

Goddard Space Flight Center

Land Information System

Introduction to Land Data Assimilation Systems (LDASs)

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Greenbelt, MD

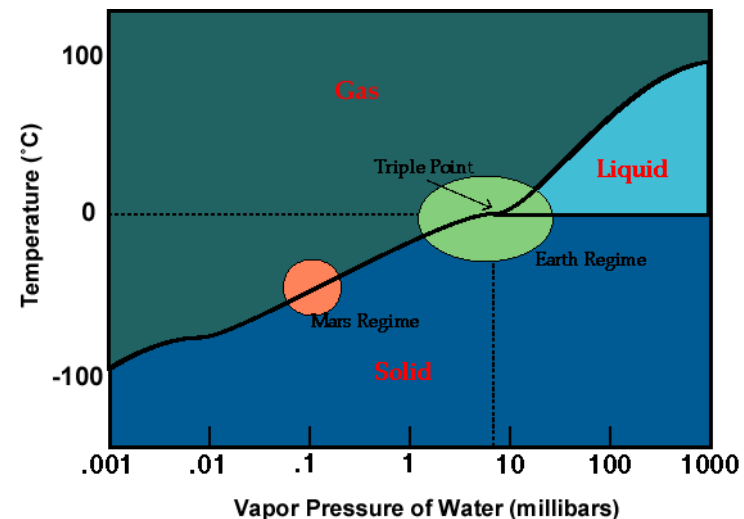
<http://lis.gsfc.nasa.gov>





The Hydrologic/Water Cycle

- The endless movement of water between the land, oceans and atmosphere
- Water moves across different reservoirs (ocean, rivers, atmosphere) through the physical processes of **evaporation**, **condensation**, **precipitation**, **infiltration**, **runoff** and **subsurface flow**
- Water goes through different phases during various stages of the water cycle
- Each phase change involves exchange of energy (and temperature changes)
 - Evaporation – takes up energy, cools the environment
 - Condensation – releases energy, warms the environment





Importance of Hydrology

- Fresh Water Resources and Availability
- Climate Change
- Agricultural planning
- Drought assessment
- Weather forecasting
- Water quality
- Food security
- Air quality
- Military applications



Key processes of the water cycle

Transformation of water from liquid to gas phase

Transpiration: water taken up by the plants released to the atmosphere

Difficult to separate the processes of evaporation and transpiration; often called **evapotranspiration**

Water escapes through the stomata (small pores on the leaves). Plants regulate the rate of transpiration by controlling the size of stomata

Under water stress conditions, plants would close the stomata to conserve energy

Soil moisture: Variable representing reservoir of water on land; controls the exchanges of water and energy between the land and atmosphere; affects **evapotranspiration, runoff, infiltration.**

Soil moisture levels are related to water resource applications; plant growth, water stress, droughts, floods

Different forms of **precipitation:** Rain, snow, hail, fog, drip, graupel, sleet

Many of the water related problems are related to the fact that precipitation is not evenly distributed in space and time

Snow: Another variable representing reservoir of water on land; intimately affects runoff, infiltration.

In many mid-latitude and high-altitude regions, the seasonal water storage and associated spring melt dominate the local hydrology.

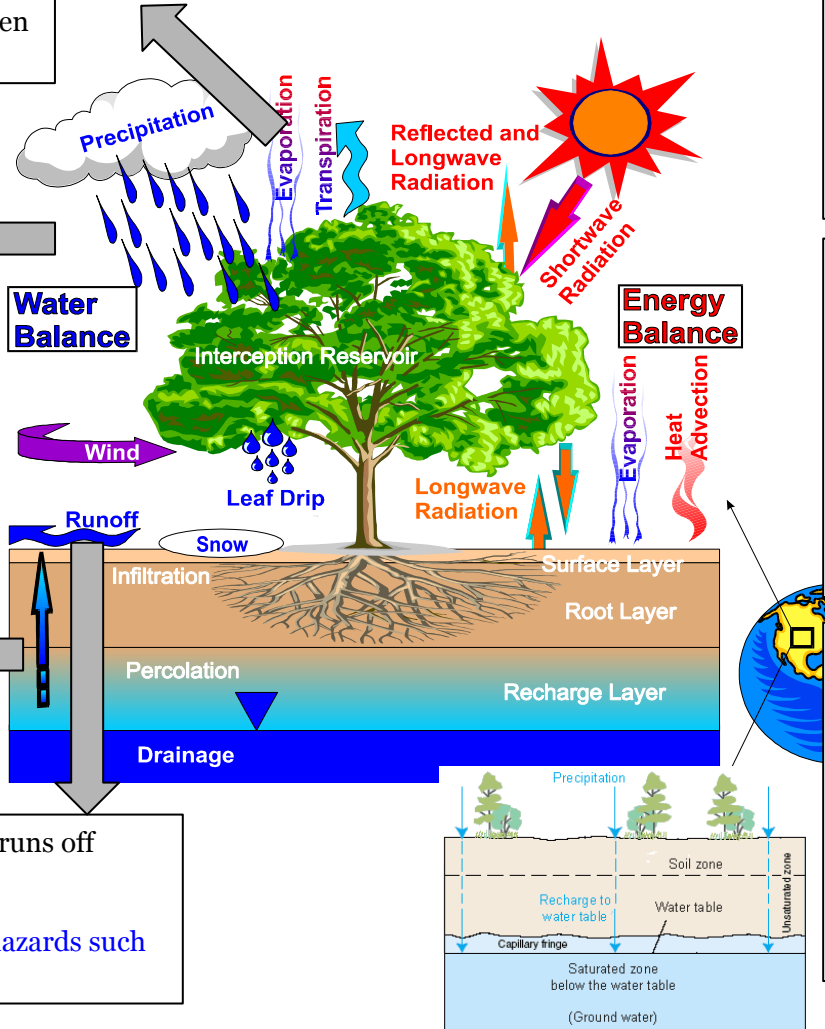
Infiltration: Some of the precipitation on land seeps into the ground to be stored in aquifers, transported to lakes and streams through subsurface flow

Groundwater/aquifer: water stored in the saturated zone. The top of the aquifer is called **water table**

Groundwater accounts for almost 33% of total water withdrawals worldwide; Key as a strategic reserve in times of drought; often ignored in management decisions.

Runoff: Water that does not infiltrate the soil runs off across the surface into streams, rivers, lakes.

Runoff and infiltration contribute to natural hazards such as floods





Challenges of water cycle monitoring

Technique	Advantages	Disadvantages
In-situ measurements	“Real” data	Labor intensive; quality control issues; spatial interpolation
Remote sensing	Spatial coverage	Resolution; Sensing limitations; retrieval errors
Numerical model	Choose any region or time period; Economical	Quality limited by input; difficulty representing complex processes





Land Surface Observations: in-situ

Precipitation: Surface Gages and Doppler Radar

Radiation: DOE-ARM, Mesonets, USDA-ARS

Surface Temperature: DOE-ARM, Mesonets, NWS-ASOS, 1

Soil Moisture: DOE-ARM, Mesonets, Global Soil Moisture Data Bank, USDA-ARS

Groundwater: Well Observations

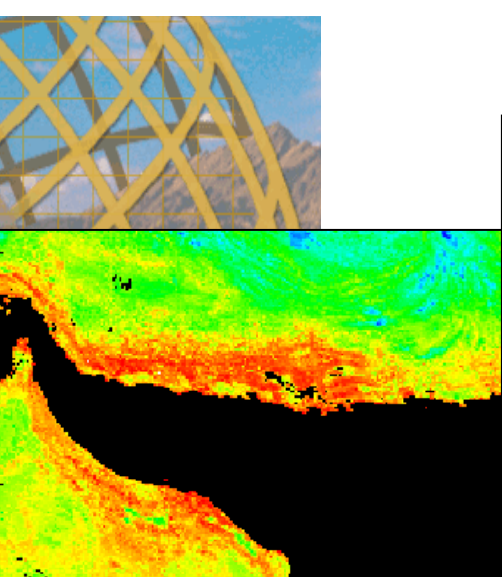
Snow Cover, Depth & Water: Field Experiments, SNOTEL

Streamflow: Real-Time Stream Gauge

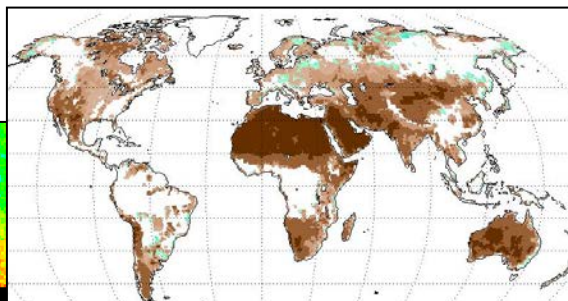
Vegetation: Field Experiments

Soils: Field Experiments

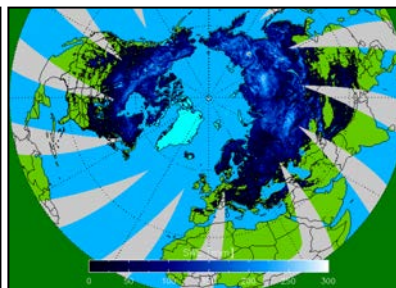




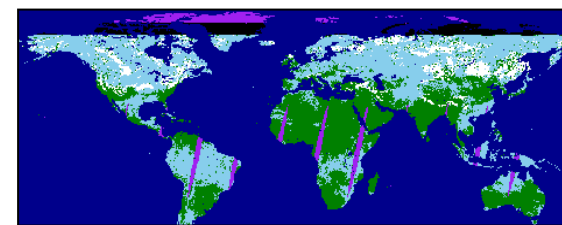
Land surface temperature
(MODIS, AVHRR, GOES, ...)



Surface soil moisture
(SMMR, TRMM, AMSR-E,
SMOS, Aquarius, SMAP)



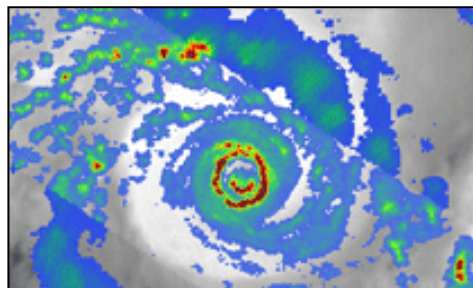
Snow water equivalent
(AMSR-E, SSM/I,
SCLP)



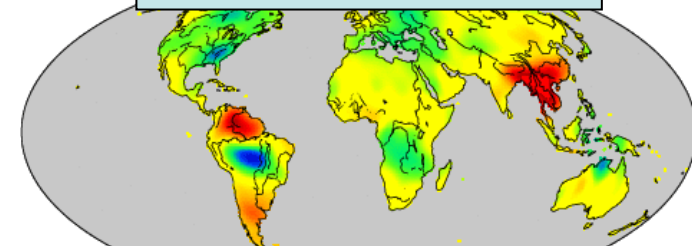
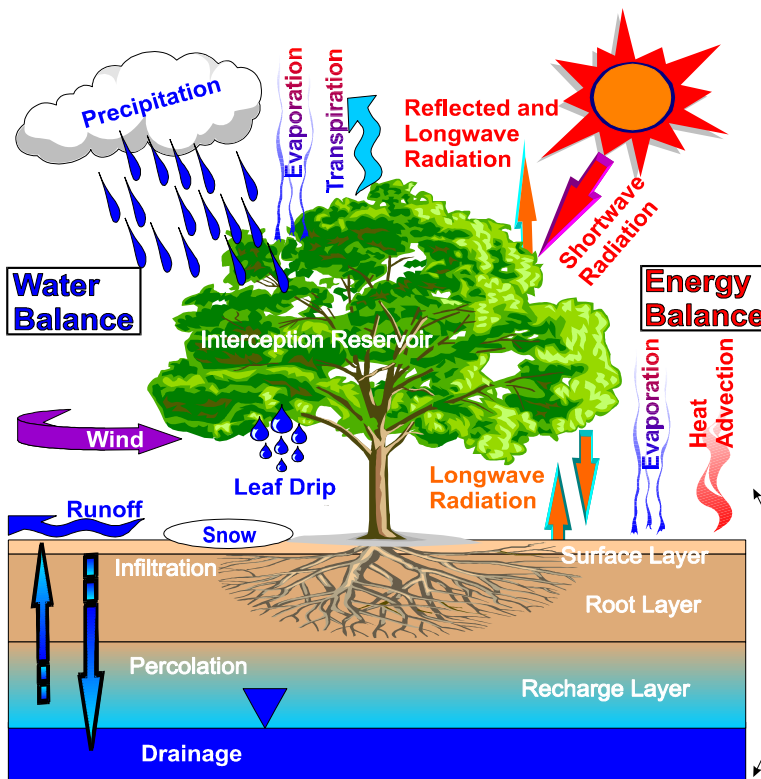
Snow cover fraction
(MODIS, VIIRS, MIS)



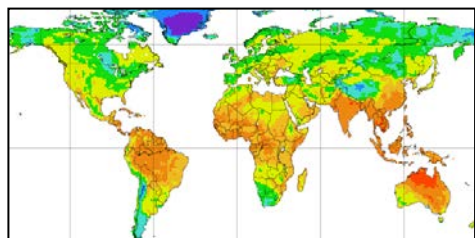
Water surface elevation
(SWOT)



Precipitation
(TRMM, GPM)



Terrestrial water storage (GRACE)



Radiation
(CERES, CLARREO)

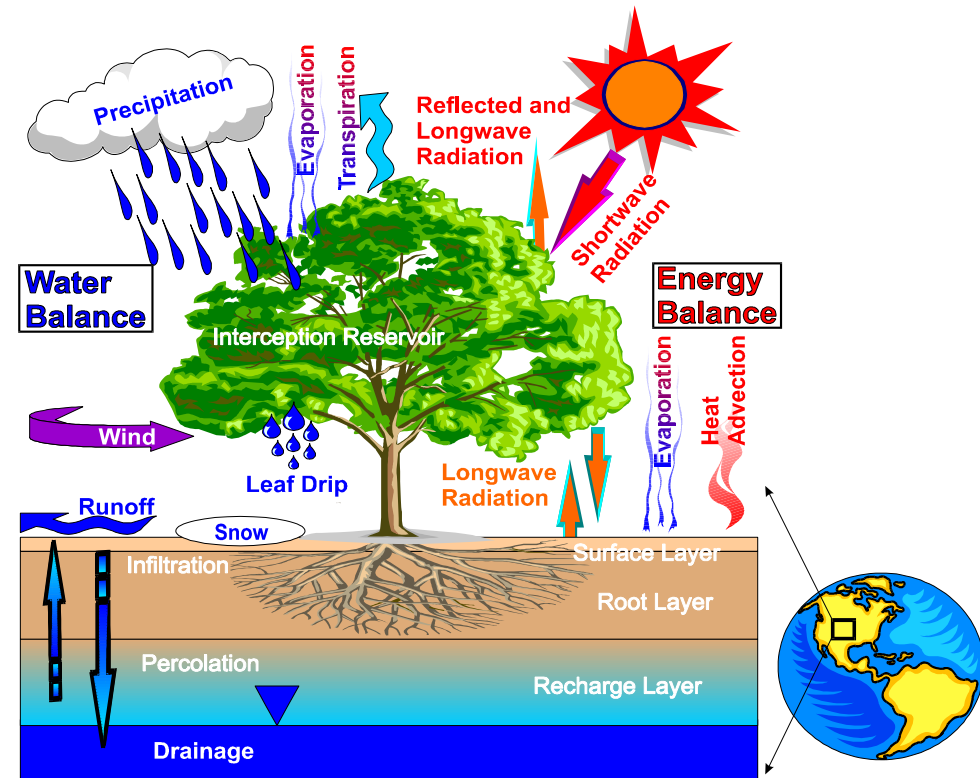
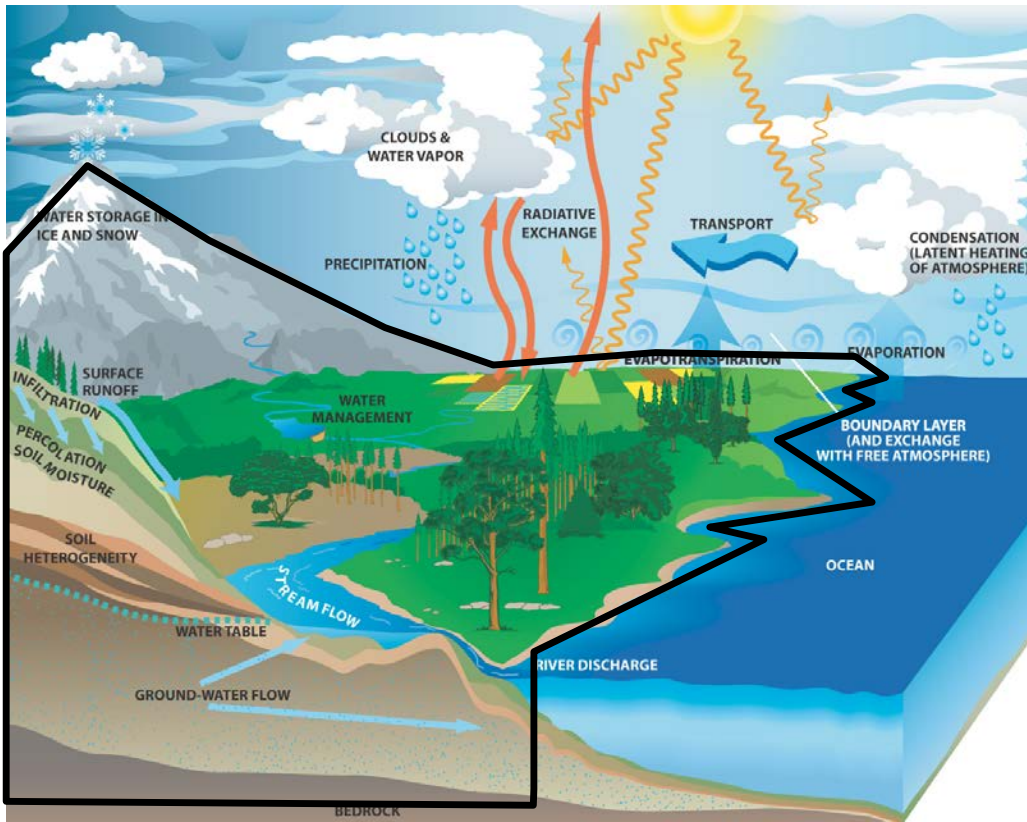


Vegetation/Carbon
(AVHRR, MODIS, DESDynI,
*ICESat-II, HypsIRI, LIST,
ASCENDS*)

Satellite observations



What are “Land surface models”?



Land surface models solve for the interaction of energy, momentum and mass between the surface and the atmosphere

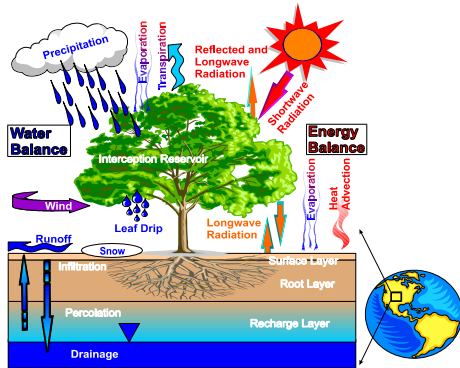
$$R_n = \lambda E + SH + G \qquad \frac{dS}{dt} = P - E - R$$

Estimates fluxes, land conditions (soil moisture, snow, runoff, ...)
e.g. : Noah, CLM, VIC, Catchment, JULES ...

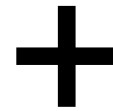




How do we combine the information from satellite observations and models?



Models

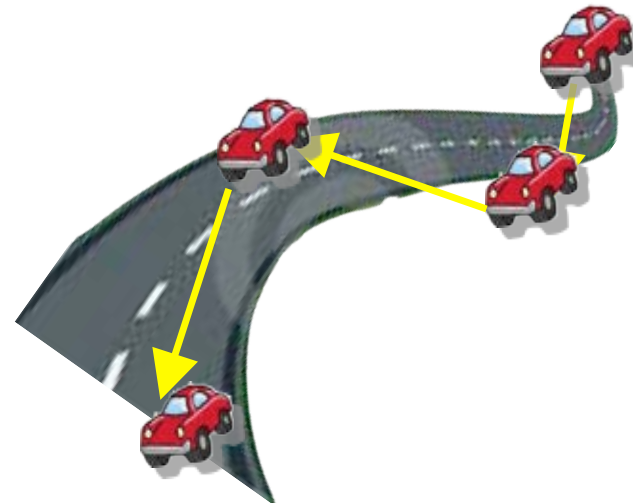


Observations

Data assimilation is the method used to incorporate observational data into model forecasts



Like a “sleepy-driver” scenario





Land Data Assimilation Systems (LDASs)

Philosophy: Use best available observations to inform models

NASA Land Information System (LIS; <http://lis.gsfc.nasa.gov>) - infrastructure that enables LDASs

Used in several US and international agencies, universities for research and applications (Famine early warning, crop forecasts, water resources management, ...)

LIS Framework
Land Information System

About - Docs - Source - Test Cases - Support - Data - ...

Software Suite

The Land Information System (LIS) is a software framework for high performance terrestrial hydrology modeling and data assimilation developed with the goal of integrating satellite and ground-based observational data products and advanced modeling techniques to produce optimal fields of land surface states and fluxes.

The LIS development is led by the Hydrological Sciences Laboratory at NASA's Goddard Space Flight Center.

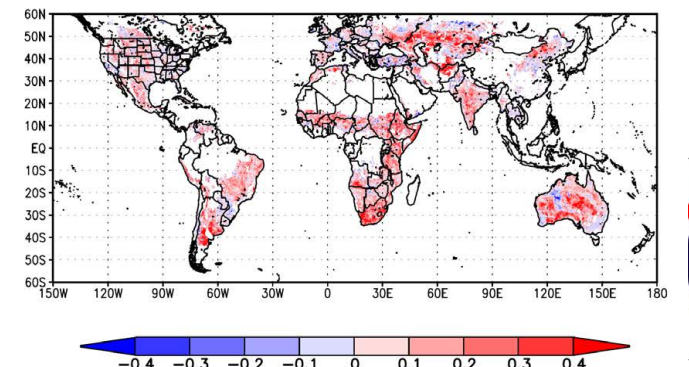
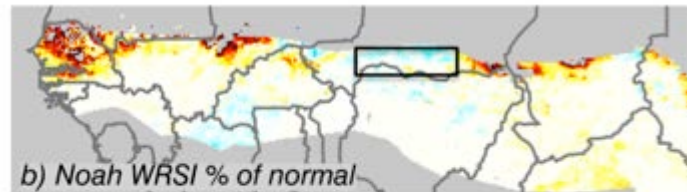
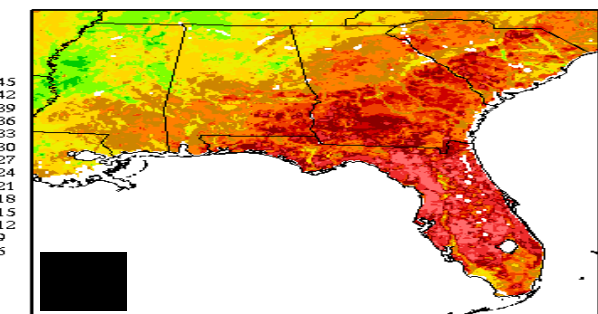
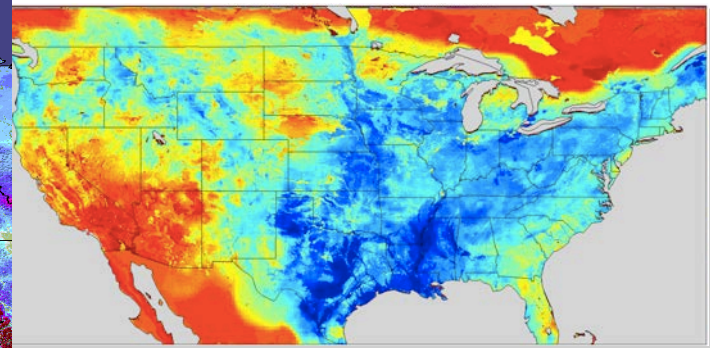
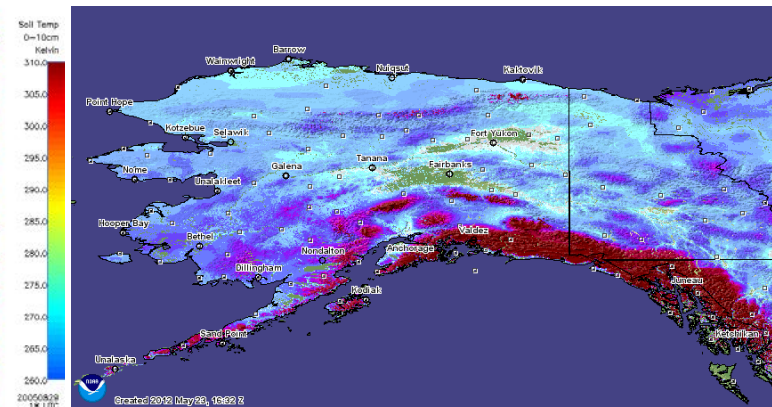
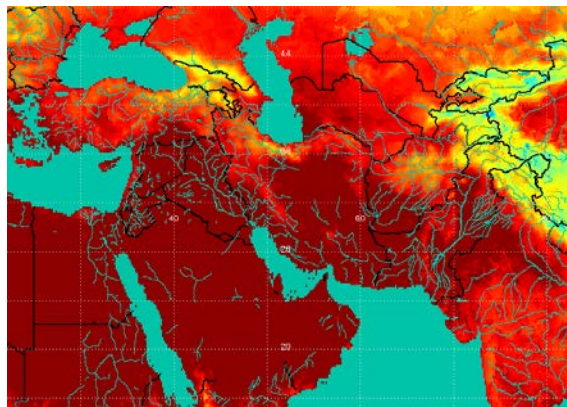
Introducing the LIS Framework

Recent

LIS 7.1 Release
On 27 May 2015, LIS 7.1 is available for release agencies and to the public. Please see the [LIS 7.1 Release](#) information about LIS 7.1 and the [Software Suite](#) information about the software suite.

Land Data Tools Release
Accompanying the LIS 7.1 public release is the [Land Data Tools](#) release. See the [LDT](#) page for more information.

Land Verification Release

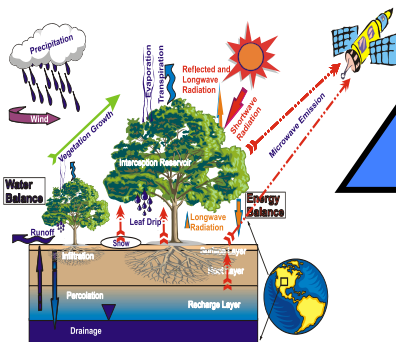


The LDAS approach

Observations



**Modeling and
Data Assimilation**



Applications





A little bit of history..

North American LDAS

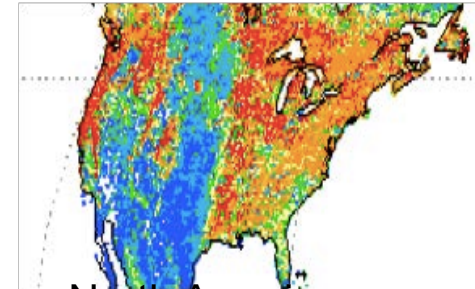
- NOAA, NASA, (and 6 other US institutions) 1998-present
- 1/8 degree resolution, central North America

Global LDAS

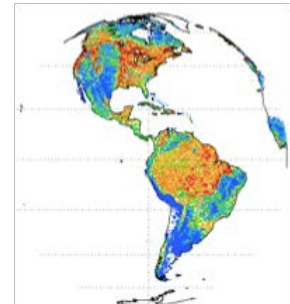
- NASA (and NOAA) 2000-present
- 1/4 and 1.0 degree resolutions, all land 60S-90N

Land Information System (LIS)

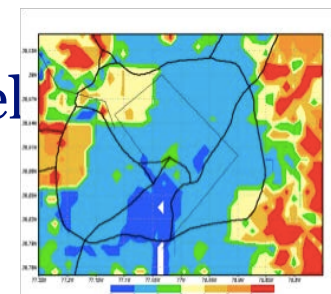
- NASA 2002-present
- Software configurable for any domain and resolution
- Multiple data assimilation options
- Can be run uncoupled or coupled to an atmospheric model



North American
LDAS
1/8th degree
spatial resolution



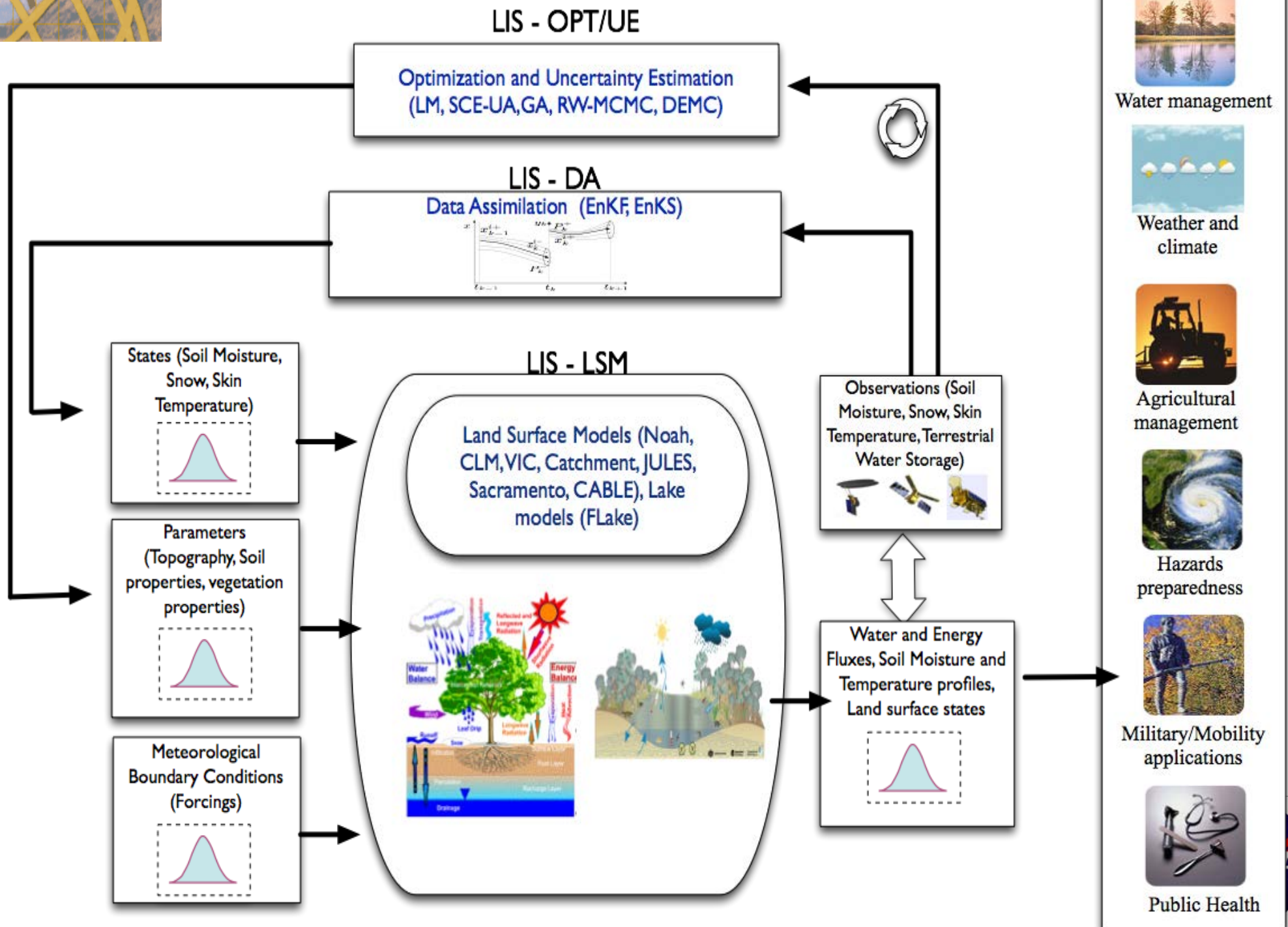
Global LDAS
1/4th degree spatial resolution



LIS
global, regional
up to 1km and finer



The LIS environment





Examples of LDAS applications...



LDAS for drought monitoring

Outputs from LDASs are used for routine drought monitoring using soil moisture, evapotranspiration, streamflow, groundwater estimates

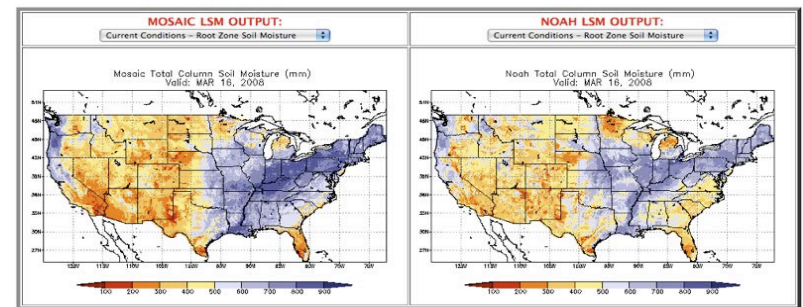
Example: NLDAS drought monitor (<http://www.emc.ncep.noaa.gov/mmb/nldas/drought/>)

Data assimilation can be used further improve drought estimation

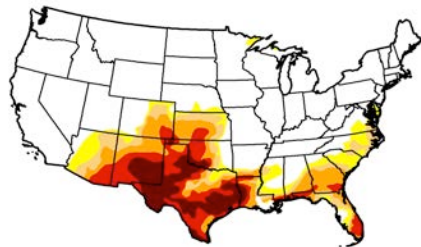


NLDAS Drought Monitor

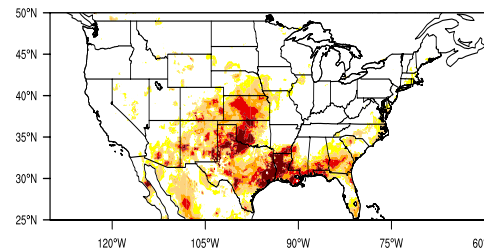
NOTE: This page is best viewed with a screen resolution of at least 1024x768
DISCLAIMER: Any data provided on this server should be used for research or educational purposes only. This data should NOT be relied on for any operational use as data gaps can occur due to hardware failure and/or model upgrading procedures.



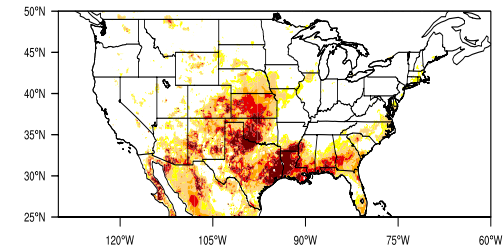
NEW!! [Click Here for Custom Percentile Image Generator!!](#)



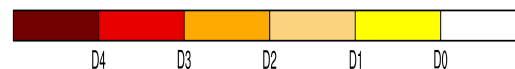
US drought monitor



LSM based drought estimate



LSM based drought estimate with data assimilation



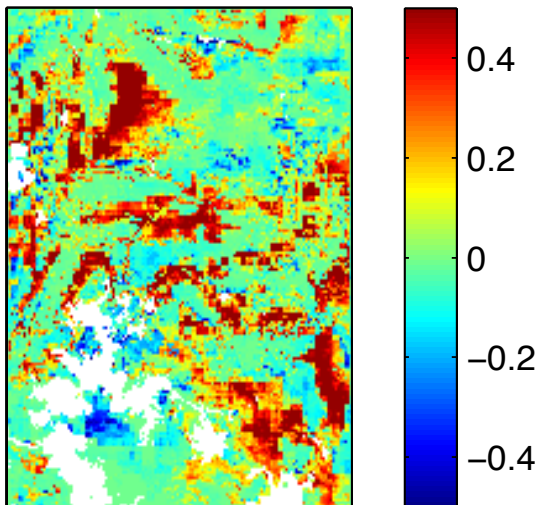
Impact of soil moisture DA on drought estimates
(May 10-17, 2011).



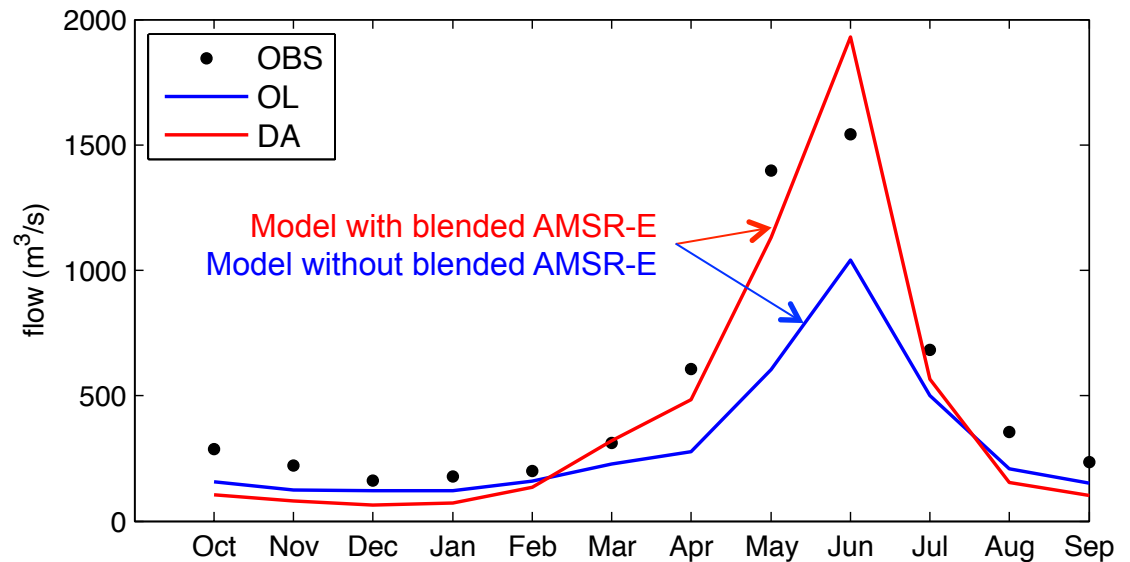
LDAS for flood monitoring

Runoff, streamflow fields from LDASs can be used for flood monitoring

Improvement in Snow Cover
Probability of Detection (POD) When
Assimilating satellite snow data



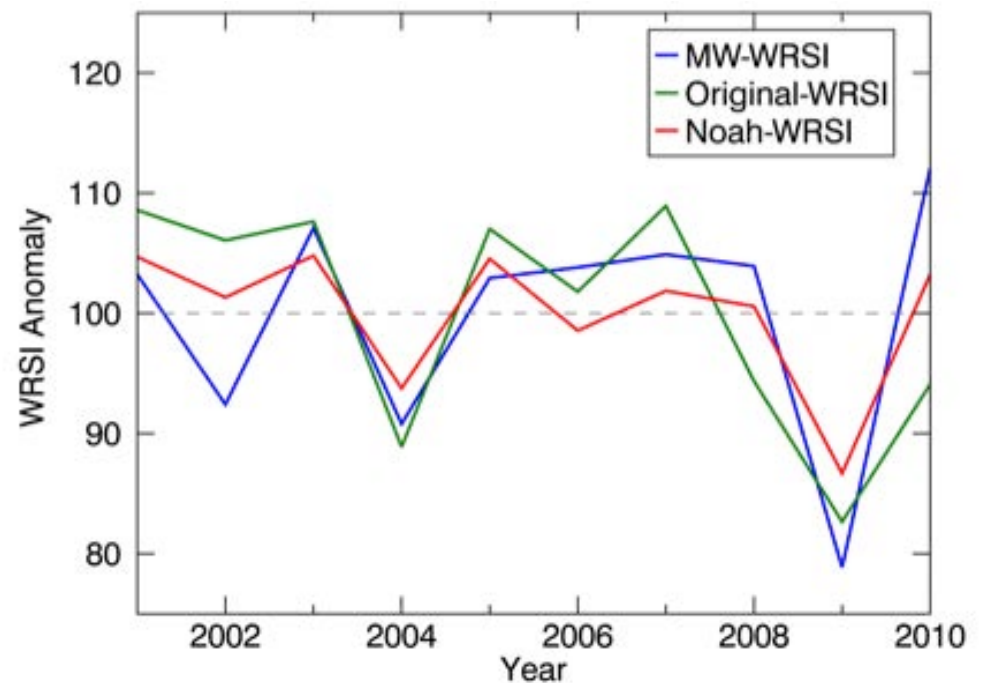
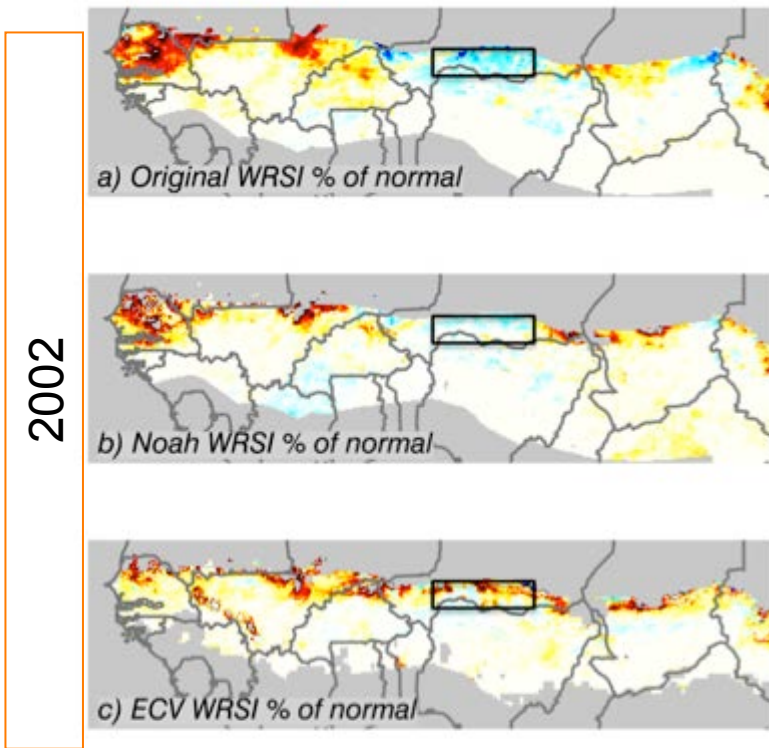
Improvement in Streamflow When Assimilating satellite
snow data (Upper Colorado River at Lees Ferry)





LDAS for estimating crop water requirements

The simulated soil moisture fields from LDAS is used to compute the water requirement satisfaction index (WRSI) and is compared to satellite derived (MW) data.

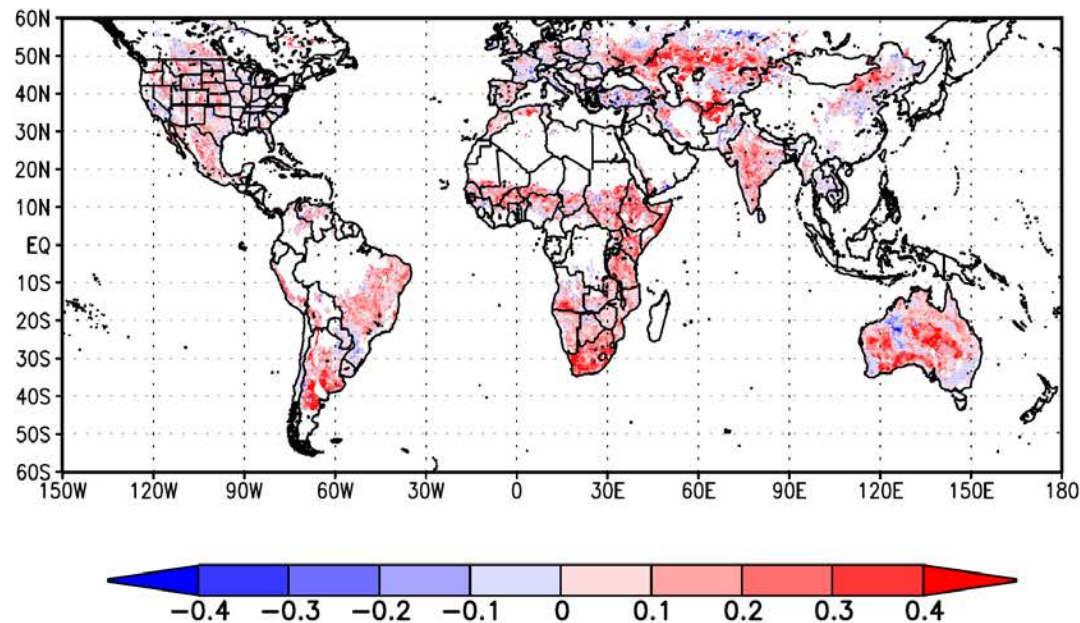




LDAS for global crop product decision support system

The US Department of Agriculture uses soil moisture outputs from LDAS towards crop product decision support

Soil moisture data from satellites (SMOS, SMAP) are incorporated into the land surface models for improved simulation of soil moisture states.



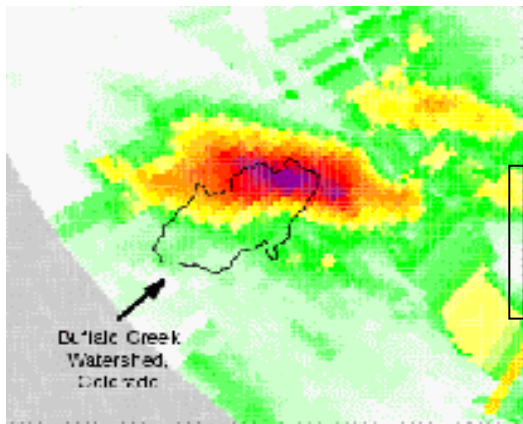
Skill improvements in soil moisture fields from incorporating satellite soil moisture observations (warm colors indicate skill improvements, cool colors denote skill degradations)





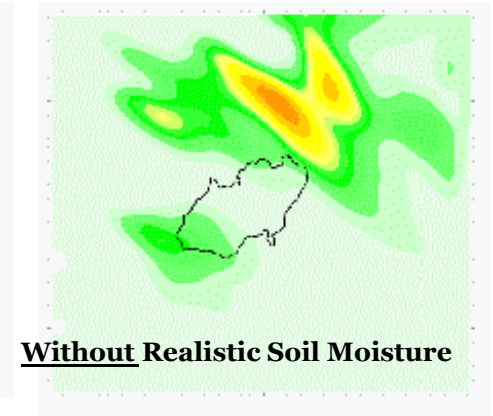
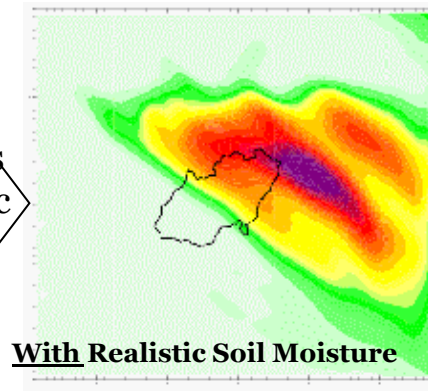
LDAS for improving weather forecasts

Realistic simulation of land conditions from a LDAS can be used to initialize weather and climate models, leading to improved weather forecasts



Observed Rainfall for Colorado Flood Event
0000Z to 0400Z 13/7/96
(Chen et al., NCAR)

Example 24-Hours
Ahead Atmospheric
Model Forecasts



NLDAS & GLDAS Data Availability

<http://disc.gsfc.nasa.gov/hydrology>

- Access via GDS, FTP, or quick-look visualization in Giovanni (below right)
 - GRIB and NetCDF formats
- 3-hourly and monthly; 1.0° and 0.25° global grids
 - On-the-fly subsetting (below left)
 - Full documentation
- NLDAS & GLDAS support a growing number of national and international hydrometeorological investigations and water resources applications

NLDAS

0.125°, 1979-present (operational at NOAA/NCEP, 3.5 day latency), to 53N, -125 to -67W, hourly/monthly: Noah, Mosaic, VIC 25

GLDAS v1

1.0°, 1979-present (1-2 month latency): Noah, Mosaic, VIC, CLM2
0.25°, 2000-present: Noah w/ MODIS snow cover assimilation

GLDAS v2

1.0° & 0.25°, 1948-2012: Noah

GLDAS v2.1 & v2.2 (coming soon)

1.0° & 0.25°, 1948-present, with multivariate data assimilation: Noah, Catchment, VIC, CLM4.5

GES DISC Hydrology

Showing (32) datasets associated with Hydrology...

Image	Dataset	Source	Temporal Resolution	Spatial Resolution	Process Level	Begin Date	End Date
	GLDAS Noah Land Surface Model L4 monthly 0.25 x 0.25 degree Version 2.0 (GLDAS_NOAH025_M_020) - Atmospheric Pressure, Atmospheric Radiation, Atmospheric Temperature	Models/Analyses Noah-LSM	1 month	0.25° x 0.25°	4	1948-01-01	2010-12-31
	GLDAS Noah Land Surface Model L4 monthly 1.0 x 1.0 degree Version 2.0 (GLDAS_NOAH10_M_020) - Atmospheric Pressure, Atmospheric Radiation, Atmospheric Temperature	Models/Analyses Noah-LSM	1 month	1° x 1°	4	1948-01-01	2010-12-31
	GLDAS Noah Land Surface Model L4 3 hourly 0.25 x 0.25 degree Version 2.0 (GLDAS_NOAH025_3H_020) - Atmospheric Pressure, Atmospheric Radiation, Atmospheric Temperature	Models/Analyses Noah-LSM	3 hours	0.25° x 0.25°	4	1948-01-01	2010-12-31
	GLDAS Noah Land Surface Model L4 3 hourly 1.0 x 1.0 degree Version 2.0 (GLDAS_NOAH10_3H_020) - Atmospheric Pressure, Atmospheric Radiation, Atmospheric Temperature	Models/Analyses Noah-LSM	3 hours	1° x 1°	4	1948-01-01	2010-12-31
	NLDAS Secondary Forcing Data L4 Monthly 0.125 x 0.125 degree (NLDAS_FOR0125_M_002) - Altitude, Atmospheric Pressure, Atmospheric Radiation	Models/Analyses Forcing-LSM	1 month	0.125° x 0.125°	4	1979-01-01	present
	NLDAS Secondary Forcing Data L4 Hourly 0.125 x 0.125 degree (NLDAS_FOR0125_H_002) - Altitude, Atmospheric Pressure, Atmospheric Radiation	Models/Analyses Forcing-LSM	1 hour	0.125° x 0.125°	4	1979-01-01	present

NASA National Aeronautics and Space Administration

Giovanni The Bridge Between Data and Science

Global Land Data Assimilation System (GLDAS)
0.25 Degree Monthly Products

Visualization Results | Download Data | Product Lineage | Acknowledgment Policy

GLDAS_NOAH025_M.001 Total evapotranspiration [(10⁻⁵kg/m²/e)] (Jun2015)

Map showing evapotranspiration values across the globe. Color scale: -0.731 (blue) to 7.851 (red).

Edit Plot Preferences | Refine Constraints

* Applies to the whole results set (all plots)



Summary

- Land Data Assimilation Systems have been developed for central North America (NLDAS), Europe (ELDAS), South America (SALDAS), Middle East North Africa (MENA-LDAS) and the globe (GLDAS)
- The common goal of these projects is to integrate all relevant data in a physically consistent manner within sophisticated land surface models to produce optimal estimates of hydrological states (e.g. soil moisture, surface temperature) and fluxes (e.g. runoff, evapotranspiration)
- The Land Information System (LIS) is an efficient and configurable software that can be used to specify an instance of LDAS
- LDASs have been used for water availability applications including drought/flood monitoring, agricultural management, weather and climate initialization.



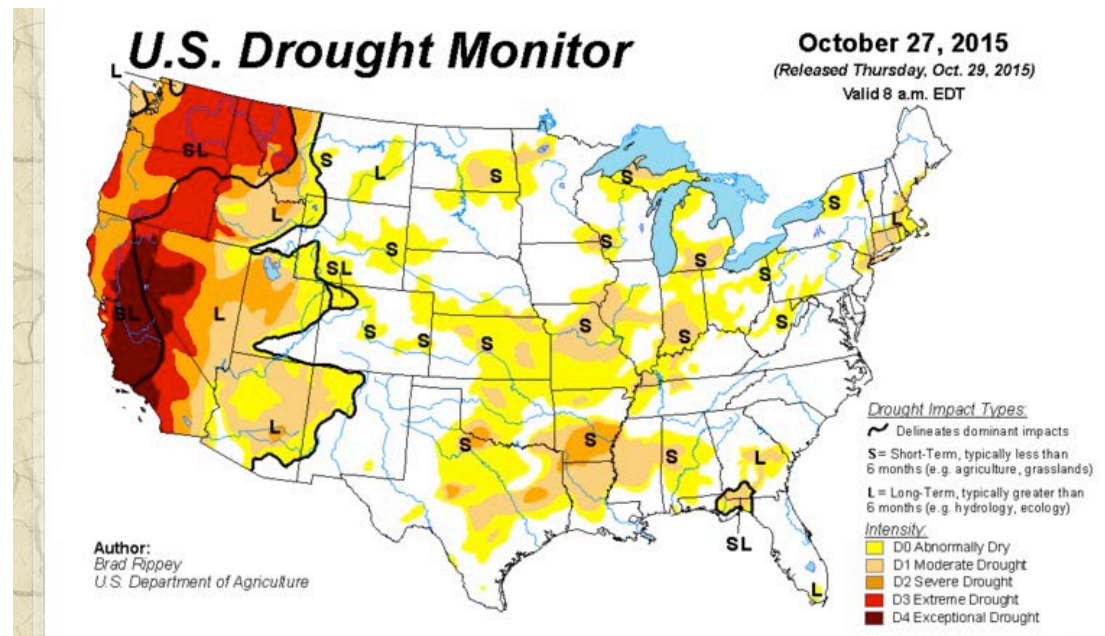


Import Water Budget Data into GIS





Live demonstration of Giovanni water budget data access, GIS import and analysis



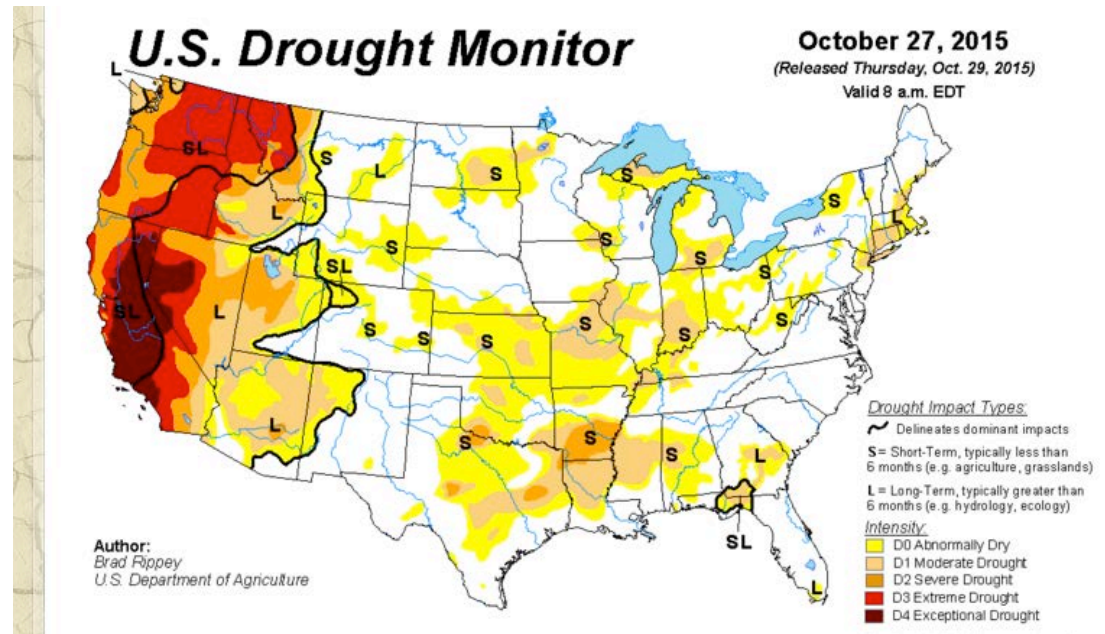
Reference, US Drought Monitor (October 27)





Giovanni Version 4

<http://giovanni.gsfc.nasa.gov/giovanni/>



Reference, US Drought Monitor (October 27)



NLDAS Data Access - Giovanni Version 4 data portal

<http://giovanni.gsfc.nasa.gov/giovanni/>

The screenshot shows the Giovanni data portal interface. At the top, there is a navigation bar with 'EARTHDATA GIOVANNI' and the tagline 'The Bridge Between Data and Science v 4.12'. Below this is a notification banner for GOCART data. The main content area is divided into several sections: 'Select Plot' with dropdown menus for 'Maps: Time-Averaged', 'Comparisons', 'Time Series', 'Vertical', and 'Miscellaneous'; 'Select Date Range' with a date input field; 'Select Variables' with expandable sections for 'Disciplines' and 'Measurements'; 'Maps Choices' with radio buttons for 'Time-Averaged', 'Animated', 'User-Defined Climatology', 'Accumulated', and 'Difference of Time Averaged'; and a 'Shapefile' section with 'Show Map' and 'Show Shapes' buttons. At the bottom, there are 'Help', 'Reset', 'Feedback', and 'Plot Data' buttons. Annotations include a red box around the 'Select Plot' dropdowns, a yellow box labeled 'Analysis/Plot Options' on the right, a yellow arrow pointing to the 'Time-Averaged' radio button, and a yellow box labeled 'Dropdown Menu options' and 'Choose Time-Averaged' on the right.

Home page
The Bridge Between Data and Science v 4.12 [Release Notes](#) [Browser Compatibility](#) [Known Issues](#)

GOCART data no longer available... [1 of 1 messages] [Read More](#)

Select Plot

- Maps: Time-Averaged
- Comparisons: Select...
- Time Series: Select...
- Vertical: Select...
- Miscellaneous: Select...

Select Date Range
YYYY-MM-DD
Valid Range: 1979

Select Variables

- Disciplines**
 - Aerosols (117)
 - Atmospheric Cl
 - Atmospheric D
 - Hydrology (114)
 - Water and Ener
- Measurements**
 - Aerosol Index (
 - Air Pressure (6
 - Air Temperatur
 - Albedo (8)
 - Altitude (4)
 - Angstrom Expc
 - Atmospheric M
 - CH4 (4)
 - CO (4)

Maps Choices

- Time-Averaged**
Interactive map of average over time at each grid cell
[Details...](#)
- Animated**
Map animated along the chosen timeline for each grid cell
[Details...](#)
- User-Defined Climatology**
Quasi climatology map
[Details...](#)
- Accumulated**
Accumulation of measurement over time at each grid point
[Details...](#)
- Difference of Time Averaged**
Difference of two time averaged variable maps
[Details...](#)

Shapefile

Variable(s) included in Plot: 0

Analysis/Plot Options

Dropdown Menu options
Choose Time-Averaged



Giovanni Version 4

<http://giovanni.gsfc.nasa.gov/giovanni/>

Select Date Range (UTC)

YYYY-MM-DD.

HH:mm

2010 - 01 - 01

00 : 00

to

2010 - 12 - 31

Valid Range: 1979-01-01 to 2015-11-09

Select Variables

▼ Disciplines

- Aerosols (128)
- Atmospheric Chemistry (36)
- Atmospheric Dynamics (135)
- Cryosphere (4)
- Hydrology (252)
- Ocean Biology (5)
- Oceanography (4)
- Water and Energy Cycle (265)

▼ Measurements

- Aerosol Index (3)
- Aerosol Optical Depth (2)
- Air Pressure (16)
- Air Temperature (29)
- Albedo (10)

Number of matches: 0 of 331

Keyword:

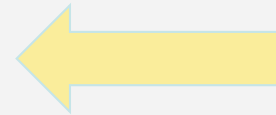
Select Region (Bounding Box or Shapefile)

Format: West, South, East, North

-180, -50, 180, 50

Show Map

Show Shapes



Temporal Search Options

Click calendar to choose the date range of interest. We will choose yearly parameters. So begin with Jan 1, 2010 to Dec 31, 2010.

Repeat for all years (2010-2015) for each parameter.





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Select Plot

Maps: Time Averaged Map Comparisons: Select... Time Series: Select... Vertical: Select... Miscellaneous: Select...

Select Date Range (UTC)

YYYY-MM-DD: HH:mm

2010 -01 -01 00:00 to 2010 -12 -31 23:59

Valid Range: 1979-01-01 to 2015-11-09

Select Variables

Disciplines

- Aerosols (128)
- Atmospheric Chemistry (36)
- Atmospheric Dynamics (135)
- Cryosphere (4)
- Hydrology (252)
- Ocean Biology (5)
- Oceanography (4)
- Water and Energy Cycle (265)

Measurements

- Aerosol Index (3)
- Aerosol Optical Depth (2)
- Air Pressure (16)
- Air Temperature (29)
- Albedo (10)
- Altitude (4)
- Angstrom Exponent (16)
- Atmospheric Moisture (34)
- Buoyancy (1)
- CH4 (8)
- CO (8)
- CO2 (1)

Number of matching Variables:

Keyword:

Select Region (Bounding Box or Shapefile)

Format: West, South, East, North

US States : California

Shape Files	Shape
Countries	<input type="radio"/> Alabama
US States	<input type="radio"/> Alaska
Watersheds	<input type="radio"/> American Samoa
	<input type="radio"/> Arizona
	<input type="radio"/> Arkansas
	<input checked="" type="radio"/> California
	<input type="radio"/> Colorado

Source: [TIGERLine](#), [US Census Bureau](#)

Spatial Search

You can manually enter the latitude/longitude of your region

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Select Plot

Maps: Time-Averaged Comparisons: Select... Time Series: Select... Vertical: Select... Miscellaneous: Select...

Select Date Range (UTC)

YYYY-MM-DD HH:mm

2014 -07 -01 04 :00 to 2014 -07 -07 04 :00 -180, -50, 180, 50

Valid Range: 1979-01-01 to 2015-03-16

Select Variables

Disciplines

- Aerosols (117)
- Atmospheric Chemistry (18)
- Atmospheric Dynamics (64)
- Hydrology (114)
- Water and Energy Cycle (120)

Measurements

- Aerosol Index (1)
- Air Pressure (6)
- Air Temperature (15)
- Albedo (8)
- Altitude (4)

Select Region (Bounding Box or Shapefile)

Format: West, South, East, North

Spatial Search

Alternatively, you can

Click **Show Map** to

select a bounding box

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GOCART data no longer available... [1 of 1 messages] [Read More](#)

Select Plot

Maps: Time-Averaged ▾ Comparisons: Select... ▾ Time Series: Select... ▾ Vertical: Select... ▾ Miscellaneous: Select... ▾

Select Date Range (UTC)

YYYY-MM-DD: HH:mm

- : to - :

Valid Range: 1979-01-01 to 2015-03-13

Select Region (Bounding Box or Shapefile)

Format: West, South, East, North

Select Variables

Number of matching Variables: 0 of 331 Total Variable(s) included in Plot:

Keyword:

Disciplines

- Aerosols (117)
- Atmospheric Chemistry (18)
- Atmospheric Dynamics (64)
- Hydrology (114)
- Water and Energy Cycle (120)

Measurements

- Aerosol Index (1)
- Air Pressure (6)
- Air Temperature (15)
- Albedo (8)
- Altitude (4)
- Angstrom Exponent (16)
- Atmospheric Moisture (23)
- CH4 (4)
- CO2 (4)

Annotations:

- A red box highlights the "Select Variables" section.
- A yellow box contains the text: "Either type the variable in the Keyword search OR Navigate through the Select Variables list".
- Yellow arrows point from the yellow box to the "Keyword" search field and the "Select Variables" list.



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Number of matching Variables: 31 of 581 Total Variable(s) included in

Keyword:

Variable Name	Source	Temp. Res.	Spat. Res.	Begin Date	End Date	Units	Vert. Slice
<input checked="" type="checkbox"/> Rainfall (unfrozen precipitation) (NLDAS_VIC0125_M v002)	NLDAS Model	Monthly	0.125 °	1979-01-02	2015-09-30	kg/m ²	-
<input checked="" type="checkbox"/> Total evapotranspiration (NLDAS_VIC0125_M v002)	NLDAS Model	Monthly	0.125 °	1979-01-02	2015-09-30	kg/m ²	-
Latent heat flux (NLDAS_VIC0125_M v002)	NLDAS Model	Monthly	0.125 °	1979-01-02	2015-09-30	W/m ²	-
Canopy water evaporation (NLDAS_VIC0125_M v002)	NLDAS Model	Monthly	0.125 °	1979-01-02	2015-09-30	W/m ²	-

Scroll down and select

Rainfall (unfrozen) and Total evapotranspiration (NLDAS VIC Annually Temporal Resolution)

(there are more variables to acquire here as well, including runoff, soil moisture, snow water equivalent, etc. The variables you will need to calculate your water budget will depend upon the complexity of your model).

GPM IMERG data will also be appropriate to obtain here.



When finished,

Click **Plot Data**





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Time Averaged Maps will be generated with the variables displayed for the year 2010 in region

1. Time Averaged Map

History

Messages] Read More

1. Time Averaged Map

Image Options

Time Averaged Map of Rainfall (unfrozen precipitation) monthly 0.125 deg. [NLDAS Model NLDAS_VIC0125_M v002] kg/m² over 2013-Jan - 2013-Dec, Shape California





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<http://giovanni.gsfc.nasa.gov/giovanni/>

You can download the data files in either NetCDF, GeoTIFF or PNG formats.
NetCDF format is easily imported into ArcMap.
Click the links to download to your desired location on your computer.

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Time-Averaged Scatter temporarily unavailable... [1 of 2 messages] [Read More](#)

2. Time Averaged Map

Click on file links to download. Files contain data portrayed in the plot images.

NetCDF:

- [q4.timeAvgMap.NLDAS_VIC0125_M_002_asnowsf.20100101-20101231.124W_32N_114W_42N.nc](#)
- [q4.timeAvgMap.NLDAS_VIC0125_M_002_weasdsfc.20100101-20101231.124W_32N_114W_42N.nc](#)
- [q4.timeAvgMap.NLDAS_VIC0125_M_002_arainsfc.20100101-20101231.124W_32N_114W_42N.nc](#)
- [q4.timeAvgMap.NLDAS_VIC0125_M_002_evpsfc.20100101-20101231.124W_32N_114W_42N.nc](#)
- [q4.timeAvgMap.NLDAS_VIC0125_M_002_bgrunsf.20100101-20101231.124W_32N_114W_42N.nc](#)
- [q4.timeAvgMap.NLDAS_VIC0125_M_002_ssrnsfc.20100101-20101231.124W_32N_114W_42N.nc](#)

PNG:

- [q4.timeAvgMap.NLDAS_VIC0125_M_002_asnowsf.20100101-20101231.124W_32N_114W_42N.png](#)
- [q4.timeAvgMap.NLDAS_VIC0125_M_002_weasdsfc.20100101-20101231.124W_32N_114W_42N.png](#)
- [q4.timeAvgMap.NLDAS_VIC0125_M_002_arainsfc.20100101-20101231.124W_32N_114W_42N.png](#)
- [q4.timeAvgMap.NLDAS_VIC0125_M_002_evpsfc.20100101-20101231.124W_32N_114W_42N.png](#)
- [q4.timeAvgMap.NLDAS_VIC0125_M_002_bgrunsf.20100101-20101231.124W_32N_114W_42N.png](#)
- [q4.timeAvgMap.NLDAS_VIC0125_M_002_ssrnsfc.20100101-20101231.124W_32N_114W_42N.png](#)

GeoTIFF:

- [q4.timeAvgMap.NLDAS_VIC0125_M_002_asnowsf.20100101-20101231.124W_32N_114W_42N.geotif](#)
- [q4.timeAvgMap.NLDAS_VIC0125_M_002_weasdsfc.20100101-20101231.124W_32N_114W_42N.geotif](#)
- [q4.timeAvgMap.NLDAS_VIC0125_M_002_arainsfc.20100101-20101231.124W_32N_114W_42N.geotif](#)
- [q4.timeAvgMap.NLDAS_VIC0125_M_002_evpsfc.20100101-20101231.124W_32N_114W_42N.geotif](#)
- [q4.timeAvgMap.NLDAS_VIC0125_M_002_bgrunsf.20100101-20101231.124W_32N_114W_42N.geotif](#)
- [q4.timeAvgMap.NLDAS_VIC0125_M_002_ssrnsfc.20100101-20101231.124W_32N_114W_42N.geotif](#)

KMZ:

- [q4.timeAvgMap.NLDAS_VIC0125_M_002_asnowsf.20100101-20101231.124W_32N_114W_42N.kmz](#)
- [q4.timeAvgMap.NLDAS_VIC0125_M_002_weasdsfc.20100101-20101231.124W_32N_114W_42N.kmz](#)
- [q4.timeAvgMap.NLDAS_VIC0125_M_002_arainsfc.20100101-20101231.124W_32N_114W_42N.kmz](#)

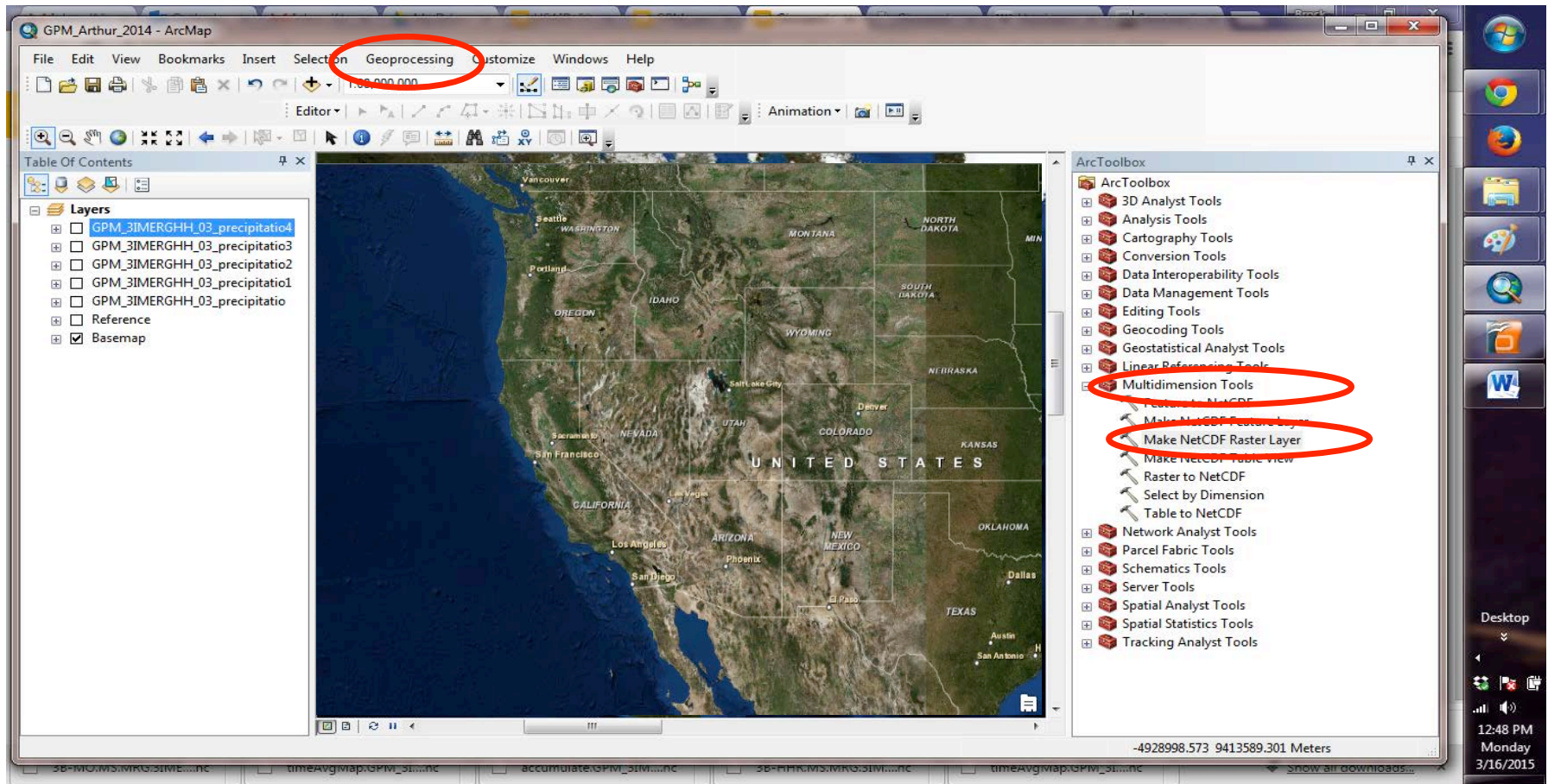
History

- 2. Time Averaged Map
 - User Input
 - Plots
 - Downloads**
 - Lineage
- 1. Time Averaged Map
 - User Input
 - Plots
 - Lineage
 - Downloads

[Acknowledgment Policy](#) [Help](#) [Feedback](#) [Back to Data Selection](#)

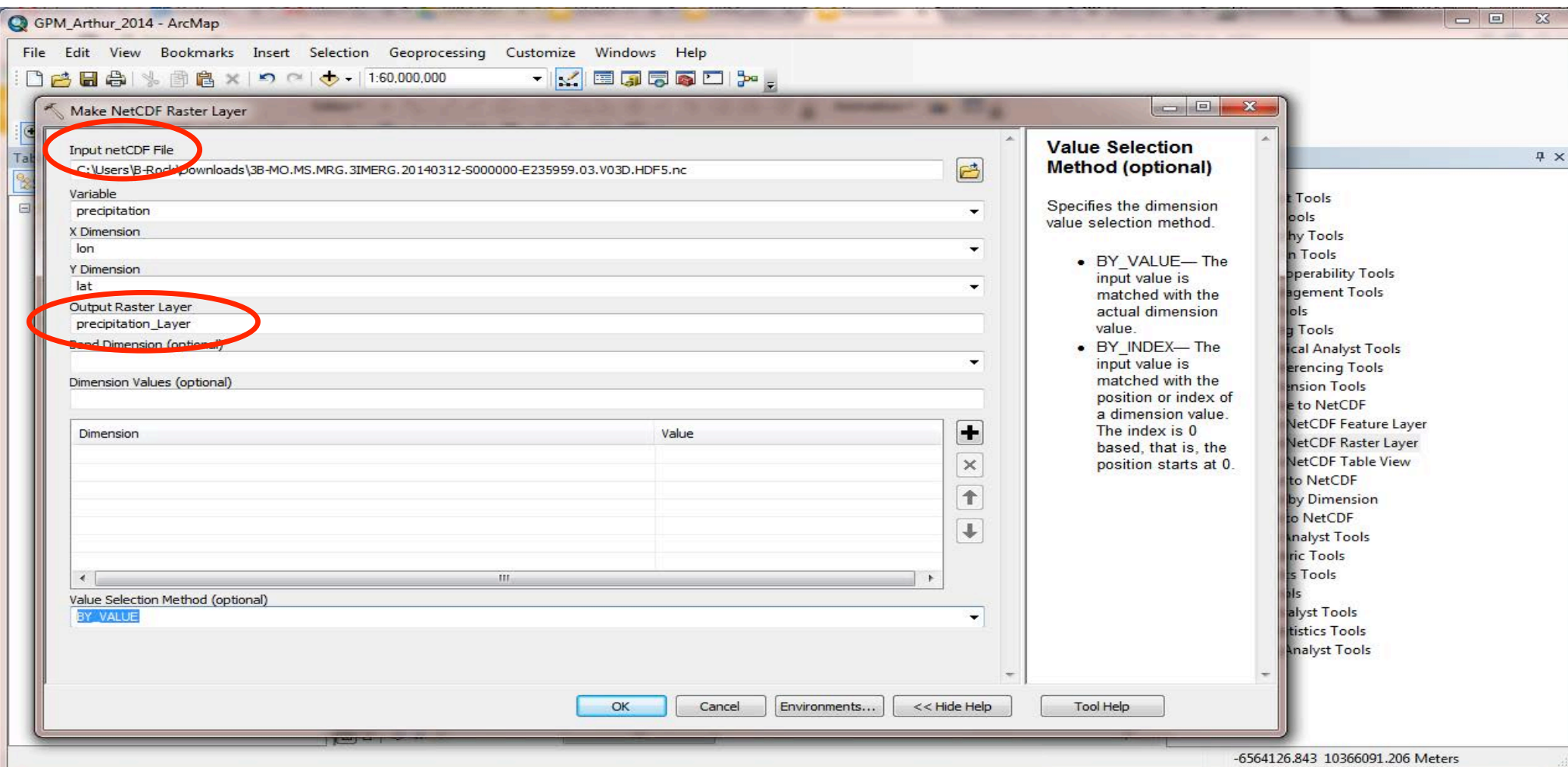


Import into GIS (ArcMAP)



Import our hydrology data - Under the Geoprocessing Tab, Open the ArcToolbox. Open the Multidimensional toolbox, choose the **Make NetCDF Raster Layer tool**

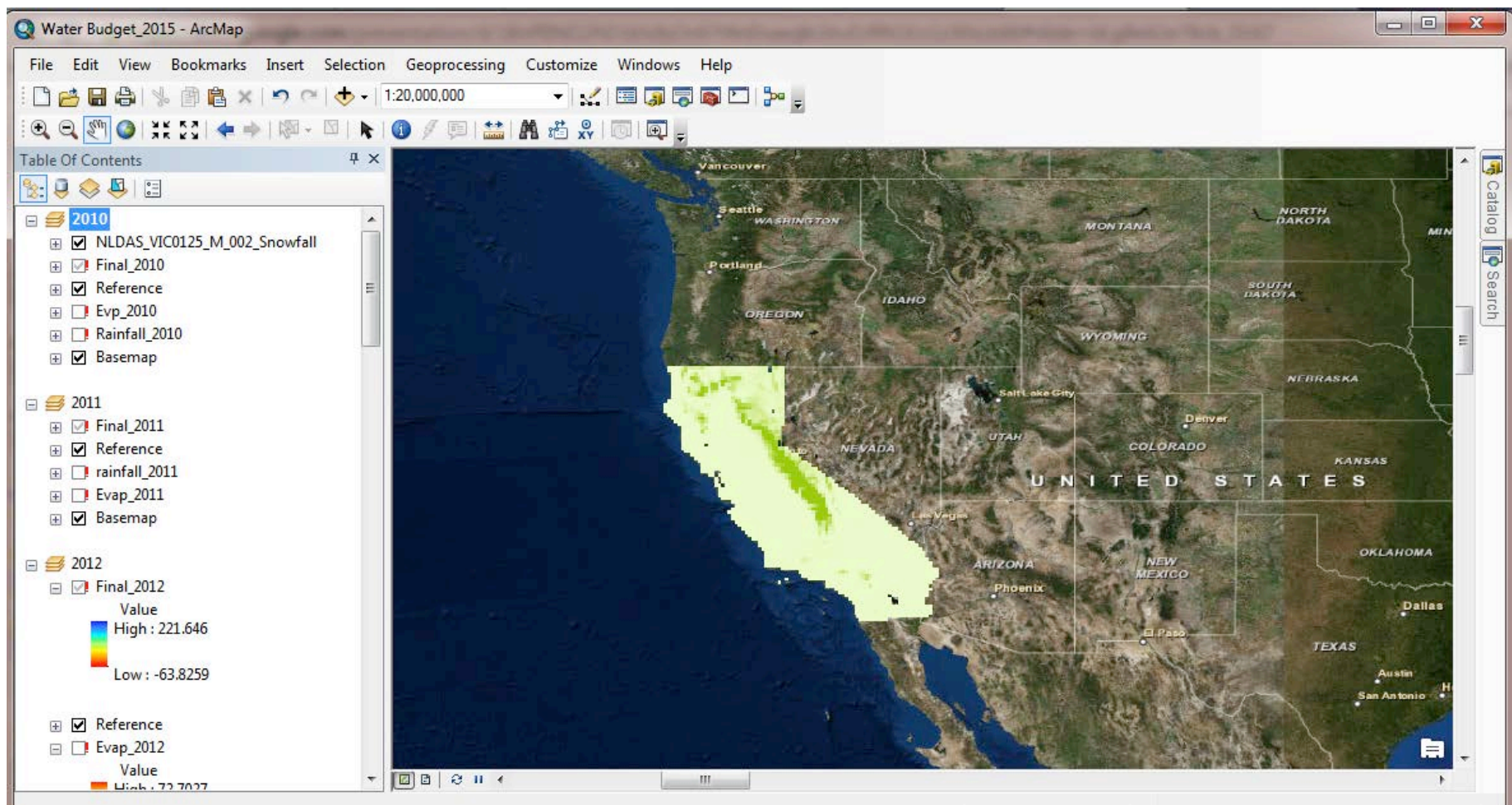
Import into GIS (ArcMAP)



For the input field, **Input netCDF File**: Navigate to and click on the previously downloaded files (one by one). The remaining fields will fill in accordingly, KEEP the default values. You may change the output file name if you choose. Click OK.

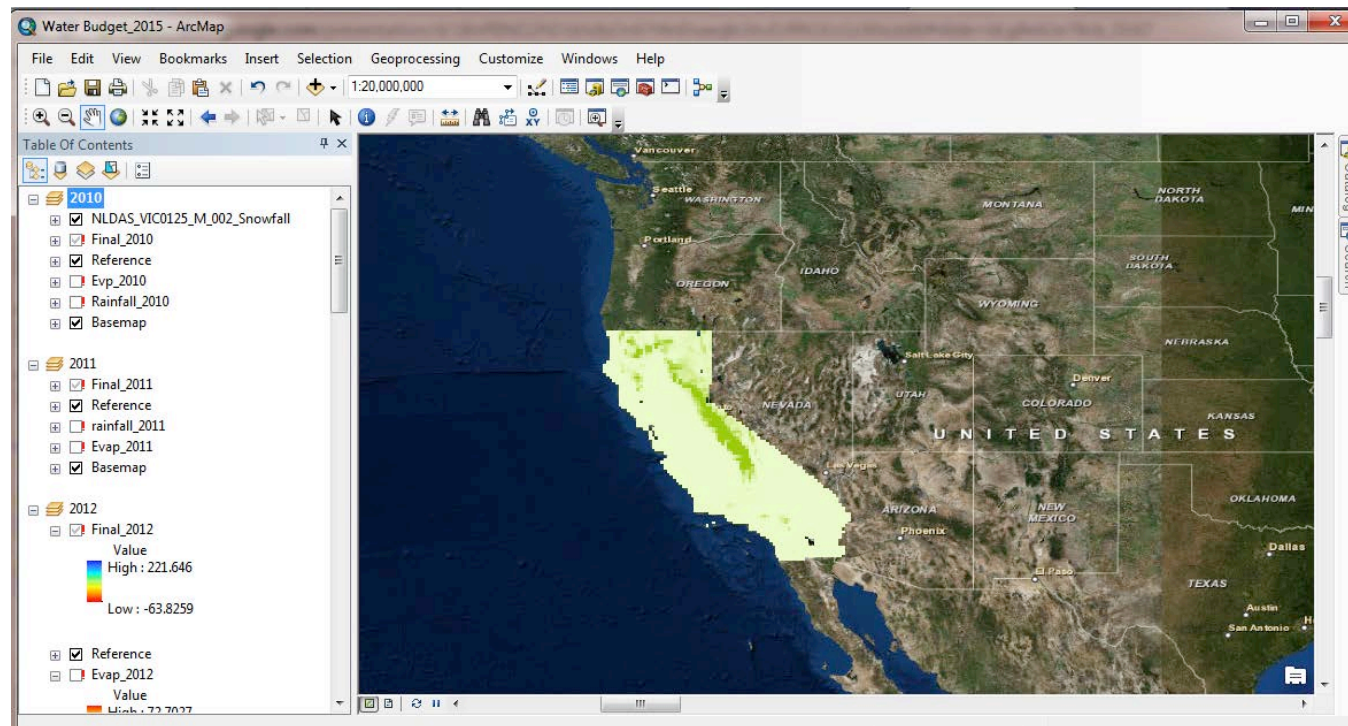


Import into GIS (ArcMAP)



The result will be in raster format in ArcMAP.
This is the area averaged snowfall for the state of California for 2010.
Raster files are ideal for spatial analysis tools and for model input.

Import into GIS (ArcMAP)



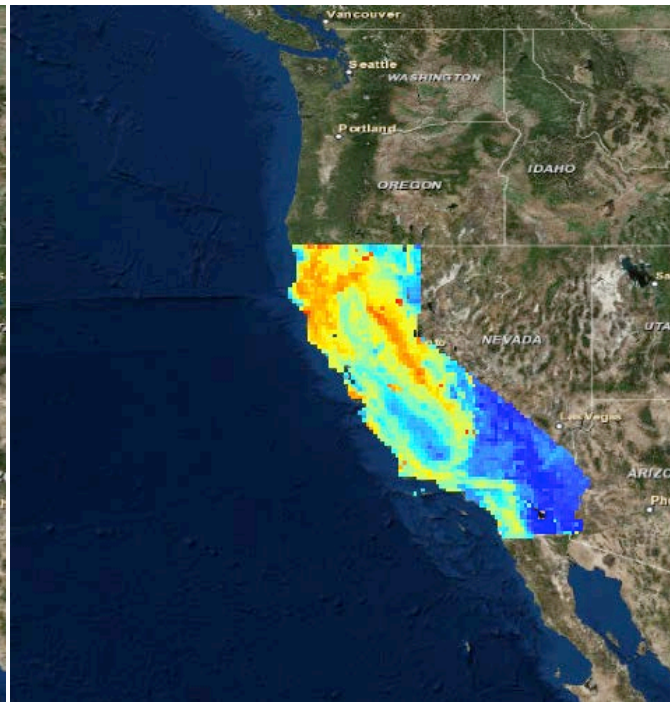
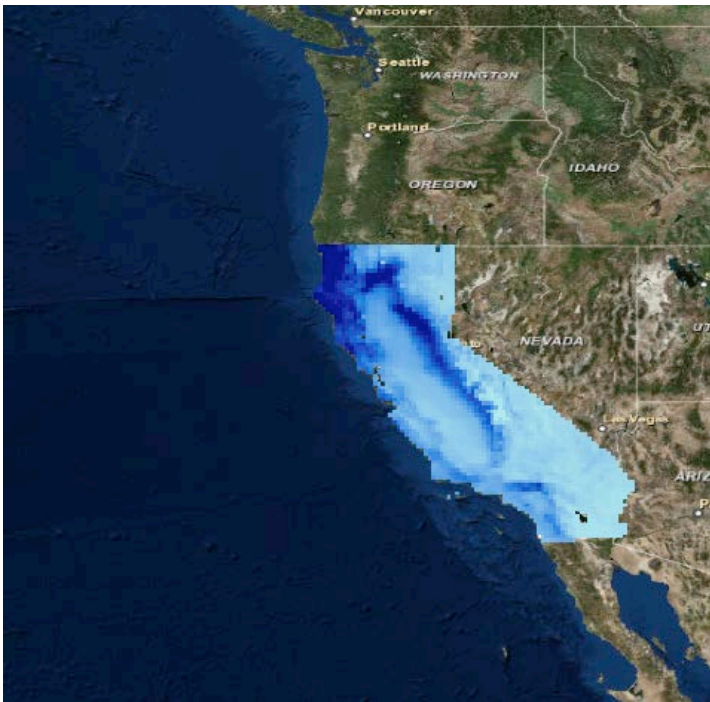
You will want to import all variables of interest for all years to prepare for the spatial analysis of your water budget.

For reference upon importing, the naming conventions for the NLDAS variable files are below:

- Subsurface runoff:** g4.timeAvgMap.NLDAS_VIC0125_M_002_bgrunscf
- Rainfall (unfrozen precipitation):** g4.timeAvgMap.NLDAS_VIC0125_M_002_arainscf
- Rainfall (frozen precipitation):** g4.timeAvgMap.NLDAS_VIC0125_M_002_awnsfc
- Total Evapotranspiration:** g4.timeAvgMap.NLDAS_VIC0125_M_002_evpsfc.
- Surface runoff (non-infiltrating):** g4.timeAvgMap.NLDAS_VIC0125_M_002_ssruncf.
- Accumulated snow water-equivalent:** g4.timeAvgMap.NLDAS_VIC0125_M_002_weasdfsfc.



Spatial Analysis



Once all variables are imported into your GIS, given the different complexities to the various models and raster calculations needed to derive a water budget, please refer to relevant literature to determine the appropriate model inputs and variables needed for your region, watershed or basin.



Common GIS Data Layers and locations to find them

Rivers/Basins	USGS HydroSHEDS	http://hydrosheds.cr.usgs.gov/
Population	NASA Socioeconomic Data and Applications Center (SEDAC)	http://sedac.ciesin.columbia.edu/
Elevation	Consortium for Spatial Information (CGIAR-CSI)	http://srtm.csi.cgiar.org/
Reservoirs	NASA Socioeconomic Data and Applications Center (SEDAC)	http://sedac.ciesin.columbia.edu/
Soil Type	ISRIC - World Soil Information	http://www.isric.org/
Dams	NASA Socioeconomic Data and Applications Center (SEDAC)	http://sedac.ciesin.columbia.edu/
Infrastructure	See various local/state/regional GIS data sites	
Land Use	Waterbase	http://www.waterbase.org

