HIDROMOD

MOHID meeting 7-8 of June, 2018 Lisbon

MOHID - Domain Decomposition Parallelization

Best practices

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Overview

- MOHID – parallelization history
- When to use each of the parallelization options?
- Domain Decomposition:
  - Performance
  - Best practices
  - Limitations
  - Implementation
  - Options
  - Output
- Conclusions

MOHID parallelization history

- **One model one thread**: Each model domain could be run in different threads
  - Functionality implemented in MPI
- **Parallel do loops**: The do loops more computational demanding are run in N threads
  - Functionality implemented in OpenMP
- **Domain decomposition**: Each model is run in N threads using a domain decomposition approach
  - Functionality implemented in MPI

When to use each of the parellization options?

One model one thread: To be efficient models must have a similar computational effort (big limitation). Straightforward way to compute this effort = columns * lines * layers / dt

Parallel do loops: Good option when you are limited to one node in a cluster (or computer)

Domain decomposition: Good option when you want to use more than one node in a cluster (distributed hardware)

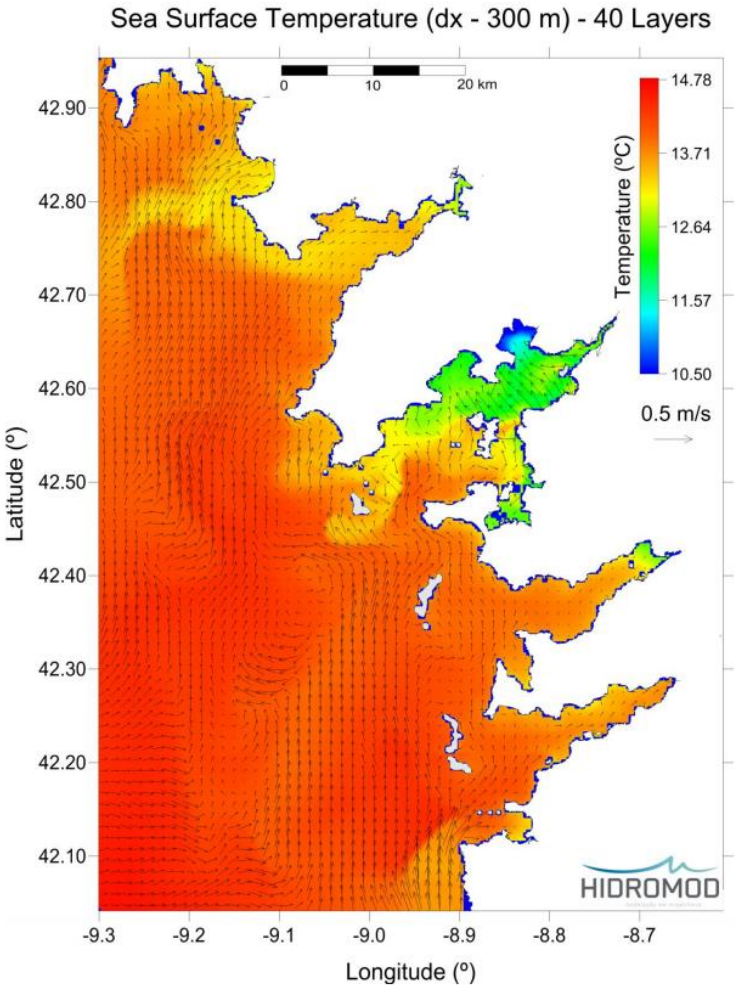
Domain decomposition – Performance

meteogalicia

https://www.researchgate.net/publication/309619365_MOHID_implementation_in_parallel_mode_following_a_domain_decomposition_approach_to_the_Rias_Baixas_area

Domain decomposition – Performance

232 columns X 305 lines X 40 layers



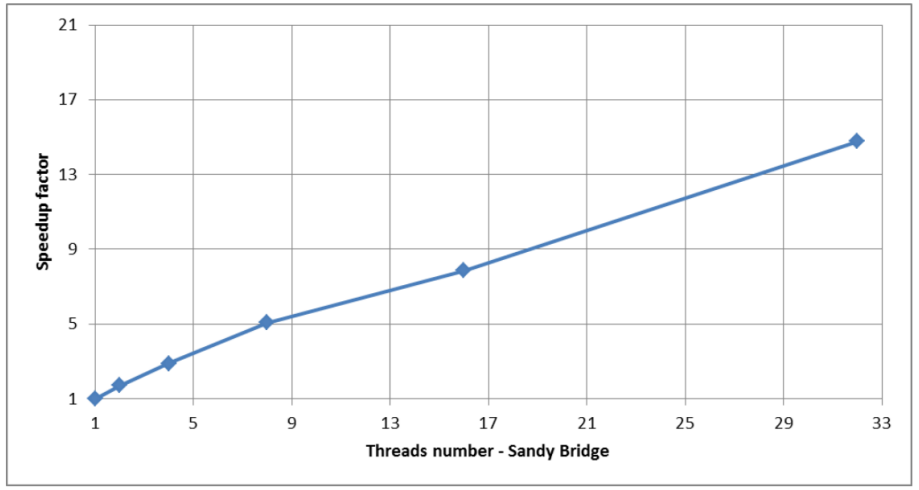


Figure 2 – Speedup factor of MOHID Rias Baixas implementation in the CESGA-SVG Sandy Bridge nodes architecture.

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Domain decomposition – Performance

- 20.000 x 400 x 10 = 80 millions cells (e.g. CMEMS IBI ~47 millions cells)
- Baroclinic 3D with k-e model for turb.
- Flat bottom
- No land points
- No 3D reference solution
- No transient results only final results
- ~60 Gb RAM

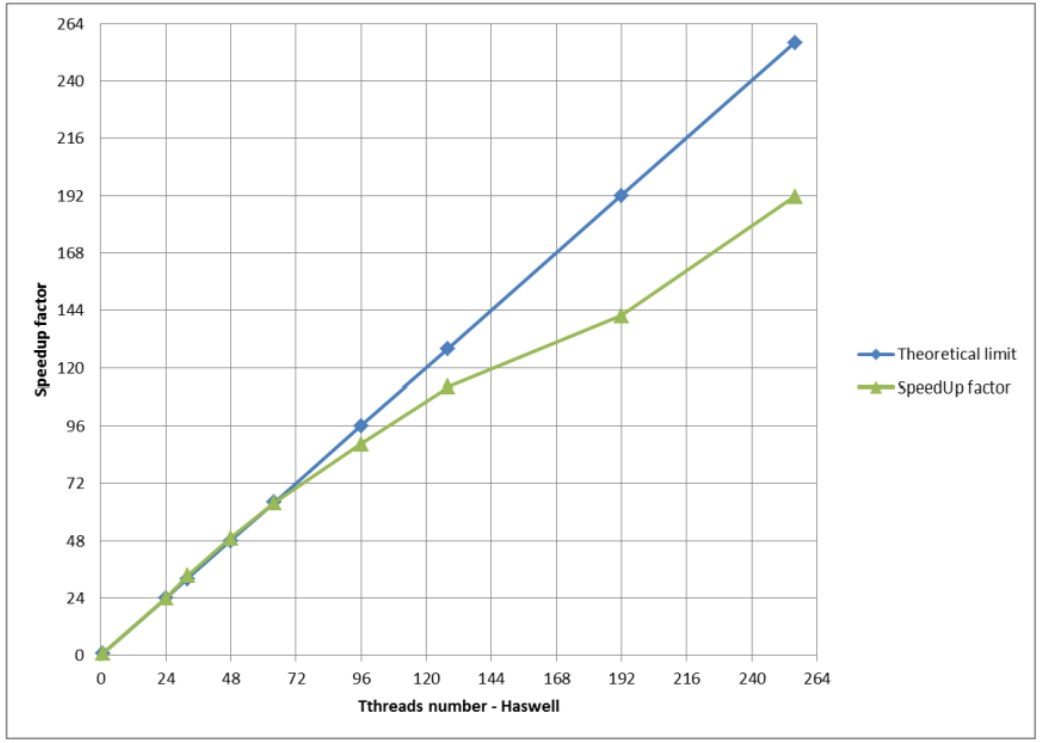


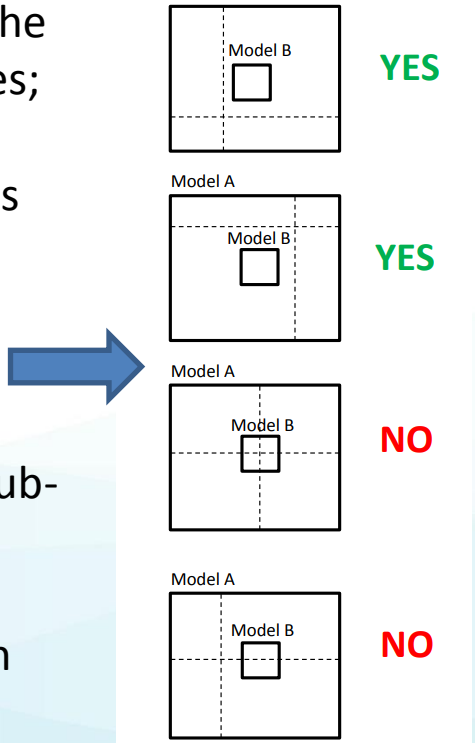
Figure 6 - Speedup factor of MOHID schematic 80 million computational cells implementation in the CESGA-SVG Haswell nodes architecture.

Domain decomposition – Best practices

- 1 thread > 50.000 computational cells;
- Avoid complex nesting trees. Best performance with no nesting. HIDROMOD breakdown online nesting trees in offline nested trees using high frequency window outputs;
- Avoid doing a nesting in a model domain where you want to use domain decomposition. Do offline nesting;
- In complex 3D implementations with large grids (e.g. BioPCOMS with dx~2km) first run a small window with no parallelization for the deepest area;
- Do not interpolate in pre-processing initial and boundary reference solutions. Let MOHID do in run time all the interpolations;

Domain decomposition – Limitations

- Need to add by hand the keyword IGNORE_ON : 1 in the time series location file and discharges_x.dat input files;
- If the outputs file size is very large the merging process can take time;
- Avoid doing domain decomposition in a father model because of the follow limitations:
    1. A nested model can only be located in a father sub-domain;
    2. If the user chooses the automatic decomposition option for the “father” model all nested models need to be located in the father sub-domain to be allocated in last (e.g. for a domain with more lines than columns will be the upper sub-domain).



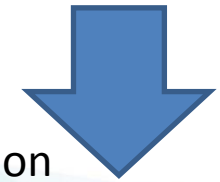
Domain decomposition – Implementation

meteogalicia

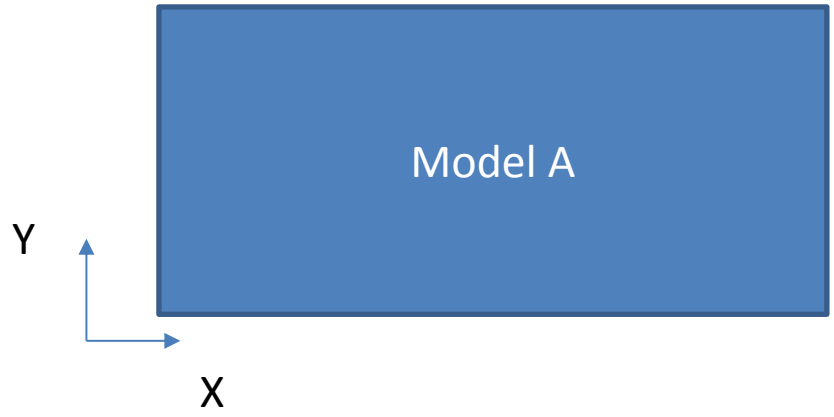
https://www.researchgate.net/publication/309487581_MOHID_parallelization_upgrade_following_a_domain_decomposition_approach

Domain decomposition – Implementation

One thread



Domain decomposition



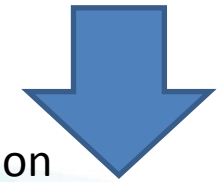
Model A1	**Model A2**	**Model A3**
Model A4	**Model A5**	**Model A6**
Model A7	**Model A8**	**Model A9**

e.g. 9 threads

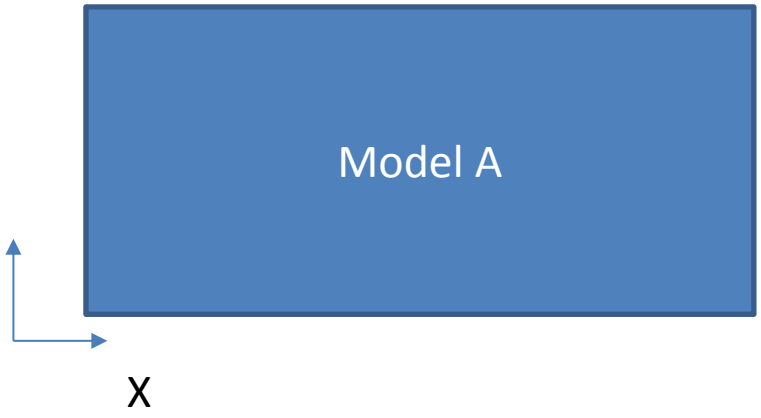
Model A is breakdown automatically in 9 independent models

Domain decomposition – Options

One thread



Domain decomposition



e.g. 9 threads

Model A1	Model A2	Model A3
Model A4	Model A5	Model A6
Model A7	Model A8	Model A9

Model A is breakdown automatically in 9 independent models

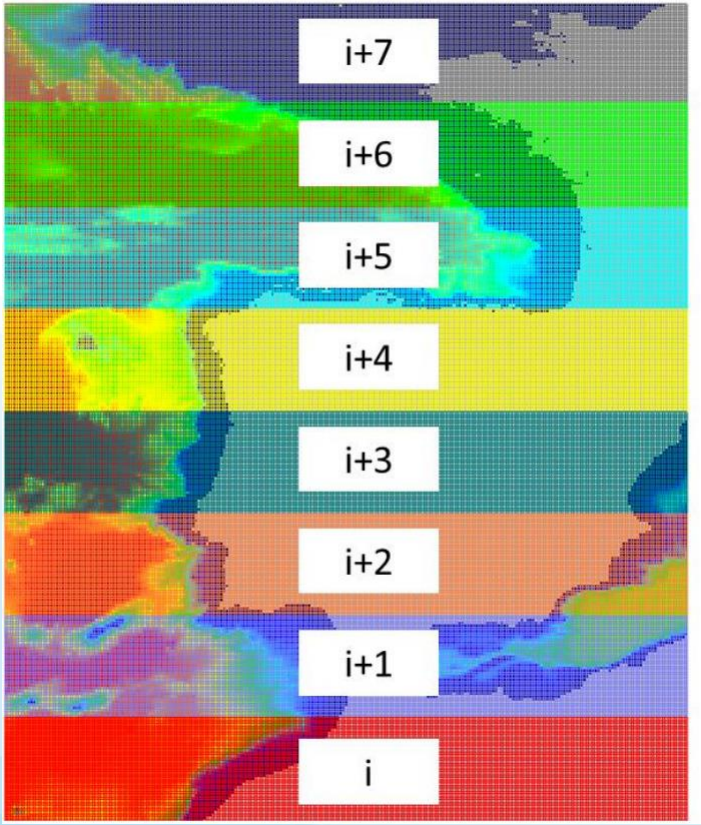
Tree.dat

```
Automatic Generated Tree File
by MOHID GUI LF
+../exe : 9 LF
```

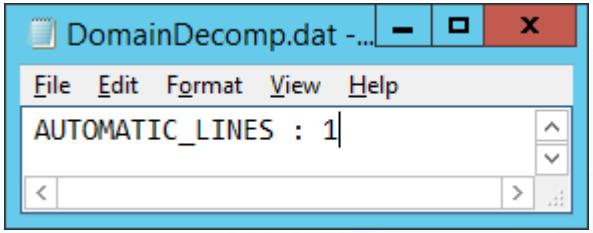
Only mandatory option

Domain decomposition – Gourmet options

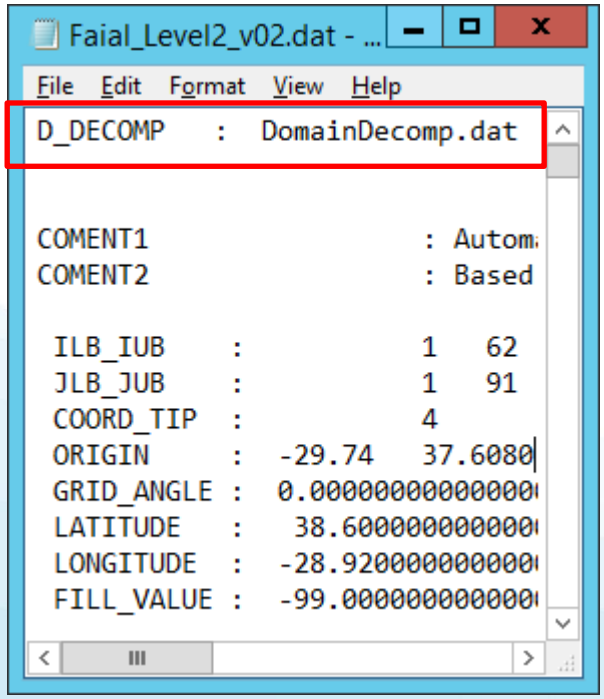
By default the sub-domains mapping is done automatically



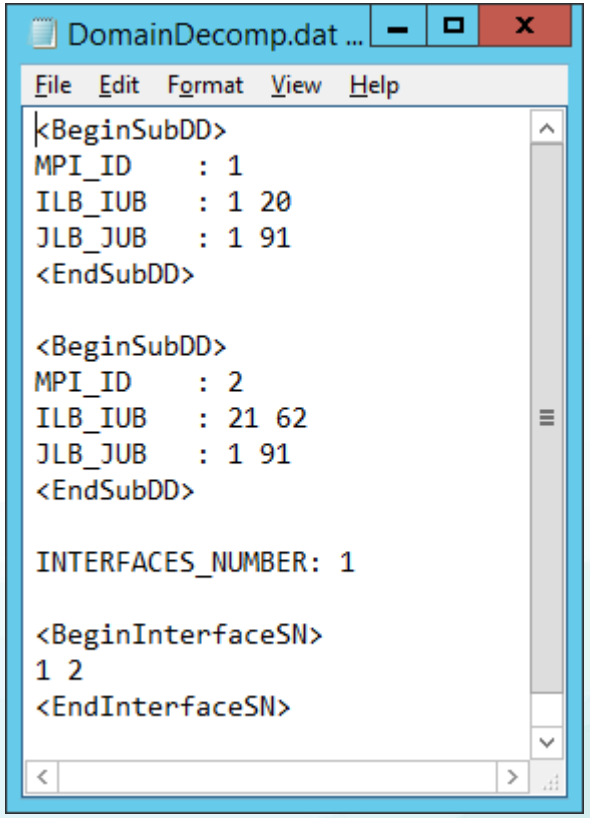
If lines > columns



Domain decomposition – Gourmet options



Sub-domains mapping by hand



Domain decomposition – Run/Output

Tree.dat - Notepad

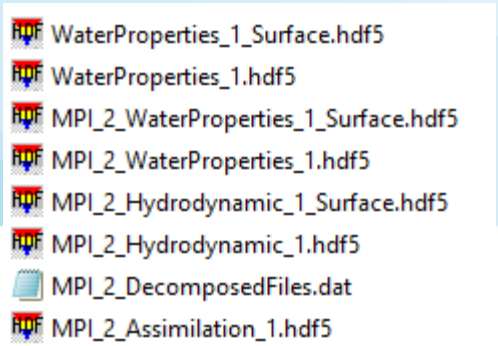
File Edit Format View Help

```
Automatic Generated Tree File
by MOHID GUI
+..\exe
++..\MadeiraLevel2\exe
+++..\MadeiraLevel2\MadeiraLevel3\exe : 10
```

run.bat - Notepad

File Edit Format View Help

```
copy ..\data\nomfich_1.dat ..\exe\nomfich.dat
copy ..\MadeiraLevel2\data\nomfich_1.dat ..\MadeiraLevel2\exe\nomfich.dat
copy ..\MadeiraLevel2\MadeiraLevel3\data\nomfich_1.dat ..\MadeiraLevel2\MadeiraLevel3\exe\nomfich.dat
mpiexec -np  12 MohidWater_mpi > display1.txt
DomainConsolidation.exe
```



MPI_2_DecomposedFiles.dat -...

File Edit Format View Help

```
MPI_2_Hydrodynamic_1.hdf5
MPI_2_Hydrodynamic_1_Surface.hdf5
MPI_2_Assimilation_1.hdf5
MPI_2_WaterProperties_1.hdf5
MPI_2_WaterProperties_1_Surface.hdf5
```

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Conclusions

- Domain decomposition parallelization is used by default in HIDROMOD consultancy work (> 20 projects) and forecast services (6 implementations) when 1 thread > 50.000 computational cells;

- MOHID code structure was build focus in the integration hydro and biogeochemical processes. The main consequence of this approach was turning MOHID in a slow model (Delft3D for 3D baroclinic hydrodynamic implementations is ~3 times faster with the same space-time discretization);

- Domain decomposition was implemented in MOHID by 1 MM. Do not solve all the MOHID computational efficiency problems but was an efficient way of minimize them;

- HIDROMD have tested the domain decomposition option in windows PC's (servers and laptops) and several hardware configurations available via CESGA using Linux operating system. There is the need to test it in other cluster flavours.

OBRIGADO!

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