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Title: Desarrollo de una interfaz para el cálculo de los niveles de profundidad en cuerpos de agua a través de batimetría (TOLTECA)

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- Ecuación de batimetría

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INTRODUCCIÓN

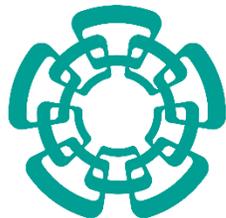
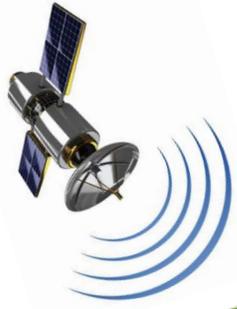
Climate monitoring and disaster prevention using a reconfigurable satellite communication system.



TOLTECA



MOTIVACIÓN



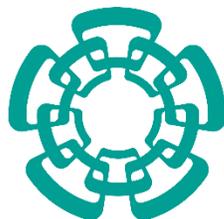
Estado del arte

- **Szilárd Szabó** (2016) realizó el artículo “Specific features of NDVI , NDWI and MNDWI as reflected in land cover categories” [1].
- **Richard P. Stumpf** (2003) realizó el artículo “Determination of water depth with high-resolution satellite imagery over variable bottom types” [2].
- **Najhan Md Said** (2017) realizó el artículo “Satellite-derived bathymetry: accuracy assessment on depths derivation algorithm for shallow water area” [3].
- **Shafiqul Islam Khondoker** (2016) realizó el artículo “Deriving river bathymetry using space borne remote sensing techniques in bangladesh” [4].
- **Rodrigo Martín Edrosa** (2014) realizó la tesis de maestría “Aplicación de la Teledetección para el Monitoreo de Eventos Hídricos Superficiales mediante Imágenes Cosmo SkyMed” [5].



Percepción Remota

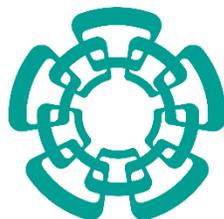
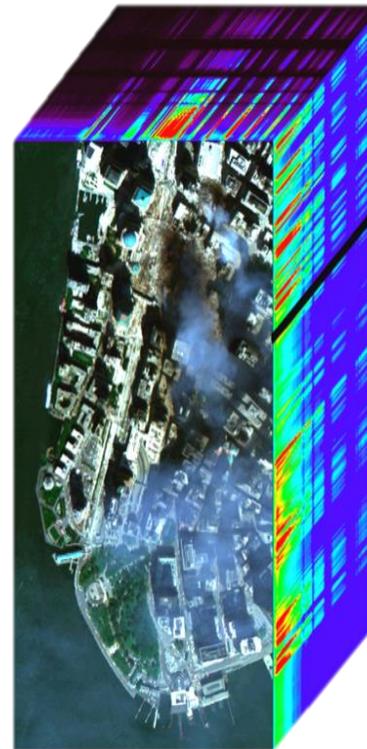
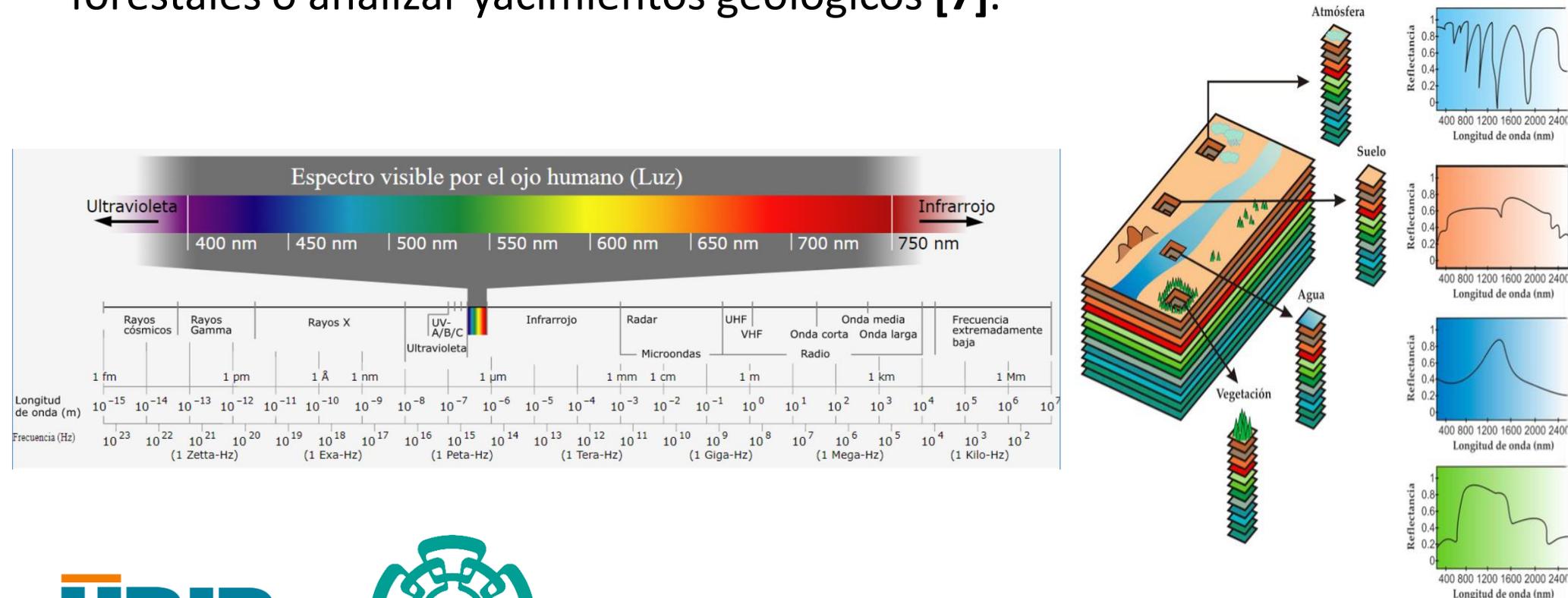
La Percepción Remota (Remote Sensing) o Teledetección puede definirse como la ciencia y arte de obtener información de un objeto analizando los datos adquiridos mediante algún dispositivo que no esta en contacto físico con dicho objeto [6].



Multiespectral

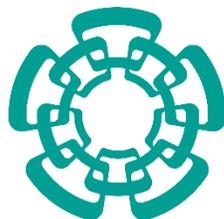
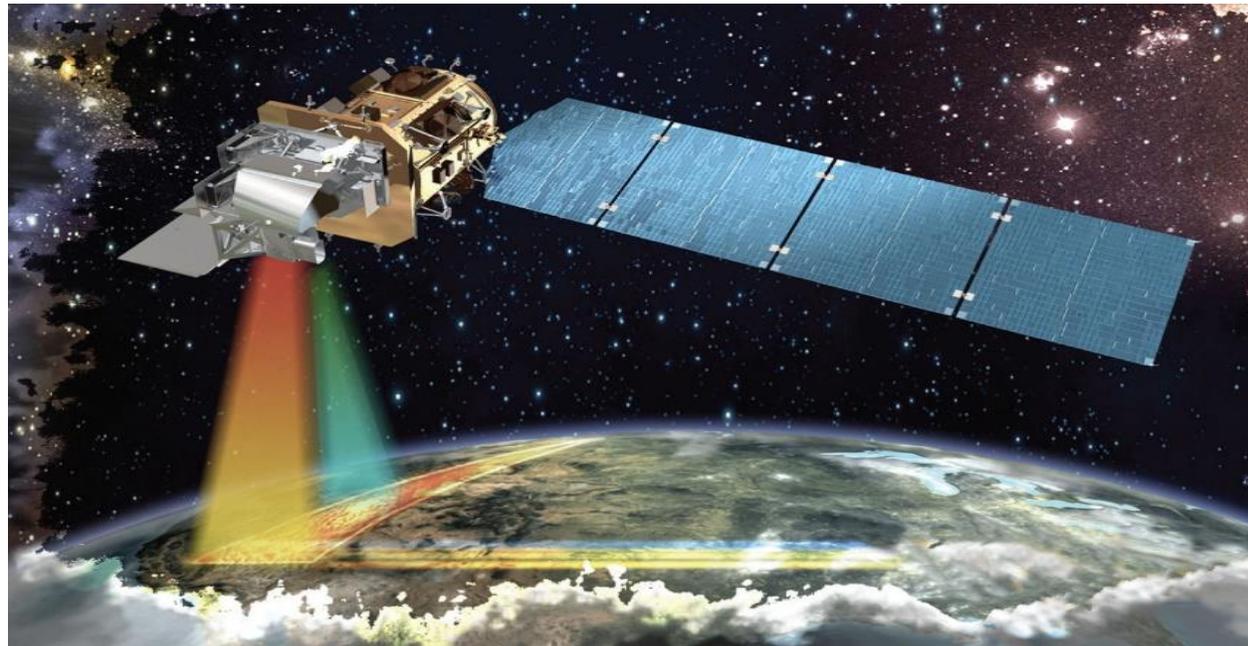
Las imágenes multispectrales nos permiten ver lo que nuestro ojo humano no ve.

Esta cualidad tan especial las convierte en una herramienta muy eficaz para estudiar el cambio climático, detectar agentes contaminantes en aguas, controlar incendios forestales o analizar yacimientos geológicos [7].



Landsat

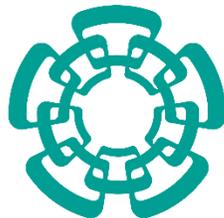
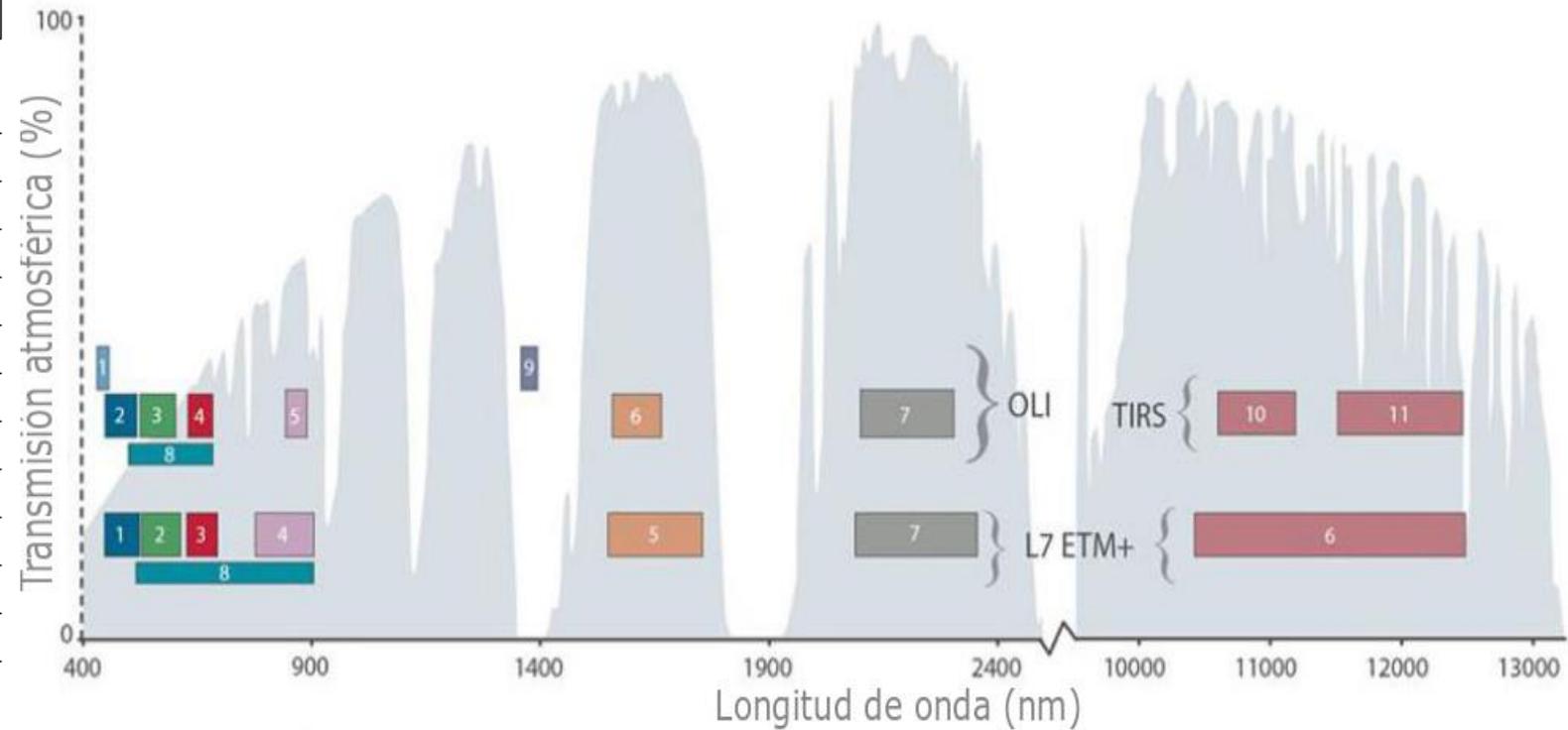
Las imágenes LANDSAT están compuestas por 8 u 11 bandas espectrales, que al combinarse producen una gama de imágenes de color que incrementan notablemente sus aplicaciones. Dependiendo del satélite y el sensor se incluye un canal pancromático y/o uno térmico; asimismo las resoluciones espaciales varían de 15, 30, 60 y 120m [8, 9].



Landsat 8

LANDSAT 8

Bandas	Ancho de Banda (μm)	Resolución
Banda 1 Coastal	0.43 a 0.45	30
Banda 2 Azul	0.45 a 0.51	30
Banda 3 Verde	0.53 a 0.59	30
Banda 4 Rojo	0.64 a 0.67	30
Banda 5 NIR	0.85 a 0.88	30
Banda 6 SWIR1	1.57 a 1.65	30
Banda 7 SWIR2	2.11 a 2.29	30
Banda 8 Pan	0.50 a 0.68	15
Banda 9 Cirrus	1.36 a 1.38	30
Banda 10 TIRS 1	10.6 a 11.19	100
Banda 11 TIR 2	11.5 a 12.51	100



Índices Espectrales

Ciertas combinaciones de m bandas forman índices espectrales físicamente significativos en el espacio espectral definido por las bandas de una imagen multispectrales [10]. Estos índices proporcionan información sobre el comportamiento del suelo, la vegetación y el agua de una escena de la superficie terrestre.

- Normalized Different Water Index

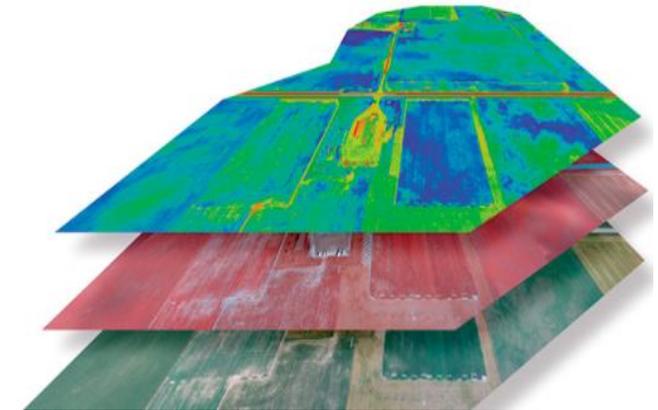
$$NDWI = \frac{G - NIR}{G + NIR} \quad (1)$$

- Normalized Different Vegetation Index

$$NDVI = \frac{NIR - R}{NIR + R} \quad (2)$$

- Normalized Different Snow Index

$$NDSI = \frac{G - SWIR}{G + SWIR} \quad (3)$$

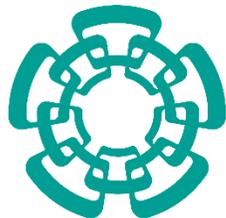
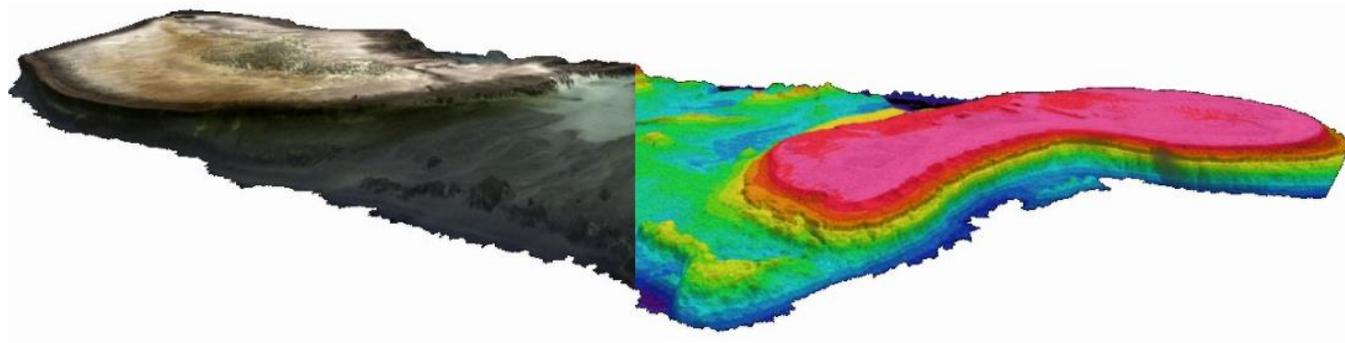


G = Green
R = Red
NIR = Near infrared
SWIR = Short Wavelength Infrared



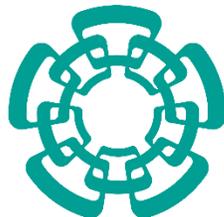
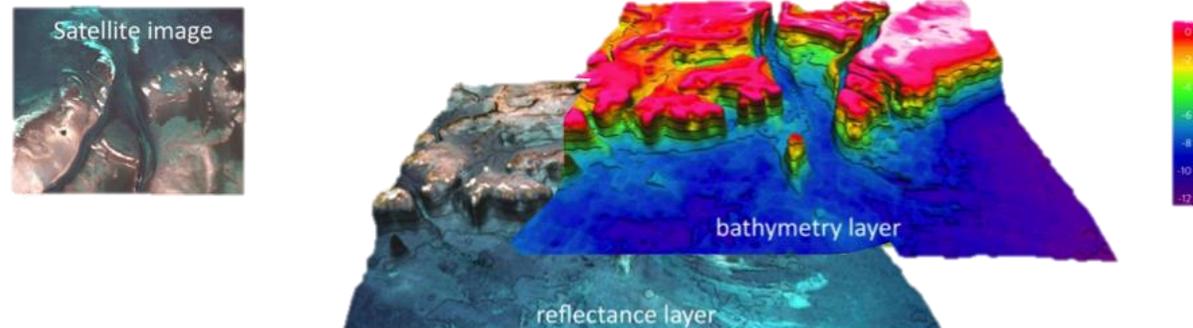
Batimetría

La batimetría es la ciencia para determinar la topografía del lecho marino. Los datos de batimetría se utilizan para generar cartas de navegación, el perfil del fondo marino, la oceanografía biológica, la erosión de las playas, el aumento del nivel del mar, etc **[12]**.



Batimetría derivada del satélite (SDB)

SDB está experimentando una mayor aceptación porque ahora se está convirtiendo en una tecnología operativa y robusta. Su principal ventaja es que ofrece la capacidad de inspeccionar de forma rápida y no intrusiva en zonas remotas, extensas o accesibles con un costo entre 5 y 10 veces menor que la mayoría de los métodos tradicionales [13, 14].



Ecuación de batimetría

Radiancia

$$L\lambda = M_L Q_{cal} + A_L \quad (4)$$

Reflectancia

$$P\lambda = M_P Q_{cal} + A_P \quad (5)$$

$L\lambda$ = Es el valor de radiancia espectral ($\frac{Watts}{m^2 * srad * \mu m}$).

M_L = Es el factor multiplicativo de escalado específico obtenido del metadato.

Q_{cal} = Es el producto estándar cuantificado y calibrado para valores de píxel (DN).

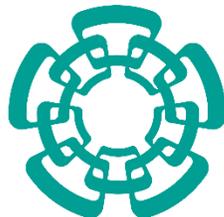
A_L = Es el factor aditivo de escalado específico obtenido del metadato.

$P\lambda$ = Es el valor de reflectancia planetaria.

M_P = Es el factor multiplicativo de escalado específico obtenido del metadato.

Q_{cal} = Es el producto estándar cuantificado y calibrado para valores de píxel (DN).

A_P = Es el factor aditivo de escalado específico obtenido del metadato.



Ecuación de batimetría

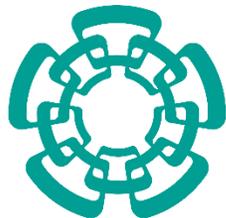
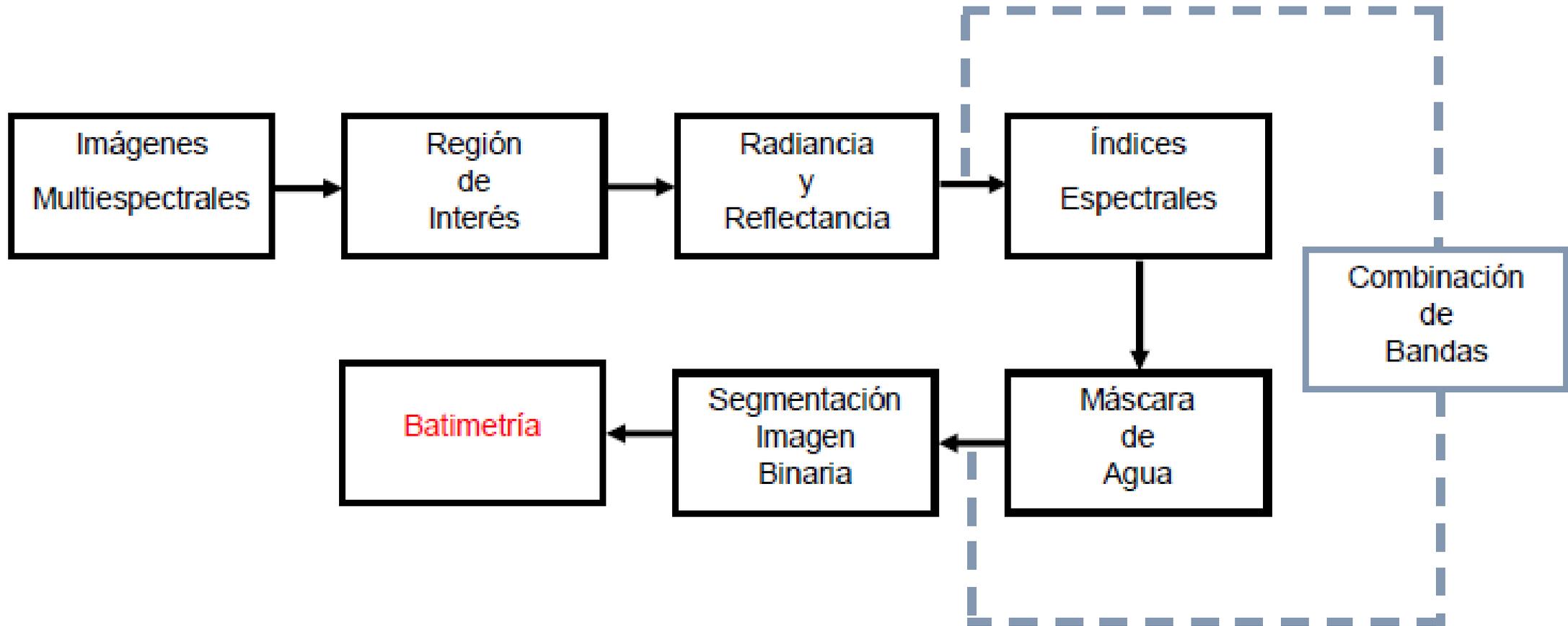
El modelo desarrollado por Stumpf [15] aplica el principio fundamental de que cada banda tiene un nivel diferente de absorción del cuerpo de agua. El diferente nivel de absorción conceptualmente generará la relación entre bandas y esta relación cambiará simultáneamente cuando la profundidad cambie.

$$z = m_1 \left(\frac{\ln(L_{obs}(Banda_{azul}))}{\ln(L_{obs}(Banda_{verde}))} \right) - m_0 \quad (4)$$

z = Batimetría (profundidad en metros).
 m_1, m_0 = son constantes sintonizables para transformar linealmente (es decir, escala y desplazamiento).
 L_{obs} = Bandas de radiancia.



Descripción de implementación



Pruebas y resultados

Interfaz 1: Batimetría Derivada de Satélite

The screenshot displays the 'Satellite Derived Bathymetry (SDB)' software interface. The interface is organized into several functional areas:

- File Management:** An 'Open' button is located at the top left, followed by a 'Name/File' input field.
- Bands Selection:** A 'Bands' section contains six radio button options: 'Band 2 - Blue', 'Band 3 - Green', 'Band 4 - Red', 'Band 5 - NIR', 'Band 6 - SWIR', and 'Band 7 - SWIR2'.
- Pre-View:** A small plot area labeled 'Pre-View' with axes from 0 to 1 and an 'Extend' button.
- Main Plot:** A large central plot area with axes from 0 to 10.
- Normalized Index:** A section with four radio button options: 'NDWI', 'NDVI', 'NDSI', and 'NDXI'.
- Band Combination:** A section with three radio button options: 'True Color', 'False Color', and 'Land / Water'.
- Depth Water:** A section containing a 'Bathymetry' button.
- Information:** A section at the bottom with an 'Information' label and a 'Details' button.
- Process:** A section at the bottom right with a 'Process' label and an empty box.



Satellite Derived Bathymetry (SDB)

Open

C:\Users\Yuriy
Shkvarko\Desktop\File1\LC08_L1TP_
177038_20170226_20170316_01_T1

Bands

- Band 2 - Blue
- Band 3 - Green
- Band 4 - Red
- Band 5 - NIR
- Band 6 - SWIR
- Band 7 - SWIR2

Normalized Index

- NDWI
- NDVI
- NDSI
- NDXI

Band Combination

- True Color
- False Color
- Land / Water

Depth Water

Bathymetry

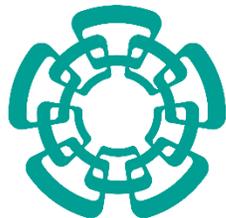
Pre-View

Information

Select the Region of Interest

Process

Ready





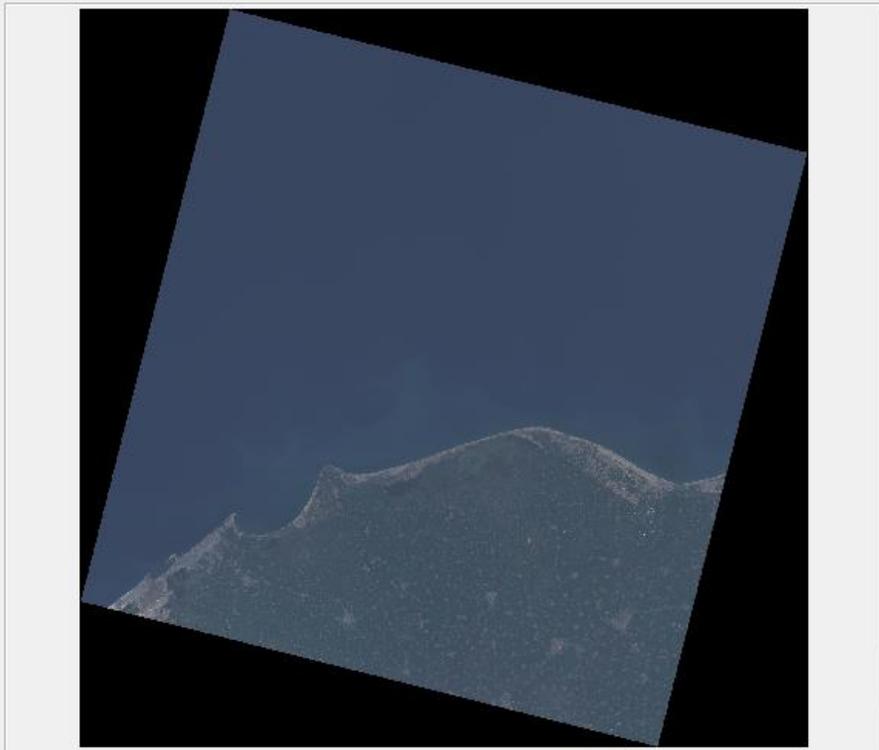
Satellite Derived Bathymetry (SDB)

C:\Users\Yuriy
Shkvarko\Desktop\File1\LC08_L1TP_
177038_20170226_20170316_01_T1

Bands

- Band 2 - Blue
- Band 3 - Green
- Band 4 - Red
- Band 5 - NIR
- Band 6 - SWIR
- Band 7 - SWIR2

Pre-View



Normalized Index

- NDWI
- NDVI
- NDSI
- NDXI

Band Combination

- True Color
- False Color
- Land / Water

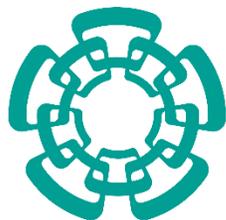
Depth Water

Information

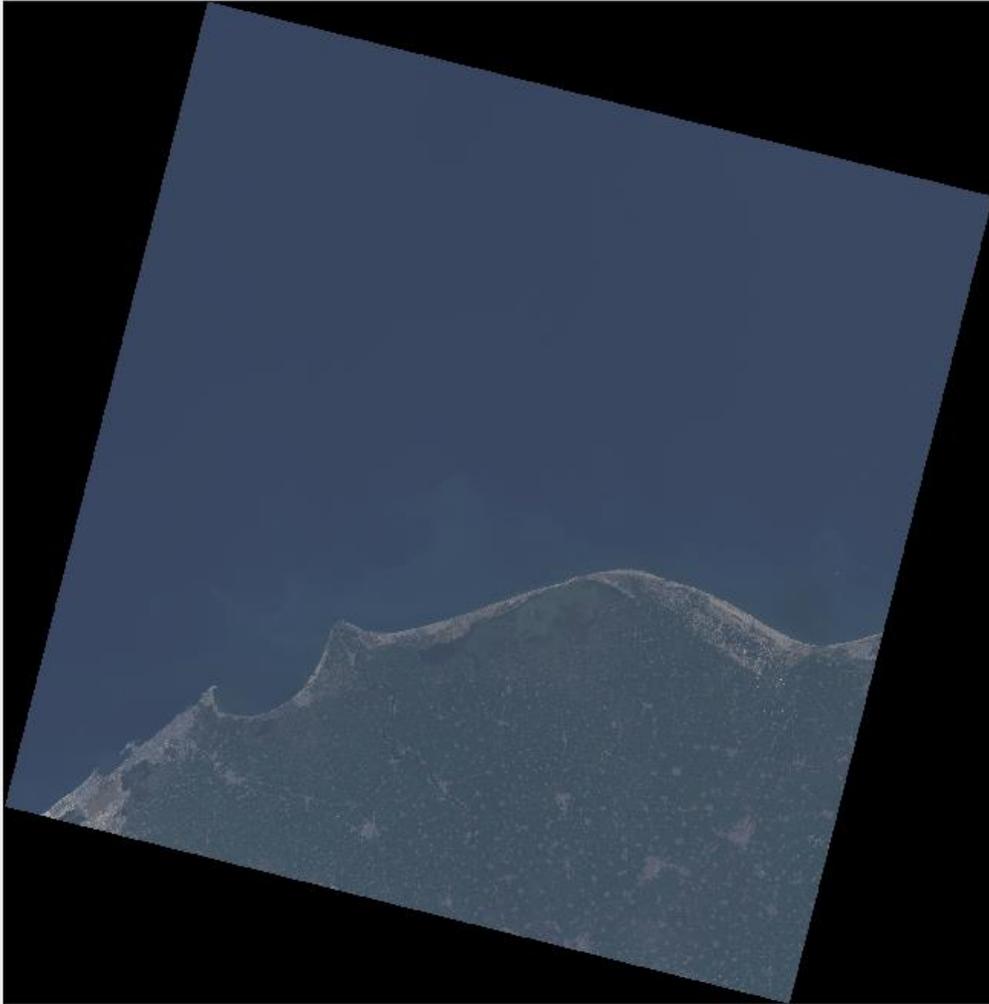
You can Start

Process

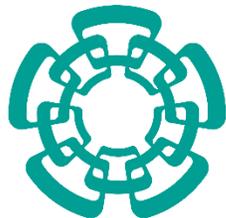
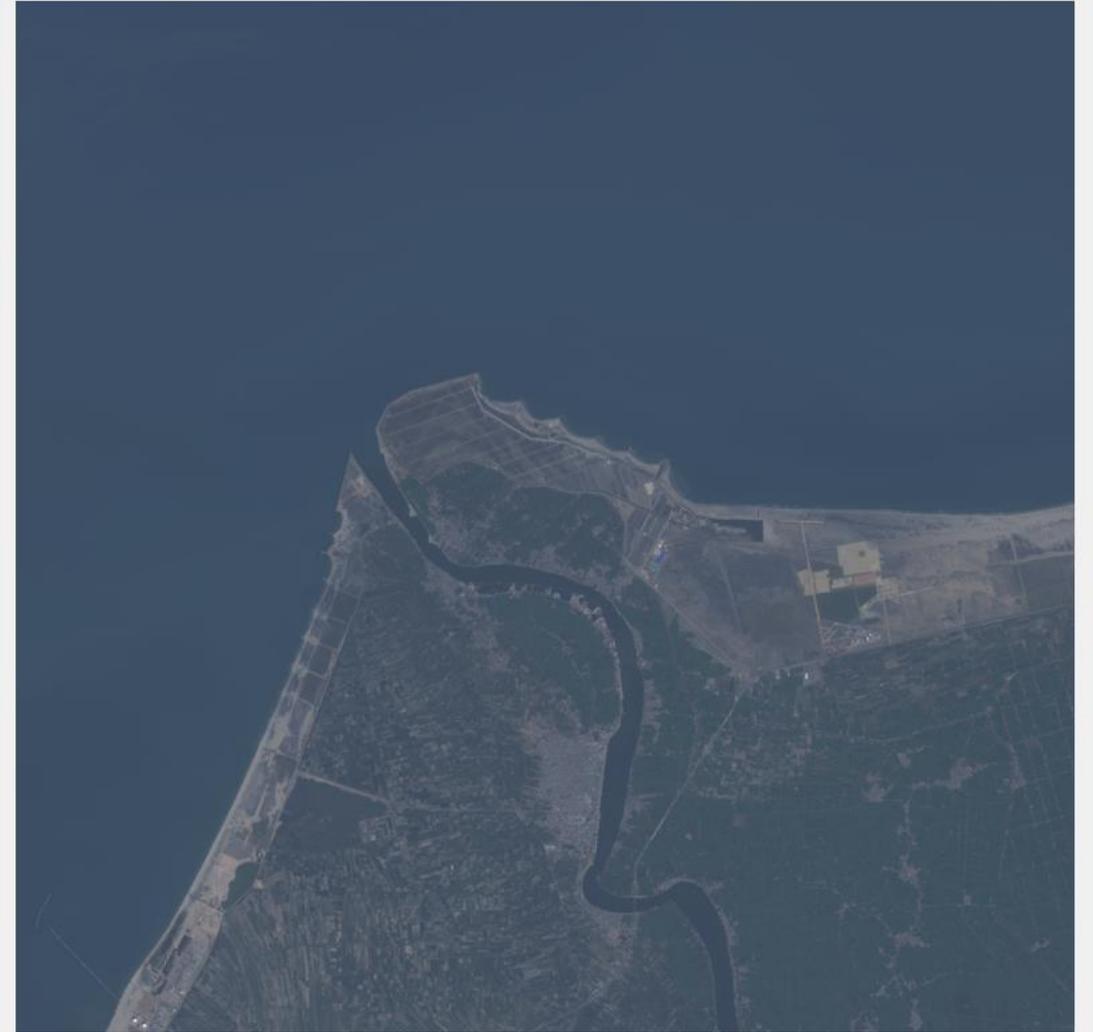
Ready

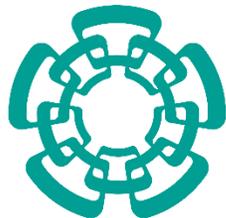
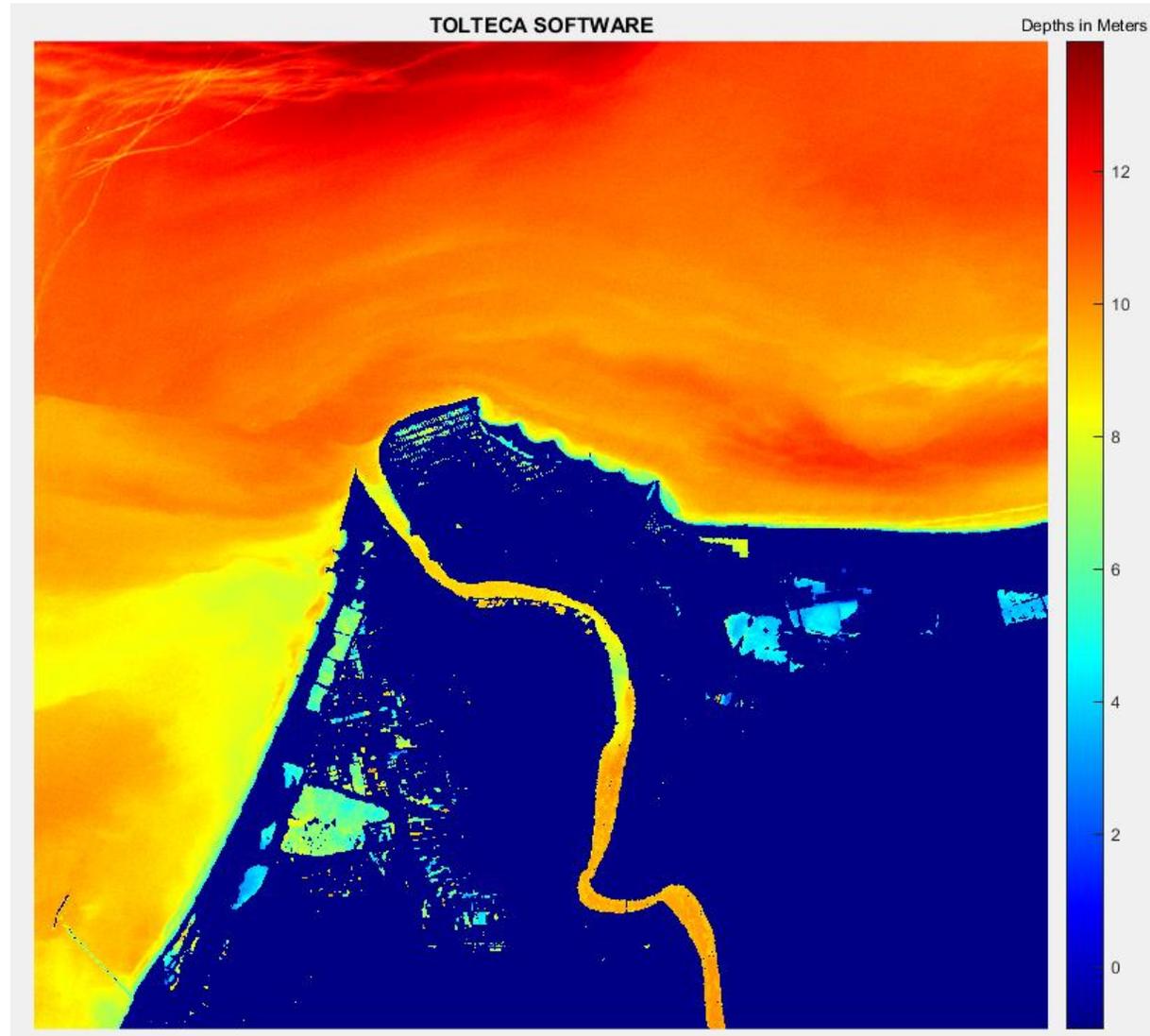


TOLTECA SOFTWARE

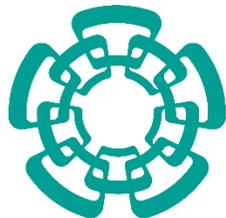
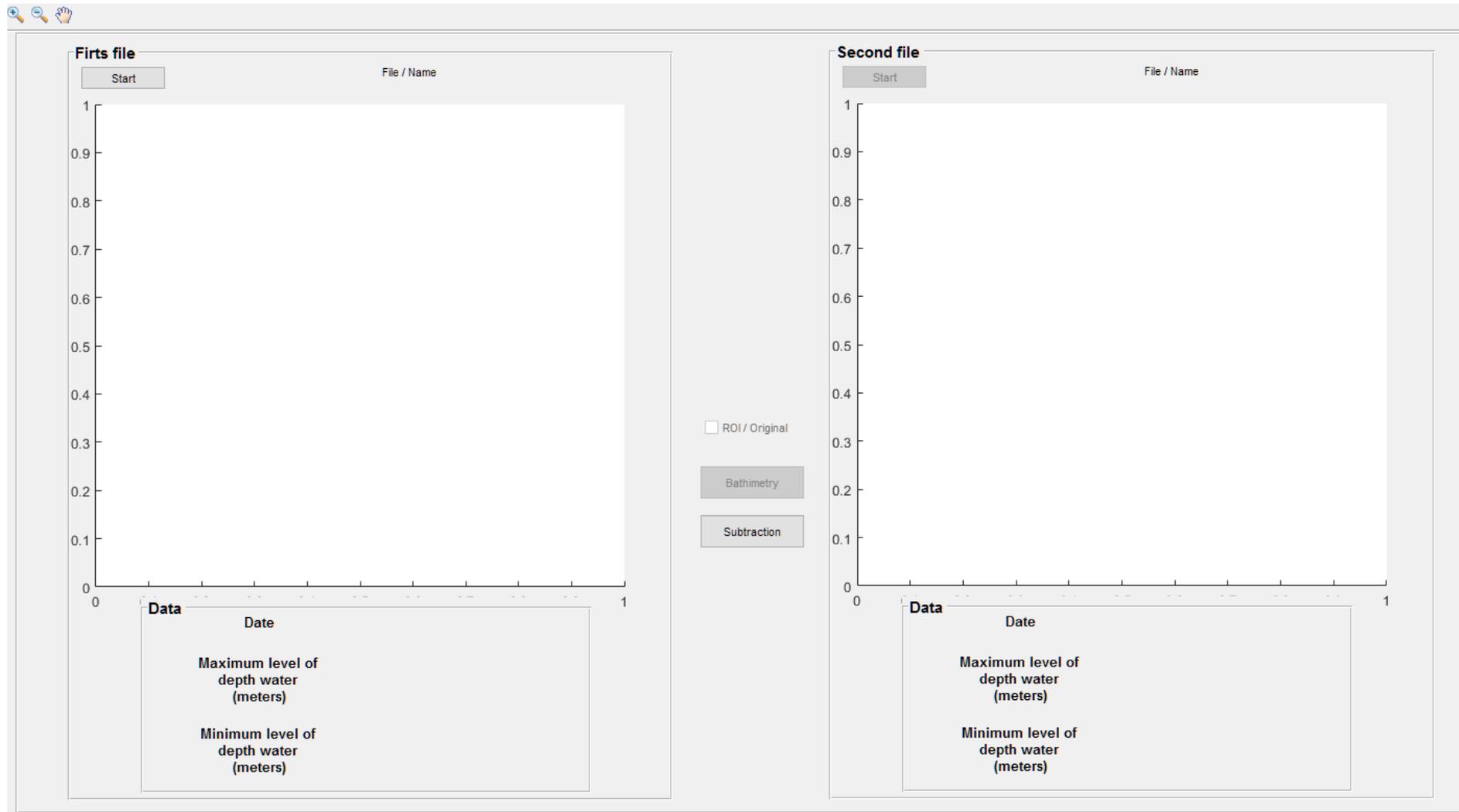


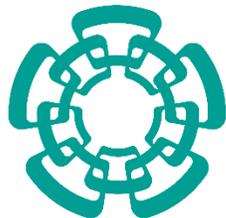
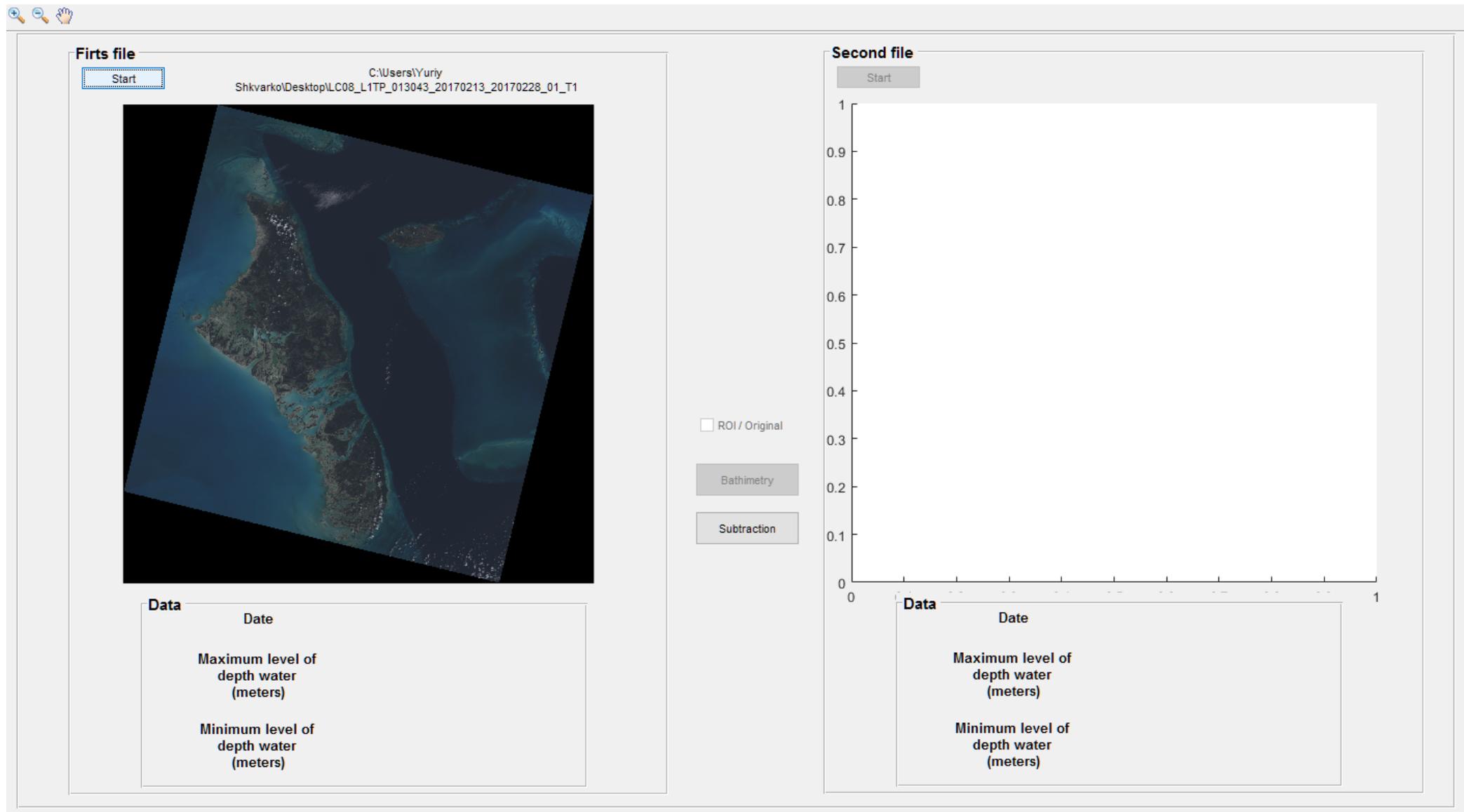
TOLTECA SOFTWARE





Interfaz 2: Comparativa de niveles de profundidad SDB







Firts file

Start

C:\Users\Yuriy
Shkvarko\Desktop\LC08_L1TP_013043_20170213_20170228_01_T1



ROI / Original

Bathimetry

Subtraction

Data	
Date	2017-02-13
Maximum level of depth water (meters)	2.30331
Minimum level of depth water (meters)	0.621905

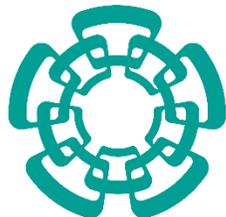
Second file

Start

C:\Users\Yuriy Shkvarko\Desktop\Nueva carpeta\Bahamas



Data	
Date	2017-12-14
Maximum level of depth water (meters)	2.33085
Minimum level of depth water (meters)	0.617293





Firts file

Start

C:\Users\Yuriy
Shkvarko\Desktop\LC08_L1TP_013043_20170213_20170228_01_T1



ROI / Original

Bathimetry

Subtraction

Data	
Date	2017-02-13
Maximum level of depth water (meters)	2.30331
Minimum level of depth water (meters)	0.621905

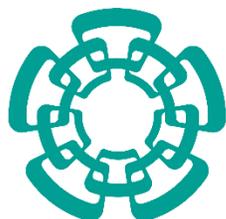
Second file

Start

C:\Users\Yuriy Shkvarko\Desktop\Nueva carpeta\Bahamas



Data	
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Maximum level of depth water (meters)	2.33085
Minimum level of depth water (meters)	0.617293

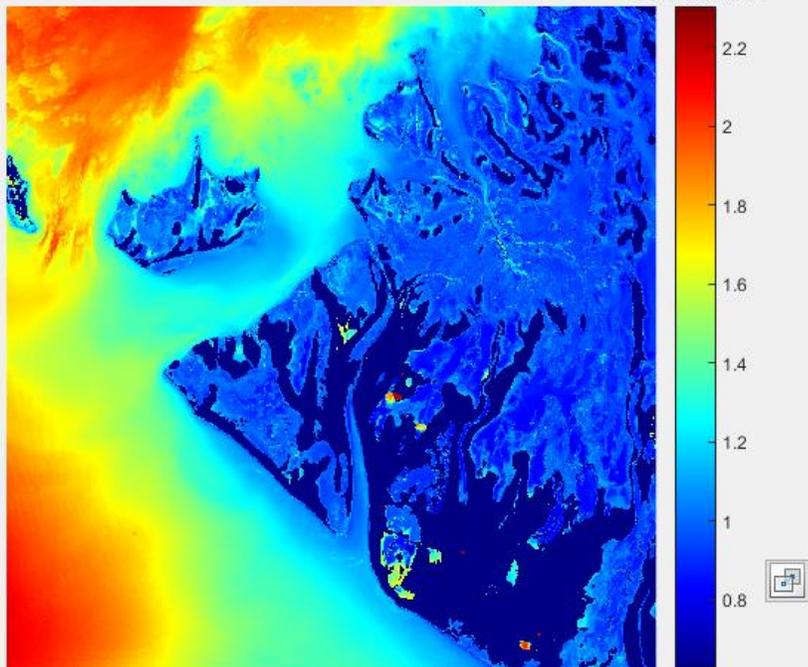




Firts file

Start

C:\Users\Yuriy
Shkvarko\Desktop\LC08_L1TP_013043_20170213_20170228_01_T1
Depths in Meters



ROI / Original

Bathimetry

Subtraction

Data

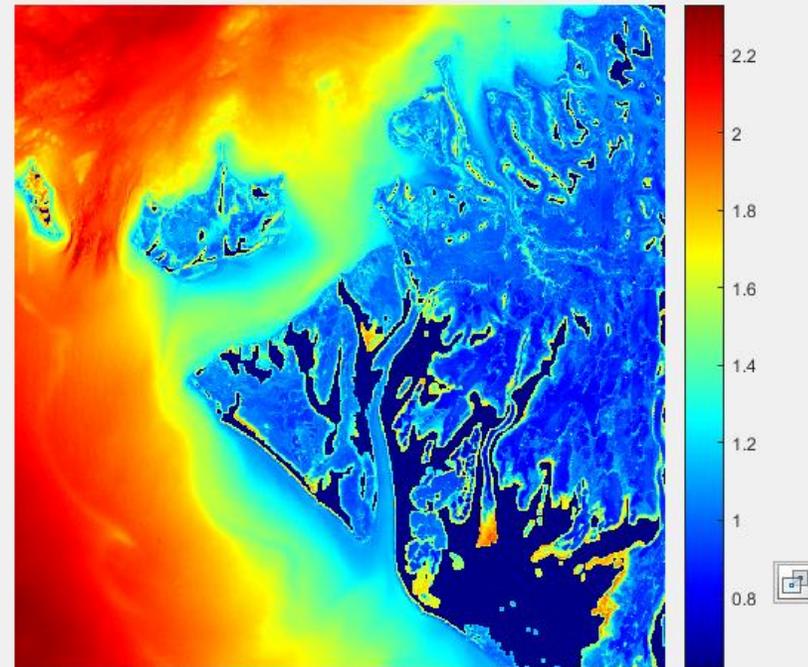
Date	2017-02-13
Maximum level of depth water (meters)	2.30331
Minimum level of depth water (meters)	0.621905

Second file

Start

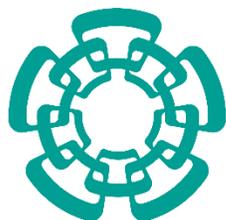
C:\Users\Yuriy Shkvarko\Desktop\Nueva carpeta\Bahamas

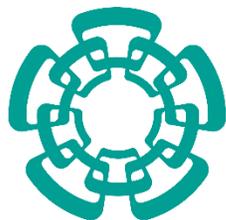
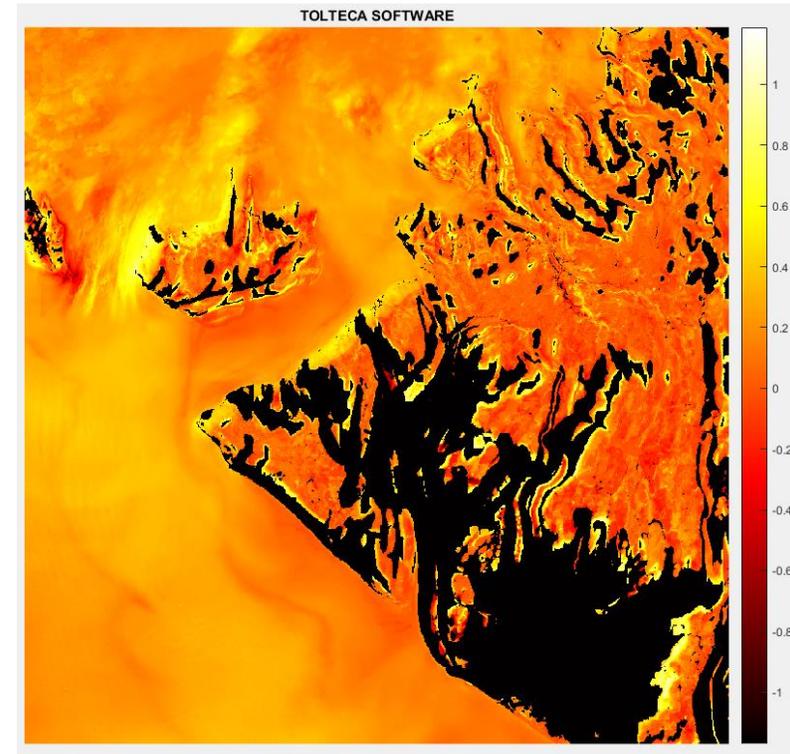
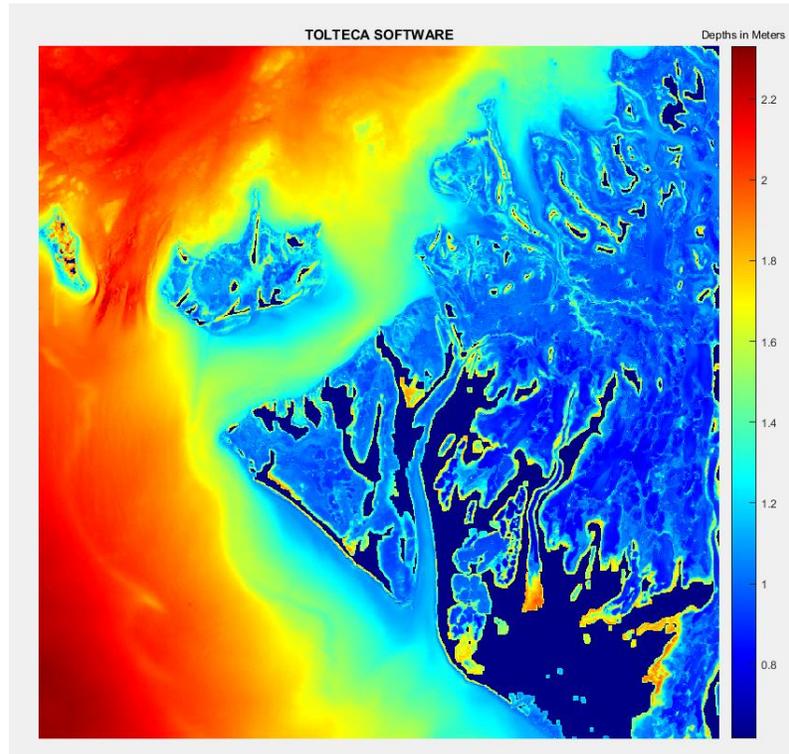
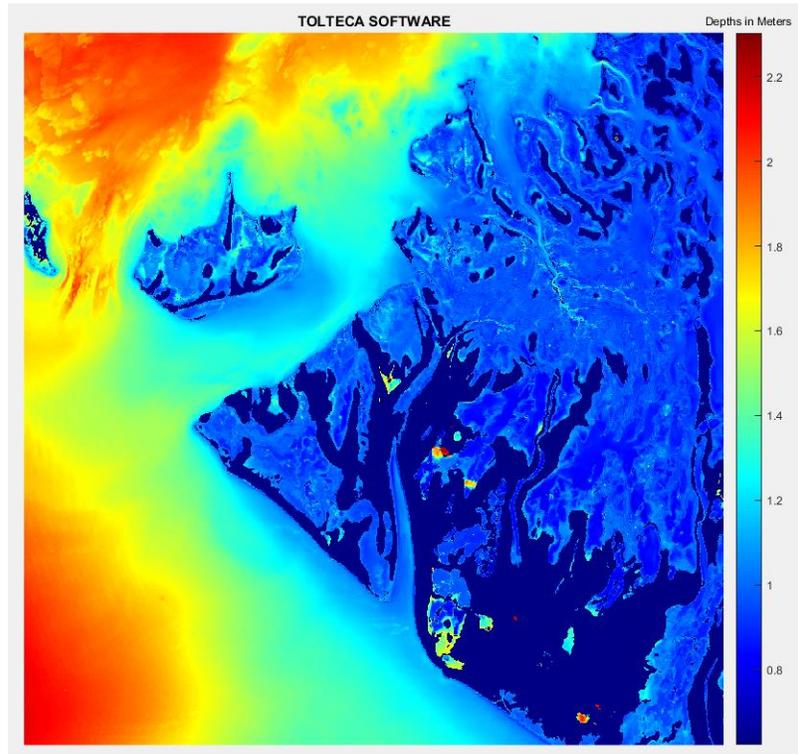
Depths in Meters



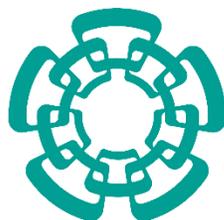
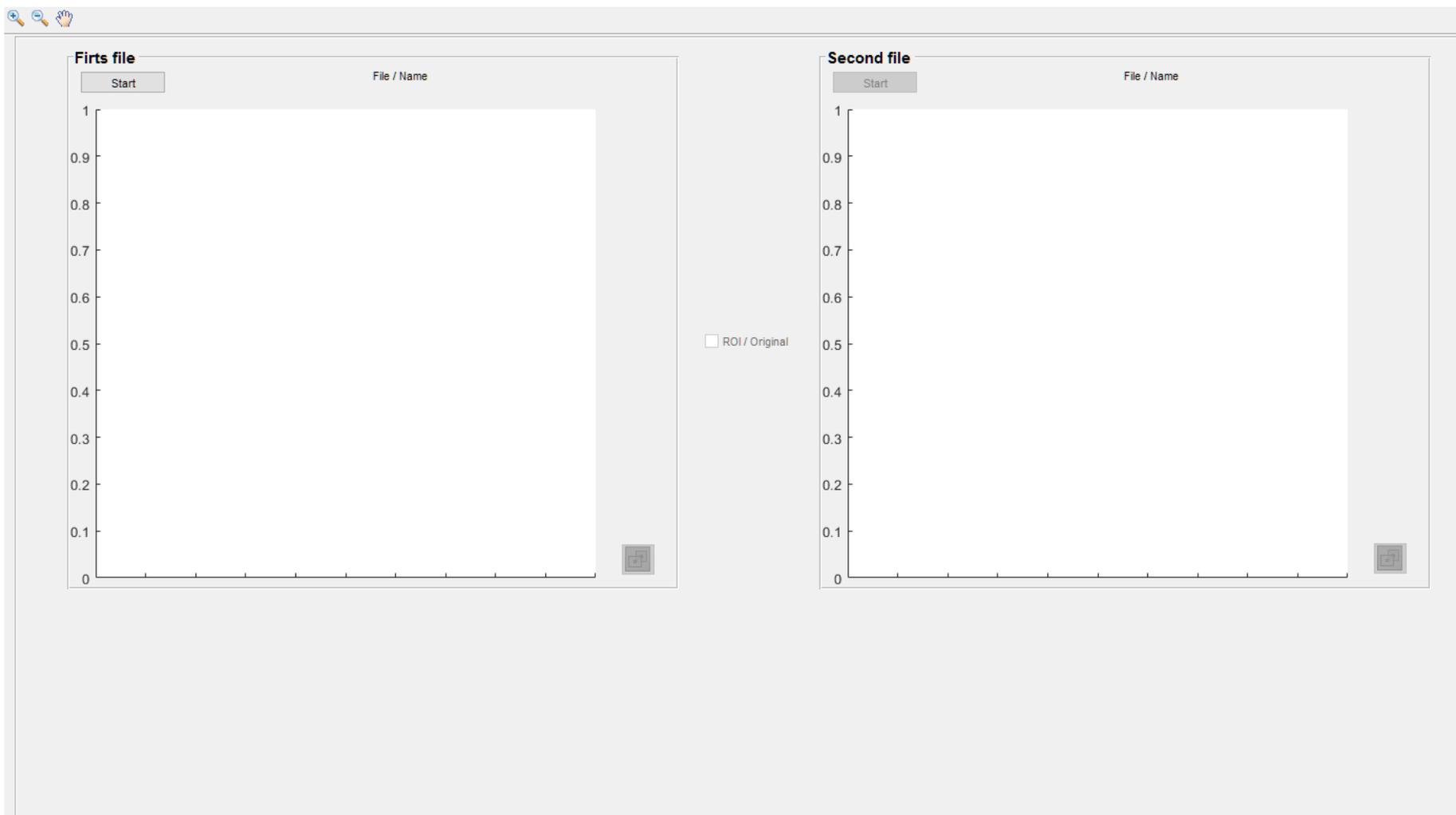
Data

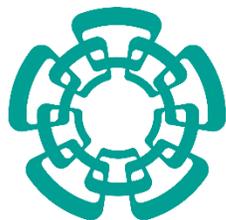
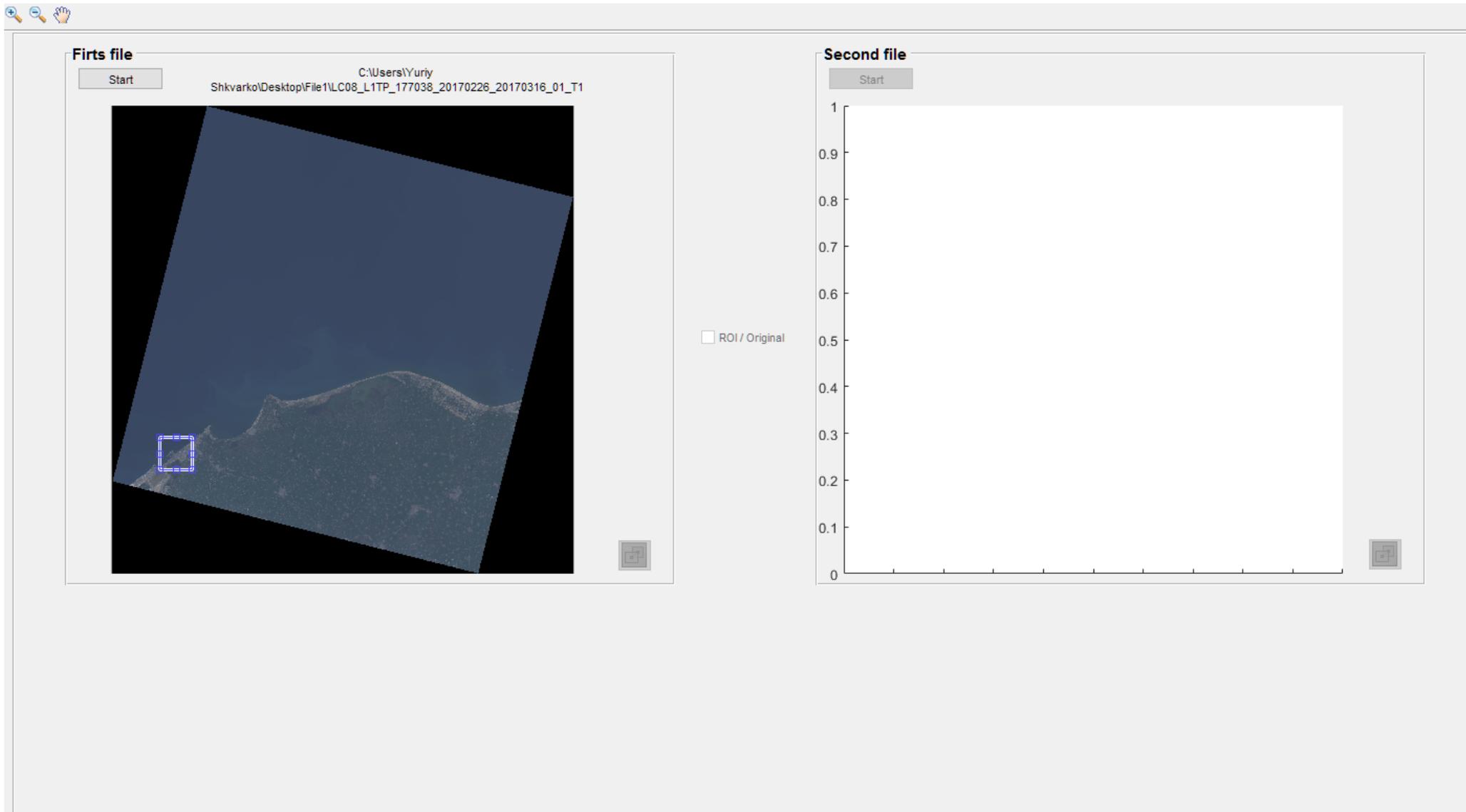
Date	2017-12-14
Maximum level of depth water (meters)	2.33085
Minimum level of depth water (meters)	0.617293

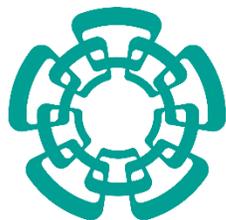
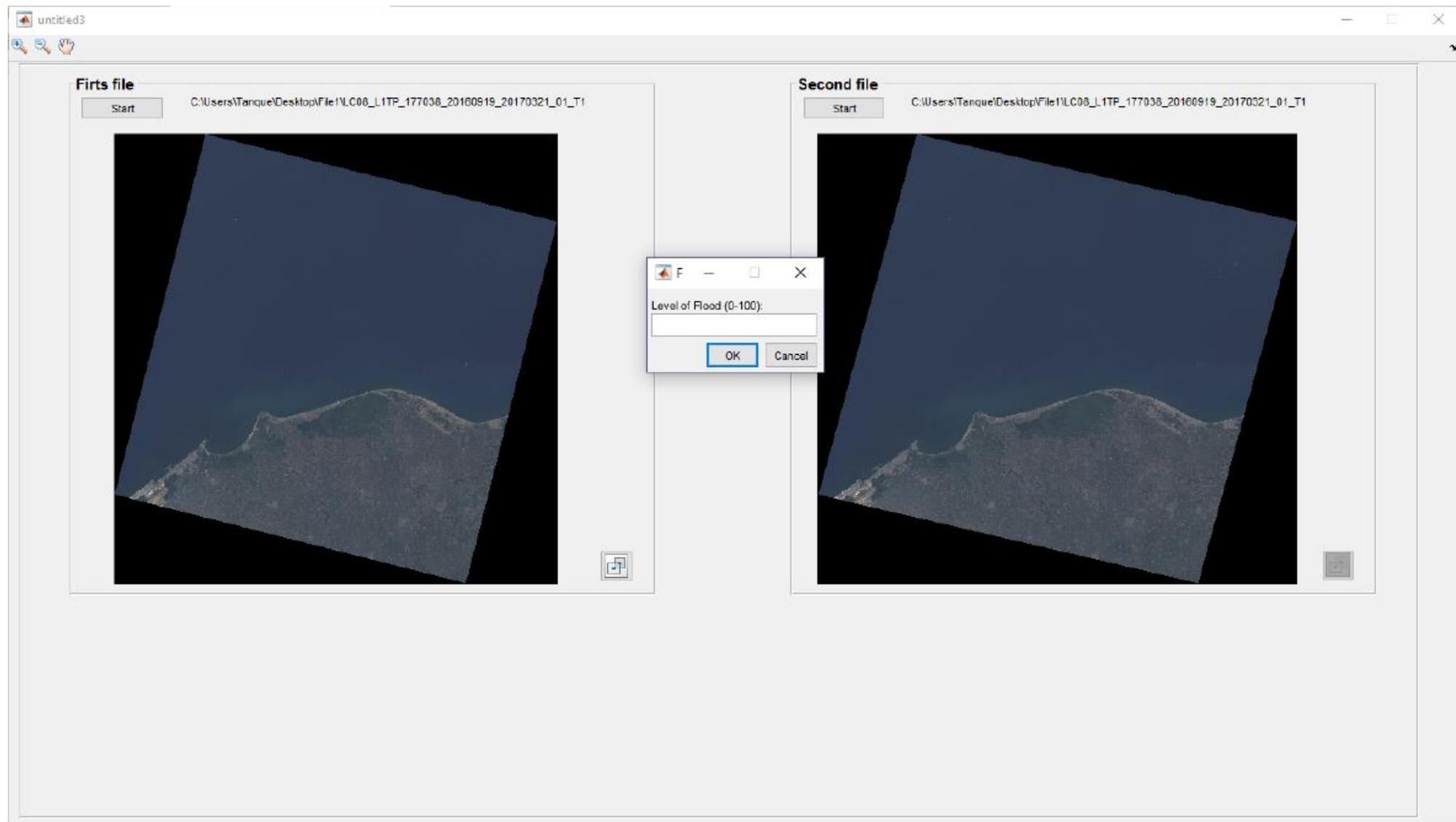


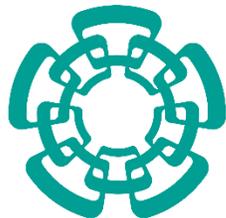
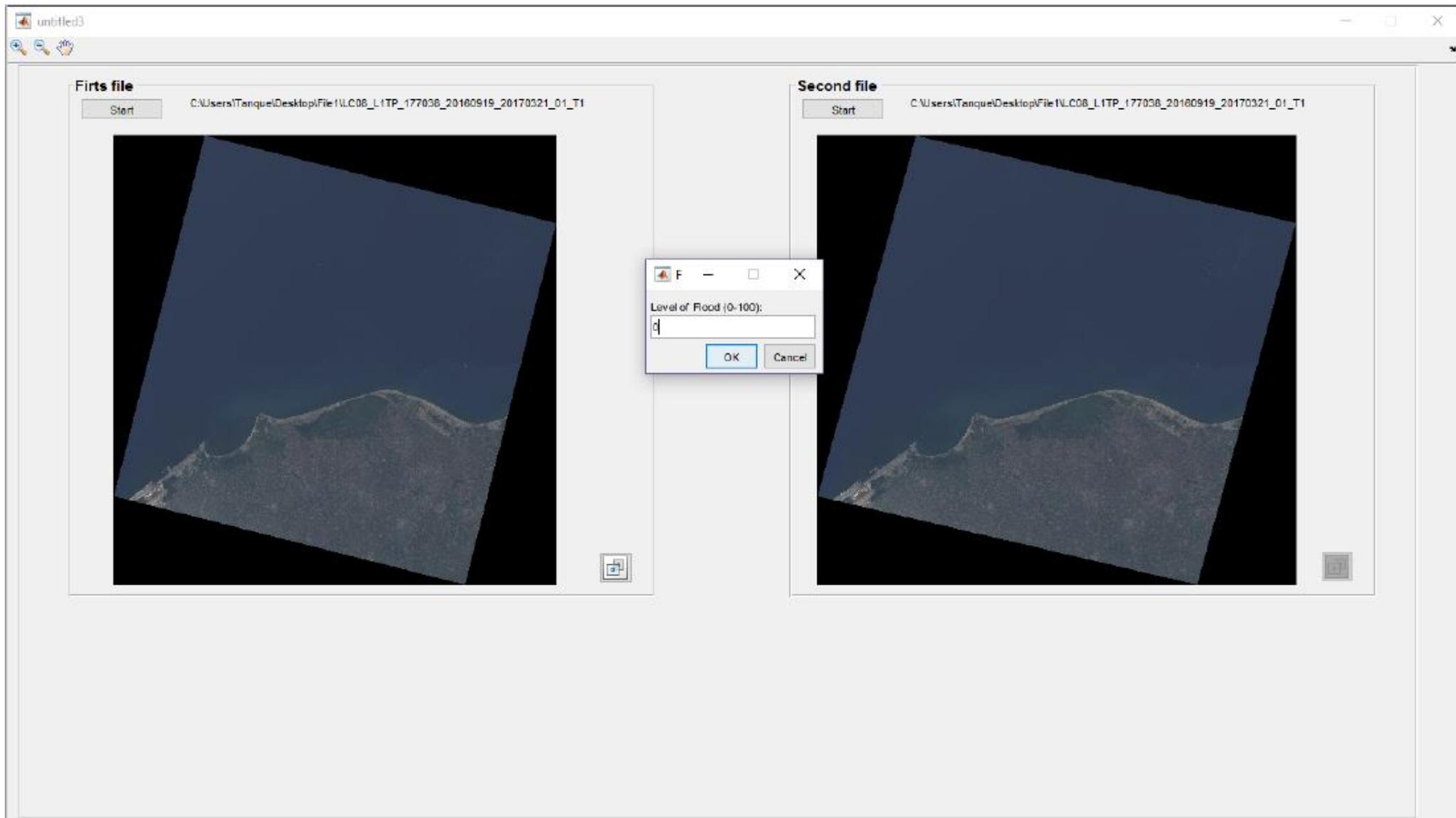


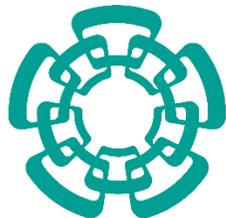
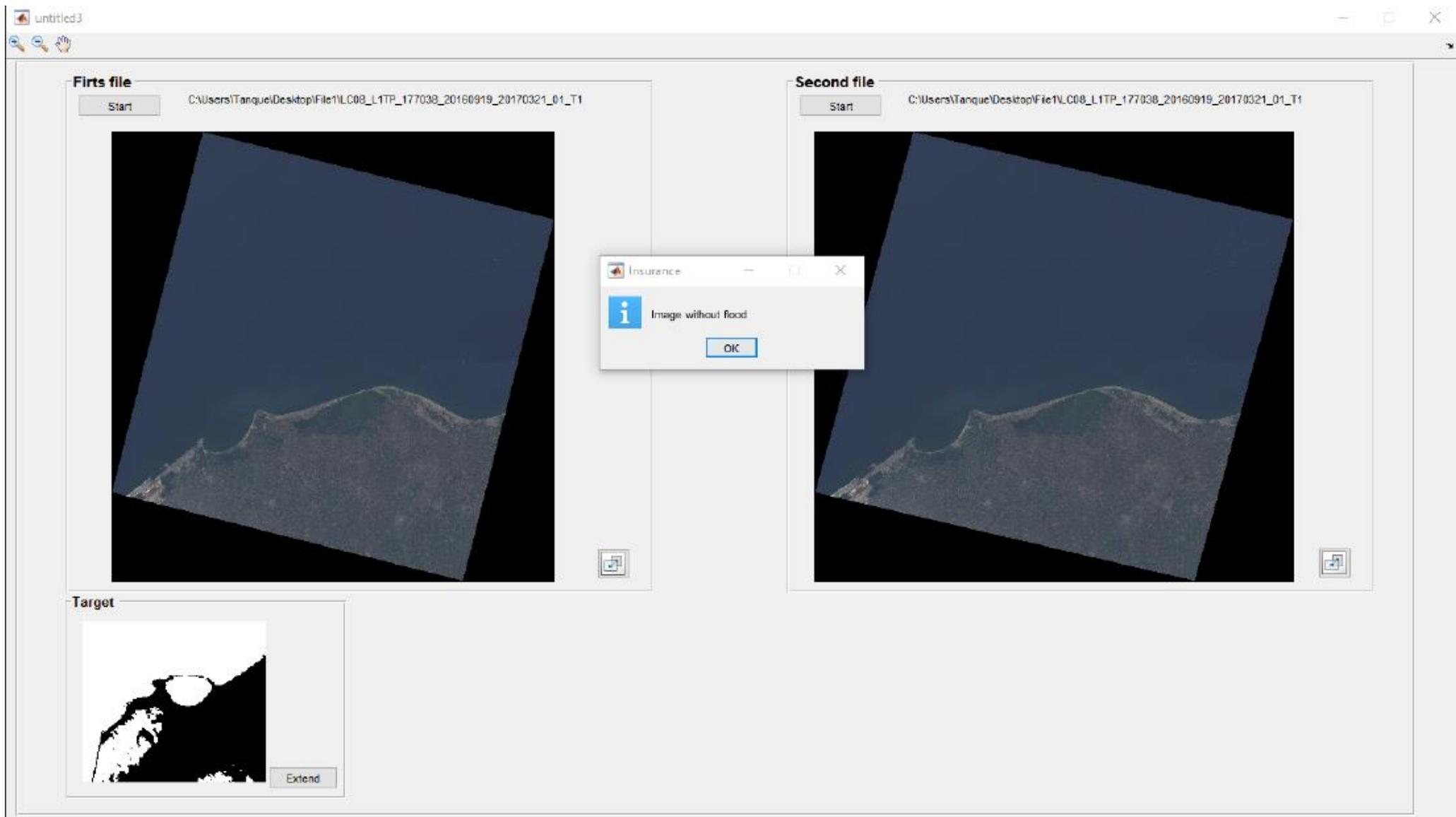
Interfaz 3: Estimación de inundación

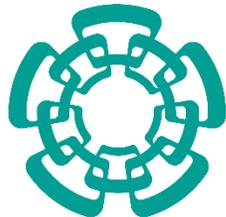
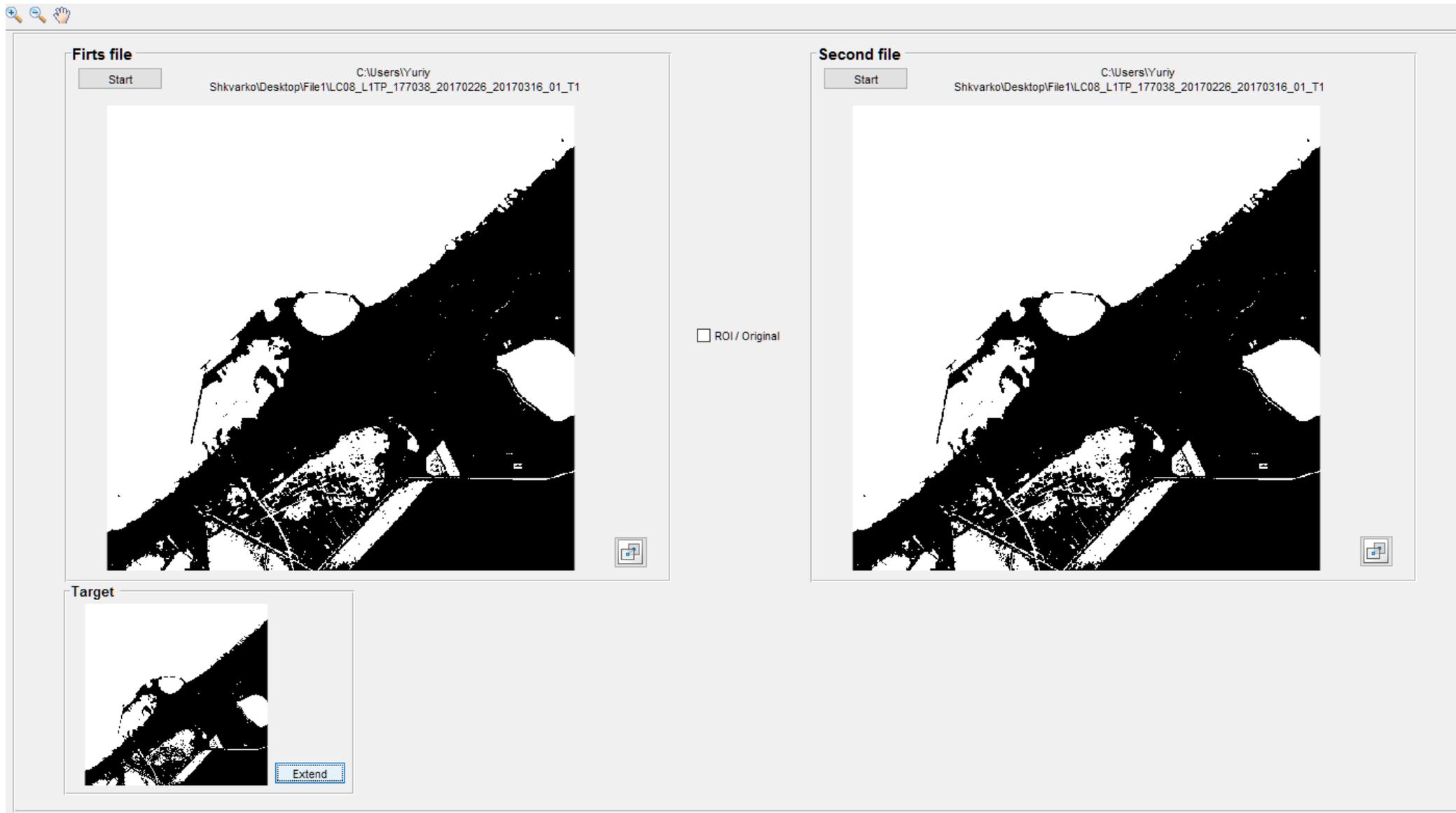


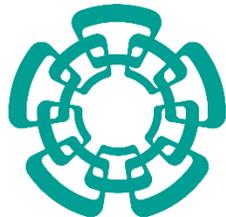
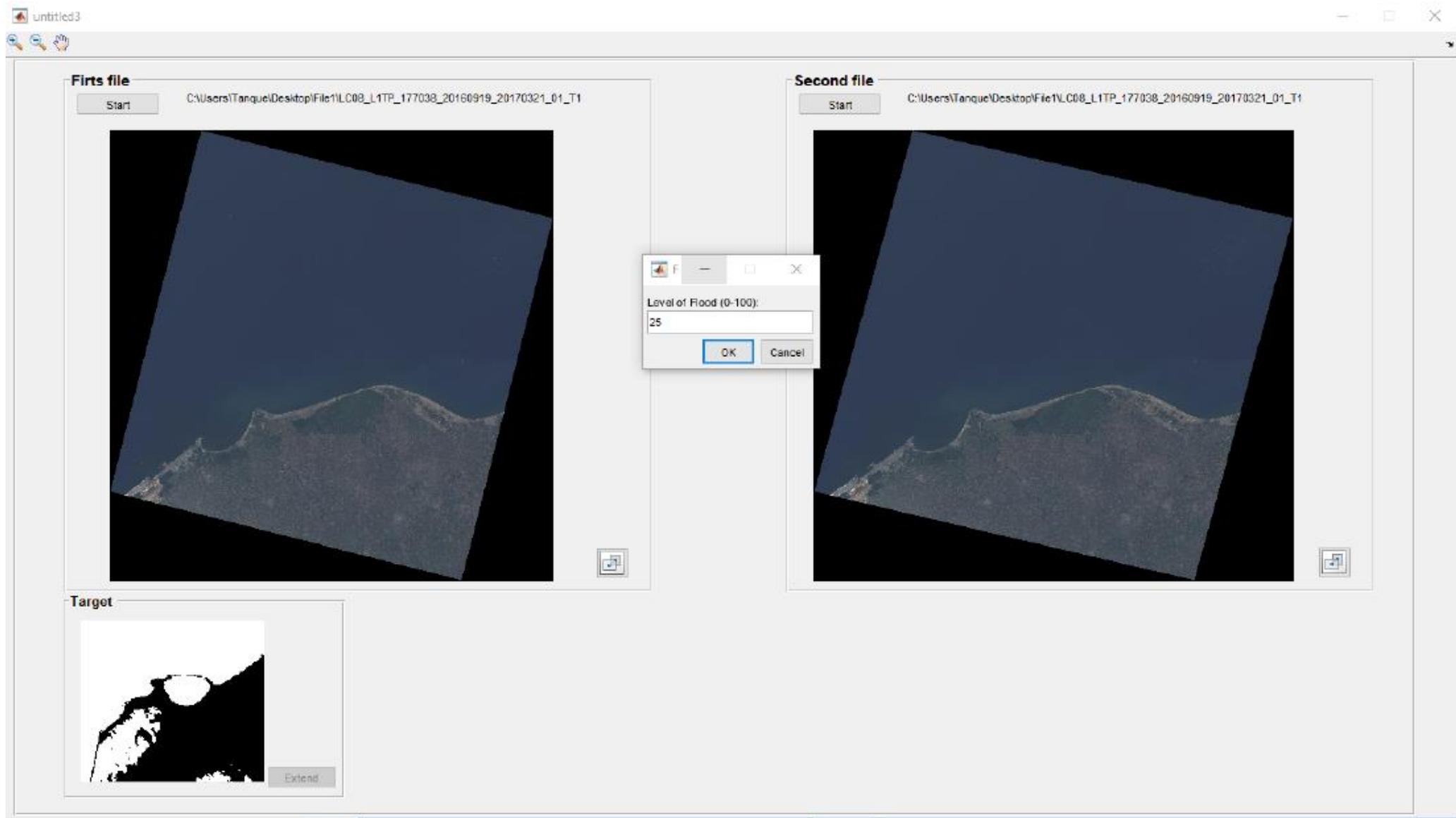


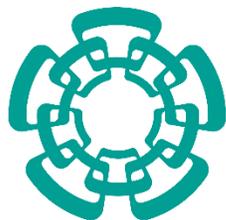
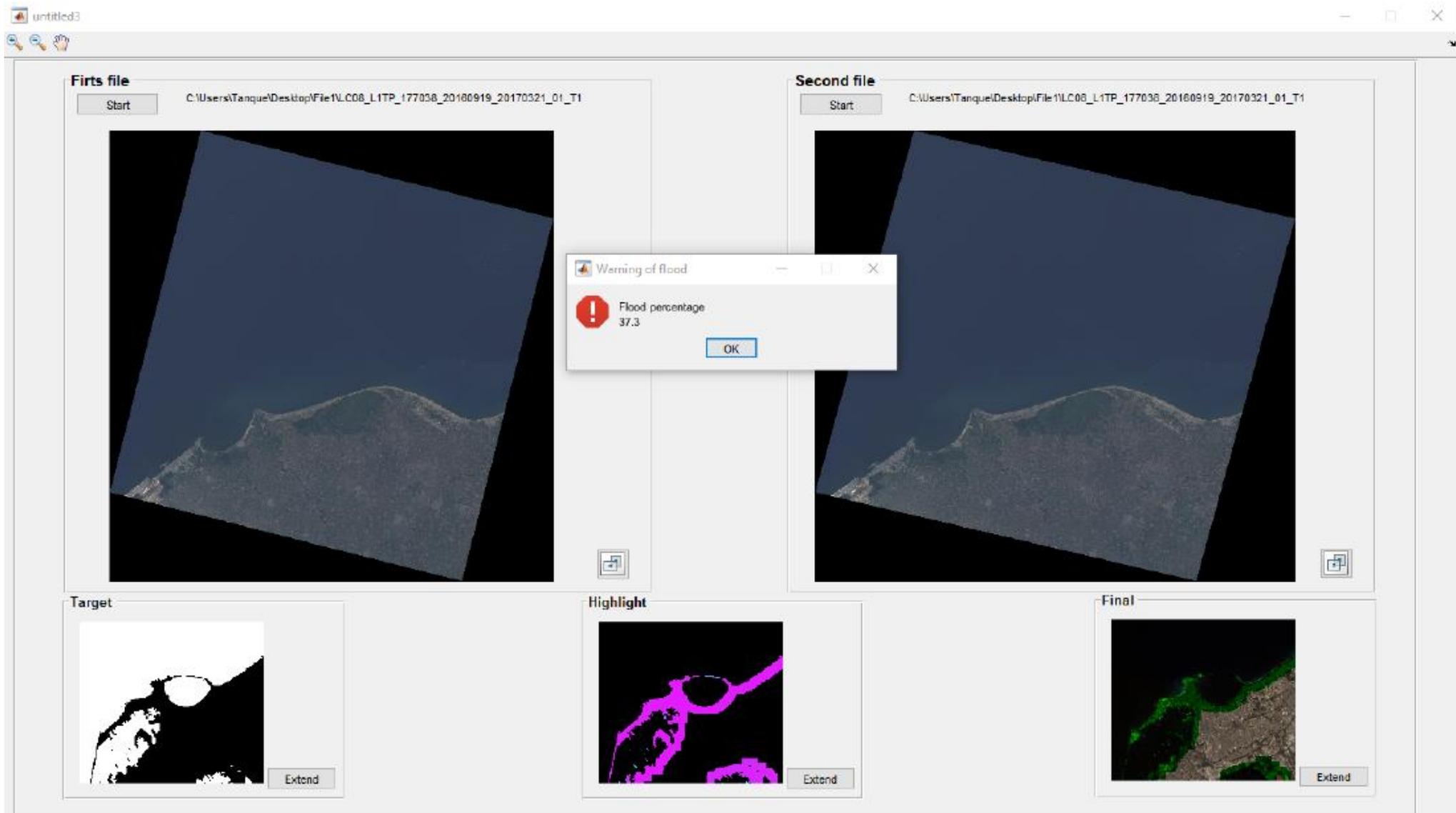


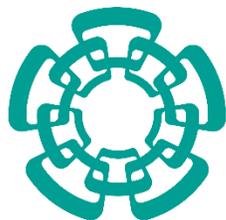
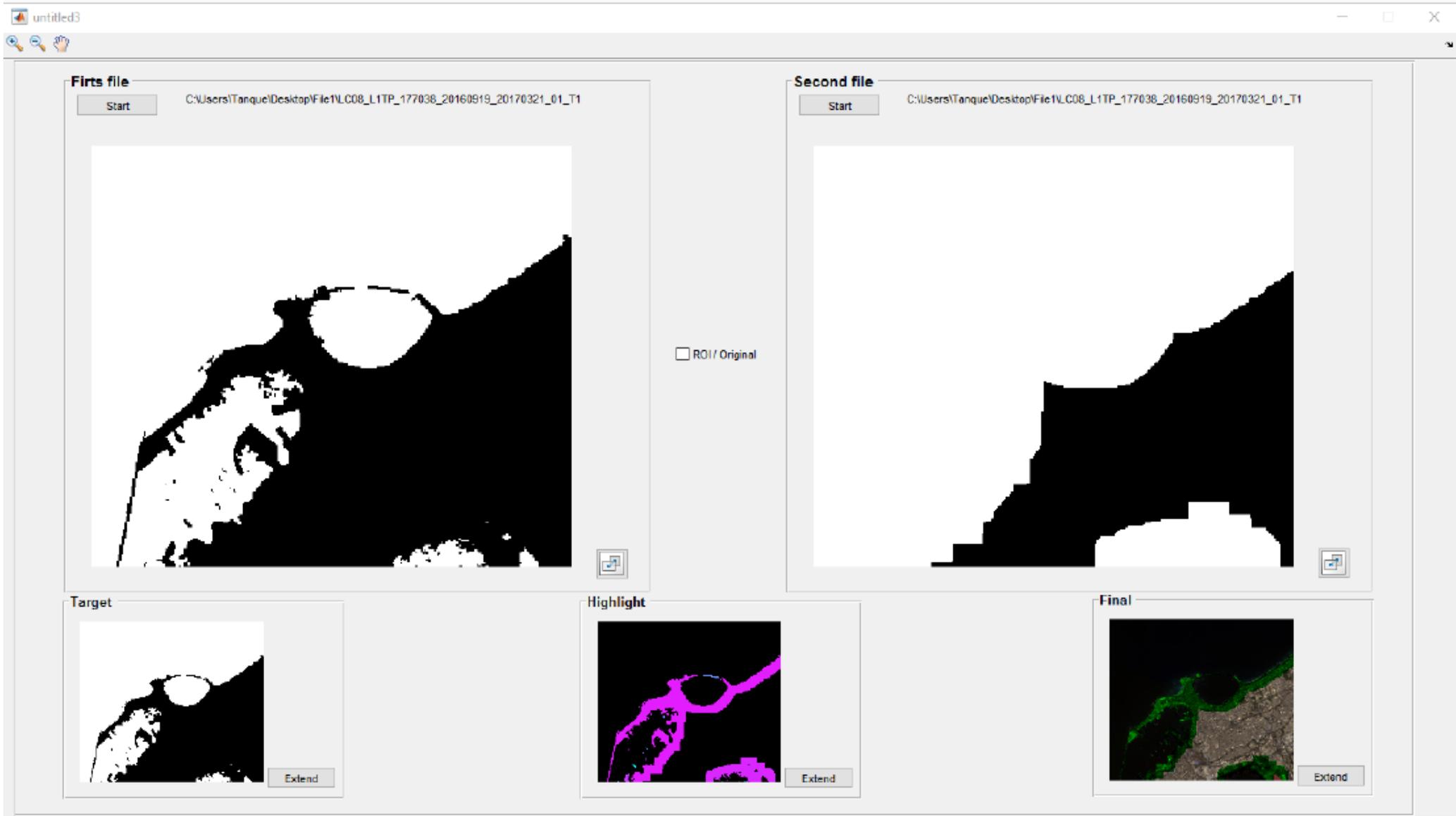


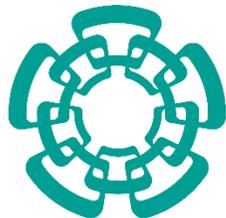
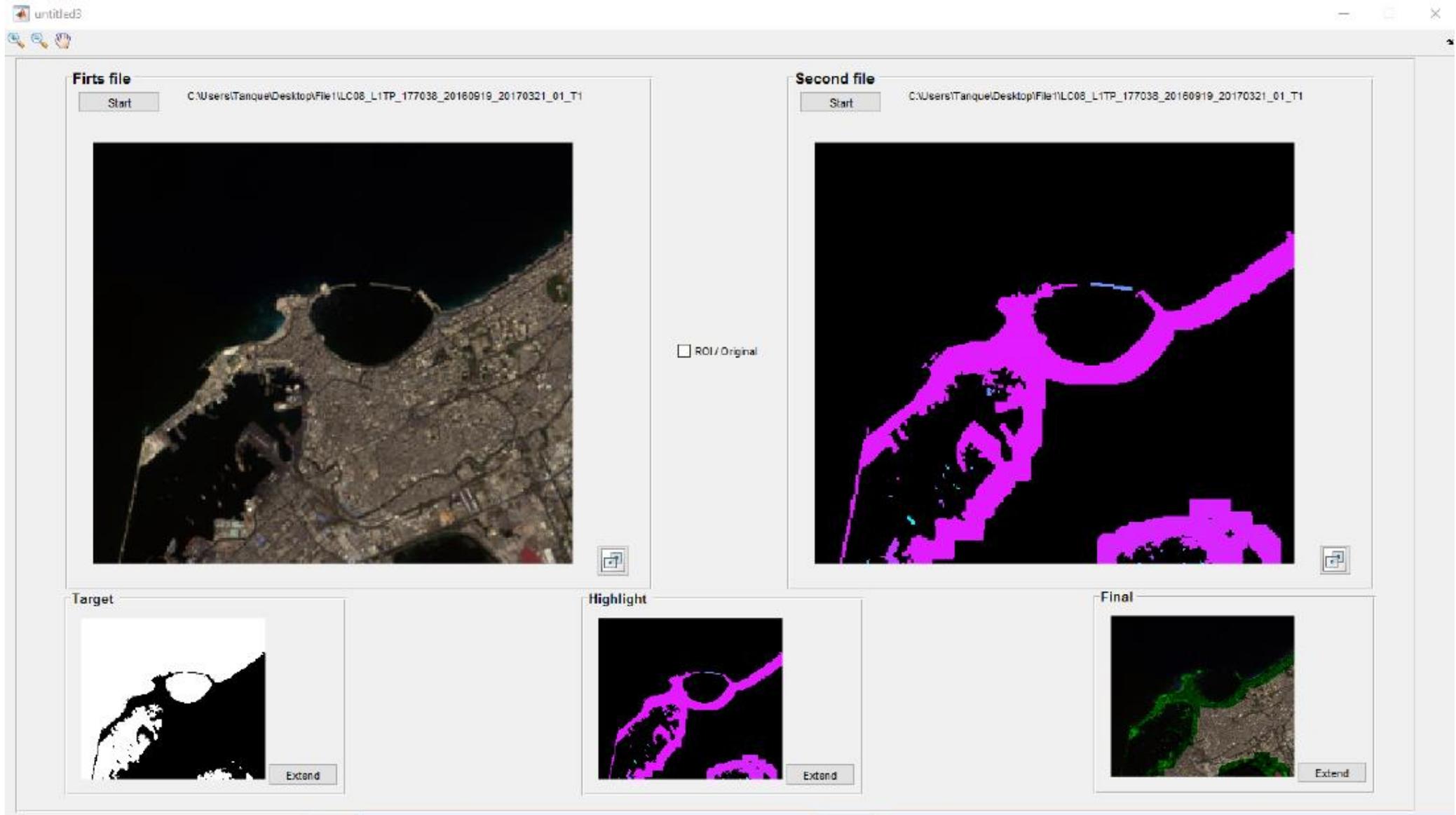


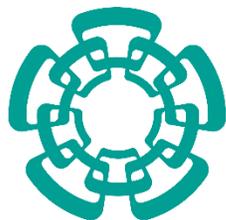
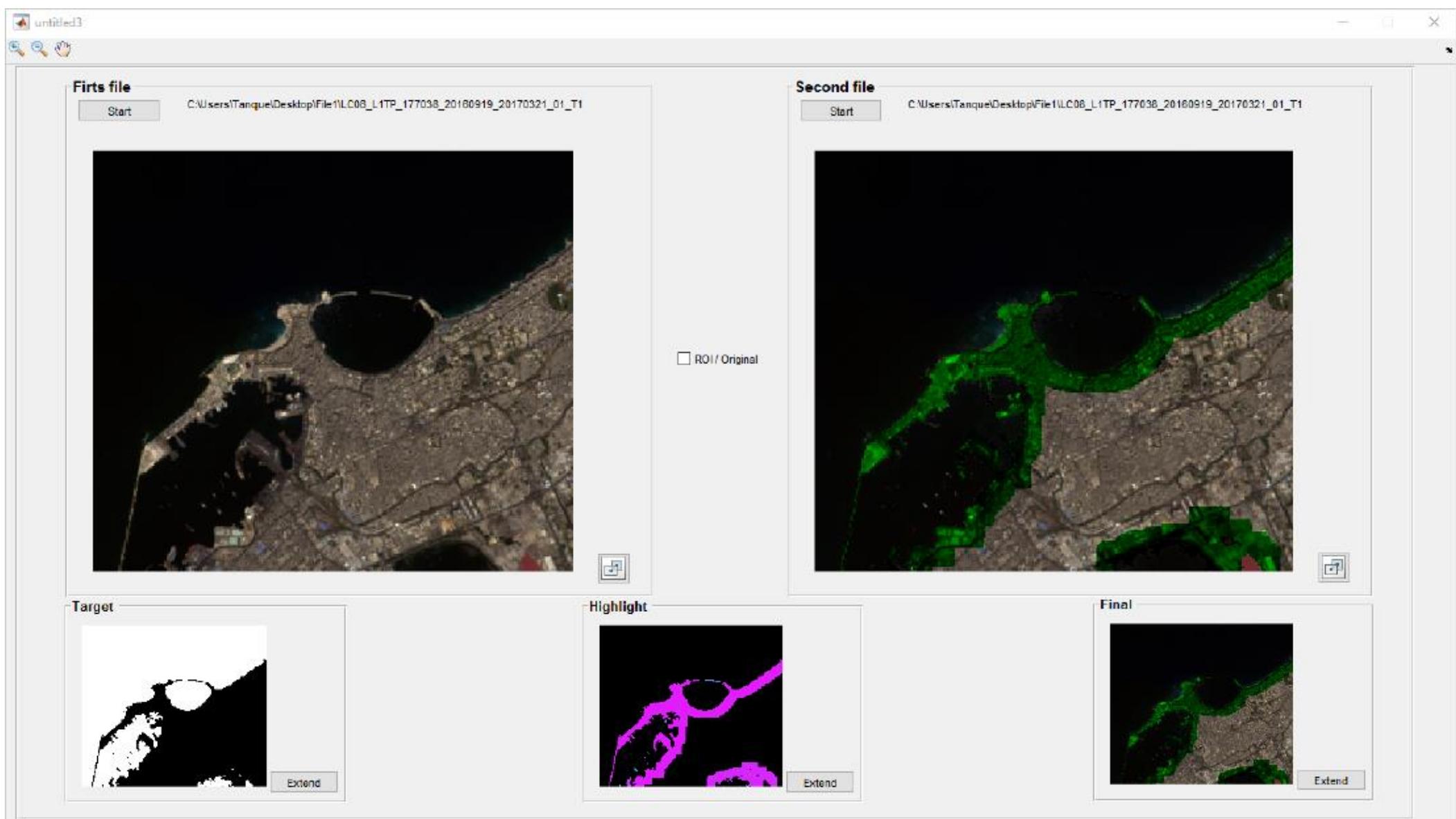


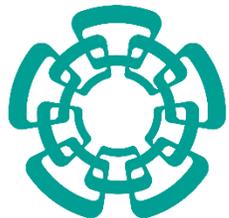
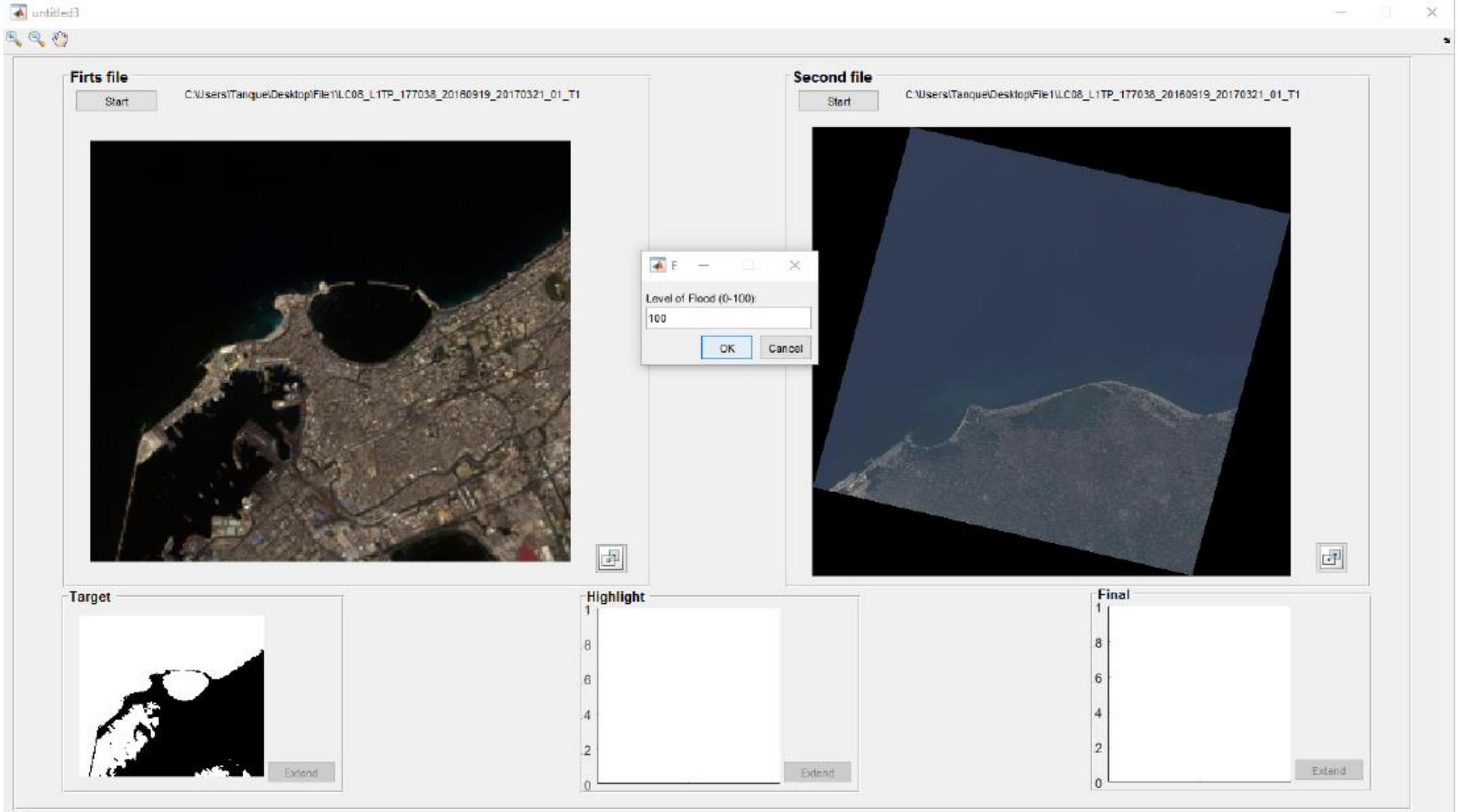


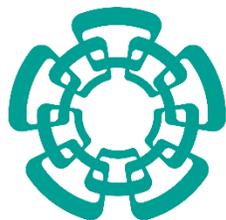
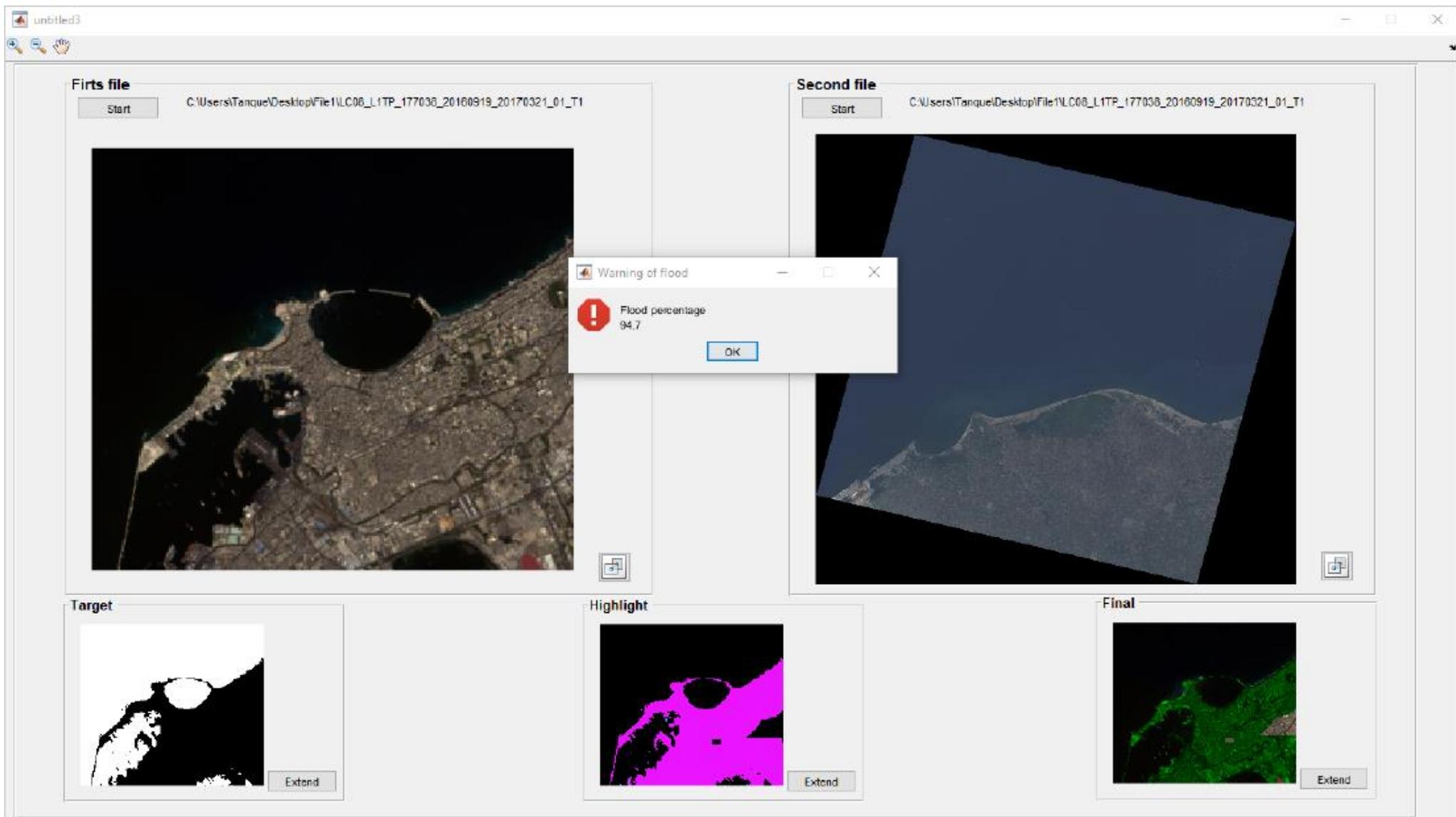


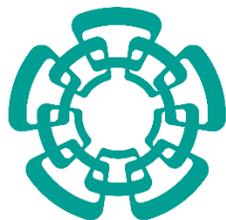
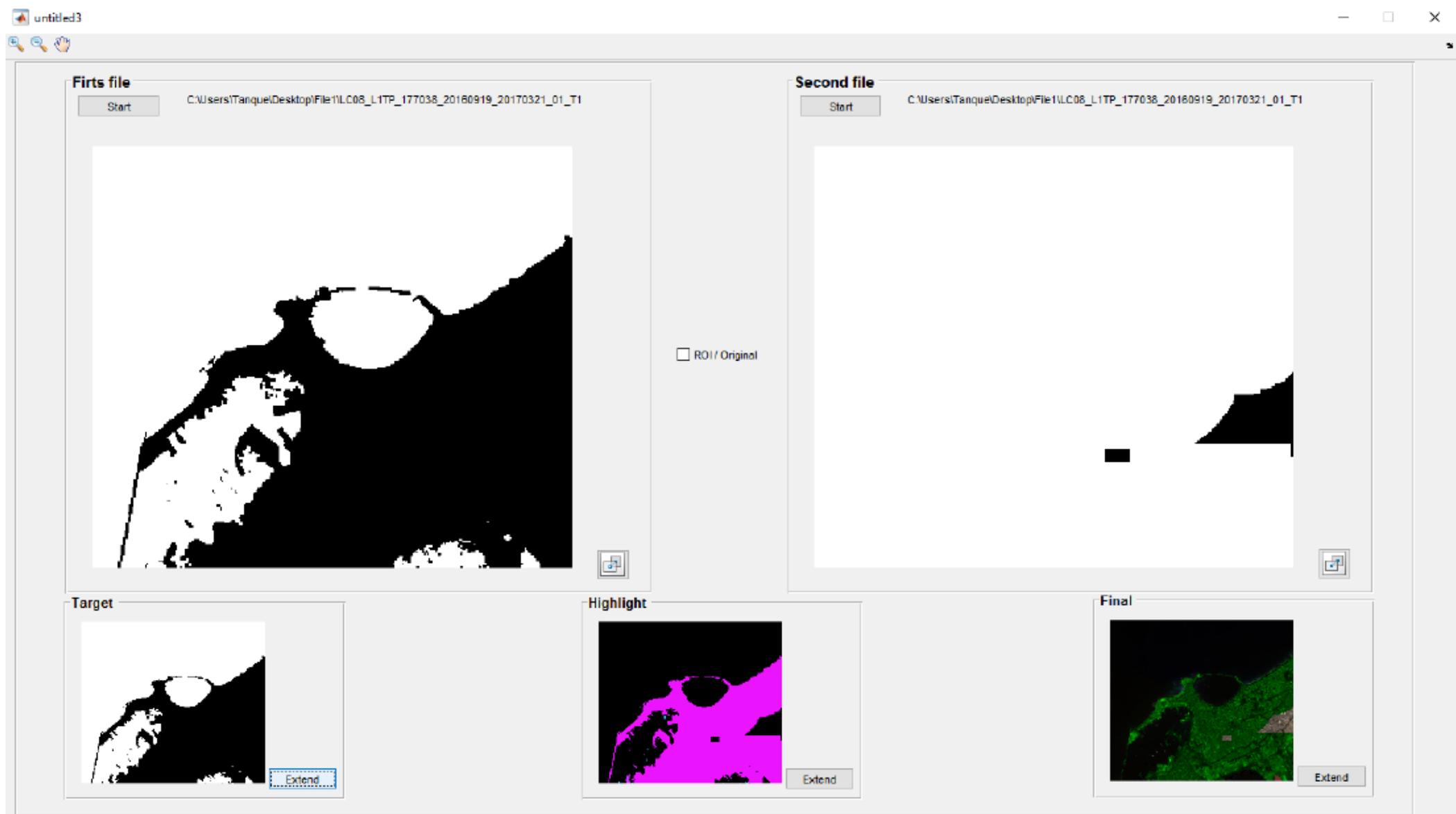


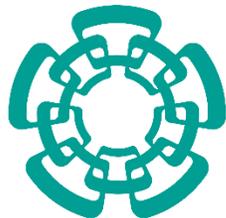
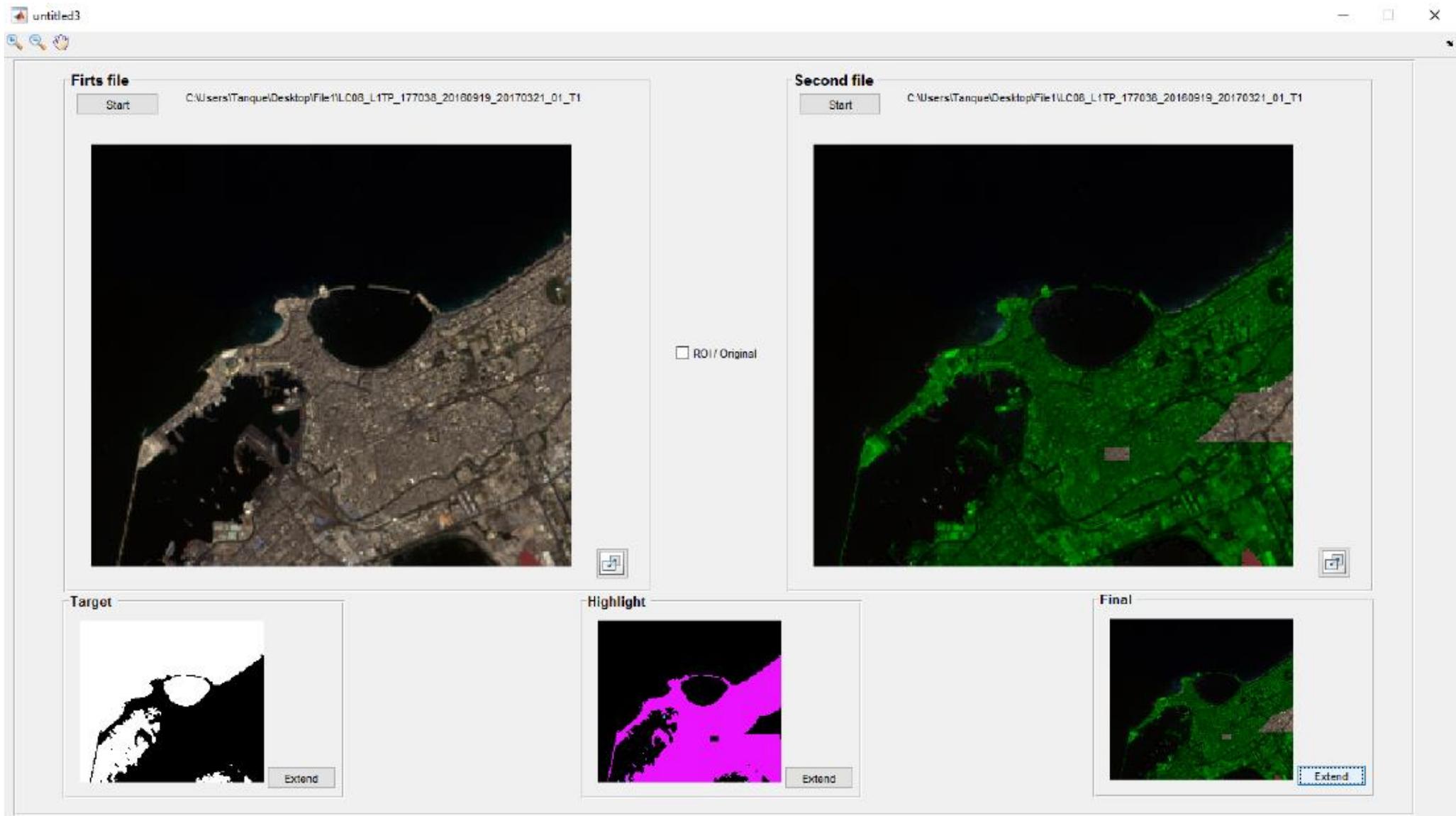






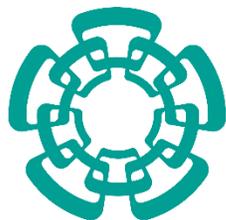






Conclusiones

- El algoritmo de **batimetría** produce resultados muy cercanos a los esperados siempre y cuando los **parámetros de ajuste** sean adecuados.
- Los **índices de diferenciación normalizada** utilizan información espectral para segmentar zonas, lo cual **simplifica** de manera muy favorable la **detección de cuerpos de agua**.
- Escenarios con **variaciones** extremas en las **profundidades** de agua complican el cálculo de la profundidad mediante SBD, por lo que se requiere una **mejor selección de los parámetros de ajuste** mediante un análisis más profundo.
- En la parte de la **estimación de inundaciones**, los operadores morfológicos fueron de vital importancia.



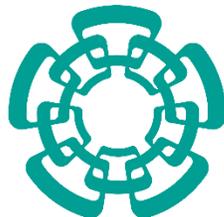
Trabajo a futuro

- Hacer **métricas** para validar la fiabilidad del resultado y poder comparar los resultados con otros artículos ya hechos.
- Aplicar **Modelos Digitales Elevación** (Digital Elevation Model, DEM) para mostrar los resultados en **3D** y sea mejor el entendimiento de estos.
- Pasar el código realizado en **Matlab** a **código abierto**.



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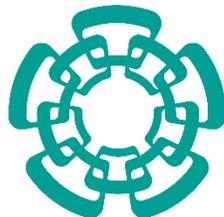
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