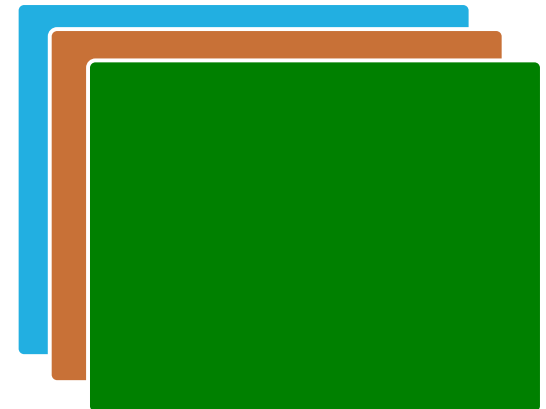
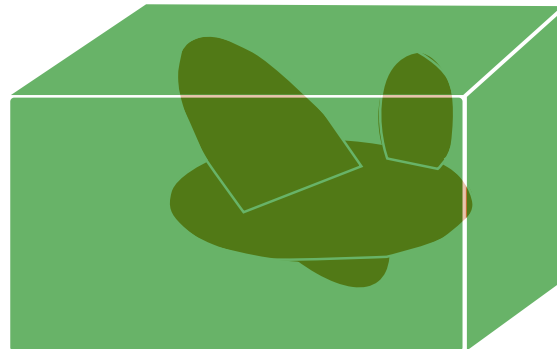
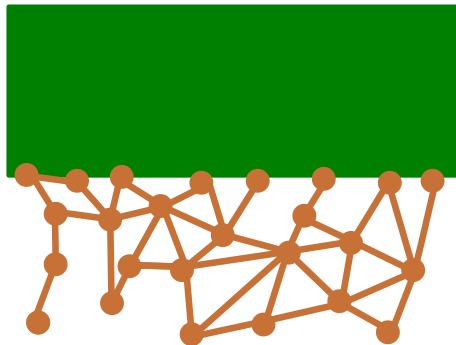
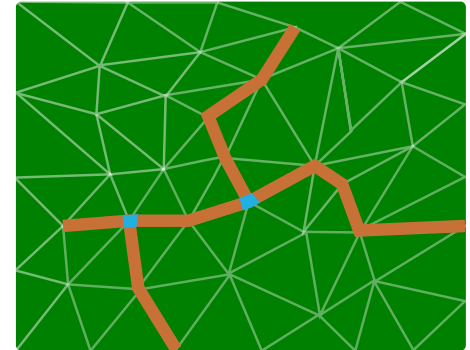
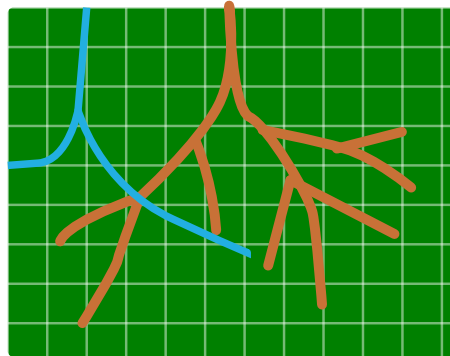
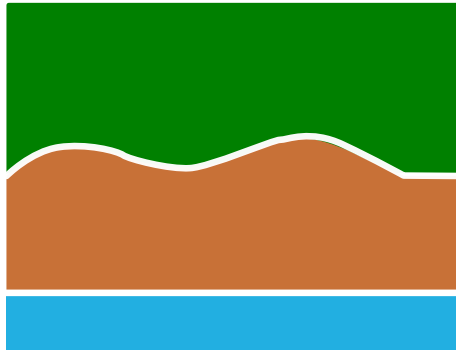




DuMu^x

The DuMu^x Multidomain Framework

Coupling Multiple Domains

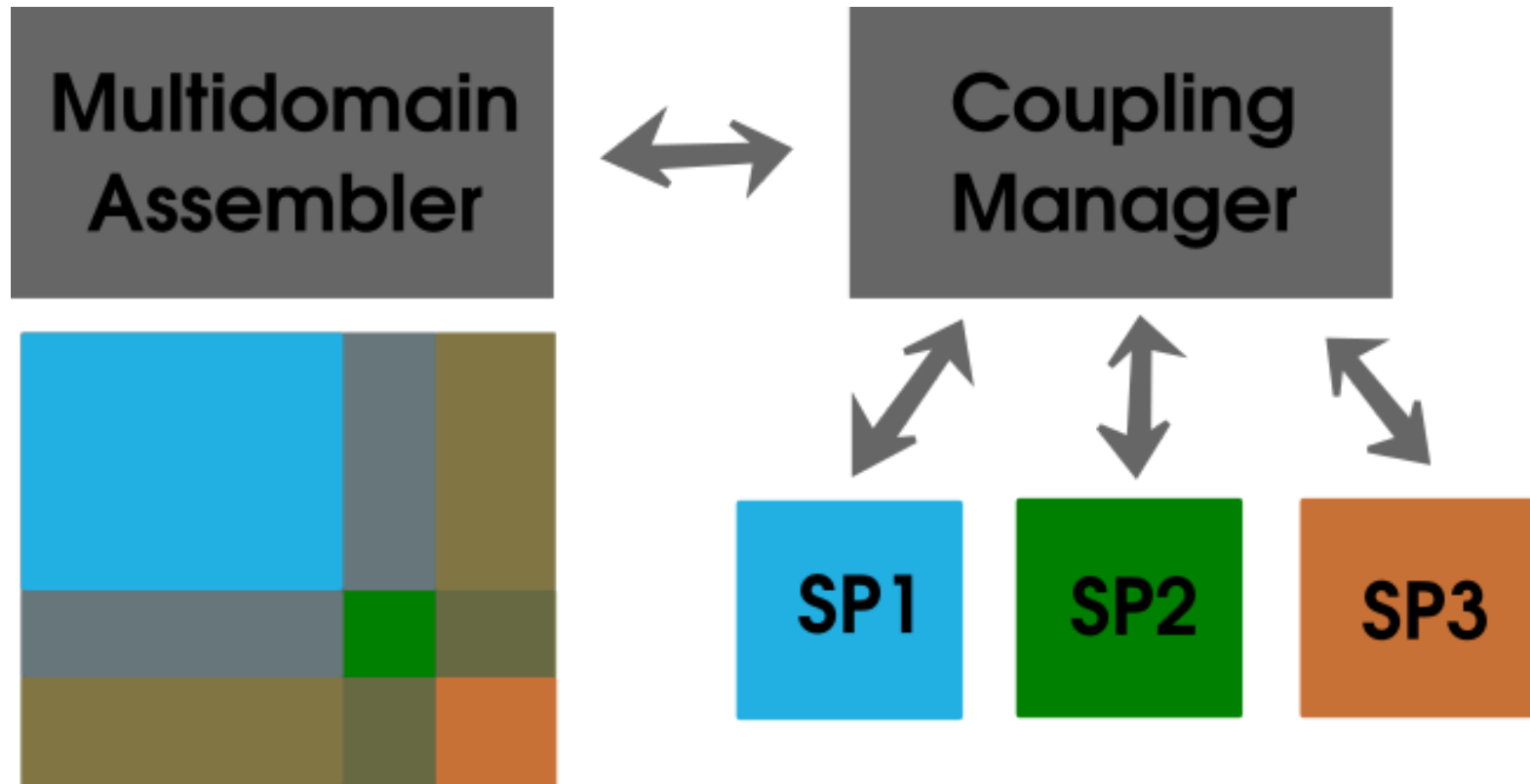


The DuMu^X Multidomain Framework

Design Goals

- Reuse existing DuMu^X models in the coupled setting
- Extensible to more than two subdomains
- Common structure for different coupling modes

DuMu^X Multidomain: General Structure

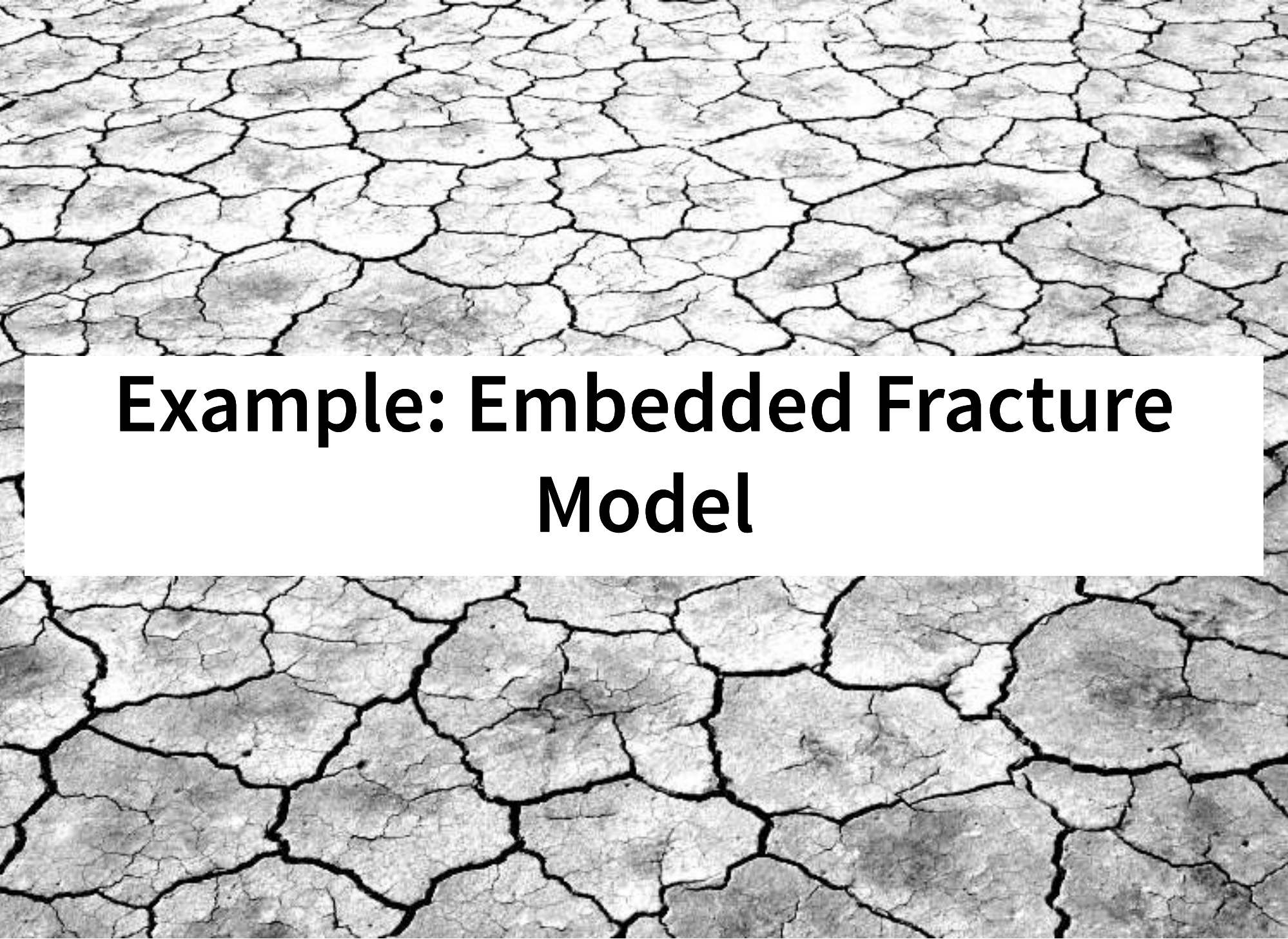


The Sub Problems

- any DuMu^X problem with
 - initial conditions
 - boundary conditions
 - associated DuMu^X model
- get a pointer to the coupling manager

The Coupling Manager

- Transfer data from one subproblem to another
 - e.g. give me the soil pressure (from the well domain)
 - e.g. give me the radius of the embedded well (from the soil domain)
- Compute the coupling stencil
- Compute the coupling residual (numerical differentiation)



Example: Embedded Fracture Model

Example: Embedded Fracture Model (Coupling Residual)

$$\begin{aligned}\frac{\partial \rho \phi}{\partial t} - \nabla \cdot \left[\frac{\rho}{\mu} \mathbf{K}_m (\nabla p_m - \rho \mathbf{g}) \right] - q \delta_\Gamma &= 0 \quad \text{in } \Omega \\ \frac{\partial \rho \phi}{\partial t} - \nabla_\tau \cdot \left[\frac{\rho}{\mu} \mathbf{K}_f (\nabla p_f - \rho \mathbf{g}) \right] + q &= 0 \quad \text{in } \Lambda \\ q &= \zeta(p_f - p_m) \quad \text{and} \quad \Gamma = \Omega \cap \Lambda\end{aligned}$$

Example: Embedded Fracture Model

(Coupling Residual / Data Transfer)

```
/*!  
 * \brief A point source at every integration point for the coupling source term  
 */  
void pointSource(PointSource& source, ...) const  
{  
    // get the pressures  
    const Scalar pressure3D = this->couplingManager().bulkPriVars(source.id())[Indices::pressureIdx]  
    const Scalar pressure2D = this->couplingManager().lowDimPriVars(source.id())[Indices::pressureId]  
  
    // calculate the source  
    const Scalar meanDistance = this->couplingManager().averageDistance(source.id());  
    const Scalar sourceValue = rho*(pressure2D - pressure3D)/meanDistance*matrixPerm/mu;  
    source = sourceValue*source.quadratureWeight()*source.integrationElement();  
}
```

Example: Embedded Fracture Model

(Coupling Residual)

```
/*!
 * \brief evaluates the element residual of a coupled element of domain i which depends on the varia
 *         at the degree of freedom with index dofIdxGlobalJ of domain j
 */
template<std::size_t i, std::size_t j, class LocalAssemblerI>
auto evalCouplingResidual(Dune::index_constant<i> domainI,

    const LocalAssemblerI& localAssemblerI,

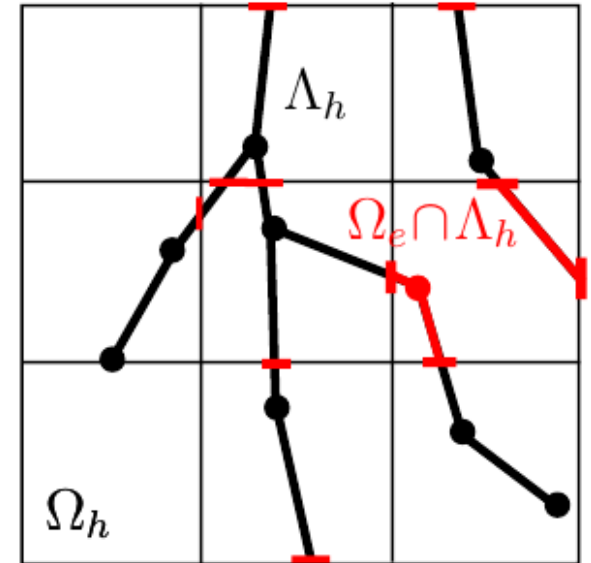
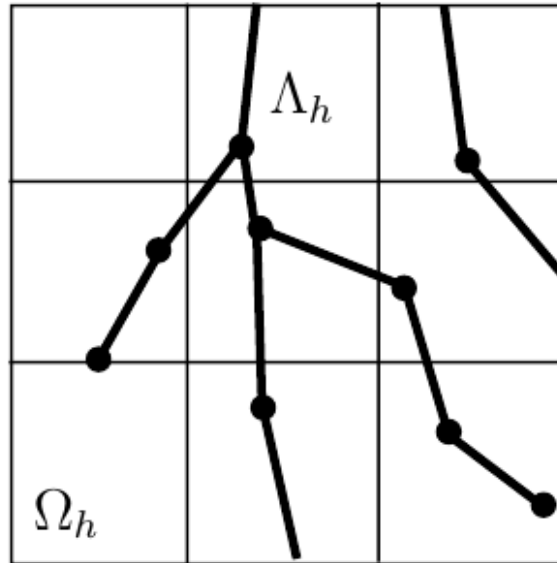
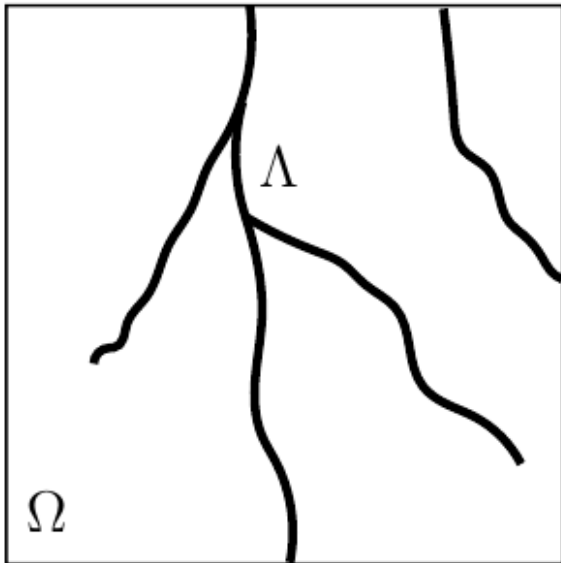
    Dune::index_constant<j> domainJ,

    std::size_t dofIdxGlobalJ)
{
    typename LocalAssemblerI::LocalResidual::ElementResidualVector residual;

    const auto& element = localAssemblerI.element();
    const auto& fvGeometry = localAssemblerI.fvGeometry();
    const auto& curElemVolVars = localAssemblerI.curElemVolVars();

    residual.resize(fvGeometry.numScv());
    for (const auto& scv : scvs(fvGeometry))
    {
        auto couplingSource = problem(domainI).scvPointSources(element, fvGeometry, curElemVolVars,
            couplingSource *= -scv.volume()*curElemVolVars[scv].extrusionFactor());
    }
}
```

Example: Embedded Fracture Model (Coupling Stencil)



Example: Embedded Fracture Model

(Coupling Stencil)

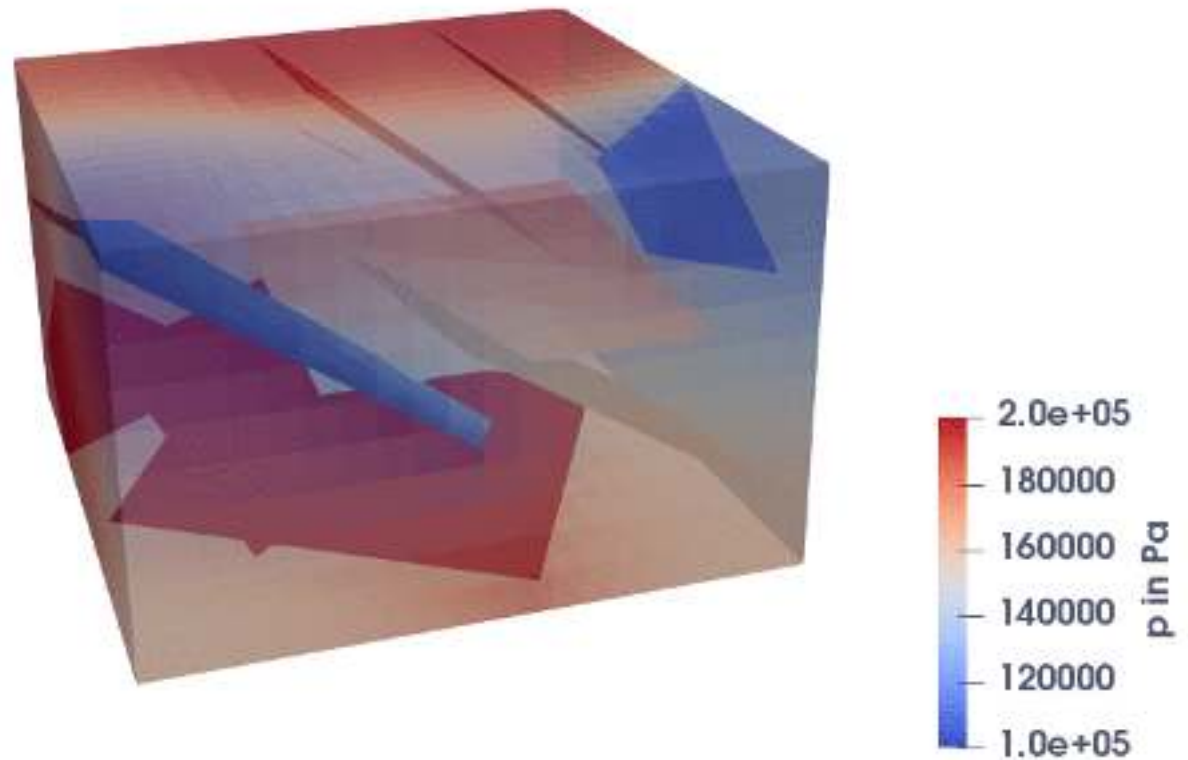
```
/*!
 * \brief returns an iterable container of all indices of degrees of freedom of domain j
 *         that couple with / influence the element residual of the given element of domain i
 */
template<std::size_t i, std::size_t j>
const CouplingStencil& couplingStencil(Dune::index_constant<i> domainI,

    const Element<i>& element,

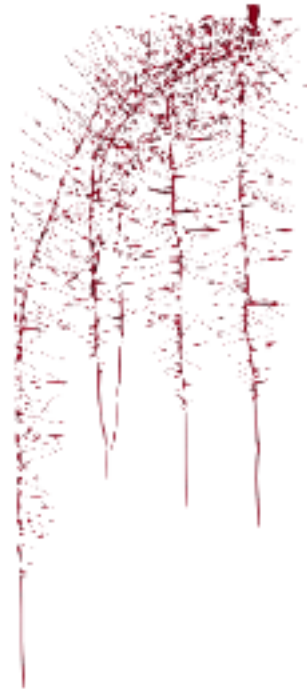
    Dune::index_constant<j> domainJ) const
{
    static_assert(i != j, "A domain cannot be coupled to itself!");

    const auto eIdx = problem(domainI).fvGridGeometry().elementMapper().index(element);
    if (couplingStencils(domainI).count(eIdx))
        return couplingStencils(domainI).at(eIdx);
    else
        return emptyStencil_;
}
```

Example: Embedded Fracture Model



Example: Root Water Uptake



0.0 days