INSPIRE Land Cover Data Specifications to model fire access time in Europe: the experience of the eENVplus project

A. Astyakopoulos, M. Bonazountas, A. Trypitsidis (EPSGR)
G. Martirano, F. Vinci, S. Morrone (EPSIT)

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Summary

- The problem targeted
- FCM (Fuel Classification Maps) for Forest Fire Management
- The ArcFUEL methodology
- An INSPIRE implementation for FCM
- The eENVplus operational scenario
The problem targeted

- Forest Fire (FF) Management requires knowledge of Fuel Classification Maps (FCMs) that are poorly available in Mediterranean countries since they are produced only at local or regional scale, without any regular updates and/or using standardized methodologies.

- Therefore available FCMs cannot support the systematic use of FF modeling at operational levels (prevention, suppression planning) of FF management.
FCMs for FF Management

Forest vegetation is considered as a “fuel” and its structure and status govern the dynamics of a fire.

This is the reason why Fuel Models and their spatial patterns (i.e. FCMs) are significant for FF Management Actions during all four phases of the FF lifecycle:

1 (Awareness phase - prior to the fire)
2 (Emergency phase - during the fire)
3 (Impacts phase - after the fire)
4 (Dissemination phase - lesson learnt).
The ArcFUEL methodology

- The eENVplus pilot on Forest Fires is based on the operational use of FAT (Fire Access Time), produced using the ArcFUEL methodology.
- It consists of cascaded steps based on the use of multi-temporal LANDSAT Thematic Mapper (TM) images for the distinction of fuel classes with different seasonal characteristics and further refinement based on ancillary data, such as burned areas, and canopy cover density derived from satellite observations.
The Land Cover (LC) data theme has been selected as the most applicable and the relevant DS has been deeply analysed.

The LC data specification does not prescribe or recommend any particular land cover nomenclature for use in INSPIRE. The approach taken by LC DS is instead to allow many different land cover nomenclatures to coexist in the context of INSPIRE.
The LC DS defines the following application schemas:

- LandCoverNomenclature application schema;
- LandCoverVector application schema;
- LandCoverRaster application schema.

In addition, a LandCoverExtension application schema is defined in order to support requirements from specific use cases and/or may be used to provide additional information.
INSPIRE Land Cover Data Specification

pkg Land Cover AS Structure

- «applicationSchema» LandCoverNomenclature
  - CorineValue
  - LandCoverClassValue
  - LandCoverNomenclature

- «applicationSchema» LandCoverVector
  - LandCoverDataset
  - LandCoverObservation
  - LandCoverUnit
  - LandCoverValue

- «applicationSchema» LandCoverRaster
  - LandCoverGridCoverage

- «applicationSchema» LandCoverExtension
  - CountableParameter
  - LandCoverDataSet
  - LandCoverObservation
  - LandCoverUnit
  - PercentageParameter
  - ParameterType
  - PresenceParameter

LC UML Packages
INSPIRE Land Cover Data Specification

LC data shall be modeled through one of the two core applications schemas:

- LandCoverVector defines a vector representation (i.e. points or surfaces) to support Land Cover data.
- LandCoverRaster defines a raster representation to support Land Cover data.

The two schemas differ only for technical reasons, related to implementation aspects:

- only one classification code is allowed per raster cell for the raster representation (multiple codes are allowed in the vector representation in order to follow LC changes).
- no mosaic description allowed for the raster representation.
An INSPIRE implementation for FCM

- Following the selection of the LandCoverRaster application schema, the use of the external file option for the encoding of the FCM values has been investigated.

- In order to physically implement this option, the indications contained in the Annex J (‘Encoding rules for TIFF and JPEG 2000 file formats’) of the “D2.8.II.2 Data Specification on Land Cover - Technical Guidelines” and in the Annex C (‘Resource identifiers’) and Annex D (‘Encoding of file-based data’) of “D2.7: Guidelines for the encoding of spatial data, Version 3.3” have been followed.
1. the range is described according to the contraints
   (=LandCoverCoreInformation here for the moment but will be another semantic description)
2. Format for Gridded Coverage (geotiff for example) support generally only 1 code (not a mosaic) in RGB mode
3. for gridded coverage, there shall be contrains to provide links between LC codes and colors (as provided by CORINE for example)
Since Land Cover Raster application schema models Land Cover data as rectified grid coverages, the ArcFUEL spatial dataset has been mapped to the LandCoverGridCoverage feature type.

```xml
<?xml version="1.0" encoding="UTF-8"?>
<gml:FeatureCollection
  gml:id="eu.Italy.Calabria.ArcFuel_FCM">
  <gml:featureMember>
    <lcr:LandCoverGridCoverage
      gml:id="ArcFuel.FCM.Calabria_LCRaster">
      ...<gml:FeatureCollection>
```
In accordance to the constraint ‘domainIsRectifiedGrid’, present in the RectifiedGridCoverage feature type, the domain of the coverage (i.e. the domainSet attribute of the LandCoverGridCoverage feature type) has been encoded as RectifiedGrid.

```xml
<gml:domainSet>
  <gml:RectifiedGrid dimension="2" gml:id="tiff_domain">
    <gml:limits>
      <gml:GridEnvelope>
        <gml:low>550780 4190560</gml:low>
        <gml:high>695380 4452960</gml:high>
      </gml:GridEnvelope>
    </gml:limits>
    <gml:axisLabels>x y</gml:axisLabels>
    <gml:origin>
      <gml:Point gml:id="grid_origin_tiff" srsName="http://www.opengis.net/def/crs/EPSG/0/3045">
        <gml:pos>550780.00 4452960.00</gml:pos>
      </gml:Point>
    </gml:origin>
    <gml:offsetVector srsName="http://www.opengis.net/def/crs/EPSG/0/3045">50 0</gml:offsetVector>
    <gml:offsetVector srsName="http://www.opengis.net/def/crs/EPSG/0/3045">0 -50</gml:offsetVector>
  </gml:RectifiedGrid>
</gml:domainSet>
```
Considering that the final ArcFUEL output, is a file-based dataset, the range set of the coverage (i.e. value of the `rangeSet` attribute in the `LandCoverGridCoverage` feature type) has been encoded using an `xlink:href` attribute for referencing to the `tiff` file (Section D.4 of “D2.7: Guidelines for the encoding of spatial data, Version 3.3”).

```xml
<gml:rangeSet>
  <gml:File>
    <gml:fileReference>Italy_Calabria.tif</gml:fileReference>
    <gml:fileStructure>Record Interleaved</gml:fileStructure>
  </gml:File>
</gml:rangeSet>
```
Regarding the FCM nomenclature, the element \textit{nomenclatureDocumentation} of the featureType \textit{LandCoverGridCoverage} has been used.

Within its \textit{LandCoverNomenclature} dataType, the attribute \textit{nomenclatureCodeList} has been used to document the 20-classes Fuel Types classification defined by ArcFUEL, through its encoding as an URI.
## Nomenclature (codes and names) of the ArcFuel FCM

<table>
<thead>
<tr>
<th>No.</th>
<th>Evergreen Broadleaved Scrub forest</th>
<th>11</th>
<th>Deciduous Coniferous open forest</th>
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<tr>
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<td>Evergreen Broadleaved open forest</td>
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<td>Deciduous Coniferous Dense forest</td>
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<td>3</td>
<td>Deciduous Broadleaved Scrub forest</td>
<td>14</td>
<td>Evergreen Mixed open forest</td>
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<td>4</td>
<td>Deciduous Broadleaved open forest</td>
<td>15</td>
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<td>5</td>
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<td>Deciduous Mixed Scrub forest</td>
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<tr>
<td>6</td>
<td>Evergreen Coniferous Scrub forest</td>
<td>17</td>
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<td>7</td>
<td>Evergreen Coniferous open forest</td>
<td>18</td>
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<tr>
<td>9</td>
<td>Deciduous Coniferous Scrub forest</td>
<td>20</td>
<td>Grasses</td>
</tr>
</tbody>
</table>
Nomenclature encoding

In addition, for the FCM nomenclature documentation, the attribute “externalDescription” of the LandCoverNomenclature data type has been used, instead of the attribute ”embeddedDescription”, which should require using LCML metalanguage.
Dataset validation

- Full conformity w.r.t. the 7 tests of CC A.1 (Application schema) of ATS has been achieved and documented.

- Detailed presentation will be given on Thursday 19.06.2014 at 10 am in Room 5: “How to Assess the Degree of Conformity to the Requirements Specified by Commission Regulation (EU) No 1089/2010 Relevant to a Dataset Belonging to INSPIRE Annex II/III Data Themes”
This data harmonization exercise is fully documented in 3 Best Practices available in the smeSpire Best Practice Catalogue (www.smespire.eu):

- How to encode a raster dataset in accordance to INSPIRE “D2.8.II.2 Data Specification on Land Cover - Technical Guidelines“
- How to assess the degree of conformity to the requirements specified by Commission Regulation (EU) No 1089/2010 relevant to a dataset belonging to INSPIRE Annex II/III data themes
- INSPIRE compliant metadata containing both discovery MD and MD for interoperability

It is offered to Civil Protection Authorities, and National- Regional- & Local Authorities.

Its aim is to guide operations and protect our forests.

The platform is customizable to meet any client’s needs
Technology:

- Asynchronous Ingestion Service
  - creation of spatio-temporal data (meteorological forecasts and indexes)
  - ingestion of data to the eENVplus SDI
  - return data via OGC services: WMS, WCS, WFS

- WPS orchestration
  - calculation of fire simulation (FAT: fire access time) - INSPIRE
  - calculation of total risk by combining a series of services
  - calculation of optimal route avoiding the fire
ArcFIRE Ingestion Service

Begin ()

- sets the parameters to download the raw meteorological data for all the active pilot areas called “Scenes”
- defines the BBOX with particular CRS and EGU (e.g. 20m.)
- all available and activated “Scenes” are stored in an XML structure which contains only one data type called “Meteo Territory”
- copies the XML attributes in the root directory of the machine where the service is running
ArcFIRE Ingestion Service

Start the Service

- Begin()
- StartArea()

Ingestion Part A

- MakeData()
- InsertDate()
- Transform()
- Forecasts()
- IgenForecasts()
- Interface A

Ingestion Part B

- Interface B
ArcFIRE Ingestion Service

- **Start Area ()**
  - queries the FTP services given by the “Meteo Territory” in a sequential order (e.g. UoA)
  - if any problem occurs in the query, the function attempts after 10 min
  - if an FTP area fails to respond, the function searches for the next available FTP server
  - compares the “ddmmyy” folders available on the FTP folder structure against the sets of raw data already downloaded
  - starts a threat for each day missing and is not prior to “Server installation date” or the “last backup date”
ArcFIRE Ingestion Service

Activity Diagram

Start the Service

- Begin()

Ingestion Part A

- StartArea()
  - Starts a Threat Loop for all "scenes" and for all "missing days" per scene
  - MakeData()
    - InsertDate()
    - Transform()
    - Forecasts()
    - IlcgfForecasts()
      - Interface A
  - Interface A

Ingestion Part B

- Interface B
ArcFIRE Ingestion Service

- Make Data ()
- downloads the raw meteorological forecasts (7 parameters) for each day missing - usually 121 files (per hour for 5 days, i.e. 5x24+1=121)
- keeps the names of the files as given by the FTP server (e.g. seihsu_LL.hhh, where hhh=forecast horizon)

- U10: x-component of wind speed (m/s)
- V10: y-component of wind speed (m/s)
- T2M: air temperature at 2m height (K)
- RH2M: relative humidity at 2m height (%)
- CLOUD: cloud fraction (%)
- MSL: mean sea-level pressure (Pa)
- RAIN: accumulated precipitation for the last 1h (mm)

### File List

<table>
<thead>
<tr>
<th>Όνομα</th>
<th>Τύπος</th>
<th>Μέγεθος</th>
<th>Χρόνος</th>
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</table>
ArcFIRE Ingestion Service

- Insert Data ()
  - parses all the files 1-by-1 per day available
  - separates the file in 7 blocks (one for each parameter)
  - Stores the data into the database (PostGIS)

<table>
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<tr>
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ArcFIRE Ingestion Service

<table>
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<th>Start the Service</th>
<th>Ingestion Part A</th>
<th>Ingestion Part B</th>
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<tbody>
<tr>
<td>Begin()</td>
<td>StartArea()</td>
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<td>FORECASTS()</td>
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<td>IGENFORECASTS()</td>
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</tr>
<tr>
<td></td>
<td>INTERFACE A</td>
<td>Interface B</td>
</tr>
</tbody>
</table>

Starts a Threat Loop for all "scenes" and "missing days" per scene.
Transform ()

- Wind Speed (WSP) transformation
  - transforms $U_{10}$ (x component, m/s) and $V_{10}$ (y component, m/s) to WPS (m/sec)
    \[
    WSP = \sqrt{U_{10}^2 + V_{10}^2}
    \]

- Wind Direction (WDI) transformation
  - transforms $U_{10}$ (x component, m/sec) and $V_{10}$ (y component, m/sec) to WDI (degrees)
    \[
    \tan \theta = \frac{x}{y} = \frac{U_{10}}{V_{10}} \implies \theta = \arctan \frac{U_{10}}{V_{10}}
    \]
Transform ()

- Temperature (TEM) transformation
  - Transforms T2M (Kelvin) to TEM (Celsius)

\[ \text{TEM}_{\text{Celsius}} = \text{TEM}_{\text{Kelvin}} - 273.15 \]

- Rain precipitation (PPD) transformation
  - Transforms RAIN (rain precipitation per hour, mm) to PPD (rain precipitation per day, mm)

\[
\begin{align*}
\text{PPD}_{001-012} &= \text{PPH}_{001} + \text{PPH}_{002} + \ldots + \text{PPH}_{012} \\
\text{PPD}_{013-036} &= \text{PPH}_{013} + \text{PPH}_{014} + \ldots + \text{PPH}_{036} \\
\text{PPD}_{037-060} &= \text{PPH}_{037} + \text{PPH}_{038} + \ldots + \text{PPH}_{060} \\
\text{PPD}_{061-084} &= \text{PPH}_{061} + \text{PPH}_{062} + \ldots + \text{PPH}_{084} \\
\text{PPD}_{085-108} &= \text{PPH}_{085} + \text{PPH}_{086} + \ldots + \text{PPH}_{108}
\end{align*}
\]
ArcFIRE Ingestion Service

![Activity Diagram](image)

- **Begin** 
- **StartArea**
  - Starts a `Threat Loops` for all "scenes" and for all "missing days" per scene

  - **MakeData**
  - **InsertDate**
  - **Transform**
  - **Forecasts**
    - **IgenForecasts**
    - **Interface A**

- **Interface B**
ArcFIRE Ingestion Service

- **Forecasts ()**
  - georeferences the raw data to forecast maps
  - resample data at higher resolution (e.g. from 1km to 20m to make them operational at regional level)
  - creates 7 sets of 121 ascii files and stores them to the DB
  - follows the name convention **SSS_YYYYMMDDHNN_hhh_XXX**
    - SSS: scene identifier (e.g. 001)
    - YYYY: year
    - MM: month
    - DD: day
    - HH: hour
    - NN: minutes
    - hhh: forecast identifier (e.g. 001 to 121)
    - XXX: code identifier for each parameter (e.g. WSP)
ArcFIRE Ingestion Service

Start the Service

- Begin()

Ingestion Part A

- StartArea()
- Starts a Threat Loops for all "scenes" and for all "missing days" per scene

- MakeData()
- InsertDate()
- Transform()
- Forecasts()
- igenForecasts()

Ingestion Part B

- Interface A
- Interface B
ArcFIRE Ingestion Service

- **Ixgen ()**
  - creates 8 meteorological indexes related to forest fires
  - stores the indexes into the database
  - follows the name convention \( SSS_{YYYYMMDDHHNN}_{hhh}_{XXX} \)
    - **SSS**: scene identifier (e.g. 001)
    - **YYYY**: year
    - **MM**: month
    - **DD**: day
    - **HH**: hour
    - **NN**: minutes
    - **hhh**: forecast identifier (e.g. 001 to 121)
    - **XXX**: code identifier for each parameter (e.g. WSP)
ArcFIRE Ingestion Service

Start the Service

1. Begin()
2. StartArea()

Ingestion Part A

- Starts a Threat Loops for all "scenes" and for all "missing days" per scene
- MakeData()
- InsertDate()
- Transform()
- Forecasts()
- IgenForecasts()

Ingestion Part B

Interface A

Interface B
ArcFIRE Ingestion Service

- Interface A () → Geobatch
  - collects the categories, zips the packages and sends them to the eENVplus Geoserver
    - BYR: fire maximum linear intensity, KW/m
    - CLO: cloud coverage (%)
    - DFM: dead fuel moisture (%)
    - HRE: air relative humidity (%)
    - PIG: probability of ignition (%)
    - PPD: air precipitation per day (mm)
    - PPH: air precipitation per hour (mm)
    - TEM: air temperature (celsius)
    - WDI: wind direction (degrees)
    - WSP: wind speed (m/sec)
ArcFIRE Ingestion Service

Start the Service

- Begin()

Ingestion Part A

- StartArea()
- Starts a Threat Loop for all "scenes" and for all "missing days" per scene
- MakeData()
- InsertDate()
- Transform()
- Forecasts()
- IxgenForecasts()

Interface A

Ingestion Part B

Interface B
ArcFIRE Web Service

- Defines the BBOX, the ignition points and the simulation date
- Requests the necessary data using a WCS GetCoverage request
- Creates the simulation folders
- Runs the ArcFireSim
- Produces the simulation coverage output
ArcFIRESim

- restores the variables
- reads fuel parameters - INSPIRE
- loads the metadata in memory (reads the files ASP, SLO, FMO, DFM, WDI, WSP)
- loads ignition points
- Behave () does all the pre-calculation for all fuel models
- Analysis () does the cellular automatic analysis process
- returns the results and statistics
Thank you!

Alkis.Astyakopoulos.@epsilon.gr, bonazountas@epsilon.gr, rtd-projects2@epsilon.gr, g.martirano@epsilon-italia.it, f.vinci@epsilon-italia.it, s.morrone@epsilon-italia.it