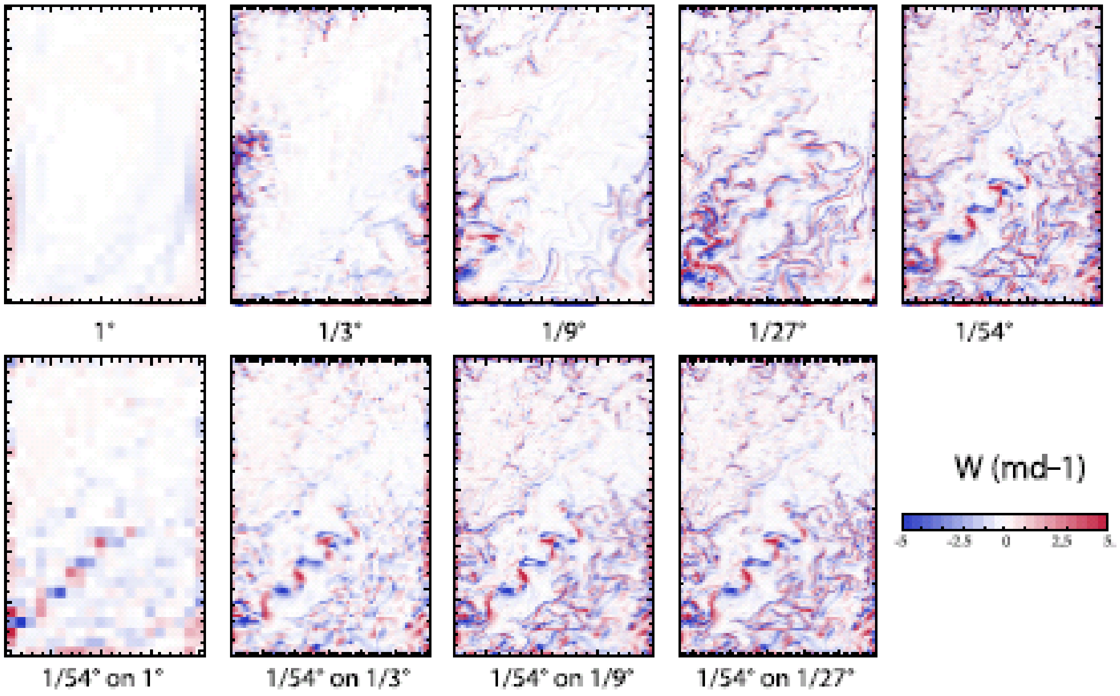
Why using coarsening ?

Why using coarsening ?

- The ”effective resolution” of eddying ocean models is much coarser than the physical model grid resolution
- tracer transport can be reconstructed to a large extent by computing tracer transport and diffusion with a model grid resolution close to the effective resolution of the physical model.



model snapshot of vertical velocity at 40m simulated with increasing grid resolution (top) and with a resolution of 1/54 degraded on coarser resolution grids (bottom)

Grid degradation of submesoscale resolving ocean models: Benefits for offline passive tracer transport, M. Lévy , L. Resplandy, P. Klein, X. Capet, D. Iovino, C. Ethé, Ocean Modelling , 2012, https://doi.org/10.1016/j.ocemod.2012.02.004

Why using coarsening ?

- Ocean mesoscale and submesoscale turbulence contribute to ocean tracer transport and to shaping ocean biogeochemical tracers distribution
- Climate simulation and ocean forecasting : need to increase resolution

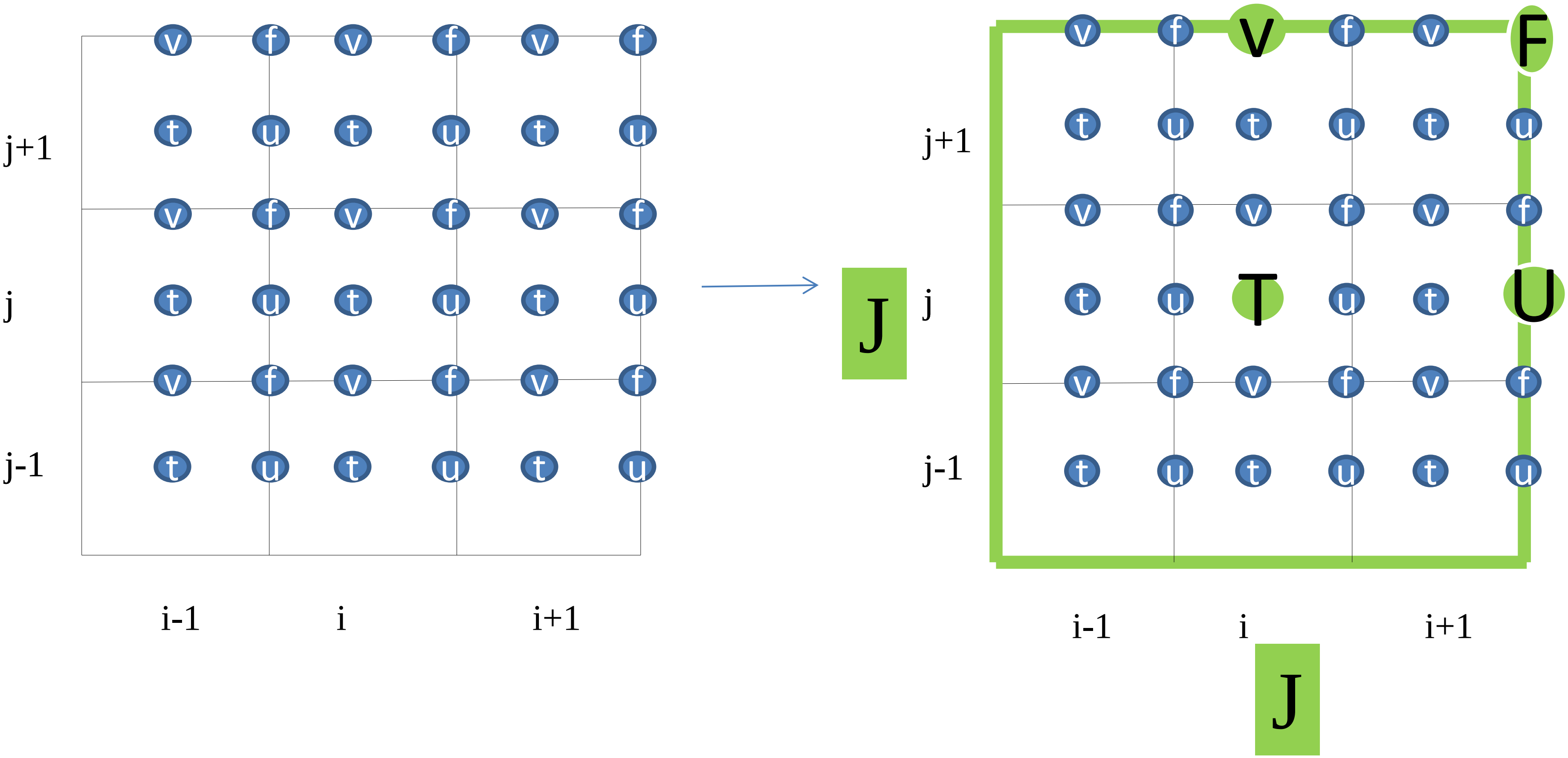
- Technological limitations

TOP-PISCES: 24 tracers
OPA-LIM: T+S+U+V+(2D+icemod) = 5 3D-fields

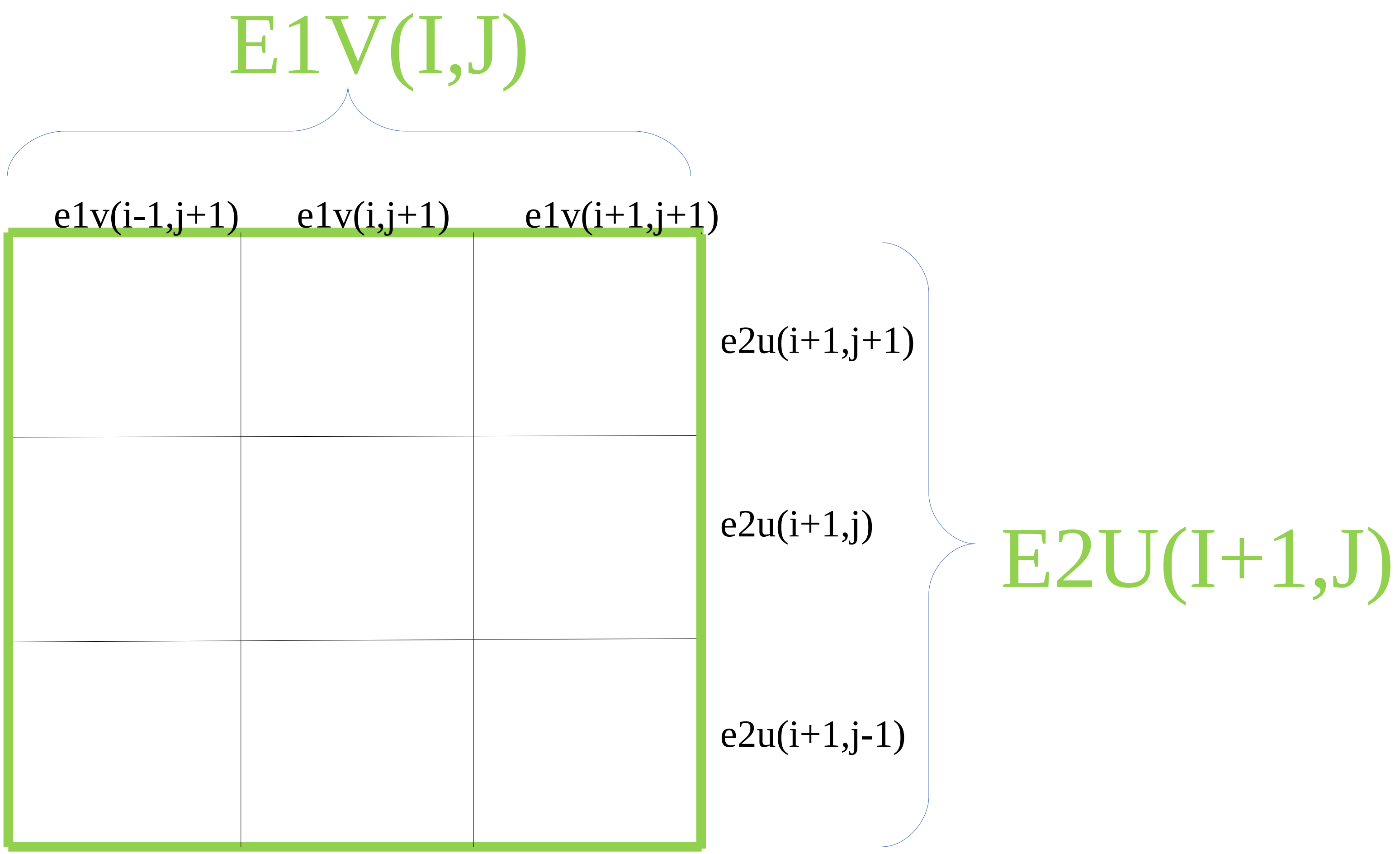
➔Storage: TOP-PISCES = 5 * (OPA-LIM)
➔CPU cost: TOP-PISCES = 3 * (OPA-LIM)   (Need to advect 24 tracers)

Coarsening methodology

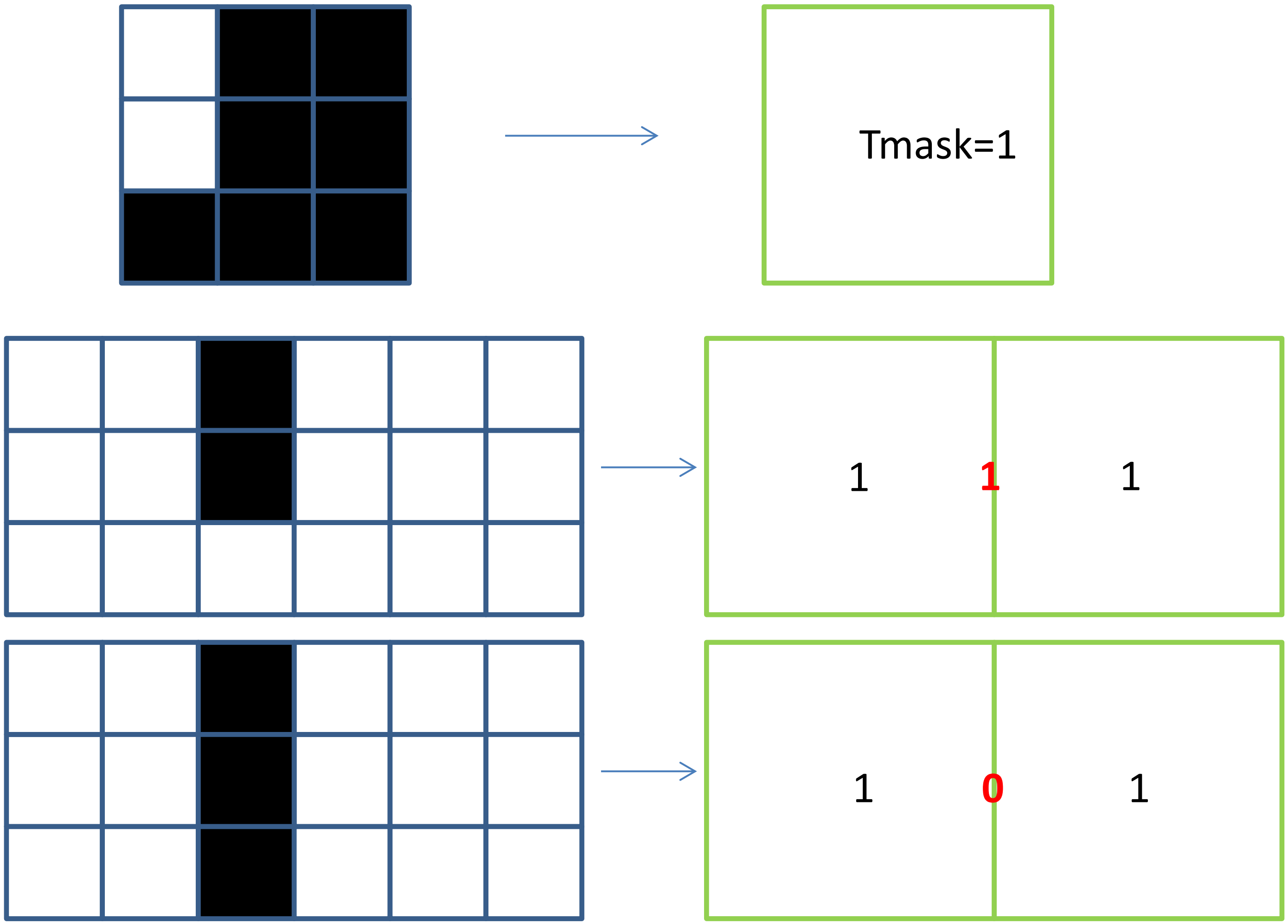
Coarsening methodology: Longitude and latiudes construction



Coarsening methodology:
Horizontal scale factors construction

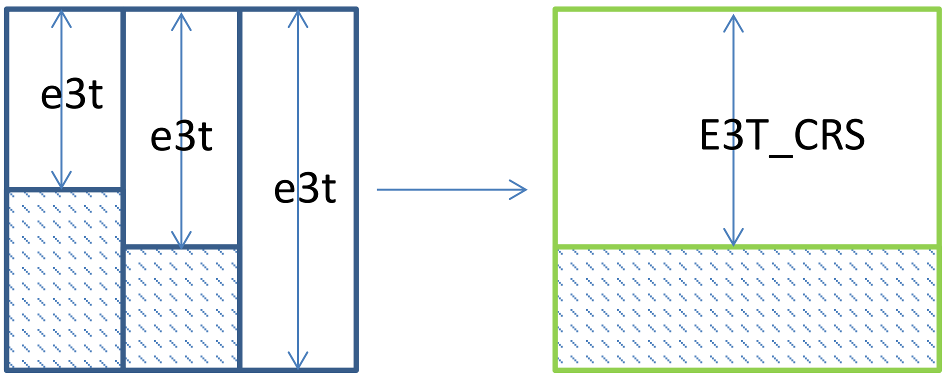


Coarsening methodology: Masks construction



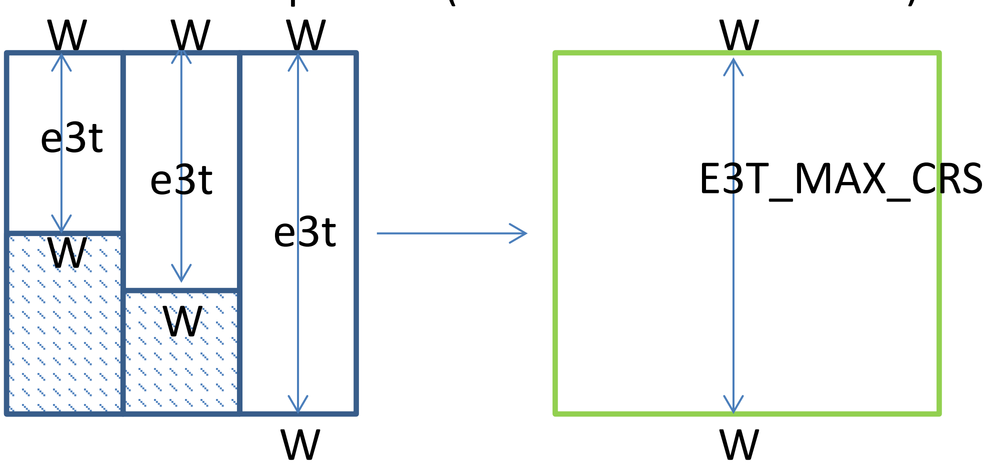
Coarsening methodology:
Vertical scale factors construction

- Divergence operator (volume conservation):



$$E3T_{CRS} = \frac{1}{e1t_{crs} * e2t_{crs}} * \sum e1t * e2t * e3t$$

- Gradient operator (distance conservation):



$$E3T_{CRS} = MAX(e3t)$$

Coarsening methodology:
Physical variables construction(1)

- **Temperature and salinity: weighted volume mean**

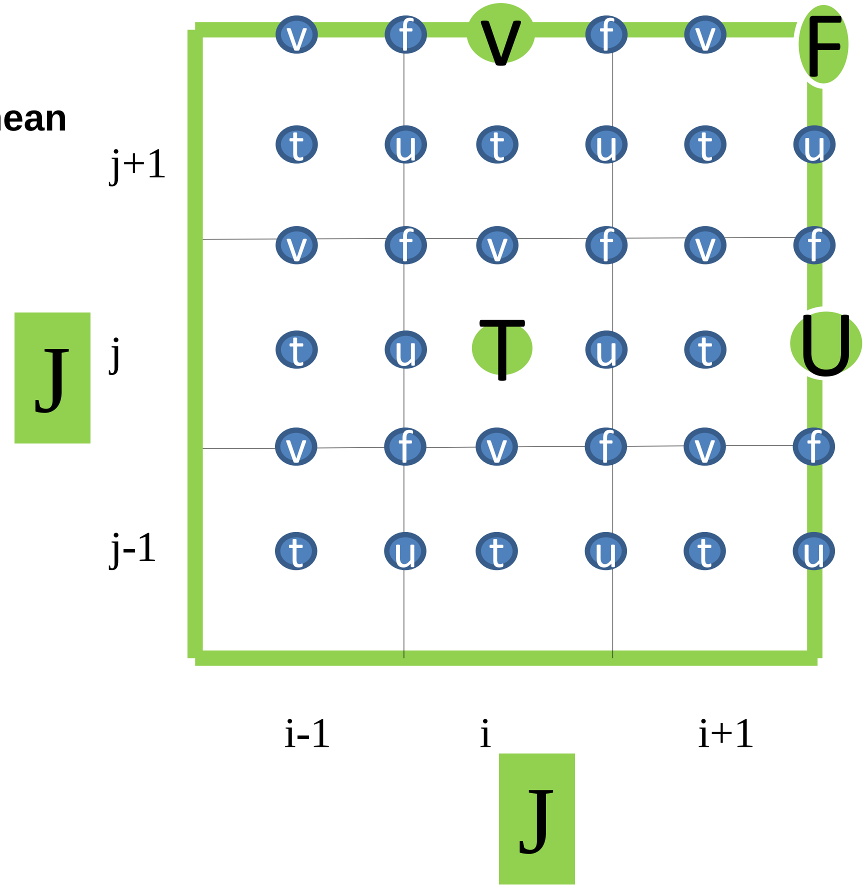
$$X_{CRS} = \frac{\sum e1t * e2t * e3t * X}{\sum e1t * e2t * e3t}$$

- **Interface fluxes: weighted area sum**

$$FU_{CRS} = \sum_{l=j-1}^{l=j+1} e2u(i+1,l) * u(i+1,l)$$

- **Surfaces fluxes: weighted area sum**

$$X_{CRS} = \sum e1t * e2t * X$$



age tracer

Passive tracer transport equation:

$$\frac{\partial X}{\partial t} + V\nabla X = D_{hor} + D_{ver} + Sources - Sink$$

Need to coarsene physical variables to run age tracer on coarsened grid:

- $V\nabla X$ **: need to coarsene fluxes at the grids interfaces**
- **D_hor: need to compute slopes and resolution dependent diffusion parameter on the coarsened grid for isopycnal diffusion**
- D_ver**: need to coarsene KZ**
- **Surface boundary condition: need to coarsene EmP**

Coarsening methodology:
Physical variables construction(2)

- **Coarsening of KZ: 5 operators proposed:**

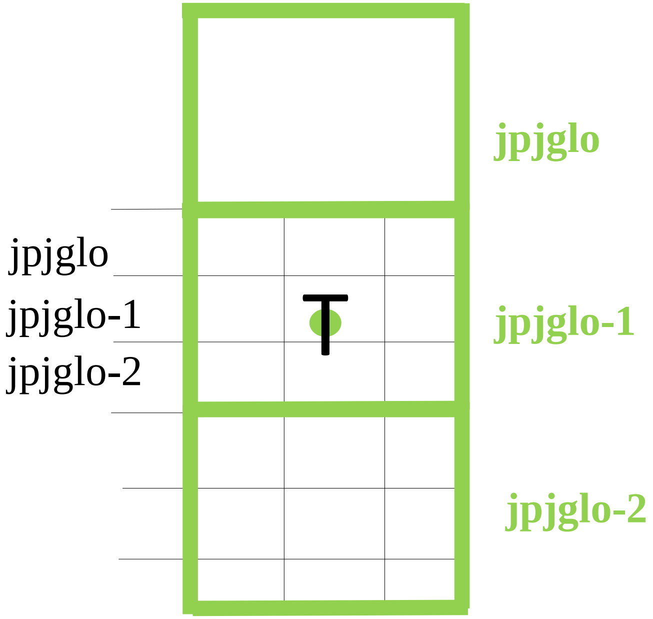
1. **KZ_CRS = MIN(KZ)**
2. **KZ_CRS = volume -weighted -mean (KZ)**
3. **KZ_CRS = MAX(KZ)**
4. **KZ_CRS = 10**(volume-weighted-mean (LOG(KZ)))**
5. **KZ_CRS = MEDIANE(KZ)**

Actual limitation of the method

Why using a factor of 3 ?
Technichal reasons

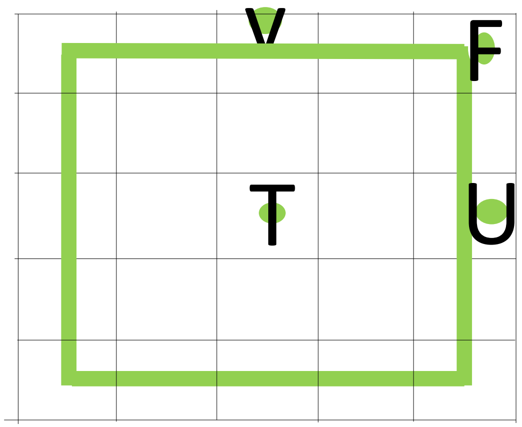
Global grids:

Pivots of mother and grand-mother grids should be superimposed



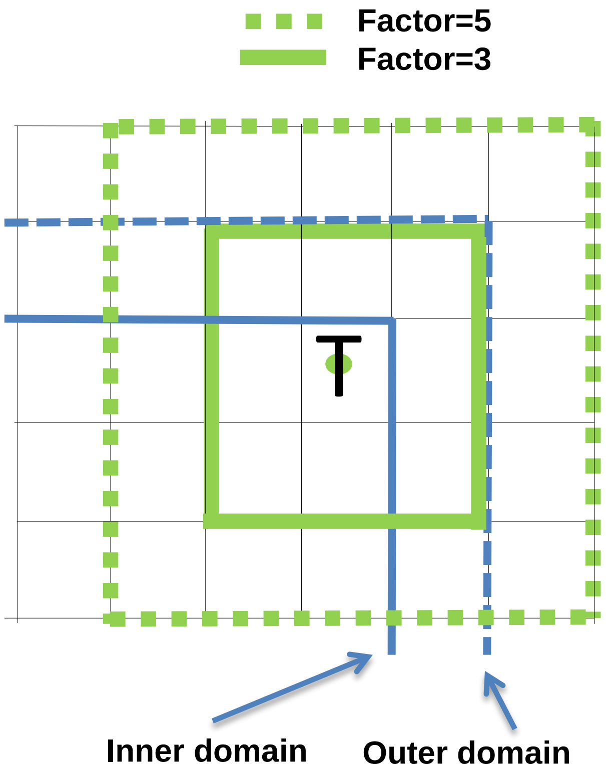
Pair factors

Need to take « half cells »

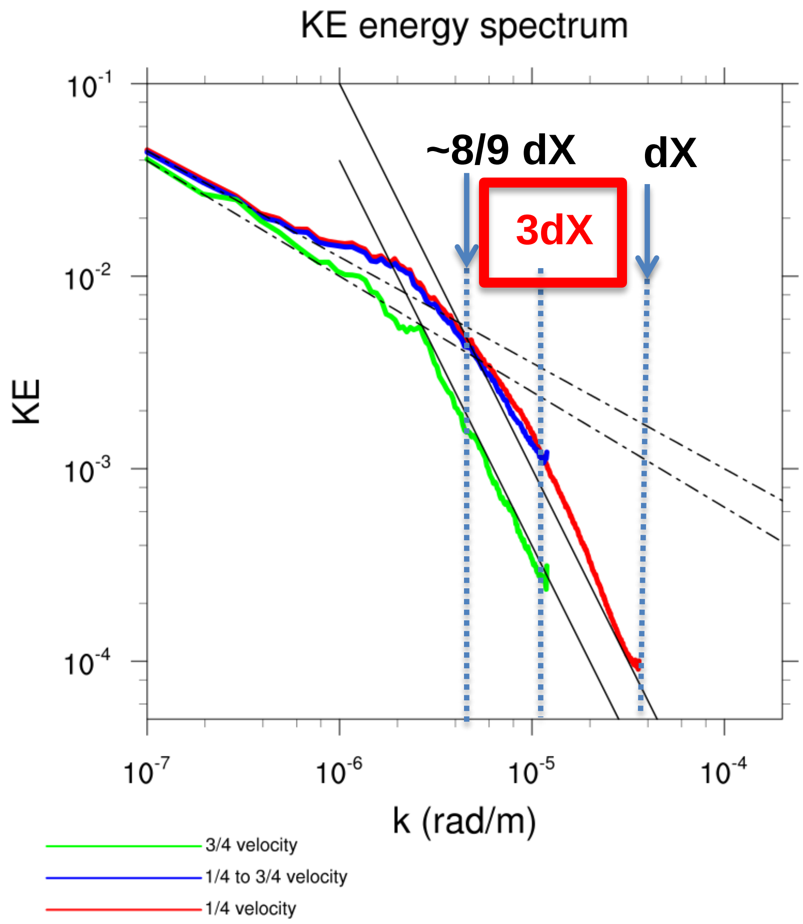


Domain decomposition:

Increase factor => increase overlapping bands



Why using a factor of 3 ?
Physical reason



- **Stay bellow effective resolution**