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Food Security monitoring through EO datasets

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PUC2- The Food Security issue

▷ Korea has low food self-sufficiency that is decreasing in the long term due to being dependant on the import of most major grains.

▷ For instance South Korea is maintaining 50% of food self-sufficiency under the influence of high self-sufficiency of rice, but grain self-sufficiency rate decreased to 20% because of the increasing import of feed grain.

▷ Overproduction of rice

- Reduced rice consumption: Korean people's eating habits have been westernized, consuming more bread etc. less rice product.
- Farmers prefer to raise rice because it is mechanized well (97.8% of process), while field agriculture is hard to be mechanized in Korea (56.3% of process).

▷ The monitoring of food security in South Korea is focused almost exclusively on rice production.

Target products

- Rice paddy extent mapping
  - Crop classification
- Crop growth monitoring
  - Phenology extraction
  - Health and status monitoring
- Crop yield estimation
  - Production trends
  - kg/ha

Data, technological and technical requirements

- ▷ Multi-year time-series of Sentinlel-1 and Sentinel-2 satellite images
- ▷ Effective and efficient storage, management and processing of such big data
- ▷ Ancillary non-EO data as input models i.e. historical crop yield statistics, crop type declarations, meteo data, field inspections, soil data, agricultural practices information

A time-series approach

- Fast changes on the agricultural land demand data of high temporal resolution (short revisit times)
- Crop phenology is the most important factor for crop type discrimination (spectrally similar vegetation) and development indicator
- Historical time-series are required for crop yield estimation (multi-year)
- Requirements: Multi-year dense time-series of both optical and SAR imagery that cover the better part of the cultivation season

A Big Data problem

▷ Data volume

- S-1: 4 x 10 x 40 x 4 = 6.4T
- S-2: 4 x 20 x 30 x 1 = 3.2 T

▷ Processing and pre-processing demands

- calibration, filtering, conversion, segmentation, machine learning

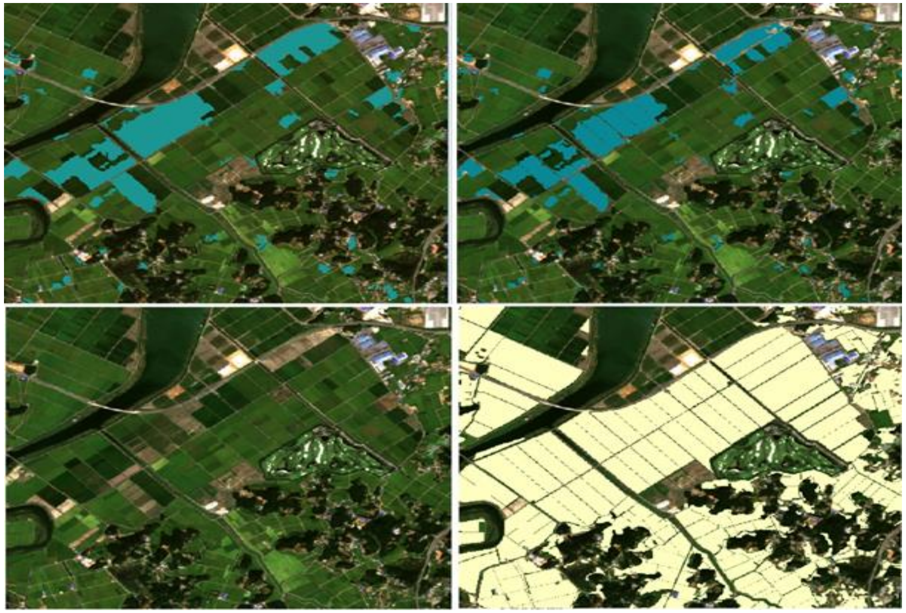
▷ Heterogeneity

- Sensors, orbits, overlap, cloud coverage, type etc.
- Need for automated processing on normalized and gridded datasets

▷ Design the methodologies under operational scenario considerations (data availability, scalability, transferability, generalization)

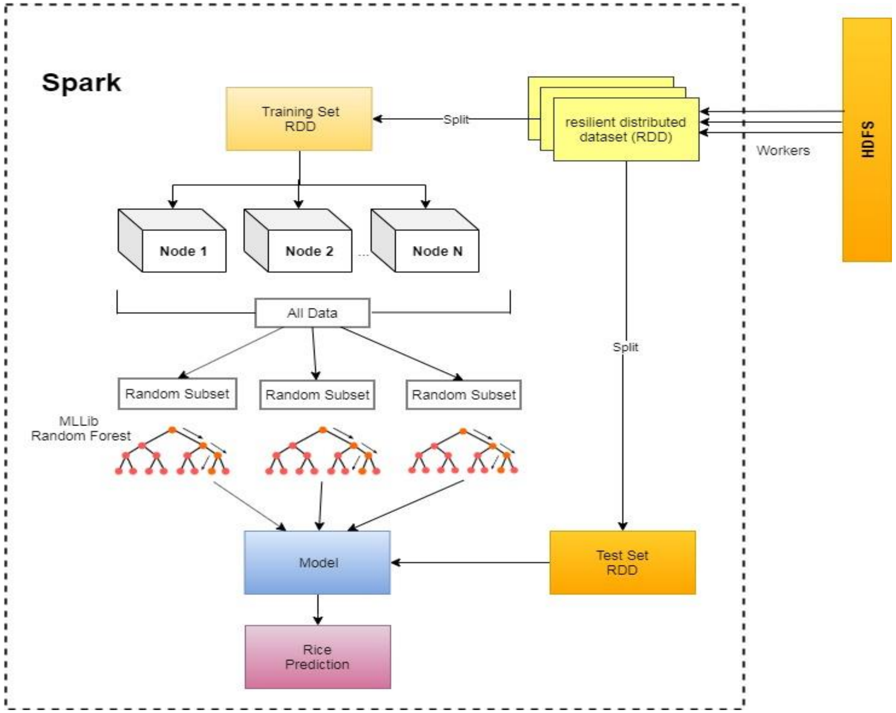
Paddy Rice Mapping

- **Training set**: Dynamic change detection of freely available Korean land cover maps of past years to be used as training for the machine learning algorithms



Paddy Rice Mapping

▷ **Distributed Random Forest**: Food security monitoring at the national scale demands time series analysis of multiple satellite images, so as to capture the crop's phenology. It becomes apparent that the size of this dataset, which is several tens of gigabytes, exceeds the memory limits of conventional machines.



Paddy Rice Mapping

- **Distributed Random Forest**: The results are very promising, with more than 85% precision and recall for the paddy rice class.
- The distributed Random Forest implementation in the HPDA environment accommodates for the big EO data and allows for the large scale pixel-based paddy rice classification. The regional application presented in this work can be linearly scaled up for the entire country, providing an accurate indication of the total paddy rice extent.

	Precision (%)	Recall (%)	F1 – score (%)
Rice	85.62	87.07	86.34
Non-rice	96.90	96.50	96.70

Future work

- **Phenology extraction**

Understanding crop phenology is critical to address the challenges of food security, environmental degradation and climate change, from the perspective of both technological innovation and socioeconomics.

Methodology: Detecting the phenological stages of rice from time-series of optimal vegetation indices against the Accumulated Growing Degree Days. This approach looks at the time series macroscopically.

- **Rice yield estimation**

Methodology: Develop a simplified version of WOFOST model, utilizing the phenology extraction product. WOFOST is a crop growth model to calculate total biomass and yields under optimal and water limited conditions for a large range of conditions and for most crop types

Thank you