

## Opening

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Latest news

Introduction of the team

Program day I:

- Meeting part I: General introduction
- Meeting Part II: Seismic data regularization
- Meeting part III: Seismic signal separation
- Recent results and Future directions SINBAD

Program day II:

- Meeting Part IV: Imaging
- Recent results and Future directions SINBAD
- SINBAD Software releases
- Steering committee meeting



## Latest news

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**DNOISE:**

Dynamic nonlinear optimization for imaging in seismic exploration (DNOISE) is funded by the Natural Sciences and Engineering Council of Canada (NSERC).

- dollar-for-dollar matching (\$ 700 k)
- **SINBAD** funded through ITF supported by BG, BP, Chevron, ExxonMobil and Shell
- **ChARM** funded by Chevron
- includes \$ 100k contribution towards cluster



## Latest news

### LIMA HPC cluster (Laboratory for Imaging and Mathematics):

- 144-CPU cluster
- Compute nodes
- 36 x IBM eServer 326m (i.e., 144 CPUs) with:
  - 2 dual-core 2.2GHz Opteron processors (4 CPUs)
  - 8 GB memory (2 GB / CPU )
  - Voltaire Infiniband x4 high-speed inter-processor network
  - -280 GB of local storage
  - 1Gb Ethernet

**Financed by 2 CFI Grants (Prof Kuske and Prof Schoetzau from Math) and NSERC CRD.**



## Latest news

### LIMA HPC cluster:



## Team

### Current team

- 1 Post-doc
- 2 PhD students and 2 MSc students
- 2 scientific programmers
- 1 Summer COOP

### DNOISE funding expands the team

- 2 additional faculty
- 1 additional Post-doc
- 5 additional MSc/PhD students

Lost one PhD student



### Additional faculty Michael Friedlaender (Ph.D.)



- ◆ Fellow Argonne
- ◆ B.A., Cornell, MSc. & Ph.D., Stanford
- ◆ Numerical optimization
- ◆ Numerical linear algebra
- ◆ Design & implementation of constrained optimization
- ◆ Scientific computing



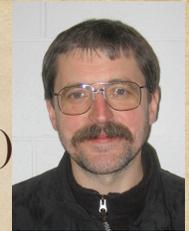
Additional faculty  
Ozgur Yilmaz (Ph.D.)



- ♦ M.A., Bogazici University, Turkey
- ♦ Ph.D., Princeton
- ♦ Applied harmonic analysis
- ♦ Signal processing
- ♦ Information theory



Additional Faculty  
Henryk Modzelewski (Ph.D.)



- ♦ Ph.D. in Atmospheric Sciences, UBC
- ♦ Scientific programming
  - ♦ High-Performance Computing
  - ♦ Development: MPI and Python
- ♦ System administration



Post-Doc. Fellow  
Challa S. Sastry



- ♦ Ph.D. in Mathematics, IIT, India
- ♦ Wavelets & Applications
- ♦ Computerized Tomography
- ♦ Image Analysis



Ph.D. student  
Peyman Moghaddam



- ♦ B.Sc. & M.Sc. in Electrical Eng., Tehran Polytechnic, Iran
- ♦ Statistical Signal Processing
- ♦ Imaging Optimization
- ♦ Parallel Programming
- ♦ Migration



Ph.D. student  
Gilles Hennenfent



- ♦ DEA (MSc level) in Photonics, Image & Cybernetics, Universite Louis Pasteur, France, 2000
- ♦ Engineer in Applied Physics, Ecole Nationale Supérieure de Physique de Strasbourg, (2000-2003)
- ♦ Data regularization



Ph.D. Student  
Rayan Saab



- ♦ M.A.Sc. in Electrical Eng., UBC
- ♦ B.E. in Computer and Communications Eng., American Univ. of Beirut
- ♦ Blind Source Separation
- ♦ Statistical Signal Processing
- ♦ Discrete Optimization
- ♦ Seismic and Biomedical Signal Processing



Ph.D. Student  
Ewout Van Den Berg



- ♦ B.Sc., and M.Sc. in Computer Sciences, Delft
- ♦ Ph.D. in Computer Sciences, UBC
- ♦ L1 minimization
- ♦ Sparse signal recovery
- ♦ Seismic signal processing



M.A.Sc. Student  
Carson Yarham



- ♦ B.Sc. in Honors Geophysics, UBC
- ♦ Signal Separation
- ♦ Matlab algorithm development
- ♦ Curvelet domain filtering



M.A.Sc. Student  
Mohammad Maysami



- ♦ B.Sc. in Petroleum Eng., Sharif Univ., Tehran
- ♦ B.Sc. in Electrical Eng., Sharif Univ., Tehran
- ♦ M.A.Sc in Geophysics, UBC
- ♦ Seismic Signal Characterization
- ♦ Well Log - Seismic Data Tie



M.A.Sc. Student  
Vishal Kumar



- ♦ M.Sc. in Exploration Geophysics, IIT.
- ♦ Joined to SLIM recently



Scientific Programmer  
Darren Thomson



- ♦ B.Sc. in Engineering Physics, UBC, 2005
- ♦ Joined SLIM in May 2005 as NSERC Summer Research Student
- ♦ Massive Parallel Curvelet Transform



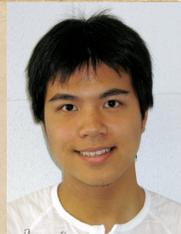
Summer Co-Op  
Sean Ross-Ross



- ♦ Undergrad in Computer Science, UBC
- ♦ Joined SLIM in 2006
- ♦ Software Development
- ♦ Development of SLIMpy



## Summer Co-Op Tim Lin



- ◆ 3rd year Undergraduate in Hon. Physics, UBC
- ◆ Joined SLIM in 2006 as summer co-op student
- ◆ Compressed Wavefield Migration and Imaging



## Misc. program

Program in the folders.

Lunches are catered.

Diner Monday night in the Sage Bistro on Campus.

Steering committee meeting Tuesday afternoon  
RSF School and Workshop, Vancouver 2006 on  
Wednes- and Thursday

- DNOISE
- Commercialization
- Future research directions



## SINBAD project

*“from seismic data to reflectivity ...”*

Stable recovery of seismic

- wavefronts in data
- reflectors in the subsurface

Data acquisition:

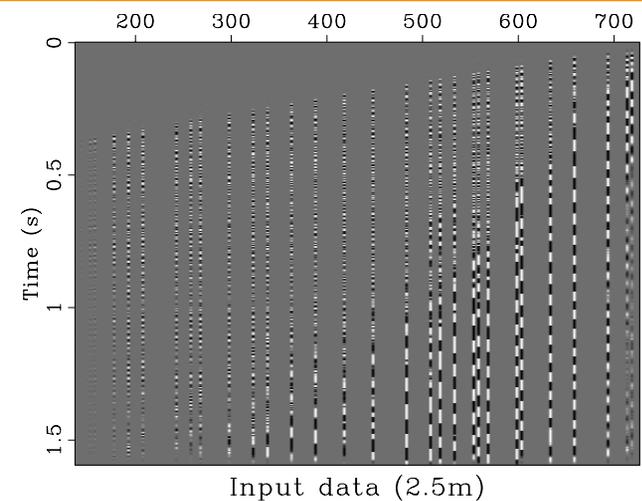
- sparsity & invariance of redundant multiscale & directional signal expansions
  - curvelets
  - wave atoms
- nonlinear sampling theory

Imaging:

- image amplitude recovery
- compressed nonlinear imaging

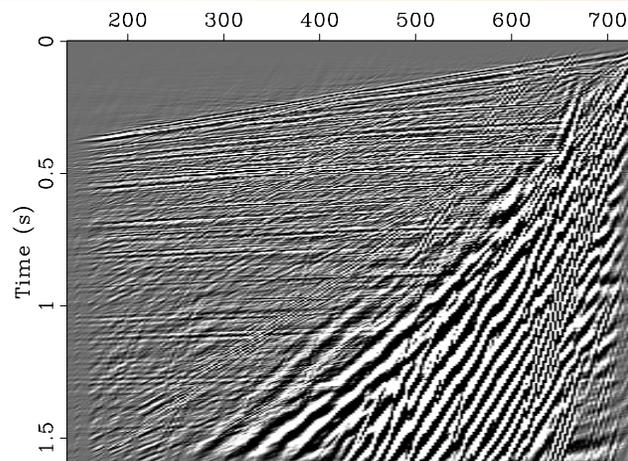


## From 20 m to 2.5 m



Seismic Laboratory for Imaging and Modeling

## From 20 m to 2.5 m

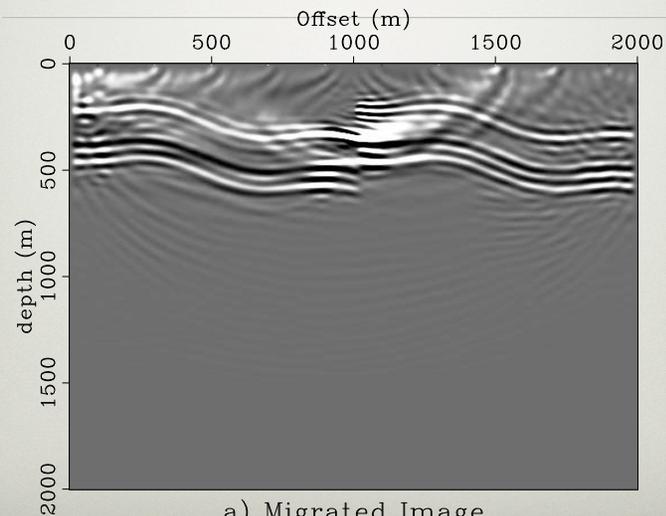


Interp. data

Seismic Laboratory for Imaging and Modeling

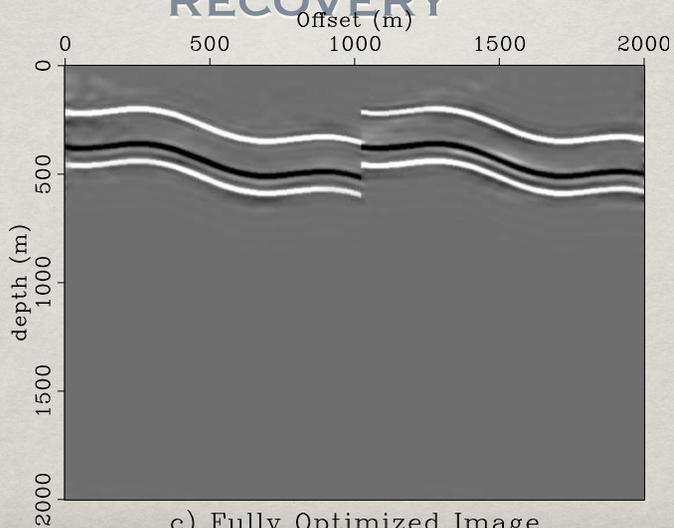
## PRELIMINARY RESULTS

### IMAGED REFLECTIVITY



a) Migrated Image

## IMAGE AMPLITUDE RECOVERY



c) Fully Optimized Image

## ChaRM Project

*“from seismic reflectivity to connectivity ...”*

Detection and characterization of seismic reflectors:

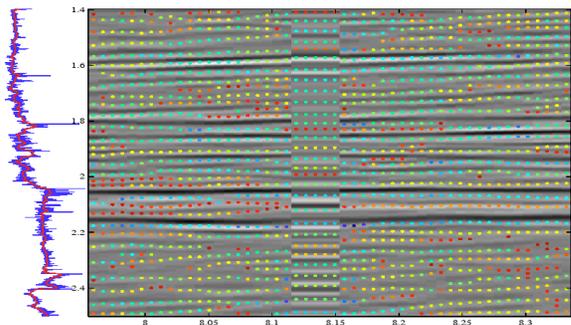
- Capture information on the fine-structure of reflectors by scale exponents
- Capture information on the mixing of binary systems (sand-shale/opal-opal-CT/Gas-Hydrates)

Reflector Modeling: relate connectivity to transport properties

- Elastic properties (bulk/shear moduli)
- Fluid properties (permeability)
- Nonlinear lithology upscaling that preserves singularities (reflectors)

# Well tie

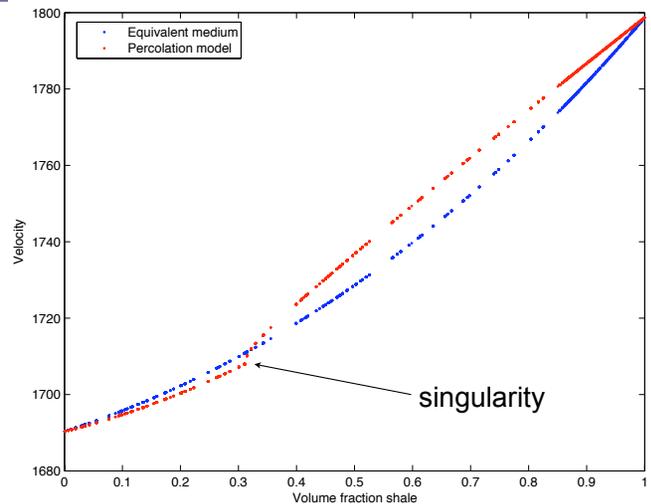
## Well versus Seismic Singularity Maps



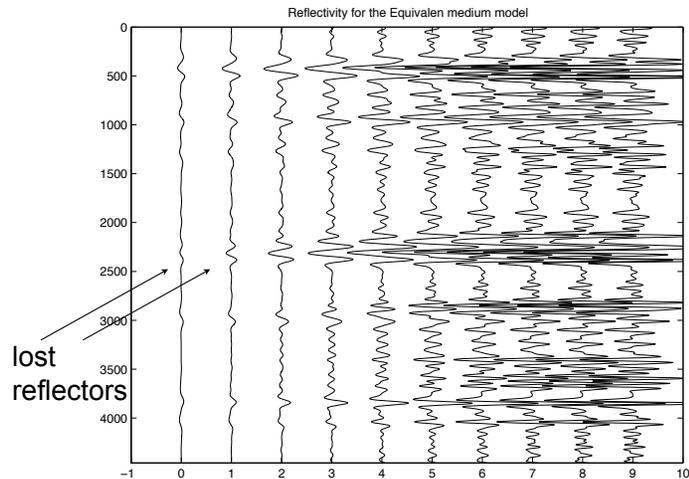
Blue sharp  
Red smooth  
Localizes & Ties

Links the sharpness of transitions in images to transitions.

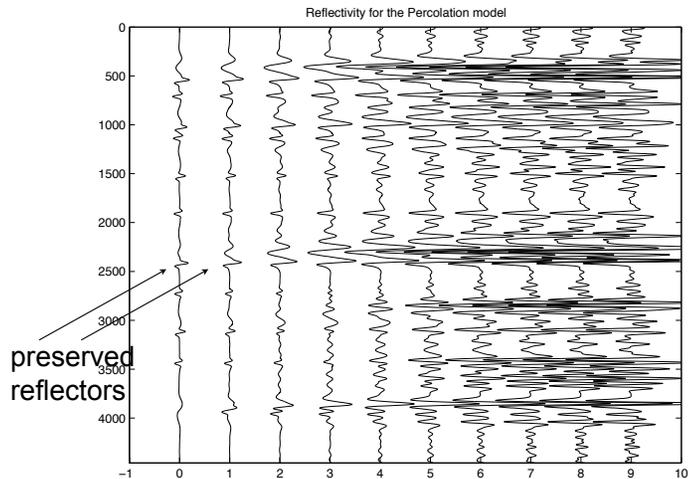
# Percolation switch: Equivalent medium average vs Percolation



# Upscaling: EM upscaled reflectivity



# Upscaling: Perc. upscaled reflectivity



## Co-workers

Imaging: Dr. Chris Stolk (TUT)

Primary-multiple separation: Dr. Eric Verschuur (TUD)

Singularity detection and characterization:  
Dr. Stephane Jaffard (Paris XII) and Dr.  
Beatrice Vedel (Orsay)

Singularity modeling: Dr. Yves Bernabe  
(MIT)



## SINBAD's main theme

Application of sparsity promoting expansions

- data recovery
- data separation
- deconvolution
- imaging

During the meeting

- Primers on recovery & sparsity transforms
- Applications to data regularization, separation & imaging
- Outlook on compressed imaging & multiple prediction



## SINBAD's main theme

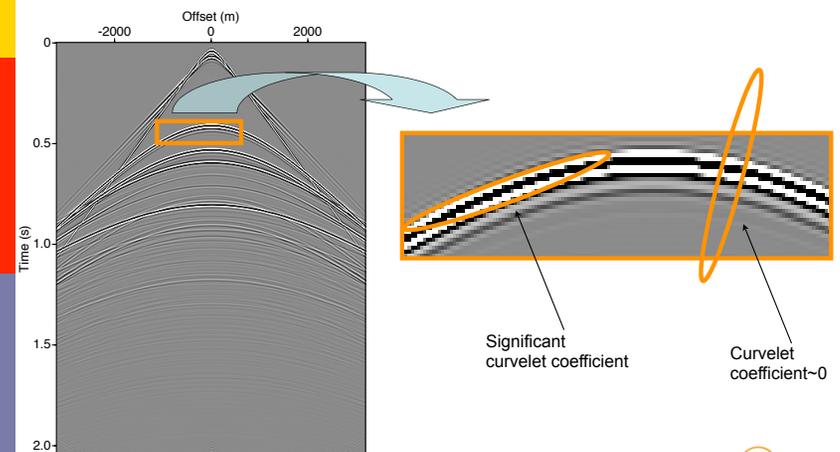
### Borrow from

- Applied & Computational Harmonic Analysis (Tao fields medal)
- Information theory
- Random matrix theory and phase transitions (Werner fields medal)
- Compressed sensing

**New NONLINEAR sampling theory for wavefields ... that exploits sparsity and continuity of wavefields!**



## Curvelets & seismic Data



## METHOD

$$\min \|\mathbf{x}\|_1 \quad \text{s.t.} \quad \|\mathbf{Ax} - \mathbf{y}\|_2 \leq \epsilon$$

$\uparrow$                        $\uparrow$   
sparsity                      data misfit  
enhancement

*When a traveler reaches a fork in the road, the  $l_1$ -norm tells him to take either one way or the other, but the  $l_2$ -norm instructs him to head off into the bushes.*

John F. Claerbout and Francis Muir, 1973

## Program

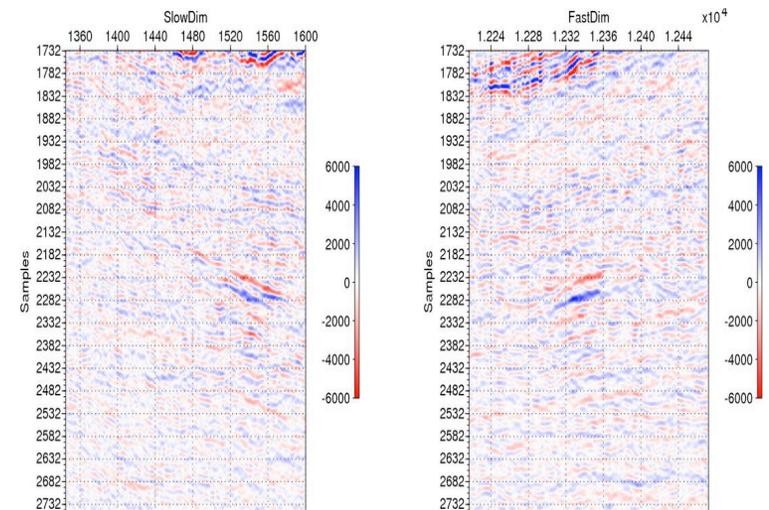
<http://slim.eos.ubc.ca/SINBAD2006/SINBAD2006/Program.html>



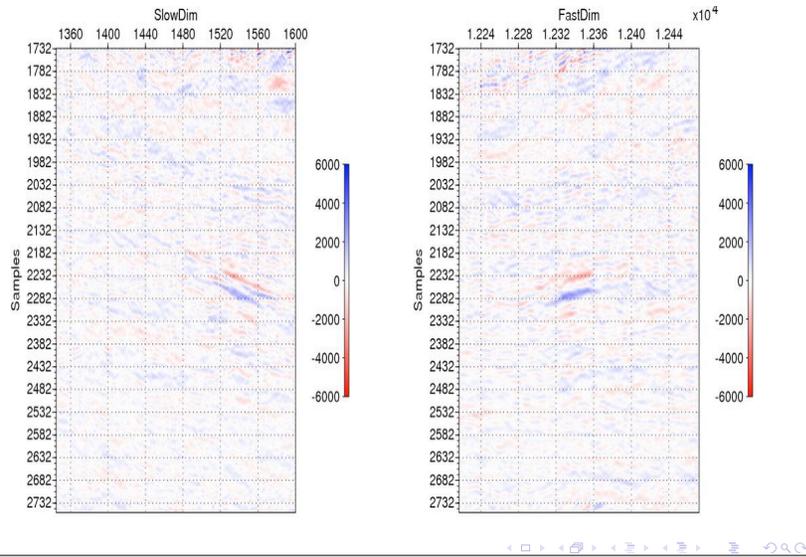
## RECOVERY 4-D DIFFERENCE CUBES

“Computation of time-lapse differences with 3D directional frame”  
with Moritz Beyreuther and Jamin Christall  
to be submitted

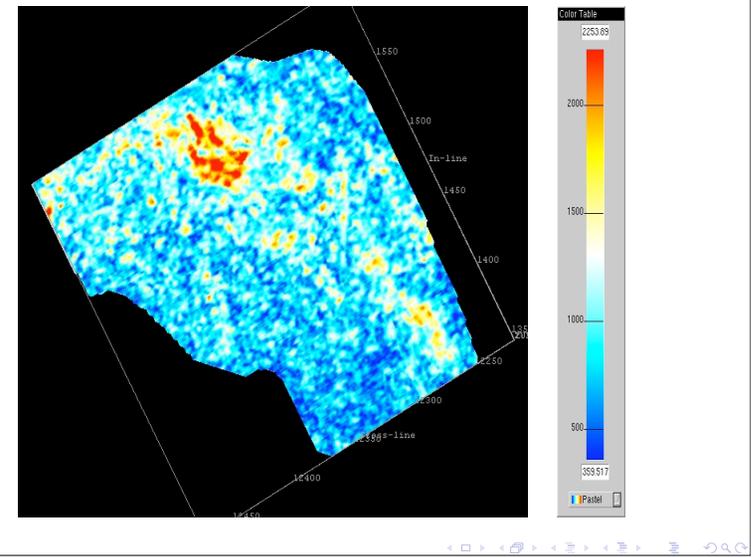
## SHETLAND FIELD: Regular Difference



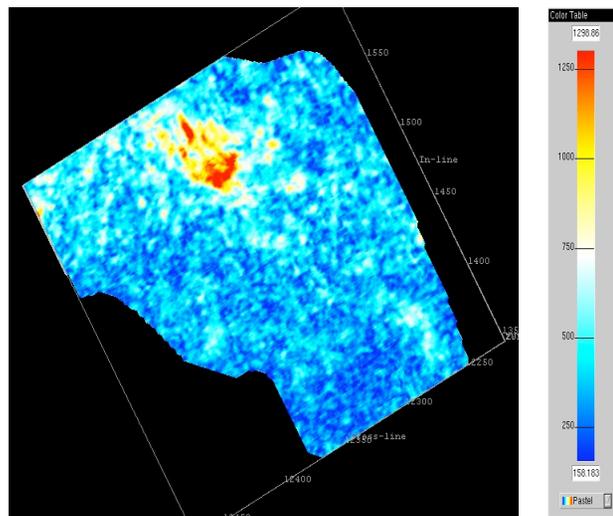
### SHETLAND FIELD: Curvelet Difference Thr: 1.2



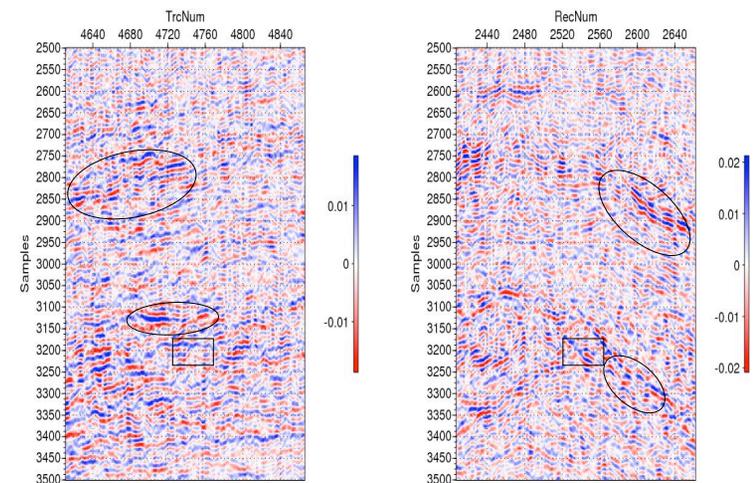
### SHETLAND FIELD: 60ms RMS Amplitude Regular



### SHETLAND FIELD: 60ms RMS Amplitude Curvelet 1.2

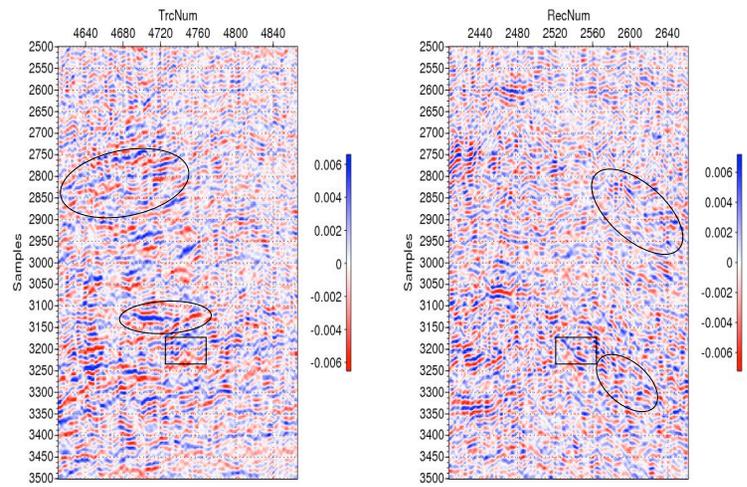


### ULA FIELD: Regular Difference



[Well/injector marked by rectangle, coherent noise marked by ellipse]

# ULA FIELD: Curvelet Difference Thr:1.2



[Well/injector marked by rectangle, coherent noise marked by ellipse]