# DIGIRES

## Decision making and uncertainty analysis for planning of wells and field development

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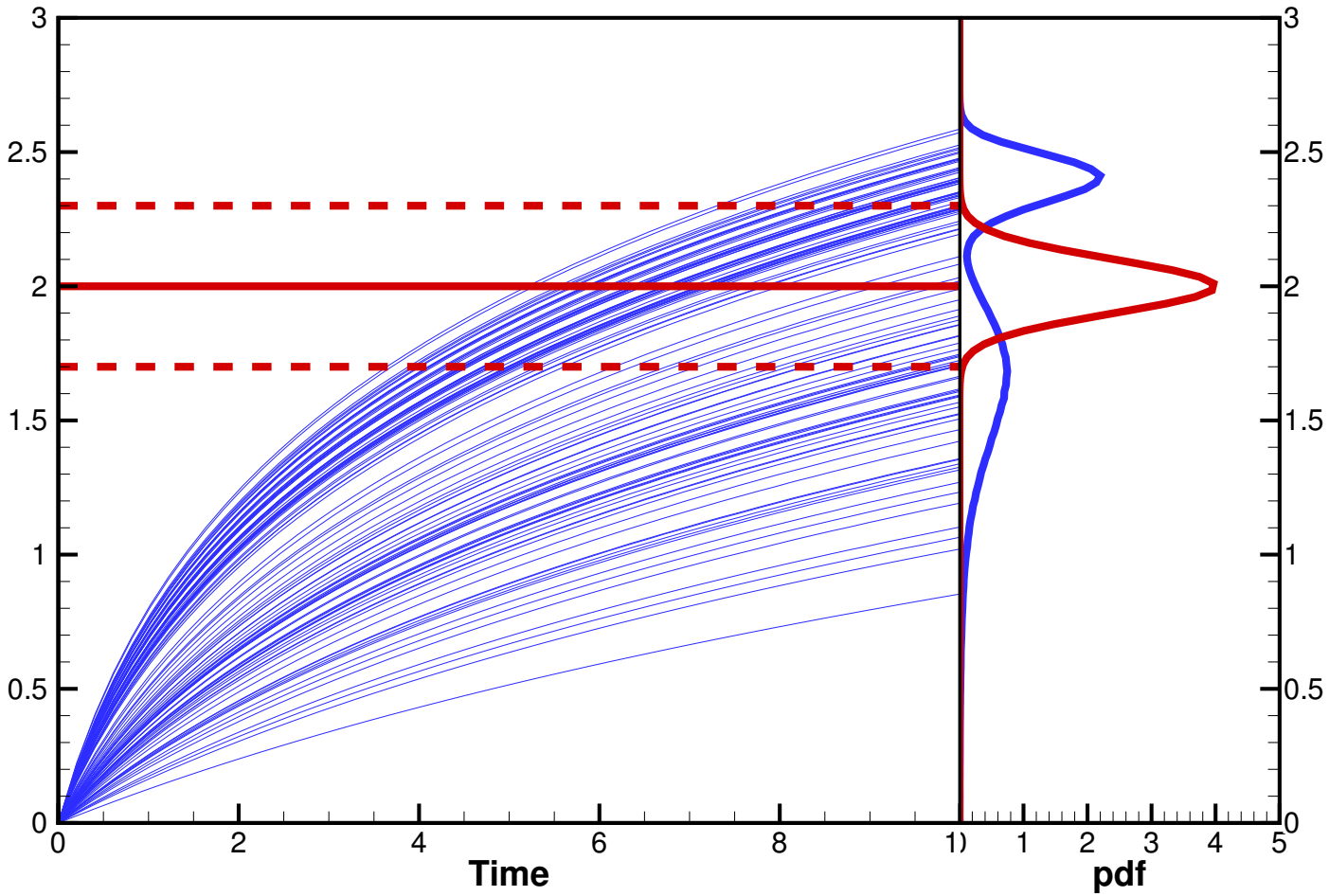
# Motivation

- Decisions are usually based on either a single model or data alone.
- There is a trend in data analytics to ignore physical models.
- How to integrate observations with models in the decision process?
- How to account for uncertainty in the decision process?

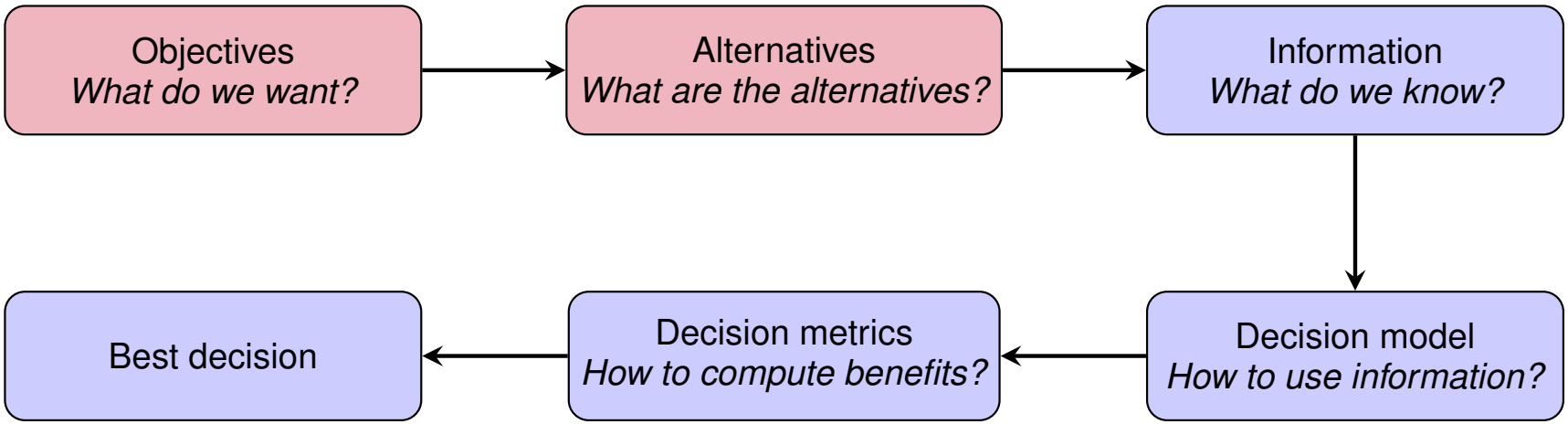
# DIGIRES objective

*to improve decision making and uncertainty analysis for the planning of wells and field development by using a generic decision-driven ensemble approach.*

# Example



# Decision-driven workflow



# Ensemble representation of uncertainty

IRIS

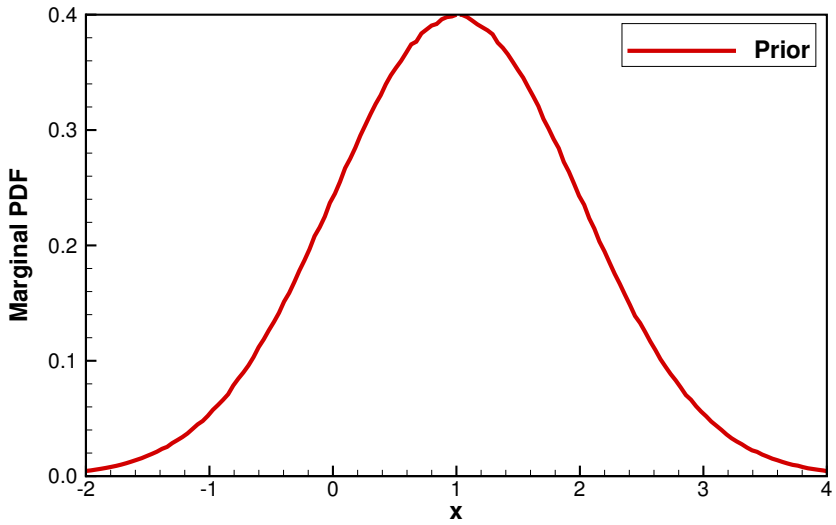
Ensemble of uncertain inputs
$f(x)$ or $\{x_i\}$

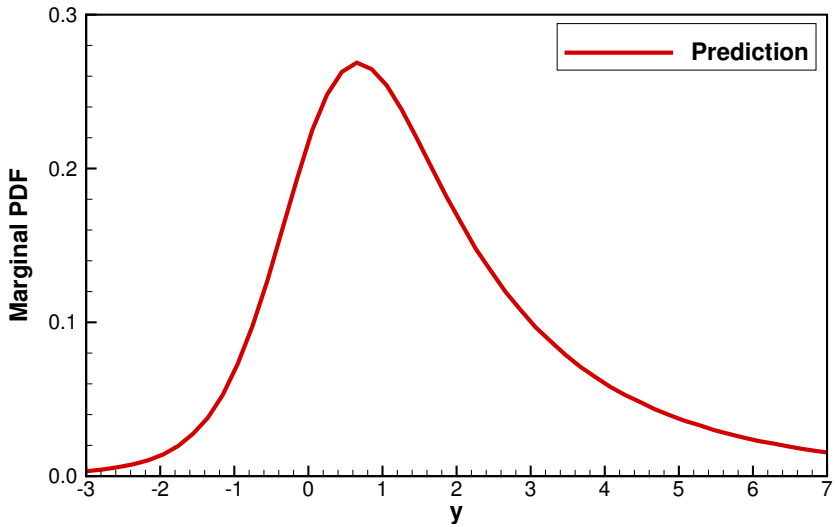
→

Multidisciplinary model
$f(y|x)$ or $y_i = g(x_i)$

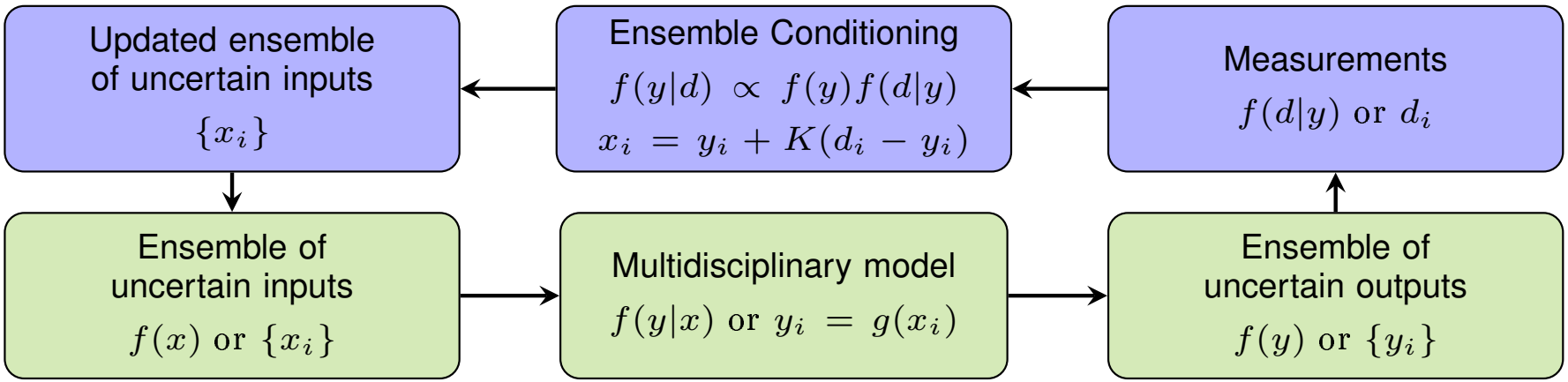
→

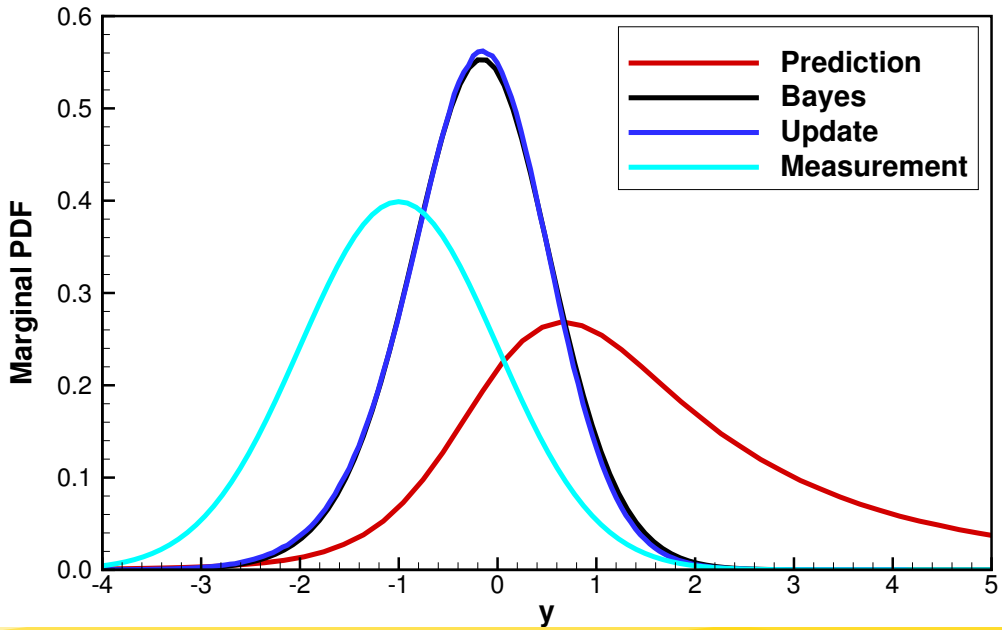
Ensemble of uncertain outputs
$f(y)$ or $\{y_i\}$



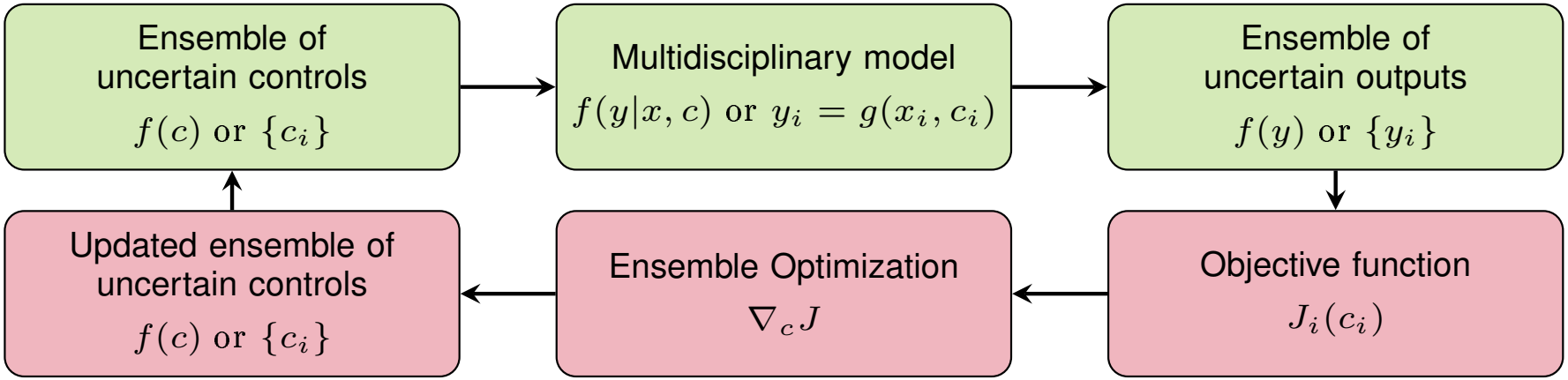



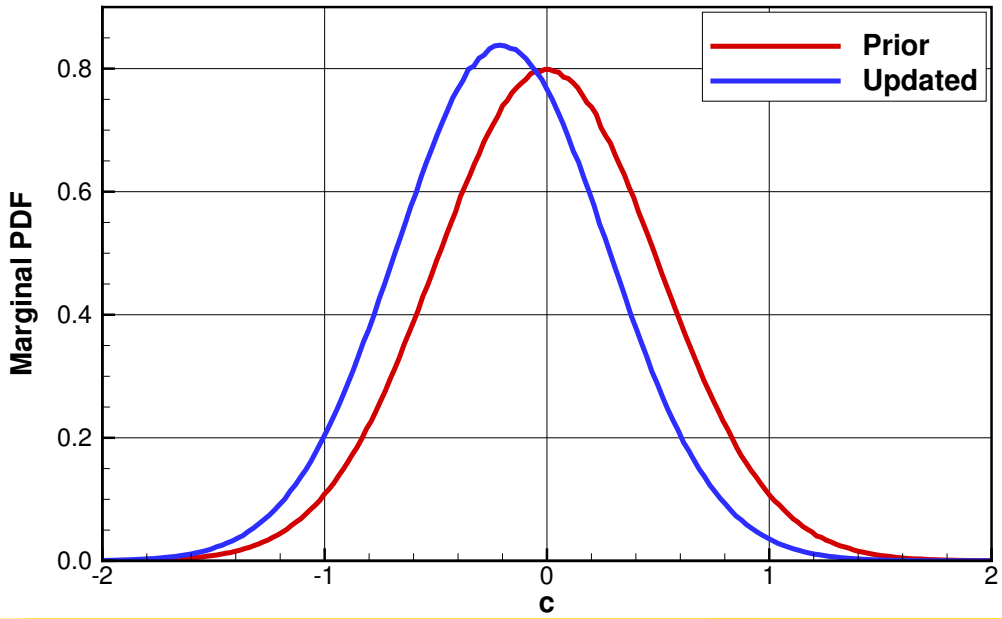
# Ensemble conditioning (EnKF)



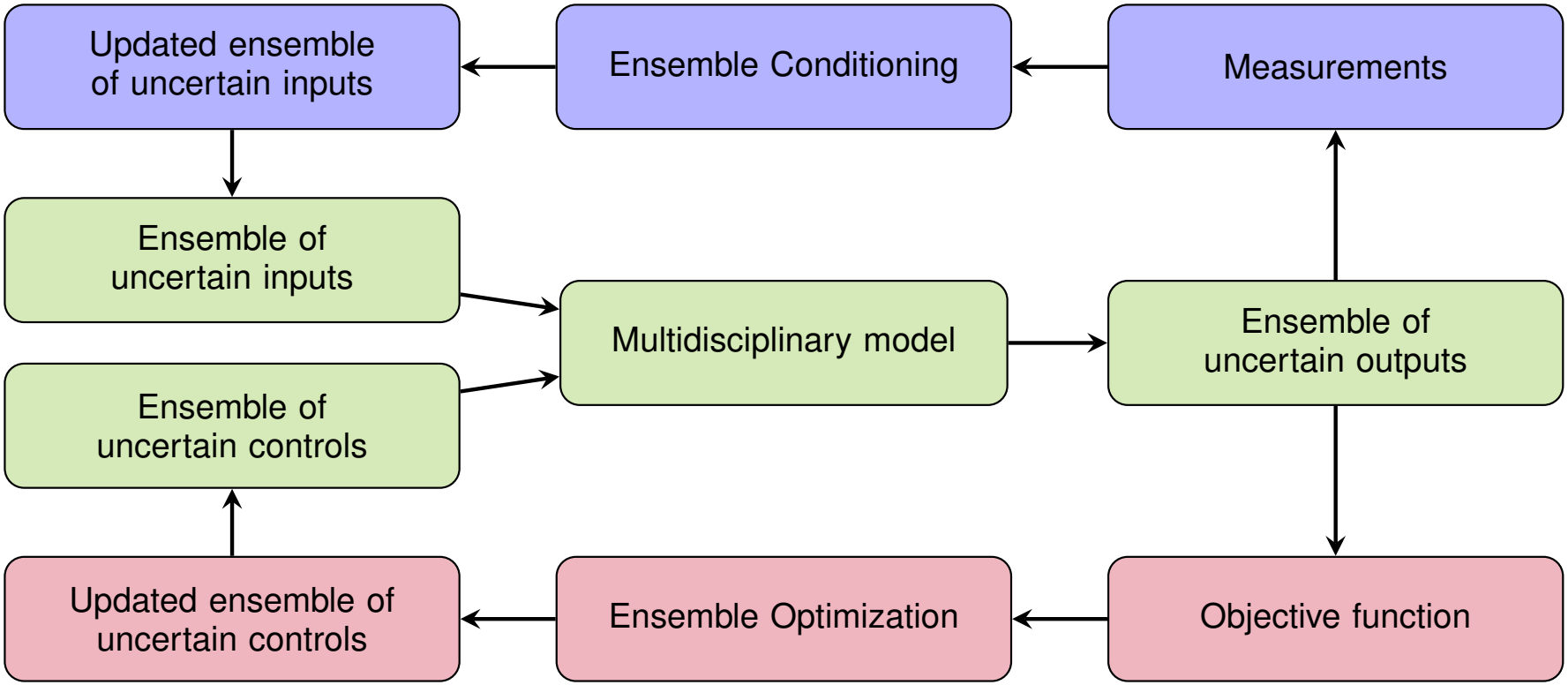



# Robust ensemble optimization (EnsOPT)



# Information workflow



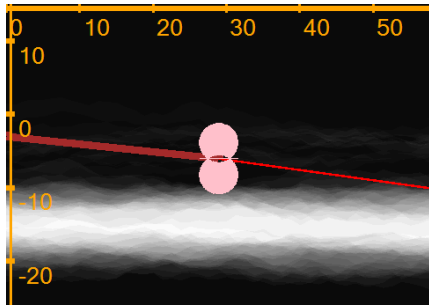
# Example: optimal placement of well

Start with:

- Initial ensemble of reservoir realizations.
- Optimal well placement for each realization.

During drilling:

- Collect measurements from EM tool.
- Update ensemble of reservoir models.
- Compute best well trajectory for each realization.
- Drill according to expected value.




Objective function based on:

- Model of oil production minus cost of well.

**S. Alyaev, E. Suter, X. Luo, E. Vefring and R. Bratvold, An Interactive Decision Support System for Geosteering Operations. SPE-191337-MS.**

**Geosteering for IOR, Petromaks-2 project.**

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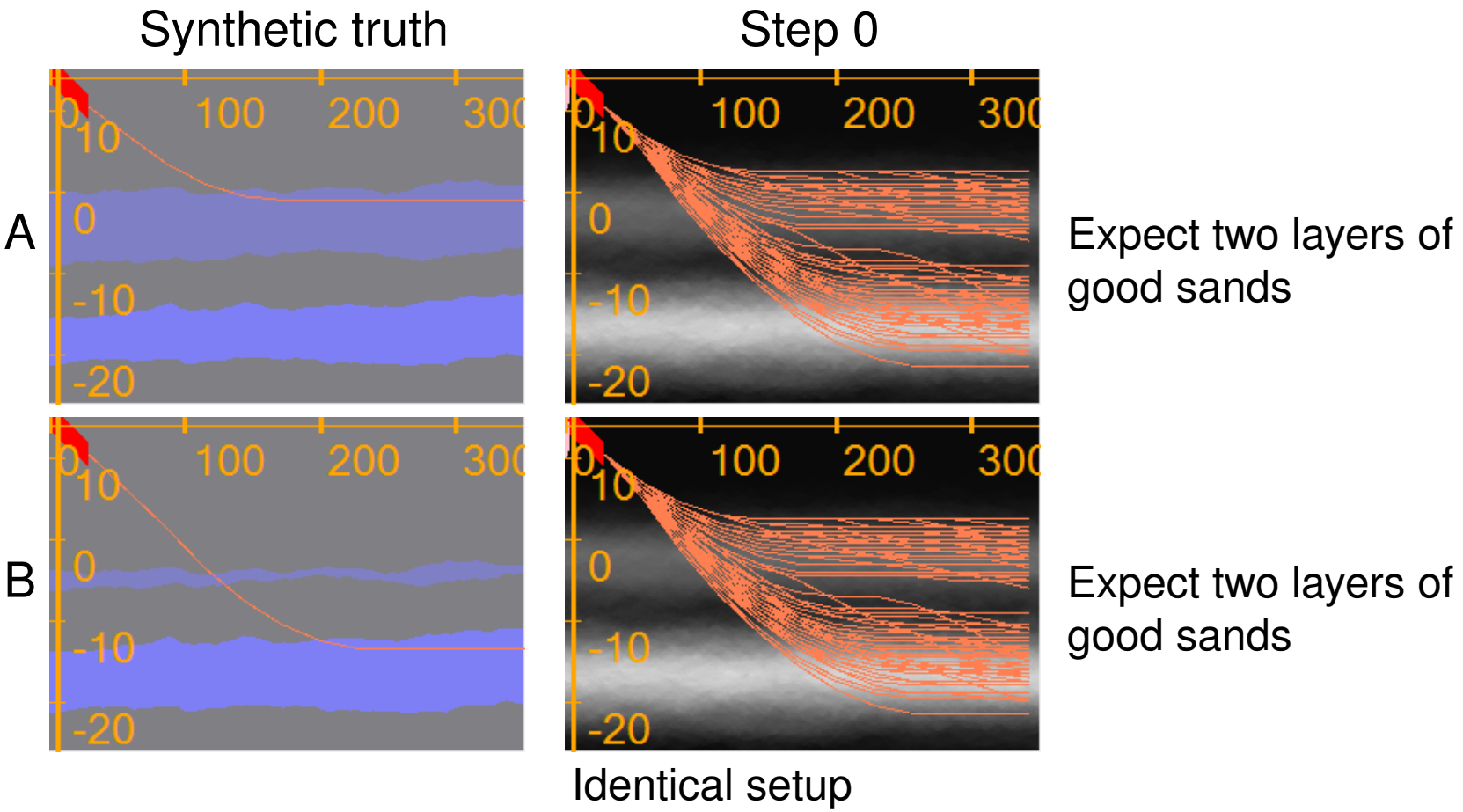

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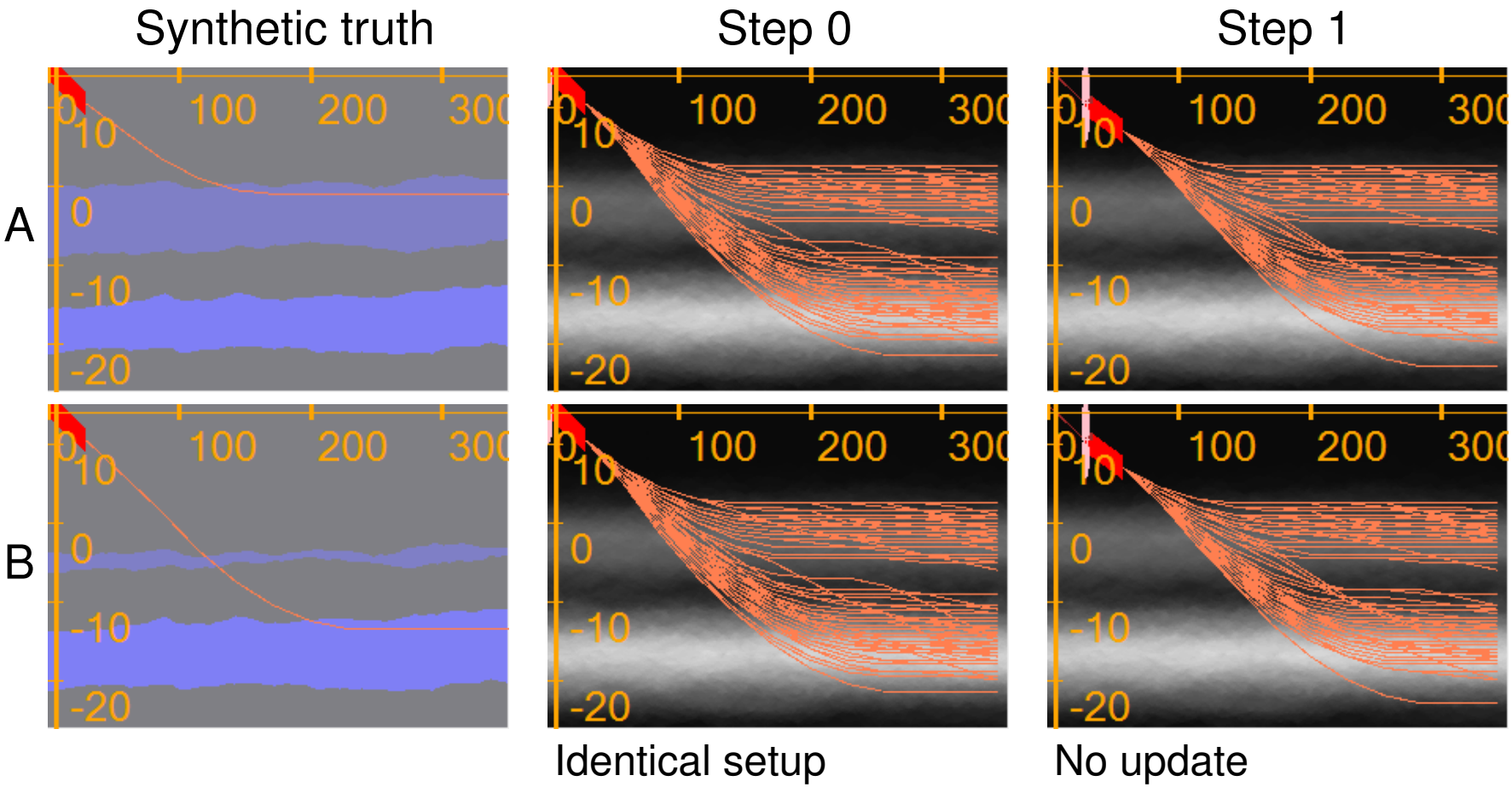

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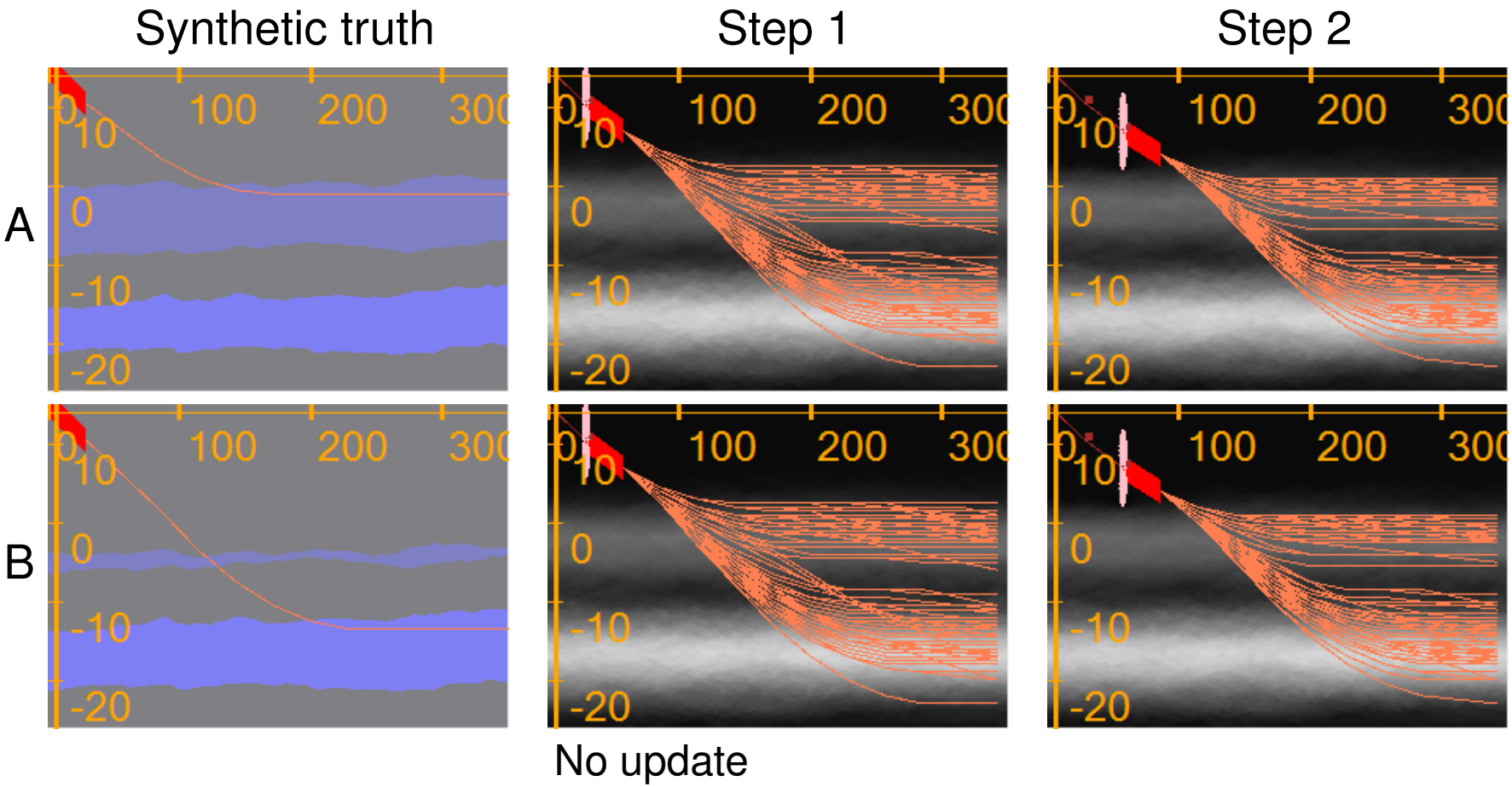


No update

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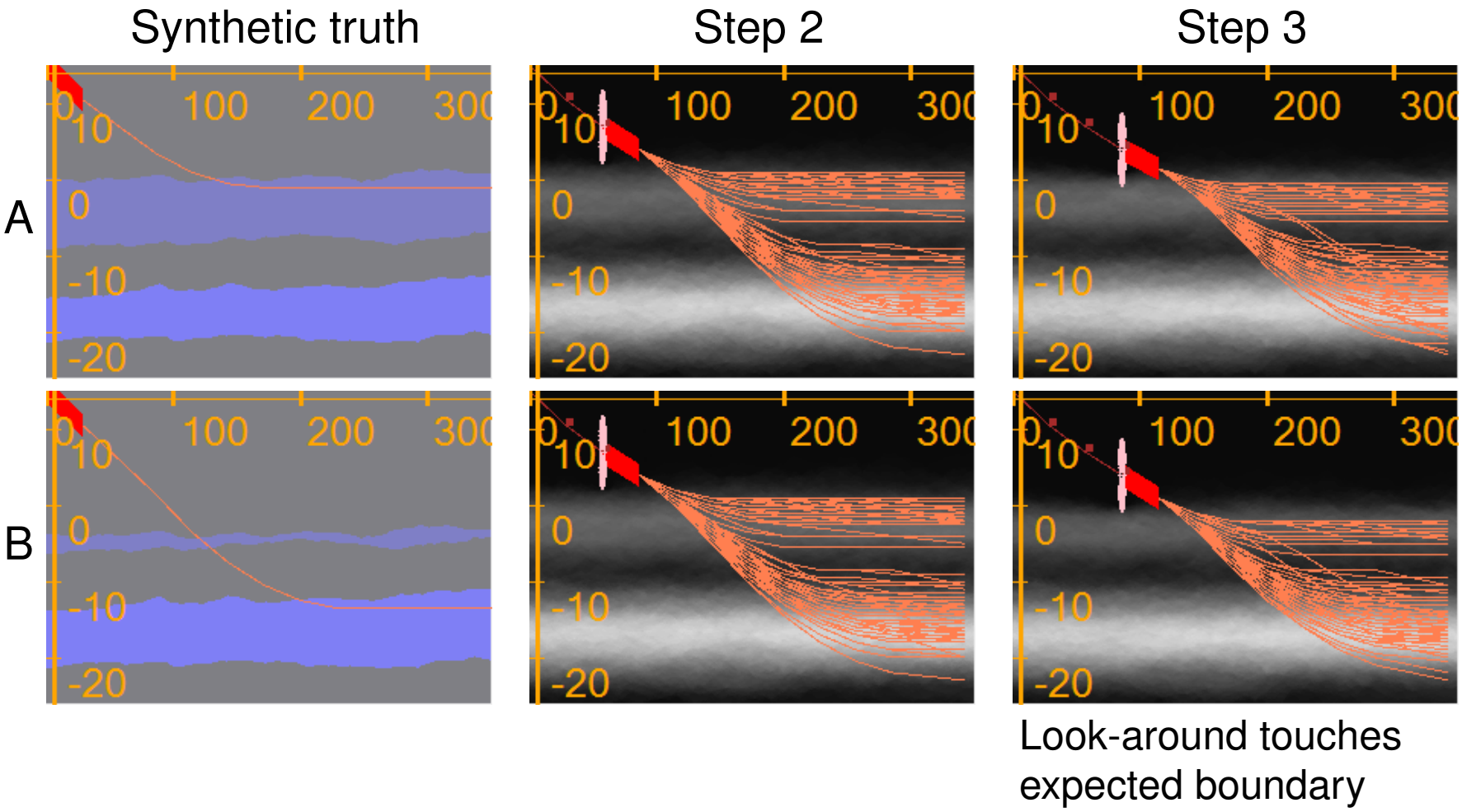
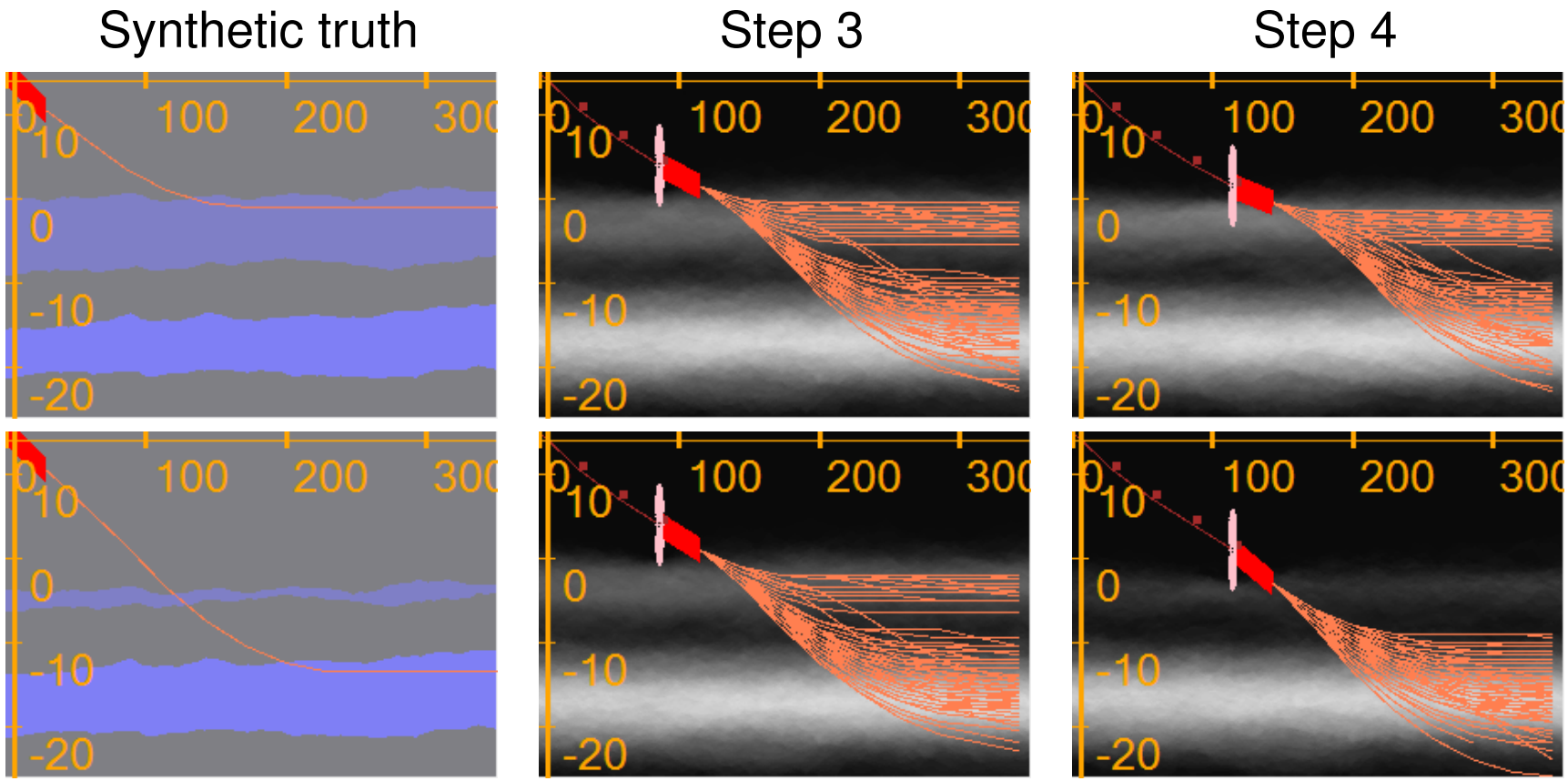



Look-around touches expected boundary

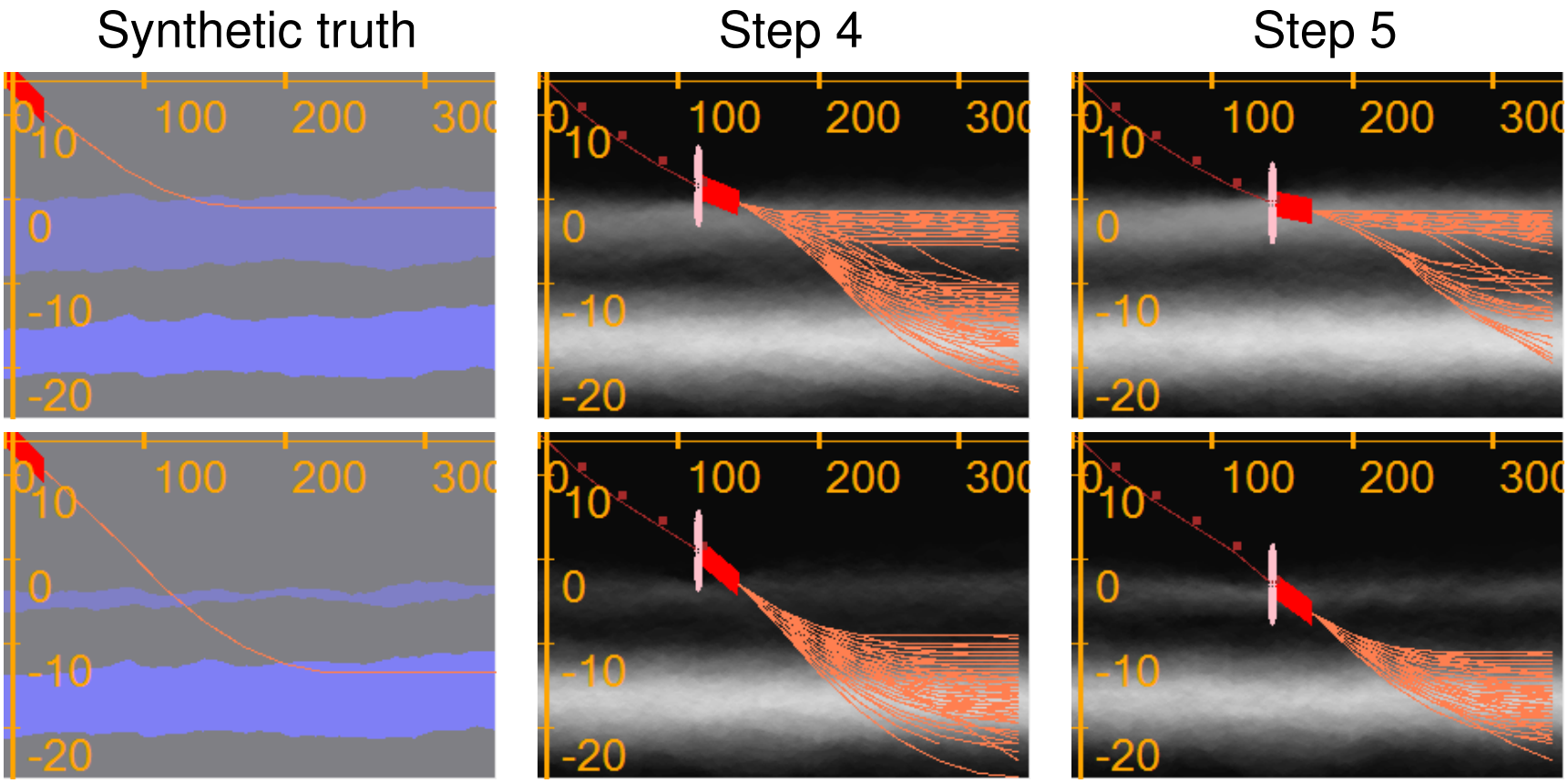
# Example: optimal placement of well




Look-around touches expected boundary

No expected top in B

# Example: optimal placement of well




No expected top in B

In A bottom layer seems better for some realizations

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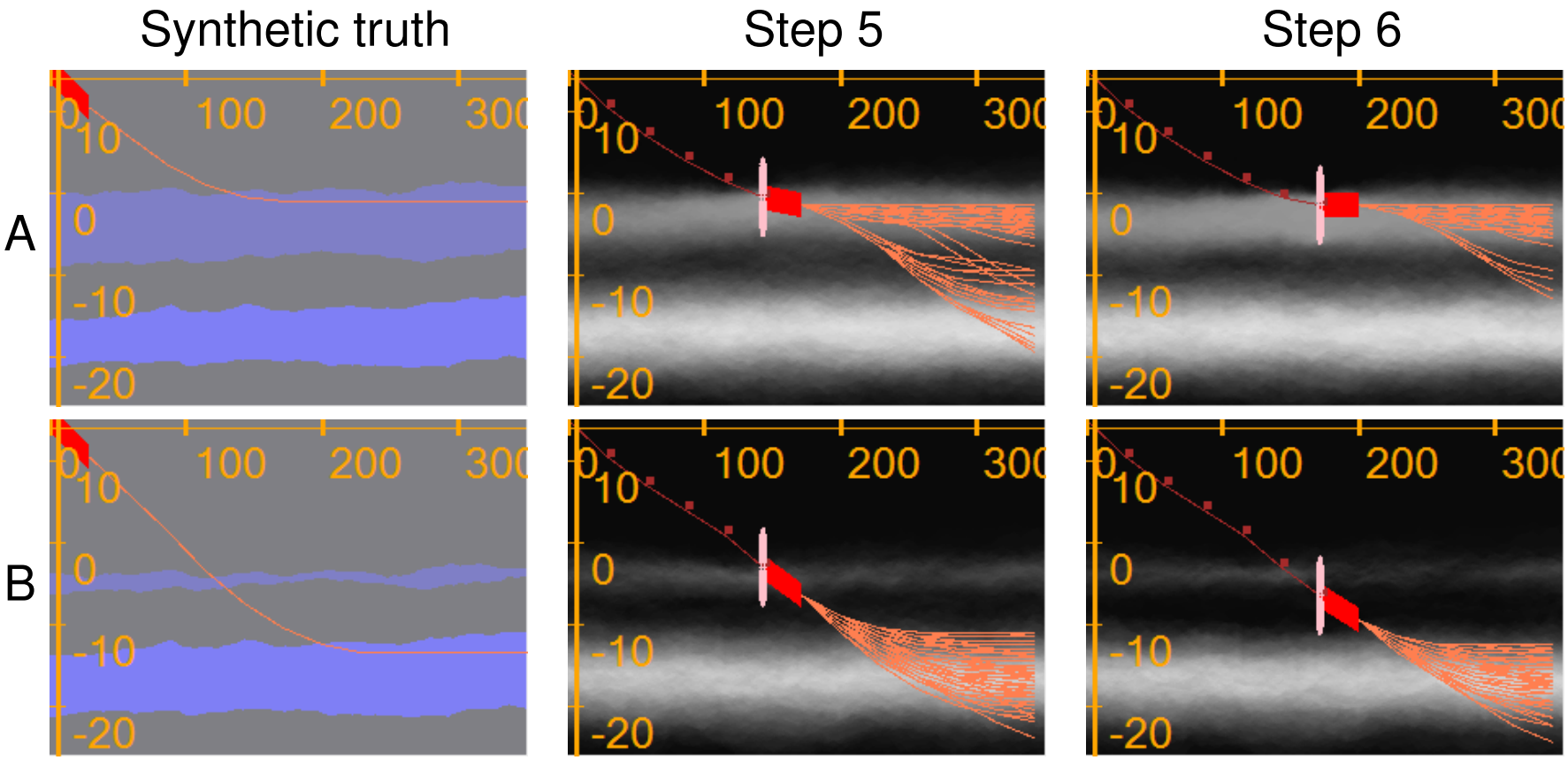


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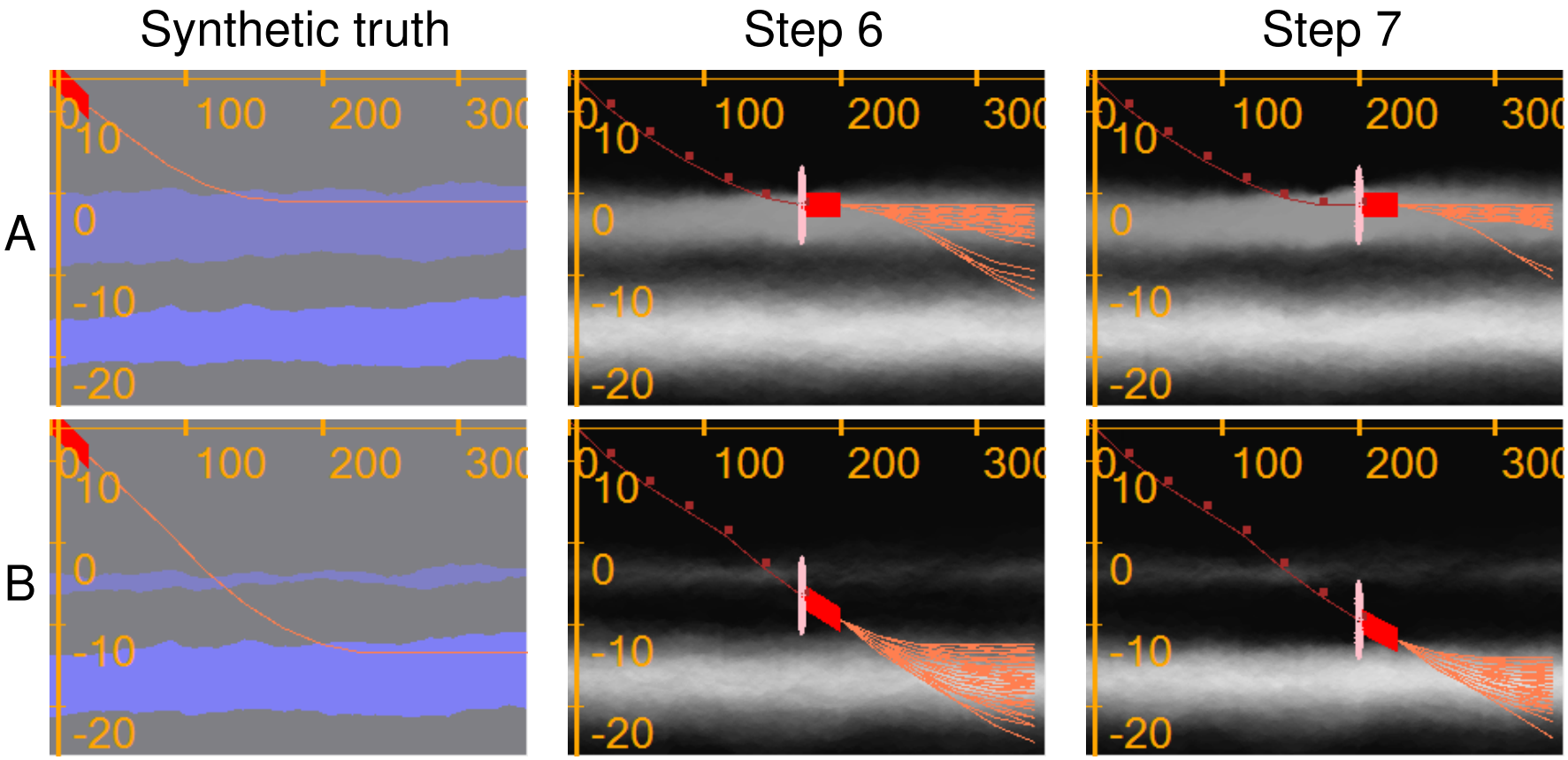

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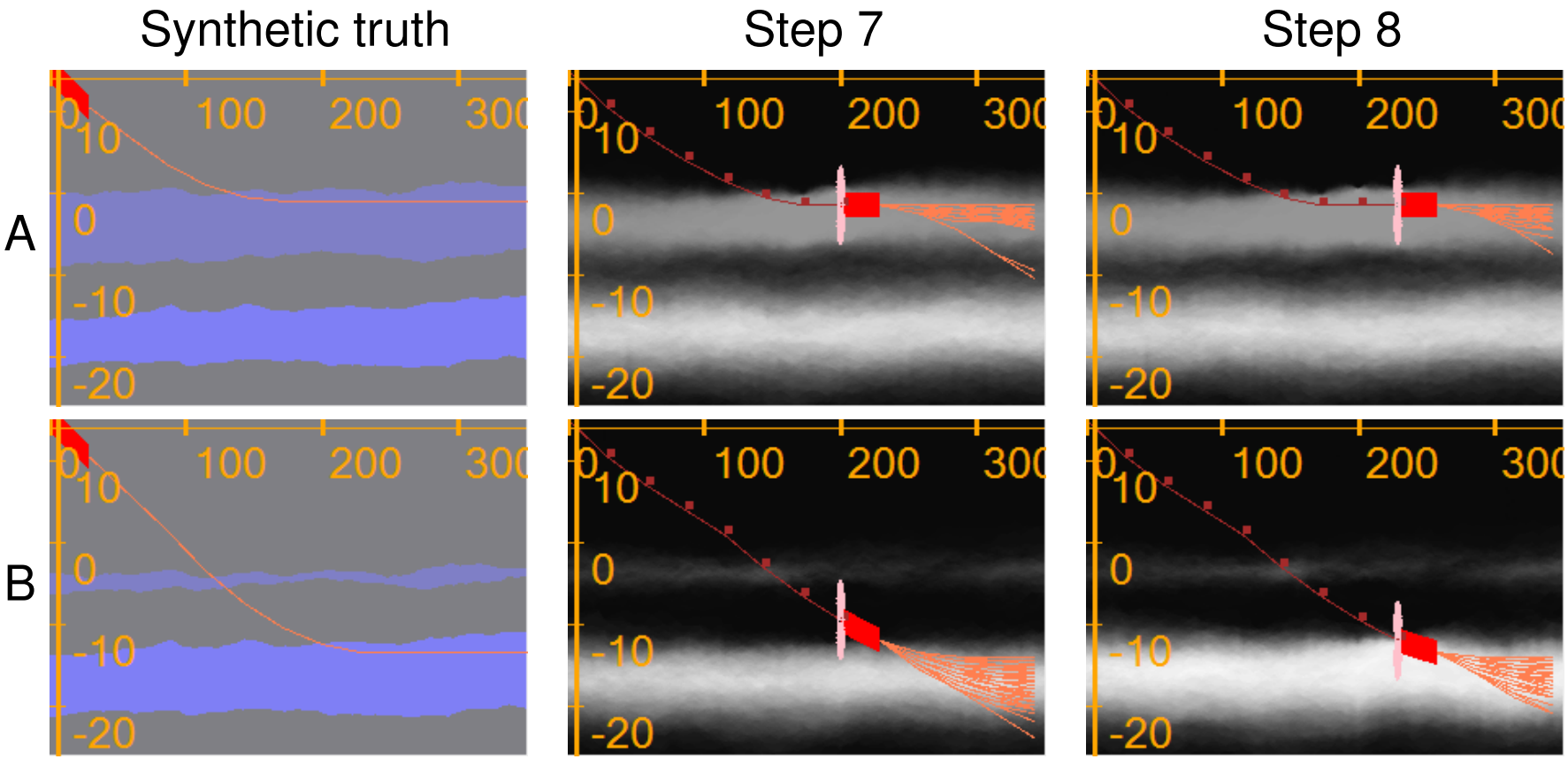


All realizations follow 'correct' layer

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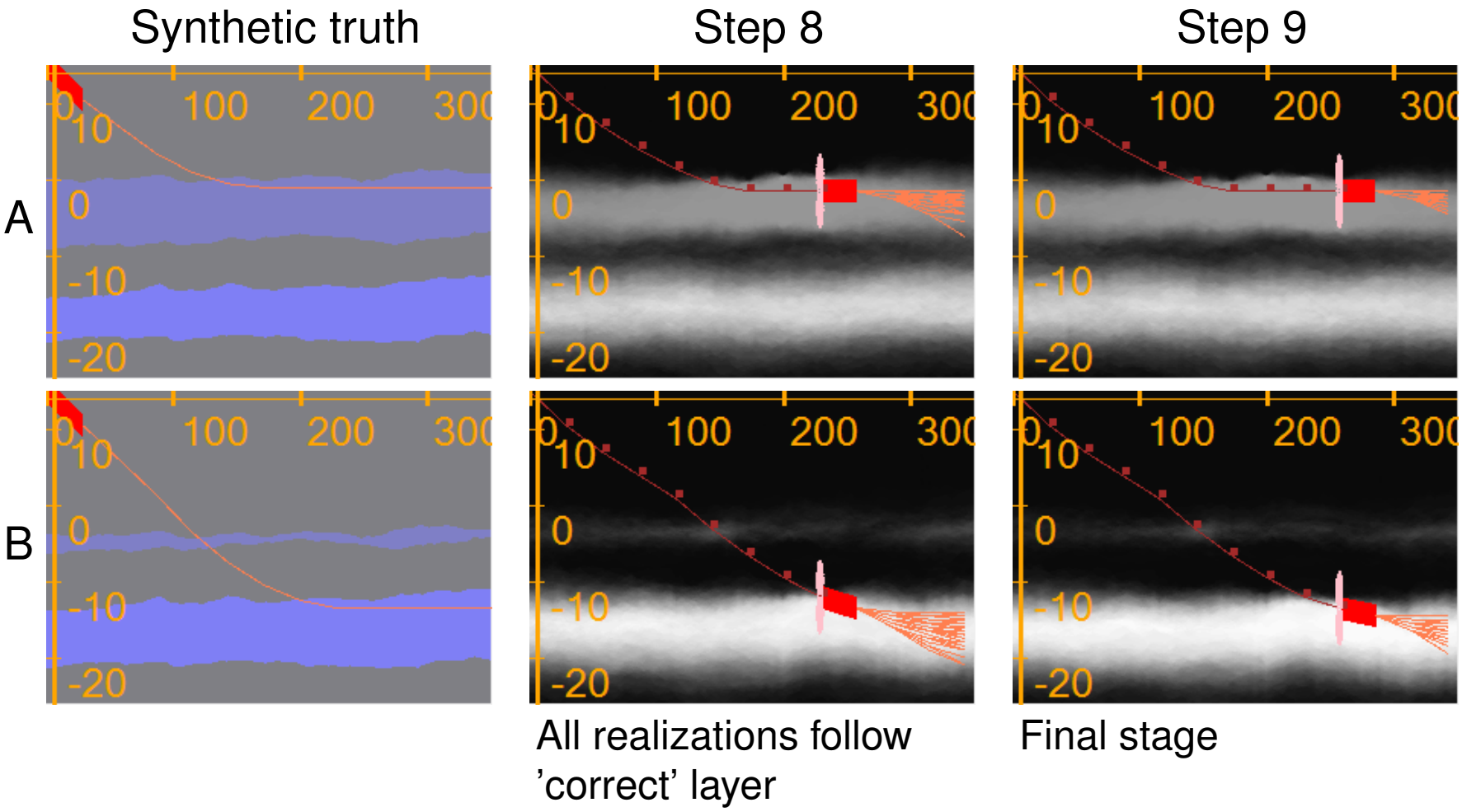
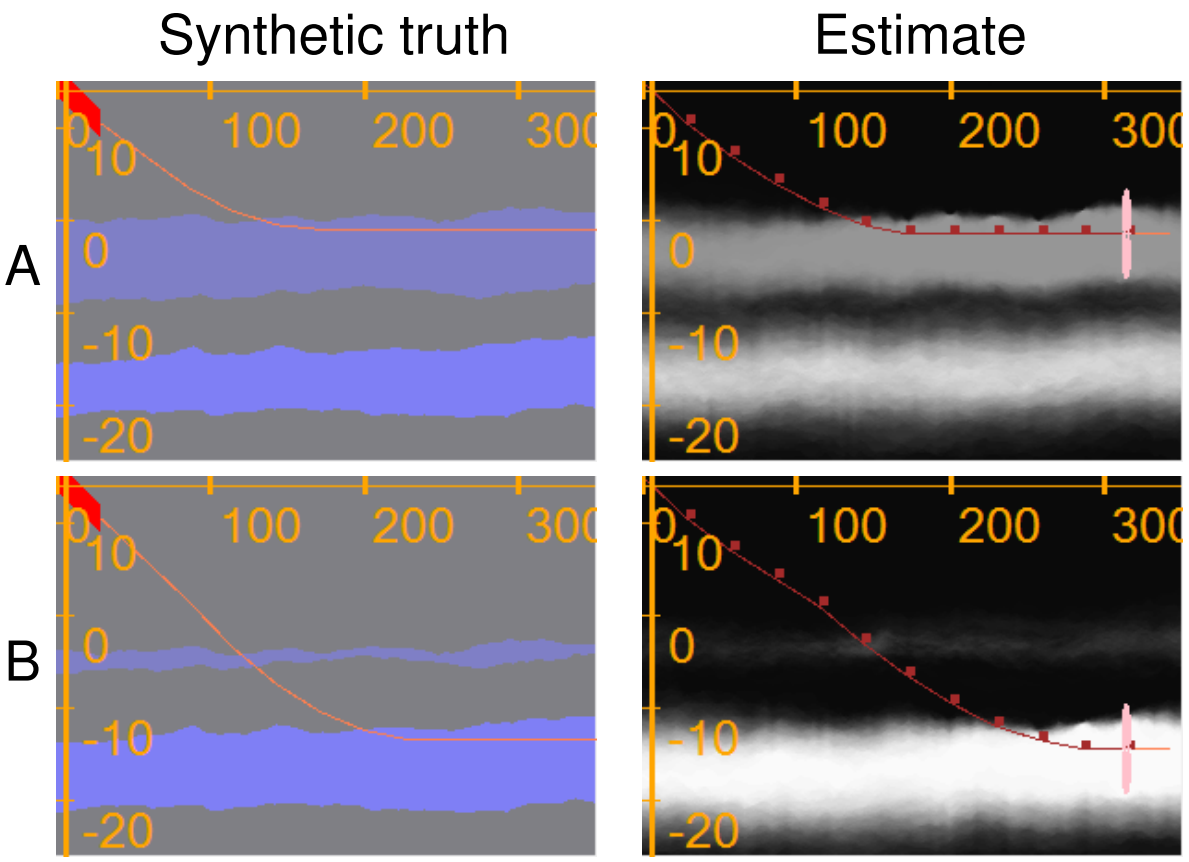



All realizations follow 'correct' layer

Final stage

# Example: Final state




The well matches the perfect trajectory.

The well is placed in optimal layer.
The placement is not perfect due to initial uncertaints.

# Acknowledgements

Norwegian Research Council Petromaks-2 projects:

- **DIGIRES: Decision-Driven Big Data and Analytics for the Digital Subsurface**, supported by the Research Council of Norway, ENI, Equinor, Aker BP, DEA, VNG, Engie, Petrobras.
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# Summary

We have presented a generic decision-driven workflow that uses:

- An ensemble of models to represent uncertainty.
- Ensemble methods for integration of measurements and models.
- Ensemble optimization for determining optimal control variables.

- Approach is applicable for most Earth-sciences models.
- Value of including information about the uncertainty?
- Impact of non-Gaussianity on decision process?