Isohyetal Map Development Using Three-Dimensional Drafting Software: Case Study of the Sarawak Region

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The Isohyetal method is commonly used to estimate mean area rainfall and rainfall distribution over a river basin. Nowadays, there are various types of software available for plotting isohyets include Surfer 10, ArcInfo, IDRISI, CARIS, HYDSTRA and Micro Survey.

However, most of these are expensive and require expensive annual renewal fees. Therefore, there is motivation to find cheaper, yet widely available software for plotting isohyets. In this study, Autocad Civil 3D, software used for planning, designing and management of all types of civil engineering projects, was chosen for generating isohyets.

The selected study area was Sarawak, the largest State in Malaysia, with plenty of undeveloped forest land. Four annual isohyetal maps of Sarawak were generated for 1980, 1990, 2004 and 2007. The results revealed that Autocad Civil 3D was able to create isohyetal maps accurately and comparable with the one plotted using HYDSTRA as prepared by Department of Irrigation and Drainage Sarawak.

KEYWORDS: Isohyetal Map; AutoCAD Civil 3D; Annual Rainfall

INTRODUCTION

There are three common methods to estimate mean areal rainfall and rainfall distribution over a river basin. One of them is isohyetal method. Isohyets is similar to contour lines found on geographical maps. The information required to plot an isohyetal map is the location of rainfall stations and its appropriate rainfall data (American Society of Civil Engineers, 2006). The isohyetal map for Malaysia year 2009 is presented in Figure 1.

There are various types of software available nowadays for plotting isohyets. These include Surfer 10, ArcInfo, IDRISI, CARIS, HYDSTRA and MicroSurvey. Surfer 10 is a contouring and three dimensional (3D) mapping program that can produce contour maps, 3D surface maps, 3D wireframe maps, vector maps, image maps and post maps (Surfer 10, 2011). ArcInfo is Geographic Information System (GIS) based software. The software allows users to perform advanced surface analysis and modelling, generate professional quality maps and place sophisticated labelling on the map (Esri,n.d.). IDRISI is the integration of GIS and Image Processing software solution for the analysis and display of digital spatial information (Clark Labs, 2009).

CARIS is equipped with digital mapping capabilities for generating 3D surface maps. CARIS is widely used in the marine, land and aviation sectors (CARIS, 2011). Besides, HYDSTRA is integrated with GIS functions for managing

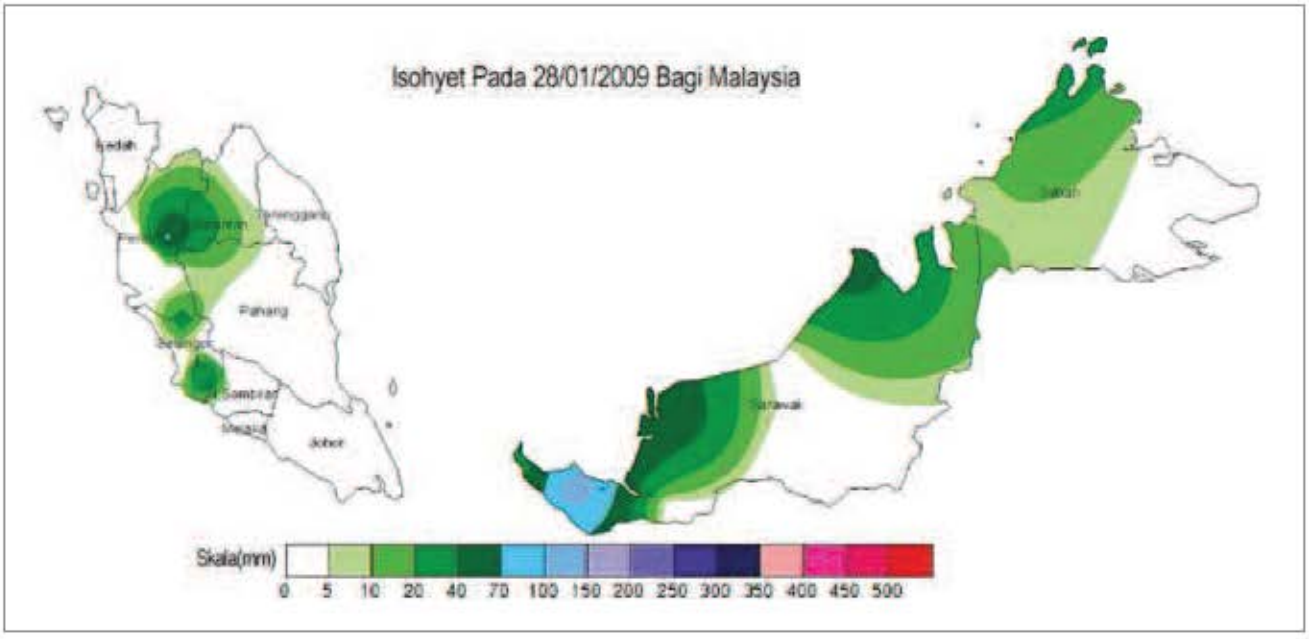

Figure 1: Isohyetal Map of Malaysia (Isohyet Maps, 2009)

large amounts of time-series data in the hydro power, water resources and wastewater industries. HYDSTRA is also able to analyse rainfall data and produce isohyetal maps (KISTERS, n.d.). MicroSurvey is able to produce contour, surface mapping or even design of roads and slopes (MicroSurvey CAD, 2010).

STUDY AREA

Sarawak experiences equatorial climate with relatively uniform temperature within the range of 23°C to 32°C throughout the year. Humidity is high, with mean monthly relative humidity above 70% (Malaysian Meteorological Department, 2010). The average rainfall is between 3,300 mm and 4,600 mm per year, depending on locality.

The rainfall pattern is mainly influenced by the southwest and northeast monsoons. The southwest monsoon (indicated by red arrows in Figure 2) is from early June to September. The wind blows from the southwest at light breeze below 15 knots (Malaysian Meteorological Department, 2010). During the monsoon season, most of the cloud condenses and falls as rain on the west side of Kalimantan before reaching Sarawak. This results in significantly lower rainfall during these few months.

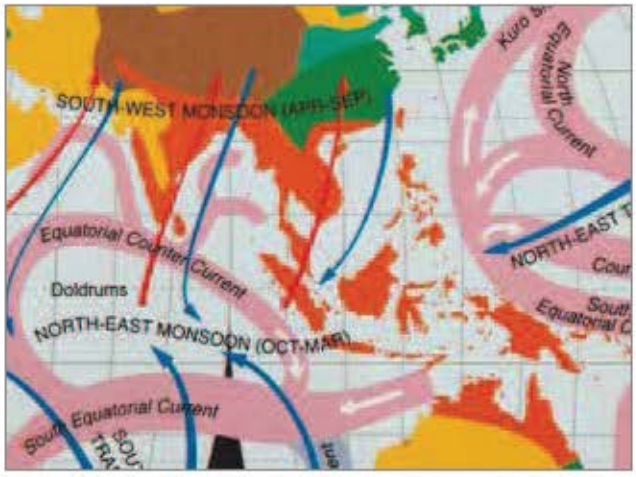

Figure 2: Southwest and northeast monsoon winds

The northeast monsoon (indicated by blue arrows in Figure 2) usually starts in early November and lasts till March. During this season, north-easterly winds blow at 15-30 knots (Malaysian Meteorological Department, 2010) and maximum rainfall occurs especially along the coastal region, causing major flooding (Department of Irrigation and Drainage Sarawak 2009).

The inland areas are relatively free from the influence of seasonal winds and experience even distribution of rainfall throughout the year.

AUTOCAD CIVIL 3D

AutoCAD Civil 3D is specially designed to support all types of civil engineering projects. Developed by Autodesk Inc., AutoCAD civil 3D utilises 2 and 3-dimensional, dynamic, model-based design technology to provide a tool for planning, designing and management purposes (AutoCAD Civil 3D, 2011). Technical drawings, geological maps as well as topographical maps are easily produced using AutoCAD Civil 3D. In addition, the software also helps users to generate and evaluate designs quickly and accurately. If there are some errors, AutoCAD Civil 3D also allows editing easily. One of the features in AutoCAD Civil 3D is the ability to produce contour plots.

METHODOLOGY

The annual total rainfall obtained from the hydrological year book is imported into AutoCAD Civil 3D for generating Isohyetal maps. The principal for plotting contour lines is adopted to generate isohyets lines. The map showing the locations of rainfall stations set up by Department of Irrigation and Drainage (DID) Sarawak, is required. The procedure for generating isohyets using AutoCAD Civil 3D is presented in Figure 3.

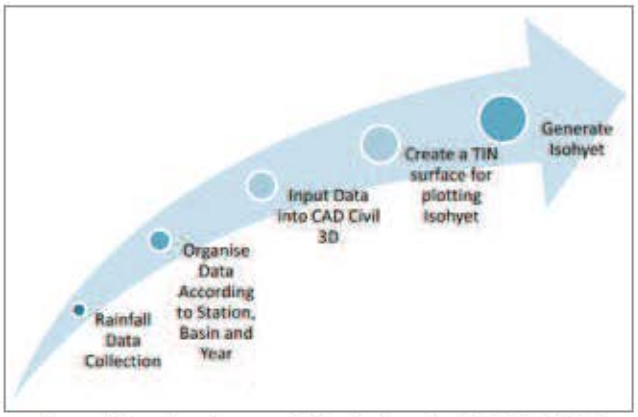

Figure 3: Procedure for generating isohyets using AutoCAD Civil 3D

Six steps for generating isohyets using AutoCAD Civil 3D are listed below.

Step 1. Create a new layer in AutoCAD Civil 3D through the *layer properties manager* function to accommodate the annual rainfall data for all rainfall stations available in Sarawak as presented in Figure 4.

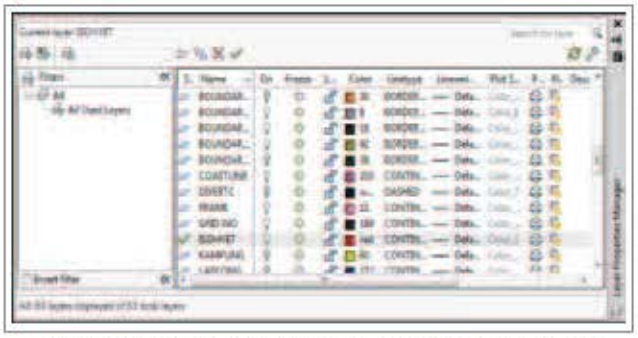

Figure 4: Create new layer using layer properties manager function

Step 2. Input the total annual rainfall data for each station into AutoCAD Civil 3D through the *create points* toolbar (refer to Figure 5). Each point created in the new layer requires the name of the station and its elevation. This elevation basically is the annual rainfall for that particular station.

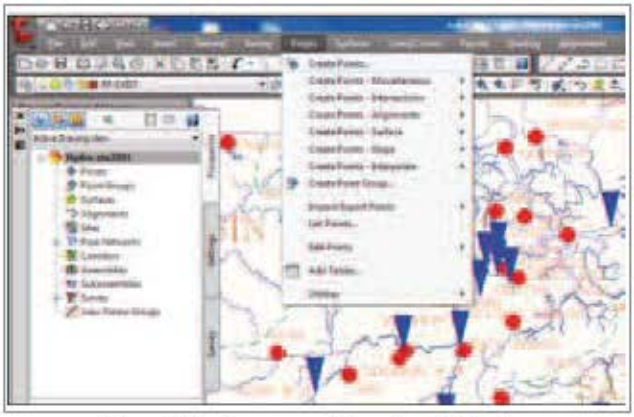

Figure 5: Dropdown menu for "create points" toolbar

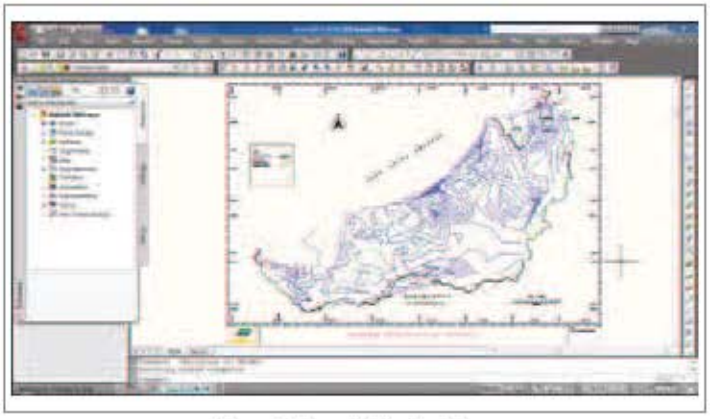

Figure 7: Generated isohyetal map

Step 3. Group together all the points created by creating a point group (refer to Figure 6). The data from this point group will be used to generate isohyets lines on Triangulated Irregular Network (TIN) surface.

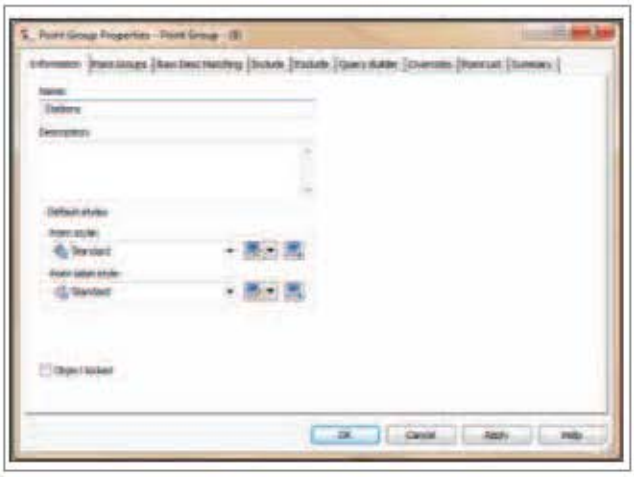

Figure 6: Creating point groups

Step 4. Create TIN surface to generate isohyetal lines through *Create Surface* function. AutoCAD Civil 3D connects the surface points that are closest together to create TIN surface.

Step 5. Import the point group into the TIN surface to generate the isohyetal lines as shown in Figure 7. The appearance of the isohyetal lines including isohyets lines intervals can be modified using *Surface Style editor* function. *Contour smoothing* function will reduce the sharp edges of the isohyetal lines drawn by AutoCAD Civil 3D.

Step 6. Label the isohyetal lines with different annual rainfall values through *adding surface labels* function to TIN surface. Multiple labels can be created concurrently by dragging the mouse across several contour lines by selecting "Contour – Multiple". Besides, the appearance of the label styles include text height, style, orientation, rotation and colour can also be modified according to user preference.

RESULTS AND DISCUSSION

Four annual isohyetal maps – for year 1980, 1990, 2004 and 2007 – were plotted using AutoCAD Civil 3D and the results presented in Figure 8, 9, 10 and 11 respectively. Results showed that most of the isohyets plotted using AutoCAD Civil 3D were comparable with the one published by DID Sarawak using HYDSTRA (DID, 1980, 1990, 2004 & 2007). These isohyetal maps can be used to study the changes in annual rainfall for Sarawak from 1980 to 2007.

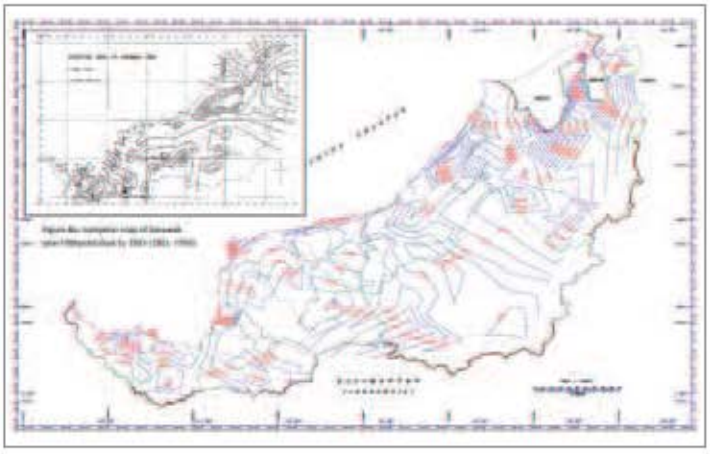

Figure 8: Generated Isohyetal map of Sarawak year 1980 with interval of 560 mm by Autocad Civil 3D

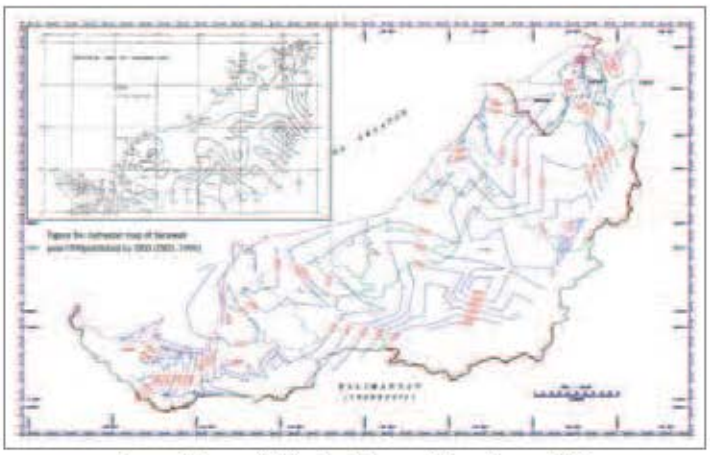

Figure 9: Generated Isohyetal map of Sarawak year 1990 with interval of 360 mm by Autocad Civil 3D

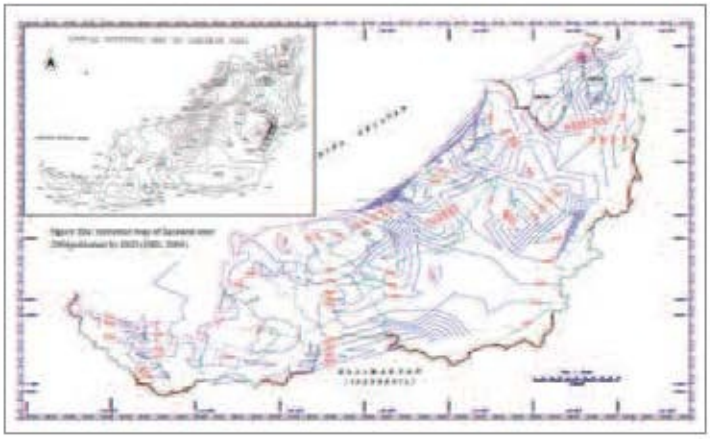

Figure 10: Generated Isohyetal map of Sarawak year 2004 with interval of 500 mm by Autocad Civil 3D

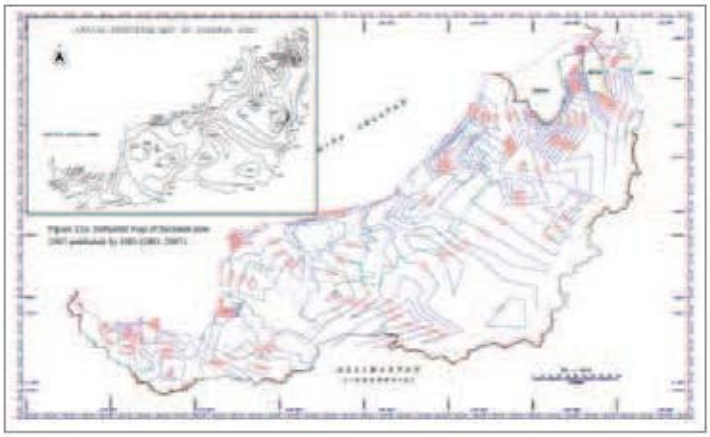

Figure 11: Generated Isohyetal map of Sarawak year 2007 with interval of 350 mm by Autocad Civil 3D

CONCLUSION

The study successfully constructed four annual isohyetal maps (1980, 1990, 2004 and 2007) for Sarawak using AutoCAD Civil 3D, which is widely available and which can be used for plotting all types of engineering drawings. By plotting the isohyetal maps, the changes of rainfall pattern can be identified and analysed. However, several limitations that may affect the accuracy of the plotted isohyets have been identified. These are:

a) Annual rainfall data obtained from the DID Sarawak contains some missing data.
b) There are fewer rainfall gauging stations in1980 than 1990, 2004 and 2007.
c) The lack of rainfall gauging stations especially in inland Sarawak, near the border with Kalimantan, Indonesia. ■