

Time variable used as cartographic localization components

Prof. M.Eng. Cartographer Roque A. Sánchez Dalotto¹
Prof. Dr. Carlos Loch²

¹ Professor at the Universidad Nacional del Litoral (UNL), Argentina
Dr. Candidate at the Programa de Pós-Graduação em Engenharia Civil
Área de Cadastro Técnico Multifinalitário e Gestão Territorial
Rua Dep. Protógenes Vieira, 23 (Santa Mônica)
88015-120 Florianópolis (SC), Brasil
✉ sanlotto@hotmail.com

² Universidade Federal de Santa Catarina (UFSC)
Laboratório de Fotogrametria, Sensoriamento Remoto e Geoprocessamento
Cx. Postal 476 - Campus Universitário
88040-900 Florianópolis (SC), Brasil
✉ loch@ecv.ufsc.br

Conteúdo	<ol style="list-style-type: none"> 1. Introduction 2. Description of the study area 3. Conventional Cartographic representation and results 4. Considerations 5. Bibliography
----------	--

Resumo: Modificaram-se os componentes de localização cartográfica em função do tempo de concentração de uma bacia hídrica. A área de estudo corresponde ao manguezal de Itacorubi (27°34'S; 48°32'W), em Florianópolis, Brasil. Utilizando GPS, 37 esgotos urbanos foram localizados. Mediram-se suas dimensões e variáveis indicadoras da qualidade da água em cada local. Para cada ponto, a distância ao nível médio do mar, a declividade média e o tempo de concentração foram calculados. Porém, a cartografia obtida na primeira etapa não era semanticamente clara, fato que obrigou à utilização de outro tipo de expressão gráfica. Suprimiu-se a representação das isócronas como linhas, e utilizou-se o tempo de concentração para aplicar uma deformação controlada aos componentes cartográficos de localização. Embora as propriedades métricas foram perdidas, obteve-se um produto que apresenta uma visão mais compreensiva da inter-relação entre as variáveis ambientais consideradas.

Palavras chave: componente de localização – componente de qualificação – cartografia – variáveis ambientais.

Abstract: A case study for modification of cartographic localization components in function of water travel time was done. Study area was Itacorubi mangrove basin (27°34'S; 48°32'W), Florianopolis city, Brazil. There, 37 urban sewerage discharges were geographically localized by GPS surveying. Sewerage discharge dimensions and water quality variables were measured. For these points, water flow channel length, mean slope to mean sea level and water travel time was calculated. Data was fed to a GIS environment. Conventional output combined many visual variables, such as color for water quality, size and shape for sewerage discharge and position for isochrones. Results were not semantically clear, so another kind of graphical expression was needed. Isochrones representation was eliminated, and water travel time values were used to apply an algorithm-controlled distortion to localization components. Metric properties were lost, but a more comprehensive vision of the interaction between these environmental variables was reached.

Keywords: localization component – qualification component – cartography – environmental variables

Resumen: Se realizó una modificación de los componentes de localización cartográfica en función del tiempo de concentración de una cuenca hídrica. El área estudiada corresponde al manglar de Itacorubi (27°34'S; 48°32'W), Florianópolis, Brasil. Fueron identificados y localizados por GPS 37 desagües urbanos, midiéndose dimensiones y variables de calidad de agua. Utilizando un sistema de información geográfica se calculó la distancia al nivel de base, pendiente media y tiempo de concentración para cada punto de descarga. La cartografía obtenida en una primera etapa no fue semánticamente clara, para lo que se propuso otro tipo de expresión gráfica. Se eliminaron las isocronas, utilizándose el tiempo de concentración para aplicar una distorsión controlada a los componentes de localización. Si bien se perdieron las propiedades métricas, se obtuvo un producto que presenta una visión más comprehensiva de la interrelación entre las variables ambientales consideradas.

Palabras clave: componente de localización – componente de calificación – cartografía – variables ambientales.

1. Introduction

Usually, two kinds of variables for cartographic representation are used: localization and qualification components. Two localization components are often perpendicular between them and give metric attributes to map. A third one, called the qualification component, is spatially perpendicular to localization axis. Its function is to model the map background by using colors, symbols, hatches or other visual variable, so classifications can be done. In order to offer an accurate interpretation of land phenomena, environmental cartography generally needs to display more than one theme in the qualification component. Incorrect association of shapes, sizes, position, color, tone or texture used as visual variables in environmental features, could result in a complex output. By using a mathematical function, modification of localization components depending of time can be done. The technique is not new. For example,

the Strasbourg University in France develops researches in this line since many years ago.

A case study for modification of cartographic localization components in function of water travel time was done. Study area was Itacorubi mangrove basin, located in 27°34'S; 48°32'W, Florianopolis city (pop.300.000), Brazil.

Itacorubi mangrove is located in the northeast border of the city. As the city grows, the mangrove supports a demographic impact, especially in terms of water pollution, garbage, buildings and roads construction. This critical situation is similar to other mangrove areas in the world. In these cases, researchers like ROBERTSON & ALONGI (1992) and SMITHSONIAN MARINE STATION (2001) demonstrate that environmental monitoring is a proper way to study mangrove habitats.

During the study, 37 urban sewerage discharges were geographically localized by GPS surveying. At each point, sewerage discharge dimensions like diameter, width and height were measured. Also, several water quality variables like temperature, pH, salts, carbonates, ammonia, phosphates and dissolved oxygen were measured.

Topographical and other thematic data were loaded into a GIS environment. By using this tool, length and mean slope to mean sea level for each site was calculated. By application of Clark's algorithm, water travel time from each discharge to mean sea level point was calculated, and from these results, 1-hour isochrones were derived. The final cartographic representation of water quality, sewerage discharge dimensions and isochrones was made in separate GIS layers. Raster base was a 20m multispectral SPOT satellite image.

When graphical output was elaborated, it combined many visual variables, such as color for water quality, size and shape for sewerage discharge and position for isochrones. These results were not semantically clear, because mixing of spatial variables like water quality or sewerage points and time variables like isochrones created a complex map. Another kind of graphical expression was needed in order to properly present the analyzed environmental phenomena. Isochrones lines were eliminated, and water travel time calculated for each point was used to apply an algorithm-controlled distortion to localization components of the map.

Using GIS functions, determination of travel time-related new coordinates for sewerage discharge points was calculated. These new travel time-related relocated points were used for orientation of the SPOT satellite image. Finally, a more clear output by combination of color variable for water quality, size and shape for sewerage discharge and plane localization for travel-time was reached.

Metric properties of the map were consequently lost, but a more comprehensive vision of the interaction between water chemical quality indicators, physical characteristics of sewerage discharges and water permanence time into the sub-basin study area was reached. These studies are part of a Dr. Thesis in Territorial Management, developed at the Civil Engineering Post graduation Program, Santa Catarina Federal University, Brazil.

2. Description of the study area

As defined by its latitudinal localization, Itacorubi mangrove is an extra tropical formation. It is a relict area kept alive by a local deviation of Brazil warm stream, and one of the southernmost mangrove area located in America (IBGE, 1990). Three species grow in this habitat: *Avicennia schaueriana* Stapf & Leechman, *Laguncularia racemosa* L. and *Rhizophora mangle* L. These species are usually found in Atlantic american mangroves (NEW MEXICO HIGHLANDS UNIVERSITY, 2001). The area is a typical basin mangrove as described by LUGO & SNEDAKER in WOODROFFE (1992), where *Avicennia* largely dominates over *Laguncularia* and *Rhizophora*, covering 98.5% of the mangrove area (SÁNCHEZ DALOTTO, 2002).

Itacorubi mangrove presents an expressive demographic impact. Pointing to minimize the problem, local legislation has defined the Itacorubi mangrove as a Permanent Preservation Area, but not always this legal situation has been respected (CAVALCANTI WALCACER, 1993). Also, municipality legislation (FLORIANÓPOLIS, 1998) protects the area, considering restrictions to constructions and land use. Trindade, Santa Monica and Itacorubi downtowns surround the area (figure 1). Mean sea level point is located in Baía Norte bay, near N=6947500 E=22745000. Study area (white line in figure 1) covers 2280000m².

In terms of cartographic projection, study area is located in the 22S UTM zone (-51°). It spans from N=6945500 to N=6948000, and from E=22744000 to E=22747500.



Figura 1 : Itacorubi mangrove, Florianópolis, Brazil.

3. Conventional Cartographic representation and results

Main goal of cartographic representation was to simultaneously and clearly represent three environmental variables: water dissolved oxygen, sewerage discharge physical dimensions and water travel time from discharge point to zero level.

As mentioned above, 37 urban sewerage discharges were geographically localized by GPS surveying. Their localization is shown in figure 2. Spatial distribution of discharge points is peripheral, with most part of discharge coming from Trindade, Santa Monica and Itacorubi downtowns.



Figura 2 : Sewerage discharge points in Itacorubi mangrove.

Using colorimetric kits, in each point many water quality variables were measured. In *PANITZ* (1986) more detailed water quality reference values for Itacorubi mangrove can be found. Figure 3 shows dissolved oxygen values using graduated colour symbols. Note that most part of water discharges have low tenor of dissolved oxygen.

Using adequate cartographic tools, there are no problems when a representation of this kind is done. Graduated colour is a simple technique that offers fast and clear interpretation of variable values. Other derived outputs like lines of dissolved oxygen concentration were obtained. In both cases, there were only one variable to represent, so a semantically clear map was obtained.

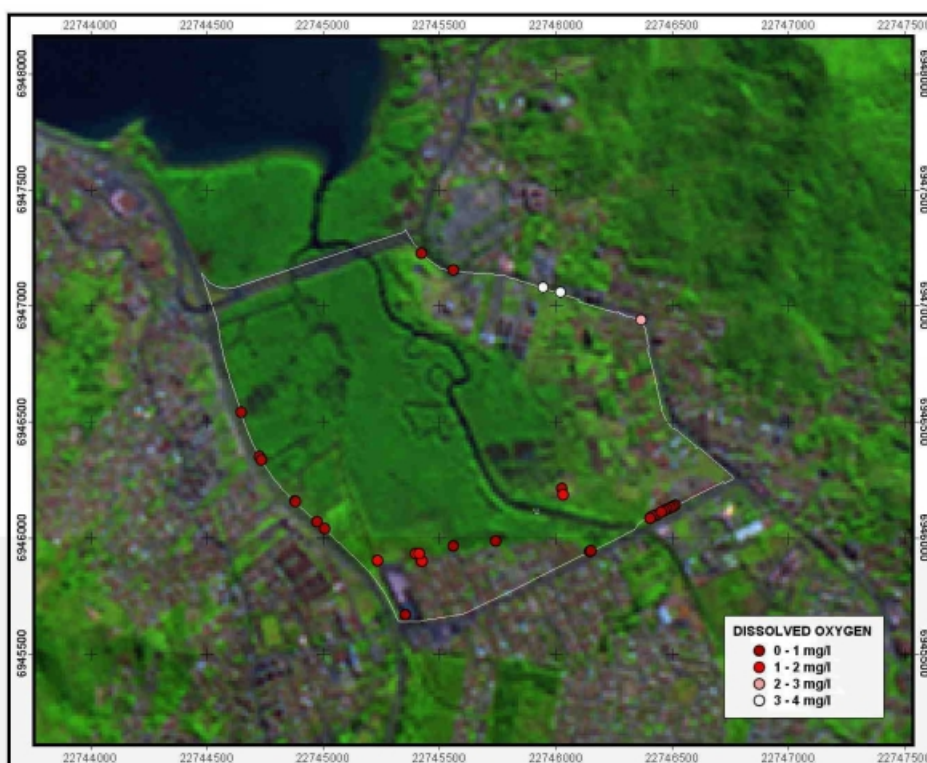


Figura 3 : Dissolved oxygen values in each Itacorubi mangrove water sewerage discharge.

Physical dimensions of discharges were measured. Using topographical techniques, diameters for round-shaped discharges and width – height for square or rectangular-shaped discharges were obtained. Figure 4 shows discharges dimensions using graduated size symbols. Note that most part of big dimension water discharges belong to Trindade and Itacorubi nets, while Santa Monica downtown has less big dimension discharges. As in dissolved oxygen representation, there were no problems when a representation of this kind was done. Also like graduated colour, graduated size is a simple technique that offers fast and consistent interpretation of variable values.

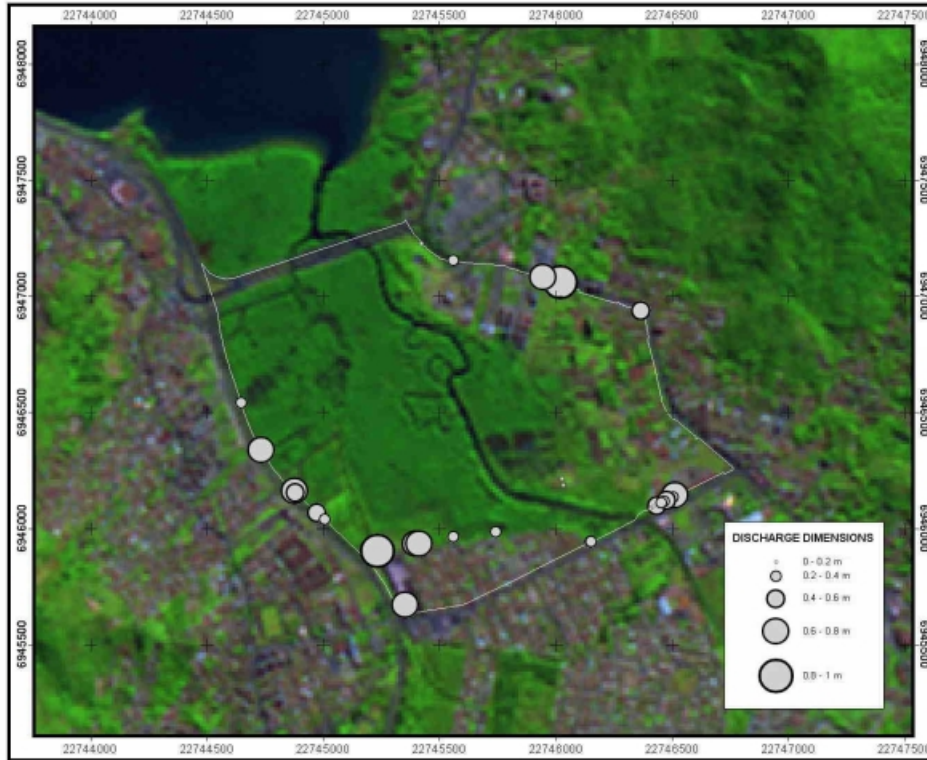


Figura 4 : Physical dimensions of Itacorubi mangrove water sewerage discharges.

Finally, by application of Clark's algorithm (LINSLEY, KOHLER & PAULHUS, 1981), water travel time from each discharge point to mean sea level was calculated. This algorithm uses length of the water flow channel, mean slope from the point to zero level and a roughness constant. As the mangrove flow net was a layer of the GIS, length of the channels was directly calculated applying GIS functions.

Digital elevation model was also part of the GIS themes, so differences between initial and final altitudes were calculated. Specific tables provided roughness constant value. Calculated water travel time ranged from 0h30m to 4h45m. From these results, 1-hour isochrones were derived. Figure 5 shows water travel time using equal time lines. Like other mentioned cartographic representations, there were no problems when a map of this kind was done. Concordantly with HAKE & GRÜNREICH (1994), isochrones represented by isolines techniques is an adequate way for understanding these environmental phenomena.



Figura 5 : Calculated isochrones for each Itacorubi mangrove sewerage discharge.

When water dissolved oxygen, sewerage discharge physical dimensions and water travel time from discharge point to zero level were represented simultaneously by graduated color symbols, graduated size symbols and equal time lines, basic semantic of each base map was altered by the new map complexity.

Isochrones representation was suppressed, and water travel time values calculated for each point were used to apply an algorithm-controlled distortion to map coordinates. Using GIS functions, determination of travel time-related new coordinates based on mean sea level point coordinates was made.

Calculation was based in water travel time-weighted Euclidean distance from each discharge point to zero level point. New relocated points were used for a geometric orientation of the SPOT satellite image. Distortion of the image was then related to water travel time, so the closer positions to zero level the minimal travel time. This concept is directly related to the basic equation $speed = space / time$. If speed is considered as a constant, higher values of time are directly related to higher values of space. Color and size variables were reserved to water dissolved oxygen values and discharge dimension representation.

Plane UTM coordinates reference was lost. Figure 6 shows the final water travel time distorted output. Note that graduated color symbols used in conjunction with graduated size and time-based plane localization is an intuitive way for understanding these variables.

Clear and small diameter points located near the mean sea level indicates a rich dissolved oxygen water being discharged from a small duct, with short time permanence into the basin. On the other hand, dark and big diameter points located far away the mean sea level

indicates poor dissolved oxygen water being discharged from a big duct, with long time permanence into the basin.

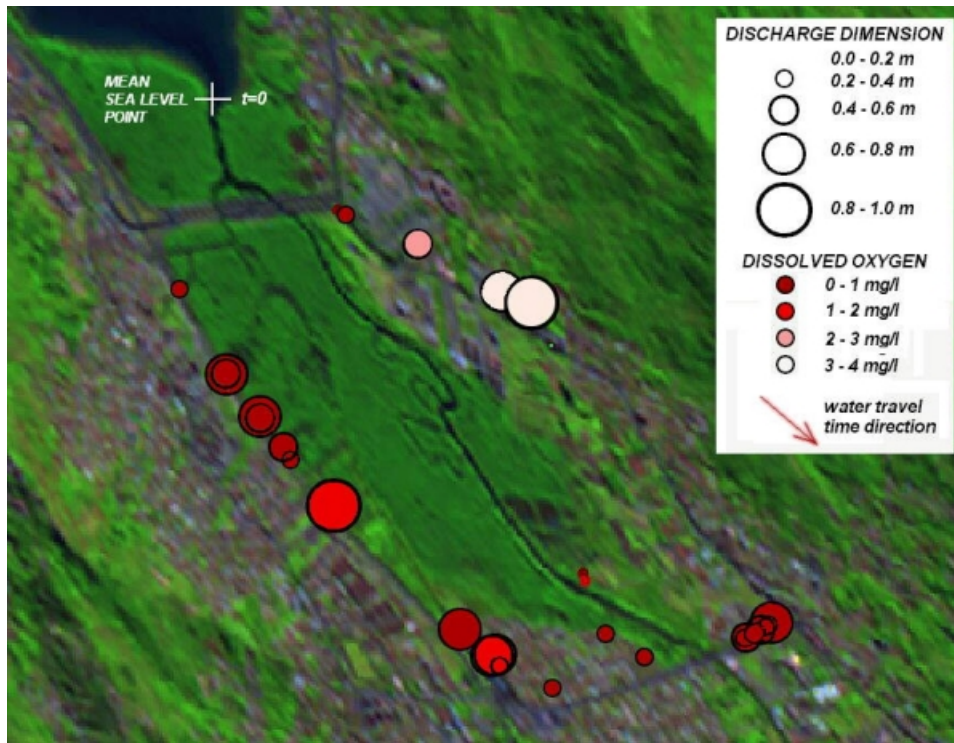


Figura 6 : Calculated isochrones for each Itacorubi mangrove sewerage discharge.

4. Considerations

Cartographic representation of time-based variables is a more complex task than physical-based variables. Conventional cartographic outputs of considered variables were not so clear, probably by the fact of simultaneous use of color, size, shape and direction variables in the same map.

By combination of color variable for water quality, size and shape for sewerage discharge and plane localization for travel-time, a more clear output was reached. There was no semantic conflict between visual variables when modification of cartographic localization components in function of water travel time was done.

When interactions between environmental variables are complex or have not well known associations, modification of cartographic localization components could be a right technique to show them into another way. Qualification component could be reserved to show more important variables. Conventional space-based localization components could be used as metric complement with time-based localization components.

By modifying cartographic localization components, metric properties of the map were consequently lost. On the other hand, a more comprehensive vision of the interaction between water chemical quality indicators, physical characteristics of sewerage discharges and water permanence time into the sub-basin study area was reached.

5. Bibliography

Linsley, R.; Kohler, M.; Paulhus, J. *Hidrologia para ingenieros*. México : McGraw-Hill, 1981. 386p.

Cavalcanti Walcacer, F. *Meio-ambiente urbano no Brasil*. In: BENJAMÍN, ANTONIO H. Dano ambiental, prevenção, reparação e repressão. São Paulo : EDITORA REVISTA DOS TRIBUNAIS, 1993. 470p.

Florianópolis. Prefeitura Municipal. IPUF - Instituto de Planejamento Urbano de Florianópolis. *Plano Diretor do Distrito Sede do Município de Florianópolis*. IPUF : Florianópolis, 1998. 238p.

Hake, G.; Grünreich, D. *Kartographie. 7.*, völlig neu bearbeitete un erweiterte Auflage. Walter de Gruyter : Berlin, 1994. 599p.

IBGE. Fundação Instituto Brasileiro de Geografia e Estatística, Diretoria de Geociências. *Geografia do Brasil – Região Sul*. Rio de Janeiro : IBGE, 1990. 420p.

New Mexico Highlands University. *Mangroves* in <http://bos.nmhu.edu/mangrove.html>, 20/09/2001. The Mangrove Ecosystem New Mexico Highlands University. page last updated May 05, 2000.

Panitz, C. *Produção e decomposição de serapilheira no mangue do Rio Itacorubi, Ilha de Santa Catarina, Florianópolis, Brasil (27° 35'S – 48° 31'W)*. Tese de Doutorado. Universidade Federal de São Carlos (SP). Departamento de Ciências Biológicas. Programa de Pós-graduação em Ecologia e Recursos Naturais, 1986. 601p.

Robertson, A.; Alongi, D. *Tropical mangrove ecosystems*. Coastal and estuarine series 41. Australian Institute of Marine Science : Queensland, Australia, 1992. 329p.

Sánchez Dalotto, R. *Aerial and close range remote sensed data for mangrove environmental monitoring*. In 29th International

Symposium on Remote Sensing of Environment. Buenos Aires, Argentina. April 2002.

Smithsonian Marine Station. *Smithsonian Marine Station at Fort Pierce* in <http://www.serc.si.edu/sms/IRLSpec.htm>, 20/09/2001.

Woodroffe, C. *Mangrove sediments and geomorphology*. In: ROBERTSON, A.; ALONGI, D. "Tropical mangrove ecosystems". Coastal and estuarine series 41. Australian Institute of Marine Science : Queensland, Australia, 1992. 329p.

