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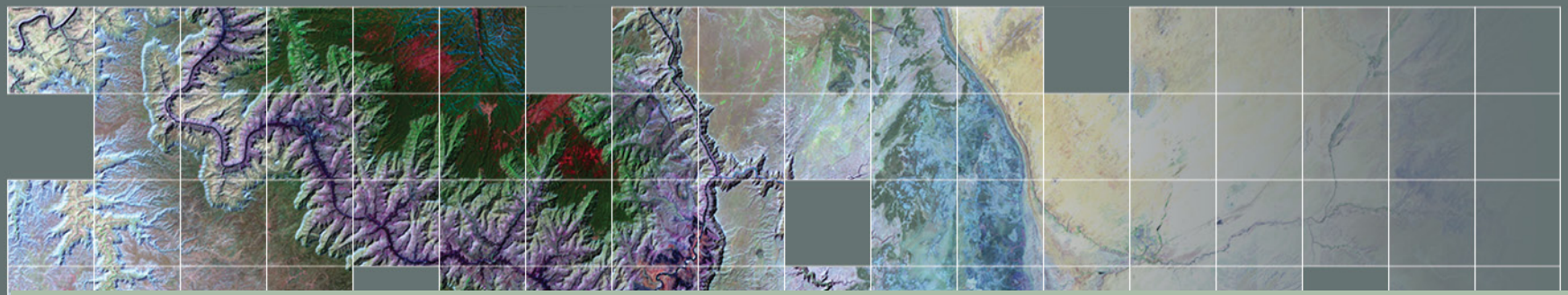
Climate Hazards Center
UC SANTA BARBARA

USAID
FROM THE AMERICAN PEOPLE

Climate and Land Use Change
Earth Resources Observation and Science (EROS) Center

Improving climate services in developing nations with Ag Out - an enhanced IMERG-based Ag Outlook System

Chris Funk, Research Director, Climate Hazards Center



Chris Funk, USGS/UCSB Climate Hazards Center

U.S. Department of the Interior
U.S. Geological Survey

Collaborators

Ag Out – An Enhanced IMERG-based Agricultural Outlook System to Support Food Security and Agriculture in the Developing World

Principal Investigator: Dr. Chris Funk (USGS/UCSB)
Co-Investigators: Dr. Shraddhanand Shukla (UCSB), Dr. Carolyn Mutter (The Earth Institute, Columbia), Dr. Frank Davenport (UCSB), Dr. Gregory Husak (UCSB)

Other Professional: Peter Peterson (UCSB), Martin Landsfeld (UCSB)

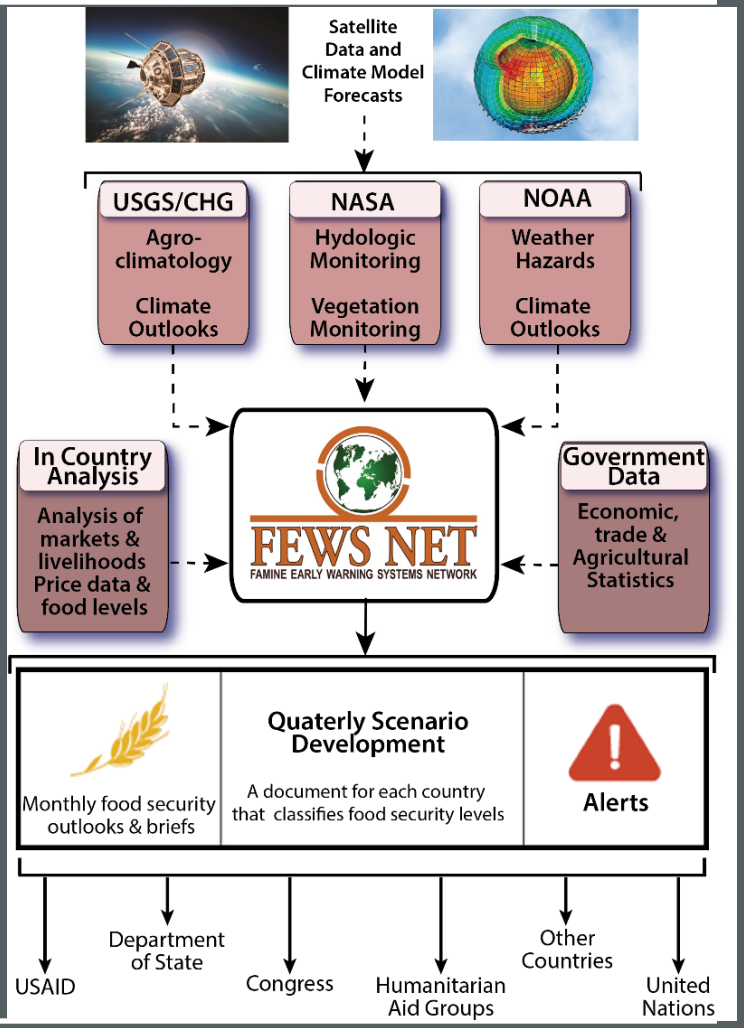
Collaborators: George Huffman (NASA GSFC), Alexander Ruane (NASA GISS), Christa Peters-Lidard (NASA GSFC), James Rowland (USGS EROS), Mike Budde (USGS EROS), Gary Eilerts (USAID FEWS NET), James Verdin (USAID FEWS NET), Curt Reynolds (USDA), Ashutosh Limaye (NASA MSFC), Inbal Becker-Reshef (UMD, Food Security and Agriculture Consortium)

advisors

end users

Applications of Agricultural Monitoring

- USAID Food For Peace provides ~4 Billion in aid each year to 85 million people
- 1 out of a hundred humans severely food insecure, up 80% since 2015



Funk, BAMS, 2019

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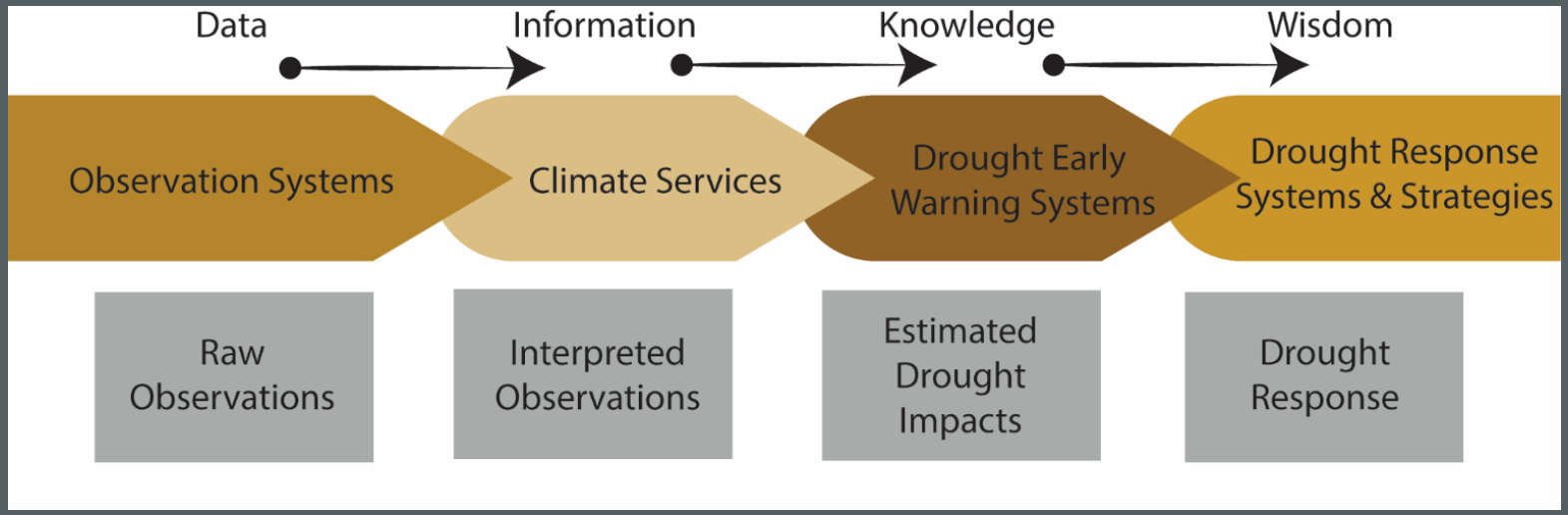
Decision support systems transform data into actionable knowlegde



Bias ☹ → Under-prediction of crop failure

Bias ☹ → Over-prediction of crop failure

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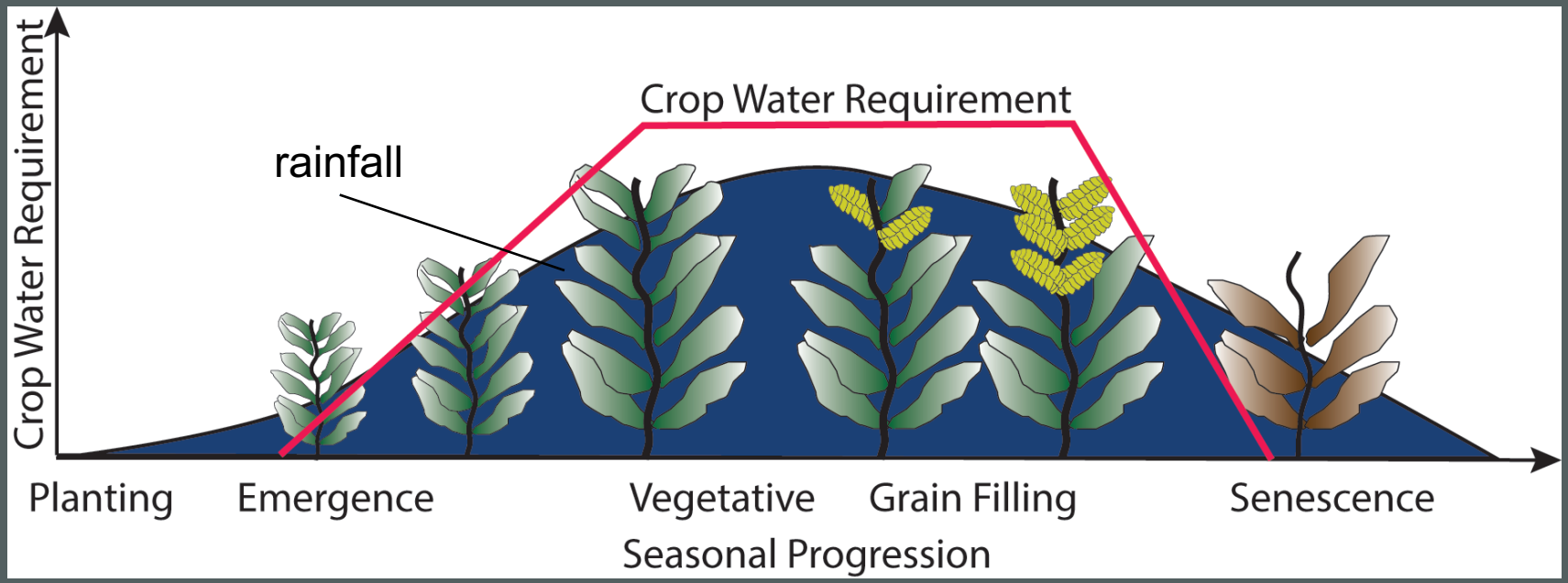
Funk & Shukla (2020) Drought Early Warning: Theory and Practice

Bias matters when model crop outcomes



Seasonal progression of crop water requirements

Funk & Shukla (2020) Drought Early Warning: Theory and Practice

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Agro-climatic monitoring window

Daily latency

Near Real Time Quantitative Precipitation Estimates

Two month latency

Gold standard gauge enhance data records

Prelim station+ Sat QPE +climatology

Final station+ Sat QPE +climatology

4.1 million Climate Hazards center IR Precipitation with Stations downloads in 2018
From 5.1 thousand unique IPs
FEWS NET, SERVIR, USDA, Harvest, WFP, JRC, Met Agencies, Crop Insurance

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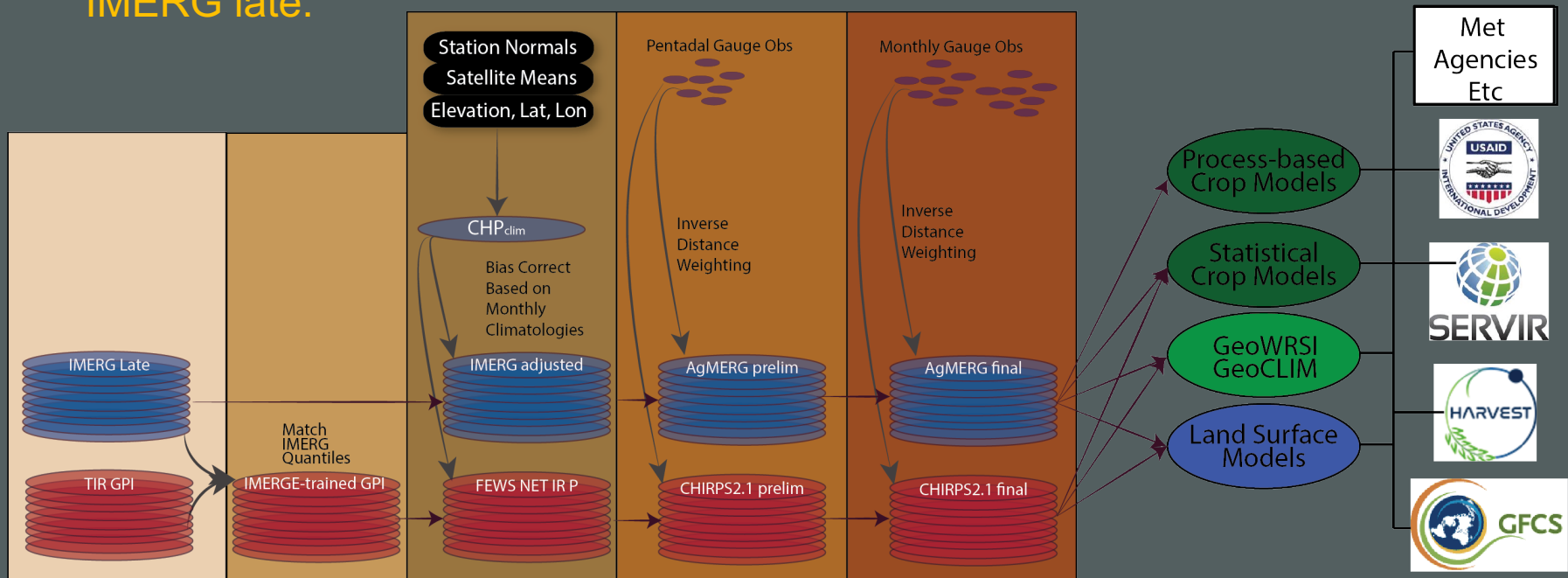
AGMERG and CHIRPS2.1 Schema

This project will develop a bias-corrected station enhanced AGMERG product designed to support global agricultural monitoring. Based on IMERG late.



Overview

- Analyze quasi-systematic errors in IMERG late
- Use these errors to adjust IMERG
- Quantify performance enhancement
- Describe CHC station processing
- Describe planned AGMERG data product

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Data …. Proof of concept study

- ~5,900 GHCN daily stations for CONUS
- ~153 Conagua stations for Mexico
- NLDAS precipitation
- IMERGLATE
- CHIRPS
- Stations selected with at least 60% non-missing data and monthly means of at least 0.5 mm per day.
- Motivated by analysis at GSFC by Daniel Sarmiento, Amy McNally, and Kim Slinski

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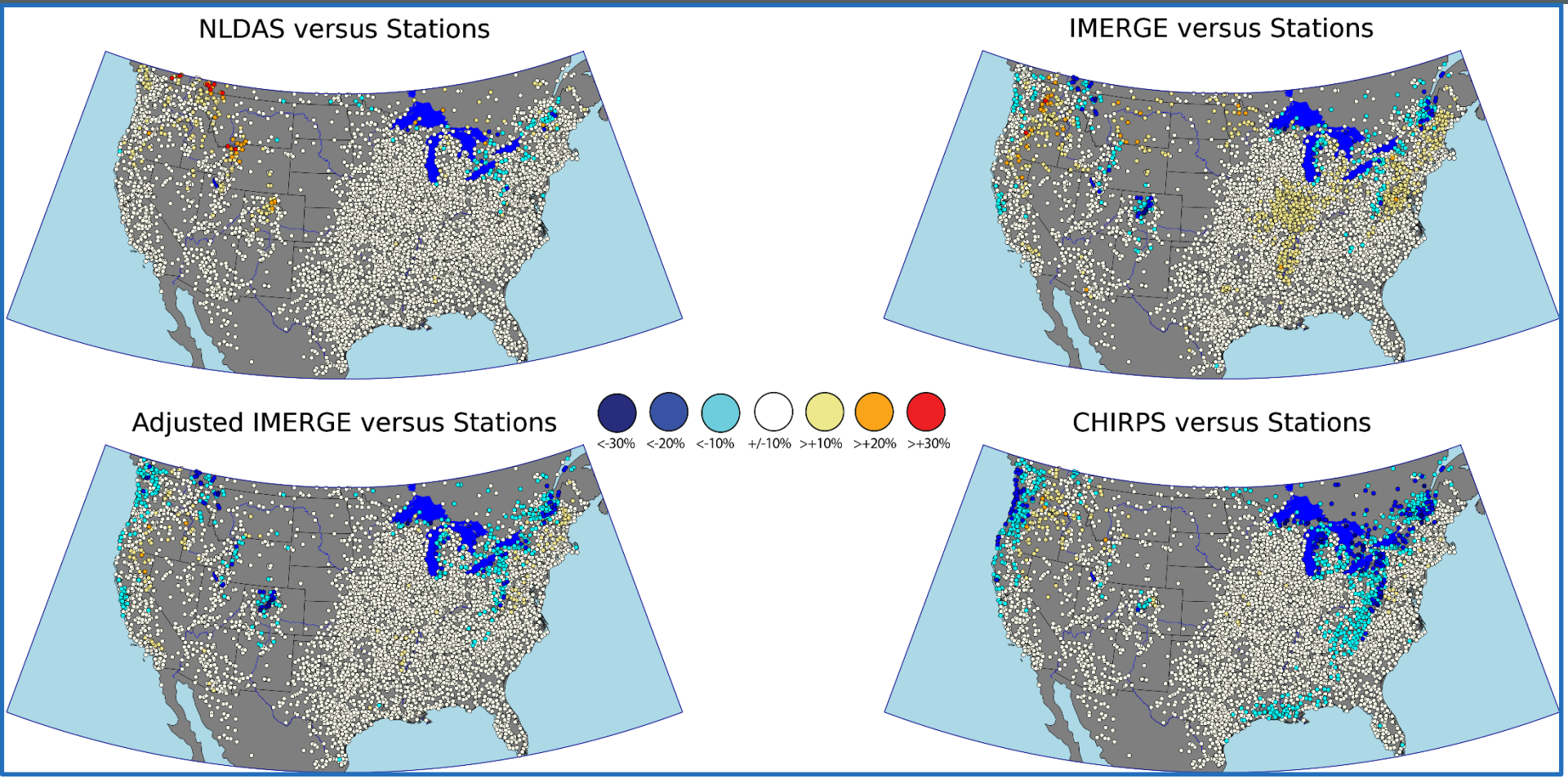
Maps of Dry Frequency Comparisons

January



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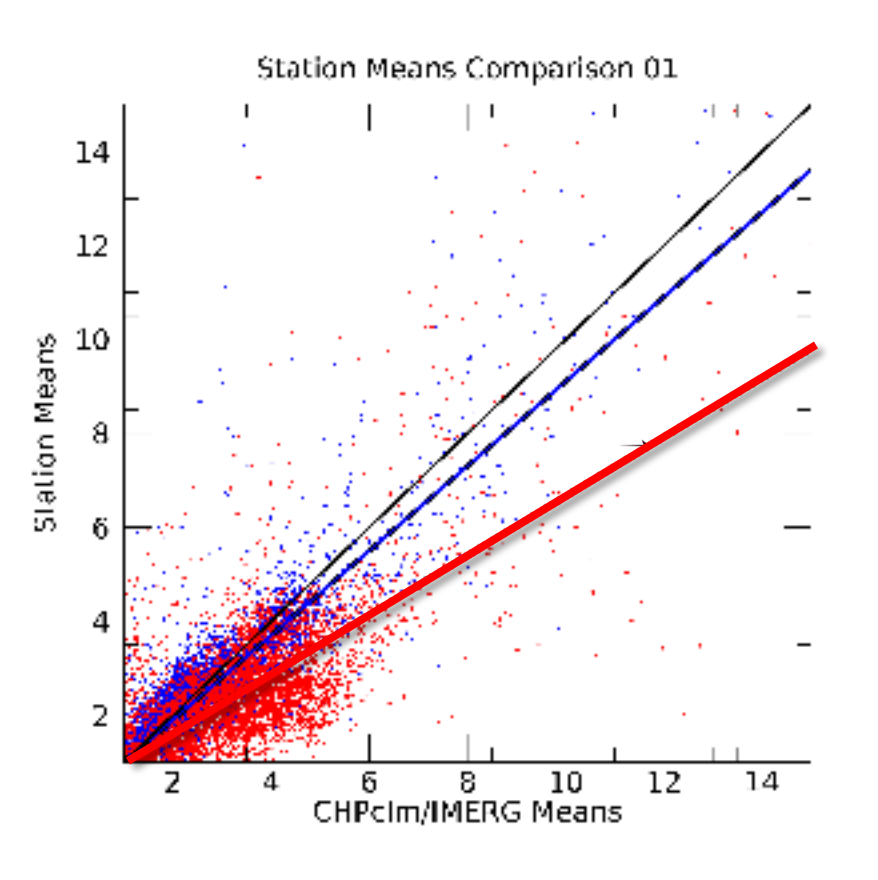
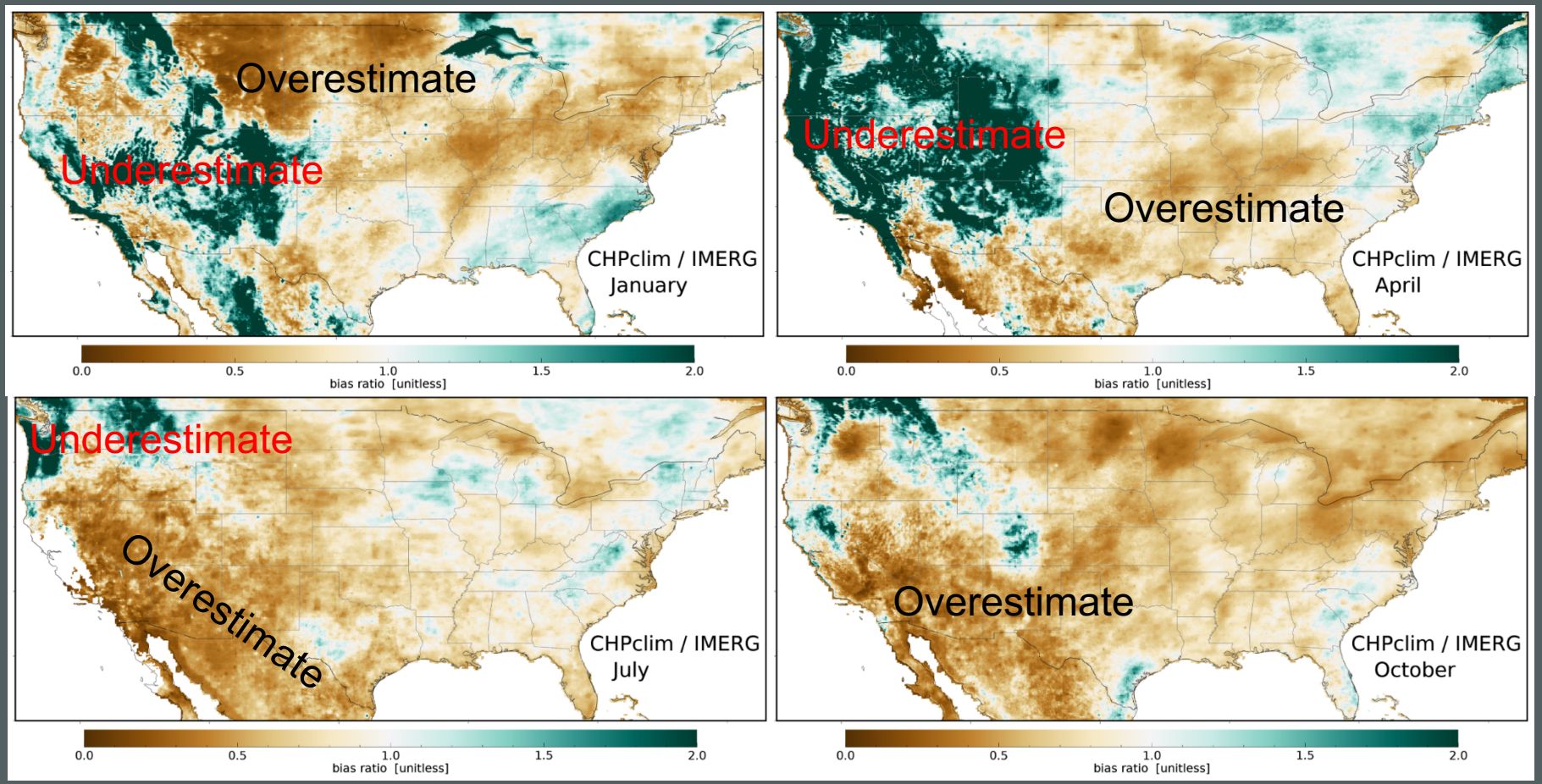
Analysis of Systematic Bias – Station and IMERG Means



AGMERG IMERG adjustment plan …

- IMERG dry/wet day frequencies very good
- IMERG detection rates for wet days good
- Don't mess with these ….
- IMERG wet days exhibit substantial bias that varies by season and location
- Reduce bias with spatially/temporally varying bias correction factors
  - $IMERG_{adj}(x,y,t) = \frac{CHPclm(x,y,t)}{Mean(IMERG(x,y,t))} * IMERG(x,y,t)$

Analysis of Systematic Bias
Ratio CHP_{clm} divided by IMERG Means



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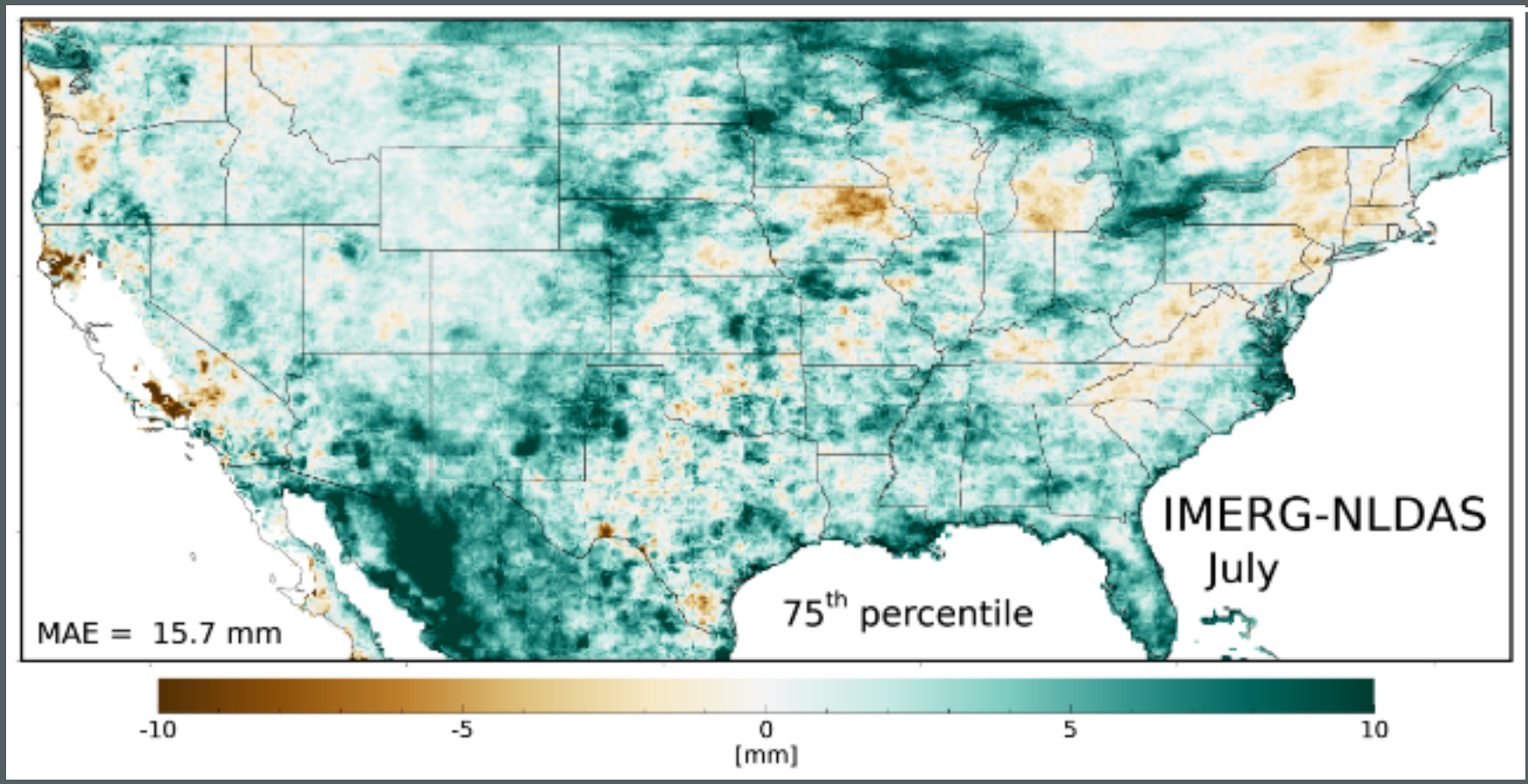
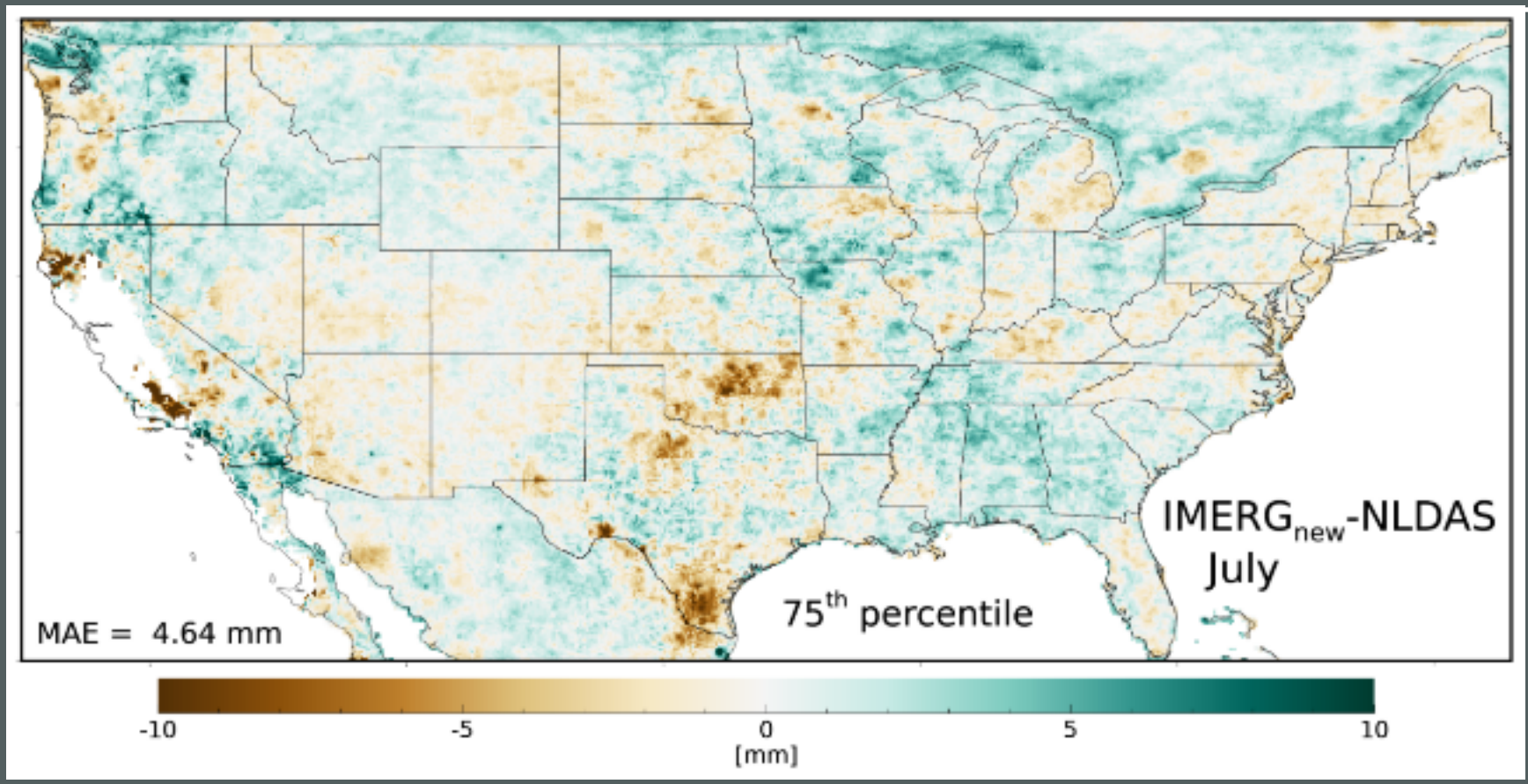
July 75th Percentile IMERG minus NLDAS

IMERG

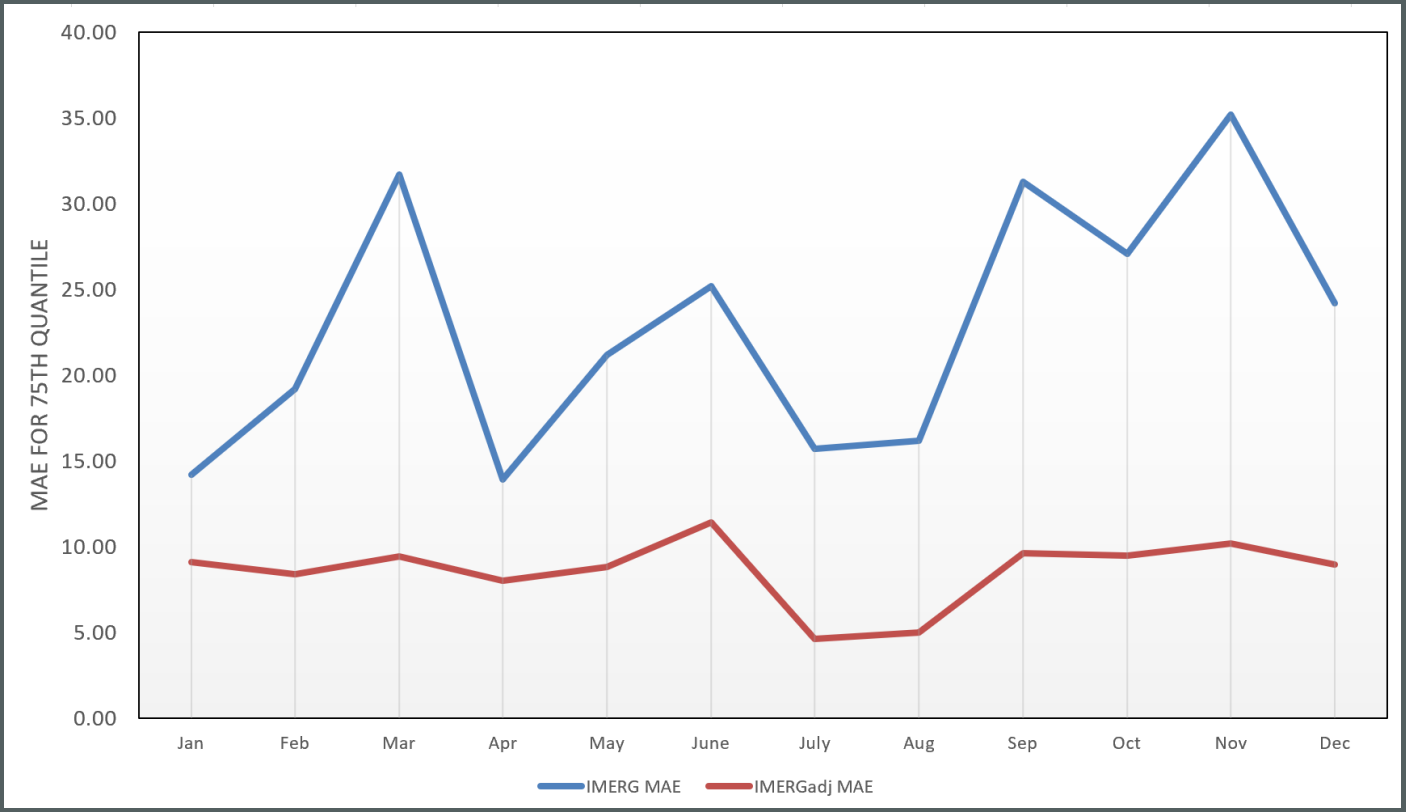


July 75th Percentile IMERG minus NLDAS

IMERG$_{adj}$



Comparison of 75th Percentile MAE values compared NLDAS



Mean Absolute Errors (MAE) compared GHCN

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
IMERG mm/day	2.9	3.1	3.0	3.0	3.6	4.1	3.8	3.5	3.3	3.5	3.4	3.6
$IMERG_{adj}$ mm/day	2.5	2.4	2.6	2.7	3.2	3.5	3.4	3.1	2.9	3.1	2.6	2.6
Improvement mm	+0.6	+.7	+.4	+.3	+.4	+.6	+.4	+.4	+.4	+.4	+1	+1
Improvement %	+21	+23	+15	+11	+13	+17	+12	+13	+14	+13	+38	+38

Correction reduces IMERG MAE by ~0.4-1 mm/day

***Future Directions**: Reduce the discrepencies in over-land retrievals …*

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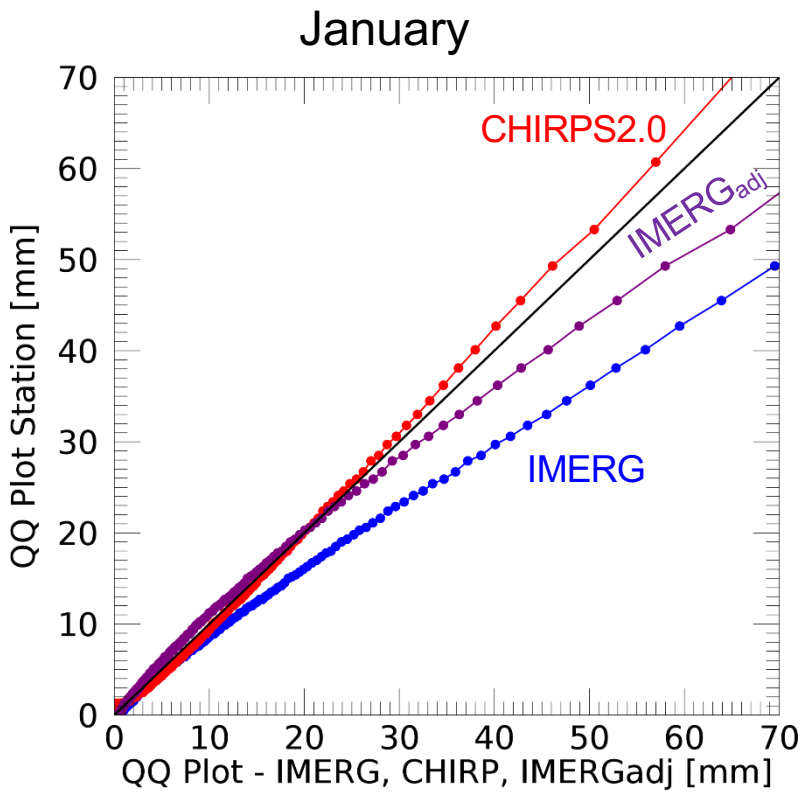
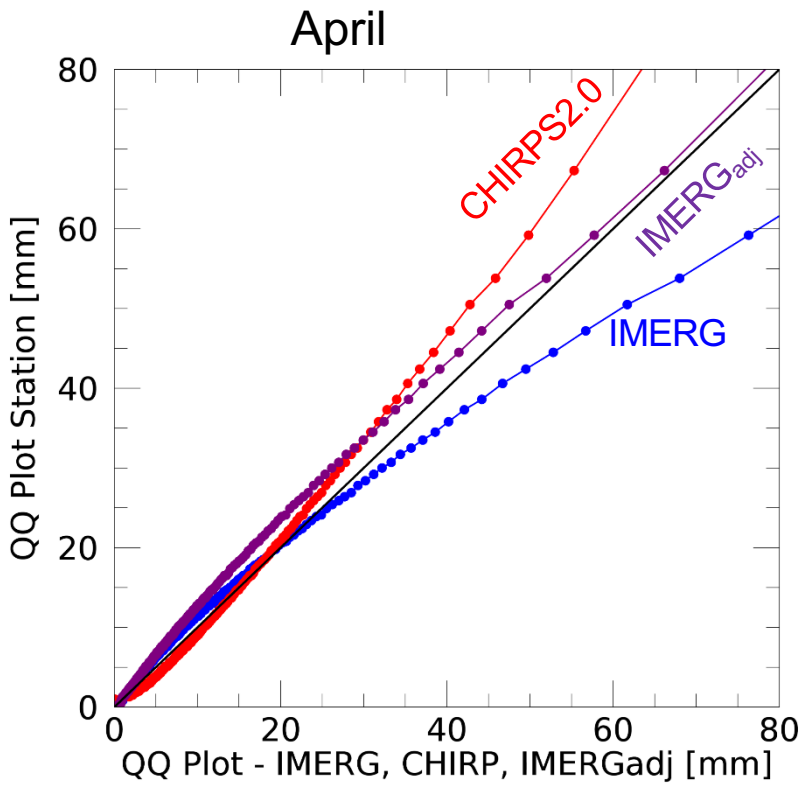
GHCN Results IMERG QQ Plots





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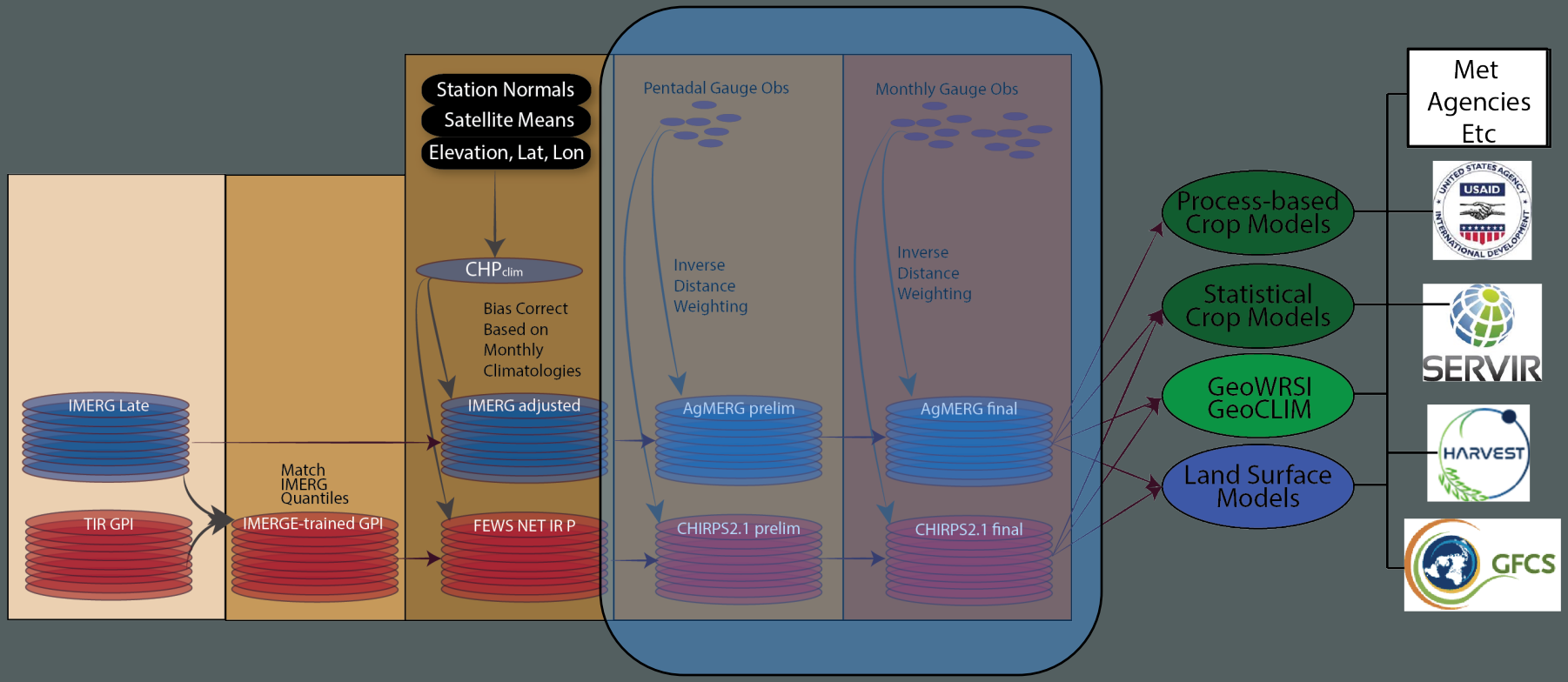
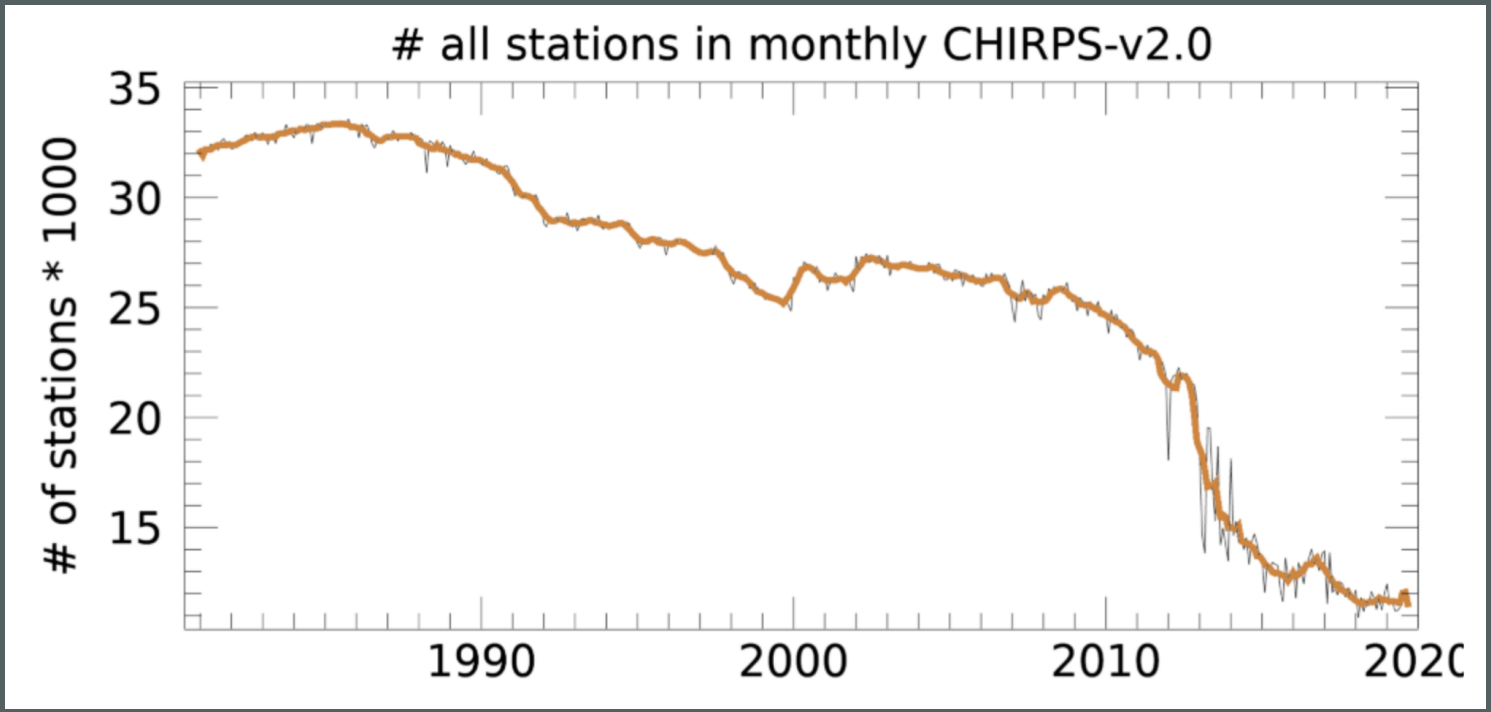
Station assimilation/interpolation



Reporting crisis and number of monthly gauge observations …



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CHC strategy uses multiple sets of stations, accumulating information

	Fixed historical	Time varying monthly	Time varying pentadal
	#Stations in new CHPclm (v2): ~80,000	#Stations in monthly CHIRPS in 2019: ~11,000	#Stations in pentadal prelim CHIRPS in 2019: ~5,000
CHC Strategy	Use high rez clim to reduce bias	Create high quality final product every month	Create OK quality prelim product every 5-6 days

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Climate Hazards P climatology version 2

- **80K *gauge-undercatch corrected* climate normals are 43K from GPCC, plus gap-fills.**
- **0.05 degree, global**

The CHPclm v2 will be produced using a new adaptive Moving Window Regression procedure (in R) with CHPclm v1 as a background.

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New CHC stations sources

Non-updating data sets

Source	# stations	location	Source	# stations	location
El Salvador	25	El Salvador	Cambodia	51	Cambodia
INTER	20	Nicaragua	Myanmar	36	Myanmar
Iran	10	Iran	Nepal	130	Nepal
SWALIM	64	Somalia	Sri Lanka	94	Sri Lanka
Nicholson-3	1,020	23 countries Africa	Vietnam	166	Vietnam
Adoum	105	Niger and Chad	Togo	9	Togo
Panama	103	Panama	Ghana	22	Ghana
Bangladesh	35	Bangladesh	Nigeria	40	Nigeria
Guatemala	45	Guatemala	ICAFE	32	Costa Rica
Sudan	28	Sudan	Honduras	26	Honduras
Haiti	11	Haiti	Uganda	14	Uganda
Thailand	119	Thailand			
Sources in progress					
MARN	130	El Salvador	Bolivia	?	Bolivia
Chile-Met	97	Chile	CR-Met	?	Costa Rica

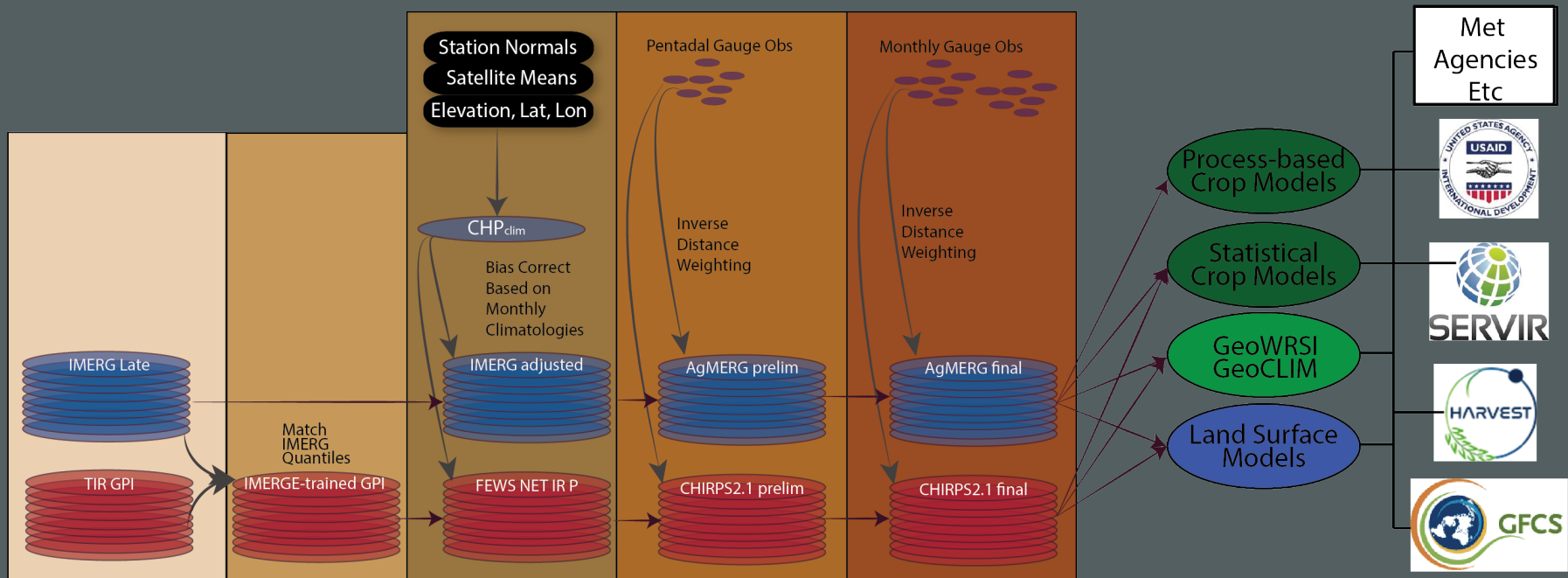
Sources that Update Monthly

Source	# stations 2019.09	location
GHCN –v2	887	Global
GHCD-daily	8,019	Global
fGTS	4,084	Global
fGSOD	4,700	Global
IDEAM	529	Colombia
Conagua	691	Mexico
SASSCAL	77	Southern Africa
INSIVUMEH	91	Guatemala
Ethiopia NMA	112	Ethiopia
ETESA	14	Panama
SWALIM	64	Somalia
SISMAT	3	Haiti

Current plan …

- **Generalize IMERG unbiasing to global context**
  - Compare with stations
- **Complete CHPclim update (version 2)**
- **Complete update of CHC station archive**
- **Begin production of beta version of AGMERG data product**
  - Pentad product every 5-6 days
  - Monthly final product once a month
- **Work with Earth Institute/NASA GISS to explore crop model applications**

Thanks!


Station Normals
Satellite Means
Elevation, Lat, Lon
Pentadal Gauge Obs
Monthly Gauge Obs
CHPclim
Bias Correct Based on Monthly Climatologies
Inverse Distance Weighting
Inverse Distance Weighting
IMERG Late
TIR GPI
Match IMERG Quantiles
IMERGE-trained GPI
IMERG adjusted
FEWS NET IR P
AgMERG prelim
CHIRPS2.1 prelim
AgMERG final
CHIRPS2.1 final
Process-based Crop Models
Statistical Crop Models
GeoWRSI GeoCLIM
Land Surface Models
Met Agencies Etc
USAID
SERVIR
HARVEST
GFCS

Proposed IMERG Late unbiasing approach

- Produce high resolution climatology by blending gauge-undercatch corrected station normals and background climatology of satellite precipitation
- Calculate means of IMERG Late for each month and location
- For IMERG Late rain days (> 1 mm), adjust using ratio of means

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Daily Correlation

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
NLDAS	0.70	0.68	0.70	0.68	0.66	0.67	0.59	0.62	0.66	0.62	0.69	0.68
IMERG	0.50	0.47	0.49	0.51	0.52	0.52	0.45	0.48	0.52	0.48	0.52	0.51
CHIRPS	0.53	0.51	0.54	0.53	0.51	0.51	0.45	0.46	0.49	0.46	0.53	0.54
IMERGAdj	0.53	0.50	0.51	0.52	0.52	0.52	0.45	0.48	0.53	0.48	0.56	0.54

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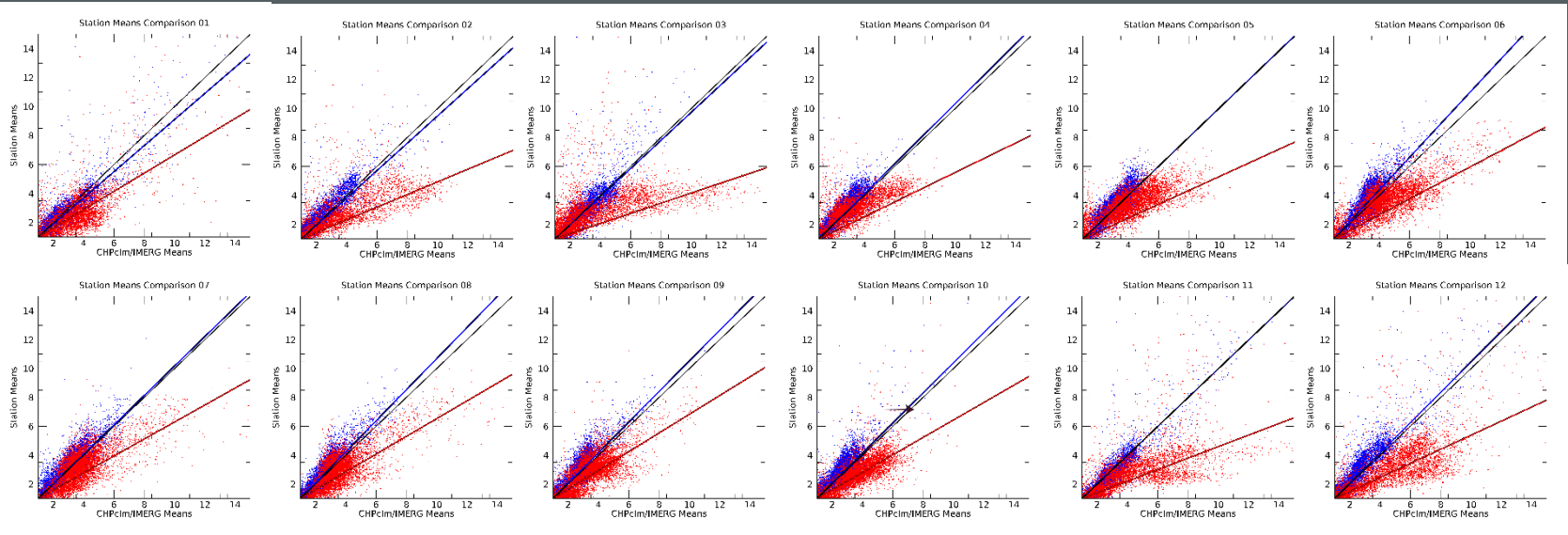
The first step involves analysis of systematic bias



Analysis of Systematic Bias – Station and IMERG Means

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Station Means	2.2	2.2	2.3	2.7	3.1	3.3	3.0	2.8	2.7	2.8	2.4	2.5
CHPclm Means	2.2	2.0	2.4	2.4	3.0	3.0	2.9	2.6	2.5	2.6	2.6	2.2
IMERG Means	2.8	2.9	2.9	2.8	3.7	4.1	3.7	3.4	3.3	3.4	3.6	3.6
CHPclm Slope	0.9	0.95	0.97	1.03	1.00	1.1	1.0	1.1	1.1	1.1	1.0	1.1
IMERG Slope	0.65	0.47	0.39	0.54	0.51	0.58	0.62	0.64	0.67	0.64	0.44	0.52

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Percent No Rain

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
GHCN	0.77	0.76	0.77	0.72	0.72	0.72	0.75	0.77	0.79	0.77	0.78	0.76
NLDAS	0.76	0.75	0.75	0.67	0.67	0.65	0.66	0.69	0.74	0.69	0.76	0.75
IMERG	0.75	0.76	0.76	0.68	0.68	0.65	0.66	0.68	0.74	0.68	0.75	0.74
CHIRPS	0.80	0.78	0.77	0.76	0.76	0.76	0.77	0.80	0.86	0.80	0.83	0.78
AdjIMERG	0.78	0.79	0.77	0.70	0.70	0.67	0.68	0.70	0.76	0.70	0.77	0.77

USGS

Probability of Detection

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
NLDAS-Wet	0.73	0.73	0.76	0.77	0.78	0.78	0.77	0.75	0.76	0.75	0.75	0.72
NLDAS-Dry	0.90	0.88	0.88	0.87	0.84	0.81	0.79	0.81	0.87	0.81	0.90	0.89
IMERG-Wet	0.58	0.55	0.58	0.61	0.69	0.71	0.71	0.70	0.68	0.70	0.62	0.59
IMERG-Dry	0.84	0.85	0.86	0.86	0.81	0.78	0.77	0.79	0.85	0.79	0.85	0.83
CHIRPS-Wet	0.46	0.47	0.50	0.51	0.49	0.50	0.49	0.47	0.39	0.47	0.42	0.48
CHIRPS-Dry	0.87	0.86	0.85	0.84	0.85	0.85	0.85	0.88	0.92	0.88	0.89	0.85
$IMERG_{Adj}$-Wet	0.54	0.52	0.56	0.60	0.67	0.69	0.69	0.68	0.65	0.68	0.60	0.54
$IMERG_{Adj}$-Dry	0.86	0.86	0.87	0.87	0.83	0.80	0.80	0.81	0.87	0.81	0.87	0.87

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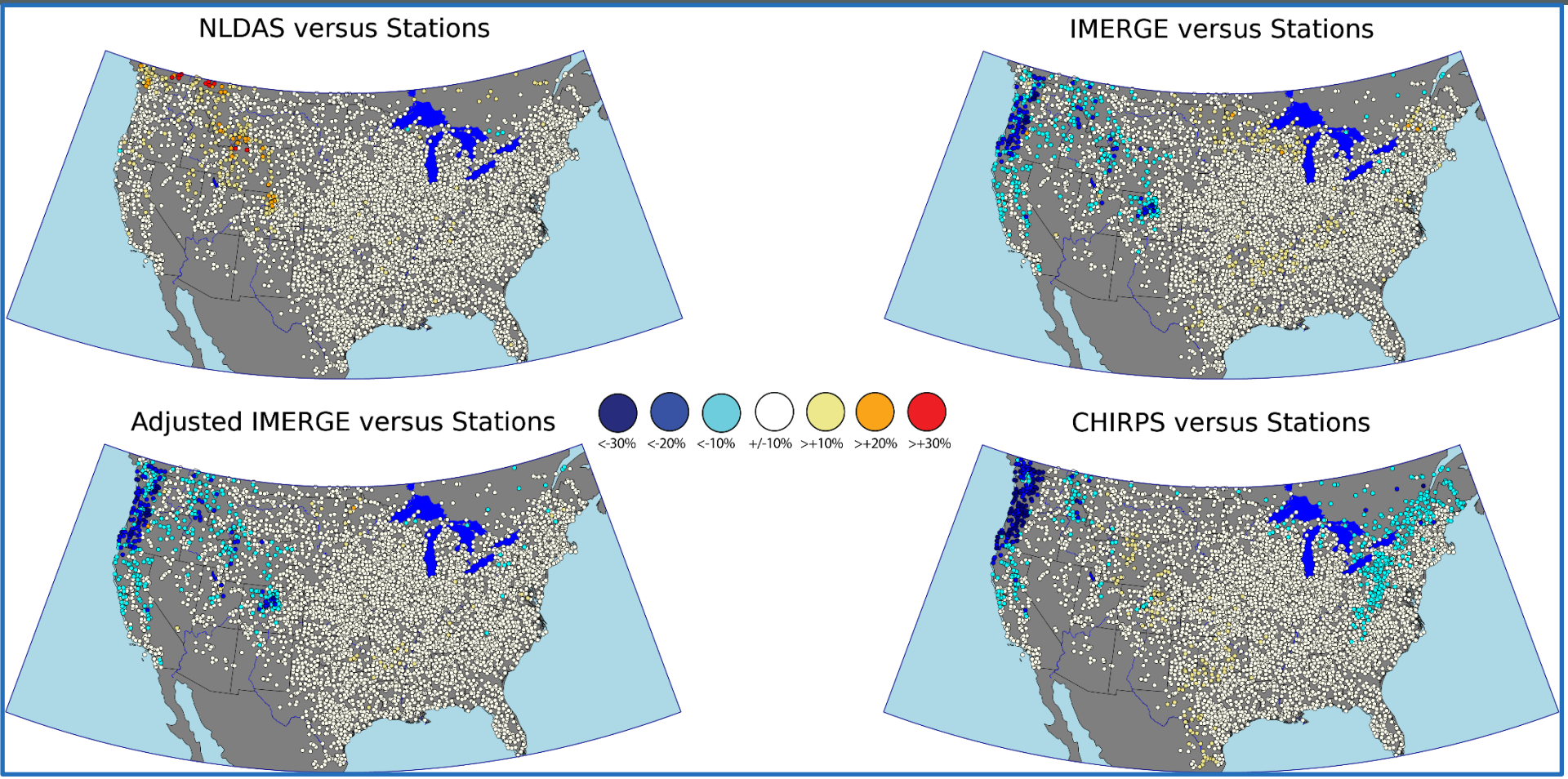
Maps of Dry Frequency Comparisons

April



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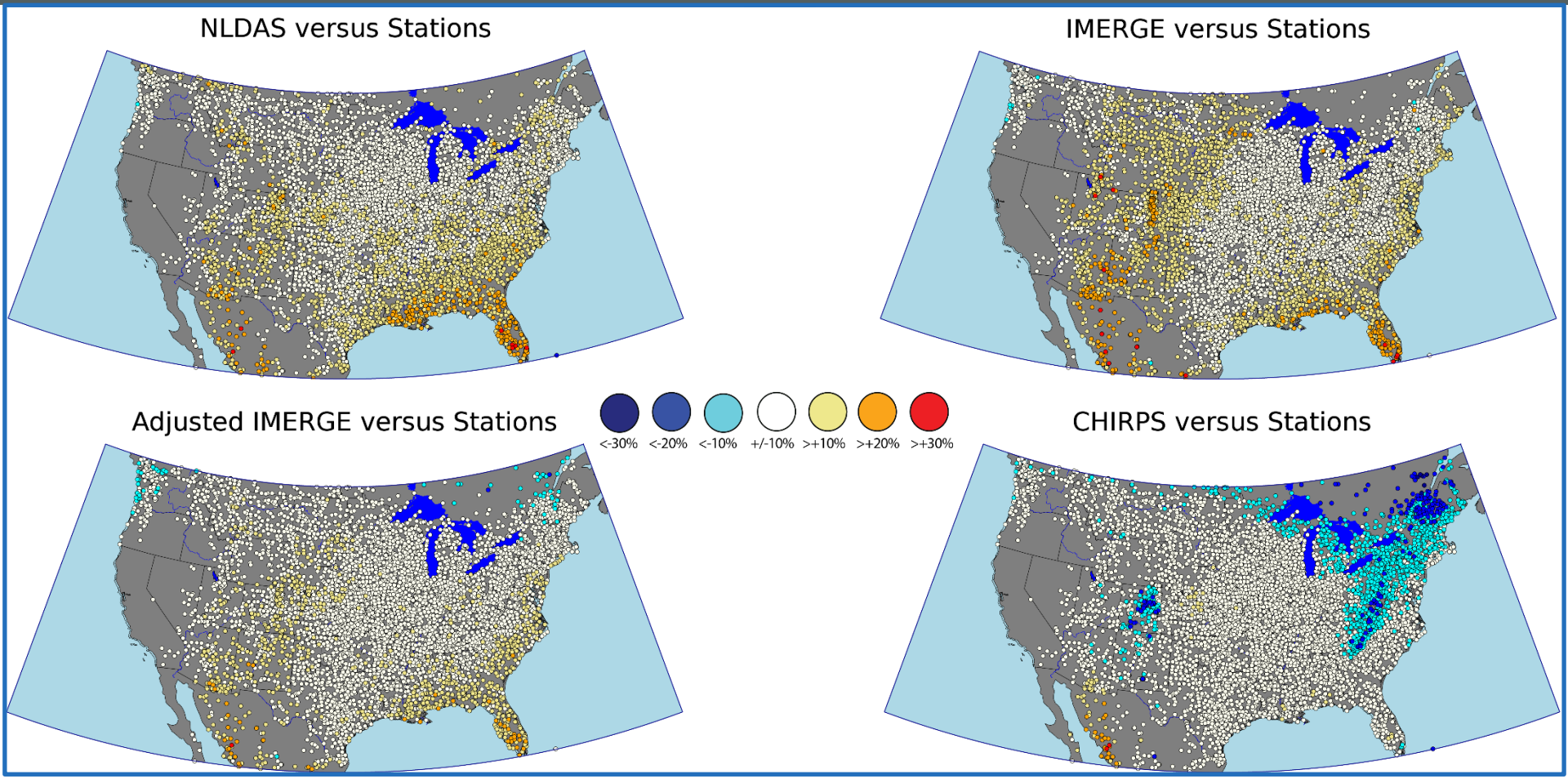
Maps of Dry Frequency Comparisons

August



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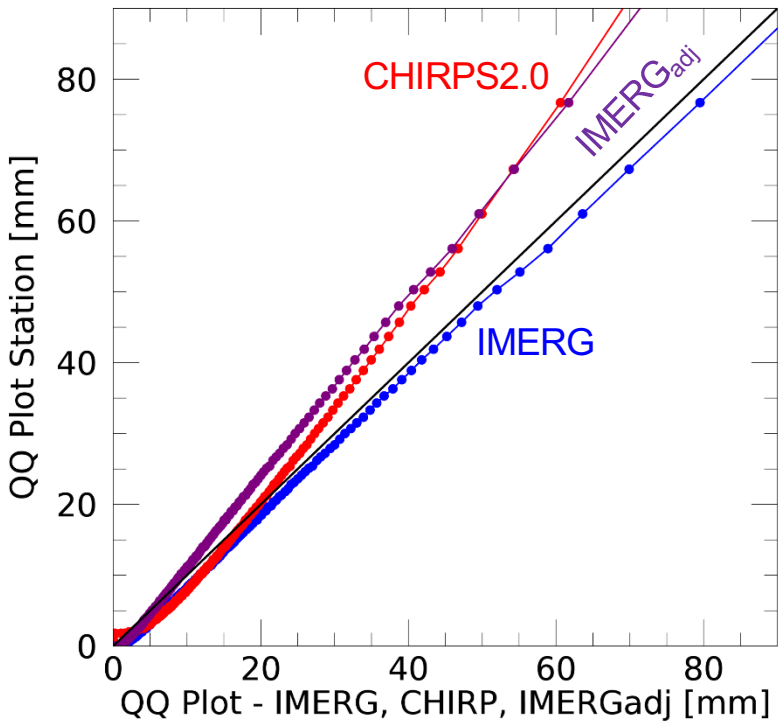
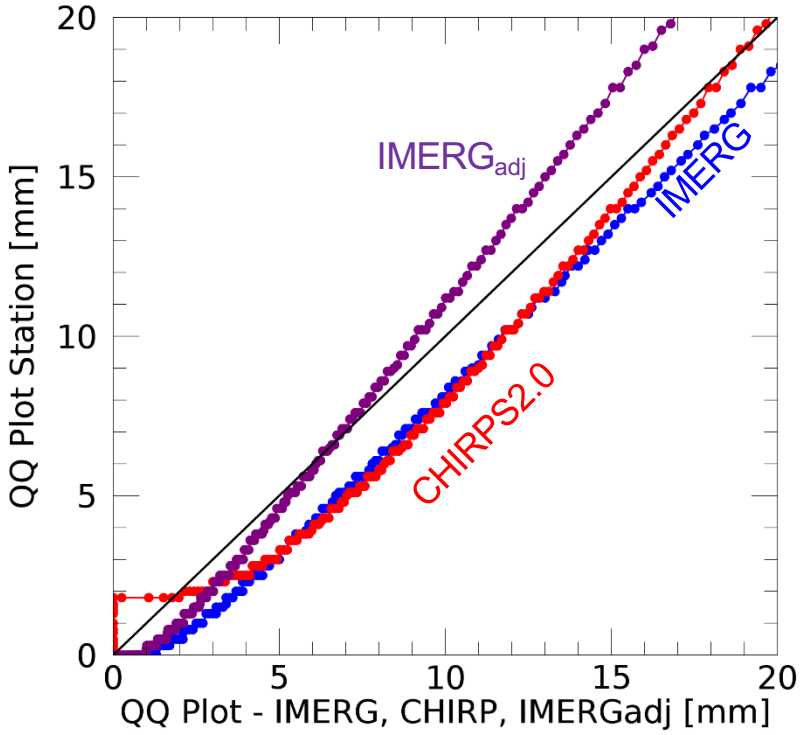
August GHCN Results IMERG QQ Plots





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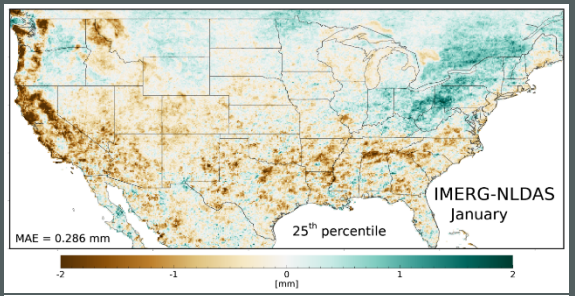
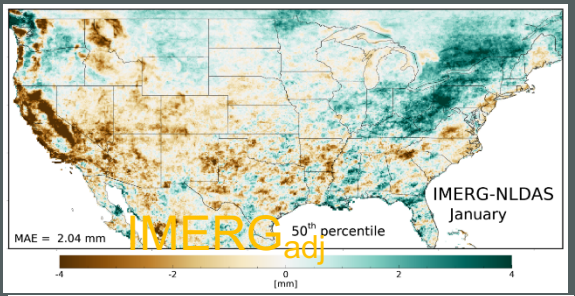
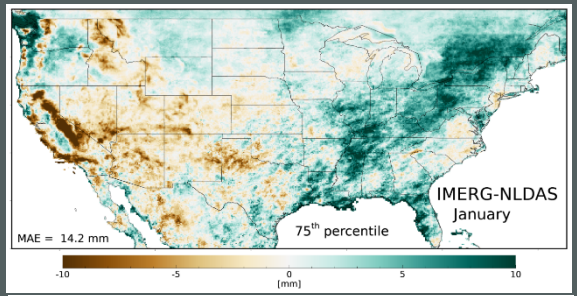
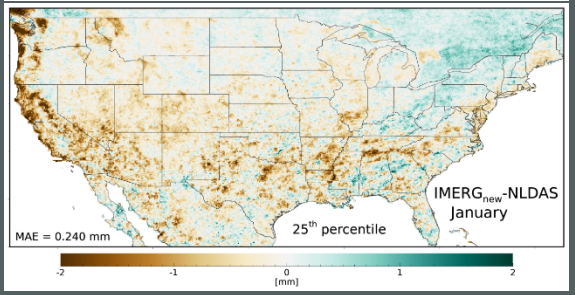
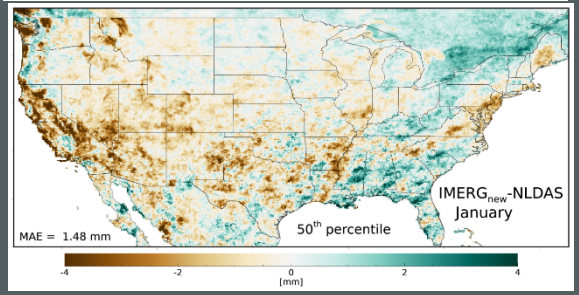
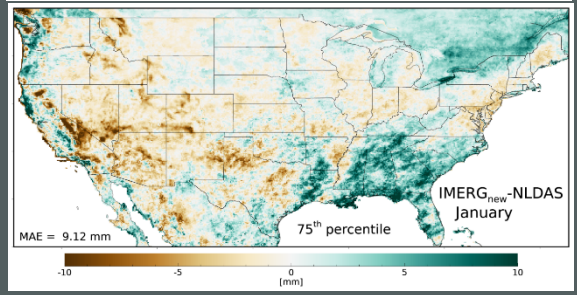
January IMERG/IMERGadj versus NLDAS

IMERG minus NLDAS

	25th Percentile	50th Percentile	75th Percentile
IMERG			
$IMERG_{adj}$			

Background

In 1995 I had a dream ….

In 1996 I drove to California and started graduate school …

In 1997 became fascinated by potential humanitarian applications of climate science and satellite data …

And remain so today …