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Time dependent inversion of surface subsidence due to dynamic reservoir compaction

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The pressure drop induced by hydrocarbon production results in reservoir compaction and associated subsidence at the surface. We introduce a novel, time dependent inversion scheme which resolves both temporal and spatial reservoir pressure drop from subsidence data in a single procedure . The theory is specifically developed to accommodate uneven sampling and gaps in the data distribution. This allows for the implementation of all surface observation sites that have been observed at at least two epochs. The method incorporates both the full prior model covariance matrix and the full data covariance matrix . They are based on correlations between model parameters and data both in space and time. The incorporation of the model covariance guarantees an implicit smoothness of the model estimate in transition zones , while maintaining specific geological features like sharp boundaries. The method is validated by a synthetic case study based on an existing gas reservoir with a highly variable transmissibility at the free water level. The prior model covariance matrix is based on a Monte Carlo simulation of the geological uncertainty in the transmissibility. The study demonstrates the strength of our approach compared to utilizing only the local uncertainty in compaction and/or Laplacian smoothing. The time dependent aspect of the method leads to a better constrained model estimate, and the possibility to identify non-linear acceleration or delay in reservoir compaction.