

GEO4D 1

Digital mapping using LiDAR data

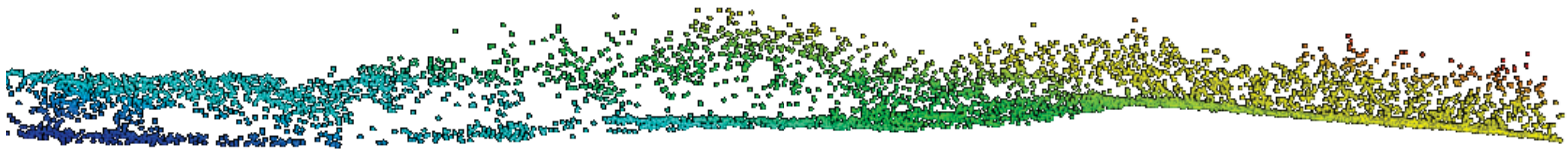
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Ponferrada, León



P4 Model validation

STEPS



FROM THE METHOD
POINT OF VIEW (FILTERING)



FROM THE MODEL
POINT OF VIEW



SUMMARY OF PRACTICAL #4 (I)



FROM THE METHOD
POINT OF VIEW (FILTERING)



RANDOM SAMPLES IN THE
STUDY AREA



GROUND POINTS
(BareEarth.las)



▲ Ground ● Object



0% **OMISSION ERROR:**
ALL THE GROUND SAMPLES ARE IN
THE BareEarth.las FILE

0% **COMMISSION ERROR:**
NONE OF THE OBJECT SAMPLES
ARE IN THE BareEarth.las FILE

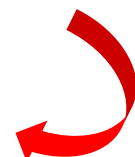
FILES WITH THE SAMPLES (points):

GROUND SAMPLES: C:\...\GEO4D\Data\CP\Method\Method_gp.txt

OBJECT SAMPLES: C:\...\GEO4D\Data\CP\Method\Method_ngp.txt

FILE TO VALIDATE (checking area) (created by using *polyclipdata.exe* in order to reduce the processing time):

BARE EARTH: C:\...\GEO4D\Results\06_CheckingArea\BE_subset.txt





COMPARISON



LET'S COMPARE

BE_subset.txt

METHOD_gp.txt

METHOD_ngp.txt

Type I Error
(OMISSION ERROR)

Type II ERROR
(COMMISSION ERROR)

$$Type I = \frac{a}{a + b}$$

$$Type II = \frac{c}{c + d}$$

a – # ground points well classified (filtered) as ground points (they are in the BE_subset.txt)

b – # ground points filtered out as objects (they are not in BE_subset.txt)

c – # object points misclassified as ground (they are in the BE_subset.txt)

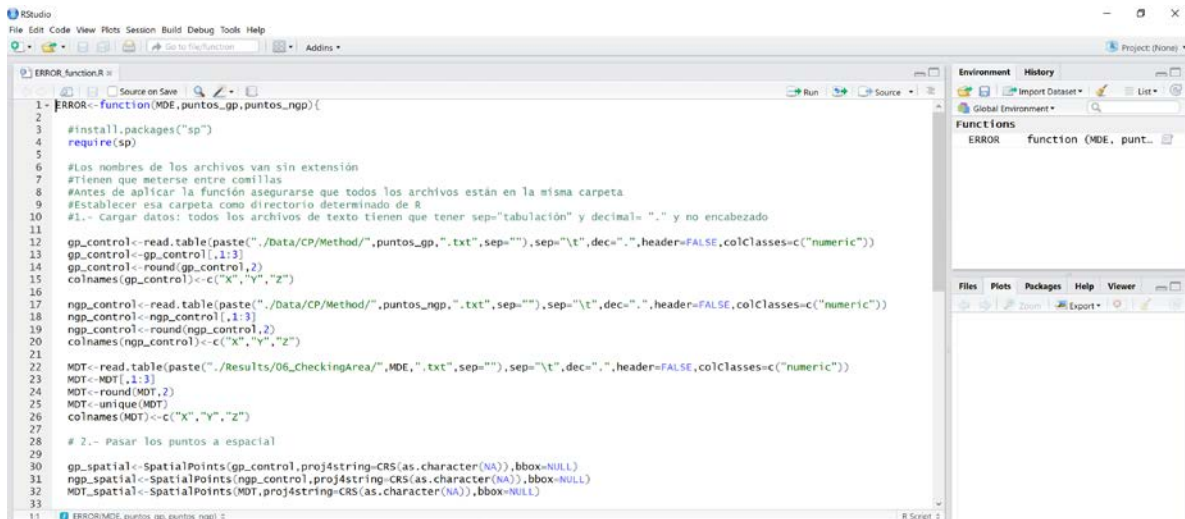
d – # object points well classified (they are not in the BE_subset.txt)

IMPORTANT:

1. The three *.txt files that we are going to use have to: use the TAB as separator, use the point (.) to separate the decimals, **NOT have a header for the fields**. Tip: use Notepad++ to check it.

STEPS TO FOLLOW:

1. Open C:\...\GEO4D\Tools
2. Double click in "method_validation_V5.R"
3. Set the working directory: "C:/.../GEO4D/"
4. Select all the lines in the script and run them
5. The script "method_validation_V5.R" has called the ERROR function. You can check the function in C:\...\GEO4D\Tools\



The screenshot shows the RStudio interface. The main editor window displays the source code for the `ERROR` function. The code includes comments in Spanish and R commands for reading data files, rounding values, and creating spatial points. The Environment pane on the right shows the function `ERROR` loaded from the file `function (MDE, punt...`.

```
1 - ERROR<-function(MDE,puntos_gp,puntos_ngp){
2
3   #install.packages("sp")
4   require(sp)
5
6   #Los nombres de los archivos van sin extensión
7   #Tienen que meterse entre comillas
8   #Antes de aplicar la función asegurarse que todos los archivos están en la misma carpeta
9   #Establecer esa carpeta como directorio determinado de R
10  #1.- Cargar datos: todos los archivos de texto tienen que tener sep="tabulación" y decimal= "." y no encabezado
11
12  gp_control<-read.table(paste("../Data/CP/Method/",puntos_gp,".txt",sep=""),sep="\t",dec=".",header=FALSE,colClasses=c("numeric"))
13  gp_control<-gp_control[,1:3]
14  gp_control<-round(gp_control,2)
15  colnames(gp_control)<-c("X","Y","Z")
16
17  ngp_control<-read.table(paste("../Data/CP/Method/",puntos_ngp,".txt",sep=""),sep="\t",dec=".",header=FALSE,colClasses=c("numeric"))
18  ngp_control<-ngp_control[,1:3]
19  ngp_control<-round(ngp_control,2)
20  colnames(ngp_control)<-c("X","Y","Z")
21
22  MDT<-read.table(paste("../Results/06_CheckingArea/",MDE,".txt",sep=""),sep="\t",dec=".",header=FALSE,colClasses=c("numeric"))
23  MDT<-MDT[,1:3]
24  MDT<-round(MDT,2)
25  MDT<-unique(MDT)
26  colnames(MDT)<-c("X","Y","Z")
27
28  # 2.- Pasar los puntos a espacial
29
30  gp_spatial<-SpatialPoints(gp_control,proj4string=CRS(as.character(NA)),bbox=NULL)
31  ngp_spatial<-SpatialPoints(ngp_control,proj4string=CRS(as.character(NA)),bbox=NULL)
32  MDT_spatial<-SpatialPoints(MDT,proj4string=CRS(as.character(NA)),bbox=NULL)
33
34 }
```

6. You will get the results of the validation on the console and in a file (Resultados.txt): GEO4D\Results\06_Validation\01_Method\results.txt

WHAT IS THE MAGNITUDE OF THE ERRORS?



OMISSION

COMMISSION

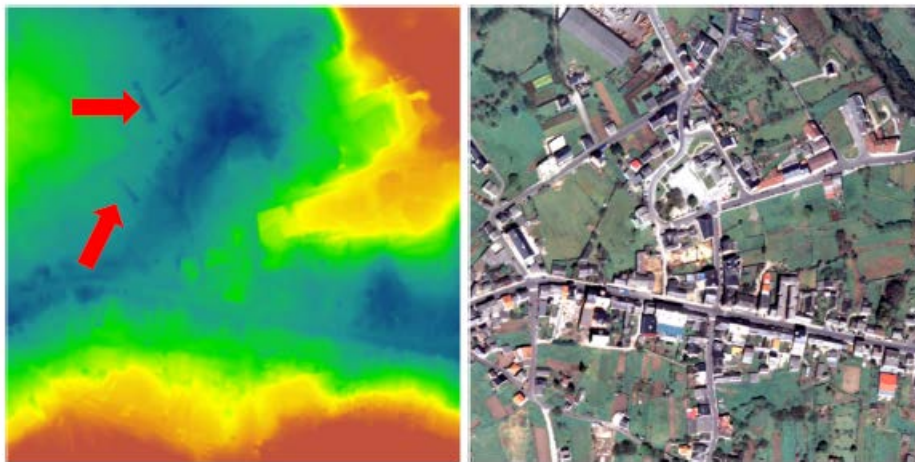
IS THE FILTERING ALGORITHM WORKING PROPERLY?



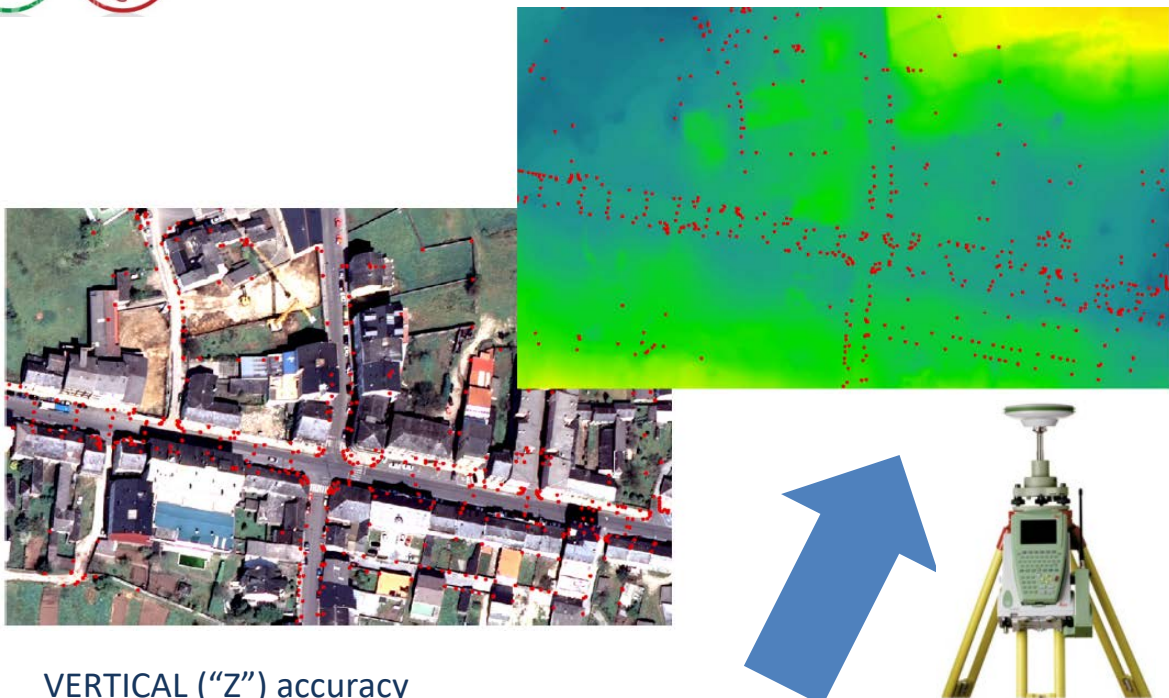
FROM THE MODEL POINT OF VIEW

HOW GOOD (ACCURATE) IS OUR DEM?

OPTION 1: VISUAL INSPECTION



OPTION 2: EXTERNAL SAMPLE



VERTICAL ("Z") accuracy

X,Y,Z data measured with TOTAL STATION, GPS

Precision of the sample: at least 3 times > LiDAR data precision

NEVER use LiDAR data to validate



FROM THE MODEL POINT OF VIEW

HOW GOOD (ACCURATE) IS OUR DEM?

ROBUST ESTIMATORS (the errors do not have to follow a normal distribution)

Accuracy measure	Error type	Notational expression
Median (50% quantile)	Δh	$\hat{Q}_{\Delta h}(0.5) = m_{\Delta h}$
Normalized median absolute deviation	Δh	$\text{NMAD} = 1.4826 \cdot \text{median}_j (\Delta h_j - m_{\Delta h})$
68.3% quantile	$ \Delta h $	$\hat{Q}_{ \Delta h }(0.683)$
95% quantile	$ \Delta h $	$\hat{Q}_{ \Delta h }(0.95)$

Höle, J. & Höle, M. (2009). Accuracy assessment of digital elevation models by means of robust statistical methods. *ISPRS Journal of Photogrammetry and Remote Sensing*, 64, pp. 394-406.

OTHER INTERNATIONAL STANDARDS (not robust):

Root mean square error	$\hat{\text{RMSE}} = \sqrt{\frac{1}{n} \sum_{i=1}^n \Delta h_i^2}$
Mean error	$\hat{\mu} = \frac{1}{n} \sum_{i=1}^n \Delta h_i$
Standard deviation	$\hat{\sigma} = \sqrt{\frac{1}{(n-1)} \sum_{i=1}^n (\Delta h_i - \hat{\mu})^2}$

$$\text{Precision}_z = 1.96 \cdot \text{RMSE}_z$$

HOW DOES **LAND COVER** AFFECT THE QUALITY OF THE DEM?

HOW DOES **SLOPE** AFFECT THE QUALITY OF THE DEM?

HOW DOES THE **INTERPOLATION ALGORITHM** AFFECT THE QUALITY OF THE DEM?

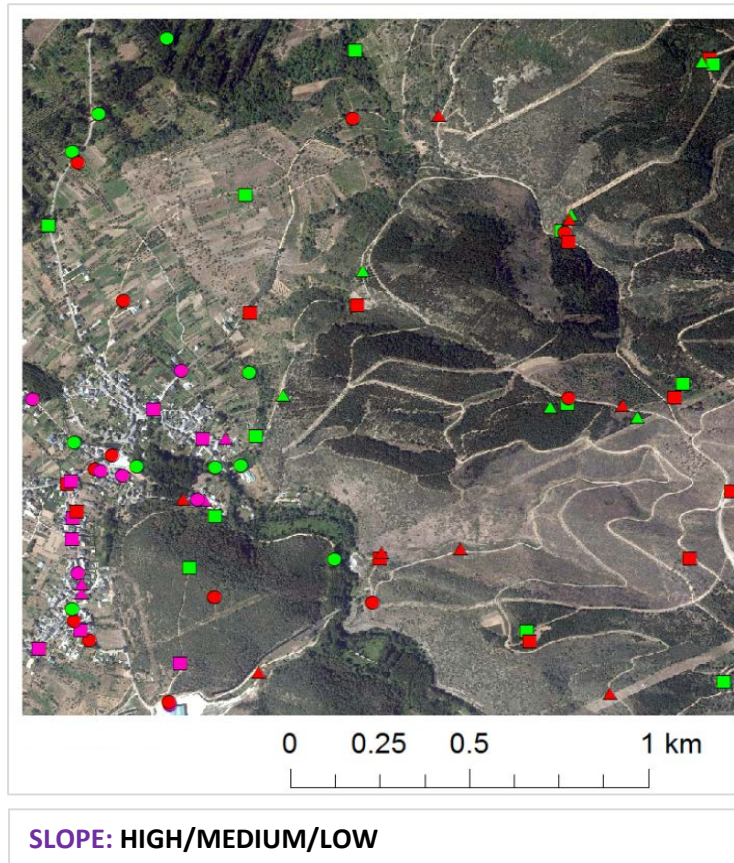
HOW DOES THE **FILTERING METHOD** AFFECT THE QUALITY OF THE DEM?

HOW DOES THE **OUTLIER REMOVAL** AFFECT THE QUALITY OF THE DEM?



FROM THE MODEL POINT OF VIEW

SAMPLES



FILES WITH THE SAMPLES (points):

D:\...\GEO4D\Data\CP\Model

ONE FILE WITH ALL THE SAMPLES: CP_MODEL.txt

3 FILES WITH THE POINTS CLASSIFIED BY SLOPE

FILES TO VALIDATE (DEM) (*.TIF)



MDE from GroundFilter: C:\...\GEO4D\Results\06_CheckingArea\DEM_GS.tif

MDE from TinSurface: C:\...\GEO4D\Results\06_CheckingArea\DEM_TS.tif

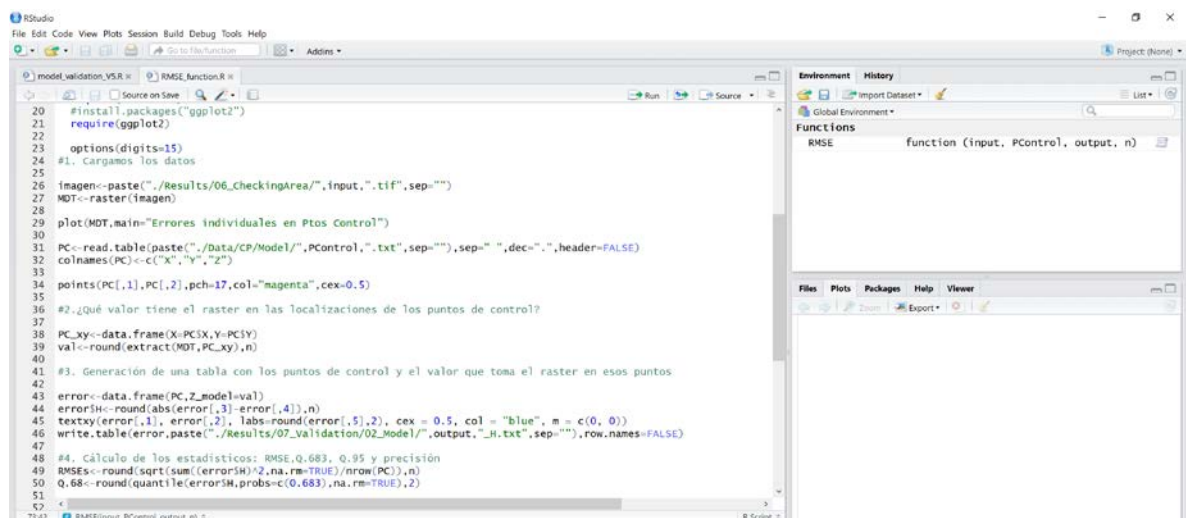
MDE from IDW (GIS): C:\...\GEO4D\Results\06_CheckingArea\DEM_IDW.tif

R SCRIPT TO USE: C:\...\GEO4D\Tools\model_validation_V5

STEPS TO FOLLOW:

1. Open C:\...\GEO4D\Tools
2. Double click in "method_validation_V5.R"
3. Set the working directory: "C:/.../GEO4D/"
4. Select all the lines in the script and run them

5. The script "method_validation_V5.R" has called the ERROR function. You can check the function in C:\...\GEO4D\Tools\



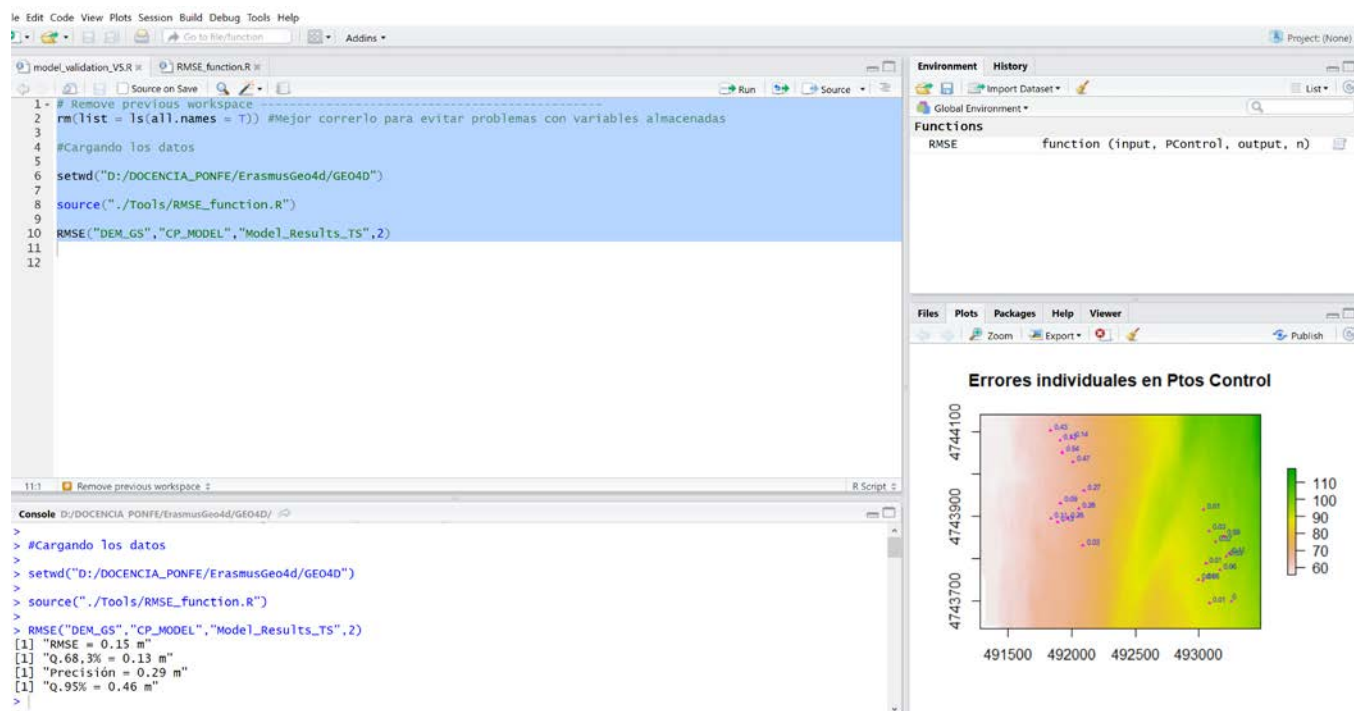
The screenshot displays the RStudio interface. The main editor window shows the script 'method_validation_V5.R' with the following code:

```
20 #install.packages("ggplot2")
21 require(ggplot2)
22
23 options(digits=15)
24 #1. Cargamos los datos
25
26 imagen<-paste("../Results/06_CheckingArea/",input, ".tif", sep="")
27 MDT<-raster(imagen)
28
29 plot(MDT,main="Errores individuales en Ptos Control")
30
31 PC<-read.table(paste("../Data/CP/Model/",PCcontrol, ".txt", sep=""), sep=" ", dec=".", header=FALSE)
32 colnames(PC)<-c("X", "Y", "Z")
33
34 points(PC[,1],PC[,2],pch=17,col="magenta",cex=0.5)
35
36 #2. ¿Qué valor tiene el raster en las localizaciones de los puntos de control?
37
38 PC_xy<-data.frame(X=PC$X,Y=PC$Y)
39 val<-round(extract(MDT,PC_xy),n)
40
41 #3. Generación de una tabla con los puntos de control y el valor que toma el raster en esos puntos
42
43 error<-data.frame(PC,Z_model=val)
44 error$H<-round(abs(error[,3]-error[,4]),n)
45 textxy(error[,1], error[,2], labs=round(error[,5],2), cex = 0.5, col = "blue", m = c(0, 0))
46 write.table(error,paste("../Results/07_Validation/02_Model/",output, ".H.txt", sep=""), row.names=FALSE)
47
48 #4. Cálculo de los estadísticos: RMSE, Q.683, Q.95 y precisión
49 RMSE<-round(sqrt(sum((error$H)^2,na.rm=TRUE)/nrow(PC)),n)
50 Q.68<-round(quantile(error$H,probs=c(0.683),na.rm=TRUE),2)
51
52
```

The Environment pane on the right shows the 'RMSE' function defined as:

```
function (input, PCcontrol, output, n)
```

6. You will get the results of the validation on the console and in the following directory:
GEO4D\Results\06_Validation\02_Model*.txt



HOW DOES THE INTERPOLATION ALGORITHM AFFECT THE QUALITY OF THE DEM?

	GridSurfaceCreate	TIN	IDW
Precision			
Q95%			

AND THE SLOPE?

	GridSurfaceCreate			TIN			IDW		
	H	M	L	H	M	L	H	M	L
Precision				??	??	??	??	??	??
Q95%				??	??	??	??	??	??



TO KNOW MORE...

Barreiro-Fernández, L., Sandra Buján, David Miranda, Ulises Diéguez-Aranda , Eduardo González-Ferreiro (2016). Accuracy assessment of LiDAR-derived digital elevation models in a rural landscape with complex terrain. *J. Appl. Remote Sens.* 10(1), 016014 (Feb 18, 2016). doi:10.1117/1.JRS.10.016014