Enhancements for Regional Events in NET-VISA v 2.3.6

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Contents

- Mini-overview of NET-VISA and reasons for missed events
- The problem and resolution for regional events
- Experimental results
- Re-evaluation of results from NDCs

Mini-overview of NET-VISA

- Generative Model
  - Probabilistic model that predicts the (mis)detections at all stations and arrival parameters
  - Includes a model of noise arrivals at stations plus coda arrivals from larger events
- Inference uses the model to determine which events are real
  - The probability of a set of arrivals being explained by an event versus the same arrivals explained by noise or coda.
  - Proposal phase generates candidate events
  - Merge phase merges candidates with events from overlapping intervals, also refines the events.

Regional events

- Built **primarily** with detections at stations less than 20 degrees away
- Typical phases -- Pn, Pg, Sn, Lg
- Body-wave magnitude (m_b) is not computed for these events.

Number of LEB events in 2013
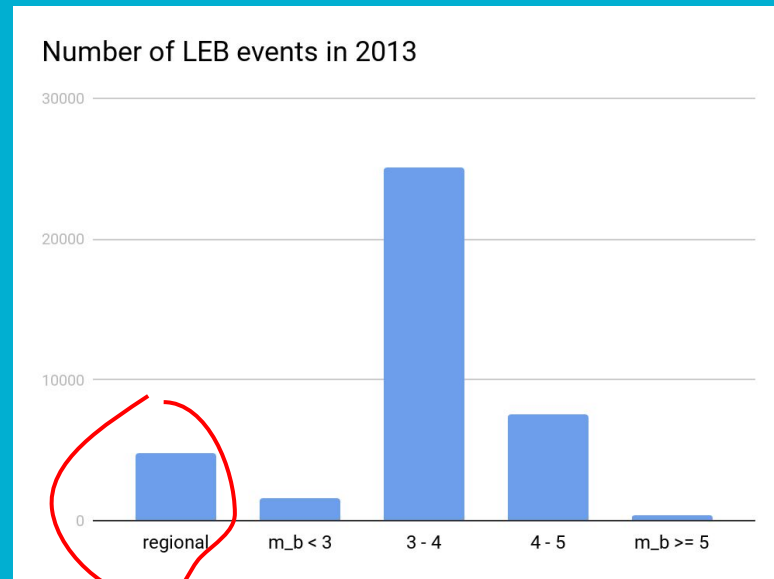
~ 10%

Three reasons why an event may not be built

—

1. The model assigns a higher probability to the associated arrivals as noise/coda rather than from the event.
   - Debugging this problem is rather easy. We simply compute theses probabilities (or the log of their ratio) for any missed event.
2. The model doesn't propose a candidate event close enough to a true event.
   - This is more of a computation cost issue.
3. The arrivals from an event are not automatically detected by DFX.
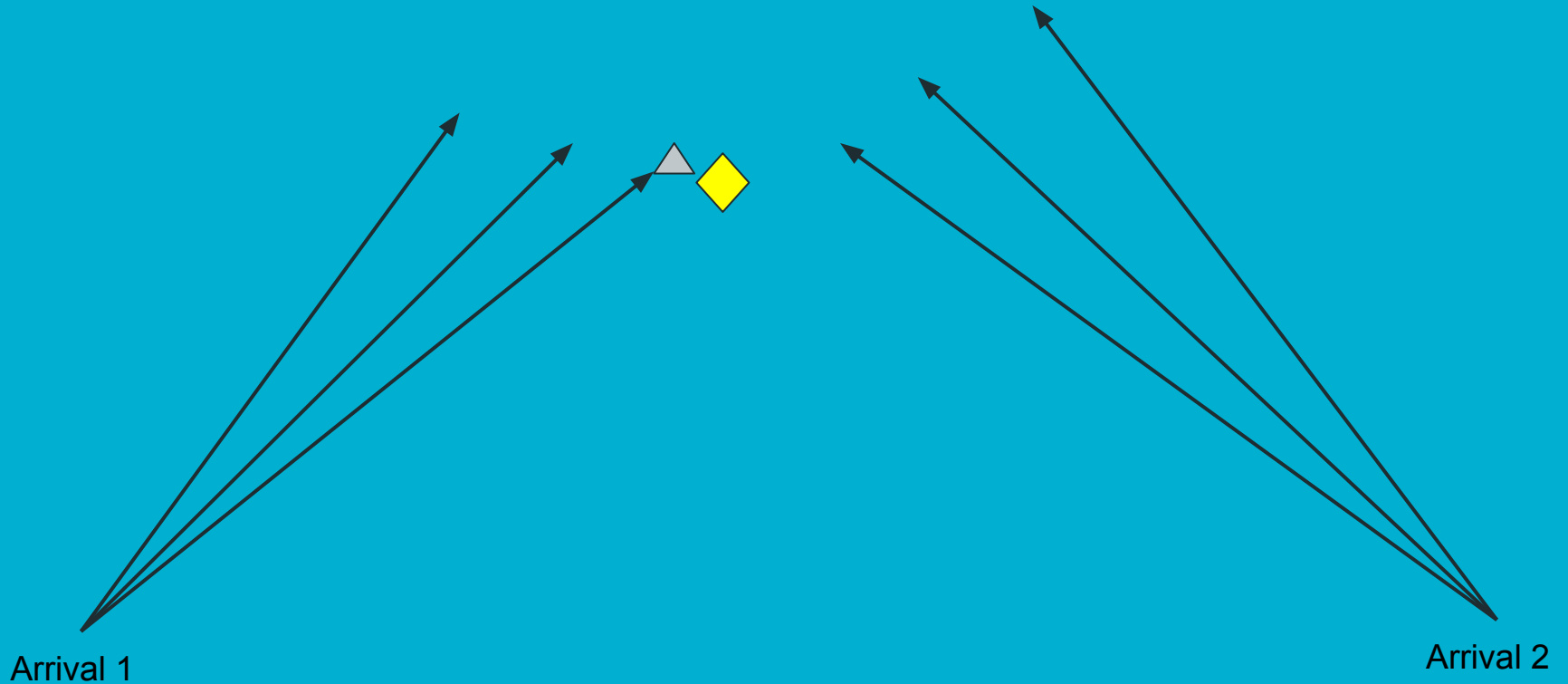   - NOTE: This is beyond the scope of NET-VISA, currently.

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    - Debugging this problem is rather easy. We simply compute theses probabilities (or the log of their ratio) for any missed event.
2. The model doesn't propose a candidate event close enough to a true event.
    - This is more of a computation cost issue. -> Main problem with missed regional events!
3. The arrivals from an event are not automatically detected by DFX.
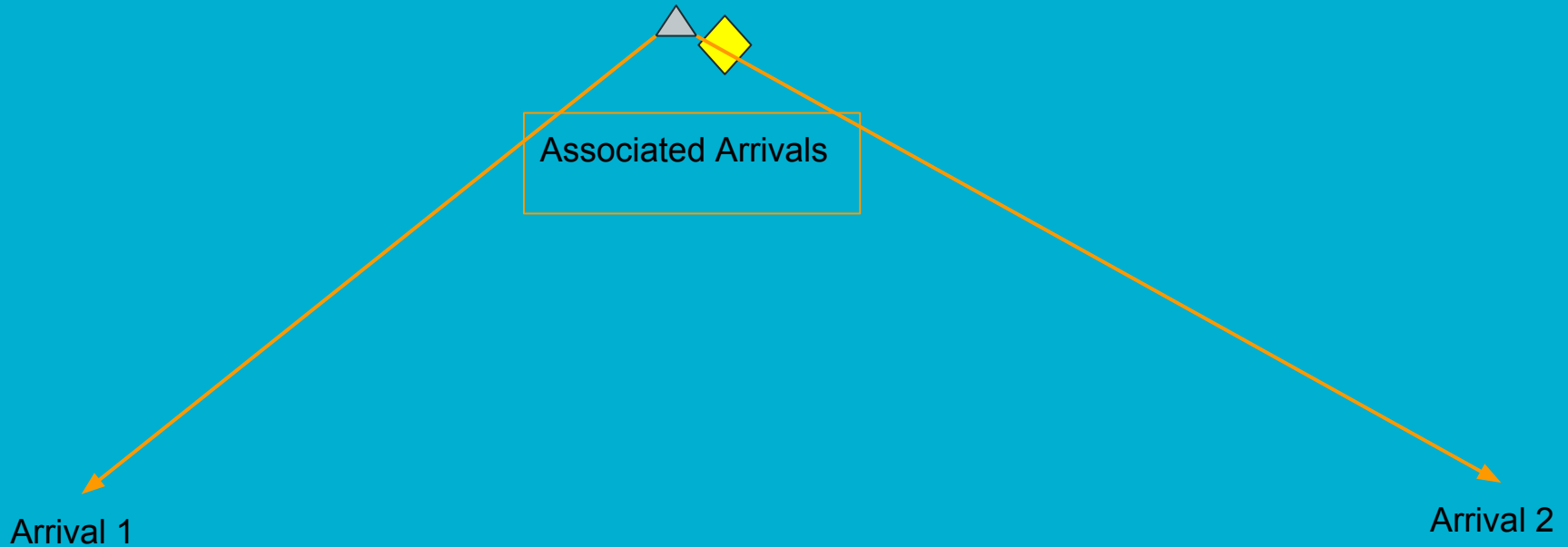   - NOTE: This is beyond the scope of NET-VISA, currently.
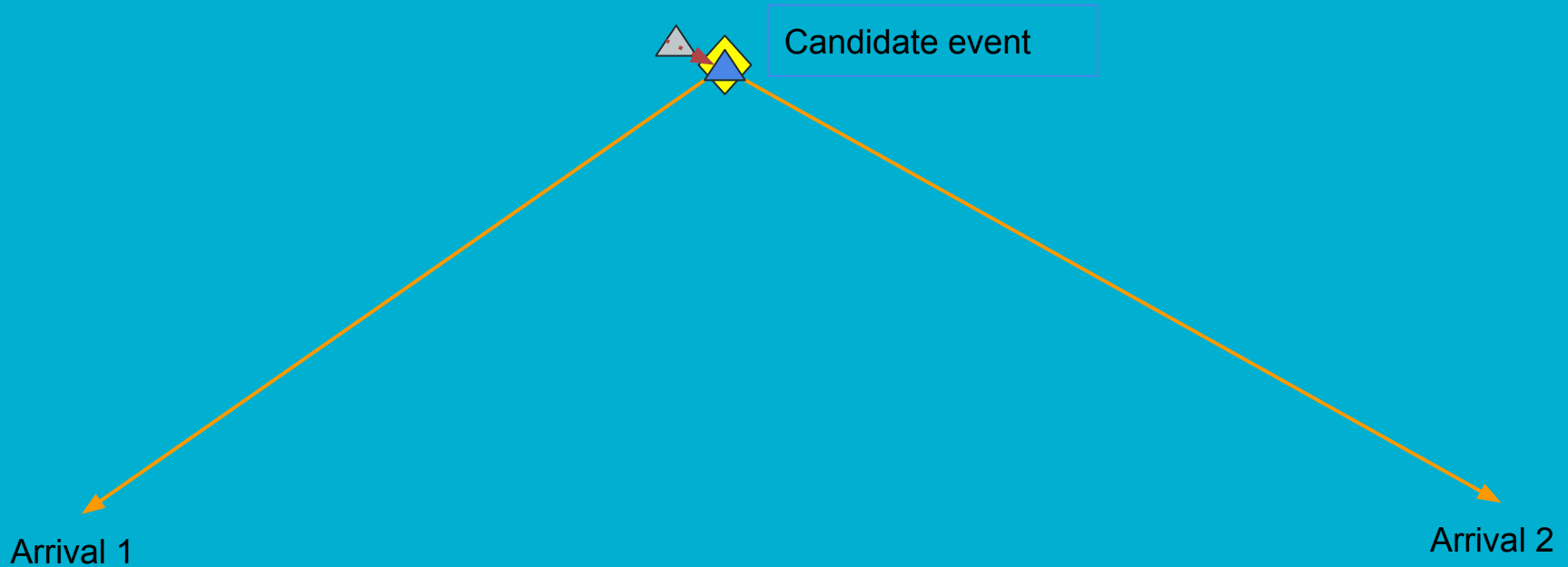
Candidate Proposal -- Invert arrivals
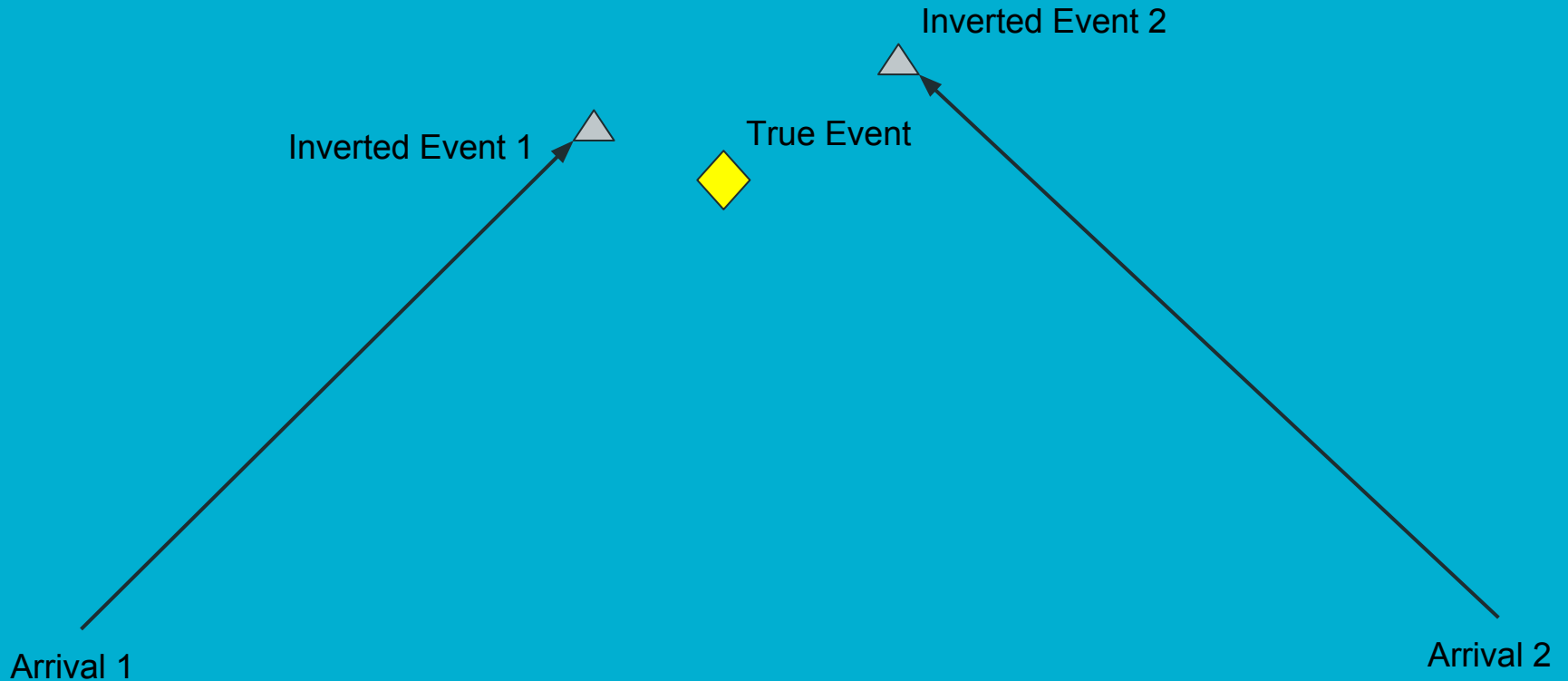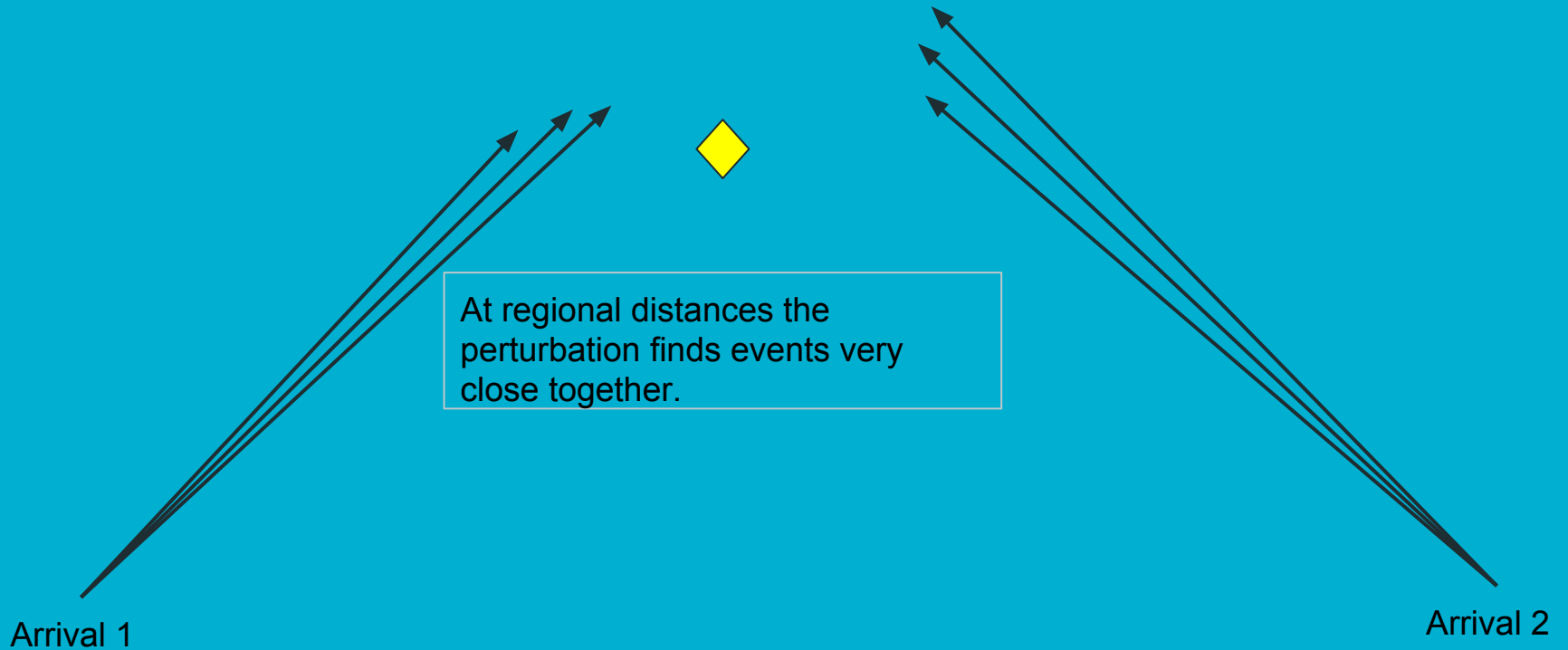
Candidate Proposal -- Perturb Inverted arrivals

Arrival 1

Arrival 2

Candidate Proposal -- Keep best inverted event

Associated Arrivals

Arrival 1

Arrival 2

Candidate Proposal -- Improve best event

Candidate event

Arrival 1

Arrival 2

Candidate Proposal -- Perturb Regional Arrivals

At regional distances the perturbation finds events very close together.

Arrival 1

Arrival 2

Candidate Proposal -- Perturb Regional Arrivals

At regional distances the perturbation finds events very close together.

Arrival 1

Arrival 2

Candidate Proposal -- Perturb Regional Arrivals

The new perturbation for regional arrivals searches in a grid around the inverted arrival.

Arrival 1

Arrival 2

# Summary of Improvements to Proposal

- Search in a small space-time ball around the inverted arrival for regional arrivals (distance less than 20 degrees)
- Also do a uniform search over the whole earth using a sparse 5 degree grid and a simplified model.
  - The uniform proposer is very CPU intensive, and so we have to currently limit the grid size as well as the model.
- Infer the inverted event magnitude rather than attempt all magnitudes
  - This actually gives runtime improvements as well
- Ignore the coda model for the proposal phase.
  - This causes fewer detections to be classified as false arrivals, and hence more events are built.

Problems with improved candidate proposal

- The previous changes implies that more real events are found
- .. But also a lot more spurious events are picked up.
- The model needed to be updated to better distinguish true from false arrivals.
 - Analysis indicated that slowness was the biggest contributor for these newly found false events.

Previous model for false arrivals

- False arrivals occur with a per-station poisson rate
- Arrival time is uniformly distributed within the time interval
- Arrival azimuth is uniformly distributed between 0 - 360 (degrees)
- Arrival slowness is uniformly distributed between 0 - 40 (seconds/degree)
- Arrival automatic phase (iphase) is given by an empirical distribution
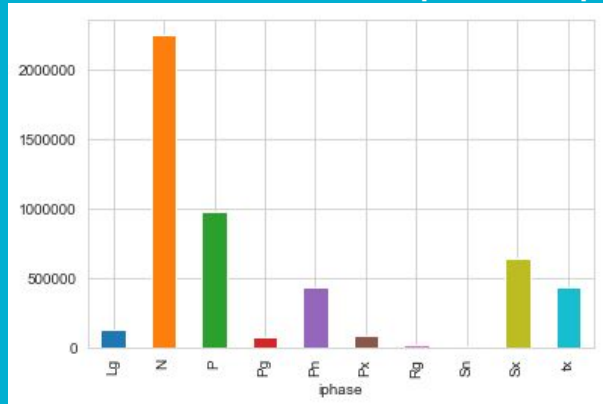
New model for false arrivals

- False arrivals occur with a per-station poisson rate
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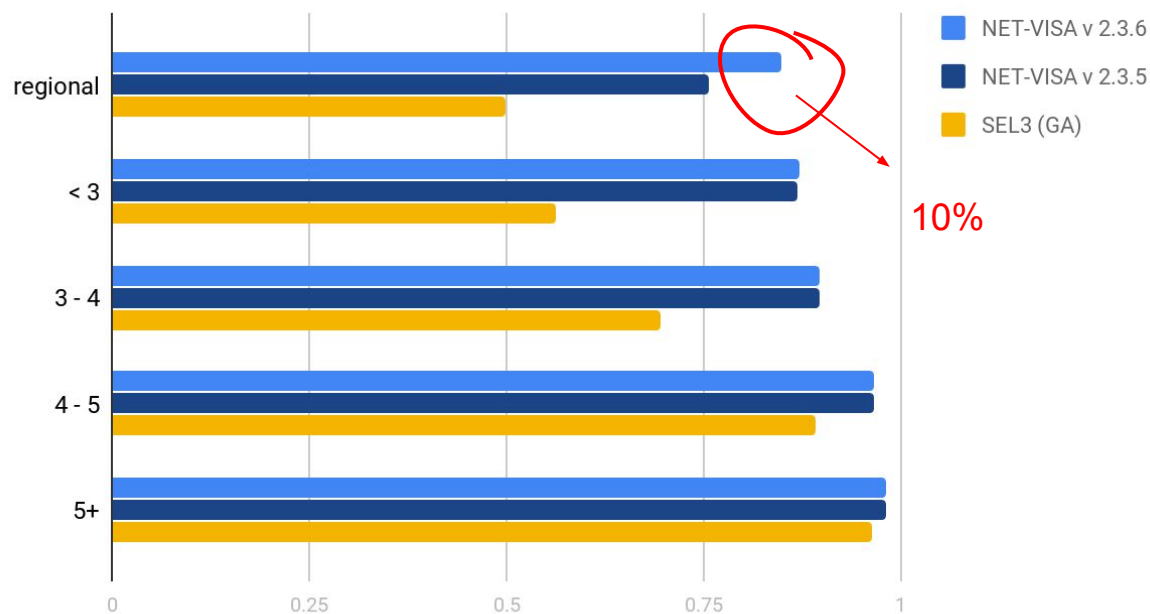- Arrival slowness is given by a per-iphase Laplacian distribution (smoothed 10x)
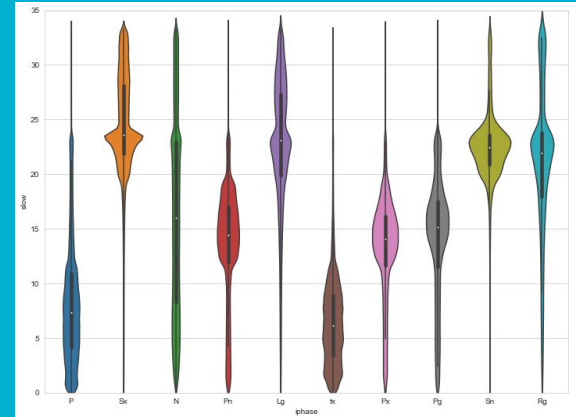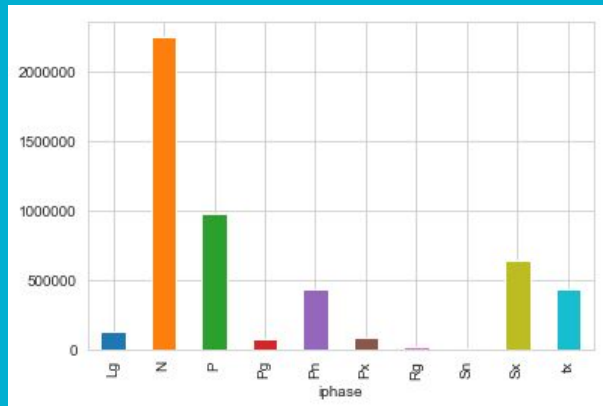
Per-iphase Slowness Distribution
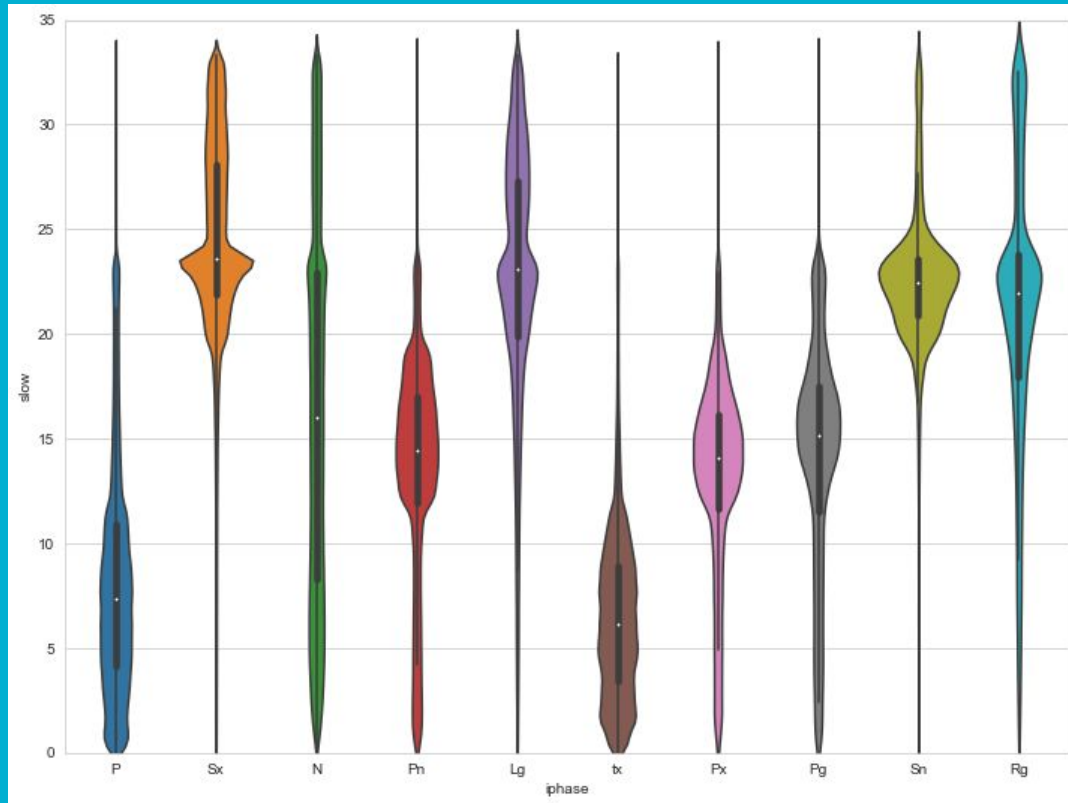
Results for 2013 with LEB as reference

Overlap with LEB by m_b

Matching Criteria - 2 common associations

	Overlap	Inconsistency
NET-VISA v 2.3.6	90.5 %	47.8%
NET-VISA v 2.3.5	89.3%	43.4%
SEL3 (GA)	70.6%	42.3%

Leigh Creek Mining Events

Data provided by Stuart Nippress, David Brown, Spiro Spiliopoulos (UK NDC, and Geoscience Australia)
Matching Criteria - 2 degrees 10 seconds

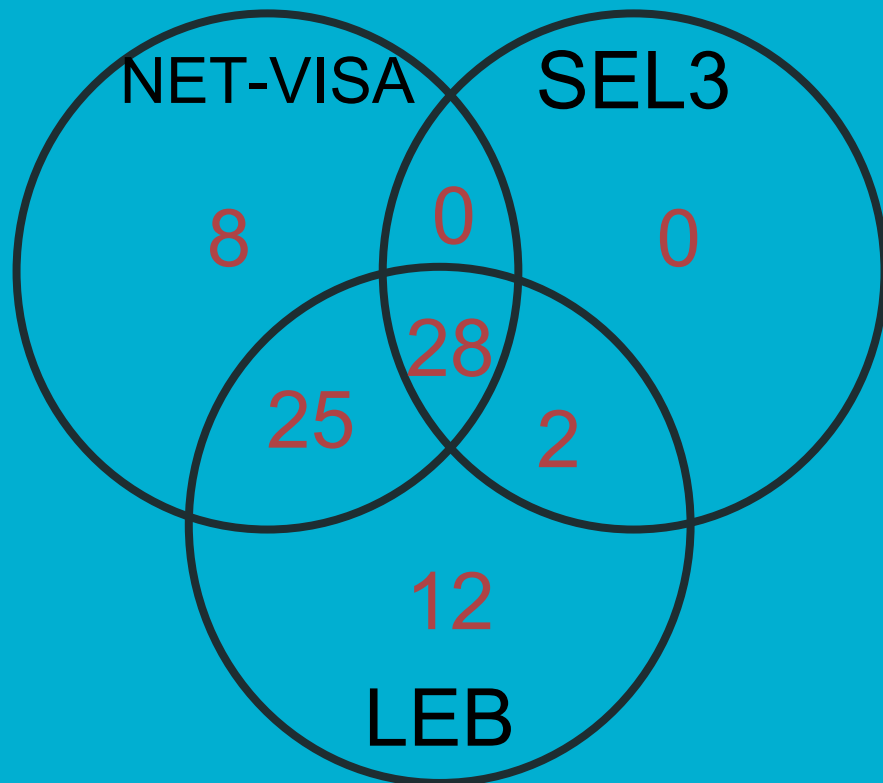| Bulletin Name	Overlap (31 events)	Distance Error (km)
NET-VISA v 2.3.6	**21**	50.2
NET-VISA v 2.3.5	**8**	38.7
SEL3 (GA)	**23**	39.6
LEB	**31**	0
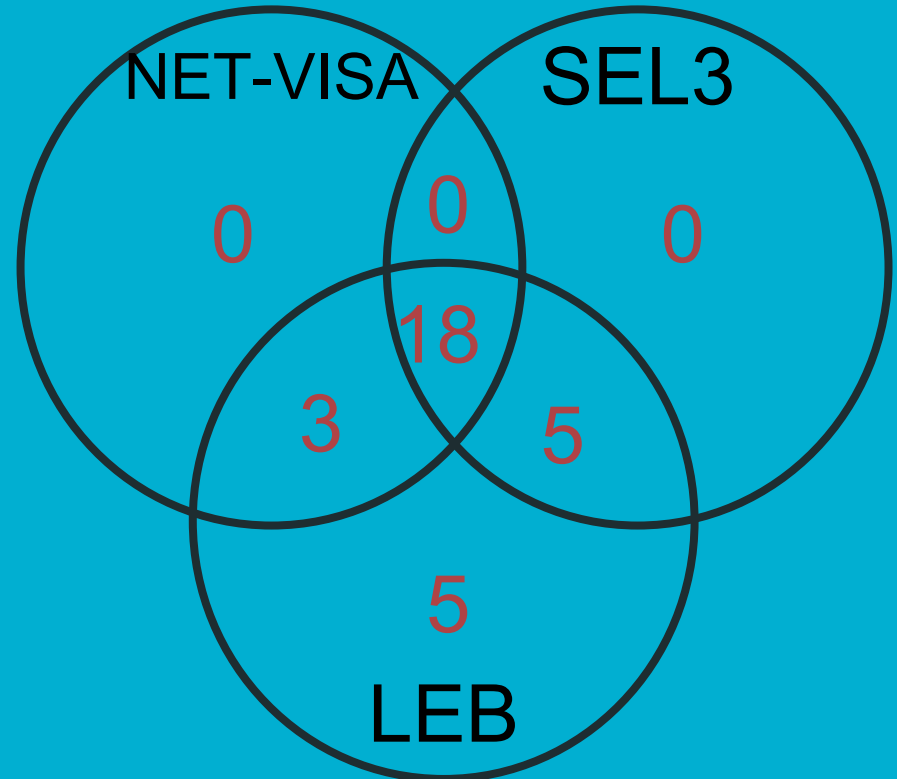
Full Australian Bulletin – 579 events

Data provided by Stuart Nippress, David Brown, Spiro Spiliopoulos (UK NDC, and Geoscience Australia)
Matching Criteria - 2 degrees 10 seconds

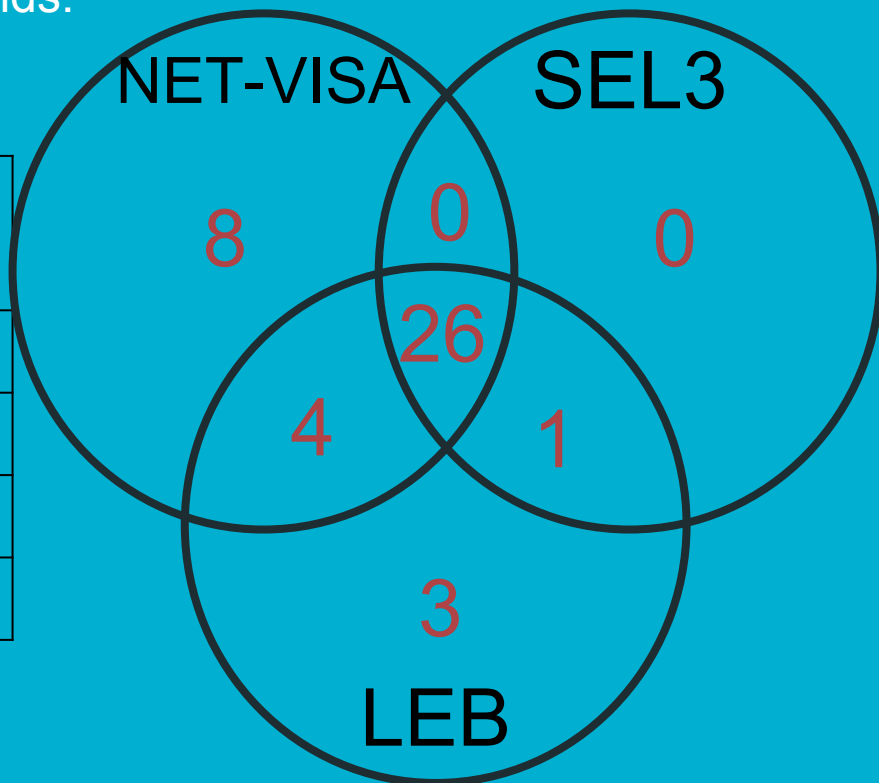| Bulletin Name	Overlap	Distance Error (km)
NET-VISA v 2.3.6	**61**	51.7
NET-VISA v 2.3.5	**42**	51.8
SEL3 (GA)	**30**	60.9
LEB	**67**	52.9

Events from South East European Countries

Data provided by Svetlana Nikolova (Senior Scientist in NIGGG of BAS)
Matching Criteria - 3 degrees and 20 seconds.

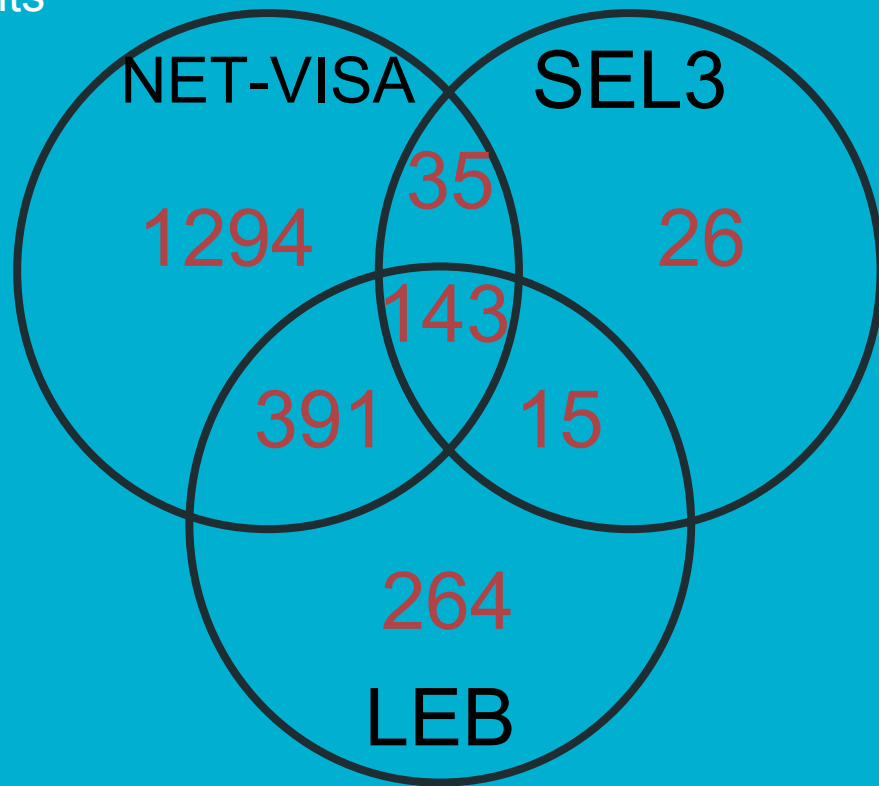| Bulletin Name	Overlap (169 events)	Distance Error (km)
NET-VISA v 2.3.6	**38**	67.8
NET-VISA v 2.3.5	**31**	51.0
SEL3 (GA)	**27**	46.2
LEB	**34**	14.5

ISC events not linked to IDC

2013 Reviewed ISC bulletin -- 25199 events
Matching Criteria - 2 degrees 10 seconds

| Bulletin Name	Overlap	Distance Error (km)
NET-VISA v 2.3.6	**1863**	62.5
NET-VISA v 2.3.5	**1247**	66.3
SEL3 (GA)	**219**	60.4
LEB	**813**	49.6

ISC events not linked to IDC

2013 _Comprehensive_ ISC bulletin -- 379432 events
Matching Criteria - 2 degrees 10 seconds

Bulletin Name	Overlap	Distance Error (km)
NET-VISA v 2.3.6	**6341**	55.9
NET-VISA v 2.3.5	**3482**	59.4
SEL3 (GA)	**1007**	51.9
LEB	**1993**	43.8

NET-VISA   SEL3

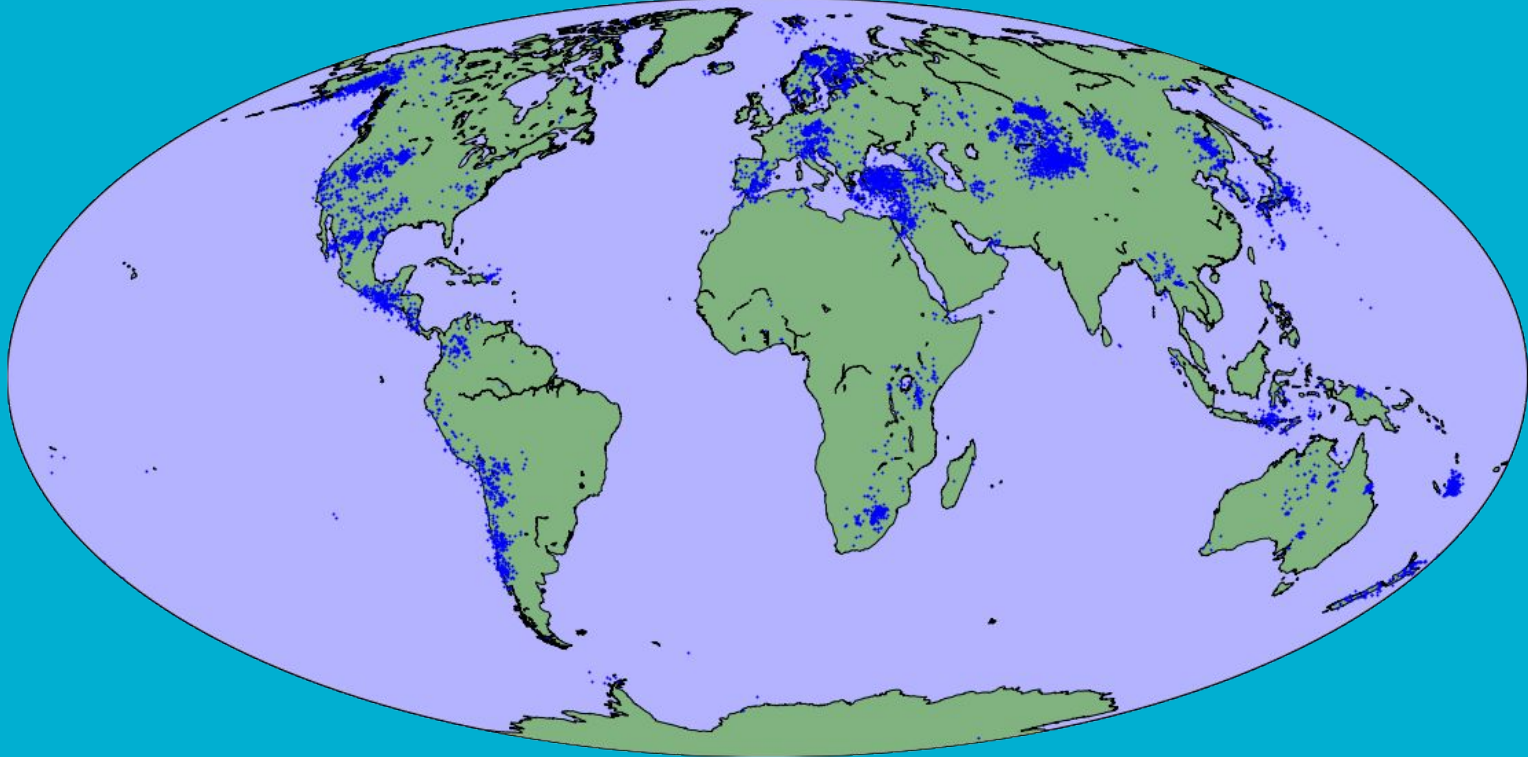4780   200   306

455

906   46

586

LEB
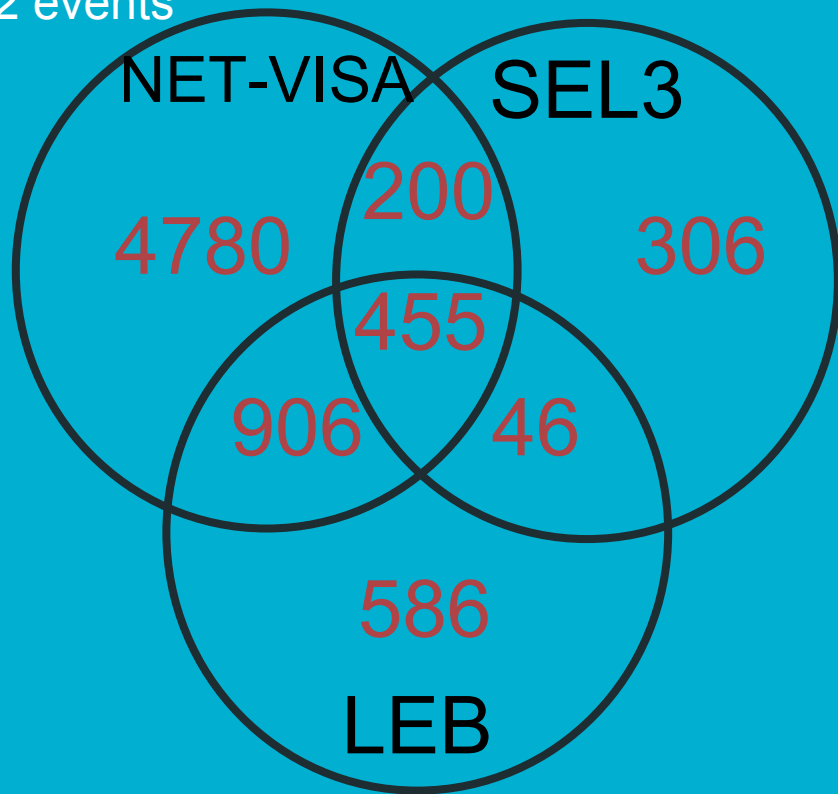
Max Arrival Distance of Events
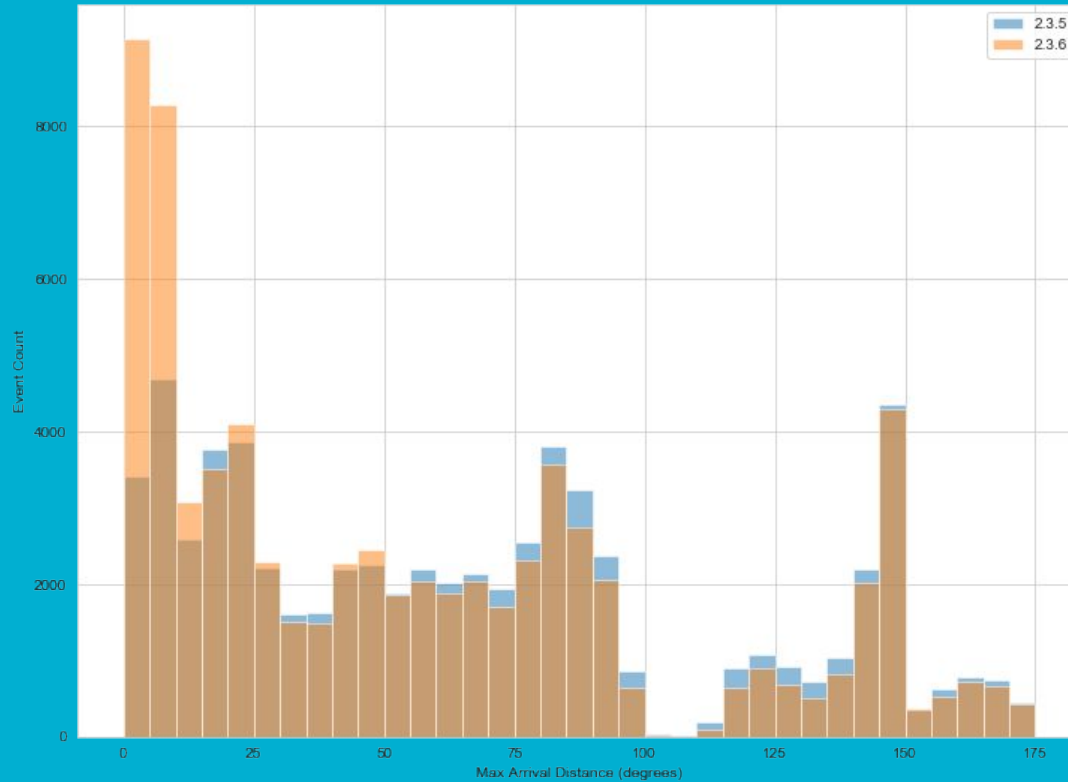
New Regional Events

New Regional Events in v2.3.6

Summary

- Performance of NET-VISA for regional events not at par with tele-seismic events.
- Root cause was related to candidate proposals for regional events.
- Improvements to candidate proposals caused many more spurious events to be built
- Model improvements to reduce spurious events
- Results with LEB as reference confirm improvements for regional events
- Further results from Bulgaria, Australia, as well as the regional portion of the ISC bulletin confirms improvement