NLDAS Views of North American 2011 Extreme Events

Hualan Rui[1], William Teng[1], Bruce Vollmer[1], David Mocko[2], Guang-Dih Lei[1]

1. GES DISC, GSFC NASA, Greenbelt, MD 20771, United States.
2. Hydrological Sciences Laboratory, GSFC NASA, Greenbelt, MD 20771, United States.

Hydrology Data and Information Services Center (HDISC)
NASA Goddard Earth Sciences (GES) Data and Information Services Center (DISC)
Help Desk: gsfc-help-disc@lists.nasa.gov
Email: Hualan.Rui@nasa.gov

AGU Chapman Feb. 19 ~ 22, 2012

Introduction

2011 was marked as one of the most extreme years in recent history. Over the course of the year, weather-related extreme events, such as floods, heat waves, blizzards, tornadoes, and wildfires, caused tremendous loss of human life and property. The North American Land Data Assimilation System (NLDAS, http://ldas.gsfc.nasa.gov/nldas/) data set, with high spatial and temporal resolutions (0.125° x 0.125°, hourly) and various water- and energy-related variables, is an excellent data source for case studies of extreme events.

This presentation illustrates some extreme events from 2011 in North America, including the Groundhog Day Blizzard, the July heat wave, Hurricane Irene, and Tropical Storm Lee, all utilizing NLDAS Phase 2 (NLDAS-2) data.

Extreme Weather 2011

On January 19, 2012, NOAA announced two additional severe weather events have reached the $1 billion damage threshold, raising 2011's billion-dollar disaster count from 12 to 14 events, and classified 2011 as a year of climate extremes in the United States.

http://www.noaanews.noaa.gov/stories2012/20120119_global_stats.html

Billion-dollar Disasters of 2011

Courtesy: NOAA

Groundhog Day blizzard	Jan. 29 - Feb. 3, 2011
Midwest/Southeast tornadoes	April 4-5, 2011
Southeast/Midwest tornadoes	April 8-11, 2011
Midwest/Southeast tornadoes	April 14-16, 2011
Southeast/Ohio Valley/Midwest tornadoes	April 25-28, 2011
Midwest/Southeast tornadoes	May 22-27, 2011
Midwest/Southeast tornadoes and severe weather	June 18-22, 2011
Southern Plains/Southwest drought and heat wave	Spring-Fall, 2011
Mississippi River flooding	Spring-Summer, 2011
Rockies and Midwest severe weather	July 10-14, 2011
Upper Midwest flooding	Summer 2011
Hurricane Irene	August 20-29, 2011
Texas, New Mexico, Arizona wildfires	Spring-Fall 2011
Tropical Storm Lee	Early Sep., 2011

Figure 1. Spatial distribution (above-left) of billion-dollar disasters 2011.
Table 1. List of 14 billion-dollar disasters 2011 (above-right).

How does 2011 compare to other years?

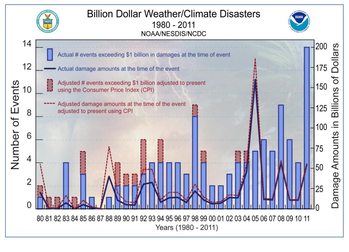


Figure 2. 1980-2011 billion dollar weather /climate disasters. (Courtesy: NOAA)

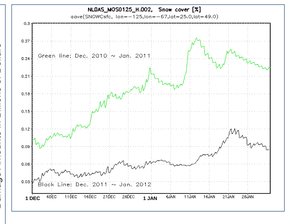
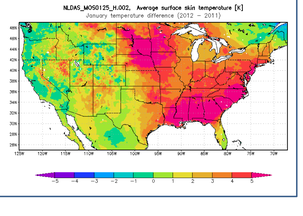


Figure 3. Time series of hourly Snow Cover (NLDAS-2 Mosaic, averaged over 125W~67W, 25N~49N) shows the Dec 2011 to Jan 2012 snow cover (black line) much less than that of Dec 2010 to Jan 2011 (green line).

Figure 4. January monthly-averaged Surface Skin Temperature differences (right, NLDAS-2 Mosaic) between 2012 and 2011. For most of the middle and eastern U.S. regions, Jan. 2012 average temperatures were 3 ~ 5 degrees higher than Jan. 2011 average temperatures, with temperature differences greater than 5 degrees for South Dakota, Nebraska, Iowa, Mississippi, Alabama, and Georgia.



Groundhog Day Blizzard

The first billion-dollar disaster of 2011 was a large winter storm that impacted many central, eastern and northeastern states, with total losses greater than $1.8 billion.

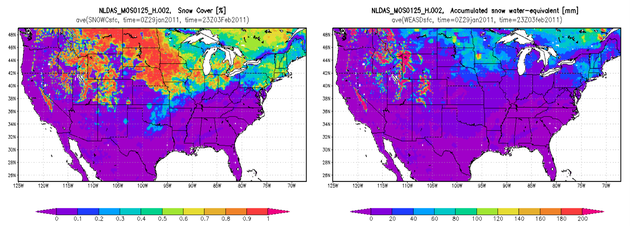


Figure 5. Snow Cover map (above-left, NLDAS-2 Mosaic averaged from Jan 29 to Feb. 3 2011) of the Groundhog Day Blizzard shows most US regions covered by snow, with high percentage (>80%) over center-north USA.

Figure 6. Snow Water - equivalent (above-right, NLDAS-2 Mosaic, averaged from Jan. 29 to Feb. 3 2011) of the Groundhog Day Blizzard. Snow Water-equivalent is one of the variables for monitoring drought and flood during winter.

Other snow related variables from NLDAS-2 Mosaic model outputs (right):

- Snow fall (frozen precipitation)
- Snow cover
- Snow depth
- Snow melt
- Snow phase-change heat flux
- Accumulated snow water-equivalent
- Sublimation (evaporation from snow)
- Albedo
- Surface temperature

Heat wave on the Plains

Spring-Fall 2011, drought and excessive heat created major impacts across Texas, Oklahoma, New Mexico, Arizona, southern Kansas, and western Louisiana. The total direct losses have approached $10 billion.

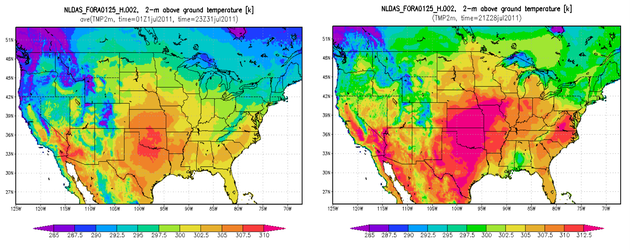
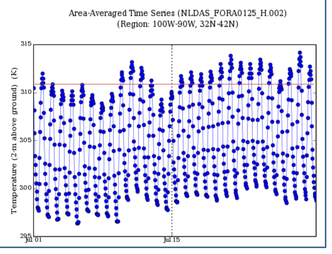


Figure 7. July 2011 Monthly-averaged Surface Temperatures (above-left, NLDAS-2 Primary Forcing) shows the heat wave in July centered on Texas and Oklahoma, with temperatures above 305°K (90°F).

Figure 8. Hourly Surface Temperatures (above-right, NLDAS-2 Primary Forcing) for 21Z July 28, 2011 shows that large areas over Texas, Oklahoma, and Missouri had temperatures above 312.5°K (103°F).

Figure 9. July 2011 time series of hourly Surface Temperature (left, NLDAS-2 Primary Forcing, averaged over the central United States) shows the daily cycle and the increasing daily lows and highs. More than 20 days in July 2011 had area-averaged daily highs above 100°F (310.93°K, red line).



Hurricane Irene

Hurricane Irene, as it moved northward along the East Coast of the United States from the Caribbean Sea through New England, brought tremendous rainfall and wind and caused at least 45 deaths and more than $7.3 billion in damages.

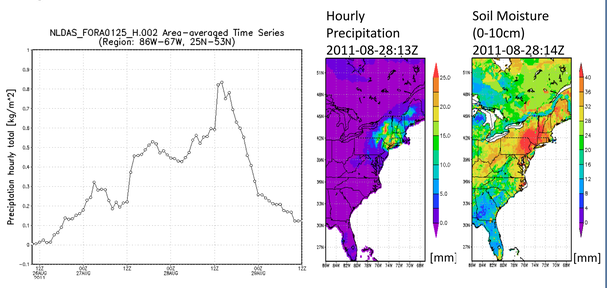


Figure 10. Time series of hourly precipitation (above-left, NLDAS-2 Primary Forcing, averaged over 86W~67W, 25N~53N) shows three rainfall peaks at 03Z August 27, 2011 for North Carolina, 19Z August 27, 2011 for Virginia, and 13Z August 28, 2011 for New York.

Figure 11. Hourly precipitation of 13Z Aug. 28, 2011 (above-middle, NLDAS-2 Primary Forcing) shows the heaviest rainfall at the time in New York, with rain rates greater than 25 mm per hour.

Figure 12. Soil Moisture of 14Z Aug., 2011 (above-right, NLDAS-2 Mosaic) shows high soil moisture content centered on New York correspondently.

Tropical Storm Lee

Tropical Storm Lee poured huge amounts of water on top of the already saturated Northeast and again inundated many inland cities, causing at least 21 deaths and more than $1.0 billion in damages.

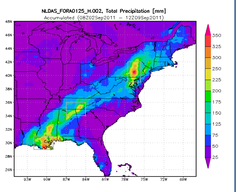
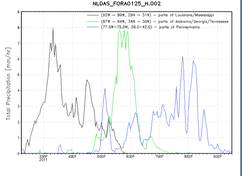


Figure 13. Accumulated precipitation between 08Z Sep. 02 and 12Z Sep. 09, 2011 (right-top, NLDAS-2 Primary Forcing) shows three heavy rain centers, with accumulated rainfall exceeding 10 inches (254 mm).

Figure 14. Area-averaged time series of hourly Precipitation (right-bottom, NLDAS-2 Primary Forcing) for the three heavy rain regions depicted by the boxes in Figure 13 shows clearly when the heaviest rain started and ended.



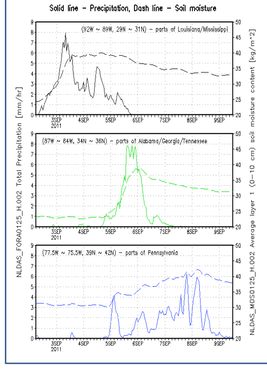


Figure 15. Time series of precipitation and soil moisture (left, NLDAS-2 Primary Forcing and Mosaic, averaged over the three heavy rain regions depicted by the boxes in Figure 13) shows the persistence of high soil moisture content, after the heavy rains from Tropical Storm Lee have contributed to flash flooding in many areas.

An hourly animation of precipitation can show the heavy rain rates and locations hour by hour and such animation can be generated via Giovanni NLDAS Hourly Portal without having to download any data.

NLDAS Data and Access

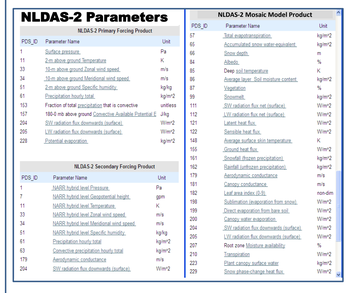
NLDAS data are accessible from the Hydrology Data and Information Services Center (HDISC) at the NASA GES DISC, http://disc.sci.gsfc.nasa.gov/hydrology.

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	✓		✓	✓	✓

Four ways to access the data

- **Mirador searching and downloading**
  - Parameter and spatial subsetting
  - NetCDF conversion (coming soon …)
- **GrADS Data Server (GDS) accesses**
  - Online visualization and data analysis
  - Parameter and spatial subsetting
  - Output Types: Binary, ASCII, Image
- **FTP downloading**
  - Quick access and batch processing
  - Navigation based on date
- **Giovanni Portals**
  - Online visualization and data analysis
  - Parameter and spatial subsetting
  - Output Types: HDF, NetCDF, ASCII, and Image (GIF/PNG and KMZ)

http://disc.sci.gsfc.nasa.gov/hydrology/data-holdings



- Giovanni is a Web-based application developed by the GES DISC 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.
- NLDAS data sets have been made available via the Giovanni NLDAS Hourly Portal.

http://disc.sci.gsfc.nasa.gov/hydrology/data-holdings/nldas-parameters

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

Summary

- To date, NLDAS has generated more than 33 (1979 – present) years of data. These quality-controlled, spatially and temporally consistent, terrestrial hydrological data could play an important role in characterizing the spatial and temporal variability of water and energy cycles and, thereby, improve our understanding of the land-surface-atmosphere interaction and the impact of land-surface processes on climate extremes.
- Using NLDAS-2 Primary Forcing and Mosaic model data, four of the 2011 billion-dollar weather/climate disasters are illustrated. NLDAS-2 data show very well the major characteristics of these extreme events, spatially and temporally. NLDAS-2 data is an excellent data source for case studies of extreme events.
- NLDAS data are accessible from the Hydrology Data and Information Services Center (HDISC) at the NASA GES DISC, http://disc.sci.gsfc.nasa.gov/hydrology.
- Giovanni NLDAS Hourly Portal provides a simple and intuitive way to visualize, analyze, and inter-compare NLDAS data without having to download the data.
- Global Land Data Assimilation System (GLDAS) has generated more than 30 (1979 – present, Version 1) and 60 (1948 – present, Version 2) years of data. All GLDAS data are also accessible via GES DISC Hydrology Portal.

NLDAS is a collaboration project among several groups (NOAA/NCEP/EMC, NASA/GSFC, Princeton University, University of Washington, NOAA/OHD, and NOAA/NCEP/CPC) and is a core project of NOAA/MAPP.