FV3 on AWS – Successes and Challenges

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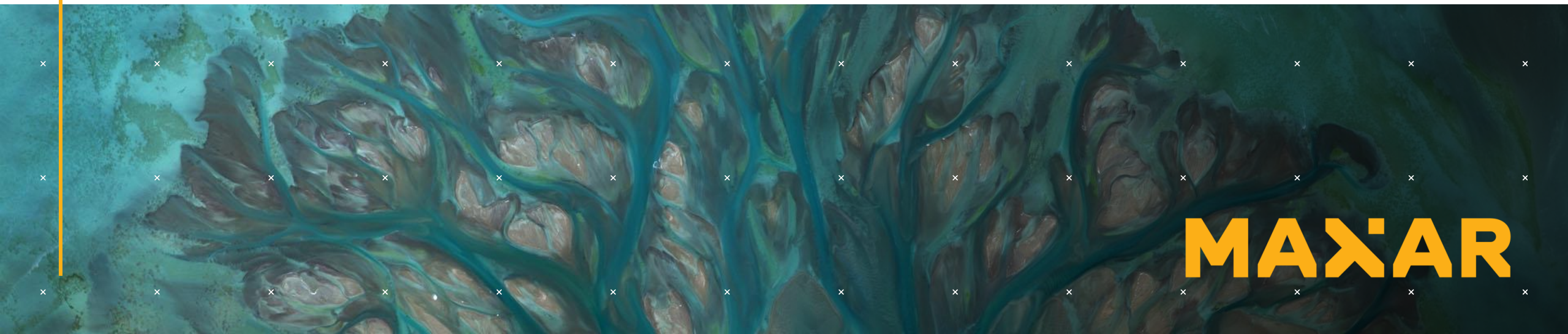
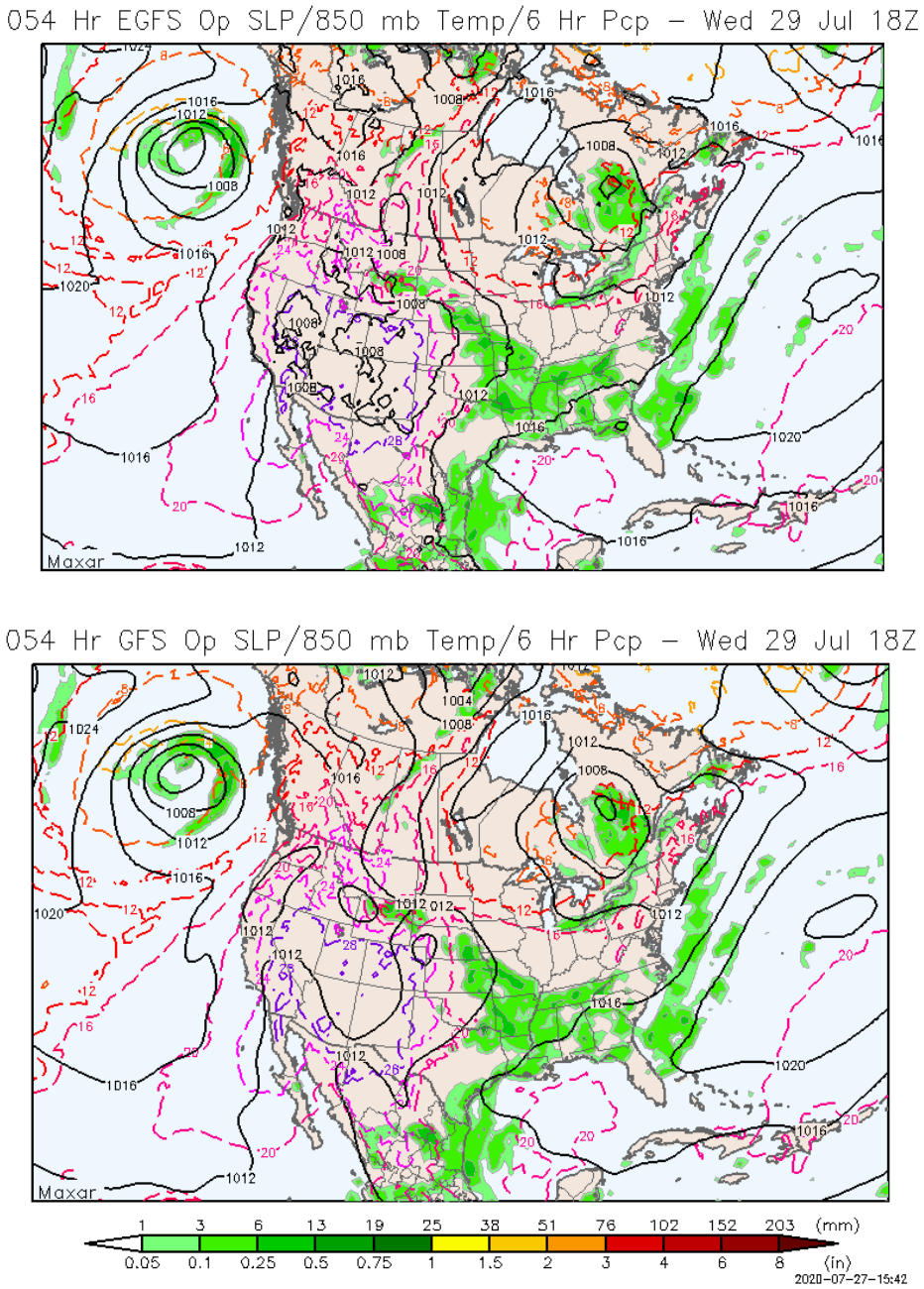


Background

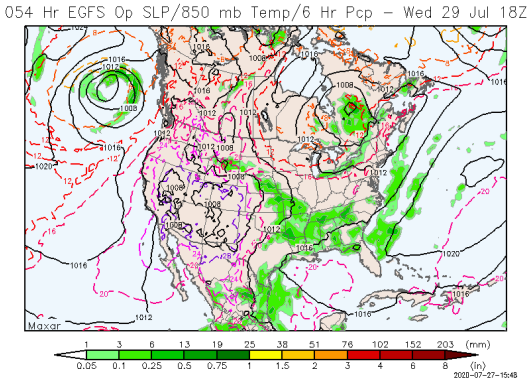
- For over a year Maxar has run, and continues to run, a numerical weather prediction (NWP) application on AWS cloud computing resources for a program called Cirrus.

- The success of the program relies on Maxar being able to run its NWP application faster than NOAA does on its supercomputer.
  - Allows Maxar to deliver the weather forecast generated by the NWP application to clients with greater lead times, guiding more informed and timely decisions.

- To achieve the required application performance, Maxar engaged with AWS to design and build a cloud computing environment as a cost-effective and scalable solution.
  - Cirrus leverages AWS EC2, ParallelCluster, EFA, FSx for Lustre and other AWS tools to build a cloud-based high-performance computing (HPC) cluster.

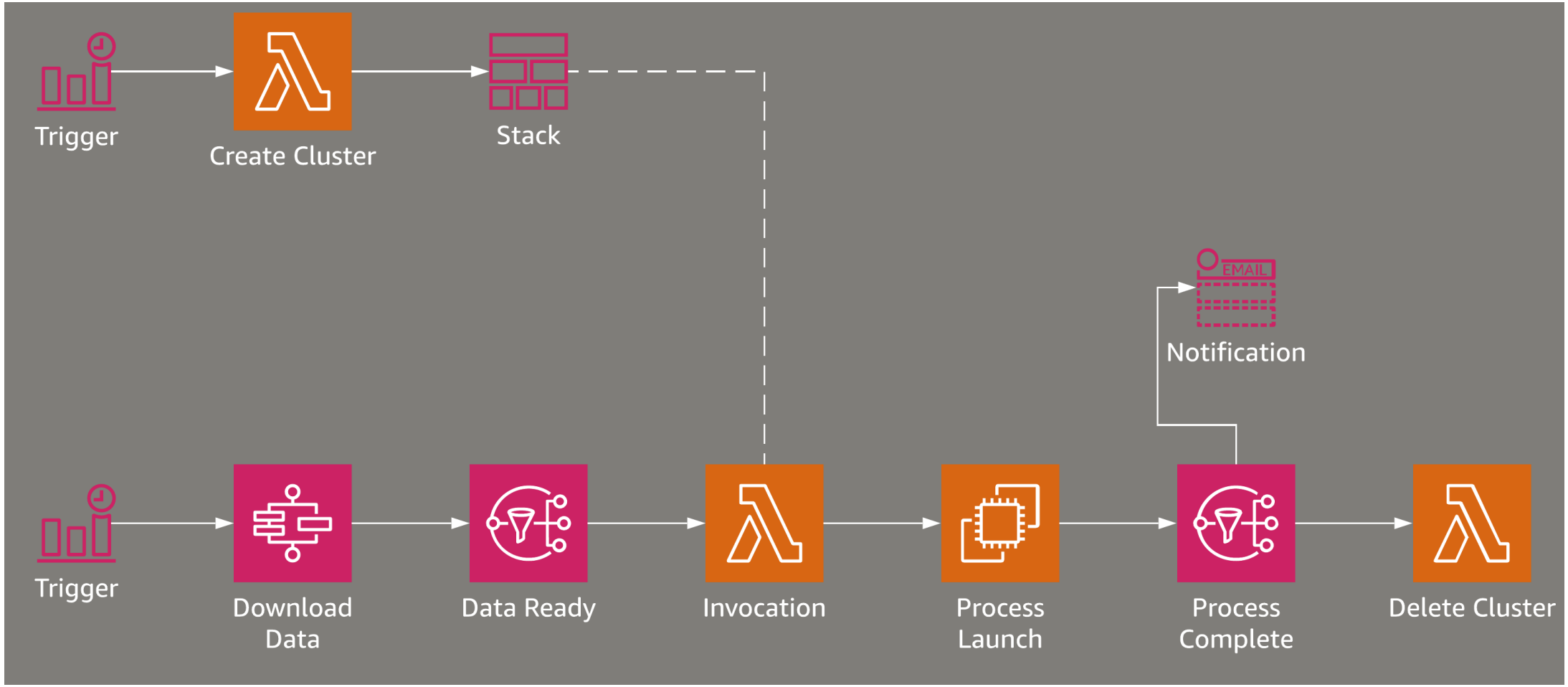


AWS FV3GFS Workflow



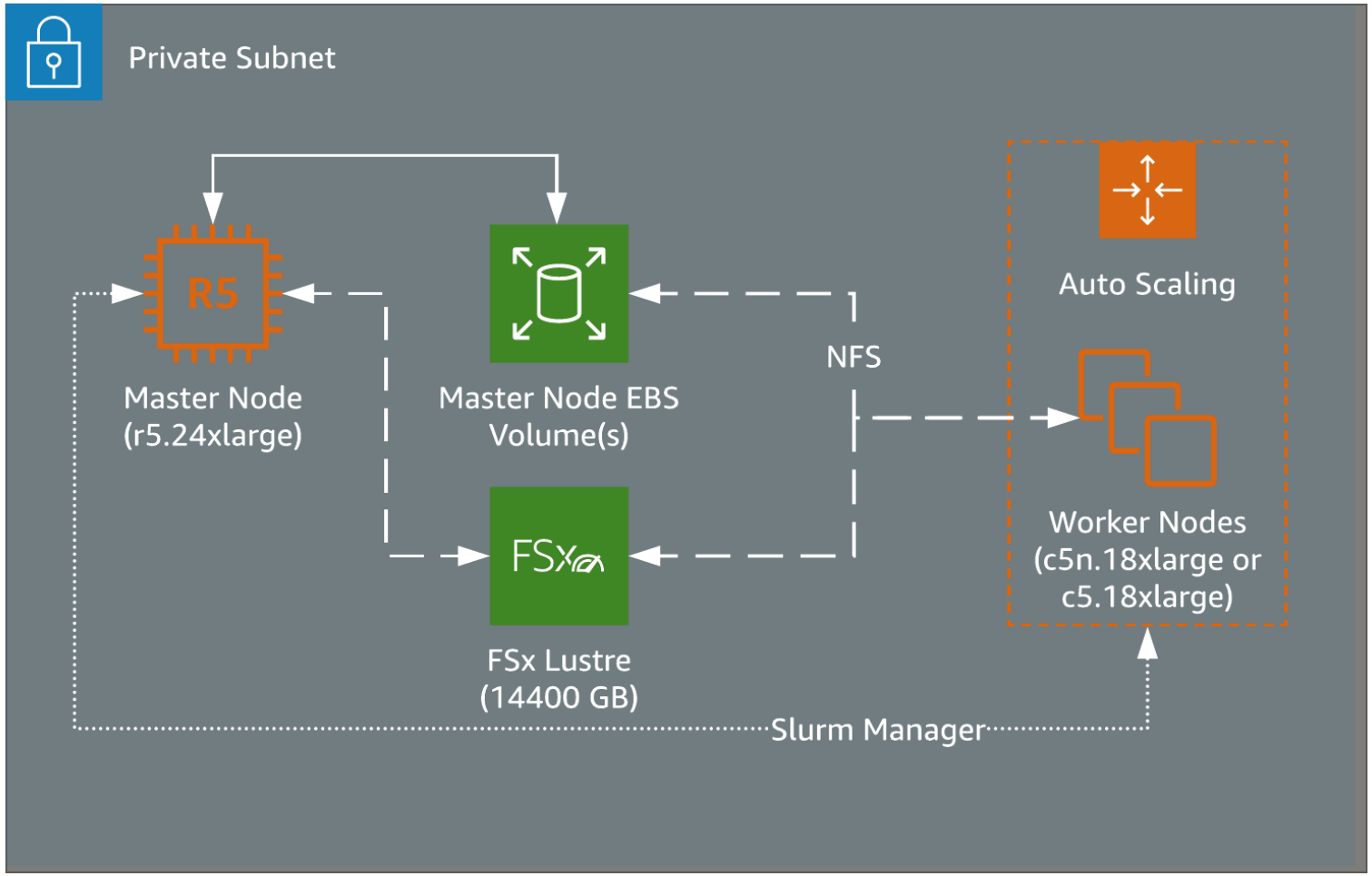
- Initial effort was to refactor NCEP/VLAB code/workflow to AWS environment
  - Recompile code, tend to any issues that compilers found (Derived types)
  - Rework the NCEP workflow to be more hardware agnostic (Directories/paths)
  - Discern model layout best suited for AWS hardware (36 cores per node)
- The entire workflow is automated from cluster spin-up to cluster spin-down
  - HPC cluster resources (EC2 instances, EBS volumes, FSx Lustre) are re-allocated each day
- Execution workflow is automated using a series of Step and Lambda functions with SNS notifications
  - CloudFormation stacks build the AWS resources for the workflow – can be deployed in any AWS region with minimal modification
  - Infrastructure updates are automatically deployed to specified regions using CodePipeline
- Workflow designed and built with AWS Professional Services

Automated FV3GFS Workflow within AWS



Maxar's AWS Cloud HPC Clusters

- Leveraging AWS ParallelCluster for cluster management
  - 2 clusters: production in us-east-1, backup in us-west-2
- Production cluster:
  - Master Node: r5.24xlarge
  - Worker Nodes: 156x c5n.18xlarge within an ASG
  - File System: 14400 GB AWS FSx Lustre (12 object storage targets [OSTs])
  - Network: AWS Elastic Fabric Adapter (EFA) with max bandwidth of 100 Gbps

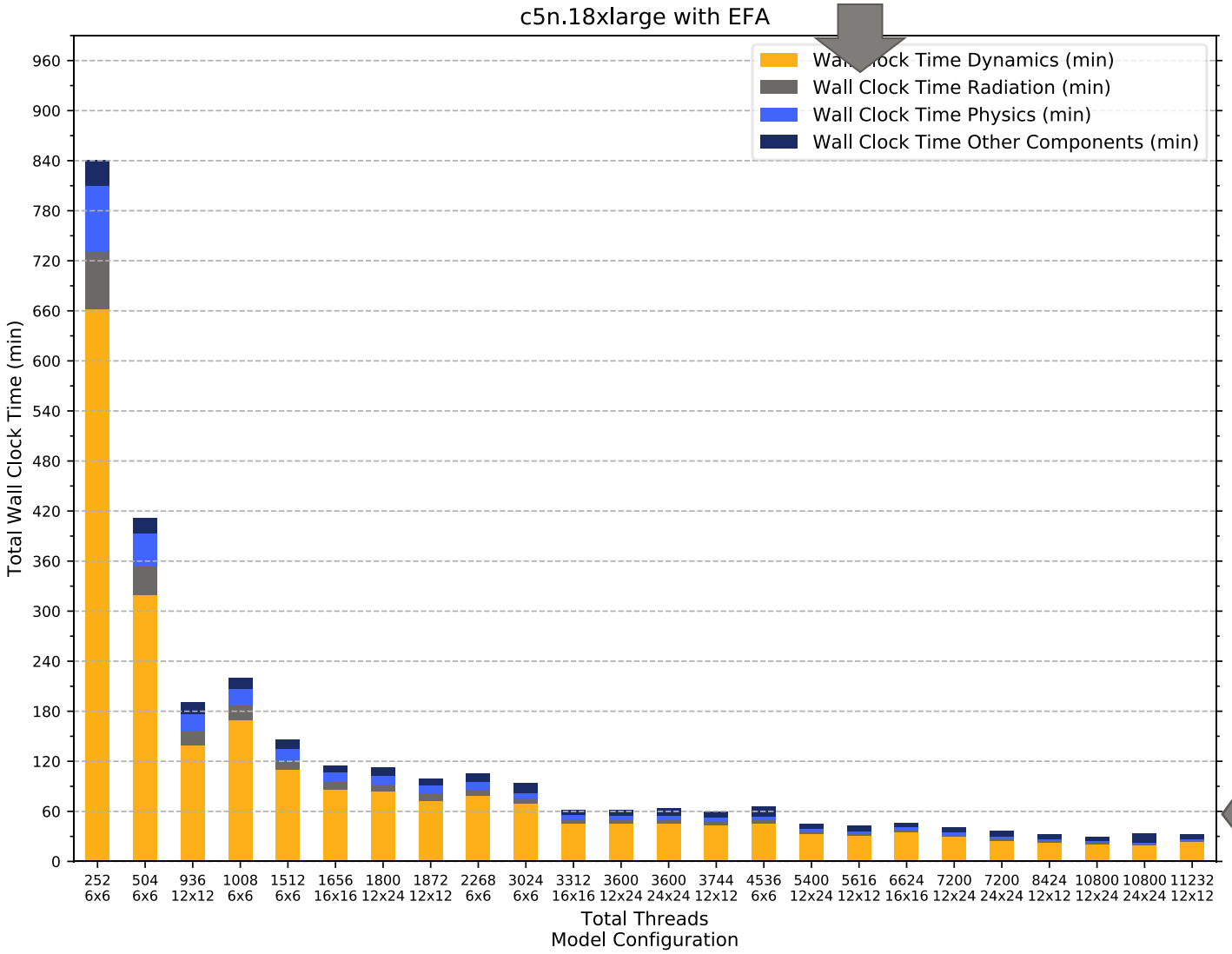


Case study on performance

- **37** different HPC cluster configurations were built to test the FV3GFS application on as little as **252** cores to over **11,000** cores.
  - Each of these clusters was built using AWS ParallelCluster to ensure consistent configuration and deployment.
- Maxar currently runs the application on both c5.18xlarge and c5n.18xlarge AWS EC2 instances.
  - **24** of the case study cluster configurations utilize c5n.18xlarge with the EFA networking adapter (max 100Gbps).
  - The remaining **13** configurations use c5.18xlarge instances with TCP networking (max 25Gbps).
- All configurations leverage a **14TB** FSx Lustre file system with a progressive file layout (PFL) across the 12 object storage targets (OSTs).

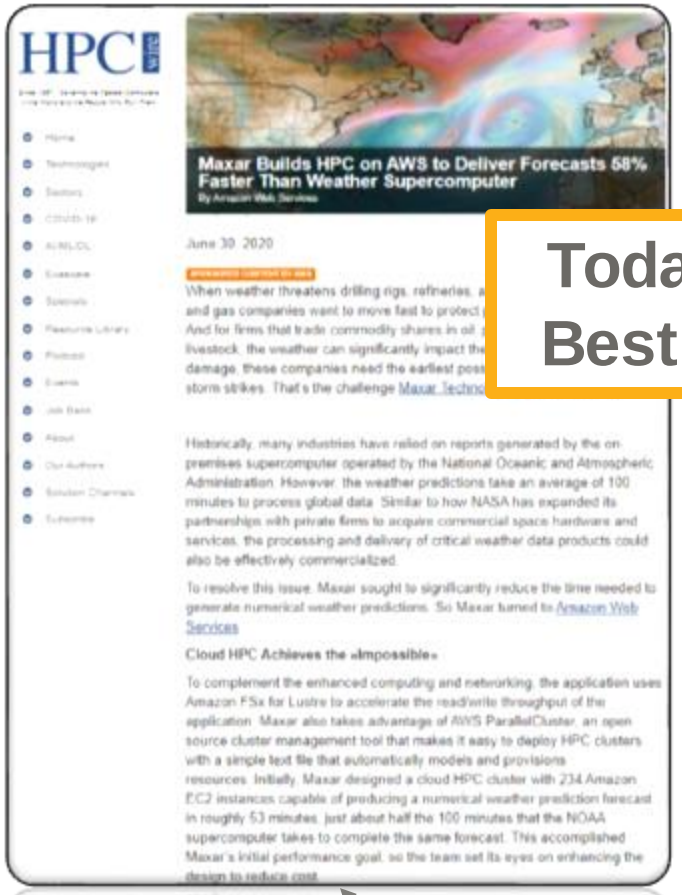
```
[aws]
aws_region_name = us-east-1
[global]
cluster_template = AZ-a
update_check = true
sanity_check = false
[cluster AZ-a]
base_os = alinux
master_instance_type = r5.24xlarge
compute_instance_type = c5.18xlarge
placement_group = DYNAMIC
vpc_settings = AZ-a
master_root_volume_size = 3000
compute_root_volume_size = 100
initial_queue_size = 100
maintain_initial_size = true
max_queue_size = 100
fsx_settings = fs
ec2_iam_role = EC2-Cluster-Generatic
extra_json = { "cluster" : { "cfn_sc
scheduler = slurm
[fsx fs]
shared_dir = /UFS
storage_capacity = 14400
imported_file_chunk_size = 1024
```

Results – Wall clock times by application component



- As core counts increase, a larger percentage of total wall clock time is spent in other parts of the application.
- Larger core counts require more communication, which partly explains more time spent in other components than the main three (dynamics, physics, and radiation).
- The scalability of the application is highly dependent on model configuration and the balance between MPI and openMP threading.

Awareness of Maxar's Cloud Based HPC for NWP



Today: MAXAR wins AWS award for Best HPC Solution for Public Sector

AWS Published Case Study

HPC Wire Article

Maxar Blog on Cloud Based HPC for NWP

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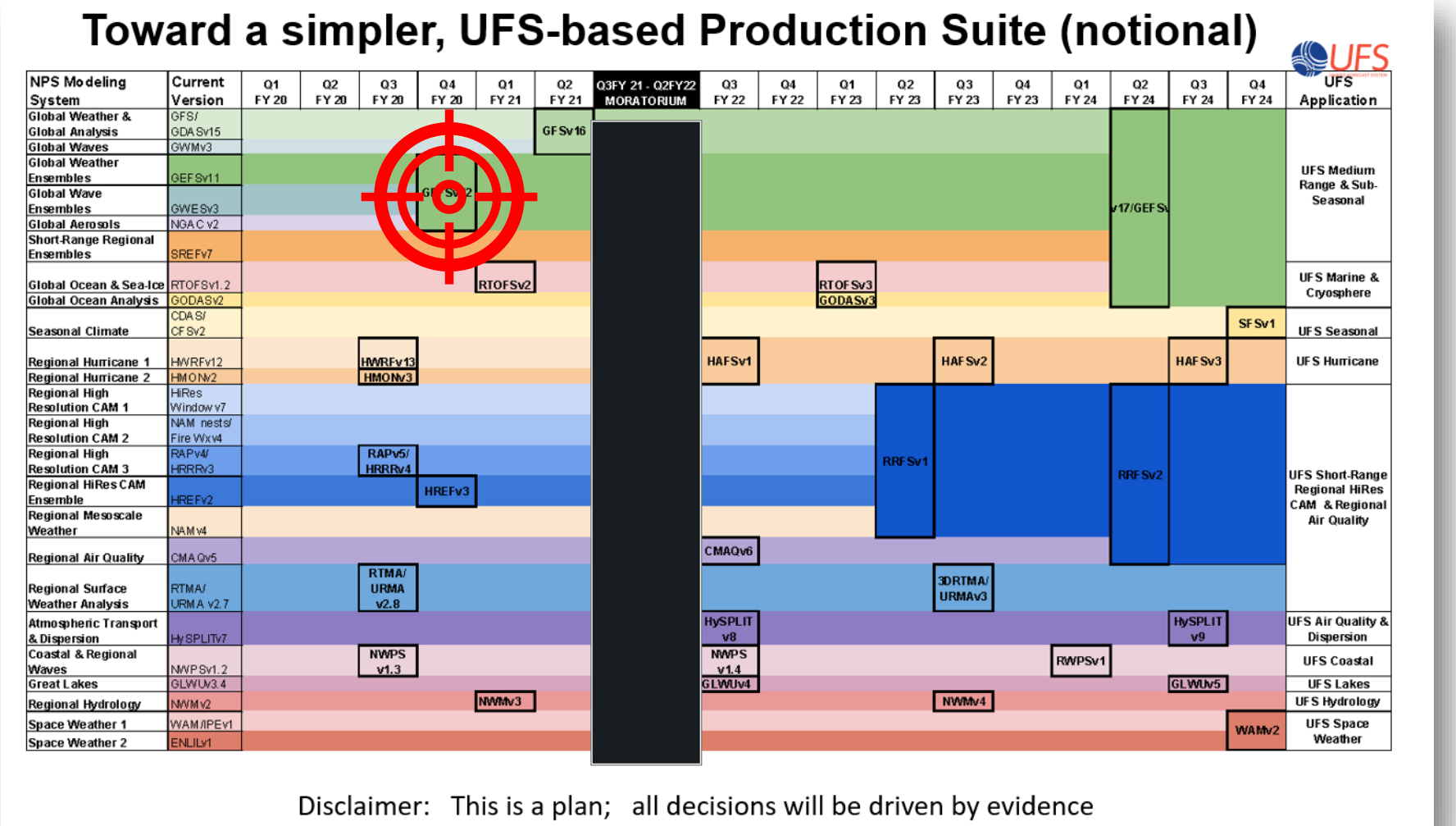
Taking on the GEFS v12



- The GEFS ensemble is set for an upgrade in September 2020.
- Running the FV3/UFS 31 times at lower resolution is a new challenge for AWS resources.

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Concluding Thoughts

- For over a year, Maxar has been running FV3 in AWS.
- CI/CD achieved via CodePipeline, for relatively easy updates to the executable code.
- AWS resources allow for scalability to core counts greater than NCEP NCO without having to purchase the physical hardware of that magnitude.
- AWS resources and tools enable creativity in costing for testing/development. User has better control of matching budget to requirements, no huge investment upfront.
- We ran FV3 using numerous configurations, with core counts from 252 to over 10000
  - We found the configuration that worked best for us, but that is NOT the configuration that is necessarily best for everyone.
  - Members of the community can use the cloud to do FV3 simulations using resources that match their budgets and scopes.
  - Using the cloud, UFS users can get just the compute they need for their work.

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