Ministério da Ciência, Tecnologia e Inovação

STRONG TEMPERATURE GRADIENTS IN THE MLT REGION ASSOCIATED TO AN INSTABILITY SOURCE

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Abstract

Na Lidar temperature measurements, covering the range 82 – 105 km, were made during 2007 and 2008 at Sao Jose dos Campos (231° S, 45.9 °W). We have studied vertical wind shear related to atmospheric tides, inferred by meteor radar, with the aim of analyzing instability generation. We have found that wind shear alone is not enough to trigger an instability. A strong temperature gradient of at least - 8K/km is required concomitantly with the wind shear in order to generate the instability. We have used two years of data from 2007 to 2008 with 28 days of simultaneous wind and temperature, totalizing 148 hours of observation. We observe several cases of strong temperature gradients and tidal wind shear. This is an evidence of possible local Gravity Wave source in the Mesosphere Lower Thermosphere region.

Introduction

The present work was based mainly in temperature data from 80 to 100 km inferred by Na Lidar over São José dos Campos (23.1° S, 45.9° W). Lidar equipment measures the scattering cross-section at the D_{2a} Na resonance transition, and at the minimum between the D_{2a} and D_{2b} peaks, making it possible to infer the temperature. For more detail see Fricke and Von Zahn (1984) and Von der Gathen (1991). See Figure 1.

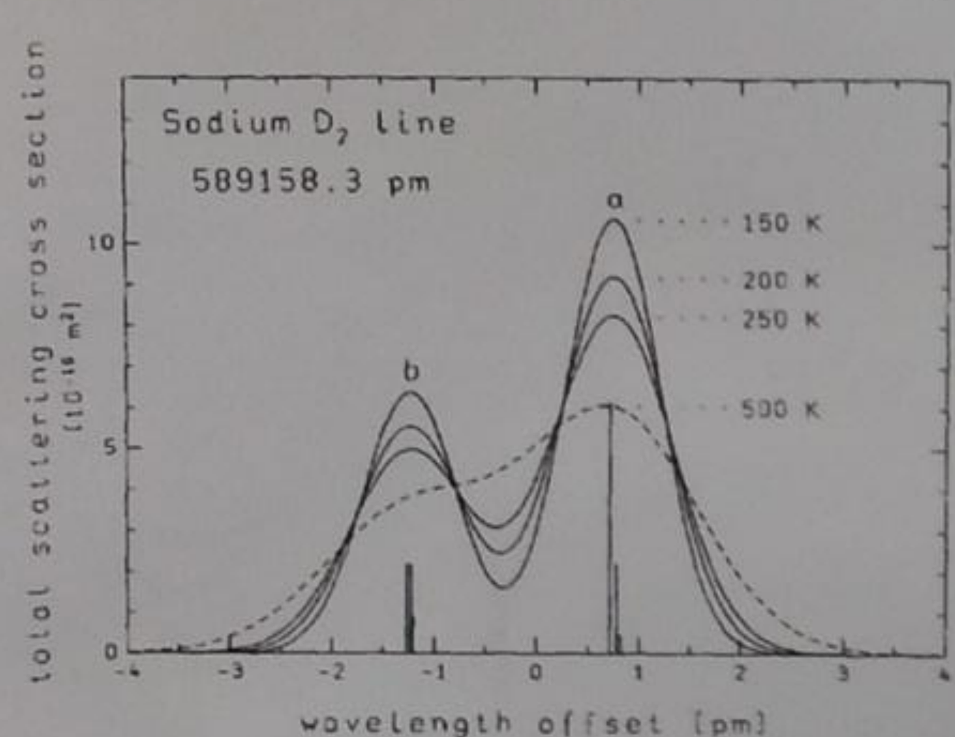

Fig 1. Variation of the total scattering cross section in the Na hyperfine structure of D_2 resonance transition with atmospheric temperature (Fricke and Zahn, 1984).

Method

Richardson's number was used as an instability indicator.

$$R_i = \frac{N^2}{\left(\frac{du}{dz}\right)^2} \qquad N^2 = \left(\frac{g\left(\frac{\partial T}{\partial z} - \alpha^*\right)}{T(z)}\right)$$

Where:

$\partial T/\partial z$ vertical gradient of temperature

$\alpha^* =$ $-9.5(K/km)$ dry adiabatic lapse rate

$R_i <$ $1/4$ Required for the shear rate to exceed the fluid's tendency to remains stratified, allowing turbulence to occur.

MLT region and tidal wind conditions were simulated in a simple model, and among several tests we estimate buoyancy frequency boundary considering equinoctial tides conditions .

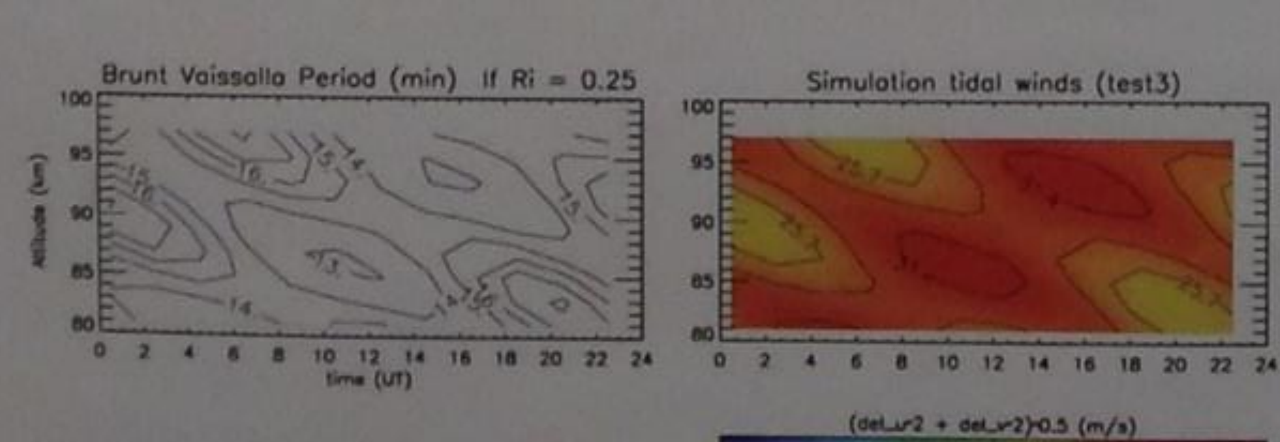

Fig 2. Buoyancy frequency boundary simulated considering equinoctial atmospheric tidal conditions

To satisfy R_i = 0.25 in equinoctial wind conditions, N ~ 13 min is enough for starting the instability which means a temperature gradient of at least -8K/km.

Hourly winds from 80 to 100 km, with 2 km height resolution, were inferred by an all-sky meteor radar at Cachoeira Paulista (22.7° S, 45° W). We have used two years of data from 2007 to 2008 simultaneous wind and temperature measurements, only for equinoctial period, when atmospheric diurnal tide has larger amplitudes. Fall time includes days in March/April and spring time September/October, totalizing 33 days.

Results

Figure 3 and 4 show the analysis for September 5th, 2008. We can observe Grad T(z) ~ -9 K/km, between 83 and 89 km, on the averaged temperature profile. At this day we can observe that instability were reached at begging of night 19:30 around 85 km and extending up to 20:30 around 89 km and coming back at 23:30 up to 24:00 below 84 km.

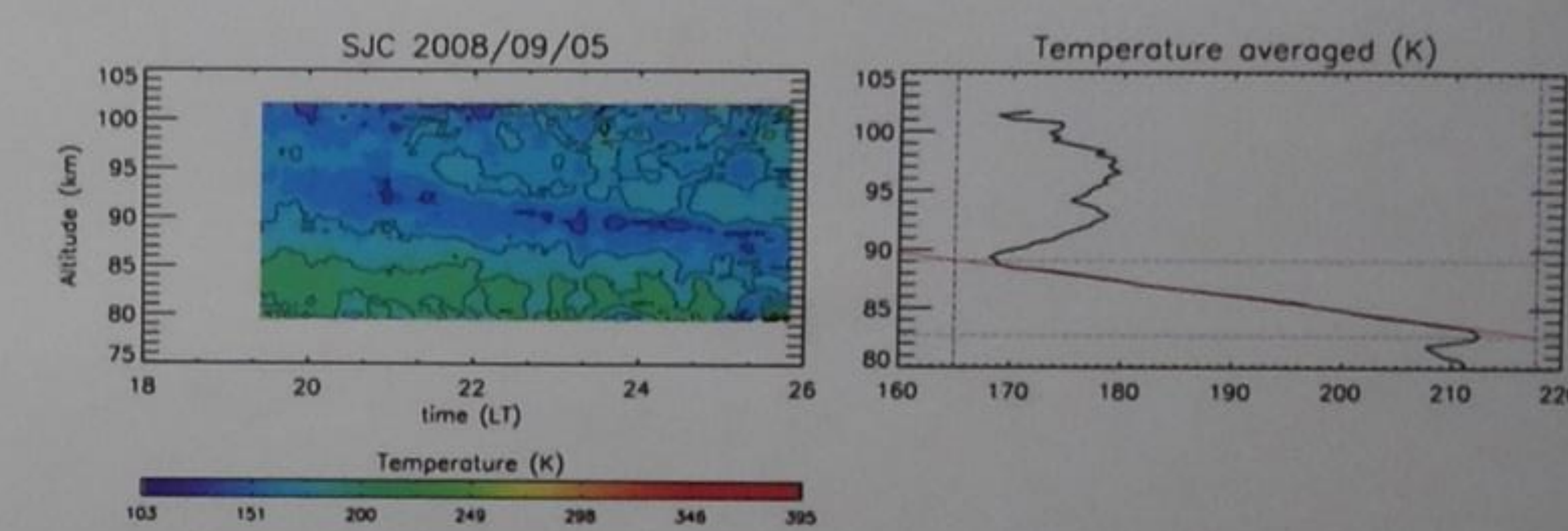

Fig 3. Shows an example of temperature measured with Lidar at Sao Jose dos Campos on September 5th, 2008

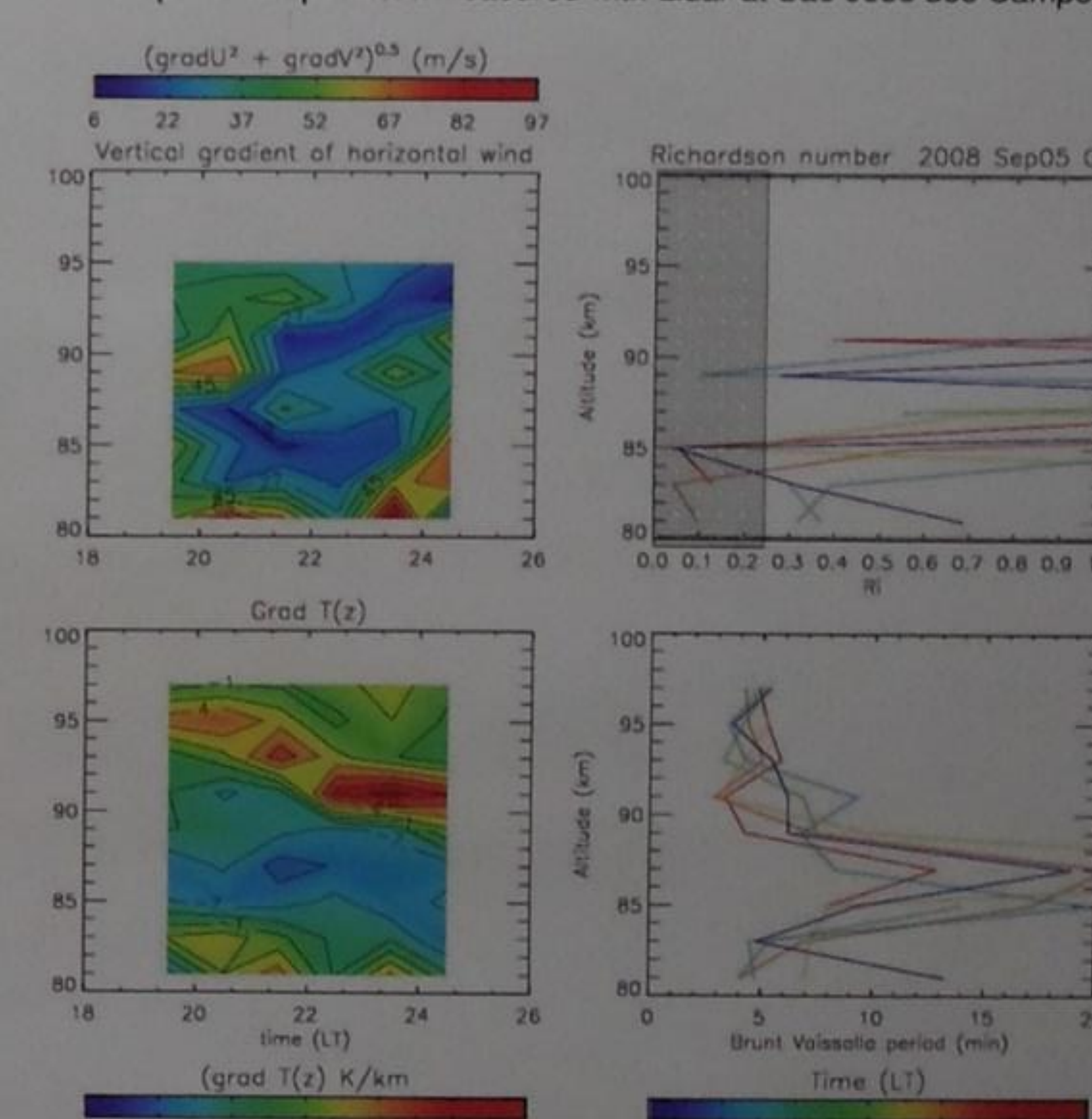

Fig 4. Shows an example of instability occurrence on September 5th, 2008. Data are from Sao Jose dos Campos (Temperature) and Cachoeira Paulista (winds)

Summary

In the present work we present the mesospheric temperature inferred by Na Lidar and winds gradients inferred by meteor radar in relatively close locations for simultaneous observations.

We have found 24 days in which the temperature profile show vertical gradients larger than -8 K/km. For all of them we can observe points of Ri < ¼ allowing instability occurrence.

Acknowledgments

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References

FRICKE, K. H. and U. von Zahn. (1985). Mesopause temperatures derived from probing the hyperfine structure of D2 resonance line of sodium by lidar. JASTP, v 47, p 499-512.

GATHEN, Peter Von Der. (1991). Saturation Effects in Na Lidar Temperature Measurements. JGR, v 96, p 3679-3690, March 1, 1991.

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