Quantifying seasonal patterns in disparate environmental variables using the PolarMetrics R package

Bjorn J. Brooks

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Broader research that I won’t talk about: Clustered phenologies & landscape dynamics

Cascade Complex fire (2007), Idaho
Polar Metrics Maps

landat.org/maps

R package

github/bjornbrooks/PolarMetrics
Where these Polar Measures Are in Use

Policy directives
National Cohesive Wildland Fire Management Strategy

Landscape analysis
Appalachian Landscape Conservation Cooperative

Forest revision planning
Texas NF

Land conservation prioritization
TNC Maryland
How Seasonal Patterns are Represented

<table>
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<tr>
<th>Year</th>
<th>Jan 3</th>
<th>Jan 11</th>
<th>Jan 19</th>
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<td>0.57</td>
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<td>1996</td>
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<td>1997</td>
<td>0.58</td>
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<table>
<thead>
<tr>
<th>Year</th>
<th>Mid Ssn DOY</th>
<th>Length of Ssn</th>
<th>Seasonality (vec. mag.)</th>
<th>...</th>
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<td>210</td>
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<td>101</td>
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</table>
A History of Extracting Circular Statistics from Environmental Data

Applications of Circular Statistics in Plant Phenology: a Case Studies Approach

Chapter
First online 15 September 2006

Abstract
Phenology is the study of recurring biological events in the plant sciences, yet not very much is known about the biological sciences, and indeed not much has been investigated. Nevertheless, the connection between the event analysis and directional data has been observed in several areas, including those in which better understanding of the relationships between different variables and the analysis of plant phenology is required.

Geophysical Research Letters
AN AGU JOURNAL

Research Letter
Peak tornado activity is occurring earlier in the heart of “Tornado Alley”
John A. Long E3, Paul C. Stay
First published: 10 September 2014
Full publication history

Land-Cover Phenologies and Their Relation to Climatic Variables in an Anthropogenically Impacted Mediterranean Coastal Area
Ignacio Melendez-Pecker 1, E3, Jose Navarro-Pedretto 1, E3, Magaly Koc 1, E3, Ignacio Gómez 2, E3, and Encarni S. Hernandez 1, E3

Abstract
Mediterranean coastal areas are experiencing rapid climatic changes. This study quantifies the effects of Mediterranean land-cover changes on climate. A time series of 2001 to 2007 was used to analyze the relationships between annual temperature changes and land-cover changes. The results show that the increase in temperature is associated with an increase in the amount of land covered by vegetation. This suggests that the increase in temperature is associated with an increase in the amount of land covered by vegetation.
Data Mining Benefits

What benefits can polar transformation offer?

- Smaller data set size
- Extraction of intuitive measures of change
- Visual enhancement of changes in timing
- Comparability of different sensor data
- Choice of calendar year or a year centered on point of least activity
Data Mining Benefits

Smaller data set size

Faster computing for subsequent analysis
Extracting Polar Measures

PolarMetrics R package calculates circular statistics for any uniformly sampled time series
Extracting Polar Measures

Procedure 4
# Transform first variable into
# its component vectors
vecs =
    calc_metrics(lef.7dy$TA,
        yr_type="cal_yr", spc=52,
        lcut=0.15, hcut=0.85,
        return.vecs=TRUE)$vectors
# Repeat calculation and return
# overall avg vecs (RV and AV)
avg_vecs =
    calc_metrics(lef.7dy$TA,
        yr_type="cal_yr", spc=52,
        lcut=0.15, hcut=0.85,
        return.vecs=TRUE)$avg.vectors
Dividing the Series & Extracting Metrics

Dividing the time series into regular cycles that begin & end at the point of least activity (anti-vector).

This makes it possible to examine differences in seasonality corresponding to empirically defined years.
Dividing the Series & Extracting Metrics

- Timing measures
  - Calendar yr or empirical yr

- Magnitude measures
Capacity for Comparison of Disparate Environmental Variables

- Comparability across sensors
- Comparable on calendar year or empirically defined year
  - Empirical year suitable for comparison across elevational, latitudinal gradients

BROOKS et al. | DMMSS, 2017
Example Applications: Nonstationarity in Facets of Seasonality

Departures from horizontal reflect shifts, trends, oscillations
Further Applications: Discriminant Functions of LC Types

Polar measures lend themselves to novel analyses that better describe the controls on land cover type.
Further Applications: Exploratory Factor Analysis
Wrap-up

The PolarMetrics R package was developed as a set of open source generalizable tools that replicate our initial data processing steps of environmental time series.

PolarMetrics is generalizable and simple, but offers significant analytical benefits:
1. Functions are flexible, simple yet describe facets of seasonality through intuitive measures
2. No matter the input the output consist of standardized measures of seasonal profile
3. Filtering/Focusing on certain parts of the year
Thank You

Bjorn J. Brooks, Ankur Desai, Danny Lee, Lars Pomara and William W. Hargrove

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