SOME INTERESTING FEATURES OF THE NOCTURNAL BOUNDARY LAYER ABOVE CAXIUANÃ AMAZONIAN RAIN FOREST USING HIGH RESOLUTION SIMULATION

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INTRODUCTION

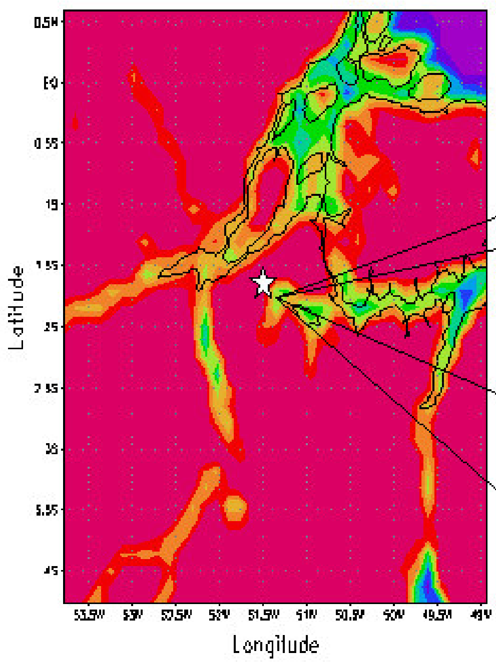
- The forest-atmosphere interaction is an important domain of the Nocturnal Boundary Layer studies (Cava et al., 2004).
- Low level jets (LLJ): relative maxima in the wind velocity vertical profiles in regions less than 1 km distant from the surface (Poulos et al., 2002).
  - They may contribute to intensify the mixture in the surface and in the region where they occur (Mahrt, 1999).
- Wind gust: relative maximum in the wind speed time series detected near the surface.
  - Considerable increase in the vertical and horizontal transports of CO2, humidity and sensible heat.
- Aspects that still need more investigation: the correct fluxes estimate, the influence of low level jets on the surface-atmosphere exchanges and the turbulence structure inside the forest canopy.
- These aspects are very important for a precise determination of the CO2 balance in the Amazon Forest.

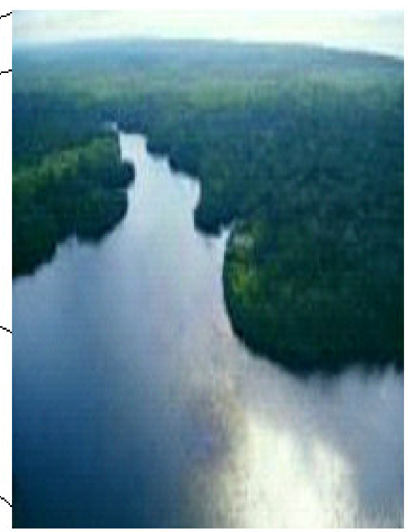
MATERIAL AND METHODOLOGY

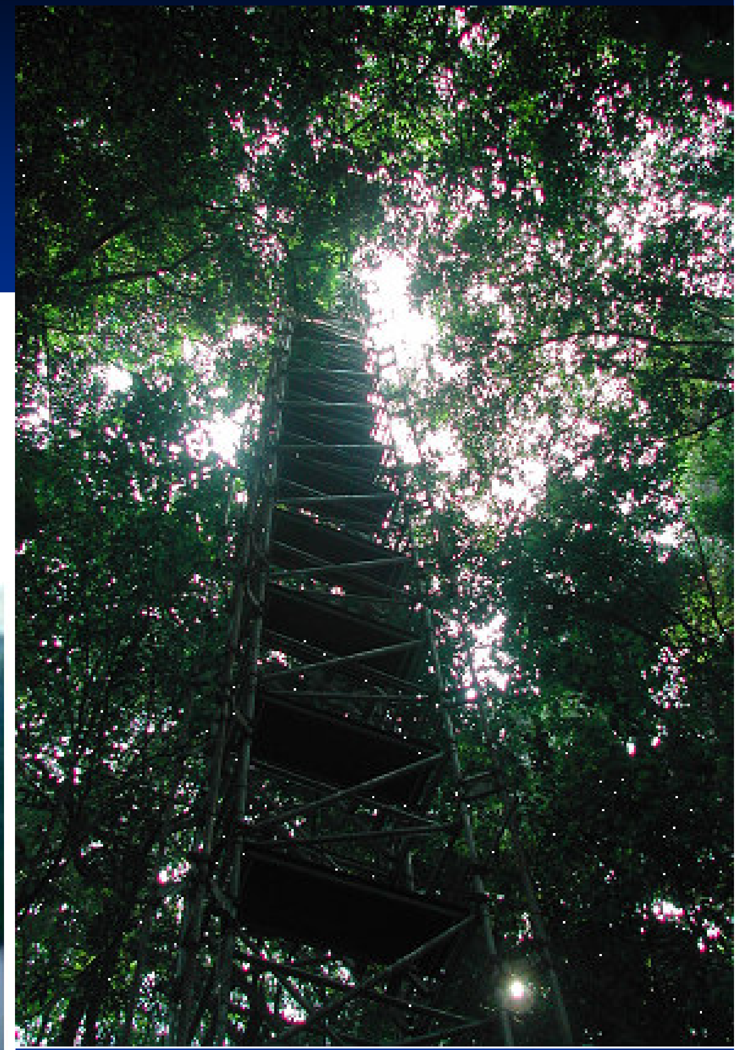
- Data collected in 2003 during Field Experiment CiMeLA in Caxiuanã (October 27 to November 17 of 2003 - dry season):
  - Vertical soundings (06, 12, 18, 00 UTC - every 3 hours in the last 3 days);
  - Wind measurements by cup anemometers “Vektor” (30s);
  - Fast response measurements (16 Hz) of the three wind velocity components, temperature, specific humidity and carbon dioxide concentration.
- Observational characteristics of the LLJs;
- Numerical modeling of the LLJs;
- Observational study of the wind gusts.

CAXIUANÃ

Rivers and topography map of Caxiuanã region.





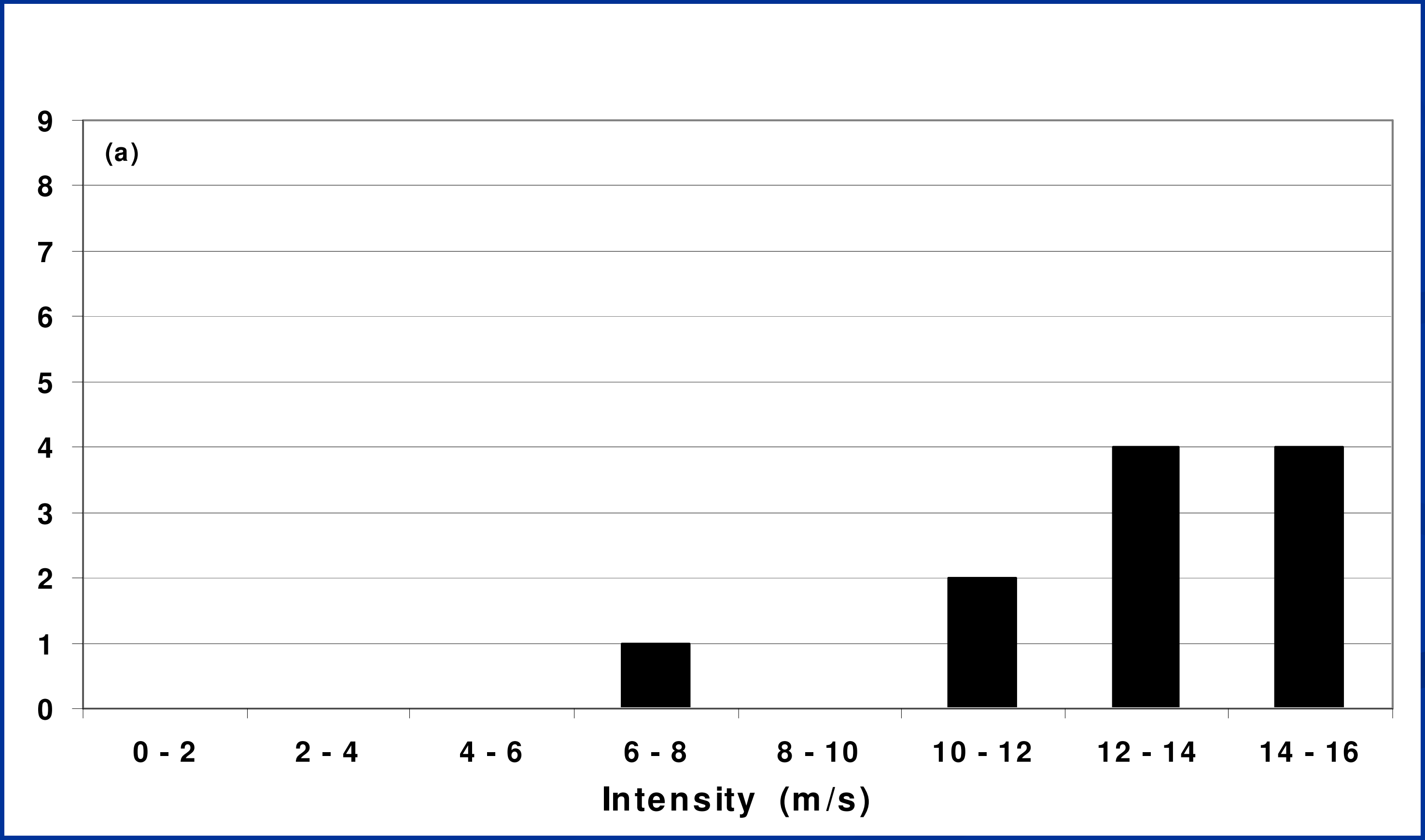


Micrometeorological tower installed in Caxiuanã Forest Reserve.

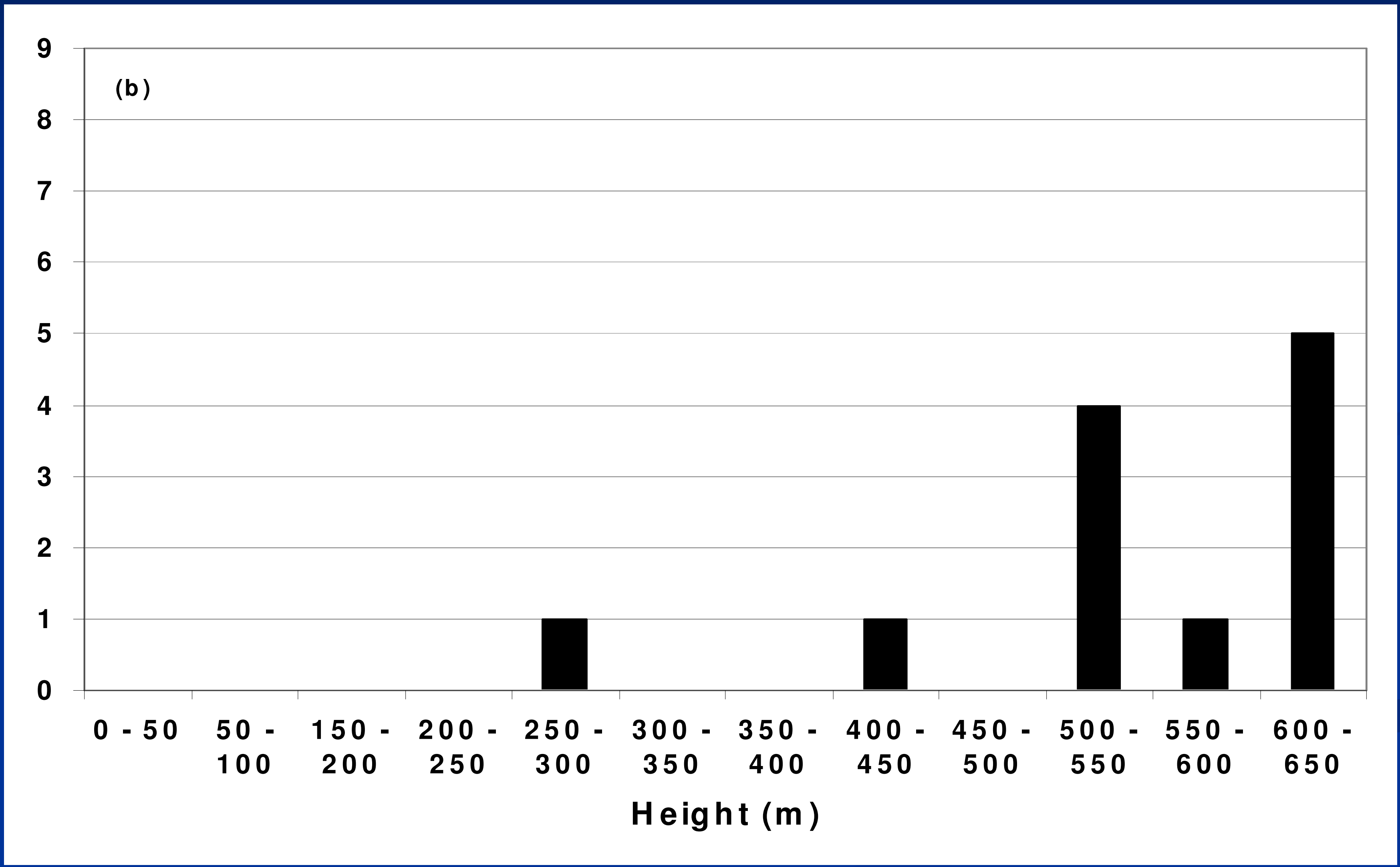
Lat.: 01°42’30”S   Lon.: 51°31’45”W

RESULTS AND DISCUSSION

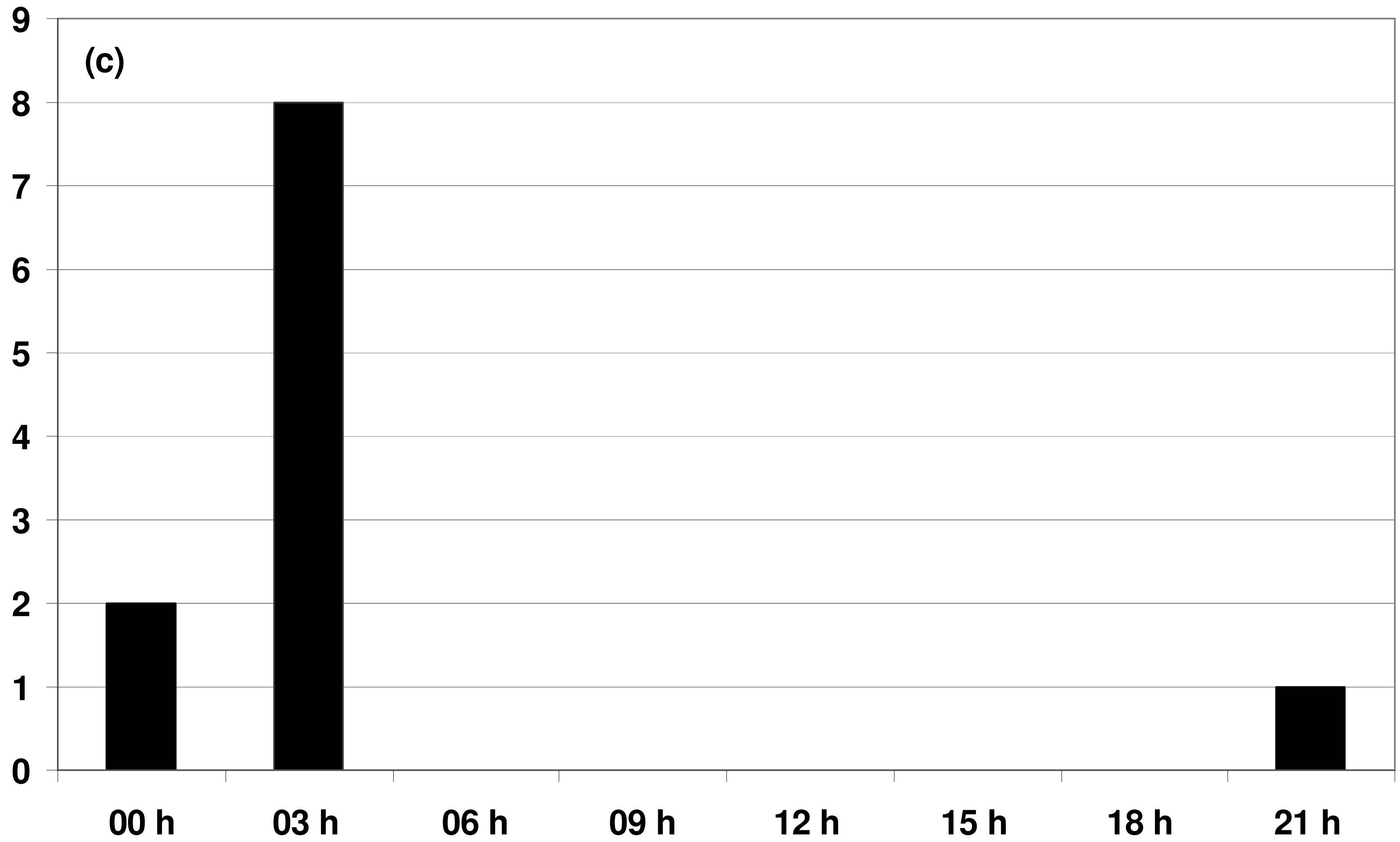
Low Level Jet Intensity (m/s)



Low Level Jet Height (m)

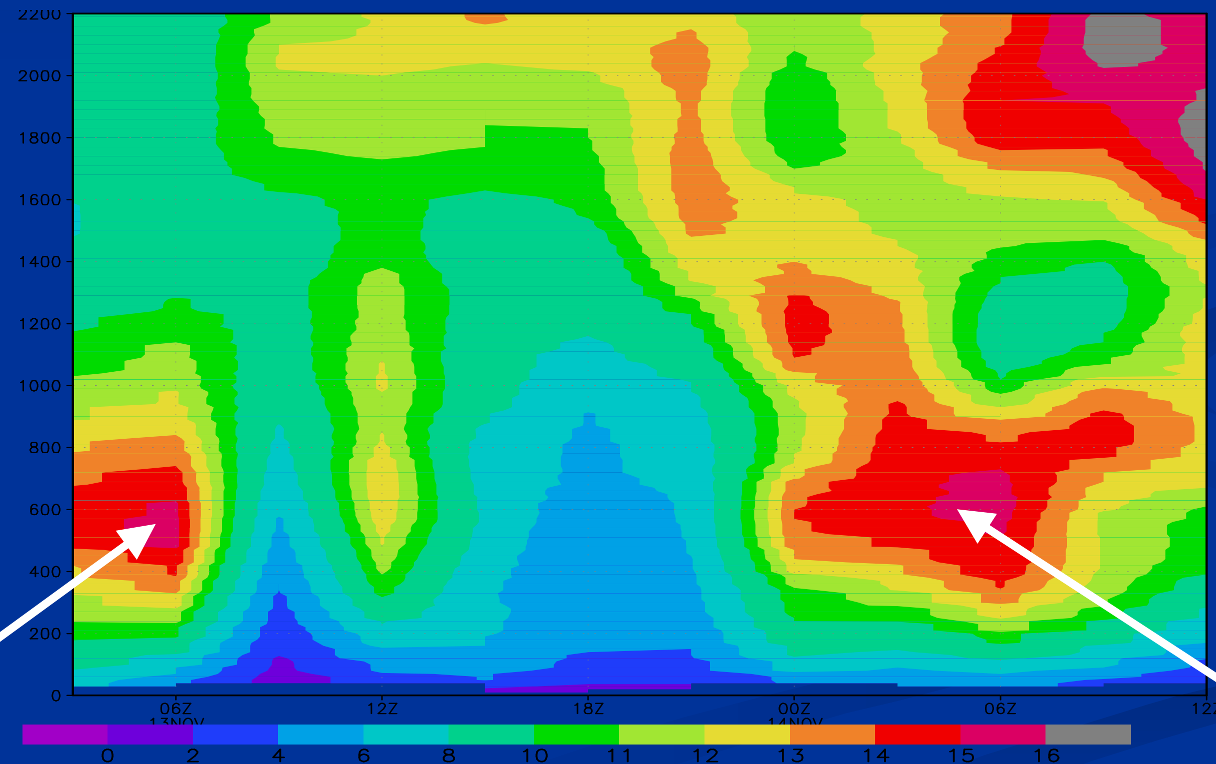


Low Level Jet Time



Observational Aspects of the Low Level Jets

***Wind speed* – Nov. 13 to 14 : radiosondes every 3 hours**



15 m/s at 06 UTC

15 m/s at 06 UTC

Numerical Experiment Description

- **BRAMS** = ***B****razilian developments on the* ***R****egional* ***A****tmospheric* ***M****odeling* ***S****ystem (****RAMS****)* (Cotton et al., 2003) to evaluate the origin of the LLJ.

- 12 soil layers until the depth of 4m.

- The vegetation distribution was produced by CPTEC (Sestini et al., 2002).

- The model's initialization was variable, each 6 hours, with the analysis of CPTEC's global model, the radiosondes and the available surface data.

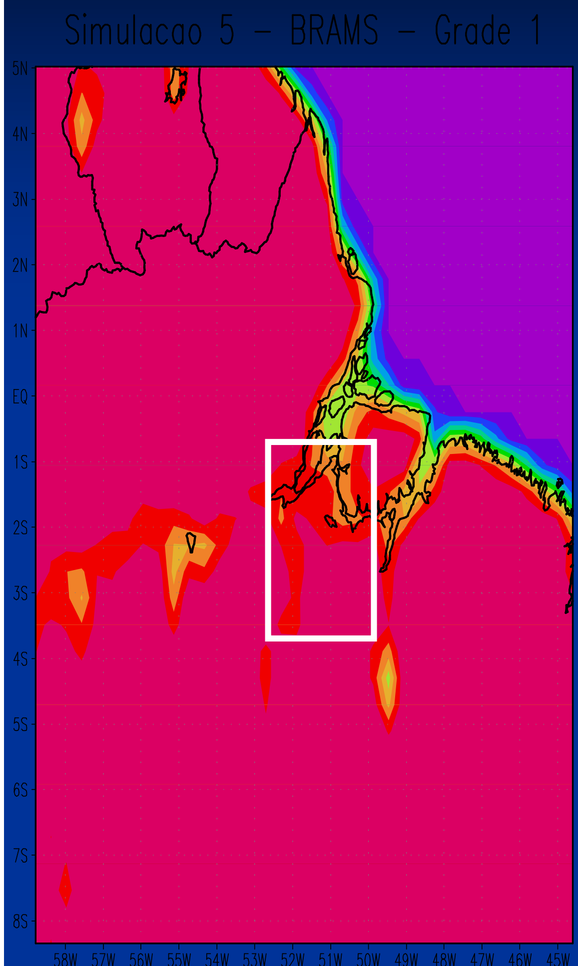
- The integration period was 48 hours, initiating on November, 12, 2003, at 12 UTC.

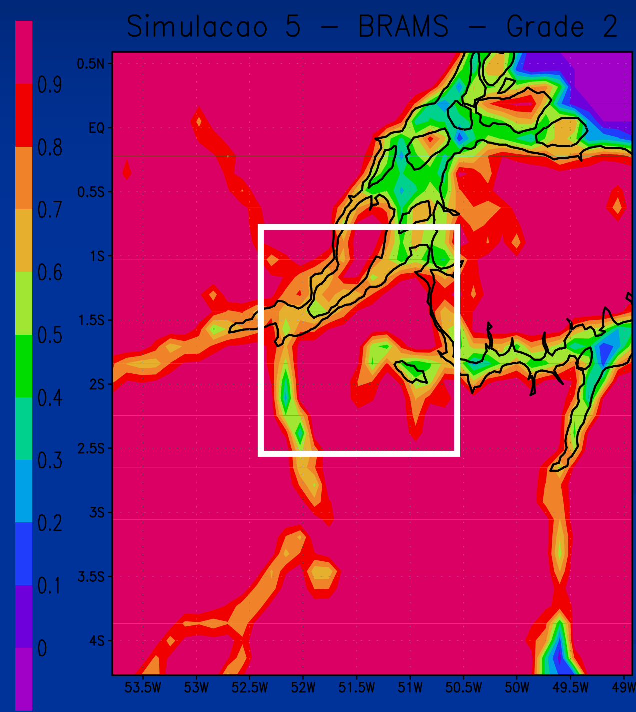
- Models of surface and vegetation, radiation, Cloud microphysics.

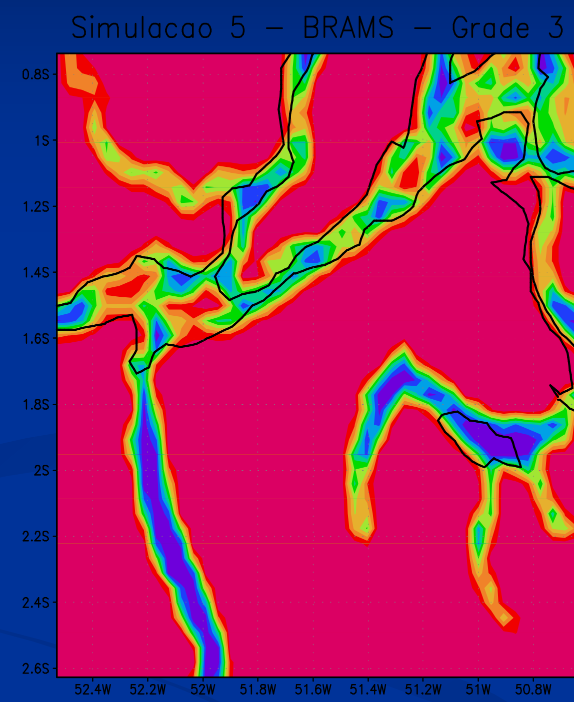
- Grell's deep convective parameterization and shallow convection parameterization.

3 Grids

- No. of points X = 37,38,44
- No. of points Y = 35,38,44
- No. of points Z = 32,32,45
- No. of points in soil = 12





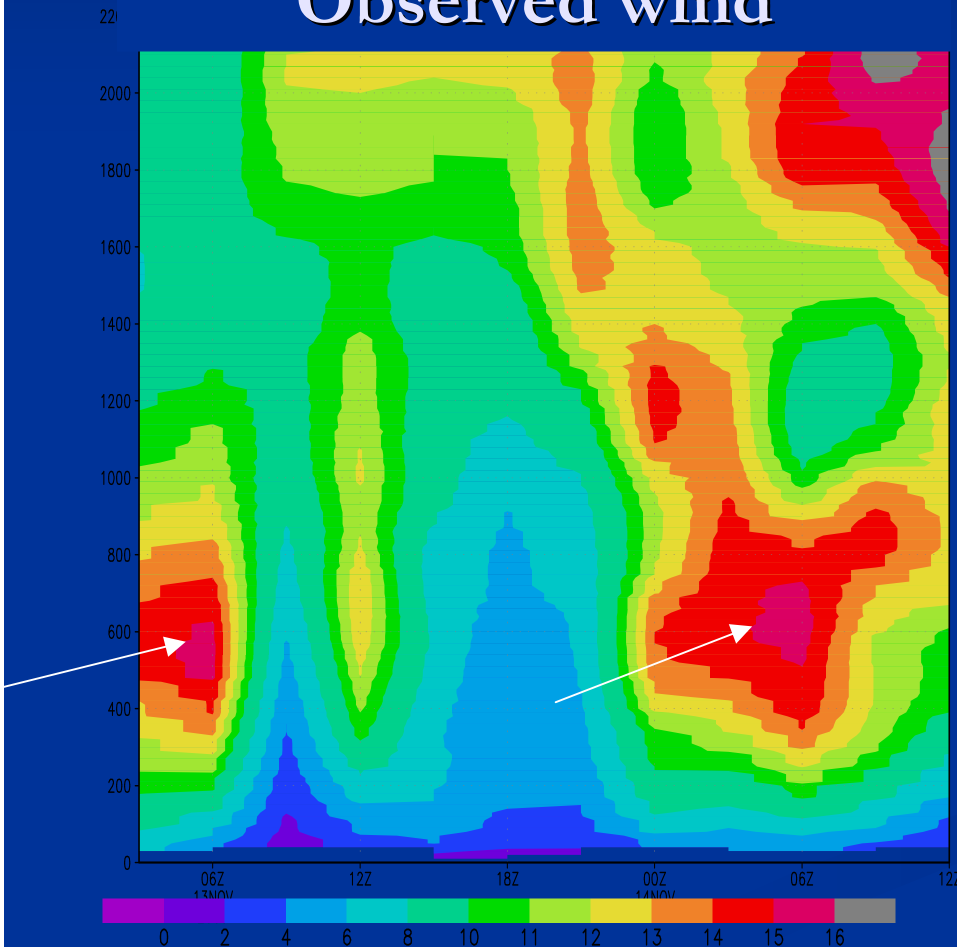


Horizontal spacing of 45, 15, 5 km

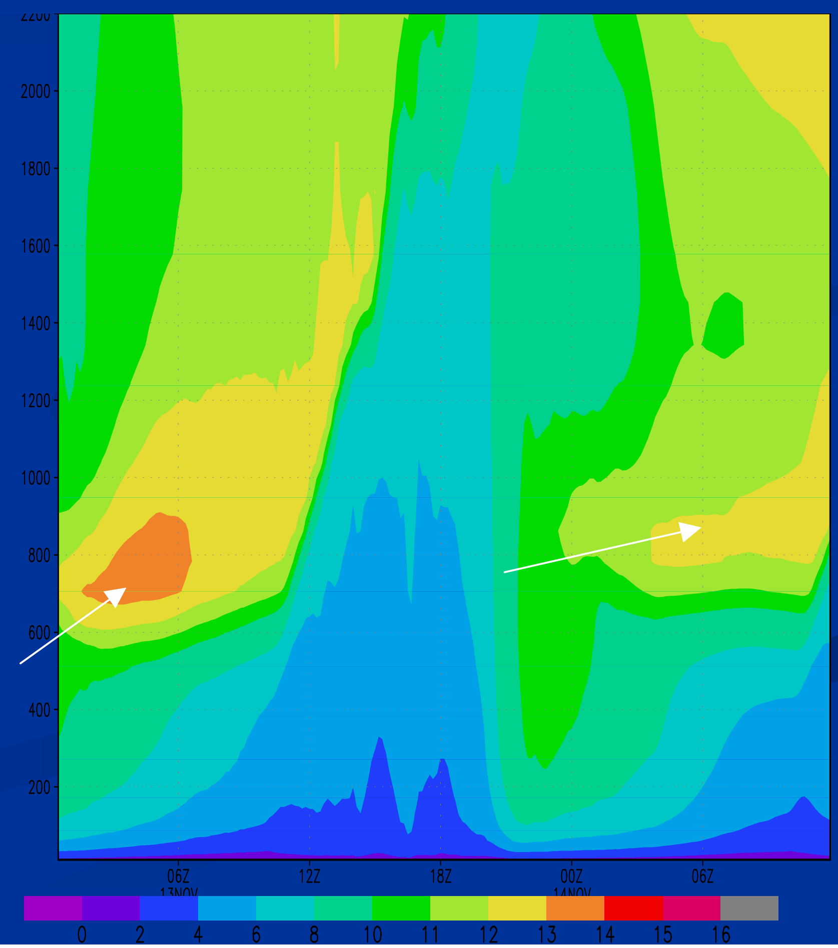
LLJ of November 13 and 14 of 2003, at 06 UTC

The magnitude of the LLJs produced by BRAMS was about 2 and 3 m/s lower and their height was higher than what was observed. This was possibly due to superficial instability and roughness problems in the model.

Observed wind



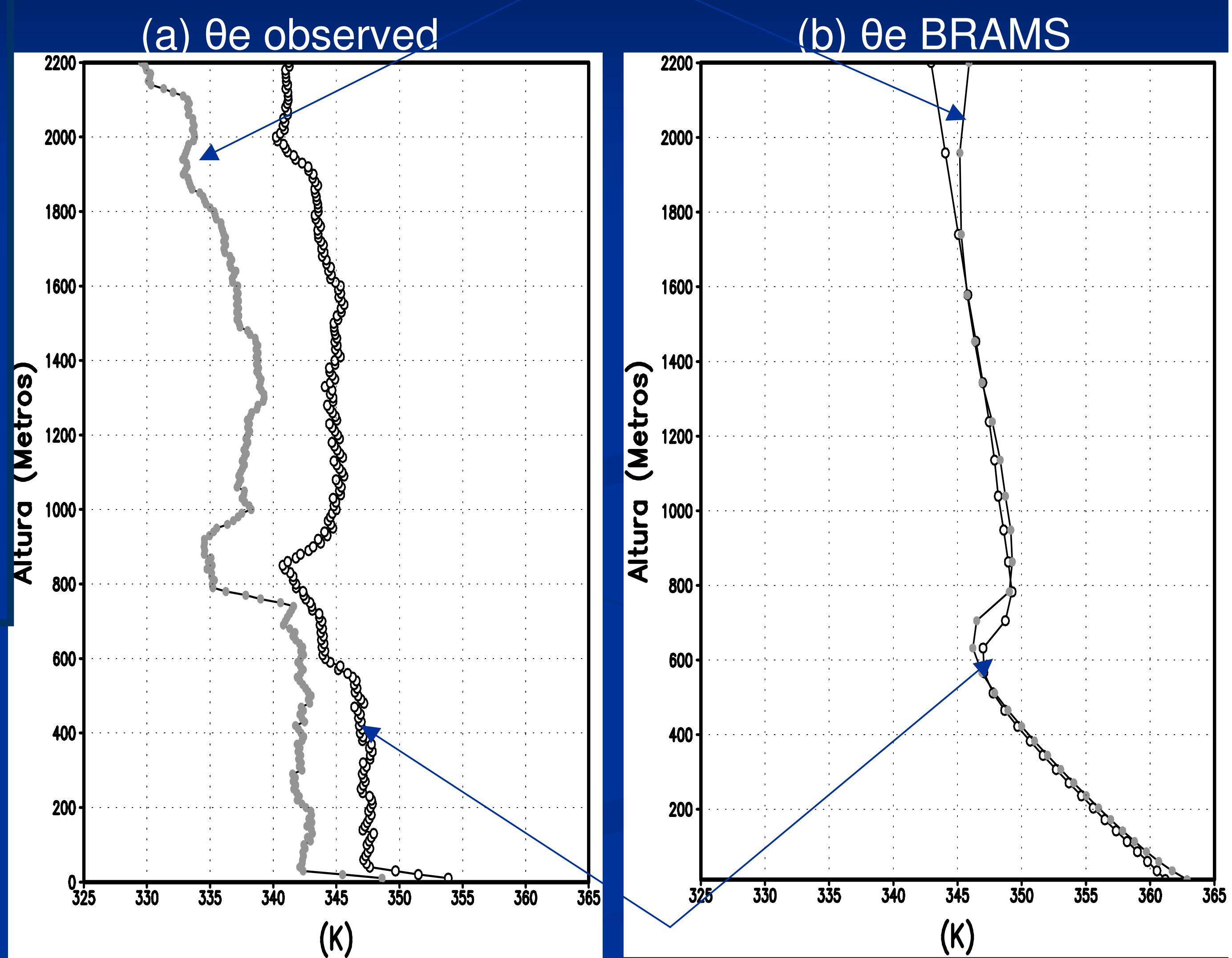
Simulated wind



Vertical Profile of Equivalent Potential Temperature (K)

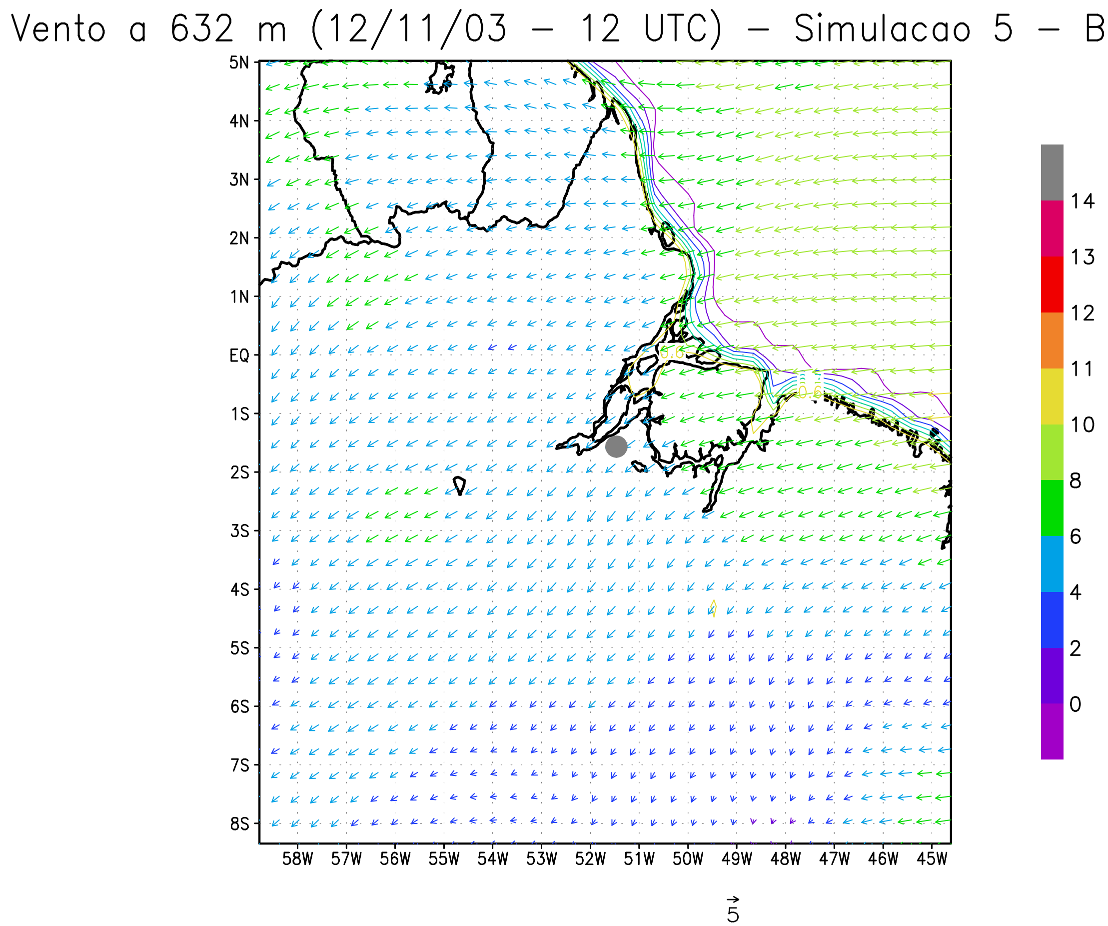
Near the LLJ height, we can observe the influence of a downdraft, where there is a decrease of equivalent potential temperature.

Nov. 13 of 2003 at 06 UTC

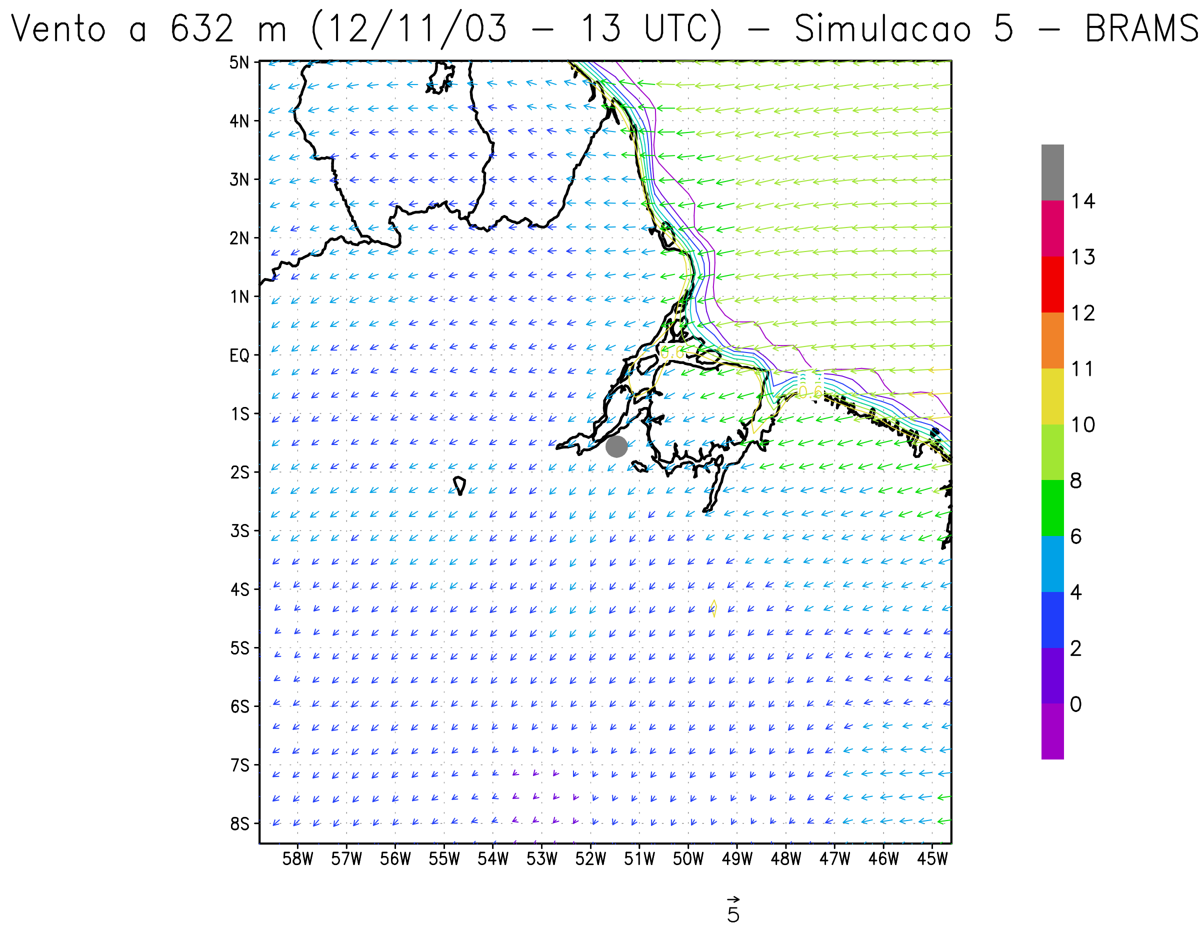


Nov. 14 of 2003 at 06 UTC

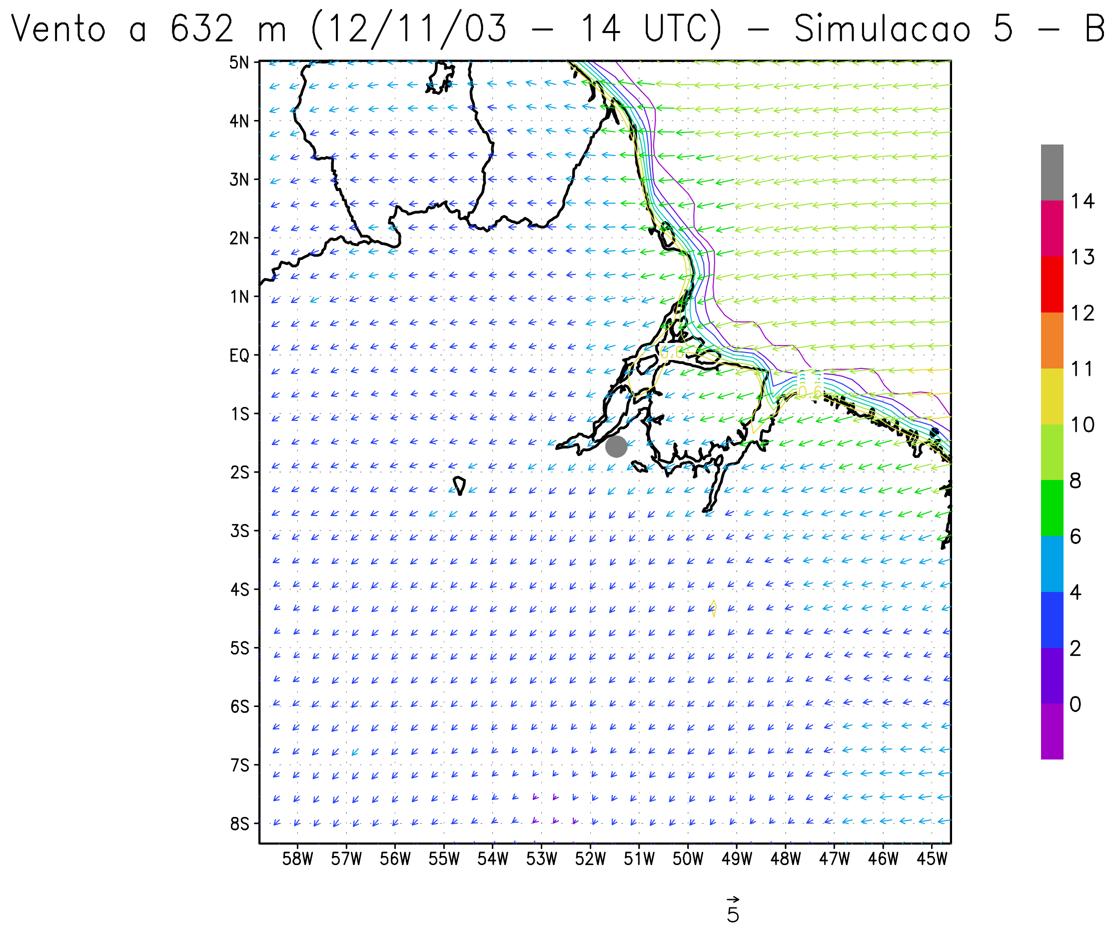
Wind at z = 632 meter Grid 1



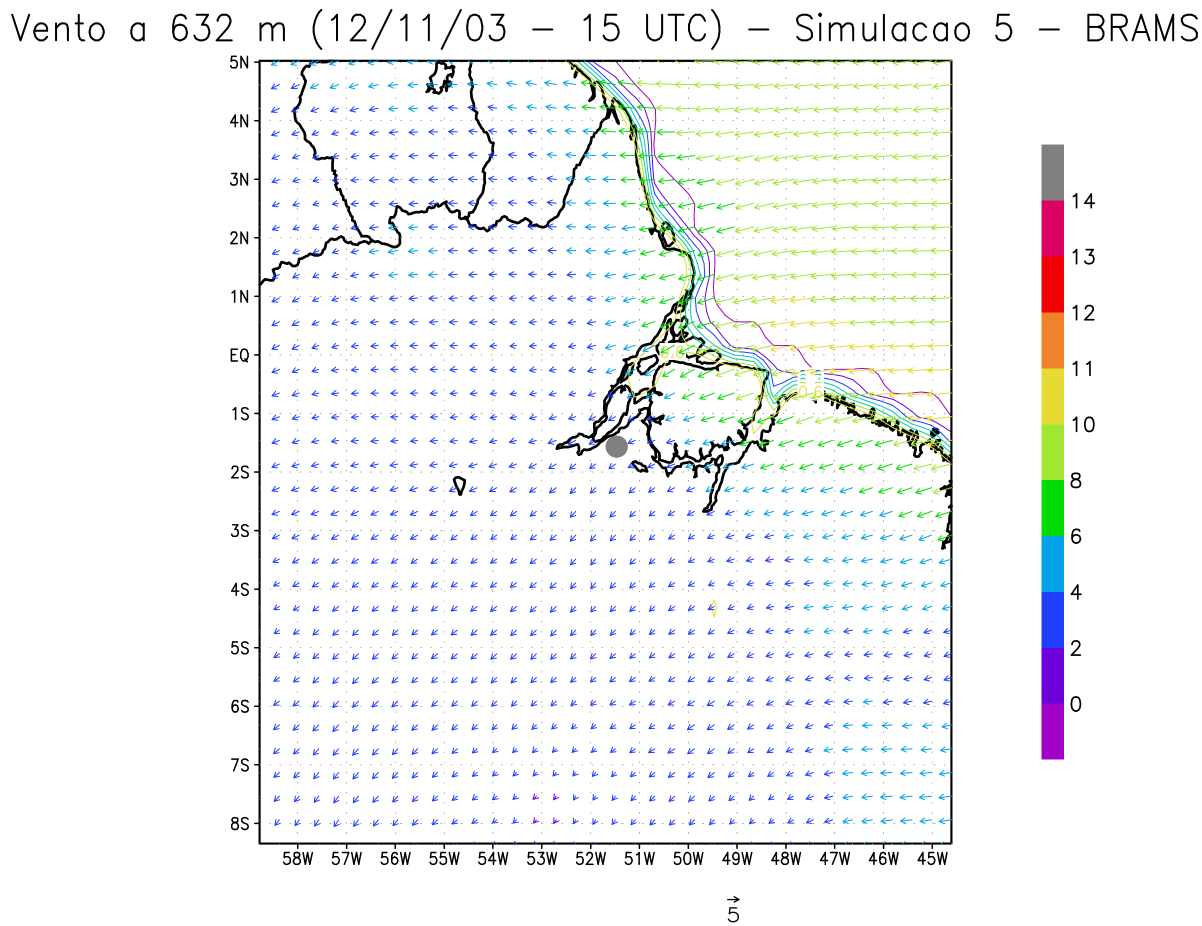
Wind at z = 632 meter Grid 1



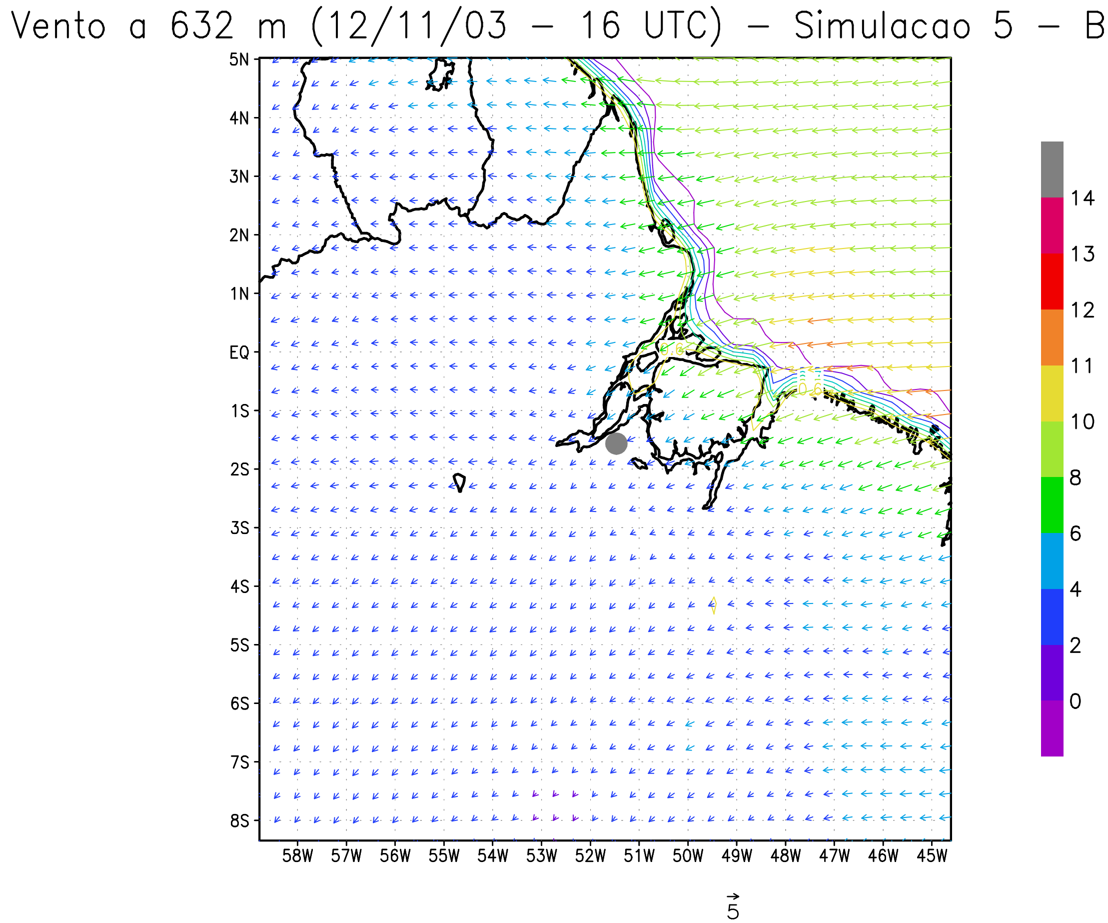
Wind at z = 632 meter Grid 1



Wind at z = 632 meter Grid 1



Wind at z = 632 meter Grid 1



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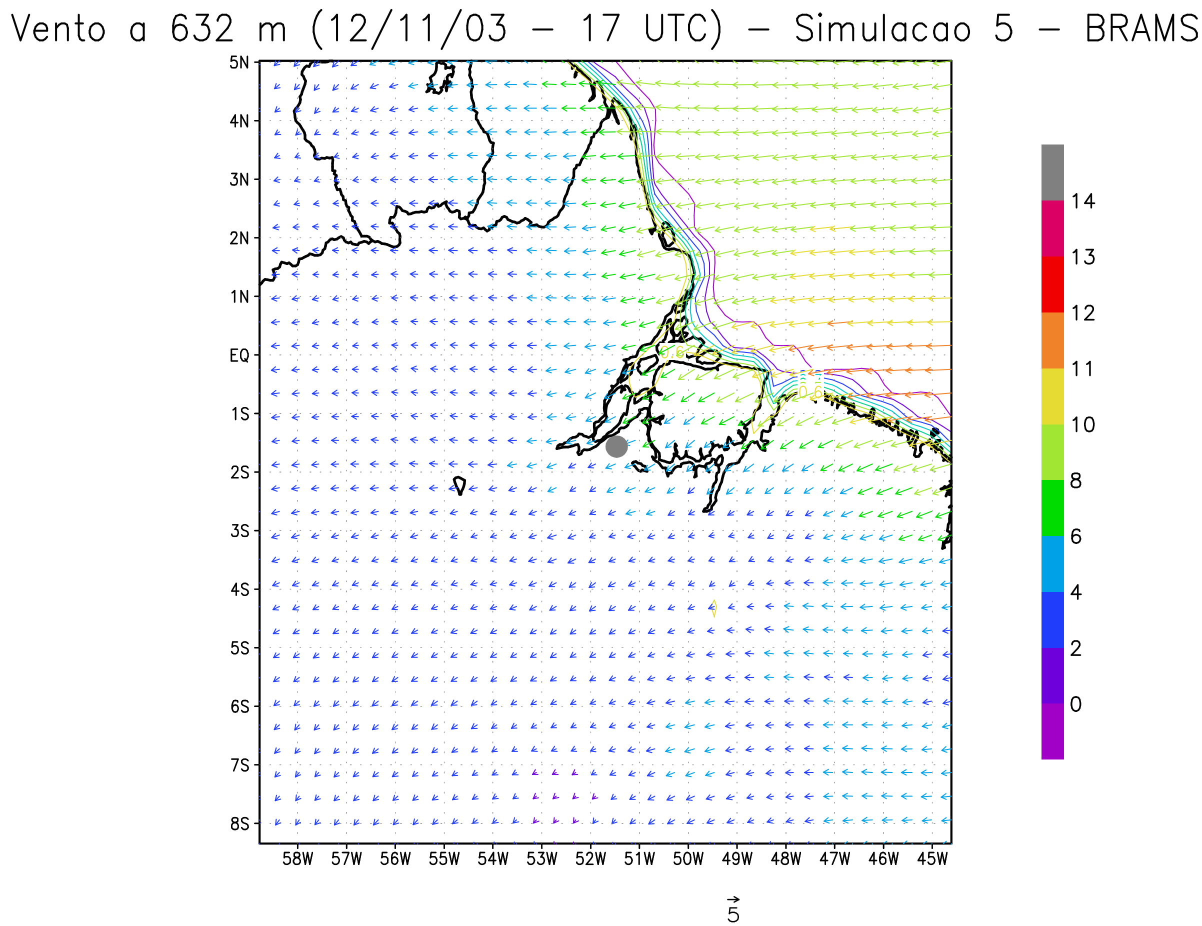

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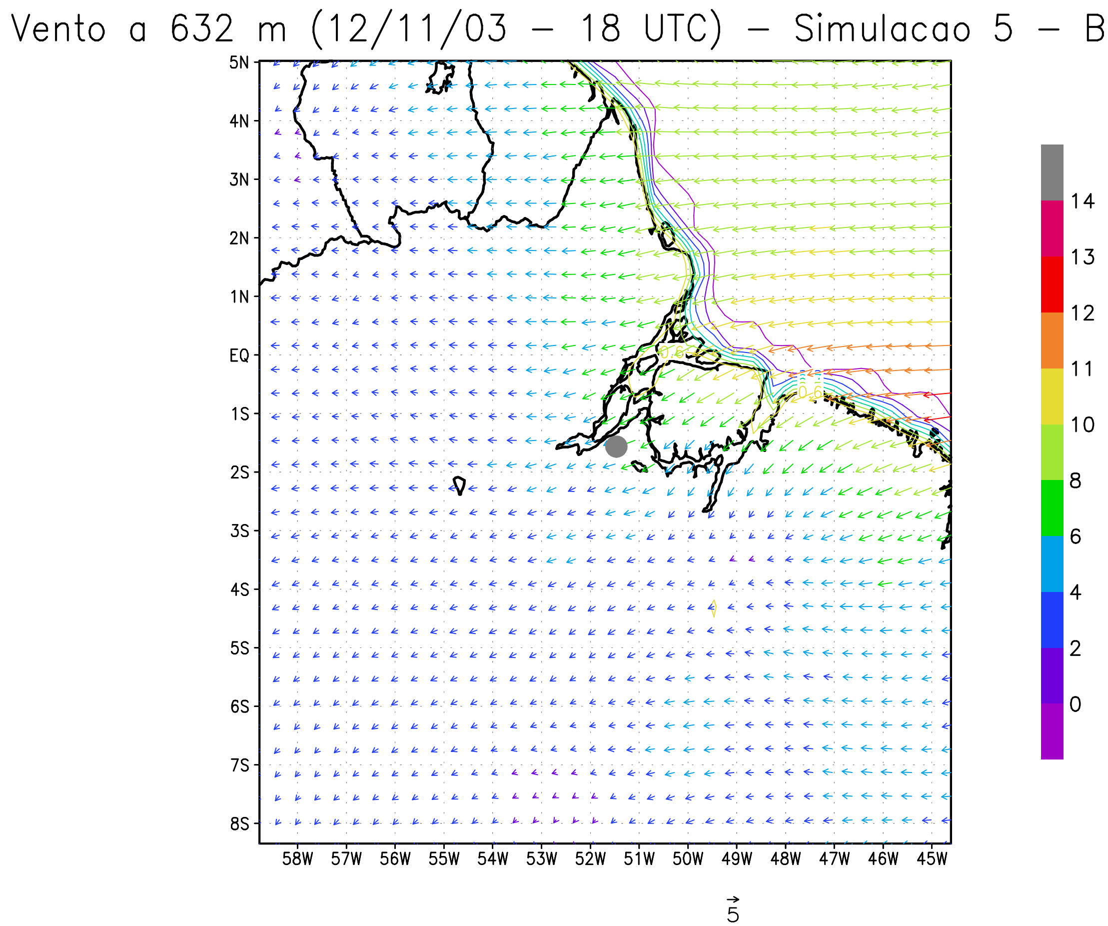
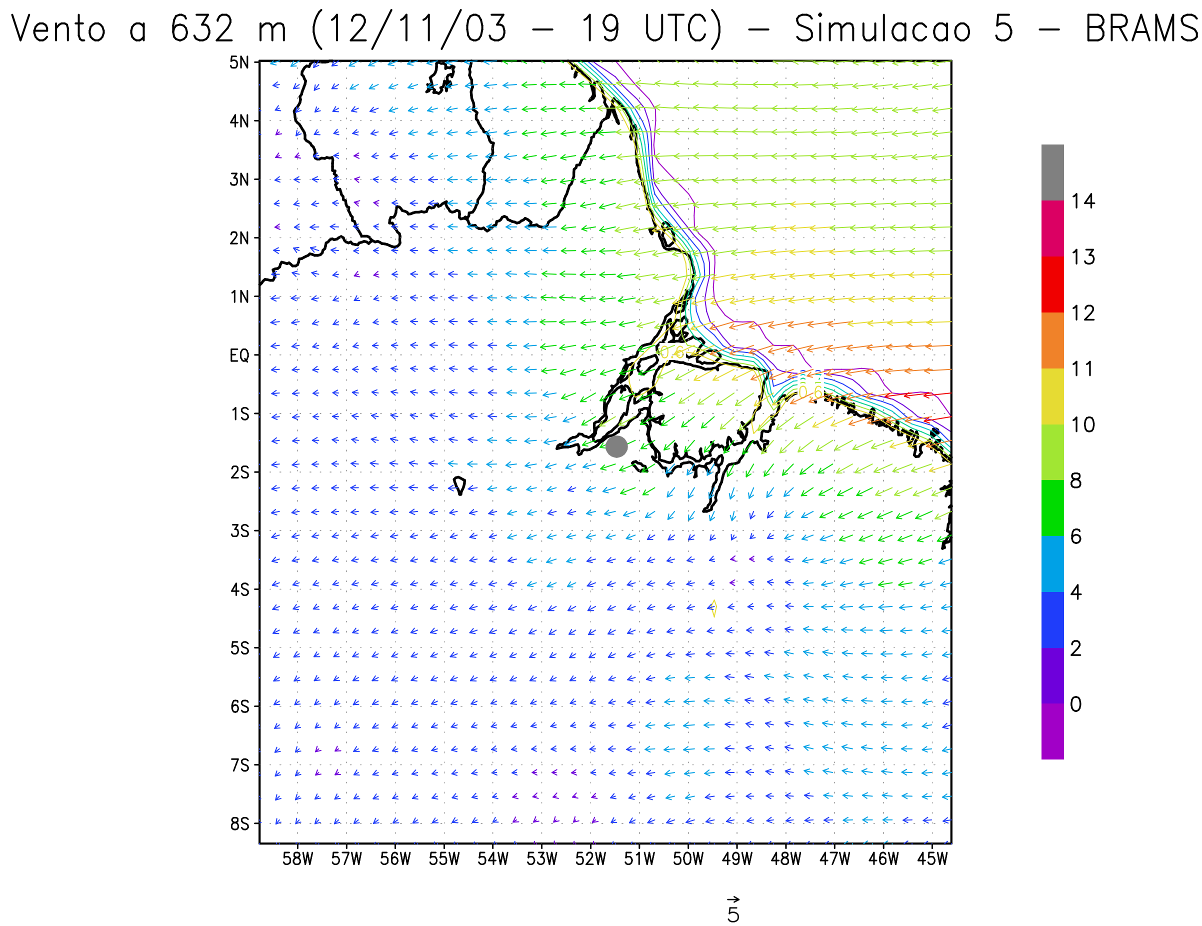
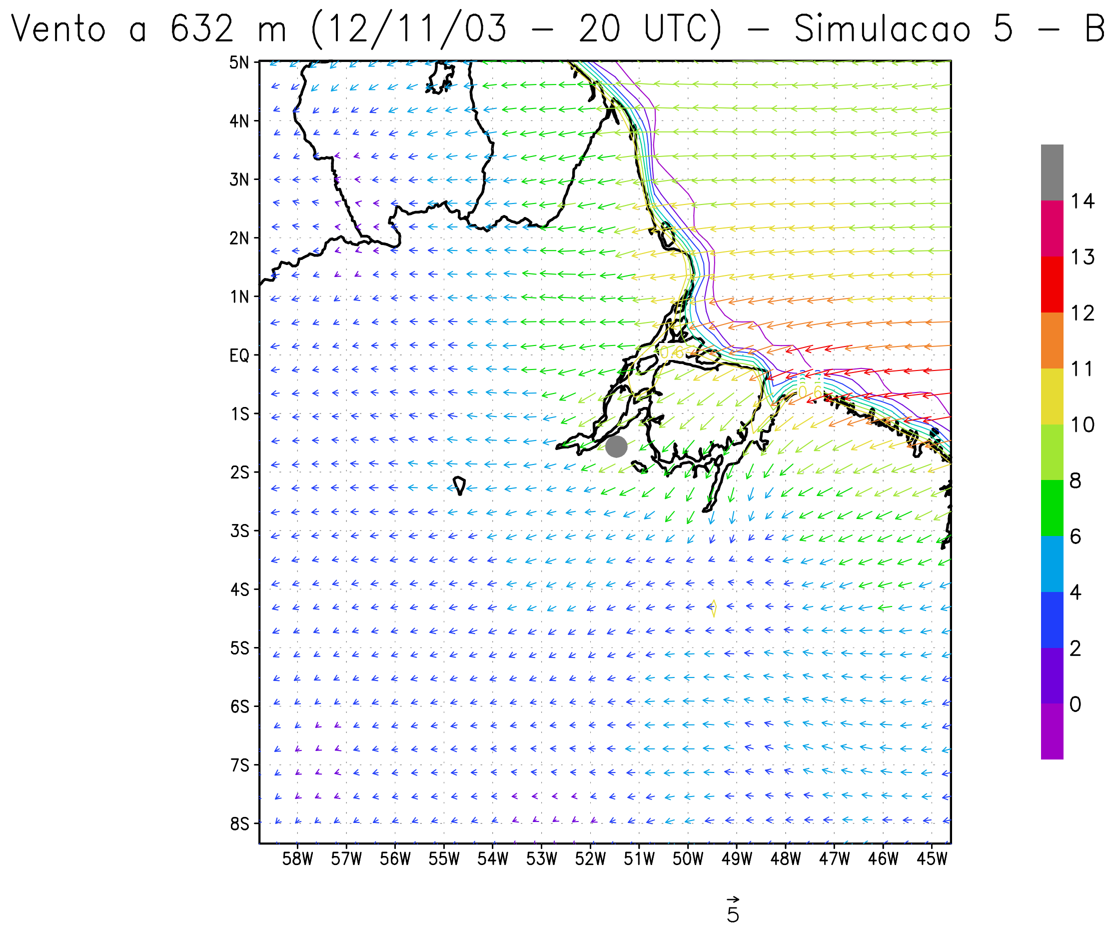


Wind at z = 632 meter Grid 1



Wind at z = 632 meter Grid 1



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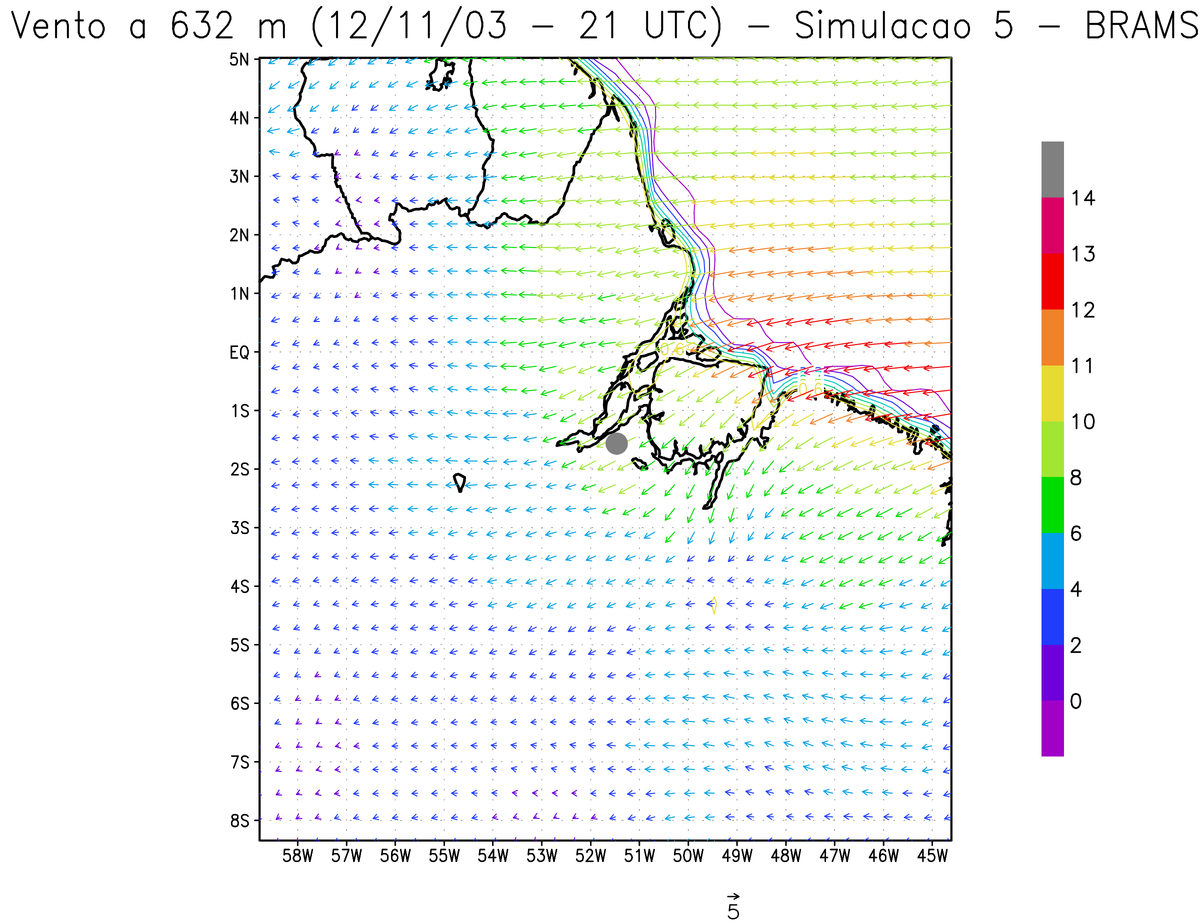

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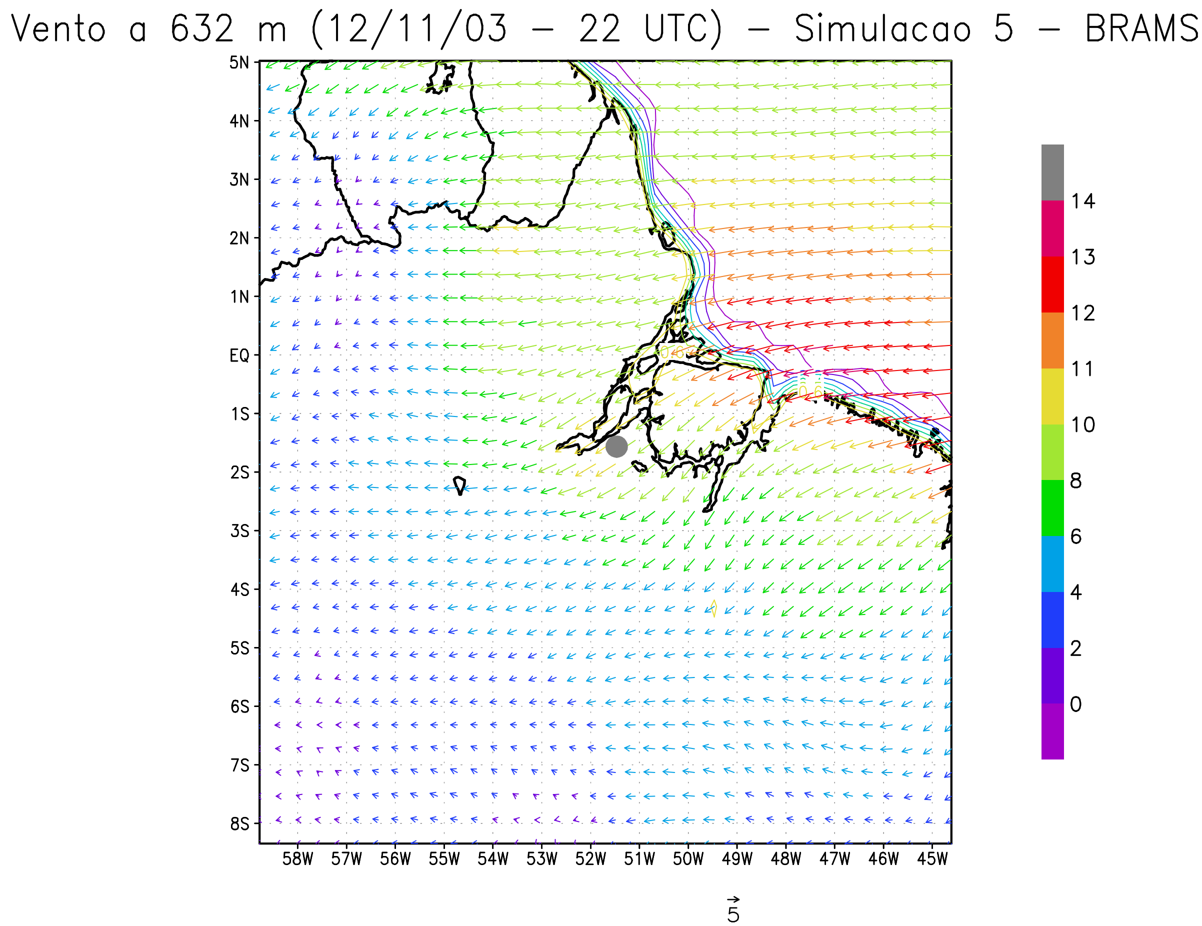

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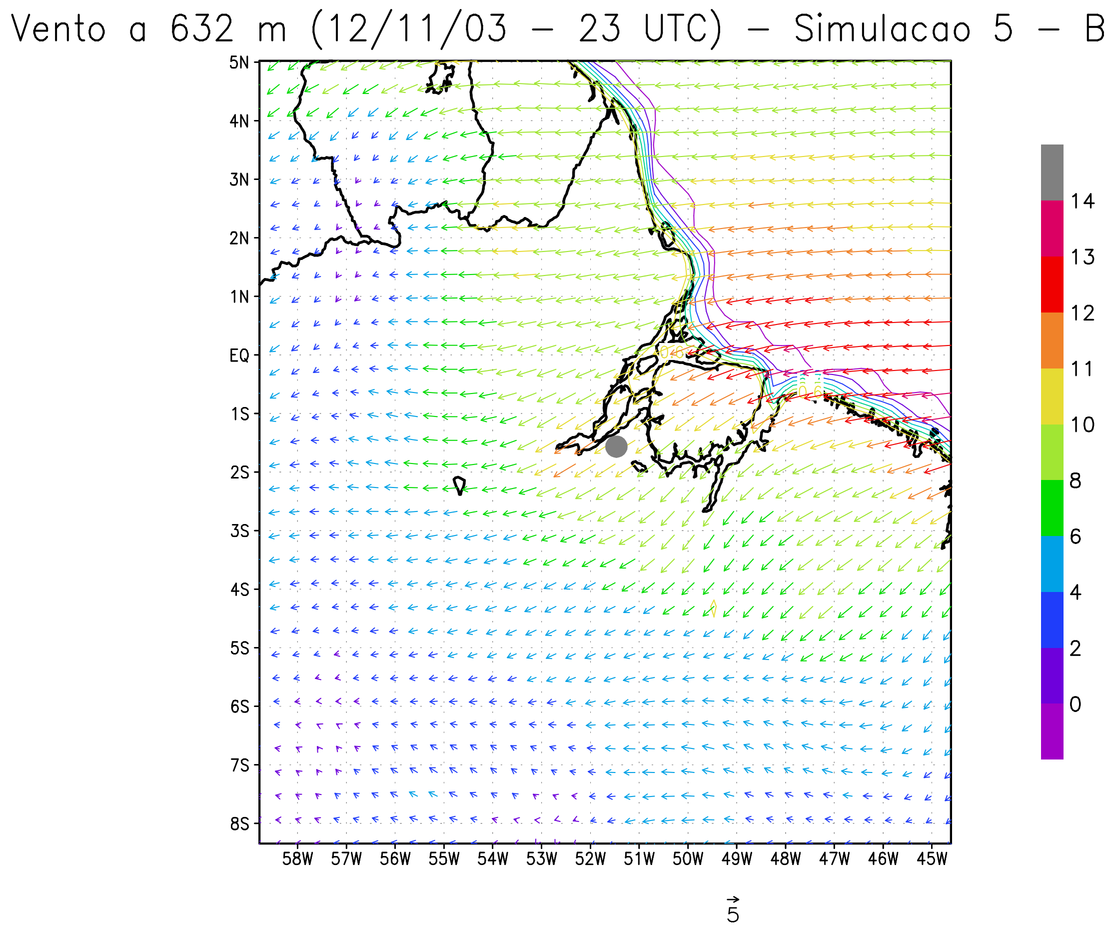
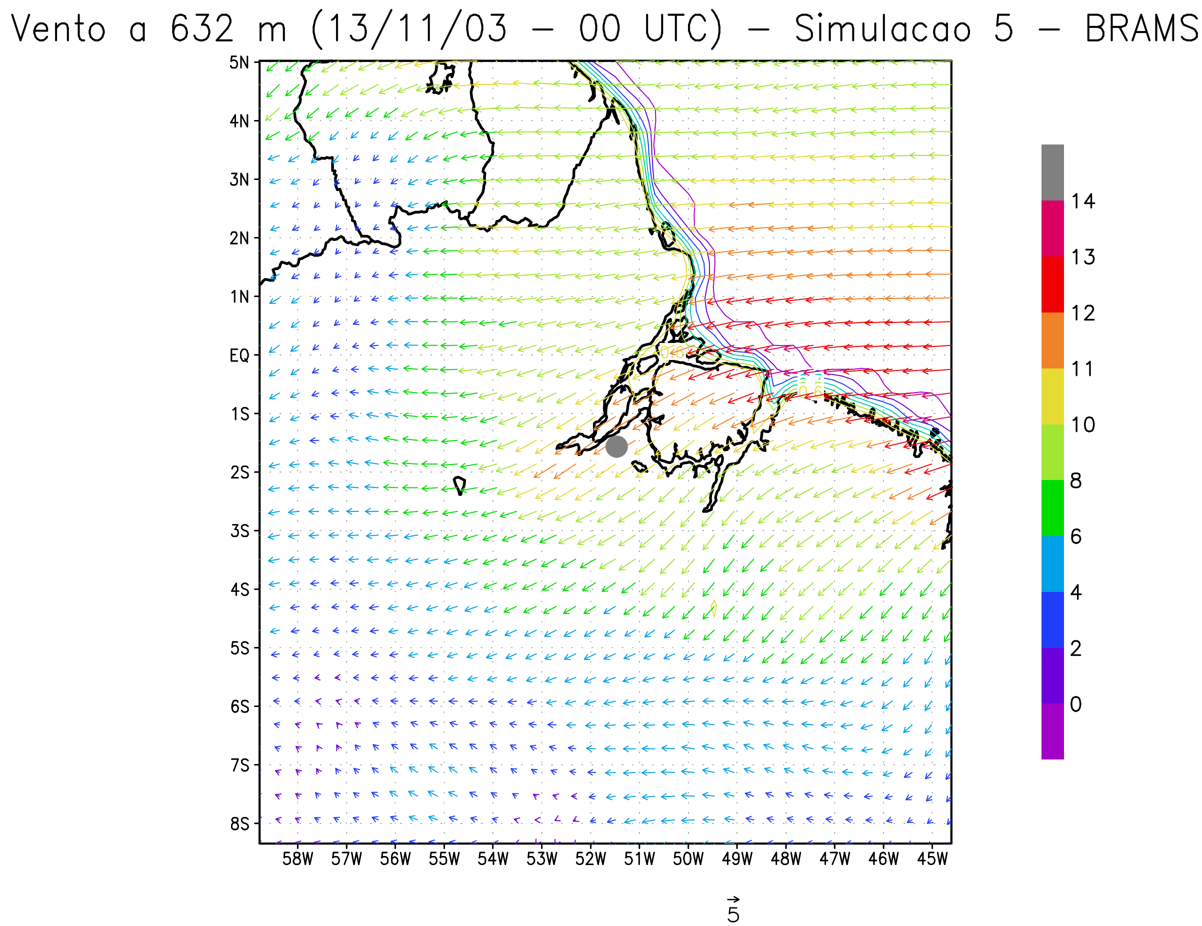
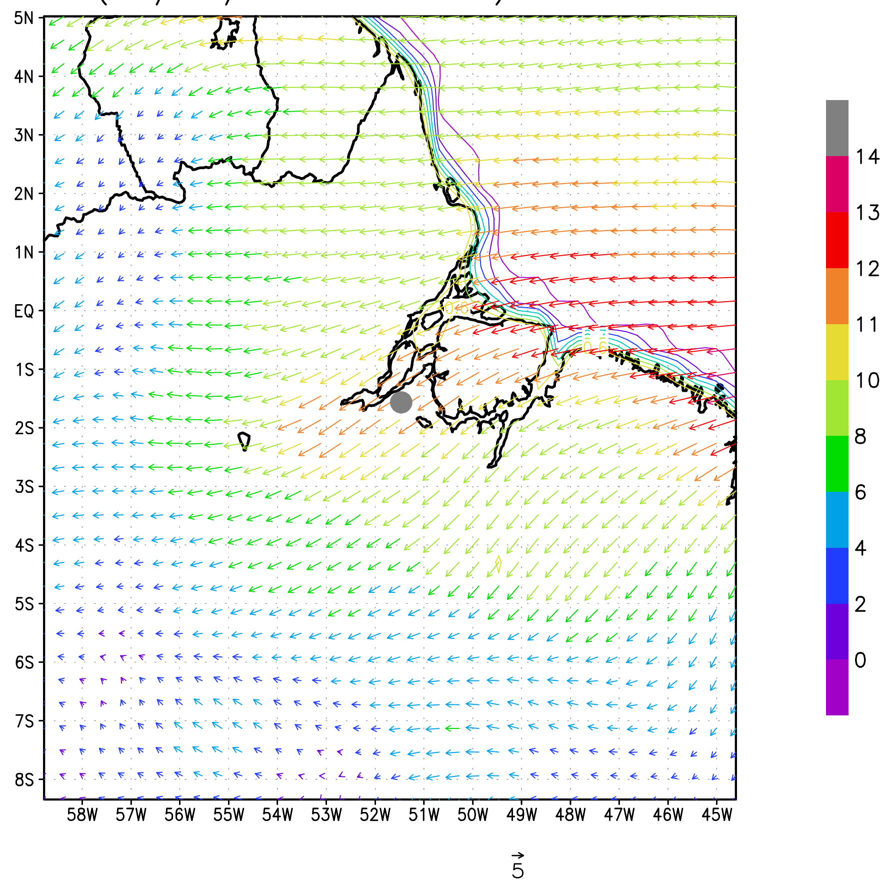


Wind at z = 632 meter Grid 1



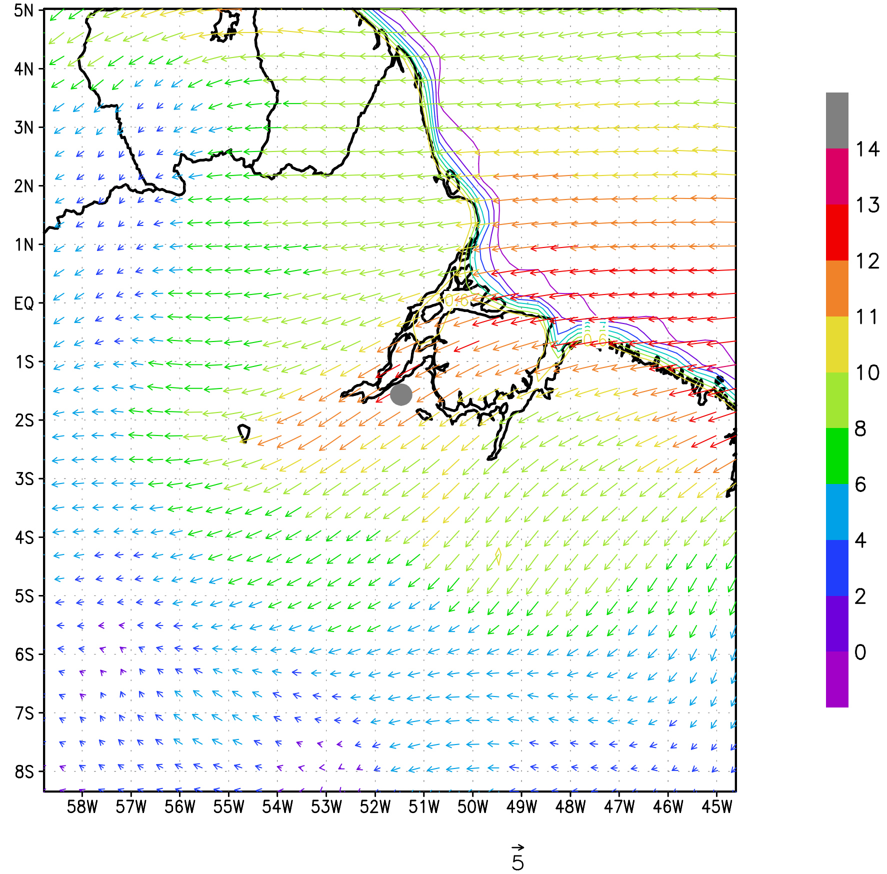
Wind at z = 632 meter Grid 1

Vento a 632 m (13/11/03 – 01 UTC) – Simulacao 5 – BRAMS

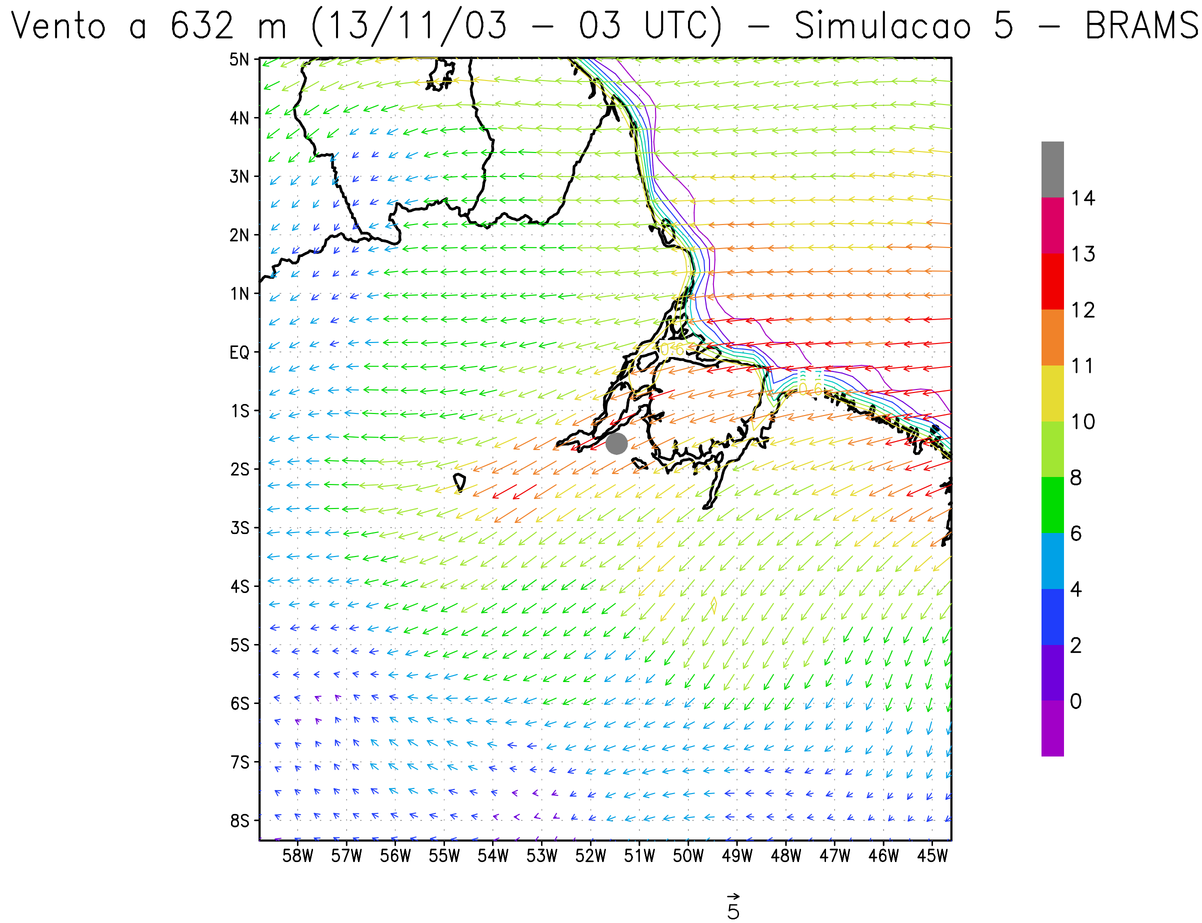


Wind at z = 632 meter Grid 1

Vento a 632 m (13/11/03 – 02 UTC) – Simulacao 5 – BRAMS



Wind at z = 632 meter Grid 1



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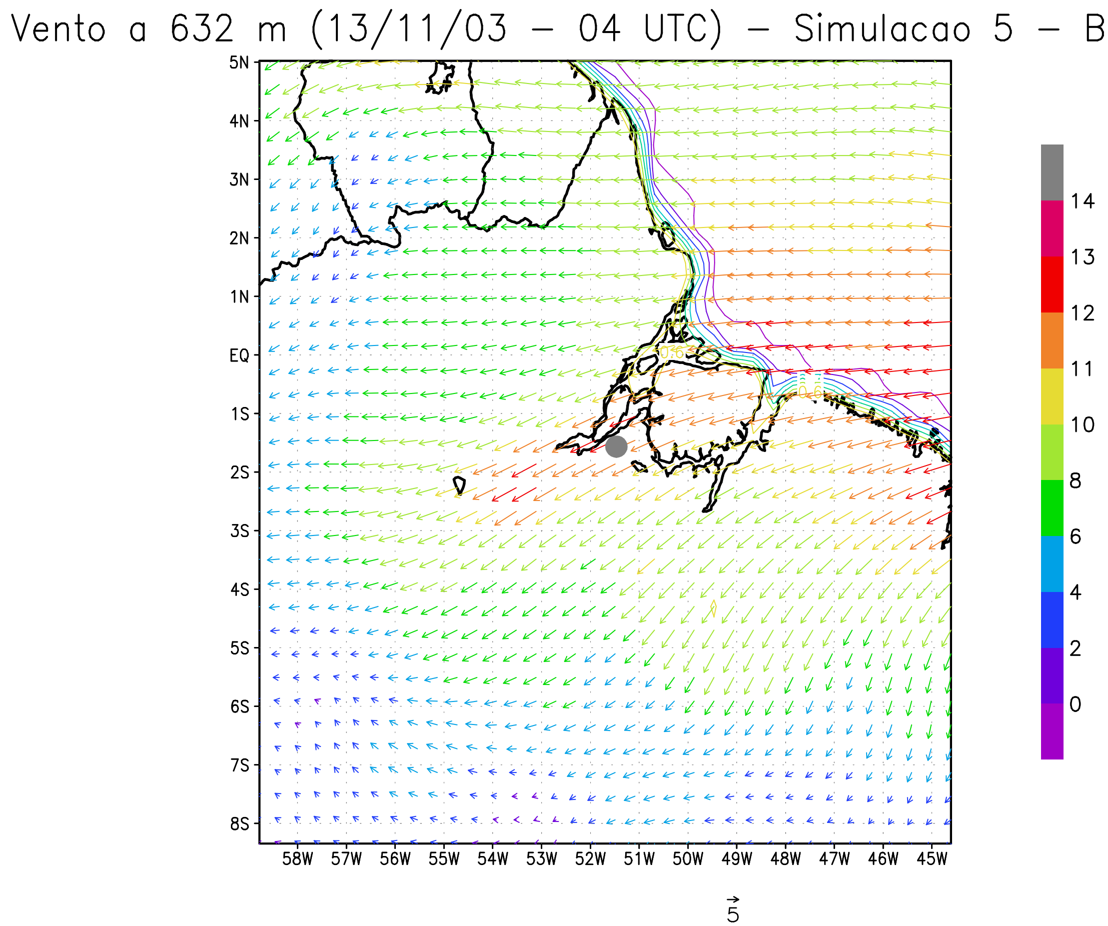

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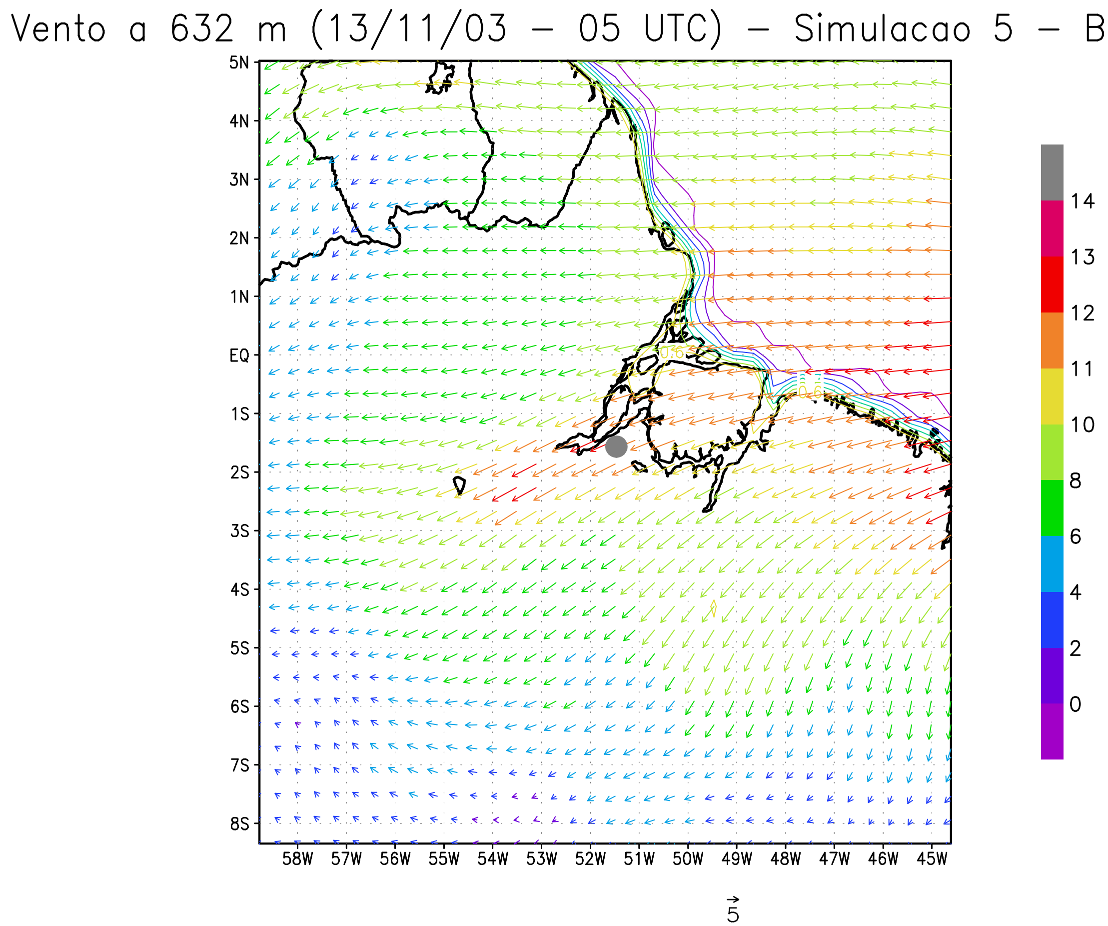

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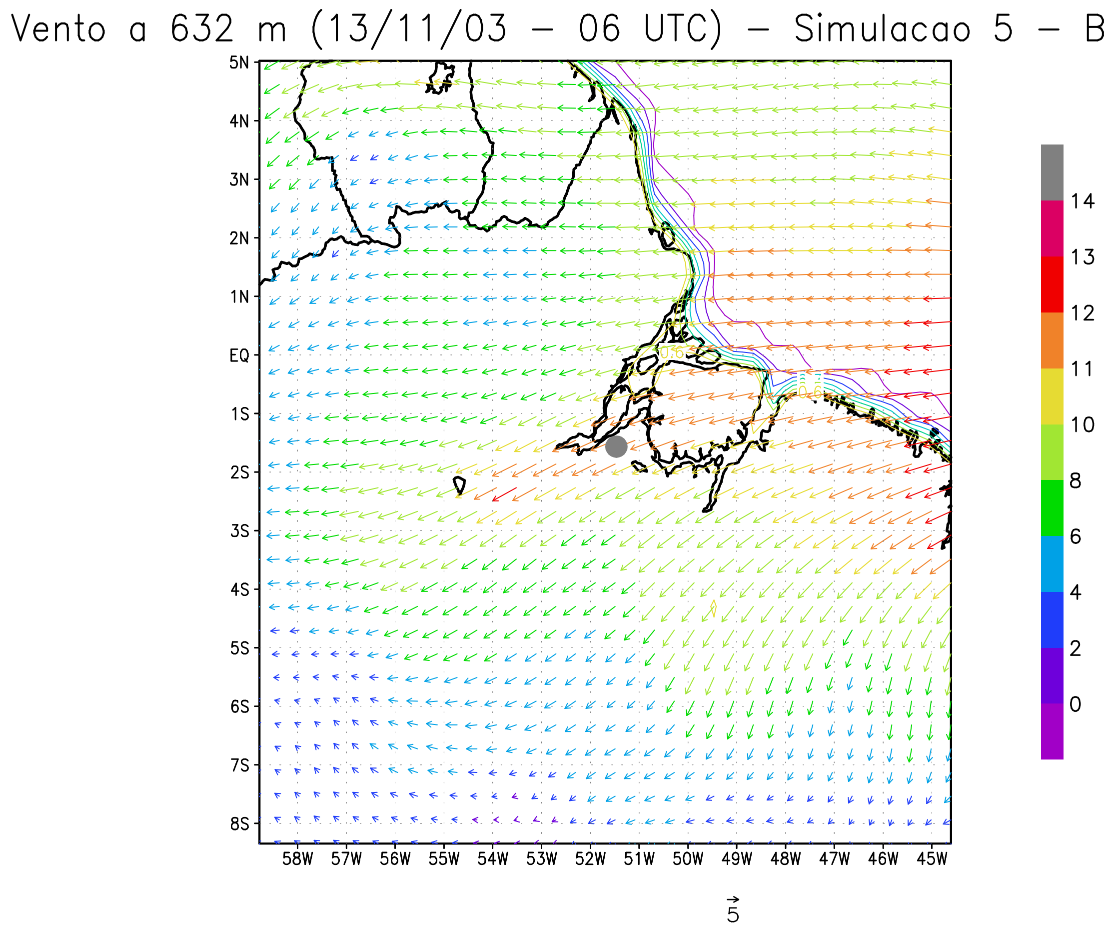

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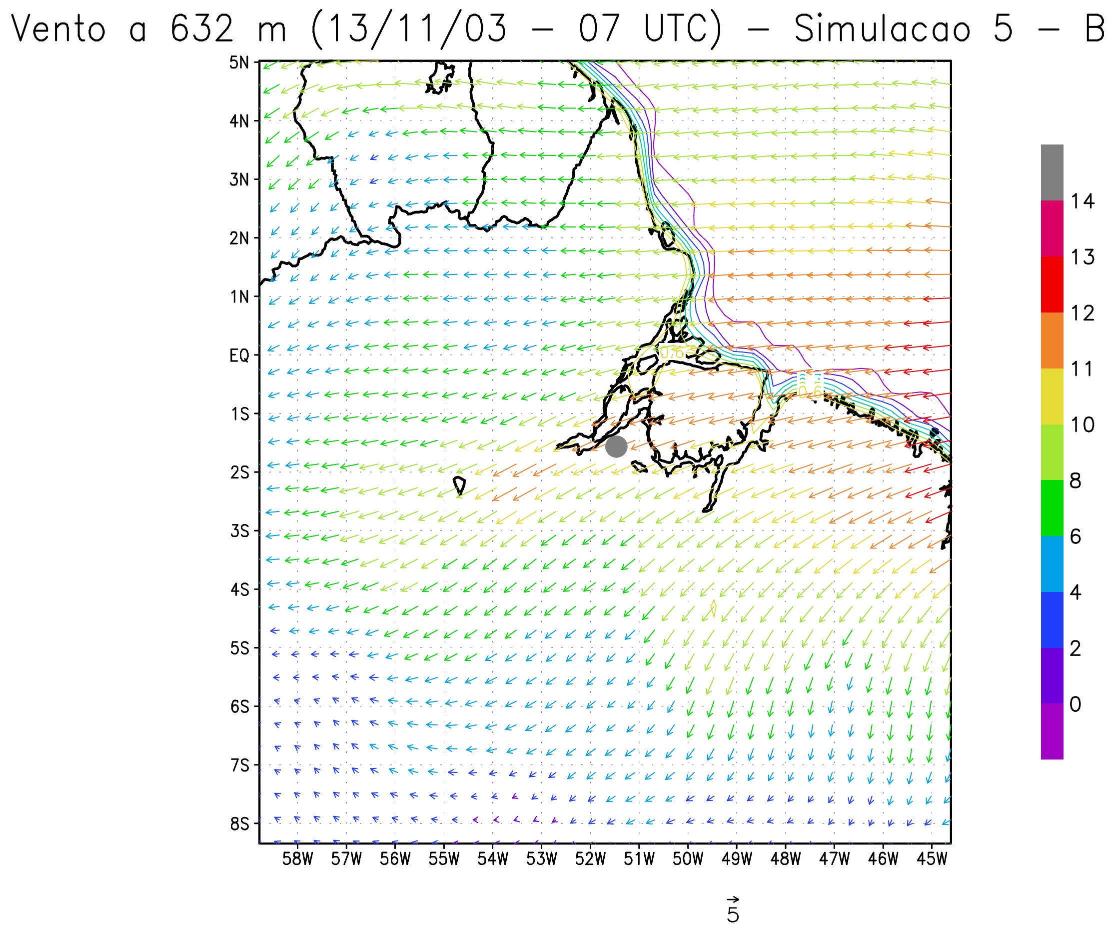

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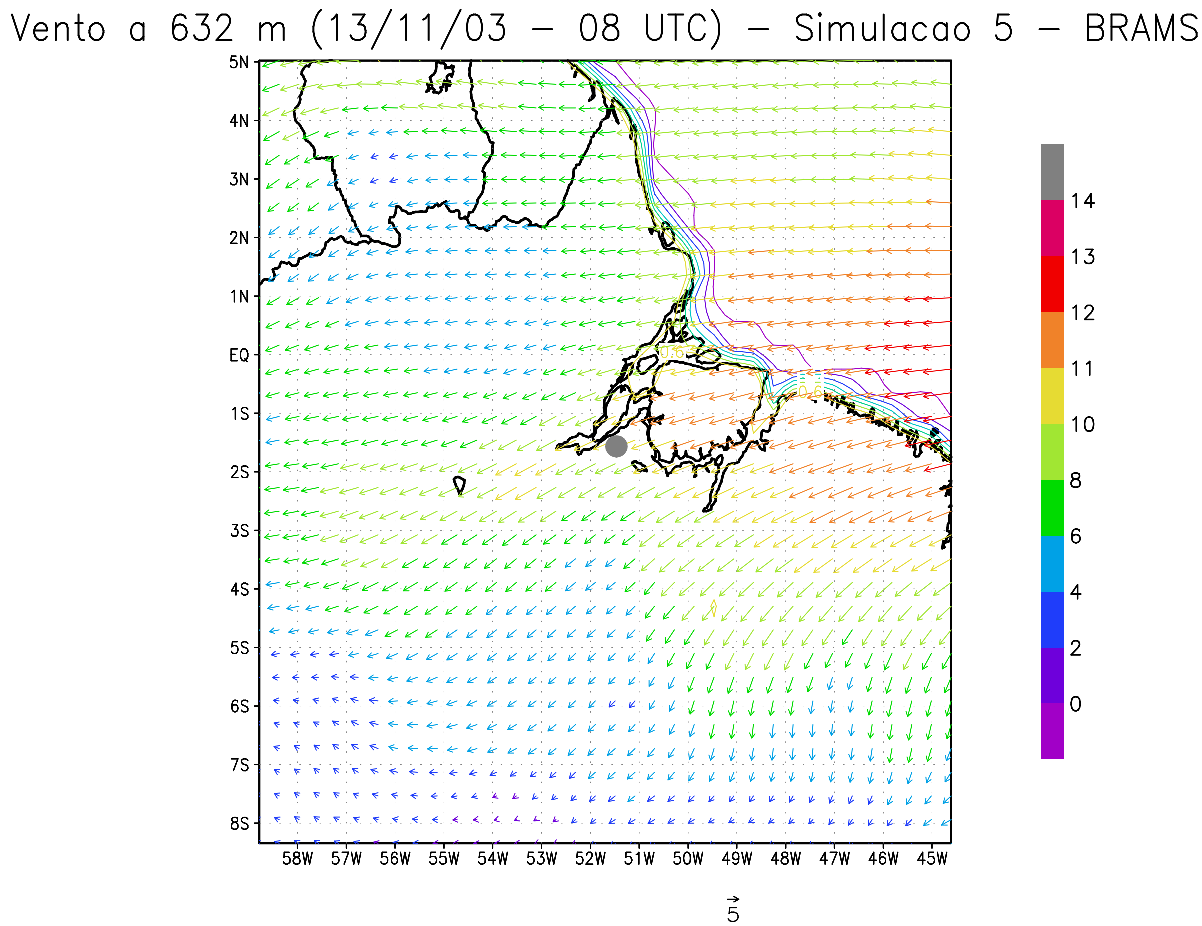

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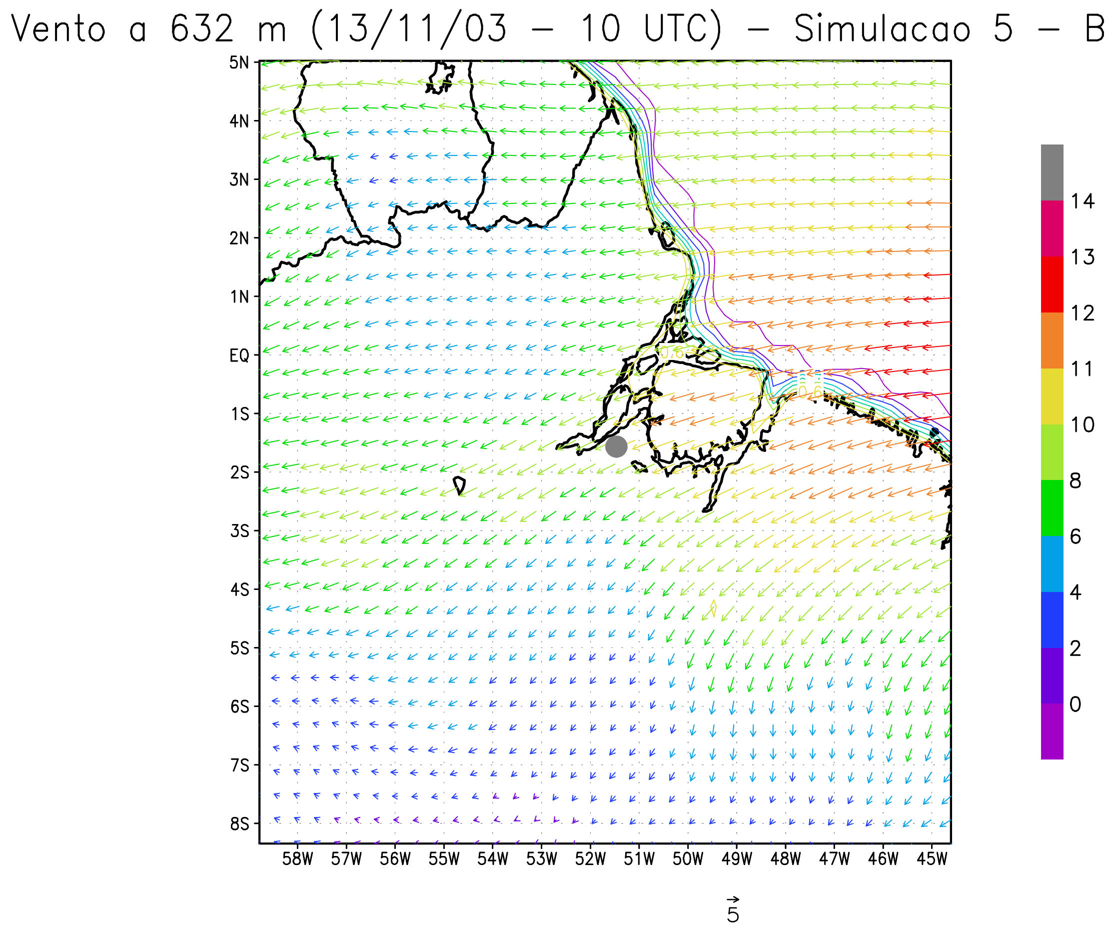

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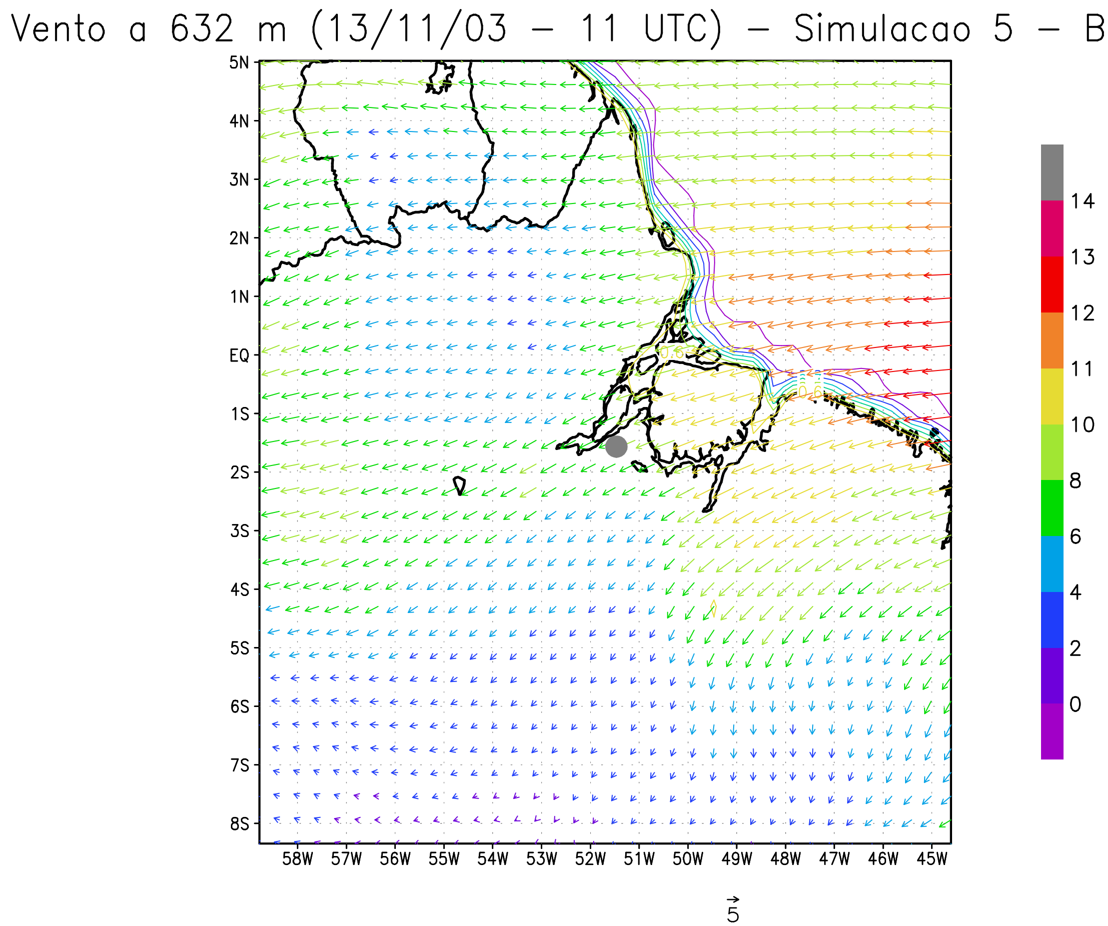
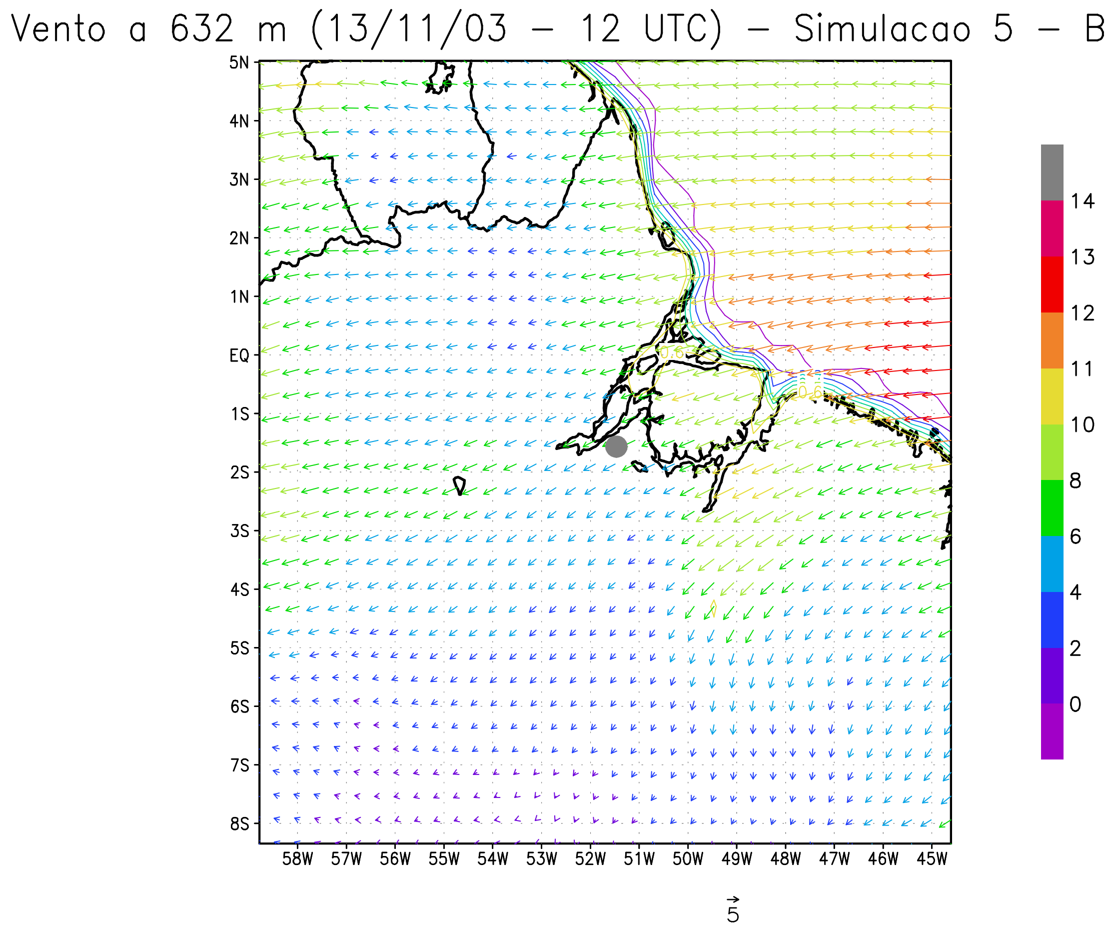


Wind at z = 632 meter Grid 1



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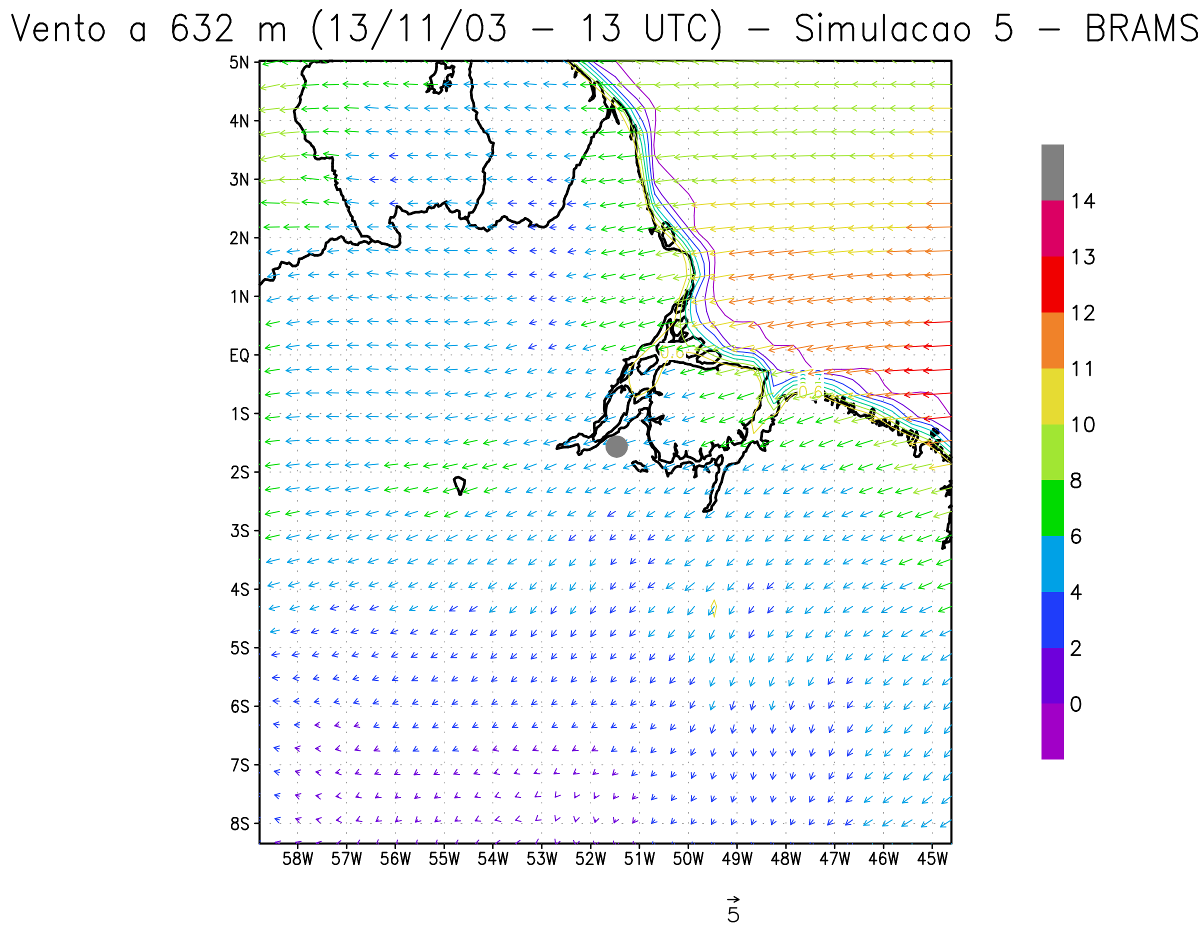
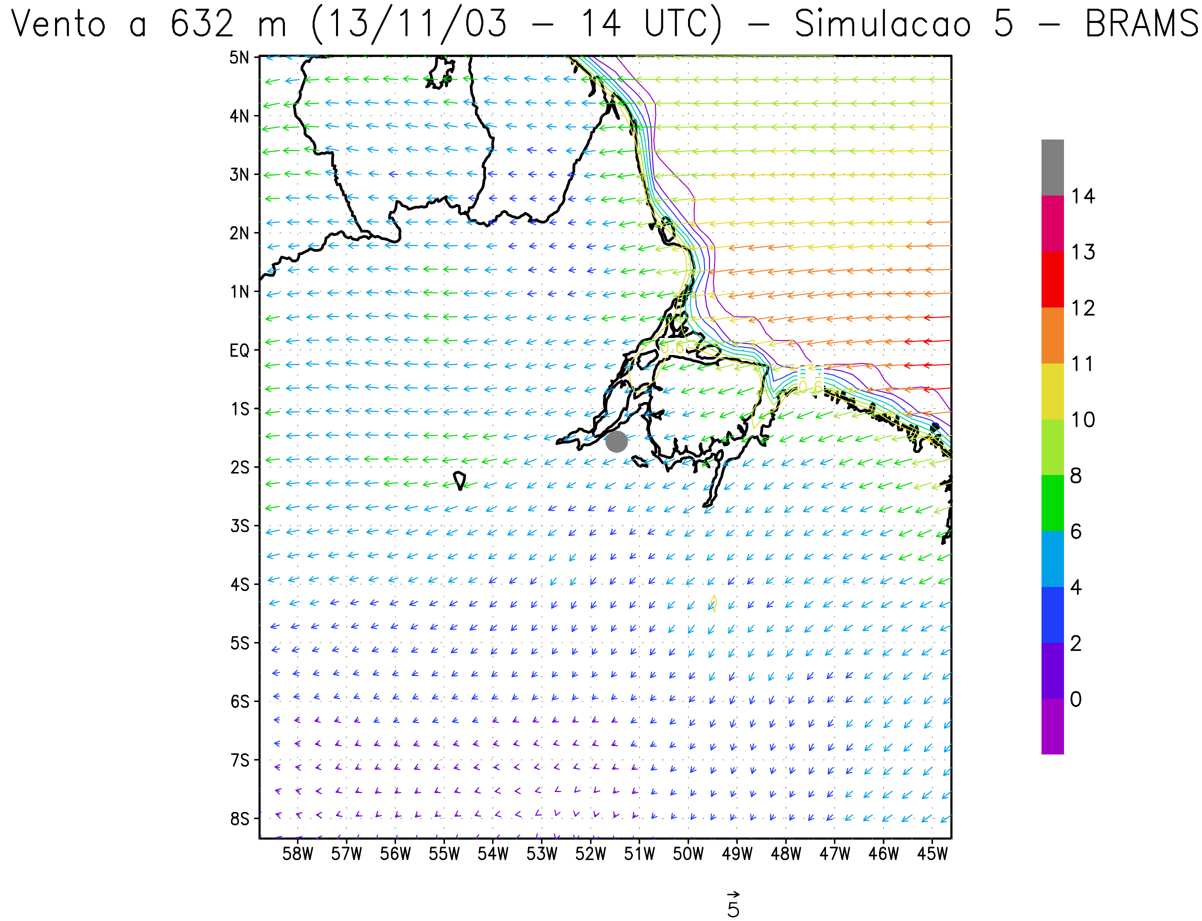


Wind at z = 632 meter Grid 1



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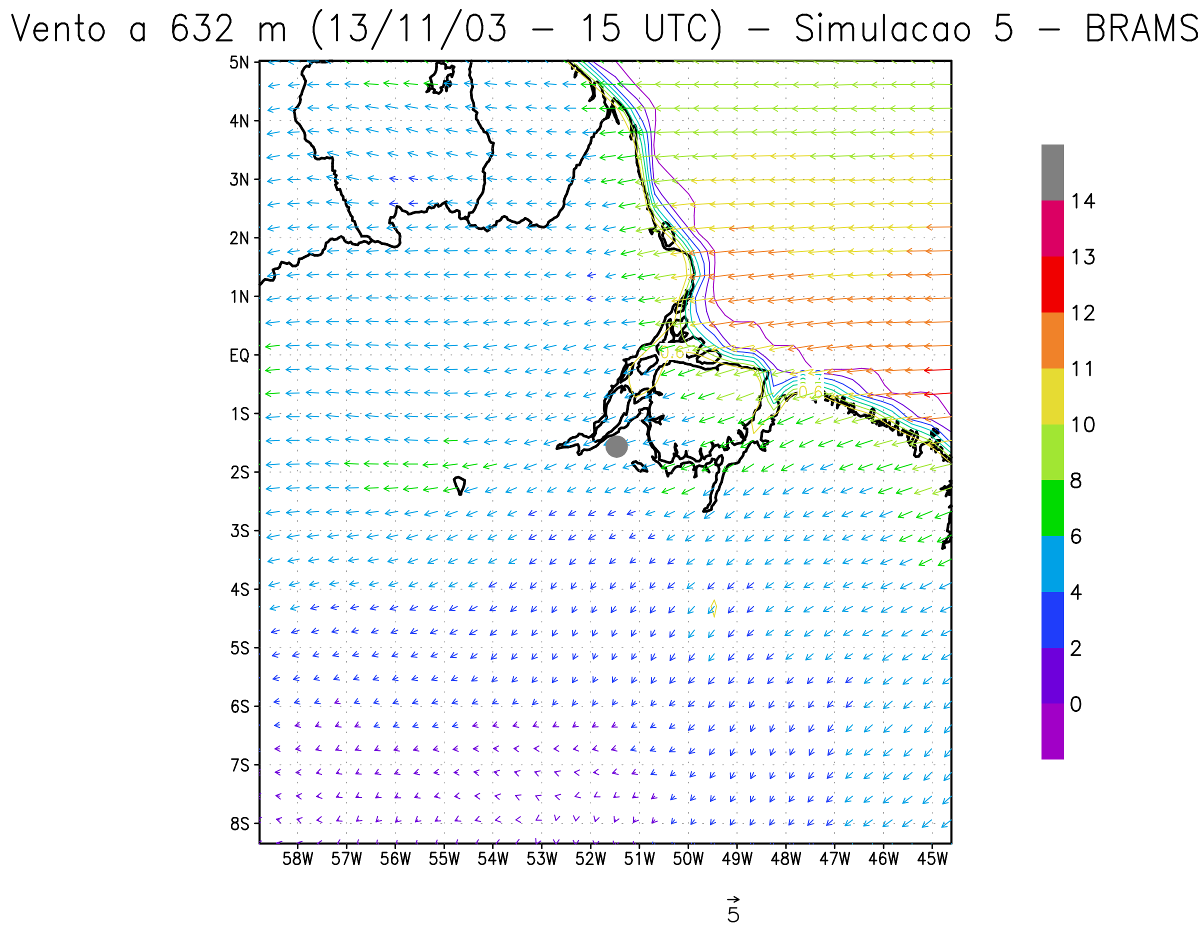

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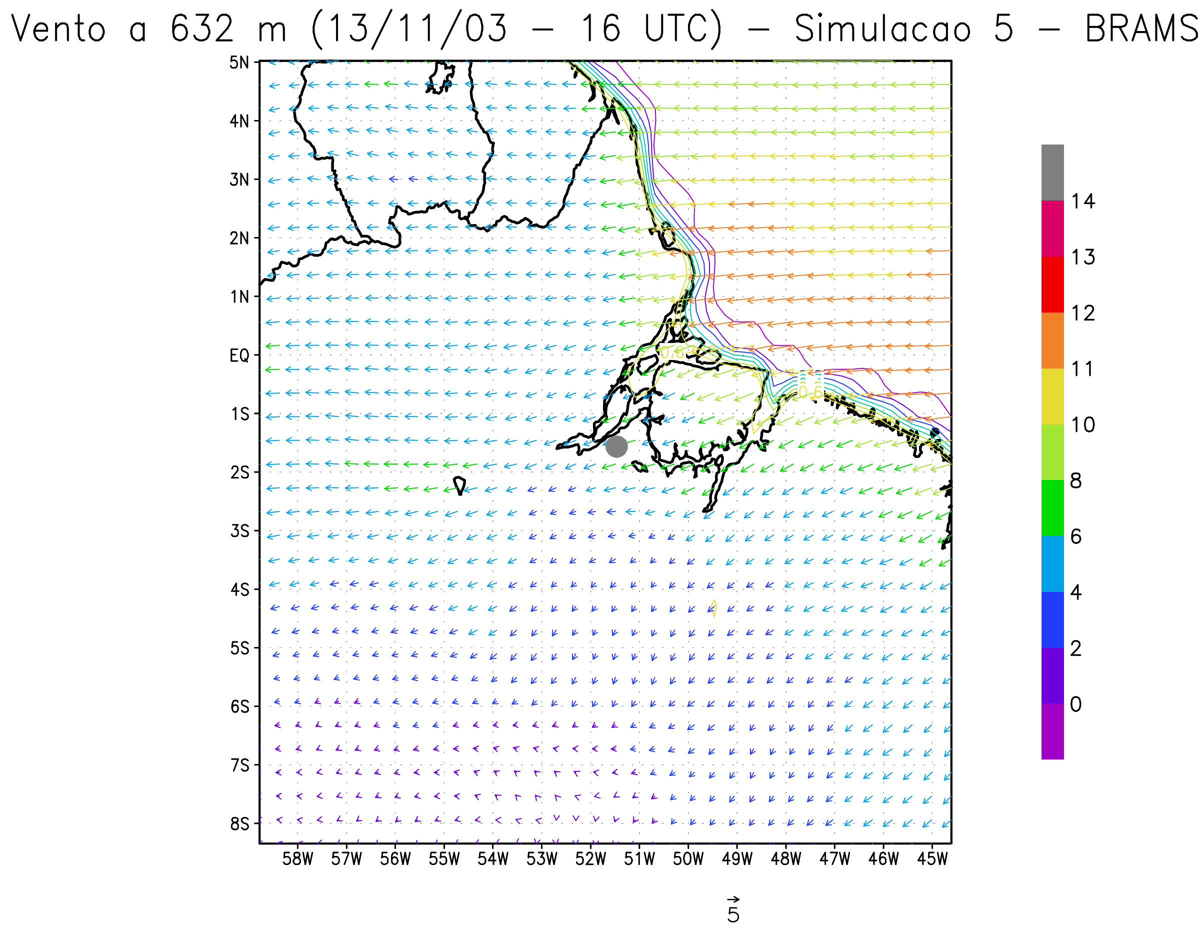

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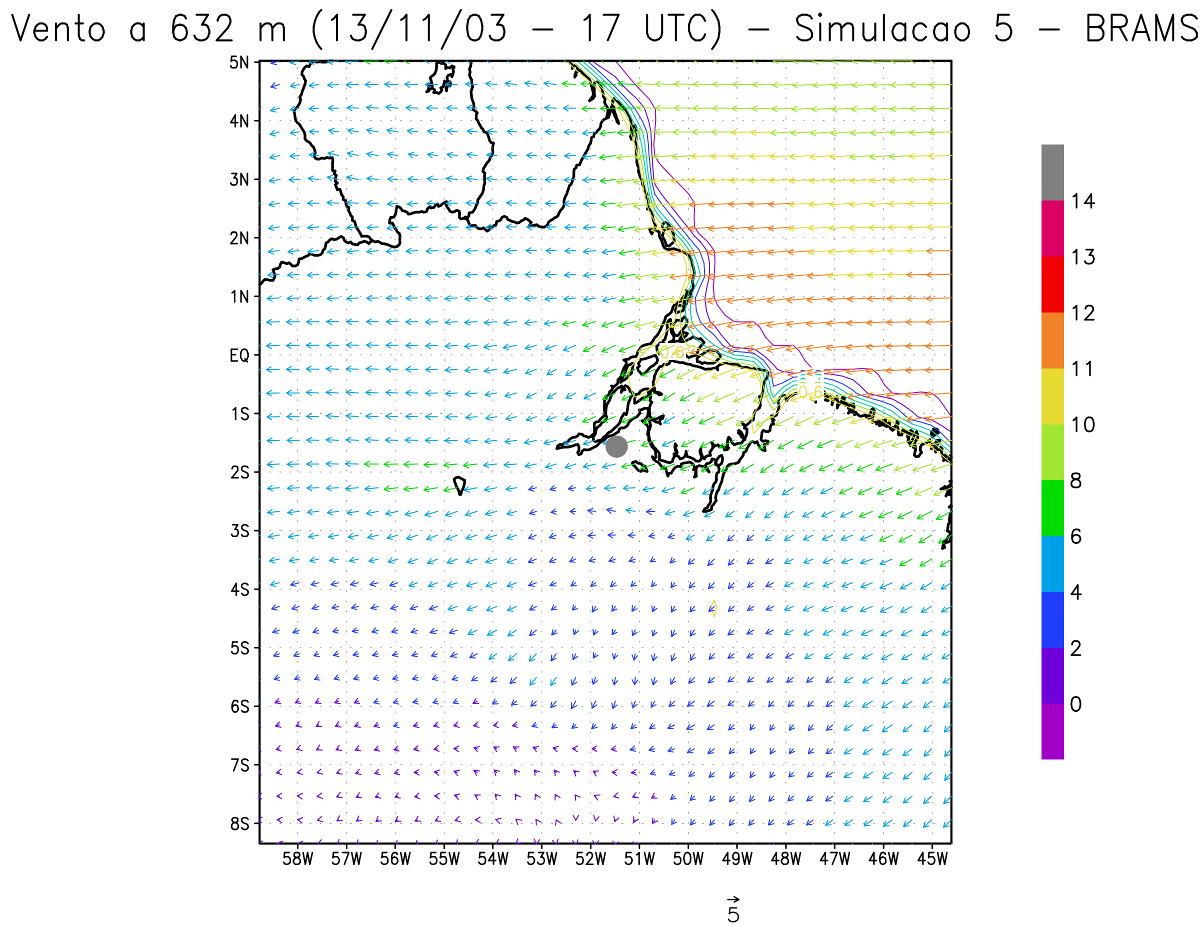

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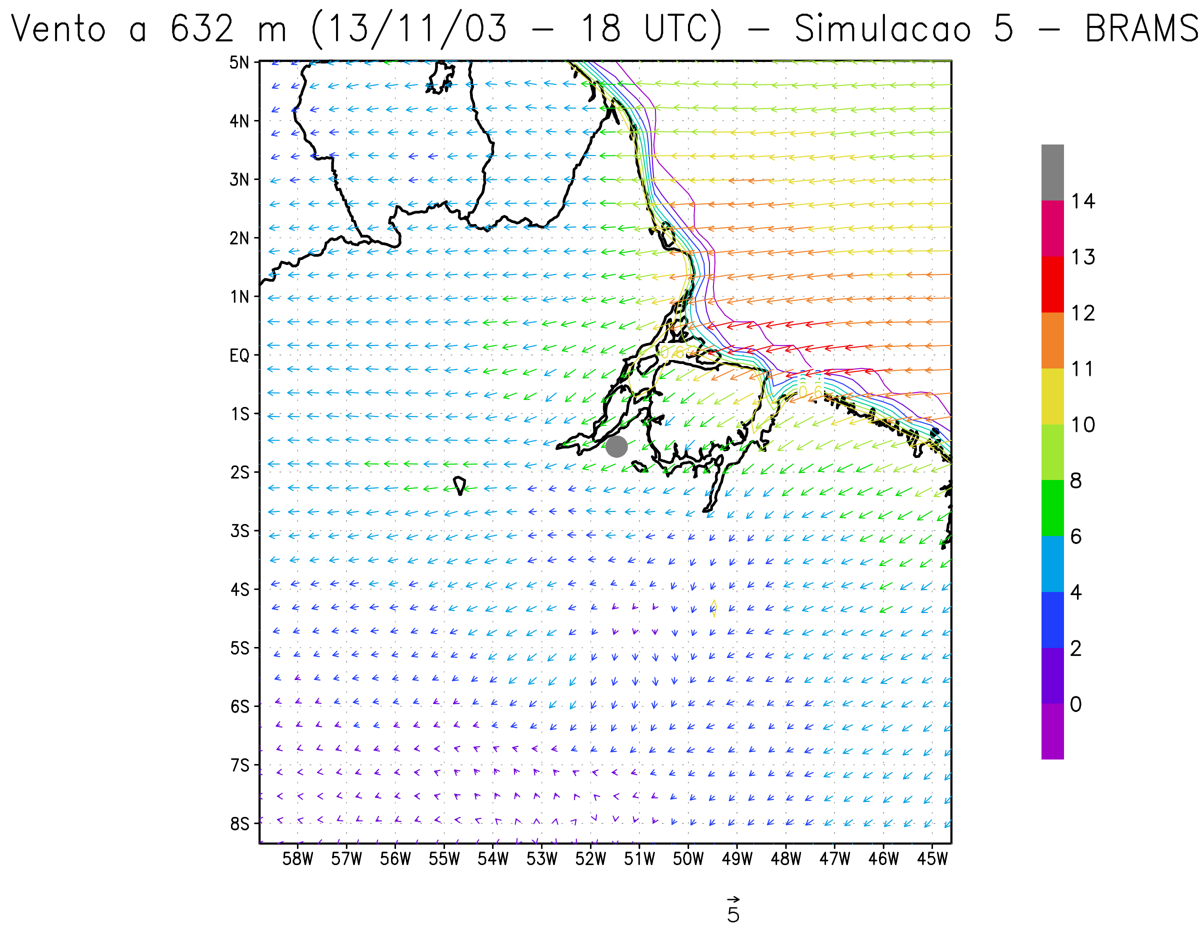

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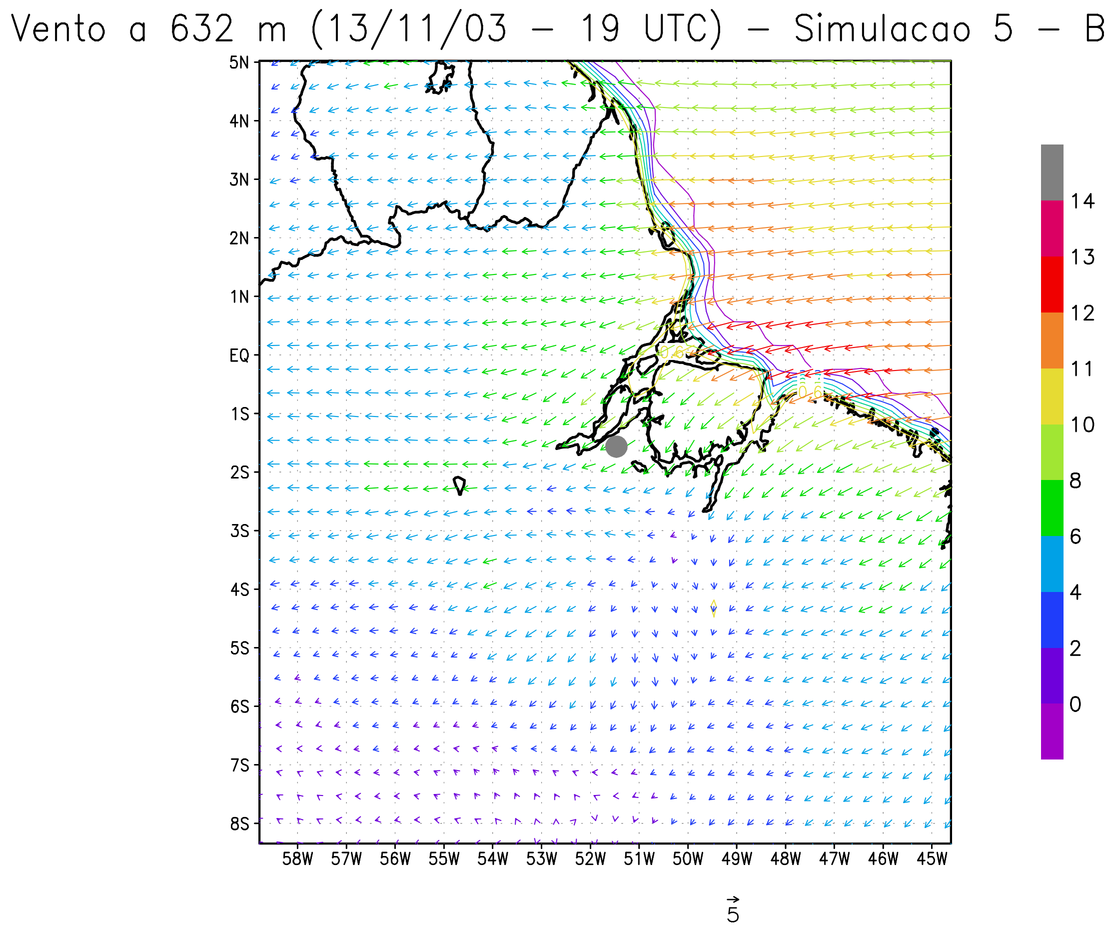

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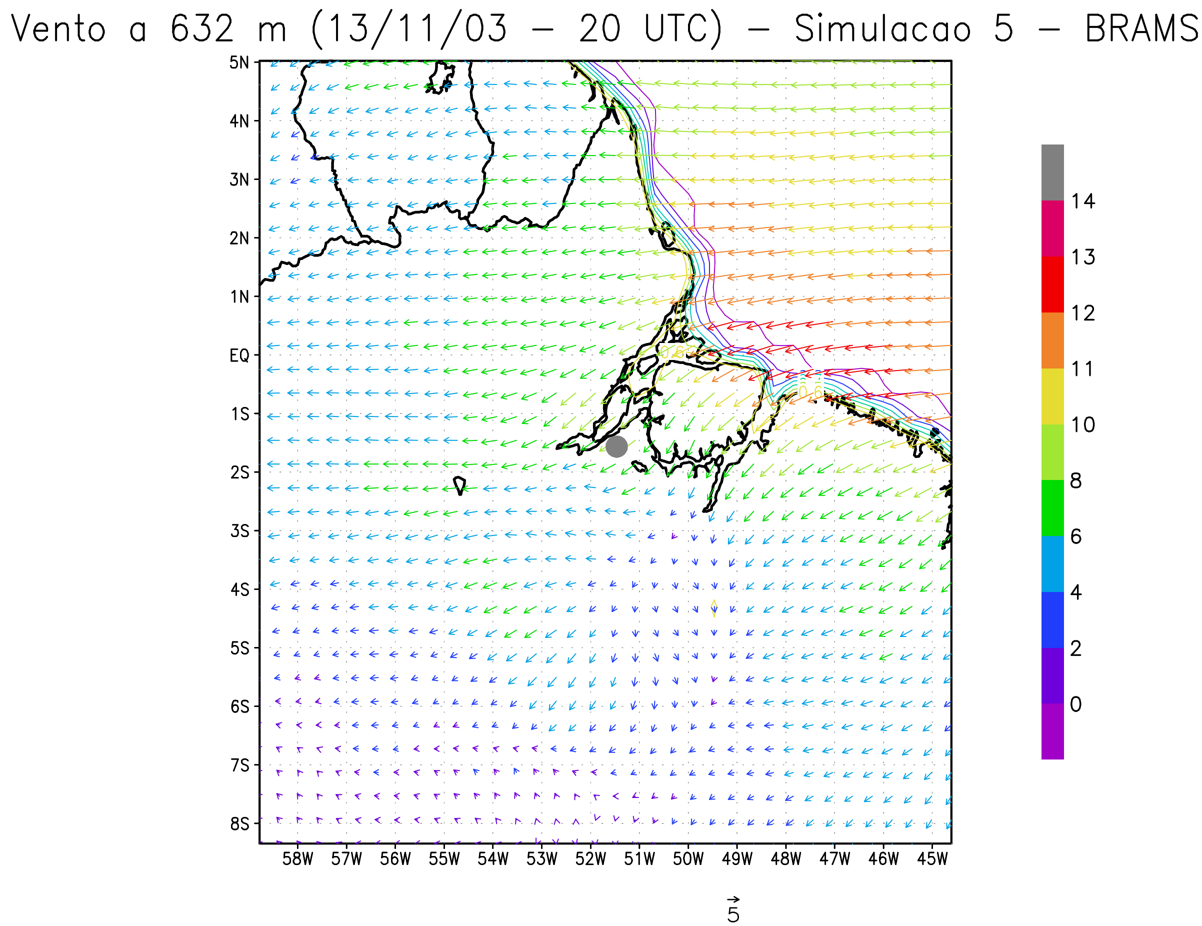

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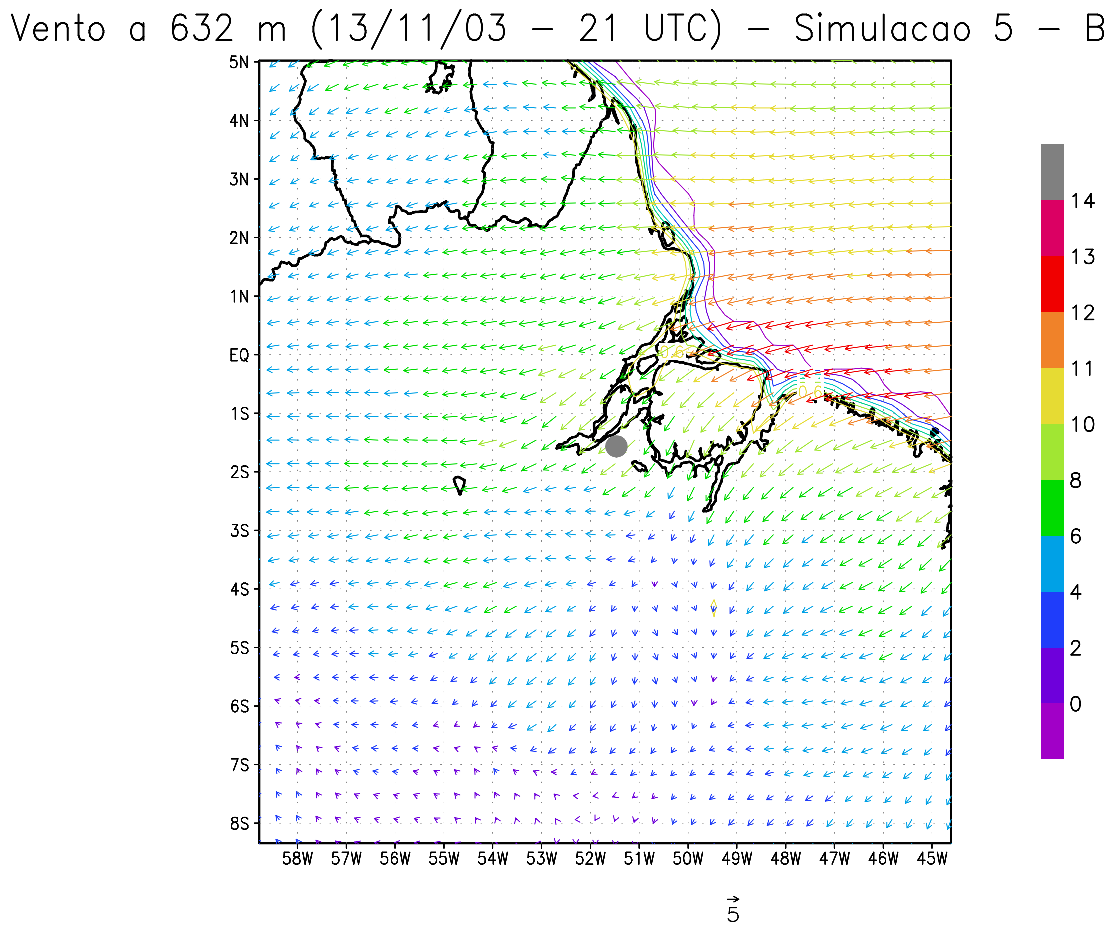

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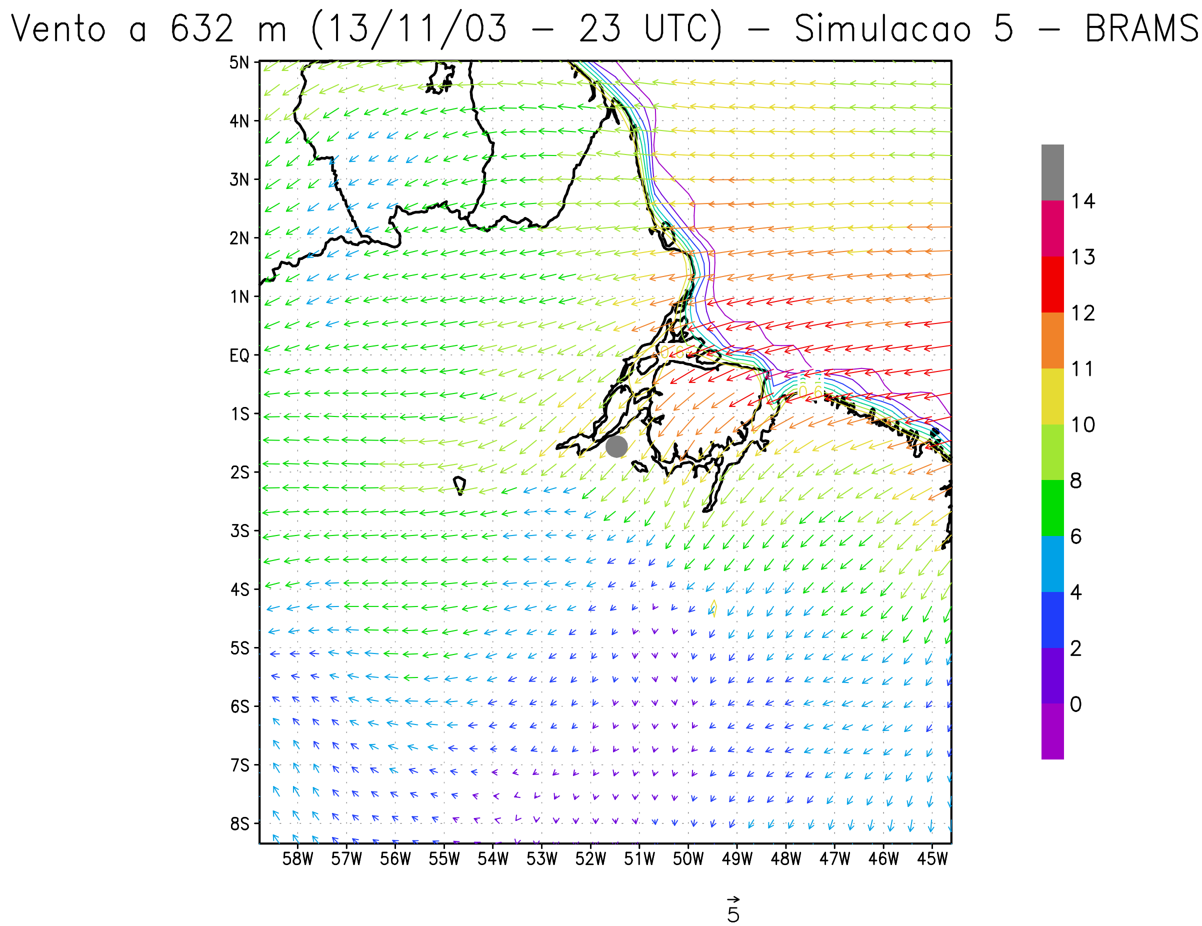

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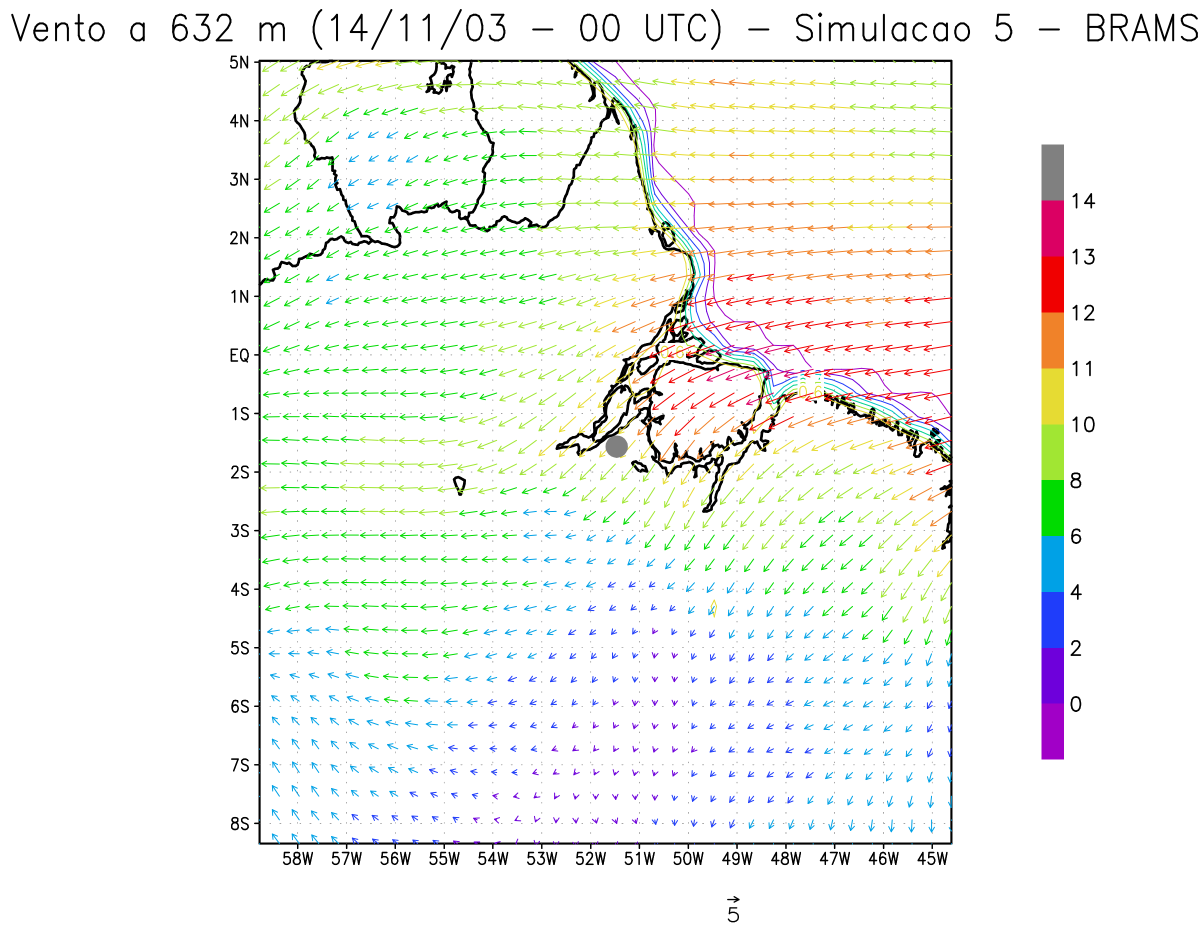

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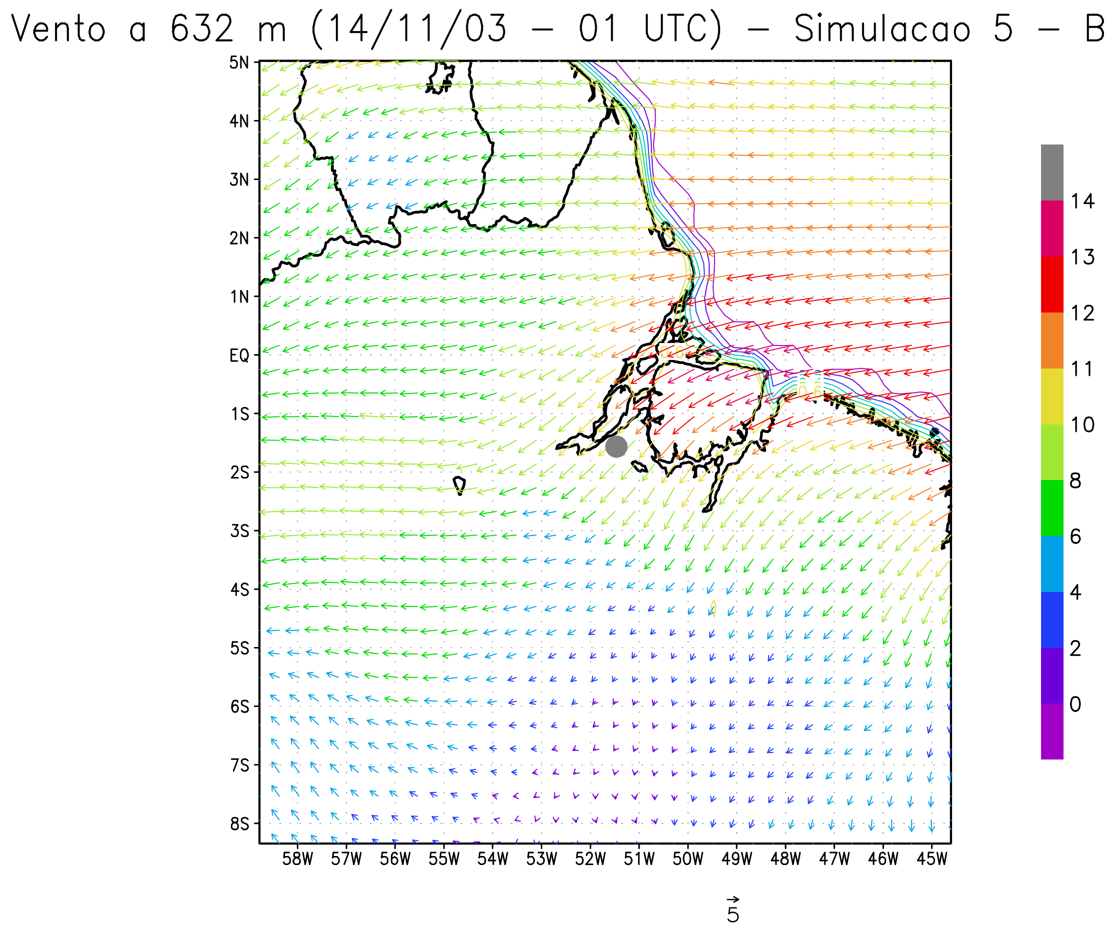

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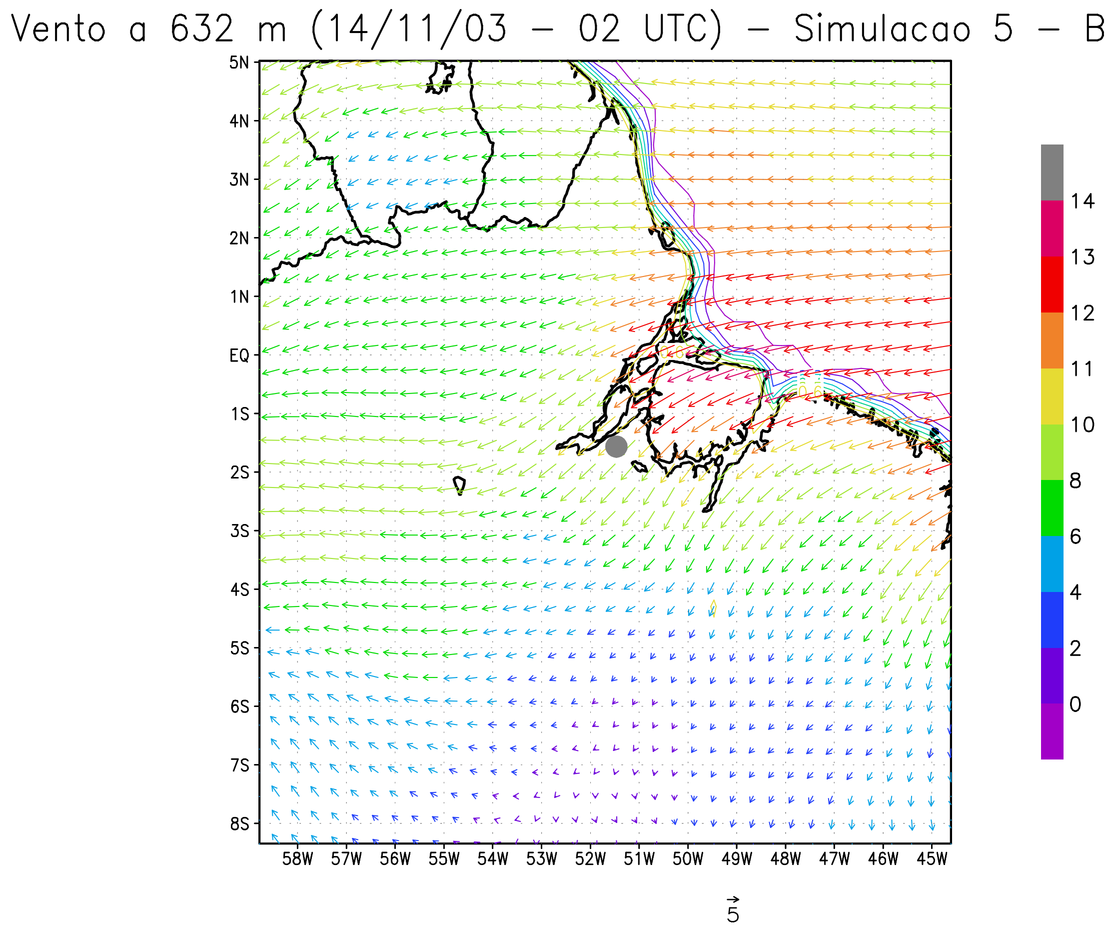

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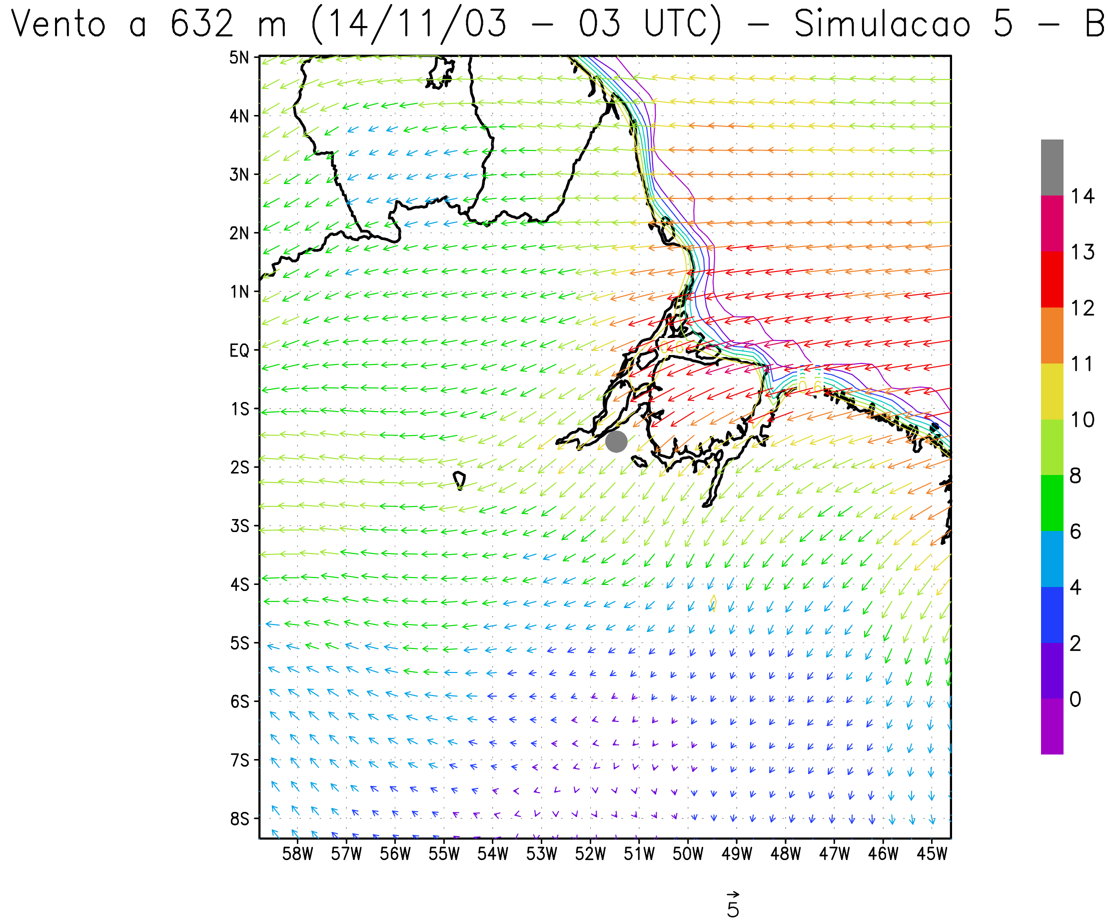

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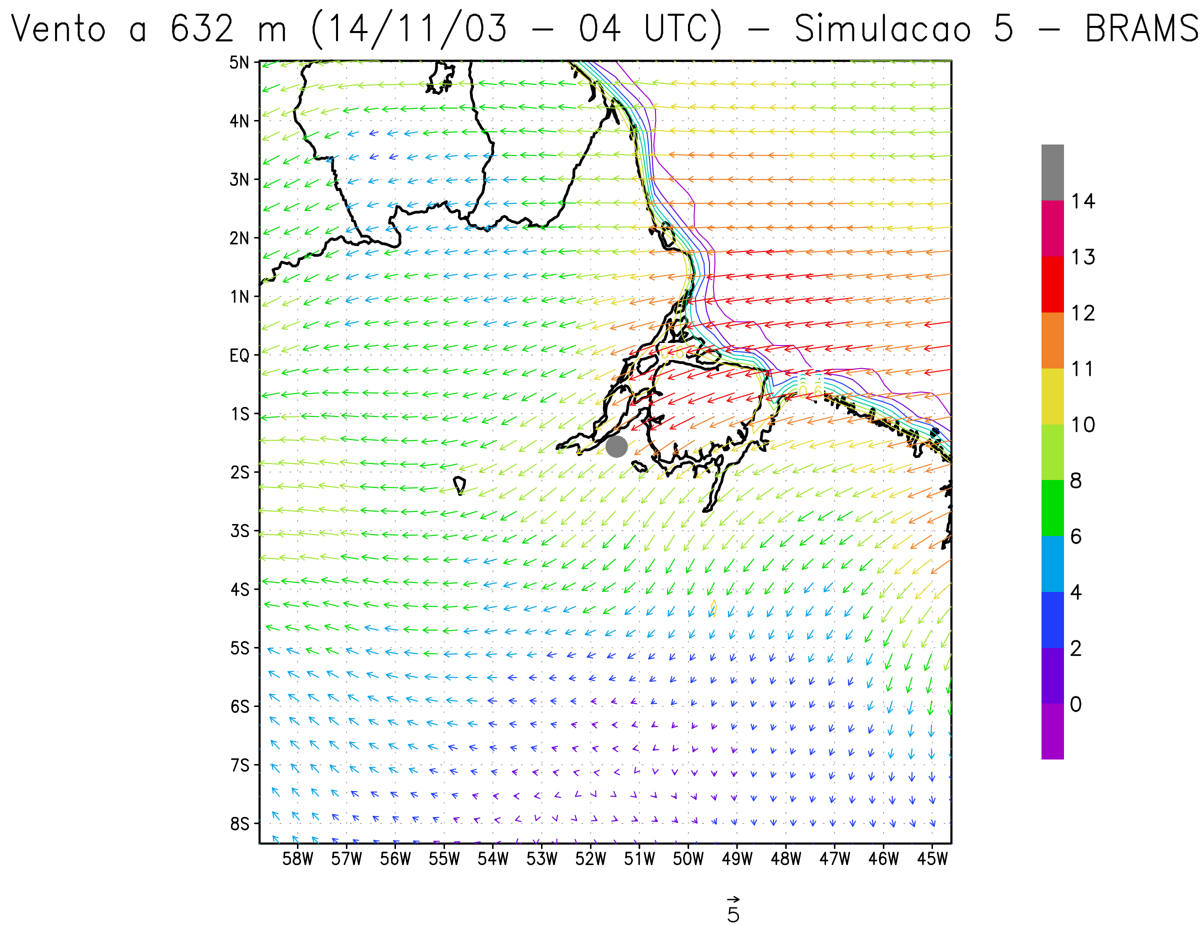
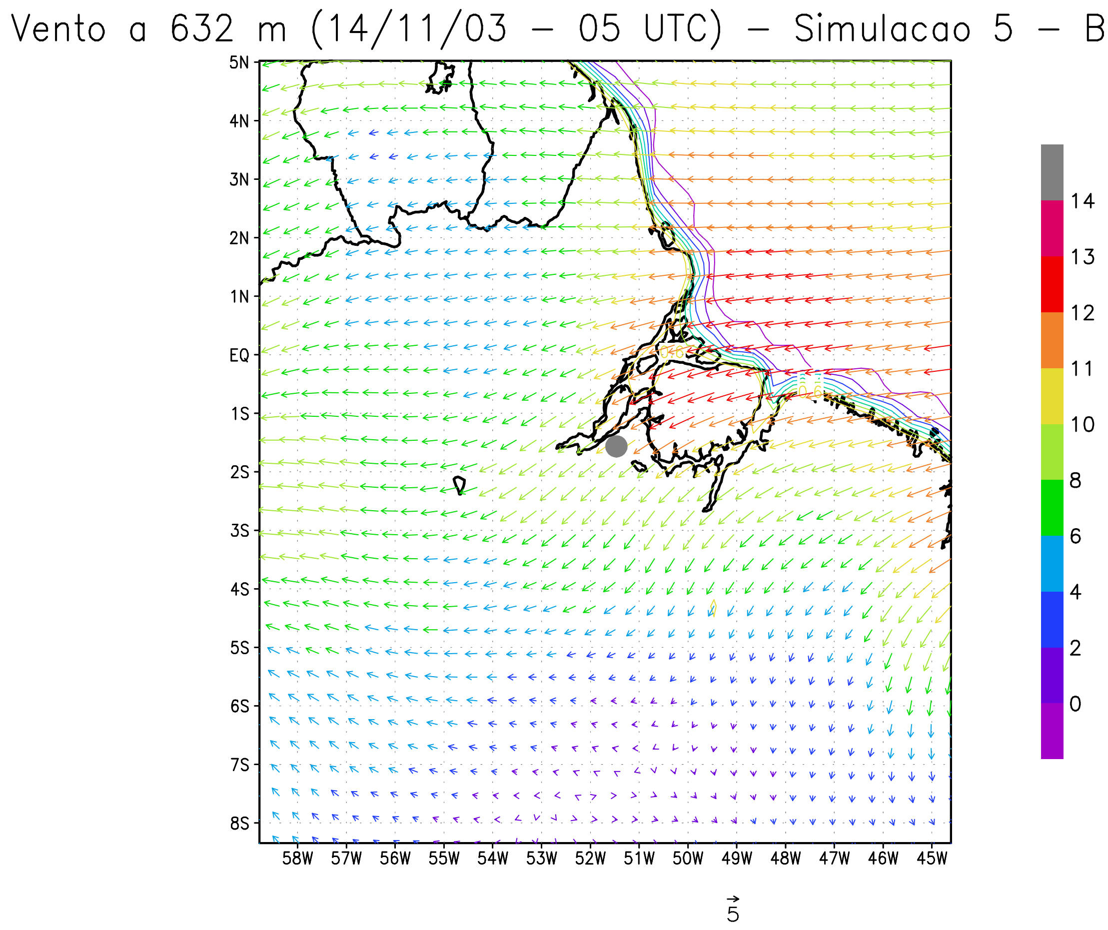


Wind at z = 632 meter Grid 1



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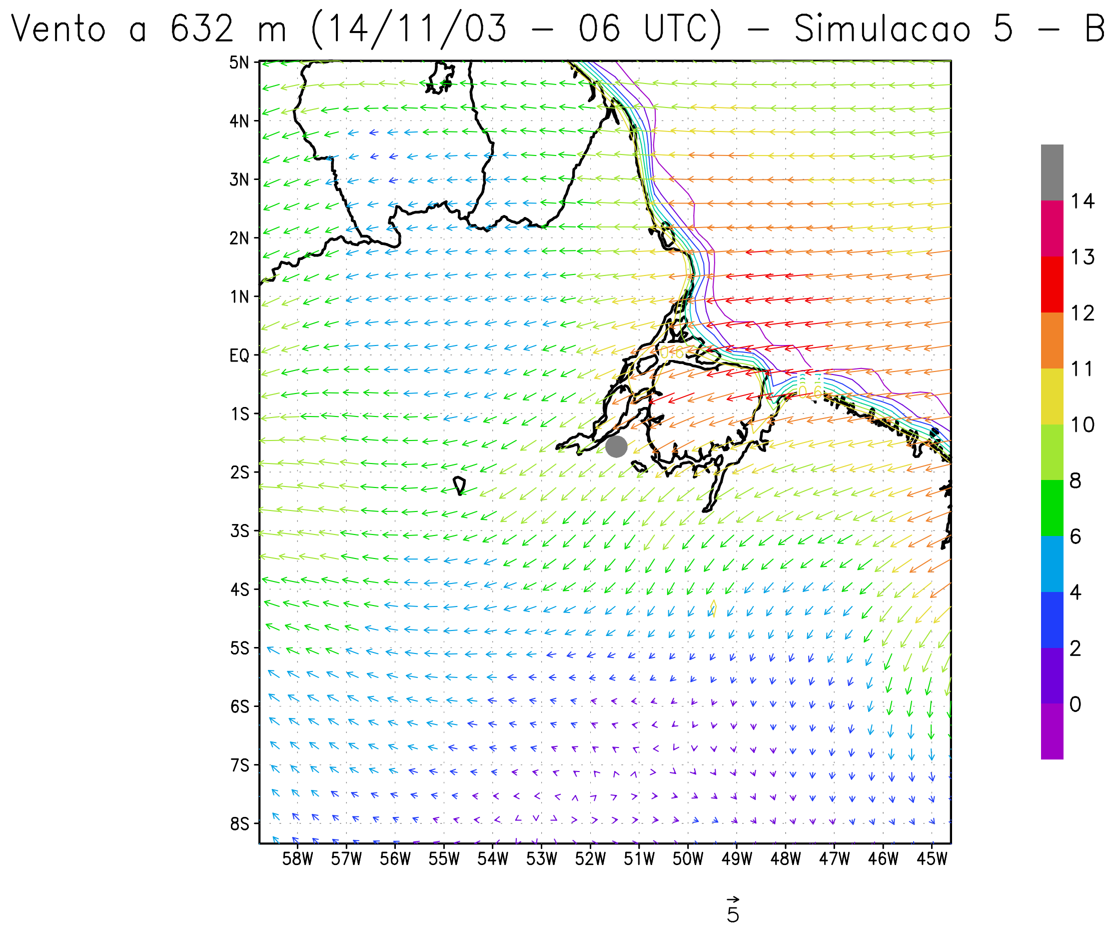

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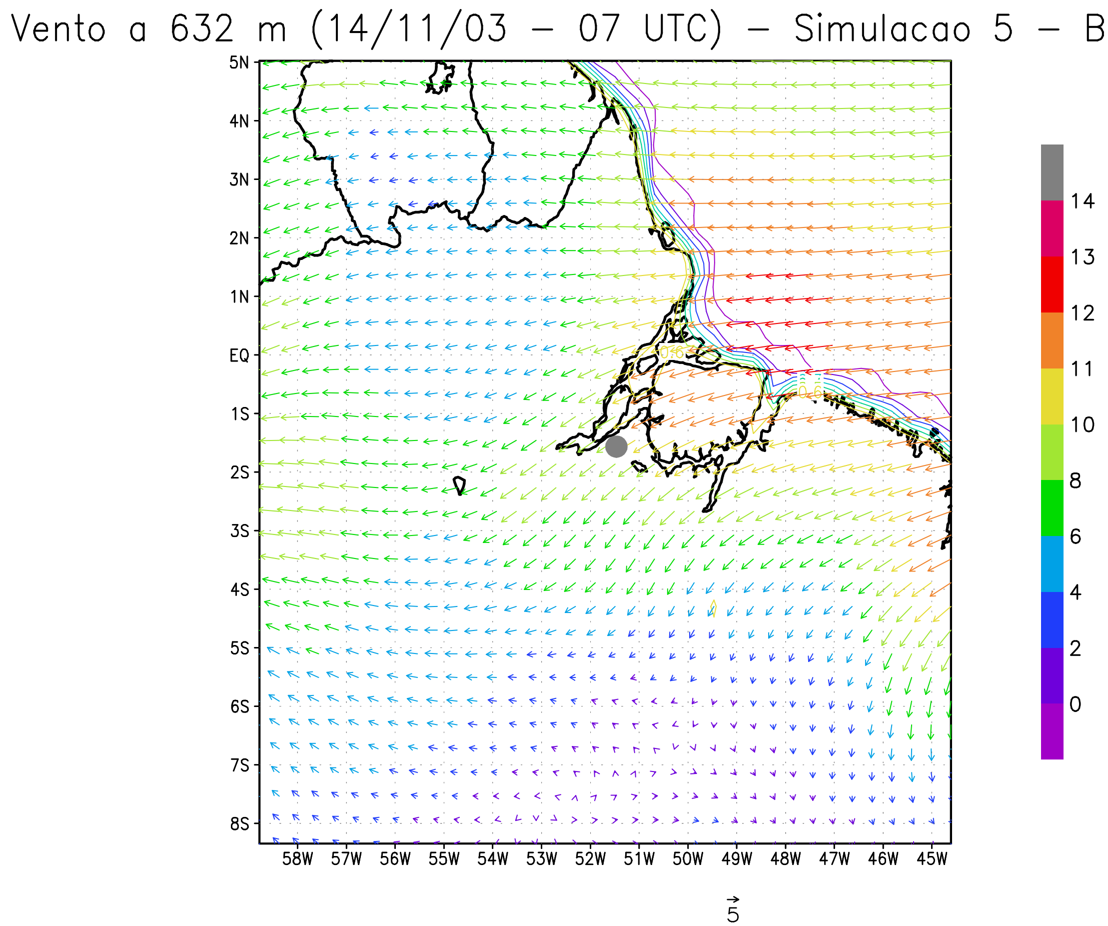

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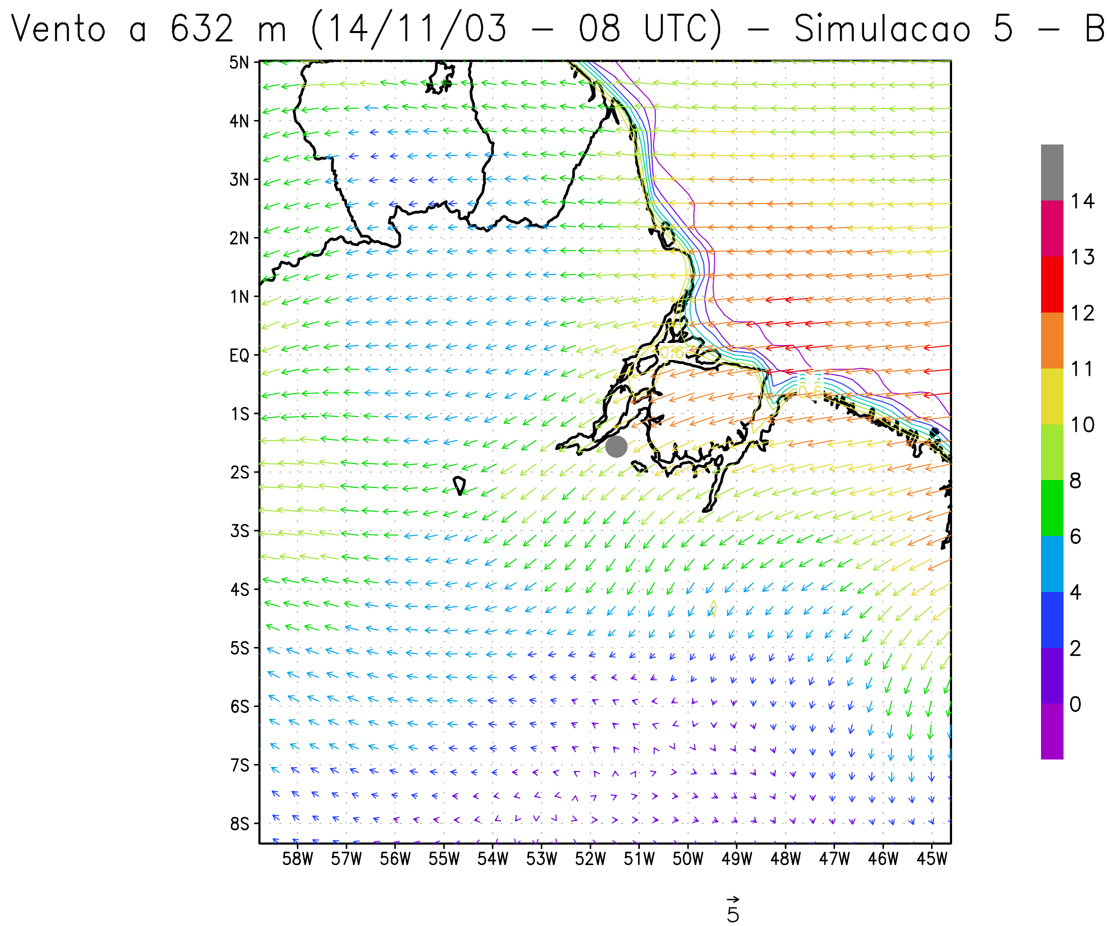

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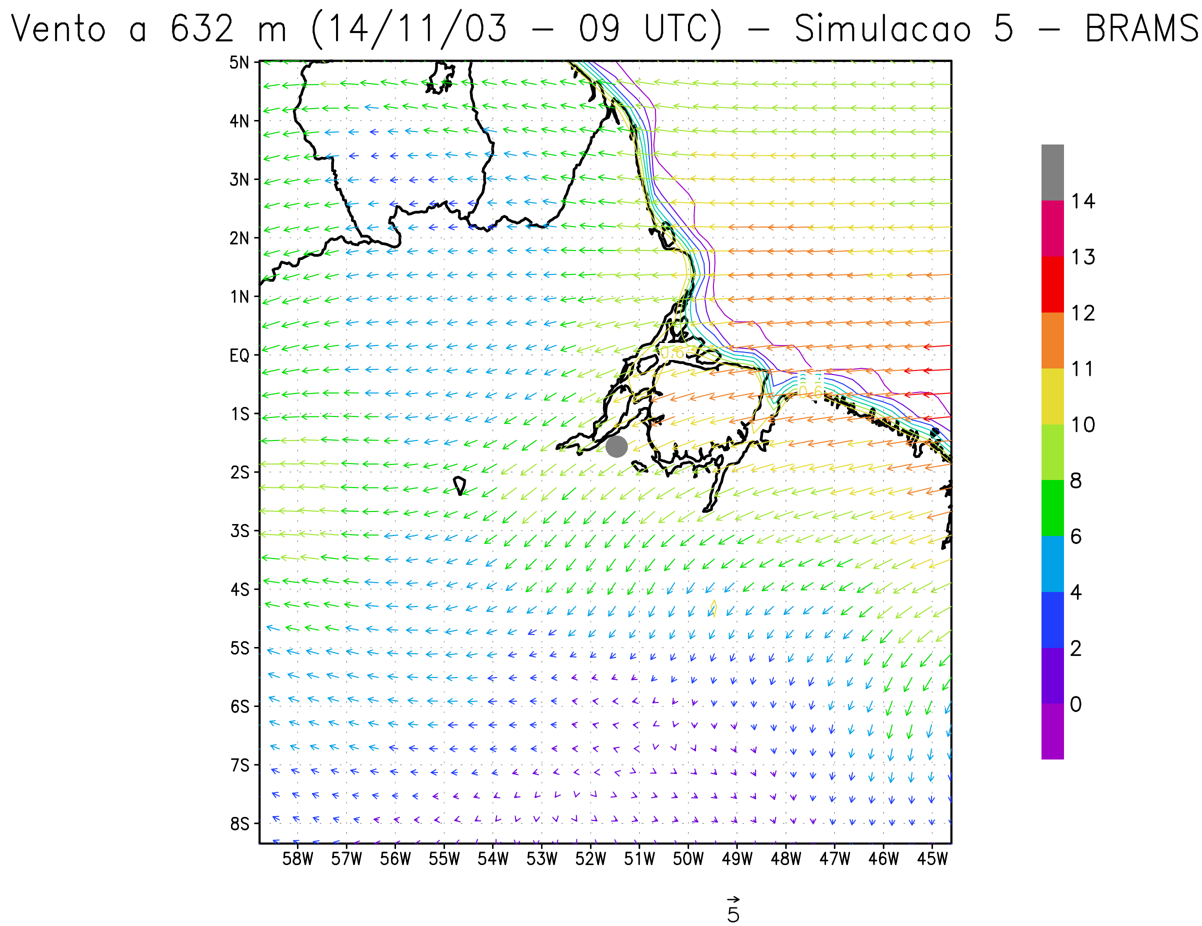

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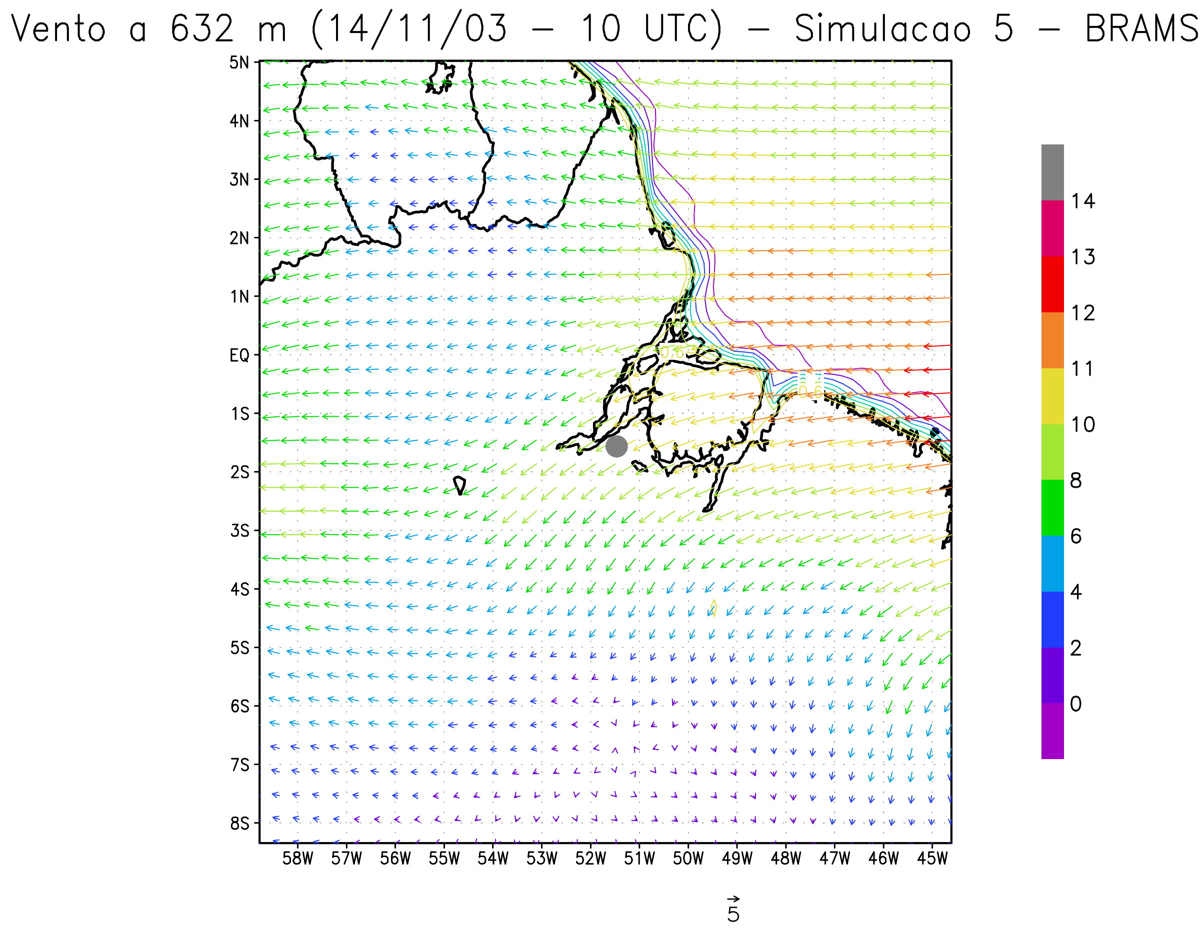

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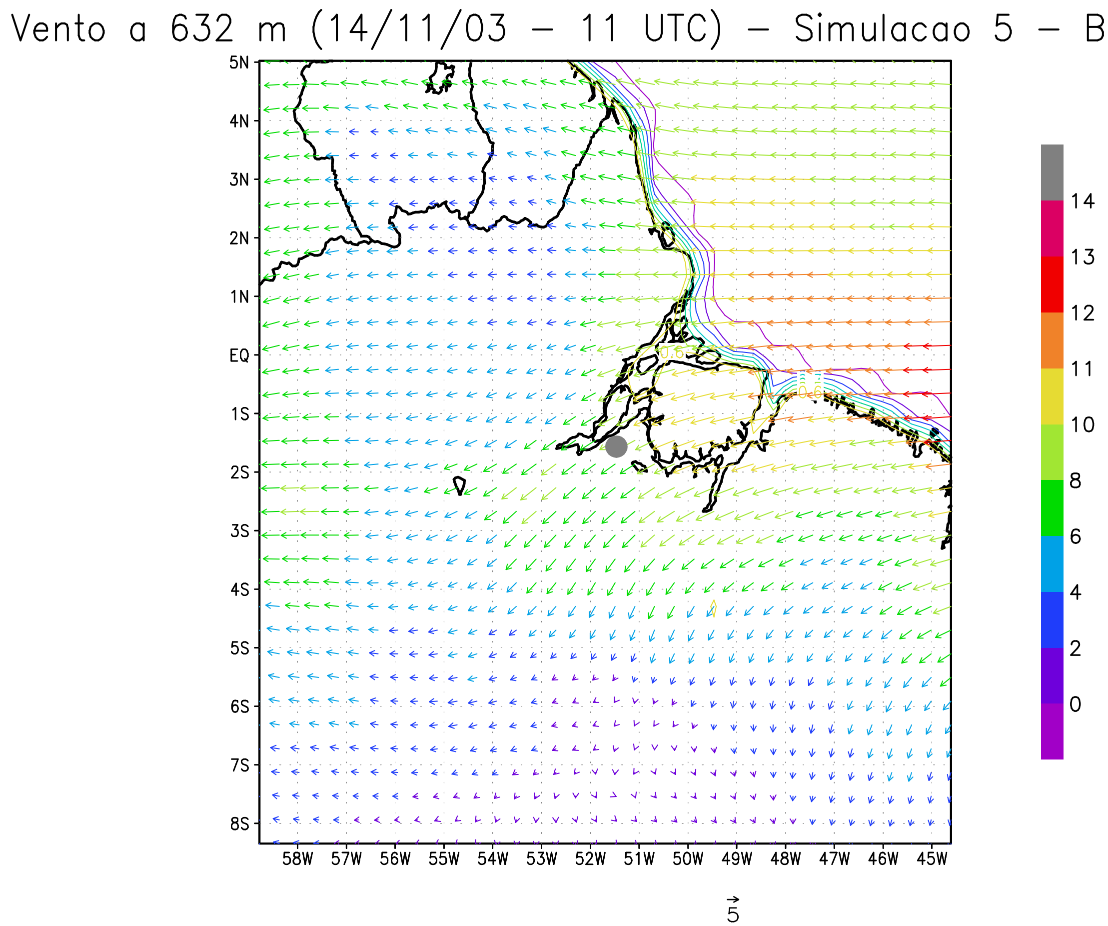


CONCLUSIONS

- The numerical simulations with this high resolution model indicated the occurrence of low level jets.
- However, it did not reproduce in detail some of the observed characteristics of the flow.
- An important aspect revealed by the simulations with BRAMS was the origin of the jets, which is associated to canalization phenomena of the flow above zones where there are some of the great rivers in the Northeast of Pará.

RESULTS AND DISCUSSION

- Wind gusts: wind speed relative maxima, identified in cup and sonic anemometers data.
- They have minimum wind speed of 4 m/s and last from 2 to 14 minutes.
- Their occurrence begins, generally, after 8 pm (LT).
- They show characteristic patterns in the evolution of statistical parameters associated to turbulent micrometeorological variables.

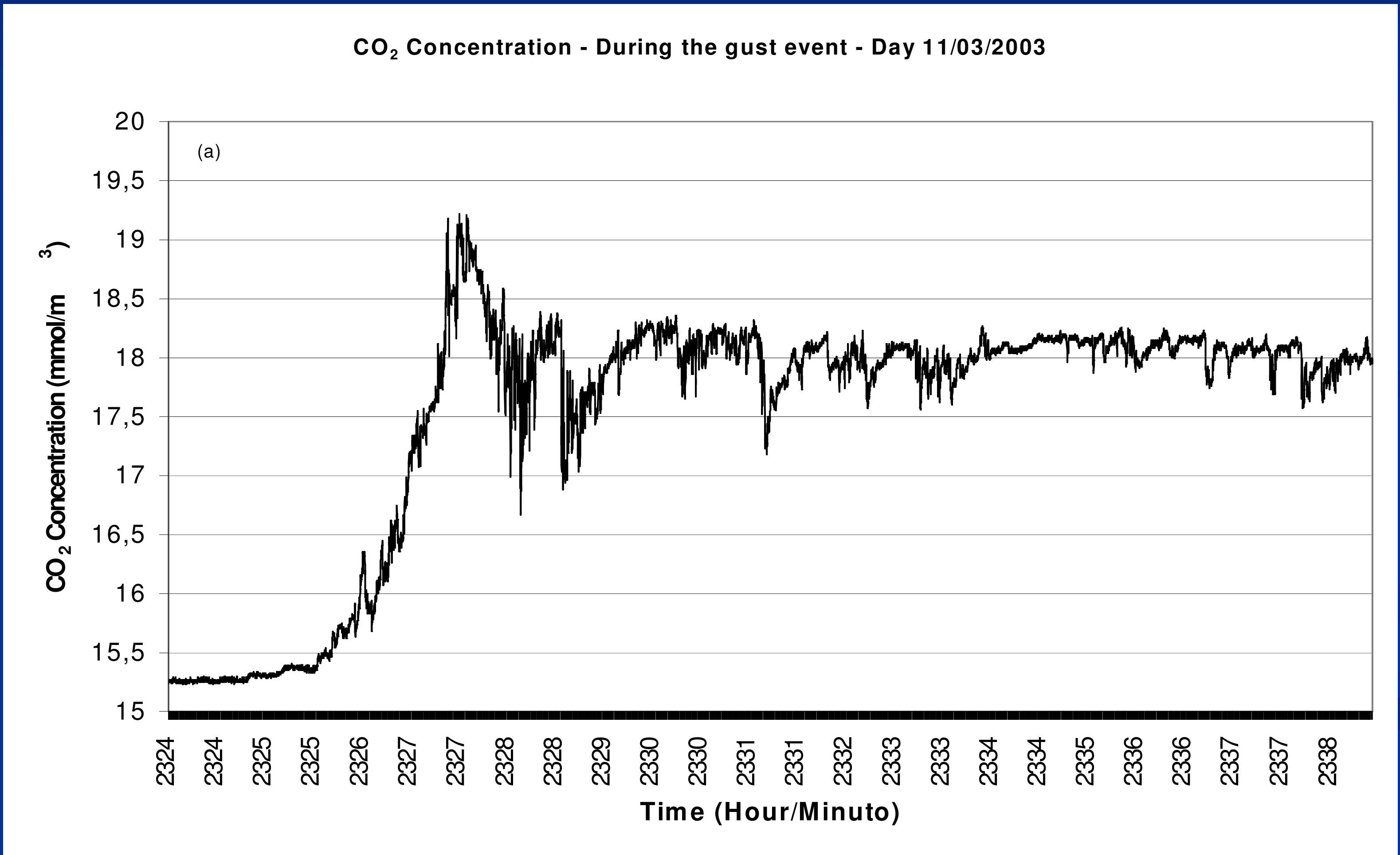
Scalars Turbulent Time Series

- Scalars like water vapor and CO_2 concentration had a sharp increase, while temperature decreased during the gust event.

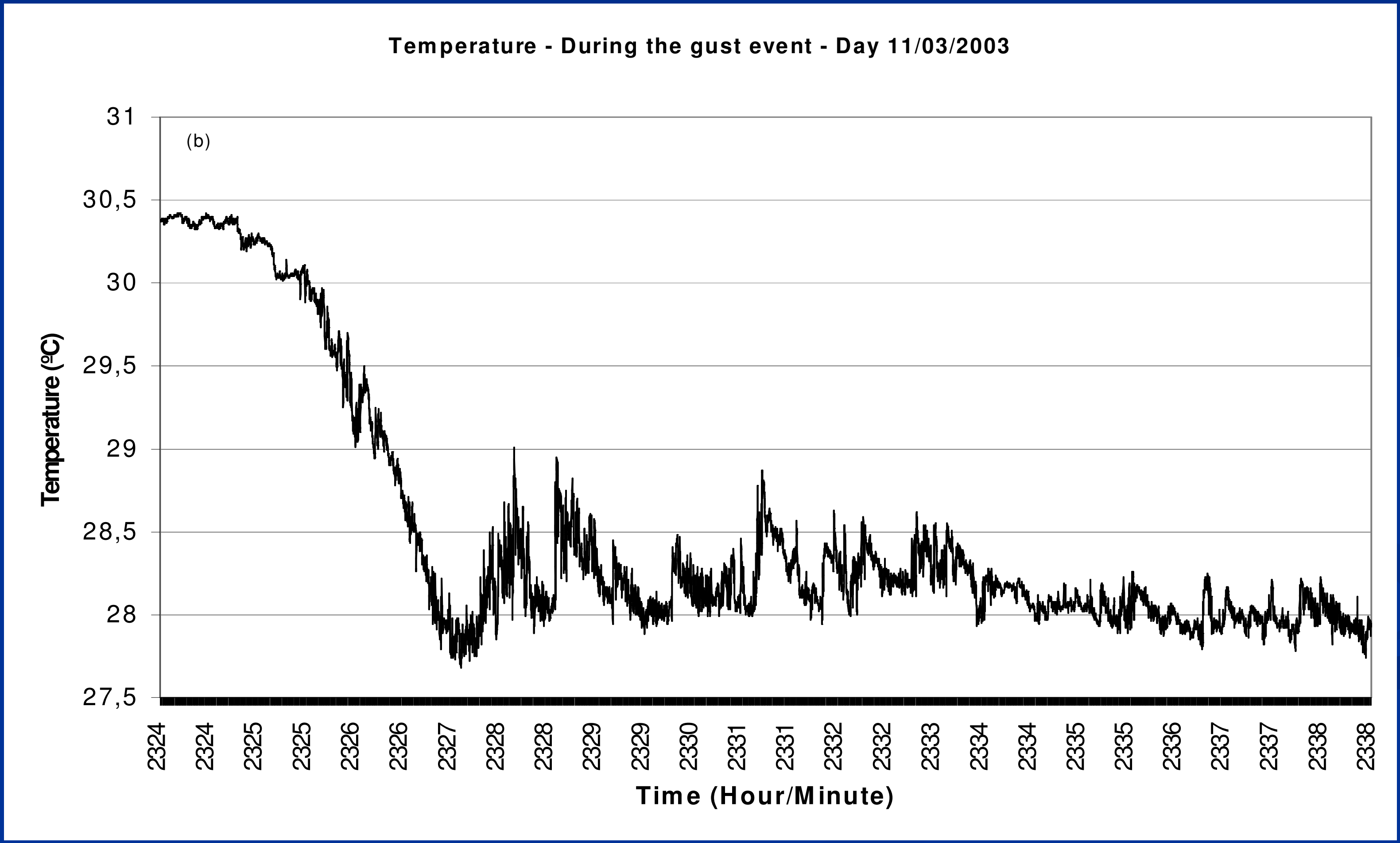
- Ramp-like coherent structures are observed. These structures occur synchronically in CO_2, water vapor and temperature time series, with "inverted" ramps for temperature.

- Their variability pattern shows a decrease in the oscillations amplitude and an increase in their frequency, which suggests the existence of a non-linear dynamics and phenomena associated to feedback processes.

Turbulent time series of sonic anemometer data during the gust of 11/03/2003: (a) CO2 concentration.



Turbulent time series of sonic anemometer data during the gust of 11/03/2003: (b) temperature.



Equivalent Potential Temperature

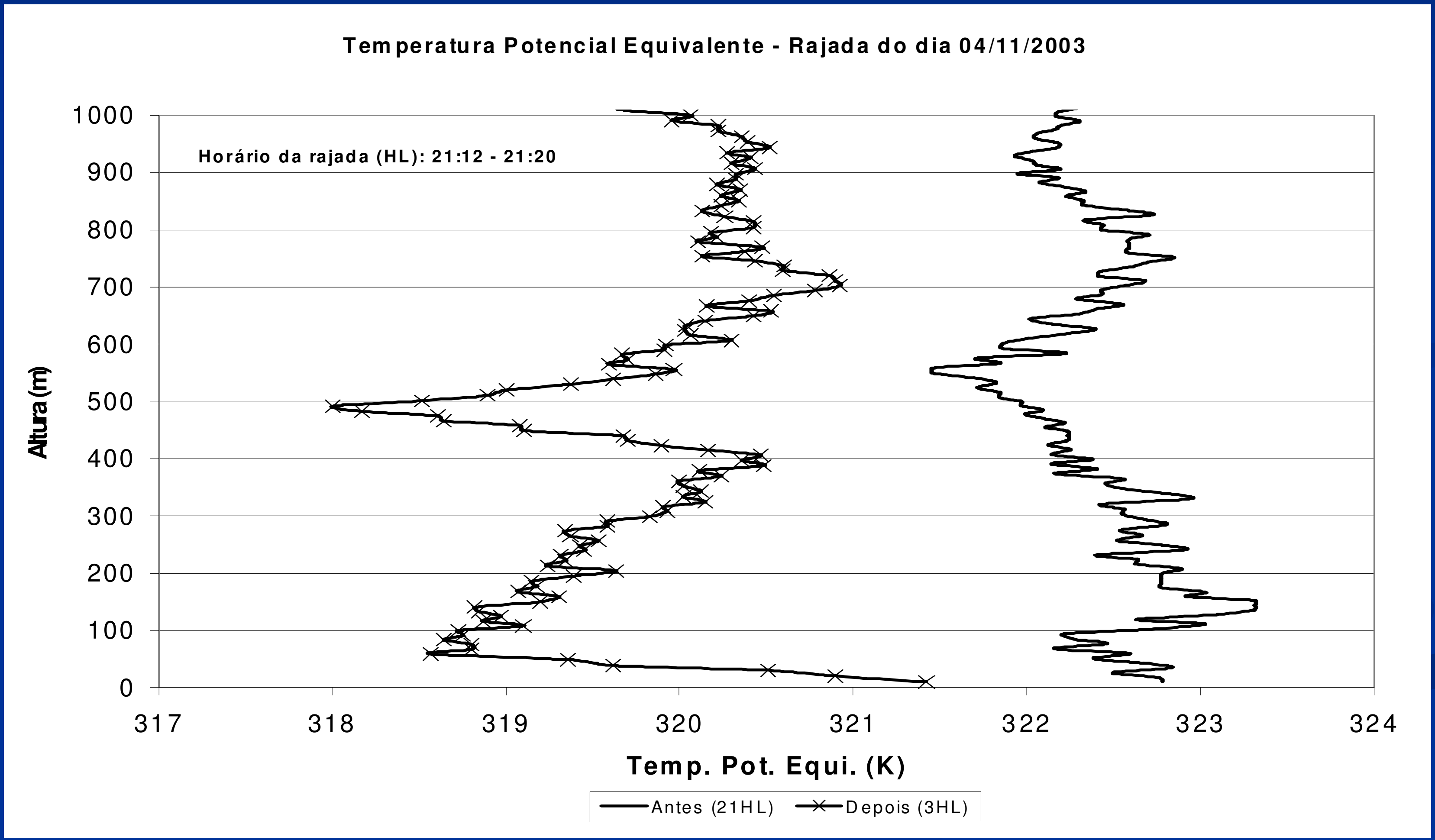
- Wind gusts direction: Northeast.

- Observed thunderstorms: Northeast.

- Considerable drop of θe after the occurrence of the wind gusts.

- This fact may be associated to the convective activity, with outflows acting as density currents in the NBL.

Vertical profiles of equivalent potential temperature before and after the gust event of 11/04/2003, which represent the typical drop in θe after the episode.



CONCLUSIONS

- The wind gusts occur between 8 pm and 12 am and may reach more than 10m/s at the top of the 56m-height tower.
- They are from Northeast and last about 10 minutes.
- These events are associated to strong turbulence in the scalars time series, which present ramp-like coherent structures during their occurrences.
- During the wind gusts, the momentum, sensible heat, water vapor and CO2 fluxes show a pronounced increase and are responsible for a considerable fraction of the forest-atmosphere exchanges relative to the whole night period.
- There is a drop in temperature and equivalent potential temperature after the gust events. This suggests that descending air currents (outflows) participate in the gusts generation process.