Improved Signal Detection at Seismometer Arrays

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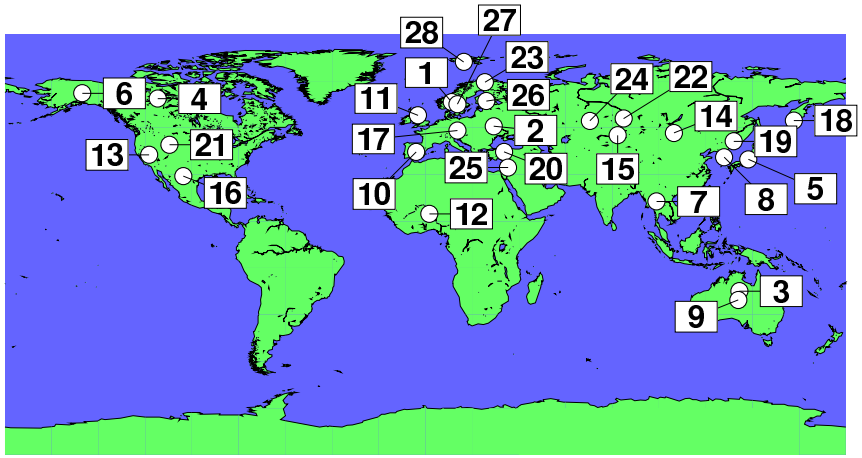
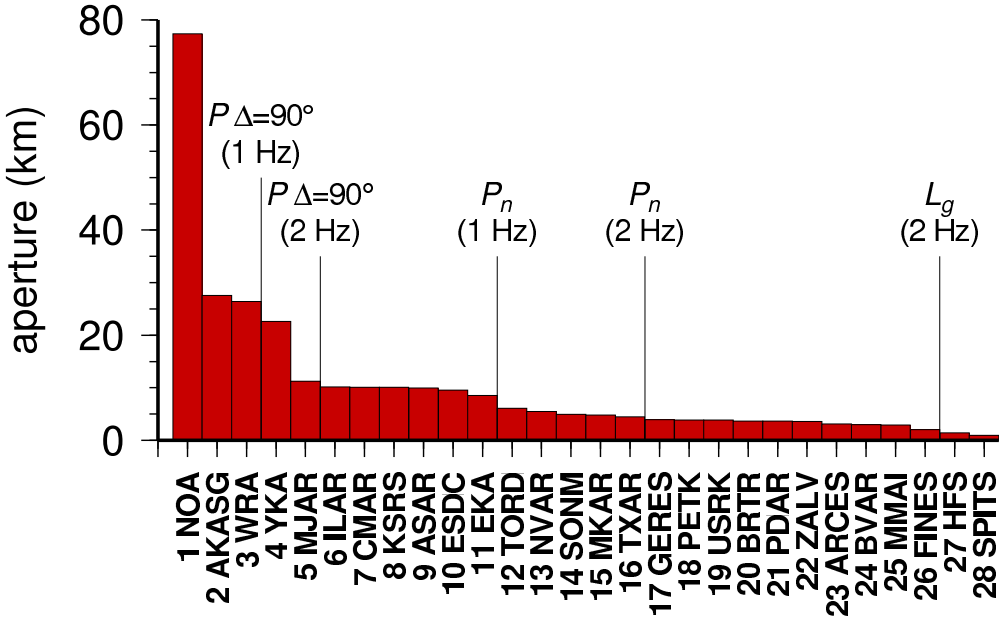
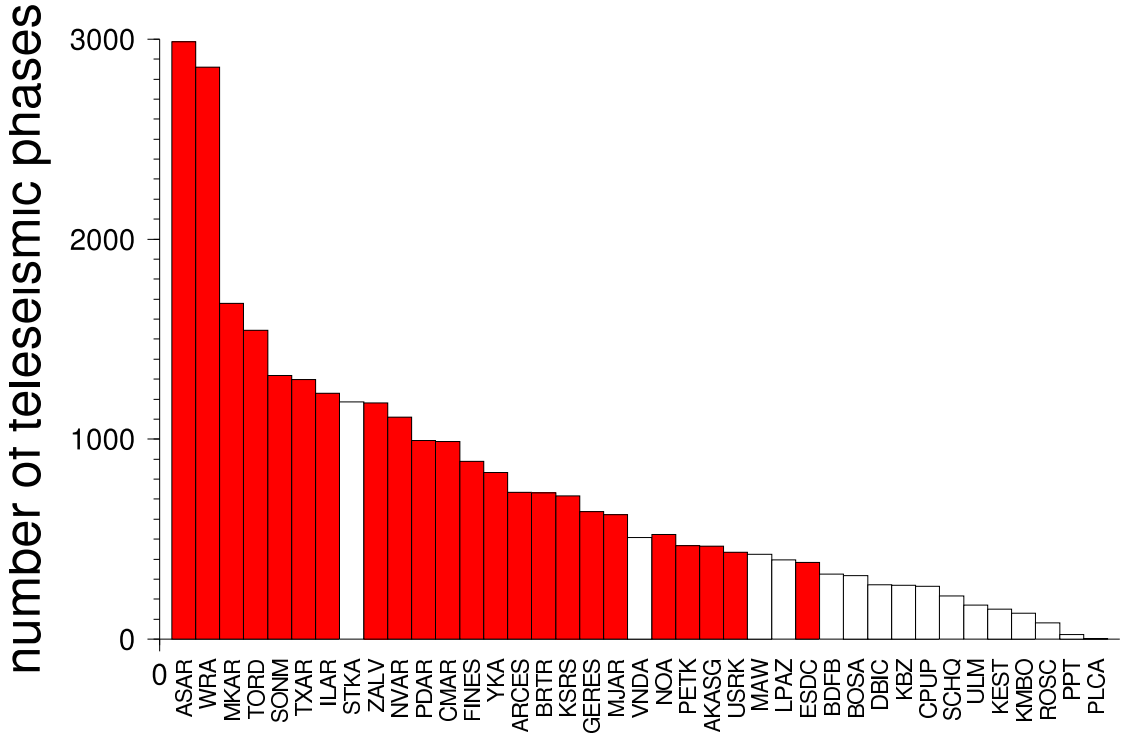
Introduction

- Ongoing project to improve signal detection at seismometer arrays with the *generalised F detector* (Selby 2008, 2011):
  - Essentially weighted least squares inverse problem using prior information.
  - Likelihood ratio test using F statistic to find probability of detection.
- Here I describe the use of prior information (i.e. the physics of the problem) to set weights and equalise detection thresholds.
- I show results of a test of 130 array-days (10 days at 13 small IMS arrays) of waveform data using a frequency-domain implementation (Selby, 2011).
- Future plans and further development.

IMS seismometer arrays







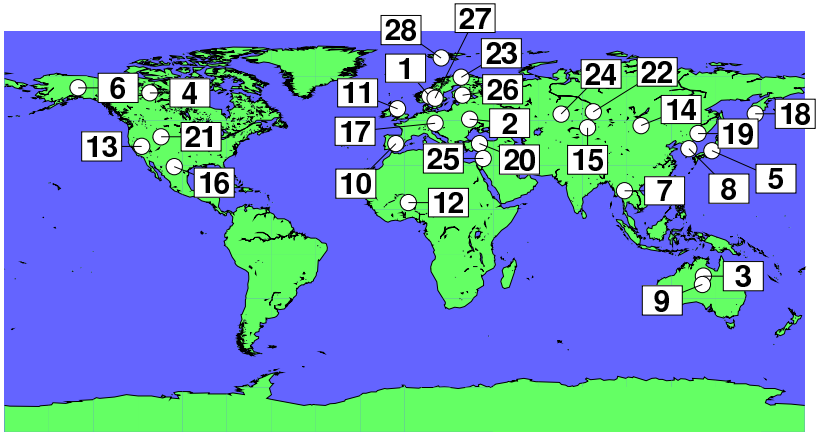
Aims

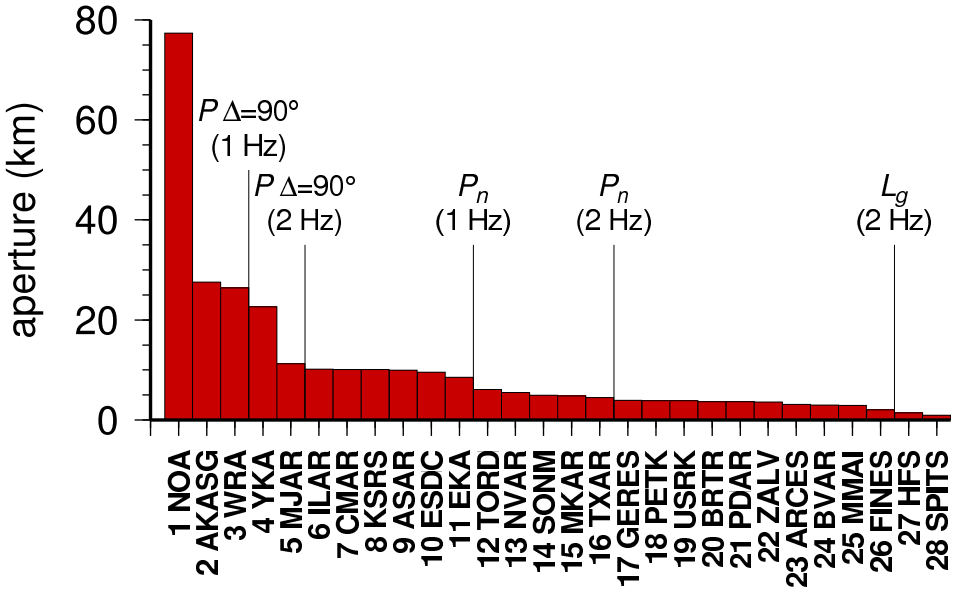
- To make *optimal use* of International Monitoring System seismometer arrays.
- Use a *common baseline* for all arrays, frequency bands, slownesses etc.
- *Avoid interactive tuning*; detection thresholds are based on physics of the problem - the prior information given to the inverse problem.
- *Improve proportion of reliable detections*:
  - Increase number of reliable detections,
  - Decrease number of (statistically) poor detections.
- Consequently *improve automatic bulletins* (event lists) by improving input to global association algorithm.
- Consequently *reduce burden on analysts*.

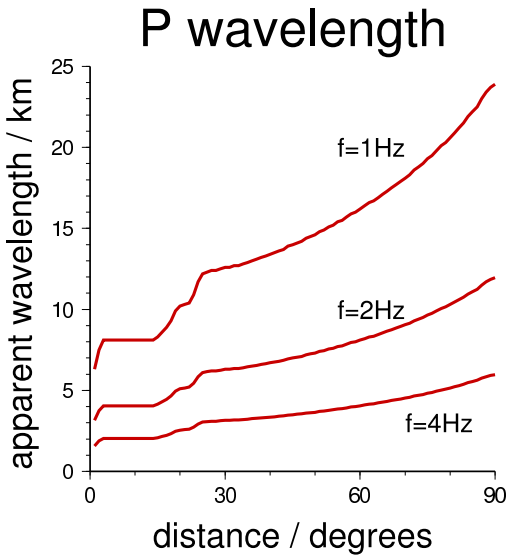
Prior information...

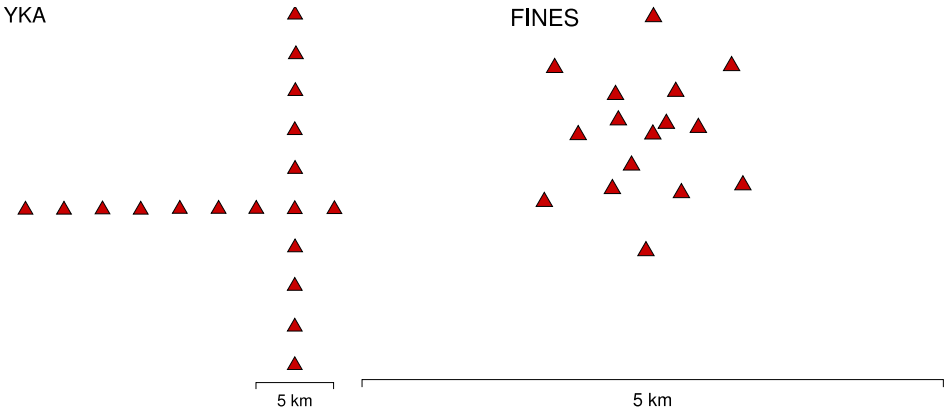
- Array aperture and signal wavelength.
- Number of channels in each array.
- Noise power spectrum at each array.
- Noise correlation between the sensors at each array.

Array aperture and signal wavelength

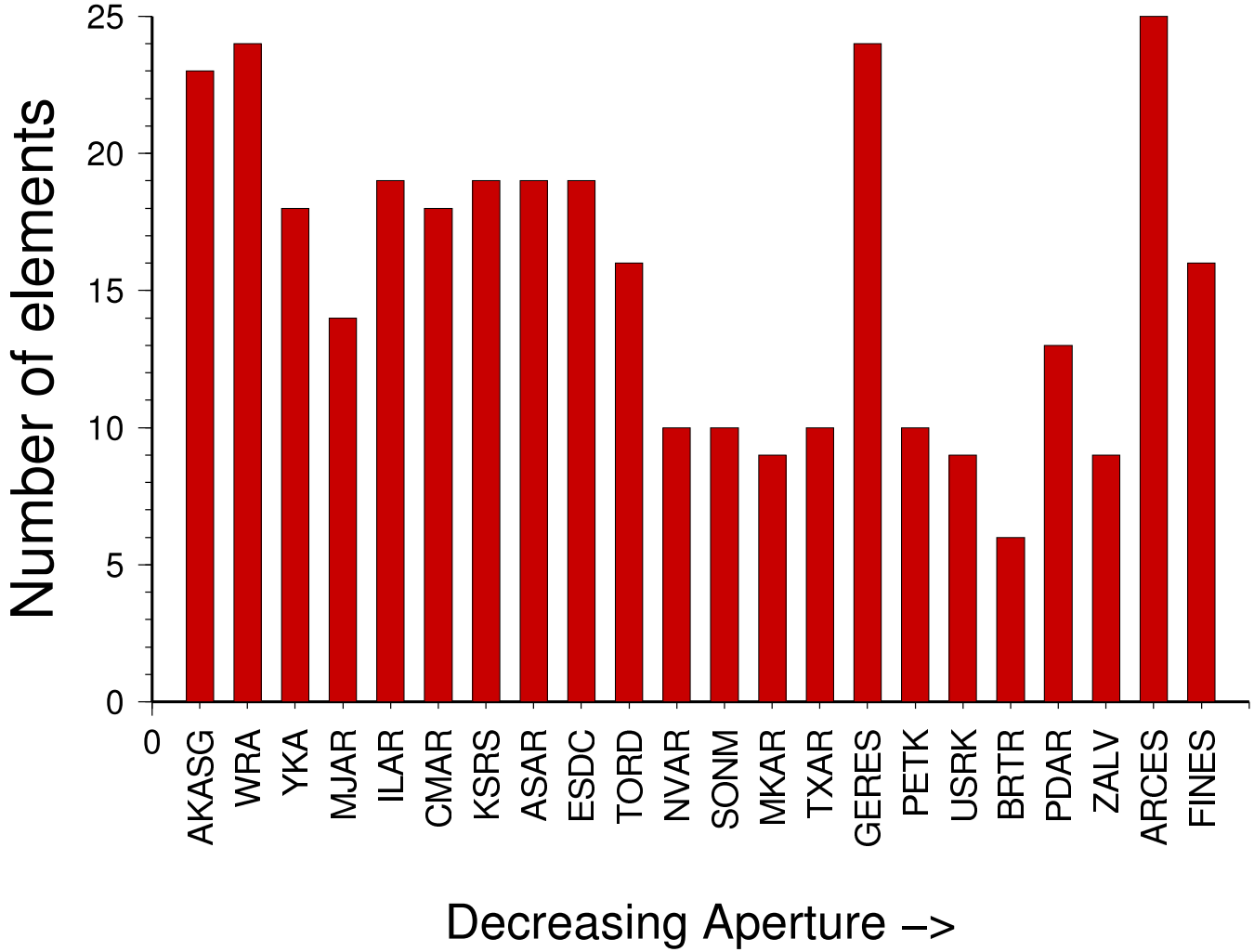




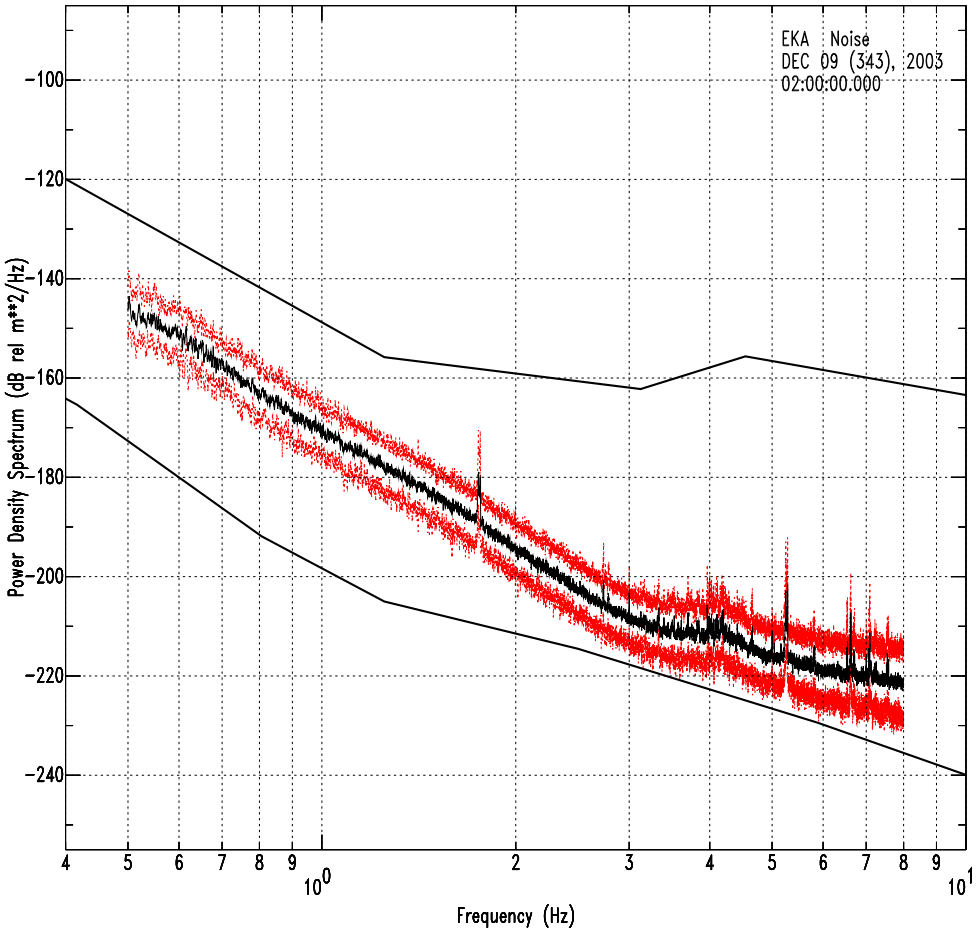




Number of channels

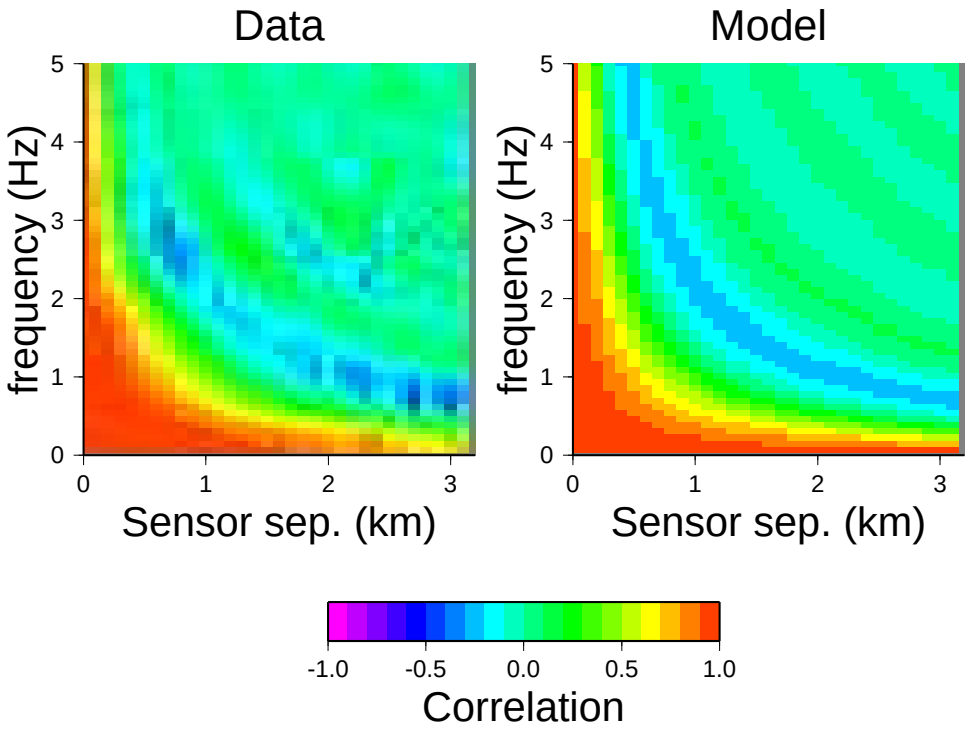


Noise power spectrum



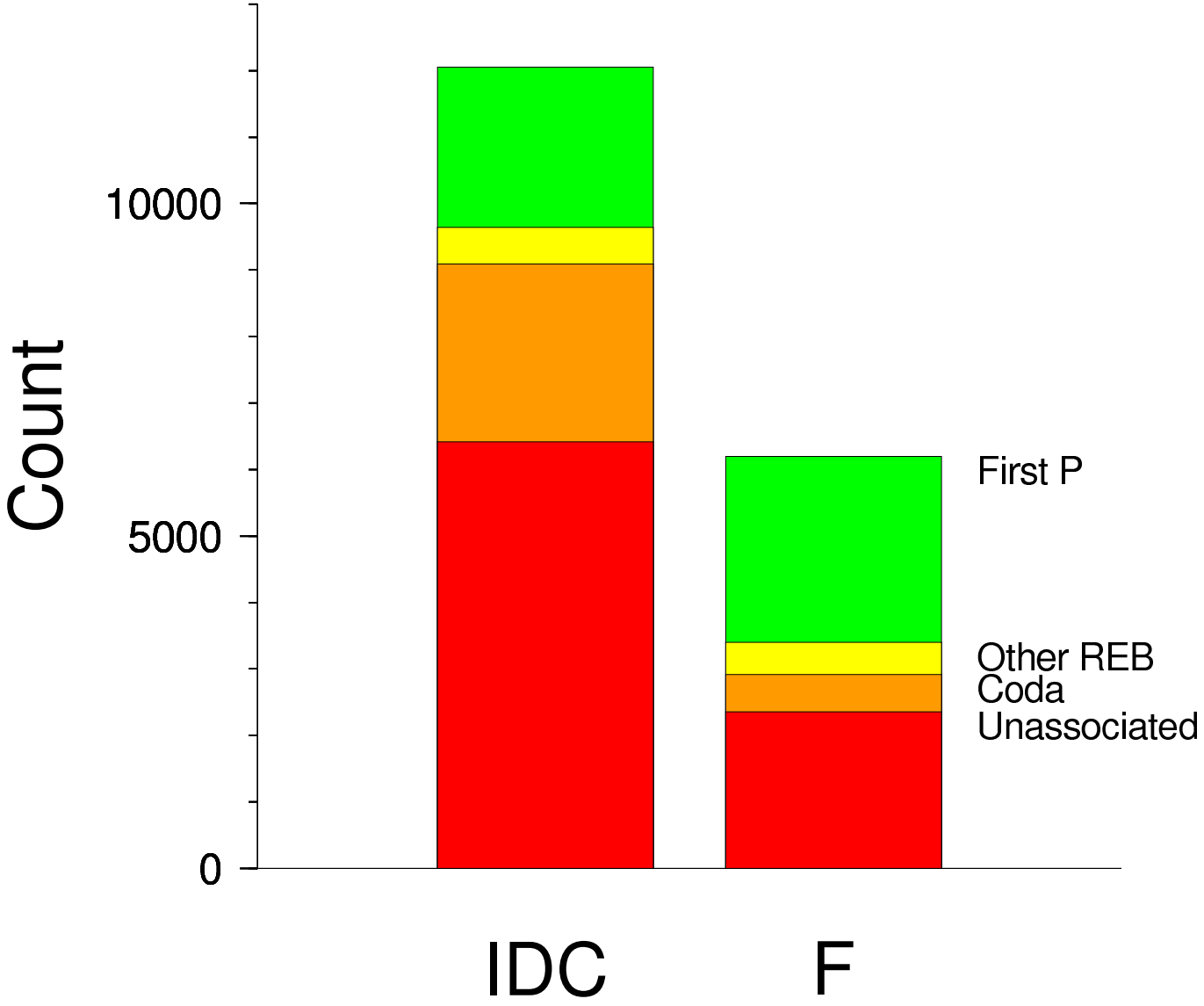
- Seismic noise generally has a red power spectrum.
- Slope of power spectrum varies with frequency.
- Noise power spectrum varies with time and from array to array.
- Shape of power spectrum influences false alarm rate.
- Adaptively whiten the noise to reduce false detections.

Noise correlation



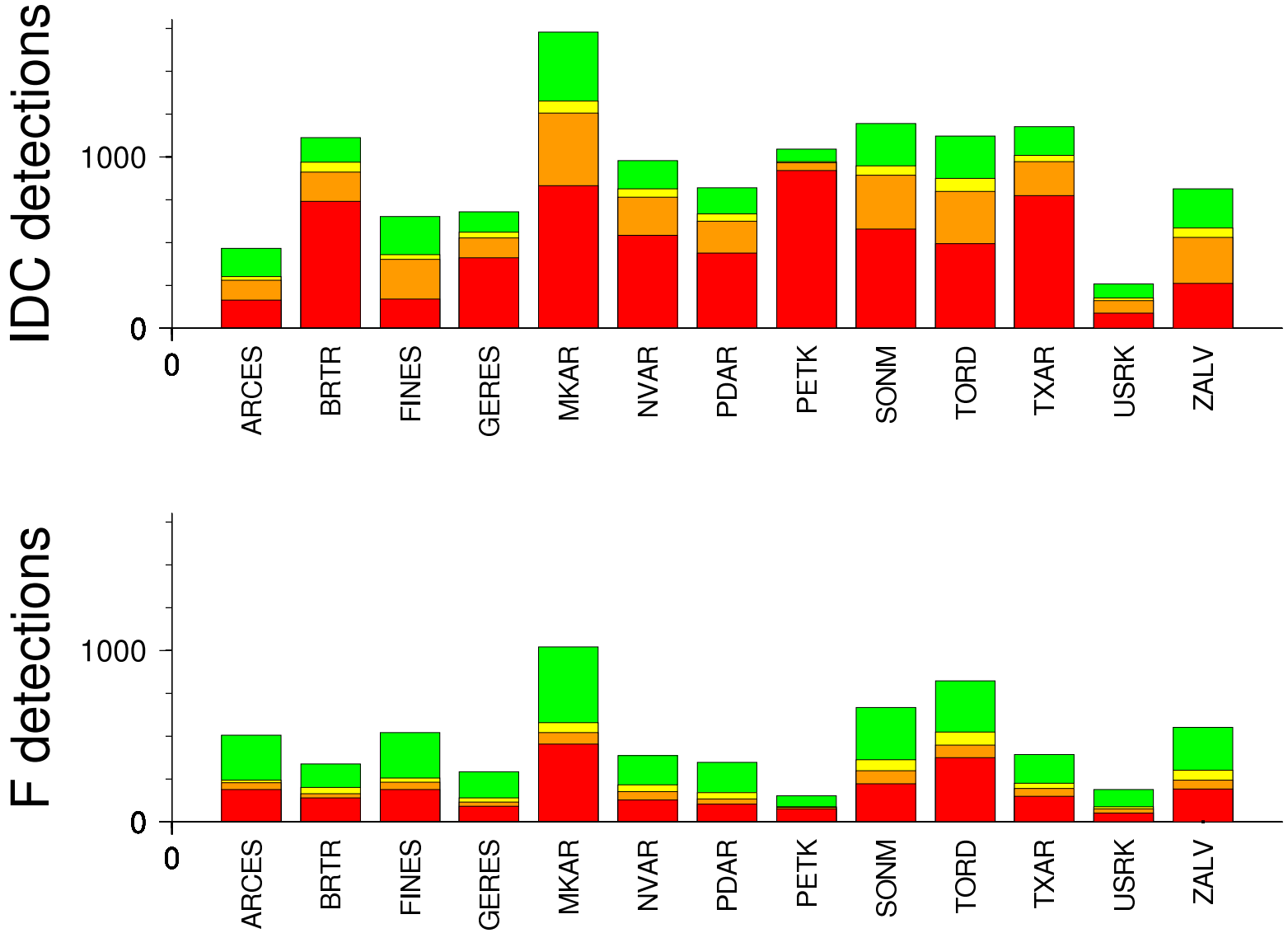
- For an ideal array design noise is uncorrelated between sensors in the array.
- Often not the case, especially at smaller arrays.
- Correlated noise increases the chance of bogus detections at certain slownesses.
- Counter using a model of correlation based on azimuthally isotropic L_g propagation.

Results

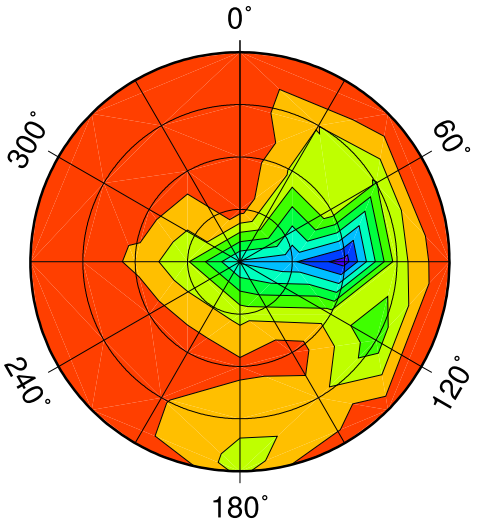


- *F* detector makes 50% of detections made by current IDC system.
- However, 10% more *F* detections are associated with REB events.

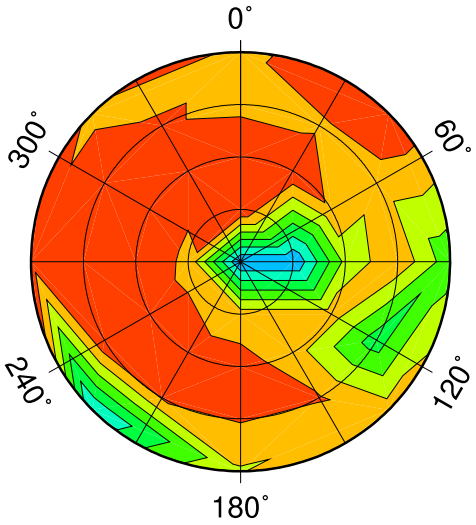
Results vary differ at each array



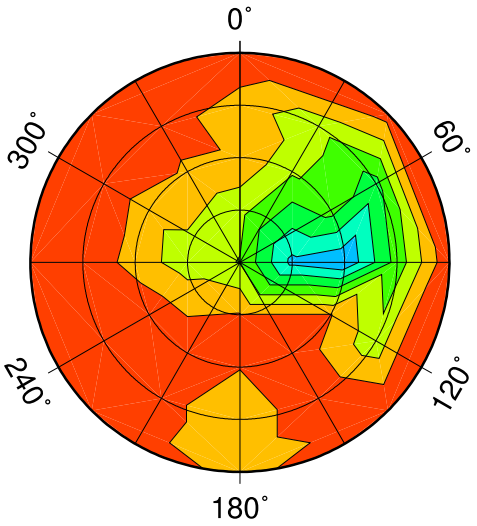
Detection comparison by slowness and azimuth



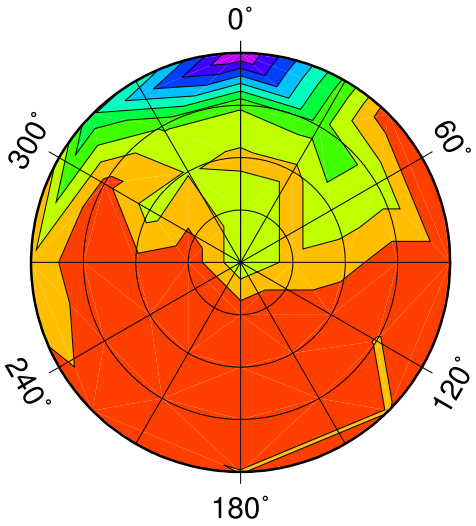
a) F ARCES associated



b) F ARCES unassociated

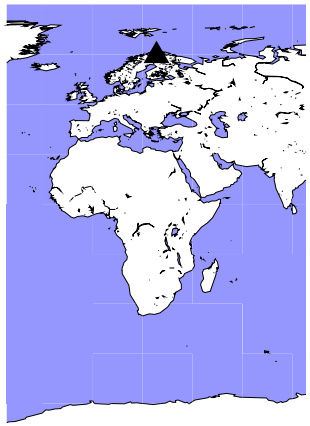


c) IDC ARCES associated



d) IDC ARCES unassociated

ARCES



fraction of detections

Papers

- Selby, N.D., 2008. Application of a generalized *F* detector at a seismometer array. *Bull. seism. Soc. Amer.*, **98**, 2469–2481.
- Selby, N.D. 2011. Improved Teleseismic Signal Detection at Small Aperture Arrays. *Bull. seism. Soc. Amer.*, **101**, (August 2011).

Current and future development

- Time domain method has been developed for use at larger arrays.
- Preliminary testing on infrasound arrays promising.
- Real time testing and input to global association algorithm being considered.
- Future developments of method:
  - Include signal correlation into the model,
    - useful for L_g,
  - SASCs and/or amplitude and time “pit corrections”,
  - Information about attenuation - t*,
  - Broadband,
  - Single channel detection.