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AGRICULTURAL CROP MAPPING USING OPTICAL AND SAR MULTI-TEMPORAL SEASONAL DATA: A CASE STUDY IN LOMBARDY REGION, ITALY

G. Fontanelli, A. Crema, R. Azar, D. Stroppiana, P. Villa, M. Boschetti

Institute for Electromagnetic Sensing of the Environment (CNR IREA), Via Bassini 15, Milan (Italy)

Consiglio Nazionale delle Ricerche

INTRODUCTION

- The availability of information about agricultural crops (i.e. typology, phenology, productivity, health) is crucial for a proper agronomic planning and management, especially for end users such as farmers and public administration.
- Remotely sensed data acquired from space sensors, both optical and SAR, have long demonstrated their capability in providing such information in a timely and reliable fashion.
- The integration of SAR and optical sensors data allow us to take advantage by the different sensitivity of both the technologies toward environmental parameters: e.g. soil roughness and moisture, plant water content and biomass for SAR and photosynthetically related vegetation features for the optical sensors.

The research has been carried out in context of the projects:

- "Space4Agri" (**Development of Innovative Earth Observation based Methodologies supporting the Agricultural Sector in Lombardy**; Agreement Framework between Regione Lombardia and CNR).

- "ERMES" (**An Earth Observation Model based RICE information Service**; EU-FP7 Collaborative Project).

Space4 Agri

ERMES
AN EARTH OBSERVATION MODEL BASED RICE INFORMATION SERVICE

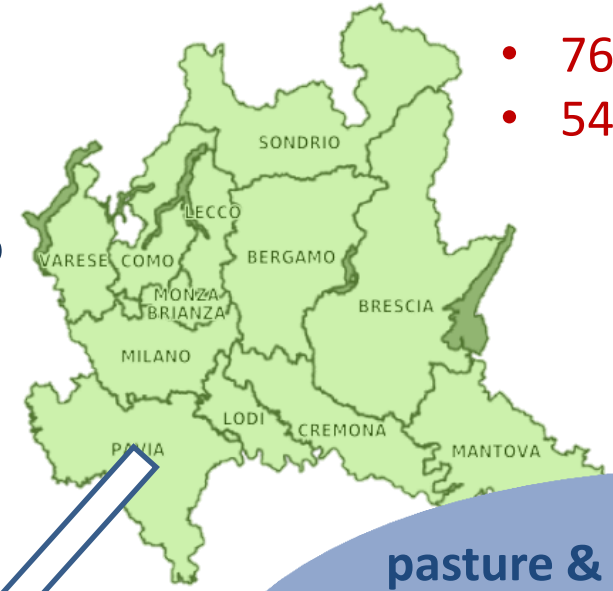
AIM OF THE RESEARCH

This work aims at:

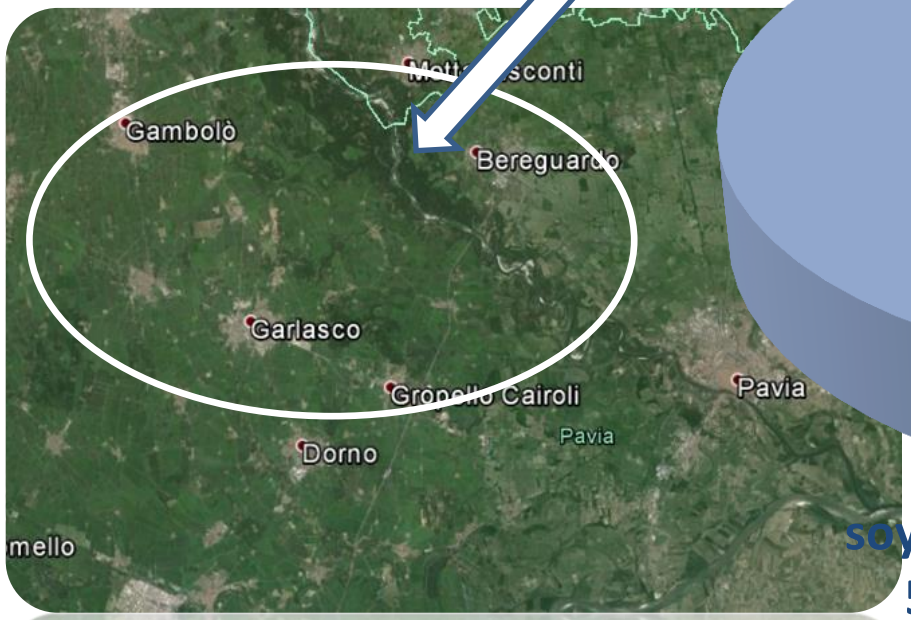
- mapping of crops in Lombardy region (northern Italy) for the year 2013, by using multi-temporal, intra-annual series of SAR and optical satellite data;
- comparing the performance:
  - of three different supervised classification algorithms,
  - at different temporal periods during the growing season.

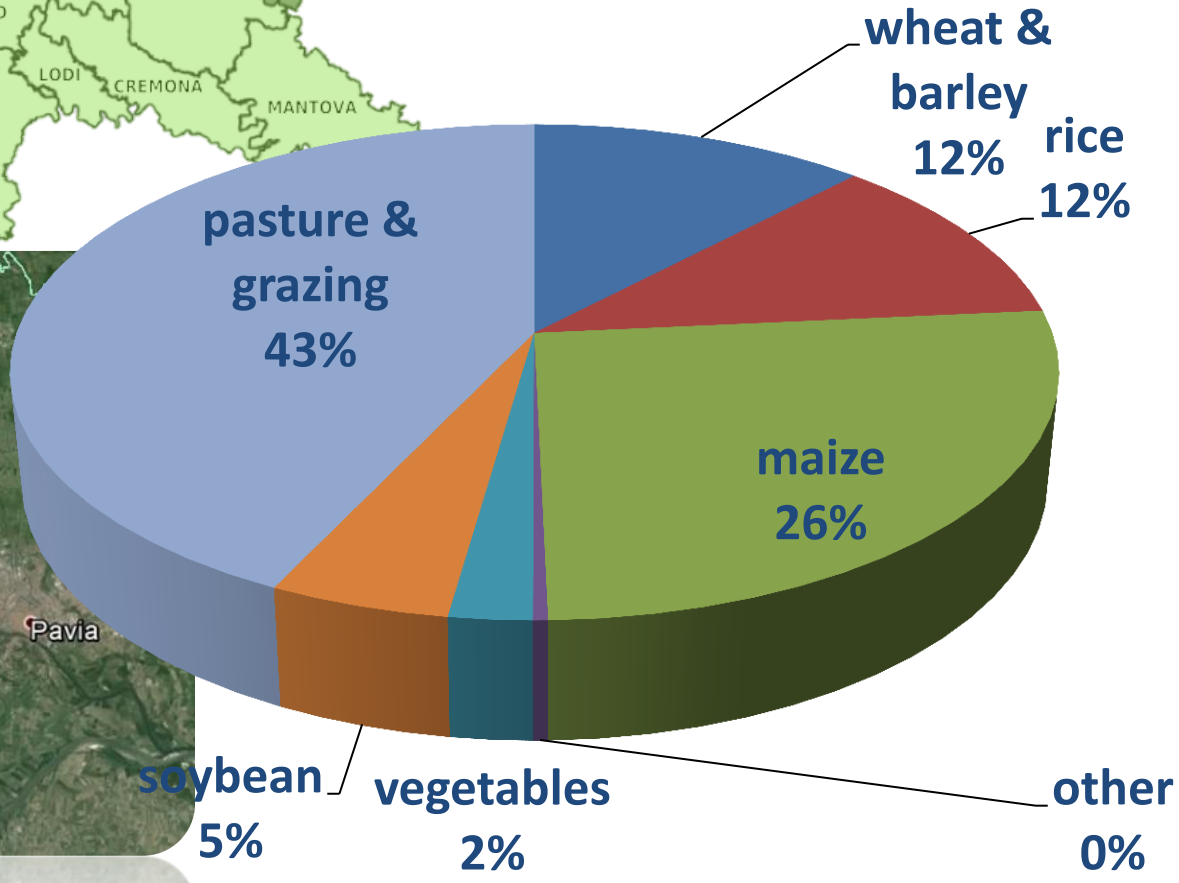
MAIN CROPS IN LOMBARDY REGION 2013

- South Lombardy Region
- Pavia province
- Framed within the Po and the Ticino river basin



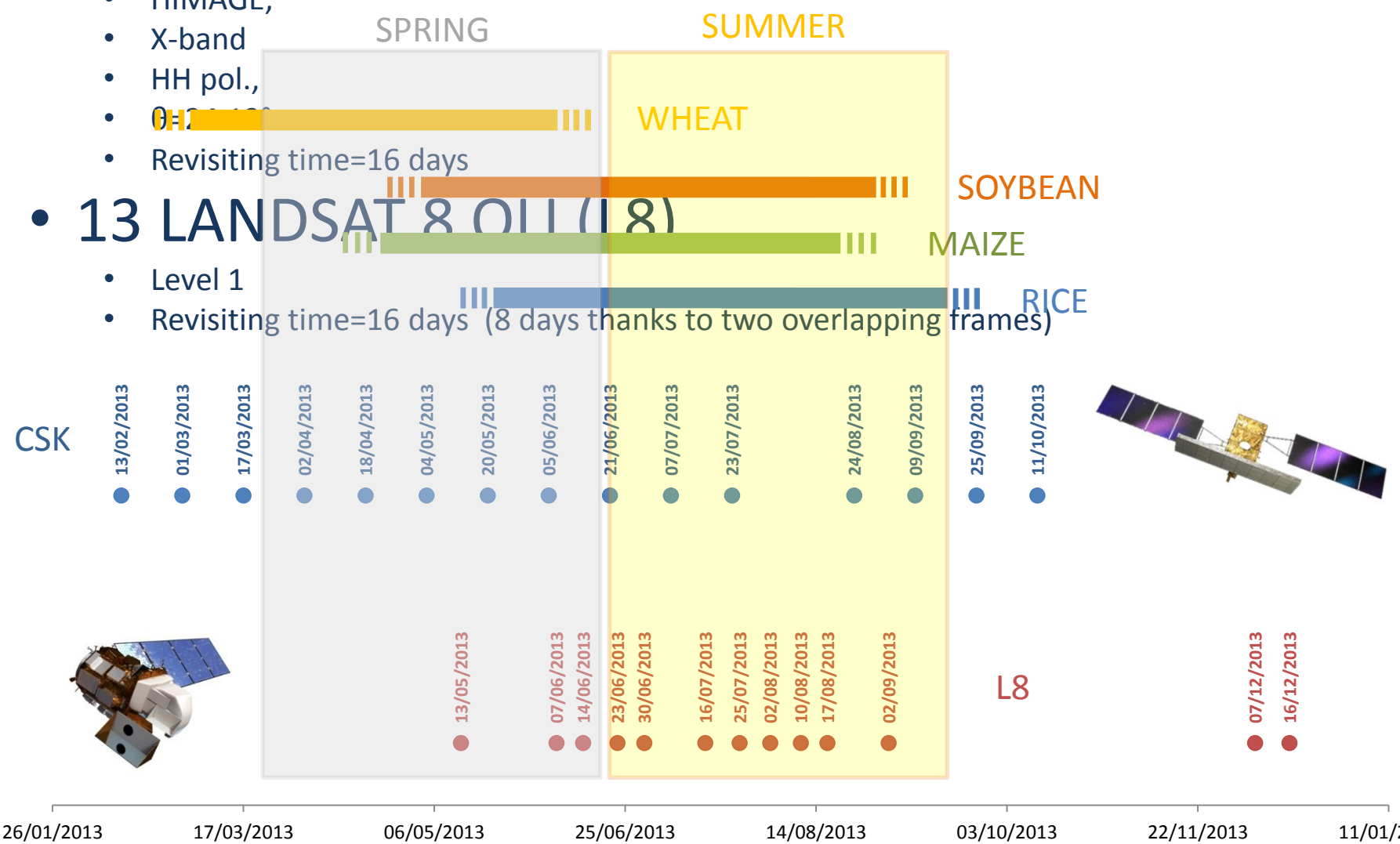
- 761701 hectares cropped in 2013
- 54333 farms



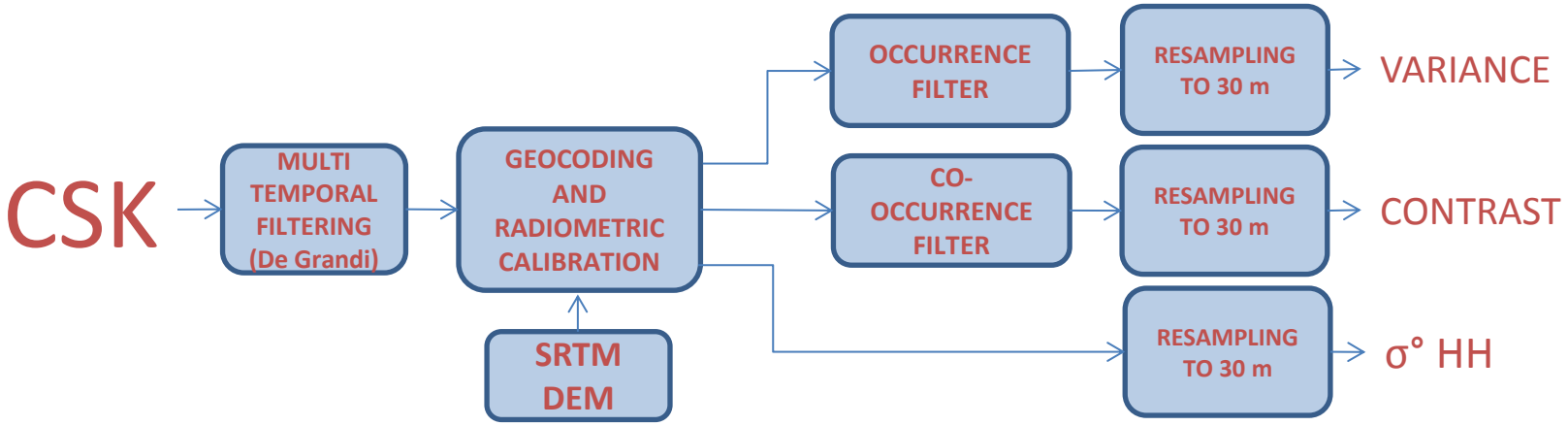


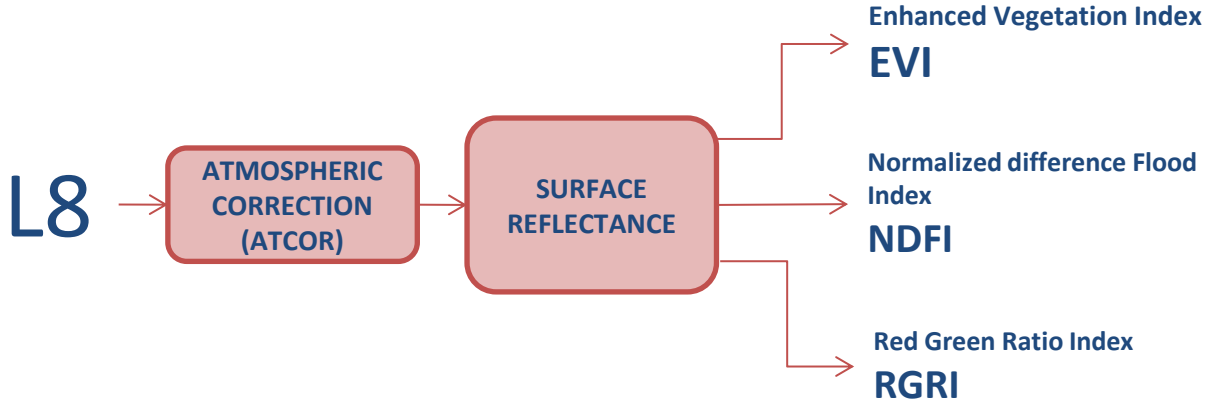
SATELLITE DATASET AND CROP SEASONALITY

- 15 COSMO-SkyMed (CSK)
  - HIMAGE,
  - X-band
  - HH pol.,
  - θ=[illegible]
  - Revisiting time=16 days
- 13 LANDSAT 8 OLI (L8)
  - Level 1
  - Revisiting time=16 days (8 days thanks to two overlapping frames)



PRE-PROCESSING OF SATELLITE DATA





PHOTOSYNTETIC ACTIVITY

Enhance the vegetation signal and a reduce the atmospheric influence, improving the sensitivity in high biomass regions and better vegetation monitoring capabilities

$$EVI = G \times \frac{\rho_{NIR} - \rho_{Red}}{\rho_{NIR} - C_1 \times \rho_{Red} - \rho_{Blue} + L}$$

FLOOD CONDITION

Sensitive to the presence of surface water

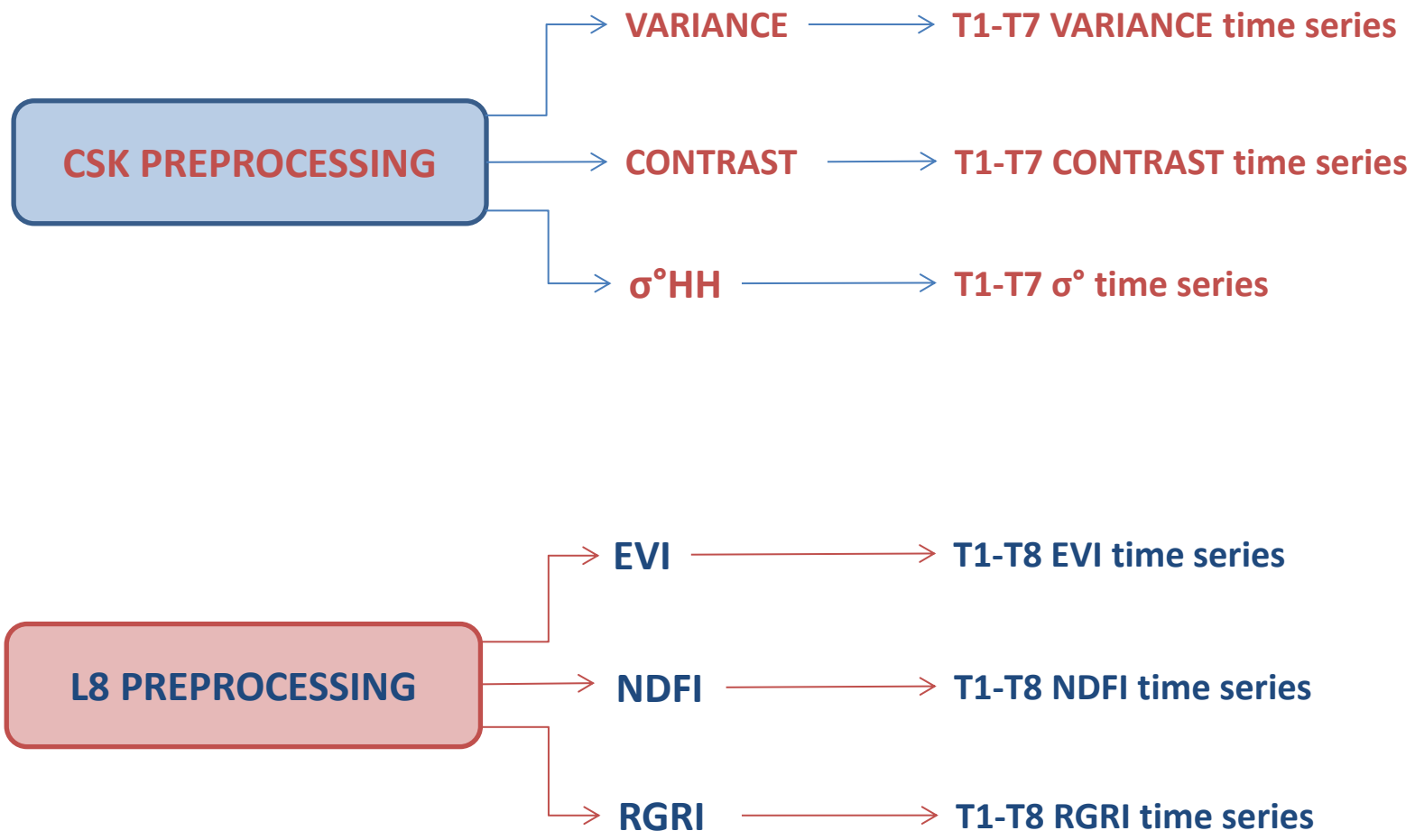
$$NDFI = \frac{\rho_{Red} - \rho_{SWIR}}{\rho_{Red} + \rho_{SWIR}}$$

LEAF STATUS AND STRESS

Indicates the relative expression of leaf spectrum caused by anthocyanin to that of chlorophyll

$$RGRI = \frac{\rho_{Red}}{\rho_{Green}}$$

TIME SERIES OF SAR AND OPTICAL FEATURES(1)



TIME SERIES OF SAR AND OPTICAL FEATURES (2)

CSK

13/02/2013

T1=44+60+76+92+108+124+140+156+172 21/06/2013

T2=44+60+76+92+108+124+140+156+172+188 07/07/2013

T3=44+60+76+92+108+124+140+156+172+188+204 23/07/2013

T4=44+60+76+92+108+124+140+156+172+188+204+236 24/08/2013

T5=44+60+76+92+108+124+140+156+172+188+204+236+252 09/09/2013

T6=44+60+76+92+108+124+140+156+172+188+204+236+252+268 25/09/2013

T7=44+60+76+92+108+124+140+156+172+188+204+236+252+268+284 10/10/2013

L8

13/05/2013

T1=133+158+165+174+181 30/06/2013

T2=133+158+165+174+181+197 16/07/2013

T3=133+158+165+174+181+197+206 25/07/2013

T4=133+158+165+174+181+197+206+213 01/08/2013

T5=133+158+165+174+181+197+206+213+222 10/08/2013

T6=133+158+165+174+181+197+206+213+222+229 17/08/2013

T7=133+158+165+174+181+197+206+213+222+229+245 02/09/2013

T8=133+158+165+174+181+197+206+213+222+229+245+341+350 16/12/2013

CSK+L8

13/02/2013

T1=44+60+76+92+108+124+140+156+172

T1=133+158+165+174+181 30/06/2013

T3=44+60+76+92+108+124+140+156+172+188+204

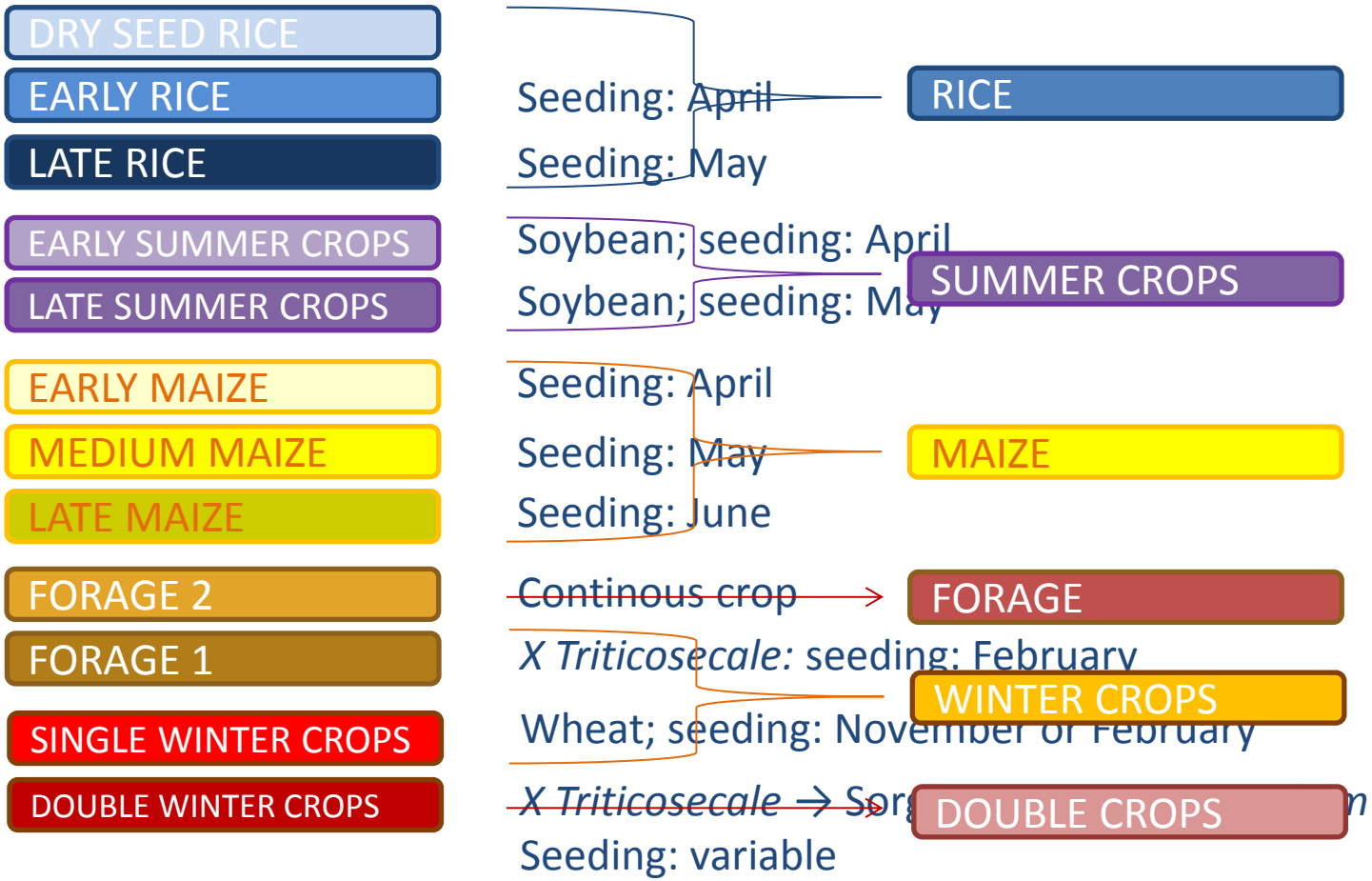
T3=133+158+165+174+181+197+206 25/07/2013

T7=44+60+76+92+108+124+140+156+172+188+204+236+252+268+284

T8=133+158+165+174+181+197+206+213+222+229+245+341+350 16/12/2013

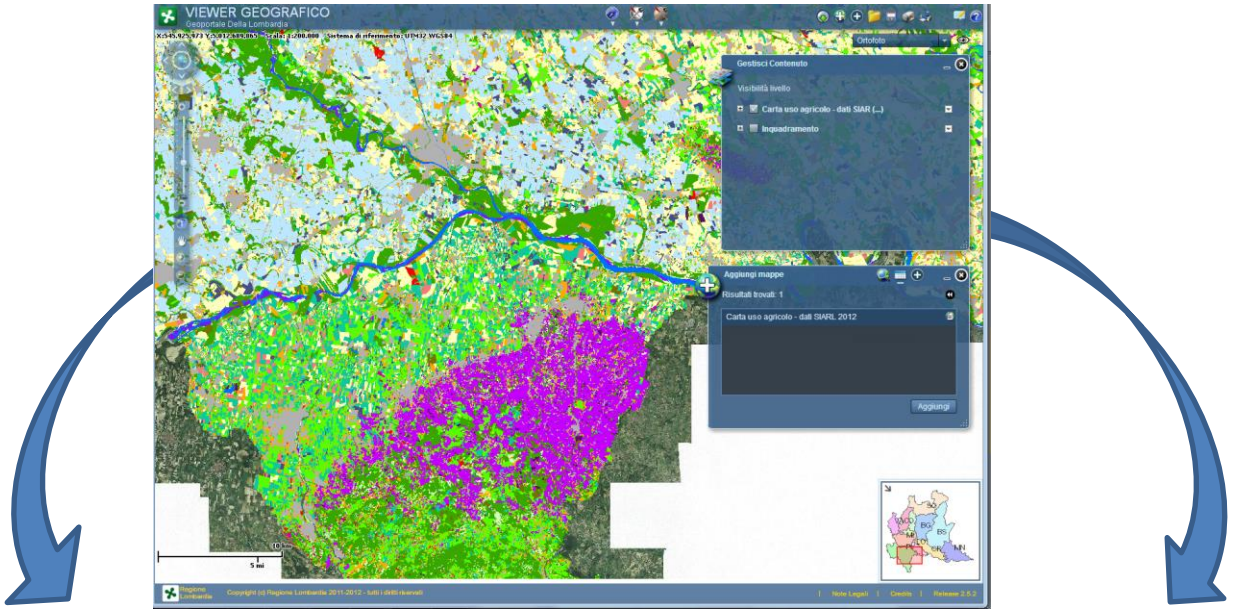
THEMATIC LEVELS

Two tematic levels of the crop maps were considered



SIARL

The S.I.A.R.L. (Sistema Informativo Agricolo della Regione Lombardia) is the informative agricultural database of Regione Lombardia used for the consulting and the updating of the documents of the Lombardy farms .



Classifiers Training

Validation

The SIARL database was used for selecting two indipendent sets of pixels for L2 (12 classes).

- The first set (2/3 of total) was used for training the classificators.
- The second set (1/3 of total) was used for assessing the accuracy of the produced maps.

CLASSIFICATION ALGORITHMS

Maximum Likelihood Classificator MLC

Spectral Angle Mapper SMA

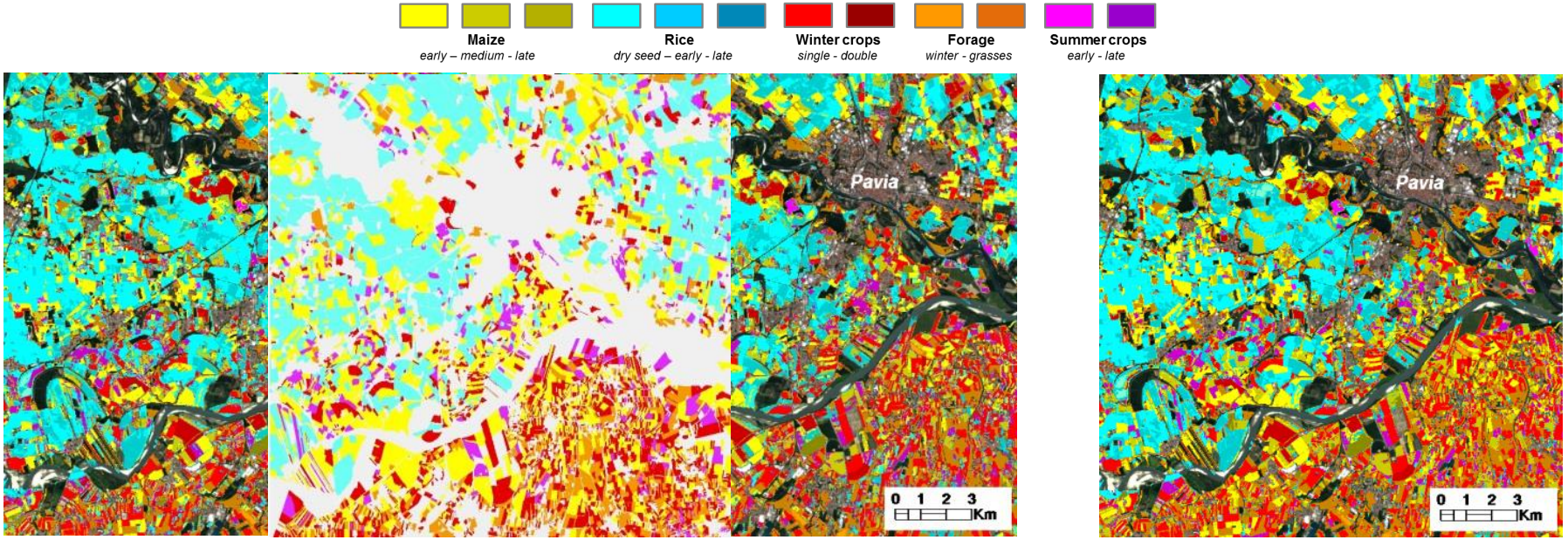
Euclidean Minimum Distance EMD

THEMATIC LEVELS			
	CSK	L8	CSK+L8
MLC	VARIANCE CONTRAST	EVI RGRI	EVI RGRI
SAM	σ°	NDFI	NDFI σ°
EMD			
SAM	VARIANCE CONTRAST σ°	EVI RGRI NDFI	EVI RGRI NDFI σ°
EMD	VARIANCE CONTRAST σ°	EVI RGRI NDFI	EVI RGRI NDFI σ°

For SAR sensor the requirement of Gaussian distributed data is satisfied after speckle filtering.

CLASSIFICATION RESULTS

According to the approach described in the previous section, crop maps were produced through the classification of each combination of thematic level (L1 and L2), supervised algorithm (MLC, EMD, SAM) and different input time series derived by single L8 or CSK sensors and their combination.



CSK+L8;T1
End of June

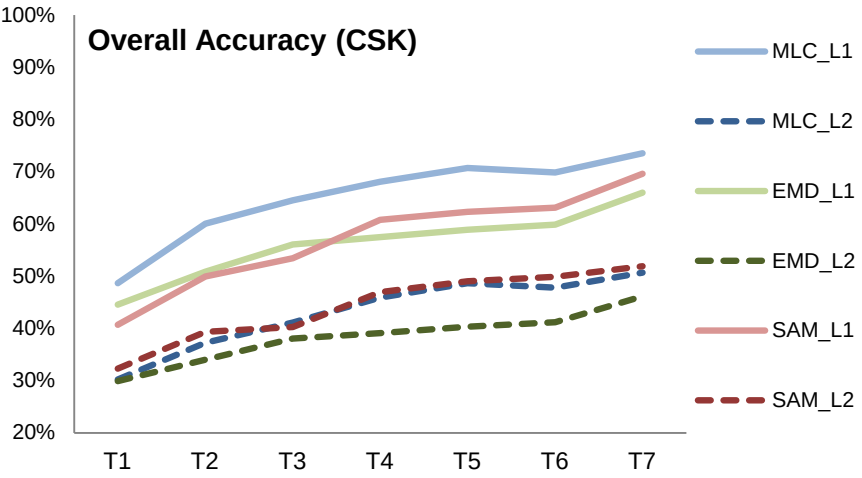
SIARL

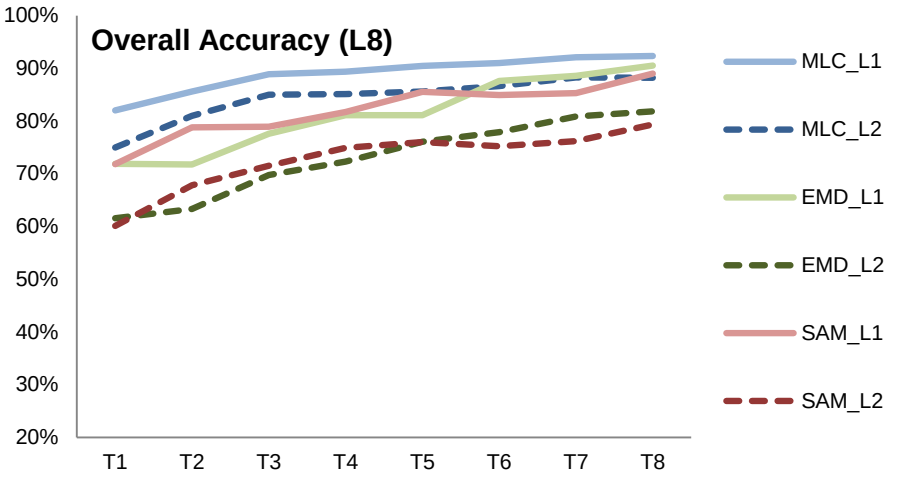
CSK+L8;T3
End of July

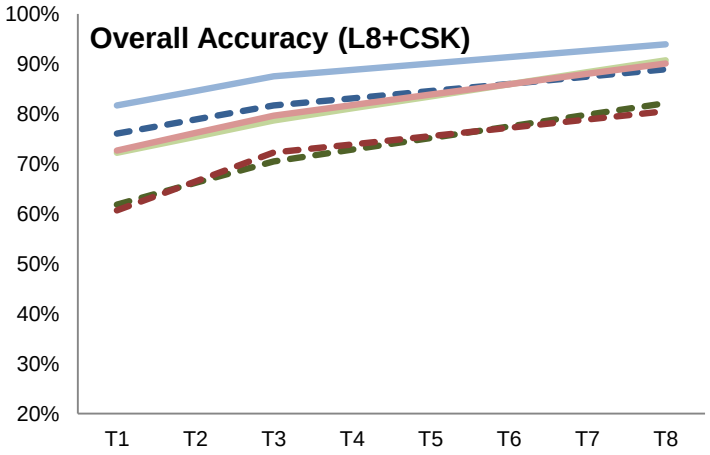
CSK+L8; T8
Half December

Level 2 crop maps of 2013 of a subset of the study area derived by MLC

RESULTS ACCURACY

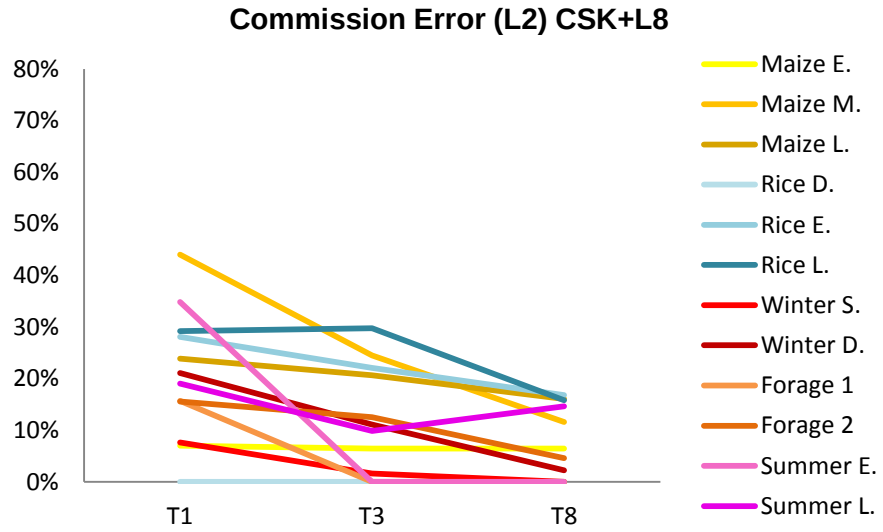


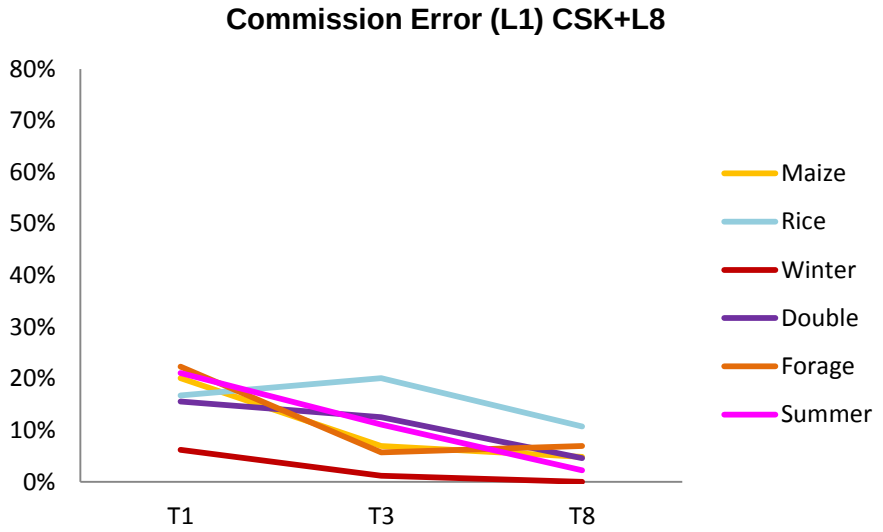


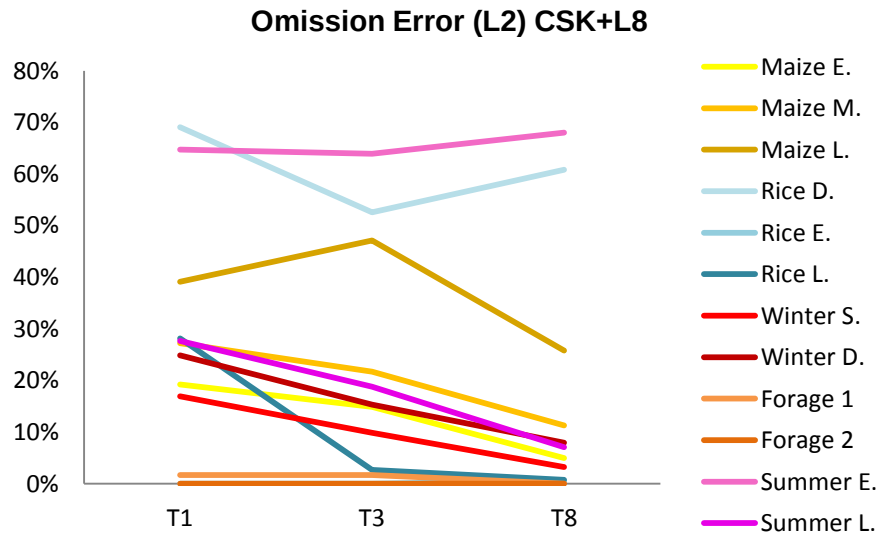


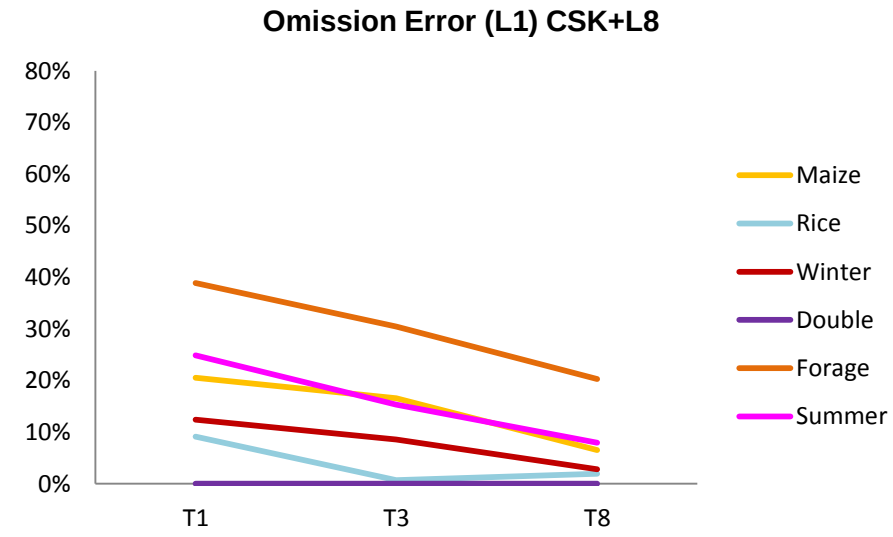
The use of optical data performs better classification accuracy for all the different sensors and for the three classificators

PERFORMANCE OF MLC: INTEGRATION OF L8 + CSK



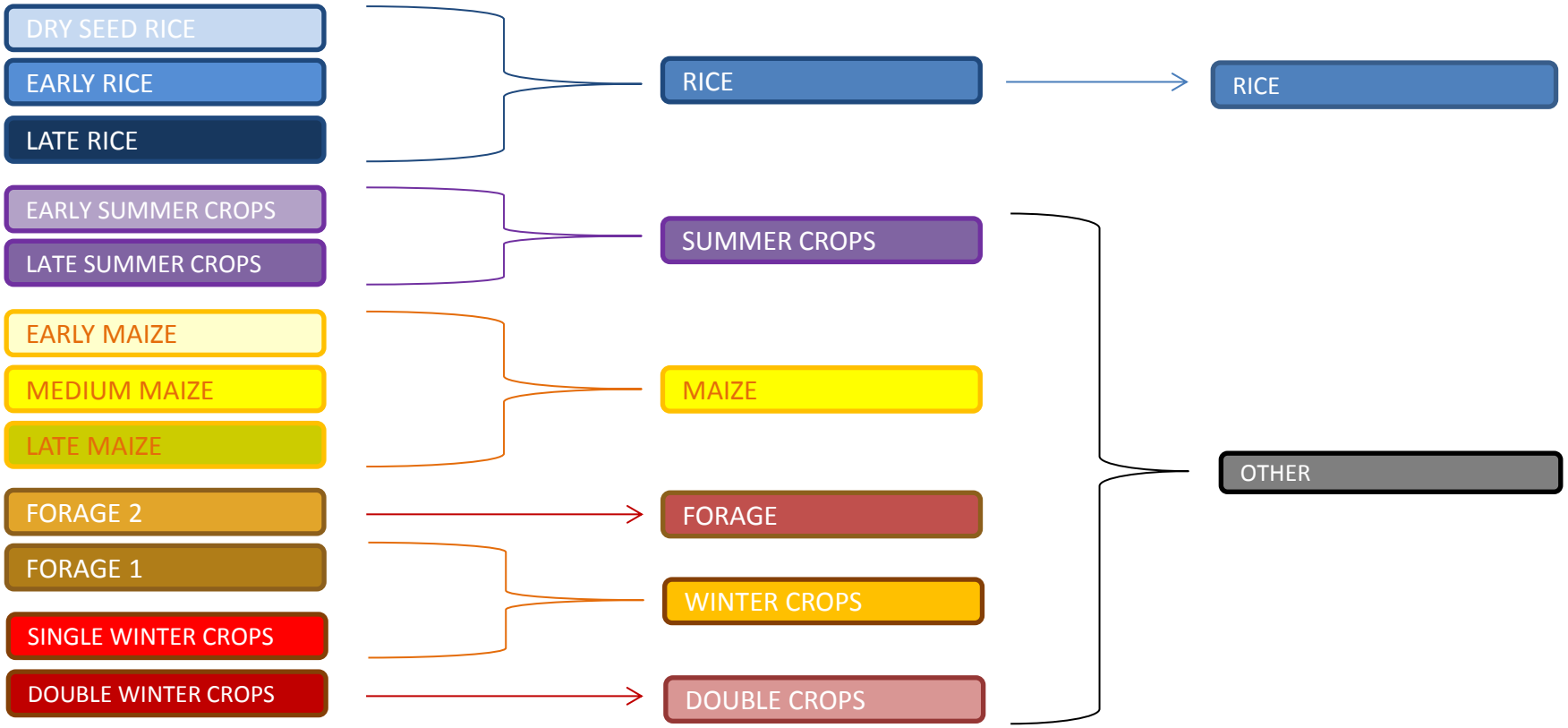




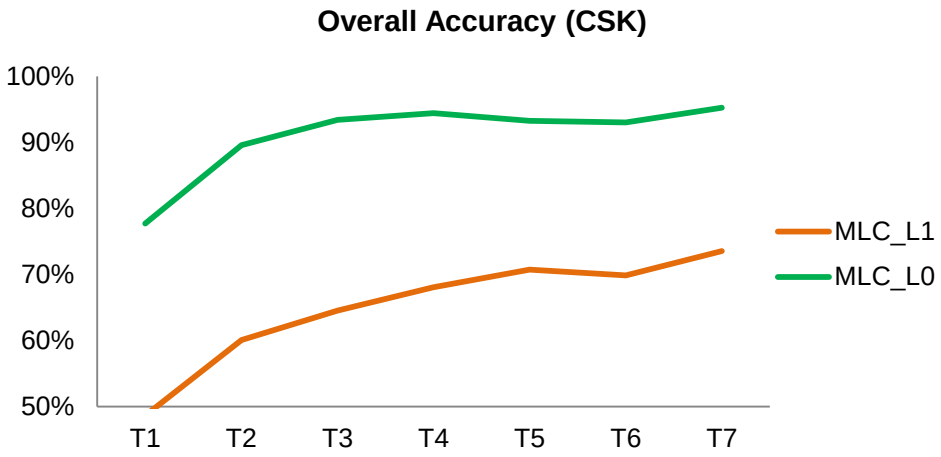


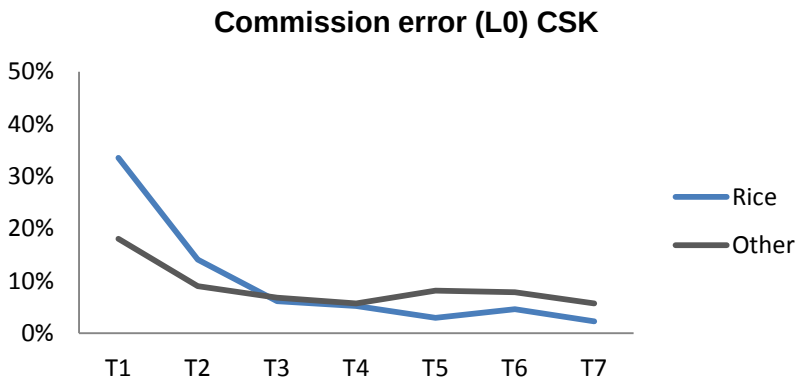
RICE MAPPING USING COSMO SKYMED

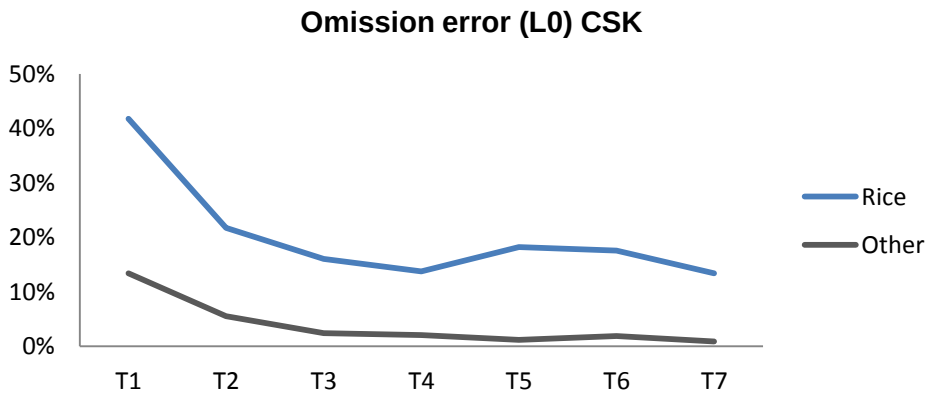
ERMES
AN EARTH OBSERVATION MODEL BASED RICE INFORMATION SERVICE



PERFORMANCE OF RICE MAPPING USING CSK







CONCLUSION

- A mapping project carried out using both optical and SAR data on an agricultural area in northern Italy where described.
- Results show that the classification accuracy obtained using only multispectral optical data is higher than the one reached using only SAR as input.
- The performance in the classification carried out using only SAR data have been partially invalidate by:
  - steep look angle (24.13°) that limits the sensitivity toward vegetation characteristics
  - single polarization
  - worst temporal resolution than optical data.
- Integrating both optical and SAR multitemporal features provides some advantages in terms of a more reliable crop map, especially during an early temporal stage scenario.
- Among the supervised algorithms tested, Maximum Likelihood shows the best overall accuracy performances at each thematic level, time step and using both optical and SAR input data.
- A more sophisticated approaches able to synthetize the temporal variability of the SAR signal should be further investigated.

THANK YOU