ELABORAZIONE DI IMMAGINI SATELLITARI TRAMITE TECNICHE DI DEEP LEARNING PER IL MONITORAGGIO DI AREE AMBIENTALI

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Bari, 31 Gennaio 2019

Outline

- Introduction to Remote Sensing
- Database
  - Sentinel-2 Database for Land Cover Classification
- Procedure for automatic classification of Sentinel-2 images
  - Instance Selection
- Results
  - Pixel-wise Land Cover Classification (SVM & RF)
- Partnership with Planetek

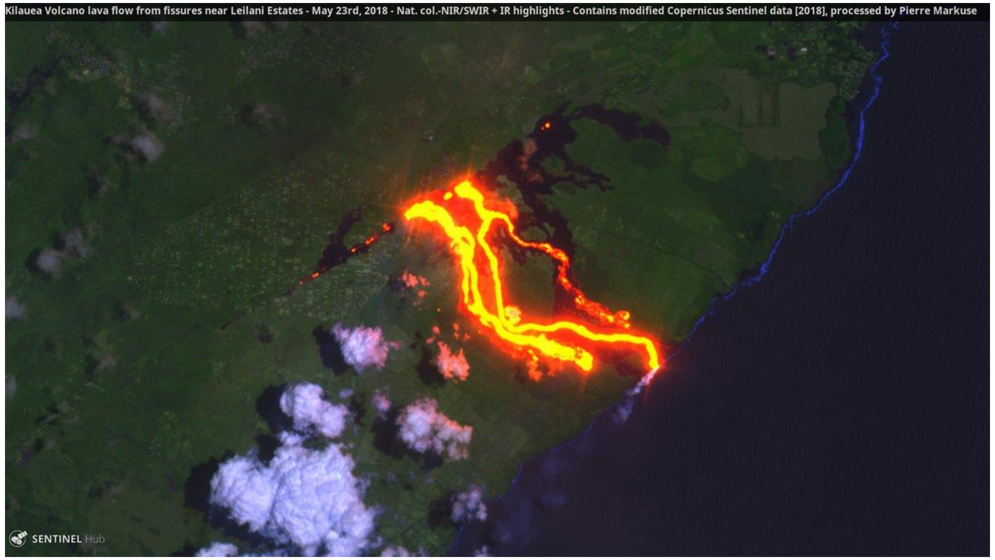
Introduction to Remote Sensing

Remote Sensing (RS):

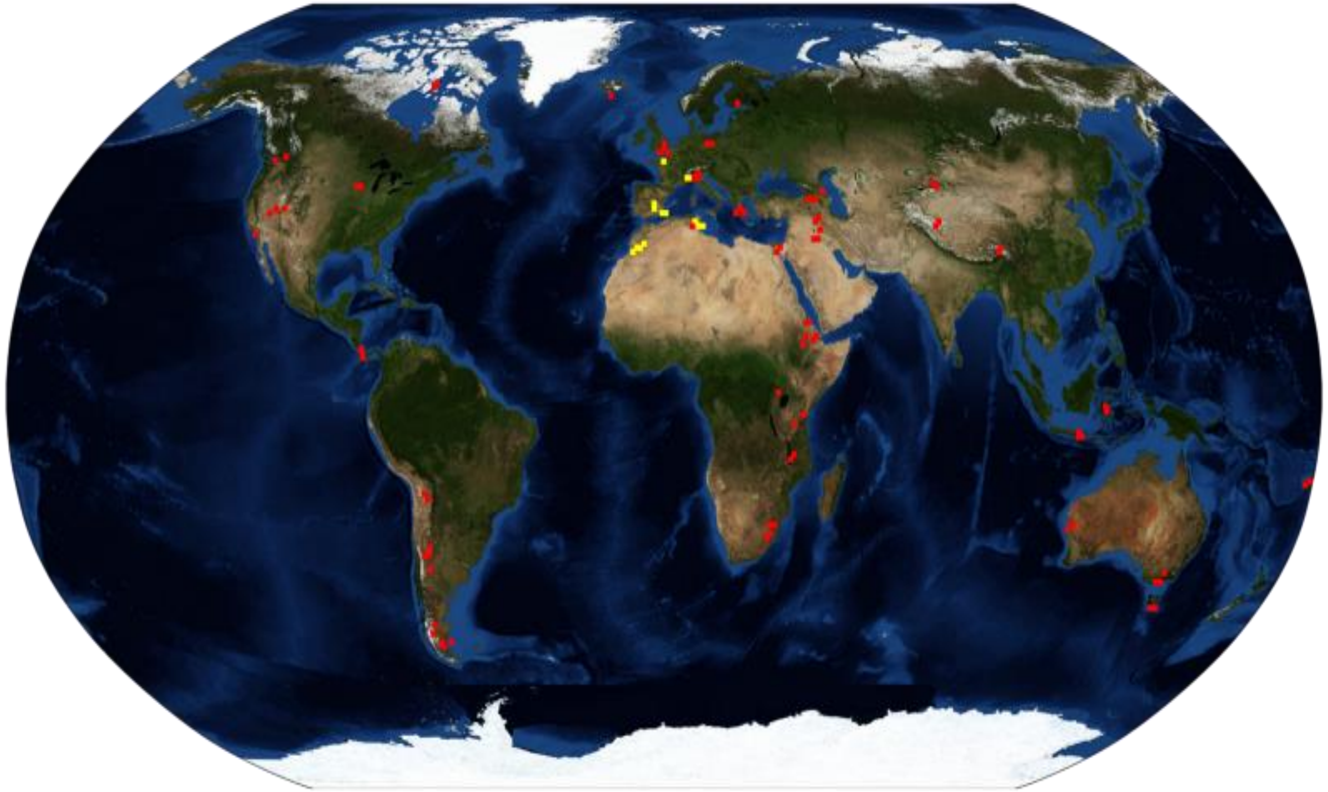
- the acquisition of information about a region of interest without any physical contact

Social and Economic Impact of RS:

- Crop production forecast
- Environmental monitoring
- Management of hazards
- Population estimates



Sentinel-2 Database for Land Cover Classification

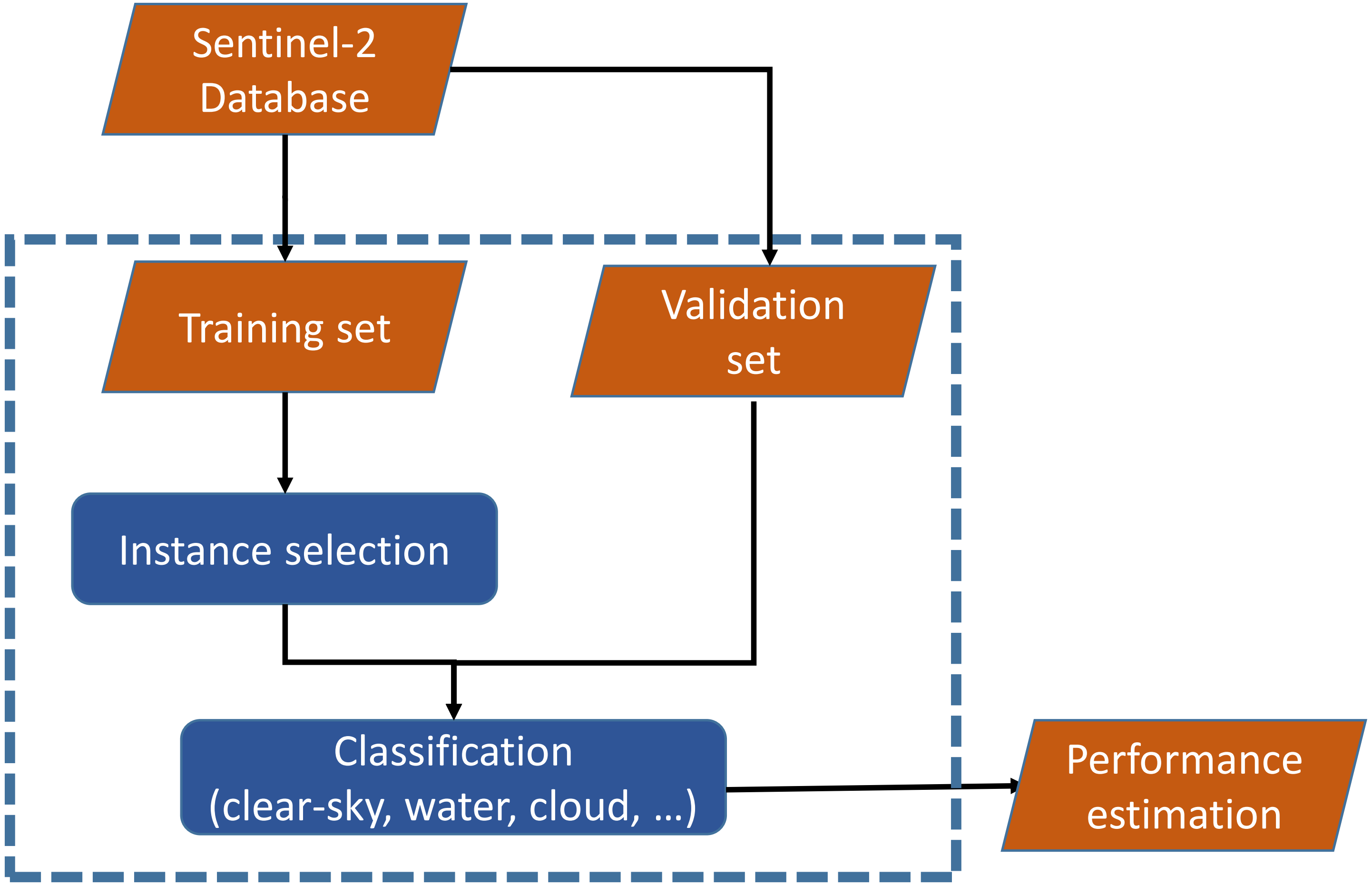


- 108 Sentinel-2 L1C TOA reflectance images
- ~ 5 million hand labelled pixels
- ~ 30 countries

- Six Semantic labels
  - Clear sky
  - Water
  - Shadow
  - Cirrus
  - Cloud
  - Snow

* Hollstein A. et al. ; (2016) Ready-to-Use Methods for the Detection of Clouds, Cirrus, Snow, Shadow, Water and Clear Sky Pixels in Sentinel-2 MSI Images. Remote Sensing MDPI

Procedure for automatic classification of satellite optical images



- 5- fold cross validation
- Instance selection performed by uniform sampling of the training set to speed up the pipeline
- Classification performed by SVM, RF and MLP

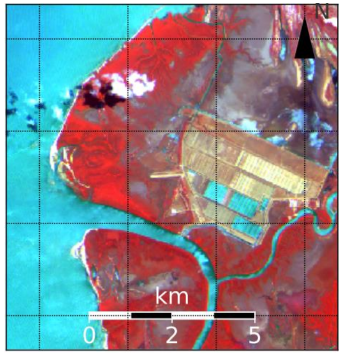
Instance Selection – Motivation

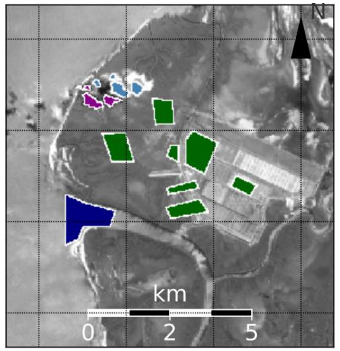
- The database consists of pixels characterized by highly correlated reflectance spectra by construction as can be show by Moran's Index*

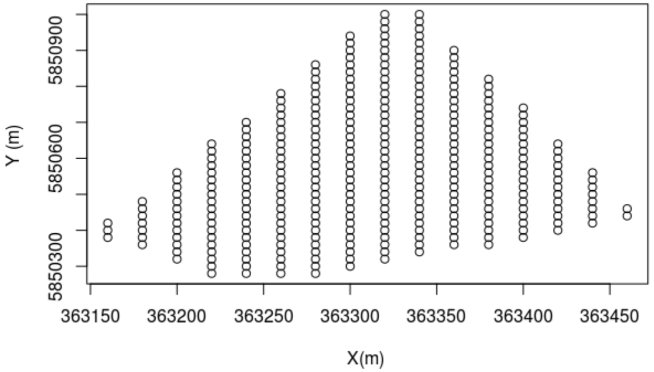
- Spatial autocorrelation statistics like Moran's I measure the degree if dependency among observation of a certain feature in a geographic space*

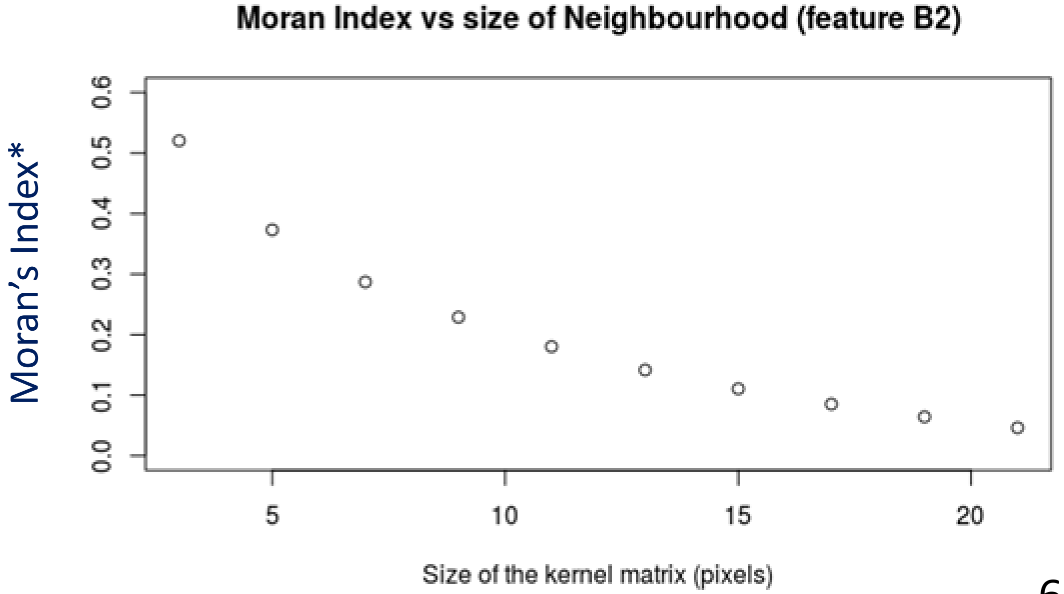
$$I_m = \frac{n}{\sum_i \sum_j w_{ij}} \frac{\sum_i \sum_j w_{ij}\,(x_i - \bar{x})(x_j - \bar{x})}{\sum_i (x_i - \bar{x})^2}$$

$0 < I_m < 1$, positive correlation





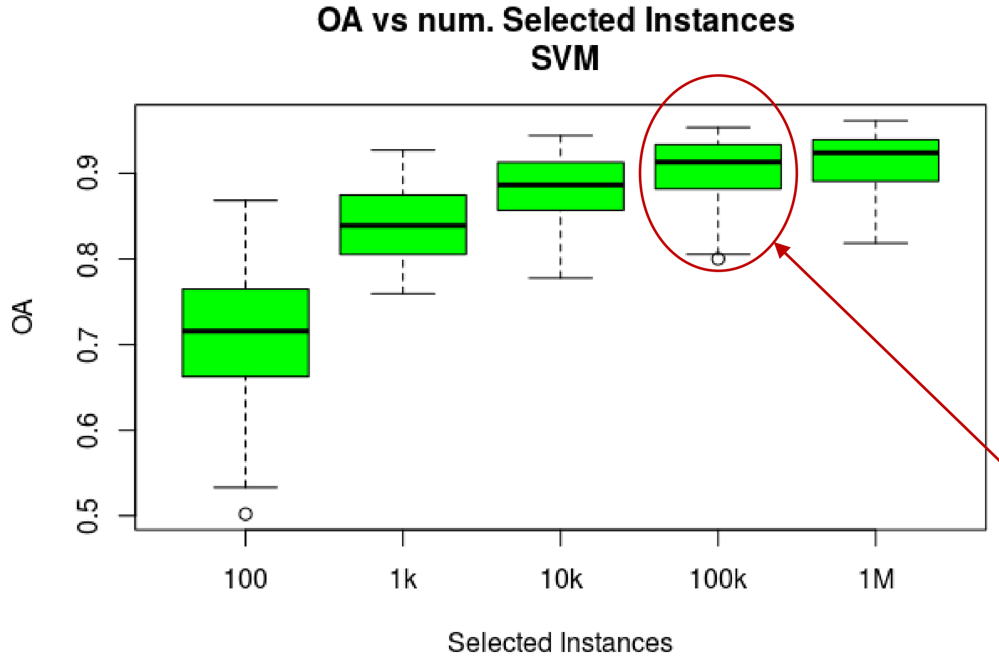




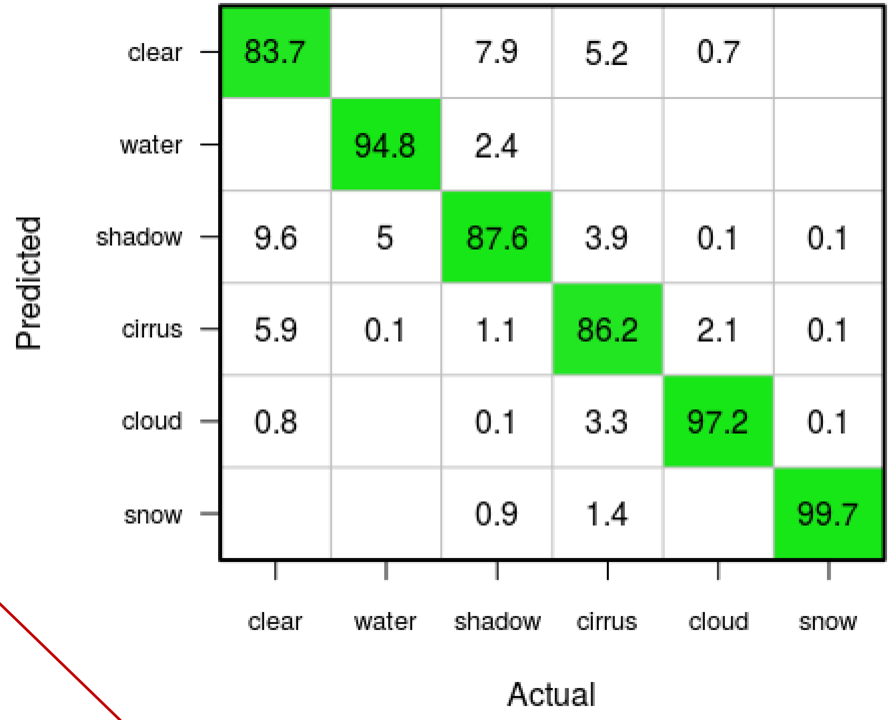
*Moran, P.A.P. (1950) , "Notes on Continuous Stochastic Phenomena" *Biometrika*, Volume 37, Issue 1-2.

Land Cover Classification – SVM

- Each pixel is described by 13 reflectance spectra



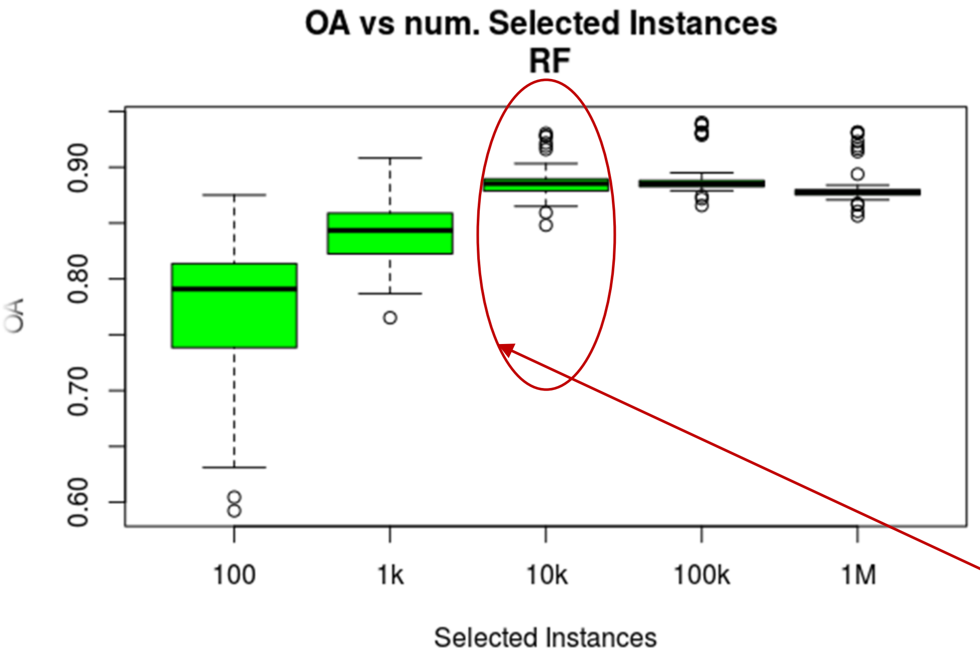
Overall Accuracy (OA) = #correctly labeled pixels / #total pixels

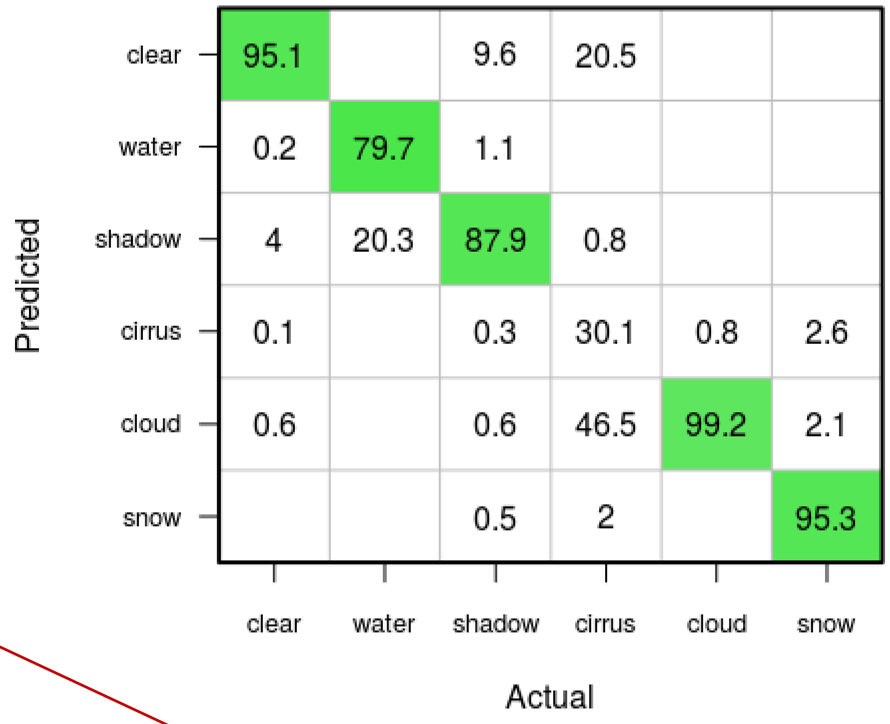


Overall accuracy = 0.92 ± 0.03

Land Cover Classification – RF

- Each pixel is described by 13 reflectance spectra





Overall Accuracy (OA) = #correctly labeled pixels / #total pixels

Overall accuracy = 0.89 ± 0.01

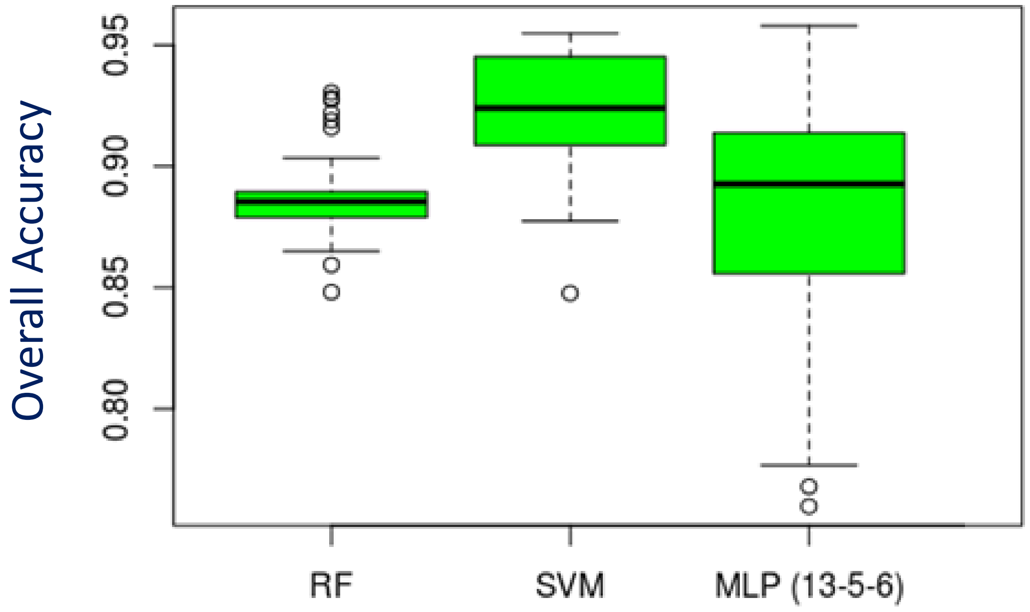
LC Classification – Comparison between classifiers

Overall Accuracy

MLP: 0.88 ± 0.04

RF: 0.89 ± 0.01

SVM: 0.92 ± 0.03



Conclusions and Future Developments

Conclusions

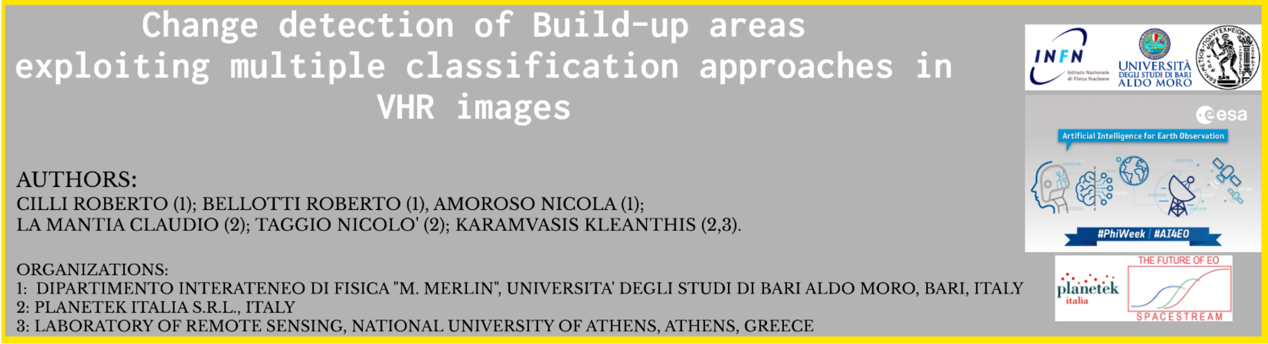
- ✓ SVM is the most accurate classifier
- ✓ RF is the most robust classifier
- ✓ RF is most effective in detecting clear-sky and cloud pixels
- ✓ SVM is most effective in detecting snow, water and cirrus pixels

Future developments

- Ensemble Classifier
- Deep Learning Techniques (based on DBN or DNN)

*Cilli R., Amoroso N., Bellotti R. *(in preparation)*

Partnership with Planetek



Partnership with Planetek

- ✓ Development of a procedure to automatically detect buildings in very high resolution satellite images of urban areas

Conferences

- The ESA Earth Observation Φ-week Open Science and Future EO, Frascati, ESRIN, 12-16/11/2018 (poster)

UNIVERSITÀ DEGLI STUDI DI BARI ALDO MORO

Exams and Seminaries

PhD Courses

- ✓ How to prepare a technical speech in English
- ✓ Management and knowledge of european research and promotion of research results
- ✓ Programming with Python for Data Science
- ✓ Image and Signal Processing
- ✓ Introduction to Parallel Computing and GPU Programming using CUDA
- ✓ Interpolation Methods and Techniques for Experimental Data Analysis
- × Introduction to C++ programming

Seminaries

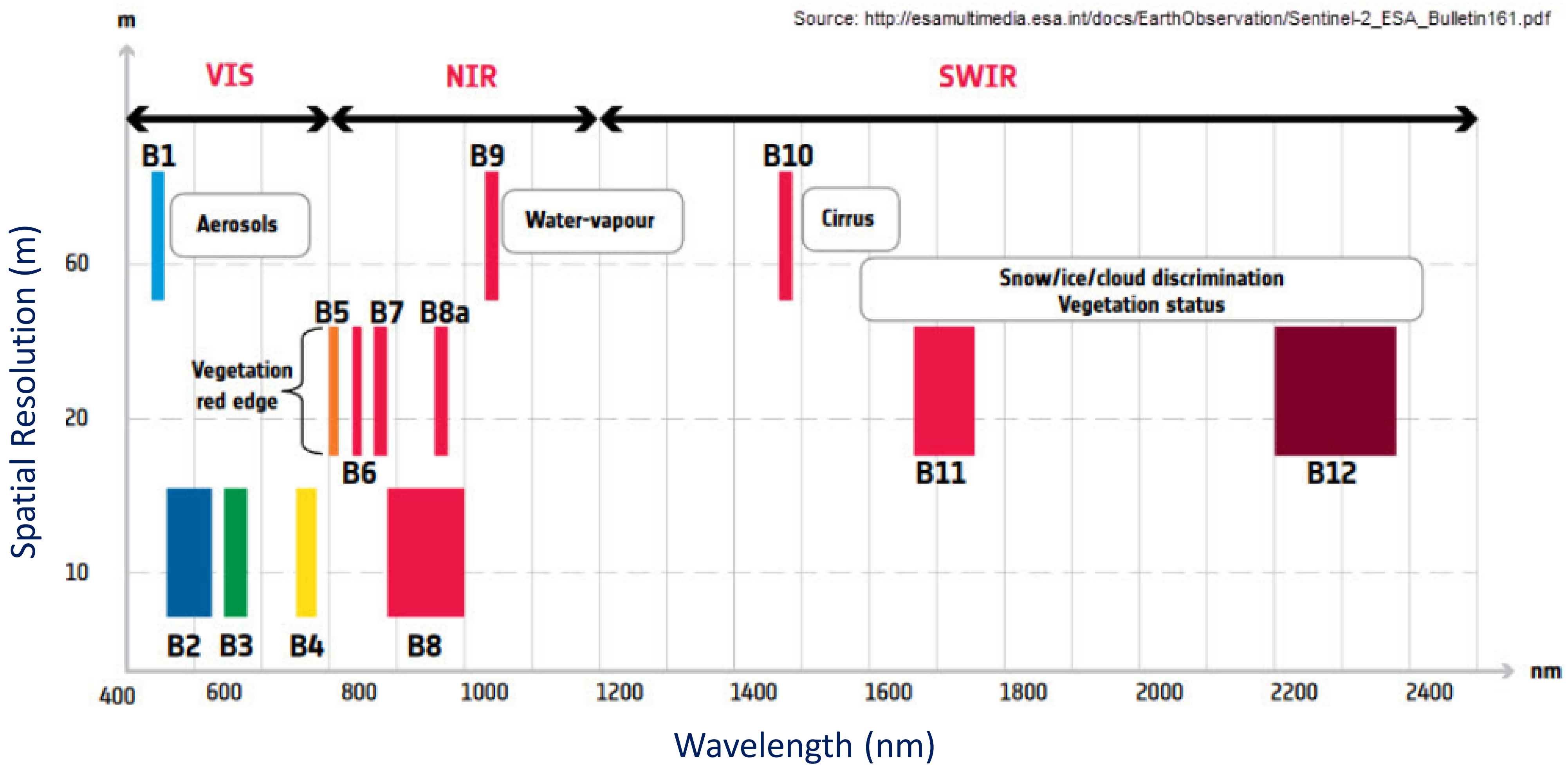
1. ‘’Cycle of lectures on SM and BSM models”. Bari, Dipartimento Interateneo di Fisica, Prof. S Khalil - Director of the Center for Theoretical Physics Zewail City for Science and Technology, Egypt. 20-23/03/2018

Thank you for your attention !

Any Questions?

Backup Slides

Sensors on board Sentinel-2 Satellites



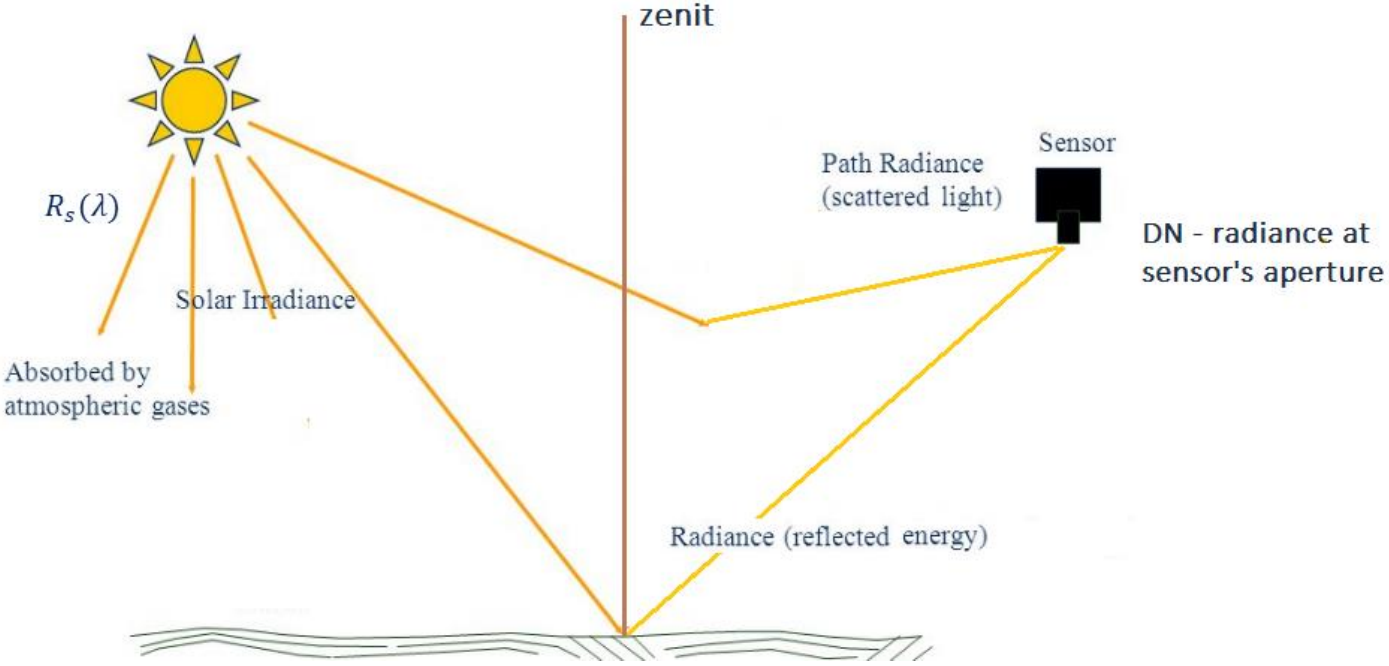
Recovery of TOA reflectances

- Recovery of Top-of-atmosphere reflectance ρ_k

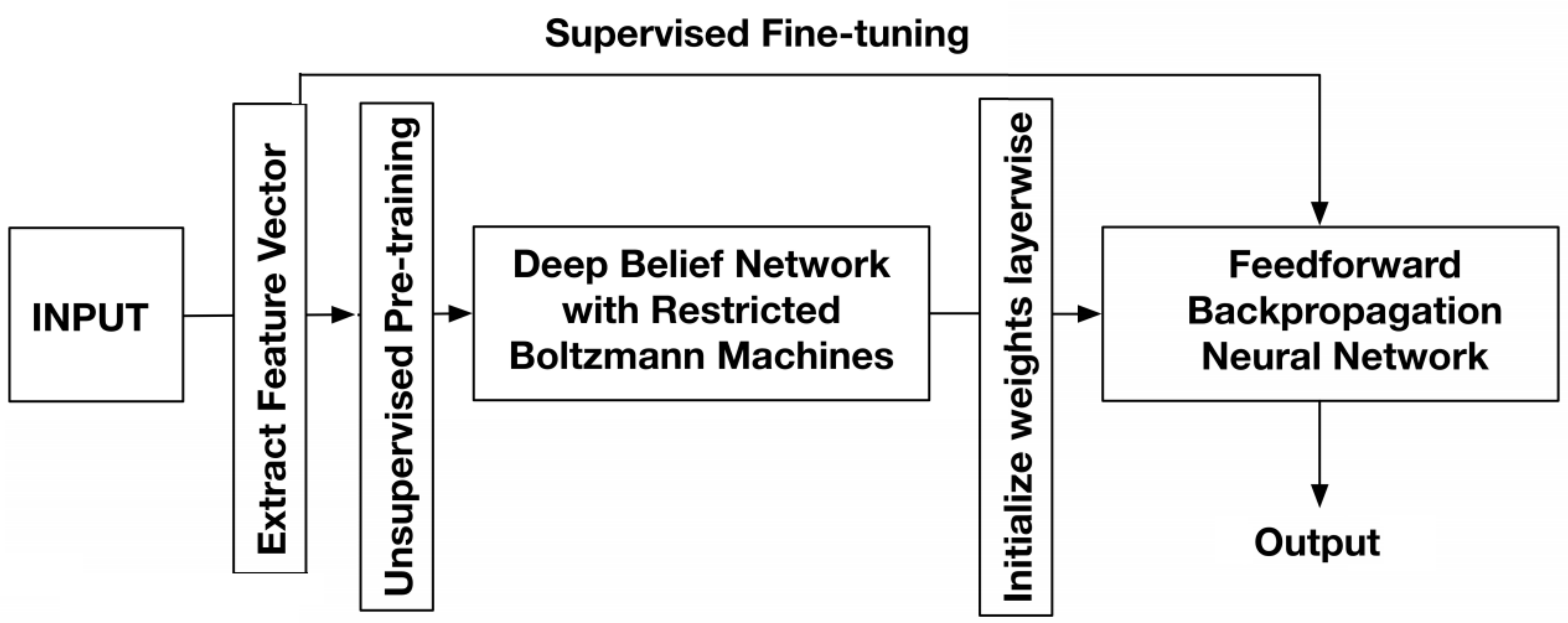
$$\rho_k(i,j) = \frac{\pi \times DN(i,j)}{A_k \times E_{s,k} \times \cos(\theta_s(i,j))} \times d(t)$$

With

- A_k calibration coefficient
- $E_{s,k} = \int d\lambda\, T_k(\lambda)\, R_s(\lambda)$ extra-terrestrial solar spectrum
- $DN(i,j)$ radiance at sensor's aperture (i.e. radiance leaving the ground * transmission factor + path radiance)
- $\theta_s(i,j)$ sun zenit angle
- $d(t) = (1 - \varepsilon \times \cos(\omega(t-2)))^2$
  correction for the sun-Earth distance variation



LC Classification – Proposal



*Hinton G.E., et al. ''A fast learning algorithm for deep belief nets''. Neural computation, 2006 - MIT Press