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Investigating Wintertime GPM-IMERG Precipitation in the North AtlanticLinette N. Boisvert¹, Mircea Grecu^{1,2} and Chung-Lin Shie^{1,3}¹NASA Goddard Space Flight Center, Greenbelt, MD, USA²GESTAR, Morgan State University, Baltimore, MD, USA³JCET, University of Maryland Baltimore County, Baltimore, MD, USA**Contents of this file**

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Introduction

This supplemental section (Text S1-S2) provides more detail on the IMERG and GPCP data products used in this study. Text S3 provides more information about the EOF analysis. The rest of the supplemental section contains Table S1, and Figure S1 which could not be included in the main body of the text due to length restrictions, but are still useful for the reader to reference if need be.

Text S1.

While there is no direct validation of satellite precipitation estimates in the midlatitude oceanic storm tracks, the GPCP product has been used and investigated in a large number of studies, i.e., the study of Adler et al. (2003) has been cited more than 5000 times and is considered reliable. In a recent study, Behrangi and Song (2020) compared the GPCP estimates to a product derived from the GPM combined estimates and a Merged CloudSat/TRMM/GPM (MCTG) product. They found that, at latitudes greater than 40 degrees, the GPM combined estimates are significantly smaller than the GPCP estimates due to the limited sensitivity of GPM radar. However, the MCTG product agrees well with the GPCP. The merging methodology,

which is described in detail in Behrangi and Song (2020), consists of blending the probability distribution functions of the GPM combined and CloudSat precipitation estimates.

Over land, the IMERG final estimates incorporate the same gauge information as the GPCP product using a very similar methodology. Over oceans, IMERG estimates are adjusted by the developers (Huffman et al. 2020) to zonally match the GPCP estimates. The fact that the two products do not match in many respects is an indication that the meridional distributions are important. But even if IMERG and GPCP matched perfectly at the monthly level, there would still be value in using the IMERG product, as the IMERG product has much better temporal and spatial resolutions, which is essential in investigating aspects like those shown in Figure 4.

Adler, R. F., Huffman, G. J., Chang, A., Ferraro, R., Xie, P., Janowiak, J. et al. (2003). The Version-2 Global Precipitation Climatology Project (GPCP) Monthly Precipitation Analysis (1979–Present). *J. Hydromet.*, 4(6), 1147-1167. [https://doi.org/10.1175/1525-7541\(2003\)004<1147:TVGPCP>2.0.CO;2](https://doi.org/10.1175/1525-7541(2003)004<1147:TVGPCP>2.0.CO;2)

Behrangi, A. and Song, Y. (2020). A new estimate for oceanic precipitation amount and distribution using complementary precipitation observations from space and comparison with GPCP. *Environmental Research Letters*, 15(12), p.124042, <https://doi.org/10.1088/1748-9326/abc6d1>.

Text S2.

The IMERG and GPCP estimates are different not only because they are derived from different observations, but also because they are derived by different algorithms optimized to achieve different objectives. Specifically, while the chief objective of the IMERG product is to provide high resolution (both in time and space) precipitation estimates, the GPCP's objective is to provide unbiased estimates at the monthly level. Both the IMERG and GPCP algorithms employ histogram matching procedures, but since the spatial resolutions are different, the associated precipitation estimates are characterized by different probability distribution functions. Moreover, the IMERG algorithm uses a Lagrangian interpolation scheme to mitigate temporal sampling effects. As a consequence, even if the instruments used by the two algorithms were exactly the same, the outcome would not be necessarily the same, given the differences in the algorithms. Nevertheless, the IMERG and GPCP estimates should be consistent at the monthly level and their developers are striving to achieve this consistency.

Text S3.

The domains do not appear the same in IMERG as for GPCP and MERRA-2 due to the missing data over the ice-covered areas. Therefore, we also calculated the EOFs using the same domain for all products (i.e. by masking out the masked IMERG regions in the GPCP and MERRA-2 domains) and the results did not significantly change. Slight changes in the EOFs appearance occurred and the correlations between the GPCP and IMERG principal components

slightly increased. However, the correlations between IMERG and MERRA slightly decreased. A possible interpretation is that MERRA is capturing reasonably well the large-scale patterns but not the small patterns, and even the large scale patterns are somewhat distorted and slightly displaced relative to the IMERG. Smaller domains (or partly masked domains) are less constrained, give more weight to small scale patterns and exacerbate the pattern displacements.

Table S1.

The correlations among the first four EOF modes for IMERG, GPCP and MERRA-2. The MERRA EOFs have been reordered (i.e., the MERRA-2 EOF mode 2 was considered EOF mode 1 and vice-versa) in these calculations. For modes larger than 4, the correlations between the products decrease, and the fact that similar patterns may explain different fractions of variability (and be ranked differently in different products) make the analysis more difficult and subjective than for the first four modes.

	Correlation Coefficient		
EOF modes	IMERG-GPCP	IMERG-MERRA	GPCP-IMERG
1	0.73	0.80	0.81
2	0.88	0.87	0.88
3	0.58	0.86	0.68
4	0.60	-0.63	-0.82

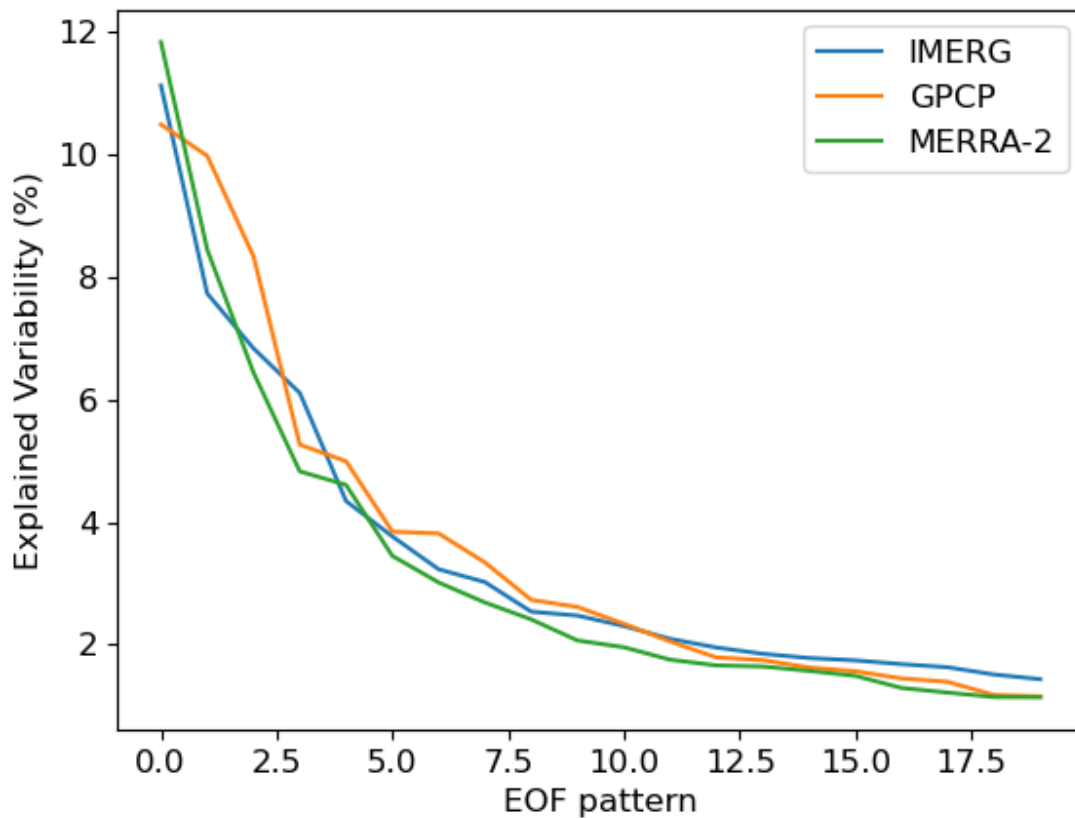


Figure S1. Percent of variability explained by the first 20 EOF patterns for IMERG, GPCP and MERRA-2.