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Earth System Dynamics
Discussions
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Interactive comment on "A wavelet-based-approach to detect climate change on the coherent and turbulent component of the atmospheric circulation" *by* D. Faranda and D. Defrance

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REFEREE:*"The wavelet-based approach is up to my knowledge a novel methodology for analyzing climate models, though it has been used for image or reservoir reconstructions. I, however, have big doubts that this method is suitable for climatology. Climate modeling demands multi-scale modeling as well but the scale separation is often difficult to de- fine and what is more important there is a multi-scale interaction that evolves in time. Therefore, the method should be first rigorously examined for climate models (starting from toy models and propagating towards more complex models) be-*

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fore drawing the conclusions about the climate system itself."

ANSWER:The wavelet approach has been devised for analyzing turbulent signals containing non-trivial scale separations. The original paper by Farge (1992) contains applications of wavelet filtering for toy models as well as for turbulent complex systems. This paper has, up to date, about 1500 citations, corresponding to just as many applications in complex fluid mechanics. The technique is not new to climate sciences as well: Torrence and Compo published in 1998 “a practical guide to wavelet analysis” in BAMS. This article is cited 7000 times. Wavelets have also been applied to the analysis of geophysical time series by several authors (Grinsted et al 2004, Ghil 2002,. . .). This vast literature explains why we did not include any validations of the methodology for toy models.

In the previous version of the paper we gave just a short introduction to the wavelet methods. We admit that, as the reviewer suggests, we could give more precise references on how the technique has been already validated in climate science. This justifies why we don’t include any further validation study of the wavelet filters. The new version will contain a more extended review of the relevant wavelet climate-related literature. We want also to remark that the paper is not about wavelet filtering that we take for granted for the reasons specified above. The wavelet filtering is here used to separate coherent and turbulent components. The originality of our analysis lies in analyzing these components separately.

References:

-Torrence, Christopher, and Gilbert P. Compo. "A practical guide to wavelet analysis." Bulletin of the American Meteorological society 79.1 (1998): 61-78.

-Grinsted, Aslak, John C. Moore, and Svetlana Jevrejeva. "Application of the cross wavelet transform and wavelet coherence to geophysical time series."Nonlinear processes in geophysics 11.5/6 (2004): 561-566.

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-Ghil, Michael, et al. "Advanced spectral methods for climatic time series."Reviews of geophysics 40.1 (2002).

REFEREE: *"Authors claim that the integral of the ACF detects the predictability. However, for that not only the correlation should be high but the error should be small, which is not shown. "*

ANSWER: The link between Correlations decay is well known in dynamical systems, although this result has not been applied so often (or sometimes just implicitly) to climate science. Some supplementary references can be found in:

-Osborne, A. Ro, and A. Provenzale. "Finite correlation dimension for stochastic systems with power-law spectra." Physica D: Nonlinear Phenomena 35.3 (1989): 357-381.

-Govindan, R. B., K. Narayanan, and M. S. Gopinathan. "On the evidence of deterministic chaos in ECG: Surrogate and predictability analysis." Chaos: An Interdisciplinary Journal of Nonlinear Science 8.2 (1998): 495-502.

-Crisanti, A., et al. "Intermittency and predictability in turbulence." Physical review letters 70.2 (1993): 166.

Since this literature is probably unknown in climate science, as the referee is pointing out, we will rewrite the new version of the manuscript better explaining the link between ACF and predictability.

REFEREE: *"Authors test the metrics on one resolution model. However, one needs to show that the wavelet-based separation gives satisfactory results by considering models with different resolutions."*

ANSWER: This is a good suggestion for validating our metrics. We performed the test on higher resolution simulation, namely the medium resolution version of the IPSL model (v5) and compared the results to the low resolution model (v3) analysed

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in the previous version of the manuscript. Results are nicely consistent between the two resolutions and we report here some examples that will be included in the new version of the manuscript: Figure 1 shows a comparison of $\Delta\Lambda$ and $\Delta\Upsilon$ between the low resolution (v3 – left panels) and medium resolution (v5 – right panels). The Δ is computed between 2050$-$2100 and 2006$-$2056 because the output for v5 are available for this period. The analysis shows that results are consistent and the spatial structures of the indicators are similar.

REFEREE*: "Authors claim that the difference between Λ2055$-$2105 and Λ2005$-$2055 detects the predictability. I am wondering about sensitivity of this metric with respect to the time interval."*

ANSWER: The reviewer also suggests to perform a sensitivity study with respect to the change in time interval. In the new version of the paper we will show and comment the results for three different time windows:

- 30years [2070 /2100 – 2006/2036] ,
- 40years [2060 /2100 – 2006/2046] ,
- 50years [2050 /2100 – 2006/2056] .

Figure 2 shows $\Delta\Upsilon$ for u_{700} and $\Delta\Lambda$ for v_{700}, in the low resolution simulation and for the three different time windows. Coherence among spatial structures is preserved for the variables shown (we will add the analysis for the other cases in the new version of the manuscript) although the intensity of changes is slightly different and generally increases by decreasing the window size. This is expected on the basis of the increased separation in the time periods considered.

Figure 3 summarizes with box-plots the additions requested by the referee. We report results for the two different scenarios, resolutions and time windows (the 30 years

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cases are not shown here because the analysis is still running for the medium resolution simulation. We will add it to the new version of the manuscript). It is interesting to notice how the turbulent component $\Delta\Upsilon$ changes with the resolution : we find that adding finer scales corresponds to richer turbulent contributions, as one would expect on theoretical basis.

Overall, we thank the referee for his comments and we believe that these additions increase the range of validity of our results and improve the quality of our work.

REFEREE: *"Moreover, authors need to describe the wavelet-based approach, define what BIC is, and to explain how the parameters were chosen."*

ANSWER: We will add these descriptions in the new version of the paper.

Interactive comment on Earth Syst. Dynam. Discuss., doi:10.5194/esd-2016-2, 2016.

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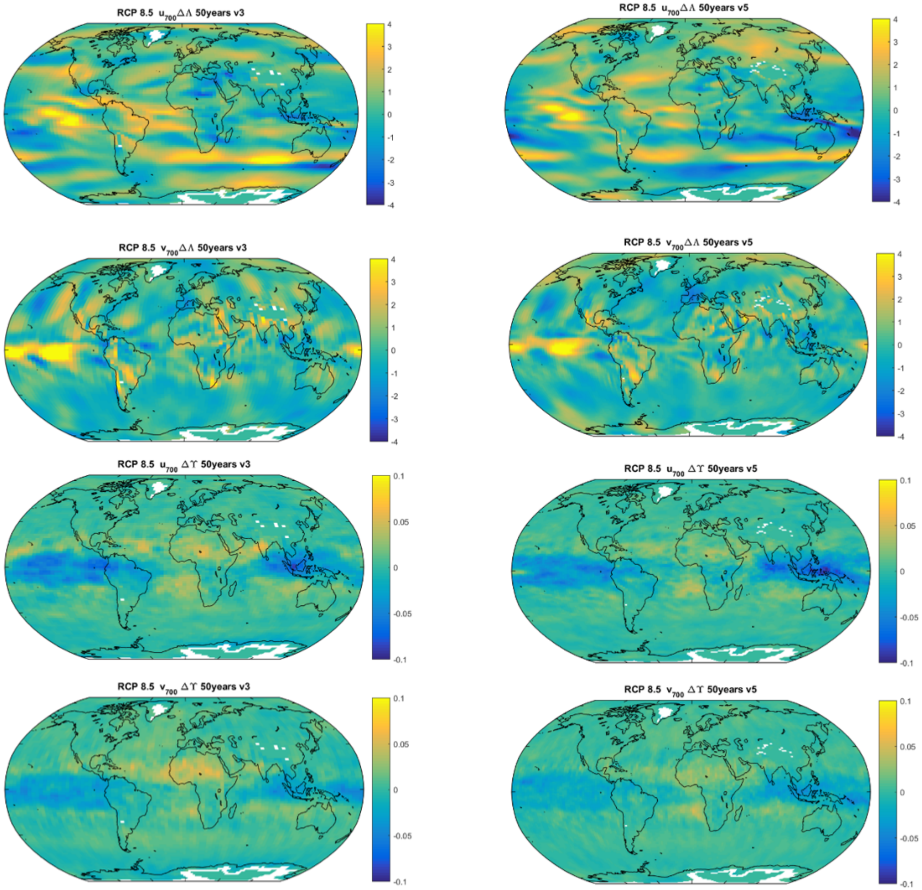

Fig. 1. Comparison of $\Delta\Lambda$ and $\Delta\Upsilon$ between the low resolution (v3 – left panels) and medium resolution (v5 – right panels). The analysis shows that coherent structures are similar

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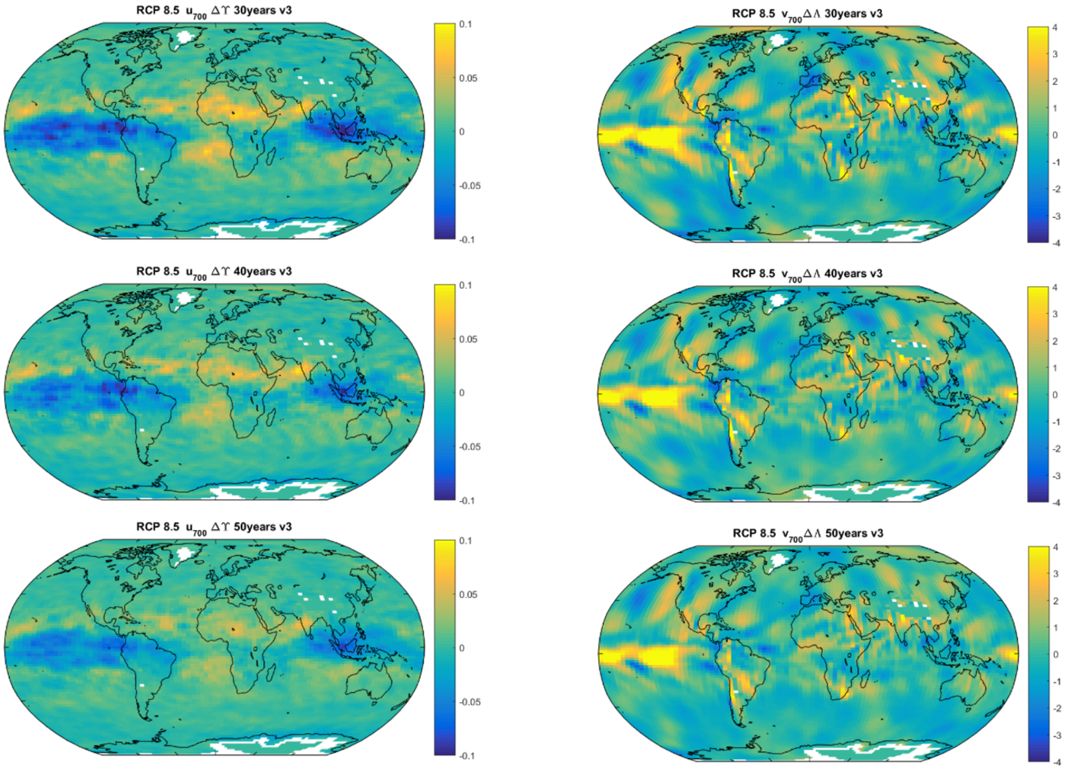

Fig. 2. Comparison of ΔY u700 and $\Delta\Lambda$ v700 for three different time windows. Upper panels: 30years [2070 /2100 – 2006/2036]. Central : 40years [2060/2100–2006/2046] . Bottom:50years [2050/2100 – 2006/2056]

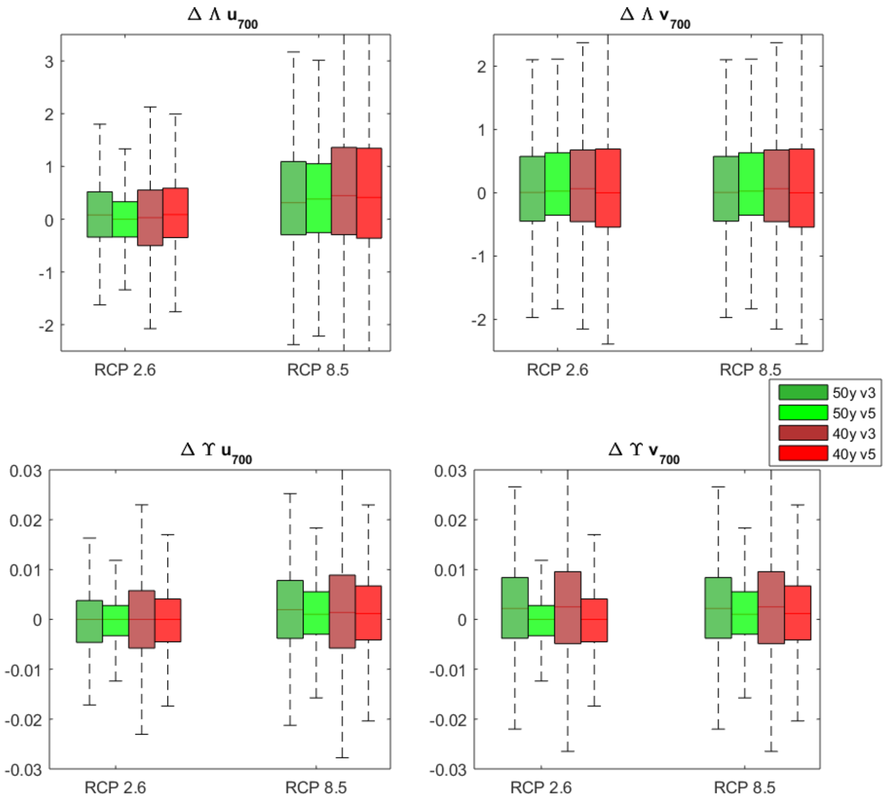

Fig. 3. Boxplots summarizing the changes among different resolutions (v3 for low resolution and v5 for high resolutions), scenarios and time intervals for each variables and indicators.

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