On GPEX and Organized Convection

Xubin Zeng
Department of Hydrology and Atmospheric Sciences
University of Arizona, Tucson, Arizona, USA
xubin@arizona.edu

GEWEX SSG Co-Chair, GPEX Interim SSG Chair

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THE UNIVERSITY OF ARIZONA.

GPEX (Global Precipitation EXperiment) – A New 10-year WCRP Lighthouse Activity

WCRP Organizational Structure

WCRP Secretariat

Joint Scientific Committee (JSC)

Lighthouse Activities

- Digital Earths
- Explaining and Predicting Earth System Change (EPESC)
- Global Precipitation EXperiment (GPEX)
- My Climate Risk (MCR)
- Research on Climate Intervention
- Safe Landing Climates (SLC)

Ongoing Activities and Fora

- Fixed-term projects
- Rapid updates, syntheses, assessments, gap analysis
- Conferences and workshops
- Diversity and capacity building: ECRs, regions
- Communications and outreach

International Offices

Core Projects

- Atmospheric Processes And their Role in Climate (APARC)
- Climate and Cryosphere (CliC)
- Climate and Ocean Variability, Predictability and Change (CLIVAR)
- Earth System Modelling and Observations (ESMO)
  - including the Coupled Model Intercomparison Project (CMIP)
- Global Energy and Water Exchanges (GEWEX)
- Regional Information for Society (RIfS)
  - including the Coordinated Regional Climate Downscaling Experiment (CORDEX)

Support Unit

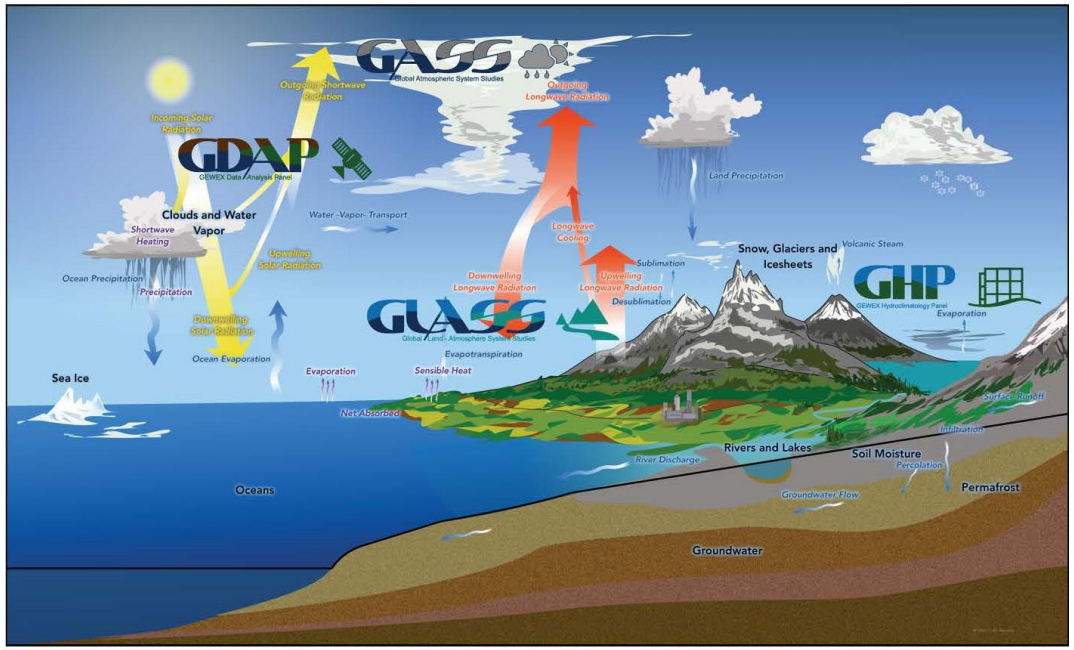
WCRP Academy

www.wcrp-climate.org

World Climate Research Programme (WCRP)

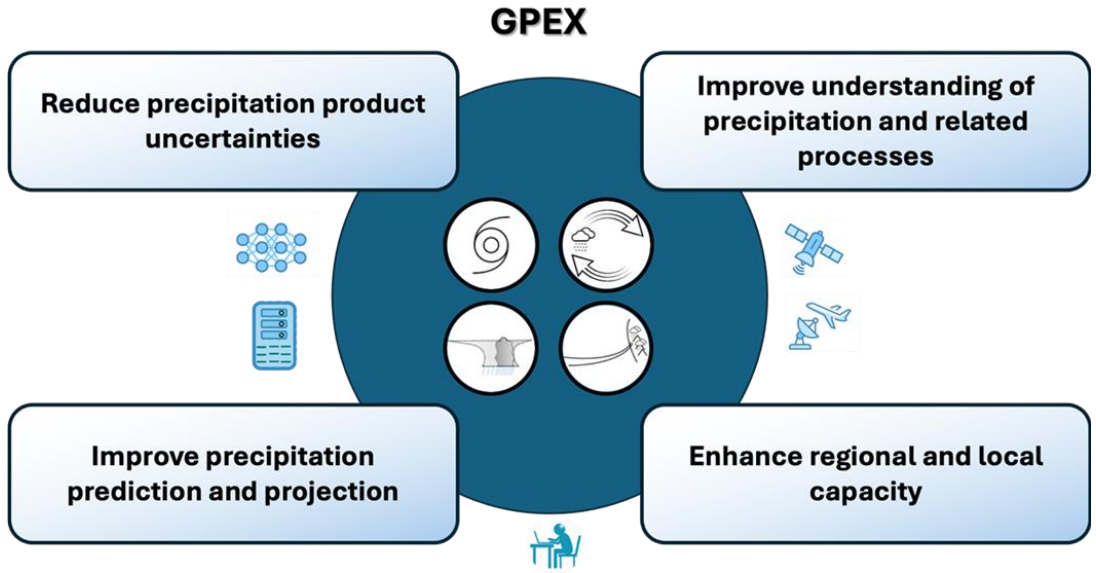
- **GEWEX**: A core project of the World Climate Research Programme (WCRP), dedicated to understanding Earth's energy and water cycles as well as their interactions with the carbon cycle in the global atmosphere and at and below the land surface.

  Co-Chairs: Jan Polcher and Xubin Zeng



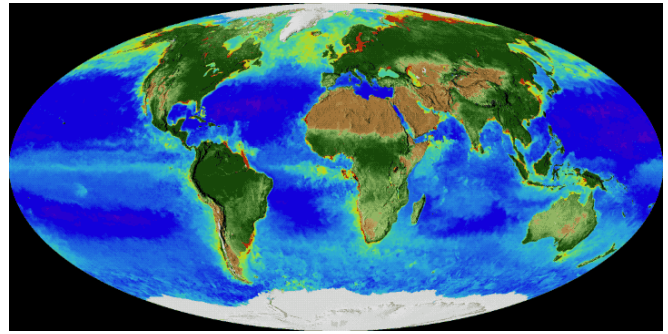
- **GPEX**: Global Precipitation Experiment is a new 10-year WCRP Lighthouse Activity, focusing on four types of organized convection: AR, MCS, TCs, monsoon.

  Chair: Xubin Zeng



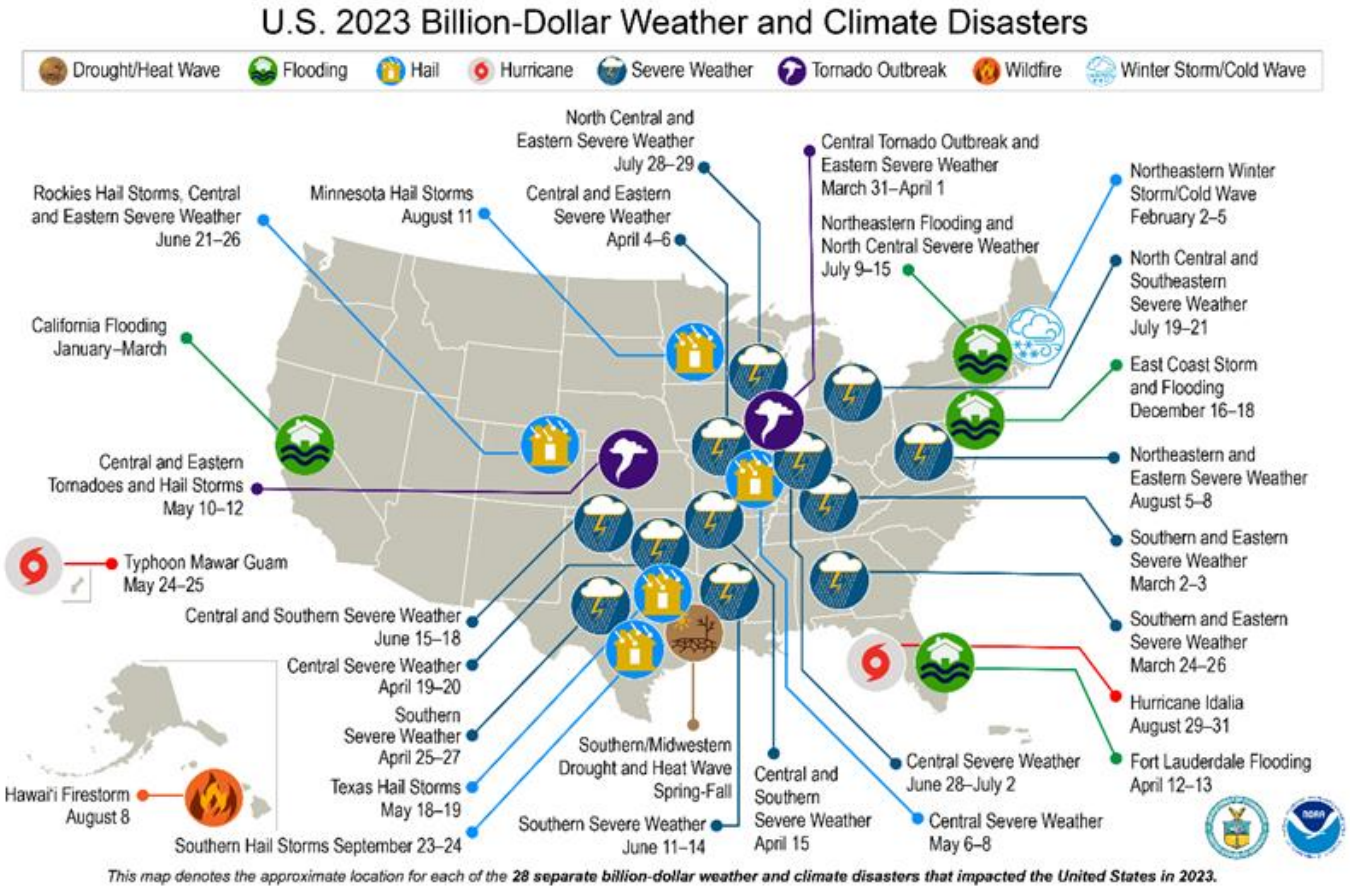
Outline

1. GPEX
2. Organized Convections
   - Mesoscale Convective Systems
   - Tropical Cyclones
   - Monsoons
   - Atmospheric Rivers



NASA visualization of plant life: land vegetation and ocean phytoplankton

- 26 of the 28 billion-dollar disasters in 2023 were associated with P
- the remaining two were due to a lack of P
- these extreme precipitation events are often associated with **organized convection**.



https://www.ncei.noaa.gov/access/billions/

GPEX Interim SSG

Represented:

GEWEX,
CLIVAR,
SPARC,
CliC,
RIfS

Digital Earth,
EPESC,
SLC,
MCR,
WCRP Academy

Monsoon panel,
WWRP,
WMO Hydrology,
USGCRP,
WCRP Experts.

Name	Country	Core Project /LHA
Zeng, Xubin	USA	GEWEX & Chair of the GPEX Science Team
A.P., Dimri	India	CliC
Alves, Lincoln	Brazil	RIfS
Boucher, Marie-Amélie	Canada	WMO Hydrology Expert
Cherchi, Annalisa	Italy	CLIVAR/GEWEX Monsoons Panel
DeMott, Charlotte	USA	CLIVAR
Gettelman, Andrew	USA	Digital Earth - LHA
Hanna, Edward	UK	CliC co-chair
Horinouchi, Takeshi	Japan	APARC
Huang, Jin	USA	USGCRP
Lennard, Chris	South Africa	WCRP Academy and CORDEX Africa
Leung, Ruby	USA	WCRP Expert
Luo, Yali	China	WWRP- Southern China Monsoon Rainfall Exp.
Pryor, Sara	USA	RIfS co-chair
Saint-Lu, Marion	France	SLC - LHA
Sobolowski, Stefan	Norway	RIfS
Steiner, Jakob	Pakistan, Austria	MCR - LHA
Stevens, Bjorn	Germany	WCRP Expert
Uhlenbrook, Stefan	UN	WMO-Hydrology Division
Wehner, Michael	USA	EPESC - LHA

Global Precipitation Experiment - A New World Climate Research Programme Lighthouse Activity

Xubin Zeng, Lincoln Alves, Marie-Amélie Boucher, Annalisa Cherchi, Charlotte DeMott, A.P. Dimri, Andrew Gettelman, Edward Hanna, Takeshi Horinouchi, Jin Huang, Chris Lennard, L. Ruby Leung, Yali Luo, Meloth Thamban, Hindumathi Palanisamy, Sara C. Pryor, Marion Saint-Lu, Stefan P. Sobolowski, Detlef Stammer, Jakob Steiner, Bjorn Stevens, Stefan Uhlenbrook, Michael Wehner, and Paquita Zuidema

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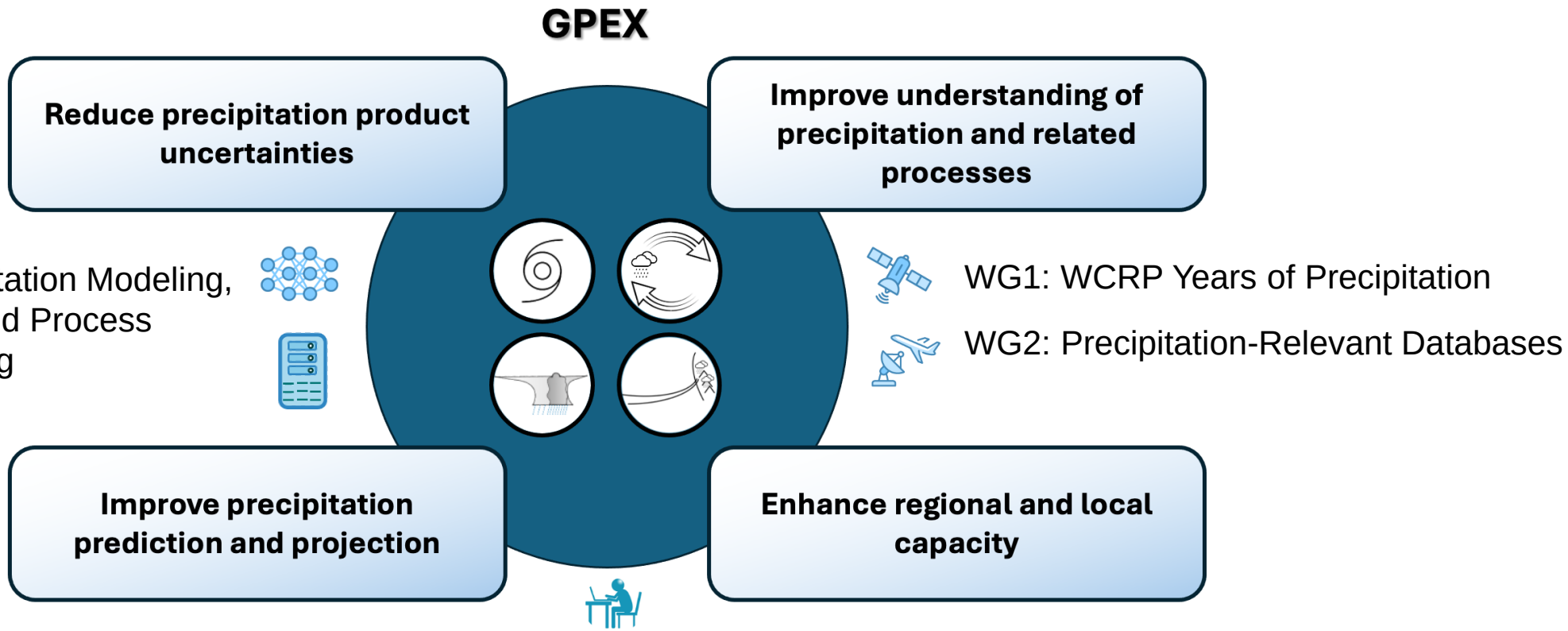
Bulletin of the American Meteorological Society



WG3: Precipitation Modeling, Prediction, and Process Understanding

WG1: WCRP Years of Precipitation

WG2: Precipitation-Relevant Databases

WG4: National/Regional Activities and Capacity Development

WG1: WCRP Years of Precipitation (YoP)

Coordinate global field campaigns with in situ, airborne, and satellite measurements of the atmosphere, land, and ocean, focusing on different storm types:

- atmospheric rivers,
- mesoscale convective systems,
- monsoons,
- tropical cyclones

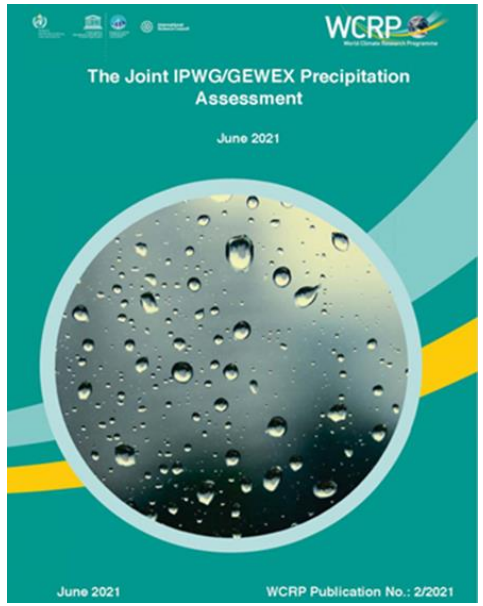
These storms occur over different seasons and between seasons over different regions.

Primary Activity: Engage with scientists and funding agencies to identify potential anchor projects for each storm type.

WG2: Precipitation-Relevant Databases

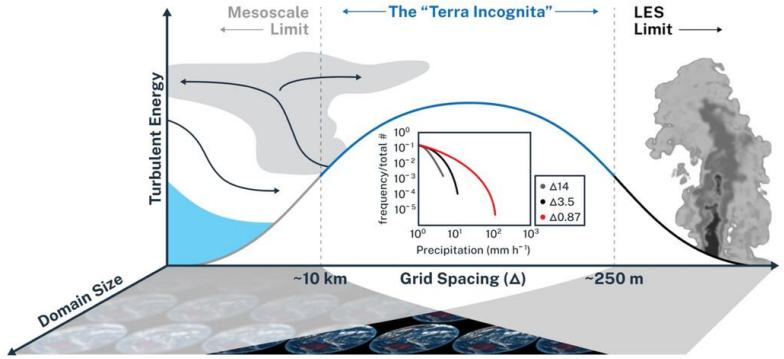
GPEX should focus on activities that will add values to existing efforts, such as:

- Work with other projects (e.g., GEWEX, RIfS) to develop global and regional gridded precipitation-relevant datasets with high temporal and spatial resolutions.
- Work with other projects (e.g., GEWEX) to set up a baseline surface precipitation network (BSPN) over land.
- Work with other projects (e.g., CLIVAR, GEWEX, SPARC) to organize a dialogue between oceanographers and atmospheric scientists to design gauges for buoys.
- Emphasize the development of low-cost, easy-to-maintain instruments for enhancing global precipitation-relevant measurement network.
- Work with other projects (e.g., GEWEX, hydrology/cryosphere community) to enhance existing ground-based observational networks



WG3: Precipitation Modeling, Prediction, and Process Understanding

- Coordinate multi-scale analysis and precipitation forecasts, and support the establishment of multi-model databases, along with common evaluation metrics.
- Coordinate modeling studies on precipitation predictability, prediction techniques and applications at various time scales
- Leverage storm resolving model ensembles developed globally or regionally (e.g., Digital Earth, CORDEX, GEWEX) and a hierarchy of models.
- Leverage the outcomes of the CMIP6 framework (and future CMIP7), with a focus on models with simulations at various resolutions (e.g., km-scale, 0.25º, and 1º).



Stephens et al. (2023)

WG4: National/Regional Activities and Capacity Development

- Work with other projects (e.g., RIfS and WCRP Academy) to support the capacity development by entraining scientists and graduate students into YoP, particularly from the Global South.

- Work with other projects (e.g., Digital Earth and GEWEX) to make storm-resolving models (SRMs) available for resource-challenged scientists in the Global South where SRMs could bring much added value.

- Support existing national/regional activities and/or the establishment of new activities, partly through capacity building.

Implementation and Timeline:

- Pre-YoP Phase (e.g.,Years 1-3): YoP planning; seek and encourage large GPEX-endorsed anchor projects for the global field campaigns

- YoP (e.g., Years 4-6): Focus on all four activities

- Post-YoP (e.g., Years 7-9): Focus on activities using new measurements.

GPEX activity will be completed and fully integrated into WCRP Core Projects in 2-3 years after YoP. This would happen in 8-10 years.

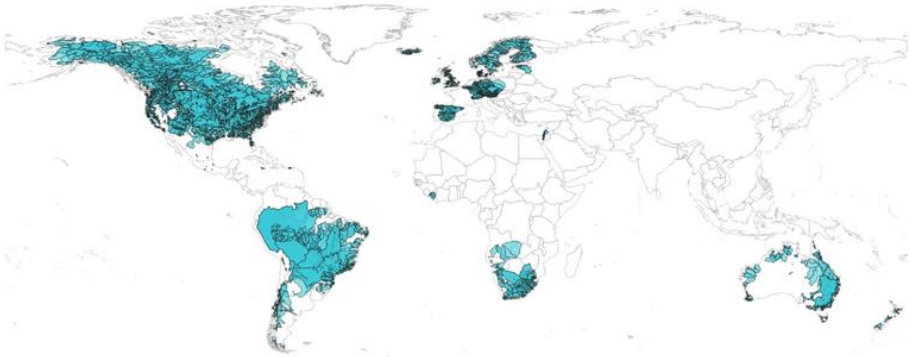
GPEX Strategy: Focus on a few activities, and do them well, with strong partnership.

Lighthouse Activities

Overview
Digital Earths
Explaining and Predicting Earth System Change
Global Precipitation EXperiment (GPEX)
My Climate Risk
Research on Climate Intervention
Safe Landing Climates

What does GPEX need from you?

- Seek leadership to coordinate: field campaigns on each storm type; development of precipitation related datasets; and modeling and prediction experiments.
- Seek membership of the four Working Groups
- Inform us of major field campaigns for the next 5 years (or in discussion).
- Any new ideas for the GPEX implementation plan?



Global collection of catchments with consistent time series & attributes (Caravan Database, Kratzert et al. 2023)

Contact: Xubin Zeng: xubin@arizona.edu
Hindumathi Palanisamy: hpalanisamy@wmo.int

Outline

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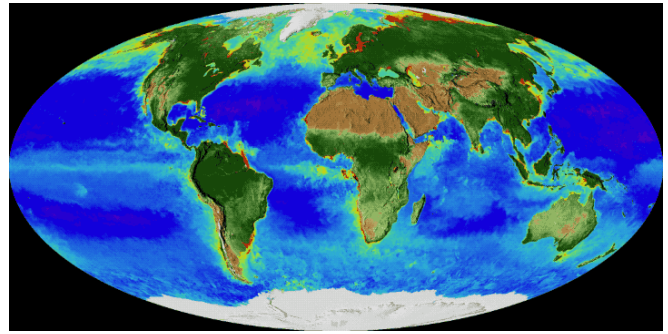
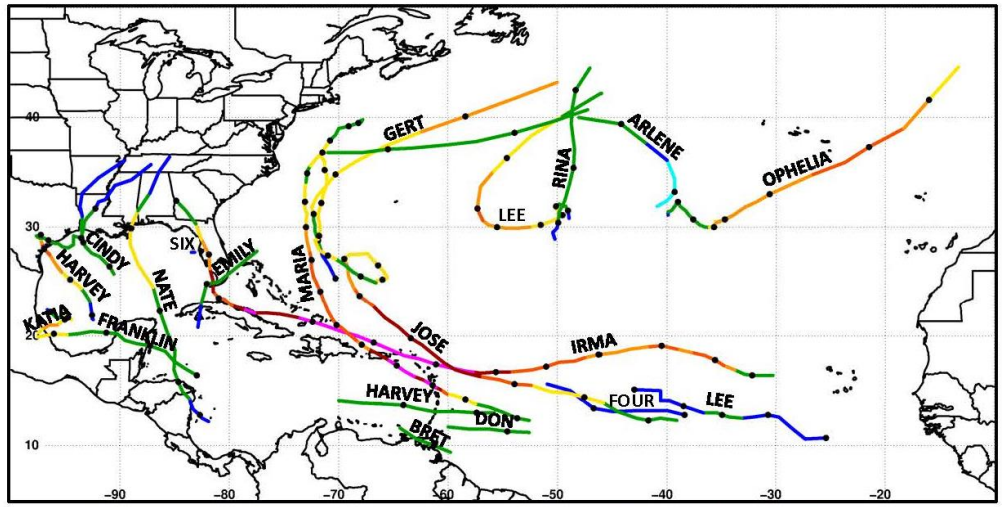
   - Tropical Cyclones
   - Monsoons
   - Atmospheric Rivers



NASA visualization of plant life: land vegetation and ocean phytoplankton

Hurricane Tracks: 2017



TROPICAL DEPRESSION: <39 mph
TROPICAL STORM: 39–73 mph
CATEGORY-1 HURRICANE: 74–95 mph
CATEGORY-2 HURRICANE: 96–110 mph
CATEGORY-3 HURRICANE: 111–129 mph
CATEGORY-4 HURRICANE: 130–156 mph
CATEGORY-5 HURRICANE: >156 mph

Data source: National Hurricane Center advisories

JOB GROWTH
UA expert: Numbers start to bear out 'buzz' about local economy
PAGE A9

TIDE MAY LOOK FAMILIAR TO CATS
'Bama, UA have followed similar paths this year
SPORTS

Arizona Daily Star
Final
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UA researchers predicted hectic Atlantic hurricane season

By Mikayla Mace
ARIZONA DAILY STAR

Two University of Arizona researchers accurately predicted an abnormally busy and intense Atlantic hurricane season, while other forecasting centers predicted otherwise.

"We were really nervous," said one of the researchers, Xubin Zeng. Other prediction centers expected an average year. "Months later, we didn't change," but other centers moved their predictions slightly closer to Zeng and his colleague's.

Zeng, director of the UA's Climate Dynamics and Hydrometeorology Center and a professor of atmospheric sciences, former graduate student Kyle Davis, and former professor Elizabeth Ritchie developed the forecasting model in 2015.

Thomas Galarneau, assistant professor in the UA's department of hydrology and atmospheric science, collaborates each season with Zeng on algorithms that go into the model to forecast that year's season.

In early June, the team predicted 11 total hurricanes in the Atlantic hurricane season stretching between June 1 and Nov. 30. Six were expected to become major hurricanes — reaching Category 3 or higher.

The team's predictions were almost spot on. A total of 10 hurricanes developed in the Atlantic this year; six were major.

"It's pretty amazing how good our prediction was," Zeng said.

Midway through the season in early August, the Climate Prediction Center, Colorado State University and Tropical Storm Risk adjusted their predictions to only a slightly-above-average year — about seven or eight total hurricanes including three or four major.

The UA team also forecast an intense season, which is measured using an

See HURRICANES, A4

Winter Street Fair off and spinning

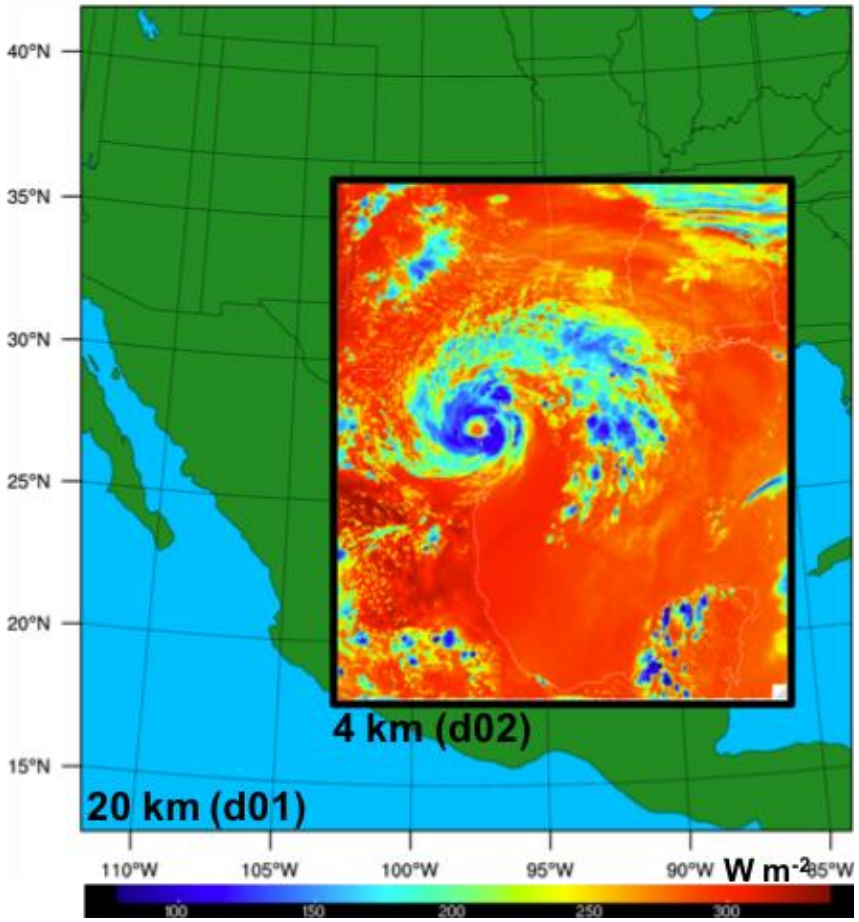
Franks offered $5M for her to

Pre-season prediction of 2017 hurricane activities

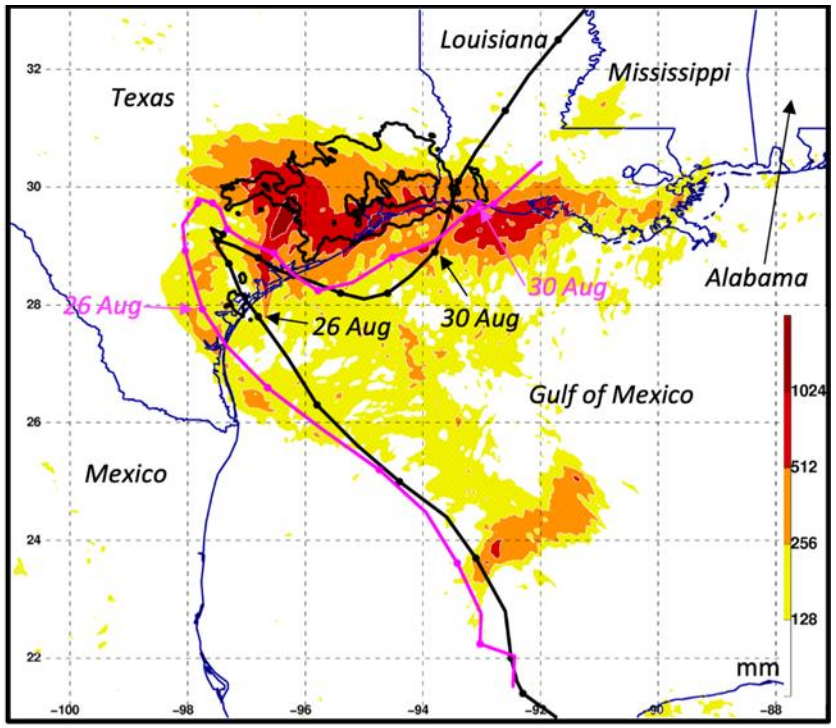
	Others	UA	OBS
Hurricane #	6-7	11	10
Major H #	2-3	6	6
ACE	~100	181	223

Davis, Zeng, Ritchie (2015, Wea. Forecasting)
Davis and Zeng (2019, Wea. Forecasting)

Q4: How does soil moisture affect upstream circulation and subsequent Hurricane Harvey (2017) Texas rainstorm?



Galarneau and Zeng (2020, MWR)



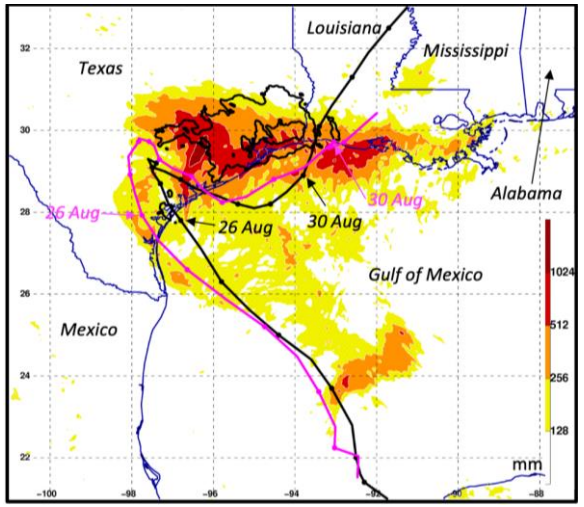
Observed track

CTL Track

CTL Rainfall (in color)

Initial Soil Moisture Experiment

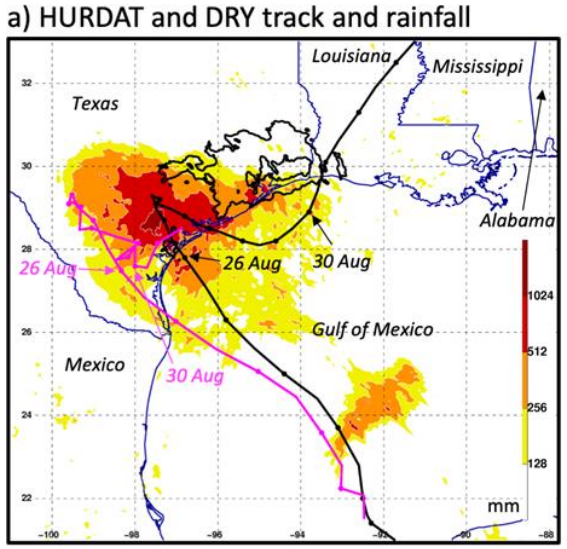
Control Simulation

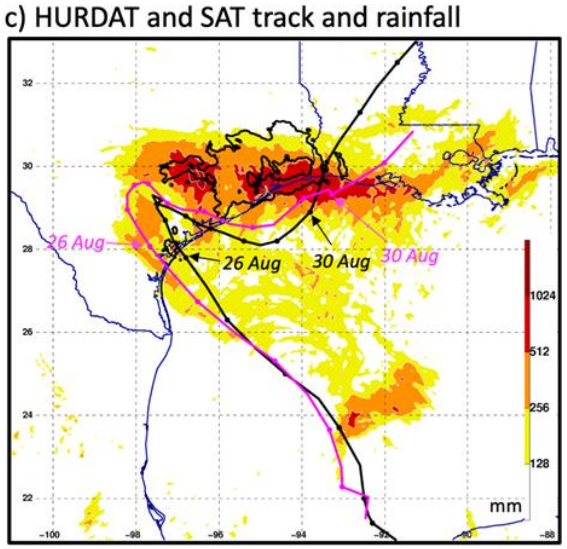


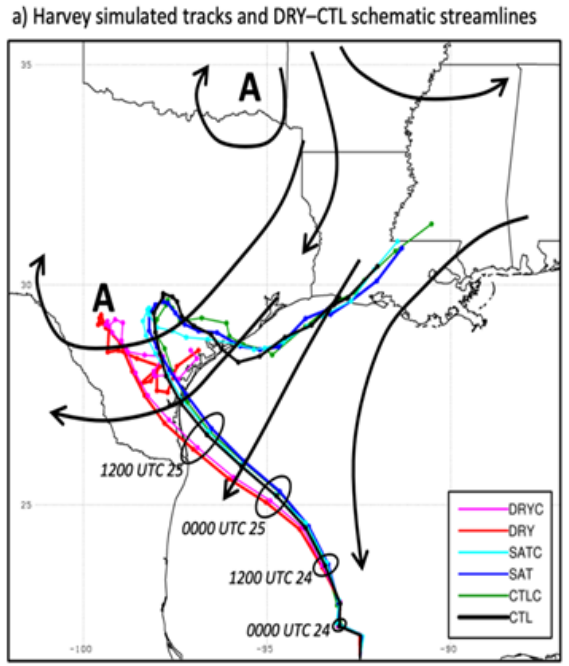
Observed track

CTL Track

CTL Rainfall (in color)







Mechanisms for the upstream effect:

Black arrows: schematic streamline perturbation (DRY–CTL) in the 850–700 hPa layer

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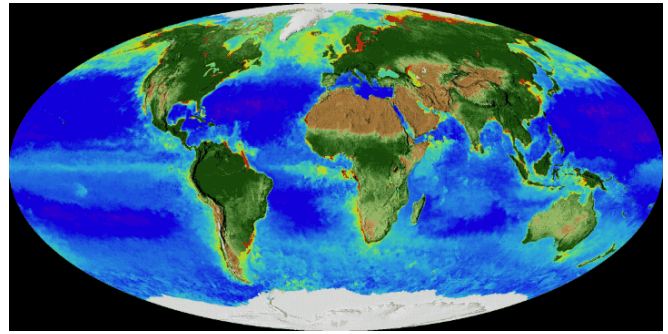
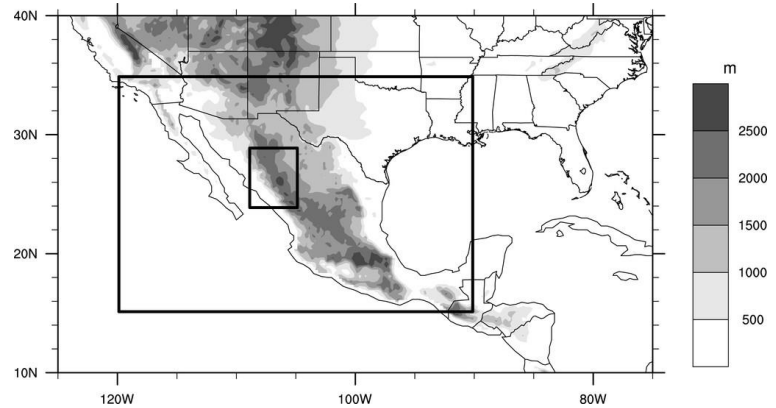
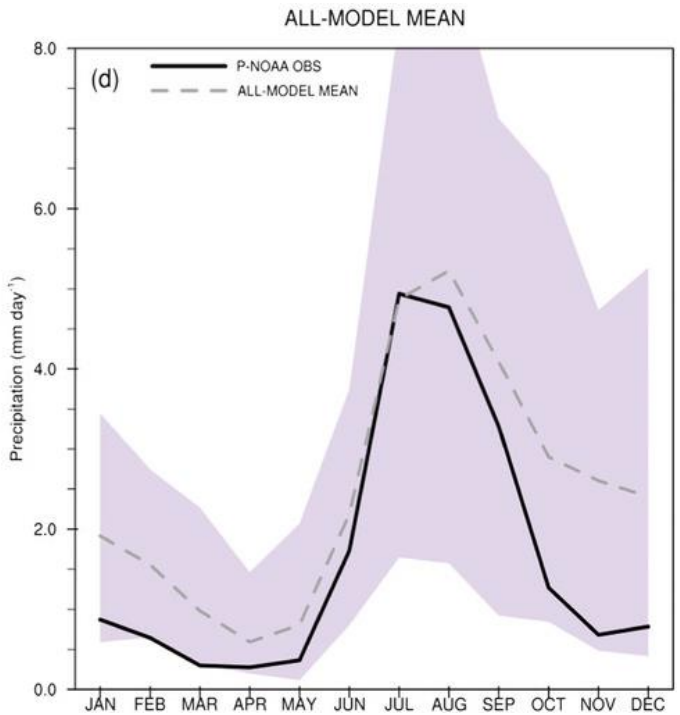


NASA visualization of plant life: land vegetation and ocean phytoplankton

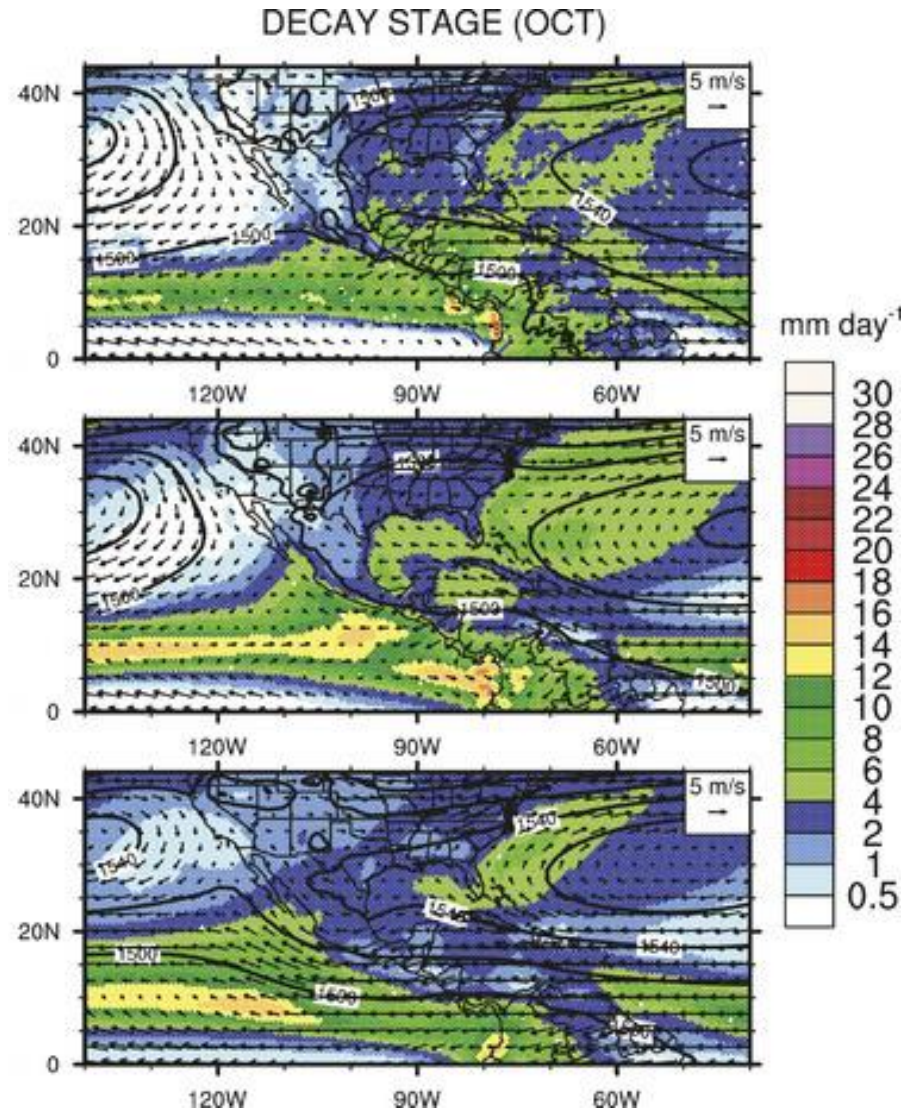
Q5: How well does CMIP models simulate North American monsoon?

CMIP5 model simulations over North America Core Monsoon Regions





Geil, Serra, Zeng (2013, J. Climate)



OBS

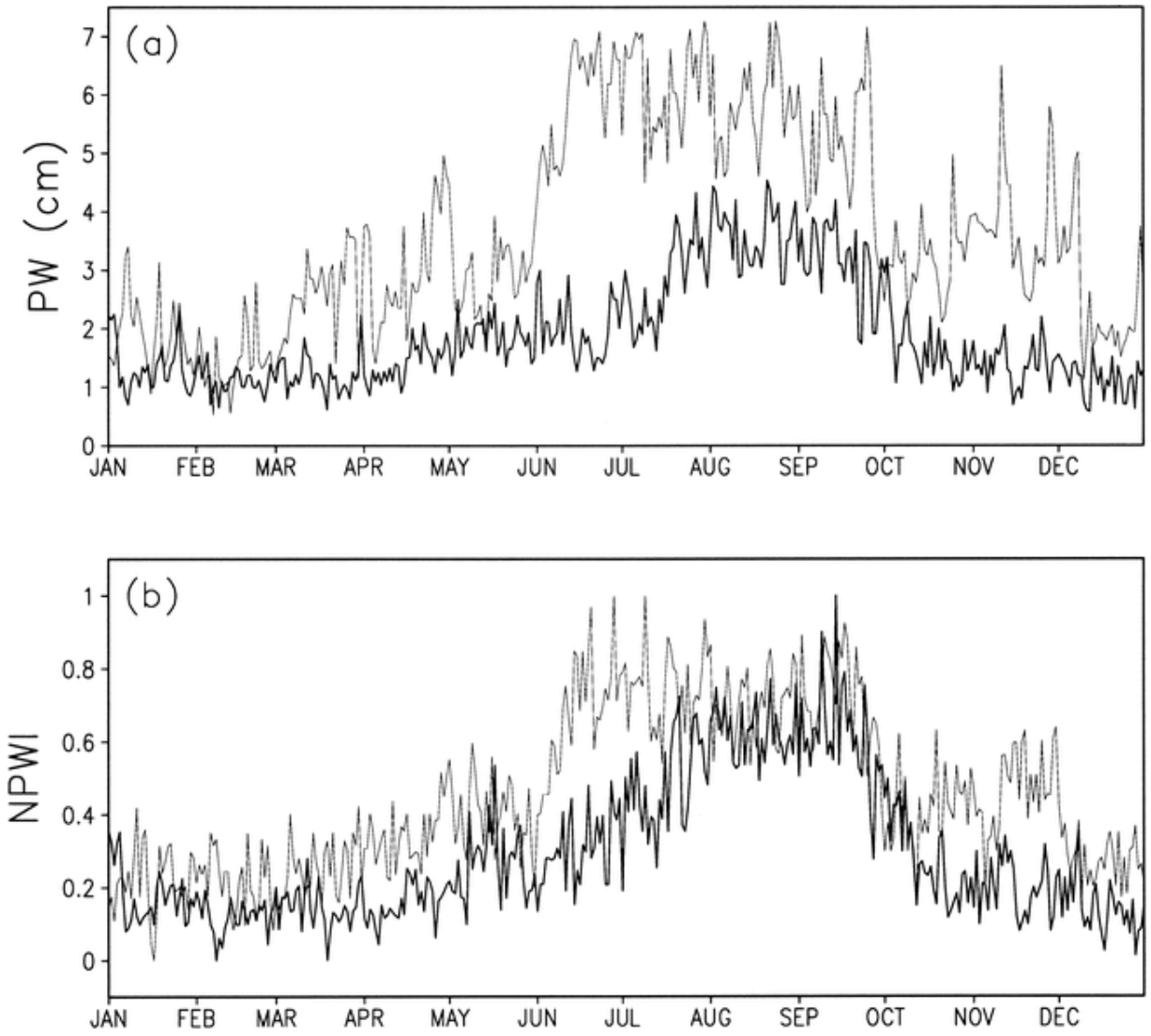
Best Models

Worst Models

Precip (colors), 850 hPa winds (vectors), 850 hPa heights (contours)

Q6: How can we define globally unified monsoon onset and retreat index?

10-year averaged daily PW over Mumbai, India (gray lines) and Southern Arizona (black lines), USA

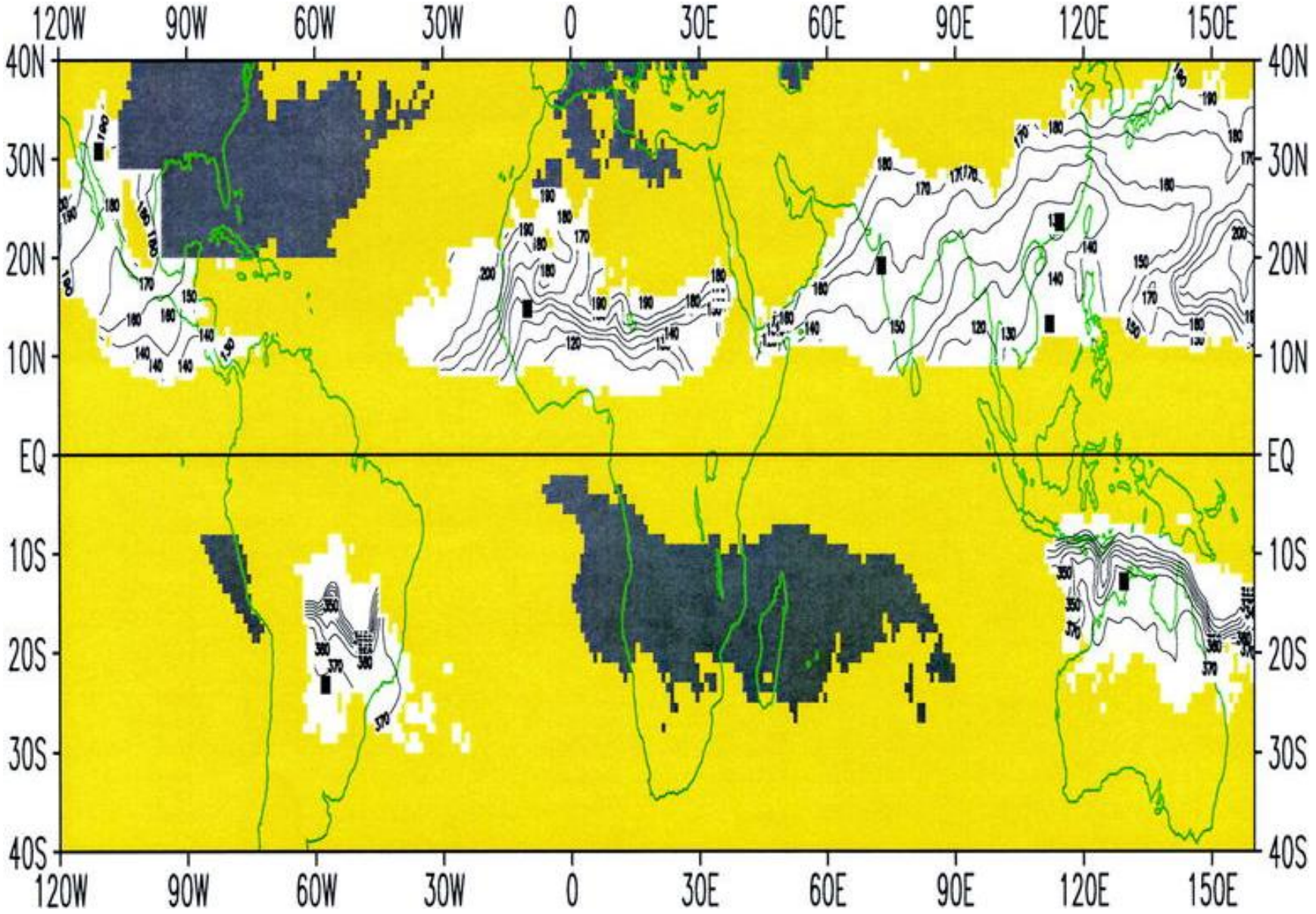


Zeng & Lu (2004, J. Climate)

$$\mathrm{NPWI} = \frac{\mathrm{PW} - \mathrm{PW}_{\min}}{\mathrm{PW}_{\max} - \mathrm{PW}_{\min}}$$

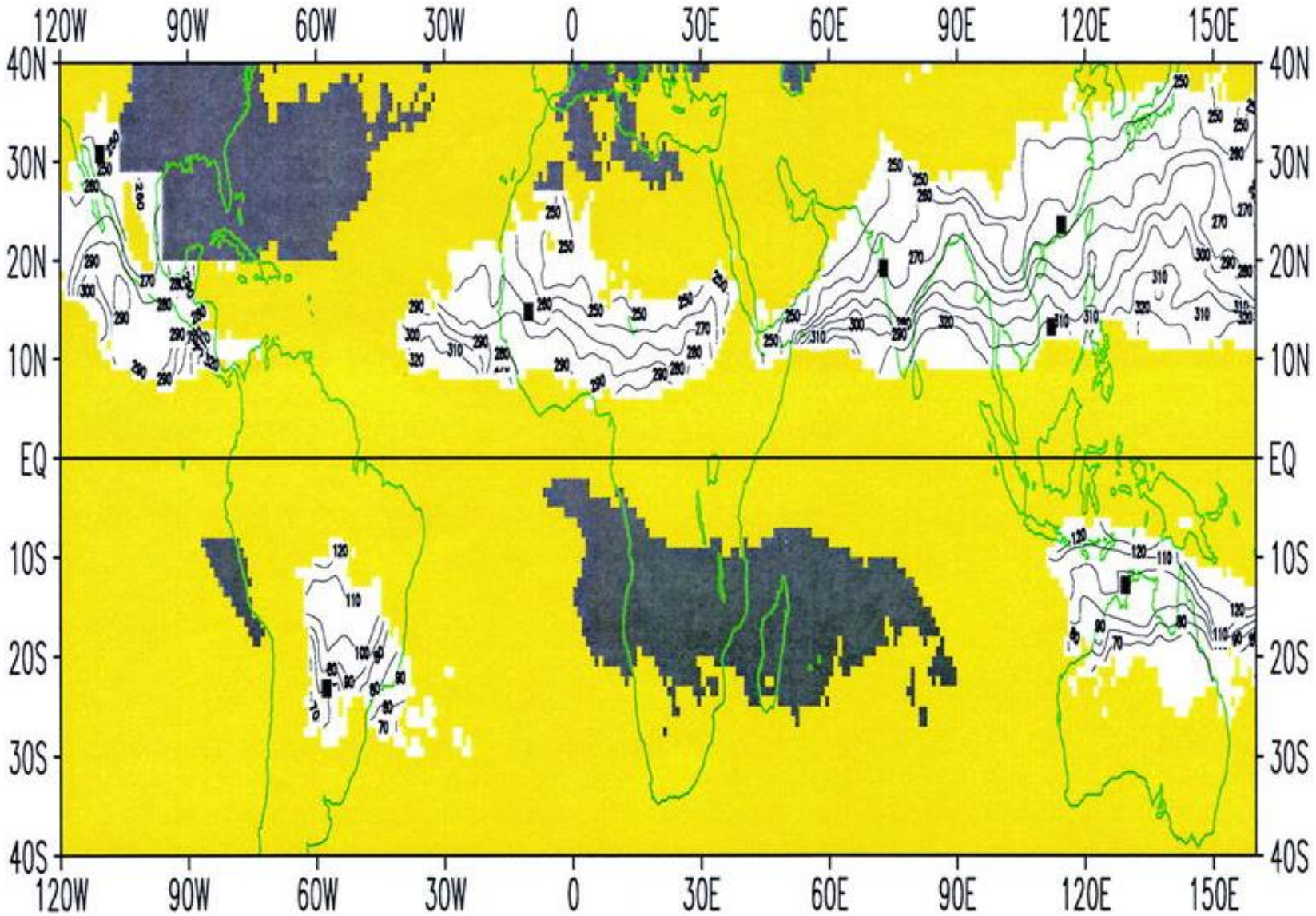
1º x1º daily mean PW, and its annual max and min averaged over 10 years.

Onset (or retreat) date for grid G is defined as the first day (d) when NWPI is greater (or less) than the Golden Ratio (0.618) for three consecutive days in seven of the nine grids centered at grid G in day d or (d ± 1)



Onset date

	Median
India	159 (161)
China	131 (130)
North Pacific	139 (133)
Arizona	188 (187)
North Africa	151
Australia	362 (359)
South America	9

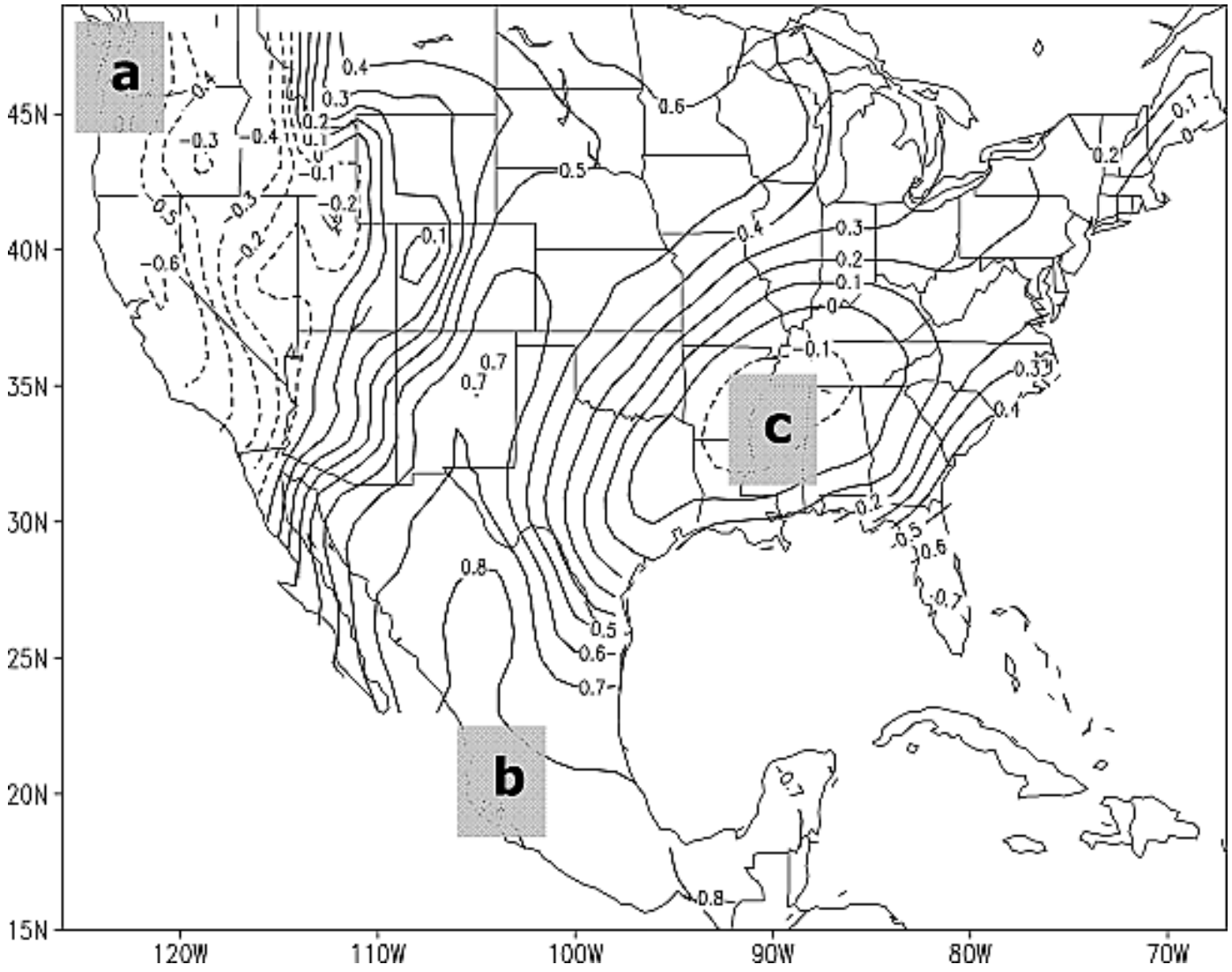


Retreat Date

	Median
India	271 (271)
China	268
North Pacific	312 (333)
Arizona	249
North Africa	267
Australia	99
South America	56

Correlation between daily P and PW.

PW can determine monsoon onset & retreat over monsoon regions, but not monsoon regions



Lu et al. (2009, JGR-Atmo)

Conclusions

- GPEX is a new 10-year WCRP Lighthouse Activity. This is the right time to get involved in field campaigns, dataset development, modeling and process understanding, and capacity development.
- GPEX field campaigns will focus on four storm types, and we have done some studies related to each of them:
  - MCS: wind and thermodynamic conditions can predict the occurrence of mesoscale convective systems over the tropics
  - TCs: soil moisture can affect upstream circulation and subsequent Hurricane Harvey (2017) Texas rainstorm.
  - Monsoons: Normalized precipitable water can be used to define globally unified monsoon onset and retreat index
  - ARs: Atmospheric river plays an important role in the extreme snowmelt over the U.S.