Proactive geosteering workflow for enhanced oil recovery

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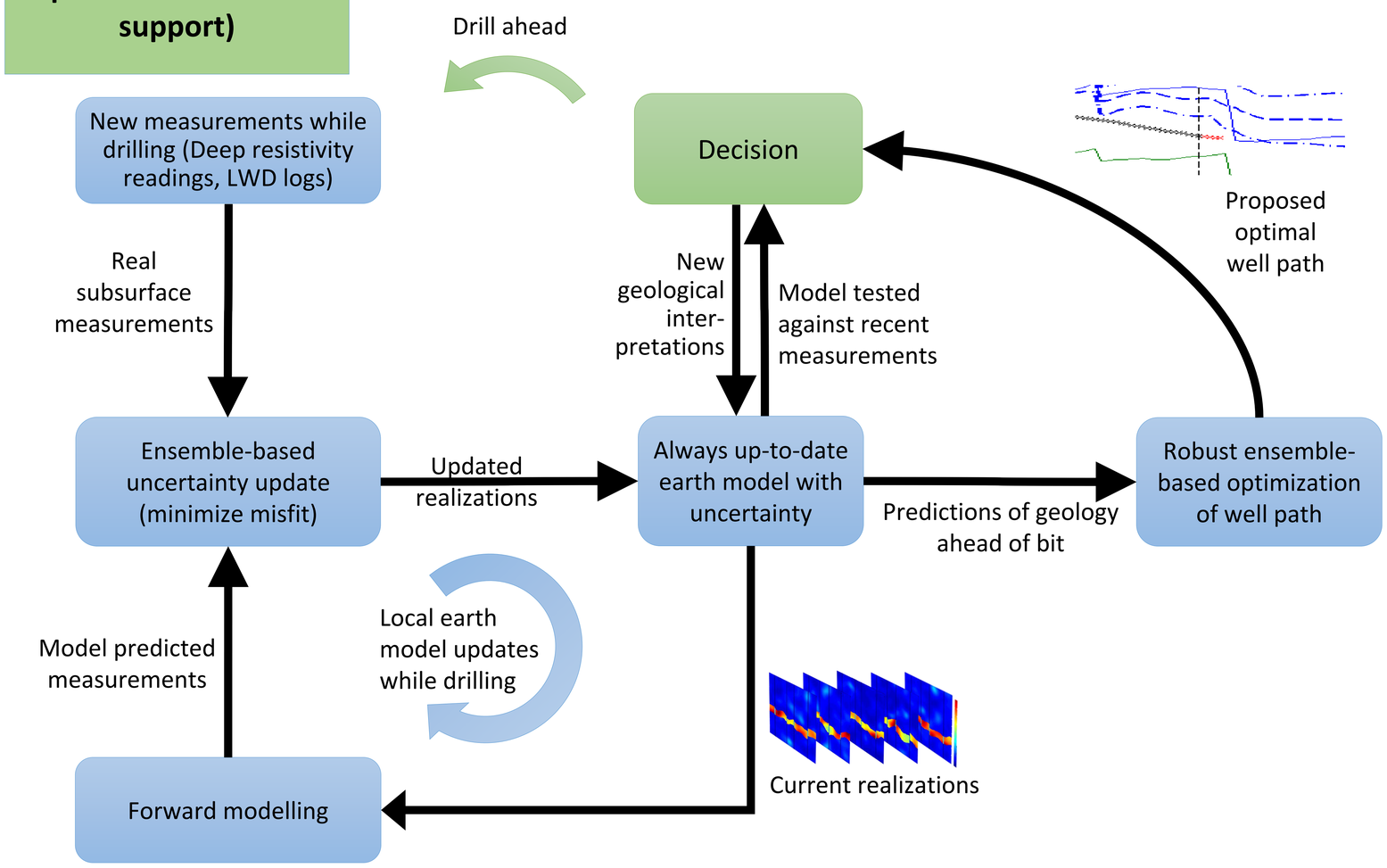
Geosteering workflow (real-time model updates and decision support)



Aims

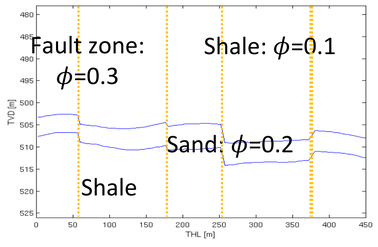
- Systematic and transparent updating of geological uncertainties around and ahead of bit while drilling
- Highly automated workflow for model-based geosteering decision support

Methods

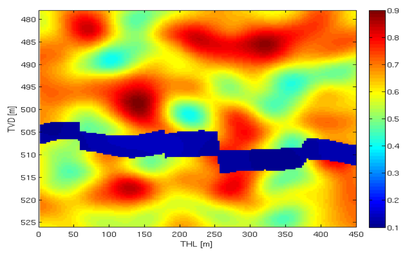
- Ensemble-based uncertainty tool automatically updates earth model realizations in real-time, based on measurements received while drilling
  - Always up-to-date earth model with uncertainties
  - Uncertainty modelling at local scale around and ahead of bit, constrained by global scale interpretations
  - Multiple different geological concepts (scenarios) at local scale can be handled simultaneously
- Local updates of global 3D earth model while drilling
  - New technology for scale management
  - Local updates of structural connectivity (topology), e.g. insertion of new fault or pinch-in of layer into earth model grid
  - Automatic/assisted control via geological parameters
  - Uncertainty in well trajectory
- Expert interaction to monitor and guide the modelling process when required
  - E.g. propose new geological scenarios to be tested against the measurements
- Optimized well path for decision support
  - Robust optimization under uncertainty over the updated ensemble of earth model realizations
  - Multiple geosteering objectives
- Risk analysis, predict outcomes of decisions under uncertainty

Case study 1: Uncertainty in structure and water saturation

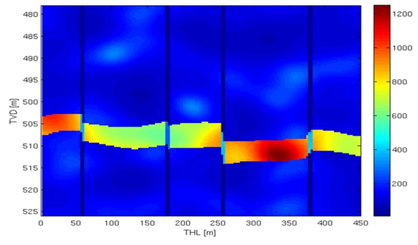
Horizons and fault locations in True Model



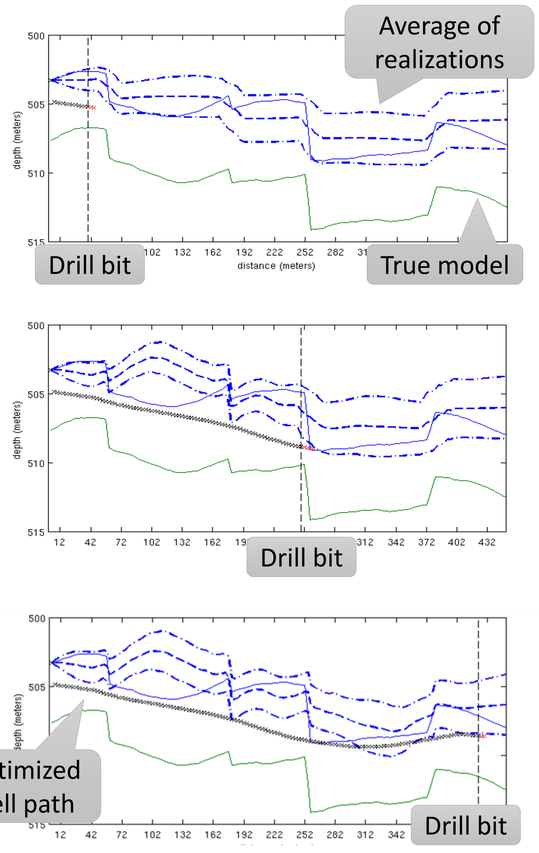
Water saturation (True model)



Resistivity (calculated via Archie's law)



Uncertainties are shown only for top horizon



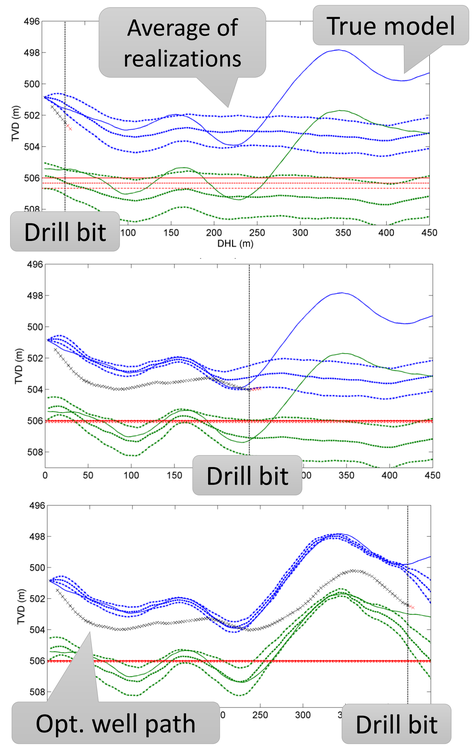
Model setup

- 100 realizations in ensemble
- Sand layer in background shale
- Simplified earth model with vertical faults
- Model parameters
  - Fault displacement and location, horizon geometries, S_w in each grid block
- Steering objectives:
  - Stay in the middle of target layer (+/- 20%)
  - Avoid water above and below

Results

- Pre-drill uncertainty in both structure and water saturation is reduced when new measurements constrain the model
- Good reservoir coverage by calculated optimized well path
- More LWD logs would further reduce uncertainties

Case study 2: uncertainty in structure



Model setup

- Uncertainty in horizons and depth of OWC
- Fixed resistivity (shale 100 ohm-m, sand 300 ohm-m, below OWC 5 ohm-m)

Results

- Reduced uncertainty in horizon geometries
- Good reservoir coverage by calculated optimized well path

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