

Dear Anonymous Referee #2,

We are extremely grateful for your valuable and fruitful comments that helped improve our manuscript. The referee's comments have been presented in blue, and our responses have been provided in black.

### General Comments

1. English is correct, but I would suggest reviewing all the document to get some word redundancies removed (this will improve general readability), like in P3 119-20 for the word “computing”: “Cloud computing is a computing resource utilization method in which IT infrastructure resources are provided through the internet, with fees paid according to computing amount and time of usage.

Answer:

Thank you for your comment. We removed the word redundancies in the manuscript to improve general readability. The English language in the revised manuscript has been corrected by native speakers.

2. I think a cost comparison can add more information and value to the paper. On P5 128 it is said: “We were able to simulate ROMS for 30 days using eight nodes (c4.8xlarge) for only approximately US\$13.”, please elaborate this more and compare it with your in-house system (maybe a table could be interesting).

Answer:

Thank you. We estimated and compared the cloud computing instance cost and local cluster according to your suggestion (Table R1).

Total price of local cluster (Intel Xeon E5-2967 v3, 28Core, 128GB, 750W) with infiniband switch (40G) was \$98,000 in 2015. Assuming that the life span of the local cluster is 3 years, the cluster price per hour would be about \$4.3 based on H/W Price, Korean electric charges (KEPCO, 2013). In the cloud cluster, expected cost would be from \$3.8 to \$12.8 according to service plan (AWS, 2017). The spot-instance type for \$3.8 is more economical.

*Change in the revised manuscript:*

We added Table R1 in the Supplementary section.

The text for the revised manuscript is as follows:

'We were able to perform ROMS for 30 days of simulation using eight nodes (c4.8xlarge) for \$12.8'.

The following table was also included added in the revised manuscript:

Table R1. Cost comparison of AWS HPC and local HPC cluster for ROMS modeling

Modeling Environment	AWS HPC cluster	Local HPC cluster
Model S/W	ROMS v.3.6	ROMS v.3.6
Grid Size	422×412×40	422×412×40
Nodes	8 Nodes (Physical:18Core×8)	3 Nodes (Physical:28Core×3)
Execution Time (For 30 days of simulation)	30 ~ 35 min	40 min
Expected Cost (Spot Instance Type)	\$3.8 (\$0.47 × 8 Node)	Not applicable
Expected Cost (On-demand Type)	\$12.8 (\$1.58 × 8 Node)	Not applicable
Expected Cost (Pre-payment Type (3 Years))	\$5.0 (\$0.62 × 8 Node)	\$4.3
Expected Cost (Pre-payment Type (5 Years))	Not applicable	\$3.3

3. Was there any kind of data validation of the outputs from AWS vs local HPC cluster? If so, could you please add them to the paper?

Answer:

Thank you for your comment. We calculated the root mean square error (RMSE) for data validation of the outputs from the AWS vs. local HPC cluster.

*Change in the revised manuscript:*

We added the following table showing the RMSEs of the temperature and the velocities between the AWS and local HPC clusters:

Table R2. RMSE of the temperature and the velocities between AWS and HPC according to the number of cores using ROMS v 3.6 (revision 783)

Cores	Temp	U m/s	V m/s
16 core	0.0057	4.7613e-004	5.0426e-004
32 core	0.0097	4.9277e-004	4.8897e-004
64 core	0.0108	5.5478e-004	5.3697e-004

Table R3. RMSE of the temperature and the velocities between AWS and HPC according to the number of cores using ROMS v.3.7 (revision 898)

Cores	Temp	U m/s	V m/s
16 core	0.0112	5.2358e-004	5.7382e-004
32 core	0.0086	5.0863e-004	5.7747e-004
64 core	0.0098	5.7419e-004	5.9089e-004

4. I suggest adding a section on the paper about pros and cons of running ROMS on the cloud vs running it locally.

Answer:

Thank you for your suggestion. Running numerical ocean modelling in the cloud and local clusters has some pros and cons. We have summarised these pros and cons in Table R4.

*Change in the revised manuscript:*

We included the following table and description in the revised manuscript:

Table R4. Comparison of the pros and cons of running numerical ocean modelling in the cloud and local clusters

	Cloud cluster	Local cluster
Accessibility	Easy to access using broad N/W (e.g. internet)	Local network-based access (sometimes remotely)
Resource usability	On-demand, spot, reserved instance	Depends on resource scheduling
Total cost	Relatively low cost (pay per use)	Relatively high cost because of overhead (management, space, technician, etc.)
Management	Online resource management (online control-dash board, self-service)	Offline resource management required(space, cost, human, trouble, etc.)
Customizing	Relatively hard to change environment Usable only based on the supported item	Relatively easy to change the local environment
Security	Relatively less secure because of remoted space and open network	More secure in local space and closed network

Technical support	Relatively slow because of online support	Relatively quick and easy from engineer support
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5. Can you please indicate if ROMS is more CPU or memory or network intensive/ bound? Can you please relate this to the type of infrastructure and its impact on any possible bottlenecks?

Answer:

Thank you. We think that ROMS is a more CPU-intensive model rather than N/W intensive. We used the c4.8xlarge instance, which had a similar-performance CPU, using 10G ethernet configuration instead of the infiniband (40G) of the general HPC. Despite the relatively lower performance of the N/W condition, the performance of the ROMS simulation was similar, suggesting that the ROMS is relatively less insensitive to the network.

6. Can this work be reproduced with other versions of ROMS? If so, please indicate it.

Answer:

Thank you for your comment. We tested the running time with other versions of ROMS (version 3.7) according to your suggestion. The running time with the number of cores showed a similar result. The RMSE was also similar (Table R3).

*Change in the revised manuscript:*

We added Table R3 in the revised manuscript.

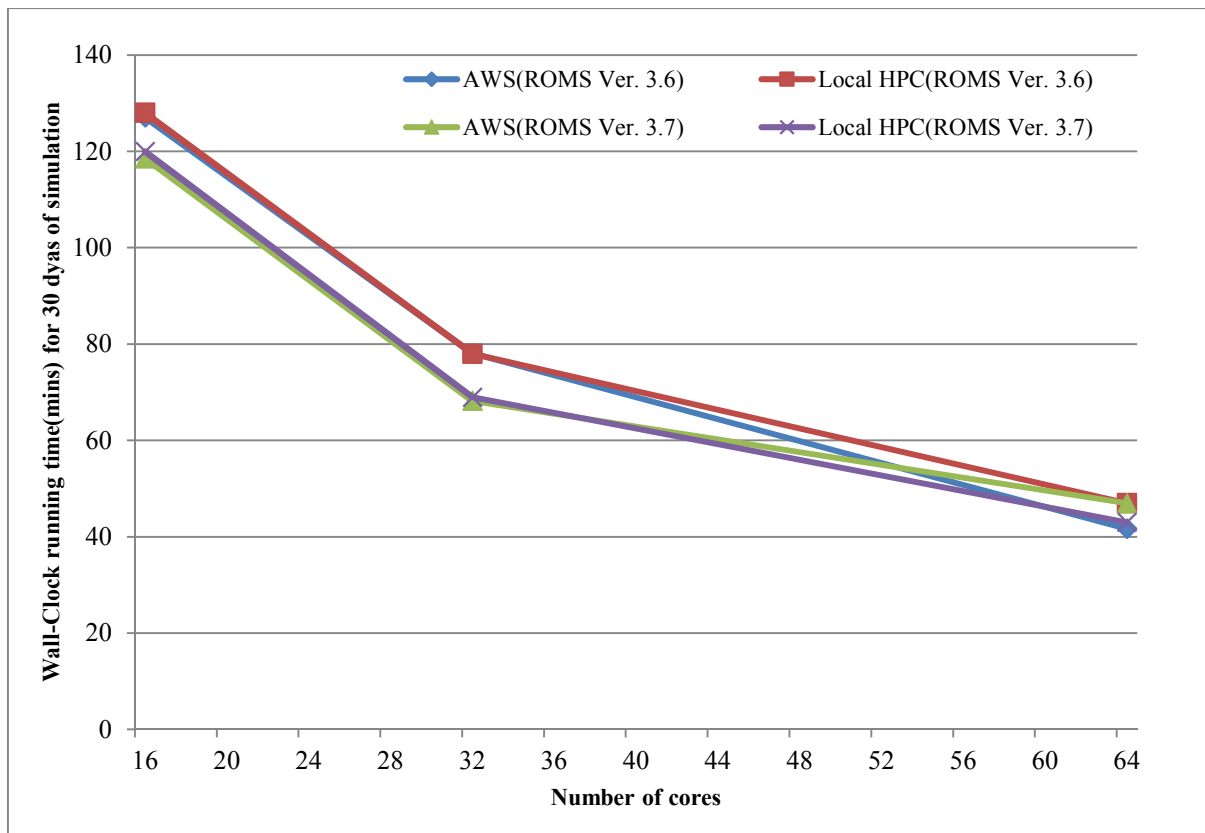


Figure R1. Comparison of the wall-clock running time for 30 days of simulation according to the cores and

ROMS versions

### Specific comments

1. P3, 119: “Cloud computing provides virtual computer resources in resource pools through the internet with rental fees flexibly charged by usage time and resources.”. This is not exact, it is true that Cloud is usually accessed via the Internet, I suggest a more formal definition like “. . . through Broad Network access (like the Internet) . . . ” (e.g. “The NIST Definition of Cloud Computing”, <http://nvlpubs.nist.gov/nistpubs/Legacy/SP/nistspecialpublication800-145.pdf> ).  
P4, 118: It should be: “Cloud computing provides virtual computing resources...”

Answer:

Thank you. We corrected this point according to your suggestion.

*Change in the revised manuscript:*

'Cloud computing provides configurable computer resources (e.g. networks, servers, storage, applications, and services) in pools with functions of self-service provisioning and automatic metering of usage and rapid provisioning and users can access through Broad Network access (like the internet).'

2. P4, 123: I think mentioning Google on this list of public providers. Also, I recommend making a reference, for instance, to Gartner’s magic quadrant for cloud infrastructure providers for 2017.

Answer:

Thank you. We agree that Google is one of the numerous public cloud providers.

*Change in the revised manuscript:*

We have included a reference about the cloud provider list in the revised manuscript.

3. P4, 126-35: Please make a reference on how Amazon has been using Xen and relate it to this paragraph.

Answer:

Thank you. AWS configures and optimises a virtual machine with hypervisor technology like Xen. We revised and included a reference according to your suggestion.

*Change in the revised manuscript:*

'Figure 2 shows the hypervisor, a server virtualisation technology that can logically divide server resources. A physical x86 server can be logically separated and assigned as a virtual machine (VM) through the hypervisor. The virtual servers in public cloud computing are examples of the utilisation of these hypervisor technologies. The AWS servers used in this study also optimise the VMs provided through this virtualisation technology like Xen (cloudacademy, 2015). The VMs can be copied and stacked in the repository in the form of images; hence, the VMs of the same configurations can be recreated by additionally creating another copy using the VM image. These techniques provide a useful method to prepare a number of nodes necessary for large-scale numerical model experiments. This is helpful for researchers, who need to set up highly complicated environments for numerical modelling.'

4. P5, 16: You say: “The most popular public cloud computing service in the market is Amazon’s AWS”, please put a reference to refute this.

Answer:

Thank you. We revised and made a reference following your comment.

*Change in the revised manuscript:*

'One of the popular public cloud services in the market is Amazon's AWS (Gartner, 2017)'.

5. P5, l20: Please define "spot-instance".

Answer:

Thank you. Spot-instance was defined in the revised manuscript.

*Change in the revised manuscript:*

'Amazon EC2 Spot-instances are spare compute capacity in the AWS cloud, which can lower Amazon EC2 cost compared to On-demand prices'.

6. P5, l25: "... and low N/W latency". Please add values on what is understood as lower network latency.

Answer:

Thank you for your comment. We tested the network latency of AWS according to the message size.

Table R4. Latency of AWS according to the message size

Message size	1 byte	2 bytes	4 bytes	8 bytes	16 bytes	32 bytes
Latency ( $\mu$ s)	36.2	38.8	36.6	35.6	40.7	36

*Change in the revised manuscript:*

'The latency values are between 36 and 41 us when the message size is less than 32 bytes'.

7. P7, l1: Please add CPU specific model, not only in here but.

Answer:

Thank you for your comment. We added a CPU-specific model in the revised manuscript.

*Change in the revised manuscript:*

Tables R5 and R6 showing more information have been added in the revised manuscript.

Table R5. Hardware and software configuration of the AWS and laboratory test environments

Type	CPU	Memory	Node	OS	Compiler
AWS HPC	32 core (vCPU) Intel Xeon E5-2666- v3 (2.9 GHz)	60G	8	Amazon Linux	PGI Compiler 16.10 NetCDF4(4.4.1) Intel Compiler 18 update 1
Laboratory HPC	28 core Intel Xeon E5-2697-v3 (2.6 GHz)	128G	3	CentOS 6.9	PGI Compiler 16.10 NetCDF4(4.4.1) Intel Compiler 18 update 1

Table R6. CPU specification of the local and AWS clusters

	Local cluster node	AWS cluster instance (c4x8large)
Architecture	x86_64	x86_64

CPU(s)	28	36
On-line CPU(s) list	0–27	0–35
Thread(s) per core	1	2
Core(s) per socket	14	9
Socket(s)	2	2
Vendor ID	Genuine_Intel	Genuine_Intel
CPU family	6	6
Model name	Intel® Xeon® CPU E5-2697 v3 at 2.6 GHz	Intel® Xeon® CPU E5-2666 v3 at 2.9 GHz
CPU MHz	2599.843	3100.012
Hypervisor vendor:	-	Xen
L1d cache	32 K	32 K
L1i cache	32 K	32 K
L2 cache	256 K	256 K
L3 cache	35840 K	25600 K

## References

AWS: Spot-Instance, available at: [https://aws.amazon.com/ec2/spot/?nc1=h\\_ls/](https://aws.amazon.com/ec2/spot/?nc1=h_ls/) (last accessed: 03 Feb 2018), 2018.

AWS: AWS Pricing, available at: [https://aws.amazon.com/ec2/pricing/on-demand/?nc1=h\\_ls](https://aws.amazon.com/ec2/pricing/on-demand/?nc1=h_ls) (last accessed: 03 March 2017), 2017c.

Cloudacademy: Xen Hypervisor, available at: <https://cloudacademy.com/blog/aws-ami-hvm-vs-pv-paravirtual-amazon> last accessed: 05 March 2017, 2015.

Gartner: Public Cloud Service, available at: <https://www.gartner.com/newsroom/id/3808563> (last accessed: 01 March 2018), 2017.

Mell, P. and Grance, T.: The NIST definition of cloud computing recommendations of the National Institute of Standards and Technology, Special Publication 800–145, NIST, Gaithersburg, available at: <http://nvlpubs.nist.gov/nistpubs/Legacy/SP/nistspecialpublication800-145.pdf> (last accessed: 10 March 2017), 2011.

ROMS: Regional Ocean Modeling System (ROMS), available at: <https://www.myroms.org/> (last accessed: 09 May 2017), 2015.