Clarifying the impact of epistemic uncertainties on future marine flooding

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With: G. Le Cozannet¹, D. Lincke², J. Hinkel²
'For every dollar that is spent trying to quantify uncertainty, we should spend 10 dollars collecting and analyzing data that would reduce uncertainty.'

Gail Atkinson (2004 World Conference on Earthquake Engineering)
Different categories of uncertainty

1. Knowledge-based (epistemic uncertainty)
   • from limited knowledge, measurement capability and modeling capability on the part of the analyst.
   • Can be reduced. Extreme case: “We expect that if we had infinite data it would be zero”

[Abrahamson 00; Straub & Schubert 08; Marzocchi et al. 04; Deck & Verdel 12,…]
Different categories of uncertainty

1. Knowledge-based (epistemic uncertainty)
   • from limited knowledge, measurement capability and modeling capability on the part of the analyst.
   • Can be reduced. Extreme case: “We expect that if we had infinite data it would be zero”

2. Randomness (aleatory uncertainty/variability)
   • “real” variability intrinsic to the physical system under study (e.g., occurrence of storms);
   • Irreducible;

[Abrahamson 00; Straub & Schubert 08; Marzocchi et al. 04; Deck & Verdel 12, …]
What are the most important epistemic uncertainties to be reduced?

- Global test case
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Role of irreducible versus epistemic uncertainties?
- Local test case
What are the most important epistemic uncertainties to be reduced?

- Global test case

Coastal flood damage and adaptation costs under 21st century sea-level rise

Hinkel et al. (2014)
Epistemic uncertainties in loss assessment

Adapted from Wilby and Dessai (2010)

Hinkel et al. (2014)
A scenario-based approach

5 Shared Socio-Economic Pathways scenarios

Based on Hinkel et al. (2014)
A scenario-based approach

3 RCP scenarios (2.6, 4.5, 8.5)

Hinkel et al. (2014)
A scenario-based approach

Hinkel et al. (2014)

The cascade of uncertainty

Future society
GHG emissions
Climate model
Regional scenario
Impact model
Local impacts
Costs

SSP
RCP
Choice in GCMs

The envelope of uncertainty

HadGEM2-ES, IPSL-CM5A-LR, MIROC-ESM-CHEM, NorESM1-M
A scenario-based approach

Hinkel et al. (2014)

3 scenarios of contributions from ice sheets and glaciers: low-med-high

The cascade of uncertainty

Future society
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Costs

SSP
RCP
Choice in GCMs
Land-ice scenarios

The envelope of uncertainty
**A scenario-based approach**

Hinkel et al. (2014)

Subsidence in delta regions: Y/N
A scenario-based approach

Hinkel et al. (2014)

SSP
RCP
Choice in GCMs
Land-ice scenarios
Subsidence
Damage function DF

The cascade of uncertainty

Future society
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The envelope of uncertainty

2 configurations of the damage function
A scenario-based approach

Hinkel et al. (2014)

2 databases for estimating the extreme sea levels (DINA-COAST & GTSR)

Vafeidis et al., 2008 ; Muis et al. 2017
A scenario-based approach

Hinkel et al. (2014)

2 Asset-to-GDP ratios: 2.8* ; 3.8

*Hallegatte et al., 2013
A scenario-based approach

Hinkel et al. (2014)

2 880 combinations!
COST: dike raising + maintenance

COST (billion US$)

| Year | Cost
<table>
<thead>
<tr>
<th></th>
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<tbody>
<tr>
<td>2020</td>
<td>30</td>
</tr>
<tr>
<td>2040</td>
<td>40</td>
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<td>2060</td>
<td>50</td>
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<td>2080</td>
<td>60</td>
</tr>
<tr>
<td>2100</td>
<td>70</td>
</tr>
</tbody>
</table>

Time

-1 std dev. to +1 std dev. around the mean.
Using a tree-based Machine Learning approach
EAD (billion US$)

Using tree-based Machine Learning approach
What are the most important epistemic uncertainties to be reduced?
- Global test case

Role of **irreducible** versus **epistemic uncertainties**?
- Local test case
Acknowledgeing uncertainty impacts public acceptance of climate scientists’ predictions

Lauren C. Howe, Bo Maclnnis, Jon A. Krosnick, Ezra M. Markowitz and Robert Socolow

Framed using predictable bounds

Framed using worse case sc.
$a_1 = 0.26^*$

Trust in scientists

$\beta_1 = 0.37^{***}$

Message acceptance

$c_1 = 0.07^*$

$c_1' = 0.04^+$

Fully bounded uncertainty (versus no/partially bounded uncertainty)
With information on **irreducible uncertainty**

\[
\begin{align*}
a_1 &= -0.36^* \\
& \\
\text{Trust in scientists} & \\
& \\
b_1 &= 0.37^{***} \\
& \\
c_1 &= -0.10^* \\
c_1' &= -0.06^* \\
& \\
\text{Message acceptance} & \\
& \\
\end{align*}
\]
Yearly probability of flooding over time?

Le Cozannet et al., 2015
Global sensitivity analysis at Palavas

Uncertainty on: yearly probability of exceeding the seawall height

Sensitivity index

Year

Global sea level rise

Wave setup

Interactions

Offshore extremes

Sea-level variability

RSL

RCP

Le Cozannet et al., 2015
Epistemic versus Irreducible

Classification Attempt!

Mostly irreducible
Extremes
Wave setup
RSL
Global sea level rise

Mostly epistemic
RCP
GSLR
Epistemic versus Irreducible

Classification Attempt!

- Classification **not** straightforward
- Most uncertainties **both** contain irreducible and epistemic part
- **Time** evolution of the irreducible/epistemic part?
Summary

- Global sensitivity analysis:
  - Defines research priorities
  - Identifies most appropriate time-frame
  - Contributes to the definition of learning scenarios (Hinkel et al. 2019)
Summary

- **Global sensitivity analysis:**
  - Defines research priorities
  - Identifies most appropriate time-frame
  - Contributes to the definition of learning scenarios (Hinkel et al. 2019)

- **Classification irreductible/epistemic**
  - Potentially alleviates the negative effect on message acceptance (Howe et al., 2019)
  - Raises practical difficulties
Thank you for your attention!

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[Global Climate Forum](http://www.globalclimateforum.org)