Digital Ocean Forum

DTO: HPC challenges

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DTO models' challenges

- **HPC main challenge: Take Earth System models to unprecedented resolution(s).**

- **Increase in grid resolution**
  - **Model computational demands**
    - Increase in **workload**: requires additional **capacity** → ORCA36 = 25k x ORCA1
    - Increase in **memory**: requires additional **resources** → ORCA36 = 1k x ORCA1
  - **Model output demands**
    - Increase in **memory**: due to memory buffers, aggregations, etc.
    - Increase in **storage** (and network) footprint → ORCA36: each 3D hourly variable = 560TB per SY

- **Integrate different paradigms (hybridization)**
  - **Different needs, different models**
 - **Different models, different hardware**
  - **Complexity !**

Computational demands: main issues

- We need more resources...

    ... but also to improve the efficiency in the exploitation of those resources

- Cannot scale by simply adding more processing elements
    - Code scalability
        - Bottlenecks, coupling, etc
    - Network capacity (latency, bandwith...)
    - Higher chances of failure
- Using accelerators
    - Dependencies
    - Portability
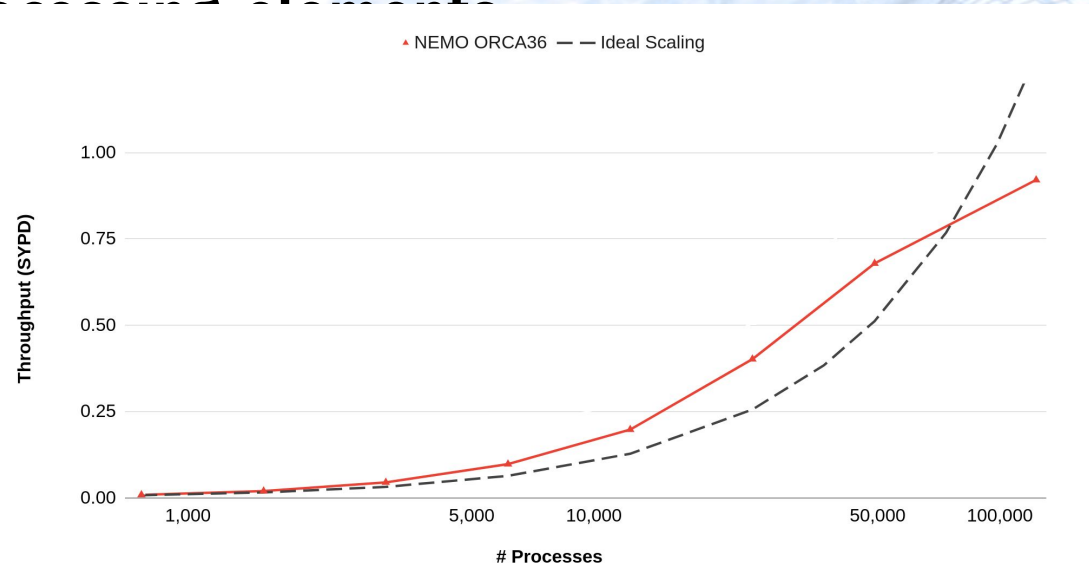
HPC efficiency
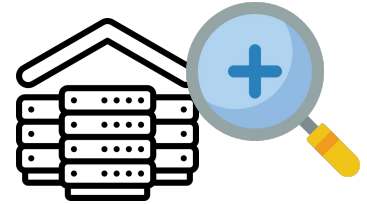
- **Computational scaling**
  - **CPU freq., IPC (Instructions per cycle), number of instructions**
    - Depends on degree of vectorization, memory usage, duplication of computations...

- **Parallel efficiency**
  - **Imbalance, serialization, transfer time**
    - Depends on workload balance, dependencies, number of messages...
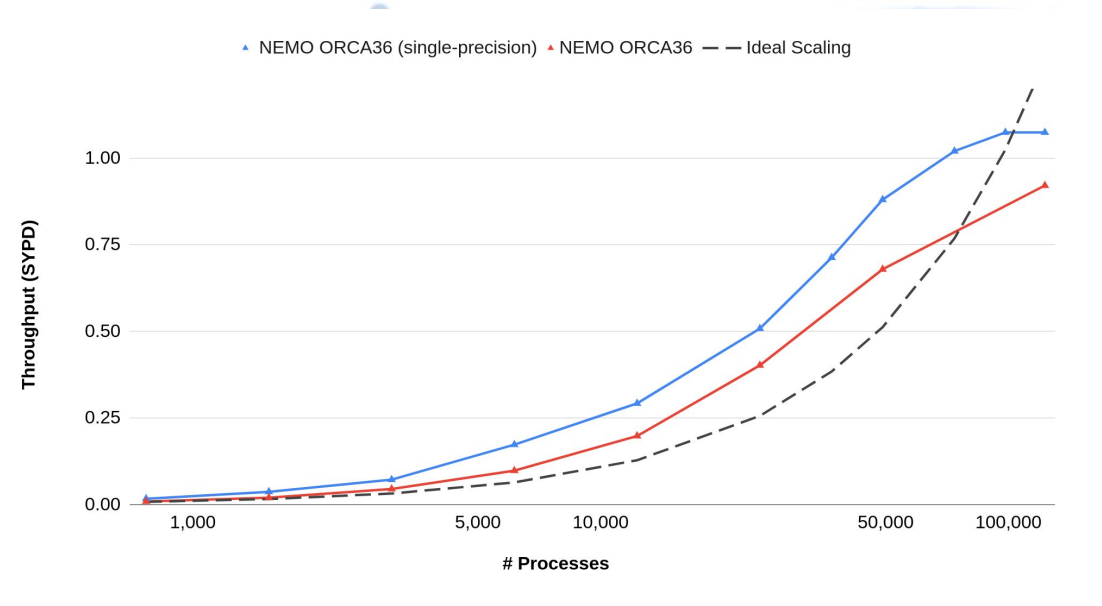
- **I/O efficiency**
  - **IOPs (input/output operations per second), write latency, write throughput...**
    - I/O parallelization level, stripe size...

Dealing with the issues

- **Reduce computational workload**
  - **Coarsening (process or space domain)**
  - **Reduced precision**
  - **Alternative algorithms (incl. ML)**

- **Improve computational speed**
  - **Increase memory exploitation**
  - **Increase parallelization (hybrid)**
  - **Offloading**

- **Dealing with high I/O needs**
  - **Reduced precision**
  - **Compression**

- **Dealing with complexity (no easy fix)**
  - **Performance analysis**
  - **Workflow/data-flow managers, schedulers, middleware, DSLs, programming models...**

Complexity

Complexity

NEMO ORCA36 (single-precision) ▴ NEMO ORCA36 — — Ideal Scaling

Throughput (SYPD)

1.00
0.75
0.50
0.25
0.00

1,000   5,000   10,000   50,000   100,000

Processes

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Thank you!

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