A GIS STUDY OF LANDSLIDES IN THE LOWER LOS AMIGOS FORELAND OF PERU

By

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CHAPTER ONE

1.1 INTRODUCTION

Landslides involving rock, mud, and debris flow are dominant geomorphic processes in humid foreland environments worldwide. The environmental variables governing landslides, however, are not well known because most mass movement studies have been confined to areas influenced by human activities. By studying patterns of landslides in natural ecosystems, government officials, policy makers, engineers, geologists and others will become better informed about likely success of prevention or amelioration programs in risk-prone areas. My study area, the lower Los Amigos Basin in Peruvian Amazon, is an ideal place to study 'natural' landslide patterns and their causes.

Increased population and economic pressures have focused landslide research on those areas where landslides have the potential to affect human lives and infrastructure (Turner and Shuster, 1996). According to Cruden and Varnes (1996), various factors control landslides. These include geological, morphological, physical and human causes. Geological causes include: material properties such as: weakness, sensitivity, degree of weathering, shear strength, jointing, bedding, schistosity, thrusts, faults, unconformities, contrast in permeability, and contrast in stiffness (Varnes, 1978). Morphological causes involve: tectonic or volcanic uplift, glacial rebound, fluvial, glacial or wave erosion of slope toe, erosion of lateral margin and deposition and vegetation removal. Similarly, physical causes involve: intense rainfall, rapid snow melt, prolonged exceptional precipitation, rapid drawdown, earthquake, volcanic eruptions, thawing, and shrink-andswell weathering. Although the human causes are negligible in this study area as there are no significant human activities, there are several human-induced landslides triggered all over the world. Human causes may be excavation of slope, loading of slope, drawdown or reservoirs, deforestation, irrigation, mining, artificial vibration, water leakage from utilities, etc.

According to Keller (2000) landslide causes can be grouped as external causes or internal causes. External causes include: loading of a slope by erosion or excavation, and earthquake shocks. Internal causes produce landslides without any recognized external changes and include such changes as increase in pore-water pressure or decrease in cohesion of the slope materials. Some causes of landslides are intermediate, having some attributes of both external and internal causes. For example, rapid groundwater draw-down involves an increase in the shear stress accompanied by decrease in shear strength caused by high pore water pressure.

The Andean Amazon foreland basin is prone to landslide activities. Indeed, the South American Andean Mountains have been subjected to a number of major landslide catastrophes. In 1962, Ancasa in Peru had a major landslide called Huscarac debris avalanche with a net volume of 13 x $10^6 m^3$. It killed 4,000-5,000 people and much of Ranrahirca village was destroyed (Guadango and Zampelli, 2000). Although the triggering factor was unknown at the time, it is believed that the landslide was triggered by heavy rain. Similarly, in 1966 in Rio de Janeiro, Brazil a major landslide of avalanches debris and mud flows occurred. That too was triggered by heavy rainfall and killed approximately 1000 people. The Nevados Huascara rock/debris avalanche in Peru, in 1970, was triggered by an earthquake of magnitude 7.7, killing 1,800 people and destroyed the town of Yungay (Guadango and Zampelli, 2000). These examples show that the tectonically active regions with high rainfall are prone to landslide activities. Several past and present landslides of San Francisco were also triggered either by heavy rain or by earthquakes resulting from tectonic activity (Griffiths, 2005).

Landslides range from simple rock/mud fall to complex slides and flows. According to Dikau et al. (1996) landslides are classified as fall, topple, slide, spread and flow. Fall and topple include detachment due to pre-existing discontinuities or tension failure surfaces. These landslides may be free fall, break up, bounce, slide or flow down slopes and may involve fluidization, liquefaction, cohesion less grain flow, heat generation or other secondary effects. Slide movement includes rotational or non-rotational and translational. In slides, the toe area may deform in a complex way. The ground can bulge, the slide may creep or even flow. Flow, bulge or slide can override existing failures. Failure might be retrogressive or progressive, and a graben often develops at the head of the landslide or it may include a toe failure. Spreads are lateral spreading of deformed ductile or soft material. Lateral spreading can develop sudden spreading failures in quick clays when the slope opens up in blocks and fissures followed by liquefaction. Sometimes, there might be a slow movement associated with denudational unloading. Flows are defined as debris movement by flow from unconfined and/or channeled failure surfaces. Flows involve a complex runout mechanism and these may be catastrophic in effect and may move in sheets or lobes. The form of movement is a function of the rheological properties of the material (Dikau et al., 1996).

According to Varnes (1978), landslides can be classified according to type of movement and type of material (Table 1.1). Their diagrams are given in Fig. 1.1.

Table 1.1 : Types of landslides depending on type of movement and type of material (Varnes, 1978) as described by Roy and Hirotoka (2006)

Type of movement		Type of material		
		Bedrock	Engineering soil	
			Predominantly coarse	Predominantly fine
Falls		Rock fall	Debris fall	Earth fall
Topples		Rock topple	Debris topple	Earth topple
Slides	Rotational	Rock slide	Debris slide	Earth slide
	Translational			
Lateral Spread		Rock spread	Debris spread	Earth spread
Flows		Rock flow (deep creep)	Debris flow (Soil creep)	Earth flow
Complex		Combination of two or more principal types of movement		

The occurrence of different kinds of landslides depends on the causes behind them and the triggering factors. Brunsden (1993) explains how different factors trigger landslides. Physical, chemical and biological weathering cause changes in the physical and chemical properties in soil and rock. Triggering factors create changes in grading, cation exchange, and cementation. These changes cause formation of weak discontinuities and increased

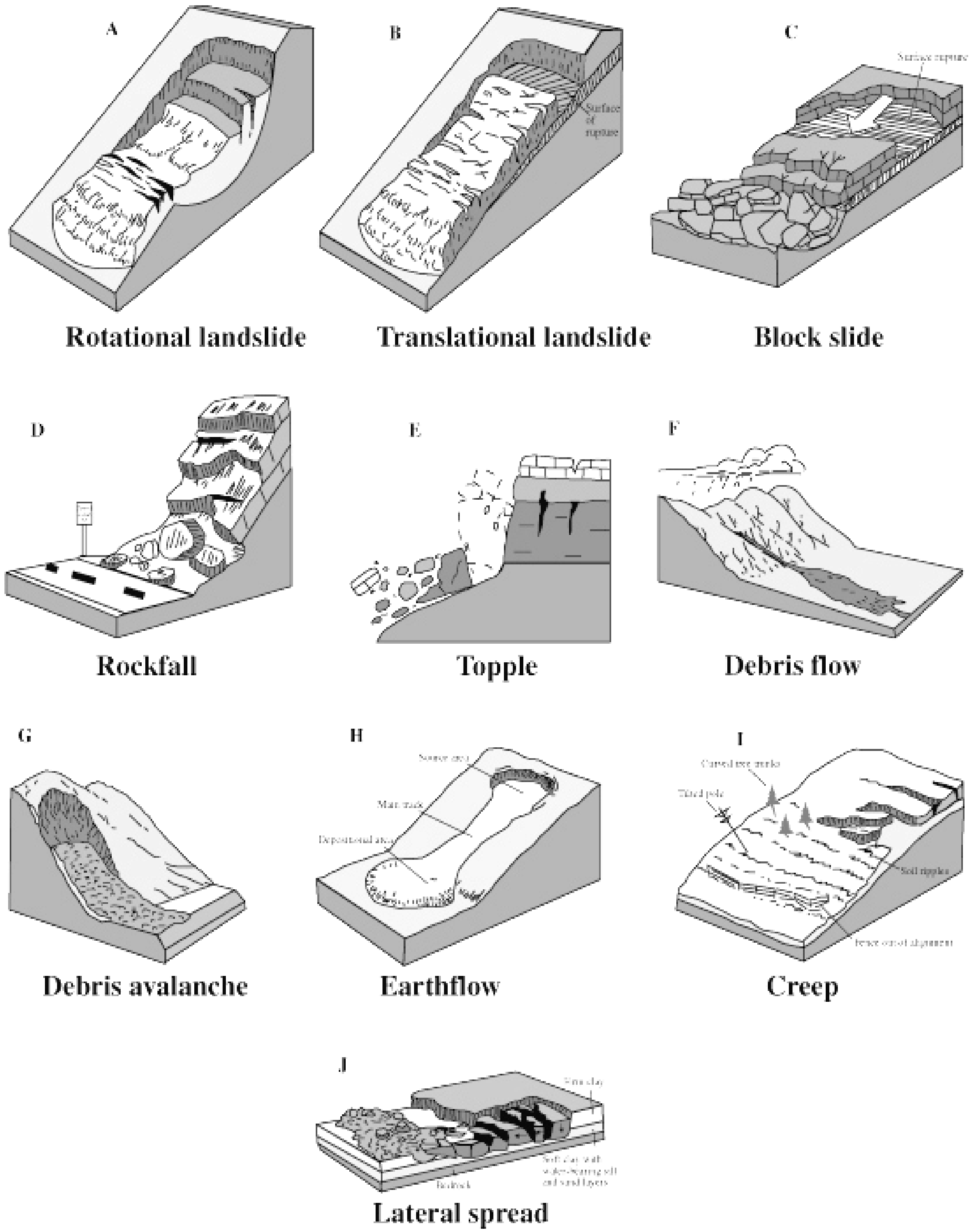


Fig. 1.1: Different types of landslides according to Varnes (1978).

depth of low strength materials. Eventually, there are changes in density, strength, permeability and pore water pressure in the soil and rock. Another type of weathering, which also changes the slope geometry, is associated with fluvial, glacial or coastal erosion. The changes in slope relief, slope height, length, angle and aspect results the changes in stress, strength and permeability along the slope and eventually triggers landslides.

Erosion and weathering can also undermine soils and rocks resulting in mechanical disintegration, solution, loss of cementing materials, leaching, and seepage. Undermining creates loss of support, consolidation of materials, changes in pore water pressure and loss of strength. Similarly, deposition of material by fluvial, glacial or mass movement processes creates long-term loading in drained areas and short-term loading in undrained areas, causing changes in relief, slope height, length, angle, and aspect of the terrain (Brunsden, 1993). Deposition of material eventually creates changes in permeability, strength and pore water pressure. Changes in water storage in groundwater can also trigger landslides. This change may cause rising or falling groundwater, development of perched water tables, surface saturation and flooding. The typical changes in this case could be floods, lake bursts, 'wet' years, intense precipitation, snow and ice melts and rapid drawdown. These changes in water storage also eventually create excess pore water pressure, changes in bulk densities and reduction in effective shear strength (Brunsden, 1993). Human interference causes similar changes in terrain.

The observation of air photos of the study area from different years shows that the majority of landslides in my study area are earth flows, and a few are rotational slides.

This observation is also supported by literature and historical landslide records. According to Chorley *et al.,* (1984) humid tropical rainforest areas undergo maximum chemical weathering, episodic mass wasting, moderate slope wash and erosion/sedimentation related fluvial processes and these areas have high dissolved and suspended loads in rivers. Morphologically, these areas contain low gradient rivers, wide, flat floodplains, and steep slopes arising abruptly from valleys, stabilized by vegetation and knife edge ridges. To identify the causes for landslide occurrences, different casual factors and triggering factors must be studied. According to Sower and Royster (1978), data for six parameters are necessary for any detailed landslide investigation: topography, geology, hydrology (groundwater and surface water), history of slope changes, weather, and vibration. Topographic data includes contour maps, surface drainage, slope profiles and data on topographic changes. Geological data includes lithology at the site, geological structure, and nature and depth of weathering. Hydrologic data include piezometric levels, variations in piezometric level, groundwater chemistry, nature and extent of surface water, seepage and data on water withdrawal. Data on history of slope changes means any information on slope changes due to natural processes (long term geological changes, erosion, and past movements), rate of movement, correlation of movement with other factors such as surface and groundwater, weather, and human activity. Weather data include precipitation, temperature and barometric changes. Similarly vibration data are seismic data, and any human induced vibration data such as blasting and heavy machinery. Site-specific landslide model which incorporates geology, geomorphology, anthropology and the range of external process is also useful (Sower and Royster, 1978).

Collecting, storing, analyzing, and manipulating the above-mentioned data are important tasks in any landslide study. Development of GIS and spatial statistical techniques are recent technological developments in earth sciences. These tools are constantly being used to improve investigation techniques and mitigative measures for the landslides in populated regions. There is improvement of quantitative methods to assess the probability of future landslide occurrences (Clerici, 2002). Most GIS-based landslide studies are, so far, most effectively used in landslide susceptibility studies and landslide hazard/risk mapping. However, some research also focus on the future prediction of landslide and landslide distribution in natural terrain. Brenning (2005) used spatial statistics to develop a spatial prediction model for landslide hazards. Guthrie and Evans (2004), after analyzing landslide frequencies and characteristics in British Columbia, Canada, concluded that GIS landslide studies must focus on landslides in natural ecosystems.

Dai (2001) used GIS techniques to study and map landslide susceptibility on the natural terrain. Burton *et al.,* (1998) used spatial statistics to generate a landslide model, and later they field checked the model. Lan *et. al.,* (2004) analyzed the dynamic characteristics of landslides in response to rainfall and concluded that the water pressure distribution and slope stability can be used as landslide predictor in GIS. Some studies even compare the different methods. Suzen and Doyuran (2004) compare the GIS based landslide susceptibility assessment methods by using multivariate and bivariate approaches. My thesis also uses hydrologic modeling to observe the soil-water interactions to model landslides. Hydrologic modeling is the quantification of hydrological processes using rainfall, soil, topography, and vegetation. In other words, hydrologic modeling solves many complex hydrological relationships/equations.

A terrain becomes unstable only when the shear stress exceeds the shear strength along some surface that becomes the failure surface. The methods used in this study in based on this principle of failure. In general, it is common for slope failures to occur during wet weather, because shear stress increases with increased weight of wetter slope materials (Fitts, 2002).

According to Mohr-Coulomb failure Criterion, for any slope:

$$\tau_f = c + \sigma_e Tan\phi \,. \tag{1.1}$$

Where, $\tau_f =$ shear strength (i.e, shear stress at failure),

c = Cohesion of material,

ϕ = Internal friction angle,

σ_e = Effective stress.

We have the relationship (Fitts, 2002):

$$\sigma_e = \sigma_t - P. \tag{1.2}$$

Where,

σ_t = Total stress and,

P = Pore water pressure.

So, Mohr-Coulomb failure Criterion becomes:

$$\tau_f = c + (\sigma_t - P) Tan\phi \,. \tag{1.3}$$

Equation (1.3) shows the stresses at failure depends on cohesion of soil (c), friction angle (Φ) and most importantly, total stress (σ_t) and pore water pressure (P).

The pore water pressure in soil and effective stress can be related to soil water content and pressure head. In other words, we can use a hydrologic model to determine these parameters by providing, rainfall data, evaporation data and soil properties data.

The hydrologic model used to observe the changes in water content and pressure head for high and low rainfall periods along with rainfall rate and evaporation rate in test sites. These observations were then used to explain the effective stress and the pore water pressure of the unsaturated soil in the area.

According to Fitts (2002), for a fixed weight at the bottom of soil column (σ_t =constant) thus:

$$d\sigma_e = -dP. \tag{1.4}$$

Where, $d\sigma_e$ = increase in effective stress and,

-dP= decrease in pore water pressure.

For the unsaturated flow, according to Bishop and Blight (1963):

$$d\sigma_e = -\rho g \kappa dH \;. \tag{1.5}$$

Where, κ = a constant, depends on the degree of saturation, soil structure, and the wetting – drying history of the soil,

ρ = density of water,

H = pressure head.

For the unsaturated soil, H >0, κ = 1,

H <0, $\kappa \leq 1$,

H << 0, κ = 0.

Hence, pore water pressure, water content and effective stress must be analyzed carefully in order to understand the failure mechanism in any landslide prone region. The hydrologic modeling was used to observe the changes in soil-water pressure head (H) with time.

The term ‘landslides’ in my study refers to any soil/rock failures that can be mapped at the 1:100,000 scale from air photos. Identifying, mapping and analyzing different classes of landslides depicted in fig.1, on a pure GIS basis is not possible; thus, every time I refer to the term ‘landslide’, I mean one of possible: cut bank erosion, side cutting by rivers, debris flow, translational and rotational slides, mappable rill/gully erosions, mud slides/flows, rock/soil fall/topple, slumps and creeps (if mappable). I did not classify landslides according to type.

My thesis has 4 chapters and two appendices. The appendix includes all initial data, processed data and outputs. In Chapter 1, I introduce the occurrences, classification, and causes of landslides. I declare my objectives. In Chapter 2, I describe my materials and methods. Chapter 3 presents results and discussion, and I present a conceptual model of the landslide process for my study area. I conclude my research project in Chapter 4.

1.2 OBJECTIVES

My thesis has three objectives.

1) Check the distribution (*i.e.,* randomness) of landslides digitized in ArcGIS for spatial trends.

   The randomness will show whether the distributions of landslides are just random or whether they are occurring due to a spatially correlated geomorphological process (*e.g.,* river meander). Such distribution can be described either qualitatively or quantitatively. Quantitative techniques are accurate, reliable, and scientifically sound.

2) Determine the relationships between environmental variables, and the occurrence of landslides.

   Since environmental variables such as water pressure in soils contributes to landslides, the degree of their dependency with landslide occurrence can be determined.

3) Develop a conceptual model for channel cross-section to show influence of landslides on fluvial and foreland processes.

CHAPTER TWO

MATERIALS AND METHODS

2.1 Study area

Peru is located on the South American continent and is well known for its highly variable geography. Because of variation in relief, rain shadows, El Nino, Humboldt Current, and wind patterns, the country comprises a multitude of climates (Escobal and Torero, 2000). My study area (Fig 2.1) lies in the south-eastern part of the country, in the foothill of the Andes, in the Amazon basin. The study area is a small portion of the much larger Madre de Dios basin. The Madre de Dios basin contains 3 sub-basins, and has a total drainage area of 47,254 km^2. The Los Amigos sub-basin is one of the three sub-basins in the Madre de Dios foreland watershed. The lower Los Amigos sub-basin with a 1,634 km^2 study area, is located between 12^0 -12.5 ^{0} latitude and $70^0 – 71^0$ longitude. The area is characterized by heavy rainfall, dense vegetation, meandering streams, and homogeneous soil types. Many swamps and oxbow lakes are common due to the sinuosity of the river. Many small and large landslides, predominantly mud flows, debris flows and mud slides are common. Sandy and silty loamy soils are the major soil types; bamboo commonly grows on exposed soils.

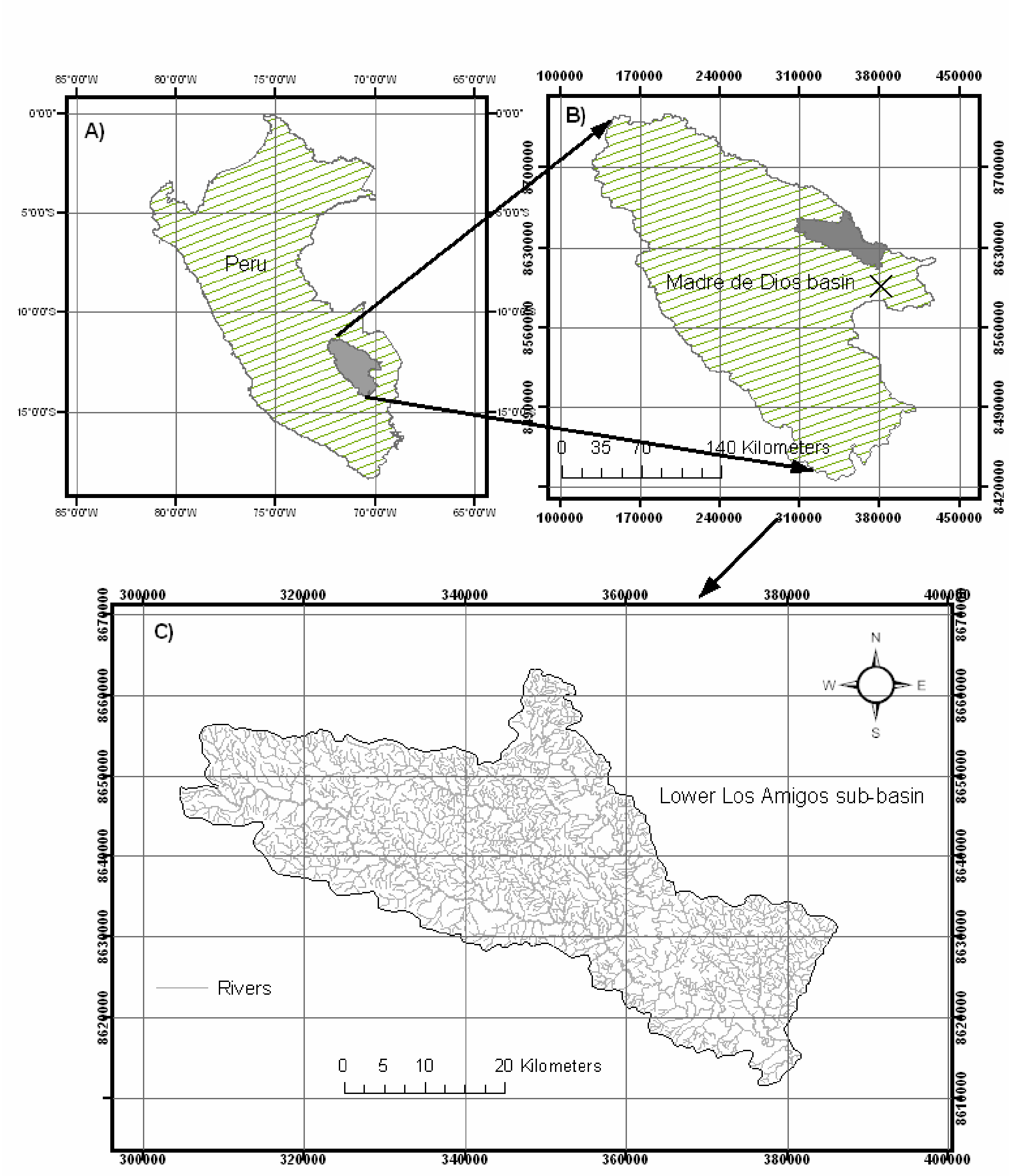


Fig. 2.1: A) Map showing Peru and Madre de Dios basin, B) Study area within Madre de Dios basin, C) My Study area. The coordinate system for map A is Lat Long and the coordinate system for other two maps B and C is Universal Transverse Mercator (UTM). The X, marks the approximate location of the Los Amigos Biological Station.

2.2 Geological and geo-morphological setting:

The Nazca Plate is moving east to north-east and is subsiding beneath the South American Plate (Jaillard *et al.,* 2000). Various studies have been conducted on the subduction of the Nazca plate and foreland basin evolution. Meschede and Barckhausen (1998), paleogeographically reconstructed the oceanic crust formed by the Cocos- Nacza spreading center and its precursors. Spreading performed in steps of 0.5 million years. During subduction, very large lithospheric plates subside beneath the crust producing a strong seismic wave. These waves travel to the surface and in many case are detected as strong earthquake and may serve as external cause of landslides

A foreland basin starts in the foothills of a mountain, and is relatively flat. It is defined as an elongate region of potential sediment accommodation that forms on continental crust between a contractional orogenic belt and the adjacent craton (Brazilian Craton for the Amazon), mainly in response to the geodynamics processes related to subduction and the resulting peripheral thrust belt (DeCelles and Giles*,* 1996). The Andean foreland basin in Peru receives a huge amount of water and loose sediments from the mountains, making the basin more prone to erosion.

This foreland basin is also a part of great Amazonian basin. The Amazonian basin is the world’s largest Cenozioc (Neogene) fluvial sedimentary basin. The study area is still deforming due to active orogenic movement which has been affecting the fluvial depositional environments in the Amazonian foreland basin throughout the Neogene-

Quaternary time (23 to 1.8 million years ago) (Rasanen *et al.,* 1991). The continuous deformation is affecting sediment transportation, deposition, and water storage. That storage sometimes explodes in the form of voluminous floods and these floods may be responsible for many landslides.

Fig. 2.2 shows the paleogeographical reconstruction of the Nazca plate subducting beneath the South American plate.

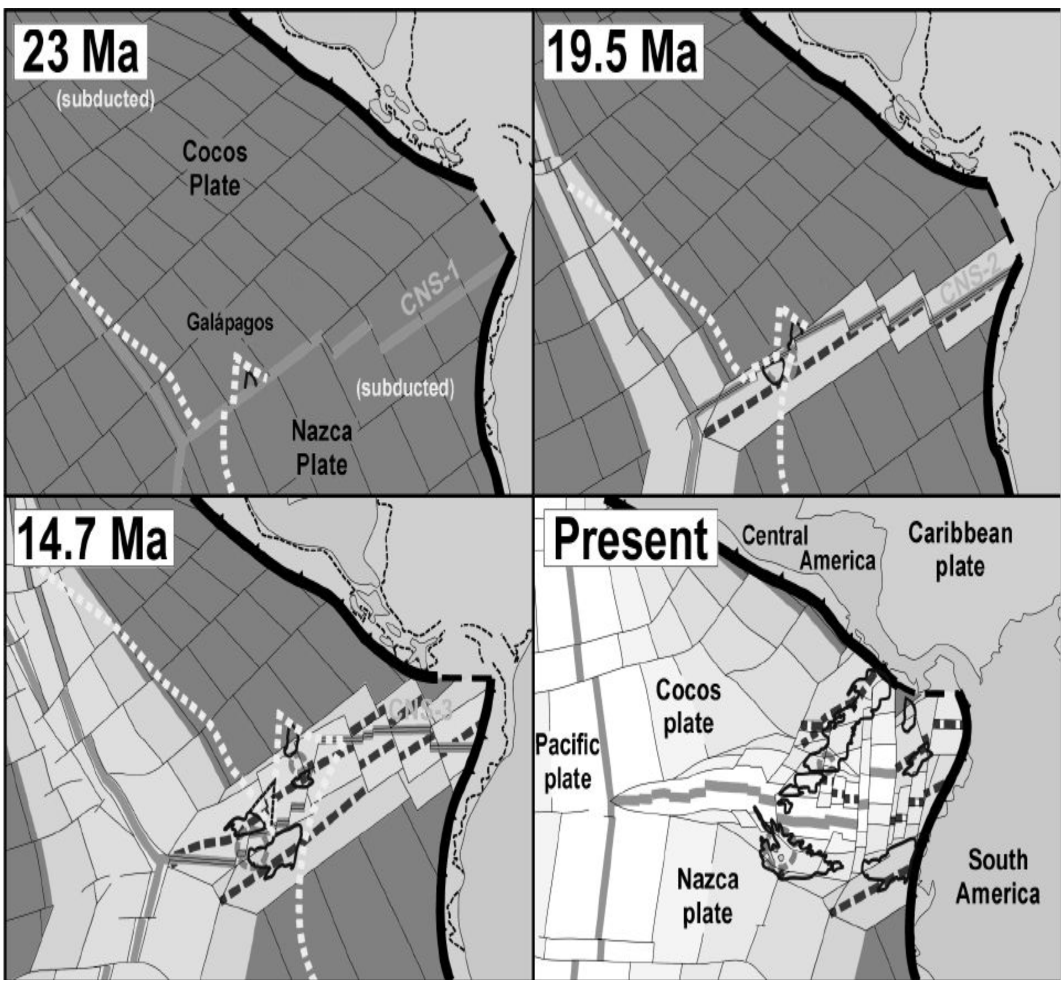


Fig. 2.2: Plates and plate boundaries. This figure shows Subduction of Nazca oceanic plate into the South American plate. This paleogeographical reconstruction was done by Meschede and Barckhausen (1998).

2.3 Rainfall:

Rainforests obviously receive more rainfall than any other part of a continent. Observing the monthly rainfall for seven years (from 1998 to 2004) by NASA's TRMM (TRMM, 2005), the recorded highest monthly accumulated rainfall was around 700mm. December-January is a generally high rainfall period and June-July is a low rainfall period. TRMM data were first obtained in ASCII (American Standard Code for Information Interchange) format from NASA's (National Aeronautics and Space Administration) TRMM website for each month of this seven year period. Data tabulation, average calculation and plotting were done by using EXCEL® (Microsoft Corporation) spreadsheet application. Fig. 2.3 shows average monthly rainfall plot for seven years. Detail data for each month are presented in appendix.

For hydrologic modeling, I used the 30 minute rainfall data for 2004 and 2005 from the Los Amigos Biological Station provided by John Janovec, Botanical Research Institute of Texas, Fort Worth. Detailed use of rainfall data is given in section 2.7.2.

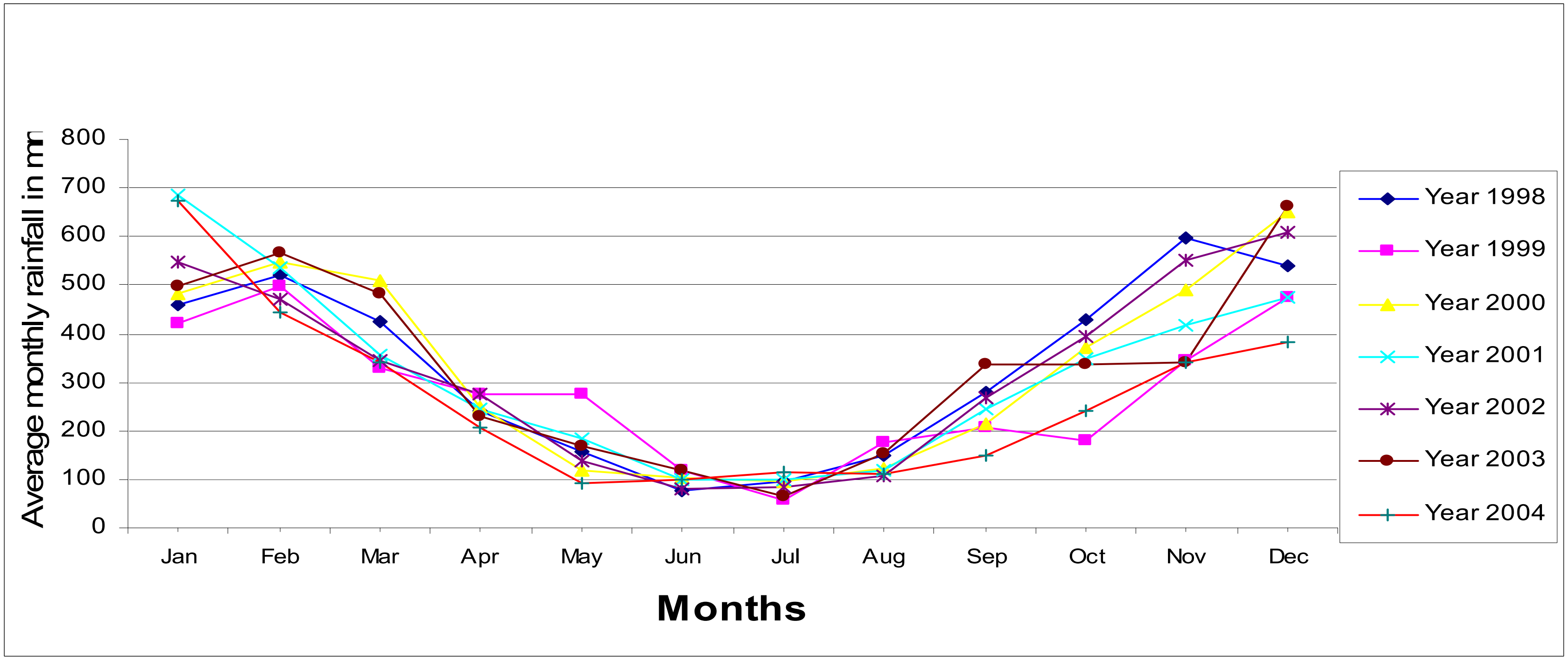


Fig. 2.3: Average monthly rainfall in mm. This plot was created by using NASA's TRMM rainfall data. January 2001 has highest rainfall recorded in these seven years period. Each year December and January receives high rainfall while June and July are relatively dry months.

2.4 Hydrology

2.4.1 Elevation and Slope

Compared to the entire Madre de Dios basin, the terrain in the lower Los Amigos sub-basin is relatively flat. The highest elevation is 422m above mean sea level and the lowest elevation is 226m above mean sea level. ASTER (Advanced Spaceborne Thermal Emission and Reflection Radiometer) DEM (Digital Elevation Model) of 30m resolution was collected and extracted for the study area. However the ASTER DEM did not cover the whole area. SRTM (Shuttle Radar Thematic Mapper) DEM with 80m resolution was used to extract the elevation for the remaining areas (SRTM, 2006). The areas with landslides were masked out from both DEMs and the random points were generated. Randomly sampled elevation points for the Los Amigos were then extracted using Hawth's analysis tool for ESRI (Environmental System Research Industries, Redlands, California) ArcGIS® 9.1. Then those points were interpolated by kriging operation using Geostatistical Analyst extension of ArcGIS® 9.1. The maps used to krig a DEM are given in fig. 2.4.1a.. Since there is little elevation variation (Fig. 2.4.1b), the slopes were relatively low (Fig. 2.4.1c): the maximum slope was 16^0. The slope was calculated using spatial analyst extension of ArcGIS® 9.1.

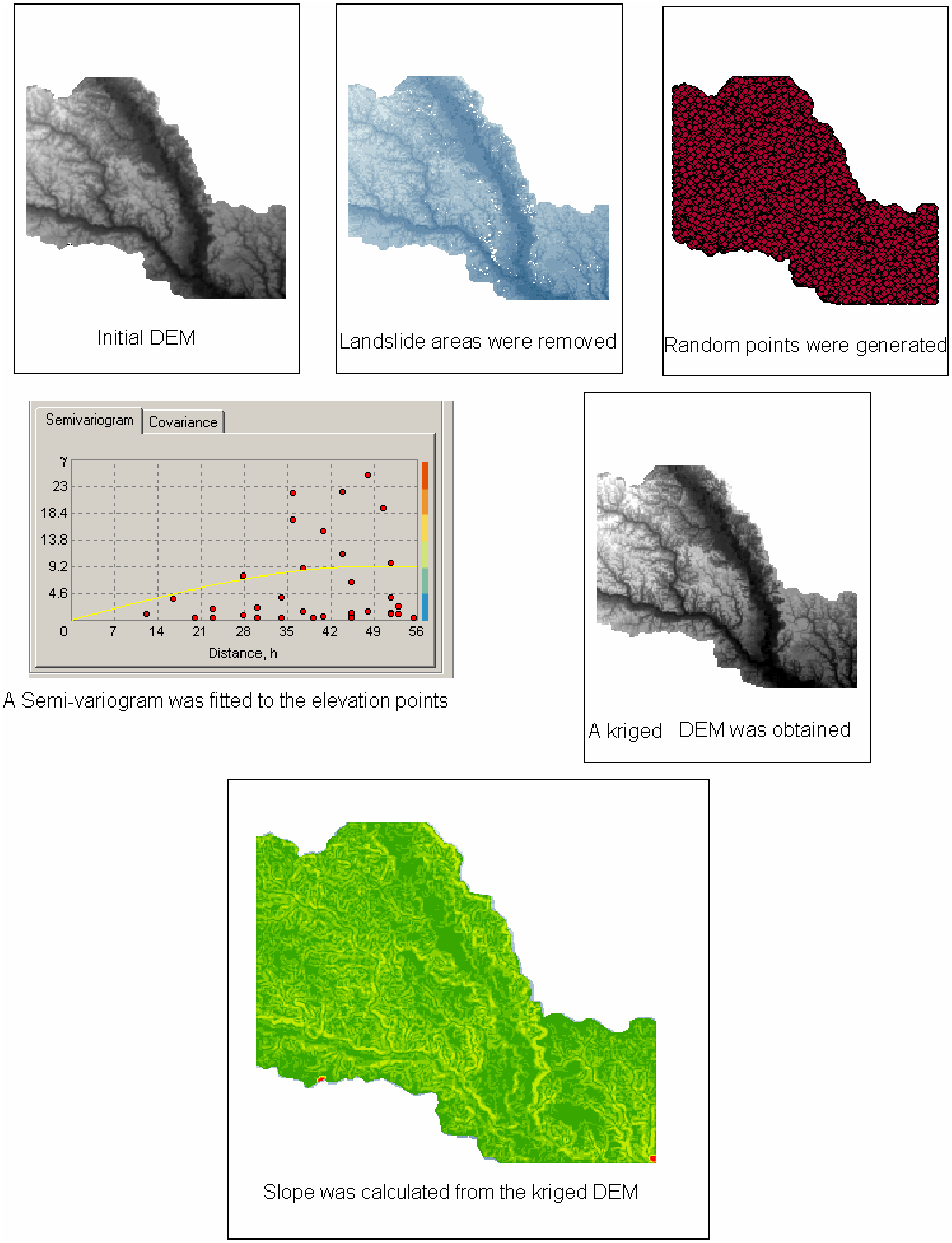


Fig.2.4.1a: re-kriging of DEM to get the slopes around landslides. Elevation generation started off from the top left corner.

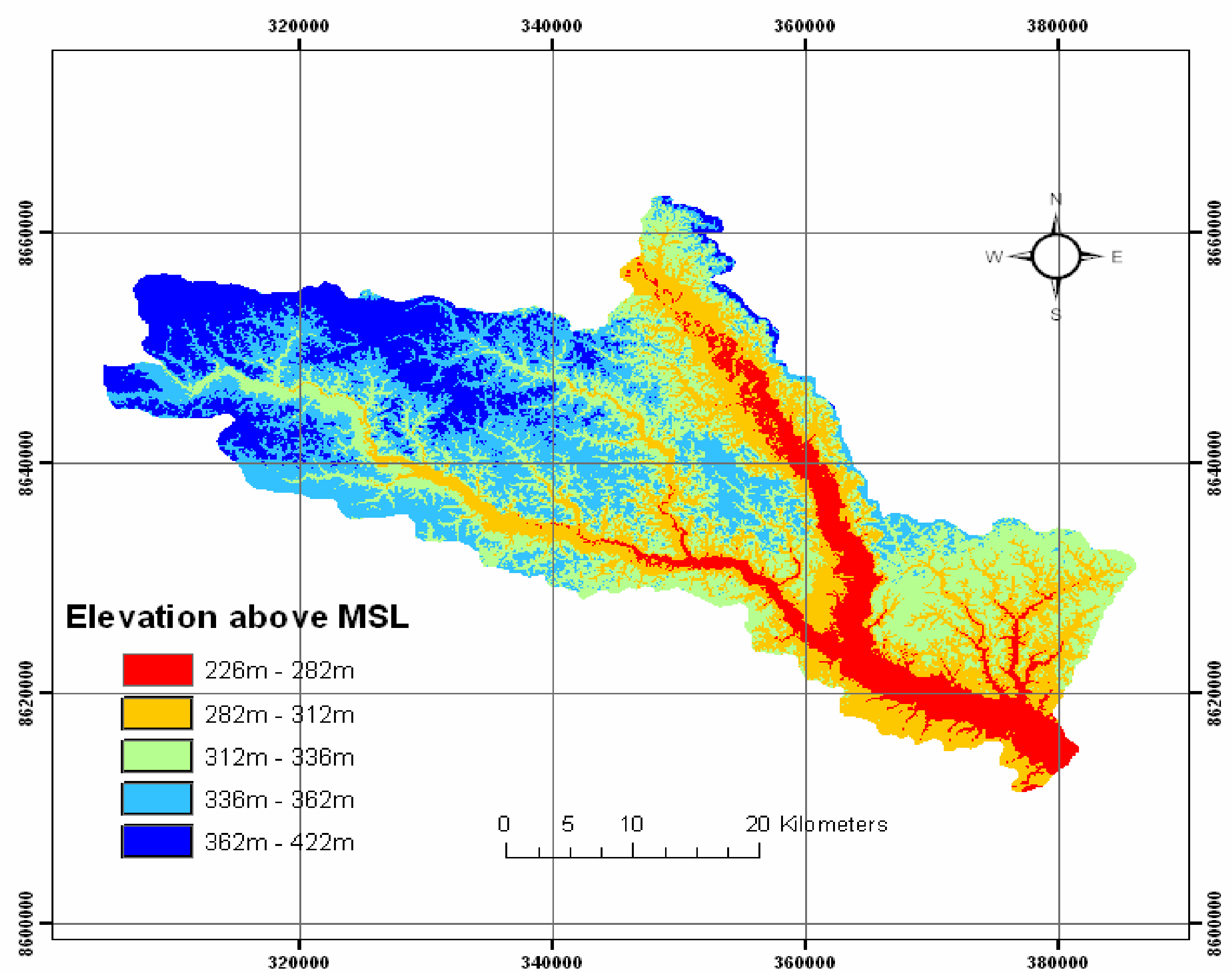


Fig. 2.4.1b.: The elevation map for the Lower Los Amigos sub-basin. The highest elevation is 422m and the lowest elevation is 226m above MSL. The coordinate system is in UTM.

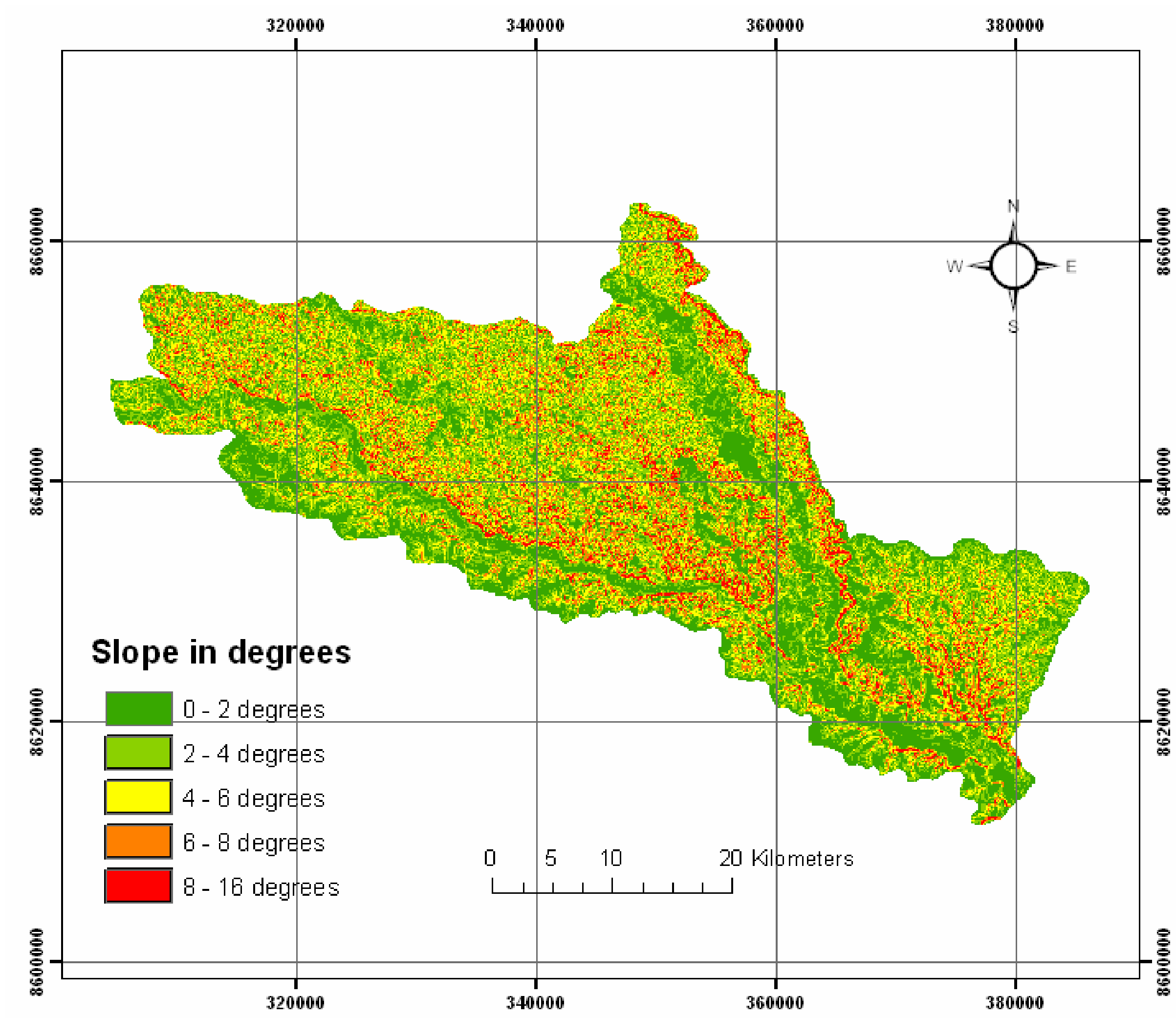


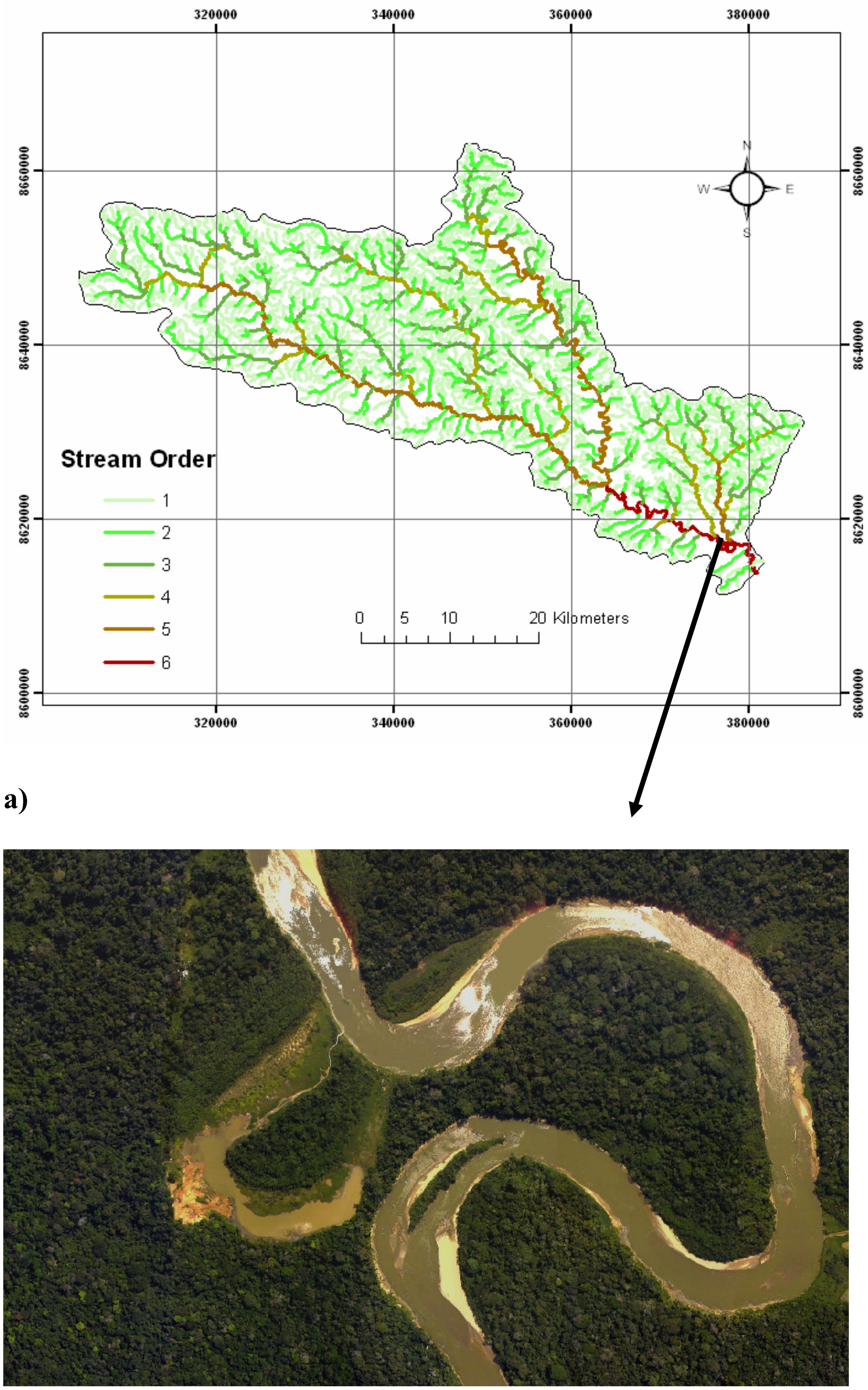
Fig. 2.4.1c.: Slope distribution in the study area. The coordinate system is UTM.

2.4.2 Drainage

The drainage pattern in the study area is mostly dendritic. Dendritic drainage patterns are recognized by their branching tree-like structure. Drainage delineation took three major steps:

1) Slicing of DEM: DEM for entire region did not show distinct drainage because of the greater variation in elevation values so the DEM was sliced into 14 smaller sections to make the drainage visible for digitizing.
2) River digitizing in ‘From node’ to ‘To node’ direction: When all visible DEM sections were loaded into Arc GIS 9.1, the digitization was carried out down river direction.
3) Network geometry and stream ordering: Network geometry was maintained and streams were ordered according to Strahler (1952) by using the RivEx extension for ArcGIS® (Duncan’s RivEx Extension for ArcGIS, http://www.rivex.co.uk, accessed on December, 2005). River ordering helped identify the major streams. The study area contains six stream orders (Fig. 2.4.2 (a)).

The main stream in the sub-basin is Los Amigos River. Los Amigos meets Madre de Dios River a few kilometers south-east from the south-eastern boundary of the study area. The highly meandering rivers continuously change their paths over time. Fig. 2.4.2 (b) shows an example meander that I commonly observed.



b)

Fig. 2.4.2: Drainage map. a) Drainage map with river order. b) A meandering river has changed its path. The coordinate system for the stream order map is UTM.

2.4.3 Watershed

The watershed was delineated using the drainage map. To draw the precise and accurate watershed, a hillshade was created from the DEM. Hillshade along with drainage network helped to identify the ridge and watershed divide. Hillshade and river network were overlayed in ArcGIS® 9.1, and the watershed shown in Fig. 2.4.3 was digitized. Since the study area is a part of the larger Madre de Dios basin, the first 7 digits of its label came from the watershed label for Madre de Dios basin. The label has 9 digits. First digit '3' means that this area is the third sub basin of the Madre de Dios basin. The Following 3 digits represent the number of upstream sub watersheds. Among the remaining 5 digits, the first three represent the watershed number for the larger Madre de Dios basin and the last 2 digits are watershed number for the study area. the watershed boundary was used to delineate my area.

2.5 Soils

A soil map obtained from government of Peru through BRIT (Botanical Research Institute of Texas) contained taxonomically classified soil polygons. I reclassified the soils by soil texture using the USDA (United States Department of Agriculture) textural soil classification triangle. To do that: I extracted the percent of silt, clay and sand from the taxonomically classified soil, and then I re-classified the soil texturally using the USDA triangle. The majority of soils were silty clay loam, sand, and silt loam. Silt loam is confined along the main river banks (Fig. 2.5).

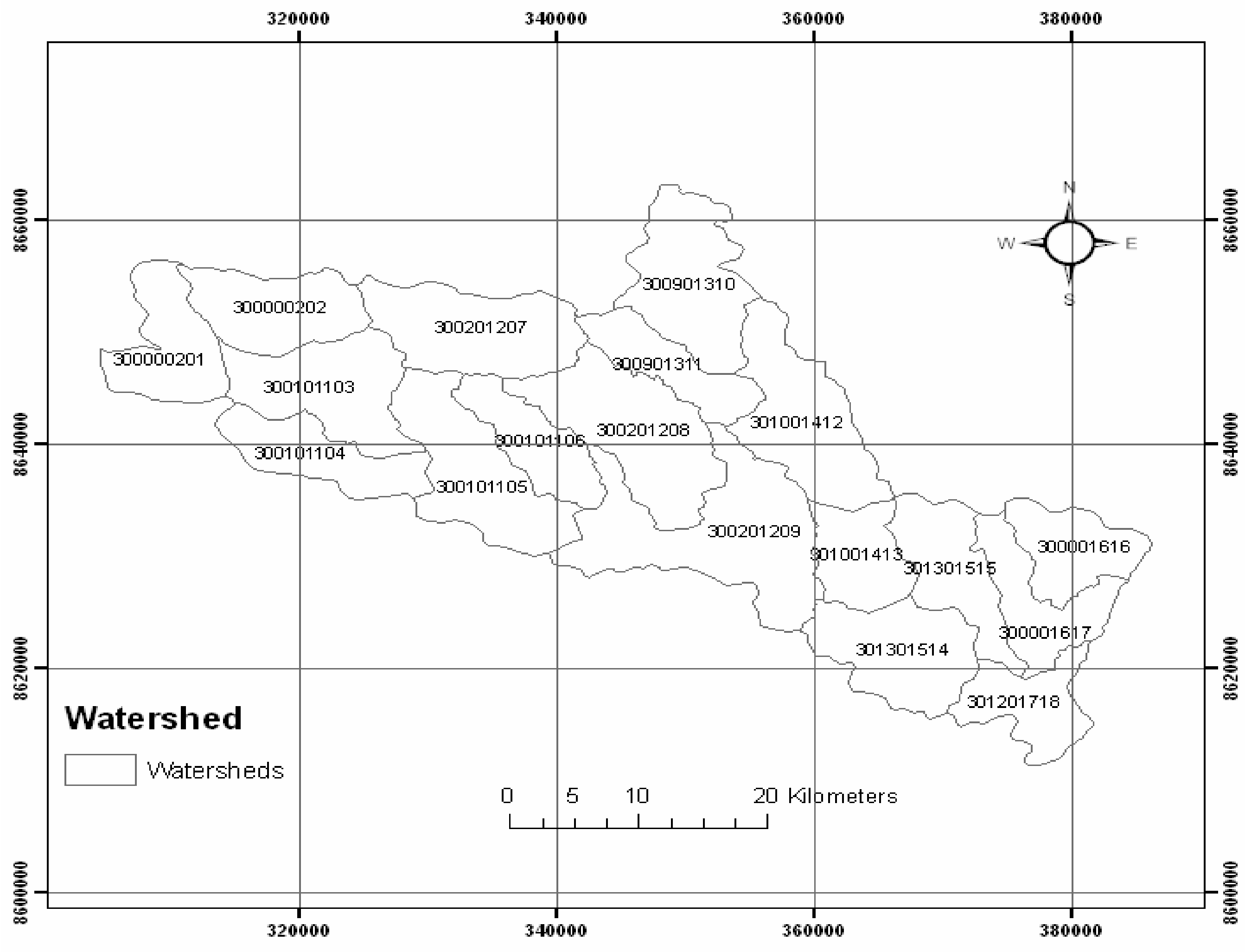


Fig. 2.4.3: Watershed map of the study area. Since this is a part of Madre de Dios basin, the first digit in this watershed corresponds to sub-basin no 3 of Madre de Dios basin. The coordinate system is in UTM.

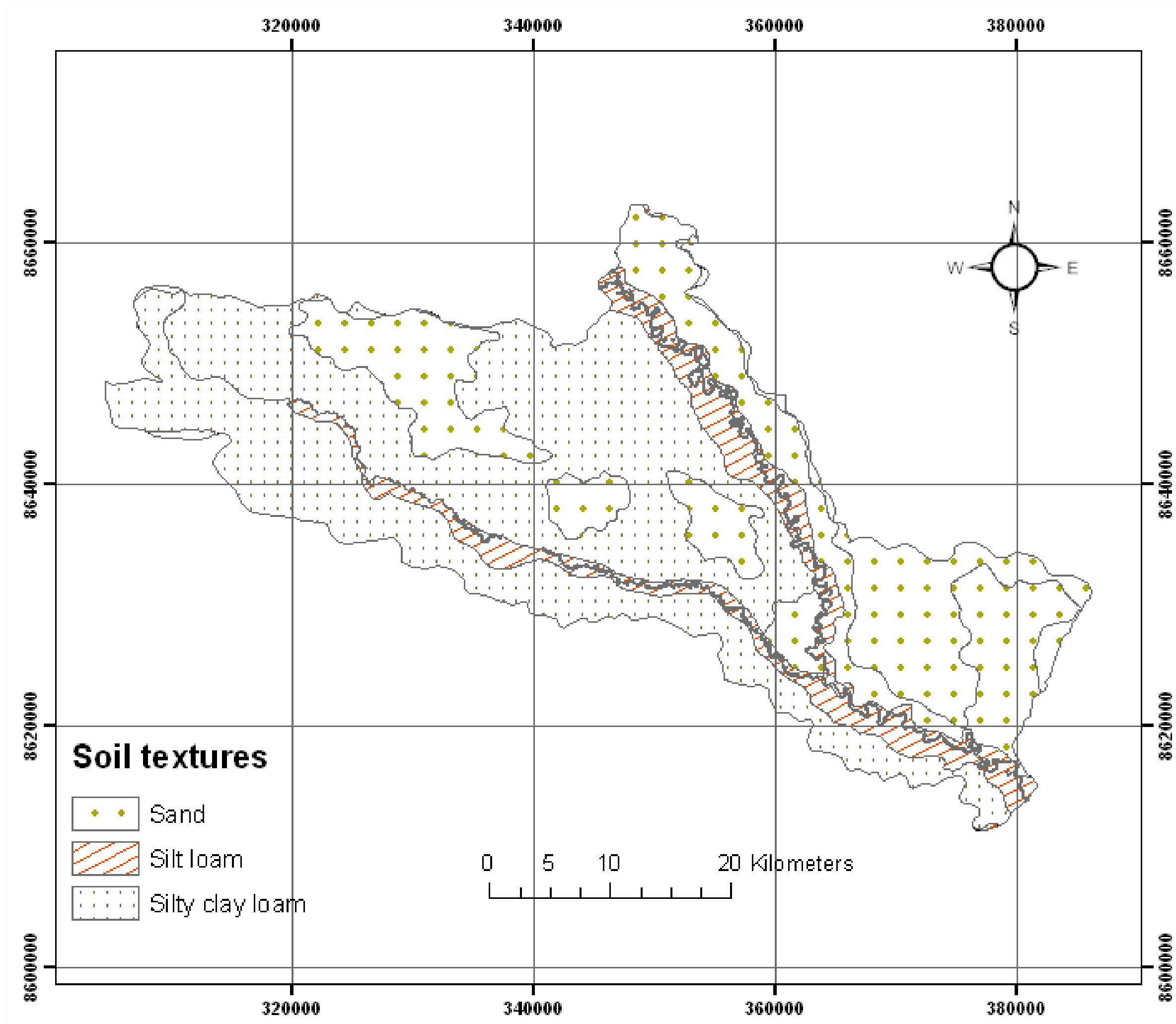


Fig 2.5: Soil distribution in study area. The classification scheme shown in this map is based on soil texture i.e., classification based on percentage of sand, silt and clay. The coordinate system is in UTM.

2.6 Landslides

Lower Los Amigos basin has hundreds of landslides confined mainly on either side of the Los Amigos river(Fig.2.6.1). Almost all the landslides are located on the sandy soil and silty loam soils. Recent landslides were identified from 5cm resolution air photos taken by Winrock International in 2003. Air photos were loaded into ArcGIS® 9.1, and landslides were digitized. A total of 381 landslides with a mean area of 2,4081 m^2 weere digitized. The total area of landslides was 8.7 km^2. The largest landslide identified had an area of 400,000 m^2. Fig. 2.6.1 - Fig 2.6.8, show example landslides photographed by Ethan Householder, a TCU Environmental Science graduate student working in Los Amigos. The purpose in presenting these photographs is to show some common types of failures and mass movements.

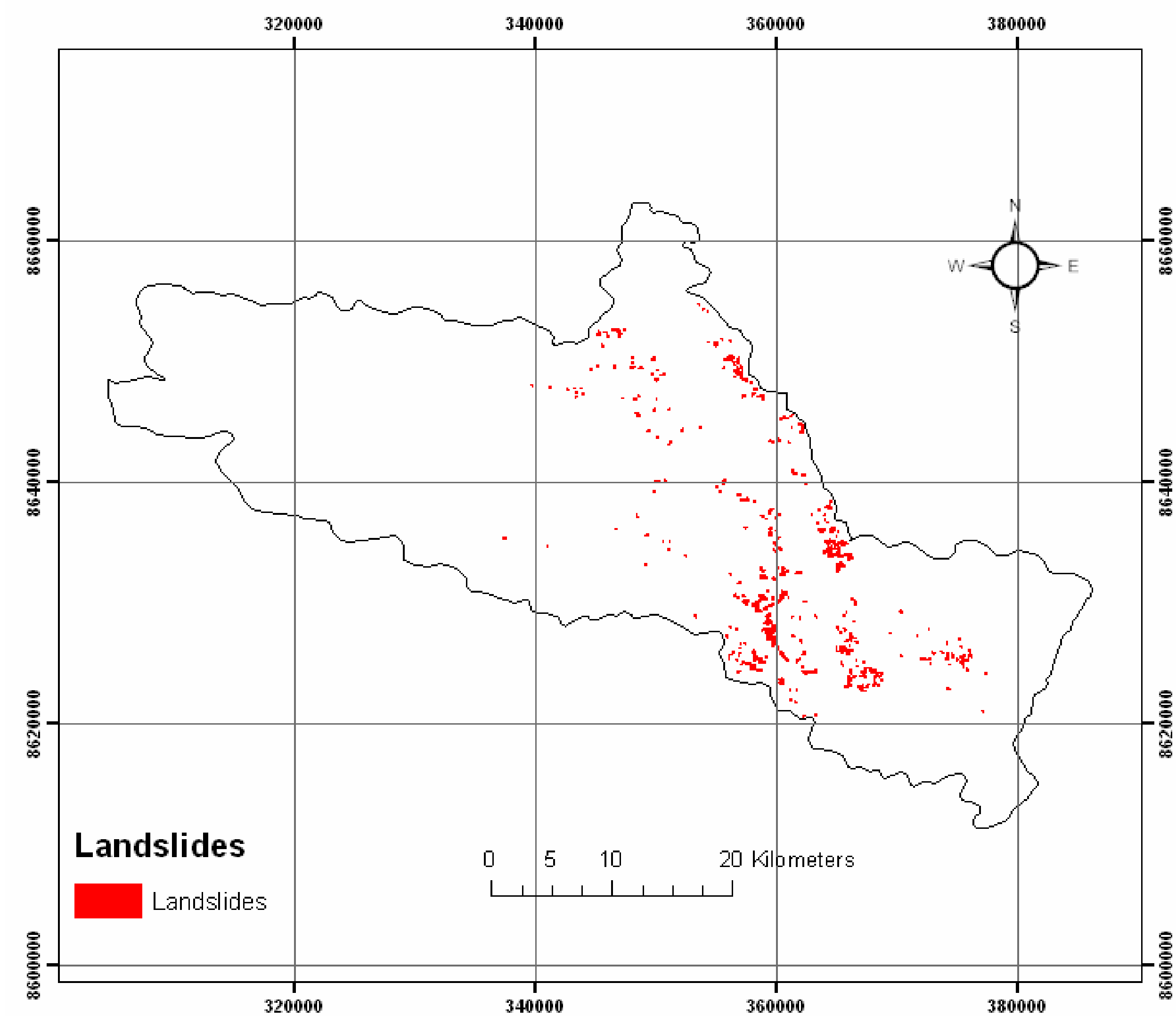


Fig. 2.6.1: Landslide distribution in the study area. Red patches are landslides. The coordinate system is in UTM.

Fig 2.6.2: Erosion at a river bank. Many river banks in the study area are unstable. Note the shallow rooting depth. The breaks (shown in white line) running along the soil profile suggest historical soil deposition. The breaks may be attenuated by wet/dry cycling of soils.

Fig 2.6.3: Another failure along the river bank. The debris deposit and landslide slopes are rapidly covered by pioneer species, bamboo.

Fig. 2.6.4: Loose sandy soils are easily eroded away by intermittent rivers and overland flow after the rainfall.

Fig. 2.6.5: Silty soils showing water erosion in exposed areas.

Fig. 2.6.6: Bamboo is a Pioneer species that rapidly colonizes landslides.

Fig. 2.6.7: A landslide: Typical example of water induced failure. Ethan is standing right on the channel.

Fig. 2.6.8: Riverside failure. This is a small translational slide. Note the second order failure from the upper scarp. The lower scarp (B) is the older one with dark colored organic lining on the surface. The upper scarp (A) is fresh.

2.7 Hydrologic modeling

The pore water pressure can internally cause soil failure. I determined pore water pressure for my study area from soil-water pressure. Soil-water pressures were obtained from hydrologic model called MIKE-SHE (DHI Inc., Denmark). MIKE-SHE is an advanced integrated hydrological modeling system. It simulates water flow in the entire land based phase of the hydrological cycle from rainfall to river flow, via various flow processes such as, overland flow, infiltration into soils, evapotranspiration from vegetation, and groundwater flow (MIKE-SHE, 2006).

2.7.1 Model essentials

To observe and explain the changes in pressure head and soil water content, hydrologic modeling was carried out. The model was run for two different months: September, 2004 and March 2005; defining 'dry' and 'wet' periods, respectively. Observing results from both periods helped me observe and explain the difference in soil water interaction in these two different time periods. The hydrologic model was MIKE-SHE (DHI Inc, Denmark). The whole modeling process involved three main steps (Fig.2.7.1).

- Input
- Running model and,
- Output

The input data for the modeling consisted of rainfall, evaporation, soil water retention parameters, hydraulic conductivity, elevation and groundwater table. Input details are presented in the next section (2.7.2). To run the MIKE-SHE model, MIKE-ZERO frameworks was used. While MIKE-SHE is a dynamic modeling system for integrated groundwater and surface resources, MIKE-ZERO is a framework that gives access to MIKE-SHE modeling system. MIKE-ZERO gave many important facilities (data editing, charting, preprocessing, running and analysis tool) for me to model the hydrology. The simulation was run at three hourly time steps. The output from the model was obtained in gridded data format. Outputs include water content in unsaturated zone, pressure head in unsaturated zone, rainfall rate in unsaturated zone and actual evaporation rate in unsaturated zone.

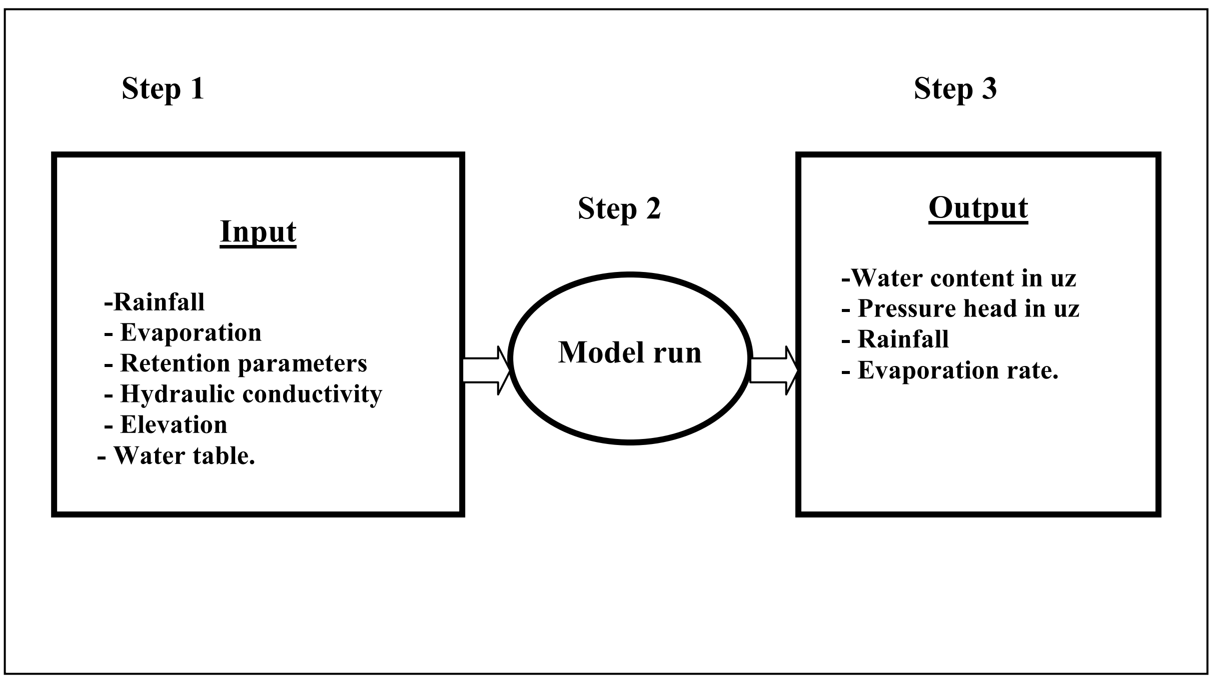


Fig. 2.7.1: General flow chart of the modeling showing different steps involved to run the model (uz refers to unsaturated zone).

2.7.2 Model Input

As stated in section 2.7.1, six input parameters were collected and used. None of the initial GIS data were in a format required by MIKE-SHE. A series of calculations and data manipulations were done before loading the data into MIKE-SHE environment. The calculation of rainfall was simple, while the calculation of evaporation, soil water retention parameters and hydraulic conductivities were more involved.

2.7.2.1 Calculation of rainfall and evaporation

Measured 30- minute weather data provided by John Janovec from BRIT (Botanical Research Institute of Texas), were used to generate evapotranspiration and rainfall data for MIKE-SHE. The initial data consisted of 30 minute measurement of rainfall, solar radiation, relative humidity, temperature and wind speed. The 30 minute measurement data were converted into three-hourly measurements using Microsoft Excel because the modeling time step was 3 hours. The flow chart in fig. 2.7.2 illustrates the steps used for the calculation of rainfall and evaporation.

The procedure for calculation of evaporation from the Pennman-Monteith equation is shown in fig. 2.7.2 (Shuttleworth, 1993). The required parameters were net radiation, latent heat, wind speed, and temperature gradient. They were calculated at 3 hourly time steps. The psychrometric constant was assumed to be constant at 0.067 kPa $^0C^{-1}$ at an average temperature of 25^0C.

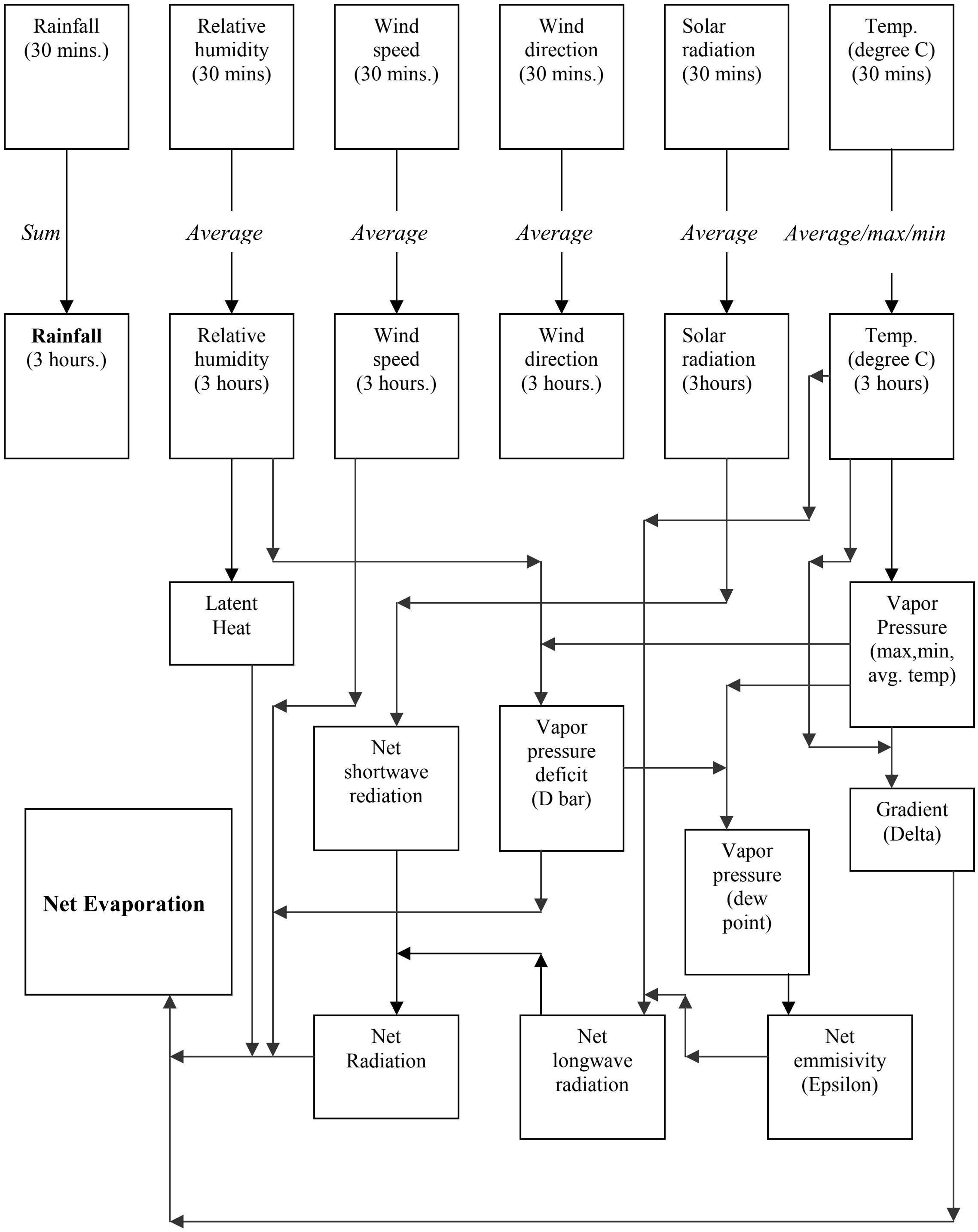


Fig. 2.7.2: Flow chart showing calculation of rainfall and evaporation. Starting from the top of the figure, the arrowheads start from the data and point towards the calculated results. Follow the arrowheads to get the parameters required to calculate the specific terms. The final result of all these calculations is rainfall and net evaporation shown in bold letters.

I used the Penman-Monteith equation (Shuttleworth, 1993)

$$E_p = \frac{\nabla}{\nabla + \gamma}(R_n + A_h) + \frac{\gamma}{\Delta + \gamma}\frac{6.43(1 + 0.536U_2)\overline{D}}{\lambda}. \qquad (2.7.1)$$

Where,

E_p = Potential evaporation/ net evaporation, mm day^{-1},

R_n = net radiation exchange for the free water surface, mm day^{-1},

A_h = energy advected to the water body, mm day^{-1}, if significant,

U_2 = wind speed measured ar 2m, ms^{-1}, $\overline{D}$ = vapor pressure deficit,

γ = psychrometric constant, kPa^{0}C^{-1}, λ =latent heat, MJkg^{-1},

∇ = gradient defined by temperature.

As mentioned earlier, γ was assumed to be constant. Also, A_h was ignored. R_n, was obtained by the sum of net shortwave radiation and net longwave radiation (Fig. 2.7.1). Net shortwave radiation was obtained from solar radiation data and net longwave radiation was obtained from net emmissivity and temperature (Shuttleworth, 1993). Net emmissivity was calculated from vapor pressure and vapor pressure was actually obtained from temperature data. Similarly, $\overline{D}$ was also calculated from vapor pressure and saturated vapor pressure. The evaporation calculations were performed in Microsoft Excel. The 3 hourly evaporation data were then loaded as a .dfs0 file into MIKE-SHE.

2.7.2.2 Calculation of soil water retention and hydraulic conductivity

Rawls *et al.,* (1993) suggested three types of soil water retention and hydraulic conductivity relationships for the modeling: Brooks and Corey relationship, Campbell relationship and Van Genuchten relationship. MIKE-SHE supports only two of them: Brooks and Corey and Van genuchten relationships. I used Van Genuchten methods because, in my case, I found this method provided better retention curves.

Van Genuchten relationship for soil water retention is given by (Rawls *et al.,* 1993):

$$\frac{\theta-\theta_r}{\phi-\theta_r}=\left[\frac{1}{1+(\alpha h)^n}\right]^m \quad . \tag{2.7.2}$$

Where, ϕ = porosity,

θ = water content,

θ_r = residual water,

α = constant given by $\alpha=(h_b)^{-1}$, where h_b = bubbling capillary pressure, kPa,

n= constant given by $n=\lambda+1$, where λ =pore size index,

m= constant given by $m=\frac{\lambda}{\lambda+1}$.

Similarly, Van Genuchten relationship for hydraulic conductivity is given by (Rawls *et al.,* 1993):

$$\frac{K(\theta)}{K_S}=\left(\frac{\theta-\theta_r}{\phi-\theta_r}\right)^{\frac{1}{2}}\left\{1-\left(\left[\frac{\theta-\theta_r}{\phi-\theta_r}\right]^{\frac{1}{m}}\right)^m\right\}^2 \tag{2.7.3}$$

Where, $K(\theta)$ = hydraulic conductivity for given water content, cm h^{-1},

K_S = fully saturated conductivity, cm h^{-1} when $\theta = \phi$.

As noted in section 2.5 of this chapter, the soil data was initially taxonomically classified. There were four major soil types: Entisols, Inceptisols, Alfisols and Ultisols. Since the data did not contain any information on soil water retention and hydraulic conductivity parameters, these soils were reclassified texturally in terms of sand, silt and clay percentages based on Nordt (2000), Wayne (2000), Hallmark (2000), and West (2000). Three textural soils were identified: sand, silt loam and silty clay loam. Once the soils were classified texturally, the water retention properties were determined from Rawls *et al.* (1982, 1993). The soil water retention and hydraulic conductivity parameters for three soils are presented in following table (Table 2.7.1).

Table 2.7.1 Soil parameters required by the unsaturated soil component of MIKE-SHE.

	Silty loam	***Silty clay loam***	***Sand***
Silt%	65.8	7	6
Sand%	20.4	65	87
Clay%	13.8	28	7
Porosity (ϕ)	0.50	0.471	0.52
Moisture at -33kPa	0.33	0.366	0.14
Moisture at -1.5MPa	0.133	0.208	0.01
K_S (cm/h)	1	0.05	20
Pore-Size index, λ	0.234	0.177	0.694
α	0.048169557	0.030712531	0.137741047
θ_r	0.015	0.04	0.02
h_b ,cm	20.76	32.56	7.26
K_S ,mm/h	0.1	0.005	2.0

2.7.3 Model Runs

After data input, the specifications required to run the model in MIKE-SHE were determined. The simulation was specified as unsaturated zone flow (UZ) dependent on rainfall and evapotranspiration. The unsaturated flow simulation was performed using the full Richard's equation (Ross, 1990). The simulation period was one month: one month each for wet (March, 2005) and dry (September 2004) periods. The time step was 3-hourly, and the grid specified was 1km X 1km. The topography was obtained from the contour shape file. The spatial distribution of precipitation was assumed to be uniform because the 30 minute rainfall data was available at the Los Amigos Biological Station. Similarly, the spatial distribution of vegetation was assumed to be uniform with a Leaf Area Index (LAI) value of 5 to represent the dense canopies. The rooting depth (RD) was specified as 1.5 m (assuming shallow tree rooting depth).

The spatial distribution of evapotranspiration was also assumed to be uniform for two reasons: 1). the entire study area has dense vegetation cover and, 2). no vegetation classification was available. The spatial distribution of soil profiles was specified as spatially non-uniform (spatially-distributed) by providing polygon data with the X and Y axes in UTM meter coordinates.

The groundwater table depth was specified as spatially-distributed, and a water table map was provided with water table depth ranging from zero meters to 15 meters from the ground surface (Fig.2.7.3): the groundwater table data for the study area could not be obtained because no piezometric instruments were installed in the study area. Thus, the groundwater table was assumed at zero meter depth to the ground at the mouth of the Los Amigos River and up to 15 meter depth from the ground surface along the first order streams in river source areas and it was also assumed that the groundwater table follows the topography. The groundwater table elevation map was obtained using the Raster Calculator of Spatial Analyst extension in ArcGIS® 9.1. The water table elevation raster map created in ArcGIS® 9.1 was not recognized by MIKE-SHE , so a contour map was created from this water table elevation map in ArcGIS® 9.1 and imported into MIKE-SHE. The actual water table elevation map was then produced in MIKE-SHE using water table contour map. This contour map was interpolated into a grid inside MIKE-SHE by bilinear interpolation.

2.7.3 Model Output:

Detailed time series output were obtained from the model. The time series outputs that I selected were pressure head in unsaturated zone, soil water content in unsaturated zone, rainfall rate, and actual soil evaporation. These outputs were obtained in MIKE-SHE in the form of gridded data which were later exported into ASCII formats to plot the data in Microsoft Excel.

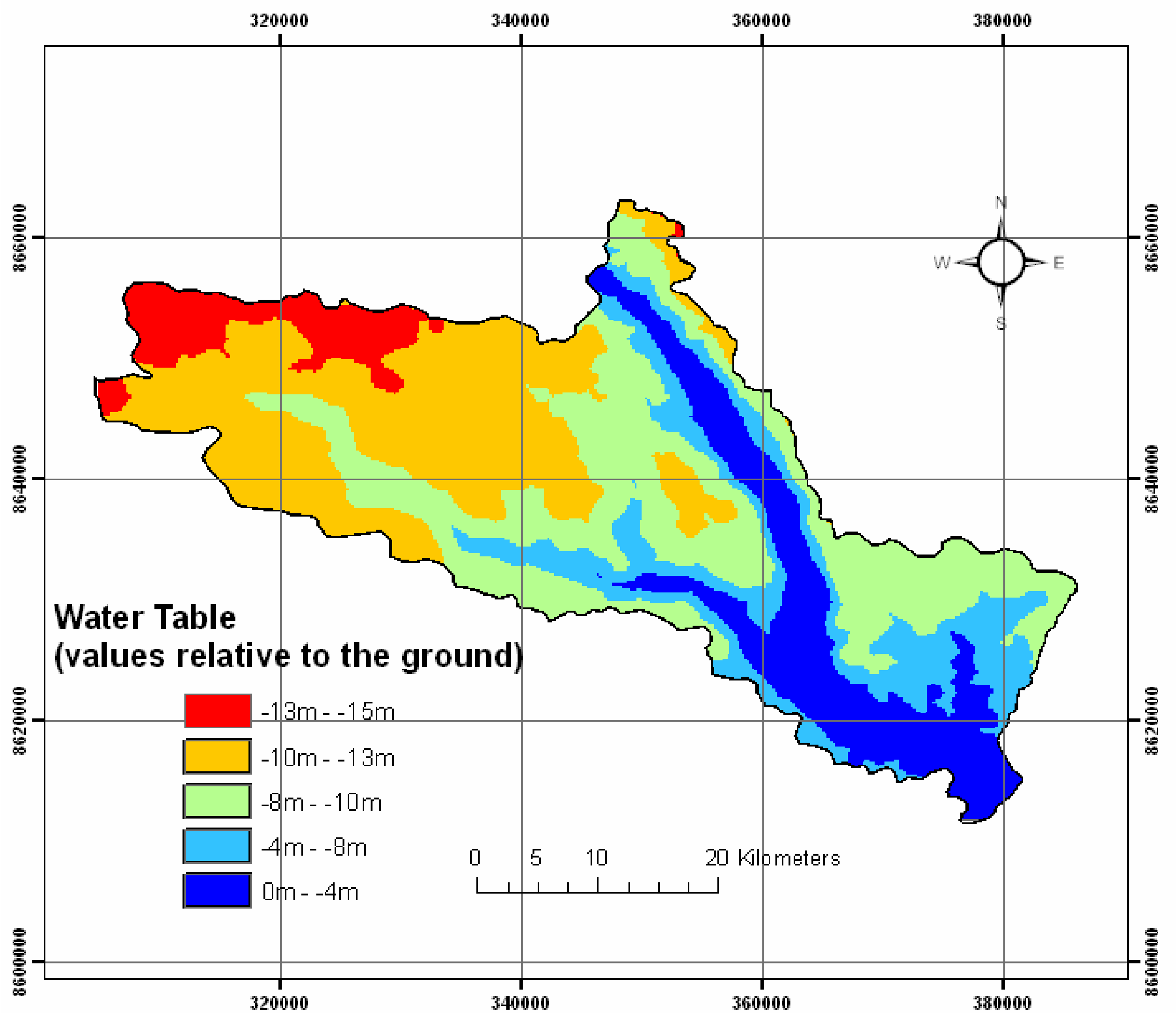


Fig. 2.7.3: Groundwater table map of the study area. The coordinate system is in UTM.

2.8 Randomness

Randomness explains the spatial trends of events. An event may be a single phenomena, object, occurrence or existence at any spatial location (Landslides occurrences are events in my study). Events are regular, clustered or random. From among several statistical methods, I used Ripley's K-function to check the randomness of landslide distribution (Ripley, 1976; Ripley, 1979; Bailey and Guttrell, 1995; Ripley, 1977). K-function is a tool for analyzing spatial point process data *i.e.,* it analyzes the spatial event points for spatial trends (Dixon, 2002). Ripley's K-function provides a test of randomness between specified area limits (Levine, 2004). Randomness is tested by comparing Ripley's K-function with Complete Spatial Randomness (CSR) where CSR represents a baseline hypothesis against which the observed patterns are compared to see whether observed patterns are regular, clustered or random (Bailey and Gatrell, 1995).

2.8.1 K-function

The theory description given by Levine (2004) is simplified and presented here.
Let us consider a spatially random distribution of N points. Suppose, the circles of radius d_s, are drawn around each points, where s represents the order of radii from the smallest radius to the largest radius. Then the number of points within the circle is counted and then summed over all points. Now, the expected numbers of points within that radius are:

$$\text{E (number of points within distance } d_i) = \frac{N}{A} K(d_s) . \qquad (2.8.1)$$

Where, N= sample size,

A= Total study area,

K(d_s) = area of circle defined by radius d_s.

In the case of CSR, the expected number of points within distance d_s is given by:

$$\text{E (number of points under CSR)} = \frac{N}{A} \pi d_s^{\,2} . \qquad (2.8.2)$$

Now, if the average number of points found within a circle of a particular radius over each point is greater than $\frac{N}{A} \pi d_s^{\,2}$ (i.e., number of points under CSR), then the points are clustered. On the other hand, if the average number of points found within a circle of a particular radius over each point is less than number of points under CSR, the points are dispersed or random.

In general, K-statistics indicates the non-randomness by counting the number of total event points within a particular radius and comparing it to the number expected on the basis of CSR. Based on this assumption, K-statistics is defined as:

$$K(d_s) = \frac{A}{N^2} \sum_{i} \sum_{i \neq j} I(d_{ij}) . \qquad (2.8.3)$$

Where,

$I(d_{ij})$ = Number of other points, j, found within distance d_s, summed over all points, i.

After completing this process, the radius of the circle is increased and the entire process is repeated. In my study, 100 intervals were used by using:

$$d_s = \frac{R}{100}. \qquad (2.8.4)$$

Where, R= radius of a circle whose area is equal to the study area,

d_s = radius distance.

Since, $K(d_s)$ is non linear, it is transformed into a square root function $L(d_s)$ to make it linear. The square root function is defined by

$$L(d_s) = \sqrt{\frac{K(d_s)}{\pi}} - d_s \quad . \qquad (2.8.5)$$

In practice, L statistics are plotted, even though the name of the statistic K is based on the K derivation given by equation (2.8.3).

The software I used was Crimestat® III (Ned Levine & Associates, Houston, TX, and the National Institute of Justice, Washington, DC). I used 1000 simulations for CSR, and I specified the circular edge correction. Edge correction was necessary because the K-function is biased near edges.

2.9 Spatial heterogeneity

To test whether landslides had spatial dependencies, I used spatial regression. Environmental variables such as slope classes, aspect, closeness to the river, soil properties, and vegetation play a role in the occurrences of landslides. Spatial regression helped with the final and the most important objective of this thesis: determining the main causes for landslides in tropical rain forests.

2.9.1 Spatial Regression

The spatial regression analysis involved a series of significance tests for regression coefficients. This was necessary to identify and confirm the spatial dependencies, and significance between landslides and environmental variables. The following paragraphs explain 2 main steps I carried out in spatial regression.

2.9.1.1. Standard linear regression or Ordinary Least Squares model (OLS)

This model finds a linear relationship between a dependent variable and a set of explanatory variables:

$$y = X\beta + \varepsilon \ . \qquad (2.9.1)$$

Where, β = regression coefficient (intercept), X= Explanatory variable,

y= Dependent variable and,

ε = Error term.

Equation (2.9.1) is for the linear relationship when, dependent variable is y and single explanatory variable is X.

The OLS estimation is called Best Linear Unbiased Estimator (BLUE) because OLS minimizes error variances. It estimates β by minimizing the sum of squared prediction errors so the term least squares is used. In order to obtain the BLUE property, certain assumptions about the random error of the regression equations are made:

i) The random error has a mean of zero

ii) The random errors are uncorrelated and they have a constant variance. Having constant variance in random errors is called homoscedastic. A test called heteroscedasticity checks for the variable variance in errors.

iii) The random errors follow a normal distribution.

2.9.1.2 Spatial dependency

If the assumptions made for BLUE are true, then there won't be any spatial dependence, but in practice this is not always true. If a value observed in one location depends on the values observed at neighboring locations, then there is spatial dependence.

2.9.1.2.1. Spatial error

In spatial error, the error terms across different spatial units are correlated i.e., the error term ε_i from spatial unit y_i and ε_j from spatial unit y_j for example, are correlated. The spatial error coefficient λ is observed for the significance in spatial error model.

2.9.1.2.2 Spatial lag

In spatial lag, the dependent variable in one place is affected by the independent variables both in that place and another place. In the spatial lag model, the lag coefficient ρ will show presence of spatial dependence.

All regression analysis was carried out using GeoDa® (Spatial Analysis Laboratory, Department of Geography, University of Illinois). The selection of a dependent variable for landslides was a major challenge. I digitized the outline of landslides as polygons using 5cm air photos (Fig. 2.6.1 from section 2.6). In order to quantify landslides as a dependent variable, I counted the number of individual landslides within a 1km X 1 km grid (Fig. 2.9.1). The landslides were counted within 1km X 1km grid because the hydrologic modeling was also run at 1km X 1km grids (Section 2.7.3), and any output obtained from hydrologic modeling would be applicable for 1km X 1km grid. I counted the number of landslides within each grid using Hawth's analysis tool 3.24 for ArcGIS® 9.1. Then each 1km X 1km grid containing landslides was assigned the number of landslides (Fig. 2.9.2).

I extracted the slope and aspect for each grid from the slope map and aspect map, respectively. At this stage, I had two independent variables which might be responsible for the landslides in the area. Another drainage dependent variable (Pressure head fluctuation) was obtained from MIKE-SHE for each landslide grid. The standard deviation in pressure head at each grid was extracted from MIKE-SHE in ASCII format to get another independent variable, H_σ. The distance from the nearest river for the each grid was determined from Hwath's analysis tool for ArcGIS® 9.1. In this way, I used landslide count as a dependent variable and slope, aspect, distance from river, and standard deviation in pressure head (H_σ) as explanatory independent variables.

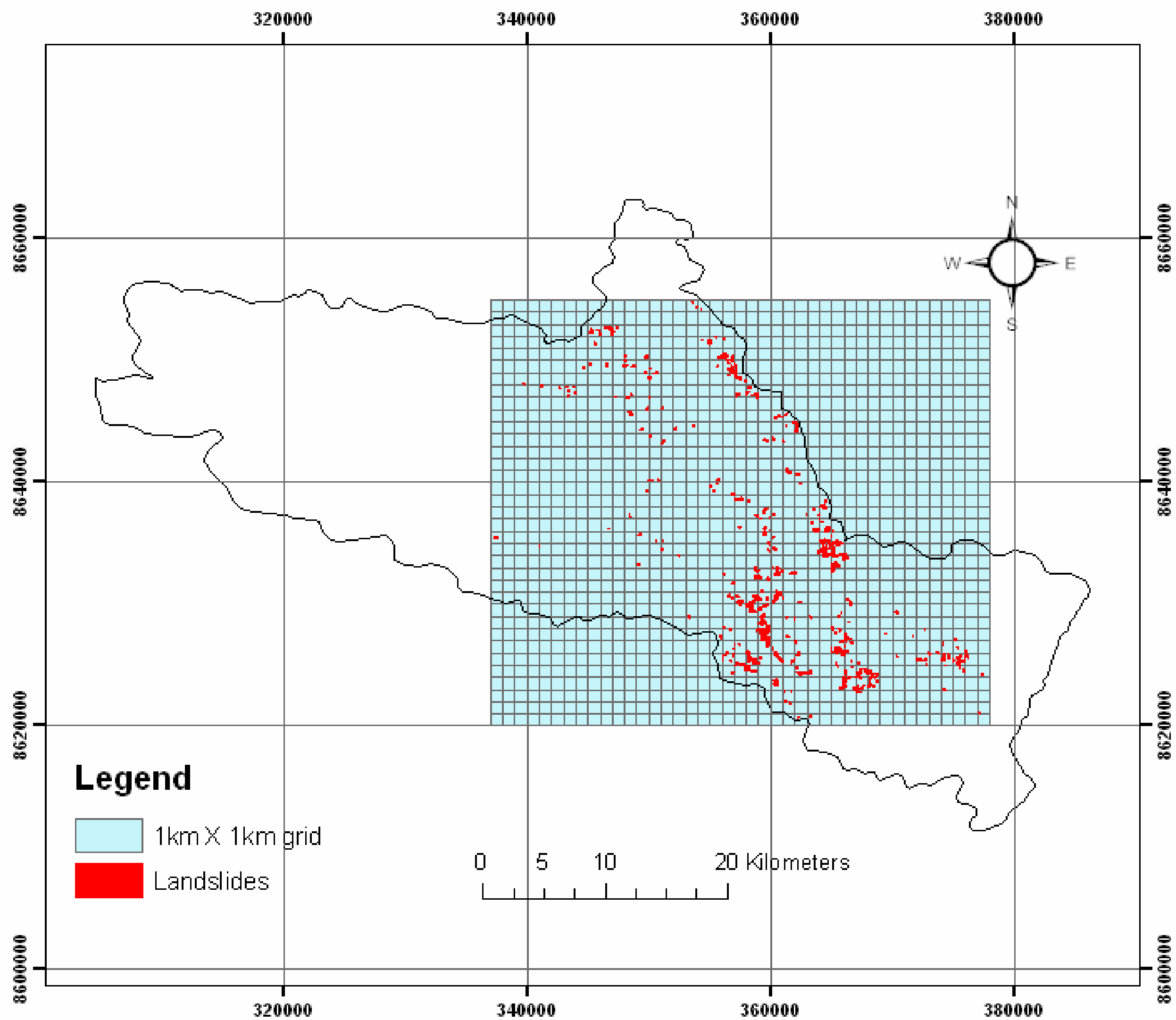


Fig. 2.9.1: 1km by 1km grid was created and overlaid on the landslide distribution. The coordinate system is UTM.

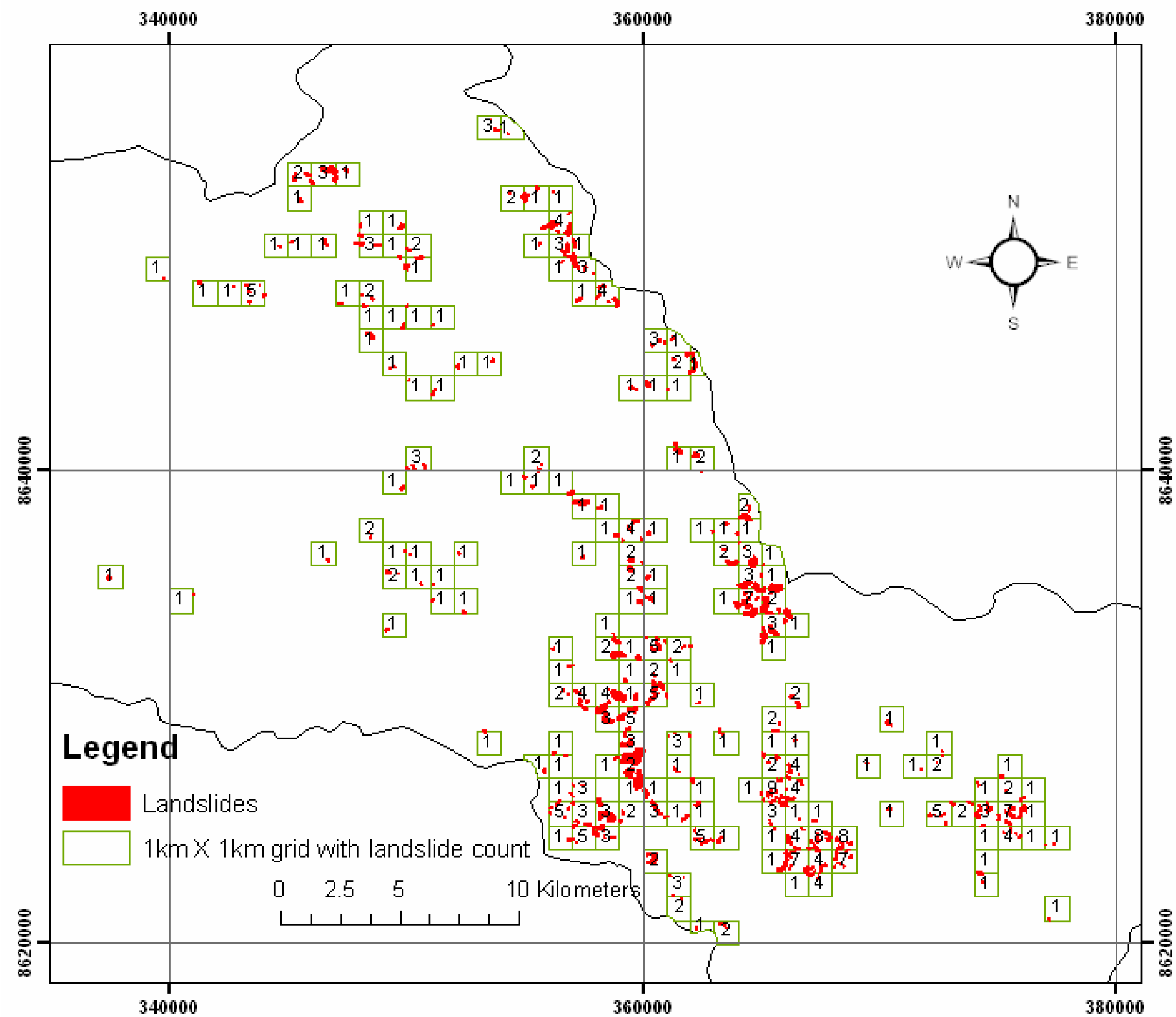


Fig. 2.9.2: Landslide count within 1km X 1km grid. The number inside each grid represents the number of landslides.

CHAPTER THREE

Results and discussion

In natural ecosystems, where accurate data on landslide are sparse or unavailable, the results from spatial analysis using GIS is a reasonable approach to understand causes of landslides. My study covers three important aspects of landslide study: landslide trend assessment, soil-water modeling using MIKE-SHE, and spatial regression.The result from the randomness checked whether there was a spatial trend. The internal cause for landslides was identified by spatial regression analysis.

3.1 Randomness

Fig. 3.1 shows the Ripley's K-function from the 381 individual landslides (before aggregating to 1km X 1km grids). The solid thick black line represents the L(d) (observed K-statistic); the grey dotted and dashed lines are 100 Monte Carlo simulation envelopes representing maximum and minimum L(d), respectively. The black dashed line at zero L(d) is the CSR line.

The K function showed clustering at 2km, and overall regional clustering up to the 13 km which was the maximum specified distance. The L(d) line is greater than both the random envelopes, suggesting non-randomness.

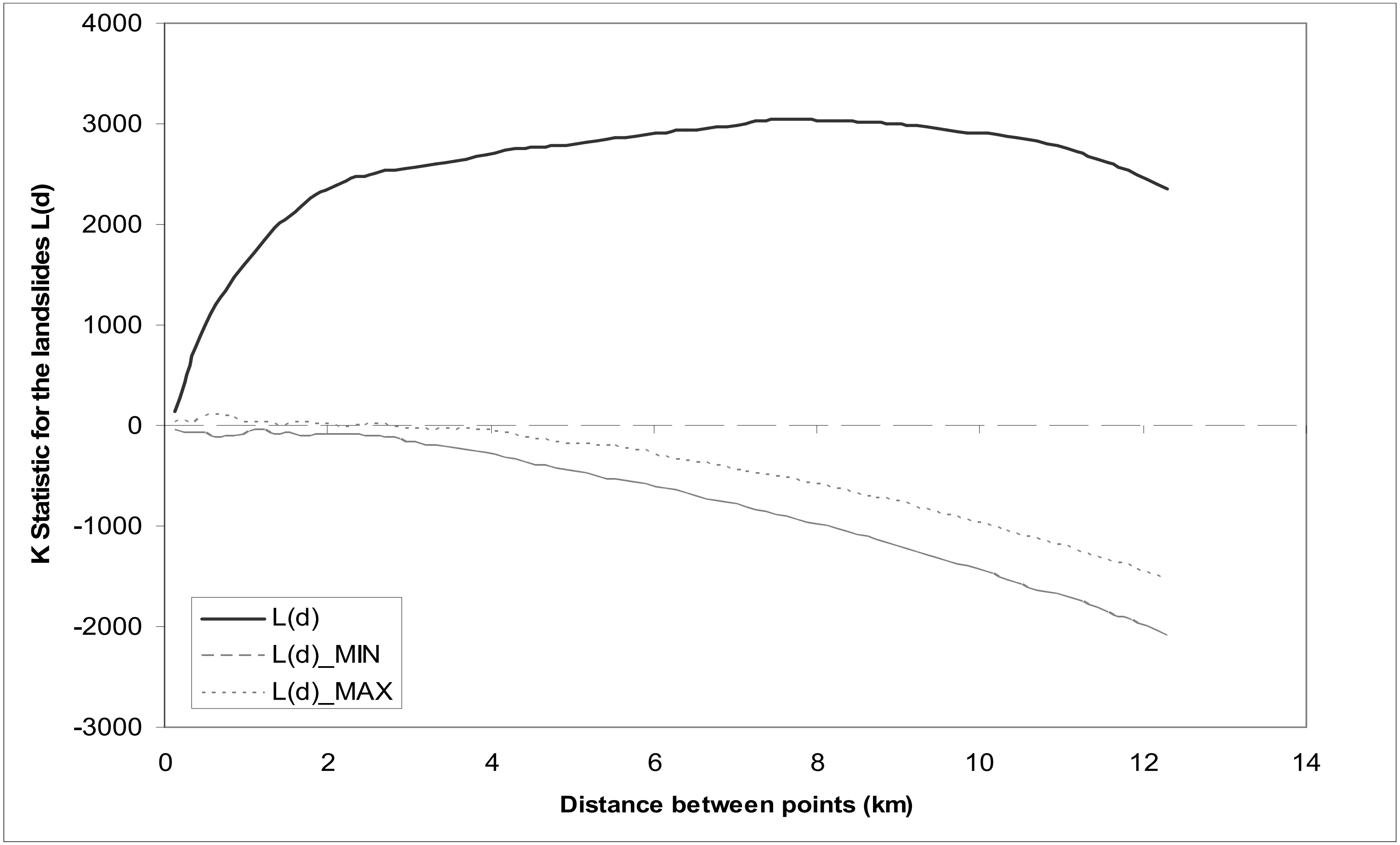


Fig. 3.1: Ripley's K-function plot for landslides. The solid black line is observed K-Statistic and the grey dotted and dashed line represents the 1000 simulation envelope. Black dashed line at zero is CSR (Complete spatial randomness) line. A clustering can be seen up to 2 km.

I propose the following possibilities for the 2km clustering: the basic soil properties at one location may not vary much within 2km radius or the similar soil water interactions may be assumed over 2 kilometer circle; The general fluvial processes on meander cutbanks can be correlated up to 2km distance from a point. These includes: cut bank erosion, failure due to chute cut off, erosion and failure due to crevasse splays, and reworking of sediments on point bars. The measurement of general meander length for the Los Amigos river suggested that the distances between meander bend was about 1 kilometer (see table 3.1). Since two meander lengths are involved in creating a cutoff, the average distance between cutoff points is close to 2km. Fig. 3.2 shows the Los Amigos meandering in 1960, 1980 and 2003. A loop length is the distance along A to B. A chute cutoff form between loops A to B and B to C; and thus, two loops are involved. Notice that in 2003, a chute cutoff had formed isolating loop B. The point bar areas of the isolated loop B are likely to contain weakened soils where landslides are more prone to occur.

3.2 Hydrologic Modeling

The variation of soil moisture content, changes in pressure head, variation in rainfall and evaporation when modeled, could give a clearer understanding of the effect of soil water contribution to landslides. Both wet and dry months have fluctuations in soil moisture content and pressure head. The changes in water content and pressure head along with rainfall rate and actual evaporation rate in two major soil types (sand and silty loam) are presented in two sections: one for wet period, and the other for dry period.

Table 3.1: River meander lengths for Los Amigos River. Distance denotes the straight distance between two adjacent apex of the meander.

Major meanders	Loop length (m)	Distance (m)
1	2433	889
2	3343	1018
3	2396	746
4	1616	918
5	2444	1017
6	1518	782
7	2158	1012
8	2245	1251
9	1565	606
10	1531	516
11	1781	869
12	2607	799
13	1160	1257
15	1837	927
16	1647	1386
17	1123	858
18	889	1216
19	3038	919
20	1199	1178
21	2970	1184
22	3427	754
23	2562	539
Average	2068	938

3.2.1 Soil water interaction in wet period

Soil water pressure frequently increases during high rainfall. There are many instances when unsaturated pressure head (suction head) approaches to zero (less than 1m or 9.8 kPa) during wet period (Fig. 3.2.1). Also, there is rapid decrease of pressure head with time when rainfall intensity is very low (Fig 3.2.2).

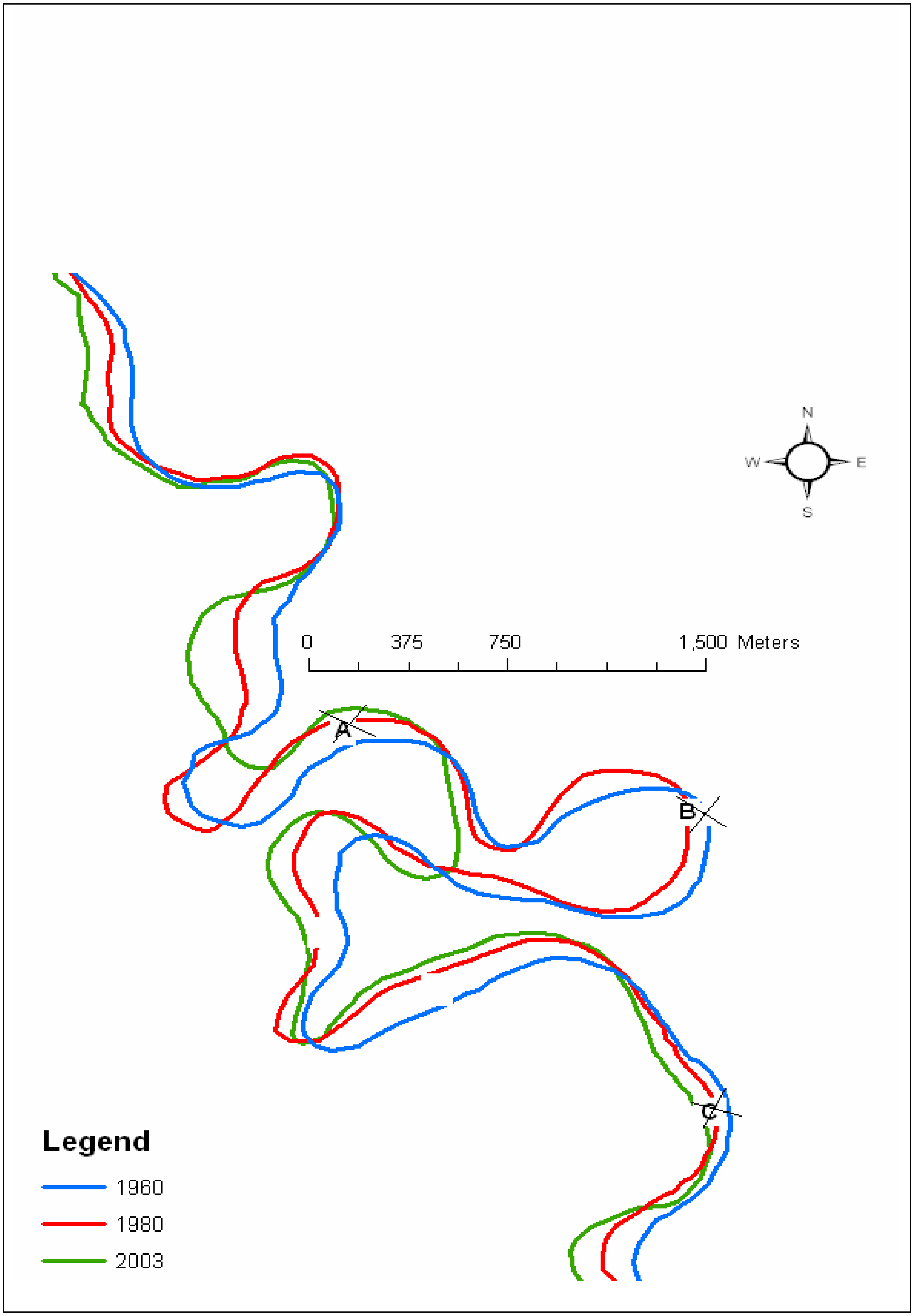


Fig. 3.2: A meandering part of Los Amigos River in 1960, 1980 and 2003. The average meander length is 1km. The loop length is the length following the river curve (eg. A - B or B – C).

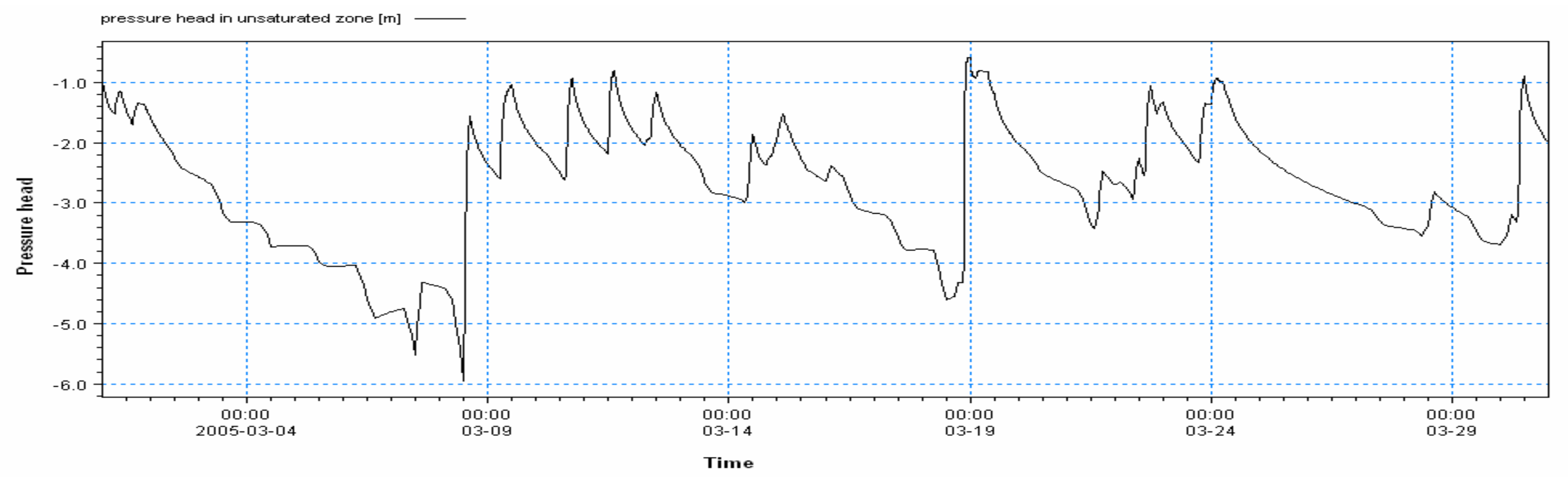


Fig. 3.2.1: pressure head in sand during wet period. Drop off in pressure head suggests rapid wetting and drying cycle of soils.

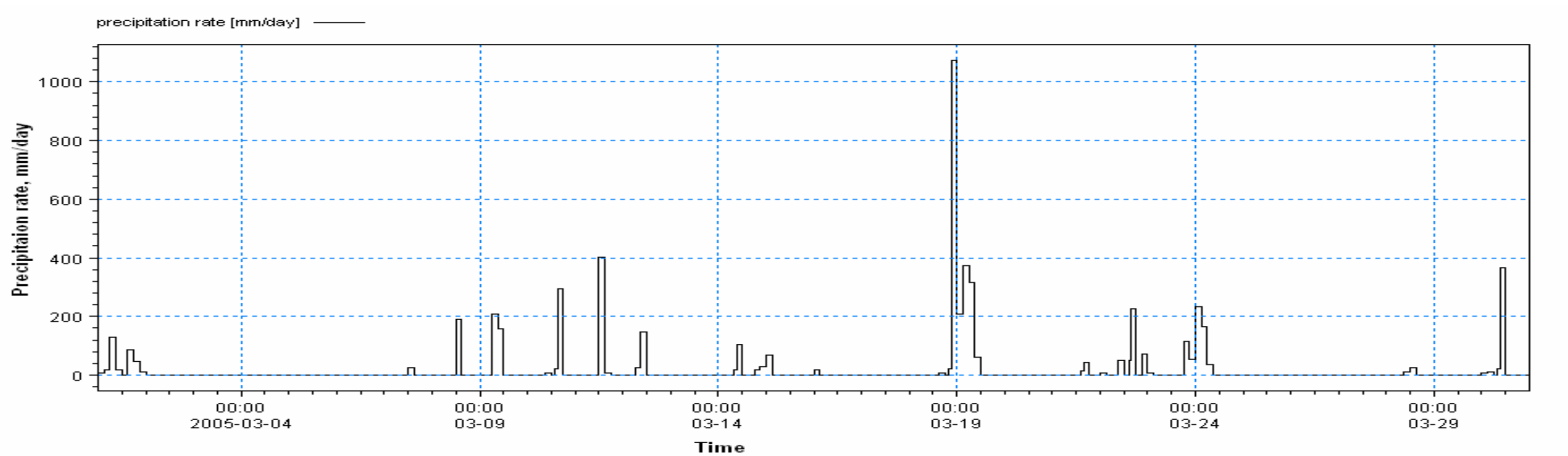


Fig. 3.2.2: Precipitation rate during wet period.

Even a very short ‘no rainfall’ period (3-5 days) created an appreciable drop in pressure head. Two factors might be responsible for decrease in pressure head. The first is dense vegetation which takes water from the soil. Since Amazonian forests have shallow rooting depth, the second responsible factor is soil water evaporation. If we look at soil-water evaporation (Fig. 3.2.4.) and rainfall (Fig. 3.2.2), the plots show the high evaporation rate following rainfall. The change in pressure head was similar overall silty loam (Fig. 3.2.4), but the pressure head fluctuations were noticeably reduced compared to the sandy soils.

3.2.2 Soil water interaction in dry period

There were no noticeable differences in the magnitude of pressure head change between wet period and dry period (Fig. 3.2.1 and 3.2.4). The only difference is low and infrequent rainfall during dry period (Fig. 3.2.6), and the more frequent soil drying cycles for the wetter period. In the dry period, the silty loam soil exhibited the similar changes in pressure head (Fig. 3.2.7).

So, for the soil texture (sandy soil and silty loam) for these example sites, it is clear that there is rapid up and down fluctuation in pressure head in the unsaturated soil zone before and following rainfall events. The change in unsaturated soil-water pressure indicates a decrease in effective stress (Since $d\sigma_e$ = -dP).

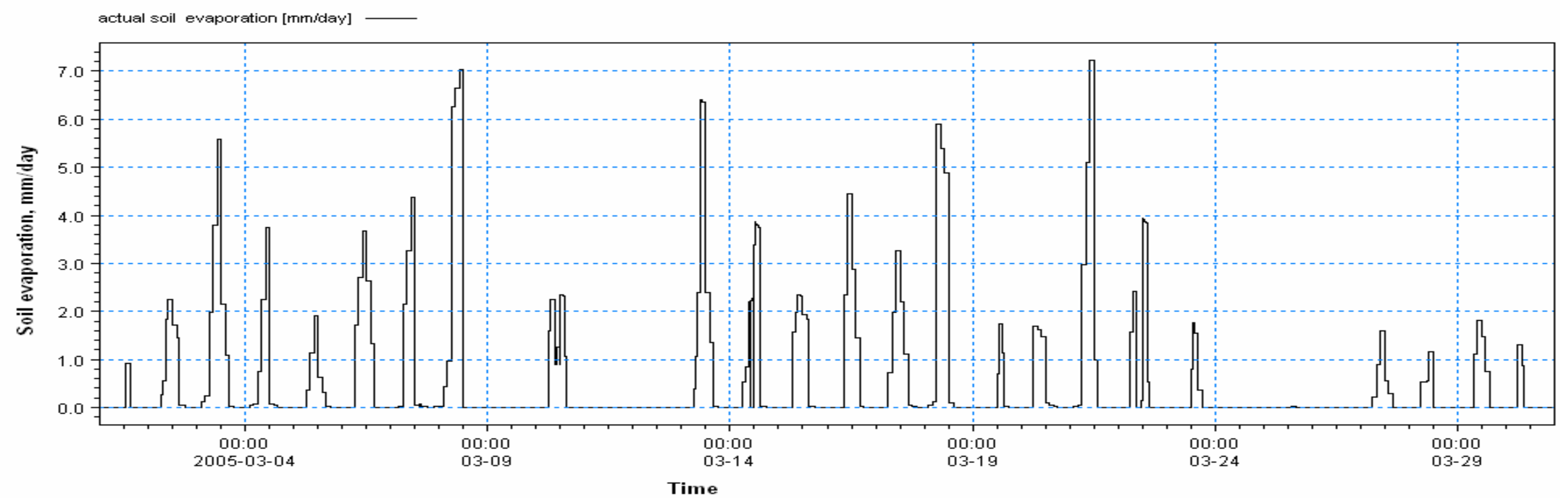


Fig. 3.2.3: Soil evaporation during wet period.

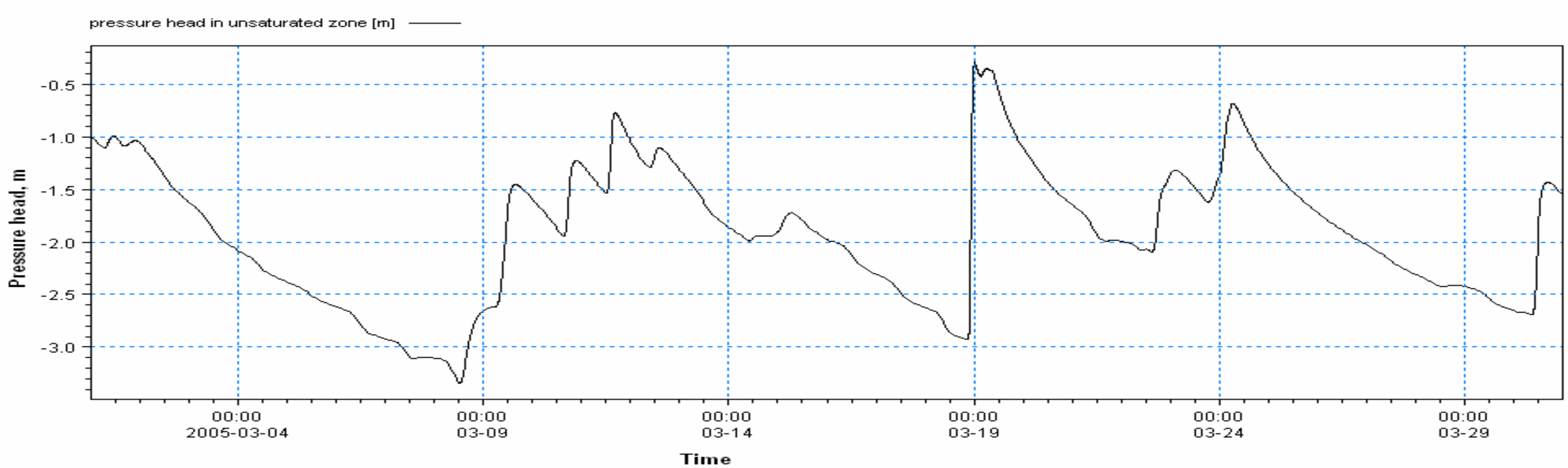


Fig. 3.2.4: Pressure head in silty loam soil during wet period.

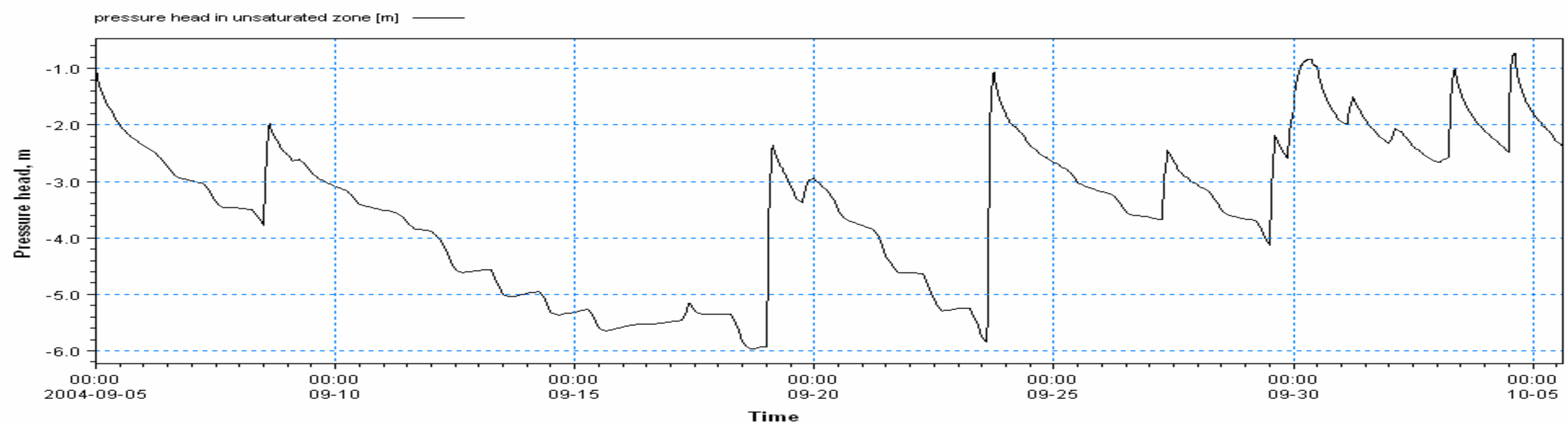


Fig. 3.2.5: Pressure head in sandy soil during dry period.

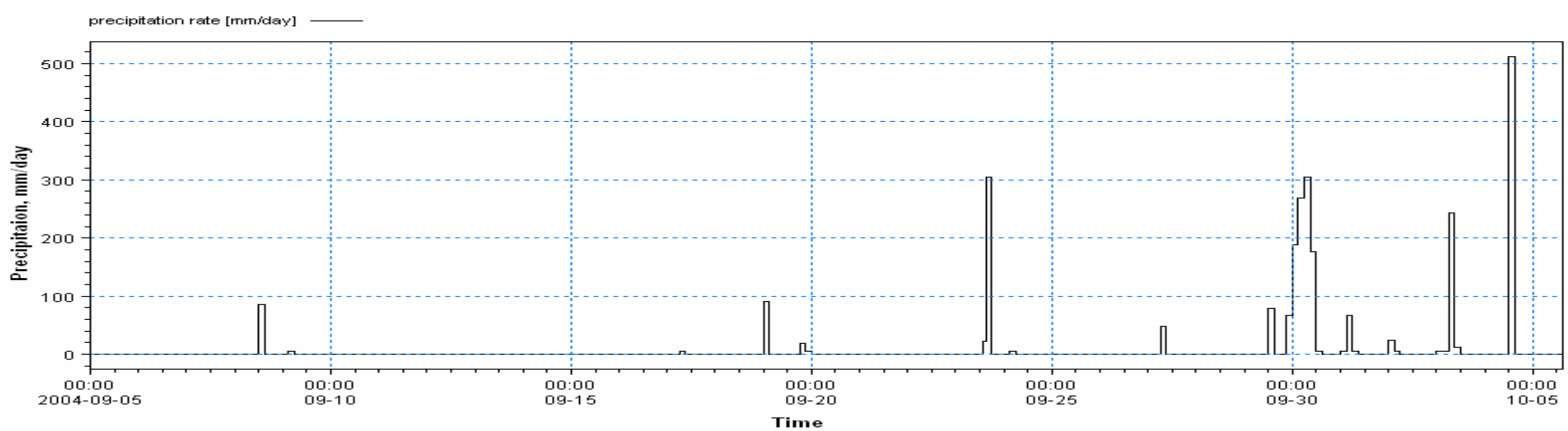


Fig. 3.2.6: Precipitation during dry period.

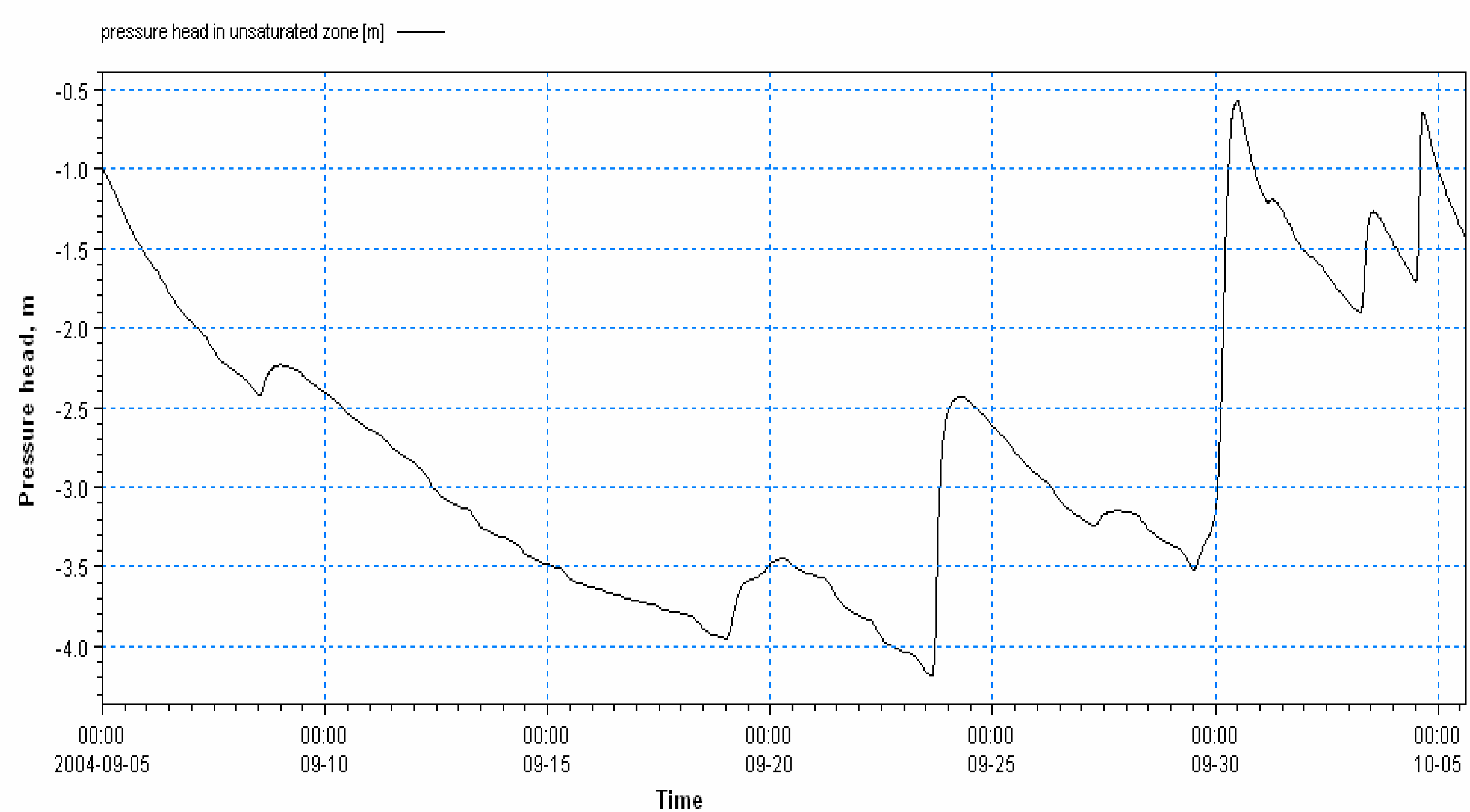


Fig. 3.2.7: Pressure head in silty loam during dry period.

Going back to Mohr-coulomb failure criterion, soil failure occurs when there is significant reduction in effective stress from change in pore water pressure, according to:

$$d\sigma_e = -\rho g \kappa dH \quad . \tag{3.2.1}$$

Comparing unsaturated flow zone output for sandy soil and silty loam, in both cases the maximum changes in water content and pressure head occurs after the rainfall. Almost all changing patterns are the same for both soil types except that for the silty loam is smoother than that for sand. In sandy soil, a number of instances of drying and wetting cycles can be observed. Interestingly, most of the landslides are located on sandy soils (see fig. 3.2.8).

Along cutbanks and stream banks, the changes in pressure head are also dependent on changes in stream depth. So indirectly, all soil failures in the study area can be explained as rainfall-induced failures. In other words hydrologic modeling suggested that these landslides are the result of continuous input of rainfall, evaporation, root water uptake and variations in water table. The following section (section 3.3) used statistical significance tests for environmental variables.

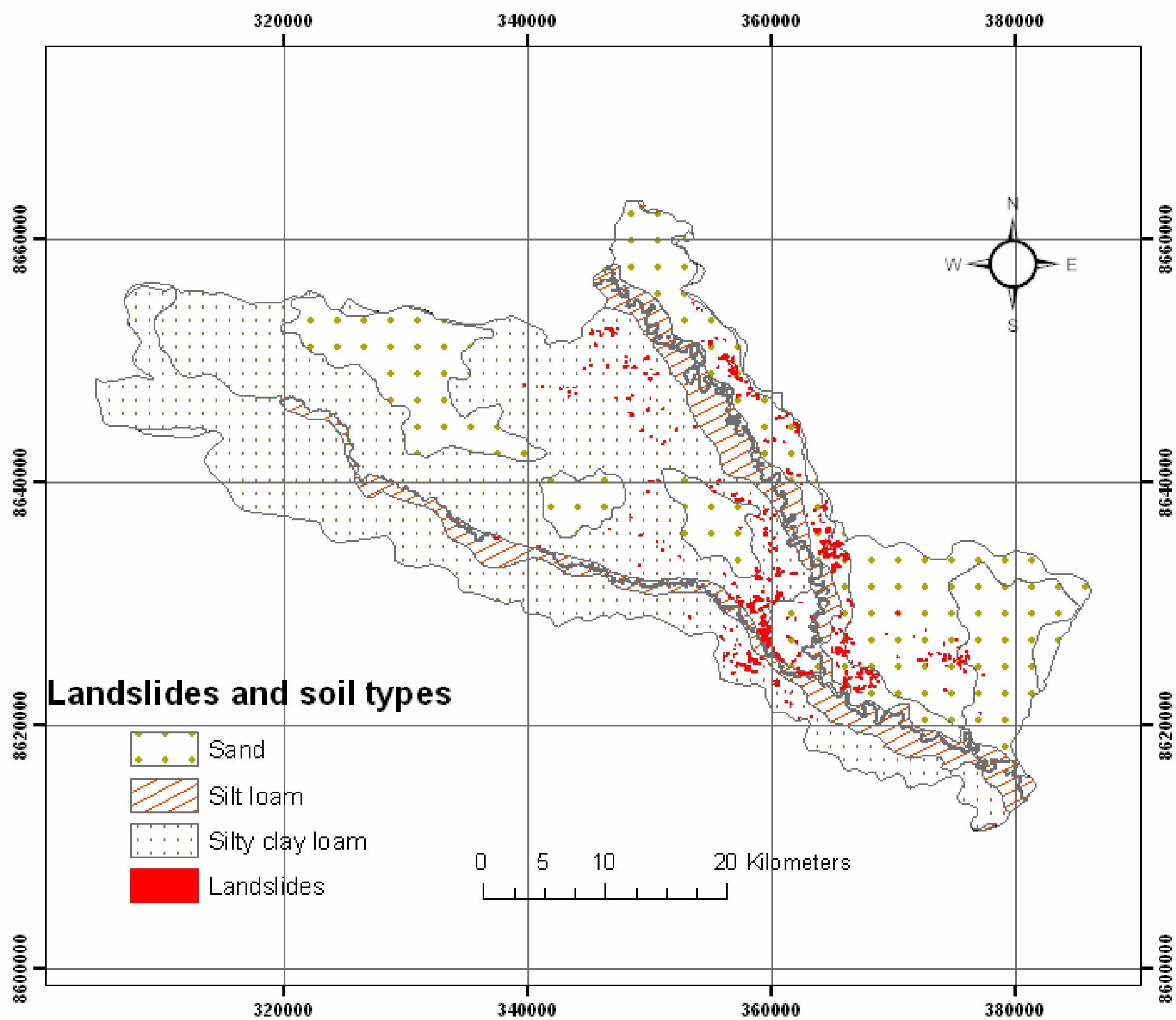


Fig. 3.2.8.: Distribution of landslides over different soil types. Majority of landslides are distributed along the sandy soil. The coordinate system is UTM.

3.3 Spatial heterogeneity

3.3.1 Result from OLS (ordinary least square estimation)

The following table (Table 3.3.1) shows the summary of output and coefficients for variables from ordinary least square estimation. The dependent variable was landslide count and the independent variables were slope, aspect, Standard deviation in pressure head for wet period (H_σ), and distance of landslide from the nearest river. The R^2 was 0.063182 for 190 observations with 185 degrees of freedom. Among the four variables: slope, aspect, distance from river and H_σ, only H_σ is positively related to landslide counts. The acceptable hypothesis here at α =0.01, is that the regression coefficients are zero except for H_σ.

Table 3.3.1: Environmental variables and corresponding regression coefficients

Independent Variable	**Probability**	**Coefficient**
Slope	0.5850986	-0.04168618
Distance from river	0.6712689	-0.000384877
H_σ, Standard deviation of pressure head	0.0058243	0.134671
Aspect	0.5308285	0.001032487

3.3.2 Spatial lag model

The spatial dependency was then re-estimated with maximum likelihood approach. The spatial lag model uses maximum likelihood method to determine the spatial dependency of the dependent variable. The following table (Table 3.3.2) shows the summary of output and variable coefficients from the spatial lag model. The R^2 was estimated as 0.131491 at 184 degree of freedom (higher than for the OLS model). The lag coefficient ρ was 0.262648. The landslide count (weight) is a new independent variable based on the weight matrix and is known as the "spatial lag term." The weight matrix is estimated after Thiessen polygon segmentation of the study area.

Table 3.3.2: Environmental variables and their corresponding regression coefficients for spatial lag model.

Variable	**Probability**	**Coefficient**
landslide count (weight)	0.0024930	0.2626478
Slope	0.9054525	-0.008601649
Distance from river	0.4324563	-0.000675276
H_σ	0.0102254	0.1189587
Aspect	0.7517502	0.0004962102

Table 3.3.2 shows that H_σ is a significant variable at α =0.05 (since Probability=0.01022 <0.05). All other variables have no significance at α =0.05.

Now, let us see how in spatial lag model, the tests of heteroscedasticity and spatial dependence appear. The result of the heteroscedasticity test gave a probability value of 0.0000027 suggesting significant spatial dependence for landslide counts. A more refined spatial regression model does not assume equal variance for error (heteroscedasticity).

3.3.3 Spatial error model (heteroscedasticity)

The following table (Table 3.3.3) shows output summary and the variable's coefficients obtained from the spatial error model. Comparing this model with the spatial lag model, we can see a coefficient λ is added as another variable; λ is a coefficient representing spatially correlated errors. The R^2 value of 0.152374 was higher than for the spatial lag model. Thus the spatial error model is a refinement over the original OLS and spatial lag model. At significance levels, α =0.05, table 3.3.3, shows that the error coefficient λ and H_σ have non-zero coefficients. The environmental variables such as slope, aspect, and distance from river have no effect in the model.

Table 3.3.3: Environmental variables and their corresponding regression coefficients for spatial error model.

Variable	Probability	Coefficient
Slope	0.5835414	0.04207117
Distance from river	0.2541708	-0.000959969
H_σ	0.0036824	0.1465408
Aspect	0.8003094	0.0004697591
λ	0.0002831	0.30932

The three regression tests: OLS, spatial lag model, and the spatial error model, respectively, provide improved regression models (higher R^2 values). This suggests adopting the spatial error model to explain the spatial heterogeneity of landslide distribution is best. Although the spatial error model seems better in this case, all three models show correlations of landslide counts only exists with the standard deviation in pressure head (H_σ).

I now explain why there is significance only for H_σ in the models.

From equation (1.3):

$$\tau_f = c + (\sigma_t - P).Tan\phi . \tag{3.3.1}$$

Equation (3.3.1) can be written as:

$$\tau_f = c + \sigma_t .Tan\phi - P.Tan\phi \tag{3.3.2}$$

For a fixed weight at the bottom of a column, σ_t = constant. Thus, assuming constant cohesion c and friction angle ϕ :

$$d\tau_f = dP.Tan\phi \tag{3.3.3}$$

Equation (3.3.3) shows that the decrease (due to negative sign) in shear strength is equal to change in pore water pressure. During the wetting and drying cycles of soil, the pore water pressure changes with soil-water pressure. The effective stress (σ_e) is reduced by this change in pore pressure by dP (equation 3.3.6). Since the effective stress represents the pressure felt between the soil particles, the soil particles get compressed and the soil pore spacing gets reduced, compacting the soil. Over many wetting and drying cycles, the soil will get more and more compact. Eventually, the pore pressure required to fail the soil will become small (assuming equilibrium conditions).

3.4 Conceptual model for landscape development and landslides

Based on results obtained from, Ripley's K-function, hydrologic modeling, and spatial regression analysis, I am ready to explain the influence of landslides on landscape development. My study area contains meandering rivers. I chose a representative cross-section of Los Amigos River (Fig. 3.4.1). The initial stage is described by normal fluvial processes: a meandering river with no landslides. Upland drainage areas receive rainfall; stream bank soils get wet. Some of the bank soils could be point bars. When rainfall fluctuates between wet and dry day, the shear strength is reduced with changes to pore water pressure (Fig. 3.4.2) resulting in a landslides on terraces (*e.g.,* X and Y were previously terraced). As a result of looser sediments in landslides, the weak soil along river banks can be eroded away by river flow.

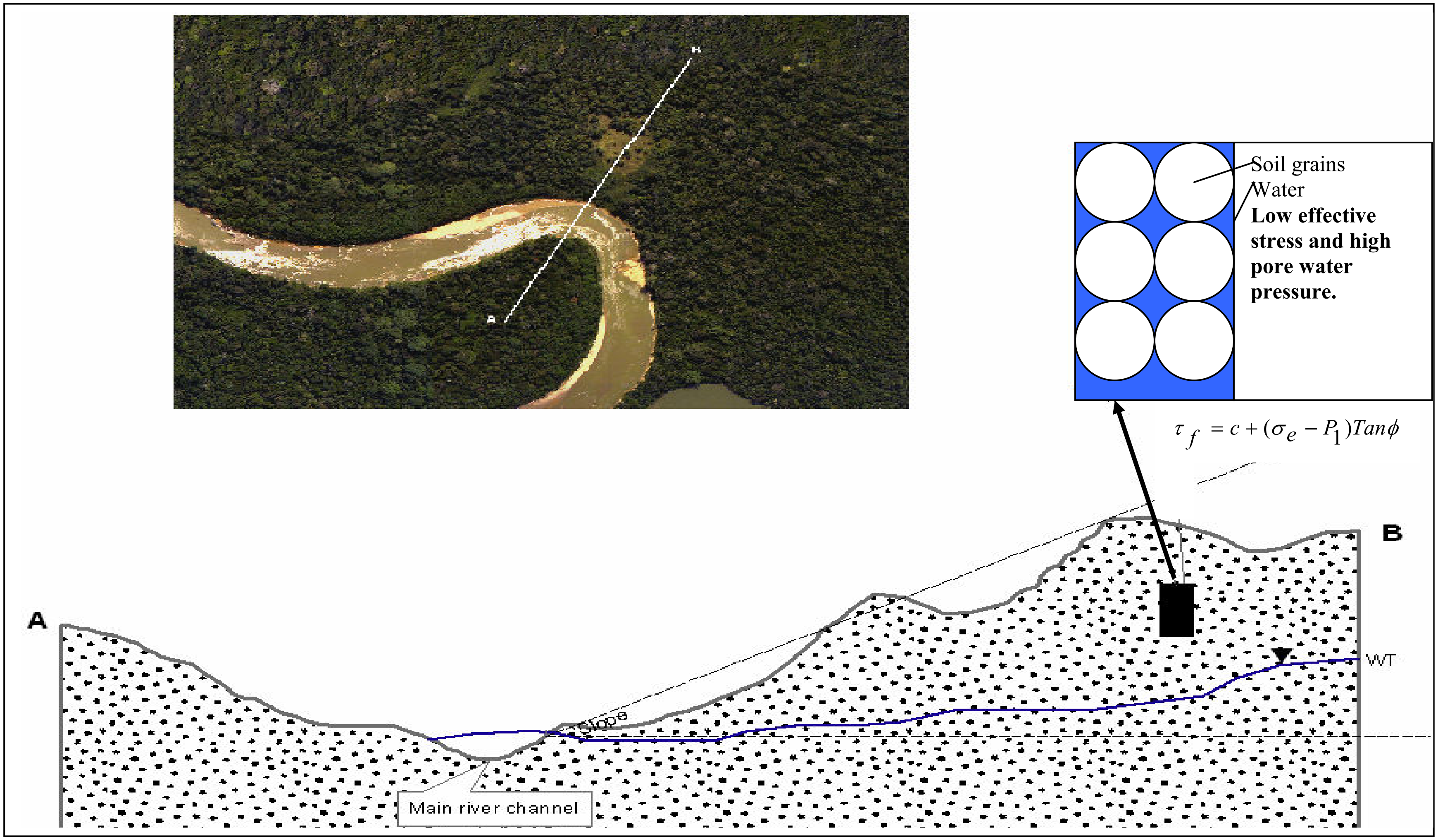


Fig. 3.4.1: Cross-sectional diagram for a meander on the Los Amigos River. This conceptual diagram shows the soil condition in absence of wet/dry cycling.

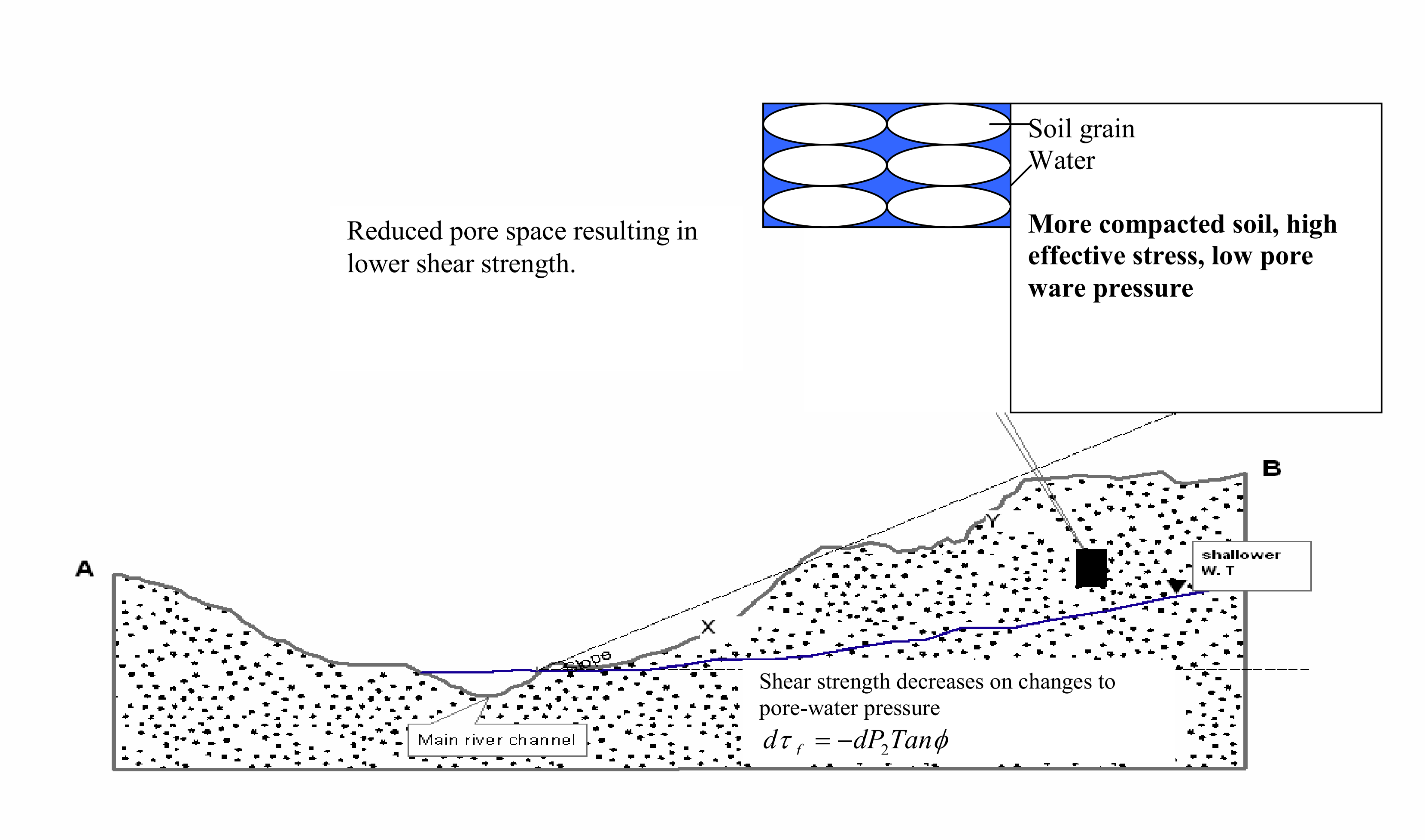


Fig. 3.4.2: Second stage cross-sectional diagram shows more compacted soils with reduced pore space. The shallower water table further reduces shear strength. Points X, and Y, represents observed landslides.

CHAPTER FOUR

Conclusions

My GIS study suggests that for terraced flood plains, a single environmental variable, variation in soil-water pressure (H_σ), is sufficient to explain landslide occurrences. H_σ is related to failure of the soil profile through $d\tau_f$.

I conclude the following:

1) The pattern of landslide distribution in lower Los Amigos sub-basin is non-random and spatially correlated at a distance of about 2km.

2) Landslide counts (within 1X1 km grids) are independent of slope, aspect, and distance from nearest river, but dependent on variation of pressure head in the soils.

It was surprising the slope was not related to landslide occurrence. My study suggests that soil failure on flat terraces due to soil moisture cycling is fundamentally sculpting the foreland basin. In watersheds with steeped slopes (*e.g.* Himalays), the loss of soil shear strength due to soil moisture cycling (which controls H_σ) is probably reducing the resistive force to soil weight along inclines.

APPENDIX – I

Monthly rainfall data for seven years:

1998

Latitude	Longitude	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
-12.75	-71.00	493.894	585.435	458.584	267.231	200.464	98.2525	92.7855	110.69	267.581	459.732	595.646	558.797
-12.75	-70.75	475.512	594.028	468.941	274.654	204.037	102.959	100.958	126.782	270.089	431.521	699.56	665.641
-12.75	-70.50	525.778	577.328	462.281	306.402	215.255	104.296	112.033	143.337	310.111	460.59	647.881	627.774
-12.75	-70.25	543.731	588.368	457.073	286.748	205.026	106.384	115.307	162.346	316.029	513.476	736.598	633.452
-12.75	-70.00	546.341	590.469	478.358	315.195	201.197	94.6198	116.648	203.939	338.849	538.012	723.276	553.393
-12.50	-71.00	462.372	573.408	453.953	202.641	139.855	81.7568	85.8195	127.004	255.448	376.483	513.45	504.883
-12.50	-70.75	444.782	536.268	414.209	251.728	191.582	83.8249	93.6566	135.611	302.596	426.827	622.374	598.63
-12.50	-70.50	458.597	530.208	436.812	266.218	184.514	88.7592	99.6072	149.762	295.419	426.601	619.622	572.045
-12.50	-70.25	495.846	532.744	446.082	274.224	183.951	98.6021	107.798	155.415	295.844	503.693	674.237	537.962
-12.50	-70.00	506.21	543.292	447.74	289.162	171.718	87.2394	124.155	202.884	306.107	479.303	688.14	545.171
-12.25	-71.00	434.875	534.718	432.668	178.429	115.247	77.4834	86.7226	121.663	253.911	381.466	483.686	485.657
-12.25	-70.75	432.543	512.223	418.956	200.999	130.886	78.5727	92.606	136.649	257.655	413.088	548.603	491.958
-12.25	-70.50	439.359	503.19	428.776	237.086	154.188	84.9865	108.119	160.418	276.411	427.323	573.892	501.227
-12.25	-70.25	469.597	497.961	433.457	263.036	164.141	92.9627	107.691	157.904	290.292	468.275	595.695	493.726
-12.25	-70.00	468.127	514.715	440.074	281.336	155.877	79.7072	121.375	202.752	307.331	455.487	668.269	573.409
-12.00	-71.00	404.361	434.959	342.8	171.693	102.128	42.5009	51.5245	102.146	220.617	338.181	447.927	432.119
-12.00	-70.75	394.449	458.381	373.738	173.274	98.1801	30.5698	61.2538	120.157	225.267	354.439	467.518	445.673
-12.00	-70.50	401.491	439.872	359.505	190.176	108.484	35.8957	61.293	119.255	231.903	352.274	503.261	489.646
-12.00	-70.25	394.741	421.828	341.582	186.055	112.918	42.3911	66.1418	133.23	243.269	351.093	544.011	547.503
-12.00	-70.00	417.28	447.483	397.806	244.08	103.498	39.6348	103.601	213.708	318.83	452.548	587.68	531.418

Monthly rainfall data for seven years (con.)

1999

Latitude	Longitude	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
-12.75	-71.00	528.297	693.432	436.693	241.867	246.281	126.866	80.1191	163.037	186.508	147.069	322.391	482.501
-12.75	-70.75	487.49	654.337	422.076	231.633	236.279	124.014	71.0091	158.49	182.49	149.445	341.215	489.413
-12.75	-70.50	458.098	530.945	353.06	229.588	229.366	122.243	64.7803	162.996	185.212	157.686	337.897	475.774
-12.75	-70.25	432.75	507.605	324.186	226.591	244.646	135.507	70.9685	193.043	212.821	169.704	347.406	472.783
-12.75	-70.00	406.017	483.374	284.481	186.421	226.949	135.479	47.7912	185.918	227.32	200.664	320.814	465.048
-12.50	-71.00	446.442	565.416	360.795	259.48	261.933	105.786	59.5715	148.358	176.226	155.934	312.248	460.305
-12.50	-70.75	421.928	535.274	348.619	248.478	256.994	118.434	64.4515	166.727	195.5	156.819	314.67	460.351
-12.50	-70.50	403.016	529.068	368.062	245.447	247.414	127.081	73.1979	178.454	193.448	161.995	333.576	468.958
-12.50	-70.25	379.901	456.32	314.063	266.108	282.914	150.812	82.5667	199.333	203.756	170.245	351.397	472.039
-12.50	-70.00	363.381	424.687	259.891	214.762	250.583	132.947	50.0096	197.479	235.035	217.918	342.014	439.195
-12.25	-71.00	437.271	506.522	333.013	342.443	337.641	107.851	59.155	197.218	228.247	156.759	317.56	495.707
-12.25	-70.75	407.804	491.457	324.56	315.22	327.424	126.439	64.1204	219.952	243.036	159.967	319.377	478.88
-12.25	-70.50	392.93	477.959	333.7	294.497	294.586	135.839	77.6946	188.501	201.057	174.72	335.151	459.788
-12.25	-70.25	383.06	453.774	325.154	308.823	317.136	148.039	68.9185	179.732	206.328	181.993	354.028	477.027
-12.25	-70.00	377.215	414.052	263.363	223.583	247.666	121.822	48.2144	187.404	247.146	231.44	361.574	462.412
-12.00	-71.00	414.646	514.443	374.193	386.33	329.544	78.8513	43.5078	202.618	230.971	172.944	329.895	442.513
-12.00	-70.75	389.606	446.547	323.915	398.308	356.114	79.186	38.2962	186.138	214.676	178.525	348.667	447.421
-12.00	-70.50	395.814	425.292	303.839	359.53	314.581	80.6418	38.0693	143.485	172.939	191.53	372.478	483.903
-12.00	-70.25	423.942	442.3	303.524	332.257	290.825	82.1929	40.609	133.006	182.591	227.328	424.635	535.189
-12.00	-70.00	435.171	411.503	262.118	231.208	216.423	96.883	37.2359	151.359	205.596	232.18	405.228	526.504

Monthly rainfall data for seven years (con.)

2000

Latitude	Longitude	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
-12.75	-71.00	489.386	585.716	560.57	244.898	102.695	87.7569	93.3415	157.537	270.446	485.638	692.726	878.206
-12.75	-70.75	493.268	593.357	517.044	202.833	96.0365	90.1745	93.3563	147.041	274.002	521.367	724.684	823.999
-12.75	-70.50	497.849	596.549	593.596	286.343	105.669	104.634	102.251	152.517	249.814	458.538	668.244	797.299
-12.75	-70.25	510.446	638.649	653.222	330.785	124.026	129.377	117.378	184.307	258.275	367.121	540.759	753.89
-12.75	-70.00	541.083	685.225	656.734	310.805	149.07	131.661	112.93	146.801	219.052	357.885	486.874	759.672
-12.50	-71.00	439.067	499.185	495.883	219.348	98.4663	87.2486	77.11	131.562	222.076	459.143	716.745	776.607
-12.50	-70.75	465.81	538.9	487.642	209.958	106.422	94.1751	74.5631	131.099	222.347	397.039	536.751	661.938
-12.50	-70.50	511.525	582.841	501.238	232.625	112.75	98.192	86.2048	148.7	234.559	339.376	488.18	671.354
-12.50	-70.25	522.415	604.577	550.52	270.237	106.086	94.0086	90.752	151.073	235.155	328.766	464.361	677.165
-12.50	-70.00	486.77	598.885	540.7	248.672	131.824	100.097	99.6047	149.875	221.071	335.561	452.591	711.999
-12.25	-71.00	484.966	497.03	468.002	231.026	118.859	93.944	69.6518	98.9634	200.373	449.576	545.805	577.854
-12.25	-70.75	483.809	506.666	471.87	237.131	125.974	114.846	82.8588	103.362	207.363	378.206	437.282	546.88
-12.25	-70.50	493.836	544.445	479.214	233.694	121.608	110.062	89.4086	118.836	202.697	305.633	388.251	581.992
-12.25	-70.25	496.942	573.626	501.715	237.746	134.675	121.94	104.728	119.048	186.604	300.618	403.39	602.921
-12.25	-70.00	468.117	545.12	457.761	194.221	118.396	114.645	113.191	113.885	204.362	351.746	445.542	622.021
-12.00	-71.00	428.083	456.757	463.62	269.744	112.258	87.8866	81.4192	77.8493	192.62	396.181	390.326	484.138
-12.00	-70.75	446.951	477.74	445.802	286.33	147.842	83.0658	70.8888	70.6024	162.648	291.816	326.413	500.261
-12.00	-70.50	490.24	505.316	481.473	307.014	143.977	93.4617	83.8685	78.7107	158.641	274.223	346.5	535.154
-12.00	-70.25	451.434	468.601	441.26	228.474	127.891	117.044	111.904	85.3915	171.117	288.433	357.604	539.444
-12.00	-70.00	448.921	474.084	437.602	187.004	116.854	107.854	120.415	117.193	198.06	340.764	397.257	521.913

Monthly rainfall data for seven years (con.)

2001

Latitude	Longitude	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
-12.75	-71.00	869.906	643.161	383.695	211.149	138.429	107.095	111.323	116.548	270.735	343.34	382.155	503.003
-12.75	-70.75	830.801	661.636	380.769	221.473	159.382	114.597	117.989	119.362	253.306	326.788	387.341	520.062
-12.75	-70.50	840.35	652.482	344.142	240.694	193.688	119.733	132.739	125.416	223.491	330.507	431.031	513.957
-12.75	-70.25	848.788	628.81	327.273	220.644	185.326	137.494	124.004	111.79	263.777	391.17	446.723	483
-12.75	-70.00	865.816	567.369	312.078	226.865	185.274	140.801	134.882	111.148	259.918	413.226	488.711	543.014
-12.50	-71.00	736.887	630.384	397.094	256.712	177.783	93.4864	97.0224	114.473	286.467	358.335	359.865	420.138
-12.50	-70.75	782.267	683.283	404.859	254.64	192.32	87.3694	77.4175	101.614	233.682	314.26	393.904	483.442
-12.50	-70.50	730.192	605.639	359.517	225.227	191.533	104.806	87.5739	105.415	219.927	337.71	454.631	503.628
-12.50	-70.25	696.267	532.643	344.268	216.758	170.32	100.688	87.1891	113.408	274.621	403.724	448.903	475.286
-12.50	-70.00	756.828	498.743	326.032	241.048	175.226	105.042	113.984	123.694	247.243	385.888	487.027	574.356
-12.25	-71.00	639.595	519.929	331.274	209.529	138.406	75.2932	68.1727	82.105	218.302	312.038	343.561	372.044
-12.25	-70.75	641.455	532.479	339.575	249.903	201.257	87.9214	73.4587	96.7163	204.764	318.64	401.899	438.443
-12.25	-70.50	618.848	518.259	370.922	247.518	219.261	112.56	86.9852	120.876	227.182	346.436	439.953	469.338
-12.25	-70.25	597.56	472.849	374.629	277.615	206.325	101.101	92.459	113.125	244.872	362.017	423.879	511.471
-12.25	-70.00	600.374	446.068	371.875	341.388	242.439	93.9191	87.0606	107.747	252.223	365.66	454.551	609.181
-12.00	-71.00	571.274	473.626	376.662	226.461	142.022	71.8043	82.5057	129.88	190.972	288.941	363.356	390.566
-12.00	-70.75	566.107	438.457	327.724	230.59	184.338	92.5976	94.4833	169.43	234.583	310.142	372.687	394.145
-12.00	-70.50	510.783	428.391	381.568	232.158	165.021	74.5917	107.04	173.374	232.343	350.8	423.989	380.802
-12.00	-70.25	509.638	374.11	322.718	278.3	218.87	88.4094	98.855	143.081	235.523	347.502	391.626	385.028
-12.00	-70.00	522.182	442.901	372.66	274.117	208.183	98.0359	81.1053	128.206	293.145	397.067	434.421	491.755

Monthly rainfall data for seven years (con.)

2002

Latitude	Longitude	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
-12.75	-71.00	597.599	554.506	415.38	279.637	128.281	91.2841	90.2976	85.4664	331.063	439.717	606.407	698.349
-12.75	-70.75	633.914	552.599	399.31	295.848	145.425	90.5556	91.8578	107.737	380.773	499.22	504.553	619.189
-12.75	-70.50	658.045	595.082	397.37	303.767	163.563	101.766	97.8509	135.429	353.194	473.542	499.669	624.384
-12.75	-70.25	617.99	569.884	376.28	318.126	182.716	95.6648	92.4983	137.492	302.873	410.72	533.911	616.223
-12.75	-70.00	610.64	529.244	316.674	282.639	199.26	81.1862	71.6167	117.069	265.53	465.298	708.203	707.879
-12.50	-71.00	499.784	492.313	391.466	252.986	94.0777	67.975	81.1581	90.3105	285.077	385.364	527.133	560.807
-12.50	-70.75	583.819	510.074	357.347	250.635	111.691	96.9848	95.8182	109.547	317.052	419.135	550.594	619.655
-12.50	-70.50	599.394	521.946	347.423	264.722	134.68	98.9385	98.8705	119.544	326.911	461.746	593.225	672.366
-12.50	-70.25	579.315	493.283	302.285	261.383	158.376	96.8699	94.5015	127.406	288.759	431.343	652.454	714.583
-12.50	-70.00	626.402	498.662	281.7	256.361	182.436	76.449	72.819	112.702	280.667	400.568	679.948	754.081
-12.25	-71.00	453.361	425.594	346.474	253.951	93.1665	66.737	70.8666	71.387	235.355	326.484	593.855	660.36
-12.25	-70.75	513.847	434.97	340.554	257.87	96.2519	81.9529	92.1298	95.539	248.29	366.076	553.594	628.141
-12.25	-70.50	502.038	406.004	340.129	282.315	118.078	84.4421	102.25	106.466	244.334	387.034	611.806	673.144
-12.25	-70.25	573.5	428.328	301.341	263.007	138.208	78.1495	102.049	124.559	215.889	339.27	565.11	606.599
-12.25	-70.00	603.863	441.893	303.361	252.447	167.265	67.3	85.0832	116.937	255.506	439.033	594.416	577.518
-12.00	-71.00	449.504	379.402	329.645	278.84	111.347	67.8797	69.0008	77.8955	215.268	345.3	460.668	500.184
-12.00	-70.75	467.784	393.213	350.86	299.342	109.608	86.1453	99.8531	106.854	222.918	317.89	451.704	508.896
-12.00	-70.50	427.62	387.873	347.988	313.251	131.701	73.4534	82.7568	105.142	217.679	326.083	457.294	504.771
-12.00	-70.25	444.717	416.917	336.011	297.621	146.224	59.6238	70.7109	100.302	179.674	276.452	409.128	462.128
-12.00	-70.00	486.824	390.374	292.223	250.214	129.447	49.8541	55.969	82.5796	205.998	359.61	469.452	479.257

Monthly rainfall data for seven years (con.)

2003

Latitude	Longitude	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
-12.75	-71.00	590.64	675.849	546.988	278.524	203.454	153.704	59.0033	175.376	348.823	287.47	285.125	753.024
-12.75	-70.75	527.023	587.941	558.177	252.185	181.797	150.925	74.0664	168.819	351.248	320.271	312.777	811.287
-12.75	-70.50	538.015	568.108	535.397	237.939	197.04	153.794	53.5378	150.539	359.183	337.089	346.636	811.721
-12.75	-70.25	488.228	553.083	534.113	241.321	146.537	112.069	52.5141	152.17	366.012	363.534	393.336	800.05
-12.75	-70.00	519.624	553.763	496.407	223.324	156.998	127.344	55.7224	154.271	392.412	399.13	342.001	574.67
-12.50	-71.00	418.061	471.459	428.989	246.256	165.212	121	57.7133	152.212	301.028	262.81	267.337	727.44
-12.50	-70.75	452.387	533.983	492.911	244.067	168.07	110.934	67.8155	166.049	332.587	314.378	311.063	724.104
-12.50	-70.50	521.906	626.754	550.915	238.742	169.78	108.103	54.9212	168.519	379.025	355.638	330.932	722.255
-12.50	-70.25	541.164	668.114	590.217	231.799	151.109	116.05	61.5092	190.665	422.422	396.222	367.675	760.423
-12.50	-70.00	528.282	581.399	492.219	220.167	177.411	137.796	75.5906	188.803	424.852	422.067	357.469	618.026
-12.25	-71.00	426.593	462.645	391.63	230.411	152.773	90.3743	65.9743	138.094	283.695	291.303	292.666	670.177
-12.25	-70.75	503.273	496.751	385.272	216.55	141.06	83.4947	70.9664	163.085	328.284	331.402	334.378	658.409
-12.25	-70.50	504.164	559.434	466.06	215.934	146.365	99.7745	62.2818	154.482	327.423	330.994	352.343	663.154
-12.25	-70.25	493.968	610.503	520.834	236.559	162.129	111.735	49.7339	137.055	328.711	359.19	366.112	644.441
-12.25	-70.00	479.471	603.427	517.304	218.046	171.807	126.179	59.7274	149.33	334.791	353.759	343.609	568.991
-12.00	-71.00	431.953	436.947	361.228	209.414	162.577	97.8158	77.3731	129.076	260.084	305.017	343.481	554.356
-12.00	-70.75	464.58	511.67	400.35	224.467	169.676	92.9438	89.0029	143.204	264.329	321.032	371.752	574.393
-12.00	-70.50	494.251	602.099	477.378	220.984	179.389	123.044	93.51	146.355	286.775	352.497	392.136	570.742
-12.00	-70.25	505.735	644.097	496.004	218.807	189.924	131.454	56.8785	133.752	314.638	344.676	364.979	514.116
-12.00	-70.00	496.792	571.041	427.642	186.812	160.821	119.795	48.7637	136.633	299.777	326.157	356.358	535.602

Monthly rainfall data for seven years (con.)

2004

Latitude	Longitude	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
-12.75	-71.00	790.426	427.032	339.049	220.281	85.7689	144.7	149.103	94.9134	138.06	230.254	346.768	384.385
-12.75	-70.75	865.923	491.856	351.896	227.752	124.323	154.954	139.567	102.766	139.368	208.71	350.83	435.171
-12.75	-70.50	886.605	551.821	380.548	270.526	136.992	116.405	121.604	111.45	152.661	241.062	429.494	509.68
-12.75	-70.25	847.438	593.359	405.576	236.17	127.292	131.993	133.992	97.8219	155.889	287.98	418.742	476.233
-12.75	-70.00	654.524	551.727	414.677	284.882	162.245	145.87	141	89.9237	161.652	287.597	415.117	493.71
-12.50	-71.00	804.117	439.674	255.94	155.62	84.5404	106.413	114.719	98.5868	119.161	180.162	281.026	341.185
-12.50	-70.75	772.504	435.379	281.496	171.769	76.6679	95.3094	117.688	111.297	132.22	186.497	292.417	359.942
-12.50	-70.50	749.656	454.244	344.866	217.193	93.639	105.121	120.077	111.123	150.622	244.598	341.269	373.085
-12.50	-70.25	742.058	442.22	391.583	238.773	83.7924	102.598	123.434	116.209	151.005	262.623	356.72	371.064
-12.50	-70.00	614.976	430.749	408.012	292.017	122.321	126.071	126.052	88.7831	171.344	298.71	356.368	427
-12.25	-71.00	700.245	405.375	248.51	135.238	79.722	68.6346	84.2721	105.298	127.751	181.686	243.97	289.197
-12.25	-70.75	627.47	372.443	301.683	173.37	64.33	66.0766	92.9572	124.072	148.786	202.927	279.929	320.657
-12.25	-70.50	601.844	362.908	367.237	230.735	66.8222	93.7207	113.156	120.298	158.688	215.889	360.745	412.454
-12.25	-70.25	618.664	412.962	372.058	208.994	74.5106	107.333	111.845	104.481	139.387	220.752	354.626	384.496
-12.25	-70.00	567.781	420.259	373.711	213.152	66.8061	101.823	111.807	101.454	158.503	262.378	370.277	405.213
-12.00	-71.00	523.9	422.184	287.267	129.716	71.6636	49.5579	83.0727	128.173	156.312	233.609	249.936	271.609
-12.00	-70.75	501.321	385.933	310.948	153.057	68.7689	57.1365	85.006	139.121	168.545	280.247	348.805	325.023
-12.00	-70.50	511.572	379.504	323.245	201.967	76.3283	71.8725	107.788	132.108	175.866	313.623	405.653	370.511
-12.00	-70.25	523.263	446.534	332.877	196.408	76.9956	72.7985	114.64	140.949	164.425	215.702	284.961	334.896
-12.00	-70.00	551.66	459.921	344.551	181.864	68.6869	79.7518	105.999	102.487	149.679	250.307	336.077	373.823

APPENDIX – II

Weather data for wet period

Date/ Time	TMP (*C)	TMP max (*C)	TMP min (*C)	RH	RH (%)	solar radiation watt/m^2	St, solar radian MJ./m^2/3hr	WND (Deg)	Rainfall (mm)	Wind speed, km/hr	U2, Wind speed m/sec	Lamda MJ/kg	e* kPa	e*max, kPa	e*min, kPa	Delta kPa/*C	Dbar, kPa	e*d, dew point vapor pressure, kPA	Epsilon, net emmisivity	Gamma, Psychrometric constant	Sn, net shortwave radiation, MJ/m^2/3hr	Ln, Long wave radiation, MJ/m^2/3hr	Rn, net radiation, MJ/m^2/3hr	Rn, net radiation mm/3hr	Ep, net evaporation, mm/3hr
3/1/05 0:00	23.7	24.4	23.7	1	100	0	0	213.8	0.25	0	0	2.44504	2.93	3.056	2.93061	0.17591	0	2.930607375	0.100333764	0.067	0	0.525596528	0.525596528	0.000214964	0.000155672
3/1/05 3:00	23.7	24	23.7	1	100	0	0	213.8	0.25	0	0	2.44504	2.93	2.984	2.93061	0.17591	0	2.930607375	0.100333764	0.067	0	0.525596528	0.525596528	0.000214964	0.000155672
3/1/05 6:00	25.2	25.2	23.7	0.975	97.47	64.7	0.029115	171.6	0.75	0	0	2.4415	3.21	3.206	2.93061	0.19023	0.00078	3.204934976	0.089367349	0.067	0.0250389	0.477681854	0.502720754	0.000205906	0.001010393
3/1/05 9:00	24.8	28	24.8	0.685	68.45	193.1333	0.08691	143.9	5.33	0.26667	17.778	2.44245	3.13	3.78	3.13024	0.18632	0.0109	3.119334433	0.092737073	0.067	0.0747426	0.493040998	0.567783598	0.000232465	0.129067995
3/1/05 12:00	25.2	25.2	24	0.54	53.98	99.03333	0.044565	156.6	0.75	0.26667	17.778	2.4415	3.21	3.206	2.98392	0.19023	0.01424	3.191470937	0.089894362	0.067	0.0383259	0.480498813	0.518824713	0.000212502	0.165699621
3/1/05 15:00	24.4	26	24.4	0.509	50.9	110.7833	0.0498525	129.4	0	0.26667	17.778	2.44339	3.06	3.361	3.05631	0.18248	0.01576	3.040557071	0.095879295	0.067	0.04287315	0.507015377	0.549888527	0.000225051	0.189701982
3/1/05 18:00	21.3	24	21.3	0.872	87.22	0	0	262.7	3.55	1.06667	71.111	2.45071	2.53	2.984	2.5332	0.15489	0.00353	2.52967862	0.117330512	0.067	0	0.594999709	0.594999709	0.000242787	0.180962279
3/1/05 21:00	21	21.3	21	0.913	91.32	0	0	121.9	2.02	0	0	2.45142	2.49	2.533	2.48701	0.15242	0.00218	2.484825789	0.119313377	0.067	0	0.602593446	0.602593446	0.000245814	0.00306685
3/2/05 0:00	21.3	21.3	21	0.928	92.8	0	0	264.2	0.5	0	0	2.45071	2.53	2.533	2.48701	0.15489	0.00181	2.531397706	0.117254865	0.067	0	0.594616094	0.594616094	0.00024263	0.002538173
3/2/05 3:00	21	21.3	21	0.995	99.53	0	0	71.27	0	0	0	2.45142	2.49	2.533	2.48701	0.15242	0.00012	2.486888259	0.119221808	0.067	0	0.602130977	0.602130977	0.000245625	0.000326268
3/2/05 6:00	23.3	23.3	21	0.958	95.75	137.2333	0.061755	112.8	0	0.8	53.333	2.44599	2.86	2.861	2.48701	0.17225	0.00114	2.859684717	0.103251567	0.067	0.0531093	0.537972448	0.591081748	0.000241654	0.040475816
3/2/05 9:00	25.6	25.6	24	0.671	67.05	238.2333	0.107205	207	0	0.26667	17.778	2.44056	3.28	3.283	2.98392	0.19421	0.01032	3.2724468	0.086741323	0.067	0.0921963	0.466136389	0.558332689	0.000228773	0.118160749
3/2/05 12:00	30.4	30.8	26	0.557	55.7	971.5667	0.437205	142.7	0	0.8	53.333	2.42923	4.34	4.442	3.36144	0.24771	0.01728	4.324106703	0.048877189	0.067	0.3759963	0.279948327	0.655944627	0.000270022	0.457008379

Date/Time	TMP (*C)	TMP max (*C)	TMP min (*C)	RH	RH (%)	solar radiation watt/m^2	St, solar radian MJ./m^2/3hr	WND (Deg)	Rainfall (mm)	Wind speed, km/hr	U2, Wind speed m/sec	Lamda MJ/kg	e* kPa	e*max, kPa	e*min, kPa	Delta kPa/*C	Dbar, kPa	e*d, dew point vapor pressure, kPA	Epsilon, net emmisivity	Gamma, Psychrometric constant	Sn, net shortwave radiation, MJ/m^2/3hr	Ln, Long wave radiation, MJ/m^2/3hr	Rn, net radiation, MJ/m^2/3hr	Rn, net radiation mm/3hr	Ep, net evaporation, mm/3hr
3/2/05 15:00	26	29.9	26	0.566	56.57	271.5667	0.122205	106.2	0	0.53333	35.556	2.43961	3.36	4.219	3.36144	0.19826	0.01646	3.3449781	0.083950062	0.067	0.1050963	0.4535571	0.5586534	0.000228993	0.352569759
3/2/05 18:00	23.7	24.4	23.7	0.774	77.38	0	0	133.1	0	0	0	2.44504	2.93	3.056	2.93061	0.17591	0.00677	2.923837166	0.10061076	0.067	0	0.527047563	0.527047563	0.000215557	0.008130207
3/2/05 21:00	22.5	23.3	22.5	0.978	97.75	0	0	135	0	0	0	2.44788	2.73	2.861	2.72559	0.16512	0.00063	2.724959136	0.108895697	0.067	0	0.561281343	0.561281343	0.000229293	0.000943573
3/3/05 0:00	22.1	22.5	22.1	0.997	99.67	0	0	135	0	0	0	2.44882	2.66	2.726	2.66009	0.16165	9E-05	2.659999574	0.111666928	0.067	0	0.572457104	0.572457104	0.000233768	0.000278748
3/3/05 3:00	21.7	22.5	21.7	1	100	0	0	139.7	0	0	0	2.44977	2.6	2.726	2.59597	0.15824	0	2.595969994	0.114431802	0.067	0	0.583459102	0.583459102	0.000238169	0.000167323
3/3/05 6:00	29.5	29.5	21.7	0.947	94.72	294.1	0.132345	185.9	0	0.8	53.333	2.43135	4.12	4.123	2.59597	0.23684	0.00177	4.121110572	0.055792739	0.067	0.1138167	0.315785335	0.429602035	0.000176693	0.048730623
3/3/05 9:00	32.8	33.2	30.4	0.635	63.53	720.5833	0.3242625	214.2	0	0.8	53.333	2.42356	4.97	5.087	4.34139	0.27879	0.01719	4.956801162	0.028305754	0.067	0.27886575	0.167311206	0.446176956	0.0001841	0.414864013
3/3/05 12:00	33.2	34.1	32.8	0.518	51.77	700.9833	0.3154425	121.4	0	1.6	106.67	2.42261	5.09	5.349	4.97399	0.28427	0.0249	5.061957649	0.025016874	0.067	0.27128055	0.148645809	0.419926359	0.000173336	1.163652124
3/3/05 15:00	26.8	33.2	26.8	0.495	49.5	262.75	0.1182375	129.6	0	0.53333	35.556	2.43773	3.52	5.087	3.52372	0.20658	0.02174	3.501977897	0.078009987	0.067	0.10168425	0.425990405	0.527674655	0.000216462	0.450306557
3/3/05 18:00	23.7	25.6	23.7	0.845	84.5	0	0	189.4	0	0	0	2.44504	2.93	3.283	2.93061	0.17591	0.00482	2.925792006	0.100530747	0.067	0	0.526628417	0.526628417	0.000215386	0.005827628
3/3/05 21:00	22.9	23.3	22.9	0.965	96.53	0	0	274.2	0	0	0	2.44693	2.79	2.861	2.79249	0.16865	0.00098	2.791509859	0.10609063	0.067	0	0.549787993	0.549787993	0.000224685	0.001356277
3/4/05 0:00	22.5	22.9	22.5	0.996	99.62	0	0	274.2	0	0	0	2.44788	2.73	2.792	2.72559	0.16512	0.00011	2.725481843	0.108873532	0.067	0	0.561167101	0.561167101	0.000229246	0.000294417
3/4/05 3:00	22.5	22.9	22.1	1	100	0	0	266.5	0	0	0	2.44788	2.73	2.792	2.66009	0.16512	0	2.725587607	0.108869048	0.067	0	0.561143987	0.561143987	0.000229237	0.000163069
3/4/05 6:00	29.1	29.1	22.5	0.951	95.07	310.75	0.1398375	218.9	0	0.26667	17.778	2.43229	4.03	4.029	2.72559	0.23213	0.00167	4.02721832	0.059048974	0.067	0.12026025	0.332452448	0.452712698	0.000186126	0.016636593
3/4/05 9:00	33.6	33.6	31.2	0.616	61.55	926.4833	0.4169175	182.3	0	0.26667	17.778	2.42167	5.2	5.202	4.544	0.28984	0.01874	5.183193906	0.021267196	0.067	0.35854905	0.127027058	0.485576108	0.000200513	0.156339592
3/4/05 12:00	35.3	35.3	34.5	0.521	52.05	912.75	0.4107375	229.5	0	1.06667	71.111	2.41766	5.72	5.717	5.46915	0.31456	0.02682	5.689767183	0.00605474	0.067	0.35323425	0.036972665	0.390206915	0.000161399	0.781295995
3/4/05 15:00	27.2	34.5	27.2	0.628	62.77	275.5	0.123975	211.6	0	0	0	2.43678	3.61	5.469	3.60739	0.21084	0.0169	3.590490821	0.074719733	0.067	0.1066185	0.41020374	0.51682224	0.000212092	0.017317119

Date/Time	TMP (*C)	TMP max (*C)	TMP min (*C)	RH	RH (%)	solar radiation watt/m^2	St, solar radian MJ./m^ 2/3hr	WND (Deg)	Rainfall (mm)	Wind speed, km/hr	U2, Wind speed m/sec	Lamda MJ/kg	e* kPa	e*max, kPa	e*min, kPa	Delta kPa/*C	Dbar, kPa	e*d, dew point vapor pressure, kPA	Epsilon, net emmisivity	Gamma, Psychrometric constant	Sn, net shortwave radiation, MJ/m^ 2/3hr	Ln, Long wave radiation, MJ/m^ 2/3hr	Rn, net radiation, MJ/m^ 2/3hr	Rn, net radiation mm/3hr	Ep, net evaporation, mm/3hr
3/4/05 18:00	24	26	24	0.974	97.35	0	0	8.4	0	0	0	2.44434	2.98	3.361	2.98392	0.1787	0.00084	2.983076717	0.098197801	0.067	0	0.51648959	0.51648959	0.000211301	0.001131087
3/4/05 21:00	23.3	23.7	23.3	0.999	99.92	0	0	8.4	0	0	0	2.44599	2.86	2.931	2.86082	0.17225	2.4E-05	2.860796999	0.10320553	0.067	0	0.537732579	0.537732579	0.000219843	0.000187202
3/5/05 0:00	22.9	23.3	22.9	1	100	0	0	8.4	0	0	0	2.44693	2.79	2.861	2.79249	0.16865	0	2.792489766	0.106049579	0.067	0	0.549575255	0.549575255	0.000224598	0.000160741
3/5/05 3:00	21.7	22.5	21.7	0.999	99.92	0	0	8.4	0	0	0	2.44977	2.6	2.726	2.59597	0.15824	2.2E-05	2.595947821	0.114432765	0.067	0	0.583464014	0.583464014	0.000238171	0.000195866
3/5/05 6:00	30.4	30.4	22.1	0.969	96.9	302.9333	0.13632	93.02	0	0	0	2.42923	4.34	4.341	2.66009	0.24771	0.00109	4.340305408	0.048332405	0.067	0.1172352	0.276828032	0.394063232	0.000162218	0.001097087
3/5/05 9:00	33.2	33.2	31.2	0.816	81.6	906.8667	0.40809	238.4	0	0.26667	17.778	2.42261	5.09	5.087	4.544	0.28427	0.00886	5.077992757	0.024518371	0.067	0.3509574	0.145683797	0.496641197	0.000205002	0.075114109
3/5/05 12:00	34.5	34.5	33.2	0.75	74.97	848.0167	0.3816075	152.6	0	1.06667	71.111	2.41955	5.47	5.469	5.08685	0.30272	0.01321	5.455933311	0.012988849	0.067	0.32818245	0.078495587	0.406678037	0.00016808	0.396143916
3/5/05 15:00	27.2	33.6	27.2	0.723	72.27	205.9	0.092655	312.9	0	0.26667	17.778	2.43678	3.61	5.202	3.60739	0.21084	0.01222	3.595172714	0.074546831	0.067	0.0796833	0.409254523	0.488937823	0.000200649	0.130737881
3/5/05 18:00	25.2	26.4	25.2	0.85	85	0	0	322	0	0	0	2.4415	3.21	3.442	3.20571	0.19023	0.00499	3.200726649	0.089531953	0.067	0	0.478561687	0.478561687	0.000196011	0.005649154
3/5/05 21:00	24.8	25.2	24.8	0.965	96.5	0	0	322	0	0	0	2.44245	3.13	3.206	3.13024	0.18632	0.00111	3.129126429	0.092349282	0.067	0	0.490979288	0.490979288	0.000201019	0.00139309
3/6/05 0:00	24.8	24.8	24.8	0.999	99.92	0	0	322	0	0	0	2.44245	3.13	3.13	3.13024	0.18632	2.6E-05	3.130209134	0.092306441	0.067	0	0.490751522	0.490751522	0.000200926	0.000177079
3/6/05 3:00	24	24.8	24	1	100	0	0	322	0	0	0	2.44434	2.98	3.13	2.98392	0.1787	0	2.983917477	0.098163728	0.067	0	0.516310378	0.516310378	0.000211227	0.000153628
3/6/05 6:00	28	28	24	0.999	99.92	132.3333	0.05955	305.6	0	0	0	2.43489	3.78	3.78	2.98392	0.2196	2.8E-05	3.779902181	0.067812413	0.067	0.051213	0.376264857	0.427477857	0.000175563	0.000162214
3/6/05 9:00	33.2	33.2	29.1	0.749	74.87	614.7	0.276615	124.7	0	1.06667	71.111	2.42261	5.09	5.087	4.02888	0.28427	0.01146	5.075397698	0.024598994	0.067	0.2378889	0.14616284	0.38405174	0.000158528	0.3601159
3/6/05 12:00	30.4	32.4	29.9	0.611	61.13	490.2167	0.2205975	132.4	0	1.33333	88.889	2.42923	4.34	4.863	4.21879	0.24771	0.01765	4.323741091	0.048889496	0.067	0.18971385	0.280018821	0.469732671	0.000193367	0.767072596
3/6/05 15:00	27.6	30.4	27.6	0.649	64.9	224.5167	0.1010325	130.1	0	1.06667	71.111	2.43584	3.69	4.341	3.69278	0.21518	0.0141	3.678681987	0.071481533	0.067	0.08688795	0.394520685	0.481408635	0.000197636	0.551009231
3/6/05 18:00	24	26.8	24	0.939	93.93	0	0	80.2	0	0	0	2.44434	2.98	3.524	2.98392	0.1787	0.00197	2.981943494	0.098243733	0.067	0	0.516731182	0.516731182	0.000211399	0.002448562

Date/ Time	TMP (*C)	TMP max (*C)	TMP min (*C)	RH	RH (%)	solar radiation watt/ m^2	St, solar radian MJ./m^ 2/3hr	WND (Deg)	Rainfall (mm)	Wind speed, km/ hr	U2, Wind speed m/sec	Lamda MJ/ kg	e* kPa	e*max, kPa	e*min, kPa	Delta kPa/ *C	Dbar, kPa	e*d, dew point vapor pressure, kPA	Epsilon, net emmisivity	Gamma, Psychrometric constant	Sn, net shortwave radiation, MJ/m^ 2/3hr	Ln, Long wave radiation, MJ/m^ 2/3hr	Rn, net radiation, MJ/m^ 2/3hr	Rn, net radiation mm/3hr	Ep, net evaporation, mm/3hr
3/6/05 21:00	22.9	23.7	22.9	0.999	99.92	0	0	80.2	0	0	0	2.44693	2.79	2.931	2.79249	0.16865	2.4E-05	2.79246592	0.106050578	0.067	0	0.549580432	0.549580432	0.0002246	0.000189834
3/7/05 0:00	22.1	22.5	22.1	1	100	0	0	80.2	0	0	0	2.44882	2.66	2.726	2.66009	0.16165	0	2.660089335	0.111663076	0.067	0	0.572437354	0.572437354	0.00023376	0.000165263
3/7/05 3:00	21.7	22.1	21.7	1	100	0	0	75.5	0	0	0	2.44977	2.6	2.66	2.59597	0.15824	0	2.595969994	0.114431802	0.067	0	0.583459102	0.583459102	0.000238169	0.000167323
3/7/05 6:00	29.5	29.5	21.7	0.994	99.37	223.5333	0.10059	148.8	0	0.53333	35.556	2.43135	4.12	4.123	2.59597	0.23684	0.00021	4.122672706	0.055738879	0.067	0.0865074	0.315480488	0.401987888	0.000165335	0.004077847
3/7/05 9:00	30.8	30.8	28	0.84	83.98	872.5333	0.39264	234.9	0	2.13333	142.22	2.42828	4.44	4.442	3.77993	0.25268	0.00658	4.435106951	0.045164289	0.067	0.3376704	0.260048353	0.597718753	0.000246149	0.447441321
3/7/05 12:00	31.6	32.4	31.2	0.665	66.53	899.0167	0.4045575	148.1	0	1.86667	124.44	2.42639	4.65	4.863	4.544	0.26287	0.01574	4.632608113	0.038671078	0.067	0.34791945	0.225014614	0.572934064	0.000236126	0.909260761
3/7/05 15:00	27.2	29.5	27.2	0.663	66.33	111.75	0.0502875	135.5	1.02	0.53333	35.556	2.43678	3.61	4.123	3.60739	0.21084	0.01301	3.594375675	0.074576257	0.067	0.04324725	0.409416073	0.452663323	0.000185763	0.265141177
3/7/05 18:00	24	26	24	0.914	91.42	0	0	219.4	0	0	0	2.44434	2.98	3.361	2.98392	0.1787	0.00272	2.981194261	0.098274107	0.067	0	0.516890936	0.516890936	0.000211465	0.003319613
3/7/05 21:00	24	24	23.7	0.997	99.67	0	0	219.4	0	0	0	2.44434	2.98	2.984	2.93061	0.1787	9.9E-05	2.983818902	0.098167722	0.067	0	0.516331388	0.516331388	0.000211236	0.000268231
3/8/05 0:00	23.7	24	23.7	0.829	82.9	0	0	219.4	0	0	0	2.44504	2.93	2.984	2.93061	0.17591	0.00506	2.925550456	0.100540632	0.067	0	0.526680201	0.526680201	0.000215407	0.006112146
3/8/05 3:00	23.3	23.7	23.3	0.781	78.12	0	0	219.4	0	0	0	2.44599	2.86	2.931	2.86082	0.17225	0.00634	2.854484342	0.10346693	0.067	0	0.539094556	0.539094556	0.000220399	0.007754272
3/8/05 6:00	27.6	28.3	23.3	0.7	70.02	165.6667	0.07455	127.8	0	0.53333	35.556	2.43584	3.69	3.846	2.86082	0.21518	0.01006	3.682726626	0.071333958	0.067	0.064113	0.393706191	0.457819191	0.000187952	0.201586066
3/8/05 9:00	31.2	31.2	27.6	0.527	52.73	644.1333	0.28986	198.1	0	2.13333	142.22	2.42734	4.54	4.544	3.69278	0.25773	0.01947	4.524533326	0.042206694	0.067	0.2492796	0.244300591	0.493580191	0.000203342	1.302282949
3/8/05 12:00	29.5	32.4	29.5	0.479	47.9	827.4667	0.37236	193.6	0	1.86667	124.44	2.43135	4.12	4.863	4.12289	0.23684	0.02341	4.099476427	0.056539707	0.067	0.3202296	0.32001315	0.64024275	0.000263328	1.466731958
3/8/05 15:00	26.8	29.1	26.4	0.491	49.05	201.9667	0.090885	88.35	7.87	1.33333	88.889	2.43773	3.52	4.029	3.44175	0.20658	0.01903	3.504688161	0.077908627	0.067	0.0781611	0.425436904	0.503598004	0.000206585	0.95576247
3/8/05 18:00	23.7	25.6	23.7	0.832	83.23	0	0	132.5	0	0	0	2.44504	2.93	3.283	2.93061	0.17591	0.00521	2.925398492	0.100546851	0.067	0	0.52671278	0.52671278	0.000215421	0.006291142
3/8/05 21:00	23.7	23.7	23.3	0.981	98.08	0	0	146.3	0	0	0	2.44504	2.93	2.931	2.86082	0.17591	0.00056	2.930052363	0.10035646	0.067	0	0.525715419	0.525715419	0.000215013	0.000809413
3/9/05	22.5	23.7	22.5	0.956	95.57	0	0	146.3	0	0	0	2.44788	2.73	2.931	2.72559	0.16512	0.00125	2.724333817	0.108922215	0.067	0	0.561418026	0.561418026	0.000229349	0.001720162

0:00																								
3/9/05 3:00	22.5	22.5	22.5	0.868	86.75	0	0	55.07	0	0	0	2.44788	2.73	2.726	2.72559	0.16512	0.00361	2.721976203	0.109022223	0.067	0	0.561933498	0.561933498	0.000229559	0.004648105
3/9/05 6:00	26	26	22.9	0.875	87.52	126.45	0.0569025	86.02	0	0	0	2.43961	3.36	3.361	2.79249	0.19826	0.00384	3.357598751	0.083467477	0.067	0.04893615	0.450949835	0.499885985	0.000204904	0.004252631
3/9/05 9:00	25.2	29.9	24.4	0.467	46.73	328.4333	0.147795	147.9	8.64	2.13333	142.22	2.4415	3.21	4.219	3.05631	0.19023	0.01938	3.186336224	0.090095638	0.067	0.1271037	0.481574667	0.608678367	0.000249305	1.652275087
3/9/05 12:00	27.2	27.2	26	0.309	30.88	241.1667	0.108525	144.4	6.6	0	0	2.43678	3.61	3.607	3.36144	0.21084	0.02408	3.583305194	0.074985318	0.067	0.0933315	0.411661774	0.504993274	0.000207238	0.02460907
3/9/05 15:00	26	28	26	0.384	38.43	73.51667	0.0330825	136.9	0	0	0	2.43961	3.36	3.78	3.36144	0.19826	0.02198	3.339456311	0.084161489	0.067	0.02845095	0.454699377	0.483150327	0.000198044	0.023610458
3/9/05 18:00	24	25.2	24	0.827	82.72	0	0	170.2	0	0	0	2.44434	2.98	3.206	2.98392	0.1787	0.00535	2.978568605	0.098380579	0.067	0	0.517450946	0.517450946	0.000211694	0.006372176
3/9/05 21:00	23.7	24	23.7	0.965	96.53	0	0	201.4	0	0	0	2.44504	2.93	2.984	2.93061	0.17591	0.00103	2.92958219	0.100375688	0.067	0	0.525816145	0.525816145	0.000215054	0.001363223
3/10/05 0:00	22.5	23.7	22.5	0.997	99.7	0	0	200.9	0	0	0	2.44788	2.73	2.931	2.72559	0.16512	8.5E-05	2.725502764	0.108872645	0.067	0	0.561162529	0.561162529	0.000229245	0.000268436
3/10/05 3:00	22.1	22.5	22.1	1	100	0	0	232	0	0	0	2.44882	2.66	2.726	2.66009	0.16165	0	2.660089335	0.111663076	0.067	0	0.572437354	0.572437354	0.00023376	0.000165263
3/10/05 6:00	25.6	25.6	22.1	0.99	98.98	105.8833	0.0476475	146.2	0	0	0	2.44056	3.28	3.283	2.66009	0.19421	0.0003	3.282469074	0.086353802	0.067	0.04097685	0.4640539	0.50503075	0.000206932	0.000481758
3/10/05 9:00	27.2	29.5	27.2	0.701	70.05	319.6167	0.1438275	153.1	0	1.06667	71.111	2.43678	3.61	4.123	3.60739	0.21084	0.01158	3.595812218	0.074523222	0.067	0.12369165	0.409124917	0.532816567	0.000218656	0.459903092
3/10/05 12:00	29.5	30.4	28	0.421	42.08	329.4167	0.1482375	108.7	0.25	0.53333	35.556	2.43135	4.12	4.341	3.77993	0.23684	0.02352	4.099367477	0.056543473	0.067	0.12748425	0.32003447	0.44751872	0.000184062	0.436645695
3/10/05 15:00	24.4	30.4	24.4	0.43	42.95	109.8	0.04941	147.9	0	0.53333	35.556	2.44339	3.06	4.341	3.05631	0.18248	0.0211	3.035210704	0.096094014	0.067	0.0424926	0.508150826	0.550643426	0.00022536	0.483761424
3/10/05 18:00	22.9	23.3	22.9	0.821	82.1	0	0	78.52	12.19	0.26667	17.778	2.44693	2.79	2.861	2.79249	0.16865	0.00506	2.787430053	0.106261623	0.067	0	0.550674118	0.550674118	0.000225047	0.065153615
3/10/05 21:00	22.9	22.9	22.9	0.954	95.35	0	0	53.9	0	0	0	2.44693	2.79	2.792	2.79249	0.16865	0.0013	2.791191258	0.106103979	0.067	0	0.549857169	0.549857169	0.000224713	0.001744986
3/11/05 0:00	22.9	22.9	22.9	0.994	99.35	0	0	30.9	0	0	0	2.44693	2.79	2.792	2.79249	0.16865	0.00018	2.792308254	0.106057183	0.067	0	0.549614659	0.549614659	0.000224614	0.000382194
3/11/05 3:00	22.5	22.9	22.5	1	100	0	0	30.9	0	0	0	2.44788	2.73	2.792	2.72559	0.16512	0	2.725587607	0.108869048	0.067	0	0.561143987	0.561143987	0.000229237	0.000163069

3/11/05 6:00	25.6	25.6	22.9	0.99	98.98	115.6833	0.0520575	39.37	0	0	0	2.44056	3.28	3.283	2.79249	0.19421	0.00031	3.282462344	0.086354062	0.067	0.04476945	0.464055297	0.508824747	0.000208487	0.000490219
3/11/05 9:00	28	29.1	26	0.669	66.85	342.1667	0.153975	190.3	0	0	0	2.43489	3.78	4.029	3.36144	0.2196	0.01225	3.767680902	0.068252791	0.067	0.1324185	0.378708346	0.511126846	0.000209918	0.012197699
3/11/05 12:00	29.9	30.4	26.8	0.474	47.38	375.4833	0.1689675	93.03	0	0	0	2.43041	4.22	4.341	3.52372	0.24162	0.02069	4.198096602	0.053150399	0.067	0.14531205	0.302423036	0.447735086	0.000184222	0.018992071
3/11/05 15:00	23.7	29.9	23.7	0.511	51.07	79.4	0.03573	190.6	16.76	0.53333	35.556	2.44504	2.93	4.219	2.93061	0.17591	0.01749	2.913115186	0.101050094	0.067	0.0307278	0.529349007	0.560076807	0.000229066	0.413410147
3/11/05 18:00	23.3	23.7	23.3	0.849	84.9	0	0	243.3	0.25	0	0	2.44599	2.86	2.931	2.86082	0.17225	0.00437	2.856448601	0.103385561	0.067	0	0.538670599	0.538670599	0.000220226	0.005399687
3/11/05 21:00	23.7	23.7	23.3	0.952	95.18	0	0	243.3	0	0	0	2.44504	2.93	2.931	2.86082	0.17591	0.00139	2.929212606	0.100390803	0.067	0	0.525895327	0.525895327	0.000215086	0.001798551
3/12/05 0:00	23.7	23.7	23.3	0.988	98.78	0	0	243.3	0	0	0	2.44504	2.93	2.931	2.86082	0.17591	0.00035	2.930255063	0.100348171	0.067	0	0.525671997	0.525671997	0.000214995	0.000570656
3/12/05 3:00	23.3	23.7	23.3	1	100	0	0	243.3	0	0	0	2.44599	2.86	2.931	2.86082	0.17225	0	2.86082113	0.103204531	0.067	0	0.537727375	0.537727375	0.00021984	0.000158276
3/12/05 6:00	28	28	23.7	0.997	99.65	162.75	0.0732375	232.5	0	0.26667	17.778	2.43489	3.78	3.78	2.93061	0.2196	0.00012	3.77981293	0.067815626	0.067	0.06298425	0.376282687	0.439266937	0.000180405	0.001353224
3/12/05 9:00	27.2	30.4	27.2	0.806	80.6	449.0167	0.2020575	96.33	1.02	0.8	53.333	2.43678	3.61	4.341	3.60739	0.21084	0.00771	3.599677987	0.074380557	0.067	0.17376945	0.408341698	0.582111148	0.000238885	0.231796233
3/12/05 12:00	28	28	26	0.67	66.98	134.3	0.060435	159.1	6.1	0.26667	17.778	2.43489	3.78	3.78	3.36144	0.2196	0.01179	3.768141152	0.068236193	0.067	0.0519741	0.378616253	0.430590353	0.000176842	0.122108395
3/12/05 15:00	27.2	29.9	27.2	0.618	61.8	116.65	0.0524925	162.2	0	0	0	2.43678	3.61	4.219	3.60739	0.21084	0.01495	3.592440305	0.074647725	0.067	0.04514355	0.409808422	0.454951972	0.000186702	0.015318522
3/12/05 18:00	25.2	26	24.8	0.905	90.5	0	0	128	0	0	0	2.4415	3.21	3.361	3.13024	0.19023	0.00308	3.202628697	0.089457544	0.067	0	0.478163955	0.478163955	0.000195848	0.003549133
3/12/05 21:00	24	25.2	24	0.987	98.7	0	0	128	0	0	0	2.44434	2.98	3.206	2.98392	0.1787	0.0004	2.983515151	0.098180032	0.067	0	0.516396132	0.516396132	0.000211262	0.000621368
3/13/05 0:00	24	24.4	24	0.992	99.23	0	0	132	0	0	0	2.44434	2.98	3.056	2.98392	0.1787	0.00023	2.983685935	0.098173111	0.067	0	0.516359729	0.516359729	0.000211247	0.000422816
3/13/05 3:00	23.3	23.7	23.3	1	100	0	0	150.5	0	0	0	2.44599	2.86	2.931	2.86082	0.17225	0	2.86082113	0.103204531	0.067	0	0.537727375	0.537727375	0.00021984	0.000158276
3/13/05 6:00	28.3	28.3	23.3	0.992	99.23	220.5833	0.0992625	151.4	0	0.53333	35.556	2.43418	3.85	3.846	2.86082	0.22296	0.00026	3.84620426	0.065435611	0.067	0.08536575	0.36452559	0.44989134	0.000184822	0.005148538
3/13/05	30.8	31.6	29.5	0.94	94.03	654.9	0.294705	152.8	0	2.66667	177.78	2.42828	4.44	4.648	4.12289	0.25268	0.00262	4.439074347	0.045032447	0.067	0.2534463	0.259289228	0.512735528	0.000211152	0.221779275

Date/Time	TMP (*C)	TMP max (*C)	TMP min (*C)	RH	RH (%)	solar radiation watt/m^2	St, solar radian MJ./m^2/3hr	WND (Deg)	Rainfall (mm)	Wind speed, km/hr	U2, Wind speed m/sec	Lamda MJ/kg	e* kPa	e*max, kPa	e*min, kPa	Delta kPa/*C	Dbar, kPa	e*d, dew point vapor pressure, kPA	Epsilon, net emmisivity	Gamma, Psychrometric constant	Sn, net shortwave radiation, MJ/m^2/3hr	Ln, Long wave radiation, MJ/m^2/3hr	Rn, net radiation, MJ/m^2/3hr	Rn, net radiation mm/3hr	Ep, net evaporation, mm/3hr
3/13/05 12:00	32.8	32.8	30.8	0.65	64.98	742.15	0.3339675	235.8	0	2.66667	177.78	2.42356	4.97	4.974	4.44169	0.27879	0.01649	4.957506702	0.028283572	0.067	0.28721205	0.167180091	0.454392141	0.00018749	1.29443717
3/13/05 15:00	26.8	32.8	26.8	0.614	61.42	236.2667	0.10632	231.1	0	0.8	53.333	2.43773	3.52	4.974	3.52372	0.20658	0.01639	3.507326091	0.077810009	0.067	0.0914352	0.424898381	0.516333581	0.00021181	0.500819069
3/13/05 18:00	24	25.6	24	0.913	91.33	0	0	151.9	0	0	0	2.44434	2.98	3.283	2.98392	0.1787	0.00272	2.981201912	0.098273796	0.067	0	0.516889304	0.516889304	0.000211464	0.003310718
3/13/05 21:00	24	24	23.7	0.994	99.4	0	0	151.9	0	0	0	2.44434	2.98	2.984	2.93061	0.1787	0.00018	2.983740041	0.098170918	0.067	0	0.516348197	0.516348197	0.000211243	0.000359913
3/14/05 0:00	22.9	23.7	22.9	1	100	0	0	151.9	0	0	0	2.44693	2.79	2.931	2.79249	0.16865	0	2.792489766	0.106049579	0.067	0	0.549575255	0.549575255	0.000224598	0.000160741
3/14/05 3:00	22.1	22.5	22.1	1	100	0	0	151.9	0	0	0	2.44882	2.66	2.726	2.66009	0.16165	0	2.660089335	0.111663076	0.067	0	0.572437354	0.572437354	0.00023376	0.000165263
3/14/05 6:00	25.6	25.6	22.5	0.987	98.72	88.25	0.0397125	111.6	0	0	0	2.44056	3.28	3.283	2.72559	0.19421	0.00039	3.282385633	0.086357026	0.067	0.03415275	0.464071224	0.498223974	0.000204143	0.000570254
3/14/05 9:00	28	28	26	0.693	69.32	224.5	0.101025	210	0	0.26667	17.778	2.43489	3.78	3.78	3.36144	0.2196	0.01096	3.768974312	0.068206151	0.067	0.0868815	0.378449558	0.465331058	0.00019111	0.113499334
3/14/05 12:00	21	26.8	21	0.502	50.17	100	0.045	154.9	4.32	2.13333	142.22	2.45142	2.49	3.524	2.48701	0.15242	0.01498	2.472028674	0.11988239	0.067	0.0387	0.605467253	0.644167253	0.000262773	1.537074988
3/14/05 15:00	21.3	21.3	21	0.535	53.45	76.46667	0.03441	236.3	0	1.33333	88.889	2.45071	2.53	2.533	2.48701	0.15489	0.01168	2.521520442	0.117689855	0.067	0.0295926	0.596821988	0.626414588	0.000255605	0.745167225
3/14/05 18:00	21	21	21	0.874	87.42	0	0	81.32	0	0	0	2.45142	2.49	2.487	2.48701	0.15242	0.00313	2.483875915	0.119355562	0.067	0	0.602806501	0.602806501	0.000245901	0.004329029
3/14/05 21:00	21	21	20.6	0.982	98.15	0	0	20.65	0.76	0	0	2.45142	2.49	2.487	2.42655	0.15242	0.00045	2.486550893	0.119236784	0.067	0	0.602206611	0.602206611	0.000245656	0.000774555
3/15/05 0:00	20.6	21	20.6	0.997	99.65	0	0	16.9	1.27	0	0	2.45236	2.43	2.487	2.42655	0.14918	8.6E-05	2.426466325	0.121920336	0.067	0	0.612417944	0.612417944	0.000249726	0.000288692
3/15/05 3:00	19.8	20.2	19.8	0.961	96.08	0	0	178.4	2.79	0	0	2.45425	2.31	2.367	2.30949	0.14287	0.00092	2.308572361	0.127284184	0.067	0	0.632425709	0.632425709	0.000257686	0.001461522
3/15/05 6:00	22.5	22.5	19.8	0.961	96.12	117.65	0.0529425	222.4	0	0	0	2.44788	2.73	2.726	2.30949	0.16512	0.00098	2.724609963	0.108910504	0.067	0.04553055	0.561357664	0.606888214	0.000247924	0.001390445
3/15/05 9:00	28	28	22.5	0.741	74.13	531.3833	0.2391225	173.9	0	1.06667	71.111	2.43489	3.78	3.78	2.72559	0.2196	0.00841	3.771516561	0.068114501	0.067	0.20564535	0.377941029	0.583586379	0.000239676	0.323582045
3/15/05 12:00	28.3	28.3	27.6	0.563	56.27	543.1333	0.24441	139.9	0	0.8	53.333	2.43418	3.85	3.846	3.69278	0.22296	0.01649	3.82997556	0.066015473	0.067	0.2101926	0.367755856	0.577948456	0.00023743	0.473691174
3/15/05 15.00	24.8	28.3	24.8	0.495	49.45	130.4	0.05868	131.5	0	0.53333	35.556	2.44245	3.13	3.846	3.13024	0.18632	0.01763	3.112601619	0.093004065	0.067	0.0504648	0.494460474	0.544925274	0.000223106	0.397379707

Date/ Time	TMP (*C)	TMP max (*C)	TMP min (*C)	RH	RH (%)	solar radiation watt/ m^2	St, solar radian MJ./m^ 2/3hr	WND (Deg)	Rainfall (mm)	Wind speed, km/ hr	U2, Wind speed m/sec	Lamda MJ/ kg	e* kPa	e*max, kPa	e*min, kPa	Delta kPa/ *C	Dbar, kPa	e*d, dew point vapor pressure, kPA	Epsilon, net emmisivity	Gamma, Psychrometric constant	Sn, net shortwave radiation, MJ/m^ 2/3hr	Ln, Long wave radiation, MJ/m^ 2/3hr	Rn, net radiation, MJ/m^ 2/3hr	Rn, net radiation mm/3hr	Ep, net evaporation, mm/3hr
3/15/05 18:00	23.7	24.8	23.7	0.867	86.72	0	0	180.4	0	0	0	2.44504	2.93	3.13	2.93061	0.17591	0.00403	2.926581965	0.100498421	0.067	0	0.526459078	0.526459078	0.000215317	0.004897146
3/15/05 21:00	22.9	23.3	22.9	0.961	96.13	0	0	209.5	0	0	0	2.44693	2.79	2.861	2.79249	0.16865	0.00109	2.791396793	0.106095367	0.067	0	0.549812542	0.549812542	0.000224695	0.001494223
3/16/05 0:00	22.9	22.9	22.9	0.996	99.62	0	0	209.5	0	0	0	2.44693	2.79	2.792	2.79249	0.16865	0.00011	2.792382721	0.106054063	0.067	0	0.549598493	0.549598493	0.000224607	0.000291342
3/16/05 3:00	22.1	22.9	22.1	1	100	0	0	255.2	0.76	0	0	2.44882	2.66	2.792	2.66009	0.16165	0	2.660089335	0.111663076	0.067	0	0.572437354	0.572437354	0.00023376	0.000165263
3/16/05 6:00	26.4	26.4	22.1	0.975	97.47	147.0333	0.066165	218.9	0	0	0	2.43867	3.44	3.442	2.66009	0.20238	0.00077	3.440973535	0.080301942	0.067	0.0569019	0.436172094	0.493073994	0.00020219	0.000963093
3/16/05 9:00	28.7	28.7	26.4	0.68	68.02	326.4833	0.1469175	175.3	0	0.26667	17.778	2.43324	3.94	3.937	3.44175	0.22751	0.0118	3.924954052	0.062639045	0.067	0.12634905	0.350802089	0.477151139	0.000196097	0.118831261
3/16/05 12:00	30.4	32	29.5	0.519	51.93	839.2333	0.377655	170.9	0	1.33333	88.889	2.42923	4.34	4.755	4.12289	0.24771	0.02134	4.320054659	0.049013623	0.067	0.3247833	0.28072977	0.60551307	0.000249262	0.927301974
3/16/05 15:00	25.2	31.6	25.2	0.533	53.27	294.1	0.132345	190.8	0	0.8	53.333	2.4415	3.21	4.648	3.20571	0.19023	0.01835	3.187359918	0.090055497	0.067	0.1138167	0.481360108	0.595176808	0.000243775	0.599645756
3/16/05 18:00	22.1	24.4	22.1	0.866	86.63	0.983333	0.0004425	227.6	0	0	0	2.44882	2.66	3.056	2.66009	0.16165	0.00382	2.656268873	0.111827105	0.067	0.00038055	0.573278246	0.573658796	0.000234259	0.004995603
3/16/05 21:00	21.3	22.1	21.3	0.978	97.77	0	0	255.9	0	0	0	2.45071	2.53	2.66	2.5332	0.15489	0.00058	2.532625063	0.117200872	0.067	0	0.594342289	0.594342289	0.000242518	0.000929392
3/17/05 0:00	21.3	21.3	21	0.999	99.92	0	0	255.9	0	0	0	2.45071	2.53	2.533	2.48701	0.15489	2.1E-05	2.533184064	0.117176286	0.067	0	0.594217606	0.594217606	0.000242467	0.000196672
3/17/05 3:00	21.3	21.3	21	1	100	0	0	255.9	0	0	0	2.45071	2.53	2.533	2.48701	0.15489	0	2.533204981	0.117175366	0.067	0	0.594212941	0.594212941	0.000242466	0.000169254
3/17/05 6:00	24.4	24.4	21.3	0.949	94.88	69.58333	0.0313125	222.6	0	0	0	2.44339	3.06	3.056	2.5332	0.18248	0.00143	3.054882668	0.095304883	0.067	0.02692875	0.503977852	0.530906602	0.000217283	0.001792768
3/17/05 9:00	29.1	30.4	26.8	0.613	61.28	562.7333	0.25323	188.7	0	0.26667	17.778	2.43229	4.03	4.341	3.52372	0.23213	0.01523	4.013658881	0.059522347	0.067	0.2177778	0.33511759	0.55289539	0.000227314	0.150888574
3/17/05 12:00	30.4	31.6	30.4	0.428	42.78	559.8	0.25191	141.1	0	0.8	53.333	2.42923	4.34	4.648	4.34139	0.24771	0.02572	4.315672489	0.049161246	0.067	0.2166426	0.281575292	0.498217892	0.000205093	0.679864486
3/17/05 15:00	27.6	32.4	27.6	0.468	46.78	272.55	0.1226475	280.3	0	0.53333	35.556	2.43584	3.69	4.863	3.69278	0.21518	0.02277	3.670015622	0.071798012	0.067	0.10547685	0.396267395	0.501744245	0.000205984	0.456244696
3/17/05 18:00	23.7	26	23.7	0.674	67.4	0.983333	0.0004425	201.1	0	0	0	2.44504	2.93	3.361	2.93061	0.17591	0.01026	2.920351338	0.100753503	0.067	0.00038055	0.527795323	0.528175873	0.000216019	0.012236228
3/17/05 21:00	23.7	23.7	23.7	0.899	89.87	0	0	191.3	0	0	0	2.44504	2.93	2.931	2.93061	0.17591	0.00297	2.927637693	0.100455226	0.067	0	0.526232803	0.526232803	0.000215224	0.00365362

Date/Time	TMP (*C)	TMP max (*C)	TMP min (*C)	RH	RH (%)	solar radiation watt/m^2	St, solar radian MJ./m^2/3hr	WND (Deg)	Rainfall (mm)	Wind speed, km/hr	U2, Wind speed m/sec	Lamda MJ/kg	e* kPa	e*max, kPa	e*min, kPa	Delta kPa/*C	Dbar, kPa	e*d, dew point vapor pressure, kPA	Epsilon, net emmisivity	Gamma, Psychrometric constant	Sn, net shortwave radiation, MJ/m^2/3hr	Ln, Long wave radiation, MJ/m^2/3hr	Rn, net radiation, MJ/m^2/3hr	Rn, net radiation mm/3hr	Ep, net evaporation, mm/3hr
3/18/05 0:00	23.3	23.7	23.3	0.982	98.15	0	0	100.5	0	0	0	2.44599	2.86	2.931	2.86082	0.17225	0.00054	2.860285423	0.103226703	0.067	0	0.537842897	0.537842897	0.000219888	0.000800436
3/18/05 3:00	23.7	23.7	22.9	1	100	0	0	86.73	0	0	0	2.44504	2.93	2.931	2.79249	0.17591	0	2.930607375	0.100333764	0.067	0	0.525596528	0.525596528	0.000214964	0.000155672
3/18/05 6:00	27.6	27.6	23.3	0.932	93.15	104.9	0.047205	96.57	0	0.26667	17.778	2.43584	3.69	3.693	2.86082	0.21518	0.00224	3.690537351	0.071049201	0.067	0.0405963	0.39213456	0.43273086	0.000177652	0.023740011
3/18/05 9:00	31.6	31.6	29.1	0.57	56.98	611.7667	0.275295	208.4	0	2.13333	142.22	2.42639	4.65	4.648	4.02888	0.26287	0.01866	4.629686395	0.038766115	0.067	0.2367537	0.225567603	0.462321303	0.000190539	1.229650452
3/18/05 12:00	32.4	32.4	32	0.474	47.4	607.8333	0.273525	172.3	0	1.33333	88.889	2.4245	4.86	4.863	4.75478	0.27339	0.0253	4.83801563	0.032063146	0.067	0.2352315	0.188531584	0.423763084	0.000174783	1.018534252
3/18/05 15:00	27.2	30.8	27.2	0.465	46.53	85.28333	0.0383775	206.7	0	0	0	2.43678	3.61	4.442	3.60739	0.21084	0.02152	3.58587043	0.074890475	0.067	0.03300465	0.411141095	0.444145745	0.000182267	0.021985613
3/18/05 18:00	24.8	26	24.8	0.835	83.47	0	0	271.9	0.25	0	0	2.44245	3.13	3.361	3.13024	0.18632	0.00537	3.124868768	0.092517823	0.067	0	0.491875344	0.491875344	0.000201386	0.006174963
3/18/05 21:00	23.7	24.4	23.7	0.953	95.33	0	0	265.1	0	0.8	53.333	2.44504	2.93	3.056	2.93061	0.17591	0.0014	2.929210427	0.100390893	0.067	0	0.525895794	0.525895794	0.000215086	0.048836387
3/19/05 0:00	21.3	22.5	21.3	0.992	99.18	0	0	157.8	44.71	2.13333	142.22	2.45071	2.53	2.726	2.5332	0.15489	0.00021	2.532990247	0.11718481	0.067	0	0.594260835	0.594260835	0.000242485	0.021906189
3/19/05 3:00	21.3	21.3	21.3	1	100	0	0	117.4	8.63	0.53333	35.556	2.45071	2.53	2.533	2.5332	0.15489	0	2.533204981	0.117175366	0.067	0	0.594212941	0.594212941	0.000242466	0.000169254
3/19/05 6:00	21.7	21.7	21.3	0.931	93.1	8.833333	0.003975	121.4	15.5	0	0	2.44977	2.6	2.596	2.5332	0.15824	0.00177	2.594200429	0.114508695	0.067	0.0034185	0.583851162	0.587269662	0.000239725	0.002446183
3/19/05 9:00	22.5	22.5	22.1	0.609	60.85	101	0.04545	55.3	13.2	0	0	2.44788	2.73	2.726	2.66009	0.16512	0.01054	2.715045144	0.109316483	0.067	0.039087	0.563450206	0.602537206	0.000246147	0.013267211
3/19/05 12:00	23.7	23.7	22.9	0.45	45	194.1167	0.0873525	163.9	2.53	0.26667	17.778	2.44504	2.93	2.931	2.79249	0.17591	0.01574	2.914868858	0.100978182	0.067	0.07512315	0.528972297	0.604095447	0.000247069	0.195354839
3/19/05 15:00	22.5	24	22.5	0.493	49.3	105.8833	0.0476475	154.9	0	0.53333	35.556	2.44788	2.73	2.984	2.72559	0.16512	0.01447	2.711114011	0.109483548	0.067	0.04097685	0.564311308	0.605288158	0.000247271	0.360693879
3/19/05 18:00	20.2	22.1	20.2	0.889	88.85	0	0	22.23	0	0	0	2.45331	2.37	2.66	2.36739	0.14599	0.0028	2.364584879	0.124719105	0.067	0	0.623071686	0.623071686	0.000253972	0.004037561
3/19/05 21:00	20.2	20.2	19.8	0.995	99.45	0	0	14.97	0	0	0	2.45331	2.37	2.367	2.30949	0.14599	0.00013	2.367259083	0.124597405	0.067	0	0.622463694	0.622463694	0.000253724	0.000351197
3/20/05 0:00	20.6	20.6	19.8	0.999	99.92	0	0	48.5	0	0.26667	17.778	2.45236	2.43	2.427	2.30949	0.14918	2E-05	2.426532579	0.121917358	0.067	0	0.612402989	0.612402989	0.00024972	0.000453495
3/20/05 3:00	20.6	20.6	20.2	1	100	0	0	109.2	0	0.26667	17.778	2.45236	2.43	2.427	2.36739	0.14918	0	2.426552312	0.121916472	0.067	0	0.612398535	0.612398535	0.000249718	0.000172323

Date/ Time	TMP (*C)	TMP max (*C)	TMP min (*C)	RH	RH (%)	solar radiation watt/m^2	St, solar radian MJ./m^2/3hr	WND (Deg)	Rainfall (mm)	Wind speed, km/hr	U2, Wind speed m/sec	Lamda MJ/kg	e* kPa	e*max, kPa	e*min, kPa	Delta kPa/*C	Dbar, kPa	e*d, dew point vapor pressure, kPA	Epsilon, net emmisivity	Gamma, Psychrometric constant	Sn, net shortwave radiation, MJ/m^2/3hr	Ln, Long wave radiation, MJ/m^2/3hr	Rn, net radiation, MJ/m^2/3hr	Rn, net radiation mm/3hr	Ep, net evaporation, mm/3hr
3/20/05 6:00	21.7	21.7	20.6	0.993	99.28	58.83333	0.026475	201.1	0	0	0	2.44977	2.6	2.596	2.42655	0.15824	0.00018	2.595790021	0.114439621	0.067	0.0227685	0.58349897	0.60626747	0.00024748	0.000405525
3/20/05 9:00	28	28	22.5	0.776	77.58	582.35	0.2620575	225.2	0	1.33333	88.889	2.43489	3.78	3.78	2.72559	0.2196	0.00729	3.772638763	0.068074055	0.067	0.22536945	0.377716608	0.603086058	0.000247685	0.348729422
3/20/05 12:00	30.8	30.8	28.7	0.586	58.57	799.9833	0.3599925	170.2	0	0.53333	35.556	2.42828	4.44	4.442	3.93675	0.25268	0.01736	4.424333755	0.045522596	0.067	0.30959355	0.262111421	0.571704971	0.000235436	0.306397523
3/20/05 15:00	26	31.6	26	0.561	56.1	376.45	0.1694025	253.6	0	0	0	2.43961	3.36	4.648	3.36144	0.19826	0.01758	3.343858341	0.083992923	0.067	0.14568615	0.453788665	0.599474815	0.000245725	0.018947925
3/20/05 18:00	22.5	24.4	22.5	0.908	90.82	0	0	354.4	0	0	0	2.44788	2.73	3.056	2.72559	0.16512	0.00265	2.722932751	0.108981642	0.067	0	0.56172433	0.56172433	0.000229474	0.003460159
3/20/05 21:00	22.1	22.5	22.1	0.995	99.53	0	0	354.4	0	0	0	2.44882	2.66	2.726	2.66009	0.16165	0.00013	2.659963669	0.111668469	0.067	0	0.572465004	0.572465004	0.000233772	0.000324143
3/21/05 0:00	21.3	22.5	21.3	1	100	0	0	94.2	0	0	0	2.45071	2.53	2.726	2.5332	0.15489	0	2.533204981	0.117175366	0.067	0	0.594212941	0.594212941	0.000242466	0.000169254
3/21/05 3:00	21.3	21.3	21	1	100	0	0	128.4	0	0	0	2.45071	2.53	2.533	2.48701	0.15489	0	2.533204981	0.117175366	0.067	0	0.594212941	0.594212941	0.000242466	0.000169254
3/21/05 6:00	26.4	26.4	21.3	0.984	98.43	226.4667	0.10191	101.2	0	0.53333	35.556	2.43867	3.44	3.442	2.5332	0.20238	0.00047	3.441278397	0.080290438	0.067	0.0876426	0.436109608	0.523752208	0.00021477	0.010014251
3/21/05 9:00	30.4	30.4	27.2	0.701	70.08	667.65	0.3004425	226.9	0	1.6	106.67	2.42923	4.34	4.341	3.60739	0.24771	0.01189	4.329500589	0.048695672	0.067	0.25838055	0.278908675	0.537289225	0.000221177	0.618035477
3/21/05 12:00	31.2	31.6	30.8	0.505	50.47	916.6667	0.4125	137.1	0	2.13333	142.22	2.42734	4.54	4.648	4.44169	0.25773	0.02251	4.521486586	0.042306975	0.067	0.35475	0.244881039	0.599631039	0.000247032	1.506117767
3/21/05 15:00	27.6	30.4	27.6	0.515	51.47	213.7333	0.09618	66.33	0	0.26667	17.778	2.43584	3.69	4.341	3.69278	0.21518	0.0195	3.673285701	0.071678551	0.067	0.0827148	0.395608067	0.478322867	0.000196369	0.205174411
3/21/05 18:00	22.9	26.4	22.9	0.863	86.25	2.933333	0.00132	77.6	1.78	0.26667	17.778	2.44693	2.79	3.442	2.79249	0.16865	0.00429	2.788203729	0.106229187	0.067	0.0011352	0.550506027	0.551641227	0.000225442	0.055215949
3/21/05 21:00	22.5	22.9	22.5	0.943	94.25	0	0	81.35	0	0	0	2.44788	2.73	2.792	2.72559	0.16512	0.00159	2.724001159	0.108936323	0.067	0	0.561490745	0.561490745	0.000229379	0.002133293
3/22/05 0:00	21.3	22.1	21.3	0.97	96.95	0	0	299.5	0	0	0	2.45071	2.53	2.66	2.5332	0.15489	0.00079	2.532413004	0.1172102	0.067	0	0.594389592	0.594389592	0.000242538	0.001207352
3/22/05 3:00	20.6	21.3	20.6	0.988	98.83	0	0	299.5	0.25	0	0	2.45236	2.43	2.533	2.42655	0.14918	0.00029	2.426262993	0.121929473	0.067	0	0.612463842	0.612463842	0.000249744	0.000563868
3/22/05 6:00	26	26.4	20.6	0.898	89.8	174.5	0.078525	234.6	0	0	0	2.43961	3.36	3.442	2.42655	0.19826	0.00299	3.358446996	0.083435074	0.067	0.0675315	0.450774775	0.518306275	0.000212454	0.003352965
3/22/05 9:00	28.7	28.7	26.8	0.64	63.95	535.3	0.240885	211.4	0	1.06667	71.111	2.43324	3.94	3.937	3.52372	0.22751	0.01345	3.923306	0.062697282	0.067	0.2071611	0.351128236	0.558289336	0.000229443	0.502662722

Date/Time	TMP (*C)	TMP max (*C)	TMP min (*C)	RH	RH (%)	solar radiation watt/m^2	St, solar radian MJ./m^2/3hr	WND (Deg)	Rainfall (mm)	Wind speed, km/hr	U2, Wind speed m/sec	Lamda MJ/kg	e* kPa	e*max, kPa	e*min, kPa	Delta kPa/*C	D bar, kPa	e*d, dew point vapor pressure, kPA	Epsilon, net emmisivity	Gamma, Psychrometric constant	Sn, net short wave radiation, MJ/m^2/3hr	Ln, Long wave radiation, MJ/m^2/3hr	Rn, net radiation, MJ/m^2/3hr	Rn, net radiation mm/3hr	Ep, net evaporation, mm/3hr
3/22/05 12:00	30.8	30.8	26	0.501	50.05	730.4	0.32868	120.2	2.03	0.8	53.333	2.42828	4.44	4.442	3.36144	0.252668	0.01949	4.42220278	0.045593522	0.067	0.2826648	0.2625198	0.5451846	0.000224515	0.507314967
3/22/05 15:00	28	32	28	0.52	52.02	355.9	0.160155	83.92	0	1.06667	71.111	2.43489	3.78	4.755	3.77993	0.21196	0.02048	3.759454182	0.068549633	0.067	0.1377333	0.380355406	0.518088706	0.000212777	0.787198833
3/22/05 18:00	22.5	26	22.5	0.869	86.85	2.933333	0.00132	112.3	9.4	0.53333	35.556	2.44788	2.73	3.361	2.72559	0.16512	0.004	2.721585386	0.109038805	0.067	0.0011352	0.562018968	0.563154168	0.000230058	0.099853636
3/22/05 21:00	22.5	22.5	22.1	0.948	94.8	0	0	353	0	0	0	2.44788	2.73	2.726	2.66009	0.16512	0.0014	2.724187331	0.108928427	0.067	0	0.561450048	0.561450048	0.000229362	0.001902085
3/23/05 0:00	22.5	22.5	22.5	0.882	88.22	0	0	136.4	3.04	0	0	2.44788	2.73	2.726	2.72559	0.16512	0.00321	2.722375956	0.109005263	0.067	0	0.56184608	0.56184608	0.000229524	0.004151648
3/23/05 3:00	22.5	22.5	22.5	0.904	90.42	0	0	28.1	0.25	0	0	2.44788	2.73	2.726	2.72559	0.16512	0.00261	2.722975585	0.108979825	0.067	0	0.561714964	0.561714964	0.00022947	0.003406963
3/23/05 6:00	23.3	23.3	22.5	0.978	97.75	29.41667	0.0132375	26.7	0	0	0	2.44599	2.86	2.861	2.72559	0.17225	0.00063	2.860192659	0.103230542	0.067	0.01138425	0.537862902	0.549247152	0.00022455	0.000914984
3/23/05 9:00	26.4	26.4	23.7	0.957	95.73	249.0167	0.1120575	78.75	0	0	0	2.43867	3.44	3.442	2.93061	0.20238	0.00136	3.440386999	0.080324077	0.067	0.09636945	0.436292321	0.532661771	0.000218423	0.001590884
3/23/05 12:00	28	28.3	26.8	0.698	69.8	342.15	0.1539675	209.5	0	0	0	2.43489	3.78	3.846	3.52372	0.2196	0.01113	3.768801391	0.068212386	0.067	0.13241205	0.378484153	0.510896203	0.000209823	0.011096585
3/23/05 15:00	25.2	26.4	25.2	0.667	66.68	146.0833	0.0657375	165.7	0	0.8	53.333	2.4415	3.21	3.442	3.20571	0.19023	0.01107	3.194638685	0.089770269	0.067	0.05653425	0.47983552	0.53636977	0.000219688	0.361872277
3/23/05 18:00	23.3	24.4	23.3	0.893	89.3	2.933333	0.00132	75.93	0	0.53333	35.556	2.44599	2.86	3.056	2.86082	0.17225	0.00317	2.857655463	0.103335581	0.067	0.0011352	0.538410188	0.539545388	0.000220584	0.076268602
3/23/05 21:00	20.6	22.1	20.6	0.998	99.83	0	0	104.3	4.83	1.86667	124.44	2.45236	2.43	2.66	2.42655	0.14918	4.2E-05	2.426509923	0.121918377	0.067	0	0.612408103	0.612408103	0.000249722	0.004055947

3/24/05 0:00	19.4	20.6	19.4	1	100	0	0	182.1	2.29	2.4	160	2.4552	2.25	2.427	2.25283	0.1398	0	2.252831002	0.129867928	0.067	0	0.641746916	0.641746916	0.000261383	0.000176697
3/24/05 3:00	19	19.4	19	1	100	0	0	143.5	9.65	1.06667	71.111	2.45614	2.2	2.253	2.19739	0.13678	0	2.197393324	0.132469498	0.067	0	0.651030491	0.651030491	0.000265062	0.000177914
3/24/05 6:00	19.4	19.4	19	0.982	98.17	26.46667	0.01191	108.3	6.85	0.53333	35.556	2.4552	2.25	2.253	2.19739	0.1398	0.00041	2.252423065	0.129886954	0.067	0.0102426	0.641840934	0.652083534	0.000265593	0.011885548
3/24/05 9:00	22.5	22.5	19.4	0.708	70.82	150.9833	0.0679425	25.53	1.52	0	0	2.44788	2.73	2.726	2.25283	0.16512	0.00726	2.718323264	0.109177263	0.067	0.05843055	0.562732621	0.621163171	0.000253756	0.009201704
3/24/05 12:00	25.2	25.2	23.3	0.494	49.38	264.7	0.119115	89.55	0	0	0	2.4415	3.21	3.206	2.86082	0.19023	0.01535	3.190358858	0.08993794	0.067	0.1024389	0.480731749	0.583170649	0.000238857	0.017127092
3/24/05 15:00	24	24.8	24	0.535	53.47	210.7833	0.0948525	215.6	0	0	0	2.44434	2.98	3.13	2.98392	0.1787	0.01423	2.969691882	0.098740884	0.067	0.08157315	0.51934604	0.60091919	0.000245841	0.016716445
3/24/05 18:00	20.6	23.3	20.6	0.861	86.12	1.966667	0.000885	125.2	0	0	0	2.45236	2.43	2.861	2.42655	0.14918	0.00367	2.422881994	0.122081467	0.067	0.0007611	0.613227322	0.613988422	0.000250366	0.005139698
3/24/05 21:00	20.6	20.6	20.2	0.96	96.03	0	0	125.2	0	0	0	2.45236	2.43	2.427	2.36739	0.14918	0.00095	2.425601514	0.121959202	0.067	0	0.612613172	0.612613172	0.000249805	0.001459068

Date/ Time	TMP (*C)	TMP max (*C)	TMP min (*C)	RH	RH (%)	solar radiation watt/ m^2	St, solar radian MJ./m^2/3hr	WND (Deg)	Rainfall (mm)	Wind speed, km/hr	U2, Wind speed m/sec	Lamda MJ/kg	e* kPa	e*max, kPa	e*min, kPa	Delta kPa/ *C	Dbar, kPa	e*d, dew point vapor pressure, kPA	Epsilon, net emmisivity	Gamma, Psychrometric constant	Sn, net shortwave radiation, MJ/m^2/3hr	Ln, Long wave radiation, MJ/m^2/3hr	Rn, net radiation, MJ/m^2/3hr	Rn, net radiation mm/3hr	Ep, net evaporation, mm/3hr
3/25/05 0:00	19.8	21	19.8	0.992	99.23	0	0	125.2	0	0	0	2.45425	2.31	2.487	2.30949	0.14287	0.00018	2.309304384	0.127250462	0.067	0	0.632258156	0.632258156	0.000257617	0.000433559
3/25/05 3:00	19.8	19.8	19.4	0.996	99.58	0	0	125.2	0	0	0	2.45425	2.31	2.309	2.25283	0.14287	9.5E-05	2.309393201	0.127246371	0.067	0	0.632237829	0.632237829	0.000257609	0.000308835
3/25/05 6:00	22.1	22.1	19.4	0.948	94.82	72.55	0.0326475	143.5	0	0	0	2.44882	2.66	2.66	2.25283	0.16165	0.00127	2.65881607	0.11171773	0.067	0.02807685	0.572717535	0.600794385	0.00024534	0.001783164
3/25/05 9:00	28	28	23.3	0.638	63.82	456.8667	0.20559	173.2	0	0	0	2.43489	3.78	3.78	2.86082	0.2196	0.01201	3.767916138	0.068244308	0.067	0.1768074	0.378661276	0.555468676	0.000228129	0.011980499
3/25/05 12:00	29.9	29.9	28.7	0.524	52.42	911.7833	0.4103025	183.5	0	0	0	2.43041	4.22	4.219	3.93675	0.24162	0.0194	4.199385003	0.053106385	0.067	0.35286015	0.302172599	0.655032749	0.000269516	0.017885263
3/25/05 15:00	26	29.1	26	0.668	66.8	203.9167	0.0917625	174.4	0	0	0	2.43961	3.36	4.029	3.36144	0.19826	0.01227	3.34917189	0.0837896	0.067	0.07891575	0.452690172	0.531605922	0.000217906	0.013256118
3/25/05 18:00	22.1	24.8	22.1	0.984	98.38	2.933333	0.00132	174.4	0	0	0	2.44882	2.66	3.13	2.66009	0.16165	0.00047	2.659621284	0.111683165	0.067	0.0011352	0.572540341	0.573675541	0.000234266	0.00075735
3/25/05 21:00	22.1	22.1	21.3	1	100	0	0	174.4	0	0	0	2.44882	2.66	2.66	2.5332	0.16165	0	2.660089335	0.111663076	0.067	0	0.572437354	0.572437354	0.00023376	0.000165263

Date/ Time	TMP (*C)	TMP max (*C)	TMP min (*C)	RH	RH (%)	solar radiation watt/ m^2	St, solar radian MJ./m^ 2/3hr	WND (Deg)	Rainfall (mm)	Wind speed, km/ hr	U2, Wind speed m/sec	Lamda MJ/ kg	e* kPa	e*max, kPa	e*min, kPa	Delta kPa/ *C	Dbar, kPa	e*d, dew point vapor pressure, kPA	Epsilon, net emmisivity	Gamma, Psychrometric constant	Sn, net shortwave radiation, MJ/m^ 2/3hr	Ln, Long wave radiation, MJ/m^ 2/3hr	Rn, net radiation, MJ/m^ 2/3hr	Rn, net radiation mm/3hr	Ep, net evaporation, mm/3hr
3/26/05 0:00	22.5	22.5	22.1	1	100	0	0	174.4	0	0	0	2.44788	2.73	2.726	2.66009	0.16512	0	2.725587607	0.108869048	0.067	0	0.561143987	0.561143987	0.000229237	0.000163069
3/26/05 3:00	22.1	22.5	22.1	0.998	99.83	0	0	174.4	0	0	0	2.44882	2.66	2.726	2.66009	0.16165	4.5E-05	2.660044454	0.111665002	0.067	0	0.572447229	0.572447229	0.000233764	0.000222005
3/26/05 6:00	24.4	24.4	22.1	1	100	82.35	0.0370575	178.2	0	0	0	2.44339	3.06	3.056	2.66009	0.18248	0	3.056312653	0.095247619	0.067	0.03186945	0.503675037	0.535544487	0.000219181	0.000160317
3/26/05 9:00	29.5	29.9	27.6	0.999	99.92	620.5667	0.279255	216.6	0	0	0	2.43135	4.12	4.219	3.69278	0.23684	3.3E-05	4.122852505	0.05573268	0.067	0.2401593	0.315445404	0.555604704	0.000228517	0.00020863
3/26/05 12:00	33.2	33.2	29.9	0.996	99.58	764.7167	0.3441225	172.8	0	0	0	2.42261	5.09	5.087	4.21879	0.28427	0.00019	5.086659274	0.024249273	0.067	0.29594535	0.144084862	0.440030212	0.000181634	0.000302741
3/26/05 15:00	28.7	32	28.7	0.962	96.15	287.25	0.1292625	120.9	0	0	0	2.43324	3.94	4.755	3.93675	0.22751	0.00167	3.935080384	0.062281481	0.067	0.11116575	0.3487996	0.45996535	0.000189034	0.001744333
3/26/05 18:00	23.3	25.6	23.3	0.991	99.07	1.966667	0.000885	49.2	0	0	0	2.44599	2.86	3.283	2.86082	0.17225	0.00029	2.860534429	0.103216397	0.067	0.0007611	0.537789199	0.538550299	0.000220177	0.000502172
3/26/05 21:00	22.1	22.9	22.1	1	100	0	0	49.2	0	0	0	2.44882	2.66	2.792	2.66009	0.16165	0	2.660089335	0.111663076	0.067	0	0.572437354	0.572437354	0.00023376	0.000165263
3/27/05 0:00	21.7	22.1	21.7	1	100	0	0	49.2	0	0	0	2.44977	2.6	2.66	2.59597	0.15824	0	2.595969994	0.114431802	0.067	0	0.583459102	0.583459102	0.000238169	0.000167323
3/27/05 3:00	21.3	21.7	21.3	1	100	0	0	49.2	0	0	0	2.45071	2.53	2.596	2.5332	0.15489	0	2.533204981	0.117175366	0.067	0	0.594212941	0.594212941	0.000242466	0.000169254
3/27/05 6:00	25.2	25.2	21.3	1	100	109.8167	0.0494175	49.67	0	0	0	2.4415	3.21	3.206	2.5332	0.19023	0	3.205712243	0.089336959	0.067	0.04249905	0.477519414	0.520018464	0.000212991	0.000157514
3/27/05 9:00	32	32	28.7	0.94	93.95	756.85	0.3405825	145.6	0	0.53333	35.556	2.42545	4.75	4.755	3.93675	0.26809	0.00263	4.752146209	0.034808149	0.067	0.29290095	0.203602751	0.496503701	0.000204706	0.044470795
3/27/05 12:00	34.1	34.1	31.2	0.852	85.15	855.8833	0.3851475	128	0	1.6	106.67	2.42049	5.35	5.349	4.544	0.29694	0.00735	5.341603372	0.016433274	0.067	0.33122685	0.098795902	0.430022752	0.000177659	0.332331484
3/27/05 15:00	30.4	34.1	30.4	0.868	86.77	439.2167	0.1976475	125.9	0	0.53333	35.556	2.42923	4.34	5.349	4.34139	0.24771	0.00641	4.334978863	0.048511431	0.067	0.16997685	0.277853421	0.447830271	0.000184351	0.115025135
3/27/05 18:00	24	26.8	24	0.963	96.28	1.966667	0.000885	129.2	0	0	0	2.44434	2.98	3.524	2.98392	0.1787	0.00121	2.982708141	0.098212739	0.067	0.0007611	0.516568161	0.517329261	0.000211644	0.001559817
3/27/05 21:00	23.3	24	23.3	1	100	0	0	129.4	0	0	0	2.44599	2.86	2.984	2.86082	0.17225	0	2.86082113	0.103204531	0.067	0	0.537727375	0.537727375	0.00021984	0.000158276
3/28/05 0:00	22.9	23.7	22.9	1	100	0	0	199.7	0	0	0	2.44693	2.79	2.931	2.79249	0.16865	0	2.792489766	0.106049579	0.067	0	0.549575255	0.549575255	0.000224598	0.000160741

Date/ Time	TMP (*C)	TMP max (*C)	TMP min (*C)	RH	RH (%)	solar radiation watt/ m^2	St, solar radian MJ./m^ 2/3hr	WND (Deg)	Rainfall (mm)	Wind speed, km/ hr	U2, Wind speed m/sec	Lamda MJ/ kg	e* kPa	e*max, kPa	e*min, kPa	Delta kPa/ *C	Dbar, kPa	e*d, dew point vapor pressure, kPA	Epsilon, net emmisivity	Gamma, Psychrometric constant	Sn, net shortwave radiation, MJ/m^ 2/3hr	Ln, Long wave radiation, MJ/m^ 2/3hr	Rn, net radiation, MJ/m^ 2/3hr	Rn, net radiation mm/3hr	Ep, net evaporation, mm/3hr
3/28/05 3:00	22.1	22.9	22.1	1	100	0	0	199.7	0	0	0	2.44882	2.66	2.792	2.66009	0.16165	0	2.660089335	0.111663076	0.067	0	0.572437354	0.572437354	0.00023376	0.000165263
3/28/05 6:00	24.4	24.4	22.1	1	100	39.21667	0.0176475	225.5	0	0	0	2.44339	3.06	3.056	2.66009	0.18248	0	3.056312653	0.095247619	0.067	0.01517685	0.503675037	0.518851887	0.000212349	0.00015532
3/28/05 9:00	28	28	25.2	0.836	83.58	324.5333	0.14604	189.2	0	0.53333	35.556	2.43489	3.78	3.78	3.20571	0.2196	0.00573	3.774196316	0.068017927	0.067	0.1255944	0.377405179	0.502999579	0.00020658	0.113174349
3/28/05 12:00	24.8	28.7	24.8	0.688	68.75	146.0667	0.06573	157.3	0.5	0.8	53.333	2.44245	3.13	3.937	3.13024	0.18632	0.01104	3.119193049	0.092742677	0.067	0.0565278	0.49307079	0.54959859	0.00022502	0.367069933
3/28/05 15:00	24	24	23.7	0.651	65.08	22.56667	0.010155	147.9	1.01	0	0	2.44434	2.98	2.984	2.93061	0.1787	0.01033	2.973591703	0.098582525	0.067	0.0087333	0.518513118	0.527246418	0.000215701	0.012160876
3/28/05 18:00	22.9	24	22.9	0.926	92.55	2.933333	0.00132	64.7	0	0	0	2.44693	2.79	2.984	2.79249	0.16865	0.00215	2.790338055	0.10613973	0.067	0.0011352	0.55004244	0.55117764	0.000225252	0.002786269
3/28/05 21:00	22.9	22.9	22.9	0.998	99.83	0	0	67.5	0	0	0	2.44693	2.79	2.792	2.79249	0.16865	4.7E-05	2.792443225	0.106051529	0.067	0	0.549585359	0.549585359	0.000224602	0.000217524
3/29/05 0:00	22.5	22.9	22.5	1	100	0	0	29.27	0	0	0	2.44788	2.73	2.792	2.72559	0.16512	0	2.725587607	0.108869048	0.067	0	0.561143987	0.561143987	0.000229237	0.000163069
3/29/05 3:00	22.1	22.5	21.7	1	100	0	0	32.3	0	0	0	2.44882	2.66	2.726	2.59597	0.16165	0	2.660089335	0.111663076	0.067	0	0.572437354	0.572437354	0.00023376	0.000165263
3/29/05 6:00	24.8	24.8	22.5	0.999	99.92	81.38333	0.0366225	58.55	0	0	0	2.44245	3.13	3.13	2.72559	0.18632	2.4E-05	3.13021082	0.092306375	0.067	0.03149535	0.490751168	0.522246518	0.000213821	0.00018467
3/29/05 9:00	28.7	28.7	26.4	0.923	92.3	512.7667	0.230745	196.6	0	1.06667	71.111	2.43324	3.94	3.937	3.44175	0.22751	0.00284	3.93391278	0.062322686	0.067	0.1984407	0.349030363	0.547471063	0.000224997	0.106321532
3/29/05 12:00	32.4	32.4	29.1	0.824	82.42	777.4333	0.349845	171.3	0	1.6	106.67	2.4245	4.86	4.863	4.02888	0.27339	0.00782	4.855493476	0.03150742	0.067	0.3008667	0.185263911	0.486130611	0.000200507	0.376554675
3/29/05 15:00	27.2	32.8	27.2	0.648	64.75	295.1	0.132795	194.5	0	0.53333	35.556	2.43678	3.61	4.974	3.60739	0.21084	0.01512	3.59226362	0.07465425	0.067	0.1142037	0.409844246	0.524047946	0.000215057	0.308175096
3/29/05 18:00	24	26	24	0.951	95.05	0.983333	0.0004425	143.5	0	0	0	2.44434	2.98	3.361	2.98392	0.1787	0.00157	2.982347001	0.098227377	0.067	0.00038055	0.516645153	0.517025703	0.00021152	0.001979562
3/29/05 21:00	22.9	23.7	22.9	1	100	0	0	43.6	0	0	0	2.44693	2.79	2.931	2.79249	0.16865	0	2.792489766	0.106049579	0.067	0	0.549575255	0.549575255	0.000224598	0.000160741
3/30/05 0:00	22.5	22.9	22.5	1	100	0	0	43.6	0	0	0	2.44788	2.73	2.792	2.72559	0.16512	0	2.725587607	0.108869048	0.067	0	0.561143987	0.561143987	0.000229237	0.000163069
3/30/05 3:00	22.9	22.9	22.5	1	100	0	0	43.6	0.25	0	0	2.44693	2.79	2.792	2.72559	0.16865	0	2.792489766	0.106049579	0.067	0	0.549575255	0.549575255	0.000224598	0.000160741

Date/Time	TMP (*C)	TMP max (*C)	TMP min (*C)	RH	RH (%)	solar radiation watt/m^2	St, solar radian MJ./m^2/3hr	WND (Deg)	Rainfall (mm)	Wind speed, km/hr	U2, Wind speed m/sec	Lamda MJ/kg	e* kPa	e*max, kPa	e*min, kPa	Delta kPa/*C	Dbar, kPa	e*d, dew point vapor pressure, kPA	Epsilon, net emmisivity	Gamma, Psychrometric constant	Sn, net shortwave radiation, MJ/m^2/3hr	Ln, Long wave radiation, MJ/m^2/3hr	Rn, net radiation, MJ/m^2/3hr	Rn, net radiation mm/3hr	Ep, net evaporation, mm/3hr
3/30/05 6:00	27.6	27.6	22.9	0.987	98.72	122.55	0.0551475	122.4	0.51	0	0	2.43584	3.69	3.693	2.79249	0.21518	0.00042	3.692365822	0.070982584	0.067	0.04742685	0.391766886	0.439193736	0.000180305	0.000553127
3/30/05 9:00	29.5	29.9	26.4	0.769	76.92	700.9833	0.3154425	161.7	0	1.33333	88.889	2.43135	4.12	4.219	3.44175	0.23684	0.00884	4.114043935	0.056036514	0.067	0.27128055	0.317165097	0.588445647	0.000242024	0.398171424
3/30/05 12:00	26.4	30.4	23.7	0.645	64.52	557.8333	0.251025	108	15.24	1.33333	88.889	2.43867	3.44	4.341	2.93061	0.20238	0.0129	3.428844698	0.080760042	0.067	0.2158815	0.43866033	0.65454183	0.000268401	0.658892473
3/30/05 15:00	29.9	30.4	28.3	0.983	98.28	406.8667	0.18309	135.5	0	0	0	2.43041	4.22	4.341	3.84646	0.24162	0.0007	4.218085606	0.052468301	0.067	0.1574574	0.298541932	0.455999332	0.000187623	0.000787052
3/30/05 18:00	24.8	26.8	24.4	1	100	4.9	0.002205	219.6	0	0	0	2.44245	3.13	3.524	3.05631	0.18632	0	3.130235219	0.092305409	0.067	0.0018963	0.490746035	0.492642335	0.0002017	0.000148353
3/30/05 21:00	24	24.8	24	1	100	0	0	192.2	0	0	0	2.44434	2.98	3.13	2.98392	0.1787	0	2.983917477	0.098163728	0.067	0	0.516310378	0.516310378	0.000211227	0.000153628
3/31/05 0:00	24	24.4	24	1	100	0	0	303.3	0	0	0	2.44434	2.98	3.056	2.98392	0.1787	0	2.983917477	0.098163728	0.067	0	0.516310378	0.516310378	0.000211227	0.000153628
3/31/05 3:00	23.3	24	23.3	1	100	0	0	114.4	0	0.26667	17.778	2.44599	2.86	2.984	2.86082	0.17225	0	2.86082113	0.103204531	0.067	0	0.537727375	0.537727375	0.00021984	0.000158276
3/31/05 6:00	21.3	22.1	21.3	0.972	97.18	3.933333	0.00177	162.9	12.96	1.06667	71.111	2.45071	2.53	2.66	2.5332	0.15489	0.00073	2.532473592	0.117207535	0.067	0.0015222	0.594376076	0.595898276	0.000243153	0.037667274
3/31/05 9:00	22.1	22.1	21.7	0.697	69.72	27.45	0.0123525	128	10.91	0	0	2.44882	2.66	2.66	2.59597	0.16165	0.00796	2.652130785	0.112004905	0.067	0.01062315	0.574189731	0.584812881	0.000238814	0.010230367
3/31/05 12:00	27.6	27.6	22.5	0.559	55.93	441.1667	0.198525	198.8	2.29	0.8	53.333	2.43584	3.69	3.693	2.72559	0.21518	0.01414	3.678640153	0.07148306	0.067	0.1707315	0.394529112	0.565260612	0.00023206	0.418077811
3/31/05 15:00	24.8	27.2	24.8	0.526	52.57	230.3833	0.1036725	195.2	0	1.06667	71.111	2.44245	3.13	3.607	3.13024	0.18632	0.01598	3.114255822	0.092938441	0.067	0.08915835	0.494111577	0.583269927	0.000238806	0.702135674

Weather data for dry period

Date/Time	TMP (*C)	TMPmax (*C)	TMPmin (*C))	RH	RH (%)	solar radiation watt/m^2	St, solar radian MJ./m^2/3hr	WND Wind Dir (Deg)	Rainfall (mm)	Wind speed, km/hr	U2, Wind speed m/sec	Lamda (latent heat), MJ/kg	e*, vapor pressure, kPa	e*max, kPa	e*min, kPa	Delta, Gradient, kPa/*C	Dbar, kPa	e*d, dew point vapor pressure, kPA	Epsilon, net emmisivity	Gamma, Psychrometric constant	Sn, net short wave radiation, MJ/m^2/3hr	Ln, Long wave radiation, MJ/m^2/3hr	Rn, net radiation, MJ/m^2/3hr	Rn, net radiation mm/3hr	Ep, net evaporation, mm/3hr
9/5/04 0:00	21.6333333	21.7	21.3	1	100	0	0	135	0	0	0	2.4499237	2.585415767	2.595969994	2.533204981	0.157678173	0	2.585415767	0.114890806	0.067	0	0.585269913	0.58526991	0.000238893	0.000167654
9/5/04 3:00	21.1	21.3	21	1	100	0	0	135	0	0	0	2.4511829	2.502322755	2.533204981	2.487005397	0.153241155	0	2.502322755	0.118537755	0.067	0	0.599490544	0.59949054	0.000244572	0.00017017
9/5/04 6:00	22.3666667	24.8	21	0.974666667	97.4667	125.4833	0.056468	152.33	0	0.266667	17.777778	2.4481923	2.703600102	3.130235219	2.487005397	0.163955941	0.000711517	2.702888585	0.109833503	0.067	0.04856205	0.565094711	0.61365676	0.000250657	0.009536685
9/5/04 9:00	29.7166667	32.4	26.8	0.6845	68.45	730.3833	0.328673	194.32	0	0.8	53.333333	2.4308395	4.174594761	4.863311198	3.523719593	0.23941684	0.013230541	4.16136422	0.054408091	0.067	0.28265835	0.308830904	0.59148925	0.000243327	0.359331903
9/5/04 12:00	33.2166667	34.1	32.4	0.539833333	53.9833	960.8	0.43236	175.32	0	1.6	106.666667	2.4225754 5	5.091603533	5.348948887	4.863311198	0.284500894	0.023496708	5.068106825	0.024825614	0.067	0.3718296	0.147541475	0.51937107	0.000214388	1.097637355
9/5/04 15:00	33.3666667	34.1	31.6	0.509	50.9	472.5333	0.21264	195.93	0	0.533333	35.555556	2.4222213	5.134530626	5.348948887	4.64834968	0.286581605	0.024543368	5.109987258	0.023526067	0.067	0.1828704	0.140092101	0.3229625	0.000133333	0.393185363
9/5/04 18:00	25.5333333	28	24.4	0.872166667	87.2167	4.9	0.002205	184.18	0	0	0	2.4407158	3.269816985	3.779930364	3.056312653	0.193543981	0.004369499	3.265447486	0.087012311	0.067	0.0018963	0.467175474	0.46907177	0.000192186	0.004898952
9/5/04 21:00	23.3666667	23.7	22.5	0.913166667	91.3167	0	0	91.183	0	0	0	2.4458313	2.872350438	2.930607375	2.725587607	0.172855634	0.002455731	2.869894707	0.10282931	0.067	0	0.536254384	0.53625438	0.000219252	0.003092961
9/6/04 0:00	22.4333333	22.9	21.7	0.928	92.8	0	0	169.45	0	0	0	2.4480349	2.714574414	2.792489766	2.595969994	0.164536966	0.001939846	2.712634569	0.109418913	0.067	0	0.563469729	0.56346973	0.000230172	0.002579724
9/6/04 3:00	21.3	21.3	21.3	0.995333333	99.5333	0	0	326.3	0	0	0	2.4507107	2.533204981	2.533204981	2.533204981	0.154892505	0.000118216	2.533086765	0.117180565	0.067	0	0.594239307	0.59423931	0.000242476	0.000324208
9/6/04 6:00	22.5166667	23.7	21	0.9575	95.75	78.41667	0.035288	85.517	0	0.533333	35.555556	2.4478381 5	2.728346993	2.930607375	2.487005397	0.1652669	0.001151243	2.727195751	0.108800872	0.067	0.03034725	0.560919033	0.59126628	0.000241546	0.028826515
9/6/04 9:00	28.95	30.8	26	0.6705	67.05	746.1	0.335745	206.73	0	1.6	106.666667	2.4326490 5	3.994117865	4.441691099	3.361439829	0.230387416	0.012855658	3.981262207	0.060656593	0.067	0.2887407	0.340826218	0.62956692	0.000258799	0.707507091

Date/Time	TMP (*C)	TMPmax (*C)	TMPmin (*C))	RH	RH (%)	solar radiation watt/m^2	St, solar radian MJ./m^2/3hr	WND Wind Dir (Deg)	Rainfall (mm)	Wind speed, km/hr	U2, Wind speed m/sec	Lamda (latent heat), MJ/kg	e*, vapor pressure, kPa	e*max, kPa	e*min, kPa	Delta, Gradient, kPa/*C	Dbar, kPa	e*d, dew point vapor pressure, kPA	Epsilon, net emmisivity	Gamma, Psychrometric constant	Sn, net short wave radiation, MJ/m^2/3hr	Ln, Long wave radiation, MJ/m^2/3hr	Rn, net radiation, MJ/m^2/3hr	Rn, net radiation mm/3hr	Ep, net evaporation, mm/3hr
9/6/04 12:00	31.733333	32.4	30.4	0.557	55.7	786.2833	0.353828	262.27	0	1.866667	124.444444	2.4260776	4.683592601	4.863311198	4.341390638	0.264596464	0.020388415	4.663204186	0.037677652	0.067	0.30429165	0.219618048	0.5239097	0.000215949	1.171653706
9/6/04 15:00	31.316667	32.8	29.9	0.56566667	56.5667	450.9833	0.202943	160.55	0	1.6	106.666667	2.42706135	4.574222631	4.973991993	4.218788397	0.259219995	0.019963655	4.554258976	0.041230062	0.067	0.17453055	0.239013729	0.41354428	0.000170389	1.001522822
9/6/04 18:00	24.433333	28.3	22.1	0.77383333	77.3833	2.93333	0.00132	201.33	0	1.066667	71.111111	2.4433129	3.062414158	3.846461372	2.660089335	0.182794432	0.007357824	3.055056334	0.095297928	0.067	0.0011352	0.504166891	0.50530209	0.00020681	0.328512604
9/6/04 21:00	21.1	21.7	20.6	0.9775	97.75	0	0	75.467	0	0	0	2.4511829	2.502322755	2.595969994	2.426552312	0.153241155	0.000565034	2.501757722	0.11856276	0.067	0	0.599617003	0.599617	0.000244624	0.000917565
9/7/04 0:00	20.6	21	20.2	0.99666667	99.6667	0	0	192.18	0	0	0	2.4523634	2.426552312	2.487005397	2.367387698	0.149177761	8.09066E-05	2.426471406	0.121920107	0.067	0	0.612416797	0.6124168	0.000249725	0.000281816
9/7/04 3:00	19.866667	20.2	19.4	1	100	0	0	284.3	0	0	0	2.4540948	2.319051277	2.367387698	2.252831002	0.143383148	0	2.319051277	0.126801958	0.067	0	0.630603317	0.63060332	0.00025696	0.000175127
9/7/04 6:00	20.933333	24.8	19	0.94716667	94.7167	124.5	0.056025	309.85	0	0.266667	17.777778	2.4515764	2.476839407	3.130235219	2.197393324	0.151876422	0.001407382	2.475432025	0.11973092	0.067	0.0481815	0.604154325	0.65233583	0.000266088	0.019933876
9/7/04 9:00	28.9	30.8	26.8	0.63533333	63.5333	771.55	0.347198	149.08	0	1.866667	124.444444	2.4327671	3.982587166	4.441691099	3.523719593	0.229808611	0.014523599	3.968063567	0.061120015	0.067	0.29858985	0.343202898	0.64179275	0.000263812	0.932027723
9/7/04 12:00	31.866667	32.4	31.2	0.51766667	51.7667	866.65	0.389993	97.25	0	2.666667	177.777778	2.4257628	4.719067414	4.863311198	4.543999587	0.266336531	0.022687298	4.696380117	0.036604136	0.067	0.33539355	0.213734081	0.54912763	0.000226373	1.84483432
9/7/04 15:00	32.4	32.8	31.6	0.495	49.5	357.8667	0.16104	183.52	0	0.8	53.333333	2.4245036	4.863311198	4.973991993	4.64834968	0.273392929	0.024296413	4.839014785	0.032031349	0.067	0.1384944	0.188344622	0.32683902	0.000134807	0.595052552
9/7/04 18:00	25.016667	27.6	23.7	0.845	84.5	3.916667	0.001763	68.9	0	0	0	2.4419365	3.170923907	3.69278196	2.930607375	0.188430483	0.005133127	3.165790781	0.090902631	0.067	0.00151575	0.484695168	0.48621092	0.000199109	0.005858461
9/7/04 21:00	22.566667	23.3	22.1	0.96533333	96.5333	0	0	68.9	0	0	0	2.4477201	2.736639795	2.86082113	2.660089335	0.165704231	0.000956958	2.735682837	0.108441404	0.067	0	0.55944401	0.55944401	0.000228557	0.001347624
9/8/04 0:00	21.45	22.1	21	0.99616667	99.6167	0	0	68.9	0	0	0	2.45035655	2.556584698	2.660089335	2.487005397	0.156140864	9.86526E-05	2.556486045	0.116153788	0.067	0	0.59023336	0.59023336	0.000240877	0.000296979
9/8/04 3:00	20.8	21	20.6	1	100	0	0	68.9	0	0	0	2.4518912	2.456616326	2.487005397	2.426552312	0.150792046	0	2.456616326	0.120569647	0.067	0	0.607284087	0.60728409	0.00024768	0.000171485

Date/Time	TMP (*C)	TMPmax (*C)	TMPmin (*C))	RH	RH (%)	solar radiation watt/m^2	St, solar radian MJ./m^2/3hr	WND Wind Dir (Deg)	Rainfall (mm)	Wind speed, km/hr	U2, Wind speed m/sec	Lamda (latent heat), MJ/kg	e*, vapor pressure, kPa	e*max, kPa	e*min, kPa	Delta, Gradient, kPa/*C	Dbar, kPa	e*d, dew point vapor pressure, kPA	Epsilon, net emmisivity	Gamma, Psychrometric constant	Sn, net short wave radiation, MJ/m^2/3hr	Ln, Long wave radiation, MJ/m^2/3hr	Rn, net radiation, MJ/m^2/3hr	Rn, net radiation mm/3hr	Ep, net evaporation, mm/3hr
9/8/04 6:00	22.4	26.4	20.2	0.950666667	95.0667	123.5333	0.05559	93.75	0	0.266667	17.777778	2.4481136	2.709082405	3.441746435	2.367387698	0.164246236	0.00143292	2.707649485	0.109630883	0.067	0.0478074	0.564306722	0.61211412	0.000250035	0.018997089
9/8/04 9:00	30.566667	32	28.7	0.6155	61.55	778.4333	0.350295	172.48	0	1.333333	88.888889	2.4288321	4.382940601	4.754775396	3.936753503	0.249772919	0.016709464	4.366231137	0.0474626	0.067	0.3012537	0.272443581	0.57369728	0.000236203	0.721575745
9/8/04 12:00	32.95	34.1	31.6	0.5205	52.05	882.3667	0.397065	181.42	0	1.6	106.666667	2.42320505	5.0160575	5.348948887	4.64834968	0.280833047	0.023968523	4.992088977	0.027198235	0.067	0.3414759	0.16108028	0.50255618	0.000207393	1.130757473
9/8/04 15:00	29.766667	34.1	24.4	0.627666667	62.7667	330.3833	0.148673	171.08	3.56	1.066667	71.111111	2.4307209	4.186607456	5.348948887	3.056312653	0.240015883	0.015647795	4.170959661	0.054079016	0.067	0.12785835	0.307165732	0.43502408	0.000178969	0.560594727
9/8/04 18:00	23.083333	24.4	22.5	0.9735	97.35	4.9	0.002205	119.98	0	0	0	2.44650025	2.823629357	3.056312653	2.725587607	0.170293642	0.000766102	2.822863255	0.104780698	0.067	0.0018963	0.544345665	0.54624197	0.000223275	0.001087326
9/8/04 21:00	21.9	22.5	21.3	0.999166667	99.9167	0	0	114.37	0	0	0	2.4492941	2.627858844	2.725587607	2.533204981	0.159937075	2.19116E-05	2.627836933	0.113051539	0.067	0	0.577986785	0.57798679	0.000235981	0.000194262
9/9/04 0:00	21.266667	21.7	21	1	100	0	0	113.9	0	0	0	2.4507894	2.528034934	2.595969994	2.487005397	0.15461624	0	2.528034934	0.117402865	0.067	0	0.595097116	0.59509712	0.000242819	0.000169409
9/9/04 3:00	21.5	21.7	21.3	0.999166667	99.9167	0	0	132.18	0	0	0	2.4502385	2.564419721	2.595969994	2.533204981	0.156558869	2.13716E-05	2.564398349	0.115807655	0.067	0	0.58887403	0.58887403	0.000240333	0.000196065
9/9/04 6:00	21.983333	23.3	21	0.969	96.9	54.9	0.024705	187.52	0.25	0	0	2.44909735	2.64124652	2.86082113	2.487005397	0.160648563	0.000828913	2.640417607	0.112508934	0.067	0.0212463	0.575862677	0.59710898	0.000243808	0.001225499
9/9/04 9:00	25.666667	27.2	24.4	0.816	81.6	352.95	0.158828	174.6	0	1.066667	71.111111	2.440401	3.295770069	3.607388303	3.056312653	0.194882397	0.006130605	3.289639464	0.086076914	0.067	0.13659165	0.462978902	0.59957055	0.000245685	0.259738165
9/9/04 12:00	27.1	28.7	25.2	0.749666667	74.9667	654.8833	0.294698	149.77	0	2.133333	142.222222	2.4370169	3.586310566	3.936753503	3.205712243	0.209769385	0.008939986	3.57737058	0.075204865	0.067	0.25343985	0.412317585	0.66575744	0.000273185	0.7041166
9/9/04 15:00	26.85	28.3	26	0.722666667	72.2667	311.7667	0.140295	165	0	1.066667	71.111111	2.43760715	3.534084857	3.846461372	3.361439829	0.207106082	0.009994956	3.524089901	0.077184167	0.067	0.1206537	0.421761893	0.54241559	0.00022252	0.402889845

Date/Time	TMP (*C)	TMPmax (*C)	TMPmin (*C))	RH	RH (%)	solar radiation watt/m^2	St, solar radian MJ./m^2/3hr	WND Wind Dir (Deg)	Rainfall (mm)	Wind speed, km/hr	U2, Wind speed m/sec	Lamda (latent heat), MJ/kg	e*, vapor pressure, kPa	e*max, kPa	e*min, kPa	Delta, Gradient, kPa/*C	Dbar, kPa	e*d, dew point vapor pressure, kPA	Epsilon, net emmisivity	Gamma, Psychrometric constant	Sn, net short wave radiation, MJ/m^2/3hr	Ln, Long wave radiation, MJ/m^2/3hr	Rn, net radiation, MJ/m^2/3hr	Rn, net radiation mm/3 hr	Ep, net evaporation, mm/3 hr
9/9/04 18:00	23.4	26	21.3	0.85	85	7.85	0.003533	251	0	0	0	2.4457526	2.878130285	3.361439829	2.533204981	0.173159171	0.004420984	2.873709301	0.102671741	0.067	0.00303795	0.535673431	0.53871138	0.000220264	0.0054348
9/9/04 21:00	20.5166667	21.3	19.8	0.965	96.5	0	0	357.2	0	0	0	2.45256015	2.414120876	2.533204981	2.309488249	0.148509469	0.000847471	2.413273404	0.122514003	0.067	0	0.614702085	0.61470209	0.000250637	0.001323971
9/10/04 0:00	19.8666667	20.6	19.4	0.999166667	99.9167	0	0	357.2	0	0	0	2.4540948	2.319051277	2.426552312	2.252831002	0.143383148	1.94974E-05	2.31903178	0.126802854	0.067	0	0.630607774	0.63060777	0.000256961	0.000202422
9/10/04 3:00	19.4	19.8	19	1	100	0	0	357.2	0	0	0	2.4551966	2.252831002	2.309488249	2.197393324	0.139795756	0	2.252831002	0.129867928	0.067	0	0.641746916	0.64174692	0.000261383	0.000176697
9/10/04 6:00	20.25	21.3	19.4	0.999166667	99.9167	65.68333	0.029558	185.18	0	0.266667	17.777778	2.45318975	2.374713611	2.533204981	2.252831002	0.146387921	1.99418E-05	2.374693669	0.124259425	0.067	0.02541945	0.62119848	0.64661793	0.000263583	0.000469576
9/10/04 9:00	25.2166667	27.6	22.5	0.748666667	74.8667	553.9333	0.24927	128.7	0	1.6	106.666667	2.44146345	3.208891257	3.69278196	2.725587607	0.190396232	0.008065751	3.200825506	0.089528086	0.067	0.2143722	0.478647935	0.69302013	0.000283854	0.517861505
9/10/04 12:00	28.9	29.5	28.3	0.611333333	61.1333	709.8	0.31941	170.17	0	1.6	106.666667	2.4327671	3.982587166	4.122885469	3.846461372	0.229808611	0.015487097	3.967100068	0.061153875	0.067	0.2746926	0.343393029	0.61808563	0.000254067	0.853985511
9/10/04 15:00	28.3333333	29.1	26.8	0.649	64.9	291.1667	0.131025	133.58	0	0	0	2.434105	3.853916242	4.028884423	3.523719593	0.223333688	0.01325482	3.840661422	0.065633523	0.067	0.1126815	0.365789825	0.47847132	0.00019657	0.01300144
9/10/04 18:00	22.55	24.8	21.3	0.939333333	93.9333	3.916667	0.001763	118.1	0	0	0	2.44775945	2.733873086	3.130235219	2.533204981	0.165557941	0.00171791	2.732155176	0.108590749	0.067	0.00151575	0.560088213	0.56160396	0.000229436	0.002291971
9/10/04 21:00	20.4666667	21	20.2	0.999166667	99.9167	0	0	118.1	0	0	0	2.4526782	2.406688768	2.487005397	2.367387698	0.14810971	2.02266E-05	2.406668542	0.122811825	0.067	0	0.615776897	0.6157769	0.000251063	0.000200405
9/11/04 0:00	20.0666667	21	19.8	1	100	0	0	118.1	0	0	0	2.4536226	2.347948448	2.487005397	2.309488249	0.144944277	0	2.347948448	0.125477764	0.067	0	0.625723081	0.62572308	0.00025502	0.000174403
9/11/04 3:00	20.5333333	20.6	20.2	1	100	0	0	118.1	0	0	0	2.4525208	2.416602699	2.426552312	2.367387698	0.148642924	0	2.416602699	0.122364036	0.067	0	0.614089001	0.614089	0.000250391	0.000172595
9/11/04 6:00	20.8333333	22.9	19.8	0.993666667	99.3667	76.48333	0.034418	58.8	0	0	0	2.4518125	2.461658518	2.792489766	2.309488249	0.151062525	0.000161563	2.461496955	0.120351781	0.067	0.02959905	0.606461702	0.63606075	0.000259425	0.000396029
9/11/04 9:00	25.5666667	28	22.9	0.839833333	83.9833	429.4333	0.193245	154.7	0	0.8	53.333333	2.44406371	3.276288496	3.779930364	2.792489766	0.193877857	0.005263413	3.271025083	0.086796344	0.067	0.1661907	0.46622396	0.63241466	0.000259119	0.169461696

Date/Time	TMP (*C)	TMPmax (*C)	TMPmin (*C))	RH	RH (%)	solar radiation watt/m^2	St, solar radian MJ./m^2/3hr	WND Wind Dir (Deg)	Rainfall (mm)	Wind speed, km/hr	U2, Wind speed m/sec	Lamda (latent heat), MJ/kg	e*, vapor pressure, kPa	e*max, kPa	e*min, kPa	Delta, Gradient, kPa/*C	Dbar, kPa	e*d, dew point vapor pressure, kPA	Epsilon, net emmisivity	Gamma, Psychrometric constant	Sn, net short wave radiation, MJ/m^2/3hr	Ln, Long wave radiation, MJ/m^2/3hr	Rn, net radiation, MJ/m^2/3hr	Rn, net radiation mm/3hr	Ep, net evaporation, mm/3hr
9/11/04 12:00	28.9833333	29.9	28	0.66533333	66.5333	489.2333	0.220155	207.88	0	1.6	106.666667	2.43257035	4.001821125	4.218788397	3.779930364	0.230773966	0.013384523	3.988436602	0.060405012	0.067	0.1893333	0.339562401	0.5288957	0.000217423	0.735594017
9/11/04 15:00	28.15	29.1	26.4	0.66333333	66.3333	307.8333	0.138525	117.88	0	1.333333	88.888889	2.43453785	3.813069562	4.028884423	3.441746435	0.221271958	0.012575562	3.800494	0.06707202	0.067	0.1191315	0.372898605	0.49203011	0.000202104	0.59762485
9/11/04 18:00	22.6166667	24.8	21.3	0.914166667	91.4167	4.9	0.002205	357.2	0	0	0	2.44760205	2.744954598	3.130235219	2.533204981	0.166143754	0.00243056	2.742524038	0.108152052	0.067	0.0018963	0.558328645	0.56022495	0.000228887	0.003165862
9/11/04 21:00	20.9666667	21.7	20.6	0.996666667	99.6667	0	0	357.2	0	0	0	2.4514977	2.481917853	2.595969994	2.426552312	0.152148543	8.37087E-05	2.481834144	0.119446267	0.067	0	0.602991249	0.60299125	0.000245969	0.000282164
9/12/04 0:00	21.2	22.1	20.2	0.829	82.9	0	0	197.33	0	0.2666667	17.777778	2.4509468	2.517722492	2.660089335	2.367387698	0.15406496	0.004298493	2.513423999	0.118047054	0.067	0	0.597820724	0.59782072	0.000243914	0.059760488
9/12/04 3:00	19.4166667	20.2	18.7	0.781166667	78.1167	0	0	20.867	0	1.333333	88.888889	2.45515725	2.255167216	2.367387698	2.15660198	0.139922556	0.004949999	2.250217217	0.129989863	0.067	0	0.642495831	0.64249583	0.000261692	0.344394036
9/12/04 6:00	18.8666667	19.4	18.7	0.700166667	70.0167	53.91667	0.024263	127.97	0	2.6666667	177.777778	2.4564558	2.179181249	2.252831002	2.15660198	0.1357892	0.006610475	2.172570774	0.133644997	0.067	0.02086575	0.655609555	0.6764753	0.000275387	0.933907635
9/12/04 9:00	22.1166667	22.9	20.6	0.52733333	52.7333	420.5833	0.189263	156.78	0	3.2	213.333333	2.44878255	2.662790727	2.792489766	2.426552312	0.161792504	0.012334336	2.650456391	0.112076887	0.067	0.16276575	0.57468847	0.73745422	0.000301151	1.797537709
9/12/04 12:00	24.8333333	26	23.7	0.479	47.9	585.3	0.263385	241.4	0	1.8666667	124.444444	2.44225045	3.145830505	3.361439829	2.930607375	0.187129505	0.016390783	3.129439722	0.092336885	0.067	0.2265111	0.491462728	0.71797383	0.00029398	1.242023268
9/12/04 15:00	24.8333333	26	23.3	0.4905	49.05	296.0833	0.133238	200.6	0	0.5333333	35.555556	2.44225045	3.145830505	3.361439829	2.86082113	0.187129505	0.01585121	3.129979295	0.092315535	0.067	0.114584225	0.491349093	0.60593334	0.000248105	0.355975069
9/12/04 18:00	18.2166667	21	16.8	0.83233333	83.2333	4.9	0.002205	302.3	0	0	0	2.45799045	2.092275666	2.487005397	1.913305695	0.131038088	0.003688927	2.088586738	0.13767279	0.067	0.0018963	0.669376172	0.67127247	0.000273098	0.005761362
9/12/04 21:00	16.6	16.8	16.4	0.98083333	98.0833	0	0	303.55	0	0	0	2.4618074	1.889152128	1.913305695	1.865266113	0.119828091	0.000362113	1.888790015	0.14759344	0.067	0	0.701819081	0.70181908	0.000285083	0.000775047
9/13/04 0:00	17.2333333	17.5	17.1	0.95566667	95.5667	0	0	265.58	0	0.2666667	17.777778	2.4603121	1.966568397	1.999986975	1.950043263	0.124118591	0.00087559	1.965692807	0.143715566	0.067	0	0.68937295	0.68937295	0.000280197	0.0148022
9/13/04 3:00	16.05	17.1	15.2	0.8675	86.75	0	0	324.6	0	0	0	2.46310595	1.824101817	1.950043263	1.727428862	0.116204881	0.002436325	1.821665491	0.151043276	0.067	0	0.712786487	0.71278649	0.000289385	0.004276702

Date/Time	TMP (*C)	TMPmax (*C)	TMPmin (*C))	RH	RH (%)	solar radiation watt/m^2	St, solar radian MJ./m^2/3hr	WND Wind Dir (Deg)	Rainfall (mm)	Wind speed, km/hr	U2, Wind speed m/sec	Lamda (latent heat), MJ/kg	e*, vapor pressure, kPa	e*max, kPa	e*min, kPa	Delta, Gradient, kPa/*C	Dbar, kPa	e*d, dew point vapor pressure, kPA	Epsilon, net emmisivity	Gamma, Psychrometric constant	Sn, net short wave radiation, MJ/m^2/3hr	Ln, Long wave radiation, MJ/m^2/3hr	Rn, net radiation, MJ/m^2/3hr	Rn, net radiation mm/3 hr	Ep, net evaporation, mm/3 hr
9/13/04 6:00	15.833333	17.9	14.4	0.875166667	87.5167	71.56667	0.032205	191.5	0	0.266667	17.777778	2.4636175	1.7990206	2.051047219	1.640576439	0.114803318	0.002304188	1.796715872	0.152341717	0.067	0.0276963	0.716762316	0.74445862	0.000302181	0.041386988
9/13/04 9:00	22.25	24	19	0.467333333	46.7333	619.6	0.27882	200.87	0	2.4	160	2.44846775	2.684488261	2.983917477	2.197393324	0.162943317	0.013799558	2.670688703	0.111208613	0.067	0.2397852	0.571266812	0.81105201	0.000331249	1.503716249
9/13/04 12:00	26.333333	27.2	25.2	0.308333333	30.8833	747.0667	0.33618	157.28	0	1.066667	71.111111	2.438827	3.428247045	3.607388303	3.205712243	0.201691957	0.02354494	3.404702105	0.081674312	0.067	0.2891148	0.443231597	0.7323464	0.000300286	0.969521466
9/13/04 15:00	25.8	26.8	24	0.384333333	38.4333	312.7333	0.14073	256.65	0	0.266667	17.777778	2.4400862	3.321902528	3.523719593	2.983917477	0.196228597	0.020032676	3.301869852	0.085605328	0.067	0.1210278	0.461264616	0.58229242	0.000238636	0.227192606
9/13/04 18:00	17.916667	21	16.4	0.827166667	82.7167	3.916667	0.001763	357.2	0	0	0	2.45869875	2.05319927	2.487005397	1.865266113	0.128893242	0.003761088	2.049438182	0.139577974	0.067	0.00151575	0.675849135	0.67736488	0.000275497	0.005953143
9/13/04 21:00	15.8	16.4	15.2	0.965333333	96.5333	0	0	357.2	0	0	0	2.4636962	1.795188282	1.865266113	1.727428862	0.114588972	0.000622734	1.794565548	0.152454046	0.067	0	0.716959986	0.71695999	0.00029101	0.001242825
9/14/04 0:00	14.866667	15.2	14.8	0.997	99.7	0	0	357.2	0	0	0	2.4658998	1.690762362	1.727428862	1.683511528	0.108723726	5.11641E-05	1.690711198	0.157961709	0.067	0	0.733311412	0.73331141	0.000297381	0.000275149
9/14/04 3:00	14.25	14.8	13.7	1	100	0	0	357.2	0	0	0	2.46735575	1.624725183	1.683511528	1.567747369	0.104990107	0	1.624725183	0.161549409	0.067	0	0.743565474	0.74356547	0.000301361	0.000183964
9/14/04 6:00	15.466667	18.7	13.7	0.989833333	98.9833	86.26667	0.03882	299.55	0	0	0	2.4644832	1.757262162	2.15660198	1.567747369	0.11246414	0.000189321	1.757072841	0.154423526	0.067	0.0333852	0.72287733	0.75626253	0.000306865	0.000519666
9/14/04 9:00	23.266667	27.2	19.4	0.7005	70.05	603.9333	0.27177	198.03	0	1.333333	88.888889	2.44060674	2.855071638	3.607388303	2.252831002	0.171947714	0.008775678	2.846295959	0.103806434	0.067	0.2337222	0.540620293	0.77434249	0.000316566	0.512667934
9/14/04 12:00	29.133333	30.8	27.2	0.420833333	42.0833	772.55	0.347648	150	0	1.6	106.666667	2.4322162	4.03664598	4.441691099	3.607388303	0.232520183	0.023308792	4.013337188	0.059533587	0.067	0.29897685	0.335328735	0.63430558	0.000260793	1.273297144
9/14/04 15:00	28.866667	30.4	26	0.4295	42.95	338.25	0.152213	102.88	0	0.266667	17.777778	2.4328458	3.974916134	4.341390638	3.361439829	0.22942342	0.021972324	3.95294381	0.061651839	0.067	0.13090275	0.346036444	0.47693919	0.000196042	0.21968152
9/14/04 18:00	20.383333	23.3	18.7	0.821	82.1	3.916667	0.001763	279.8	0	0	0	2.45287495	2.394346367	2.86082113	2.15660198	0.147445467	0.004490594	2.389855773	0.123571783	0.067	0.00151575	0.618884339	0.62040009	0.000252928	0.006311733
9/14/04 21:00	18.166667	18.3	17.9	0.9535	95.35	0	0	279.8	0	0	0	2.4581085	2.085718079	2.103245085	2.051047219	0.130678528	0.000965873	2.084752206	0.137858606	0.067	0	0.66981973	0.66981973	0.000272494	0.001644806

Date/Time	TMP (*C)	TMPmax (*C)	TMPmin (*C))	RH	RH (%)	solar radiation watt/m^2	St, solar radian MJ./m^2/3hr	WND Wind Dir (Deg)	Rainfall (mm)	Wind speed, km/hr	U2, Wind speed m/sec	Lamda (latent heat), MJ/kg	e*, vapor pressure, kPa	e*max, kPa	e*min, kPa	Delta, Gradient, kPa/*C	Dbar, kPa	e*d, dew point vapor pressure, kPA	Epsilon, net emmisivity	Gamma, Psychrometric constant	Sn, net short wave radiation, MJ/m^2/3hr	Ln, Long wave radiation, MJ/m^2/3hr	Rn, net radiation, MJ/m^2/3hr	Rn, net radiation mm/3hr	Ep, net evaporation, mm/3hr
9/15/04 0:00	17.233333	17.5	17.1	0.9935	99.35	0	0	280.5	0	0	0	2.4603121	1.966568397	1.999986975	1.950043263	0.124118591	0.000128376	1.966440021	0.143678263	0.067	0	0.689194016	0.68919402	0.000280125	0.000385511
9/15/04 3:00	16.583333	17.1	16.4	1	100	0	0	281.3	0	0	0	2.46184675	1.887151442	1.950043263	1.865266113	0.119716905	0	1.887151442	0.147676917	0.067	0	0.702054494	0.70205449	0.000285174	0.000182844
9/15/04 6:00	17.916667	21	16.4	0.98983333	98.9833	86.26667	0.03882	293.95	0	0	0	2.45869875	2.05319927	2.487005397	1.865266113	0.128893242	0.00022124	2.052978029	0.139404962	0.067	0.0333852	0.675011392	0.70839659	0.000288118	0.000529097
9/15/04 9:00	26.066667	29.1	22.9	0.6685	66.85	573.55	0.258098	106.17	0	0.533333	35.555556	2.4394566	3.374709749	4.028884423	2.792489766	0.198944493	0.011306428	3.363403321	0.083245828	0.067	0.22196385	0.450153314	0.67211716	0.000275519	0.241567643
9/15/04 12:00	30.583333	31.2	29.5	0.47383333	47.3833	729.4	0.32823	164.3	0	1.6	106.666667	2.42879275	4.387114547	4.543999587	4.122885469	0.249979673	0.02280113	4.364313416	0.047526851	0.067	0.2822778	0.2728727	0.55515007	0.00022857	1.176631397
9/15/04 15:00	30.566667	31.6	28.7	0.51066667	51.0667	345.1167	0.155303	240.02	0	0.266667	17.777778	2.4288321	4.382940601	4.64834968	3.936753503	0.249772919	0.021004886	4.361935715	0.047606532	0.067	0.13356015	0.273269776	0.40682993	0.0001675	0.196412461
9/15/04 18:00	22.8	26	21.3	0.849	84.9	4.9	0.002205	350.2	0	0	0	2.4471692	2.775631234	3.361439829	2.533204981	0.167763768	0.004450457	2.771180777	0.106943905	0.067	0.0018963	0.553461576	0.55535788	0.000226939	0.005615771
9/15/04 21:00	20.266667	21	19.8	0.95183333	95.1833	0	0	350.2	0	0	0	2.4531504	2.377159983	2.487005397	2.309488249	0.146519763	0.001155156	2.376004827	0.124199873	0.067	0	0.621041842	0.62104184	0.000253161	0.001761126
9/16/04 0:00	19.15	19.4	18.7	0.98783333	98.7833	0	0	350.2	0	0	0	2.45578685	2.218040958	2.252831002	2.15660198	0.137905398	0.000268241	2.217772717	0.131509364	0.067	0	0.647639997	0.64764	0.00026372	0.000565768
9/16/04 3:00	18.683333	19	18.3	1	100	0	0	350.2	0	0	0	2.45688865	2.154355354	2.197393324	2.103245085	0.134434604	0	2.154355354	0.134511886	0.067	0	0.658206919	0.65820692	0.000267903	0.000178794
9/16/04 6:00	19.316667	21	18.3	0.9965	99.65	64.71667	0.029123	326.75	0	0.266667	17.777778	2.45539335	2.241181659	2.487005397	2.103245085	0.139163214	8.03294E-05	2.24110133	0.130415683	0.067	0.02504535	0.643719809	0.66876516	0.000272366	0.00139859
9/16/04 9:00	25.233333	27.6	23.3	0.806	80.6	373.5167	0.168083	142.03	0	0	0	2.4414241	3.212073019	3.69278196	2.86082113	0.190560821	0.006356995	3.205716024	0.089336811	0.067	0.14455095	0.477732029	0.62228298	0.000254885	0.007196877
9/16/04 12:00	28.283333	29.5	27.2	0.66983333	66.9833	453.9167	0.204263	137.33	0	0	0	2.43422305	3.842738646	4.122885469	3.607388303	0.222769805	0.012761394	3.829977253	0.066015413	0.067	0.17566575	0.367674209	0.54333996	0.000223209	0.012568464
9/16/04 15:00	29.55	30.8	28	0.618	61.8	301.9667	0.135885	196.4	0	0	0	2.43123245	4.13476867	4.441691099	3.779930364	0.237429082	0.015703297	4.119065373	0.05586327	0.067	0.1168611	0.3163935	0.4332546	0.000178204	0.014641272
9/16/04 18:00	23.266667	26	22.1	0.905	90.5	3.916667	0.001763	125.2	0	0	0	2.4460674	2.855071638	3.361439829	2.660089335	0.171947714	0.002860226	2.852211411	0.103561121	0.067	0.00151575	0.539342712	0.54085846	0.000221113	0.003592555

Date/Time	TMP (*C)	TMPmax (*C)	TMPmin (*C))	RH	RH (%)	solar radiation watt/m^2	St, solar radian MJ./m^2/3hr	WND Wind Dir (Deg)	Rainfall (mm)	Wind speed, km/hr	U2, Wind speed m/sec	Lamda (latent heat), MJ/kg	e*, vapor pressure, kPa	e*max, kPa	e*min, kPa	Delta, Gradient, kPa/*C	Dbar, kPa	e*d, dew point vapor pressure, kPA	Epsilon, net emmisivity	Gamma, Psychrometric constant	Sn, net short wave radiation, MJ/m^2/3hr	Ln, Long wave radiation, MJ/m^2/3hr	Rn, net radiation, MJ/m^2/3hr	Rn, net radiation mm/3hr	Ep, net evaporation, mm/3hr
9/16/04 21:00	21.033333	21.7	20.6	0.987	98.7	0	0	113.72	0	0	0	2.4513403	2.492102053	2.595969994	2.426552312	0.152694023	0.000326464	2.491775589	0.119004974	0.067	0	0.601308291	0.60130829	0.000245298	0.000603611
9/17/04 0:00	20.133333	20.6	19.4	0.99233333	99.2333	0	0	220.12	0	0	0	2.4534652	2.357650555	2.426552312	2.252831002	0.145467839	0.000179376	2.357471179	0.125043179	0.067	0	0.624123113	0.62412311	0.000254384	0.000422186
9/17/04 3:00	18.85	19	18.7	1	100	0	0	260.2	0	0	0	2.45649515	2.176914053	2.197393324	2.15660198	0.135665579	0	2.176914053	0.133438834	0.067	0	0.654448793	0.65444879	0.000266416	0.00017834
9/17/04 6:00	20.166667	22.1	19	0.99233333	99.2333	55.8833	0.025148	238.63	0	0	0	2.45350455	2.355221748	2.660089335	2.197393324	0.145336798	0.000186204	2.355035545	0.125154249	0.067	0.02162685	0.624535535	0.64616238	0.000263363	0.000437921
9/17/04 9:00	22.683333	26	21.3	0.94033333	94.0333	239.2	0.10764	161.75	0.25	0.266667	17.777778	2.44744465	2.75607531	3.361439829	2.533204981	0.166731315	0.001758569	2.754316741	0.10765412	0.067	0.0925704	0.556259263	0.64882966	0.000265105	0.022996131
9/17/04 12:00	29.55	31.2	27.6	0.64983333	64.9833	706.85	0.318083	134.33	0	1.6	106.666667	2.43123245	4.13476867	4.543999587	3.69278196	0.237429082	0.014421232	4.120347439	0.055819054	0.067	0.27355095	0.316143076	0.58969403	0.000242549	0.77495775
9/17/04 15:00	30.366667	31.2	28.3	0.61416667	61.4167	311.7667	0.140295	82.967	0	0.266667	17.777778	2.4293043	4.333121864	4.543999587	3.846461372	0.247303027	0.016186598	4.316935266	0.049118699	0.067	0.1206537	0.281208067	0.40186177	0.000165423	0.152565096
9/17/04 18:00	23.8	26.4	22.1	0.91333333	91.3333	3.916667	0.001763	94.2	0	0	0	2.4448082	2.948284305	3.441746435	2.660089335	0.176836833	0.002644129	2.945640176	0.099719856	0.067	0.00151575	0.523084719	0.52460047	0.000214577	0.00325637
9/17/04 21:00	21.516667	21.7	21	0.994	99.4	0	0	94.2	0	0	0	2.45019915	2.567036053	2.595969994	2.487005397	0.156698414	0.000152489	2.566883564	0.115699046	0.067	0	0.588454863	0.58845486	0.000240166	0.000366149
9/18/04 0:00	20.733333	21	20.6	1	100	0	0	94.2	0	0	0	2.4520486	2.446559016	2.487005397	2.426552312	0.150252318	0	2.446559016	0.121019278	0.067	0	0.608996094	0.60899609	0.000248362	0.000171768
9/18/04 3:00	20.266667	20.6	20.2	1	100	0	0	95.6	0	0	0	2.4531504	2.377159983	2.426552312	2.367387698	0.146519763	0	2.377159983	0.124147421	0.067	0	0.620779564	0.62077956	0.000253054	0.000173649
9/18/04 6:00	21.216667	24	19.8	0.98716667	98.7167	104.9167	0.047213	123.73	0	0	0	2.45090745	2.52029715	2.983917477	2.309488249	0.154202624	0.00033966	2.51995749	0.117758764	0.067	0.04060275	0.5964958	0.63709856	0.000259944	0.000628093
9/18/04 9:00	29.05	32	25.6	0.69316667	69.3167	669.6	0.30132	174.85	0	1.333333	88.888889	2.43241295	4.017266432	4.754775396	3.2827717	0.231548698	0.012330936	4.004935496	0.059827311	0.067	0.2591352	0.336611781	0.59574698	0.0002449	0.565240121
9/18/04 12:00	33.633333	34.9	32.4	0.50166667	50.1667	781.3667	0.351615	128.92	0	1.866667	124.444444	2.4215917	5.211621401	5.591678668	4.863311198	0.290312068	0.02605035	5.185571052	0.021194115	0.067	0.3023889	0.126645575	0.42903448	0.0001771	1.394684055
9/18/04 15:00	33.166667	34.9	31.6	0.5345	53.45	380.4	0.17118	157.97	0	0.533333	35.555556	2.4226935	5.077363897	5.591678668	4.64834968	0.283810137	0.023833666	5.05353031	0.025279183	0.067	0.1472148	0.150139054	0.29735385	0.000122737	0.384632514

Date/Time	TMP (*C)	TMPmax (*C)	TMPmin (*C)	RH	RH (%)	solar radiation watt/m^2	St, solar radian MJ./m^2/3hr	WND Wind Dir (Deg)	Rainfall (mm)	Wind speed, km/hr	U2, Wind speed m/sec	Lamda (latent heat), MJ/kg	e*, vapor pressure, kPa	e*max, kPa	e*min, kPa	Delta, Gradient, kPa/*C	Dbar, kPa	e*d, dew point vapor pressure, kPA	Epsilon, net emmisivity	Gamma, Psychrometric constant	Sn, net short wave radiation, MJ/m^2/3hr	Ln, Long wave radiation, MJ/m^2/3hr	Rn, net radiation, MJ/m^2/3hr	Rn, net radiation mm/3hr	Ep, net evaporation, mm/3hr
9/18/04 18:00	25.45	28.3	24	0.874166667	87.4167	4.9	0.002205	267.2	0	0	0	2.44091255	3.253686935	3.846461372	2.983917477	0.192711408	0.004297447	3.249389488	0.087635117	0.067	0.0018963	0.46999457	0.47189087	0.000193326	0.004837764
9/18/04 21:00	23.55	24	22.9	0.9815	98.15	0	0	309.4	0	0	0	2.44539845	2.904265394	2.983917477	2.792489766	0.174530659	0.000534318	2.903731076	0.101435273	0.067	0	0.530293743	0.53029374	0.000216854	0.000790172
9/19/04 0:00	23.15	24	22.9	0.9965	99.65	0	0	261.35	0	0.266667	17.777778	2.44634285	2.835027762	2.983917477	2.792489766	0.170893562	0.000101087	2.834926674	0.104278633	0.067	0	0.542225137	0.54222514	0.000221647	0.00144344
9/19/04 3:00	21.6	23.3	21	0.96083333	96.0833	0	0	249.87	3.81	0.533333	35.555556	2.4500024	2.580152726	2.86082113	2.487005397	0.157397715	0.001047283	2.579105443	0.115165691	0.067	0	0.586404946	0.58640495	0.000239349	0.027329163
9/19/04 6:00	22.3833333	24.4	21	0.961166667	96.1167	109.8	0.04941	279.37	0	0	0	2.44815295	2.706340041	3.056312653	2.487005397	0.164101035	0.001076328	2.705263714	0.109732397	0.067	0.0424926	0.564701874	0.60719447	0.000248021	0.001519719
9/19/04 9:00	28.4	30.4	26.4	0.741333333	74.1333	632.3333	0.28455	154.22	0	1.066667	71.111111	2.4339476	3.868863717	4.341390638	3.441746435	0.224087398	0.010066191	3.858797526	0.064986488	0.067	0.244713	0.362504174	0.60721717	0.000249478	0.380893213
9/19/04 12:00	32.8	33.6	31.6	0.562666667	56.2667	724.5	0.326025	196.4	0	1.6	106.666667	2.4235592	4.973991993	5.201930456	4.64834968	0.278787325	0.021539279	4.952452714	0.028442504	0.067	0.2803815	0.168119515	0.44850101	0.000185059	1.021823711
9/19/04 15:00	33.45	34.5	31.6	0.4945	49.45	396.1	0.178245	169.7	0	1.066667	71.111111	2.42202455	5.158514464	5.469145903	4.64834968	0.287743043	0.02557197	5.132942494	0.022816027	0.067	0.1532907	0.136011768	0.28930247	0.000119447	0.796339296
9/19/04 18:00	25.4166667	28	23.7	0.867166667	86.7167	4.9	0.002205	163.1	0	0	0	2.44099125	3.247254364	3.779930364	2.930607375	0.192379224	0.004456915	3.242797449	0.087891234	0.067	0.0018963	0.47157735	0.47305404	0.000193796	0.005019136
9/19/04 21:00	24.0833333	24.4	23.7	0.961333333	96.1333	0	0	128.9	0.76	0.8	53.333333	2.44413925	2.998875169	3.056312653	2.930607375	0.17948151	0.00115747	2.997717698	0.097605143	0.067	0	0.513948425	0.51394843	0.000210278	0.039820862
9/20/04 0:00	22.1	22.5	21.7	0.996166667	99.6167	0	0	68.417	0.25	0	0	2.4488219	2.660089335	2.725587607	2.595969994	0.161649137	0.000101997	2.659987339	0.111667453	0.067	0	0.572459796	0.5724598	0.000233769	0.000294217
9/20/04 3:00	21.15	21.3	21	1	100	0	0	71.7	0	0	0	2.45106485	2.510012303	2.533204981	2.487005397	0.153652591	0	2.510012303	0.118197743	0.067	0	0.598177311	0.59817731	0.000244048	0.000169944
9/20/04 6:00	22.2	25.6	21	0.974666667	97.4667	155.8833	0.070148	77.583	0	0	0	2.4485858	2.676333659	3.28277117	2.487005397	0.162510955	0.000730838	2.675602821	0.11099822	0.067	0.06032685	0.569800163	0.63012701	0.000257343	0.001102045
9/20/04 9:00	29.7666667	32	26.8	0.680166667	68.0167	701.9667	0.315885	180.7	0	1.6	106.666667	2.4307209	4.186607456	4.754775396	3.523719593	0.240015883	0.013238693	4.173368763	0.053996455	0.067	0.2716611	0.306696793	0.57835789	0.000237937	0.705377425
9/20/04 12:00	33.5666667	34.1	32.8	0.519333333	51.9333	777.45	0.349853	148.6	0	1.866667	124.444444	2.4217491	5.192255152	5.348948887	4.973991993	0.289375667	0.024809468	5.167445685	0.021751771	0.067	0.30087315	0.129864928	0.43073808	0.000177862	1.33150123

Date/Time	TMP (*C)	TMPmax (*C)	TMPmin (*C))	RH	RH (%)	solar radiation watt/m^2	St, solar radian MJ./m^2/3hr	WND Wind Dir (Deg)	Rainfall (mm)	Wind speed, km/hr	U2, Wind speed m/sec	Lamda (latent heat), MJ/kg	e*, vapor pressure, kPa	e*max, kPa	e*min, kPa	Delta, Gradient, kPa/*C	Dbar, kPa	e*d, dew point vapor pressure, kPA	Epsilon, net emmisivity	Gamma, Psychrometric constant	Sn, net short wave radiation, MJ/m^2/3hr	Ln, Long wave radiation, MJ/m^2/3hr	Rn, net radiation, MJ/m^2/3hr	Rn, net radiation mm/3hr	Ep, net evaporation, mm/3hr
9/20/04 15:00	33.25	34.5	30.4	0.532666667	53.2667	380.3833	0.171173	232.03	0	0.8	53.33333333	2.42249675	5.10111587	5.469145903	4.341390638	0.284962179	0.022923954	5.078191916	0.024512185	0.067	0.14720835	0.145742131	0.29295048	0.000120929	0.543988138
9/20/04 18:00	25.98333333	28.3	24.8	0.866333333	86.6333	5.883333	0.002648	357.2	0	0	0	2.43965335	3.358129463	3.846461372	3.130235219	0.198092398	0.004662759	3.353466704	0.083625377	0.067	0.00227685	0.451702262	0.45397911	0.000186083	0.005118981
9/20/04 21:00	23.66666667	24.4	23.3	0.977666667	97.7667	0	0	357.2	0	0	0	2.445123	2.924735653	3.056312653	2.86082113	0.175603696	0.000660747	2.924074906	0.100601027	0.067	0	0.526759954	0.52675995	0.000215433	0.000935313
9/21/04 0:00	23.1	23.3	22.9	0.999166667	99.9167	0	0	357.2	0	0	0	2.4464609	2.826475201	2.86082113	2.792489766	0.170443455	2.35555E-05	2.826451646	0.104631242	0.067	0	0.543691543	0.54369154	0.000222236	0.000188012
9/21/04 3:00	22.3	22.5	22.1	1	100	0	0	119.07	0	0	0	2.4483497	2.692664553	2.725587607	2.660089335	0.16337665	0	2.692664553	0.110269233	0.067	0	0.566824856	0.56682486	0.000231513	0.000164183
9/21/04 6:00	23.85	28.3	21.7	0.948333333	94.8833	131.3833	0.059123	125.17	0	0	0	2.44469015	2.957157607	3.846461372	2.595969994	0.177301137	0.001648189	2.955509418	0.099317669	0.067	0.05084535	0.52132594	0.57217129	0.000234047	0.002098471
9/21/04 9:00	31.43333333	33.6	29.1	0.612833333	61.2833	728.4333	0.327795	187.27	0	1.866667	124.444444	2.4267859	4.604620191	5.201930456	4.028884423	0.260716097	0.017869319	4.586750871	0.040166184	0.067	0.2819037	0.233203389	0.51510709	0.000212259	1.038688455
9/21/04 12:00	35.91666667	37.1	34.9	0.427833333	42.7833	918.6333	0.413385	126.1	0	1.866667	124.444444	2.41620075	5.913887758	6.309073177	5.591678668	0.323948379	0.034046068	5.87984169	0.000522612	0.067	0.3555111	0.00321687	0.35872797	0.000148468	1.679769498
9/21/04 15:00	34.01666667	36.6	29.1	0.467833333	46.7833	374.5167	0.168533	70.067	0	1.066667	71.111111	2.42068665	5.324198372	6.139388459	4.028884423	0.295745669	0.027056079	5.297142292	0.017782699	0.067	0.14493795	0.10679265	0.2517306	0.000103991	0.825291856
9/21/04 18:00	25.03333333	27.6	23.7	0.674	67.4	0.983333	0.000443	204.38	0	1.333333	88.888889	2.4418963	3.174072822	3.69278196	2.930607375	0.18859364	0.010796125	3.163276697	0.09100156	0.067	0.00038055	0.48533114	0.48571169	0.000198908	0.584083849
9/21/04 21:00	22.56666667	22.9	22.1	0.898666667	89.8667	0	0	351.55	0	0	0	2.4477201	2.736639795	2.792489766	2.660089335	0.165704231	0.00276264	2.733877155	0.108517836	0.067	0	0.559838322	0.55983832	0.000228718	0.003583472
9/22/04 0:00	21.96666667	22.5	21.3	0.9815	98.15	0	0	347.3	0	0	0	2.4491367	2.638564229	2.725587607	2.533204981	0.160506052	0.000486438	2.638077791	0.112609752	0.067	0	0.57624854	0.57624854	0.000235286	0.000784661
9/22/04 3:00	21.15	21.7	20.6	1	100	0	0	273.27	0	0	0	2.45106485	2.510012303	2.595969994	2.426552312	0.153652591	0	2.510012303	0.118197743	0.067	0	0.598177311	0.59817731	0.000244048	0.000169944
9/22/04 6:00	22.85	26.8	20.6	0.9315	93.15	147.0667	0.06618	244.23	0	0	0	2.44705115	2.784049359	3.523719593	2.426552312	0.168207897	0.002037968	2.782011391	0.106488923	0.067	0.0569148	0.55147939	0.60839419	0.000248623	0.002669606
9/22/04 9:00	31.33333333	33.2	28	0.569833333	56.9833	734.3333	0.33045	195.02	0	1.6	106.666667	2.427022	4.578554435	5.086853141	3.779930364	0.259433282	0.019070974	4.559483462	0.041058742	0.067	0.284187	0.238072687	0.52225969	0.000215185	0.956172029

Date/Time	TMP (*C)	TMPmax (*C)	TMPmin (*C))	RH	RH (%)	solar radiation watt/m^2	St, solar radian MJ./m^2/3hr	WND Wind Dir (Deg)	Rainfall (mm)	Wind speed, km/hr	U2, Wind speed m/sec	Lamda (latent heat), MJ/kg	e*, vapor pressure, kPa	e*max, kPa	e*min, kPa	Delta, Gradient, kPa/*C	Dbar, kPa	e*d, dew point vapor pressure, kPA	Epsilon, net emmisivity	Gamma, Psychrometric constant	Sn, net short wave radiation, MJ/m^2/3hr	Ln, Long wave radiation, MJ/m^2/3hr	Rn, net radiation, MJ/m^2/3hr	Rn, net radiation mm/3hr	Ep, net evaporation, mm/3hr
9/22/04 12:00	35.4	36.2	34.9	0.474	47.4	893.1167	0.401903	200.17	0	1.6	106.666667	2.4174206	5.748186889	6.006501392	5.591678668	0.316065952	0.030503214	5.717683675	0.005236501	0.067	0.34563615	0.032017653	0.3776538	0.000156222	1.316878031
9/22/04 15:00	34.8	36.2	32	0.46533333	46.5333	422.55	0.190148	79.7	0	1.066667	71.111111	2.4188372	5.560824442	6.006501392	4.754775396	0.307113715	0.02876848	5.532055962	0.010715477	0.067	0.16352685	0.065009823	0.22853667	9.4482E-05	0.853098546
9/22/04 18:00	26.45	29.1	24.8	0.83466667	83.4667	4.9	0.002205	14.1	0	0	0	2.43855155	3.451901349	4.028884423	3.130235219	0.202903972	0.005918206	3.445983143	0.080112968	0.067	0.0018963	0.435436208	0.43733251	0.000179341	0.006333289
9/22/04 21:00	23.916667	24.4	23.7	0.95333333	95.3333	0	0	14.1	0	0	0	2.44453275	2.969024919	3.056312653	2.930607375	0.177921809	0.001396948	2.967627971	0.098824735	0.067	0	0.519204333	0.51920433	0.000212394	0.001784179
9/23/04 0:00	23.3	23.7	22.9	0.99183333	99.1833	0	0	14.1	0	0	0	2.4459887	2.86082113	2.930607375	2.792489766	0.172249906	0.000233693	2.860587437	0.103214203	0.067	0	0.537777769	0.53777777	0.000219861	0.000438407
9/23/04 3:00	22.766667	22.9	22.5	1	100	0	0	164.78	0	0	0	2.4472479	2.770031503	2.792489766	2.725587607	0.167468232	0	2.770031503	0.106992237	0.067	0	0.553462328	0.55346233	0.000226157	0.000161532
9/23/04 6:00	23.866667	27.2	22.1	0.931	93.1	129.4167	0.058238	243.05	0	0.266667	17.777778	2.4446508	2.960120548	3.607388303	2.660089335	0.177456134	0.00216228	2.957958268	0.099217978	0.067	0.05008425	0.52091955	0.5710038	0.000233573	0.02679011
9/23/04 9:00	31.166667	33.2	28.3	0.6085	60.85	705.9	0.317655	161.73	0	1.6	106.666667	2.4274155	4.535396367	5.086853141	3.846461372	0.25730701	0.017486963	4.517909404	0.042424759	0.067	0.2731833	0.245455249	0.51863855	0.000213659	0.882374933
9/23/04 12:00	35.416667	35.8	34.9	0.45	45	831.3667	0.374115	134.53	0	1.6	106.666667	2.41738125	5.753468572	5.876113985	5.591678668	0.316317701	0.03153643	5.721932142	0.005112153	0.067	0.3217389	0.031264101	0.353003	0.000146027	1.360669942
9/23/04 15:00	34.366667	36.2	32.4	0.493	49.3	339.2167	0.152648	112.53	0	0.533333	35.555556	2.4198603	5.428822555	6.006501392	4.863311198	0.300780758	0.027554975	5.401267581	0.014631218	0.067	0.13127685	0.088267764	0.21954461	9.07262E-05	0.425606342
9/23/04 18:00	22.816667	27.6	21.7	0.8885	88.85	2.933333	0.00132	180.23	12.7	1.6	106.666667	2.44712985	2.778434803	3.69278196	2.595969994	0.167911701	0.003505979	2.774928824	0.106786353	0.067	0.0011352	0.552770685	0.55390589	0.000226349	0.24990351
9/23/04 21:00	21.566667	21.7	21.3	0.9945	99.45	0	0	279.15	0	0	0	2.4500811	2.574899047	2.595969994	2.533204981	0.157117679	0.000141052	2.574757995	0.115355266	0.067	0	0.587104617	0.58710462	0.000239627	0.000350648
9/24/04 0:00	21.15	21.7	20.6	0.99916667	99.9167	0	0	153.3	0	0	0	2.45106485	2.510012303	2.595969994	2.426552312	0.153652591	2.09272E-05	2.509991376	0.118198668	0.067	0	0.598181991	0.59818199	0.00024405	0.000197562
9/24/04 3:00	20.733333	21	20.6	1	100	0	0	156.1	0	0	0	2.4520486	2.446559016	2.487005397	2.426552312	0.150252318	0	2.446559016	0.121019278	0.067	0	0.608996094	0.60899609	0.000248362	0.000171768

Date/Time	TMP (*C)	TMPmax (*C)	TMPmin (*C))	RH	RH (%)	solar radiation watt/m^2	St, solar radian MJ./m^2/3hr	WND Wind Dir (Deg)	Rainfall (mm)	Wind speed, km/hr	U2, Wind speed m/sec	Lamda (latent heat), MJ/kg	e*, vapor pressure, kPa	e*max, kPa	e*min, kPa	Delta, Gradient, kPa/*C	Dbar, kPa	e*d, dew point vapor pressure, kPA	Epsilon, net emmisivity	Gamma, Psychrometric constant	Sn, net short wave radiation, MJ/m^2/3hr	Ln, Long wave radiation, MJ/m^2/3hr	Rn, net radiation, MJ/m^2/3hr	Rn, net radiation mm/3hr	Ep, net evaporation, mm/3hr
9/24/04 6:00	21.483333	22.5	21	0.99283333	99.2833	55.88333	0.025148	168.95	0.25	0	0	2.45027785	2.561805719	2.725587607	2.487005397	0.156419429	0.000186785	2.561618934	0.115929183	0.067	0.02162685	0.589358649	0.6109855	0.000249354	0.000417369
9/24/04 9:00	26.066667	29.5	22.9	0.77583333	77.5833	521.55	0.234698	206.72	0	0.8	53.333333	2.4394566	3.374709749	4.122885469	2.792489766	0.198944493	0.007750983	3.366958766	0.083110156	0.067	0.20183985	0.449419669	0.65125952	0.000266969	0.244268734
9/24/04 12:00	30.916667	32	29.1	0.58566667	58.5667	811.75	0.365288	135.48	0	1.6	106.666667	2.42800575	4.471322163	4.754775396	4.028884423	0.254144989	0.018196815	4.453125348	0.044565986	0.067	0.31414725	0.256997557	0.57114481	0.000235232	0.92706207
9/24/04 15:00	31.516667	32.4	29.5	0.561	56.1	355.8833	0.160148	121.65	0	0	0	2.42658915	4.626440047	4.863311198	4.122885469	0.261789164	0.019724702	4.606715345	0.039514358	0.067	0.13772685	0.229670049	0.3673969	0.000151405	0.0169991
9/24/04 18:00	24.7	27.2	23.3	0.90816667	90.8167	4.9	0.002205	70.3	0	0	0	2.4426833	3.111609911	3.607388303	2.86082113	0.185353023	0.002969986	3.108639925	0.093161303	0.067	0.0018963	0.49463194	0.49652824	0.000203272	0.00349912
9/24/04 21:00	22.966667	23.3	22.9	0.99533333	99.5333	0	0	70.3	0	0	0	2.4467757	2.803778388	2.86082113	2.792489766	0.169248058	0.000131911	2.803646477	0.105582699	0.067	0	0.5476487	0.5476487	0.000223825	0.000320803
9/25/04 0:00	22.3	22.5	22.1	1	100	0	0	70.3	0	0	0	2.4483497	2.692664553	2.725587607	2.660089335	0.16337665	0	2.692664553	0.110269233	0.067	0	0.566824856	0.56682486	0.000231513	0.000164183
9/25/04 3:00	22.366667	22.5	22.1	1	100	0	0	70.3	0	0	0	2.4481923	2.703600102	2.725587607	2.660089335	0.163955941	0	2.703600102	0.10980321	0.067	0	0.564938853	0.56493885	0.000230758	0.000163815
9/25/04 6:00	23	26	21.3	0.98433333	98.4333	118.6333	0.053385	117.42	0	0	0	2.446697	2.809437622	3.361439829	2.533204981	0.169546242	0.000461747	2.808975875	0.105360005	0.067	0.0459111	0.546739677	0.59265078	0.000242225	0.000734457
9/25/04 9:00	30.433333	32.4	27.2	0.70083333	70.0833	649.0167	0.292058	146.95	0	0.8	53.333333	2.4291469	4.349673126	4.863311198	3.607388303	0.248124039	0.012670755	4.337002371	0.048443408	0.067	0.25116945	0.277585686	0.52875514	0.000217671	0.334612322
9/25/04 12:00	33.65	34.5	32.8	0.50466667	50.4667	854.8833	0.384698	161.95	0	1.6	106.666667	2.42155235	5.216472746	5.469145903	4.973991993	0.290546563	0.025864172	5.190608575	0.0210393	0.067	0.33083985	0.125747799	0.45658765	0.000188552	1.189127255
9/25/04 15:00	33.233333	34.5	30.8	0.51466667	51.4667	383.35	0.172508	226.42	0	0.266667	17.777778	2.4225361	5.096357775	5.469145903	4.441691099	0.284731458	0.024050298	5.072307477	0.024695026	0.067	0.14835645	0.146797312	0.29515376	0.000121837	0.203285398
9/25/04 18:00	25.85	28.7	24.4	0.8625	86.25	2.933333	0.00132	241.9	0	0	0	2.43996815	3.331748659	3.936753503	3.056312653	0.196735437	0.004807733	3.326940926	0.084641346	0.067	0.0011352	0.456375561	0.45751076	0.000187507	0.005303531
9/25/04 21:00	23.716667	24.4	22.9	0.9425	94.25	0	0	241.9	0	0	0	2.44500495	2.933547091	3.056312653	2.792489766	0.17606527	0.001681531	2.93186556	0.100282322	0.067	0	0.525445019	0.52544502	0.000214906	0.002134771

Date/Time	TMP (*C)	TMPmax (*C)	TMPmin (*C))	RH	RH (%)	solar radiation watt/m^2	St, solar radian MJ./m^2/3hr	WND Wind Dir (Deg)	Rainfall (mm)	Wind speed, km/hr	U2, Wind speed m/sec	Lamda (latent heat), MJ/kg	e*, vapor pressure, kPa	e*max, kPa	e*min, kPa	Delta, Gradient, kPa/*C	Dbar, kPa	e*d, dew point vapor pressure, kPA	Epsilon, net emmisivity	Gamma, Psychrometric constant	Sn, net short wave radiation, MJ/m^2/3hr	Ln, Long wave radiation, MJ/m^2/3hr	Rn, net radiation, MJ/m^2/3hr	Rn, net radiation mm/3hr	Ep, net evaporation, mm/3hr
9/26/04 0:00	21.7666667	22.5	21.3	0.9695	96.95	0	0	241.9	0	0	0	2.4496089	2.6065184	2.725587607	2.533204981	0.158804231	0.000801966	2.605759875	0.114006873	0.067	0	0.581818312	0.58181831	0.000237515	0.001196224
9/26/04 3:00	21.3833333	21.7	21	0.98833333	98.8333	0	0	332.38	0	0	0	2.45051395	2.5461705 4	2.595969994	2.487005397	0.155584992	0.000296507	2.545874033	0.116618866	0.067	0	0.592060508	0.59206051	0.000241607	0.000556047
9/26/04 6:00	22.9666667	26	21	0.898	89.8	129.4167	0.058238	232.98	0	0.8	53.333333	2.4467757	2.80377838	3.361439829	2.487005397	0.169248058	0.002982707	2.800795681	0.105701909	0.067	0.05008425	0.548267033	0.59835128	0.000244547	0.107520045
9/26/04 9:00	29.7	31.6	27.2	0.6395	63.95	694.1167	0.312353	215.15	0	1.6	106.666667	2.4308783	4.17059797	4.64834968	3.607388303	0.239217438	0.014880968	4.155716229	0.054601966	0.067	0.26862315	0.309863171	0.57848632	0.000237974	0.79493925
9/26/04 12:00	33.8333333	34.5	33.2	0.5005	50.05	837.25	0.376763	210.03	0	1.6	106.666667	2.4211195	5.27009673	5.469145903	5.086853141	0.293136481	0.026363608	5.243733125	0.019411215	0.067	0.32401575	0.116294564	0.44031031	0.000181862	1.20399929
9/26/04 15:00	33.4333333	35.3	31.6	0.52016667	52.0167	348.0333	0.156615	119.75	0	0.266667	17.777778	2.4220639	5.15370993	5.71658473	4.64834968	0.287510441	0.024867206	5.128842727	0.022942722	0.067	0.1346889	0.136737298	0.2714262	0.000112064	0.208639278
9/26/04 18:00	26.45	29.1	24.8	0.8685	86.85	5.883333	0.002648	174.4	0	0	0	2.43855155	3.451901349	4.028884423	3.130235219	0.202903972	0.004707121	3.447194228	0.080067303	0.067	0.00227685	0.435188009	0.43746486	0.000179395	0.005064894
9/26/04 21:00	24.4	24.4	24.4	0.948	94.8	0	0	95.167	0	0	0	2.4433916	3.056312653	3.056312653	3.056312653	0.182476711	0.001589283	3.05472337	0.095311263	0.067	0	0.50401159	0.50401159	0.000206275	0.001966723
9/27/04 0:00	23.9166667	24.4	23.3	0.88216667	88.2167	0	0	225.48	0	0.533333	35.555556	2.44453275	2.969024919	3.056312653	2.86082113	0.177921809	0.003486178	2.965538741	0.098909645	0.067	0	0.519650429	0.51965043	0.000212577	0.081739283
9/27/04 3:00	22.7666667	23.3	22.5	0.90416667	90.4167	0	0	48.767	0	0	0	2.4472479	2.77031503	2.86082113	2.725587607	0.167468232	0.002676821	2.767354683	0.107104848	0.067	0	0.554044855	0.55404485	0.000226395	0.003446735
9/27/04 6:00	22.3	22.5	22.1	0.9775	97.75	13.73333	0.00618	169.45	0	0	0	2.4483497	2.692664553	2.725587607	2.660089335	0.16337665	0.000605889	2.692058664	0.110295081	0.067	0.0053148	0.566957724	0.57227252	0.000233738	0.000924924
9/27/04 9:00	23.0833333	24	22.5	0.95733333	95.7333	146.0667	0.06573	161	2.02	0.533333	35.555556	2.44650025	2.823629357	2.983917477	2.725587607	0.170293642	0.001218028	2.822411329	0.104799528	0.067	0.0565278	0.544443486	0.60097129	0.000245645	0.029741222
9/27/04 12:00	28.7666667	30.8	25.2	0.698	69.8	619.6167	0.278828	204.13	0	1.333333	88.888889	2.4330819	3.951980121	4.441691099	3.205712243	0.228271096	0.011547579	3.940432542	0.062092681	0.067	0.23979165	0.348049508	0.58784116	0.000241604	0.53536268
9/27/04 15:00	29.4833333	30.4	27.6	0.66683333	66.6833	420.6167	0.189278	138.28	0	1.333333	88.888889	2.43138985	4.118931009	4.341390638	3.69278196	0.236637865	0.013383593	4.105547417	0.056329893	0.067	0.16277865	0.318755402	0.48153405	0.000198049	0.602985144
9/27/04 18:00	23.8	26.4	22.1	0.893	89.3	5.883333	0.002648	79.017	0	0	0	2.4448082	2.948284305	3.441746435	2.660089335	0.176836833	0.003264482	2.945019823	0.099745159	0.067	0.00227685	0.523217446	0.5254943	0.000214943	0.003984119

Date/Time	TMP (*C)	TMPmax (*C)	TMPmin (*C))	RH	RH (%)	solar radiation watt/m^2	St, solar radian MJ./m^2/3hr	WND Wind Dir (Deg)	Rainfall (mm)	Wind speed, km/hr	U2, Wind speed m/sec	Lamda (latent heat), MJ/kg	e*, vapor pressure, kPa	e*max, kPa	e*min, kPa	Delta, Gradient, kPa/*C	Dbar, kPa	e*d, dew point vapor pressure, kPA	Epsilon, net emmisivity	Gamma, Psychrometric constant	Sn, net short wave radiation, MJ/m^2/3hr	Ln, Long wave radiation, MJ/m^2/3hr	Rn, net radiation, MJ/m^2/3hr	Rn, net radiation mm/3hr	Ep, net evaporation, mm/3hr
9/27/04 21:00	21.5666667	22.1	21.3	0.99833333	99.8333	0	0	83	0	0	0	2.4500811	2.574899047	2.660089335	2.533204981	0.157117679	4.32775E-05	2.57485577	0.115351	0.067	0	0.587082909	0.58708291	0.000239618	0.000224027
9/28/04 0:00	21.2666667	21.7	21	1	100	0	0	83	0	0	0	2.4507894	2.528034934	2.595969994	2.487005397	0.15461624	0	2.528034934	0.117402865	0.067	0	0.595097116	0.59509712	0.000242819	0.000169409
9/28/04 3:00	20.85	21.7	20.2	1	100	0	0	83	0	0	0	2.45177315	2.464183004	2.595969994	2.367387698	0.151197918	0	2.464183004	0.12023197	0.067	0	0.605995348	0.60599535	0.000247166	0.000171271
9/28/04 6:00	22.05	24.8	20.6	0.98166667	98.1667	110.7833	0.049853	156.8	0	0	0	2.44893995	2.651999515	3.130235219	2.426552312	0.161219677	0.000509372	2.651490143	0.112032444	0.067	0.04287315	0.573942024	0.61681517	0.00025187	0.000823342
9/28/04 9:00	29.45	30.8	26.8	0.70816667	70.8167	750.9833	0.337943	119.77	0	1.6	106.666667	2.43146855	4.111031985	4.441691099	3.523719593	0.236243088	0.011622862	4.099409123	0.056542033	0.067	0.29063055	0.319814925	0.61044548	0.00025106	0.627096511
9/28/04 12:00	33.0166667	34.1	31.6	0.49383333	49.3833	520.5667	0.234255	176.03	0	1.6	106.666667	2.42304765	5.03485219	5.348948887	4.64834968	0.281746279	0.025301496	5.009550693	0.026651642	0.067	0.2014593	0.157980636	0.35943994	0.000148342	1.190643021
9/28/04 15:00	32.2	34.5	29.5	0.53466667	53.4667	328.4333	0.147795	166.63	0	0.8	53.333333	2.4249758	4.808777365	5.469145903	4.122885469	0.270728665	0.02231746	4.786459906	0.033708286	0.067	0.1271037	0.197686672	0.32479037	0.000133936	0.550709319
9/28/04 18:00	24.8333333	27.2	23.7	0.86116667	86.1167	1.966667	0.000885	264.4	0	0	0	2.4423685	3.136465224	3.607388303	2.930607375	0.186643593	0.004538459	3.131926765	0.092238493	0.067	0.0007611	0.49060972	0.49137082	0.000201186	0.005237719
9/28/04 21:00	23.1666667	23.3	22.9	0.96033333	96.0333	0	0	289.7	0	0	0	2.4463035	2.837883631	2.86082113	2.792489766	0.171043821	0.00112124	2.836762391	0.104202326	0.067	0	0.54195026	0.54195026	0.000221538	0.001511069
9/29/04 0:00	22.4333333	22.5	22.1	0.99233333	99.2333	0	0	315	0	0	0	2.4480349	2.714574414	2.725587607	2.660089335	0.164536966	0.000206451	2.714367963	0.109345254	0.067	0	0.563090406	0.56309041	0.000230017	0.0004206
9/29/04 3:00	22.0333333	22.1	21.7	0.99583333	99.5833	0	0	182.35	0	0	0	2.4489793	2.649307688	2.660089335	2.595969994	0.161076738	0.000109501	2.649198187	0.112130993	0.067	0	0.574317194	0.57431719	0.000234513	0.000304473
9/29/04 6:00	23.4	26.8	21.3	0.94816667	94.8167	111.7667	0.050295	161.03	0	0.266667	17.777778	2.4457526	2.878130285	3.523719593	2.533204981	0.173159171	0.001569753	2.876560532	0.102554035	0.067	0.0432537	0.535059315	0.57831302	0.000236456	0.01989465
9/29/04 9:00	29.6833333	31.2	28	0.63816667	63.8167	654.9	0.294705	158.9	0	2.933333	195.555556	2.43091765	4.166602962	4.543999587	3.779930364	0.239018175	0.015059377	4.151543585	0.054745282	0.067	0.2534463	0.31060811	0.56405441	0.000232034	1.464136848
9/29/04 12:00	32.7	34.1	30.8	0.52416667	52.4167	763.7167	0.343673	172.03	0	2.133333	142.222222	2.4237953	4.946118775	5.348948887	4.441691099	0.277430448	0.023293564	4.922825211	0.029375831	0.067	0.29555835	0.173409412	0.46896776	0.000193485	1.472472444
9/29/04 15:00	28.9333333	34.5	23.3	0.668	66.8	335.2833	0.150878	169	3.3	1.6	106.666667	2.4326884	3.990271075	5.469145903	2.86082113	0.230194345	0.013827745	3.97644333	0.060825701	0.067	0.12975465	0.341701025	0.47145568	0.0001938	0.761446353

Date/Time	TMP (*C)	TMPmax (*C)	TMPmin (*C))	RH	RH (%)	solar radiation watt/m^2	St, solar radian MJ./m^2/3hr	WND Wind Dir (Deg)	Rainfall (mm)	Wind speed, km/hr	U2, Wind speed m/sec	Lamda (latent heat), MJ/kg	e*, vapor pressure, kPa	e*max, kPa	e*min, kPa	Delta, Gradient, kPa/*C	Dbar, kPa	e*d, dew point vapor pressure, kPA	Epsilon, net emmisivity	Gamma, Psychrometric constant	Sn, net short wave radiation, MJ/m^2/3hr	Ln, Long wave radiation, MJ/m^2/3hr	Rn, net radiation, MJ/m^2/3hr	Rn, net radiation mm/3 hr	Ep, net evaporation, mm/3 hr
9/29/04 18:00	23.0166667	24	22.5	0.98333333	98.3833	10.78333	0.004853	260.2	0	0.266667	17.777778	2.44665765	2.812270977	2.983917477	2.725587607	0.1696955	0.000461518	2.811809459	0.105241687	0.067	0.00417315	0.546248624	0.55042177	0.000224969	0.006059041
9/29/04 21:00	22.0333333	22.5	21.7	1	100	0	0	260.2	0	0	0	2.4489793	2.649307688	2.725587607	2.595969994	0.161076738	0	2.649307688	0.112126283	0.067	0	0.574293074	0.57429307	0.000234503	0.000165615
9/30/04 0:00	22.1	22.5	21.7	1	100	0	0	260.9	2.8	0	0	2.4488219	2.660089335	2.725587607	2.595969994	0.161649137	0	2.660089335	0.111663076	0.067	0	0.572437354	0.57243735	0.00023376	0.000165263
9/30/04 3:00	21.85	22.5	21	0.99833333	99.8333	0	0	187.28	7.87	1.866667	124.444444	2.44941215	2.619854723	2.725587607	2.487005397	0.159511461	4.34383E-05	2.619811285	0.113398365	0.067	0	0.579367138	0.57936714	0.000236533	0.003926523
9/30/04 6:00	20.9333333	21	20.6	1	100	10.76667	0.004845	122.12	11.17	1.333333	88.888889	2.4515764	2.476839407	2.487005397	2.426552312	0.151876422	0	2.476839407	0.119668313	0.067	0.0041667	0.603838415	0.60800511	0.000248006	0.000172089
9/30/04 9:00	20.6	20.6	20.6	0.99916667	99.9167	54.9	0.024705	201.35	12.7	1.866667	124.444444	2.4523634	2.426552312	2.426552312	2.426552312	0.149177761	2.02213E-05	2.426532091	0.12191738	0.067	0.0212463	0.612403099	0.6336494	0.000258383	0.002030961
9/30/04 12:00	21.15	21.7	20.6	0.99583333	99.5833	143.1333	0.06441	180.25	7.36	1.6	106.666667	2.45106485	2.510012303	2.595969994	2.426552312	0.153652591	0.000104636	2.509907667	0.118202366	0.067	0.0553926	0.598200709	0.65359331	0.000266657	0.008218558
9/30/04 15:00	22.1	22.5	21.7	0.9615	96.15	165.6667	0.07455	226.18	0.25	0.533333	35.555556	2.4488219	2.660089335	2.725587607	2.595969994	0.161649137	0.0010244	2.659064935	0.111707046	0.067	0.064113	0.572662767	0.63677577	0.000260034	0.026160447
9/30/04 18:00	20.7166667	21.7	20.2	0.99066667	99.0667	4.9	0.002205	355.8	0	0	0	2.45208795	2.44405032	2.595969994	2.367387698	0.150117642	0.000231623	2.443818696	0.121141949	0.067	0.0018963	0.60947515	0.61137145	0.000249327	0.000484163

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ABSTRACT

A GIS STUDY OF LANDSLIDES IN THE LOWER LOS AMIGOS FORELAND OF PERU

by Suresh P. Khanal, MS, 2006
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A GIS study of landslides in the lower Los Amigos sub-basin in Peru, where human influence on drainage is nearly non-existent, was performed to determine environmental variables controlling landslides. GIS layers consisted of slope, landslides (381 digitized), Soils, and elevation.

I applied Ripley's K-function to estimate spatial extent of correlation between the landslides. The MIKE-SHE hydrologic model was used to determine the unsaturated soil-water pressure in the soil profile. Spatial regressions were performed between landslide counts in a 1X1 km grid and environmental variables: slope, aspect, distance of landslide from nearest river, and soil-water pressure. My conclusions are that landslides were spatially correlated at about 2km lengths, and variations of pore-water pressure in the soils significantly controlled landslide occurrence. Landslides along river meander paths may be an important factor that controls the evolution of foreland basins.