Using netCDF and HDF in ArcGIS

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Outline

- NetCDF and HDF in ArcGIS
- Visualization and Analysis
- Sharing
- Customization using Python
- Demo
- Future Directions
Scientific Data and Esri

- Direct support - NetCDF and HDF
- OPeNDAP/THREDDS – a framework for scientific data networking, integrated use by our customers
- Users of Esri technology
  - National Climate Data Center
  - National Weather Service
  - National Center for Atmospheric Research
  - U. S. Navy (NAVO)
  - Air Force Weather
  - USGS
  - Australian Navy
  - Australian Bur.of Met.
  - UK Met Office
NetCDF Support in ArcGIS

- ArcGIS reads/writes netCDF since version 9.2
- An array based data structure for storing multidimensional data.
- N-dimensional coordinates systems
- X, Y, Z, time, and other dimensions
- Variables – support for multiple variables
- Temperature, humidity, pressure, salinity, etc
- Geometry – implicit or explicit
  - Regular grid (implicit)
  - Irregular grid
  - Points
Gridded Data

Regular Grid

Irregular Grid
Reading netCDF data in ArcGIS

- NetCDF data is accessed as
  - Raster
  - Feature
  - Table

- Direct read
- Exports GIS data to netCDF
Climate and Forecast (CF) Convention
http://cf-pcmdi.llnl.gov/

Initially developed for
- Climate and forecast data
- Atmosphere, surface and ocean model-generated data
- Also for observational datasets

- The CF conventions generalize and extend the COARDS (Cooperative Ocean/Atmosphere Research Data Service) convention.

- CF is now the most widely used conventions for geospatial netCDF data. It has the best coordinate system handling.
NetCDF and Coordinate Systems

• Geographic Coordinate Systems (GCS)
  • X dimension units: degrees_east
  • Y dimension units: degrees_north

• Projected Coordinate Systems (PCS)
  • X dimension standard_name: projection_x_coordinate
  • Y dimension standard_name: projection_y_coordinate
  • Variable has a grid_mapping attribute.
  • CF 1.6 conventions currently supports thirteen predefined coordinate systems (Appendix F: Grid Mappings)

• Undefined
  • If not GCS or PCS

• ArcGIS writes (and recognizes) PE String as a variable attribute.
NetCDF Tools

Toolbox: Multidimension Tools

- Make NetCDF Raster Layer
- Make NetCDF Feature Layer
- Make NetCDF Table View
- Raster to NetCDF
- Feature to NetCDF
- Table to NetCDF
- Select by Dimension
NetCDF Layer/Table Properties

- Raster
- Feature
- Table
Changing Time Slice

Time = 1
Reading HDF in ArcGIS
# HDF Raster Support

<table>
<thead>
<tr>
<th>Raster Concept</th>
<th>ArcGIS 10.1 Support</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Raster Format</strong></td>
<td>• HDF4</td>
</tr>
<tr>
<td></td>
<td>• read: open a HDF subdataset as a Raster Dataset</td>
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<tr>
<td></td>
<td>• write: APIs available but not exposed in UI</td>
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<td></td>
<td>• HDF5</td>
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<tr>
<td></td>
<td>• read: open a HDF subdataset as a Raster Dataset</td>
</tr>
<tr>
<td></td>
<td>• write: not supported at this time</td>
</tr>
<tr>
<td><strong>Raster Type</strong></td>
<td>• HDF4, HDF5</td>
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<td></td>
<td>• direct ingest of one or many HDF subdatasets into a Mosaic Dataset using the</td>
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<tr>
<td></td>
<td>Raster Dataset Raster Type or the Table Raster Type</td>
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<tr>
<td></td>
<td>* Esri interested in discussing other Raster Types</td>
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<tr>
<td><strong>Raster Product</strong></td>
<td>* Esri interested in discussing other Raster Products</td>
</tr>
<tr>
<td><strong>Raster Product Definition</strong></td>
<td>* Esri interested in discussing other Raster Product Definitions</td>
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Displaying MODIS LST Data

HDFView

ArcGIS
Using netCDF Data in ArcGIS

Behaves the same as any layer or table

• Display
  • Same display tools for raster and feature layers will work on netCDF raster and netCDF feature layers.
  • Mosaic dataset and function

• Graphing
  • Driven by the table just like any other chart.

• Animation
  • Multidimensional data can be animated through a dimension (e.g. time, pressure, elevation)

• Analysis Tools
  • A netCDF layer or table will work just like any other raster layer, feature layer, or table. (e.g. create buffers around netCDF points, reproject rasters, query tables, etc.)
Visualizing with animation

- Use animation to visualize temporal changes in a dataset
Spatial and Temporal Analysis

- Several hundreds analytical tools available for raster, features, and table

- Temporal Modeling
  - Looping and iteration in ModelBuilder and Python
Sources of Scientific Data

• NOAA
  - National Climatic Data Center (NCDC)
  - National Oceanographic Data Center (NODC)
  - Earth System Research Laboratory, Physical Science Division

• NASA
  - Global Change Master Directory (GCMD)
  - EOSDIS Data Center

• USGS
  - Earth Resources Observation and Science (EROS) Center

• Unidata’s Motherload THREDDS Data Server (TDS)

• .... and many more
Sharing

• **Map Service**
  - Makes maps available to the web.

• **Image Service**
  - Provides access to raster data through a web service.

• **Geoprocessing Service**
  - Exposes the analytic capability of ArcGIS to the web.

• **Map Package**
  - To share complete map documents and the data referenced by the layer it contains.

• **Geoprocessing Package**
  - To share your geoprocessing workflow.
Script Tools

- Python is used to build custom tools for specific tasks or datasets
Reading Features from a netCDF File

- Input netCDF File: C:\cwr.nc
  - Variables:
    - lat (Latitude)
    - lon (Longitude)
    - time (Time)
    - date (Date)
    - elevation (Mean sea level elevation)
    - varea (Absolute area covered by land)
    - vreg (VEMAP vegetation classification)
    - mask (VEMAP geog mask)
    - pptx (Precipitation)
  - Output Feature Layer: receiLayer

- Input netCDF File: C:\Surface_METAR_20120322_0000.nc
  - Variables:
    - minimum time observation (minimum time observation)
    - maximum time observation (maximum time observation)
    - number stations (no description available)
    - lastChild (latest report for this station)
    - numChildren (number of reports for this station)
    - station_id (Station id)
    - station_description (Geographic station description)
    - wmo_id (Numeric WMO Identifier)
    - latitude (Station latitude)
  - Output Feature Layer: WindspeedLayer
Generate Rainfall Statistics

- Calculates specified statistics for all time steps
- Outputs a raster catalog
- Optionally outputs a netCDF file
Community Developed Tools

- Geoprocessing Resource Center
  http://resources.arcgis.com/geoprocessing/

- Marine Geospatial Ecology Tools (MGET)
  - Developed at Duke Univ.
  - Over 180 tools for import management, and analysis of marine data

- Australian Navy tools
  (not publicly available)
New NetCDF Tools (under development)

- OPeNDAP to NetCDF
- Clip
- Extract By Variable
- Extract By Dimension
- Append By Dimension
- Variable Statistics
- Temporal Statistics
OPeNDAP to NetCDF (OPeNDAP)
Scientific Data Workshop, Ocean Summit and Future Initiatives

- Esri recently hosted Ocean Summit in November 2012
- And Scientific Data Workshops in February 2012
- To understand the future need for scientific data support in ArcGIS
- Ongoing efforts - require close collaboration with all of you

- Some of the future initiatives are:
  - Support netCDF in mosaic dataset
  - Continue to support netCDF classic and netCDF4
  - Provide better support for HDF5
  - Provide tool to consume data served using THREDDS/OPeNDAP
  - Continue to support the evolving CF convention
  - Support a strong developer experience for netCDF and HDF using Python

- What else?
Things to Consider…

- Embrace the Common Data Model (netCDF, HDF etc.)
- Use Data and metadata standards (OGC, CF etc)

- Provide “mechanism” so that we can access scientific data using a single set of APIs….
- and can expect data to be CF complainant

- Make your data “spatial” (by specifying geographic or a projected coordinate system)
- Clearly define workflow and requirements
- Create sample tools where possible
Thank You

Please complete a session evaluation form.

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