CPC International Drought Early Warning System for Food Security: Current Status and Challenges

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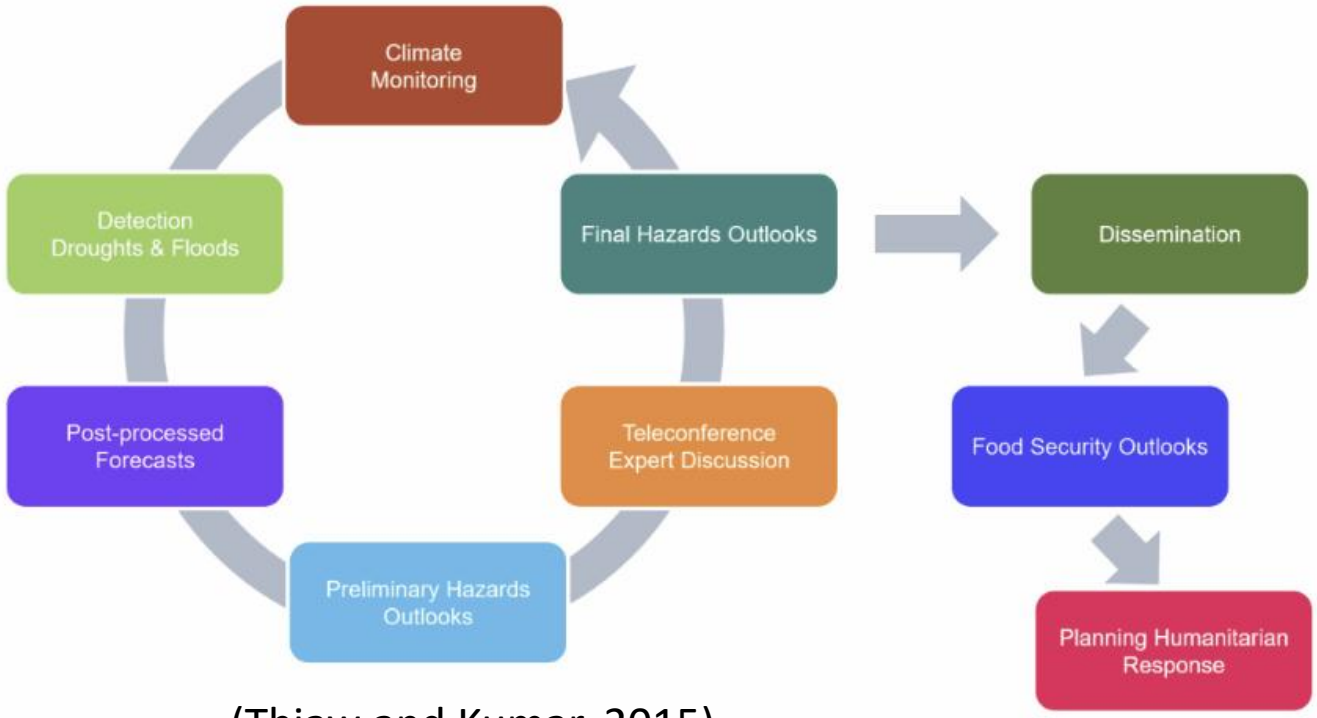
1. CPC/NCEP/NOAA International Desk
2. Entarian (ERT)
3. UCAR

Food Security Early Warning

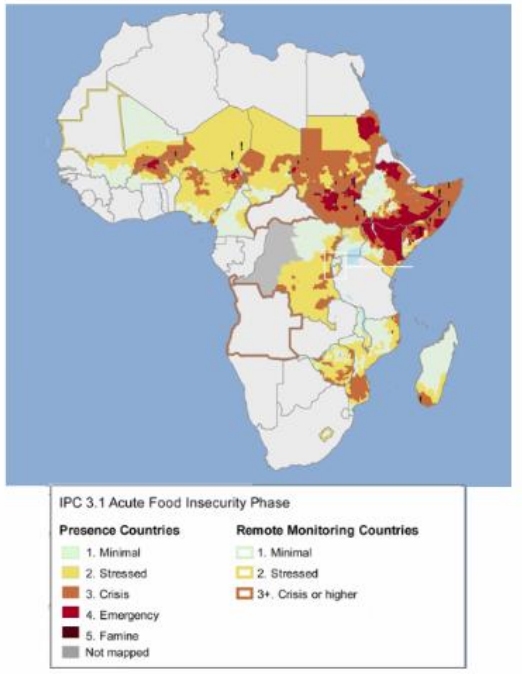
FEWS NET

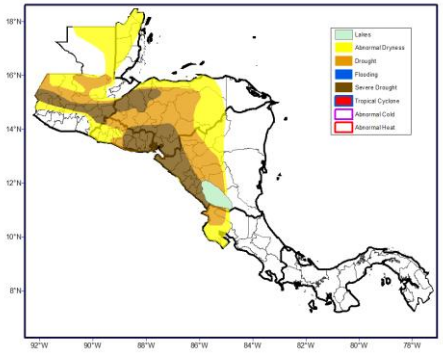
Famine Early Warning Systems Network

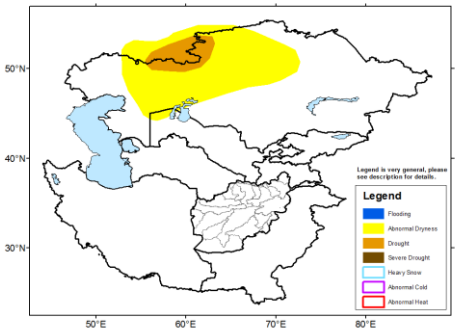
Integrating weather, climate, and land information to inform humanitarian response planning.



(Thiaw and Kumar, 2015)







- The CPC African Desk was established in 1994 at CPC to provide support for the prolonged drought in the Sahel.
- The CPC International Desks were an evolution of the African Desk services to the rest of the developing world including central Asia, and central America in order to meet needs of the United States Agency for International Development (USAID).
- NWS products and services are foundational to this U.S. foreign mission

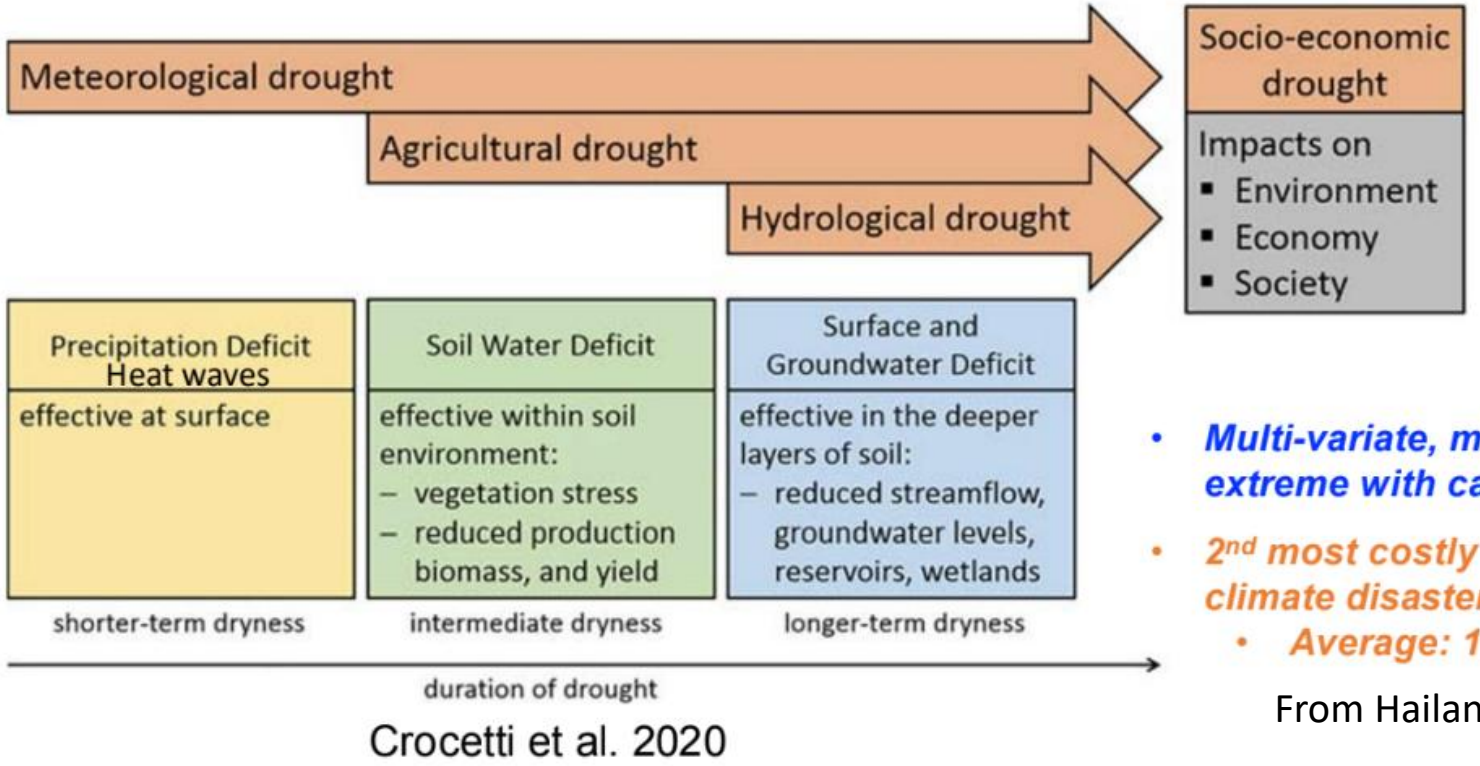
CPC International Drought Early Warning System

- Purpose:
  - To monitor in near-real time drought onset and evolution to support the hazards outlooks over international food insecure regions
  - To provide access to reliable drought information to global stakeholders and international users
  - Issue drought outlooks serve as basis for food security outlooks of the USAID Famine Early Warning Systems Network (FEWS NET)
  - Global coverage, focus on the regions that exhibit food security vulnerability

https://www.cpc.ncep.noaa.gov/products/international/drought/drought.shtml

Drought

- **A period of abnormally dry weather** sufficiently long enough to cause a shortage of water (AMS Glossary)



- ***Multi-variate, multi-faceted dry extreme with cascading impacts***
- ***2nd most costly weather and climate disaster in the U.S.***
  - ***Average: 11.2 billon/event***

From Hailan Wang

- Drought is one of the dominant natural hazards that could devastate many economic sectors, especially in the developing world.
- Drought monitors and outlooks are critical input for the FEWS NET food security outlooks that help decision makers respond to and plan for humanitarian crisis

International Drought Monitor: Convergence of Evidences

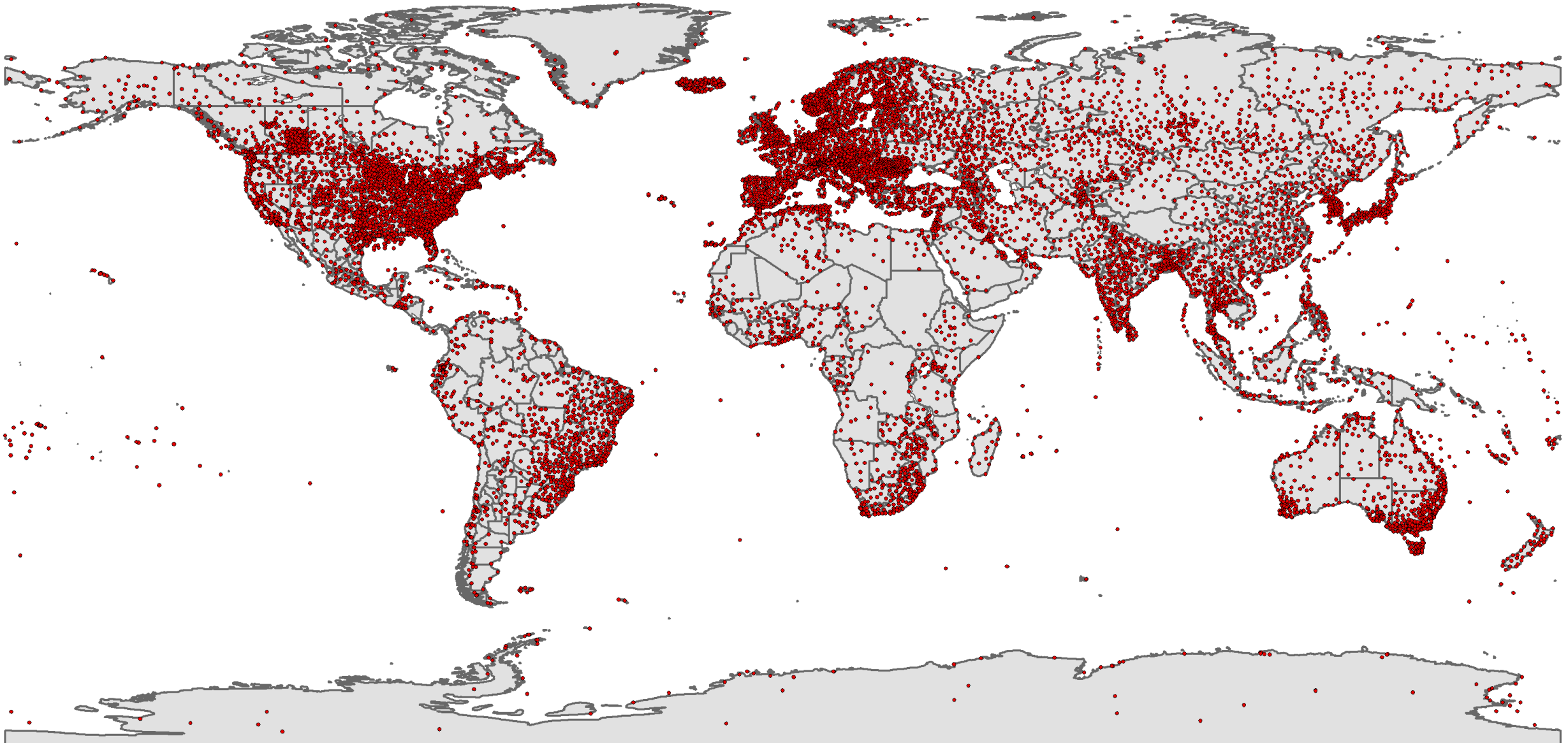
- Meteorological drought
  - Precipitation deficient (anomalous, anom. percent etc.) at multiple time scale, from 1week to 2 years
  - Multiple data: gauge based, satellite retrieval, merge/adjusted
  - Standardized Precipitation Indices (SPIs), from 1,3,6,12 to 24 months accumulated Prcp
  - Standardized Precipitation-Evapotranspiration Index (SPEI) (Vicente-Serrano et al. 2010)
- Agricultural Drought
  - Soil Moisture anomalies and tendencies
  - Soil Moisture Percentile (SMP)
- Hydrological Drought
  - Standardized Runoff Indices (SRIs)
  - Runoff percentile
- flash drought
  - Evaporative Demand Drought Index (EDDI): (Hobbins et al. 2016)
  - Standardized Evaporative Stress Ratio (SESR)
- Vegetation impact
  - Normalized Difference Vegetation Index (NDVI)
  - Vegetation Health index (VHI)

https://www.cpc.ncep.noaa.gov/products/international/drought/drought.shtml

Global real-time Precipitation

- **CPC unified Gauge-based analysis of daily precipitation**
  - unified precipitation products with consistent quantity and improved quality by combining all information sources available
  - taking advantage of the optimal interpolation (OI) objective analysis technique
- **CMORPH satellite Precipitation**
  - CPC Morphing Technique (MORPH)
  - Global grid with 8km-by-8km spatial resolution
  - Temporal resolution is 30 minutes
- **African Rainfall Estimation Algorithm Version 2 (RFE2)**
  - Daily GTS rain gauge data for up to 1000 stations
  - AMSU microwave satellite precipitation estimates up to 4 times per day
  - SSM/I satellite rainfall estimates up to 4 times per day
  - GPI cloud-top IR temperature precipitation estimates on a half-hour basis.
- **Multi-Source Weighted-Ensemble Precipitation (MSWEP) v2.1**
  - leverages machine learning to merge and bias-correct satellite and model data

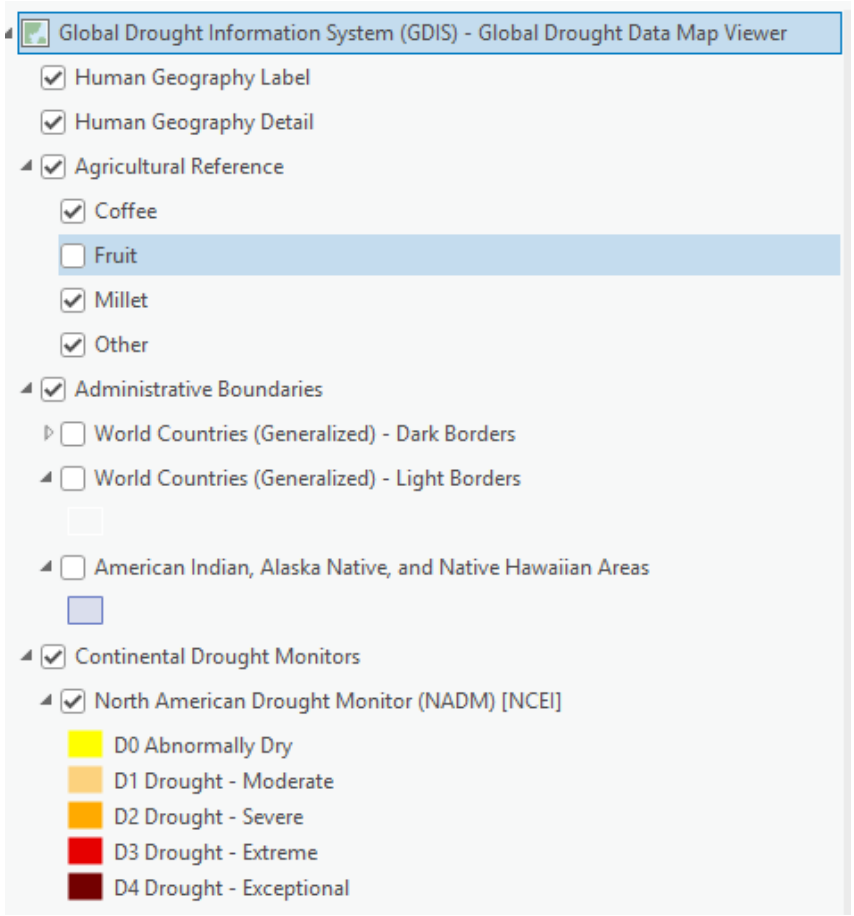
CPC Climate Assessment Database (CADBv2)
Global Station Observation Summaries

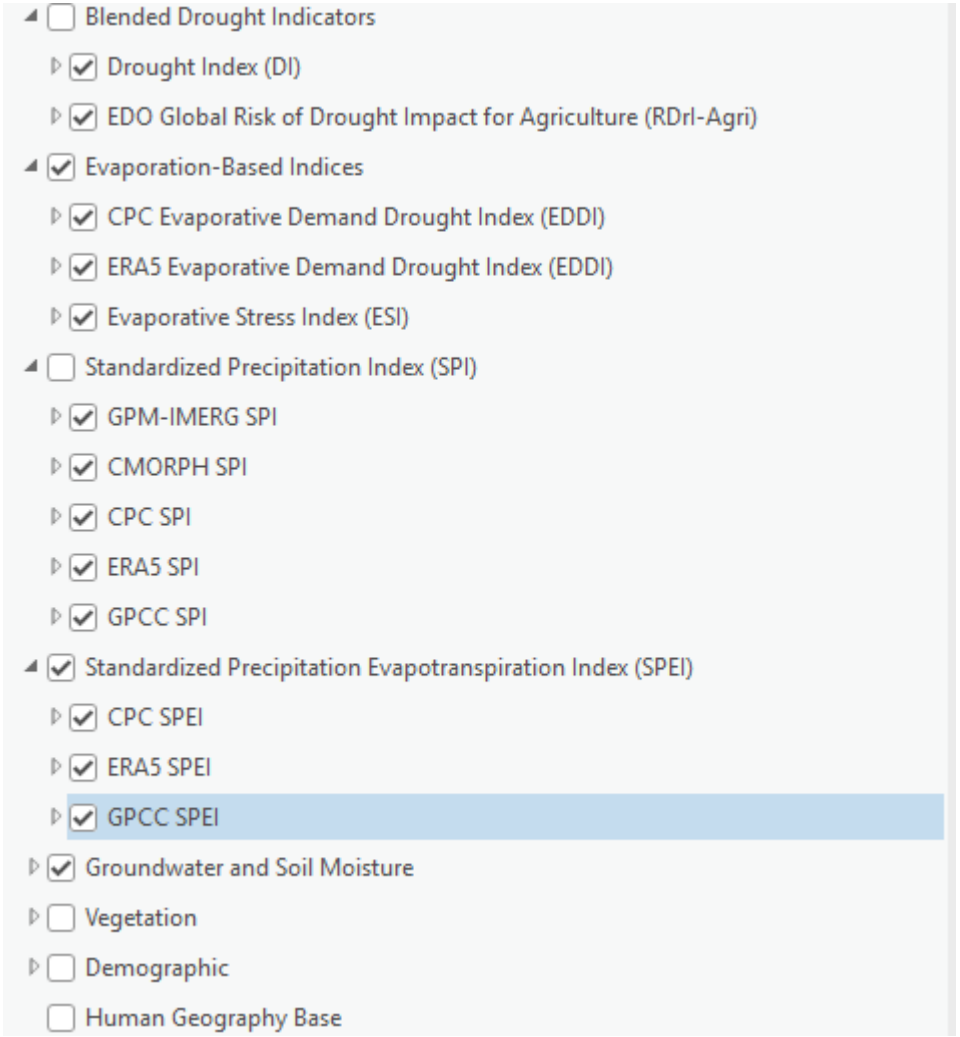


Land surface model analysis

- **CPC leaky bucket model**
  - gauge-based precipitation forcing
  - Single layer water balance model (updated SWE scheme 2020)
  - CPC global soil moisture analysis
- **NCEP CORe reanalysis**
  - Replace the NCEP/NCAR reanalysis 1 (CDAS)
  - Coupled Land surface analysis:
    - Soil Moisture : SOILM, SOILW, SOILL
    - Evapotranspiration (ET): EVBS, EVCW, TRANS,LHTFL
    - Potential Evaporation: PEVPR
    - Hydrological variables: WATR, WEASD, WILT
- **NASA Land Data Assimilation System (LDAS)**
  - GLDAS Noah Land Surface Model L4 3 hourly 0.25 x 0.25 degree V2.1
  - NLDASv3 NoahMP model 0.01x0.01 (Central America and Caribbean)

NOAA Global Drought Information System (GDIS) - Global Drought Data Map Viewer





Hybrid approach: instead of using a single drought index

Convergence Of Evidences !!!

Objective

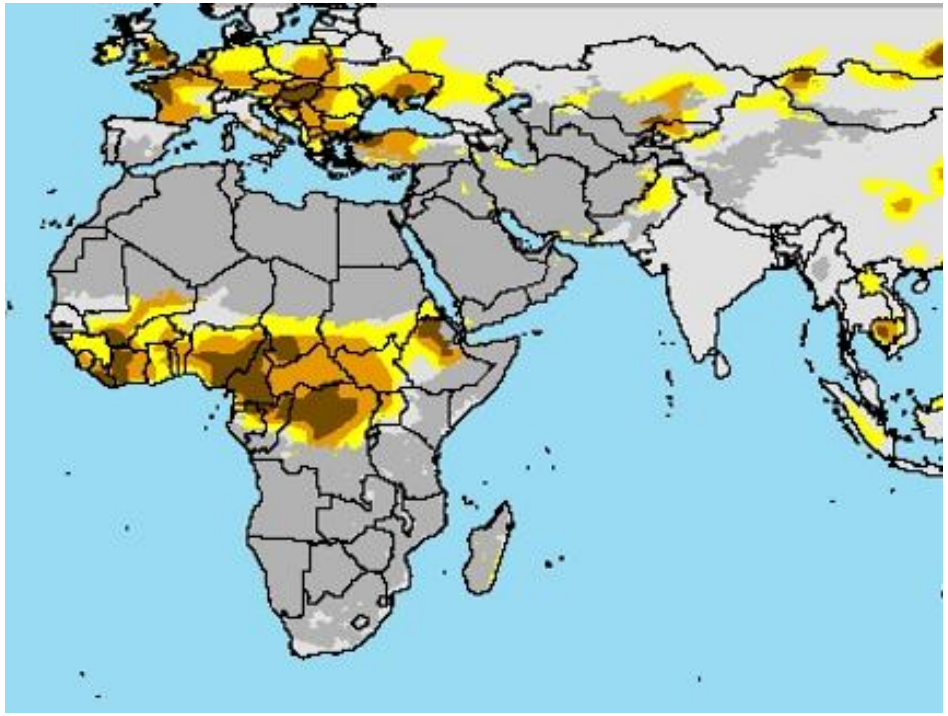
Physical drought indicators & indices

+

Knowledge Based

local expertise and impacts incorporated

=



Type of drought:

1. **Meteorological drought**
2. **Agricultural drought**
3. **Hydrological drought**
4. **Snow drought**
5. **ecological drought**

Length/timescale

1. **Flash drought**
2. **Short-term drought**
3. **long-term drought**

Green in development

International Desk /CPC Drought Criteria

Abnormal dryness

a. Area has registered cumulative **4-week precipitation and soil moisture ranking less than the 30th percentile, with an SPI of 0.4** standard deviation below the mean.
b. Area is expected to receive below-average precipitation (less than 80% of normal) during the outlook period.

Drought

a. Area must have previously been defined as “Abnormal Dryness”
b. Area has continued to register seasonal precipitation and soil moisture deficits that have resulted in since the beginning of the rainfall season an **eight-week cumulative precipitation, soil moisture, and runoff below the 20th percentile rank, and an SPI of 0.8** standard deviation below the mean
c. Developing drought conditions must be supported by field observations, including impacts of moisture shortages on crops and water resources.

Severe Drought

a. Area must have previously been defined as “Drought”
b. Area has continued to register seasonal precipitation and soil moisture deficits that have resulted in since the beginning of the rainfall season a **twelve-week cumulative precipitation, soil moisture, and runoff below the 10th percentile rank and an SPI of 1.2** standard deviation below the mean
c. Severe drought conditions must be supported by field observations, including impacts of moisture shortages on crops and water resources.

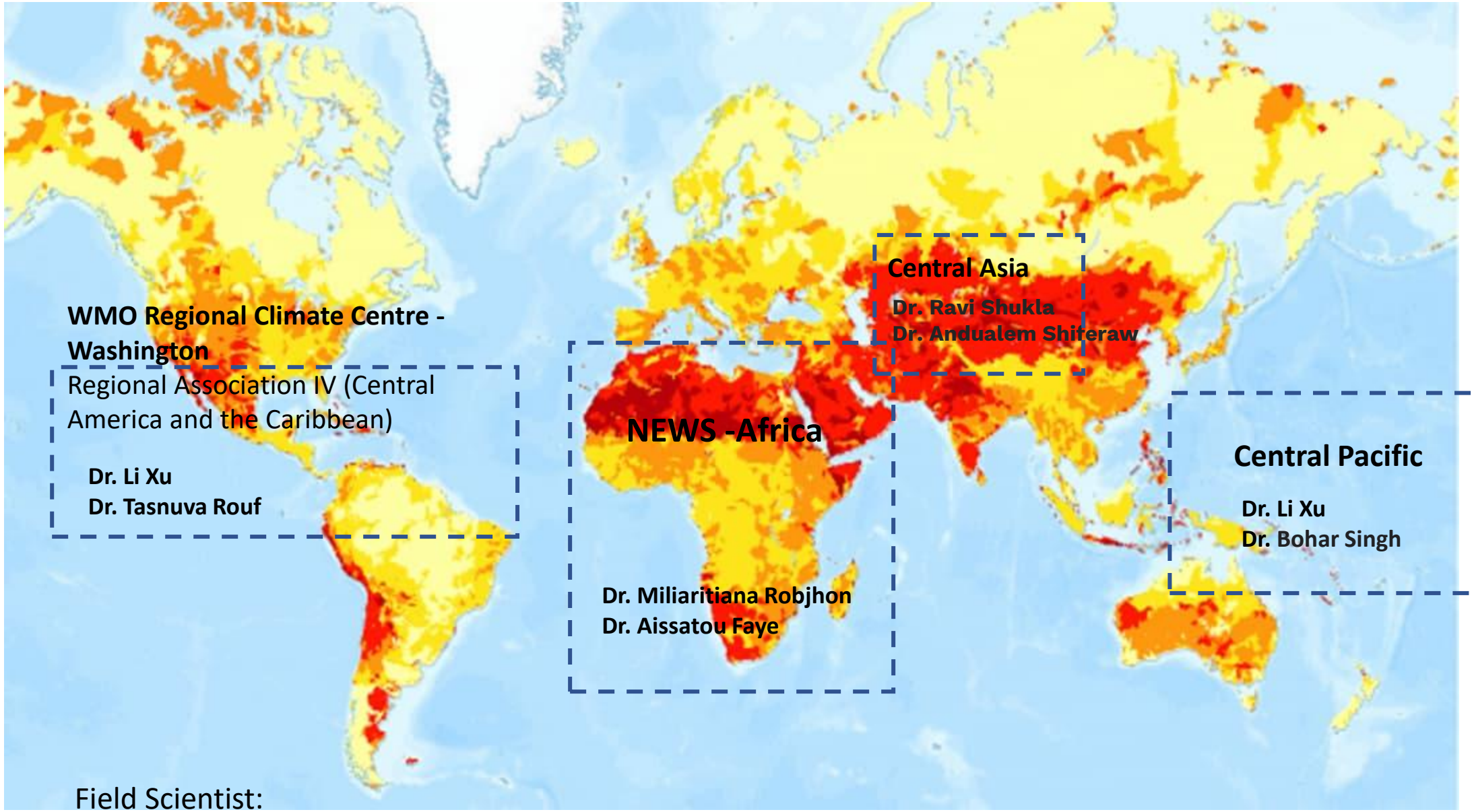
USDM Objective Drought Categories Based On Historical Likelihood

			Ranges				
Category	Description	Possible Impacts	Palmer Drought Severity Index (PDSI)	CPC Soil Moisture Model (Percentiles)	USGS Weekly Streamflow (Percentiles)	Standardized Precipitation Index (SPI)	Objective Drought Indicator Blends (Percentiles)
D0	Abnormally Dry	Going into drought: • short-term dryness slowing planting, growth of crops or pastures Coming out of drought: • some lingering water deficits • pastures or crops not fully recovered	-1.0 to -1.9	21 to 30	21 to 30	-0.5 to -0.7	21 to 30
D1	Moderate Drought	• Some damage to crops, pastures • Streams, reservoirs, or wells low, some water shortages developing or imminent • Voluntary water-use restrictions requested	-2.0 to -2.9	11 to 20	11 to 20	-0.8 to -1.2	11 to 20
D2	Severe Drought	• Crop or pasture losses likely • Water shortages common • Water restrictions imposed	-3.0 to -3.9	6 to 10	6 to 10	-1.3 to -1.5	6 to 10
D3	Extreme Drought	• Major crop/pasture losses • Widespread water shortages or restrictions	-4.0 to -4.9	3 to 5	3 to 5	-1.6 to -1.9	3 to 5

The same as the USDM drought standard, but without exceptional drought (D4) due to observational records limitation.

Long period of record is important!

Global Drought vulnerability index



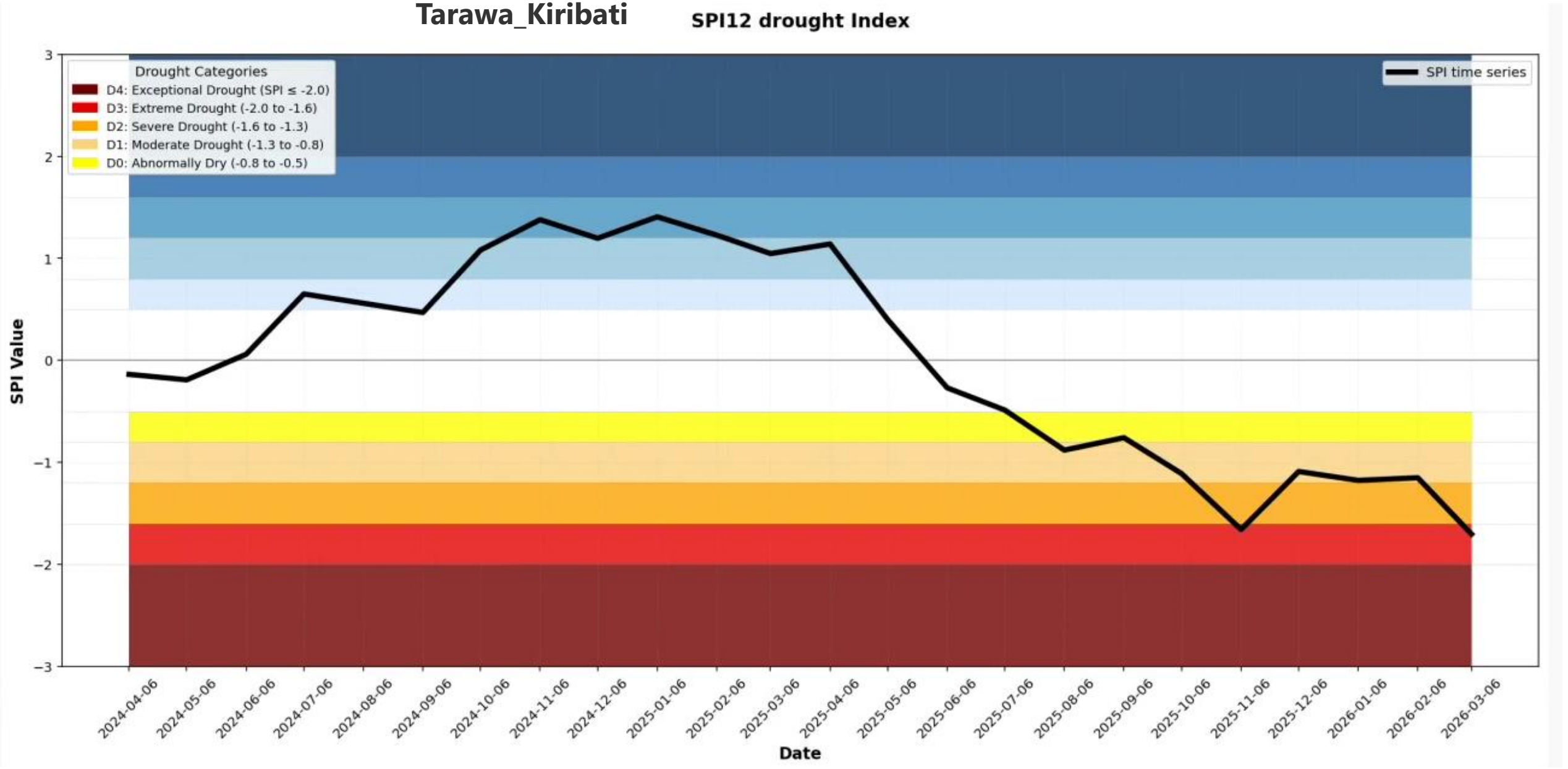
Field Scientist:

Feedback from the FEWS.net hazard outlook briefing and seasonal forecast review

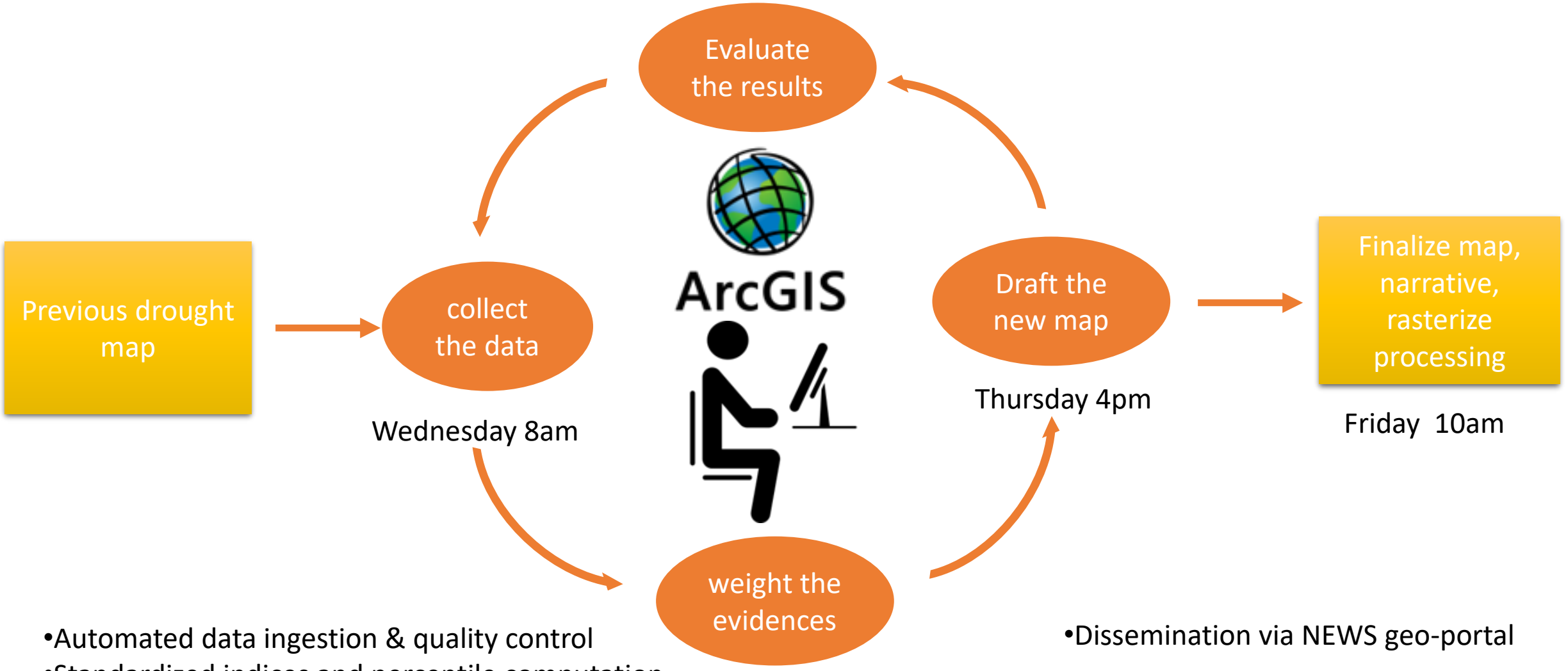
Key drought concerns for regions

- **Africa & Middle East**
  - Agriculture drought (lack soil moisture obs.)
  - Sahel region long-term drought, desertification
  - Hydrological drought (Africa great lake, Niger river, Senegal river etc.)
- **Central America & Caribbeans**
  - Short-term drought (less than 6 month)
  - NASA NLDASv3
- **Central Asian**
  - Snow drought (previous SWE deficit)
  - scarce station obs.
  - NASA FLDAS system
  - Inconsistent between different satellite rainfall retrievals
- **Central Pacific**
  - Water availability (Reservoir, fresh water etc)
  - Small island and atoll, Station scale
  - Can’t resolving by Land surface model

Drought Tendency



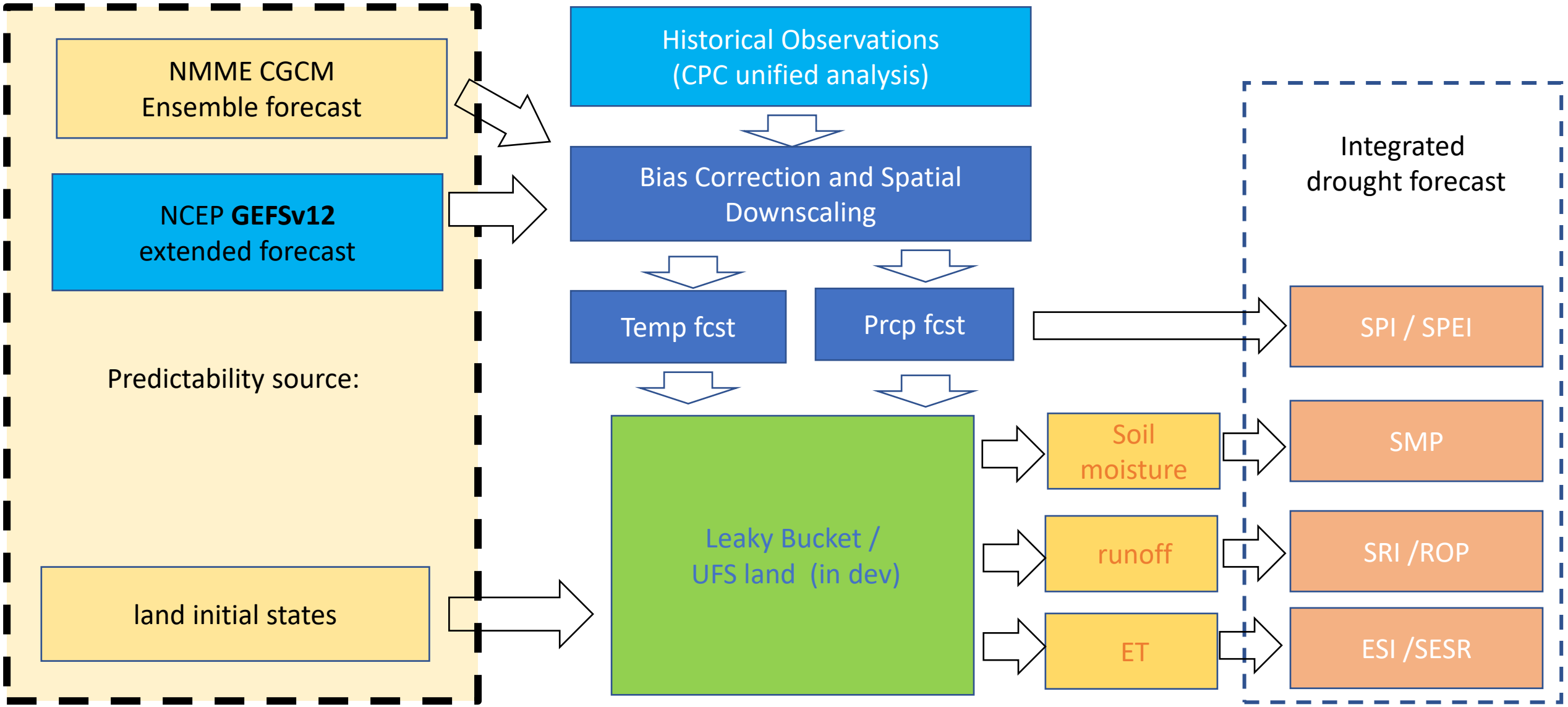
Weekly Drought Monitor Workflow



- Automated data ingestion & quality control
- Standardized indices and percentile computation
- Real-time mapping and visualization

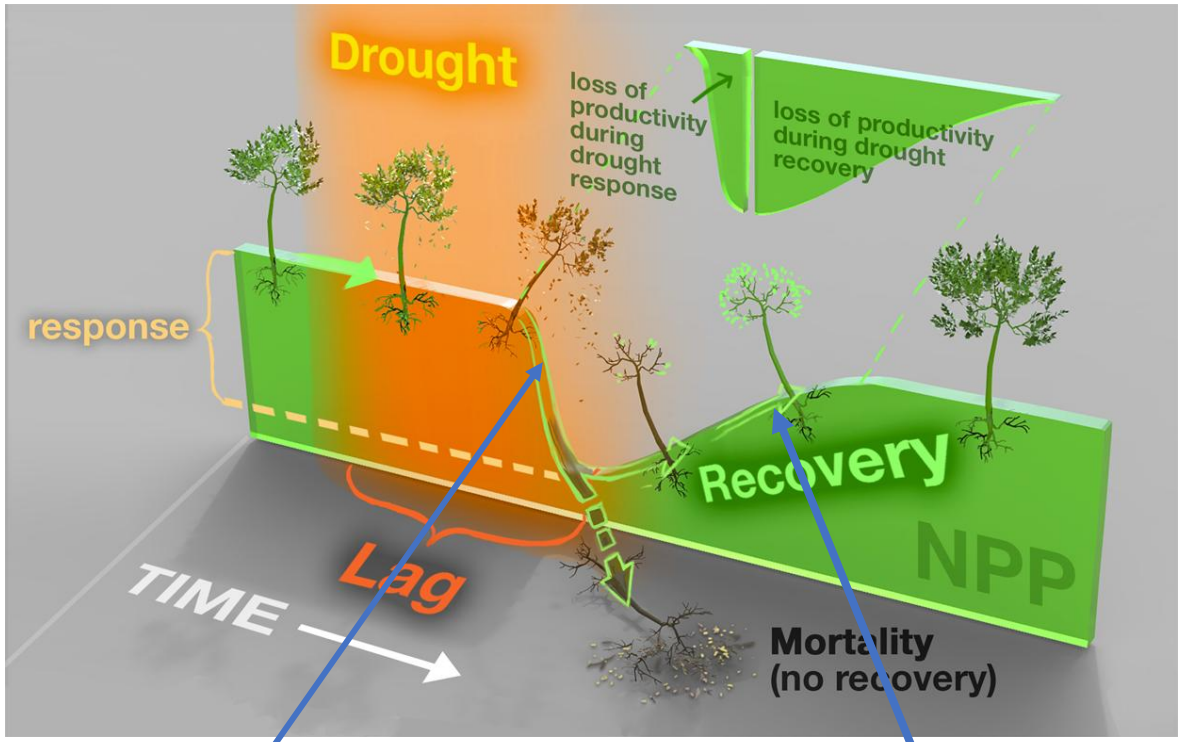
- Dissemination via NEWS geo-portal

CPC global drought objective forecast system



International Drought Key Messages (KM)

- CPC international desk Hazard outlook forecast **D0 (abnormal dryness)**
- Begin **closely monitor** drought development
- When drought **onset to D1 (moderated drought)** begin issue **drought key messages**
- **Including current drought conditions, impact and future outlooks**
- **Weekly update** drought key messages
- Stop monitor when **drought demise to D0**
- **global meteorological monitoring + forecast capability (CPC international desk)**
- **Local drought expertise /domain knowledge**

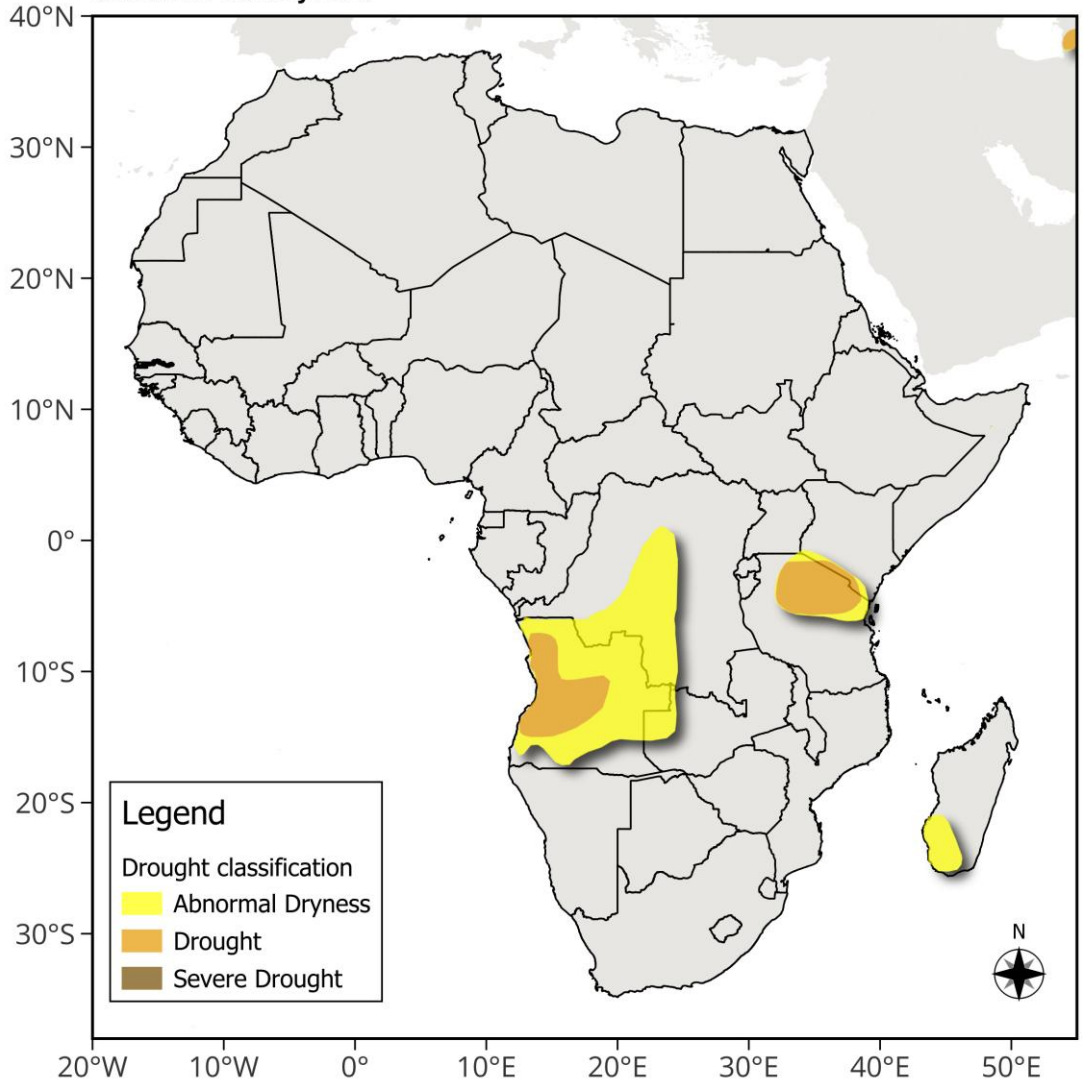


Begin drought key messages (D0 -> D1)

End drought key messages (D1 -> D0)

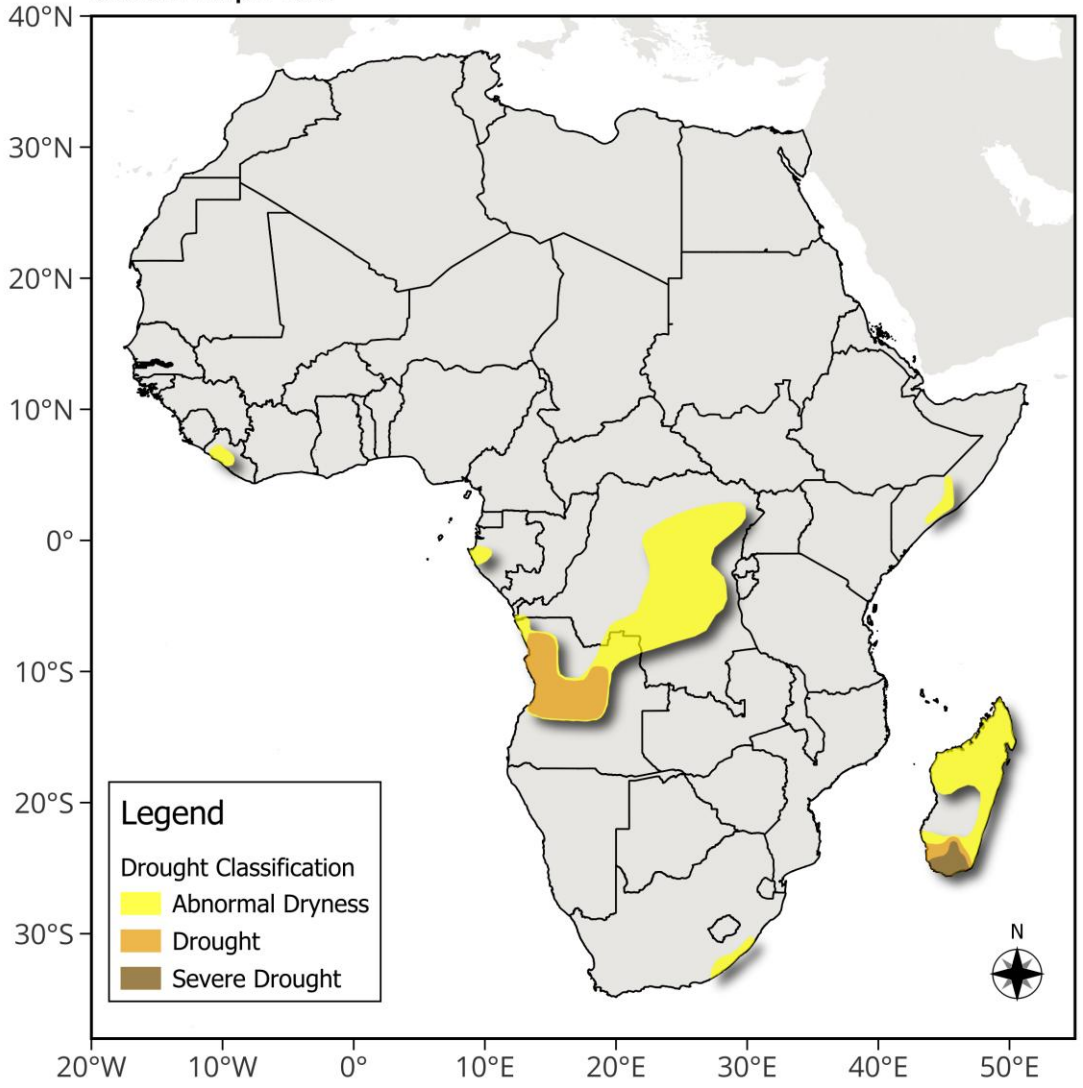
Africa Drought Monitoring

Issued: 6 February 2026



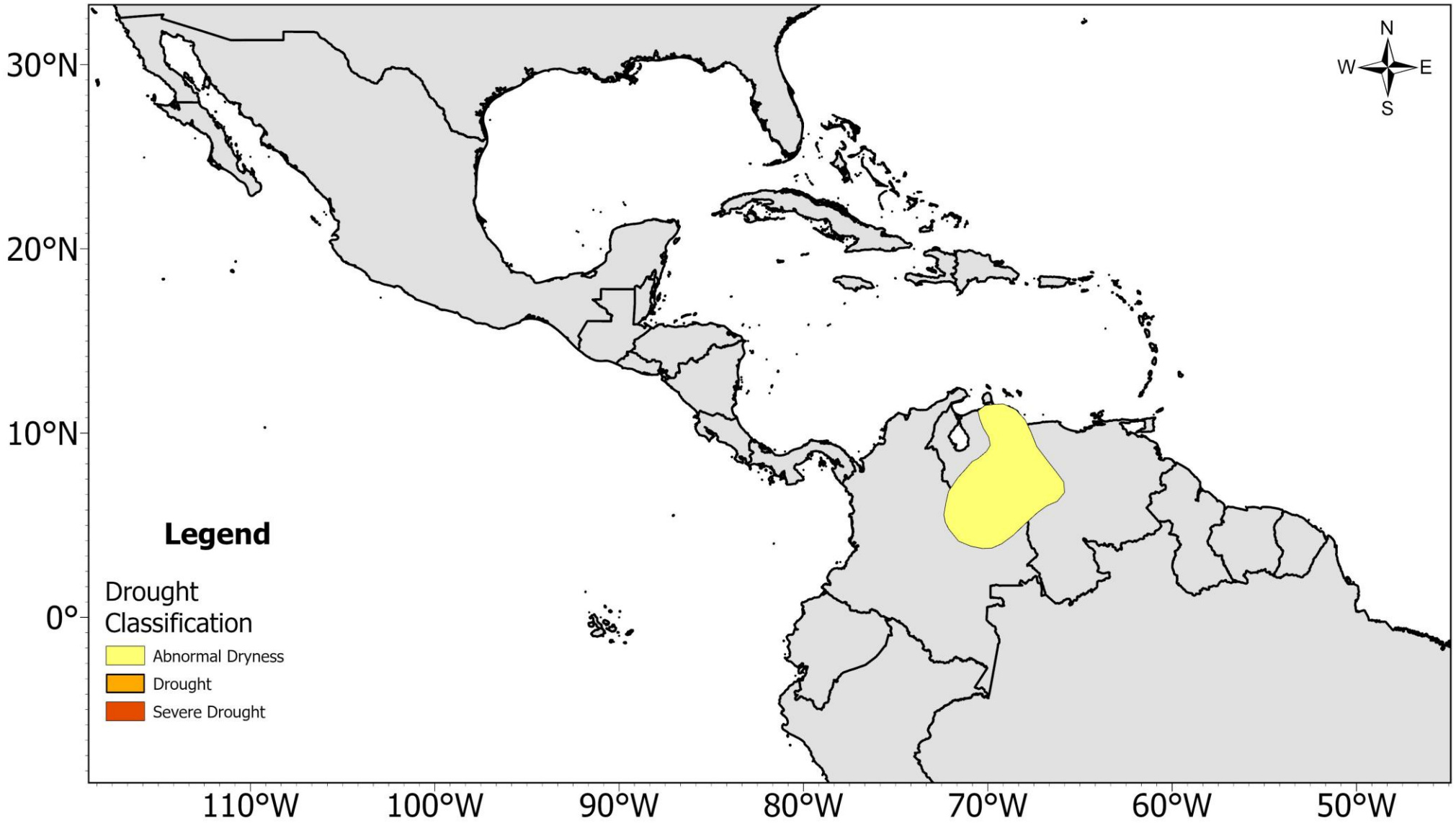
Africa Drought Monitoring

Issued: 24 April 2026



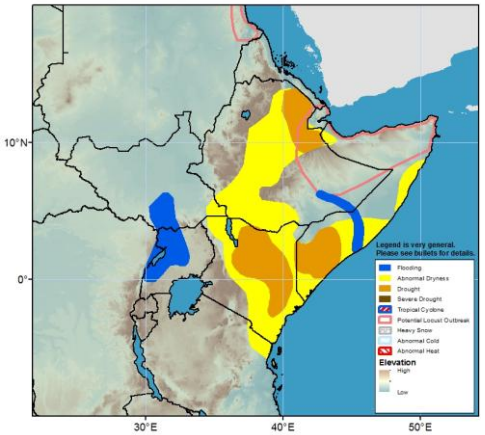
Experimental Drought Monitoring (CA, Caribbean & NSA)

Issued : 24 April 2026

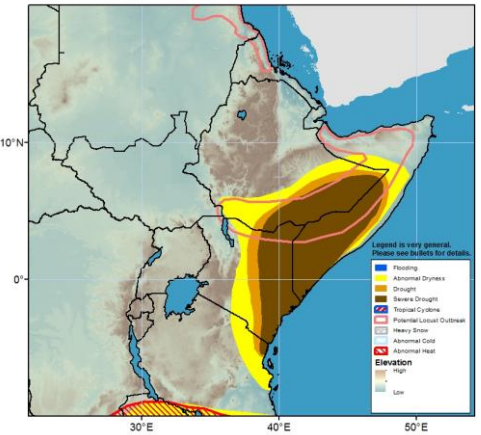


Evolution of Great Horn of Africa Hazards

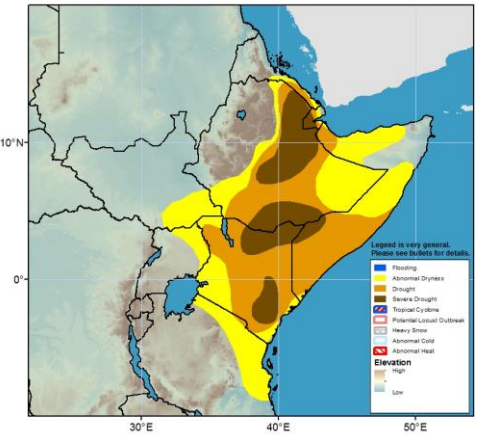
MAM 2021 (05/27)



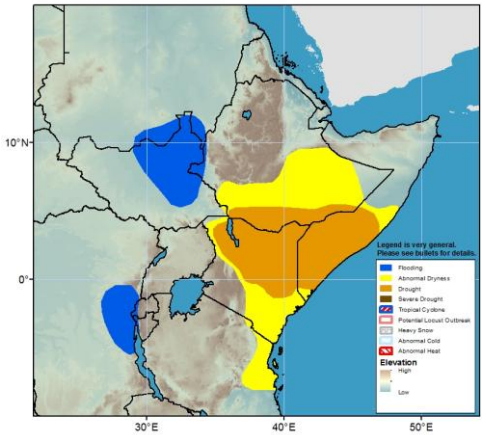
OND 2021 (12/30)



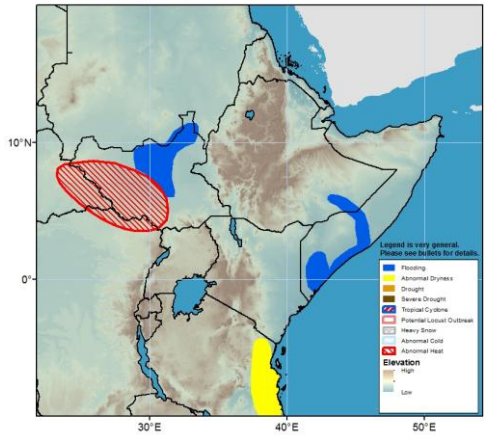
MAM 2022 (05/26)



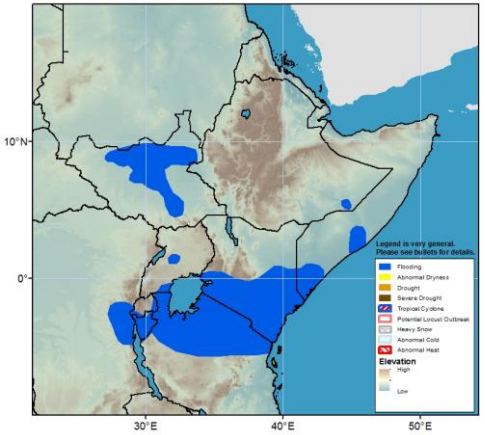
OND 2022 (12/29)



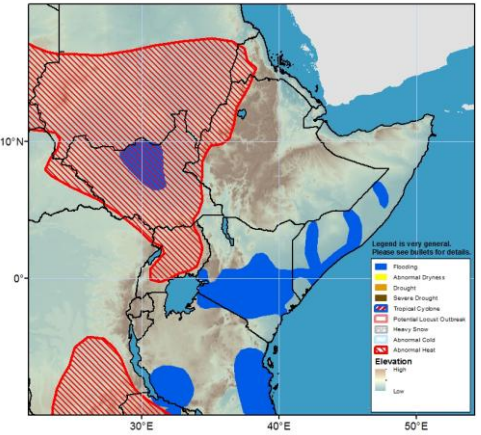
MAM 2023 (05/25)



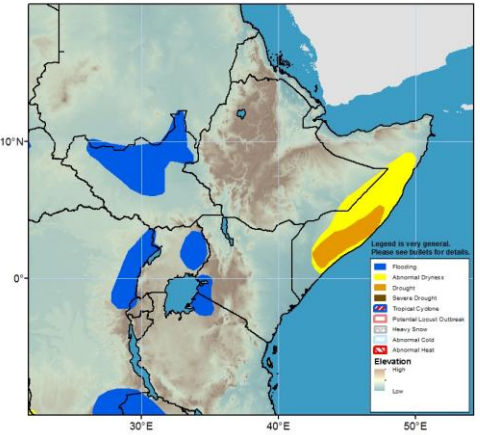
OND 2023 (12/28)



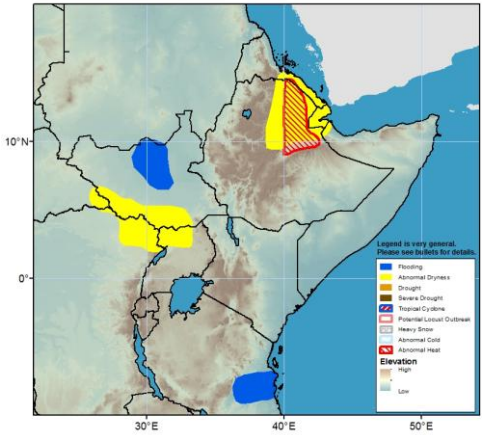
MAM 2024 (05/30)



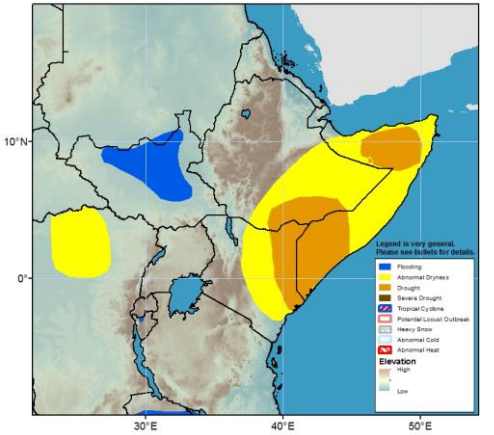
OND 2024 (12/26)



MAM 2025 (05/29)



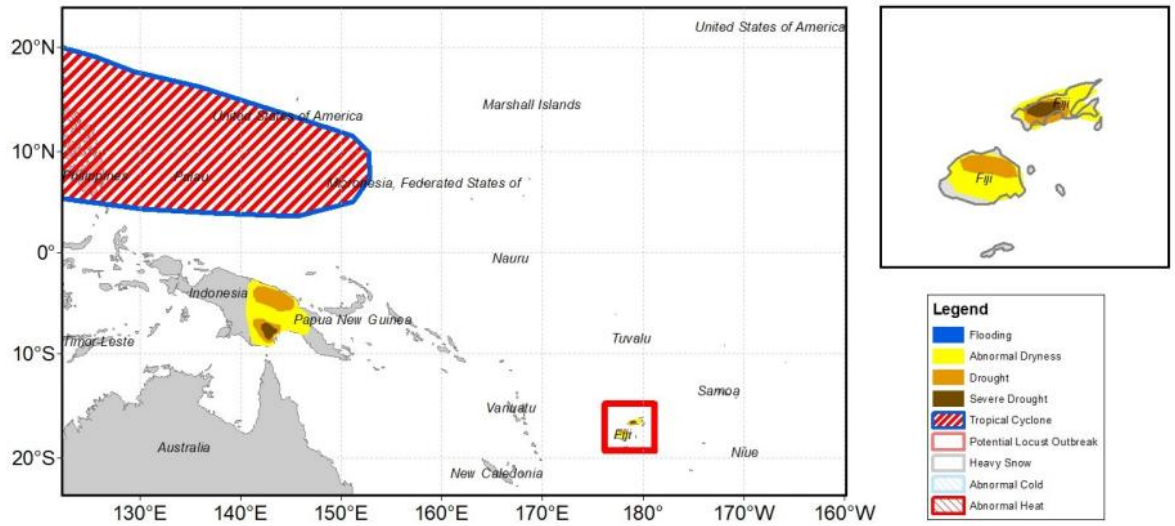
OND 2025 (11/20)



Four consecutive seasonal droughts during 2021-2022, followed by wet seasons from MAM 2023-MAM 2024, then return of seasonal droughts since OND 2024

Drought Early Warning Training

- President's Emergency Plan for Adaptation and Resilience (PREPARE) and NOAA Early Warning System (NEWS)
  - Caribbean Heat health Early Warning workshop at Kingston, Jamacia (15-19 Apr, 2024)
  - Central Pacific drought and flooding Early Warning workshop at Nadi, Fiji (14-25 July, 2024)
  - NOAA Early Warning System –Africa training workshop, Dakar, Senegal (10-22 Jan 2026)



Summary

- Drought monitor and outlook is a **key mission** of the CPC Int'l Desks to support Famine Early warning System Network(FEWS.net)
- CPC's International Drought Monitor provides critical tool for drought resilience under climate stress, provide **real-time, seamless, objective** drought conditions based on meteorological, hydrological and agricultural droughts
- Ongoing development on Drought key Message (KM) products aims to improve **accuracy, timeliness, and usability** for Impact-Based Decision Support Services (IDSS)
- A critical component of **NOAA Early Warning System (NEWS)**