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OGC® OWS-9 OWS Innovations WCS for LIDAR Engineering Report Report

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Abstract

This Engineering Report is prepared as a deliverable for the OGC Web Services, Phase 9 (OWS-9) initiatitive of the Innovations Coverages Sub-Thread. This document represents the OWS-9 OWS Innovations WCS for LIDAR Engineering Report. In this report, the implementation of WCS 2.0 service that serves the LIDAR data in NITF format is introduced. This service supports the JPEG 2000 output format along with GMLJP2 metadata description as well as the JPIP protocol to deliver the output JPEG2000 data.

Keywords

ogcdoc, OGC document,ows9, ows-9, wcs, lidar, jpip

What is OGC Web Services 9 (OWS-9)?

OWS-9 builds on the outcomes of prior OGC interoperability initiatives and is organized around the following threads:

- **Aviation**: Develop and demonstrate the use of the Aeronautical Information Exchange Model (AIXM) and the Weather Exchange Model (WXXM) in an OGC Web Services environment, focusing on support for several Single European Sky ATM Research (SESAR) project requirements as well as FAA (US Federal Aviation Administration) Aeronautical Information Management (AIM) and Aircraft Access to SWIM (System Wide Information Management) (AAtS) requirements.

- **Cross-Community Interoperability (CCI)**: Build on the CCI work accomplished in OWS–8 by increasing interoperability within communities sharing geospatial data, focusing on semantic mediation, query results delivery, data provenance and quality and Single Point of Entry Global Gazetteer.

- **Security and Services Interoperability (SSI)**: Investigate 5 main activities: Security Management, OGC Geography Markup Language (GML) Encoding Standard Application Schema UGAS (UML to GML Application Schema) Updates, Web Services Façade, Reference Architecture Profiling, and Bulk Data Transfer.

- **OWS Innovations**: Explore topics that represent either new areas of work for the Consortium (such as GPS and Mobile Applications), a desire for new approaches to existing technologies to solve new challenges (such as the OGC Web Coverage Service (WCS) work), or some combination of the two.

- **Compliance & Interoperability Testing & Evaluation (CITE)**: Develop a suite of compliance test scripts for testing and validation of products with interfaces implementing the following OGC standards: Web Map Service (WMS) 1.3 Interface Standard, Web Feature Service (WFS) 2.0 Interface Standard, Geography Markup

Language (GML) 3.2.1 Encoding Standard, OWS Context 1.0 (candidate encoding standard), Sensor Web Enablement (SWE) standards, Web Coverage Service for Earth Observation (WCS-EO) 1.0 Interface Standard, and TEAM (Test, Evaluation, And Measurement) Engine Capabilities.

The OWS-9 sponsors are: AGC (Army Geospatial Center, US Army Corps of Engineers), CREAF-GeoViQua-EC, EUROCONTROL, FAA (US Federal Aviation Administration), GeoConnections - Natural Resources Canada, Lockheed Martin Corporation, NASA (US National Aeronautics and Space Administration), NGA (US National Geospatial-Intelligence Agency), USGS (US Geological Survey), UK DSTL (UK MoD Defence Science and Technology Laboratory).

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Contents

OGC® OWS-9 OWS Innovations WCS for LIDAR Engineering Report Report

1 Introduction

1.1 Scope

This document represents the OWS-9 OWS Innovations WCS for LIDAR Engineering Report. In this report, the implementation of WCS 2.0 service that serves the LiDAR HRE data in NITF format is introduced. This service supports the JPEG 2000 output format along with GMLJP2 metadata description as well as the JPIP protocol to deliver the output JPEG2000 data.

This document is applicable to OGC® GML in JPEG 2000 for Geographic Imagery (GMLJP2) Implementation Specification [OGC 05-047r2] and OGC® Web Coverage Service 2.0 – Core [OGC 09-110r4] along with its extensions.

1.2 Document contributor contact points

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1.3 Revision history

Date	Release	Editor	Primary clauses modified	Description
2012-10-02	0.1	Yuanzheng Shao, Weiguo Han	All	Initial version
2012-12-03	0.2	Yuanzheng Shao, Weiguo Han	Section 4, 5, 6	Add the detailed implementation framework
2012-12-17	1.0	Weiguo Han, Yuanzheng Shao		Finalize this document

1.4 Forward

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. The Open Geospatial Consortium shall not be held responsible for identifying any or all such patent rights.

Recipients of this document are requested to submit, with their comments, notification of any relevant patent claims or other intellectual property rights of which they may be aware that might be infringed by any implementation of the standard set forth in this document, and to provide supporting documentation.

2 References

The following documents are referenced in this document. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. For undated references, the latest edition of the normative document referred to applies.

- *OGC 06-121r9*, OGC® Web Services Common Standard, Version 2.0
- *OGC 05-047r2*, OGC® GML in JPEG 2000 for Geographic Imagery (GMLJP2) Implementation Specification, Version 1.0
- *OGC 09-110r3*, OGC® Web Coverage Service 2.0 Interface Standard Core, Version 2.0
- *NGA.IP.0002_1.0,* NGA Standardization Document - Implementation Profile for High Resolution Elevation (HRE) Products, Version 1.0

3 Terms and definitions

For the purposes of this report, the definitions specified in Clause 4 of the OWS Common Implementation Standard [OGC 06-121r3] and in GML in JPEG 2000 for Geographic Imagery (GMLJP2) Implementation Specification [OGC 05-047r2] shall apply. In addition, the following terms and definitions apply:

3.1 JPEG2000

JPEG 2000 is an image compression standard and coding system. It was created by the Joint Photographic Experts Group (JPEG) committee in 2000 with the intention of superseding their original discrete cosine transform-based JPEG standard (created in 1992) with a newly designed, wavelet-based method.

3.2 JPIP

JPIP (JPEG 2000 Interactive Protocol) is a compression streamlining protocol that works with JPEG 2000 to produce an image using the least bandwidth required. It can be very

useful for medical and environmental awareness purposes, among others, and many implementations of it are currently being produced.

3.3 NITF

The National Imagery Transmission Format Standard (NITFS) is a U.S. Department of Defense (DoD) and Federal Intelligence Community (IC) suite of standards for the exchange, storage, and transmission of digital-imagery products and image-related products.

4 Conventions

4.1 Abbreviated terms

API	Application Programming Interface
ESA	European Space Agency
DoD	Department of Defense
GDAL	Geospatial Data Abstraction Library
GMLCOV	OGC GML 3.2.1 Application Schema – Coverages
GMU	George Mason University
HRE	High Resolution Elevation
IC	Intelligence Community
JPEG	Joint Photographic Experts Group
JPIP	JPEG 2000 Interactive Protocol
LiDAR	Light Detection And Ranging
NGA	National Geospatial-Intelligence Agency
NITF	National Imagery Transmission Format
OWS	OGC Open Web Service
OWS-9	OGC Web Services Initiative, Phase 9
SDK	Software Development Kit
TRE	Tagged Record Extension
UML	Unified Modeling Language

WCS Web Coverage Service

4.2 UML notation

Diagrams presented using the Unified Modeling Language (UML) static structure diagram follow Subclause 5.2 of [OGC 06-121r3].

5 Overview

This report introduces the technical implementation of GMLJP2 WCS service for the LiDAR HRE data in NITF format with its native Tagged Record Extension (TRE). A general program is built to convert data from NITF format to JPEG2000 format and transform native TREs to GML metadata. Moreover, a JPIP server is set up to deliver the response of WCS to clients using JPIP protocol.

Open source geospatial package Geospatial Data Abstraction Library (GDAL) is utilized in data reformatting and re-projection because it supports multiple geospatial data formats, including GeoTIFF and NITF. However, GDAL does not support the JPEG2000 format with its default configuration, so it is re-configured with OpenJPEG library (or Japser library) to support JPEG2000 format in the GMU GMLJP2 WCS implementation.

ESA JPIP server is configured to support JPIP protocol in the implementation. It is found that ESA JPIP server doesn't support the JPEG2000 file generated from GDAL directly. So Kakadu software (including command line tools and APIs, freely obtained from Kakadu Software, www.kakadusoftware.com) is adopted to generate the output data in JPEG2000 format.

In the implementation, GeoTIFF serves as an intermediate data format between NITF and JPEG2000, that is, the original source data in NITF format is converted to the one in GeoTIFF format using GDAL, and then the GeoTIFF file is converted to the output JPEG200 file using Kakadu. A metadata converter is developed to transform metadata information in NITF format to GMLJP2 metadata in XML format. Finally, ESA JPIP server will deliver the responses in JPIP protocol, and GMU WCS server is responsible for handling the HTTP requests.

The whole process is illustrated in Figure 1. The technical details will be described in Section 6.

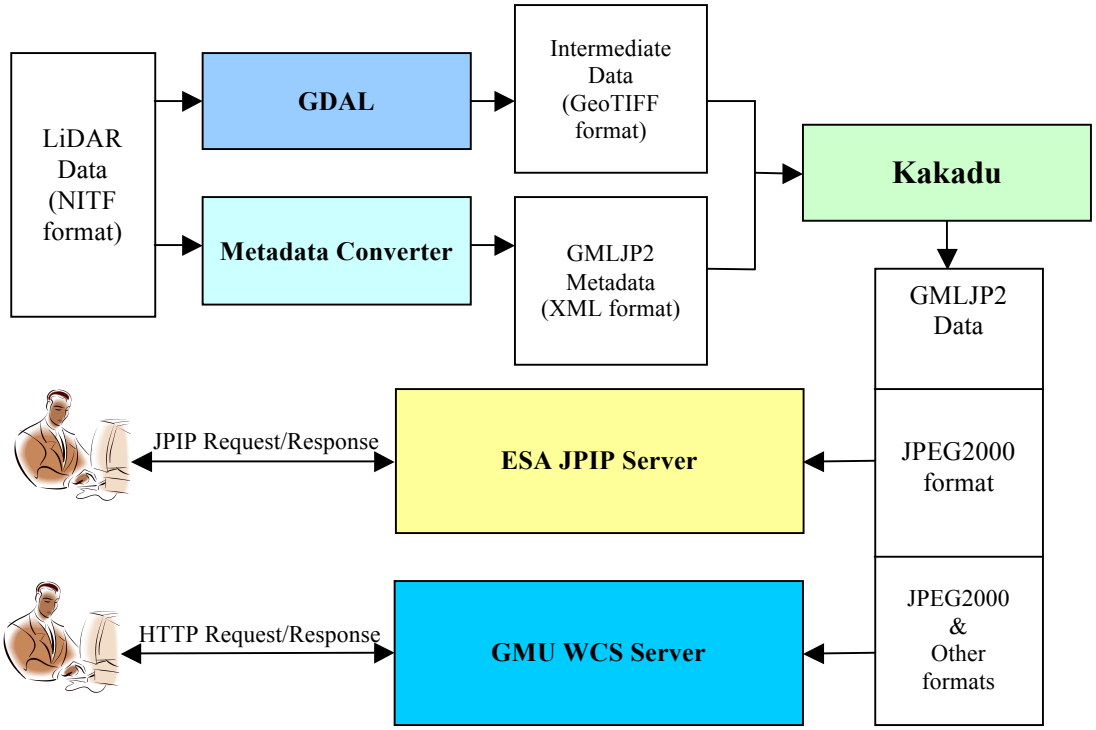

Figure 1. GMU GMLJP2 WCS implementation framework

6 GMLJP2 WCS implementation

6.1 Data selection

The following four LiDAR HRE sample files provided by NGA are used in the implementation and testing of the GMLJP2 WCS service:

- Case1_HRE10G324642N1170747W_Uxx.hr5
- Case2_HRE10G324642N1170747W_Uxx.hr5
- Case3_HRE10G324642N1170747W_Uxx.hr5
- Case4_HRE10G324642N1170747W_Uxx.hr5

These HRE files are in NITF format and their metadata information are described in the NITF Headers/Sub-Header and TREs. Taking the sample data of Case1_HRE10G324642N1170747W_Uxx.hr5 as an example, its headers, sub-headers and TREs are retrieved and listed as the following:

1) Header information

```
<headers>
  <field name="CLEVEL" value="03"/>
  <field name="ENCRYP" value="0"/>
  <field name="FBKGC" value="000000"/>
  <field name="FDT" value="20081201000000"/>
  <field name="FHDR" value="NITF02.10"/>
```

```
  <field name="FSCATP" value=""/>
  <field name="FSCAUT" value=""/>
  <field name="FSCLAS" value="U"/>
  <field name="FSCLSY" value="US"/>
  <field name="FSCLTX" value=""/>
  <field name="FSCODE" value=""/>
  <field name="FSCOP" value="00000"/>
  <field name="FSCPYS" value="00000"/>
  <field name="FSCRSN" value=""/>
  <field name="FSCTLH" value="FO"/>
  <field name="FSCTLN" value=""/>
  <field name="FSDCDT" value=""/>
  <field name="FSDCTP" value=""/>
  <field name="FSDCXM" value=""/>
  <field name="FSDG" value=""/>
  <field name="FSDGDT" value=""/>
  <field name="FSREL" value=""/>
  <field name="FSSRDT" value=""/>
  <field name="FTITLE" value="HRE High Resolution Elevation Data HRE10G324642N1170747W_Uxx.hr5"/>
  <field name="ONAME" value="NGA"/>
  <field name="OPHONE" value="1-800-455-0899"/>
  <field name="OSTAID" value="NGA"/>
  <field name="STYPE" value="BF01"/>
</headers>
```

2) Sub-header information

```
<subheaders>
  <field name="ABPP" value="32"/>
  <field name="CCS_COLUMN" value="0"/>
  <field name="CCS_ROW" value="0"/>
  <field name="IALVL" value="0"/>
  <field name="IC" value="NC"/>
  <field name="ICAT" value="DTEM"/>
  <field name="ICORDS" value="D"/>
  <field name="IDATIM" value="20041201000000"/>
  <field name="IDLVL" value="1"/>
  <field name="IGEOLO" value="+32.781-117.129+32.781-117.126+32.778-117.126+32.778-117.129"/>
  <field name="IID1" value="HRE"/>
  <field name="IID2" value="HRE0120081201"/>
  <field name="ILOC_COLUMN" value="0"/>
  <field name="ILOC_ROW" value="0"/>
  <field name="IMAG" value="1.0"/>
  <field name="IMODE" value="B"/>
  <field name="IREP" value="NODISPLY"/>
  <field name="ISCATP" value=""/>
  <field name="ISCAUT" value=""/>
  <field name="ISCLAS" value="U"/>
  <field name="ISCLSY" value="US"/>
  <field name="ISCLTX" value=""/>
  <field name="ISCODE" value=""/>
  <field name="ISCRSN" value=""/>
  <field name="ISCTLH" value="FO"/>
  <field name="ISCTLN" value=""/>
  <field name="ISDCDT" value=""/>
  <field name="ISDCTP" value=""/>
  <field name="ISDCXM" value=""/>
  <field name="ISDG" value=""/>
  <field name="ISDGDT" value=""/>
```

```
    <field name="ISORCE" value="IFSAR"/>
    <field name="ISREL" value=""/>
    <field name="ISSRDT" value=""/>
    <field name="PJUST" value="R"/>
    <field name="PVTYPE" value="R"/>
    <field name="TGTID" value=""/>
</subheaders>
```

3) TREs information

```
<tres>
   <tre name="PIAPRD" location="file">
      <field name="ACCESSID" value=""/>
      <field name="FMCONTROL" value=""/>
      <field name="SUBDET" value=""/>
      <field name="PRODCODE" value=""/>
      <field name="PRODUCERSE" value=""/>
      <field name="PRODIDNO" value=""/>
      <field name="PRODSNME" value="HRE"/>
      <field name="PRODUCERCD" value=""/>
      <field name="PRODCRTIME" value="20081201000000"/>
      <field name="MAPID" value=""/>
      <field name="SECTITLEREP" value="00"/>
      <field name="REQORGREP" value="00"/>
      <field name="KEYWORDREP" value="00"/>
      <field name="ASSRPTREP" value="00"/>
      <field name="ATEXTREP" value="02"/>
      <repeated name="ATEXT" number="2">
         <group index="0">
            <field name="ATEXT" value="HREG120081201"/>
         </group>
         <group index="1">
            <field name="ATEXT" value="RSF0120081201"/>
         </group>
      </repeated>
   </tre>
</tres>
```

6.2 Metadata interoperability

To implement the GMLJP2 WCS service, the metadata of headers, sub-headers, and NITF TREs will be converted to the GMLJP2 elements according to the schema files, which are provided by the sponsor. The specific schema files are obtained from the following link:

https://portal.opengeospatial.org/files/?artifact_id=50045

Taking the sample data of Case1_HRE10G324642N1170747W_Uxx.hr5 as an example, its headers/sub-headers and TREs are converted to the corresponding elements in GMLJP2 (Refer to Annex A).

6.3 WCS implementation

In the implementation of this WCS service, the WCS 2.0 specification is adopted and the following three mandatory operations are implemented:

- GetCapabilities
- DescribeCoverage
- GetCoverage

Currently, only HTTP/GET method is supported.

If the output format is specified as image/jpeg2000, this WCS service will insert the GMLJP2 metadata to the XML box in the output JPEG2000 data by calling API function of Kakadu SDK.

6.4 WCS usage

The request parameters and sample URL are listed in Annex B.

6.5 JPIP protocol support

The JPIP server also is set up to support the delivery of the generated JPEG2000 data via JPIP protocol.

To get the output data via JPIP protocol, the output format in the GetCoverage request needs to be specified as the following:

format=text/xml;urn:ogc:def:wcs:2.0:jpip-response

The request and response example are given in Annex C.

Annex D introduces how to visualize the JPIP stream and check the GMLJP2 metadata information via the third-party JPIP client software.

7 Future work

Geospatial data products in other raster formats will be served with GMLJP2 using the similar solution and a general metadata schema will be defined for these data products accordingly in the implementation.

Annex A: GMLJP2 XML document for the sample data

```
<?xml version="1.0" encoding="UTF-8"?>
<gmljp2:RootFeatureCollection xmlns:geopsb="http://www.example.org/nitf/tre/geopsb"
  xmlns:geolob="http://www.example.org/nitf/tre/geolob"
  xmlns:histoa="http://www.example.org/nitf/tre/histoa" xmlns:saxon="http://saxon.sf.net/"
  xmlns:maplob="http://www.example.org/nitf/tre/maplob"
  xmlns:prjpsb="http://www.example.org/nitf/tre/prjpsb"
  xmlns:piaprd="http://www.example.org/nitf/tre/piaprd" xmlns:xlink="http://www.w3.org/1999/xlink"
  xmlns:eop="http://www.opengis.net/eop/2.0" xmlns:gml="http://www.opengis.net/gml/3.2"
  xmlns:ntf="http://www.example.org/nitf" xmlns:gmlcov="http://www.opengis.net/gmlcov/1.0"
  xmlns:om="http://www.opengis.net/om/2.0" xmlns:gmljp2="http://www.opengis.net/gmljp2/2.0"
  xmlns:swe="http://www.opengis.net/swe/2.0" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
  xsi:schemaLocation="http://www.example.org/nitf
http://129.174.131.8:9003/ows9_ic/schema/gmljp2v2.0/NITF_2.1.xsd  http://www.example.org/nitf
http://129.174.131.8:9003/ows9_ic/schema/gmljp2v2.0/NITF_TRE_Types.xsd http://www.opengis.net/gmljp2/2.0
http://129.174.131.8:9003/ows9_ic/schema/gmljp2v2.0/GMLJP2.xsd http://www.example.org/nitf/tre/geopsb
http://129.174.131.8:9003/ows9_ic/schema/gmljp2v2.0/GEOPSB-TRE.xsd http://www.example.org/nitf/tre/geolob
http://129.174.131.8:9003/ows9_ic/schema/gmljp2v2.0/GEOLOB-TRE.xsd http://www.example.org/nitf/tre/histoa
http://129.174.131.8:9003/ows9_ic/schema/gmljp2v2.0/HISTOA-TRE.xsd http://www.example.org/nitf/tre/maplob
http://129.174.131.8:9003/ows9_ic/schema/gmljp2v2.0/MAPLOB-TRE.xsd http://www.example.org/nitf/tre/prjpsb
http://129.174.131.8:9003/ows9_ic/schema/gmljp2v2.0/PRJPSB-TRE.xsd http://www.example.org/nitf/tre/piaprd
http://129.174.131.8:9003/ows9_ic/schema/gmljp2v2.0/PIAPRD-TRE.xsd "
  gml:id="FC001">
  <ntf:sourceFileMetadata>
    <ntf:FileHeader>
      <ntf:fhdr>NITF</ntf:fhdr>
      <ntf:fver>02.10</ntf:fver>
      <ntf:clevel>1</ntf:clevel>
      <ntf:stype>BF01</ntf:stype>
      <ntf:ostaid>NGA</ntf:ostaid>
      <ntf:fdt>2008-12-01T00:00:00</ntf:fdt>
      <ntf:ftitle>HRE High Resolution Elevation Data HRE10G324642N1170747W_Uxx.hr5</ntf:ftitle>
      <ntf:fsclas>U</ntf:fsclas>
      <ntf:fsclsy>US</ntf:fsclsy>
      <ntf:fscode/>
      <ntf:fsrel/>
      <ntf:fsdctp/>
      <ntf:fsdcxm/>
      <ntf:fsdg/>
      <ntf:fsdgdt>1900-01-01</ntf:fsdgdt>
      <ntf:fscltx/>
      <ntf:fscatp/>
      <ntf:fscaut/>
      <ntf:fscrsn/>
      <ntf:fssrdt>1900-01-01</ntf:fssrdt>
      <ntf:fsctln/>
      <ntf:fscop>0</ntf:fscop>
      <ntf:fspys>0</ntf:fspys>
      <ntf:encryp>0</ntf:encryp>
      <ntf:fbkgc>000000</ntf:fbkgc>
      <ntf:oname>NGA</ntf:oname>
      <ntf:ophone>1-800-455-0899</ntf:ophone>
      <ntf:xhd>
        <piaprd:DataSetMetadata>
          <piaprd:cetag>PIAPRD</piaprd:cetag>
          <piaprd:prodSnme>HRE</piaprd:prodSnme>
          <piaprd:prodCrTime>2008-12-01T00:00:00</piaprd:prodCrTime>
          <piaprd:aText>HREG120081201</piaprd:aText>
          <piaprd:aText>RSF0120081201</piaprd:aText>
        </piaprd:DataSetMetadata>
```

```
      </ntf:xhd>
    </ntf:FileHeader>
  </ntf:sourceFileMetadata>
  <gmljp2:featureMember>
    <gmljp2:CodeStreamData gml:id="CodeStream1">
      <gml:boundedBy xmlns:wcs="http://www.opengis.net/wcs/2.0"
        xmlns:wcseo="http://www.opengis.net/wcseo/1.0">
        <gml:Envelope axisLabels="lon lat" srsDimension="2"
          srsName="http://www.opengis.net/def/crs/EPSG/0/4326" uomLabels="deg deg">
          <gml:lowerCorner>-117.129 32.778</gml:lowerCorner>
          <gml:upperCorner>-117.126 32.781</gml:upperCorner>
        </gml:Envelope>
      </gml:boundedBy>
      <ntf:imageMetadata>
        <ntf:ImageSubheader>
          <ntf:im>1</ntf:im>
          <ntf:iid1>HRE</ntf:iid1>
          <ntf:idatim>2004-12-01T00:00:00</ntf:idatim>
          <ntf:tgtid/>
          <ntf:iid2>HRE0120081201</ntf:iid2>
          <ntf:isclas>U</ntf:isclas>
          <ntf:isclsy>US</ntf:isclsy>
          <ntf:iscode/>
          <ntf:isctlh>FO</ntf:isctlh>
          <ntf:isrel/>
          <ntf:isdcdt>1900-01-01</ntf:isdcdt>
          <ntf:isdcxm/>
          <ntf:isdg/>
          <ntf:isdgdt>1900-01-01</ntf:isdgdt>
          <ntf:iscatp/>
          <ntf:iscaut/>
          <ntf:iscrsn/>
          <ntf:issrdt>1900-01-01</ntf:issrdt>
          <ntf:isctln/>
          <ntf:encryp>0</ntf:encryp>
          <ntf:nrows>1</ntf:nrows>
          <ntf:ncols>1</ntf:ncols>
          <ntf:pvtype>R</ntf:pvtype>
          <ntf:irep>NODISPLY</ntf:irep>
          <ntf:icat>DTEM</ntf:icat>
          <ntf:abpp>1</ntf:abpp>
          <ntf:pjust>R</ntf:pjust>
          <ntf:icords>D</ntf:icords>
          <ntf:igeolo>
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              <gml:lowerCorner>-117.129 +32.778</gml:lowerCorner>
              <gml:upperCorner>-117.126 +32.781</gml:upperCorner>
            </gml:Envelope>
          </ntf:igeolo>
          <ntf:ic>NC</ntf:ic>
          <ntf:imode>B</ntf:imode>
          <ntf:nbpr>1</ntf:nbpr>
          <ntf:nbpc>1</ntf:nbpc>
          <ntf:nppbh>0</ntf:nppbh>
          <ntf:nppbv>0</ntf:nppbv>
          <ntf:nbpp>1</ntf:nbpp>
          <ntf:idlvlv>1</ntf:idlvlv>
          <ntf:ialvl>0</ntf:ialvl>
          <ntf:iloc>00000000</ntf:iloc>
          <ntf:imag>0</ntf:imag>
```

```
        </ntf:ImageSubheader>
      </ntf:imageMetadata>
      <gmljp2:coverage>
        <ntf:RectifiedGridCoverage gml:id="RectifiedGrid1">
          <gml:rectifiedGridDomain>
            <gml:RectifiedGrid xmlns:wcs="http://www.opengis.net/wcs/2.0"
              xmlns:wcseo="http://www.opengis.net/wcseo/1.0" dimension="2"
              gml:id="Case1_HRE10G324642N1170747W_Uxx.hr5_grid">
              <gml:limits>
                <gml:GridEnvelope>
                  <gml:low>0 0</gml:low>
                  <gml:high>333 357</gml:high>
                </gml:GridEnvelope>
              </gml:limits>
              <gml:axisLabels>lon lat</gml:axisLabels>
              <gml:origin>
                <gml:Point gml:id="Case1_HRE10G324642N1170747W_Uxx.hr5_grid_origin"
                  srsName="http://www.opengis.net/def/crs/EPSG/0/4326">
                  <gml:pos>-117.129 32.781</gml:pos>
                </gml:Point>
              </gml:origin>
              <gml:offsetVector srsName="http://www.opengis.net/def/crs/EPSG/0/4326"
                >9.00901e-06 0.0</gml:offsetVector>
              <gml:offsetVector srsName="http://www.opengis.net/def/crs/EPSG/0/4326">0.0
                -8.40336e-06</gml:offsetVector>
            </gml:RectifiedGrid>
          </gml:rectifiedGridDomain>
          <ntf:rangeSet>
            <gml:File>
              <gml:rangeParameters nilReason="unknown"/>
              <gml:fileName/>
              <gml:fileStructure/>
            </gml:File>
          </ntf:rangeSet>
        </ntf:RectifiedGridCoverage>
      </gmljp2:coverage>
    </gmljp2:CodeStreamData>
  </gmljp2:featureMember>
</gmljp2:RootFeatureCollection>
```

Annex B: Request parameters of GMLJP2 WCS

Table 1 GetCapabilities operation

Parameter	Description	Values	Mandatory/Optional
service	Requested service	*WCS*	Mandatory
request	Type of request	*GetCapabilities*	Mandatory
version	Version number	*2.0*	Mandatory
sections	Comma-separated section names	ServiceIdentification ServiceProvider OperationsMetadata Contents	Optional
Sample request http://ows9.csiss.gmu.edu/cgi-bin/ows9/gmuwcs?service=WCS&version=2.0&request=GetCapabilities			

Table 2 DescribeCoverage operation

Parameter	Description	Values	Mandatory/Optional
service	Requested service	*WCS*	Mandatory
request	Type of request	*GetCapabilities*	Mandatory
version	Version number	*2.0*	Mandatory
coverageId	valid coverageID of coverage(s)	Example: ▪ NITF:"/home/shao/ows9/jpip/data/NITF_Sample_Data/Files/LandSat_Vendor3_1.ntf": Data	Mandatory
Sample request http://ows9.csiss.gmu.edu/cgi-bin/ows9/gmuwcs?service=WCS&version=2.0& request=describeCoverage&coverageId=NITF:"/home/yshao/ows9/jpip/data/			

NITF_Sample_Data/Files/Case1_HRE10G324642N1170747W_Uxx.hr5":Data

Table 3 GetCoverage operation

Parameter	Description	Values	Mandatory/Optional
service	Requested service	*WCS*	Mandatory
request	Type of request	*GetCapabilities*	Mandatory
version	Version number	*2.0*	Mandatory
coverageId	valid coverageID of coverage(s)	Example: ▪ NITF:"/home/shao/ows9/jpip/data/NITF_Sample_Data/Files/LandSat_Vendor3_1.ntf":Data	Mandatory
subset	Trimming and (or) slicing of coverage dimension	Examples: ▪ Long,http://www.opengis.net/def/crs/EPSG/0/4326(-120,-100) ▪ Long,EPSG:4326(-120,-100) ▪ Lat,http://www.opengis.net/def/crs/EPSG/0/4326(20,40) ▪ Lat,EPSG:4326(20,40) ▪ phenomenonTime("2009-01-01") ▪ phenomenonTime("2009-01-01T12:12:00Z","2009-01-07")	Optional
format	Requested format of coverage to be returned	Examples: ▪ image/nitf ▪ image/jpeg2000 ▪ application/x-netcdf ▪ image/tiff	Mandatory
outputcrs	CRS for the requested output coverage	Examples: ▪ http://www.opengis.net/def/crs/EPSG/0/32612 ▪ http://www.opengis.net/def/crs/EPSG/0/4326	Optional
mediatype	Coverage delivered directly as image file or enclosed in GML structure	Example: ▪ multipart/mixed	Optional
size/resolution	Specify the output width/height or resolution per axis.	Examples: ▪ size=Long(20) ▪ size=x(50) ▪ resolution=long(0.01) ▪ resolution=y(0.3)	Optional

interpolation	interpolation method to be used	Examples: ▪ nearest(default) ▪ bilinear ▪ cubic ▪ cubicspline ▪ lanczos	Optional
Sample request http://ows9.csiss.gmu.edu/cgi-bin/ows9/gmuwcs?service=WCS&version=2.0&request=GetCoverage&coverageid=NITF:"/home/yshao/ows9/jpip/data/NITF_Sample_Data/Files/Case1_HRE10G324642N1170747W_Uxx.hr5":Data&format=image/jpeg2000&mediatype=multipart/mixed http://ows9.csiss.gmu.edu/cgi-bin/ows9/gmuwcs?service=WCS&version=2.0&request=GetCoverage&coverageId=NITF:%22/home/yshao/ows9/jpip/data/NITF_Sample_Data/Files/Case1_HRE10G324642N1170747W_Uxx.hr5%22:Data&format=iamge/JPEG2000&subset=Lat,http://www.opengis.net/def/crs/EPSG/0/4326(32.779,32.780)&subset=Long,http://www.opengis.net/def/crs/EPSG/0/4326%(-117.128,-117.127)			

Annex C: Request and response of GetCoverage for JPIP coverage

Request example:

http://ows9.csiss.gmu.edu/cgi-bin/ows9/gmuwcs?service=WCS&version=2.0&request=GetCoverage&coverageid=NITF:%22/home/yshao/ows9/jpip/data/NITF_Sample_Data/Files/Case1_HRE10G324642N1170747W_Uxx.hr5%22:Data&format=text/xml;urn:ogc:def:wcs:2.0:jpip-response

Response example:

```
<?xml version="1.0" encoding="UTF-8"?>
<Coverages xmlns="http://www.opengis.net/wcs/2.0"
xmlns:ows="http://www.opengis.net/ows"
   xmlns:owcs="http://www.opengis.net/wcs/2.0/ows"
xmlns:xlink="http://www.w3.org/1999/xlink"
   xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
   xsi:schemaLocation="http://schemas.opengis.net/ows/2.0 ../owsCoverages.xsd">
   <Coverage>
      <Abstract>JPIP (JPEG 2000 Interactive Protocol) is a compression streamlining
protocol that works with JPEG 2000 to produce an image using the least bandwidth
required. GMU CSISS developed JPIP-enabled GMLJP2 WCS service which could
deliver the response of GetCoverage request in JPEG2000 format via JPIP protocol. The
URL included in this XML could be opened by Kakadu JPIP client, LEADTOOLS JPIP
Client or any other JPIP clients.
      </Abstract>
      <Reference
xlink:href="jpip://ows9.csiss.gmu.edu:9002/ows9cache/Case1_HRE10G324642N1170747W_Uxx.20121003143311.jp2"  xlink:role="urn:ogc:def:role:WCS:2.0:coverage"/>
   </Coverage>
</Coverages>
```

Annex D: Tools to visualize JPIP stream

1. Kakadu Client

(1) Download the Kakadu Win32 Executables from here, and install them on your local computer.

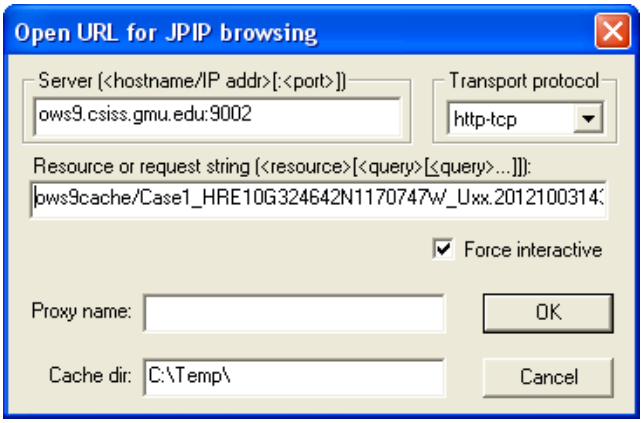
(2) Send a GetCoverage request and specify the response format as JPIP protocol, then retrieve the JPIP URL from the response, as shown in Annex C.

(3) Open the executable program named kdu_show.exe, and click File -> Open JPIP URL. In the pop up window, specify the following values in the corresponding box:

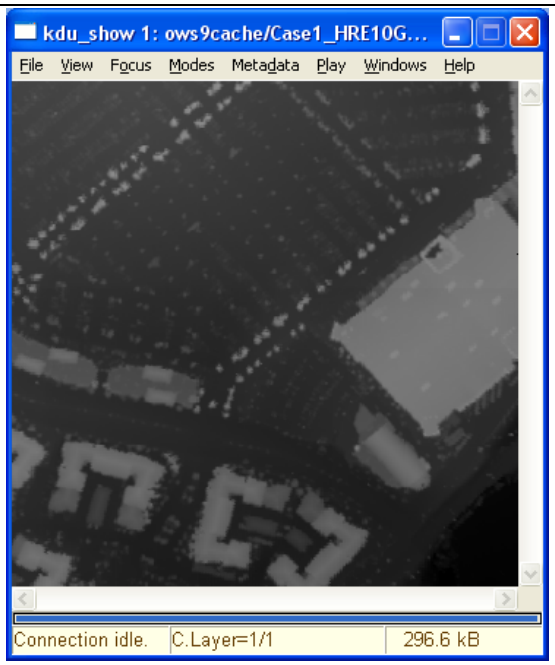
Server: *ows9.csiss.gmu.edu:9002*

Transport protocol: *http-tcp*

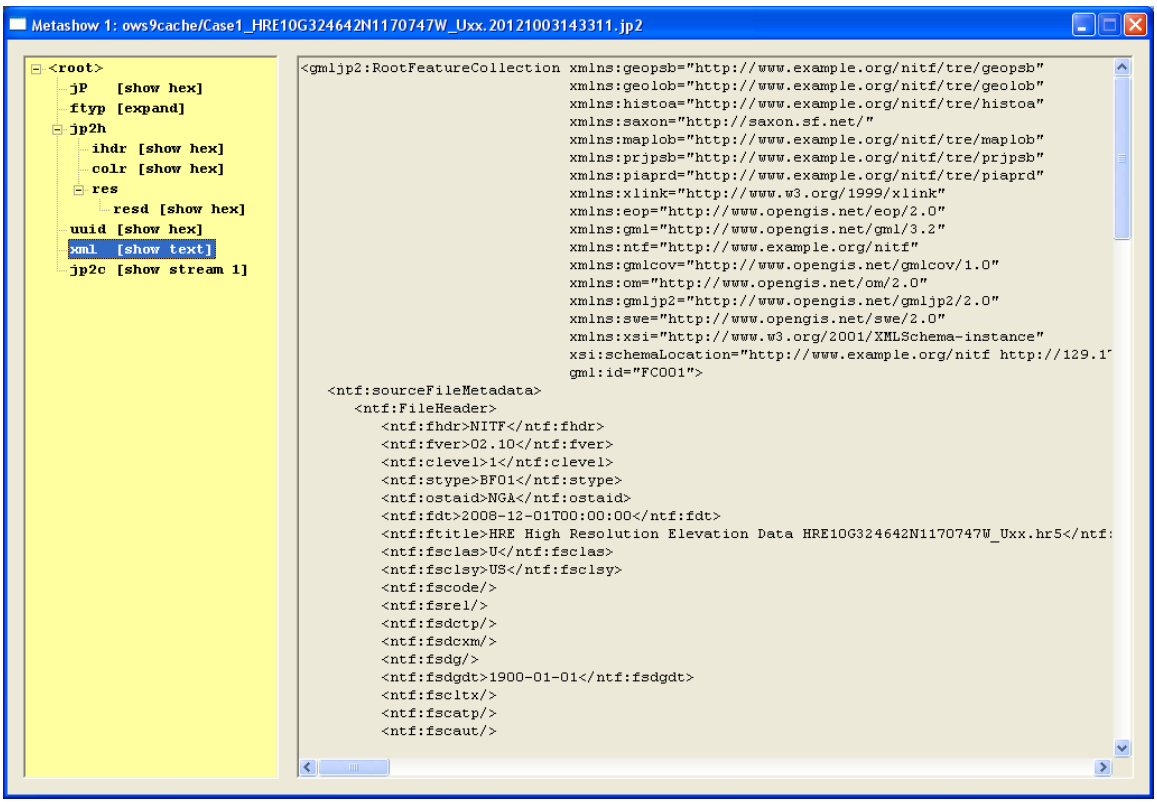
Resource or request string: path of the output JPEG2000 data



Then click OK button, the image will be shown in the window, as seen in the following figure:



(4) To check the metadata information, click Metadata -> Open Metadata. A window will be displayed, as seen in the following figure.



Please note that click the “xml” tag to display the GMLJP2 metadata.