

Nighttime Marine Pollution over large coastal cities analysis with DMSP-OLS satellite images.

Universidad Nacional de Rosario – Facultad de Ciencias Exactas, Ingeniería y
Agrimensura – Centro de Sensores Remotos – CONAE – NASA – CONICET

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Lic. Laura Balparda Lic. Olga Corna
Lic. Gabriel Cotlier. Tec. Diego A. G. López



Universidad
Nacional de
Rosario



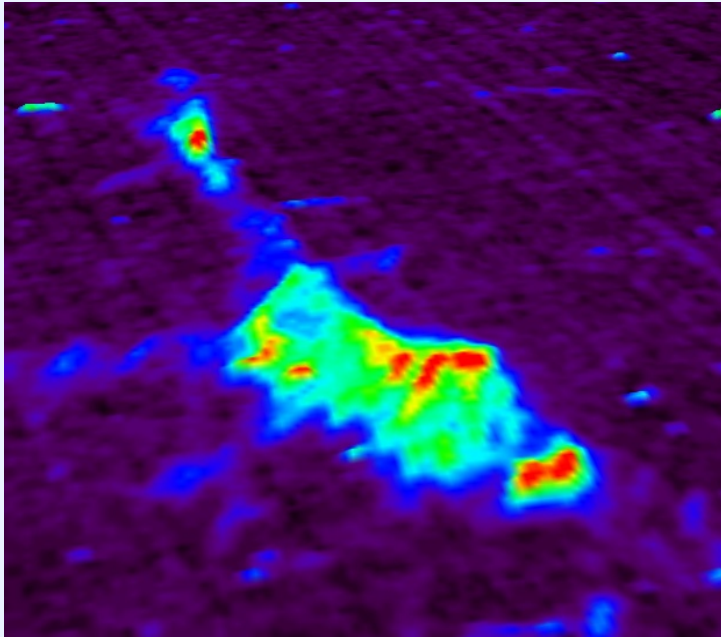
Facultad de
Ciencias Exactas,
Ingeniería
y Agrimensura



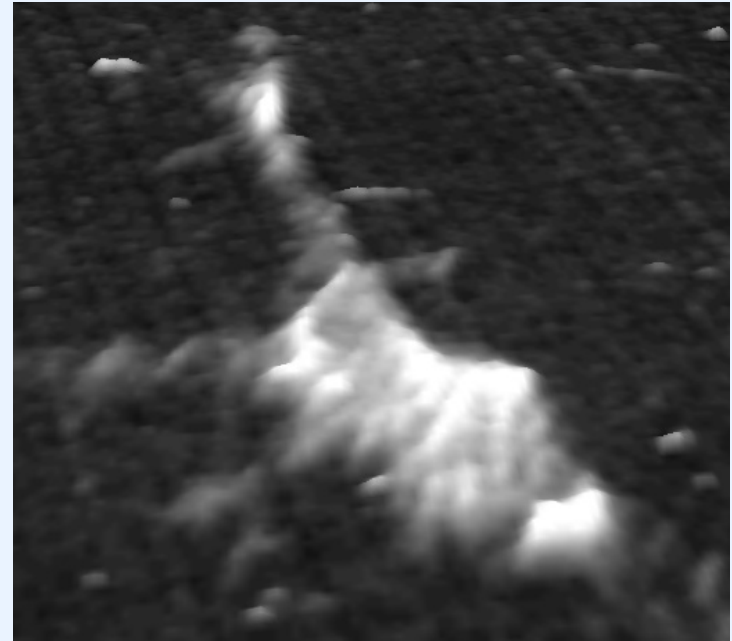
Centro de
Sensores
Remotos



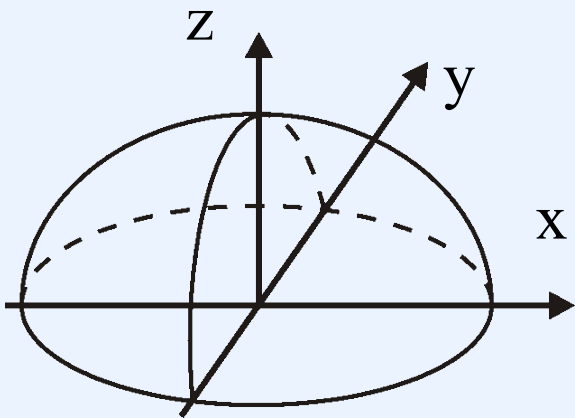
Luminic intensity 3D Display of satellite sensed data.



Rainbow Lookup Table



Grey Scale Lookup Table



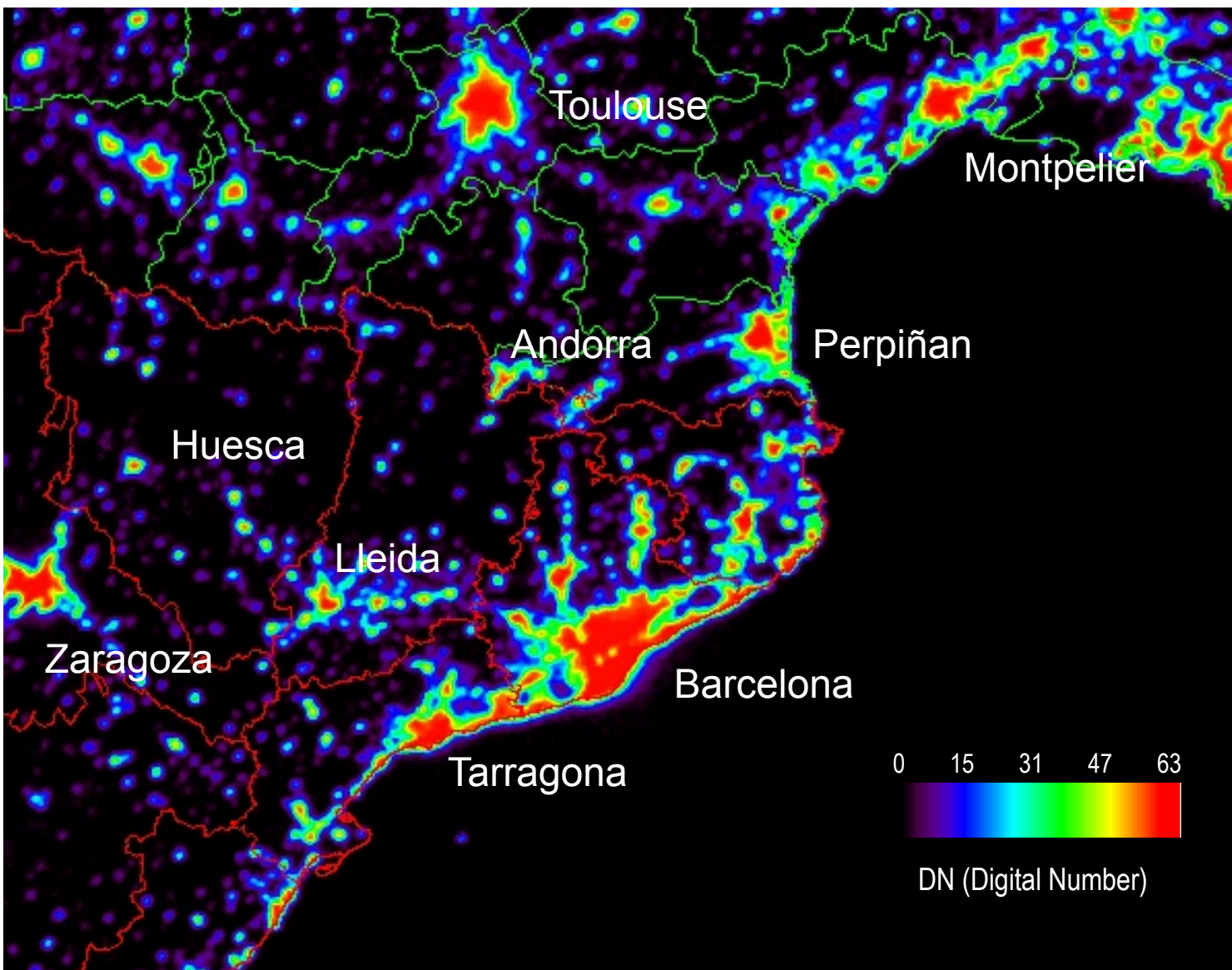
Energy pattern distribution over urban areas looks like a dome, the x-y plane are the illuminated area and the z axis the energy quantity.

Barcelona

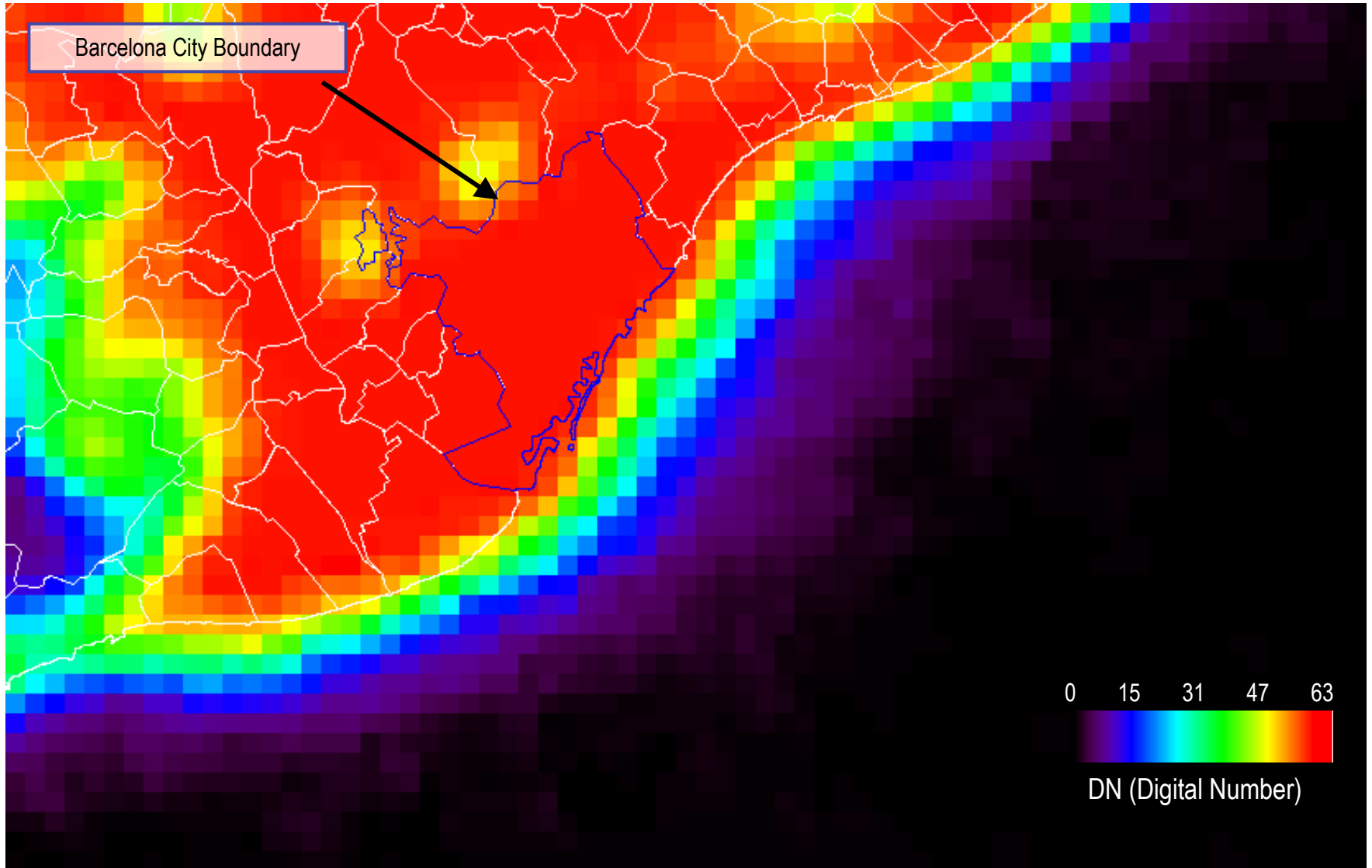


Real Color. Landsat 5 TM. 04/10/2011.

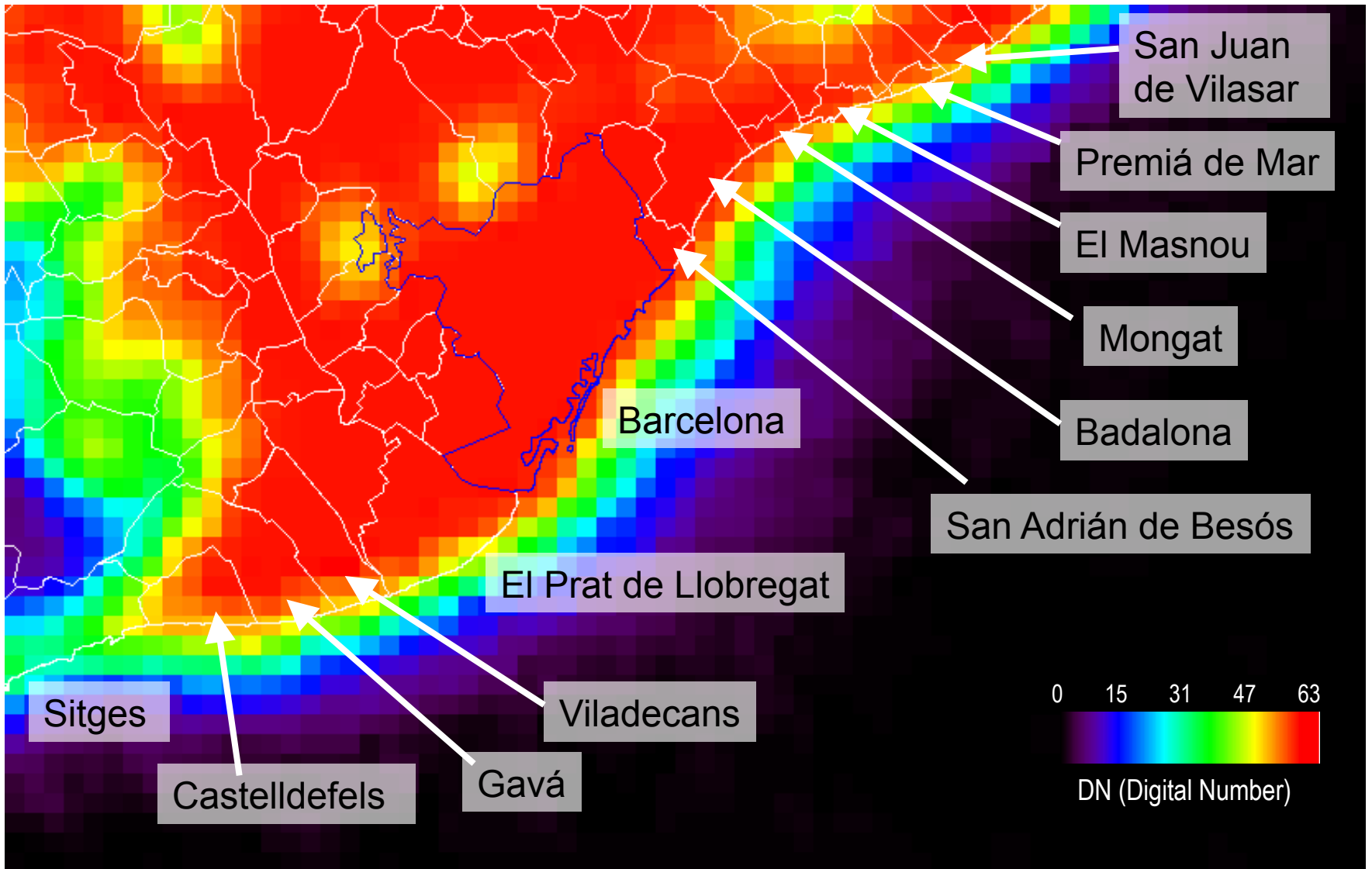
Barcelona



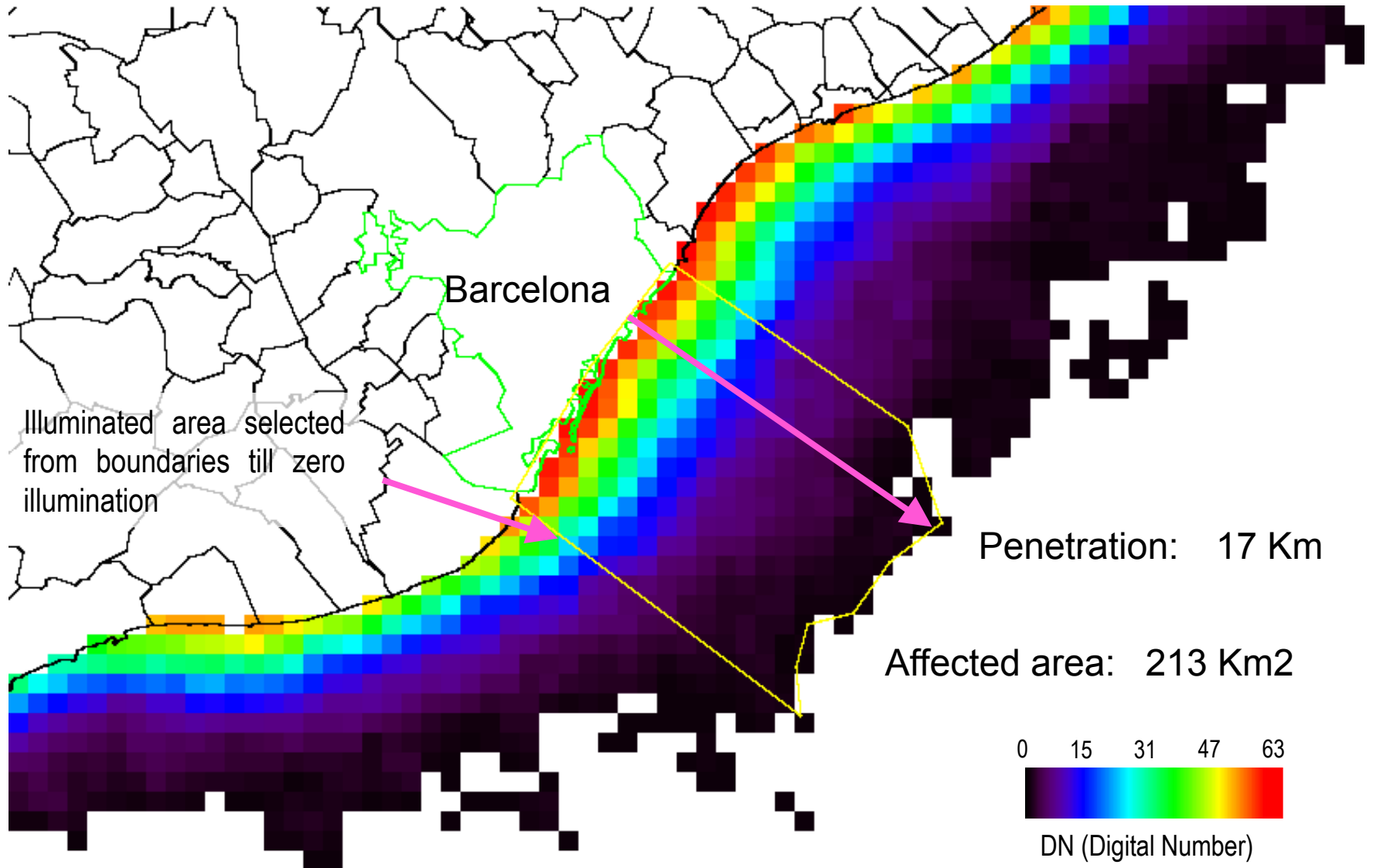
Barcelona



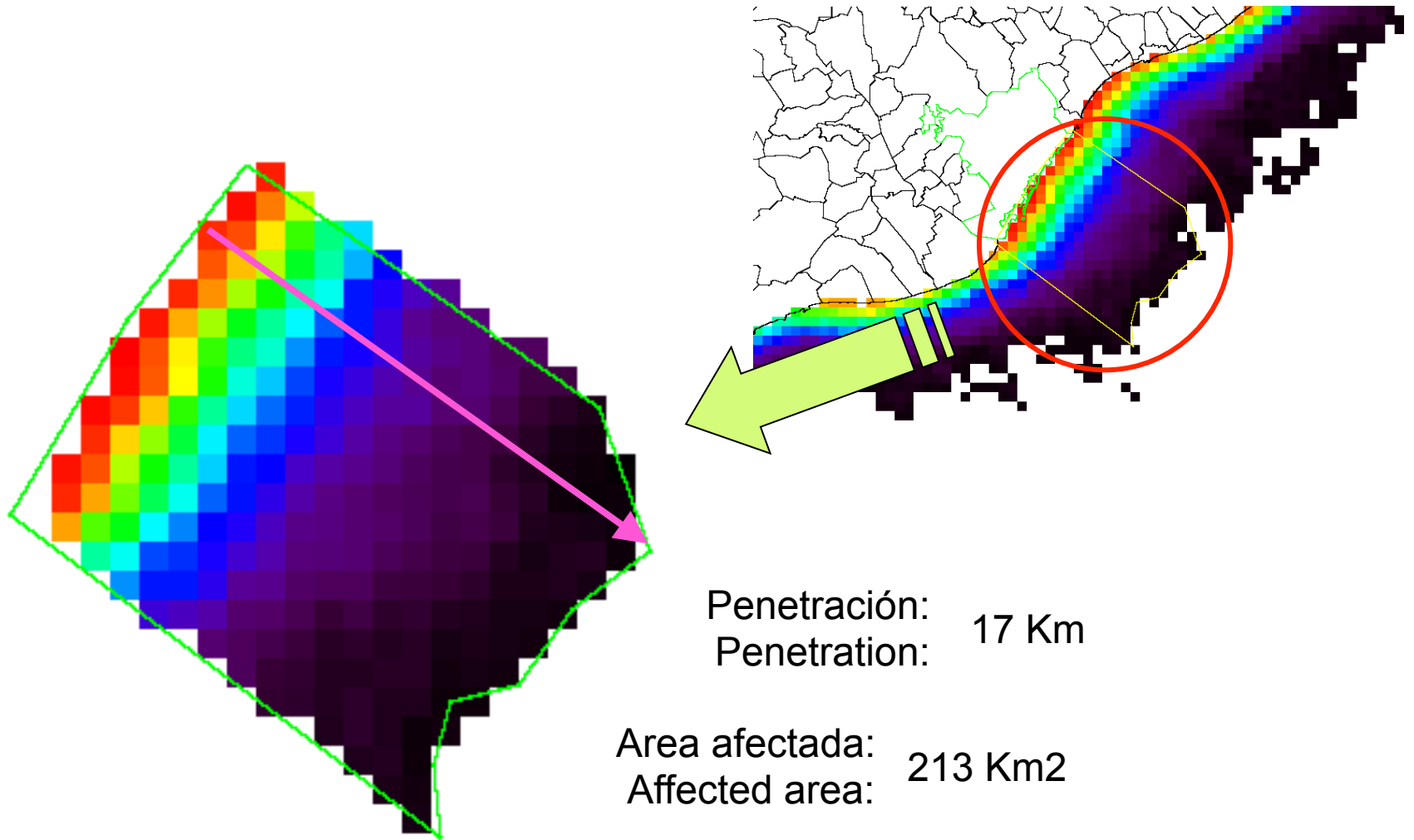
Barcelona



Barcelona

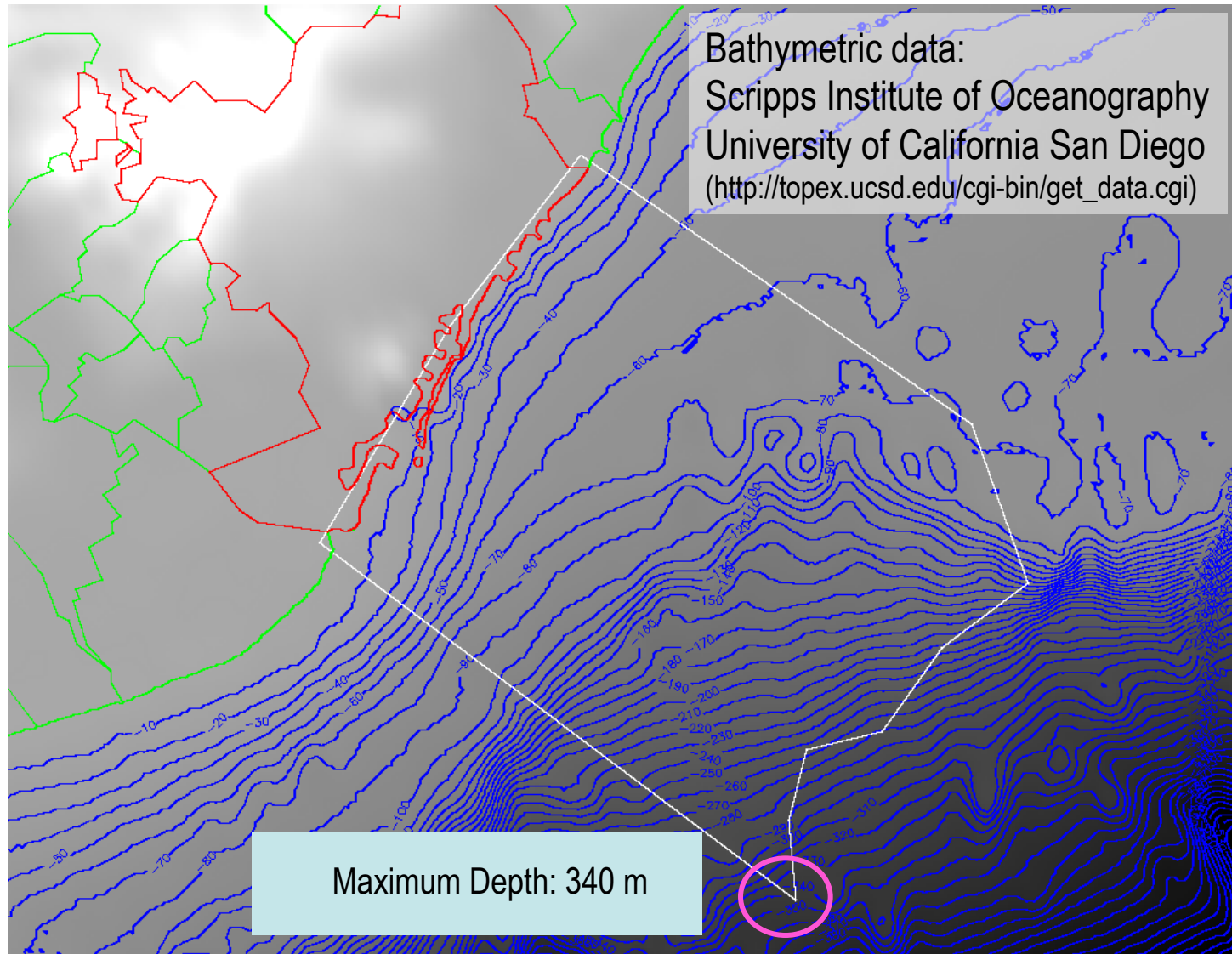


Barcelona

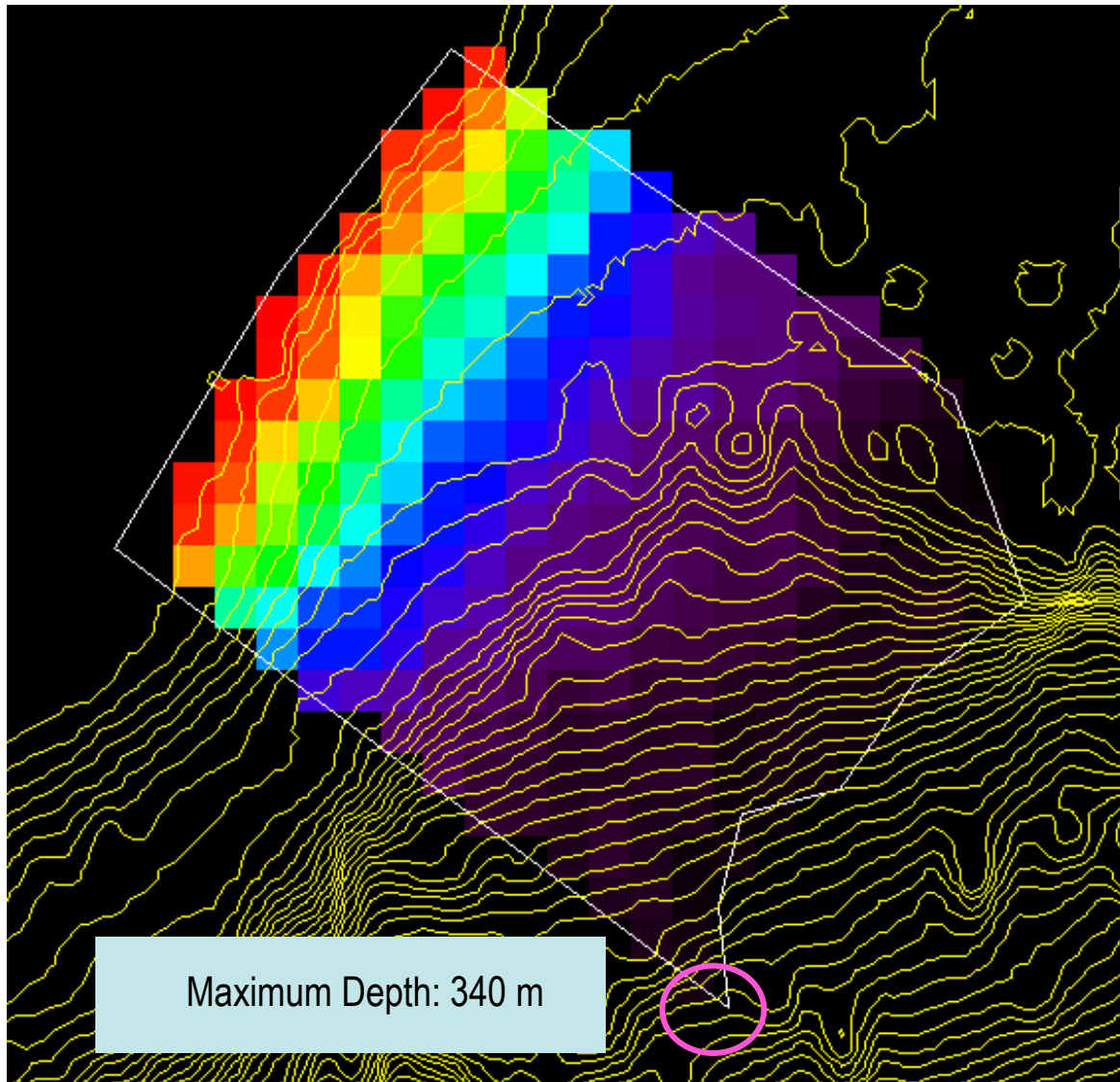


ND (Número Digital)
DN (Digital Number)

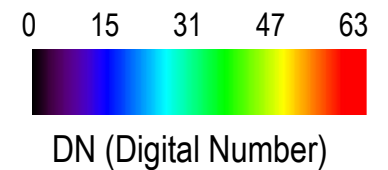
Barcelona



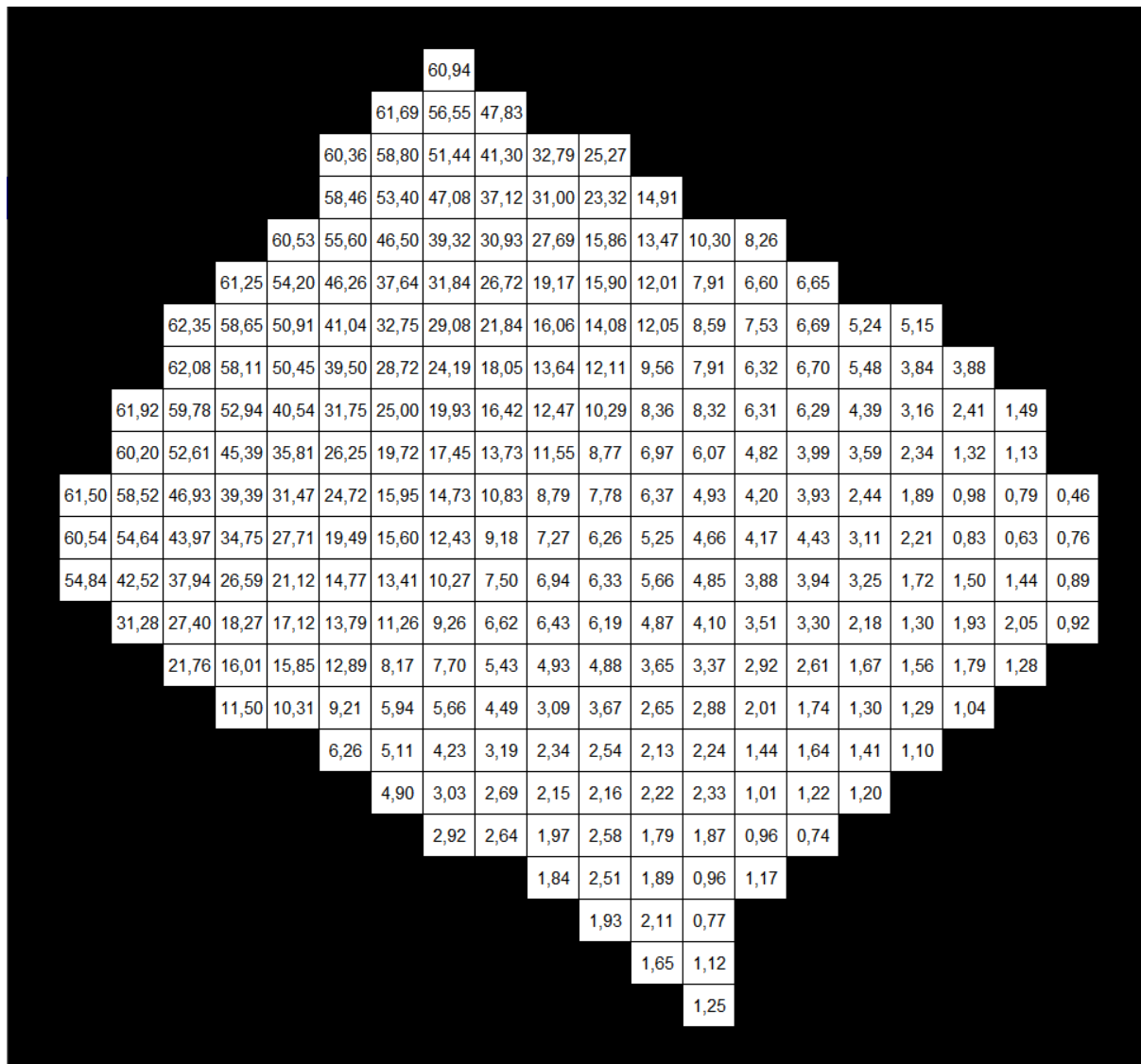
Barcelona



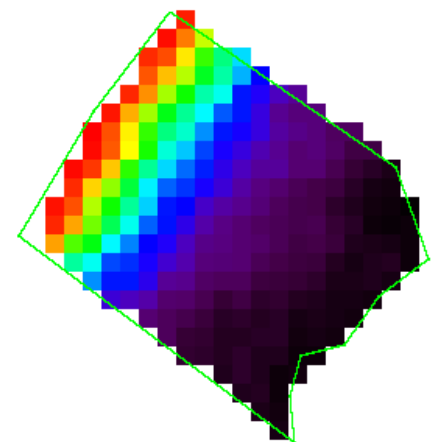
10 meters steps depth levels



Barcelona



Illuminated area DN
(Digital Number) pixels
values.



0 15 31 47 63



DN (Digital Number)

Cities Summary

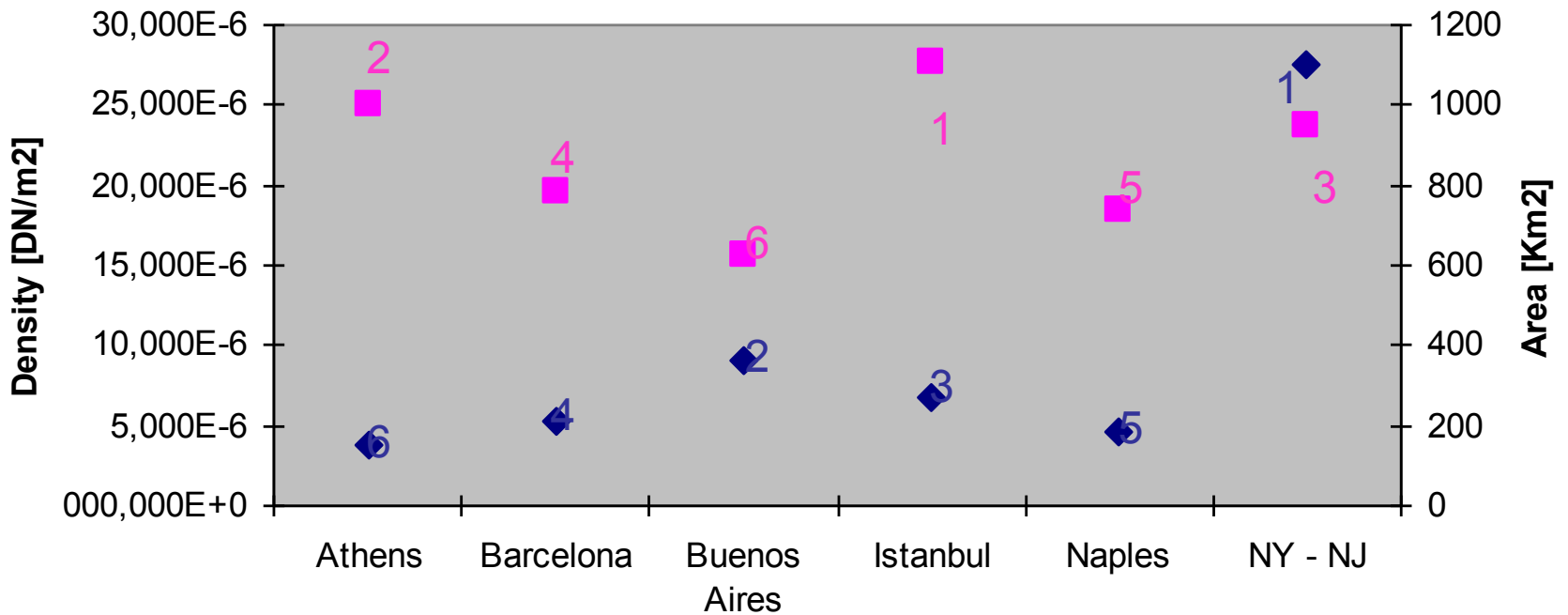
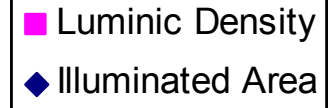
Luminic Density = DN Total Pixels / Illuminated Area



City	Area (Km2)	Penetration (Km)	Depth (m)	Total Illuminated Area		Luminic Density	
				DN	Radiancia Radiance	DN	Radiancia Radiance
Naples	187	19	375	3450,96	1,98552E-06	18,454E-6	10,618E-15
Athens	152	17,7	95	3806,03	2,39083E-06	25,040E-6	15,729E-15
Buenos Aires	365	25	2	5709,14	2,95301E-06	15,641E-6	8,090E-15
Barcelona	213	17	340	4191,00	2,43122E-06	19,676E-6	11,414E-15
Istanbul	273	23,3	1240	7551,75	4,91549E-06	27,662E-6	18,005E-15
New York – New Jersey	1104	32,3	30	23231,38	15,70014E-06	23,760E-6	14,285E-15

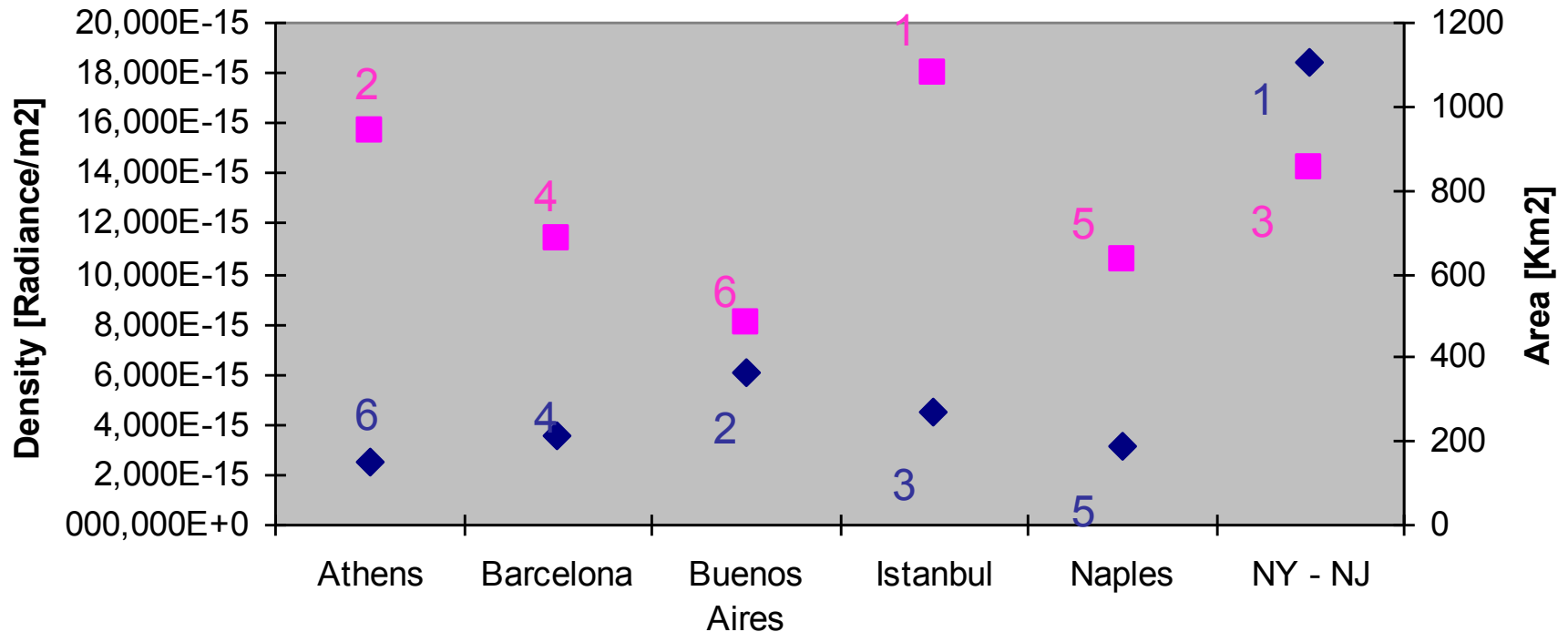
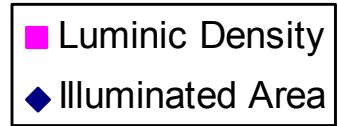
DN Cities Summary Chart

Luminic Density / Illuminated Area



Radiance Cities Summary Chart

Luminic Density - Illuminated Area



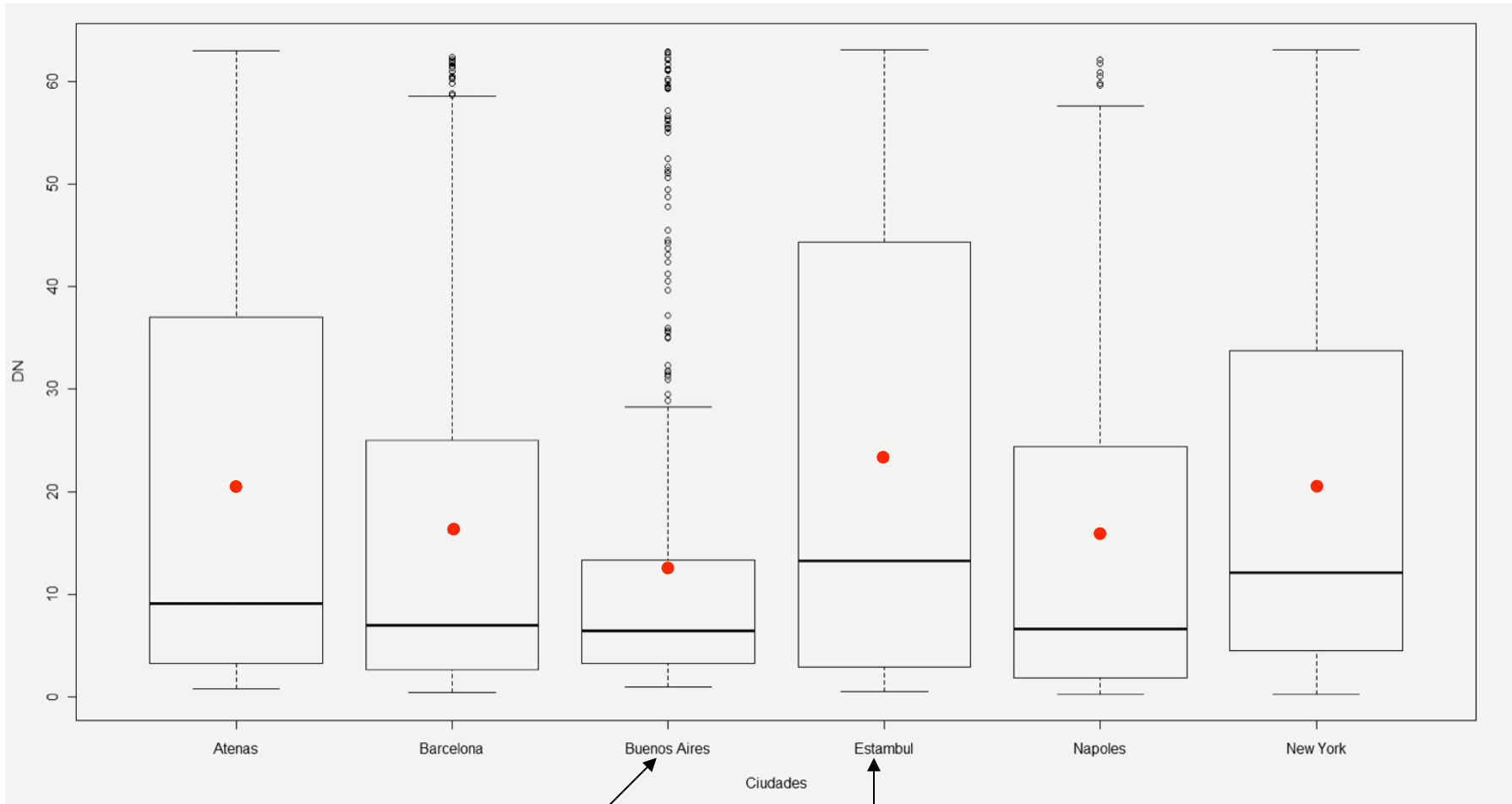
Illuminated Area Interpretation DN and Radiance Luminic Density.

On previous charts can be noticed:

1. Buenos Aires has the lesser average luminic density with a large polluted area.
2. Istambul followed by Athens and New York/ New Jersey areas have the highest average luminic density but emphasizing that New York / New Jersey area is very large in surface, about 4 times the second area in importance (in comparison with Buenos Aires).

Cities Summary.

Box Plot. DN Data.

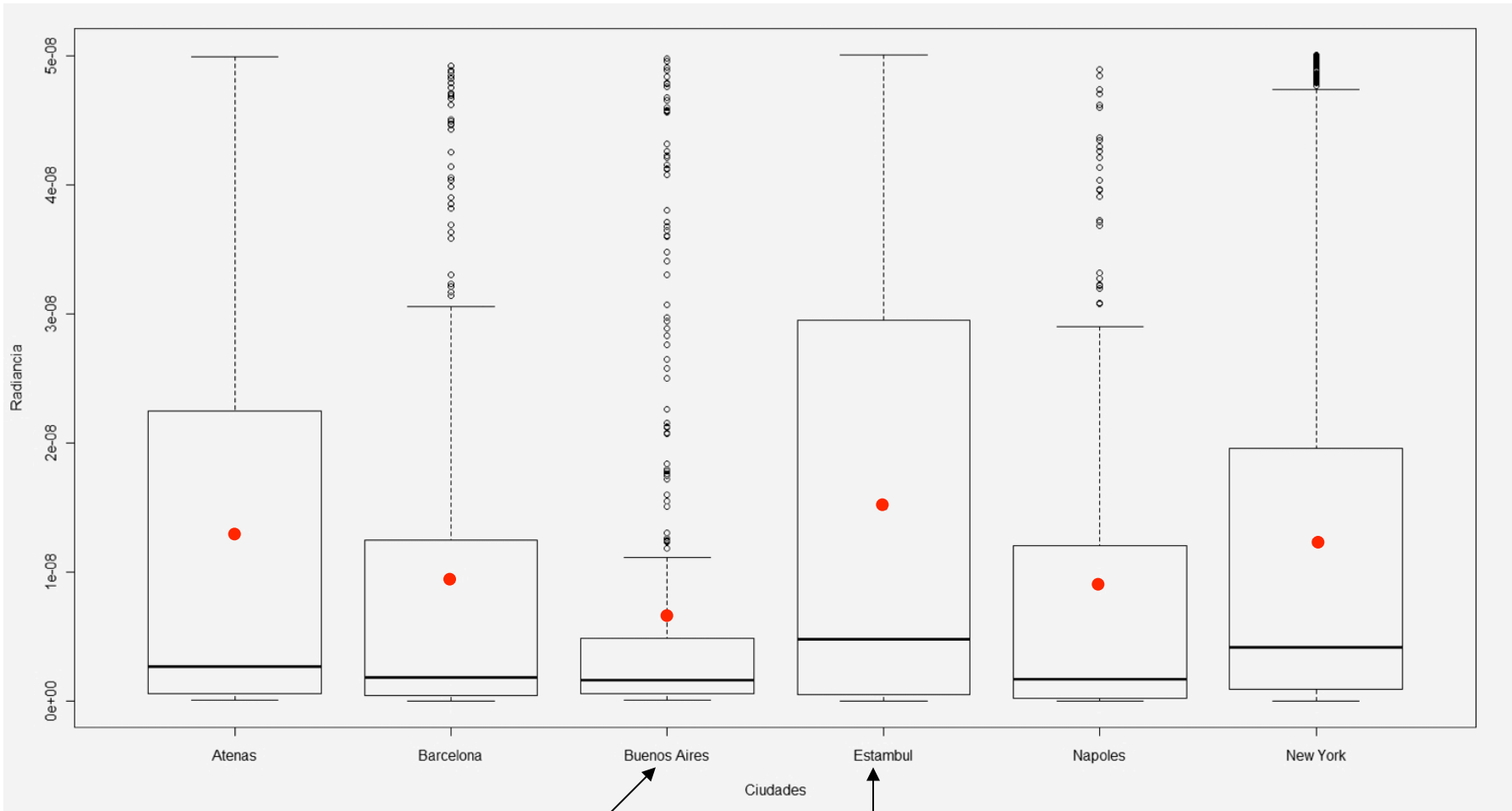


Lesser dispersion with low values and large quantity of outliers (atypical values).

Greater dispersion with high values and outliers absence (atypical values).

Cities Summary.

Box Plot. Radiance Data.

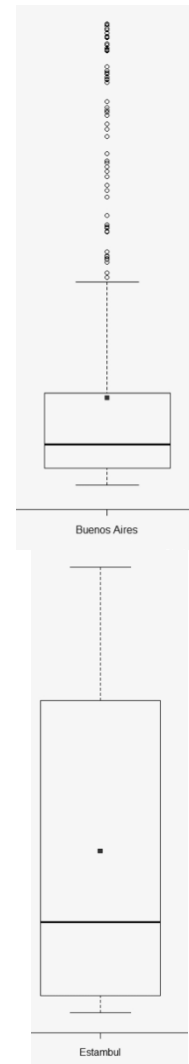


Lesser dispersion with low values and large quantity of outliers (atypical values).

Greater dispersion with high values and outliers absence (atypical values).

Box Plot Interpretation

1. Buenos Aires DN have the lowest dispersion and small values, indicating that the satellite receives less energy in that area; despite being the one with a significant number of outliers. Lesser dispersion with low values and large quantity of outliers (atypical values).
2. Istanbul DN have large dispersion and higher values (no outliers are observed in the distribution). Greater dispersion with high values and outliers absence (atypical values).



Our research limits

1. Our target is to research with satellite images the possible light pollution over coastal lines of shoreline large cities.
2. We are not marine biologist.
3. We will try to work all our data in the near future with marine biologists.

Fin

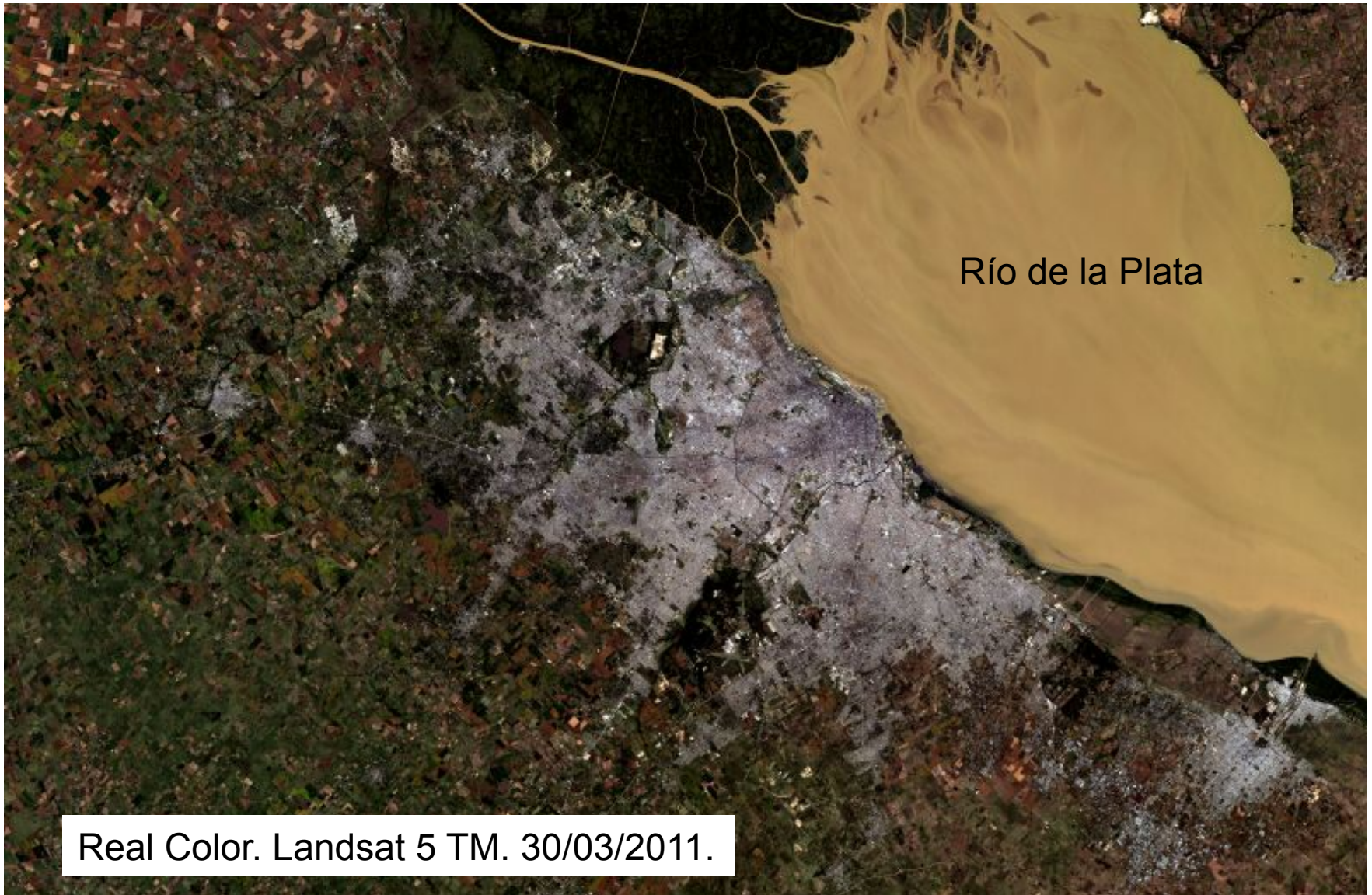
Polución Marina (en inglés)

Es la alteración nociva del estado natural de un medio como consecuencia de la introducción de un agente totalmente ajeno a ese medio (contaminante), causando inestabilidad, desorden, daño o malestar en un ecosistema, en un medio físico o en un ser vivo.

El contaminante puede ser una sustancia química, energía (como sonido, calor, o luz), o incluso genes. A veces el contaminante es una sustancia extraña, o una forma de energía, y otras veces una sustancia natural.

Es siempre una alteración negativa del estado natural del medio, y por lo general, se genera como consecuencia de la actividad humana considerándose una forma de impacto ambiental.

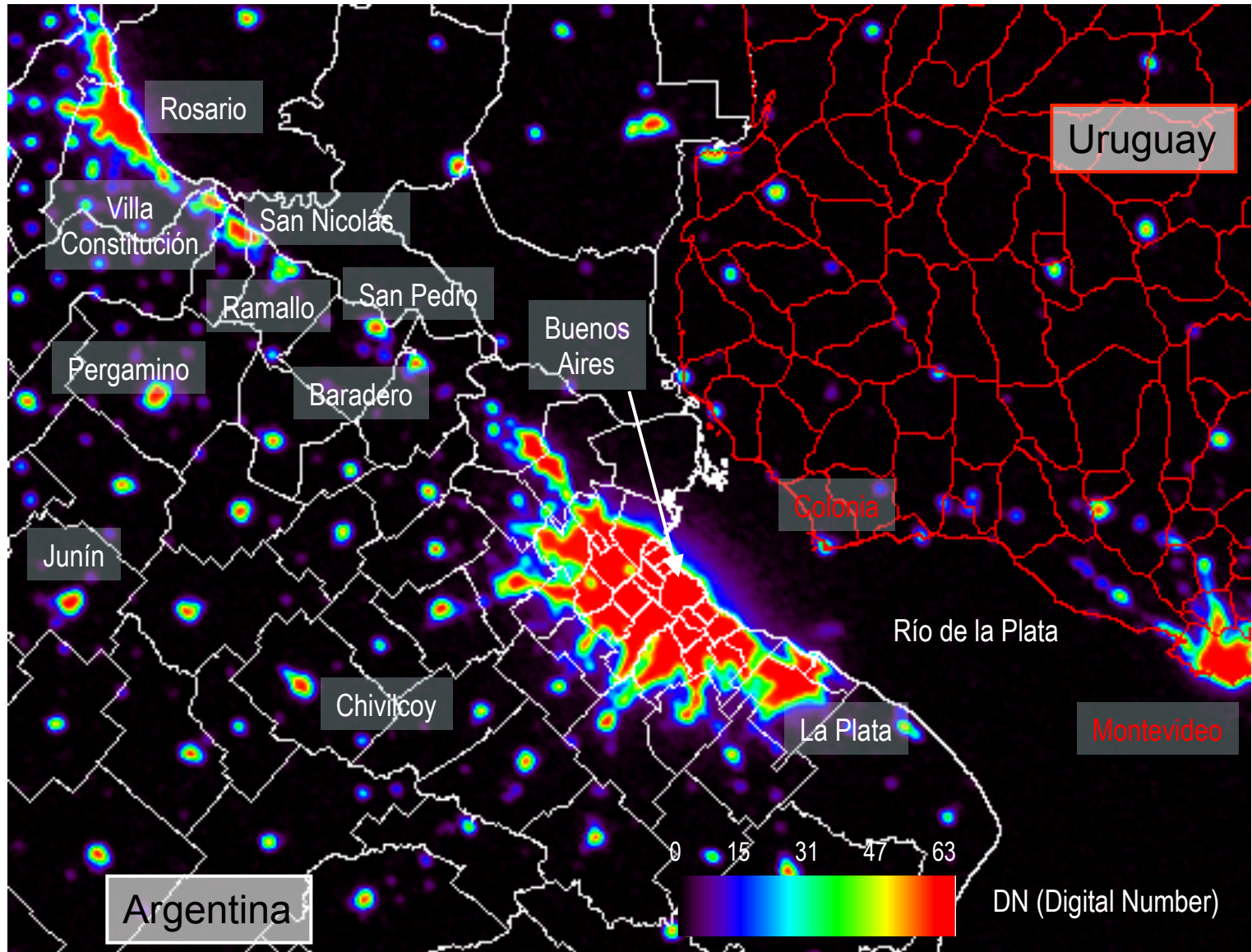
Buenos Aires



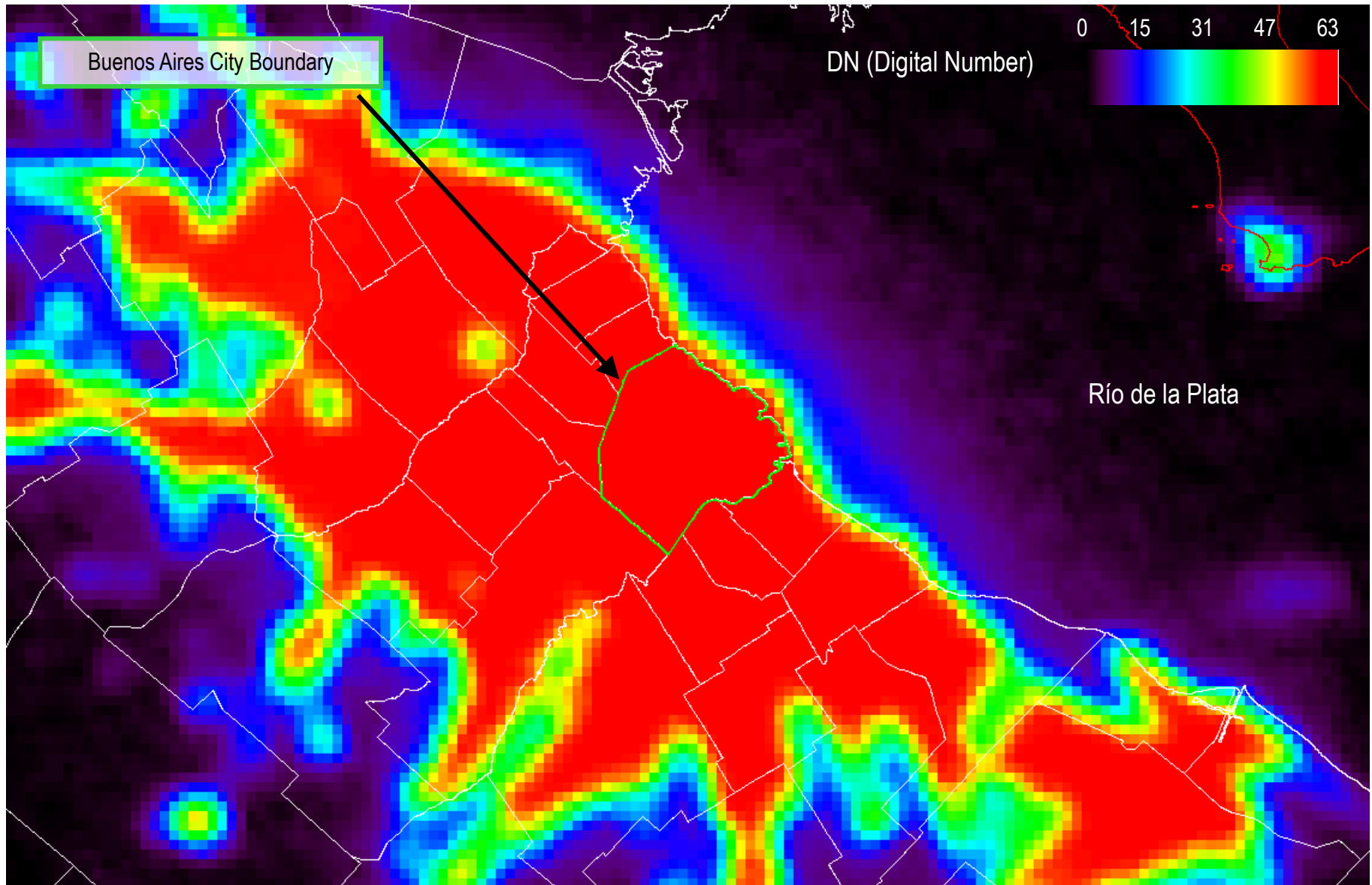
Río de la Plata

Real Color. Landsat 5 TM. 30/03/2011.

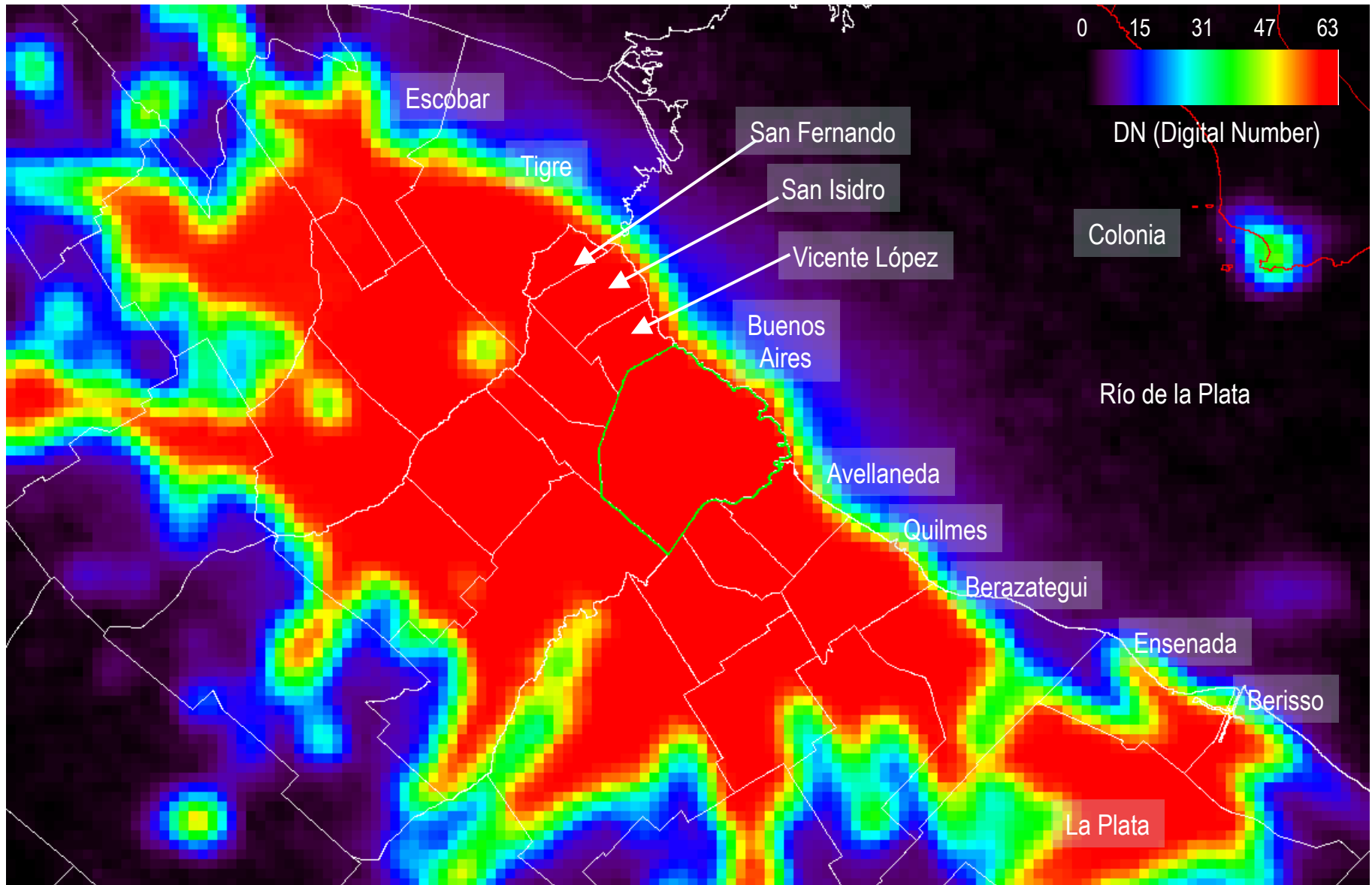
Buenos Aires



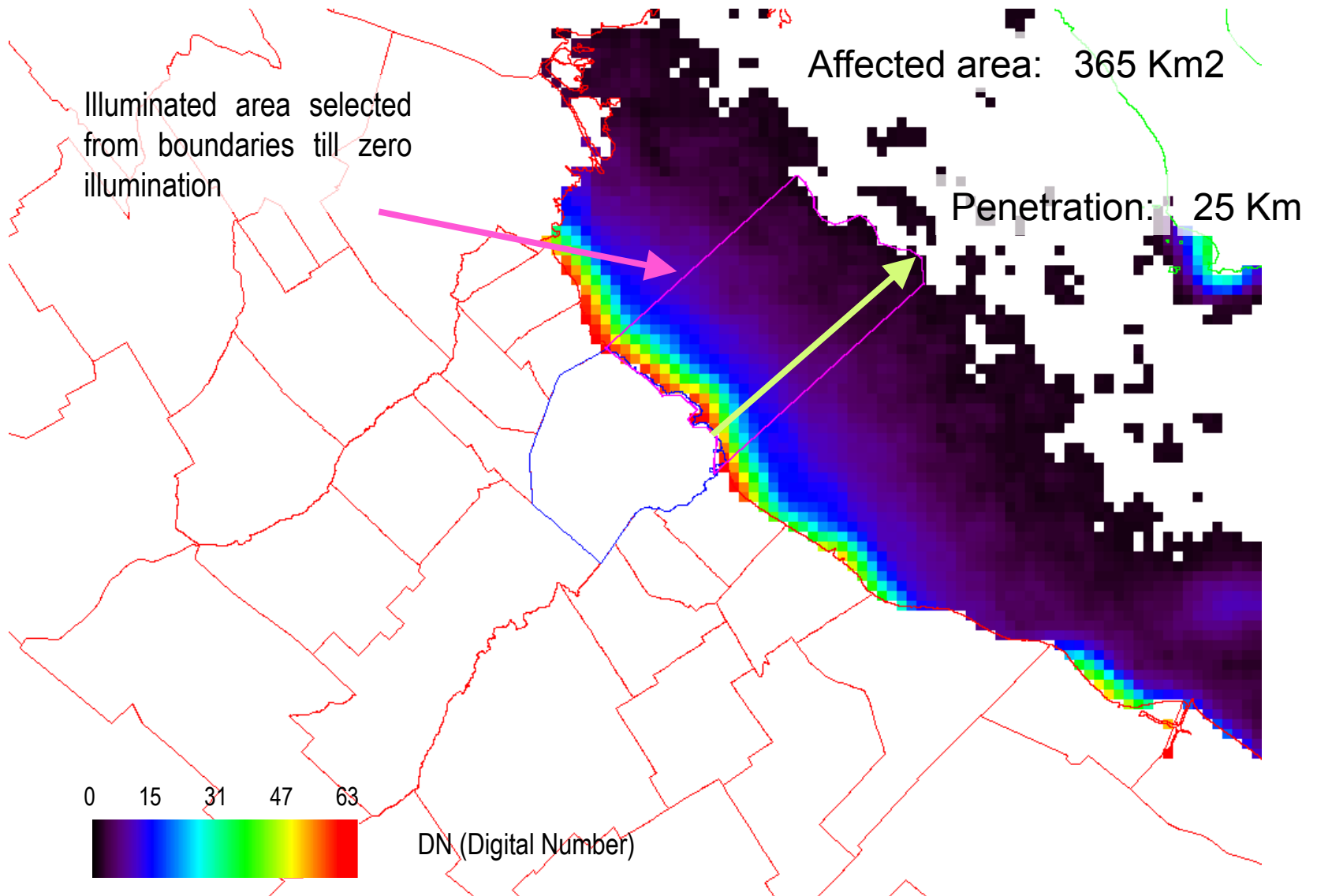
Buenos Aires



Buenos Aires

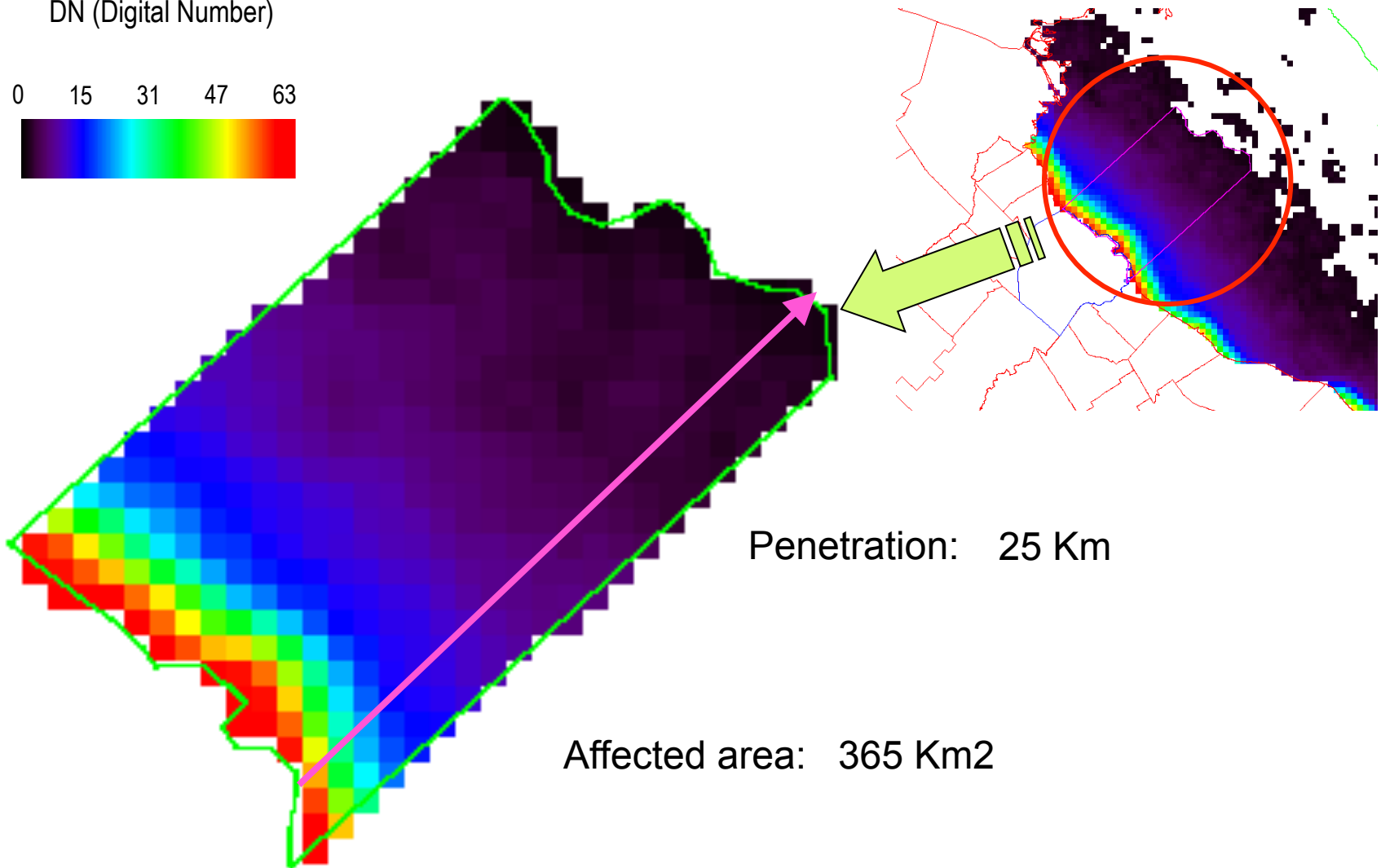
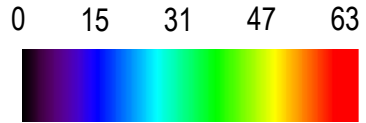


Buenos Aires



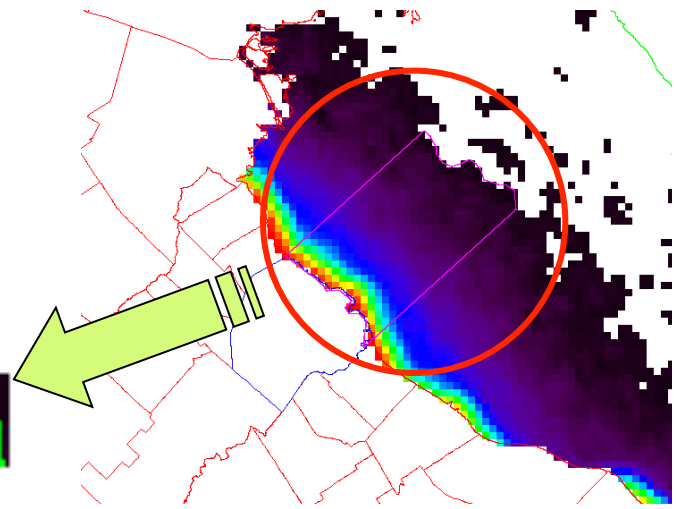
Buenos Aires

DN (Digital Number)

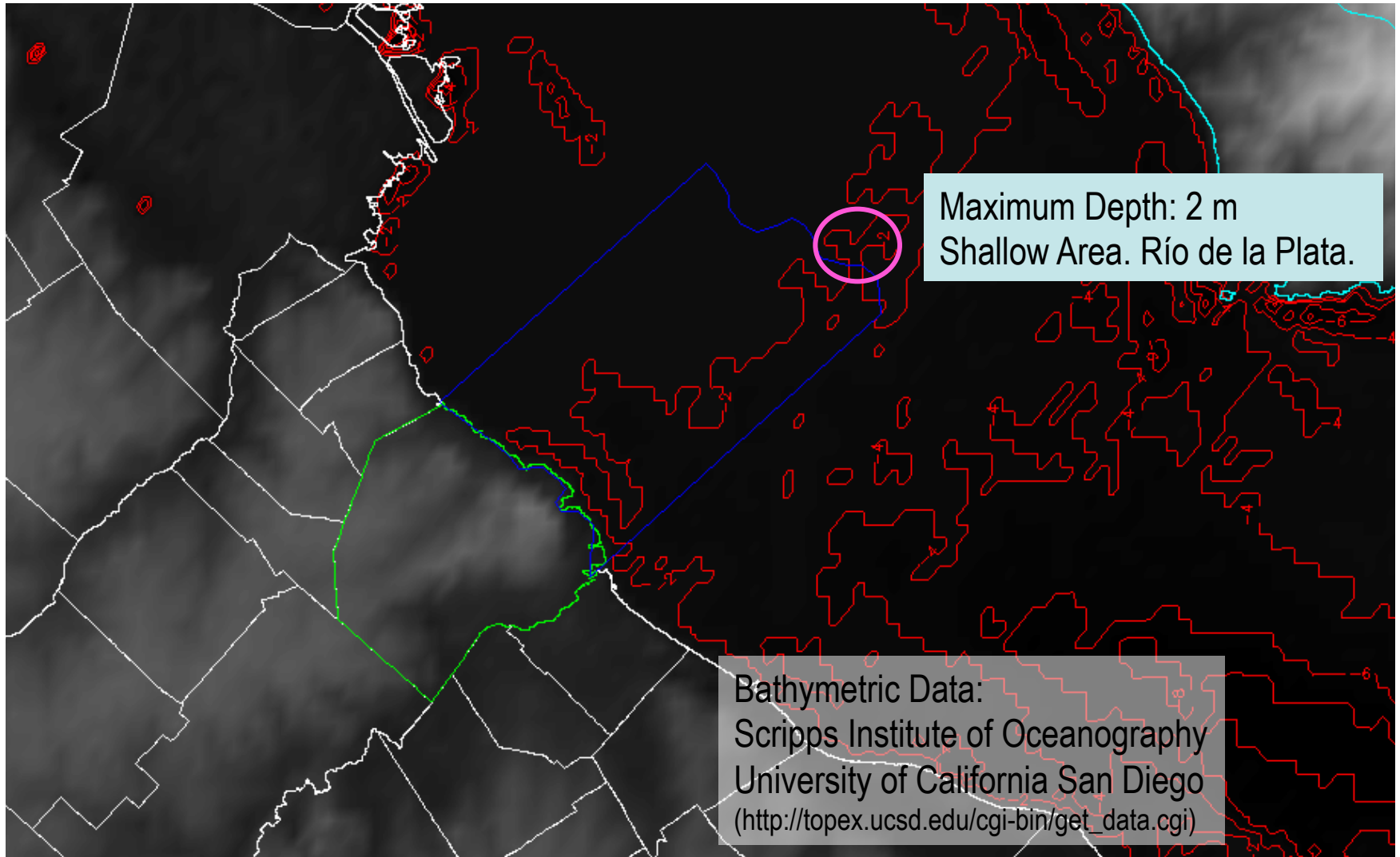


Penetration: 25 Km

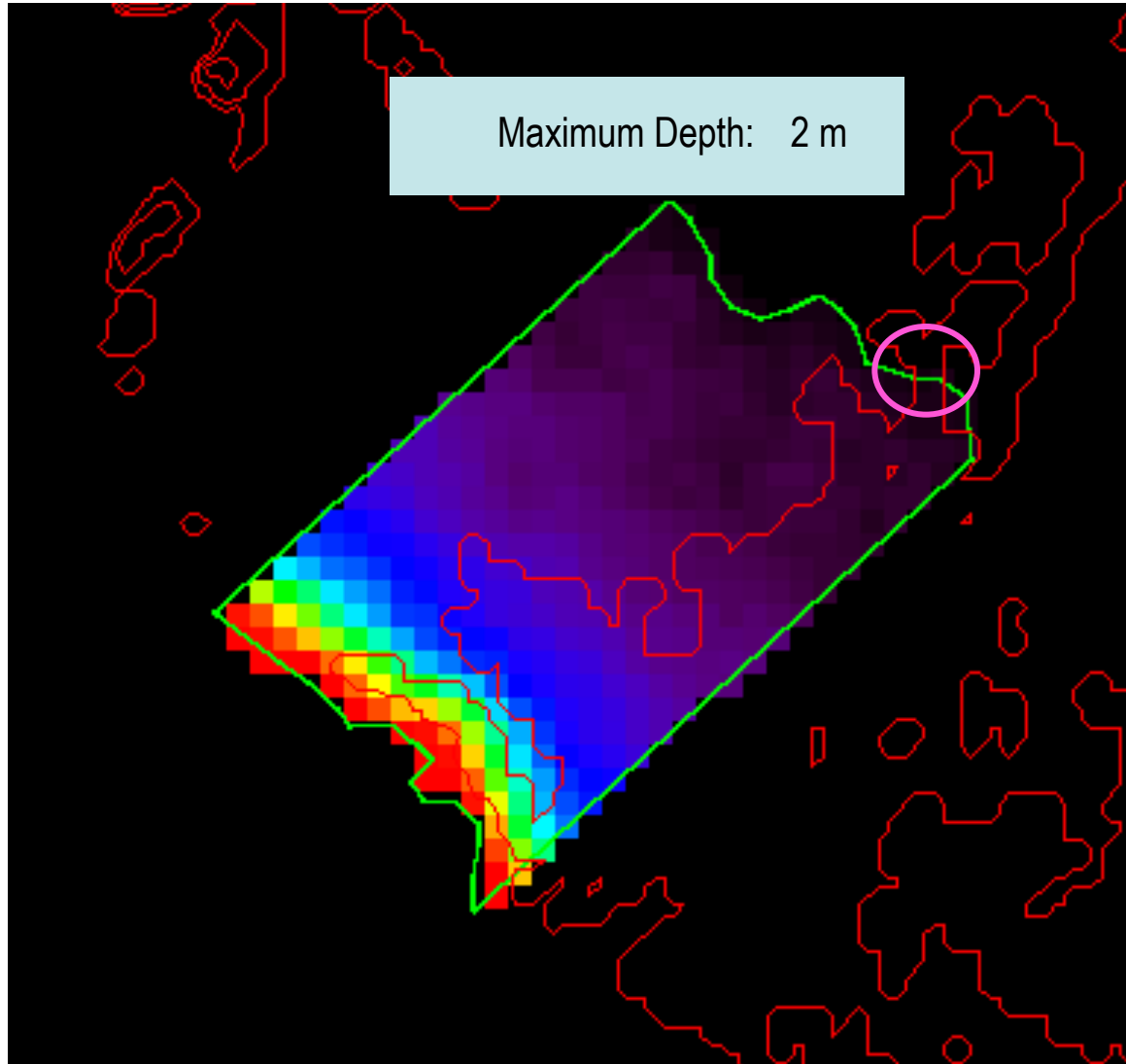
Affected area: 365 Km²



Buenos Aires



Buenos Aires



2 meters steps depth levels

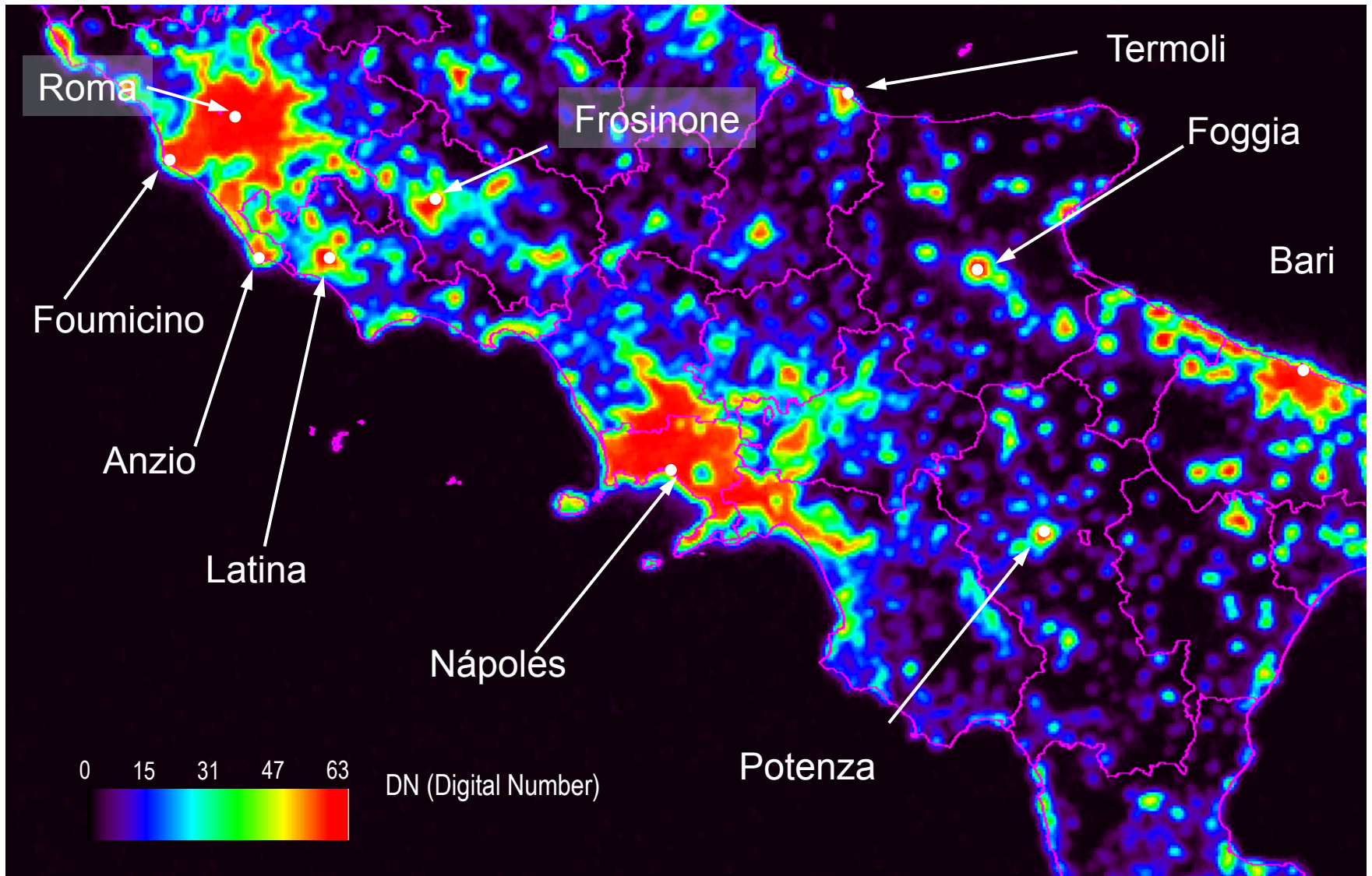
DN (Digital Number)



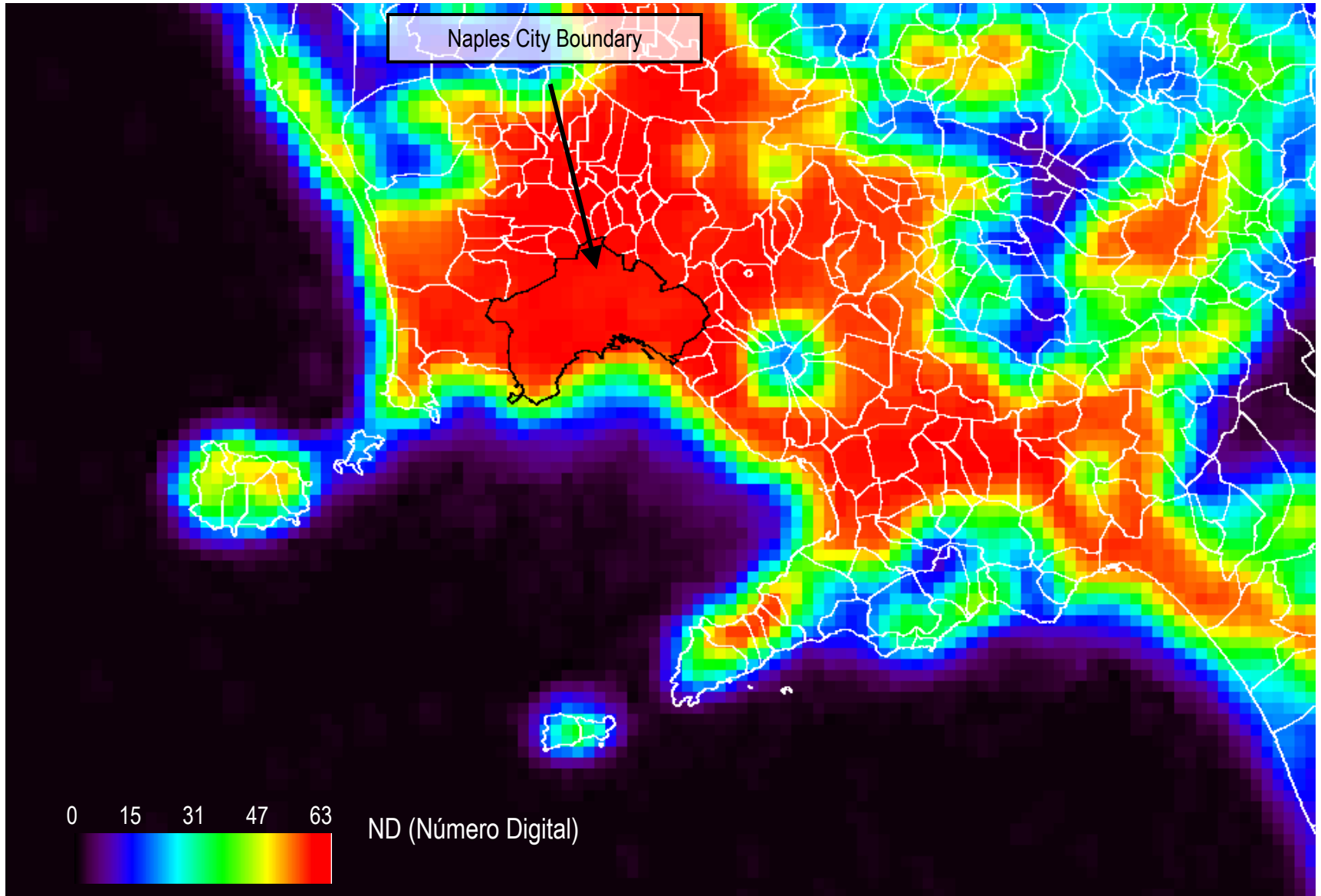
Naples



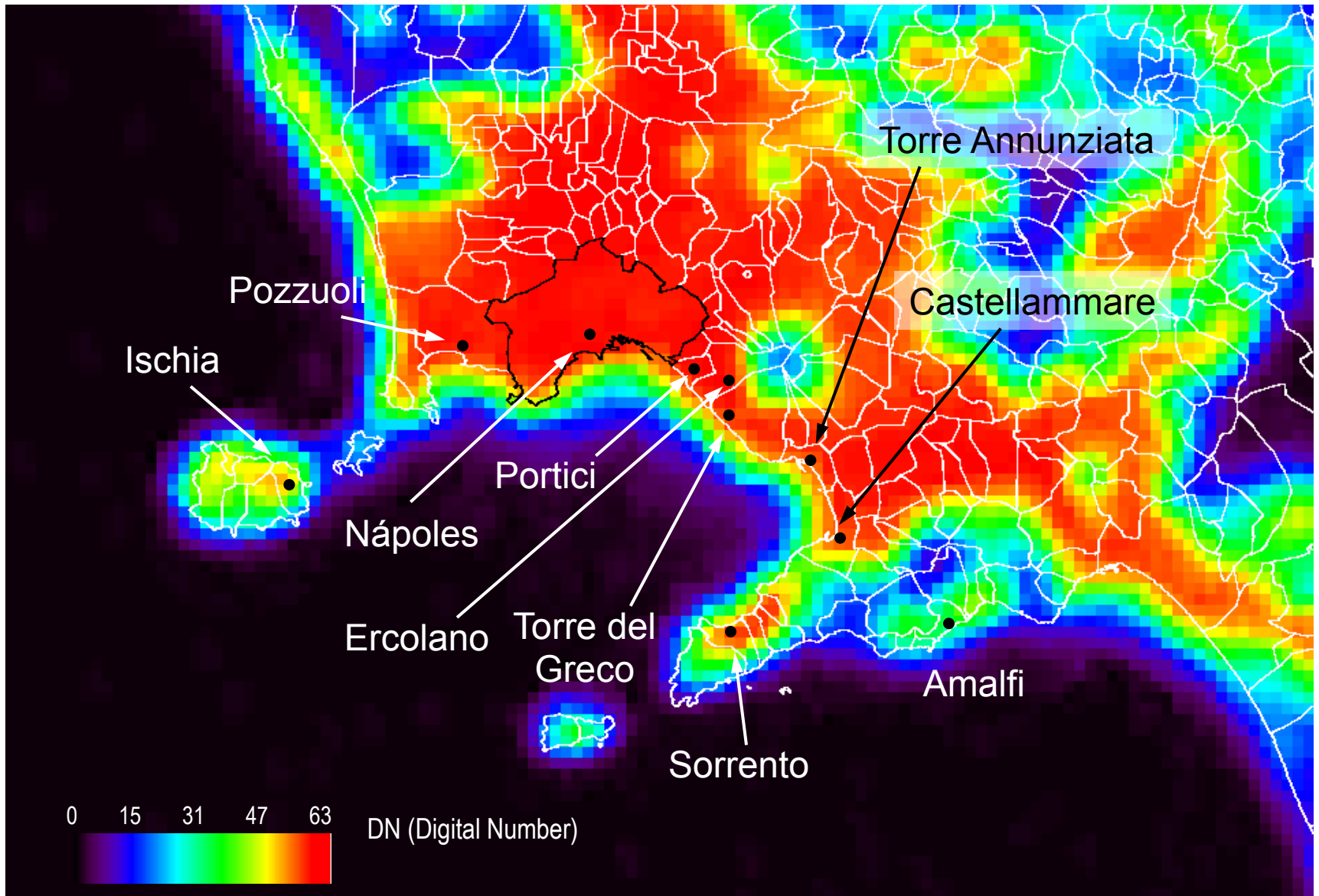
Naples



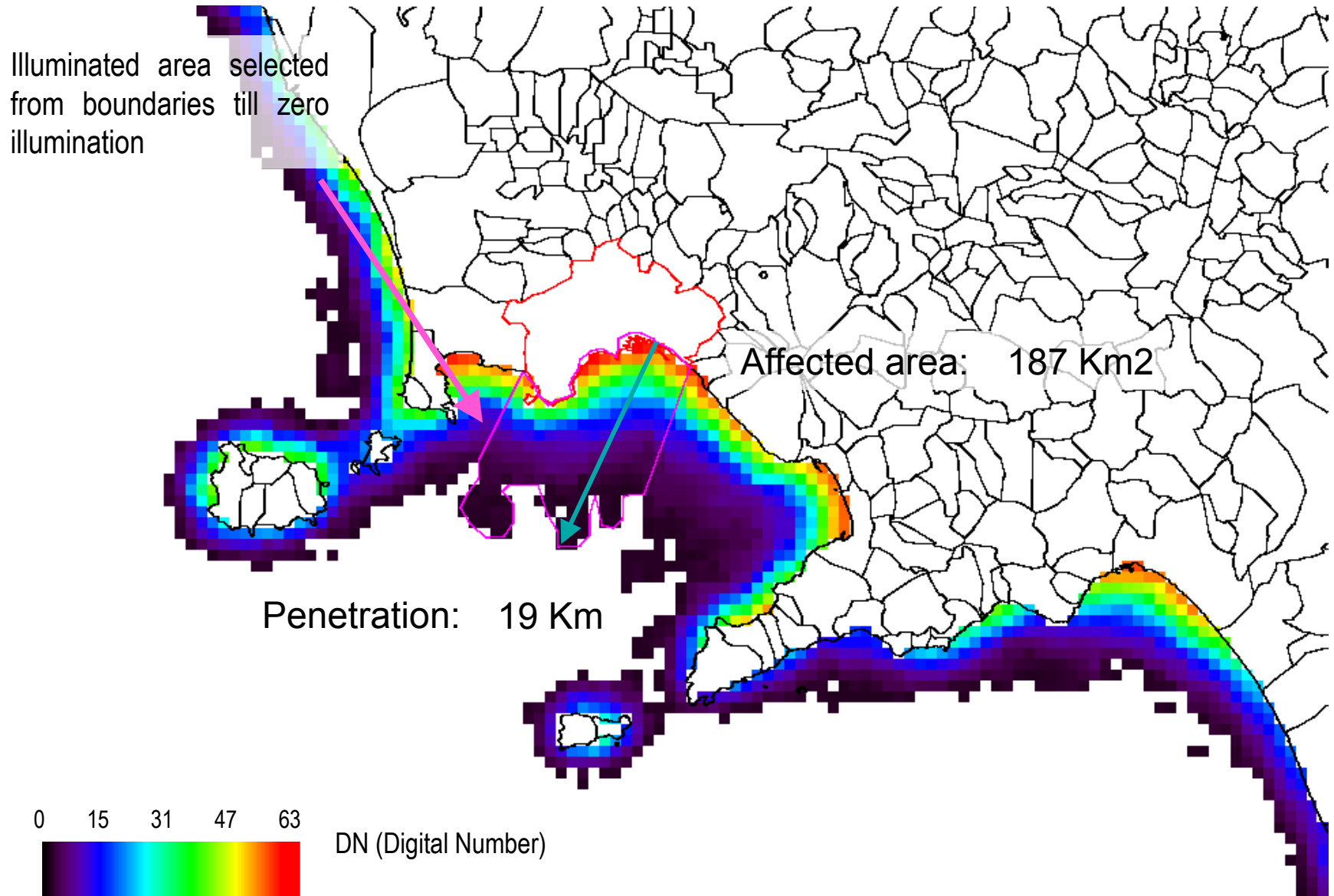
Naples



Naples



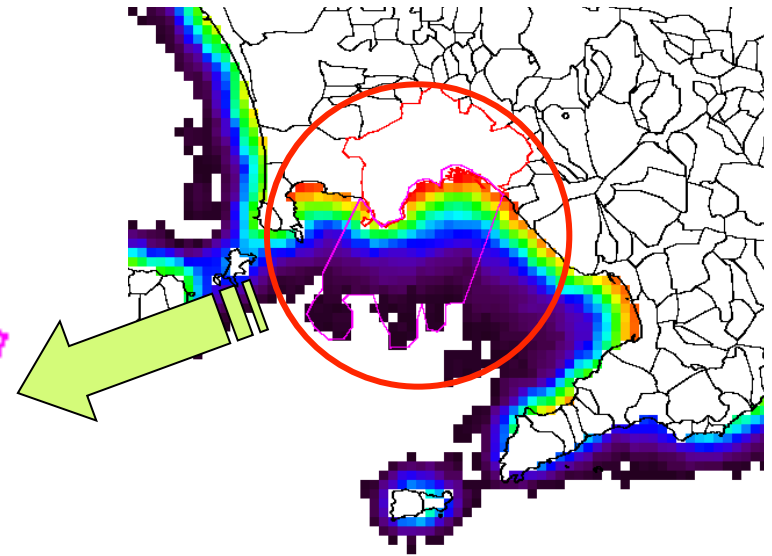
Naples



Naples

DN (Digital Number)

0 15 31 47 63

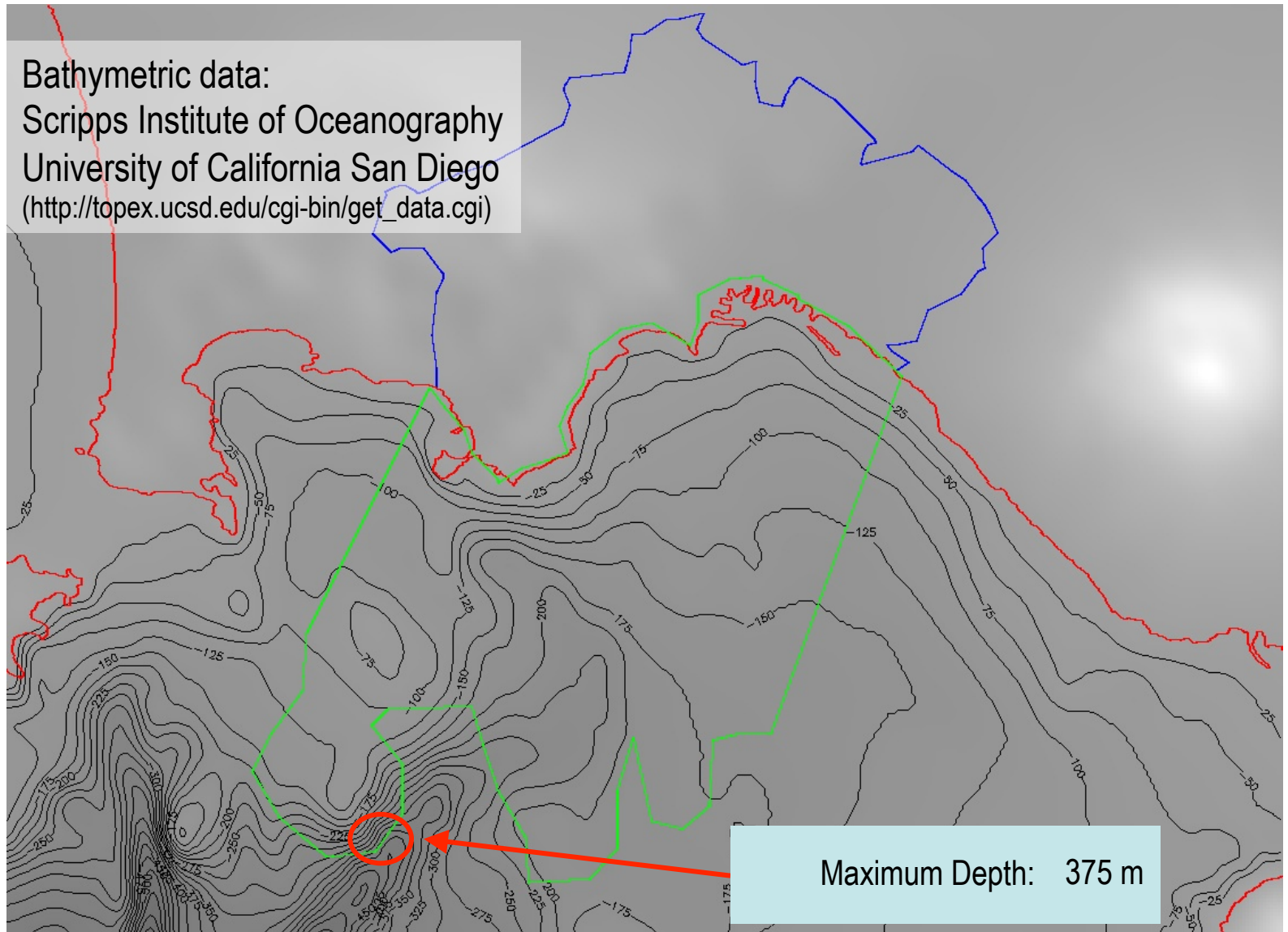


Affected area: 187 Km²

Penetration: 19 Km

Naples

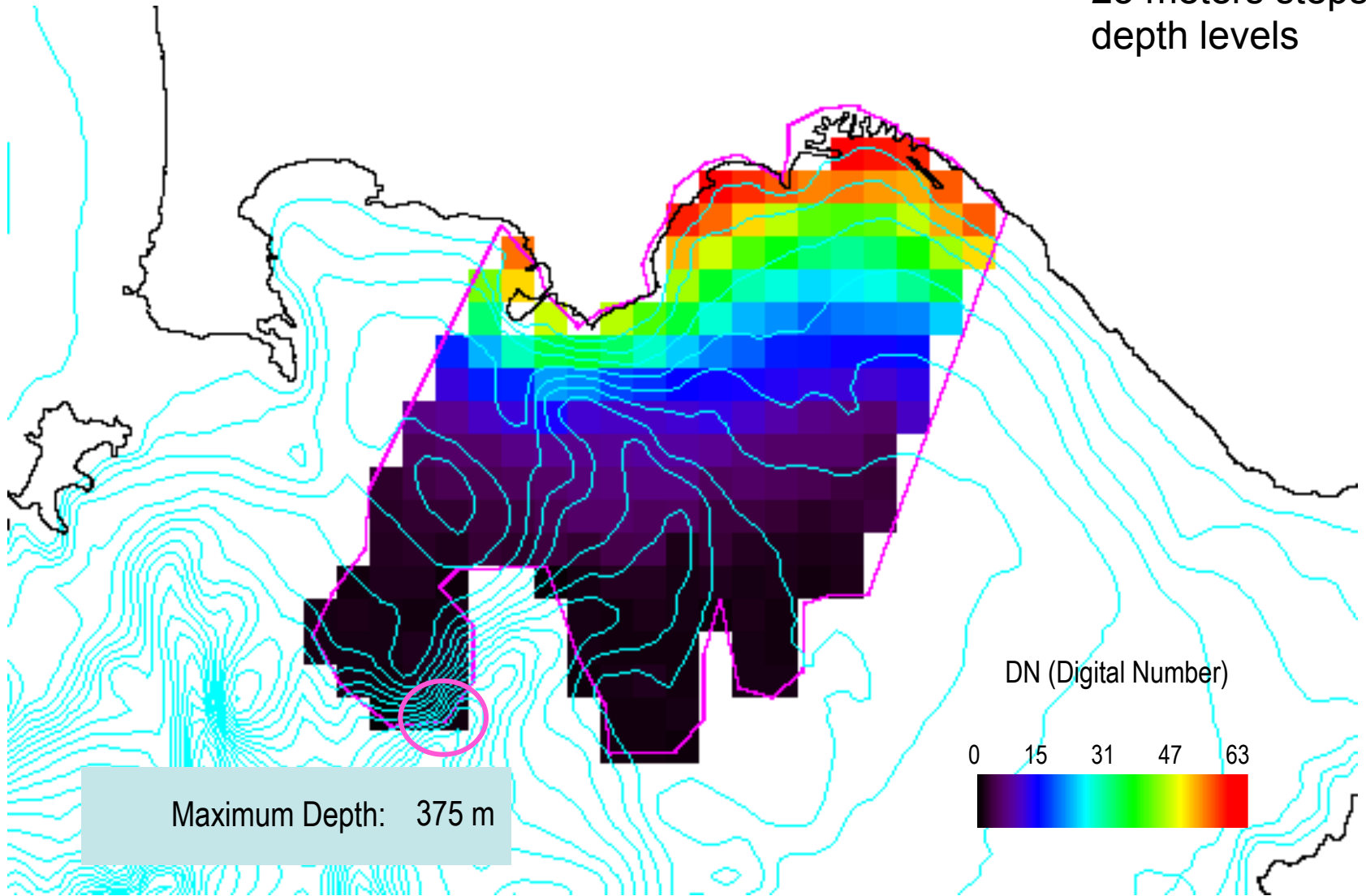
Bathymetric data:
Scripps Institute of Oceanography
University of California San Diego
(http://topex.ucsd.edu/cgi-bin/get_data.cgi)



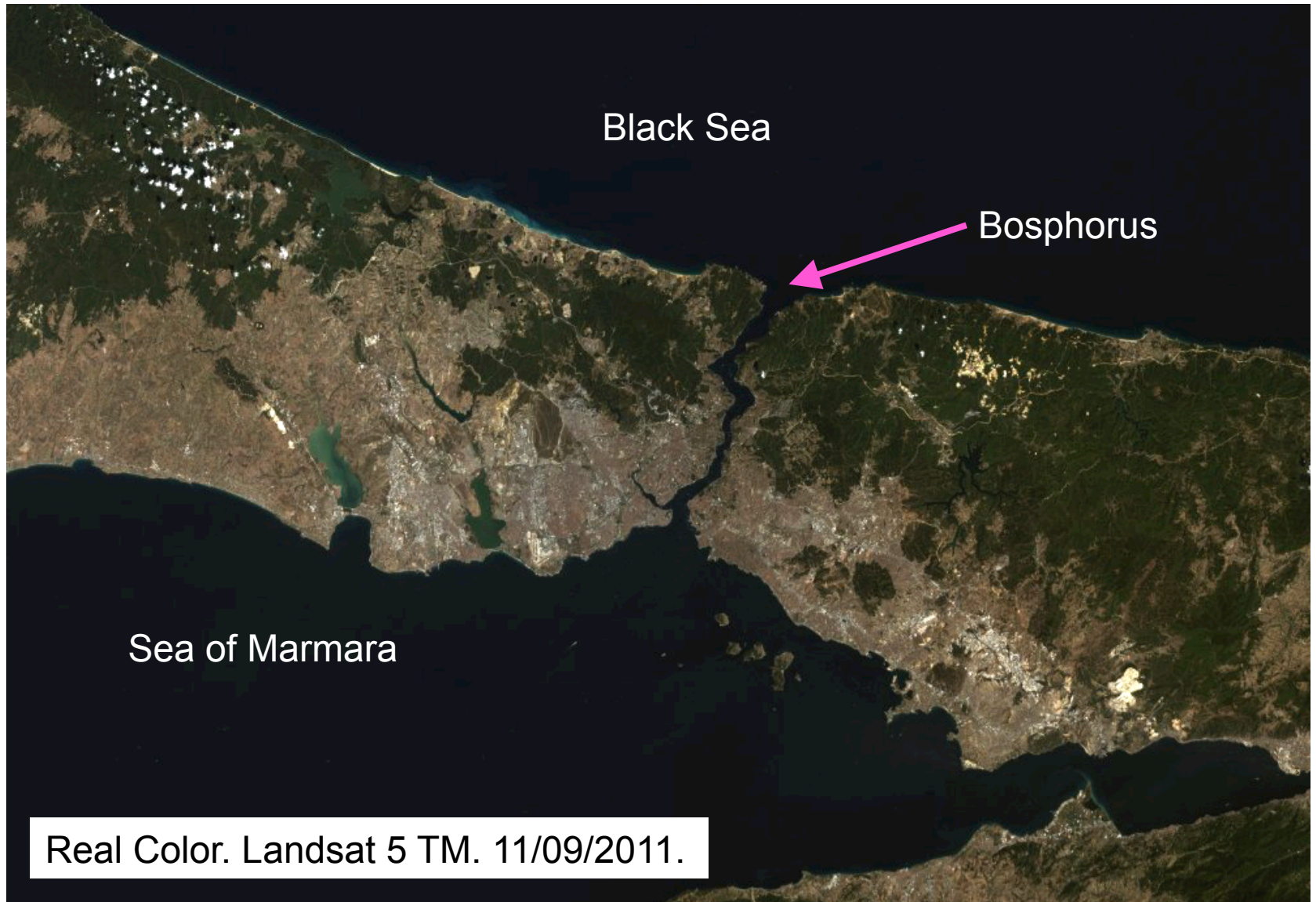
Maximum Depth: 375 m

Naples

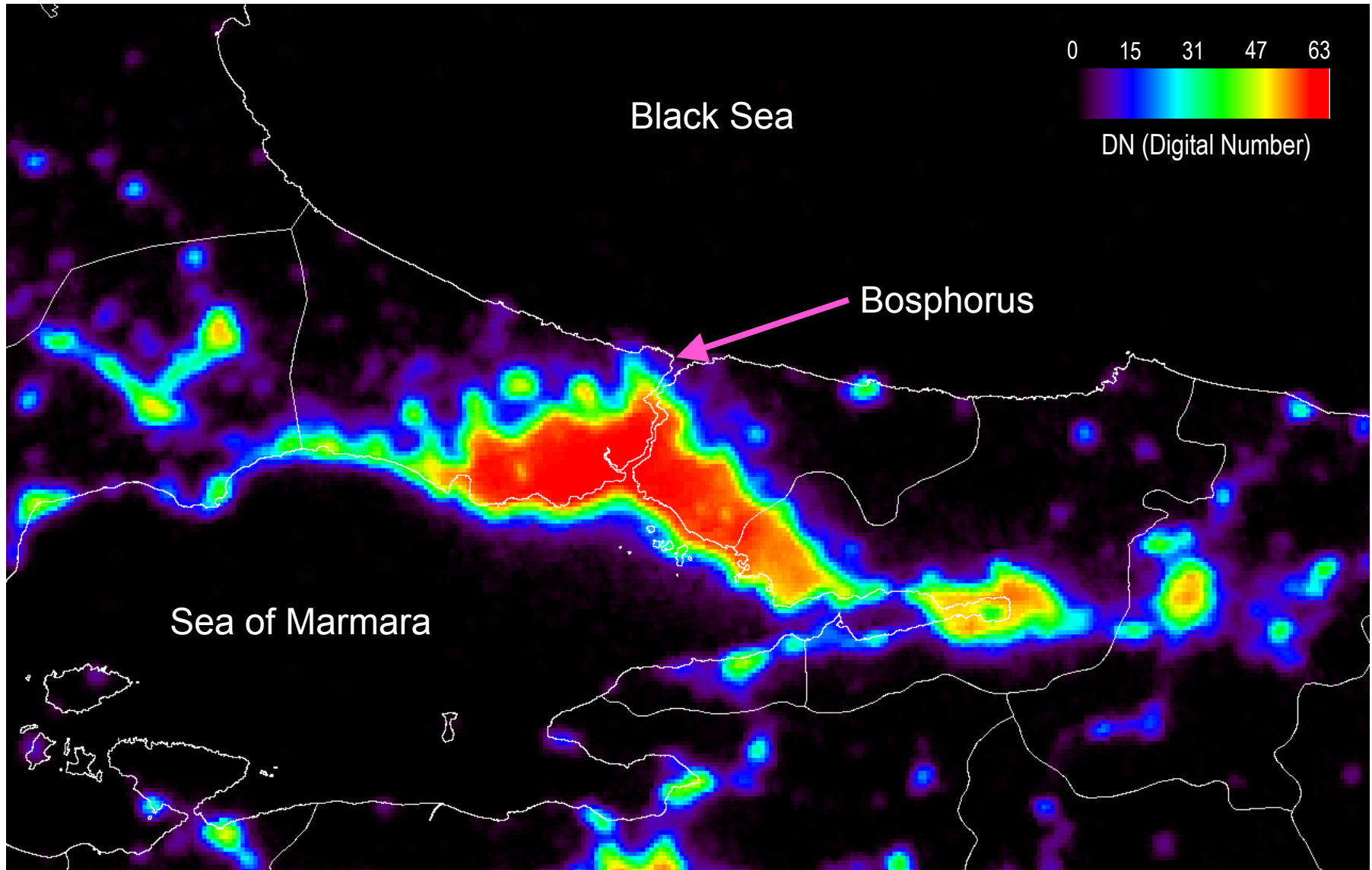
25 meters steps
depth levels



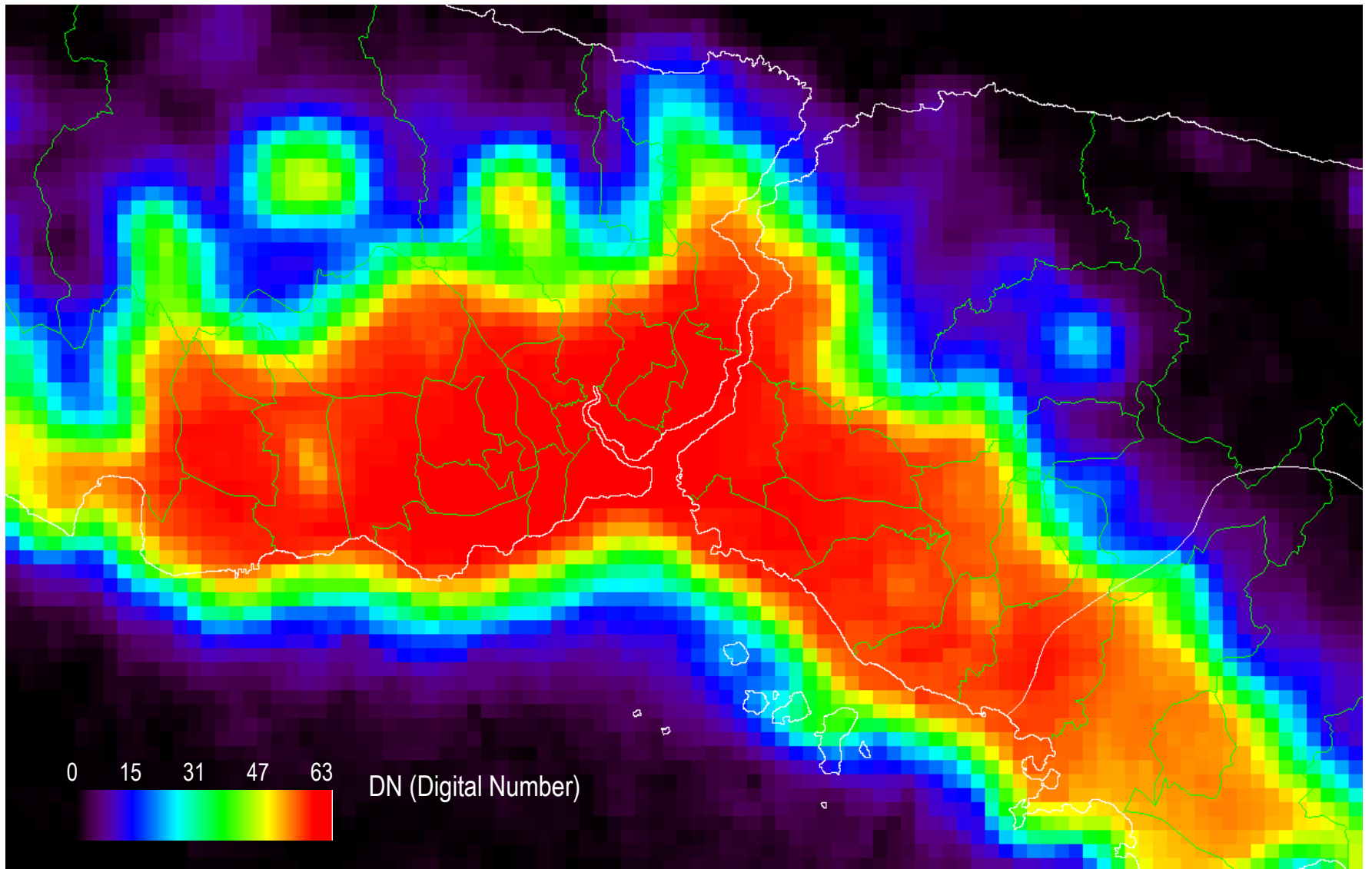
Istanbul



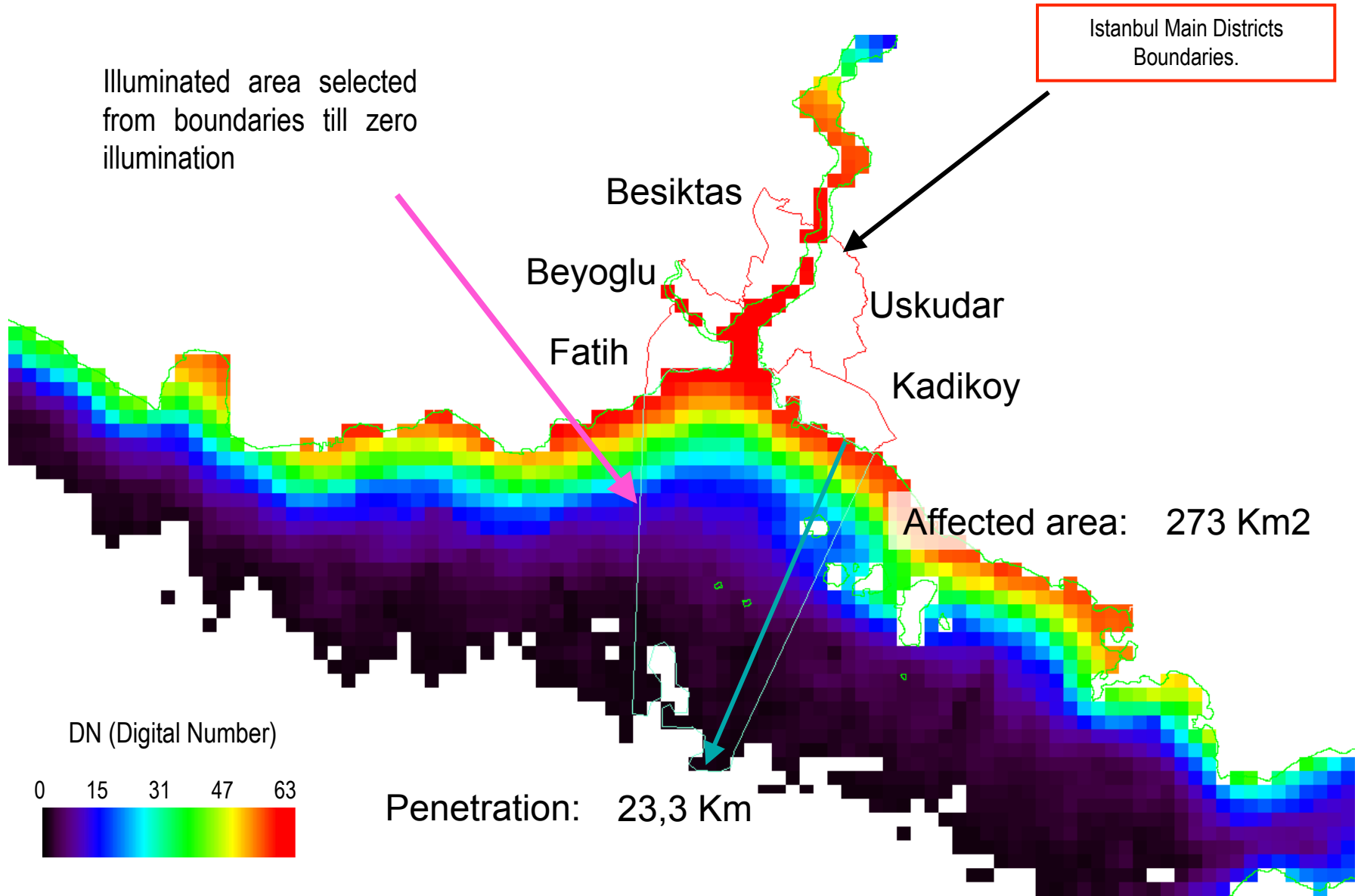
Istanbul



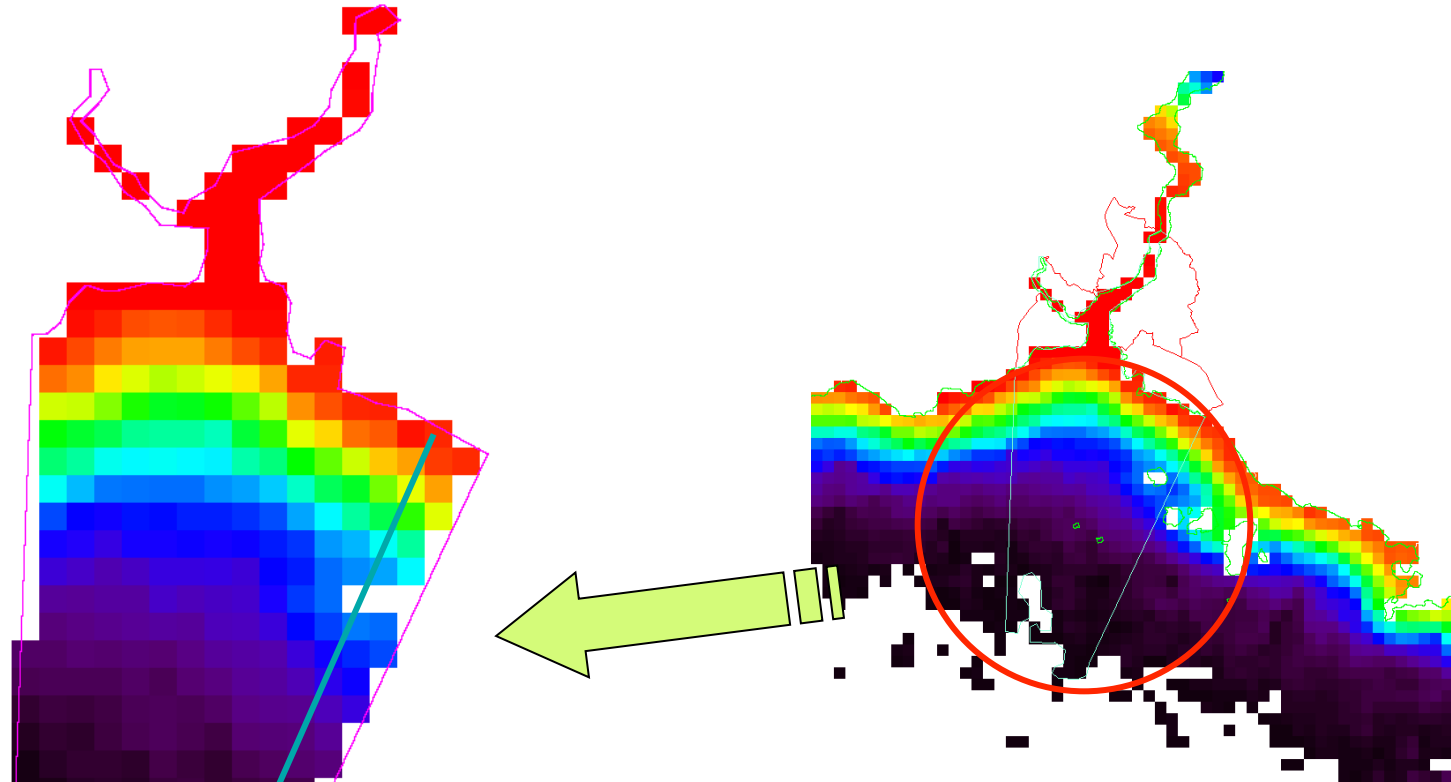
Istanbul



Istanbul



Istanbul



Affected area: 273 Km²

Penetration: 23,3 Km

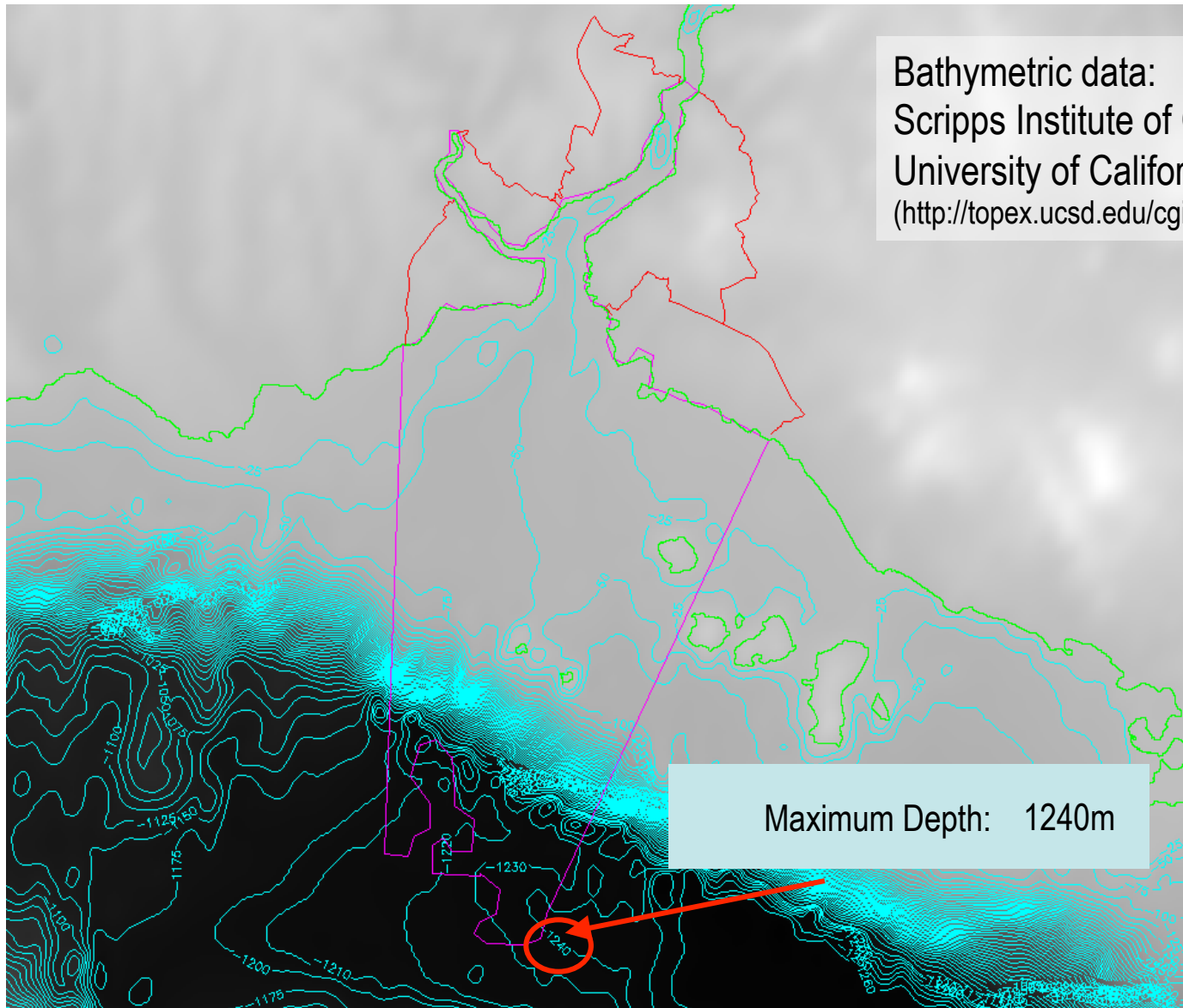
0 15 31 47 63



DN (Digital Number)

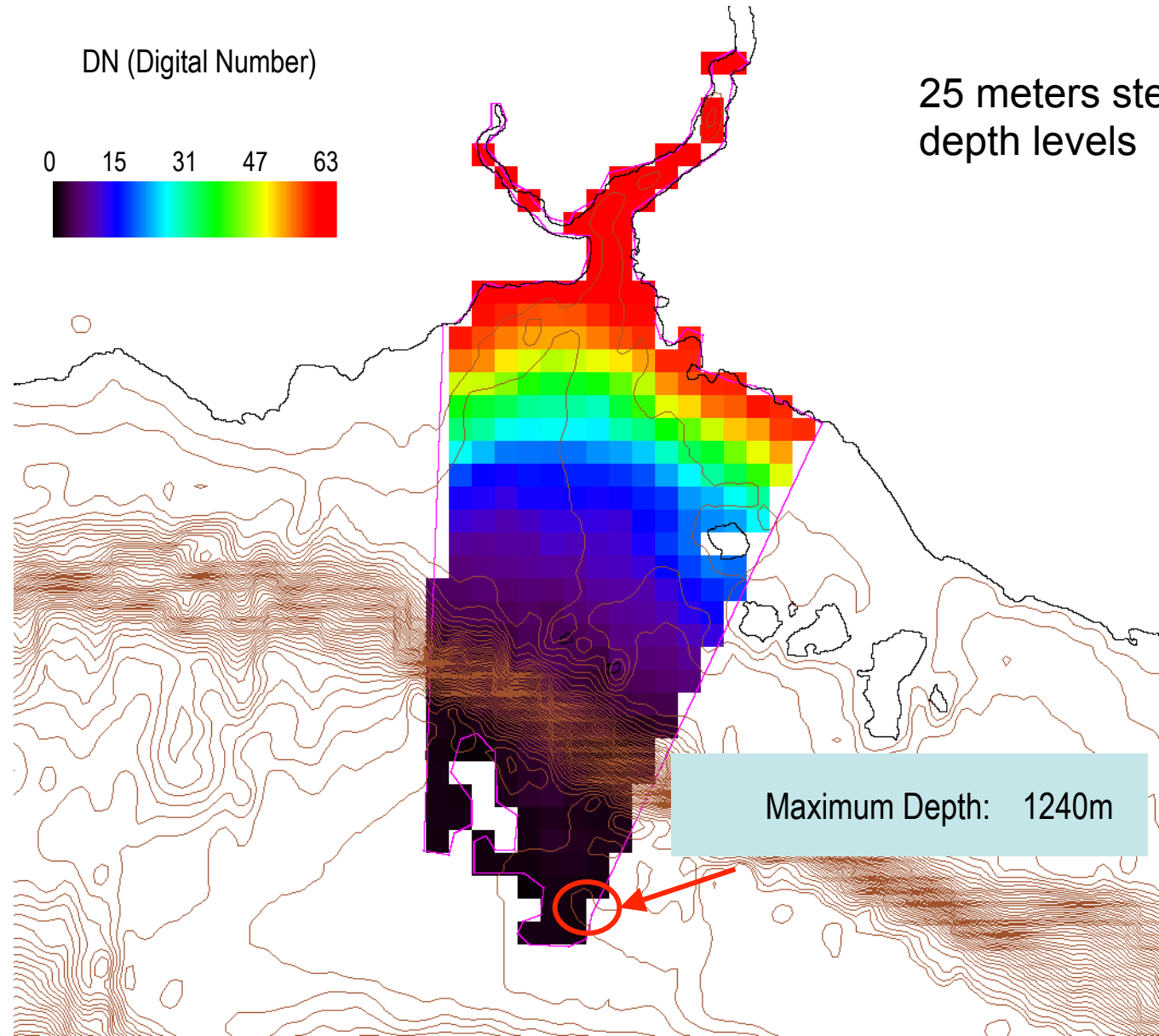
Istanbul

Bathymetric data:
Scripps Institute of Oceanography
University of California San Diego
(http://topex.ucsd.edu/cgi-bin/get_data.cgi)



Maximum Depth: 1240m

Istanbul

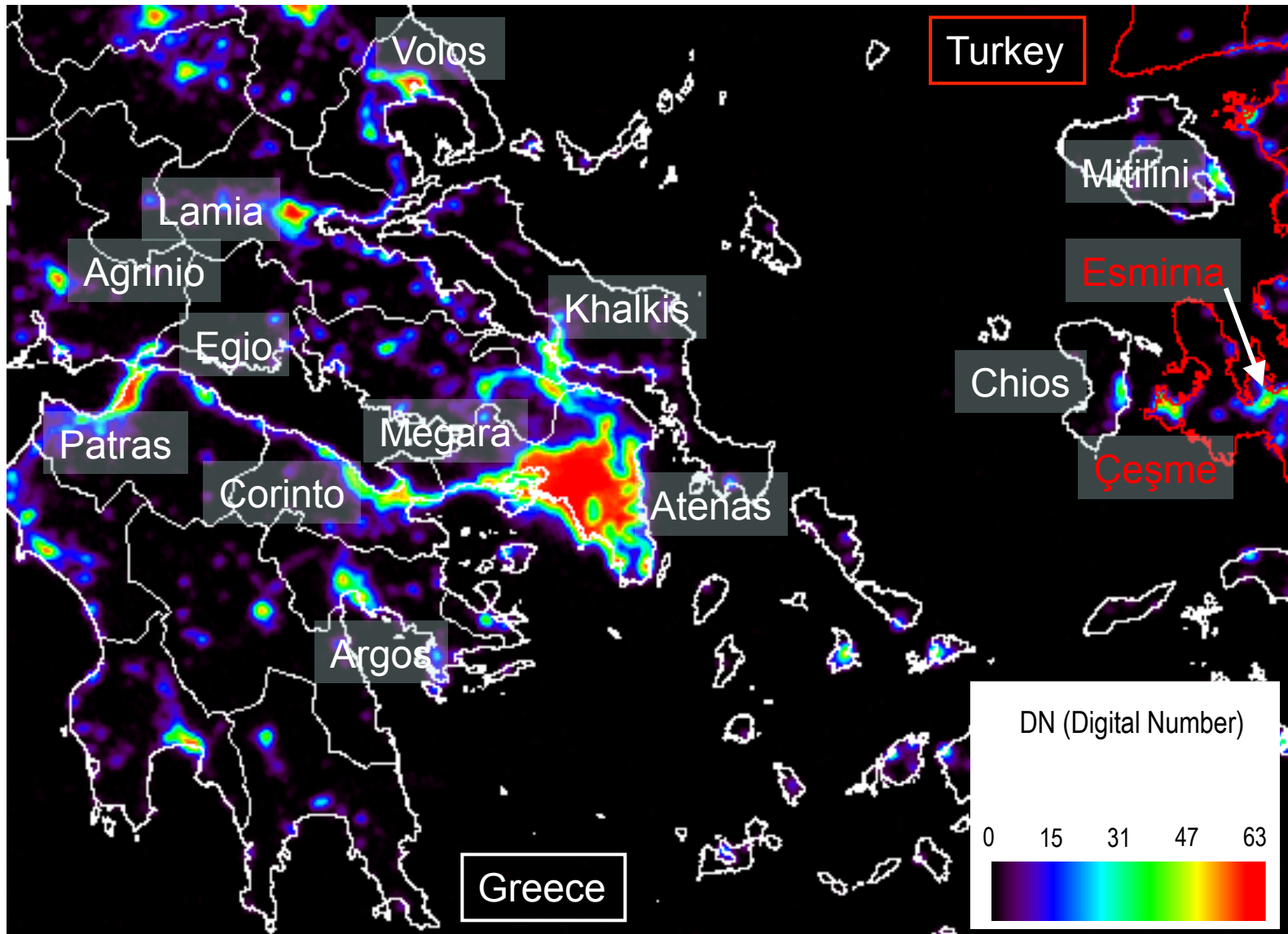


Athens

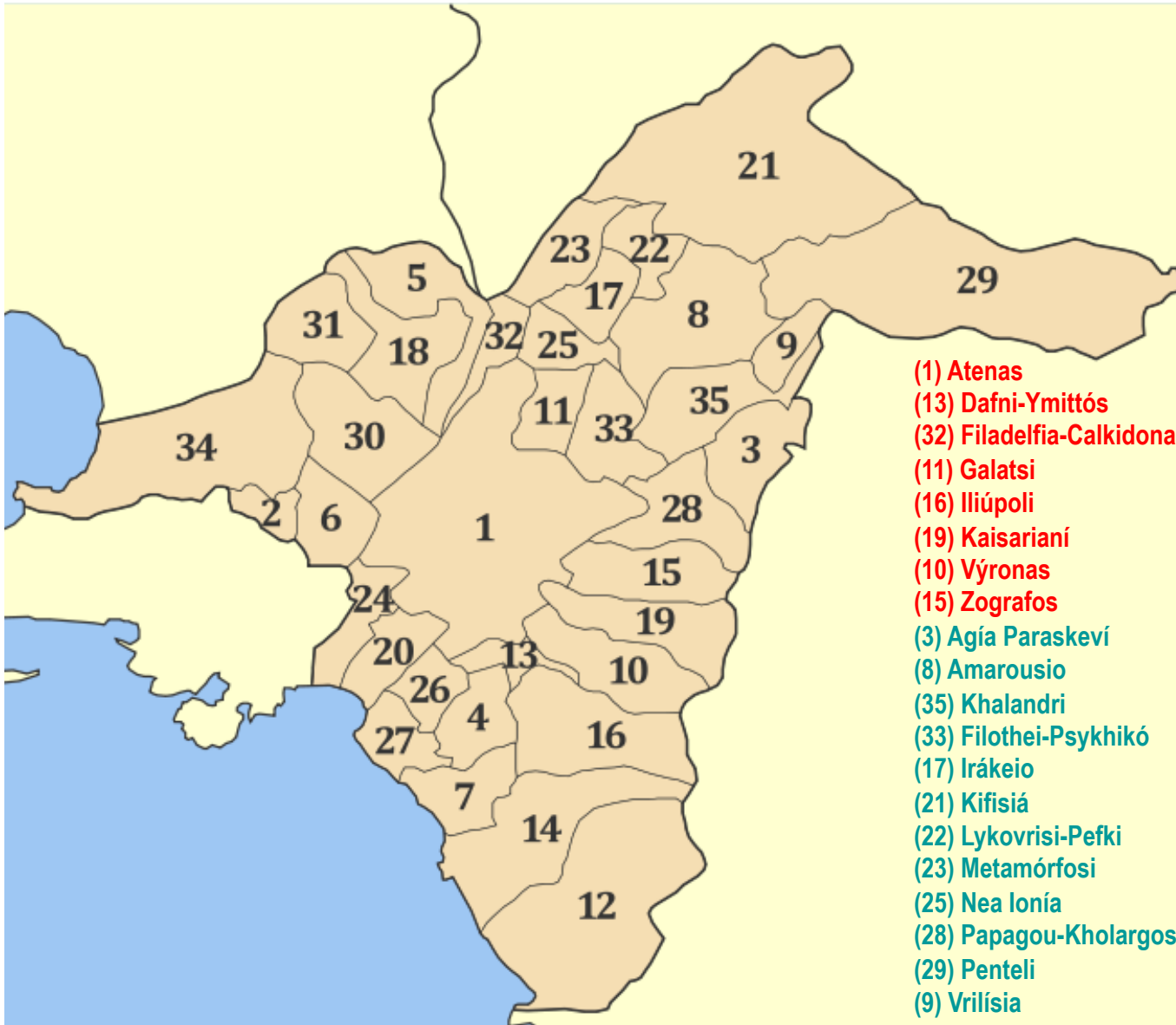


Color Real. Landsat 5 TM. 22/06/2009.

Athens



Great Athens



Central
Septentrional
Meridional
Occidental

- (1) Atenas
- (13) Dafni-Ymittós
- (32) Filadelfia-Calkidona
- (11) Galatsi
- (16) Iliúpoli
- (19) Kaisarianí
- (10) Výronas
- (15) Zografos
- (3) Agía Paraskeví
- (8) Amarousio
- (35) Khalandri
- (33) Filothei-Psykhikó
- (17) Irákeio
- (21) Kifisiá
- (22) Lykovrisi-Pefki
- (23) Metamórfosi
- (25) Nea Ionía
- (28) Papagou-Kholargos
- (29) Penteli
- (9) Vrilisia

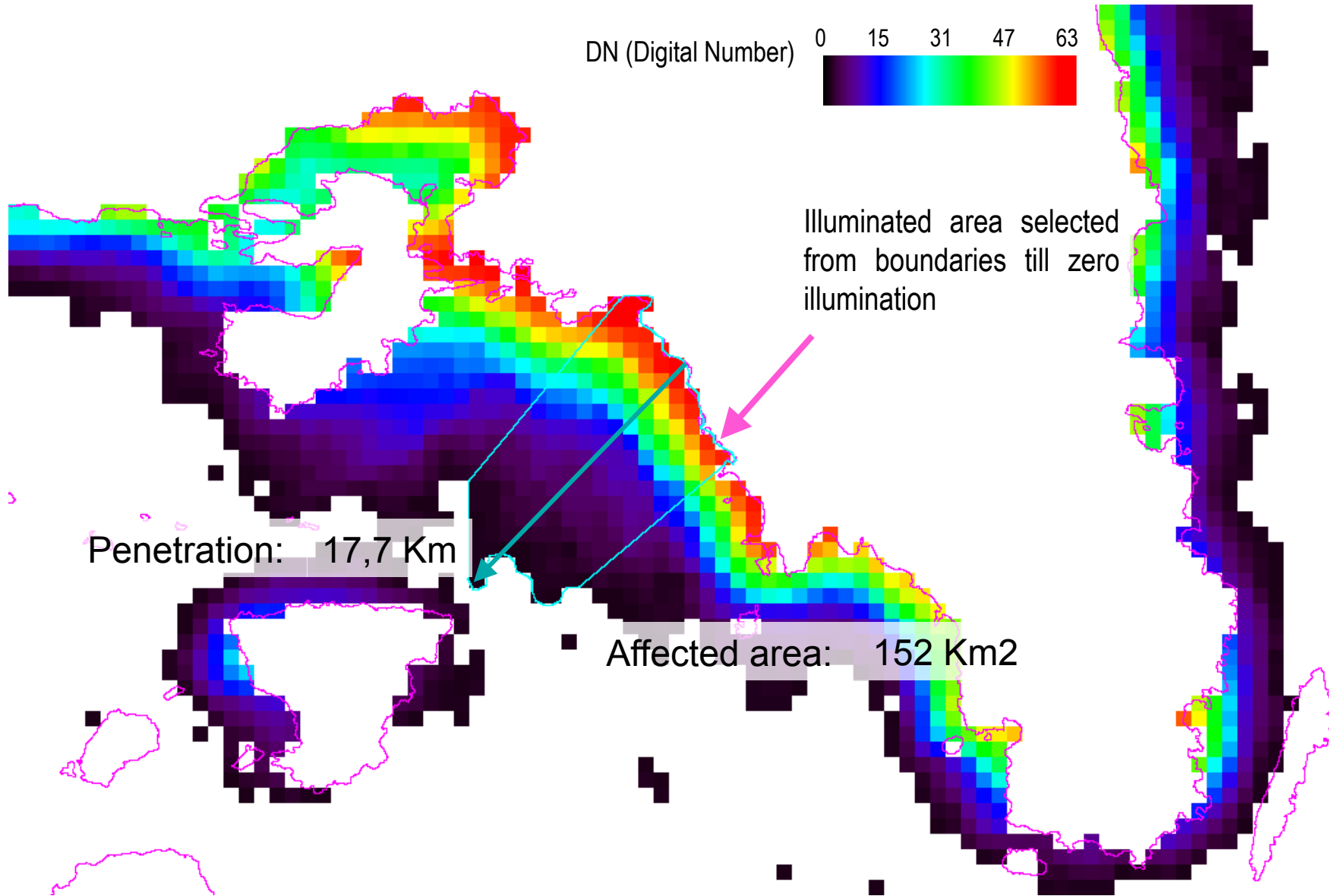
- (4) Agíos Dimitrios
- (7) Álimos
- (14) Elinikó-Argyroúpoli
- (12) Glifada
- (20) Kallithea
- (24) Moskhato-Tavros
- (26) Nea Smirni
- (27) Palaio Fáliro
- (2) Agía Varvara
- (8) Agíoi Anárgyroi-Kamateró
- (6) Aigaleo
- (34) Khaidari
- (18) Ílio
- (30) Peristeri
- (31) Petroúpoli

Athens

DN (Digital Number) 0 15 31 47 63



Illuminated area selected from boundaries till zero illumination

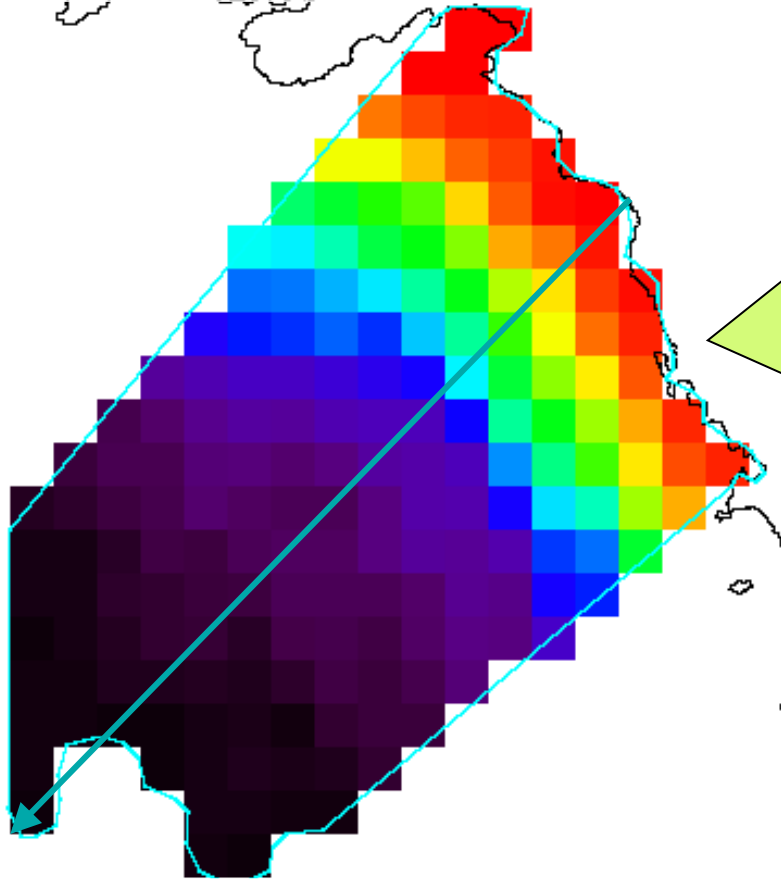


Penetration: 17,7 Km

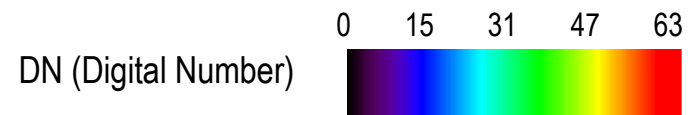
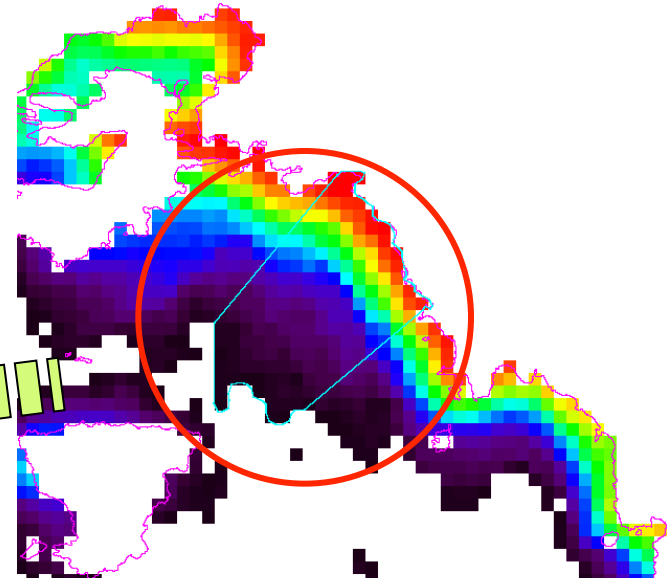
Affected area: 152 Km²

Athens

Affected area: 152 Km²



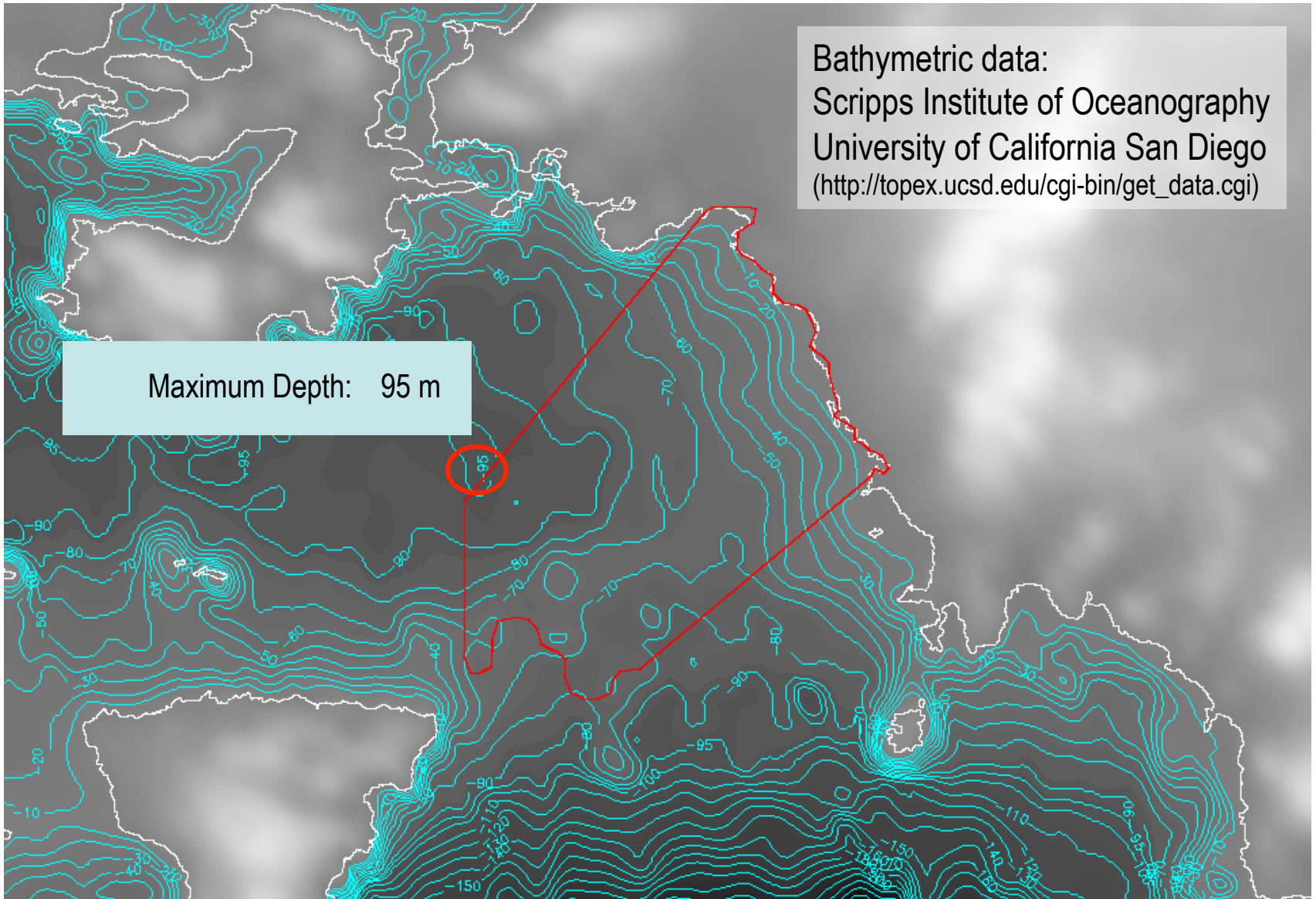
Penetration: 17,7 Km



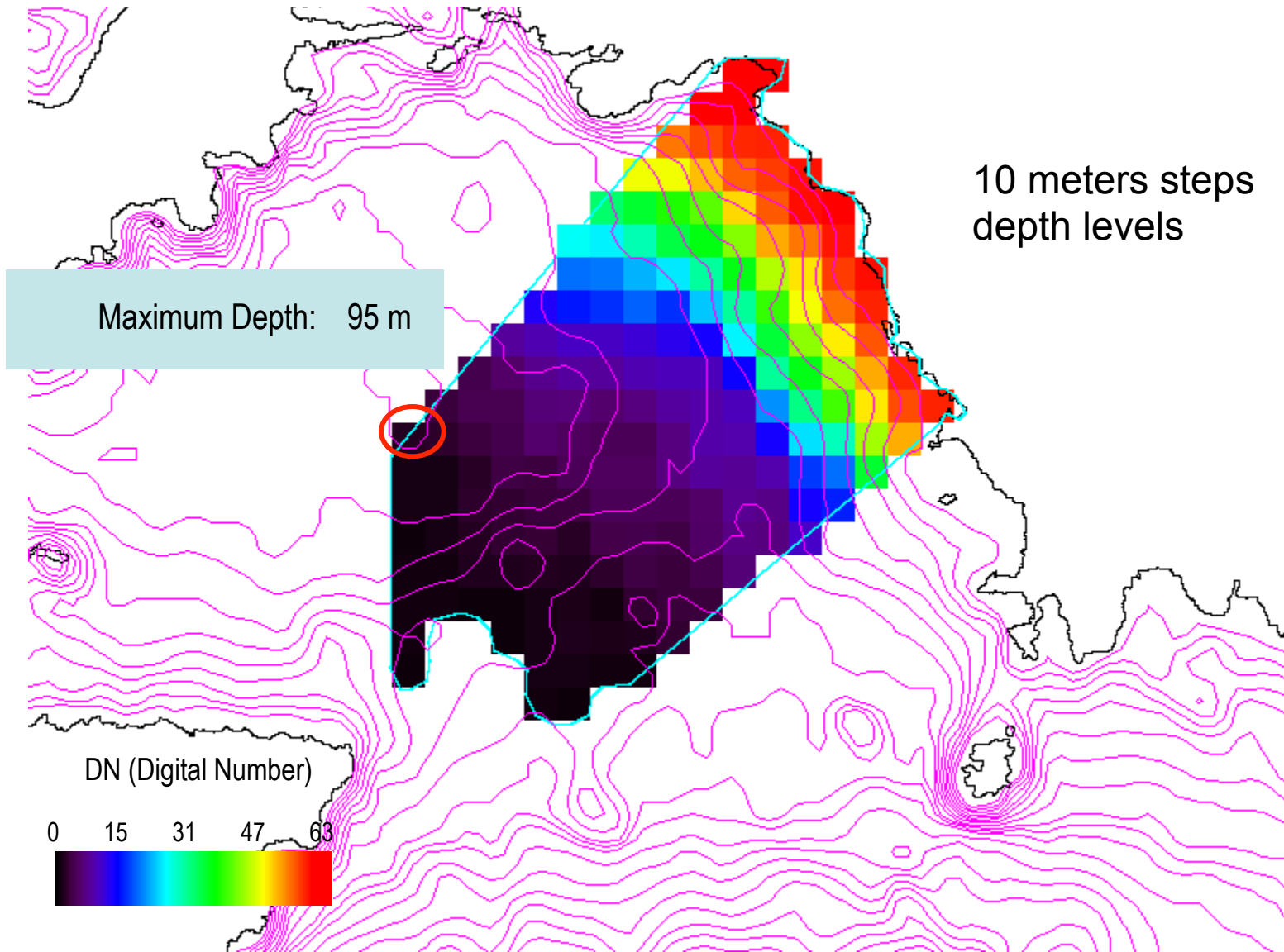
Athens

Bathymetric data:
Scripps Institute of Oceanography
University of California San Diego
(http://topex.ucsd.edu/cgi-bin/get_data.cgi)

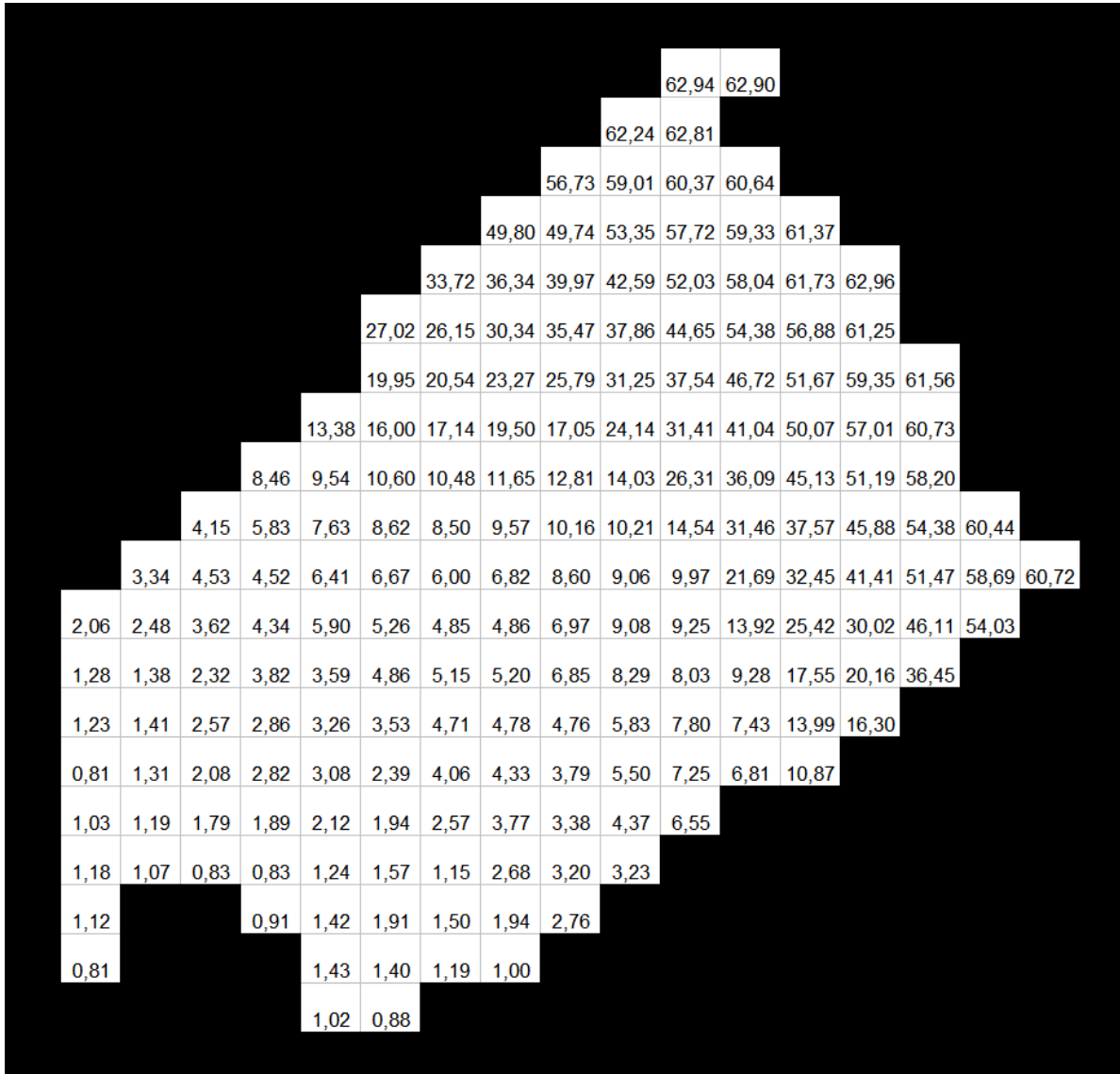
Maximum Depth: 95 m



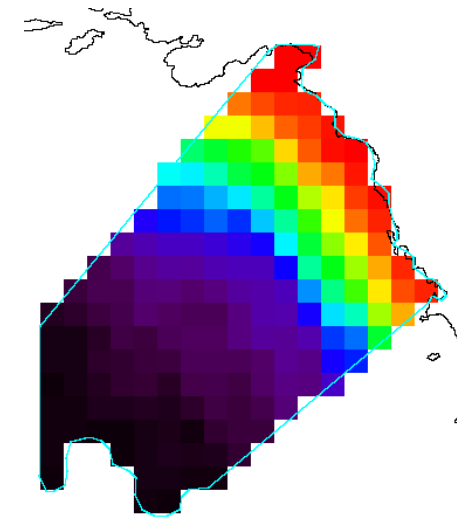
Athens



Athens



Illuminated area DN (Digital Number) pixels values.



DN (Digital Number)

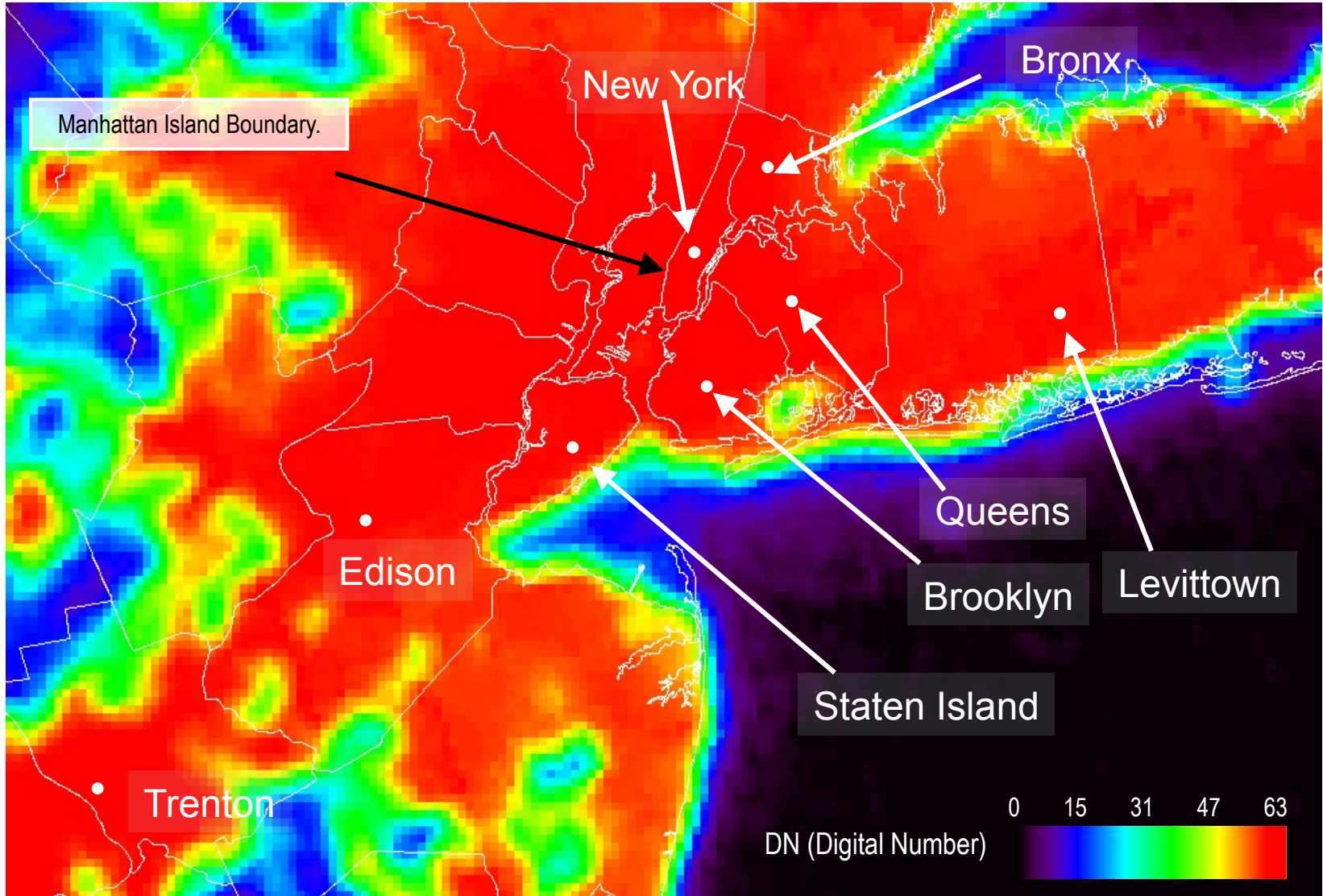


New York

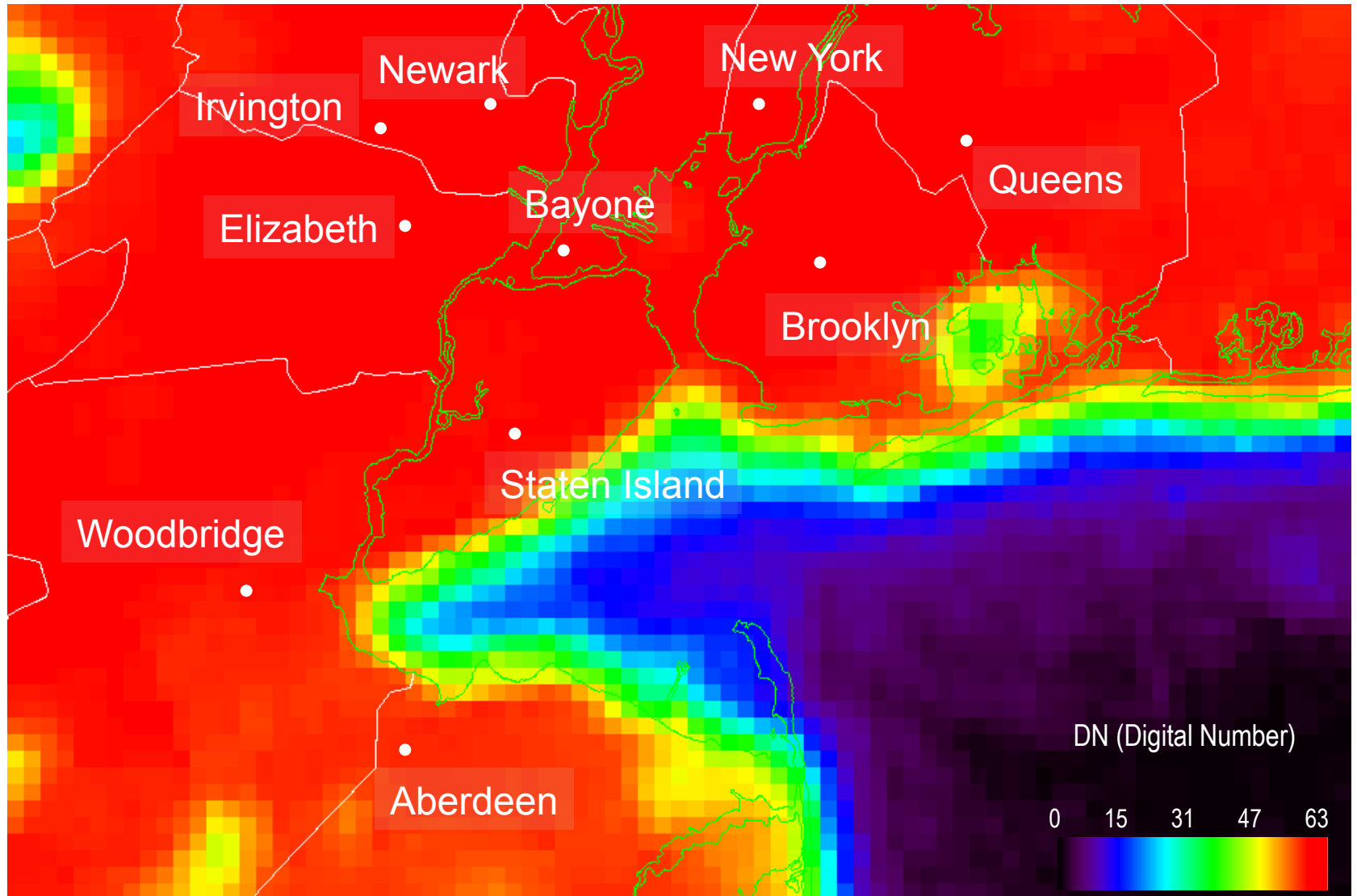


Real Color. Landsat 7 ETM+. 04/07/2005.

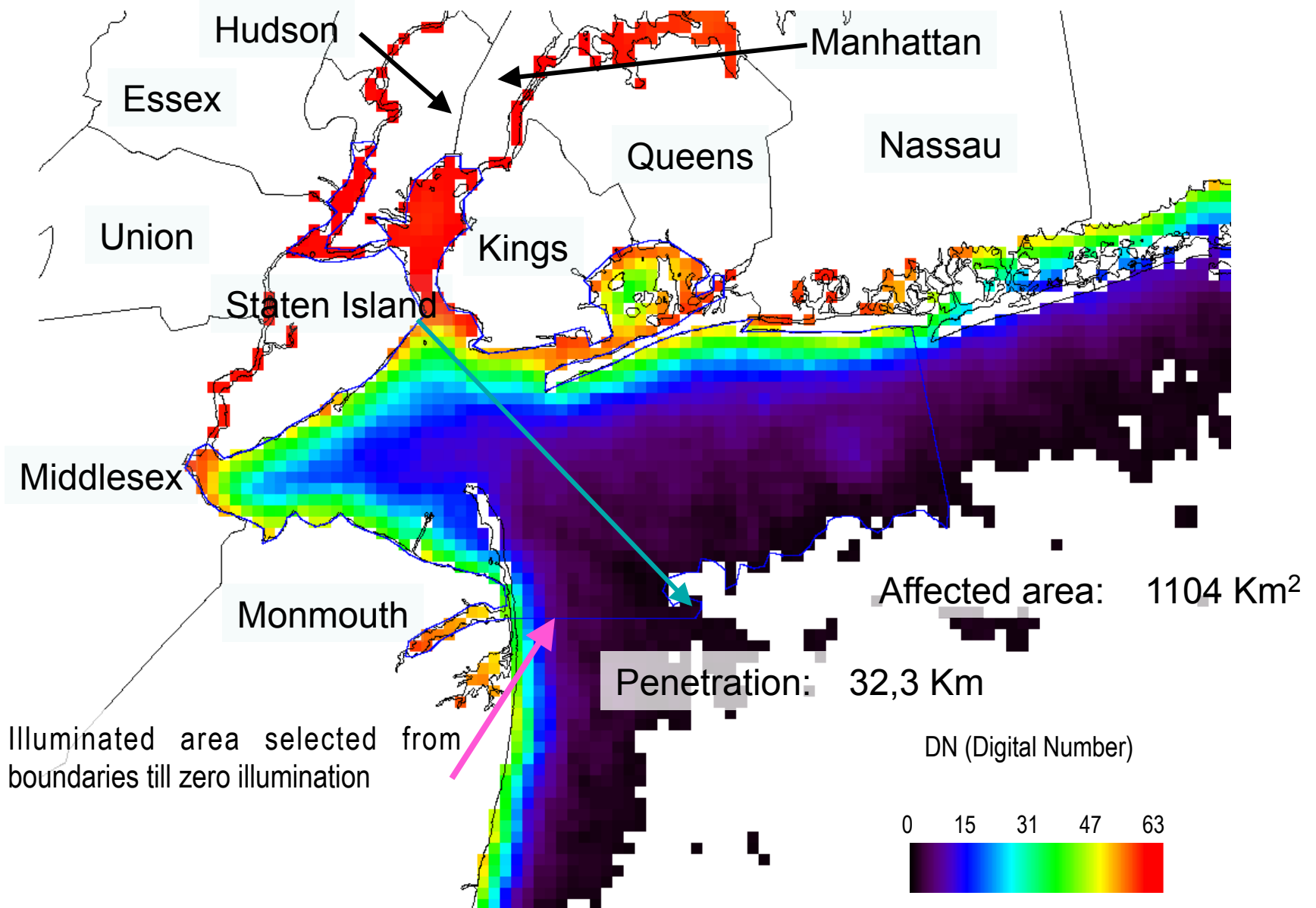
New York – New Jersey



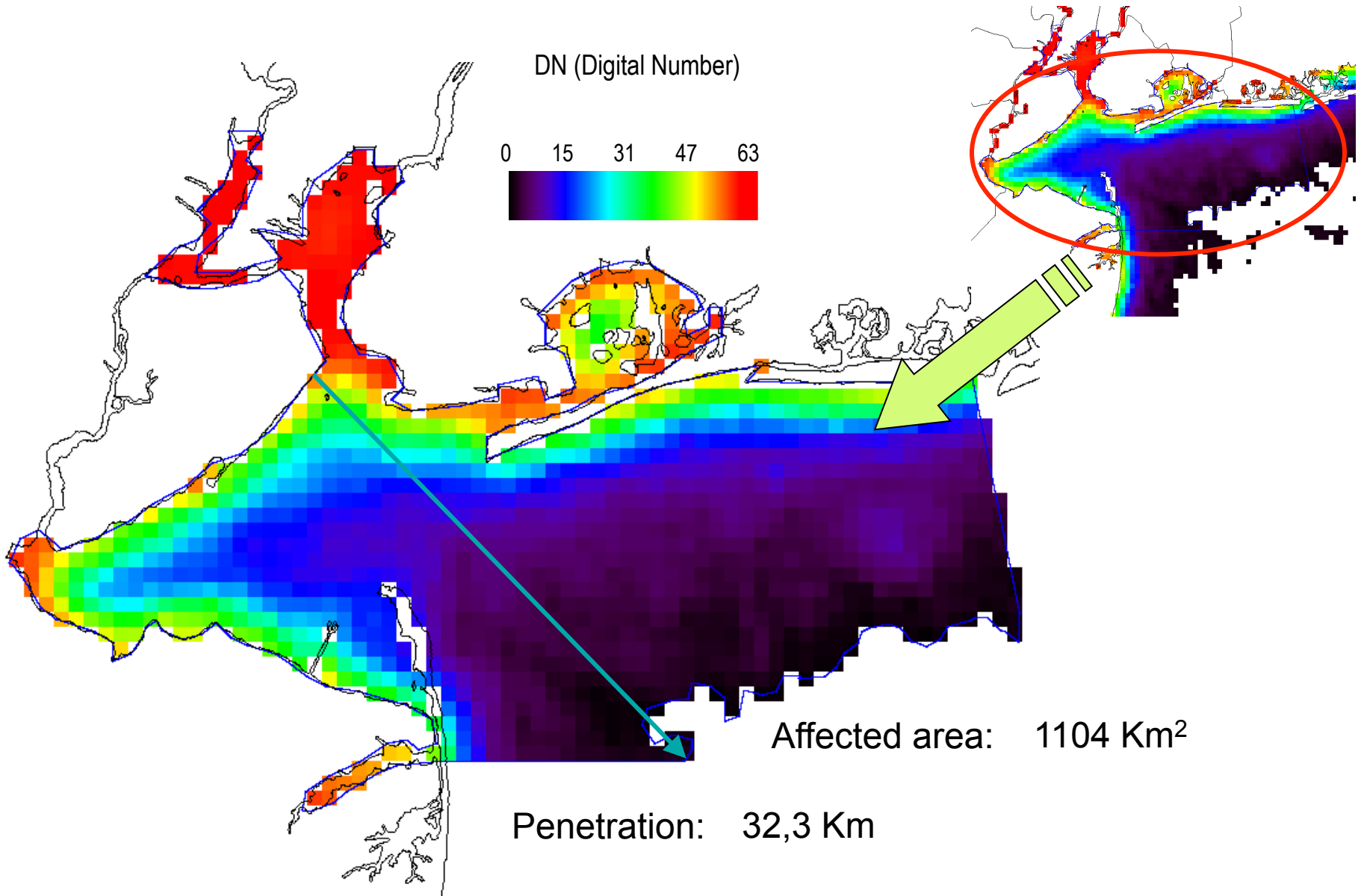
New York – New Jersey



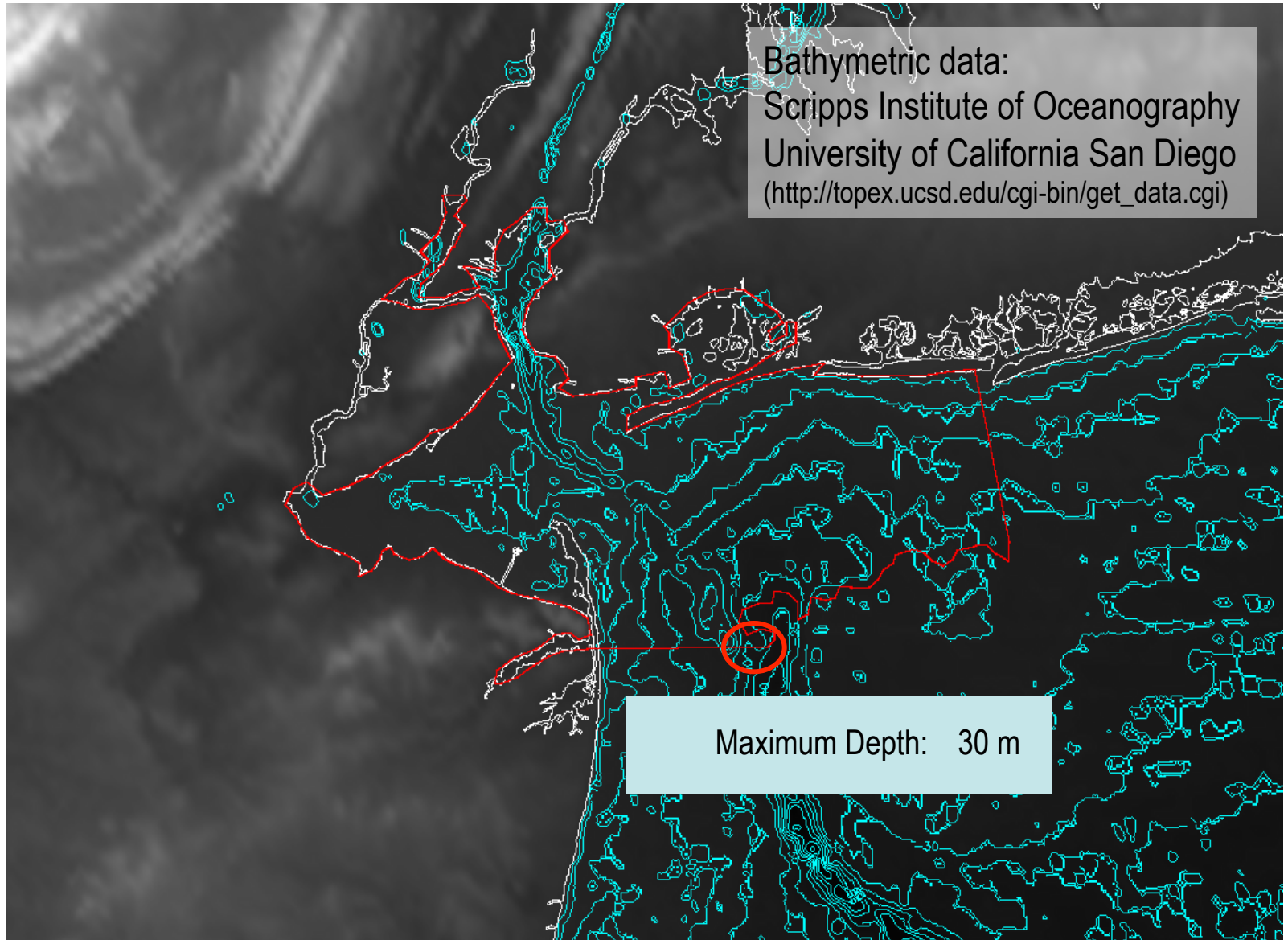
New York – New Jersey



New York

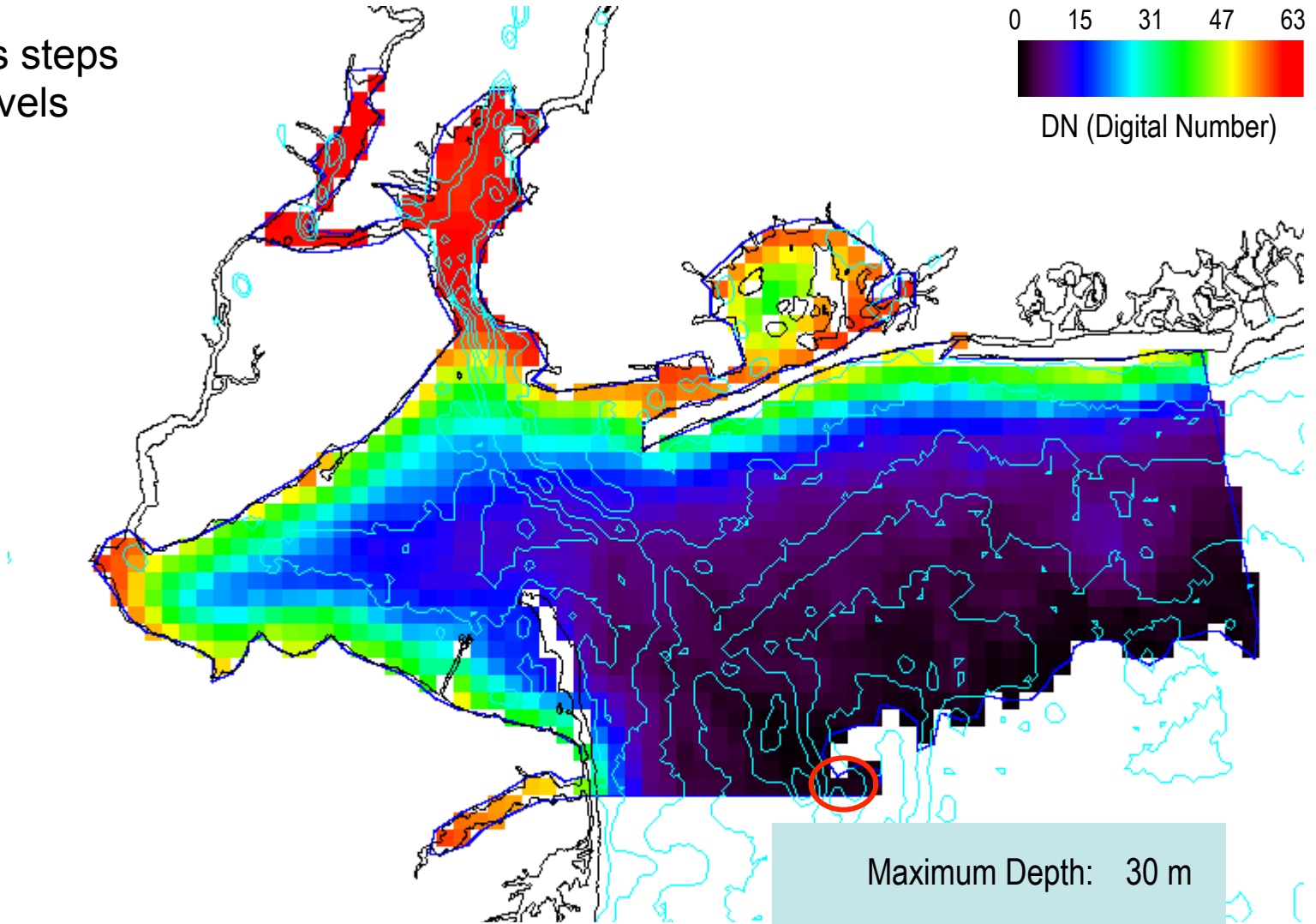


New York



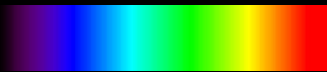
New York

5 meters steps
depth levels

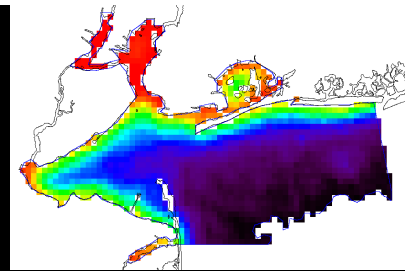


New York

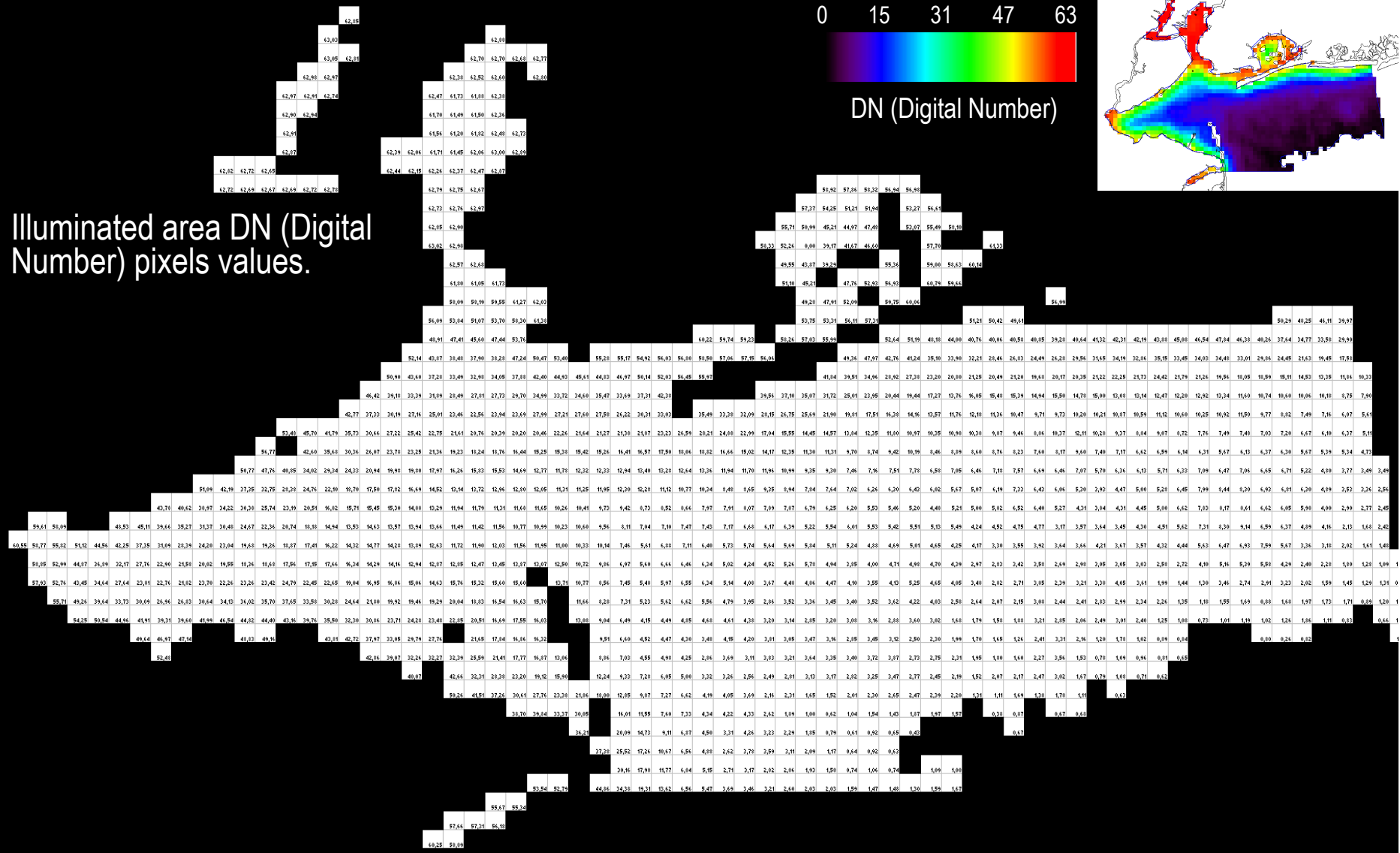
0 15 31 47 63



DN (Digital Number)



Illuminated area DN (Digital Number) pixels values.



Resumen Ciudades

Datos en DN.

Ciudad	N	Media	IC 95%		Mediana	Varianza	Desv. típ.	Mín.	Máx.	Rango	Amplitud interc	Asimetría	Curtosis
			LI	LS									
Atenas	187	20,353	17,266	23,440	9,060	457,922	21,399	0,810	62,960	62,150	34,280	0,868	-0,826
Barcelona	258	16,244	13,969	18,519	6,959	344,282	18,555	0,465	62,354	61,889	22,458	1,284	0,324
Buenos Aires	451	12,659	11,236	14,082	6,440	236,415	15,376	0,970	62,850	61,880	10,110	2,031	3,158
Estambul	326	23,165	20,682	25,648	13,255	519,432	22,791	0,540	63,090	62,550	41,585	0,714	-1,094
Nápoles	220	15,686	13,281	18,092	6,650	327,759	18,104	0,270	62,100	61,830	22,655	1,222	0,185
New York	1280	20,493	19,414	21,572	12,080	387,349	19,681	0,260	63,050	62,790	29,248	0,924	-0,516

Datos en Radiancia.

Ciudad	N	Media	IC 95%		Mediana	Varianza	Desv. típ.	Mínimo	Máximo	Rango	Amplitud interc.	Asimetría	Curtosis
			LI	LS									
Atenas	187	1,28E-08	1,04E-08	1,52E-08	2,73E-09	2,84E-16	1,69E-08	7,30E-11	5,00E-08	4,99E-08	2,24E-08	1,119	-0,325
Barcelona	258	9,42E-09	7,68E-09	1,12E-08	1,84E-09	2,03E-16	1,42E-08	3,20E-11	4,92E-08	4,92E-08	1,21E-08	1,645	1,387
Buenos Aires	451	6,55E-09	5,45E-09	7,65E-09	1,63E-09	1,41E-16	1,19E-08	9,60E-11	4,98E-08	4,97E-08	4,30E-09	2,476	5,056
Estambul	326	1,51E-08	1,31E-08	1,71E-08	4,83E-09	3,42E-16	1,85E-08	4,00E-11	5,01E-08	5,01E-08	2,92E-08	0,949	-0,766
Nápoles	220	9,03E-09	7,23E-09	1,08E-08	1,72E-09	1,83E-16	1,35E-08	1,40E-11	4,89E-08	4,89E-08	1,19E-08	1,605	1,330
New York	1280	1,23E-08	1,15E-08	1,32E-08	4,20E-09	2,43E-16	1,56E-08	1,30E-11	5,01E-08	5,01E-08	1,86E-08	1,263	0,216

Box Plot



Outliers = Valores atípicos = Valores extremos

$$L_s = Q_3 + 1.5 Q_r \quad \text{Límite superior}$$

Q_3 3er cuartil: el 75% de las observaciones toma valores menores o iguales a Q_3

Media

Mediana = Q_2 2do cuartil: el 50% de las observaciones toma valores menores o iguales a Q_2

Q_1 1er Cuartil: el 25% de las observaciones toma valores menores o iguales a Q_1

$$L_i = Q_1 - 1.5 Q_r \quad \text{Límite inferior}$$

$Q_r = Q_3 - Q_1$ Recorrido Intercuartílico: el 50% de las observaciones está entre los valores de $Q_3 - Q_1$

Observaciones

- Medidas de posición central:
 - Media (promedio, suma de todos los valores dividido el total de observaciones).
 - Mediana (valor de las observaciones que divide a la distribución en dos partes iguales, coincide con $Q_2=50\%$).
 - Modo (valor más frecuente).
- Otras medidas:
 - Min.: valor mínimo de la distribución.
 - Máx: valor máximo de la distribución.
 - Q_1 : primer cuartil. El 25% de las observaciones toma valores menores o iguales a Q_1 .
 - Q_2 : segundo cuartil. El 50% de las observaciones toma valores menores o iguales a Q_2 .
 - Q_3 : tercer cuartil. El 75% de las observaciones toma valores menores o iguales Q_3 .
- Medidas de dispersión:
 - el desvío estándar (promedio de la suma de los desvíos al cuadrado, indica cuan concentrada o dispersas están las observaciones respecto de la media).
 - rango o amplitud (Máx. – Min.).
 - rango intercuartil ($Q_3 - Q_1$).

Observaciones

- Medidas de distribución:
 - Coeficiente de asimetría: permite decidir si una distribución es simétrica respecto de la media (valor central). Es asimétrica cuando este valor se aleja del “cero”.
 - Coeficiente de curtosis: permite decidir si una distribución tiene sus valores muy concentrados o dispersos respecto de la media (valor central). Un valor de la curtosis distante del cero refiere una distribución que se aleja de la distribución normal o gaussiana.
- Cuando la Media, Mediana y el Modo son iguales, se dice que la distribución está centrada en media.
- Cuando la Media se aleja de la Mediana y el coeficiente de asimetría se aleja de cero, estamos en presencia de una distribución asimétrica que se aleja de la distribución normal. En este caso es aconsejable utilizar otra medida de posición central, como la mediana o el modo.

Observaciones

Ls = $Q3 + 1.5 Qr$: Límite superior del boxplot, puede o no ser igual al máximo.

Li = $Q1 - 1.5 Qr$: Límite inferior del boxplot, puede o no ser igual al mínimo

Bajo la hipótesis de una distribución normal, en el rango **Li** y **Ls** debería concentrarse el 95% de los datos.

Radiancia

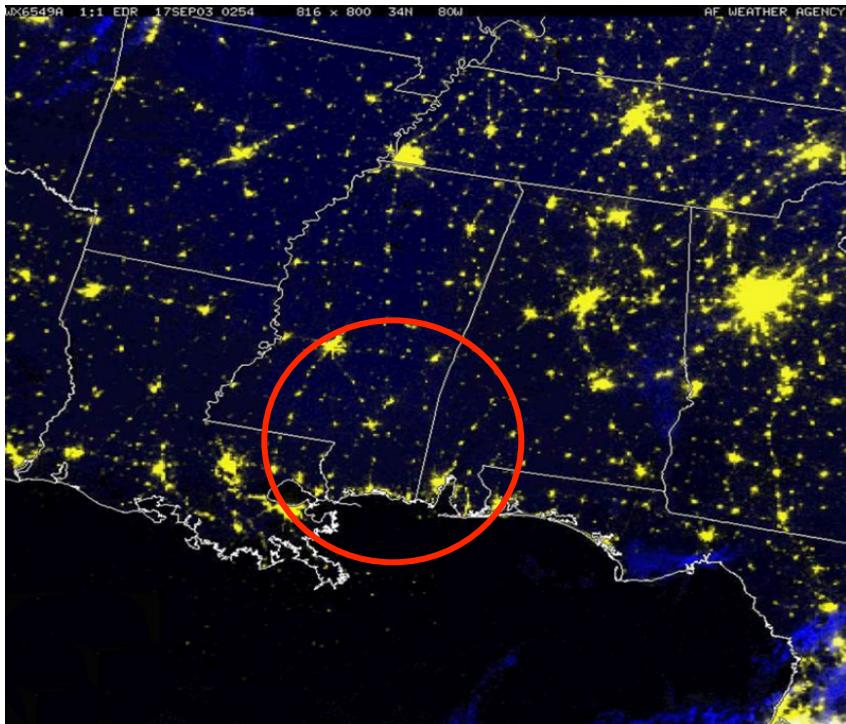
Radiancia (L). Total de **energía radiada por unidad de área y por ángulo sólido (W)**. Es un término fundamental en teledetección, por que, de hecho, describe lo que mide el sensor. Se cuantifica en **vatios por metro cuadrado y estéreo-radian (W/m²sr)**.

Fórmula →
$$\frac{\delta I \cos(\theta)}{\delta A}$$

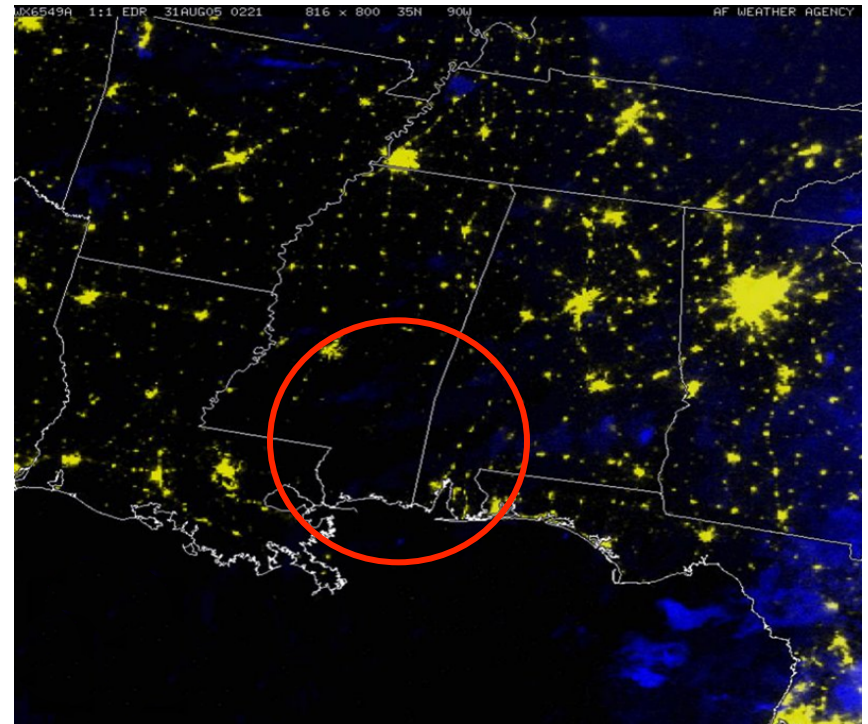
Derivada parcial de Intensidad radiante respecto de la superficie

New Orleans

Katrina Hurricane – August 2005.



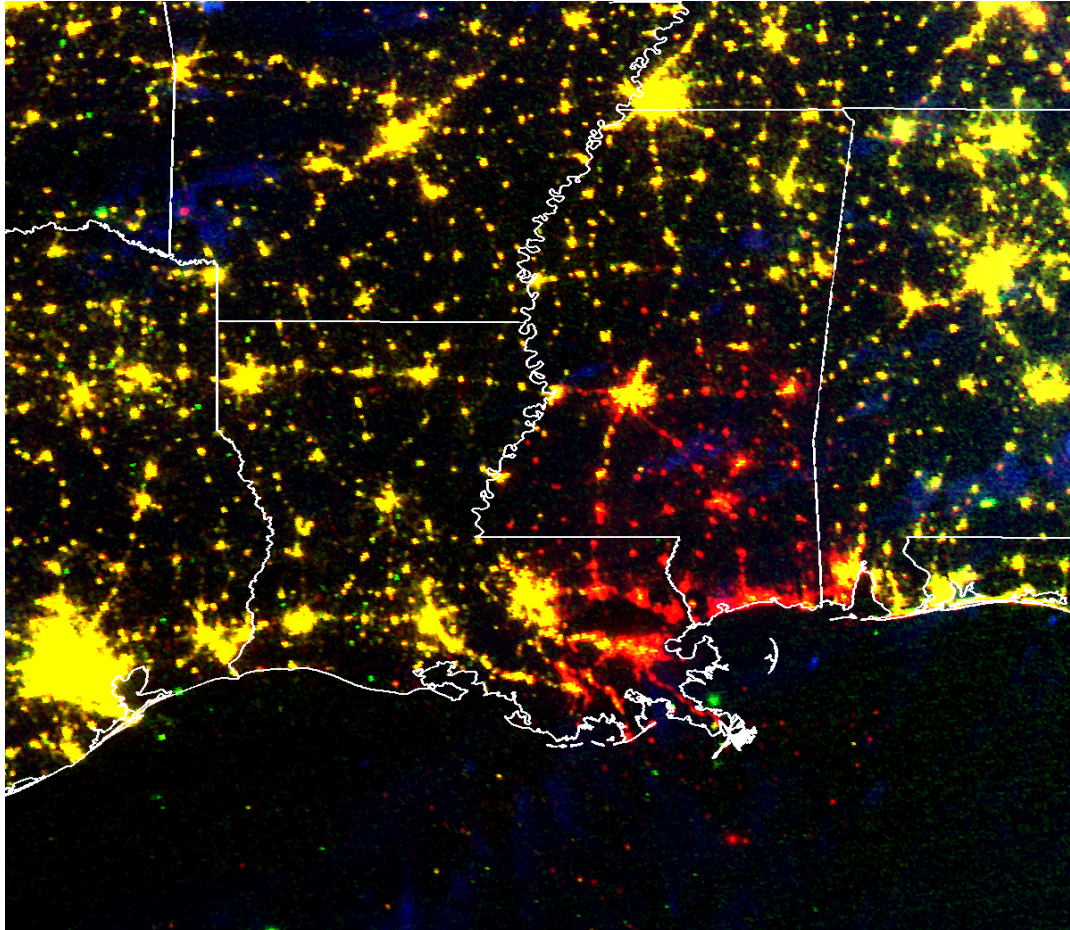
September 17, 2003



August 31, 2005

New Orleans

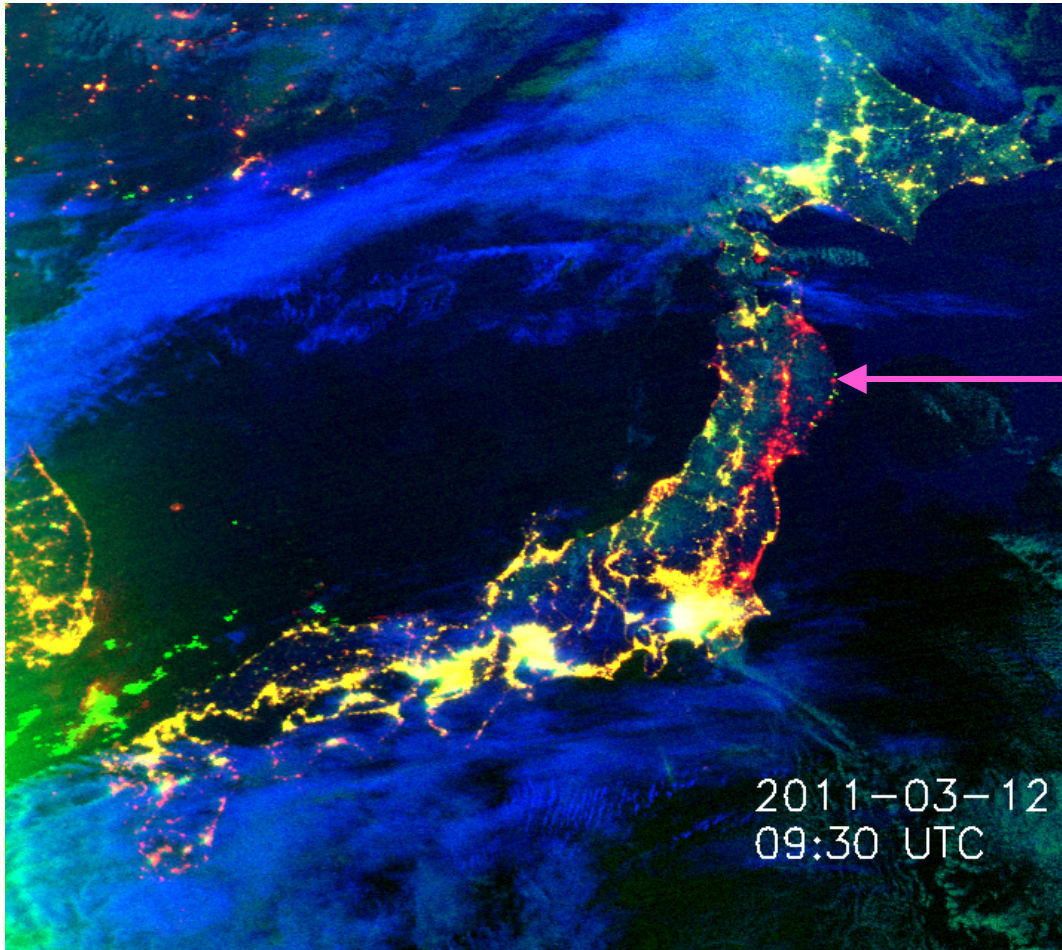
Katrina Hurricane – August 2005.



3 years Color Composite identifying in red the affected area.

Mito – Sendai

Tsunami – March 2011.



Yellow = Lights on.
Blue y Green = Clouds.
Magenta = Cloud gloom.
Red = Blackout.

Green Dots: new lights, several coastal cities upnorth Sendai.