

JIDE 2017

VIII Jornadas Ibéricas de

Infraestructuras de Datos Espaciais

Lisboa | 15 - 17 novembro 2017



INSTITUTO
GEOGRÁFICO
NACIONAL



GOBIERNO
DE ESPAÑA
MINISTERIO
DE FOMENTO

JIIIDE 2017

LCLU-STATS

Contributo metodológico para cartografia anual de ocupação do solo com imagens de satélite

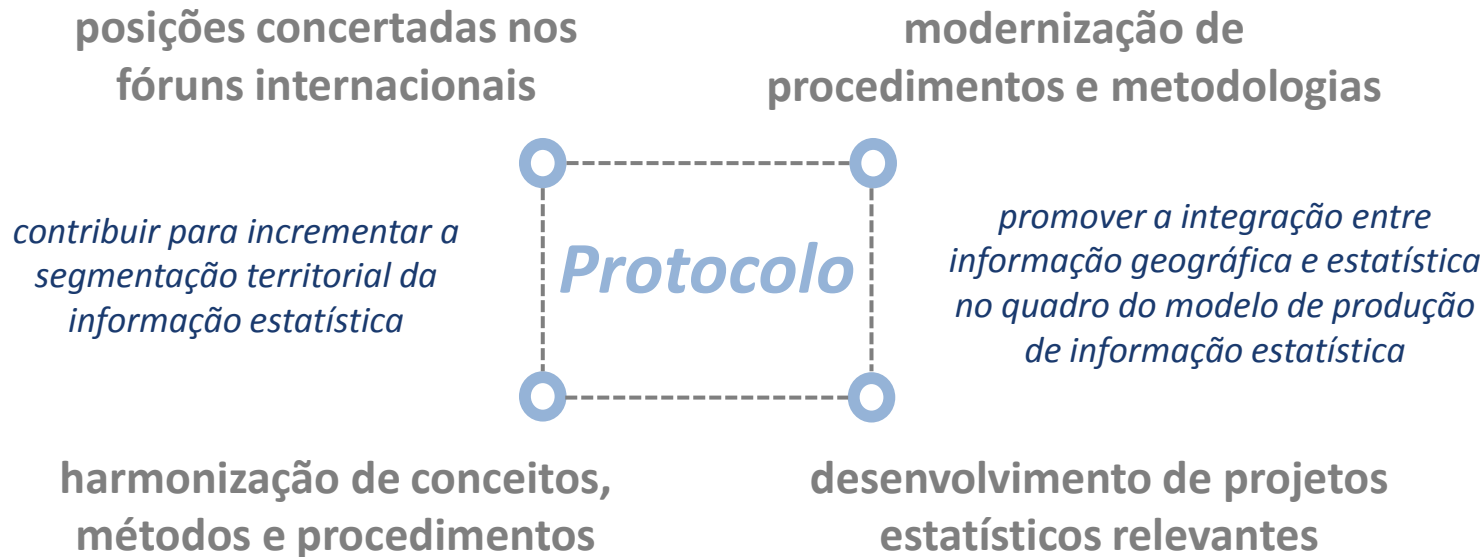
Hugo Costa^a, Francisco Vala^b, Filipe Marcelino^a, Mário Caetano^a

^aDireção-Geral do Território (DGT)

^bInstituto Nacional de Estatística (INE)



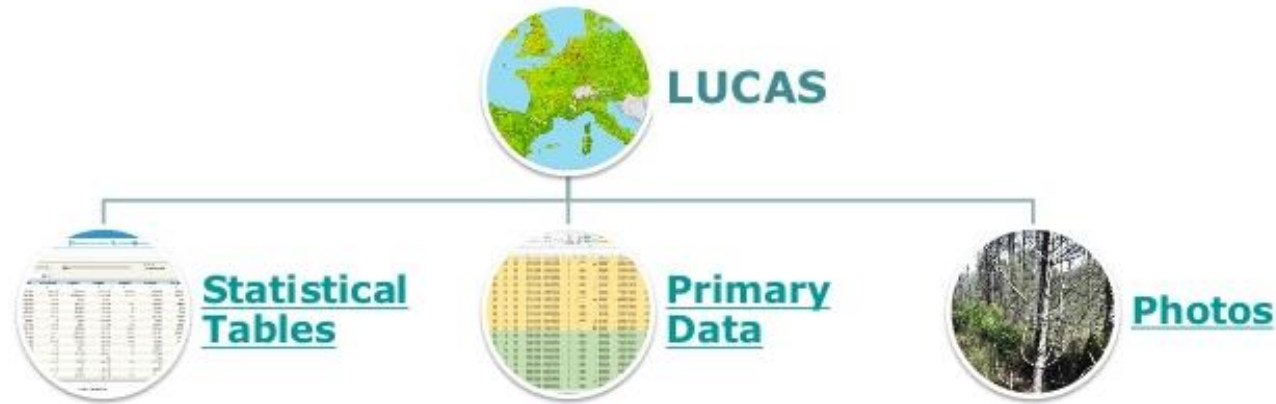
Protocolo de colaboração entre o INE e a DGT



LUCAS - *Land Use and Land Cover Area Survey*

LUCAS

Inquérito por amostragem areolar trienal com pontos de observação de recolha de informação sobre o uso e a ocupação do solo



Recolha in situ



Representatividade
ao nível das NUTS

Qualidade

Estudos cofinanciados
pela CE/ESTAT

Sistemas de informação EM



LCLU-STATS

Provision of harmonised land cover/land use information: LUCAS and national systems

- Entidades Participantes: Instituto Nacional de Estatística (INE)
Direção-Geral do Território (DGT)
- Financiamento: Eurostat (contracto N.º 08441.2015.002-2015.724)
- Duração: 2016-2017



Objectivos do projeto LCLU-STATS

Objectivos do Eurostat

- Disponibilização de dados harmonizados sobre ocupação e uso do solo coerentes com as nomenclaturas LCLU do SEE, ao nível das **NUTS III, para 2013-15**
- Utilização de dados oficiais de **fontes nacionais**, promovendo a integração das nomenclaturas LCLU dos sistemas de informação nacionais e SEE
- Descrição da metodologia e avaliação de **qualidade dos resultados**
- Estudo de viabilidade para o **reporte regular** de estatísticas LCLU pelo SEE

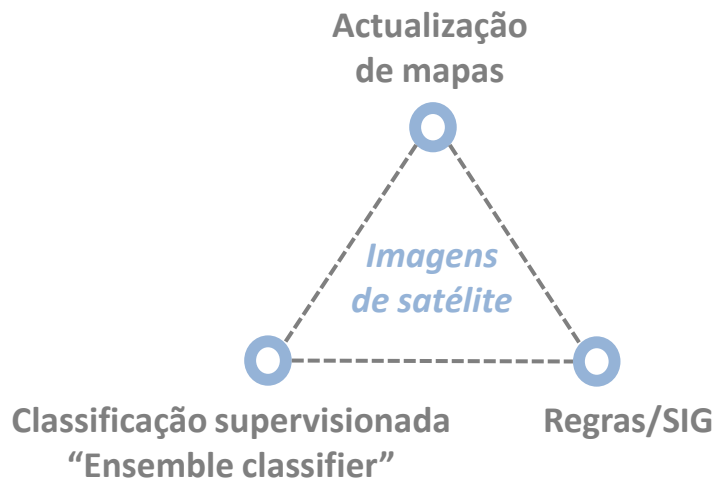
Objectivos específicos INE/DGT

- Desenvolver uma metodologia sustentada na **classificação automática de imagens de satélite e técnicas de estimação em pequenos domínios** ancorada na **COS 2010** e no uso de informação auxiliar (oficial e nacional)
- Produzir cartografia anual de ocupação do solo para o período entre **2010 e 2015** e produção de cartografia de uso do solo para o ano de **2013**, para Portugal Continental
- Propor uma abordagem metodológica tendo em vista a sua **transposição para outros EM**

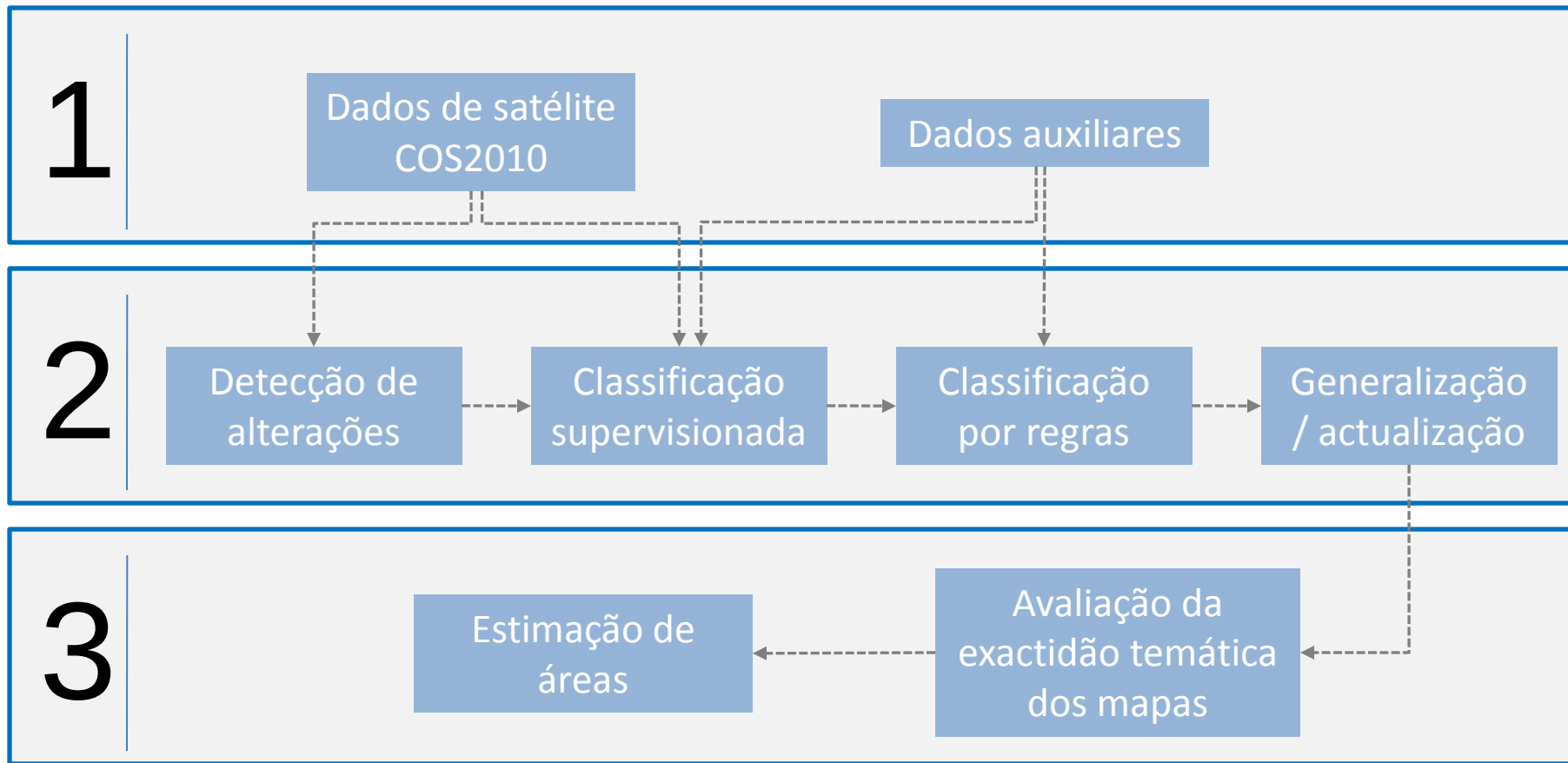


Objectivos da DGT

- Produção de uma série temporal de mapas
- Actualização sucessiva de mapas pré-existentes (detecção de alterações e sua classificação)
- Investigação aplicada com o objectivo de ganhar escala no futuro
- Produção operacional de cartografia anual de ocupação do solo na era dos Sentinelas



Metodologia LCLU-STATS



Nomenclatura de ocupação do solo

Class	Description	Reference
A ARTIFICIAL LAND		
Roofed built-up areas	Roofed constructions which can be entered by persons.	LUCAS
Artificial non built-up areas	Non built-up areas characterized by an artificial and/or impervious cover of hard artificial materials, concrete, gravel.	LUCAS
Other built-up areas	Other artificial areas (such as power plants and water sewage plants).	LUCAS
B CROPLAND		
Cropland	Areas where crops are planted and cultivated.	LUCAS
C WOODLAND		
Broadleaved forest	Woodlands composed of more than 75% of broadleaved species.	FAO/LUCAS
Coniferous forest	Woodlands composed of more than 75% of coniferous species.	FAO/LUCAS
Mixed forest	Woodlands composed of broadleaved and coniferous trees comprising both >25% of the tree canopy.	FAO/LUCAS
Other land with tree cover	Agricultural or urban land with 10% or more tree cover able to reach a height of 5 meters at maturity.	FAO/LUCAS
D SHRULAND		
Shrubland	Areas dominated (at least 10% of the surface) by shrubs and low woody plants normally not able to reach more than 5m of height. It may include sparsely occurring trees with a canopy below 10%.	LUCAS
E GRASSLAND		
Grassland	Sown or self-seeded grassland, grass like plants and forbs without trees and shrubland, and which is not included in the crop rotation on the holding.	LUCAS/ ACS
F BARE LAND AND LICHENS/MOSS		
Consolidated bare surfaces and deposits	Consolidated bare surfaces, organic and chemical deposits.	INSPIRE
Unconsolidated bare surfaces and deposits	Unconsolidated bare surfaces, organic and chemical deposits and intertidal flats assigned to inland area.	INSPIRE
G WATER AREAS		
Inland water bodies	Inland areas of still standing surface water.	LUCAS
Inland running water	Inland channels of running water.	LUCAS
H WETLANDS		
Wetlands	Areas that fall between land and water, and wet for long enough periods that the plants and animals living in or near them are adapted to, and often dependent on, wet conditions for at least part of their life cycle.	LUCAS



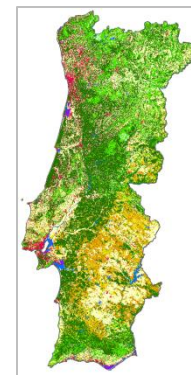
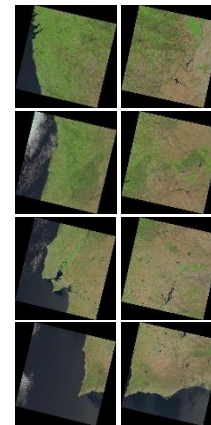
Nomenclatura de ocupação do solo

Class
A Artificial land
Roofed built-up areas
Artificial non built-up areas
Other built-up areas
B CROPLAND
Non-irrigated crops
Irrigated crops
Rice fields
Vineyards
Fruit trees
Olive groves
Complex cultivation patterns
C WOODLAND
Broadleaved forest
Clear cuts of broadleaved forest
Burnt broadleaved forest
Coniferous forest
Clear cuts of coniferous forest
Burnt coniferous forest
Mixed forest
Clear cuts of mixed forest
Burnt mixed forest
Other land with tree cover
D SHRULAND
Shrubland
Burnt shrubland
E GRASSLAND
Grassland
Burnt grassland
F BARE LAND AND LICHENS/MOSS
Mineral extraction sites
Bare rock
Beaches, dunes and sand
Bare soil
G WATER AREAS
Inland water bodies
Inland running water
H WETLANDS
Wetlands



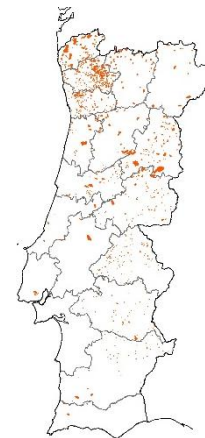
Dados principais

- Imagens Landsat 5, 7 e 8
 - Imagens de primavera e verão de 2010 a 2015
- COS2010
 - Interpretação visual de imagens aéreas de grande resolução espacial
 - Uso de diversa informação auxiliar



Dados auxiliares

- Sistema de Identificação Parcelar (IFAP)
- Pedreiras e parques eólicos (DGEG)
- Áreas ardidas (ICNF)



Detecção de alterações

NDVI differencing

Dados
multi-espectrais

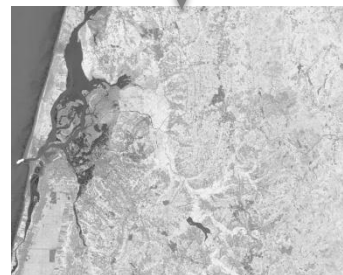
ano x



ano x+1

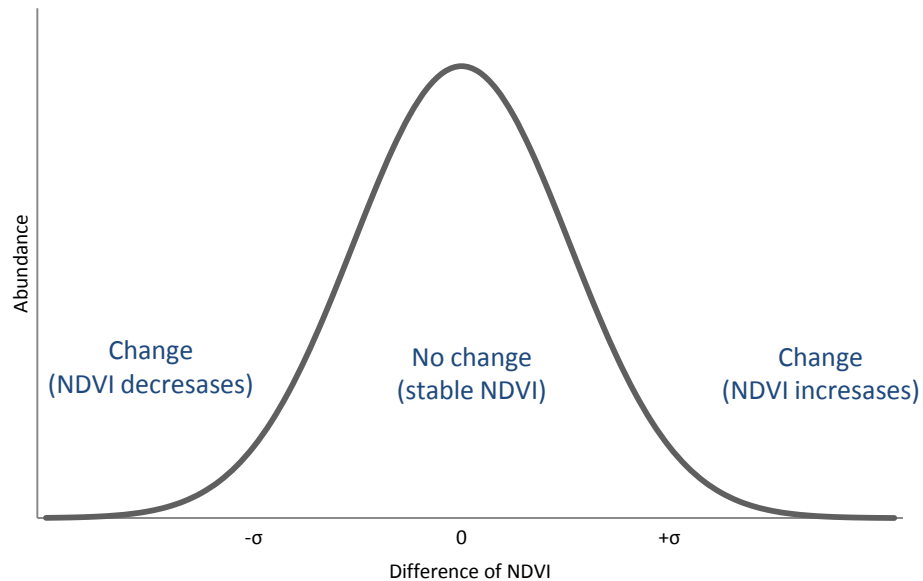


NDVI
 $(IF-V)/(IF+V)$



Diferença

Detecção de alterações



Detecção de alterações

2010-2011

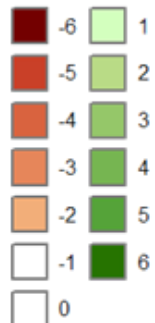
2011-2012

2012-2013

2013-2014

2014-2015

Std from de mean
difference of NDVI



Only strong changes are relevant
(like <-2 or >2 standard deviations from the mean)



Classificação supervisionada

Spectral training classes

Consolidated bare surfaces

Unconsolidated bare surfaces

Non-irrigated crops

Irrigated crops

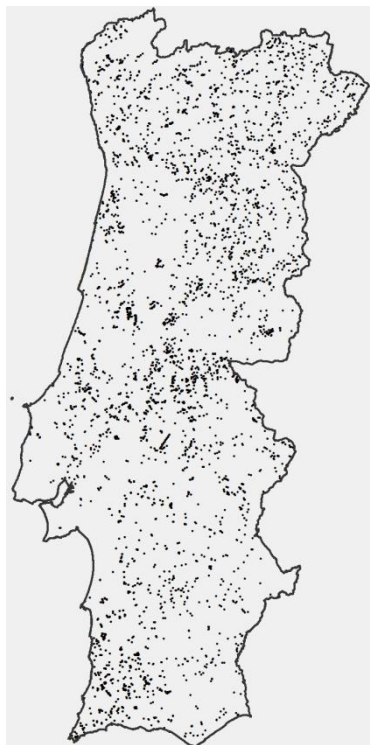
Forest

Shrubland

Grassland

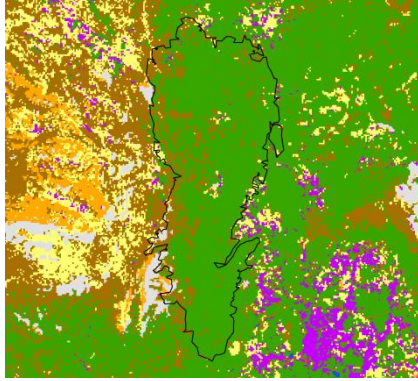
Beaches, dunes and sand

Water

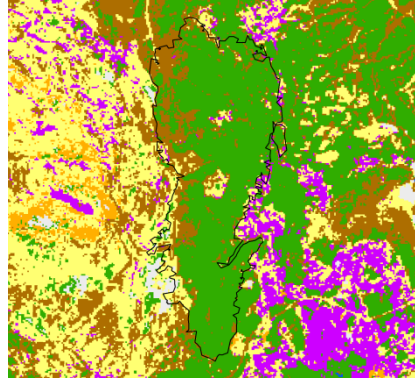


Ano	Número de pontos de treino
2011	3756
2012	3365
2013	3692
2014	3893
2015	4252

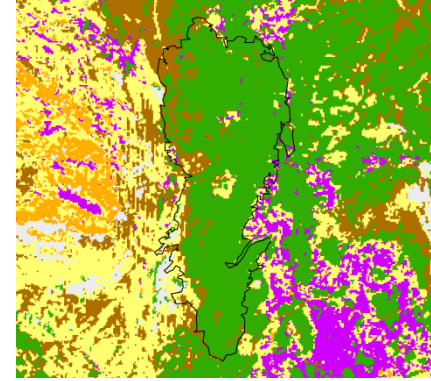
Classificação supervisionada



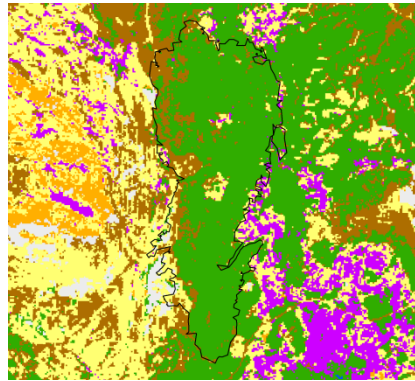
ANN



Random forest



SVM



Ensemble classifier

Classificação por regras

- Integração da classificação supervisionada e dados SIG
- Interpretação da classificação supervisionada no contexto do mapa
- Correção de erros de classificação
- Regras *if-then-else*

```

226 #####
227 #####
228 #####
229 #####
230 # RULES FOR LAND COVER CHANGE BASED ON IMAGE CLASSIFICATION
231 #####
232 maptemp<-map0
233 #####
234 ### New crops (Z...) ###
235 threshold211<-stats[which(stats$class==211),"diffNDVI.4"]
236 threshold212<-stats[which(stats$class==212),"diffNDVI.2"]
237
238 ind<-map0==211 &map1==212 # change between Irrigated and Non-irrigated crops
239 maptemp[ind]<-212
240
241 ind<-map0==212 &map1==211 # change between Irrigated and Non-irrigated crops
242 maptemp[ind]<-211
243
244 new211<-(map0==312|map0==322|map0==332) &map1==211 &diffNDVI-threshold211 # Forest -> clear cut -> Non-irrigated crops
245 maptemp[new211]<-211
246
247 new212<-(map0==312|map0==322|map0==332) &map1==212 &diffNDVI-threshold212 # Forest -> clear cut -> Irrigated crops
248 maptemp[new212]<-212
249
250 ind<-map0==411 &map0==411 &(map1==211) &diffNDVI-threshold211 &bay0==0 # Natural grasslands -> Non-irrigated crops
251 maptemp[ind]<-211
252
253 ind<-map0==411 &map0==411 &(map1==212) &diffNDVI-threshold212 &bay0==0 # Natural grasslands -> Irrigated crops
254 maptemp[ind]<-212
255
256 ind<-map0==421 &map1==211 &magnitude<=0 &diffNDVI-threshold211 &bay0==0 # shrublands-> Non-irrigated crops
257 maptemp[ind]<-211
258
259 writeRaster(ind, Filename="c:/Tixo/c421_c211.tif",format="Griff", overwrite=T)

```

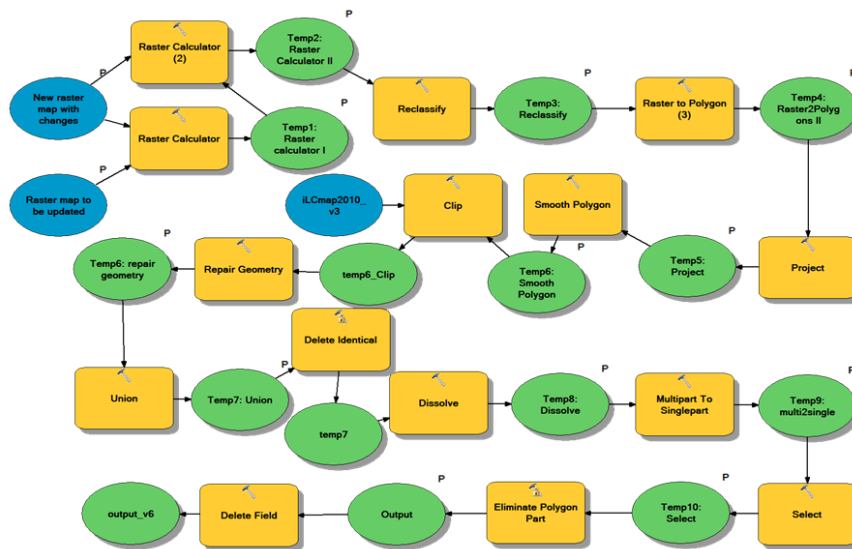


Classificação por regras

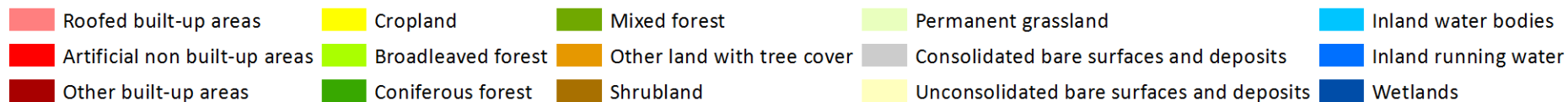
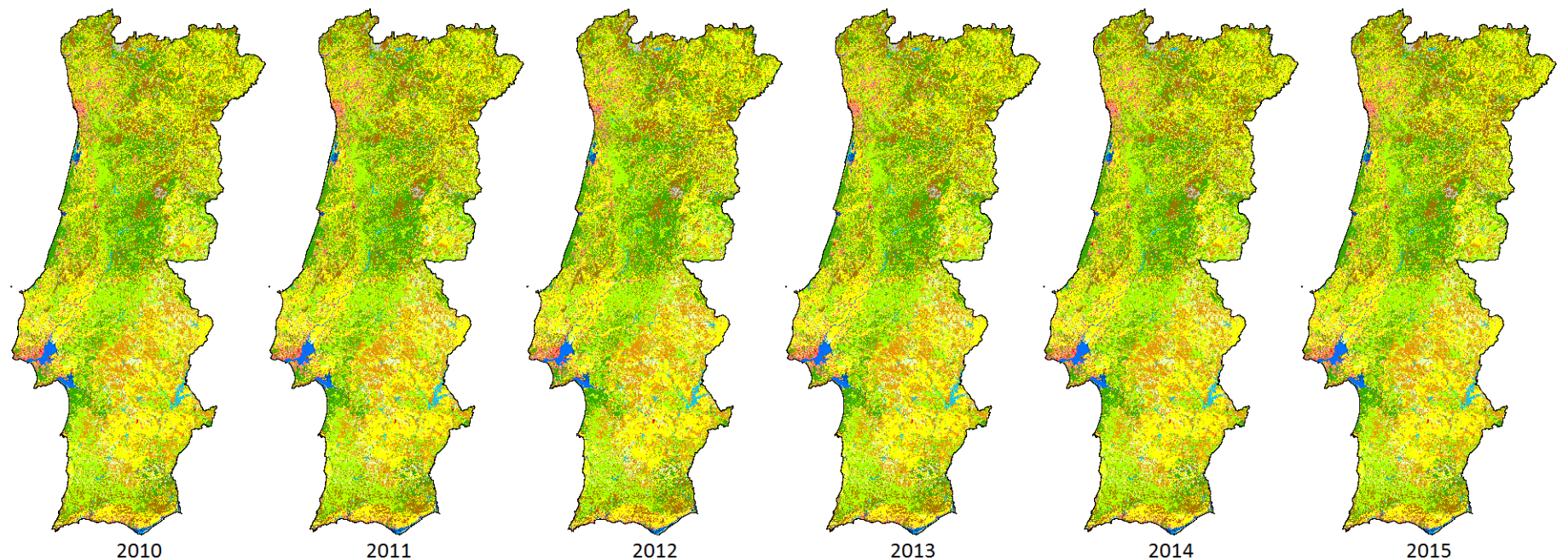
Class	Subclass	Spectral	Rule	Auxiliary data
Roofed built-up areas	Roofed built-up areas		yes	
Artificial non built-up areas	Artificial non built-up areas		yes	
Other built-up areas	Other built-up areas		yes	yes [DGED]
Cropland	Non-irrigated crops	yes	yes	yes [IFAP]
	Irrigated crops	Yes	yes	yes [IFAP]
	Rice fields		yes	
	Vineyards		yes	yes [IFAP]
	Fruit trees		yes	yes [IFAP]
	Olive groves		yes	yes [IFAP]
	Complex cultivation patterns			
Broadleaved forest	Broadleaved forest	yes	yes	
	Clear cuts		yes	yes [ICNF]
	Burnt		yes	
Coniferous forest	Coniferous forest	yes	yes	
	Clear		yes	yes [ICNF]
	Burnt		yes	
Mixed forest	Mixed forest	yes	yes	
	Clear cuts		yes	yes [ICNF]
	Burnt		yes	
Other land with tree cover	Other land with tree cover			
Shrubland	Shrubland	yes	yes	
	Burnt shrubland		yes	yes [ICNF]
Permanent grassland	Permanent grassland	yes	yes	
	Burnt grassland		yes	yes [ICNF]
Consolidated bare surfaces and deposits	Mineral extraction sites	yes	yes	yes [DGED]
	Bare rock	yes	yes	
Unconsolidated bare surfaces and deposits	Beaches, dunes and sand	yes	yes	
	Bare soil	Yes	yes	
Inland water bodies	Inland water bodies	yes	yes	yes [IFAP]
Inland running water	Inland running water			
Wetlands	Wetlands			

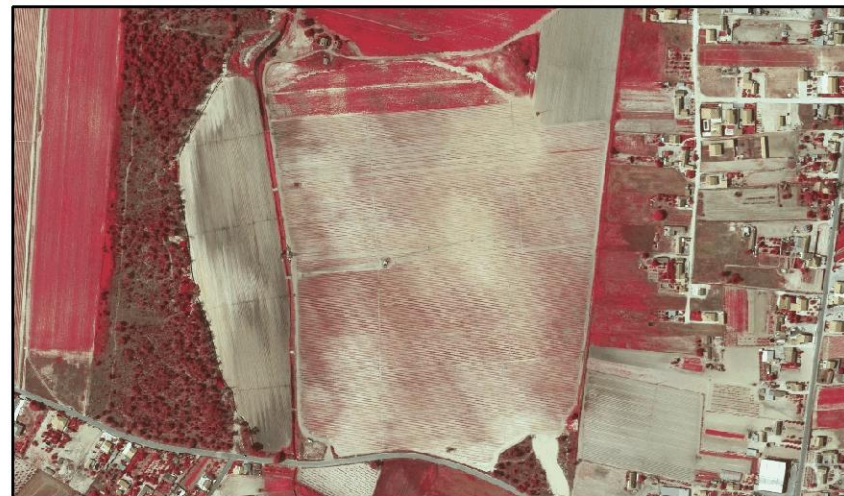
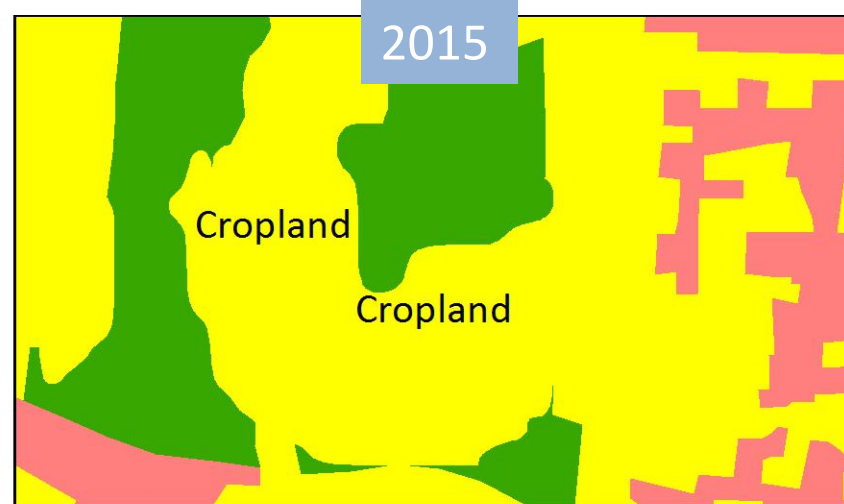
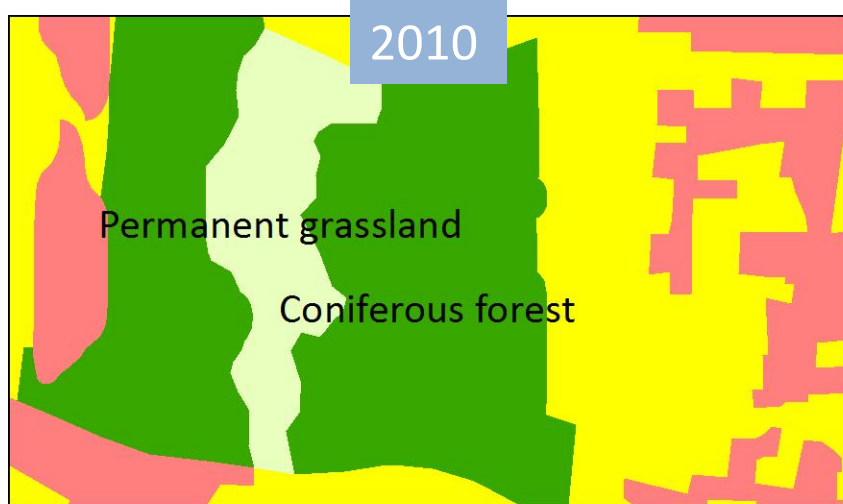
Generalização / actualização dos mapas

- Vectorização das alterações
- Actualização do mapas com as alterações
- Generalização cartográfica das alterações superiores a 1 hectare (UMC)



Resultados





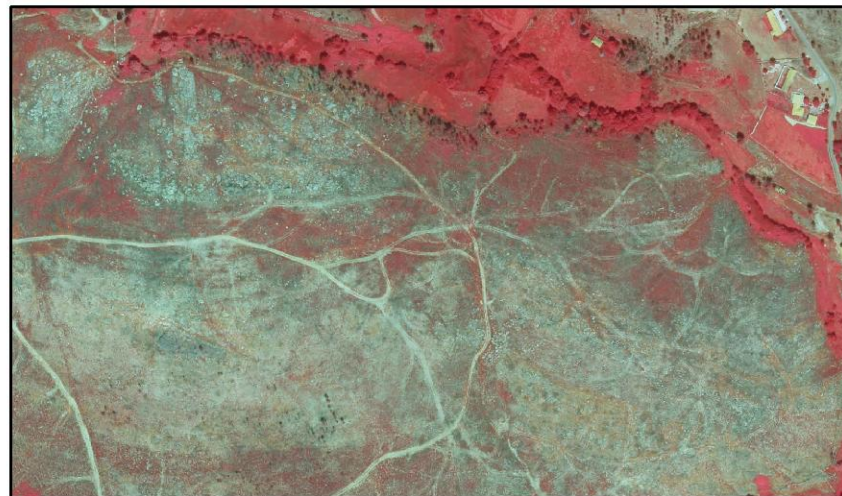
2010

Coniferous forest



2012

Shrubland



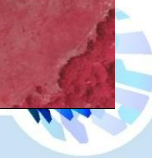
2010

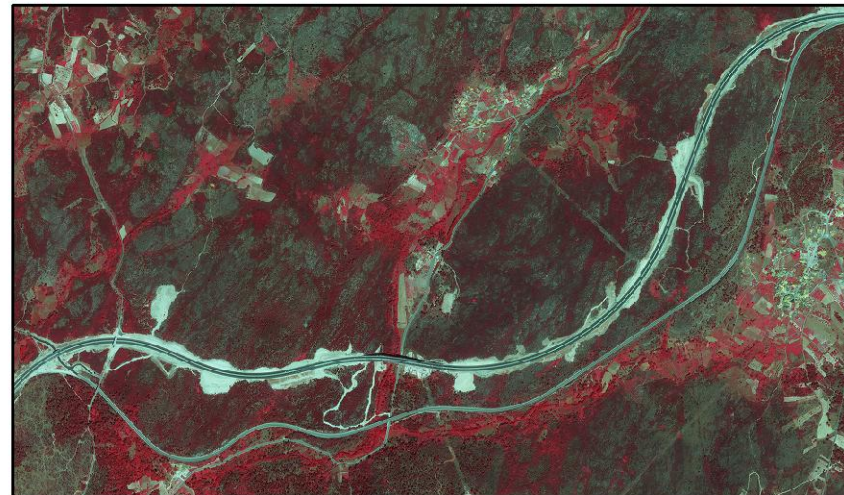
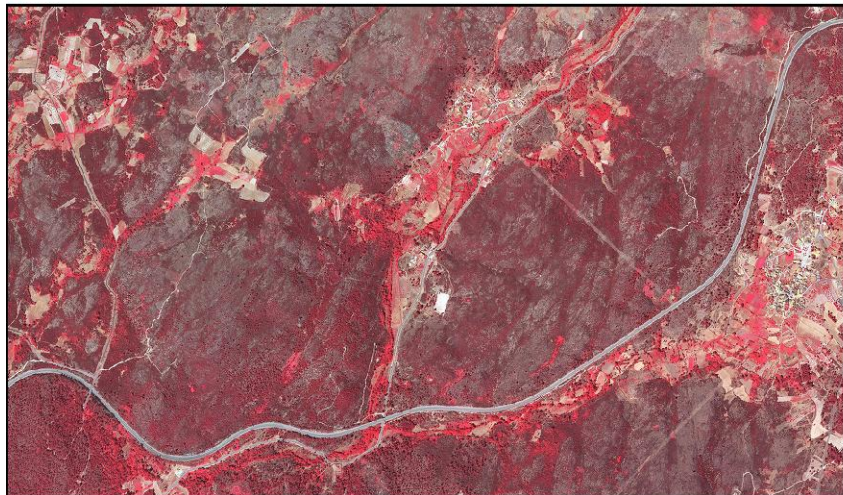
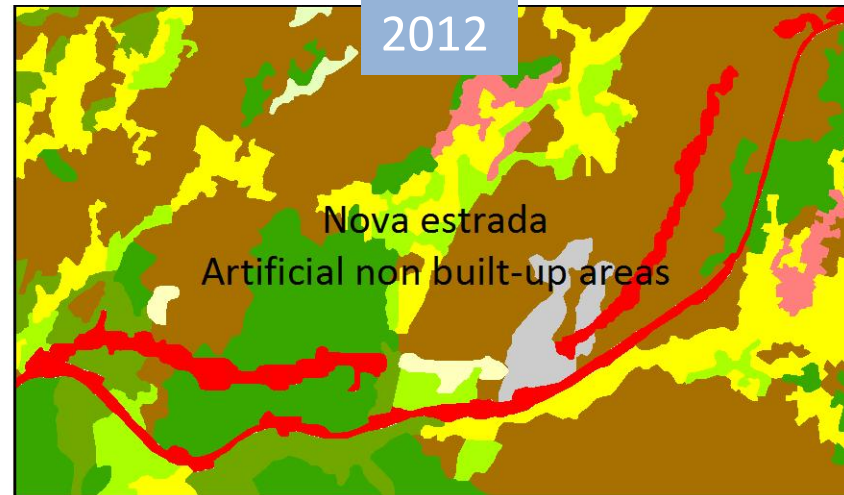
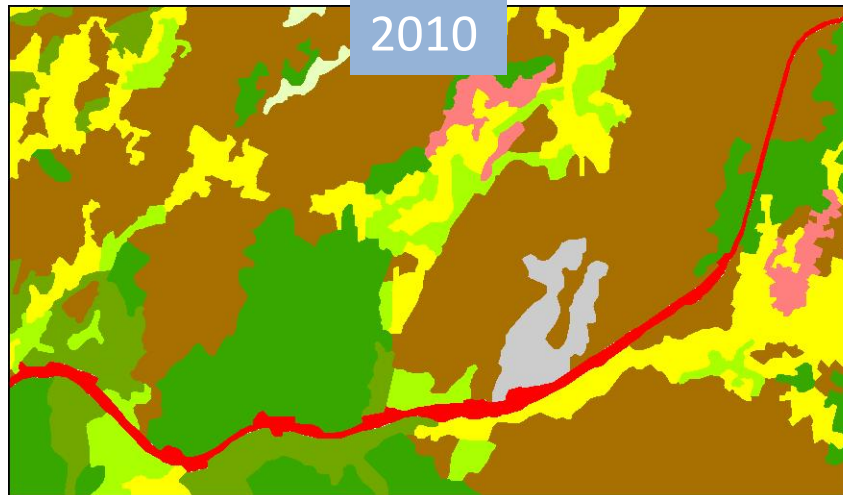
Cropland



2015

Roofed build-up area





Avaliação da exactidão temática

- Amostragem aleatória estratificada (100 pontos por classe)
- Exactidão global
- Exactidão por classe de ocupação do solo
 - Exactidão do produtor (erro de omissão)
 - Exactidão do utilizador (erro de comissão)

Table 2
Error matrix of estimated area proportions, $\hat{p}_{ij}$ (Fig. 1). Map categories are the rows while the reference categories are the columns.

Class	1	2	...	q	Total
1	$\hat{p}_{11}$	$\hat{p}_{12}$	...	$\hat{p}_{1q}$	$\hat{p}_{1\cdot}$
2	$\hat{p}_{21}$	$\hat{p}_{22}$	...	$\hat{p}_{2q}$	$\hat{p}_{2\cdot}$
...	...	...	...	...	...
q	$\hat{p}_{q1}$	$\hat{p}_{q2}$	...	$\hat{p}_{qq}$	$\hat{p}_{q\cdot}$
Total	$\hat{p}_{\cdot 1}$	$\hat{p}_{\cdot 2}$	...	$\hat{p}_{\cdot q}$	1

$$\hat{p}_{ij} = W_i \frac{n_{ij}}{n_i}$$

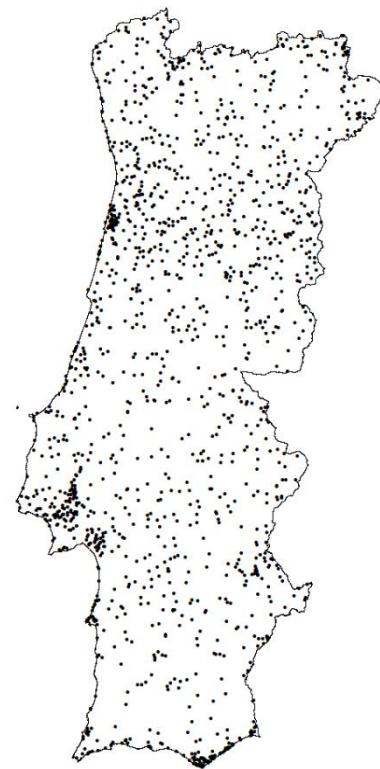
$$\hat{Y} = \sum_{h=1}^H N_h \bar{y}_h / N,$$

$$\hat{U}_i = \frac{\hat{p}_{ii}}{\hat{p}_{i\cdot}}$$

$$\hat{p}_{ij} = \frac{\hat{p}_{ji}}{\hat{p}_{\cdot j}}$$

$$\hat{O} = \sum_{j=1}^q \hat{p}_{ij}$$

$$\hat{R} = \frac{\sum_{h=1}^H N_h^2 \bar{y}_h^2}{\sum_{h=1}^H N_h^2 \bar{y}_h},$$



Making better use of accuracy data in land change studies: Estimating accuracy and area and quantifying uncertainty using stratified estimation

Pontus Olofsson ^{a,*}, Giles M. Foody ^b, Stephen V. Stehman ^c, Curtis E. Woodcock ^a

^a Department of Earth and Environment, Boston University, 675 Commonwealth Avenue, Boston, MA 02215, USA

^b School of Geography, University of Nottingham, University Park, Nottingham NG7 2RD, UK

^c Department of Forest and Natural Resources Management, State University of New York, 1 Forestry Drive, Syracuse, NY 13210, USA

International Journal of Remote Sensing, 2014
Vol. 35, No. 13, 4923–4939, <http://dx.doi.org/10.1080/01431161.2014.930207>



TECHNICAL NOTE

Estimating area and map accuracy for stratified random sampling
when the strata are different from the map classes

Stephen V. Stehman^a

College of Environmental Science & Forestry, State University of New York, Syracuse,
NY 13210, USA

■ Estimativas de área compensadas para os erros temáticos dos mapas

$$\hat{A}_j = A_{tot} \sum_i W_i \frac{n_{ij}}{n_i}$$

$$\hat{Y} = \sum_{k=1}^H N_k^2 \bar{y}_k / N,$$

$$S(\hat{p}_j) = \sqrt{\sum_{i=1}^q W_i^2 \frac{n_i(1-n_i)}{n_i-1}}$$

$$\hat{V}(\hat{Y}) = (1/N^2) \sum_{k=1}^H N_k^2 (1 - n_k/N_k) S_{yk}^2 / n_k^4,$$

$$S(\hat{A}_j) = A_{tot} \times S(\hat{p}_j).$$

$$\hat{A}_j \pm 2 \times S(\hat{A}_j)$$

Table 2
Error matrix of estimated area proportions, $\hat{p}_{ij}$ (Fig. 1). Map categories are the rows while the reference categories are the columns.

Class	1	2	...	q	Total
1	$\hat{p}_{11}$	$\hat{p}_{12}$	...	$\hat{p}_{1q}$	$\hat{p}_{1\cdot}$
2	$\hat{p}_{21}$	$\hat{p}_{22}$	...	$\hat{p}_{2q}$	$\hat{p}_{2\cdot}$
...	...	...	...	...	...
q	$\hat{p}_{q1}$	$\hat{p}_{q2}$	...	$\hat{p}_{qq}$	$\hat{p}_{q\cdot}$
Total	$\hat{p}_{\cdot 1}$	$\hat{p}_{\cdot 2}$	...	$\hat{p}_{\cdot q}$	1

$$\hat{p}_{ij} = W_i \frac{n_{ij}}{n_i}$$

$$\hat{Y} = \sum_{k=1}^H N_k^2 \bar{y}_k / N,$$

$$\hat{U}_i = \frac{\hat{p}_{ii}}{\hat{p}_{i\cdot}}$$

$$\hat{R} = \frac{\sum_{k=1}^H N_k^2 \bar{y}_k}{\sum_{k=1}^H N_k^2 \bar{x}_k},$$

$$\hat{O} = \sum_{j=1}^q \hat{p}_{jj}$$



Contents lists available at SciVerse ScienceDirect

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journal homepage: www.elsevier.com/locate/rse



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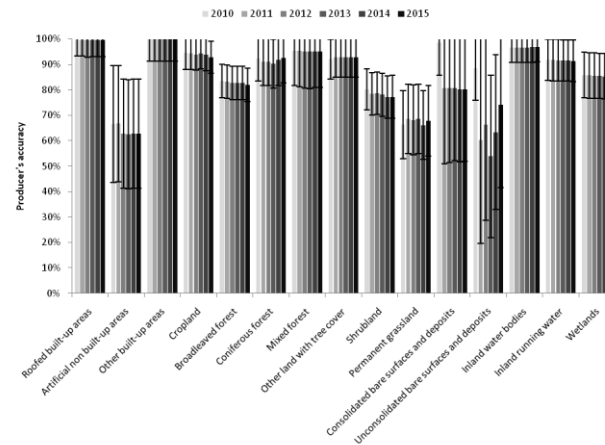
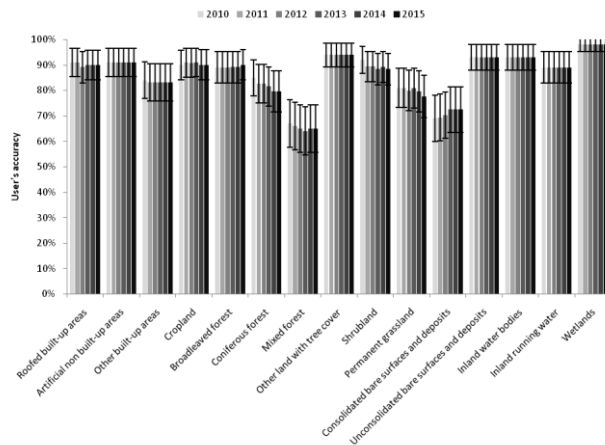
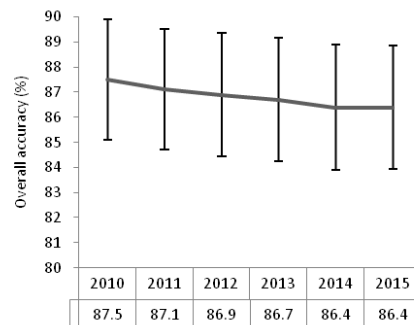
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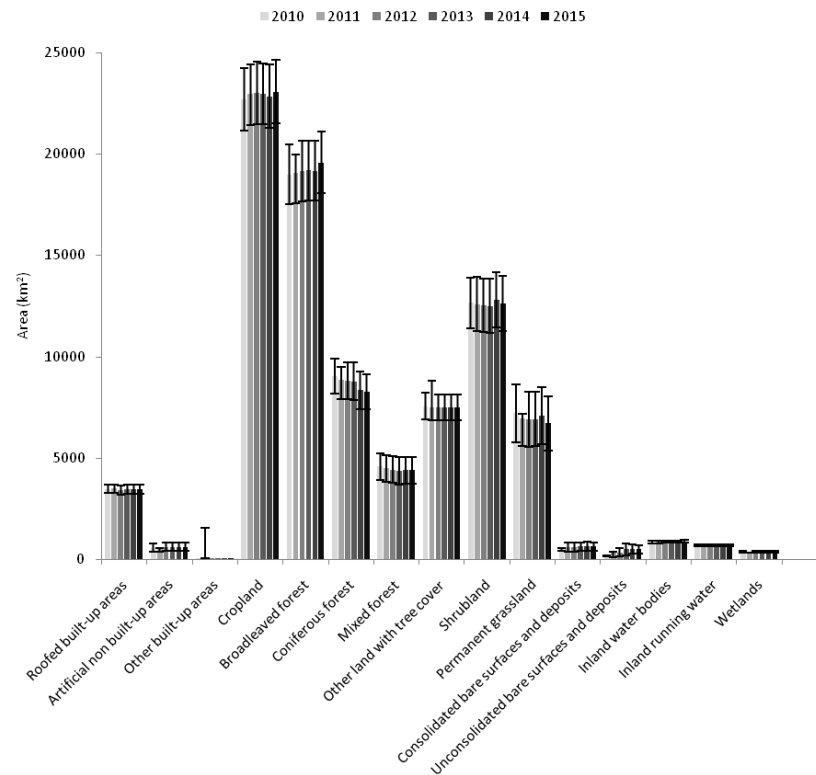
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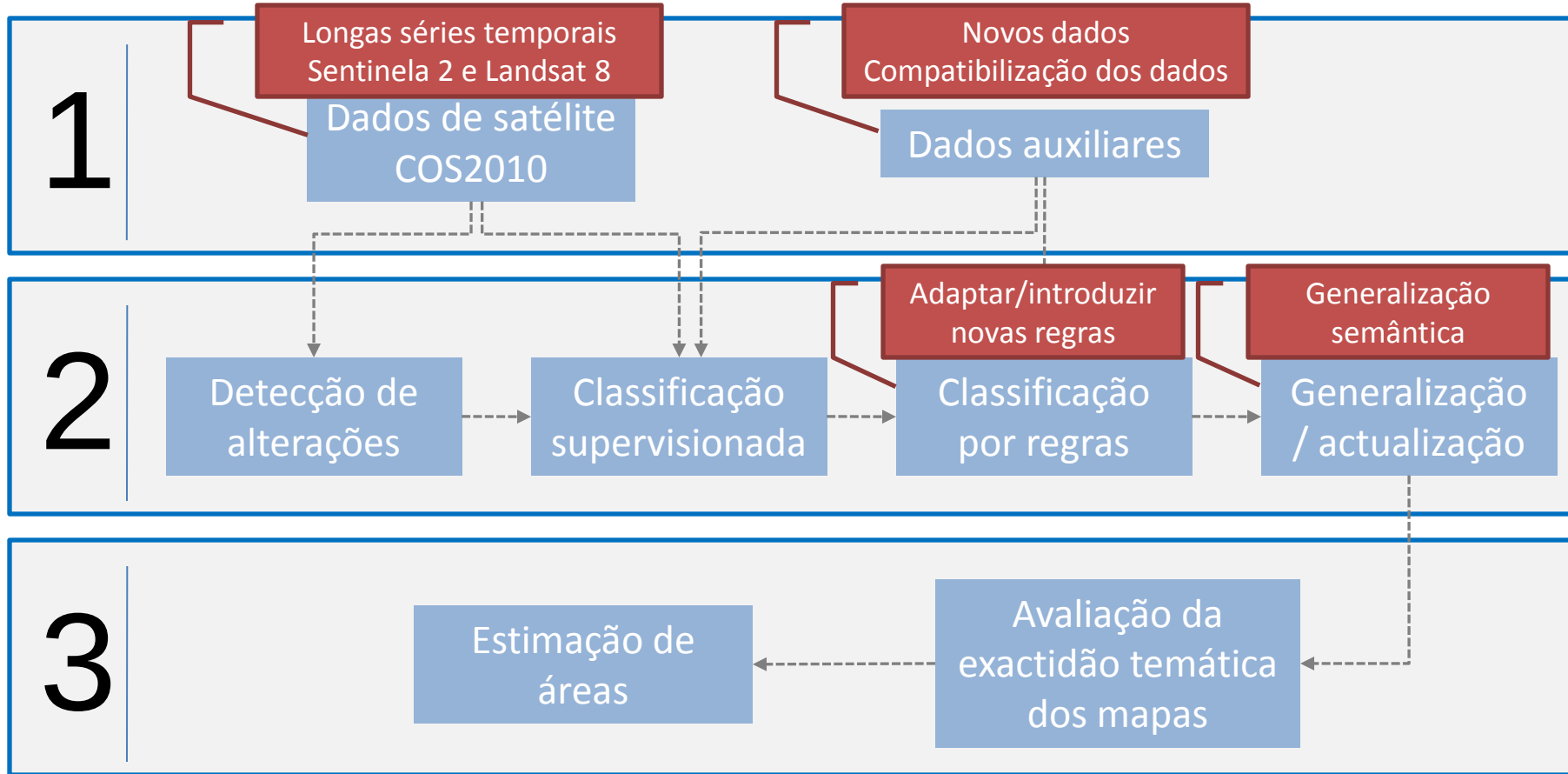
Avaliação da exactidão temática



Estimação de áreas



Evolução da metodologia



LCLU-STATS

Provision of harmonised land cover/land use information: LUCAS and national systems

hcosta@dgterritorio.pt

francisco.vala@ine.pt

fmarcelino@dgterritorio.pt

mario.caetano@dgterritorio.pt



INSTITUTO NACIONAL DE ESTATÍSTICA
STATISTICS PORTUGAL

