Horizontal Coherence of Acoustic Field in the East China Sea
(Some Preliminary Results)

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Outline of the Talk

- Introduction
- The method used for the data processing on the horizontal received array
- Some preliminary result of the data processing
- Conclusion(?) And the further work

Introduction

- The horizontal variant of the ocean can cause the different variant on the delay time of the signal between two sensors, at the same time cause variant on the horizontal coherence.
- Analyze the horizontal coherence and the delay time of the signal may gained some information for the tomography

Introduction

- For analyze the variant of the receive signal data, many undetermined factors affects the process's quality: variant of the array's shape, position, variant of the source's range,etc.
- The relationship between each frequency of the signal (broadband signal process) is often considered as stable, when we try to solve the indeterminations cause by the array's shape,position,range,etc.

Introduction

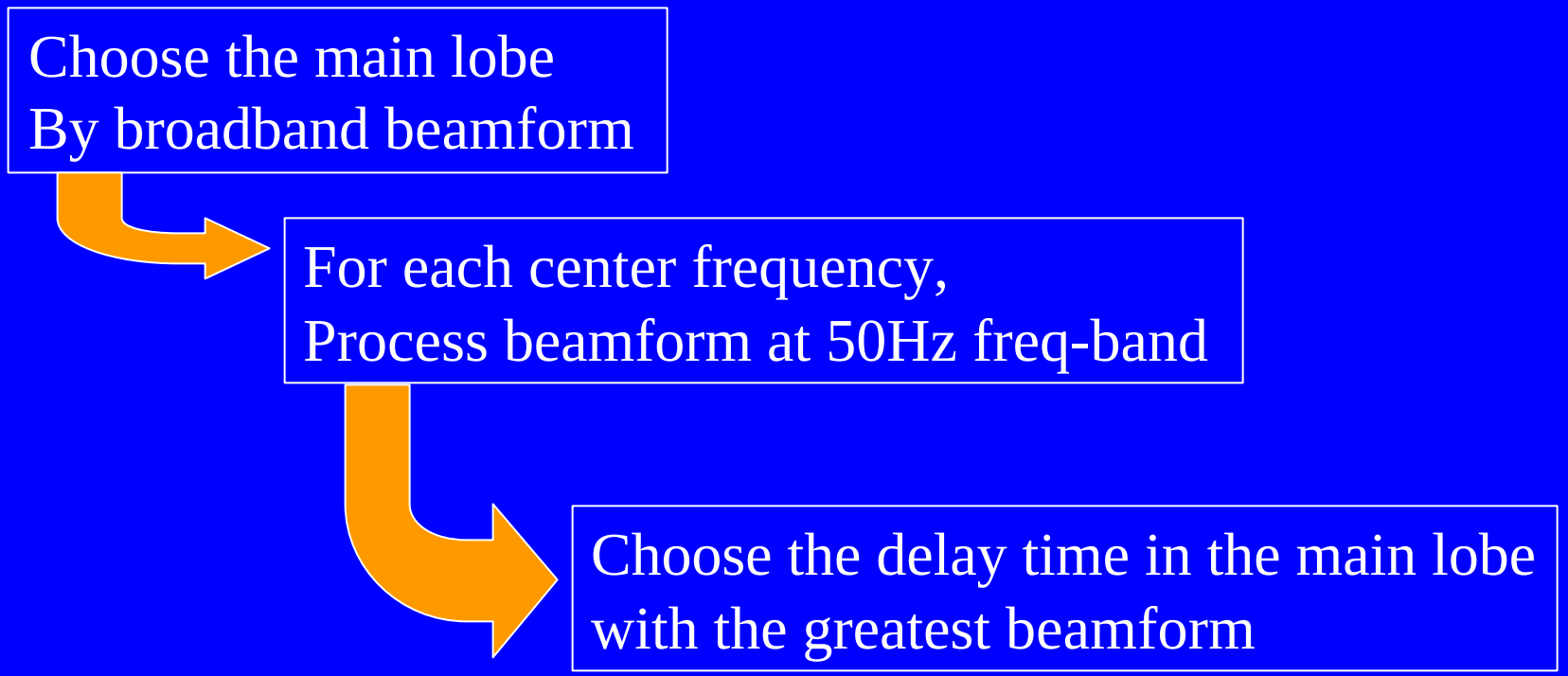
- The data we want to process is received by a flexible horizontal line array, ASIEAX in the east china sea
- 16 receiver sensors, among with 2 sensors fail in the experiment
- 116 groups of explosive signal for the sound propagation (we used for the delay time and the horizontal coherence's estimation)
- The nominal space of the line array is:
- 4.0m,8.0m,…, while in the experiment they fluctuate slightly all the time.

The Method Used for the Process

- The variant of the shape the array
  - Consider the time delay and the coherence between two sensors' data
- The grating lobe of the time delay estimation cause by the space great than the half-wavelength
  - First calculate the beam forming of the broadband received signal, then search for each frequency

The Method Used for the Process

- **The flowchart of the process**



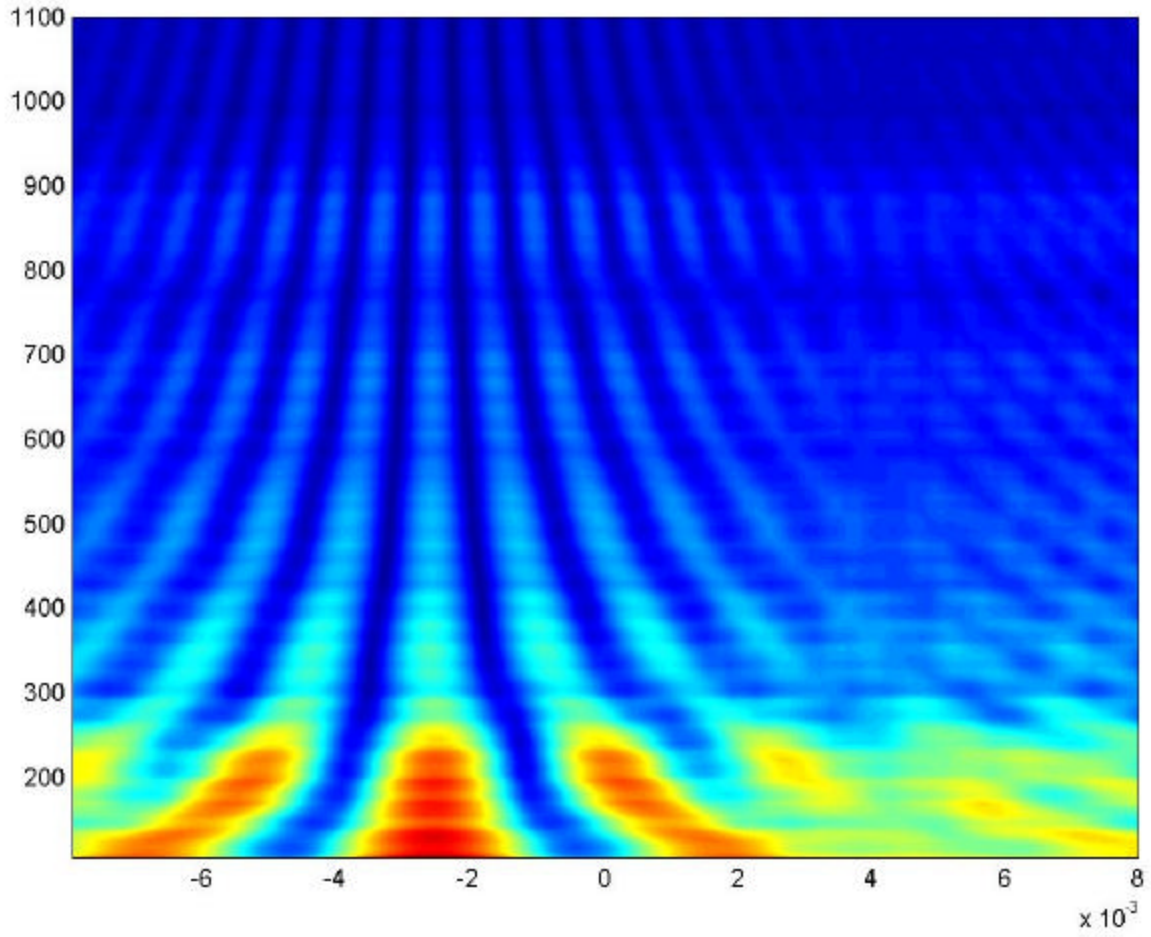
Some Preliminary Result of the Data Processing

- The beam forming of the signal between no.1 and no.3 sensors
- The delay time and the horizontal coherence between no.1 and no.2(no.3,…) signals
  - From different range and different space

Some Preliminary Result of the Data Processing

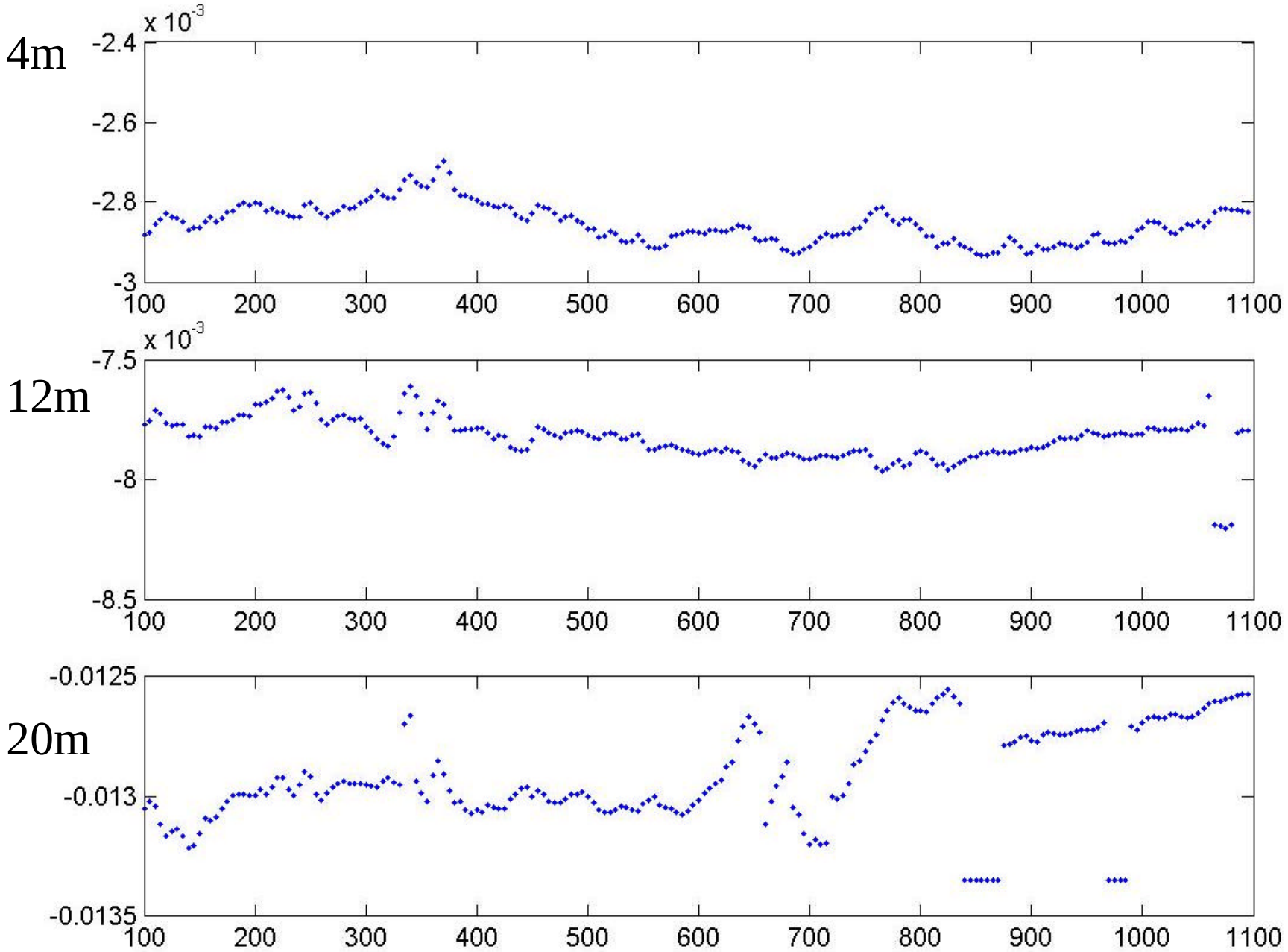
- Focusing on a signal result on a single range and space for explain the process
  - Horizontal coherence for slightly delay time compensate
  - Time delay for different center frequency about different sensor space
  - Horizontal coherence for different center frequency about different sensor space
  - Compare the time delay and the coherence for different center frequency
  - The ambiguity (grating lobes) occurred in the time delay estimation

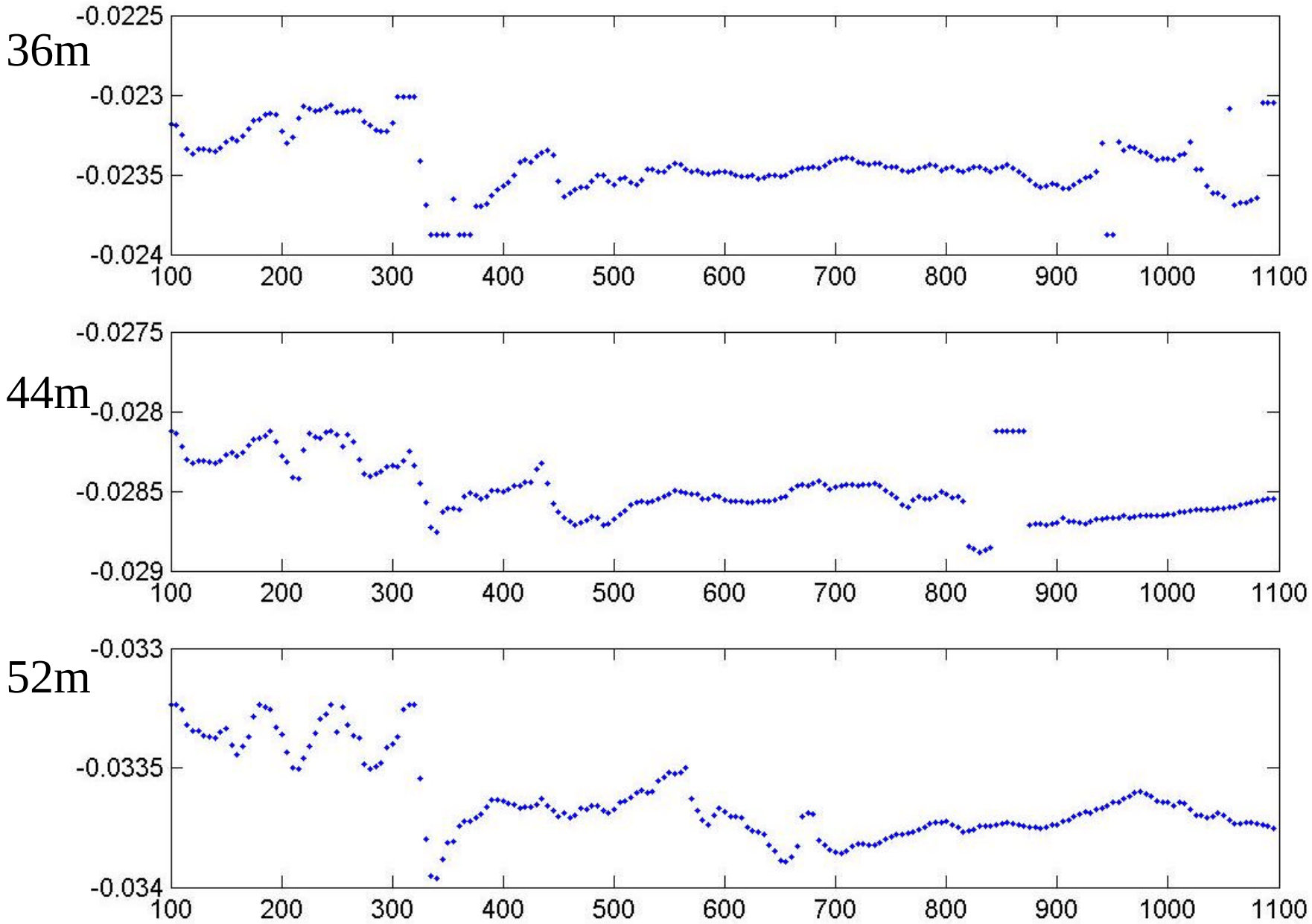
The Beam Forming of the Signal Between No.1 and No.3 Sensors



The Delay Time and the Horizontal Coherence

- From different range
  - 3km~30km
- From different space
  - 4m~116m


4m
x 10^-3
-2.4
-2.6
-2.8
-3
100
200
300
400
500
600
700
800
900
1000
1100
12m
x 10^-3
-7.5
-8
-8.5
20m
-0.0125
-0.013
-0.0135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-0.0225
-0.023
-0.0235
-0.024
100
200
300
400
500
600
700
800
900
1000
1100
44m
-0.0275
-0.028
-0.0285
-0.029
100
200
300
400
500
600
700
800
900
1000
1100
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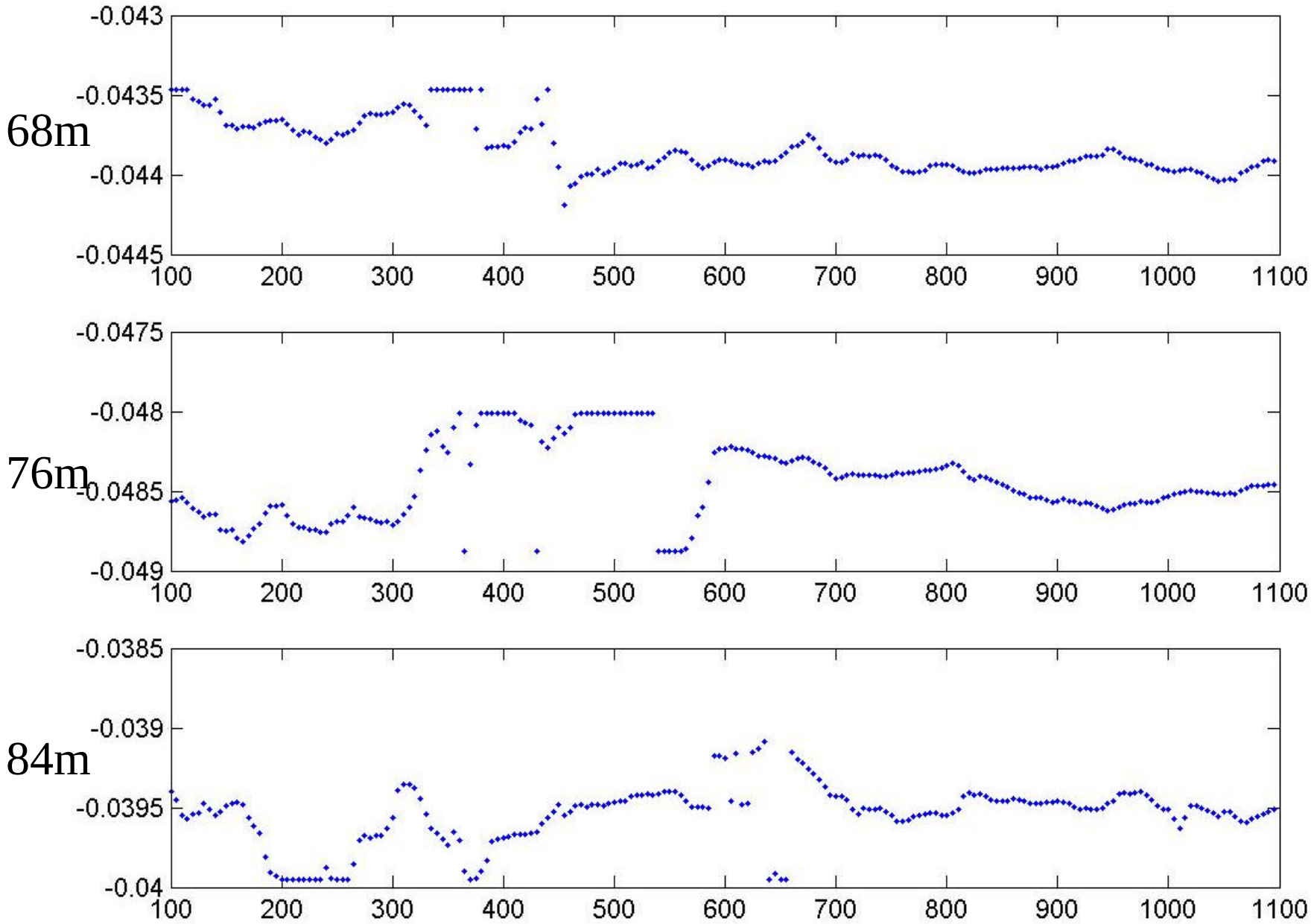
-0.0335
-0.034
100
200
300
400
500
600
700
800
900
1000
1100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200
300
400
500
600
700
800
900
1000
1100
76m
-0.0475
-0.048
-0.0485
-0.049
100
200
300
400
500
600
700
800
900
1000
1100
84m
-0.0385
-0.039
-0.0395
-0.04
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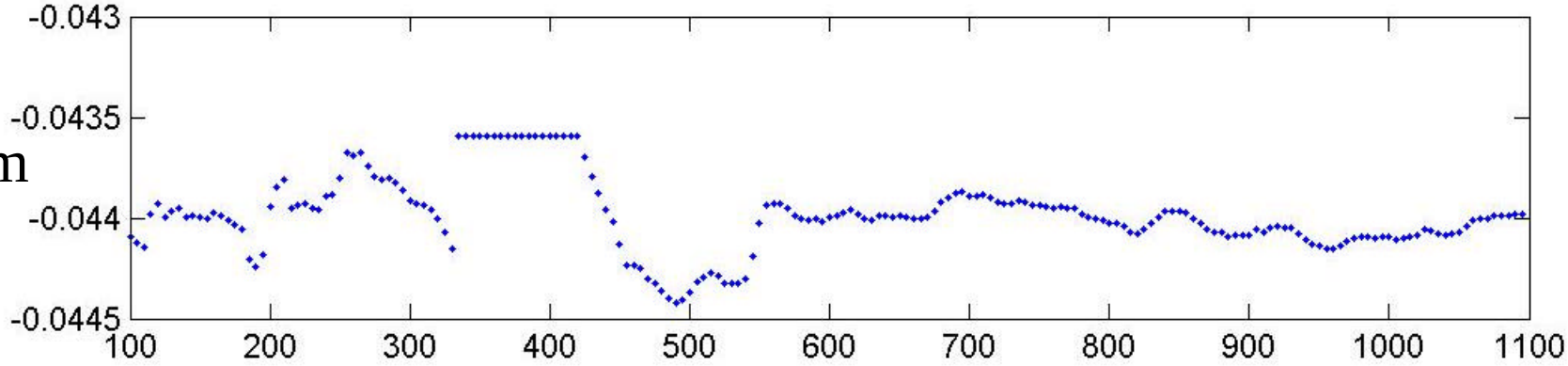
200
300
400
500
600
700
800
900
1000
1100

92m



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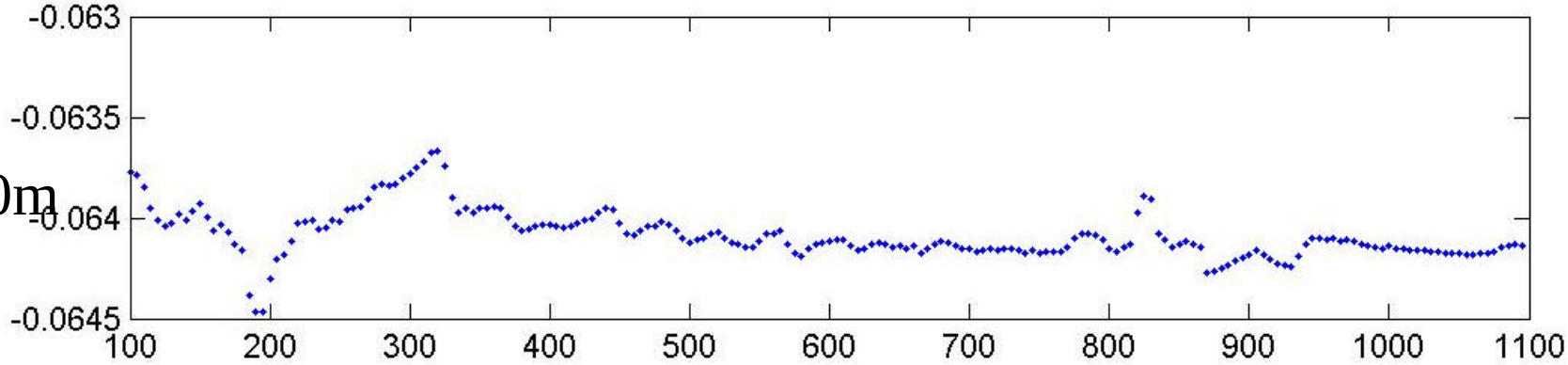
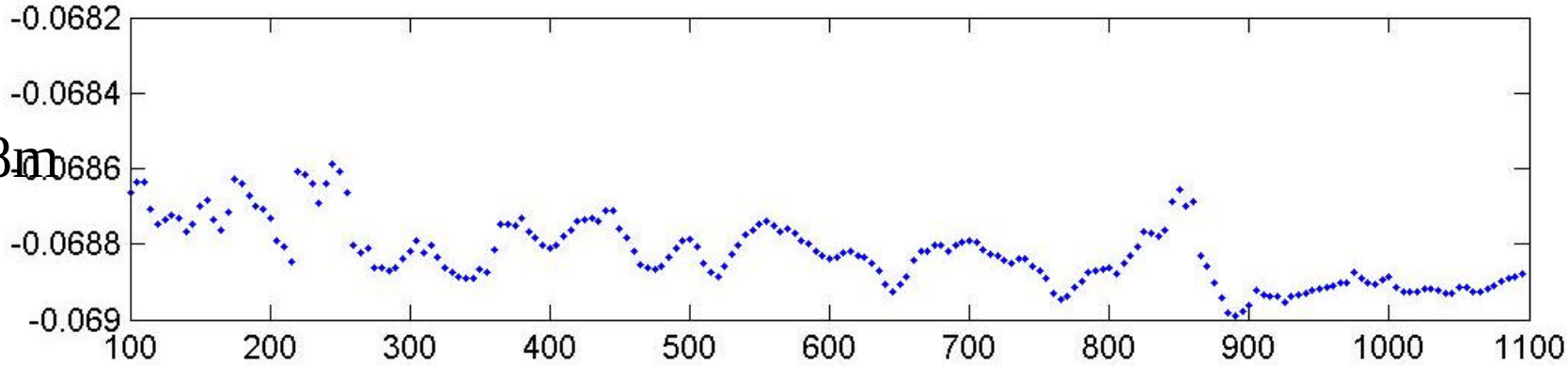
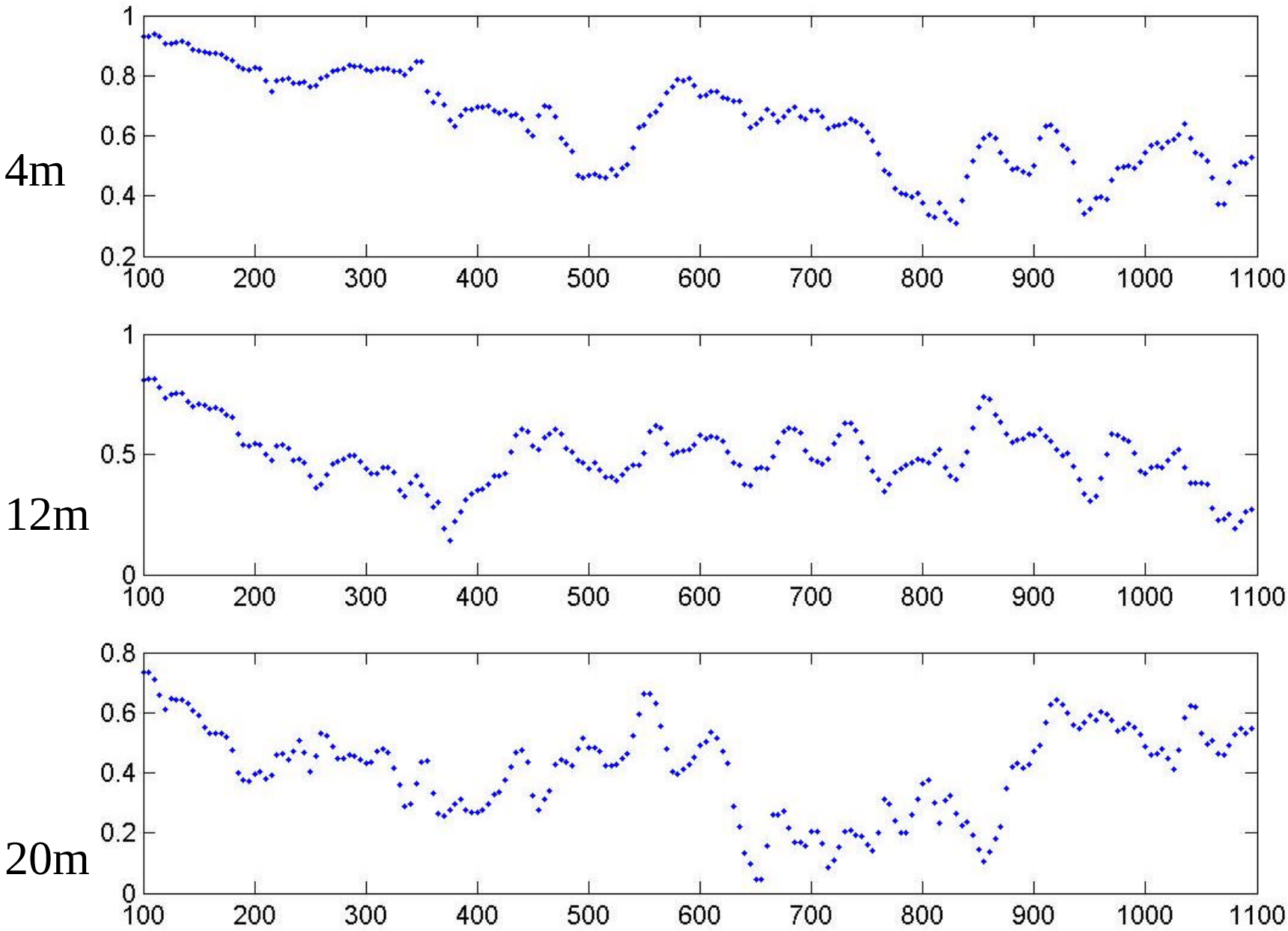
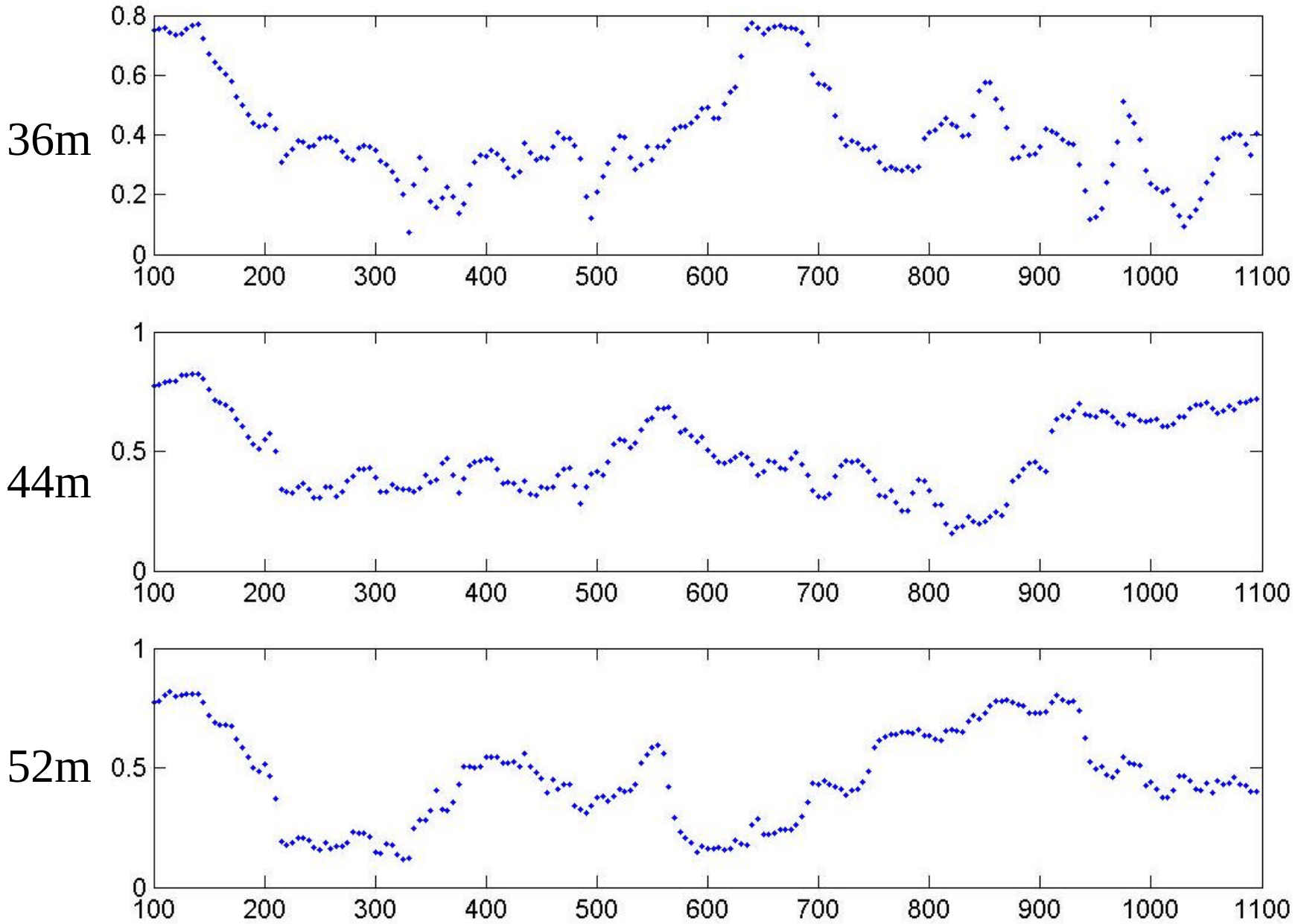
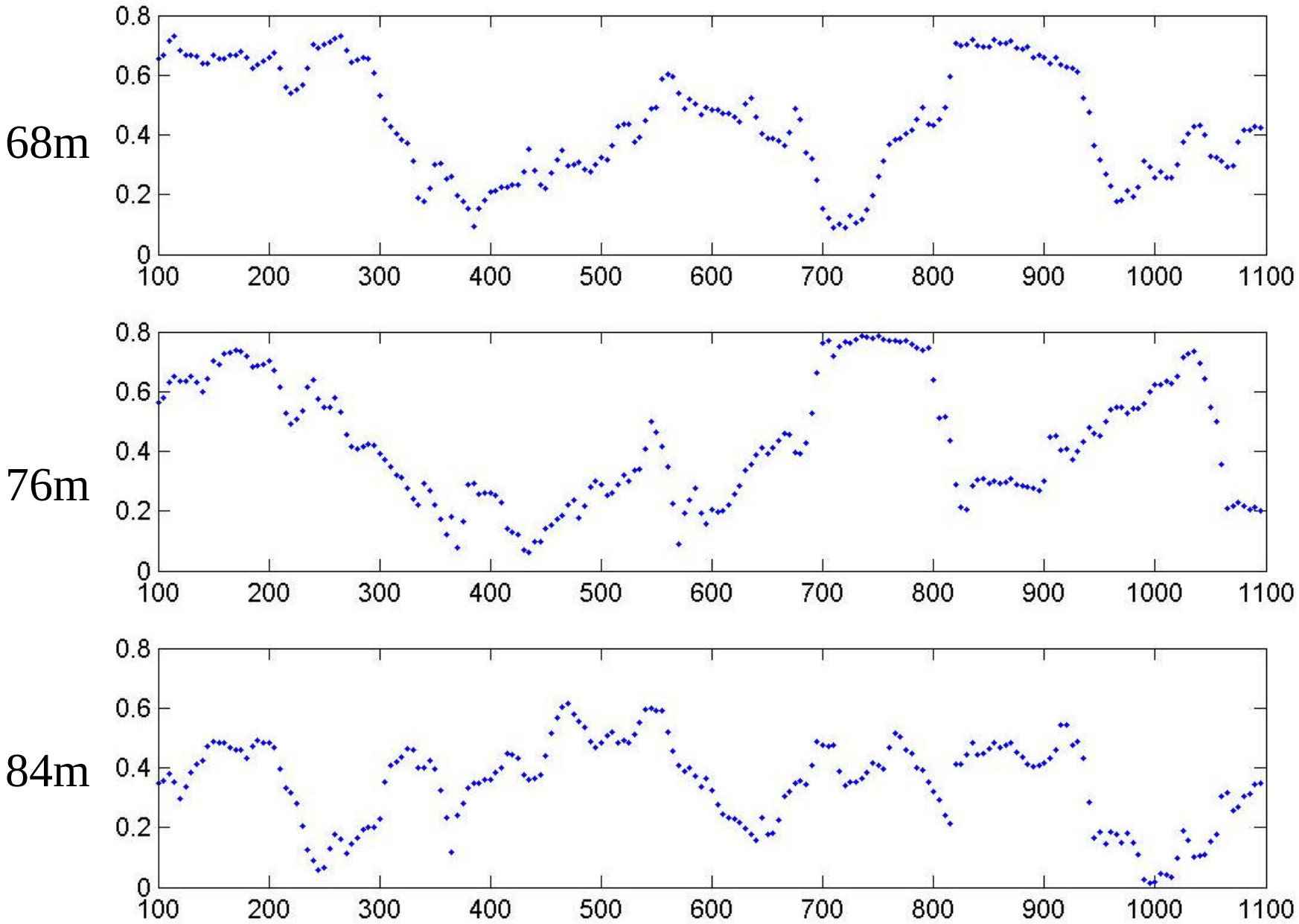


108m

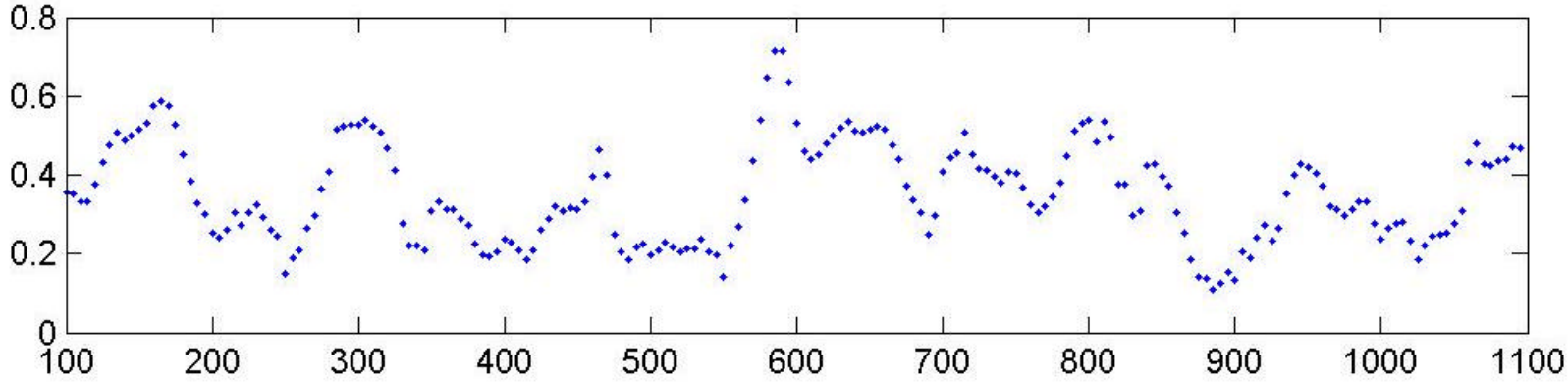



4m
12m
20m
1
0.8
0.6
0.4
0.2
0.5
0
100
200
300
400
500
600
700
800
900
1000
1100


36m
0.8
0.6
0.4
0.2
0
100
200
300
400
500
600
700
800
900
1000
1100
44m
1
0.5
0
100
200
300
400
500
600
700
800
900
1000
1100
52m
1
0.5
0
100
200
300
400
500
600
700
800
900
1000
1100


68m
76m
84m
0.8
0.6
0.4
0.2
0
100
200
300
400
500
600
700
800
900
1000
1100

92m



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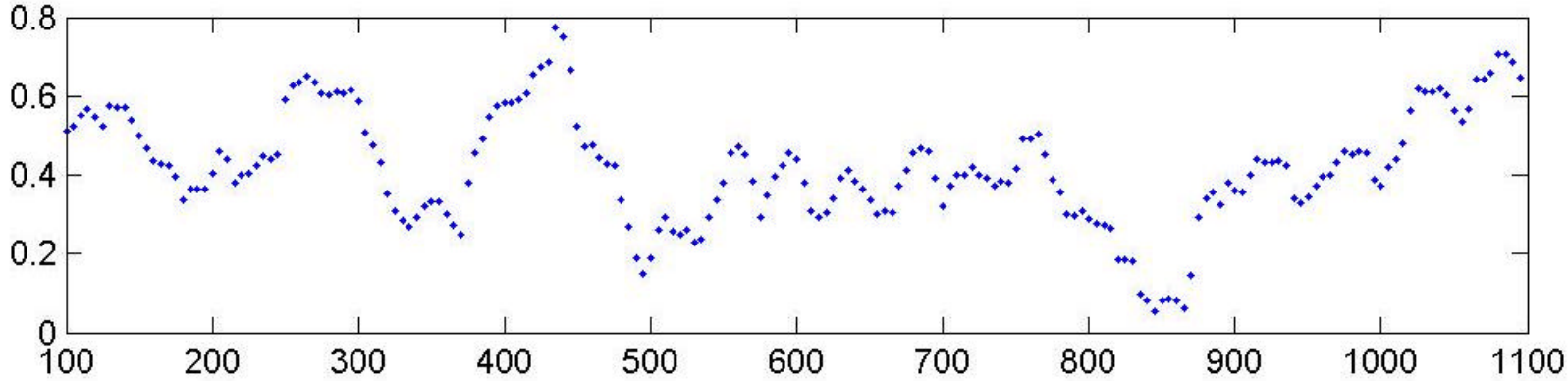

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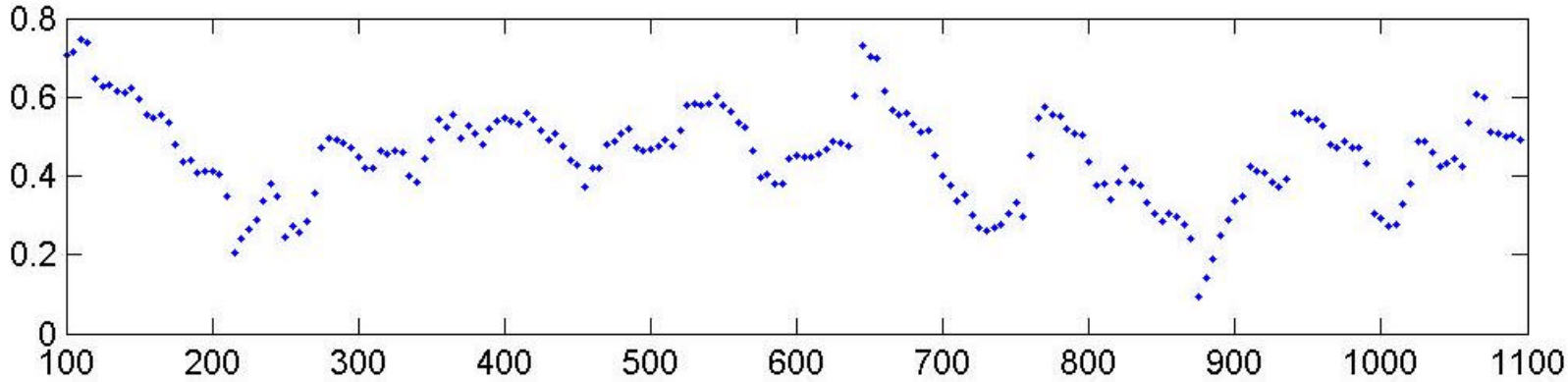
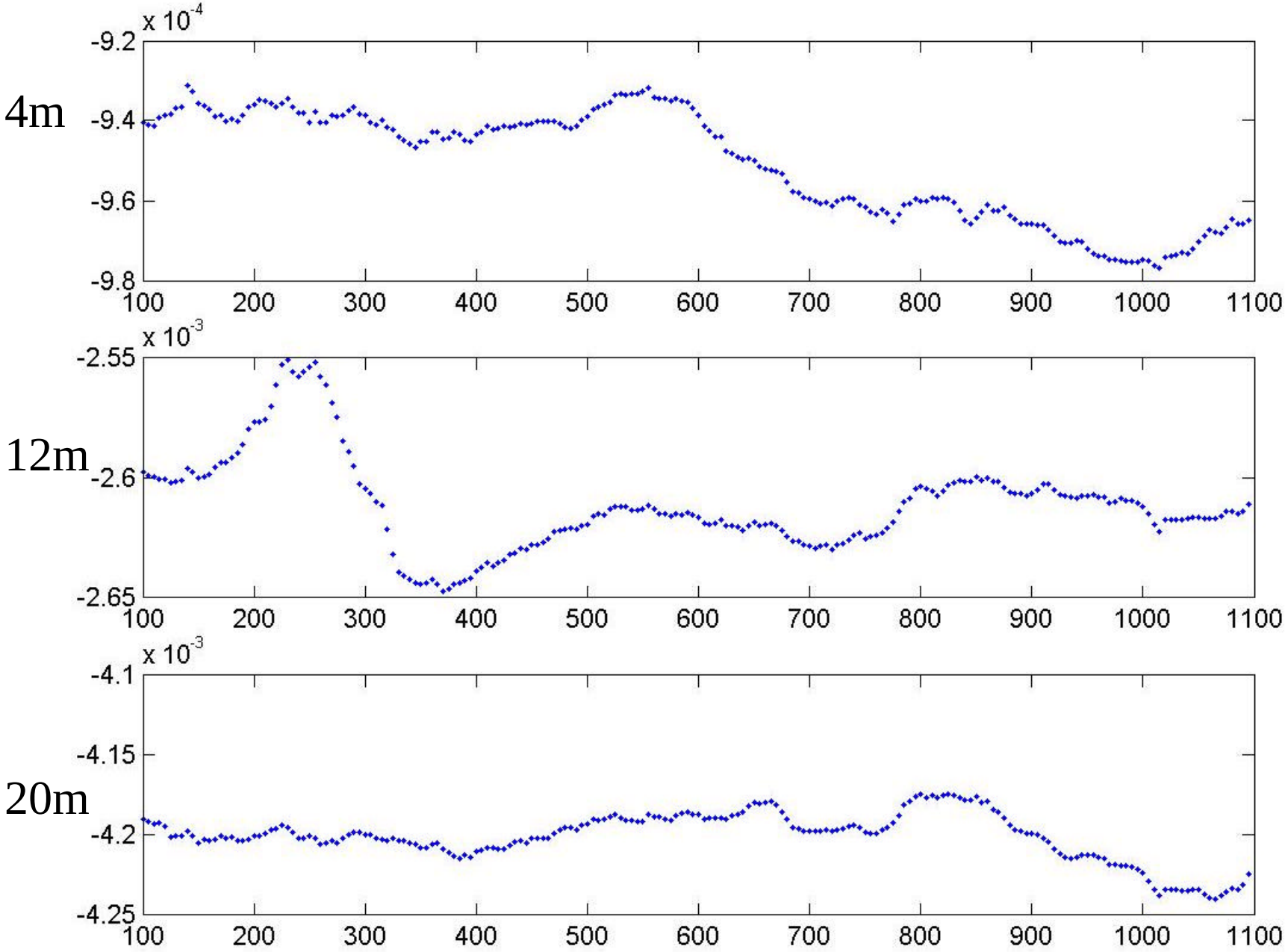


Focusing on a Signal Result on 30 Km

- Horizontal coherence for slightly delay time compensate

Focusing on a Signal Result on 30 Km

- Time delay for different center frequency about different sensor space


4m
x 10^-4
-9.2
-9.4
-9.6
-9.8
100
200
300
400
500
600
700
800
900
1000
1100
12m
x 10^-3
-2.55
-2.6
-2.65
100
200
300
400
500
600
700
800
900
1000
1100
20m
x 10^-3
-4.1
-4.15
-4.2
-4.25
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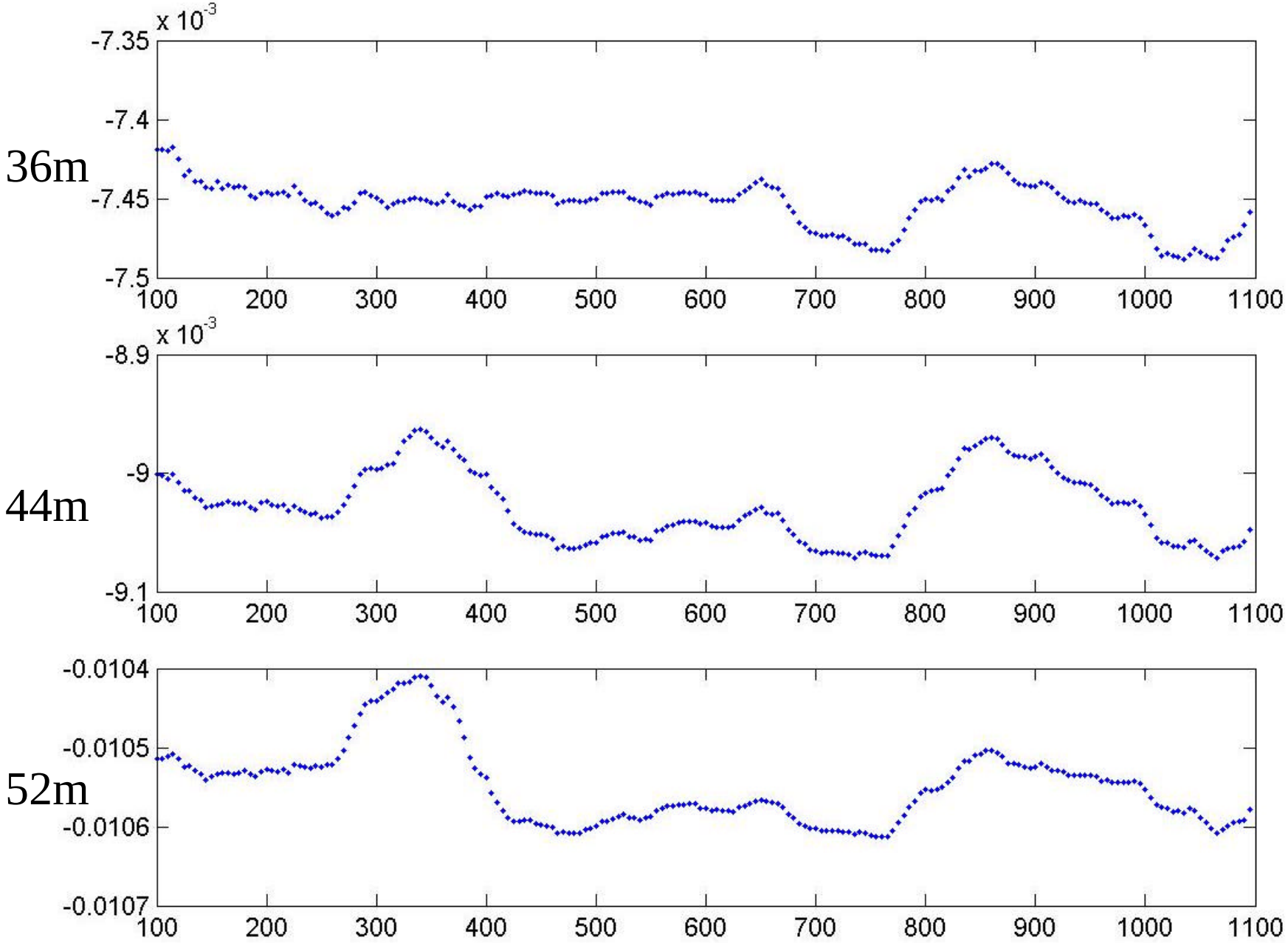
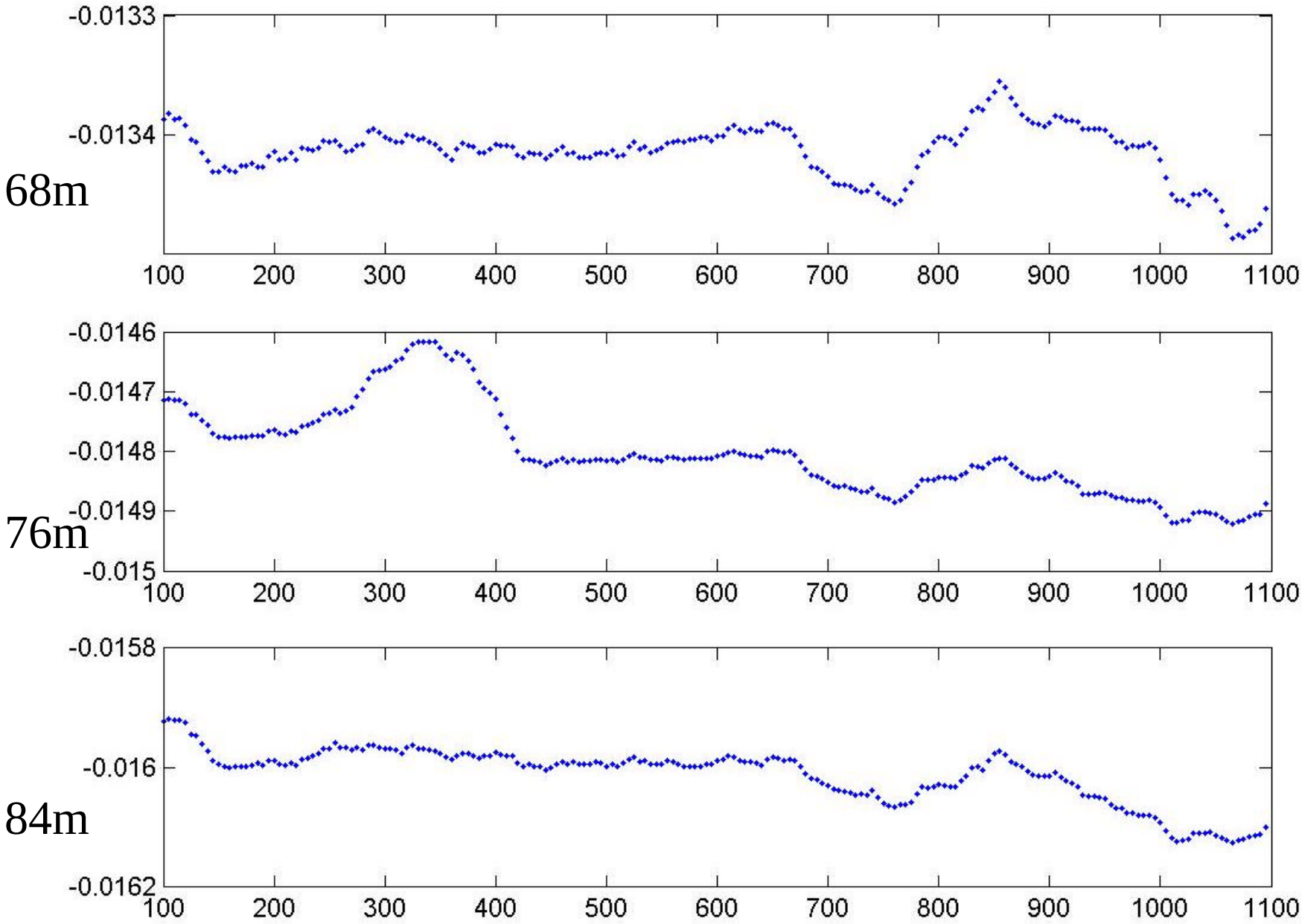
300
400
500
600
700
800
900
1000
1100


36m
x 10^-3
-7.35
-7.4
-7.45
-7.5
100
200
300
400
500
600
700
800
900
1000
1100
44m
x 10^-3
-8.9
-9
-9.1
52m
-0.0104
-0.0105
-0.0106
-0.0107


68m
-0.0133
-0.0134
100
200
300
400
500
600
700
800
900
1000
1100
76m
-0.0146
-0.0147
-0.0148
-0.0149
-0.015
100
200
300
400
500
600
700
800
900
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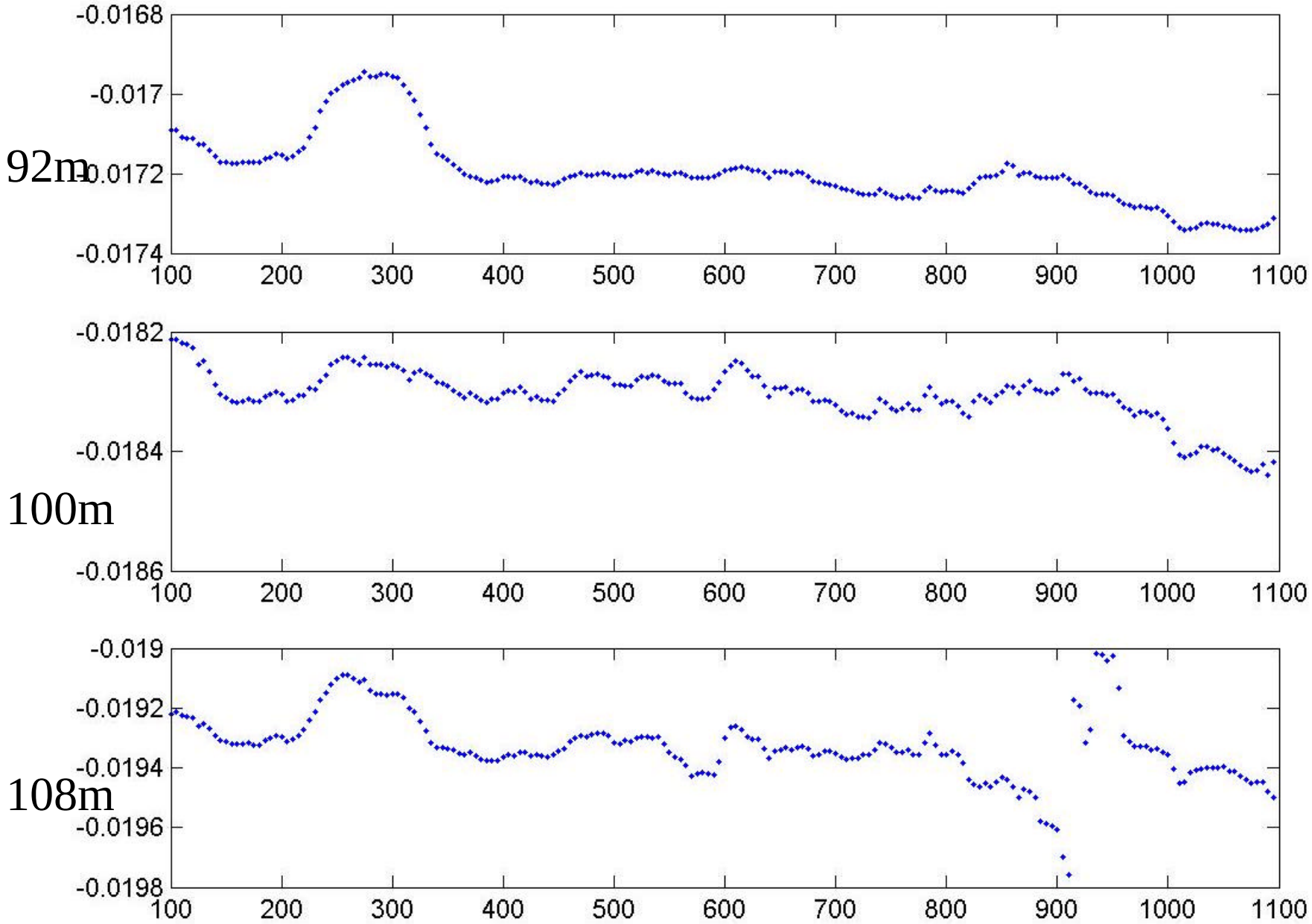
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-0.0172
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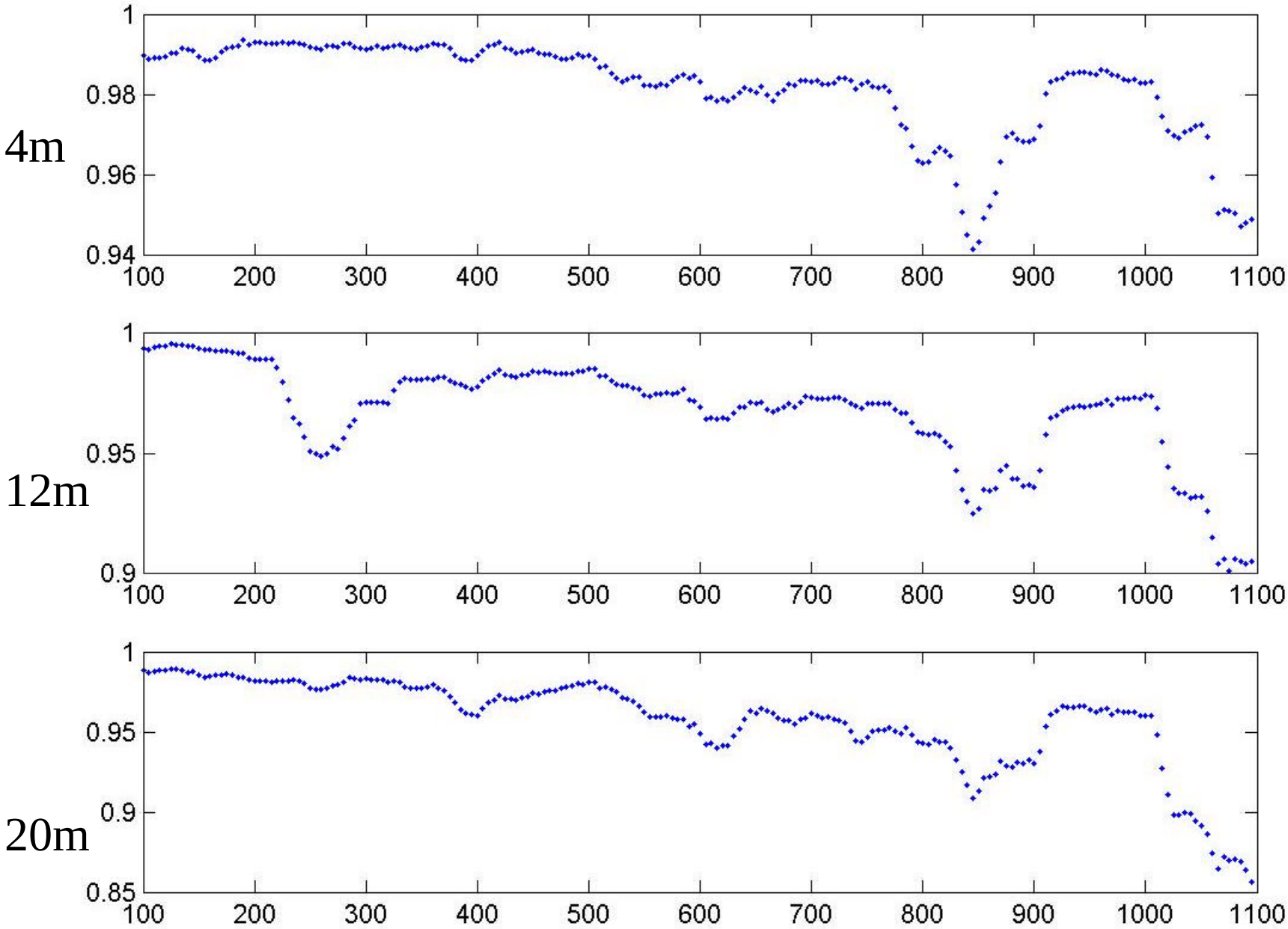
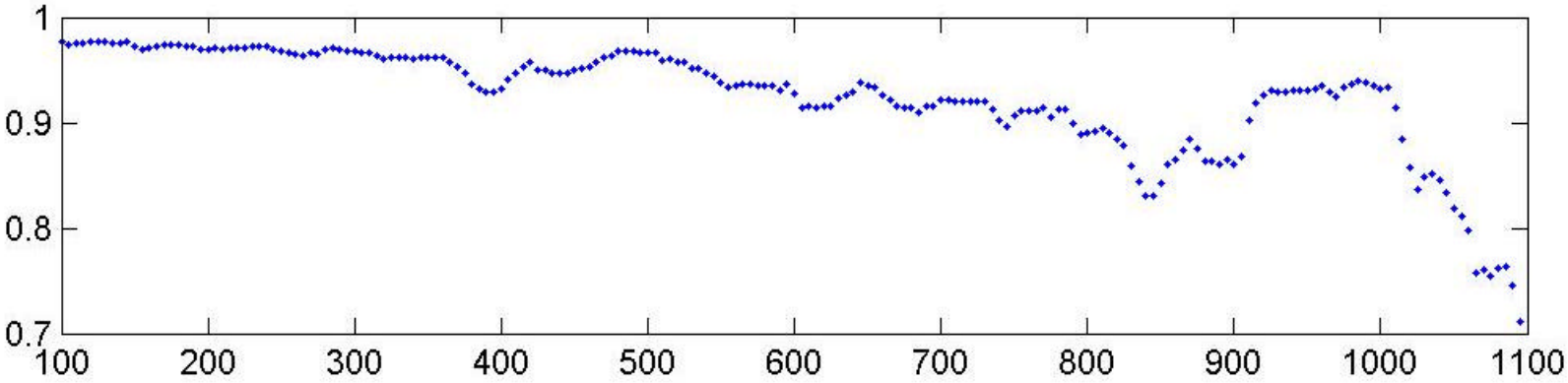
100
200
300
400
500
600
700
800
900
1000
1100
100m
-0.0182
-0.0184
-0.0186
108m
-0.019
-0.0192
-0.0194
-0.0196
-0.0198

Focusing on a Signal Result on 30 Km

- Horizontal coherence for different center frequency about different sensor space


4m
1
0.98
0.96
0.94
100
200
300
400
500
600
700
800
900
1000
1100
12m
1
0.95
0.9
100
200
300
400
500
600
700
800
900
1000
1100
20m
1
0.95
0.9
0.85
100
200
300
400
500
600
700
800
900
1000
1100

36m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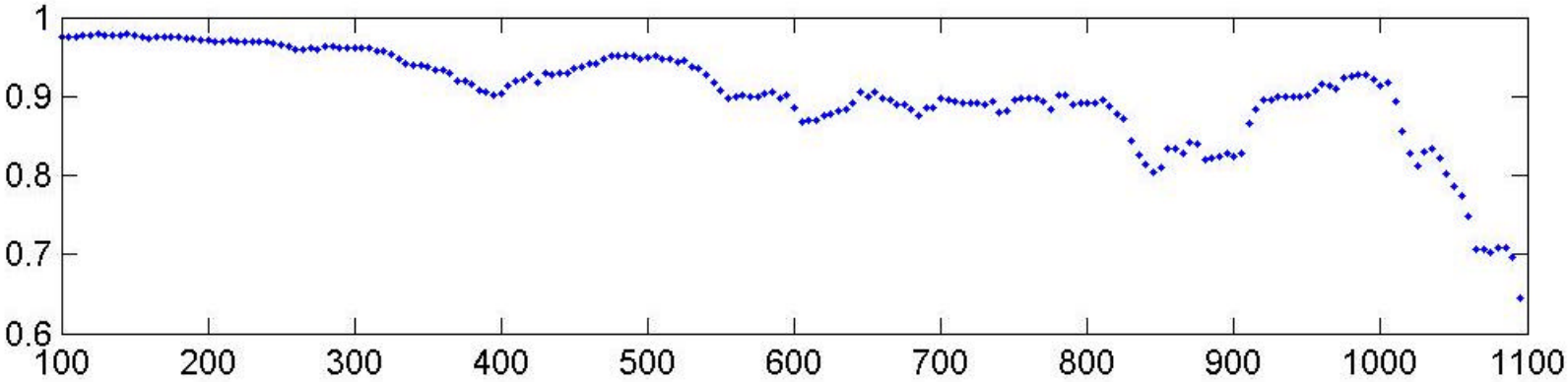
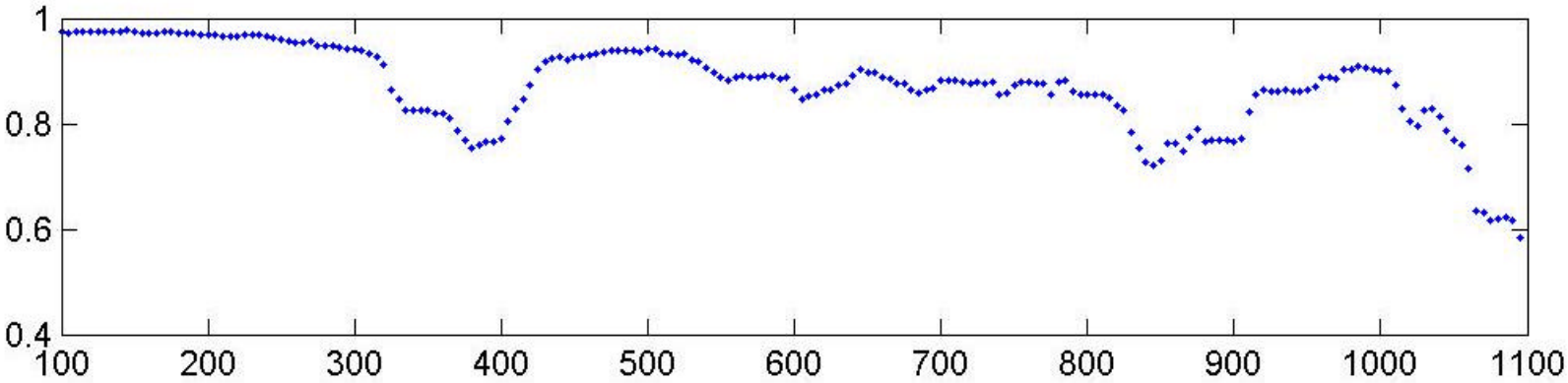
0.9
0.8
0.7
100
200
300
400
500
600
700
800
900
1000
1100

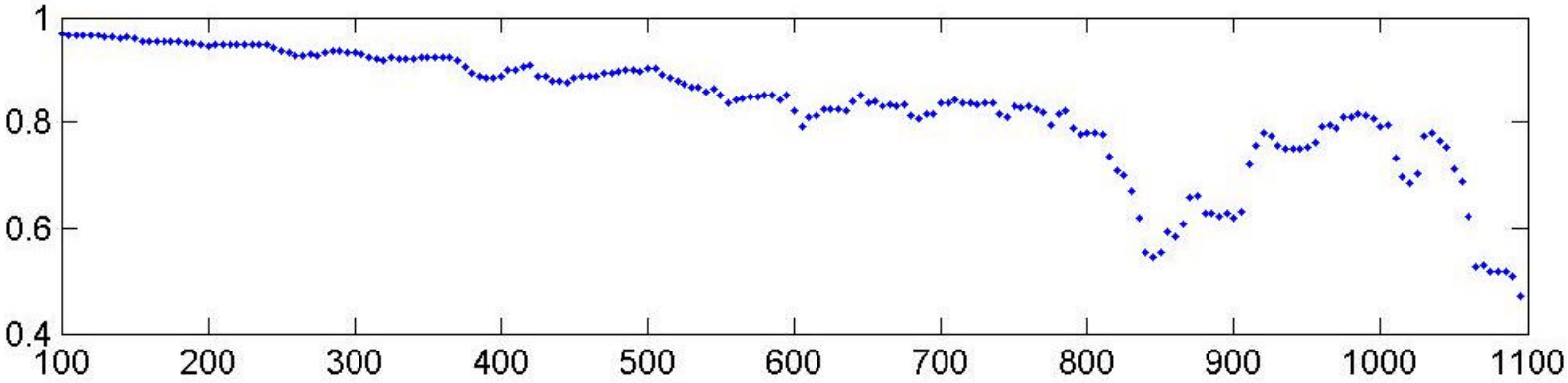
44m


1
0.9
0.8
0.7
0.6
100
200
300
400
500
600
700
800
900
1000
1100

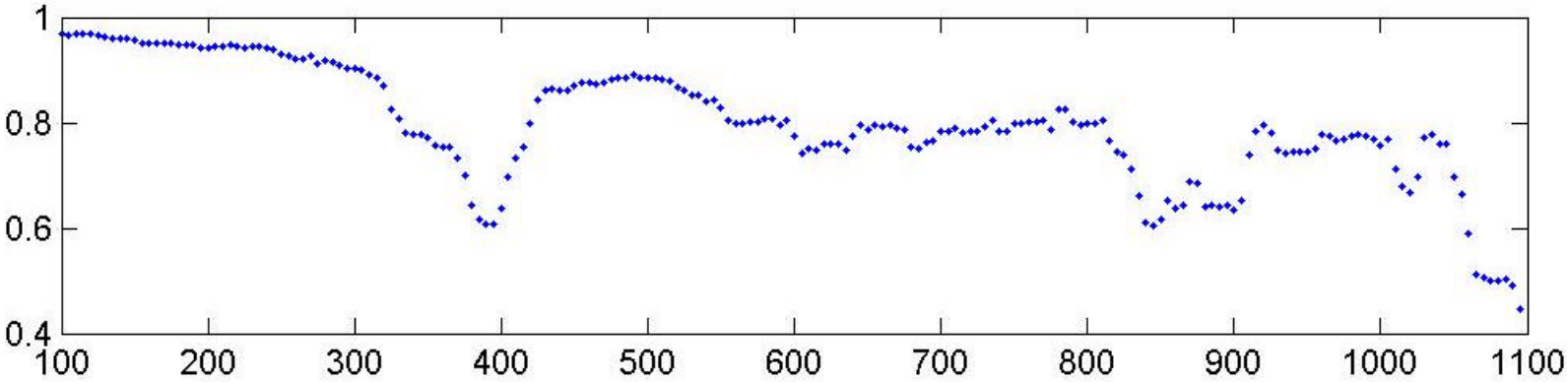
52m


1
0.8
0.6
0.4
100
200
300
400
500
600
700
800
900
1000
1100

68m


1
0.8
0.6
0.4
100
200
300
400
500
600
700
800
900
1000
1100

76m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0.6
0.4
100
200
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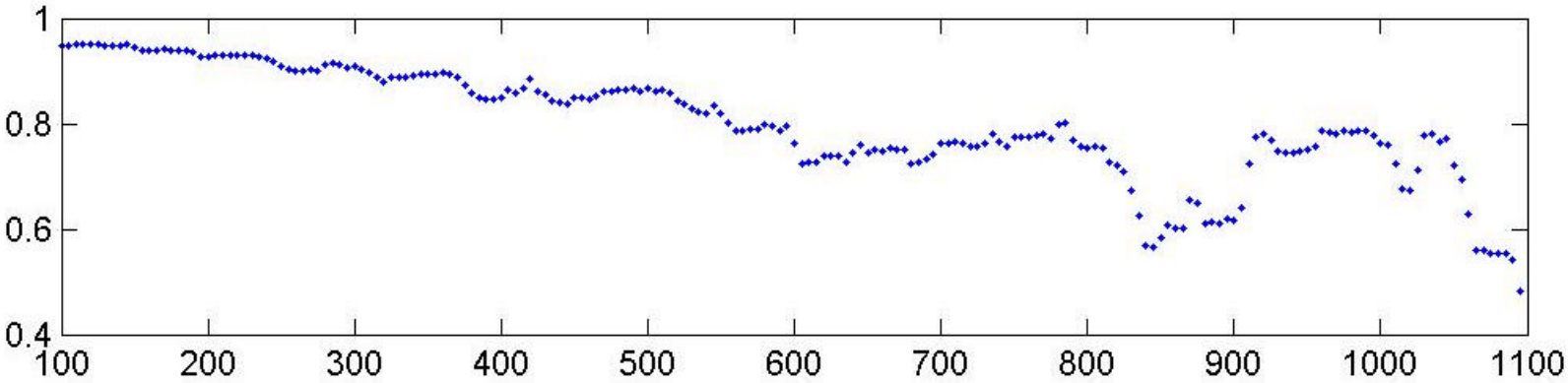
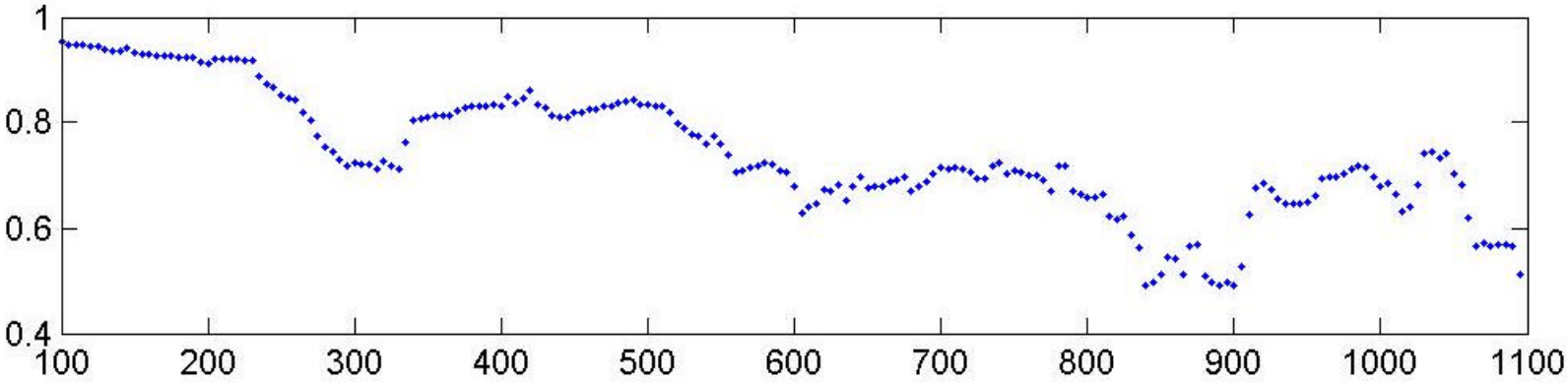
500
600
700
800
900
1000
1100

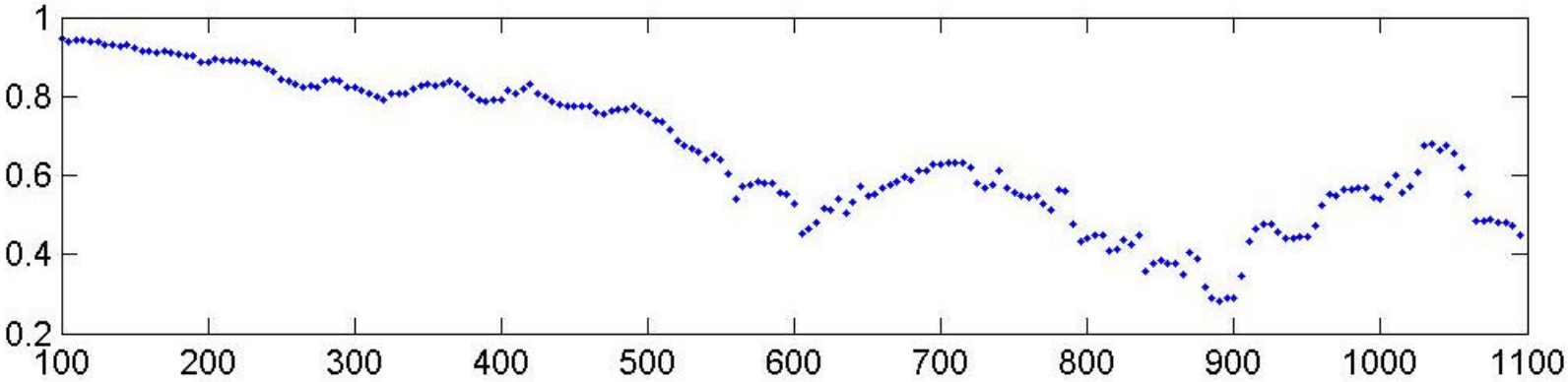
84m


1
0.8
0.6
0.4
100
200
300
400
500
600
700
800
900
1000
1100

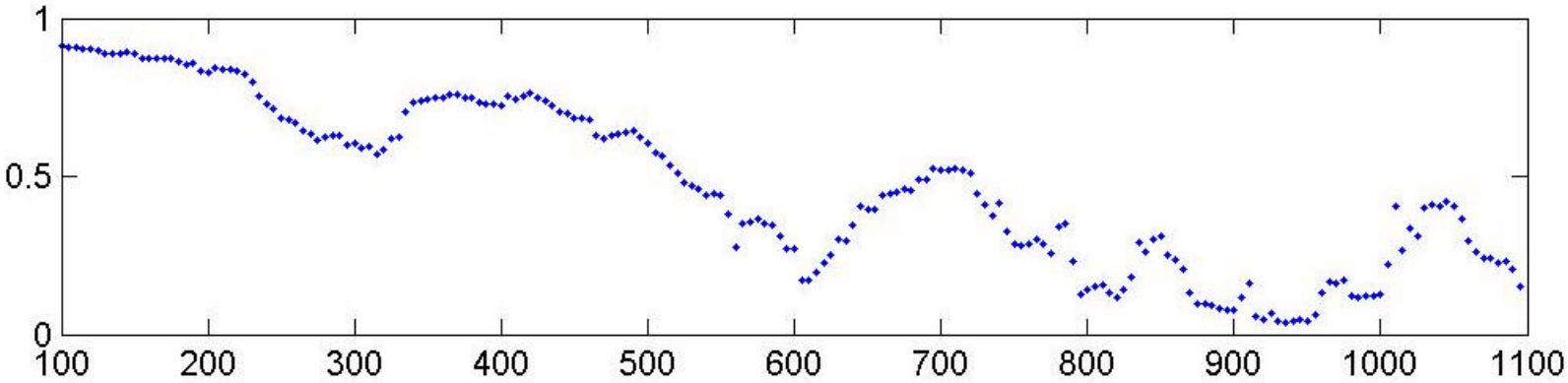
92m



100m

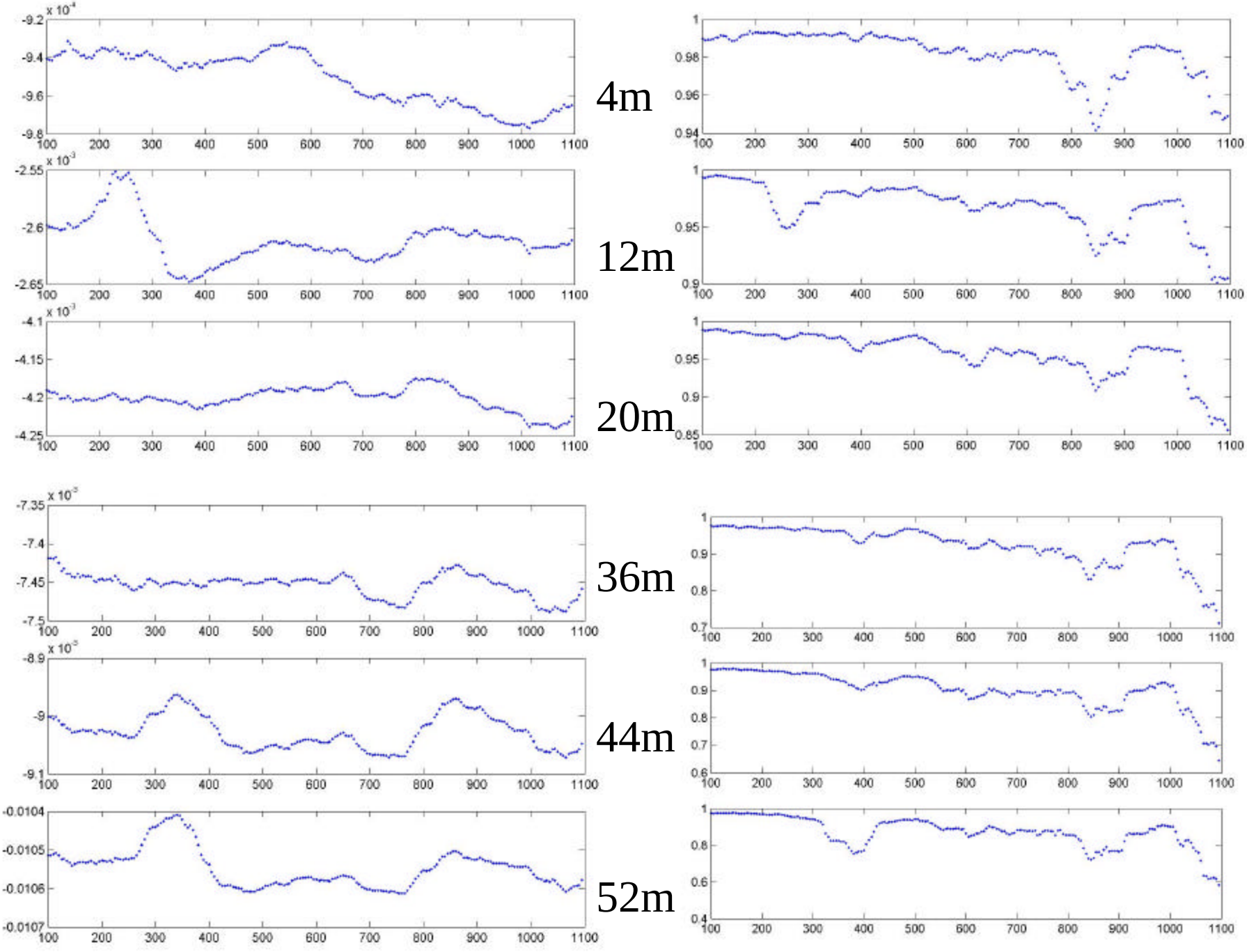


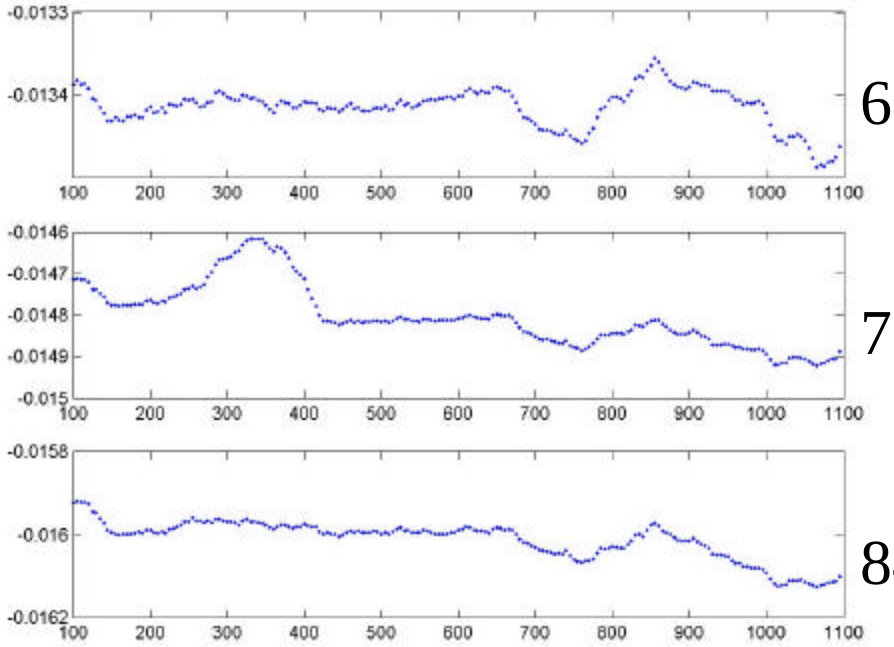
108m



Focusing on a Signal Result on 30 Km

- Compare the time delay and the coherence for different center frequency

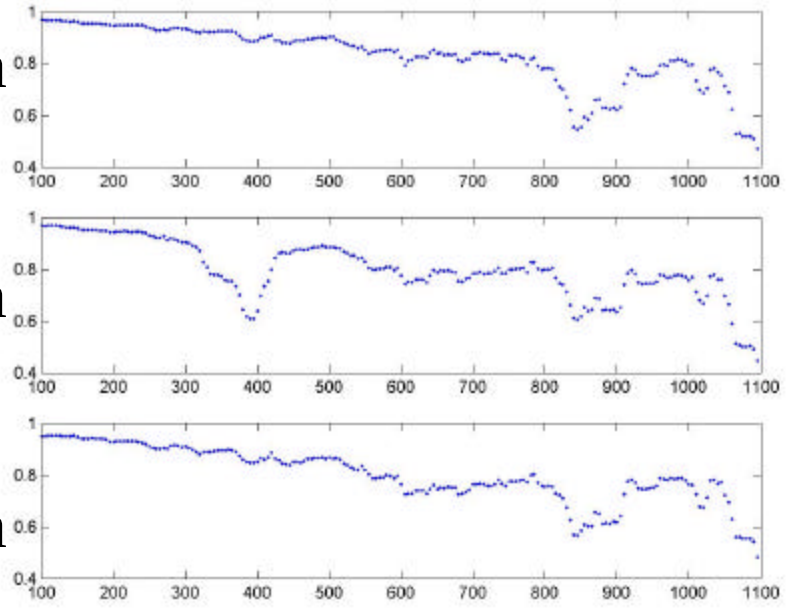

4m
12m
20m
36m
44m
52m

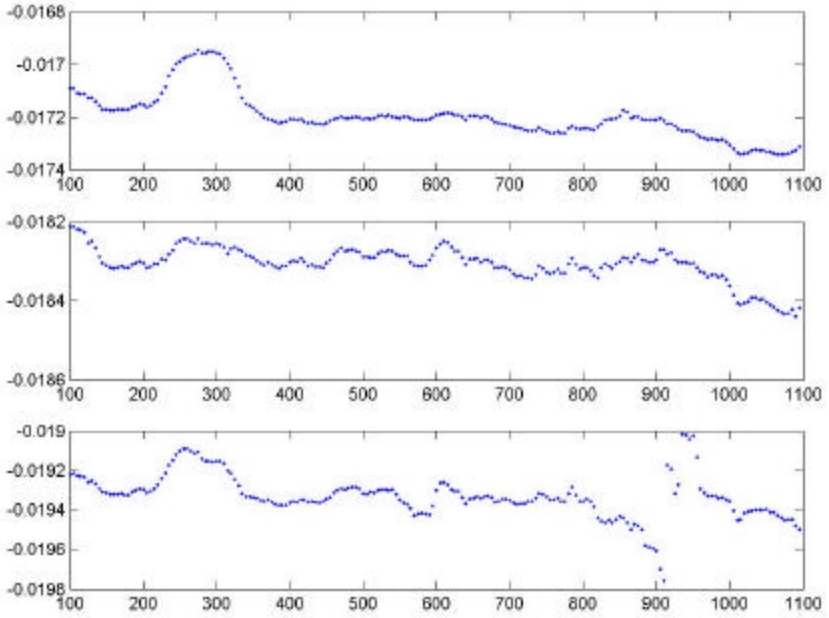


68m

76m

84m

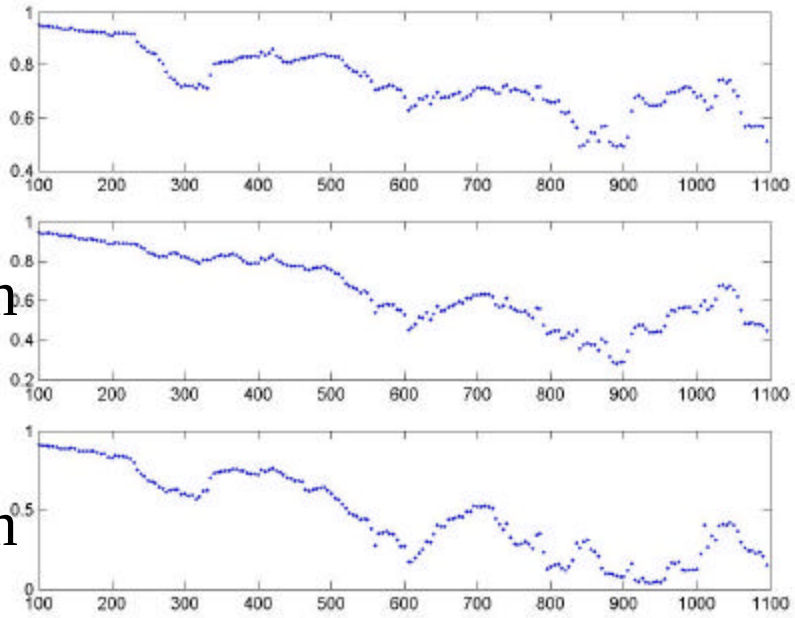




92m

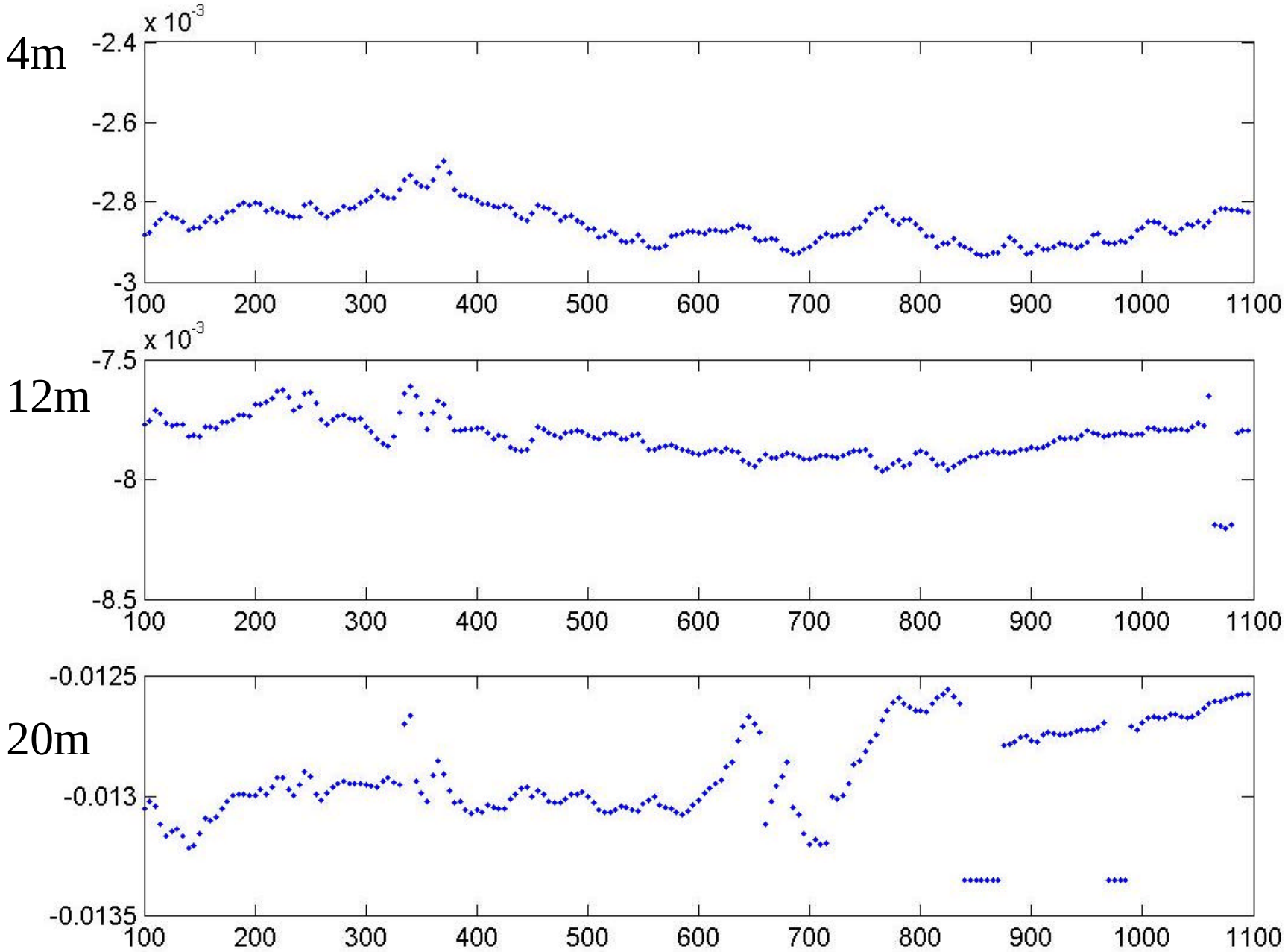
100m

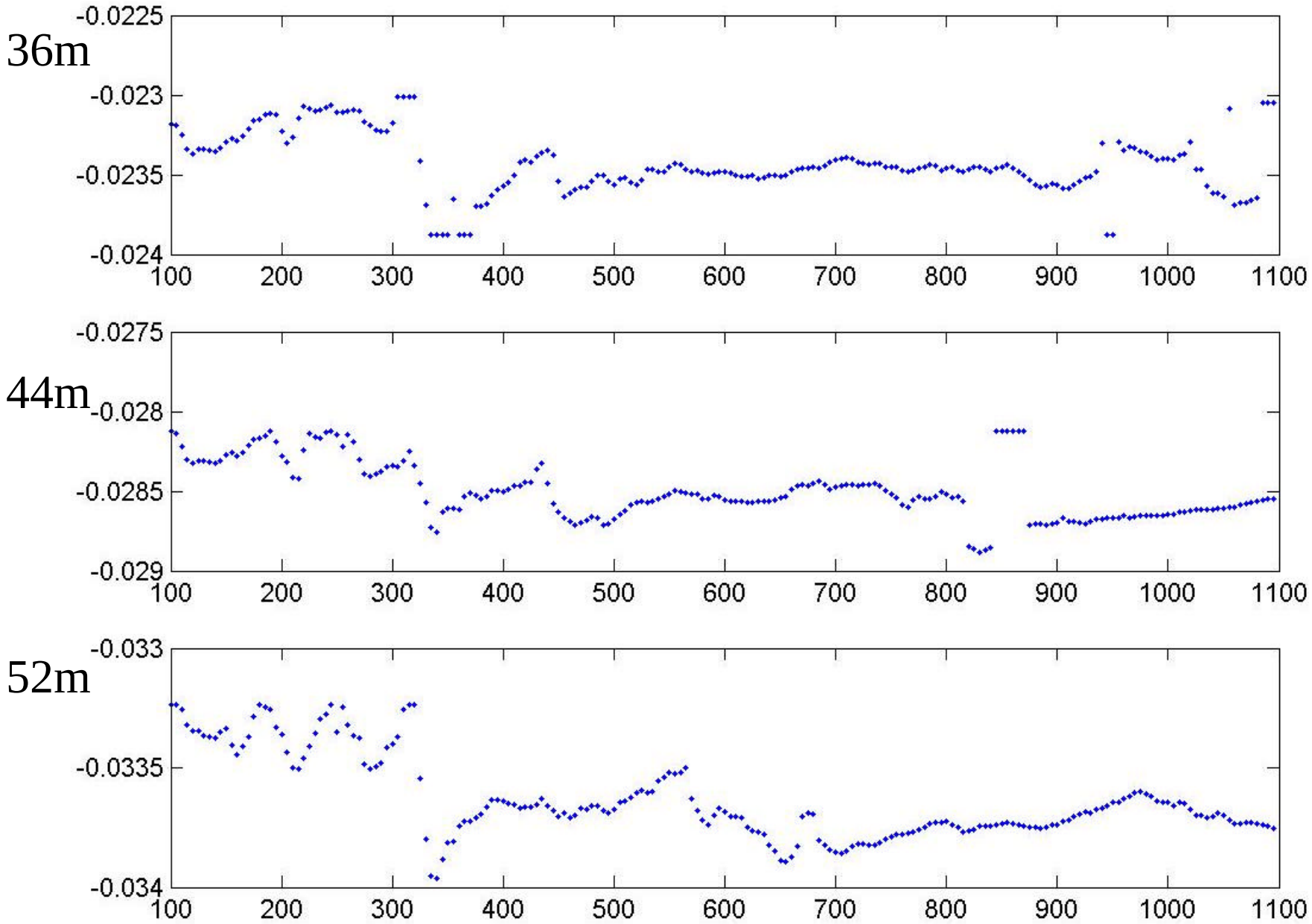
108m

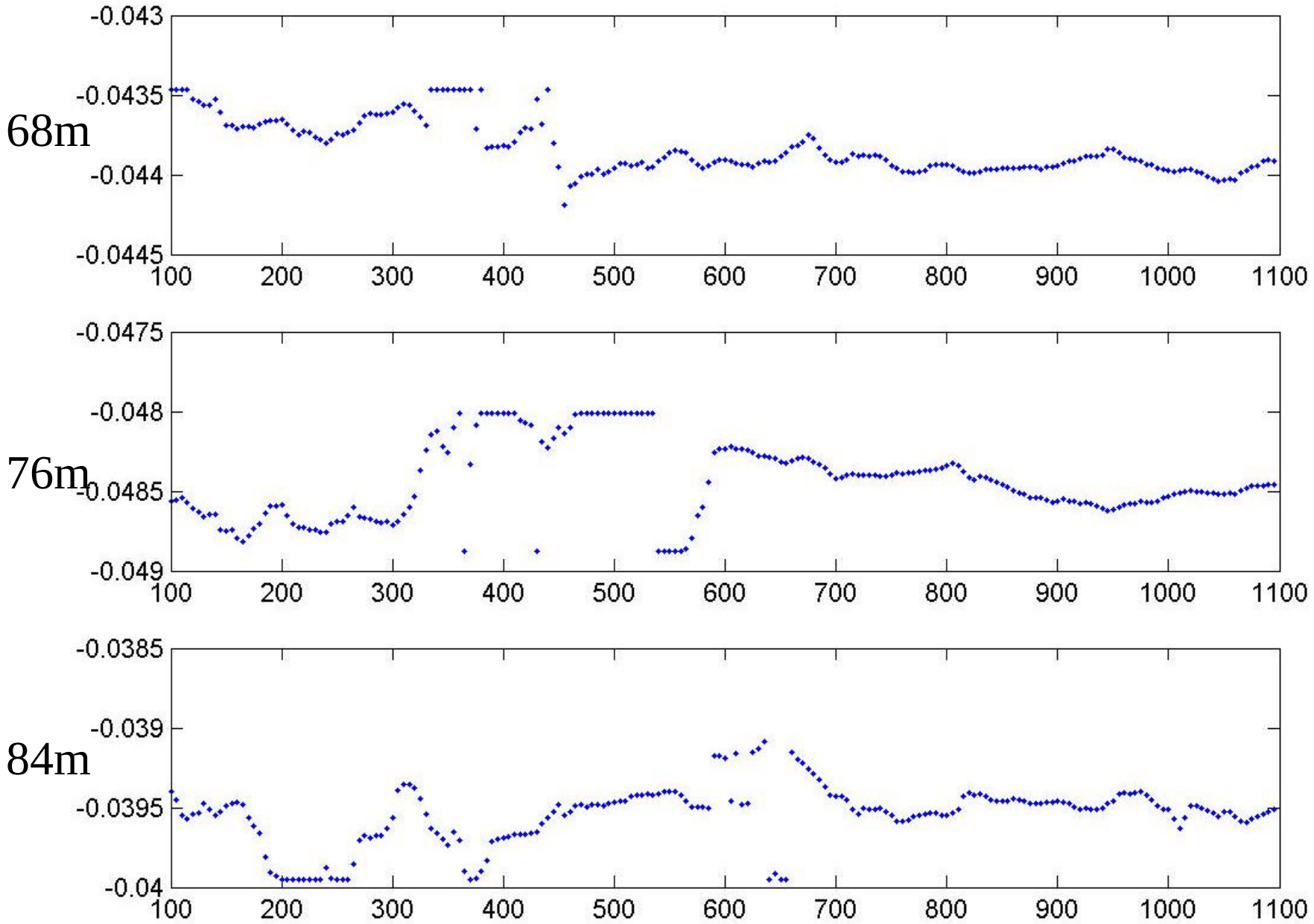


Focusing on a Signal Result on 3 Km

- The ambiguity (grating lobe)occurred in the time delay estimation


4m
x 10^-3
-2.4
-2.6
-2.8
-3
100
200
300
400
500
600
700
800
900
1000
1100
12m
x 10^-3
-7.5
-8
-8.5
20m
-0.0125
-0.013
-0.0135


36m
-0.0225
-0.023
-0.0235
-0.024
100
200
300
400
500
600
700
800
900
1000
1100
44m
-0.0275
-0.028
-0.0285
-0.029
100
200
300
400
500
600
700
800
900
1000
1100
52m
-0.033
-0.0335
-0.034
100
200
300
400
500
600
700
800
900
1000
1100


68m
-0.043
-0.0435
-0.044
-0.0445
100
200
300
400
500
600
700
800
900
1000
1100
76m
-0.0475
-0.048
-0.0485
-0.049
100
200
300
400
500
600
700
800
900
1000
1100
84m
-0.0385
-0.039
-0.0395
-0.04
100
200
300
400
500
600
700
800
900
1000
1100

Conclusion (Preliminary ?) and the Further Work

- The time delay most time got less with the frequency grow
- The coherence for slightly delay time compensate changes only a little
- At some frequency, the coherence at every space goes down, make we guess that it is because of the source
- Some phenomena often occurs when the coherence at every space goes down

The Further Work

- Calculate the time delay for each pair of sensors, at different center frequency, at different space, different range and different sources' and receivers' depth, using propagation model
- Analyze the affection of the variant of the propagation channel to the delay time estimation and horizontal coherence

- **Find some useful experiment data of fixed point source and receiver, long time fluctuation. Since in the east china sea experiment, the bottom-mooring line array lost, and the south china sea experiment has also the corresponding data we need, and thus we would continue the data process for the SCS experiment fluctuation data.**