PERSIANN CDR Applications and "Societal Benefits"

Soroosh Sorooshian, KuoLin Hsu

and the CHRS Team

Center for Hydrometeorology and Remote Sensing
University of California Irvine

NOAA Climate Data Record (CDR) Annual Meeting
Asheville NC, August 4-6 2015

University of California Irvine (UCI) Past

and many more …

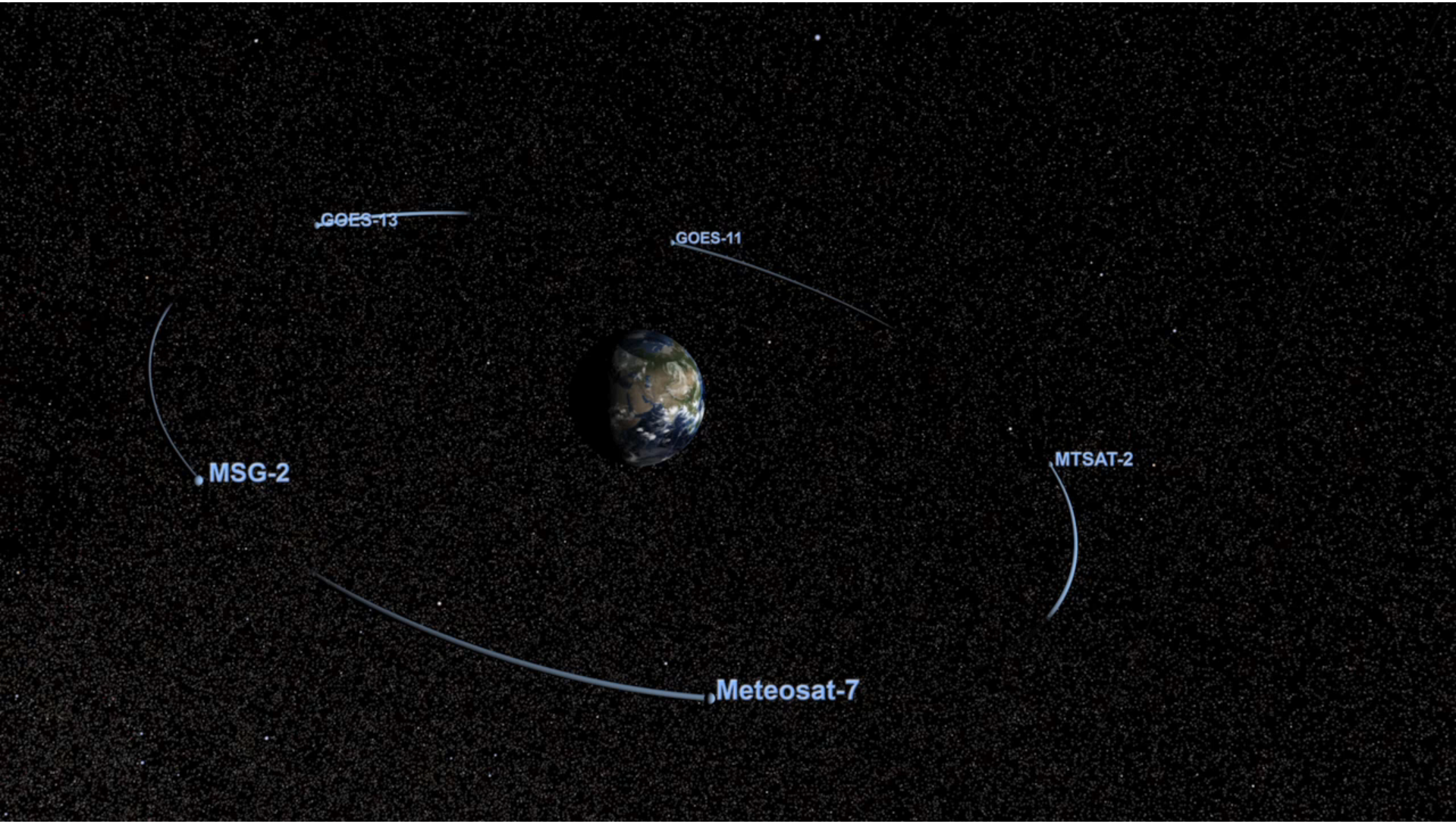
Precipitation Estimation from Remotely Sensed Information using Artificial Neural Networks (PERSIANN)

Kuolin Hsu
Algorithm Development

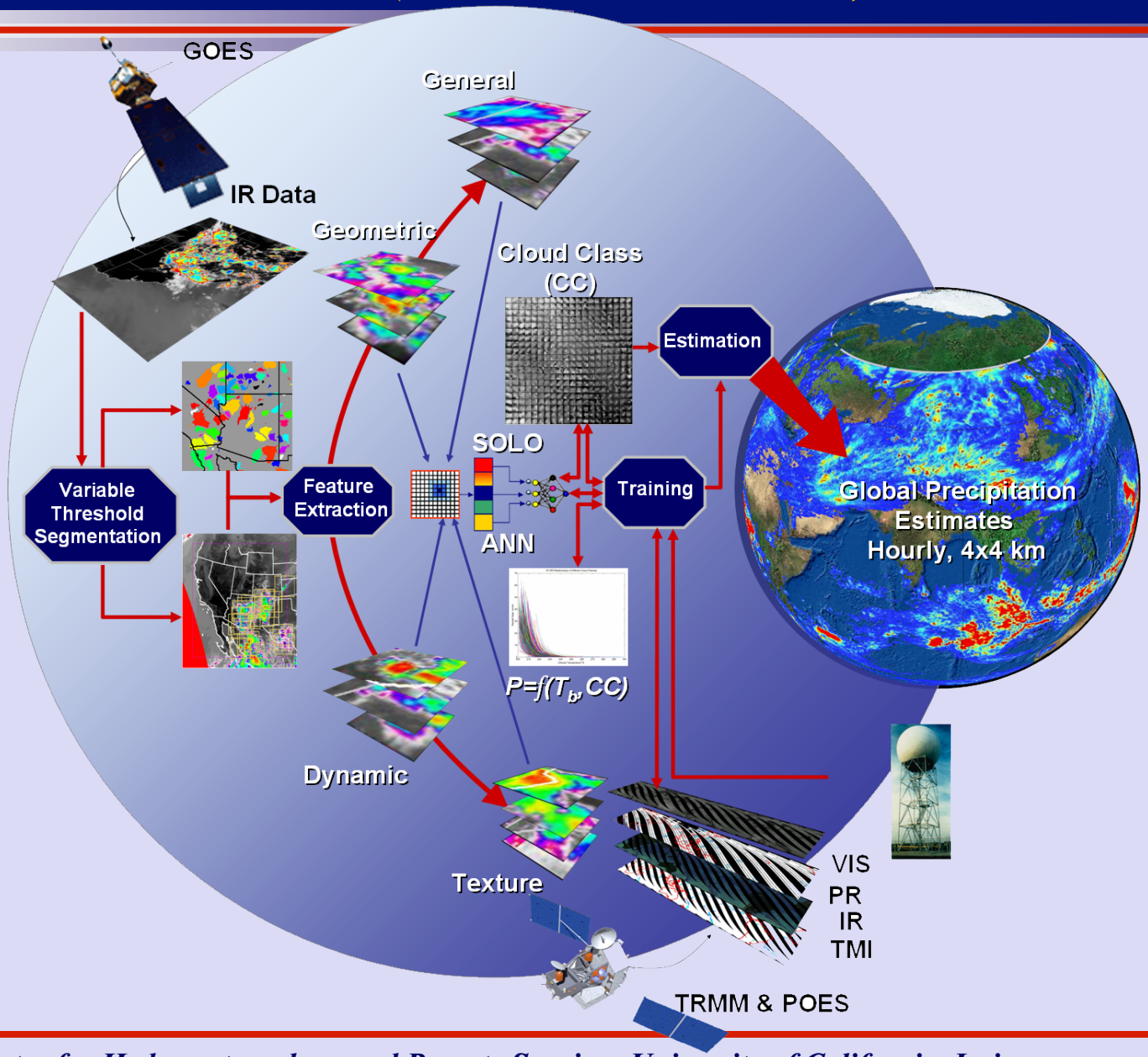
Bisher Imam
G-WADI website development

Center for Hydrometeorology and Remote Sensing, University of California, Irvine

Geostationary Satellites Infrared (IR) Channel Tb



PERSIANN-CCS (Real-time 4 km)



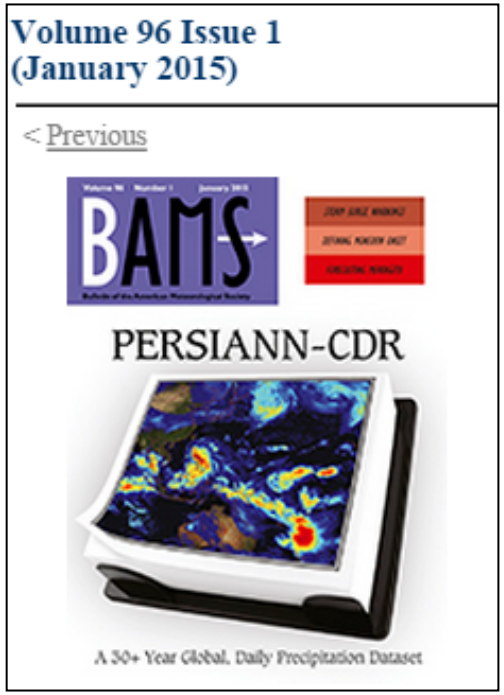
PERSIANN Extensions: Climate-Related

- PERSIANN-CDR
- PERSIANN-CONNECT

PERSIANN -CDR

http://www.ncdc.noaa.gov/cdr/operationalcdrs.html

- *Daily Precipitation Data*
- *Data Period: 1983~2014*
- *Coverage: 60°S ~ 60°N*
- *Spatial Resolution: 0.25°x0.25°*



Ashouri, Hsu et al., BAMS, 2015.

PERSIANN-CDR: PERSIANN Climate Data Record

http://www.ncdc.noaa.gov/cdr/operationalcdrs.html

NOAA NATIONAL CLIMATIC DATA CENTER
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

Home | Operational CDRs | Developmental CDRs | Opportunities | Library | SEARCH NCDC

CLIMATE DATA RECORD PROGRAM

- Serving the Public
- Data
- Development Guidelines
- Contact Us

News

Climate Data and Applications Workshop - A Focus on Precipitation - Dec 3-4, 2013

Congratulations Cheng-Zhi Zou

2013 CDR Annual Meetings Presentations now available

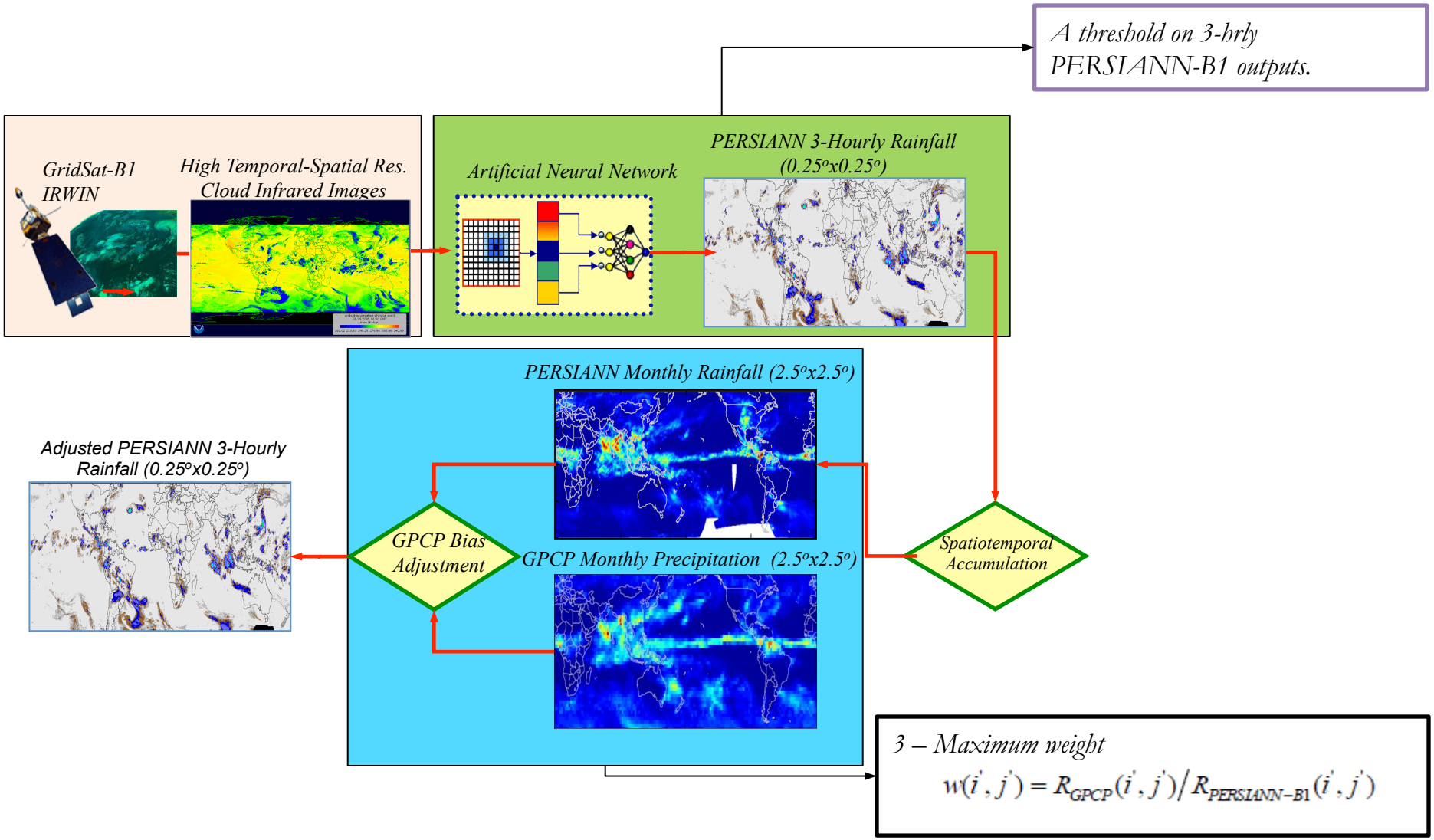
Operational Climate Data Records (CDRs)

In addition to embracing the National Research Council CDR definition (Climate Data Records from Environmental Satellites: Interim Report 2004) , NOAA operational CDRs are routinely assessed for quality and systematically generated. The first step in establishing an operational CDR includes public posting of the source code that generated the CDR dataset, the dataset itself, and supporting documentation through a six-phase Research-to-Operations process that is described in the Developers Guidelines.

Once posted to the NCDC webpage, the CDRs are grouped by Fundamental CDRs and Thematic (Atmospheric, Oceanic, and Terrestrial) CDRs. Fundamental CDRs are sensor data (e.g. calibrated radiances, brightness temperatures) that have been improved and quality controlled over time, together with the ancillary data used to calibrate them. Thematic CDRs are geophysical variables derived from the FCDRs, such as sea surface temperature and sea ice concentration, and they are specific to various disciplines. Thematic CDRs are often generated by blending satellite observations, in-situ data, and/or model output.

Atmospheric CDRs	Information	Serving Public	Available Data Access	Source Code	Documentation
Aerosol Optical Thickness	Overview Contact Us Registration		Use Agreement THREDDS FTP		Algorithm Description Data Flow Diagram Maturity Matrix
Mean Layer Temperatures - RSS	Overview Contact Us Registration		Use Agreement THREDDS FTP		Algorithm Description Data Flow Diagram Maturity Matrix
Mean Layer Temperatures - UAH	Overview Contact Us Registration		Use Agreement THREDDS FTP		Algorithm Description Data Flow Diagram Maturity Matrix
Outgoing Longwave Radiation	Overview Contact Us Registration		Use Agreement THREDDS FTP		Algorithm Description Data Flow Diagram Maturity Matrix
Precipitation - PERSIANN-CDR	Overview Contact Us Registration		Use Agreement THREDDS FTP		Algorithm Description Data Flow Diagram Maturity Matrix

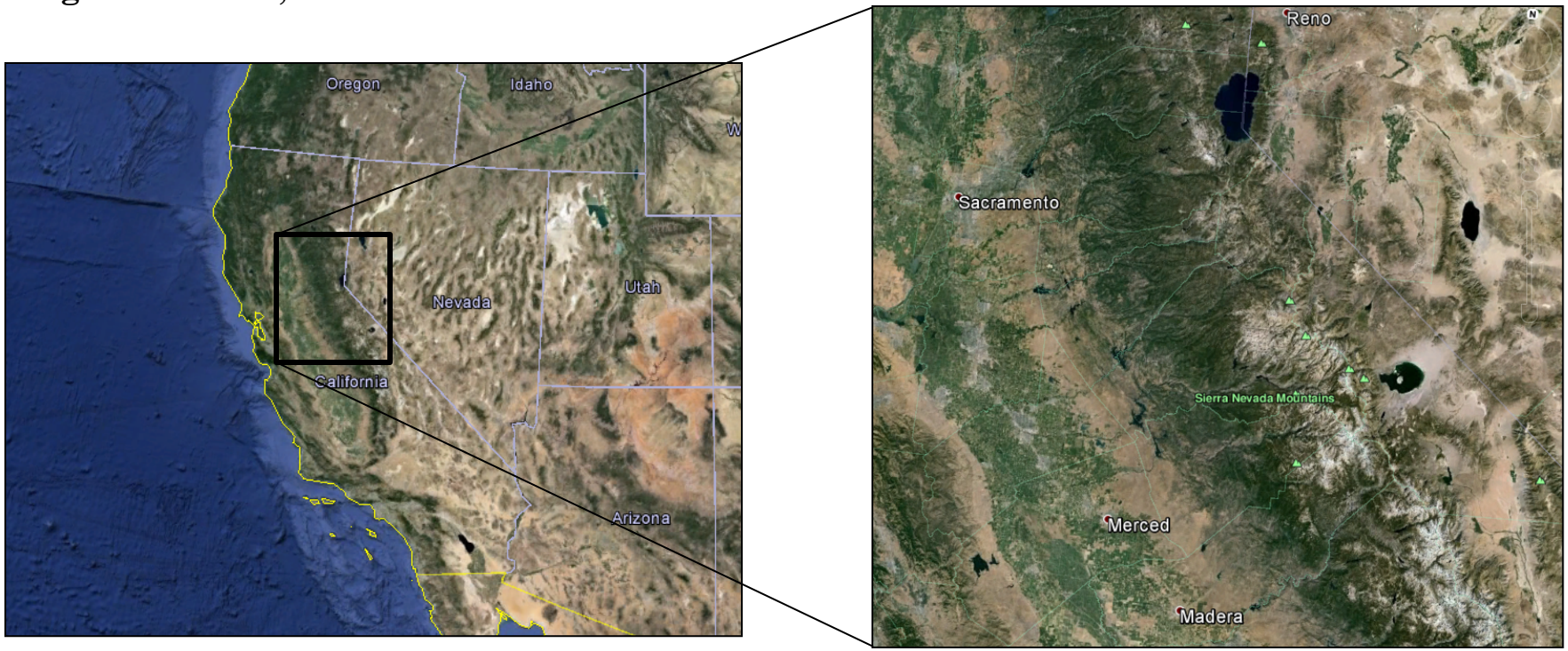
PERSIANN-CDR Algorithm



Sierra-Nevada Mountain Region

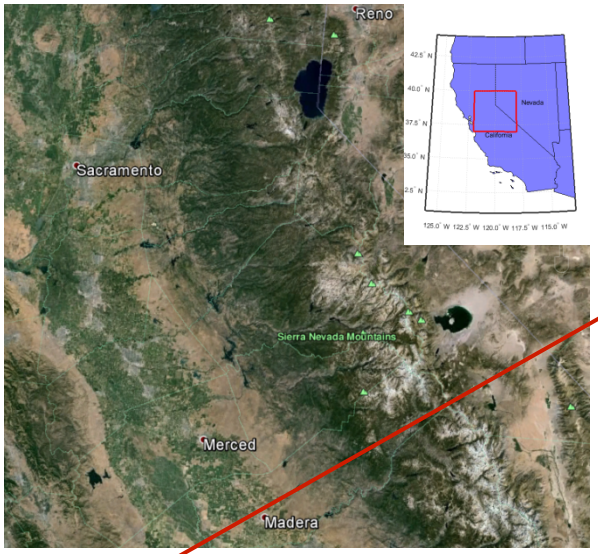
Area: 63,100 square kilometers (24,370 sq mi)

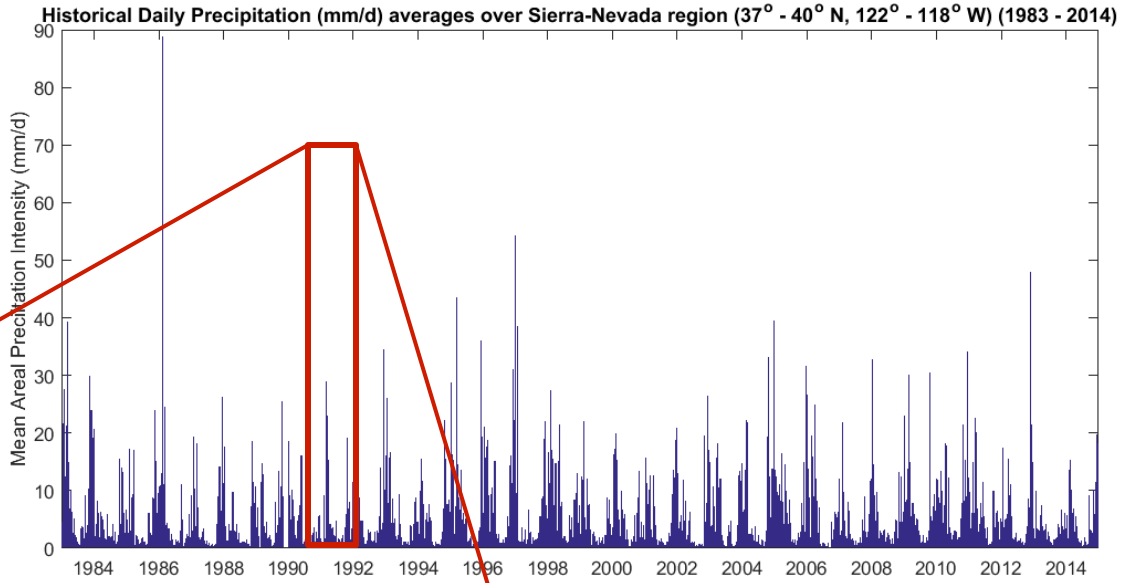
Length: 400 mile, Width: 64 mile.

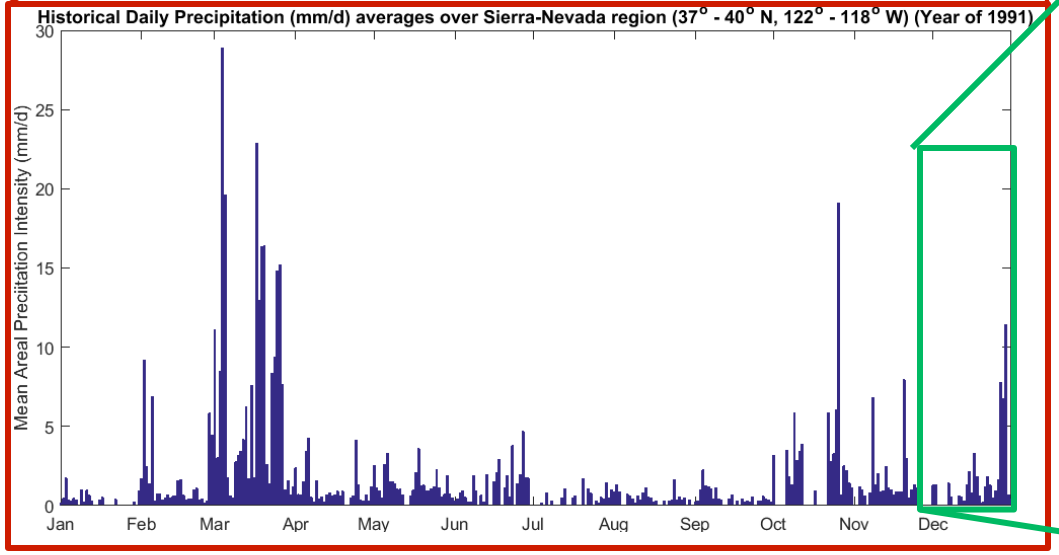


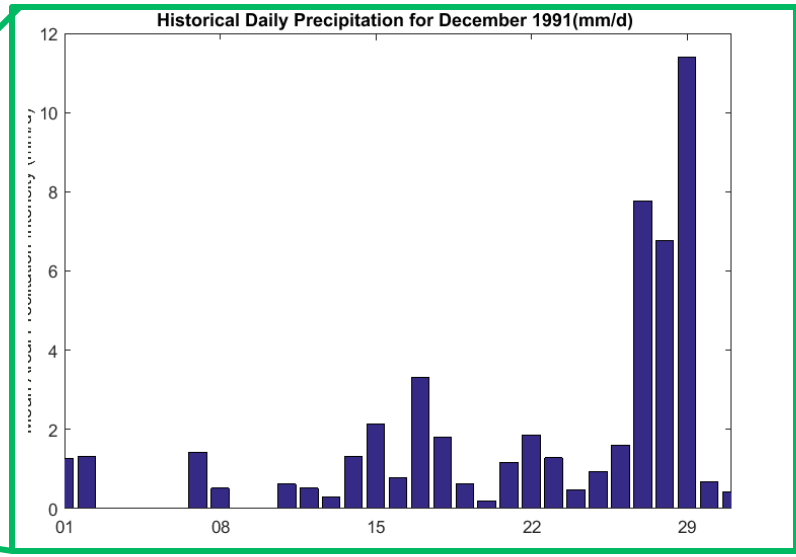
Source: Google Earth

Sierra-Nevada Mountain (California and Nevada)

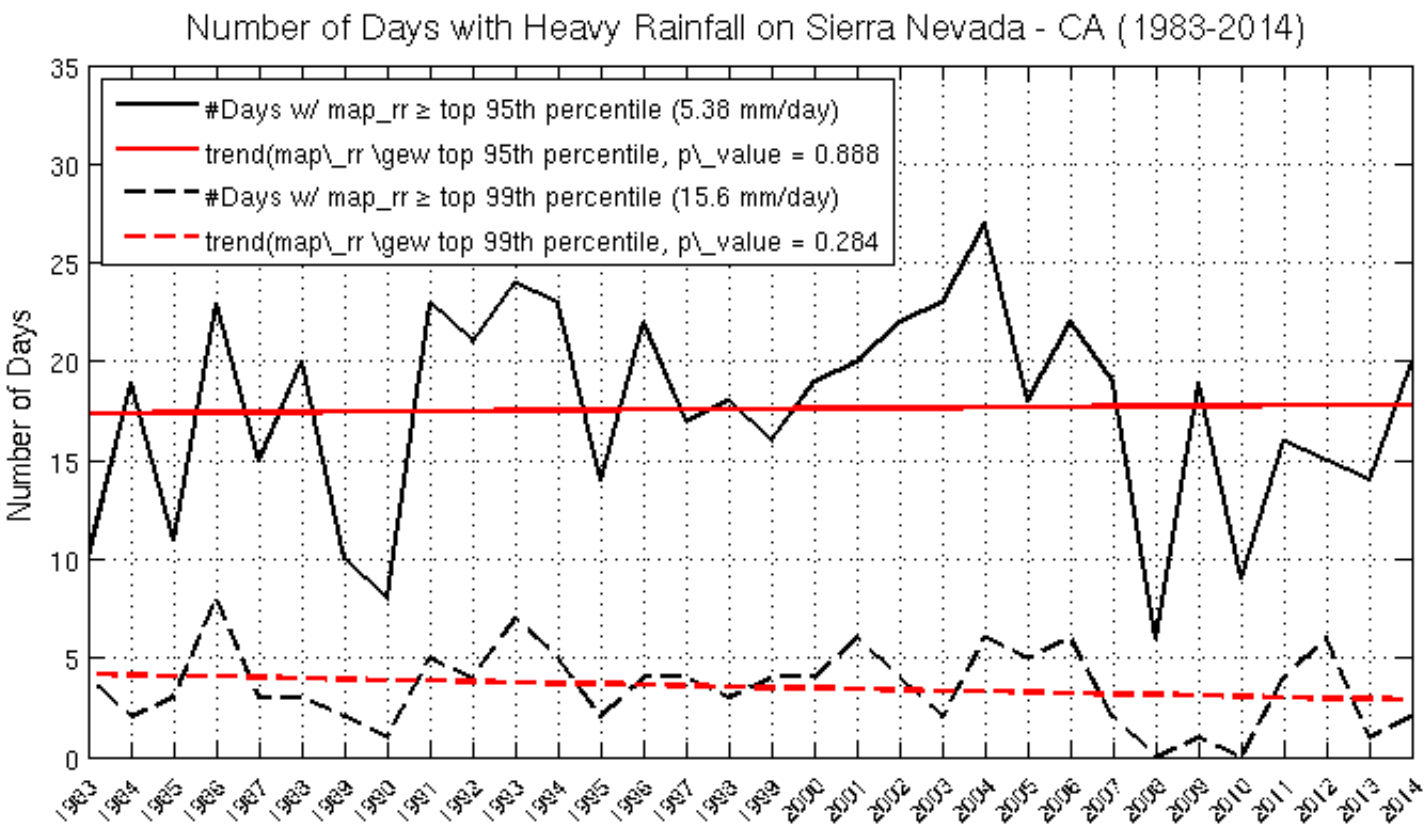








Trend in the number of heavy rainy days

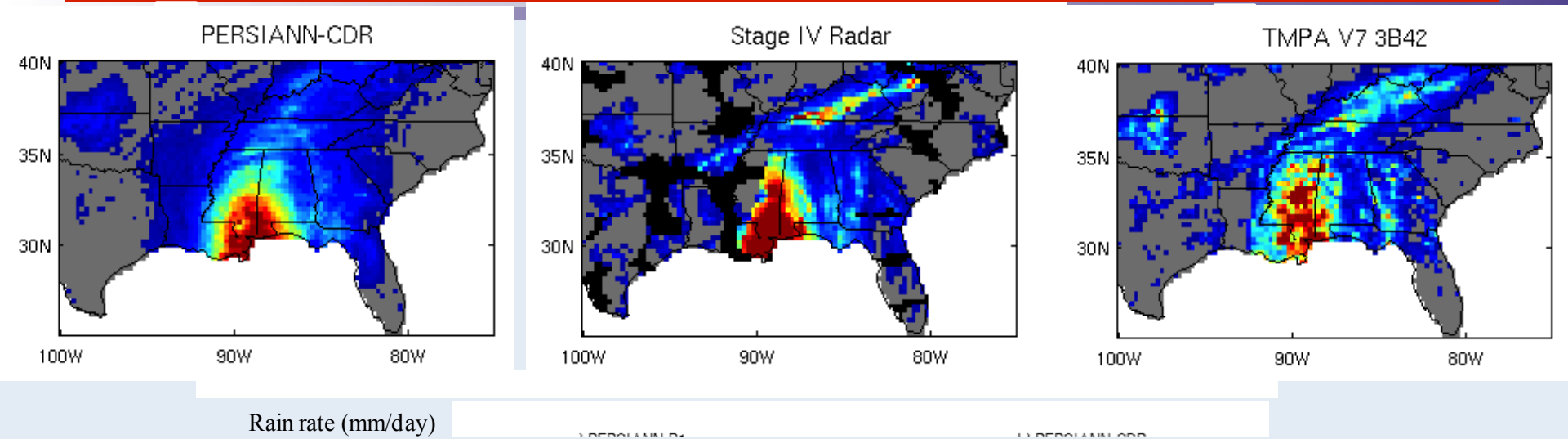


Though a reduction in extreme precipitation events is identified in the recent years (after 2007), at a 5% significance level (95% CI), none of the above trends is statistically significant.

Testing and Validation of PERSIANN-CDR Product

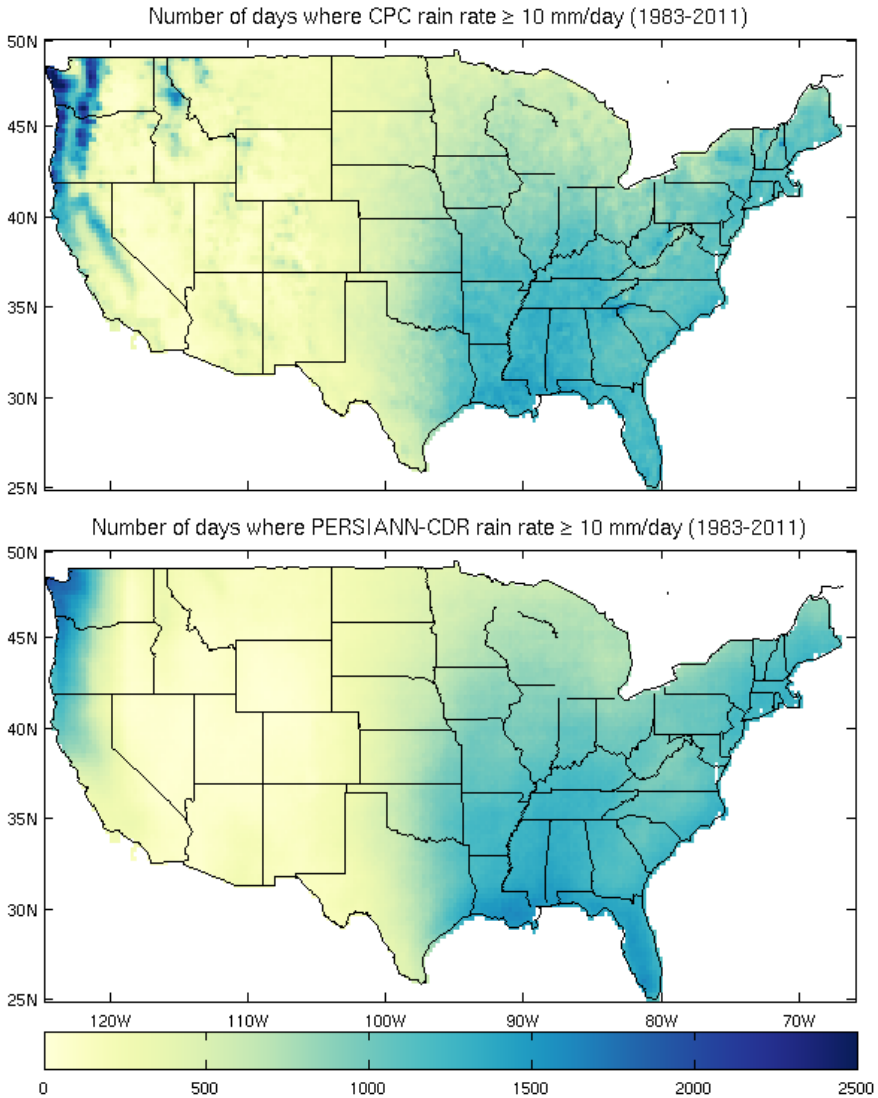
Center for Hydrometeorology and Remote Sensing, University of California, Irvine

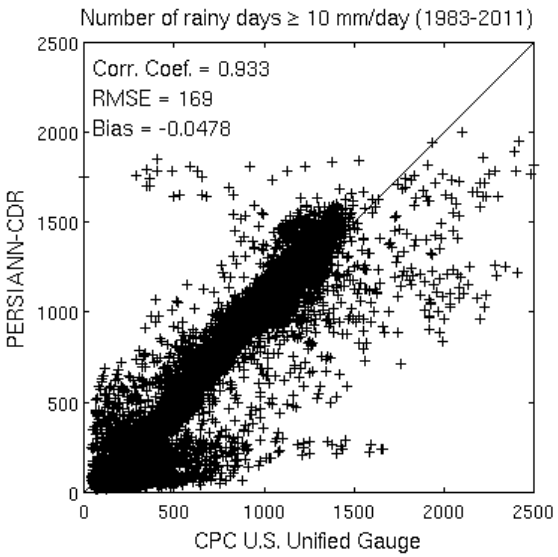
Testing of PERSIANN-CDR: Hurricane Katrina, 2005



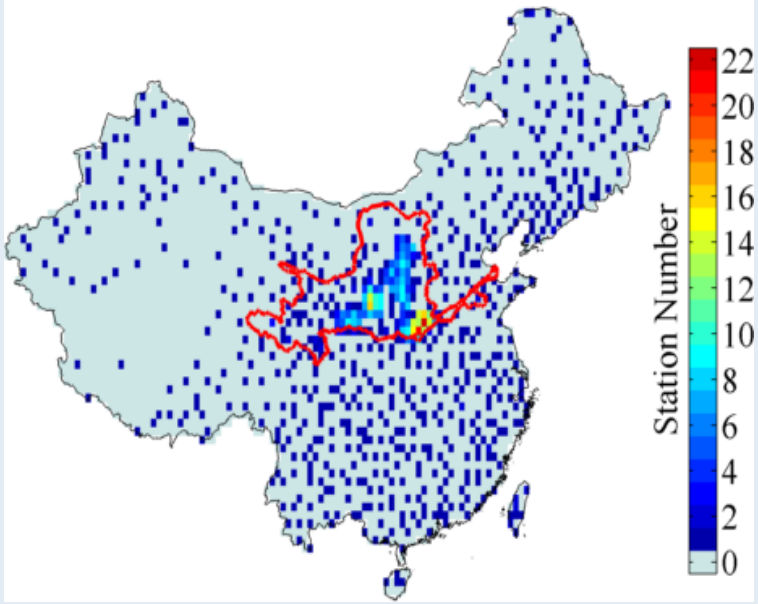
Rainfall (mm/day) over land during Hurricane Katrina on 29 August 2005 from PERSIANN-CDR (top row left), Stage IV Radar (top row middle, Lin and Mitchell 2005), and TMPA v7 (top row right, Huffman *et al.* 2007). Black and gray pixels show radar blockages and zero precipitation, respectively. Scatter plots of PERSIANN-CDR and TMPA versus Stage IV Radar data are provided in the bottom row.

Testing of PERSIANN-CDR: Number of Rainy days >= 10 mm/day

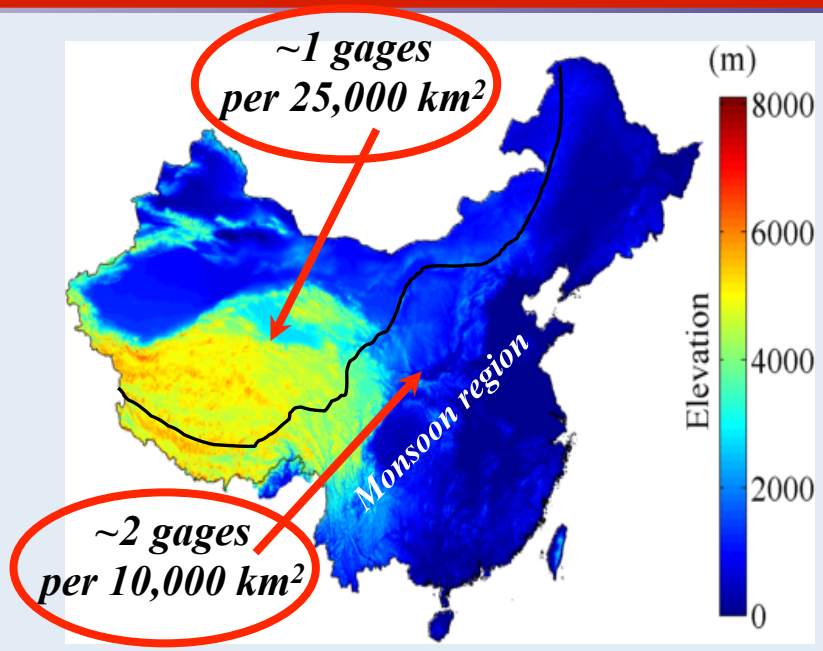




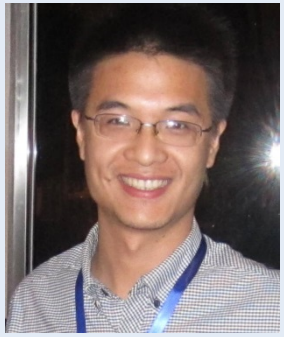
PERSIANN-CDR Evaluation over China



EA Rain Gauge Distribution



Elevation Map



Dr. Chiyuan Miao - BNU

Gauge data: *daily precipitation over East Asia (EA) (Xie et al., 2007)*

- *More than 2200 ground-based stations across China*
- *0.5° resolution*
- *Period 1983-2006*

PERSIANN-CDR: *up scaled into the same resolution as EA (0.5°)*

Miao et.al. J. of Hydrometeorology 2015

Evaluation Indices

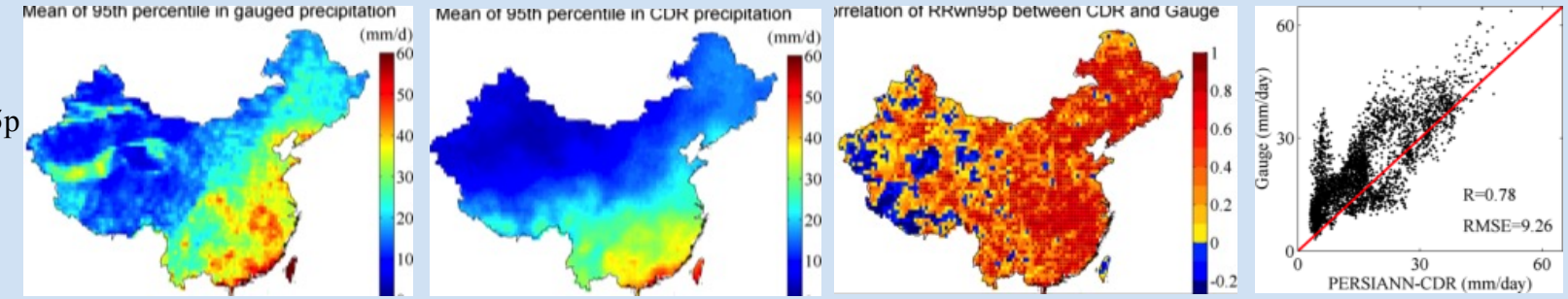
ID	Definition	Unit
RR95p	The 95th percentile of annual precipitation on wet days (precipitation ≥ 1mm)	mm/day
R10mmTOT	Annual total precipitation when daily precipitation ≥ 10mm	mm
R10mm	Annual count of days when precipitation ≥10mm	Days

Extreme precipitation indices used in the analysis

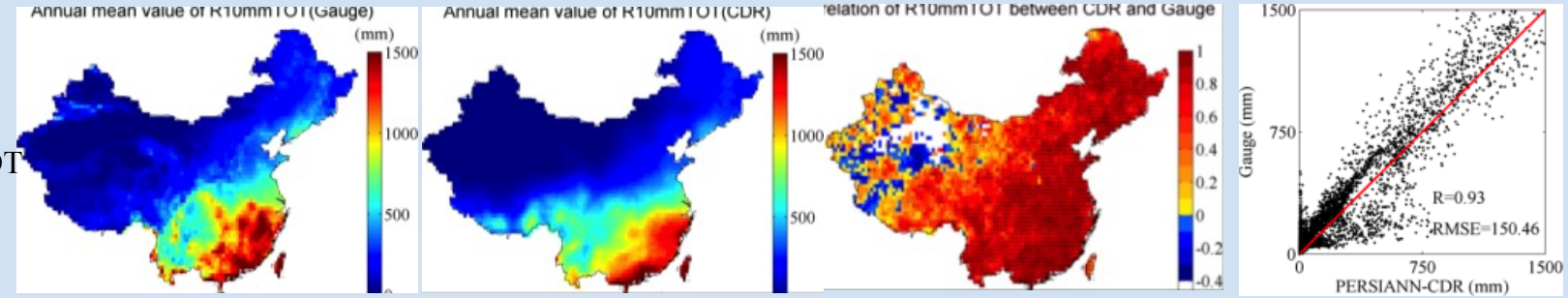
Results: Entire China

EA | PERSIANN-CDR | Pixel correlation | Scatterplot of mean

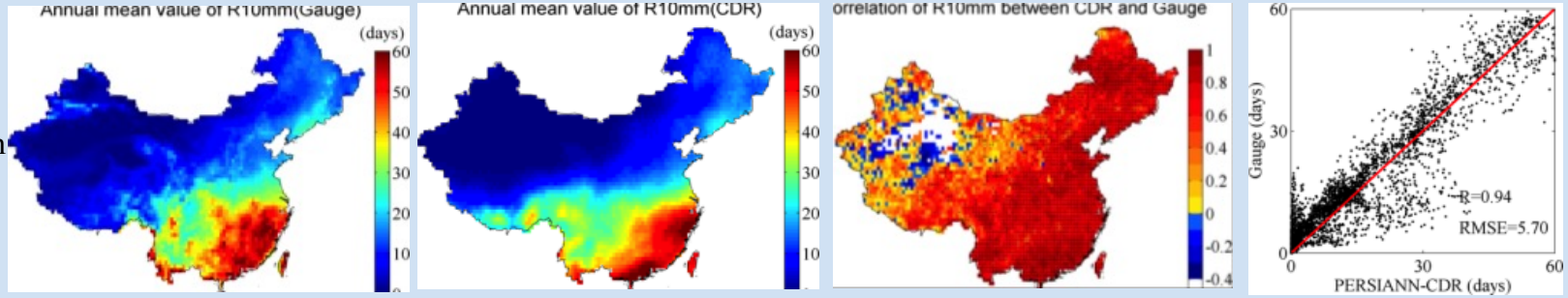
RR95p



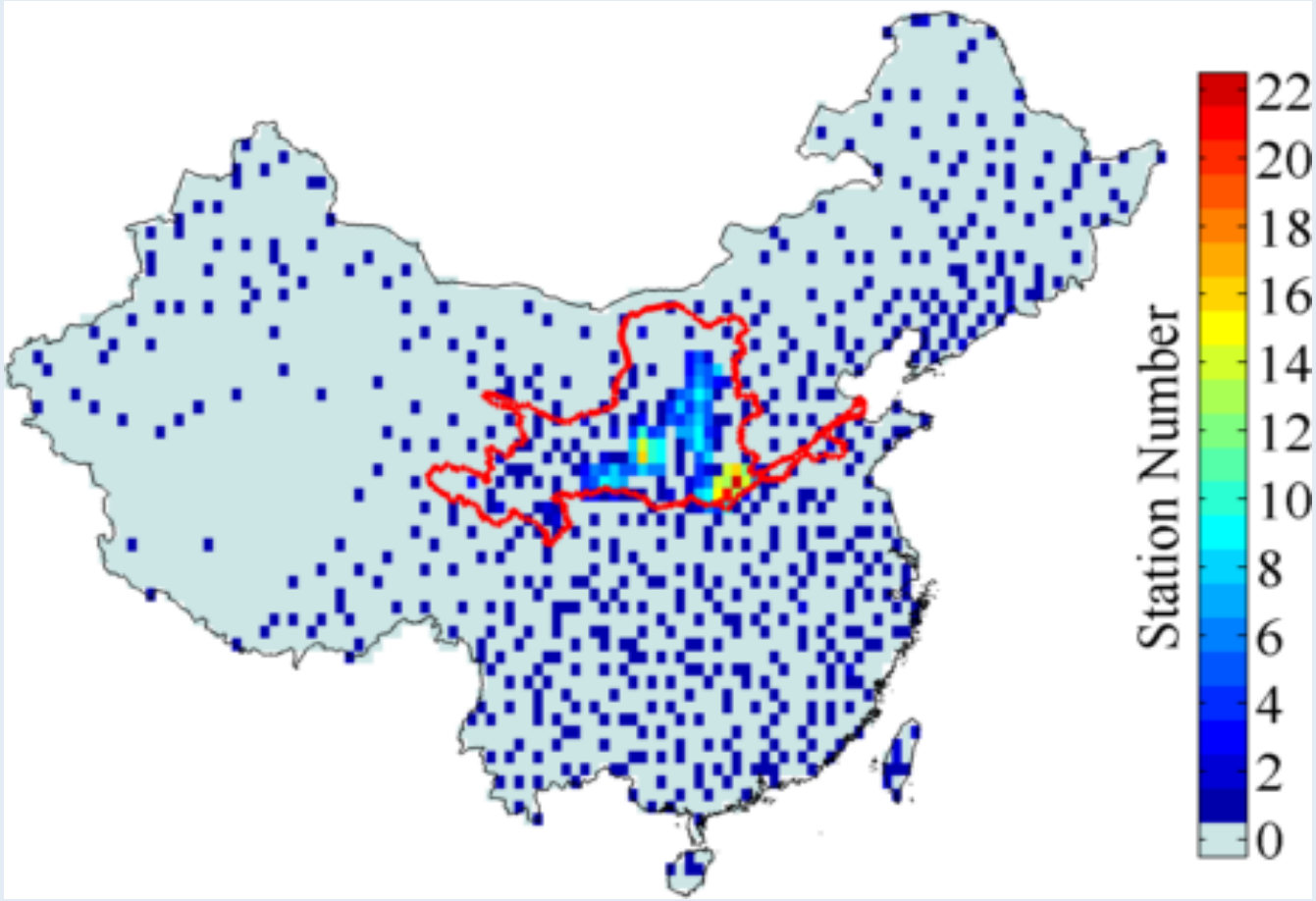
R10mmTOT



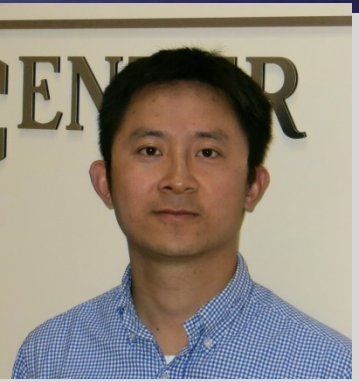
R10mm



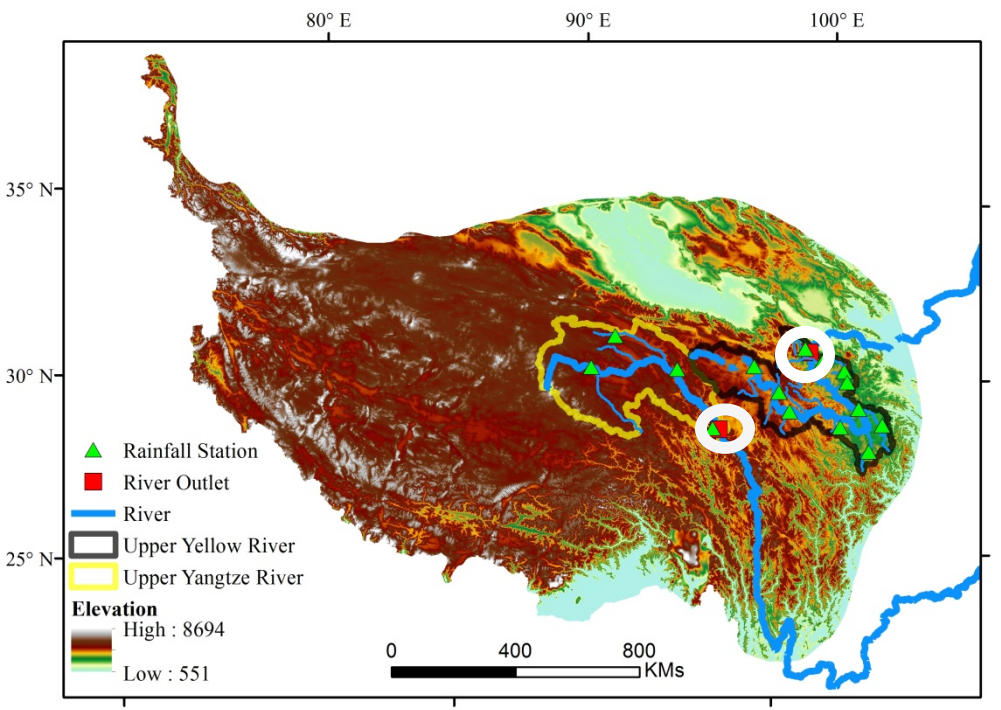
PERSIANN-CDR Evaluation: Zooming over the Yellow River Region



PERSIANN-CDR Evaluation in Tibetan Plateau



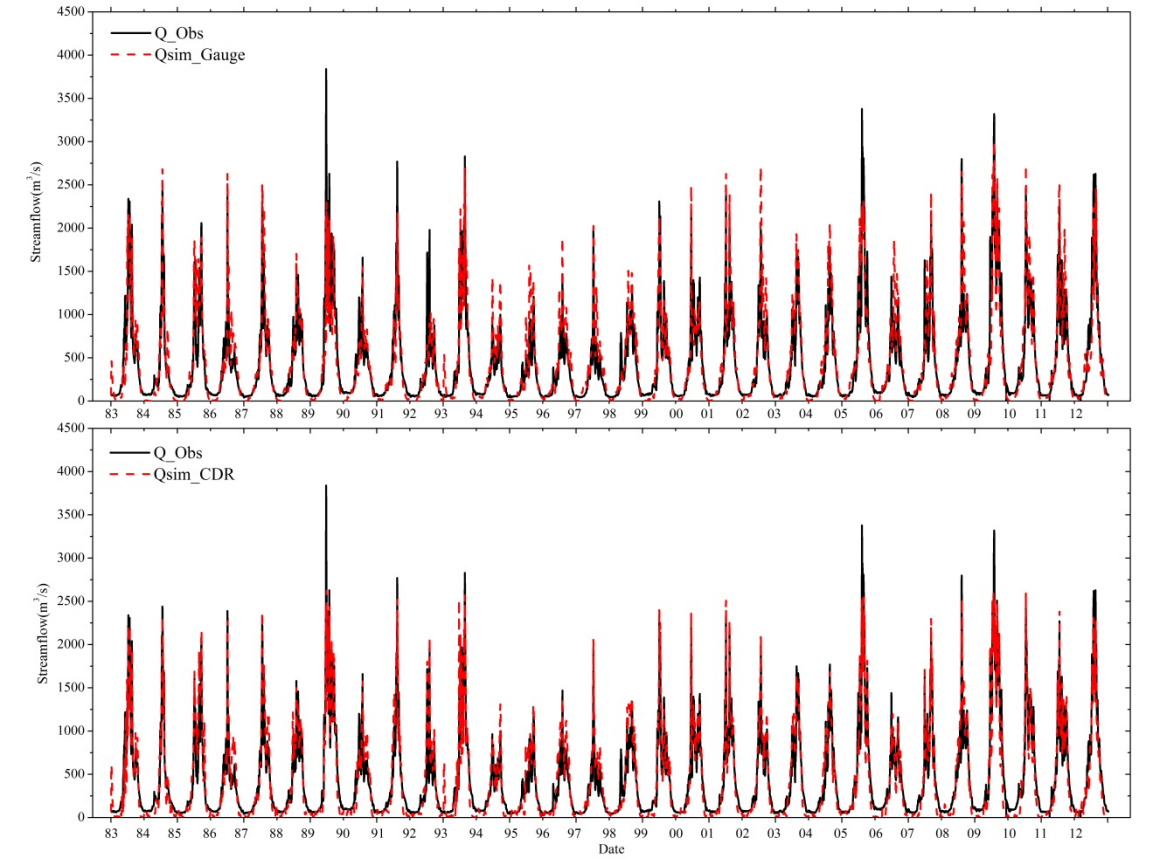
Dr. Xiaomang Liu



TianTian Yang

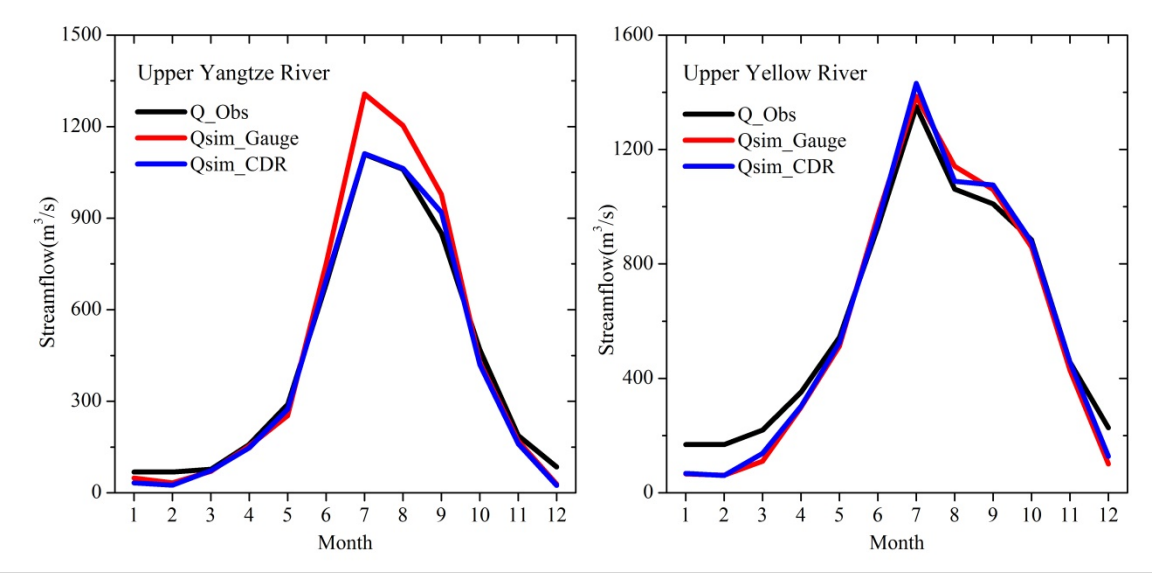
The selected river basins (the upper Yellow River and upper Yangtze River Basin) on the Tibetan Plateau and location of rainfall stations and river outlets.

PERSIANN-CDR Evaluation in Tibetan Plateau



The comparison between the simulated daily streamflow (red) with PERSIANN-CDR and ground-based precipitation and the observed data (black) at the outlets of the upper Yangtze River Basin.

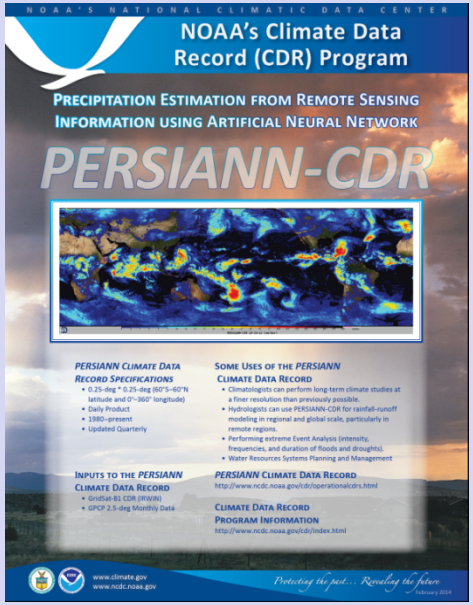
PERSIANN-CDR Evaluation in Tibetan Plateau



Comparisons of the simulated and observed average monthly streamflow driven by the gauge-based precipitation and PERSIANN-CDR precipitation for the two basins from 1983 to 2012.

PERSIANN-CDR:

Potential Usefulness for Model testing



Ashouri et al., BAMS 2015

China

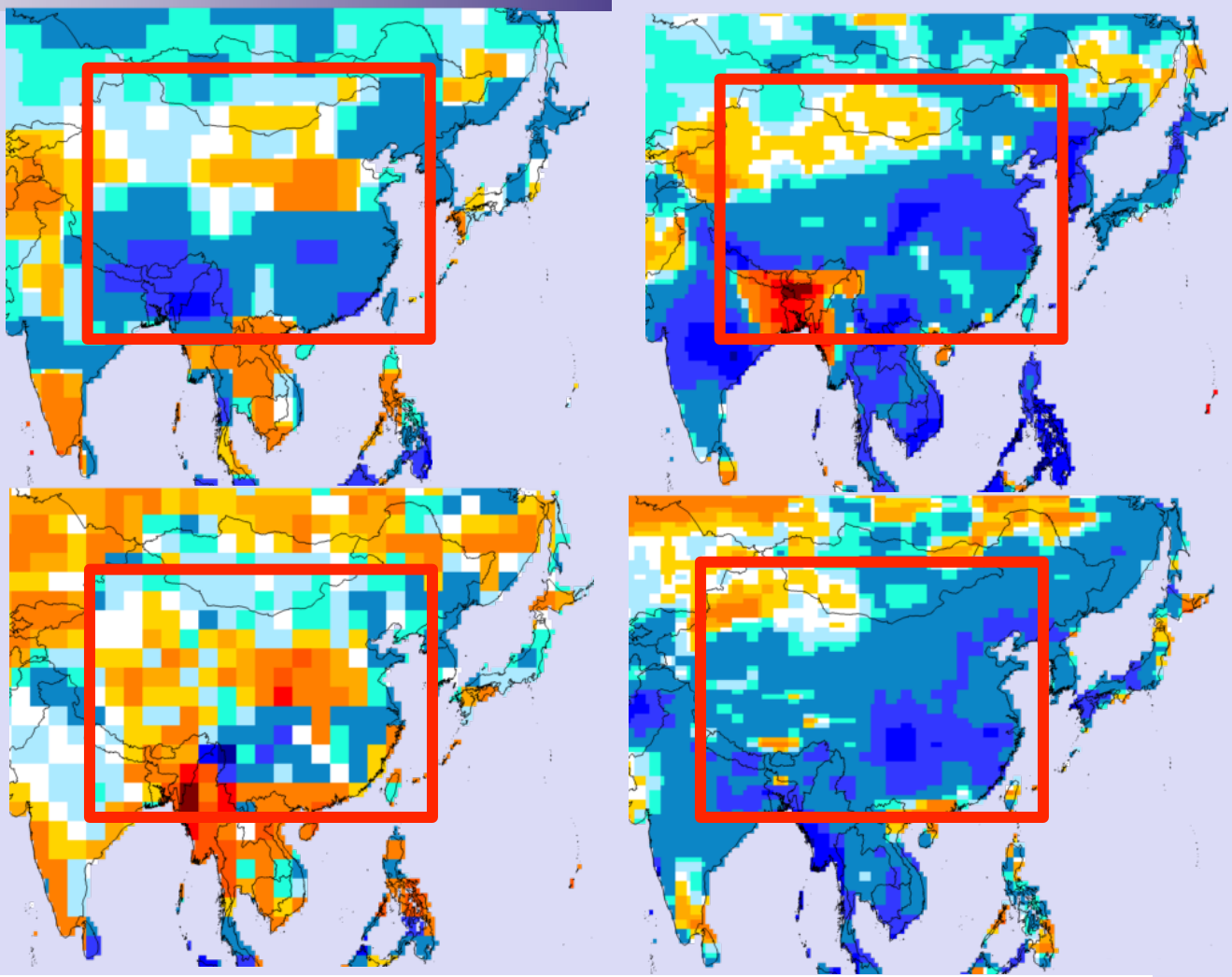
RCP2.6 ("Low": 2.6 W/m^2, Equivalent CO_2 conc. 421 ppm by 2100)

bcc_csm1_1 (Chinese GCM)

MIROC5 (Japanese GCM)

GISS-E2-R (U.S. GCM)

HadGEM2-ES (U.K. GCM)



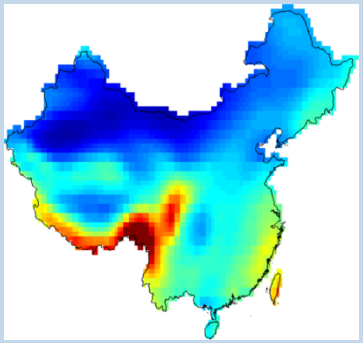
Precipitation change (mm per day per decade)

-.5 -.4 -.3 -.2 -.1 -.05 -.01 -.005 -.001 .001 .005 .01 .05 .1 .2 .3 .4 .5

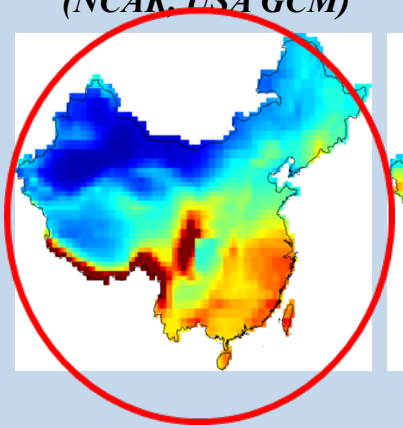
Resolution: 0.5°x0.5°

CMIP5 Models' historical simulation (1983-2005): CHINA

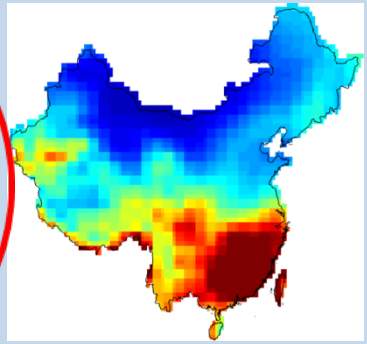
bcc_csm1_1_m
(Chinese GCM)



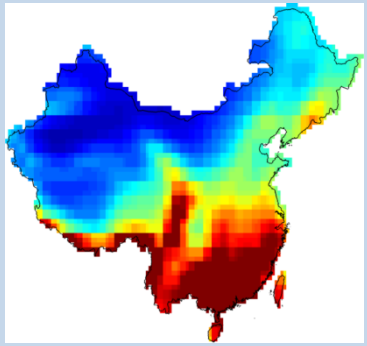
CCSM4
(NCAR, USA GCM)



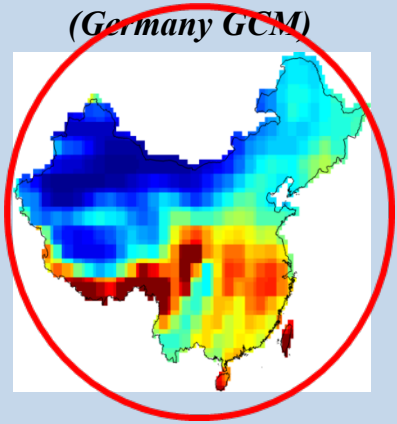
HadGEM2-ES
(U.K GCM)



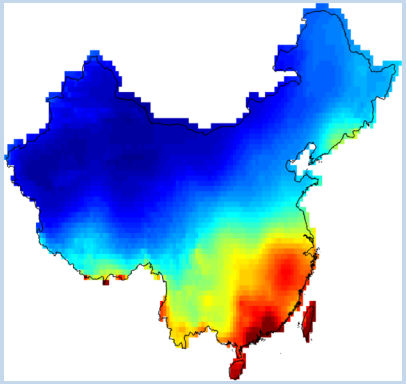
MIROC5
(Japan GCM)



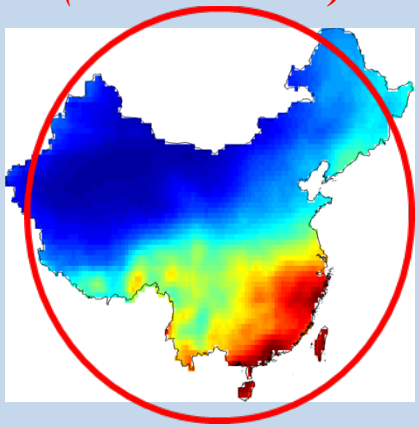
MPI-ESM-MR
(Germany GCM)

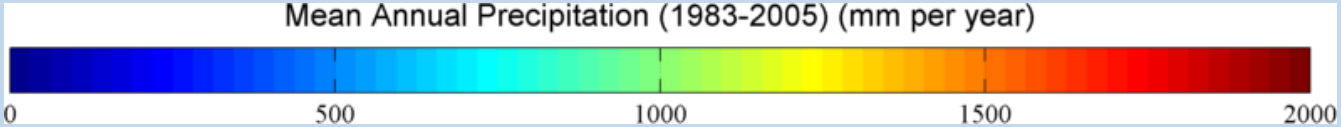


Observation
(CRU Dataset)



Observation
(PERSIANN-CDR)



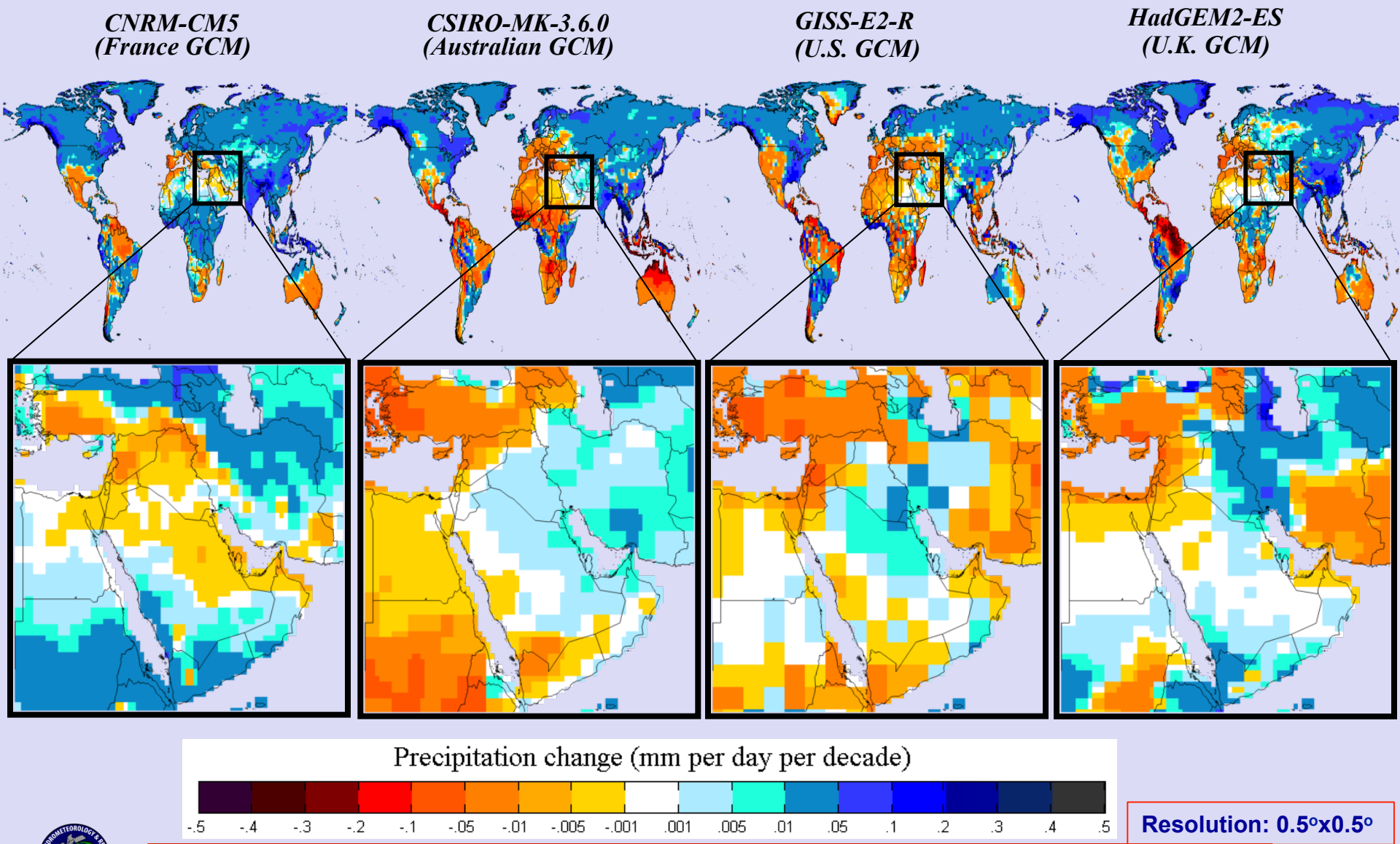


Middle East Region: Focus on Iran

IPCC AR5 Scenarios

Time period: 2006-2099

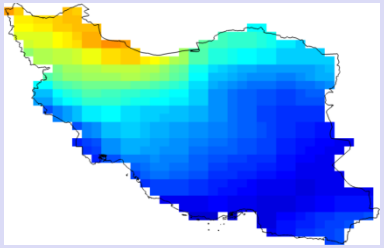
RCP8.5 ("High": 8.5 W/m^2, Equivalent CO_2 conc. 936 ppm by 2100)



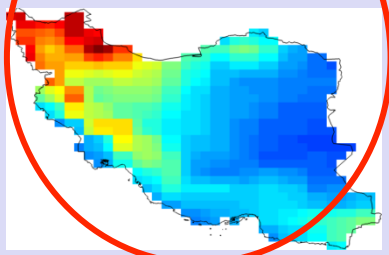
Resolution: 0.5°x0.5°

CMIP5 Models' historical simulation (1983-2005): IRAN

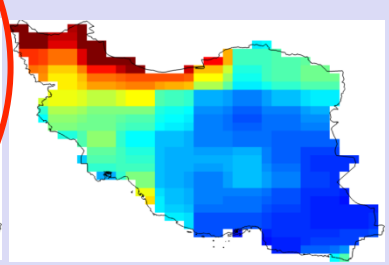
bcc_csm1_1_m
(Chinese GCM)



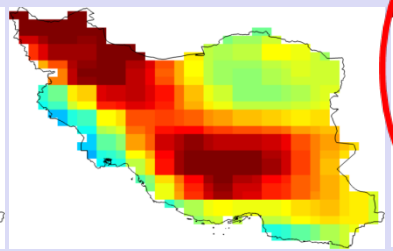
CCSM4
(NCAR, USA GCM)



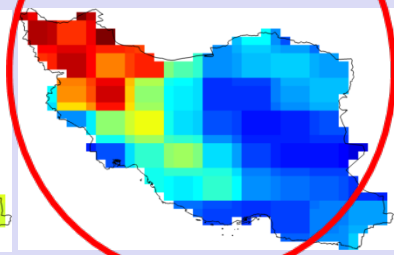
HadGEM2-ES
(U.K GCM)



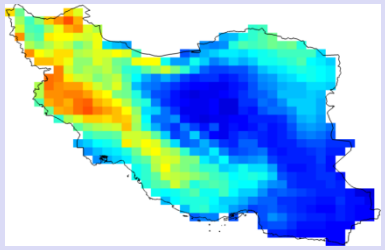
MIROC5
(Japan GCM)



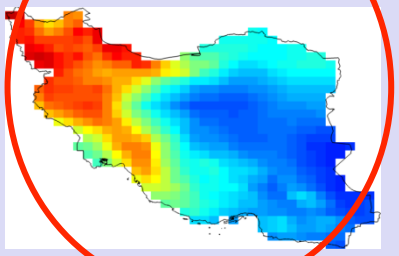
MPI-ESM-MR
(Germany GCM)

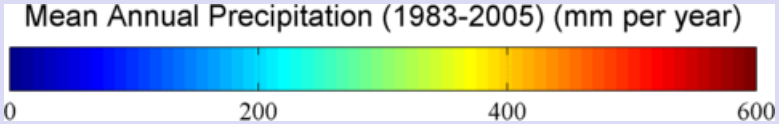


Observation
(CRU Dataset)

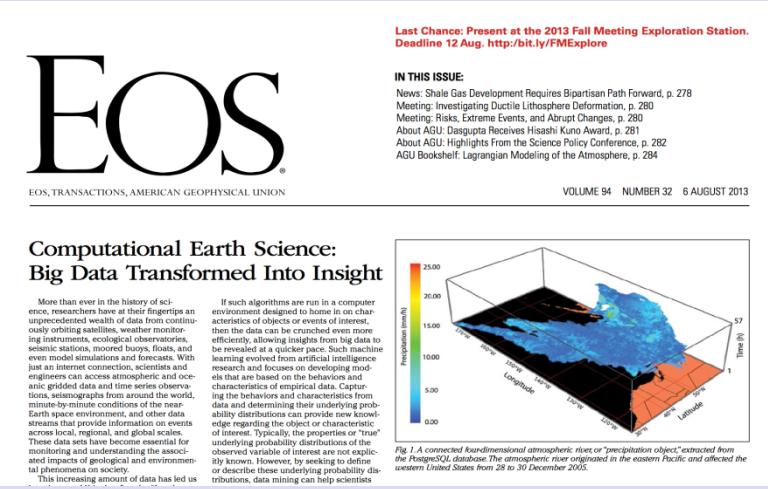


Remotely Sensed Estimates
(PERSIANN-CDR)





Potential New Directions



EOS

EOS, TRANSACTIONS, AMERICAN GEOPHYSICAL UNION

Last Chance: Present at the 2013 Fall Meeting Exploration Station. Deadline 12 Aug. http:/bit.ly/FMExplore

IN THIS ISSUE:

News: Shale Gas Development Requires Bipartisan Path Forward, p. 278
Meeting: Investigating Ductile Lithosphere Deformation, p. 280
Meeting: Risks, Extreme Events, and Abrupt Changes, p. 280
About AGU: Dasgupta Receives Hisashi Kuno Award, p. 281
About AGU: Highlights From the Science Policy Conference, p. 282
AGU Bookshelf: Lagrangian Modeling of the Atmosphere, p. 284

VOLUME 94 NUMBER 32 6 AUGUST 2013

Computational Earth Science: Big Data Transformed Into Insight

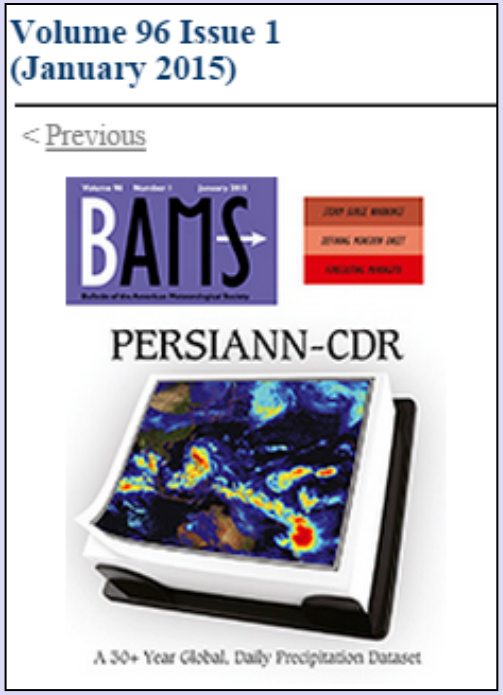
More than ever in the history of science, researchers have at their fingertips an unprecedented wealth of data from continuously orbiting satellites, weather monitoring instruments, ecological observatories, seismic stations, moored buoys, floats, and even model simulations and forecasts. With just an internet connection, scientists and engineers can access atmospheric and oceanic gridded data and time series observations, seismographs from around the world, minute-by-minute conditions of the near-Earth space environment, and other data streams that provide information on events across local, regional, and global scales. These data sets have become essential for monitoring and understanding the associated impacts of geological and environmental phenomena on society.

This increasing amount of data has led us

If such algorithms are run in a computer environment designed to home in on characteristics of objects or events of interest, then the data can be crunched even more efficiently, allowing insights from big data to be revealed at a quicker pace. Such machine learning evolved from artificial intelligence research and focuses on developing models that are based on the behaviors and characteristics of empirical data. Capturing the behaviors and characteristics from data and determining their underlying probability distributions can provide new knowledge regarding the object or characteristic of interest. Typically, the properties or "true" underlying probability distributions of the observed variable of interest are not explicitly known. However, by seeking to define or describe these underlying probability distributions, data mining can help scientists

Fig. 1. A connected four-dimensional atmospheric river, or "precipitation object," extracted from the PostgreSQL database. The atmospheric river originated in the eastern Pacific and affected the western United States from 28 to 30 December 2005.

S. Sellars, et.al., EOS Trans. (2013),



Volume 96 Issue 1 (January 2015)

< Previous

BAMS

PERSIANN-CDR

A 30+ Year Global, Daily Precipitation Dataset

Ashouri, Hsu et al., BAMS, 2015.

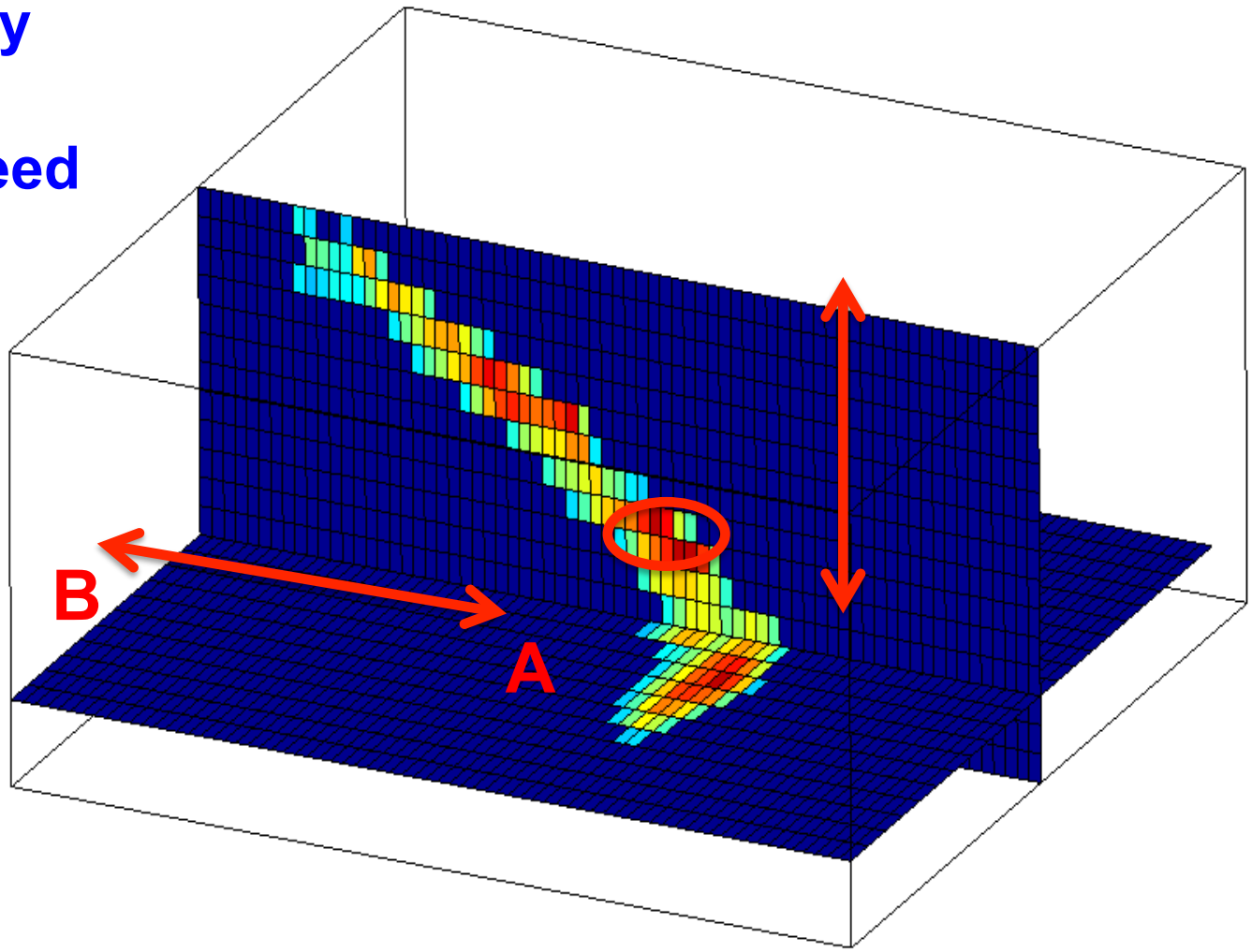
CHRS CONNECT Database Development

Dr. Phu Nguyen - CHRS

Dr. Hao Liu - CHRS

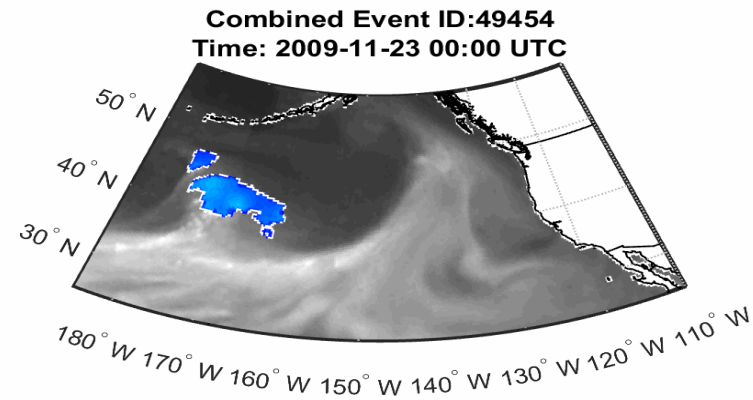
4-D Objects Characteristics

1) Max Intensity
2) Duration
3) Average Speed



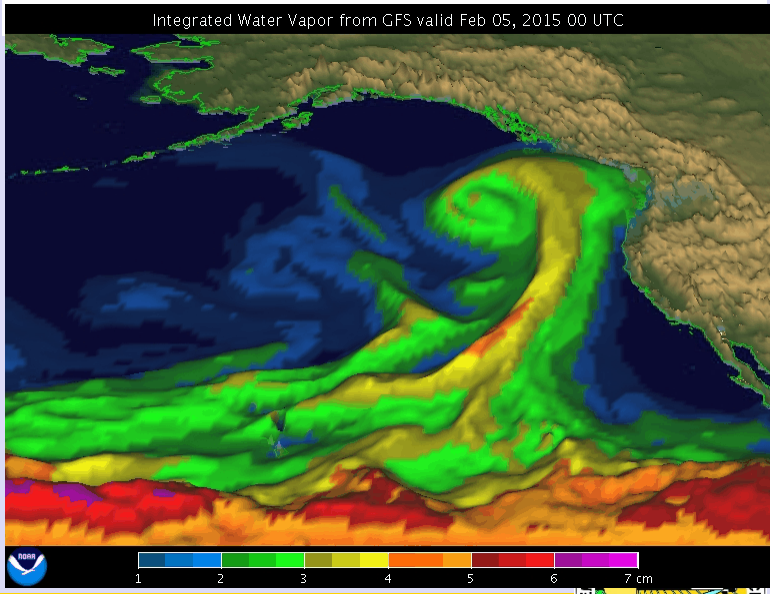
Application of CHRS-CONNECT Database: An Example

- CHRS-CONNECT Features:
  - Current dataset (2000 - present, hourly)
  - Track evolving system through space and time
  - Identify and categorized rainfall systems (i.e., AR)
  - Obtain object's atributes & statistic
  - Advanced search based on storm features



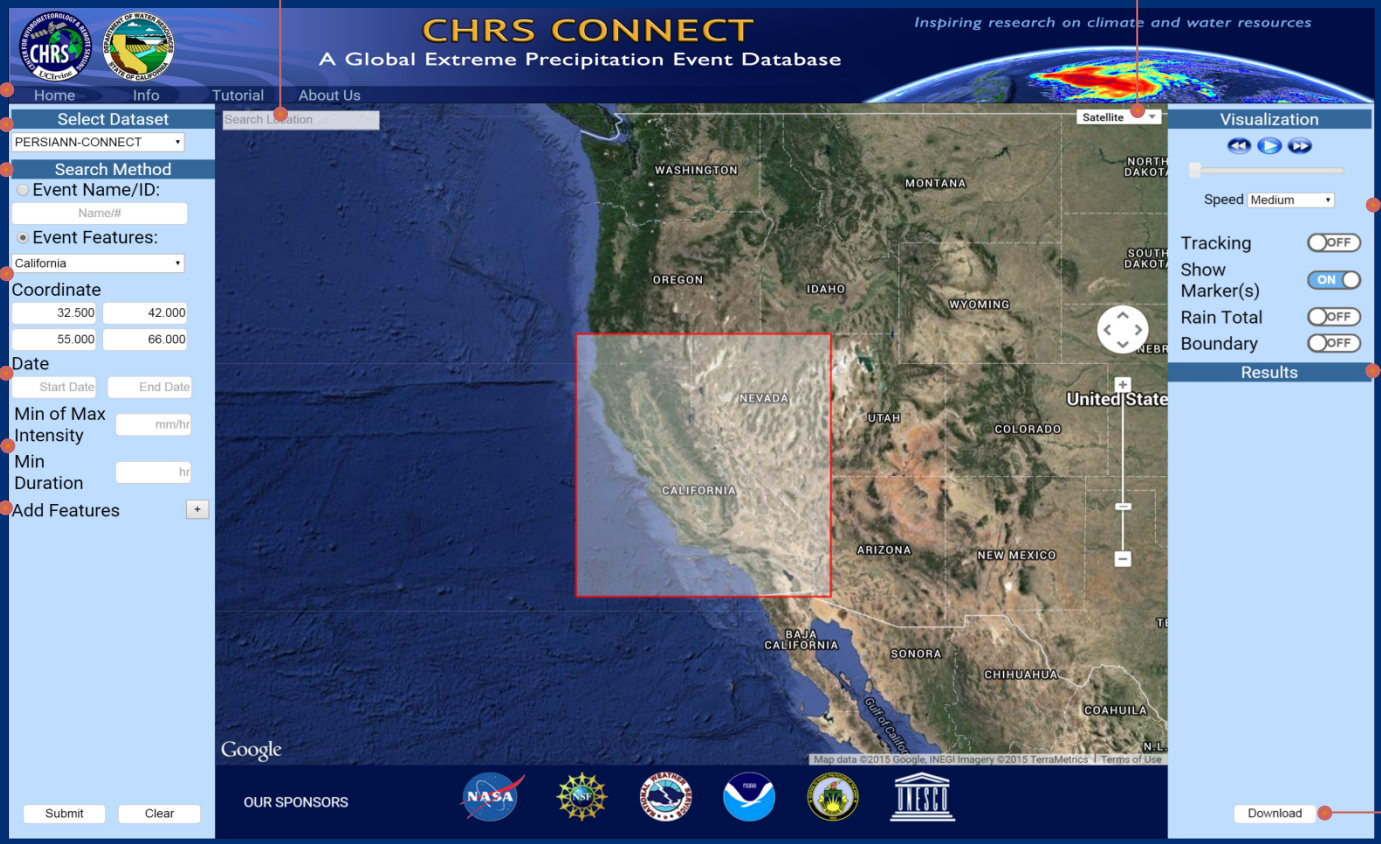
Source: UCI & NOAA

- Atmospheric River (AR, Dettinger et al, 2011)
  - Narrow water vapor "rivers"
  - 1000 km wide, > 2000 km long
  - Water vapor band that is above a threshold
  - Contribute to 30 ~50% California's annual precipitation



Connect.eng.uci.edu

CHRS CONNECT Interface



Navigation Bar

Dataset Selection

Search Method

Spatial Selection

Time Period

Define Extreme Event

Search by Features

Search Location

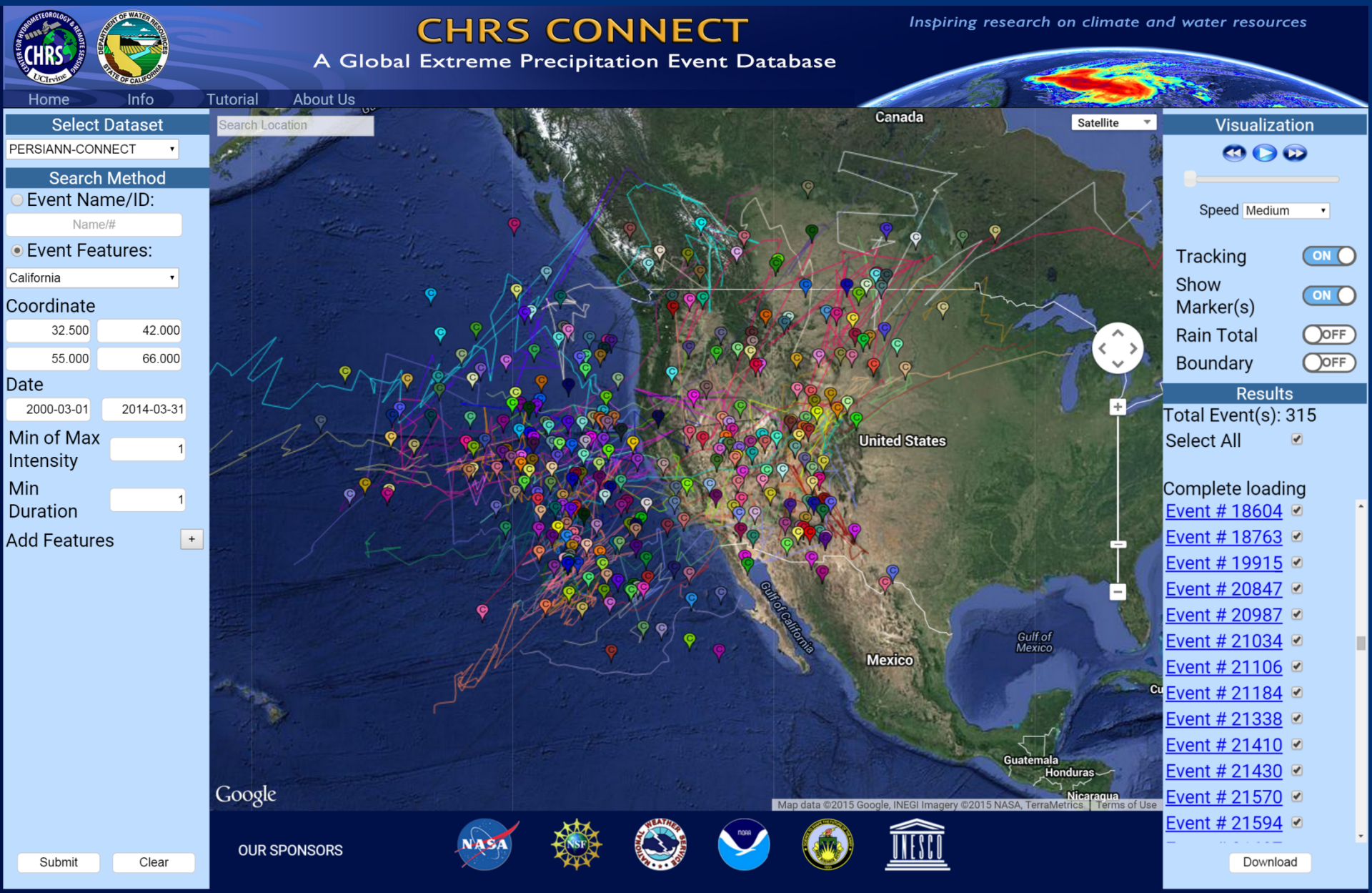
Base maps

Visualization Tools

List of Events Found

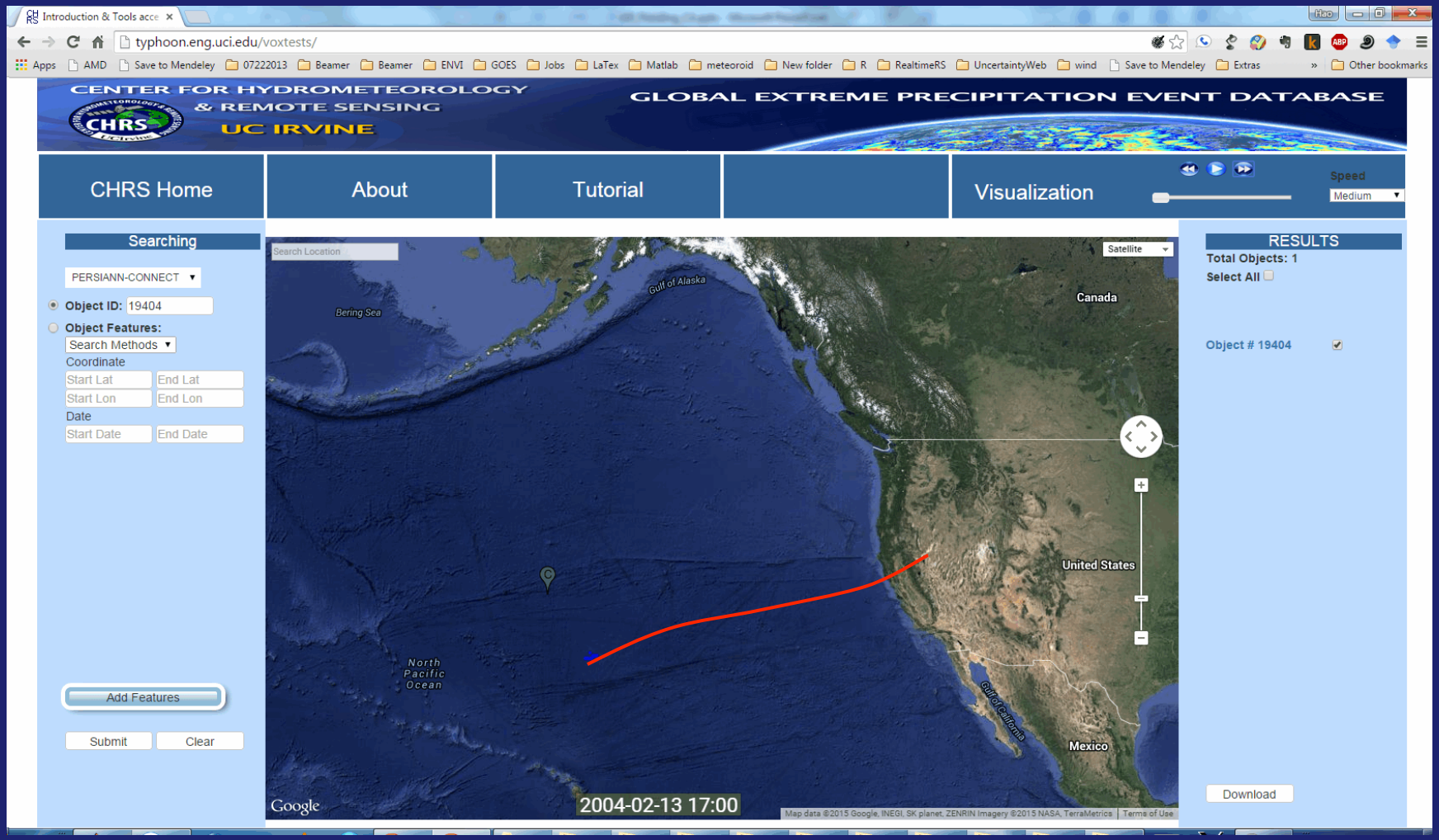
Download Results

Current CHRS CONNECT System

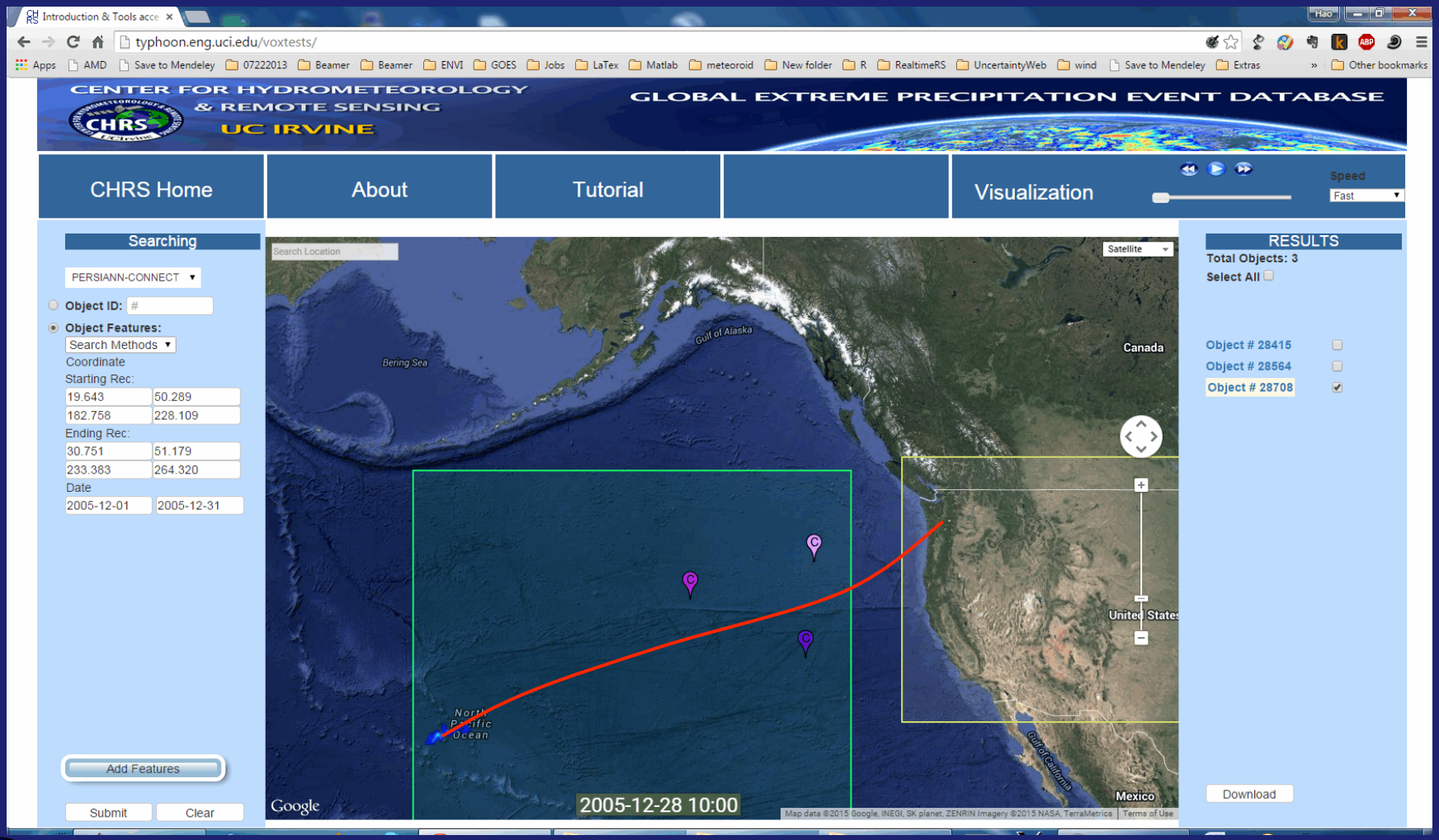


Search Events by Start-End Region Domain
(Showing both Centroids and Tracking of Events)

AR events visualization using PERSIANN-CONNECT: 2004 Feb.



AR event visualization using PERSIANN-CONNECT: 2005 Dec.



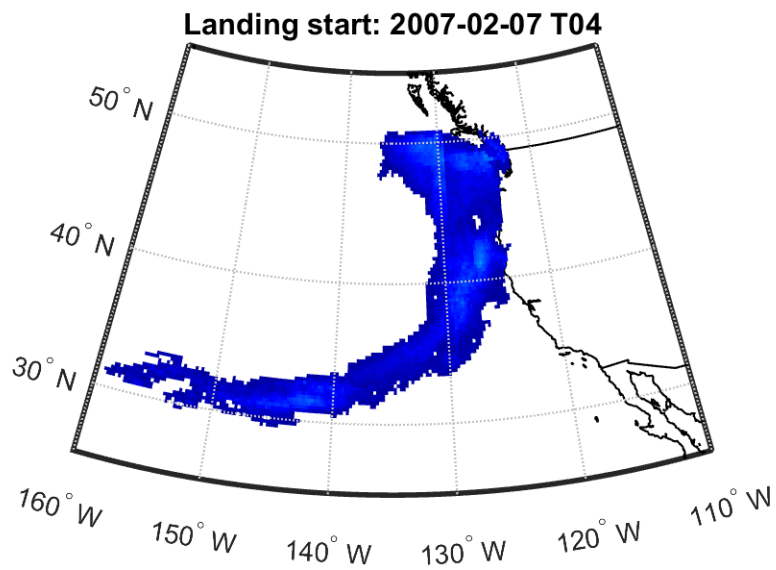
Build AR events database using PERSIANN-CONNECT

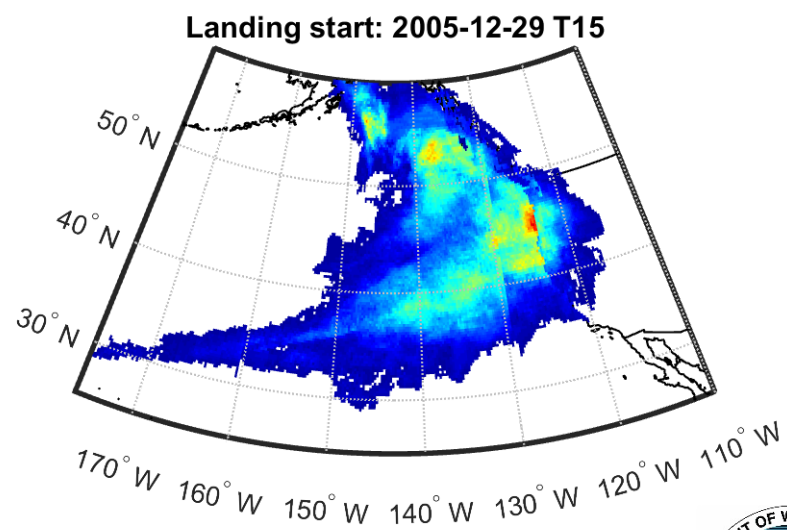
- **Sorting CHRS-CONNECT database for the ARs:**
  - **Produce rainfall over California**
  - **Originate from West Pacific**
  - **Different from hurricanes**

PERSIANN-CONNECT Picked up 164 AR events (2000 to 2010)

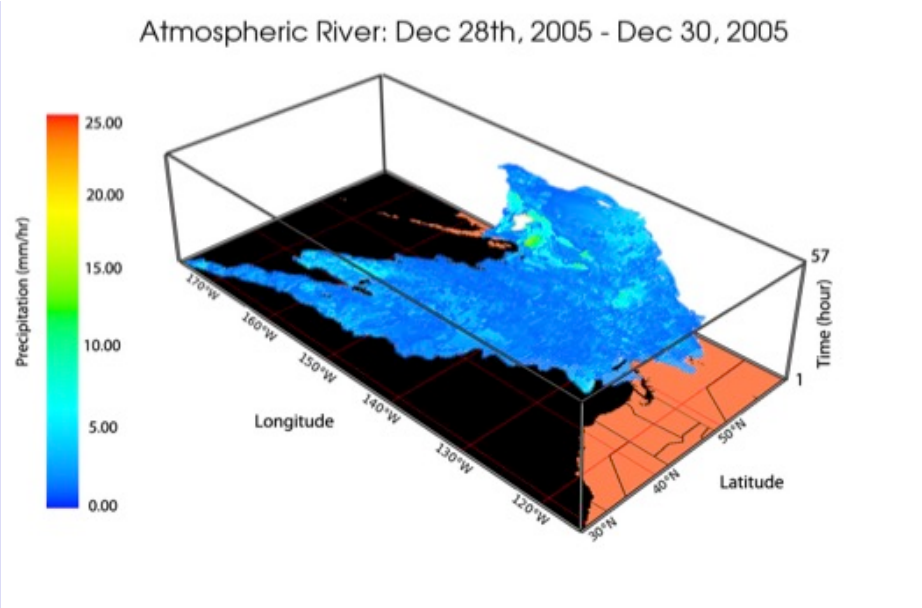
PERSIANN-CDR-CONNECT will be the longest record of AR event (1983-2015)

Storm Objects accumulated precipitation amounts & coverages

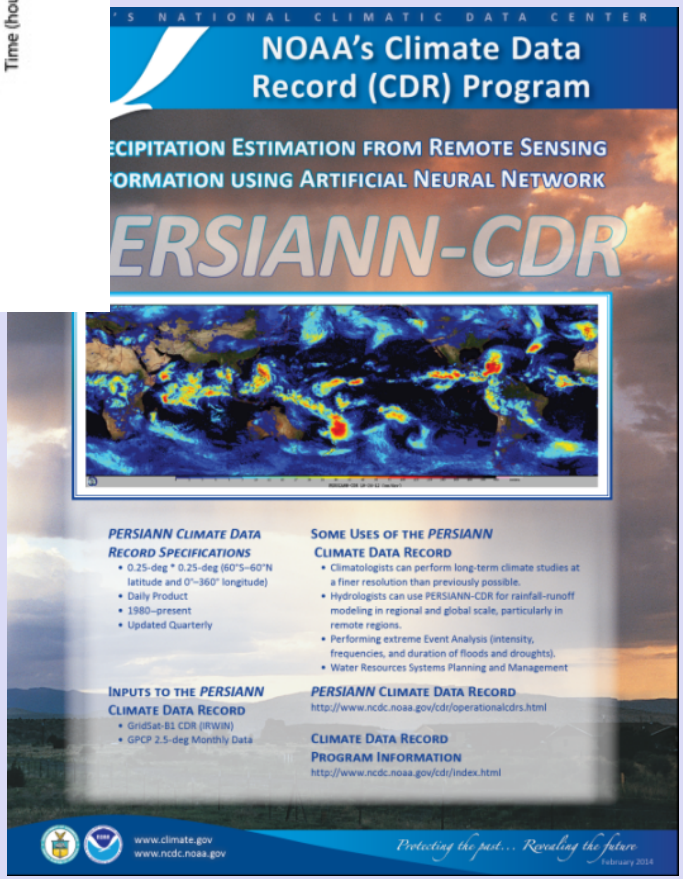




Next Logical Step!



Incorporate PERSIANN-CDR into CHRS CONNECT



PERSIANN Satellite Product On Google Earth

Mobile Devices App:

- *Rain Mapper*
- *IRain*

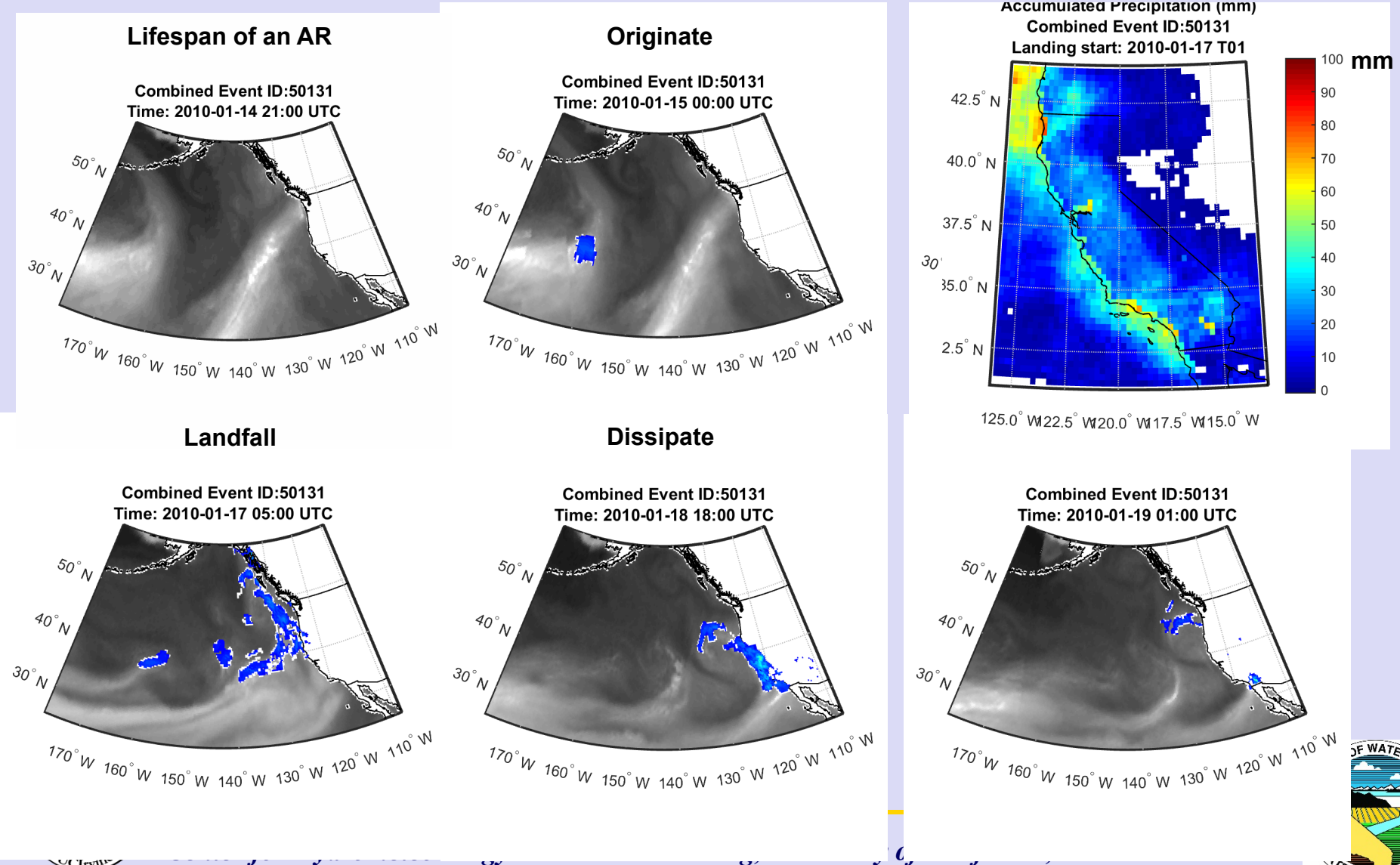
Dr. Phu Nguyen

Thank You for the Invitation
08/14/2009
Somewhere in New Mexico, USA - Photo: J. Sorooshian

Back up slides

CHRS-CONNECT Captures the lifespan of an AR event

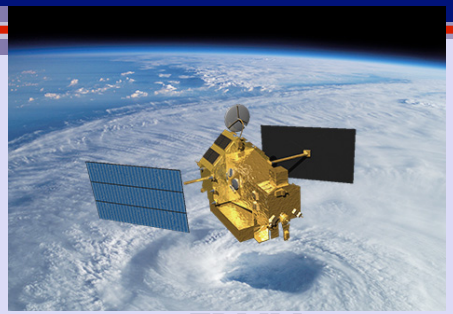
- **AR hits California Coast (5 Evolving Stages in CHRS-CONNECT)**



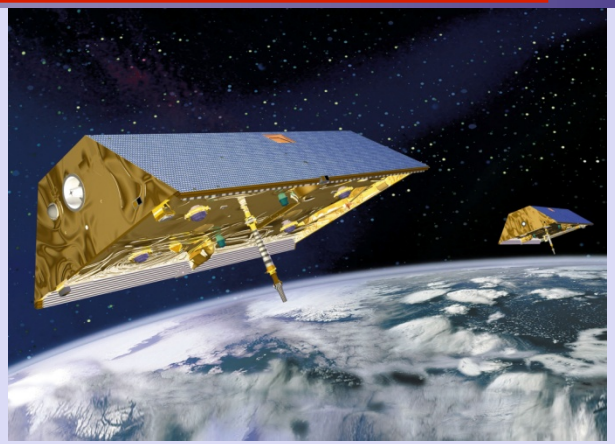
How about the testing of all other Remote Sensing Observations and Model Generated Data??

Hydrologically - Relevant Remote Sensing Missions

SMOS
ESA's Soil Moisture and Ocean Salinity (2009)

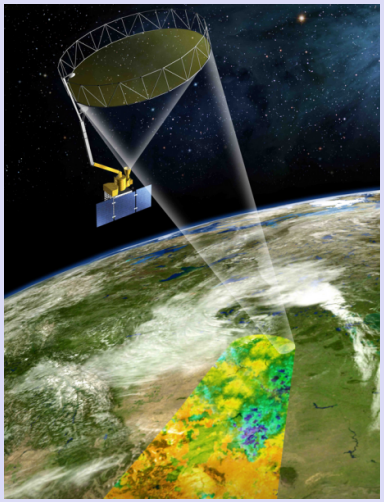


TRMM
The Tropical Rainfall Measuring Mission

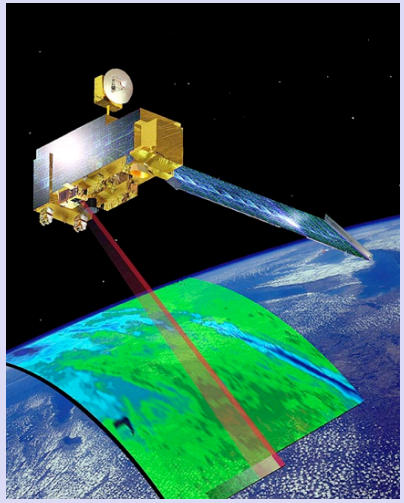


GRACE
Gravity Recovery and Climate Experiment (2002)

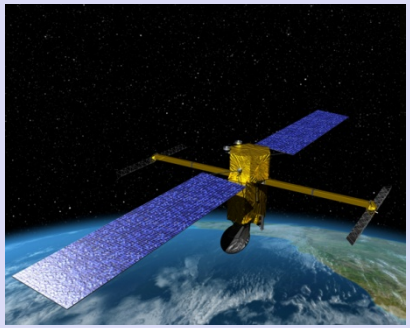
GPM
Global Precipitation Measurements (2014)



SMAP
Soil Moisture Active Passive Satellite(2014)

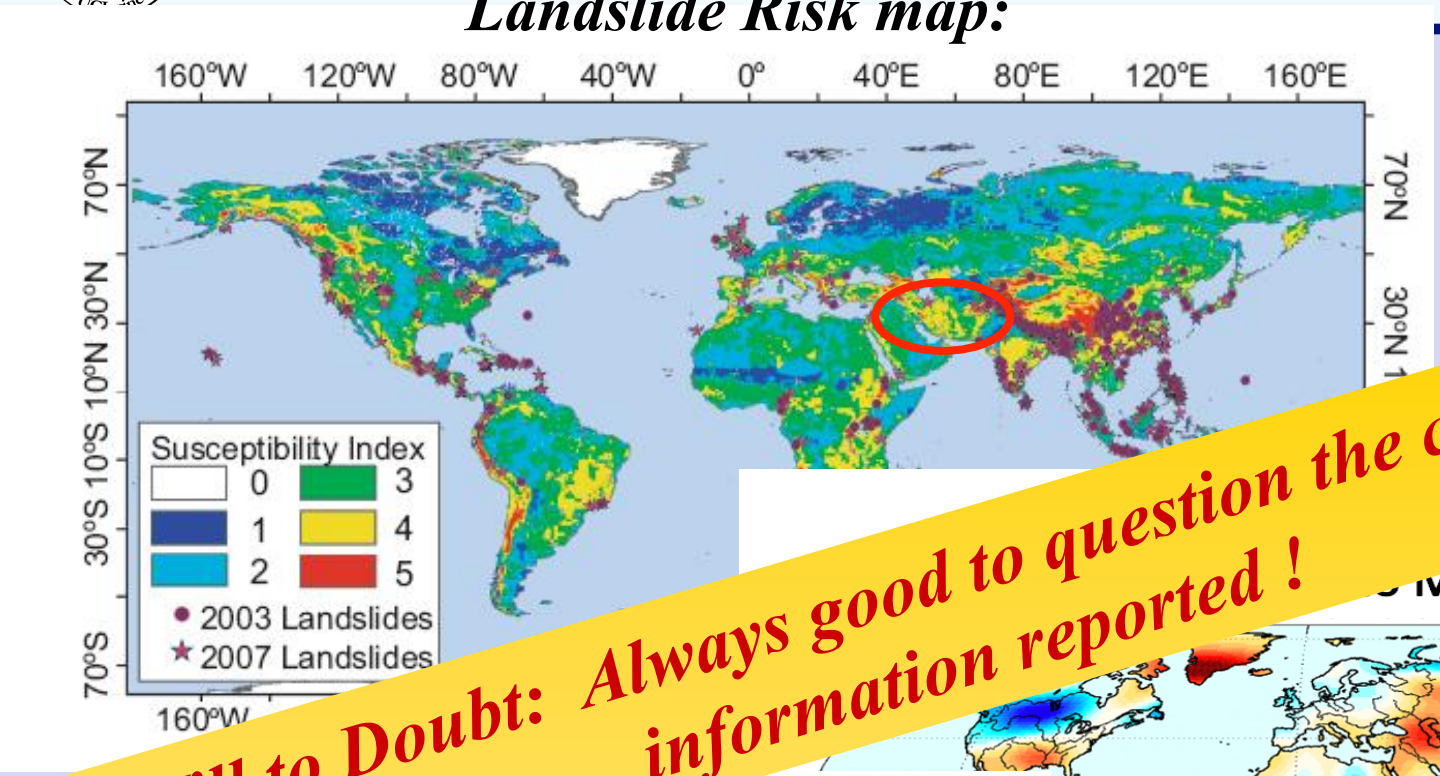


MODIS
Moderate Resolution Imaging Spectroradiometer (1999) , (2002)

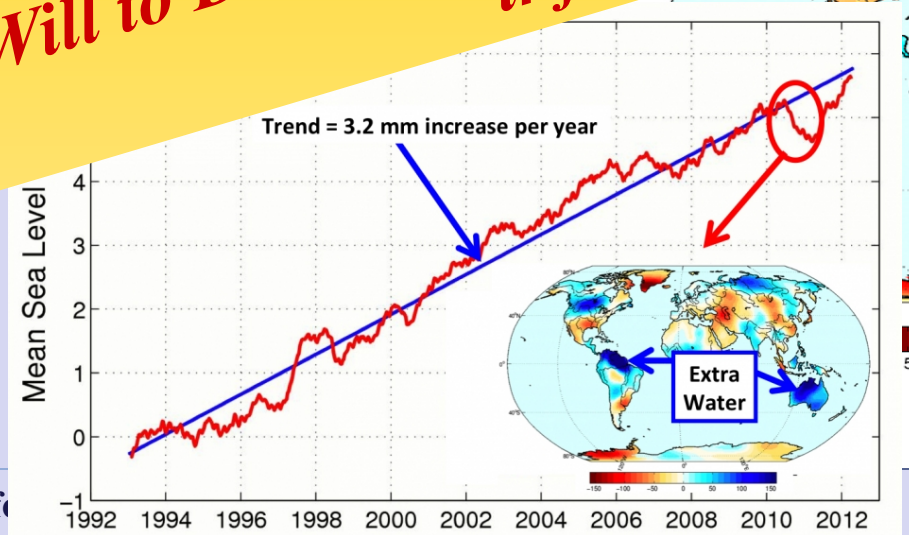


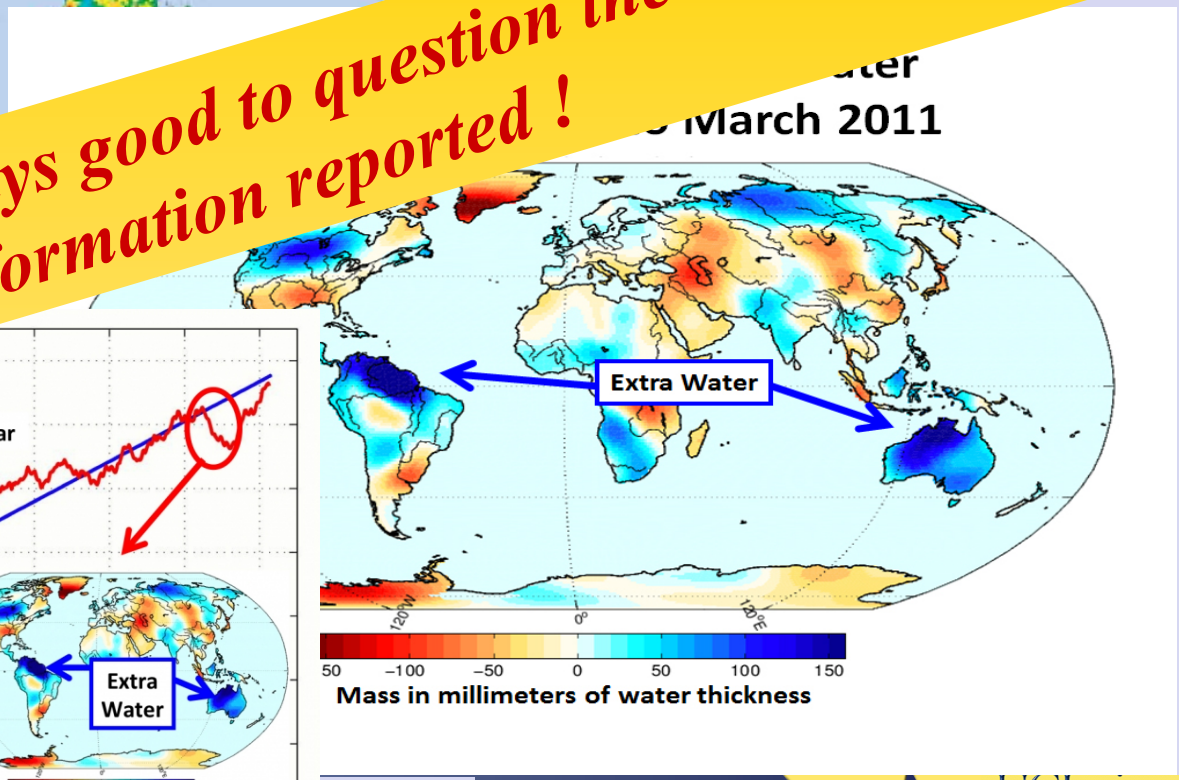
SWOT
Surface Water and Ocean Topography (2020)

Landslide Risk map:



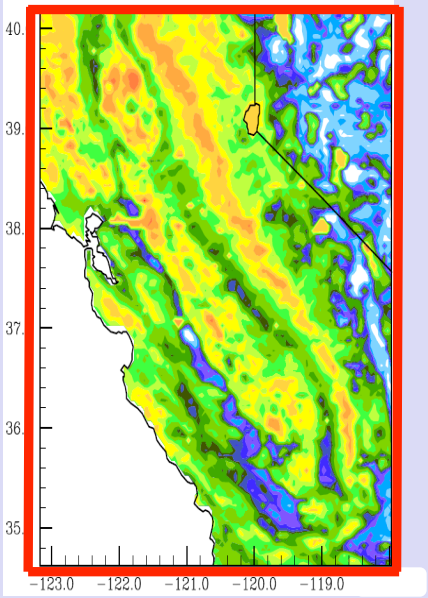
Will to Doubt: Always good to question the credibility of information reported !



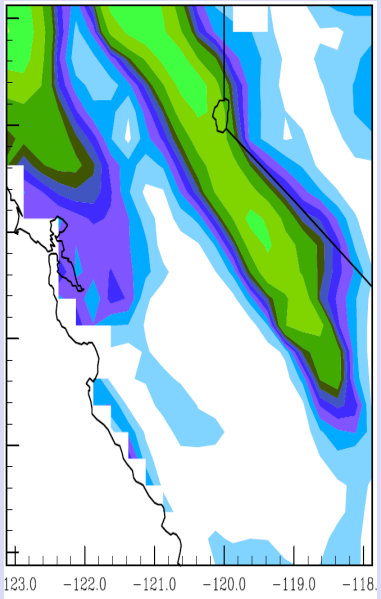


"Observed" vs "Model-Generated" Data

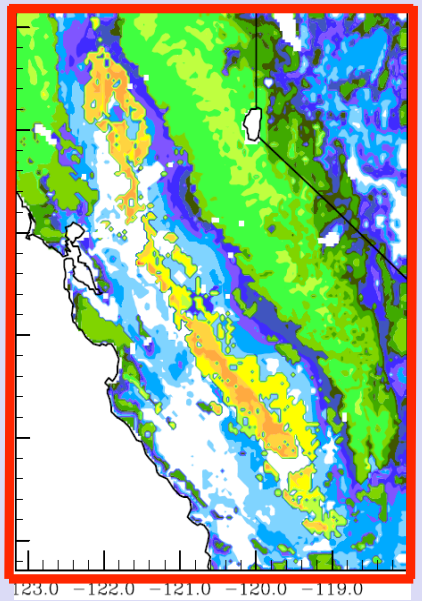
MODIS



GLDAS/Noah

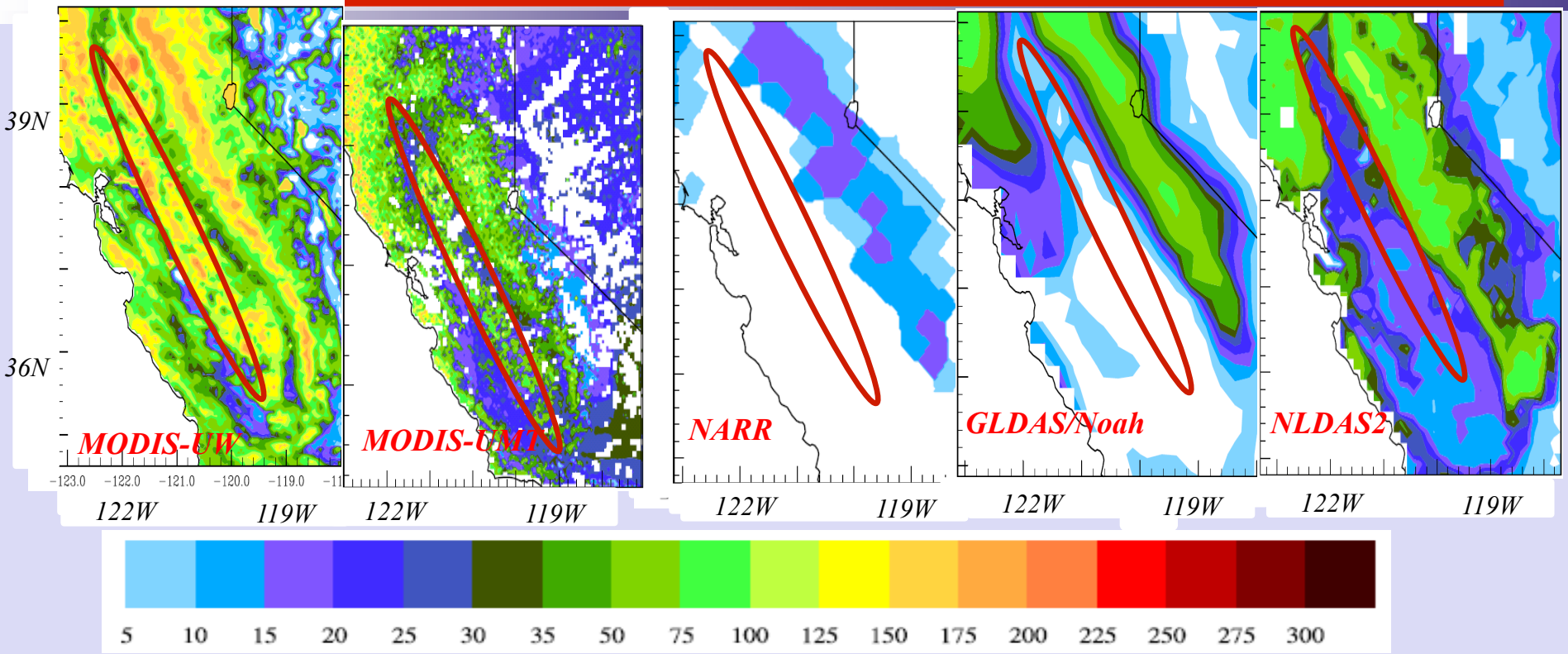


MM5R



Sorooshian et al. 2011 & 2012

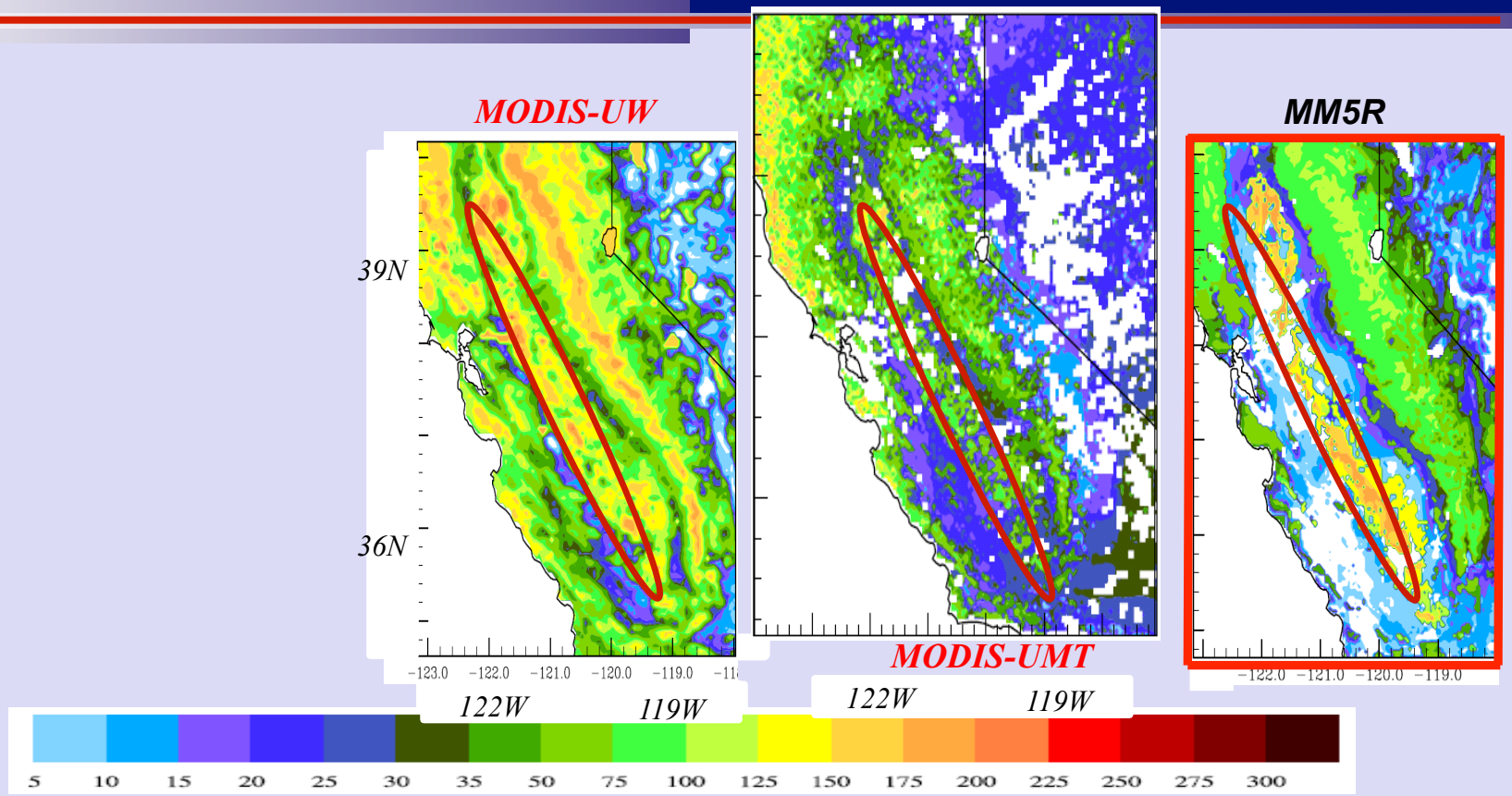
Actual ET Estimates From Different Data sets– JJA 2007



2007 JJA Monthly ET (mm)

Li et al, 2011

Actual ET comparison-spatial distribution – JJA 2007



Monthly ET (mm/month)

An Important Dilemma for the modeling application community will be:

Which Remotely Sensed ET Product should be used for model testing and validation??

What is the Message?

- ***Despite advances to date, predicting the future Hydro-Climate variables will remain a major challenge:***

- ***Future is complex and observing and modeling its [illegible] challenging. So, "have a will to doubt [illegible] "generated" by models.***

Factoring in Resiliency in water resources system's design and planning is still the safest approach!

- ***Long-term and sustained observation programs are critical, especially for model verification. Without some degree of verifiability, hard to expect their use***