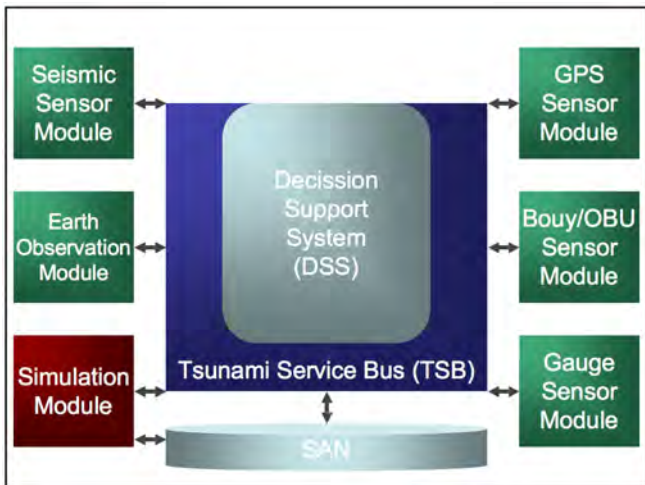
Jörn Behrens

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## System Overview

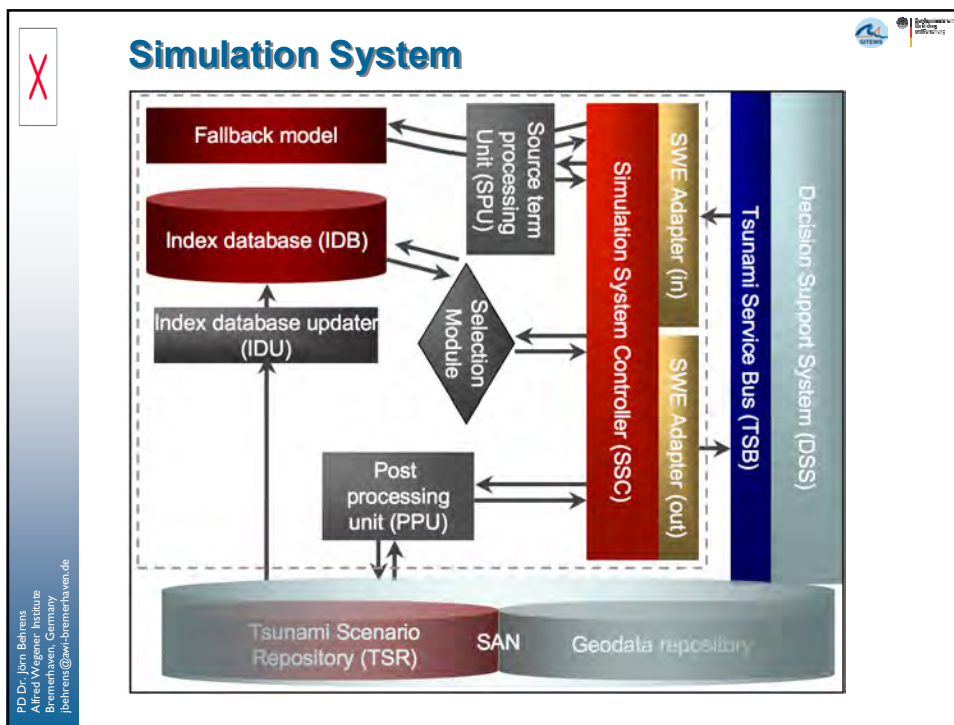


```

    graph TD
      subgraph Sensors
        SSM[Seismic Sensor Module]
        GSM[GPS Sensor Module]
        EOM[Earth Observation Module]
        BOSM[Bouy/OBU Sensor Module]
        GSM2[Gauge Sensor Module]
      end
      subgraph Core
        DSS[Decision Support System (DSS)]
        TSB[Tsunami Service Bus (TSB)]
      end
      subgraph Other
        SM[Simulation Module]
        SAN[SAN]
      end
      SSM <--> DSS
      GSM <--> DSS
      EOM <--> DSS
      BOSM <--> DSS
      GSM2 <--> DSS
      DSS <--> TSB
      SM <--> TSB
      TSB <--> SAN
  
```

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**TsunAWI**

- Unstructured mesh
- Finite elements
- Non-linear shallow water eq.
- With run-up/inundation
- Full set of documents
- Restructured and cleaned
- License (GPL-like)
- First Evaluations (see below)
- Gforge repository (gforge.awi.de) soon available

The slide includes a technical document cover for "TsunAWI Technical Documentation Part I: Mathematical, numerical, and implementation concepts" dated Friday, 2 February 2007. Below the document is a map showing a coastal area with a color-coded simulation result, likely representing inundation depth or wave height, with a vertical scale from 0.00 to 7.00.

Logos for GEF and the German Federal Government are visible in the top right corner.

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## TsunAWI Discretization

$$\sum_l \int_{\partial\tau_l} \left( \frac{\partial h}{\partial t} b_h - (h + H) \mathbf{v} \cdot \nabla b_h \right) dx + \sum_l \int_{\partial\tau_l} (h + H) b_h \mathbf{v} \cdot \mathbf{n}_l d\Gamma = 0,$$

$$\sum_l \int_{\partial\tau_l} \left( \frac{\partial \mathbf{v}}{\partial t} b_v - (\nabla \cdot (\mathbf{v} b_v)) + f(\mathbf{e}_r \times \mathbf{v}) b_v + g \nabla h b_v \right) dx + \sum_l \int_{\partial\tau_l} (\mathbf{v} \mathbf{v} \cdot \mathbf{n}_l) b_v d\Gamma + \sum_l \int_{\partial\tau_l} [\mathbf{v}] [a(b_v)] d\Gamma = 0.$$

$b_h$

$b_v$

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## TsunAWI Validation

### Run-up Benchmark

$t=0$

$t=160s$

$t=175s$

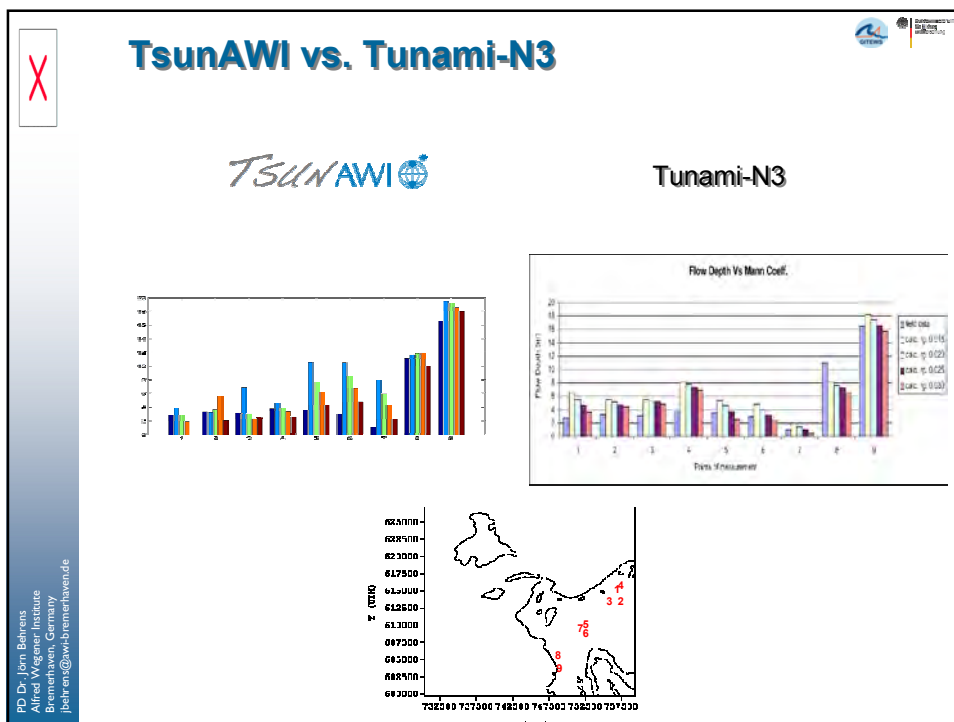
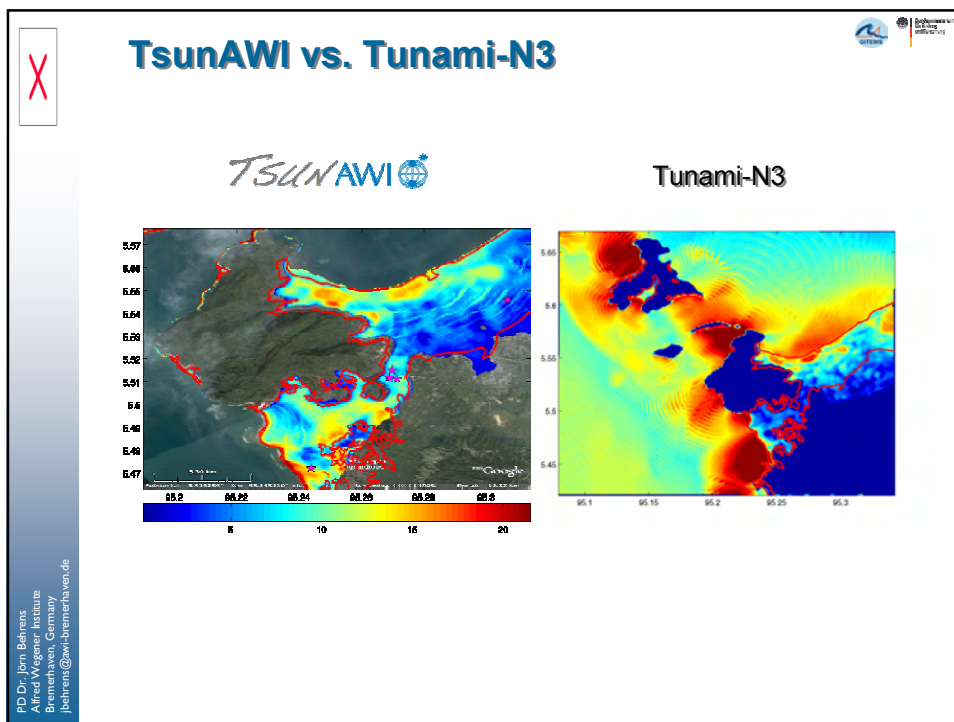
$t=220s$

— modelled SSH
— analytical solution
— initial condition

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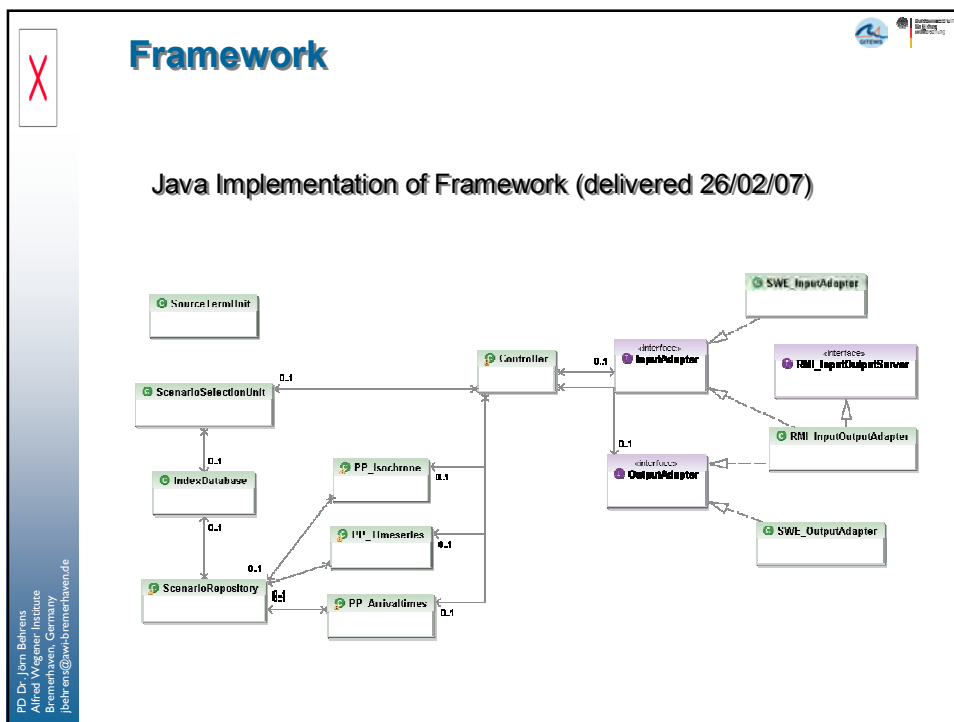
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## TsunAWI Animation


Zur Anzeige wird der QuickTime™ Dekompressor „-“ benötigt.

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## System design


- Documents describing:
  - Design
  - Requirements
  - Interfaces (in progress)
  - Use cases (to come)
  - Data quality
- Implementation of version 0.5 (05/2007)
- Concept for version 12/2007



Tsunami Project Documentation  
Document No. 001

**Simulation system design**  
Jörn Behrens (Joern.Behrens@awi.de)


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Tsunami Project Documentation  
Document No. 002

**Simulation system interfaces and data products**  
Jörn Behrens (Joern.Behrens@awi.de)

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Tsunami Project Documentation  
Document No. 003

**Simulation system requirements**  
Jörn Behrens (Joern.Behrens@awi.de)

**Executive Summary**  
This document formulates the requirements necessary to operate the simulation system within the AWI. One can find here the initial requirements for the different system components. The initial focus lies on the primary data requirements necessary for the simulation system to generate meaningful results. The first focus lies on the requirements for the simulation system to obtain satellite data.


**We advised that this is a preliminary document and subject to change!**  
Because the technical requirements may still change, some our statements are not yet available. We will update the document as soon as reliable data is available.

**Related Documents**

1. The simulation system design document (Doc. No. 001) gives an overview over the simulation system components.
2. The simulation system interfaces and products document (Doc. No. 002) gives an insight description of the interfaces and data products to other modules and the DBS.

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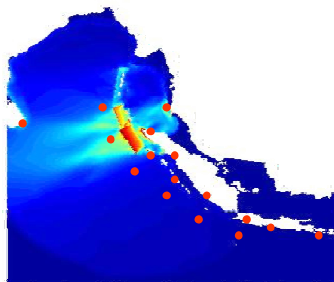
## Indexing

**Indexed positions:**

- Seismic parameters
- Buoy positions
- GPS sensor positions
- Gauge positions
- Positions of interest

**Indexed values:**


- Epicenter, Magnitude
- Gauge time series
- GPS rupture vectors
- Wave heights
- Arrival times



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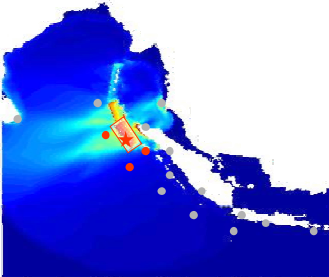


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## Selection

Comparison Data:

- Epicenter, Magnitude  $(\lambda, \phi) + M$
- Gauge time series  $ssh_{\lambda, \phi}(t)$
- GPS rupture vectors  $\vec{x}_{\lambda, \phi}$
- Wave heights  $ssh_{\lambda, \phi}(t_i)$
- Arrival times  $t_{\lambda, \phi}$




**Example:**

$(\lambda^0, \phi^0) + M^0$

$ssh_{\lambda^i, \phi^i}(t) \quad i = 1 : 3$

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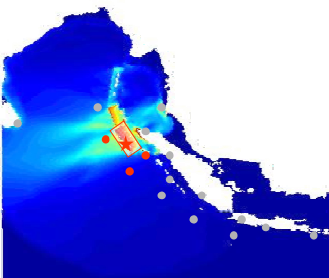
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## Best fit

**Given:**

$(\lambda^0, \phi^0) + M^0$

$ssh_{\lambda^i, \phi^i}(t) \quad i = 1 : 3$



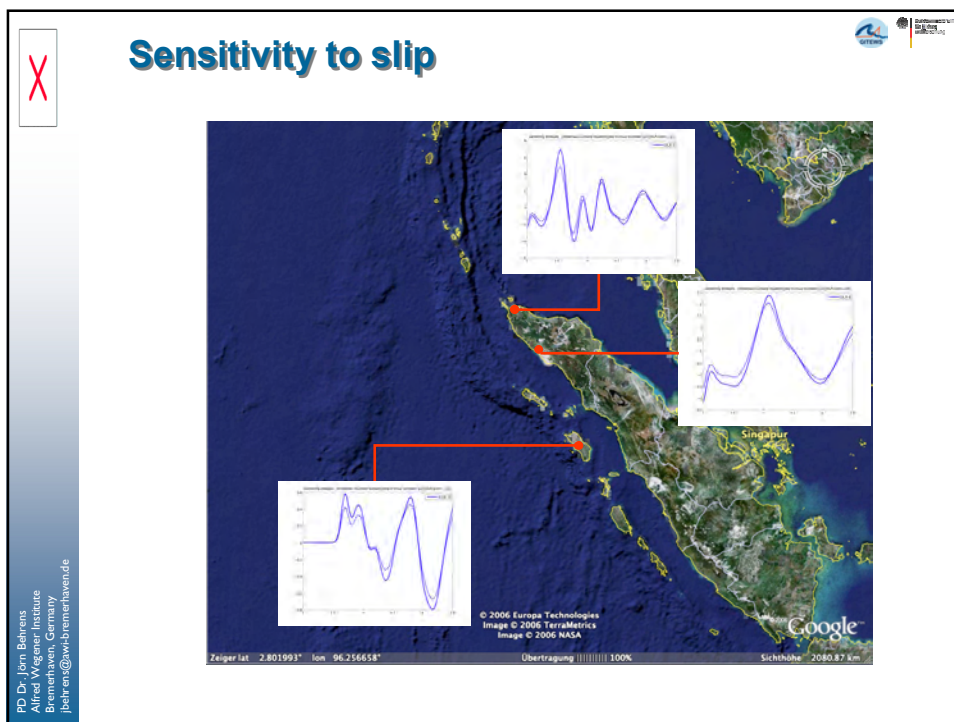
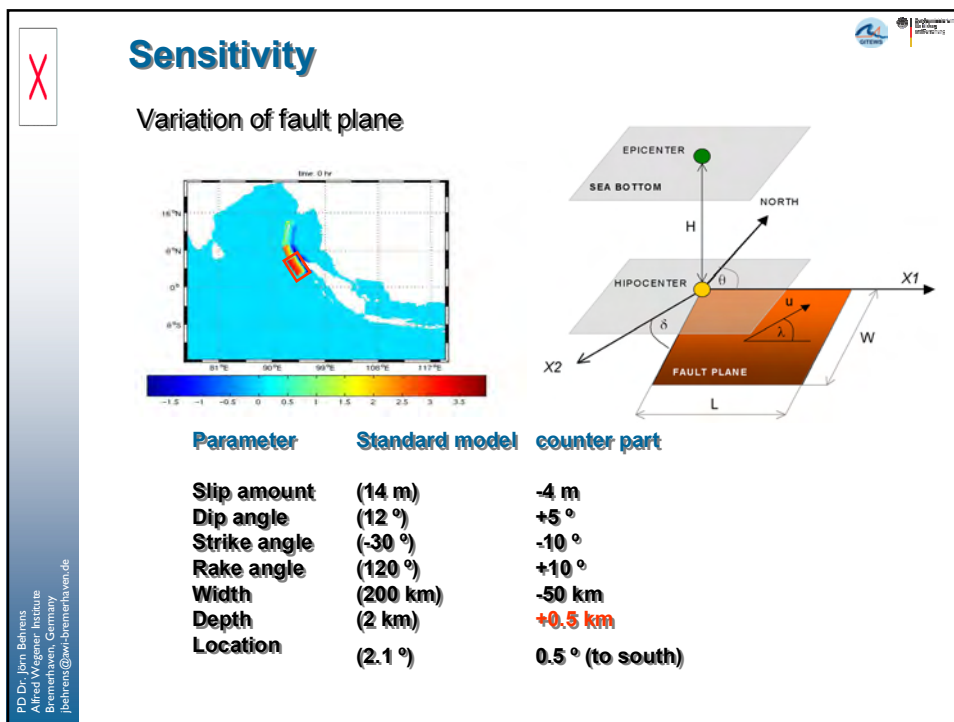
Best fit in least squares sense:

$$\min_{\text{all scenarios } s} \left[ w_{loc} \|(\lambda^0, \phi^0) - (\lambda^s, \phi^s)\|_2^2 + w_{mag} (M^0 - M^s)^2 + w_{ssh} \sum_i \|ssh_{\lambda^i, \phi^i}(t) - ssh_{\lambda^i, \phi^i}^s(t)\|_t^2 \right]^{\frac{1}{2}}$$

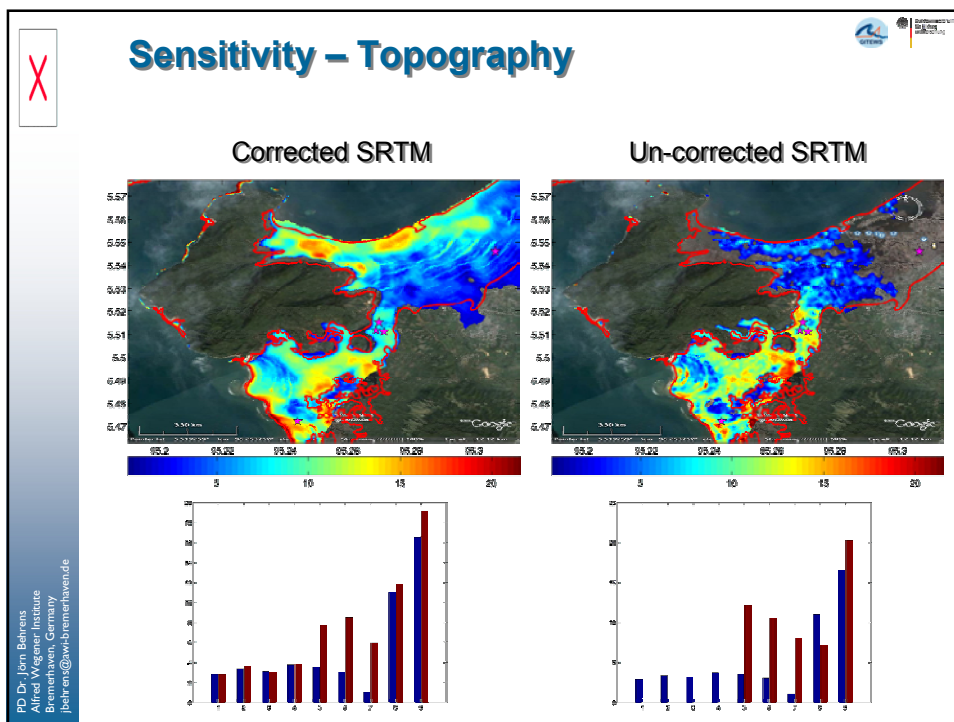
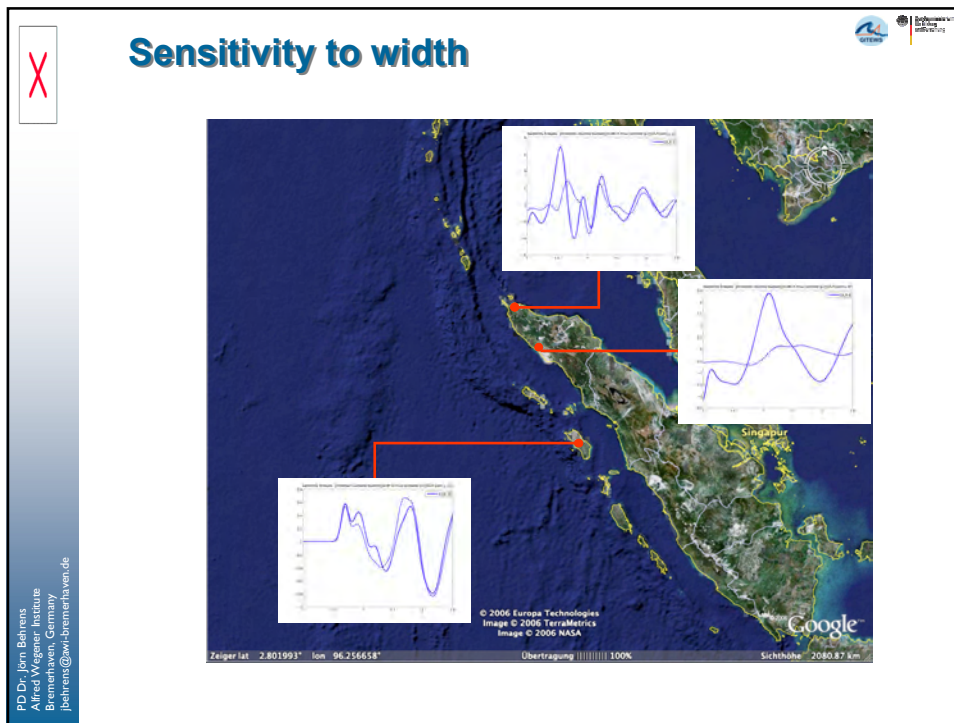
$w_x$ , weights

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### Conclusions

- Pre-computed scenarios
- Scenarios with
  - Sophisticated source model
  - Seamless deep-shallow
  - Run-up
- Index database
- Multi-Sensor selection
- Open interfaces (OGC, etc.)
- Intense sensitivity analysis

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