A quasi-experimental coastal region eddy diffusivity applied in the APUGRID model

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Reply to Reviewer #1

This paper presents new information (eddy difusivites) derived for a costal region at southeast Brazil that can be used for air quality dispersion. The results are compared with the Copenhagen Experiment.

We thank the reviewer for the useful comments and suggestions. Our responses to the comments are given below:

There are few small mistakes (marked on the attached version).

We agree with the reviewer. Your suggestions has been included.

My main question is:
why to compare results from a tropical region (although coastal) with a mid latitude results (Copenhagen)

The Copenhagen experimental site is limited by the Øresund coast, approximately 7 km east of the TV tower. Therefore, the turbulent effect acting on the tracer dispersion is an environment of the convective internal boundary layer (CIBL). The width of Øresund strait, the water portion separating Denmark and Sweden, is about 20 Km. On the western side of Øresund lies Copenhagen with its urban area. This area has high surface roughness due to the urban character. Thusly, this represents a turbulent environment occurring in a region with relatively cold water and warm land surface. As a consequence, the turbulent structure acting on the tracer dispersion can be considered as one present in the coastal inner boundary layer.

Our quasi-experimental convective eddy diffusivities for a coastal site were derived from the turbulent observations originated by differences in surface temperature and aerodynamic roughness occurring between land and water atmospheric environments. The important characteristic here is the fact that there is a CIBL in the tropical region (Brazil) and also in mid-latitude (Copenhagen). Furthermore, the principal aim of this study is to not establish a comparison between the different eddy diffusivities parameterizations but, specifically to evaluate and test our quasi-experimental coastal eddy diffusivities with experimental concentrations results measured in a CIBL (Copenhagen diffusion experimental). Further, it is difficult to found in the literature coastal observed concentrations that allow the validation of our new coastal eddy diffusivities.

Also, I guess that a deeper discussion about the thermal stratification and the formation of an internal boundary layer (IBL) and its influence on the results are needed.

In the new version of the manuscript, we follow the reviewer suggestion. In the manuscript we add the following discussion:

The coastal internal boundary layers (CIBL) are generated by differences in surface temperature and aerodynamic roughness occurring between land and water atmospheric environments. Considering that a large number of power plants and industrial complexes and hence polluting installations are constructed in coastal regions it is necessary to obtain CIBL turbulent parameters that are employed in dispersion models to describe the coastal air pollution. The growing interest in the dispersion issues regarding pollutants emission in coastal areas demands the knowledge of the turbulent structure of the planetary boundary layer in this region. However, the characteristics of the turbulence in these boundary layers vary complexly in space and time due to the sudden changes in the surface characteristics, as heat flux and roughness, in the sea-land interface.

In the occurrence of sea-breeze, the stably stratified air mass over the water reaches the coast and starts to be heated by the land surface. Thus, a convective boundary rises from the surface developing a Thermal Internal Boundary Layer (TIBL) that increases in height as it advances over the land. The TIBL is topped by a stably stratified inversion layer that affects the atmospheric diffusion in coastal regions. Therefore, to improve the response of the dispersion models is necessary to provide a truthful description of the turbulence through the TIBL. In this sense, several observational experiments are performed using airborne, tethered balloons and fixed mast measurements techniques (Ogawa and Ohara, 1985; Durand et al., 1988; Smedman and Högström, 1983; Shao et al. 1991). Wind-tunnel experiments and numerical simulations are found in Hara et al. (2009). The experimental investigation that was performed by Martins et al. (2018) showed that the magnitudes of the coastal convective vertical eddy diffusivities are greater than those observed in the continental regions (far from coastal regions). Therefore, we believe that this strong vertical turbulence, occurring in the CIBL, can be responsible for the enhanced dispersion contaminant and as a consequence such effect may decrease the contaminant concentration. This physical description taking into account the high magnitudes of the coastal eddy diffusivities allowed to obtain the fairly good results when the simulated concentrations were compared with those observed.

Also, the methodology is very short and there is only 1 figure and 1 table (It may be associated with the length permitted as it was a paper coming from a Proceedings).

In the new version of the manuscript, two tables have been attached:

Table A1. Meteorological conditions during the Copenhagen dispersion experiments.

Exp.	**U_{115m} (ms^{-1})**	**U_{10m}(ms^{-1})**	**u_*(ms^{-1})**	**L(m)**	**σ_w(ms^{-1})**	**h(m)**
1	3.4	2.1	0.37	-46	0.83	1980
2	10.6	4.9	0.74	-384	1.07	1920
3	5.0	2.4	0.39	-108	0.68	1120
4	4.6	2.5	0.39	-173	0.47	390
5	6.7	3.1	0.46	-577	0.71	820
6	13.0	7.2	1.07	-569	1.33	1300
7	7.6	4.1	0.65	-136	0.87	1850

8	9.4	4.2	0.70	-72	0.72	810
9	10.5	5.1	0.77	-382	0.98	2090

Meteorological parameters for the Copenhagen runs are shown in Table A1, being **U_{115m}** the mean wind velocity measured at 115 m, **U_{10m}** the mean wind velocity measured at 10 m, **u_*** the friction velocity, **L** the Obukhov length, **σ_w** the vertical wind velocity variance and **h** the convective boundary layer dept.

Table A3 – Observed and estimated crosswind-integrated concentrations normalized by the emission rate (**C^y/Q**) for Copenhagen experiment:

Exp.	**Sampler distance (m)**	**Q (gs^{-1})**	**$C^y/Q_{Observed}*10^4$ (sm^{-2})**	**$C^y/Q_{predicted}*10^4$ (sm^{-2})**
1	1900	3.2	6.48	8.44
1	3700	3.2	2.31	6.72
2	2100	3.2	5.38	1.34
2	4200	3.2	2.95	1.00
3	1900	3.2	8.20	8.88
3	3700	3.2	6.22	7.34
3	5400	3.2	4.30	4.34
4	4000	2.3	11.66	10.27
5	2100	3.2	6.71	7.98
5	4200	3.2	5.84	6.59
5	6100	3.2	4.96	2.81
6	2000	3.1	3.96	3.30
6	4200	3.1	2.22	2.58
6	5900	3.1	1.83	1.19
7	2000	2.4	6.70	3.70
7	4100	2.4	3.25	2.83
7	5300	2.4	2.22	1.73
8	1900	3.0	4.16	5.19
8	3600	3.0	2.02	4.34
8	5300	3.0	1.52	2.67
9	2100	3.3	4.58	4.28
9	4200	3.3	3.11	3.21

9	6000	3.3	2.59	1.22

In Table A3 the results of the predicted cross wind-integrated concentrations for the Copenhagen experiment obtained for the APUGRID model are compared with experimental data.

Supplementary:

How many profiles (daytime/nighttime, summer/winter time) have been used to derive those formulations?!

To derive our quasi-experimental convective eddy diffusivities profiles, 1-h observation wind velocity time series intervals are tested for quality control requirements. Unstable conditions were considered as daytime time series which $-150 \leq L < 0$, where *L* is Obukhov length. From a total of four months of observations (August–November 2016), 343 1-h unstable intervals are retained. The variances and time scale profiles used to estimate the K_i vertical profiles are obtained averaging the whole 343 individuals profiles.

Why this assumption?! What are the thermal stratification at Copenhagen experiment (mid latitude) and how this can be compared with SE Brazil?! Also, depending on the wind speed (if is around 10 m/s), probably the thermal stratification is close to the neutral! The authors should explain better this point.

We believe that the dispersion process near to the surface does not depend with the latitude. The micrometeorological parameters that control the dispersion process are the same in mid-latitude and SE Brazil.

The presence of a slightly convective stratified boundary layer can be seen in *u* and *v* turbulent energy spectra (Kaimal et al., 1972; Martins et al.,2018). In this situation, it can be observed in spectral curves a structure that contains two peaks; one low-frequency peak and one high-frequency peak. This reflects the impact of the larger convective eddies on the turbulent structure (Garratt et al., 1992). Although the Linhares-ES CIBL data has been collected in the different latitude of the Copenhagen data the mean wind speed vertical profile as can be seen in Fig.1 also presents in high levels velocity magnitudes of the order of 10 ms^{-1}.

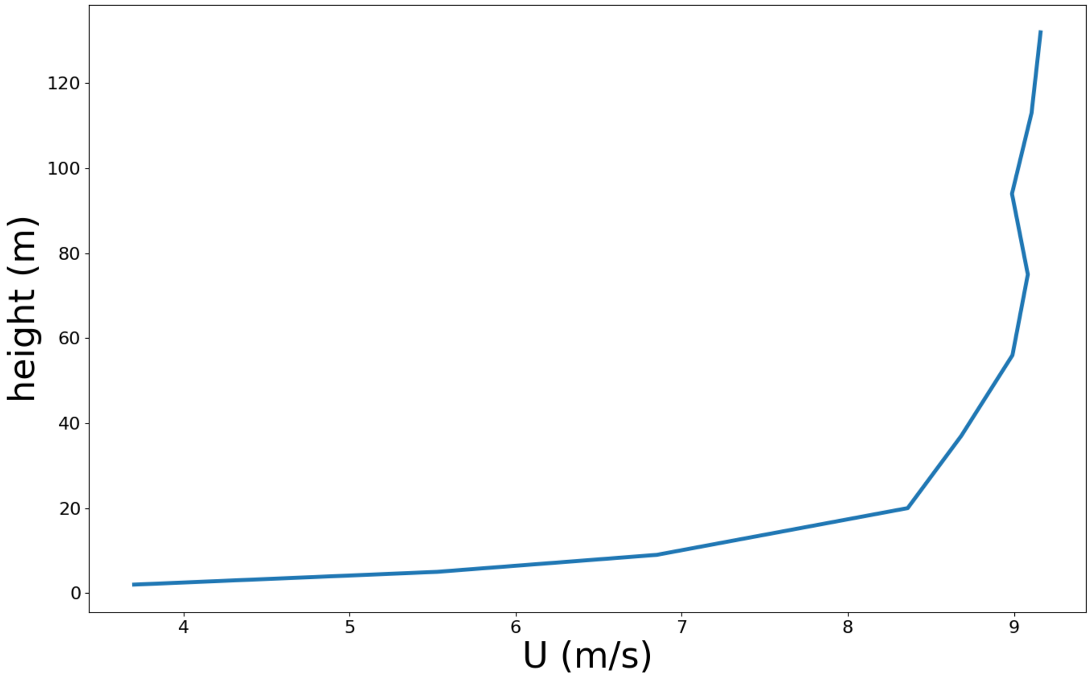

Fig.1: Mean wind speed vertical profile from CIBL Linhares-ES data.

Only to be coastal region is not a good example for the results to be compared, I guess.

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