METHODS FOR MODELLING MULTI-HAZARDS IN THE METEOR PROJECT

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METEOR project

Modeling Exposure Through Earth Observation Routines

- Three-year project
- Funded by UK Space Agency
- Aims to develop innovative application of Earth Observation (EO) technologies to improve understanding of exposure
- Specific focus on pilot countries Nepal and Tanzania
- Consortium of eight organizations

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Methods for Modelling Multi-hazard in METEOR

• Testing existing methodologies
• The Greiving Model
• The Kappes Model
• Expert Elicitation and Weighting
• Developing protocols for modelling METEOR data
• Sensitivity testing
Landslide hazard 1

(rainfall triggered)

Seismic hazard

PGA values due to earthquake ground shaking with 10% probability of exceedance in 50 years

Landslide hazard 2

(seismic trigger)

Flood hazard

Fluvial and pluvial flood data for 1 in 5, 10, 20, 50, 75, 100, 200, 250, 500 and 1000 year return periods

METEOR Hazard Outputs (Nepal)

Multi-hazard modelling
Introduction to multi-hazards

Single hazards exhibit various characteristics such as: time of onset, duration and extent

Multi-hazard assessments are complicated by:
1. Hazards may be related to each other, and cumulative (cascades)
2. The impacts on elements at risk can be different for differing hazards and occasionally opposing
3. The differences between hazard characteristics and therefore the methods used to observe and monitor them
4. Any of the existing measures of hazard quantification need to be adapted to allow for comparison of multiple hazards
Testing methodologies

- Previous models have focused on: the frequency of events and use of historic dollar losses, as a proxy for infrastructure impact or exposure.
- In the METEOR project we don’t have the baseline of data at a national level required for a fully quantitative model.
- Therefore selected a semi-quantitative model, including developing indicators.
- Two methodologies selected to test data: Greiving (2006) and Kappes (2012).
The Greiving Model

Defines vulnerability as ‘the degree of fragility of a system or community towards natural and technological hazards’

Consider 3 types of hazard exposure:
1) Economic
2) Social
3) Ecological

Calculation of integrated Risk. From: Greiving, 2006
The Greiving Model

1. Generate hazard maps – display the location and intensity of spatially relevant hazards.
2. Production of an integrated hazard map – Compile data into one map displaying overall hazard potential.
3. Create vulnerability map – collect social and economic vulnerability data to assess overall vulnerability of a region.
4. Compile Integrated risk map: Integrate hazard and vulnerability maps to show the overall vulnerability of each region.

Network to apply the Greiving method to the METEOR data.

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The Kappes Model

1. Identification of the inundation zone and inundation depth zones
2. Identification of factors that affect vulnerability of buildings and people and collection of data
3. Calculation of the vulnerability of individual buildings within the inundation zone using a multi criteria evaluation method
4. Display of building vulnerability and human vulnerability

Indicator based vulnerability model

From: Kappes et al., 2012, Applied Geography.
Interacting hazards

Assess the inter-relationships between hazards by creating a hazard matrix.
Expert Elicitation and Weighting

In both of the models tested, hazard and vulnerability indicators are weighted differently to reflect their relationships to each other.

Weights underpinned by fragility curve, inventories of data and expert elicitation.
The Greiving Model: Results

Integrated risk map created by following the Greiving et al method – insert maps show risk in Dar es Salaam (high) and Dodoma (low)
The Kappes Model: Results

Earthquake hazard and relative vulnerability index maps, created following the Kappes model.
Testing methodologies

Greiving: National scale integrated risk with a regional resolution.

Kappes: Retains 90m resolution but generates unique outputs for each hazard.

METEOR model is therefore a hybrid of these models.
METEOR Protocols for modelling multi-hazards

Hazard Assessment
- Fluvial Flood Assessment
  - 1 in 100 years, undefended

Exposure
- Flow Flood Index
  - (%Bid1 * BidW1) + (Bid2 * BidW2) + ....

Relative Vulnerability
- Relative Fluvial Flood Vulnerability

Data is normalised and classified

Develop Index
- % of building types per pixel calculated
- Weights defined for each building code - controlled by materials and number of floors

Can be weighted independently if required

Part 1
- Relative Flood Vulnerability Map
METEOR Protocols for modelling multi-hazards
Sensitivity Analysis

Hazard Assessment

Exposure

Fluvial Flood Assessment (1 in 100 years, undefended)

Fluvial Flood Index * (%Bid1 * Bid(W1) + (Bid2 * Bid(W2)) * ...)

Develop Index
% of building types per pixel calculated
Weights defined for each building code - controlled by materials and number of floors

Relative Vulnerability

Relative Fluvial Flood Vulnerability

Can be weighted independently if required

Relative Landslide Vulnerability Map

Relative Earthquake Vulnerability Map

Data normalised

Hazard weighted independently

Part 1

Relative Flood Vulnerability Map

Part 2

Multi-hazard Map

Data is normalised and classified
Summary

• The METEOR project has produced: single hazard assessments (earthquake, landslide and flood) and exposure data for Nepal.

• We reviewed existing multi-hazard models and tested two differing models, using draft data from Tanzania.

• This models did not quite fit the needs of the METEOR project and so we have create a hybrid, semi-quantitative model that allows us to assess multi-hazards at a national scale, but with a resolution of c.90m.

• We are still in the final stages of sensitivity analysis to determine the effect of data uncertainty on these model outputs.
Key References


• Menoni, S. (2006) Integration of harmonized risk maps with spatial planning decision processes. Deliverable 5.1, ARMONIA.


