<QuakeML>

Recent Developments,
First Applications,
Future Prospects

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EQ Catalog Formats

— many existing formats

— all have common elements, but differ in details (are specialized)

— need a format that allows to merge common features, has enough flexibility to account for individual peculiarities

— must be extensible

— XML

```
9172296 le 2001/01/01,00:07:48.800    34.2810    -118.4500  17.71  1.20  h 0.8
CI      HLL HHZ --     34.1764  -118.3597   193.0 P .. e  0.4   14.27    3.581
CI      OAT EHZ --     34.3436  -118.6144  1089.0 P .. e  0.6   16.62    4.200
CI      DJJ HHZ --     34.1062  -118.4550   268.0 P .. e  0.6   19.43    3.959
```

```
$loc 19990101000043.1000 46.33000-112.11400  6.3000H MB     9 93    36.2000 0.1600
0.800099.9000L                    $mag  1.50c MB
$loc 19990101000452.1670 32.81700-116.15500  6.0000H CI    10            0.1760         0.0000
0.0000L 19990101      9074802 $magP 1.871 CI            19990101      9074802 $add$loc
9074802      9074802
$loc 19990101003922.2000 36.82367-121.41566  2.5500H NC    26 42    4.0000 0.3100         0.4300
1.5600L 20070223          $magP 1.42d NC    20 0.19    20070223          $add$loc  26   0
22316 0    0.3700226 4    0.4300 4385    1.5700            30211867
```

```
5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5
PDE   2005/01/01 01:20:05.4   13.78   -88.78 193.1 5.0 0.0 EL SALVADOR
C200501010120A    B:  4     4  40 S: 27    33  50 M:  0     0    0 CMT: 1 TRIHD:  0.6
CENTROID:       -0.3 0.9   13.76 0.06   -89.08 0.09 162.8 12.5 FREE S-20050322125201
23   0.838 0.201 -0.005 0.231 -0.833 0.270   1.050 0.121 -0.369 0.161   0.044 0.240
V10    1.581 56   12   -0.537 23 140   -1.044 24 241    1.312    9 29   142 133 72    66
PDE   2005/01/01 01:42:24.9    7.29    93.92   30.0 5.1 0.0 NICOBAR ISLANDS, INDIA R
C200501010142A    B: 17    27  40 S: 41    58  50 M:  0     0    0 CMT: 1 TRIHD:  0.7
CENTROID:       -1.1 0.8    7.24 0.04    93.96 0.04  12.0   0.0 BDY  S-20050322125628
23  -1.310 0.212   2.320 0.166 -1.010 0.241   0.013 0.535 -2.570 0.668   1.780 0.151
V10    3.376 16 149    0.611 43   44   -3.987 43 254    3.681 282 48   -23   28 73 -136
```

Why XML?

— Character-based, thus (hopefully) future-proof

— Machine- and Human-readable

— Semantics can be coded in <tag> names

— Tree-like structure, maps hierarchy of elements

— Many open-source processing tools exist

— Extensible; local extensions do not break standard

— Ubiquitous in modern information technology, e.g., Web Services, RSS feeds, …

QuakeML Elements

Earthquake catalog
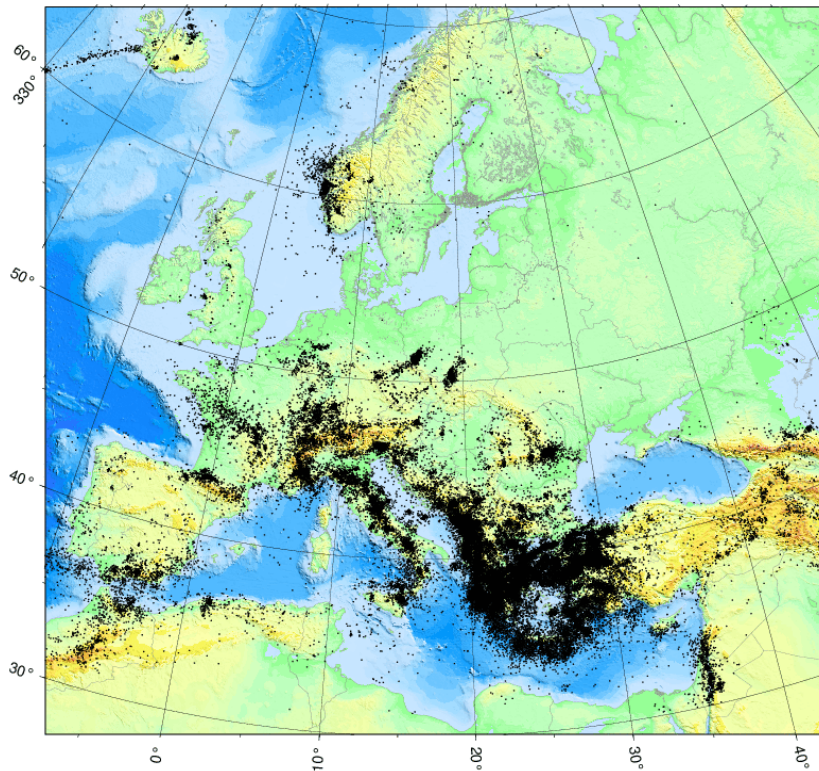
QuakeML 1.0 provides basic event description:

— Event
— Origin
— Pick
— Arrival
— Magnitude
— Amplitude
— Focal Mechanism
— Moment Tensor

Community Aspects / Timeline

2002 — First QuakeML experiments started

Fall 2006 — Collaborative development initiated (ETH & GFZ)

Early 2007:
- European meeting on XML formats (Paris, Jan 2007)
- Input from wider community:
    USGS, IRIS, EMSC, ORFEUS, ISTI
- Inclusion of focal mechanism & moment tensor
- Public web site & internal Wiki on-line

December 2007 — Proposed Recommendation
www.quakeml.org/Documents
Request for Comments process started

Now — Public Wiki, www.quakeml.org

Summer 2008 — next QuakeML release, including suggestions from RFC

QuakeML Schema

## UML class diagram of QuakeML:
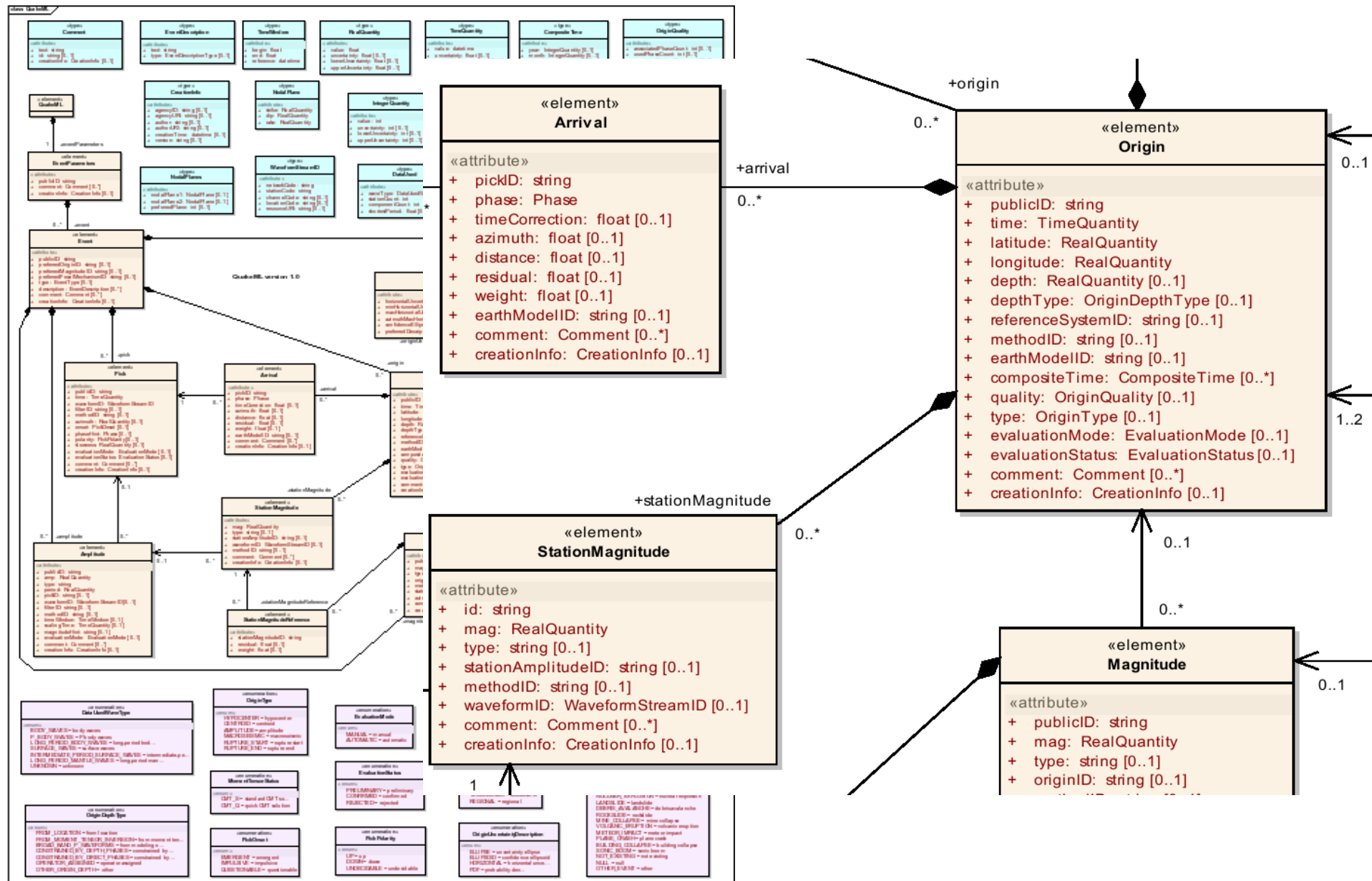
QuakeML / XML Representation

+origin

0..*

«element»
Origin

0..1

«attribute»
+   publicID: string
+   time: TimeQuantity
+   latitude: RealQuantity
+   longitude: RealQuantity
+   depth: RealQuantity [0..1]
+   depthType: OriginDepthType [0..1]
+   referenceSystemID: string [0..1]
+   methodID: string [0..1]
+   earthModelID: string [0..1]
+   compositeTime: CompositeTime [0..*]
+   quality: OriginQuality [0..1]
+   type: OriginType [0..1]
+   evaluationMode: EvaluationMode [0..1]
+   evaluationStatus: EvaluationStatus [0..1]
+   comment: Comment [0..*]
+   creationInfo: CreationInfo [0..1]

1..2

0..1

```
<origin publicID="smi:local/origin">
    <time>
        <value>2008-04-03T05:07:23Z</value>
    </time>
    <latitude>
        <value>44.368</value>
    </latitude>
    <longitude>
        <value>10.297</value>
    </longitude>
    <depth>
        <value>8.0</value>
    </depth>
    <depthType>from moment tensor inversion</depthType>
</origin>
```
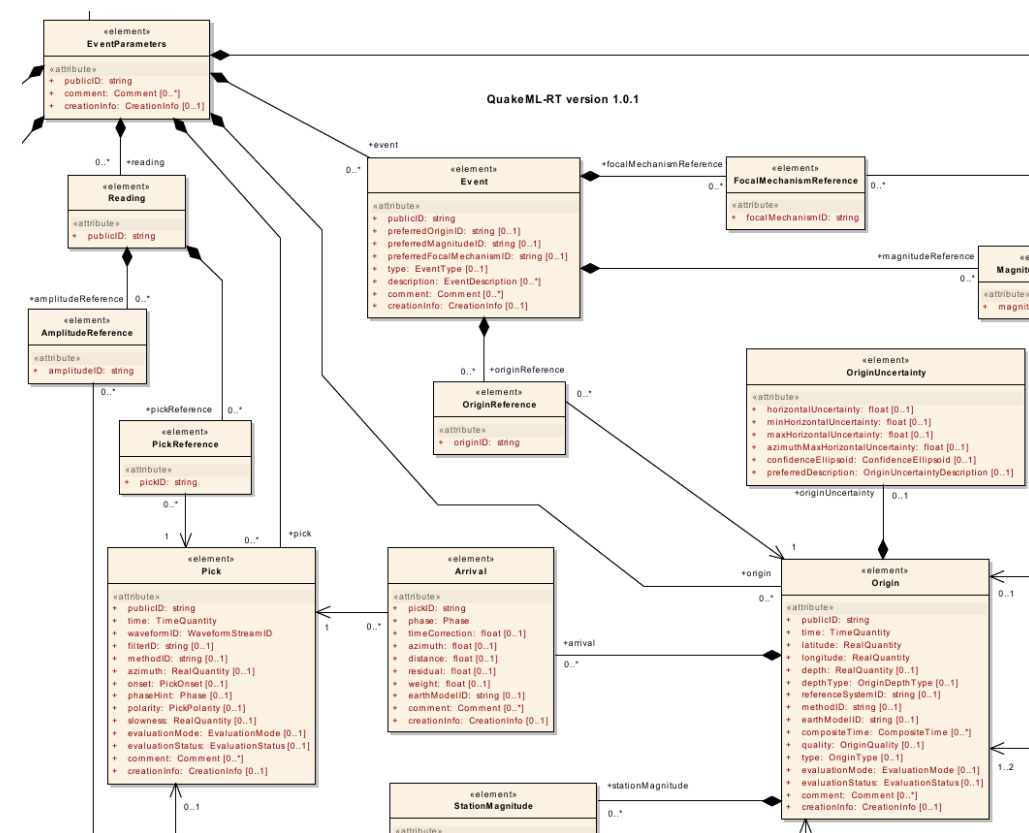
QuakeML / QuakeML-RT

— QuakeML   Earthquake catalogs (hierarchical)

— QuakeML-RT   Flat, uses references
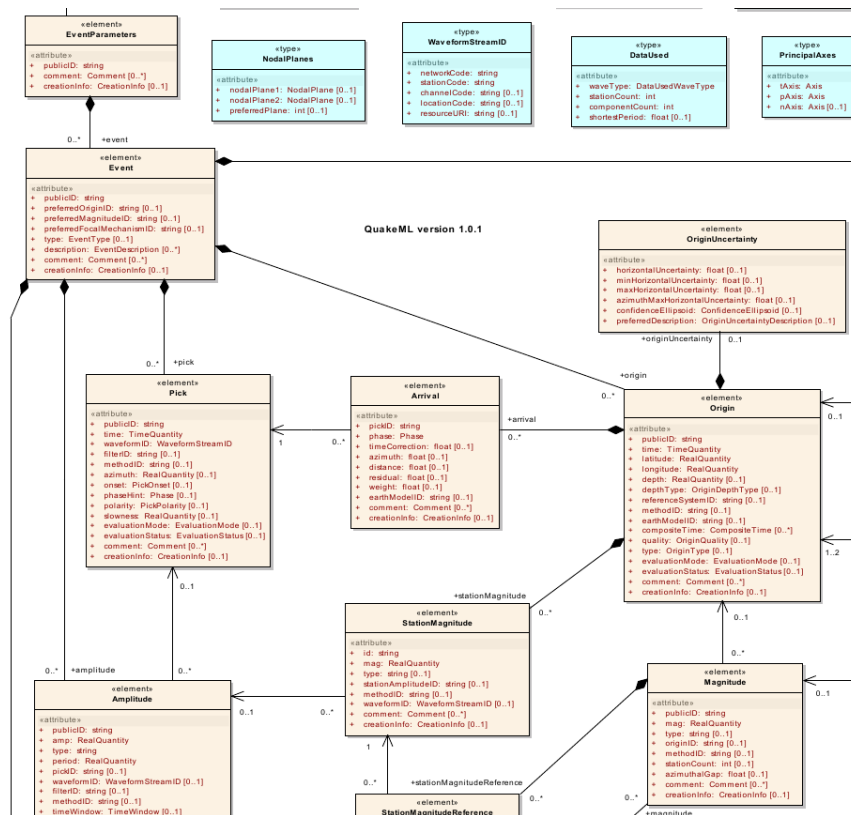
QuakeML Applications

In operation:

— EQ Catalog Web Service, GNS Science, New Zealand

— EQ Catalog Web Service, EMSC (prototype)

— Data exchange EMSC ↔ ORFEUS, via QWIDS

— SeisComP3, based on QuakeML (RT) data model

Under development:

— Integration of QuakeML in CSEP (Collaboratory for the Study of Earthquake Predictability) test center, SCEC, www.cseptesting.org

— QuakePy (Python package), ETH & SCEC/USC

Planned:

— QuakeML distribution of regional moment tensors (ETH)

— SCSN EQ catalog distribution

— ANSS & Sub-Networks will provide QuakeML data within the next year (D. Oppenheimer)

— Implementation at NEIC under way (R. Buland)

NERIES (EU) project recommends QuakeML as preferred data exchange format

QuakePy

- Object-oriented Python toolkit for seismicity analysis
- Based on QuakeML data model
- www.quakepy.org (public Wiki)
- get code from SVN repository:

  https://quake.ethz.ch/svn/quakepy
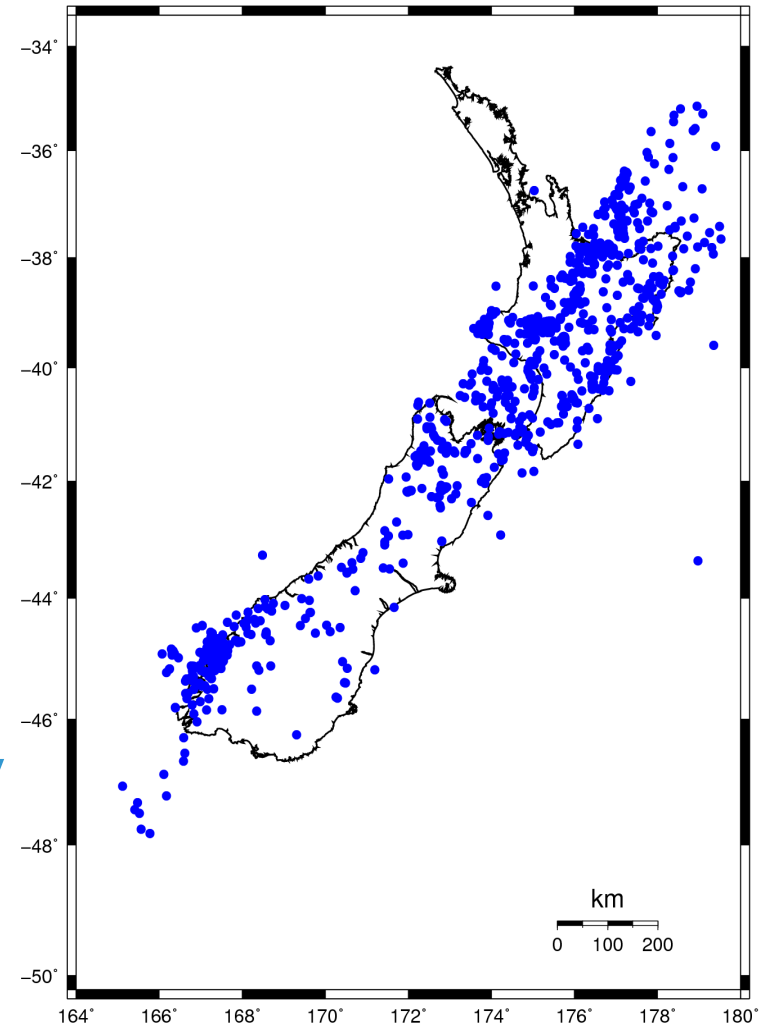

```
fab@desdemona:~/prog/pyprog/quakepy> python
>>> cat = QPCatalog('http://magma.geonet.org.nz/services/quake/search?
    startDate=2007-10-10&endDate=2007-12-13')
>>> plot = QPSeismicityPlot().plot_gmt(cat,'nz-seismicity.eps')
```

QuakePy/Catalog Import

— QuakeML   read/write

— Global CMT (ndk)   read/write

— 'ZMAP'   read/write

— SCSN 'stp phase'   read

planned:

— ANSS (will be used in CSEP, for testing region California)

— GSE2.0 (will be used in CSEP/EU, for testing region Italy)

QuakePy / Completeness

```
<QPGrid>
 <grid>
  <depthLayer at="7.5">
   <cell lat="34.9" lon="-121.9">
    <PMCData>
     <probability magnitude="1.7">0.001</probability>
     <probability magnitude="1.8">0.002</probability>
     <probability magnitude="1.9">0.002</p
     <probability magnitude="2.0">0.003</p
     <mp probability="0.9">3.4</mp>
     <mp probability="0.95">3.4</mp>
     <mp probability="0.99">3.5</mp>
     <mp probability="0.999">3.6</mp>
    </PMCData>
   </cell>
   ...
  </depthLayer>
 </grid>
</QPGrid>
```

— First results for SCSN network shown at completeness.usc.edu/service

— First large-scale application in QuakePy: Network recording completeness

— use PMC method (probability-based magnitude of completeness, Schorlemmer & Wössner 2008, http://completeness.usc.edu)
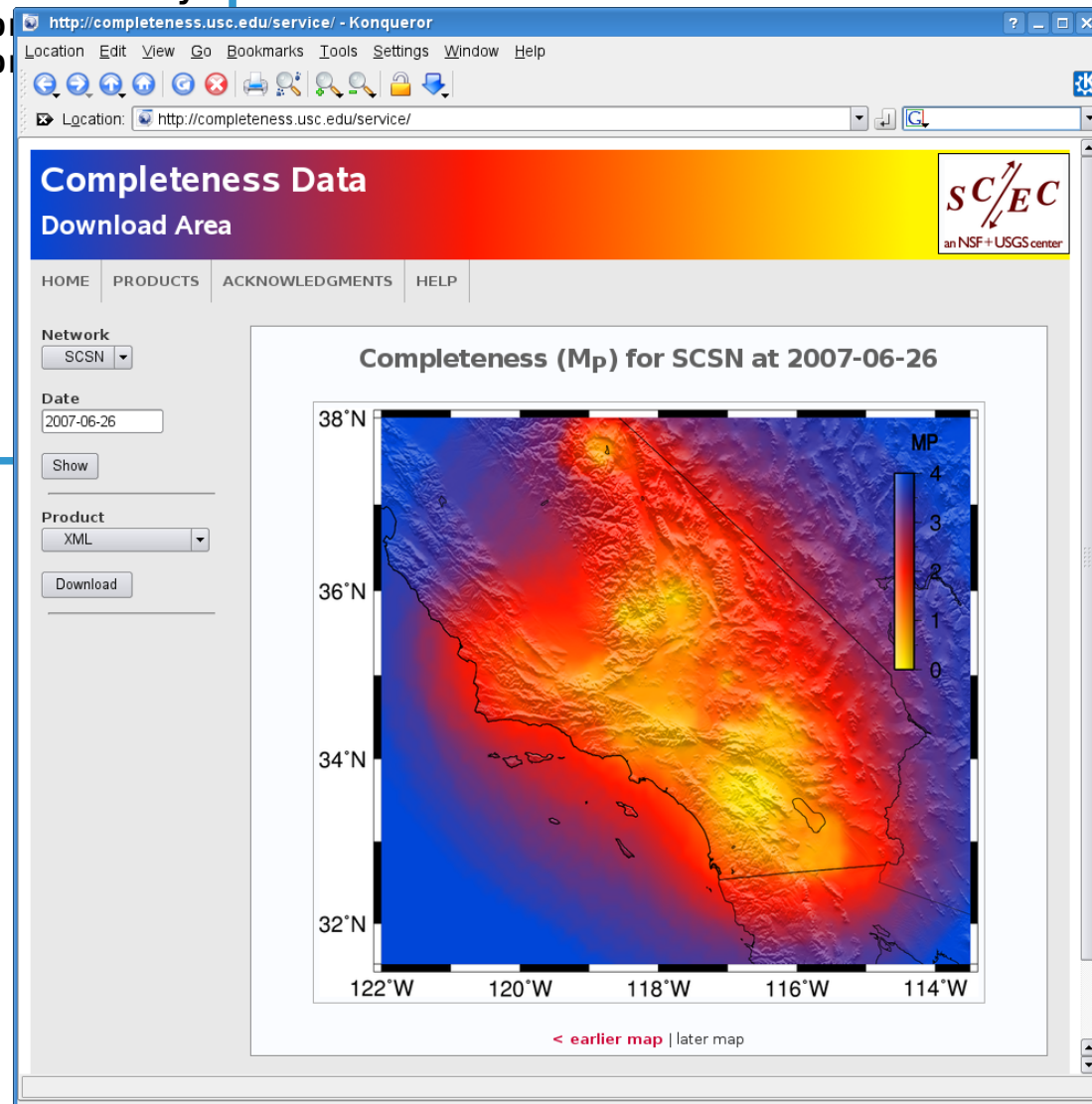
Outlook / Further Development

— QuakePy (ETH Zurich & SCEC/USC)

— Include macroseismic event description (ETH Zurich)

— Seismic Inventory (ETH & GFZ Potsdam)
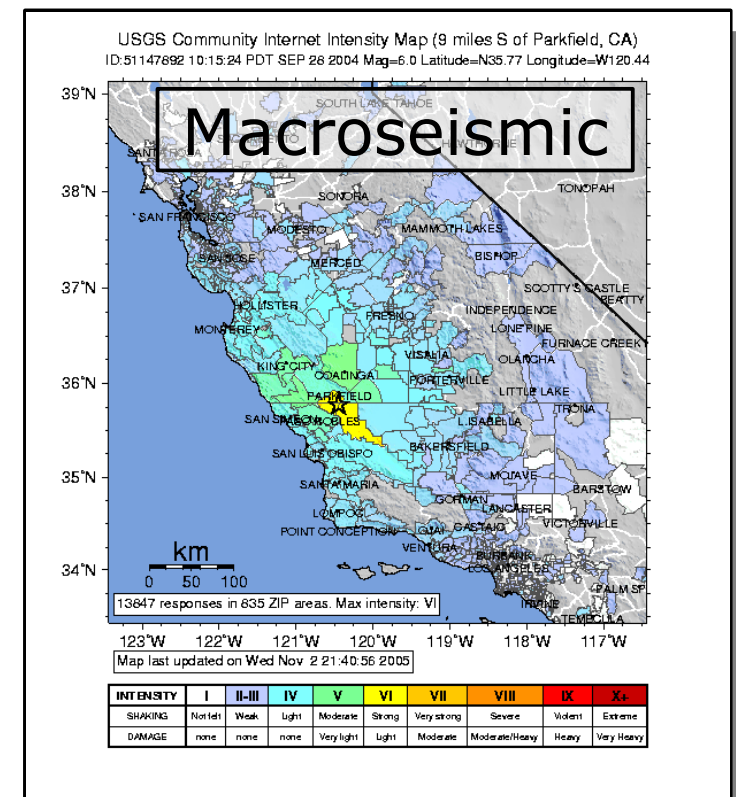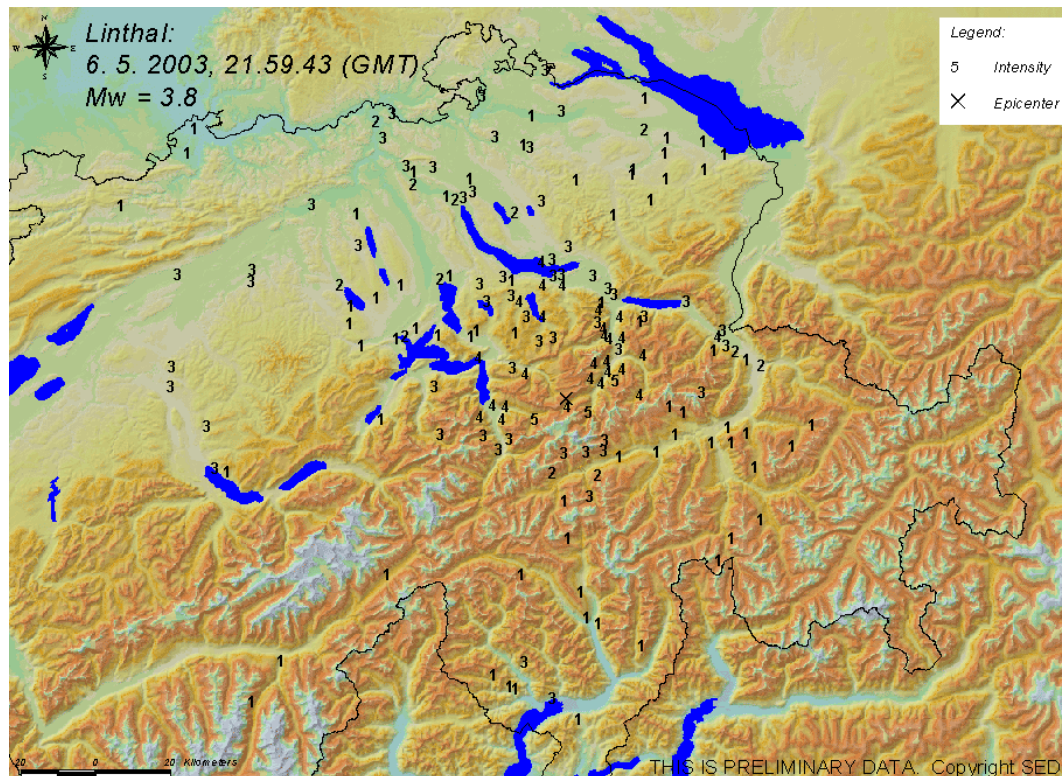
Contact the QuakeML Group

— Visit our websites

http://www.quakeml.org

http://www.quakepy.org

— Write us

quakeml@sed.ethz.ch

— for participating in the request for comments process: Send us your email-address and you will receive the RFC documents

— for questions

— for suggestions