Provenance-enabled Automatic Data Publication

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From The Times

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Unrecognised Leonardo da Vinci portrait revealed by his fingerprint

Provenance: motivation

- At the toolbar (menu, whatever) associated with a document there is a button marked "Oh, yeah?". You press it when you lose that feeling of trust. It says to the Web, "so how do I know I can trust this information?"

...

The result of pressing on the "Oh, yeah?" button is either a list of assumptions on which the trust is based, or of course an error message indicating either that a signature has failed, or that the system couldn't find a path of trust from you to the page.

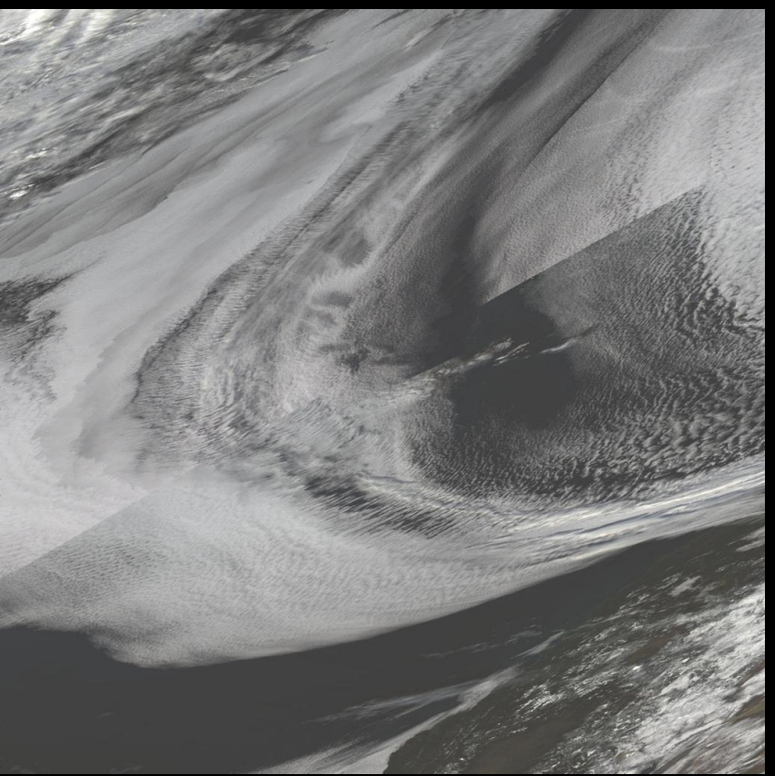
- —Tim Berners-Lee (1995)

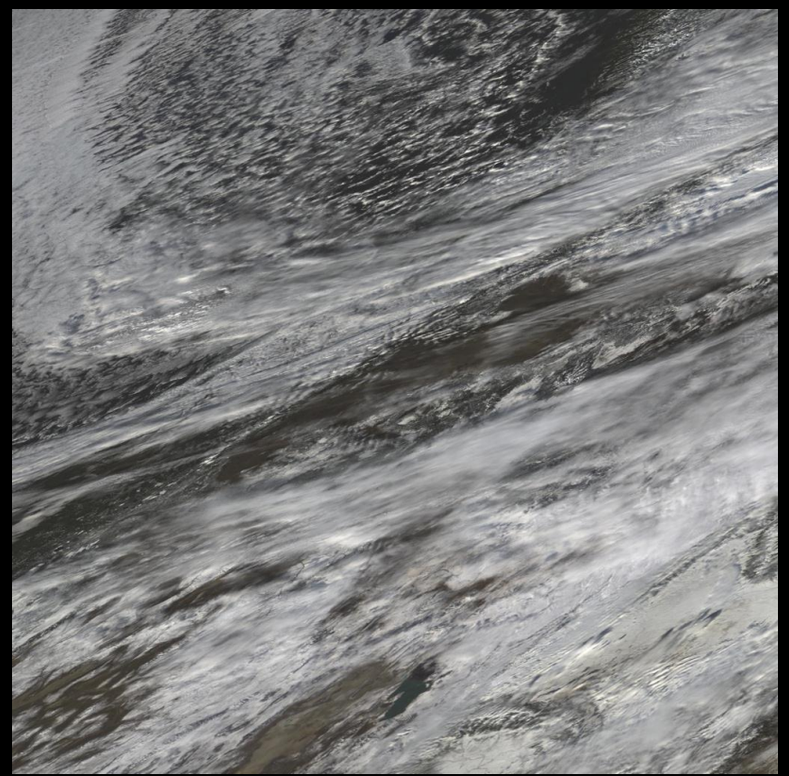
Provenance: “working’ definition

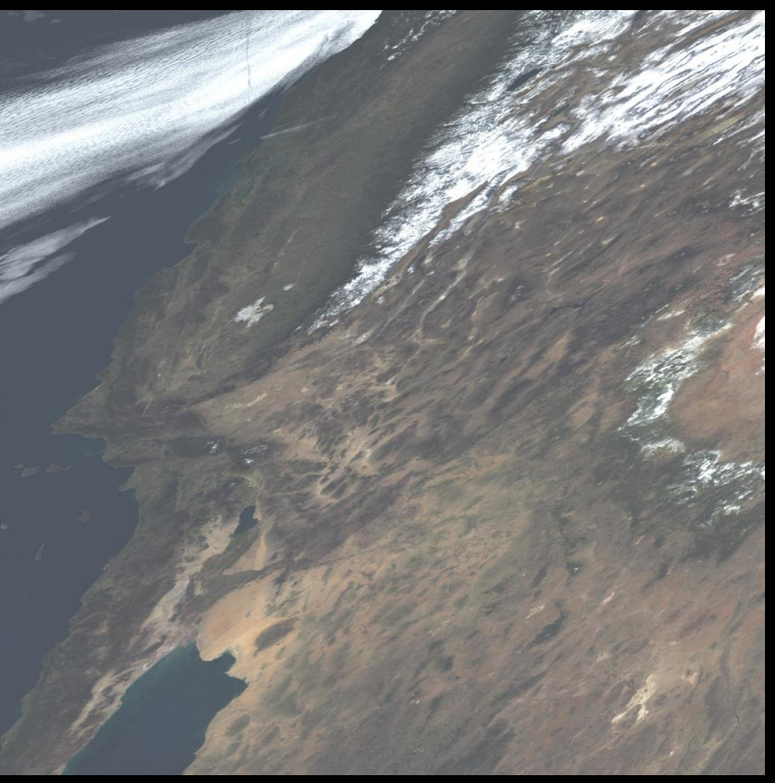
- **Provenance of a resource is a record that describes entities and processes involved in producing and delivering or otherwise influencing that resource.** Provenance provides a critical foundation for assessing authenticity, enabling trust, and allowing reproducibility. Provenance assertions are a form of contextual metadata and can themselves become important records with their own provenance.

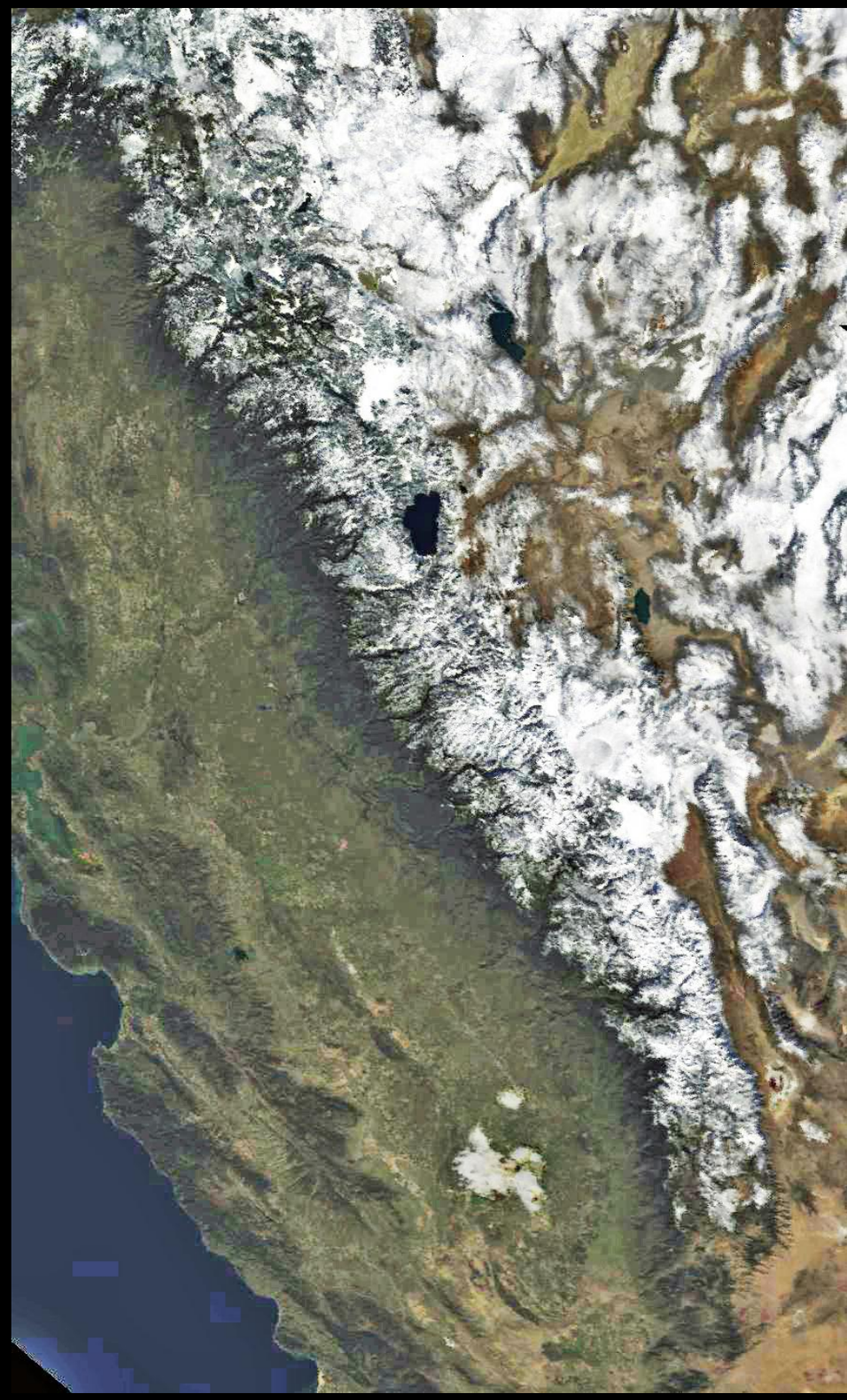
—W3C Provenance Incubator Group (2010)

from 50 Kft
to
0.5 ft









mosaic.sh:

```
  mosaicFn="MOD09GA.A2008019.sn.005.hdf"  mrtmosaic -i
tile.lis -o $mosaicFn  resample -p MRT.prm -g MRT.log
```

tile.lis:

```
  MOD09GA.A2008019.h08v04.005.2008022125449.hdf
MOD09GA.A2008019.h08v05.005.2008022134646.hdf
MOD09GA.A2008019.h09v04.005.2008022151755.hdf
```

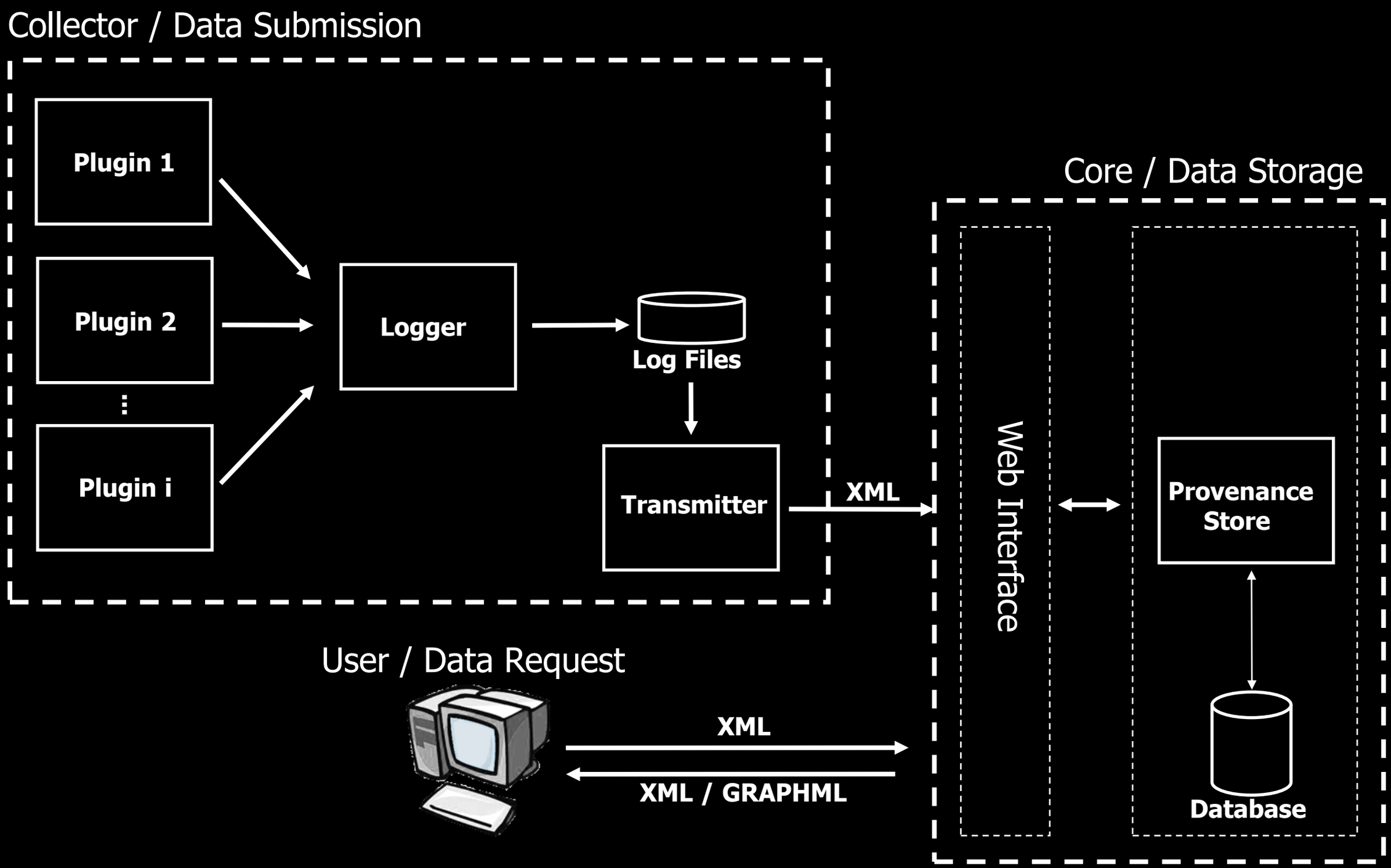
MRT.prm:

```
  INPUT_FILENAME=./MOD09GA.A2008019.sn.005.hdf
SPATIAL_SUBSET_TYPE=INPUT_LAT_LONG
SPATIAL_SUBSET_UL_CORNER=(41.5000 -122.4000)
SPATIAL_SUBSET_LR_CORNER=(35.0000 -117.6000)
OUTPUT_FILENAME=MOD09GA.A2008019.sn_cal-aea.005.Refl.hdf
RESAMPLING_TYPE=NN  OUTPUT_PROJECTION_TYPE=AEA  DATUM=WGS84
OUTPUT_PROJECTION_PARAMETERS=(0.0 0.0 34.00 40.50 -120.00 \
    0.00 0.00 -4000000.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00)
OUTPUT_PIXEL_SIZE=500  SPECTRAL_SUBSET=(0 0 0 0 0 0 0 0 0 0 1
1 1 1 1 1 1 0 0 0)
```

provenance in ES3

- input file(s) → process → output file(s)
- collected automatically by tracing
  - process creation
  - program execution
  - filesystem I/O

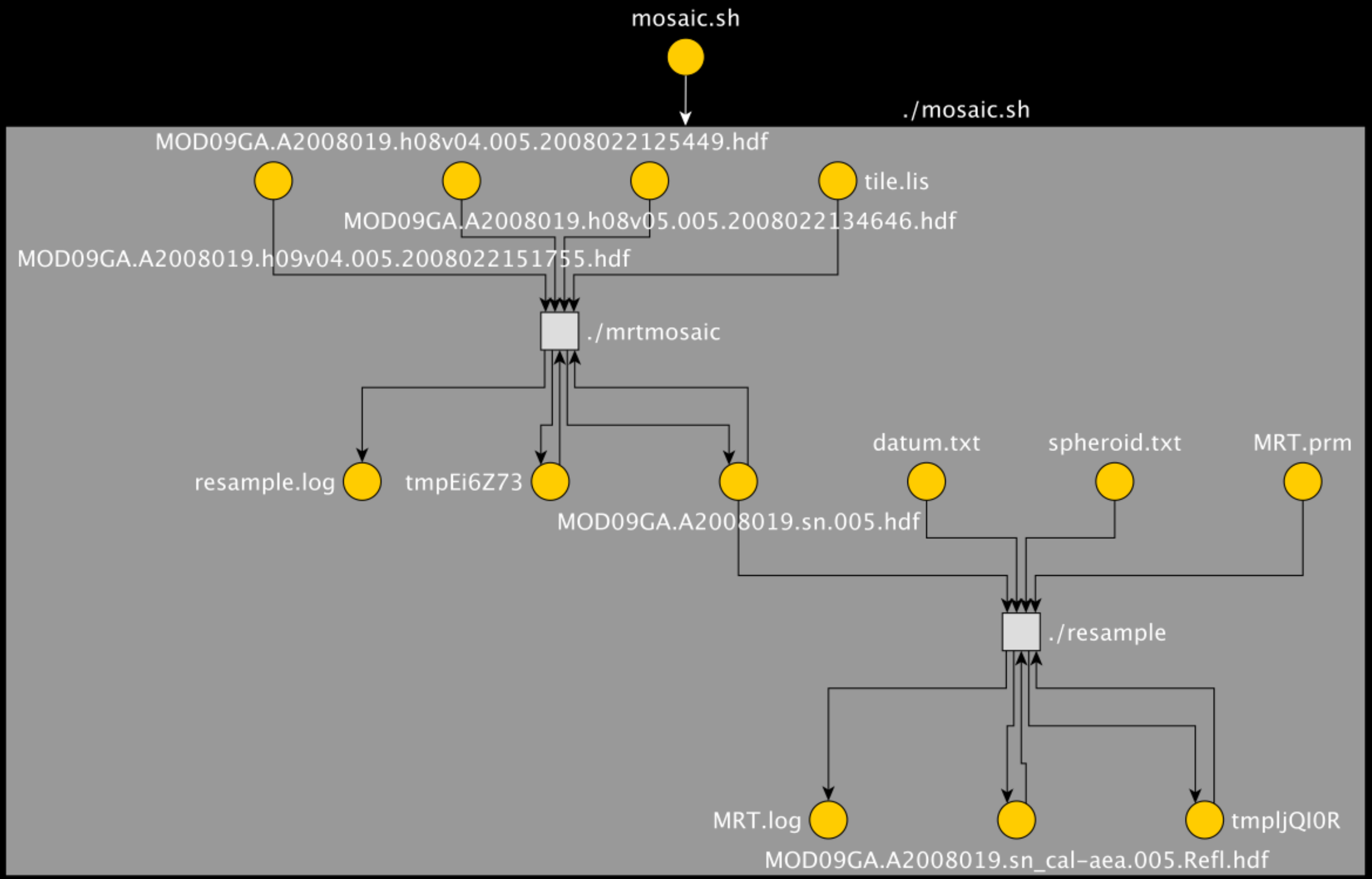
ES3 architecture

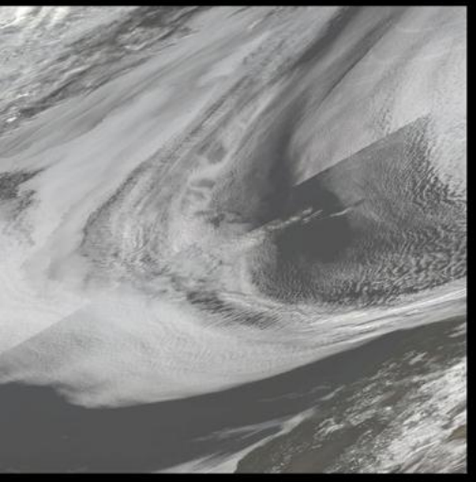


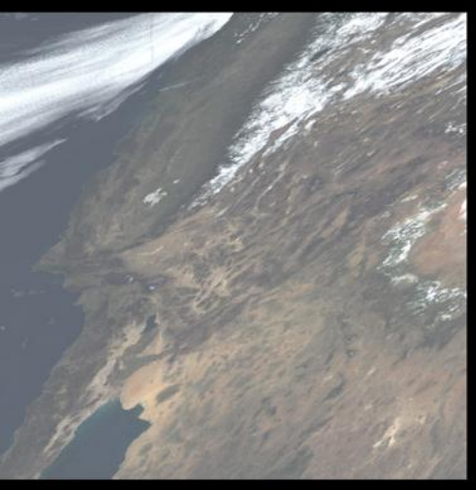
```
4810  1213121515.708913 execve("./mosaic.sh", ["mosaic.sh"], [...]) = 0...4810
1213121515.712317 open("/lib/libc.so.6", O_RDONLY) = 3...4810  1213121515.717415
open("./mosaic.sh", O_RDONLY|O_LARGEFILE) = 34810  1213121520.732852 clone(...) = 48304830
1213121520.735487 execve("./mrtmosaic", \
         ["mrtmosaic", "-i", "tile.lis", "-o", "MOD09GA.A2008019.sn.005.hdf"], [...]) = 04830
1213121520.768912 open("tmpEi6Z73", O_WRONLY|O_CREAT|O_TRUNC, 0666) = 34830  1213121520.769899
open("tile.lis", O_RDONLY) = 34830  1213121521.159965
open("MOD09GA.A2008019.h08v04.005.2008022125449.hdf", O_RDONLY) = 44830  1213121521.290125
open("MOD09GA.A2008019.h08v05.005.2008022134646.hdf", O_RDONLY) = 44830  1213121521.715161
open("MOD09GA.A2008019.h09v04.005.2008022151755.hdf", O_RDONLY) = 44830  1213121689.009340
open("tmpEi6Z73", O_WRONLY|O_CREAT|O_APPEND, 0666) = 44830  1213121522.161875
open("MOD09GA.A2008019.sn.005.hdf", O_RDWR|O_CREAT|O_TRUNC, 0666) = 44830  1213121689.010752
open("resample.log", O_WRONLY|O_CREAT|O_APPEND, 0666) = 44830  1213121689.071644 exit_group(0)
= ?4810  1213121689.299345 clone(...) = 49044904  1213121689.301804 execve("./resample", \
         ["resample", "-p", "MRT.prm", "-g", "MRT.log"], [...]) = 04904  1213121689.654760
open("tmpljQI0R", O_WRONLY|O_CREAT|O_APPEND, 0666) = 34904  1213121689.657942 open("MRT.prm",
O_RDONLY) = 34904  1213121689.864752 open("./MOD09GA.A2008019.sn.005.hdf", O_RDONLY) = 34904
1213121690.623884 open("MOD09GA.A2008019.sn_cal-aea.005.Refl.hdf", \
         O_RDWR|O_CREAT|O_TRUNC, 0666) = 44904  1213121714.410092 open("MRT.log",
O_WRONLY|O_CREAT|O_APPEND, 0666) = 34904  1213121714.457637 open("MOD09GA.A2008019.sn_cal-
aea.005.Refl.hdf", O_RDONLY) = 34904  1213121714.458947 open("MOD09GA.A2008019.sn_cal-
aea.005.Refl.hdf", O_RDWR) = 34904  1213121714.463607 open("./MOD09GA.A2008019.sn.005.hdf",
O_RDONLY) = 44810  1213121714.615284 exit_group(0)   = ?
```

```
<init time="20080610T181514Z" stime="20080610T181155.707233Z"
      pstime="20080610T181155.707233Z" pid="4783" ppid="4783" language="bash"
      user="peter" hostname="localhost.localdomain"></init><exec
time="20080610T181515Z" routine="./mosaic.sh" pid="4810">  <arguments>  </arguments>
<io>    <pipe read="true" id="std-in"/>    <pipe write="true" id="std-out"/>
<pipe write="true" id="std-err"/>    <file read="true">/etc/ld.so.cache</file>
<file read="true">/lib/libtermcap.so.2</file>    <file
read="true">/lib/libdl.so.2</file>    <file read="true">/lib/libc.so.6</file>
<file read="true" write="true">/dev/tty</file>    <file
read="true">/usr/lib/locale/locale-archive</file>    <file
read="true">/proc/meminfo</file>    <file read="true">/usr/lib/gconv/gconv-
modules.cache</file>    <file
read="true">/home/peter/Test/ES3/RegressionTests/MODSCAG/mosaic.sh</file>
</io></exec>
```

```
<ES3Request type="storeTransformation">  <transformation>
<timestamp type="execution">20080610T181515Z</timestamp>
<provenance>      <link>        <type>1/0</type>
<fromUuid>
          7af82a69-fa7a-4aec-abdf-eb009f5e2cab
        </fromUuid>      </link>    </provenance>
<collection>/default</collection>    <workflowUuid>
      b2189b33-349c-434d-bf73-3f8817dccbd5
    </workflowUuid>    <containsWorkflowUuid>
      2c4310db-4949-4fab-a82e-1282432257c3
    </containsWorkflowUuid>    <uuid>197dc9ee-3dbf-447b-
871a-e11a0288a7ba</uuid>    <name>./mosaic.sh</name>
</transformation></ES3Request>
```


mosaic.sh
./mosaic.sh
MOD09GA.A2008019.h08v04.005.2008022125449.hdf
tile.lis
MOD09GA.A2008019.h08v05.005.2008022134646.hdf
MOD09GA.A2008019.h09v04.005.2008022151755.hdf
./mrtmosaic
resample.log
tmpEi6Z73
datum.txt
spheroid.txt
MRT.prm
MOD09GA.A2008019.sn.005.hdf
./resample
MRT.log
tmpljQI0R
MOD09GA.A2008019.sn_cal-aea.005.Refl.hdf





mosaic.sh:

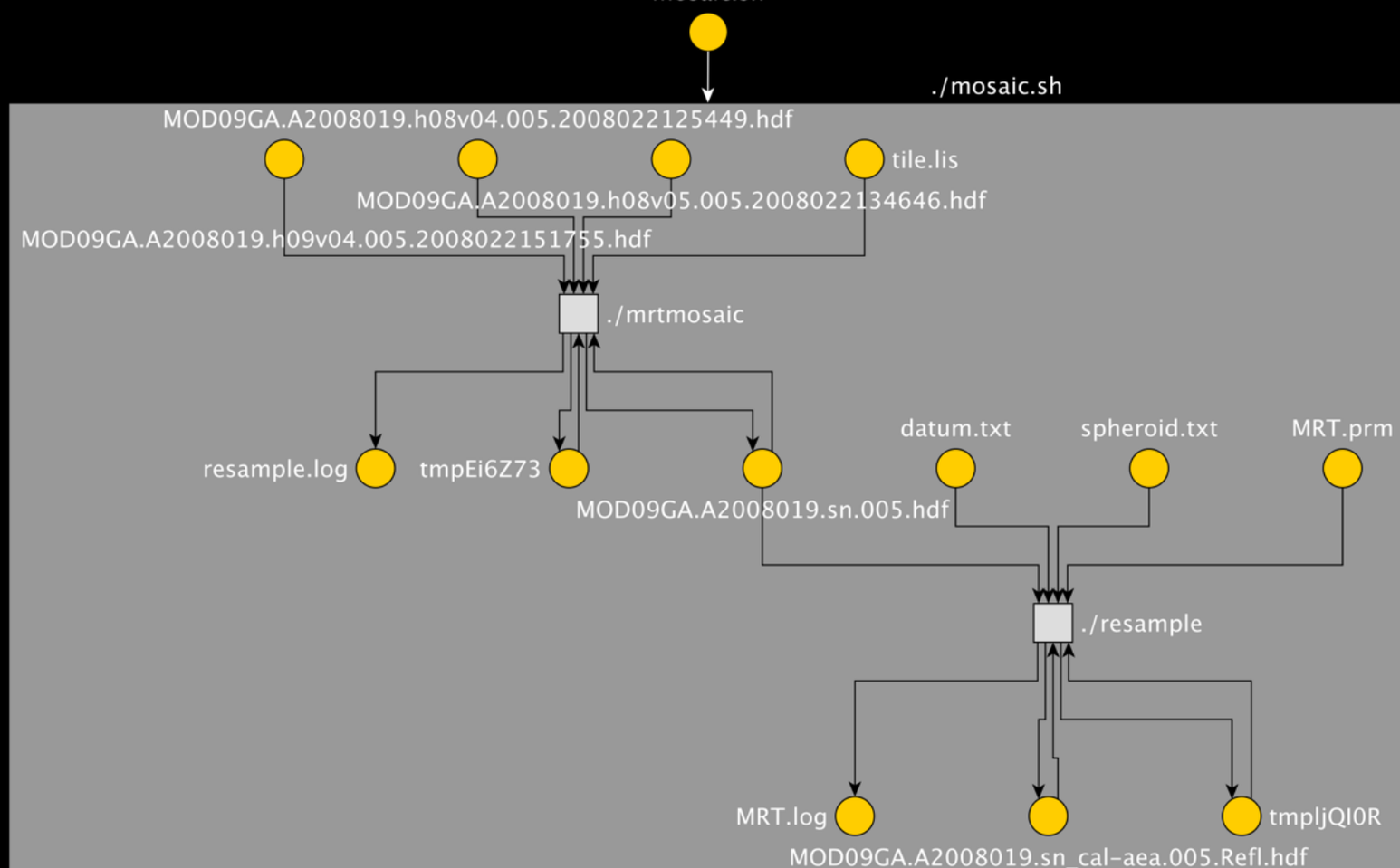
```
mosaicFn="MOD09GA.A2008019.sn.005.hdf"
mrtmosaic -i tile.lis -o $mosaicFn
resample -p MRT.prm -g MRT.log
```

tile.lis:

```
MOD09GA.A2008019.h08v04.005.2008022125449.hdf
MOD09GA.A2008019.h08v05.005.2008022134646.hdf
MOD09GA.A2008019.h09v04.005.2008022151755.hdf
```

MRT.prm:

```
INPUT_FILENAME=.
SPATIAL_SUBSET_T
SPATIAL_SUBSET_U
SPATIAL_SUBSET_L
OUTPUT_FILENAME=
RESAMPLING_TYPE=
OUTPUT_PROJECTIO
DATUM=WGS84
OUTPUT_PROJECTIO
  0.00 0.00 -400
OUTPUT_PIXEL_SIZ
SPECTRAL_SUBSET=
```



data publication

- evaluate object's antecedents against publication assertions
- if antecedents justify publication, then object is publishable

“publish” tool

- retrieve object’s provenance
- traverse depth-first
- foreach antecedent
  - automatically endorse if assertion valid
  - else manually endorse
- save endorsements in provenance graph

automatic endorsement

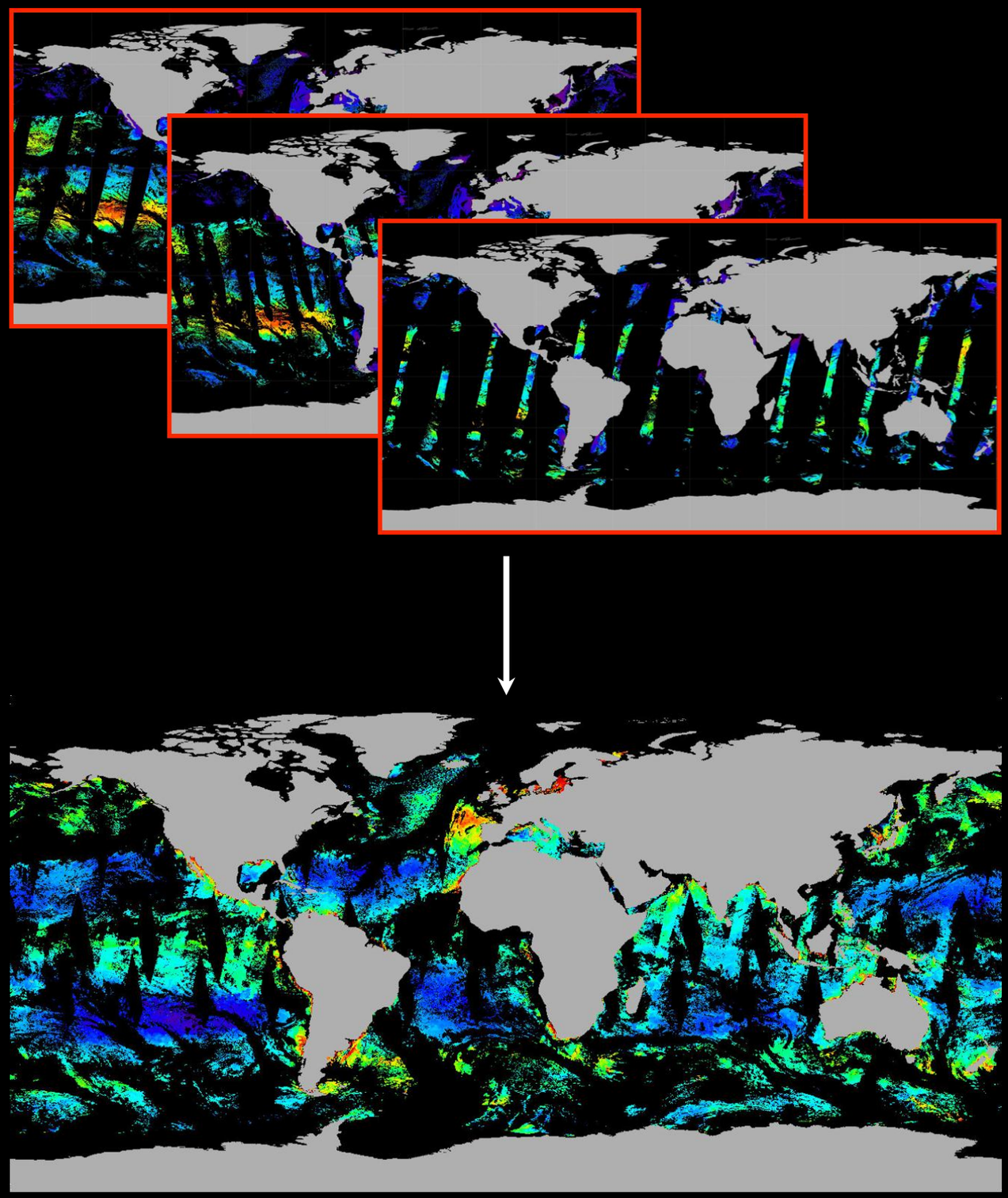
- filename patterns
  - if matches a `glob` expression
- version control
  - if == a committed version in a repository
- transitivity
  - if all antecedents are endorsed

manual endorsement

- endorse
  - optional comment
- ignore
  - object is irrelevant
- skip
  - punt for now

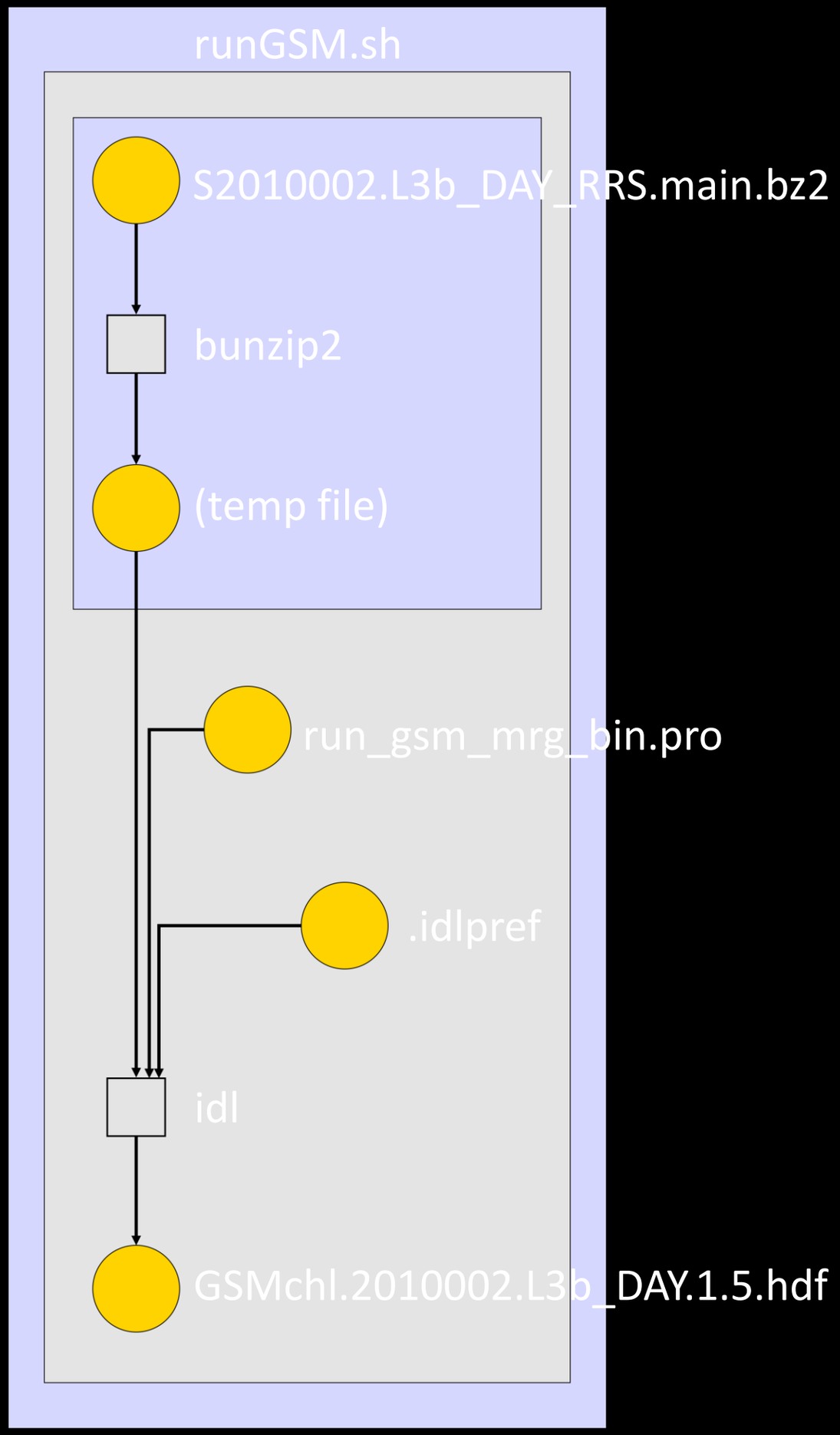
example

- ocean color algorithm



example

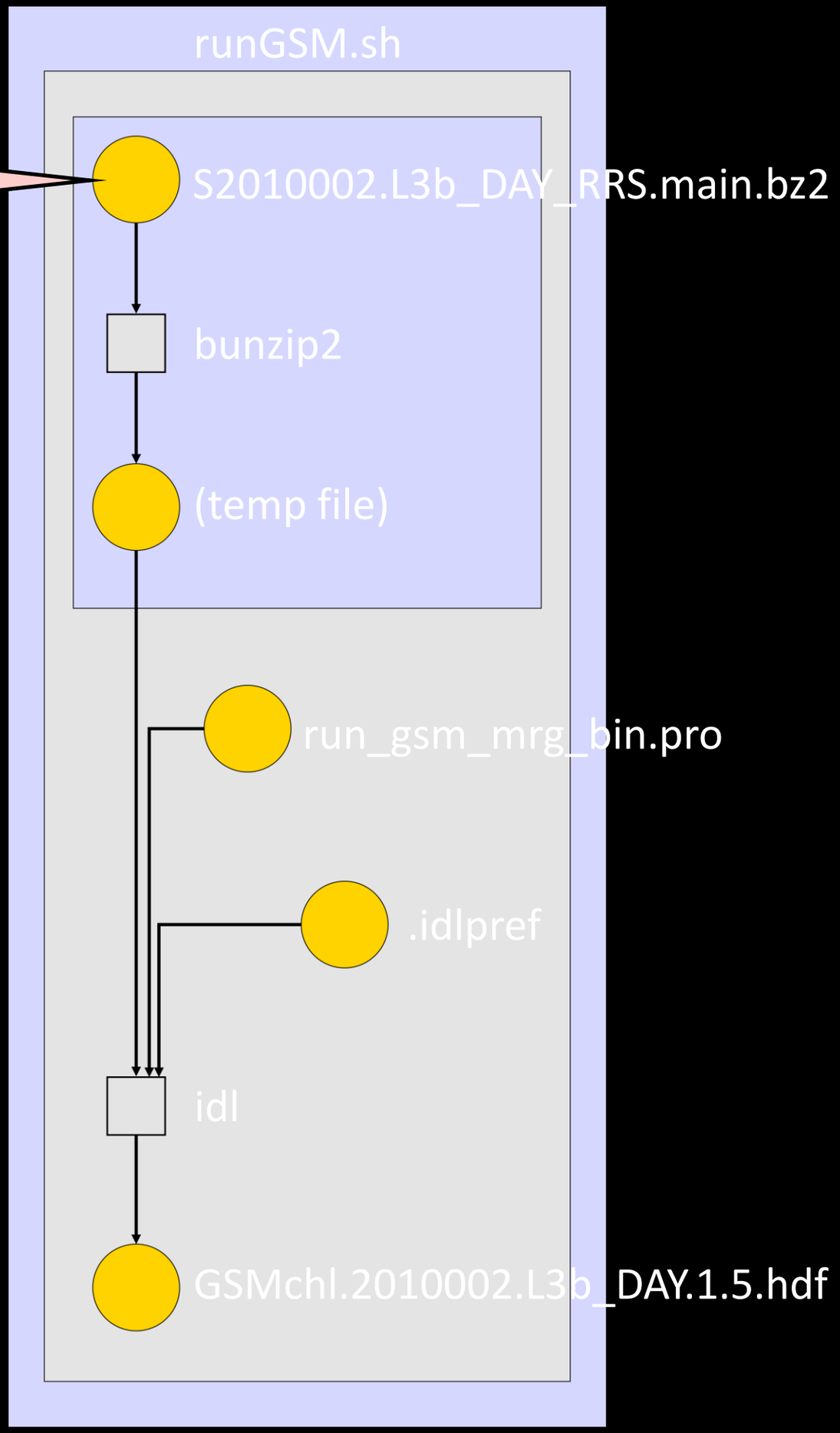
- ocean color algorithm
- provenance captured by ES3; rendered as dataflow graph
- now, let's *publish*→



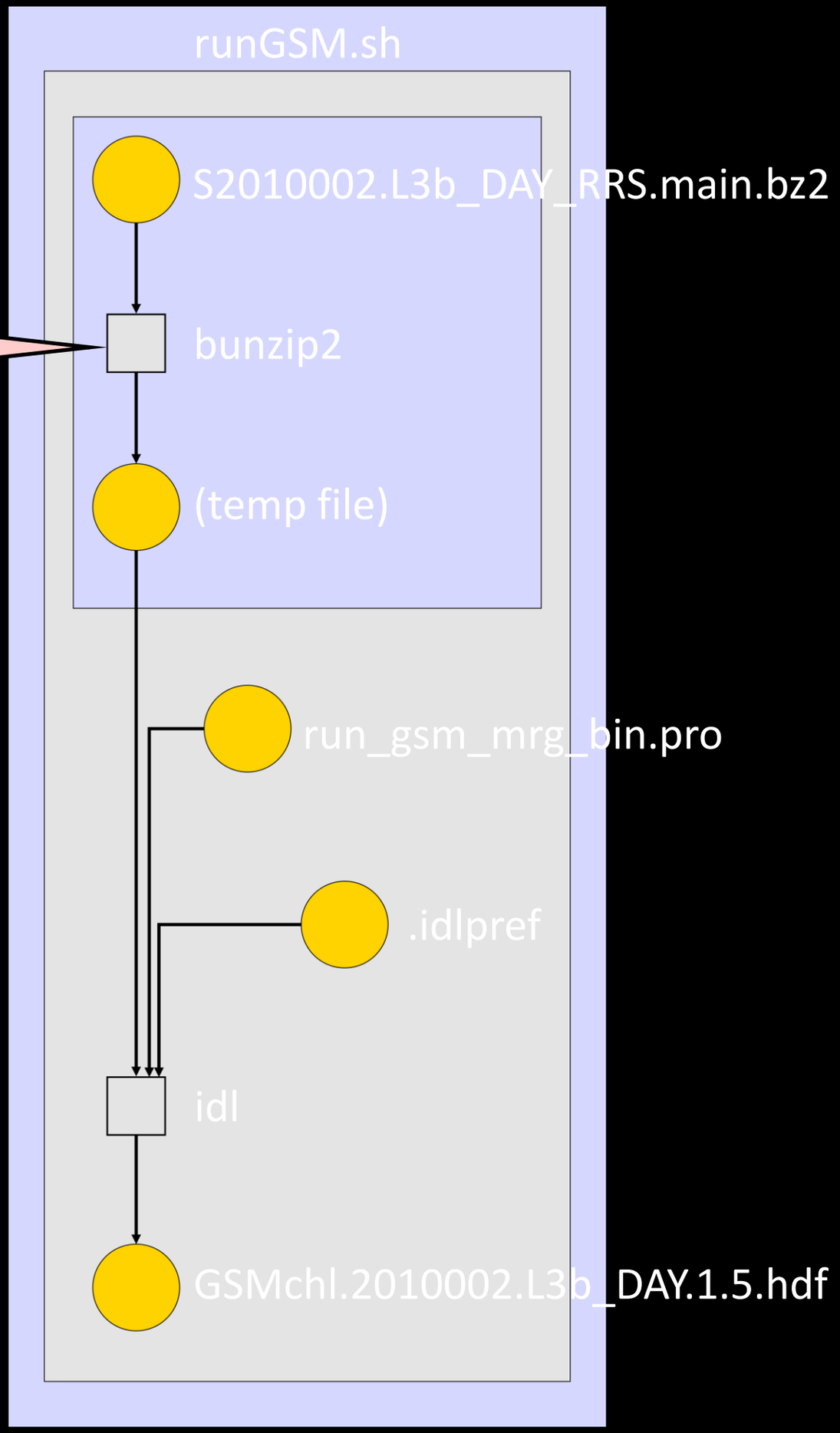
Endorsed by: glob rule: `*/data/*.bz2`

Annotation: SeaWiFS reprocessing 5.2

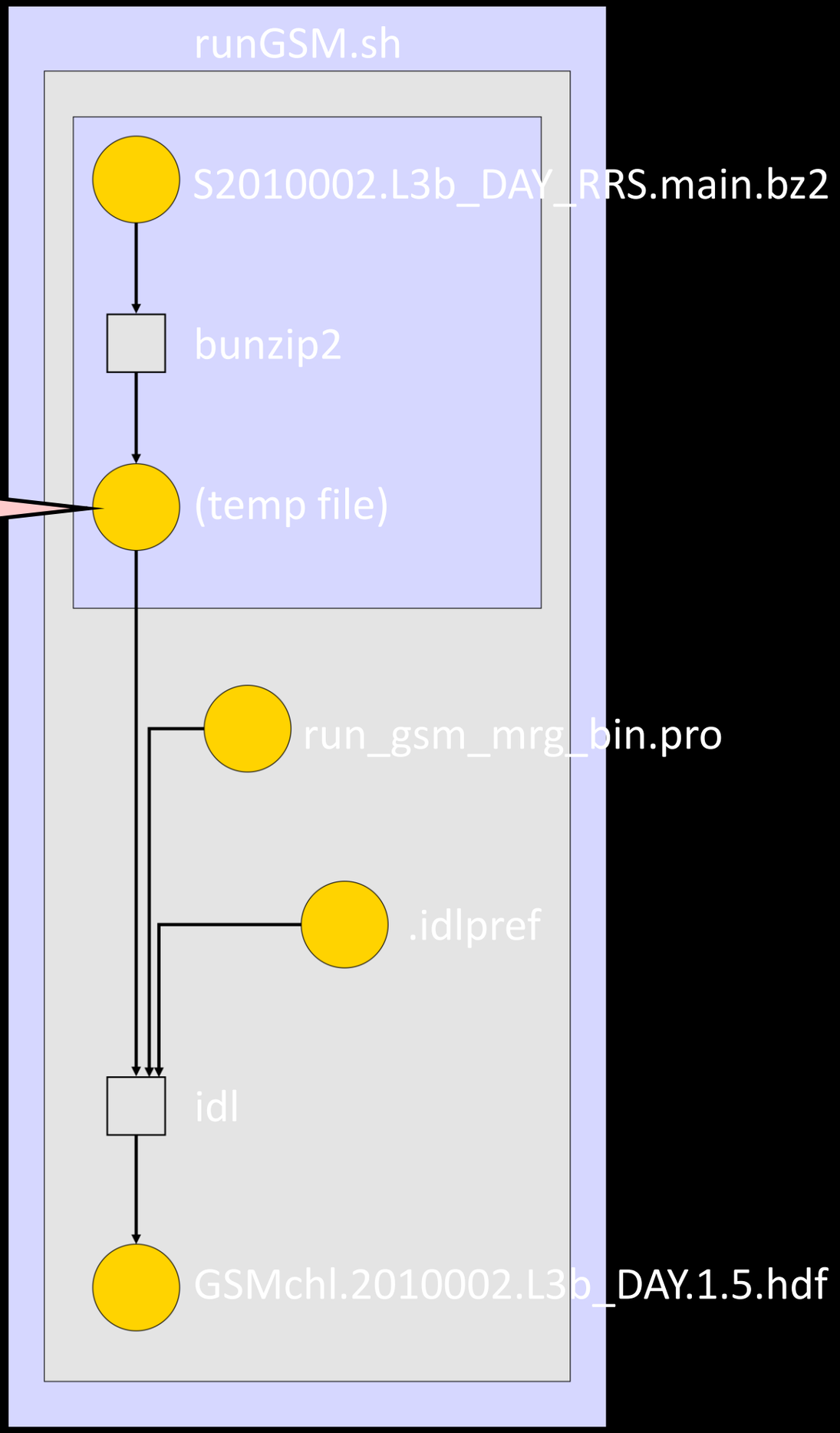
Assertion check: file (at time referenced) was unchanged since rule creation (failed assertion may indicate annotation is incorrect)



Endorsed by: glob rule: `/usr/bin/*`
Annotation: operating system tool
Assertion check: (none)



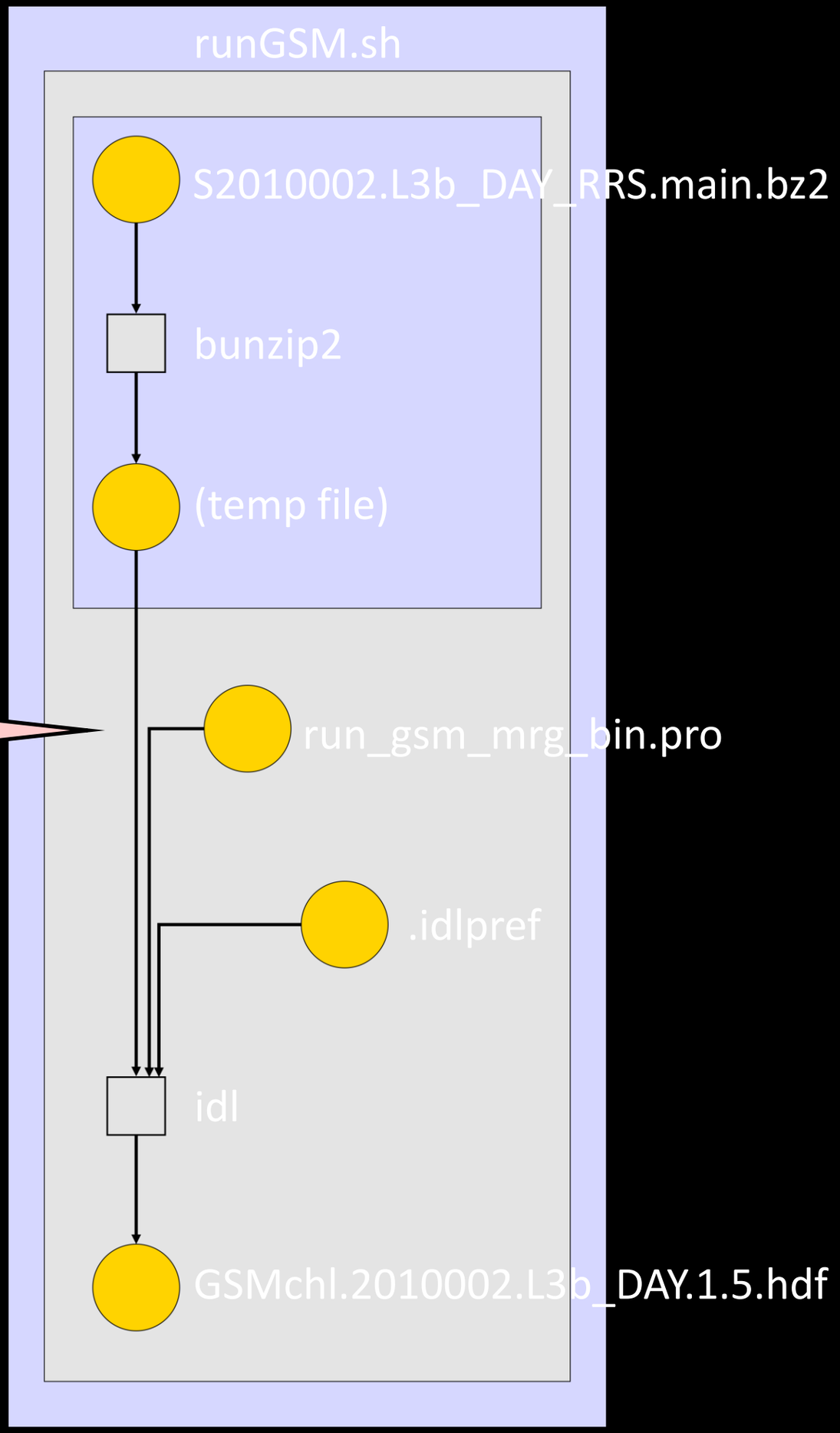
Endorsed by: transitivity

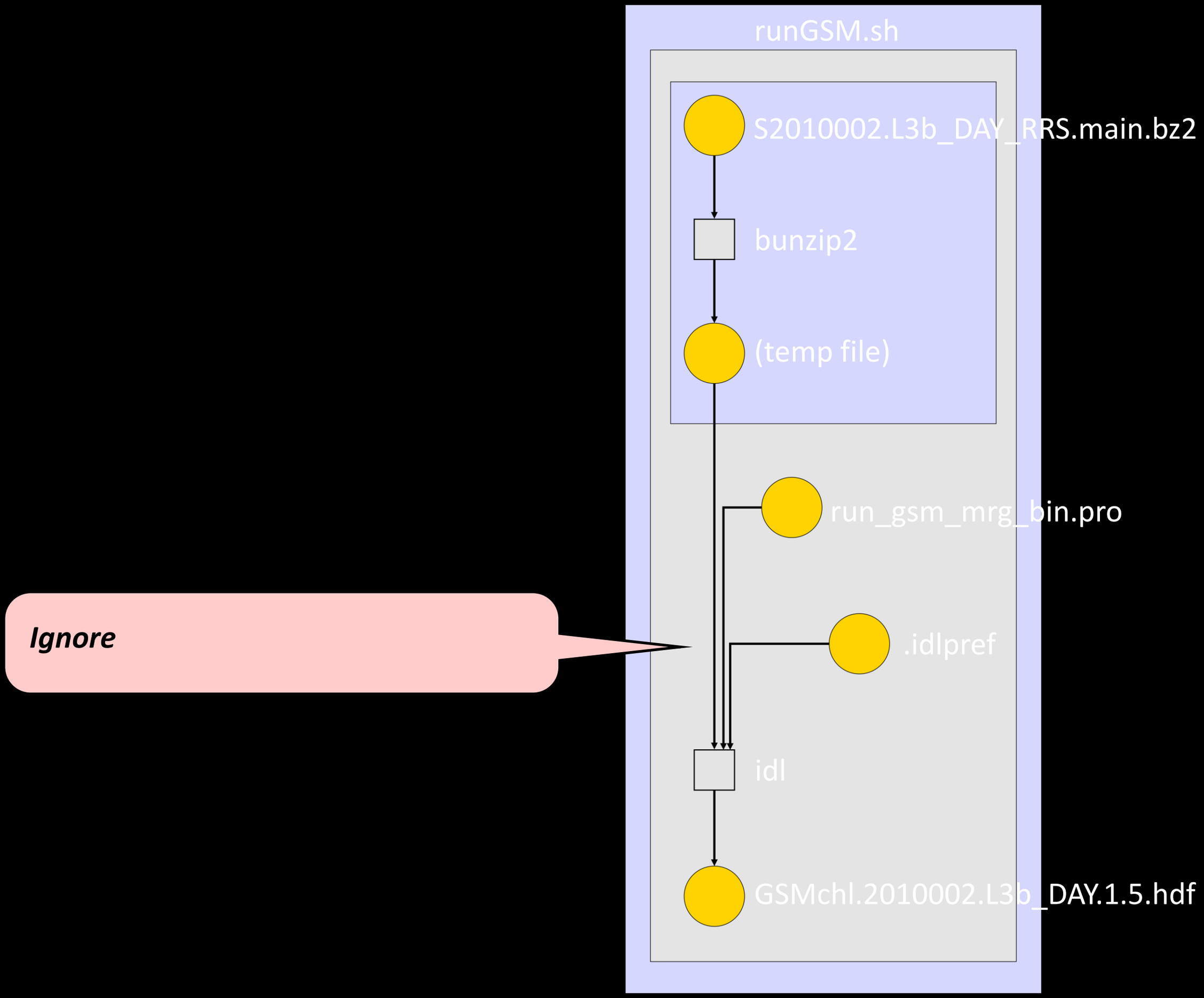


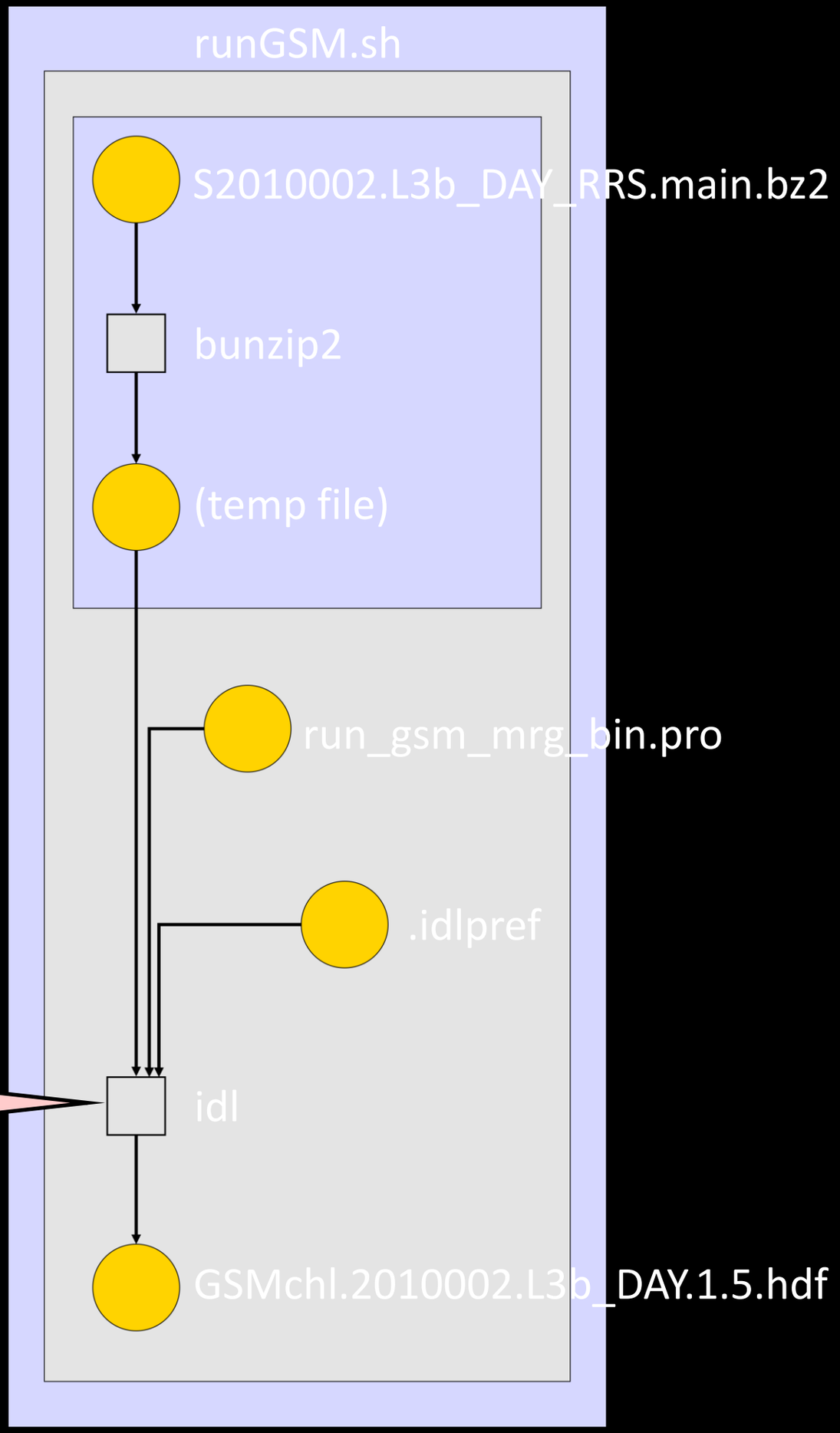
Endorsed by: version control system rule

Annotation: GSMS

Assertion check: file (at time referenced) corresponded to committed version (failed assertion may indicate uncommitted code was used)



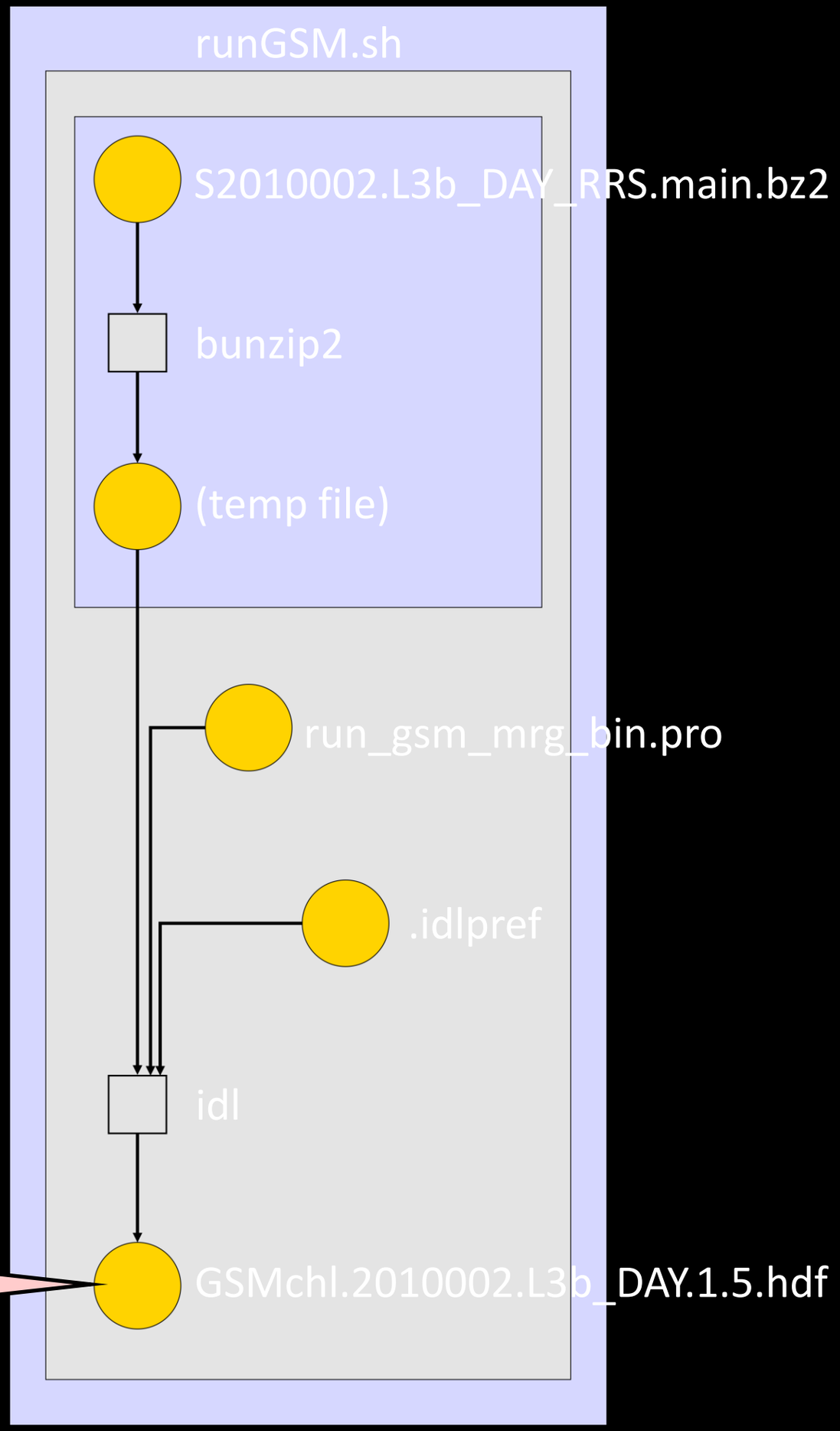

runGSM.sh
S2010002.L3b_DAY_RRS.main.bz2
bunzip2
(temp file)
run_gsm_mrg_bin.pro
.idlpref
idl
GSMchl.2010002.L3b_DAY.1.5.hdf
Ignore



Endorsed by: glob rule: `/itt/idl/*`

Annotation: IDL 8.0

Assertion check: file (at time referenced) was unchanged since rule creation (failed assertion may indicate annotation is incorrect)



Endorsed by: transitivity

issues & next steps

- granularity
  - read/write file → provenance graph cycle
- compilation
  - versioned source vs. executed binary
- distributed version control
  - single “version” in multiple changesets

Thanks!