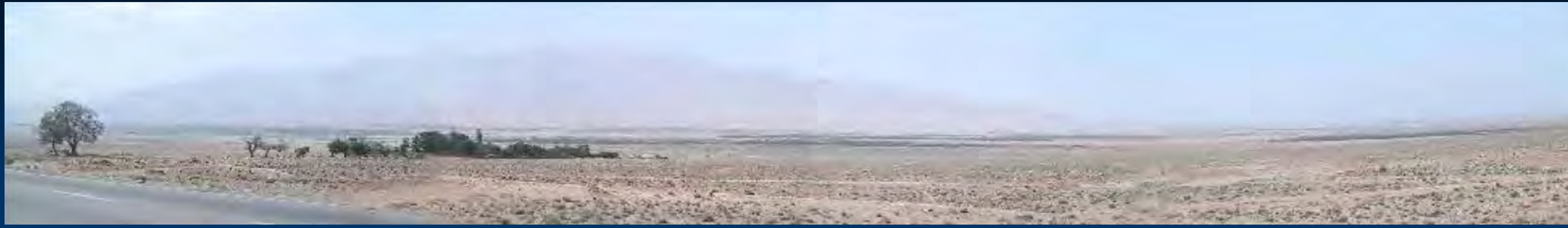


Review of CHRS Satellite Datasets: The Challenges in Their Development for Application in Hydrometeorology

Soroosh Sorooshian

Center for Hydrometeorology and Remote Sensing
University of California Irvine

29th GEWEX-SSG Meeting
Sanya Bay, China February 5-10 2017

Research Team: Present and Recent Past

and many more …

Some Definitions and Scope of this Presentation

Definitions

"Tools" : Models

" Data" : - In-situ and RS Observations

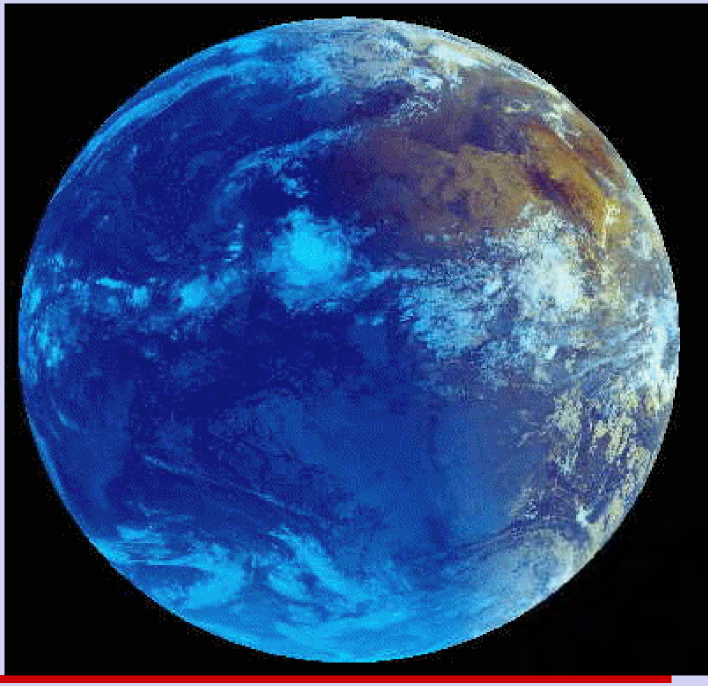
- Model-Generated

Scope: Focus on Precipitation

Climate, Hydrology and Water Resources

- ***How will Climate effect water Availability?***

- ***Can we predict the future changes which are responsive to "user" needs?***



Prediction Requirements for Water Resources

Short Range – · – · – · – · – · – · – · – · – · – · – · – · – · – · – · –> Long Range

hours - - - -> days - - - -> weeks - - -> months - - -> seasons - - -> years - - - - - -> decades

Flash Flood Warning

Flash Flood Guidance

Headwater Guidance

Flood Forecast Guidance

Reservoir Inflow Forecasts

Spring Snow Melt Forecasts

Water Supply Volume

Short-range ***Mid-range*** ***Long-range***

Forecast Requirements

Prediction Requirements for Water Resources

Short Range – · – · – · – · – · – · – · – · – · – · – · – · – · – · – · – · –>Long Range

hours ----> days ----> weeks ---> months --> seasons --> years ------> decades

Flash Flood Warning

Flash Flood Guidance

Headwater Guidance

Flood Forecast Guidance

Reservoir Inflow Forecasts

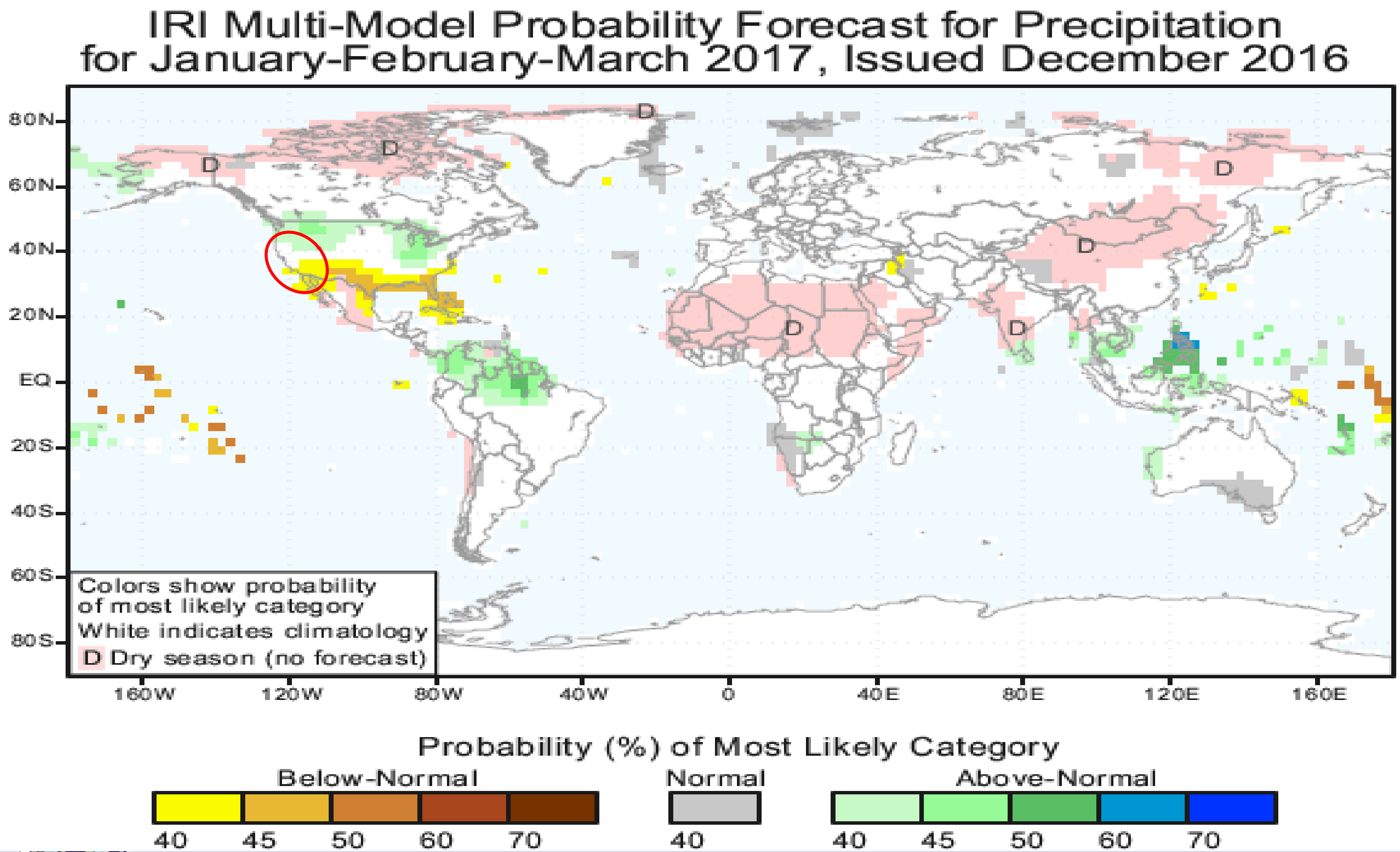
Spring Snow Melt Forecasts

Water Supply Volume

Mid-range

Forecast Requirements

IRI 3-Month Multi-Model Probability Precipitation Forecast



Climate-Scale approaches to addressing hydrologic extremes

Short Range – · – · – · – · – · – · – · – · – · – · – · – · – · – · –>Long Range

hours – – – –> days – – – –> weeks – – –> months – – > seasons – – > years – – – – – –> decades

Flash Flood Warning

Flash Flood Guidance

Headwater Guidance

Flood Forecast Guidance

Reservoir Inflow Forecasts

Spring Snow Melt Forecasts

Water Supply Volume

Long-range

Forecast Requirements

Western U.S. future model projections

Dr. Chiyuan Miao - BNU

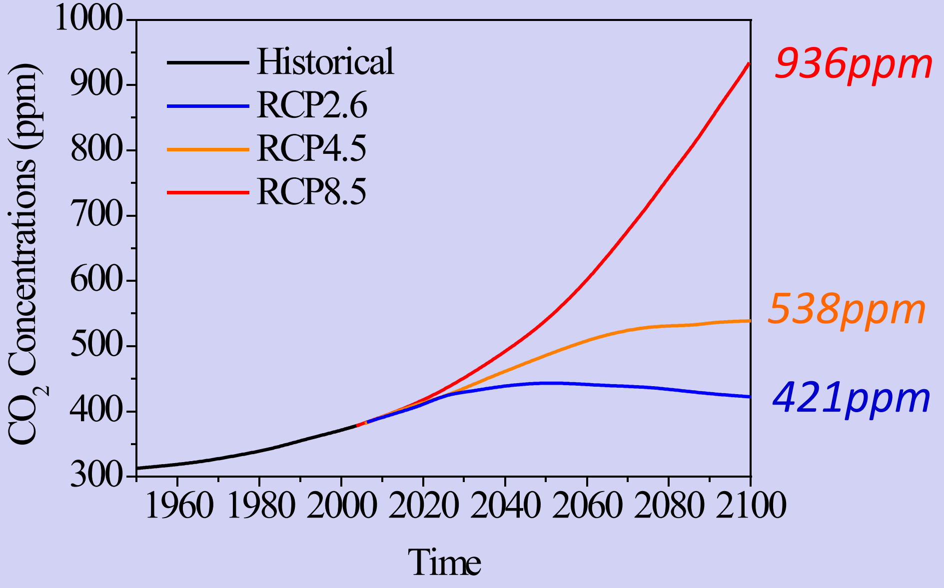
Future Modeling Scenarios – IPCC AR5

Representative Concentration Pathways (RCP) Scenarios:

RCP2.6: represent 'low' scenarios featured by the radiative forcing of 2.6 W/m² by 2100, the resulting CO_2-equivalent concentrations is 421 ppm in the year 2100 .

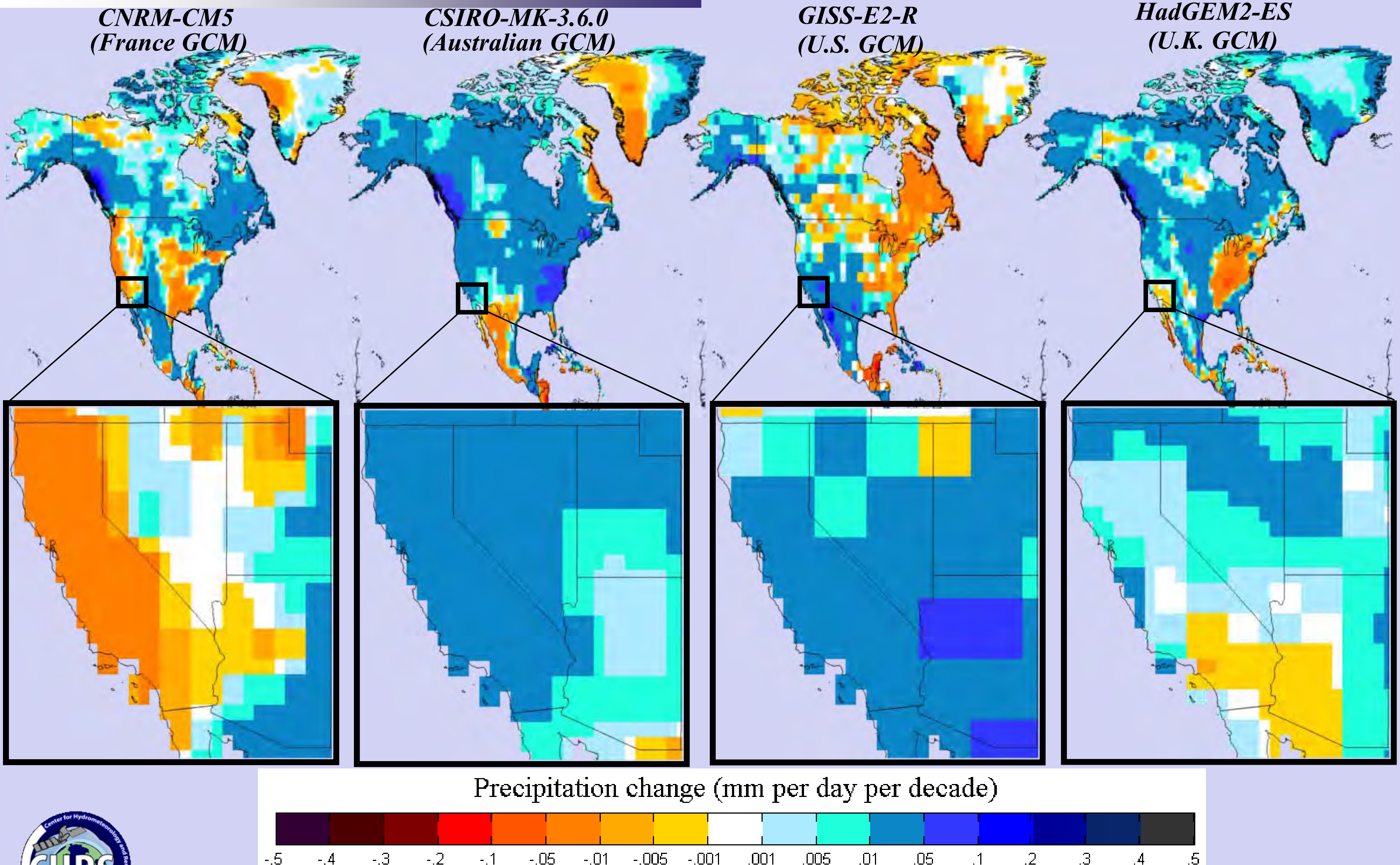
RCP4.5: represent 'medium' scenarios featured by the radiative forcing of 4.5 W/m² by 2100, the resulting CO_2-equivalent concentrations is 538 ppm in the year 2100 .

RCP8.5: represent 'high' scenarios featured by the radiative forcing of 8.5 W/m² by 2100, the resulting CO_2-equivalent concentrations is 936 ppm in the year 2100 .



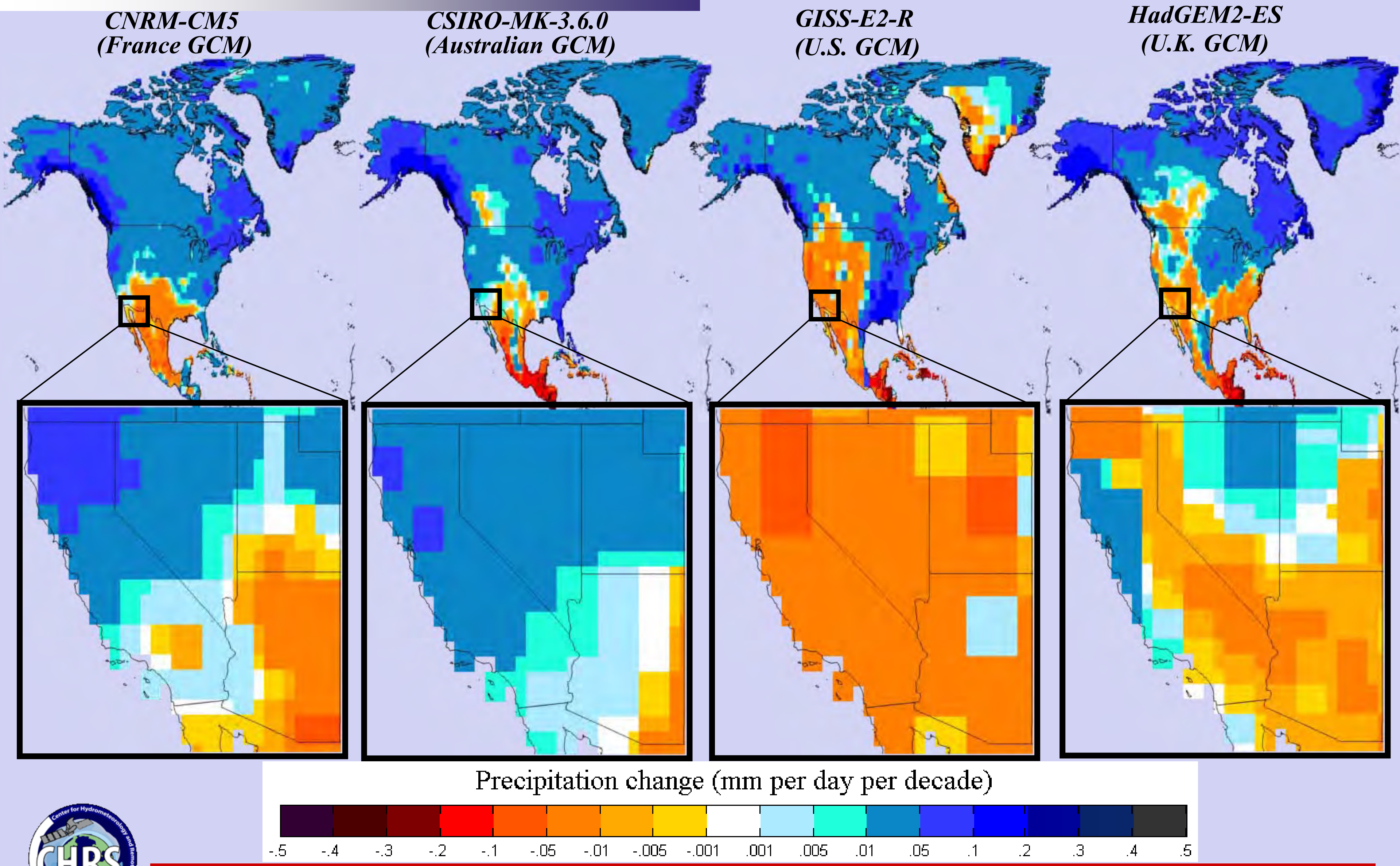
RCP2.6

Time period: 2006-2099



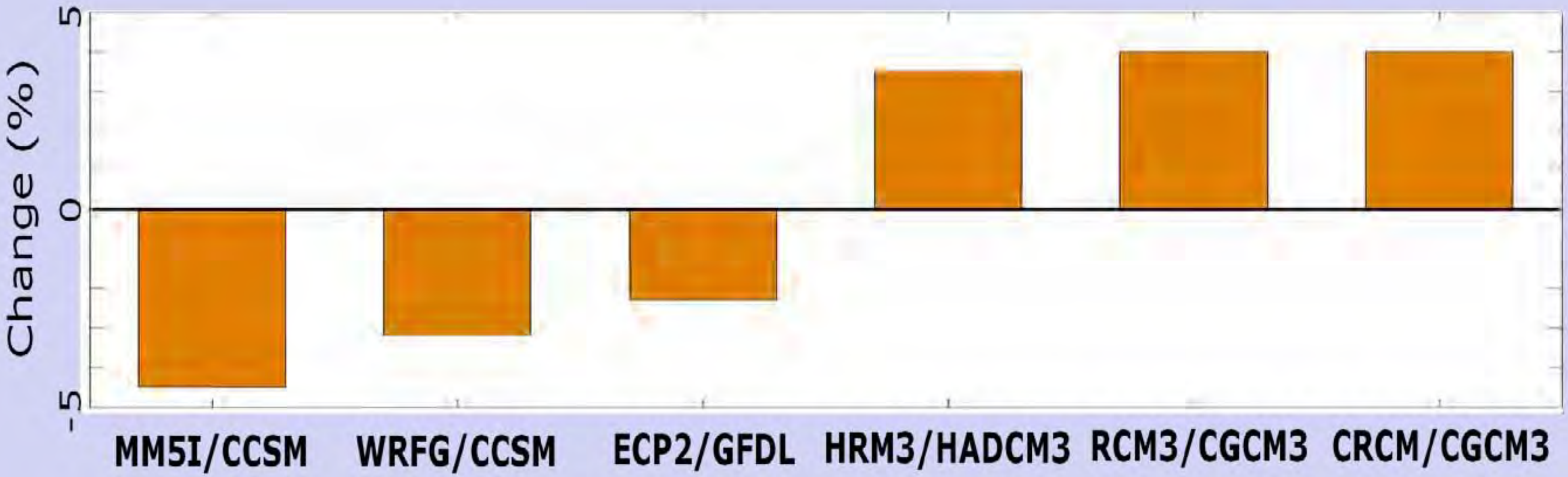
RCP8.5

Time period: 2006-2099



Recent Evaluation of RCM/GCM over Western U.S.

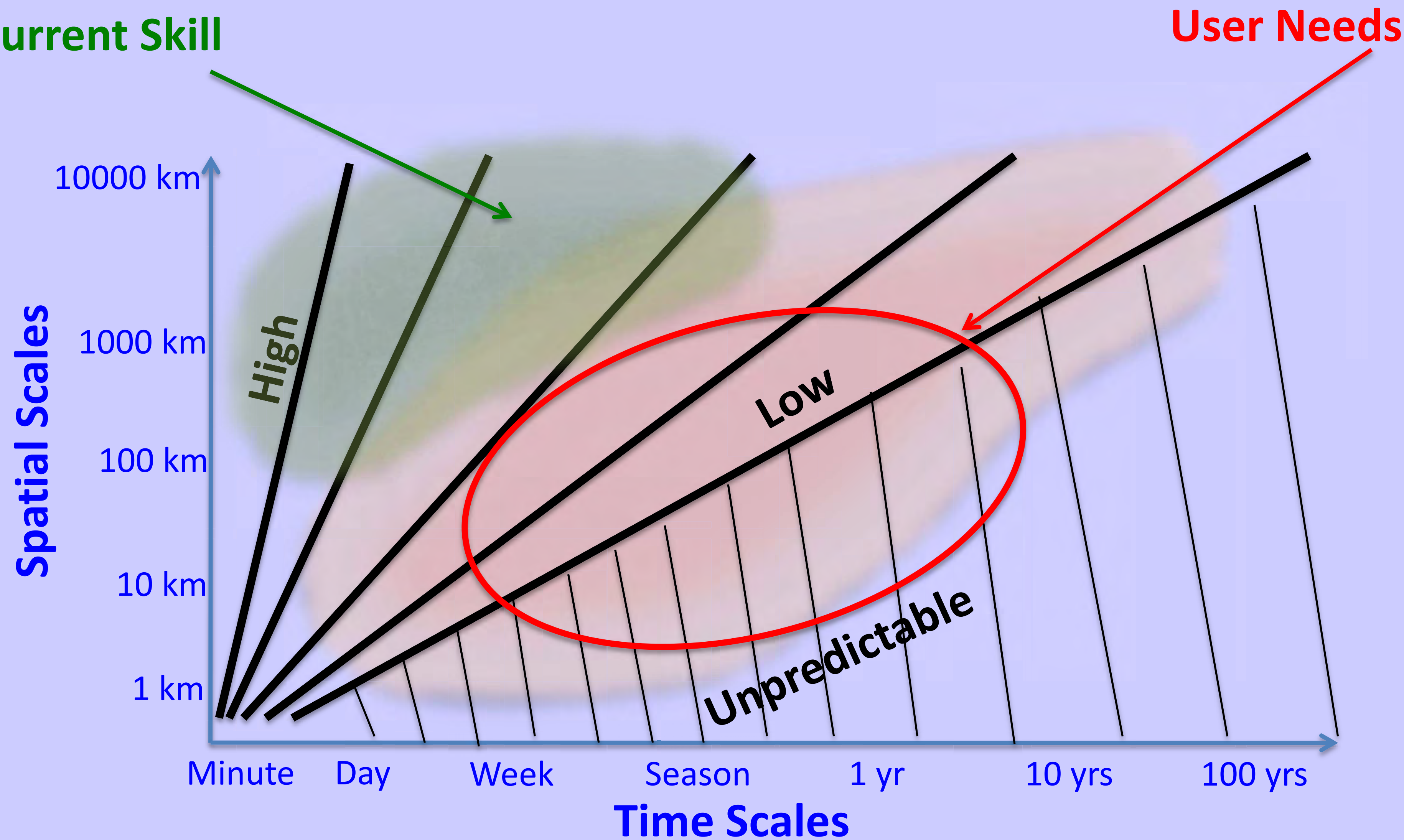
Models indicate different signs and magnitudes of changes in the mean precipitation over the Western U.S. under the SRES A2 emissions scenario.



Trend of area-average precipitation (comparing 2040-2070 with 1970-2000)

Wei Chu 2011

Drought Predictability



Provided by Siegfried Schubert 2011

Information Relevant to Water Resources Planning

- Models Projections
- Observations

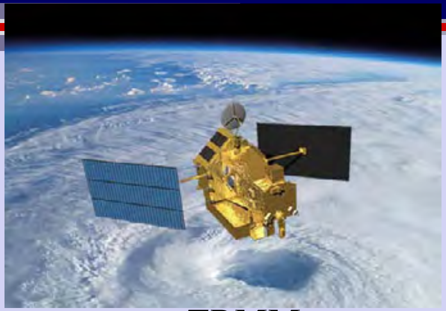
For a user of model information about future, the question maybe:

Which model (or groups of models) should be "trusted" for their "Accuracy"

Answer is partly related to how well should we trust observations used as both input and reference to test the models:

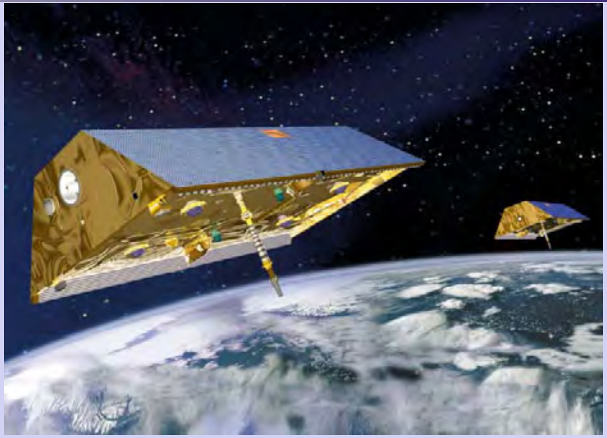
How Much Trust in Remote Sensing Observations??

Hydrologically - Relevant Remote Sensing Missions



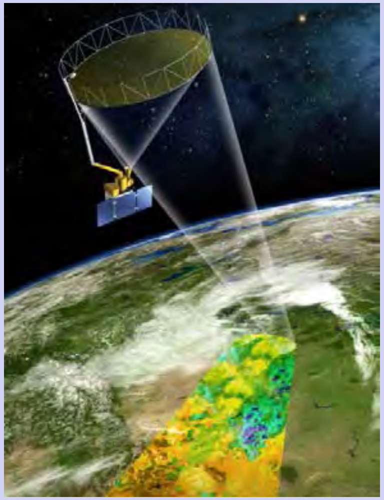
TRMM
The Tropical Rainfall Measuring Mission

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



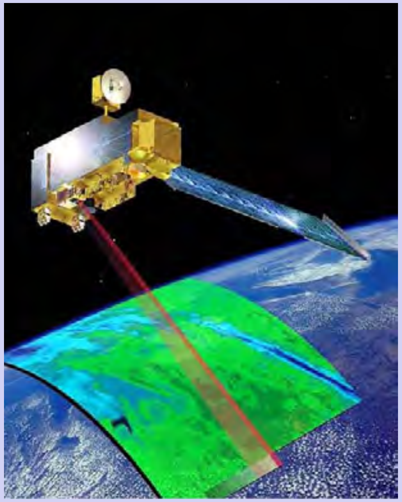
GRACE
Gravity Recovery and Climate Experiment (2002)

GPM
Global Precipitation Measurements (2014)



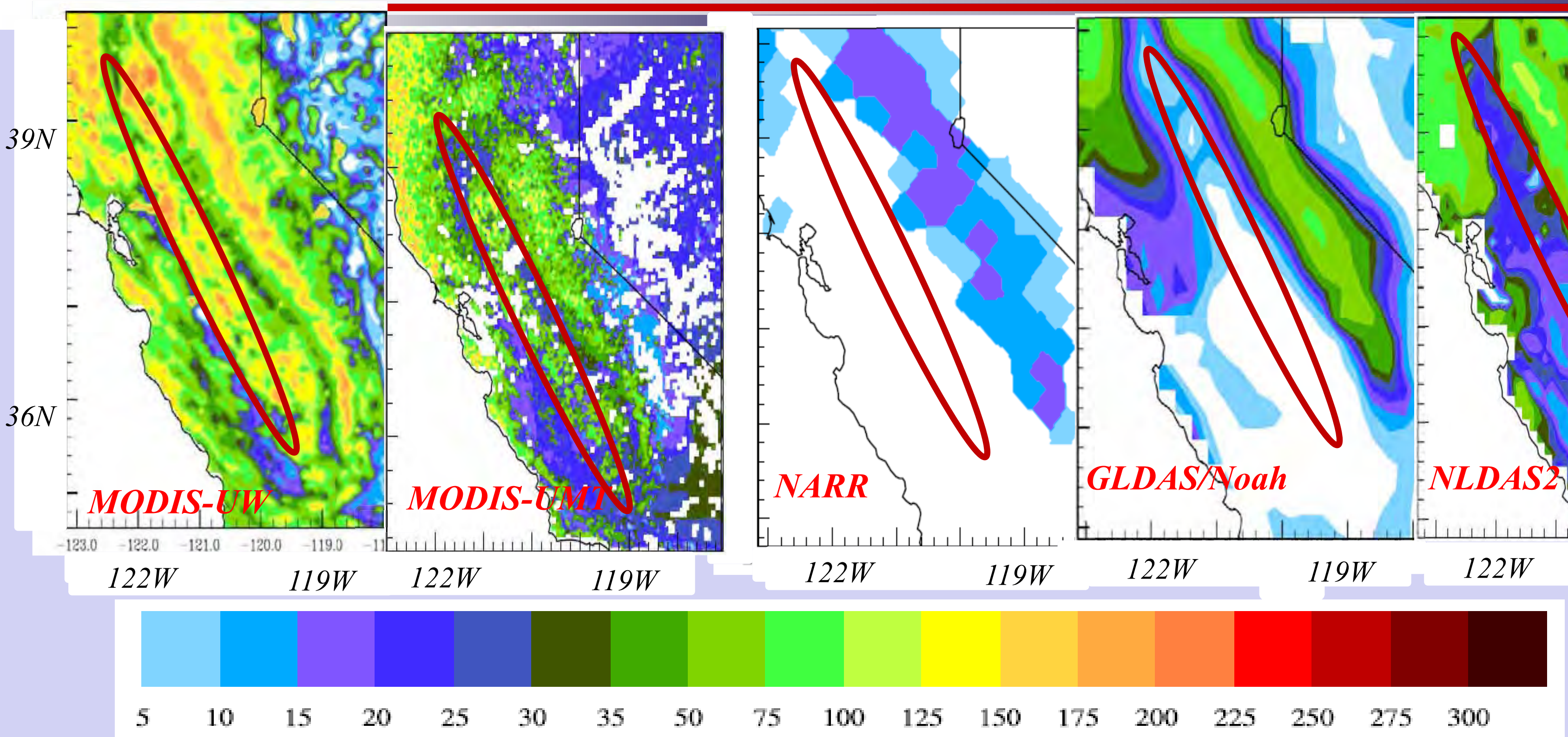
SMAP
Soil Moisture Active Passive Satellite(2014)

SWOT
Surface Water and Ocean Topography (2020)



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

Actual ET Estimates From Different Data sets– JJA 2007



2007 JJA Monthly ET (mm)

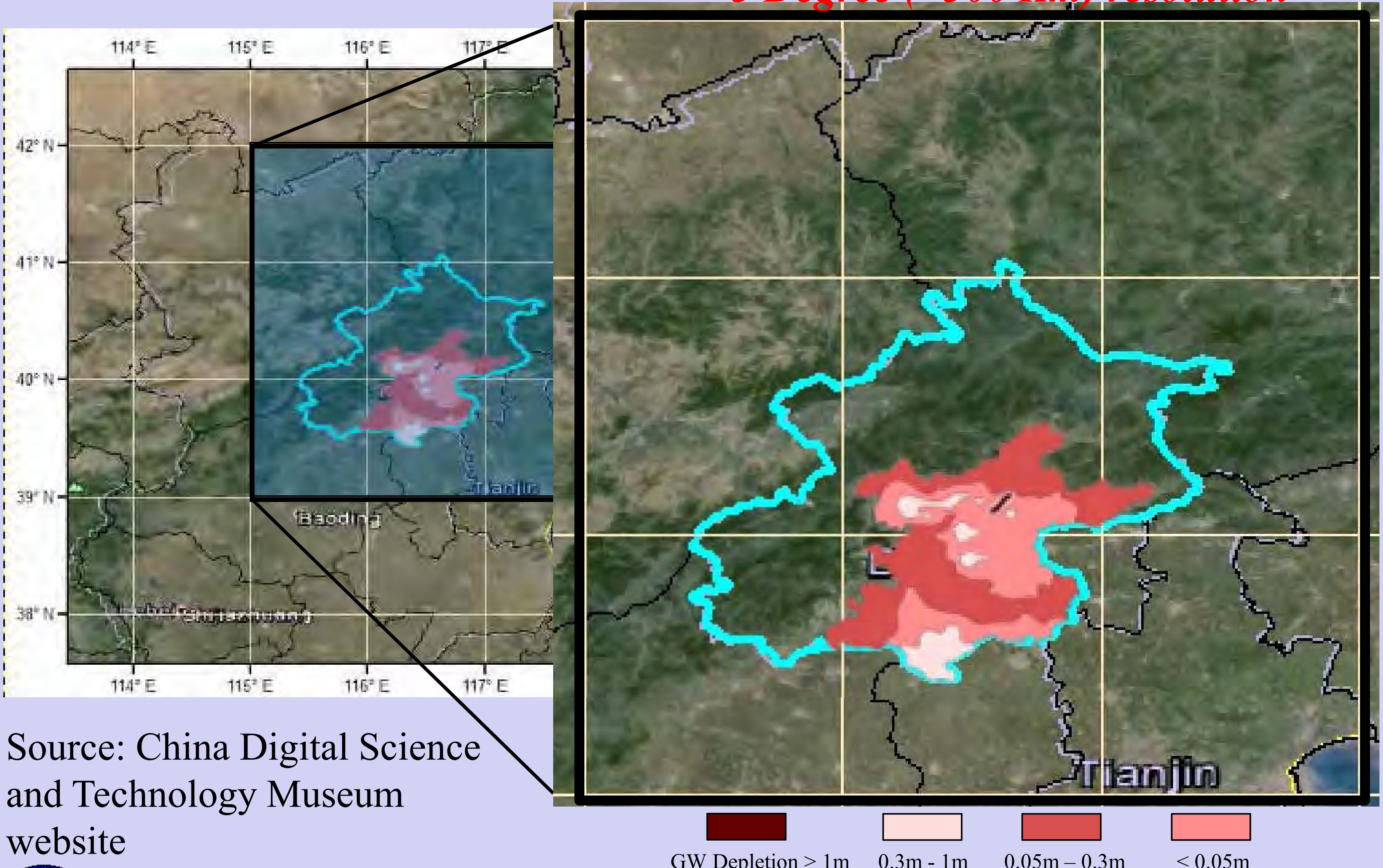
An Important Dilemma for the modeling application community will be:

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

Sorooshian et al. 2011, 2012 & 2014

GRACE Satellite Footprint

3 Degree (~300 Km) resolution



Source: China Digital Science and Technology Museum website

Created by: N. Nasrollahi. Tiantian Yang & S. Sarachi

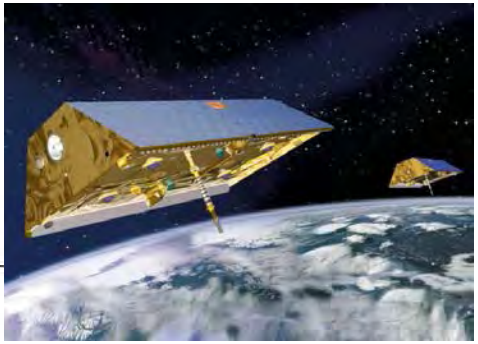
Finally: Recent Reaction to Overblown Stories About Ground Water Detection by Remote Sensing

Groundwater

Technical Commentary/

Bringing GRACE Down to Earth

by William M. Alley[1] and Leonard F. Konikow[2]



GRACE
Gravity Recovery and Climate Experiment (2002)

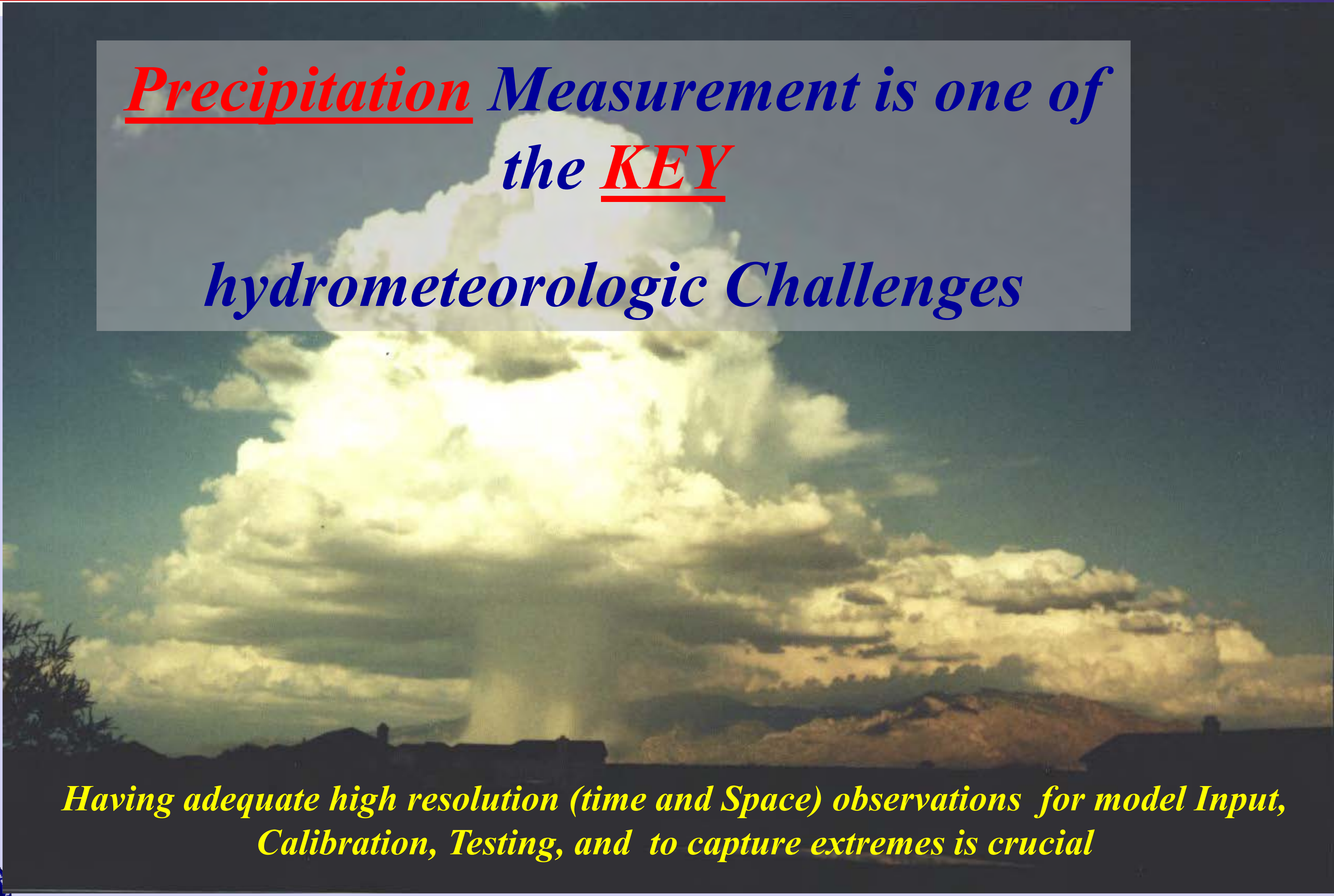
Introduction

NASA's Gravity Recovery and Climate Experiment (GRACE), which is a joint mission of the United States and Germany, uses a pair of coupled satellites to measure spatial and temporal changes in the Earth's gravity field. From these data, estimates of changes (time-variable anomalies) in mass are derived. In turn, the mass changes are attributed primarily to changes in water content (Tapley et al. 2004; Tiwari et al. 2009; Rodell et al. 2009; Famiglietti and Rodell 2013). Changes in water mass can arise from several hydrologic components, including soil

GRACE Provides a One-Dimensional Indicator of the Status of a Large Three-Dimensional Groundwater Body: It Is Not a Management Tool

GRACE data provide precise monthly estimates of total change in water storage (accuracy of 1.5 cm equivalent water height) over a large footprint—a resolution on the order of 200,000 km^2 (Famiglietti and Rodell 2013). Many aquifers that play a critical role in meeting human needs, however, occur at scales of 100s or 1000s of km^2, much smaller than the GRACE footprint.

A Key Requirement!



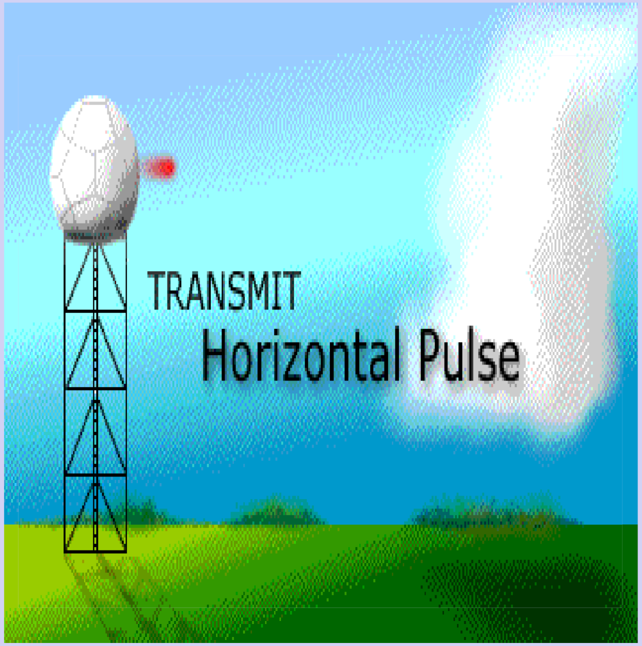
Precipitation* Measurement is one of the *KEY

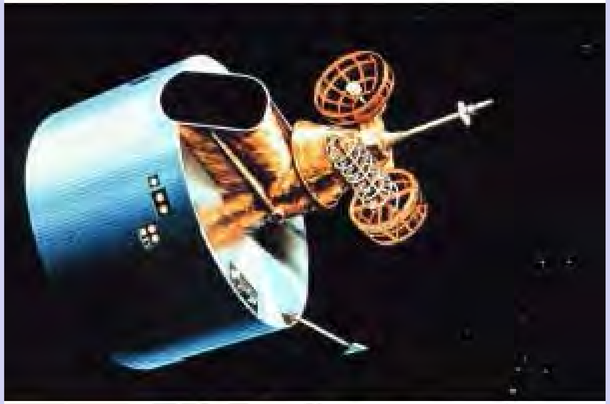
hydrometeorologic Challenges

Having adequate high resolution (time and Space) observations for model Input, Calibration, Testing, and to capture extremes is crucial

Precipitation Observations: Which to trust??

Rain Gauges



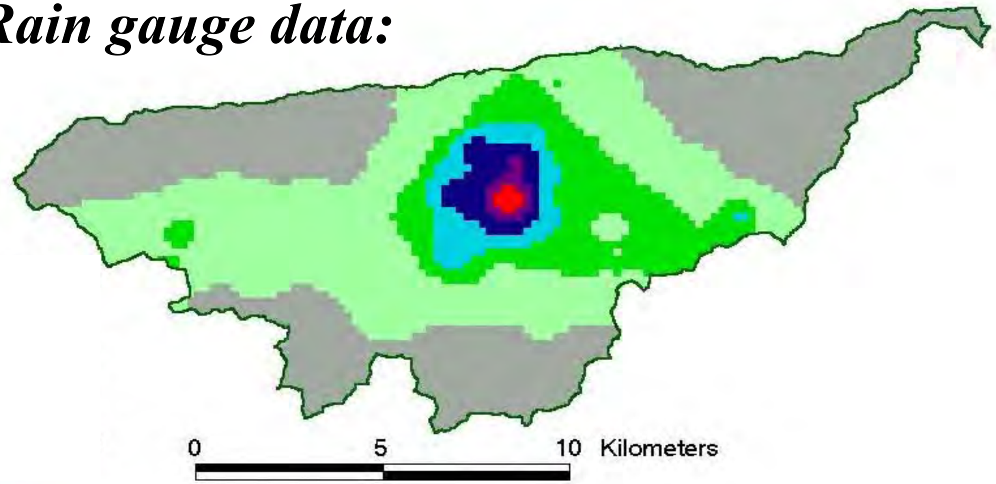


Satellite

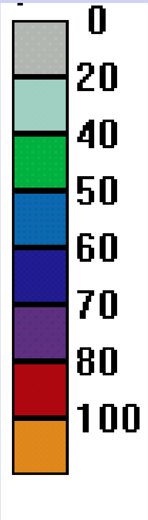
Radar-Gauge Comparison (Walnut Gulch, AZ)

Precipitation event: Aug. 11, 2000

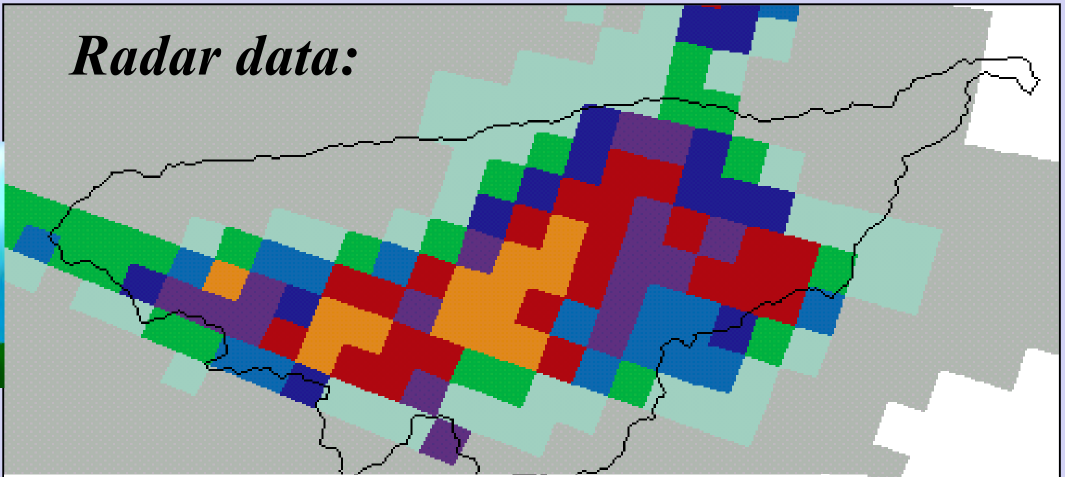
Rain gauge data:



Storm depth (mm)



Radar data:

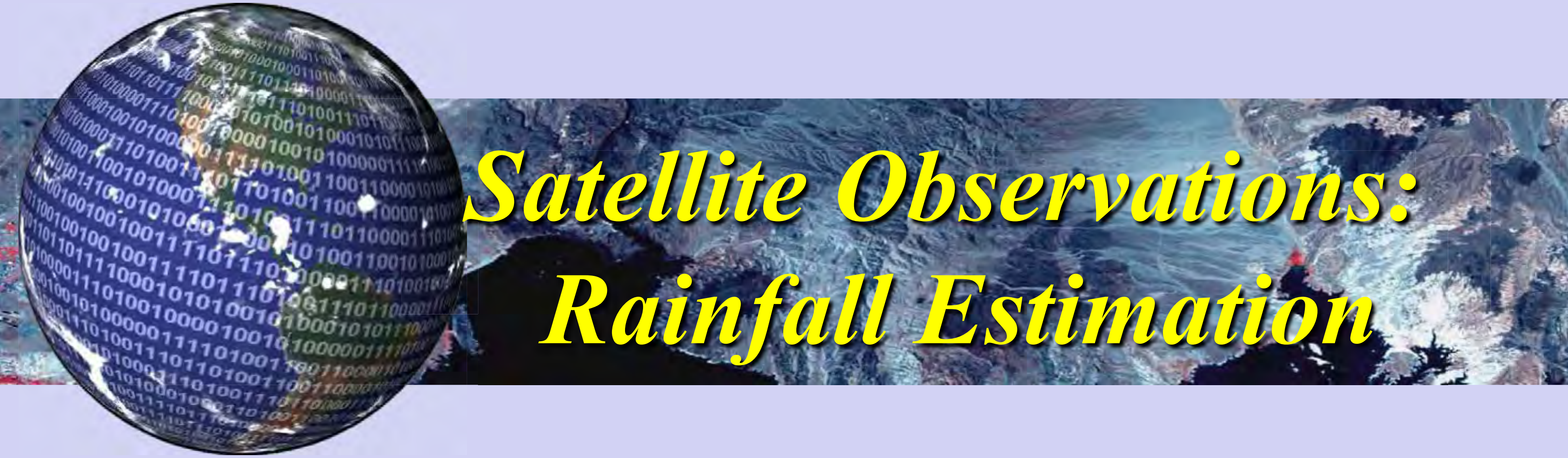


Z=300R$^{1.4}$, 2.4^{o} elevation, HailThresh=56 dbz

70% overestimation by the radar!

Morin et al ADWR 2005

Space-Based Observations for Model Testing

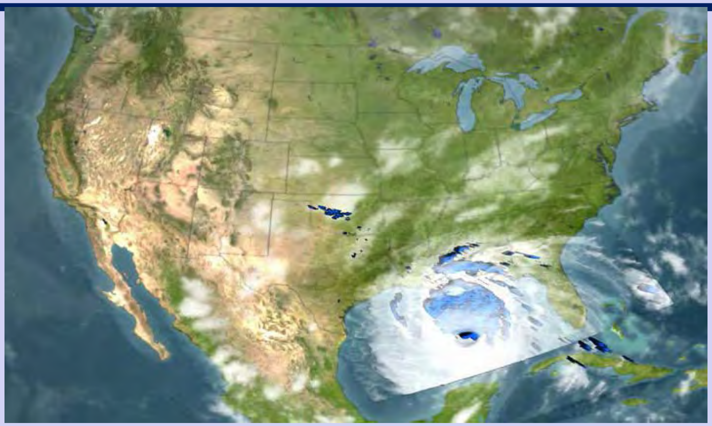


Satellite Observations: Rainfall Estimation

Satellite Data for Precipitation estimation

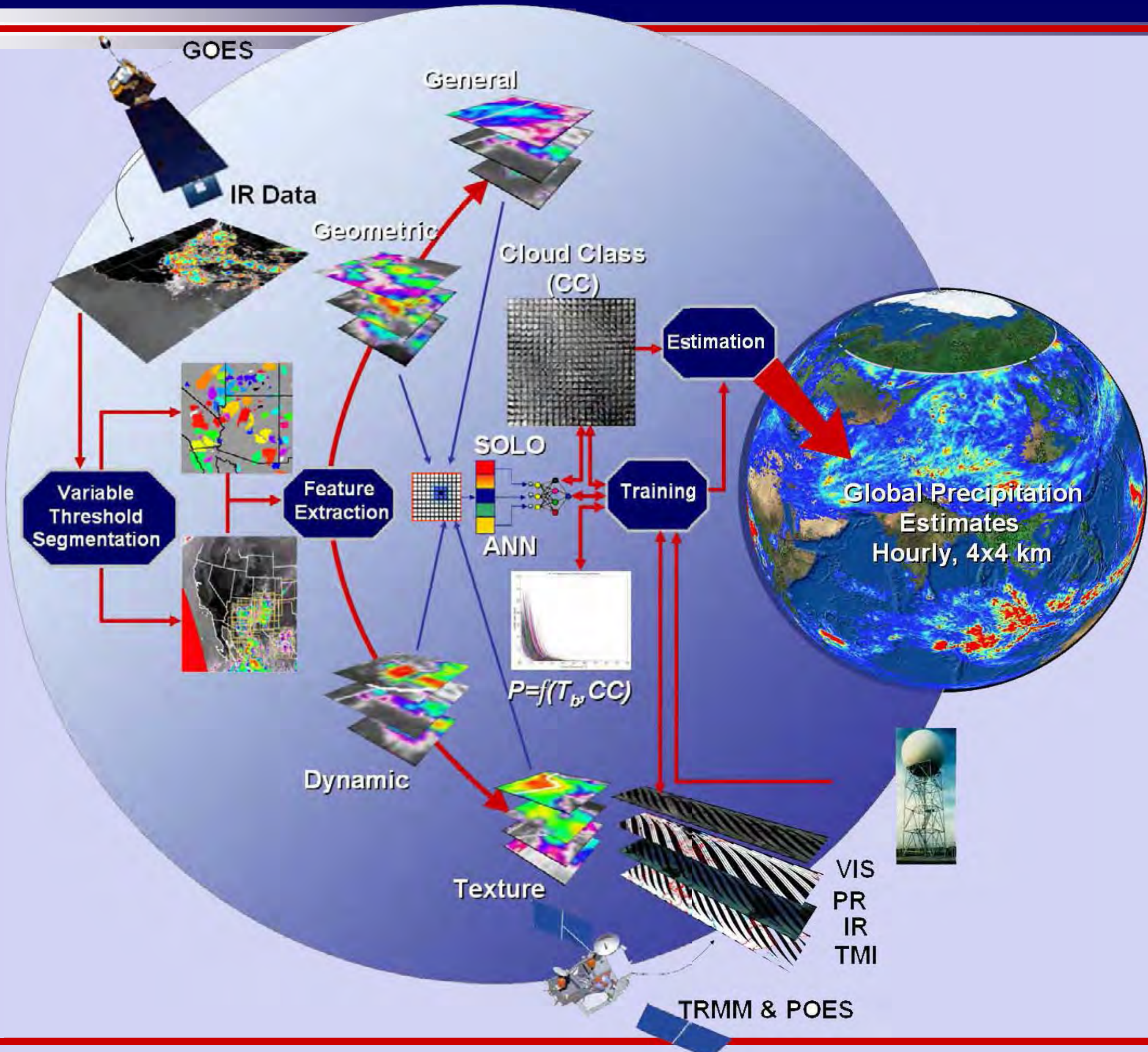
Geostationary IR
Cloud top data
15-30 minute temporal resolution

Passive Microwave (SSM/I)
Some characterisation of rainfall
~2 overpasses per day per spacecraft, moving to 3-hour return time (GPM)



TRMM precipitation RADAR
3D imaging of rainfall
1-2 days between overpasses
(S-35°N-35 °)

PERSIANN-CCS (Real-time 4 km)



CHRS RainSphere

An Integrated System for Global Satellite Precipitation Data and Information

http://rainsphere.eng.uci.edu

PERSIANN Extensions: Climate-Related

- PERSIANN- CDR (Climate Data Record)

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.

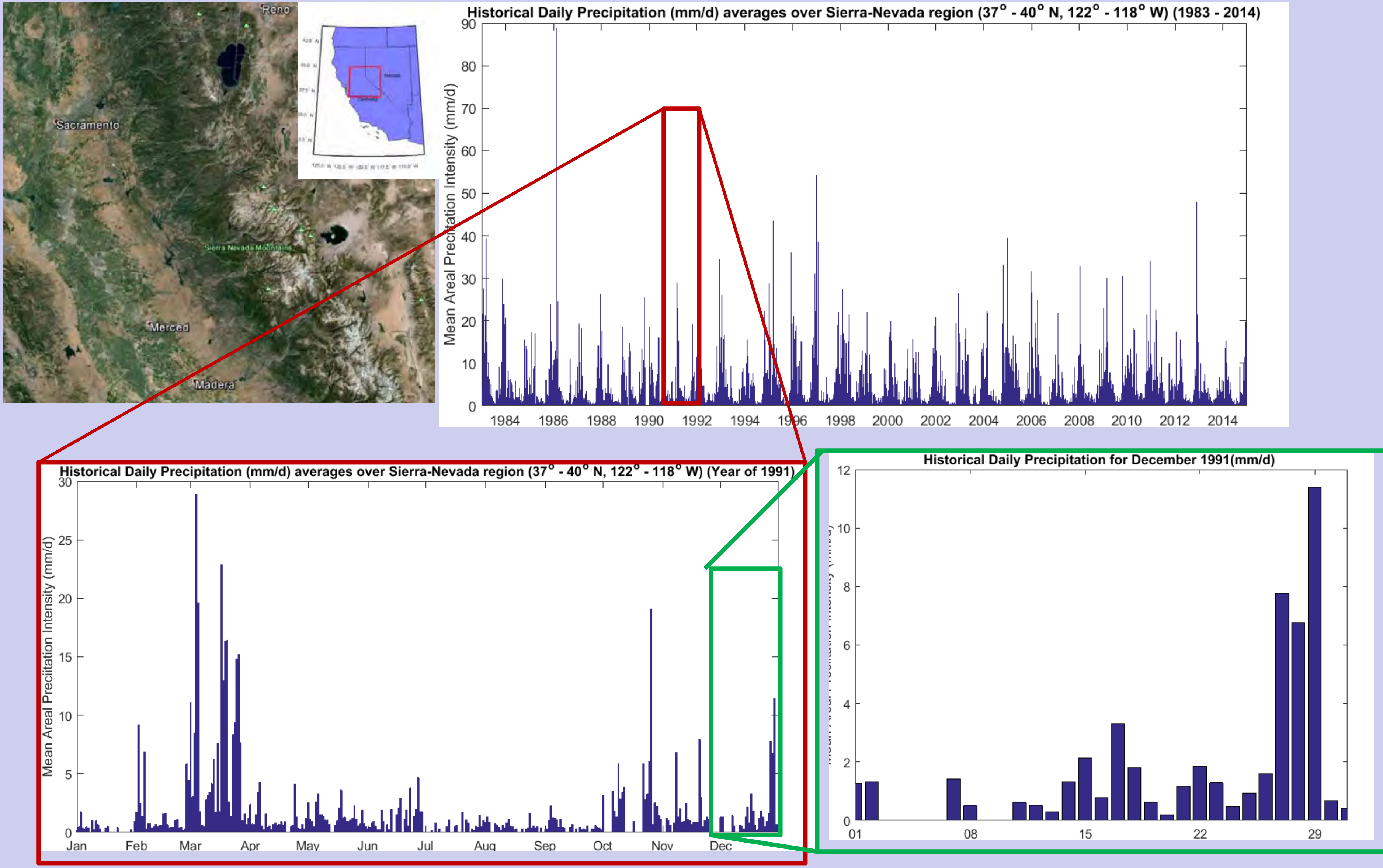
Sierra-Nevada Mountain Region

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

Length: 400 mile, Width: 64 mile.

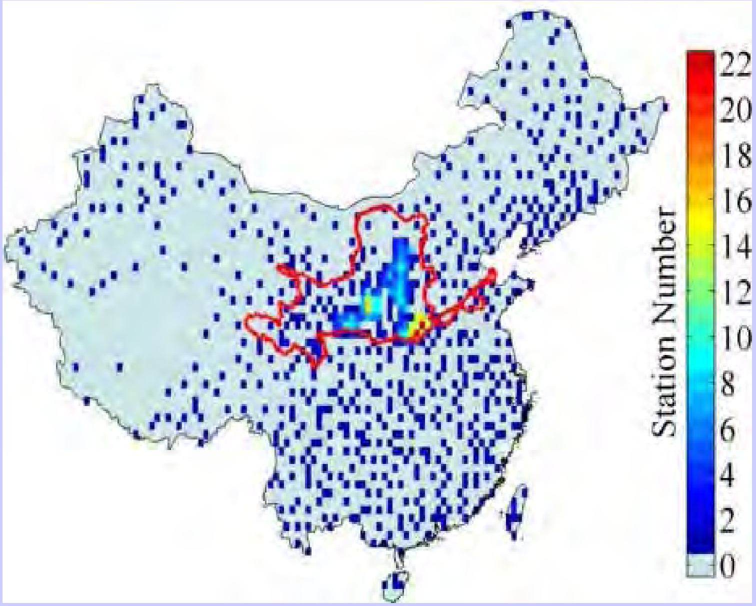
Map Source: Google Earth

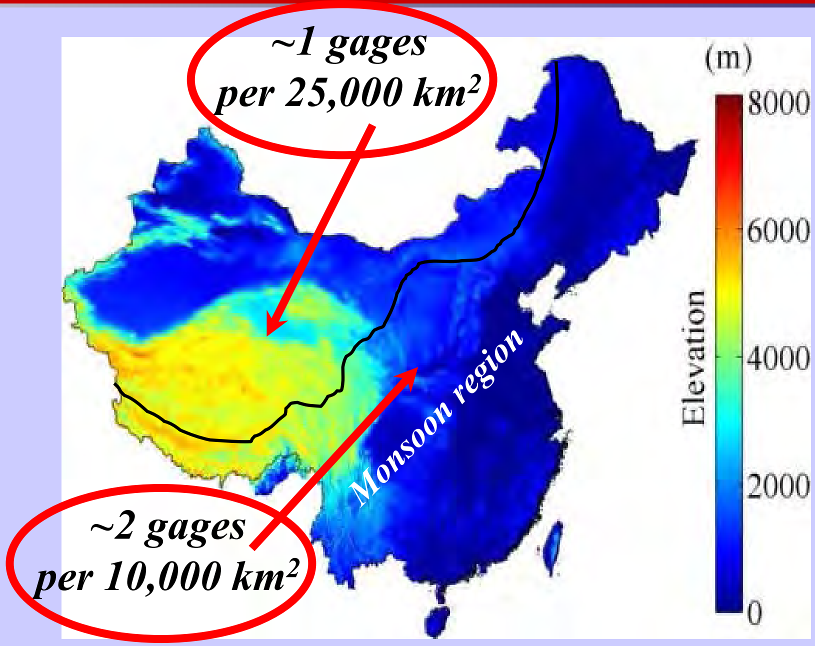
Sierra-Nevada Mountain (California and Nevada)



Many Regional Evaluation of PERSIANN CDR Are Being Reported:

PERSIANN-CDR Evaluation over China





EA Rain Gauge Distribution

Elevation Map

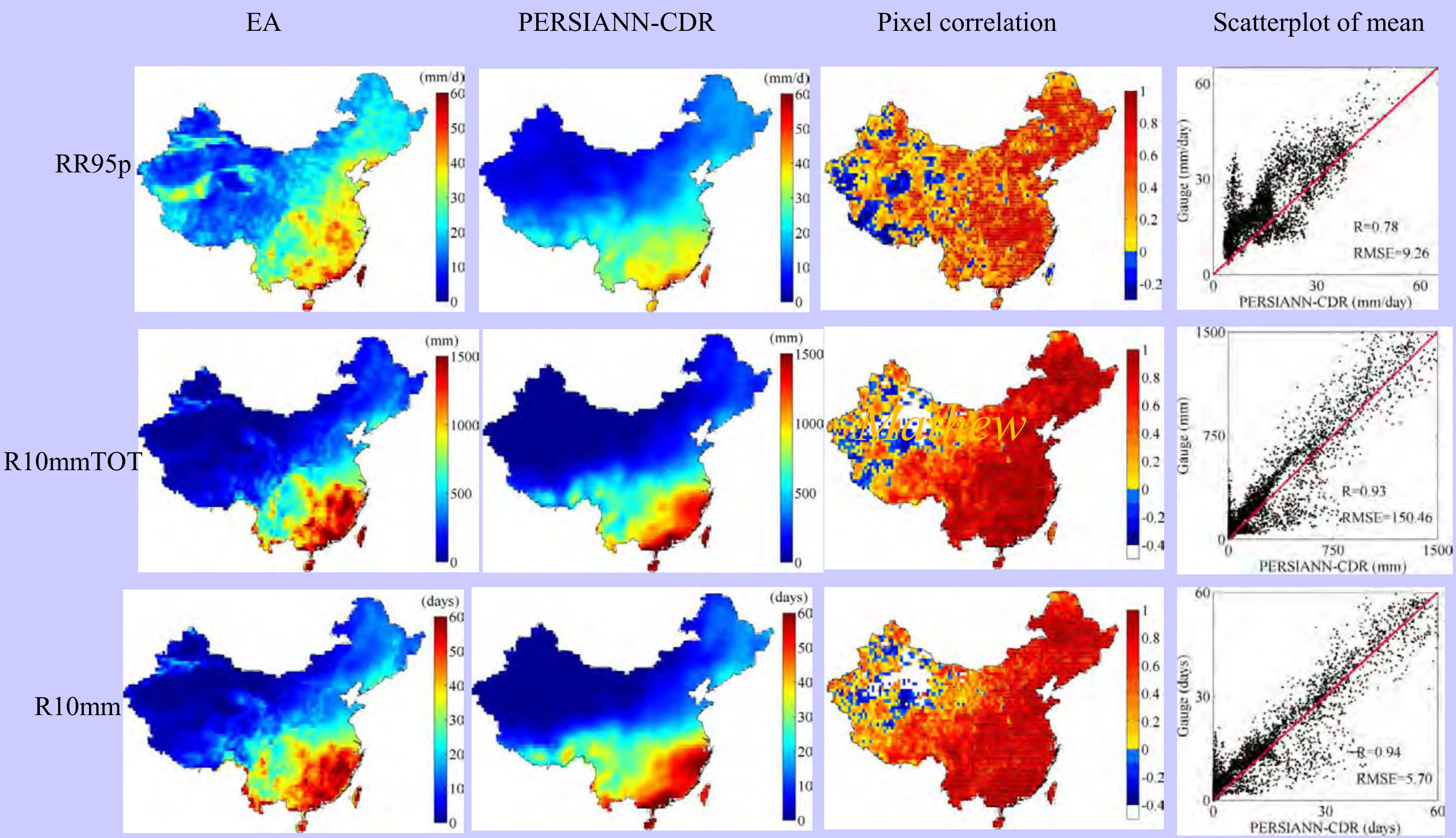
Dr. Chiyuan Miao - BNU

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°)*

Results: Entire China



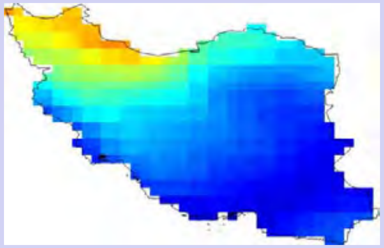
Miao et al., JHM 2015

Hydrologically-Relevant Data

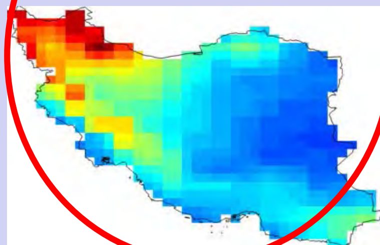
What is the value of this data set to application and Modeling communities?

Model historical simulation (1983-2005)

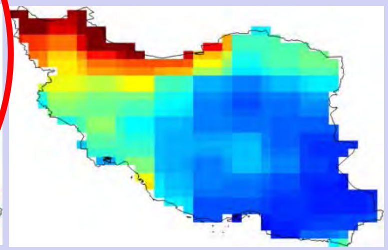
bcc_csm1_1_m
(Chinese GCM)



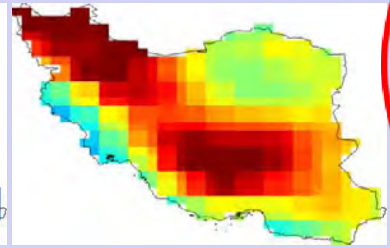
CCSM4
(NCAR, USA GCM)



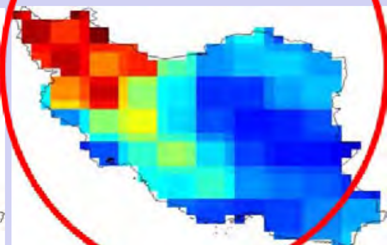
HadGEM2-ES
(U.K GCM)



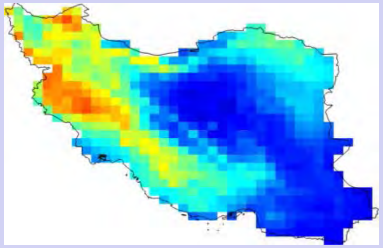
MIROC5
(Japan GCM)



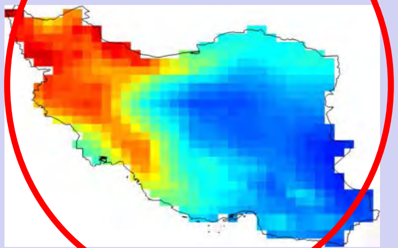
MPI-ESM-MR
(Germany GCM)



Observation
(CRU Dataset)



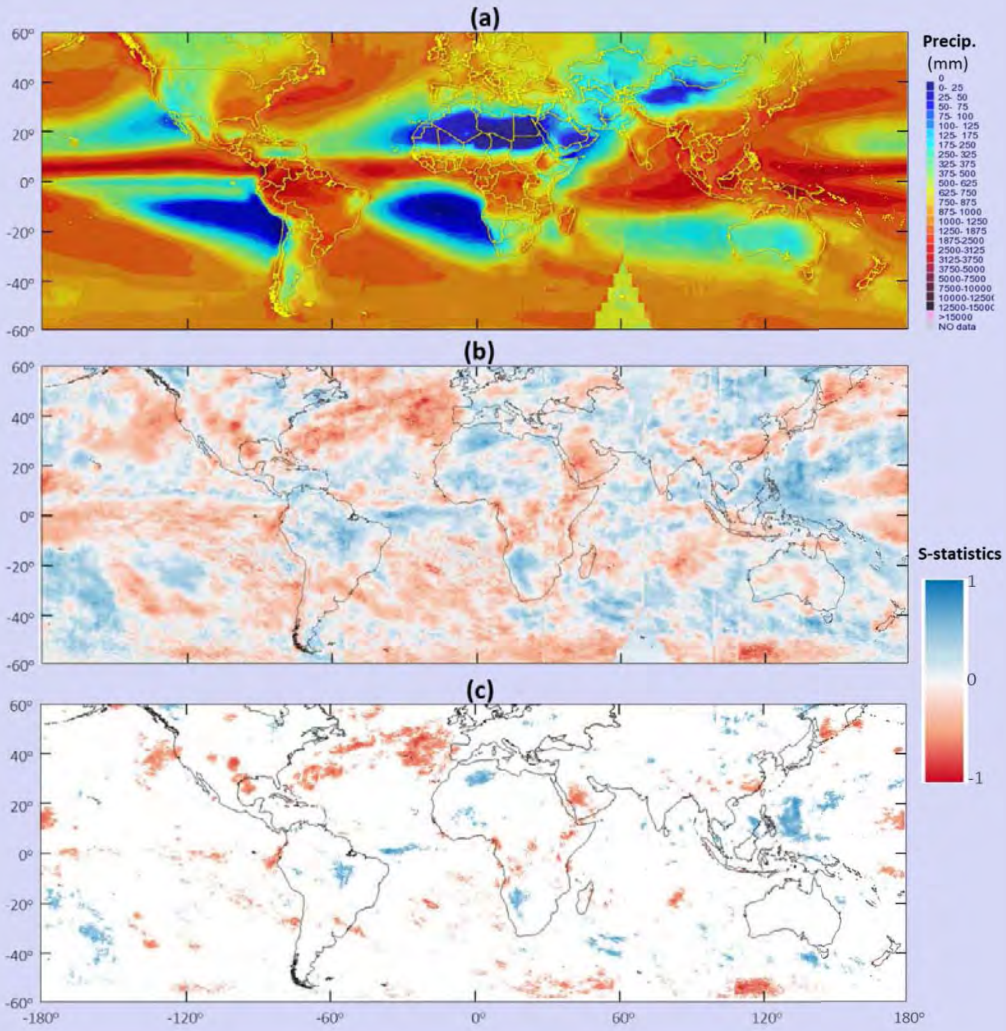
Remotely Sensed Estimates
(PERSIANN-CDR)



PERSIANN-CDR Application:

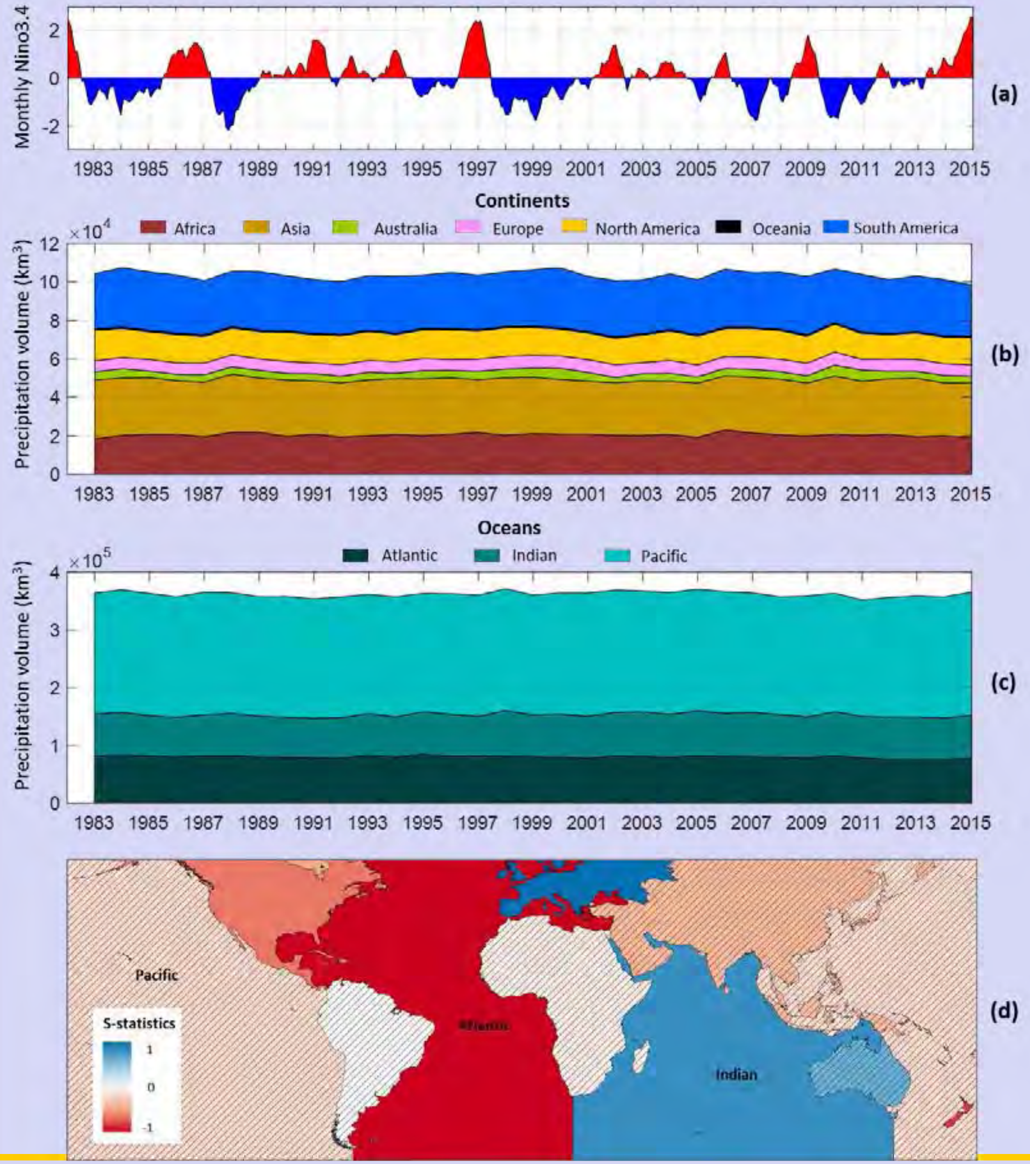
Global precipitation trends across spatial scales

Rainfall Trend Analysis: Pixel-based



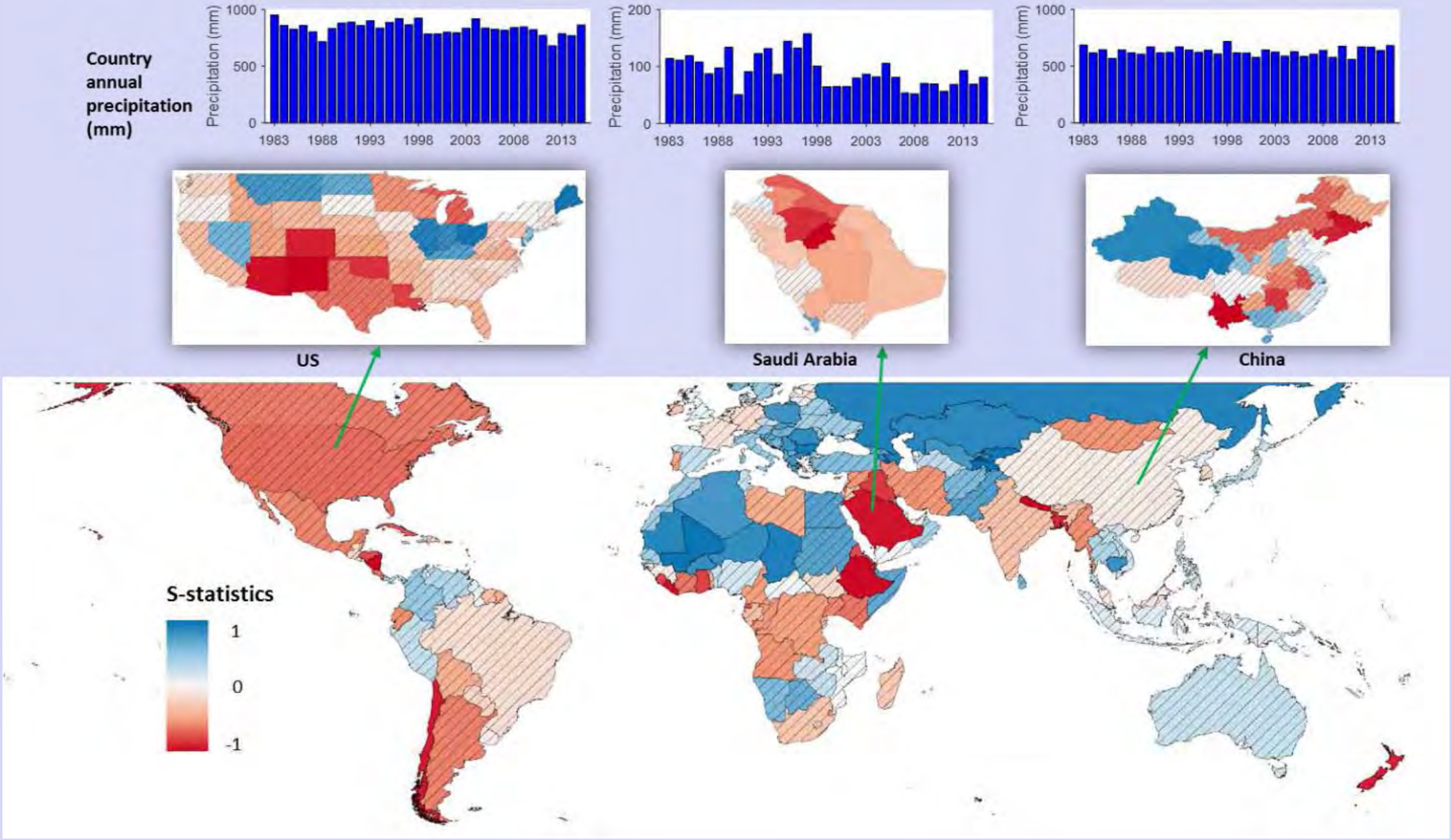
Annual mean precipitation in mm (a) and pixel-based precipitation trends (b, c) from 1983 to 2015 from PERSIANN-CDR

Rainfall Trend Analysis: Continents and Oceans



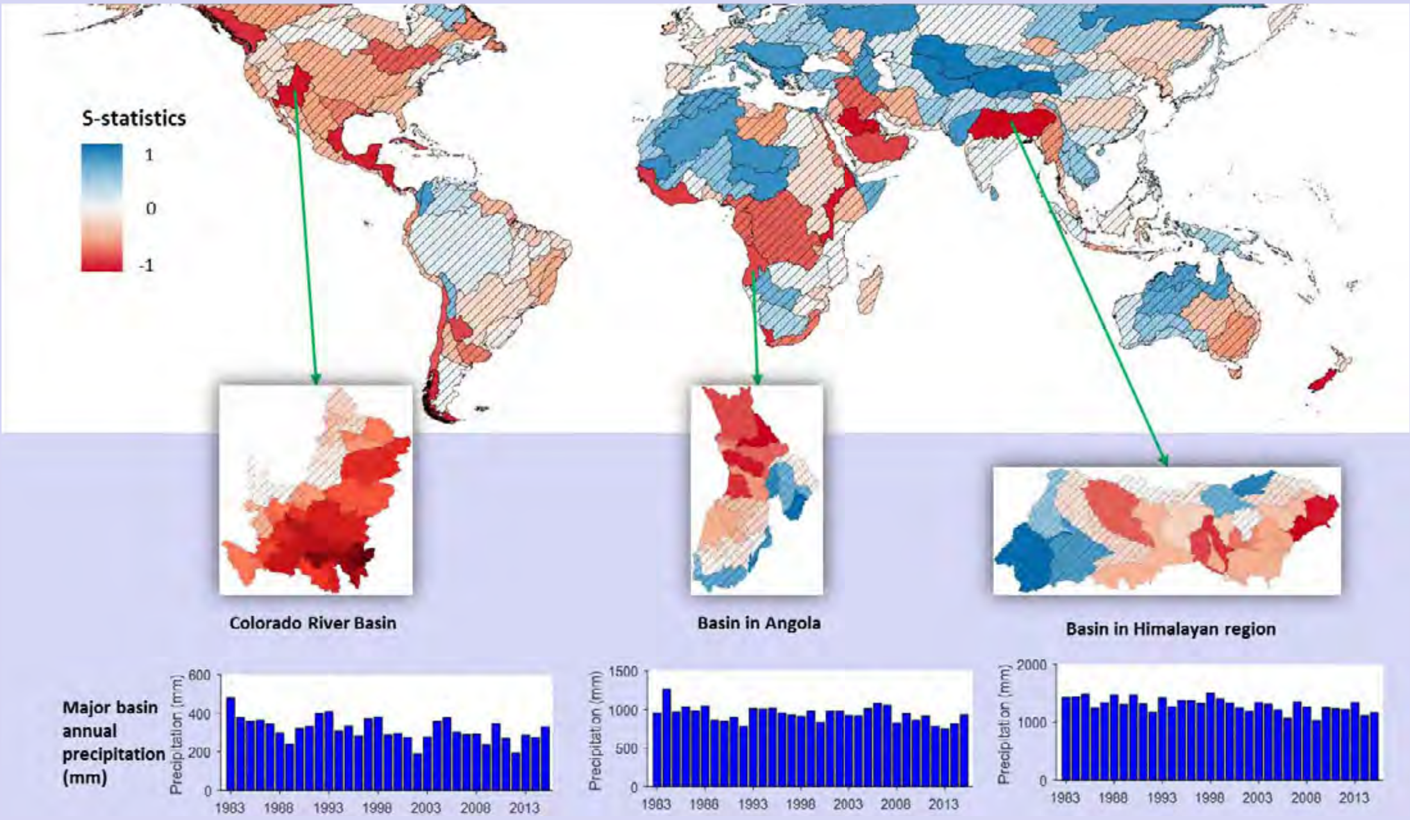
Monthly Nino3.4 (a) Changes in precipitation volume (b, c) and precipitation volume trends (d) over continents and oceans.

Rainfall Trend Analysis: Countries and Political Divisions



Precipitation trends from 1983 to 2015 over 201 countries (60ºN - 60ºS) and state/province political divisions of US, Saudi Arabia and China

Rainfall Trend Analysis: Basins and Watersheds



Precipitation trends from 1983 to 2015 over 237 global major basins

PERSIANN Websites and Apps

- CHRS RainSphere
- CHRS iRain
- CHRS Data Portal
- PERSIANN-CONNECT

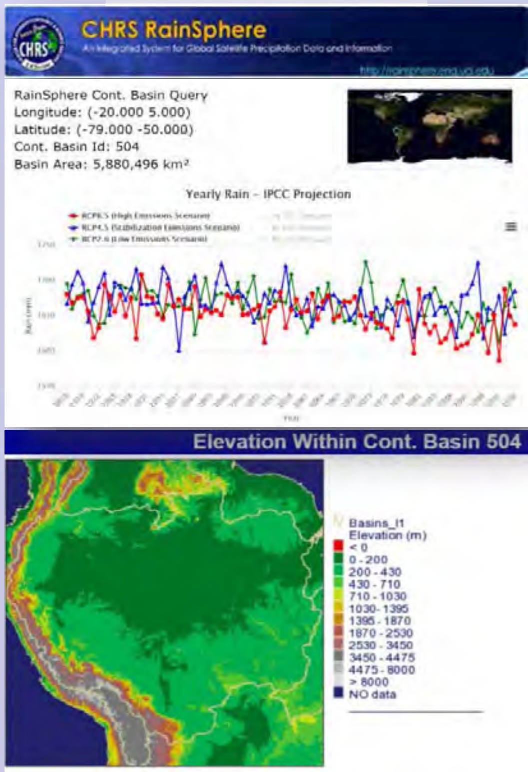
RainSphere Interface

http://rainsphere.eng.uci.edu

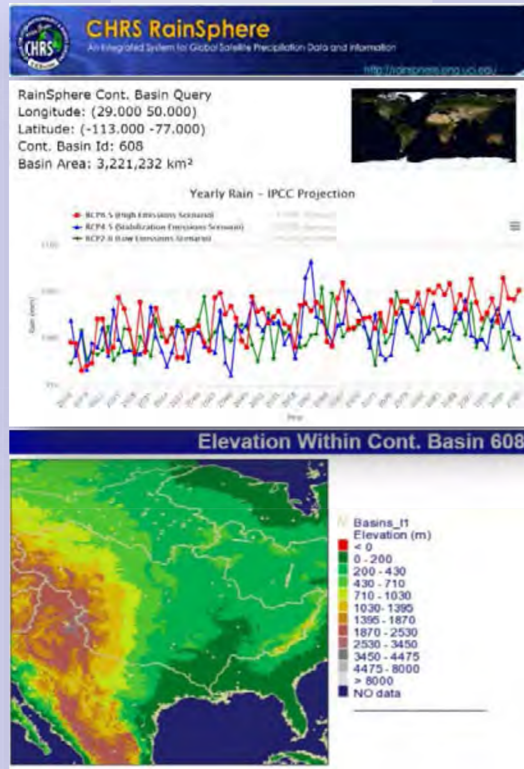
RainSphere

Future Projection

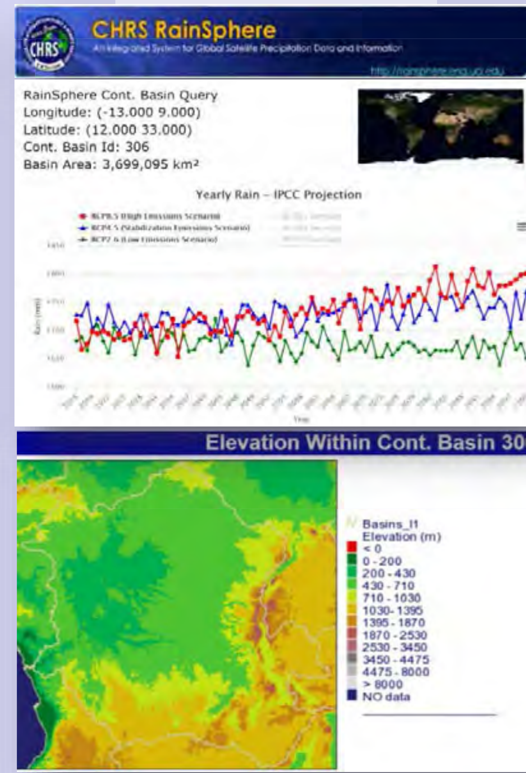
Amazon



Mississippi



Congo



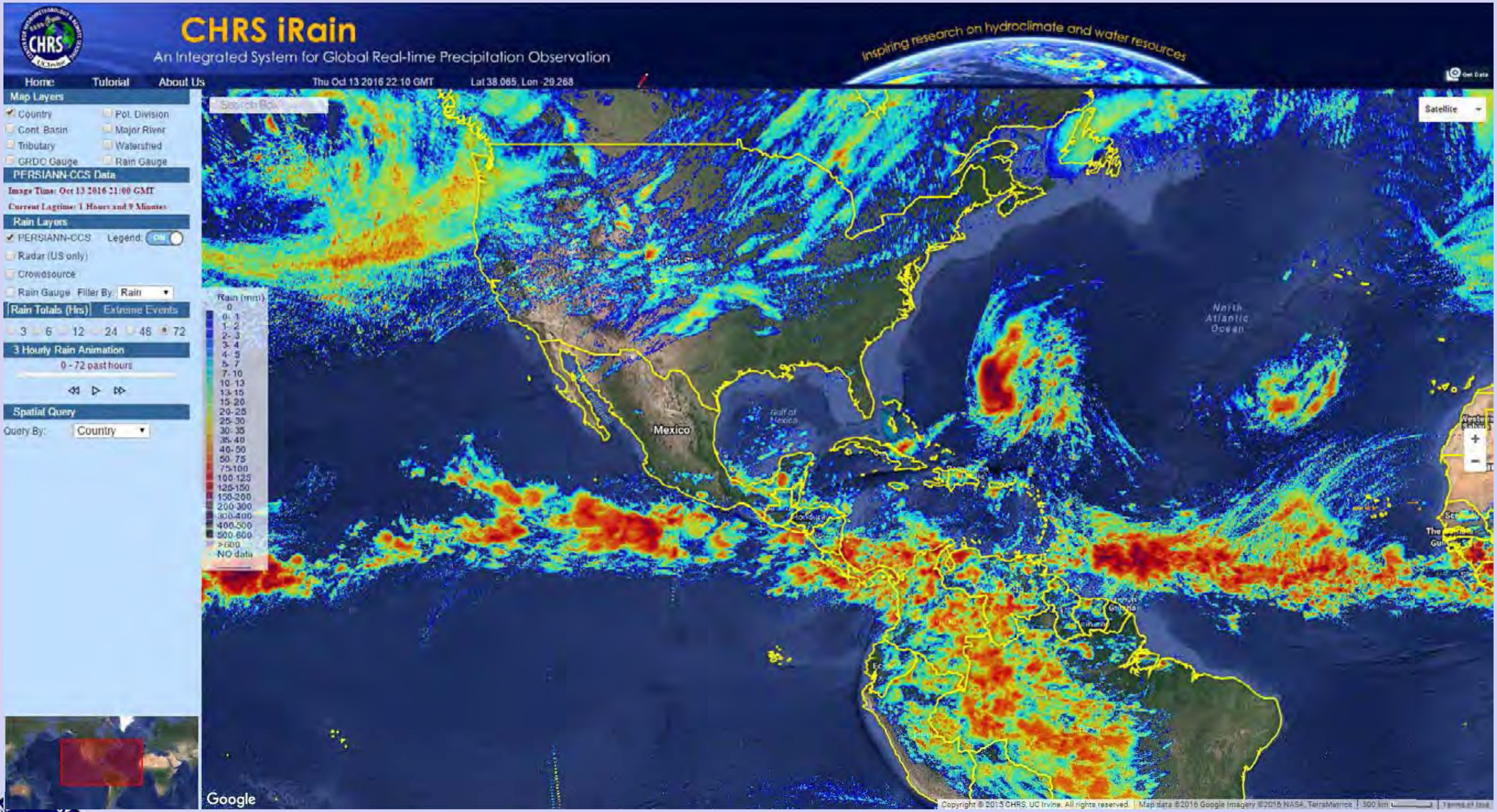
CHRS iRain

An Integrated System for Global Real-time Precipitation Observation

http://irain.eng.uci.edu

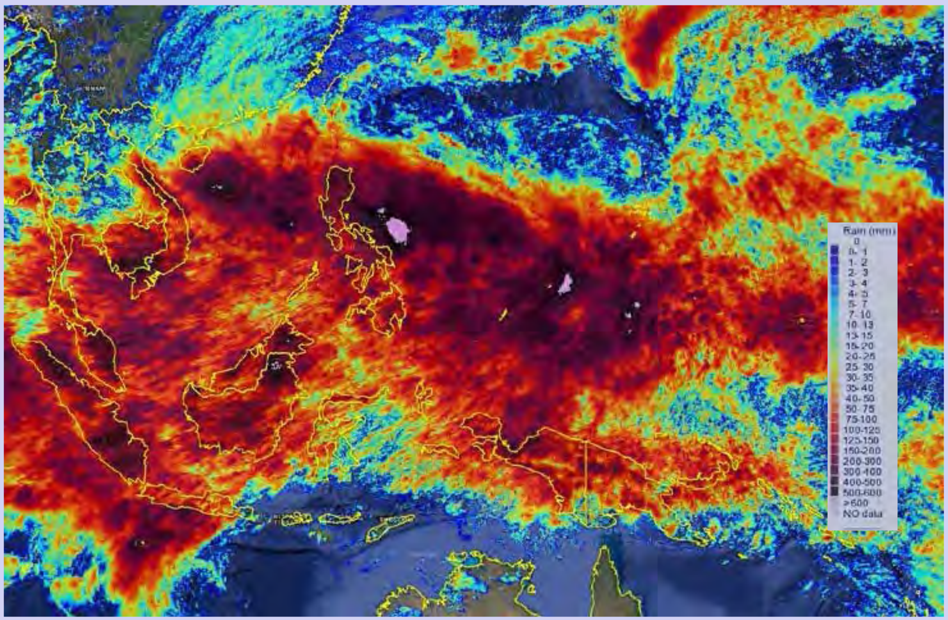
iRain Interface

http://irain.eng.uci.edu

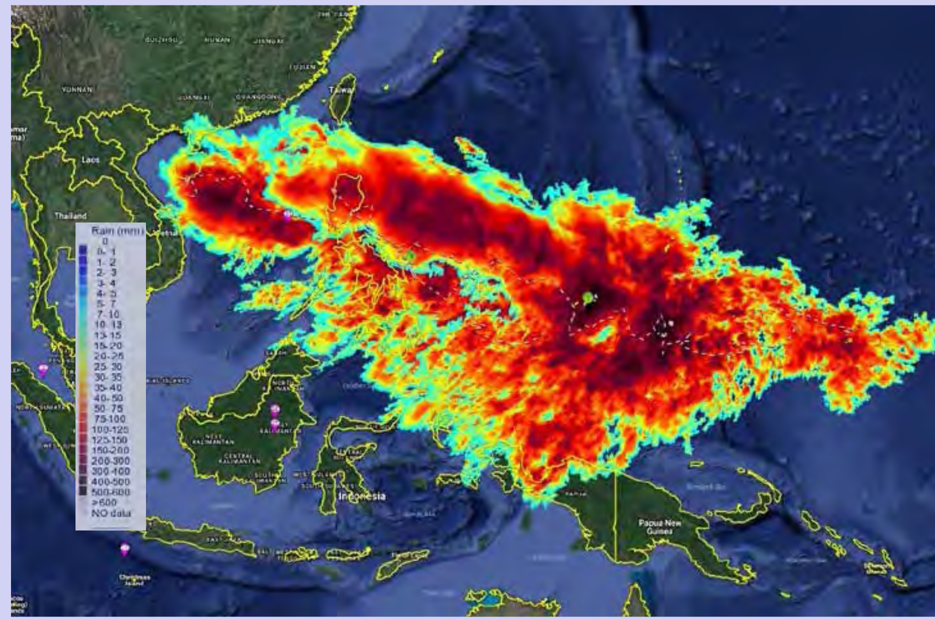


Typhoons Sarika and Haima October 2016

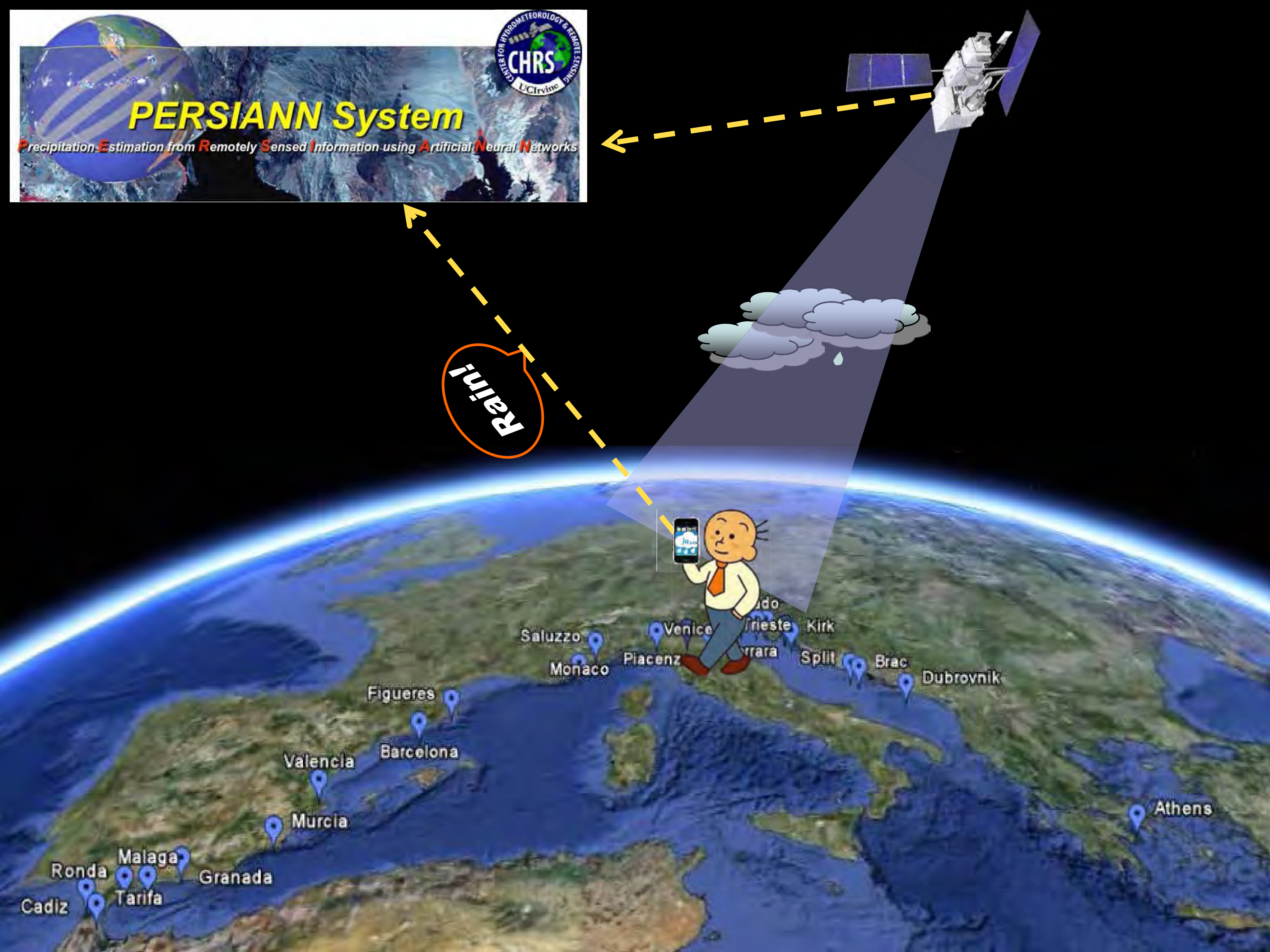
Monitoring Typhoons Sarika and Haima on CHRS iRain System (iRain.eng.uci.edu) Using Real-time Global High Resolution (4km) Satellite Precipitation PERSIANN-CCS Data



Rain Accumulation October 10 – 20, 2016

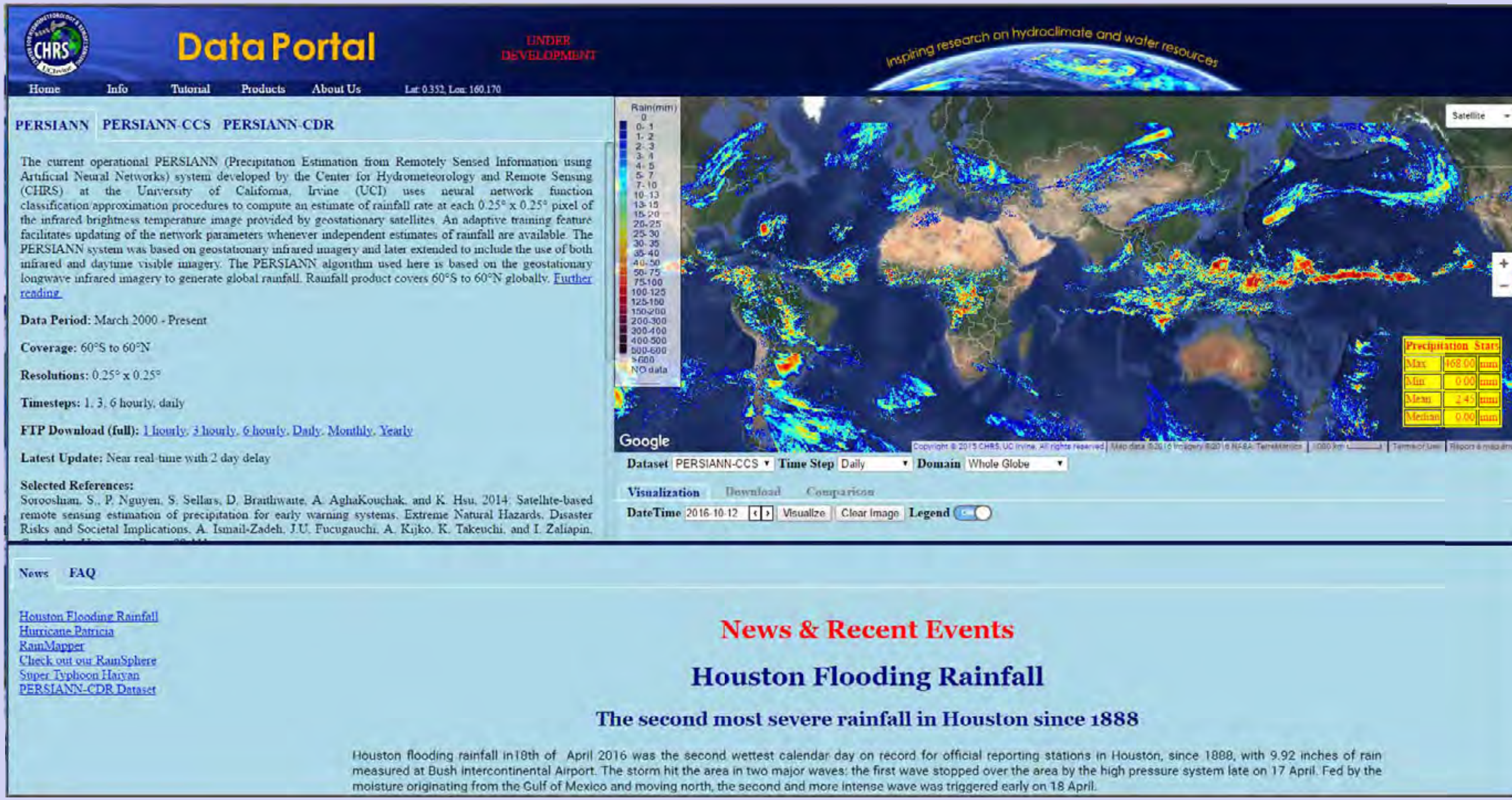


Rain totals of Typhoons Sarika and Haima extracted using CHRS CONNECT Algorithm


PERSIANN System
Precipitation Estimation from Remotely Sensed Information using Artificial Neural Networks
CHRS
CENTER FOR HYDROMETEOROLOGY & REMOTE SENSING
UCIrvine
Rain!
Saluzzo
Venice
Trieste
Kirk
Monaco
Piacenz
Split
Brac
Dubrovnik
Figueres
Barcelona
Valencia
Murcia
Malaga
Ronda
Granada
Tarifa
Cadiz
Athens

CHRS Data Portal

http://chrsdata.eng.uci.edu



Who Uses CHRS Products

CHRS User Statistics

Overall | CHRS Homepage | G-WADI | iRain | RainSphere | Data Portal | CONNECT

Total Visits: 570,957 since 01-Jan-2010
Countries: 195 countries registered

#	Country	Total Visits
1	United States	372,328
2	China	39,859
3	France	20,766
4	Thailand	16,494
5	Japan	15,766
6	Germany	12,903
7	Ukraine	7,745
8	Iran, Islamic Republic Of	7,104
9	Canada	5,859

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

CHRS iRain and Rainsphere Development Team

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