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Whether hydro-sediment-morphodynamic modelling is adapted for large scale and long term simulation in topography changes? (Zixiong Zhao et al)

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1 Backgrounds

- The hydro-sediment-morphodynamic modeling is pretty important for taking the advantages of high precision and accuracy. Because it takes into account the feedback between **water flow** and **sediment transport** and **topography changes**.
  - Cao et al 2004, 2007
  - Hu and Cao 2009

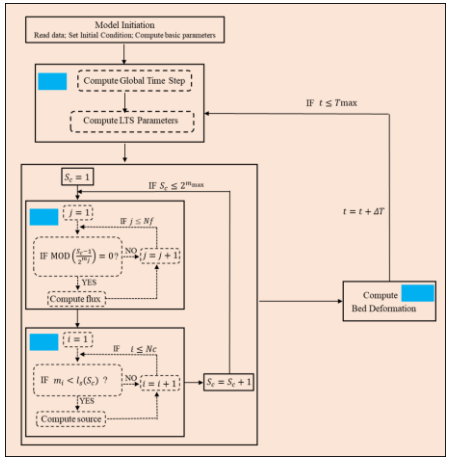
- But the poor efficiency constrain the scope of application for the model and long-term simulations in large areas are increasingly needed.

$$\Delta t_i^{CFL} = Cr\left(\frac{R_{A_i}}{\sqrt{u_{A_i}^2 + v_{A_i}^2} + \sqrt{gh_{A_i}}}\right)$$

$$\Delta t_g = \min\left(\Delta t_1^{CFL}, \Delta t_2^{CFL}, \ldots, \Delta t_{Nc}^{CFL}\right)$$

- In recent decades, computational hydraulics and sediment modelling have a great development due to compute technology.

2 Hydro-morphodynamic model



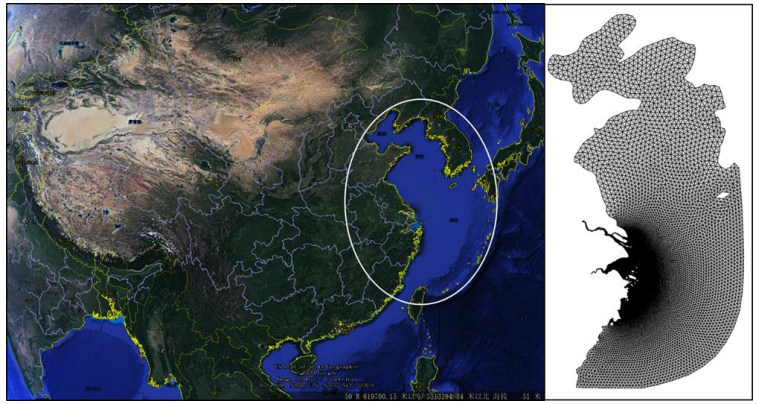
- ✓ Local Time Step (Algorithm)

For each subroutine:

- ✓ OPEN MP (CPU parallel)
- ✓ MPI (CPU parallel)
- ✓ CUDA Fortran (GPU parallel)

3 Results

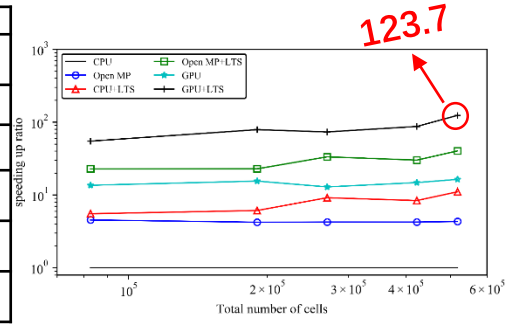
The model is employed to simulate the entire Chinese waters' topography change. We used different meshes to analysis its efficiency with certain technology.



- Large scale simulated possibility analysis

Simulation Area =124E4 km^2 Simulated Time =1 day

Number of Cells	Computational cost (seconds)				
	CPU	Open MP	Open MP + LTS	GPU	GPU +LTS
82717	5688.4	1252.6	249.6	418.4	103.7
190308	10538.7	2493.0	461.2	679.3	133.8
269945	42080.6	9894.2	1260.2	3262.2	573.9
422853	63127.4	14852.6	2097.2	4266.1	724.2
518175	102645.3	23717.7	2549.8	6267.1	829.4



- Long term simulated possibility analysis

Number of Cells = 82717

Simulated time	Computational cost				
	CPU	Open MP	Open MP + LTS	GPU	GPU +LTS
1 day	94.8 (mins)	20.9 (mins)	4.2 (mins)	7.0 (mins)	1.7 (mins)
1 month*	2844.0 (mins)	627.0(mins)	126.0 (mins)	210.0 (mins)	51.0 (mins)
1 month	-	-	121.5 (mins)	226.4 (mins)	58.2 (mins)
1 year*	24.0 (day)	5.2 (day)	1 (day)	1.9 (day)	0.5 (day)

*: speculated time

- Conclusion 1 :With the help of GPU parallel technology and LTS, the performance of model has two orders of magnitude times improvement with respect to CPU, when applied to field case, breaking the limit of simulating large scale in morphodynamic model.
- Conclusion 2: The result that a year simulation can be finished within half day shows that long term simulation (50-100 year) is possible using the present model.

Hence, it is possible for the hydro-sediment-morphodynamic model to simulate topography changes in large scale area and long term, when combining GPU parallel technology and LTS.