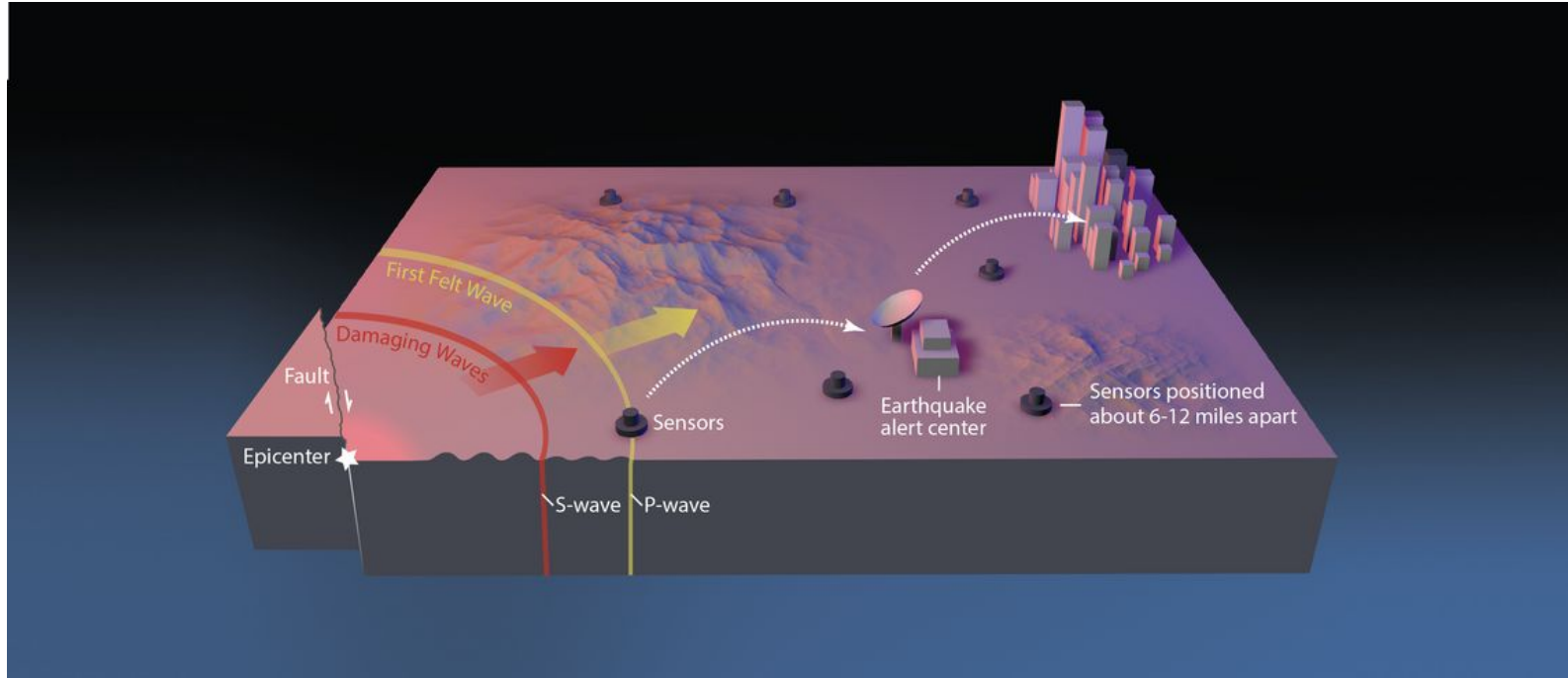# The Transformer Earthquake Alerting Model
How deep learning opens new possibilities in earthquake early warning
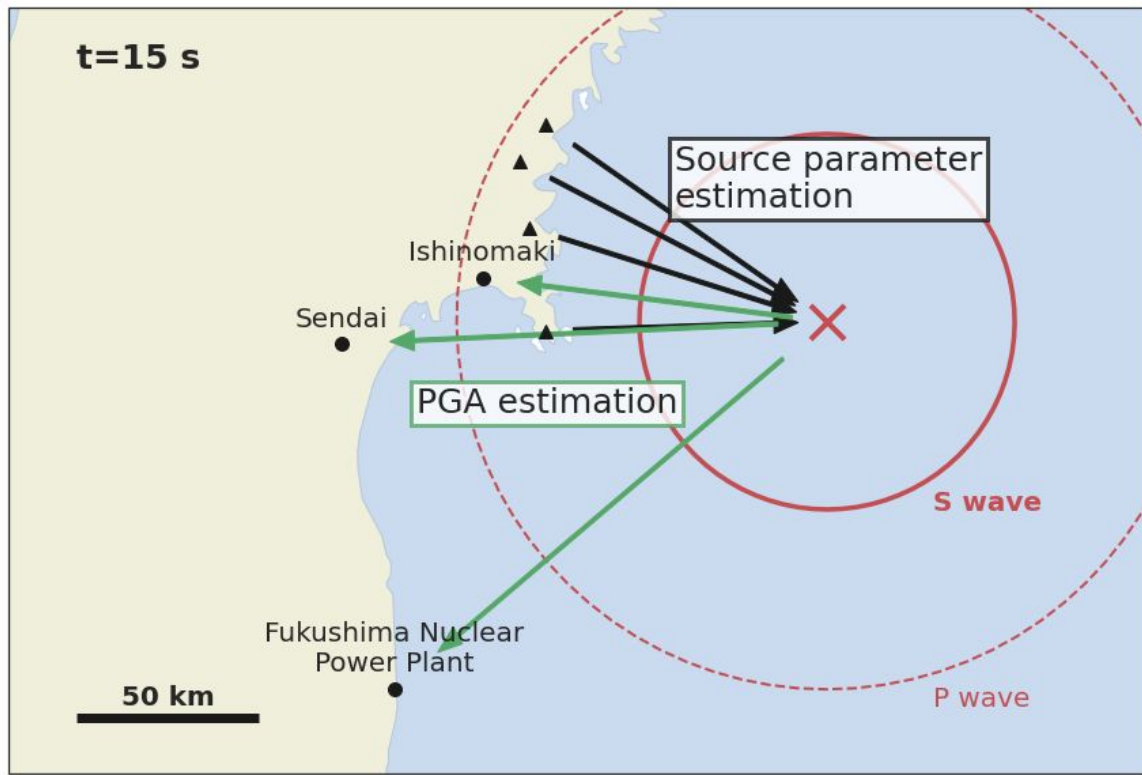
Jannes Münchmeyer

Earthquake early warning

Source: USGS, https://www.usgs.gov/media/images/shakealert-earthquake-early-warning-system-us-western-states

Source estimation based warning

Advantages:

- Early estimates
- Long warning times

Disadvantages:

- Simplified modelling
- Saturation for large events

Propagation based warning

Advantages:

- High accuracy for large events
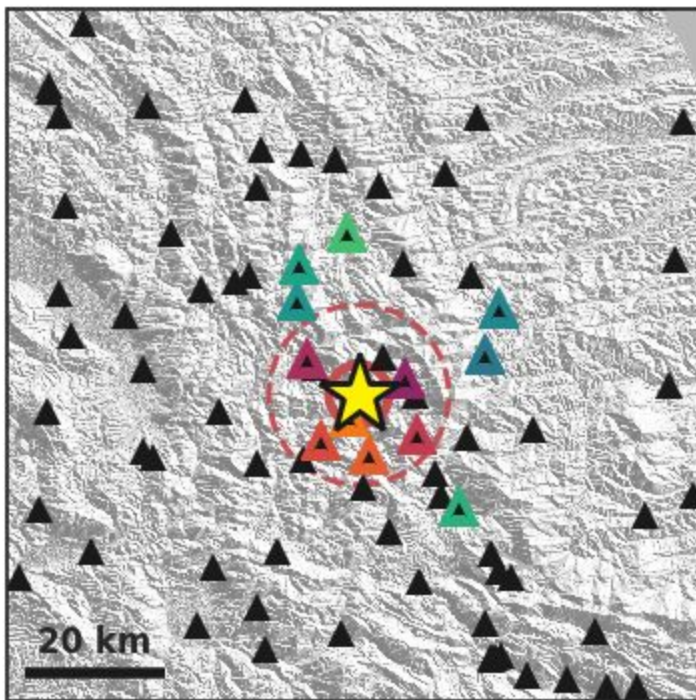- No saturation for large events
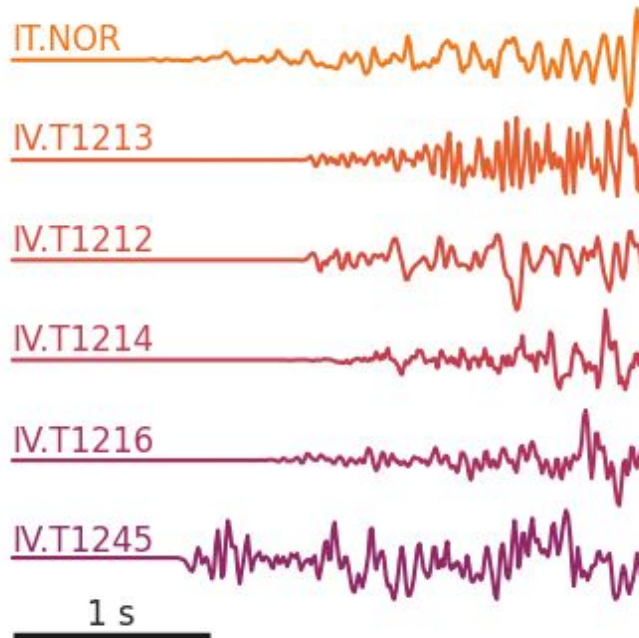
Disadvantages:

- Short warning times

Deep Learning for early warning

Idea: Use deep learning to build a system that has both a global and a local view of an earthquake.
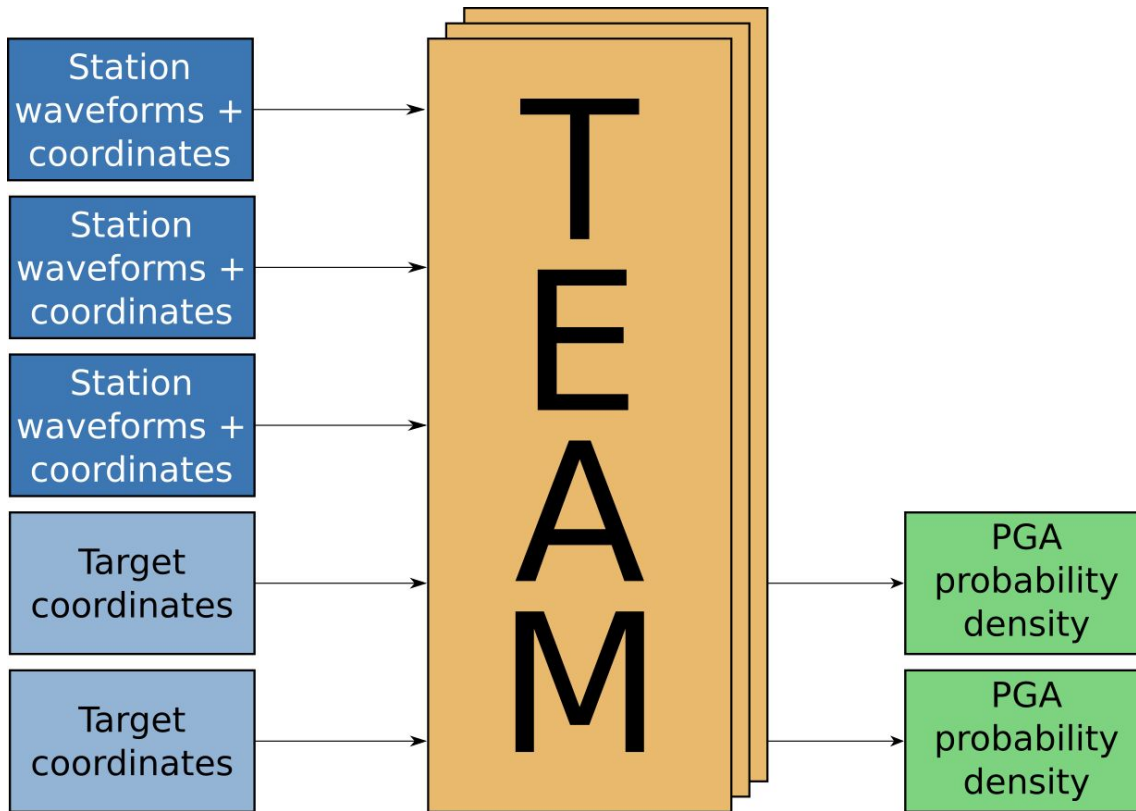
TEAM - Event detection

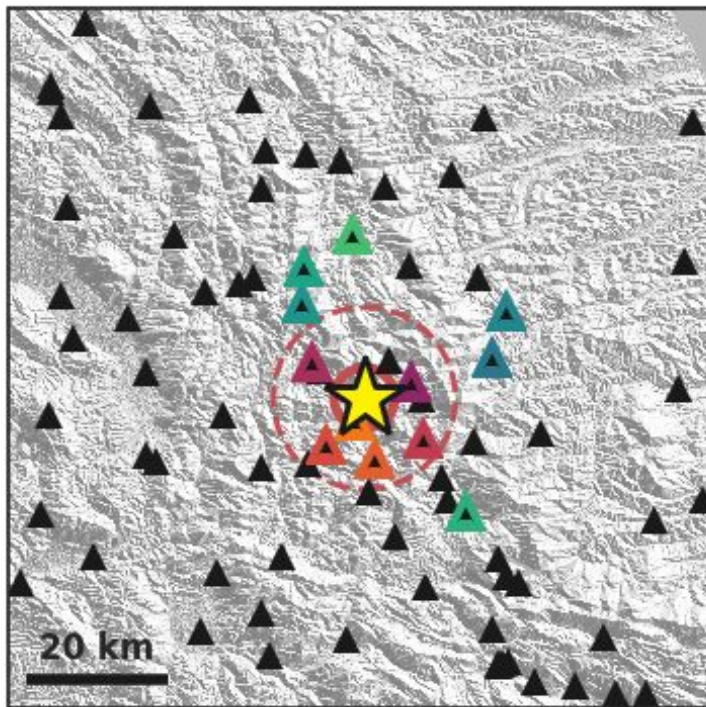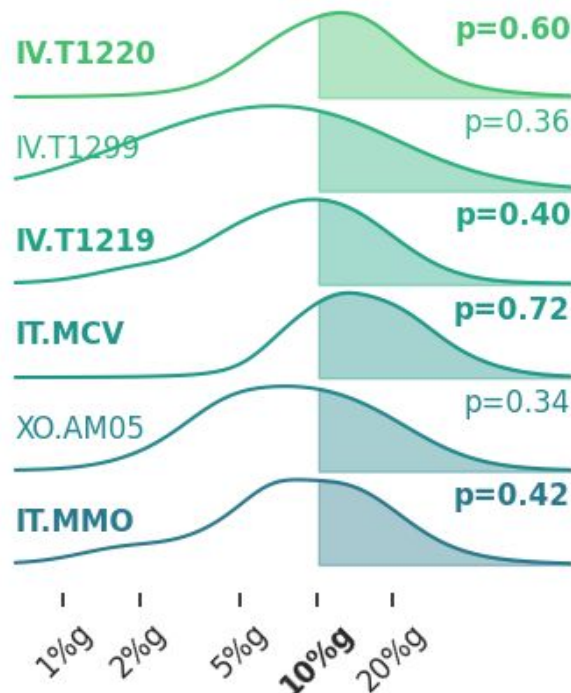30/10/2016 Norcia event, Central Italy $M_w = 6.5$ 2.5 s after first P arrival

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TEAM - PGA estimation
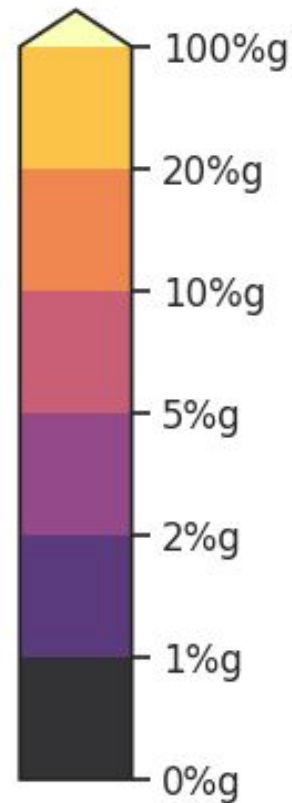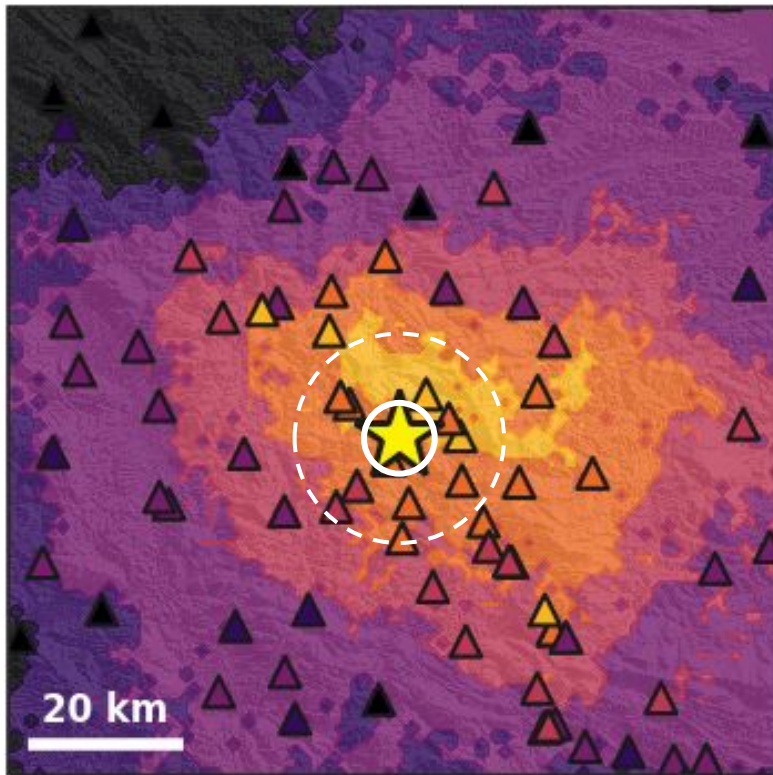
TEAM - Thresholding

30/10/2016 Norcia event, Central Italy $M_w = 6.5$ 2.5 s after first P arrival
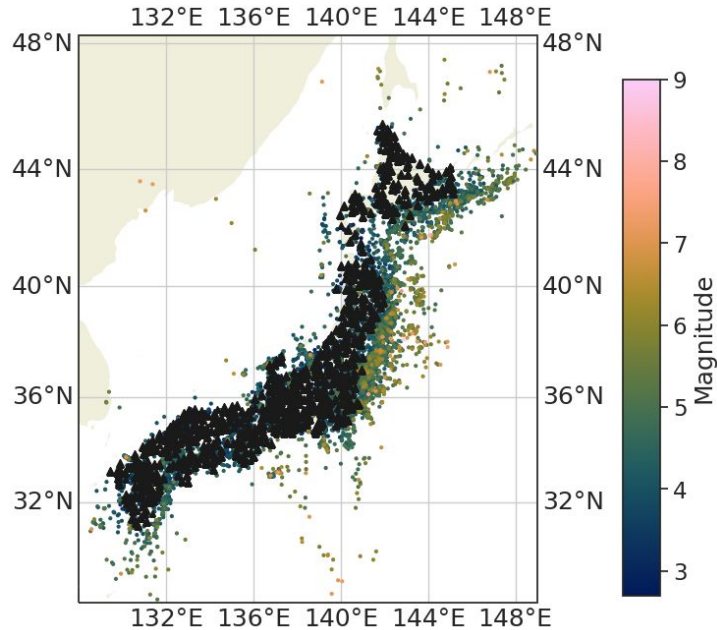
TEAM - Predicted Shakemap

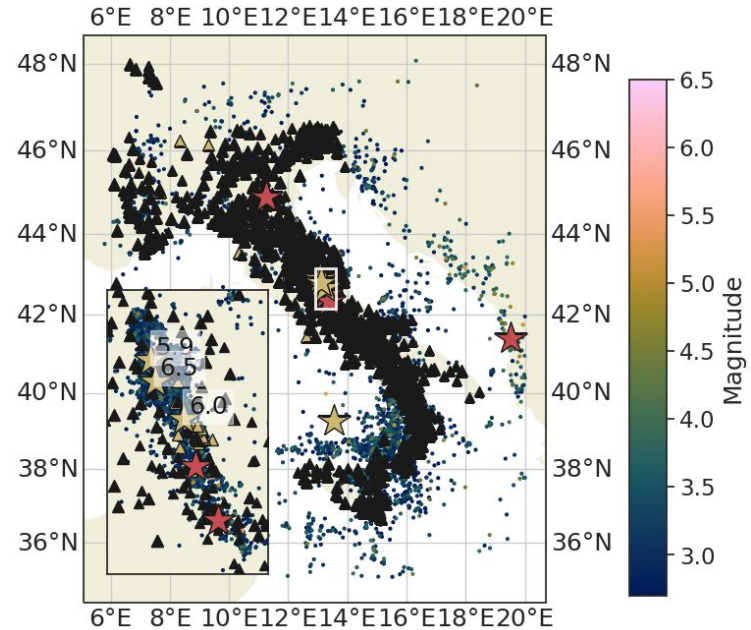30/10/2016 Norcia event, Central Italy

$M_w = 6.5$

2.5 s after first P arrival

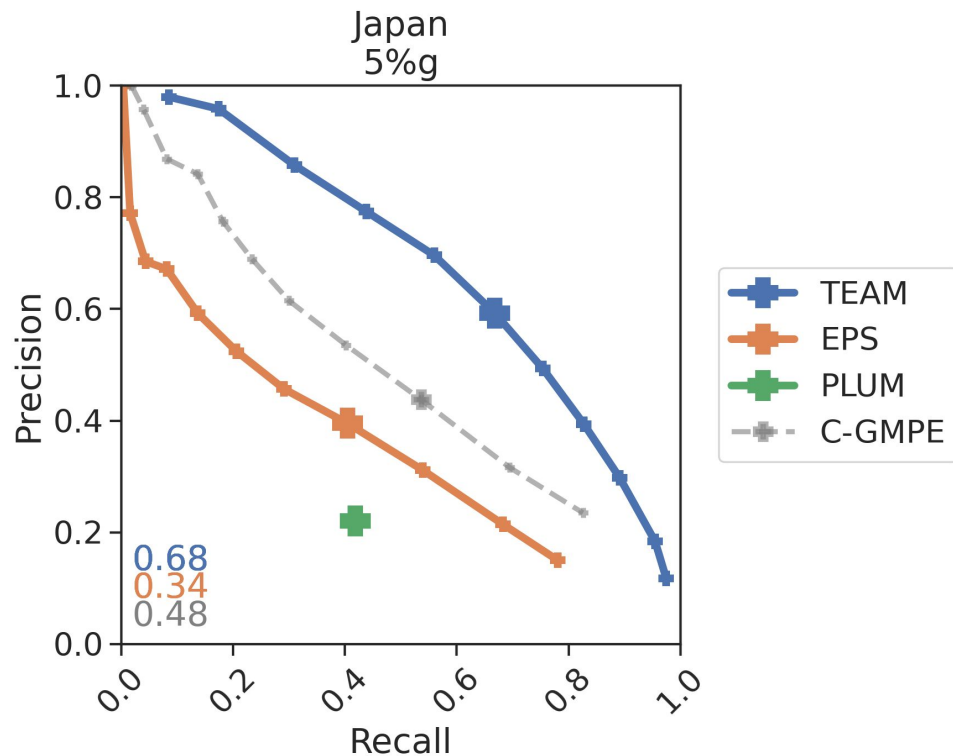# Evaluation in different hazard scenarios

13,512 events - 372,661 traces
Train: 1997 - 2012   Max. M$_w$: 9.0
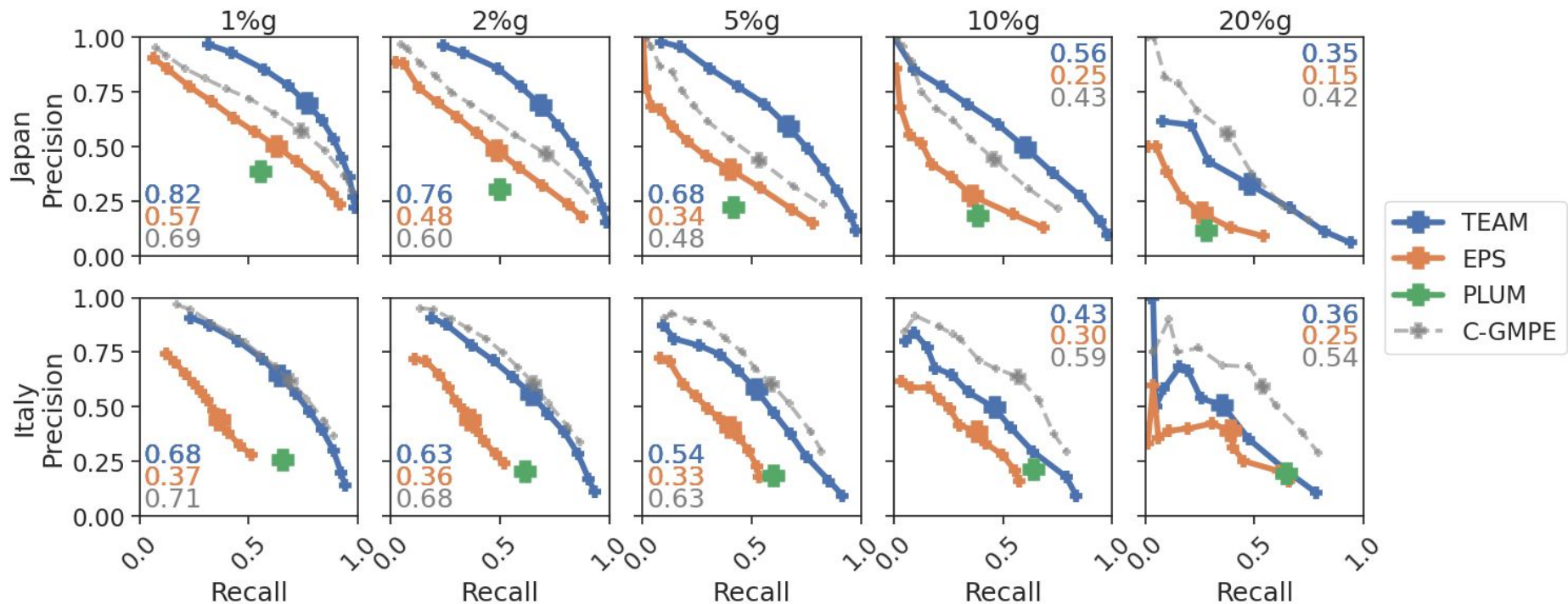Test: 2013 - 2018   Max. M$_w$: 8.1

7,055 events - 494,183 traces
Train: 2008 - 2015 & 2017 - 2019   Max M$_w$: 6.1
Test: 2016   Max M$_w$: 6.5

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Comparison to classical approaches

Japan
5%g

Comparison to classical approaches

Conclusion

The transformer earthquake alerting model (TEAM):

- Introduces a new, data driven strategy for earthquake early warning
- Outperforms classical approaches across different hazard scenarios