

# Supporting Information for “Detection of Extreme Phenomena in the stable boundary layer over the Amazonian forest”

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## Additional Supporting Information (Files uploaded separately)

1. Dataset S1: time series of wind velocity ( $u, v$  and  $w$ ) and sonic temperature  $T$  ( $K$ ), measured at 1  $Hz$  on May 2, 2013 at height 48  $m$ ; file S1.zip.
2. Dataset S2: time series of wind velocity ( $u, v$  and  $w$ ) and sonic temperature  $T$  ( $K$ ), measured at 1  $Hz$  on March 24, 2014 at height 48  $m$ ; file S2.zip
3. Dataset S3: time series of wind velocity ( $u, v$  and  $w$ ), sonic temperature  $T$  ( $K$ ), end ozone mixing ration,  $O_3$  (ppbv), measured at 1  $Hz$  on April 13, 2014 at height 48  $m$ ; file S3.zip.
4. Dataset S4: time series of wind velocity ( $u, v$  and  $w$ ), sonic temperature  $T$  ( $K$ ), end ozone mixing ration,  $O_3$  (ppbv), measured at 1  $Hz$  on May 16, 2014 at height 48  $m$ ; file S4.zip.
5. Dataset S5: time series of wind velocity ( $u, v$  and  $w$ ) and sonic temperature  $T$  ( $K$ ), measured at 1  $Hz$  on December 8, 2014 at height 48  $m$ ; file S5.zip.

## Text

Figure 1 shows some analysis for the night of May 2, 2013. In this night there was an extreme phenomena (EP) occurrence around 0030 UTC. Figure 1a-b show the results of the application of tests for the detection of early warning signals (EWS), proposed by [1], for temperature ( $\theta$ ) values and horizontal wind speed ( $V$ ),

respectively. The blue and red lines correspond to the trends of the autocorrelation function and variance values, respectively. It is possible to notice an increase in the values of the autocorrelation function and the normalized variance immediately before the outbreak of the EP (around 0030 UTC). Figure 1c-d presents the recurrence graphs [2] corresponding to  $\theta$  and  $V$ , respectively. A sudden change in the dynamics of the system can be observed around 0030 UTC, in which there is an intensification of hotter bands in the recurrence graph for both turbulent variables used. After this time the structure resembling a chess board that individualize recurrence processes are no longer verified. Figure 1e-f show time frequency diagram of the phases of Morlet's wavelet coefficients for  $\theta$  and  $V$ , respectively. It is possible to notice the emergence of a phase singularity in a range of various scales at 0030 UTC, similar as discussed by [3] in their analyzed cases of convective processes in the Indonesian atmosphere.

Figures 2, 3 and 4 are similar to Figure 1, but they show the nights of March 24, May 16 and December 8, 2014, respectively. Hereupon it is noted an increase in the values of the autocorrelation function and the normalized variance immediately before the outbreak of the EP. Added to that, a sudden intensification of hotter bands in the recurrence graph for both turbulent variables and an emergence of a phase singularity in the time frequency diagram of Morlet's wavelet coefficients before the outbreak of the EP (at 0940 UTC for the night of March 24, at 0445 UTC for May 16 and at 0700 UTC for December 8th) are also observed.

## References

- [1] Dakos V, Scheffer M, van Nes EH, Brovkin V, Petoukhov V, Held H. Slowing down as an early warning signal for abrupt climate change. *Proc. Natl. Acad. Sci.* 2008; 105:14308–14312.
- [2] Marwan N, Romano MC, Thiel M, Kurths J. Recurrence plots for the analysis of complex systems *Phys. Rep.* 2007; 438:237–329.
- [3] Weng H, Lau KM. Wavelets, period doubling, and time–frequency localization with application to organization of convection over the tropical western Pacific, *J. Atmospheric Sci.* 1994; 51:2523–2541.

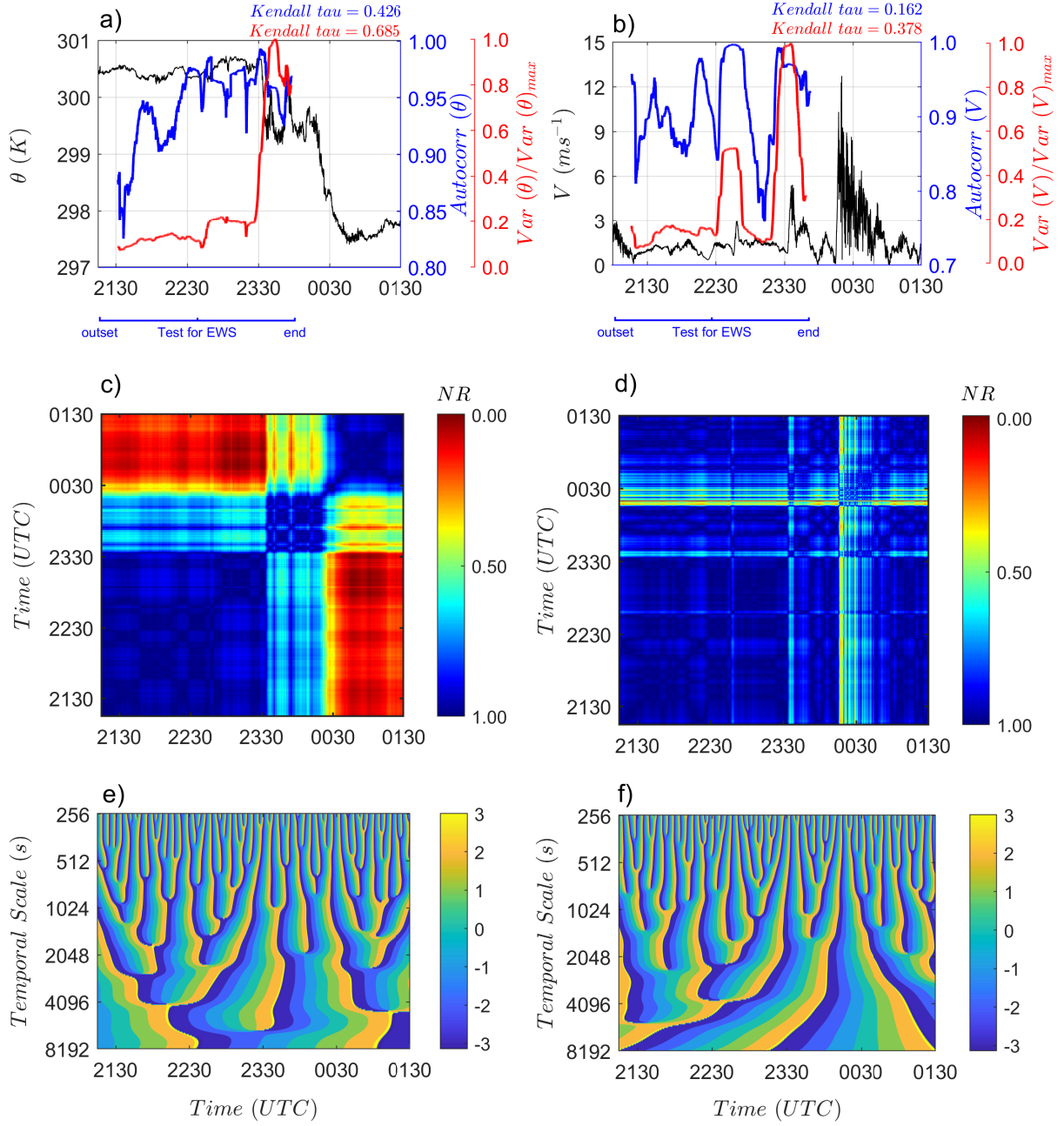


Figure 1: Night of May 02, 2013: Autocorrelation function (blue) and variance (red) associated to the time series (black) for: (a) temperature ( $\theta$ ) and (b) horizontal wind speed ( $V$ ). Recurrent plots (RP) for: (c)  $\theta$  and (d)  $V$ . The vertical bars represent the Normalized Recurrence ( $NR = RP/(RP)_{\max}$ ). Phase of the Morlet wavelet for: (e)  $\theta$  and (f)  $V$ . The outbreak of the EP occurs around 0030 UTC.

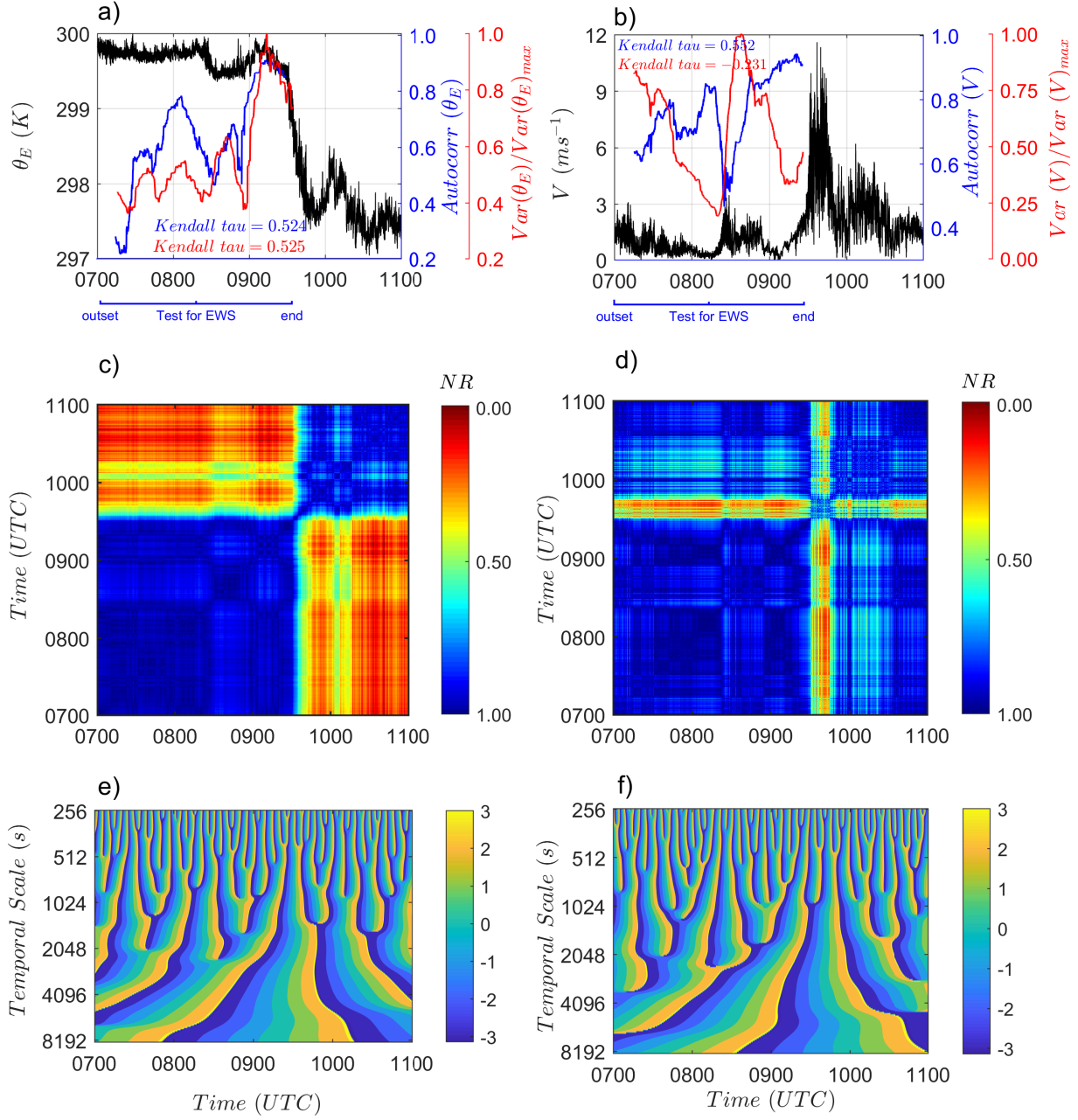


Figure 2: Night of March 24, 2014: Autocorrelation function (blue) and variance (red) associated to the time series (black) for: (a) temperature ( $\theta$ ) and (b) horizontal wind speed ( $V$ ). Recurrent plots (RP) for: (c)  $\theta$  and (d)  $V$ . The vertical bars represent the Normalized Recurrence ( $NR = RP/(RP)_{\max}$ ). Phase of the Morlet wavelet for: (e)  $\theta$  and (f)  $V$ . The outbreak of the EP occurs around 0940 UTC.

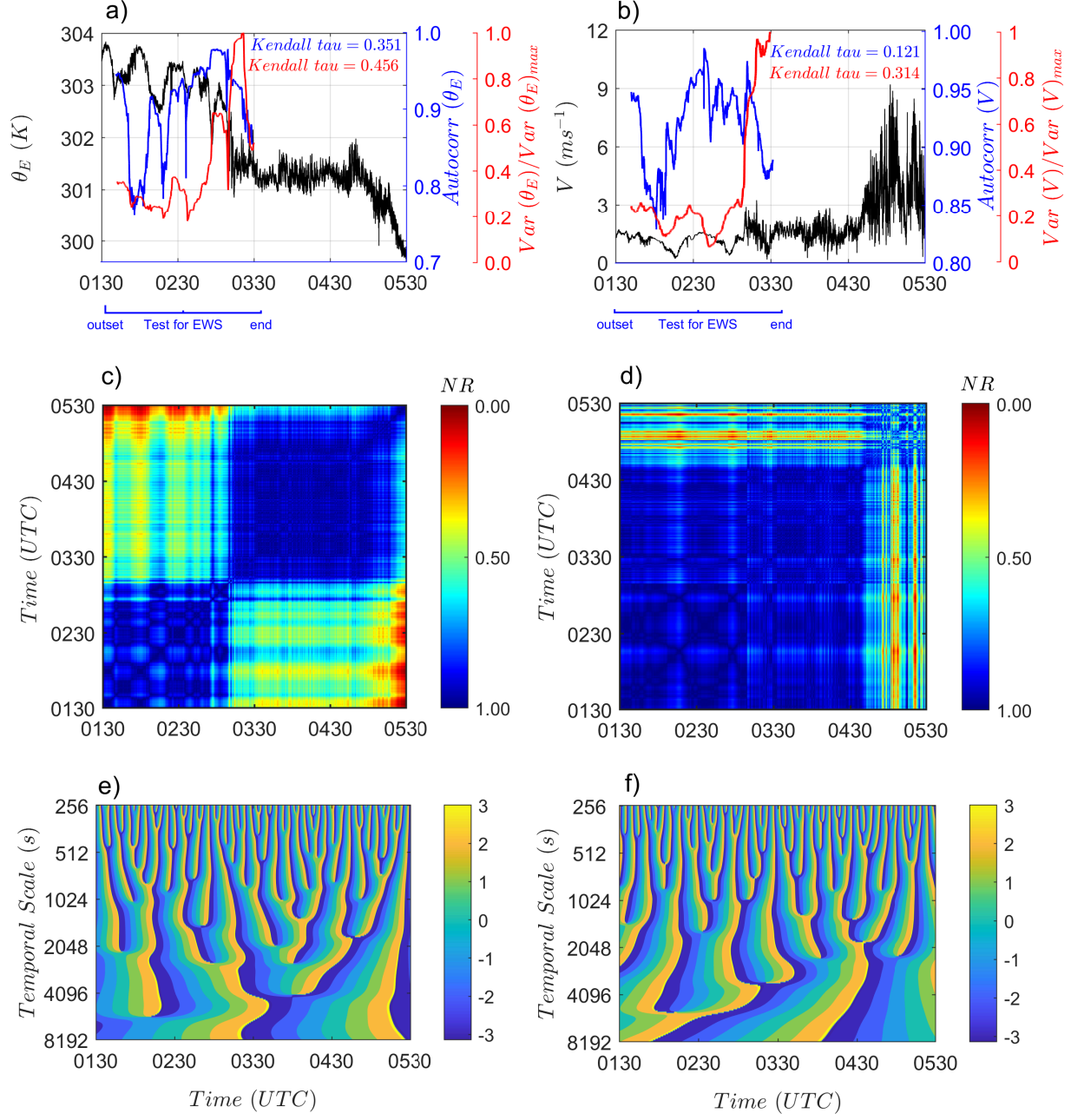


Figure 3: Night of May 16, 2014: Autocorrelation function (blue) and variance (red) associated to the time series (black) for: (a) temperature ( $\theta$ ) and (b) horizontal wind speed ( $V$ ). Recurrent plots (RP) for: (c)  $\theta$  and (d)  $V$ . The vertical bars represent the Normalized Recurrence ( $NR = RP/(RP)_{max}$ ). Phase of the Morlet wavelet for: (e)  $\theta$  and (f)  $V$ . The outbreak of the EP occurs around 0445 UTC.

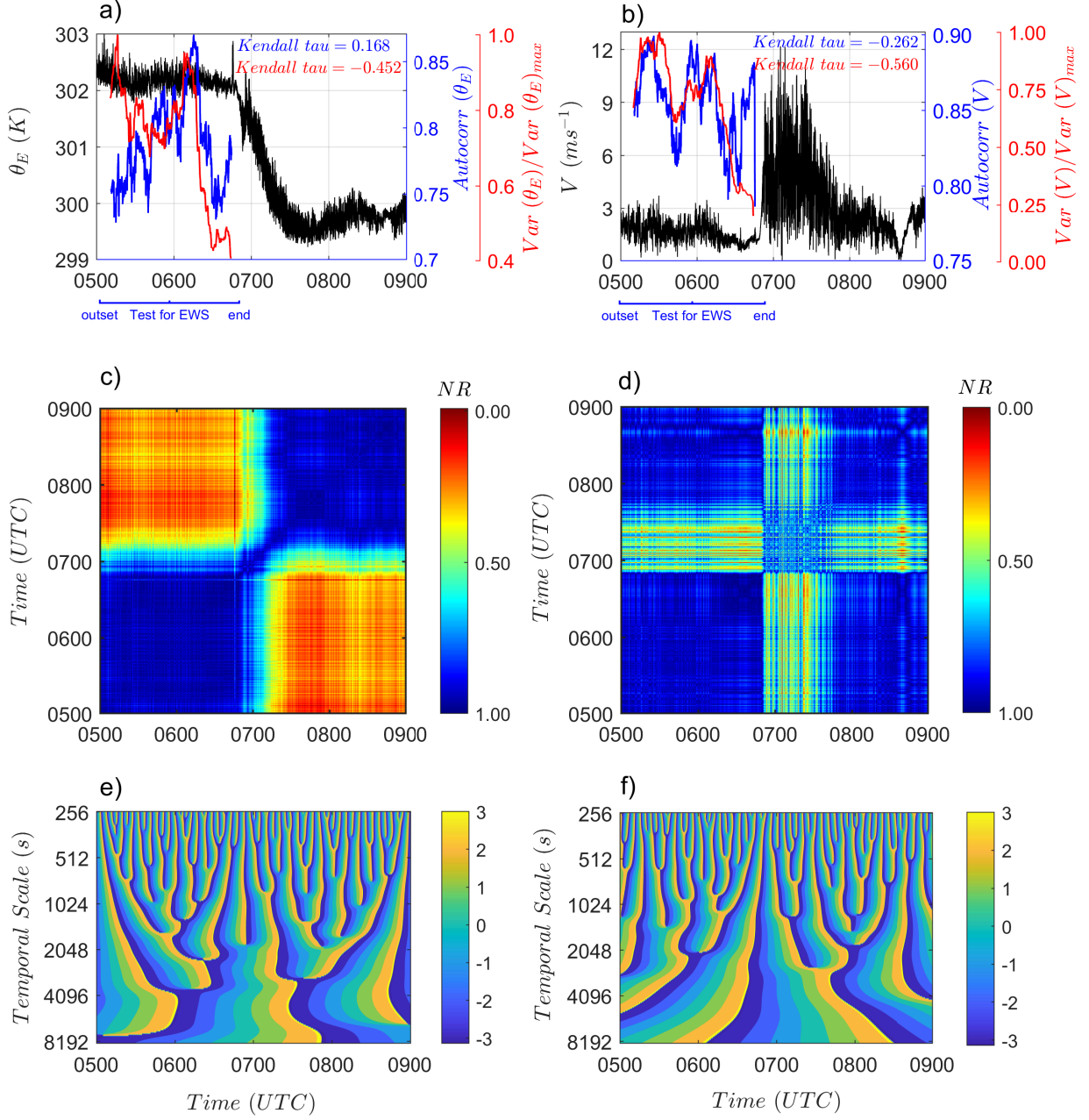


Figure 4: Night of December 08, 2014: Autocorrelation function (blue) and variance (red) associated to the time series (black) for: (a) temperature ( $\theta$ ) and (b) horizontal wind speed ( $V$ ). Recurrent plots (RP) for: (c)  $\theta$  and (d)  $V$ . The vertical bars represent the Normalized Recurrence ( $NR = RP/(RP)_{max}$ ). Phase of the Morlet wavelet for: (e)  $\theta$  and (f)  $V$ . The outbreak of the EP occurs around 0700 UTC.