HiOOS Data Management and Communications (DMAC)

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data
servers
metadata
services
viewers
data, servers, metadata, services, viewers
NetCDF: Network Common Data Form
**NetCDF: Network Common Data Form**

- **time series:**
  - nearshore sensors
  - water quality buoys
  - tide gauges
  - gliders
  - high frequency radios
  - forecast models

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**HiOOS - Hawai‘i Ocean Observing System**

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time series:
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- water quality buoys
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- forecast models
  - ocean circulation
  - ocean waves
  - atmosphere

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NetCDF: Network Common Data Form

time series:
nearshore sensors
water quality buoys
tide gauges

ROMS: Regional Ocean Modeling System
SWAN: Simulating WAves Nearshore
WRF: Weather Research and Forecasting

NWW3: NOAA/NCEP WaveWatch III
GFS: NOAA/NCEP Global Forecast System

forecast models
ocean circulation
ocean waves
atmosphere

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Structured grids:

Regular grids:

- Cartesian grid
- Rectilinear grid

Irregular grids:
- Curvilinear grid

Unstructured grids:

- [Image of unstructured grid]
- [Image of another unstructured grid]
- [Image of a third unstructured grid]
Structured grids:

Regular grids:
- Cartesian grid: linear, unvarying
- Rectilinear grid: linear, but varying in one dimension

Irregular grids:
- Curvilinear grid: linear, but varying in two dimensions

Unstructured grids:
- Connection between points must be explicitly defined; cannot be computed
- Complex, difficult, manual, but much more flexible

i & j are integer array indices ("index space")
map to
x & y are floating point lat/lon coordinates ("coordinate space")

Examples:
- Squares
- Rectangles
- Quadrilateral polygons: quadrangles or tetragons
- Triangles

Equations:
- Cartesian grid: \( x = i \), \( y = j \)
- Rectilinear grid: \( x = i \times \text{transform} \), \( y = j \times \text{transform} \)
- Curvilinear grid: \( x = (i \times \text{transform}) + (j \times \text{transform}) \), \( y = (i \times \text{transform}) + (j \times \text{transform}) \)
NetCDF: Network Common Data Form

time series:

- nearshore sensors
- water quality buoys
- tide gauges
- gliders
- high frequency radios
- forecast models

- point
- trajectory
- radial
- grid

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TDS: THREDDS Data Server

Thematic Realtime Environmental Distributed Data Services
data servers metadata services viewers

TDS: THREDDS Data Server

Thematic Realtime Environmental Distributed Data Services

• data catalog: organize and present your NetCDF data in one place
• virtual aggregations: more than a simple file server
• modifications to data/metadata via NetCDF Markup Language (NcML)
TDS: THREDDS Data Server

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Dapper

- used for DChart and ERDDAP viewers
- specifically for NetCDF point data
data servers metadata services viewers

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OOS Tethys

- Sensor Observation Service (SOS)
- specifically for NetCDF point data

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• descriptive information: who, what, when, where, why, how
• standardized vocabularies
• machine-readable format (XML)
• enable community-wide search and discovery
THREDDS Dataset Inventory Catalog Specification

- presents metadata on TDS catalog page
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CF: NetCDF Climate and Forecast Metadata Convention
- global attributes + standard variable names + standard data organization + etc.
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NetCDF Attribute Convention for Dataset Discovery
• global attribute fields
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ISO 19115-2: Geographic Information – Metadata
- international standard; will be auto-generated from the above standards
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• standard protocols for accessing data over HTTP
• data accessed via URL; customize result via parameter values:
  REST = Representational State Transfer
• import data directly into user’s software client (Matlab, ArcGIS, etc.)
• enable community-wide data interoperability

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OPeNDAP: Open-source Project for a Network Data Access Protocol
• subset data via index ranges (e.g. [start:stride:stop], [0:5:50]); get ASCII or binary
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**NetCDF Subset Service**
- subset gridded data via lat/lon, time, and/or depth; get ASCII, XML, or NetCDF
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WMS: Web Map Service
• for gridded data, get image (JPG, PNG, GIF, KMZ); specify projection, space, time, etc.
**WCS: Web Coverage Service**
- for gridded data, get GeoTIFF; specify projection, space, time, resolution, etc.

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**SOS: Sensor Observation Service**
- for point data, get XML (**O&M**); specify space, time, etc.
data servers metadata services viewers

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**NetCDF Subset Service**

**WMS**: Web Map Service

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**SOS**: Sensor Observation Service
LAS: Live Access Server

- view gridded data: produce maps and plots; animate, compare, Google Earth, download
LAS: Live Access Server
• view gridded data: produce maps and plots; animate, compare, Google Earth, download

DChart: Dapper Chart
• view point or gridded data: dynamic plots or maps; download; Google Maps/Earth
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ERDDAP: Environmental Research Division’s Data Access Program
- view/download gridded data or download point data; get table; embed elsewhere
ERDDAP > griddap > Make a Graph

Dataset Title: Simulating Waves Nearshore (SWAN) Regional Wave Model: Oahu
Dataset ID: SWAN_Oahu_Best
Institution: University of Hawai‘i
Information: Summary | Variables | Background | Data Access Form

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

Dimension Ranges
- time (UTC)
- altitude (m)
- latitude (degrees_north)
- longitude (degrees_east)

Graph Settings
- Color Bar: 
- Continuity: 
- Scale: 

Redraw the Graph

Then set the File Type: htmlTable and Download the Data or an Image
or view the URL: http://oos.soest.hawaii.edu/erddap/griddap/SWAN_Oahu_f

Things You Can Do With Your Graphs
- Web page authors can embed a graph of the latest data in a web page using HTML <img> tags.
- Anyone can use Slide Sorter to build a personal web page that displays graphs of the latest data, each in its own, draggable slide.
- Anyone can use or make Google Gadgets to display images with the latest data on their Goggle home page.
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**LAS: Live Access Server**
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**DChart: Dapper Chart**
- view point or gridded data: dynamic plots or maps; download; Google Maps/Earth

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**Google Maps API and Google Earth**
- HiOOS Data Viewer: one application for viewing all our data, plus others (in progress)
future directions

- Google Maps API Version 3
- add **HFR** and models to HiOOS Data Viewer (*+ lots others...*)
- add data plots to info pop-ups in HiOOS Data Viewer
- next LAS version will allow vector plots
- explore ncWMS and Godiva2
- webapp to monitor system health: data + servers + services
- finish adding metadata in TDS
- mobile devices?
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Forecast Model Run Collection (FMRC)

1. **run time** = start of the model run (i.e. when it was kicked off) (a.k.a. **analysis time** or **generating time**)
2. **forecast time** = the time series that the model produces; can be a forecast, nowcast, or hindcast (a.k.a. **valid time**)
3. **forecast offset** or **forecast hour** = difference between run time and forecast time

### 2D Time Coordinates:

The forecast times vary for each run time, so an FMRC by definition has 2D time coordinates:

```plaintext
String runtime(run=8);
  :long_name = "Run time for model";
  :standard_name = "forecast_reference_time";
  :_CoordinateAxisType = "RunTime";
  data: "2006-09-05T12:00:00Z", "2006-09-06T12:00:00Z", "2006-09-07T12:00:00Z", "2006-09-08T12:00:00Z", "2006-09-09T12:00:00Z", "2006-09-10T12:00:00Z", "2006-09-11T12:00:00Z", "2006-09-12T12:00:00Z"

double time(run=8, time=16);
  :units = "hours since 2006-09-05T12:00:00Z";
  :long_name = "forecast (valid) time";
  :standard_name = "time";
  :_CoordinateAxisType = "Time";
  data: 
  {90.0, 96.0, 102.0, 108.0, 114.0, 120.0, 126.0, 132.0, 138.0, 144.0, 150.0, 156.0, 162.0, 168.0, 174.0, 180.0}, 
  {114.0, 120.0, 126.0, 132.0, 138.0, 144.0, 150.0, 156.0, 162.0, 168.0, 174.0, 180.0}, 
  {138.0, 144.0, 150.0, 156.0, 162.0, 168.0, 174.0, 180.0}, 
  {156.0, 162.0, 168.0, 174.0, 180.0}, 
  {174.0, 180.0}, 
  {198.0, 204.0}, 
  {212.0, 218.0, 224.0, 230.0, 236.0, 242.0, 248.0, 254.0, 260.0, 266.0, 272.0, 278.0, 284.0, 290.0, 296.0, 302.0, 308.0, 314.0, 320.0, 326.0, 332.0, 338.0, 344.0, 350.0}
```

Each data variable will have both run time and forecast time dimensions: e.g. `float temp(run,time,depth,lat,lon);`

### 1D Time Coordinates:

TDS can be used to create different views/slices of an FMRC on a single time axis:

1. **run time:**
   - **Forecast Model Run** = the time series (forecast times) for a particular model run (run time)
2. **forecast time:**
   - **Best Time Series** = the time series (forecast times) constructed from the most recent model run available
   - **Constant Forecast Date** = data with the same forecast time across different model runs (run times)
3. **forecast offset or forecast hour:**
   - **Constant Forecast Offset** = data for the same forecast offset or forecast hour (e.g. 0 hour, +6 hour, etc.) across different model runs
Forecast Model Run = time series (forecast times) for a particular model run (runtime)
**1D Time Coordinates:**

**Constant Forecast Date** = data with same forecast time across different model runs

**NOTE:** final timestamp = nowcast (runtime = forecast time)

**NOTE:** successively shorter forecasts
Constant Forecast Offset = data for same forecast offset (e.g. +1 day, +6 hours, etc.) across different model runs.

1D Time Coordinates:
Best Time Series = time series from most recent model run available = all nowcasts (+0 offset) + latest model forecasts (right column)