What Do Climate Models Tell Us: Western United States & Spain

Soroosh Sorooshian

Center for Hydrometeorology and Remote Sensing
University of California Irvine

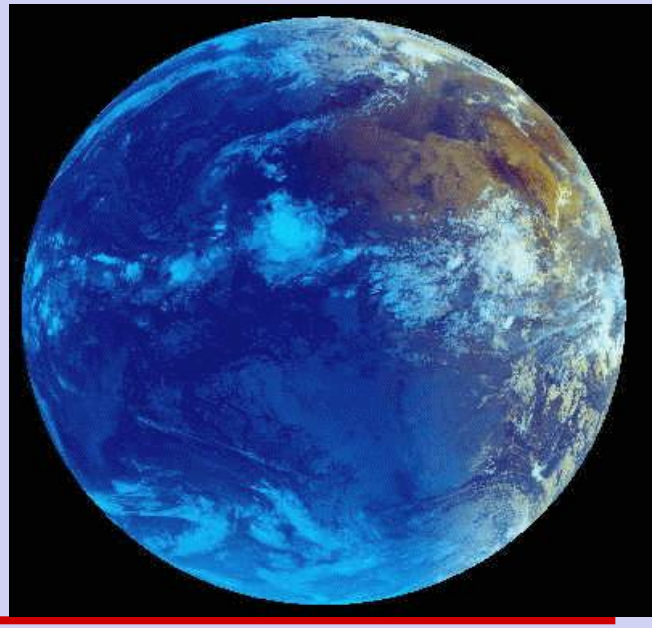
The Botin & Rosenberg workshop :
Adapting Water Rights to Face Climate Change Impacts
Botín Foundation, Calle de Castelló,
Madrid, Spain 25 April, 2019

University of California Irvine (UCI) Past

Climate, Hydrology and Water Resources

- *How will Climate change effect precipitation variability and water Availability?*

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

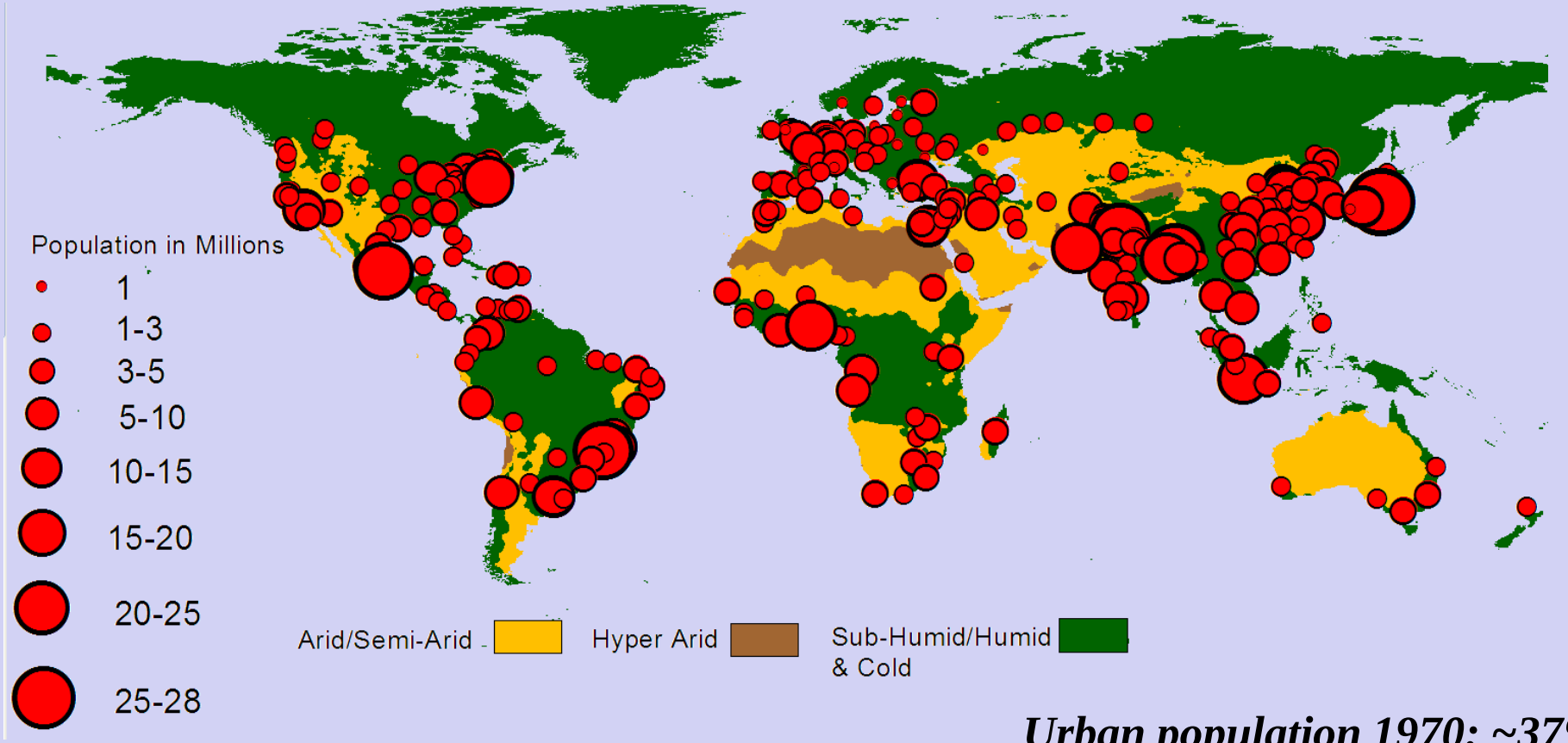


Stresses On Water Resources and Related Ecosystems:

- ***Population Impact*** *(More Predictable!)*
- ***Climate Impact*** *(Less Predictable!)*

Increasing Population: Number of Mega Cities

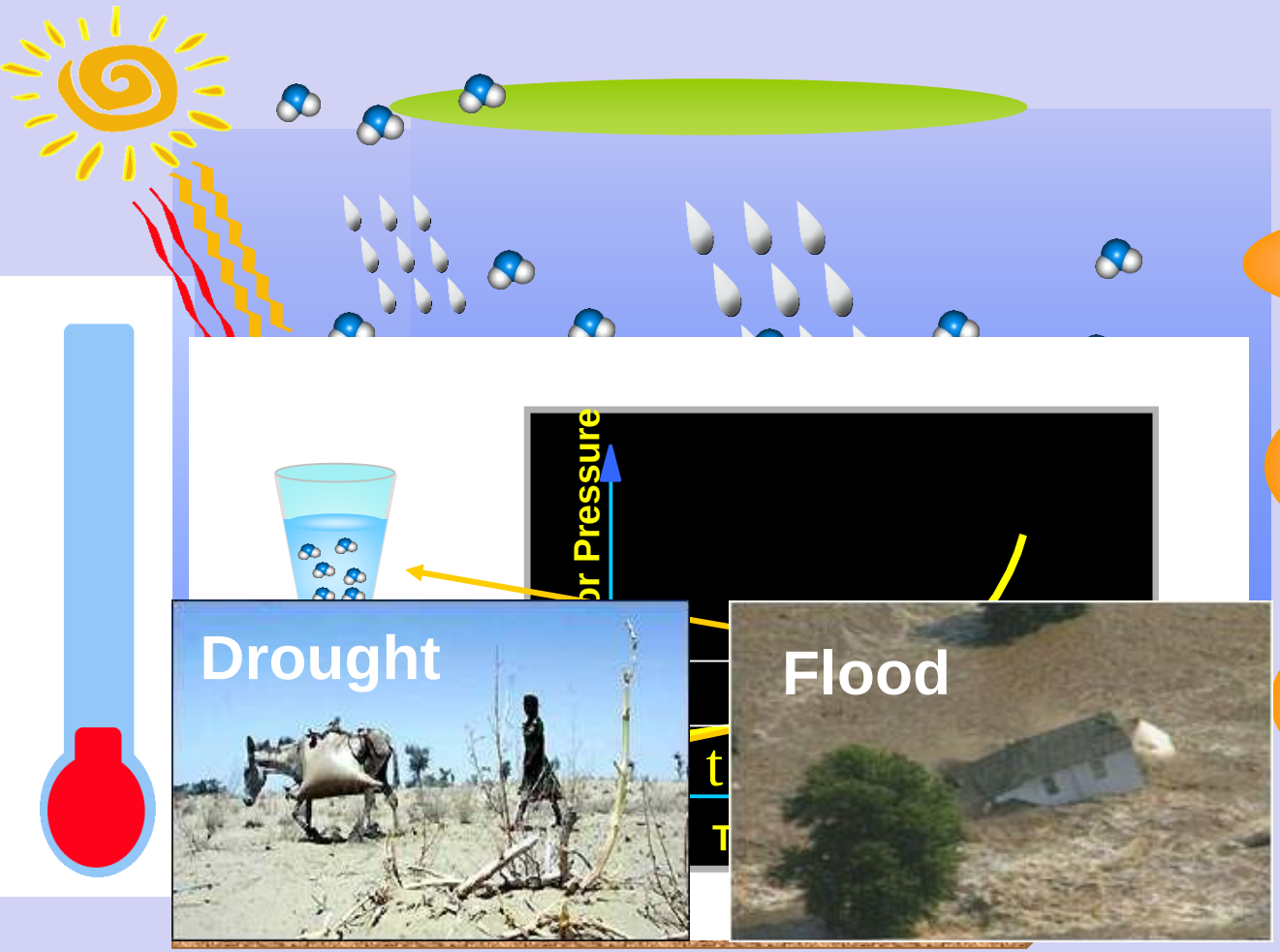
Projected Global Population: 8.3 Billion by 2025

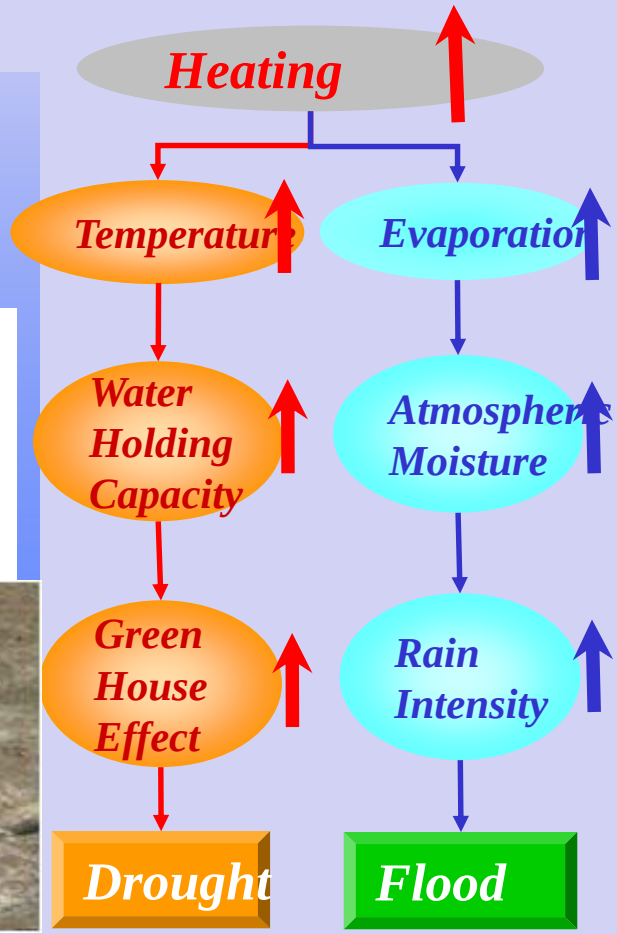


Urban population 1970: ~37%
2010: ~53%

Took 200,000 years of human history for world's population to reach 1 billion; and only 200 years more to reach 7 billion plus.

Global Warming And Hydrologic Cycle Connection





Created by: Gi-Hyeon Park

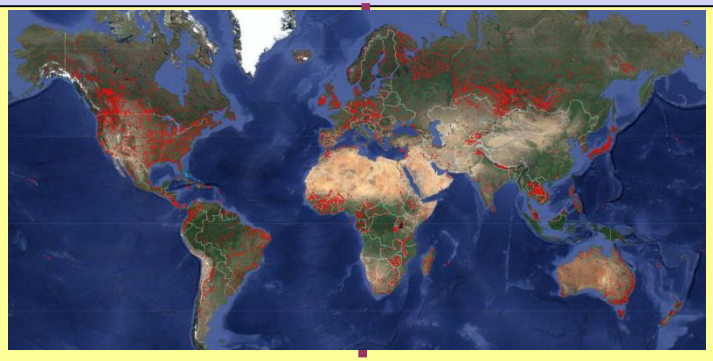
Center for Hydrometeorology and Remote Sensing, University of California, Irvine

Information Relevant to Water Resources Planning

- *Observations*

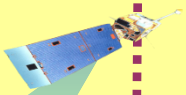
- *Models Projections*

Hydroclimate of the Past and Future: Observation &Modeling



Proxy Records

Instrumental data



Future Projections (model Generated)

Past

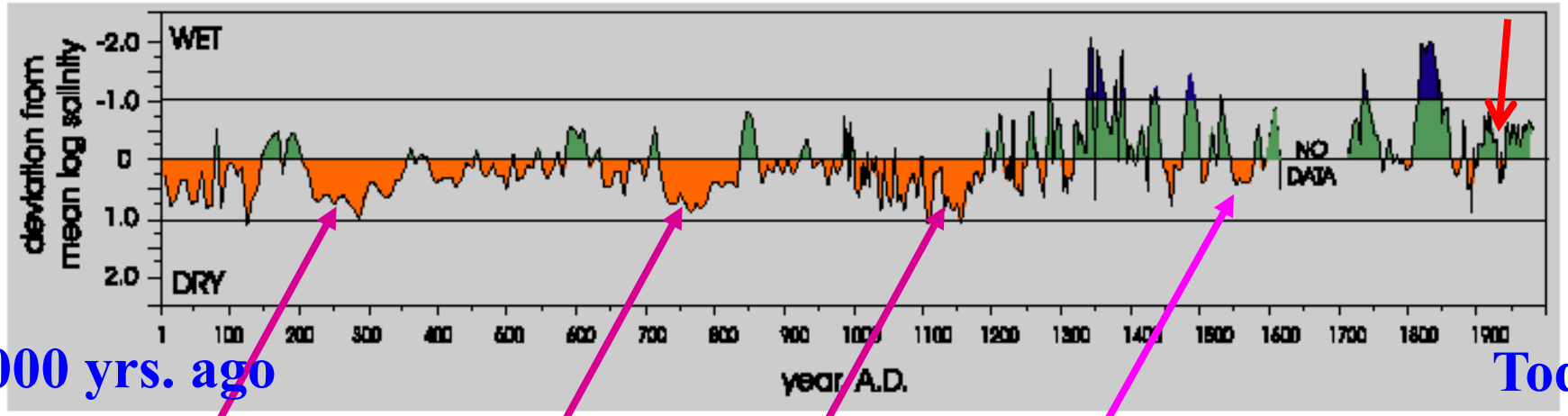
Future

- 200 years **Present**

Time

2000-year Climate history of central U.S.

The US Mid-West



Dust Bowl

2000 yrs. ago

Today

1930's dustbowl

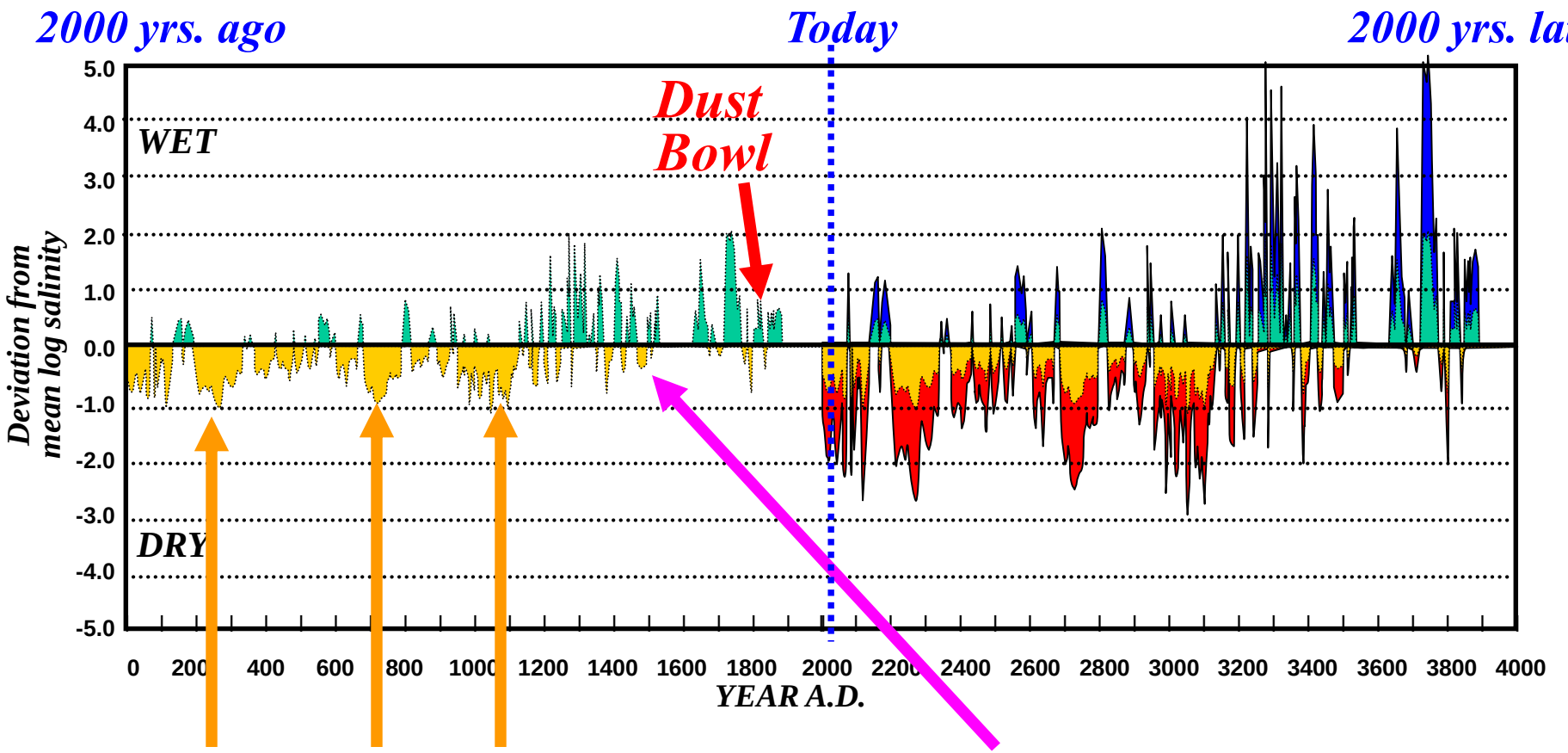
16th century "megadrought"

>100 year "megadroughts"

Source: Overpeck 2004

Will Nature Repeat Itself ?????

The US Breadbasket: The Mid-West



Source: Overpeck 200

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

Climate-Scale approaches to addressing hydrologic extremes

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

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

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Water Supply Volume

Long-range

Forecast Requirements

What Do Climate Models Tell Us About the Future?

Western U.S. future model projections

Dr. Chiyuan Miao - BNU

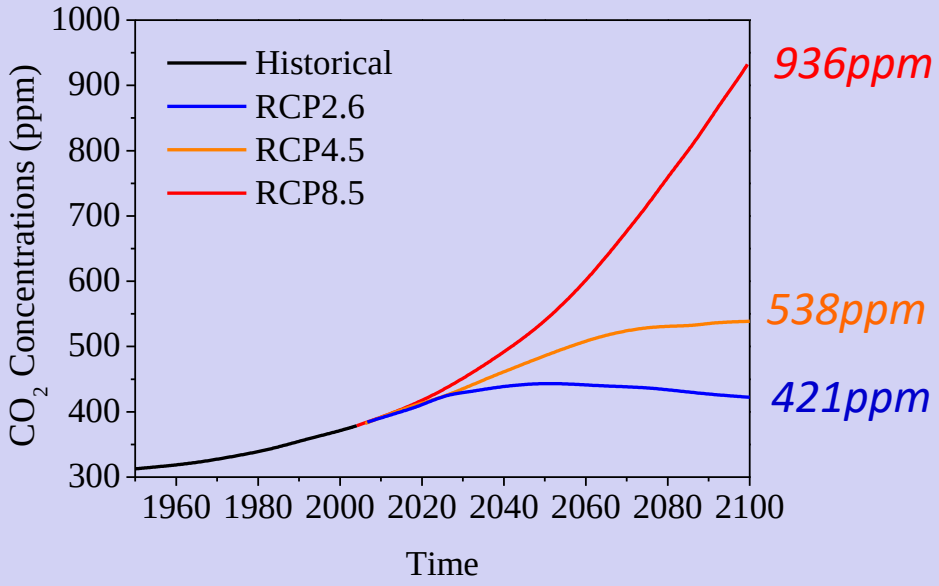
Future Modeling Scenarios – IPCC AR5

Representative Concentration Pathways (RCP) Scenarios:

RCP2.6: represent 'low' scenarios featured by the radiative forcing of 2.6 W/m^2 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/m^2 by 2100, the resulting CO_2-equivalent concentrations is 538 ppm in the year 2100 .

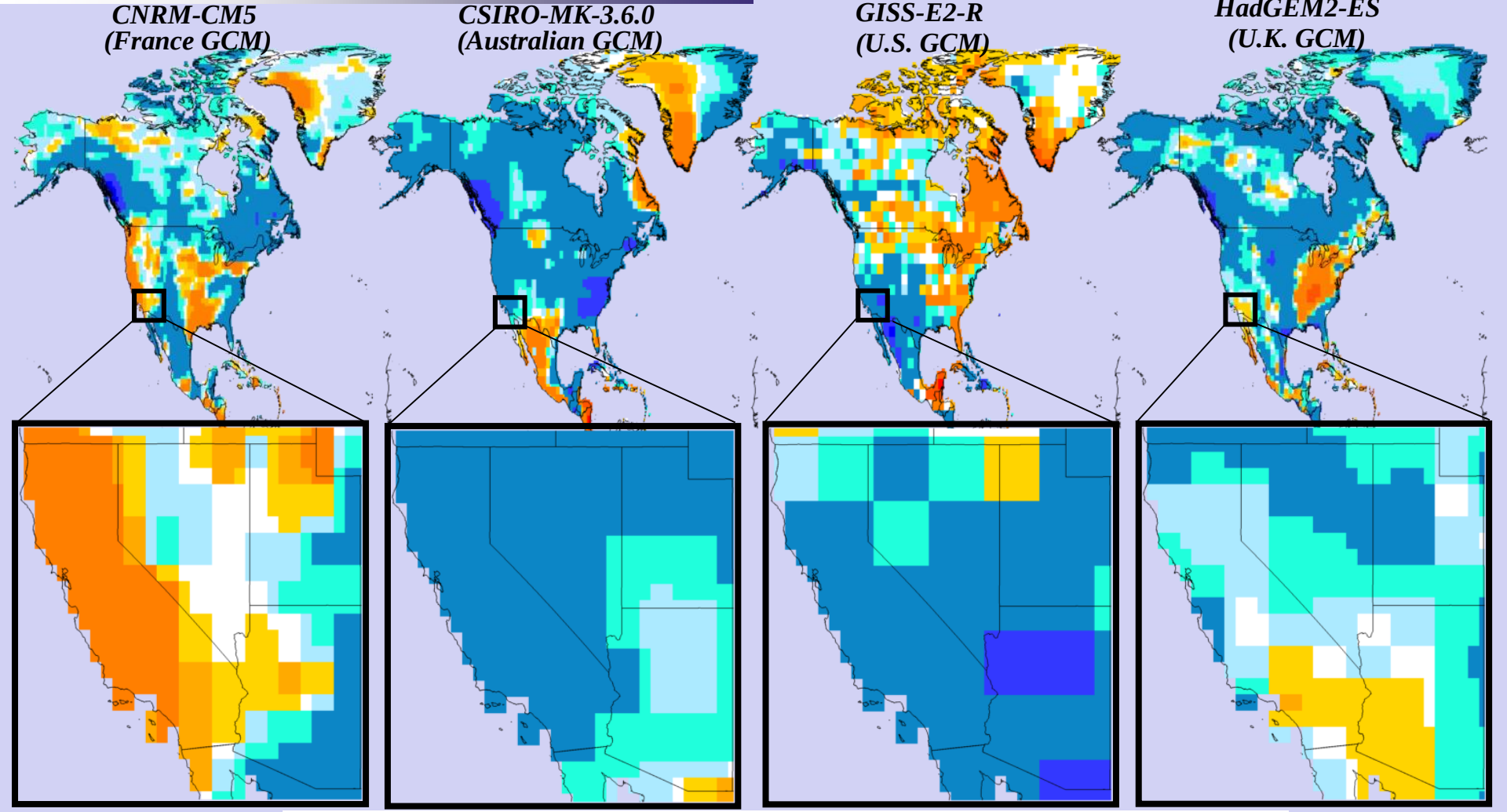
RCP8.5: represent 'high' scenarios featured by the radiative forcing of 8.5 W/m^2 by 2100, the resulting CO_2-equivalent concentrations is 936 ppm in the year 2100 .



IPCC AR5 Scenarios

Time period: 2006-2099

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



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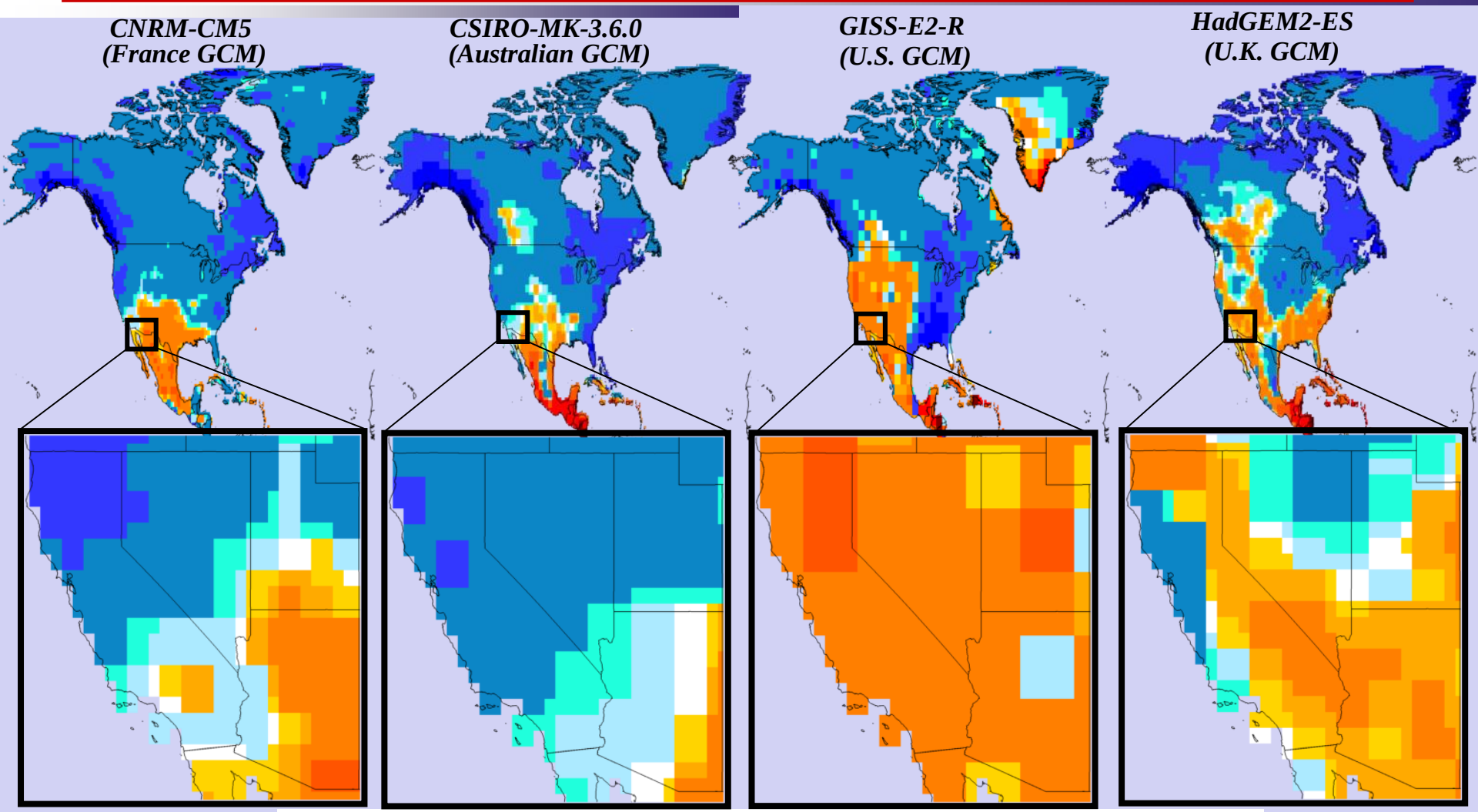
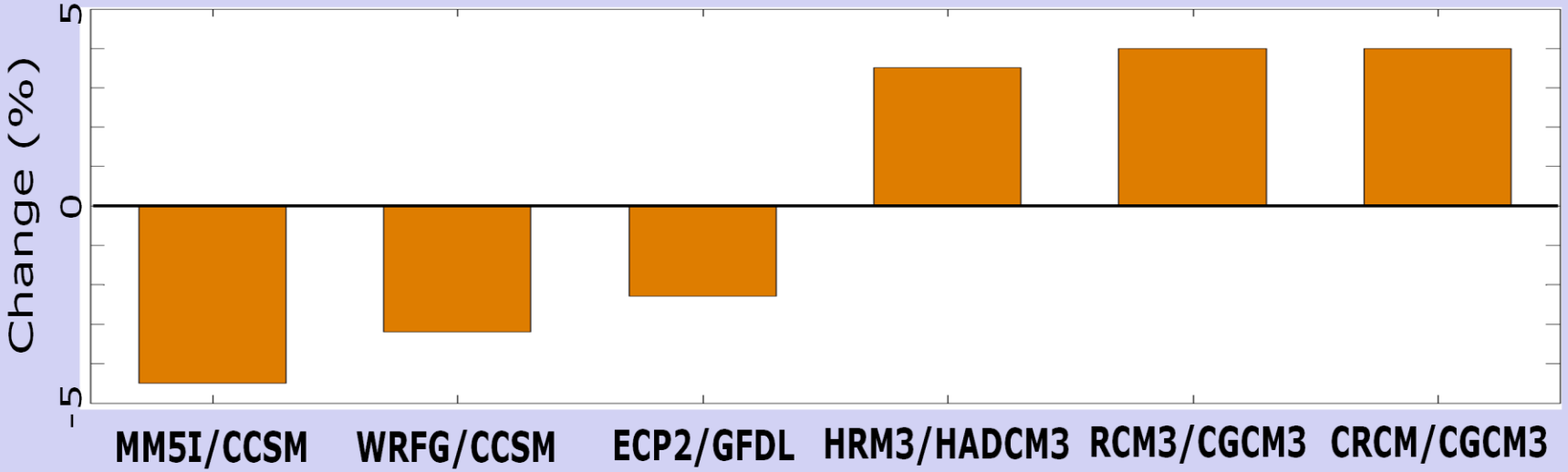


Recent Evaluation of RCM/GCM over Western U.S.

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

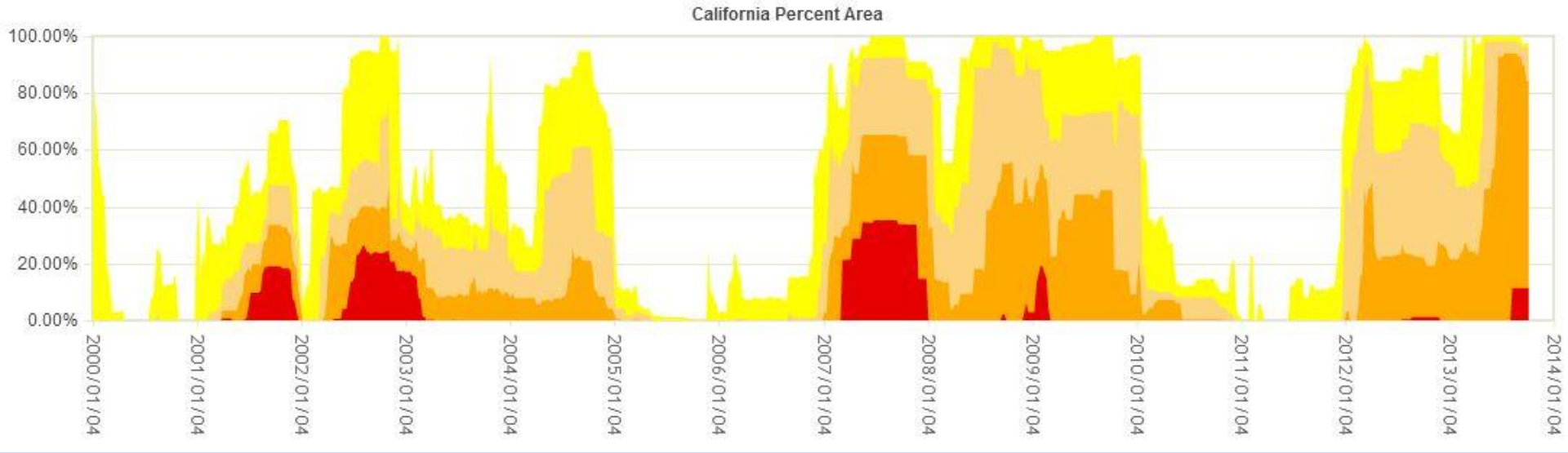


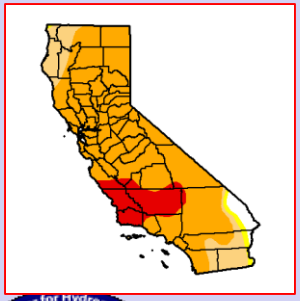
Trend of area-average precipitation (comparing 2040-2070 with 1970-2000)

Wei Chu 2011

California Drought Conditions (2000 ~ Present): high variability but no trend

"The U.S. Drought Monitor, a composite index that includes many indicators, is the drought map that policymakers and media use in discussions of drought and in allocating drought relief."





U.S. Drought Monitor for California – Oct.8 2013

Data Source: http://droughtmonitor.unl.edu/DataArchive.aspx

Spain + Portugal

IPCC AR5 Scenarios

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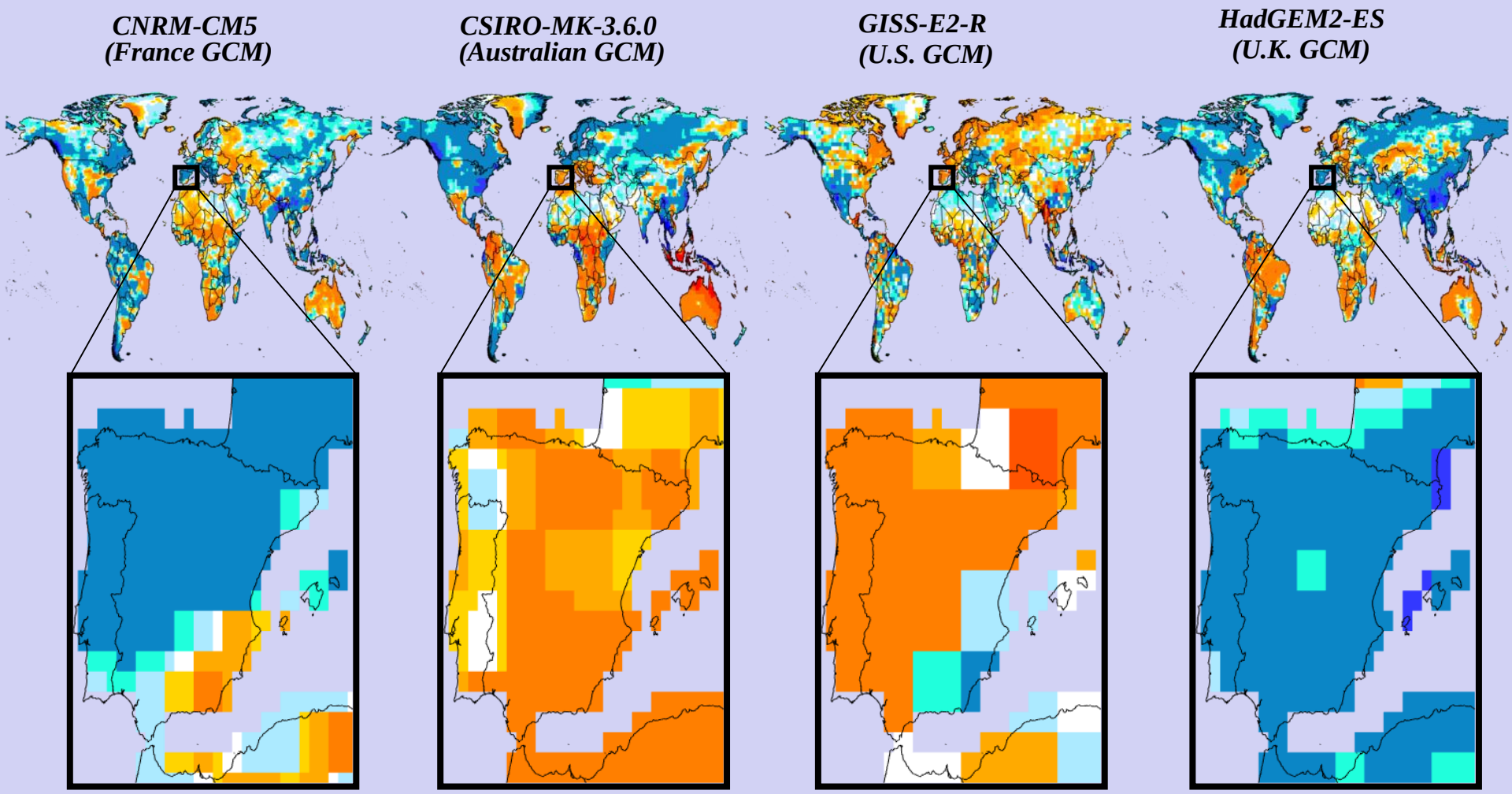

Resolution: 0.5°x0.5°

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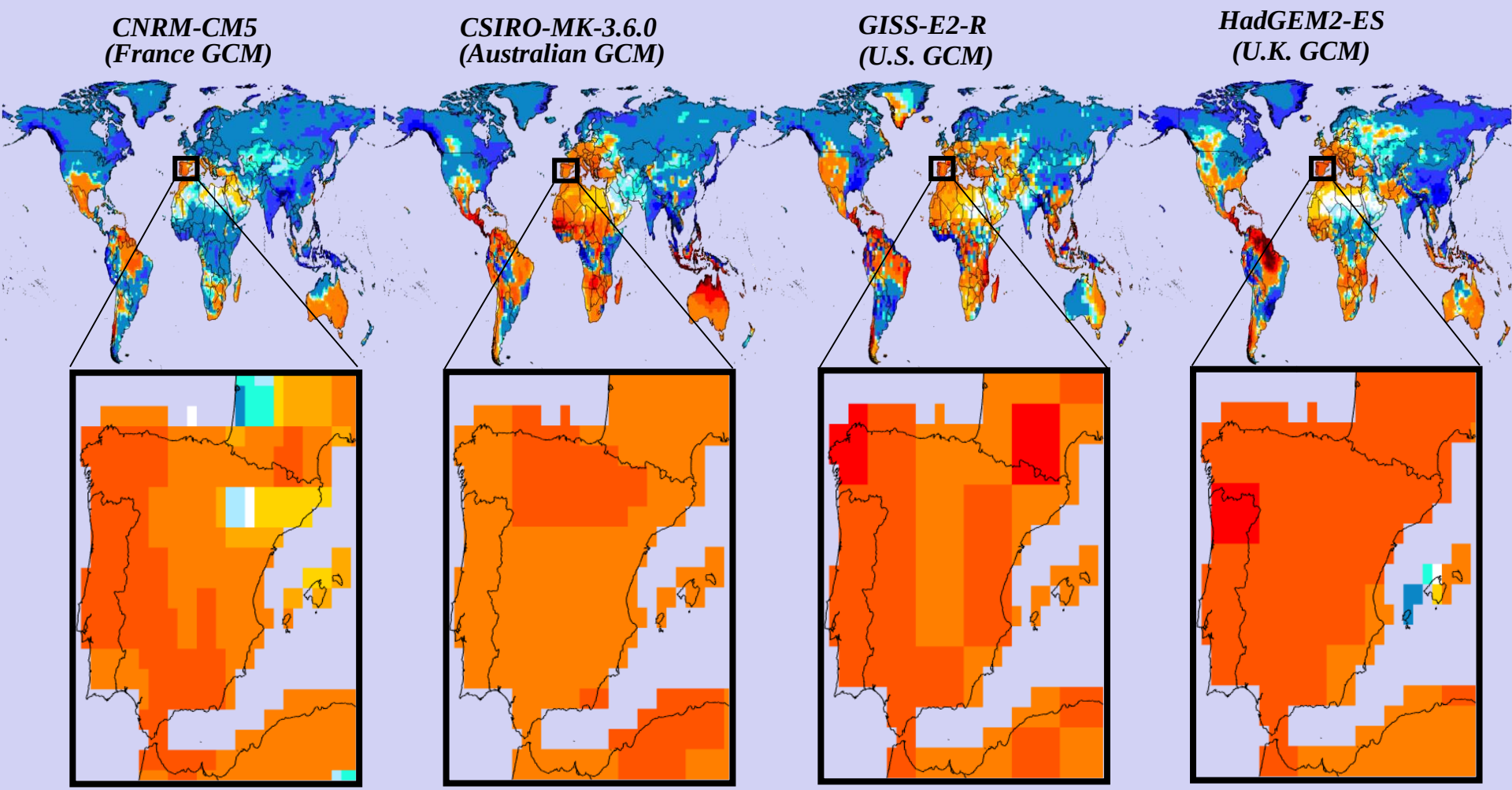

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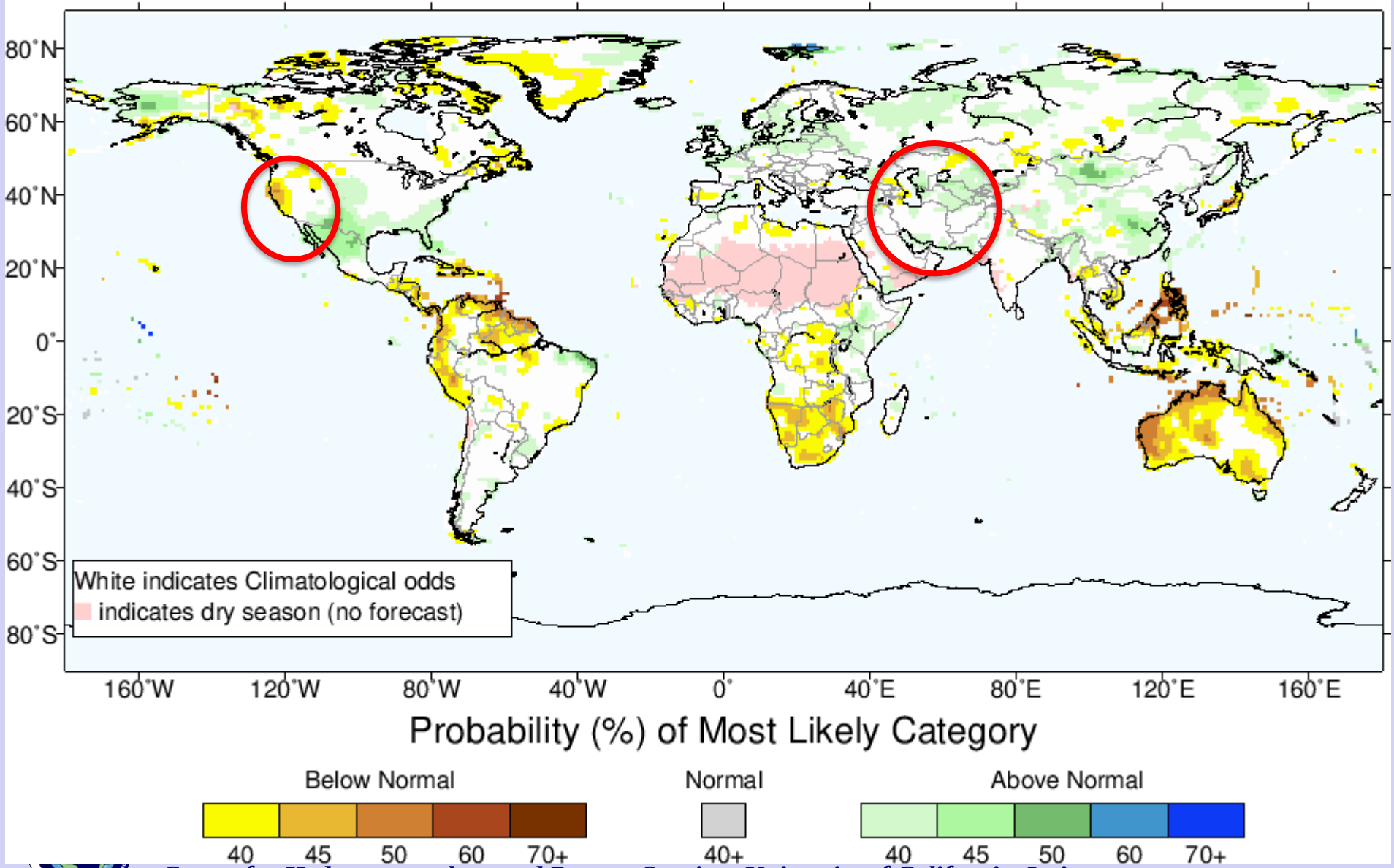
- Water Supply Volume

Mid-range

Forecast Requirements

IRI Multi–Model Probability Forecast for Precipitation for January–February–March 2019, Issued December 2018



How About Recent Observations?

The Past 35 years (1983-2017)

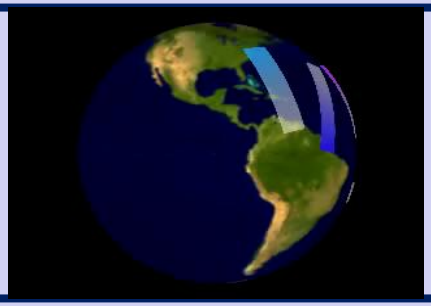
Precipitation Estimation from Remotely Sensed Information using Artificial Neural Networks (PERSIANN)

PERSIANN System

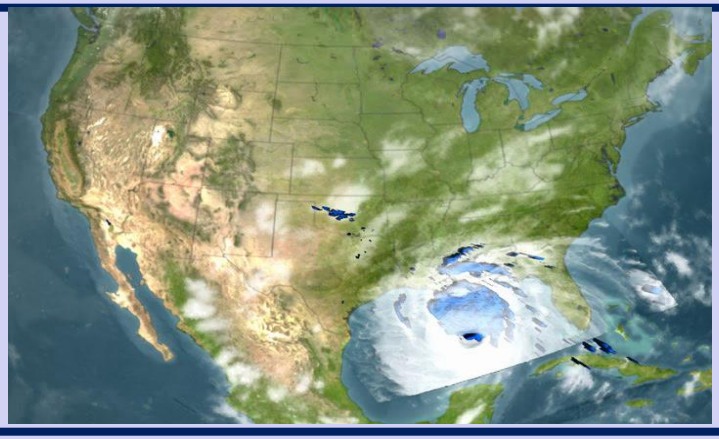
Precipitation Estimation from Remotely Sensed Information using Artificial Neural Networks

Satellite Data for Precipitation estimation

Geostationary IR
Cloud top data
15-30 minute temporal resolution

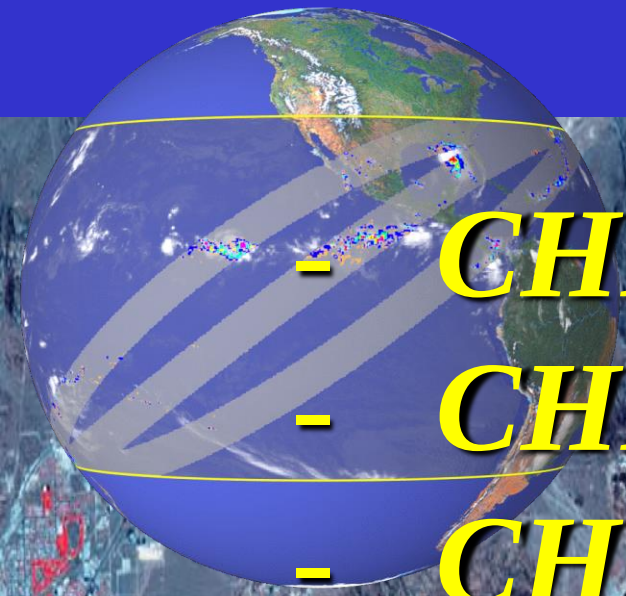


Passive Microwave (SSM/I)
Some characterisation of rainfall
~2 overpasses per day per spacecraft, moving to 3-hour return time (GPM)



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

PERSIANN Websites and Apps

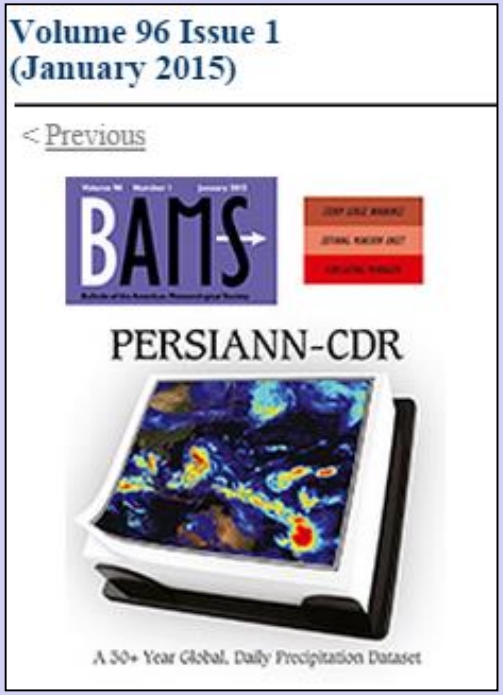


- CHRS iRain
- CHRS RainSphere
- CHRS Data Portal

PERSIANN-CDR

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

- *Daily Precipitation Data*
- *Data Period: 1983~2018*
- *Coverage: 60°S ~ 60°N*
- *Spatial Resolution: 0.25°x0.25°*



Ashouri, Hsu et al., BAMS, 2015.

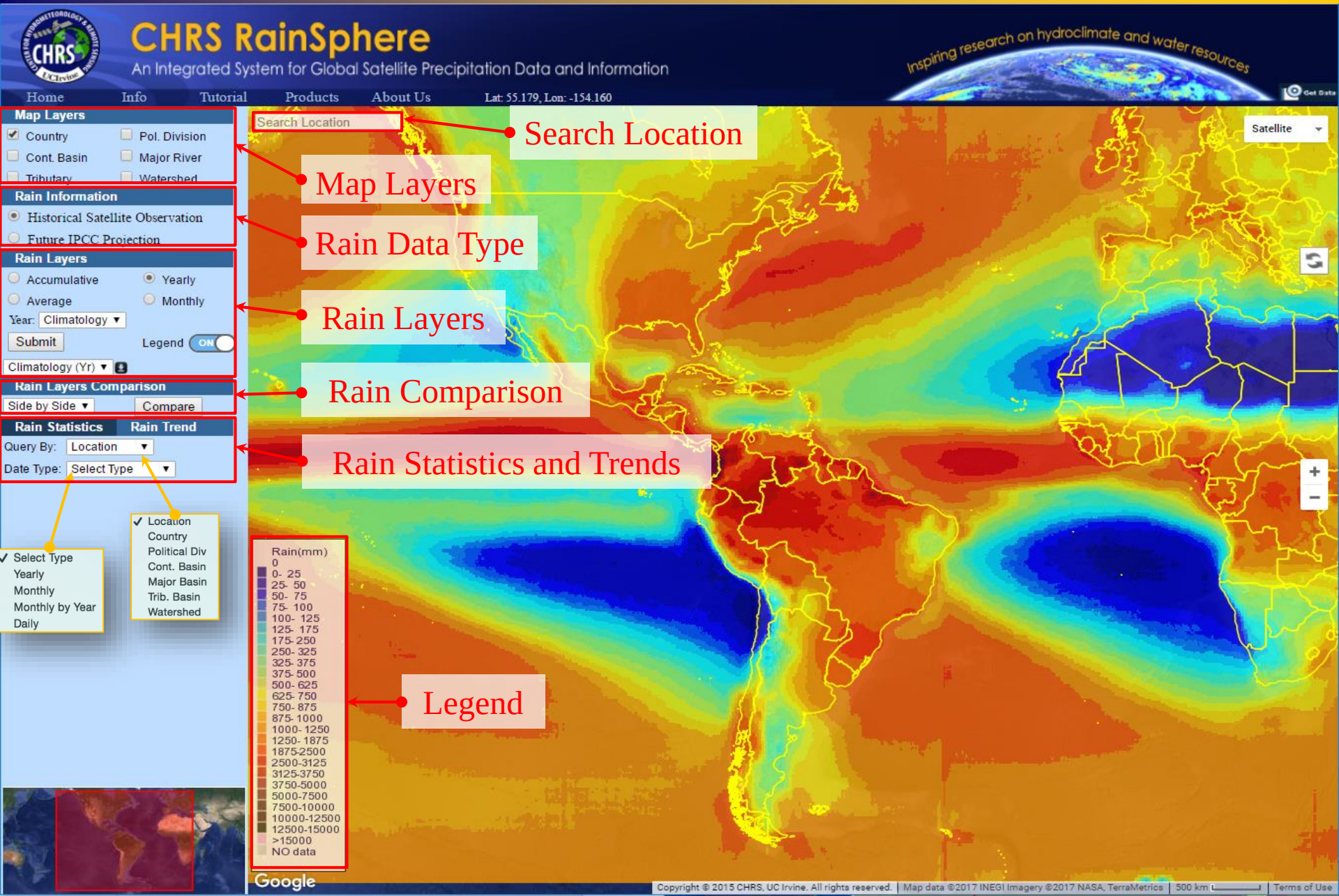
PERSIANN Extensions: Climate-Related

CHRS RainSphere

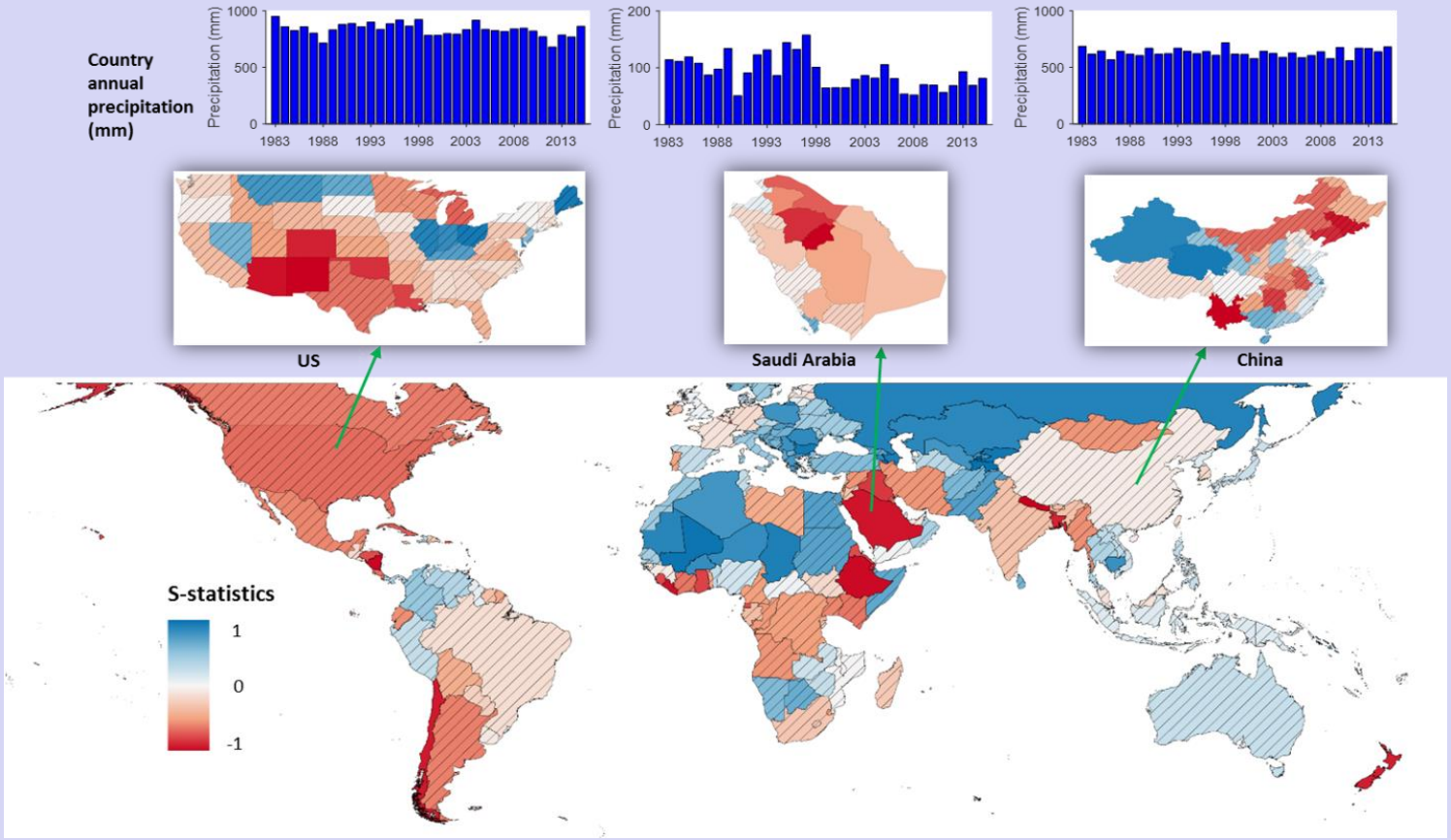
An Integrated System for Global Satellite Precipitation Data and Information

CHRS RainSphere

Rainsphere.eng.uci.edu



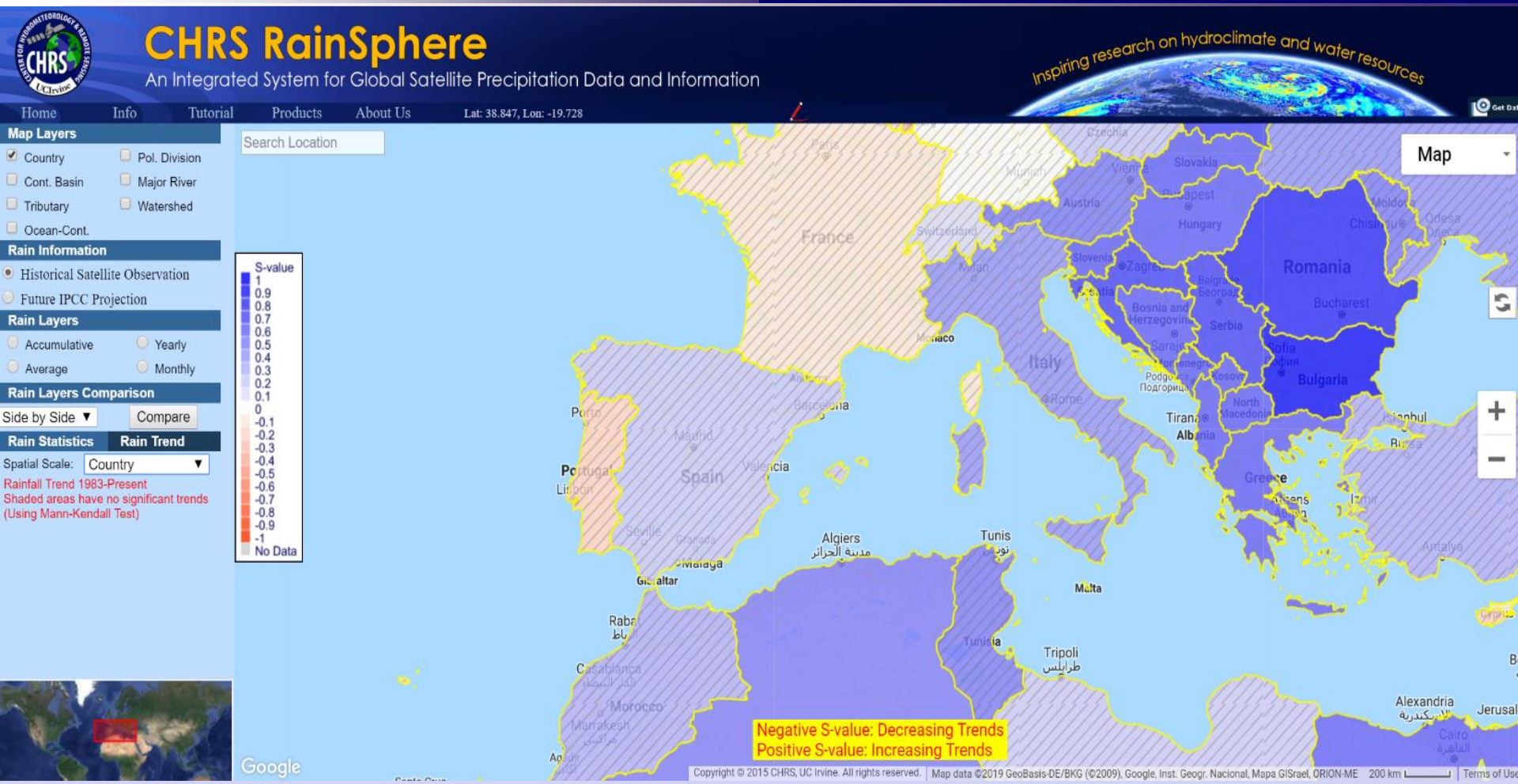
Rainfall Trend Analysis: Countries and Political Divisions



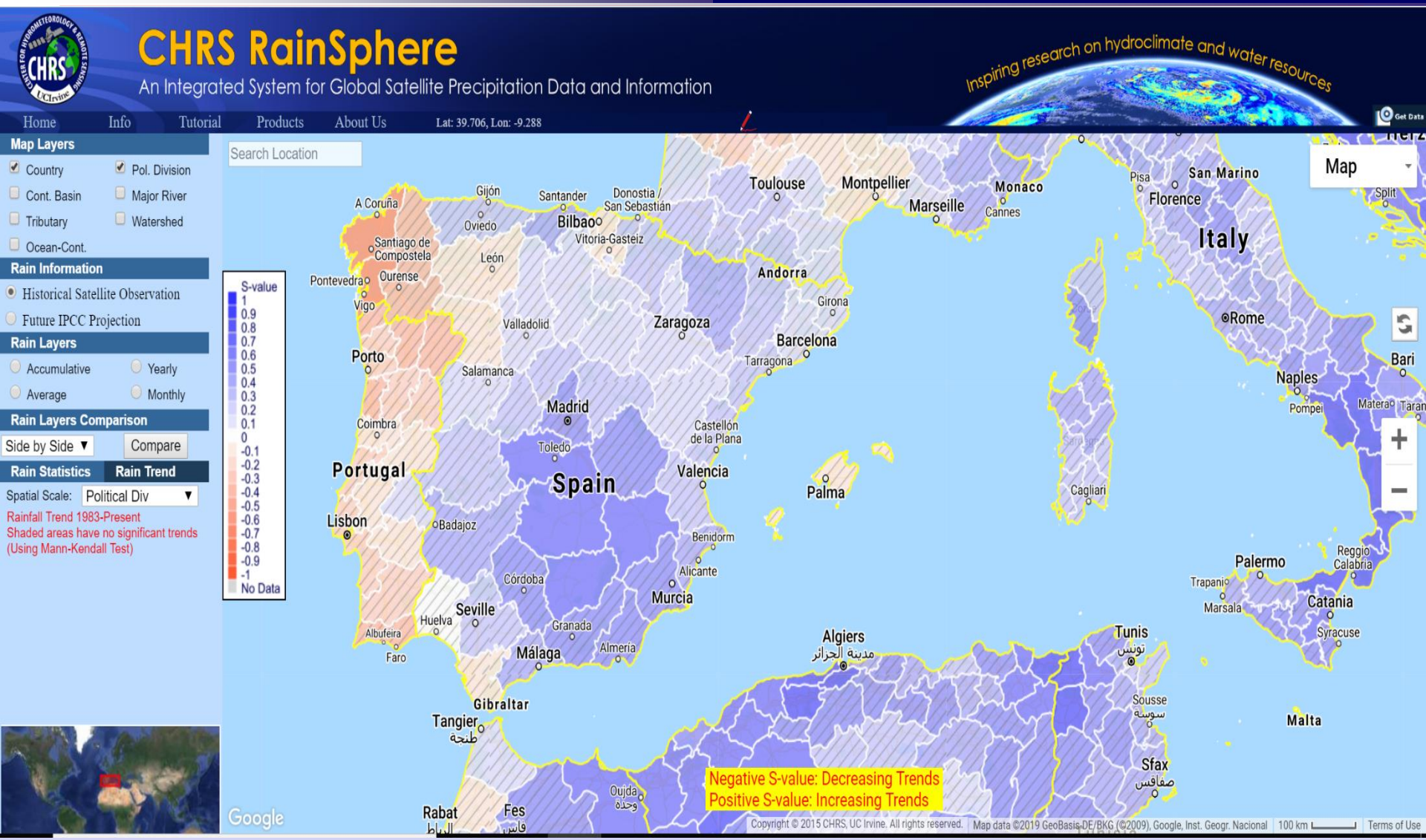
Precipitation trends from 1983 to 2017 over 201 countries (60°N - 60°S) and state/province political divisions of US, Saudi Arabia and China

Nguyen et al. BAMS (2018)

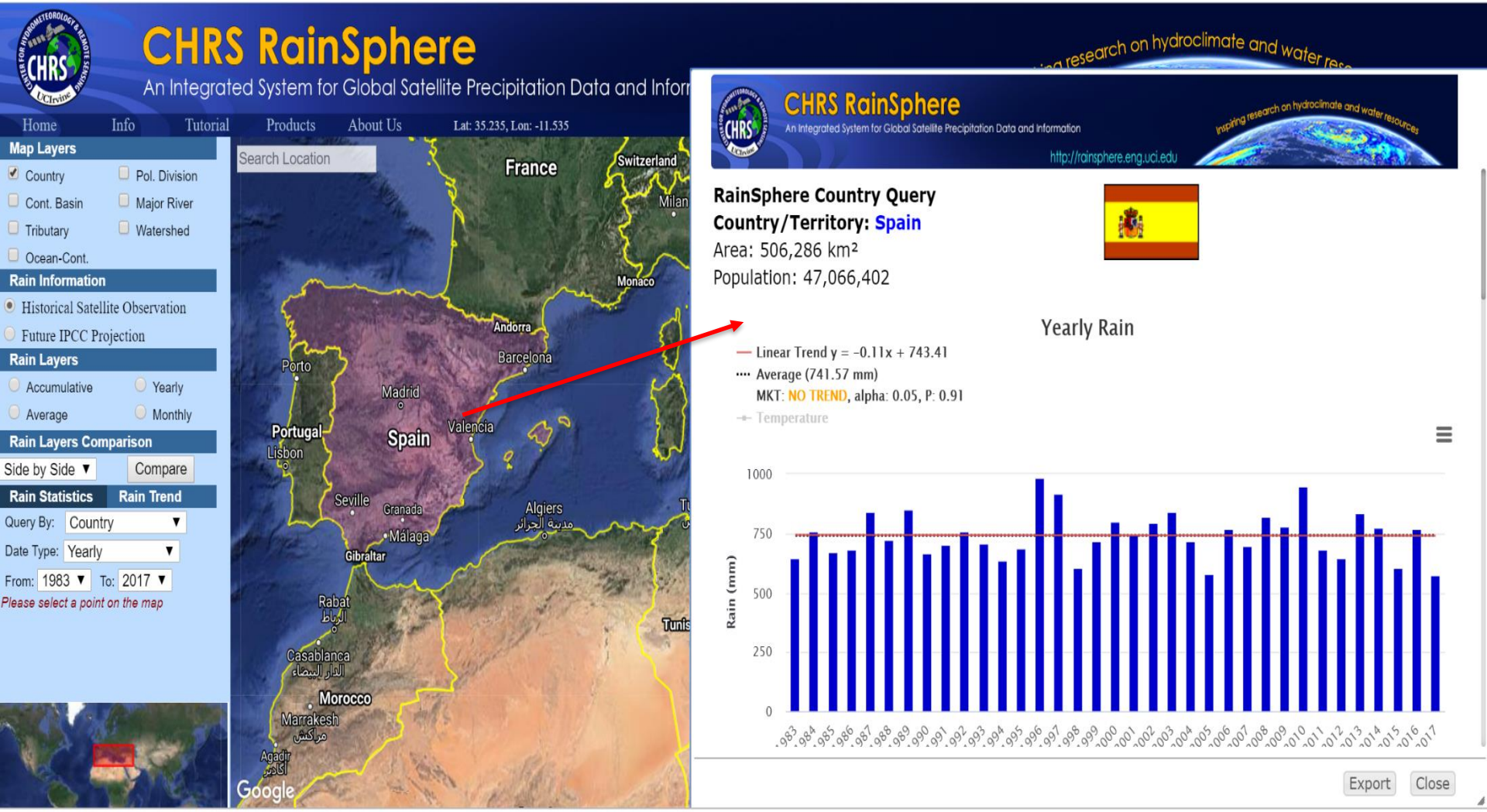
Rainfall Trend Analysis By Countries: Spain and Portugal



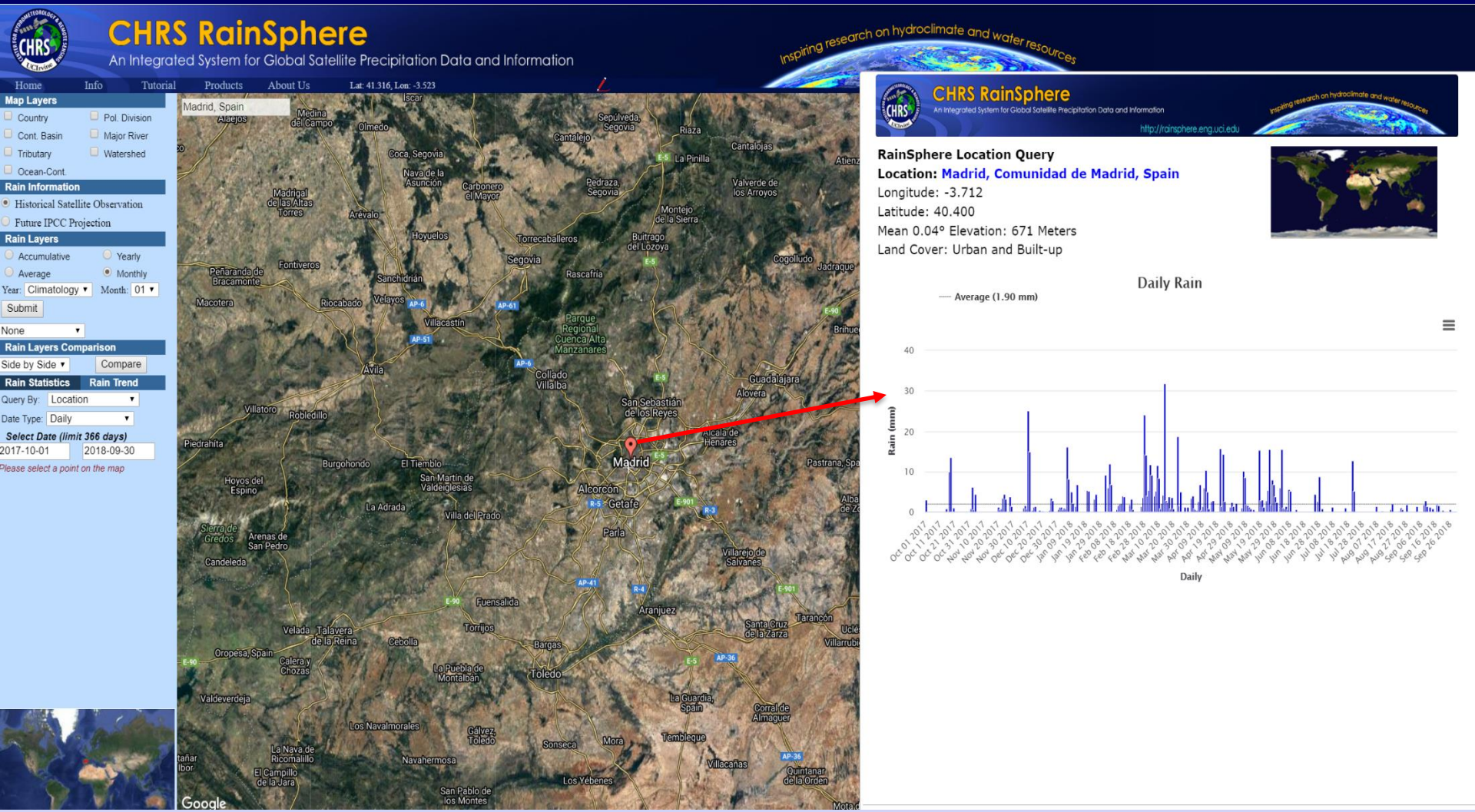
Rainfall Trend Analysis: By Political Divisions Spain &Portugal



34 Years of Satellite Annual Rainfall Obs. Over Spain Showing No Trend.



CHRS RainSphere – Dailey Rainfall Madrid WY 2018



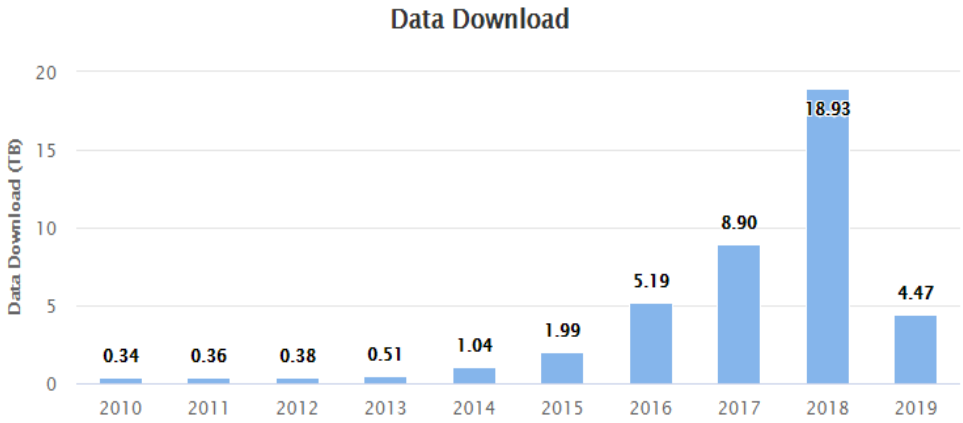
Usage of CHRS's products

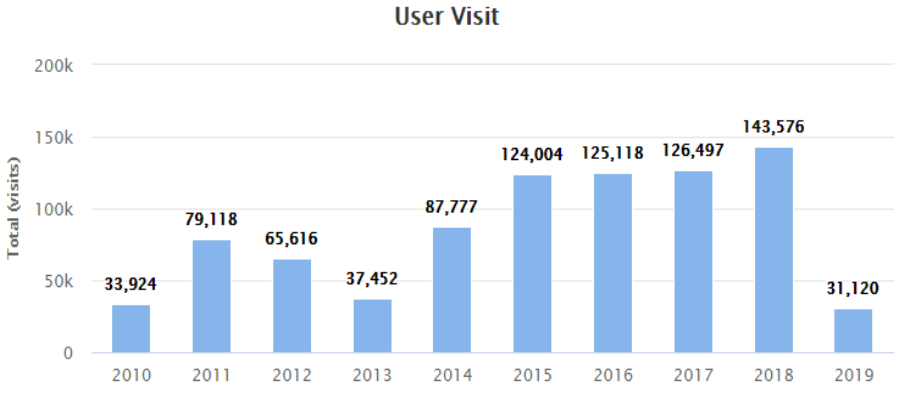
CHRS User Statistics

Overall | CHRS Homepage | iRain | RainSphere | Data Portal | CONNECT

Total Visits: 855,414 since 01-Jan-2010
Countries: 205 countries registered

#	Country	Total Visit
1	United States	482,90
2	China	45,06
3	Israel	37,95
4	Thailand	32,00
5	Private IP	26,37
6	France	22,35
7	Iran, Islamic Republic Of	18,73





Take Home Message

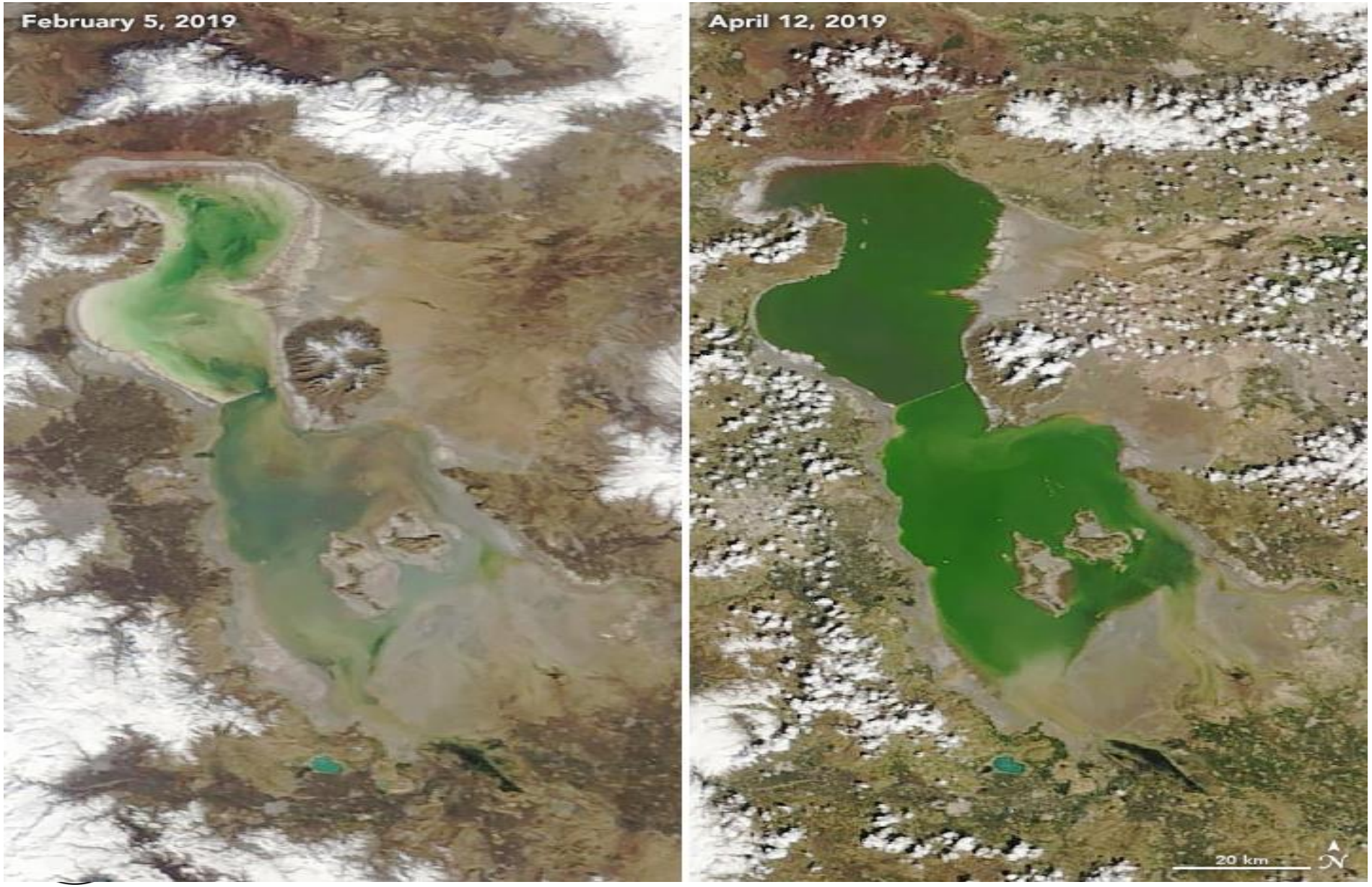
- *Despite advances to date, predicting the future Hydro-Climate variables will remain a major challenge:*

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

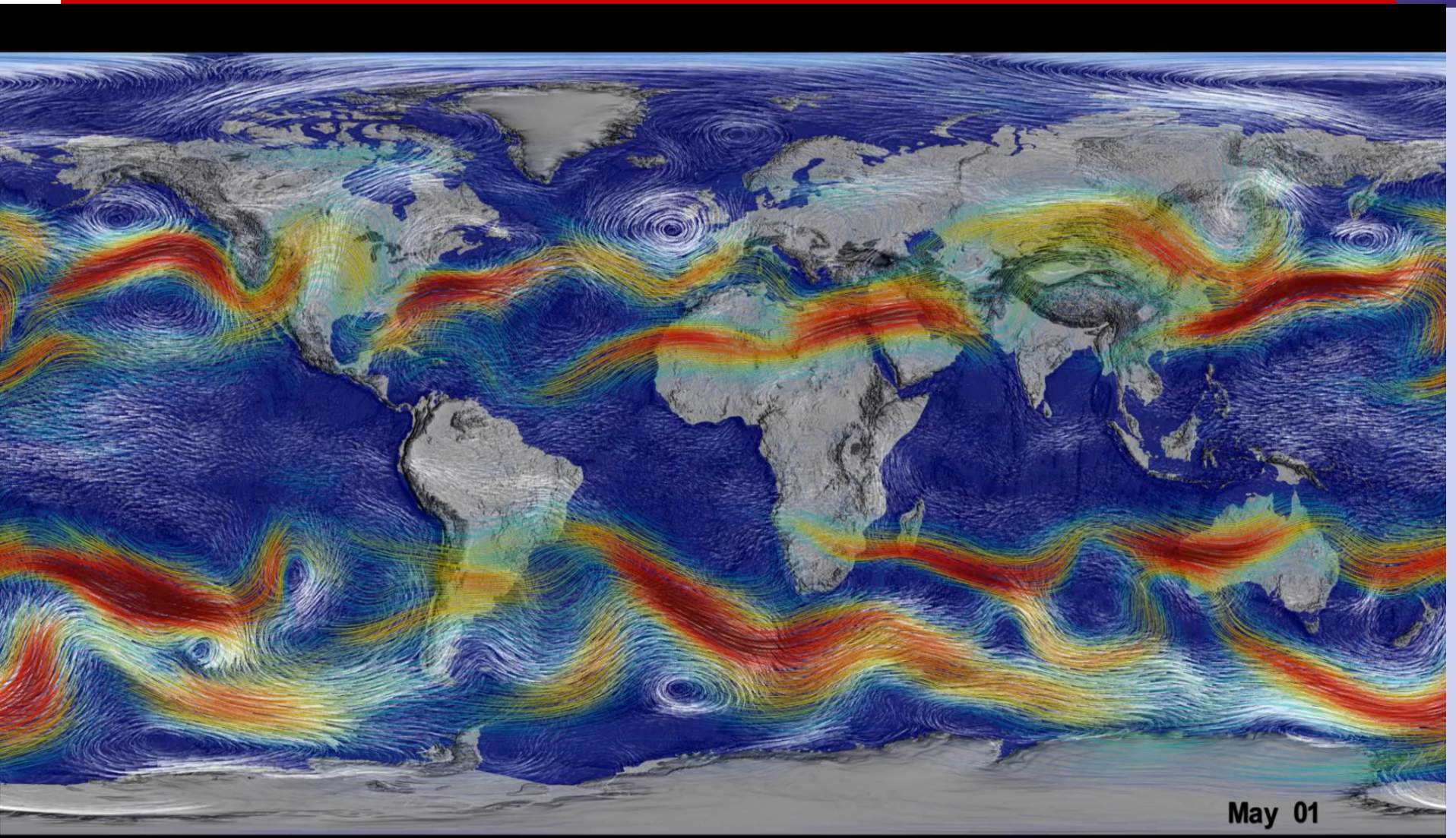
From one Extreme to Another: Lake Urmia Iran



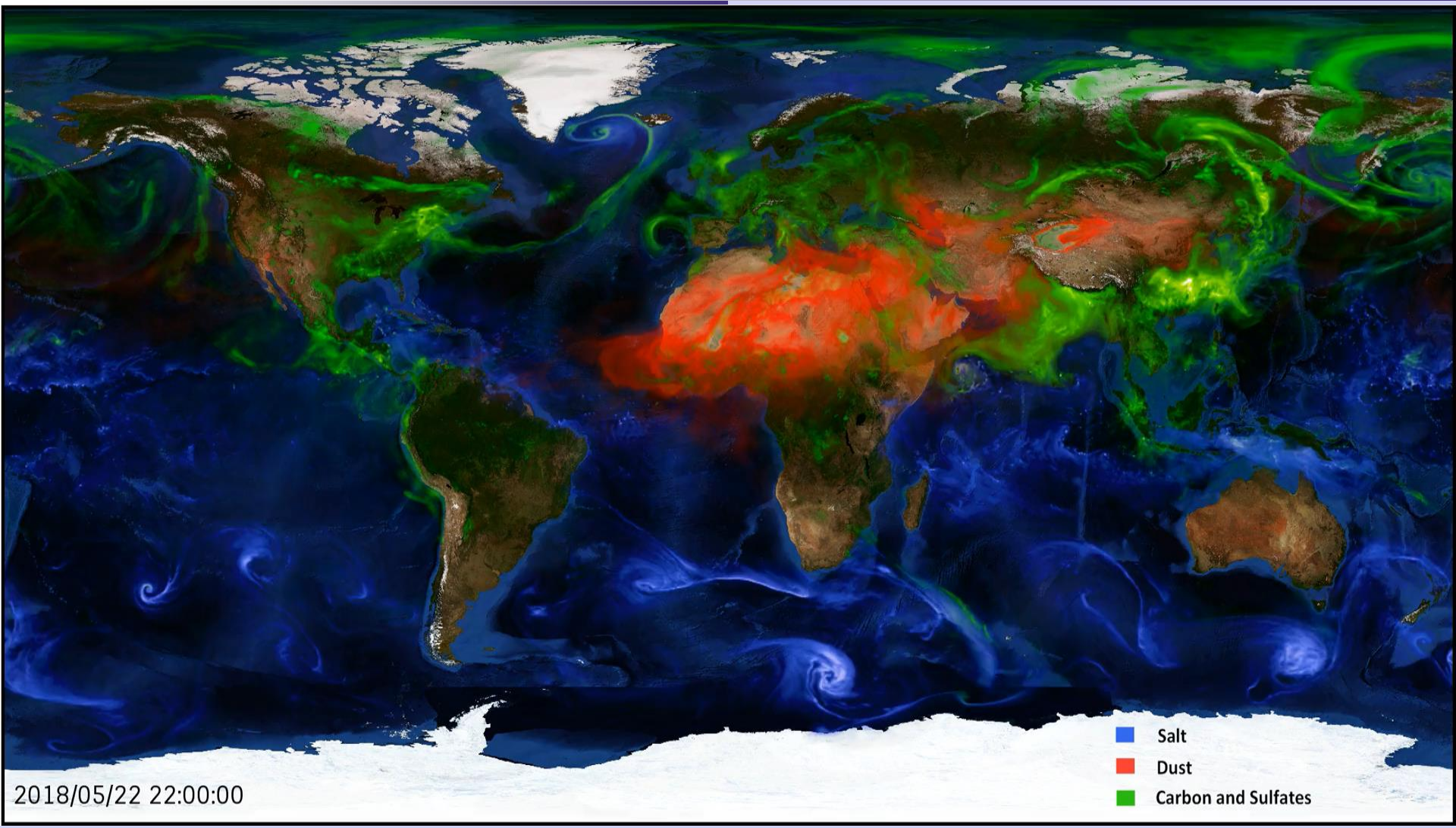

Thank You for Hosting us
and Listening
08/14/2009
Somewhere in New Mexico, USA - Photo: J. Sorooshian

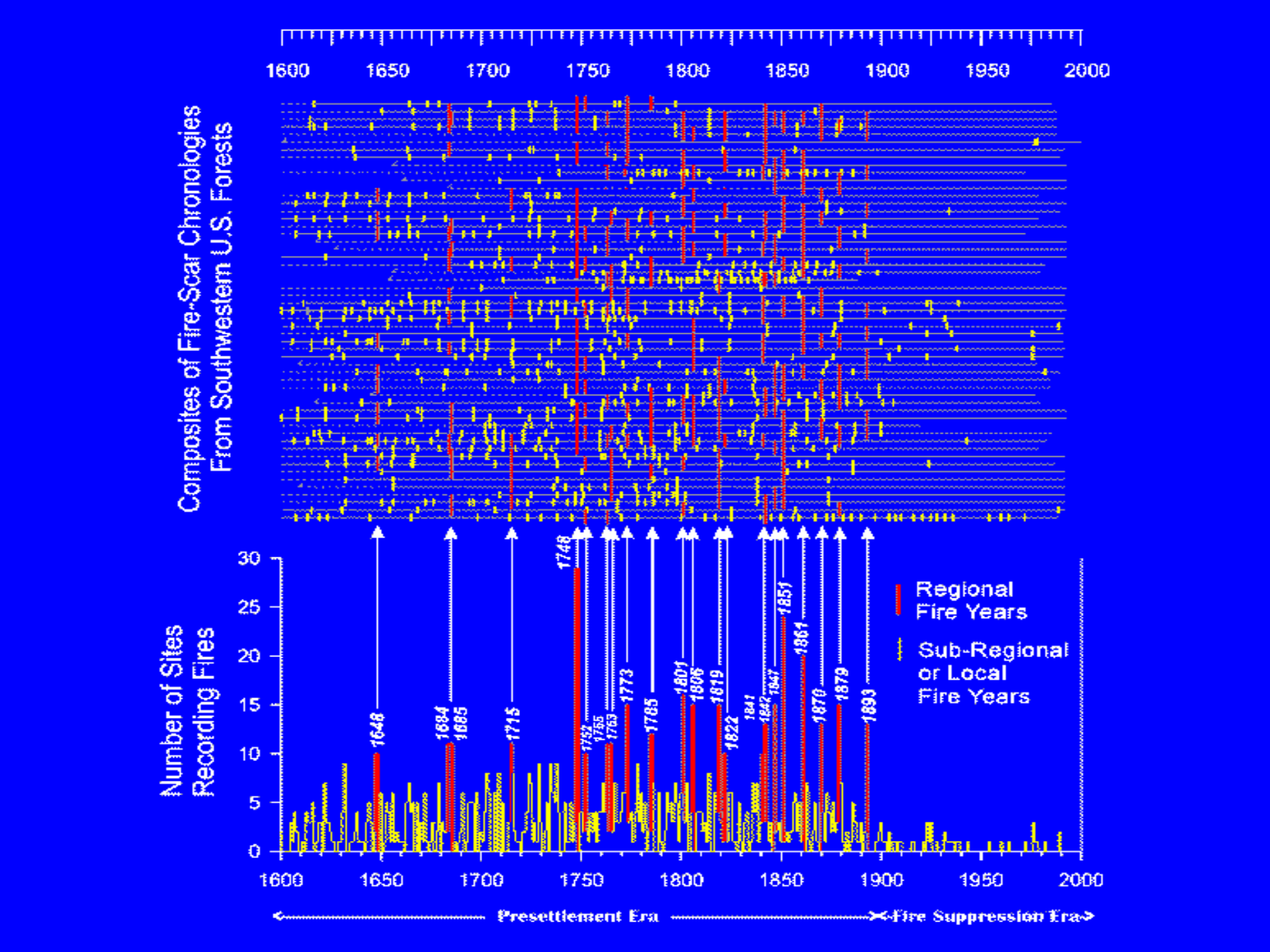
BACK up Slides

Atmospheric (Air) Circulations



A snapshot of Aerosol and other Pollutants' Movement Around the Globe




Composites of Fire-Scar Chronologies
From Southwestern U.S. Forests
1600
1650
1700
1750
1800
1850
1900
1950
2000
Number of Sites
Recording Fires
0
5
10
15
20
25
30
1648
1684
1685
1715
1748
1752
1755
1763
1773
1785
1801
1806
1819
1822
1841
1842
1847
1851
1861
1870
1879
1893
Regional
Fire Years
Sub-Regional
or Local
Fire Years
Presettlement Era
Fire Suppression Era

Seasonal-Scale Predictions

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

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

Flash Flood Warning

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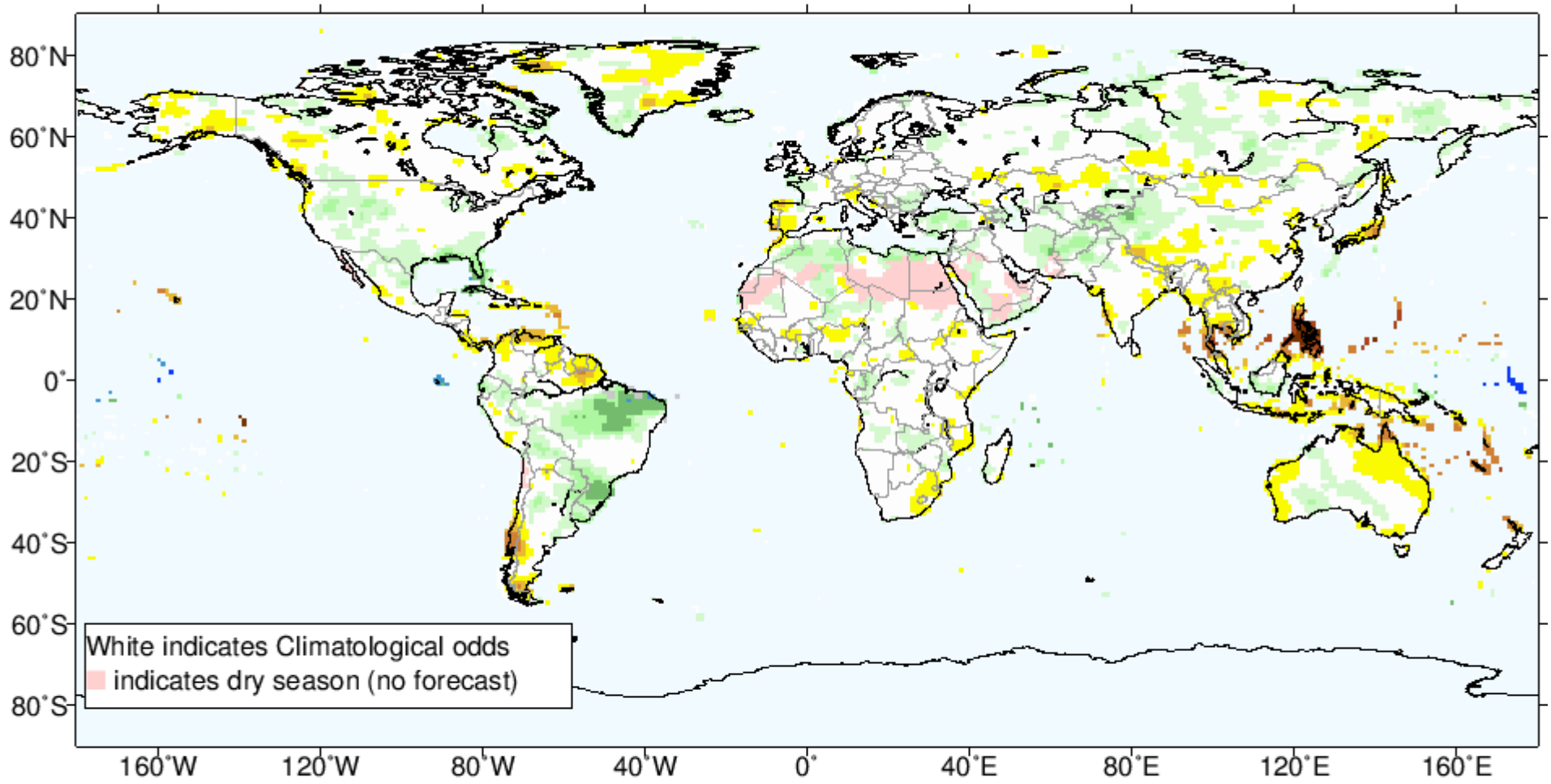
Forecast Requirements

IRI Multi–Model Probability Forecast for Precipitation for April–May–June 2019, Issued March 2019



Probability (%) of Most Likely Category

Below Normal: 40 45 50 60 70+

Normal: 40+

Above Normal: 40 45 50 60 70+

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

Wei Chu 2011

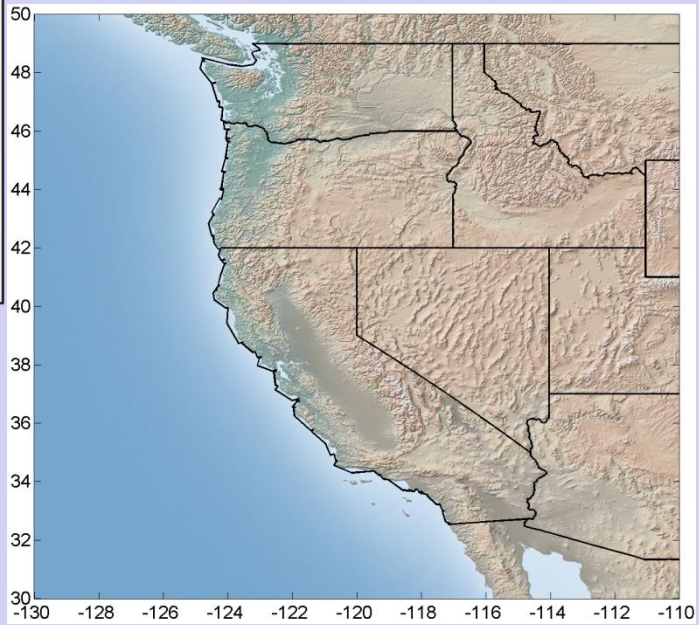
Regional Models	Climate Models: GFDL	CGCM3	HADCM3	CCSM
CRCM		✓		
ECP2	✓			
HRM3			✓	
MM5I				✓
RCM3		✓		
WRFG				✓

Current period:1971-2000

Future period: 2041-2070

Spatial Res.: 50 km

Temporal Res.: daily



study region

Outputs of six RCM/GCM sets:

North American Regional Climate Change Assessment Program (NARCCAP)

Emissions Scenario:

A2: regionally oriented and fast economic growth