Characterizing Variability of Synoptic and Cloud Regimes over the ARM Azores Site and the Northeast Atlantic

C. S. Fish[1], D. B. Mechem[1], M. A. Miller[2], S. E. Yuter[2], and S. P. de Szoeke[3]

[1]Atmospheric Science Program, Department of Geography, University of Kansas; [2]Department of Marine, Earth, and Atmospheric Sciences, North Carolina State University;
[3]College of Oceanic and Atmospheric Sciences, Oregon State University

Introduction and motivation

The Azores lie in a region of substantial variability in cloud and synoptic properties, as demonstrated during a 20-month deployment of the ARM Mobile Facility (AMF) on Graciosa Island. We explore this variability using the clustering technique of self-organizing maps (SOMs). The SOM algorithm finds twenty-five characteristic synoptic states based on monthly 500-mb geopotential height anomalies from ERA–Interim (reanalysis). Once these characteristic states are determined, other fields from reanalysis, satellite data, and surface observations are projected onto these characteristic states. For every month, the clustering algorithm consistently identifies four archetypical synoptic patterns based on the relationship of the 500-mb geopotential pattern relative to the Azores: pre-trough, trough, post-trough, and ridge. The location and persistence of low clouds are strongly related to the location and intensity of the Bermuda High. Post-trough and ridge patterns are the most conducive to liquid-phase clouds in the vicinity of the Azores and are accompanied by surface-level high pressure and subsidence, and the region, even in summer, is punctuated by frequent synoptic intrusions.

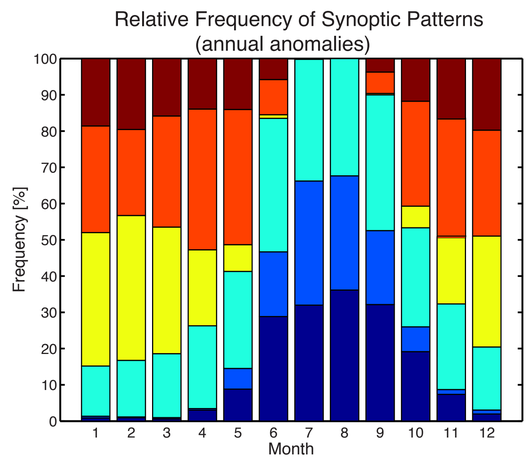
We focus on the following objectives:

- *Identifying preferential synoptic states over the NE Atlantic*
- *Projecting cloud system properties onto these synoptic states to explore joint variability between cloud and synoptic states.*

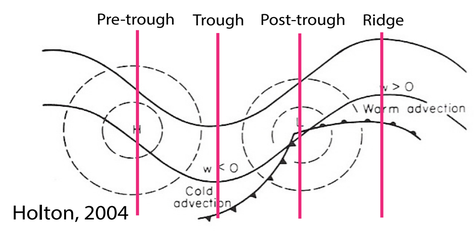
Analysis procedure

1. Choose period of interest and field on which to run SOM analysis: June and January 500-mb geopotential heights from ERA–Interim, 1979–2012 (1020 and 1054 samples respectively, one for each day), or the entire January-to-December period
2. Calculate normalized anomalies
3. Choose number of nodes: 25
4. Run SOM algorithm
5. Project MODIS total cloud fraction and other ERA–Interim fields onto SOM nodes

Synoptic Pattern Annual Cycle



To examine the annual cycle, 500mb geopotential heights over the entire data set are used to initialize the SOM algorithm.



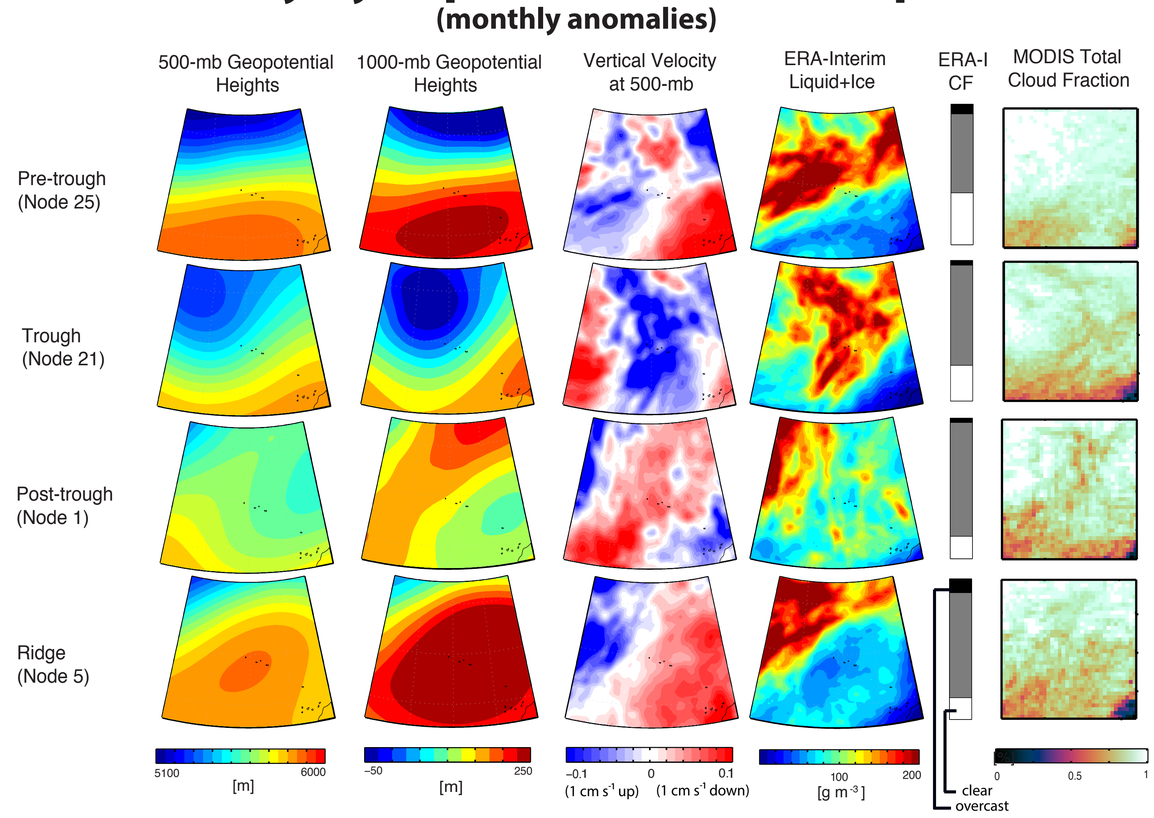
Nodes are categorized by which weather pattern is the most dominant feature over the domain.

- Winter months are primarily dominated by trough and post-trough patterns.
- Summer months are dominated by ridge and zonal pattens.
- All months contain some level of pre-trough patterns.

Even though ridge conditions associated with the Bermuda high dominate the summer months, the Azores nevertheless experiences periodic intrusions of synoptic systems. This necessitates a closer examination of individual months, namely June and January as representatives of summer and winter, respectively.

January Synoptic and Cloud Properties

(monthly anomalies)



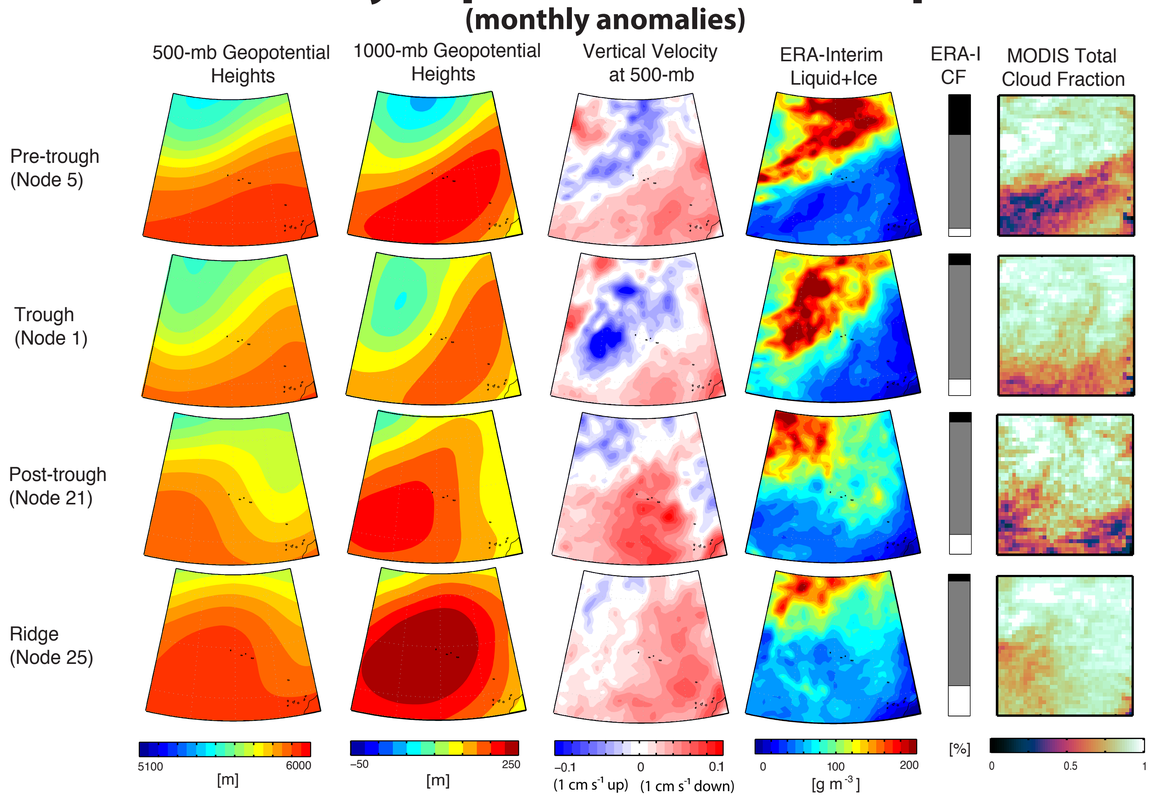
Icelandic low is present in January, and the Bermuda high is present in both January and June

Post-trough and ridge patterns are the most conducive to clouds in the vicinity of the Azores and are accompanied by surface-level high pressure and subsidence.

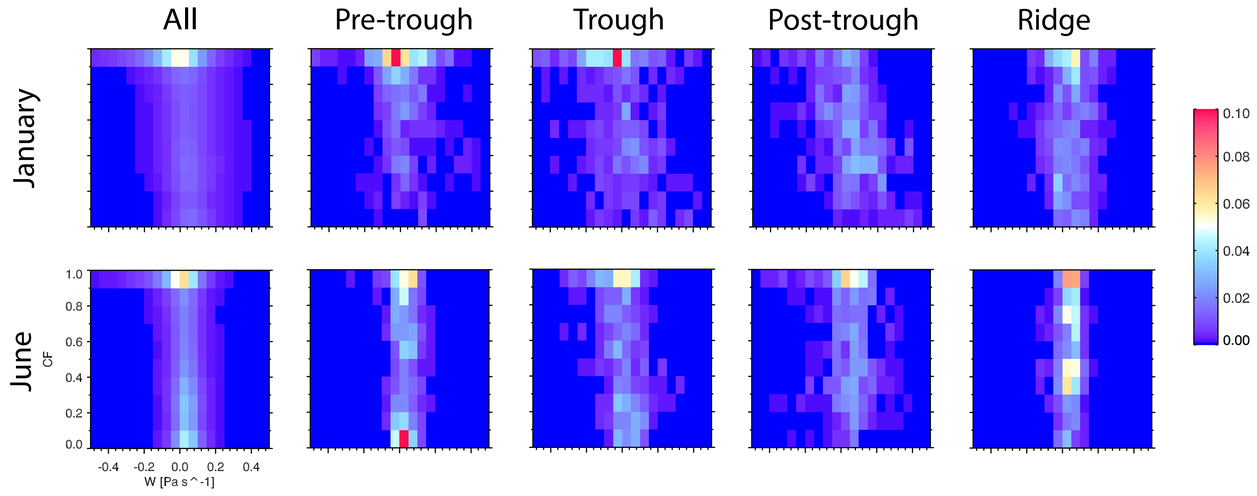
Joint density plot demonstrates no cloud fraction sensitivity to vertical motion, except for a weak dependence in the trough and post-trough regimes.

June Synoptic and Cloud Properties

(monthly anomalies)



Joint PDFs of ERA-Interim Cloud Fraction and Vertical motion at the Azores



Summary and discussion

- The SOM algorithm successfully identifies synoptic regimes and transitions on multiple timescales over the Northeast Atlantic.
- More often than not, the Azores lie in a gradient of synoptic and cloud properties.
- The location and persistence of clouds over the Northeast Atlantic are strongly related to the location and intensity of the Bermuda High but also synoptic systems associated with the Icelandic low.
- We find evidence of synoptic "intrusions" over the Azores region in the cloud fraction and near-surface height field, but these occurrences are not associated with strong 500-mb forcing over the Azores themselves.

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