ELICITING DEPENDENCE: THE WHY, THE WHAT AND THE HOW

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Outline

- Why should one care?
- What should one worry about?
- How should one ask about dependence?
- How to benefit from all the answers?

Working Group 2 (WG 2) : *Dependence Elicitation*

- Members of WG 2
- Possible outputs

Why should one care?

Why should one care?

UK, 2014

"The Floods: High water everywhere"

"UK floods: The winners and losers"

Why should one care?

"Floods are like snowflakes, says Andrew McKenzie of the British Geological Survey, a research body: none is quite like another. **Rivers can overflow**, as in Somerset. **Groundwater can flood**, as in the Thames Valley. **Tides can surge**, inundating villages, as they have in Lincolnshire. **Rain can pound down too quickly to be absorbed**. None of these is rare on its own. But over the past two months Britain has been subject to the whole lot, often in combination, over a large area."

Extract from The Economist, Feb 15th 2014, *The floods: High water everywhere*
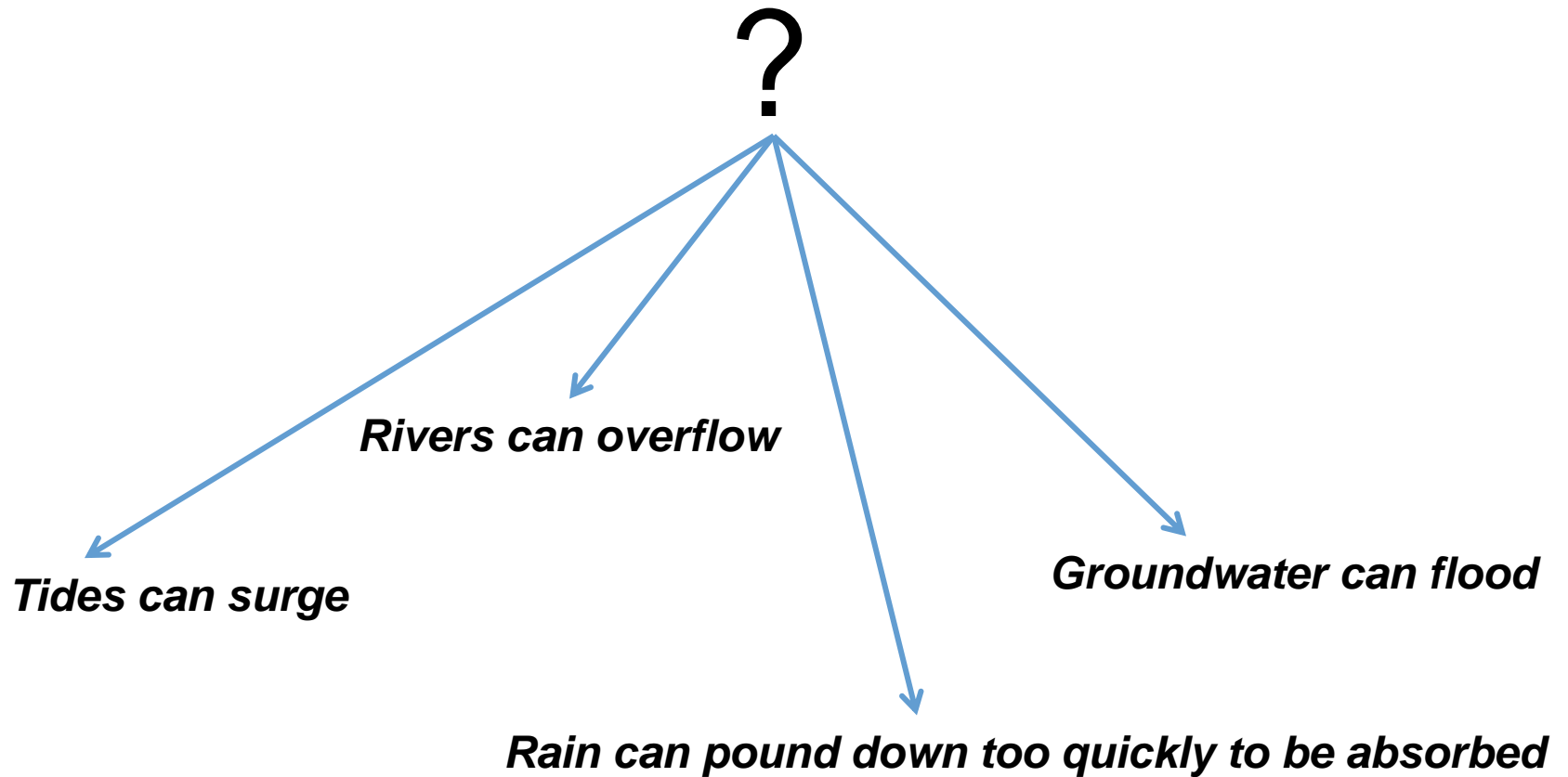
Why should one care?

Rivers can overflow

Tides can surge

Groundwater can flood

Rain can pound down too quickly to be absorbed

- Is there a reason for them happening in combination?

- Is there dependence between them?

  - It would be if a common factor influences all!

Why should one care?

?

Rivers can overflow

Tides can surge

Groundwater can flood

Rain can pound down too quickly to be absorbed

Why should one care?

Met Office's chief scientist,
Dame Julia Slingo

[…] Julia Slingo said: 'there was "no definitive answer" as to what had caused the period of stormy weather in the UK but that "all the evidence suggests there is a link to climate change'.

Climate Change

Rivers can overflow

Tides can surge

Groundwater can flood

Rain can pound down too quickly to be absorbed

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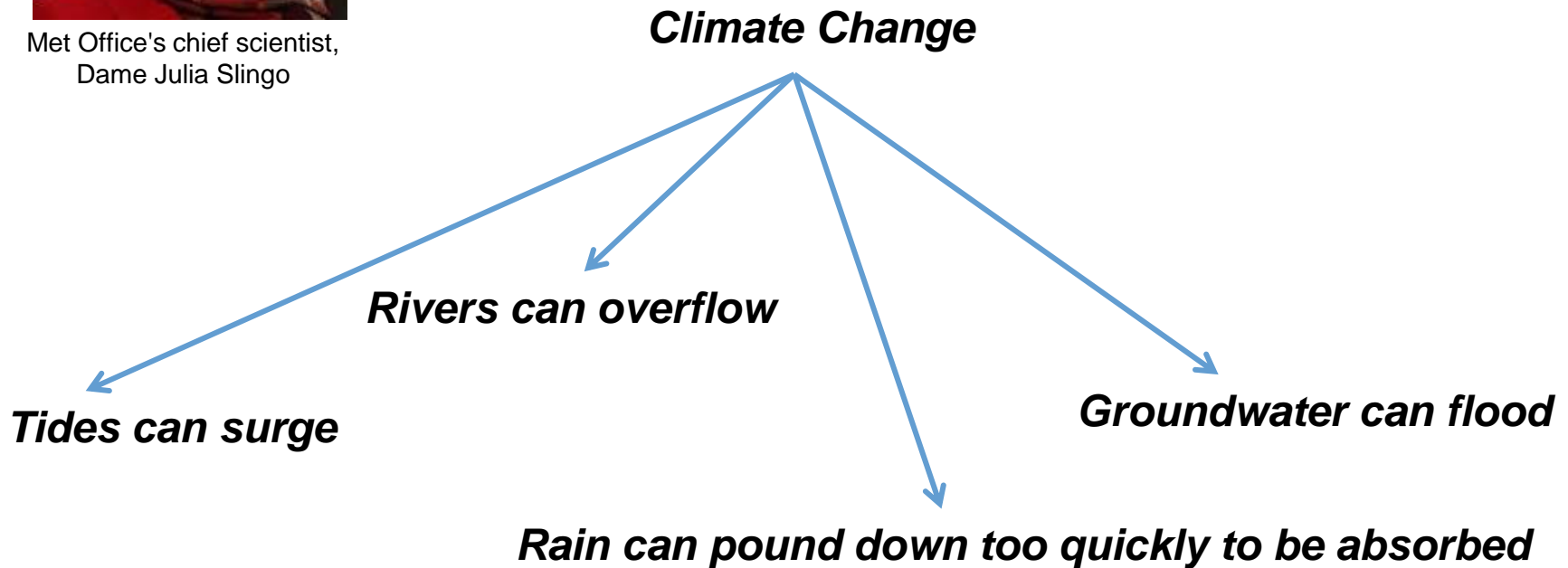
What should one worry about?

Acknowledging dependence

So the occurrence of a river overflow
and
the occurrence of a tidal surge are dependent

Dependence Acknowledged
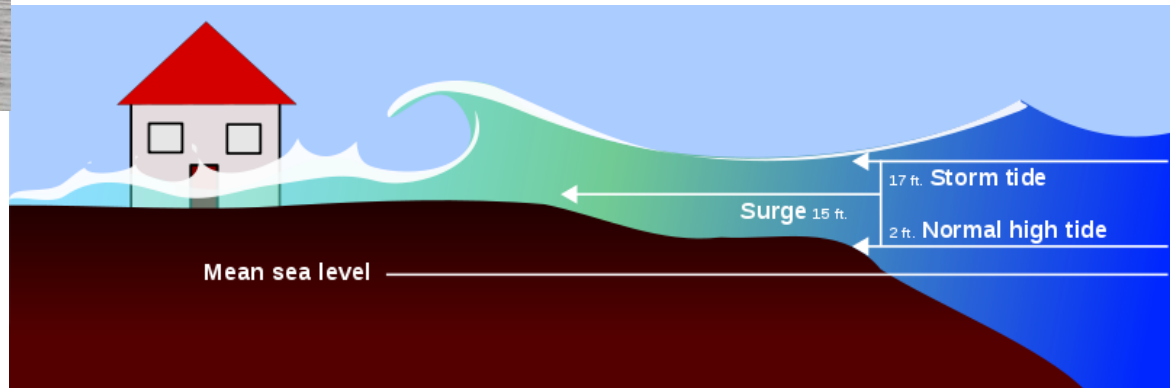
How "dependent" are they? What can one expect?

Dependence Quantification

We want to…

- Avoid disasters
- Be prepared
- Minimise losses

- Predict flood risk accurately
- Strengthen protection against damaging floods

Dependence quantification

- Causes of uncertainty are often interrelated/ dependent

- Ignoring these dependencies may lead to large errors in the models

- Shortage of empirical data inevitably requires input from expert judgment

- Dependence amongst many uncertain variables is a very complex affair

What should we worry about?

"Is the occurrence of a river overflow *correlated* with the occurrence of a tidal surge?"
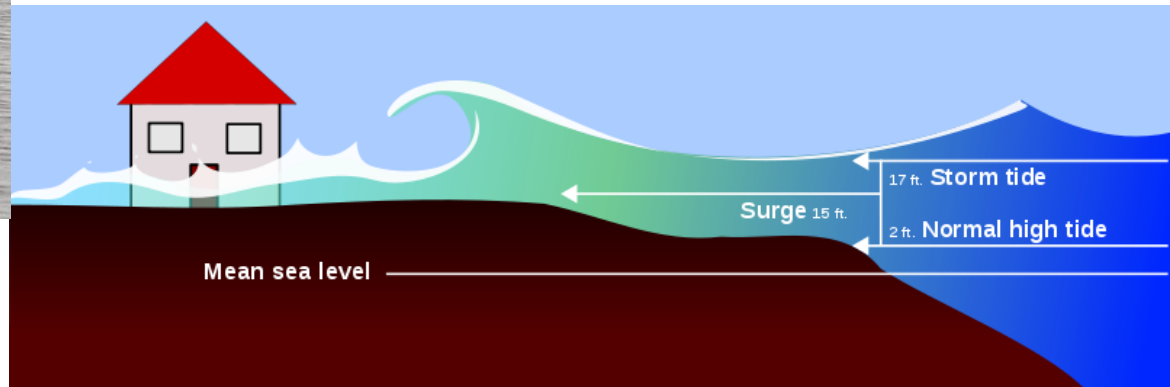
"What is the chance that one variable exceeds a threshold, given that the other does too?"

"What is the chance that one variable is extreme, given that the other is?"

How should one ask about dependence?

How should we ask?

- Are the variables that we are interested in correlated?

- If they are, what is the best way to look at their correlation?
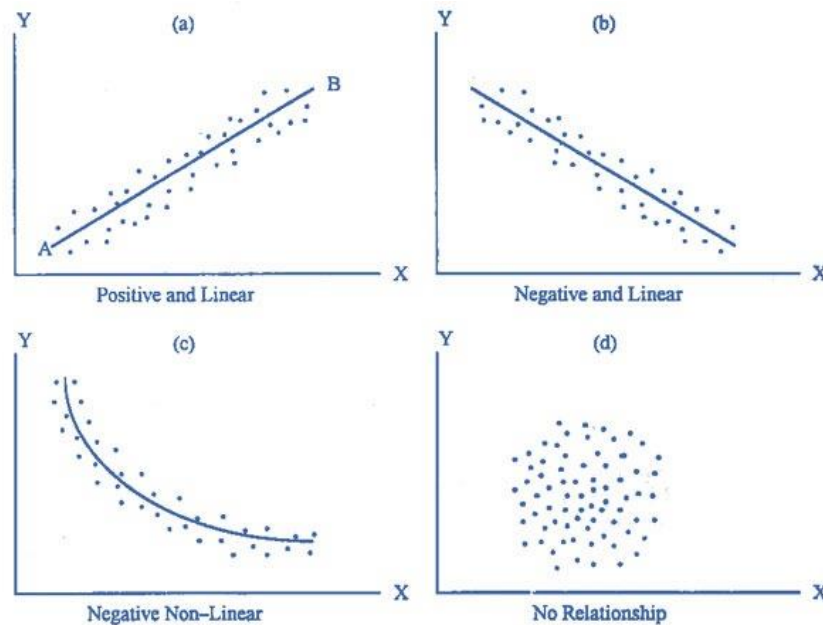
How should we ask?

Thirteen Ways to Look at the Correlation Coefficient

Joseph Lee Rodgers; W. Alan Nicewander

The American Statistician, Vol. 42, No. 1. (Feb., 1988), pp. 59-66.

Linear dependence (alone) can be seen as a:

- standardized covariance
- geometric mean of 2 regression slopes
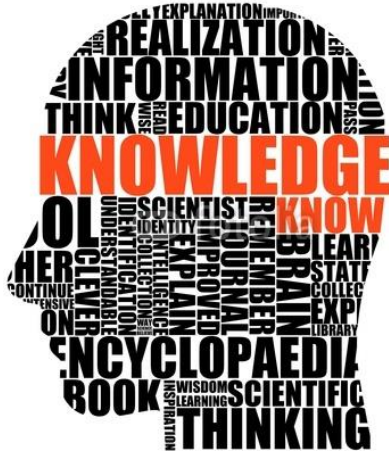- proportion of variability accounted for

How about nonlinear dependence?

How about dependence between extreme events?

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How should we ask?

- Ask experts only about outcomes of possible (but infeasible) measurements/experiments

- Keep it simple and intuitive

How should we ask?

- "What is the chance that one variable exceeds a *threshold*, given that the other does too?"

- Depending on the threshold we choose, we can extract information about

    - "average" dependence

    - "extreme" dependence

Example : Wind loads

- Wind loads on high rise building facades

- When the façade design includes a ventilated cavity *pressure equalization across the façade panels* becomes a factor of importance

- How does the wind pressure outside of one cavity **correlates** with the wind pressure inside the same (or a different) cavity?
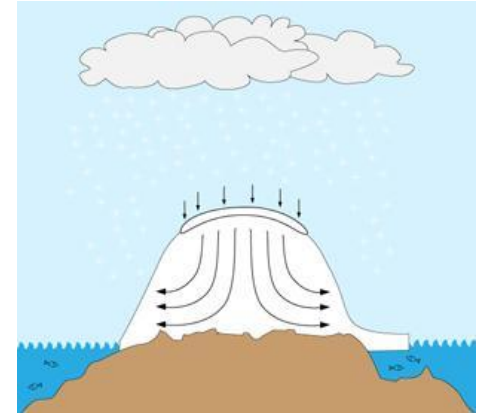
Example: Ice2Sea

- Until recently the amount of snow falling on the surface (*accumulation*) was equalled by the mass leaving the ice sheet as melt water *runoff* or *discharge* of icebergs

- This is no longer the case

- The Greenland ice sheet (GIS) now delivers more mass out than it receives
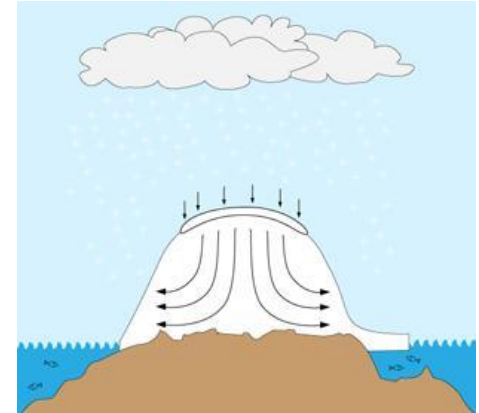
Example: Ice2Sea

- How will the ice sheet respond to the even larger increase in temperatures we should expect in the future?

- How large will the loss of mass be in a warmer future?

- How much freshwater will the Greenland ice sheet add to global sea level?

Example: Ice2Sea

EXPERT JUDGEMENT ASSESSMENT

Quantifying uncertainty on thin ice

The contribution of ice sheets to sea-level rise still has large uncertainties that are yet to be quantified.

R. M. Cooke

The GIS contribution to sea level rise in 2100, with 2 C global warming was modelled using three variables:

1. *Runoff*
2. *Discharge*
3. *Accumulation*

Example: Ice2Sea

Greenland Ice Sheet, 2100, with 2C warming

Suppose the actual value of the runoff *contribution is above your median value, what is your probability that* accumulation *is also above its median value, Probability = _____*

If these uncertainties are independent, the probability is 1/2; probabilities greater than 1/2 indicate positive association, less than 1/2 indicate negative association.

Suppose the actual value of the runoff *contribution is above your 95% value, what is your probability that* accumulation *is also above its 95% value, Probability = _____*

If these uncertainties are independent, the probability is 0.05; probabilities greater than 0.05 indicate positive association, less than 0.05 indicate negative association.

How to benefit from all the answers?

Aggregation

- "The more the merrier"

- Several experts generate several opinions

- Need for aggregation

Aggregation

- Contribution to a final answer should be weighted according to their performance as dependence assessors

- How should we measure performance?

Members of WG 2

WG2 composition

Roger Cooke
David Rios
Ahti Salo
Oswaldo Morales Napoles
Charles R Twardy
Bo Lindqvist
Fabrizio Ruggeri
Jim Smith
Willy Aspinall
Paolo Giudici
Dorota Kurowicka
Kevin Wilson
Matthew Revie
Olivier Jaquet
Andreas Charalambous
Annemarie Christophersen
Rob Buxton
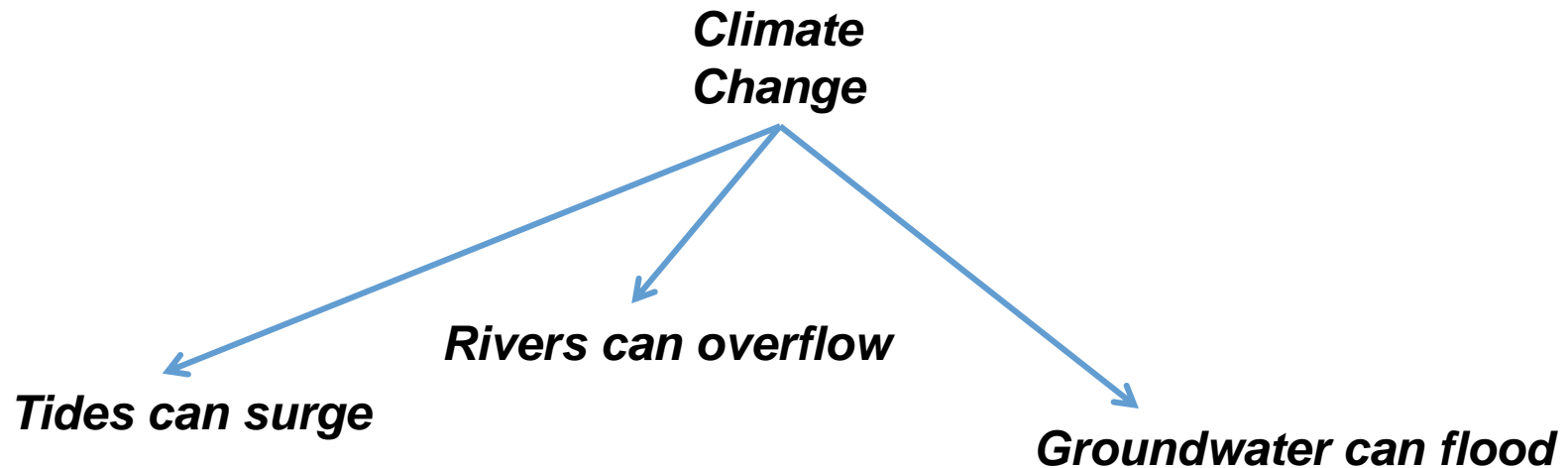Anca Hanea

Possible outputs

WG 2 outputs

- List of references for eliciting dependence

    ✓ A first step towards a systematic review of existing literature

- Literature review

    ✓ A thorough literature review of the most relevant references identified above

WG 2 outputs

- Eliciting dependence through exceedence probabilities vs. correlations

  ✓ The wind loads example & invited talk (Oswaldo Morales)

- Eliciting tail ("extreme") dependence

  ✓ The Ice2Sea example & plenary talk (Roger Cooke)

- Eliciting dependences using ordinal questionnaire data

  ✓ Operational risk problems -- self-assessment questionnaires

WG 2 outputs

- Use structured expert judgement to elicit (parts of) the structure of a graphical probabilistic model

    ✓ In what way and what sort of questions could we formulate for the experts such that, their answers help us build a graphical structure?

Climate Change

Rivers can overflow

Tides can surge

Groundwater can flood

Thank You

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