

Review of “TempestExtremes v2.1: A Community Framework for Feature Detection, Tracking and Analysis in Large Datasets” in Geoscientific Model Development (gmd-2020-303)

The authors present an updated version of the feature detection and tracking framework TempestExtremes (TE), after the first version of TE has been published in 2017. After reading that paper and the present manuscript, I am highly intrigued by TE for several reasons:

- Abstracting the grid by representing it as a graph allows for supporting unstructured grids and leveraging the capabilities and performance of an optimized general-purpose graph library in a very elegant way.
- Given the prevalence of a relatively small number of operations/algorithms in many feature detection tools, a tool that implements them robustly and allows users to combine them definitely has merit, especially for relatively simple analyses.
- The interface as demonstrated in the examples seems to strike a good balance between consistency and relative simplicity on the one hand and flexibility to combine operators etc. on the other hand.

That being said, the present manuscript is not about TE per se, but specifically about version 2 and new features introduced since version 1. Crucially, TE now supports 2d (areal) features in addition to point (nodal) features, and is also capable of tracking them over time based on their spatial extent. This is an important step toward more general applicability of TE, especially high-resolution data that is becoming ever more prevalent today. New operators/kernels and tools to create feature profiles and composites are useful additions to TE as a comprehensive feature analysis framework.

As for the manuscript itself, it is on track but still a bit raw. After the initial submission was criticized by the editor for being too much like a software manual, the authors did improve the structure of the paper. However, in parts it still reads too much like a software tutorial (first major comment). Furthermore, while the authors demonstrate the wide applicability of TE, not enough is said about its limitations (second major comment), and while performance is frequently stressed as a point of focus, too little information about its actual performance is provided, especially compared to the tools with which it is compared scientifically (third major comment). These major comments are followed by a couple minor comments/suggestions (some of which are more crucial than others), which in turn are followed by a host of textual corrections/suggestions.

Once the major and (relevant) minor comments have been addressed, I am certain the manuscript will be in a good state for publication. I am looking forward to the revised version.

25 May 2021

Major comments

1. Section 3

The sections with example commands should be restructured such that the primary focus is on the physical phenomena, analyses and criteria, with the example commands and remarks on argument syntax coming second.

I do agree with the authors' response to the Editor in that it makes sense to include the commands with options in the paper because they illustrate the capabilities and limitations of TE in real applications. Given that the paper is about a specific version of TE, there is no danger of the commands becoming outdated (provided proper versioning by the developers), it may just be succeeded by later versions with a different interface.

Even though each example section is framed by a short introduction subsection in the beginning and a short discussion subsection in the end, overall, the section still reads too much like a tutorial than like a scientific paper. I propose the following changes:

First, while it makes sense subdividing the sections into individual subsection for each tool (e.g., "Step 1: DetectNodes"; "Step 2: StichNodes"), please change the titles to reflect the process/analysis step rather than the tool (e.g., "Step 1: Identification" or "Identify TCs"; "Step 2: Tracking" or "Track TCs over time"). "Step 1: Generate trajectories" is already a good example of this.

Second, please restructure the individual (sub-) sections. Now, they generally start with the command and go through the options while commenting on fields, thresholds and physical processes as needed. Instead, start by describing the goal of the step from a physical or algorithmic perspective, state what fields or algorithmic steps this requires, what thresholds are used, etc., and refer to any figures. Once the reader has the full picture of the analysis (step), show the TE command used to achieve it, and provide any crucial remarks on options (but leave out any others that are better suited for a separate user guide or tutorial, as suggested by the Editor).

Furthermore, in some instances the comparisons with literature results should be extended a bit; these are listed as minor comments.

2. Limitations

While the authors convincingly show that TE is able to replace many existing feature tracking tools, they hardly address its limits, i.e., what tools/algorithms are too complex or sophisticated to be easily replaced with TE.

An example for is the comparison with the IMILAST algorithms for extratropical cyclone identification/tracking (lines 356-357). The authors state that "other ETC detection algorithms analogous to those [in IMILAST] can be configured using TE's command line options." It would be interesting to know, however, how many of those algorithms can easily be replicated with TE, and whether there are some that are too sophisticated or complex, and in that case, what TE is lacking to do so.

These points can be briefly addressed in place like in the IMILAST example, and there should be at least a short discussion of the limitations of TE in the Discussion.

3. Performance

Throughout the paper, TE's ability to run efficiently in parallel on supercomputers is mentioned several times. However, not much is provided to substantiate this. On the one hand, when parallelism is mentioned, details on what is parallelized are usually missing (see minor comments). On the other hand, no performance measurements are provided. It would be helpful if at least a few comparisons with other tools could be added to give the reader at least some idea about the performance of TE beyond the qualitative descriptions currently in the manuscript.

Minor comments

Line 3: The equivalence of nodes and grid points is not necessarily clear if one is not aware of the graph representation of the grid in TE; also refer to nodal features as point features, either with "[both] point (nodal) [and areal features]" or "nodal (point)"

Lines 6-8: Extend with specific examples of both kernels and analyzed features, ideally including a scientific finding

Line 20: I am not sure how to understand "valid" in quotes; I'd suggest to just remove quotes, or alternatively provide a brief explanation like "valid trackers (in the sense of ...)"

Line 23: Same as on line 3 (abstract) regarding "nodal"

Line 33: Please briefly elaborate on the relevance of the correspondence between feature tracking and MapReduce, i.e., that it allows you to leverage existing work on this algorithms, as you wrote in the 2017 paper ("A key advantage of employing this framework is that substantial work has been undertaken to understand optimal strategies for parallelization of MapReduce-type algorithms (e.g., Prabhat et al., 2012) in order to mitigate bottlenecks associated with I/O and load balancing.")

Line 44: Please define "CF"

Lines 63-64: What do you mean by "applicability to either unstructured or structured grids"? Version 1 already handled unstructured grids, and therefore also structured grids. What has changed in this regard?

Line 90: I have a bit a hard time understanding what you mean by "snapshot". Intuitively, I understand a snapshot as the state of a full field at a certain moment, which makes the input fields to TE "snapshots" of the model state at that time step. However, "storm extraction" suggests that you understand "snapshot" as a certain part of a field, e.g., within a storm mask. My intuition may be wrong, but either way, could you please define what "snapshot" means in the context of this paper?

Line 100: What is parallelized with MPI? Space (domain decomposition), or something else?

Line 105: Could you briefly elaborate on the support of splitting/merging? What are the limits, in particular, with respect to the number of involved features -- only one-to/from-two, also one-to/from-many (and how many) or even many-to/from-many?

Line 115-124: I'd suggest not to use the variable names (min_overlap_prev etc.), given you don't use any variable names in the sections on the other executables. Try to reformulate in plain text or use more conventional (math-like) symbols similar to " $u_{(kt,max)}$ " in Table 1. As it is now, this paragraph looks too much like a software manual.

Line 115-124: Could you provide an example where it is useful to constrain the maximum overlap (with max_overlap_*)? If there is none (apart from special cases), you could also just drop the maximum thresholds from this paragraph and stick to the minimum thresholds (the former are documented in the user manual, after all, if someone needs them).

Line 130: What is parallelized with MPI?

Line 145: Please add the data set(s) used for atmospheric river tracking, for consistency with all other examples

Lines 147-148: You already mentioned above why you show them ("effective at conveying ..."); only do this once

Lines 148: I don't understand "tunings" in this context; please reformulate this

Line 178: Replace "resolution of [ocean fronts]" by "resolving"

Line 204 and other commands: Add backslashes (line continuation) to the end of multiline commands that contain explicit newlines to make them valid shell commands

Lines 218-219: Please briefly elaborate on closed contours being desirable. If I understand correctly, you mean desirable over neighboring grid points to identify extrema, but it is hard to understand without having read the 2017 paper

Line 241: Consider defining the various TE file types ("nodefile" etc.), i.e., format, content, produced by what, in a table

Line 357: Do you mean a "more complex algorithm" than the one employed here, or more complex than those in IMILAST that can be represented with TE? Please clarify

Line 379: Please extend the comparison with other ETC trackers to a few sentences

Line 398: Replace "claimed in" by "found by"

Line 400: Replace "verify this claim" by "reproduce this result" (or "... finding")

Lines 402-403: The description of "ERA5_IVT_files.txt" definitely belongs in a user manual rather than here (see main comment on Section 3)

Line 505: Parallelized over what? Also, could you please elaborate on what exactly you are comparing here; would it for instance be very hard to achieve similar parallelism in Python, or are you just assuming that a "Python script" only contains a bunch of sequential commands (in which case you should at least precede it by "simple")?

Line 519: It would be helpful to accompany formulations like "stitch together blobs from each timeslice" with more generally-understandable equivalents, e.g., "The last step in block detection is to track the blocking areas over time, i.e., to stitch ... timeslice", or at least replace "[tracking of] blobs [in space]" by "blocking areas (blobs)"

Line: 549: Replace "command line arguments" with a synonym for functionality (that these are exposed as command line arguments is not relevant in this context)

Line 552: Remove "on the command line"; the main point is that they are exposed, how does not matter in this context

Line 554: Mention that this paper presents TE version 2 and reference the 2017 paper on version 1 again

Lines 568-569: Move "Using ... reanalysis" after the next sentence; also, cite the section, as you do for the subsequent results

Table 1, "radial_profile": What do you mean by "python-format array"? If you mean the dimension ordering, that should rather be C-style (i,j,k) or Fortran-style (k,j,i)

Figure 4: Add label to color bar (variable, unit)

Typos, grammar, punctuation

Line 2: Remove hyphen between "Earth" and "system"

Line 14: Move "such as large-scale meteorological patterns" out of parentheses; consider preceding "such" by comma and using semicolons between examples ("model performance (...); ... patterns (...); ...")

Lines 15-16: Replace "by which we can analyze" with "for analyzing"

Line 16: Remove parentheses around "and anticipated in the next decade"

Line 19: Replace "permit" by "provide"

Line 21: Replace "to [the choice of tracker]" by "with respect to"; remove "herein"

Line 22: Remove hyphen between "scientifically" and "driven"

Line 27: Remove hyphen between "regionally" and "relevant"

Line 38: Consider replacing "many" with, e.g., "a set of"

Line 40: Add comma after "i.e."

Line 42: Replace "command line(s)" by "commands" (or "command(s)")

Line 46: Replace ": namely" by "as", or turn "its kernels ..." into a standalone sentence

Line 49: Consider replacing "total" by "full"

Line 51: Consider removing "namely"

Line 60: Replace parentheses around "organized by executable" by a comma before "organized"

Lines 61-62: Remove the part of the sentence after "version 1.0". It's confusing to state that you won't emphasize DetectNodes and StichNodes (which sounds like you won't describe them), only to start with a section on exactly those two

Line 67: Replace "downselected" (?) by, e.g., "selected" or "detected" or "identified"

Line 69: Start new sentence after "chain"

Line 71: Replace "subsetting -- e.g." by "subsetting. For example,"

Line 72: Add commas after "e.g.'s"

Line 79: Add comma before "except"

Line 84: Replace dash after "information" by comma

Line 98: Replace "day" by "d" in unit

Line 99: Remove "using"

Line 104: Replace "in [sequential]" by "at"

Line 106: Consider replacing (or complementing) "recombining" with "merging"

Line 107: Add "is" before "illustrated"

Line 109: It looks like "(time id, blob id)" would be regular parenthetical expression, with the sentence finishing after "form". Consider putting it in quotes

Line 114: Replace "sequential times" by "subsequent time steps"

Line 126: Consider removing the quotes around "core"

Line 137: Replace "(NCO, Zender (2008))" with "(NCO; Zender, 2008)"

Line 139: Replace dash after "features" with comma

Line 141: Replace "command lines" with "commands" (twice); replace "these commands" with "they"

Line 144: Reformulate "and subsequent employ" (I'm not entirely sure what you want to say here)

Line 147: Replace "command lines" with "commands"

Line 154: Replace "used" by synonym (e.g., "employed") to reduce duplication

Line 173: Replace "criteria" with "criterion"

Line 188: Replace "[threshold]. This choice was made to [address]" with "in order to" and merge the two sentences

Line 202: Replace "minima" with "minimum"; replace "command line" with "command" (or "shell command")

Line 215: Replace "stringed together" with "separated"

Line 218: Replace "criteria" with "criterion"

Line 219: Replace "makes the criteria more robust" by "makes it more robust" or, e.g., "increases robustness"

Line 220: Replace "criteria" with "criterion"

Line 222: Replace "criteria" with "criterion"

Line 225: Replace "criteria" with "criterion"

Line 238: Replace "minima" with "minimum"

Lines 254-255: Replace "timeslices" by "time slices" (twice)

Line 295: Replace "consider" with "consist"

Line 315: Replace parentheses around "2017" by a comma after "Zarzycki"

Line 328: Replace "their process-level evaluation" by, e.g., "evaluating them at a process-level"

Line 334: Add "the" after "both"

Line 337: Replace "storm trajectories" by "storms"

Line 342: Replace "criteria" with "criterion"

Line 350: Replace "criteria" with "criterion" (unless there are indeed multiple DetectNodes criteria to satisfy)

Line 356: Replace "(IMILAST, Neu et al. (2013))" by "(IMILAST; Neu et al., 2013)"

Line 378: Replace "Step 1" with "step 1"

Line 389: Add "a" before and "of" after both "grid spacing" and "resolution"

Line 392: Replace "maximized" by, e.g., "largest" ("maximized" sounds like maximizing precipitation in the center was a compositing criterion)

Line 393: Move "equatorward" before "advection"

Line 395: Remove "other" before "hand-compositing"

Line 409: Replace "criteria" with "criterion"

Lines 423-424: Remove parentheses around "imposing .. 15" and reformulate (is "minimum area per blob" one of the isolated features, or is it a second criterion imposed on high-IVT features?)

Line 427: Add comma before "we can filter"

Lines 432-433: Either remove comma after "blobfiles" or add one also after "in_data_list"

Line 434: Add "at" before "18:00 UTC"

Line 444: Remove "lis"

Line 460: Replace "exhibits results" with, e.g., "produces results that"

Line 465: Add, e.g., "which are" between "blocking events," and "synoptic-scale" to prevent this from erroneously being read as a list at first

Lines 465-466: Replace "phenomenon" by "phenomena" ("blocking events" are plural); alternatively, reformulate to "[atmospheric blocking, which is a synoptic-scale weather] phenomenon ..."

Line 471: Reformulate "Z500 (geopotential height at 500 hPa)" to "compute the geopotential height anomaly at 500 hPa by applying the Z500 algorithm" (as it is, it looks like an inverted acronym definition)

Line 482: Replace "[below the] surface" by "ground"

Line 483: Simplify "and consequently ... employed" to, e.g., "which can cause problems", or just remove it

Line 505: Remove "using" before "a Python script"

Line 510: Replace "points to" by "contains"

Lines 515-516: Move "as candidate blob points" before "where 500 hPa"

Line 517: Replace "are" by "area"

Line 520: Replace "command line" by "command"

Line 527: Add comma before "then"

Line 549: Simplify "has further continued to remain focused" on, e.g., "focuses"

Lines 551-552: Replace parentheses around "including .. weather" by a comma after "specific features"

Line 552: Remove "features" after "those"

Line 560: Remove "in hand"

Line 564: Replace "results related to" with "against"

Line 566: Reformulate without "would" ("allow one to"? "enable"? ...)

Line 569: Reformulate "It will further continue to maximize its", e.g., "Continued focus will be on maximizing" or "A focus of TE will continue to be on maximizing" or so

Algorithm 2, caption: Replace "[closed contour] criteria" with "criterion"

Figure 1, caption: Add comma after "e.g."

Figure 2, caption: Reformulate sentence around "and applying" as there's something wrong

Figure 5, caption: Add "Shown" before "from left to right"; reformulate last sentence so it doesn't start with "11,164" (e.g., "Each composite includes ...")

Table 1, "eval_ace": Replace parentheses around "2000" by a comma after "al."

Table 1, "eval_acepsl": Add comma after "currently"

Table 1, "eval_ike": Replace "that [instantaneous]" by "the"; add "where" before "u_i"

Table 1, "radial_profile": Consider adding "by radial distance" (or similar) after "binning"

Table 1, "lastwhere": Replace "such as" by "e.g."; add comma before "identify"; add comma after "e.g."

Table 1, "lastwhere": What is returned; the array index? Or the distance?

Table 1, "value": Add comma before "extract"

Table 1, "max_closed_contour": Add comma before "determine"; replace "could be used to satisfy" by "satisfies"

Table 1, "region_name": Remove "containing"; replace dash after "latitude" by period and start a new sentence; add comma before "then the point"