UDOMORE Depth

Consistent stochastic depth conversion

Attention :

UDOMORE Community

10/02/2016

UDOMORE DEPTH: CONSISTENT STOCHASTIC DEPTH CONVERSION

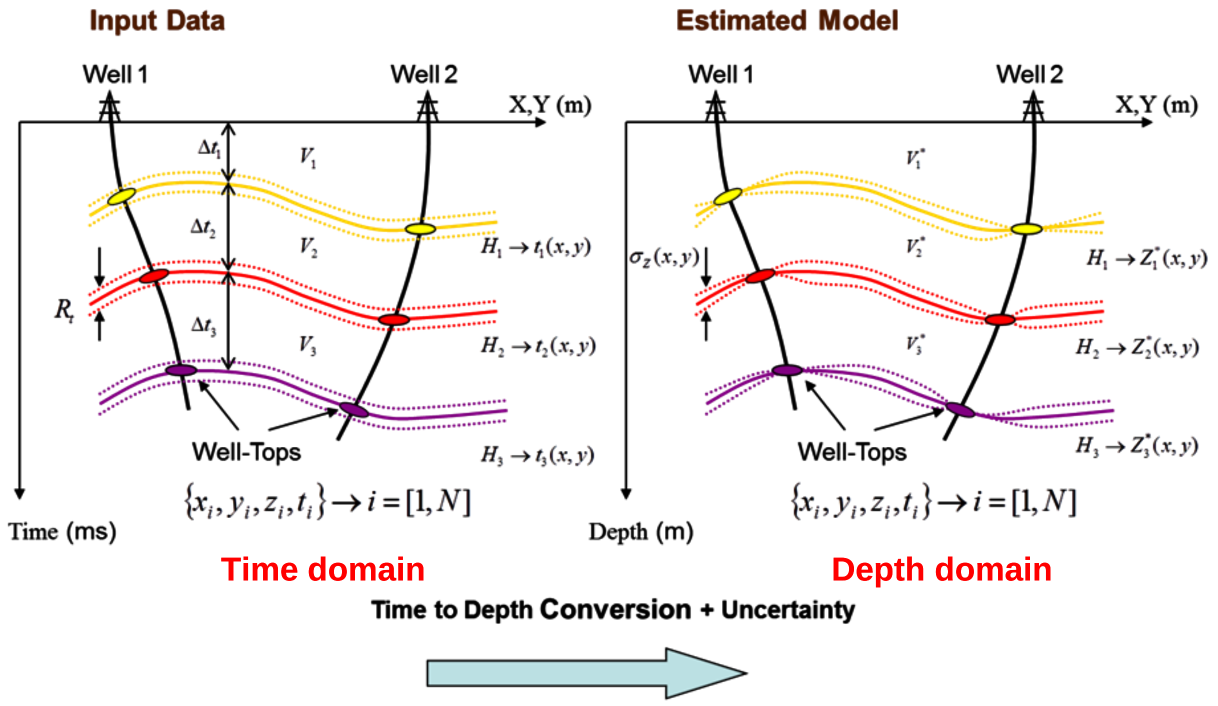
Performing depth conversion using mainstream deterministic/stochastic frameworks can lead to bias and result in flawed depth models. With the UDOMORE Depth Ocean plug-in to Petrel, Seisquare offers a consistent stochastic depth conversion framework to address bias at its core, which ultimately maximizes the accuracy of depth models and better supports E&P decision-making.

Consistent stochastic depth conversion using UDOMORE Depth:

Seisquare advocates that the most consistent stochastic framework for vertical depth conversion combines a “multilayer” approach with “stochastic” velocity model building. It relies on Bayesian Co-Kriging [Abrahamsen 1993, Omre 1987, Omre & al 1989, Sandjivy & al 2009] of the well depth markers using appropriate time derived external drifts.

The main argument in favor of using Bayesian Co-Kriging is consistent integration of all sources of uncertainty throughout all layers within a unique probability (or “stochastic”) model. From a mathematical standpoint, the stochastic model guarantees unbiased estimations of depth, interval velocities, thicknesses, and volumes, as well as realistic confidence intervals (P10, P50, P90 values).

The figure below expresses the approach:



The input is a combination of available data sets, prior knowledge about interval velocity functions and all sources of associated uncertainties:

- Time interpretation horizons + local picking uncertainty;
- Interval velocity functions (prior values) + parameter ranges and residual velocity uncertainty;
- Well tops + possible associated uncertainty.

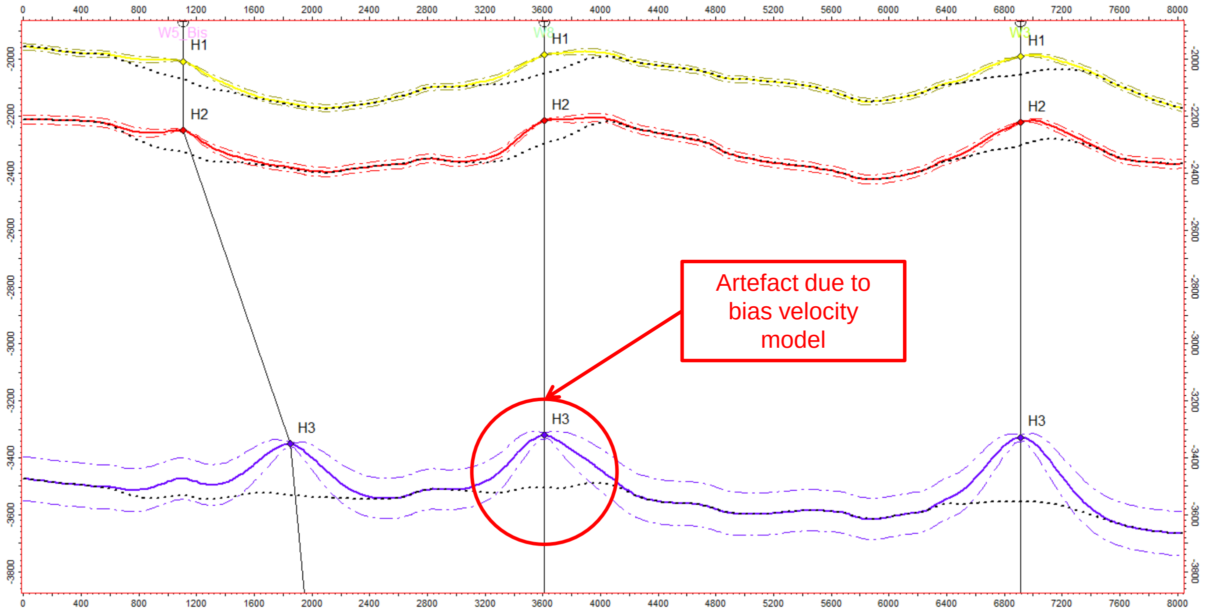
The output is an estimation of the depth of each individual horizon and each interval velocity, associated with quantified uncertainty values. With Kriging, by construction, depth estimates are unbiased (average of well tying residuals = 0) and have maximum possible accuracy/precision (i.e. minimal kriging standard deviation).

Benchmarking UDOMORE Depth against mainstream software solutions:

Under mainstream depth conversion frameworks, there are two main sources of bias: first, the “base case” velocity model; second, the “layer cake” framework.

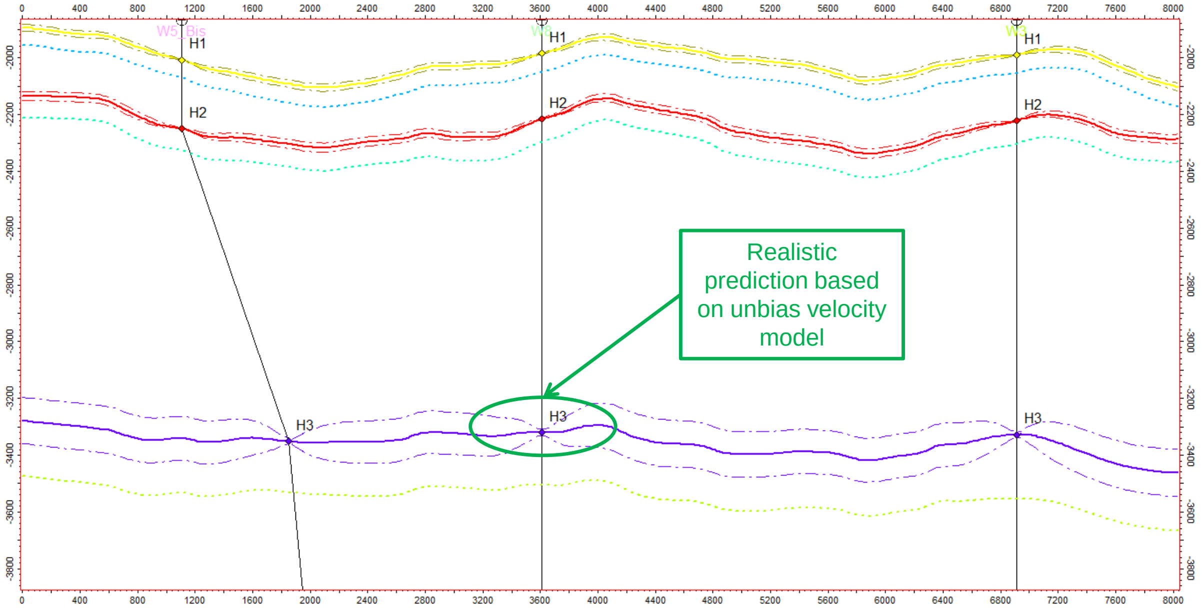
- The “base case” velocity model: usually computed as the sum of a velocity “trend” model built from interval velocity functions and well tying velocity “residuals”. The velocity “trend” model is usually deterministic and taken for granted (i.e. there is an assumption that the velocity “trend” model has no uncertainty). At best, only local well tying depth or velocity “residual” uncertainty is simulated around the trend (using kriging or other interpolators). This is a strong and risky assumption: no matter how good a velocity “trend” model may be, it never fully reflects the true unknown velocity model; it always contains inherent uncertainty that needs to be addressed.
- The “layer cake” approach: Z_{top} (top of a layer in depth) interpreted at time $T = T_{top}$, controls the conversion of the layer immediately below. This is also a strong and risky assumption: in a “layer cake” depth conversion case, Z_{top} results from depth converting the previous layer. As mentioned above, Z_{top} may contain bias which propagates through successive layers in depth. Uncertainty cannot be quantified correctly with this framework, as exposed by P. Abrahamsen (1993, Bayesian Kriging for Seismic Depth conversion of Multi-layer Reservoir, in A. Soares (ed.) in his example on deviated wells.

A benchmark of consistent stochastic vs. mainstream depth conversion approaches, using exactly the same prior inputs, shows considerable differences:



Time-to depth conversion model based on the mainstream framework

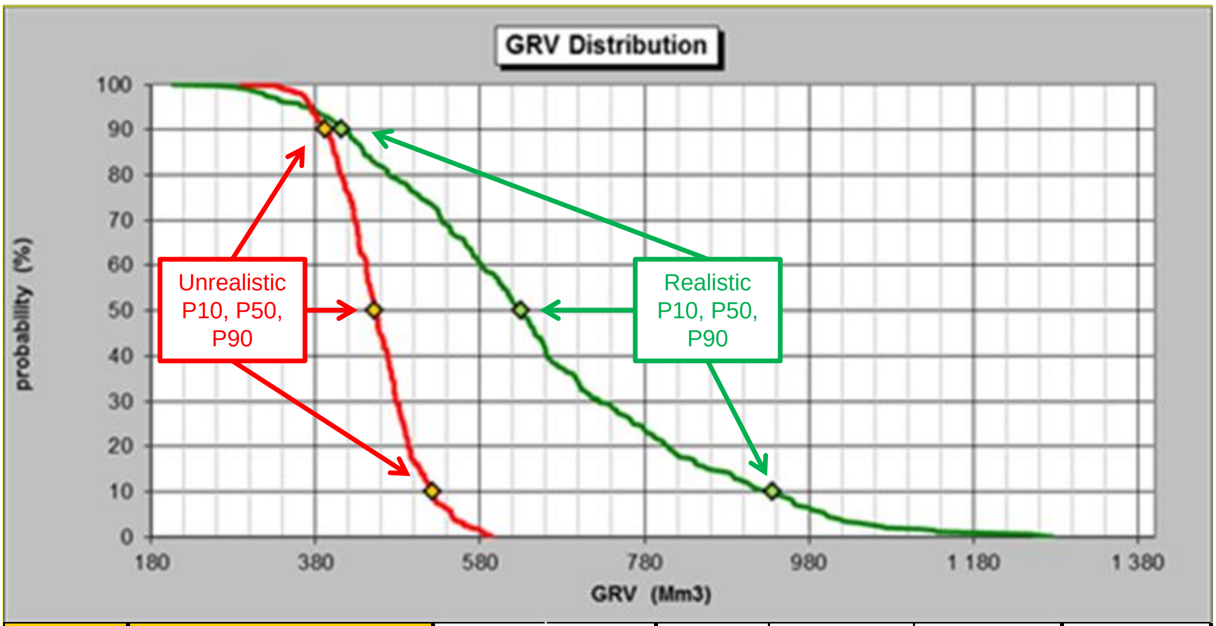
UDOMORE Depth



Realistic prediction based on unbias velocity model

Time-to depth conversion model based on the consistent stochastic framework

- Under the mainstream framework, the velocity "trend" model is taken for granted, well-tops are fitted by a simple kriging of residuals, and bias is propagated from layer to layer. This results in unrealistic structures in depth.
- Under the consistent stochastic framework the "stochastic" velocity model is considered with a degree of uncertainty (uncertainty on velocity "trend" model parameters and additional uncertainty due to local heterogeneities). This results in realistic structures in depth.



Unrealistic P10, P50, P90

Realistic P10, P50, P90

GRV (Mm3)	Scenario	Estimated Depth		P10	P50	P90	Dispersion
	Scenario 1	318	P99.7	523	452	393	28.81%
	Scenario 2	446	P84.	935	631	413	82.84%

In RED: volume predictions based on the mainstream framework (Scenario 1)
In GREEN: volume predictions based on the consistent stochastic framework (Scenario 2)

- Under the mainstream framework (scenario 1), volumes are computed using biased depth simulations (linked to underestimation of uncertainty on the velocity model). This results in unrealistic P10 P50 P90 GRV estimates;
- Under the consistent stochastic framework (scenario 2), volumes are computed using realistic depth simulations (thanks to a consistent estimation of uncertainty on the velocity model). This results in realistic P10 P50 P90 GRV estimates.

Adopting one rather than the other framework can have critical impact on E&P decision-making. The consistent stochastic framework exposed in this note has produced excellent results in E&P on-shore and off-shore operations in Continental Europe, Middle-East, North Africa, Norway South Atlantic and UK. The output depth and velocity models and associated volume predictions are recognized for accuracy/precision, better consistency through time, and are easy to update as new data comes in. This framework is made seamlessly accessible to users thanks to Seisquare's UDOMORE Depth Ocean plug-in to Petrel. For additional information and a demo, contact seisquare@seisquare.com.

References

Omre, H. 1987, Bayesian kriging merging observations and qualified guesses in kriging. Math. Geol, 19 (1), 25-39

Omre, H. & Halvorsen, K. B. 1989, 'The Bayesian bridge between simple and universal kriging'. Math. Geol, 21 (7), 767-786

Abrahamsen, P. 1993, Bayesian Kriging for Seismic Depth conversion of Multi-layer Reservoir, in A. Soares (ed.) « Geostatistics Troia '92 ». Pp. 385-398

Sandjivy, L. & Shtuka, A. 2009, Depth conversion and associated uncertainties using consistent velocity model: a probabilistic unified model based on Bayesian framework