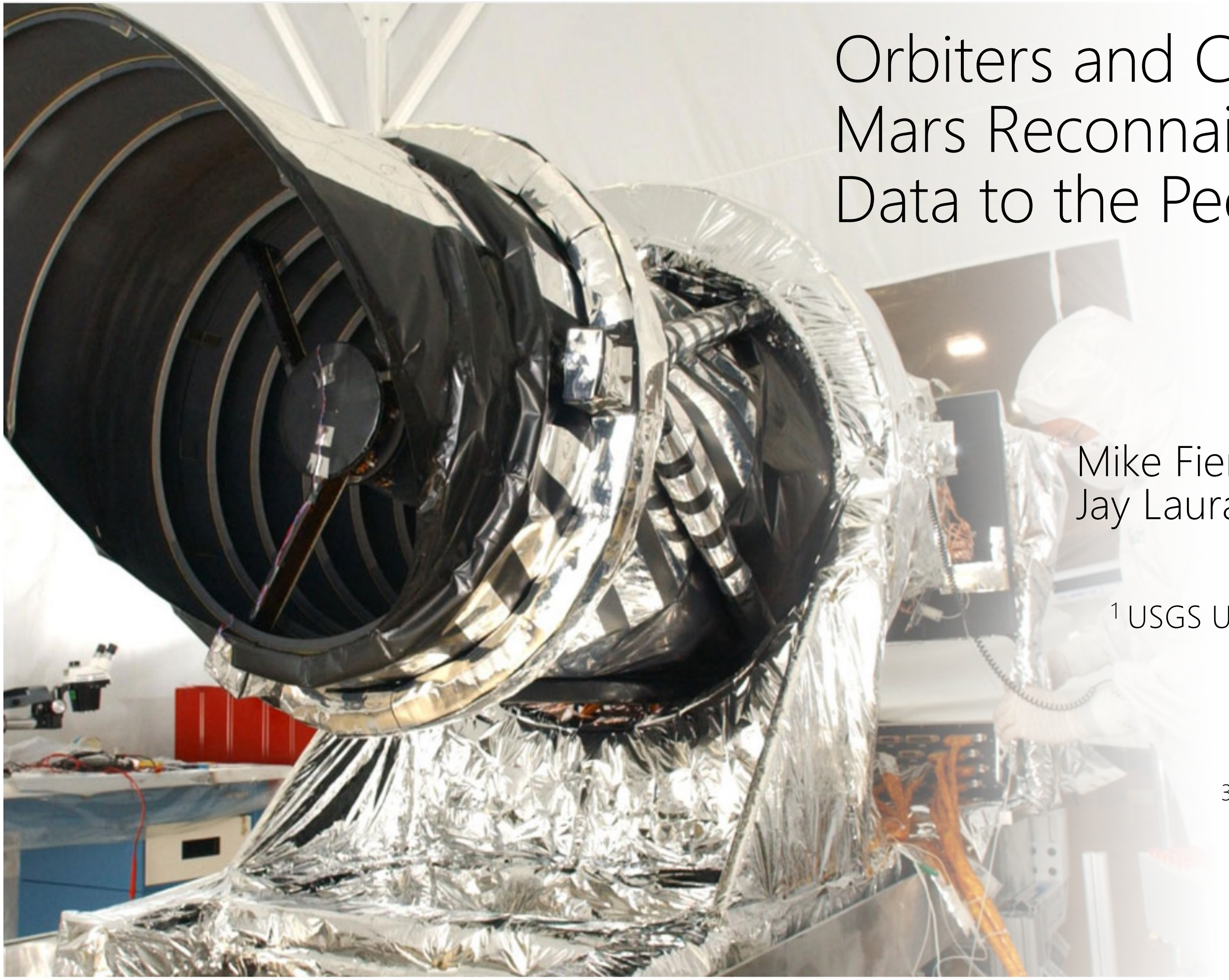

Orbiters and Clouds: Bringing Mars Reconnaissance Orbiter Data to the People

Mike Fienen[1], Sam Congdon[2],
Jay Laura[3], Brendan Wakefield[2]

[1] USGS Upper Midwest Water Science Center,
Madison, WI

[2]USGS Cloud Hosting Solutions,
Bozeman,MT

[3] USGS Astrogeology Science Center,
Flagstaff, AZ

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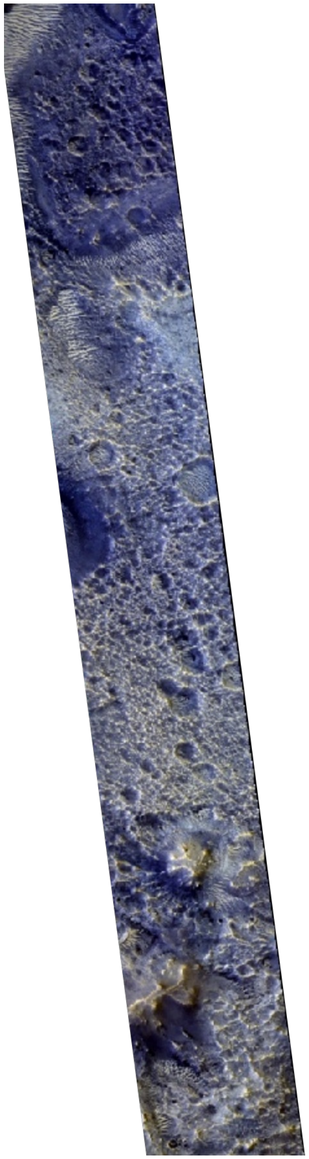

Overview

Building on the legacy of `condor_annex`, we created an open-source, pool-on-demand AWS-based platform for high-throughput computing with HTCondor

We illustrate with an example of making Mars Reconnaissance Orbiter HiRISE imagery data more open and accessible for science

On Premises Resource Seems Ideal – *we have been running a large cluster for years*

0. Can be difficult to buy and maintain
   on-premises computational resources
1. Consider the full costs on premises
   buying equipment
   the human cost of maintenance
   power/cooling
   carbon footprint of lacking efficiency
2. Who gets priority?

What about the cloud?

The Good Stuff:

0. Can scale big
1. Can configure things pretty much how you want
2. “Bring the compute to the data”
3. Everyone gets their own cluster

The Bad Stuff:

0. IT nerdery overload to get going 🤓
1. Ubiquity of error has a side effect

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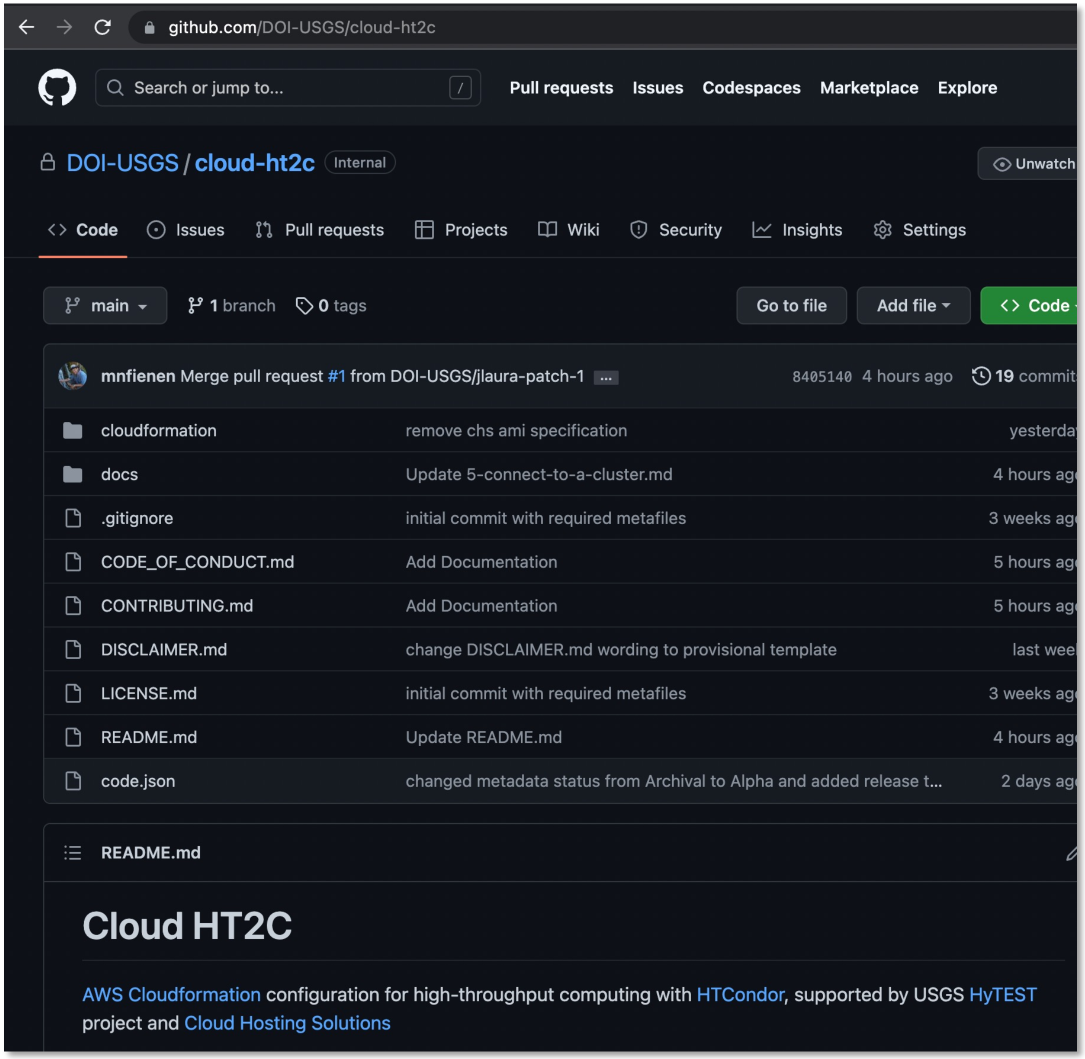
cloud-ht2c

Alpha Version 0.1



github.com/DOI-USGS/cloud-ht2c

DOI-USGS / cloud-ht2c Internal

mnfienen Merge pull request #1 from DOI-USGS/jlaura-patch-1 … 8405140 4 hours ago 19 commit

cloudformation	remove chs ami specification	yesterda
docs	Update 5-connect-to-a-cluster.md	4 hours ag
.gitignore	initial commit with required metafiles	3 weeks ag
CODE_OF_CONDUCT.md	Add Documentation	5 hours ag
CONTRIBUTING.md	Add Documentation	5 hours ag
DISCLAIMER.md	change DISCLAIMER.md wording to provisional template	last wee
LICENSE.md	initial commit with required metafiles	3 weeks ag
README.md	Update README.md	4 hours ag
code.json	changed metadata status from Archival to Alpha and added release t...	2 days ag

README.md

Cloud HT2C

AWS Cloudformation configuration for high-throughput computing with HTCondor, supported by USGS HyTEST project and Cloud Hosting Solutions

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Architecture of `cloud-ht2c`

0. Configure an AMI (Amazon Machine Image)

   AMI=blueprint.

   Single running instance=one building from the blueprint

   There are a few prereqs for the AMI

1. Spin up a cluster on demand using cloudformation yml configuration

   decide which AMI and architecture to base the control node and each worker on

   decide how many workers you want

   choose optional spot option

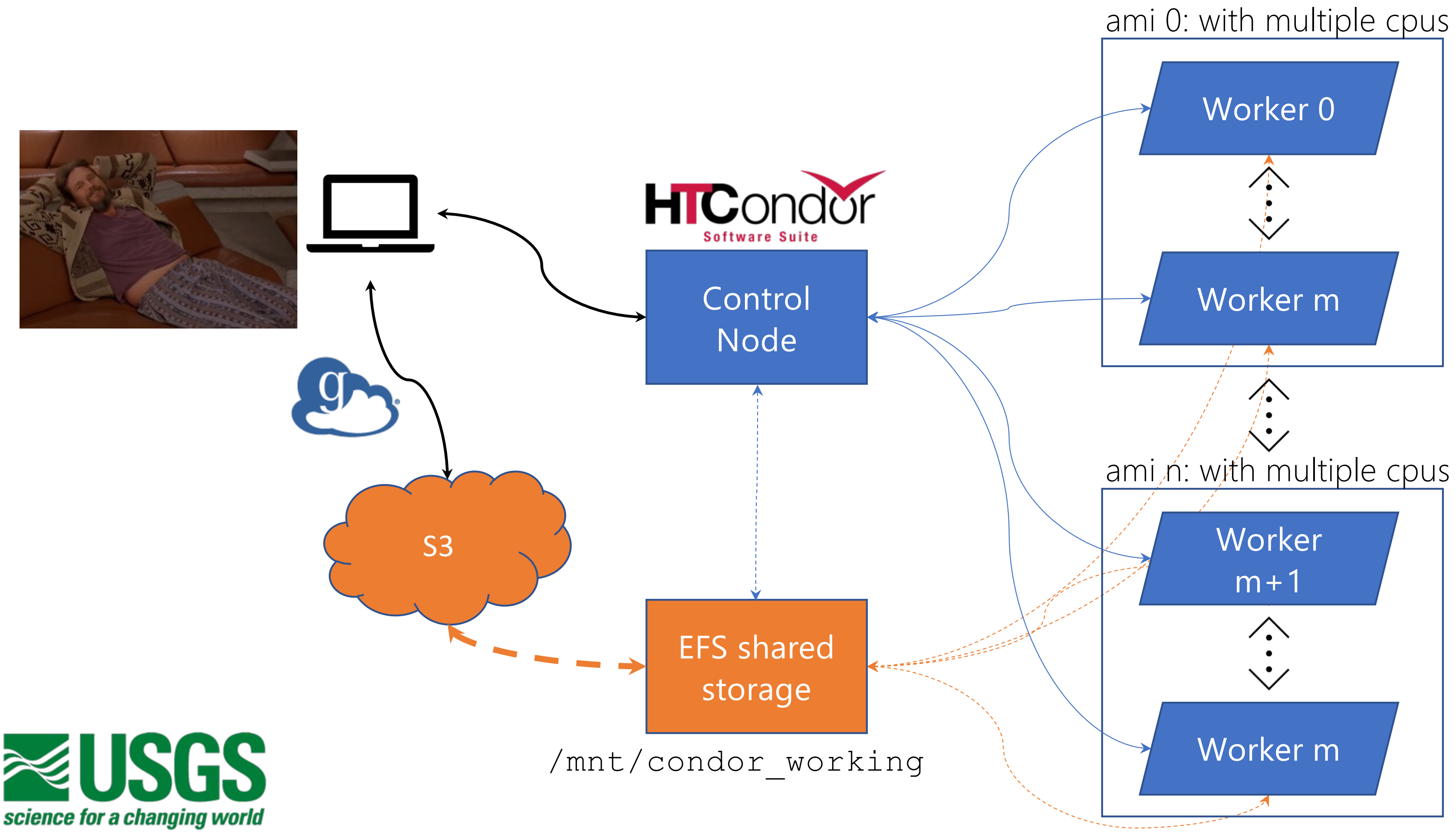
   assign timeout options

2. Cloudformation coordinates a flexible setup
   with a single central manager and workers can come and go

   HTCondor uses TCP/IP so port 9618 is open

   Also ports 9700-9710 are available for PEST/PEST++

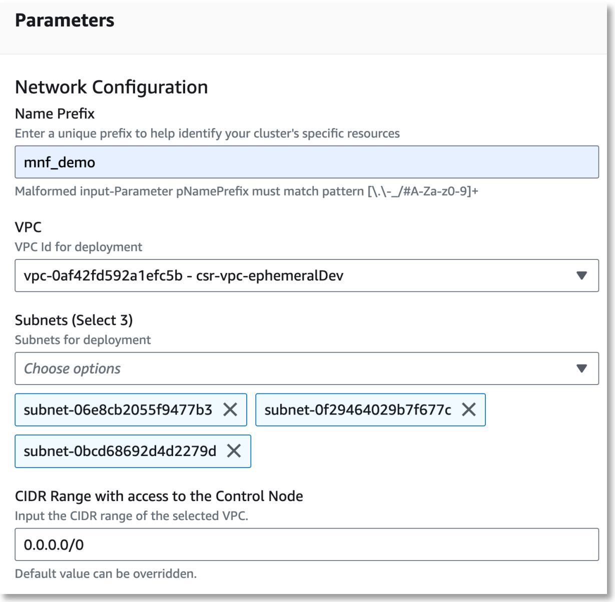
Cloud-based hybrid of HPC and HTC



Configuring a cloud-based compute cluster

Thanks to Todd Miller for the lowdown!

1.



Parameters

Network Configuration

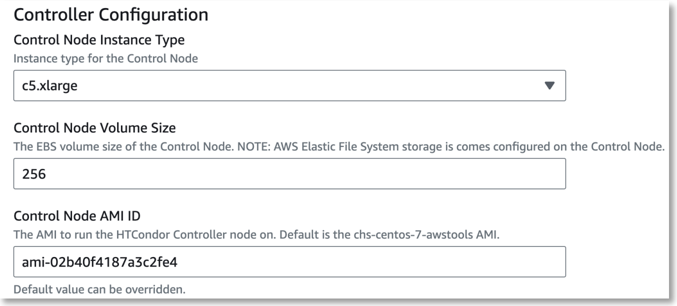
Name Prefix
Enter a unique prefix to help identify your cluster's specific resources
mnf_demo
Malformed input-Parameter pNamePrefix must match pattern [\.\-_/#A-Za-z0-9]+

VPC
VPC Id for deployment
vpc-0af42fd592a1efc5b - csr-vpc-ephemeralDev ▼

Subnets (Select 3)
Subnets for deployment
Choose options ▼
subnet-06e8cb2055f9477b3 ✕ subnet-0f29464029b7f677c ✕
subnet-0bcd68692d4d2279d ✕

CIDR Range with access to the Control Node
Input the CIDR range of the selected VPC.
0.0.0.0/0
Default value can be overridden.

2.



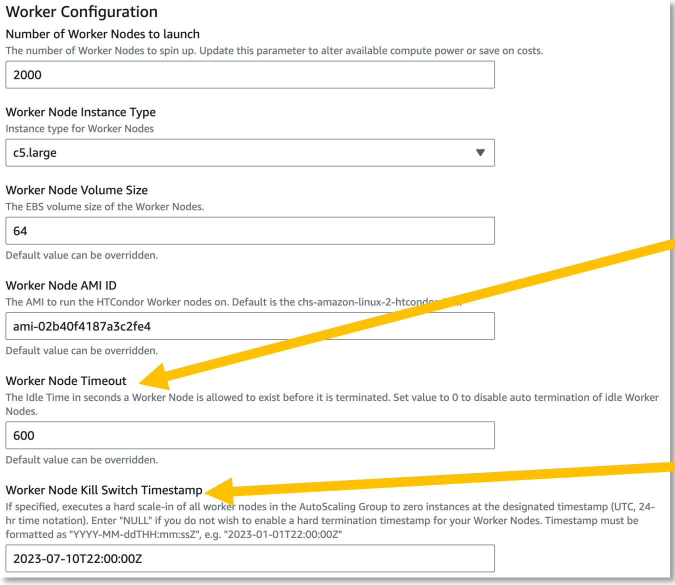
Controller Configuration

Control Node Instance Type
Instance type for the Control Node
c5.xlarge ▼

Control Node Volume Size
The EBS volume size of the Control Node. NOTE: AWS Elastic File System storage is comes configured on the Control Node.
256

Control Node AMI ID
The AMI to run the HTCondor Controller node on. Default is the chs-centos-7-awstools AMI.
ami-02b40f4187a3c2fe4
Default value can be overridden.

3.



Worker Configuration

Number of Worker Nodes to launch
The number of Worker Nodes to spin up. Update this parameter to alter available compute power or save on costs.
2000

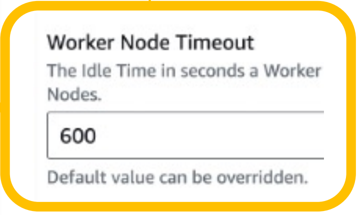
Worker Node Instance Type
Instance type for Worker Nodes
c5.large ▼

Worker Node Volume Size
The EBS volume size of the Worker Nodes.
64
Default value can be overridden.

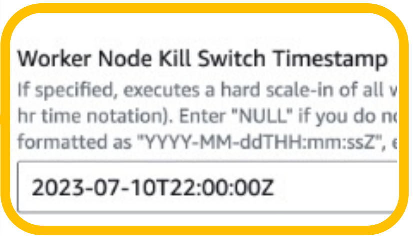
Worker Node AMI ID
The AMI to run the HTCondor Worker nodes on. Default is the chs-amazon-linux-2-htcondor...
ami-02b40f4187a3c2fe4
Default value can be overridden.

Worker Node Timeout
The Idle Time in seconds a Worker Node is allowed to exist before it is terminated. Set value to 0 to disable auto termination of idle Worker Nodes.
600
Default value can be overridden.

Worker Node Kill Switch Timestamp
If specified, executes a hard scale-in of all worker nodes in the AutoScaling Group to zero instances at the designated timestamp (UTC, 24-hr time notation). Enter "NULL" if you do not wish to enable a hard termination timestamp for your Worker Nodes. Timestamp must be formatted as "YYYY-MM-ddTHH:mm:ssZ", e.g. "2023-01-01T22:00:00Z"
2023-07-10T22:00:00Z

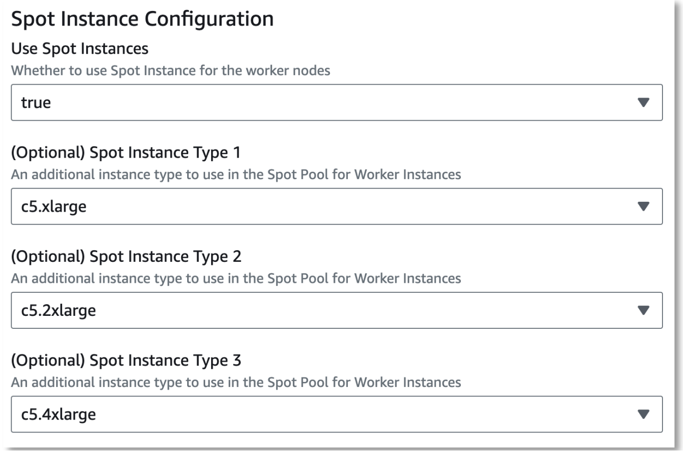


Worker Node Timeout
The Idle Time in seconds a Worker
Nodes.
600
Default value can be overridden.



Worker Node Kill Switch Timestamp
If specified, executes a hard scale-in of all w
hr time notation). Enter "NULL" if you do nc
formatted as "YYYY-MM-ddTHH:mm:ssZ", e
2023-07-10T22:00:00Z

4.



Spot Instance Configuration

Use Spot Instances
Whether to use Spot Instance for the worker nodes
true ▼

(Optional) Spot Instance Type 1
An additional instance type to use in the Spot Pool for Worker Instances
c5.xlarge ▼

(Optional) Spot Instance Type 2
An additional instance type to use in the Spot Pool for Worker Instances
c5.2xlarge ▼

(Optional) Spot Instance Type 3
An additional instance type to use in the Spot Pool for Worker Instances
c5.4xlarge ▼

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How to deploy dependencies and model files

Amazon EFS

`/mnt/condor_working`

wine

Amazon Machine Image (AMI)

"AMI is the OG Docker"

conda/**conda-pack**

Package conda environments for redistribution

docker

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Increasing complexity

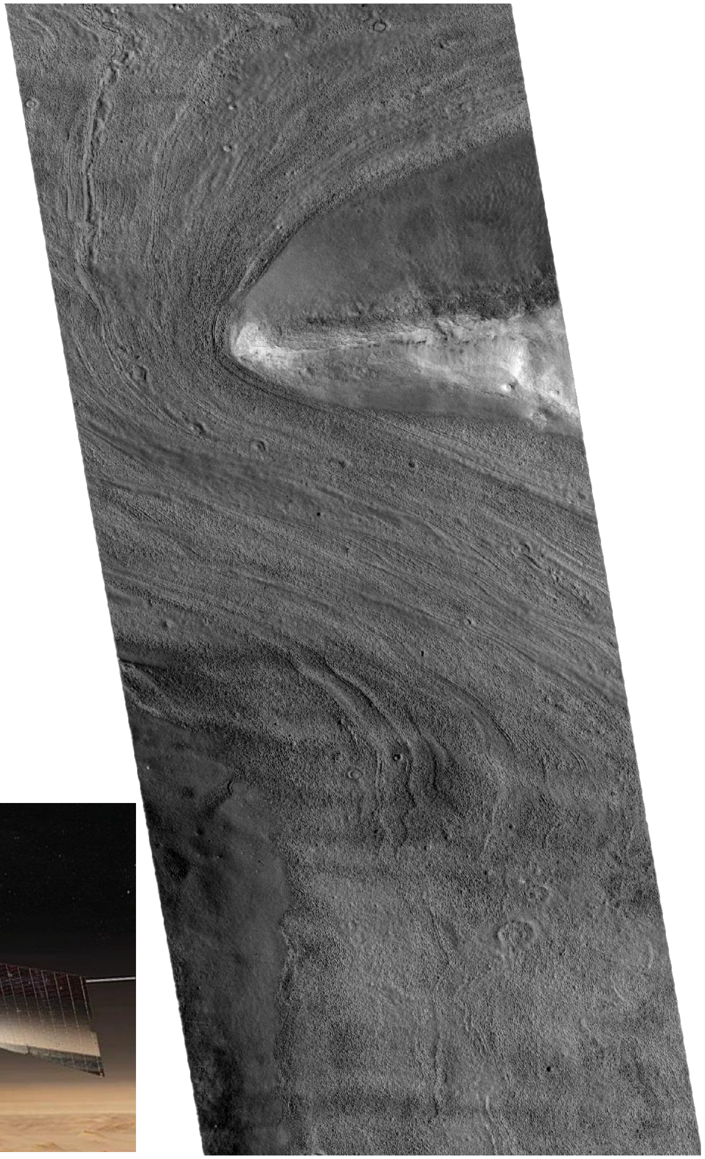
Mars Reconnaissance Orbiter and Analysis Ready Data

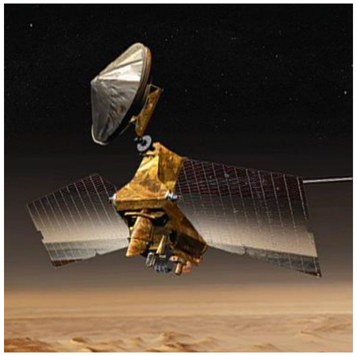
Different missions have different specs/needs.

Big issues are image format (JPEG 2000 are not registered in space so harder to find). Cloud-optimized geoTIFF is explorable via browser.

Common projections enhance interoperability

Processing and serving the entire dataset empowers scientists to focus on the science rather than endless fussing with a complex image/geo-processing workflow





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Mars Reconnaissance Orbiter and Analysis Ready Data by the Numbers

155,317 total images to process

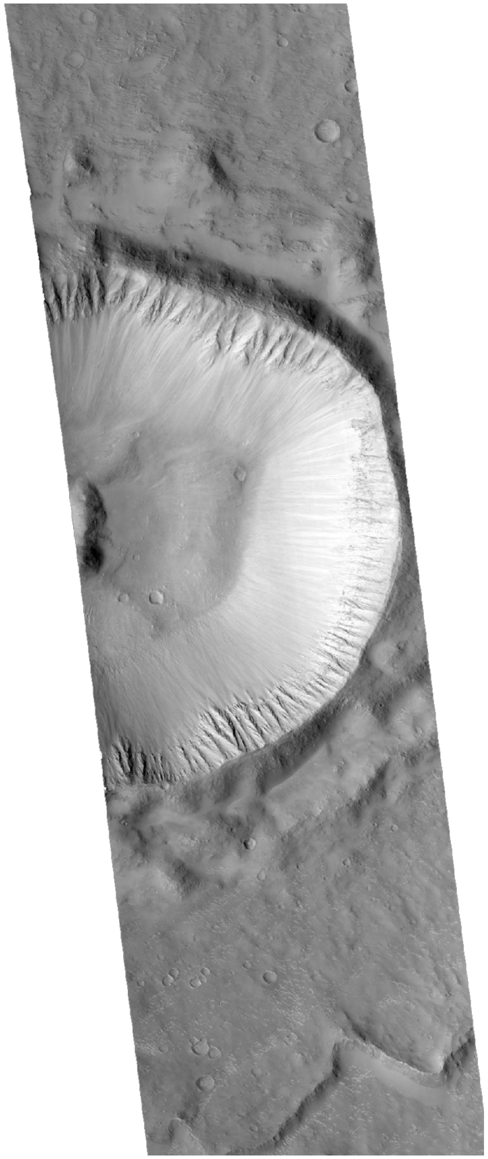
Input from USGS/NASA S3 bucket: 100 TB

Output to NASA/Amazon Registry of Open Data S3: 114 TB

2,000 AMIs supporting 4,664 concurrent jobs

Total wall time: about 4 hours
(not quite enough time to watch *The Martian* twice!)

Cost: about 10% of planned (#spotInstnaces)



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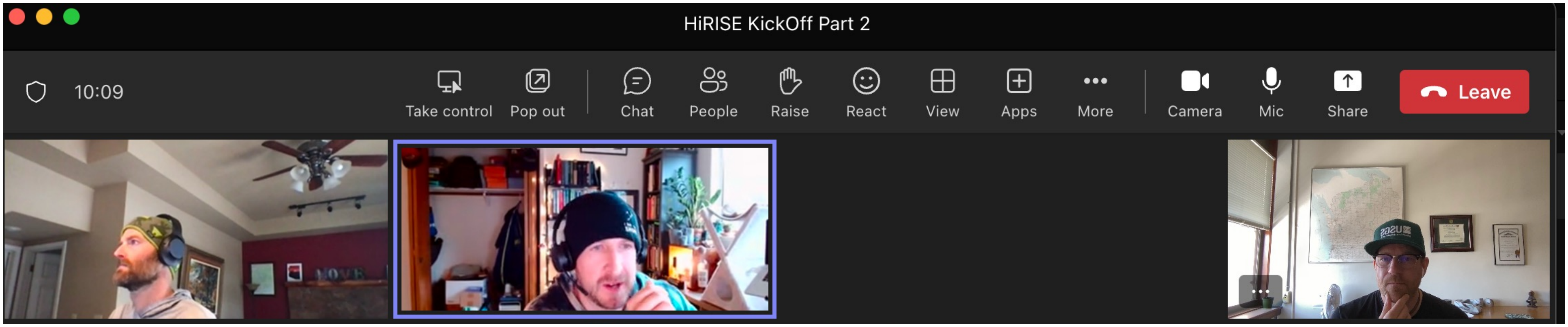

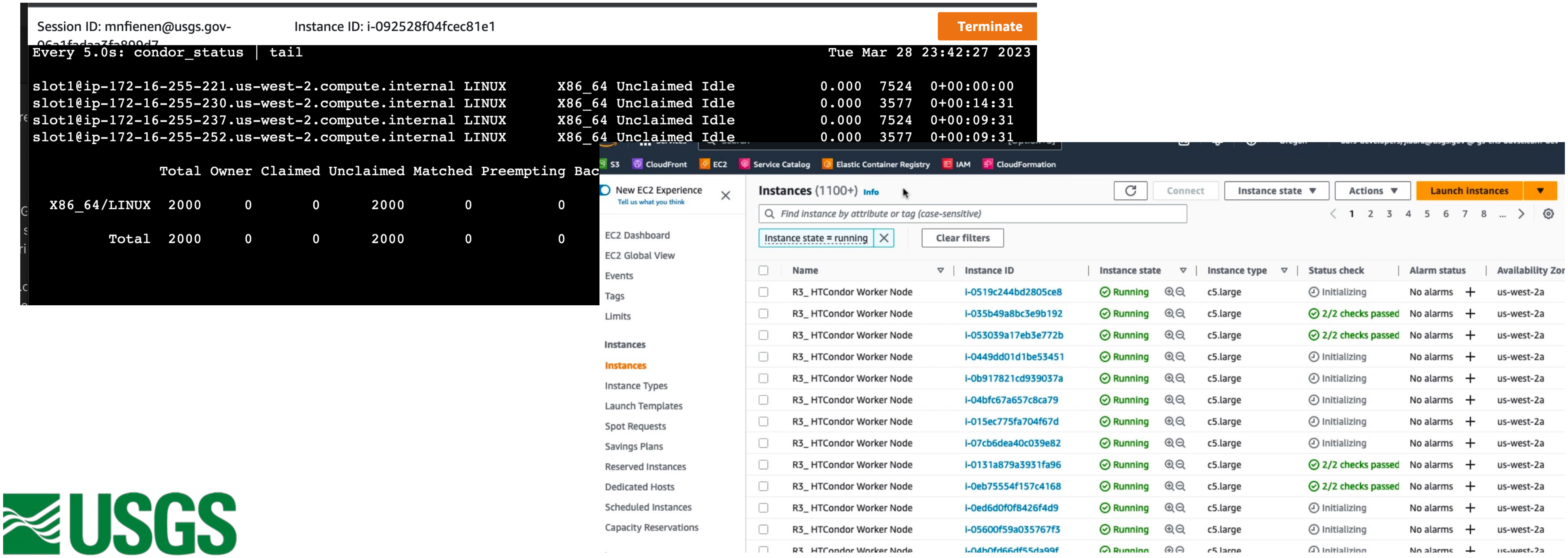

Session ID: mnfienen@usgs.gov-06a1fadaa7fa899d7   Instance ID: i-092528f04fcec81e1

```
Every 5.0s: condor_status | tail                                                          Tue Mar 28 23:42:27 2023

slot1@ip-172-16-255-221.us-west-2.compute.internal LINUX      X86_64 Unclaimed Idle          0.000  7524  0+00:00:00
slot1@ip-172-16-255-230.us-west-2.compute.internal LINUX      X86_64 Unclaimed Idle          0.000  3577  0+00:14:31
slot1@ip-172-16-255-237.us-west-2.compute.internal LINUX      X86_64 Unclaimed Idle          0.000  7524  0+00:09:31
slot1@ip-172-16-255-252.us-west-2.compute.internal LINUX      X86_64 Unclaimed Idle          0.000  3577  0+00:09:31

                  Total Owner Claimed Unclaimed Matched Preempting Bac

  X86_64/LINUX    2000     0       0      2000       0          0

         Total    2000     0       0      2000       0          0
```

Instances (1100+) Info

Find instance by attribute or tag (case-sensitive)

Instance state = running

□	Name	Instance ID	Instance state	Instance type	Status check	Alarm status	Availability Zor
□	R3_ HTCondor Worker Node	i-0519c244bd2805ce8	✓ Running	c5.large	Initializing	No alarms +	us-west-2a
□	R3_ HTCondor Worker Node	i-035b49a8bc3e9b192	✓ Running	c5.large	✓ 2/2 checks passed	No alarms +	us-west-2a
□	R3_ HTCondor Worker Node	i-053039a17eb3e772b	✓ Running	c5.large	✓ 2/2 checks passed	No alarms +	us-west-2a
□	R3_ HTCondor Worker Node	i-0449dd01d1be53451	✓ Running	c5.large	Initializing	No alarms +	us-west-2a
□	R3_ HTCondor Worker Node	i-0b917821cd939037a	✓ Running	c5.large	Initializing	No alarms +	us-west-2a
□	R3_ HTCondor Worker Node	i-04bfc67a657c8ca79	✓ Running	c5.large	Initializing	No alarms +	us-west-2a
□	R3_ HTCondor Worker Node	i-015ec775fa704f67d	✓ Running	c5.large	Initializing	No alarms +	us-west-2a
□	R3_ HTCondor Worker Node	i-07cb6dea40c039e82	✓ Running	c5.large	Initializing	No alarms +	us-west-2a
□	R3_ HTCondor Worker Node	i-0131a879a3931fa96	✓ Running	c5.large	✓ 2/2 checks passed	No alarms +	us-west-2a
□	R3_ HTCondor Worker Node	i-0eb75554f157c4168	✓ Running	c5.large	✓ 2/2 checks passed	No alarms +	us-west-2a
□	R3_ HTCondor Worker Node	i-0ed6d0f0f8426f4d9	✓ Running	c5.large	Initializing	No alarms +	us-west-2a
□	R3_ HTCondor Worker Node	i-05600f59a035767f3	✓ Running	c5.large	Initializing	No alarms +	us-west-2a
□	R3_ HTCondor Worker Node	i-04b0fd66df55da99f	✓ Running	c5.large	Initializing	No alarms +	us-west-2a

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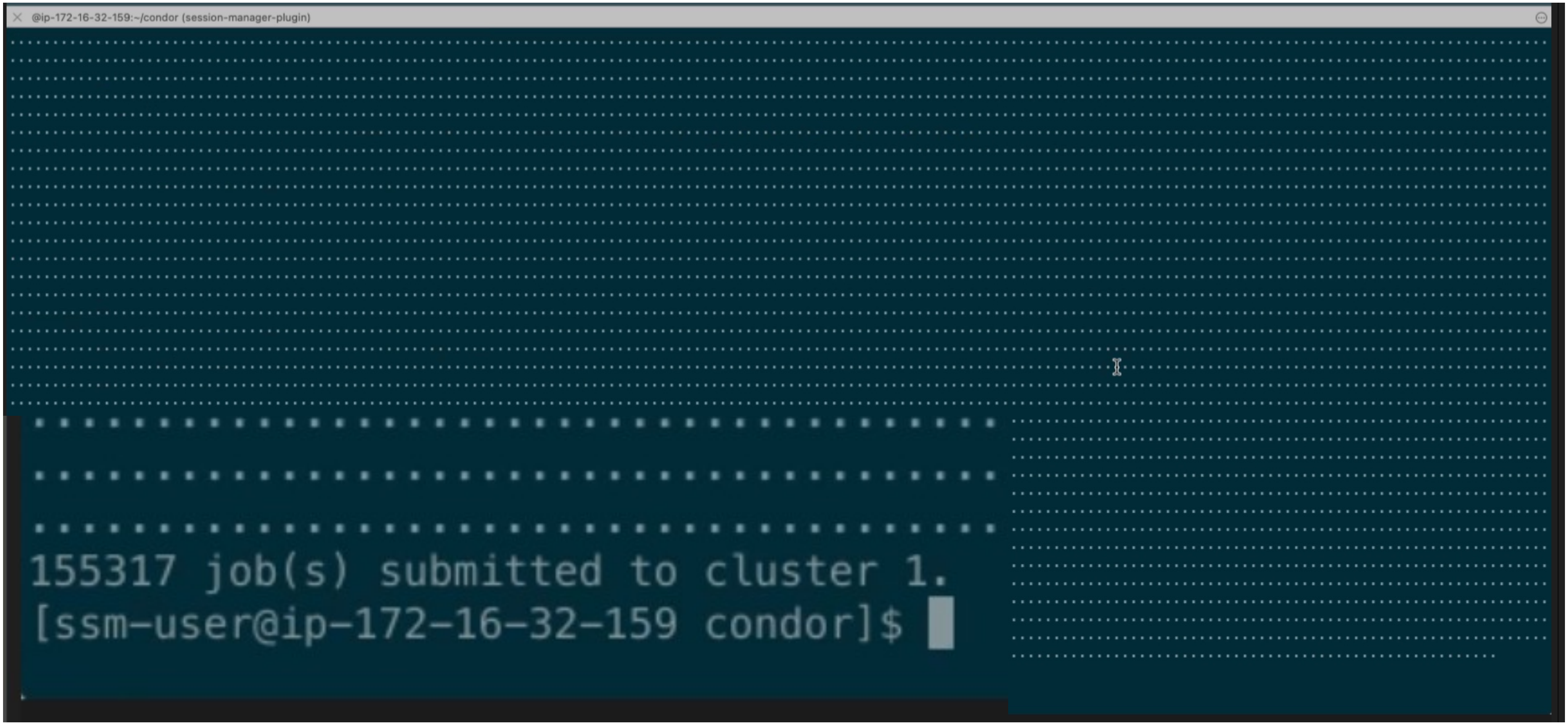
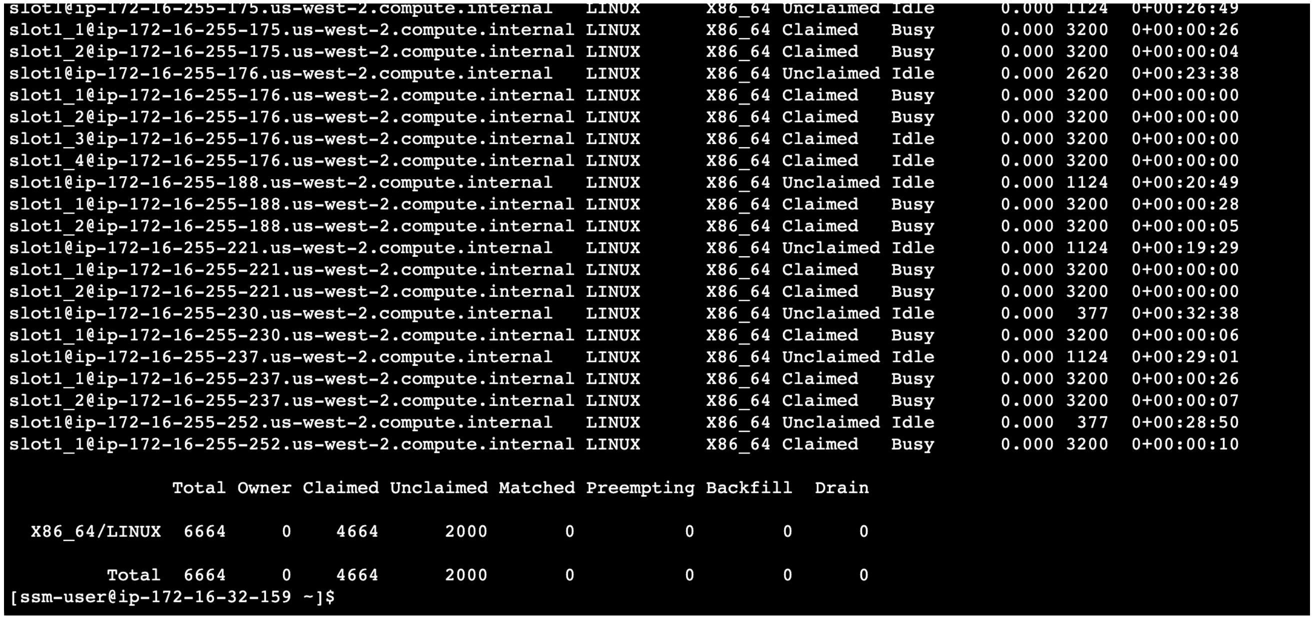
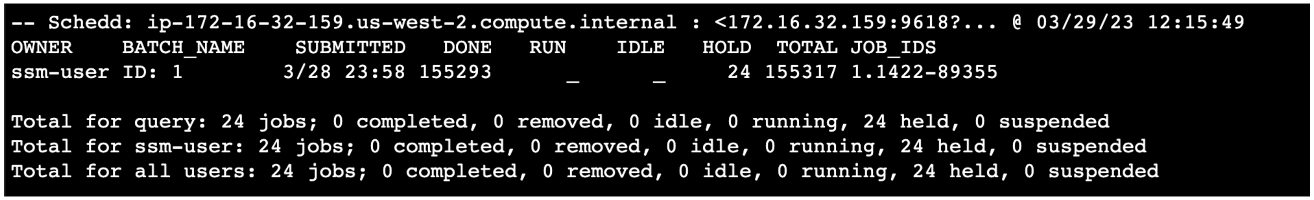


```
.......................................
.......................................
.......................................
155317 job(s) submitted to cluster 1.
[ssm-user@ip-172-16-32-159 condor]$
```

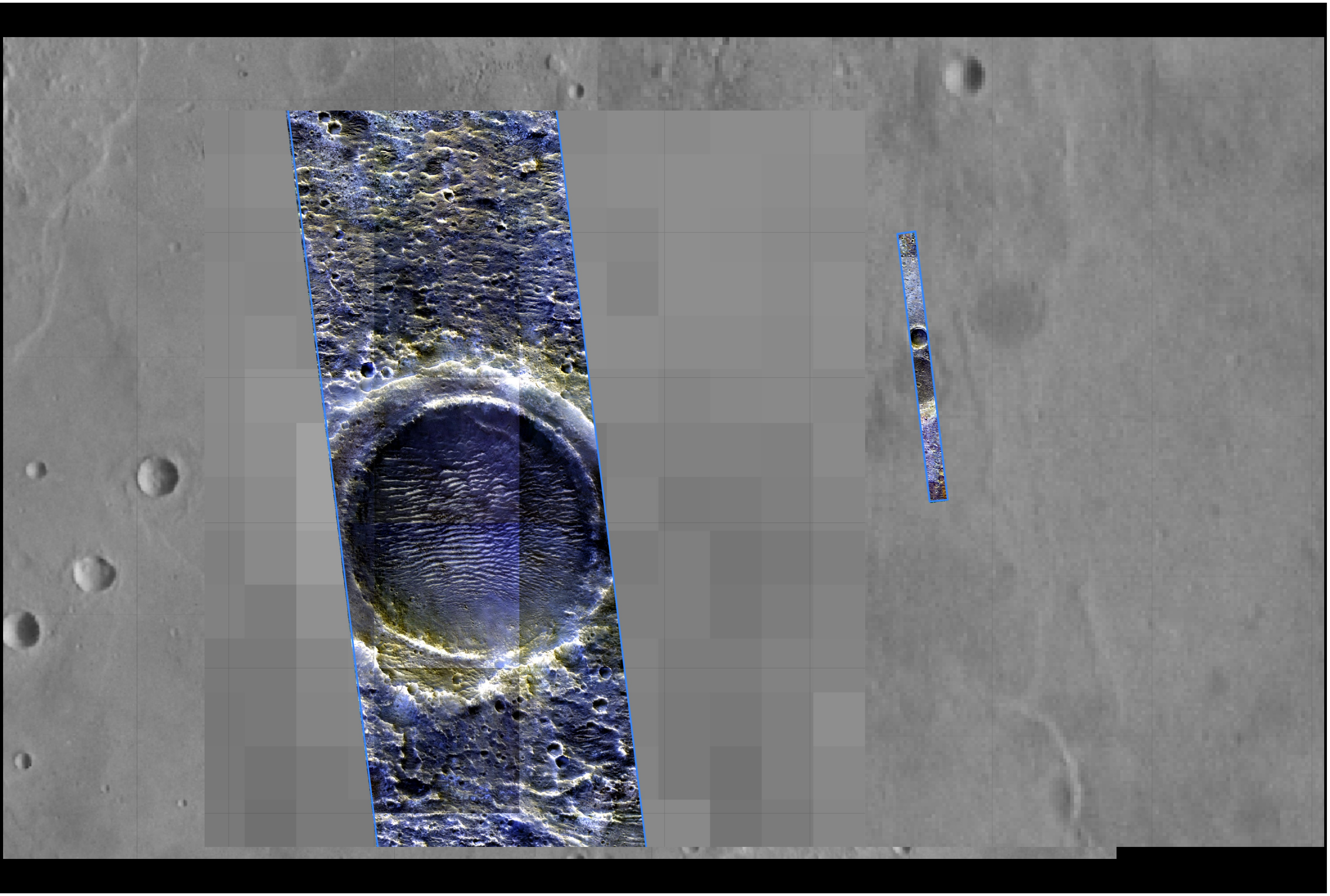
That's a lot of dots!



```
slot1@ip-172-16-255-175.us-west-2.compute.internal   LINUX      X86_64 Unclaimed Idle      0.000 1124  0+00:26:49
slot1_1@ip-172-16-255-175.us-west-2.compute.internal LINUX      X86_64 Claimed   Busy      0.000 3200  0+00:00:26
slot1_2@ip-172-16-255-175.us-west-2.compute.internal LINUX      X86_64 Claimed   Busy      0.000 3200  0+00:00:04
slot1@ip-172-16-255-176.us-west-2.compute.internal   LINUX      X86_64 Unclaimed Idle      0.000 2620  0+00:23:38
slot1_1@ip-172-16-255-176.us-west-2.compute.internal LINUX      X86_64 Claimed   Busy      0.000 3200  0+00:00:00
slot1_2@ip-172-16-255-176.us-west-2.compute.internal LINUX      X86_64 Claimed   Busy      0.000 3200  0+00:00:00
slot1_3@ip-172-16-255-176.us-west-2.compute.internal LINUX      X86_64 Claimed   Idle      0.000 3200  0+00:00:00
slot1_4@ip-172-16-255-176.us-west-2.compute.internal LINUX      X86_64 Claimed   Idle      0.000 3200  0+00:00:00
slot1@ip-172-16-255-188.us-west-2.compute.internal   LINUX      X86_64 Unclaimed Idle      0.000 1124  0+00:20:49
slot1_1@ip-172-16-255-188.us-west-2.compute.internal LINUX      X86_64 Claimed   Busy      0.000 3200  0+00:00:28
slot1_2@ip-172-16-255-188.us-west-2.compute.internal LINUX      X86_64 Claimed   Busy      0.000 3200  0+00:00:05
slot1@ip-172-16-255-221.us-west-2.compute.internal   LINUX      X86_64 Unclaimed Idle      0.000 1124  0+00:19:29
slot1_1@ip-172-16-255-221.us-west-2.compute.internal LINUX      X86_64 Claimed   Busy      0.000 3200  0+00:00:00
slot1_2@ip-172-16-255-221.us-west-2.compute.internal LINUX      X86_64 Claimed   Busy      0.000 3200  0+00:00:00
slot1@ip-172-16-255-230.us-west-2.compute.internal   LINUX      X86_64 Unclaimed Idle      0.000  377  0+00:32:38
slot1_1@ip-172-16-255-230.us-west-2.compute.internal LINUX      X86_64 Claimed   Busy      0.000 3200  0+00:00:06
slot1@ip-172-16-255-237.us-west-2.compute.internal   LINUX      X86_64 Unclaimed Idle      0.000 1124  0+00:29:01
slot1_1@ip-172-16-255-237.us-west-2.compute.internal LINUX      X86_64 Claimed   Busy      0.000 3200  0+00:00:26
slot1_2@ip-172-16-255-237.us-west-2.compute.internal LINUX      X86_64 Claimed   Busy      0.000 3200  0+00:00:07
slot1@ip-172-16-255-252.us-west-2.compute.internal   LINUX      X86_64 Unclaimed Idle      0.000  377  0+00:28:50
slot1_1@ip-172-16-255-252.us-west-2.compute.internal LINUX      X86_64 Claimed   Busy      0.000 3200  0+00:00:10

               Total Owner Claimed Unclaimed Matched Preempting Backfill  Drain

  X86_64/LINUX  6664     0    4664      2000       0          0        0      0

         Total  6664     0    4664      2000       0          0        0      0
[ssm-user@ip-172-16-32-159 ~]$
```



```
-- Schedd: ip-172-16-32-159.us-west-2.compute.internal : <172.16.32.159:9618?... @ 03/29/23 12:15:49
OWNER    BATCH_NAME    SUBMITTED   DONE   RUN    IDLE   HOLD  TOTAL JOB_IDS
ssm-user ID: 1        3/28 23:58 155293      _      _     24 155317 1.1422-89355

Total for query: 24 jobs; 0 completed, 0 removed, 0 idle, 0 running, 24 held, 0 suspended
Total for ssm-user: 24 jobs; 0 completed, 0 removed, 0 idle, 0 running, 24 held, 0 suspended
Total for all users: 24 jobs; 0 completed, 0 removed, 0 idle, 0 running, 24 held, 0 suspended
```



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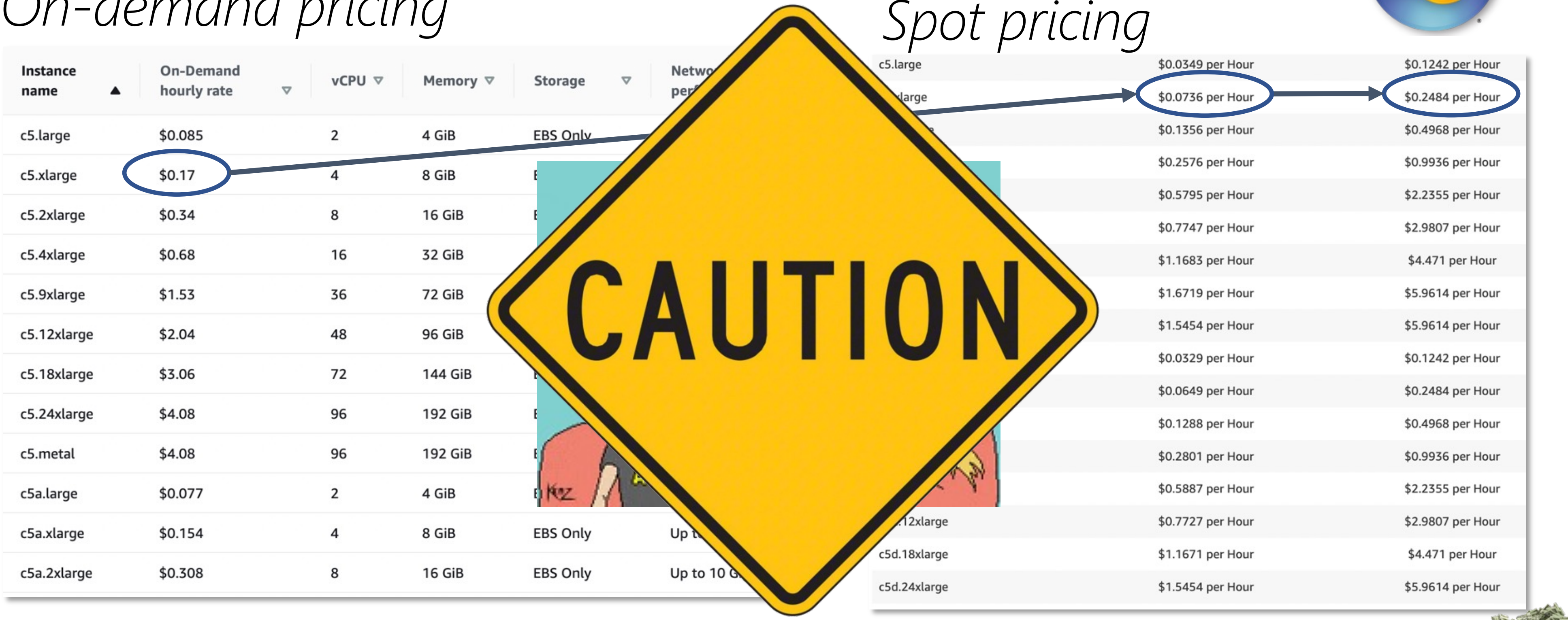
Let’s talk about MONEY

On-demand pricing

Spot pricing



Instance name ▲	On-Demand hourly rate ▽	vCPU ▽	Memory ▽	Storage ▽	Netwo perf
c5.large	$0.085	2	4 GiB	EBS Only	
c5.xlarge	$0.17	4	8 GiB	E	
c5.2xlarge	$0.34	8	16 GiB	E	
c5.4xlarge	$0.68	16	32 GiB		
c5.9xlarge	$1.53	36	72 GiB		
c5.12xlarge	$2.04	48	96 GiB		
c5.18xlarge	$3.06	72	144 GiB	E	
c5.24xlarge	$4.08	96	192 GiB	E	
c5.metal	$4.08	96	192 GiB	E	
c5a.large	$0.077	2	4 GiB	E	
c5a.xlarge	$0.154	4	8 GiB	EBS Only	Up t
c5a.2xlarge	$0.308	8	16 GiB	EBS Only	Up to 10 G

c5.large	$0.0349 per Hour	$0.1242 per Hour
xlarge	$0.0736 per Hour	$0.2484 per Hour
	$0.1356 per Hour	$0.4968 per Hour
	$0.2576 per Hour	$0.9936 per Hour
	$0.5795 per Hour	$2.2355 per Hour
	$0.7747 per Hour	$2.9807 per Hour
	$1.1683 per Hour	$4.471 per Hour
	$1.6719 per Hour	$5.9614 per Hour
	$1.5454 per Hour	$5.9614 per Hour
	$0.0329 per Hour	$0.1242 per Hour
	$0.0649 per Hour	$0.2484 per Hour
	$0.1288 per Hour	$0.4968 per Hour
	$0.2801 per Hour	$0.9936 per Hour
	$0.5887 per Hour	$2.2355 per Hour
.12xlarge	$0.7727 per Hour	$2.9807 per Hour
c5d.18xlarge	$1.1671 per Hour	$4.471 per Hour
c5d.24xlarge	$1.5454 per Hour	$5.9614 per Hour

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Let’s talk more about MONEY

Break it down:

each CPU on-demand is ~$0.043/hr

but likely need to reserve some (25%?) CPUs for OS, so **~$0.057/hr**

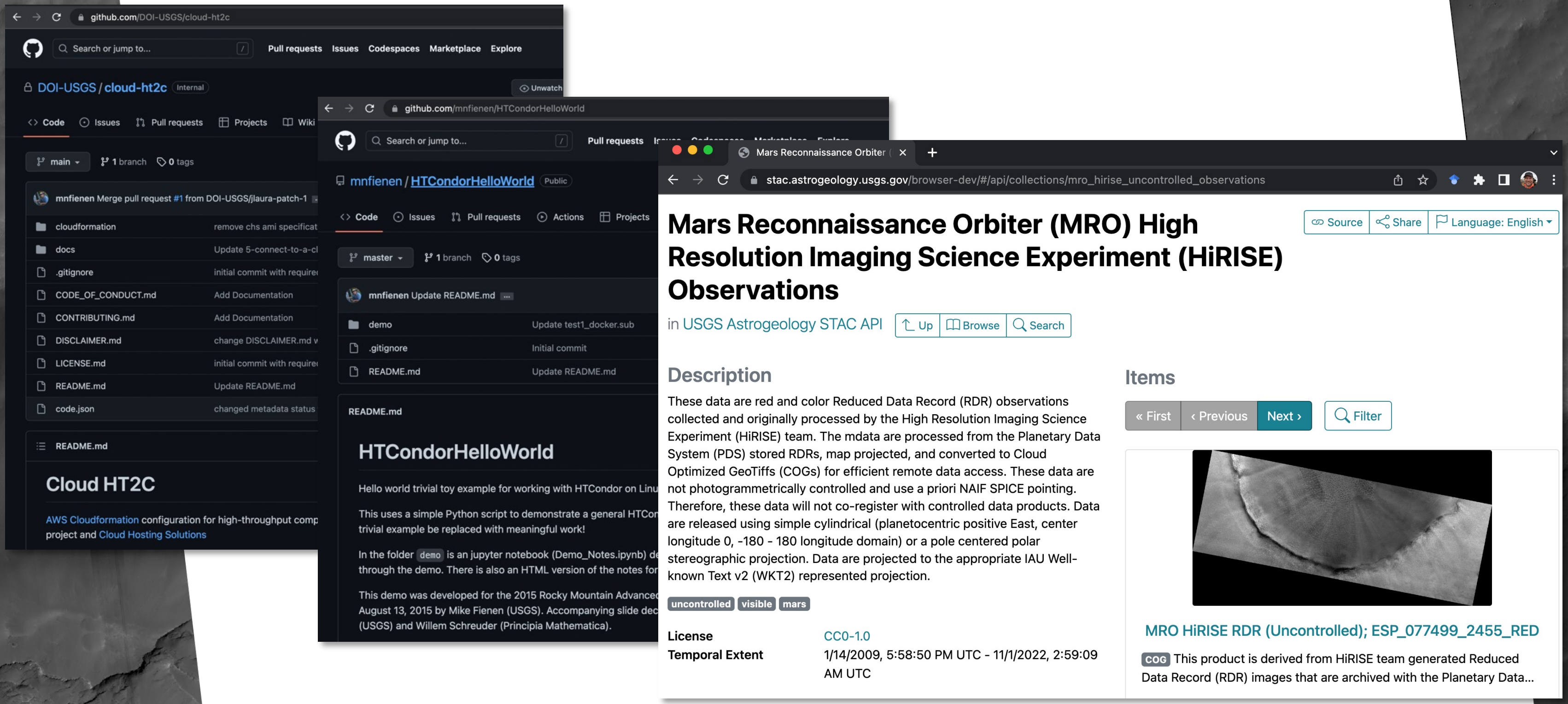
Spot market? Cost is often ~40%-50% so maybe **$0.02-$0.03/hr**?

BUT! If runs get dropped, can add up – think about forward runtimes

Spot is cheaper for AMIs with more CPUs, but that may hurt performance

THANKS!

Go kick the tires on cloud-ht2c – just remember it's
Alpha v 0.1 – let me know how it goes mnfienen@usgs.gov



github.com/DOI-USGS/cloud-ht2c

DOI-USGS / cloud-ht2c Internal

mnfienen Merge pull request #1 from DOI-USGS/jlaura-patch-1

cloudformation	remove chs ami specificat
docs	Update 5-connect-to-a-cl
.gitignore	initial commit with require
CODE_OF_CONDUCT.md	Add Documentation
CONTRIBUTING.md	Add Documentation
DISCLAIMER.md	change DISCLAIMER.md w
LICENSE.md	initial commit with require
README.md	Update README.md
code.json	changed metadata status

README.md

Cloud HT2C

AWS Cloudformation configuration for high-throughput comp
project and Cloud Hosting Solutions

github.com/mnfienen/HTCondorHelloWorld

mnfienen / HTCondorHelloWorld Public

mnfienen Update README.md ...

demo	Update test1_docker.sub
.gitignore	Initial commit
README.md	Update README.md

README.md

HTCondorHelloWorld

Hello world trivial toy example for working with HTCondor on Linu

This uses a simple Python script to demonstrate a general HTCon
trivial example be replaced with meaningful work!

In the folder `demo` is an jupyter notebook (Demo_Notes.ipynb) de
through the demo. There is also an HTML version of the notes for

This demo was developed for the 2015 Rocky Mountain Advanced
August 13, 2015 by Mike Fienen (USGS). Accompanying slide dec
(USGS) and Willem Schreuder (Principia Mathematica).

Mars Reconnaissance Orbiter (

stac.astrogeology.usgs.gov/browser-dev/#/api/collections/mro_hirise_uncontrolled_observations

Mars Reconnaissance Orbiter (MRO) High Resolution Imaging Science Experiment (HiRISE) Observations

in USGS Astrogeology STAC API

Description

These data are red and color Reduced Data Record (RDR) observations collected and originally processed by the High Resolution Imaging Science Experiment (HiRISE) team. The mdata are processed from the Planetary Data System (PDS) stored RDRs, map projected, and converted to Cloud Optimized GeoTiffs (COGs) for efficient remote data access. These data are not photogrammetrically controlled and use a priori NAIF SPICE pointing. Therefore, these data will not co-register with controlled data products. Data are released using simple cylindrical (planetocentric positive East, center longitude 0, -180 - 180 longitude domain) or a pole centered polar stereographic projection. Data are projected to the appropriate IAU Well-known Text v2 (WKT2) represented projection.

uncontrolled visible mars

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Temporal Extent	1/14/2009, 5:58:50 PM UTC - 11/1/2022, 2:59:09 AM UTC

Items

MRO HiRISE RDR (Uncontrolled); ESP_077499_2455_RED

COG This product is derived from HiRISE team generated Reduced Data Record (RDR) images that are archived with the Planetary Data...

HyTEST

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