Monitoring Geological CO_2 storage

O. Kolbjørnsen[1], M. Ulvmoen[1], V.L. Hauge[1], R. Hauge[1], B. Fjellvoll[1], T.A. Johansen[2], E.H. Jensen[2], J. Dvorkin[3], G. Mavko[3], A. Furre[4], D. Johnston[5]
1: Norwegian Computing Center (NR); 2: University of Bergen (UiB), 3: Stanford University/Petrophysical Consulting, Inc. (PCI); 4: Statoil Petroleum AS; 5: ExxonMobil Exploration and Production, Norway

NFR project 207097/E20

Main goal

Improved quantitative prediction of the spatial distributions of CO_2 in subsurface storage.

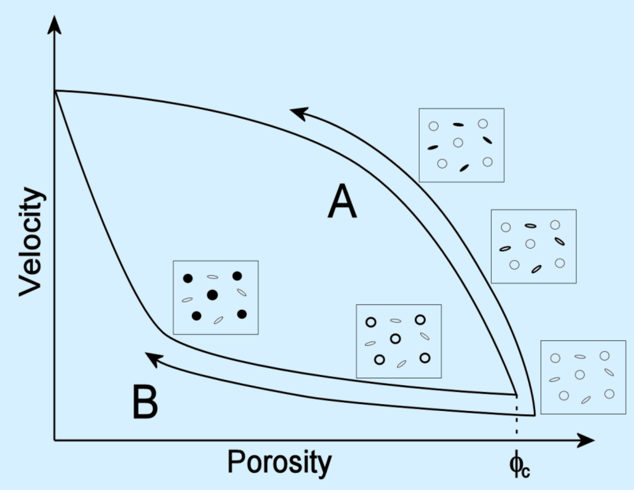
Project time scale: 2011 – 2014

Contribution to CO_2-handling

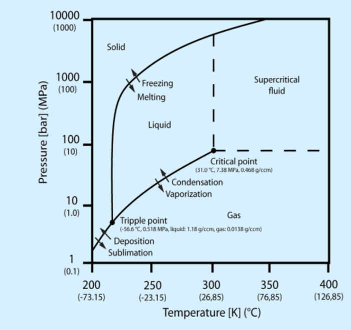
- A rock physics library provides the basis for a systematic approach to CO_2 monitoring
- Joint inversion of multiple data sources constrained by rock physics models assures consistent use of data
- Quantitative interpretation of inversion provides the spatial distribution of CO_2 in subsurface storage
- Reliable prediction of CO_2 ensures public safety and support for continued CO_2 storage
- Quantitative assessment of CO_2 saturation provides the limits for storage rates and capacity essential for the economy of a storage site in emission trading

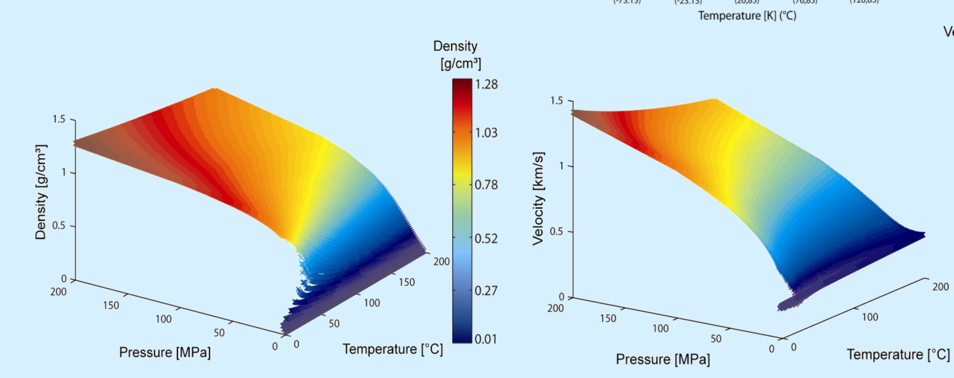
Rock physics library

Matrix properties

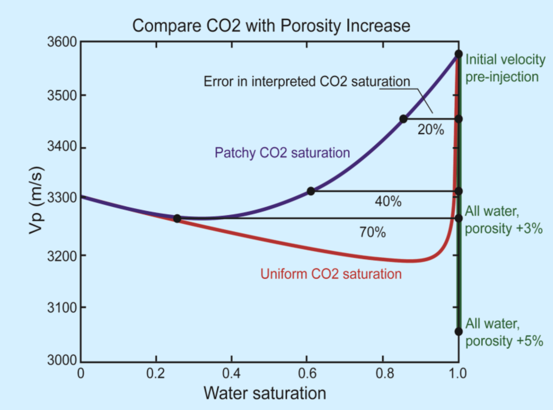


Fluid properties



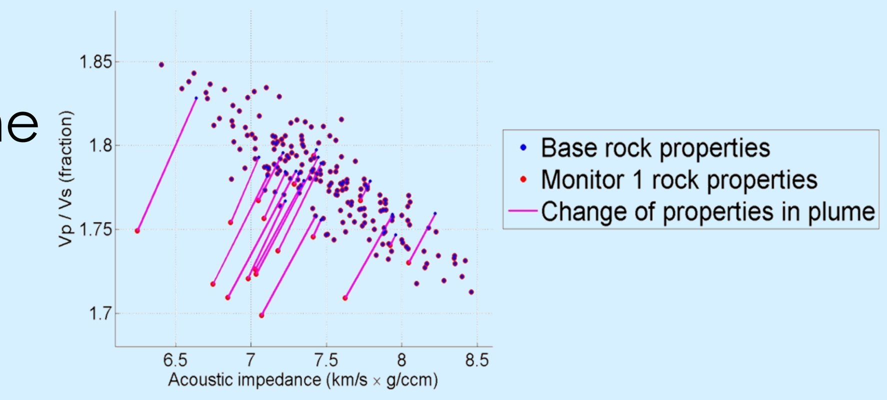


Fluid filling in porous rock



Understanding of the rock constituents and texture, fluid properties, and the pore space filling is the fundament of data interpretation

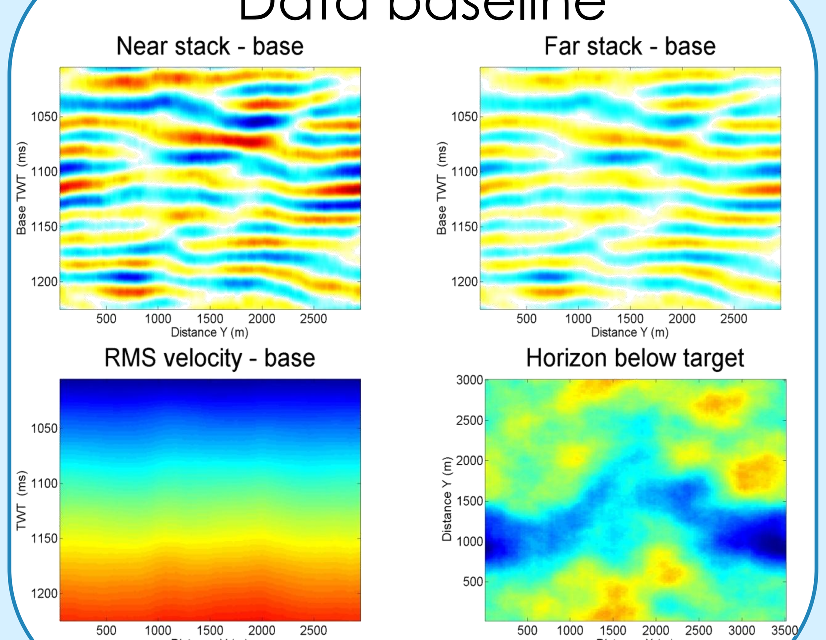
Change in seismic parameters from time of base to monitor



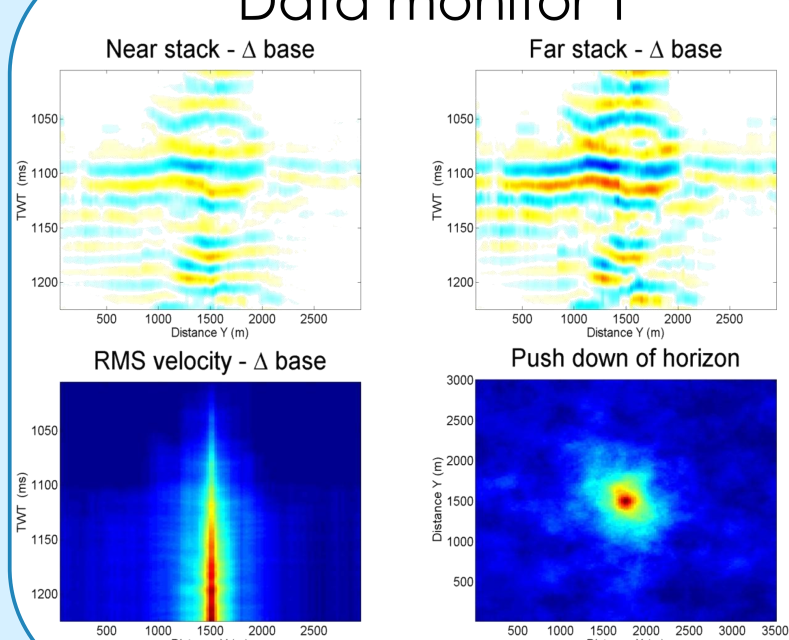
Approach verified in synthetic case

Repeated measurements of multiple types

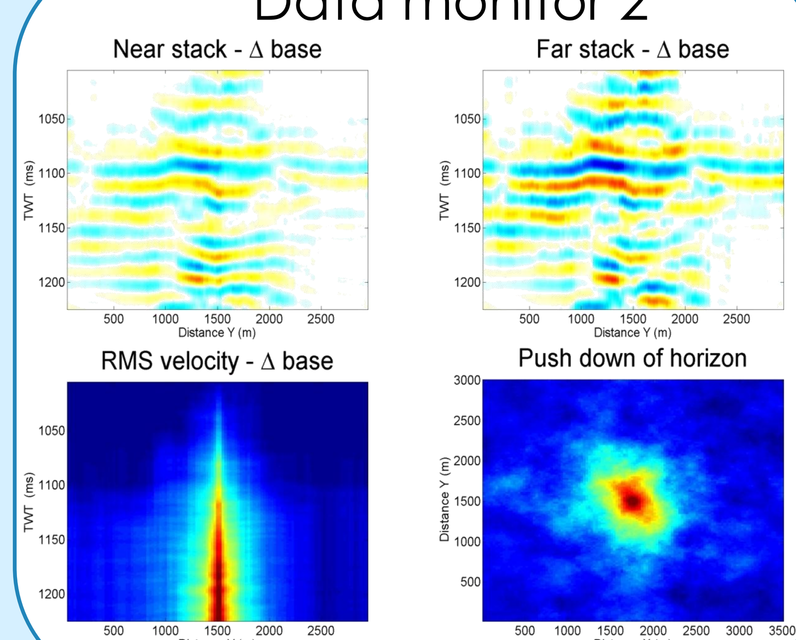
Data baseline



Data monitor 1



Data monitor 2



Generating synthetic data

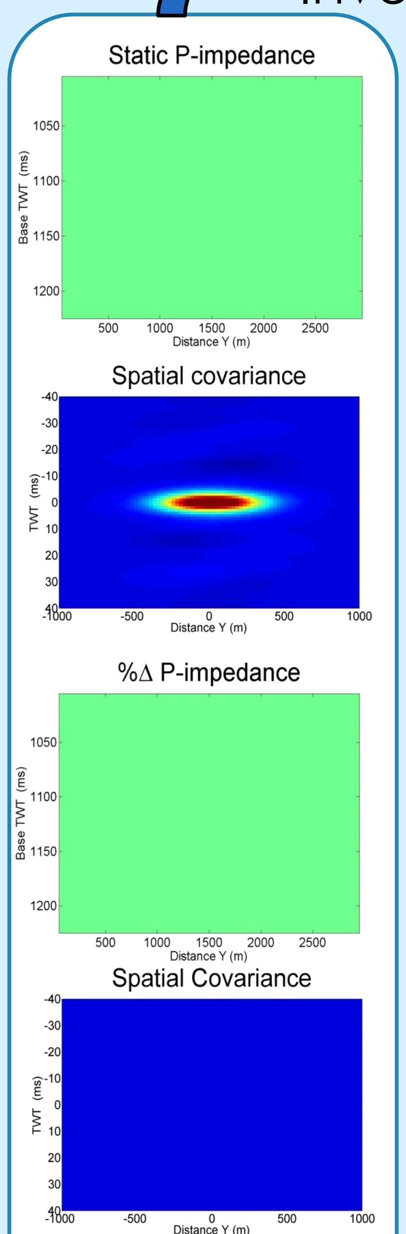
Inversion Inversion Inversion

Predicted properties

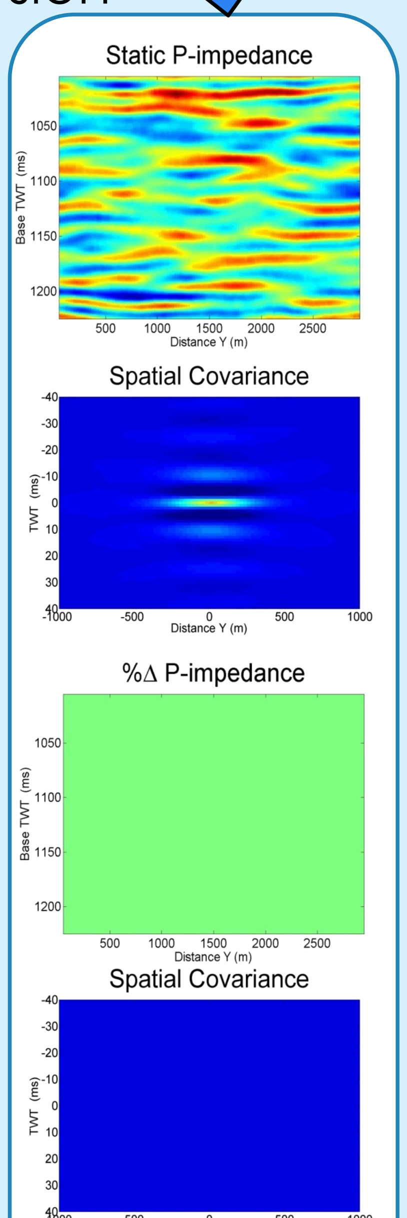
Original properties

Static seismic parameters

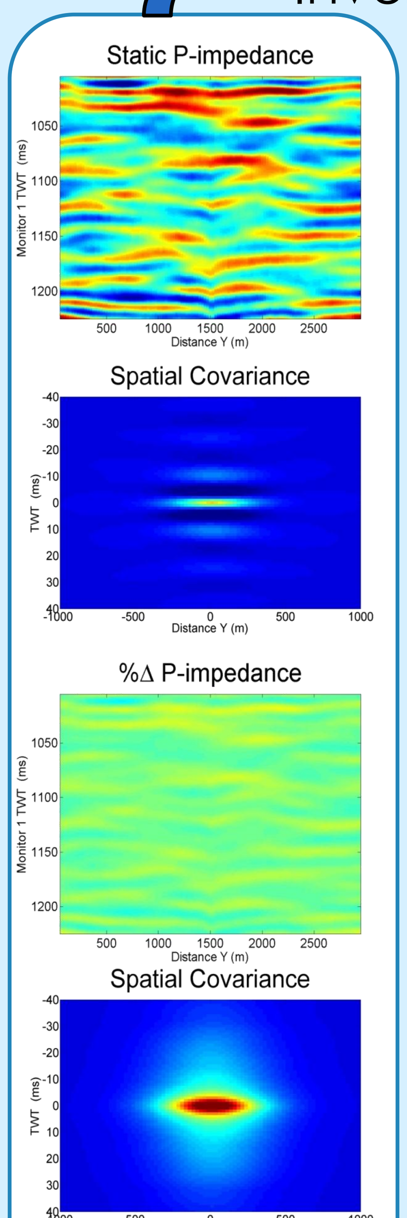
Dynamic seismic parameters



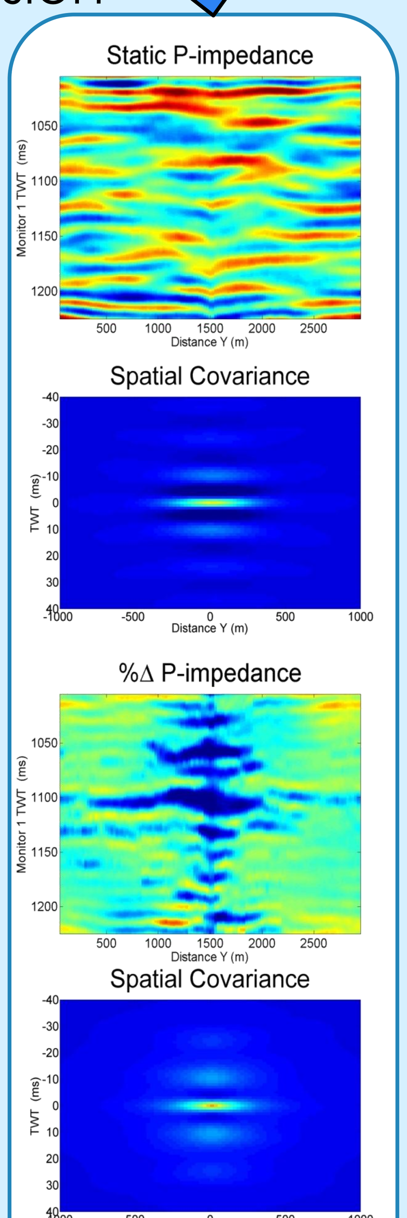
$p^*(\boldsymbol{m}_0)$



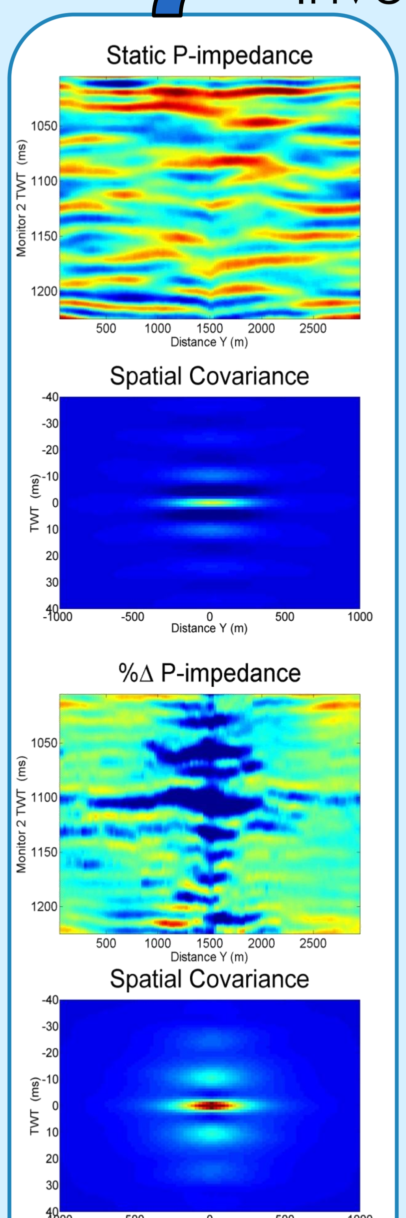
$p^*(\boldsymbol{m}_0|\boldsymbol{d}_0)$



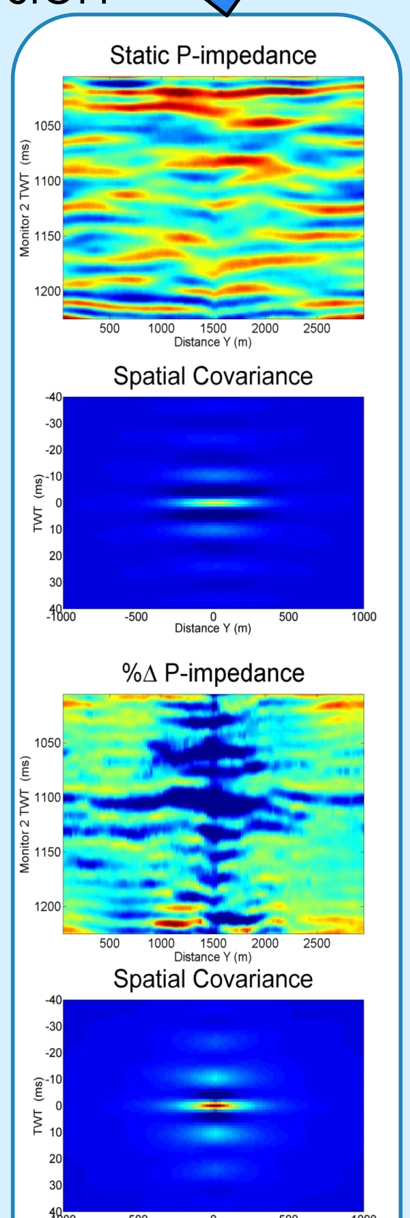
$p^*(\boldsymbol{m}_1|\boldsymbol{d}_0)$



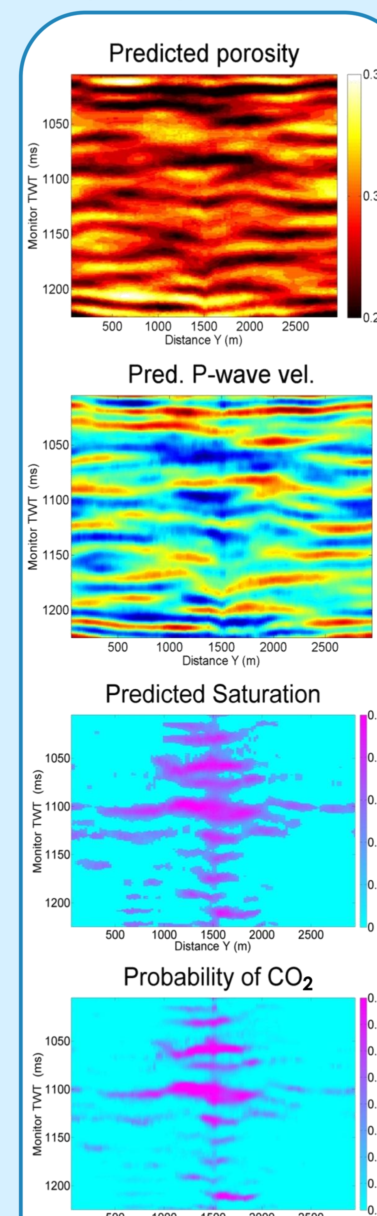
$p^*(\boldsymbol{m}_1|\boldsymbol{d}_0, \boldsymbol{d}_1)$



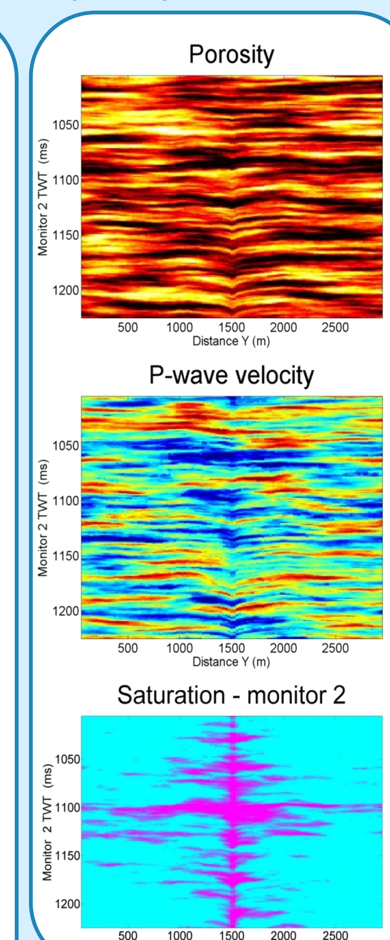
$p^*(\boldsymbol{m}_2|\boldsymbol{d}_0, \boldsymbol{d}_1)$



$p^*(\boldsymbol{m}_2|\boldsymbol{d}_0, \boldsymbol{d}_1, \boldsymbol{d}_2)$



$p(\boldsymbol{r}_2|\boldsymbol{d}_0, \boldsymbol{d}_1, \boldsymbol{d}_2)$



In synthetic example:

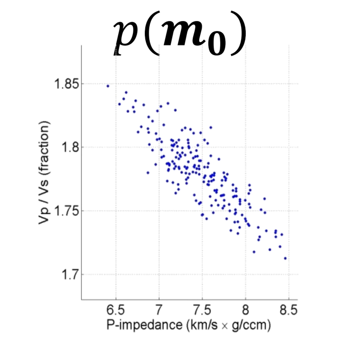
Data displayed is a sub-selection of those used in the joint inversion.

Joint posterior distribution of three seismic parameters (PI, V_P/V_S, density), are computed in a 3D-grid. A slice of PI is displayed.

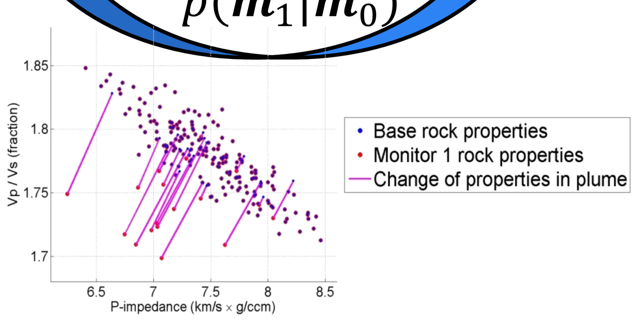
Stochastic rock physics

Propagation Propagation

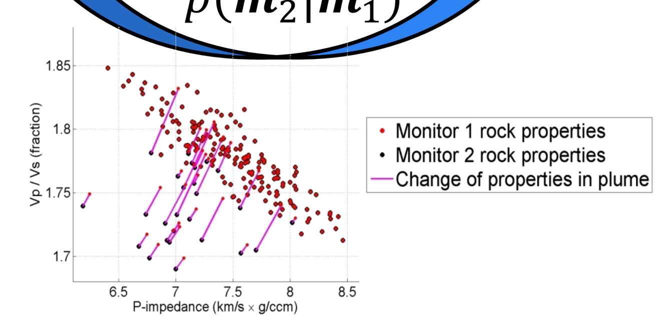
$p(\boldsymbol{m}_0)$



$p(\boldsymbol{m}_1|\boldsymbol{m}_0)$



$p(\boldsymbol{m}_2|\boldsymbol{m}_1)$



Equation for rock physics inversion

$$p(\boldsymbol{r}|\boldsymbol{d}) \propto \int p(\boldsymbol{r}|\boldsymbol{m}) \frac{p^*(\boldsymbol{m}|\boldsymbol{d})}{p^*(\boldsymbol{m})} p(\boldsymbol{m})\, \mathrm{d}\boldsymbol{m}$$

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