Risk and hazard mapping over large areas

presentation by

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Global Landslide and Avalanche Hotspots

Investigator:

NGI / ICG (International Centre for Geohazards)

Sponsor: ProVention Consortium
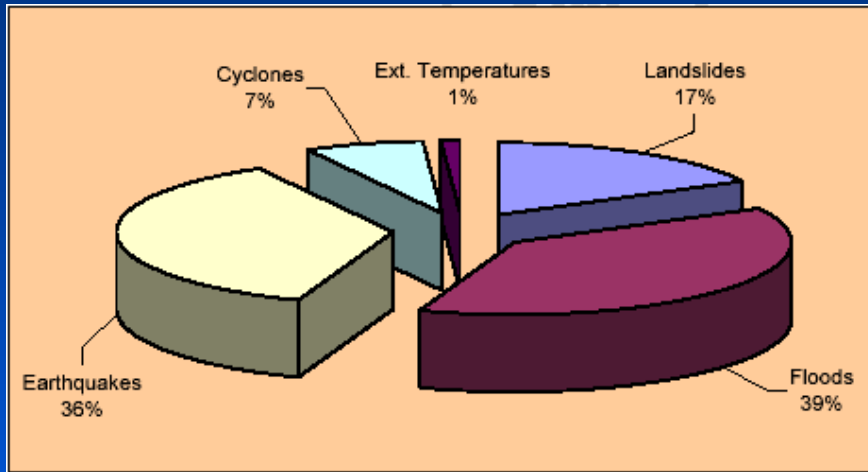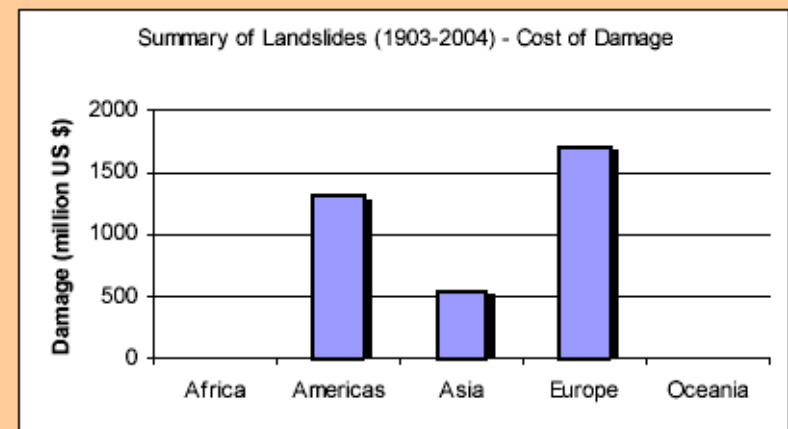
Landslide and Avalanche

The most frequent natural hazard due to geological processes is slope instability

Oslo, Fall 2000

Venezuela, December 1999

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Global landslide statistics

Casualties for different natural hazards during 1990 - 1999
Source: CRED
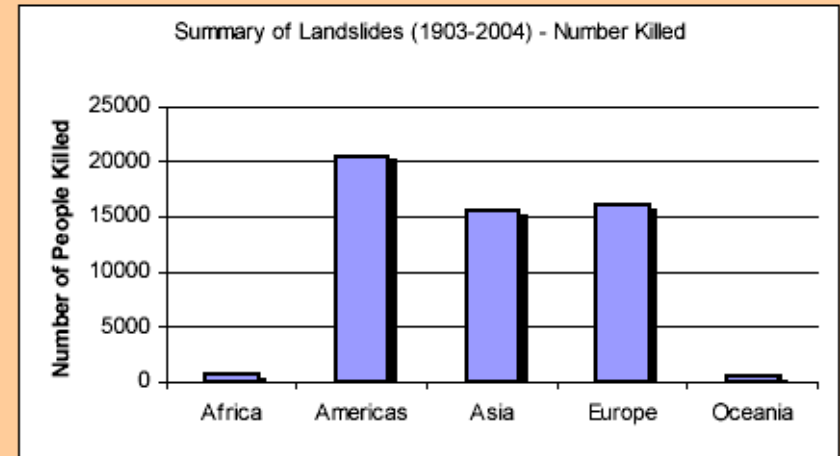
Much of damage and casualties attributed to earthquakes and floods are caused by the landslides triggered by them.

Landslides as a consequence

Earthquakes

Major landslides/ground failures
- 2001 El Salvador Earthquakes
- 1999 Turkey Earthquake
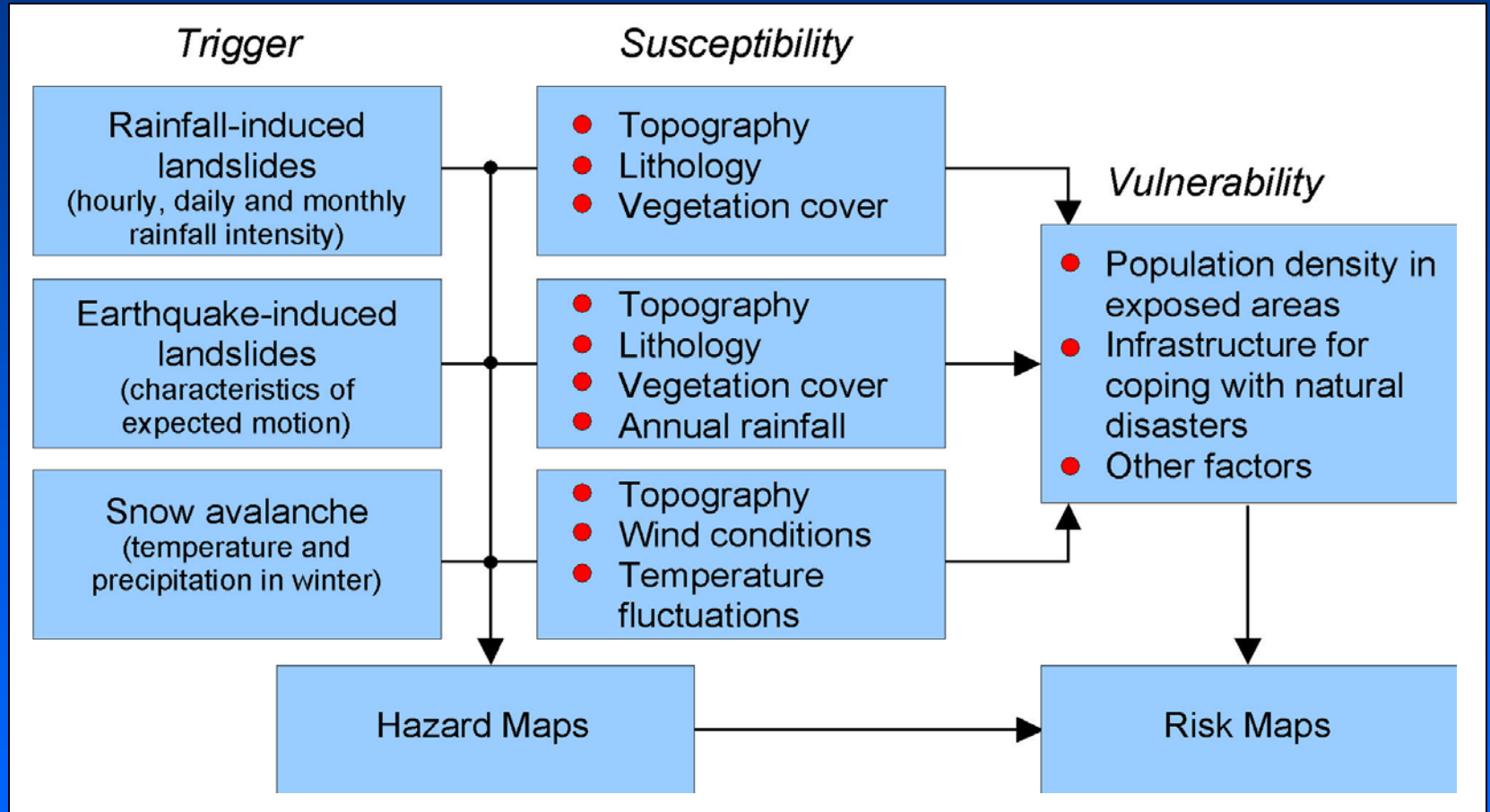- 1976 Guatemala Earthquake
- 1964 Alaska Earthquakes

Heavy precipitation & flooding

Major landslide damage
- 2005 Hurricane Stan in Guatemala
- 1999 Venezuela flooding disaster
- 1998 Hurricane Mitch disaster
- Monsoon rain in Asian countries

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Approach for development of global landslide & avalanche hazard & risk maps

Model for Landslide Hazard Mapping

Hazard = SUSCEPTIBILITY * TRIGGER

(after Mora & Vahrson)

- SUSCEPTIBILITY: Function of slope, lithology (geology), soil moisture, …..

- TRIGGER: Function of seismicity and precipitation

Global soil moisture index S_H

(1961 – 1990)

global annual soil moisture index 1961 - 1990
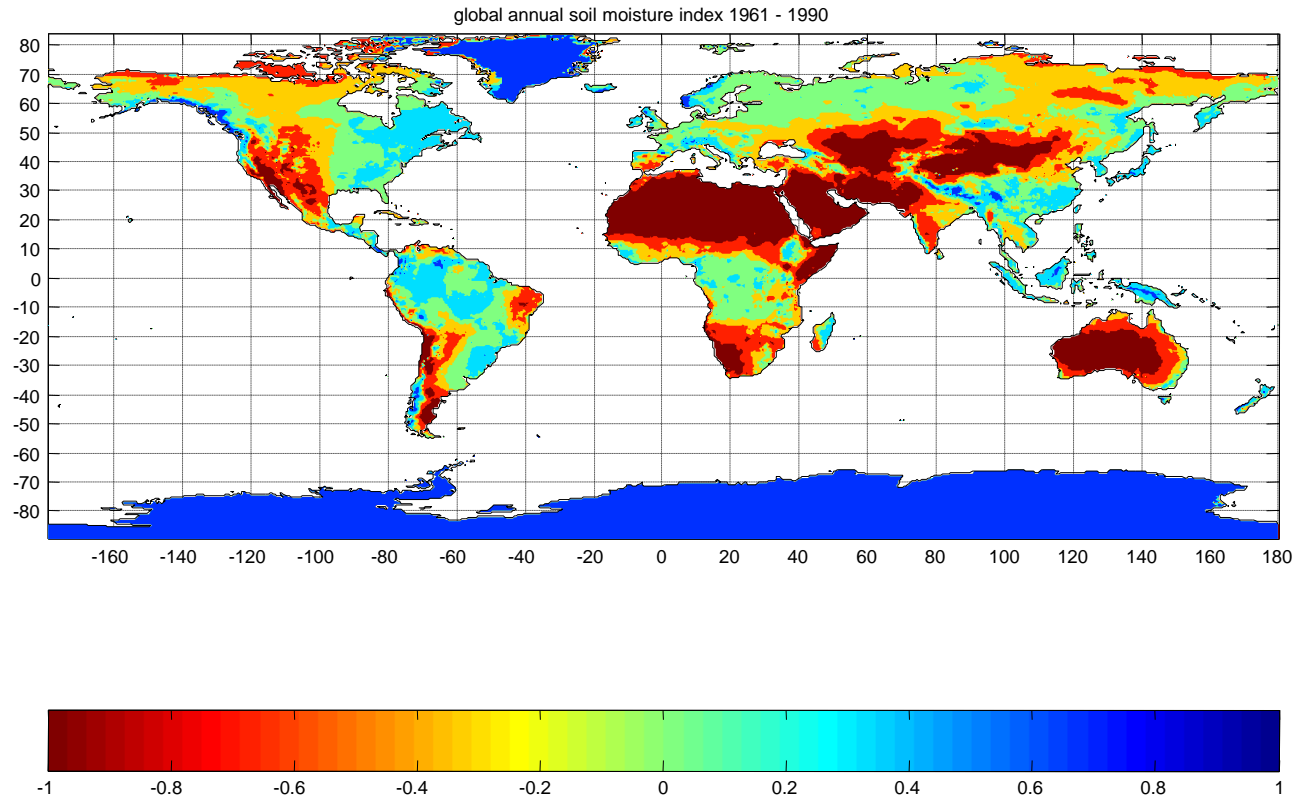
Expected monthly extreme values for the 100-year event (mm / month)

Expected monthly exstreme values for a 100 year event

Seismic trigger factor

GLOBAL SEISMIC HAZARD MAP

Produced by the Global Seismic Hazard Assessment Program (GSHAP),
a demonstration project of the UN/International Decade of Natural Disaster Reduction, conducted by the International Lithosphere Program.

Global map assembled by D. Giardini, G. Grünthal, K. Shedlock, and P. Zhang
1999
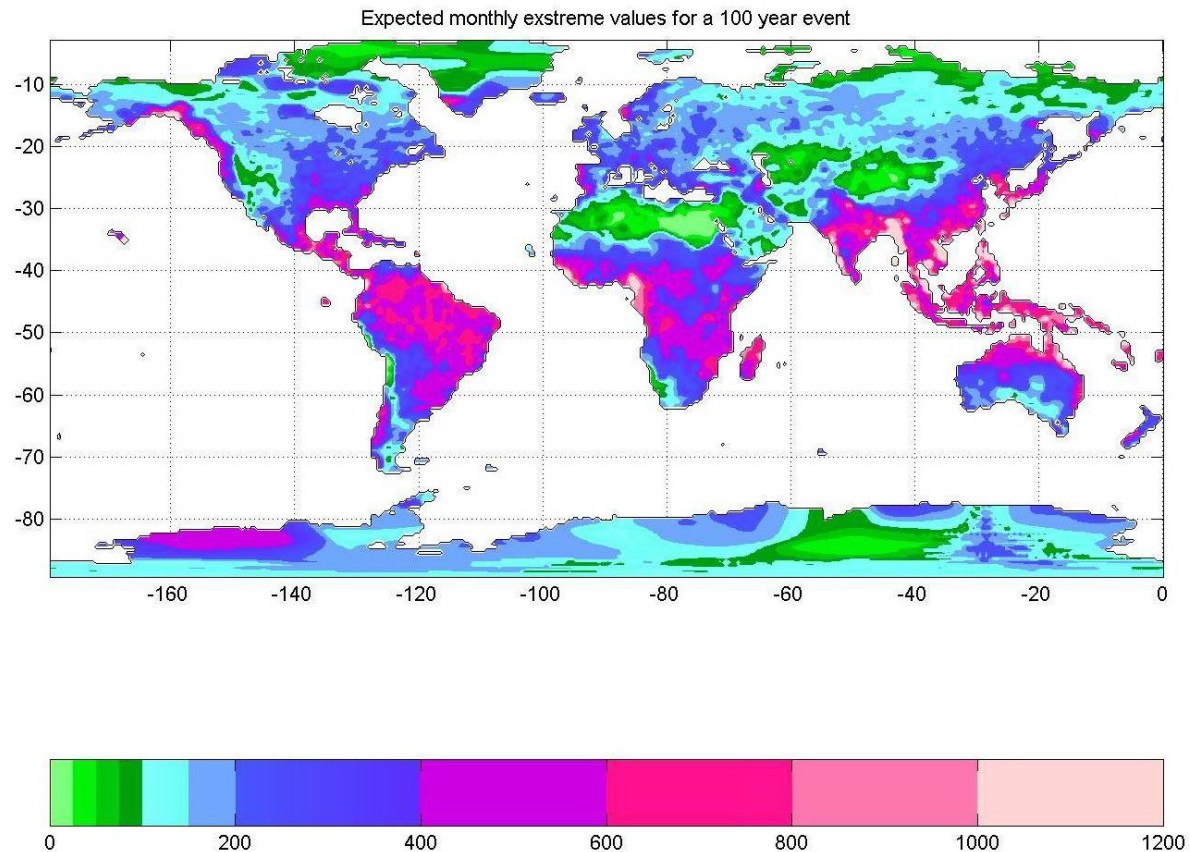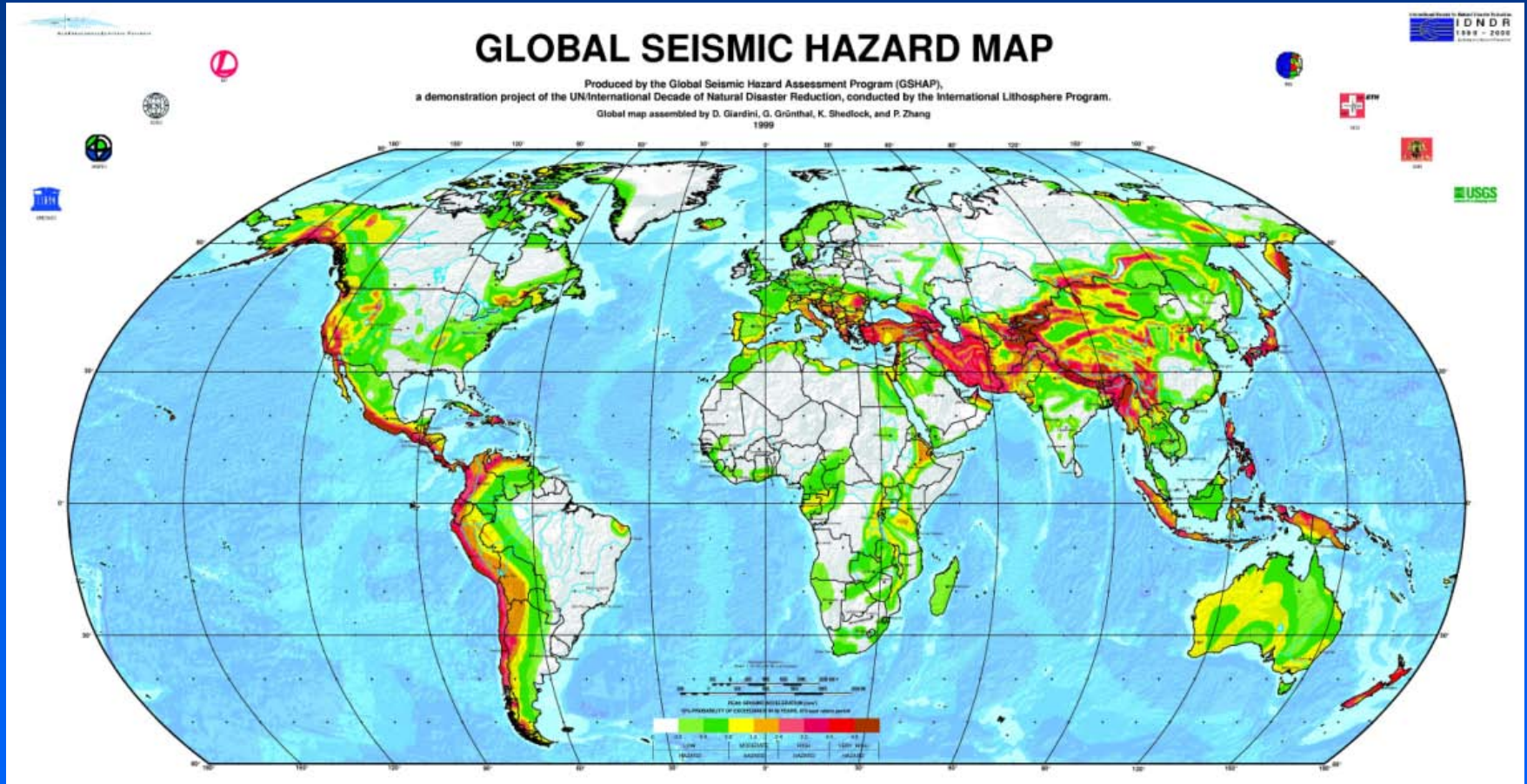
Hazard prediction and validation Armenia - Landslide

Global Hot-Spot Landslide Hazard Zonation - NGI classification and Landslide inventory for Armenia

Global Landslide Hazard Zonation - Hot-Spots

Landsl_MV_rec
VALUE

- 1
- 2
- 3
- 4
- 5
- 6

0   0.05   0.1   0.2   0.3   0.4
Decimal Degrees

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Jamaica landslides

Global Hot-Spot Landslide Hazard Zonation
Case study Jamaica

Hotspots for landslide hazards

Global Landslide Hazard Zonation Hot-Spots

Global Landslide
- Negligible
- Very low
- Low
- Low to moderate
- Moderate
- Medium
- Medium to high
- High
- Very high

0 1 550 3 100   6 200   9 300   12 400
Kilometers
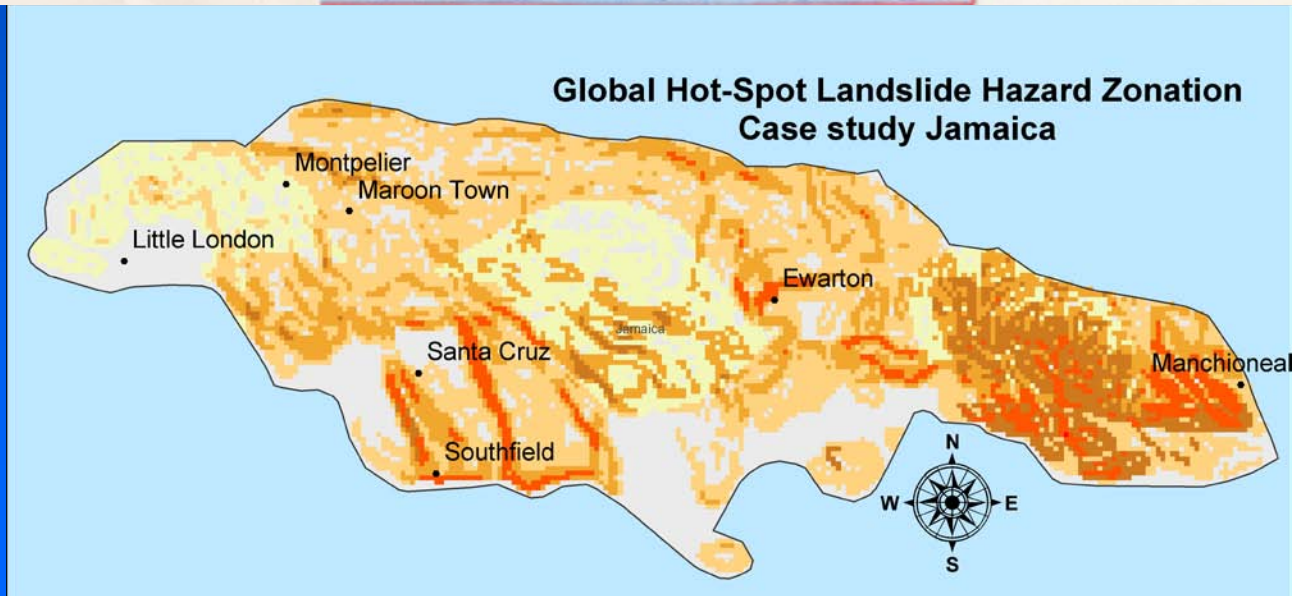
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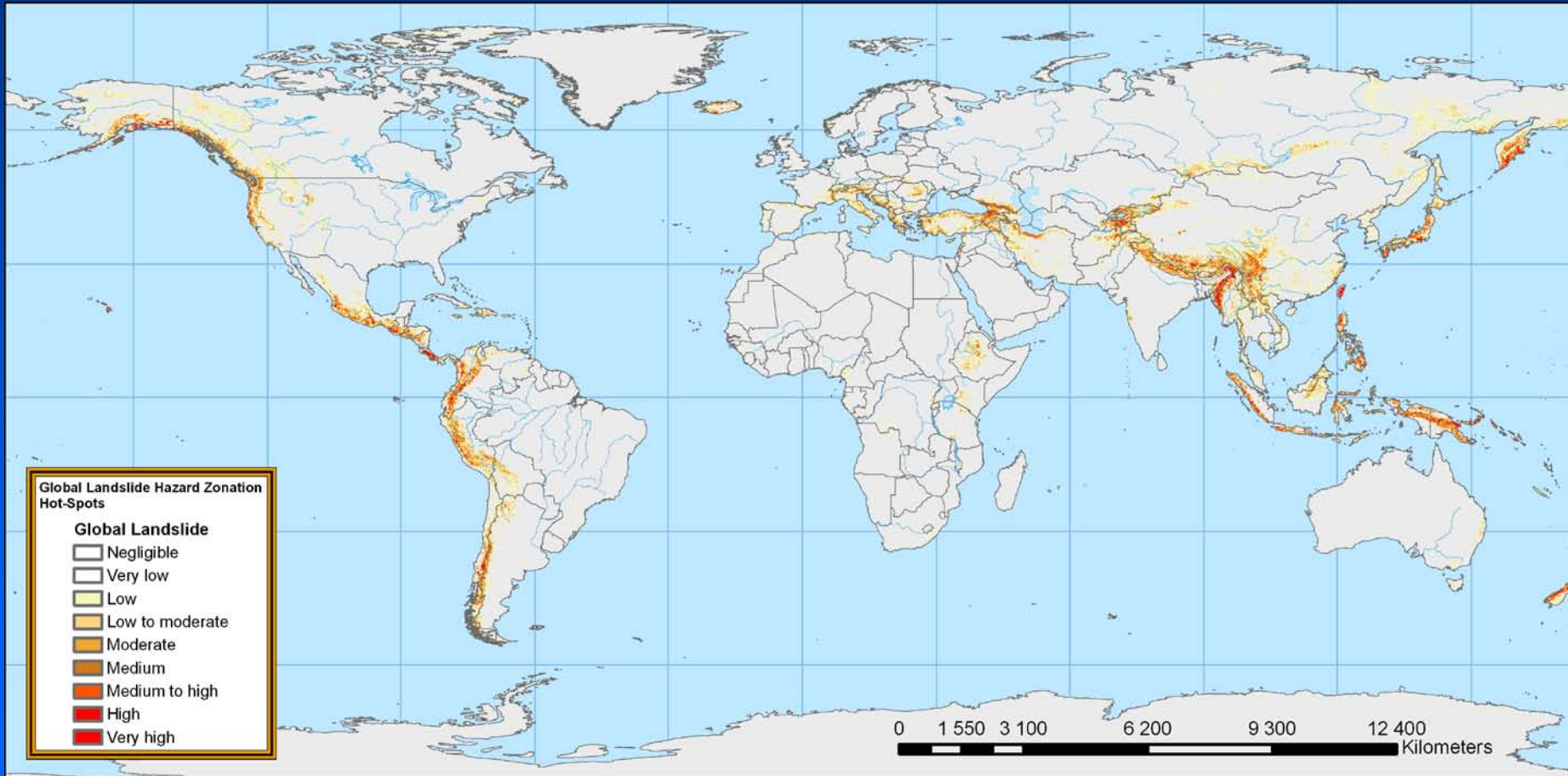
Hotspots for landslide hazards
Central and South America

Hotspots for landslide hazards Middle East and Central Asia

Landslide Classification

Landslide Hazard

Negligible to very low	(Class 1-2)
Low	(Class 3)
Low to moderate	(Class 4)
Moderate	(Class 5)
Medium	(Class 6)
Medium to high	(Class 7)
High	(Class 8)
Very high	(Class 9)

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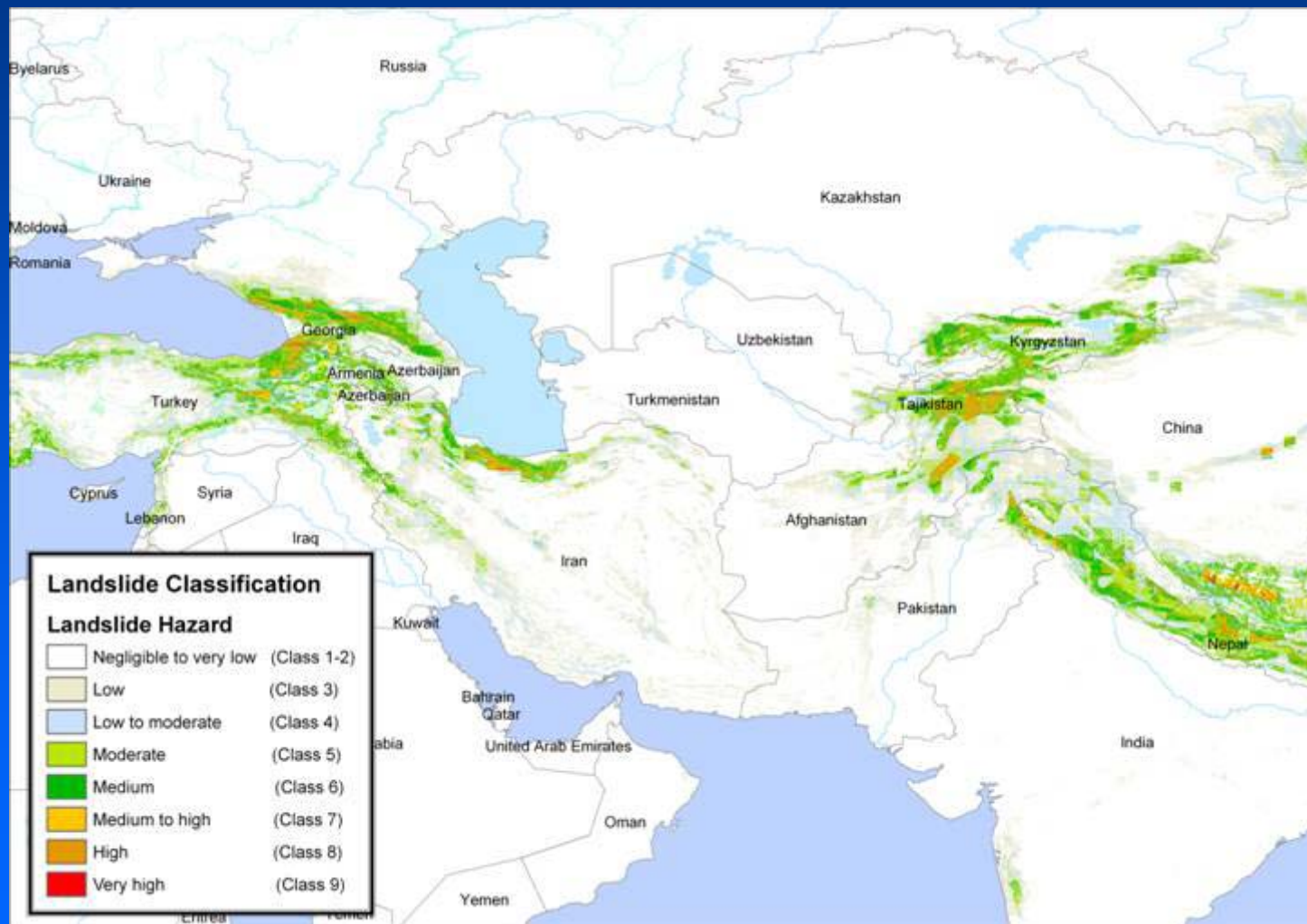
Risk Model
(based on expected No. of fatalities)

Risk proxy = Hazard * Exposed Population * Vulnerability

or

Risk proxy = Physical Exposure * Vulnerability

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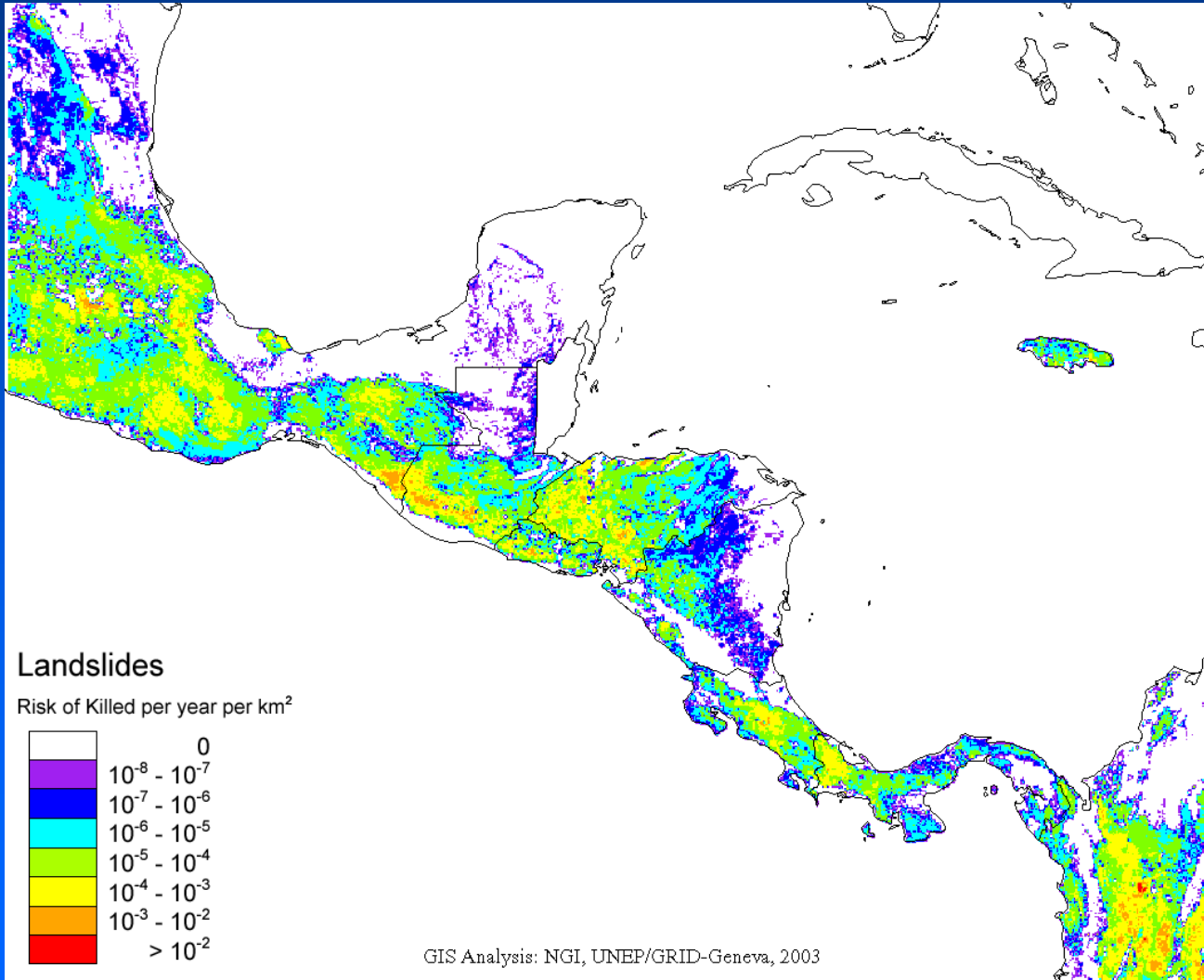Geohazards

Vulnerability indicators

Vulnerability indicators

Categories of vulnerability	Indicators	Source
Economic	Gross Domestic Product per inhabitant at purchasing power parity	WB
	Human Poverty Index (HPI)	UNDP
	Total dept service (% of the exports of goods and services),	WB
	Inflation, food prices (annual %),	WB
	Unemployment, total (% of total labour force)	ILO
Type of economical activities	%age of arable land	FAO
	%age of urban population	UNPOP
	%age of agriculture's dependency for GDP	WB
	%age of labour force in agricultural sector	FAO
Dependency and quality of the environment.	Forests and woodland (in %age of land area),	FAO
	%age of irrigated land	
	Human Induced Soil Degradation (GLASOD)	FAO UNEP
Demography	Population growth,	UNPOP
	Urban growth,	GRID[4]
	Population density,	GRID[5]
	Age dependency ratio,	WB
Health and sanitation	Average calorie supply per capita,	FAO
	%age of people with access to adequate sanitation,	WHO / UNICEF
	%age of people with access to safe water (total, urban, rural)	WHO / UNICEF
	Number of physicians (per 1000 inh.),	WB
	Number Hospital Beds	WB
	Life Expectancy at birth for both Sexes	UNPOP
	Under five years old mortality rate	UNPOP
Politic	Index of Corruption	WB
Early warning capacity	Number of Radios (per 1000 inh.)	WB
Education	Illiteracy Rate,	WB
	School enrolment,	UNESCO
	Secondary (% gross),	UNESCO
	Labour force with primary, secondary or tertiary education	WB
Development	Human Development Index (HDI)	UNDP
Risk	Victims (killed by landslides)	CRED

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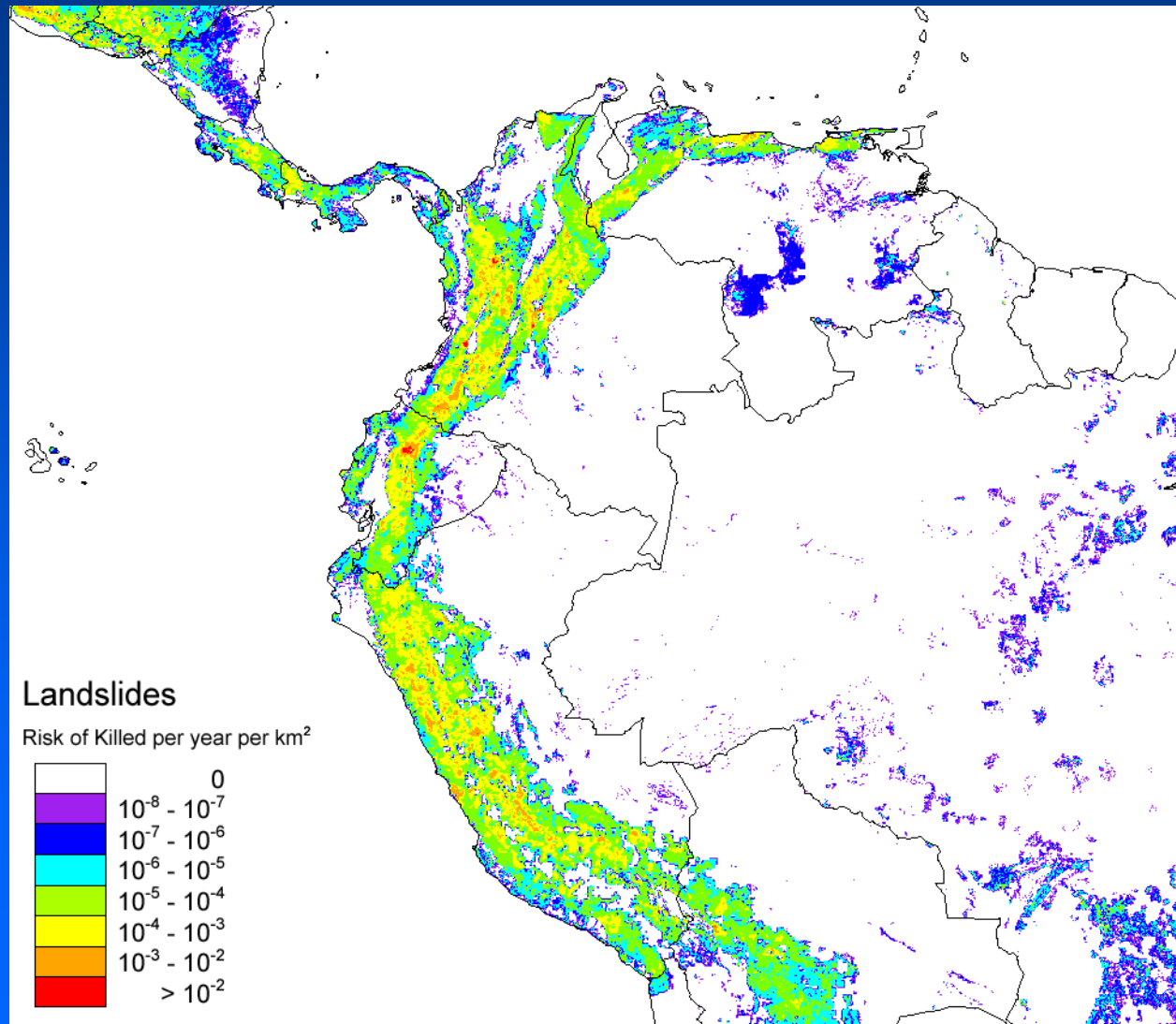International Centre for Geohazards

Results of vulnerability / risk multi-regression analysis

- 98% of the recorded landslide victims lived in countries affected by landslide classes 5 and higher.

- Physical exposure, Human development index (HDI), %age forest, and %age arable land explain 73% of the landslide risk on national level.

Distribution of Risk from proxy in Central America

Landslides

Risk of Killed per year per km²

	0
	$10^{-8} - 10^{-7}$
	$10^{-7} - 10^{-6}$
	$10^{-6} - 10^{-5}$
	$10^{-5} - 10^{-4}$
	$10^{-4} - 10^{-3}$
	$10^{-3} - 10^{-2}$
	$> 10^{-2}$

GIS Analysis: NGI, UNEP/GRID-Geneva, 2003

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Distribution of Risk from proxy in South America

Landslides

Risk of Killed per year per km^2

	0
(purple)	$10^{-8} - 10^{-7}$
(blue)	$10^{-7} - 10^{-6}$
(cyan)	$10^{-6} - 10^{-5}$
(green)	$10^{-5} - 10^{-4}$
(yellow)	$10^{-4} - 10^{-3}$
(orange)	$10^{-3} - 10^{-2}$
(red)	$> 10^{-2}$

Distribution of Risk proxy in Central Asia

Landslides

Risk of Killed per year per km²

(white)	0
(purple)	$10^{-8} - 10^{-7}$
(blue)	$10^{-7} - 10^{-6}$
(cyan)	$10^{-6} - 10^{-5}$
(green)	$10^{-5} - 10^{-4}$
(yellow)	$10^{-4} - 10^{-3}$
(orange)	$10^{-3} - 10^{-2}$
(red)	$> 10^{-2}$
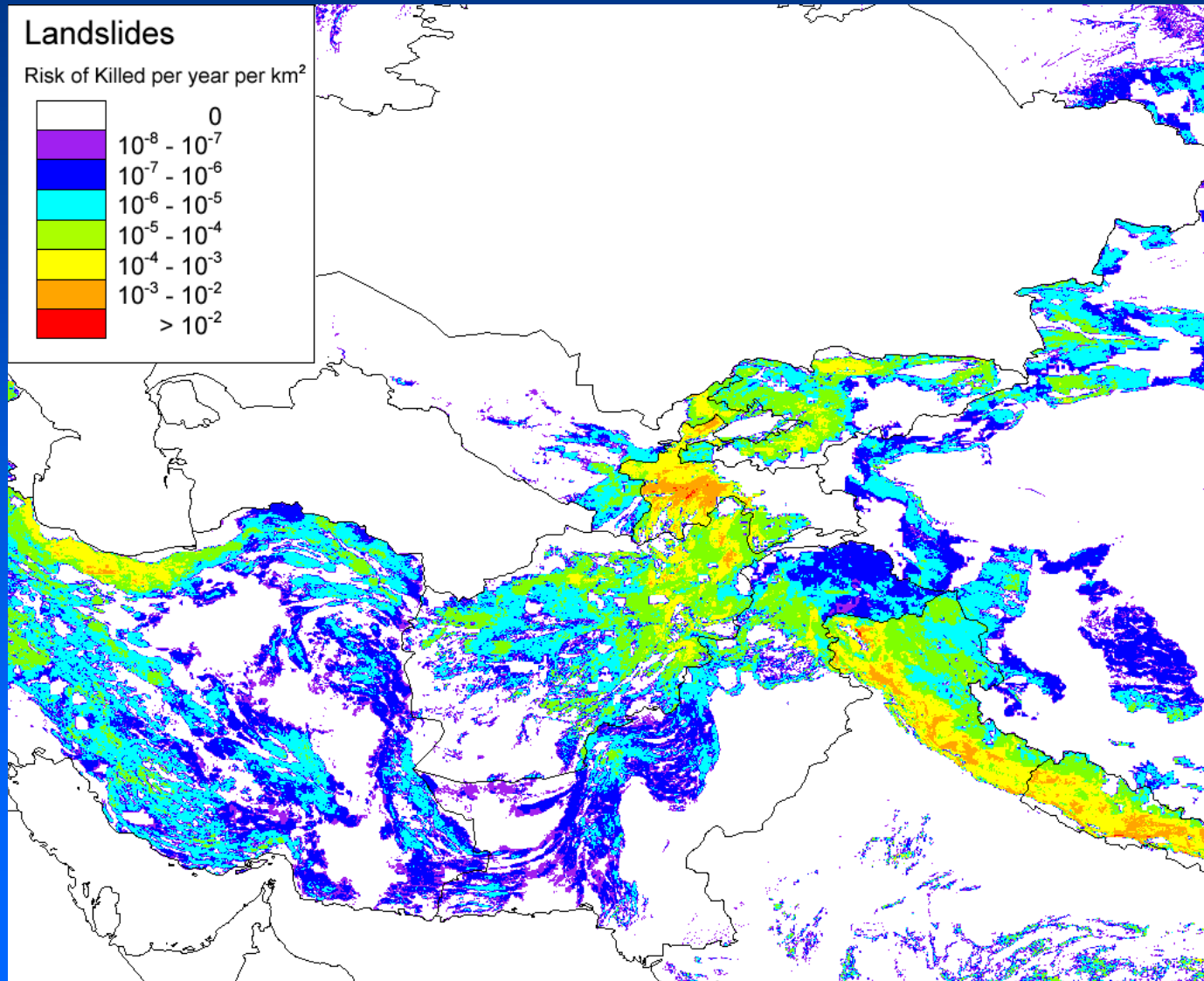
CONCLUSIONS - Hazard

No surprises on hazard:

- Mountainous areas with lots of rainfall and earthquake activity are susceptible to landslides.

- Mountainous areas with lots of snowfall in winter are susceptible to snow avalanche.

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CONCLUSIONS - Risk

- 98% of the recorded landslide victims lived in countries affected by landslide classes 5 and higher (on a scale of 1 – 9).

- Physical exposure, Human Development Index (HDI), %age forest, and %age arable land explain 73% of the landslide risk on national level.