CONTACT

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Hydrometeorology

Hydrometeorology is an interdisciplinary science involving the study and analysis of the interrelationships between the atmospheric and land phases of water as it moves through the hydrologic cycle.

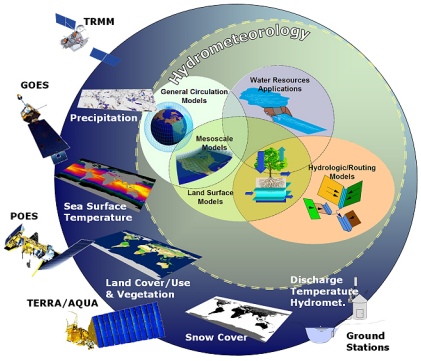
Problems addressed by hydrometeorology include determining the occurrence and the spatial and temporal distribution of precipitation, major storms, snow-fall, accumulation and melt, runoff, evaporation, and evapotranspiration.

As mentioned by encyclopedia Britannica, "the boundaries of hydrometeorology are not clear cut", for as a science, it overlaps with several branches of meteorology, with physical and statistical hydrology, with water resources management, and with physics. However, the scientific focus of hydrometeorology remains on studying the transfer of water and energy between the land surface and the lower atmosphere.

Remote Sensing

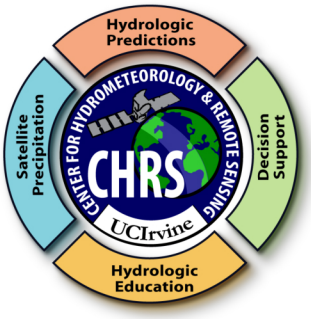
The advent of remote sensing observations solidified the role of hydrometeorology as an integral branch of earth science.

Hydrometeorologists can now study the precipitation process and the temporal and spatial at global scale and at high resolutions. Remote sensing observations of snow cover properties and extent also provide hydrometeorologists with the necessary information to understand and assess the seasonal, annual, and inter-annual variability of snow accumulation and snow-melt. These are essential for improved forecasting of water resources availability.



The CHRS Mission

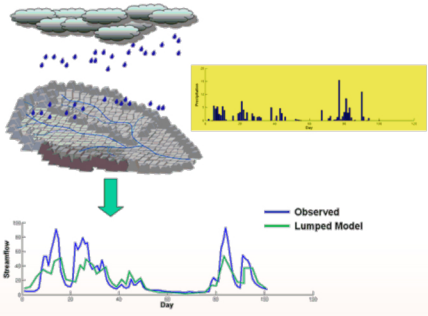
- Improve hydrologic prediction through development and refinement of hydrologic models and use of advanced observations, particularly from remote sensing sources
- Develop mathematical algorithms capable of estimating precipitation both from space-based and in-situ observations at spatial and temporal resolutions relevant to hydrologic applications, particularly in the semi-arid environments
- Develop decision support tools for generating and evaluating a variety of hydro-meteorological and hydro-climatologic information required by the water resources management community
- Contribute to the education of well-trained hydrologists and water resources engineers responsive to the growing needs of public and private sectors at the state, national, and international levels.



CHRS will pursue its mission through interdisciplinary research and education involving faculty and students from Engineering, Physical Sciences, and Social Ecology, as well as cooperation with a number of other universities and national laboratories.

The CHRS Mission

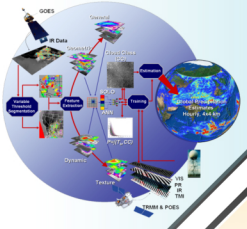
Building Global Capacity for Forecast and Mitigation of Hydrologic Disasters through the development of means to extend the benefits of space and weather agencies' vast technological resources, which are untapped, into applications that can assist hydrologists and water resource managers worldwide and through equitable access to relevant information



Improve the performance and reliability of hydrologic, flood, and water supply forecasting models, particularly those used by the National Weather Service and other operational agencies.

Develop state-of-the-art systems to estimate rainfall from satellite obsevations at global scale and high spatial and temporal resolutions.

Utilizating information technology to provide world-wide access to real-time global precipitation products: http://hydis.eng.uci.edu/gwadi



Hydrologic Predictions

Satellite Precipitation

Decision Support

Hydrologic Education

CENTER FOR HYDROMETEOROLOGY & REMOTE SENSING
CHRS
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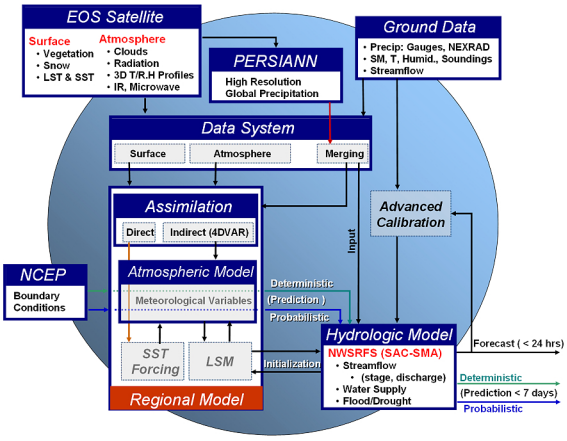
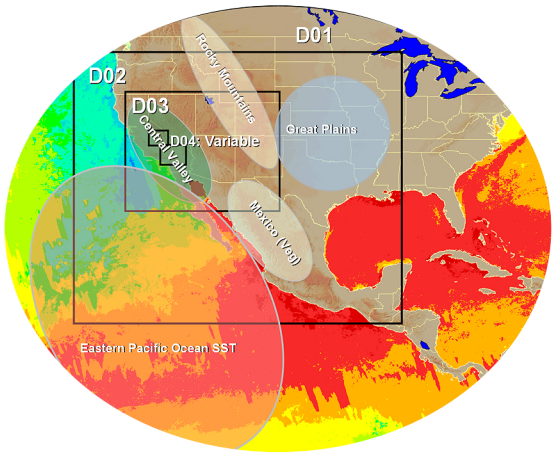
Improve California's water supply mangement through:
- Forecast system (CaliForecast)
- Improved decision optimization

Prepare the next generation of hydrologists and water resources engineers.

IMPROVING HYDROLOGIC PREDICTIONS

CHRS researchers bring together satellite information, atmospheric models, land surface models, ground observations, and hydrologic models to improve the quality and timeliness of hydrometeorologic forecasts. Most studies are conducted over the Southwestern U.S., with modeling applied at increasingly higher spatial resolutions of nested domains reaching resolutions suitable for hydrologic forecasting and water resource management applications.



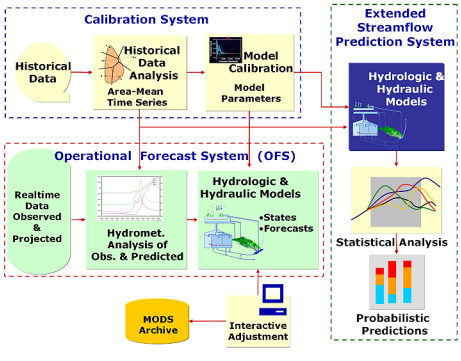


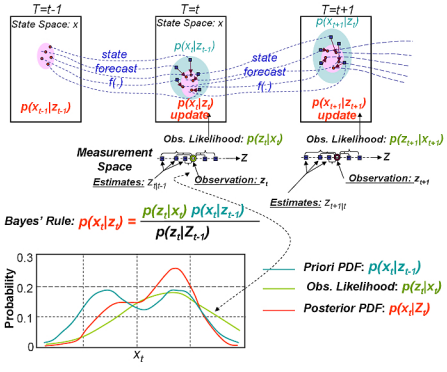
CURRENT STUDIES

- To understand seasonal and inter-annual variability, observations from NASA's TERRA and AQUA satellites of sea surface temperature over the eastern Pacific Ocean, and satellites are used to force coupled models.
- Irrigation practices in the central valley (1/6th of irrigated land in the US) are simulated using offline irrigation mangement software to improve the realism and parameterization of soil moisture components in coupled land-surface atmosphere models.

FOCUS ON APPLICATIONS

Refining hydrologic models, particularly those which are used in the National Weather Service's River Forecasting System (NWSRFS) for flood forecasting, is an important element of CHRS research. Research areas involved include developing advanced model calibration techniques, improving process description, and developing innovative approaches to evaluate model performance. CHRS researchers have long history of collaborative research with the NWS.



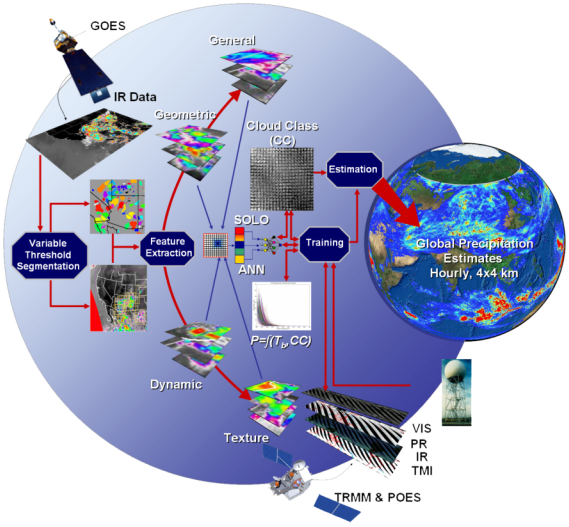


Global Preceipitation Estimation from Satellite Data

PERSIANN

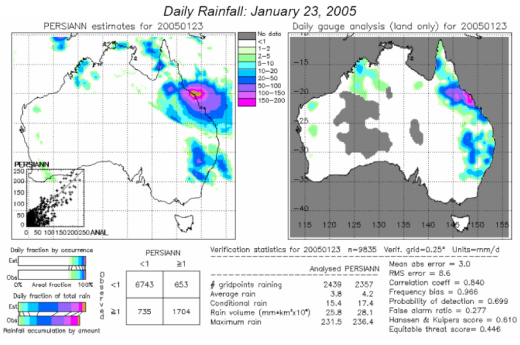
The PERSIANN (Precipitation Estimation from Remotely Sensed Information using Artificial Neural Networks) applies neural network classification/approximation procedures to infrared (IR) brightness temperature data, which are obtained from geostationary satellites to estimate precipitation at 0.04° x 0.04° pixel resolutions.

Adaptive training facilitates updating of the model parameters using independent estimates of rainfall. Coupled with a cloud classification scheme, the current version of PERSIANN uses IR data from a fleet of geostationary satellites (GOES-11, GOES-12, MTSAT, Metsat-6, and Metsat-7) to generate real-time global coverage of hourly rainfall at 4x4 km. CHRS operates the real-time provisional system at the NOAA's National Environmental Satellite, Data, and Information Service (NESDIS), with parameters being regularly updated at CHRS using independent microwave-based rainfall estimates from low-orbital satellites, including TRMM, NOAA-15, -16, -17, DMSP F13, F14, F15, and AQUA.



Validation

Being the only academic group outside of NASA with global satellite precipitation products, CHRS researchers are at the forefront of satellite precipitation validation efforts. The global PERSIANN precipitation estimates are routinely evaluated by independent research groups as well as by international data archiving efforts such as GEWEX-CEOP. The results of the evaluation program provide important information of the model capability to crossover various seasons and climate regions.

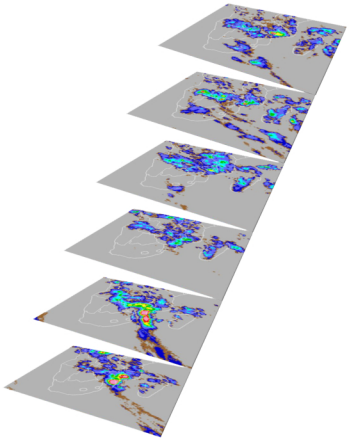


Cross validation of rainfall over Australia hosted by the Australian Bureau of Meteorology Research Centre

Applications

PERSIANN products have been used in:

1. Analyzing diurnal variability of global precipitation
2. Analysis of flood causing severe storms (e.g. Mozambique flood in Sept. 2011, see figure below)
3. Providing input for hydrologic and mesoscale modeling studies
4. Providing capacity building in developing countries through UNESCO

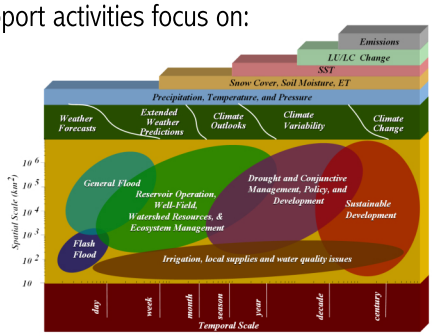


Decision Support

Motivation

Access to hydrometeorologic information is integral to modern decision making in management of floods, droughts, and, more generally, water resources. CHRS decision support activities focus on:

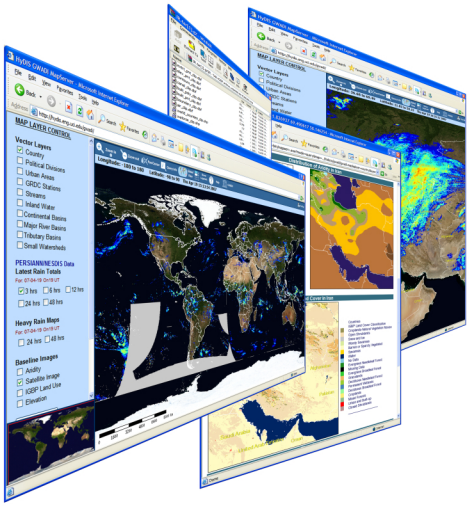
1. Providing access to high resolution near real-time global precipitation estimates to water resources management community, particularly in developing countries where adequate hydrometeorological observations are lacking.
2. Integrating advanced models and modern observations to support water resources management agencies in California as well as the semi-arid southwestern US.

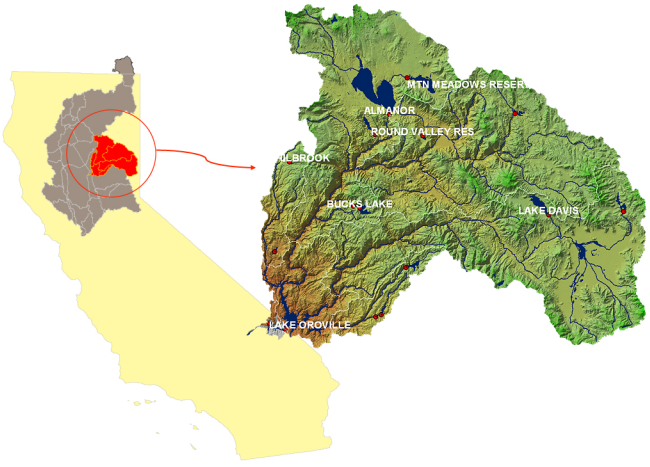


UNESCO G-WADI

As one of the initial partners of UNESCO's Water and Development Information for Arid Lands - A Global Network G-WADI CHRS researchers developed the G-WADI GeoServer. The GeoServer is an interactive web interface to near-realtime precipitation estimation, along with a suite of other GIS data and information such as aridity, land cover, digital elevation, streams, and watersheds. Using the advanced MapServer technology, the interface allows the users to zoom in on major storm events, and to query using multi-scale hierarchy of political and hydrologic divisions. The GeoServer is now one of UNESCO's recognized tools for building hydrometeorologic capacity in developing countries.

6 Hourly 0.25° : http://hydis8.eng.uci.edu/hydis-unesco 3 Hourly 0.04° : http://hydis.eng.uci.edu/gwadi/





CaliForecast

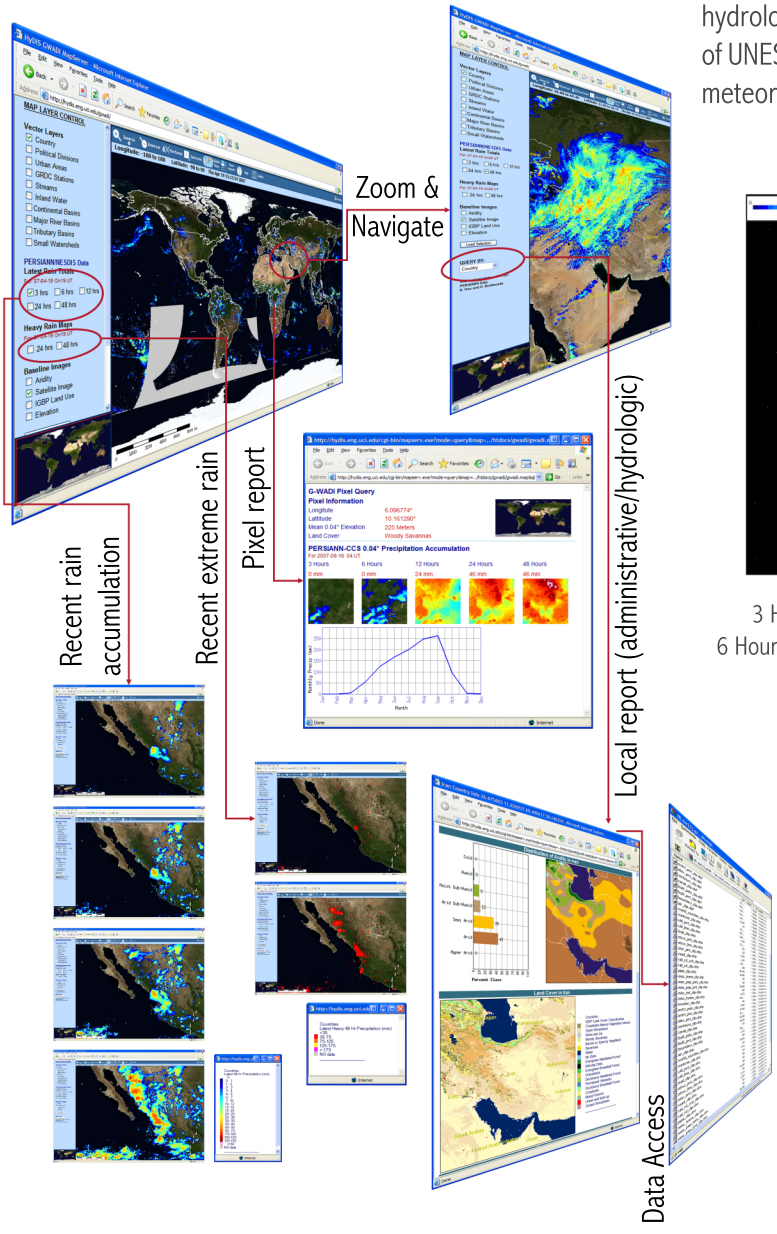
CHRS researchers, in collaboration with colleagues from the University of Washington are developing a water supply forecasting system for watersheds above key reservoirs in Northern California (e.g. feather river watershed above Lake Oroville). The system, which is based on the UW West-wide forecasting, will assimilate modern snow observations from NASA satellites and will provide probabilistic streamflow forecast and key forecasting points required by the California Department of Water Resources. The CaliForecast system will be transferred to CADWR at the end of the NASA funded project.

High Resolution Satellite Precipitation Server

Motivation

Provide access to high resolution near real-time global precipitation estimates to water resources management community, particularly in developing countries where adequate hydrometeorological observations are lacking.

Current Products



UNESCO G-WADI

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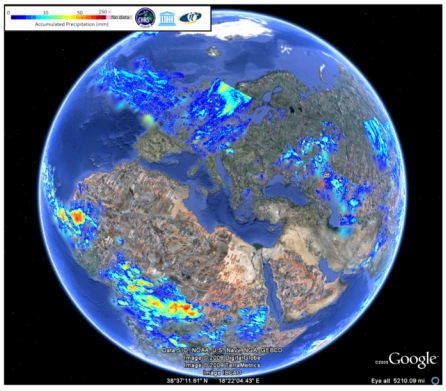


3 Hourly 0.04° : http://hydis.eng.uci.edu/gwadi/
6 Hourly 0.25° : http://hydis8.eng.uci.edu/hydis-unesco

Awards

The United Nations Educational, Scientific, and Cultural Organization (UNESCO) has CHRS as a co-recipient of the 2007 Great Man-Made River International Water Prize.

Hydrologic Education

Focus on Excellence

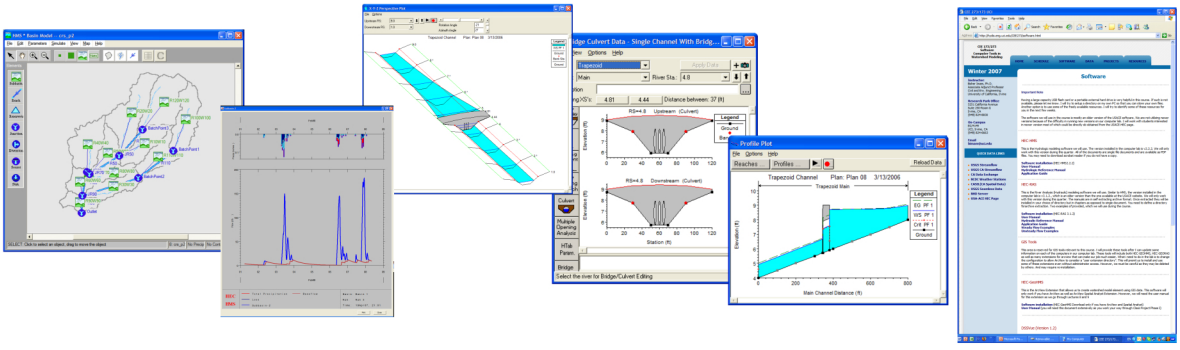
In addition to supervising undergraduate, graduate, and post-doctoral research, CHRS affiliated faculty teach several undergraduate and graduate courses at the Department of Civil and Environmental Engineering.

Courses taught by CHRS affiliated faculty include both core degree courses such as Fluid Mechanics (Hsu), Hydrology (Sorooshian), and Numerical Methods for Engineering (Gao), and upper division/graduate courses focusing on hydrologic modeling such as Watershed Modeling (Imam) and Mathematical Modeling of Hydrologic Systems (Sorooshian, Gao, Hsu).

Focus on Hydrologic Skills

Hydrologic and watershed modeling courses focus on practical applications. The watershed modeling course introduces civil engineering, environmental engineering, and earth system science students to industry standard hydrologic and hydraulic modeling tools. With exposure to the US Army Corps of Engineers Hydrologic Engineering Center (HEC) suite of models including the HEC-HMS (Hydrologic Modeling System) and HEC-RAS (River Analysis System), students become familiar with modeling software used by consulting firms, flood control districts, counties, and cities across the US.

Students are also trained on using Geographic Information Systems (GIS) to identify the hydrologic and hydraulic characteristics of watershed projects. Teams of students study various coastal watersheds in Southern California as a class project.



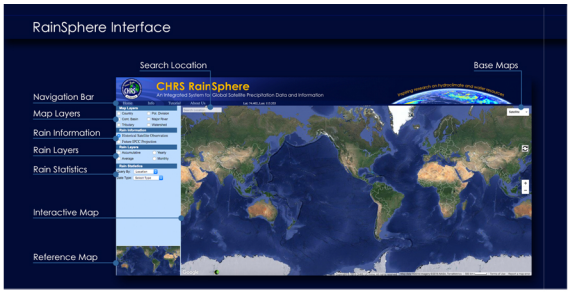
Internships

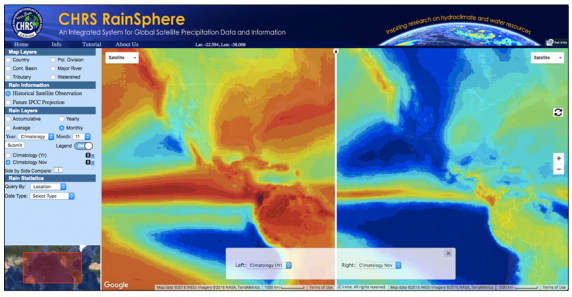
Undergraduate students actively participate in CHRS research. Mentored by CHRS researchers, undergraduate students are exposed to scientific research and work closely with their graduate colleagues.

RAINSPHERE

HTTP://RAINSPHERE.ENG.UCI.EDU

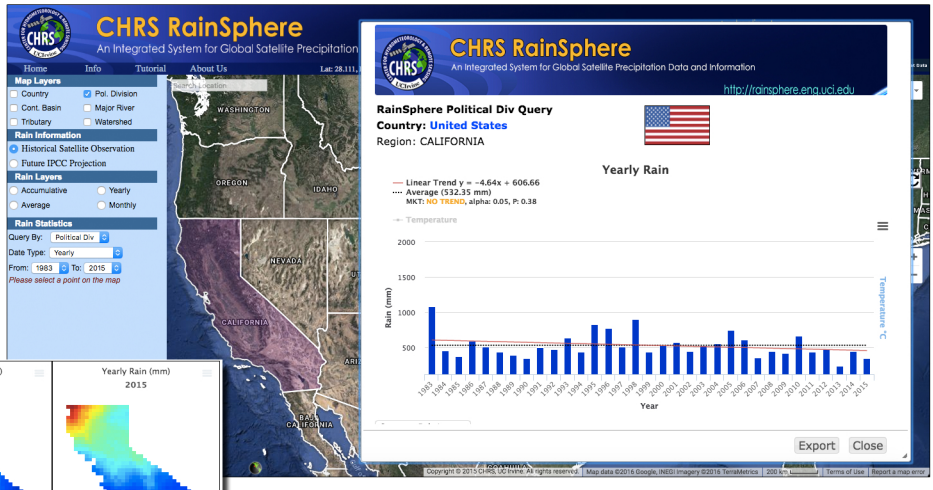
RainSphere is an integrated system for global satellite precipitation data and information, developed by the Center for Hydrometeorology and Remote Sensing, and serves as a useful tool for understanding climate change and climate variability in terms of precipitation trends in space and time. A tutorial on how to navigate through the system is provided in both forms of image slides and video on the website.

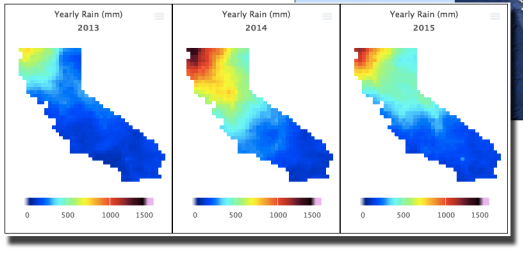




The interface allows users to visualize and query spatiotemporal statistics of global daily satellite precipitation from the PERSIANN-CDR data set (Ashouri et al. 2015) from 1983 up to the present date, and IPCC future projection (Ensemble mean IPCC projected precipitation data from 29 CMIP5 models were obtained from the Canadian Climate Data and Scenarios at http://ccds-dscc.ec.gc.ca) up to 2100. CHRS RainSphere utilizes a multitude of open source software including MapServer by the University of Minnesota, Highcharts by Highsoft AS, and GoogleMaps API by Google. High spatiotemporal resolution (25 km, daily) PERSIANN-CDR data provides the capability of studying extreme hydrometeorological phenomena.

The user may query by different categories and by different date types any time between the years of 1983 and the present date. Shown is a query of California by political division from 1983 until 2015.





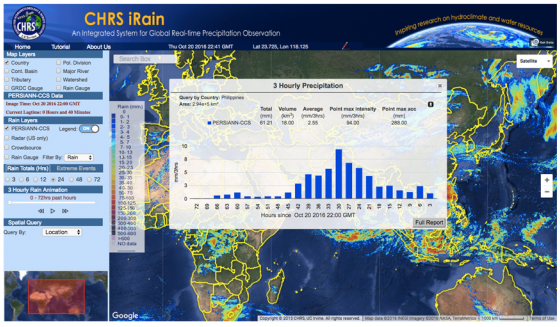
The figure to the left shows California's 3 Year rainfall images from 2013 through 2015.

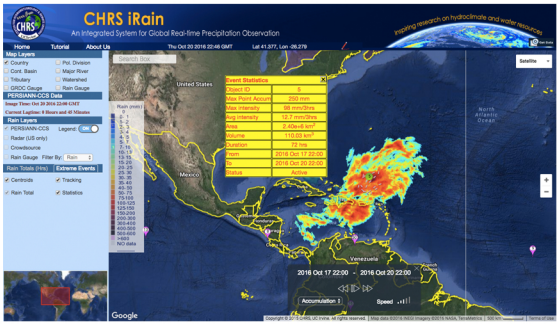
iRain

http://irain.eng.uci.edu

iRain allows users to visualize real-time global satellite precipitation observations and track extreme precipitation events globally. iRain provides access to real-time global high-resolution (~4km) satellite precipitation products from the PERSIANN-CCS (Precipitation Estimation from Remotely Sensed Information using the Artificial Neural Networks - Cloud Classification System), which has been developed by the research team at CHRS.

The building block of iRain rests on the satellite precipitation estimates generated by the PERSIANN algorithm which has been under development for over two decades. More detailed information about PERSIANN-CCS can be found at http://chrs.web.uci.edu





Acknowledgements

iRain is the product developed by Dr. Phu Nguyen, Assistant Adjunct Professor in the Center for Hydrometeorology & Remote Sensing (CHRS) at UCI, and his team, which includes a dedicated group of mostly undergraduate students including April Huie, David Furman, Hoang Tran, Phat Huynh, and Thanh N. Palacios.

Financial support of the following agencies is acknowledged:

- NASA funding resulted in the development of the PERSIANN algorithm and several of its variations.
- ICIWaRM of the US Army Corps of Engineers has provided a major part of support for Mr. Dan Braithwaite, Programmer Analyst III at CHRS.
- The US Army Research Office's support has resulted in additional refinement of the PERSIANN algorithm.
- Cooperation with UNESCO's G-WADI program has been critical to the dissemination of data worldwide.
- NOAA funding through the Climate Data Record (CDR program) resulted in the PERSIANN-CDR dataset.

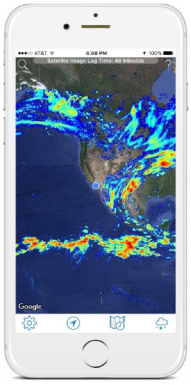
The following members of CHRS (former and current) are greatly acknowledged: Kuolin Hsu, Xiogang Gao, Bisher Imam, Dan Braithwaite, Hamed Ashouri, Andrea Thorstensen, Scott Sellars, Ali Behrangi.

Soroosh Sorooshian, Ph.D. NAE
CHRS Director

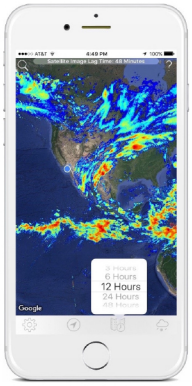
iRain - The App

The iRain app allows users to not only visualize real-time global satellite precipitation observations and track extreme precipitation events globally, but also report their local rainfall information to supplement our data by using the crowdsourcing functionality of the app. A useful feature of iRain is that real-time rainfall observation data can easily be shared through social networks i.e. Facebook, Twitter. In addition, rainfall events can now be viewed as an animation to observe their change over time, as an accumulation of rain or as a time lapse. Precise measurement of rainfall at a given point can be observed by zooming in to the map.

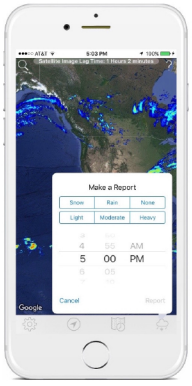
The app is licensed to the Center for Hydrometeorology & Remote Sensing (CHRS) at the University of California, Irvine (UCI). iRain is available for iOS and Android devices.



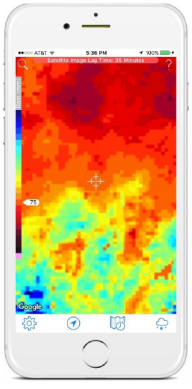
The main interface of iRain app



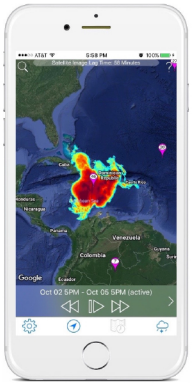
Users can view the rain total over a period of time of their choice.



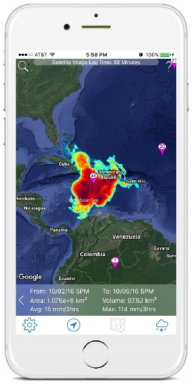
Users can report rainfall at their location and view reports of others, supplementing our satellite data.



When zoomed in, users can measure the rainfall in mm of a particular location.



View the extreme event movement as an animation. iRain can show this animation as an accumulation of rain or as a time lapse.

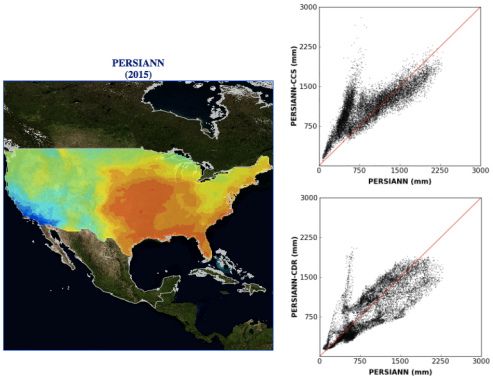


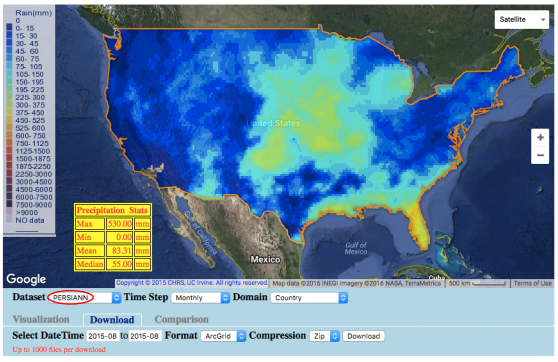
View various characteristics of a particular extreme event.

DATA PORTAL

HTTP://CHRSDATA.ENG.UCI.EDU

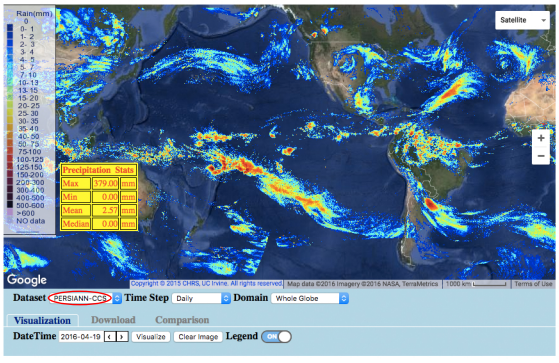
The CHRS Data Portal allows users to visualize, download, and compare precipitation estimates between different domains, conditions, and dates. The current operational PERSIANN (Precipitation Estimation from Remotely Sensed Information using Artificial Neural Networks) system uses neural network function/classification approximation procedures to compute an estimate of rainfall rate.





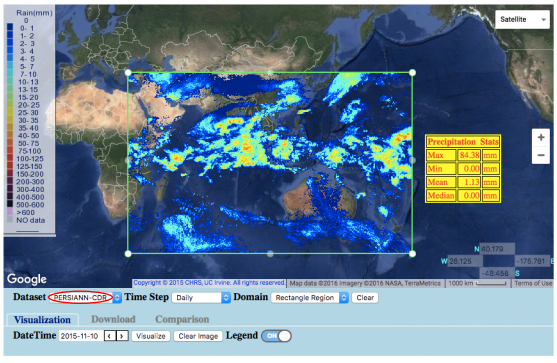
PERSIANN

The PERSIANN system was based on geostationary infrared imagery and later extended to include the use of both infrared and daytime visible imagery. The PERSIANN algorithm used here is based on the geostationary long wave infrared imagery to generate global rainfall. Rainfall product covers 60°S to 60°N globally. An adaptive training feature facilitates updating of the network parameters whenever independent estimates of rainfall are available.



PERSIANN-CCS

The PERSIANN-Cloud Classification System enables the categorization of cloud-patch features based on cloud height, areal extent, and variability of texture estimated from satellite imagery. At the heart of PERSIANN-CCS is the variable threshold cloud segmentation algorithm; it enables the identification and separation of the individual patches of clouds, of which can be classified to describe the relationship between the rain-rate and brightness temperature.



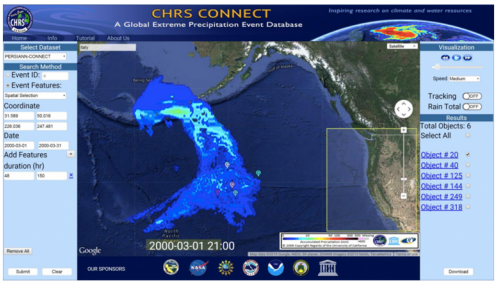
PERSIANN-CDR

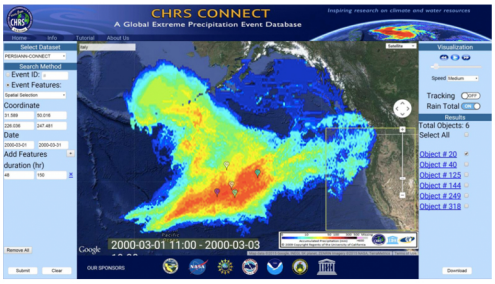
PERSIANN-Climate Data Record is aimed at addressing the need for a consistent, long-term (30+ years), high-resolution, and global precipitation dataset for studying the changes and trends in daily precipitation, especially extreme precipitation events, due to climate change and variability. PERSIANN-CDR is generated to maintain consistency of the GridSat-B1 infrared data and the Global Precipitation Climatology Project at 2.5 deg monthly scale throughout the entire record.

CHRS CONNECT Dataset

http://connect.eng.uci.edu

Global satellite and remote sensing observations capture an enormous amount of data for essentially every precipitation event that occurs. Using PERSIANN precipitation estimates, we define individual precipitation events as segmented or "connected" objects in four-dimensional (4D) space (longitude, latitude, time, and intensity (mm/hr)). This dataset is called PERSIANN-CONNECT. We store the segmented precipitation objects in a publicly available ftp directory and PostgreSQL database. The database can be used to subset and download precipitation objects.





Applications of the Data

* Precipitation event visualization and comparison
  - Search for specific events or characteristics
* Extreme precipitation event analysis
  - Create a data subset to include extreme events for a particular region
* Weather and climate studies
  - Gain insight into the changes in precipitation event characteristics
* Engineering Applications
  - Use objects for "storm design" or precipitation scenario development hydrological modeling and resource planning

What is Our Purpose?

Many advances in the theoretical understanding of atmospheric and oceanic dynamics have been based on numerical modeling. We seek additional advances by harnessing the vast amounts of remote sensing information and focusing on a data driven and computer vision approach, which looks at observational and modeled data from a 4D perspective. By viewing precipitation events as objects in space and time, we provide enhanced information regarding the evolution of the event itself, as well as its characteristics

The Connectivity Algorithm

The connectivity algorithm is designed to ensure that all pixels of precipitation estimates are connected (assuming a set intensity threshold) in both space and time, allowing for the feature to be analyzed as a 4D object. Using Matlab, a code was developed by researchers at CHRS for precipitation event segmentation. A precipitation voxel is defined as a volumetric unit of precipitation. The algorithm uses 4D space (longitude, latitude, time and intensity) and looks for connected voxels in space and time. If two voxels have at least one connection (face, corner or edge) in space or time, they can be grouped into a common object. The algorithm segments all of the objects, labels them, and puts them in a descriptive table. We exclude a large number of small precipitation events by setting a few algorithm criteria. In this version of the algorithm, we apply a threshold of precipitation intensity at 1 millimeter per hour (mm/hr), precipitation duration at 24 hours, and limit the number of connections in space and time to 6 (i.e. faces of the voxel). Future versions of this dataset will experiment with different combinations of these criteria to determine the optimal settings for viewing precipitation as objects

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