The Adaptive Ecosystem Climatology (AEC) *

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NASA Biodiversity and Ecological Forecasting Team Meeting May 23-25, 2017

*Patent Pending
Partner/End-User Organizations

NOAA National Centers for Environmental Information
NOAA Atlantic Oceanographic and Meteorological Laboratory
NOAA Southeast Fisheries Science Center
EPA Gulf Ecology Division
BOEM Gulf of Mexico Region
Decision-making needs and tools

**NOAA**
- ecosystem based management tools – models need temperature, salinity, plankton fields for initial conditions

**EPA**
- GoM hypoxia model – needs open boundary conditions

**BOEM**
- environmental sensitivity and marine productivity assessments in relation to potential impacts of offshore energy development

*in-situ* climatologies  Earth Observations  Models
U.S. West Coast
Bio-Physical Coupling

MODIS Chlorophyll
August 28, 2005
Data Assimilation example using NRL’s Coupled Ocean Data Assimilation system (NCODA)

Ocean Obs

Ocean QC

3D MVOI

Innovations

Increments

First Guess

Forecast Fields Prediction

Model forecast fields and prediction errors are used in the QC of newly received ocean observations

Sequential Incremental Update Cycle

Analysis-Forecast-Analysis

Ocean Model

Physical, bio-optical model, 5 days forecast

12 hour restart

NCODA, Physical observations assimilation

Updated with physics 12 hour restart

Multivariate data assimilation of bio-optical properties

Updated with physics and bio-optics 12 hour restart

Physical, bio-optical model, 5 days forecast

12 hour restart

NCODA, Physical observations assimilation

Updated with physics 12 hour restart

Multivariate data assimilation of bio-optical properties

Updated with physics and bio-optics 12 hour restart
Forecast/nowcast/hindcast

AEC product

MMDDYYYY
Aug 31, 2015

New observational data
(remote-sensing and/or in situ)
one or more variables
MMDDYYYY
Aug 31, 2015

Initial approximation
“first guess”
MMDD
Aug 31

Static Climatology
Jan01-Dec31 (366 days)
MMDD


Long-term Earth Observations (MODIS aqua)

Long-term Coupled Bio-physical Simulation Model Run
(biological, chemical, optical, and physical variables)


Sta®c Climatology
Jan01-Dec31 (366 days)


Long-term Earth Observations (MODIS aqua)
tatic

ecosystem

limatology
**Gulf of Mexico** (available)
18-30°N x 79-98°W
- MODIS Aqua (2003-2013)
  - 1 km resolution
  - Chlorophyll
  - Sea Surface Temperature

NCOM-COSINE Model (1980-2012)
- 4 km resolution
  - Chlorophyll
  - Phytoplankton groups
  - Zooplankton groups
  - Temperature
  - Salinity
  - Water velocity (U,V)

- **USWEST** (available soon)
29–53°N x 115-135°W
- MODIS Aqua (2003 – 2016)
  - 1 km resolution
  - Chlorophyll
  - Sea Surface Temperature

NCOM-COSINE Model (1999-2006)
- 9 km resolution (4 km in prep)
  - Chlorophyll
  - Phytoplankton groups
  - Zooplankton groups

- **USEAST**
24-46°N x 64-82°W
- MODIS Aqua (2003 – 2016)
  - 1 km resolution
  - Chlorophyll
  - Sea Surface Temperature

- Blended EO/Model in prep.
EO Whole Domain Climatology

NE Atlantic Spring Bloom

California Current Upwelling
Model and EO
Monthly Chlorophyll Climatologies

MODIS aqua CHL Climatology Jan

Model CHL Climatology Jan

2003-2016

1999-2006

Will continue to 2018
daptive cosystem limatology

AEC
Summary

Earth Observation August 31, 2015

Log$_{10}$ Total Chlorophyll (mg m$^{-3}$)

Chlorophyll (mg/m$^3$)

AEC August 31, 2015

Log$_{10}$ Total Chlorophyll (mg m$^{-3}$)

Chlorophyll (mg/m$^3$)

SEC August 31

Log$_{10}$ Total Chlorophyll (mg m$^{-3}$)

Chlorophyll (mg/m$^3$)

AEC Aug 31, 2015

mg CHL m$^{-3}$

Longitude (°W)

Latitude (°N)
Web portal current status:

- Change in the physical location of the OceanNOMADS server and data storage from Stennis Space Center, MS to Nashville, TN
- Automated AEC tools are being converted from fortran/Matlab to python scripts
Crowdsourcing:
Oskit App:

Water Temperature (°C)
Temperature: 0-40°C
Depth: 0-100 m

Water Salinity (psu)
Temperature: 0-40°C
Depth: 0-100 m

Sechi Disk Depth (m)
Depth: 0-100 m

Weather:

Connection Status: OK

Upload
Thanks:

**NASA:** Maury Estes, Woody Turner.

**BOEM:** Joseph Christopher, Rebecca Green.

**EPA:** Richard Greene, John Leherter.

**NOAA:** Rebecca Allee, Russ Beard, Scott Cross, Christopher Gledhill, Arnaud Grüss, George Halliwell, Christopher Kelble, Steve Morton, Woody Nero, Rost Parsons, Angela Sallis, Michael Schirripa.

**NRL:** Adam Lawson

**NRL/ONR Summer Interns:** Rachel Holliday, Sam Holliday, Francis Prikasky, Suhaas Yerramreddy
Naval Research Laboratory Gulf of Mexico Adaptive Ecosystem Climatology (AEC)

The Naval Research Laboratory Adaptive Ecosystem Climatology (AEC) combines an ocean model with Earth observations to provide a synoptic view of the typical (climatic) state of the ocean for every day of the year. The current version of AEC (beta4) is a research-quality product constructed for the Gulf of Mexico. The AEC comprises two sets of climatological mean fields: one derived from a coupled biophysical model simulation and one derived from satellite observations. The model-based daily climatology is derived from a 33-year simulation (1980–2012) of a 4-km resolution, coupled biophysical ocean model that uses the Navy Coastal Ocean Model (NCOM) hydrodynamics and the Carbon Silicate Nitrogen Ecosystem (COSINE) marine biochemistry. The model assimilates altimetry data and satellite sea surface temperature from the Advanced Very High Resolution Radiometer (AVHRR). It is forced by boundary conditions prescribed by the 1/8° Global NCOM, and by atmospheric fluxes prescribed by NASA's Modern Era Retrospective-Analysis for Research and Applications (MERRA). The satellite daily climatology provides chlorophyll concentration and sea surface temperature derived from the Moderate Resolution Imaging Spectroradiometer (MODIS) level-1 data processed at 1-km resolution and spanning the period 2003–2013. Each calendar day in the climatology represents a 5-day rolling average centered on that day, with data from all 11 years included. Thus, the value at each pixel is an average of up to 55 individual data values.

**AEC beta4 netCDF files contain (Model):**
- sea surface elevation, ocean temperature, salinity, eastward and northward currents, along with phytoplankton, diatoms, micro-zooplankton, and meso-zooplankton distributions at standard depths through the water column;
- (Satellite): sea surface temperature and sea surface chlorophyll.

<table>
<thead>
<tr>
<th>Product</th>
<th>Grid/Scale</th>
<th>POR</th>
<th>Model Cycle</th>
<th>Output Time Step</th>
<th>Access</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model-based climatology</td>
<td>1/25°</td>
<td>1 year climatology</td>
<td>1 day</td>
<td>1 day</td>
<td>TDS agg, TDS files, ERDDAP 2D, ERDDAP 3D</td>
</tr>
<tr>
<td>Satellite-based climatology</td>
<td>1/100°</td>
<td>1 year climatology</td>
<td>1 day</td>
<td>1 day</td>
<td>TDS agg, TDS files, ERDDAP</td>
</tr>
</tbody>
</table>

Coverage area for the Naval Research Laboratory's Gulf of Mexico Adaptive Ecosystem Climatology.
Dataset Title: AEC Model Climatology 3D  
Institution: Naval Research Laboratory, Stennis Space Center, MS  
Information: Summary | License | FGDC | ISO 19115 | Metadata | Background | Data Access Form

Graph Type: surface
X Axis: longitude
Y Axis: latitude
Color: water_temp

Dimensions
- Start: 2000-12-31T00:00:00Z
- Stop: 2000-12-31T00:00:00Z
- time (UTC) specify just 1 value → 2000-12-31T00:00:00Z
- depth (m) specify just 1 value → 0.0
- latitude (degrees_north) → 18.09165 → 30.73087
- longitude (degrees_east) → -98.0 → -77.36

Graph Settings
- Color Bar:
- Scale:
- Continuity:
- N Sections:
- Draw the land mask:

Redraw the Graph. (Please be patient. It may take a while to get the data.)

Optional:
- Then set the File Type: .htmlTable and Download the Data or an Image
- or view the URL: http://ecowatch.ncdc.noaa.gov/erddap/griddap/AEC_gomex_model_climo_3d.htmlTable

Things You Can Do With Your Graphs

Well, you can do anything you want with your graphs, of course. But some things you might not have considered are:

- Web page authors can embed a graph of the latest data in a web page using HTML <img> tags.
- Anyone can use ERDDAPs Slide Sorter to build a personal web page that displays graphs with the latest data (or other images or HTML content), each in its own, draggable slide.
**Dataset Title:** AEC Model Climatology 3D  
**Institution:** Naval Research Laboratory, Stennis Space Center, MS  
**Information:** Summary | License | FGDC | ISO 19115 | Metadata | Background | Make a graph

### Dimensions

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Start</th>
<th>Stride</th>
<th>Stop</th>
<th>Size</th>
<th>Spacing</th>
</tr>
</thead>
<tbody>
<tr>
<td>time (Forecast time for ForecastModelRunCollection, UTC)</td>
<td>2000-12-31T00:00:00Z</td>
<td>1</td>
<td>2000-12-31T00:00:00Z</td>
<td>366</td>
<td>1 day (even)</td>
</tr>
<tr>
<td>depth (m)</td>
<td>0.0</td>
<td>1</td>
<td>-2.0</td>
<td>40</td>
<td>-128.2051 (uneven)</td>
</tr>
<tr>
<td>latitude (degrees_north)</td>
<td>30.73087</td>
<td>1</td>
<td>30.73087</td>
<td>349</td>
<td>0.0363196 (uneven)</td>
</tr>
<tr>
<td>longitude (degrees_east)</td>
<td>-77.36</td>
<td>1</td>
<td>-77.36</td>
<td>517</td>
<td>0.04 (even)</td>
</tr>
</tbody>
</table>

### Grid Variables (which always also download all of the dimension variables)

- `✓` water_temp (Temperature, degree_Celsius)
- `✓` water_u (U Velocity, m/s)
- `✓` water_v (V Velocity, m/s)
- `✓` salinity (psu)
- `✓` sphy (Small Phytoplankton, micromoles N/L)
- `✓` diatoms (micromoles N/L)
- `✓` mezoo (Mesozooplankton, micromoles N/L)
- `✓` mizoo (Microzooplankton, micromoles N/L)

**File type:** .htmlTable - View a .html web page with the data in a table. Times are ISO 8601 strings.  
More info

Just generate the URL:  
[Documentation / Bypass this form](#)
.asc - View OPeNDAP-style comma-separated ASCII text.
.csv - Download a comma-separated ASCII text table (line 1: names; line 2: units; ISO 8601 times).
.csvp - Download a .csv file with line 1: name (units). Times are ISO 8601 strings.
.csv0 - Download a .csv file without column names or units. Times are ISO 8601 strings.
.das - View the dataset's metadata via an OPeNDAP Dataset Attribute Structure (DAS).
.dds - View the dataset's structure via an OPeNDAP Dataset Descriptor Structure (DDS).
.dods - OPeNDAP clients use this to download the data in the DODS binary format.
.esriAscii - Download an ESRI ASCII file (lat lon data only; lon must be all below or all above 180).
.fgdc - View the dataset's FGDC .xml metadata.
.graph - View a Make A Graph web page.
.help - View a web page with a description of griddap.
.html - View an OPeNDAP-style HTML Data Access Form.
.htmlTable - View a .html web page with the data in a table. Times are ISO 8601 strings.
.iso19115 - View the dataset's ISO 19115-2/19139 .xml metadata.
.json - View a table-like JSON file (missing value = 'null'; times are ISO 8601 strings).
.mat - Download a MATLAB binary file.
.nc - Download a NetCDF-3 binary file with COARDS/CF/ACDD metadata.
.ncHeader - View the header (the metadata) for the .nc file.
.ncml - View the dataset's structure and metadata as an NCML .xml file.
.odvTxt - Download time,lat,lon,otherVariables as an ODV Generic Spreadsheet File (.txt).
.tsv - Download a tab-separated ASCII text table (line 1: names; line 2: units; ISO 8601 times).
.tsvp - Download a .tsv file with line 1: name (units). Times are ISO 8601 strings.
.tsv0 - Download a .tsv file without column names or units. Times are ISO 8601 strings.
.xhtml - View an XHTML (XML) file with the data in a table. Times are ISO 8601 strings.
.geotiff - View a grayscale GeoTIFF .tif file (for lat lon data; lon must be all below or all above 180).
.kml - View a Google Earth .kml file (for lat, lon data only).
.smallPdf - View a small .pdf image file with a graph or map.
.pdf - View a standard, medium-sized .pdf image file with a graph or map.
.largePdf - View a large .pdf image file with a graph or map.
.smallPng - View a small .png image file with a graph or map.
.png - View a standard, medium-sized .png image file with a graph or map.
.largePng - View a large .png image file with a graph or map.
.transparentPng - View a .png image file (just the data, without axes, landmask, or legend).
Catalog http://ecowatch.ncddc.noaa.gov/thredds/catalog/aec_model/catalog.html

Dataset: AEC Model/AEC.beta4.GOM5i0.04.0000123100.nc

- Data size: 231.6 Mbytes
- ID: AEC_model/AEC.beta4.GOM5i0.04.0000123100.nc

Access:

1. OPENDAP: /thredds/dodsC/aec_model/AEC.beta4.GOM5i0.04.0000123100.nc
2. HTTPServer: /thredds/fileServer/aec_model/AEC.beta4.GOM5i0.04.0000123100.nc
3. WCS: /thredds/wcs/aec_model/AEC.beta4.GOM5i0.04.0000123100.nc
4. WMS: /thredds/wms/aec_model/AEC.beta4.GOM5i0.04.0000123100.nc
5. NCML: /thredds/ncml/aec_model/AEC.beta4.GOM5i0.04.0000123100.nc
6. UDDC: /thredds/uddc/aec_model/AEC.beta4.GOM5i0.04.0000123100.nc
7. ISO: /thredds/iso/aec_model/AEC.beta4.GOM5i0.04.0000123100.nc

Dates:

- 2014-09-23T18:33:02Z (modified)

Viewers:

- Godiva2 (browser-based)
- NetCDF-Java ToolsUI (webstart)
November 9, 2011

SST

sea_water_temperature (degree_Celsius)
at 0.0m

Path
Salinity
Temperature
Sea Surface Height
Currents

Profiles:

Timeseries:

Lon: -93.2632814794922, Lat: 23.70578824999998
Lon: -93.268320062499998, Lat: 23.9023114375
Lon: -93.30359397753904, Lat: 23.74610074999997
Lon: -93.2632814794922, Lat: 23.66547575