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Interactive comment on "The structure of the haze plume over the Indian Ocean during INDOEX: tracer simulations and LIDAR observations" *by* G. Forêt et al.

Anonymous Referee #1

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The structure of the haze plume over the Indian Ocean during INDOEX: trace simulations and LIDAR observations

G. Forêt, C. Flamant, S. Cautenet, J. Pelon, F. Minvielle, M. Taghavi and P. Chazette.

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Summary

This paper presents a model analysis of aerosol measurements made during INDOEX-

IFP 1999. The measurements show several layers of aerosols that exist simultaneously (the so-called haze-layer). The major question is whether or not these enhanced aerosol concentrations can be attributed to source regions and how transport (regional but also local) affect the aerosol distribution. From INDOEX it is known that local circulations over coastal regions have a large impact on trace gas and aerosol variations, and this study tries to separate out different source regions and different circulations. The authors use a regional (nested) model and transport tracers that are representative for major pollution sources in India. They show that the measured aerosol distribution can be understood by analyzing the model simulation with passive tracers. The paper is logically structured and the authors present convincing evidence that the model can be used to attribute measured aerosol variations to the various sources and they show the role of different circulations. Previous publications are sufficiently referred to where appropriate in the paper. This paper is a nice addition to the existing knowledge of - and continuation of research about - the Indian winter monsoon circulation. The findings are important for our understanding of these local circulations and their impact on pollutant transport from southern Asia and nicely highlight the complexity of the winter monsoon circulation.

I have two more serious concerns that need to be addresses (see below), although it should be relatively straightforward for the authors to address them. I also have few suggestions on changes and or additions to the paper which should not take too much time but from which I think they would improve the paper. I hope that the authors will seriously consider these suggestions.

Major issues

Page 3283, section 4.1

Line 6-12, enhanced precipitation and liquid water mixing ratio are well correlated with tracer patterns. This should be confirmed by the NOAA 15 infrared image in figure 8b. However, I cannot distinguish the “elevated clouds” in figure 8b. The image is too dark

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and covers a too large area to distinguish the features mentioned in the text. I think I found the image used for figure 8b (Indian Ocean field Catalog; www.joss.ucar.edu), but I could not find cloudy areas for most of the enhanced tracer regions in figure 8a. Either some more effort should be put in proving with the satellite image that cloud patterns correlate with the enhanced tracer fields or it should be removed.

Page 3287-3288, section 4.2

Line 20-25, line 1-20. It is noted that the tracer concentrations increases from 6-8 March at P1 (but actually also for P2 and P3, see figure 12). It is argued that this increase might be caused by recirculation of air through entrainment in the MABL and the subsequent landward advection and uptake in the next-day sea breeze circulation. Although I like this idea and think it might be an explanation, I think figures 6,7 and 10 suggest another mechanism. On 6 March tracers from eastern India are transported vertically and by orographic lifting over the western Ghats, and then advected slowly westward between 1-3 km altitude (figure 10c to 10d), causing an area of enhanced tracer concentrations. The next day a sudden increase in tracer concentration occurs (figure 10e, around 75-76E, 1-2 km altitude) which slowly moves downward but which appears to be from a different origin. Figure 6d/7cd suggest that certain pathways through the western Ghats along the Indian west coast exist where tracers from Madras and Hyderabad enter the Arabian Sea region. At the same time figures 10gh suggest that entrainment only plays a minor role as the tracer plume in figures 10e-h does not appear to penetrate in the ABL (75W, above the MBL up to 2 km altitude depending on the time). Separating the tracers in figure 12 to its individual sources could provide a definite answer as to whether recirculation through the ABL might play a role. Depending on the outcome of this analysis the conclusions also need to be adjusted.

Minor issues

Page 3279-3280, section 3

It would be extremely helpful to have a plot of the geographical distribution and absolute

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values of the surface tracer-emission field used in the model.

Page 3274, section 2.1

In this section two times is referred to the typical meteorological conditions, however it is not explained what those conditions are (northeasterly trace winds from the Asian continent to the ITCZ on the central Indian Ocean, descending air in the free troposphere, preventing vertical mixing, the existence of two separate layers within the trade-wind layer (marine ABL and the “haze layer”). It would be helpful to describe these meteorological conditions in a few sentences because they are typical for the winter monsoon circulation.

Page 3276, section 2.2

The last paragraph describes the large scale circulation flow over the northern Indian Ocean. It would be very helpful if a figure was added which shows all the features of the general circulation as described in this paragraph. It might even be possible to add sort of a “weather-chart” to the already existing figure 4 to avoid adding another figure to the paper.

Page 3278, section 2.4

Here is referred to back-trajectory calculations from the HYPSPLIT 4 model. However, they are hot shown in a figure, which should be mentioned. If possible refer to a publication where these results are shown or (preferably) add them in a figure to the paper (or maybe add them to figure 1 ??).

Line 18-19, ’Temperature inversion was observed to be highest for the profile closes to the coast (i.e. profile 5).’ Is that highest in temperature change over the inversion or highest in altitude?

Line 23-25, the highest MABL during the east-west leg are found closest to the coast. Intuitively I would expect then a gradient in sea surface temperatures that correlates with the height of the MABL. Does such a gradient exist, and if not, what might then be

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the cause of the gradient?

Page 3280, section 3

Line 4-10, it would be helpful to mention the typical vertical model resolution close to the surface for the different model setups (39 levels below 4000 m. msl would be roughly 100 m ???), especially since it is stated that the vertical resolution is sufficient to simulate the local circulations at the Indian west coast.

Line 20-29, a comparison between measured and modeled wind speed and direction at 850 hPa shows that some discrepancies are found over the “western Ghats”. These differences are attributed to local circulations that are not resolved by the model. However, my question is whether the low wind speeds for this day at this altitude and which also might play a role, as I would expect it to be more difficult to model low wind speeds compared to high wind speeds?

Page 3281

Line 7, a “history of the airmasses” of 7-10 days is mentioned. Where do the 7-10 days come from (reference ?)?

Page 3281, section 4, first paragraph

It is explained how the aerosol-tracer experiment was setup. What is missing is: Which emission from the EDGAR database are used as proxy for aerosol emissions, and which EDGAR version? Why are the emissions for R3 and R4 75% of those in R1 and R2?

Page 3282, section 4.1

Line 11, the 5 a.u. aerosol unit ias said to be chosen arbitrarily, yet in section 4.2, page 3284, line 21 it is argued that the choice of the 5 a.u. aerosol unit “allowed for the most realistic simulation-derived plume structure when compared to airborne LIDAR measurements”. Is the first statement (arbitrary choice) then not true?

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Page 3286, section 4.3

Line 7-9. The sea breeze circulation is the result of differential heating between land and ocean surface. Land gets much warmer than the sea during daytime resulting in a local circulation. During night, this differential heating is absent therefore a sea breeze circulation is not possible and thus will not be observed. The CBL is therefore NOT shallower due to a lack of a sea breeze circulation, it is the other way around. During daytime, strong surface radiative heating leads to an unstable temperature profile in the CBL leading to a rise in CBL height and also drives the sea breeze circulation. During night, no surface radiative heating occurs and thus an increase in CBL height and the formation of a sea breeze circulation cannot occur. A few lines should be added explaining that “such an explosive situation” is not only not observed, it even cannot occur.

Typos and textual changes

Page 3270, line 23, ’... branch of breeze circulation during the next day.’ should be ’... branch of the sea breeze circulation during the next day.’

Page 3270, line 26, ’... is shown to small compared to ...’ should be ’... is shown to be small compared to...’

Page 3271, lines 5-7: start the sentence with ‘Aerosols are an important factor of climate change due to their radiative impact...’ and remove the part after the comma in line 5.

Page 3271, line 8, put ’In such integrated analyses’ at the end of this sentence: ’Models are a valuable ... ... measurements in such integrated analyses.’

Page 3271, line 12, ’uncertainties associated with ... sources and emissions as well as aerosol optical properties.’ Modeling the impact of aerosols on radiation definitely also suffers from uncertainties in aerosol optical properties.

Page 3274, line 9, ’India is known as an important...’, change to ’India is an important...’

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Page 3274, lines 12-13, 'Sources are located in the large cities...' change to 'Source are located both in large cities...', and remove the subsequent comma in line 12, possible also remove '... as well as ...'.

Page 3274, lines 23-25, change to 'The northerly/northeasterly winter monsoon flow transports the highly polluted air masses over the Indian Ocean.'

Page 3275, line 2, change to: 'The Maldives Islands are the focus point...'. I think various INDOEX publications have established that the Maldives really are a locations where different air masses meet.

Page 3275, lines 10-12, rephrase this sentence, and write it in past tense since you refer to the results from another paper. Since you refer to a particular period, this is not a climatology. For example: 'Two near-equatorial convergence zones were found in the Indian Ocean region. One along 2-5N and one around the equator, which was more intense [Verver et al., 2001].'

Page 3275, lines 13-14, change to: 'The northern converngence zone was more active during February while the southern convergence zone become dominant in March, ...'

Page 3276, lines 18-19, change to: 'The MET-OFFICE C-130 released 12 dropsondes and 12 soundings on 7 March 1999.'

Page 3279, line 13, '... included in the RAMS model ...'

Page 3280, line 20, replace 'be' with 'are'.

Page 3285, line 22, change 'Continent' to 'Continental'

Page 3286, lines 7-9, change to 'During night such an explosive combination of a sea breeze and orographic lifting is not observed ...'.

Page 3289, line 3, 'same general trend than during ...', change 'than' to 'as'.

Page 3289, line 4-5, 'During the third cycle (8-9 March), resembles that of the two

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others, ...' needs rephrasing to something like 'The third cycle (8-9 March) resembles that of the two other...'.

Page 3289, line 24, remove 'It is obvious that', this is unnecessary.

Page 3290, lines 10-12, change to 'Comparing the distribution from S2 (Fig. 9a) to the observations (Fig 2), the structure of the plume is better retrieved, with the exception of southern part due to the presence ...'.

Page 3290, lines 15-16, change to '... observed in this region which is the consequence ...'.

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