A New Climatology for Investigating Storminess Influences on the Extratropics

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MCMS
The MAP Climatology of Mid-Latitude Storminess

Overview

What is this MCMS?

MCMS stands for the MAP Climatology of Mid-latitude Storminess dataset. Mid-latitude storminess in this case means the area confined to the sea level pressure (SLP) depression around a mid-latitude baroclinic cyclone (or just cyclone). MCMS rests on two operations: 1) finding and tracking cyclones and 2) objectively delineating the area under each cyclone's influence (storminess). These operations are elaborated below.

Why make MCMS?

Because cyclones are a primary weather-maker outside the tropics as well as a specific process that can be isolated in both observations and model results. Cyclone activity strongly shapes the distribution many quantities on both climatic and meteorological scales. Today's climate models can in principle resolve basic cyclone features but they are unlikely to represent other key features such as fronts very well (Naud et al. 2010). Indeed, mid-latitude storm clouds are a key source of inter-model spread in climate sensitivity (Williams and Tselioudis 2007).

Who might MCMS and for what?

The MCMS provides a detailed assessment of the areas under the influence of mid-latitude cyclones and those that are not. The temporal-spatial variability of storminess can be used to give phenomenological context or as a screen for weather sensitive data. MCMS data will be made available for a variety of reanalysis products (e.g., NCEP Reanalysis I and II, ERA-40, ERA-Interim, MERRA). The software for working with this MCMS data will also be made available, as will the source code to allow the create of new MCMS datasets from climate model output or other numerical analysis.

Our Approach

Center Finding

MCMS uses the most popular method for locating cyclones; as depressions in the sea level pressure (SLP) field. At its most basic level this means scanning the SLP field for local minima in a time independent manner and then refining the list of potential cyclones with additional criteria. This process ignores some open-wave cyclones which is why MCMS alters the conventional minima finding method to exclude only SLP maxima and then apply extra scrutiny to isolate likely cyclones. MCMS also employs a unique method for limiting the effects of SLP noise in over high or steep topography which allows for the retention of more cyclones over these areas that conventional methods allow.

Center Tracking

With the centers now identified we then attempt to associate them into cyclone tracks via nearest neighbor and other similarity arguments. For this MCMS defines a dissimilarity score for each potential connection. This score is based on a preference for connections with relatively small changes in track course, SLP and position. A connection is made for the connection with the lowest dissimilarity score. Multiple potential connections are rare events (< 5% of cases), which mean that the primary tracking problem is deciding whether to extend an existing track or terminate it and begin a new one. The last step of the tracking process ensures that retained tracks meet certain user tunable criteria (e.g., minimum travel and duration).

MCMS retains a record all discarded centers, and the reason for their rejection, which is useful for refining the method as understanding how various criteria impact the final results.

Continue to "**Defining Storminess.**" →

Application/Examples

Example of MCMS Compositing:

Composite a) shows the climatological likelihood that a given point in the composite domain is enclosed by the outer most SLP contour of the cyclone being composited (i.e., storminess).

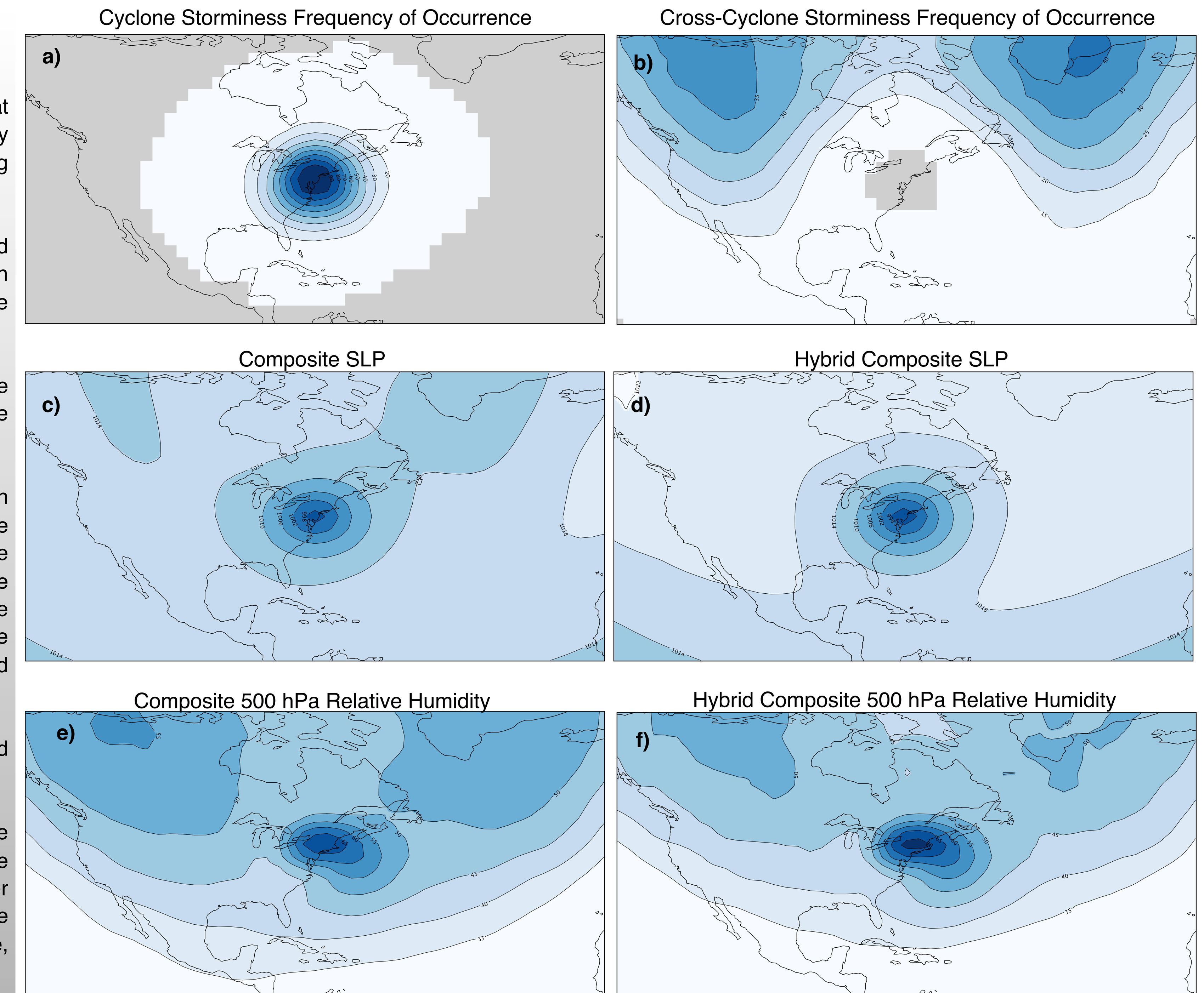
Composite b) shows the the climatological likelihood that a given point in the composite domain falls within the storminess area of a cyclone other than the one being composited.

Composite c) shows the climatological SLP composite collected in the conventional manner of centering the composited domain over each cyclone center.

Composite d) shows a hybrid SLP composite, which differs from a conventional composite in that the cyclone storminess from cyclones **other** than the one being composited are masked to reduce the contamination of multiple cyclones within the compositing domain. Multiple cyclone centers are allowed in this case when they are linked by shared contours (e.g., ATTS).

Composites e) and f) are the same as those in c) and d) except for relative humidity.

All composites were accumulated on a fixed-size domain of 11,000x3600 km upon which each cyclone was projected. The final composites are centered over New York City for scale. The data comes from the NCEP/NCAR Reanalysis II (Northern Hemisphere, NDJFM, 1979-2011).



Example of MCMS Filtering:

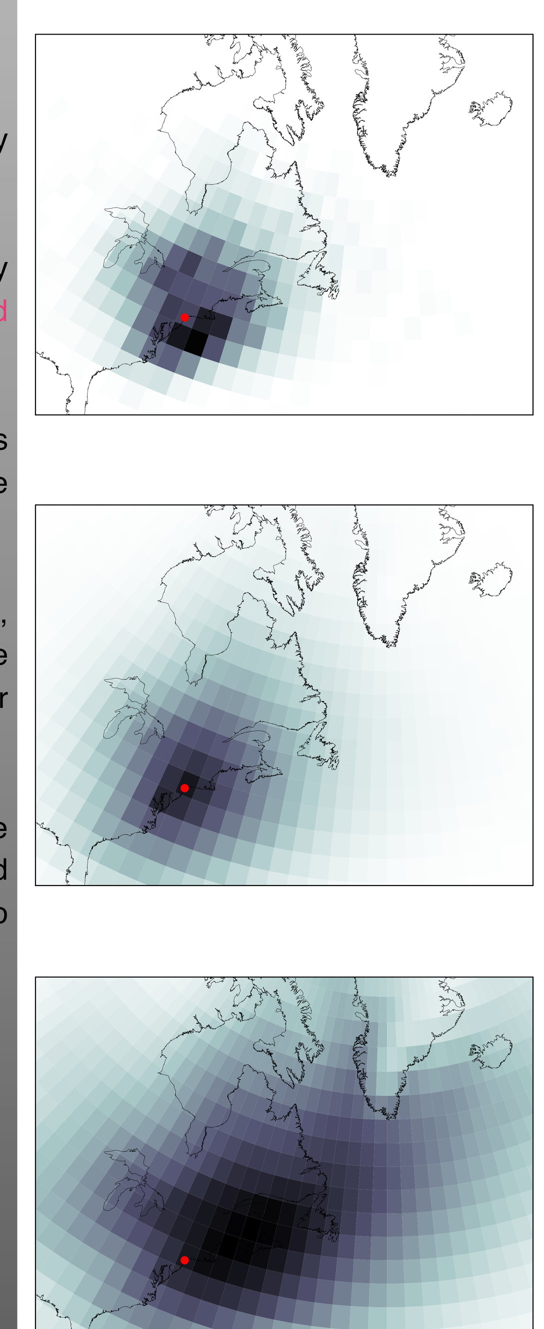
MCMS data can be used to contextualize or screen by the presence or absence of cyclone activity.

Here we show various views of recent cyclone activity near a fictitious ARM site in New York City (NYC red dot, darker shades more activity).

The uppermost panel includes only the cyclone centers whose stormy area passes over NYC. Note how the **center count** peaks over the storm tracks.

The middle panel uses a **whole storm count.** That is, it counts both the stormy area and the centers. Note how this count peaks over the city and extends further out.

The bottom panels is a whole storm count as before but includes the **whole track** of all storms that passed over NYC at any point. Note how the count peak is to the north of NYC.



About the MCMS datasets and software:

To encourage these works MCMS data from several reanalysis efforts will be made publicly available (e.g., NCEP Reanalysis I and II, ERA-40, ERA-Interim, MERRA). MCMS data files come in the form of specially formatted plain text files.

Although this formatting is well documented and easily expressed in most programming languages, MCMS provides a number of tools for manipulating and analyzing the data it produces. A simple gridded storminess mask is also available in NetCDF.

For those interested in applying MCMS to other data (e.g., center-finding, tracking and storminess), we offer the full suite of MCMS source code. MCMS is written the python programming language.

MCMS will be made available as soon as we can setup a proper home for both the datasets and source code. In the mean time, the following site acts as a stand-in and will point the main site when it comes online:

http://gcss-dime.giss.nasa.gov/mcms/mcms.html

Users can freely modify, improve and extend the MCMS toolset and are encouraged make these changes available to the wider community. Plans are already under way to improve MCMS operations at polar latitudes, to accommodate very high resolution numerical input and to allow center-finding with alternative fields such as vorticity.

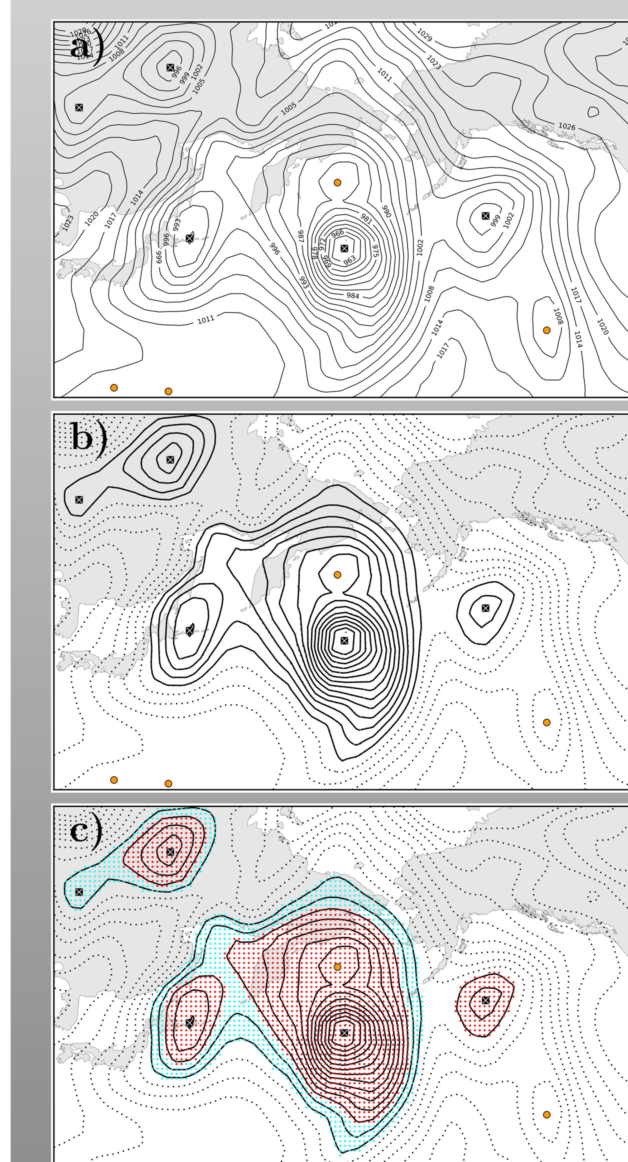
Our Approach Cont.

Defining Storminess

The method described in this section, which we call attribution, delineates the region of influence around any give cyclone. This is done with the idea that a cyclone's area of influence or "storminess" is bound by the unique set of concentric sea level pressure (SLP) contours surrounding that cyclone. MCMS labels this area as a cyclone's attributed or ATT contours. When the outermost closed contour encloses more than one cyclone center a new storminess label is applied to the shared contours (ATTS).

An example of this process is shown below along with the associated kept and discarded cyclone centers. It is interesting to note that without the benefit of the discarded center database it would not be apparent that MCMS detected a cyclone center within the closed 1008 hPa contour found in the lower right of the figure. Because MCMS saves this information we not only know that MCMS properly detected this center, but that it was discarded because that system eventually merges with the stronger system to its northwest and the resulting track is too short for retention.

Example of MCMS Attribution:



Panel a) shows the initial SLP contours along with the associated kept (black squares w/ white pluses) and discarded cyclone centers (orange open circles).

Panel b) highlights the cyclone containing contours (dark solid lines).

Panel c) shows the flood filled areas defined by the outermost closed contours unique to a single center (ATT areas, in red) and those shared by multiple centers (ATTS areas, in cyan).

References

Bauer, M., G. Tselioudis, & W. Rossow 2012: A New Climatology for Investigating Storm Influences on the Extratropics. *J. Climate* **Submitted**.

Naud, C.M., A.D. Del Genio, M. Bauer & W. Kovari 2010: Cloud Vertical Distribution Across Warm and Cold Fronts in CloudSat-CALIPSO Data and a General Circulation Model. *J. Climate*, 23, 3397-3415, doi:10.1175/2010JCLI3282.1.

Williams, K. D. & G. Tselioudis (2007). GCM Intercomparison of Global Cloud Regimes: Present-day Evaluation and Climate Change Response. *Clim. Dynam.*, 29, 231-250, doi:10.1007/s00382-007-0232-2.