

Title: Probabilistic seasonal outlook for the rainy season over India by monitoring the onset dates using GPM IMERG satellite-based precipitation

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An interesting manuscript which presents a local-scale method of predicting the onset and demise dates of the rainy season over India, using rainfall-based observations. Relationships between the onset/demise dates, rainfall amount and season length of the rainy season have been explored and statistically quantified. The highlighted application to real-time forecasting using IMERG rainfall is particularly relevant for seasonal forecasting.

The context of how this rainfall-based index fits into the existing indices of onset date definition could be better explored. Some discussion on local vs regional-large scale methods would be appropriate, including explanation on why it's useful to have different metrics to quantify onset/demise. The application to forecasting is clearly demonstrated, but the argument and motivation for an additional onset definition against numerous other indices could be stronger.

There is a significant amount of literature regarding the relationships between the Indian monsoon, ENSO and the IOD. Although the findings here are that the influence of ENSO/IOD on the defined rainy season metrics is weak, the importance of such teleconnections for the Indian monsoon system shouldn't be understated. There are also several other teleconnections such as the Madden-Julian Oscillation and Boreal Summer Intraseasonal Oscillation. It's mentioned in the introduction that Noska & Misra (2016) found links between rainy season onset dates and cross-equatorial upper-ocean heat transport in the Indian Ocean. It may be outside of the scope of this manuscript to explore the potential relationships between all teleconnections, but they should be alluded to in the context of further work.

General:

- Monsoon onset over Kerala is clearly defined at the beginning, but terminology such as 'onset date' and 'season length' throughout is ambiguous. Be specific and consistent with terms to improve clarity regarding whether the Indian summer monsoon season or the rainy season is being referred to. Similarly, be clear on whether a single onset date (e.g. MoK) is being referenced, or whether you mean the collection of local onset dates defined at gridpoints.

Abstract

Concisely summarised, covering key points regarding methodology, results and suggested application.

1. Introduction

L37-38: IMD also uses outgoing longwave radiation as a condition for monsoon onset over Kerala.

L43-54: Increase in rainfall is mentioned as a definition for monsoon onset, but the change in wind direction as a pre-requisite should be mentioned (i.e. following the traditional definition of a monsoon).

L46-59: Following Bombardi et al. (2019) - <https://doi.org/10.1002/joc.6264>, it may be worth noting that onset definitions broadly fall into two categories: local scale and synoptic-large scale.

L52: 'somewhat identical' is an oxymoron – suggest changing to 'somewhat similar'.

L52-54: Fitzpatrick et al. (2016) - <https://doi.org/10.1002/2016GL070711> – would be a useful reference here.

L56-58: rainy season is mentioned here but isn't defined until the following paragraph. Suggest moving this sentence to the following paragraph.

L56-73: Interannual variability is discussed in terms of ENSO and IOD, but reference should be made to the high internal variability of the Indian monsoon system. For example, contributions from intraseasonal oscillations.

L75-85: is the variable season the same as the rainy season? Keep terminology consistent. It might be useful to justify why you're considering the rainy season instead of the Indian monsoon season here, e.g. by highlighting results from Noska & Misra (2016) that showed stronger correlations between rainy season onset & seasonal anomalies (as noted in L94-100), or by the implication that characteristics of the upcoming monsoon season can be forecast earlier than current methods, based on pre-monsoon rainfall.

L78: More correct to say 'climatological southwest monsoon season' than 'fixed southwest monsoon season'.

L85: Change 'even though the southwest monsoon is the main rainy season' to something like 'even though the southwest monsoon is the main component of our defined rainy season'.

L87-90: It'd be worth highlighting why there are so many attempts to predict the onset and why it's challenging – linking back to separation of spatial scales.

L96: For clarity, change 'with variations in the onset and demise dates' to 'with variations in the onset and demise dates of the rainy season'.

L90, 96, 99: There are a few references to seasonal rainfall and seasonal mean anomalies – it's unclear if this refers to the summer season or the defined rainy season. Be specific and use 'summer', 'JJAS' or 'rainy season' instead of 'seasonal'.

L99-100: Clarify that the onset date referred to is the onset date of the rainy season, and whether the 'forthcoming rainy season' refers to Indian summer monsoon rainfall or also includes pre- & post- monsoon rainfall (e.g. from tropical cyclones).

L99-106: To strengthen the argument for the necessity of another onset index, the benefits of a local-scale method (such as presented here) should be highlighted against large-scale methods. Also, it could be made clearer that a spatial map of onset date evolution is being produced, unlike some wind-based methods of definition which only predict the onset date over Kerala.

2. Data and Methodology

L156: Remove dashes in Equation (1). Makes it hard to read. Same comment for the rest of equations throughout the manuscript.

L159-161: Do you mean you count the number of days between the onset and demise dates? I.e. it is not an estimate. Otherwise, please explain how seasonal length is defined.

L180-190: Make sure all equations are numbered and specifically referred to in the text.

L187: Explain what S^2_{em} is in the text and what this equation is computing.

3. Results

Figure 2:

- subplots (a) and (b) should show the dates on the colorbar – i.e use '29th April' instead of '120 days'. Or add contours with dates similar to IMDs isochrones. Also suggest spacing contours on 7-day intervals rather than 10.
- Subplots (c)-(h): show the units on the colorbar (e.g. 'days' or 'mm').
- Update caption to refer to the correct subplots; currently (b), (c) and (d) are repeated in the last two lines, should be referring to (f), (g) and (h).

L284-294: it would be useful to include results from IMERGs final product for comparison, instead of speculation. For example, an extra column could be added to Figures S2 & S3 to show differences between the late and final IMERG runs. This would add robustness to the argument for using IMERG late run for real-time forecasting.

L299: Do you mean the local onset date or the all-India onset date? Be clear and consistent with these terms.

Figure 3: Suggest adding a contour at +/- 0.6 to highlight the regions that are most strongly correlated.

Figure 4: Change colorbar to diverging either side of 1.

4. Summary and Concluding Remarks

Could better explain how this method would complement existing onset date indices (e.g. provides local scale map of onset dates) as well as current forecasting techniques. For example, this method could be used to give an early indication of monsoon season length & intensity for certain parts of India, given that the index is based on the rainy season and considers pre-monsoon rainfall.

A couple of sentences suggesting areas for further research should be included, such as considering the influence of teleconnections other than ENSO and IOD.

References

Please include DOIs for easy look-up of references.

Supplementary

Figure S1: typo in title of subplot (a) – change ‘Variabale’ to ‘Variable’.