Coupling a moving-mesh to a fixed grid

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Contents

- What do we want from the sea-ice model?
  - What is neXtSIM?
  - Why a Lagrangian moving mesh?
- The coupling problem
  - Dynamic mesh and domain decomposition
  - Conservative remapping
- The road ahead

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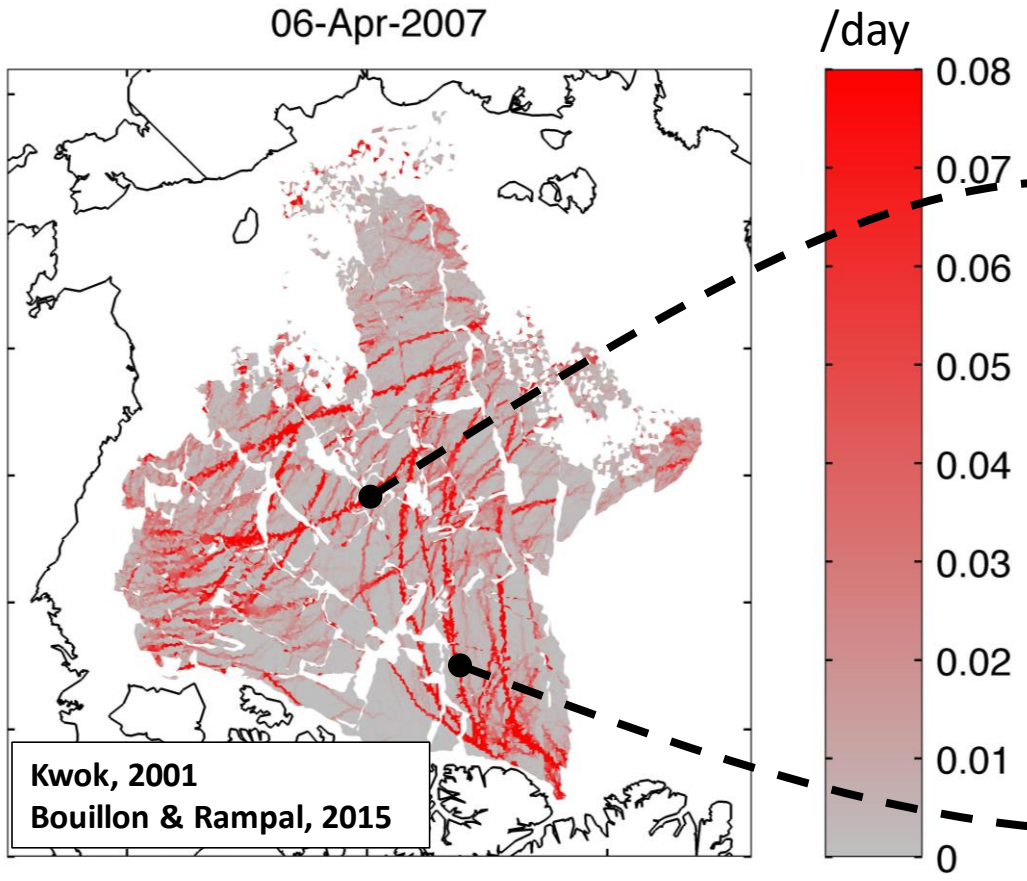
Pack-ice is a fracturing solid

"LKF: Heterogeneous and intermittent"

sea ice deformation rate (Data: SAR - Radarsat)



"Piecewise rigid motion"

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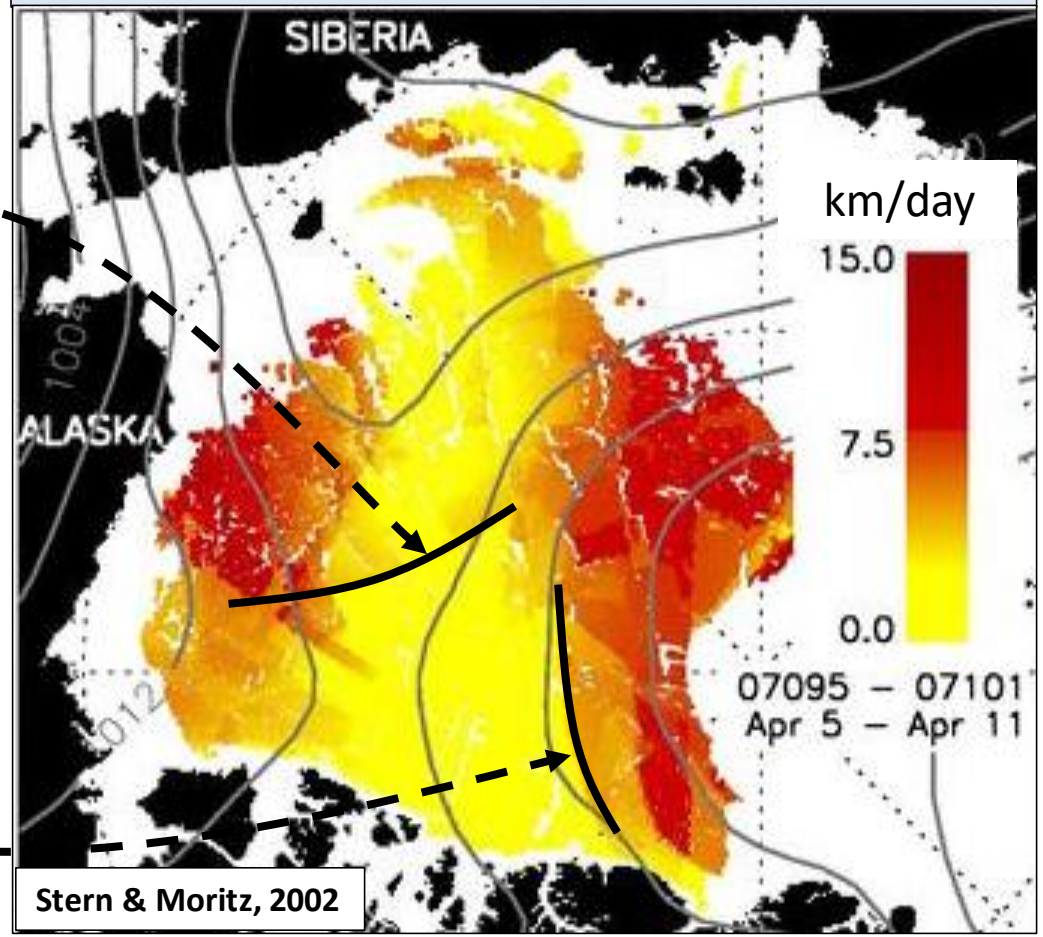

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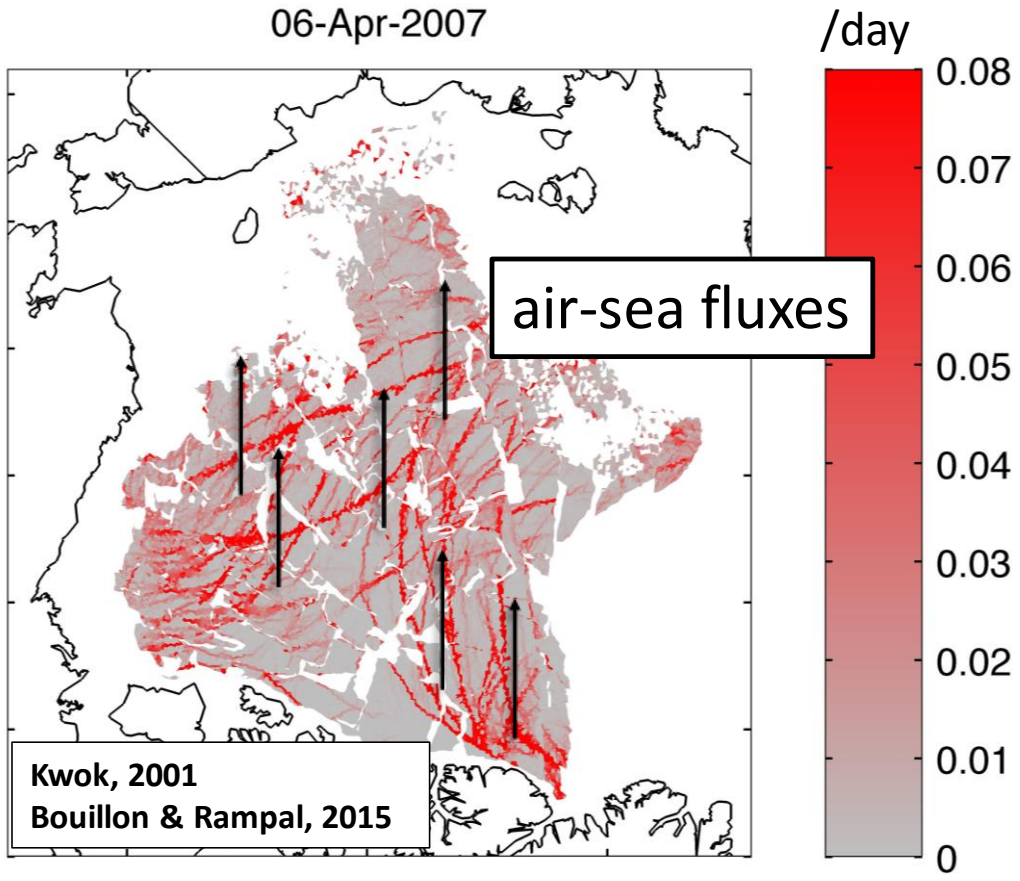

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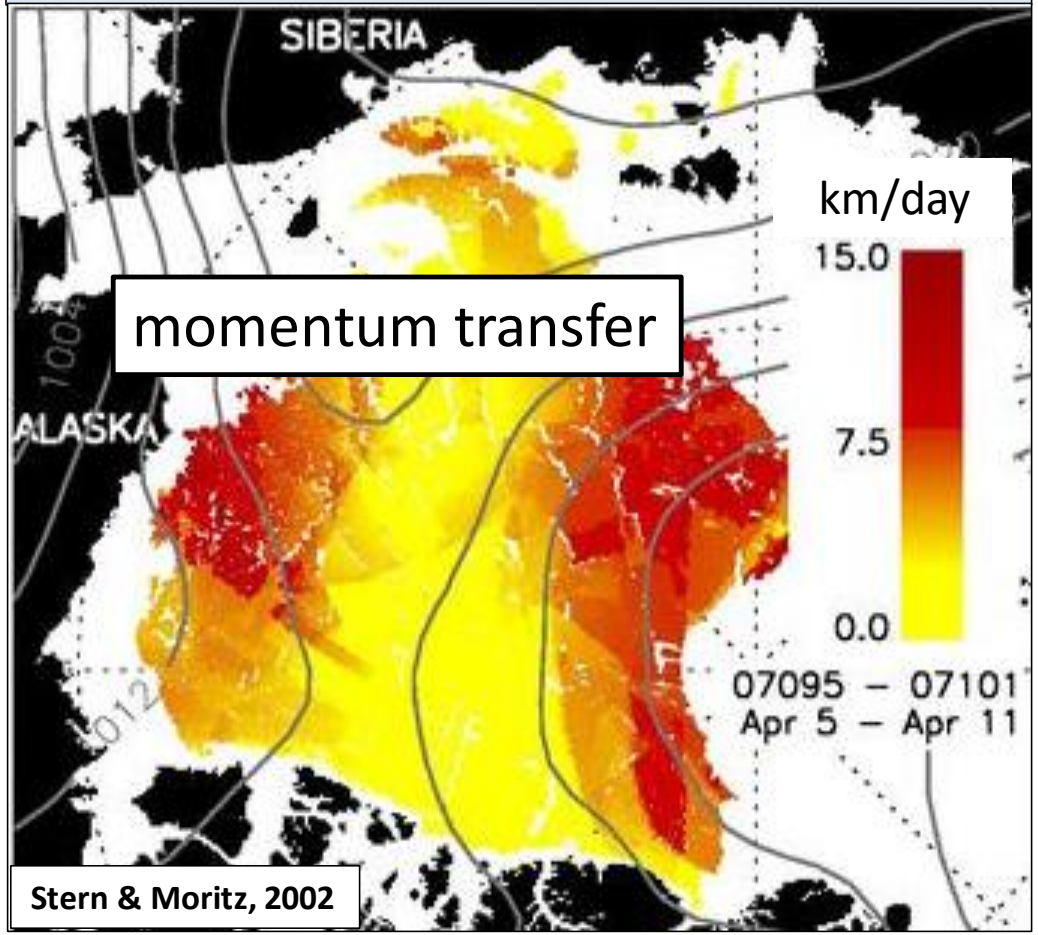

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Bouillon and Rampal, 2015
Rampal et al., 2016
Samaké et al., 2017
Dansereau et al., 2017
Rampal et al., 2019

Maxwell-elasto-brittle rheology
- Long-range elastic interaction
- Memory of ice damage

Lagrangian moving mesh
- Finite-Element discretisation
- Adaptive remeshing

- The road ahead

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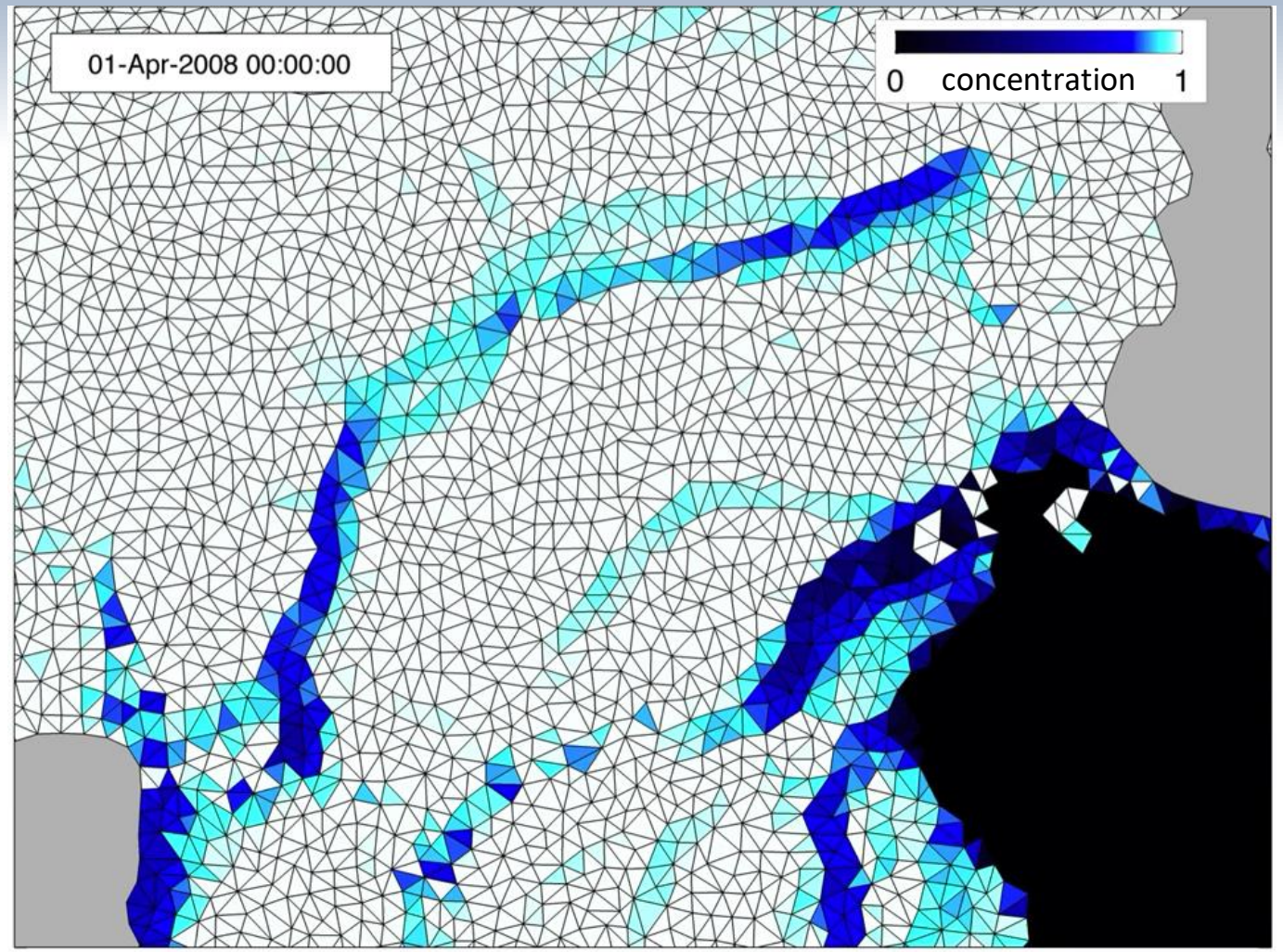
1. Localisation
2. Localisation
3. Localisation

Localisation is neXtSIM's key feature



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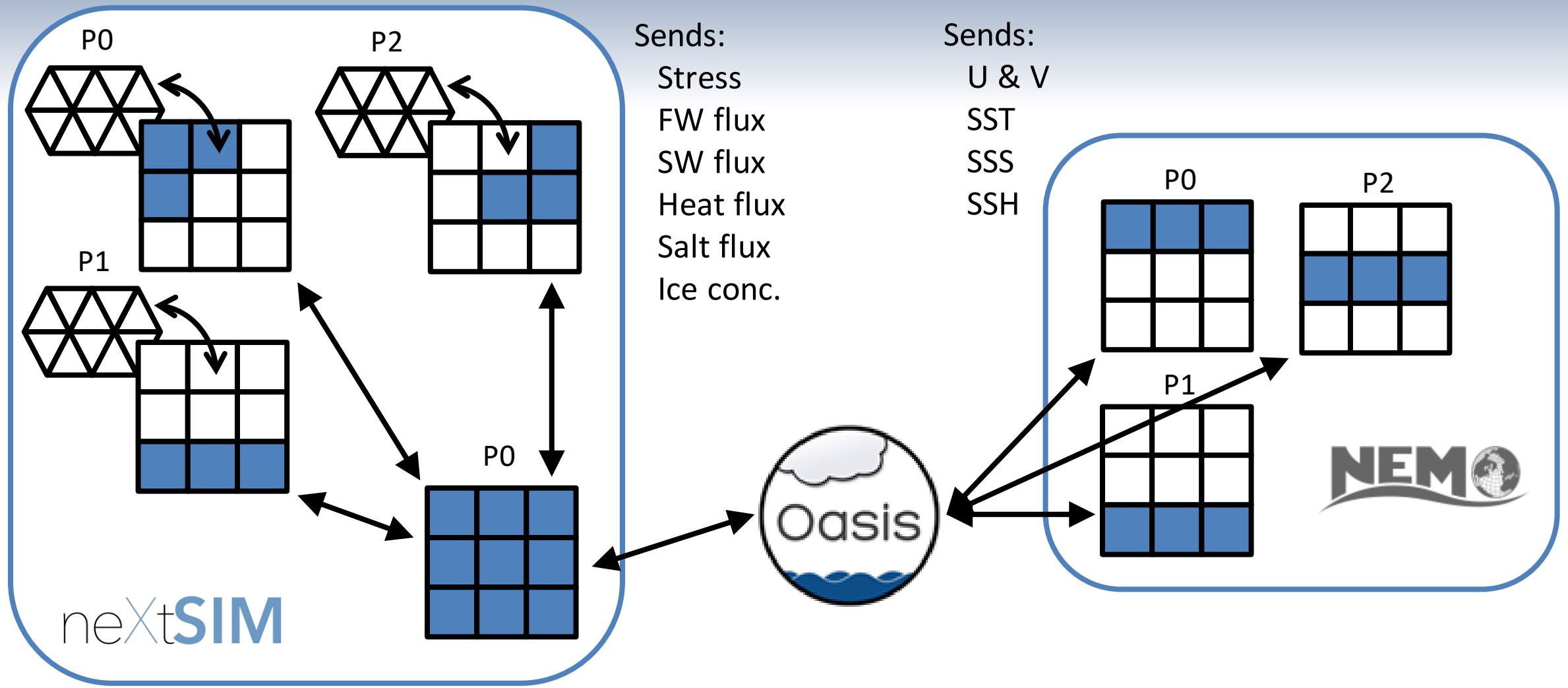
Coupling moving mesh is hard

- When the mesh is too deformed we remesh:
  1. Gather all fields to the root processor
  2. Generate new mesh and domain decomposition
  3. Scatter the new fields to the compute nodes
- Mesh and domain decomposition are dynamic
- Coupler should recompute weights and communication paths … but nobody does that!

Solution: Coupling exchange grid



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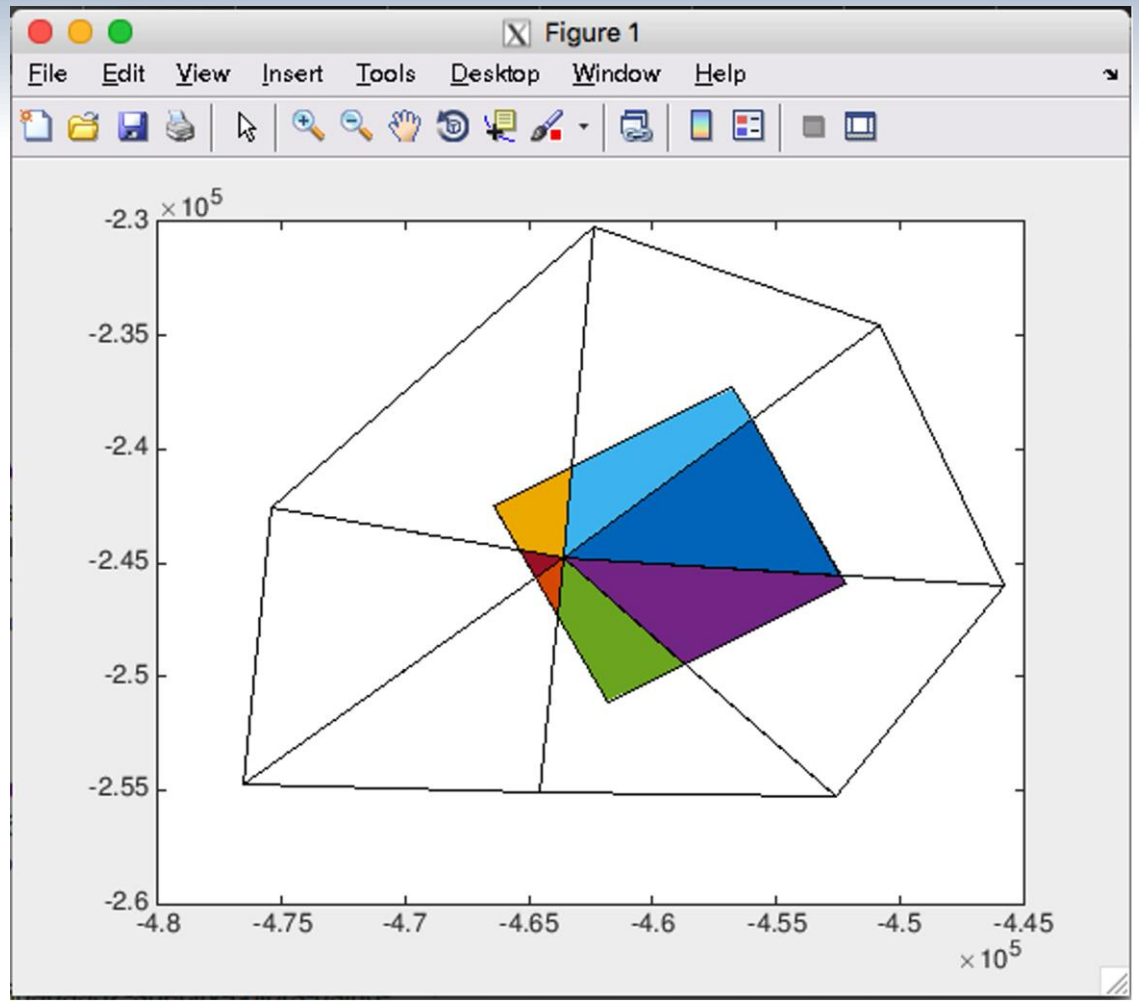
Need conservative remapping

- Fluxes between ice and ocean must be conserved!

- Use weighted averages of overlapping areas of grid cells and triangles
- Interpolation weights are calculated on the root when remeshing
- Interpolation is done in parallel

Conservative remapping algorithm

- For each grid cell find the triangle covering its centre point (quadtree).
- Do three checks (recursive):
  1. Check & record which vertexes are inside the cell
     => If inside: Call self for surrounding triangles
  2. Check & record which of the grid cell corners are inside the triangle
  3. Look for & record intersections between the triangle and cell
     => If intersecting: Call self for other triangle
- We now know all corner and intersection points => also know all areas.



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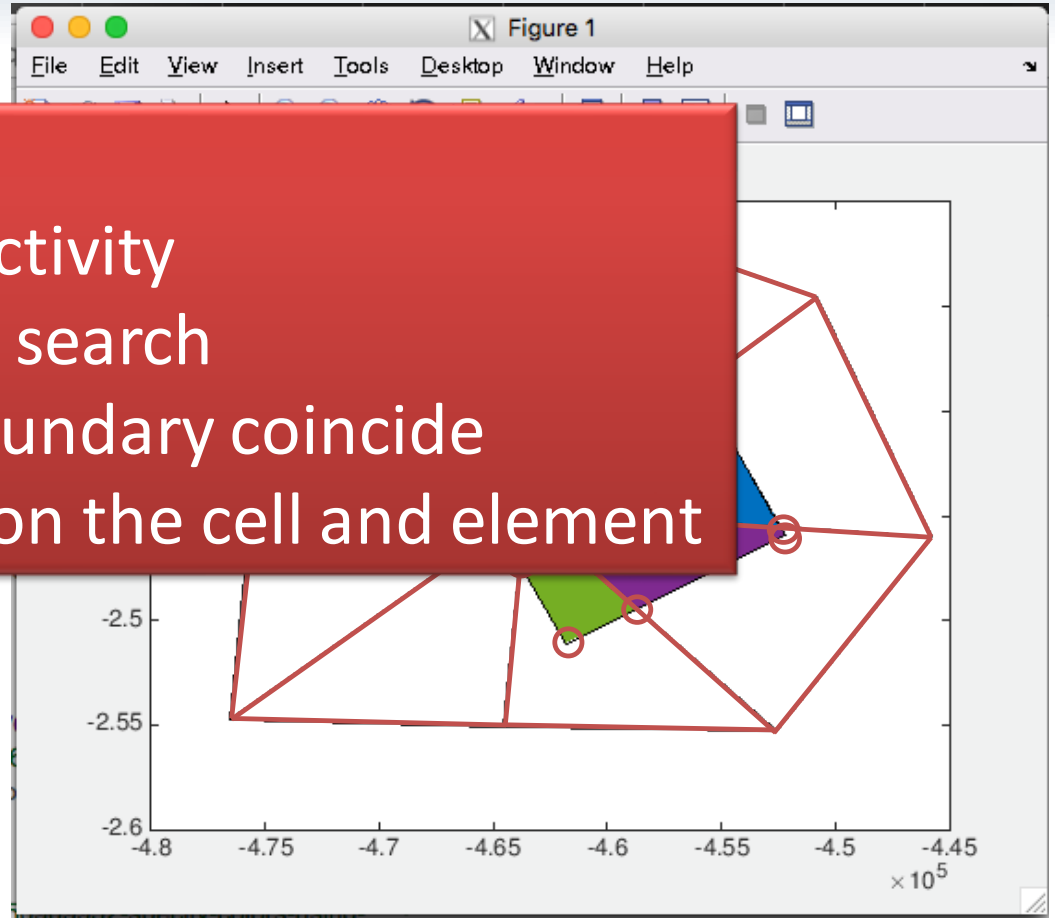

"Easy" because:

- We know mesh connectivity
- We have a quick (tree) search
- Mesh and grid land boundary coincide
- All fields are constant on the cell and element

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What's the future for a Lagrangian mesh?

Future remeshing

- Remeshing on the root is a bottle neck.
- All remeshing and interpolation should be done in parallel
- This requires a complete re-write of the remeshing algorithm

Thank you!

Future coupling

- Doing coupling through the root is a bottle neck
- For parallel coupling we need either:
  - A new coupler which can reorganise communication paths at runtime
  - A new remeshing scheme with static domain splitting
- We need to do all interpolation (including weight calculation) in parallel