Sea bed diffraction and impact on 4D seismic data – *observations from synthetic modeling and field data*

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Objective

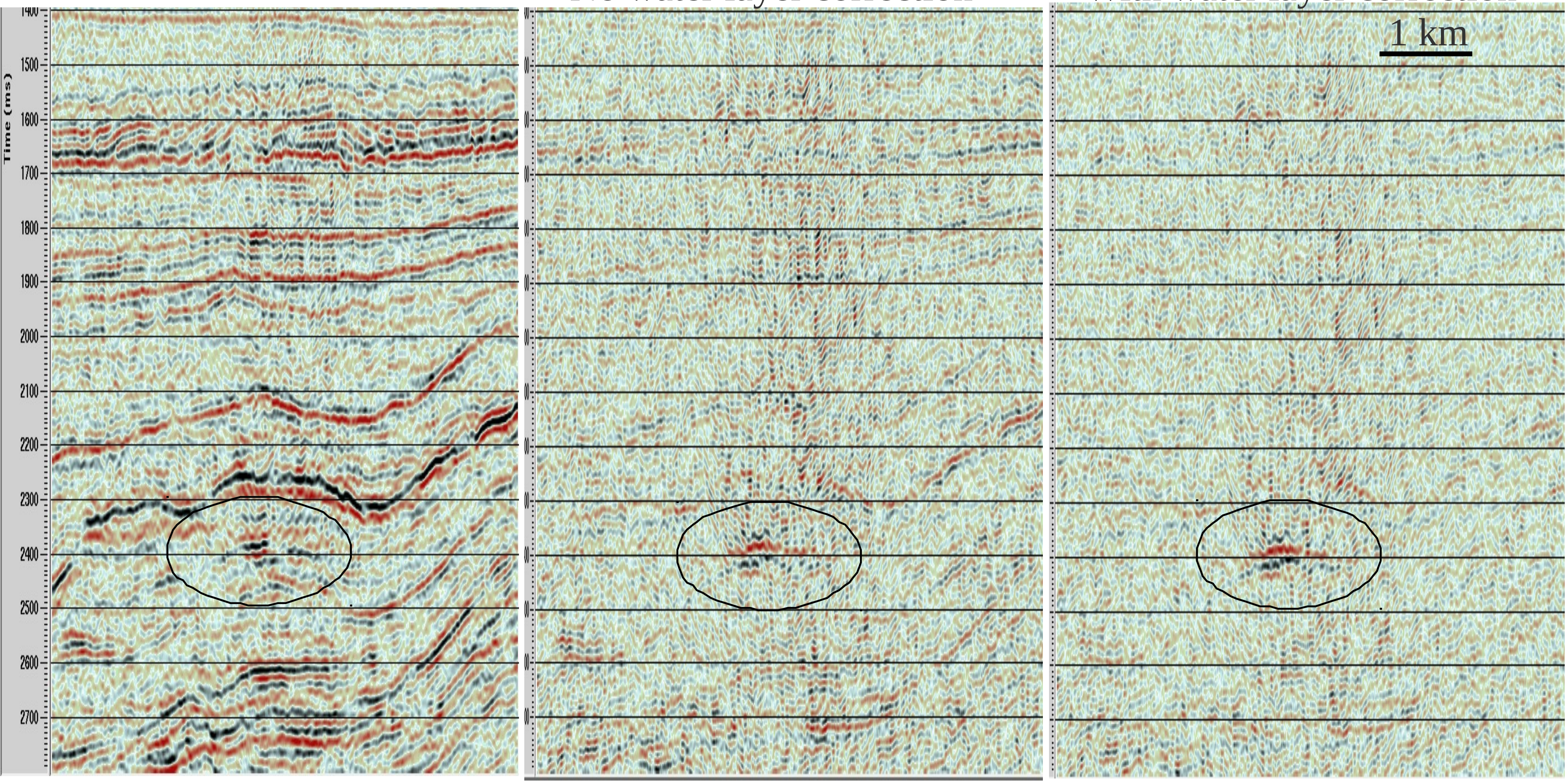
- **Better understand the influence of sea bed diffractions on water layer correction in 4D processing**
  - **Corrections for water layer changes very important in 4D processing**
  - **Diffracted multiples degrade 4D quality**

Motivation

Migrated stack

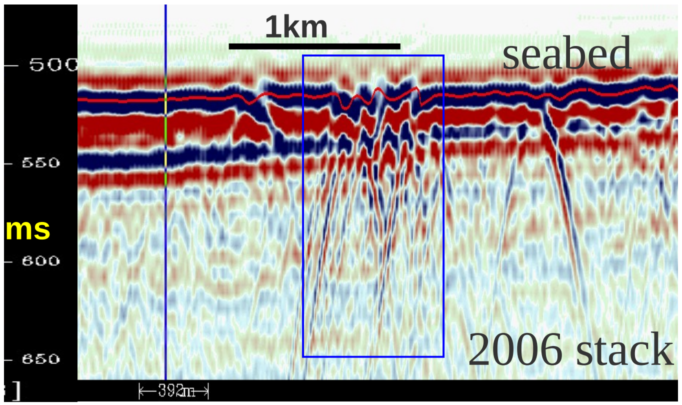
4D difference
No water layer correction

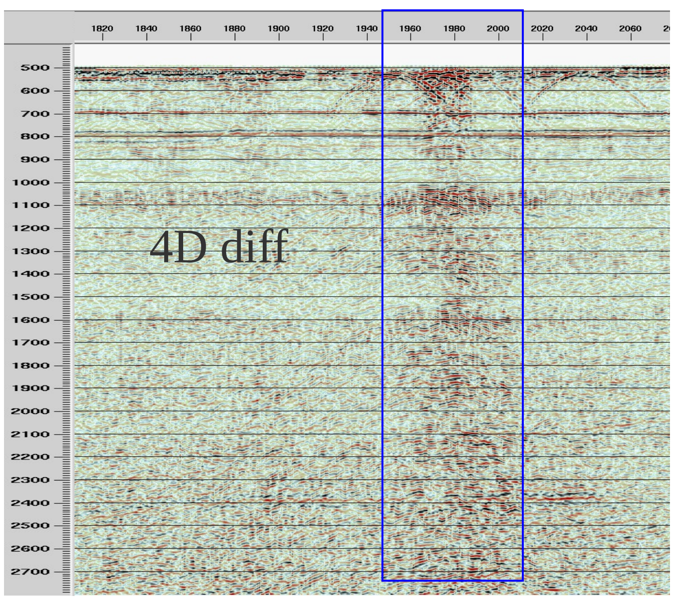
4D difference
With water layer correction



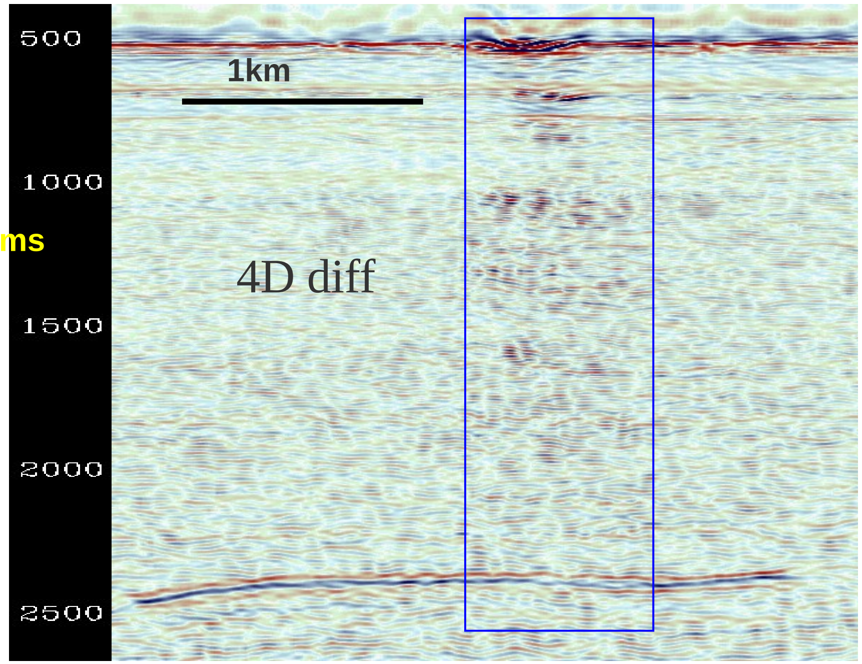
Motivation
Diffractions and diffracted multiples

Unmigrated





Final 3D migration



Diffracted multiples a problem in 4D

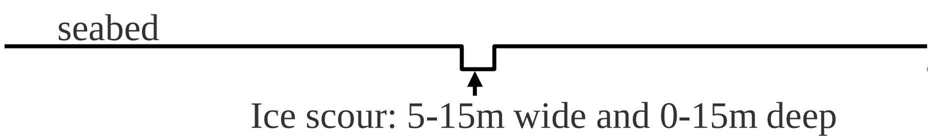
- difficult to repeat in 4D
- difficult to remove in processing

Sea bed diffractions and impact on time shift correction

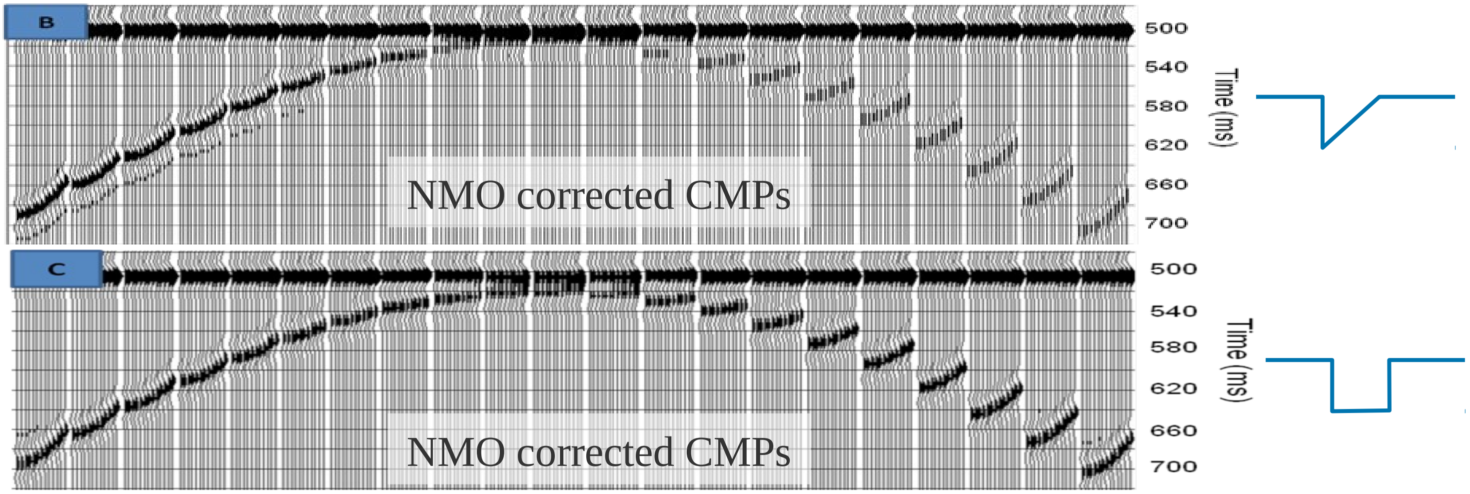
- Data examples
  - 2D FD modelling of seabed diffractions
  - Field data from Norne 2006 and 2008

2D modelling of point diffractions

Model



Modelling



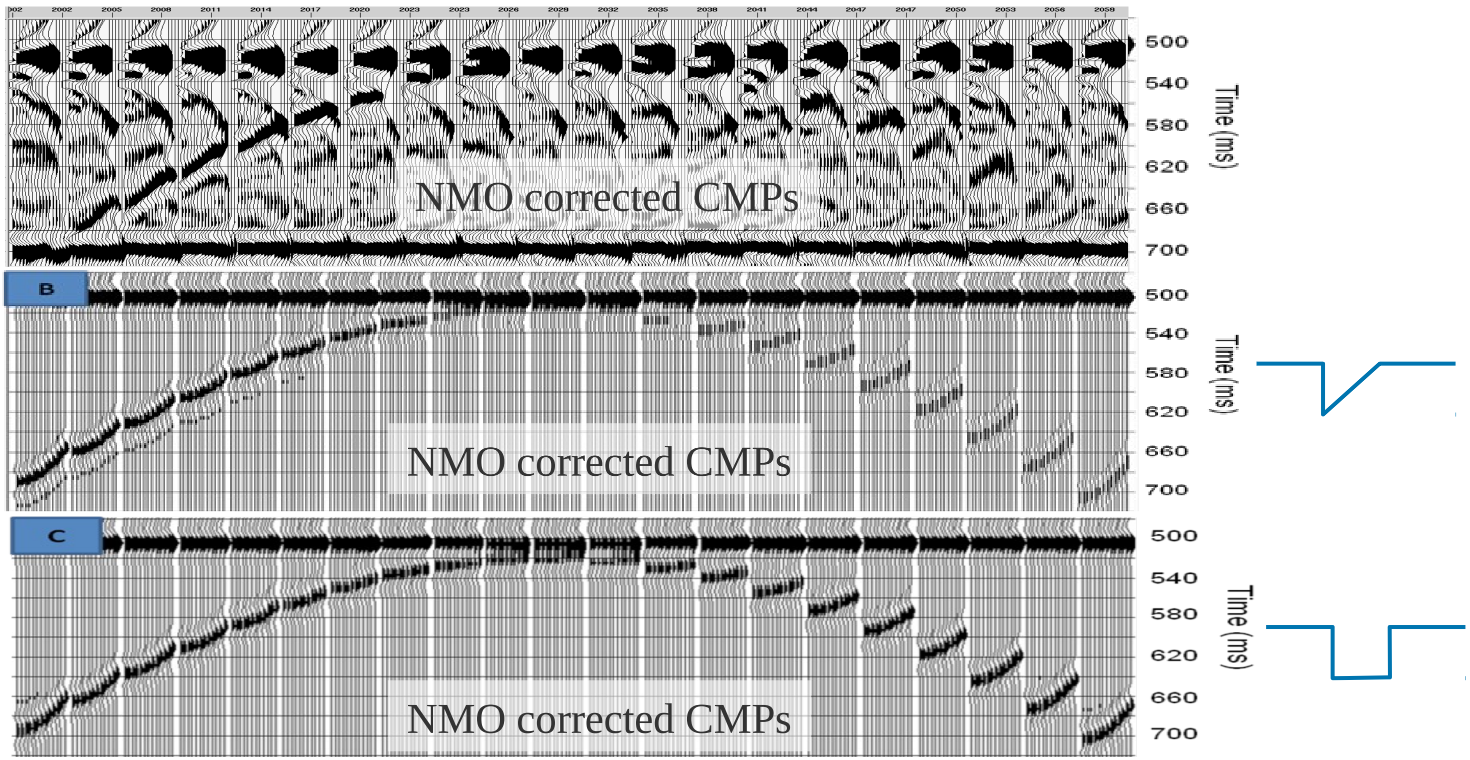
2D modelling of point diffractions

Observations:

- Diffractions can not be flattened using standard primary reflection NMO correction
- Asymmetrical amplitude strength → asymmetrical ice scour shape is likely

Real

Modelling

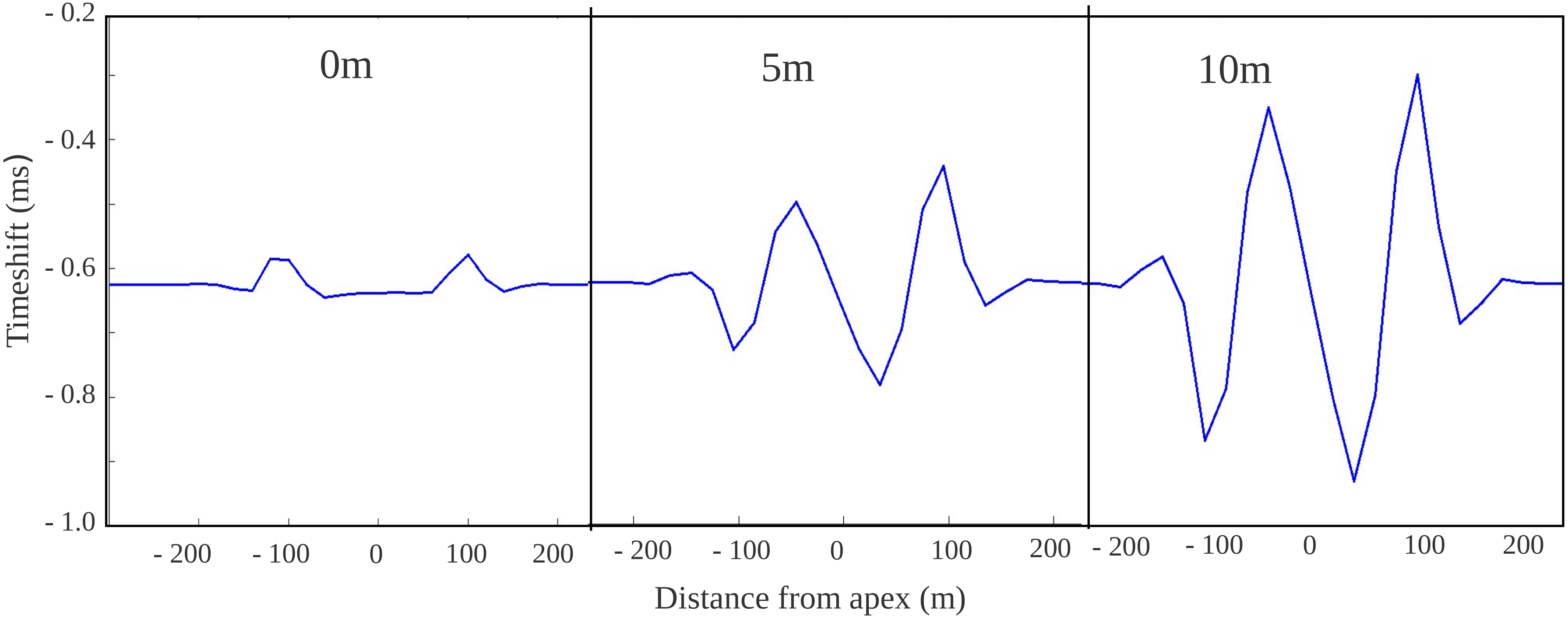


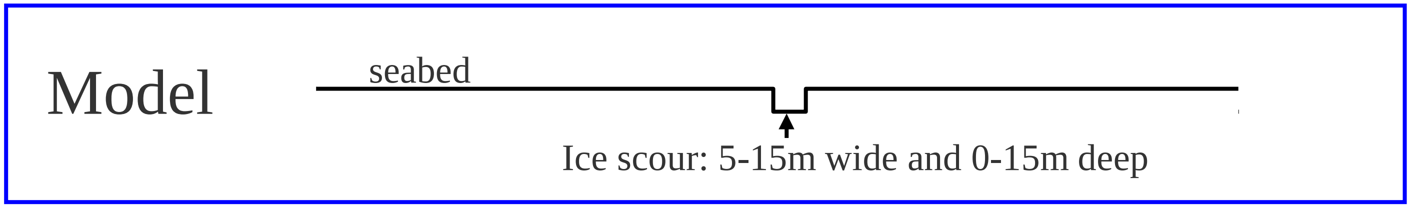
Factors controlling seabed time shift in diffraction tuning area – FD modelling

- Sea velocity changes → (2-3 m/s)
- Relative amplitude strength of diffraction → stronger contrast in ice scour than outside
- Acquisition mis-position → Varying

Acquisition mis-position and seabed time shift

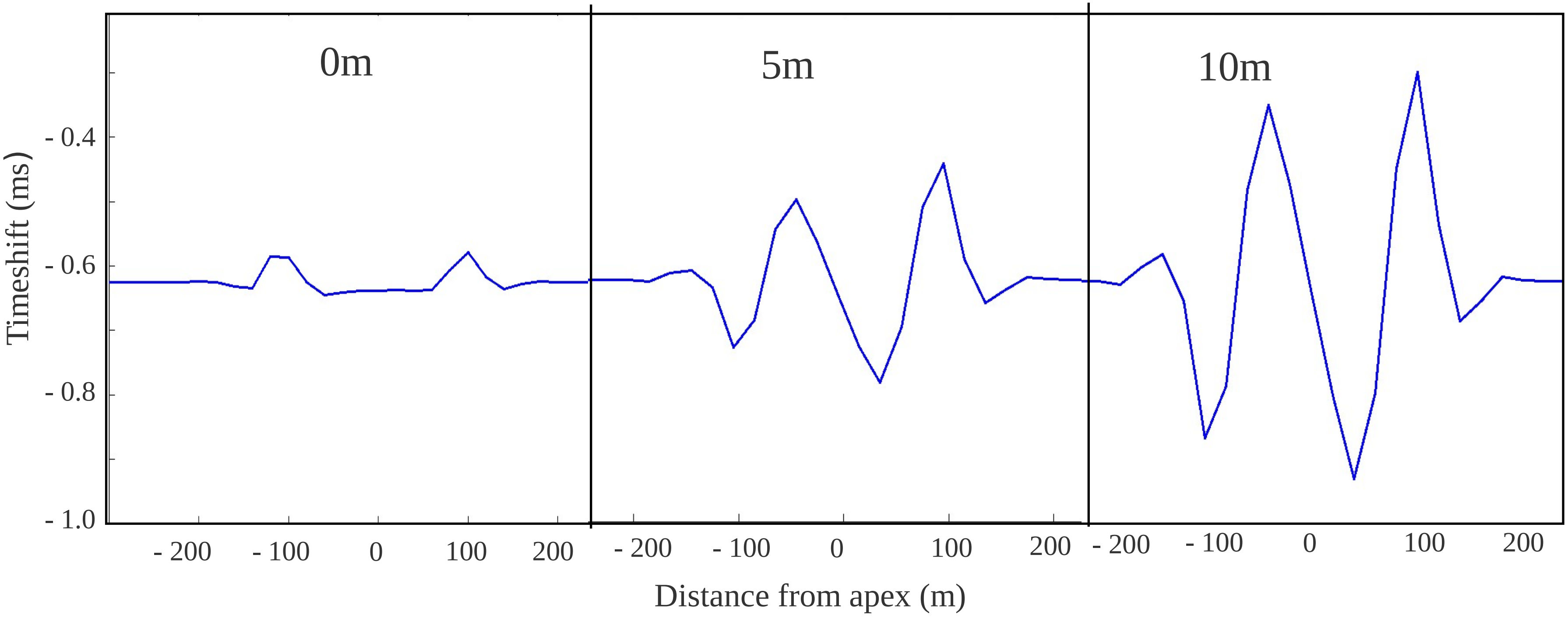
- Acquisition mis-position





Acquisition mis-position and seabed time shift

- Acquisition mis-position



- Mis-positioning creates non-negligible time shift error

Approximations for time shift error caused by tuning

assuming harmonic input signal

$$\tau = \frac{\dfrac{2h_2}{v_2}\left(1+\alpha+\alpha\sqrt{1+\dfrac{(x-a)^2}{h_2^2}}+\alpha^2\sqrt{1+\dfrac{(x-a)^2}{h_2^2}}\right)-\dfrac{2h_1}{v_1}\left(1+\alpha+\alpha\sqrt{1+\dfrac{x^2}{h_1^2}}+\alpha^2\sqrt{1+\dfrac{x^2}{h_1^2}}\right)}{(1+\alpha)^2}$$

,

V_1, V_2 - base and monitor sea velocity

α - Amplitude ratio between seabed and diffraction

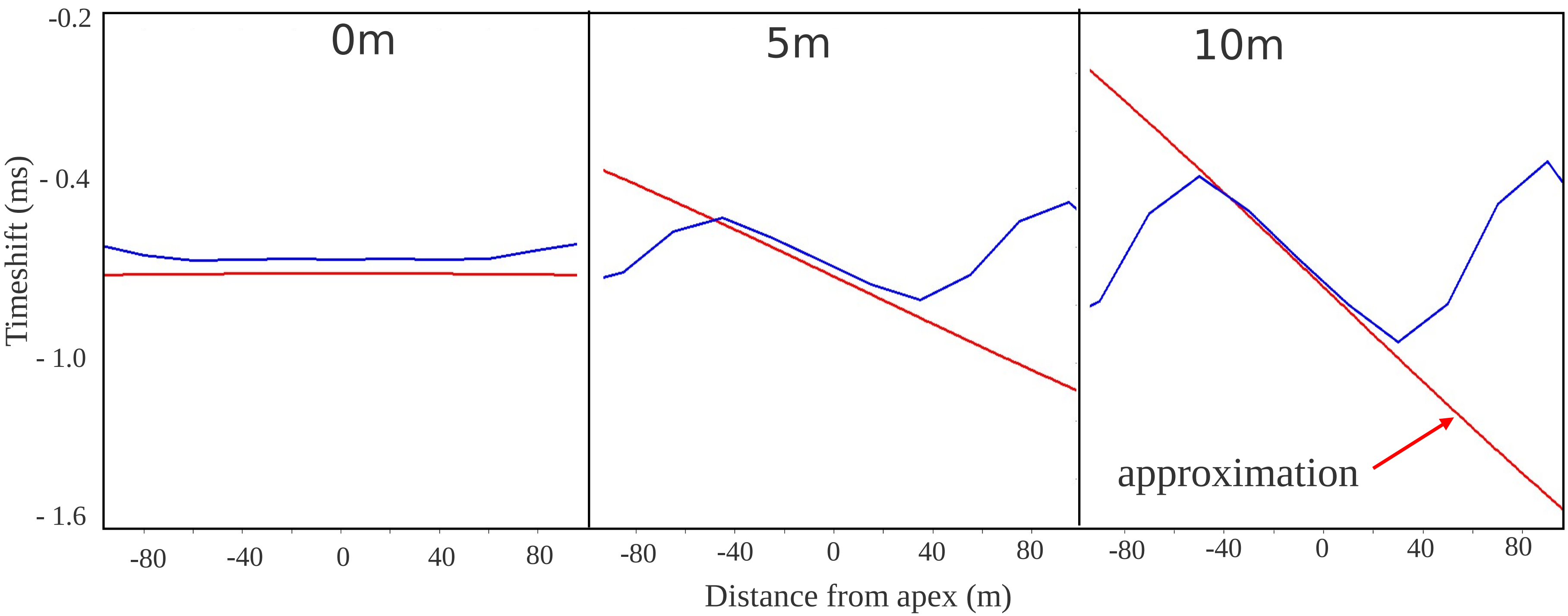
h – water depth

x – distance from diffraction apex

a= mis-positioning between base and monitor

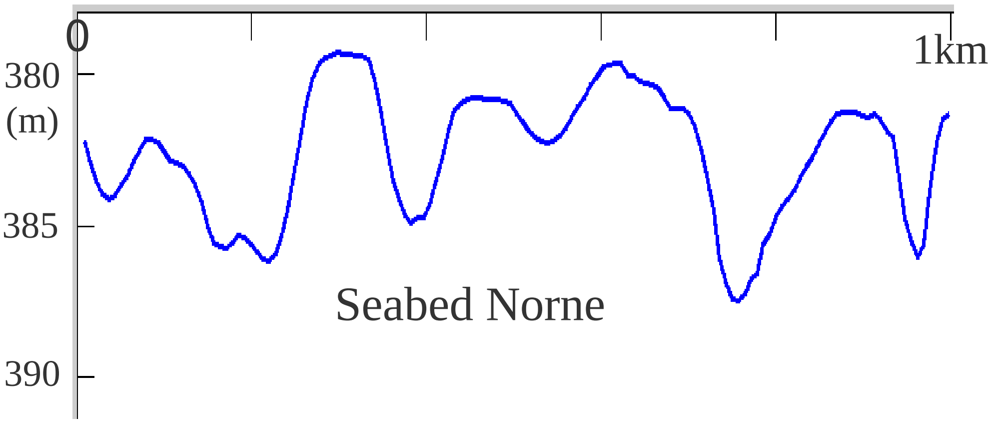
Valid for small offsets, where the two signal are inside same lobe

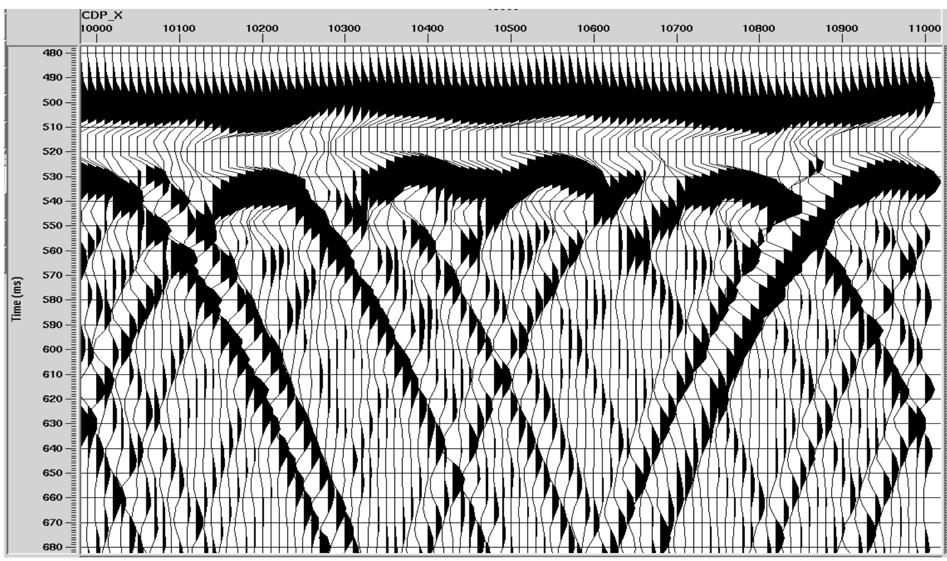
Approximations for time shift error caused by tuning



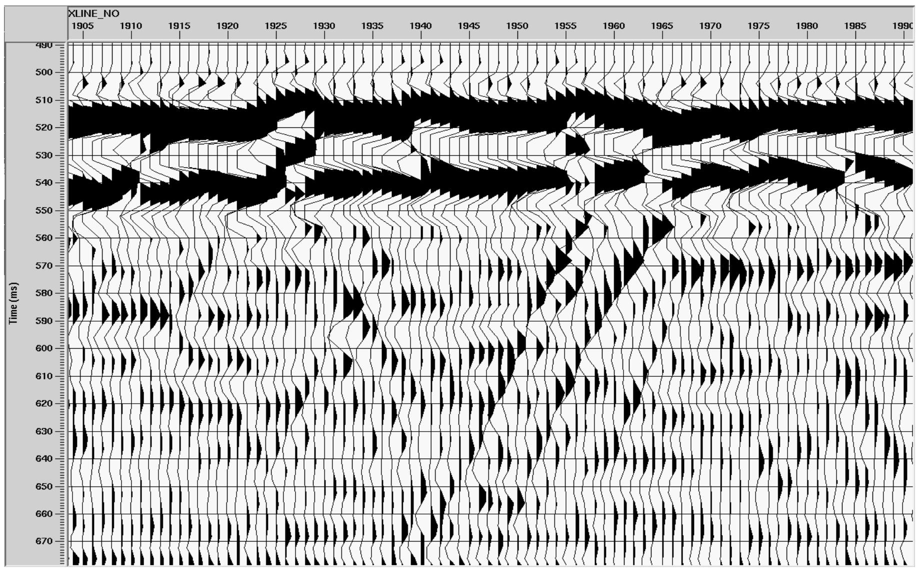
Approximation ok up to ca. 40m from apex point

2D FD modelling and field data

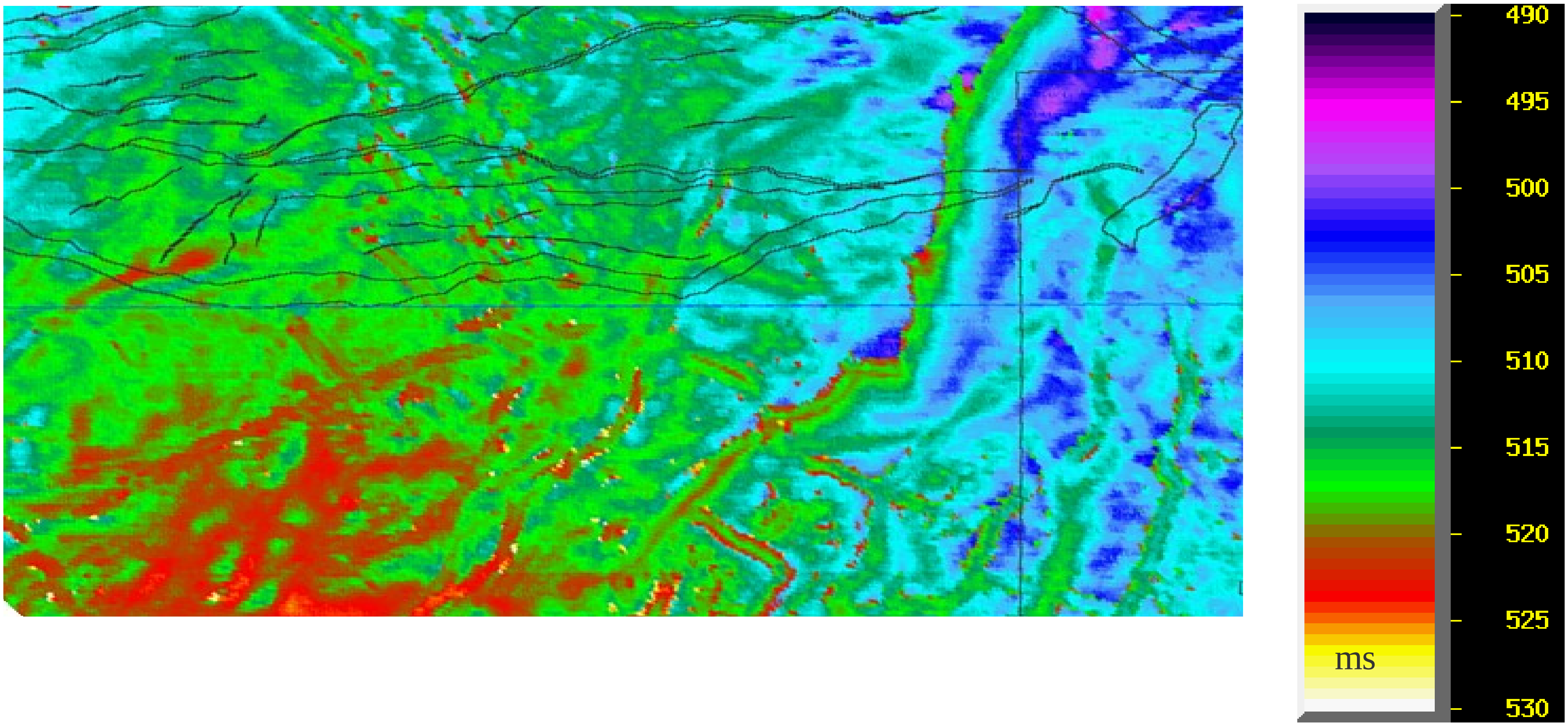




Field data Norne

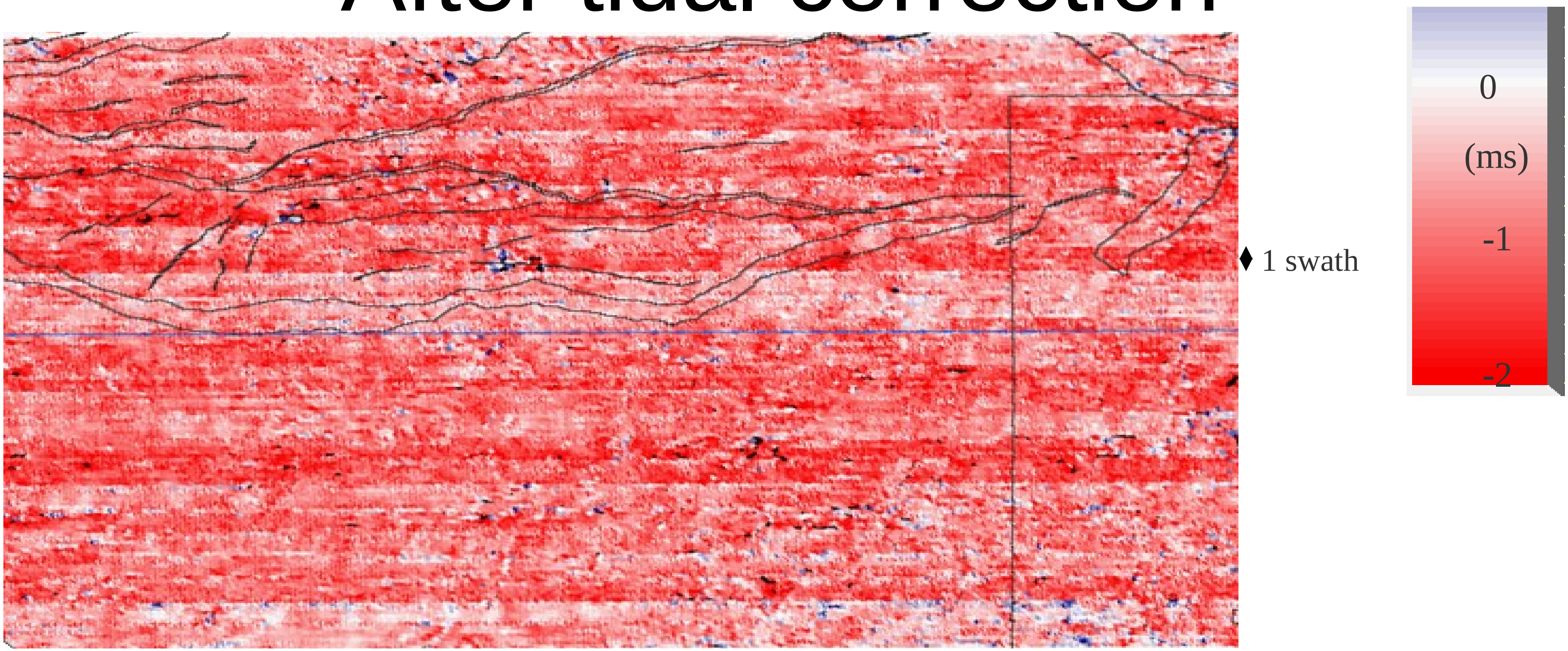


Seabed time map Norne



Seafloor time shift 2006-2008

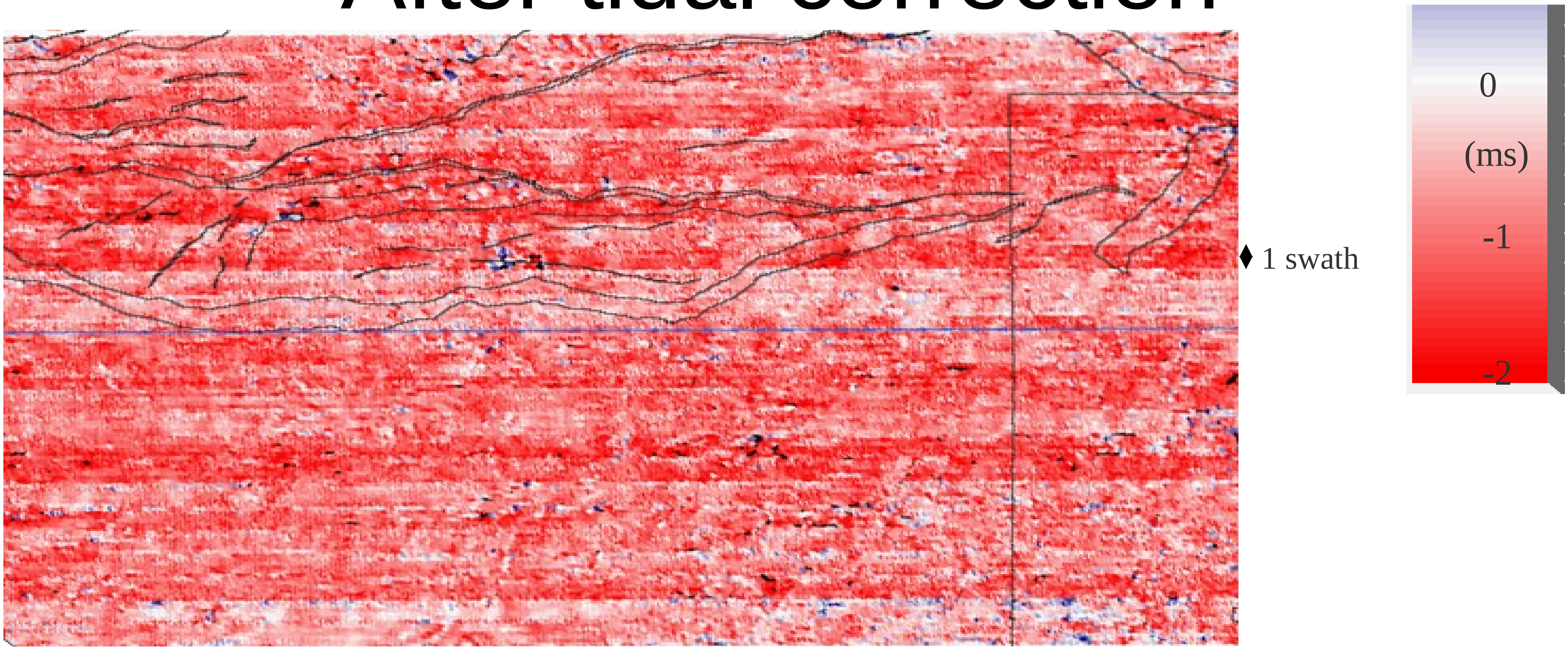
After tidal correction



Time shift related to:

- Variation of sea velocity (lateral and with calendar time)
- Geometrical mis-positioning
- Error in tidal correction

Seafloor time shift 2006-2008
After tidal correction



Time shift related to:

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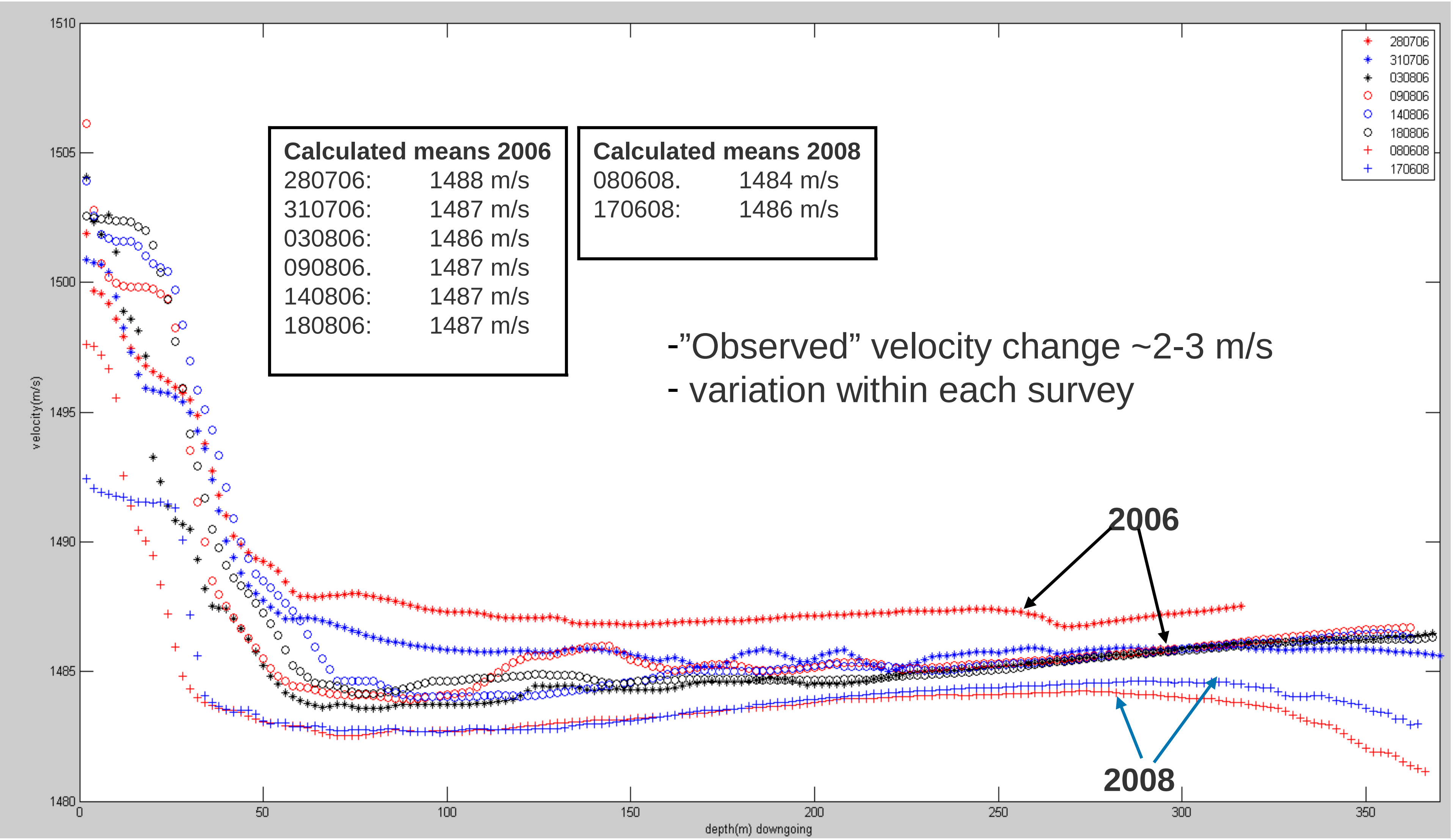
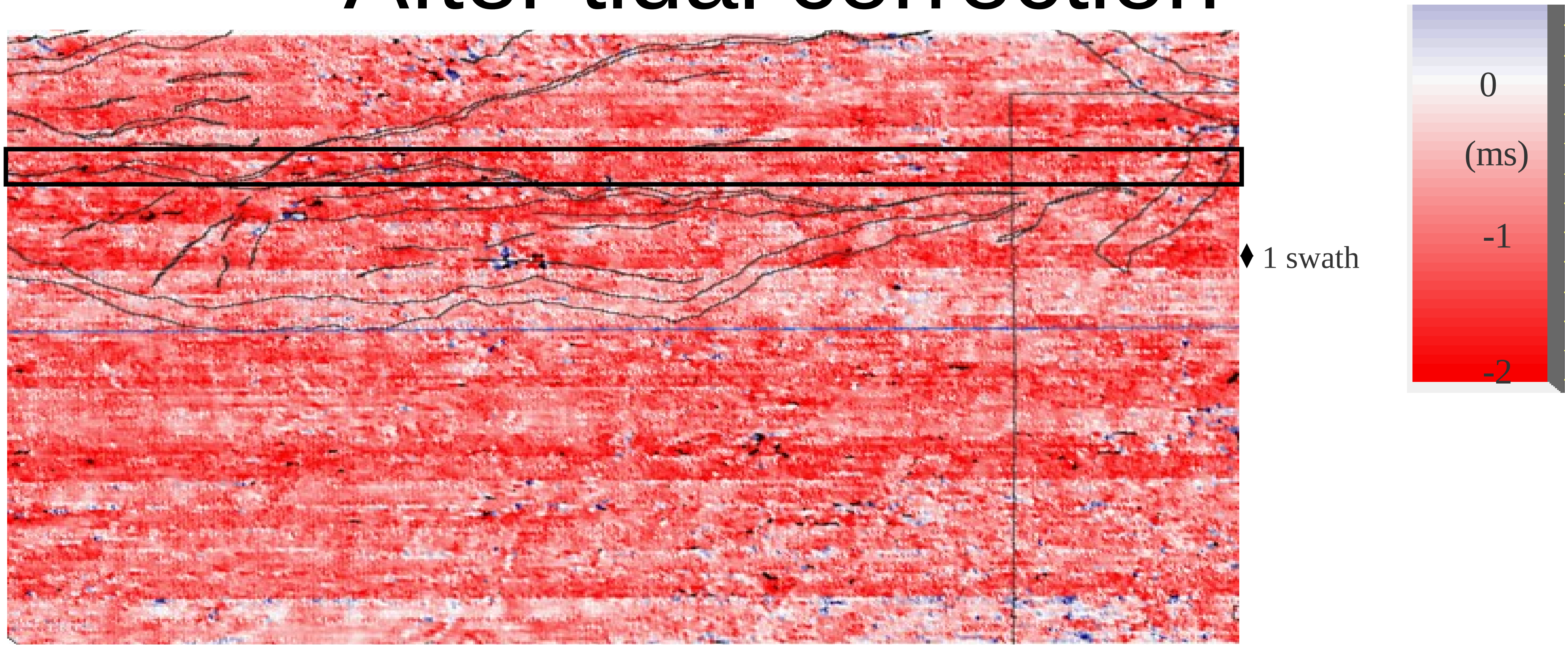
Velocity profiles 2006 and 2008



Based on measured temperatures and salinities

Seafloor time shift 2006-2008
After tidal correction

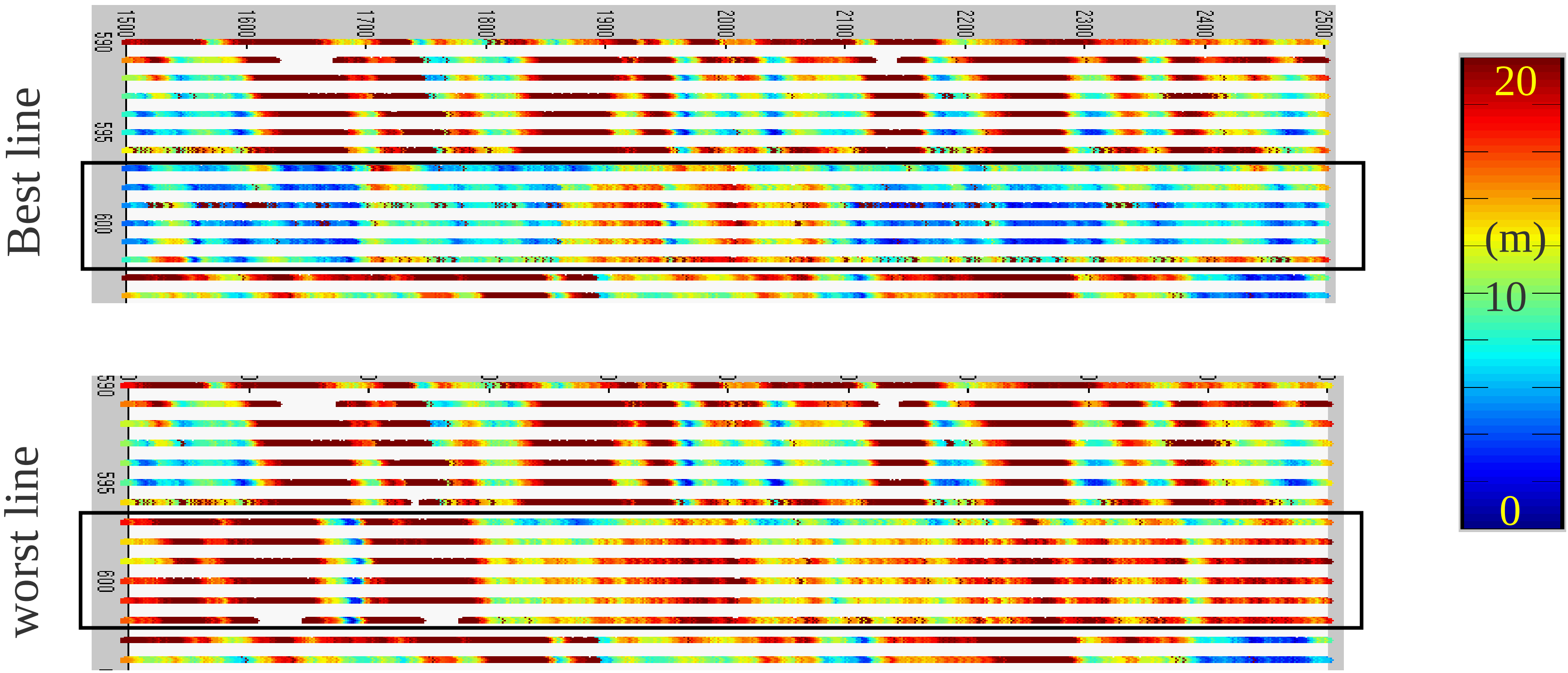


Time shift related to:

- Variation of sea velocity (lateral and with calendar time)
- Geometrical mis-positioning
- Error in tidal correction

Two examples of geometrical mis-position

D(Source) + D(receiver)

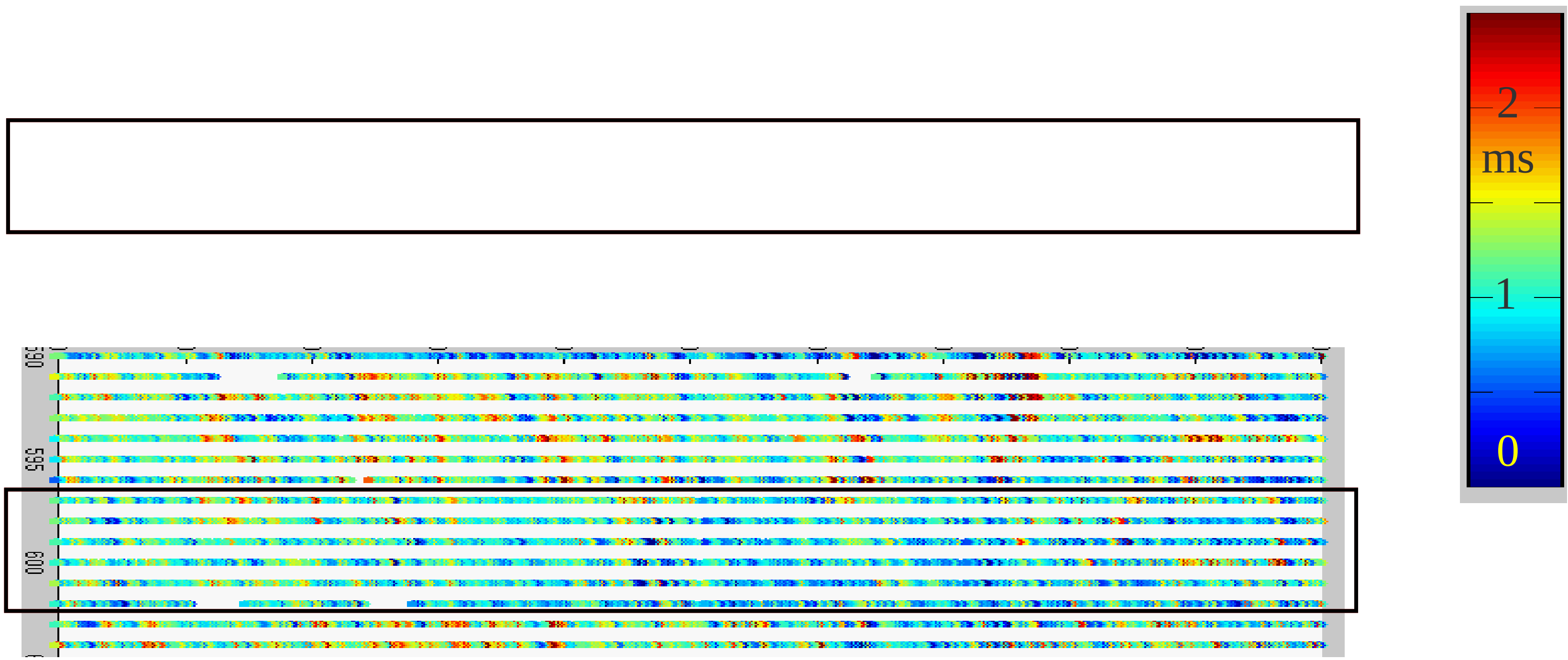


…and corresponding Seabed time shift

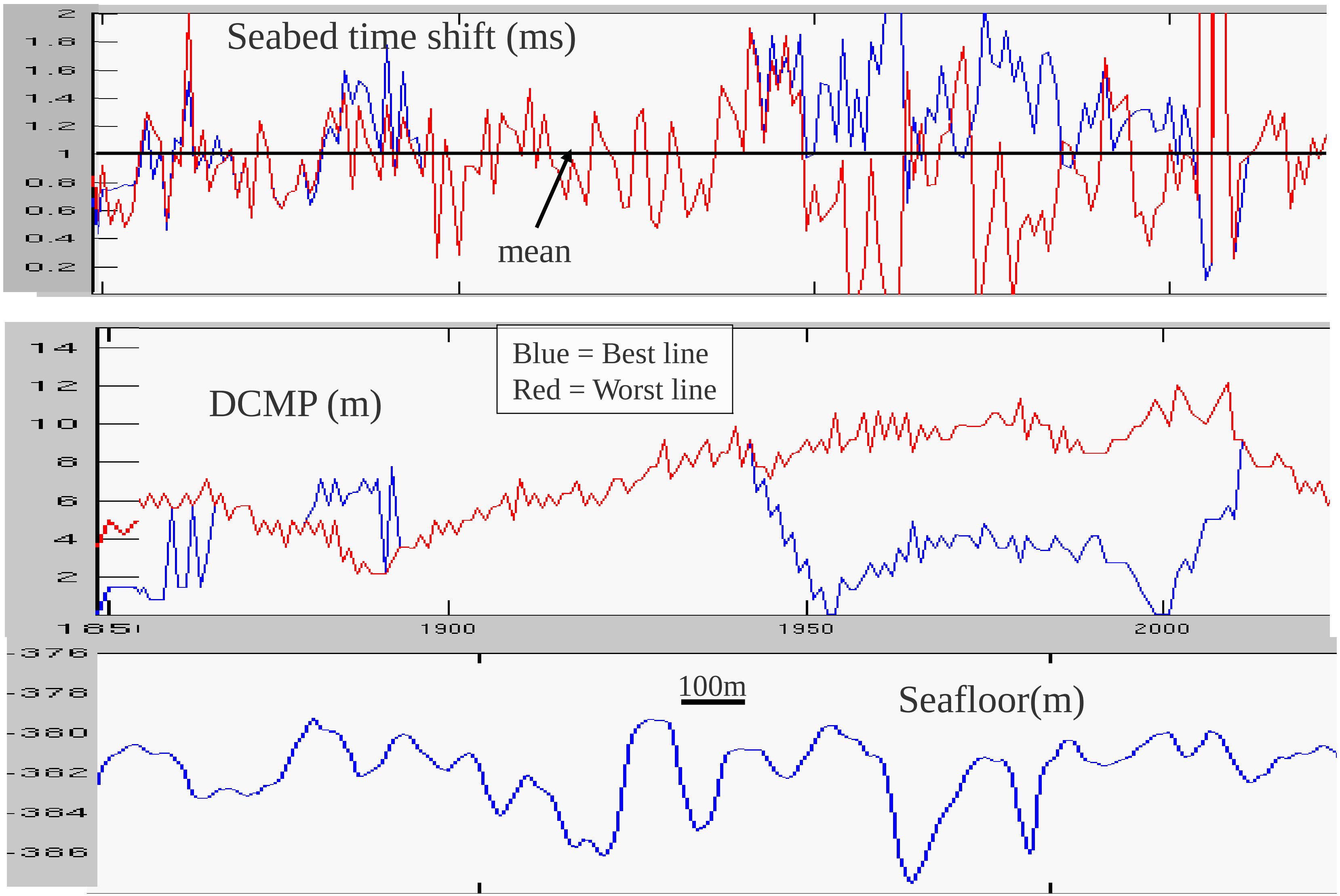
Time shift (ms)

Best line

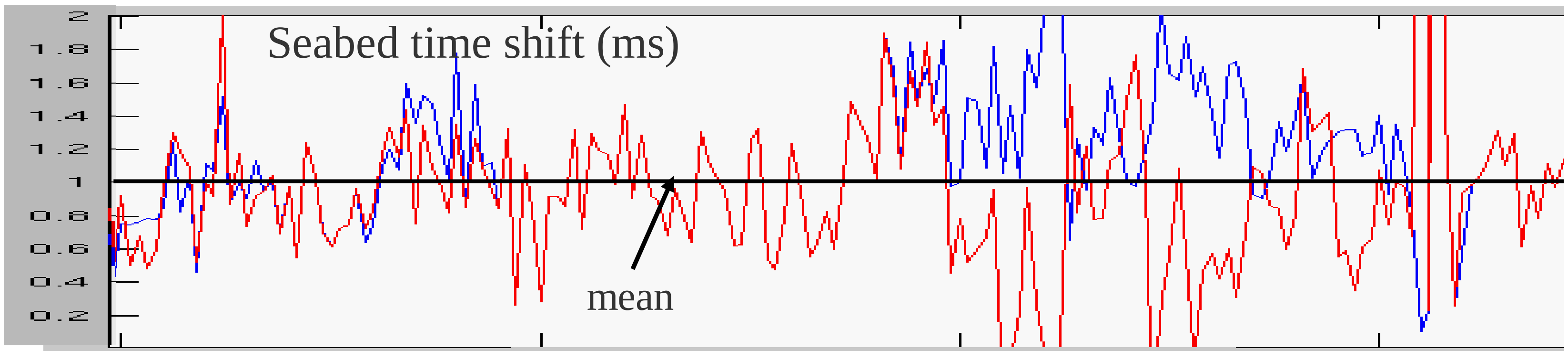
worst line



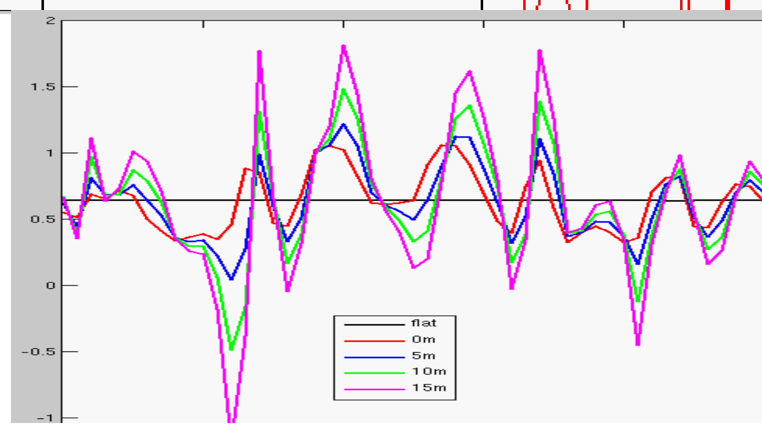
Time shift related to complex sea bottom and geometrical mis-position

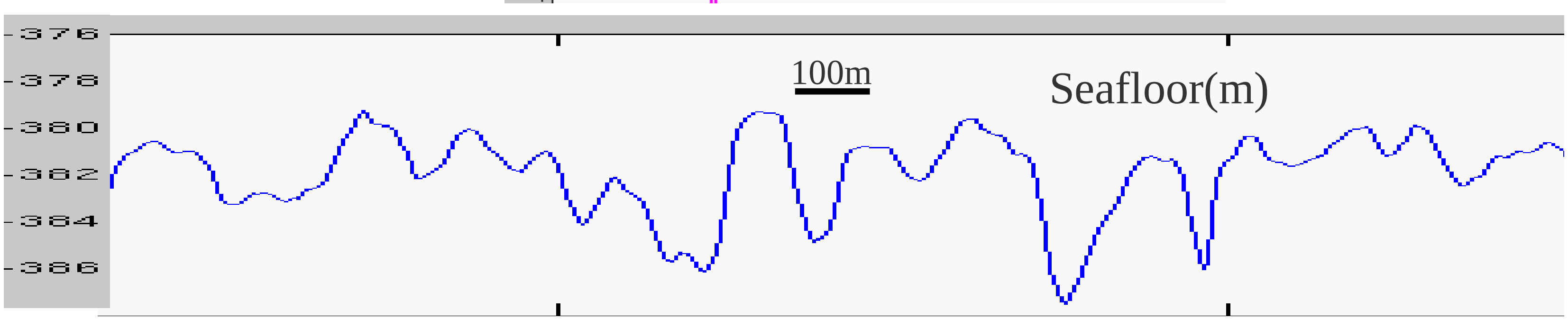


Time shift related to complex sea bottom and geometrical mis-position



2D FD modelling
(DVp=3m/s)





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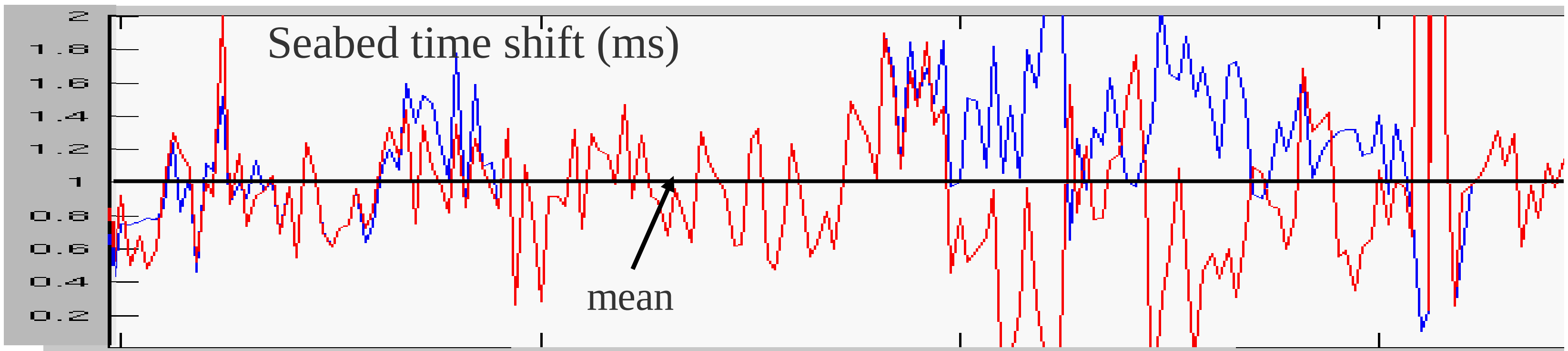

2D FD modelling
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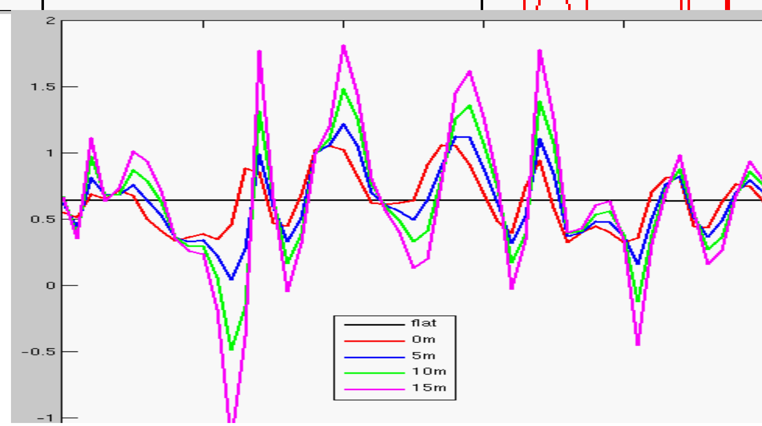
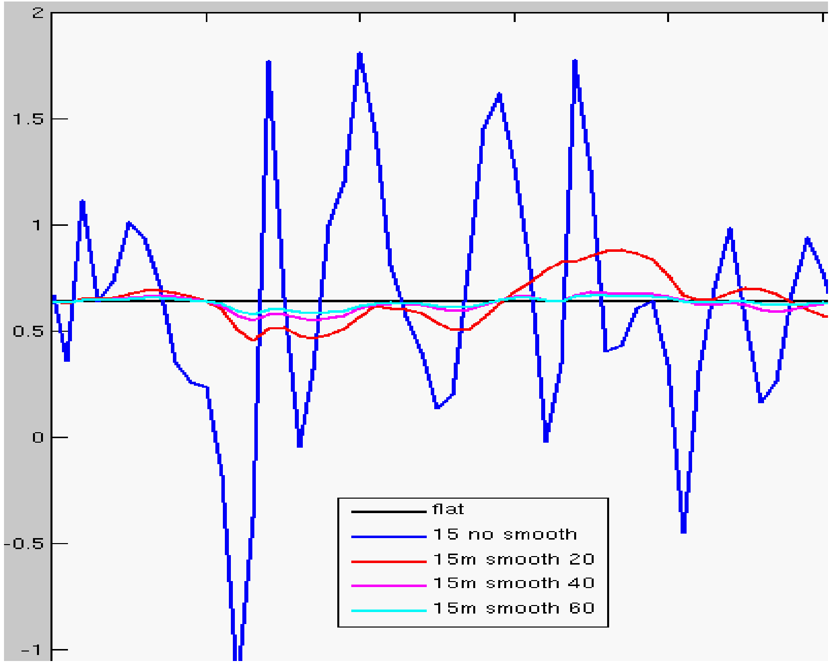


Observation

- Seabed time shift strongly dependent on geometrical repeatability and complexity of the seabed

Complex sea bottom and geometrical mis-position
Smoothing of time shift

Modelled data –
Seabed time shift (ms)



- Smoothing line by line remove much of the disturbance from complex sea bottom , but this is based on the assumption that the seabed irregularities do not create systematic time shift error

Conclusions

- Seabed time shifts strongly depend on change in water velocity, geometrical repeatability and complexity of the seabed
- The effect of geometrical mis-positioning is important
- Smoothing line by line removes much of the disturbance from complex sea bottom and is the recommended method

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Statoil

Acknowledgments

- Statoil and their partners ENI Norge AS and Petoro for permission to use their data

- NFR for financial support to the ROSE project at NTNU

- Børge Arntzen and Jon A. Haugen and for help and support with the FD modelling

- Hussein Mehdizadeh for Promax help