Identifying active faults in Switzerland using relocated earthquake catalogs and optimal anisotropic dynamic clustering

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Identifying active faults in Switzerland using relocated earthquake catalogs and optimal anisotropic dynamic clustering

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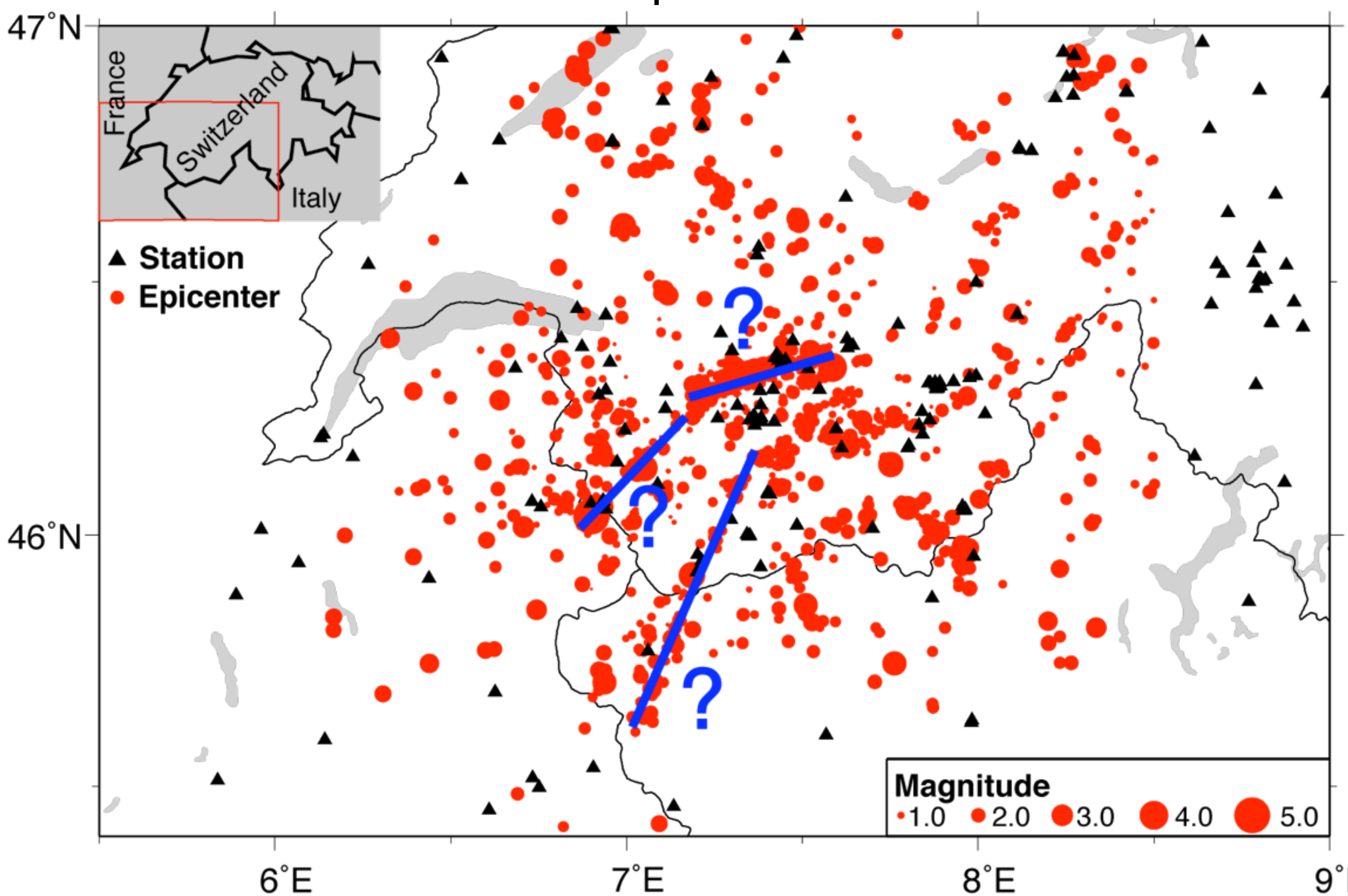
Motivation

General interest: Linking faults and earthquakes
→ e.g. for hazard assessment

Not quantitative!

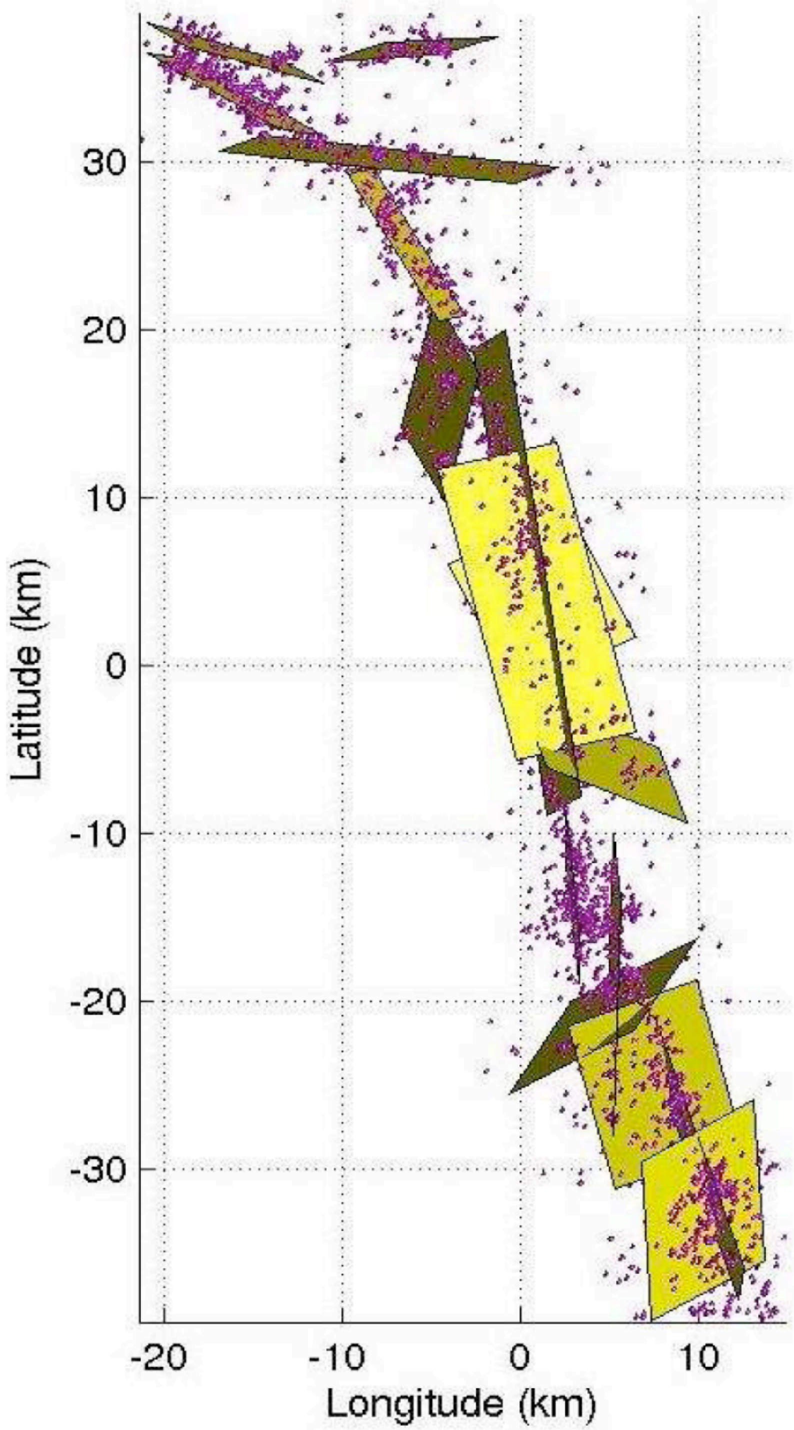
Earthquakes from 01/2001 - 09/2010



Motivation (cont.)

3D optimal anisotropic dynamic clustering (OADC) method (Ouillon et al., 2008)

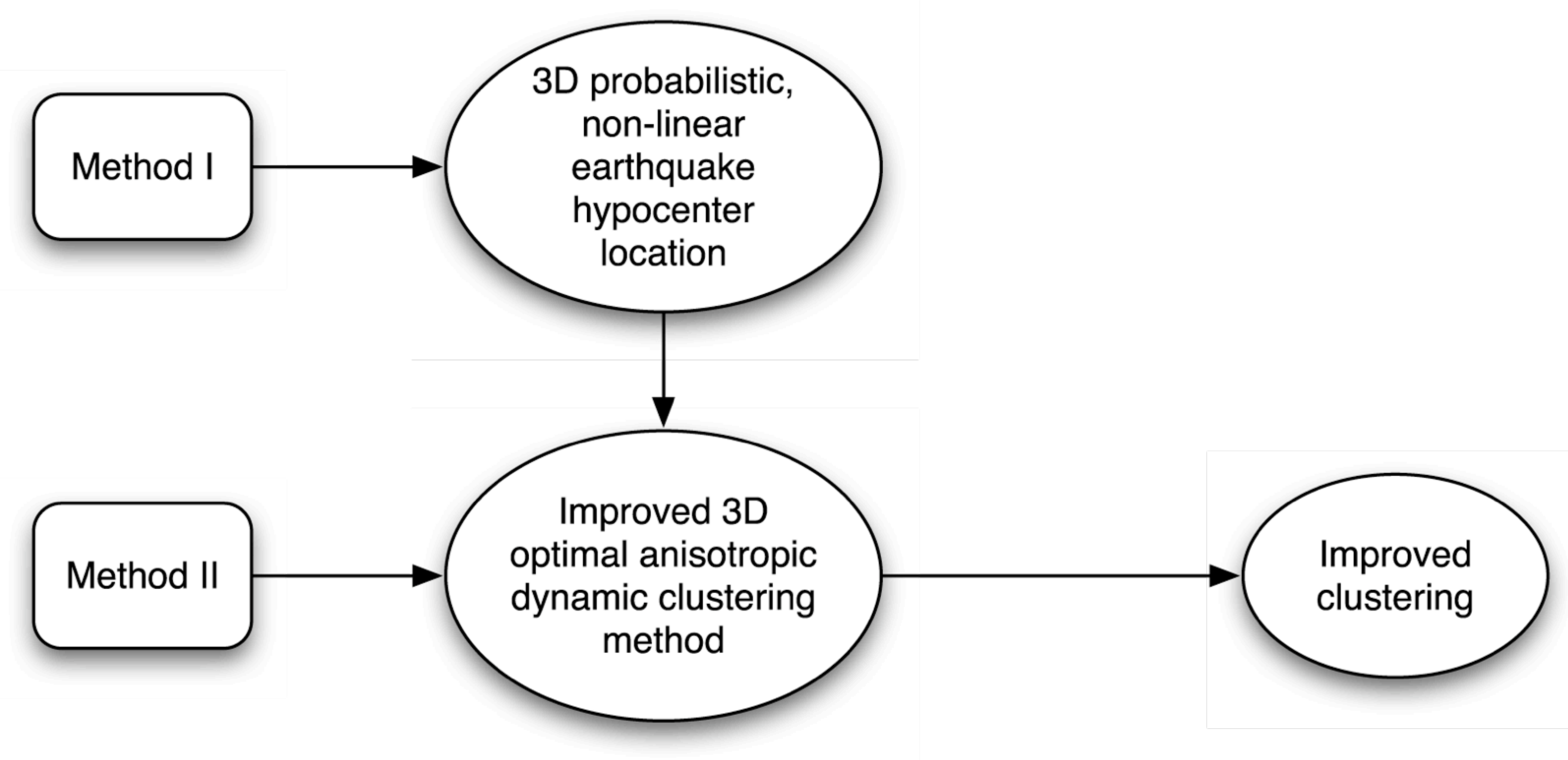
- 1992 Landers, California, aftershock sequence
- Method is able to reconstruct planar structures (faults) from seismicity
- Limitations!
  → Single point for hypocenter location
  → Stopping criterion based on a priori, isotropic location uncertainties of earthquakes



Ouillon et al., 2008

Motivation (cont.)

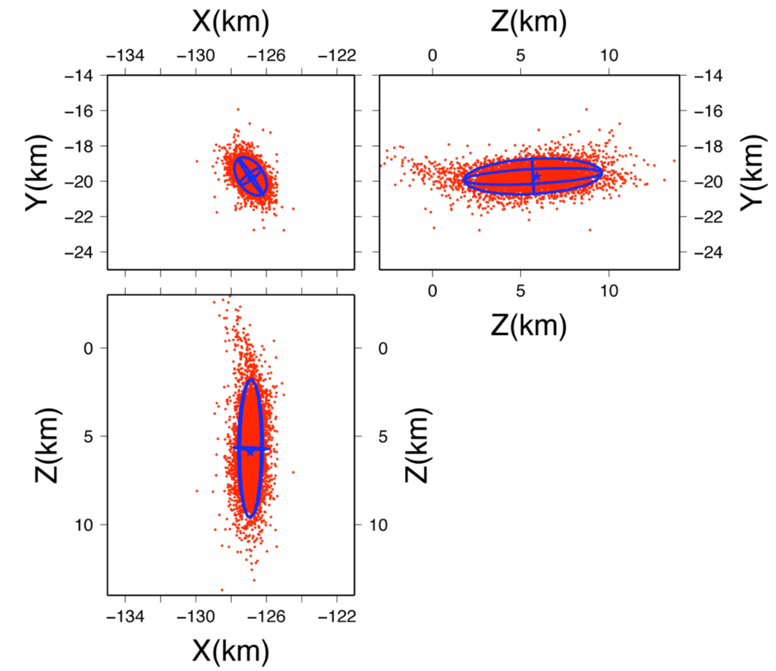
Approach used in this study



Method I

3D probabilistic, non-linear earthquake hypocenter location

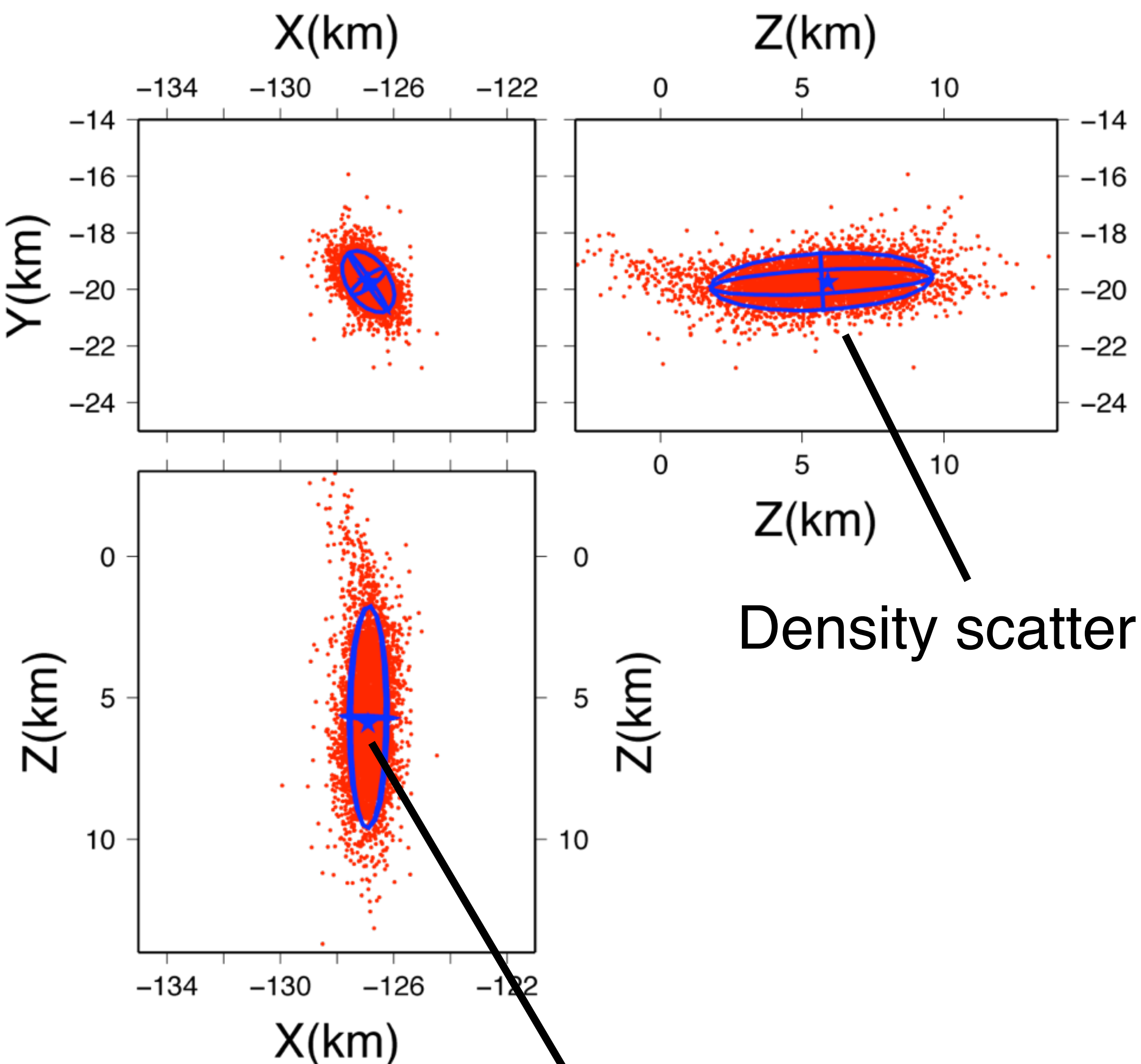
- Posteriori probability density function (PDF): Representation of the probabilistic solution to the location problem, including complete information on uncertainties (Tarantola and Valette, 1982)
- Probabilistic, non-linear, global-search earthquake location in 3D media (NonLinLoc, A. Lomax, http://alomax.free.fr/nlloc/)
- Oct-tree importance sampling algorithm to compute PDF in 3D



Method I (cont.)

Two example PDFs

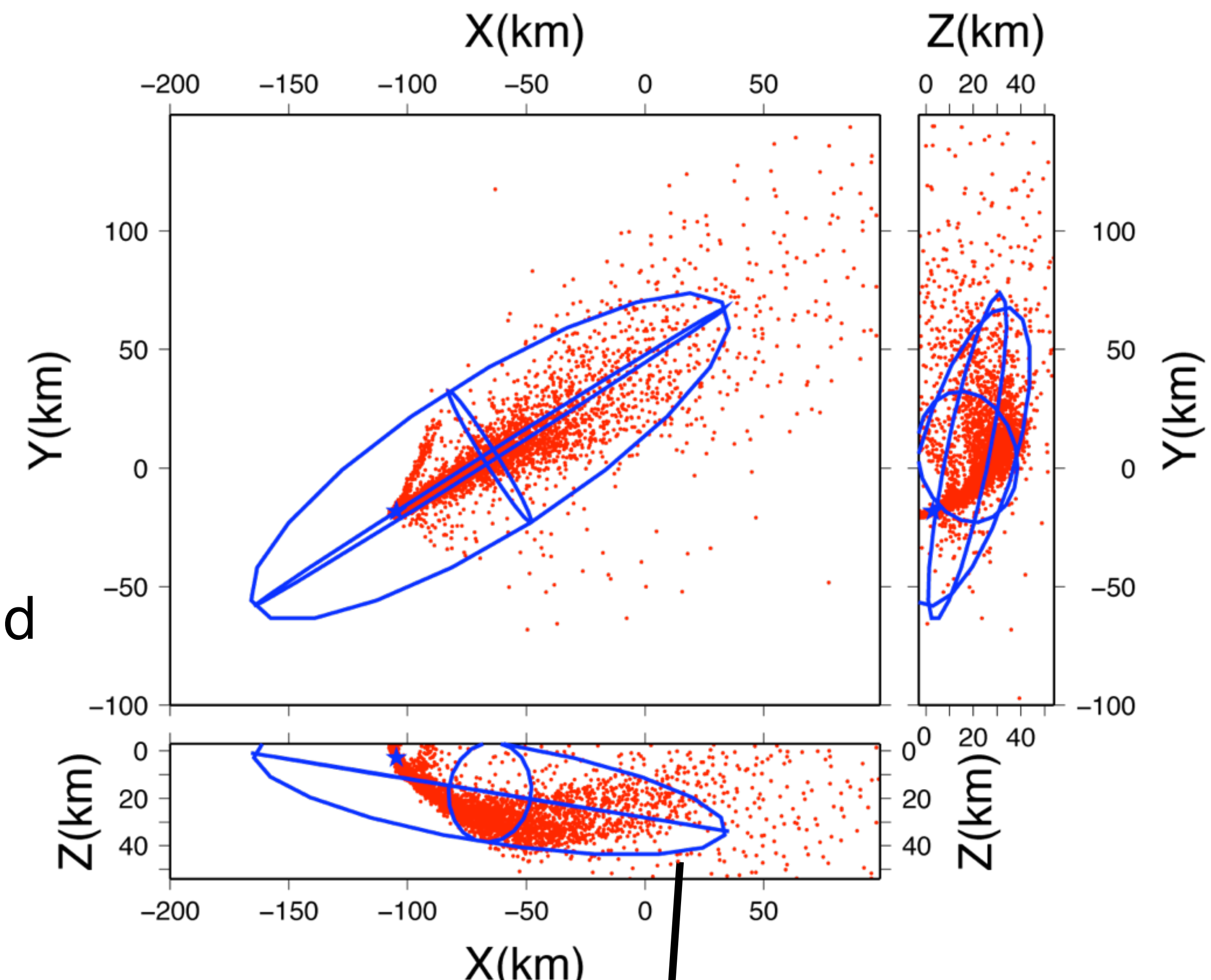
Nphs: 8, Gap: 69°, Dist: 5.9 km



Density scatter cloud

Maximum likelihood location (star)

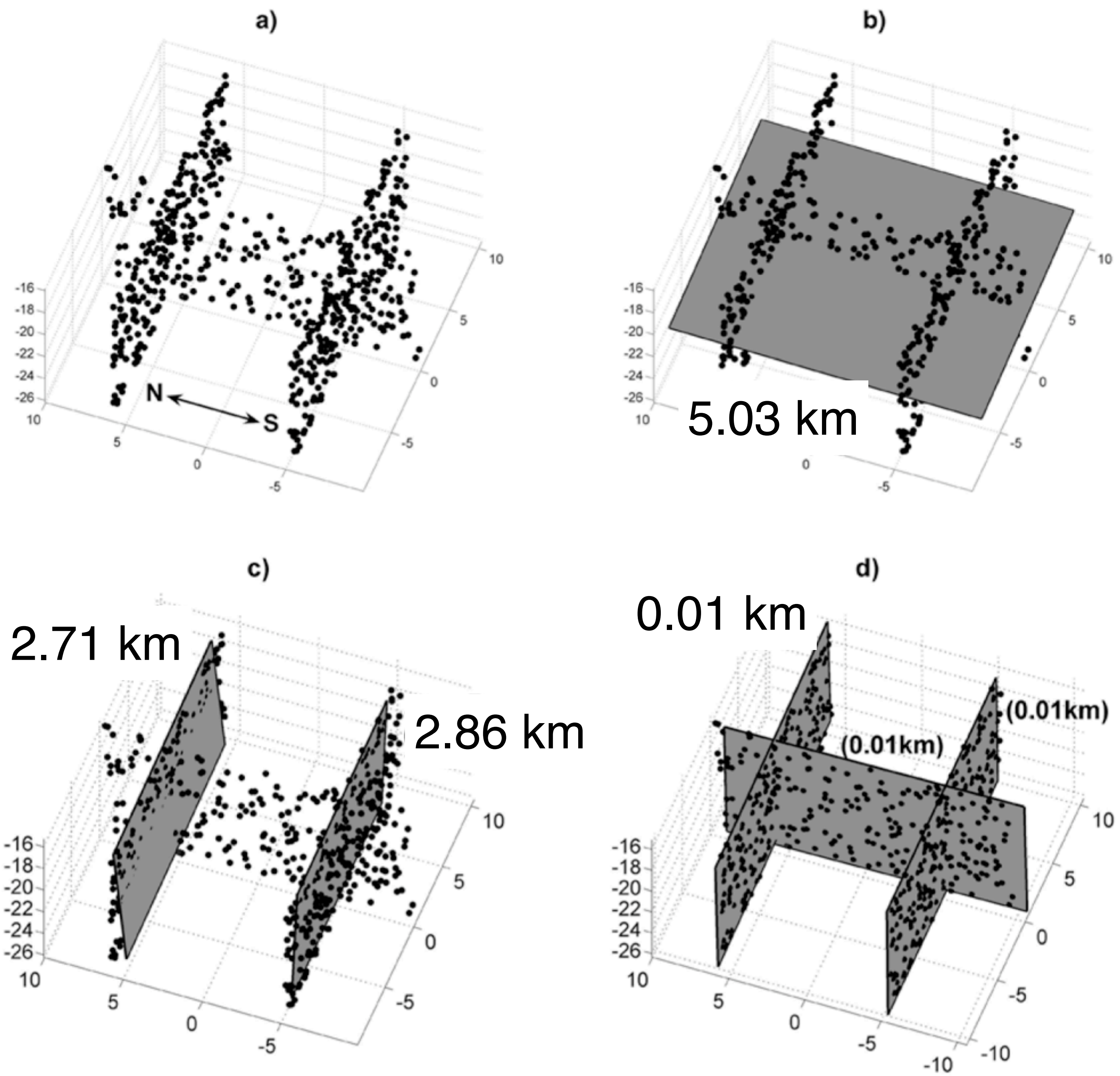
Nphs: 6, Gap: 135°, Dist: 4.4 km



68% confidence ellipsoid

Method II

Traditional OADC method

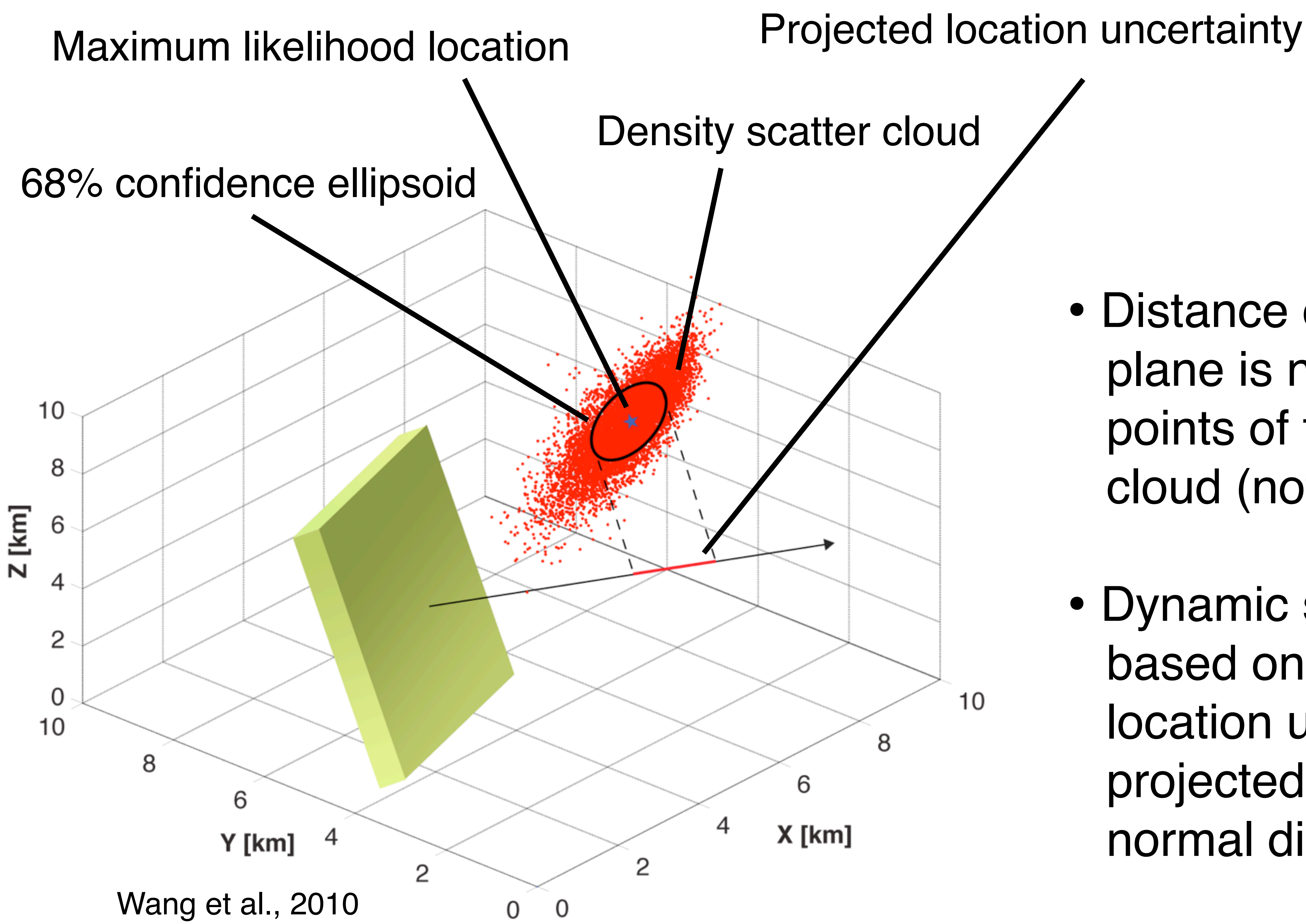


Ouillon et al., 2008

- Based on k means clustering
- Assignment of earthquakes (single points) to planes by their distance
- Clustering stops when thickness of plane is smaller than a priori, isotropic location uncertainties of earthquakes

Method II (cont.)

Improved OADC method



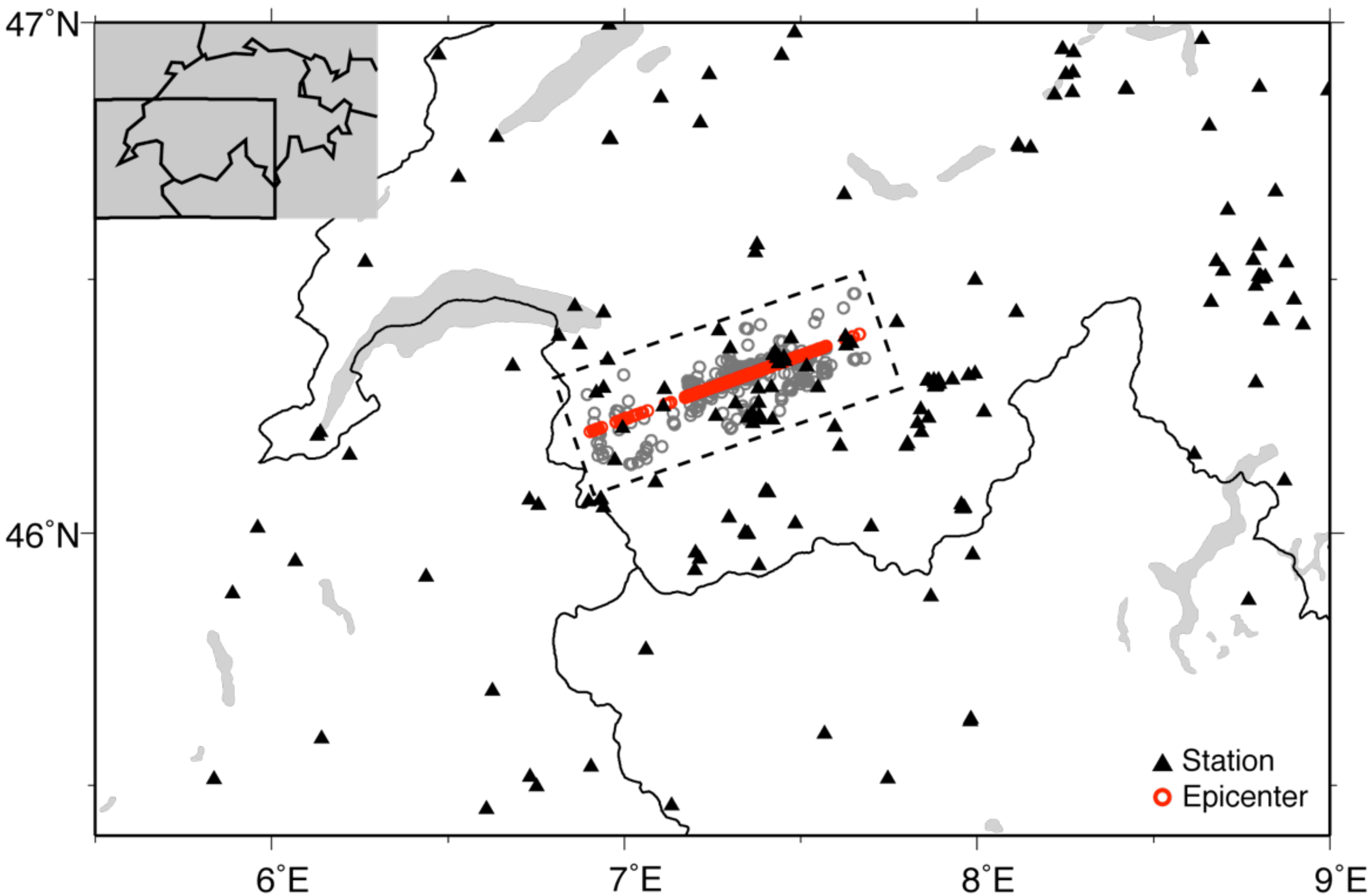
Wang et al., 2010

- Distance of earthquake to plane is now based on points of the density scatter cloud (not just single point)
- Dynamic stopping criteria based on individual location uncertainties projected onto plane normal direction

Results

Synthetic test with a real station geometry

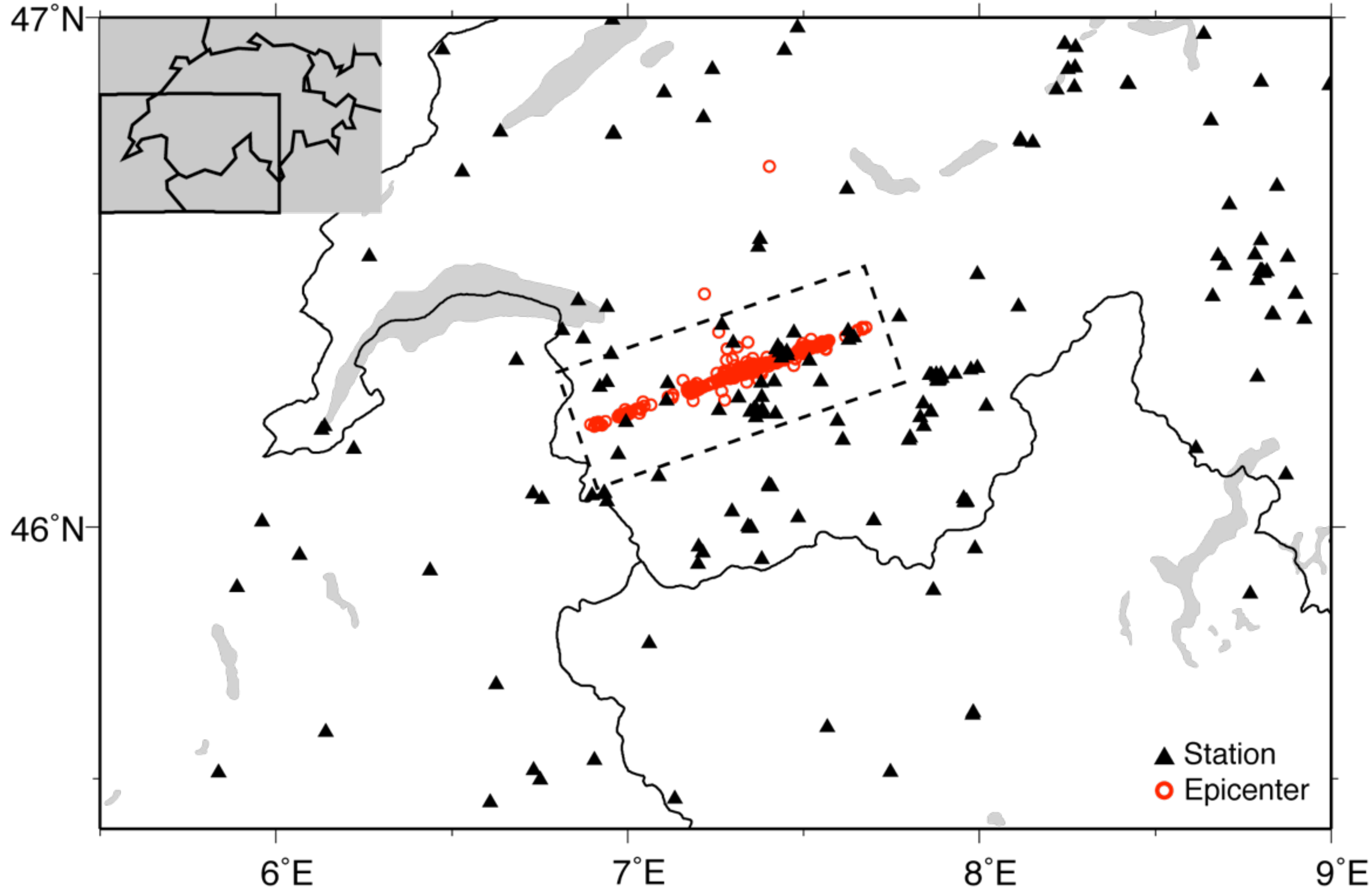
- Projection of events on one vertical fault plane
- Calculation of synthetic travel times including Gaussian noise



Results (cont.)

Synthetic test with a real station geometry

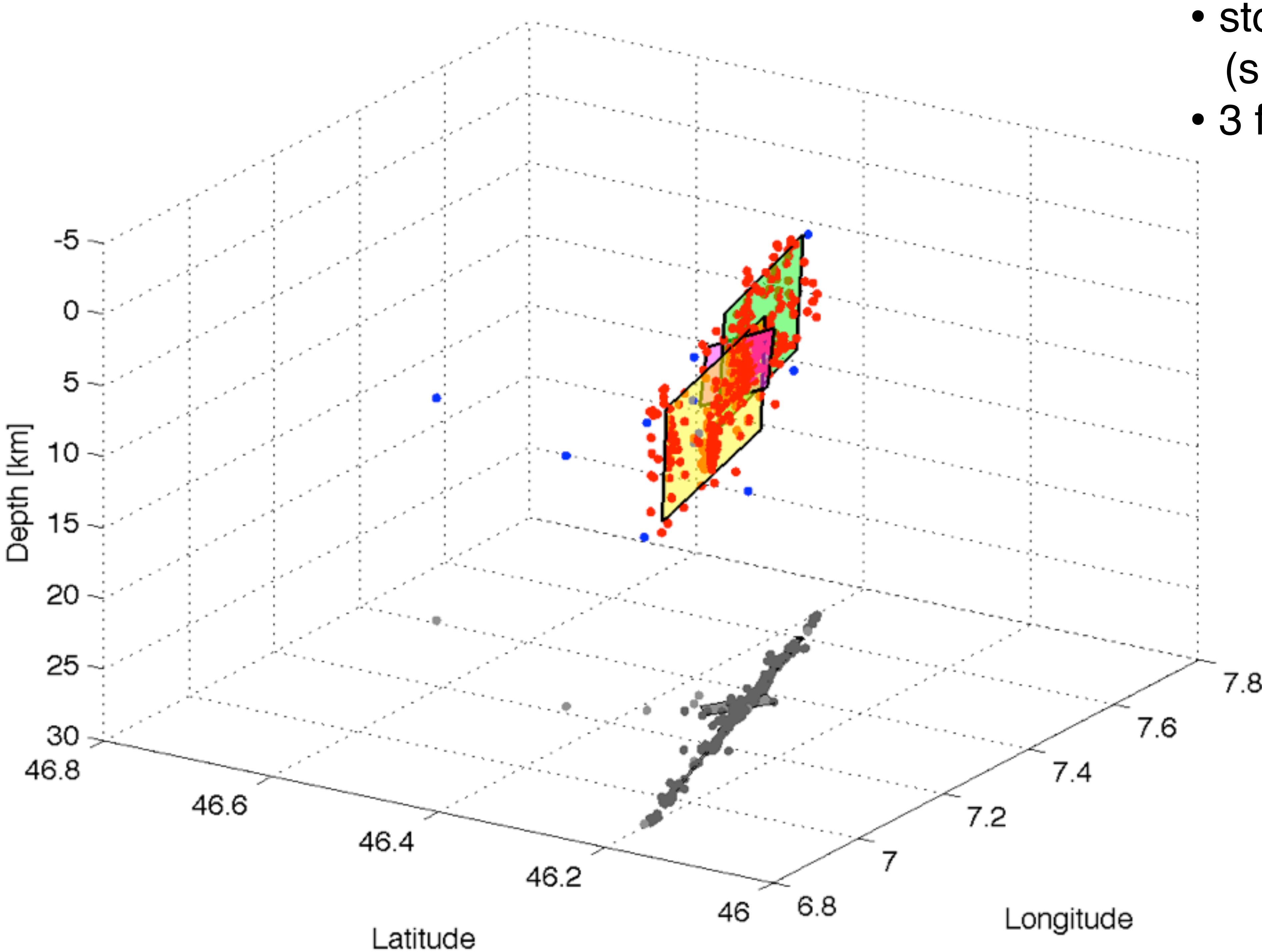
- Relocation of events using the same velocity model (3D)



Results (cont.)

Traditional OADC

- stopping criterion: 0.50 km (smaller than real error)
- 3 fault planes (instead of 1)

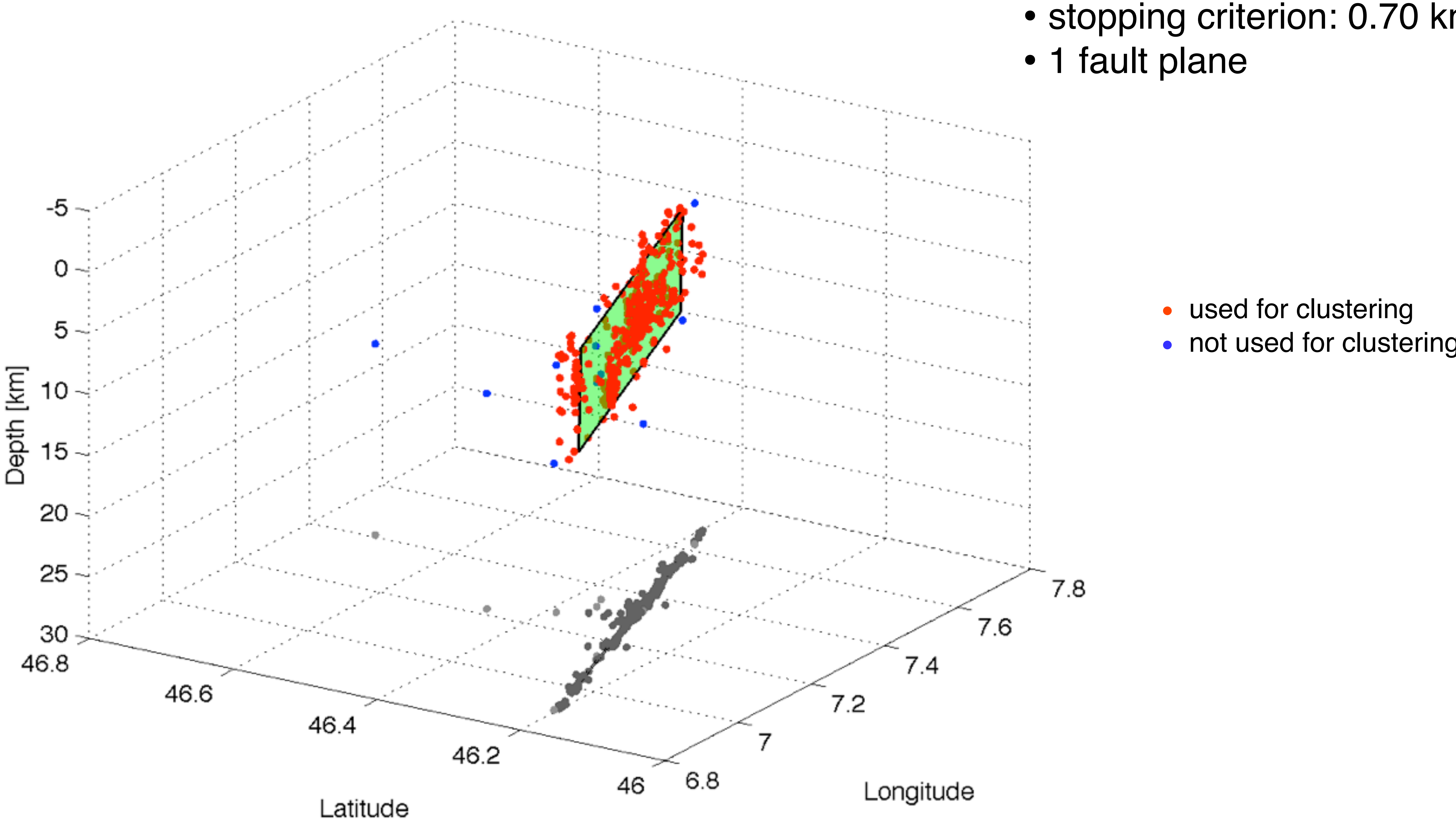


- used for clustering
- not used for clustering

Results (cont.)

Traditional OADC

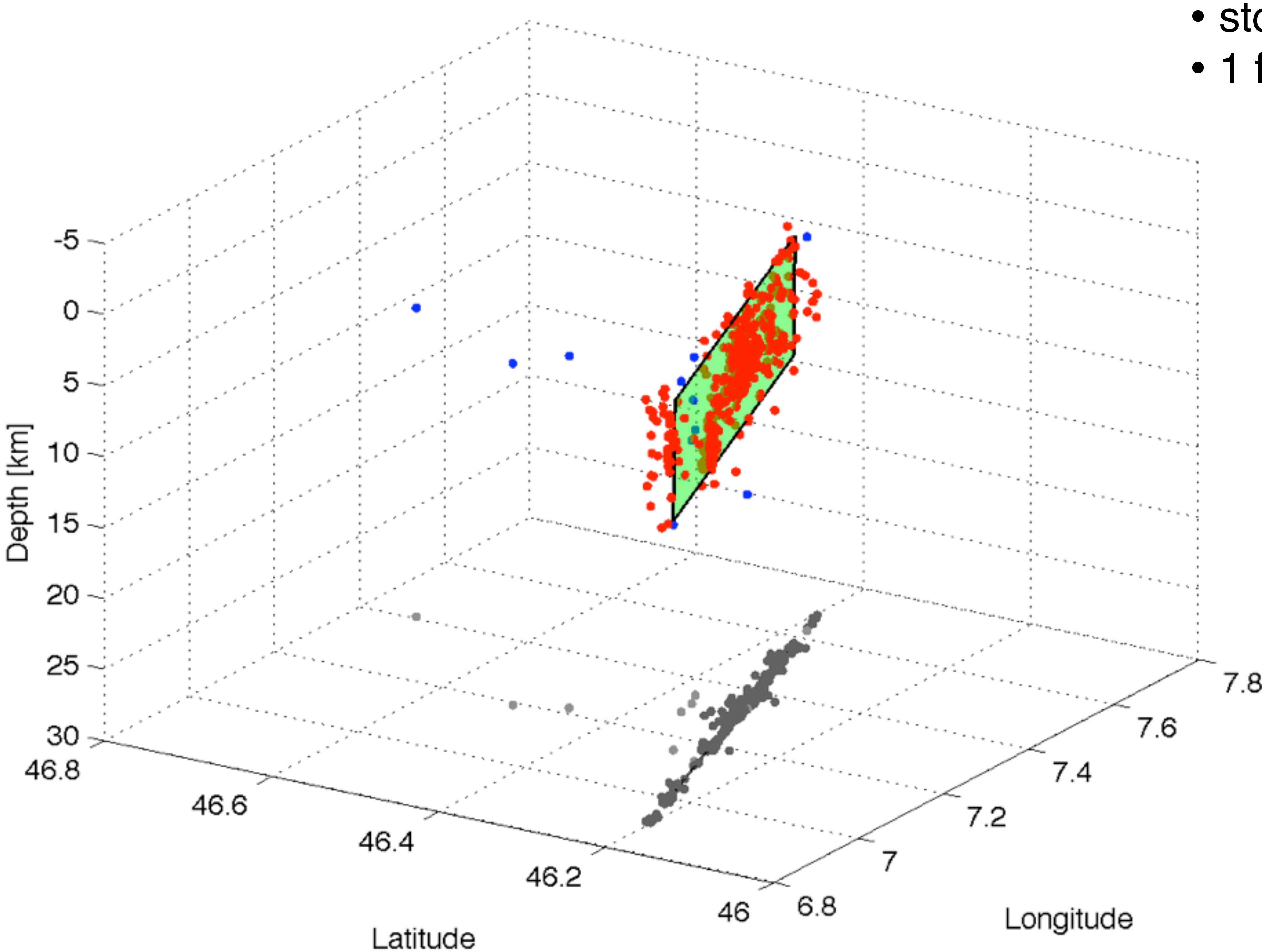
- stopping criterion: 0.70 km
- 1 fault plane



Results (cont.)

Improved OADC

- stopping criterion: 0.68 km
- 1 fault plane



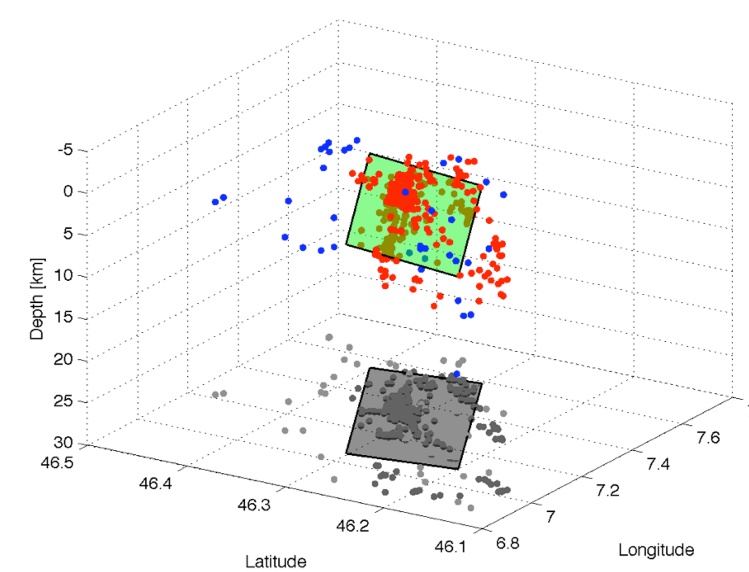
- used for clustering
- not used for clustering

Conclusions

- The traditional OADC method was improved by including location uncertainties
- Clustering results are sensitive to location uncertainties
- Clustering is not meaningful without information on realistic location uncertainties
- 3D probabilistic, non-linear earthquake hypocenter location yields the required location uncertainties (PDF) as needed for clustering

Outlook

- Parameter studies of the improved OADC method with synthetic data
- Application of the method to real data in Switzerland
- Interpretation of the results including information from other geophysical methods (seismotectonics, ...)



Thank you!