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Certain aspects of incident global solar radiation distribution over the project area with special reference to Lake Victoria

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ABSTRACT. With the aid of mean monthly fully analysed charts of incident global solar radiation (IGSR) over the Project Area, isopleth planimetering was used to derive the mean monthly values of IGSR over Lake Victoria. A graphical presentation of results indicated a wave configuration for each of the five years of study 1970 to 1974, as well as for the 5-year mean. Two maxima of IGSR were found to occur during or about the equinoxes and two minima each at or about the summer and winter solstices. The waveform approximated in phase that constructed from Angot values over equatorial regions but differed in amplitude. The sunshine duration was found to be in good phase with the IGSR at least for the individual year plots but not quite so for the 5-year mean.

By comparing the mean monthly charts to the 5-year mean monthly charts of IGSR over the Project Area also, the main quasi-permanent configurations of this parameter were brought to light. Three centres of low IGSR were found to exist; one over Lake Victoria, the second over east central Uganda with an extension northwestwards as a trough along or parallel to Lake Kyoga and the Kyoga Nile and both surrounded by high IGSR values while the third lay in Kenya outside the belt of surrounding highs. The monthly and seasonal changes in the order of magnitude of the centres were small, approximating the order of the observational error in IGSR as recommended by the World Meteorological Organization (WMO 1971), for which reason therefore, they were said to be semi-stationary.

1. Introduction

The East African lakes of Victoria, Kyoga and Mobutu Sese Seko together with the upper reaches of the White Nile form a coupled system of great importance for the social and economic developments of the millions of people who inhabit their catchments as well as those who live in the Nile Valley — the Sudan and Egypt. These lakes regulate the flow of the White Nile.

By far the largest and also the most important is Lake Victoria which has a surface area of some 70,000 sq. km including the islands. It ranks second to Lake Superior as a fresh water lake in the world. Lakes Mobutu Sese Seko and Kyoga are of limited extents approximately 6000 and 5000 sq. km respectively. The catchment area of the upper Nile basin up to Nimule at the Uganda/Sudan border is some 411,000 sq. km of which 87% lies in Uganda, Kenya and Tanzania and the remaining 13 % in Rwanda, Burundi and Zaire. The project area, as shown in Fig. 1, is 80 per cent of the upper Nile basin.

The potential control and regulation of the lakes, Nile system offer several advantages to be gained. These can adequately be summarised to include schemes for irrigation to realize agricultural development, swamp reclamation, hydroelectric power generation, transportation, fisheries, recreation and domestic and industrial utilization. The realization of the potential of the system was sharpened by the unprecedented rise in the levels of the lakes in the catchment area with subsequent submersion of shorelands in the early sixties (RAF 66-025, UNDP/WMO Tech. Rep. 1, 1974). For Lake Victoria, the mean level rose by 1·25 m in 1962 over that of the previous year. The level actually started rising in November 1961 and reached its peak in May 1964. Such a peak had not been recorded since the beginning of the century. With this 'signal' therefore, attention was focused on the control of the levels of these lakes using them for storage and regulation. The five countries, namely, Egypt, Sudan, Uganda Kenya and Tanzania, therefore, requested the assistance of the United Nations Development Programme in a hydrometeorological survey with the aim of studying the water balance of the lakes. The hydrometeorological survey of the catchments of Lakes Victoria, Kyoga and Mobutu

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Fig. 1. The project area and radiation network

Sese Seko was therefore initiated with its headquarters at Entebbe in August 1967. In 1972, the five countries requested Rwanda and Burundi to join so that the operational areas of the project could well be extended to cover the Lake Victoria catchment there. Zaire joined in 1977 while Ethiopia is an observer.

2. Objectives of paper

This paper deals with certain aspects (to be specified) of incident global solar radiation distribution over the project area with special reference to Lake Victoria. This special reference is understandable since the White Nile which provides for the life saving vegetations in many parts of the Sudan and Egypt originates from this lake at Jinja in Uganda. The water balance studies of Lake Victoria is therefore of immense importance. In addition, because of its large size, it goes further to bring about local influences to bear on the climatology of the surrounding areas.

Evaporation is a component of the water balance equation. Its determination by the energy balance technique necessitates the availability of radiation data. It is therefore evident that fields of radiation not only over the lake but also in the rest of the project area be known. Over the land parts such fields are also important for determining evapotranspiration. The objectives of this paper are concerned with the incident global solar radiation component and these can be put thus :

(1) Survey the mean monthly and 5-year mean monthly distribution of IGSR over Lake Victoria for the period 1970 to 1974.

(2) Present 5-year mean monthly maps (at representative months of January, April, July and October) of IGSR over the project area for the same period as in (1) and in so doing show the existence of the quasi-permanent centres of low and high IGSR over the Area.

(3) Prove the semi-stationariness of such centres in (2).

Implicit in the contention of the production of mean maps is the fact that these are useful because they can convey quite a rapid, vivid and impressive picture of the spatial distributions of a parameter. In addition they provide patterns which might prove useful for understanding of the physical relationship between different hydrometeorological parameters. Mean values may also remove noises of random nature. Indeed for this reason they have been used extensively for specified periods of time for studying the behaviour of the general circulation.

3. Network, instrumentation and data used

At present there is a reasonably adequate network of IGSR stations throughout the length and breadth of the project area to provide data for the operational use of energy budget computations. Of a total number of 77 radiation observing stations, 35 are maintained by the project, the rest being administered by various agencies includding water development departments (or ministries), the then East African Meteorological Department (EAMD), agriculture, forestry as well as game departments in parts of the project falling in the respective participating countries. Fig. 1 shows the radiation network in the project area. It may be pointed out that Entebbe has three different observatories with the Hydrometeorological Survey Project (HMS), the EAMD and the Water Development Department each maintaining an observatory.

Over Lake Victoria, the network density is somewhat below adequate and is characterized by the presence of only 5 island stations somehow unevenly located and therefore not conforming to a reasonable grid from the point of view of overwater radiation network design. There are 8 shore stations. Not net radiometer stations nor incident longwave radiation stations exist in the project area. It is therefore evident that to apply energy budget tehniques to hydrometeorological problems over Lake Victoria, the longwave radiation components will have to be estimated empirically whereas the shore and island stations can be used to estimate the mean IGSR over the lake, the reflected component being taken care of adequately by the well established knowledge of the nearly constant albedo (3-6%) of a water surface throughout the electromagnetic spectrum.

The instrumentation (for the project area as a whole) consisted of the following:

(1) Moll-Gorczynski pyranometers at each of the coastal stations, namely, Entebbe, Kisumu, Musoma, Mwanza and Bukoba.

(2) Rimco automatic solarimeter at the central island station of Nabuyongo in Lake Victoria.

(3) Gunn-Bellani radiation integrators at the rest of the stations.

(4) All stations were equipped with the Campbell-Stokes sunshine recorder (tropical model).

The data were extracted from climatological year books published regularly by the Data Processing Centre of the HMS at Entebbe. These contained daily totals of IGSR, mean monthly as well as annual values for most of the first order meteorological stations and with complete yearly returns though not for others. As Rwanda and Burundi joined the project in 1972, the radiation data from stations in this part of the project area were only available for 1974 and were thus excluded; the Zairean part actually had no data. With regard to the representativeness of the data, those from the Moll-Gorczynski pyranometers and the Gunn-Bellani radiation integrators were quite acceptable. Because the Moll.-Gorczynski pyranometer data at the project's Entebbe meteorological station were not included in the climatological year books (they being unprocessed at the time), observations of the then EAMD Gunn-Bellani integrator (at nearby Entebbe International Airport) were substituted. Rimco solarimeter data from the island station of Nabuyongo were, however, unacceptable on account of their unreliable nature. The data showed a tendency of falling levels with time suggesting a possible loss of instrument sensitivity.

4. Mode of analysis and computation

4.1. *Temporal distribution of IGSR over Lake Victoria*

The mean monthly values of IGSR over the whole of the project area were plotted on charts and analysed at isoline intervals of 20 cal cm^{-2} day^{-1}. The isoline values over Lake Victoria were then planimetered leading to each mean monthly IGSR, R_s, being computed through the relationship :

$$R_s = \frac{\sum_{i=1}^{N} A_i R_i}{\sum_{i=1}^{N} A_i} \quad \text{cal/cm}^2\text{/day} \qquad (1)$$

where A_i = partial area between two isolines of IGSR

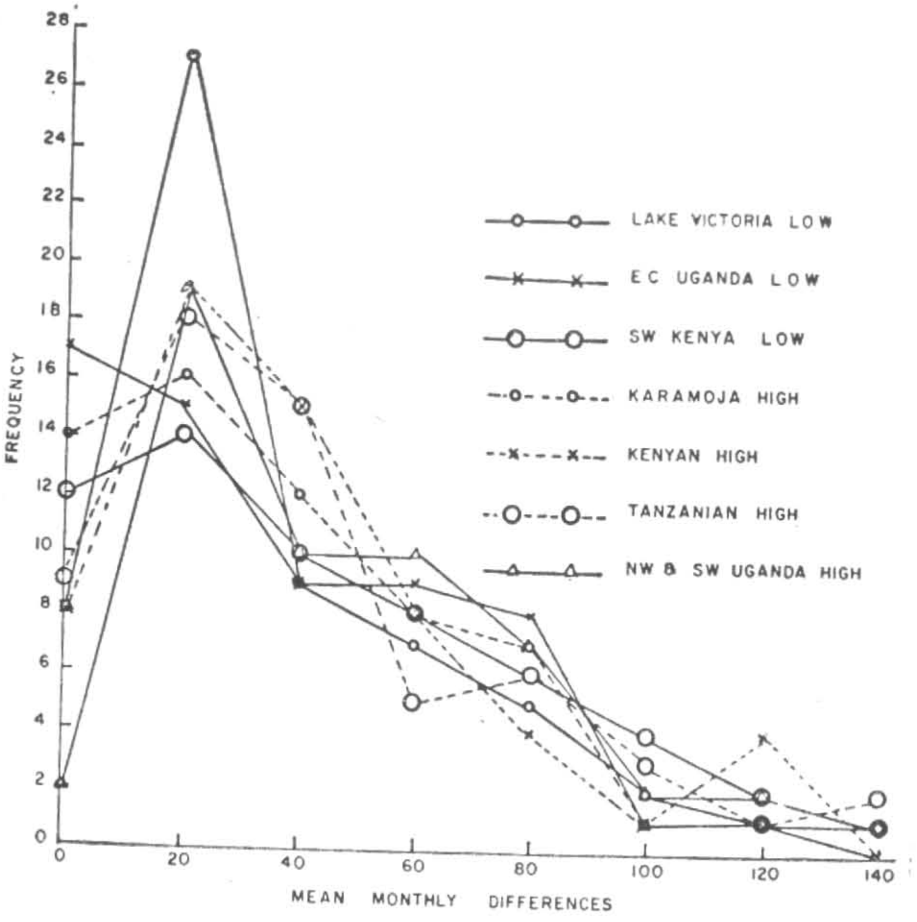

Fig. 2. Frequency diagram of mean monthly differences of incident global solar radiation

TABLE 1

Incident global solar radiation (cal/cm²/day) over Lake Victoria

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1970	377	473	425	453	443	448	406	375	402	412	403	386	417
1971	423	456	477	391	423	431	407	383	451	444	442	394	427
1972	432	374	481	458	426	384	429	436	442	427	416	440	429
1973	442	472	486	429	411	413	395	421	394	441	378	406	424
1974	454	471	399	418	379	389	351	405	423	432	396	434	413
5-Year mean	426	449	454	430	416	413	398	404	422	431	407	412	422

R_i = mean value of IGSR over the partial area, A_i

N = total number of partial areas.

Because of the rather sparse observational data over Lake Victoria, considerable care and effort was exercised in arriving at the final mean monthy IGSR.

The following technique was adopted :

First, the monthly value for the lake taking the average of the shore station radiation data was computed. Next, the monthly value for the lake taking the average of the shore and island station radiation was calculated and lastly a comparison was made between the first and second values so computed. If the second value was greater than the first, the analysis and the planimetering of the relevant chart was checked; otherwise to the contrary, the planimetered value was accepted. This technique was adopted because of the indication of centres of low IGSR configuration over the lake as revealed by the analyses. However, a source of bias in the statistics that went into the analyses of the averaging was that some of the shore and island stations had missing data for months, some for as long as a year. In such cases the averaging number was reduced from 8 to 6 (shore stations) and from 13 to 8 (for shore and island stations).

4.2. *Delineation of significant features revealing the quasi-permanent configurations*

Each of the fully analysed mean monthly charts (in 4.1 above) of the IGSR over the project area spanning the five years under study were carefully examined and all possible existing configurations together with their corresponding frequencies were noted as follows :

Configuration	Frequency of existence out of 60 occasions
(*a*) Low over L. Victoria	55
(*b*) Low to the east central of Uganda north of L. Victoria and extending northwestwards along Lake Kyoga and the Kyoga Nile as a trough	60
(*c*) Low over southwest Kenya	59
(*d*) Low to the northwest, southwest, south or southeast of or over Entebbe (This configuration is not to be confused with that over L. Victoria should it lie on the lake)	29
(*e*) High over the extreme northeast of the project area in Uganda's Karamoja region	60
(*f*) High over the Kenyan highland part of the project area approximately on 0°N, 35°E	60
(*g*) High to the east and southern shores of Lake Victoria on the Tanzanian land part of the project area	60
(*h*) High to the northwest of Uganda	60
(*i*) High to the southwest of Uganda	55

It may be noted that the low or high centre above refers to the isoline enclosing value in configuration under consideration. The choice of the quasi-permanent features as arrived at by a process of elimination as regards the (arbitrary) probability of finding a particular configuration on all sixty monthly charts (for 5 years). If the probability was 55/60 or above ($\geqslant$90 per cent), the feature was accepted as quasi-permanent, otherwise no quasi-permanency was conceived for probabilities below 55/60. By the successive application of this principle, the configurations (*a*) to (*i*) reduced to the following:

(*i*) Low over Lake Victoria

(*ii*) Low to the east central of Uganda

(*iii*) Low over southwest Kenya

(*iv*) High over Karamoja

(*v*) High over Kenyan part of project area

(*vi*) High over Tanzanian part of the project area

(*vii*) The combined highs of northwest and southwest Uganda (as a matter of fact these two were a coupled system and were occasionally separated by cols though on five occasions they were separated by lows).

In addition, 5-year mean monthly maps of incident global solar radiation were also prepared using 5-year mean monthly IGSR values for the period 1970 to 1974. The above seven configurations were then compared to the features appearing on the 5-year mean monthly maps.

4.3. *Delineation of significant features revealing the existence of semi-stationariness*

The procedure was as follows :

(*i*) The month-to-month differences (regardless of sign) of each centre of the seven configurations were determined only to reveal the following characteristics :

(a) There were zero differences for upto 3 consecutive months.

(b) There were 20 cal cm^{-2} day^{-1} differences for up to 5 consecutive months

(c) Maximum differences observed weres some 120-140 cal cm^{-2} day^{-1}.

(*ii*) A frequency diagram of such differences for each configuration was constructed revealing a peak at around 20 cal cm^{-2} day^{-1} as shown in Fig. 2.

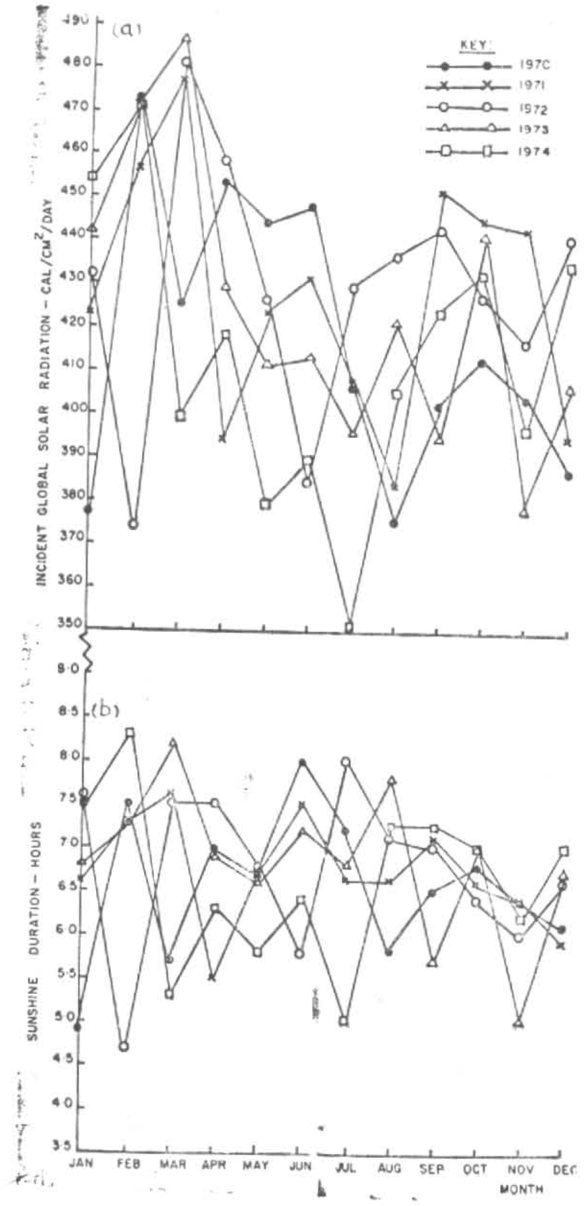

Fig. 3. March of mean monthly (a) incident global solar radiation and (b) sunshine duration over Lake Victoria, 1970 to 1974

5. Results and general discussion

5.1. *Temporal distribution of IGSR over Lake Victoria*

A graphical presentation was adopted for preference, however, a tabular form of results is provided in Table 1. Fig. 3 (a) shows at the IGSR monthly plots for each of the 5 years while Fig. 3(b) shows the mean monthly plots of the sunshine duration for the respective period (obtained in much the same way as the IGSR — by isoline analysis). Fig. 4 shows the plots of the 5-year mean monthly IGSR and the 5-year mean monthly sunshine duration (broken lines).

Monthly plots for all years did not display regular and smooth patterns. All were characterized by some kind of 'saw-teeth' shapes of maximum and minimum IGSR. However, features of outstanding clarity were the definite primary peaks occurring in and around February or March. These cascaded

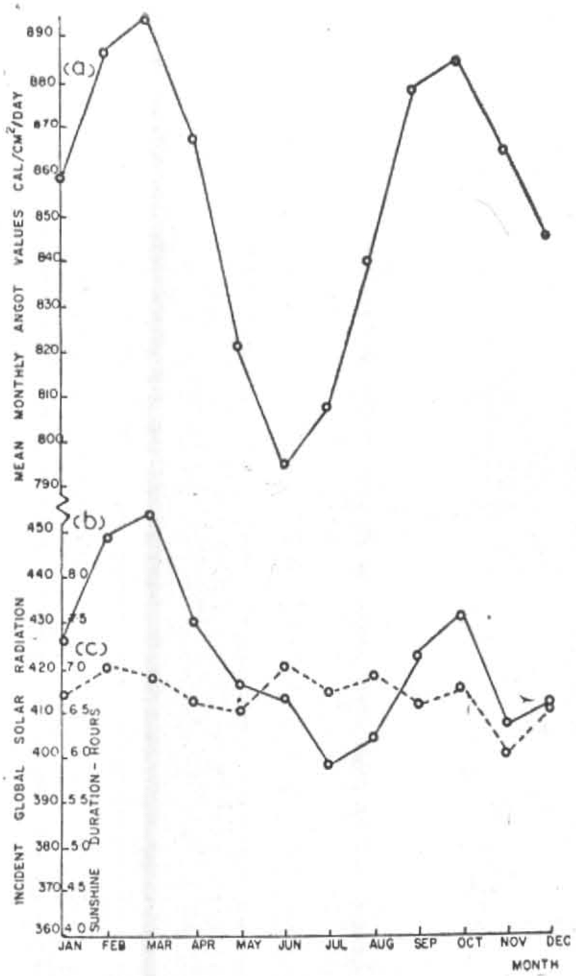

Fig. 4. Monthly march of five-year mean values of Angot values for equatorial latitudes, incident global solar radiation and sunshine duration over Lake Victoria

through a series of maxima and minima reaching their lowest point about July or August, though this happened earlier (June) in 1972. This cascading process is well examplified by 1974 in Fig. 3(a). Secondary peaks then followed in September or October, then to minima again during November, December or January. On the 5-year mean level, the primary and secondary maxima were brought out clearly respectively in March and October with the minima in July and November as shown in Fig. 4.

A feel for the order of magnitude of the IGSR showed that :

(*i*) The lowest mean monthly IGSR occurred in July 1974 (351 cal cm^{-2} day^{-1}) while the maximum was in March 1973 (486 cal cm^{-2} day^{-1}).

(*ii*) The mean annual variations were rather small ranging from 413 cal cm^{-2} day^{-1} in 1974 to 429 cal cm^{-2} day^{-1} in 1972.

(*iii*) The 5-year mean monthly values showed a minimum of 398 cal cm^{-2} day^{-1} in July and a maximum in March (454 cal cm^{-2} day^{-1}) with an 'annual' mean of 422 cal cm^{-2} day^{-1}.

Any study seeking the interpretation of the climatology of Lake Victoria must not disregard its location. Generally speaking, it can be said to lie wholly south of the equator which runs across its northern shores. Its 'centroid' is located very roughly at about 1° S, 33°E. The consequence of this location is that the lake witnesses the overhead sun twice each year as the latter migrates. Therefore the interpretation of the temporal distributions of the IGSR pattern must be attributed, among other things, to this fact. Whereas the month-to-month pattern for a particular year does not display (in some cases) a definite trend either upward or downward, the seasonal patterns do show some consistent rhythm. In fact the picture is brought out more clearly by a resort to the 5-year mean

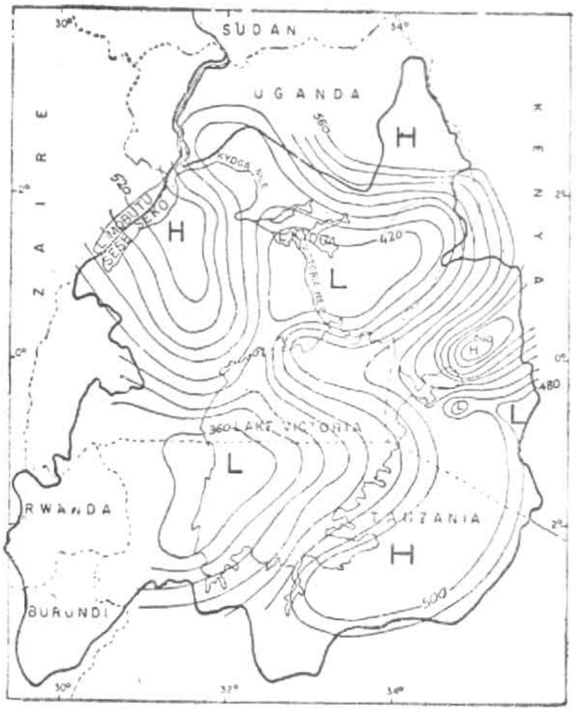

Fig. 5. January

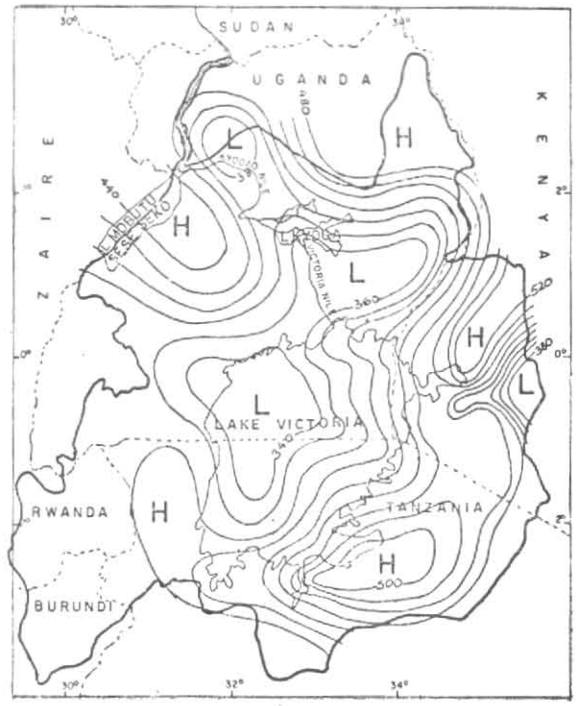

Fig. 7. July

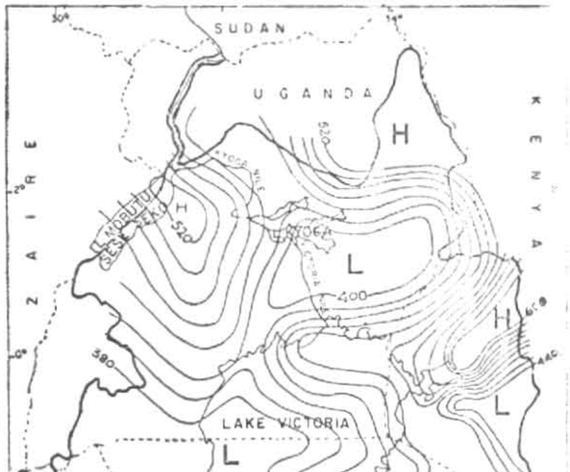

Fig. 6. April

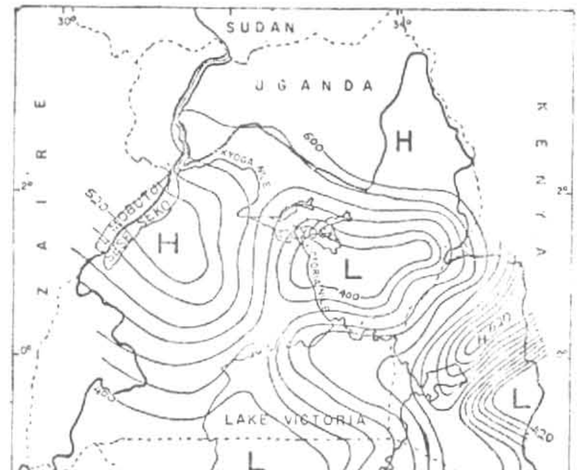

Fig. 8. October

Figs. 5-8. Five-year mean monthly incident global solar radiation distribution over the project area

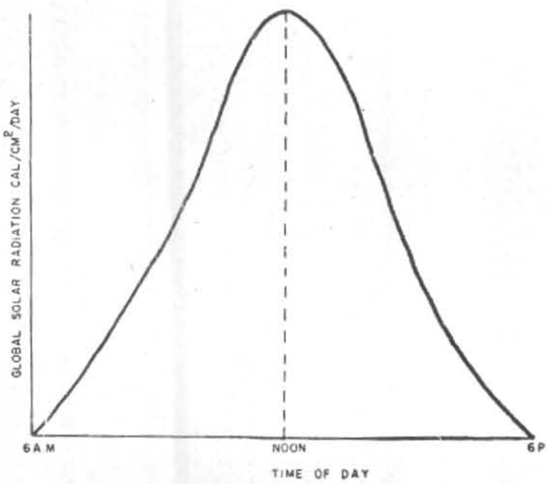

Fig. 9. Daily variation of incident global solar radiation — idealized

configuration. Thus indications of a complete phase relationship between this observed distribution and the equatorial latitude Angot values*, that is, the total solar radiation at the top of the atmosphere in one day, were evident although the amplitudes were dissimilar as shown in Fig. 4.

5.2. *Comparison of the temporal distribution of IGSR over Lake Victoria with that of sunshine duration*

Processes which are known to deplete the solar radiation from reaching the earth surface are :

(*i*) Rayleigh scattering by pure air molecules,

(*ii*) Abosrption by atmospheric gases in selected wavelength bands of the electromagnetic spectrum, especially by water vapour and clouds and

(*iii*) Extinction by particulate scattering especially haze layers.

The extent of the effects of factors (*i*) and (*iii*) cannot be stated categorically, however, water vapour and clouds may be the dominant ones over the project area and more particularly over Lake Victoria. The use of the amount of cloudiness as a measure or otherwise has the advantage that it can be observed both day and night although night values are generally of a doubtful quality. However, it has the disadvantage that equal amounts of clouds as reported do not always seem to refer to the same degree of cloudiness. Per cent sunshine (or relative sunshine duration) contains essentially the same disadvantage as using the amount of cloudiness, however, it is only an index to cloudiness during the daytime. Thus although in Figs. 3(a) and (b) the sunshine durations do show very good trends to the IGSR, it is clear that there is no linear relationship as far as actual values are concerned. This point is illustrated by considering the peaks of IGSR and sunshine duration during February 1970 and June 1970 with reference to Figs. 3(a) and (b). A value of 473 cal cm^{-2} day^{-1} corresponds to a sunshine duration of 7.5 hours in February whereas in June a value of 448 cm^{-2} day^{-1} corresponds to a sunshine duration of 8.0 hours. In this regard it can be asked why a lower value of IGSR could not correspond to a lower value of sunshine duration as well; or similarly with higher values. The 5-year mean plots were quite satisfactory although the sunshine duration did not display the same trend from May to June and from August to September in Fig. 4. It may probably be that in these 5-year mean values, as in individual years, the minimum in June or July occurred at a time when the sun was far to the north and at a time when the mean precipitation (clouds and water vapour) over Lake Victoria was at a minimum. Thus although the IGSR was low because of astronomical and geometrical factors, the sunshine duration continued to be high in 'supposedly' cloud free months (minimum precipitation).

5.3. *Quasi-permanency*

The resulting configurations obtained by the process of elimination matched those constructed from the analysis of the 5-year mean values. This led one to think that the seven features exhibited some form of quasi-permanency in view of the IGSR distribution over the project area. Figs. 5 to 8 show these features. Thus only 4 out of 12 charts have been presented for the representative months of January, April, July and October. This was done in uniformity with literature from the rest of the world and to a lesser extent because of the small spatial and temporal variabilities exhibited by the IGSR fields.

For contrasting between the minimum and maximum centres of IGSR, those selected for

*Angot values are available in the Smithsonian Meteorological Tables—Sixth Revised edition. These values were plotted against the corresponding specific days. A smooth curve was then drawn through these points. The Angot values for each day in the month was then read off from the graph; a summation of such values was made and the average taken to give the mean for the month

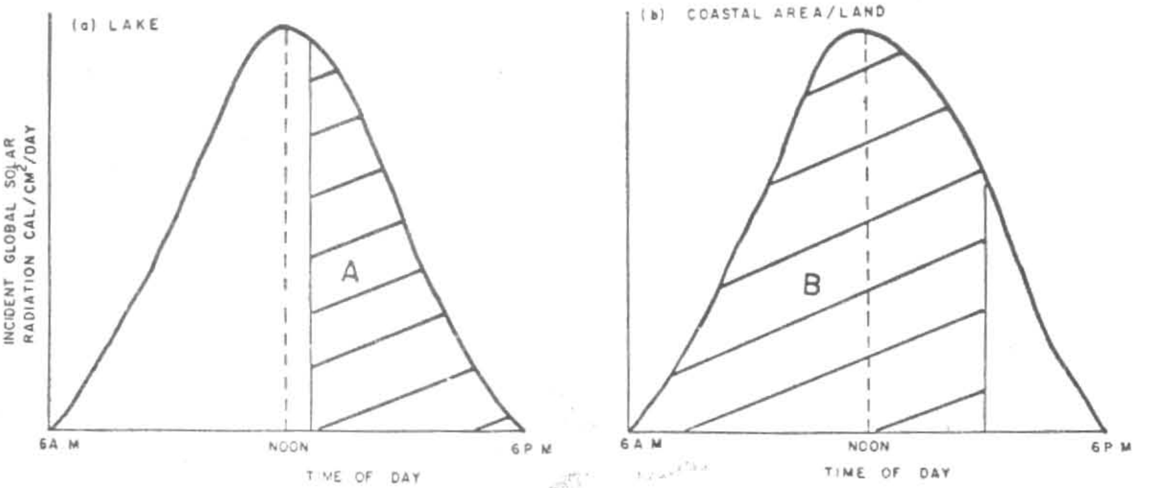

Fig. 10. Proportion of incident global solar radiation (shaded) at the surface over (a) Lake Victoria (b) Eastern coast of lake and adjacent land areas during a rainy day — idealized

Note : Area A less than area B

interpretation were the low over Lake Victoria and the high radiation centre over the Kenyan part of the project area bordering the northeastern shores of Lake Victoria. The intensity of radiation falling on a given receiver on the earth's surface is influenced by a number of factors which may adequately be classified as astronomical, geometrical, physical and meteorological. Thus in a transparent atmosphere where there is no absorption by water vapour and clouds, no reflection back to space by clouds and no scattering by pure air molecules and particulate matter, the daily variation of the IGSR at a point would follow a symetrical cosine response depicted by the graph in Fig. 9. Over the project area, possibly because of the 'clean' nature of the atmosphere resulting from being 'washed' by the 'continuous' precipitation throughout the year, particulate scattering can reasonably be ignored for most of the time except over the drier areas (for a period of approximately 3-4 months per year on average) in extreme northern and southern parts as well as some portions in the east and west of the project area. The extent to which particulate matter can be advected into the central regions of the project area is, however, not clearly understood. But it can be guessed that since the prevalent flow over the area is mainly some easterly and thus from the drier parts of Kenya and central Tanzania, the influx of particulate matter is almost probable. With this single aspect apart in any case, the main depletion of IGSR over Lake Victoria is thus due to water vapour and clouds and therefore is bound to flow very closely the dynamics of the rain producing mechanisms there. Datta (1977) in a study of the dynamics of precipitation over Lake Victoria, showed that over the west coast, west lake and central lake, the maximum precipitation occurs during the early morning with a peak around 0800 hr. Thus the clouds are apt to remain well up to midday thus shutting out the sun for over half the daytime (some allowance may be made for part of the diffuse component which reaches the surface). Evidence for this has been provided by satellite cloud pictures over Lake Victoria as pointed out by (Flohn 1972). Over the east coast, Datta (1977) has also shown that the chances of precipitation increase after 1600 hr by which time a very high proportion of the daily solar radiation has already been recorded. There is no reason why this aspect should not be extended to the adjacent land areas where continentality and lake breeze effects are very prominent. Thus inland maximum development should coincide with the peak of the lake breeze effect producing maximum convergence with the prevailing easterlies. This leads one to think that maximum insolation should occur over the adjacent land areas and minimum insolation over Lake Victoria during rainy periods (days). These features are clearly brought to light by consideration of Figs. 10 (a) and (b) which are indeed self explanatory. Further inland, it may be added that the high radiation values over Kenya lie in a rainshadow region under the influence of the Kenyan highlands of the eastern Rift Valley. The precipitation dynamics there may somewhat be different.

It may be noted that following the study of Datta (1977), the low radiation centre over Lake Victoria is located near the west coast and indeed this is what has been observed for almost every month during the period 1970 to 1974. The low values of radiation over east central Uganda, north of Lake Victoria lacks any sound interpretation at the moment but it is probable that active convergence here may be the prime dynamical factor reinforced by continentality. Relief may play a part in explaining the daily variation of cloud formation and dissipation over southwest Kenya where a low IGSR centre is prevalent. The drifting of clouds from the higher areas to its east and the persistence of clouds in the morning perhaps require further studies. Lastly, the surrounding belt of highs may be attributed to the different continentalities since lake breeze effects have limited capabilities of penetration inland.

5.4. *Semi-stationariness*

On the semi-stationariness side, the frequency diagrams in Fig. 2 indicate that in all cases the month-to-month differences did not exceed 20 cal cm^{-2} day^{-1} 50 per cent of occassions for each configuration. According to the WMO (1971) the error in the observation of global solar radiation must not exceed 1 cal cm^{-2} hr^{-1} (corresponding to an observational error of about 24 cal cm^{-2} day^{-1}). Therefore, the analysis indicated that the monthly increases or decreases in the order of the IGSR lay within or was equivalent to the observational error and hence the month-to-month differences are small. This slow-changing pattern can thus be reasonably said to be semi-stationary. Season-to-season differences also indicated some parallelism to what has already been arrived at. Here they never exceeded 40 cal cm^{-2} day^{-1} 50% of occasions for each configuration (not shown). In view of the above reasoning, therefore, it seems reasonable to say that in equatorial regions, the IGSR patterns is semi-stationary, that is, slowly changing with time.

6. Conclusions

The investigations presented in this paper have clearly brought to light some realistic findings concerning the monthly distribution of IGSR over Lake Victoria. However, before giving a restatement of these findings, the limitations to which the analysis has been subjected must be mentioned. These are :

(*a*) The missing records which could have been vital for the improvement of the statistics of the overestimates (or otherwise) of IGSR over Lake Victora.

(*b*) The rather uneven network density of radiation stations over the lake (with low density over the northeast quadrant).

(*c*) The unrepresentativeness of the Rimco solarimeter data at Nabuyongo island due, perhaps, to changes in sensitivity of the instrument there.

Nevertheless with the careful utilization of the available data at hand, at the findings can be put thus :

(*i*) The extremes of mean monthly IGSR were 351 cal cm^{-2} day^{-1} in July 1974 and 486 cal cm^{-2} day^{-1} in March 1973.

(*ii*) For each of the five years of study 1970 to 1974, the IGSR field exhibited some form of wave configuration, although on a gross scale, with two maxima and two minima during the year and in phase with the polar migration of the sun but with the amplitudes about half of the Angot values for equatorial latitudes. A primary maximum with a higher value occurred in or about March while the secondary maximum occurred in September or October with minima in July and November according to the 5-year mean graph in Fig. 4.

(*iii*) In general with all problems of over-water investigations, the chief difficulty atleast in the initial stages, is associated with the representativeness of the data over the water body itself (reservoir or lake). The direct approach to solving the problem (where no over-water data exist) is through the use of shore station data. Therefore, based on the comparison of averages for shore and island stations, shore stations alone and the planimetered mean monthly values of IGSR over Lake Victoria, an over estimate in IGSR can be expected if only averages of shore *plus* island station data are used. The same also holds if only shore station data are used. In this case the overestimate will be larger. The above treatment, in any case, has been for an extensive water body which can bring about local influences to bear on the climatology of the surrounding areas and *vice versa*. Over limited water bodies such as lakes Kyoga and Mobutu Sese Seko which may be said to have no appreciable effect on the local weather, the use of shore station data can be considered optimistically valid. Even the extrapolation of overland isolines across the lakes can be representative enough. On the other hand, the problems relating to instrumentation such as that leading to the unrepresentativeness of Nabuyongo data can be dealt with more effectively by proper maintenance, careful handling and frequent recalibration of the instrument there. It is not intended to indulge in the drawbacks of certain types of instrumentation in this paper, however, a full and separate treatment is expected to be presented in a future communication.

With regard to the distribution of IGSR over the project area as a whole, the analysis revealed the prevalence of the following quasi-permanent features :

(*i*) Lake Victoria low — this, on month-to-month basis, was always somewhere on the lake but mostly to the western part.

(*ii*) Low to the east central of Uganda extending northwestwards along Lake Kyoga and the Kyoga Nile as a trough

(*iii*) Low over southwest Kenya

(*iv*) High over Karamoja

(*v*) High over Kenyan highland part of the project area

(*vi*) High over Tanzania

(*vii*) High over southwest and northwest Uganda.

Generally speaking then, with the exception of the Kenyan low, the IGSR configuration is such that the permanent low over Lake Victoria together with that of east central Uganda are both surrounded on all sides (except for parts to the west of Lake Victoria) by highs having centres approximately on the areas (*iv*) to (*vii*) above. In addition, the features indicated some form of semi-stationariness in the sense that they have orders of magnitude which are only slowly changing with time. For slightly more than half the number of cases, the monthly changes were found to be within the range or equivalent to the observational error in solar radiation as recommended by the WMO (1971).

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