

MOTIVATION

Source inversion techniques are routinely applied to retrieve features of the rupture process. However, kinematic inversions are affected by a number of epistemic uncertainties, leading to a large variety of potential source models for a single event (Mai et al. 2007). It is thus imperative to properly understand the origin of this variability to improve our understanding of the rupture process.

The very first step is to test the forward problem. As part of the Source Inversion Validation (SIV) project, we carried out forward-modeling tests to compute synthetics at a set of stations, for a specified velocity structure and different source scenarios: a simple point source and a "realistic" extended source, for strike-slip and dip-slip cases.



Wave speed (km/s) / Density (g/cm³)

Dip-slip extended fault test

X [km]



Strike-slip extended fault test



PARTICIPANTS AND METHODS

hypo depth = 9.8 km

"Source point" exercise, 9 participants using:

- AXITRA **A1, A2, A3** Discrete wavenumber method, Bouchon (1981) Kennett (1979) propagator matrix technique
- Zhu and Riveira (2002) **Z1, Z2, Z3** Discrete wavenumber method Thompson-Haskell propagator matrix technique
- COMPSYN C1, C2 Discrete wavenumber method Finite-element method (Olson et al. 1984)
- Discontinuous Galerkin (Martin Kaeser's code) D1 Finite-element method combined with the explicit time integration method using arbitrary high-order derivatives

Extended fault exercise, 4 participants using:

AXITRA A4, A5, Ainv Note that Ainv is commonly used for source inversion studies (e.g. Cotton & Campillo 1995)





Principle of the forward problem computation in Cotton & Campillo (1995) inversion procedure (A_{inv} method)

COMPSYN C3

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RESULTS 1: "POINT SOURCE" TESTS

- In such simple cases, some discrepancies still appear, even between modelers using similar methods (time shifts, amplitude, frequency content)
- But basically, differences remain very small at low frequency (< 2 Hz)</p>
- In the dip-slip case, for stations close to the source, some synthetics are affected by strong artefacts)





Waveform comparison for strike-slip point source at station 10 - [0 - 5Hz]

			M		
X – m/s	CORR = 1.000	~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~	Marrow	TSHIFT =	= -0.112
	L2 = 1.0e+01			SCAL = 1	.00e+00
	CORR = 0.988		$\ $	TSHIFT =	= 0.000
	L2 = 2.6e+02		A	SCAL = 1	.00e+00
	CORR = 0.954		M	TSHIFT =	= 0.000
	L2 = 9.5e+02		A	SCAL = 1	.28e+00
	CORR = 0.961		M	TSHIFT =	= 0.000
	L2 = 8.1e+02		N	SCAL = 1	.13e+00
	CORR = 0.989		$\ M \ $	TSHIFT =	= 0.000
	L2 = 2.8e+02		N	SCAL = 1	.08e+00
	CORR = 0.998		//m	TSHIFT =	= -0.022
	L2 = 4.0e+01		N	SCAL = 1	.05e+00
	CORR = 0.986		I m	TSHIFT =	= 0.000
	L2 = 3.7e+02		N	SCAL = 1	.31e+00
	CORR = 0.988	James	Mps-	TSHIFT =	= 0.090
	L2 = 2.8e+02			SCAL = 1	.09e+00
		1	• •	8	10
	U 2	Time -	- S	0	10
	— A1	(ref.)			Z3
	A2)			C1
	A3)			C2
	<u> </u>				D1

____ Z2



Waveform comparison for dip-slip point source at station 2 - [0 - 5Hz]

	0 2	4 Time	6 2 _ c	8	10		0	2
		V]			
	L2 = 1.7e+01			SCAL =	1.08e+00		L2 = 7	.8e+00
	CORR = 0.991	M	~~~~	TSHIFT	= 0.090		CORF	8 = 0.994
	L2 = 1.6e+01			SCAL =	1.22e+00		L2 = 1	.3e+01
	CORR = 0.991			TSHIFT	= 0.022		CORF	R = 0.991
	L2 = 1.2e+01			SCAL =	1.03e+00		L2 = 9	.5e+00
	CORR = 0.993		~~~~~	TSHIFT	= -0.022		CORF	1 = 0.993
	L2 = 3.4e + 01			SCAL =	9.97e-01	ŗ		V
। ×	CORR = 0.982			TSHIFT	= 0.000		CORF	R = 0.792
m/s	L2 = 1.1e+02			SCAL =	1.33e+00) E		V
	CORR = 0.961	y lon		TSHIFT	= 0.000	S	CORF	8 = 0,784
	L2 = 1.7e+02			SCAL =	1.77e+00		L2 = 1	.2e+02
	CORR = 0,939			TSHIFT	= 0.000		CORF	R = 0.925
	L2 = 9.7e+00			SCAL =	9.96e-01		L2 = 7	.2e+00
	CORR = 0.995	W	~~~~~	TSHIFT	= 0.000		CORF	R = 0.995
	L2 = 1.0e+01	Wares		SCAL =	9.29e-01			- A A a
				TSHIFT	= -0.112		CORP	i = 0.804









CORR = 0.999

= -0.112
1.01e+00
= 0.000
1.00e+00
= 0.000
1.40e+00
= 0.000
1.14e+00
= 0.000
1.13e+00
= -0.022
1.02e+00
= 0.000
1.32e+00
= 0.090
1.13e+00
]



CORR = max. autocorr. function

SCAL = scaling factor to get the reference PGV

TSHIFT = time shift

L2 = L2-norm

 $\mathsf{TSHIFT} = -0.112$







	CORR = 0.992	M	TSHIFT = -0.112
	L2 = 5.3e+00	S Wranner	SCAL = 1.05e+00
	CORR = 0,996	٨	
		\sim	SCAL = 9.97e-01
	L2 = 2.4e + 00	V	
	CORR = 0.943	Apr	TSHIFT = 0.000
	L2 = 4.0e+01	V	SCAL = 1.42e+00
	CORR = 0,959	٨	TSHIFT = 0.000
n/s	L2 = 2.7e+01	N harrison	SCAL = 1.23e+00
	CORR = 0.981	٨	
N	\square	\sim	TSHIFT = 0.000
	L2 = 1.3e+01	V	SCAL = 1.09e+00
	CORR = 0,996	٨	TSHIFT = -0.022
	L2 = 2.8e+00	~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~	SCAL = 1.03e+00
	CORR = 0.993		TSHIFT = 0.022
	L2 = 4.5e+00		SCAL = 1.18e+00
	CORR = 0,993	M	TSHIFT = 0.090
	12 = 5.1e+00	~ p	SCAL = 1.08e+00
		W	
		1	
	0 2	4 6	8 10

Time – s



CONCLUSION

- polate procedure







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RESULTS 2: EXTENDED SOURCE TESTS

Some significant differences appear in the whole frequency range (0 - 5 Hz)

Discrepancies mainly arise from the various techniques used to interpolate the rupture parameters on the fault plane

Waveform comparison for strike-slip extended source at station 10 – [0 – 5Hz]

Waveform comparison for strike-slip extended source at station 10 – [0 – 1Hz]

EFFECTS ON INVERTED SLIP IMAGES

We deploy a frequency-domain inversion technique (Cotton & Campillo 1995) to investigate the effects of these uncertainties on inferred slip distributions

Forward problem is computed using A_{inv} technique (see figure bottom left) up to 1 Hz Inverted synthetic data are calculated using A_{inv} and A4, A5, C3

Inversion results are strongly affected. Choosing adequate smoothing constraints is then crucial



These simple tests reveal that modelers need a perfect understanding of the use, the definitions, and the corresponding input parameters of the codes deployed for forward computation

There is a need to clearly understand the uncertainties arising from the rupture parameter inter-

The observed uncertainties might have a strong impact on the inferred rupture process features