A test of the precursory acceleration moment release model on some recent New Zealand earthquakes.

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- Method
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- Conclusion

Reference

- Bowman, D. D. ,et al.,1998,An observational test of the critical earthquake concept., Journal of Geophysical Research,1-22.

- Robinson Russell,2000,A test of the precursory acceleration moment release model on some recent New Zealand earthquakes,Geophys.J,104,568-576.

Introduction

- In the recent years there has been a trend towards the view that large earthquakes are inherently unpredictable.

  (Geller et al.1997)----self-organized criticality.

- Another view is that in a given fault network there are distinctive large defining events that serve to move the crust well away from the critical state.

  (Bowman et al.1998)

- Assuming the latter view to be corrected, it is possible to derive mathematical models of the evolving seismicity prior to a large defining event.

- In this study, this potential forecasting method is referred to as the AMR method (for Accelerating Moment Release).

Method

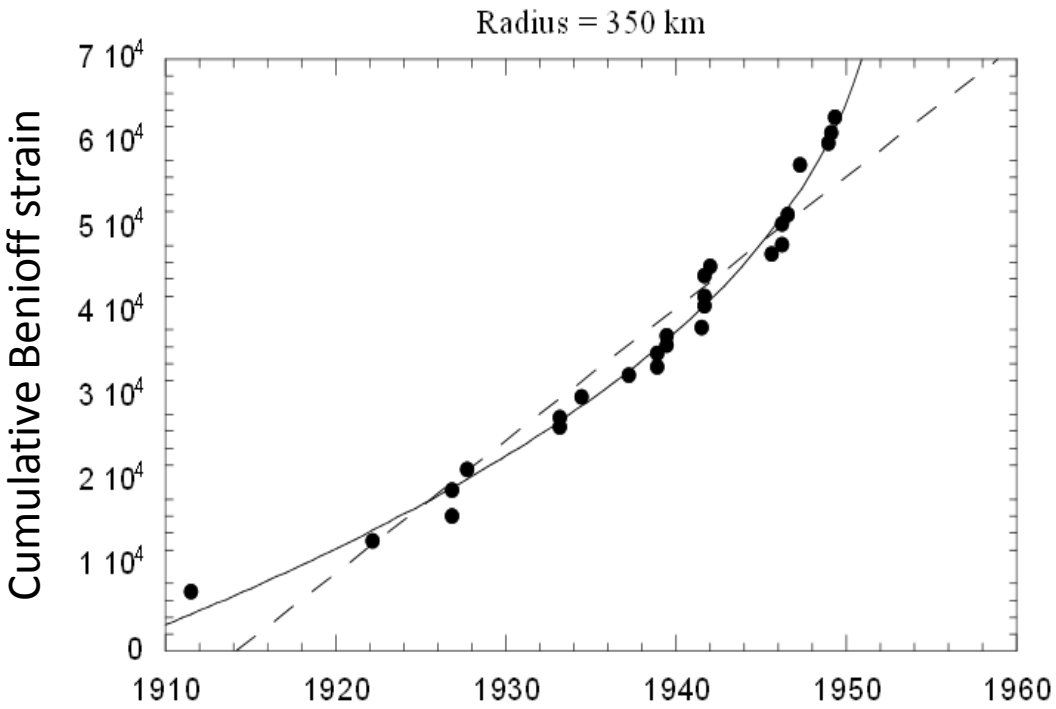
Power law time to failure equation

(Bufe and Varnes [1993])

1989 Loma Prieta earthquake

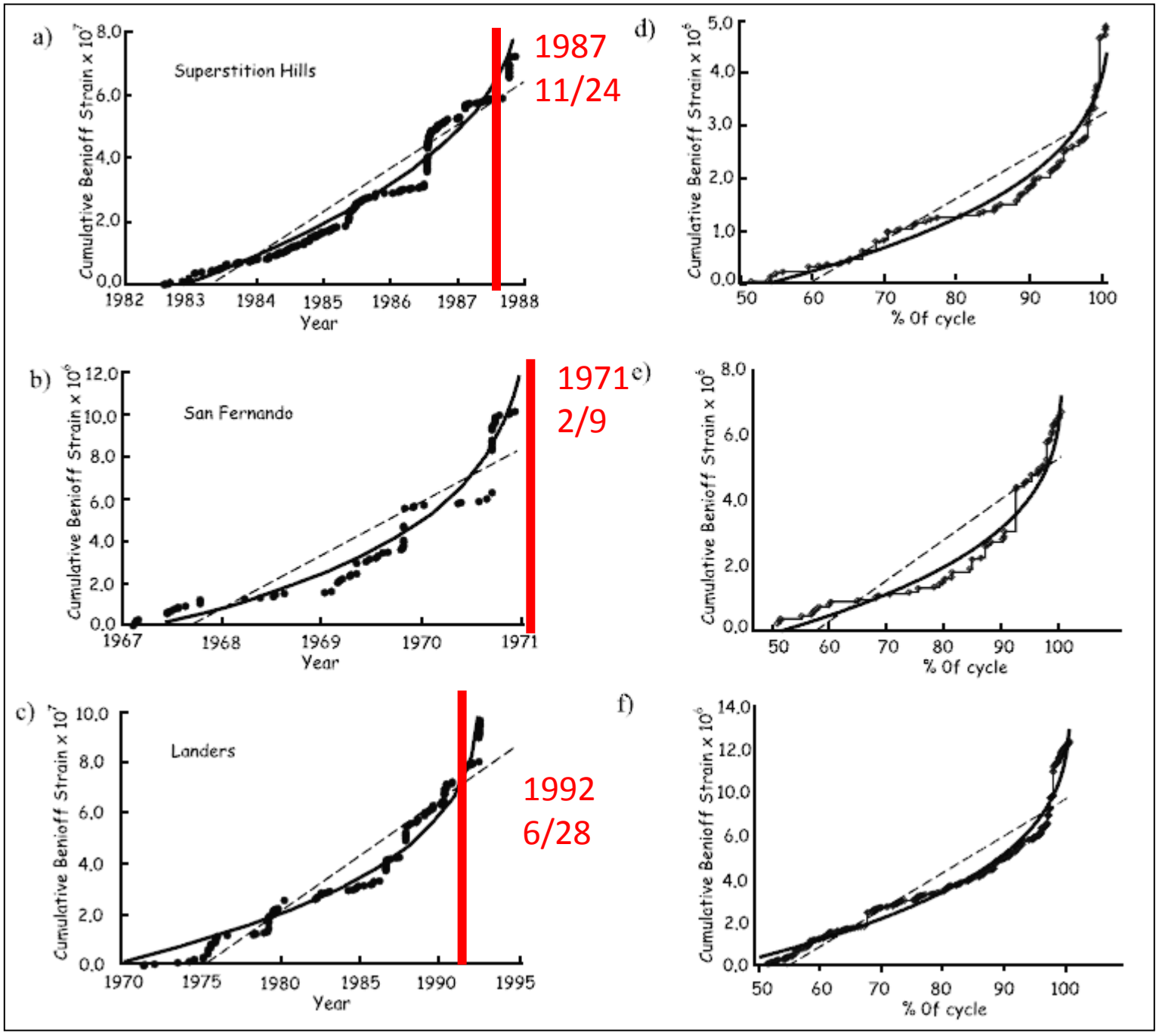
$$e(t) = A + B(tf\text{-}t)^m$$

$$\epsilon(t) = \sum_{i=1}^{N(t)} E_i(t)^{1/2}$$



These models suffer from the fundamental limitation that the effects should be most prominent close to the future epicenter rather than several fault lengths away.

Ei is the energy of the ith event and N(t) is the number of events at time t.

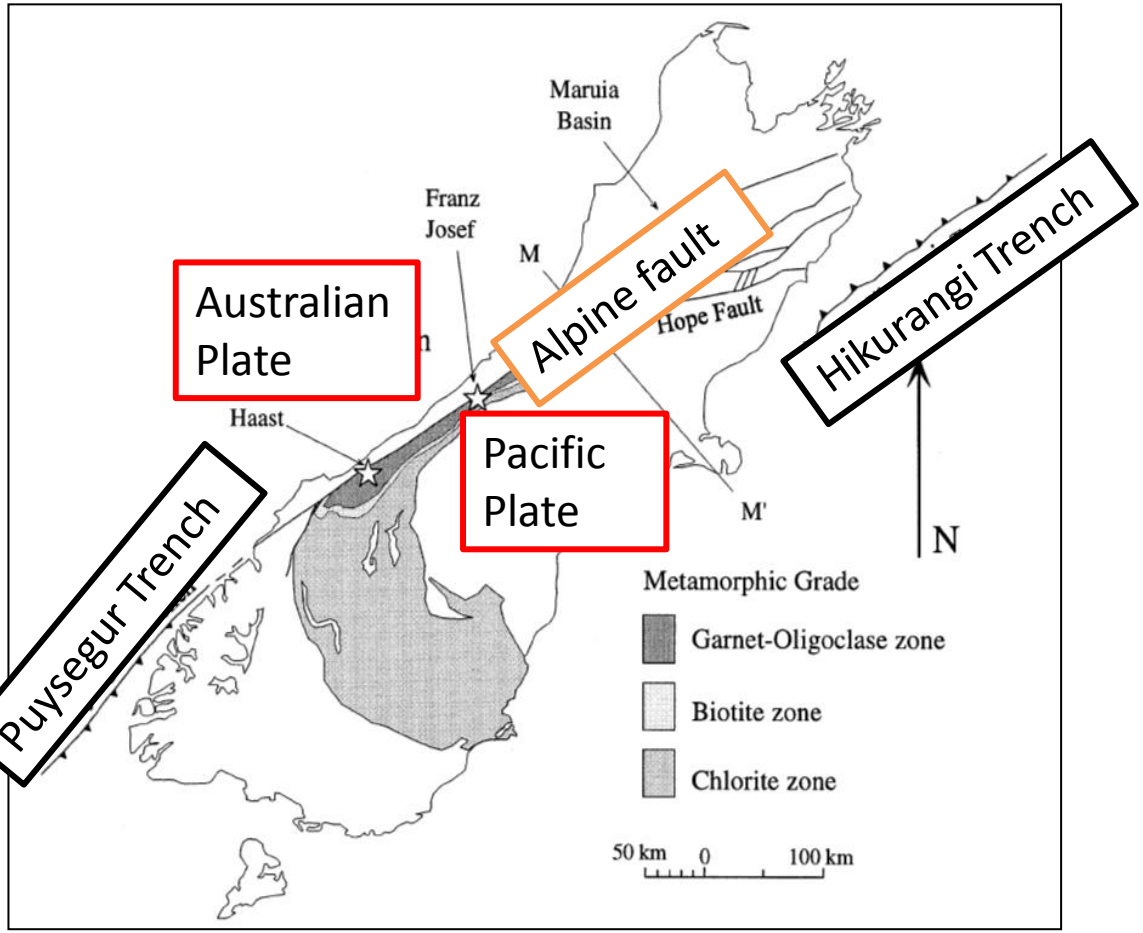


(Geoffrey et al. 2002)

Examples

Tectonic of New Zealand background

Boundary between the Pacific and Australian plates.
Northern- subducted Pacific plate.
Southern-subducted Australian plate.



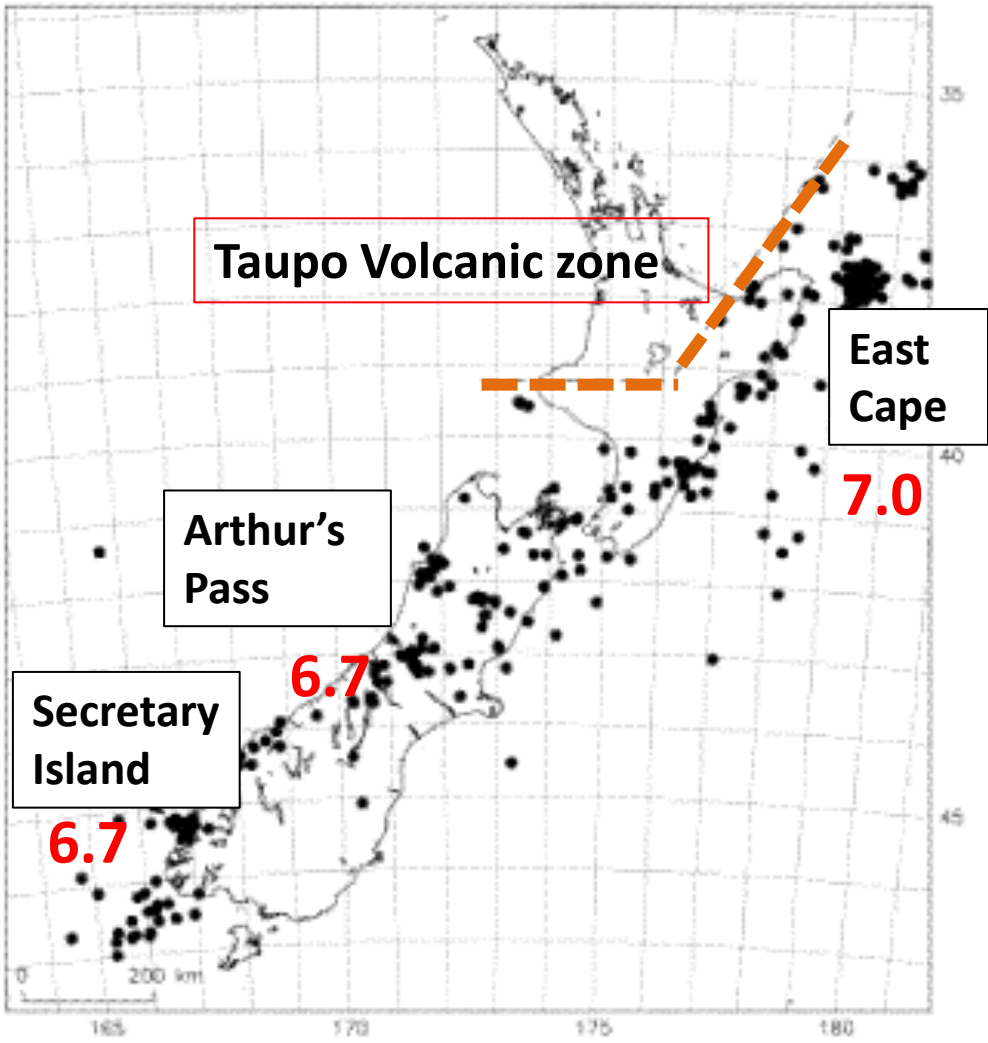
(Batt et al.1998)

New Zealand earthquakes data

Seismicity region:

36-47° S, 164 ° E-177° W
Catalogue New Zealand Seismological Observatory 1964-1998
Magnitude larger 5.0
Log M_o=1.5M_L+9.05

East Cape 1995.2.5
largest New Zealand event since 1942.
Arthur's Pass 1994.6.18
Largest of a regional cluster of moderate magnitude events in the central South island form 1984-1995.
Secretary Island 1993.8.10
shallow subduction thrust event just off the southwest coast of the South island.



Test the three earthquake

Log R =-0.2+0.36M

Given the position and time of the main shock. Jau'me & Sykes(1999)

Is the preceding seismicity consistent with the equation?

1. the Circular region

   why have to use the circular

   how to calculate the circular

Could a search of accelerating moment release have indentified the position and times of the events beforehand?

2. Develop a grid-search proced

   generate a set of equally space

   New Zealand and look at the s

   region centred at those grid p

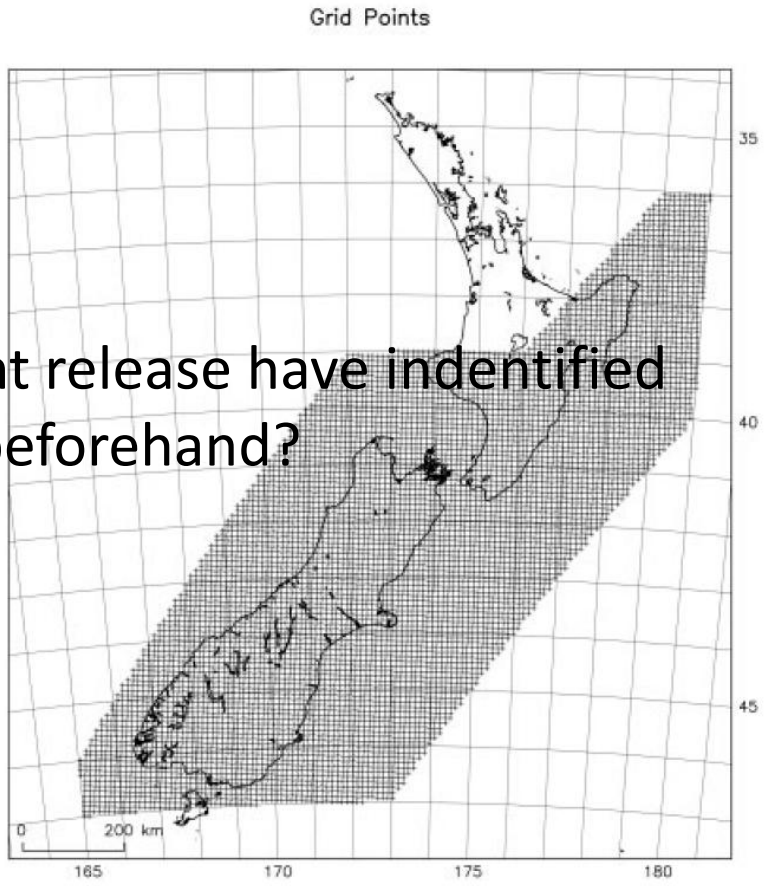


Figure 3. The grid points used as centres of potential precursory

Test the three earthquake

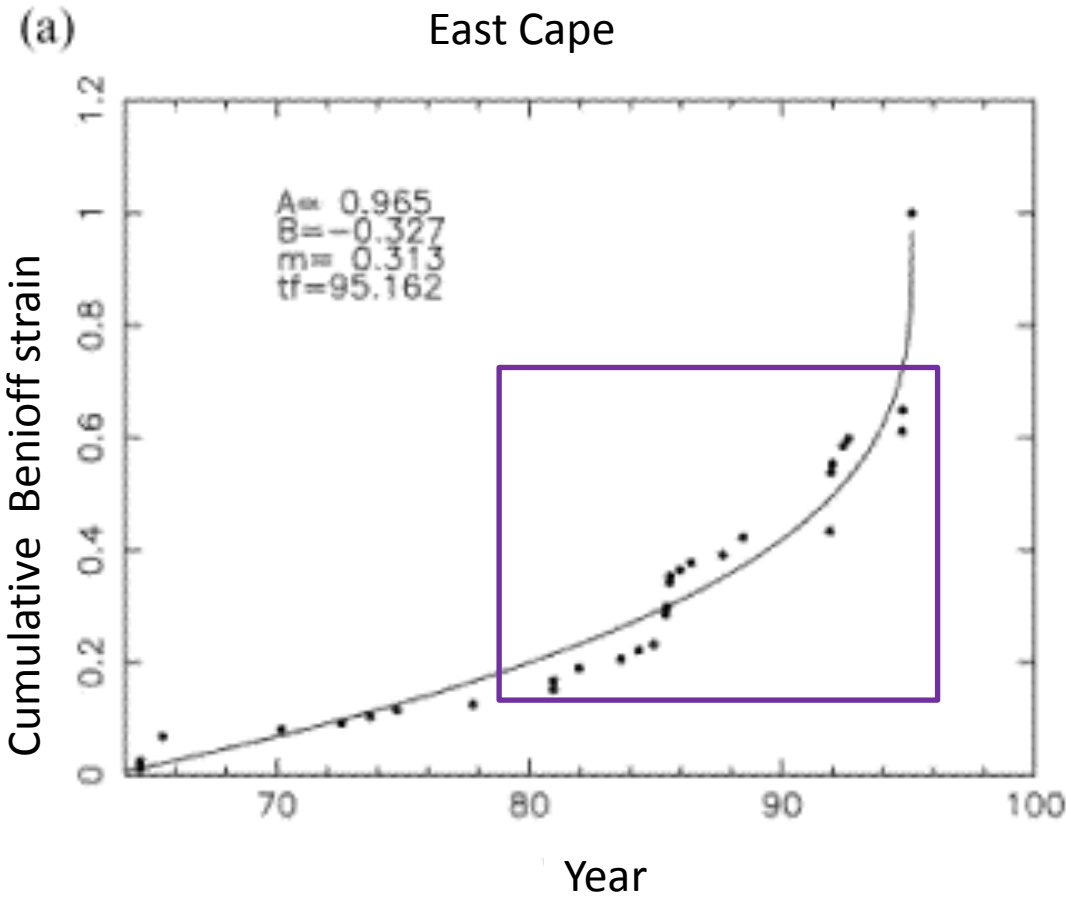
Use the method 1

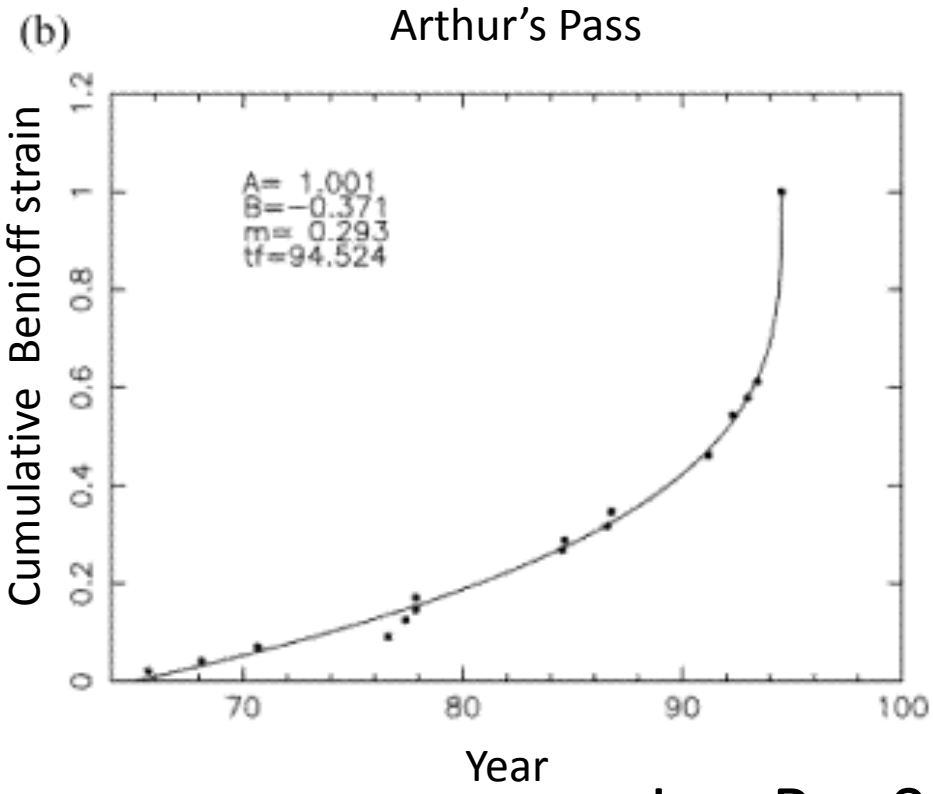
Log R =-0.2+0.36M

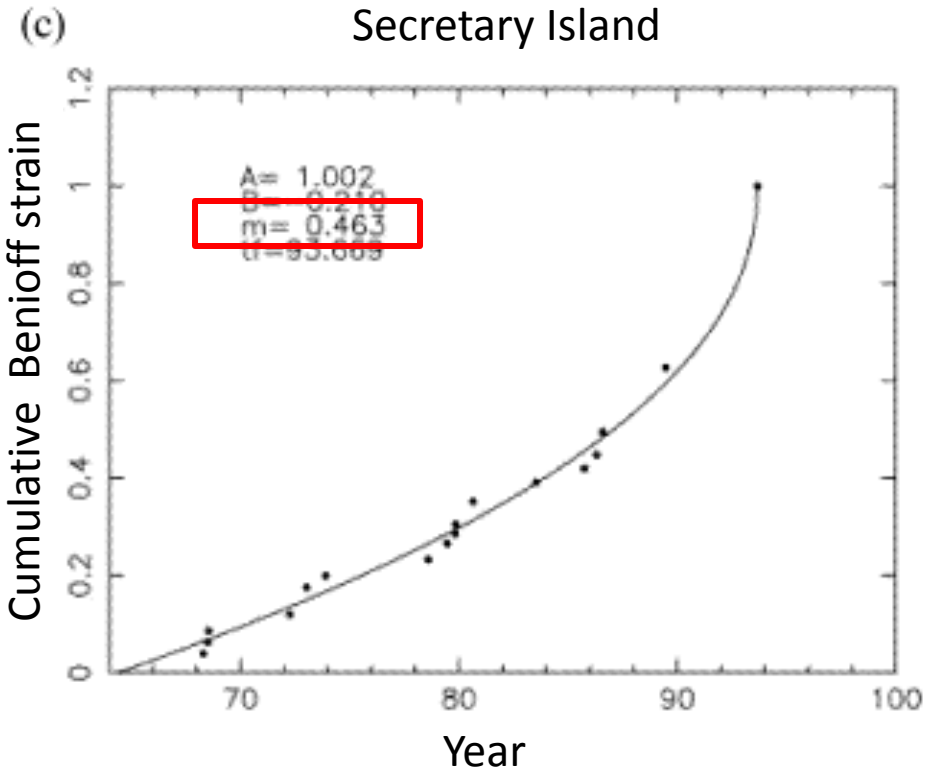
Jau'me & Sykes(1999)

This requires knowledge of the size of a precursory region appropriate for the event's magnitude.
The relation between the main shock magnitude and radius R of a circular precursory region.

There are then 1331 possible combination of R and region center. (11X11 X11)







Log R =-0.2+0.36M

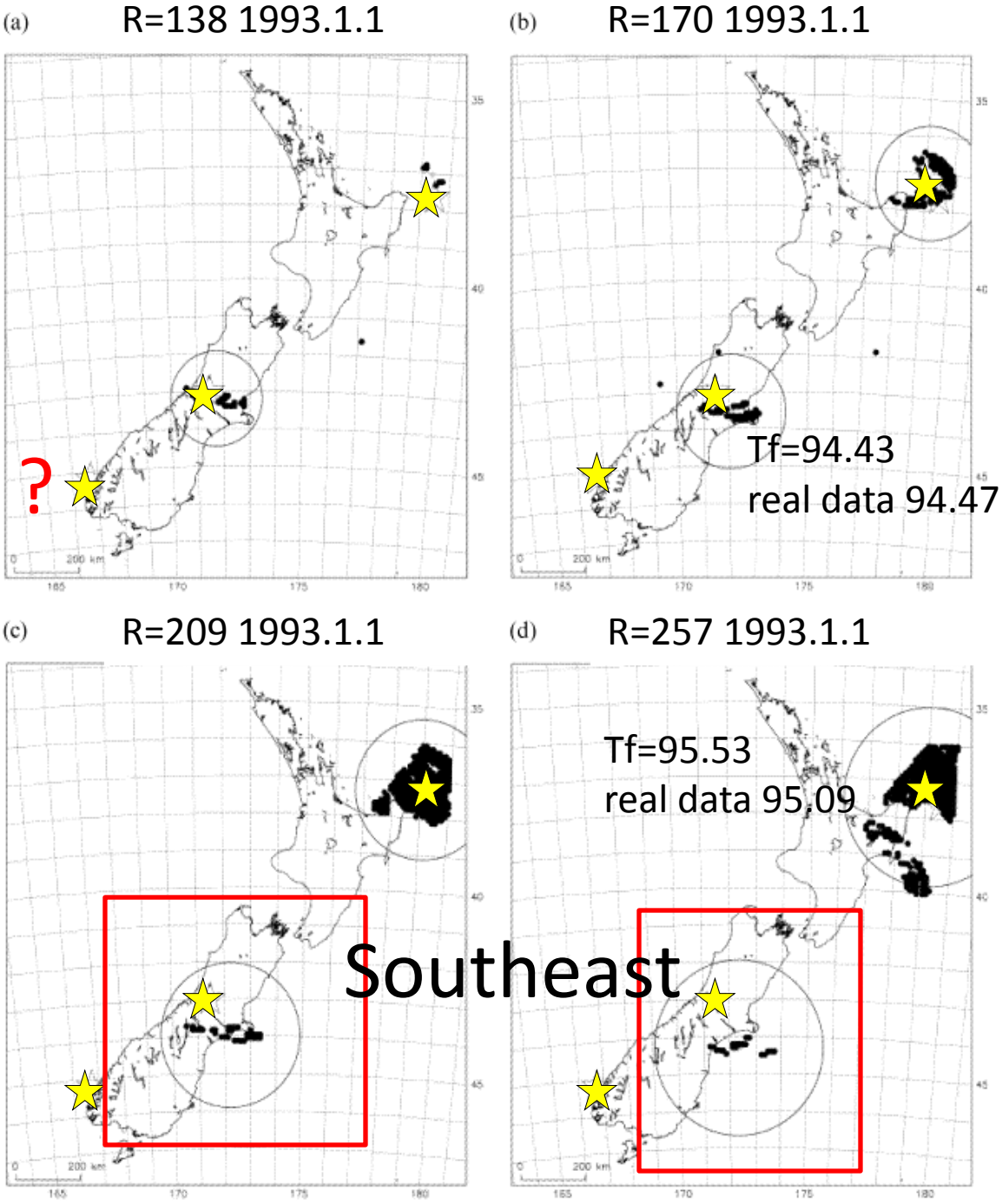
Jau'me & Sykes(1999)

Region	Mw	Circular region from equation	Circular region	Epicenter	center	displacement
1(E)	7.0	209	167	37.65° S 179.49° E	37.15° S 179.24° E	**60NNW**
2(A)	6.7	163	139	43.01° S 171.46° E	43.11° S 170.78° E	**56SSW**
3(S)	6.7	163	122	45.21° S 166.71° E	45.21° S 166° E	**56W**

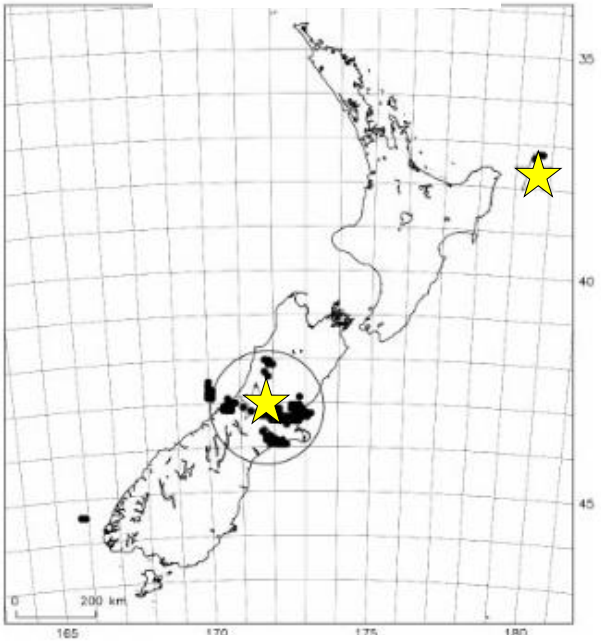
50-60Km offset

Use the method 2

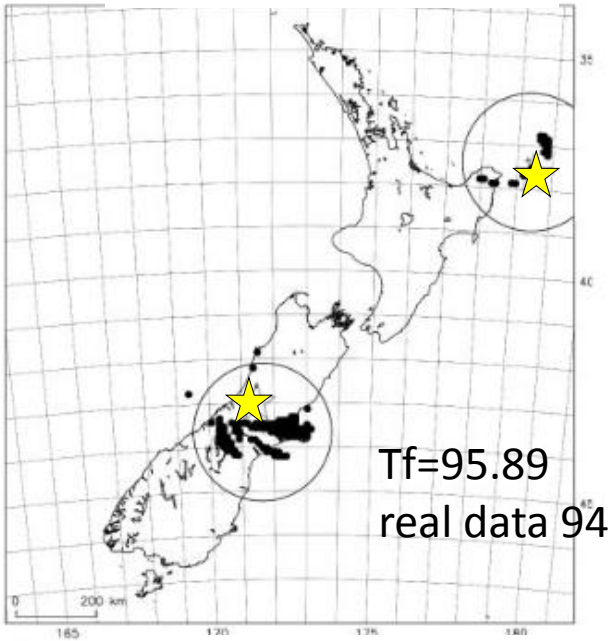
The grid used has a spacing of 10Km. The search is made for radii appropriate for main shock magnitudes (6.5 6.75 7 7.25 radii=138 170 209 257) for end dates of 1993 1994 1995 January 1.



(a) R=138 1994.1.1



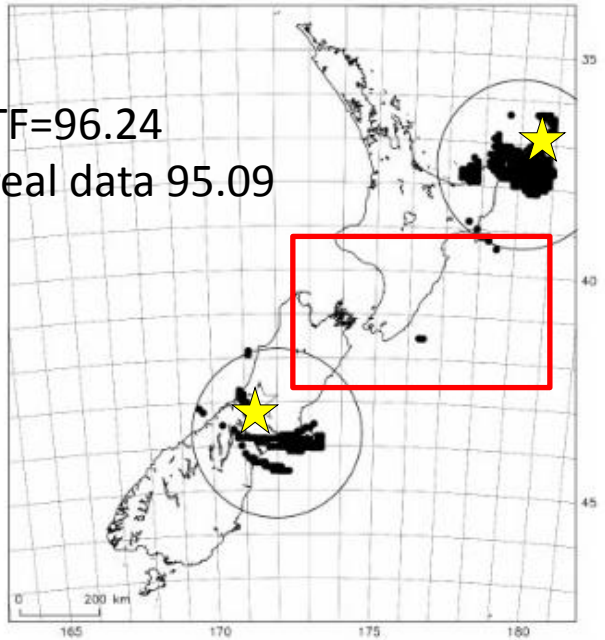
(b) R=170 1994.1.1



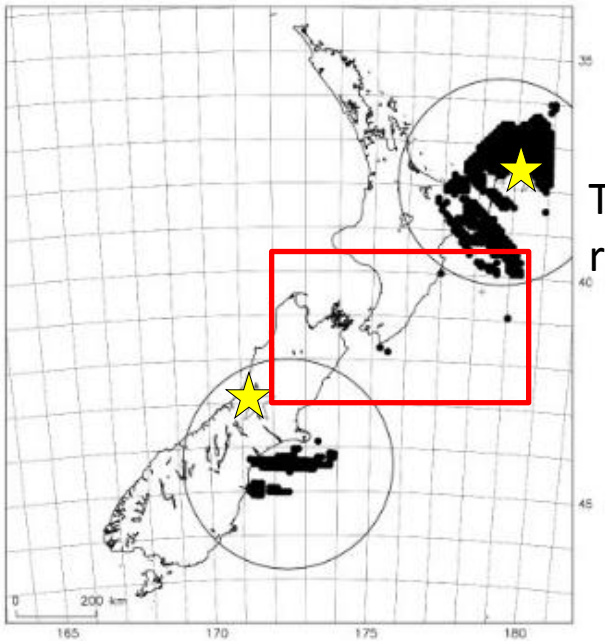
Tf=95.89
real data 94.47

(c) R=209 1994.1.1

TF=96.24
real data 95.09



(d) R=257 1994.1.1



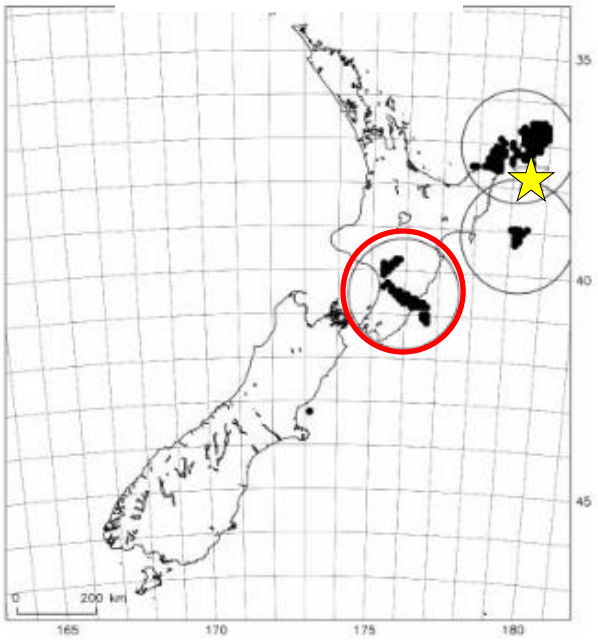
TF=95.02
real data 95.09

disjointed R=138 cluster of positive grid points near the future epicenter of the E earthquake.

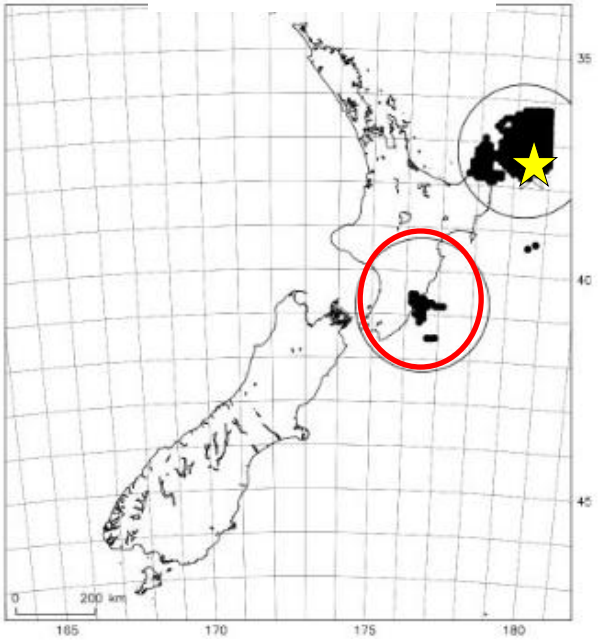
The average Tf are too late from about 2-3 years.

The tf for these cluster are all in 1996 and there has been no large main shock in that region up to present time

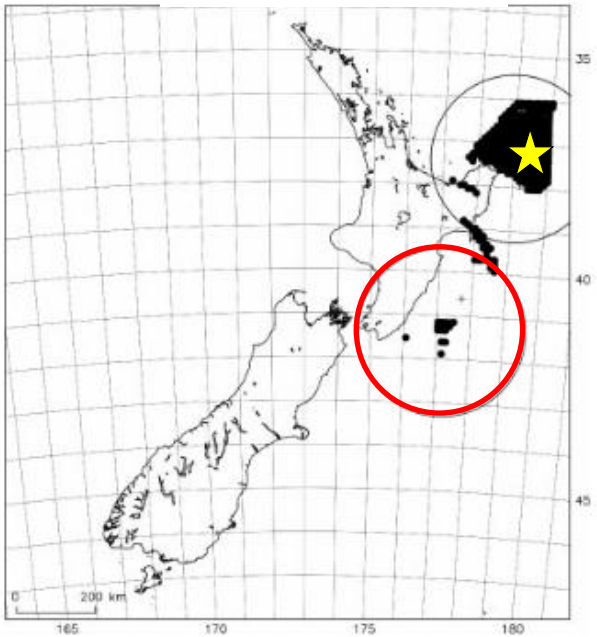
(a) R=138 1995.1.1



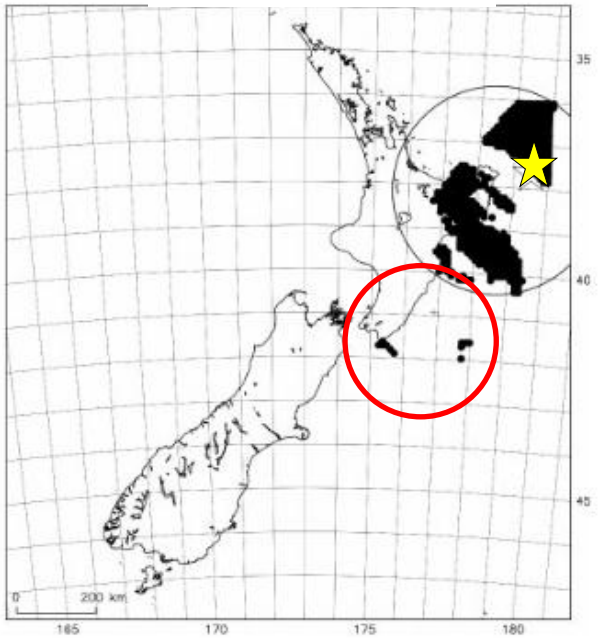
(b) R=170 1995.1.1



(c) R=209 1995.1.1

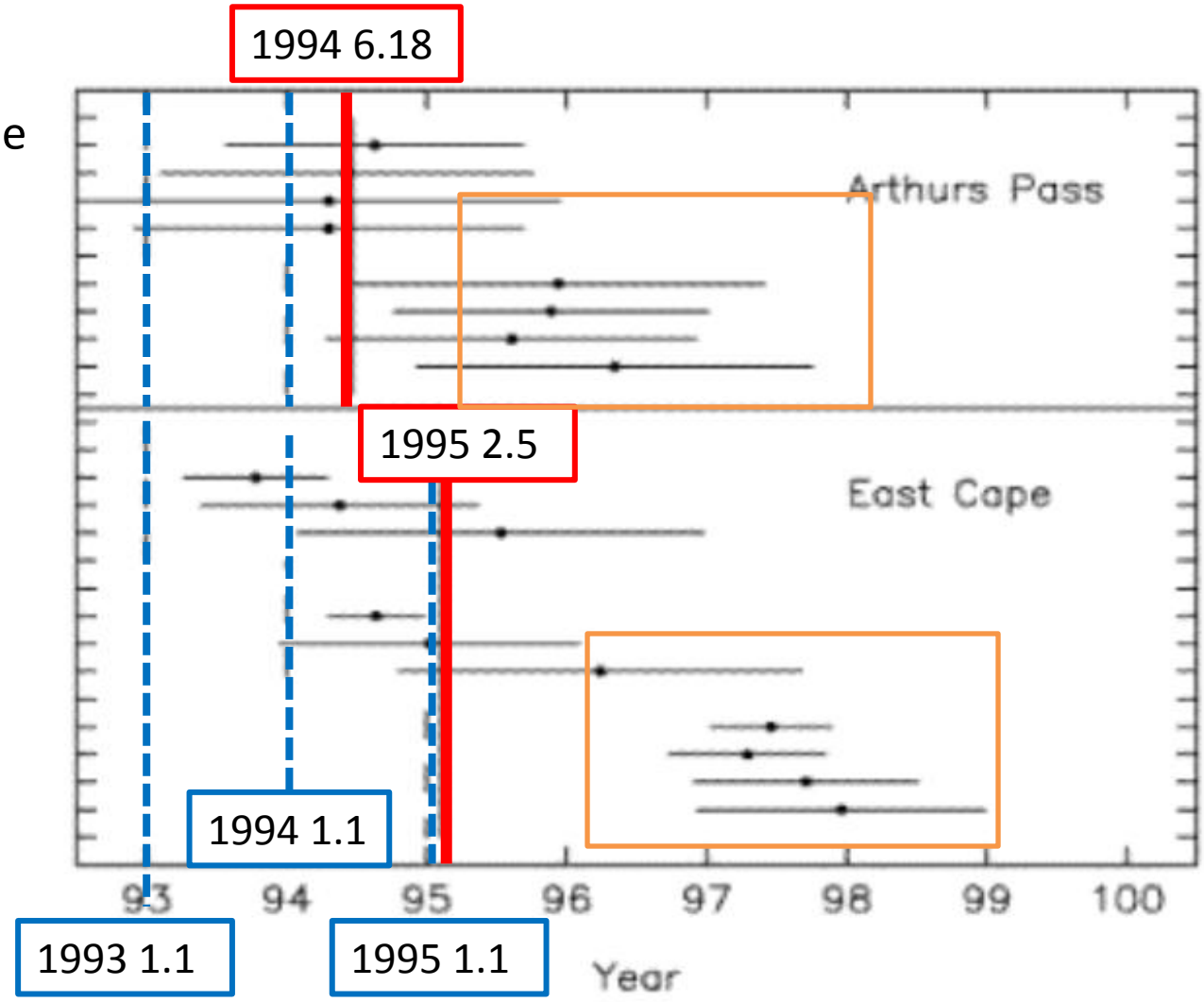


(d) R=257 1995.1.1



The main shock times are only loosely constrained !

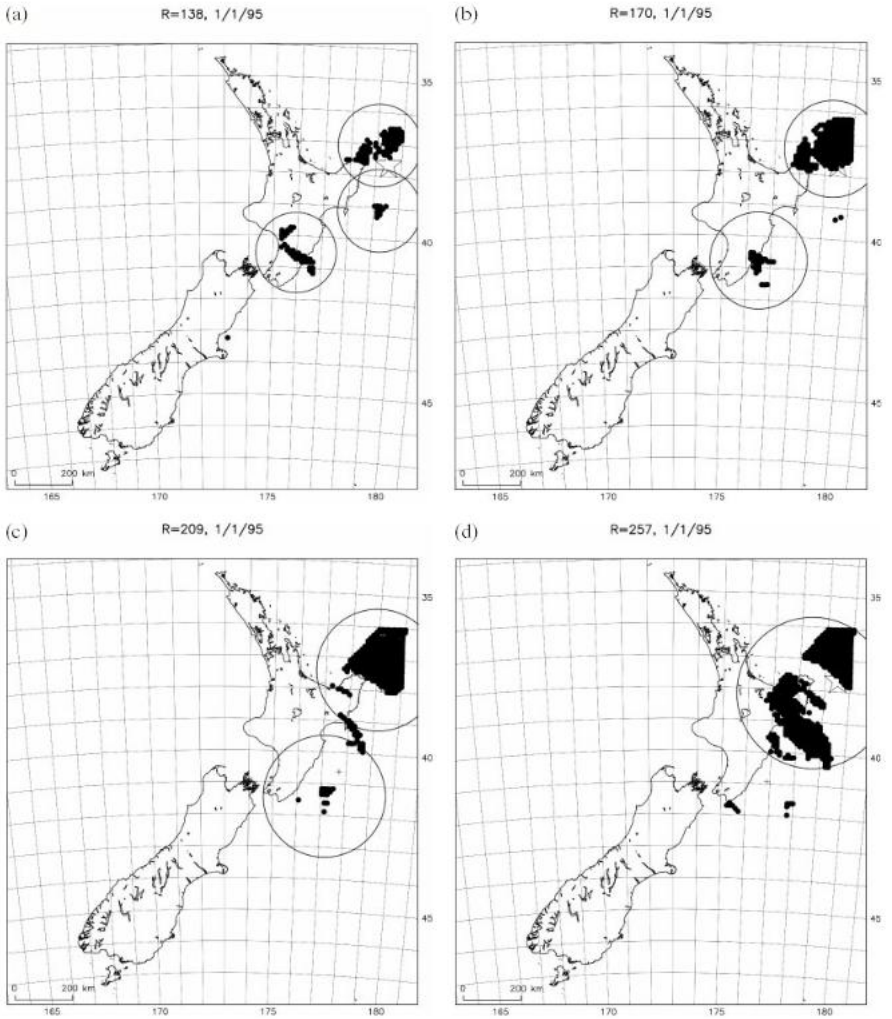
Red line indicates that the earthquake occur time. Blue dash line shows the time of 1993.1.1 and 1994.1.1 and 1995.1.1.



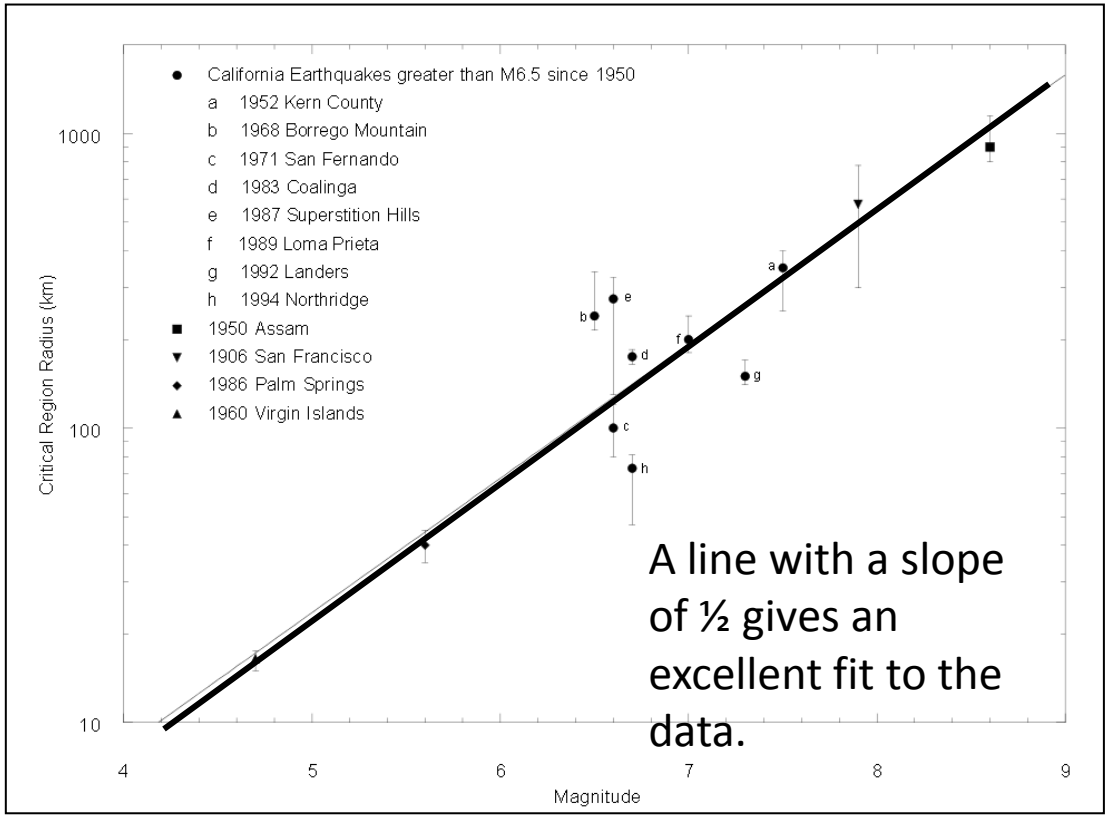
Discussion

- How can the possible overlap
  main shocks of similar size be

- This problem may have preve
  form detecting an AMR patte
  Radius serve to remove the s
  magnitude similar to the mai
  (Huang1998)



- The relation with magnitude and circular region?



Dobrovolsky(1979)reports a similar scaling log R=0.43M
Log R =-0.2+0.36M
Jau'me & Sykes(1999)

One simple possibility is that the energy of the final event scales with the volume of the crust approaching criticality, such that.
$R^3 \propto E$

Kanamori and Anderson(1975)

$$\log R^3 = 3 \log R \propto \log E \propto \frac{3}{2} M_s$$

$$\log R \propto \frac{1}{2} M_s$$

Conclusion

- 1. The result of this study provide qualified support for the AMR(accelerating moment release) model of earthquake occurrence, and show that, in retrospect, two out of three of the largest New Zealand , that is the Arthurs Pass and East Cape earthquake in the last decade could have been forecast by this model.
- 2.For all three events, a circular precursory region can be found such that the moment release rate of the included seismicity is modeled significantly better by the proposed accelerating model than by a linear moment release model.

- 3. By this model,the earthquakes the result is positive in terms of location, such as the offset by 50-60Km from the associated main shock epicenter, but the main shock times are only loosely constrained.

- Thanks for your attention!