Generalizations of the Common-Reflection-Surface Stack

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- the simplest case: 2-D zero-offset simulation

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- Outlook

Related presentations:

B003	Stacking velocity analysis with CRS Stack attributes
B015	3D zero-offset Common Reflection Surface Stack for land data – real data example
B016	Improved resolution in time and depth processing by macromodel independent CRS Stacking
P165	Topographic correction using CRS parameters
P166	2D and 3D ZO CRS stack for a complex top-surface topography
P167	A fourth-order CRS moveout for reflection and diffraction events

Basic concepts (I)

Basic ideas:

- entirely data-oriented approach

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- entirely data-oriented approach
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Inherent assumptions:

- coherent reflection events exist in the pre-stack data
- paraxial approximation holds in vicinity of central ray

Basic concepts (II)

Establish relationship between

- subsurface reflector segment and
- its kinematic reflection response in the pre-stack time domain

by means of hypothetical experiments.

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Parameters or CRS wavefield attributes:

- curvatures of hypothetical wavefronts
- their propagation directions

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Spatial CRS stacking operator:

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- determination by means of coherence analysis in pre-stack data

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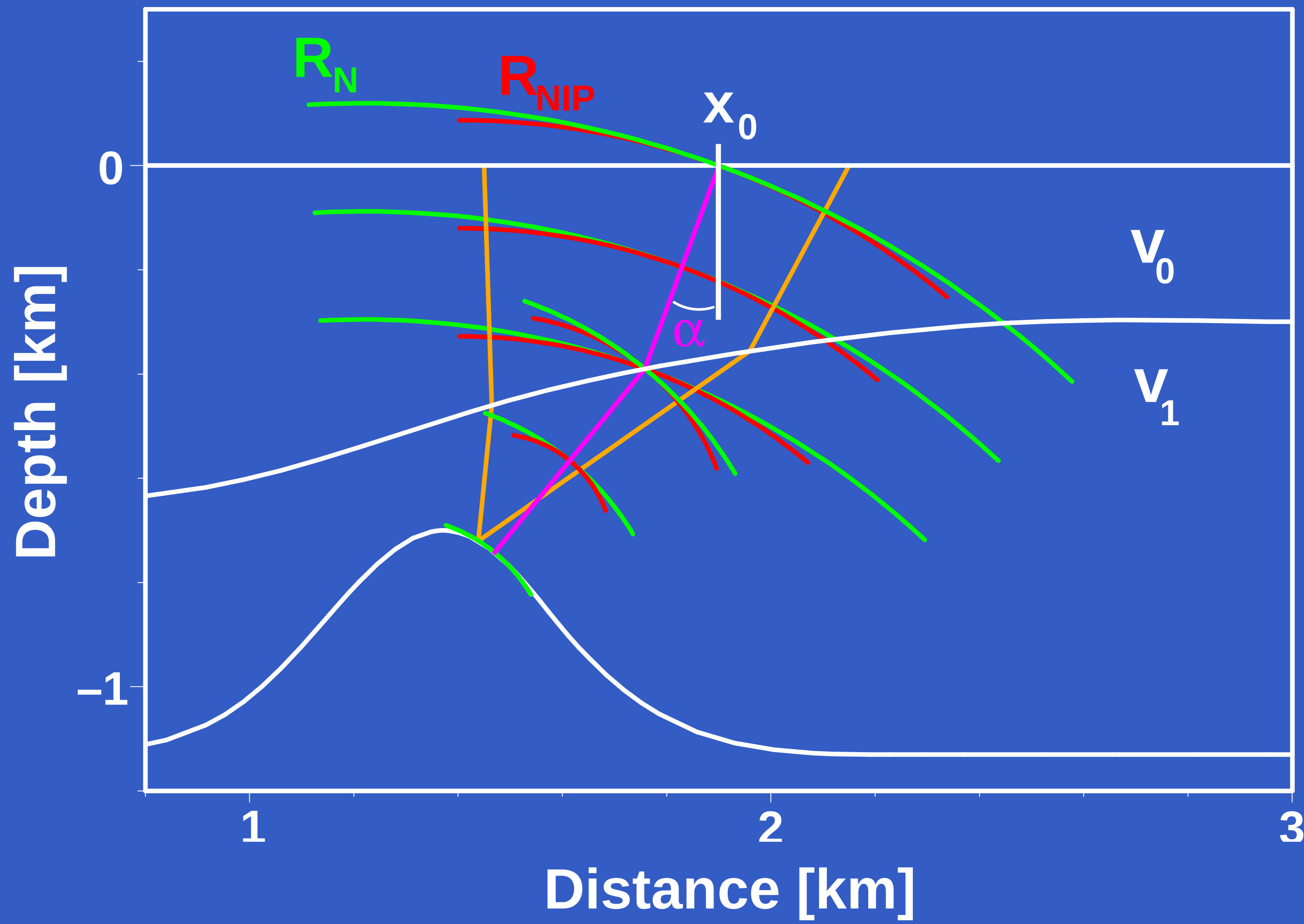
Spatial CRS stacking operator:

- parameterized by CRS wavefield attributes
- actual properties of reflector segment *not* required
- second-order approximation of reflection traveltime
- determination by means of coherence analysis in pre-stack data
- generalization of well-known velocity analysis

Simplest case: 2-D ZO (I)



Simplest case: 2-D ZO (II)

Traveltime approximation for 2-D:

$$t_{hyp}^2 = \left(t_0 - \frac{2\sin\alpha}{v_0}\,m\right)^2 + \frac{2\,t_0\cos^2\alpha}{v_0}\left(\frac{m^2}{R_N} + \frac{h^2}{R_{NIP}}\right)$$

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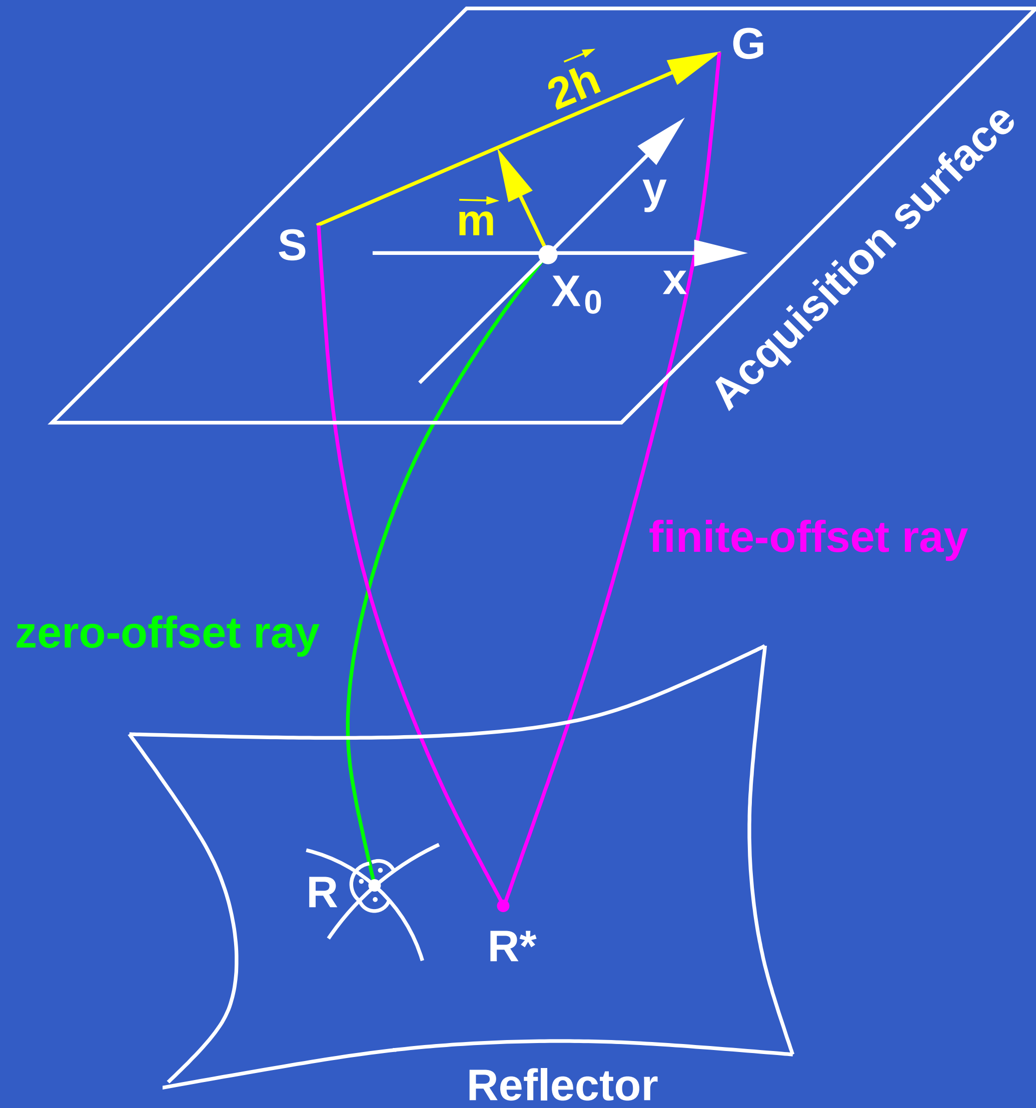
α	emergence angle of normal ray
R_{NIP}, R_N	local radii of NIP and normal wavefronts
v_0	near-surface velocity
t_0	zero-offset traveltime
h	half-offset between shot and receiver
m	midpoint displacement

Extension to 3-D ZO (I)

$$\vec{h} = \frac{1}{2}\begin{pmatrix} x_G - x_S \\ y_G - y_S \end{pmatrix}$$

$$\vec{m} = \frac{1}{2}\begin{pmatrix} x_G + x_S \\ y_G + y_S \end{pmatrix}$$



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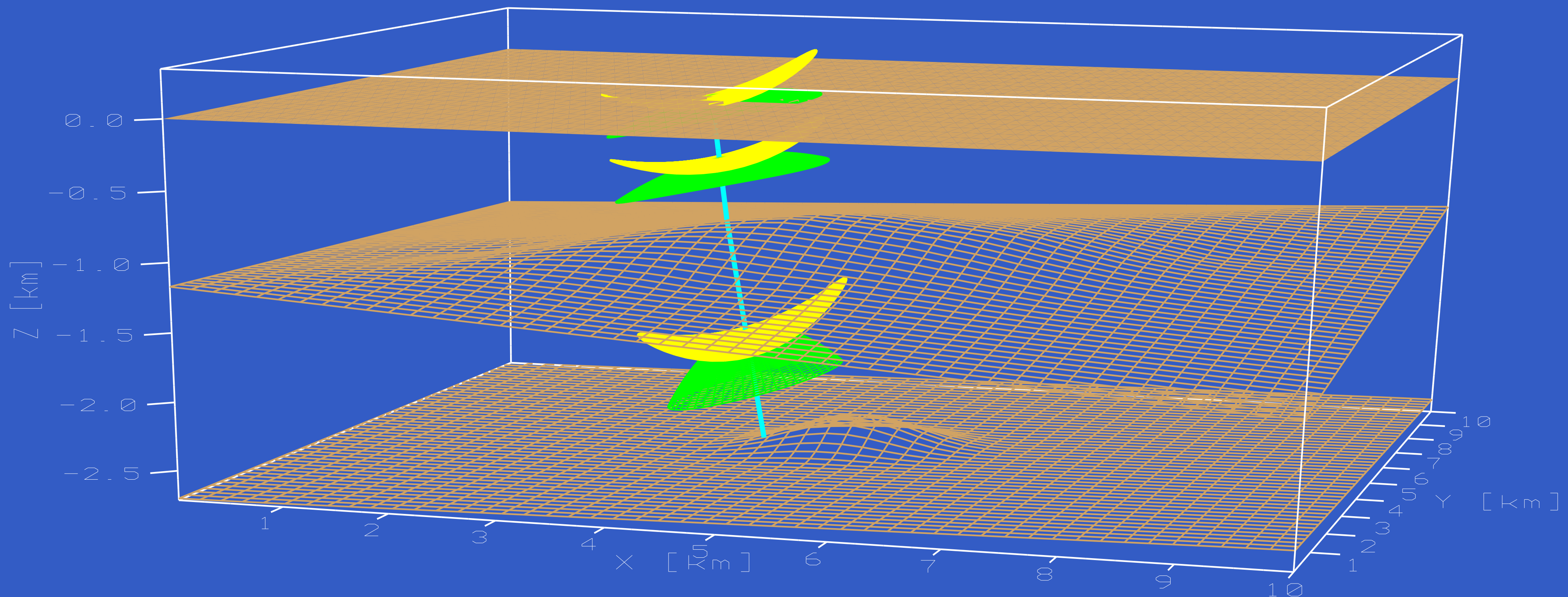

Hypothetical experiments for ZO in 3-D

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$$t_{hyp}^2 = \left(t_0 - \frac{2}{v_0} \vec{c} \cdot \vec{m} \right)^2 + \frac{2\,t_0}{v_0} \left(\vec{m}^T \underline{A} \vec{m} + \vec{h}^T \underline{B} \vec{h} \right)$$

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$\vec{c}$	propagation direction of wavefronts
$\underline{B}, \underline{A}$	curvatures of NIP and normal wavefronts
v_0	near-surface velocity
t_0	zero-offset traveltime
$\vec{h}$	half-offset vector between shot and receiver
$\vec{m}$	midpoint displacement vector

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Consequences:

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  - common-shot experiment
  - common-midpoint experiment

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Consequences:

- other hypothetical experiments required
- increased number of wavefield attributes
  - three wavefront curvatures
  - two propagation directions

Summary of extensions

Multi-parameter moveout operators for data-oriented stacking

2-D zero-offset
3 parameters

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- curvature of surface almost constant within stacking aperture

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- explicit consideration of shot and receiver elevation required
- propagation directions and near-surface velocity provide corrections
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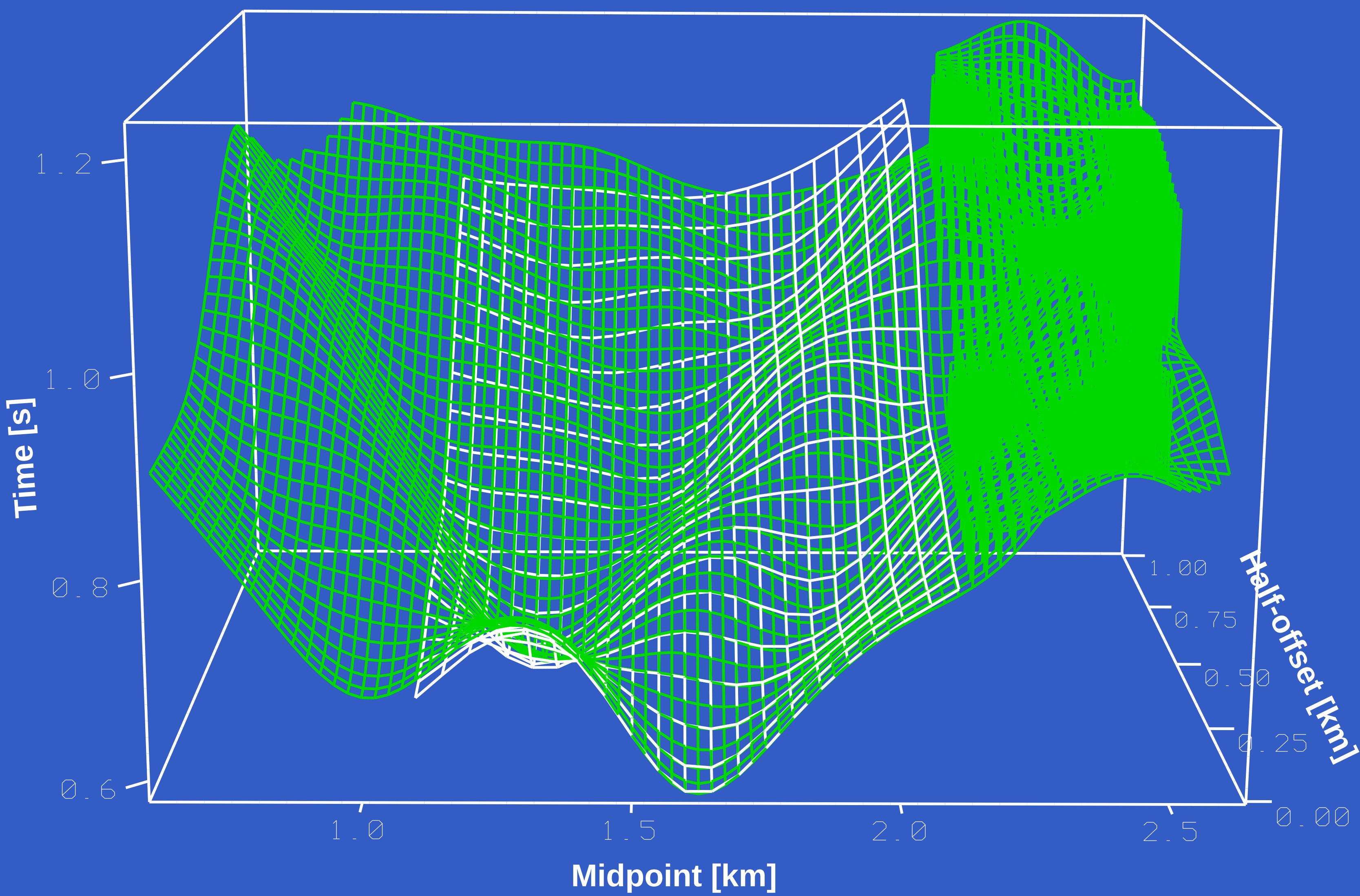
- applicable to all configurations, 2-D/3-D, ZO/FO
- geometrical meaning of the attributes is preserved and refers to chosen datum

Topography (III)



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New features of the CRS stack method:

- central ray can be chosen arbitrarily
- any arbitrary configuration can be simulated
- applicable to 2-D and 3-D data
- topography can be considered for known near-surface velocity
  - with a smooth model of the acquisition surface
  - or actual source/receiver elevations for complex topography

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- implementation of the 3-D counterparts

Acknowledgments

This works was supported by the sponsors of the *Wave Inversion Technology Consortium.*

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