

Field spectroscopy to support precision agriculture

La espectroscopía de campo como soporte a la agricultura de precisión

J. González-Piqueras¹,

¹Grupo de Teledetección y SIG, *Instituto Desarrollo Regional*, Universidad de Castilla-La Mancha, Albacete, Spain



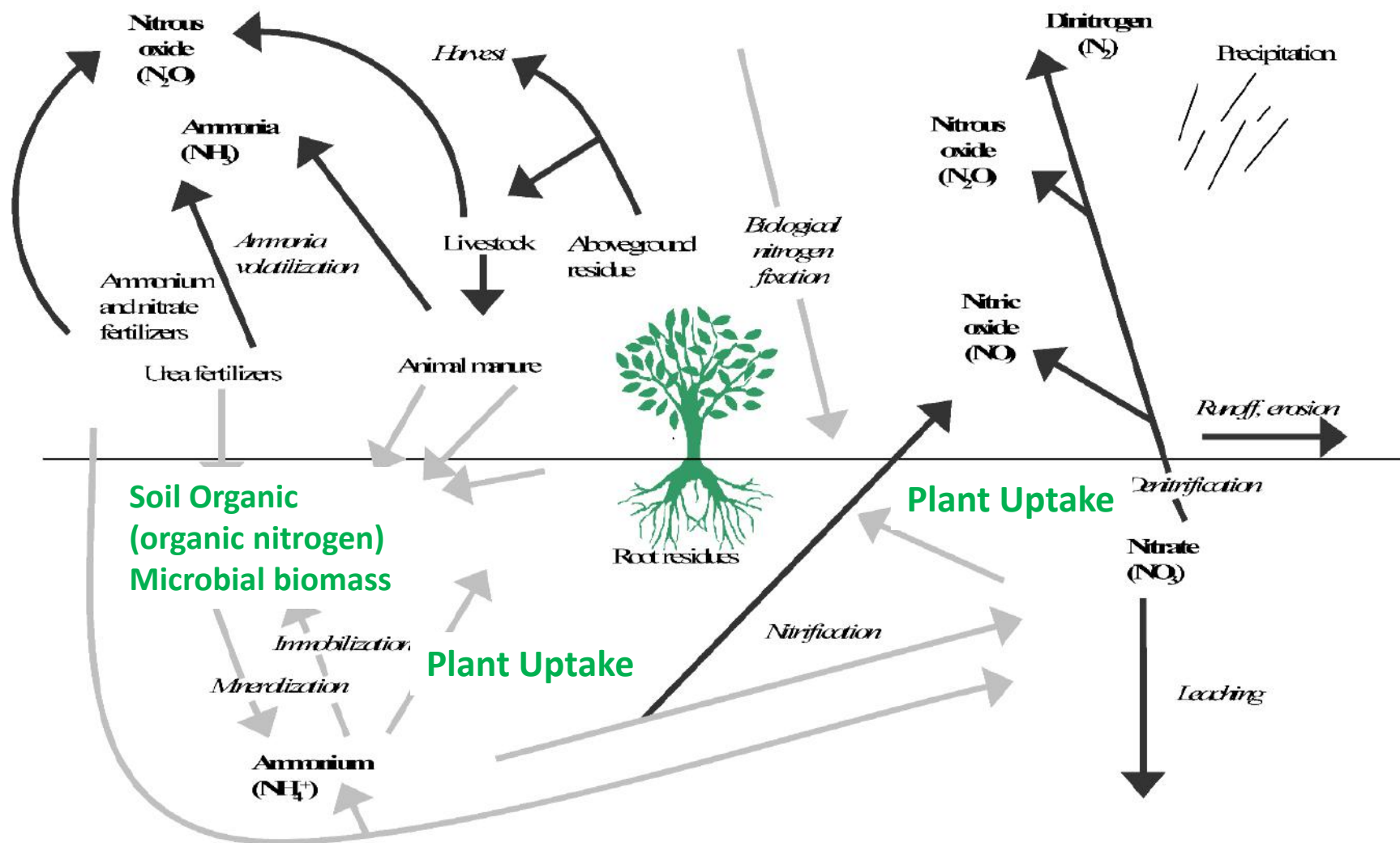
TABLE OF CONTENTS

Field Spectroscopy to Support Precision Agriculture

- Introduction and motivation
- Field work strategy: Examples
 - Crop
 - Soil
- Storing data
 - Spectral libraries
 - Metadata
- Processing
- Conclusions

INTRODUCTION

Field Spectroscopy to Support Precision Agriculture



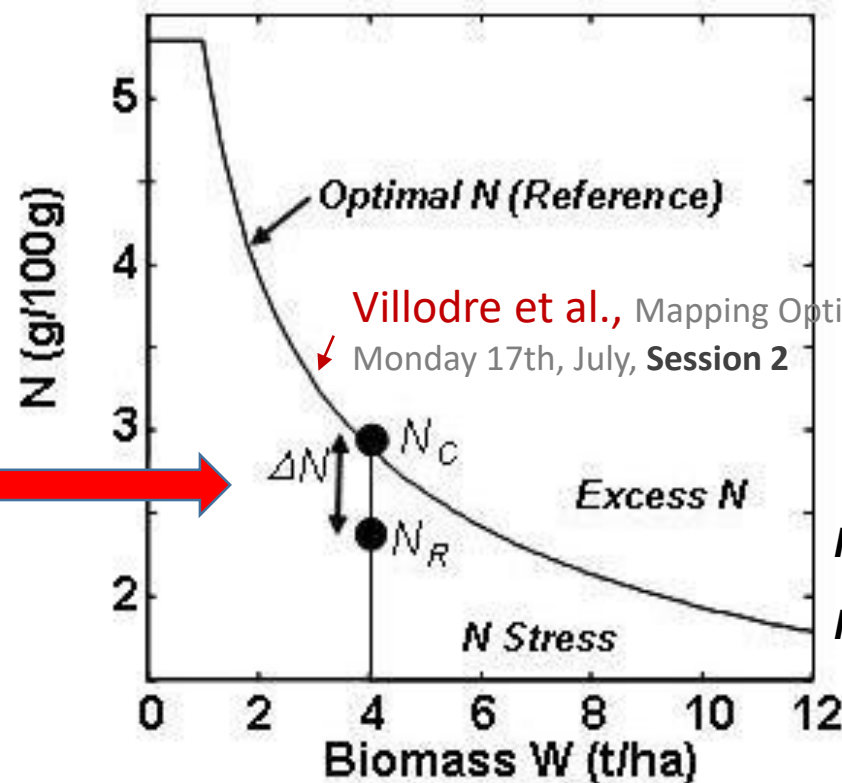
The Nitrogen cycle. Source: OECD (2001) Environmental Indicators for Agriculture-Volume 3: Methods and Results, Publication Service, Paris, France

Protocolos y Librerías espectrales en Espectroscopía de campo: de las buenas prácticas a una mayor utilidad de los datos

Madrid, Instituto Nacional de Técnica Aeroespacial (INTA) - 7 de marzo de 2019

INTRODUCTION

Field Spectroscopy to Support Precision Agriculture



Villodre et al., Mapping Optimum Nitrogen Crop Uptake, ECPA (2017) –
Monday 17th, July, Session 2

$$N_C = 5.35 \text{ if } W \leq 1 \text{ t/ha}$$

$$N_C = 5.35 \cdot W^{-0.442} \text{ if } W > 1 \text{ t/ha}$$

N Nutrition Index

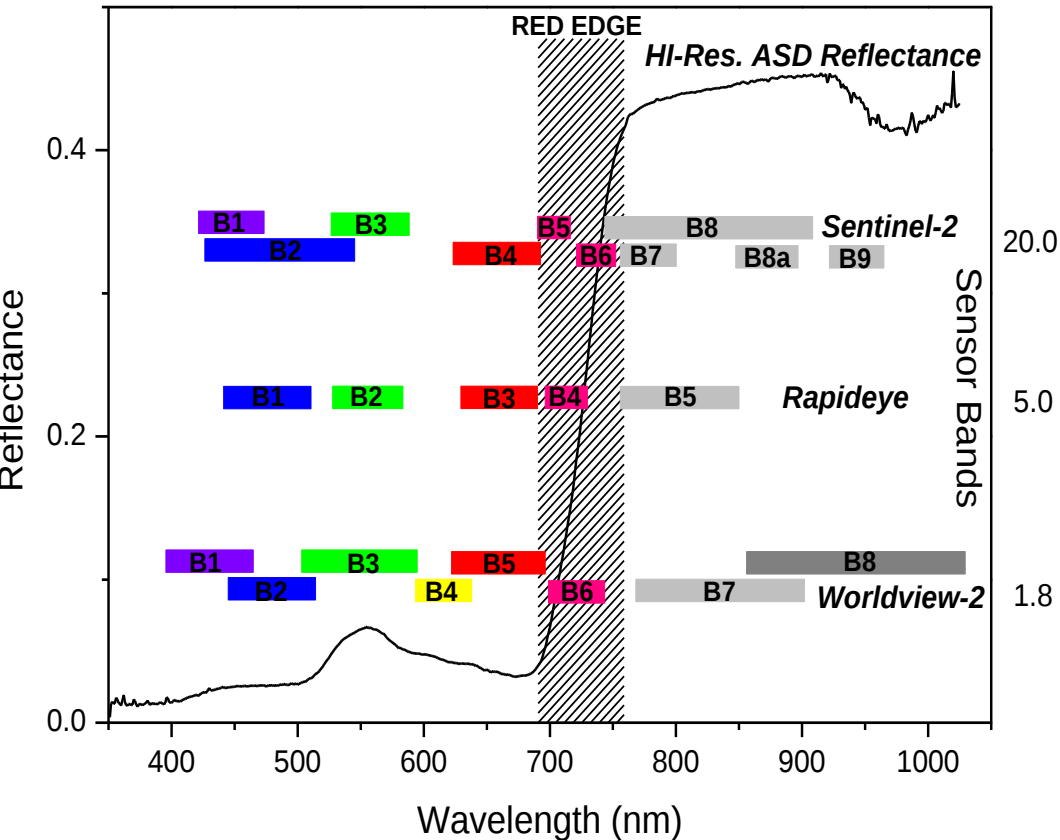
$$NNI(\text{Dimensionless}) = \frac{N_R \left(\frac{g}{100 \text{ g total biomass}} \right)}{N_C \left(\frac{g}{100 \text{ g total biomass}} \right)}$$

$$N_R \left(\frac{g}{100 \text{ g total biomass}} \right) = \frac{QN \left(\frac{g}{m^2} \right)}{\text{Biomass} \left(\frac{g}{m^2} \right)} \leftarrow \text{Campos et al., (2017)}$$

INTRODUCTION

Field Spectroscopy to Support Precision Agriculture

Wheat Reflectance Casa Jara April 17th 2015



$$NDRE = \frac{(R_{790} - R_{720})}{(R_{790} + R_{720})}$$

$$REP = 700 + 40 \cdot \frac{[(R_{670} + R_{780})/2 - R_{700}]}{R_{740} - R_{700}}$$

$$CI = \frac{R_{790}}{R_{720}} - 1$$

INTRODUCTION

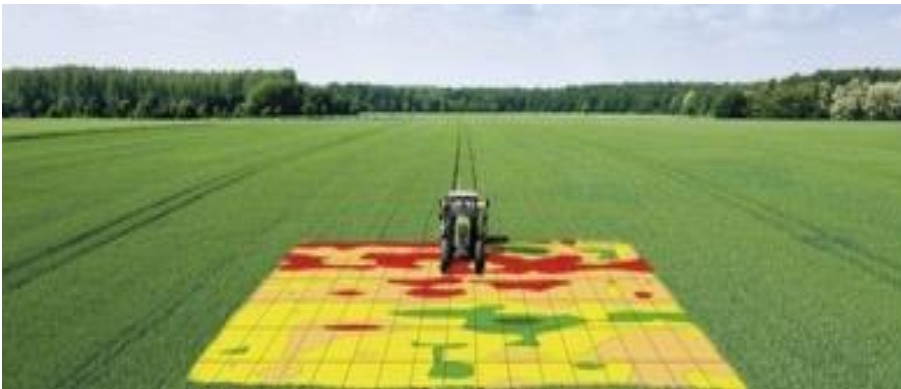
Field Spectroscopy to Support Precision Agriculture

Vegetation Index	Formula	Use	Reference
Normalized difference red edge index (NDRE)	$\frac{(R_{790} - R_{720})}{(R_{790} + R_{720})}$	Sensitive variations in Chlorophyll and N.	Fitzgerald et al. (2010)
Red edge chlorophyll index ($CI_{red\ edge}$)	$\frac{R_{790}}{R_{720}} - 1$	Estimation of N plant uptake.	Gitelson et al. (2005)
MERIS terrestrial chlorophyll index (MTCI)	$\frac{(R_{750} - R_{710})}{(R_{710} - R_{680})}$	N uptake before heading.	Dash and Curran (2004)
Canopy chlorophyll content index (CCCI)	$\frac{(NDRE - NDRE_{MIN})}{(NDRE_{MAX} - NDRE_{MIN})}$	N uptake across growth stages.	Fitzgerald et al. (2010)
REP	$700 + 40 \cdot \frac{[(R_{670} + R_{780})/2 - R_{700}]}{R_{740} - R_{700}}$	Sensitive variations in Chlorophyll and N.	Guyot et al. (1988)
Angular Insensitivity Vegetation Index (AIVI)	$\frac{R_{445} \cdot (R_{720} + R_{735}) - R_{573} \cdot (R_{720} - R_{735})}{R_{720} \cdot (R_{573} + R_{445})}$	N at different view zenith angles.	He et al- (2016)

OBJECTIVES

Field Spectroscopy to Support Precision Agriculture

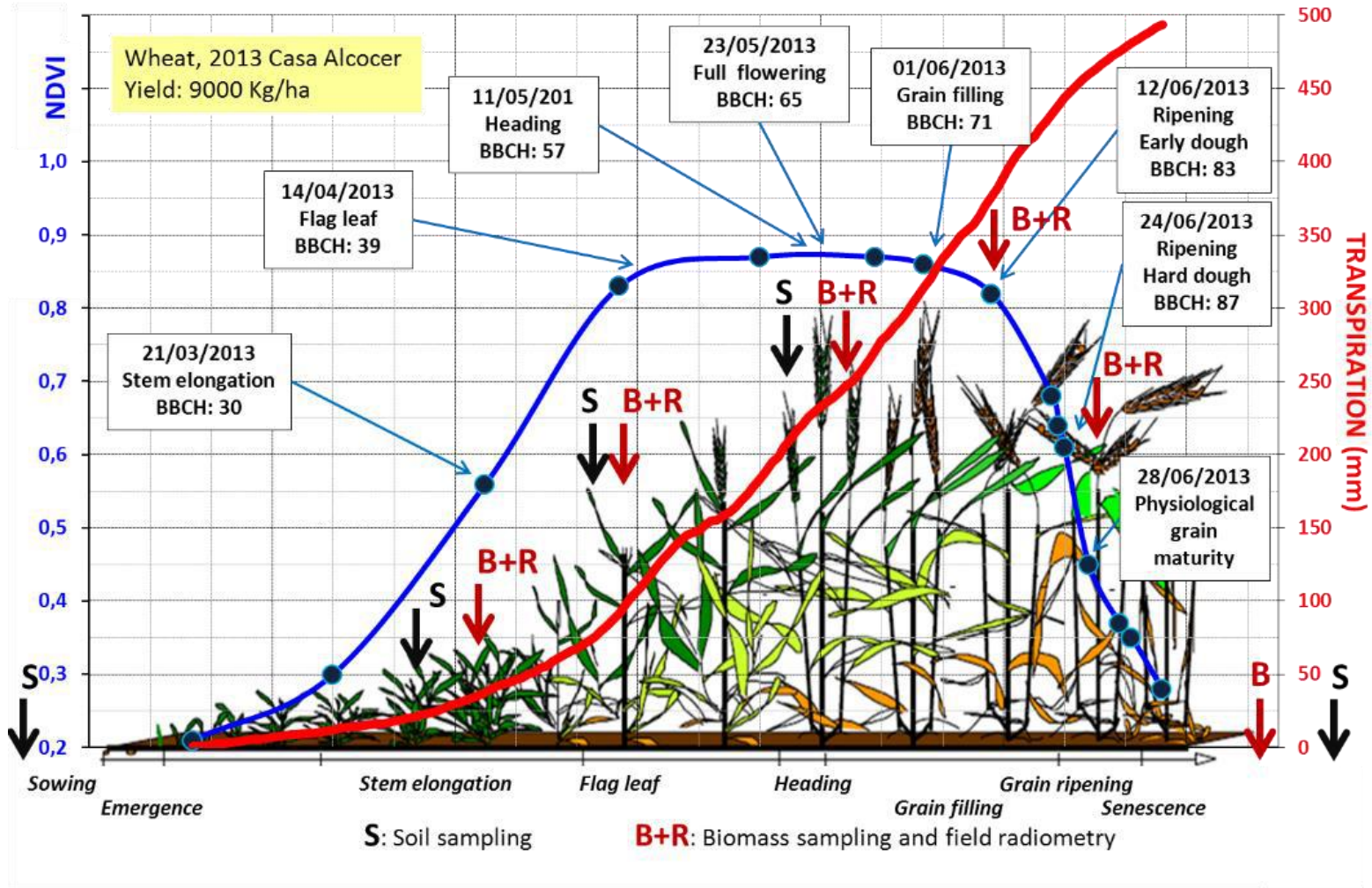
- Map the nitrogen content in the crop using remote Sensing techniques.
- Derive NNI (*Nitrogen Nutrition Index*) maps for variable rate fertilization.



Protocolos y Librerías espectrales en Espectroscopía de campo: de las buenas prácticas a una mayor utilidad de los datos
Madrid, Instituto Nacional de Técnica Aeroespacial (INTA) - 7 de marzo de 2019

FIELD WORK STRATEGY

Field Spectroscopy to Support Precision Agriculture

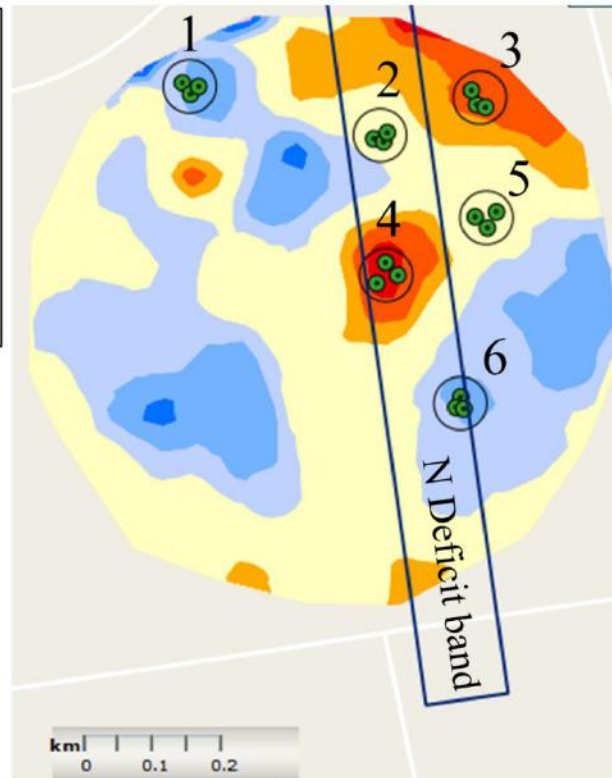
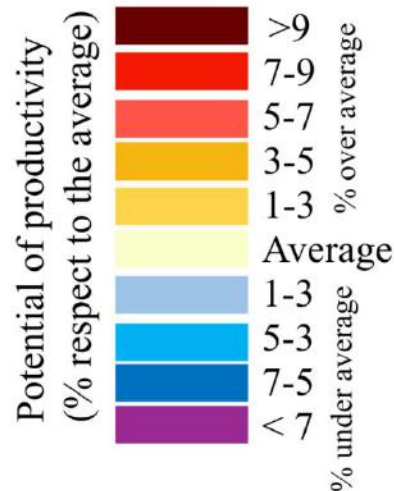


Protocolos y Librerías espectrales en Espectroscopía de campo: de las buenas prácticas a una mayor utilidad de los datos
Madrid, Instituto Nacional de Técnica Aeroespacial (INTA) - 7 de marzo de 2019

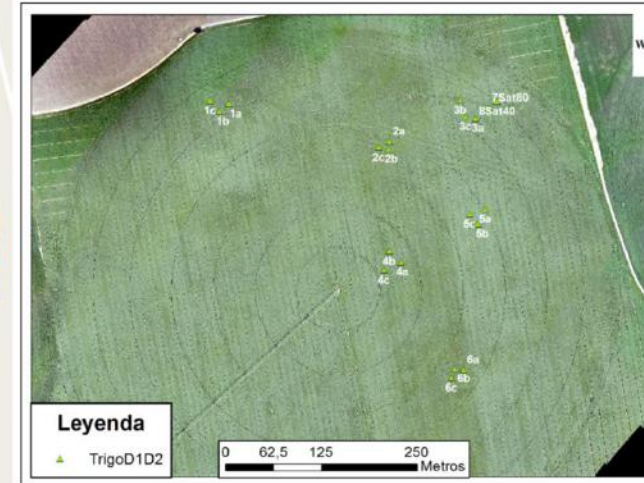
FIELD WORK STRATEGY

Field Spectroscopy to Support Precision Agriculture

Wheat, year 2016



● Radiometry, Biomass and N sampling



Orthophotography during crop development on year 2016 with ground simple distance (GSD) of 5 cm

FIELD WORK STRATEGY

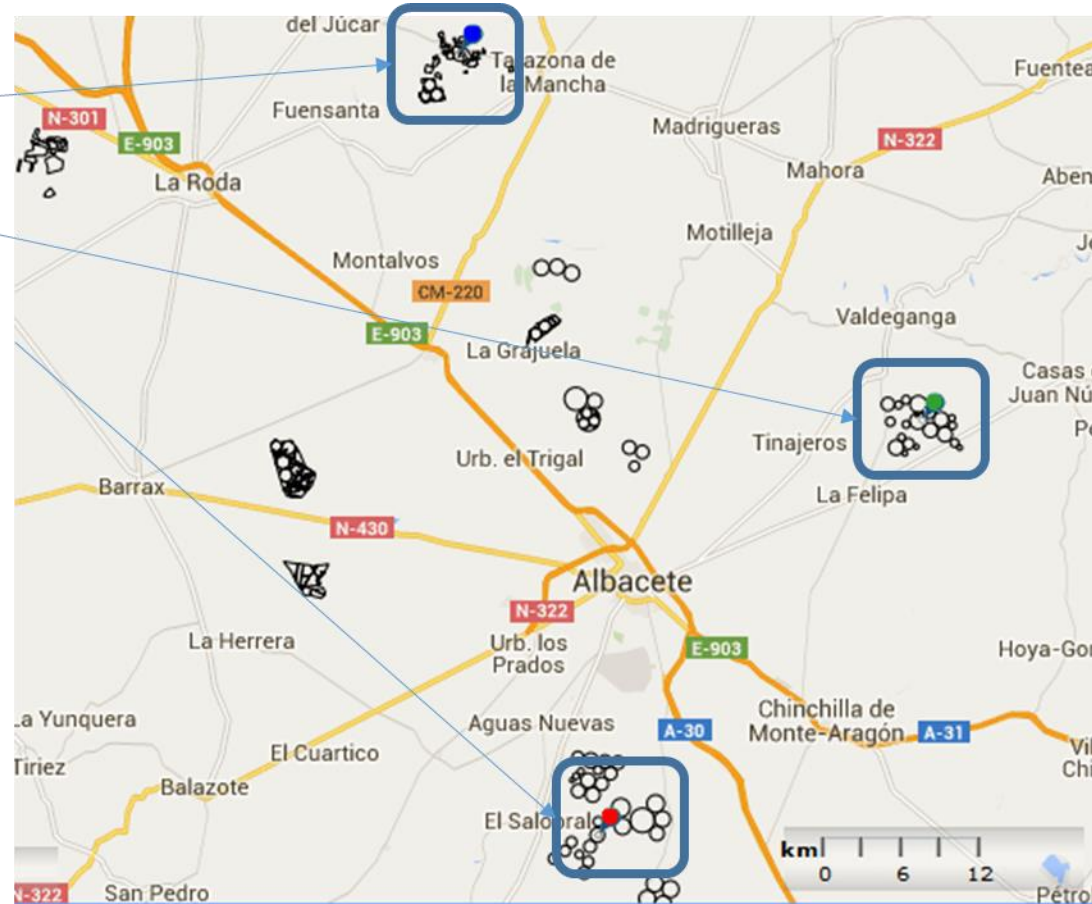
Field Spectroscopy to Support Precision Agriculture

 Casa Jara

 Casa del Monte

 Dehesa Los Llanos

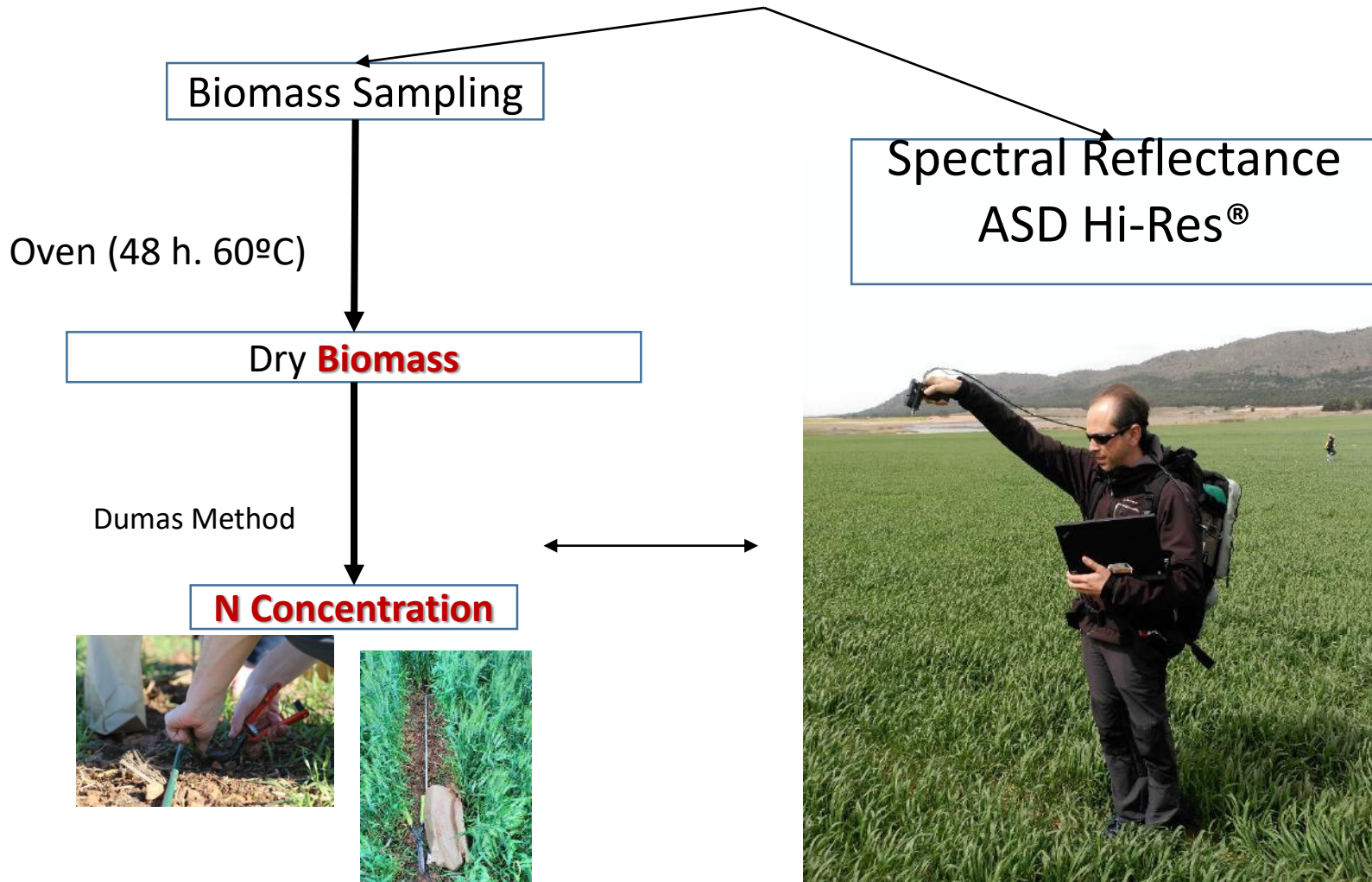
 *L8 images TOC (in spider)*



FIELD WORK: METHODOLOGY

Field Spectroscopy to Support Precision Agriculture

Measurements at Field

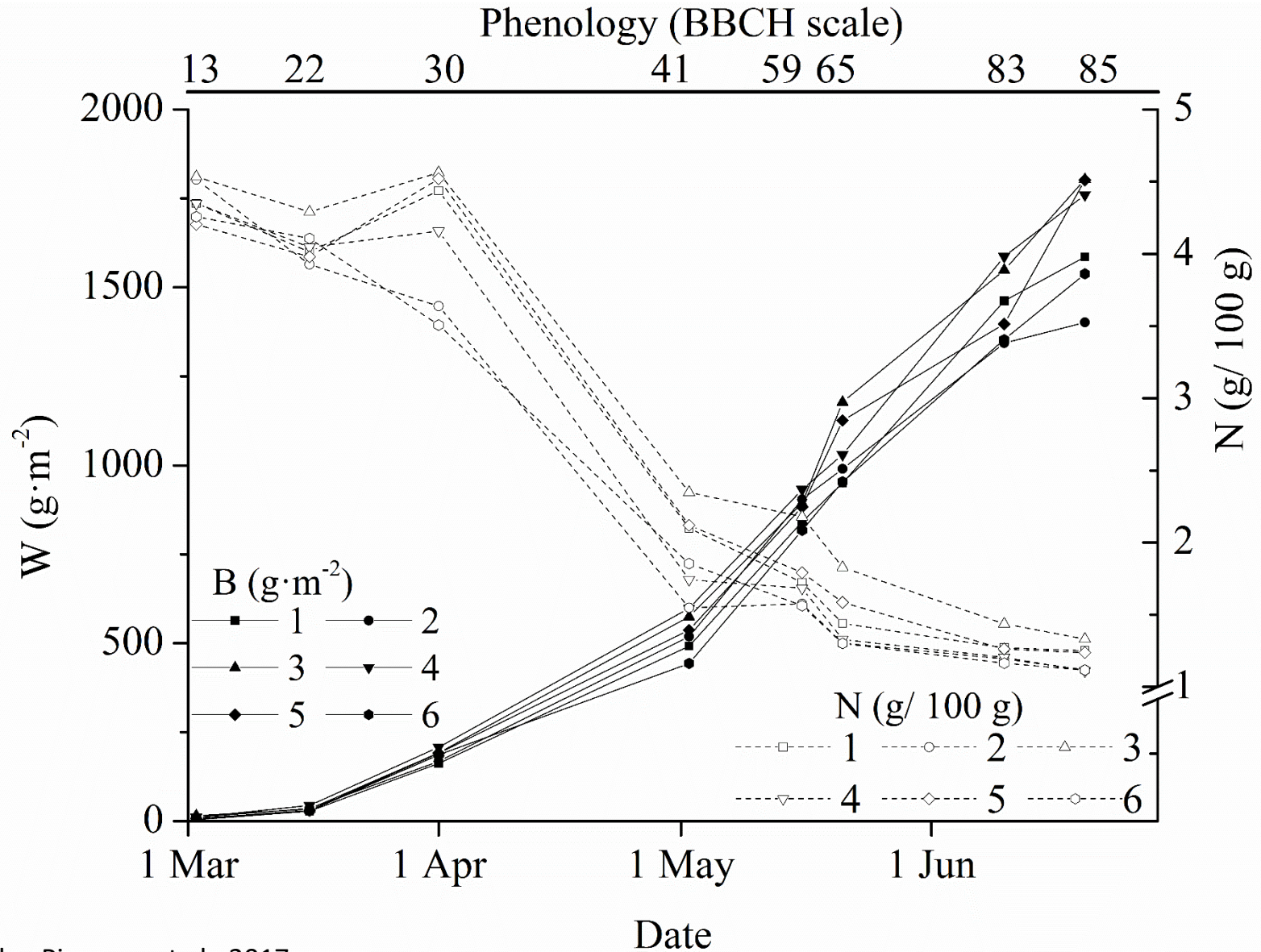


Protocolos y Librerías espectrales en Espectroscopía de campo: de [illegible] a [illegible] datos

Madrid, Instituto Nacional de Técnica Aeroespacial (INTA) - 7 de marzo de 2019

FIELD WORK: AT FIELD CROP MONITORING

Field Spectroscopy to Support Precision Agriculture



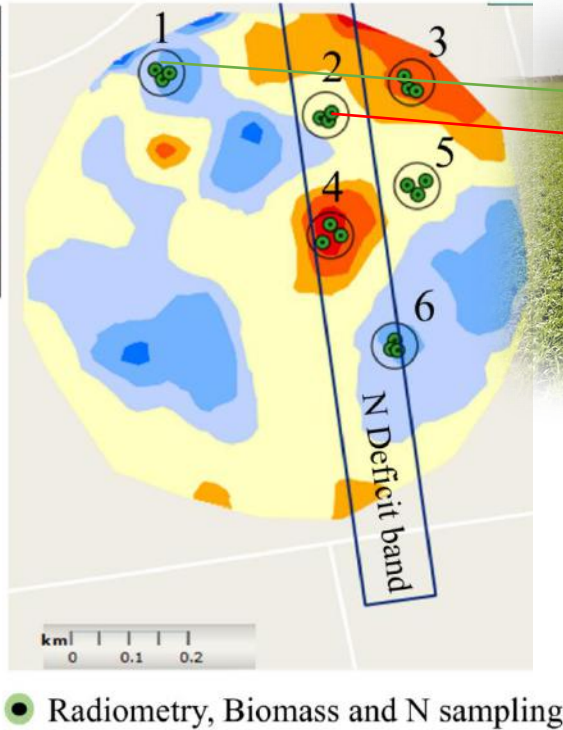
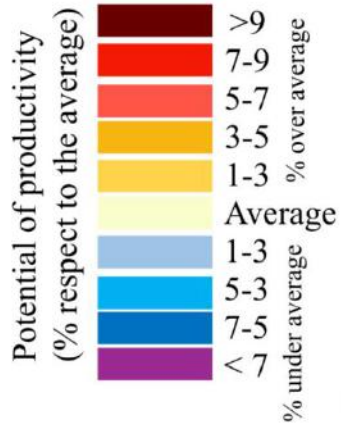
DATA STORE: ACQUISITION PROTOCOL

Field Spectroscopy to Support Precision Agriculture

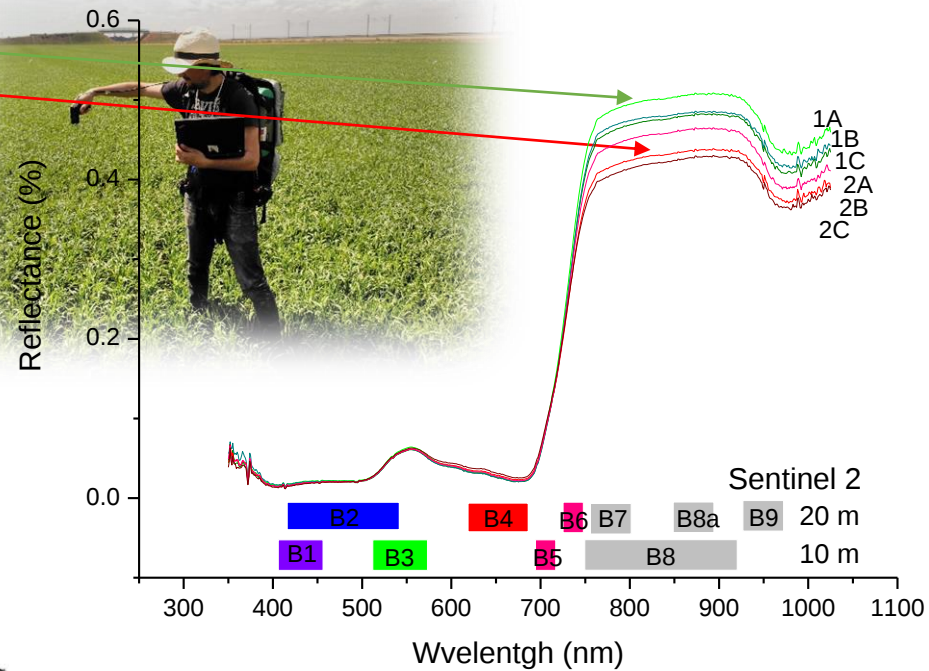
BBCH stage	Pre	11	21	29	39	55	73	85	90
									
Farming operations	✓	✓	✓	✓	✓	✓	✓	✓	✓
Date	✓	✓	✓	✓	✓	✓	✓	✓	✓
Assessment									
• Emergence		✓							
• Diseases		✓	✓	✓	✓	✓	✓	✓	
• Pests		✓	✓	✓	✓	✓	✓	✓	
• Accidents		✓	✓	✓	✓	✓	✓	✓	
Sampling, measurement and analysis									
Soil (30/60 cm)	✓			✓	✓				✓
Water						✓			
Above ground plant biomass									
• Complete				✓	✓		✓	✓	
• Parties									✓
Plant height								✓	
Yield components									✓
Radiometry			✓	✓	✓	✓	✓	✓	
Yield map									✓
Quality									✓

DATA STORE: SPEC. LIBRARIES CROP

Field Spectroscopy to Support Precision Agriculture



● Radiometry, Biomass and N sampling



DATA STORE: SPEC. LIBRARIES CROP

Field Spectroscopy to Support Precision Agriculture

Excel Online

- Solo lectura

Iniciar sesión

OneDrive > 1. Campaña 2015

Editar en el explorador

Descargar

Imprimir

Compartir

!

Vínculos deshabilitados

No se admiten vínculos a libros externos y, por ello, se deshabilitaron.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1						Ponderación										
2	CodFinca	Finca				Profundidad	Text Simpl	IpH	ICE	IMO	ICaCO3 total	ICaliza activa	IP	IK	Suma	
3	CJ	Casa Jara				15%	10%	5%	10%	25%	5%	5%	15%	10%	100%	
4	LT	Las Tiesas														
5	DL	Dehesa Los Llanos														
6	CM	Casa del Monte														
7	OF	Ontalafia														
8	OR	Orán														
9																
10	Campaña															
11	2015	Campaña de recolección														
12																
13	CodSp															
14	TrB	Trigo blando														
15	Mz	Maíz grano														
16																

<

Ayudar a mejorar Office

DATA STORE: SPEC. LIBRARIES CROP

Field Spectroscopy to Support Precision Agriculture

Excel Online

Solo lectura

Iniciar sesión

OneDrive > 1. Campaña 2015

Editar en el explorador

Descargar

Imprimir

Compartir

...

	D	E	F	G	H	I	J	K	L	M	N	O	Q	R	S	T	U	V	W	X	
	Muestreo	CodC	Orden	OrdenCeb	Cod	CodF	Campa	CodS	CodR	CodZ	Órga	Sub	Mas	Nº	Masa	Masa	Al (mg/kg)	As (mg/kg)	Be (mg/kg)	Bi (mg/kg)	B (mg/kg)
3	re	amp	nl	a																	
4	Bio 1	1a	1		CJ 2015 TrB F2 Z0 Sa	CJ	2015 TrB	F2	Z0	Ent	a		83.0	1	7.5	75.5	146.2	0.00	0.00	0.00	
5	Bio 1	1b	1		CJ 2015 TrB F2 Z0 Sb	CJ	2015 TrB	F2	Z0	Ent	b		89.7	1	7.5	82.2	637.0	0.26	0.94	0.00	
6	Bio 1	1c	1		CJ 2015 TrB F2 Z0 Sc	CJ	2015 TrB	F2	Z0	Ent	c		102.2	1	7.5	94.7	124.4	0.00	0.00	0.00	
7	Bio 1	2a	2		CJ 2015 TrB F0 Z0 Sa	CJ	2015 TrB	F0	Z0	Ent	a		108.2	1	7.5	100.7	295.9	0.00	0.00	0.00	
8	Bio 1	2b	2		CJ 2015 TrB F0 Z0 Sb	CJ	2015 TrB	F0	Z0	Ent	b		81.5	1	7.5	74.0	203.0	0.00	0.00	0.00	
9	Bio 1	2c	2		CJ 2015 TrB F0 Z0 Sc	CJ	2015 TrB	F0	Z0	Ent	c		77.7	1	7.5	70.2	413.3	0.00	0.00	0.00	
10	Bio 1	3a	3		CJ 2015 TrB F1 Z0 Sa	CJ	2015 TrB	F1	Z0	Ent	a		129.8	1	7.5	122.3	236.5	0.00	0.00	0.00	
11	Bio 1	3b	3		CJ 2015 TrB F1 Z0 Sb	CJ	2015 TrB	F1	Z0	Ent	b		116.2	1	7.5	108.7	185.9	0.00	0.00	0.00	
12	Bio 1	3c	3		CJ 2015 TrB F1 Z0 Sc	CJ	2015 TrB	F1	Z0	Ent	c			1	7.5		140.9	0.00	0.00	0.00	
13	Bio 1	4a	4		CJ 2015 TrB F2 Z1 Sa	CJ	2015 TrB	F2	Z1	Ent	a		127.0	1	7.5	119.5	192.2	0.00	0.00	0.00	
14	Bio 1	4b	4		CJ 2015 TrB F2 Z1 Sb	CJ	2015 TrB	F2	Z1	Ent	b		126.6	1	7.5	119.1	139.1	0.00	0.00	0.00	
15	Bio 1	4c	4		CJ 2015 TrB F2 Z1 Sc	CJ	2015 TrB	F2	Z1	Ent	c		159.7	1	7.5	152.2	165.4	0.00	0.00	0.00	
16	Bio 1	5a	5		CJ 2015 TrB F0 Z1 Sa	CJ	2015 TrB	F0	Z1	Ent	a		77.9	1	7.5	70.4	401.0	0.00	0.00	0.00	
17	Bio 1	5b	5		CJ 2015 TrB F0 Z1 Sb	CJ	2015 TrB	F0	Z1	Ent	b		113.3	1	7.5	105.8	196.1	0.00	0.00	0.00	
18	Bio 1	5c	5		CJ 2015 TrB F0 Z1 Sc	CJ	2015 TrB	F0	Z1	Ent	c		87.7	1	7.5	80.2	234.6	0.00	0.00	0.00	

Nomen

Soil

SoilC

SoilC1

Bio (0)

Bio

BioC

BioC1

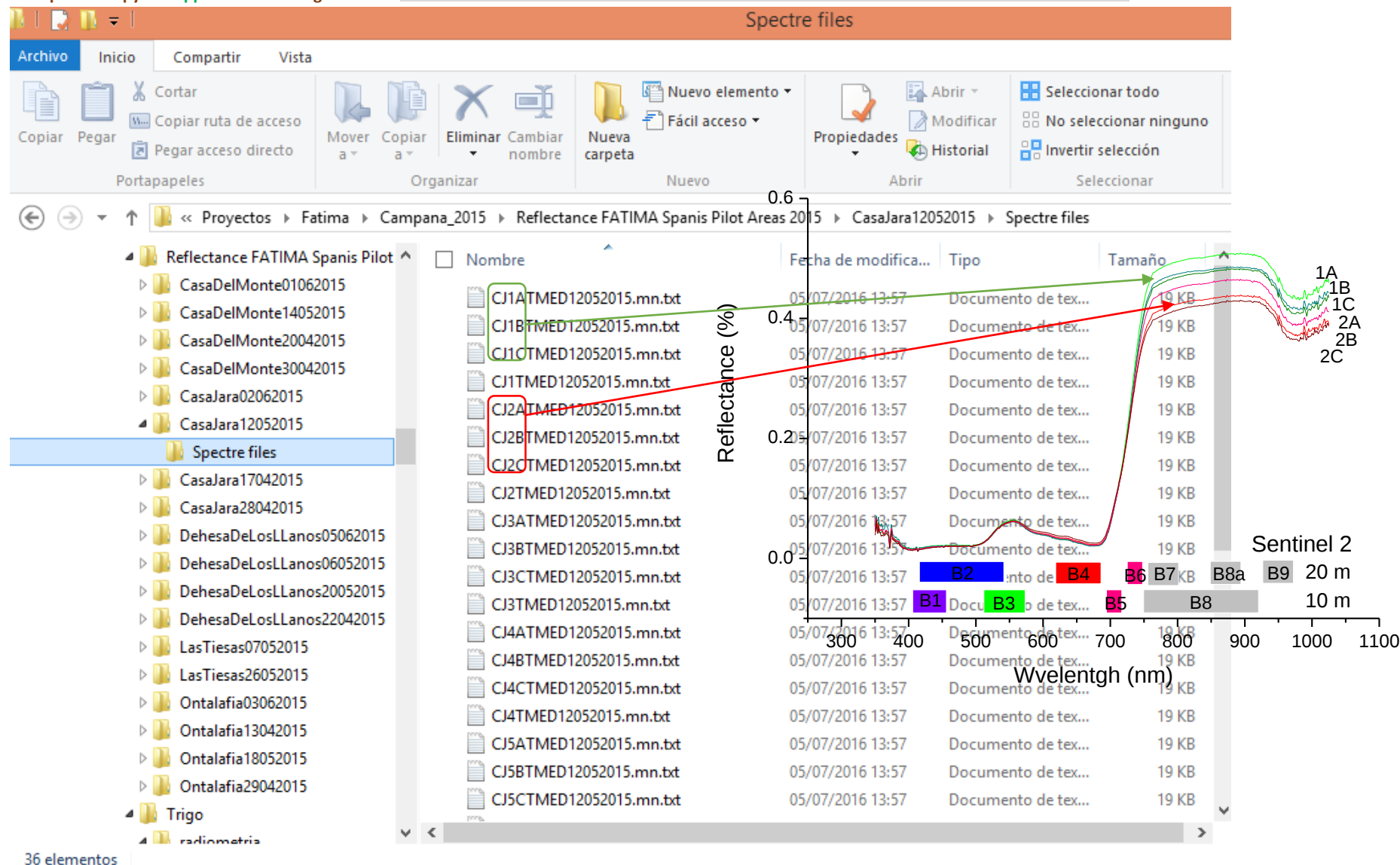
Water

Dates

...

DATA STORE: SPEC. LIBRARIES CROP

Field Spectroscopy to Support Precision Agriculture



The screenshot displays the MATLAB R2017a interface. The Editor window shows a script named 'indices.m' with the following code:

```

328 %Calculo de AIVI con la respuesta espectral de
329 tabla{k+1,132} = AIVI(TR);
330 tabla{k+1,133} = AIVI(TRSgol);
331 tabla{k+1,134} = AIVI(TRSpline);
332 %Calculo de AIVI con la respuesta espectral de
333 [tabla{k+1,135} tabla{k+1,136}] = AIVIS2(TR);
334 [tabla{k+1,137} tabla{k+1,138}] = AIVIS2(TRSgol);
335 [tabla{k+1,139} tabla{k+1,140}] = AIVIS2(TRSpline);
336
337 tabla{k+1,141} = ReflectividadNIRB8aS2(TR);
338 tabla{k+1,142} = (ReflectividadNIRB8aS2(TR) - ReflectividadNIRB8aS2(TRSgol));
339 tabla{k+1,143} = (1+0.5) * (ReflectividadNIRB8aS2(TR) - ReflectividadNIRB8aS2(TRSgol));
340
341 end

```

The Workspace window shows a scatter plot of N (gr/m2) vs REP. The plot includes a linear regression line and the equation $N = 1.40 \cdot \text{REP} - 990$ with $R^2 = 0.83$.

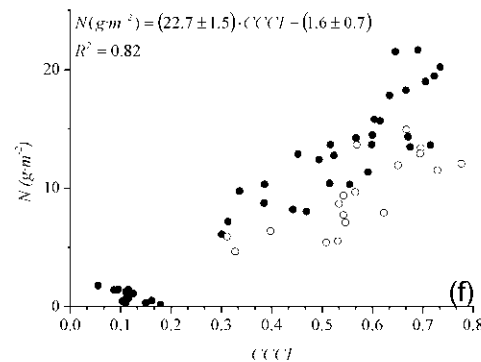
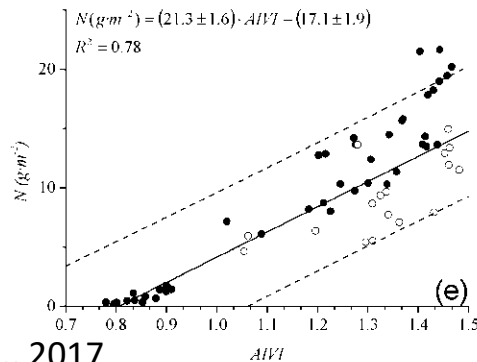
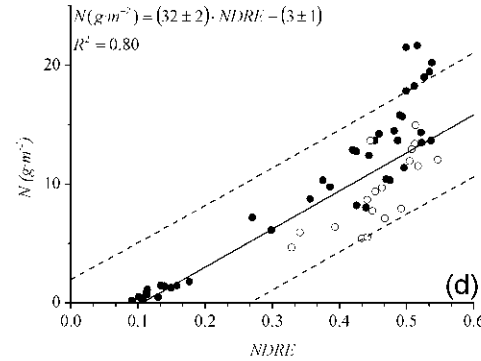
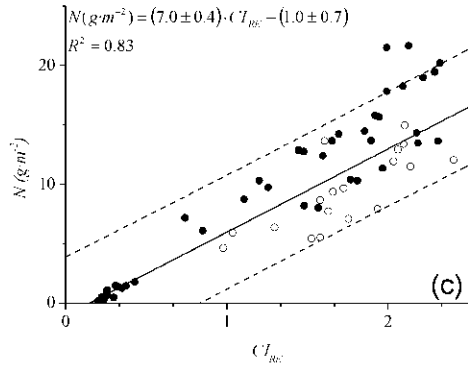
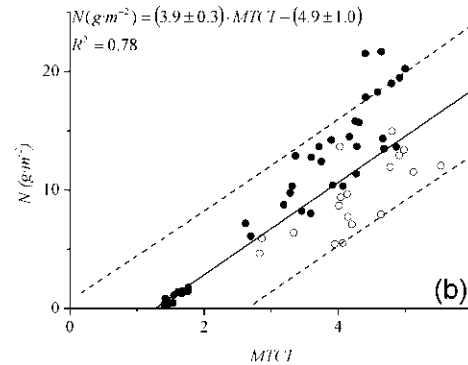
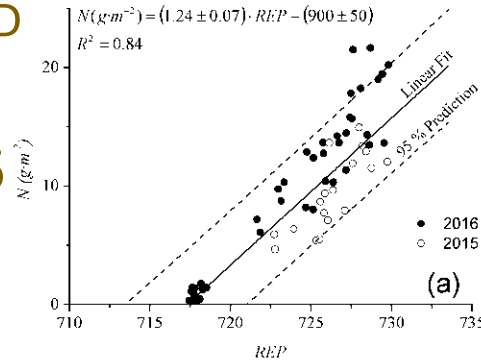
The Command Window shows a list of files in the current folder, including:

- 20160502_CJP1_TRG_XXX_1A.mn.rts.txt
- 20160502_CJP1_TRG_XXX_1B.mn.rts.txt
- 20160502_CJP1_TRG_XXX_1C.mn.rts.txt
- 20160502_CJP1_TRG_XXX_1MEDIA.mn.rts.txt
- 20160502_CJP1_TRG_XXX_2A.mn.rts.txt
- 20160502_CJP1_TRG_XXX_2B.mn.rts.txt
- 20160502_CJP1_TRG_XXX_2C.mn.rts.txt
- 20160502_CJP1_TRG_XXX_2MEDIA.mn.rts.txt
- 20160502_CJP1_TRG_XXX_3A.mn.rts.txt
- 20160502_CJP1_TRG_XXX_3B.mn.rts.txt
- 20160502_CJP1_TRG_XXX_3C.mn.rts.txt
- 20160502_CJP1_TRG_XXX_3MEDIA.mn.rts.txt
- 20160502_CJP1_TRG_XXX_4A.mn.rts.txt
- 20160502_CJP1_TRG_XXX_4B.mn.rts.txt
- 20160502_CJP1_TRG_XXX_4C.mn.rts.txt
- 20160502_CJP1_TRG_XXX_4MEDIA.mn.rts.txt
- 20160502_CJP1_TRG_XXX_5A.mn.rts.txt
- 20160502_CJP1_TRG_XXX_5B.mn.rts.txt
- 20160502_CJP1_TRG_XXX_5C.mn.rts.txt

FIELD WORK: N UPTAKE CALIBRATION

Field Spectroscopy to Support Precision Agriculture

NARROW BAND WHEAT YEAR 2015 & 2016



González-Piqueras et al., 2017

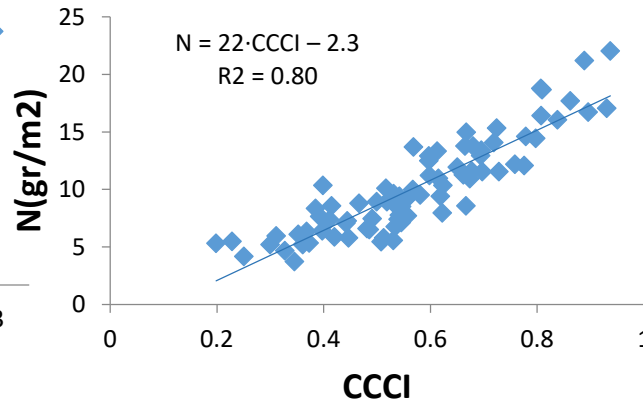
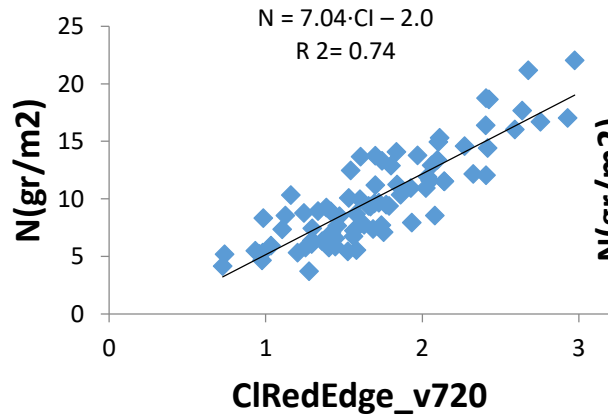
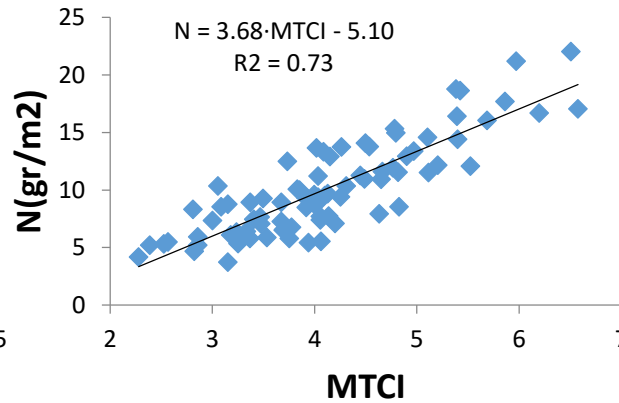
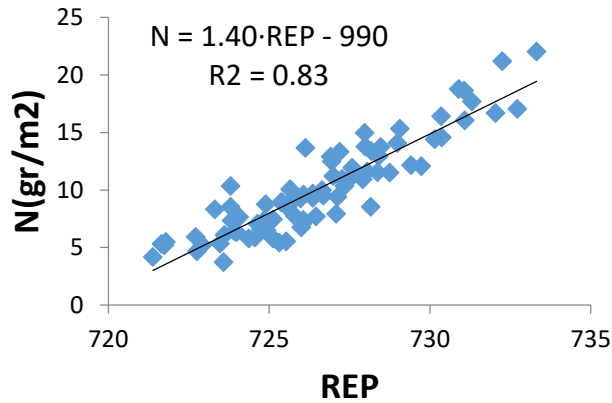
Protocolos y Librerías espectrales en espectroscopia de campo: de las buenas prácticas a una mayor utilidad de los datos

Madrid, Instituto Nacional de Técnica Aeroespacial (INTA) - 7 de marzo de 2019

FIELD WORK: N UPTAKE CALIBRATION

Field Spectroscopy to Support Precision Agriculture

Casa Jara, Casa del Monte & Dehesa los Llanos



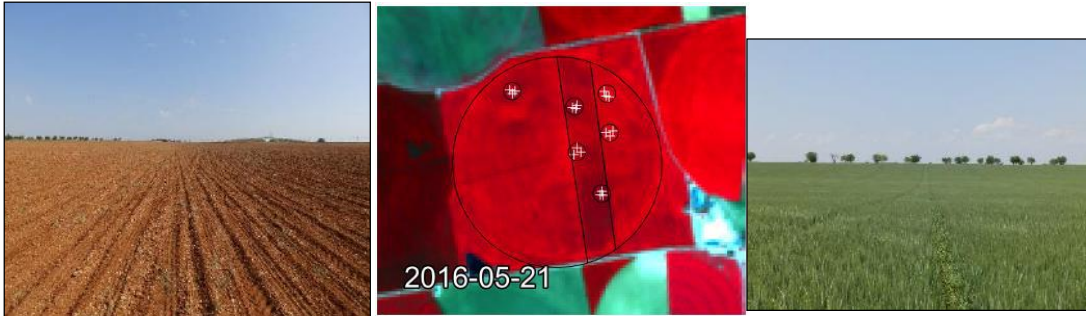
**NARROW BAND
WHEAT 2016
SPATIAL
VALIDATION**

FIELD WORK: S2 ATMOSPHERIC CORRECTION

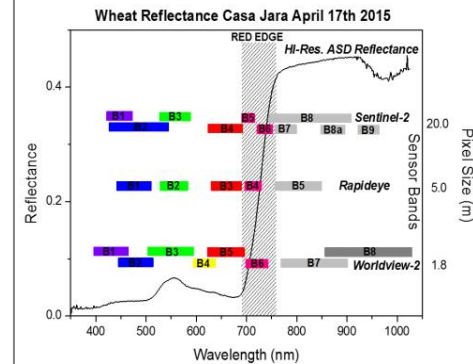
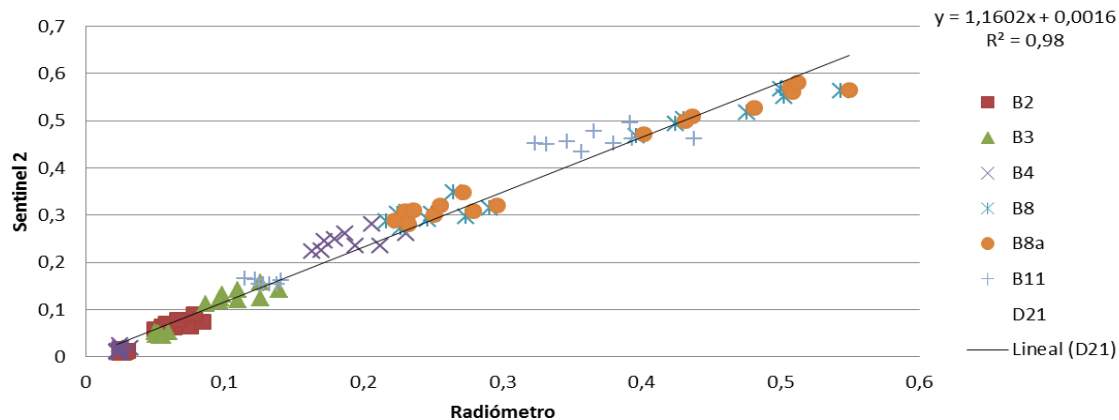
Field Spectroscopy to Support Precision Agriculture



Atmospheric correction (sen2cor)



Relación entre los valores medidos con Sentinel 2 y el radiómetro. Día 21.



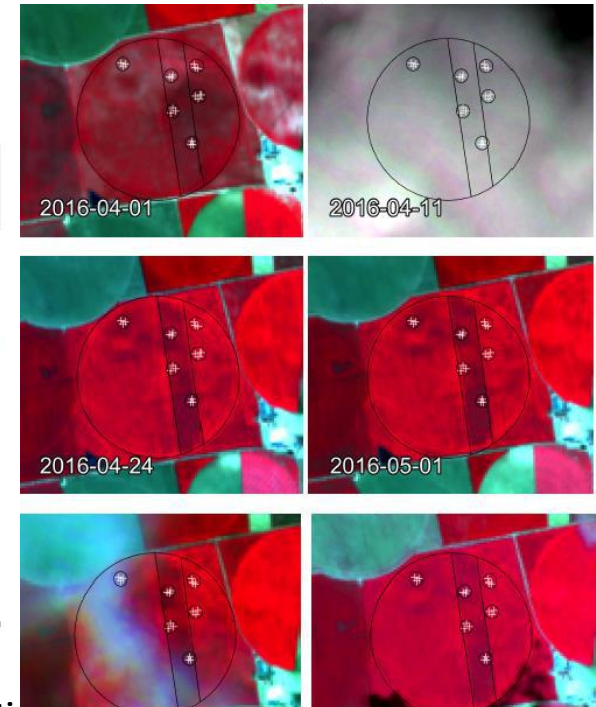
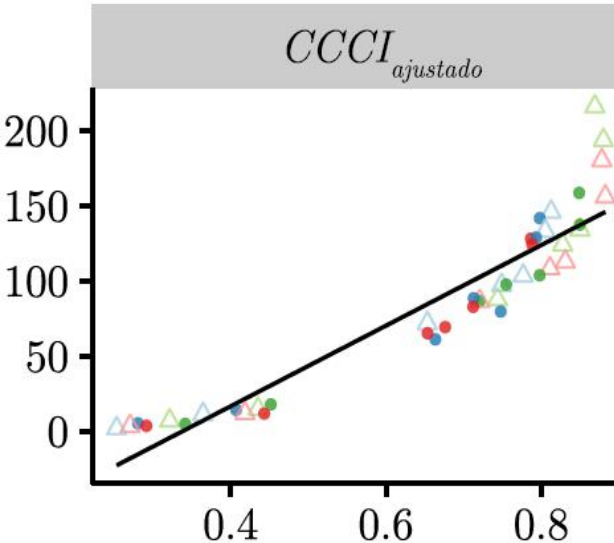
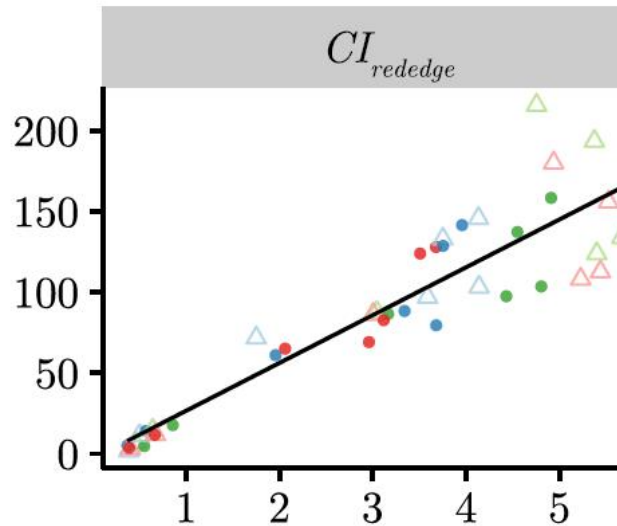
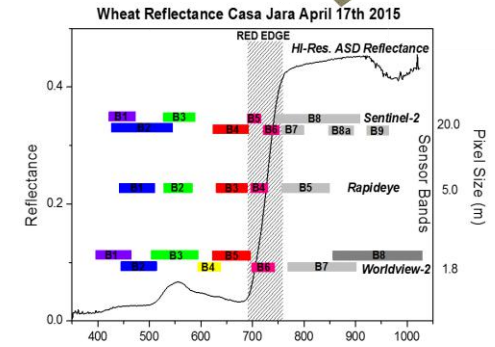
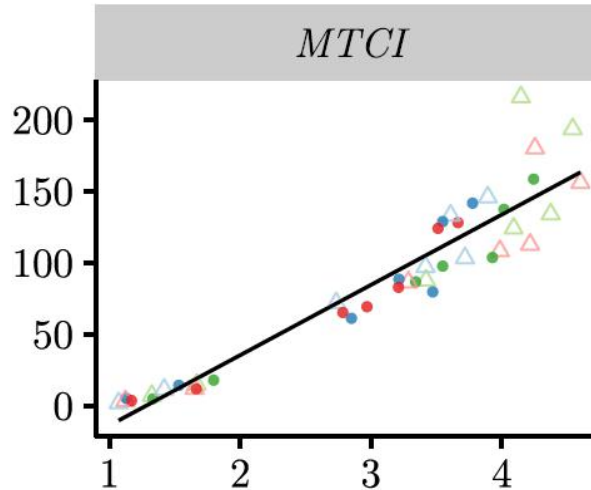
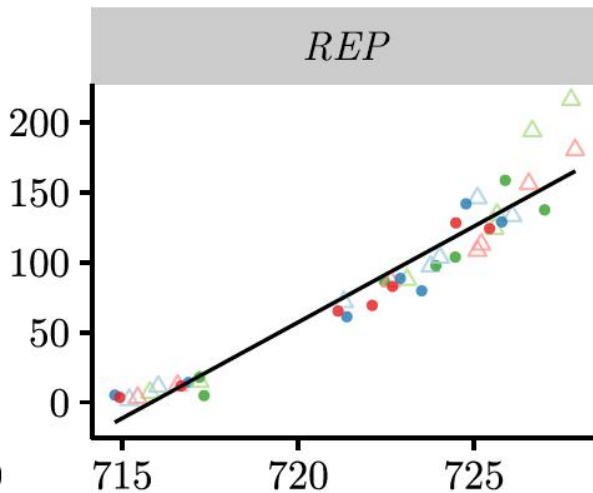
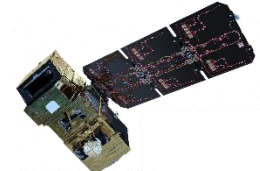
Adrián Moncholí, 2016

Protocolos y Librerías espectrales en Espectroscopía de campo: de las buenas prácticas a una mayor utilidad de los datos

Madrid, Instituto Nacional de Técnica Aeroespacial (INTA) - 7 de marzo de 2019

FIELD WORK: S2 NNI MAP

Field Spectroscopy to Support Precision Agriculture



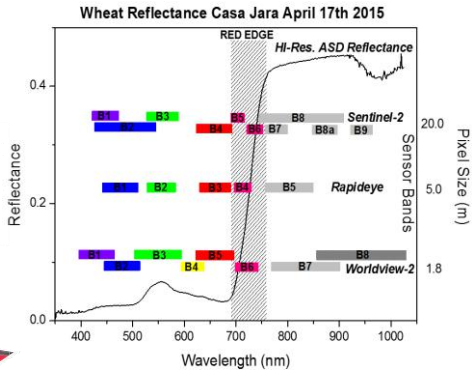
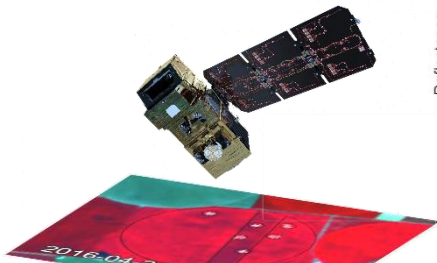
Protocolos y Librerías espectrales en Espectroscopía de campo: de las buenas prácticas a una mayor utilidad de los datos

Madrid, Instituto Nacional de Técnica Aeroespacial (INTA) - 7 de marzo de 2019

FIELD WORK: S2 NNI MAP

Field Spectroscopy to Support Precision Agriculture

Resultados del ajuste en Casa Jara de los índices red-edge obtenidos de las imágenes de Sentinel 2A frente a QN medido en campo.



Index	Slope (m)	Intercept (n)	R ²
REP	1.37 ±0.06	-980 ±40	0.87
MTCI	4.9 ±0.2	-6.3 ±0.8	0.89
CI _{RE}	3.0 ±0.5	-3.0 ±0.6	0.84
NDRE	27 ±2	-4 ±1	0.81
AIVI	-	-	-
CCCI	26.7 ±1.2	-9.0 ±0.5	0.87

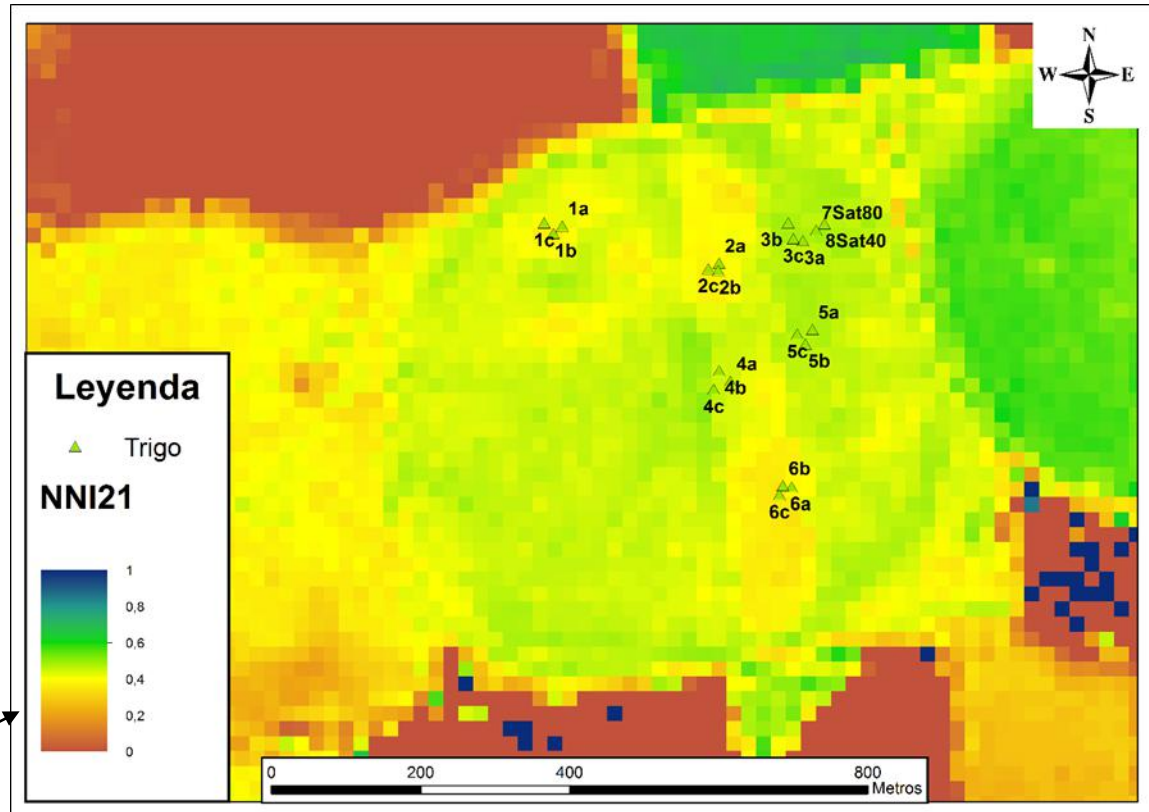
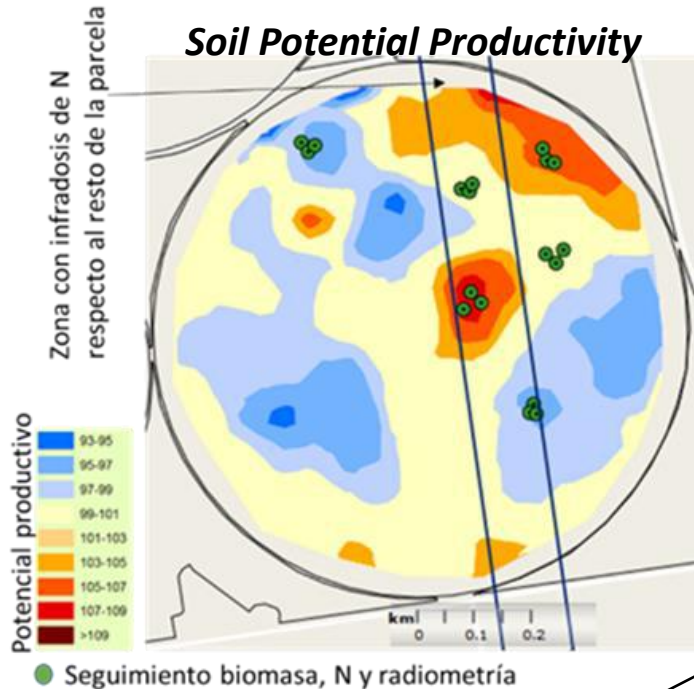
Pro

is datos

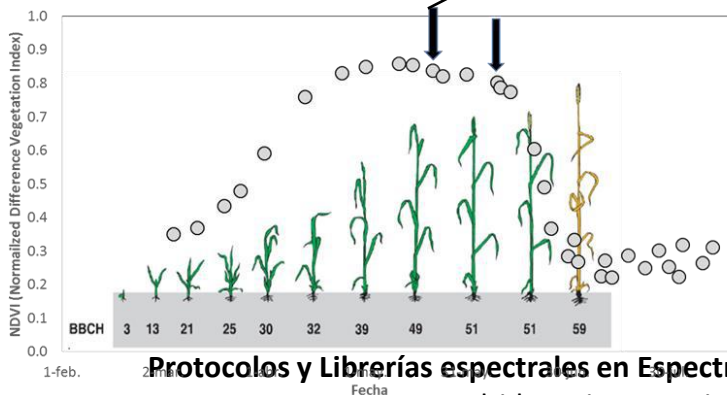
Indirect Nitrogen Nutrition Index (NNI) map on wheat 21st May 2016, from Red-Edge Sentinel 2A bands

Albacete (Casa Jara), Spain

Soil Potential Productivity



NDVI Multisensor (Combinando Landsat 8 y Sentinel 2A) trigo Casa Jara 2016

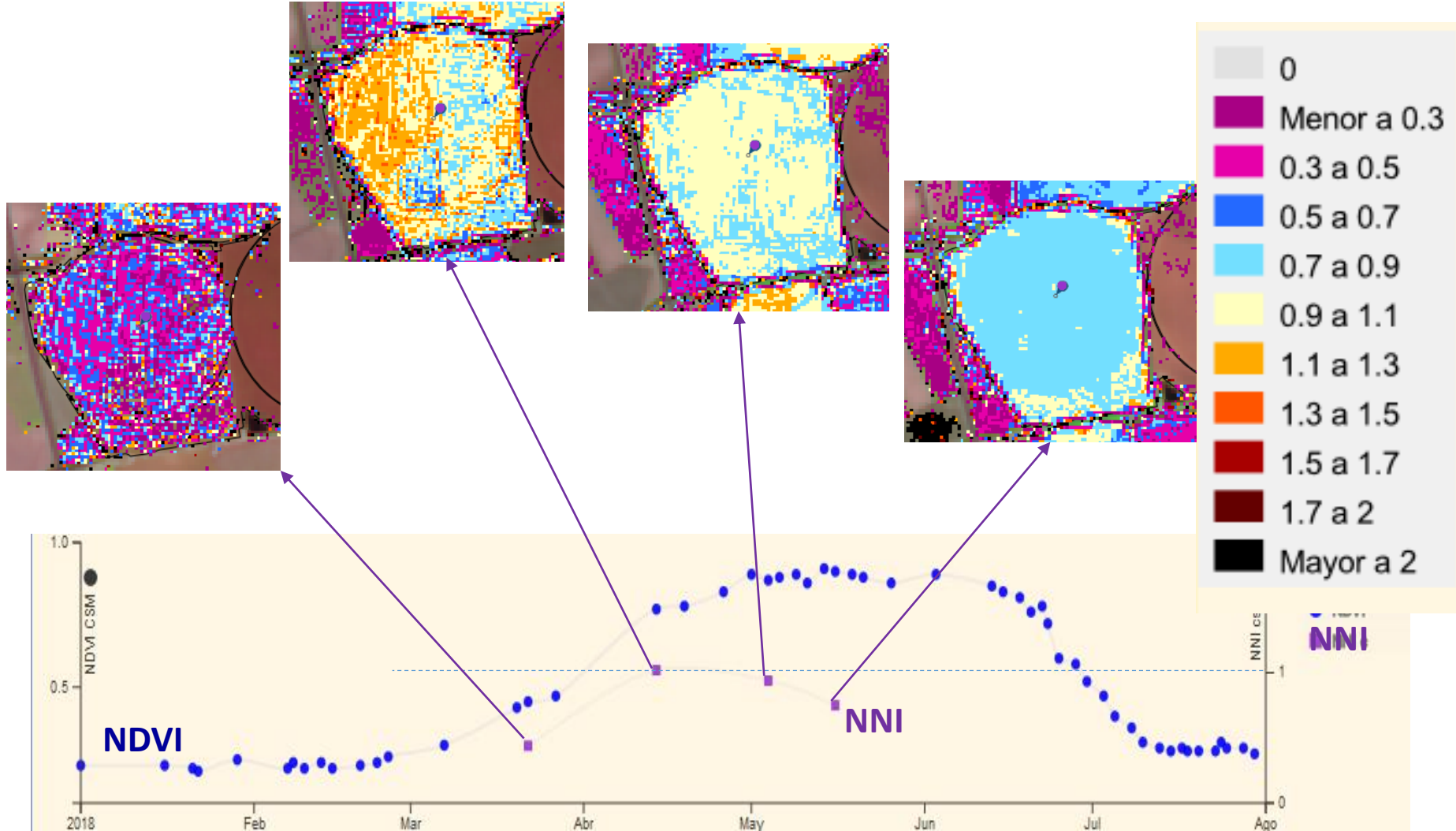


Protocolos y Librerías espectrales en Espectroscopía de campo: de las buenas prácticas a una mayor utilidad de los datos

Madrid, Instituto Nacional de Técnica Aeroespacial (INTA) - 7 de marzo de 2019

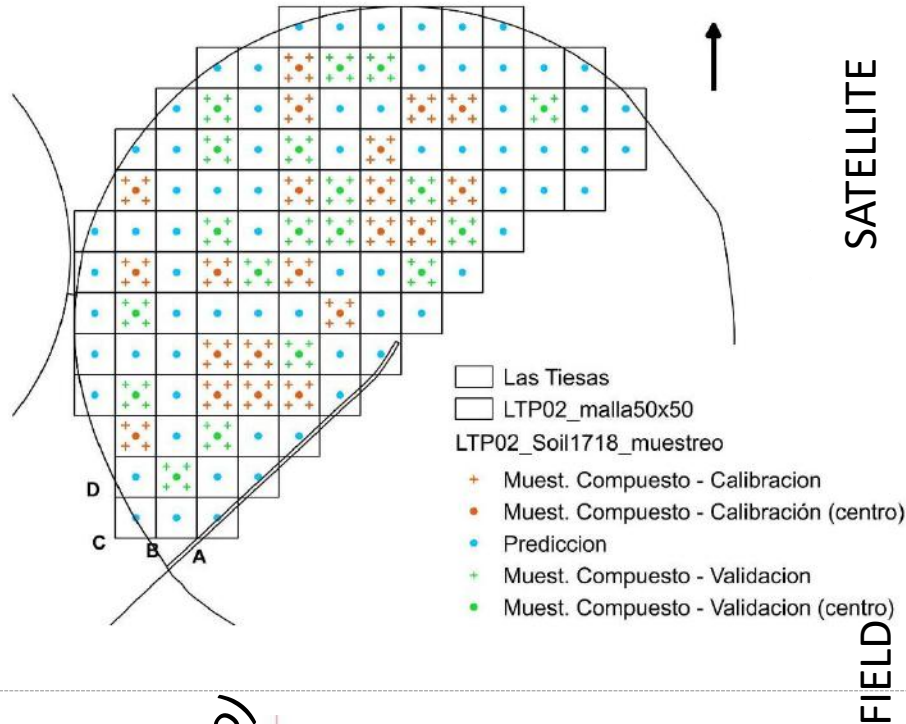
FIELD WORK: NNI MAP DECISION SUPPORT

Field Spectroscopy to Support Precision Agriculture

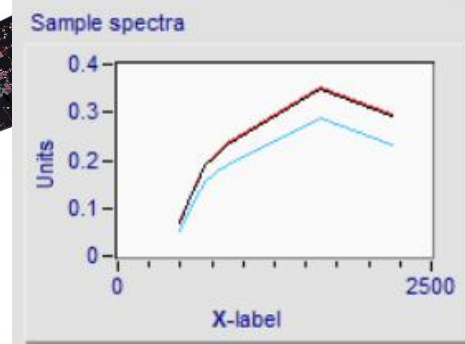
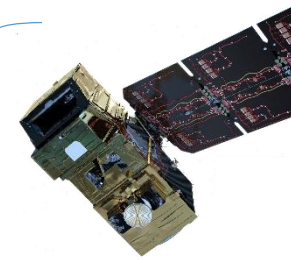


FIELD WORK: SOIL

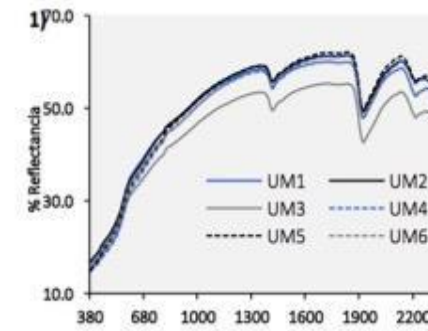
Field Spectroscopy to Support Precision Agriculture



SATELLITE



DIRECT MEASUREMENT

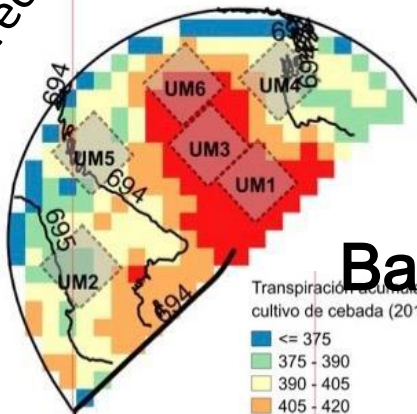


FIELD

LABORATORY



Áreas 1 ha: 6 UM
 (Unidades de Muestreo)



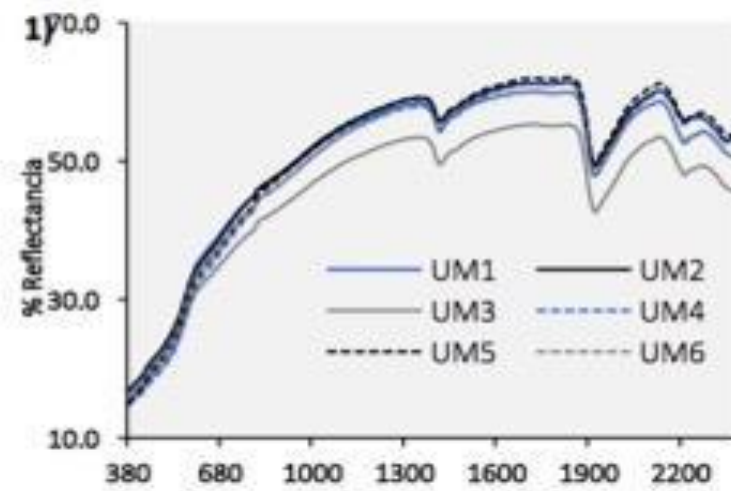
Barley

de campo: de las buenas prácticas a una mayor utilidad de los datos

DATA PROCESS: SOIL

Field Spectroscopy to Support Precision Agriculture

_m_Ev_values_10nm%																
	A	B	C	D	E	F	G	H	I	J	K	AC	AD			
1	0	sand_%	silt_%	clay_%	pH	CE1_5_mm	Cl-_ppm	SO42-_ppm	SOM_%	N_%	CN	420	430			
2	B18Va	11.63	46.19	42.18	8.23	0.51	28.33	69.14	2.75	0.14	11.2	7.25482791	7.35028415	7.67		
3	B18Vc	11.63	46.19	42.18	8.23	0.51	28.33	69.14	2.75	0.14	11.2	8.71150419	8.6696442	8.924		
4	B18Ve	11.63	46.19	42.18	8.23	0.51	28.33	69.14	2.75	0.14	11.2	9.63114753	9.45012123	9.643		
5	B19Va	14.14	49.82	36.03	8.22	0.56	35.39	106.57	2.63	0.14	11.04	7.34725048	7.53875299	7.877		
6	B19Vc	14.14	49.82	36.03	8.22	0.56	35.39	106.57	2.63	0.14	11.04	7.45586246	7.51396709	7.759		
7	B19Ve	14.14	49.82	36.03	8.22	0.56	35.39	106.57	2.63	0.14	11.04	7.5597686	7.51269518	7.720		
8	C24Va	23.67	49.31	27.01	8.41	0.51	31.83	76.86	2.38	0.12	11.81	8.55826326	8.35827845	8.515		
9	C24Vc	23.67	49.31	27.01	8.41	0.51	31.83	76.86	2.38	0.12	11.81	9.71374727	9.47037197	9.645		
10	C24Ve	23.67	49.31	27.01	8.41	0.51	31.83	76.86	2.38	0.12	11.81	7.54707135	7.59231679	7.874		
11	C25Va	25.61	49.51	24.88	8.39	0.48	31.82	87.14	2.59	0.1	15.5	7.74518353	8.00123196	8.299		
12	C25Vc	25.61	49.51	24.88	8.39	0.48	31.82	87.14	2.59	0.1	15.5	8.32642649	8.50476598	8.834		
13	C25Ve	25.61	49.51	24.88	8.39	0.48	31.82	87.14	2.59	0.1	15.5	7.97605053	8.15662101	8.451		
14	C27Va	32.92	42.59	24.5	8.41	0.42	31.91	81.71	2.65	0.11	13.42	10.1926763	10.4730486	10.87		
15	C27Vc	32.92	42.59	24.5	8.41	0.42	31.91	81.71	2.65	0.11	13.42	10.8048504	10.7789824	11.04		
16	C27Ve	32.92	42.59	24.5	8.41	0.42	31.91	81.71	2.65	0.11	13.42	8.85838681	9.11353203	9.467		
17	C28Va	22.89	50.09	27.02	8.39	0.48	30.07	62.86	3.15	0.18	9.95	7.67805739	7.91876153	8.208		
18	C28Vc	22.89	50.09	27.02	8.39	0.48	30.07	62.86	3.15	0.18	9.95	9.47152216	9.69355834	10.0057051	10.475601	10.8362843
19	C28Ve	22.89	50.09	27.02	8.39	0.48	30.07	62.86	3.15	0.18	9.95	11.1955937	11.5180462	11.9287773		
20	C33Va	27.19	45.41	27.39												
21	C33Vc	27.19	45.41	27.39												
22	C33Ve	27.19	45.41	27.39												
23	D42Va	24.37	45.63	29.99												
24	D42Vc	24.37	45.63	29.99												
25	D42Ve	24.37	45.63	29.99												
26	E51Va	15.93	45.52	38.55												
27	E51Vc	15.93	45.52	38.55												
28	E51Ve	15.93	45.52	38.55												
29	F56Va	26.29	50.06	23.65												
30	F56Vc	26.29	50.06	23.65												
31	F56Ve	26.29	50.06	23.65												
32	F59Va	35.18	41.18	23.65												
33	F59Vc	35.18	41.18	23.65												
34	F59Ve	35.18	41.18	23.65												
35	F60Va	18.46	50.19	31.35												
36	F60Vc	18.46	50.19	31.35												
37	F60Ve	18.46	50.19	31.35												
38	F61Va	14.23	49.29	36.48												
39	F61Vc	14.23	49.29	36.48												
40	F61Ve	14.23	49.29	36.48												
41	H77Va	32.4	46.47	21.13												
42	H77Vc	32.4	46.47	21.13												
43	H77Ve	32.4	46.47	21.13												
44	H79Va	29.58	46.35	24.07												
45	H79Vc	29.58	46.35	24.07												
46	H79Ve	29.58	46.35	24.07												



ParLeS version 3.1

ParLeS Import Data Modelling Data Manipulations PCA PLSR Cross Validation PLSR Model Import Data Prediction PLSR Predict Bagging-PLSR

DATA FOR MODELLING

Get file for modelling

%C:\Users\Elena Pareja Serrano\Desktop\Tesis\FieldASD\m_Ev_values_10nm%.txt

Header information - data for modelling

0 sand_ % silt_ % clay_ % pH CE1_5_mmhosom Cl-_ppm SO42-_ppm SOM_ % N_ % CN N-NO3-_ppm P_ppm Carb_ % Caliza_ % K_meq100g Na_meq100g Ca_meq100g Mg_meq100g K/g

Total Number of y variables

27

Select y variable for modelling

size y size X

60 209

y variables

11.63	46.19	42.18	8.23	0.51	28.33	69.14	2.75
11.63	46.19	42.18	8.23	0.51	28.33	69.14	2.75
11.63	46.19	42.18	8.23	0.51	28.33	69.14	2.75
14.14	49.82	36.03	8.22	0.56	35.39	106.57	2.63
14.14	49.82	36.03	8.22	0.56	35.39	106.57	2.63
14.14	49.82	36.03	8.22	0.56	35.39	106.57	2.63

Labels

B18Va	2.75	7.25483	7.35028	7.67843	8.00065	420
B18Vc	2.75	8.7115	8.66964	8.92482	9.30726	430
B18Ve	2.75	9.63115	9.45012	9.64391	9.93507	440
B19Va	2.63	7.34725	7.53875	7.87769	8.30811	450
B19Vc	2.63	7.45586	7.51397	7.75963	8.10729	460
B19Ve	2.63	7.55977	7.5127	7.72088	8.09507	470

X variables

7.25483	7.35028	7.67843	8.00065	420
8.7115	8.66964	8.92482	9.30726	430
9.63115	9.45012	9.64391	9.93507	440
7.34725	7.53875	7.87769	8.30811	450
7.45586	7.51397	7.75963	8.10729	460
7.55977	7.5127	7.72088	8.09507	470

DATA TO MERGE

☐ Check to merge files from a single directory

Directory with files to merge

%C:\

File extension (e.g. *.txt)

Size merged data

*.txt 0 0 SAVE MERGED FILE

Histogram y

No Occurrence

y

y Statistics

mean 2.80

st dev 0.32

med. 2.68

max. 3.60

min. 2.38

skew 0.03

Sample spectra

Units

X-label

utilidad de los datos

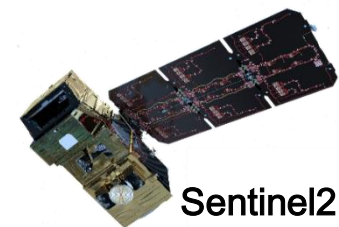
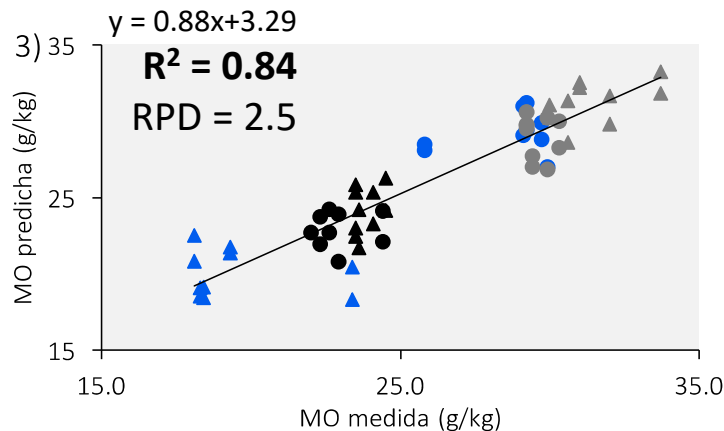
DATA PROCESS: SOIL

Field Spectroscopy to Support Precision Agriculture

MO: Organic Matter



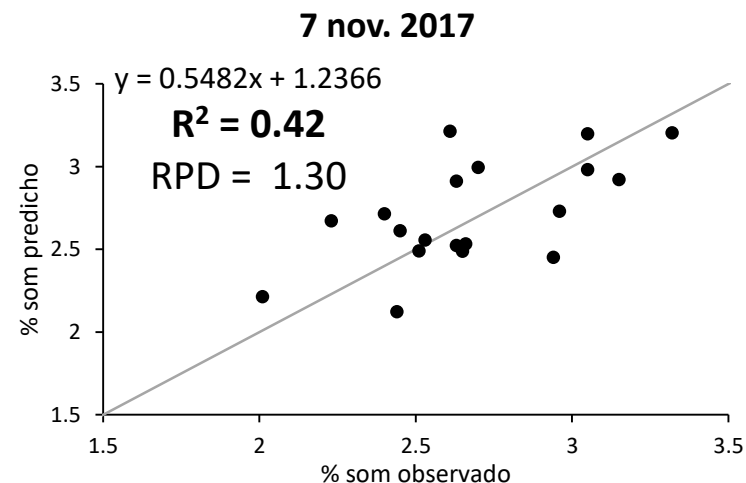
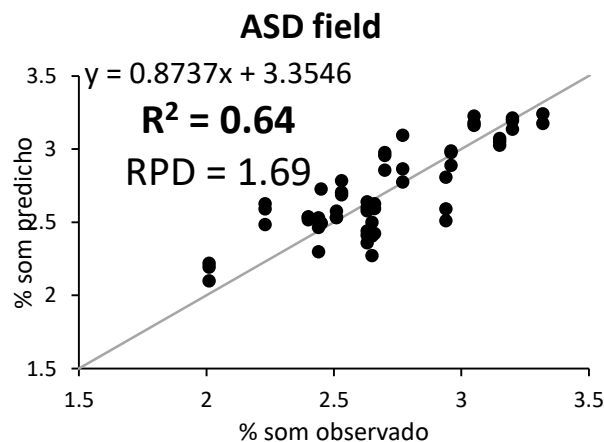
Integrating
Sphere-
Laboratory



Sentinel2 –
remoto



Radiómetro
En campo



Protocolos y Librerías espectrales en Espectroscopía de campo: de las buenas prácticas a una mayor utilidad de los datos

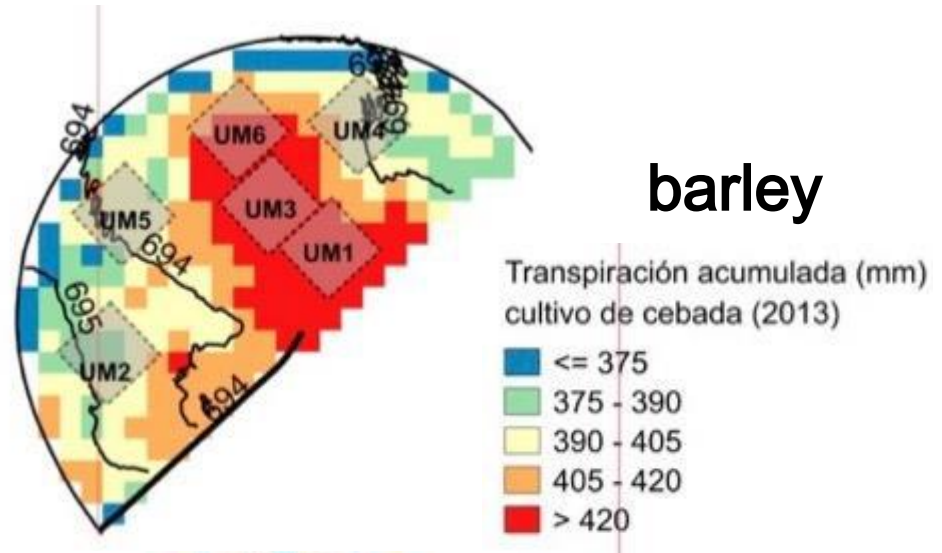
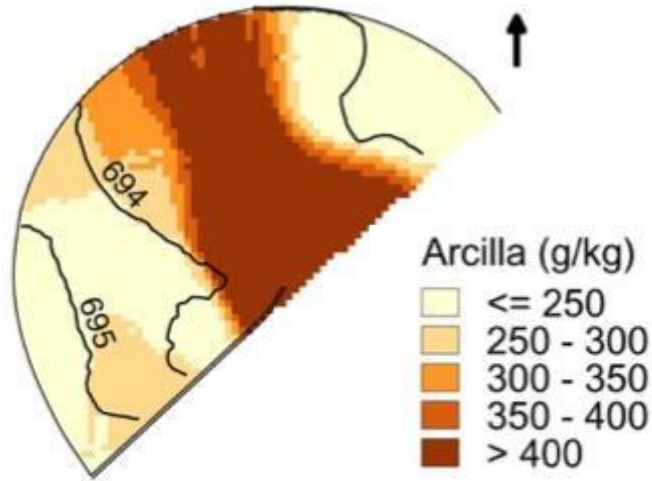
Pareja Serrano, Elena, 2018 Madrid, Instituto Nacional de Técnica Aeroespacial (INTA) - 7 de marzo de 2019

DATA PROCESS: SOIL

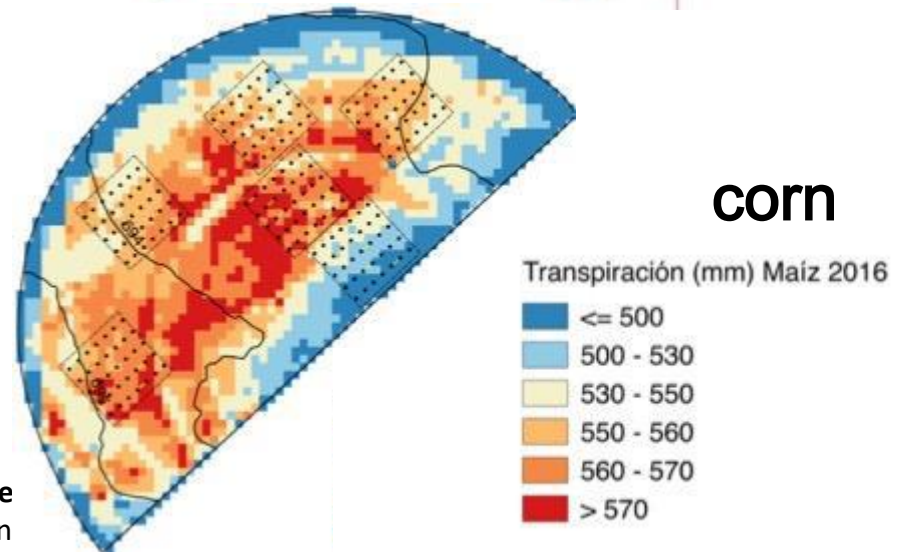
Field Spectroscopy to Support Precision Agriculture

Clay– transpiration

barley



corn



CONCLUSIONS

ESTIMACIÓN NNI BANDAS RED EDGE

- Provide reliable (guarantee quality) data to users (UAV & Satellite).
- Instruments at field are operational.
- Radiometry is implemented in the information supplied to the users.

ACKNOWLEDGEMENTS

ESTIMACIÓN NNI BANDAS RED EDGE

FATIMA

(**F**arming Tools for external nutrient **I**ntputs and water
Management)

European Union's Horizon 2020 (G. A. Nº 633945).



Unión Europea

HERMANA

(**H**ERramienta para el **M**Anejo de fertilización **N**itrogenada y
Agua sostenible)

Spanish Ministry of Economy and Competitiveness (AGL2015-68700-R)



ANIATEL

[Optimización en el uso del agua y del nitrógeno en el cultivo del almendro a través de prácticas agronómicas y técnicas de teledetección]

SBPLY/17/180501/000357



Castilla-La Mancha



Unión Europea

Protocolos y Librerías espectrales en Espectroscopía de campo: de las buenas prácticas a una mayor utilidad de los datos

Madrid, Instituto Nacional de Técnica Aeroespacial (INTA) - **7 de marzo de 2019**