Automatically Generate a Radiometrically Terrain Corrected (RTC) Sentinel-1 Image using Cloud Computing

Source: ASF Staff

This data recipe demonstrates use of the *ASF CloudFormation Template* to automate the processing of Sentinel-1 RTC products in Amazon Web Services (AWS).

The goal is to process a downloaded Sentinel-1 GRDH product:

… to a radiometrically terrain corrected (RTC) product:

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A) Prerequisites:

1. You must have an AWS Account
2. You must create an EC2 Instance. The instance won't be used for processing, but is necessary in order to create a private key file, subnets, and security group. You will stop the instance once it has been launched.

   For instructions on creating an AWS account and launching an EC2 instance, use these links:

   - To create a new account
     - https://portal.aws.amazon.com/billing/signup#/start
   - To launch an EC2 Instance
     - https://docs.aws.amazon.com/AWSEC2/latest/UserGuide/EC2_GetStarted.html#ec2-launch-instance

   Important: When you have launched your EC2 instance and the Instance State is in a "running" status, select the instance and click **Actions** > **Instance State** > **Stop**. *This will prevent your account being charged for an instance you're not using!*

B) Background

What is the CloudFormation Template?

The *ASF CloudFormation Template* automates the processing of Sentinel-1 RTC products.

The CloudFormation template itself is a set of instructions for AWS components to know when and how to talk to one another. For example, the template creates and connects a variety of AWS components, like a queue for managing work, and EC2 instances that do the actual work (RTC in this case).

Figure 1 visualizes the *ASF CloudFormation Template* and shows how the different components relate to one another.

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Figure 1. Diagram showing the workflow of the ASF CloudFormation Template.

The workflow goes like this:

1. New files (objects to process) that need RTC are put into the S3 **Input Bucket**, which is like a folder or directory, but in the cloud and used for storage.
2. When files land in the bucket, a job queue is notified to keep track of each bit of work. Each file gets its own message in the queue.
3. When work is waiting in the queue, an alarm will trigger the AutoScaling group to create EC2 machines (C5 blocks in the diagram that are created based on a public AMI provided by ASF) to do the work.
    a. One EC2 machine will process one file waiting in the queue, creating an RTC product from the file in the input bucket.
4. As RTC products are created, they are stored in the S3 **Output Bucket**, where you can then download them.

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C) Materials List

1. The *s1_rtc_cloudformation_OpenSource east_v0.txt* file
2. Go to Vertex (https://search.asf.alaska.edu) and download a Sentinel-1 GRDH product, or click on this link to download a sample image:
   S1B_IW_GRDH_1SDV_20180417T161803_20180417T161817_010525_01330D_7E38

   Note: This recipe will work with Sentinel-1 GRDH data *except for data located above 60 degrees latitude*. You can also process more than one GRDH product at a time.

D) Steps for Applying RTC

Creating the CloudFormation Stack

This first setup deploys the *Sentinel-1 RTC CloudFormation Stack*. A stack is a collection of AWS resources that you can manage as a single unit. When you are done creating the stack, you will be ready to apply RTC to the Sentinel-1 GRDH image.

1. Make sure you are in the **US East (N. Virginia)** region (upper right of the page near your name).

2. Click on the **Services** at the upper left of the page and type “cloudformation” (without quotes) in the search bar, then click <Enter>

3. From the CloudFormation Stacks page, click on <Create Stack>

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4. Under **Choose a template**, click on the <CHOOSE FILE> button

   a. Navigate to and highlight the *s1_rtc_cloudformation_OpenSource east_v0.txt* file

   b. Click <OPEN> or <Choose> to select this file

   c. Click on the <NEXT> button in lower right-hand corner

5. Parameters page

   a. Name your stack:

      i. Use this format for this tutorial: YOURLASTNAME-

         - For example, a person named Mary Smith would be: SMITH-

Note: The hyphen at the end of your name is important!

   b. Select a **KeyName**

      i. *Navigate to and select the private key .pem file created with your EC2 Instance by using the search bar and drop down menu.*

   c. Select a **SecurityGroup**

      i. *Select the security group created with your EC2 Instance using the next search bar and drop down menu.*

   d. For **SNSTopicUser** enter your email address in place of “email@domain.com”

   e. Select one or more **Subnets**

      i. *Select the subnet(s) created with your EC2 Instance using the search bar and drop down menu.*

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Note: If you have many subnets, click the first three

f. Click on <NEXT> button in lower right-hand corner

6. Options page

   a. Leave the default settings (don't change anything)

   b. Scroll to the bottom and click on the <NEXT> button in lower right-hand corner

7. Review page

   a. Scroll down and check the box next to: *I acknowledge that AWS CloudFormation might create IAM resources.*

   b. Click the <CREATE> button in lower right-hand corner

The CloudFormation Stacks Page

In the CloudFormation Stacks page, you can see the stack that you created or are in the process of creating.

1. Select your MYLASTNAME- stack in the "Stack Name' column

2. Click on the **Events** tab (below the Stack Name list). Click the <Refresh> button to see the *CloudFormation* stack creation steps during the deployment

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3. Wait for the stack to have the status CREATE_COMPLETE

   Note: If the status is ROLLBACK_COMPLETE then the *CloudFormation* template ran into an error. You can scroll through the Events tab to see what happened. If you see an error about a resource that "did not stabilize", then wait an hour or so and try again. This is a transient error with AWS that will eventually clear up.

   Important: Check your email Inbox – you should receive an email from AWS for a subscription to *CloudWatch* notifications. Click the Confirm subscription link and you will receive email notifications when your stack grows (adds EC2 Instances to do work) and shrinks (removes EC2 Instances when work is completed).

Process RTC using the CloudFormation Stack

In this section, you will upload a Sentinel-1 GRDH file to your Input bucket, automatically begin RTC processing, and download the finished product from your Output bucket. While the example shows you processing a single file, you can drop many files into the Input bucket and they will process in parallel automatically.

1. Once your Stack creation is complete, click on **Services** at the top of the page and type "S3" in the search bar and click on "S3 – Scalable Storage in the Cloud"

2. On the **Amazon S3** page, look for two bucket names that are prefixed with your LASTNAME-. You should see:

   a. An **Input Bucket** (bucket name: LASTNAME-s3s1rtcinput-) where configuration files, workflows, and the Sentinel-1 file to be processed are stored

   b. An **Output Bucket** (bucket name: LASTNAME-s3s1rtcoutput-) where the final processed product will be stored

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3. Click on your Input bucket to see what objects are in that bucket

   a. At first, you should have no objects in this bucket, but it will eventually be populated by the series of files seen to the right.

4. To add a Sentinel-1 product to the Input bucket for RTC processing

   a. Click on the <UPLOAD> button.

   b. Click <ADD FILES> located in the center of the new window.

   c. In the file browser, navigate to and select the sample file for this tutorial, then click <OPEN> or <Choose>.

      i. Note that you can upload multiple files (by ctrl-clicking) to be processed

   d. Click <UPLOAD>

      ii. You can monitor the status of the upload using the progress bar at the bottom of the window.

5. In a few minutes, processing will automatically begin. You can watch the progress by checking the Output bucket. An intermediary file will be created for each step in the four-step processing workflow, but these intermediary files (with file extension .dim) will be automatically removed when processing is complete.

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Note: Processing was started by a *CloudWatch* alarm that was created during the *CloudFormation* stack creation. This alarm detects when a new file is added to the processing queue. Another alarm was created to detect when new Instances are created and terminated during processing. You can monitor the alarms by clicking on **Services** at the top of the page and typing “cloudwatch” in the search bar.

6. Check your Output bucket for the finished RTC product (with file extension *.tif*).

7. Click the checkbox next to the product to view file information and to <DOWNLOAD> the file to your computer.

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Cleaning up the Stack

When processing has completed and the RTC product has been downloaded, the stack can be deleted to prevent incurring any additional charges to your account.

Always remember to download the finished product files in your Output bucket BEFORE you delete the stack!

To delete the *CloudFormation* Stack

1. Empty the Input and Output buckets

   a. Click on **Services** at the top of the page, type “s3” in the search bar, then <Enter>

   b. Select the **Input** bucket by clicking on the icon next to the bucket name, then click the action “Empty Bucket”

   - Enter the bucket name (copy and paste) in the “Type the name of the bucket to confirm” box and click <CONFIRM>

   c. Make sure the Input bucket is still selected, then click the action “Delete bucket”

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- Enter the bucket name (copy & paste) in the “Type the name of the bucket to confirm deletion” dialog and click <CONFIRM>

d. Repeat steps b and c for the **Output** bucket

2. Click on Services at the top of the page, type “cloudformation” in the search bar, then <Enter>

a. In the *CloudFormation Stacks* page, you will see all of your deployed stacks

b. Select the YOURLASTNAME- stack

c. Click on <ACTIONS>, then select Delete Stack

- A Delete Stack warning is displayed
- Verify the stack name, then click the <Yes, Delete> button

3. Monitor stack deletion progress by clicking on the “Events” tab, then the <Refresh> button

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4. When the stack disappears from the Stack Name list, the deletion is complete.

   Note: You can always redeploy the stack using the Template and run additional processing at any time. So don't worry if you deploy, then delete, then redeploy this template many times. That is the intent of the template.

   Important: If you keep files in an S3 bucket, you will be charged a monthly fee for storing them!

E) Estimated Cost

- Processing one file costs approximately $0.12 and takes about 20-30 minutes

Downloaded .tif file imported and viewed (Gamma0_VH band) in the Sentinel-1 Toolbox.

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