The Value of Observations for Reduction of Earthquake-Induced Loss of Life on a Global Scale

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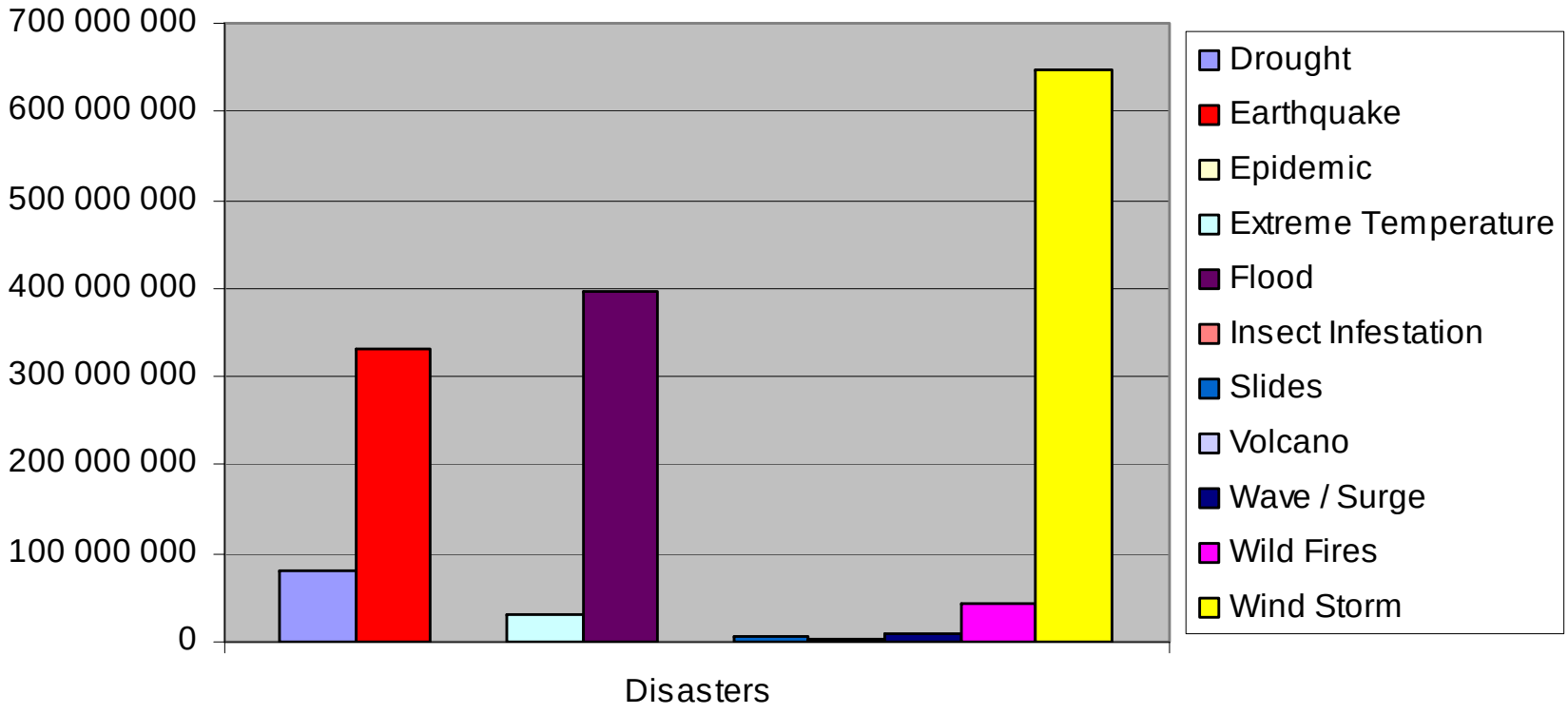
Disasters / OE assessment methodology

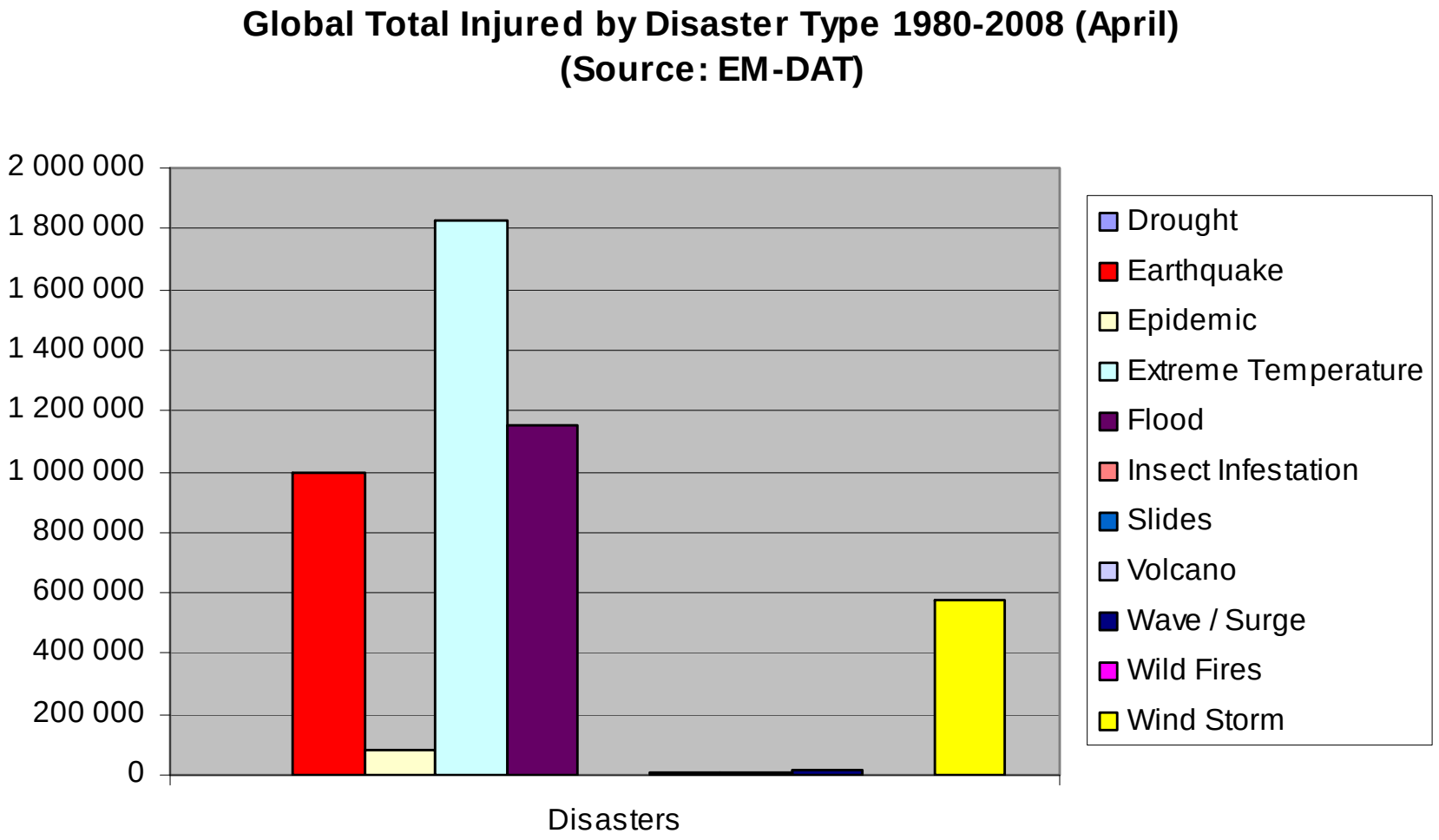
1. Drought
2. Earthquake
3. Epidemic
4. Extreme Temperature
5. Flood
6. Insect Infestation
7. Landslides / Avalanches
8. Volcano
9. Wild Fires
10. Tsunami / Sea Level Rise
11. Wind Storm

Earthquakes / Global Facts

Global Total Damage in US$(,000)
by Disaster Type 1980-2008 (April)
(Source: EM-DAT)

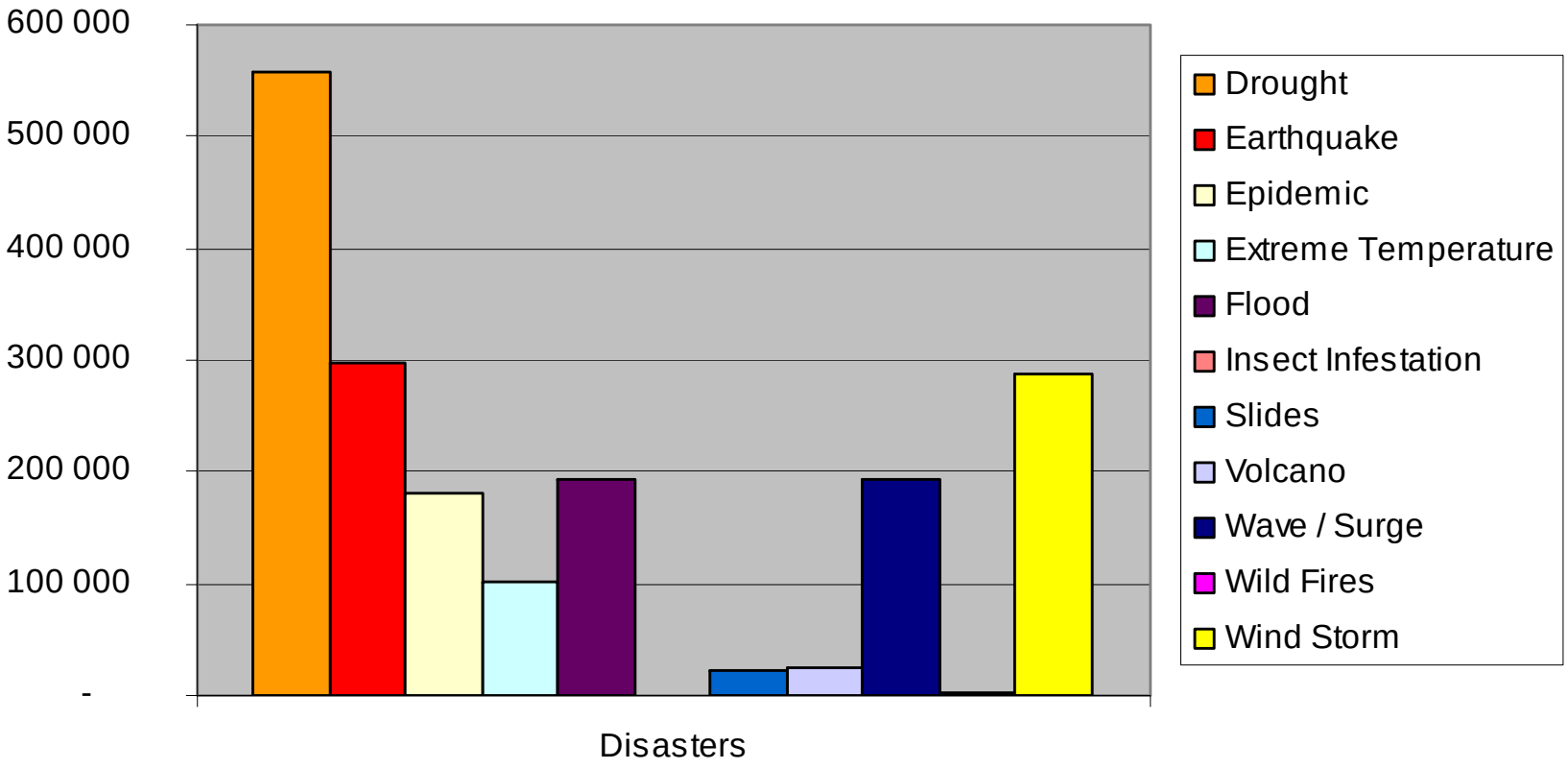


Earthquakes / Global Facts



Earthquakes / Global Facts

Global Total Deaths by Disaster Type 1980-2008 (April)
(Source: EM-DAT)



Earthquakes / Global Facts

- India 26 Jan 2001 (Gujarat)
  Fatalities > 20,000
  Affected > 6,300,000
- Pakistan 8 Oct 2005 (Bagh)
  Fatalities > 73,000
  Affected > 5,100,000
- China 12 May 2008 (Sichuan)
  Fatalities > 69,000
  Affected > 4,800,000

Earthquakes / Knowledge Limitations

- Prediction – impossible
- Prevention – impossible

Earthquakes / Knowledge Limitations

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- What can be done?
- How Earth Observations may help?

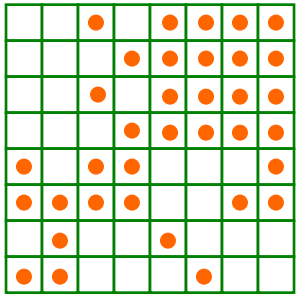
Earthquakes / Role of EO

- Prediction – impossible
- Prevention – impossible

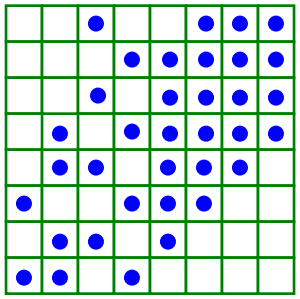
- What can be done?
- How Earth Observations may help?

- Better planning of locations of new buildings
- Better response in the aftermath of an event

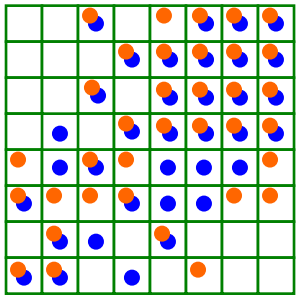
EO for Earthquake Damage Assessment*



Damage
(severity ~ magnitude)



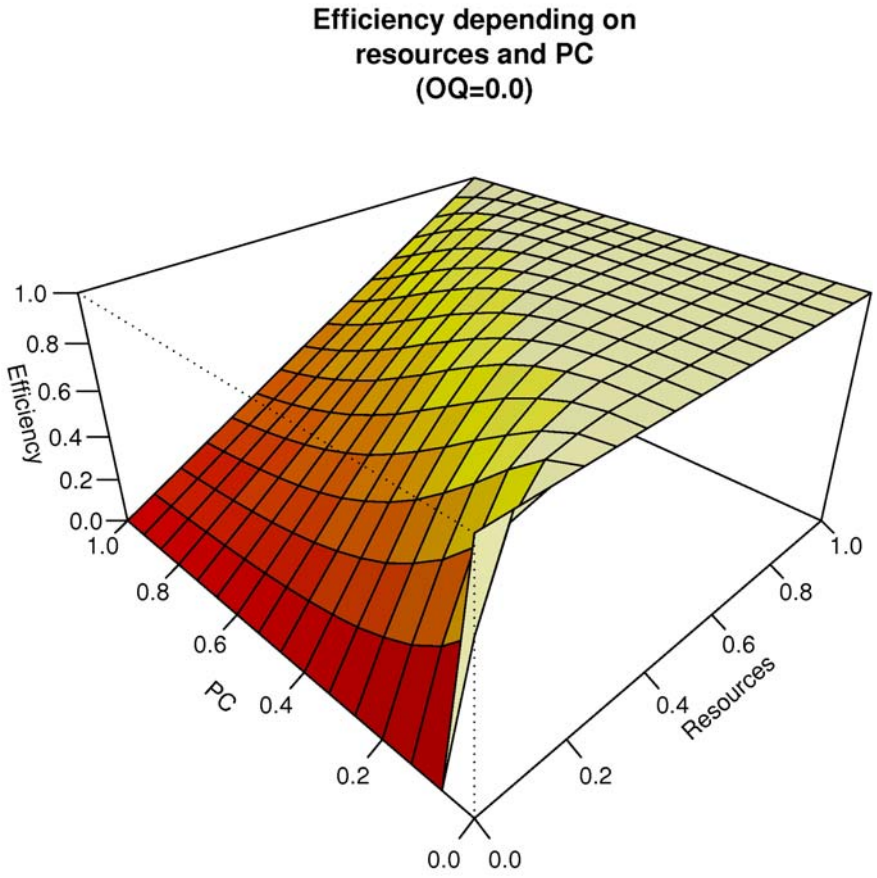
"Sensors" Network
(density = OQ)

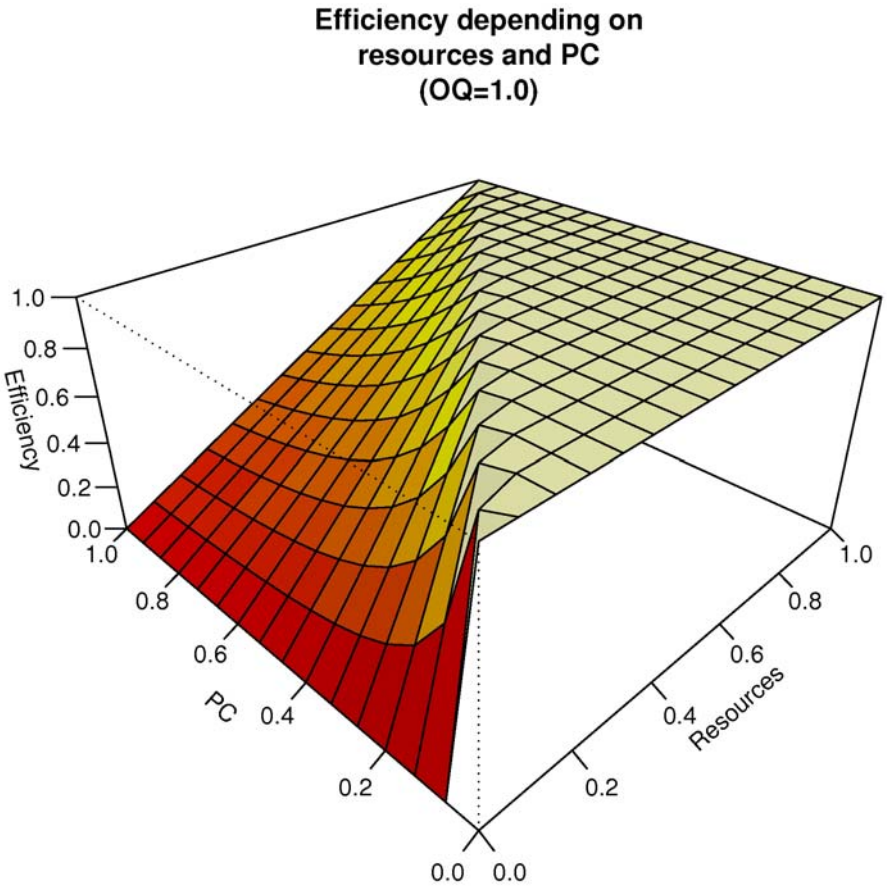


Rapid Damage Assessment
(incomplete)

* Part of the EQ Rapid Response Model developed by E. Moltchanova, N. Khabarov, and M. Obersteiner (2007)

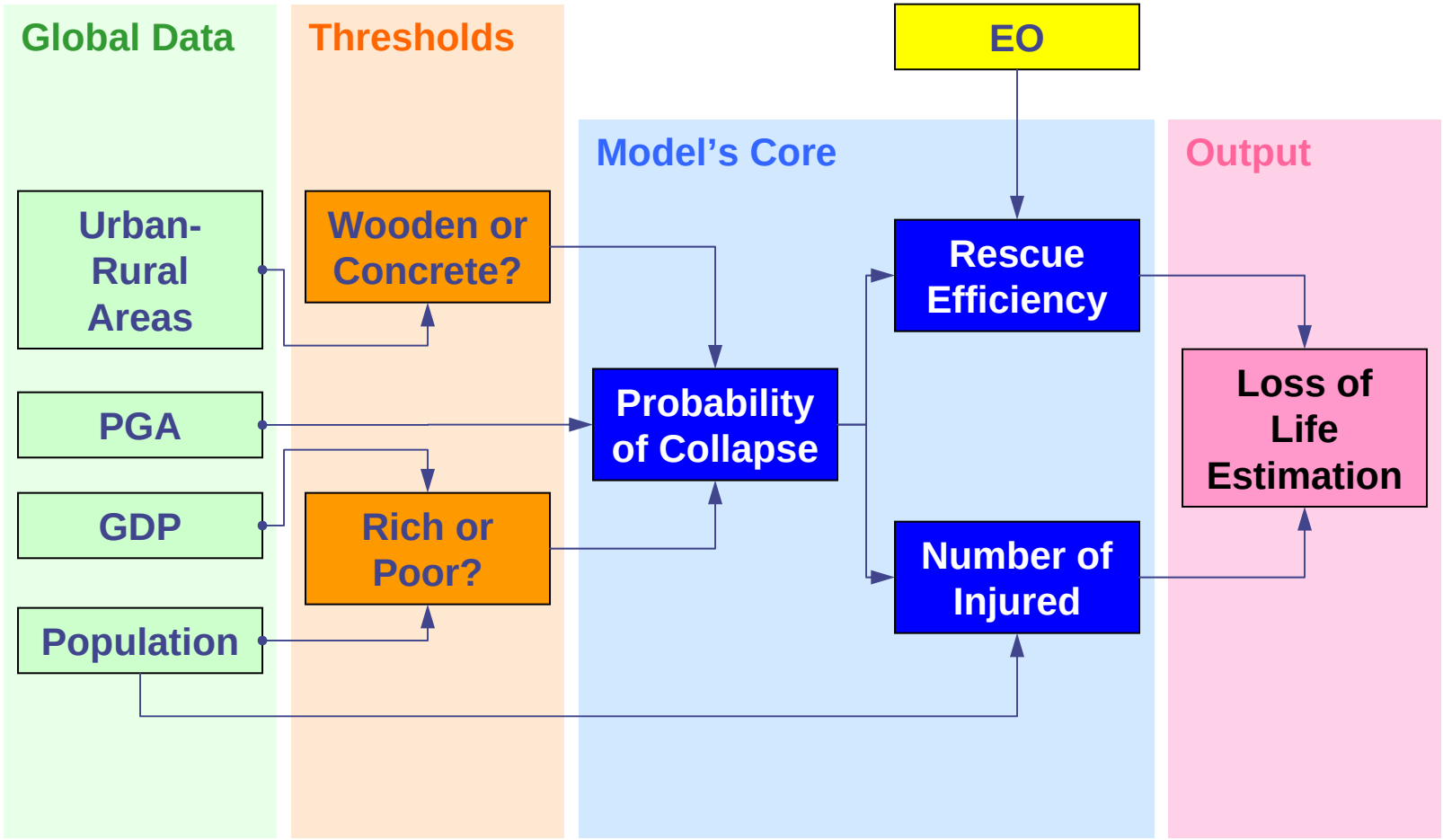
Rescue Efficiency*



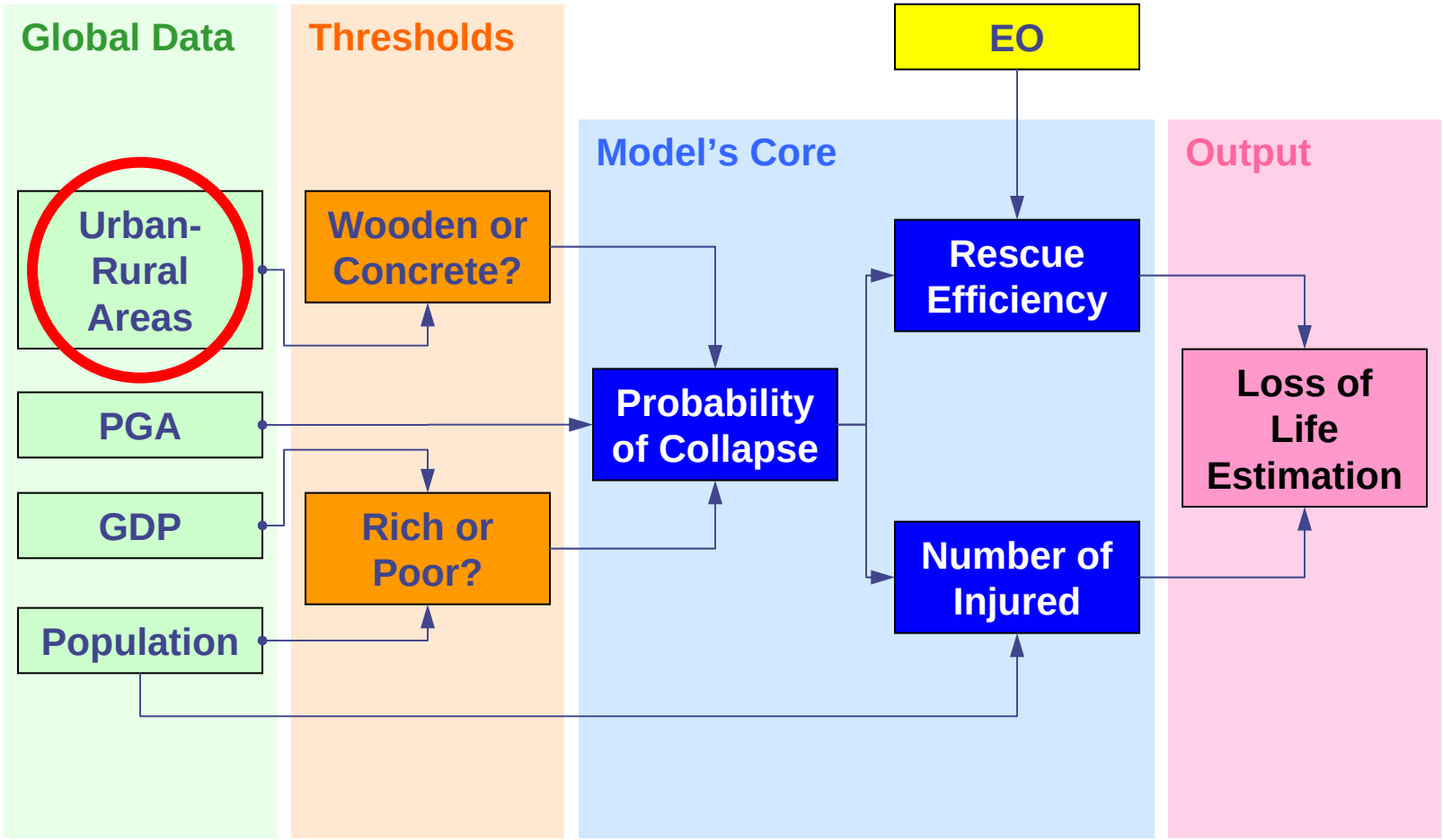


* Result from the EQRR Model developed by E. Moltchanova, N. Khabarov, and M. Obersteiner (2007)

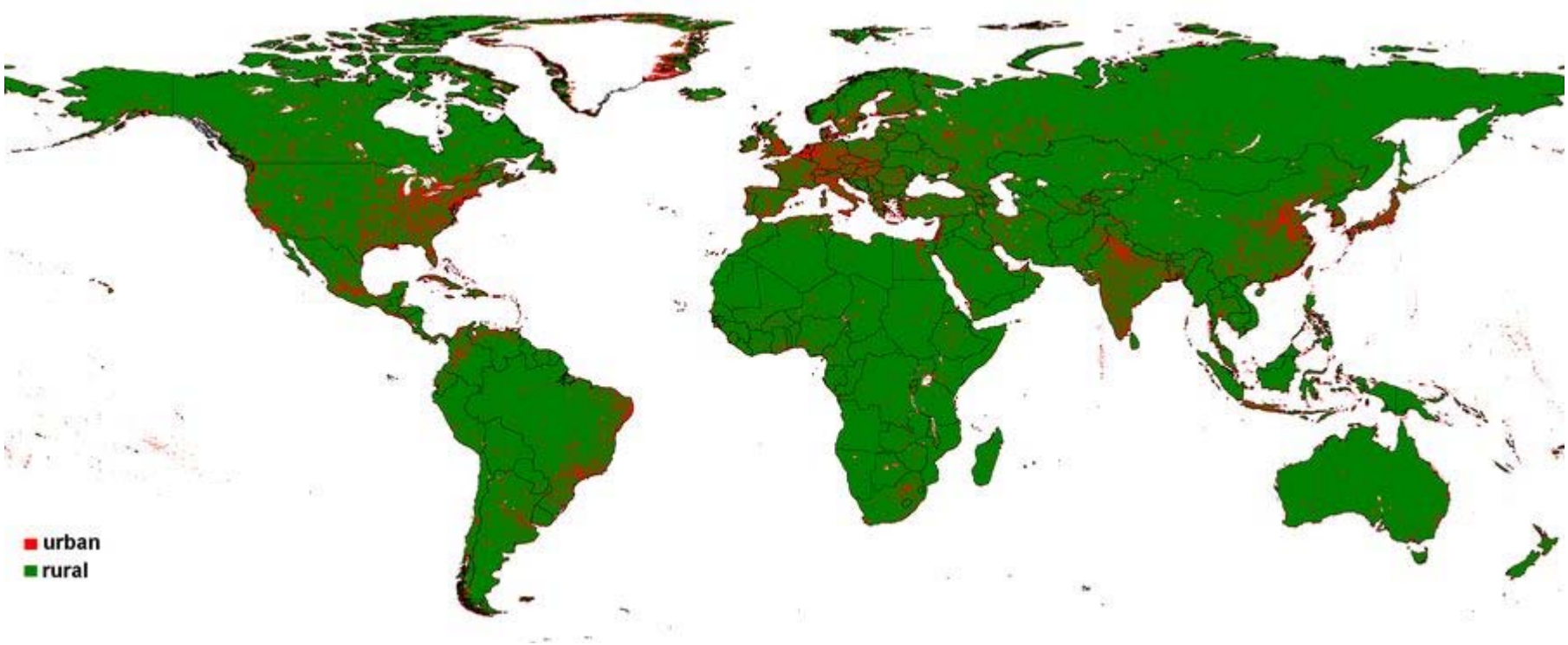
Model Scheme / Global EQ EO assessment methodology



Model Scheme / Global EQ EO assessment methodology

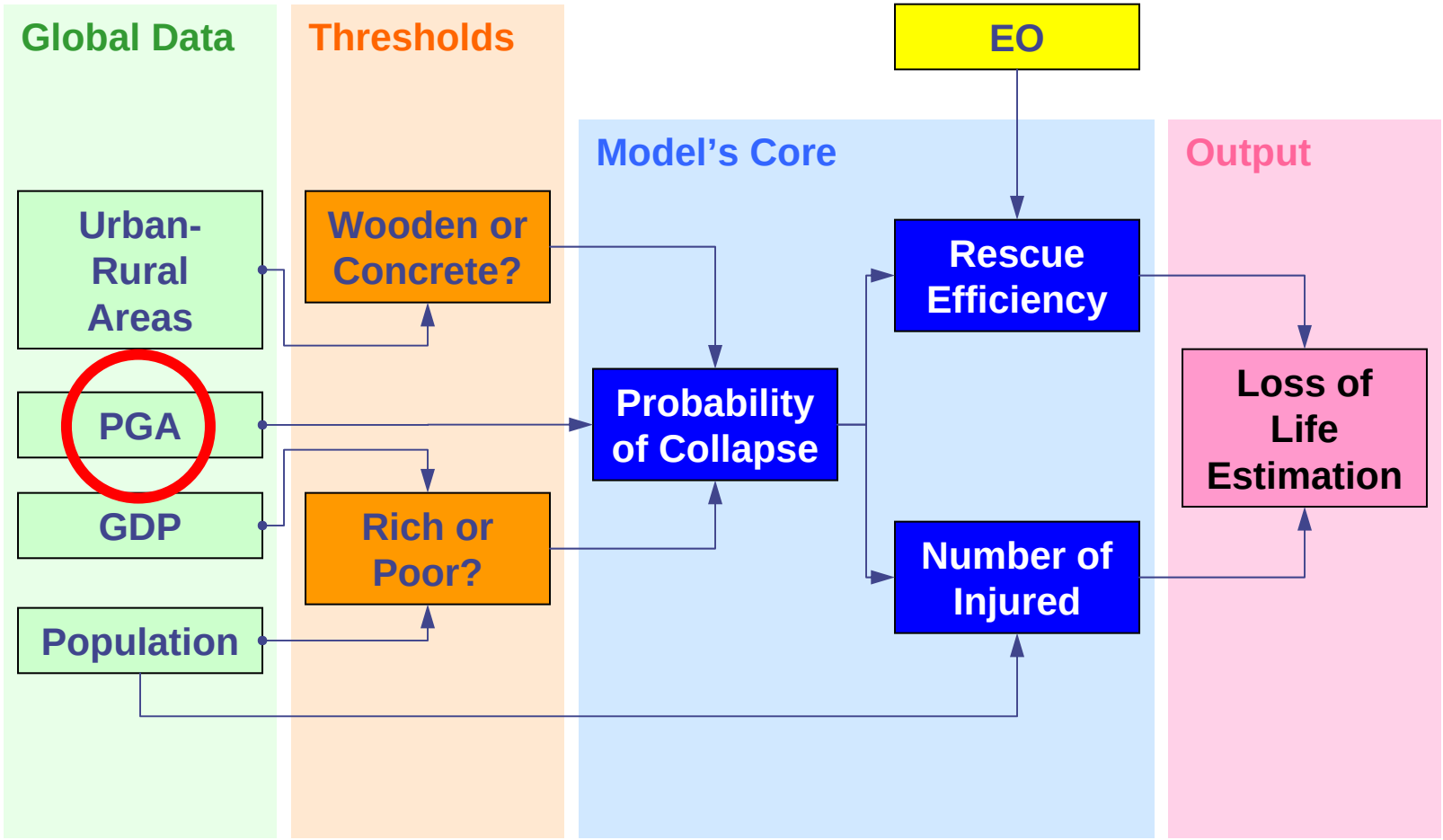


GRUMP urban extent data

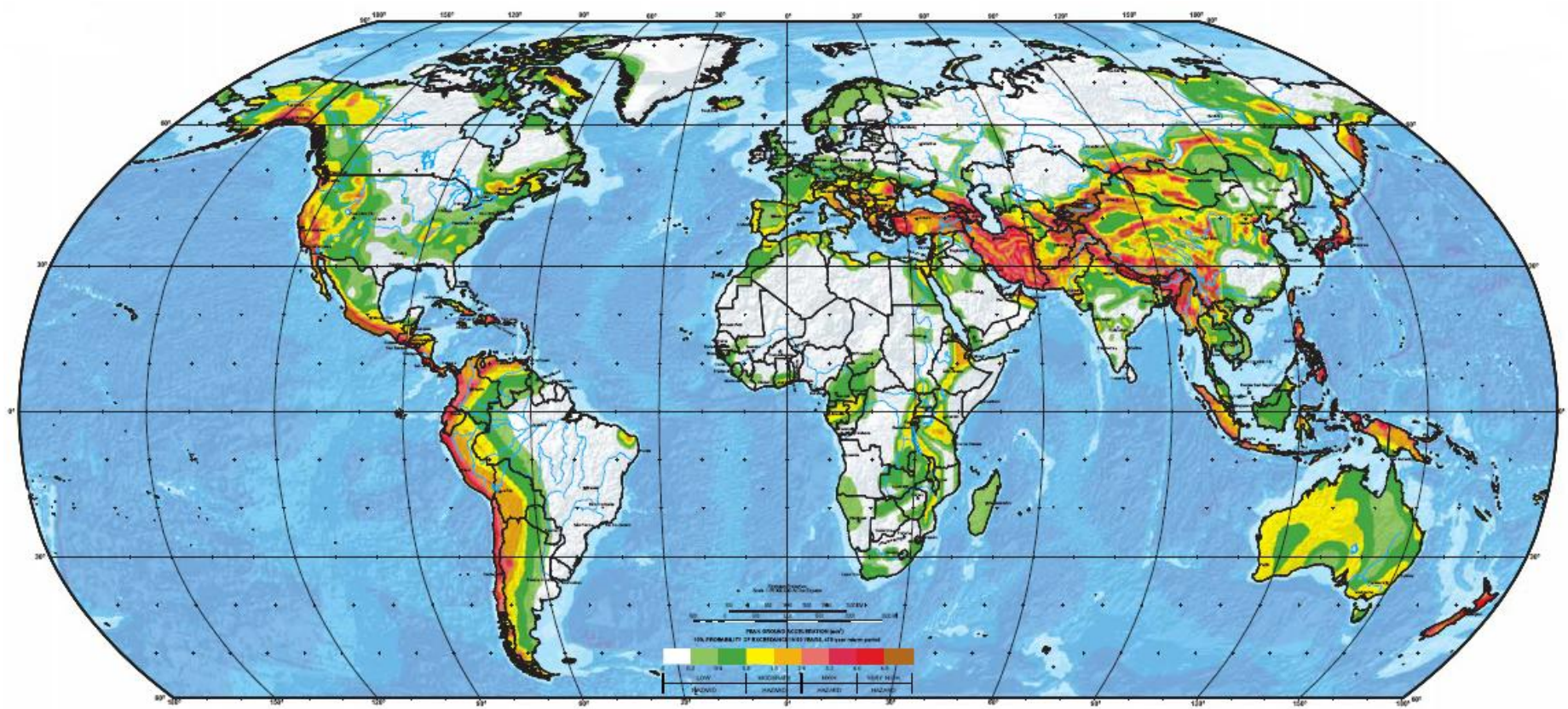


Source: Global Rural-Urban Mapping Project (GRUMP, 2004). Urban/Rural Extents

Model Scheme / Global EQ EO assessment methodology

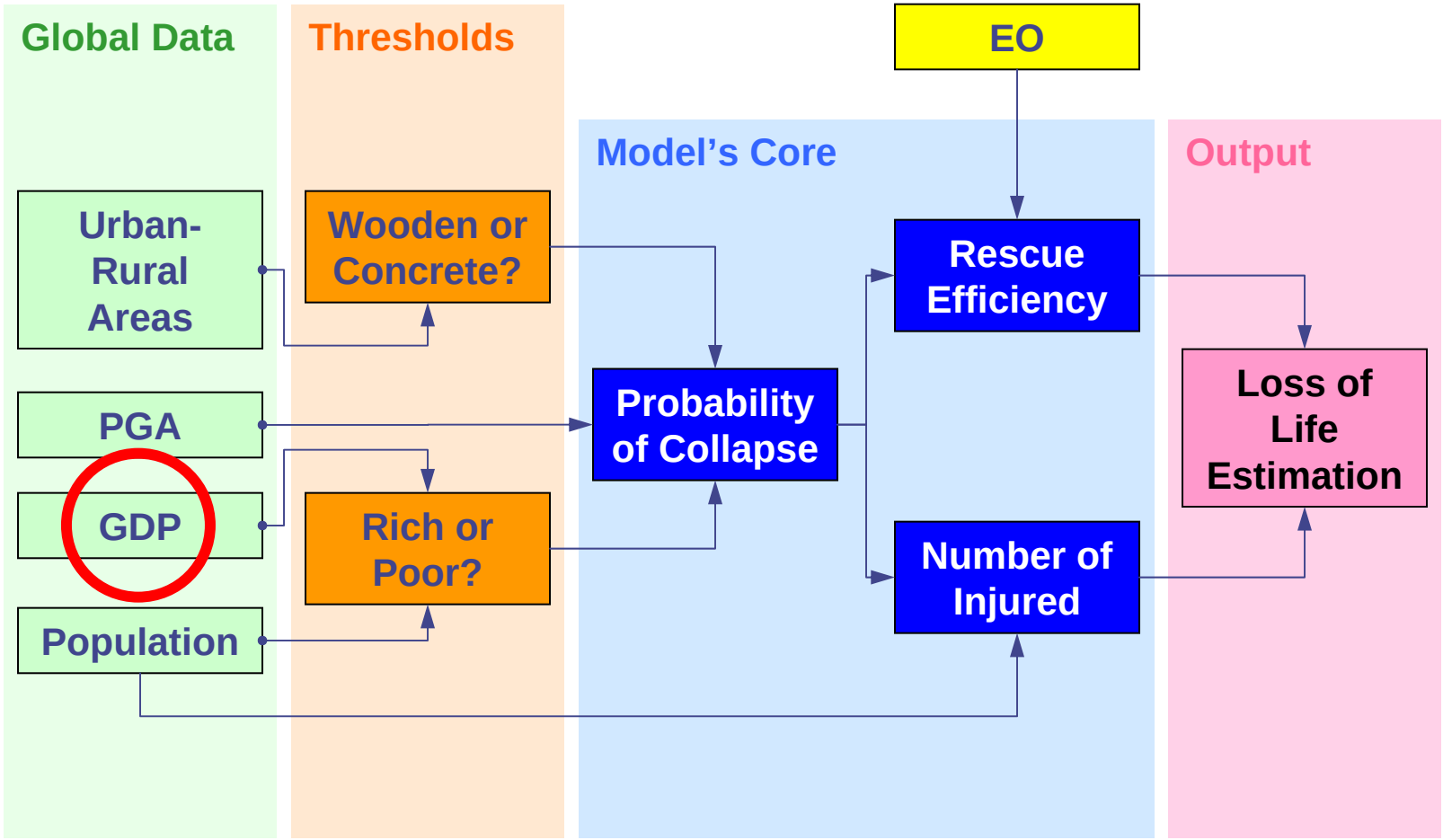


Global Seismic Hazard Map by GSHAP

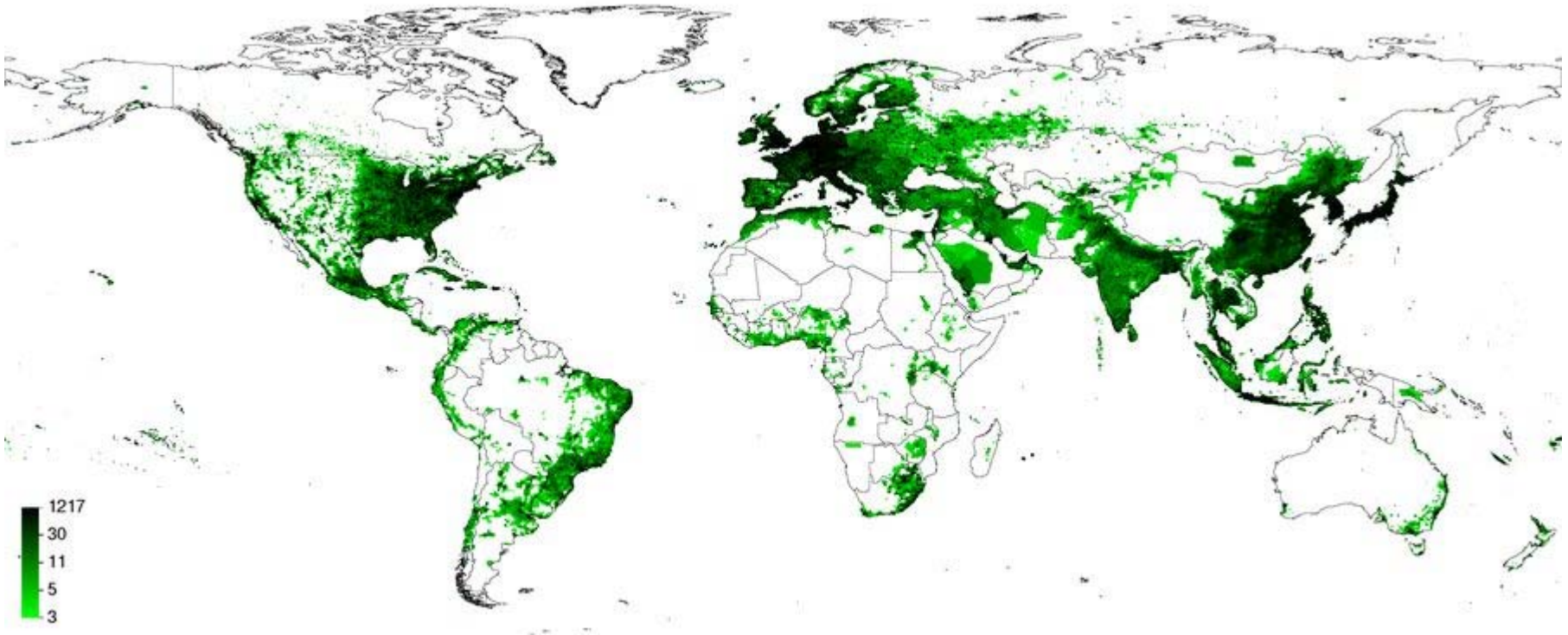


Source: Global Seismic Hazard Assessment Program (GSHAP), 2000. Global Seismic Hazard Map

Model Scheme / Global EQ EO assessment methodology

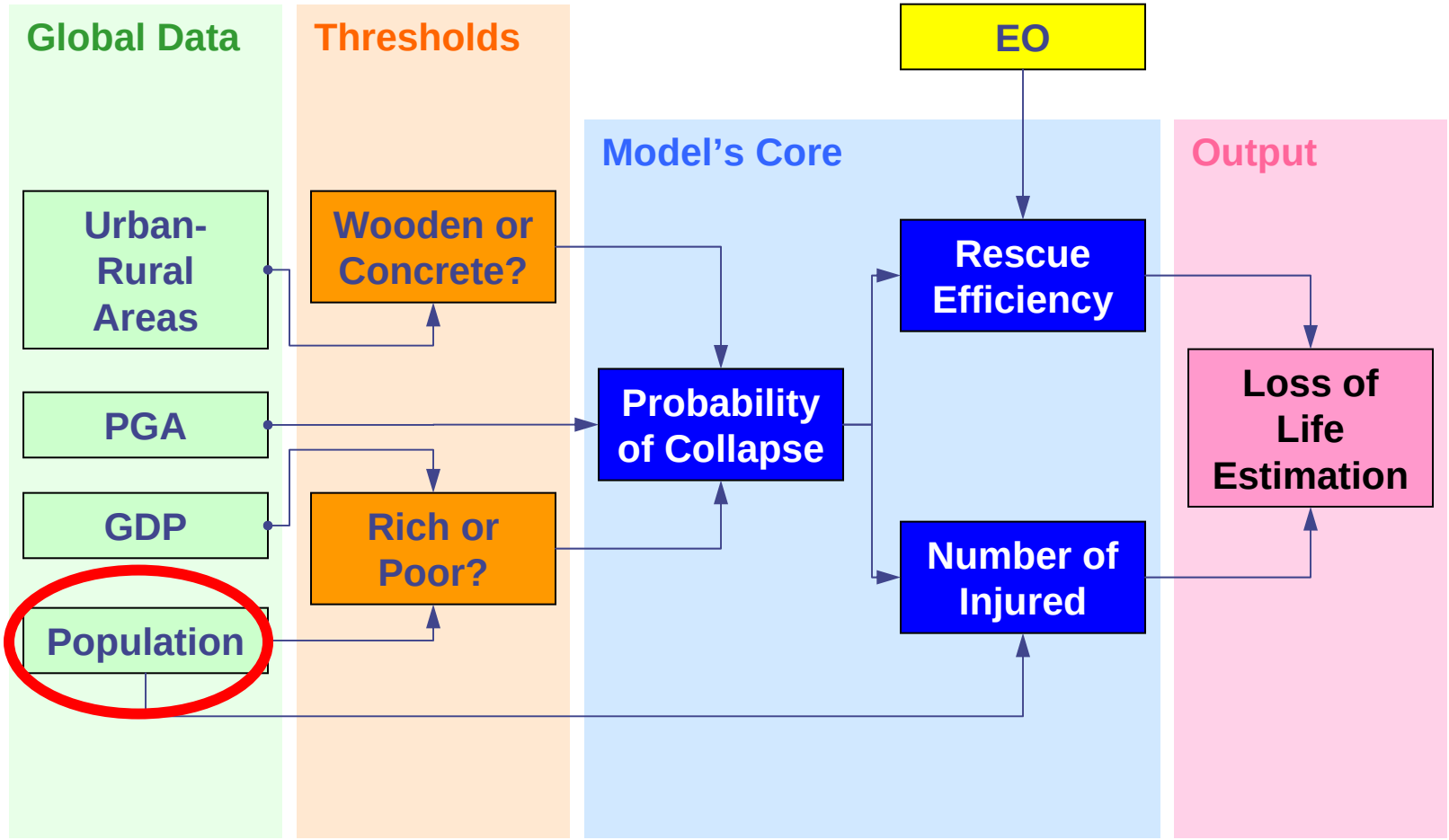


GDP projection for 2025 (SRES B2 scenario)

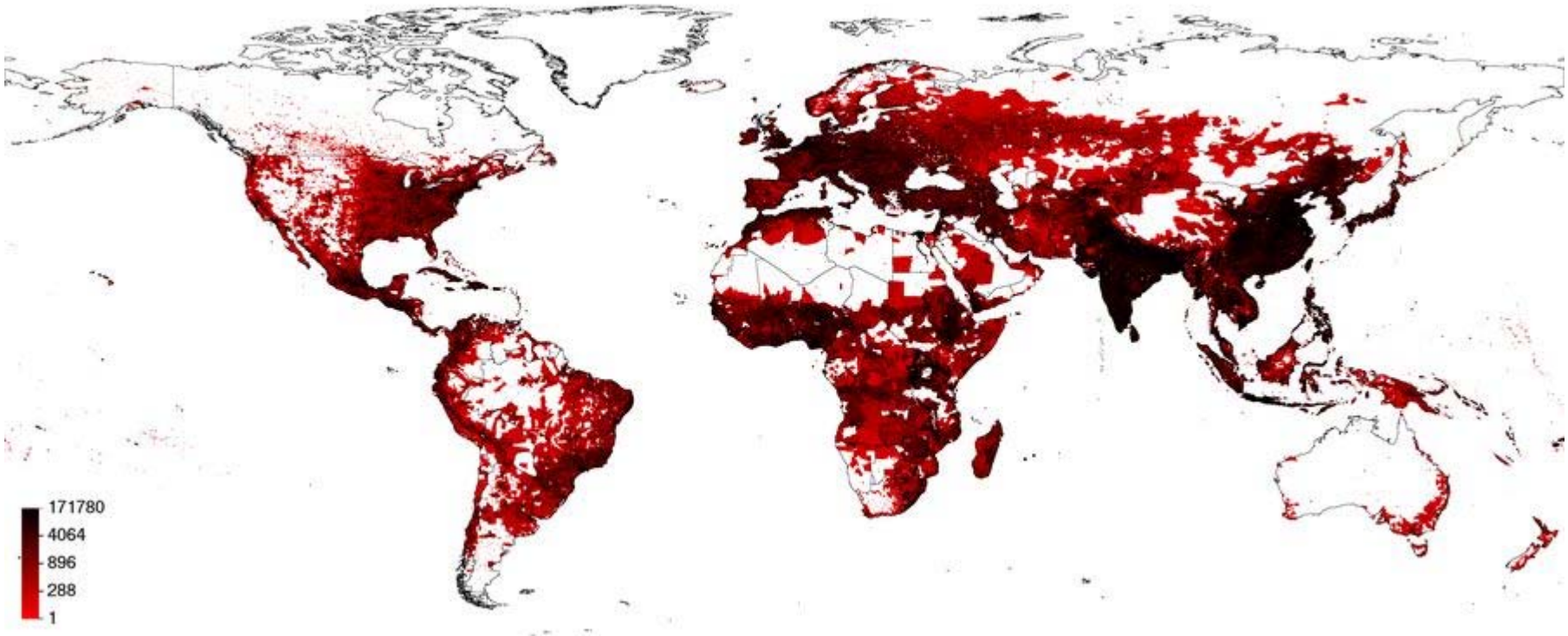


Source: Center for International Earth Science Information Network (CIESIN), 2002. Gridded Global GDP

Model Scheme / Global EQ EO assessment methodology

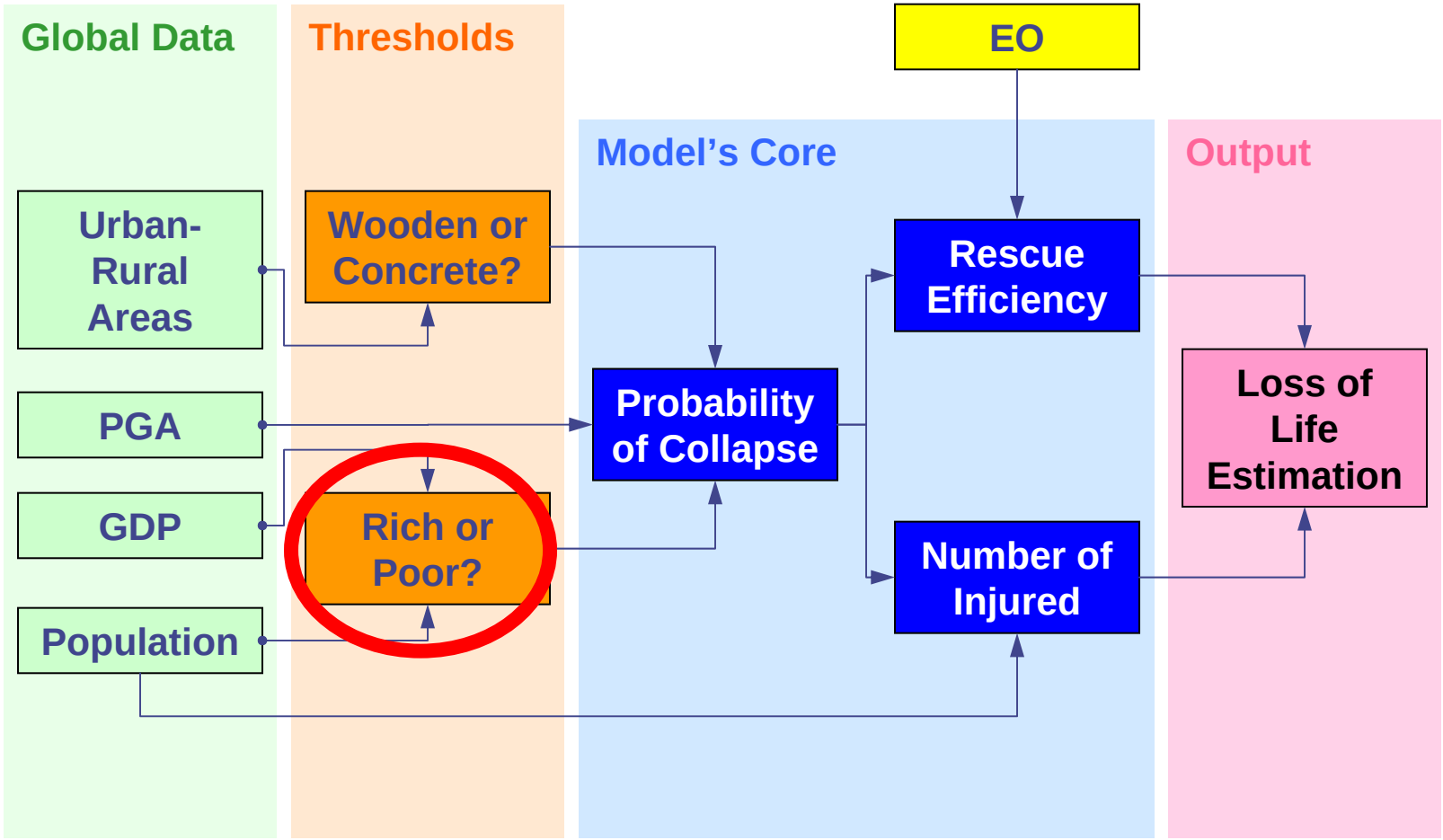


GRUMP population data for 2000

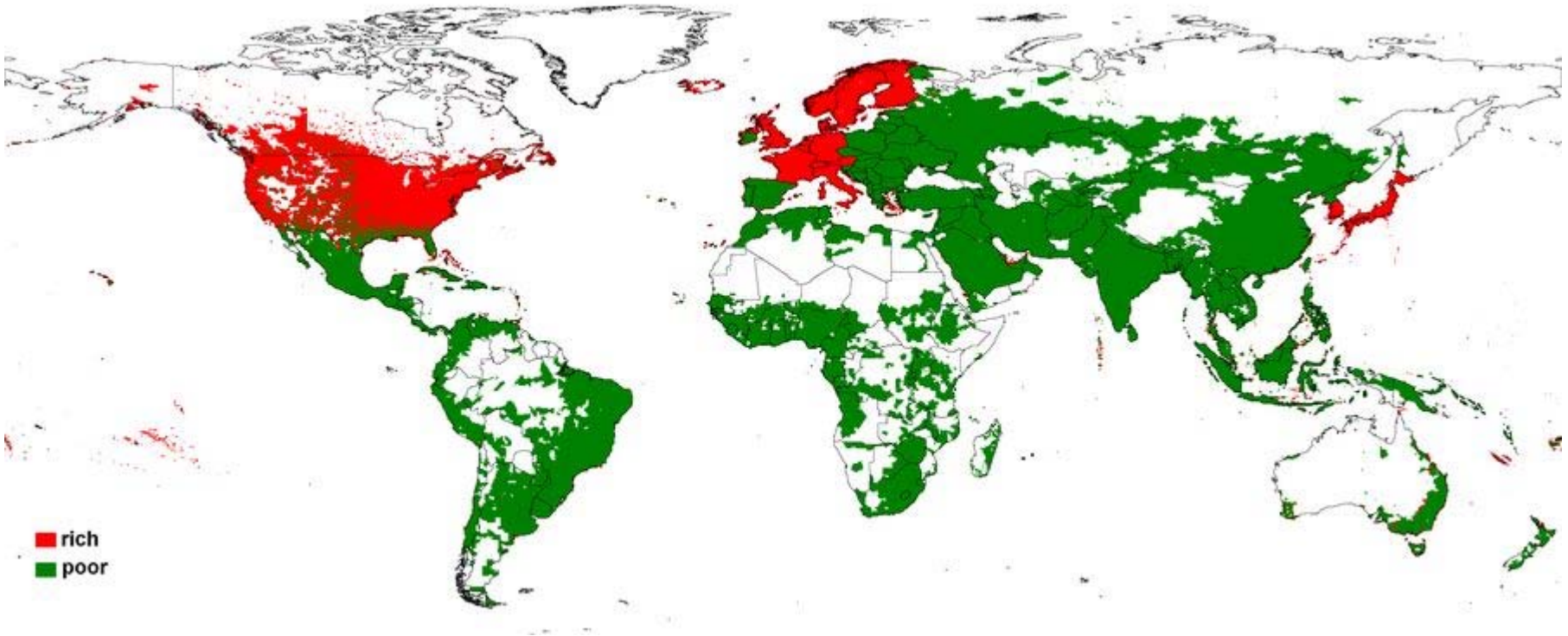


Source: Global Rural-Urban Mapping Project (GRUMP), 2004. Urban/Rural Population grids

Model Scheme / Global EQ EO assessment methodology

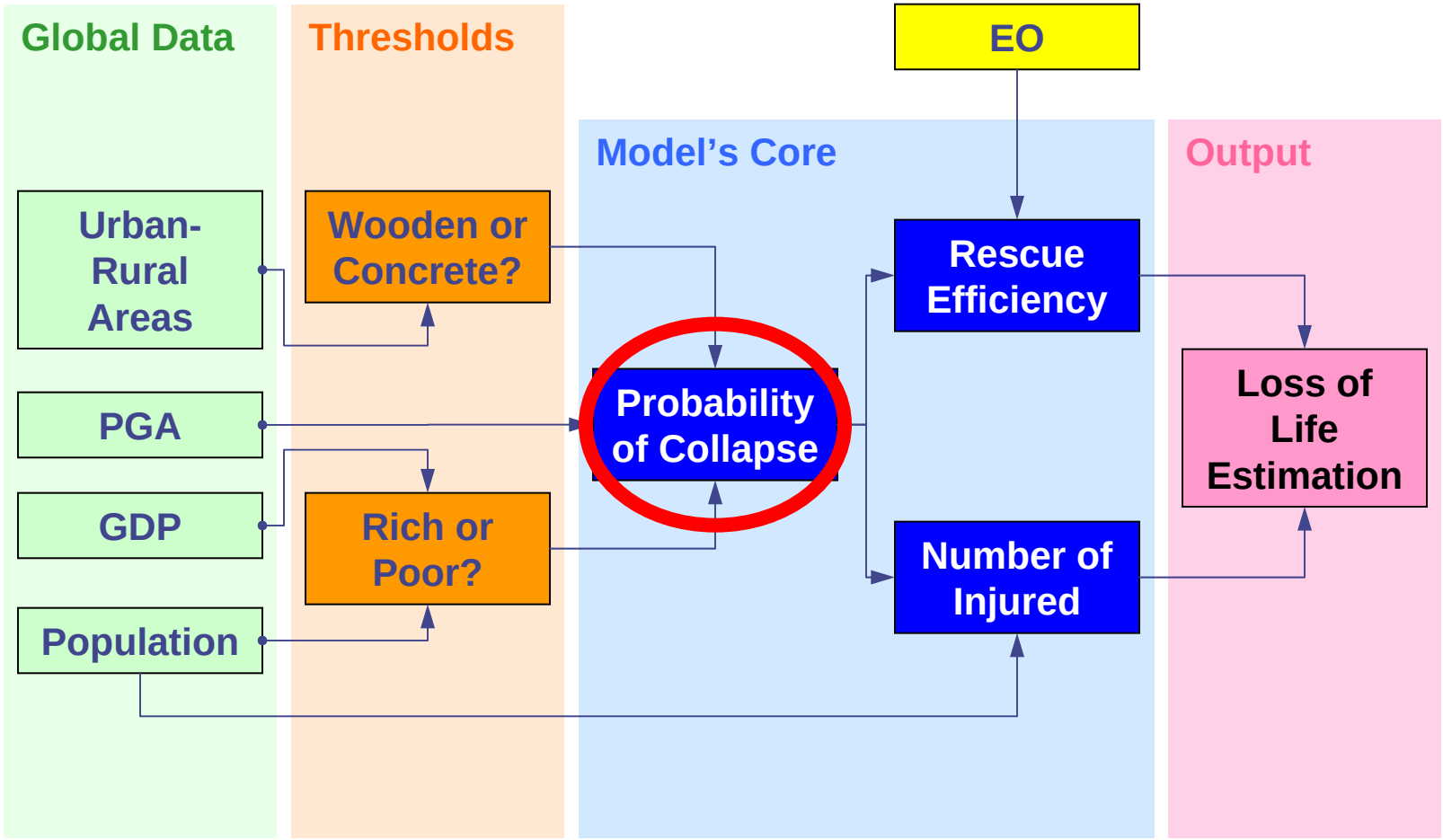


GDP per capita (rich/poor countries)



Source: Center for International Earth Science Information Network (CIESIN), 2002. Gridded Global GDP and population

Model Scheme / Global EQ EO assessment methodology



Model Scheme / Probability of Collapse

Japan Meteorological Agency seismic intensity scale

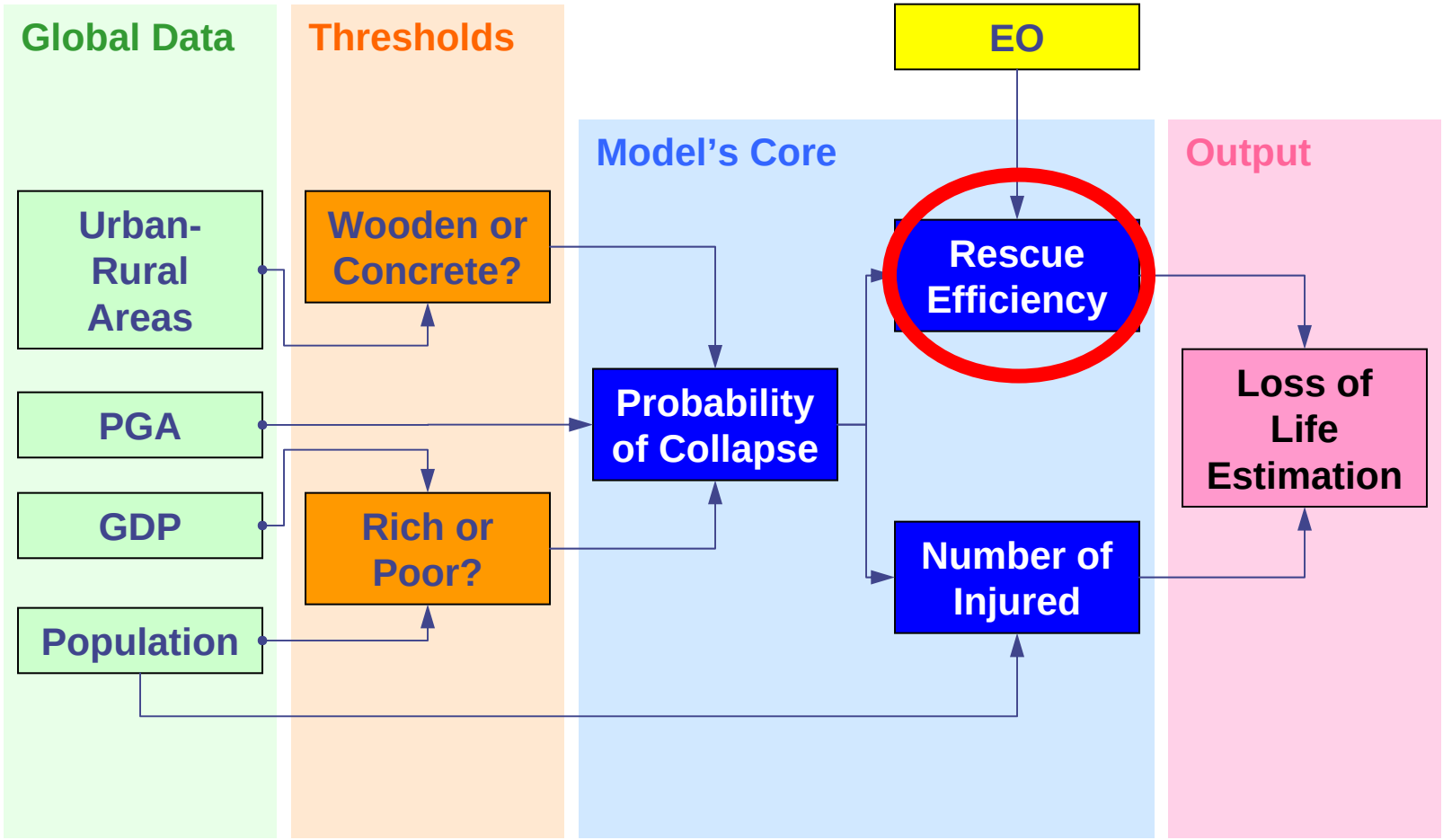
Source: http://www.jma.go.jp/jma/kishou/know/shindo/shindokai.html

Model Scheme / Probability of Collapse

Japan Meteorological Agency seismic intensity scale

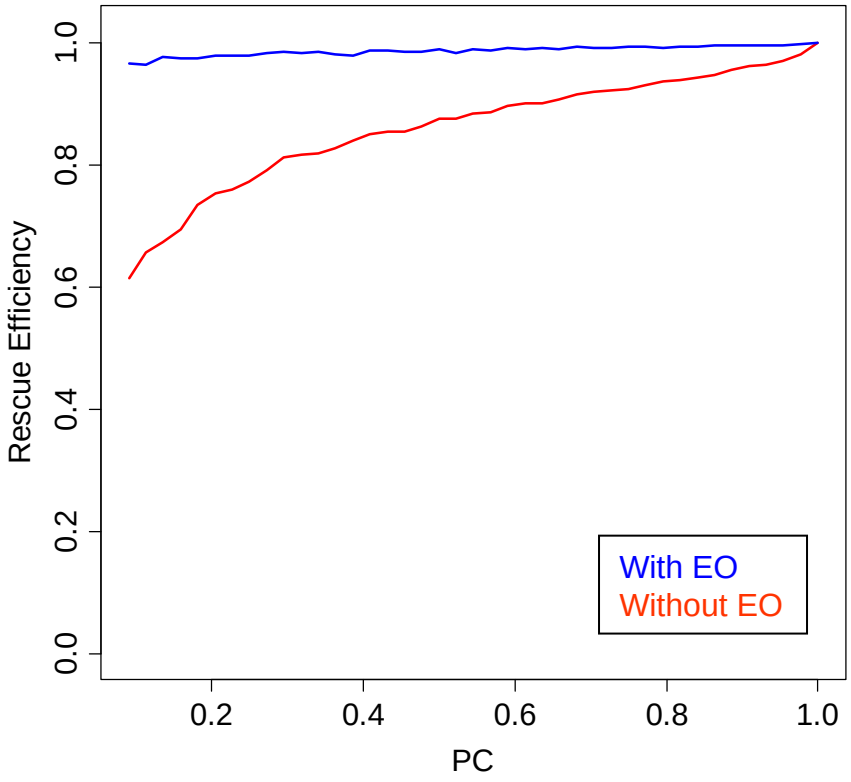
JMA scale	Wooden Houses	Reinforced Concrete Buildings	PGA threshold
6 lower	Occasionally, less earthquake-resistant houses collapse and even walls and pillars of highly earthquake-resistant houses are damaged.	Occasionally, walls and pillars of less earthquake-resistant buildings are destroyed.	1.4 m/s^2
6 upper	Many less earthquake-resistant houses collapse. In some cases, even walls and pillars of highly earthquake-resistant houses are heavy damaged.	Occasionally, less earthquake-resistant buildings collapse. In some cases, even highly earthquake-resistant buildings suffer damage to walls and pillars.	4.5 m/s^2
7	Occasionally, even highly earthquake-resistant buildings are severely damaged and lean.	Occasionally, even highly earthquake-resistant buildings are severely damaged and lean.	14 m/s^2

Model Scheme / Global EQ EO assessment methodology

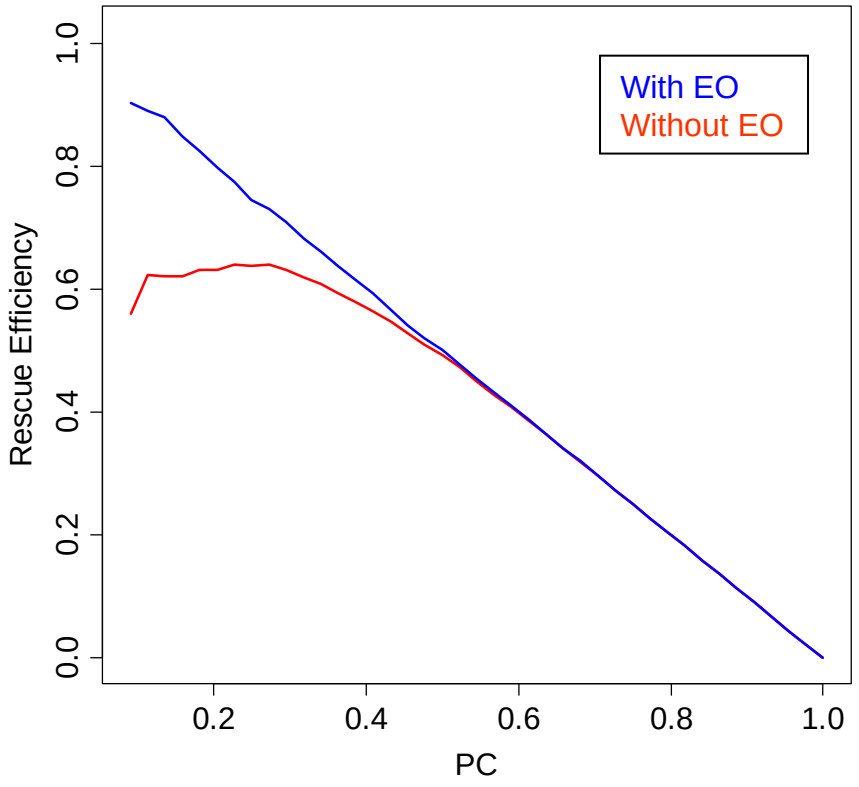


Model Scheme / Rescue Efficiency Assessment*

"Sufficient" amount of resources



Vulnerable resources (decreasing)



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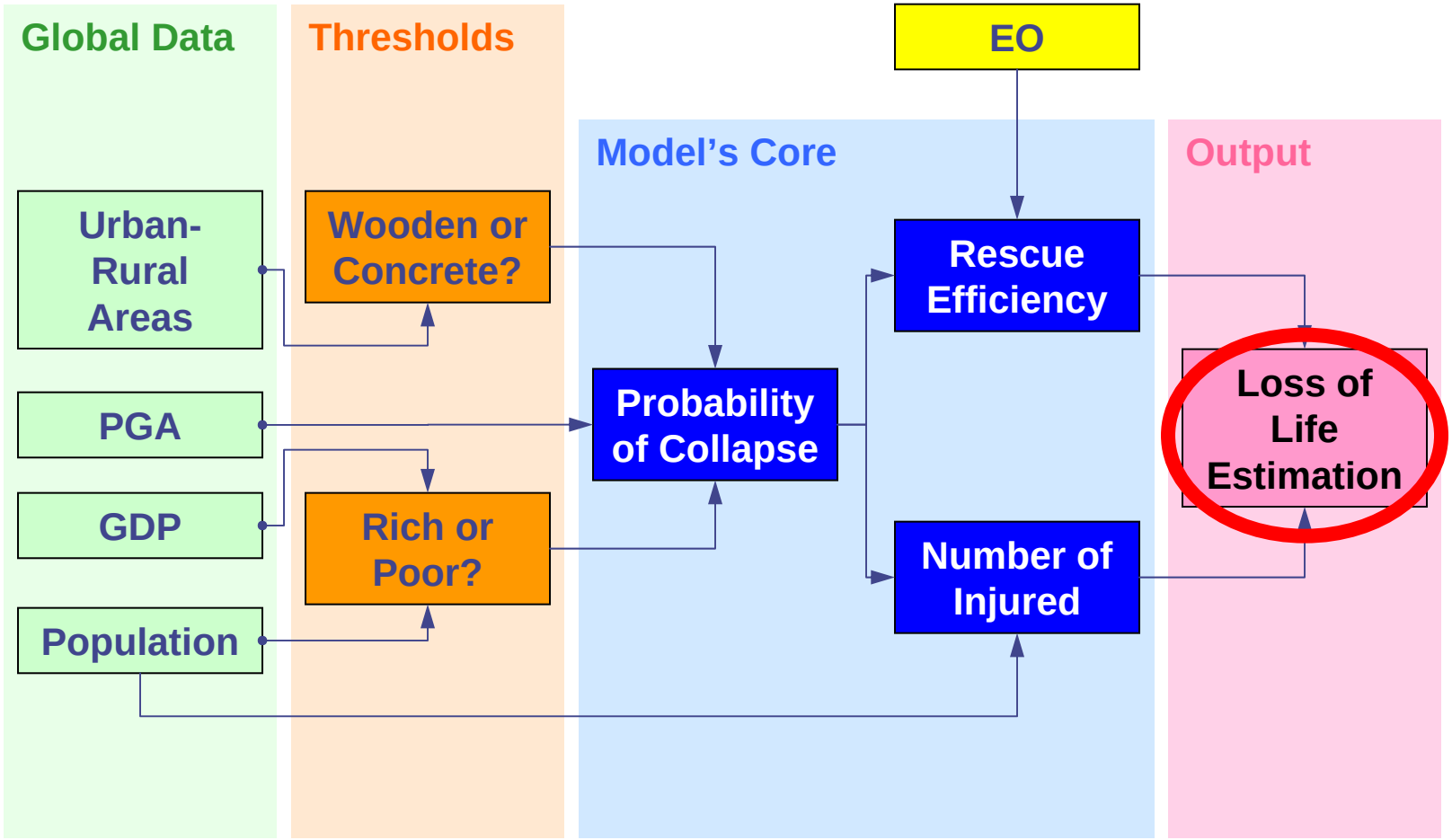
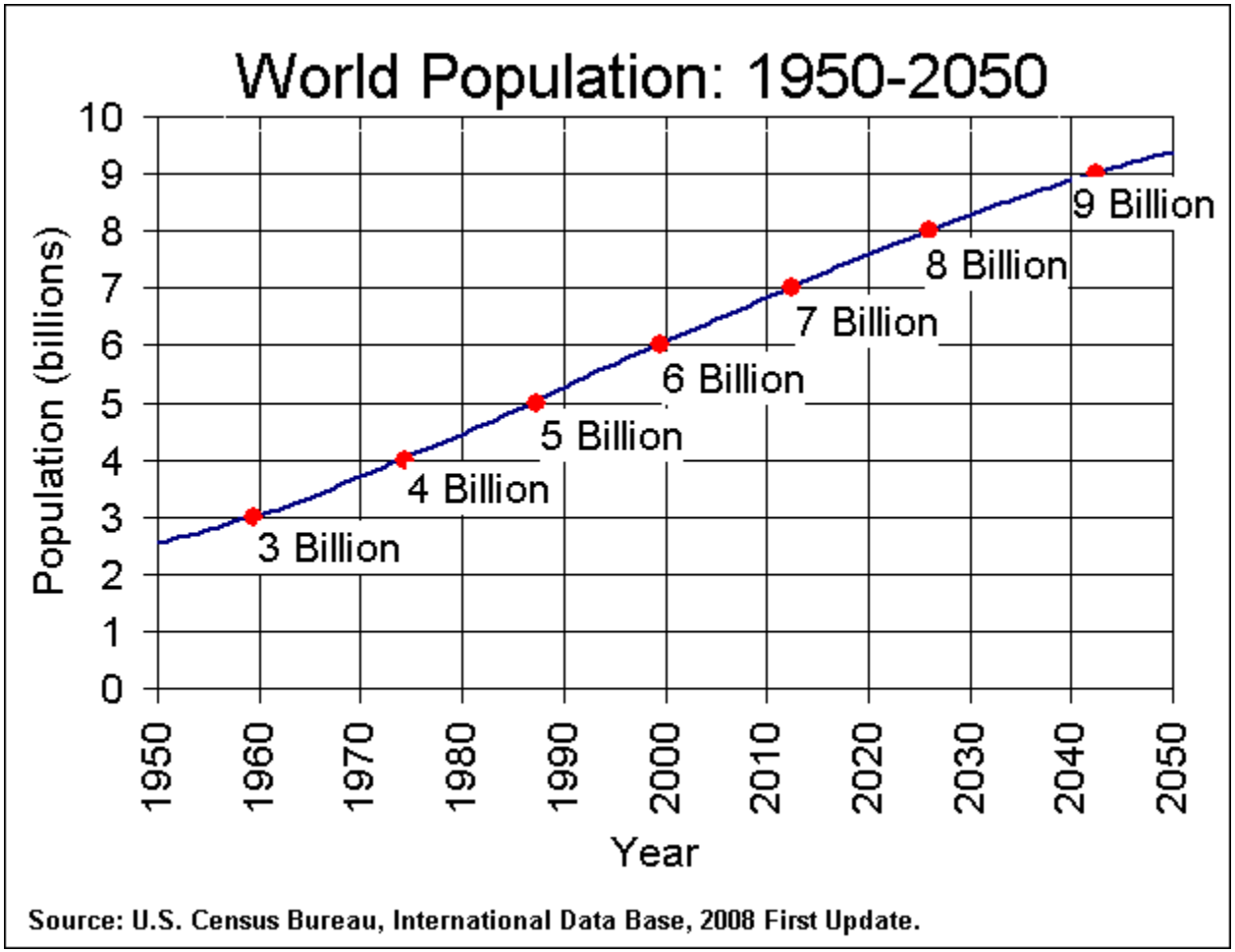
Model Scheme / Global EQ EO assessment methodology



Model Validation / Global Results



Model Validation / Global Results

EM-DAT: EQ 1980 – 2008 (April) killed: 300 000

Rescaling to 30 years:
714 000 x (30 years / 50 years) = 430 000

Population growth adjustment:
1980 – 2000 ~ (4.5 + 6.0) / 2 = 5.25

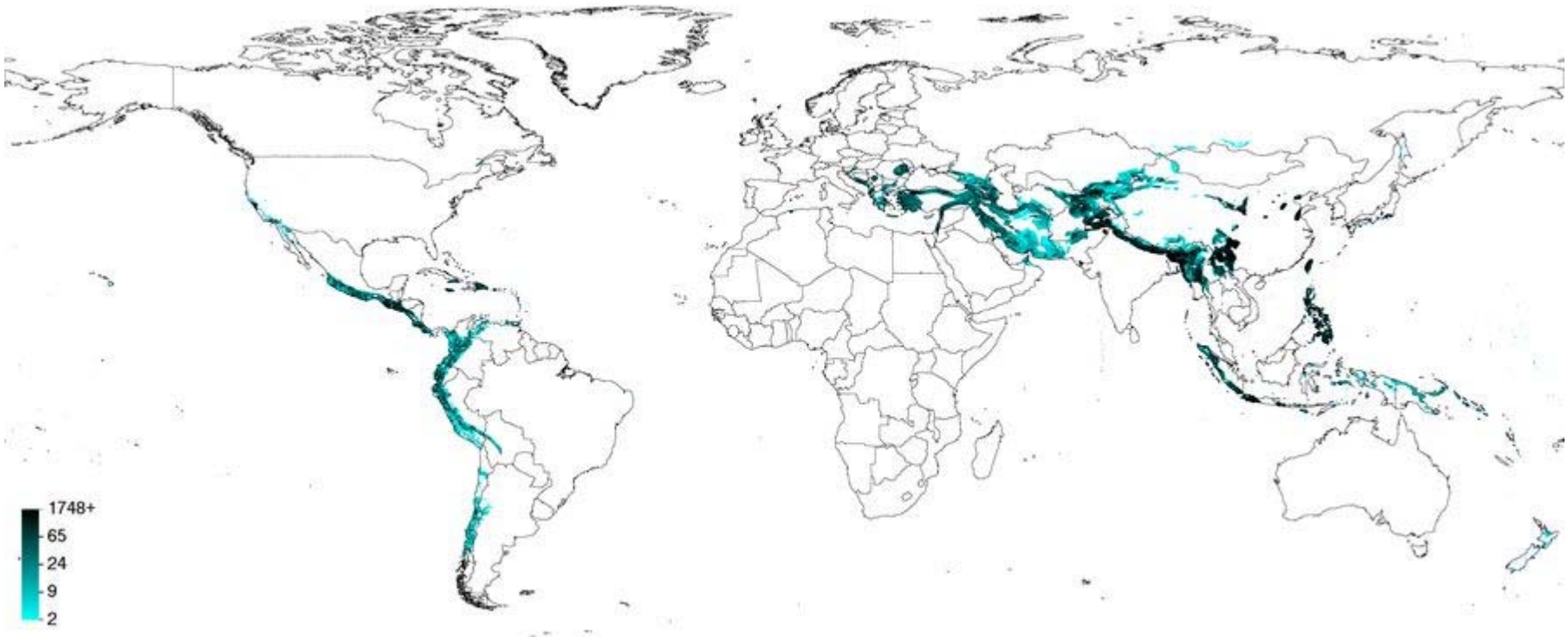
430 000 x (5.25 / 6.0) = 370 000

(upper value: 1 437 000 x 30 / 50 x 5.25 / 6.0 = 750 000)

Global Estimation

Fatalities:

- Historical data (EM-DAT) ≈ 370 000
- Model results without observations: 374 000 (750 000)
- Model results with observations: 37 000 (590 000)



Model verification / Regional-Scale Case Studies

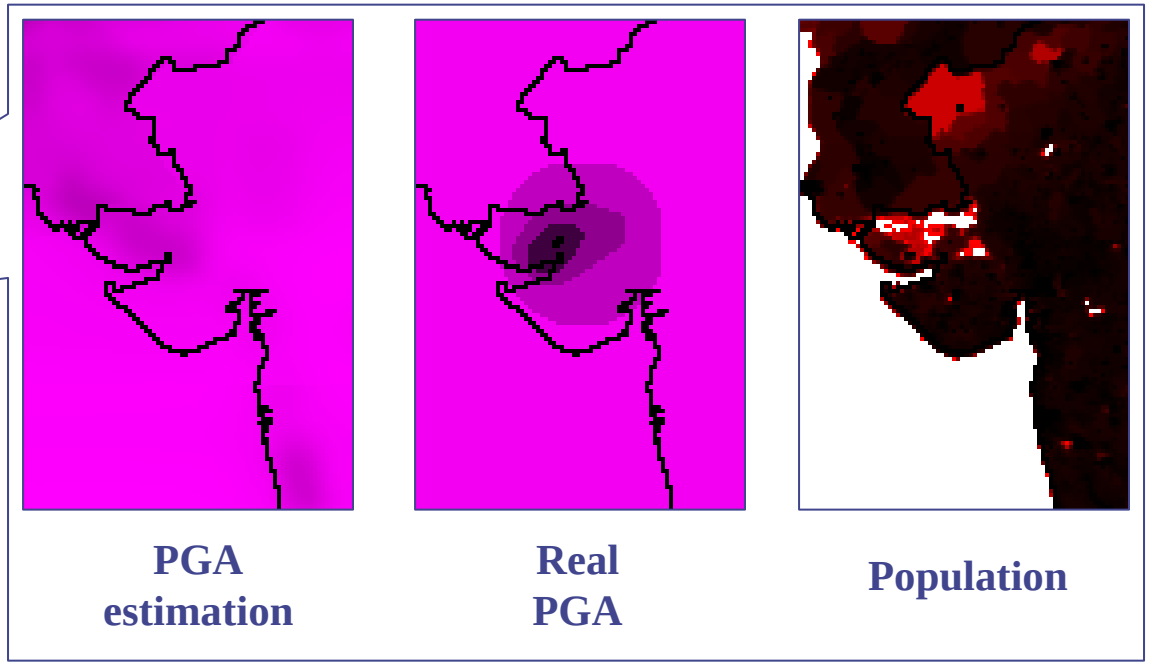
- 3 case studies
- Real seismic data (U.S. Geological Survey, USGS)
- Quality of estimates - good

Case study	Real data	Model results	
		Sufficient resources	Vulnerable resources
Sichuan, China	69 000+	84 700	307 017
Gujarat, India	20 000+	12 878	32 450
Loma Prieta, USA	72	25	27

PGA maps: GSHAP and real data

Gujarat earthquake. India, January 26, 2001

- Magnitude – 7.7
- About 340 000 buildings destroyed
- Killed – 20 000+
- Injured – 166 836



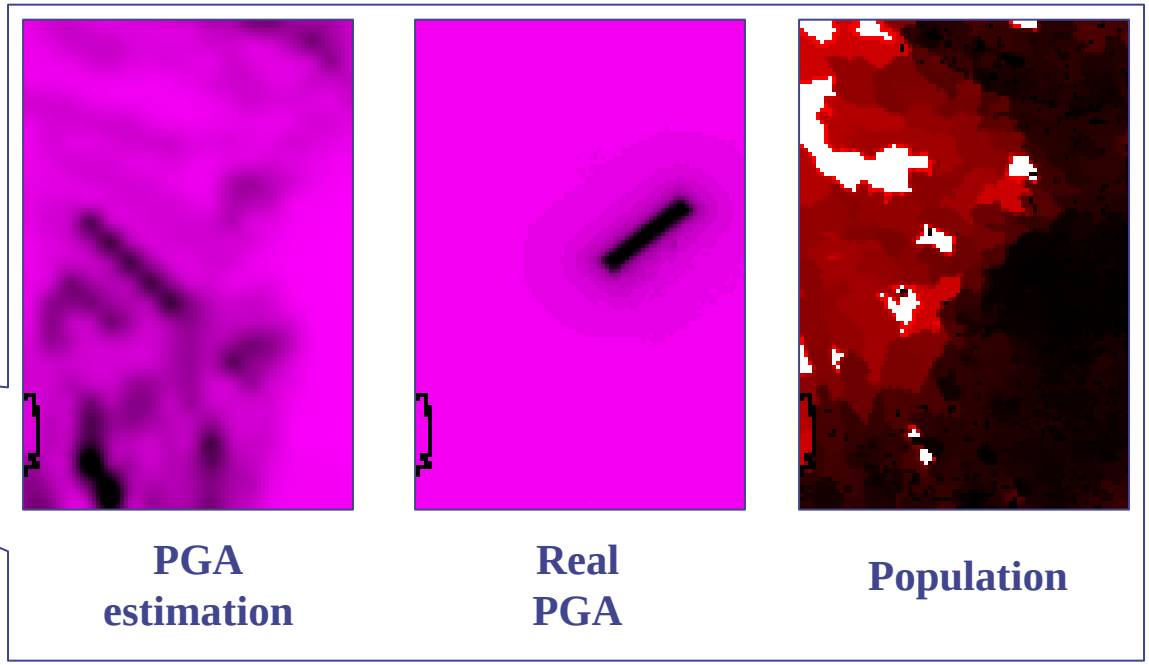
PGA estimation | Real PGA | Population

Sources: U.S. Geological Survey, National Earthquake Information Center , GSHAP

PGA maps: GSHAP and real data

Sichuan earthquake. China, May 12, 2008

- Magnitude – 7.9
- Killed – 69 000+
- Missing – 17 000+
- Injured – 375 000



PGA estimation | Real PGA | Population

Sources: U.S. Geological Survey, National Earthquake Information Center , GSHAP

EQ Model Features Meeting GEO-BENE Objectives

- ✓ Observations-Explicit
- ✓ Real Data Used
- ✓ Quantitative Result
- ✓ EO Benefits Baseline Present
- ✓ EO Cost-Benefit Analysis*
- ✓ System of Systems Effect*
- ✓ Global Scale
- ✓ Model Validation

* described by the local scale model

Thank you!

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