# NET RADIATION IN THE NORTHEAST REGION OF BRAZIL

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**ABSTRACT -** For many climatological studies net radiation at the earths surface is necessary. Measured values of this parameter are not often available. Mean monthly values of net radiation at some stations in NE Brazil evaluated using Morton's (1983) procedure are reported in this paper. The maximum and minimum values of net radiation noticed are 393 and 166 cal $cm^{-2}$ $min^{-1}$.

## INTRODUCTION

Net radiation is an important parameter in several methods of estimating water loss from the surface. Measured net radiation data is not often available. Linacre (1968) has suggested several equations for computing of net radiation. Karuna Kumar and Rao (1985) have used these procedures for studying the spatial distribution of net radiation in India. In many parts of NE region of Brazil net radiation data is not available. The objective of this study is to estimate the net radiation at some stations in this region based on Morton's (1983) approach.

## MATERIALS AND METHODS

Mean monthly values of air temperature, vapour pressure and incoming solar radiation at twenty eight stations in different parts of NE region of Brazil were used in this study.

The zenith value of dry season clear 1sky albedo is given by

$$a_{zd} = 0.26 - 0.00012 P_A \left(\frac{p}{p_s}\right)^{0.5} \left[1 + \left|\frac{\Phi}{42}\right| + \left[\frac{\Phi}{42}\right]^2\right] \quad (1)$$

$$0.11 \le a_{zd} \le 0.17$$

where $P_A$ is the mean annual precipitation in mm, $\phi$ is the latitude and p and ps are the station pressure and 1013 mb respectively.

The zenith value of clear sky albedo ( $a_z$ ) is obtained as follows

$$a_z = a_{zd}$$

$$0.11 \le a_z \le 0.5\left(0.91 - \frac{V_d}{V}\right) \quad (2)$$

$$c_0 = V - V_d \qquad 0 \le c_0 \le 1$$

where $V_d$ and V are the actual and saturation vapour pressures.

Clear sky albedo is then computed from the following expression

$$a_0 = a_z \left( \frac{\exp(1.08) - \left(2.16\frac{\cos z}{\pi} + \sin z\right)\exp(0.012z)}{1.473(1 - \sin z)} \right) \quad (3)$$

where 'z' is the zenith distance of the Sun at noon.

The mean albedo 'a' is given by

$$a = a_0\left[s + (1-s)\left(1 - \frac{z}{330}\right)\right] \quad (4)$$

where s is the sunshine ratio.

Net long wave radiation loss from the surface ($L_n$) is computed as follows:

The proportional increase in downward long wave radiation due to clouds ($\rho$) is

$$\rho = 0.18\left[(1-c_2)(1-s)^2 + c_2(1-s)^{0.5}\right]\frac{p_s}{p} \quad (5)$$

$$c_2 = 10\left(\frac{V_d}{V} - s - 0.42\right)$$

$$L_N \ge 0.05\varepsilon\sigma(T+273)^4 \quad \text{and} \quad 0 \le c_2 \le 1.0$$

Using $\rho$, $V_d$ and T, $L_n$ is computed as:

$$L_N = \varepsilon\sigma(T+273)^4\left[1 - (0.71 + 0.007V_d\frac{p}{p_s})(1+\rho)\right] \quad (6)$$

where $\varepsilon$ is the emissivity and $\sigma$ is the Stefan-Boltzman constant.

$\varepsilon\,\sigma = 5.22 \times 10^{-8}$ $Wm^{-2}$ $K^{-4}$

Net radiation is then obtained from the expression

$$R_n = R_s(1-a) - L_N \quad (7)$$

where $R_s$ is the global radiation.

## RESULTS AND DISCUSSION

Net radiation values at the selected stations are given in Table 1

A large variation in monthly mean values of net radiation in the region is noticed, the maximum and minimum values being 393 Cal $cm^{-2}$ $day^{-1}$ and 166 Cal $cm^{-2}$ $day^{-1}$, respectively. In the case of incoming solar radiation the maximum and minimum values observed are 606 and 316 Cal $cm^{-2}$ $day^{-1}$, respectively. The ratio between net radiation and incoming solar radiation (Qn/Qs) varied between 73% and 41%. At 24 out of 28 stations the maximum value of this ratio during the year occurred in March or April. Likewise at 26 stations the lowest value of the ratio occurred in July or August.

As in the case of net radiation a steep variation was found in the values of net longwave radiation .The

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maximum and minimum values noticed are 150 and 43 Cal $cm^{-2}$ $day^{-1}$, respectively. At most of the stations the maximum values during the year of Ln occurred during the months August-October and the minimum values during the months March-May.

The net radiation values given in Table 1 are based on the assumption of equality of surface and air temperatures. If these temperatures are different the error involved may be significant in arid and semiarid climates. According to Linacre (1968), net radiation flux decreases by about 10 Cal $cm^{-2}$ $day^{-1}$ for each degree centigrade that the surface temperature exceeds the air temperature.

## REFERENCES


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Table 1. Mean monthly values of net radiation (Cal $cm^{-2}$ $day^{-1}$).

| Station/ State | Jan. | Feb. | Mar. | Apr. | May | Jun. | Jul. | Aug. | Sep. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Patos-PB | 249 | 309 | 328 | 285 | 211 | 169 | 167 | 211 | 250 | 279 | 264 | 243 |
| S.Gonçalo-PB | 296 | 319 | 354 | 313 | 272 | 211 | 215 | 271 | 309 | 341 | 315 | 285 |
| Monteiro-PB | 264 | 286 | 304 | 281 | 227 | 197 | 200 | 256 | 279 | 295 | 259 | 245 |
| J.Pessoa-PB | 326 | 329 | 344 | 313 | 255 | 240 | 236 | 275 | 303 | 340 | 330 | 309 |
| C.Grande-PB | 265 | 288 | 294 | 259 | 219 | 194 | 196 | 225 | 256 | 287 | 280 | 254 |
| Barreras-BA | 352 | 329 | 317 | 296 | 223 | 206 | 207 | 241 | 268 | 283 | 306 | 351 |
| Irece-BA | 315 | 302 | 314 | 261 | 190 | 173 | 166 | 187 | 217 | 229 | 259 | 296 |
| Ilheus-BA | 345 | 336 | 331 | 254 | 230 | 218 | 212 | 253 | 326 | 319 | 335 | 335 |
| Salvador-BA | 377 | 348 | 360 | 288 | 222 | 197 | 209 | 261 | 289 | 317 | 347 | 355 |
| Gauratinga-BA | 343 | 306 | 318 | 255 | 207 | 197 | 185 | 228 | 245 | 274 | 262 | 334 |
| Lençães-BA | 311 | 292 | 287 | 251 | 189 | 217 | 182 | 223 | 266 | 245 | 280 | 307 |
| Caravelas-BA | 411 | 393 | 347 | 266 | 215 | 180 | 191 | 235 | 247 | 272 | 300 | 371 |
| B.J.Lapa-BA | 332 | 309 | 316 | 266 | 191 | 176 | 167 | 208 | 240 | 256 | 273 | 308 |
| Surubim-PE | 327 | 331 | 331 | 289 | 254 | 231 | 229 | 280 | 310 | 343 | 341 | 311 |
| Cabrobo-PE | 270 | 272 | 313 | 278 | 216 | 189 | 173 | 210 | 232 | 262 | 268 | 267 |
| Petrolina-PE | 315 | 323 | 352 | 298 | 307 | 202 | 192 | 236 | 270 | 305 | 314 | 311 |
| Recife-PE | 352 | 348 | 339 | 295 | 258 | 232 | 233 | 282 | 321 | 351 | 355 | 339 |
| Barbalha-CE | 290 | 285 | 298 | 280 | 234 | 205 | 209 | 262 | 278 | 294 | 295 | 279 |
| Moradanova-CE | 258 | 288 | 306 | 294 | 245 | 218 | 225 | 225 | 246 | 254 | 239 | 215 |
| Quixeramobim-CE | 242 | 284 | 310 | 292 | 256 | 223 | 203 | 220 | 251 | 265 | 242 | 229 |
| Sobral-CE | 280 | 314 | 309 | 303 | 270 | 254 | 243 | 254 | 289 | 293 | 283 | 257 |
| Fortaleza-CE | 279 | 288 | 253 | 244 | 248 | 238 | 242 | 297 | 338 | 332 | 318 | 314 |
| Jaguaruana-CE | 257 | 284 | 275 | 277 | 238 | 218 | 226 | 257 | 283 | 289 | 295 | 286 |
| Crateus-CE | 260 | 290 | 317 | 301 | 259 | 211 | 184 | 205 | 236 | 236 | 225 | 194 |
| Cruzeta-RN | 251 | 310 | 334 | 320 | 264 | 223 | 209 | 238 | 263 | 276 | 281 | 250 |
| Própria-SE | 389 | 368 | 374 | 324 | 267 | 245 | 241 | 287 | 291 | 378 | 385 | 352 |
| Floriano-PI | 280 | 281 | 315 | 285 | 253 | 232 | 215 | 252 | 286 | 297 | 279 | 258 |
| Areia-PB | 290 | 297 | 307 | 284 | 214 | 217 | 207 | 248 | 274 | 314 | 293 | 258 |