The road to real time ground shaking maps is paved with ORB packages

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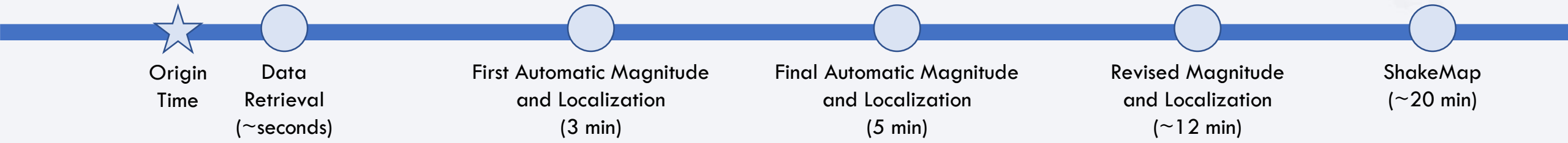
Giovanni Costa

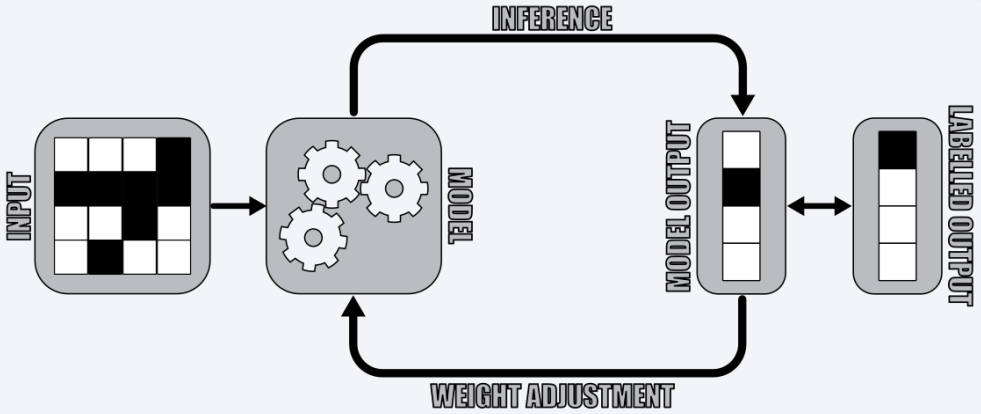
Why shakemaps in real time?

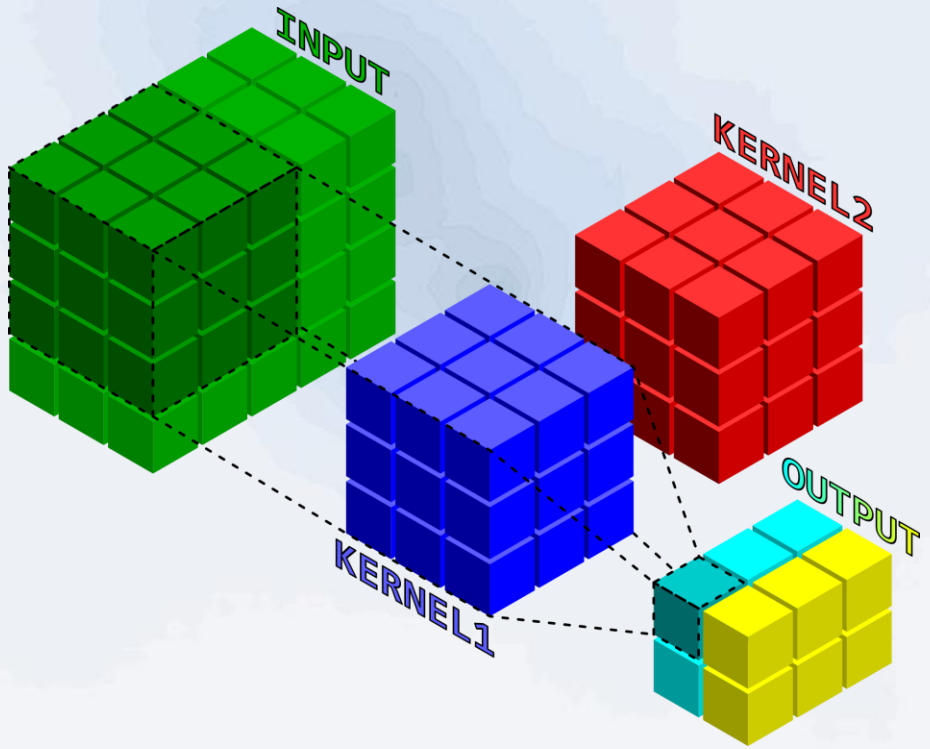
- Ground shaking maps have been used for many applications:
  - Post-emergency management
  - Risk assessment
  - Etc.
- Traditional methods (i.e. ShakeMap) relies on GMPEs and thus on estimates of the event location and magnitude
- Since these estimates can encounter delays, we wanted to develop a method that can leverage the data available in real time (ground motion parameters)



ConvNets and supervised learning

- Kernel values are learned during training
- Non-linearity introduced with activation functions on layer outputs
- The neural network approximate the (unknown) function that maps the input-output pairs





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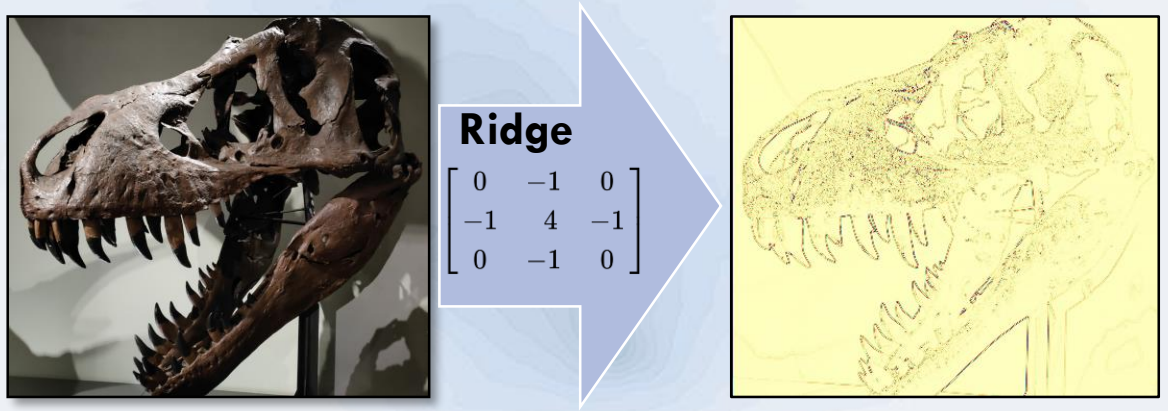
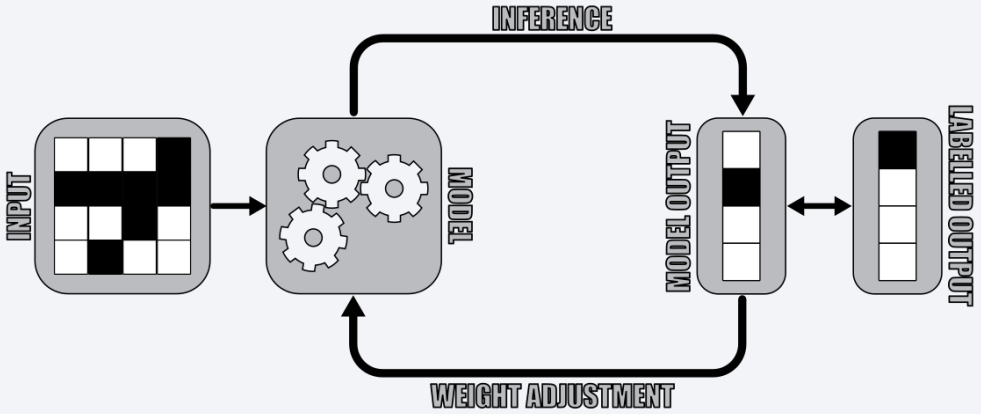
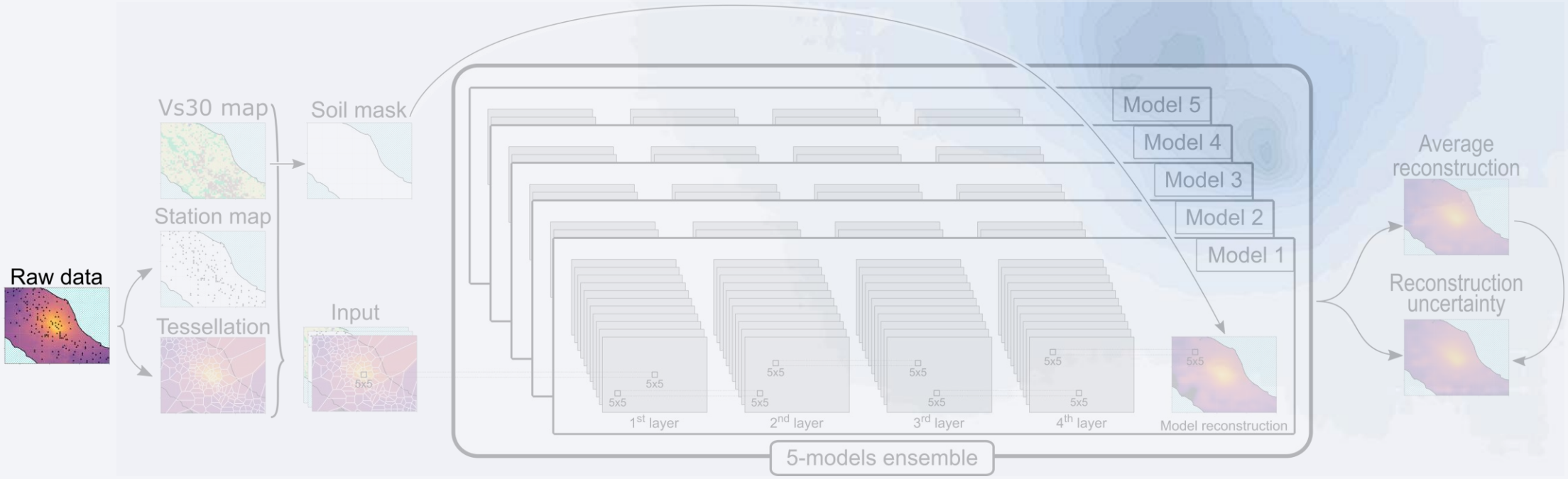




Fornasari et al. (2022)
doi: 10.1785/0120220034

ShakeRec

Use a CNN to reconstruct the ground motion field from sparse values



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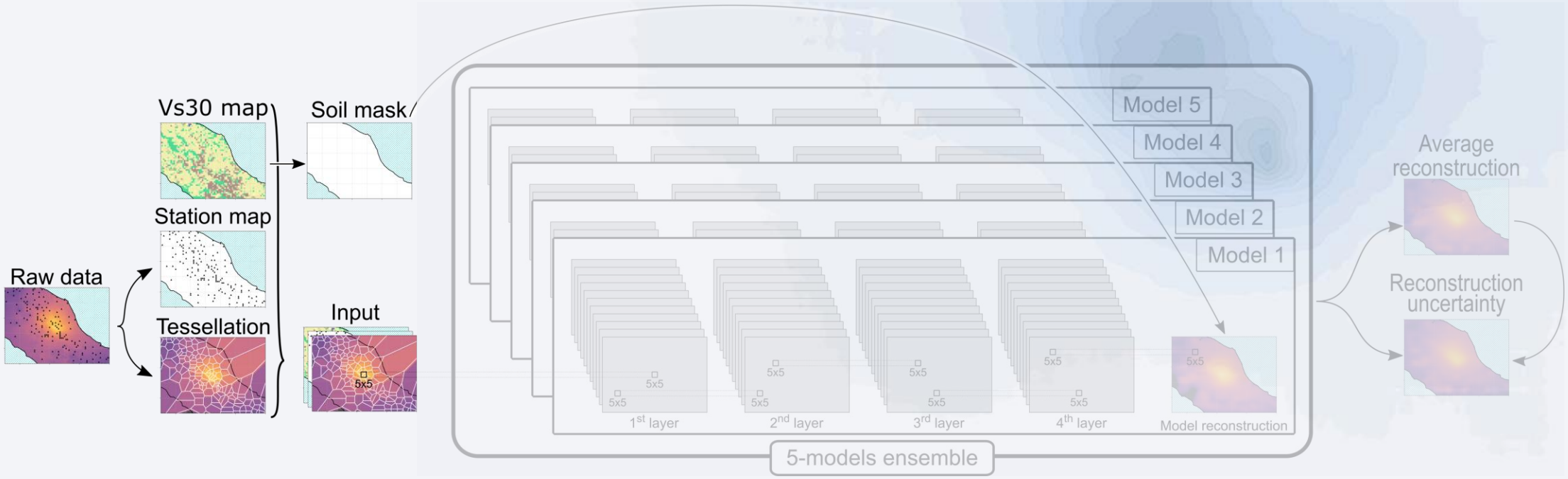

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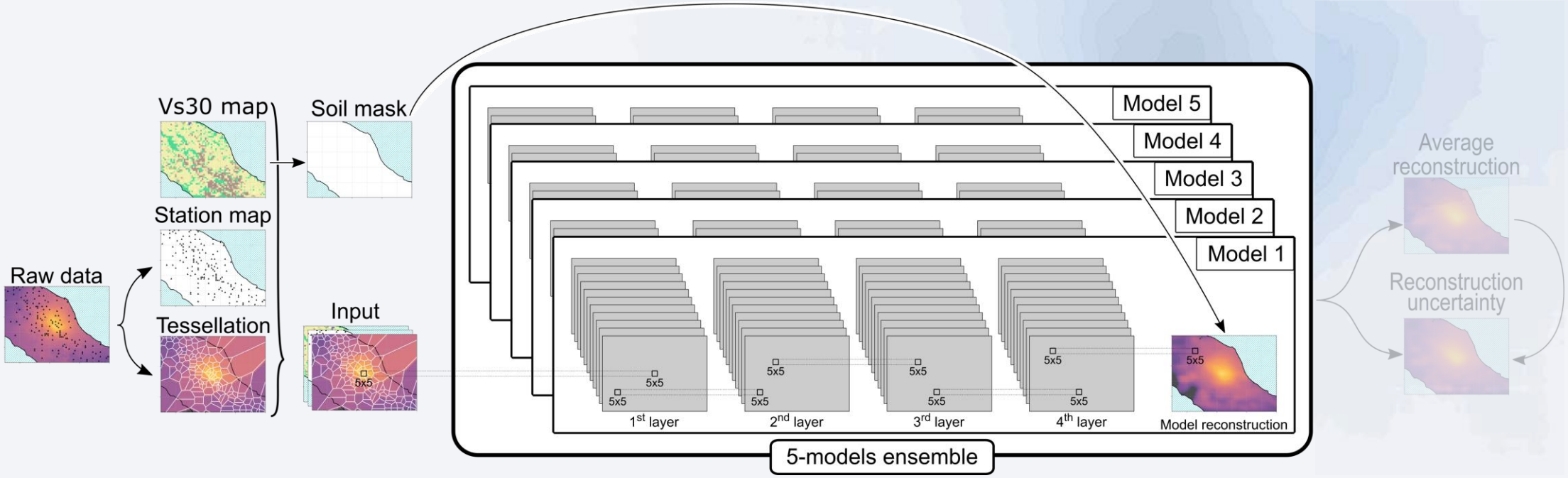

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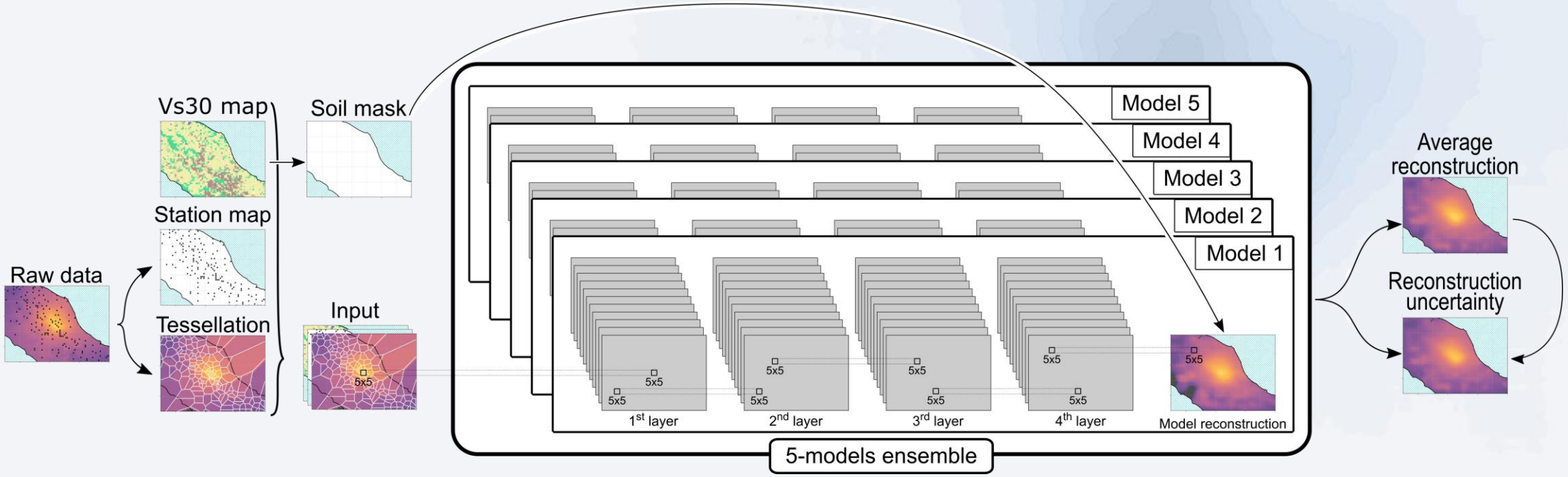

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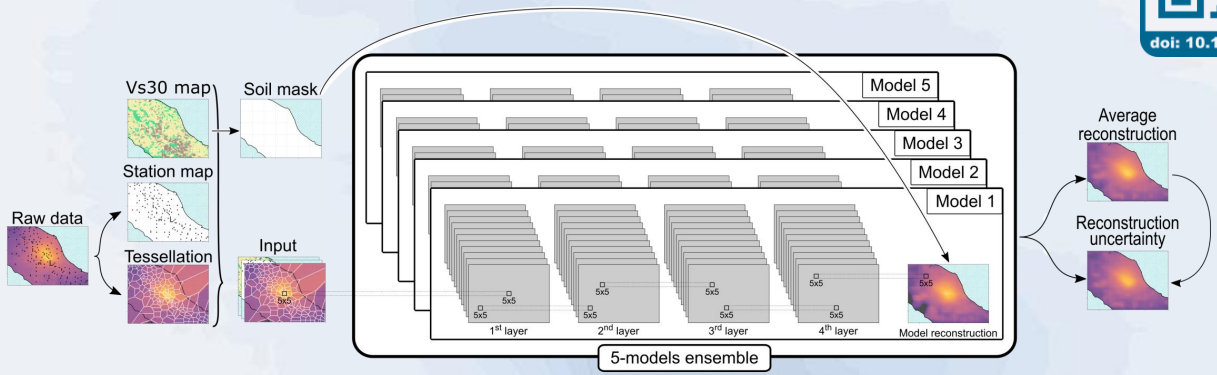

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Capabilities:

Compatibility with ShakeMap results
Real-time updates
Stable over time

Limitations:

Fixed (low) resolution
Naive uncertainty estimation
Low interpretability

Where's Antelope?

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Custom Python package to read and process the data from the ORB:

- Object oriented (1 object/station)
  - Store data
  - Store meta-data
- With multiprocessing in mind
  - Internal "buffers"
  - Multiple stations per process

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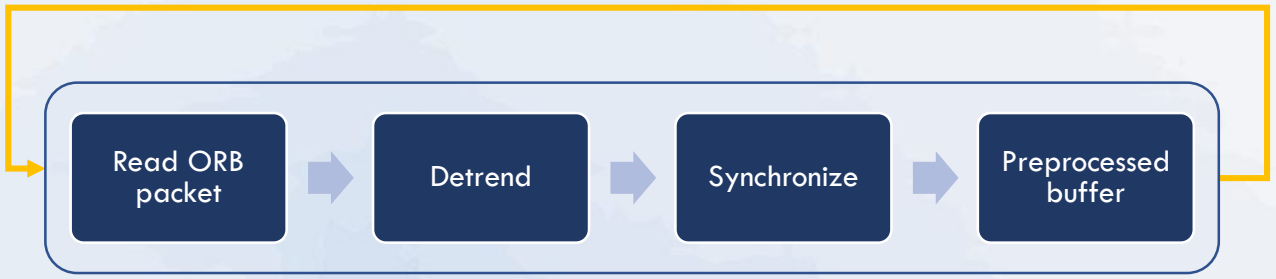

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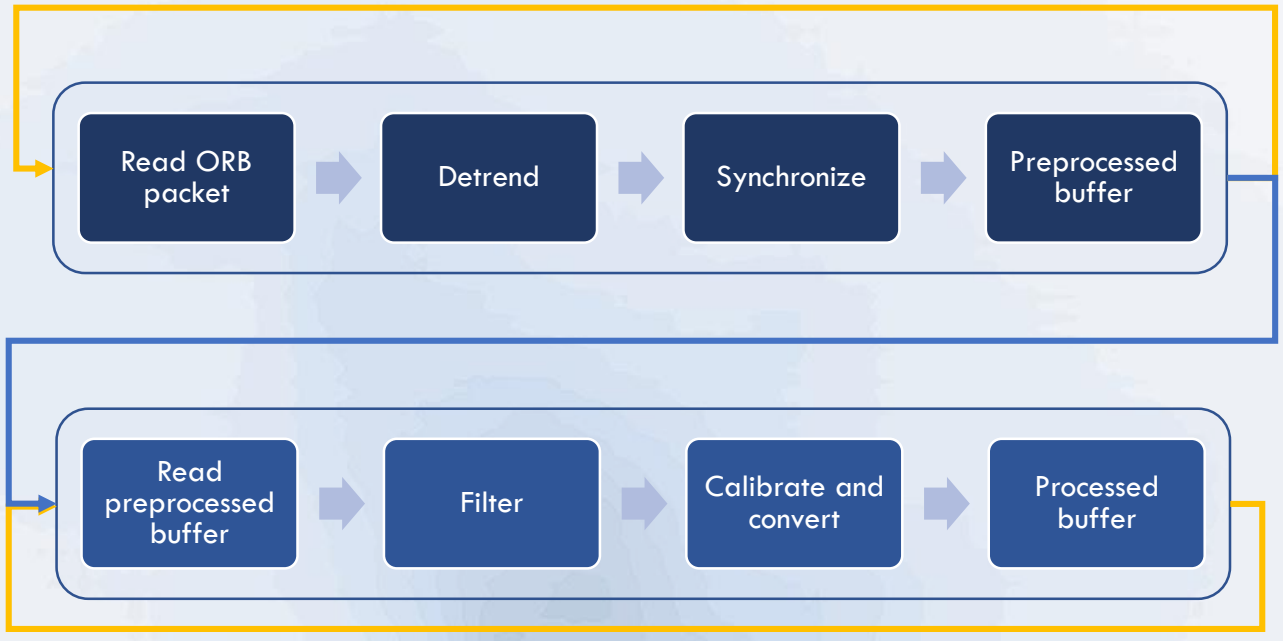

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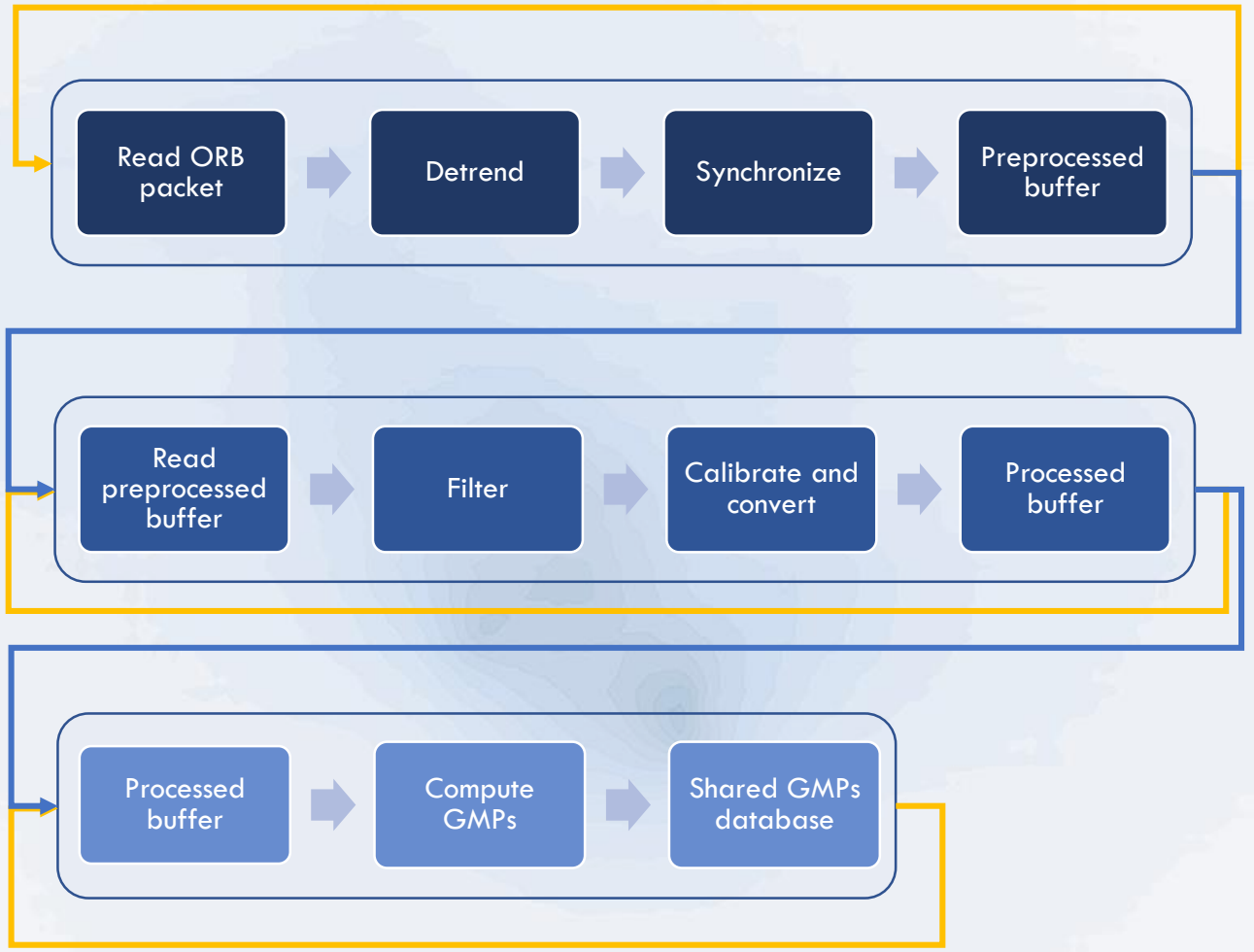

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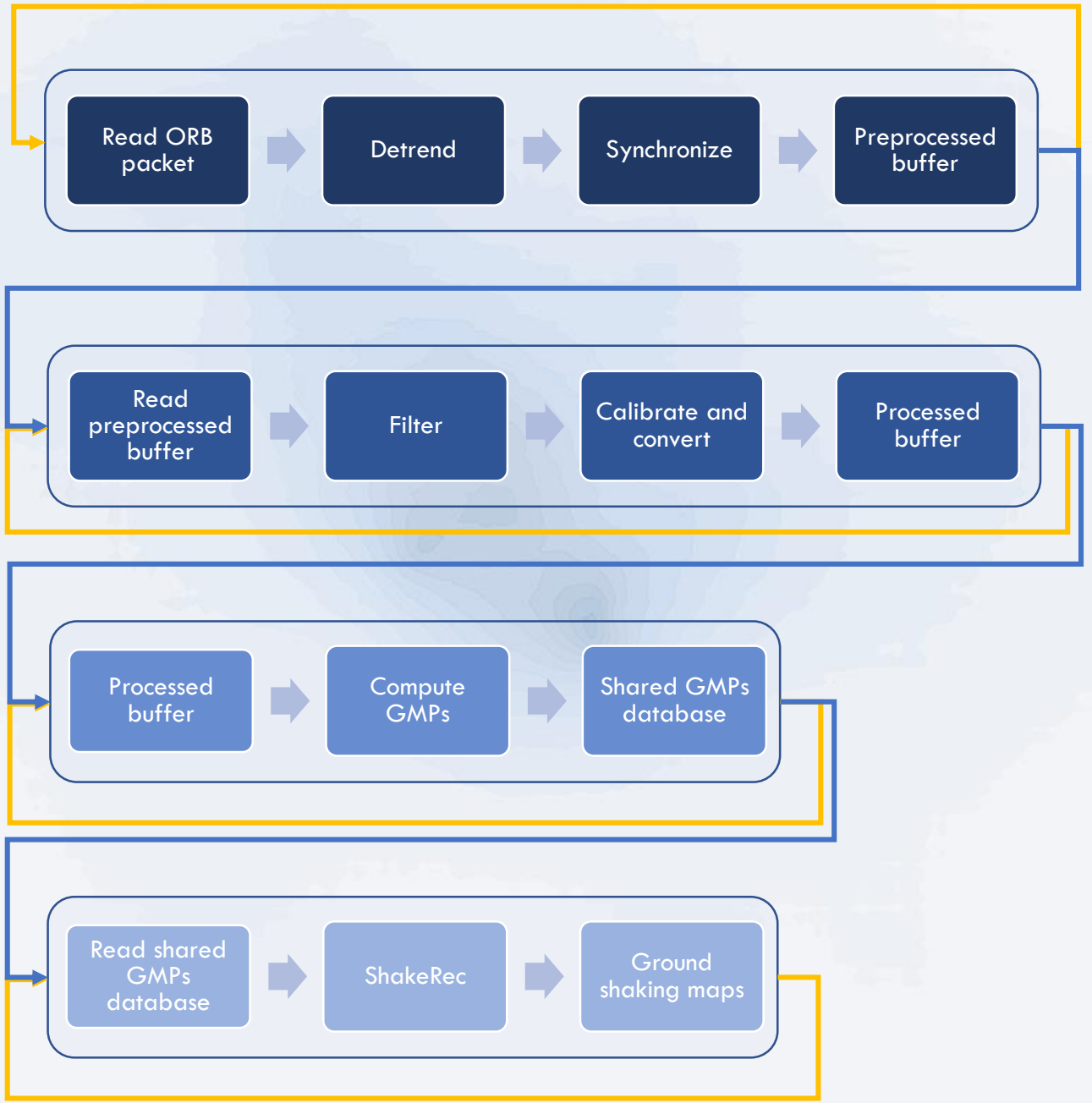
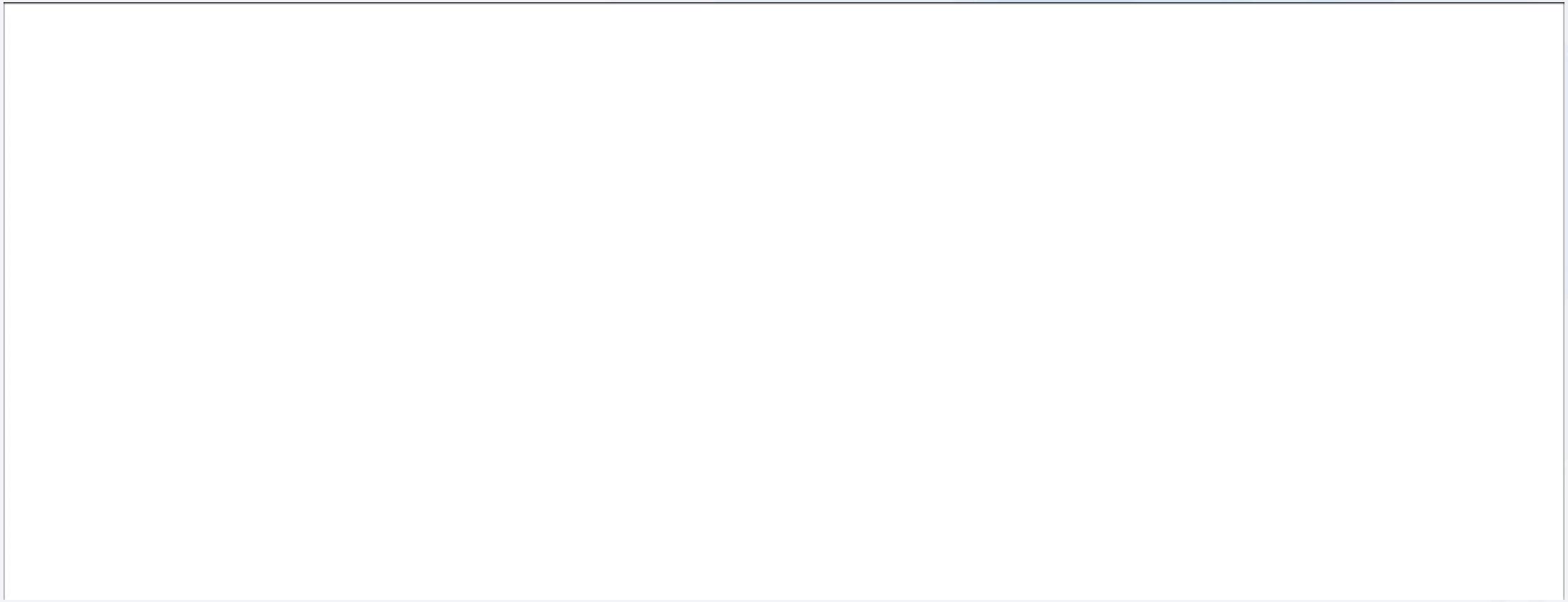


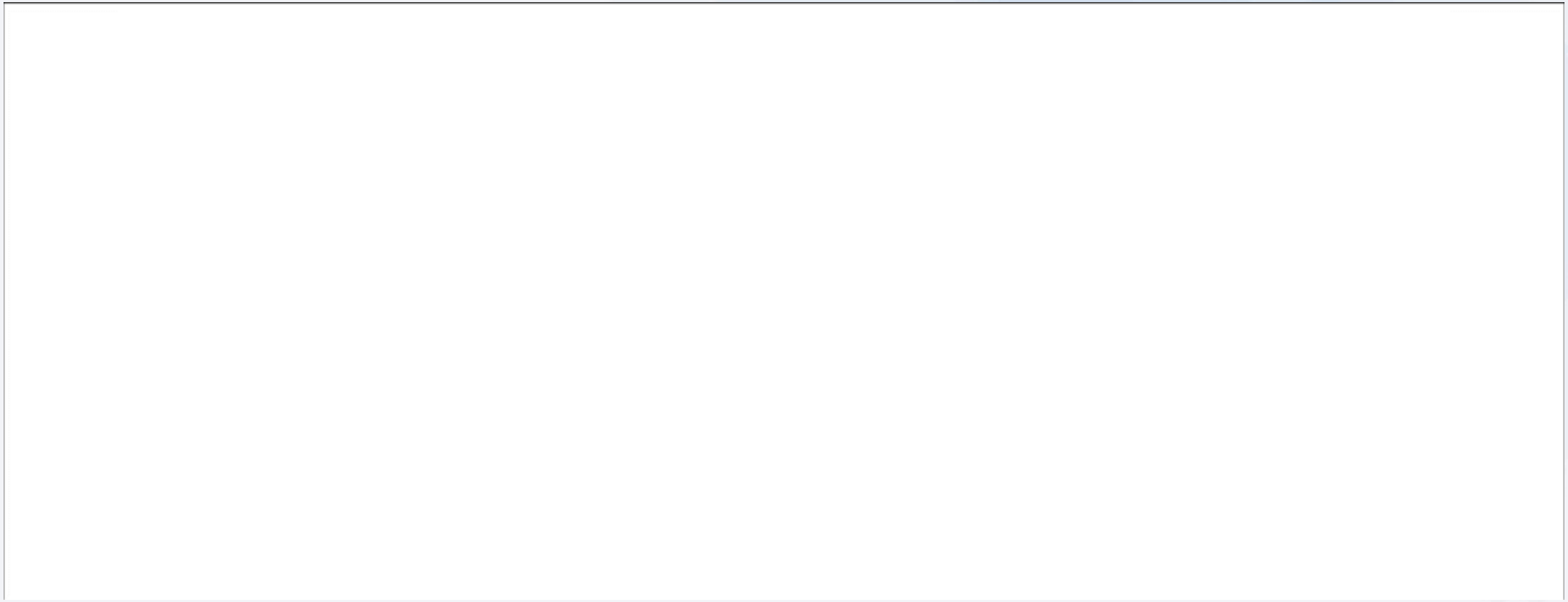
A few ShakeRec examples

Costa Marchigiano Pesarese - M5.7



Data: DPC and INGV

Bargagli - M4.1



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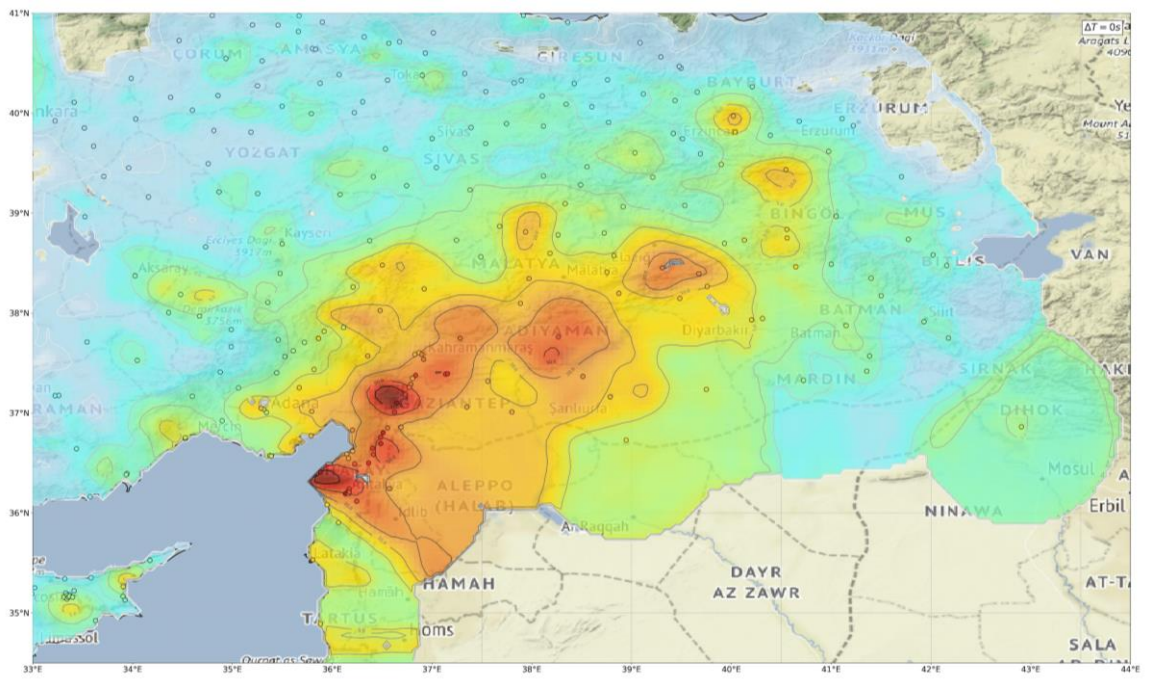
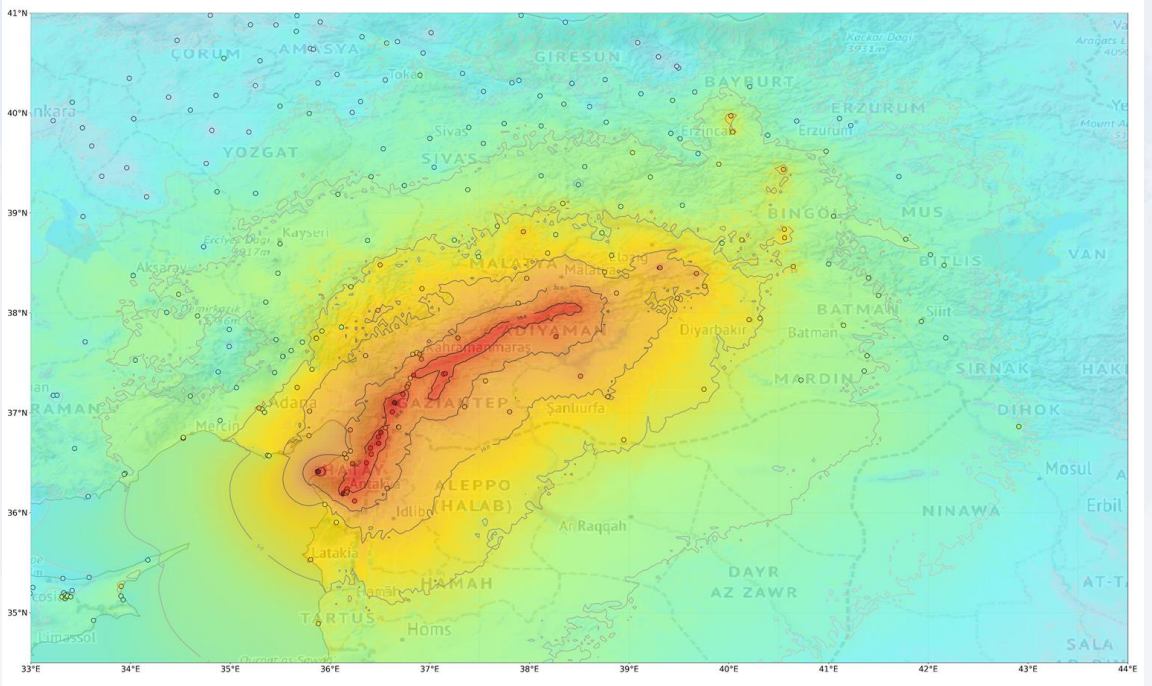
Gaziantep – M7.8





Data: USGS

Hybrid ShakeRec

- Use a NN to bypass the GMPE and then use ShakeMap
- Adopt conditional neural processes ('Gaussian processes'-inspired neural networks)
- Data augmentation and fine-tuning
- Multi-resolution approach

Advantages:

- Better interpretability
- Better uncertainty estimation
- No "fixed grid" output

Difficulties:

- How to introduce site effects?
- How to address poorly instrumented regions?
- Computational power…

Thanks for your attention!

Questions?

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