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BEAM PROGRAMMING TUTORIAL

How to use BEAM in your own programs and how to extend the platform



Sentinel-3 OLCI/SLSTR & MERIS/(A)ATSR Workshop, ESRIN, Oct 2012

Overview

- Introduction to the BEAM Software (15 min)
- Exercise 1:

Generate a quicklook from MERIS L1b (15 min)

- Exercise 2: Compute FLH from MERIS L1b (30 min)
- Exercise 3: Integrated FLH tool extending BEAM (60 min)

BEAM Software Overview and Runtime Configuration

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Graphical User Interface - VISAT



4

Command-Line Interface - GPT

 BEAM Command Line T-target>=<file> Defines a target product. Valid for graphs only. <target> must be the identifier of a node in the graph. The node's output will be written to <file>.</file></target></file> -S<source/>=<file> Defines a source product. <cource> is specified by the operator or the graph. In an XML graph, all occurrences of S{source>} will be replaced with references to a source product located at <file>.</file></cource></file> -P<name>=<value> Defines a processing parameter, cname> is specific for the used operator or graph. In an XML graph, all occurrences of S{cname>} will be replaced with value>. Overwrites parameter values specified by the '-p' option.</value></name> Operators: Aatsr.SST BandMaths Create a product with one or more bands using mathematical expressions. Performs spatial and temporal aggregation of pixel values into 'bin' cells Collocate two products based on their geo-codings. Merige ClusterAnalysis Performs an expectation-maximization (EM) cluster analysis. Performs a expectation=maximization (EM) cluster analysis. Performs to ALMoxy copying raster data from any number of source products to a specified tt. Meris.Exr Meris.Case2Regional Meris.Lakes Compute the BRR of a MERIS Llb product. Performs IOP retrieval on Llb MERIS products. Including atmospheric correction Performs IOP retrieval on turing an mospheric correction Performs IOP retrieval for eutrophic and boreal Lakes on Llb MERIS products. Read Reproject Reads a product from disk. Reproject Reads a product from disk. Reproject Reads a product from disk. Reproject Reads a product to a target Coordinate Reference System. Create a spatial and/or spectral subset of a data product. Writes a data product to a tile. Writes data product to a tile. Write Writes data product to a tile. 	~		
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Write Writes a data product to a file. glint.Flint Flint Processor.		Operators: Aatsr.SST BandMaths Binning Collocate EMClusterAnalysis FlhMci KMeansClusterAnalys Merge ct. Meris.Brr Meris.Case2Regional Meris.CorrectRadiom Meris.GlintCorrection Meris.Lakes spheric correction. Meris.N1Patcher Mosaic PixEx Read Reproject Subset	Computes sea surface temperature (SST) from (A)ATSR products. Create a product with one or more bands using mathematical expressions. Performs spatial and temporal aggregation of pixel values into 'bin' cells Collocates two products based on their geo-codings. Performs an expectation-maximization (EM) cluster analysis. Computes fluorescence line height (FLH) or maximum chlorophyll index (MCI). Performs a K-Means cluster analysis. Allows copying raster data from any number of source products to a specified Compute the BRR of a MERIS L1b product. Performs IOP retrieval on L1b MERIS products, including atmospheric correction MERIS atmospheric corrections on MERIS L1b data products. MERIS atmospheric correction using a neural net. Performs IOP retrieval for eutrophic and boreal Lakes on L1b MERIS products, Copies an existing N1 file and replaces the data for the radiance bands Creates a mosaic out of a set of source products. Extracts pixels from given locations and source products. Reads a product from disk. Reprojection of a source product to a target Coordinate Reference System. Create a spatial and/or spectral subset of a data product.
		Write glint.Flint	Writes a data product to a file. Flint Processor.

BEAM Installation Directory

- beam-4.10.x
 - bin
 - □ lib
 - modules
 - config
 - beam.config

BEAM 's home directory Application executables Common, 3rd -party libraries Application and plug-in modules Application configuration file(s)

Why develop with BEAM?

- Access EO raster data, metadata, no-data, flags, ...
- Simple and effective programming models
- Reuse a rich software infrastructure
- It is free, it is open source
- It is widely used
- It is very well tested
- It is supported by ESA, used by NASA





BEAM Development Use Cases

1. Use or embed BEAM

- Write batch-mode scripts
- Program stand-alone applications
- Develop web-services

2. Extend BEAM

- Add EO data readers, writers
- Add EO data processing nodes
- Add map projections, DEMs
- Add VISAT actions, tool bars and tool windows

3. Clone BEAM

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Customize and brand VISAT

Architecture and Application Programming Interfaces

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Architecture Overview





Module-based Architecture

- BEAM module:
 - Name
 - Description
 - Version
 - Authors
 - Changelog
 - Dependencies
 - Extension points
 - <u>Extensions</u>

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- Simple extension model:
 - Host module provides <u>extension point</u>, e.g. "product-reader"
 - Client module provides extension to host's <u>extension point</u>, e.g.

"seawifs-reader"

Clients can be hosts

VISAT Module Manager

🕂 Install 🔀 Update 📼 Uninstall	Clear	Filt	er category:	-
Installed Modules Module Updates	Available Modules			
Name	Version	State	Action	
CHRIS/Proba Product Reader	1.5-SNAPSHOT	Active		
Collocation	1.1	Active		
Envisat Product Reader	1.3-SNAPSHOT	Active		
ESRI Shapefile Reader	2.0	Active		
GeoTIFF Product Module	1.1-SNAPSHOT	Active		
GETASSE30 DEM Reader	1.0	Active		
HDF Library	2.3	Active		Ξ
HDF5 Product Writer	1.0	Active		
Landsat TM Product Reader	1.1.1	Active		
Level-3 Binning Processor	2.0.101	Active		
Level-3 Mosaic Processor	2.2.101	Active		
MERIS Boreal Lakes Processor	1.0.2	Active		
MERIS Case-2 Core Module	1.0	Active		T
Module Information				
Module description:				^
The Level 2 Division December	Alexandrea Alexandrea Alexandrea	a sea t and 0 aired		-
The Level-5 binning Processor	ustributes the contribution	s of a Level 2 pixel	s in satemite coordin	ates
to a fixed Level 3 grid using a g	eographic reference system	n.		
Changelog				-



Important Extension Points

- EO Data
 - Data processor plug-ins (GPF operators, Ex3)
 - Data product reader plug-ins
 - Data product writer plug-ins
- VISAT User Interface
 - VISAT actions
 - VISAT tool windows
 - VISAT branding

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Important system-level APIs

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Module beam-core *Commonly used classes* org.esa.beam.framework.datamodel Product Model API org.esa.beam.framework.dataio Data I/O API Module beam-gpf Graph processing framework org.esa.beam.framework.gpf GPF API org.esa.beam.framework.gpf.ui GPF user interface components Module beam-ui User interface org.esa.beam.framework.ui **UI** components Module beam-visat-rcp VISAT Rich Client Platform org.esa.beam.visat VISAT application comp. Module ceres-core Module runtime Module API, System utilities com.bc.ceres.core

Useful Links for Programmers

- Homepage <u>www.brockmann-consult.de/beam/</u>
- Programming tutorial <u>www.brockmann-consult.de/beam/wiki</u>
- Software downloads <u>www.brockmann-consult.de/beam/software</u>
- API documentation <u>www.brockmann-consult.de/beam/doc/apidocs</u>
- Source repository <u>github.com/bcdev/beam</u>
- User forum <u>www.brockmann-consult.de/beam/forum</u>



Exercise 1: Generating a quicklook image from MERIS L1b

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Exercise 1 Contents

- Prepare a Java IDE for programming with BEAM
- Inspect a simple Java program
- Introduce some important objects
- Introduce the BEAM generic product model
- Demonstrate that you don't need objectoriented programming skills



Tutorial Requirements

- BEAM 4.10.x binaries and sources
- Java Software Development Kit
 - Java SE JDK 1.6
 <u>www.oracle.com/technetwork/java/javase</u>
- Java Development Environment
 - IntelliJ IDEA 11 Community
 www.jetbrains.com/idea/

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- Used for BEAM development and this tutorial, but Eclipse, NetBeans work fine as well
- Example IDEA projects: ~/IdeaProjects/Ex1, Ex2, Ex3

Ex1: Lead Through (1/2)

- Start IDEA
- Open project Ex1
- Inspect project folder
- Have a look at the Java source file in src
- Compile
- Produce syntax error and compile, remove error
- Run the program (right click class)
- Add command-line argument: MERIS L1b file
- Run again

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Sync project folder, open PNG quicklook image

Java Naming Conventions

- Interface / Class names
 - CamelCase, first character upper-case
 - GeoCoding, Product, RasterDataNode
- Variable names
 - CamelCase, first character lower-case
 - backgroundColor, threshold, minValue
- Constant names
 - All letters upper-case, underscore
 - DIALOG_TITLE, BUFFER_SIZE_LIMIT
- Method / Function names
 - CamelCase, first character lower-case
 - getSampleValue, computeTile, isClosed
- Package names

- all lower-case
- beam, syke, binning

Product Data Model (1/2)

 A "Product" object contains objects of type "Band"



The ProductIO class can be used to open data product files

Ex1: Lead Through (2/2)

- Open project settings dialog
- Have a look at Global Library beam-4.10.3
 Library (JAR) containing directories bin, lib and modules
- Have a look at the module dependencies and see beam-4.10.3, close project settings dialog
- Inspect used object instances of classes:
 ProductIO, Product, Band, ImageIO, IOException
- Change code!

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- to print out band names
- to process multiple inputs
- to not handle the exception

IDEA Setup: Add global BEAM Library

[Ex2] -	/src/fi/syke/Fl	uorescenceLine	HeightProcessor.java - IntelliJ IDEA 11.1.3
efactor	<u>B</u> uild R <u>u</u> n <u>T</u> ool	s VC <u>S W</u> indow	Help
	Fluorescence	LineHeightProcess	or 💌 🕨 🕸 🔛 🕋 🖉
nceLineH	leightProcessor		
÷ ☆-	ExtractDat	aAtGeoPoint iava Structure	× C Eluorescencel ineHeightProcessor java ×
- 1	🔁 💼	🗄 🖻 🗎	Global Library 'beam-4.10'
rocess	- Project Setti Project Modules Libraries Facets Artifacts Platform Sett SDKs Global Libraries	theam-4.10	Name: beam-4.10 Classes Classes Classes Classes Classes Chome/marta/beam-4.10.3/lib Chome/marta/beam-4.10.3/modules Come/marta/beam-4.10.3/bin/ceres-launcher.jar Sources Come/marta/beam-4.10.3-sources Come/marta/beam-4.10.3-sources Come/marta/beam-4.10.3-sources Come/marta/beam-4.10.3-sources Come/marta/beam-4.10.3-sources Come/marta/beam-4.10.3-sources Come/marta/beam-4.10.3-sources Come/marta/beam-4.10.3-sources Come/marta/beam-4.10.3-sources Come/marta/beam-4.10.3-sources Come/marta/beam-4.10.3-sources Come/marta/beam-4.10.3-sources Come/marta/beam-4.10.3-sources Come/marta/beam-4.10.3-sources Come/marta/beam-4.10.3-sources Come/marta/beam-4.10.3-sources Come/marta/beam-4.10.3-sources Come/marta/beam-4.10.3-sources Come/marta/beam-4.10.3-sources
			OK Cancel Apply Help
	}		

IDEA Setup: Add Module Dependency

Ex2] -	x2] - [Ex2]/src/fi/syke/FluorescenceLineHeightProcessor.java - IntelliJ IDEA 11.1.3							
, <u>z</u> e <u>R</u>	e <u>R</u> efactor <u>B</u> uild R <u>u</u> n <u>T</u> ools VC <u>S</u> <u>W</u> indow <u>H</u> elp							
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'oint eigh	Project Settin Project Modules Libraries		Module 'Ex2' Name: Ex2 Sources Paths Dependencies Module SDK: Project SDK (1.6) New Edit					
	Facets Artifacts Platform Sett SDKs Global Libraries		Export Module source> Module source> Module source>	Scope ↔ Compile ▼ ↔ ♦				
			Dependencies storage format: Intellij IDEA (.iml)					
/bin,			OK Cancel A	pply Help				
< <u>k</u> >		BEAM Pro	ogramming Tutorial, Sentinel-3 OLCI/SLSTR & MERIS/(A)ATSR Workshop, ES	RIN, Oct 2012				

Exercise 2: Computing FLH from MERIS Level 1b

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Exercise 2 Contents

- Create a new product object from scratch
- Add a Fluorescence Line Height (FLH) band object to the product object
- Compute FLH pixels for the new band
- Write a data product in a specific data format
- Run VISAT from the IDE in order to inspect, validate, analyse the output
- Write a script that invokes the program



Fluorescence Line Height (FLH)

- Used as an indicator for the biological activity of the phytoplankton.
- Phytoplankton chlorophyll fluorescence at 680.5 nm is measured and its height above a baseline through the measurements at 664 nm and 708 nm is calculated

• FLH =
$$L_2 - k*[L_1 + a*(L_3 - L_1)]$$

a = $(\lambda_2 - \lambda_1) / (\lambda_3 - \lambda_1)$

"Interpretation of the 685 nm peak in water-leaving radiance spectra in terms of fuorescence, absorption and scattering, and its observation by MERIS" J. F. R. Gower, R. Doerffer, G. A. Borstad, Int. J. Remote Sensing, 1999, vol. 20, no. 9, 1771-1786.

Ex2: Lead Through

- Open project Ex2
- Inspect Java code
- Run code, edit configuration in order to specify input file
- Inspect BEAM-DIMAP data product: FLH.dim, FLH.data
- Run program in debug mode
- Open configuration dialog, and add a VISAT configuration (see next slide) to look into generated FLH
- Change code!
 - Output format as parameter: e.g. NetCDF, GeoTIFF
 - Normalize L1, L2, and L3 using sun spectral flux and cos(VZA) or make code handle MERIS L2 inputs ("radiance_" → "reflec_")
 - Parameterise bands used for provision of L1, L2, and L3

VISAT Invocation Configuration

- Main class:
 - com.bc.ceres.launcher.Launcher
- Java VM options:
 - -Xmx1024M -Dceres.context=beam
- Program arguments:
 - ~/IdeaProjects/Ex2/FLH.dim
- Working directory:
 - ~/beam-4.10.3
- Use classpath of module:
 - Ex2

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Product Data Model (2/2)





Exercise 3: Integrated FLH tool extending BEAM / VISAT

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Exercise 3: Contents

- Introduction to BEAM plug-ins and the module descriptor file
- Introduction to the BEAM graph processing framework - GPF
- Turn the FLH code into a GPF operator, a special plug-in type for data processors
- Introduce the GPF command-line tool gpt
- Demonstrate how the FLH operator integrates into VISAT and the command-line tool gpt



Processing Framework Requirements

- Processor implementation code shall abstract from
 - physical file format of EO data
 - file I/O
 - configuration & parameterisation, parameter value access
- Avoid I/O overhead between processing steps
- Exploit multi-core CPU architectures
- The framework shall be extendible, e.g. it shall be possible to add new processors as plug-ins
- Create processing chains or even graphs composed of processing nodes.
 Processing nodes shall
 - be reusable in other graphs, e.g. MERIS Cloud Screening
 - be easily configurable in terms of processing parameters
 - be easily configurable in terms of the algorithm implementation

Processing Graph Example





BEAM Graph Processing Framework

- Simple data processing and programming model
 - For a particular node, clients (Java developers) implement how a raster tile is being computed
 - Parameter values are "injected" by the framework
- Implements the "pull-processing" paradigm

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- A processor is represented by its processing graph
- Product processing requests are translated into raster-tile-requests propagated backwards through the graph
- Tile requests are automatically parallelised depending on CPU cores
- Generated user interfaces: Command-line tool gpt and VISAT GUI
- Operators can be dynamically added to BEAM via plug-in modules
- Allows to construct directed, acyclic processing graphs

Processing Framework

Why "Framework"?

- BEAM calls your code when it is time to Don't call us, we call you.
- Abstract interfaces comprising callback functions clients must implement
- Rapid processor development
 - Forget about processing environment
 - Concentrate on data and algorithm



```
@SourceProduct Product source;
@TargetProduct Product target;
```

boolean slitCorrection;

```
@Override
```

```
public void initialize() throws OperatorException {
    int width = source.getSceneRasterWidth();
    int height = source.getSceneRasterHeight();
    target = new Product("noisered", "", width, height);
    // todo - add bands to target product
```

```
@Override
```

GPF Operator Configuration

```
<node id="noisered">
```

```
<operator>NoiseRedOp</operator>
```

<sources>

```
<sourceProduct>${sourceProduct}</sourceProduct>
```

```
</sources>
```

```
<parameters>
```

```
<smoothingOrder>23</smoothingOrder>
```

```
<slitCorrection>true</slitCorrection>
```

```
<neighbourhoodType>N4</neighbourhoodType>
```

```
</parameters>
```

```
</node>
```

gpt – The GPF Command-Line Tool

```
- 🗆 🗙
Command Line
> gpt -h NoiseRedOp
Usage:
  qpt NoiseRedOp [options]
Description:
  Performs a noise reduction on CRIS/Proba images
Source Options:
  -Ssource=(file)
                         Sets source 'source' to <filepath>.
                          This is a mandatory source.
Parameter Options:
  -PslitCorrection=<boolean>
                                          Whether or not to perform sclit correction 
Default value is 'false'.
                                         The type of neighbourhood pixel consideration
Value must be one of 'N2', 'N4', 'N8'.
Default value is 'N4'.
  -PneighbourhoodType=<string>
                                         The number of scans to use for smoothing
Valid interval is (0,50].
Default value is '25'.
  -PsmoothingOrder=<int>
Graph XML Format:
  <operator>NoiseRedOp</operator>
       (sources)
         <source>${source}</source>
       </sources>
       parameters>
          <slitCorrection>boolean</slitCorrection>
         <neighbourhoodType>string</neighbourhoodType>
<smoothingOrder>int</smoothingOrder>
       </parameters>
     </node>
  </graph>
> gpt NoiseRed0p -PslitCorrection=true -Ssource=in.hdf_
                                                                                                      • 2
۰.
```



GPF Processor GUI

CHRIS Noise Reduction	E CHRIS Noise Reduction	×
I/O Parameters Processing Parameters	I/O Parameters Processing Parameters	
Source Product Name:	smoothingOrder:	25
CHRI5_SO_041001_472A_31	neighbourhoodType: N4	~
Target Product Name:		
CHRIS_SO_041001_472A_31_noisered		
Save as: BEAM-DIMAP 💙		
Directory: C:\Dokumente und Einstellungen\Norman		
Open in VISAT		
Run Close Help	<u>R</u> un <u>C</u> lose	<u>H</u> elp



GPF Programming Model

Product p0 = ProductIO.readProduct("MER_1P.N1");
Map<String,Object> params1 = ...;
Map<String,Object> params2 = ...;
Map<String,Object> params3 = ...;

Product p1, p2, p3;

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p1 = GPF.createProduct("SmileCorrOp", params1, p0);

p2 = GPF.createProduct("CloudMaskOp", params2, p1);

GPF Architecture (1/2)





GPF Architecture (2/2)

- Clients provide their compiled Operator Java code packed into JAR modules
- A JAR module publishes its operator services via metadata (Service Provider Interface, SPI)
 - META-INF/services/ org.esa.beam.framework.gpf.OperatorSpi
- Once GPF is started, e.g. by VISAT or gpt, it loads all operator plug-ins it finds on its dynamic classpath
 - %BEAM4_HOME%/modules/*.jar
 - %BEAM4_HOME%/lib/*.jar

Ex3: Lead Through (1/3)

- Open Ex3 project in IDEA
- Inspect the Java source code in the src directory
- Understand the abstract Java class Operator
 - Special GPF Java annotations
 @OperatorMetadata, @SourceProduct, @TargetProduct,
 @Parameter
 - Callback methods initialize() and computeTileStack()
- Inspect special resource files

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- Inspect module descriptor file src/module.xml
- Inspect the file in META-INF/services/

Ex3: Lead Through (2/3)

- Create an IDEA configuration to invoke the standard gpt tool → check that the new FLH operator plugged-in
- Run gpt FLH <file>
- Create an IDEA configuration to invoke the VISAT → check that the new FLH processor plugged-in. Check how parameters translate in GUI components
- Run the FLH processor from VISAT

Ex3: Lead Through (2/3)

- In IDEA, open project settings, add an artifact ex3.jar in order to create a Java JAR module (see next slides)
- Put ex3.jar into BEAM's module directory, start VISAT → Extension installed
- Check installed module in Module Manager

 \rightarrow This plug-in module can now be *deployed*



gpt Invocation Configuration

- Main class:
 - com.bc.ceres.launcher.Launcher
- Java VM options:
 - -Xmx1024M -Dceres.context=beam
 -Dbeam.mainClass=org.esa.beam.framework.gpf.main.GPT
- Program arguments:
 - -h or <op-name> <source-file>
- Working directory:
 - ~/beam-4.10.3
- Use classpath of module:
 - Ex3

FLH Tool in gpt

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VISAT Invocation Configuration

- Main class:
 - com.bc.ceres.launcher.Launcher
- Java VM options:
 - -Xmx1024M -Dceres.context=beam
- Program arguments:

none

- Working directory:
 - ~/beam-4.10.3
- Use classpath of module:
 - Ex3

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FLH Tool in Module Manager

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FLH Tool in Main Menu

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0° © Image: Navigation Q Colour Manipulation FLH Operator developed during the MERIS/AATSR Workshop, Esrin, Oct 2012	2 10:54:14 55M of \$7M	J

FLH Tool GUI

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Options for BEAM in Batch-Mode

- 1. Use BEAM's command-line tools
 - o from a command-line shell
 - from shell scripts
 - o from Python, IDL, MATLAB scripts
- 2. Use the BEAM Java libraries to directly call BEAM functions
 - o from your Java program
 → BEAM Programming Tutorial, Thursday, 15:00-17:00
 - o from your C or Python program
 → In progress, 1st version expected Spring 2013
 → We are happy to consider your requirements!
- 3. Use the VISAT Scripting Console (experimental)
 - Use BEAM libraries within VISAT to automate work
 - Python (Jython) and JavaScript, see VISAT Help

Outlook

- C & Python Language Support
 - C Processing and Analysis API
 - Python Processing and Analysis API
 - Spring 2013
- Sentinel Data Support
 - S1 SAR
 - S2 MSI
 - S3 OLCI, SLSTR, Synergy
 - Summer 2013

Thanks for your attention!

→ Get instant support in the BEAM user forum

BEAM Programming Tutorial, Sentinel-3 OLCI/SLSTR & MERIS/(A)ATSR Workshop, ESRIN, Oct 201255

Complementary Material

BEAM Programming Tutorial, Sentinel-3 OLCI/SLSTR & MERIS/(A)ATSR Workshop, ESRIN, Oct 201256

GPF Operator Anatomy (1/3)

```
@OperatorMetadata alias "NoiseRedOp",
                 version "1.0".
                 authors "Ralf Quast",
                 copyright "(c) 2008 by Brockmann Consult",
                 description "Performs a noise reduction on"
                                 + " CHRIS/Proba images."
public class NoiseRedOp extends Operator {
   @SourceProduct alias "source"
   private Product sourceProduct
   @TargetProduct
   private Product targetProduct
   @Parameter defaultValue "false"
   private boolean slitCorrection
   @Parameter(interval="(0,50]". defaultValue="25"
   private int smoothingOrder
   @Parameter(valueSet={"N2", "N4", "N8"}, defaultValue="N2")
    private String neighbourhoodType;
   // ...
```

}

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GPF Operator Anatomy (2/3)

esa

If single target bands can be computed independently of each other, e.g. NDVI or algorithms which perform single band filtering:

```
public class NoiseRedOp extends Operator {
  public void initialize() throws OperatorException {
      // validate and process source products and parameter values
      // create, configure and set the target product
   }
  public void computeTile(Band targetBand,
                           Tile targetTile,
                           ProgressMonitor pm)
                                        throws OperatorException {
       // Obtain source tiles for used bands of source products
       // Process samples of source tiles to samples of target tile
      // Set samples of single target tile
   }
}
```

GPF Operator Anatomy (3/3)

esa

If single target bands cannot be computed independently of each other, e.g. model inversion algorithms based on neural networks:

```
public class NoiseRedOp extends Operator {
  public void initialize() throws OperatorException {
      // validate and process source products and parameter values
      // create, configure and set the target product
   }
  public void computeTileStack(Map<Band, Tile> targetTiles,
                                Rectangle targetTileRectangle,
                                ProgressMonitor pm)
                                              throws OperatorException {
       // Obtain source tiles for used bands of source products
      // Process samples of source tiles to samples of target tiles
      // Set samples of all given target tiles
  }
}
```

How GPF "drives" Operators

- 1. GPF knows about all registered Operators (Plug-in)
- 2. GPF encounters a required node (GUI, CLI, XML graph)
 - 1. The client's Operator class is found by its alias
 - 2. The **SourceProduct**, **TargetProduct** and **Parameter** annotations are analysed
 - 3. The client's Operator object is created
 - 4. Source products and parameter values are injected
- 3. GPF calls **Operator.initialize()**. In this method, the client provides code to
 - 1. validate and process source products and parameter values
 - 2. create, configure and set the target product
- GPF calls either Operator.computeTile() or
 Operator.computeTileStack() in case raster data is required

Configuring Resources in IDEA

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Creating a JAR in IDEA (1/4)

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Creating a JAR in IDEA (2/4)

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Creating a JAR in IDEA (3/4)

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Creating a JAR in IDEA (4/4)

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	amming Tutorial Sopting a OLCUSI STR & MERIS/(A)ATSR Workshop, ESRIN, OC

Invocation of Command-line Tools

Invocation of **gpt.bat** via a dedicated launcher program (**cereslauncher.jar**). All JARs found in BEAM's **lib** and **modules** directories are put on the classpath (see also scripts in **%BEAM4_HOME%/bin**):

@echo off

```
set BEAM4_HOME=C:\Program Files\beam-4.10.3
```

```
"%BEAM4_HOME%\jre\bin\java.exe" ^
```

-Xmx1024M \wedge

-Dceres.context=beam \land

"-Dbeam.mainClass=org.esa.beam.framework.gpf.main.GPT" ^

"-Dbeam.home=%BEAM4_HOME%" ^

"-Dncsa.hdf.hdflib.HDFLibrary.hdflib=%BEAM4_HOME%\...\jhdf.dll" ^

"-Dncsa.hdf.hdf5lib.H5.hdf5lib=%BEAM4_HOME%\...\jhdf5.dll" ^

-jar "%BEAM4_HOME%\bin\ceres-launcher.jar" %*

exit /B 0

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