INTERCOMPARISION OF FLUX, BULK AND GRADIENT RICHARDSON NUMBER AND ITS SPATIAL AND TEMPORAL VARIATION AS REVEALED BY INTERDISCIPLINARY PANTANAL EXPERIMENT (IPE-1) MAY 1998

K. P. R. Vittal Murty*, Edson P. Marques Filho*, Gannabathula S. S. D. Prasad*, Leonardo Deane de Abreu Sá
Divisão de Ciências Meteorológicas/INPE (murty@met.inpe.br)
Antônio Ocimar Manzi*
CPTEC/INPE
Amaury de Souza
Departamento de Física/Universidade Federal do Mato Grosso do Sul (fax: (067)787.3093)
Bart Kruijt
Institute of Ecology and Resource Management /University of Edinburgh

Resumo

Para obtermos o comportamento universal dos parâmetros meteorológicos na camada limite superficial, necessitamos estabelecer alguma propriedade de medida da estabilidae atmosférica. Neste trabalho foram utilizados como indicadores da estabilidade as diferentes formas do número de Richardson, calculados com os dados obtidos no IPE-1. A comparação dos diferentes indicadores revelaram um padrão esperado, de acordo com o ciclo diurno da superfície terrestre. As variações de $\frac{Ri_g}{Ri_f}$ e $\frac{Ri_g}{Ri_b}$ mostraram-se opostas durante todo o dia, exceto ao meio dia, quando são iguais.

Keywords

Micrometeorology, variability, Richardson number, Pantanal.

1 - Introduction

The surface layer of the atmosphere which is a very important buffer zone between the underlying surface and atmosphere above, experiences wide changes in temperature, wind and humidity both in space and time.

When we search for universal behavior in the boundary layer or see for proper scaling parameters we need to establish proper measure of stability in the surface layer.

The most widely used indicator in the laboratory and early atmospheric woks is the gradient Richardson number Ri_g, a nondimentional parameter representing the relative importance of buoyancy and shear in producing turbulence. It is expressed as

$$Ri_g = \frac{\frac{g}{\bar{\theta}}\frac{\partial \bar{\theta}}{\partial z}}{\left(\frac{\partial \bar{u}}{\partial z}\right)^2} \tag{1}$$

where $\frac{g}{\bar{\theta}}$ is the buoyancy parameter, g is acceleration due to gravity and $\bar{\theta}$ is the average potential temperature and $\bar{u}$ is the average wind.

(*) The authors are grateful to CNPq for providing finantial grant.

Ri is positive in stable stratification and negative in unstable stratification and zero for neutral stratification. The advantage in using Richardson number is that it contains gradients of mean quantities and easy to measure. Above a critical value Ri_c the flow becomes laminar from turbulent. Between the values 0 and Ri_c the turbulent flow in dominantly mechanical in origin, generated by wind shear. For negative values of Ri the turbulence is both mechanical and convective (Kaimal and Finnigan, 1994).

Two others forms of Richardson number, flux Richardson number Ri_f and bulk Richardson number Ri_b are some times used wich are given as

$$Ri_f = \frac{\frac{g}{\bar{\theta}}\overline{(w'\theta')}}{\overline{(u'w')}\left(\frac{\partial \bar{u}}{\partial z}\right)} \approx \frac{K_h}{K_m} Ri_g \qquad (2)$$

$$Ri_b = \frac{\frac{g}{\bar{\theta}}\frac{\overline{(\theta_z - \theta_0)}}{2}}{\left(\frac{\bar{u}_z}{z}\right)^2} \qquad (3)$$

Here u', w', θ' are the pulsations. Ri_f is a mixture of eddy correlation and mean gradient can be computed only when pulsations in u, w and θ are measured with sensitive instruments. Ri_b is a useful index of stability particularly under conditions of low wind shear (for which Ri_g is very sensitive and becomes undependable) (Murty and Vittal Murty,1993). The suffix z represent to particular height $'z'$.

In this article Ri_g, Ri_f and Ri_b are computed for Pantanal data and compared. Ri_{g1} and Ri_{g2} are estimated based on the values at heights (3.8m and 15.7m) and (8.1m and 21.5m) respectively Ri_{f1} and Ri_{f2} also worked out correspondently but $(u'w')$ and $(w'\theta')$ are computed for sonic fast response data. Even though the data is available throughout the experiment, we are representing the data for a typical day (141) corresponding to 21 may 1998.

2 - Results and discussion

The relation between $\frac{Ri_{g1}}{Ri_{f1}}$ shows interesting march with time. In the early hours the ratio is negative from 6:00 a.m. hours to 18:00 hours it is near zero and from 18:00 hours to 23:00 hours it is positive. More or less same type of pattern was reflected with $\frac{Ri_{g2}}{Ri_{f2}}$ which was estimated at different layer above the first layer between 8.1m and 21.5m . Since Ri_f is related with Ri_g as $Ri_f = \frac{K_h}{K_m} Ri_g$ the ratio $\frac{Ri_g}{Ri_f}$ can be taken as indicator of variation $\frac{K_m}{K_h}$. That is K_h is negative in the early hours and positive rest of the time. The momentum flux dominated in the evening and early night hours. The ratio Ri_{g1} and Ri_b that there is a close correspondense in the night and early morning hours and Ri_b is an over estimate compared to Ri_g. This can be explained by week gradients in wind velocity. It is interesting to note whenever there are flutuation in graphs a) and b) the graph c) shows a constant value and where a) and b) show no variation there is variation in graph c). But at noon all the ratios are very nearly zero.

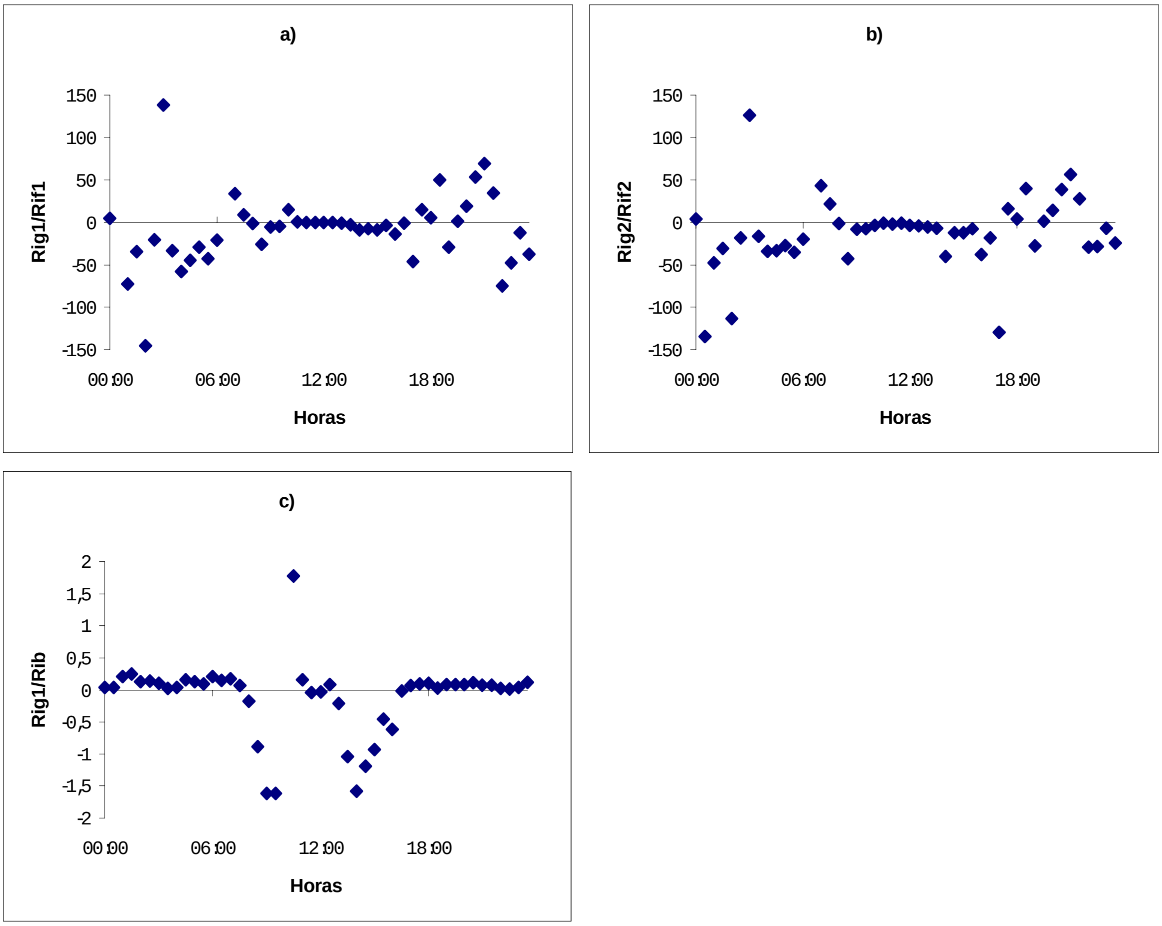

Fig.1 - Relation between different forms of Richardson number as revealed from IPE-1 on the julian day 141.

3 - Conclusions

1) An inter comparision of differents forms of Richardson number which were estimated from IPE-1 reveal expected patterns;
2) The $\frac{K_m}{K_h}$ is negative during the night and early hours and is positive in the evening. This shows that K_h is negative during the night and early hours and is positive in the day time;
3) There is dominance of K_m in the evening hours and up to 23:00 hours in the night;
4) Ri_g is always an over estimate compared to Ri_b;
5) The variation of $\frac{Ri_g}{Ri_f}$ and $\frac{Ri_g}{Ri_b}$ are opposite in nature whenever $\frac{Ri_g}{Ri_f}$ is negative or positive $\frac{Ri_g}{Ri_b}$ is costant and near zero. Whenever $\frac{Ri_g}{Ri_b}$ is varying $\frac{Ri_g}{Ri_f}$ is costant and near zero.

4 - Acknowledgement

The authors give thanks for the support received from the Fundação de Amparo à Pesquisa do Estado de São Paulo, FAPESP (proc. n° 98/00105-5) and from the Conselho Nacional de Desenvolvimento Científico e Tecnológico, CNPq (procs. n^{os} 381.699/97-8, 381.690/97-0, 139.164/96-0).

Acknowledgement is also given to all the people involved in the IPE-1 Project organization and data collecting: Drs. Regina Célia dos Santos Alvalá, Clóvis Angeli Sansigolo, Ralf Gielow, Plínio

Carlos Alvalá, Clóvis M. do Espirito Santo and Mrs. Paulo Rogério Aquino Arlino, Luis Eduardo Rosa, Celso von Randow, Jorge Martins de Melo, Sabrina B. Monteiro Sambatti, Elizabete Cária Moraes of INPE, Drs. Edson Kassar, Hamilton Germano Pavão, Masao Uetanabaro and Mrs. Carla Muller, Jorge Gonçalves and Waldeir Moreshi Dias of Universidade Federal do Mato Grosso do Sul, Dr. Yadvinder Malhi of University of Edinburgh, Dr. Maria Lúcia Meirelles of EMBRAPA/CPAC, Dr. Romísio Geraldo Bouhid André of UNESP/Jaboticabal.

Special thanks are due also to Dr. Nelson L. Dias of SIMEPAR and Dr. Paulo Henrique Caramori of IAPAR who provided kindly a sonic anemometer and a hygrometer to be used during the IPE-1 campaign.

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