Production of a land use for radioecological modeling needs around the Fukushima Daichii nuclear plant (Japan)

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Software : QGis (Orfeo Tools Box) ArcGis

An unprecedented disaster !

The accident that damaged the Fukushima Daiichi Nuclear Power Plant (FD NPP) site in March 2011 resulted in massive atmospheric releases of radioactive substances that were dispersed and deposited onto the continental and oceanic surfaces. The widespread deposition resulted in populations being exposed to γ radiation from external exposure or through the ingestion of contaminated foodstuffs. The most seriously contaminated terrestrial areas are within 80km of the damaged site, and comprise forests (70%), agricultural fields (including rice paddy) or meadows (20%), and inhabited areas (10%).

After

Before

Arrival of the wave

Rice paddy

After

Discontinuous urban fabrics

Continuos urban fabricsa

Post accidental studies

For the purpose of several projects related to the post-accidental management of the nuclear accident of Fukushima Daichii in the 100 km area, the understanding of radionuclide transfers in various compartments of the environment and to take into account local specificities of the environment, it was necessary to have a "good" land use, as recent and as accurate as possible. A land use inventory for this area of Japan has been achieved (ALOS [JAXA-Japan], Globe land cover 30 [NGCC-China], Kondo [?] ...) none of them was satisfactory: too old, not suitable nomenclature, area, large unit (25 ha) ...

Therefore, it was decided to define a land use by satellite images digital processing, for an area of about 10.000 km² around the Fd NPP. Land use elements to be identified are those classically used and defined by the modeling tools. Although accurate, the nomenclature is nevertheless simple (about 10 classes).

Remote Sensing – Processings - Results

Nov. 13, 2013 | July 22, 2014 | Sept. 17, 2013

LANDSAT-8 scenes

April 13, 2014

May 31, 2015

USGS science for a changing world

SPOT-5 scenes

ISIS

The «raw» material

For a near field (50 km area), SPOT-5 scenes were used (10 m resolution). Two diachronic images were available with a relatively low proportion of clouds (November 13, 2013 and July 22, 2014). Rice paddy fields are clearly identifiable, the deciduous/evergreen differentiation is also obtained for these two dates, the level of leaf chlorophyll being much lower in mid-November.

For a field called distant (100 km area), LANDSAT-8 scenes were used (30 m resolution). Three images were available with a small amount of cloud (September 17, 2013, April 13, 2014 and May 31, 2015).

The computed land use

The processing of SPOT-5 images and LANDSAT-8 images is operated by supervised classification based on SVM algorithm. The "Support Vector Machines" are a supervised statistical learning method, considered in the literature as the most efficient classifier. In fact, SVM is a discriminative classifier formally defined by a separate hyperplane. The SVM algorithm is integrated in the library Open-source OrfeoToolBox (OTB) developed by CNES (OpenCV based on [Lib SVM])

The challenge for discriminating classes of land use is to process multi-temporal images.

Rather than processing each data independently, multi-temporal spectral signatures can be directly analyzed by a single process. For this, it is necessary to stack the tapes of all the images into a single concatenated data on which can be carried supervised classification.

This is an immediate medium and without intermediate process to take into account the multi-temporal spectral characteristics.

A validation was used to evaluate the quality of the 2 classifications. the producer's accuracy (omission error) is higher 90% for 5 classes: continuous urban fabric, discontinuous urban fabric, evergreen, water and bare soil. The user's accuracy (commission error) is around 90%. The KHAT coefficients (Cohenov Kappa) iare respectively 0.75 for the SPOT-5 classification and 0.77 for Landsat-8.

OpenCV

Yamagata | Sendai | 100 km

Yonezawa | 50 km

Fukushima

Aizuwakamatsu

Koriyama

FD NPP

Kuronso | Iwaki

Hitachi

- Continuous urban fabric
- Discontinuous urban fabric
- Rice fields
- Grasslands
- Bare soils
- Deciduous
- Evergreen
- Water bodies (Inland waters)
- Water bodies (Estuaries and Ocean)
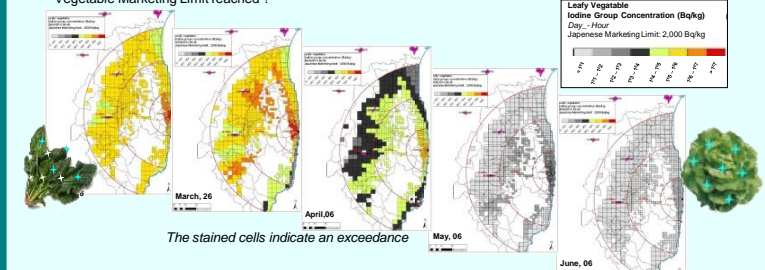
30 | 60 | 90 | 120 km

Applications

Modeling the land use (for our modeling platform)

Issue: Dividing the land use in 'meshes' for modeling

Percentage of each class in each meshe

Representation of the land use with thresholds

The calculations will be performed in the different meshes

The results will be shown in the meshes

Crop Grid

Fukushima

Koriyama | FD NPP

Iwaki

Agricultural meshes (Threshold >10%)
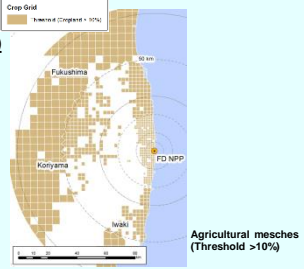
Marketing limit

Issue: Concentration of radionuclides in food

For example, for Iodine group, how much time does it take and how far is the Leafy Vegetable Marketing Limit reached ?

Leafy Vegetable Iodine Group Concentration (Bq/kg) Day.- Hour Japenese Marketing Limit: 2,000 Bq/kg

March, 26 | April, 06 | May, 06 | June, 06

The stained cells indicate an exceedance

Wet and dry deposits

Issue: Modeling ¹³⁷Cs deposits.

Wet deposit in western areas and to the North-West of the nuclear site.

Dry deposit mainly to the South.

Cs137 Wet Deposit March 15, 2011 in kBq/m²

Cs137 Total Deposit March 15, 2011 in kBq/m²

FD NPP
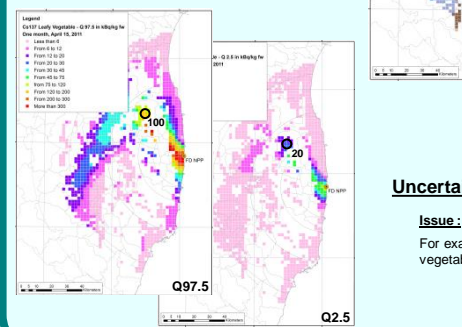
Uncertainties

Issue : Probalistic approach (Bayesian).

For example, predicting uncertainties in the ¹³⁷Cs in leafy vegetable, one month after the deposit (percentile).

Cs137 Leafy Vegetable – Q.97.5 in kBq/kg fw One month, april 15, 2011

-100

-20

Q97.5

Q2.5

Conclusion & perspectives

Remote sensing has permitted to perform a recent land use from multi-spectral and multi-temporal satellite scenes (SPOT-5 and LANDSAT-8) for an area of over 30,000 square kilometers around the nuclear site Fukushima Daiichi (Japan). The classification is adapted for our needs, the accuracy is very good (about 90%).

With the recent launch of the first satellite Sentinel-2A (10 m resolution, equivalent to that of SPOT-5 images) and a second (SENTINEL-2B) planned for the beginning of 2017, the Copernicus project opens interesting perspectives for this type of study. The acquisition of free images, with a 5 days visit interval for each point of the Earth's land, will quickly allow to constitute a splendid database to track various changes on the ground and plant phenology.

The advantage of using SPOT5 scenes is the fact that the resolution is the same of Sentinel2A&B. The algorithms used may be resumed when these scenes will be available. With LANDSAT8 scenes, we can also expect a good durability and we will able to detect changes in the landscape over several years (even decades).

SENTINEL 2