



## Receiver function modellering

Thomas R. N.  
Jansson

### Indledning

Seismiske bølger  
Seismogram

### Receiver function

Deconvolution

### Inverst problem

Inversions  
metoder  
Levenberg-  
Marquardt  
Neighbourhood  
search

B. H. Jacobsen

### Fremtiden

### Afslutning

# Receiver function modellering

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11 April 2008

# Oversigt

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## Om specialet

Specialet startede d. 15 Januar. Målet er at undersøge hvordan man "bedst" løser det inverse problem at finde hastighedsstrukturen under en seismisk station ud fra receiver functions.



# Seismiske bølger

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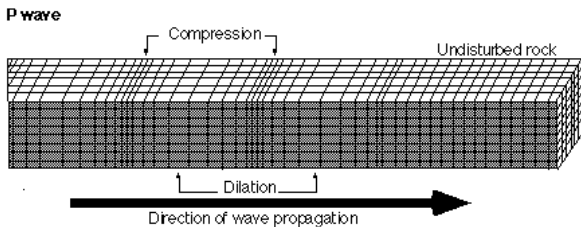
Indledning  
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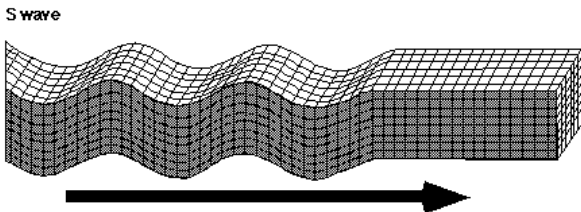
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(Modified from Bruce A. Bolt, *Earthquakes: A Primer*. W H. Freeman & Company. 1978.)



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# Jordens opbygning

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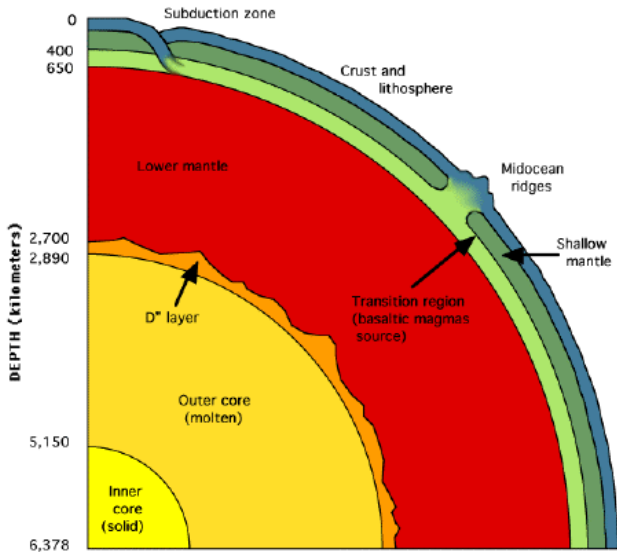
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# Seismogram

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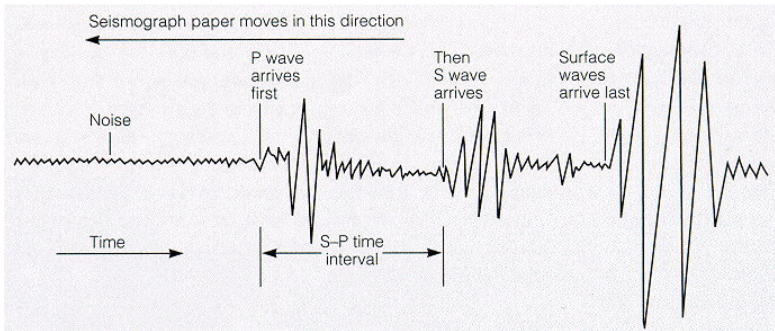
Indledning  
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# Seismogram fra Grønland, 3 komponenter



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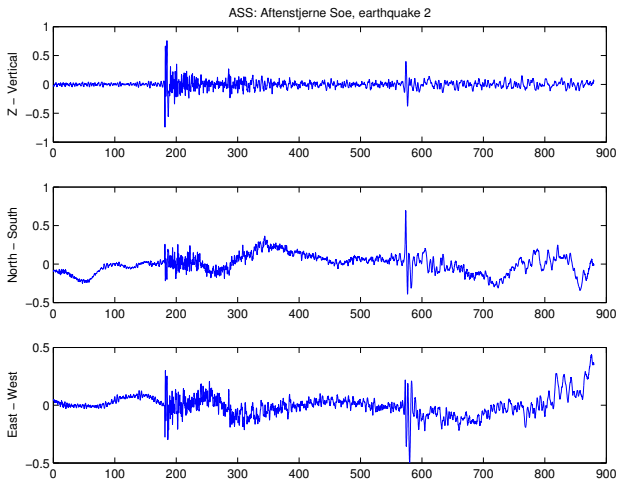
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# Hvad er en Receiver function?

## Receiver function modellering

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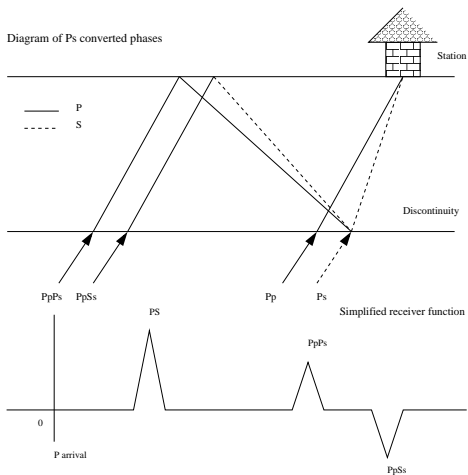
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# Hvad er en Receiver function?

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## Afslutning

- Teleseismiske jordskælv (mere end  $30^\circ$  væk).
- Isoleret seismisk station.
- Bølgen der ankommer har information om:
  - Kilde effekter
  - Effekter fra rejsen gennem jorden
  - Modtager effekter.
- Når en P-bølge rammer et grænselag afbøjes P-bølgen og der dannes en ny S-bølge.
- Roterer de 3 komponenter ind i et L-Q-T koordinat system, hvor L er orienteret i retning af den direkte P bølge. Q er vinkelret på L og indeholder dermed mest SV energi. T er orthogonalt på L og Q.





# Deconvolution

## Receiver function modelling

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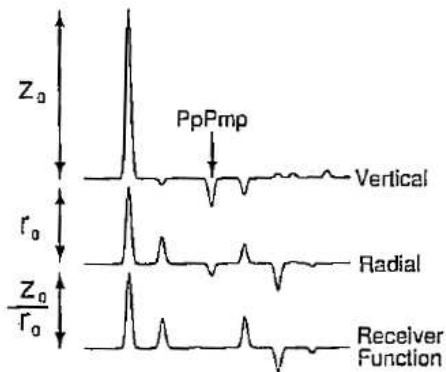
## Fremtiden

## Afslutning

Tager de roterede seismogramkomponenter i vertikal og radial retning og Fourier transformerer dem ind i frekvensdomænet, hvor man dividerer dem for at fjerne de fælles informationer, fra kilden,  $S(\omega)$ , og rejsen gennem jorden,  $T(\omega)$ .

$$H(\omega) = \frac{S(\omega)T(\omega)R(\omega)}{S(\omega)T(\omega)Z(\omega)} = \frac{R(\omega)}{Z(\omega)}$$

$H(\omega)$  er den Fourier transformerede receiver funktionen.



*Vertikal og radial data og bereregnet receiver function, fra [2].*

De individuelle toppe i RF korresponderer til individuelle ankomster i den radiale komponent. Receiver functions kan kan siges at være den radiale komponent uden P multiplier.



# Inverst problem - finde hastighedsmodel ud fra data

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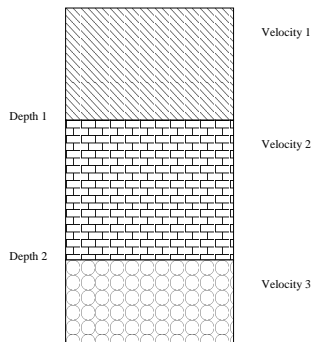
## Fremtiden

## Afslutning

Vi observerer en receiver function,  $\mathbf{d}$ , og vil gerne finde den hastighedsprofil,  $\mathbf{m}$ , der gav anledning til dette, altså et inverst problem. Hvis  $\mathbf{G}$  er sammenhængen mellem data og model, ønske vi at finde de modeller,  $\mathbf{m}$ , der ligger tættest på de observerede data.

$$d_j = G_j[\mathbf{m}], j = 1, 2, 3, \dots, N$$

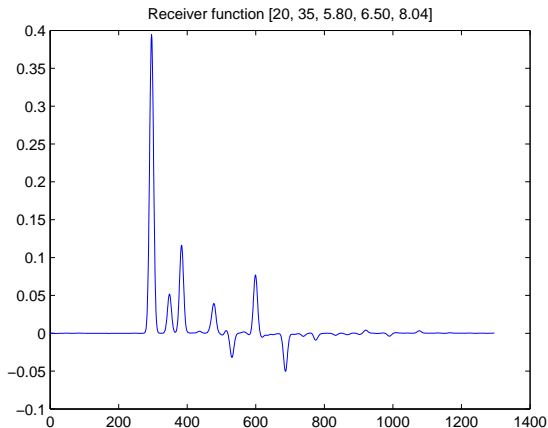
- $d_j$ :  $N=1296$  data punkter
- $G_j$ : Modellen
- $\mathbf{m} = [d1, d2, v1, v2, v3]$ :  $M=5$  dimensional model-parameter vektor.





# Forward model

Bo Holm Jacobsen's forward model.



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# Inversions metoder

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## Afslutning

- Exhaustive search (grid search)
- Levenberg-Marquardt
- Neighbourhood Search



# Levenberg-Marquardt

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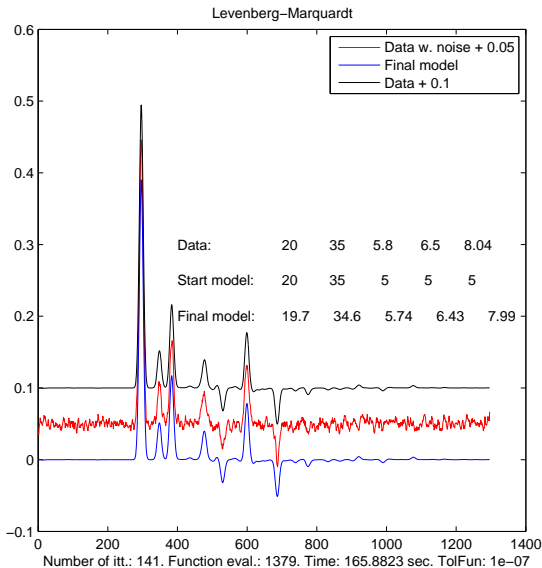
### Levenberg-Marquardt

Neighbourhood search

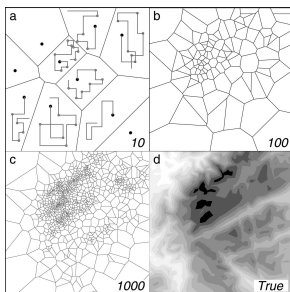
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### Fremtiden

### Afslutning



- 1 Vælg  $n_s$  samples i parameterrummet
- 2 Beregn misfitet for hvert punkt og find de  $n_r$  bedste modeller.
- 3 Generer  $n_s$  nye modeller inde i Voronoicellerne af de  $n_r$  bedste modeller.
- 4 Gå tilbage til punkt 2.



Figur fra artikel [4].



# Neighbourhood algoritmen

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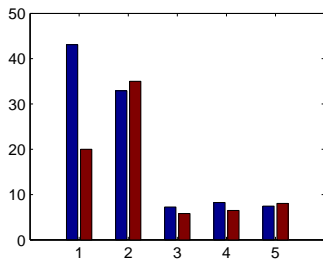
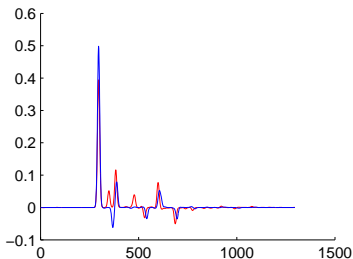
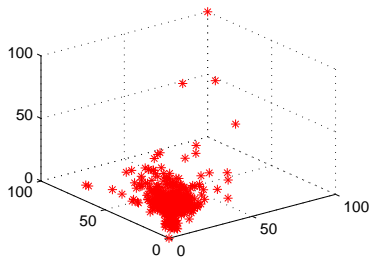
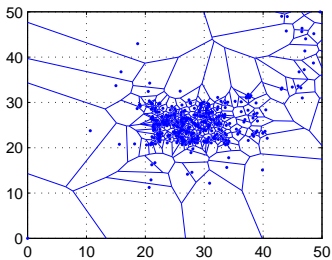
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# B. H. Jacobsen - 0 iterationer

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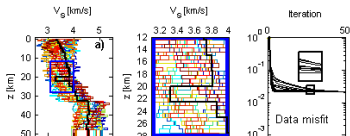
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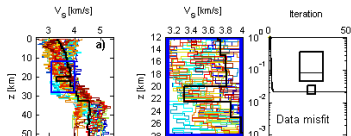
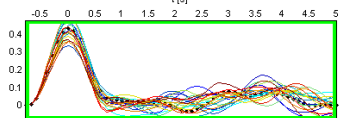
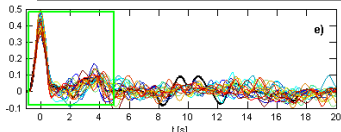
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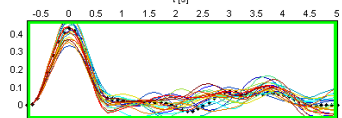
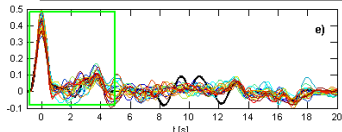
Afslutning



Classical stratification in depth - rather slow convergence



New stratification in delay time - rather fast convergence





# B. H. Jacobsen - 1 iterationer

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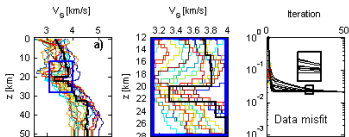
Levenberg-  
Marquardt

Neighbourhood  
search

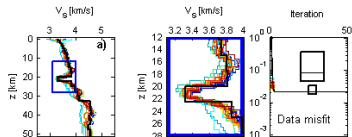
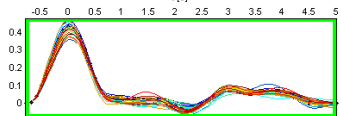
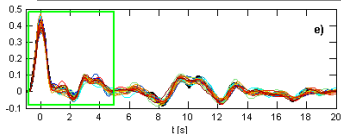
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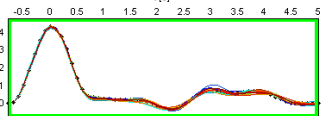
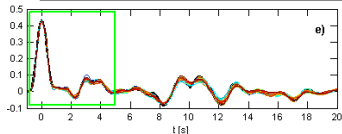
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# B. H. Jacobsen - 5 itterationer

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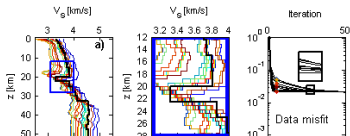
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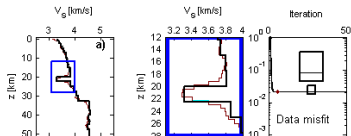
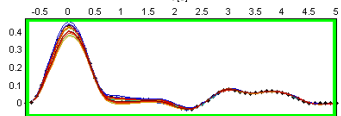
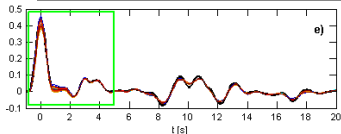
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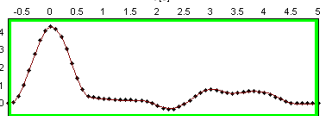
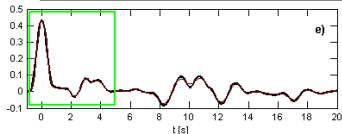
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- Bruge mange faste dybder og kun variere hastigheden.
- Bruge rejsetid i stedet for dybde og hastighed som B. H. Jacobsen.
- Kombinere to metoder - random walk og efterfølgende Levenberg-Marquardt.

# Tak for I ville lytte



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### Referencer



C. A. Langston: *Structure under Mount Rainier, Washington, inferred from teleseismic body waves*, J. Geophys. Res. 84(B9), 4749-4762, **1979**



Charles J. Ammon: *The isolation of receiver effects from teleseismic P waveforms*, Bulletin of the seismological Society of America 81(6), 2504-2510, **1991**



T. Dahl-Jensen, T.B. Larsen, I. Woelbern, T. Bach, W. Hanka, R. Kind, S. Gregersen, K. Mosegaard, P. Voss, and O. Gudmundsson: *Depth to Moho in Greenland: receiver-function analysis suggests two Proterozoic blocks in Greenland*, Earth and Planetary Science Letters 205(3-4), Elsevier, 379-393, **2003**



R. Rickwood, and Malcolm Sambridge: *Efficient parallel inversion using the Neighbourhood Algorithm*, Geochemistry Geophysics Geosystems 7(11), Q11001, November **2006**

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