TIKIM –

Dealing with Noise

University
Learning for Development

Contents

- Noise on Input Data
- TIKIM generated noise
- Consequences of Acquisition Irregularities
- Fold Compensation
- TIKIM weighting
- Mutes

Noise in TIKIM

The S/N of the TIKIM migrated output is affected by…..

- **Noise present in input data….**
  - ✓ **coherent noise**
  - ✓ **random noise**
  - ✓ **irregular amplitudes**
- **Impulse response distortion caused by irregularities in the acquisition….**
  - ✓ **offset/azimuth/positioning/fold**
- **Migration noise generated by limitations of the algorithm…**
  - ✓ **signal stretch**

Noise in the Input Data

Organized noise

This will be processed by the migration - like any coherent signal.

Depending on the migration parameters it may, or may not, migrate coherently.

It should therefore be taken care of *prior* to migration!

Random noise

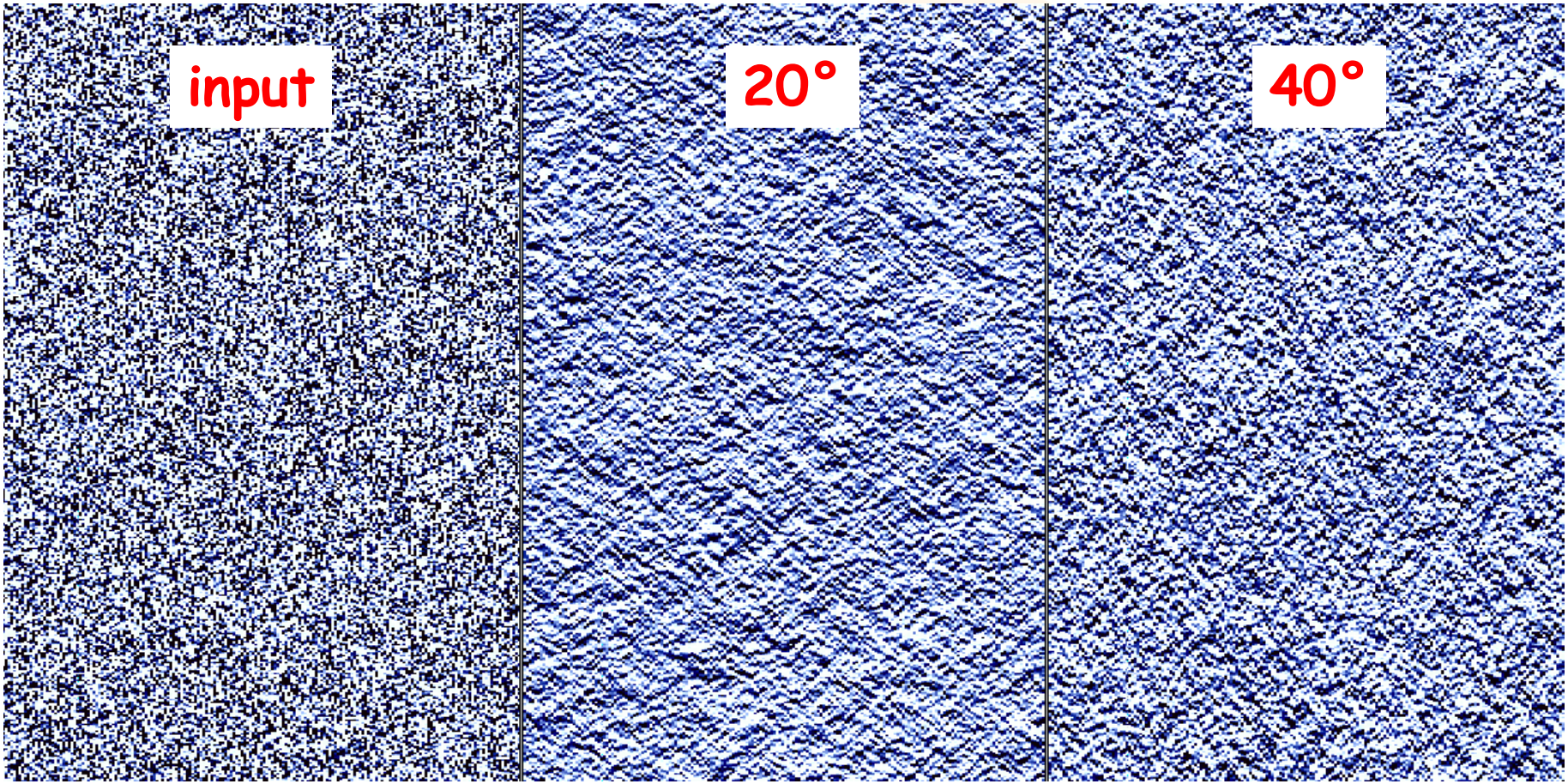
Unsurprisingly random noise behaves differently to coherent noise.

Migration tends to act as a filter, re-enforcing alignments, and structuring noise.

Steeper operators will tend to create some noise on their own.

Noise in input data - synthetic

This input contains purely random noise and was migrated for two different values of dip limit.



High Amplitude Noise in input data

High amplitude traces will create migration artifacts in the image, e.g. the well known migration ‘smiles’…

These traces should be edited before migration.

Acquisition Irregularities in TIKIM

By '**perfect**' acquisition we mean…

- regular trace positioning
- regular azimuth and offset
- no missing traces
- an invariant wavelet is also an assumption behind the amplitude and phase correction applied within **TIKIM.**

A departure from any of these assumptions will deteriorate the signal and create noise.

TIKIM is especially sensitive to the azimuth variations and trace positioning.

This sensitivity tend to abate as we go deeper.

Acquisition Irregularity Compensation in TIKIM

TIKIM therefore requires the input data to be spatially regularly sampled.

A simple way to regularize the trace positioning is simply to bin re-centre the traces prior to migration while preserving the trace azimuth and offset.

This can be done outside TIKIM by applying a translation to the source and receiver coordinates.

Acquisition Irregularity Compensation in TIKIM

Parameter NOREG

- If the true trace position is to be used

  (regularisation before TIKIM).

Parameter REG

- If the trace position is to be considered to be at the bin centre, regardless of its true location.

  (True offset and azimuth values are preserved.)

Parameters valid for the 3D option only

Before TIKIM - REG2D: Bin centering - Outline

- **The module has two options:**

1st option: Data Type

- **IL** - Inlines
- **XL** - Crosslines
- **CM** - CMPs
- **CG** - Cable Gathers

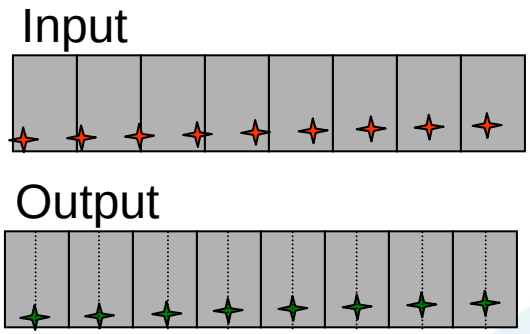
2nd option: Algorithm

- **FR** - Fourier Reconstruction
- **LR** - Linear Radon Regularization
- **PR** - Parabolic Radon Regularization
- **DF** - De-aliased FK Regularization

REG2D – Data Types

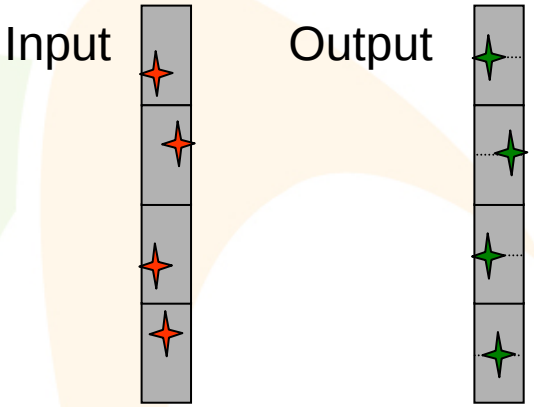
• Inlines (IL)

- Regularization to bin centre along inline



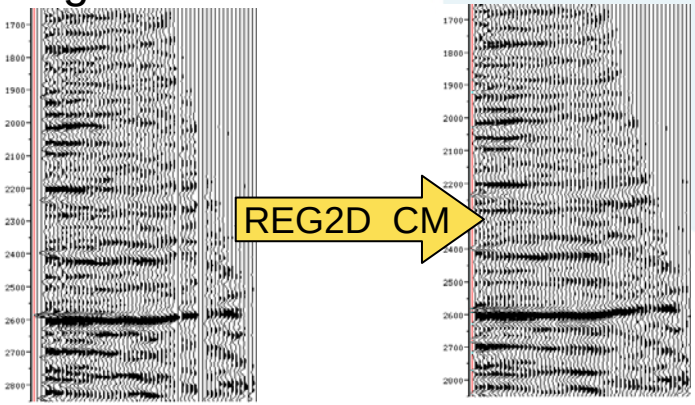
• Crosslines (XL)

- Regularisation to bin centre along crossline



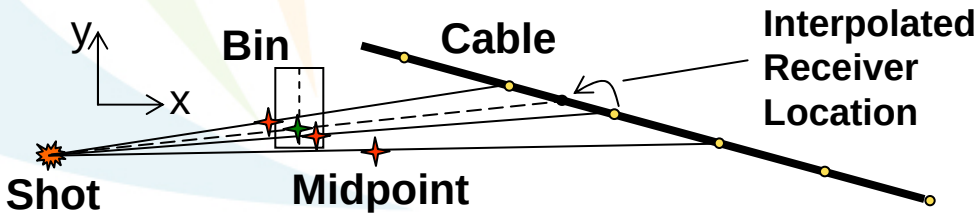
• CMPs (CM)

- Regularization to offset class centre.



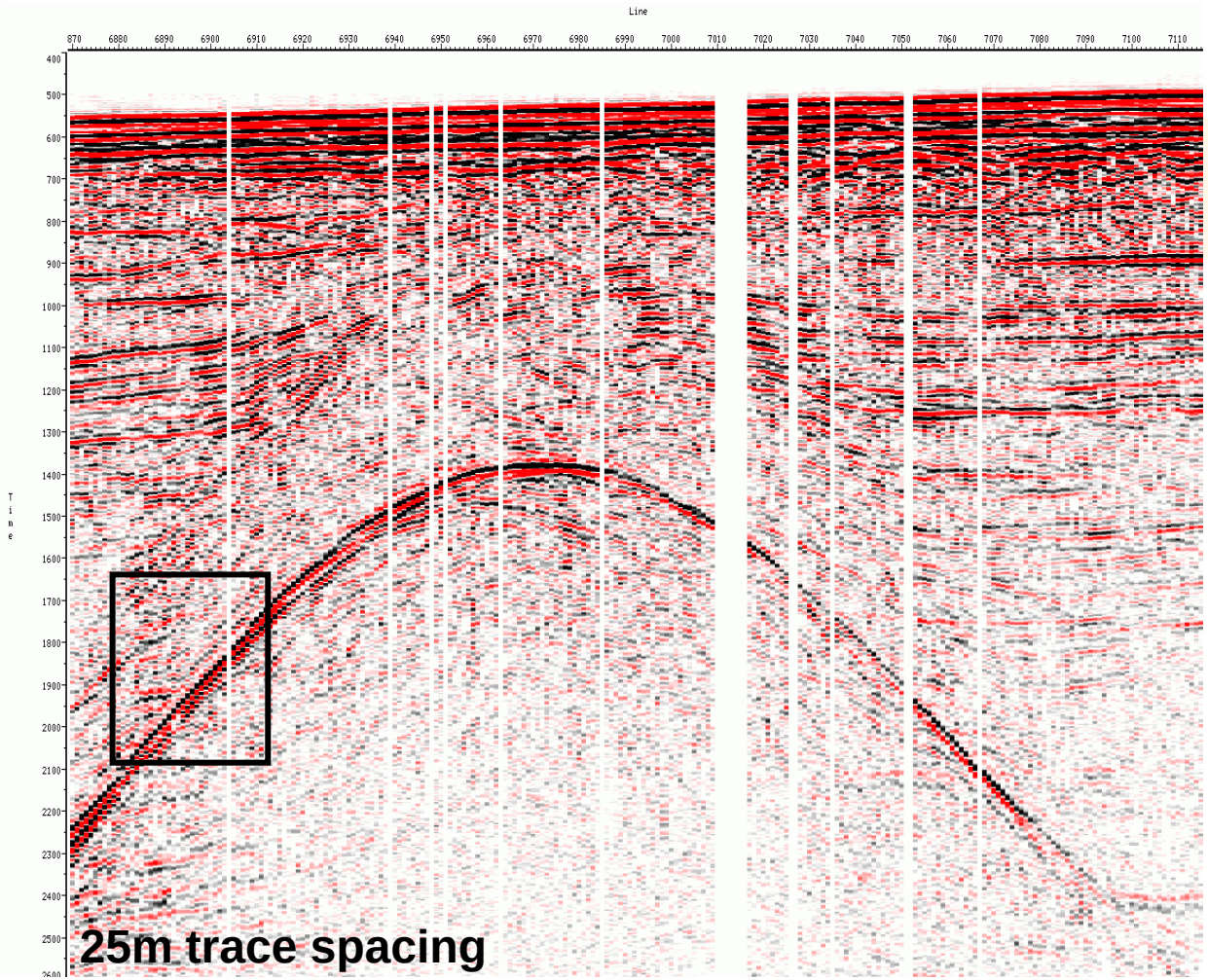
• Cable Gather (CG)

- Regularization to bin centre along inline.

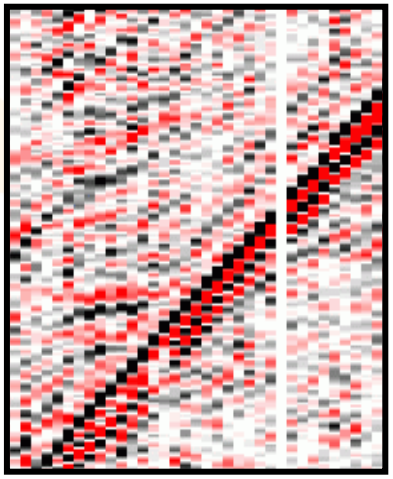


CGGVeritas University
Learning for Development

REG2D – Input



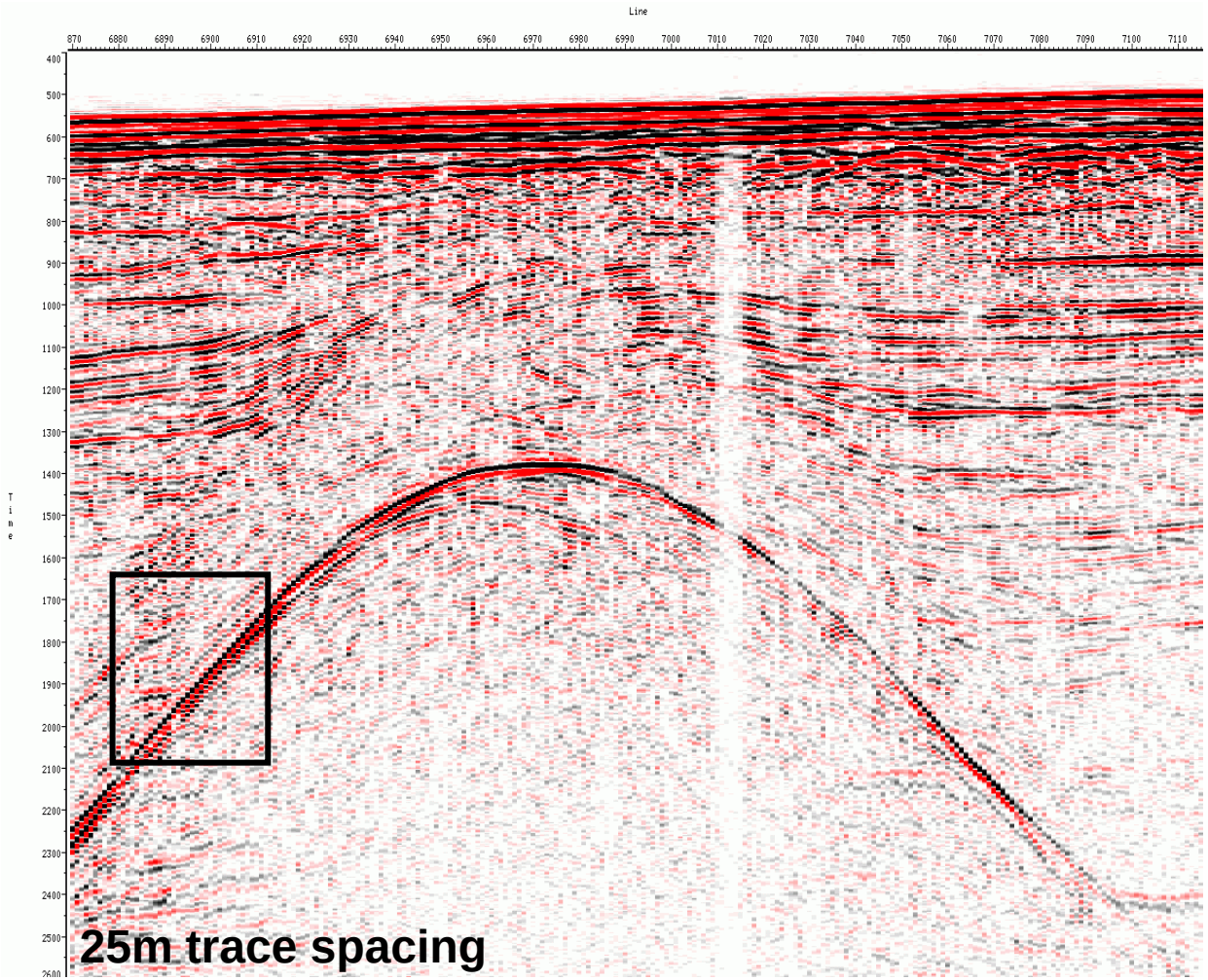
Zoom



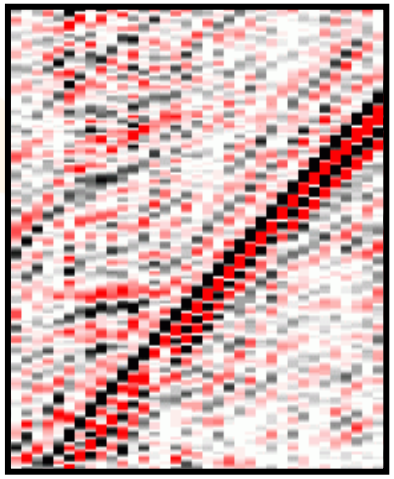
Input Data

CGGVeritas University
Learning for Development

REG2D – Linear Radon Regularization



Zoom

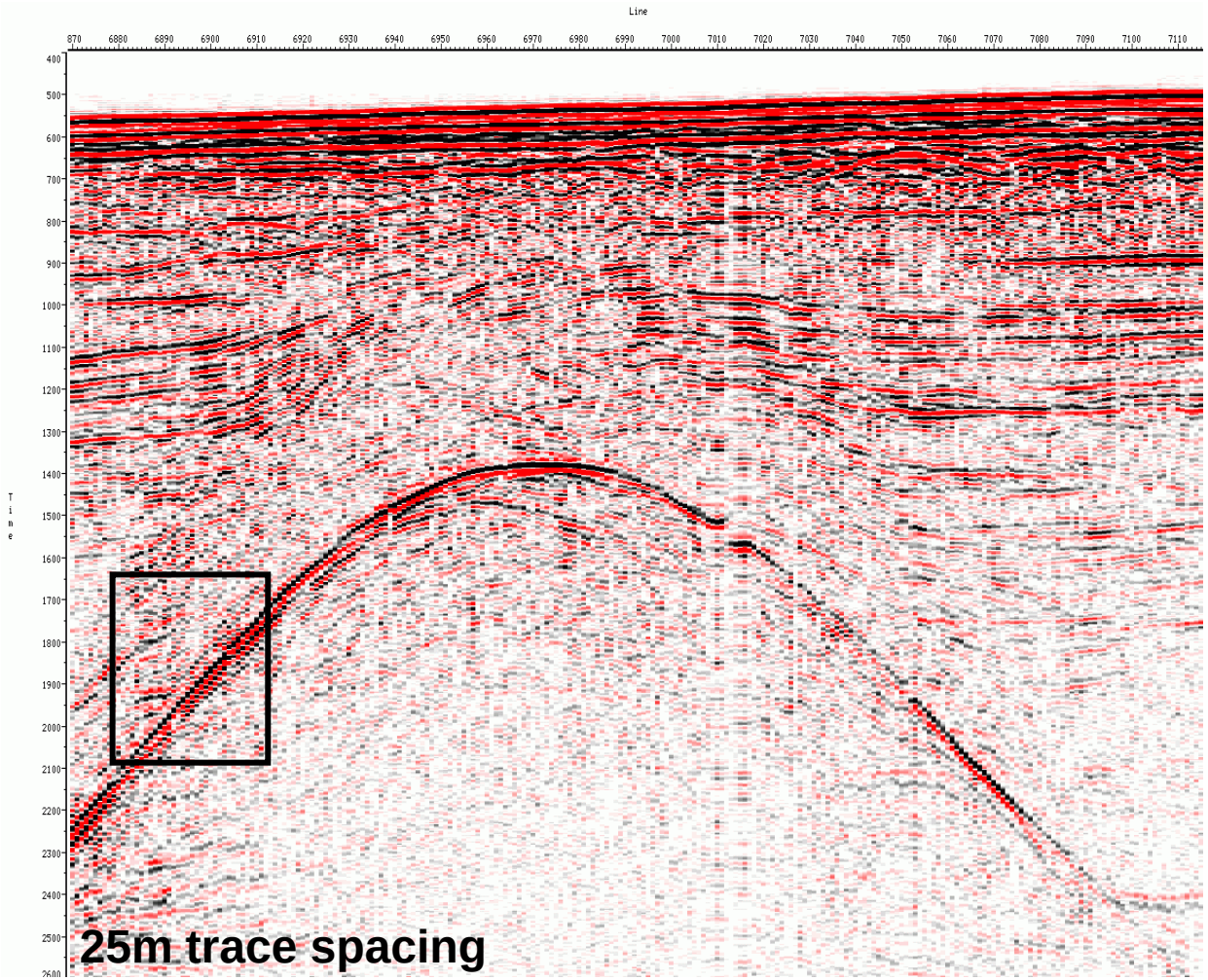


- **Handles aliased energy**
- **Poor amplitude preservation, especially in large gaps**

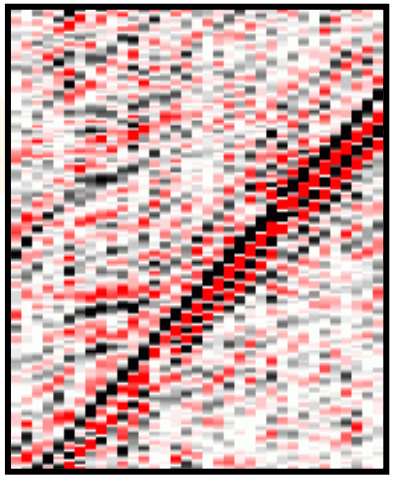
Linear Radon regularization

CGGVeritas University
Learning for Development

REG2D – Fourier Reconstruction



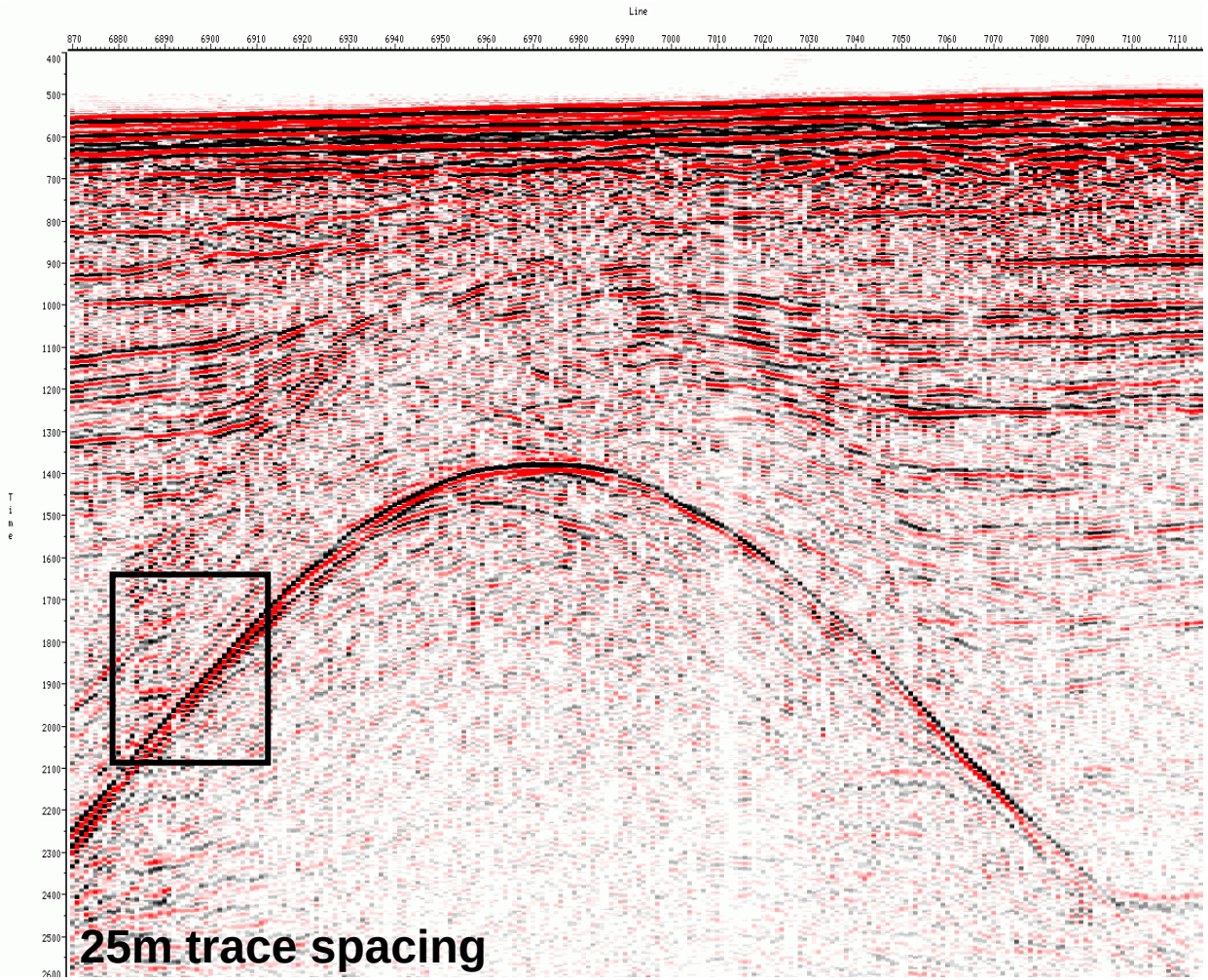
Zoom



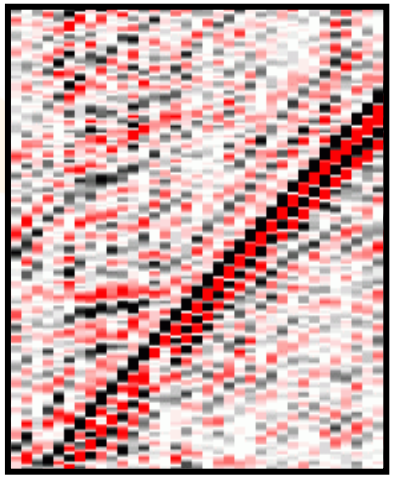
- **Can not handle aliased energy**
- **Good amplitude preservation**

Fourier Reconstruction

REG2D – De-aliased FK Regularization



Zoom



- **Good handling of aliased energy**
- **Good amplitude preservation**

De-aliased FK Regularization

CGGVeritas University
Learning for Development

REG2D – Job Example

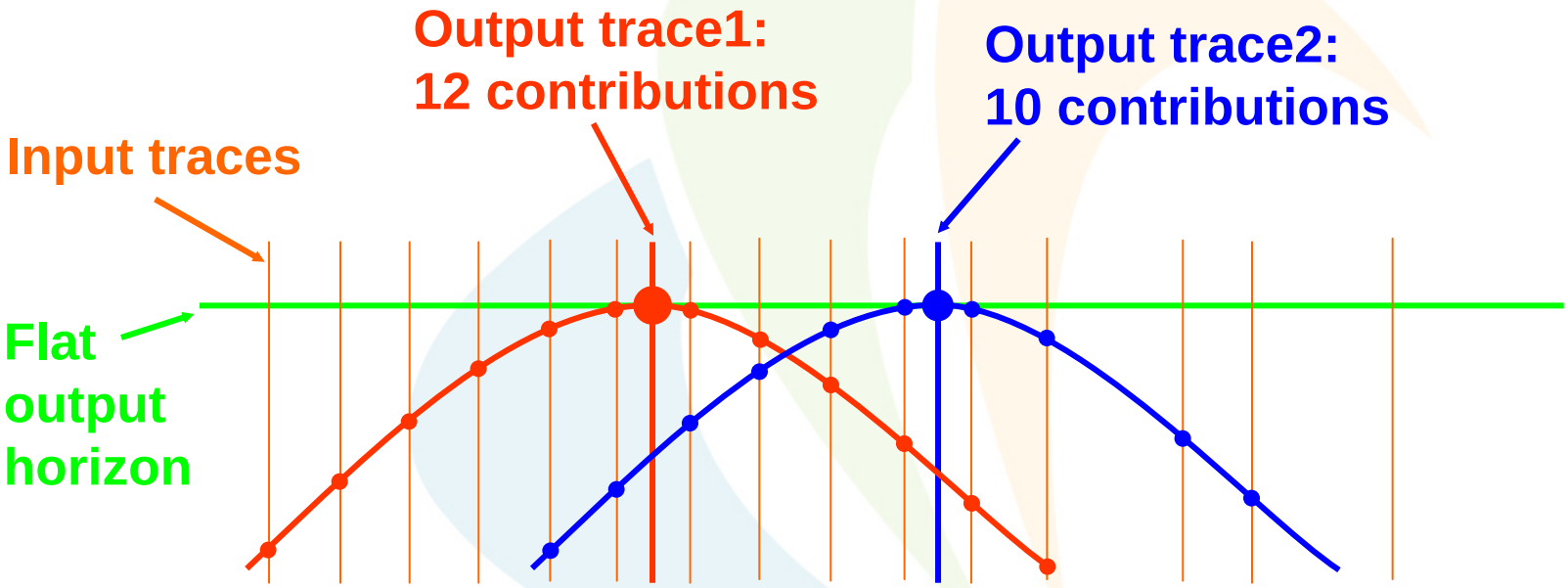
```
* LIBRI GR 01                    XOR   310501.13,YOR  5972559.21,
                                 AZX  1.56205397,AZY 6.27444295,
                                 DCDP  6.25,DLINE 6.25

** MAKE SURE DATA IS GRIDDED ONTO 6.25M OUTPUT GRID
* MODET XY    ==      ++        INV,LGR1,MOTXPT62,MOTYPT63,MOTXRE60,MOTYRE61
** SORT TO CROSSLINE-INLINE ORDER
* BSORT       ==      02        SORT=ONE4,TWO19,
                                NT2000000,PROCS=YB2,
* ENDLP
************************************************************
* DLOOP             2
* SELTR       ==      ++        MNGT=Y=MOT4,
* REG2D XL DF ==      03        B3,MTR,MARK64,MTR: to fill in bins that were empty on input
                                LGR1,VMAX1200,PFOLD61,
                                NCX81,TAPX40,NCT300,TAPT100,
* ENDLP
************************************************************
* BOUCL               3
```

CGGVeritas University
Learning for Development

Fold Regularisation

Fold regularisation is also an important step in reducing noise from Kirchhoff migrations.

Consider two output traces constructed from an irregular input dataset



The output samples therefore will have an imprint of the fold irregularity in their resulting amplitudes.

We now consider how to remove this effect.

Fold Regularisation

Normally land and marine data require different processing

Marine Streamer Data

Since there is generally good S/N: Aim is to build complete single fold offset cubes: Achieved by depopulation and restoration of missing traces.

Multi-azimuth land Data

Since there is generally a poor S/N: Aim is to keep all recorded traces and weight samples according to the fold. A dynamic binning can be used to borrow traces from adjacent bins to in fill holes.

Missing Trace effects

The best practice for compensating for missing traces should normally be to interpolate them.

This is commonly achieved by running

HABIN to remove duplicate traces

MISTR to interpolate missing traces
(or parameter MTR in REG2D)

Missing Trace effects

A question…

Is it an acceptable approach to simply use trace duplication?

(HABIN can also duplicate traces)

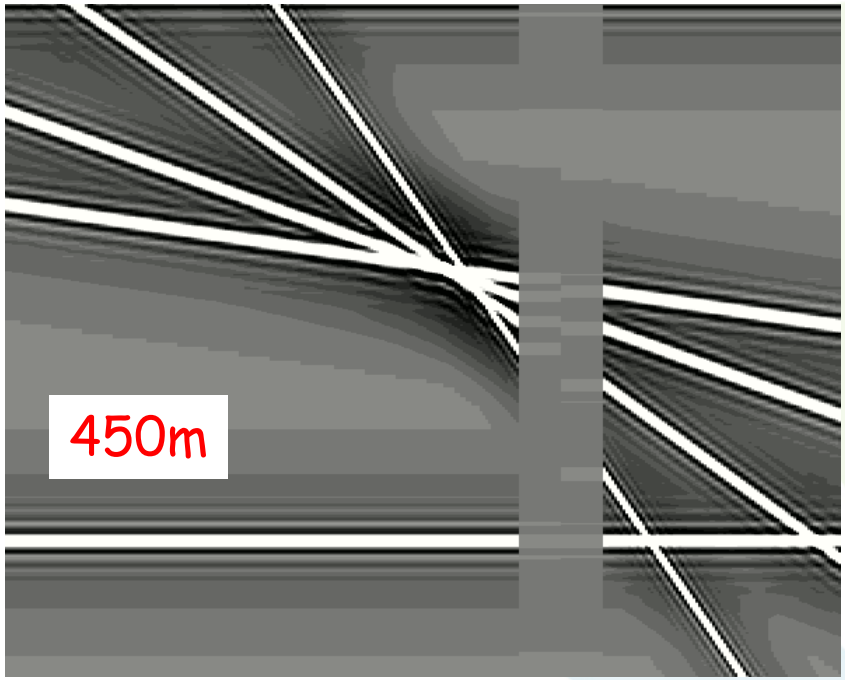
Sometimes!

- **The following slides illustrate why it is *not* always acceptable to use a simple trace duplication approach.**
  - **The model used consists of holes up to 450m wide, first created and then filled with duplicated traces from each edge.**
  - **The effects of migration on a flat event plus a series of dipping events (2°, 5°, 10° and 20°) in a 0.5-1.0s window is considered.**

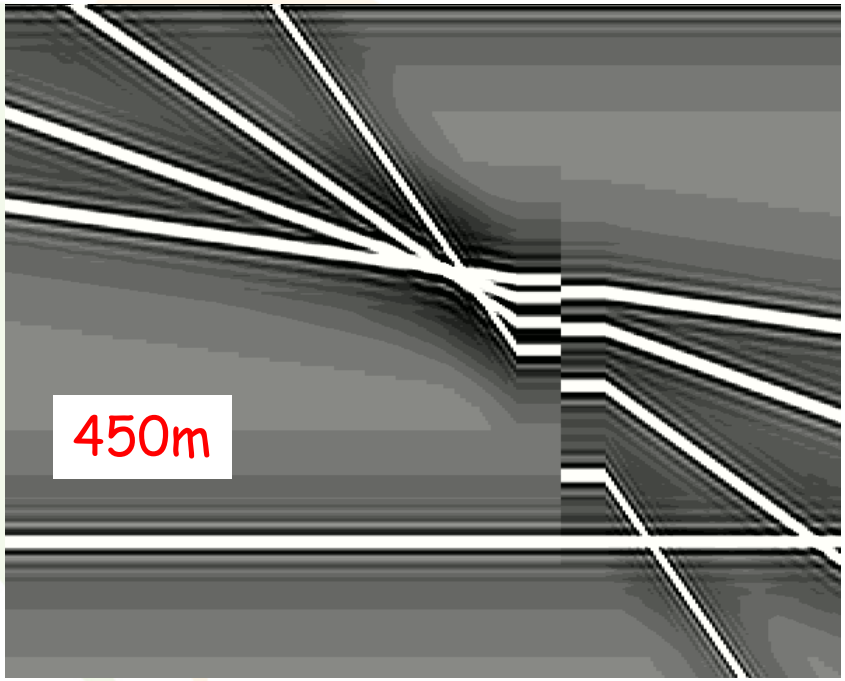
Missing Trace Effects

Input model traces…

input no duplication



input with duplication

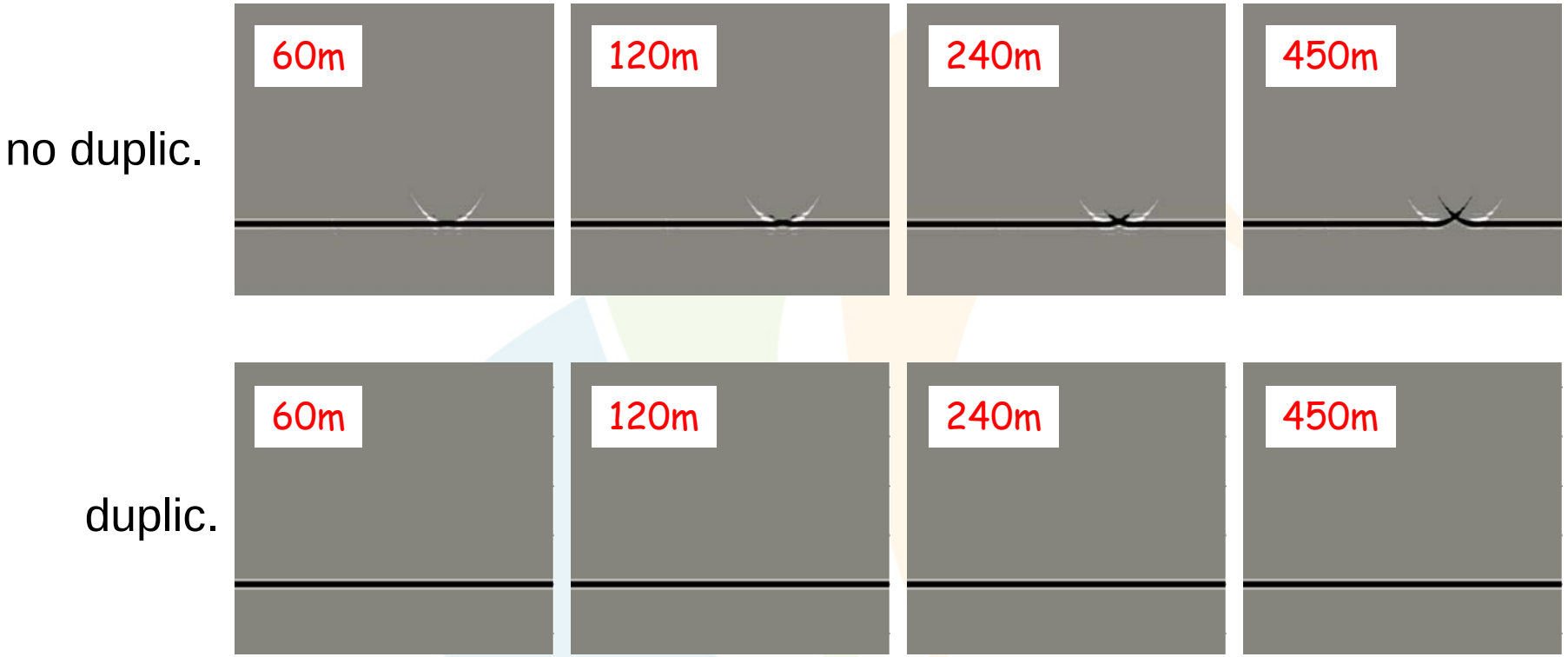


Each input section was migrated for a single 600m offset.

Let's look at the results

Acquisition Irregularity Compensation on real data

Effect of migrating duplicated traces on the flat event….



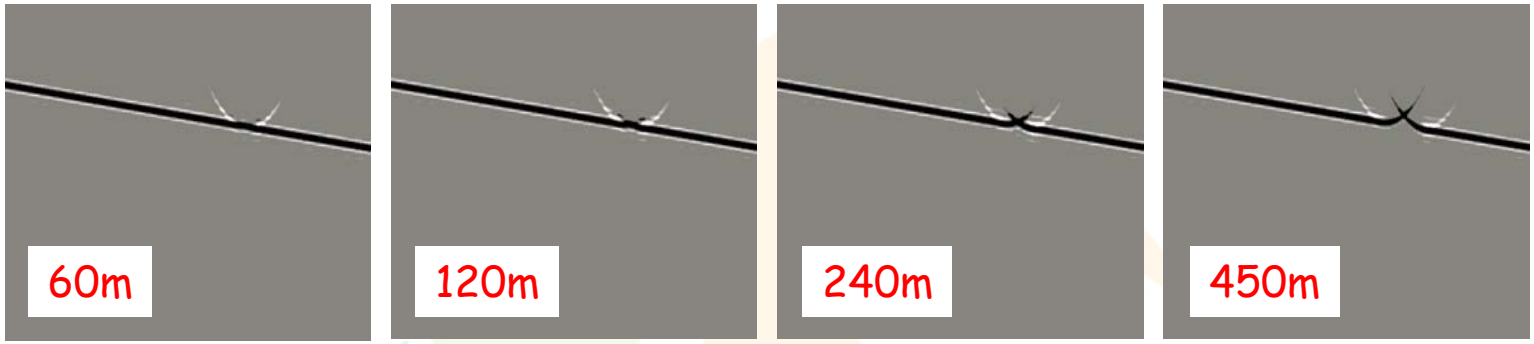
As might be expected duplication does a perfect job, although amplitude variations would not be taken into account.

For flat layered data there is hardly any limitation in the gap size that can be filled and trace duplication is a very effective tool for regularization before migration.

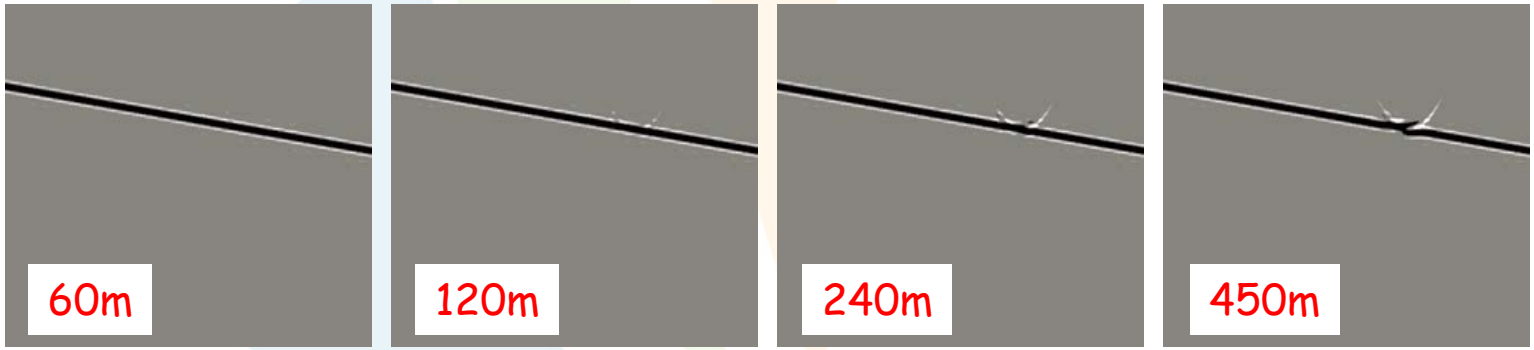
Acquisition Irregularity Compensation on real data

Effect of migrating duplicated traces on the 2^{O} dip event….

no duplic.



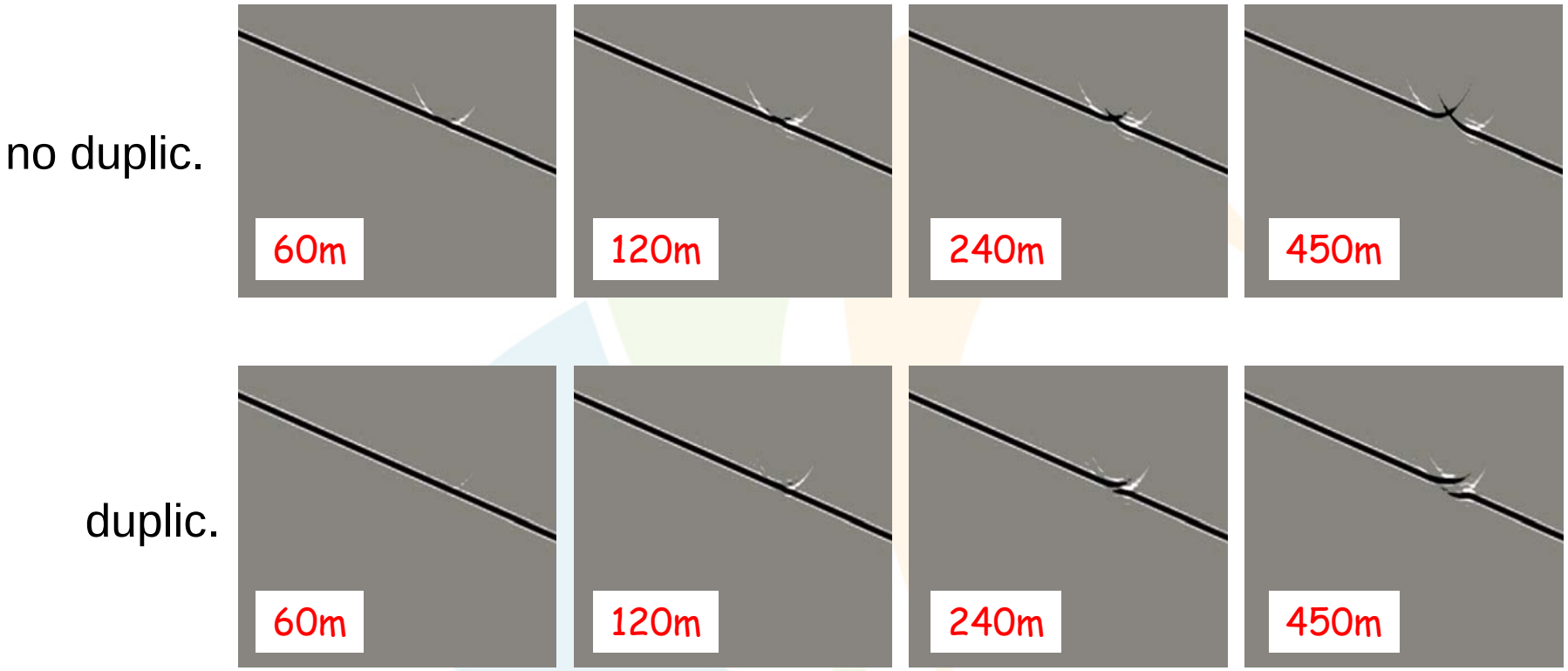
duplic.



For small dips trace duplication does a good job.

Acquisition Irregularity Compensation on real data

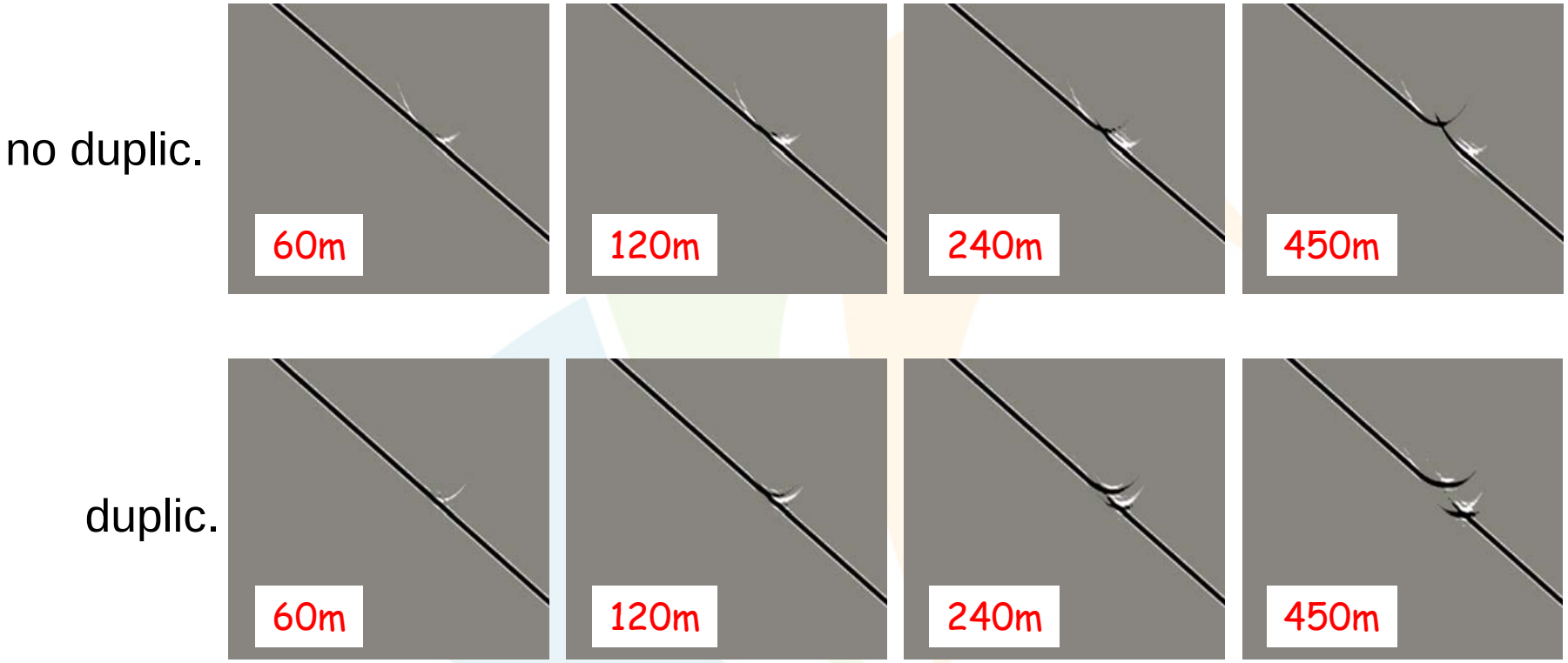
Effect of migrating duplicated traces on the 5^{O} dip event….



The limitations for this type of interpolation start to show and for large holes little or nothing is gained.

Acquisition Irregularity Compensation on real data

Effect of migrating duplicated traces on the 10^{O} dip event….

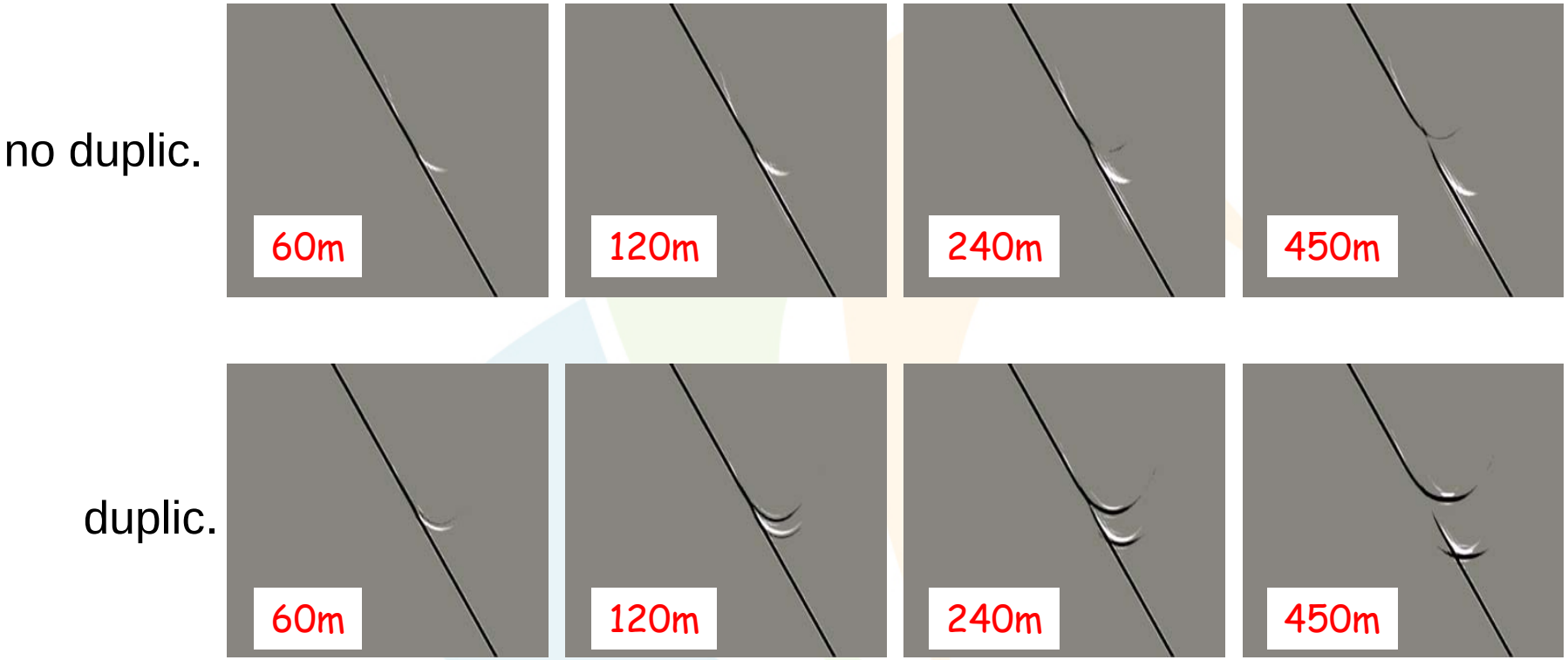


For yet steeper dips the duplication starts to create its own artifacts creating portions of flat events in the data..

CGGVeritas University
Learning for Development

Acquisition Irregularity Compensation on real data

Effect of migrating duplicated traces on the 20^{O} dip event….



The effect worsen with increasing dips.

Without duplication the steeper the dip the less affected the event becomes. The migration steepens the dips but also collapses the hole, reducing the gap.

Trace duplication on the other hand preserves the gap length.

CGGVeritas University
Learning for Development

TIKIM WEIGHTING

Different types of weighting exist in TIKIM.

‘Stack Weighting’

There are two different types of stack weighting

- **Assumed regular acquisition:**
  Migrated samples of individual input traces are weighted

- **Assumed irregular acquisition:**
  Area weighting OR a weighting based on the number of actual contributions compared to a theoretical number based on an idealized ‘regular’ acquisition.

Fold Compensation – N parameter

An important aspect is the multiplicity of traces within a bin (fold).

- **Parameter N defines the amount of weighting applied to the output traces using the following formula…..**

$$Weight, W = \left(\sqrt{p} \text{ x } \frac{N}{100} \right) + \left(p \text{ x } \frac{100 - N}{100} \right)$$

Where….

p is the sum of the amplitudes at a given output sample

N is the defined parameter, between 0 and 100.

Therefore …

If N0 is coded the output amplitude is equal to p : i.e. the output retains it's original amplitude.

If N100 is coded the output amplitude becomes equal to root p

CGGVeritas University
Learning for Development

Scaling and Fold Compensation

- **The traditional way of compensating for irregular fold is to apply *Bin Harmonisation* by using module HABIN.**
- **After HABIN traces will have been scaled according to the fold.**

  e.g. If a bin contains 3 traces with the same offset class these traces amplitudes are divided by 3, and this weighting factor is also written into Word 34.

- **After HABIN various header words will have been updated.**
  - **e.g. 3, acts as a flag to indicate duplicated traces**
- **If any traces have subsequently been dropped the scaling may remain with a definite (unwanted) impact on the amplitudes.**

.

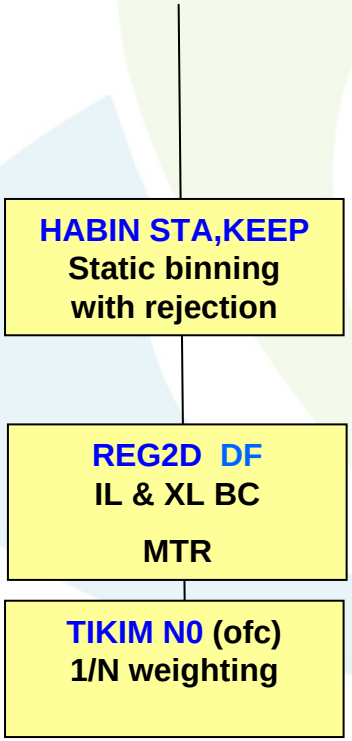
Fold Compensation

- As discussed, when possible, traces should be dropped to regularize the fold per bin and offset class prior to running TIKIM.
  - N defines the amount of weighting applied to the output traces.
    - Use with care for surveys with large variations in fold
  - NP means traces are not weighted (N and NP are mutually exclusive)
  - DEHAB de-applies the HABIN weighting prior to migration

Recommended if traces are dropped after HABIN to regularize fold

Regularization - The 2D marine best practice

REG2D option DF



Data Muting

Another important aspect to noise control is the application of some form of mute.

There are several kind of mutes that TIKIM can apply….

- **According to mute function - LMU/MUTE**
  - ✓ user-defined (recommended)
  - ✓ similar to type of first break mute applied before stacking
  - ✓LMU only reads libri. MUTE is required to apply the mute
- **According to Input Word6 - REMUTE**
- **According to migration stretch - SMU**
  - ✓ automatic
  - ✓ similar to SMU in module FANMO

Data Muting

3 Mute Options……

If no mutes specified Word6 of input traces will be the start of the TIKIM computation.

Important to check that Word6 is set correctly! (some levels of FANMO set it incorrectly)

As the preferred option however, mutes should not be applied in TIKIM, unless a 'light mute' to guide the migration start time.

Ideally run mute tests on output migrated gathers where possible