Satellite Rainfall Products: Joel Michaelsen's Humanitarian Legacy – CHIRPS

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Climate Diagnostics and Prediction Workshop

2018.10.24 UCSB, Santa Barbara, Ca.

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chg.ucsb.edu/data/chirps

Climate **H**azards center **I**nfra**R**ed **P**recipitation with **S**tations

CHIRPS

- CHIRPS developed by Famine Early Warning Systems Network (FEWS NET)

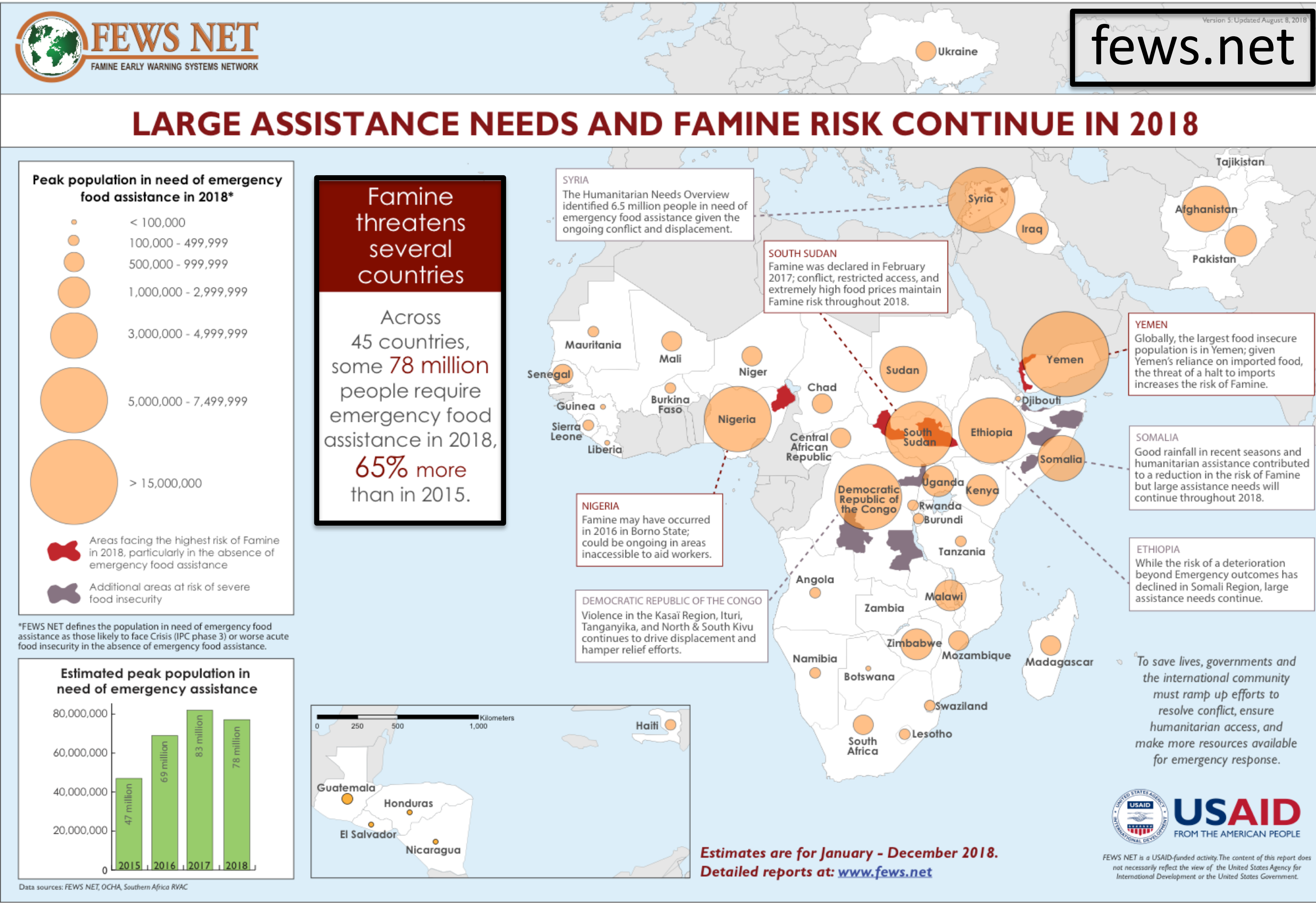
- CHIRPS designed for agricultural drought monitoring.

- CHIRPS process as transparent as possible.
  - Lots of supporting diagnostic files, open to adding more.

- Adding station data improves CHIRPS.
  - Reporting crisis.

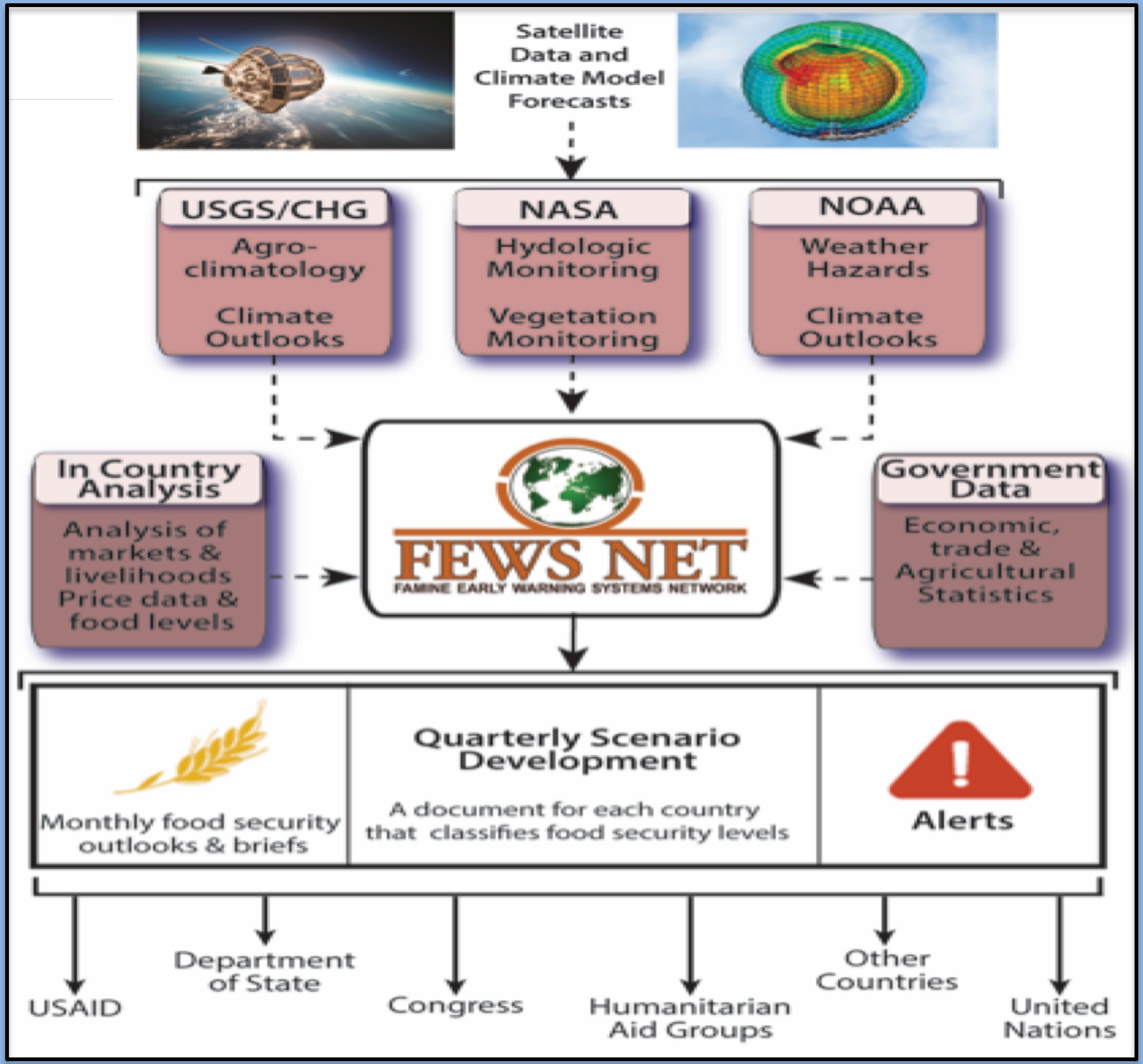
- CHIRPS v2.0 downloaded from 1165 unique IP addresses in September 2018.

- Three products,
  - **CHIRP** satellite, no stations, **pentads** w/ 2 day lag
  - **CHIRPS prelim**: CHIRP + GTS/Conagua stations, **pentads** w/ 2 day lag
  - **CHIRPS final**: uses all stations, **pentad, monthly** w/ ~3 week lag



FEWS NET provides objective, evidence-based analysis to help government decision-makers and relief agencies plan for and respond to humanitarian crises.

Drought Monitoring



Africa datasets: ARC2 (1983-present) RFE2 (2000-present) TAMSAT-3 (1983-present)

Table 1. Non-exhaustive overview of freely available (quasi-)global gridded *P* datasets. If a particular dataset is available in different spatial resolutions or in different variants we only listed the "best" one (e.g., we list the gauge-adjusted 3B42 variant of TMPA rather than the non-gauge-adjusted 3B42RT variant). The datasets are sorted first by source and then alphabetically by short name. MSWEP has been added for the sake of completeness.

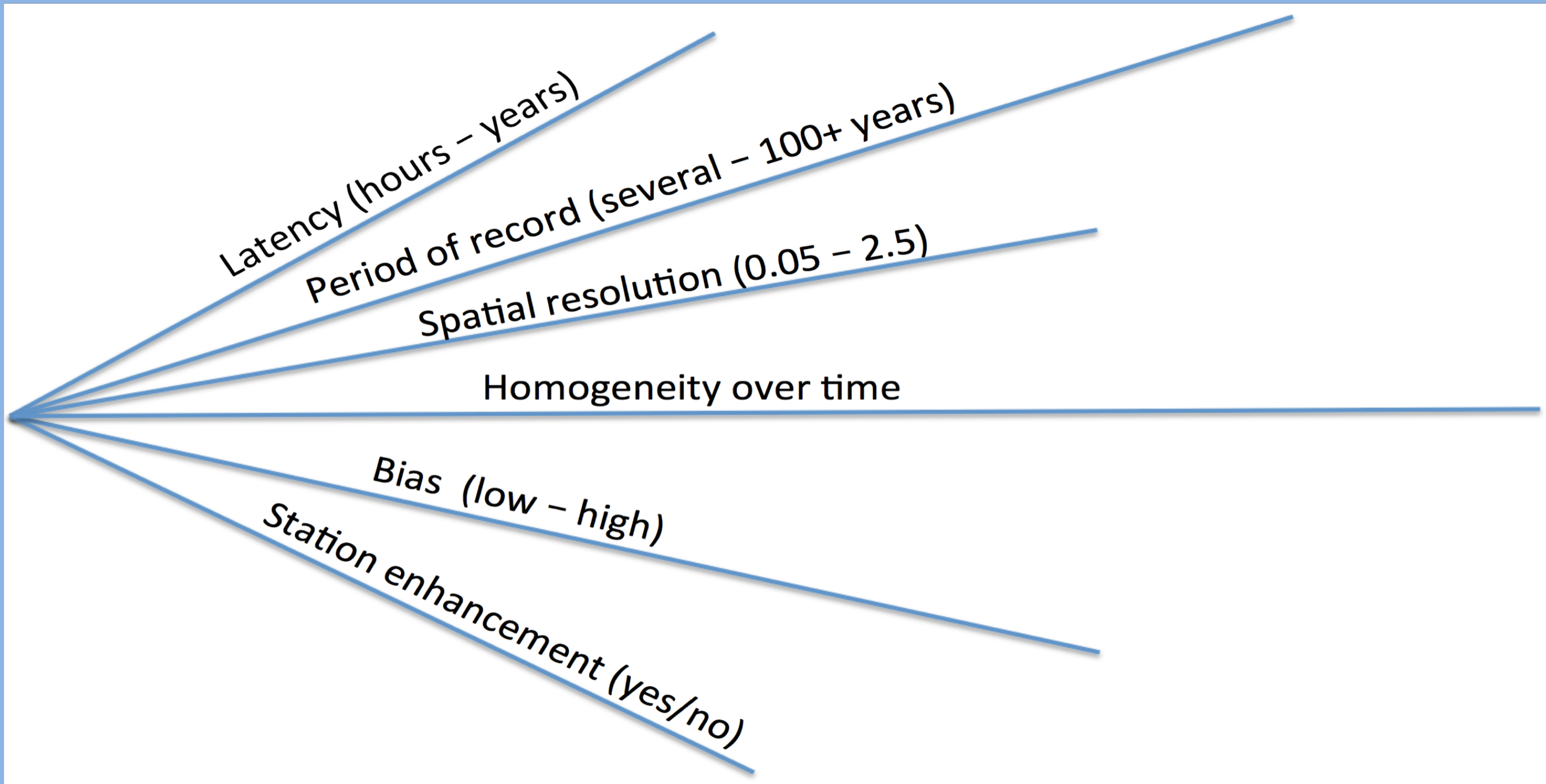
	Short name	Full name and details	Data source(s)	Spatial resolution	Spatial coverage	Temporal resolution	Temporal coverage	Reference(s)
1	CPC Unified	Climate Prediction Center (CPC) Unified	Gauge	0.5°[a]	Global	Daily	1979–present	Xie et al. (2007), Chen et al. (2008)
2	CRU	Climatic Research Unit (CRU) Time-Series (TS)	Gauge	0.5°	Global	Monthly	1901–2014	Harris et al. (2013)
3	GPCC	Global Precipitation Climatology Centre (GPCC) Full Data Reanalysis and First Guess	Gauge	0.5°[b]	Global	Monthly	1901–present	Schneider et al. (2014)
4	PREC/L	PRECipitation REConstruction over Land (PREC/L)	Gauge	0.5°	Global	Monthly	1948–present	Chen et al. (2002)
5	UDEL	University of Delaware (UDEL)	Gauge	0.5°	Global	Monthly	1901–2014	Matsuura and Willmott (2009)
6	CHIRPS	Climate Hazards group Infrared Precipitation with Stations (CHIRPS)	Gauge, satellite	0.05°	50° N–50° S	Daily	1981–present	Funk et al. (2015a)
7	CMORPH	CPC MORPHing technique (CMORPH)	Gauge, satellite	0.25°	60° N–60° S	Daily	1998–present	Joyce et al. (2004)
8	GPCP-1DD	Global Precipitation Climatology Project (GPCP) 1-Degree Daily (1DD) Combination	Gauge, satellite	1°	Global	Daily	1996–2015	Huffman et al. (2001)
9	GSMaP-MVK	Global Satellite Mapping of Precipitation (GSMaP) Moving Vector with Kalman (MVK)	Gauge, satellite	0.1°	60° N–60° S	Hourly	2000–present	Iguchi et al. (2009)
10	IMERG	Integrated Multi-satellitE Retrievals for GPM (IMERG)	Gauge, satellite	0.1°	60° N–60° S	30 min	2014–present	Huffman et al. (2014)
11	PERSIANN-CDR	Precipitation Estimation from Remotely Sensed Information using Artificial Neural Networks (PERSIANN) Climate Data Record (CDR)	Gauge, satellite	0.25°	60° N–60° S	6 hourly	1983–2012	Ashouri et al. (2015)
12	TMPA 3B42	TRMM Multi-satellite Precipitation Analysis (TMPA) 3B42	Gauge, satellite	0.25°	50° N–50° S	3 hourly	1998–present	Huffman et al. (2007)
13	MERRA-Land	Modern Era Retrospective-Analysis for Research and Applications (MERRA)-Land	Gauge, reanalysis	$0.5° \times 0.67°$	Global	Hourly	1979–present	Reichle et al. (2011)
14	PFD	Princeton global meteorological Forcing Dataset	Gauge, reanalysis	0.25°	Global	3 hourly	1948–2012	Sheffield et al. (2006)
15	WFDEI	WATCH Forcing Data ERA-Interim (WFDEI)	Gauge, reanalysis	0.25°	Global	3 hourly	1979–2014	Weedon et al. (2014)
16	NCEP-CFSR	National Centers for Environmental Prediction (NCEP) Climate Forecast System Reanalysis (CFSR)	Reanalysis	0.3125°	Global	Hourly	1979–2010	Saha et al. (2010)
17	ERA-Interim	European Centre for Medium-range Weather Forecasts ReAnalysis Interim (ERA-Interim)	Reanalysis	0.25°[c]	Global	3 hourly	1979–2014	Dee et al. (2011)
18	JRA-55	Japanese 55-year ReAnalysis (JRA-55)	Reanalysis	1.25°	Global	3 hourly	1959–present	Kobayashi et al. (2015)
19	CHOMPS	Cooperative Institute for Climate Studies (CICS) High-Resolution Optimally Interpolated Microwave Precipitation from Satellites (CHOMPS)	Satellite	0.25°	60° N–60° S	Daily	1998–2007	Joseph et al. (2009)
20	SM2RAIN-ASCAT	Based on Advanced Scatterometer (ASCAT) data (Brocca et al., 2016)	Satellite	0.5°	Global	Daily	2007–2015	Brocca et al. (2014)
21	CMAP	CPC Merged Analysis of Precipitation (CMAP)	Gauge, satellite, reanalysis	2.5°	Global	5 day	1979–present	Xie and Arkin (1996, 1997)
22	MSWEP	Multi-Source Weighted-Ensemble Precipitation (MSWEP)	Gauge, satellite, reanalysis	0.25°	Global	3 hourly	1979–2015	This study

[a] 0.25° spatial resolution for the conterminous USA. [b] 1° spatial resolution for 2014–present. [c] ~ 80 km effective spatial resolution (i.e., the resolution of the employed atmospheric model).

MSWEP: 3-hourly 0.25 global gridded precipitation (1979–2015) by merging gauge, satellite, and reanalysis data (HESS 2017)

Hylke E. Beck1 , Albert I. J. M. van Dijk2 , Vincenzo Levizzani3 , Jaap Schellekens4 , Diego G. Miralles5,6 ,Brecht Martens5 , and Ad de Roo1

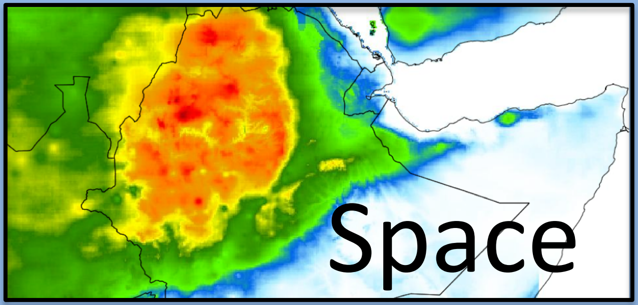
Things to consider when choosing a rainfall products



Latency: flash floods / trends
Resolution: scale of interest
Bias: agroclimatology

PoR: Index Insurance
homogeneity: trends/anomalies
added stations: fine tuning

Overview of CHIRPS process



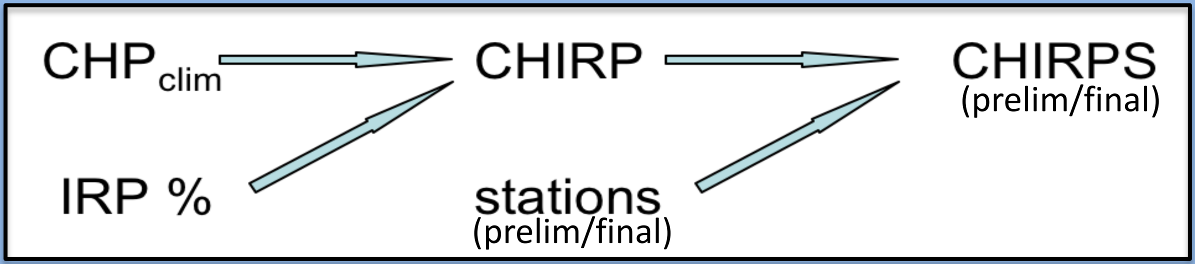
& Time

1) Create historic climatology **CHPclim.**
   captures spatial variability

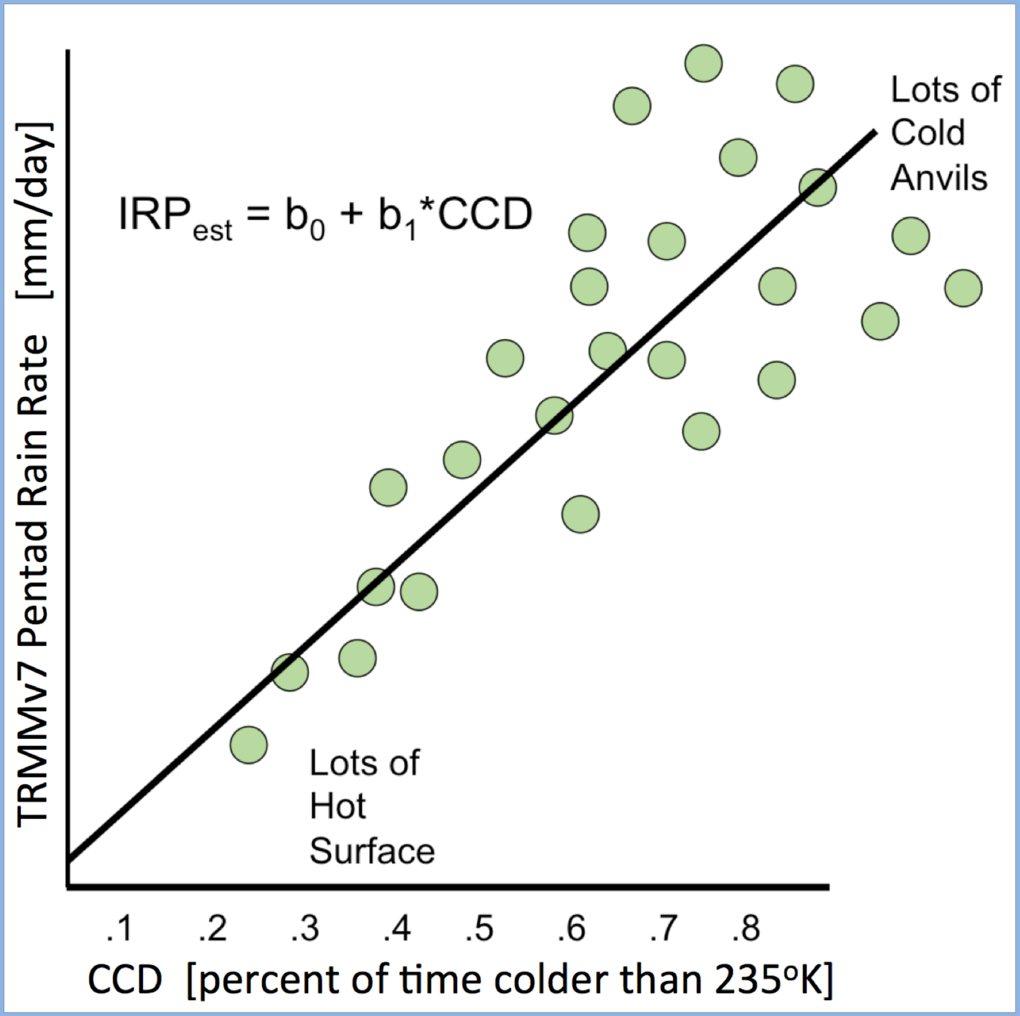
2) Convert IR data to precipitation estimate **IRP**
   Use TRMM-V7 data to determine coefficients b_0 and b_1
   IRP = b_0 + b_1*(Cold Cloud Duration Percent)

3) Apply time variability of IRP to CHPclim to make **CHIRP**
   CHIRP = CHPclim * (IRP %normal)

4) Blend in station observations with CHIRP to make **CHIRPS**

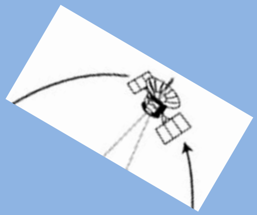


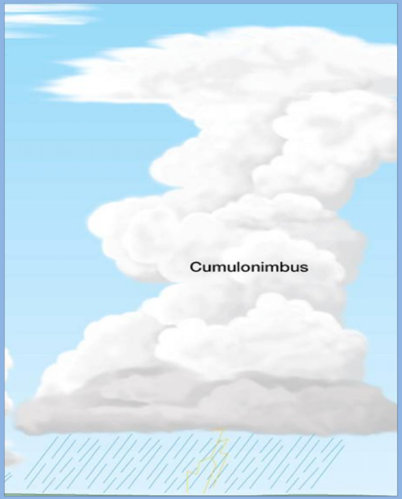
Convert IR data to precipitation estimate **IRP** at the **pentad** time step.



Y axis: Each dot is the daily rain rate [mm/day] based on TRMM-V7 data for given 0.25 degree pixel and pentad.

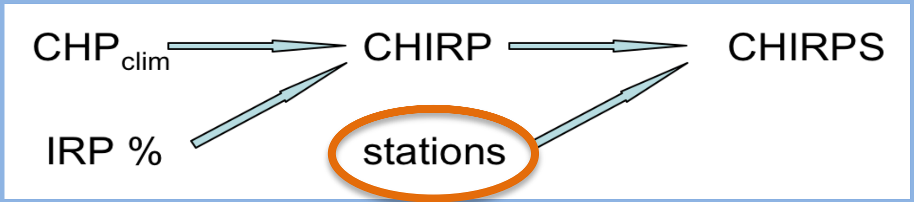
X axis: Each dot is CCD calculated over all (240) half-hourly IR values for given pixel and pentad.





IRP = b_0 + b_1*(Cold Cloud Duration Percent)

Station data Quality Control



- Badness plots
- GSOD duplicates
- Too big/ too small
- False zeroes (GTS, GSOD)
- zscore out of bounds (> 4)
- > 2000 or > 5 * CHIRP
- **Reality checks**

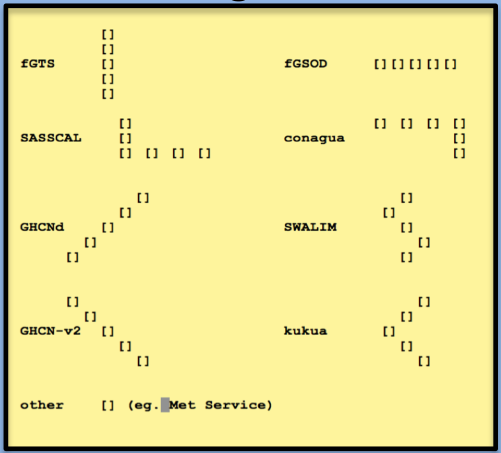
<u>Station sources last month</u>

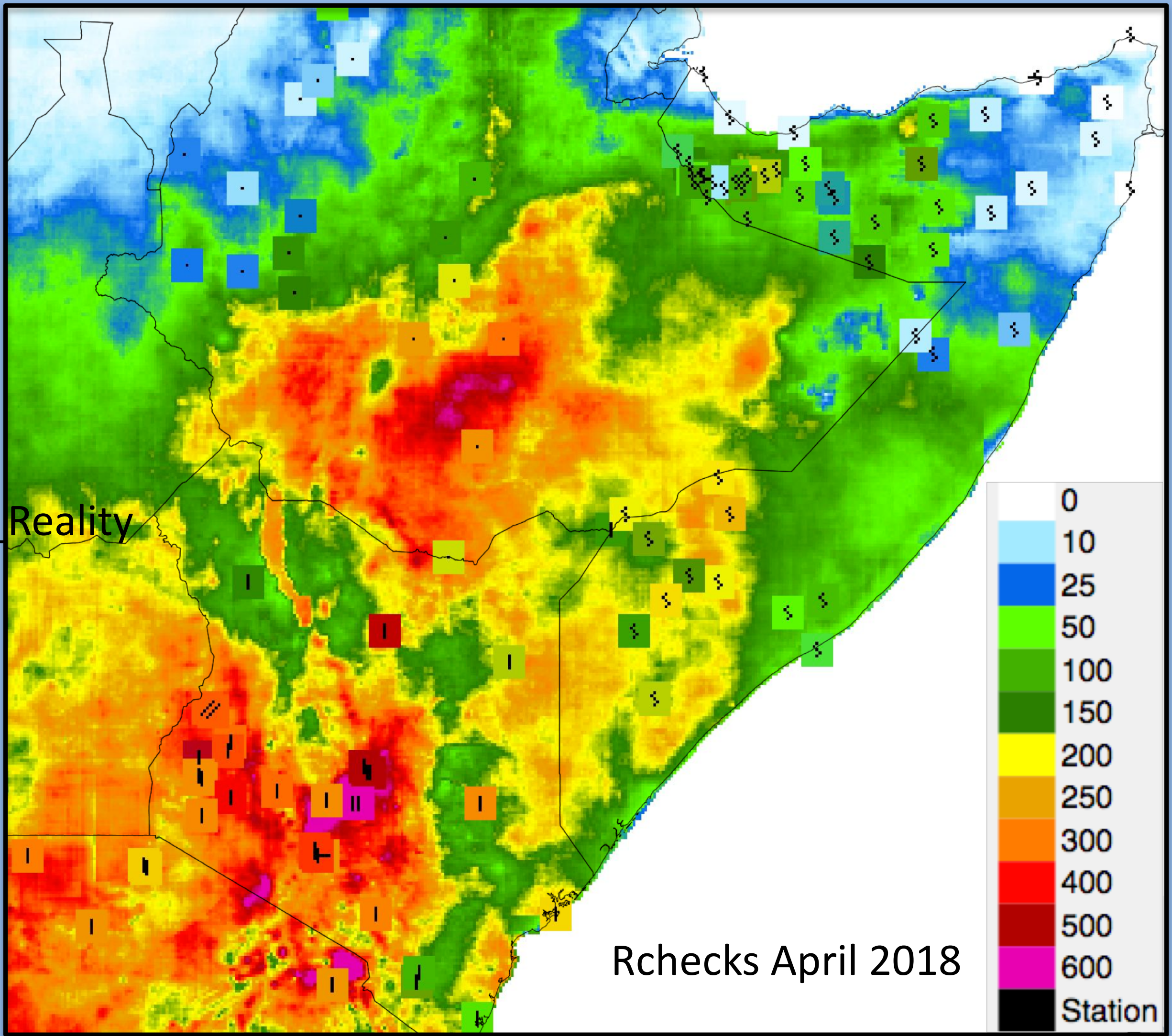
GHCN-v2
GHCN-daily
fGTS
fGSOD
Ethiopia
IDEAM
Conagua
SASSCAL
SWALIM

Reality checks using Early Warning Explorer (EWX)

chg-ewxtest.chg.ucsb.edu

Rchecks legend





Station center value = station_seqnum in CSCD database

chg-wiki.chg.ucsb.edu/wiki/CHIRPS_Reality_Checks

April 2018

Rchecks Highlights

East Africa Consistent with reports of much higher than normal rainfall, which led to a number of disasters and impacts in east Africa, CHIRPS shows highly above average rainfall in April 2018. Extreme rains (>100 mm in 24 hrs) and flash flooding were reported on several days in cities across the country, incl. Marsabit (4/13-4/14), Garissa (4/16-4/17), and Kitui (4/23-4/24). Between 4/9-4/26 the Red Cross estimates 211,000 people were evacuated and 50 people were killed by damages Floodlist. Final April 2018 CHIRPS data is based on a relatively high number of stations in Kenya- more than normal- and CHIRPS estimates and stations are in general agreement, albeit in some areas CHIRPS is probably overestimating to some degree (see other entries below). CHIRPS data shows April rainfall was >100 mm above average in many areas of southern Ethiopia, southern Somalia, Kenya, Uganda, and Tanzania. Anomalies ~ 300mm are shown in some of the high elevation zones. The spatial pattern and size of anomalies are overall similar to those shown in ARC2 data.

Somalia SWALIM and Ethiopia NMA contributions to CHIRPS: SWALIM and Ethiopia NMS stations were highly influential for CHIRPS- reports in some areas of southern Somalia, southern Ethiopia, and eastern Kenya were ~100mm lower than CHIRP estimates. Result is that while CHIRPS shows above average precip across region, some of these areas anaomlies are weaker than otherwise would be based on satellite estimate (e.g. ~54 mm vs 180 mm)

China Stations were important for correcting CHIRP estimates in central-northern china and southeastern china. ~60 stations reported contrasting anomalies to CHIRP, with above average rainfall in central-northern china and below average rainfall in southeastern china. CHIRP showed below average across most of southern china. Could not find news reports to validate, but number of stations in agreement give support for CHIRPS accuracy.

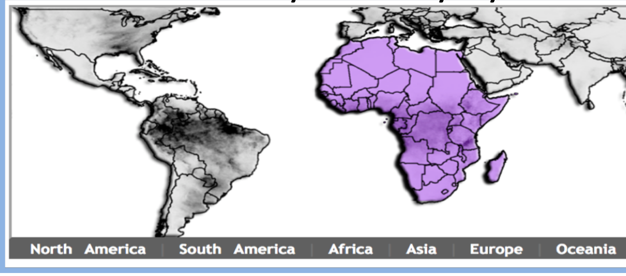
Southeast Asia Stations were important for correcting CHIRP to above average rainfall in Thailand and northern area of Laos. ~25 stations show general agreement about this.

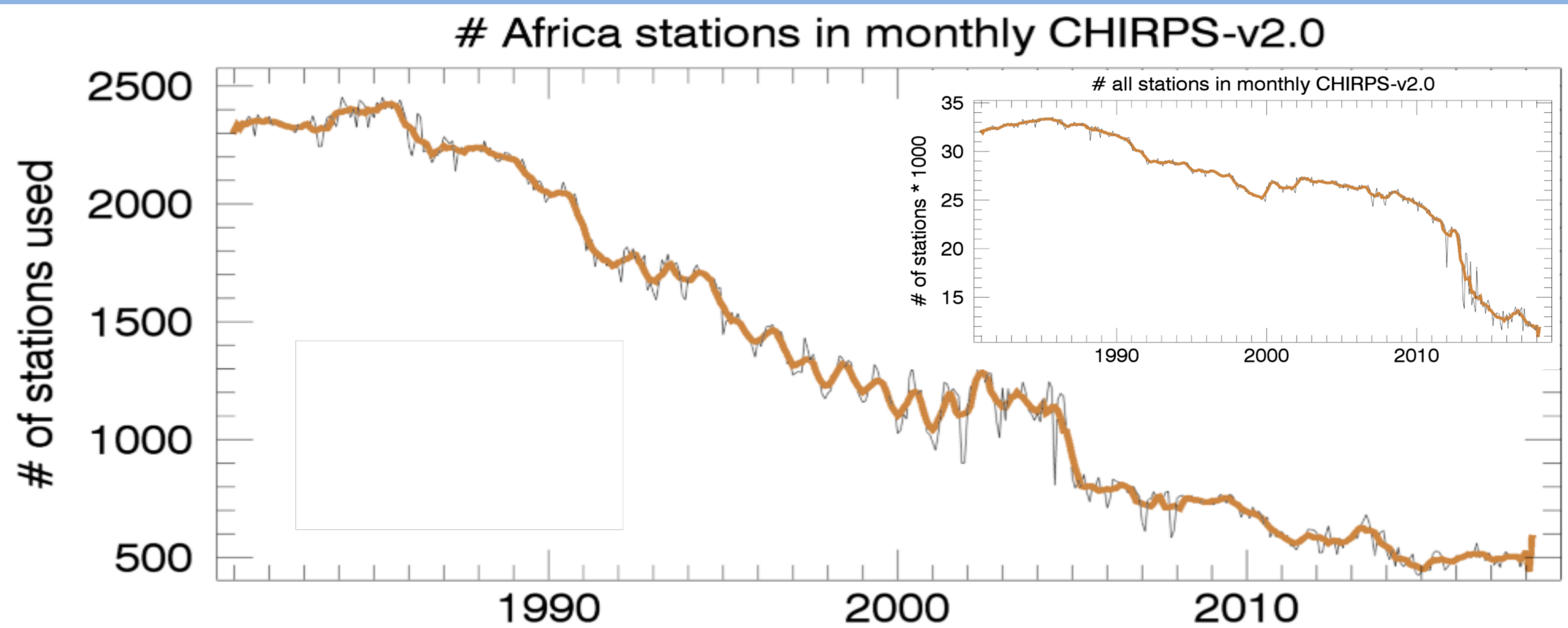
CHIRPS improvements During Rchecks on the first version of CHIRPS Final, it was identified that were substantially fewer stations than usual in east Africa and that CHIRP was overestimating rainfall in some areas. The combination of these factors gave concern that it might be reducing accuracy of CHIRPS data this month. Rcheckers and Pete Peterson, data curator, worked together to identify why so few stations were getting through (explained below). After these efforts, which resulted in a more stations being included and other positive outcomes, the final CHIRPS final is regarded with confidence. Including of a higher number of stations helped correct CHIRP overestimation in some areas e.g. coastal Kenya now shows ~150mm as opposed to ~300mm, which is more in line with stations, and Kilimanjaro shows values closer to ICPAC-blended data from bulletins. Positive outcomes of these efforts are better station coverage in east Africa in April 2018, identification of a screening step that needs to be evaluated more closely, and some of the added stations were in support of CHIRPS estimates, which is always great see. The reason for the initial lack of stations was identified- it was a data quality screening step (false-zero screening) that reduced 26 available GTS stations to 2. GSOD were reduced also such that Kenya only had 4 stations in CHIRPS. The hypothesis is that two factors in processing reduced number of days with reports to below the required threshold for them to be used for monthly totals. One factor was that there were no GTS reports on the GTS ftp site for one day (4/29), which counted against the monthly tally for the stations. Two, there may have been days where reports of 0mm were incorrectly identified as false, potentially b/c of extremely high CHIRP values. To get the stations back in Pete omitted the false zero screening step in east Africa countries. Screening steps are one of the processing features that will be revisited in the planned CHIRPS v3.0. In the meantime, an extra check may be introduced to processing prevent this type of problem.

Contributors: Laura Harrison, Will Turner, Marty Landsfeld

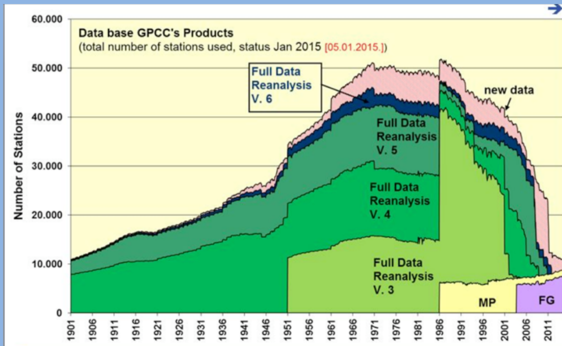
Reporting crisis

Stations Used by Country by Month



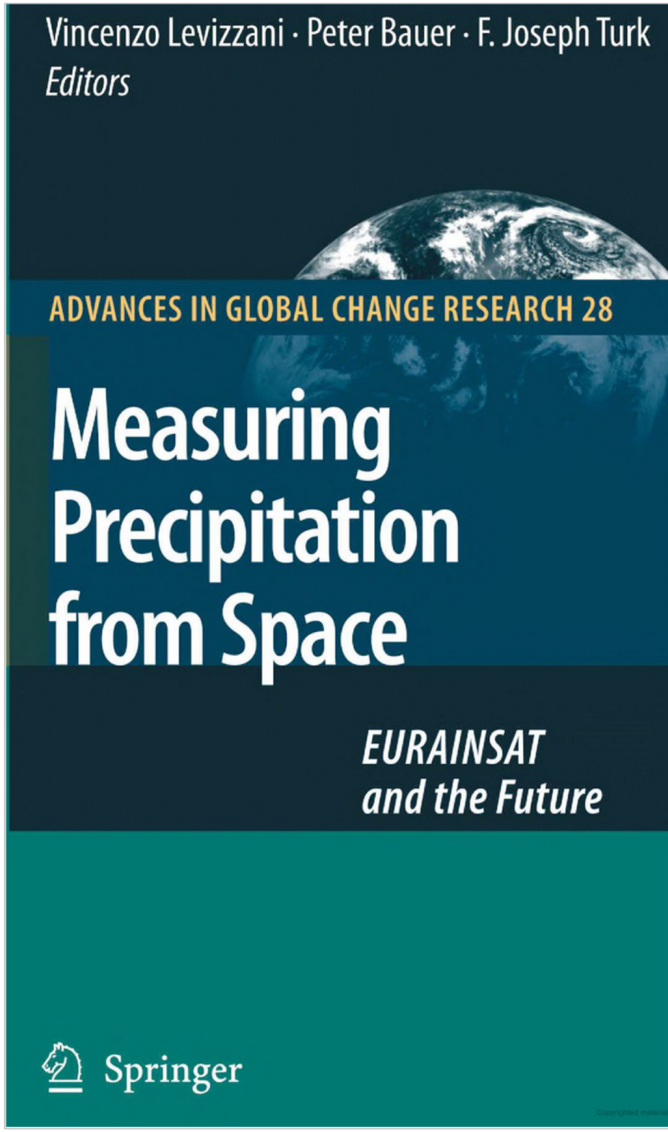


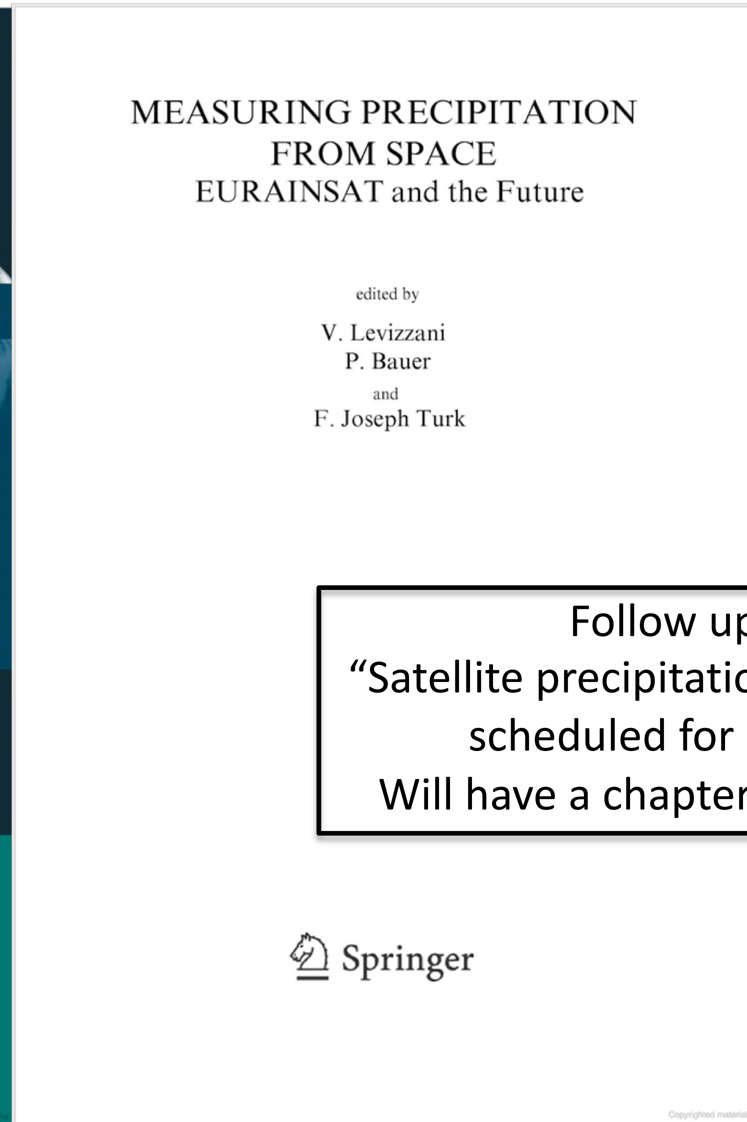
Met Services under reporting.
Tried to monetize data, but nobody paid.
Gauges break down, not replaced,
Lag in reporting.
GPCC sees similar decline.



Open Question:
How do we get more station data into our precipitation products?

Measuring Precipitation from Space EURAINSAT and the Future 2007
Editors: Levizzani, V., Bauer, P., Turk, F. Joseph 52 papers




MEASURING PRECIPITATION FROM SPACE
EURAINSAT and the Future

edited by

V. Levizzani
P. Bauer
and
F. Joseph Turk

Springer

Follow up book
“Satellite precipitation measurement”
scheduled for end of 2018
Will have a chapter on CHIRPS v2.1

CHIRPS v2.1

- New CHPclim
  - Starts with 29k locations used in current CHIRPS,
  - adds another 1000+ from new sources,
  - adds in 72k GPCC values and
  - finishes with 25k FAO values
  - Uses moving window across whole globe, not with 50+ separate tiles
- Fixed degenerative CCD locations
- New CHIRP calculation has extra correction term to fix general underestimated low vales and overestimated high values stations
  - **CHIRP** = CHPclim * (IRP %normal) + **correction**
- No duplicates in the station blending step
- Available…… soon!

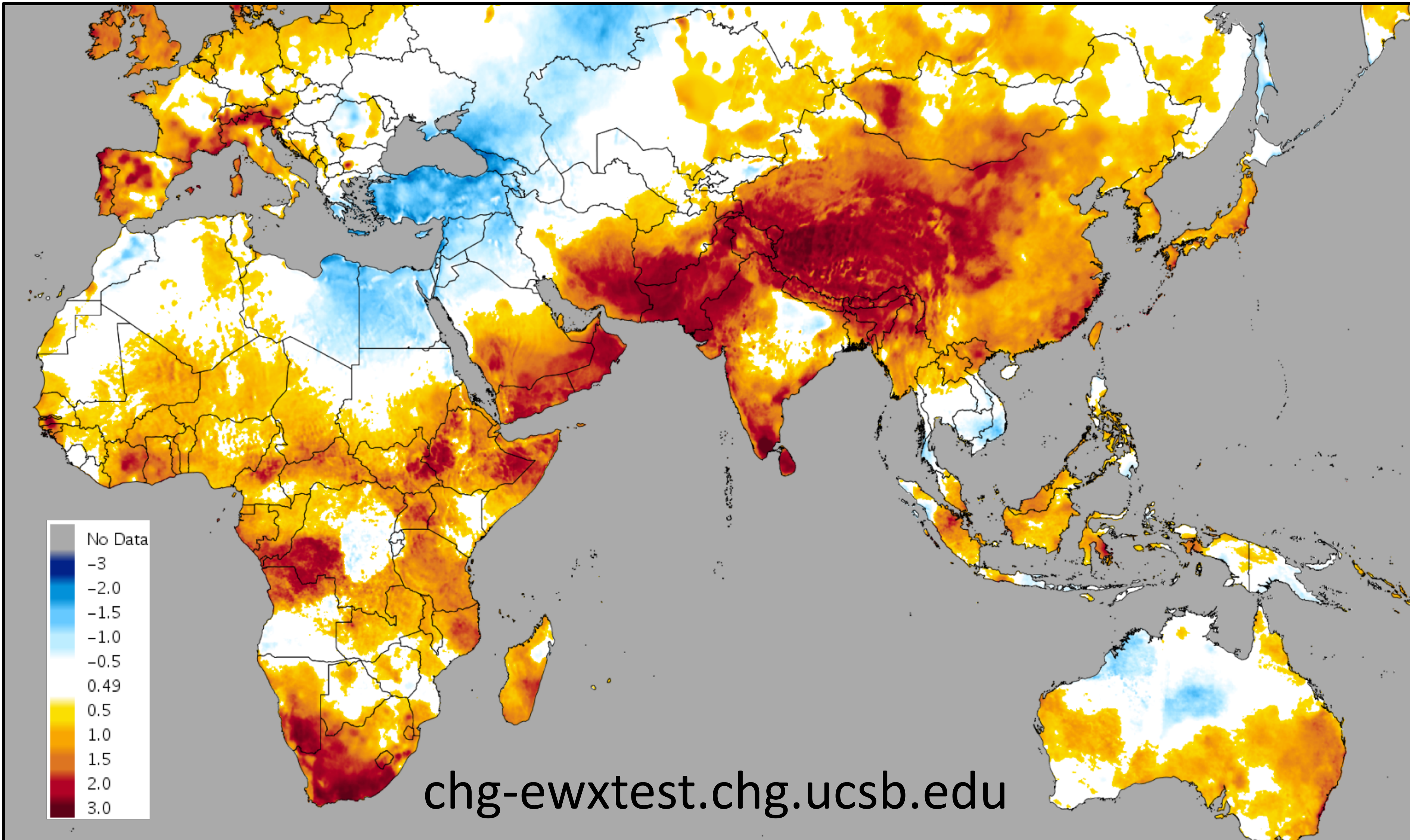
CHIRTSmax: monthly Tmax CDR

- $0.05^0 \times 0.05^0$ spatial resolution
- Monthly time step
- Over land
- 60S-70N latitude range
- 1983-2016 temporal range

- Next will go from a Climate Data Record to a monitoring product

- Take a look at CHIRTSmax here
  - chg-ewxtest.chg.ucsb.edu

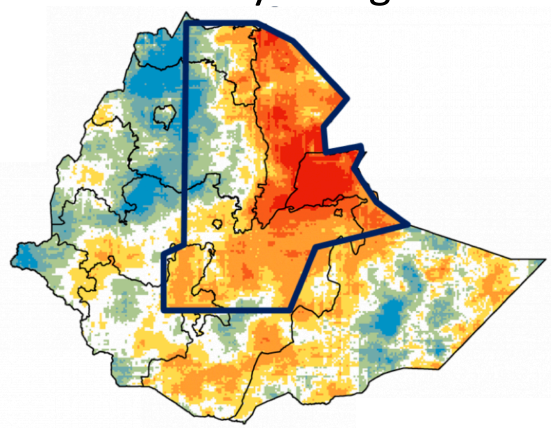
CHIRTSmax standardized anomaly for December 2016



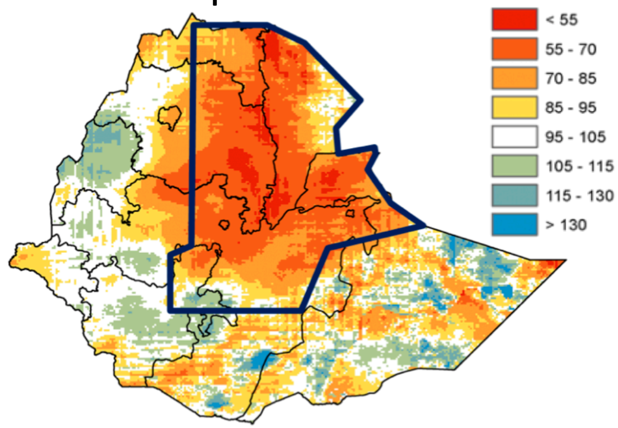
Food security emergency in central/eastern Ethiopia follows worst drought in more than 50 years
http://www.fews.net/east-africa/ethiopia/alert/december-4-2015

2015 Rains as a % of 1981-2014 average

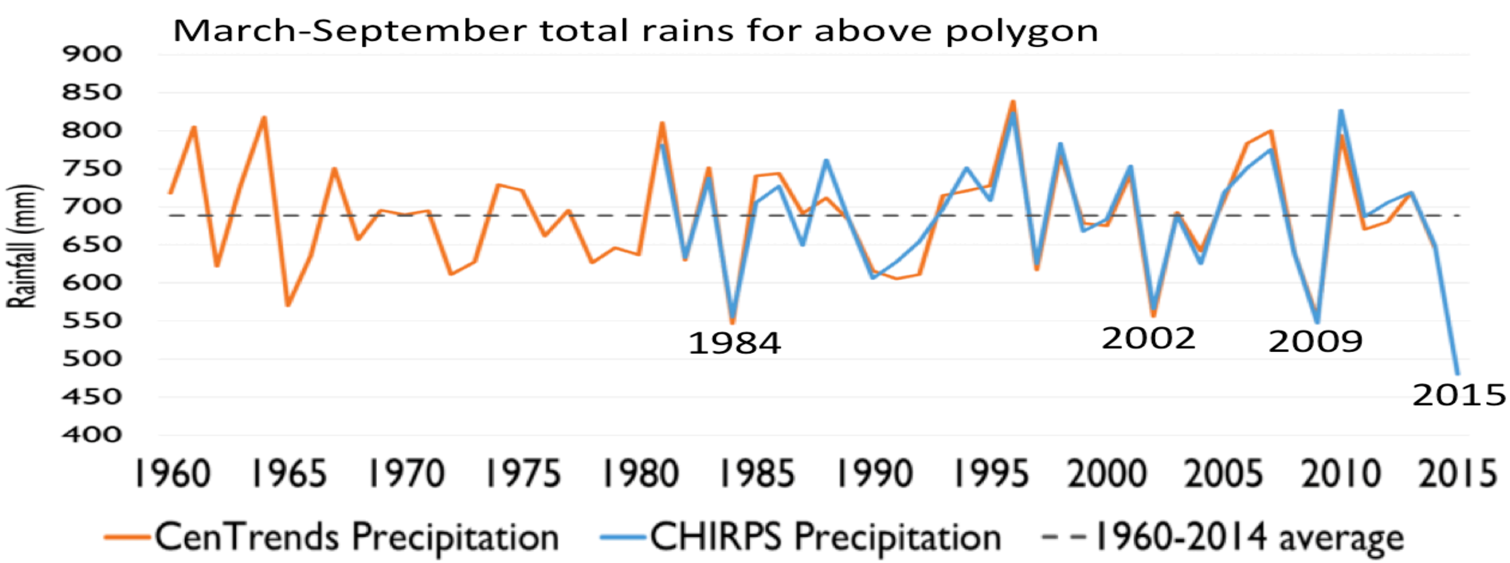
Feb-May - Belg



Jun-Sep - Kiremt



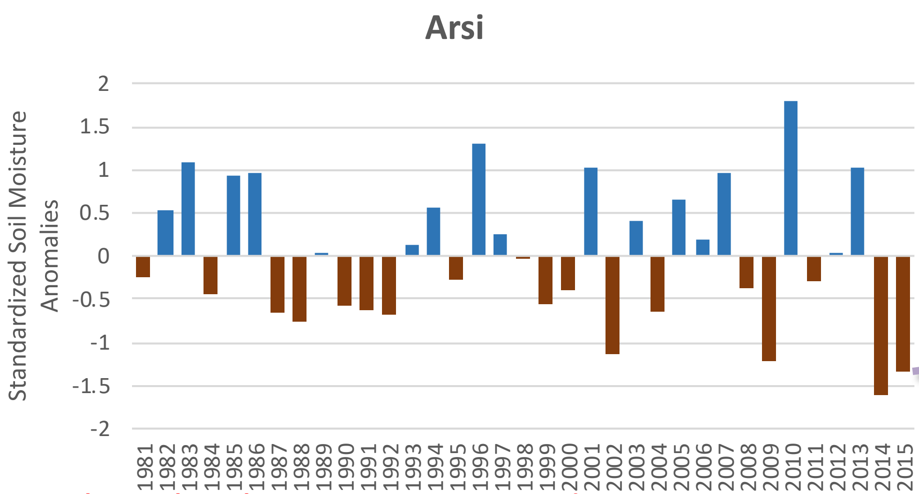
Ethiopia Population Density

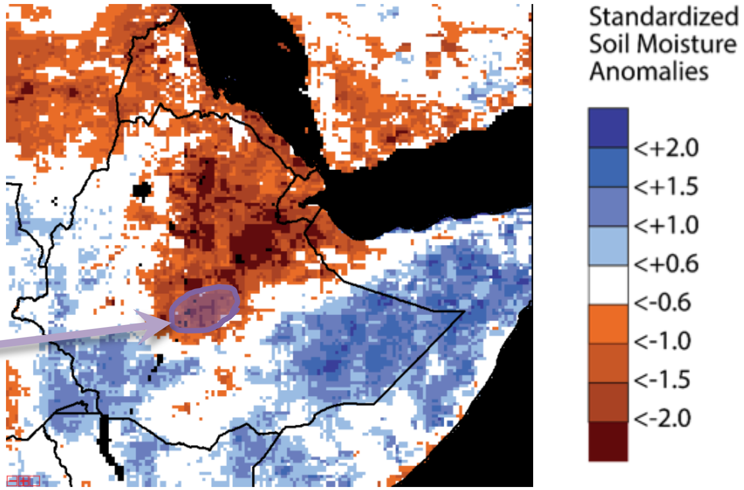


Daily CHIRPS in FEWS NET Land Data Assimilation System (FLDAS) provides Soil Moisture

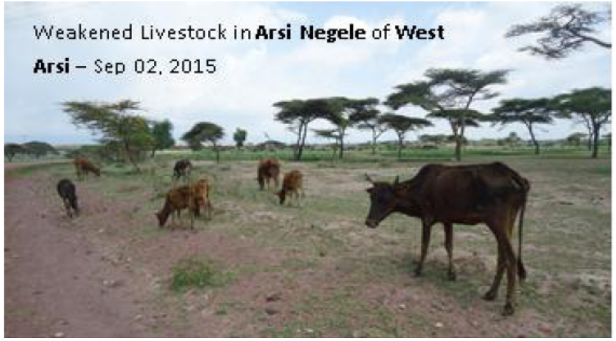
Arsi Assessment: *"Both Belg and Kiremt rainfall were not favorable for seasonal agricultural activities due to high moisture Deficit … Signs of malnutrition are increasing"*

- Getachew Abate (FEWS NET) and Kelbessa Beyene (WFP)





Back-to-back most extreme dry seasons on record!



Closing thoughts

- Precipitation not a winner-take-all space.
  - Many precipitation datasets, what's your bulls-eye?
- CHIRPS does what it was designed to do very well.
  - High resolution, low latency, low bias, homogeneous, long period of record (38 years), good # of stations.
  - **Climatology** + **Cold Cloud Duration IRP** + **station data**
  - CHIRPS bridges the gap between long term climate records and near term drought monitoring.
  - New version 2.1 will be even better
- Reporting crisis: How to get more stations reporting?
- There are people behind the pixels.

Thank You Joel!

EOT

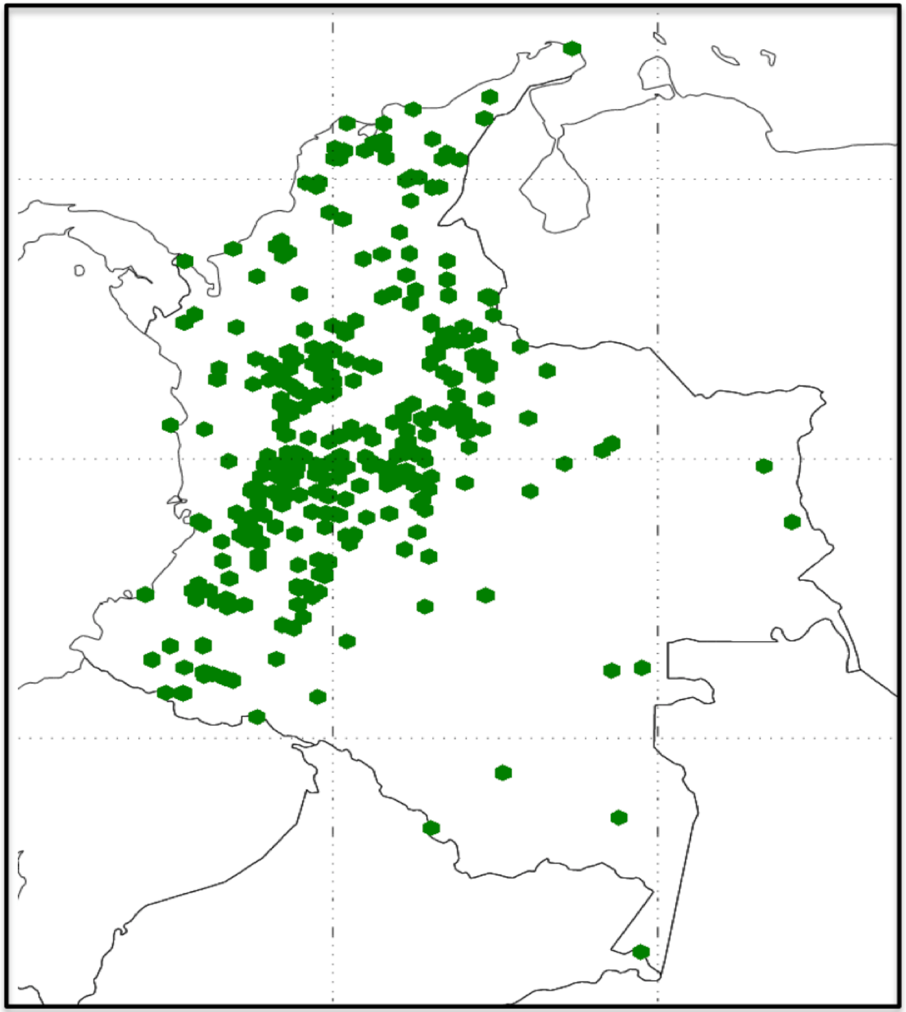
When I was a kid, Pluto was a planet!

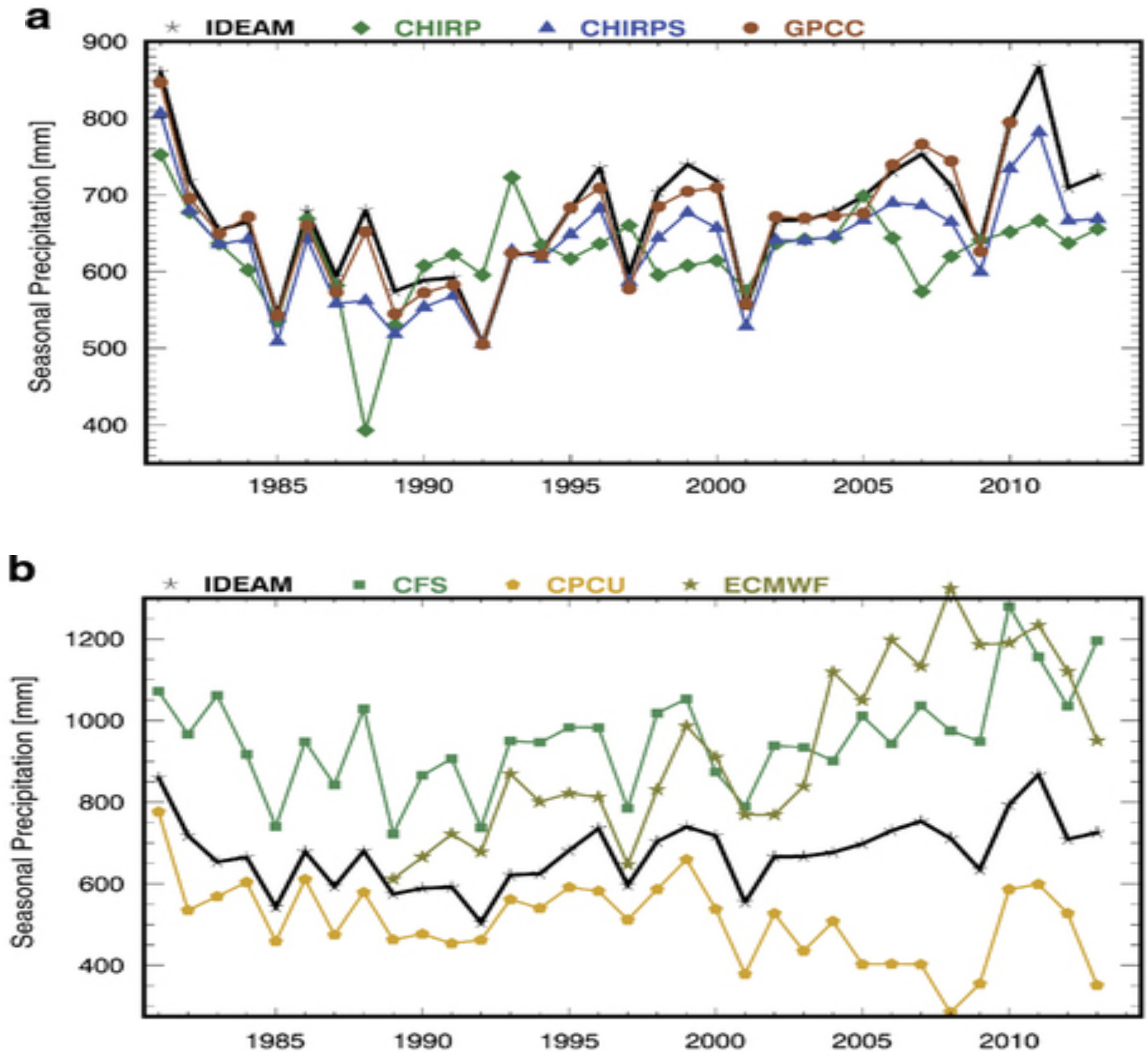
Colombia IDEAM SON

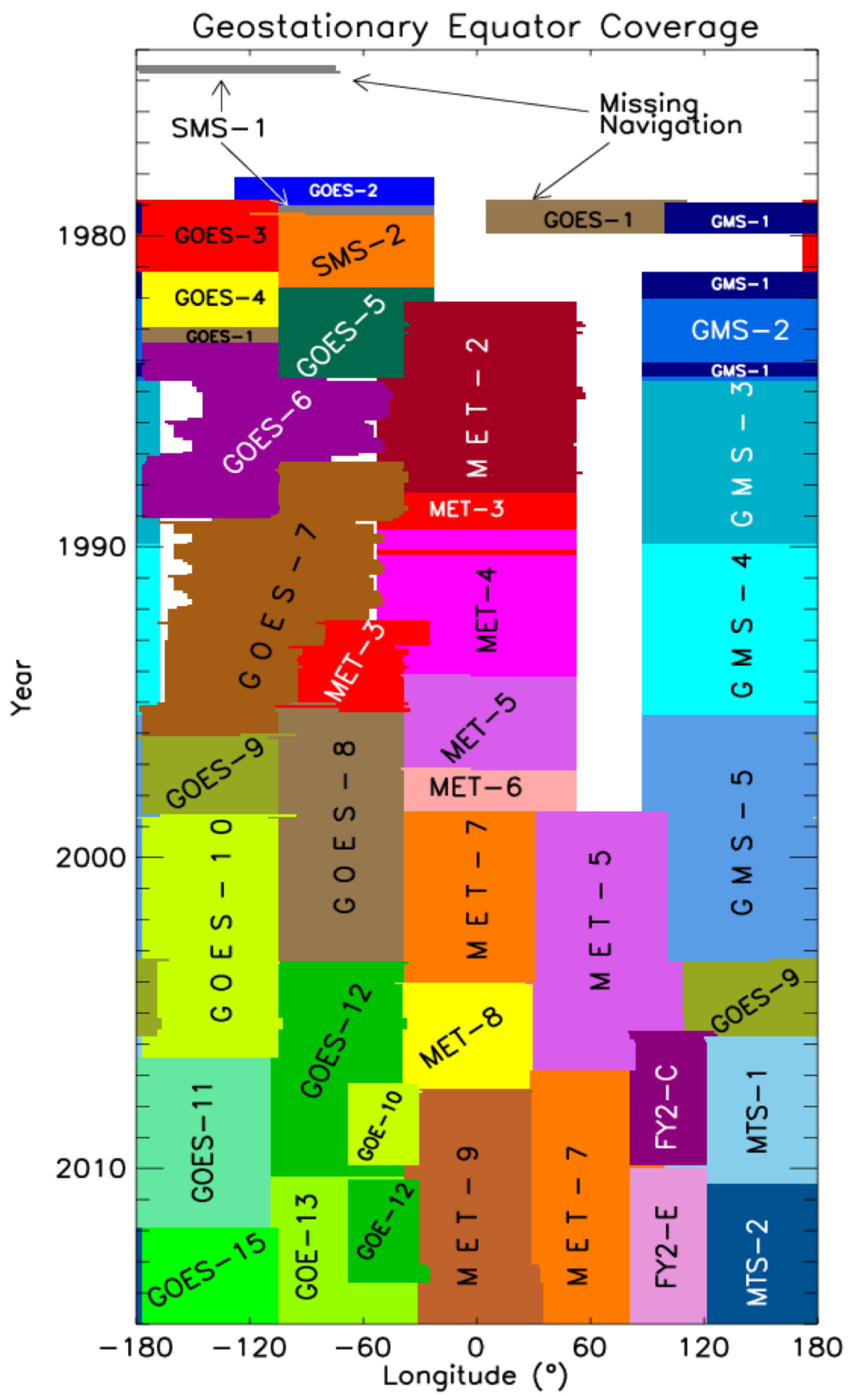
SON time series stats

Source	correlation	MAE
CHIRP	0.39	65.7
CHIRPS	0.97	38.3
CFS	0.76	221.0
CPC-Unif	0.45	154.0
ECMWF	0.76	203.0
GPCC	0.96	20.6

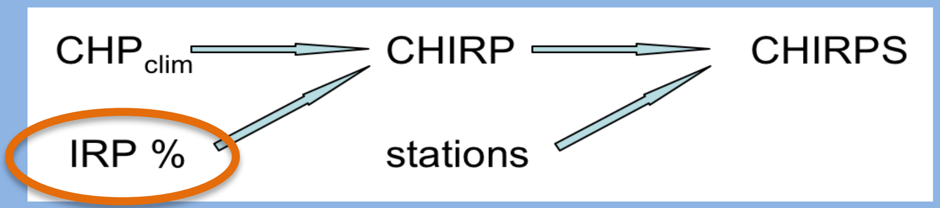
338 validation stations




a
IDEAM
CHIRP
CHIRPS
GPCC
Seasonal Precipitation [mm]
900
800
700
600
500
400
1985
1990
1995
2000
2005
2010
b
IDEAM
CFS
CPCU
ECMWF
Seasonal Precipitation [mm]
1200
1000
800
600
400
1985
1990
1995
2000
2005
2010



The Challenge of Geostationary Satellite Data



chg.geog.ucsb.edu/tools/geoclim

GeoCLIM

- Blend station information with satellite data to create improved datasets

- Analyze seasonal trends and/or historical climate data

- Analyze drought for a selected region by calculating the standardized precipitation index (SPI)

- Create visual representations of climate data, create scripts (batch files) to quickly and efficiently analyze large quantities of climate data

- View and/or edit shapefiles and raster files, and extract statistics from raster datasets to create time series. (video- GeoCLIM overview)