Corrections for manuscript acp-2011-823 "Continuous detection and characterization of the sea breeze in clear sky conditions using Meteosat Second Generation"

Reviewer 1

Thank you very much for the thorough reading of the article and providing stimulating and constructive comments, mainly as regarded to the proposed methodology. We studied each of these comments in depth and treated them accordingly including rewriting of some sections and added new figures. We believe that these changes made based on the above mentioned comments will improve significantly the manuscript.

General comments

1.1 The article does not give enough details on the methodology and its limits.

- We appreciate very much the questions raised on the methodology. This issue is treated in sections 1.3 – 1.7.

1.2 There is no discussion about the expected uncertainty of the SB timing and penetration estimation.

- The uncertainty of the SB timing is discussed in section 1.8, and the uncertainty of the SB penetration estimation is discussed in section 1.9.

1.3 There is also no discussion about possible false alarm events (the method is based on surface temperature information which is not always associated with observable sea-breeze circulation, as for instance in the presence of sustained onshore synoptic flow).

- We agree that in cases of sustained onshore synoptic flow the SB is masked, and its detection can be regarded as false alarm. Following this important comment, we added a parameter that estimates whether the "disturbance" is of mesoscale or synoptic nature. For this sake we added a new panel in figure 3 that demonstrates the criterion. In (new) Figure 3d we show the original deviation from climatology together with the following model:

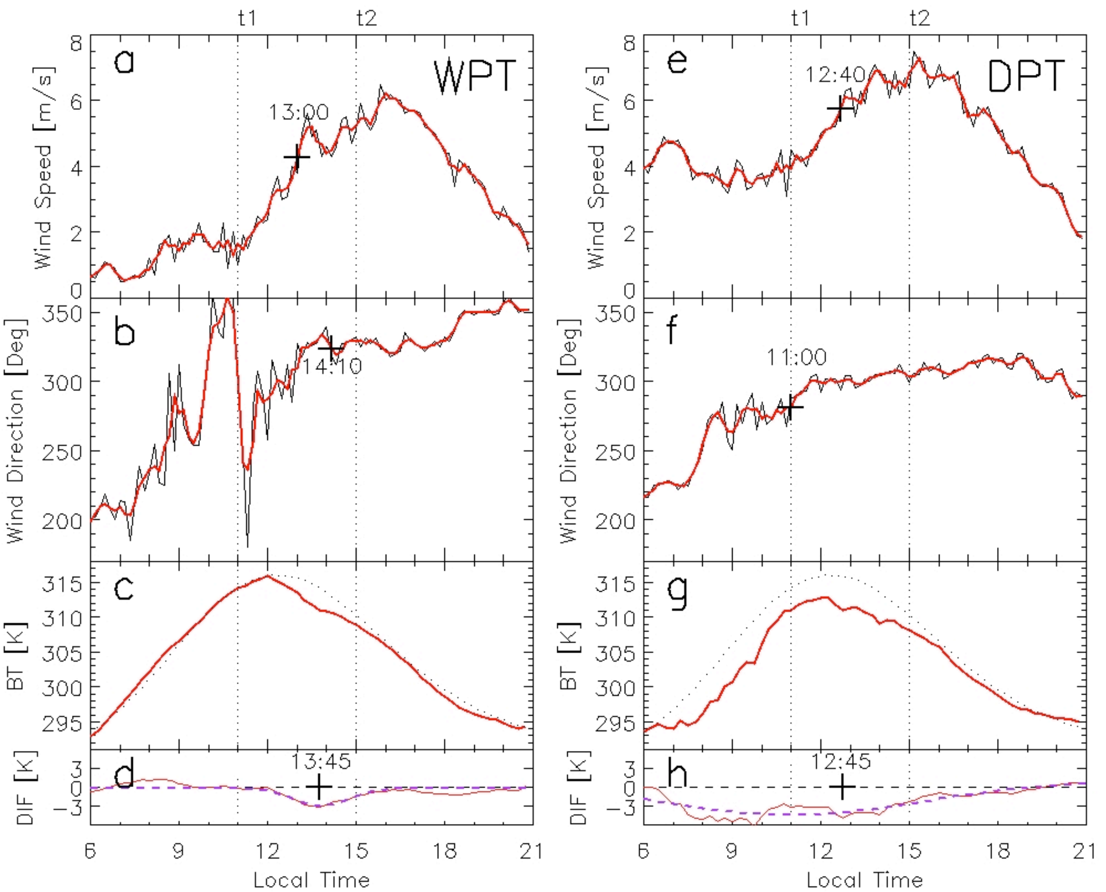
$$f(t) = const + \frac{1}{\sigma\sqrt{2\pi}} \cdot e^{-\frac{(t-\mu)^2}{2\sigma^2}} .$$

This model is a Guassian simulating a disturbance generated by a mesoscale or synoptic-scale wind flow demonstrated as dashed purple lines in figures 3d and 3h. σ estimates the duration of the disturbance, and the agreement between the model and the deviation from climatology is also quantified. It is evident in figure 3d for the WPT case that mesoscale feature is dominant ($\sigma \sim$ 1hr) where the model fits nicely the deviation from climatology, as compared to the DPT case in figure 3h where the dashed purple line does not fit well the deviation from climatology, and the disturbance duration (σ) exceeds 4hrs.

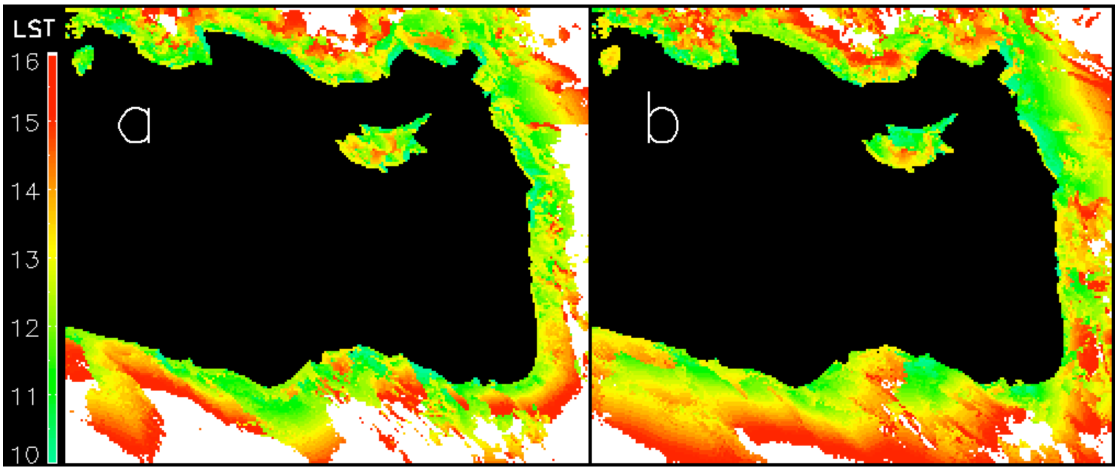
To eliminate pixels with false alarm detection, we applied the two criteria presented in new figure 3. The first is selecting pixels with mesoscale disturbance duration ($\sigma < 2$ hrs). The second criterion was a threshold reflecting the degree of agreement between the model and disturbance for the selected pixels. New figure 6 depicts the SB timing after filtering out pixels identified as false alarm. The resultant picture shows only areas with the gradual colors featuring the onshore SB penetration.

1.4 The calibration of the method is questionable

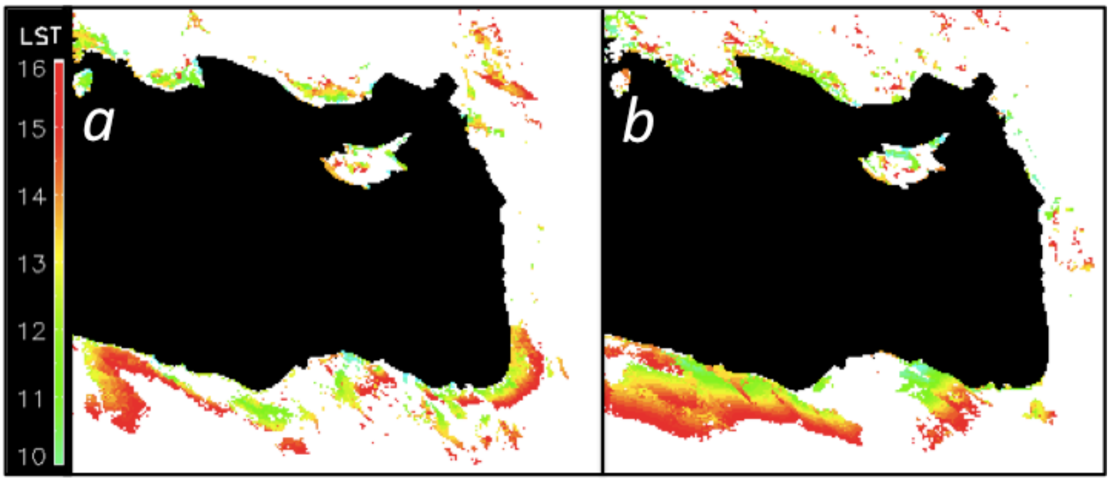
➢ See our detailed response in section 1.11.



(New) Figure 3. Detecting the sea breeze using time series from 7 July 2010, representing WPT synoptic category, of wind speed (a) and wind direction (b) from Halutza meteorological station. The red lines in (a) and (b) are running average over three 10 min. time steps. The red line in (c) represents time series of brightness temperature (BT) from MSG pixel collocated with Halutza meteorological station. The dotted line represents the climatological BT for that pixel. The thin red line in (d) is the deviation of the pixels BT from its expected climatological value (horizontal black dashed line). The SB is searched in the time interval (t_{early}:t_{late}) according to its distance from the coast. The maximal deviation is detected at 13:45 LT in (d). The dashed purple line in (d) is a Gaussian with $\sigma \sim 1$hr, typical to meso-scale disturbance. Panels (e,f,g,h) are the same as (a,b,c,d) for 21 July 2010, representing DPT synoptic category. Note the stronger winds (e), the uniform wind direction after 11:00 LT (f), and the large discrepancy between the MSG measured BT (red line) and the climatological values (dotted line) between 7:00 and 15:00 LT, representing synoptic scale cold advection featuring DPT (g). The Gaussian in (h) shows $\sigma > 4$hrs representing a synoptic-scale disturbance, and does not fit the observed deviation as well as the model in (d) as the disturbance in this case stems from cold advection of synoptic scale nature.



(Old) Figure 6.



(New) Figure 6. The (local) time in the green-yellow-red color bar represents the timing of maximum deviation of MSG 10.8μm brightness temperature from its climatological value (see Fig. 3d) for pixels with $\sigma < 2$ hrs and passed the "agreement" threshold as demonstrated for a single pixel in figures 3d and 3h. The gradual green-yellow-red colour pattern depicts the SB propagation for (a) July 7 2010 (WPT), and (b) July 21 2010 (DPT).

Specific comments

Methodology

1.5 This approach necessarily assumes a priori that the MSG measurement can produce reliable information on SB.

- Examinations of sequence of MSG data in the summer over the East Mediterranean have shown distinct onshore penetration of the SB. We added a figure and an animation file (see figure 4 and supplementary materials) to visually demonstrate the SB propagation.

1.6 The method also relies on BT anomaly at one pixel. There is no consideration of land/sea thermal contrast.

- We also realize that land/sea thermal contrast is the mechanism responsible for the SB generation. Indeed we tried to quantify it by measuring the maximal BT over predefined boxes over the sea and adjacent land. However the signal was "noisy". We think that this could be attributed to the large spatial variability characterizing the land surface temperature (Lensky and Dayan 2011). The technique used here to detect the SB is based on the capability to detect fine scale climatology (topo-climate). The small signal of the SB might be lost while averaging thousands of pixels in the boxes.

1.7 Would there be any situation where the main signal is over the sea and not over the land?

- We detect the SB by the observed temperature anomaly caused by marine-air cooling the underlying warm terrain. This thermal contrast (between the air and underlying surface) does not exist over the sea; therefor our method cannot detect such situations.

Uncertainty issues

1.8 There is no discussion about the uncertainty of the estimation of the SB timing. Above what value of the BT anomaly (instantaneous BT measurement with respect to the BT climatology) is the SB timing estimate reliable?

- The BT anomaly was also our first guess for assessment of the uncertainty, but we found that the duration of the anomaly is doing a better job in discriminating between the SB (~1 hour) vs. synoptic scale cold advection (>4 hours), while the magnitude of the BT anomaly may differ for both SB and the cold advection. Also, as shown in new figure 6, the gradual green-yellow-red colour pattern depicts the SB propagation.

1.9 The authors do not discuss the uncertainty on the estimation of the SB inland range. Is it the MSG horizontal resolution?

- We do not think that the spatial resolution of the MSG limits the capability to monitor the SB penetration; we added a figure (4) and an animation file (see supplement in the interactive discussion) demonstrating inland penetration of the SB.

  As regarded to the uncertainty of inland penetration, indeed the uncertainty is proportional to the distance from the shore. This stems from the time interval

(t_1:t_2) during which the SB is searched in each pixel. This interval increases with the distance from shore according to the equations in page 33363. As the time interval increases, the chance for misdetection of the SB due to other possible phenomena increases. Nevertheless, after including the two criteria in 1.3 suspected false alarm pixels were removed as shown in new figure 6.

1.10 Is there any smoothing window which partly correlates adjacent pixels?

- No spatial smoothing was performed, the analysis of the time series in the individual pixels are completely independent.

1.11 The surface weather stations used to validate/calibrate the method are located within a 100 km size area (Fig. 1) which is the typical length scale of sea-breeze circulation (typical Rossby deformation radius; see Rotunno, 1983; Drobinski and Dubos, 2009). Do the authors think the surface measurements to be sufficiently independent to consider the calibration of the method applicable to other parts of the world (as shown in the last figure)?

- The SB timing detected by satellite does not depend on external parameters except for t1 and t2 (i.e., no calibration involved). The iterative procedure was applied to the surface meteorological data in order to set the criteria for SB detection using wind speed and wind direction. The purpose of this procedure was to assess the role of the synoptic scale on the SB. The timing of SB from satellite and surface data is independent. High correlations between both timings imply weak synoptic flow, while low correlations indicate strong synoptic flow.

Generalization of the results

1.12 In this article, only three synoptic situations are investigated. Independent of the synoptic conditions, how often does the MSG retrieval provide SB false alarm? In other words, a thermal gradient does not imply necessarily a sea breeze circulation. Synoptic flow can "hide" the breeze flow (sustained onshore wind for instance; see Estoque, 1062; Arritt, 1993).

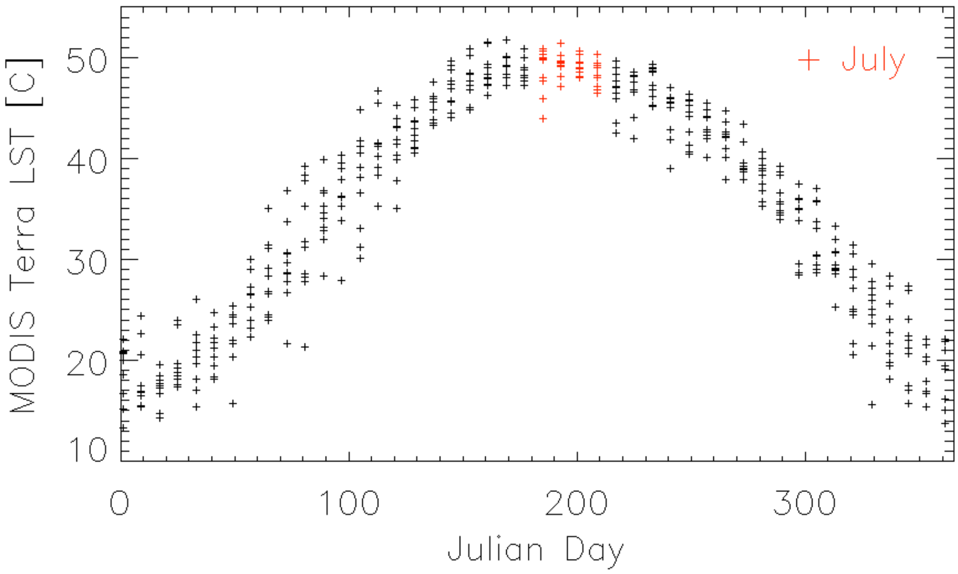
- We fully agree that synoptic flow can "hide" the breeze flow, as shown in new figure 3h. However this was treated with the new criteria introduced in our detailed response in section 1.3.

1.13 Would there be any possibility to test the method against measurements collected in field campaigns in the Mediterranean area (Milan et al., 1996; Zerefos et al., 2002; Lelieveld et al., 2002; Drobinski et al., 2007; at least comparison with published information on SB penetration and timing)?

- Our main intension in this manuscript was to demonstrate the use of geostationary satellite data to detect the SB in clear sky conditions, when the SB is accentuated. Unfortunately all the references mentioned rely on database prior to the launch of MSG satellite in 2003, and we do not have access to data from more recent campaigns. We will be happy to cooperate on this issue, should such data would become available.

1.14 The use of only few days in July 2010 is rather frustrating to discuss the reproducibility of the method. With a geostationary satellite in space for several years, one could expect a systematic evaluation of the method to discuss in depth its limits (calibration issues, false alarms, uncertainty). I think the extension of the dataset used for calibration/evaluation would be of very large value to give more confidence on the robustness of the method.

- We chose July as representative of the summer season governed by a sole synoptic system (i.e. Persian Trough), which persist between mid May to mid September. For other seasons, under other synoptic systems, the SB is much weaker and the sky are much more cloudy, therefore the proposed method is not expected to perform better than other existing methods. The inter-annual variability of the summer conditions over the EM is very small (see figure below). Regarding the calibration issues, false alarms, and uncertainty, as mentioned above, we believe that calibration is not a limit on the method (see 1.11). The false alarm and uncertainty issues were treated in 1.3-1.9.



8 days averaged MODIS Terra Land Surface Temperature product for 2001-2010 from the pixel collocated with 'Halutza' meteorological station (same pixel as shown in figure 3). Terra is a sun synchronous satellite passing at ~11:00 AM LT. July LST are colored in red, showing a small inter-annual variation as compared to the other seasons.

Reference

Lensky, I. M., and U. Dayan, 2011: Detection of Finescale Climatic Features from Satellites and Implications for Agricultural Planning. *Bull. Amer. Meteor. Soc.*, **92**, 1131–1136.