Bridging the Gap between NASA Hydrological Data and the Geospatial Community

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Introduction

There is a vast and ever-increasing amount of data on the Earth's interconnected energy and hydrological systems, and yet one challenge persists: increasing the usefulness of these data for, and thus their use by, geospatial communities. The Hydrology Data and Information Services Center (HDISC), part of the Goddard Earth Sciences DISC, has continually worked to better understand the hydrological data needs of geospatial end users, to thus better able to bridge the gap between NASA data and geospatial communities.

Hydrological Data at HDISC NASA

- The goal of a land data assimilation system (LDAS): generate optimal fields of land surface states and fluxes and, thereby, facilitate hydrology and climate modeling, research, and forecasting.
- NLDAS: North American Land Data Assimilation System (Mitchell et al., 2004)
- GLDAS: Global Land Data Assimilation System (Rodell et al., 2004)

Table 1. Basic characteristics of the NLDAS and GLDAS products

	NLDAS	GLDAS
Content	Water and energy budget data, forcing data	
Spatial coverage	Conterminous US, parts of southern Canada and northern Mexico	All land north of 60° South
Spatial resolution	0.125°	0.25° and 1.0°
Temporal coverage	Phase-1: Aug.1, 1996 - Dec. 31, 2007 Phase-2: Jan. 1, 1979 – present	Version-1 1.0°: Jan. 1, 1979 - present 0.25°: Feb. 24, 2000 - present Version-2: Jan. 1, 1948 - present
Temporal resolution	Hourly (monthly is coming soon)	3-hourly and monthly
Forcing	Multiple data sets derived from satellite measurements, radar estimation, precipitation gauges, and atmospheric analyses	Multiple data sets derived from satellite measurements and atmospheric analyses
Land surface models	Mosaic, NOAH, SAC, VIC	CLM, Mosaic, NOAH, VIC
Output format	GRIdded Binary (GRIB)	
Elevation definition	GTOPO 30	
Vegetation definition	University of Maryland, 1 km	

Both NLDAS and GLDAS data sets have recently been improved.

- With the motivation of creating more climatologically consistent data sets, GLDAS-2 data have been generated by using the Princeton meteorological dataset (Sheffield et al, 2006) and upgraded versions of Land Surface Models (LSMs).
- The NLDAS Phase 1 data (1996 – 2007) were added to the GES DISC archives and released to the public, to allow easier comparisons between the two phases of NLDAS.

Table 2. LSM model versions for GLDAS-1 and GLDAS-2.

Model	Resolution	GLDAS-1	GLDAS-2	Remarks
NOAH	1.0°	Version 2.7	Version 2.7.1	Updated model parameters that specify the initial soil temperature
CLM	1.0°	Version 2.0	Version 3.5	Used MODIS based parameter data sets, stand alone
VIC	1.0°	Version 4.4 Water balance mode	Energy balance mode	Includes all variables
Mosaic	1.0°	GSFC-LDAS/GLDAS version		Switched model from Mosaic to Catchment
Catchment	1.0°		LIS6 version	
NOAH	0.25°	Version 2.7, Snow DA (data assimilation): direct insertion	Version 2.7.1, Snow DA: forward-looking	Updated model parameters that specify the initial soil temperature

More information about GLDAS and NLDAS and model data validation can be found at Land Data Assimilation Systems Web site at http://ldas.gsfc.nasa.gov/nldas/.

GLDAS and NLDAS Data Access

All NLDAS and GLDAS data are accessible from the HDISC NASA (http://disc.sci.gsfc.nasa.gov/hydrology). To facilitate access to these data by various user communities, the HDSIC has implemented several convenient data access methods.

- **Mirador** searching and downloading (Lynnes et al., 2009) - Includes keyword searching, hierarchical navigation based on projects and on Science Areas. Provides spatial and parameter subsetting and data format conversion. http://mirador.gsfc.nasa.gov/
- **GrADS Data Server (GDS)** access - Provides parameter and spatial subsetting. Outputs data in binary, ASCII, or image. Performs any operation that can be expressed in a single GrADS expression. http://hydro1.sci.gsfc.nasa.gov/dods/
- **Anonymous ftp** downloading - Navigation based on model year and date; simple and fast direct data downloading. ftp://hydro1.sci.gsfc.nasa.gov/data/s4pa/
- **Giovanni** visualization and analysis - a Web-based application developed by the GES DISC NASA.

Table 3. GLDAS and NLDAS data access at http://disc.sci.gsfc.nasa.gov/hydrology/data-holdings.

Data Type (Short Name)	Description	FTP	GDS	Mirador Navigation	Mirador Search	Giovanni * (Visualization)
NLDAS-1, 0.125 degree, North America						
NLDAS_FOR0125_H.001	Hourly forcing	✓	✓	✓	✓	✓
NLDAS-2, 0.125 degree, North America						
NLDAS_FORA0125_H.002	Hourly primary forcing	✓	✓	✓	✓	✓
NLDAS_FORB0125_H.002	Hourly secondary forcing	✓	✓	✓	✓	✓
NLDAS_MOS0125_H.002	Hourly Mosaic	✓	✓	✓	✓	✓
GLDAS-2, 1.0 degree, Global						
GLDAS_NOAH10_3H_E1.002	3 hourly Noah experiment 1	✓	✓	✓	✓	✓
GLDAS_NOAH10_M_E1.002	Monthly Noah experiment 1	✓	✓	✓	✓	✓
GLDAS-1, 0.25 degree, Global						
GLDAS_NOAH025SUBP_3H	3 hourly Noah	✓	✓	✓	✓	
GLDAS_NOAH025_M	Monthly Noah	✓	✓	✓	✓	
GLDAS-1, 1.0 degree, Global						
GLDAS_CLM10SUBP_3H	3 hourly CLM	✓	✓	✓	✓	✓
GLDAS_CLM10_M	Monthly CLM	✓	✓	✓	✓	✓
GLDAS_MOS10SUBP_3H	3 hourly Mosaic	✓	✓	✓	✓	✓
GLDAS_MOS10_M	Monthly Mosaic	✓	✓	✓	✓	✓
GLDAS_NOAH10SUBP_3H	3 hourly Noah	✓	✓	✓	✓	✓
GLDAS_NOAH10_M	Monthly Noah	✓	✓	✓	✓	✓
GLDAS_VIC10_3H	3 hourly VIC	✓	✓	✓	✓	✓
GLDAS_VIC10_M	Monthly VIC	✓	✓	✓	✓	✓
LPRM/AMSR-E/Aqua L2B Surface Soil Moisture, Ancillary Params, and QC						
LPRM_AMSRE_SOILM2_V001	Hourly global	✓		✓	✓	

Bridging the Gap ("Digital Divide")

- Data Volume: Vast and increasing, NLDAS/GLDAS estimated total around 20 TB
- Data Format: NLDAS/GLDAS in GRIB (GRIdded Binary), and many others in HDF or NetCDF.
- Data Organization: All variables one time step per file, inefficient for time series retrieving.

Hydrologic information science commonly requires data to be at specific geo-locations, often as time series. In order to retrieve a single point complete time series for one parameter, e.g., a user has to go through the entire data archive, often of volumes in the Terabytes. This is the "Digital Divide," described by Maidment et al. (2010).

Examples of NASA GES DISC efforts in increasing the usefulness of these data for, and thus their use by, the geospatial communities.

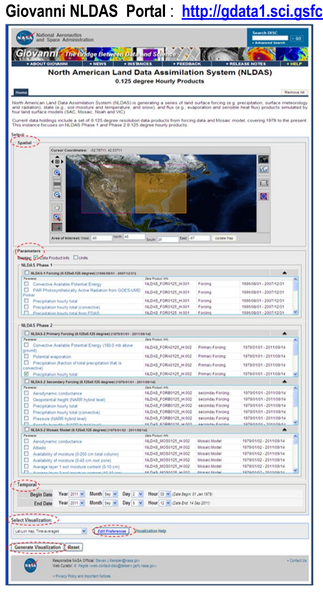
Giovanni: Online Visualization and Analysis

Giovanni: GES DISC Interactive Online Visualization ANd ANalysis Infrastructure

Giovanni (http://disc.sci.gsfc.nasa.gov/techlab/giovanni/) is a NASA Goddard data analysis and visualization system that provides a simple and intuitive way to visualize, analyze, and access vast amounts of Earth science remote sensing data, without having to download the data (Acker and Leptoukh, 2007; Berrick et al., 2009). It is an online application that allows researchers to rapidly explore data, so that spatial-temporal variability, anomalous conditions, and patterns of interest can be directly analyzed online before optional downloading of data. Giovanni has contributed to many users' science research efforts and applications (http://disc.sci.gsfc.nasa.gov/giovanni/additional/publications).

Users can simply select a specific region or location point, one or more parameters, spatial and temporal ranges, and the visualization function (e.g., latitude-longitude map, time series), and get the result in image, ASCII, netCDF, or HDF format. ASCII outputs can be directly input to GIS, Excel, and other software packages for further studies, together (possibly) with data from other sources. NLDAS hourly, GLDAS 3-hourly, and GLDAS monthly data are available via Giovanni NLDAS and GLDAS portals.

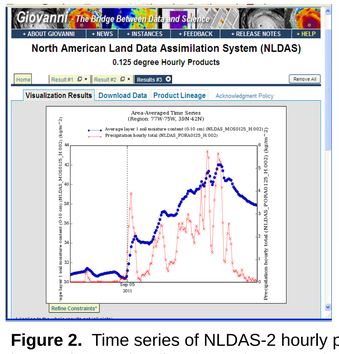
Giovanni NLDAS Portal : http://gdata1.sci.gsfc.nasa.gov/daac-bin/G3/gui.cgi?instance_id=NLDAS0125_H



Left: GUI interface for Giovanni NLDAS portal, which provides visualization, analysis, and inter-comparison for NLDAS Phase 1 and 2 forcing and model data.

Right: Top: Average hourly precipitation of NLDAS-2 Primary Forcing for Tropical Storm Lee (Sep. 2 – 9, 2011). The image was generated by NLDAS Giovanni portal at GES DISC. Bottom: Giovanni GUI for "Download Data".

Figure 1. Giovanni NLDAS hourly portal and sample results.

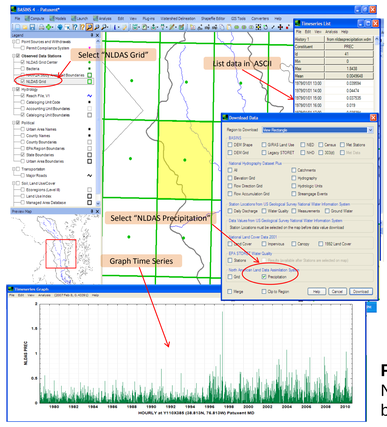


Both time series plot and ASCII outputs were generated by Giovanni NLDAS portal.

Figure 2. Time series of NLDAS-2 hourly precipitation (primary forcing) and average layer 1 (0-10cm) soil moisture from Mosaic model.

Integrate NASA NLDAS precipitation data into BASINS

BASINS: Better Assessment Science Integrating Point & Nonpoint Sources



BASINS, http://water.epa.gov/scitech/datait/models/basins, created by the U.S. Environmental Protection Agency (EPA), is a multi-purpose environmental analysis system that integrates a GIS, national watershed data, and state-of-the-art environmental assessment and modeling tools into one convenient package.

- In collaboration with BASINS project, NASA HDISC has made the NLDAS precipitation data available via BASINS interface, thus making the data spatially searchable and allowing BASINS users access to single point 30-year time series of hourly NLDAS precipitation data in a single request (Fig. 3).
- To enable these capabilities and ensure operational performance, the NLDAS GRIB data were reprocessed (reorganized) by parameter and spatial subsetting, archived in a way optimized for time series retrieval, and incorporated into the GrADS Data Server (GDS).
- Because NLDAS covers all of CONUS and parts of Canada and Mexico, with high temporal and spatial resolutions (hourly 0.125° x 0.125°), the data are in high demand by the hydrological community.

Figure 3. Top: Screen snapshots of BASINS interface, showing availability of NLDAS data. **Bottom:** 30-year time series of NLDAS-2 precipitation, generated by NASA GDS and accessed via, and graphed by, BASINS.

Integrate NASA hydrological data into CUAHSI HIS

CUAHSI: Consortium of Universities for the Advancement of Hydrologic Science, Inc.

- The CUAHSI Hydrologic Information System (HIS), http://his.cuahsi.org/, is an internet-based system for sharing hydrologic data.
- In collaboration with the Hydrologic Sciences Branch GSFC NASA and CUAHSI HIS, NASA HDISC has integrated NLDAS into CUAHSI HIS. GLDAS and other NASA hydrological data will be integrated into HIS.
- Work has focused on developing a Web service that serves NASA hydrological data, as time series, and corresponding metadata in WaterML.

With the HDISC Web service registered in CUAHSI HIS, the NLDAS, GLDAS, and other NASA hydrological data could become searchable, retrievable, and analyzable, along with hydrologic data from other sources available via HIS. This enhanced data access will facilitate, for the broad CUAHSI HIS user community, the use of NASA hydrological data.

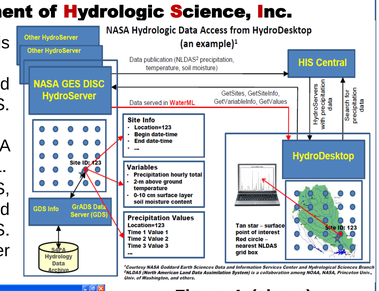


Figure 4 (above). Schematic of NASA hydrological data access from CUAHSI HIS' client, HydroDesktop.

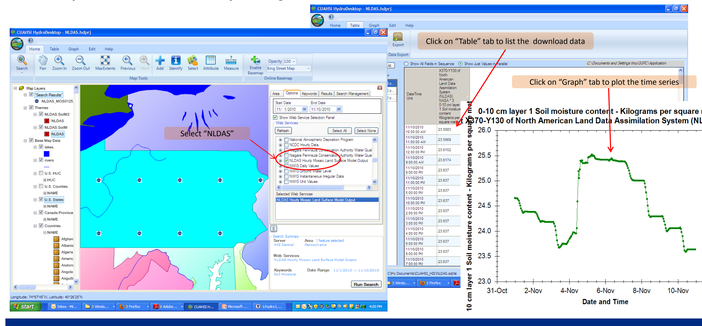


Figure 5 (Left). Screen snapshots of the HydroDesktop showing selected NLDAS data and time series graph.

Conclusions

- The gap, or "Digital Divide," between NASA hydrological data and the geospatial community is a longstanding one and still to be bridged. The key to bridging this gap is a better understanding of the hydrological data needs of the geospatial end users, which is a central focus of the NASA HDISC.
- The availability of the GLDAS and NLDAS data sets via NASA Giovanni portals is one approach to facilitate the integration of NASA data by end users.
- The two ongoing, collaborative efforts between HDISC and EPA BASINS and CUAHSI HIS have already demonstrated the potential of user-customized Web services for enhanced access to and use of NASA data, in these two cases, in the form of on-the-fly retrieval of long duration time series for a geographical point.