FVCOM Annual Climatology for Temperature, Stratification, and Currents (1978-2013)
Northeast United States
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Prepared for*:*
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1. INTRODUCTION

These products are rasterized grids that depict annual climatology of physical oceanographic conditions in the Northwest Atlantic from the years 1978 to 2013 for surface and bottom temperature (Celsius), surface and bottom currents (meters/second), and stratification (σ_T/m).

A climatology is a long term average of a given environmental variable, e.g. a monthly climatology is the mean value for a given month over a certain time range, while an annual climatology is the mean value for a set of years over a certain time range. The data are based on a 36-year hindcast of the Northeast Coastal Ocean Forecast System (NECOFS) from School of Marine Science and Technology, University of Massachusetts Dartmouth (http://fvcom.smast.umassd.edu/necofs/). NECOFS is an integrated atmosphere-ocean model system designed for the northeast US coastal region, which includes the unstructured grid Finite-Volume Community Ocean Model (FVCOM) and surface wave model. NECOFS has been validated by hindcast experiments from 1978. More details about NECOEF can be found at http://fvcom.smast.umassd.edu/necofs/.

NECOEF hosts monthly mean data for a suite of metocean variables, including temperature, salinity, and currents. These data were downloaded and processed in Matlab and ArcGIS to create consolidated netCDF files to obtain mean monthly, seasonal, and annual values, as well as climatological monthly, seasonal, and annual values for the full hindcast. Data were downloaded via opendap for temperature, salinity and current speed (U and V). The only manipulation to temperature and current data was calculating mean/min/max/standard deviation using MATLAB built-in functions. Speed and direction for current data are calculated post nc files. For stratification, the provided parameter (*Density surface – Density*

20 m (or bottom if shallower)/difference in depth between 2 observations) was used. Firstly, temperature and salinity were needed for the entirety of the water column in order to find the temperature and salinity at 20 m or shallower.

- Loop through each nodal point
- Keep every surface temperature and salinity point – calculate density at the surface using sigmat
- At each point, find depth of water column. If depth < 20m, use bottom temperature and bottom salinity. If depth > 20 m, find the two nearest depth indexes and interpolate the T/S at those points. If depth = 20m, use that T/S.
- After running through for data at 20 m, calculate density for 20 m depth using sigma-t Stratification is then defined as (density surface - density 20 m)/difference in h

The annual climatological means for these variables were converted to raster grids with a resolution of 0.002 decimal degrees. Currents rasters are 2-dimensional containing bands for speed and direction, while temperature and stratification rasters are 1-dimensional.

2. PURPOSE

To support coastal and ocean planning.

3. SOURCES AND AUTHORITIES

- Unstructured Finite Volume Coastal Ocean Model (FVCOM), University of Massachusetts Dartmouth (UMass-Dartmouth) Marine Ecosystem Dynamics Modeling Laboratory (MEDML)
- Woods Hole Oceanographic Institute (rich signell's code) https://github.com/rsignell-usgs

4. DATABASE DESIGN AND CONTENT

Dataset Name:

temperature_surface_climatology_1978to2013_annual
temperature_bottom_climatology_1978to2013_annual
currents_surface_climatology_1978to2013_annual
currents_bottom_climatology_1978to2013_annual
stratification_climatology_1978to2013_annual

stratification_climatology_1978to2013_annual:

(This example represents data details specific to the climatological stratification grid; other products have similar types of information.)

Native storage format: ArcGIS File Geodatabase Raster
Columns and Rows: 12543, 12911
Number of Bands: 1
Cell Size: 0.002
Source Type: generic
Pixel Type: floating point
Pixel Depth: 32 Bit
Statistics:
Minimum: -0.1441485732793808
Maximum: 2.08730936050415
Mean: 0.02674907830124648
Standard Deviation: 0.01959840792083234

Dataset Status: Complete

5. SPATIAL REPRESENTATION

Reference System: GCS North American 1983
Horizontal Datum: North American Datum 1983
Ellipsoid: Geodetic Reference System 1980
Linear Unit: Meter (1.0)
Angular Unit: Degree (0.0174532925199433)
False Easting: 0.0
False Northing: 0.0
Central Meridian: 0.0

Geographic extent: -76.76 to -65.50, 35.00 to 44.62

IS0 19115 Topic Category: environment, oceans

Place Names:
Atlantic Ocean, Cape Cod Bay, Cape May, Connecticut, Delaware, Delaware Bay, Georges Bank, Gulf of Maine, Hudson Canyons, Hudson River, Long Island Sound, Maine, Massachusetts, Massachusetts Bay, New Hampshire, New Jersey, New York, New York Bight, Northwest Atlantic, Rhode Island, Rhode Island Sound, United States

Recommended Cartographic Properties:
(Using ArcGIS ArcMap nomenclature)
Stretch, Standard Deviations (2.5), Precipitation color ramp (inverted)

Scale range for optimal visualization: 1,000,000

6. DATA PROCESSING

Processing environment: ArcGIS 10.3, Matlab R2012b, Windows 7 Professional, Intel Core i5 CPU

	Process Steps Description
1	Download all available FVCOM hindcast data in netCDF format from UMass-Dartmouth server (date range is 1978-2013) at two levels for currents (surface and bottom) and at three levels for temperature and salinity (surface, 20-meter depth, and bottom).
2	Generate mean stratification using temperature and salinity to derive density information based on Unesco standard of seawater properties computation (UNESCO, 1983).
3	Process individual netCDF files using Matlab to obtain statistics for monthly, seasonal, annual, and climatological means, as well as for annual statistics. Store the results in new annual netCDF files which contain 13 variables that contain monthly and annual mean values for each year.
4	Download the netCDF4 python library and tools from github repository to import data from netCDF files into GIS format
5	Modify python scripts as needed and import netCDF data into GIS • Import temperature and stratification data into ArcGIS TIN format using ArcGIS 3D Analyst license to leverage the LandXML tool, which stores latitude, longitude, and modeled data values for each node of the unstructured FVCOM grid. • Import currents data into both ArcGIS point and polygon shapefile format. Points contain speed and direction variables. Polygons contain speed and depth variables.
6	Convert surface/bottom temperature and stratification TINs to raster format • TIN TO RASTER (3D Analyst), resolution = 0.002 decimal degrees
7	Convert surface/bottom currents point shapefiles to raster format • NATURAL NEIGHBOR (Spatial Analyst) interpolation to point shapefiles (resolution = 0.002 decimal degrees). Perform interpolation twice using speed variable and direction variable. • EXTACT BY MASK to clip interpolated current rasters to extent of FVCOM unstructured grid • COMPOSITE BANDS to create 2-dimensional rasters that store both speed and direction

7. QUALITY PROCESS

Completeness: Data contain the full FVCOM hindcast available as of the publication date.

Positional Accuracy: NECOFS model has been validated by hindcast experiments, and is capable of reproducing accurately both tidal and subtidal motions in the New England Shelf regions. Gridding the spatial representations of the FVCOM data into structured grids introduces additional positional uncertainty. Increasing resolution generally creates raster surfaces that more closely represent the original FVCOM surface. In this case a 0.002 decimal degree resolution was chosen because it approximated the smallest edge present in the unstructured FVCOM grid. Because the raster is a cell structure, it cannot maintain the hard and soft breakline edges that may be present in TIN products (e.g. temperature, stratification) or the preciseness inherent in point data (e.g. currents). Additional uncertainty is introduced into the currents products due to use of an interpolation technique which predicts data values based on a local subset of point samples that surround a given point. Whereas conversion from TIN to raster more closely reflects the trends in the original surface, interpolating from points ensures that interpolated values are within the range of sampled points.

Timeliness: 1978-2013

Use restrictions: None.

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