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The impact of mountainous skirts direction of Iran on differences in altitude of water and ice equilibrium line of quaternary

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Abstract

One of the factors influencing the altitude of water and ice equilibrium line is the amount of the energy received from sun which depends on the radiation angles of sun and the slope. Thus, as the surfaces slopes vary, the absorption of energy will also change. Initially, this article makes an attempt to measure the radiation angle and the energy absorbed daily by the surface of land with respect to different slopes and directions. Then, the differences between the amounts of energy absorbed by two different surfaces varying in terms of slope and direction will be estimated, considering a constant temperature. Consequently, the energy differences will be converted to altitude differences, using the statistical relations. This paves the way for the estimation of the differences in altitude of water and ice equilibrium line. Although this article has used a hypothetical altitude, the resulting finding can also be used in the context of the past ages because the altitude of water and ice equilibrium line was low at the ice age of quaternary. This study had the following findings; 1- Averaged reduction of temperature of environment is .48 per 100 meters increasing in height with reduction of temperature in Iran about 5-12°C in quaternary period height of snow is downer about 1042-2500 then current circumstance. 2- The highest impact of the land surfaces directions on the altitude of ice and water equilibrium line can be seen in the skirts whose mountainous ridges expansion is west and east. 3- The north-south expansion of mountainous ridges doesn't have any effect on the difference in altitude of ice and water equilibrium line.

Key words: altitude, water and ice equilibrium, quaternary, energy, sun radiation, slope

Introduction

In this article has been attempted by help of SPSS and surfer soft ware's and implement of densitizing and kriging to present a realistic analysis on structure of differences between the altitude of water and ice equilibrium line of quaternary in Iran. The level of energy role, temperature and geographical latitude can be specified on the regional structure of Iran latitude of water and ice equilibrium line. Such

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analysis are very useful, for example it shows that by increasing 1°C degree in environment temperature, the permanent height of snow rise up to 208 m (in case of decrease in environment temperature to 4.8°C leads to increase height up to 1000 meters) It makes possible to estimate isotherm line in every place of country at any slope and direction. The Iran altitude of water and ice equilibrium increase from was to east due to influence of thermal, cooling and humid cells position and from north to south because of the geographical latitude effects. A one degree increase in geographical latitude in slope of 13º will decline the height of permanent snow from 140m (Northern skirts) to 204 meters (eastern north skirts).

The historical Back ground of the topic

The words, glacier equilibrium line, water and ice equilibrium line and permanent height of snow are common in the glacial literature. In glacial equilibrium line, the level accumulation and ice melting are equal meaning that in a glacier two sub system can be explored. One is the ingredient accumulation section including part of glacier that more ingredient accumulated during a year and have less melting thus accumulation exceeds fraction (abrasion) the other is abrasion section which includes inverse effects, meaning that abrasion is much more compare to accumulation level, these two section borders called as glacial equilibrium line (Motamed, 2000). The water and ice equilibrium line is the line between marginal limit of glacier`s latch and level of running water caused by ice melting. Glacier would move due to various factors such as slope gravity and so on. This movement would be possible till glacier melting equal to its movements (Mahmoudi1990).

This border is known as water and ice equilibrium line. For the first the term "time permanent height of snow" had been used by Libutery (Bellreopomlor 1990) and then the term have been defined by (Sehcheglova and klebelsberg) quoted by Schweitzer 1970 as: the limit on horizontal surfaces and upper which for whole year is covered by snow. In Bellreopomlor opinion permanent height of snow was named glacial equilibrium line. Latu (Libutery and Miserly) quoted by (Schweitzer 1970, king 1970, Hawkins 1989, Humlum 1986, Ritter et al. 1993) made difference between permanent height of snow and glacier equilibrium line and have believed that could not be equal because they have various height usually permanent height of snow is higher than glacier equilibrium, in (Hawkins) opinion 1985. There is several meaning for ecological snow line which has general and limited application; this term in spite of its name refers to a level and surface, where equilibrium line is precise term with more application. In glacier equilibrium line separates ice accumulation region from ice melting one (Selby 1986, Humlum 1988). In geomorphologic view permanent height of snow is important in this respect which indicates the lowest level of glacier climate (Humlum 1998). The first condition for glacial formation is presence of permanent height of snow on the earth (0 degree isotherm) the permanent height of snow is a factor that shows relationship between glacier and climate and the dominant glacial climate on the permanent height of snow support the glacier durability, in case height of permanent line of snow exceed some more leads to mountainous glacier regression and destruction of ice cap (calyptras).

Each glacier at us higher glacier equilibrium line, is able to romove gravel from itself, in some cases, the melting snow water from upper section of equilibrium line. In the melting section influencing by freezing weather transformed to complete ice. These conditions providing the glacier aliment from lower parts (Dallaloghli 2003). There glacial latch have been element from high mountainous regions have capability to come down to foot of mountain and impose their effect to whole valley. The extent of progression can be recognized from geomorphic witnesses, almost all the height values given by various researchers (Scholars) in case of moraine observation and glaciers effects in the height less than 3000m indicating the height of ice and water equilibrium line in Iran. In Touchal northern skirts, the moraine came down up to 2200m till Shahrestanak valley bottom (Aivazi 1995) (Hagedorn et al. 1974) in the Shirkooh-Yazd indicating the existence of glaeial moraines at the height 1800 to 2800m that showing 2 glacial phases (Mahmoudi1887). Right has estimated permanent height of snow lowering up to 1800m from sea level in Kurdistan Mountains. He had observed moraines in small valley high 2600m in west south of Aznaa- Oshtorankooh (Aivazi 1995). In the Gorgan Rood valley glacial latch came down to the height of 1200m and its moraines obstructed Gorgan Rood main valley which made a crag of more than 10 meters height (Zomorrodian 2002, Pedrami 1982) refers to a glacial marks in Kashan which had been protected its lateral moraines very well. According to him glacial latchs of Sardab Rood and Chaloos River in old turgidity had been lowered up to those days Caspian water level.

He talks about small cirques with the height of 1700 m in Rood Barak village west side as well. There are about 50 large and small known cirques that most of them placed at 1800m height and more. Regarding one cirque has come down to 1600m height (Mahmoudi 1997). Ramesht (2002) is one of the researchers in glaciology of central Iran. Approved the findings of scientists like Hagedorn and Kuhle. He studied the glaciers of 1600m height and more with relience on geomorphologic observation and abrasion effects. In several point of central Iran such as Zefreh- Shirkooh emphasized on descending of ice letches till plain lands. Obviously the receiving energy from sun play vital role in lowering water and ice equilibrium line, which is affected by direction and slope of land surfaces. In this case few studies are available tough. Ramesht 2002, shoshtari zadeh 2003 have referred to Zefreh and Salafchegan ice and water equilibrium line difference of 200m very shortly.

Methodology of Data

To specify permanent height of snow or height of water and ice equilibrium line according to given isotherms by the researchers. 0 degree for permanent height of snow and 5 degree for ice of water equilibrium line are required to specify temperature difference in sloped surfaces. Temperature itself is result of various factors such as receiving energy from sun which is depends on solar radiation angle and its constant. So for this purpose we have to estimate the receiving energy from sun in various slopped surfaces. The degree of energy receiving from the sun is affected by quantity and slope direction, geographical latitude and etc. for estimation of annual radiation angle average in constant slopped surfaces. The equation I has been used (Joe Michal sky 1988) and along with this equation. The following step carried out:

1. Medium month day was used for estimation of monthly radiation angle average.

2. To specify the monthly radiation angle average in medium day of month, every 4 minute. Radiation angle was calculated and by their summation the average has been calculated.

3. Monthly radiation angle average was estimated for slope of 0 up to 90^{o} degree one by one. (Second stop was repeated 90 times)

4. For slope of horizontal surfaces in 360^{o} degree scale may be infinite variable. In this article 16 directions with 12.5 degree distance have been selected as follows:

North, North- northern east, northern east, east- northern east, east, east- Southern east, southern east, south- southern east, south, south- southern west, southern west, west- southern west, west- Northern west, northern west and North- northern west.

The monthly radiation angle average have been calculated for energy direction and slope degree (second step was repeated 16 times)

Equation I

$$\cos\theta = \sin\sigma\sin\varphi\cos\beta - \sin\sigma\cos\varphi\sin\beta\cos\gamma + \cos\sigma\cos\varphi\cos\beta\cos\sigma + \cos\sigma\sin\varphi\sin\beta\cos\gamma\sin\omega + \cos\sigma\sin\beta\sin\gamma\sin\omega$$

Solar radiation angle θ: the angle between solar direct radiation line and the vertical direction on horizon surface which is sun height angle supplementary.

Slope angle β: the angle between concerned plane surface and horizon surface.

δ: Solar dip angle for any special day of year which approximate value calculated by equation II (Stickler, 1999)

Equation II $\delta = 23.45\sin(360\frac{284+n}{365})$

In equation II n represents the number of day in a year. δ Calculation for all the days is very tough wok, so as referred, month median day have been used means that the day which solar dip angle in atmosphere outward surface is proximity value of monthly mean (Azad et al 1998).

γ Plane direction angle: perpendicularity on plane image deviation with local meridian of longitude. In northern hemispheres where γ=0 plane direction has been towards south completely and when plane direction is towards eastern south, γ has negative (-) value angle plane towards western south γ takes positive value. This angle varies up to ±180.

ω: Solar hour angle, which conventionally is negative value for pre meridian and positive for post meridian and can be achieved by the equation III.

Equation III ω=(X-12)*15

X considered as hour and indeed constant 12 is the solar meridian. Basis of 15 is the 15° earth relation in an hour, in order to different length of day during the year. For precise calculation X assigned as a variable with maximum range of 5 to 20 for June and July and minimum range of 7 to 17 for December and January. For Cosθ estimation in equation I digits accordingly between 105- 135 varying by 4 digit interval and substituting ω (earth radiation is one degree every 4 minute this variation provide the radiation angle for energy 4 minute). In case region excludes the solar radiation solar height become less than zero (negative) and the estimated quantities do not contain the data and have not any effect on monthly solar radiation angle. The reason for this calculation is estimation of annual radiation angle in sloped surfaces with different direction. For horizontal plane β value is zero and equation I get simplified to equation IV.

Equation IV

$$\cos\theta = \cos\sigma \cos\varphi \cos\omega + \sin\sigma \sin\varphi$$

For estimation of total receiving energy during each unit of time equation V is used (Alizadeh 2006)

Equation V I=W. $\sin\alpha$

I: Amount of receiving energy per minute Cal/Cm^2

W: Solar constant at point of space which earth atmosphere is formed (started) its quantity is Cal/Cm^2 per minute.

α: Sun height- the angle between sun direct radiation side and horizon direction and θ supplementary (radiation angle) so Cos θ is equal to Sin α and in equation VI $\sin\alpha$ can be substituted by Cos θ.

5. Annual average of radiation in every direction and every slope degree have been specified by repeating the above mentioned steps for 12 months.

6. Annual average of radiation angle for 16 geographical latitude in Iran (25° to 40°) calculated by above steps as well.

7. Value of solar constant on the earth surface is affected by many factors such as geographical latitude, sun radiation duration (time), variegation rate, relative humidity, water vapor pressure, regularity of weather and etc. For solar constant value estimation on earth surface, given values of energy on horizontal balance of radiometer networks were used for higher confidence coefficient.

Data of ecological station equipped with radiometer during index period (1966-91) and including temperate, total radiation on horizon surfaces height and geographical altitude and latitude of the stations. The quantity of energy received by station has been estimated by Khalili (1997) and temperature average and others required information have been collected from metrology organization site. Spatial variation of receiving radiation sun are negligible in compare with some of meteorological factors such as rainfall, except micro ecological conditions which may influence visibility at point because of special cloud coverage situation or related phenomenas. Every station can represent the radiation condition of a region up to 100 km of distance and more (Azad et al. 1972) considering this and 16 radiometry station in country and by illustrating perpendicular line between a bistation networks. Iran was divided into 16 parts (Khalili 1997). Regarding that in the Quaternary period the north region was influenced by Atlantic ocean and Meditrean and Caspian sea (Tahoni 2004) and further more because of 2 different existing climatically region in north Iran, for accurate examination of quantity of received energy in north Alborz skirts, Tehran station information's were used. Although in estimation, Ramsar station data in Caspian littoral regions are more general and its data can be used for receiving energy station in northern skirts (Khalili 1997). Considering lack of high peaks examination of Persian Gulf and Oman sea littoral regions had been ignored (plan I)

8. Then average receiving energy from sun on earth surface horizontal balance during year ($^{Cal}/_{Cm^2}$ per minutes a day) dividing on Cos$_{\theta}$ (annual radiation angle of horizon surface).

9. By dividing outcome value of previous step on total numbers of minutes a day (24 hour- 1440 min) we obtain the value of annual average of solar constant for any station on the earth.

Regarding to these discussions, in 32º geographical latitude (Yazd) the annual average of receiving energy from sun on horizontal balance of earth surface is 542/3 $^{Cal}/_{Cm^2}$ per day (Budget, planning organization) and annual average of sun radiation angle (Cos 0.514708) has been estimated for 59.2º so by the equation V have:

$$542.3=W*0.514708$$

$$W = \frac{542.3}{0.514708} = 1053.61\ \mathrm{cal/cm^2/Day}$$

$$W = \frac{1053.61}{1440} = 0.732\ \mathrm{cal/cm^2/Min}$$

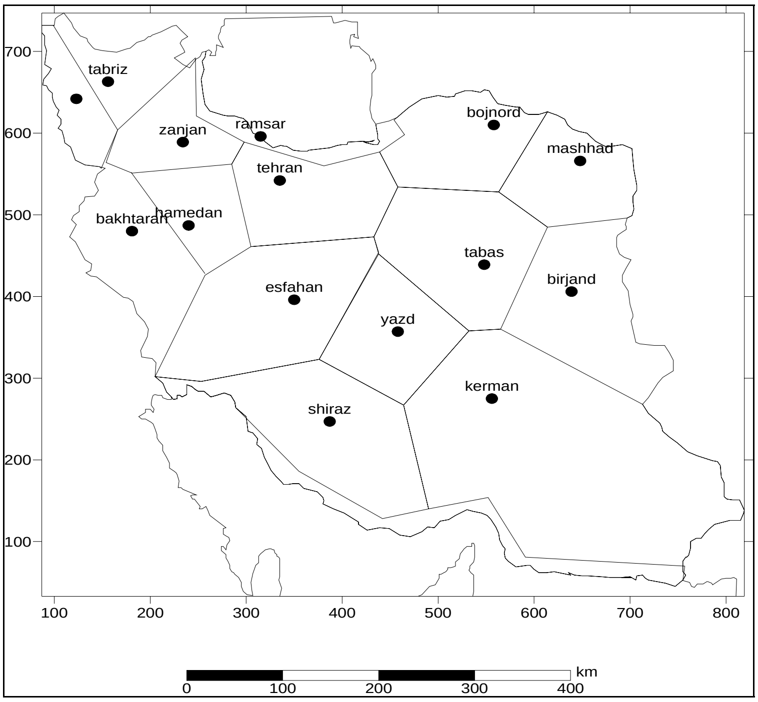

Figure 1: Iran explanting regarding to receiving energy from sun

Means annual average of solar constant for (altitude 32ºof horizon surface is 0.732 Cal/Cm^2 per minute.

10- quantity of receiving energy for every slope and direction of slopped earth surfaces can be arrived from equation 6.

Equation6

$$\frac{\text{annual average of receiving energy from sun}}{\text{Cos}\theta \text{ in horizon surface}} * (\text{Cos}\theta \text{ annual surface})$$

11. for energy transformation into temperature, first between the monthly average of receiving energy (Cal/Cm^2 per day) and monthly average of temperature (°C) in every station linear equation established (table 1) then annual average of receiving energy calculated in previous step with help of these equations, had replaced with temperature average.

12. for estimating average of earth surface slope by using the value of slope situation in Iran according to 109 page of Iran slope map (Aivazi 1995) and equation 7, the regions which have possibility of transforming and passing of Quaternary glacier have been carried out.

Table 1: Temperature and energy equation in selected stations

Station	temperature of energy equation in each station	Correlation co efficient	Station	temperature of energy equation in each station	Correlation co efficient
Ahvaz	T= -1.933+0.0647E	0.927	Shiraz	T= -9.317+0.0577E	0.916
Bakhtaran	T= -10.458+0.0623E	0.899	Tabas	T= -5.796+0.063E	0.954
Birjand	T= -10.142+0.058E	0.955	Tabriz	T= -9.315+0.0465E	0.930
Bojnord	T= -8.533+0.0597E	0.933	Tehran	T=-7.59+0.0613E	0.929

Esfahan	T= -10.525+0.0595E	0.923	Zanjan	T= -11.918+0.058E	0.902
Hamedan	T=-12.326+0.063E	0.926	Yazd	T= -7.341+0.0483E	0.975
Kerman	T= -11.57+0.064E	0.967	Oromieh	T= -9.309+0.0464E	0.928
Mashhad	T=-7.822+0.060E	0.956			

Equation 7 $S = \sum \frac{a*s}{A}$

S: Average of slope for assigned surface.

a: Area percentage of each slope parts to percentage area of total assigned surfaces.

s: slope percentage of each port of surfaces.

A: sum of total percentage of assigned area.

For example average slope of skirts surface or mountainous or rocky surfaces are calculating as follows:

$$\frac{6*40+11*22.5+9*12.5}{26} = 23.3\% = 13^\circ$$

And average of interior plateau slope, plateaus and littoral plateaus trace on slope surfaces of diluvia plateaus, glassy, pediment, wild skirts of plateaus, margins and abrasive surface:

$$\frac{9\times12.5+12\times7.5+9\times4+20\times1.5}{50} = 3.42\% = 1.96^\circ$$

For example at 1230 m height (Yazd) earth surface with 13° slope to eastern north have mean temperature of 16.177°C and to southern most mean temperature will be 4°C. Now regarding to environment temperature tall 4.8°C per 1000m in Iran (Masoodian 2003) we have:

$$\frac{16/177 \times 1000}{4/8} = 3370.2 + 1230 = 4600.2$$

So actual permanent height of snow in northern east skirts is at 4600m height and southern west skirts will be at 5608 m. Estimated permanent height of snow in northern east is very close to the permanent height of snow given by Grouter (1978) for Shirkooh (4600-4700m). So we can generalize directions of northern west- south east with inffluence of earth surface with 13° slope towards northern east (shady skirts) and southern west (sun exposed) for central Iran Mountains. So likewise for the rest of Iran regions after specifying direction and affluent earth surface slope for receiving solar energy, the permanent height of snow and height of water and ice equilibrium line had been calculated, 28 height peak of country were specified by examination of affluent earth surface direction on quantity of receiving energy which affluent direction are as follows: 19 cases the northern east and southern west skits (67.86%) double peak, west- northern west and east- northern east (7.14%) five-peaked, east- northern east and west-southern west (17.86%) and double peak, eastern and western skirts (7.14%). In any part of Iran the affluent surface in permanent height of snow cannot be in south or north direction. By comparing 2 station (Ahvaz of Tabriz) with almost 6° geographical latitude difference and same geographical altitude (48.5°) locations what is resulted is the permanent height of snow with different direction by increasing geographical latitude have intangible variation which can be ignored.

In other words, difference in snow line has least relativity with geographical latitude and at every geographical latitudes this different in most sun exposed or shaded areas is about 1500m. This value is more than 500m for east- southern east and west- northern west skirts and in west or west direction is zero.

Variation average of snow line height between shady and sun exposed skirts is around 1435m, and average of Iran snow line height is 4170m, and its median is 4353m. The table Π shows the water a ice equilibrium line height difference in Yazd.

Table 2: water a ice equilibrium line height difference in Yazd

Direction / City	N or S	SSE or NNW SSW or NNE	SE or NW SW or NE	ESE or WNW WSW or ENE	E or W
Yazd	1608	1429	1008	540	0

Conclusion

The most outstanding direction of earth surface slope of Iran rough skirts are towards northern east and southern west. Such directions are spread from 28^{o} to38^{o} northern latitude 46^{o} to 62^{o} eastern altitude. The permanent height of snow at 13^{o} slopped surface of southern west skirts of Shirkooh- Yazd is 5608m, and for northern east skirts is 4600m and their permanent height of snow difference is more than 1008m, in case of 8.8°c environment temperature fall in Pleistocene period the permanent height of snow had been 1834 m less than actual permanent height of snow, means that permanent height of snow for shaded skirts would be 2760 m, its water and ice equilibrium line in case of accordance with Quaternary 5°C temperature, had been 1042 m less than permanent height of snow at 1725m height. Some parts of Tallish Mountains (Bagharodagh peak. Iran- Turkey and Iran- Iraq Boundary Mountains (Ghandil peak) have northern-southern expansion. This expansion examination in different geographical latitude representing that in earth surface skirts such expansions towards east and west have no effect on quantity of solar receiving energy and do not cause any different in height of water and ice equilibrium line the slope of earth surface skirt of Peru peak in Kurdistan is towards north- northern east and south- southern west. Such surface can lead to 1436m height difference in water and ice equilibrium line.

The affluent direction a Sabalan peak skirts is west- northern west and east- south east, and for Sahand, Hezar, Taftan, and Shahvar (Kurdistan and Kermanshah border) mountain skirts are toward east-northern east and west- southern west, the earth surface of those two group function convectively regarding to receiving energy and with geographical latitude proportion creating height difference between 523 to 586m in water and ice equilibrium line. In shady skirts any degree increase or decrease in earth surface slope can cause about 40m decrease or increase on height of snow line and for sun exposed skirts any degree decrease or increase in slope leads to 29m decrease or increase in height of snow line.

If assume the water and ice equilibrium line regarding maximum height difference from north to south with 13º slope and 1608m height, and examine the assumptive height of water and ice equilibrium line of other direction based on this height the results are shown in figure I (geographical latitude 32º north and geographical altitude 54º east). As seen in this figure, height of water and ice equilibrium line of the south direction. Coinciding to 1608m by reducing disposition of earth surface slope direction to south, water and ice equilibrium line height decreased gradually till that become zero for northern slopped earth surfaces meaning that permanent height of snow as well as water and ice equilibrium line reach to the maximum in south and minimum in north.

Figure 2: Assumptive height of water and ice equilibrium line in different direction (Yazd)

Regarding to quantity of solar receiving energy if we divide the direction of earth surface slope of Iran rough skirts into 2 eastern and western halves for both halves by increasing distance from south, water and ice equilibrium line will reduced so because of less received energy water and ice equilibrium line place in lower height and approach us median in west or east direction. Afterward the height of water and ice equilibrium line reduces till that reaches to its minimum in north. Therefore, two eastern and western halves regarding energy receiving function convectively to each other. As whale water and ice equilibrium line in east to south skirt compare to east to north skirts is higher due to more solar receiving energy the same situation can be seen in west to south skirts as well as west to north skirts.

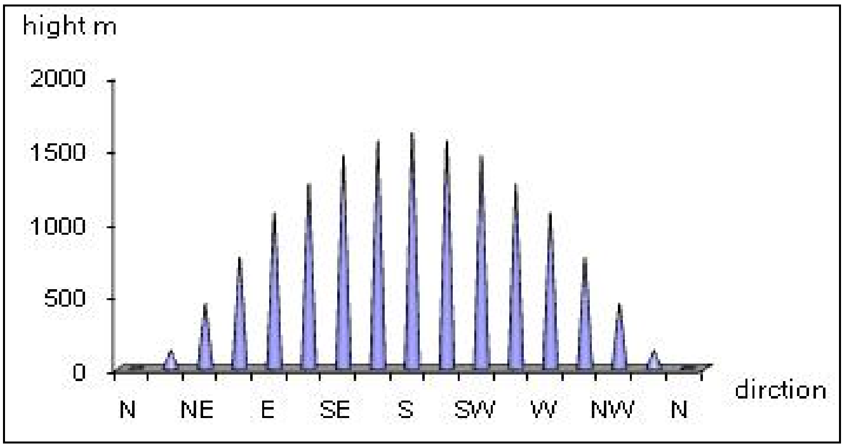

Figure 2: Assumptive height of water and ice equilibrium line in different direction (Yazd)

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