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# IRRIGATION REQUIREMENTS AND GROUND WATER DEVELOPMENT

George H. Hargreaves

Utah State University

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16. Abstracts

This paper presents a moisture availability index that is suggested for use in evaluating water balance conditions. It further presents a method for estimating irrigation requirements that has been evaluated using Brazilian climatic data.

Comprehensive tables are provided including a detailed explanatory use of the tables on the following topics: (a) Mean monthly values of extra-terrestrial radiation expressed as equivalent evaporation in millimeters per month at 20 degrees C; (b) Crop coefficients, K; and (c) Moisture availability analysis including climatic data.

Other technical data is provided on mean values of measured and computed evaporation and evapotranspiration in inches as well as a comparison of measured and computed evaporation with Class A Pan Evaporation.

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# IRRIGATION REQUIREMENTS AND GROUND WATER DEVELOPMENT

by George H. Hargreaves[1]

Irrigation development from ground water frequently receives less consideration than is warranted. This is partially because surface streams and reservoirs are more visible. Sometimes ground water development is delayed because of uncertainties of ground water yields and of development costs. In many instances the principal problems are shortage of equipment and of specialists trained in ground water development and in water resources development planning.

According to Souto Maior (10)[2], usable water in the underground reservoirs of the sedimentary basins of the Great Northeastern Region of Brasil is twenty times the present capacity of all surface reservoirs in the area. Within these basins the paucity of area irrigated results not from the shortage of water available but rather from scarcity of good lands and the absence of economic conditions, equipment and trained specialists required for development and use of the water potential.

A knowledge of irrigation requirements and of vegetative water use relationships is essential to a good definition of the water balance and of potential ground water recharge. Gaspary and Rebaucas as quoted by Souto Maior (10) indicate that in the Northeast there is a linear relationship between annual precipitation and groundwater recharge for the range 500-1000 mm. Probably, however, precipitation excess over potential evapotranspiration will provide a more satisfactory index of potential ground water recharge. This paper presents a moisture availability index that is suggested for use in evaluating water balance conditions.

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[1] Research Engineer, Agricultural and Irrigation Engineering, Utah State University, Logan, Utah.

[2] Numbers in parentheses refer to the Appendix-References.

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The basic philosophy of irrigation development requires further evaluation. There is considerable tendency in many countries to promote the construction of large federal irrigation systems utilizing surface water supplies. Many of these have been constructed at considerable cost in areas where previous experience with irrigation has been largely lacking. In some cases many years have passed prior to full project development and utilization, resulting in large costs for interest on investment during construction and project development. In a few cases, where projects have been constructed to provide irrigation as a supplement to rainfall, benefits have not justified more than partial utilization of the project facilities resulting in large economic losses to the economy of the country. These costly mistakes can be eliminated by more careful planning. Interest on investment during development can be greatly reduced provided that groundwater conditions favor an initial development using ground water resources.

In areas where ground water resources are available, desirable public policy may include subsidies aiding the private development of irrigation from ground water in order to develop a sound basis of experience for future developments. Important public projects can thus be postponed until the needs and demands for them are clearly indicated.

A reliable methodology for evaluating the needs for irrigation and the amounts of water required can provide a most useful planning tool for ground water and other water resources planning and development activities. This paper presents a method for estimating irrigation requirements that has been evaluated using Brazilian climatic data.

## DEFINITION OF TERMS

Actual Evapotranspiration, ETA, is the use of water by agricultural crops including direct evaporation from moist soils and wet vegetation. It depends on the climate, the crop, the soil moisture supply, and the timing and methods of irrigation. The climatic factors are considered in the estimation of potential evapotranspiration. Crop factors influencing actual evapotranspiration include percentage of ground cover, height and total leaf surface and other plant characteristics. Evapotranspiration is limited by soil moisture availability within the root zone and by practices that reduce evaporation.

Potential Evapotranspiration, ETP, is the amount of water transpired from an actively growing, short green plant cover (usually grass) with a full crop cover and a continuously adequate moisture supply. It is dependent upon climate and can be estimated from climatic parameters, the most important of which are available incoming radiation, temperature, relative humidity, and wind velocity. The incoming radiation is related to the extraterrestrial radiation that reaches the outer atmosphere, and the factors that influence its transmission through the atmosphere such as thickness of the atmosphere as determined by elevation and the percentage of possible sunshine or cloudiness. The energy available for evapotranspiration depends principally upon incoming radiation and energy transported through air mass transfer. Potential evapotranspiration depends upon available energy and upon conditions that influence vapor transfer. The climatic parameters are not independent of each other but are interrelated in a complex manner.

Dependable Precipitation, PD, is the precipitation that has a specified probability of occurrence based on an analysis of long-time precipitation records. For irrigation development, a seventy-five percent probability level, or the rainfall that may be expected to occur three years out of four years, has been selected as a reasonable value for most conditions. For some crops or special conditions, a different probability level may be more appropriate.

For this study the dependable precipitation on a seventy-five percent level has been estimated from its approximate relationship to the mean monthly precipitation from the equation

$$PD = -35 + .75 \times PM \qquad (1)$$

in which

PM = the mean monthly precipitation in mm.

Equation 1 was developed by plotting the seventy-five percent probability of precipitation (that equaled or exceeded three years out of four) from a gamma analysis as a function of mean precipitation. It is a best fit relationship for precipitation data for fifteen locations in Northeast Brazil having long records. The precipitation data are available from "Dados Pluviometricos Mensais in Natura" (9).

Moisture Availability Index, MAI, is the ratio of dependable precipitation to the estimated potential evapotranspiration and can be defined as

$$MAI = PD/ETP \qquad (2)$$

It is an index of the adequacy of precipitation for meeting the moisture requirements for most agricultural crops. Hargreaves (4) proposed the following classification of precipitation deficiencies:

| MAI | Adequacy |
|---|---|
| 0 - .33 | Very deficient |
| .34 - .67 | Moderately deficient |
| .68 - 1.00 | Somewhat deficient |
| 1.01 - 1.33 | Adequate |
| 1.34 and above | Excessive |

Moisture Deficit, ETDF, is taken as the difference between the potential evapotranspiration and the dependable precipitation. This difference can be estimated from the climatic parameters. It is an index of the irrigation requirement but must be considered along with other factors such as effective precipitation and available soil moisture storage capacity. The equation for the moisture deficit or potential evapotranspiration deficit can be written

$$ETDF = ETP - PD \qquad (3)$$

Effective Precipitation, PEF, is the precipitation that enters the soil and is retained within the root zone of the crop grown. It is dependent upon the rainfall intensity and infiltration capacity of the soil, on the type of vegetative cover, upon rooting depth of the crop or vegetation and soil moisture retaining properties of the soil, primarily its texture. Under some conditions nearly all of the precipitation is effective, and under other conditions much of the precipitation may run off the surface or pass through the root zone and not be effective. Differences in management of adjacent fields including soil condition and crop cover sometimes produce very large variations in the effectiveness of precipitation.

Available Soil Moisture Storage Capacity is considered to be the difference between the upper level of moisture that is retained by a well drained soil, or field capacity, and the lower level at which plants wilt, or wilting percentage. Both of these indices can be estimated from physical tests on soils: the field capacity by the moisture equivalent determined by a centrifuge test, or the .5 atmosphere percentage test, and the wilting percentage by the plant technique, or the fifteen atmosphere percentage test. The available moisture storage capacity may also be determined directly by field sampling and gravometric moisture determinations after an adequate irrigation as moisture is depleted until symptoms of wilting occur.

## IRRIGATION REQUIREMENTS

A wide variety of methods have been used for estimating irrigation requirements. Most are fairly suitable for use under climatic conditions similar to those used for deriving the methodology. Few can be applied over a wide range of differing vapor transfer conditions (influenced principally by differences in relative humidity and wind speed). The Bureau of Reclamation (USBR) is currently using a modified Jensen-Haise method. The primary climatic variables used are solar radiation and temperature. As described by Gibbs (3), adjustments are also included for humidity and elevation. Estimates of potential evapotranspiration (ETP) are for conditions of moderate windspeeds. Crop curves or crop coefficients are used with estimated values of ETP in order to obtain estimated actual crop consumptive use. Irrigation requirements are estimated so as to provide for water losses and non-uniformity of water application. When necessary, provision is also usually made for a leaching requirement.

Other methods widely used for estimating irrigation requirements include the Blaney-Criddle and the Thornthwaite methods. Both are based upon mean monthly air temperature and daytime hours. Modifications of these methods provide usable results at low humidities or for very uniform humidity and wind speed conditions. Neither should be used, however, as a generalized equation or for conditions of variable relative humidity above about sixty-five percent (twenty-four-hour average).

At Pasaje, Ecuador, a first order meteorologic station is equipped with a Class A pan. Low advective conditions prevail so that the Class A pan evaporation data provide a good index of potential evapotranspiration. Relative humidity is high with monthly twenty-four-hour mean values of in the general range of eighty-one to eighty-eight percent. Hasan and Jones (7) made an analysis of the evaporation data using various methods. The results are given as follows:

Mean Values of Measured and Computed Evaporation and Evapotranspiration, in Inches, Based on Pasaje 1965-1970 Data

| Month (1) | $E_p$ (2) | $E_{po}$ (3) | $E_{ps}$ (4) | $E_{pc}$ (5) | $E_o$ (6) | $U'$ (7) | $E_t$ (8) |
|---|---|---|---|---|---|---|---|
| January | 4.33 | 4.23 | 2.77 | 3.65 | 3.65 | 6.72 | 5.09 |
| February | 4.30 | 4.17 | 2.67 | 3.47 | 3.62 | 6.07 | 4.33 |
| March | 5.21 | 4.60 | 3.09 | 4.24 | 4.47 | 6.71 | 5.33 |
| April | 5.13 | 4.70 | 3.17 | 4.23 | 4.20 | 6.44 | 4.98 |
| May | 4.26 | 3.76 | 2.62 | 3.56 | 3.60 | 6.44 | 5.12 |
| June | 3.18 | 2.94 | 1.93 | 2.64 | 2.87 | 5.97 | 4.46 |
| July | 2.70 | 2.49 | 1.67 | 2.23 | 2.70 | 6.03 | 4.48 |
| August | 2.78 | 2.57 | 1.73 | 2.24 | 2.88 | 5.90 | 4.47 |
| September | 2.69 | 2.40 | 1.67 | 2.00 | 2.81 | 5.90 | 4.14 |
| October | 2.35 | 2.37 | 1.58 | 1.88 | 2.77 | 6.18 | 4.40 |
| November | 2.86 | 2.91 | 1.89 | 2.11 | 2.88 | 6.09 | 4.16 |
| December | 3.85 | 4.17 | 2.49 | 2.91 | 3.41 | 6.48 | 4.61 |
| Total | 43.62 | 41.31 | 27.28 | 35.16 | 40.06 | 74.93 | 55.57 |

$E_p$ = US Weather Bureau Class A pan.
$E_{po}$ = Piche evaporimeter in open air.
$E_{ps}$ = Piche evaporimeter in louvered screen.
$E_{pc}$ = Hargreaves' pan evaporation.
$E_o$ = Penman's open water evaporation.
$U$ = Blaney-Criddle's consumptive use for bananas.
$E_t$ = Thornthwaite's potential evapotranspiration.

Comparison of Measured (Piche) and Computed Evaporation with Class A Pan Evaporation

| Method of measurement or calculation (1) | Regression equation (2) | Correlation coefficient (3) |
|---|---|---|
| Piche (open air) | $E_{po} = -8.021 + 1.131\ E_p$ | 0.820 |
| Piche (screened) | $E_{ps} = -1.498 + 0.663\ E_p$ | 0.840 |
| Hargreaves | $E_{pc} = 11.229 + 0.549\ E_p$ | 0.766 |
| Penman | $E_o = 27.894 + 0.280\ E_p$ | 0.620 |
| Blaney-Criddle | $U = 73.135 + 0.044\ E_p$ | 0.194 |
| Thornthwaite | $E_t = 54.010 + 0.036\ E_p$ | 0.115 |

Although at Pasaje, Piche evaporation correlates fairly well with evaporation and irrigation requirements, it is not recommended for general use. This is because the relationship varies widely in different locations with differing climatic conditions. This variation is probably due principally to an exponential relationship between Piche evaporation and wind velocity.

The Hargreaves equation used in the study by Hasan and Jones is a modification proposed in 1968. This procedure has since been superseded.

It is evident from the analysis presented and the correlation coefficients that the Blaney-Criddle and Thornthwaite methods do not give satisfactory results since only a very small percentage of the variance is predicted (less than four percent for Blaney-Criddle and less than 1.5 percent for Thornthwaite).

It is proposed that a methodology used for estimating irrigation requirements should meet the following criteria:

1. Provide reasonable estimates when evaluated using measured evapotranspiration and/or Class A pan evaporation.

2. Be usable with the data available from the area under study.

3. Have sufficient simplicity so as to provide ease of computation and be readily adaptable to both slide rule and computer calculation.

4. Be readily transferable to other areas having differing climatic conditions.

Satisfactory methods for estimating irrigation requirements can be developed based upon temperature, day length, relative humidity and wind speed. However, for most latitudes extraterrestrial radiation correlates well with day length and when corrected for percentage of sunshine or cloud cover and elevation, it can be used to provide fairly accurate estimates of solar radiation. Extraterrestrial radiation can be expressed in equivalent depth of evaporation resulting in potential evapotranspiration equations that are dimensionally sound.

An equation for potential evapotranspiration, ETP, given by Hargreaves (4), developed as an improvement of equations given by Christiansen and Hargreaves (2), can be written

$$ETP = .35 \times RT \times CT \times CH \times CW \times CE \qquad (4)$$

in which

RT = extraterrestrial radiation expressed as equivalent evaporation by dividing the radiation (cal/cm$^2$/day) by the heat of vaporization at the mean temperature, TM, and converting to appropriate units, mm per day or mm per month (Table 1)

$$CT = 0.40 + 0.024 \times TM \qquad (4a)$$

(TM = mean temperature in °C)

$$CH = 0.05 + 1.42 \times (1.00 - HM)^{1/2} \qquad (4b)$$

(HM = mean monthly relative humidity read at 1200, 1800 and 2400 hours mean Greenwich time, expressed decimally; CH has a maximum value of 1.00)

$$CW = 0.80 + 0.0016 \times W2 \qquad (4c)$$

(W2 = Wind speed in km/day at an anemometer height of 2.0 m, 24-hour totalized value)

$$CE = 1.00 + 0.0004 \times EL \qquad (4d)$$

(EL = elevation above sea level in meters)

TABLE 1. MEAN MONTHLY VALUES OF EXTRATERRESTRIAL RADIATION EXPRESSED AS EQUIVALENT EVAPORATION IN MILLIMETERS PER MONTH AT 20 DEGREES C.

| LATITUDE DEGREES | MONTH |  |  |  |  |  |  |  |  |  |  |  |  |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
|  | JAN. | FEB. | MAR. | APR. | MAY | JUNE | JULY | AUG. | SEP. | OCT. | NOV. | DEC. | ANNUAL |
| 5 | 442. | 419. | 482. | 467. | 468. | 443. | 463. | 477. | 469. | 473. | 435. | 434. | 5472. |
| 4 | 447. | 422. | 483. | 465. | 465. | 439. | 458. | 475. | 469. | 475. | 439. | 440. | 5479. |
| 3 | 452. | 426. | 484. | 464. | 461. | 434. | 454. | 472. | 469. | 478. | 444. | 446. | 5484. |
| 2 | 458. | 429. | 485. | 462. | 457. | 429. | 449. | 469. | 469. | 481. | 448. | 451. | 5488. |
| 1 | 462. | 432. | 486. | 460. | 453. | 424. | 445. | 467. | 469. | 483. | 453. | 457. | 5490. |
| 0 | 467. | 435. | 487. | 458. | 449. | 419. | 440. | 464. | 468. | 485. | 457. | 462. | 5491. |
| -1 | 472. | 437. | 488. | 456. | 444. | 414. | 435. | 460. | 468. | 488. | 461. | 467. | 5490. |
| -2 | 477. | 440. | 489. | 454. | 440. | 409. | 430. | 457. | 467. | 490. | 465. | 472. | 5488. |
| -3 | 481. | 443. | 489. | 451. | 435. | 404. | 425. | 454. | 465. | 491. | 469. | 477. | 5484. |
| -4 | 485. | 445. | 489. | 449. | 431. | 398. | 420. | 450. | 465. | 493. | 473. | 482. | 5479. |
| -5 | 490. | 447. | 489. | 446. | 426. | 393. | 414. | 446. | 464. | 495. | 476. | 486. | 5472. |
| -6 | 494. | 449. | 486. | 443. | 421. | 387. | 409. | 442. | 463. | 496. | 480. | 491. | 5463. |
| -7 | 498. | 451. | 488. | 440. | 416. | 381. | 403. | 439. | 461. | 497. | 483. | 495. | 5454. |
| -8 | 501. | 453. | 487. | 437. | 411. | 376. | 398. | 434. | 460. | 499. | 486. | 500. | 5442. |
| -9 | 505. | 455. | 487. | 434. | 406. | 370. | 392. | 430. | 458. | 499. | 489. | 504. | 5429. |
| -10 | 509. | 457. | 486. | 431. | 400. | 364. | 386. | 426. | 456. | 500. | 492. | 508. | 5415. |
| -11 | 512. | 458. | 485. | 427. | 395. | 358. | 380. | 421. | 454. | 501. | 495. | 512. | 5399. |
| -12 | 515. | 459. | 484. | 424. | 389. | 352. | 374. | 417. | 452. | 502. | 498. | 516. | 5381. |
| -13 | 518. | 461. | 483. | 420. | 384. | 346. | 368. | 412. | 450. | 502. | 500. | 519. | 5363. |
| -14 | 521. | 462. | 481. | 416. | 378. | 339. | 362. | 407. | 447. | 502. | 503. | 523. | 5342. |
| -15 | 524. | 463. | 480. | 412. | 372. | 333. | 356. | 403. | 445. | 502. | 505. | 526. | 5320. |
| -16 | 527. | 463. | 478. | 408. | 366. | 327. | 350. | 397. | 442. | 502. | 507. | 529. | 5297. |
| -17 | 530. | 464. | 476. | 404. | 360. | 320. | 343. | 392. | 439. | 502. | 509. | 532. | 5272. |
| -18 | 532. | 465. | 474. | 400. | 354. | 313. | 337. | 387. | 436. | 502. | 511. | 535. | 5246. |
| -19 | 534. | 465. | 472. | 395. | 348. | 307. | 330. | 382. | 433. | 501. | 513. | 538. | 5219. |
| -20 | 536. | 465. | 470. | 391. | 342. | 300. | 323. | 376. | 430. | 500. | 514. | 541. | 5190. |
| -21 | 538. | 465. | 468. | 386. | 335. | 293. | 317. | 371. | 427. | 500. | 516. | 544. | 5159. |
| -22 | 540. | 465. | 465. | 381. | 329. | 287. | 310. | 365. | 423. | 499. | 517. | 546. | 5127. |
| -23 | 542. | 465. | 462. | 377. | 322. | 280. | 303. | 359. | 420. | 498. | 518. | 548. | 5094. |
| -24 | 544. | 465. | 460. | 372. | 316. | 273. | 296. | 353. | 416. | 496. | 519. | 551. | 5059. |
| -25 | 545. | 465. | 457. | 366. | 309. | 266. | 289. | 347. | 412. | 495. | 520. | 553. | 5024. |
| -26 | 547. | 464. | 454. | 361. | 302. | 259. | 282. | 341. | 408. | 493. | 521. | 554. | 4986. |
| -27 | 548. | 464. | 450. | 356. | 295. | 252. | 275. | 335. | 404. | 492. | 521. | 556. | 4948. |
| -28 | 549. | 463. | 447. | 351. | 289. | 245. | 268. | 329. | 400. | 490. | 522. | 558. | 4908. |
| -29 | 550. | 462. | 443. | 345. | 282. | 237. | 260. | 323. | 395. | 488. | 522. | 559. | 4867. |
| -30 | 550. | 461. | 440. | 339. | 275. | 230. | 253. | 316. | 391. | 486. | 522. | 561. | 4824. |
| -31 | 551. | 460. | 436. | 334. | 268. | 223. | 246. | 310. | 386. | 484. | 522. | 562. | 4781. |
| -32 | 552. | 458. | 432. | 328. | 260. | 216. | 238. | 303. | 382. | 481. | 522. | 563. | 4736. |
| -33 | 552. | 457. | 428. | 322. | 253. | 209. | 231. | 296. | 377. | 479. | 522. | 564. | 4690. |
| -34 | 552. | 455. | 424. | 316. | 246. | 201. | 224. | 290. | 372. | 476. | 522. | 565. | 4643. |

Mean climatic data for Brazil have been published for the period 1931-60 in "Normais Climatologicas" (8). These data do not include wind speed measurements.

In general, wind velocities are greater during dry months and lower during the rainy season. Although location, surrounding terrain, distance from the ocean and other factors influence wind speed, use of a relationship based on precipitation should improve the estimation of potential evapotranspiration. The best fit relationship for Bebedouro near Petrolina, Bahia, can be written

$$W2 = 200 - 0.65 \times PREC \tag{5}$$

in which

W2 = wind speed in km/day at an instrument height of 2.0 m

PREC = precipitation in mm per month.

Potential evapotranspiration as calculated using equation 4 is based upon lysimeter data for grass. In order to convert ETP to ETA or the actual evapotranspiration by crops, ETP needs to be multiplied by a crop coefficient, K, thus

$$ETA = K \times ETP \tag{6}$$

Table 2 from a report by Bolivian-Utah State-USAID Study Team (1) gives values of K for various crops. In the event that a specific crop is not given in Table 2, values of K for a similar crop will usually provide a reasonable estimate of evapotranspiration.

## CLIMATE, POTENTIAL EVAPOTRANSPIRATION AND MOISTURE AVAILABILITY INDEX, NORTHEAST DATA

Equation 4 was evluated using the relationships between ETP and Class A pan evaporation at several locations in Brazil. Subject to the limitations in the climatic data, it is believed that this equation provides a satisfactory estimation of potential evapotranspiration. Potential evapotranspiration as estimated from equation 4 is presented for twenty-three Northeast locations in Table 3.

Table 3 also presents the available climatic data and estimation of dependable precipitation, PD; evapotranspiration deficit, ETDF; and the

Table 2. Crop Coefficients, K

| Crop | Root Depth in Meters | Full Crop Cover | | Seasonal K | |
|---|---|---|---|---|---|
| | | Range in K | Average K | Range | Mean |
| Field and Oil Crops | 1.00-1.30 | 1.10-1.32 | 1.22 | .73-.99 | .89 |
| Fruits | | | | | |
| Grapefruit | 1.20 | | .79 | | .79 |
| Naval Oranges | 1.07 | | .65 | | .65 |
| Grain and Forage Crops | 1.12-1.35 | 1.08-1.70* | 1.37* | 95-1.15 | 1.04* |
| Grass Crops | | | | | |
| Bermuda Lawn | 1.19 | | 1.05 | | 1.05 |
| Green Manure Crops | .86-1.31 | 97-1.22 | 1.11 | .85-1.18 | .96 |
| Winter Venetables | .64- .95 | 1.22-1.86* | 1.45* | .85-1.18 | 1.01* |
| Summer Vegetables | .86- .95 | 1.22-1.40 | 1.28 | .82- .84 | .83 |

*Values appear higher than normal based on other experimental data.

Notes: Root depth is the zone from which 90 percent of soil moisture depletion occurred. Coefficients are to be used with estimated potential evapotranspiration, ETP.

Source: Erie, L. J., Orrin F. French and Karl Harris, "Consumptive Use of Water by Crops in Arizona." (Tech. Bulletin 169: University of Arizona Agricultural Experimental Station, 1965), 44 pp.

Middleton, J. E., O. W. Pruitt, P. C. Crandall and M. C. Jensen, "Central and Western Washington Consumptive Use and Evaporation Data, 1954-62" Bulletin 681: Washington State University Agricultural Experiment Station, 1967), 7 pp.

Table 3. Moisture Availability Analysis Including Climatic Data

82.476 CAXIAS MARANHAO LAT 4 52 LONG 43 21 ELEV 77

| MO | TM | HM | TD | PREC | INS | RMM | CT | CH | CW | FTP | PD | ETDF | MAI |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 26.8 | .77 | 10.3 | 169. | 190. | 493. | 1.04 | .73 | .94 | 124. | 92. | 33. | .74 |
| 2 | 26.2 | .83 | 9.7 | 243. | 157. | 450. | 1.03 | .64 | .87 | 91. | 147. | -56. | 1.62 |
| 3 | 26.1 | .84 | 9.5 | 288. | 165. | 491. | 1.03 | .62 | .82 | 90. | 181. | -91. | 2.01 |
| 4 | 26.2 | .84 | 9.5 | 283. | 184. | 449. | 1.03 | .62 | .83 | 83. | 177. | -94. | 2.14 |
| 5 | 26.3 | .81 | 9.8 | 72. | 244. | 430. | 1.03 | .67 | 1.04 | 110. | 19. | 90. | .17 |
| 6 | 25.9 | .75 | 11.2 | 19. | 263. | 396. | 1.02 | .76 | 1.10 | 119. | 0. | 119. | .00 |
| 7 | 25.7 | .69 | 13.0 | 8. | 291. | 418. | 1.02 | .84 | 1.11 | 139. | 0. | 139. | .00 |
| 8 | 26.7 | .63 | 14.3 | 3. | 309. | 450. | 1.04 | .92 | 1.12 | 168. | 0. | 168. | .00 |
| 9 | 28.1 | .60 | 14.0 | 13. | 275. | 468. | 1.07 | .95 | 1.11 | 186. | 0. | 186. | .00 |
| 10 | 28.7 | .60 | 13.3 | 29. | 266. | 499. | 1.09 | .95 | 1.09 | 197. | 0. | 197. | .00 |
| 11 | 28.4 | .65 | 12.1 | 66. | 233. | 480. | 1.08 | .89 | 1.05 | 171. | 15. | 156. | .09 |
| 12 | 27.6 | .71 | 11.2 | 95. | 213. | 490. | 1.06 | .82 | 1.02 | 152. | 37. | 116. | .24 |
| AVE | 26.9 | .73 | 11.5 | 107. | 232. | 459. | 1.05 | .78 | 1.01 | 136. | 56. | 80. | .58 |

82.578 TFRFZINA PIAUI LAT 5 5 LONG 42 49 ELEV 79

| MO | TM | HM | TD | PREC | INS | RMM | CT | CH | CW | ETP | PD | ETDF | MAI |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 27.2 | .77 | 10.3 | 175. | 195. | 494. | 1.05 | .73 | .94 | 126. | 96. | 30. | .76 |
| 2 | 26.5 | .83 | 9.5 | 235. | 165. | 450. | 1.04 | .64 | .88 | 92. | 142. | -50. | 1.54 |
| 3 | 26.2 | .85 | 9.1 | 311. | 167. | 491. | 1.03 | .60 | .80 | 84. | 198. | -114. | 2.35 |
| 4 | 26.3 | .83 | 9.2 | 254. | 191. | 449. | 1.03 | .64 | .86 | 90. | 155. | -66. | 1.73 |
| 5 | 26.6 | .81 | 9.7 | 91. | 252. | 429. | 1.04 | .67 | 1.03 | 107. | 33. | 74. | .31 |
| 6 | 26.4 | .74 | 11.3 | 15. | 279. | 395. | 1.03 | .78 | 1.10 | 124. | 0. | 124. | .00 |
| 7 | 26.5 | .65 | 13.5 | 8. | 307. | 417. | 1.04 | .89 | 1.11 | 150. | 0. | 150. | .00 |
| 8 | 27.6 | .57 | 15.0 | 6. | 322. | 449. | 1.06 | .98 | 1.11 | 183. | 0. | 183. | .00 |
| 9 | 29.1 | .55 | 14.7 | 9. | 292. | 468. | 1.10 | 1.00 | 1.11 | 200. | 0. | 200. | .00 |
| 10 | 29.5 | .57 | 13.7 | 28. | 280. | 499. | 1.11 | .98 | 1.09 | 208. | 0. | 208. | .00 |
| 11 | 29.2 | .61 | 12.6 | 60. | 250. | 481. | 1.10 | .93 | 1.06 | 183. | 10. | 173. | .06 |
| 12 | 28.2 | .68 | 11.3 | 105. | 213. | 491. | 1.08 | .85 | 1.01 | 159. | 44. | 115. | .28 |
| AVE | 27.4 | .71 | 11.7 | 108. | 243. | 460. | 1.06 | .81 | 1.01 | 142. | 57. | 86. | .59 |

Table 3. (Continued)

82.696 AREIA PARAIBA LAT 6 58 LONG 35 41 ELEV 624

| MO | TM | HM | TD | PREC | INS | RMM | CT | CH | CW | ETP | PD | ETDF | MAI |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 22.8 | .81 | 10.0 | 55. | 0. | 500. | .95 | .66 | 1.06 | 119. | 6. | 113. | .05 |
| 2 | 23.0 | .83 | 9.7 | 94. | 0. | 453. | .95 | .64 | 1.02 | 102. | 35. | 67. | .35 |
| 3 | 22.8 | .85 | 8.9 | 159. | 0. | 489. | .95 | .60 | .95 | 96. | 84. | 12. | .88 |
| 4 | 22.3 | .88 | 8.0 | 157. | 0. | 442. | .94 | .55 | .96 | 76. | 83. | -5. | 1.07 |
| 5 | 21.5 | .90 | 7.2 | 205. | 0. | 418. | .92 | .49 | .91 | 61. | 119. | -58. | 1.94 |
| 6 | 20.2 | .91 | 6.6 | 237. | 0. | 383. | .88 | .46 | .87 | 49. | 143. | -93. | 2.90 |
| 7 | 19.6 | .90 | 7.0 | 185. | 0. | 404. | .87 | .49 | .93 | 57. | 104. | -46. | 1.81 |
| 8 | 19.6 | .88 | 7.7 | 142. | 0. | 439. | .87 | .53 | .97 | 71. | 71. | -1. | 1.01 |
| 9 | 20.5 | .85 | 8.7 | 54. | 0. | 461. | .89 | .61 | 1.05 | 95. | 5. | 90. | .06 |
| 10 | 21.6 | .81 | 9.8 | 25. | 0. | 498. | .92 | .66 | 1.09 | 119. | 0. | 119. | .00 |
| 11 | 22.2 | .81 | 10.3 | 28. | 0. | 485. | .93 | .58 | 1.09 | 120. | 0. | 120. | .00 |
| 12 | 22.6 | .81 | 10.3 | 38. | 0. | 498. | .94 | .67 | 1.08 | 122. | 0. | 122. | .00 |
| AVE | 21.6 | .85 | 8.7 | 115. | 0. | 456. | .92 | .59 | 1.00 | 91. | 54. | 36. | .84 |

82.795 CAMPINA GRANDE PARAIBA LAT 7 13 LONG 35 53 ELEV 527

| MO | TM | HM | TD | PREC | INS | RMM | CT | CH | CW | ETP | PD | ETDF | MAI |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 24.3 | .70 | 10.5 | 27. | 0. | 501. | .98 | .82 | 1.09 | 159. | 0. | 159. | .00 |
| 2 | 24.4 | .72 | 10.1 | 43. | 0. | 454. | .99 | .80 | 1.08 | 138. | 0. | 138. | .00 |
| 3 | 24.4 | .76 | 9.6 | 74. | 0. | 490. | .99 | .75 | 1.04 | 135. | 21. | 115. | .15 |
| 4 | 23.8 | .79 | 8.7 | 94. | 0. | 442. | .97 | .70 | 1.02 | 110. | 35. | 75. | .32 |
| 5 | 22.6 | .84 | 7.4 | 127. | 0. | 417. | .94 | .62 | 1.00 | 87. | 53. | 34. | .61 |
| 6 | 21.4 | .85 | 6.8 | 118. | 0. | 382. | .91 | .59 | 1.00 | 73. | 54. | 20. | .73 |
| 7 | 20.6 | .85 | 7.4 | 84. | 0. | 403. | .89 | .60 | 1.03 | 80. | 28. | 52. | .35 |
| 8 | 20.7 | .81 | 8.3 | 58. | 0. | 438. | .90 | .67 | 1.06 | 100. | 9. | 91. | .09 |
| 9 | 21.9 | .75 | 9.5 | 24. | 0. | 462. | .93 | .76 | 1.09 | 127. | 0. | 127. | .00 |
| 10 | 22.9 | .71 | 10.6 | 13. | 0. | 499. | .95 | .82 | 1.11 | 153. | 0. | 153. | .00 |
| 11 | 23.7 | .70 | 10.6 | 16. | 0. | 486. | .97 | .83 | 1.10 | 154. | 0. | 154. | .00 |
| 12 | 24.0 | .70 | 10.6 | 19. | 0. | 499. | .98 | .82 | 1.10 | 157. | 0. | 157. | .00 |
| AVE | 22.9 | .76 | 9.2 | 57. | 0. | 456. | .95 | .73 | 1.06 | 123. | 17. | 106. | .19 |

Table 3. (Continued)

82.697 GUARABIRA PARAIBA LAT 6 51 LONG 35 29 ELEV 101

| MO | TM | HM | TD | PREC | INS | RMM | CT | CH | CW | ETP | PD | ETDF | MAI |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 26.9 | .75 | 11.7 | 42. | 0. | 501. | 1.05 | .76 | 1.08 | 150. | 0. | 150. | .00 |
| 2 | 27.0 | .76 | 11.5 | 63. | 0. | 454. | 1.05 | .75 | 1.05 | 132. | 12. | 120. | .09 |
| 3 | 27.0 | .77 | 10.8 | 98. | 0. | 491. | 1.05 | .73 | 1.02 | 135. | 38. | 97. | .28 |
| 4 | 26.3 | .79 | 9.9 | 123. | 0. | 444. | 1.03 | .69 | .99 | 111. | 57. | 54. | .52 |
| 5 | 25.4 | .82 | 9.0 | 151. | 0. | 420. | 1.01 | .65 | .96 | 94. | 78. | 16. | .83 |
| 6 | 24.2 | .84 | 8.5 | 203. | 0. | 385. | .98 | .62 | .91 | 75. | 117. | -43. | 1.57 |
| 7 | 23.6 | .84 | 8.8 | 88. | 0. | 407. | .97 | .62 | 1.03 | 88. | 31. | 57. | .35 |
| 8 | 23.5 | .83 | 9.6 | 56. | 0. | 441. | .96 | .64 | 1.06 | 102. | 7. | 95. | .07 |
| 9 | 24.6 | .79 | 11.0 | 22. | 0. | 463. | .99 | .70 | 1.10 | 123. | 0. | 123. | .00 |
| 10 | 25.6 | .76 | 12.2 | 12. | 0. | 500. | 1.01 | .75 | 1.11 | 149. | 0. | 149. | .00 |
| 11 | 26.3 | .75 | 12.3 | 20. | 0. | 486. | 1.03 | .76 | 1.10 | 147. | 0. | 147. | .00 |
| 12 | 26.7 | .75 | 11.9 | 46. | 0. | 499. | 1.04 | .76 | 1.07 | 149. | 0. | 149. | .00 |
| AVE | 25.6 | .79 | 10.6 | 77. | 0. | 458. | 1.01 | .70 | 1.04 | 121. | 28. | 93. | .31 |

82.798 JOAO PESSOA PARAIBA LAT 7 6 LONG 34 52 ELEV 28

| MO | TM | HM | TD | PREC | INS | RMM | CT | CH | CW | ETP | PD | ETDF | MAI |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 26.6 | .76 | 7.4 | 62. | 267. | 502. | 1.04 | .74 | 1.06 | 143. | 11. | 132. | .08 |
| 2 | 26.8 | .77 | 7.4 | 79. | 235. | 455. | 1.04 | .73 | 1.04 | 125. | 25. | 101. | .20 |
| 3 | 26.8 | .78 | 7.6 | 173. | 231. | 491. | 1.04 | .71 | .94 | 120. | 95. | 26. | .79 |
| 4 | 26.3 | .81 | 7.6 | 227. | 214. | 443. | 1.03 | .67 | .88 | 95. | 135. | -40. | 1.42 |
| 5 | 25.3 | .84 | 7.3 | 301. | 208. | 418. | 1.01 | .62 | .81 | 74. | 191. | -117. | 2.58 |
| 6 | 24.3 | .84 | 7.1 | 348. | 192. | 384. | .98 | .61 | .76 | 61. | 226. | -165. | 3.70 |
| 7 | 23.7 | .84 | 7.2 | 190. | 207. | 405. | .97 | .62 | .92 | 79. | 108. | -29. | 1.37 |
| 8 | 23.7 | .82 | 7.5 | 132. | 231. | 440. | .97 | .66 | .98 | 96. | 64. | 33. | .66 |
| 9 | 24.7 | .79 | 7.4 | 61. | 237. | 463. | .99 | .71 | 1.06 | 120. | 11. | 110. | .09 |
| 10 | 25.6 | .77 | 7.3 | 23. | 282. | 500. | 1.01 | .74 | 1.10 | 144. | 0. | 144. | .00 |
| 11 | 26.1 | .76 | 6.9 | 31. | 280. | 487. | 1.03 | .74 | 1.09 | 141. | 0. | 141. | .00 |
| 12 | 26.4 | .76 | 7.1 | 41. | 282. | 500. | 1.03 | .74 | 1.08 | 144. | 0. | 144. | .00 |
| AVE | 25.5 | .80 | 7.3 | 139. | 239. | 457. | 1.01 | .69 | .98 | 112. | 72. | 40. | .91 |

Table 3. (Continued)

82.779 UMBUZEIRO PARAIBA LAT 7 42 LONG 35 42 ELEV 497

| MO | TM | HM | TD | PREC | INS | RMM | CT | CH | CW | ETP | PD | ETDF | MAI |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 23.9 | .74 | 10.3 | 25. | 0. | 503. | .97 | .78 | 1.09 | 149. | 0. | 149. | .00 |
| 2 | 24.0 | .75 | 10.0 | 43. | 0. | 455. | .98 | .76 | 1.08 | 129. | 0. | 129. | .00 |
| 3 | 23.9 | .77 | 9.4 | 77. | 0. | 489. | .97 | .73 | 1.04 | 129. | 23. | 107. | .18 |
| 4 | 23.2 | .81 | 8.4 | 106. | 0. | 440. | .96 | .66 | 1.01 | 100. | 45. | 56. | .45 |
| 5 | 22.1 | .86 | 7.3 | 137. | 0. | 414. | .93 | .58 | .98 | 78. | 68. | 10. | .97 |
| 6 | 20.9 | .87 | 6.8 | 151. | 0. | 379. | .90 | .56 | .96 | 66. | 78. | -12. | 1.18 |
| 7 | 20.2 | .87 | 7.3 | 119. | 0. | 401. | .88 | .57 | 1.00 | 72. | 55. | 17. | .76 |
| 8 | 20.2 | .84 | 8.0 | 82. | 0. | 436. | .88 | .62 | 1.03 | 88. | 27. | 61. | .30 |
| 9 | 21.2 | .80 | 8.8 | 32. | 0. | 461. | .91 | .68 | 1.09 | 111. | 0. | 111. | .00 |
| 10 | 22.4 | .75 | 9.9 | 19. | 0. | 500. | .94 | .76 | 1.10 | 139. | 0. | 139. | .00 |
| 11 | 23.2 | .73 | 10.6 | 17. | 0. | 488. | .96 | .78 | 1.10 | 144. | 0. | 144. | .00 |
| 12 | 23.5 | .74 | 10.4 | 21. | 0. | 501. | .96 | .78 | 1.13 | 147. | 0. | 147. | .00 |
| AVE | 22.4 | .79 | 8.9 | 69. | 0. | 456. | .94 | .69 | 1.05 | 113. | 25. | 88. | .31 |

82.893 GARANHUNS PBCO LAT 8 53 LONG 36 31 ELEV 927

| MO | TM | HM | TD | PREC | INS | RMM | CT | CH | CW | ETP | PD | ETDF | MAI |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 21.9 | .75 | 11.6 | 39. | 0. | 507. | .93 | .76 | 1.08 | 139. | 0. | 139. | .00 |
| 2 | 21.9 | .76 | 11.2 | 55. | 0. | 456. | .93 | .74 | 1.05 | 121. | 6. | 114. | .05 |
| 3 | 21.9 | .77 | 10.8 | 111. | 0. | 488. | .93 | .73 | 1.00 | 119. | 48. | 71. | .40 |
| 4 | 21.2 | .81 | 9.6 | 134. | 0. | 435. | .91 | .67 | .98 | 94. | 66. | 29. | .70 |
| 5 | 19.8 | .87 | 7.9 | 224. | 0. | 407. | .88 | .56 | .89 | 64. | 133. | -69. | 2.09 |
| 6 | 18.8 | .90 | 7.1 | 231. | 0. | 371. | .85 | .51 | .88 | 51. | 138. | -87. | 2.70 |
| 7 | 17.8 | .91 | 7.1 | 213. | 0. | 393. | .83 | .48 | .90 | 51. | 124. | -73. | 2.43 |
| 8 | 17.9 | .89 | 7.7 | 155. | 0. | 430. | .83 | .52 | .96 | 65. | 82. | -17. | 1.26 |
| 9 | 19.2 | .83 | 8.8 | 66. | 0. | 458. | .86 | .63 | 1.05 | 95. | 14. | 81. | .15 |
| 10 | 20.6 | .78 | 10.4 | 30. | 0. | 500. | .89 | .71 | 1.09 | 126. | 0. | 126. | .00 |
| 11 | 21.5 | .76 | 11.4 | 36. | 0. | 491. | .92 | .75 | 1.08 | 132. | 0. | 132. | .00 |
| 12 | 22.0 | .75 | 11.7 | 39. | 0. | 506. | .93 | .76 | 1.08 | 141. | 0. | 141. | .00 |
| AVE | 20.4 | .82 | 9.6 | 111. | 0. | 454. | .89 | .65 | 1.00 | 100. | 51. | 49. | .81 |

Table 3. (Continued)

82.799 BOIANA PBCO LAT 7 33 LONG 34 59 ELEV 11

| MO | TM | HM | TD | PREC | INS | RMM | CT | CH | CW | ETP | PD | ETDF | MAI |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 26.0 | .75 | 11.1 | 87. | 0. | 504. | 1.02 | .76 | 1.03 | 141. | 31. | 110. | .22 |
| 2 | 26.0 | .75 | 10.7 | 151. | 0. | 455. | 1.02 | .76 | .96 | 119. | 78. | 41. | .66 |
| 3 | 25.9 | .76 | 10.3 | 232. | 0. | 490. | 1.02 | .75 | .88 | 116. | 139. | -23. | 1.20 |
| 4 | 25.4 | .77 | 9.7 | 326. | 0. | 441. | 1.01 | .73 | .75 | 89. | 209. | -120. | 2.35 |
| 5 | 24.8 | .79 | 9.3 | 361. | 0. | 416. | 1.00 | .70 | .74 | 75. | 236. | -160. | 3.12 |
| 6 | 23.8 | .82 | 9.5 | 388. | 0. | 381. | .97 | .66 | .72 | 61. | 256. | -195. | 4.20 |
| 7 | 23.3 | .83 | 9.9 | 259. | 0. | 403. | .96 | .63 | .85 | 73. | 159. | -87. | 2.19 |
| 8 | 23.3 | .83 | 10.3 | 175. | 0. | 438. | .96 | .64 | .94 | 88. | 96. | -9. | 1.10 |
| 9 | 24.5 | .80 | 10.4 | 92. | 0. | 462. | .99 | .68 | 1.02 | 111. | 34. | 76. | .31 |
| 10 | 25.2 | .78 | 10.9 | 51. | 0. | 501. | 1.00 | .72 | 1.07 | 135. | 3. | 132. | .02 |
| 11 | 25.7 | .76 | 11.2 | 52. | 0. | 488. | 1.02 | .74 | 1.07 | 138. | 4. | 134. | .03 |
| 12 | 25.9 | .76 | 11.2 | 76. | 0. | 502. | 1.02 | .75 | 1.04 | 141. | 22. | 118. | .16 |
| AVE | 25.0 | .78 | 10.4 | 188. | 0. | 457. | 1.00 | .71 | .92 | 107. | 106. | 2. | 1.30 |

82.781 NAZARE DA MATA PBCO LAT 7 44 LONG 35 15 ELEV 87

| MO | TM | HM | TD | PREC | INS | RMM | CT | CH | CW | ETP | PD | ETDF | MAI |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 26.4 | .74 | 11.4 | 38. | 258. | 505. | 1.03 | .77 | 1.08 | 153. | 0. | 153. | .00 |
| 2 | 26.5 | .76 | 10.6 | 64. | 216. | 456. | 1.04 | .74 | 1.05 | 130. | 13. | 117. | .10 |
| 3 | 26.2 | .79 | 9.9 | 109. | 224. | 490. | 1.03 | .70 | 1.01 | 126. | 47. | 79. | .37 |
| 4 | 25.6 | .82 | 9.0 | 151. | 207. | 441. | 1.01 | .65 | .96 | 99. | 78. | 20. | .79 |
| 5 | 24.7 | .85 | 8.3 | 197. | 190. | 415. | .99 | .60 | .92 | 80. | 112. | -32. | 1.41 |
| 6 | 23.5 | .86 | 8.0 | 197. | 173. | 380. | .96 | .58 | .91 | 68. | 113. | -45. | 1.66 |
| 7 | 22.9 | .85 | 8.4 | 128. | 189. | 402. | .95 | .60 | .99 | 79. | 61. | 18. | .78 |
| 8 | 22.9 | .83 | 9.0 | 77. | 204. | 437. | .95 | .63 | 1.04 | 96. | 23. | 73. | .24 |
| 9 | 23.7 | .80 | 10.2 | 39. | 232. | 462. | .97 | .68 | 1.08 | 115. | 0. | 115. | .00 |
| 10 | 24.8 | .77 | 11.3 | 21. | 268. | 501. | 1.00 | .74 | 1.10 | 142. | 0. | 142. | .00 |
| 11 | 25.6 | .74 | 11.8 | 27. | 262. | 489. | 1.01 | .77 | 1.09 | 147. | 0. | 147. | .00 |
| 12 | 26.1 | .74 | 11.6 | 33. | 273. | 503. | 1.03 | .77 | 1.09 | 151. | 0. | 151. | .00 |
| AVE | 24.9 | .80 | 10.0 | 90. | 225. | 457. | 1.00 | .69 | 1.03 | 115. | 37. | 78. | .45 |

Table 3. (Continued)

82.898 RECIFE (OLINDA) PBCO LAT 8 1 LONG 34 51 ELEV 56

| MO | TM | HM | TD | PREC | INS | RMM | CT | CH | CW | ETP | PD | ETDF | MAI |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 27.0 | .76 | 5.7 | 40. | 281. | 506. | 1.05 | .74 | 1.08 | 149. | 0. | 149. | .00 |
| 2 | 27.1 | .77 | 5.7 | 89. | 240. | 457. | 1.05 | .73 | 1.03 | 125. | 32. | 93. | .25 |
| 3 | 27.0 | .79 | 5.9 | 197. | 236. | 491. | 1.05 | .70 | .92 | 116. | 113. | 3. | .97 |
| 4 | 26.6 | .81 | 6.2 | 248. | 213. | 440. | 1.04 | .67 | .86 | 93. | 151. | -59. | 1.63 |
| 5 | 25.6 | .83 | 6.1 | 335. | 201. | 414. | 1.01 | .64 | .77 | 73. | 216. | -143. | 2.96 |
| 6 | 24.7 | .83 | 5.8 | 318. | 186. | 378. | .99 | .64 | .79 | 67. | 204. | -137. | 3.06 |
| 7 | 24.2 | .82 | 5.8 | 224. | 198. | 400. | .98 | .66 | .89 | 81. | 133. | -52. | 1.65 |
| 8 | 24.2 | .80 | 5.9 | 146. | 214. | 437. | .98 | .68 | .97 | 99. | 75. | 24. | .76 |
| 9 | 25.0 | .78 | 5.5 | 62. | 244. | 462. | 1.00 | .71 | 1.06 | 121. | 12. | 110. | .10 |
| 10 | 25.9 | .76 | 5.5 | 37. | 280. | 502. | 1.02 | .74 | 1.08 | 144. | 0. | 144. | .00 |
| 11 | 26.4 | .76 | 5.6 | 25. | 285. | 490. | 1.03 | .74 | 1.09 | 144. | 0. | 144. | .00 |
| 12 | 26.7 | .76 | 5.6 | 40. | 294. | 504. | 1.04 | .74 | 1.08 | 147. | 0. | 147. | .00 |
| AVE | 25.9 | .79 | 5.8 | 147. | 239. | 457. | 1.02 | .70 | .97 | 113. | 78. | 35. | .95 |

82.994 MACEIO ALA LAT 9 40 LONG 35 42 ELEV 46

| MO | TM | HM | TD | PREC | INS | RMM | CT | CH | CW | ETP | PD | ETDF | MAI |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 26.5 | .76 | 6.7 | 58. | 281. | 512. | 1.04 | .74 | 1.05 | 146. | 9. | 137. | .06 |
| 2 | 26.7 | .77 | 6.8 | 63. | 244. | 459. | 1.04 | .73 | 1.05 | 130. | 12. | 117. | .10 |
| 3 | 26.6 | .79 | 6.6 | 135. | 240. | 489. | 1.04 | .70 | .98 | 122. | 66. | 56. | .54 |
| 4 | 26.1 | .81 | 6.1 | 225. | 216. | 435. | 1.03 | .67 | .89 | 93. | 134. | -41. | 1.44 |
| 5 | 25.3 | .83 | 5.5 | 345. | 194. | 405. | 1.01 | .64 | .76 | 69. | 224. | -154. | 3.22 |
| 6 | 24.3 | .82 | 5.5 | 264. | 186. | 369. | .98 | .66 | .85 | 71. | 163. | -92. | 2.30 |
| 7 | 23.7 | .81 | 5.6 | 216. | 199. | 391. | .97 | .67 | .90 | 80. | 127. | -47. | 1.59 |
| 8 | 23.7 | .78 | 5.6 | 134. | 213. | 429. | .97 | .71 | .98 | 102. | 65. | 36. | .64 |
| 9 | 24.5 | .77 | 6.0 | 86. | 229. | 459. | .99 | .73 | 1.03 | 119. | 29. | 90. | .25 |
| 10 | 25.3 | .76 | 6.2 | 59. | 268. | 503. | 1.01 | .74 | 1.05 | 139. | 9. | 130. | .07 |
| 11 | 25.9 | .76 | 6.8 | 31. | 282. | 495. | 1.02 | .75 | 1.09 | 145. | 0. | 145. | .00 |
| 12 | 26.3 | .76 | 6.8 | 38. | 292. | 511. | 1.03 | .74 | 1.08 | 148. | 0. | 148. | .00 |
| AVE | 25.4 | .79 | 6.2 | 138. | 237. | 455. | 1.01 | .71 | .98 | 114. | 70. | 44. | .85 |

Table 3. (Continued)

83.096 ARACAJU SER LAT 10 55 LONG 37 5 ELEV 6

| MO | TM | HM | TD | PREC | INS | RMM | CT | CH | CW | ETP | PD | ETDF | MAI |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 26.5 | .77 | 6.2 | 43. | 253. | 516. | 1.04 | .73 | 1.08 | 148. | 0. | 148. | .00 |
| 2 | 26.8 | .77 | 6.4 | 45. | 226. | 461. | 1.04 | .73 | 1.07 | 133. | 0. | 133. | .00 |
| 3 | 26.9 | .78 | 6.3 | 107. | 274. | 488. | 1.05 | .72 | 1.01 | 130. | 45. | 85. | .35 |
| 4 | 26.4 | .79 | 6.2 | 162. | 214. | 431. | 1.03 | .70 | .95 | 104. | 86. | 18. | .83 |
| 5 | 25.4 | .81 | 6.0 | 263. | 190. | 399. | 1.01 | .67 | .85 | 80. | 162. | -82. | 2.03 |
| 6 | 24.5 | .80 | 5.9 | 177. | 186. | 362. | .99 | .69 | .94 | 80. | 98. | -17. | 1.21 |
| 7 | 23.8 | .80 | 6.0 | 161. | 179. | 384. | .97 | .69 | .95 | 85. | 86. | -1. | 1.01 |
| 8 | 23.7 | .78 | 6.0 | 104. | 201. | 424. | .97 | .72 | 1.01 | 105. | 43. | 62. | .41 |
| 9 | 24.5 | .77 | 5.9 | 54. | 214. | 456. | .99 | .73 | 1.06 | 122. | 5. | 117. | .04 |
| 10 | 25.4 | .77 | 6.1 | 50. | 242. | 504. | 1.01 | .73 | 1.07 | 139. | 3. | 136. | .02 |
| 11 | 25.8 | .78 | 6.3 | 49. | 246. | 499. | 1.02 | .72 | 1.07 | 136. | 2. | 134. | .01 |
| 12 | 26.2 | .78 | 6.4 | 38. | 268. | 516. | 1.03 | .71 | 1.08 | 143. | 0. | 143. | .00 |
| AVE | 25.5 | .78 | 6.1 | 104. | 220. | 453. | 1.01 | .71 | 1.01 | 117. | 44. | 73. | .49 |

83.195 ITABAIANINHA SER LAT 11 17 LONG 37 49 ELEV 225

| MO | TM | HM | TD | PREC | INS | RMM | CT | CH | CW | ETP | PD | ETDF | MAI |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 25.1 | .77 | 11.1 | 41. | 0. | 517. | 1.00 | .73 | 1.08 | 145. | 0. | 145. | .00 |
| 2 | 25.4 | .77 | 11.1 | 41. | 0. | 461. | 1.01 | .73 | 1.08 | 130. | 0. | 130. | .00 |
| 3 | 25.2 | .73 | 10.7 | 91. | 0. | 487. | 1.00 | .71 | 1.03 | 125. | 33. | 92. | .27 |
| 4 | 24.5 | .82 | 9.6 | 112. | 0. | 428. | .99 | .65 | 1.00 | 97. | 49. | 48. | .51 |
| 5 | 23.1 | .86 | 8.2 | 160. | 0. | 396. | .95 | .59 | .95 | 74. | 85. | -11. | 1.14 |
| 6 | 22.0 | .87 | 8.4 | 106. | 0. | 359. | .93 | .57 | 1.01 | 67. | 45. | 23. | .67 |
| 7 | 21.2 | .88 | 8.3 | 131. | 0. | 381. | .91 | .55 | .98 | 66. | 63. | 3. | .95 |
| 8 | 21.2 | .86 | 8.9 | 86. | 0. | 421. | .91 | .59 | 1.03 | 82. | 29. | 53. | .36 |
| 9 | 22.1 | .83 | 9.9 | 55. | 0. | 454. | .93 | .64 | 1.06 | 101. | 7. | 95. | .06 |
| 10 | 23.4 | .81 | 10.6 | 53. | 0. | 503. | .96 | .67 | 1.06 | 122. | 5. | 117. | .04 |
| 11 | 24.4 | .79 | 10.9 | 72. | 0. | 499. | .99 | .70 | 1.05 | 128. | 19. | 109. | .15 |
| 12 | 25.0 | .78 | 10.7 | 51. | 0. | 517. | 1.00 | .71 | 1.07 | 139. | 3. | 136. | .02 |
| AVE | 23.5 | .82 | 9.9 | 83. | 0. | 452. | .97 | .65 | 1.03 | 106. | 28. | 78. | .35 |

Table 3. (Continued)

83.097 PROPRIA SER LAT 10 12 LONG 36 52 ELEV 34

| MO | TM | HM | TD | PREC | INS | RMM | CT | CH | CW | ETP | PD | ETDF | MAI |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 27.2 | .70 | 10.5 | 30. | 0. | 514. | 1.05 | .83 | 1.09 | 171. | 0. | 171. | .00 |
| 2 | 27.9 | .70 | 10.6 | 24. | 0. | 461. | 1.07 | .83 | 1.10 | 157. | 0. | 157. | .00 |
| 3 | 27.8 | .71 | 10.0 | 47. | 0. | 489. | 1.07 | .81 | 1.07 | 159. | 0. | 159. | .00 |
| 4 | 26.8 | .76 | 9.4 | 90. | 0. | 433. | 1.04 | .74 | 1.03 | 121. | 33. | 88. | .27 |
| 5 | 25.2 | .82 | 7.9 | 158. | 0. | 402. | 1.00 | .65 | .96 | 88. | 84. | 5. | .95 |
| 6 | 23.8 | .84 | 7.6 | 123. | 0. | 366. | .97 | .62 | .99 | 76. | 57. | 19. | .75 |
| 7 | 23.0 | .84 | 7.5 | 111. | 0. | 388. | .95 | .61 | 1.00 | 79. | 49. | 30. | .61 |
| 8 | 22.9 | .83 | 8.1 | 80. | 0. | 427. | .95 | .64 | 1.04 | 94. | 25. | 69. | .26 |
| 9 | 24.3 | .78 | 9.2 | 40. | 0. | 457. | .98 | .71 | 1.08 | 120. | 0. | 120. | .00 |
| 10 | 25.8 | .74 | 10.3 | 25. | 0. | 504. | 1.02 | .77 | 1.09 | 152. | 0. | 152. | .00 |
| 11 | 26.8 | .71 | 10.7 | 36. | 0. | 497. | 1.04 | .82 | 1.06 | 161. | 0. | 161. | .00 |
| 12 | 27.4 | .70 | 10.6 | 22. | 0. | 514. | 1.06 | .82 | 1.10 | 172. | 0. | 172. | .00 |
| AVE | 25.7 | .76 | 9.4 | 66. | 0. | 454. | 1.02 | .74 | 1.05 | 129. | 21. | 109. | .24 |

83.179 BARRA BAHIA LAT 11 5 LONG 43 10 ELEV 408

| MO | TM | HM | TD | PREC | INS | RMM | CT | CH | CW | ETP | PD | ETDF | MAI |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 26.7 | .65 | 12.5 | 89. | 270. | 517. | 1.04 | .89 | 1.03 | 175. | 32. | 143. | .18 |
| 2 | 26.8 | .67 | 11.9 | 93. | 251. | 462. | 1.04 | .87 | 1.02 | 152. | 35. | 118. | .23 |
| 3 | 26.6 | .69 | 11.9 | 119. | 256. | 488. | 1.04 | .85 | 1.00 | 153. | 54. | 99. | .35 |
| 4 | 26.4 | .66 | 12.5 | 62. | 278. | 430. | 1.03 | .88 | 1.06 | 146. | 11. | 135. | .08 |
| 5 | 25.5 | .60 | 14.2 | 16. | 299. | 398. | 1.01 | .94 | 1.10 | 149. | 0. | 149. | .00 |
| 6 | 24.5 | .55 | 16.0 | 0. | 304. | 361. | .99 | 1.00 | 1.12 | 142. | 0. | 142. | .00 |
| 7 | 24.1 | .53 | 16.5 | 0. | 319. | 383. | .98 | 1.00 | 1.12 | 149. | 0. | 149. | .00 |
| 8 | 25.0 | .48 | 16.8 | 0. | 329. | 424. | 1.00 | 1.00 | 1.12 | 169. | 0. | 169. | .00 |
| 9 | 27.2 | .46 | 15.6 | 8. | 288. | 457. | 1.05 | 1.00 | 1.11 | 190. | 0. | 190. | .00 |
| 10 | 28.6 | .48 | 13.9 | 32. | 285. | 505. | 1.09 | 1.00 | 1.09 | 212. | 0. | 212. | .00 |
| 11 | 27.5 | .60 | 12.2 | 118. | 245. | 500. | 1.06 | .95 | 1.00 | 179. | 53. | 126. | .30 |
| 12 | 26.4 | .68 | 11.5 | 147. | 242. | 517. | 1.03 | .86 | .97 | 158. | 75. | 83. | .47 |
| AVE | 26.3 | .59 | 13.8 | 57. | 281. | 453. | 1.03 | .94 | 1.06 | 165. | 22. | 143. | .13 |

Table 3. (Continued)

83.339 CAETITE BAHIA LAT 14 4 LONG 42 29 ELEV 872

| MO | TM | HM | TD | PREC | INS | RMM | CT | CH | CW | ETP | PD | ETDF | MAI |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 22.0 | .77 | 10.9 | 134. | 208. | 525. | .93 | .74 | .98 | 127. | 65. | 62. | .51 |
| 2 | 22.3 | .76 | 11.2 | 92. | 206. | 463. | .94 | .75 | 1.02 | 120. | 34. | 86. | .29 |
| 3 | 22.4 | .77 | 10.8 | 127. | 208. | 482. | .94 | .73 | .99 | 118. | 60. | 58. | .51 |
| 4 | 21.6 | .77 | 10.7 | 63. | 205. | 417. | .92 | .73 | 1.05 | 106. | 13. | 94. | .12 |
| 5 | 20.4 | .75 | 11.1 | 19. | 222. | 379. | .89 | .76 | 1.10 | 102. | 0. | 102. | .00 |
| 6 | 19.2 | .73 | 11.5 | 11. | 221. | 341. | .86 | .78 | 1.11 | 92. | 0. | 92. | .00 |
| 7 | 18.7 | .71 | 12.1 | 12. | 234. | 363. | .85 | .81 | 1.11 | 101. | 0. | 101. | .00 |
| 8 | 19.5 | .66 | 13.2 | 10. | 262. | 408. | .87 | .88 | 1.11 | 125. | 0. | 125. | .00 |
| 9 | 21.6 | .62 | 13.7 | 13. | 244. | 448. | .92 | .92 | 1.11 | 152. | 0. | 152. | .00 |
| 10 | 22.8 | .65 | 13.0 | 59. | 225. | 504. | .95 | .90 | 1.06 | 164. | 9. | 155. | .06 |
| 11 | 22.2 | .74 | 10.9 | 185. | 164. | 506. | .93 | .77 | .93 | 122. | 104. | 18. | .85 |
| 12 | 22.1 | .78 | 10.4 | 164. | 177. | 527. | .93 | .72 | .95 | 121. | 88. | 33. | .73 |
| AVE | 21.2 | .73 | 11.6 | 74. | 215. | 447. | .91 | .79 | 1.04 | 121. | 31. | 90. | .25 |

83.076 IBIPETUBA BAHIA LAT 11 1 LONG 44 31 ELEV 434

| MO | TM | HM | TD | PREC | INS | RMM | CT | CH | CW | ETP | PD | ETDF | MAI |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 24.6 | .78 | 13.2 | 125. | 0. | 516. | .99 | .72 | .99 | 129. | 59. | 70. | .45 |
| 2 | 24.6 | .79 | 12.8 | 145. | 0. | 461. | .99 | .70 | .97 | 111. | 74. | 37. | .67 |
| 3 | 24.6 | .80 | 12.2 | 136. | 0. | 487. | .99 | .68 | .98 | 115. | 67. | 48. | .58 |
| 4 | 24.5 | .78 | 13.5 | 73. | 0. | 429. | .99 | .71 | 1.04 | 112. | 20. | 92. | .18 |
| 5 | 23.4 | .74 | 16.0 | 11. | 0. | 397. | .96 | .77 | 1.11 | 117. | 0. | 117. | .00 |
| 6 | 21.9 | .69 | 19.0 | 1. | 0. | 360. | .93 | .84 | 1.12 | 112. | 0. | 112. | .00 |
| 7 | 21.5 | .65 | 20.1 | 1. | 0. | 382. | .92 | .89 | 1.12 | 125. | 0. | 125. | .00 |
| 8 | 22.3 | .60 | 21.2 | 1. | 0. | 423. | .94 | .95 | 1.12 | 150. | 0. | 150. | .00 |
| 9 | 24.9 | .58 | 20.1 | 7. | 0. | 456. | 1.00 | .97 | 1.11 | 175. | 0. | 175. | .00 |
| 10 | 26.3 | .61 | 17.2 | 53. | 0. | 504. | 1.03 | .93 | 1.07 | 184. | 4. | 179. | .02 |
| 11 | 25.5 | .72 | 13.8 | 158. | 0. | 499. | 1.01 | .80 | .96 | 138. | 83. | 55. | .60 |
| 12 | 24.8 | .78 | 12.8 | 198. | 0. | 516. | 1.00 | .71 | .91 | 119. | 114. | 6. | .95 |
| AVE | 24.1 | .71 | 16.0 | 76. | 0. | 453. | .98 | .81 | 1.04 | 132. | 35. | 97. | .29 |

Table 3. (Continued)

83.238 PARATINGA BAHIA LAT 12 41 LONG 43 11 ELEV 422

| MO | TM | HM | TD | PREC | INS | RMM | CT | CH | CW | ETP | PD | ETDF | MAI |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 25.8 | .72 | 12.1 | 107. | 238. | 522. | 1.02 | .80 | 1.01 | 153. | 45. | 107. | .30 |
| 2 | 25.7 | .72 | 12.0 | 129. | 243. | 463. | 1.02 | .80 | .99 | 132. | 62. | 70. | .47 |
| 3 | 25.8 | .73 | 11.7 | 115. | 219. | 486. | 1.02 | .79 | 1.00 | 139. | 51. | 88. | .37 |
| 4 | 25.9 | .70 | 12.8 | 40. | 260. | 424. | 1.02 | .83 | 1.08 | 138. | 0. | 138. | .00 |
| 5 | 25.1 | .63 | 14.2 | 11. | 281. | 389. | 1.00 | .91 | 1.11 | 140. | 0. | 140. | .00 |
| 6 | 24.4 | .58 | 15.6 | 0. | 277. | 351. | .99 | .97 | 1.12 | 134. | 0. | 134. | .00 |
| 7 | 24.3 | .57 | 15.6 | 1. | 279. | 373. | .98 | .98 | 1.12 | 144. | 0. | 144. | .00 |
| 8 | 25.6 | .53 | 15.3 | 0. | 305. | 417. | 1.01 | 1.00 | 1.12 | 168. | 0. | 168. | .00 |
| 9 | 27.5 | .52 | 14.7 | 8. | 252. | 454. | 1.06 | 1.00 | 1.11 | 190. | 0. | 190. | .00 |
| 10 | 28.3 | .57 | 13.8 | 42. | 247. | 506. | 1.08 | .98 | 1.09 | 206. | 0. | 206. | .00 |
| 11 | 26.4 | .68 | 11.8 | 149. | 203. | 504. | 1.03 | .85 | .96 | 152. | 77. | 75. | .51 |
| 12 | 25.6 | .74 | 11.8 | 153. | 224. | 523. | 1.01 | .78 | .96 | 142. | 80. | 62. | .56 |
| AVE | 25.9 | .64 | 13.4 | 63. | 252. | 451. | 1.02 | .89 | 1.05 | 153. | 26. | 127. | .18 |

82.979 REMANSO BAHIA LAT 9 41 LONG 42 4 ELEV 411

| MO | TM | HM | TD | PREC | INS | RMM | CT | CH | CW | ETP | PD | ETDF | MAI |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 27.5 | .51 | 14.7 | 92. | 0. | 512. | 1.06 | 1.00 | 1.02 | 198. | 34. | 164. | .17 |
| 2 | 27.5 | .52 | 14.6 | 65. | 0. | 460. | 1.06 | 1.00 | 1.05 | 183. | 14. | 169. | .07 |
| 3 | 27.1 | .51 | 14.2 | 108. | 0. | 489. | 1.05 | 1.00 | 1.01 | 184. | 46. | 138. | .25 |
| 4 | 27.3 | .51 | 14.7 | 35. | 0. | 435. | 1.06 | 1.00 | 1.08 | 177. | 0. | 177. | .00 |
| 5 | 27.0 | .50 | 15.1 | 10. | 0. | 406. | 1.05 | 1.00 | 1.11 | 168. | 0. | 168. | .00 |
| 6 | 26.0 | .50 | 15.6 | 1. | 0. | 369. | 1.02 | 1.00 | 1.12 | 151. | 0. | 151. | .00 |
| 7 | 25.6 | .50 | 15.8 | 1. | 0. | 392. | 1.01 | 1.00 | 1.12 | 158. | 0. | 158. | .00 |
| 8 | 26.0 | .48 | 16.1 | 0. | 0. | 430. | 1.02 | 1.00 | 1.12 | 176. | 0. | 176. | .00 |
| 9 | 27.2 | .46 | 15.8 | 4. | 0. | 460. | 1.05 | 1.00 | 1.12 | 192. | 0. | 192. | .00 |
| 10 | 28.3 | .45 | 15.3 | 10. | 0. | 504. | 1.08 | 1.00 | 1.11 | 215. | 0. | 215. | .00 |
| 11 | 28.0 | .47 | 14.6 | 78. | 0. | 496. | 1.07 | 1.00 | 1.04 | 197. | 23. | 173. | .12 |
| 12 | 27.5 | .48 | 14.5 | 93. | 0. | 512. | 1.06 | 1.00 | 1.02 | 198. | 35. | 163. | .18 |
| AVE | 27.1 | .49 | 15.1 | 41. | 0. | 455. | 1.05 | 1.00 | 1.08 | 183. | 13. | 170. | .07 |

Table 3. (Continued)

83.386 JANUARIA M.G. LAT 15 30 LONG 44 21 ; ELEV 439

| MO | TM | HM | TD | PREC | INS | RMM | CT | CH | CW | ETP | PD | ETDF | MAI |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 25.1 | .79 | 10.7 | 147. | 227. | 530. | 1.00 | .71 | .97 | 129. | 75. | 54. | .58 |
| 2 | 25.3 | .77 | 11.1 | 105. | 218. | 466. | 1.01 | .74 | 1.01 | 125. | 44. | 81. | .35 |
| 3 | 25.2 | .78 | 10.8 | 103. | 231. | 481. | 1.00 | .71 | 1.01 | 125. | 42. | 82. | .34 |
| 4 | 24.6 | .76 | 11.2 | 52. | 235. | 413. | .99 | .75 | 1.07 | 117. | 4. | 113. | .04 |
| 5 | 23.3 | .72 | 13.0 | 11. | 255. | 372. | .96 | .80 | 1.11 | 112. | 0. | 112. | .00 |
| 6 | 22.2 | .69 | 14.4 | 1. | 251. | 333. | .93 | .84 | 1.12 | 104. | 0. | 104. | .00 |
| 7 | 22.0 | .64 | 14.5 | 1. | 265. | 355. | .93 | .90 | 1.12 | 119. | 0. | 119. | .00 |
| 8 | 23.4 | .57 | 15.5 | 1. | 281. | 402. | .96 | .98 | 1.12 | 150. | 0. | 150. | .00 |
| 9 | 25.5 | .57 | 15.2 | 16. | 244. | 446. | 1.01 | .98 | 1.10 | 174. | 0. | 174. | .00 |
| 10 | 26.4 | .63 | 13.6 | 57. | 215. | 506. | 1.03 | .91 | 1.06 | 179. | 8. | 171. | .04 |
| 11 | 25.2 | .76 | 11.2 | 165. | 167. | 510. | 1.00 | .75 | .95 | 130. | 89. | 42. | .68 |
| 12 | 24.7 | .81 | 10.2 | 217. | 174. | 533. | .99 | .68 | .89 | 114. | 127. | -14. | 1.12 |
| AVE | 24.4 | .71 | 12.6 | 73. | 230. | 446. | .99 | .81 | 1.04 | 132. | 32. | 99. | .26 |

83.483 PIRAPORA M.G. LAT 17 21 LONG 44 57 ELEV 412

| MO | TM | HM | TD | PREC | INS | RMM | CT | CH | CW | ETP | PD | ETDF | MAI |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 24.7 | .78 | 10.6 | 220. | 195. | 535. | .99 | .71 | .89 | 120. | 130. | -11. | 1.09 |
| 2 | 24.9 | .78 | 11.1 | 143. | 198. | 467. | 1.00 | .71 | .97 | 115. | 72. | 43. | .63 |
| 3 | 24.7 | .78 | 11.4 | 127. | 214. | 478. | .99 | .72 | .99 | 119. | 60. | 59. | .51 |
| 4 | 23.5 | .77 | 12.9 | 63. | 232. | 404. | .96 | .73 | 1.05 | 107. | 12. | 95. | .11 |
| 5 | 21.3 | .74 | 15.2 | 11. | 269. | 360. | .91 | .77 | 1.11 | 100. | 0. | 100. | .00 |
| 6 | 19.9 | .72 | 17.0 | 3. | 261. | 320. | .88 | .80 | 1.12 | 90. | 0. | 90. | .00 |
| 7 | 19.7 | .69 | 17.2 | 3. | 274. | 343. | .87 | .84 | 1.12 | 100. | 0. | 100. | .00 |
| 8 | 21.5 | .61 | 17.8 | 1. | 290. | 392. | .92 | .94 | 1.12 | 135. | 0. | 135. | .00 |
| 9 | 24.1 | .58 | 16.1 | 19. | 221. | 440. | .98 | .97 | 1.10 | 164. | 0. | 164. | .00 |
| 10 | 25.3 | .64 | 12.9 | 75. | 197. | 505. | 1.01 | .90 | 1.04 | 170. | 21. | 149. | .13 |
| 11 | 24.9 | .74 | 11.1 | 202. | 181. | 514. | 1.00 | .77 | .91 | 128. | 116. | 11. | .91 |
| 12 | 24.4 | .79 | 10.2 | 278. | 154. | 539. | .99 | .70 | .83 | 110. | 173. | -64. | 1.58 |
| AVE | 23.2 | .72 | 13.6 | 95. | 224. | 442. | .96 | .80 | 1.02 | 121. | 49. | 72. | .41 |

Table 3. (Continued)

83.385 SAO FRANCISCO M.G. LAT 15 57 LONG 44 52 ELEV 440

| MO | TM | HM | TD | PREC | INS | RMM | CT | CH | CW | ETP | PD | ETDF | MAI |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 24.1 | .81 | 13.6 | 208. | 0. | 531. | .98 | .66 | .90 | 111. | 121. | -10. | 1.09 |
| 2 | 24.4 | .81 | 14.7 | 137. | 0. | 466. | .99 | .67 | .98 | 108. | 68. | 40. | .63 |
| 3 | 24.1 | .82 | 13.9 | 159. | 0. | 480. | .98 | .65 | .95 | 104. | 84. | 19. | .81 |
| 4 | 23.3 | .80 | 15.5 | 67. | 0. | 410. | .96 | .69 | 1.05 | 102. | 15. | 87. | .15 |
| 5 | 21.6 | .77 | 17.6 | 14. | 0. | 369. | .92 | .74 | 1.11 | 98. | 0. | 98. | .00 |
| 6 | 19.8 | .74 | 19.2 | 3. | 0. | 329. | .88 | .78 | 1.12 | 89. | 0. | 89. | .00 |
| 7 | 20.0 | .69 | 19.8 | 2. | 0. | 352. | .88 | .84 | 1.12 | 103. | 0. | 103. | .00 |
| 8 | 21.7 | .62 | 20.4 | 1. | 0. | 399. | .92 | .92 | 1.12 | 135. | 0. | 135. | .00 |
| 9 | 24.2 | .50 | 18.8 | 27. | 0. | 444. | .98 | .95 | 1.09 | 161. | 0. | 161. | .00 |
| 10 | 25.7 | .64 | 16.3 | 65. | 0. | 505. | 1.02 | .90 | 1.05 | 174. | 14. | 160. | .08 |
| 11 | 24.6 | .75 | 13.5 | 195. | 0. | 511. | .99 | .74 | .92 | 122. | 111. | 11. | .91 |
| 12 | 24.2 | .82 | 12.6 | 278. | 0. | 534. | .98 | .65 | .83 | 101. | 173. | -72. | 1.71 |
| AVE | 23.1 | .74 | 16.3 | 96. | 0. | 444. | .96 | .77 | 1.02 | 117. | 49. | 69. | .45 |

moisture availability index, MAI. Column headings for Table 3 are as follows:

| Column Number | Symbol | |
|---|---|---|
| 1 | MO | Month of the year. |
| 2 | TM | Mean monthly temperature in °C. |
| 3 | HM | Mean monthly relative humidity expressed decimally. |
| 4 | TD | Mean monthly temperature difference in °C (mean maximum temperature minus mean minimum temperature). |
| 5 | PREC | Mean monthly precipitation in mm. |
| 6 | INS | Insulation - monthly sunshine hours. |
| 7 | RMM | Monthly extraterrestrial radiation for the latitude and mean temperature expressed as equivalent mm of evaporation. |
| 8 | CT | A monthly temperature coefficient (equation 4a). |
| 9 | CH | A monthly humidity coefficient (equation 4b). |
| 10 | CW | A monthly wind coefficient based on estimated wind (equation 4c). |
| 11 | ETP | Estimated potential evapotranspiration (equation 4). |
| 12 | PD | Estimated dependable precipitation (equation 1). |
| 13 | ETDF | Evapotranspiration deficit (equation 3). |
| 14 | MAI | Moisture availability index (equation 2). |

Hargreaves (5, 6) proposed the use of Class A pan evaporation and estimated evapotranspiration in the determination of possible ground water recharge. Data from a watershed in Nicaragua indicate good agreement between measured groundwater outflow and outflow from the equation

$$GWO = PREC - ETA - SWR \qquad (7)$$

in which

GWO = groundwater outflow plus or minus changes in storage

PREC = measured precipitation

ETA = estimated actual evapotranspiration by the crops and vegetation of the watershed

SWR = measured surface water runoff.

The development of values for ETA for a watershed is a laborious process and requires fairly detailed information on the areas in various types of vegetative cover as well as the dormant or dry periods of the vegetation. The evapotranspiration deficit, ETDF, and the moisture availability index, MAI, are easily estimated and should correlate well with potential ground water recharge.

A review of the values of MAI given in Table 3 indicates that rainfall is severely deficient during ten months at Barra and during twelve months at Remanso. In general for the semi-arid Northeast, rainfall is severely deficient during about seven to nine months of the year.

An unpublished thesis study made by Mirnezami cited by Hargreaves (4) indicates a high degree of correlation between yields of unfertilized dry farmed wheat and MAI. It is therefore proposed that further research be carried out on the MAI-production function relationship and that MAI be more widely used as an index indicating water deficiencies and precipitation excesses in water balance, water use and resource development planning studies.

## CONCLUSION

Large quantities of usable groundwater are reported in the underground reservoirs of the sedimentary basins of the Northeast. With severe water deficiencies during seven to nine months throughout large portions of the Northeast, there is a definite and well established need for irrigation to increase agricultural production. Irrigation from ground water is proposed in areas where feasible as a means of stimulating infrastructure growth and of developing the knowledge of irrigation and other conditions prerequisite to a fairly rapid utilization of surface water supplies after groundwater supplies are mined or after the more economical groundwater developments are utilized.

Additional study is recommended in order to further define the relationships between evapotranspiration deficits, the moisture availability index, crop production and yields and potential ground water recharge.

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