Relative Particle Density (RPD) calculations using High Frequency Radar (HFR) observed surface currents around Palmer Deep Canyon from January to March of 2020

Website: https://www.bco-dmo.org/dataset/917926
Data Type: Other Field Results
Version: 1
Version Date: 2024-01-08

Project
» Collaborative Research: Physical Mechanisms Driving Food Web Focusing in Antarctic Biological Hotspots (Project SWARM)

Contributors	Affiliation	Role
Kohut, Joshua	Rutgers University	Principal Investigator
Klinck, John M.	Old Dominion University (ODU)	Co-Principal Investigator
Oliver, Matthew	University of Delaware	Co-Principal Investigator
Statscewich, Hank	Rutgers University	Co-Principal Investigator
Veatch, Jacquelyn	Rutgers University	Student
York, Amber D.	Woods Hole Oceanographic Institution (WHOI BCO-DMO)	BCO-DMO Data Manager

Abstract
Relative Particle Density (RPD) reports the position of drifters at a single timestamp by normalizing the density of drifters within a gridded bin system in the study field. Relative Particle Density calculations begin with releasing virtual particles over a regular grid and tracking them through a velocity field (High Frequency Radar observed surface currents). RPD is then quantified by summing the number of drifters in each grid box, and normalizing by the median number of drifters in all grid boxes. New particles were released in a regular grid across the 80 % coverage of the HFR footprint every three hours. Particles were not counted until they had been advected in the velocity field for 6 hours (when the autocorrelation of the HFR velocities cross the e-fold), and were no longer counted when they were advected out of the HFR domain, or after they became three days old. Given the average residence time of 2 days (Kohut et al., 2018), the three-day threshold was 245 chosen to coordinate with the time phytoplankton will spend in the surface layer of the study domain. This methodology follows that used by (Oliver et al., 2019; Veatch et al., 2022, preprint: not peer reviewed). RPD reports the normalized number of drifters present in each gridded bin at each timestamp (Veatch et al., 2024 Figure 2C). Two dimensional HFR data is used to calculate RPD, creating the assumption that the integrated surface divergence is zero, and no particles are lost from the surface due to vertical velocities. Therefore, RPD will map the instantaneous concentration of surface associated particles across the entire domain given the evolving surface current fields provided by the HFR.

Table of Contents

Coverage

Location: Palmer Deep Canyon in the coastal ocean west of the Antarctic Peninsula (~ 64.3 W, 64.9 S)
Spatial Extent: **N**:-64.7 **E**:-63.8 **S**:-65 **W**:-64.6
Temporal Extent: 2020-01-09 - 2020-03-31

Methods & Sampling

Methods for these LCS results can be found in Veatch, et al. (2024, in revision).

Relative Particle Density provides the normalized density of drifters within each gridded bin of the study system. Relative Particle Density calculations begin with tracking virtual particles through a velocity field that are released over a regular grid. RPD is calculated by summing the number of drifters in each grid box, and normalizing by the median number of drifters in all grid boxes. In the following analysis, new particles were released in a regular grid across the 80 % coverage of the HFR footprint every three hours. Particles were not counted until they had been advected in the velocity field for 6 hours (when the autocorrelation of the HFR velocities cross the e-fold), and were no longer counted when they were advected out of the HFR domain, or after they became three days old. Given the average residence time of 2 days (Kohut et al., 2018), the three-day threshold was chosen to coordinate with the time phytoplankton will spend in the surface layer of our study domain. This methodology follows that used by (Oliver et al. 2019). RPD reports the normalized number of drifters present in each gridded bin at each timestamp. Two dimensional RPD assumes that no particles are lost from the surface layer due to vertical velocity, meaning that the integrated surface divergence in the x-y plane is assumed to be zero. Therefore, RPD will map the instantaneous concentration of surface associated particles across the entire domain given the evolving surface current fields provided by the HFR.

Data Processing Description

All data were processed using MATLAB 2019b. Scripts used for data analysis can be found at https://github.com/JackieVeatch/SWARM_LCS.
* Curatorial note: See supplemental file SWARM_LCS-related_to_bcodmo_917926_917914_v1.zip which contains a release corresponding to commit (10931d9).

BCO-DMO Processing Description

* netcdf file imported into BCO-DMO. No changes made.
* A copy of code repository supplied by submitter https://github.com/JackieVeatch/SWARM_LCS (commit 10931d9) forked to BCO-DMO for curatorial purposes and a release was made on 2024-01-08 https://github.com/BCODMO/SWARM_LCS/releases/tag/related_to_bcodmo_91792.... No changes to the code were made. Zip file of this release attache as a supplemental file.

[table of contents | back to top]

Data Files

File

RPD data (netCDF format)

filename: RPD.nc

(NetCDF, 7.73 MB)
MD5:ce23884ad106f22ec0f62313d132584d

RPD data in netCDF format.

NetCDF header:

```
ncdump -h RPD.nc
netcdf RPD\ \(1\) {
dimensions:
	Time = 1511 ;
	Lon = 29 ;
	Lat = 23 ;
	Char = 20 ;
variables:
	double Normalized_Particle_Density(Time, Lat, Lon) ;
		Normalized_Particle_Density:long_name = "normalized particle density gridded" ;
		Normalized_Particle_Density:standard_name = "relative_particle_density" ;
		Normalized_Particle_Density:units = "normalized particles in gridbox" ;
		Normalized_Particle_Density:FillValue = "NaN" ;
	double Lon(Lon) ;
		Lon:long_name = "Longitude" ;
		Lon:standard_name = "longitude" ;
		Lon:units = "degrees_east" ;
		Lon:FillValue = "NaN" ;
	double Lat(Lat) ;
		Lat:long_name = "Latitude" ;
		Lat:standard_name = "latitude" ;
		Lat:units = "degrees_north" ;
		Lat:FillValue = "NaN" ;
	double Time(Time) ;
		Time:long_name = "Time" ;
		Time:standard_name = "time" ;
		Time:units = "days since 0000 01-01-T00:00:00; datenum serial date number" ;
		Time:FillValue = "NaN" ;
		Time:calendar = "georgian" ;
		Time:TimeZone = "GMT" ;
	char Time_readable(Char, Time) ;
		Time_readable:long_name = "Time" ;
		Time_readable:standard_name = "time" ;
		Time_readable:units = "date_string" ;
		Time_readable:FillValue = "NaN" ;
		Time_readable:calendar = "georgian" ;
		Time_readable:TimeZone = "GMT" ;
}
```

[table of contents | back to top]

Supplemental Files

File
Relative Particle Density (alternate format, Matlab) filename: RPD_mat_files.zip (ZIP Archive (ZIP), 888.75 KB) MD5:02db6f7a963e2685804686272c7cd721 Data in alternate format (matlab .mat). These files contain the same dataset as the primary file for this dataset RPD.nc (netCDF). Note that the .nc file contains datetime in string format while the .mat files contain only matlab datenum type. Variable Name Size Bytes Class Attributes RPD_coords 667x2 10672 double RPD_time 1x1511 12088 double part_dens_gridded 29x23x1511 8062696 double Files in .zip package: RPD_gridded_season.mat part_dens_gridded = lon x lat x time relative particle density, normalized to hourly result RPD_coordinates.mat RPD_coords = coordinates of gridded RPD decimal degrees longitude, latitude RPD_time.mat RPD_time = timestamp of RPD results. serial date number. a serial date number represents the whole and fractional number of days from January 0,0000 in the proleptic ISO calendar.
SWARM_LCS (github code release) filename: SWARM_LCS-related_to_bcodmo_917926_917914_v1.zip (ZIP Archive (ZIP), 33.15 KB) MD5:0a80fa71bfa25eee2b5f1a607d194f99 Code release made from https://github.com/JackieVeatch/SWARM_LCS forked to BCO-DMO https://github.com/BCODMO/SWARM_LCS/releases/tag/related_to_bcodmo_917926_917914_v1 for curatorial purposes. The repository was forked from https://github.com/JackieVeatch/SWARM_LCS on 2024-01-08. No changes to the code were made. Release corresponds to commit https://github.com/JackieVeatch/SWARM_LCS/commit/10931d9a1508316fa65e2f82fd6052882d4e0aea Repository README: code for the calculation of Lagrangian coherent structures from HFR observed surface currents in Palmer Deep Canyon RPD calculations can be computed following instructions in "READ_ME.docx" in this repo. FTLE calculations can be computed using "backward_ftle_loop_short.m" within George Haller's LCS toolbox. Place "backward_ftle_loop_short.m" in the LCS-Tool-master/demo/ocean_dataset directory within toolbox. Access toolbox here: Haller, K. O. F. H. G. LCS Tool: A Computational Platform for Lagrangian Coherent Structures. https://github.com/jeixav/LCS-Tool-Article/. Haller, K. O. F. H. G. LCS Tool: A Computational Platform for Lagrangian Coherent Structures (https://doi.org/10.48550/arXiv.1406.3527)

[table of contents | back to top]

Related Publications

Okubo, A. (1970). Horizontal dispersion of floatable particles in the vicinity of velocity singularities such as convergences. Deep Sea Research and Oceanographic Abstracts, 17(3), 445–454. https://doi.org/10.1016/0011-7471(70)90059-8
Methods

Oliver, M. J., Kohut, J. T., Bernard, K., Fraser, W., Winsor, P., Statscewich, H., Fredj, E., Cimino, M., Patterson-Fraser, D., & Carvalho, F. (2019). Central place foragers select ocean surface convergent features despite differing foraging strategies. Scientific Reports, 9(1). https://doi.org/10.1038/s41598-018-35901-7
Methods

Onu, K., Huhn, F., & Haller, G. (2014). LCS Tool : A Computational Platform for Lagrangian Coherent Structures. https://github.com/jeixav/LCS-Tool-Article/ *ArXiv*. https://doi.org/10.48550/ARXIV.1406.3527 https://doi.org/10.48550/arXiv.1406.3527
Software

Veatch, J., Fredj, E., & Kohut, J. (2022). High Frequency Radars as Ecological Sensors: Using Lagrangian Coherent Structures to Quantify Prey Concentrating Features. OCEANS 2022, Hampton Roads. https://doi.org/10.1109/oceans47191.2022.9977356 https://doi.org/10.1109/OCEANS47191.2022.9977356
Methods

Veatch, J., Kohut, J., Oliver, M., Statscewich, H., Fredj, E. (2024) Quantifying the role of sub-mesoscale lagrangian transport features in the concentration of plankton in a coastal system ICES JMS, In Revision.
Results

Weiss, J. (1991). The dynamics of enstrophy transfer in two-dimensional hydrodynamics. Physica D: Nonlinear Phenomena, 48(2–3), 273–294. https://doi.org/10.1016/0167-2789(91)90088-q https://doi.org/10.1016/0167-2789(91)90088-Q
Methods

[table of contents | back to top]

Related Datasets

IsRelatedTo

Veatch, J., Klinck, J. M., Oliver, M., Statscewich, H., Kohut, J. (2024) **High Frequency Radar (HFR) observed surface currents at Palmer Deep Canyon in the coastal ocean west of the Antarctic Peninsula in 2020.** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2024-01-08 doi:10.26008/1912/bco-dmo.917884.1 [view at BCO-DMO]
Relationship Description: The "High Frequency Radar, Palmer Deep" dataset provided the observed surface currents (velocity field) from which these Relative Particle Density were calculated from.

[table of contents | back to top]

Parameters

Parameters for this dataset have not yet been identified

[table of contents | back to top]

Instruments

Dataset-specific Instrument Name	High Frequency Radar
Generic Instrument Name	High Frequency Radar
Generic Instrument Description	High (5-50 MHz) frequency radar transmits electromagnetic waves and records the backscattered signal. Oceanographic usage includes sea surface radar in which the backscattered signals are analyzed to obtain surface current and wave parameters.

[table of contents | back to top]

Project Information

Collaborative Research: Physical Mechanisms Driving Food Web Focusing in Antarctic Biological Hotspots (Project SWARM)

Coverage: West Antarctic Peninsula

NSF Award Abstract:
Undersea canyons play disproportionately important roles as oceanic biological hotspots and are critical for our understanding of many coastal ecosystems. Canyon-associated biological hotspots have persisted for thousands of years Along the Western Antarctic Peninsula, despite significant climate variability. Observations of currents over Palmer Deep canyon, a representative hotspot along the Western Antarctic Peninsula, indicate

that surface phytoplankton blooms enter and exit the local hotspot on scales of ~1-2 days. This time of residence is in conflict with the prevailing idea that canyon associated hotspots are primarily maintained by phytoplankton that are locally grown in association with these features by the upwelling of deep waters rich with nutrients that fuel the phytoplankton growth. Instead, the implication is that horizontal ocean circulation is likely more important to maintaining these biological hotspots than local upwelling through its physical concentrating effects. This project seeks to better resolve the factors that create and maintain focused areas of biological activity at canyons along the Western Antarctic Peninsula and create local foraging areas for marine mammals and birds. The project focus is in the analysis of the ocean transport and concentration mechanisms that sustain these biological hotspots, connecting oceanography to phytoplankton and krill, up through the food web to one of the resident predators, penguins. In addition, the research will engage with teachers from school districts serving underrepresented and underserved students by integrating the instructors and their students completely with the science team. Students will conduct their own research with the same data over the same time as researchers on the project. Revealing the fundamental mechanisms that sustain these known hotspots will significantly advance our understanding of the observed connection between submarine canyons and persistent penguin population hotspots over ecological time, and provide a new model for how Antarctic hotspots function.

To understand the physical mechanisms that support persistent hotspots along the Western Antarctic Peninsula (WAP), this project will integrate a modeling and field program that will target the processes responsible for transporting and concentrating phytoplankton and krill biomass to known penguin foraging locations. Within the Palmer Deep canyon, a representative hotspot, the team will deploy a High Frequency Radar (HFR) coastal surface current mapping network, uniquely equipped to identify the eddies and frontal regions that concentrate phytoplankton and krill. The field program, centered on surface features identified by the HFR, will include (i) a coordinated fleet of gliders to survey hydrography, chlorophyll fluorescence, optical backscatter, and active acoustics at the scale of the targeted convergent features; (ii) precise penguin tracking with GPS-linked satellite telemetry and time-depth recorders (TDRs); (iii) and weekly small boat surveys that adaptively target and track convergent features to measure phytoplankton, krill, and hydrography. A high resolution physical model will generalize our field measurements to other known hotspots along the WAP through simulation and determine which physical mechanisms lead to the maintenance of these hotspots. The project will also engage educators, students, and members of the general public in Antarctic research and data analysis with an education program that will advance teaching and learning as well as broadening participation of under-represented groups. This engagement includes professional development workshops, live connections to the public and classrooms, student research symposia, and program evaluation. Together the integrated research and engagement will advance our understanding of the role regional transport pathways and local depth dependent concentrating physical mechanisms play in sustaining these biological hotspots.

This award reflects NSF's statutory mission and has been deemed worthy of support through evaluation using the Foundation's intellectual merit and broader impacts review criteria.

[table of contents | back to top]

Funding

Funding Source	Award
NSF Office of Polar Programs (formerly NSF PLR) (NSF OPP)	OPP-1745009
NSF Office of Polar Programs (formerly NSF PLR) (NSF OPP)	OPP-1744884
NSF Office of Polar Programs (formerly NSF PLR) (NSF OPP)	OPP-1745011

[table of contents | back to top]