Drought Monitoring and Forecasting

Online Workshop on Global Tools for Flood and Drought Prediction

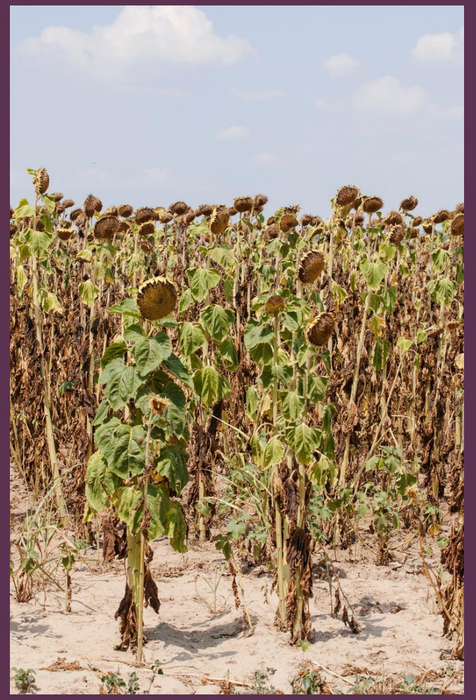
08-10 December 2025

WORLD METEOROLOGICAL ORGANIZATION

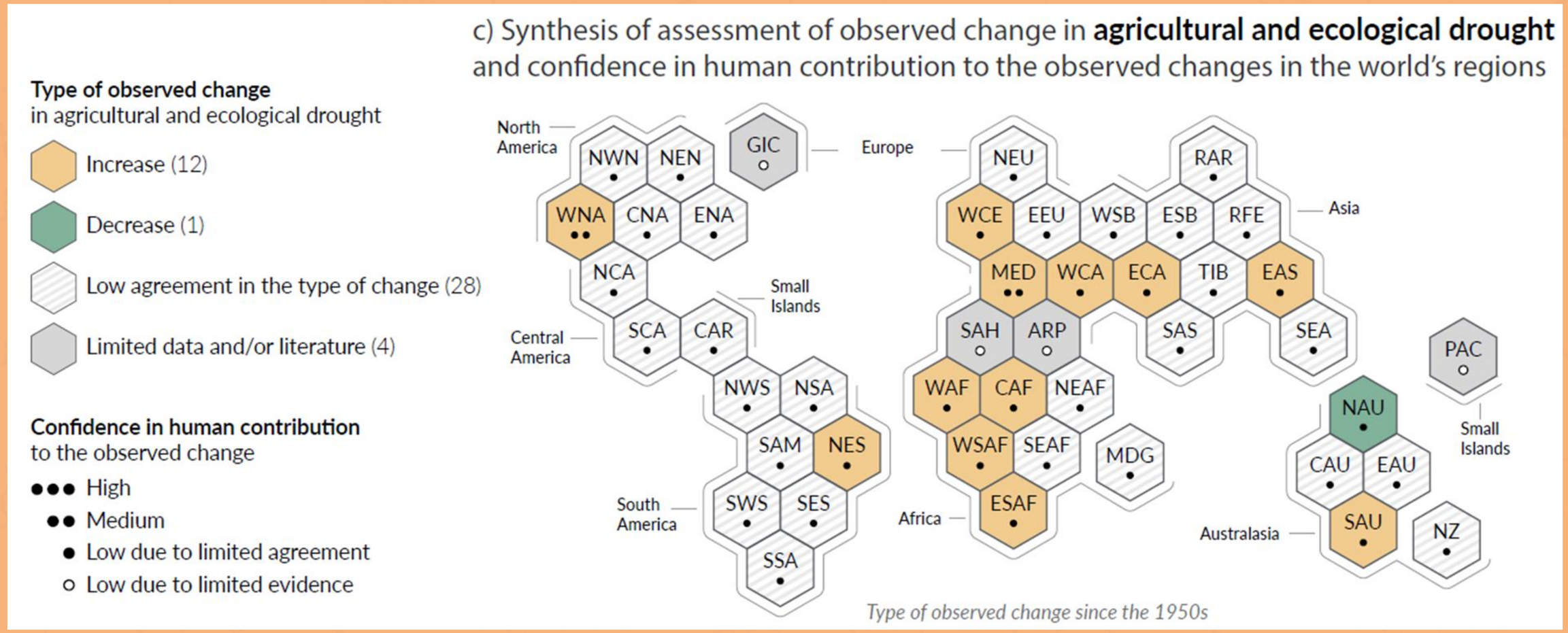
GLOBAL WATER PARTNERSHIP ORGANISATION

Droughts are among the most complex natural hazards

- Drought is a natural phenomenon, drought disaster are not
- Drought is a creeping phenomenon with a slow onset.
- Impacts of drought can accumulate gradually.
- Lack of a precise and universal definition for drought leads to confusion about when a drought begins and when it ends.
- Leads to uncertainty on the precise time to implement emergency response actions or mitigation measures.



Observed increase in droughts

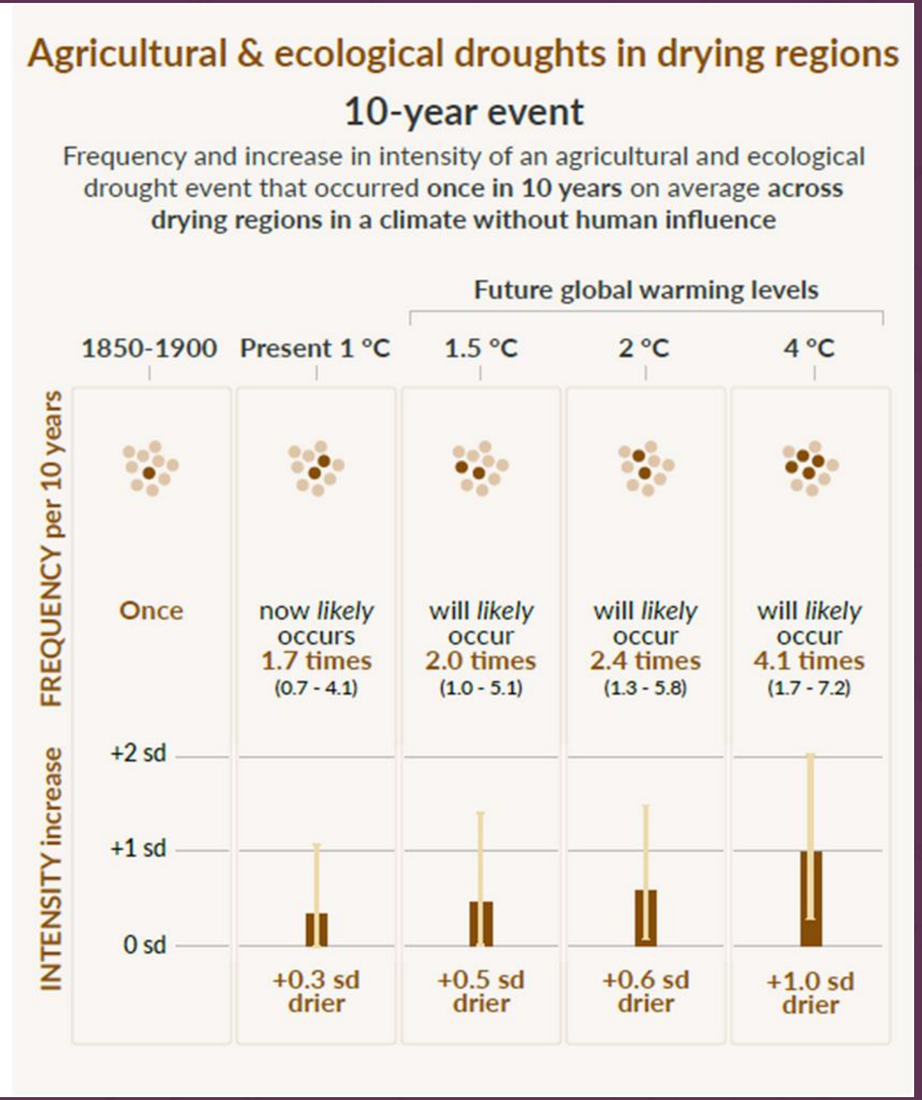


6th Assessment Report of the IPCC, WGI, 2021

Projections for future drought

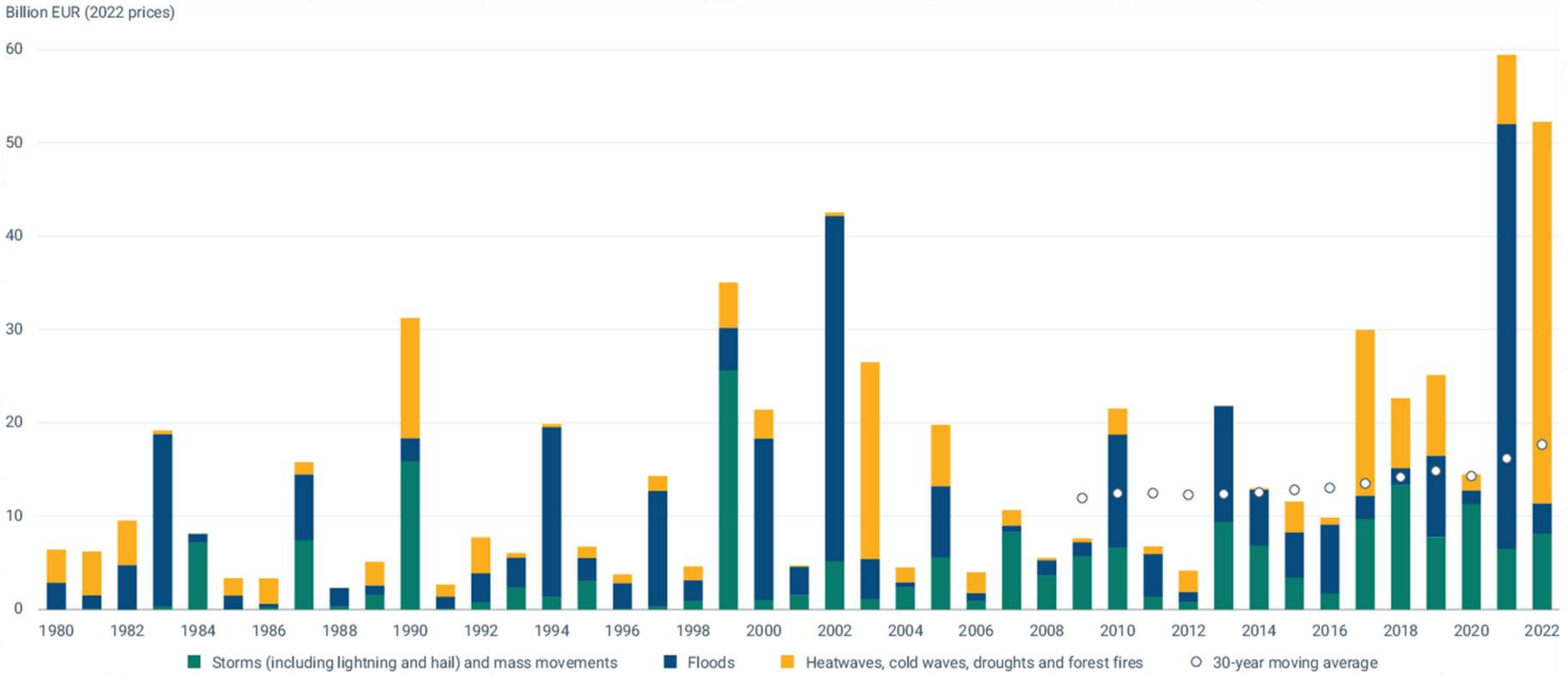
Even in a “best case” scenario, when achieving Paris goals (1.5°C warming):

- Drought will occur 2 times more often and will be significantly more severe
- “There will be an increasing occurrence of some extreme events unprecedented in the observational record with additional global warming, even at 1.5°C of global warming.”



6th Assessment Report of the IPCC, WGI, 2021

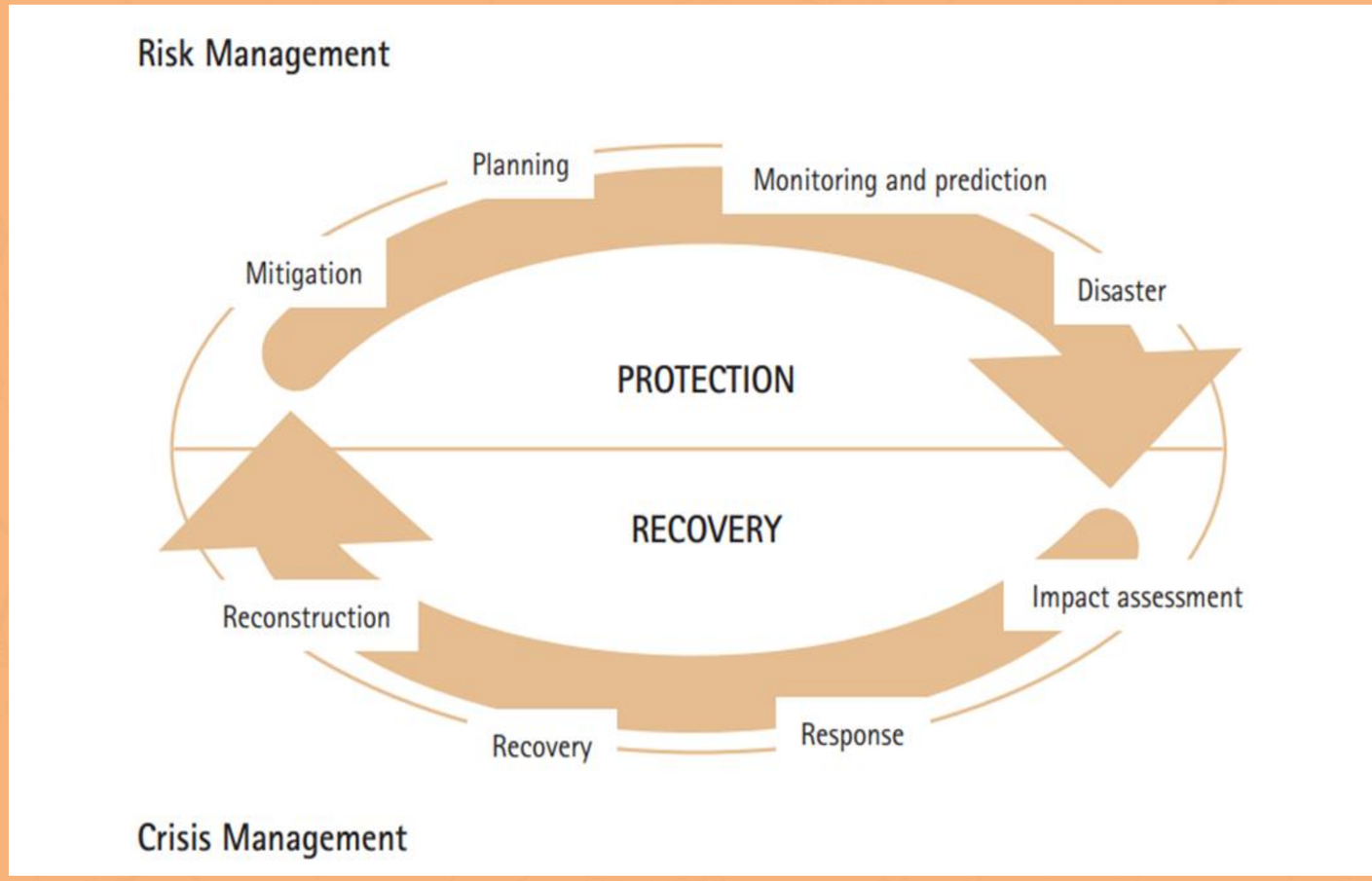
Why does this matter economically?



EEA 2025

How do we go from CRISIS management to RISK management?

- Developing integrated monitoring and drought early warning systems and associated information delivery systems
- Improvement and application of seasonal and shorter-term forecasts
- Developing preparedness plans at various levels/ sectors
- Adopting mitigation actions and programmes
- Providing an organizational structure and coordination within and between levels of government and with stakeholders.



INTEGRATED DROUGHT MANAGEMENT PROGRAMME

IDMP: 12 Years of Integrated Drought Management

Established in **2013 after a joint High-Level Meeting** of WMO, GWP, FAO, UNCCD and other partners.

- Partner base continuously growing: 47 partners in 2025
- 4 Regional Programmes work on IDM implementation

Approach:

- Runs a HelpDesk to respond to requests
- Community of Practice
- Develops and contributes to IDM components of projects
- Develops knowledge products
- Capacity building and training on IDM
- Virtual Exchanges 3-4 times a year
- Youth Empowerment

The three pillars of Integrated Drought Managment

Early Warnings for All (EW4ALL)

- Invitation to combine this with partners objective and subjective data to create a holistic index, covering the four key components of MHEWS

Disaster risk knowledge

Systematically collect data and undertake risk assessments

- Are the hazards and the vulnerabilities well known by the communities?
- What are the patterns and trends in these factors?
- Are risk maps and data widely available?

Detection, observations, monitoring, analysis and forecasting of hazards

Develop hazard monitoring and early warning services

- Are the right parameters being monitored?
- Is there a sound scientific basis for making forecasts?
- Can accurate and timely warnings be generated?

Preparedness and response capabilities

Build national and community response capabilities

- Are response plans up to date and tested?
- Are local capacities and knowledge made use of?
- Are people preapred and ready to react to warnings?

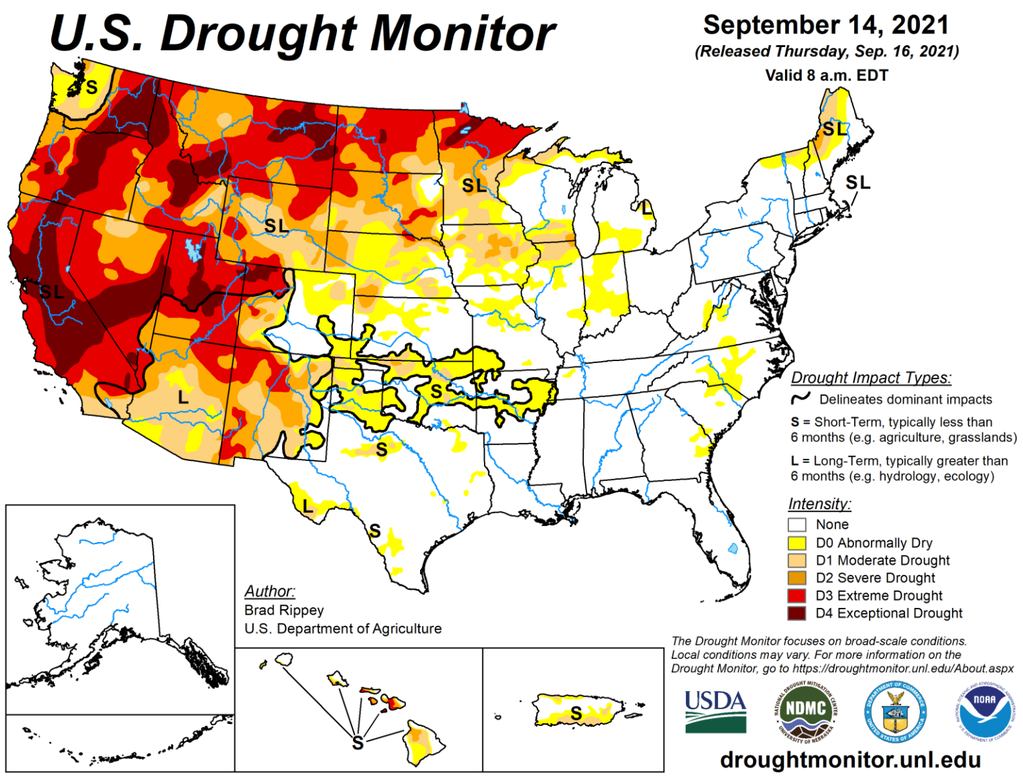
Warning dissemination and communication

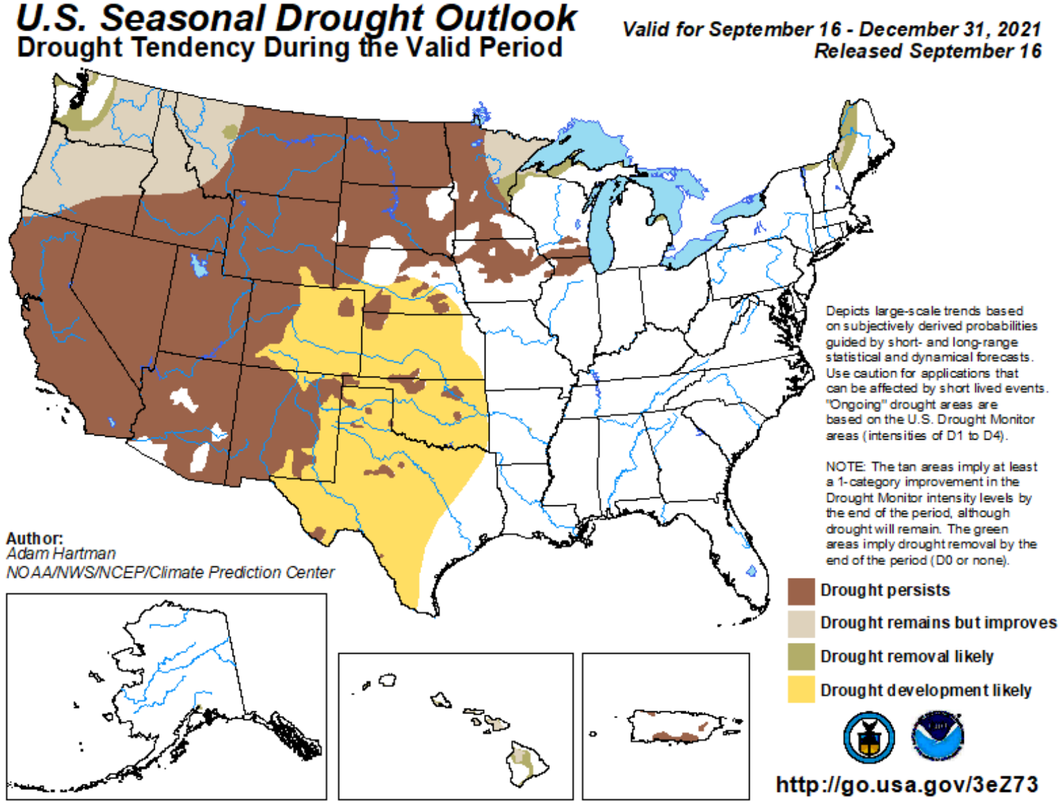
Communicate risk information and early warnings

- Do warnings reach all of those at risk?
- Are the risks and warnings understood?
- Is the warning information clear and usable?

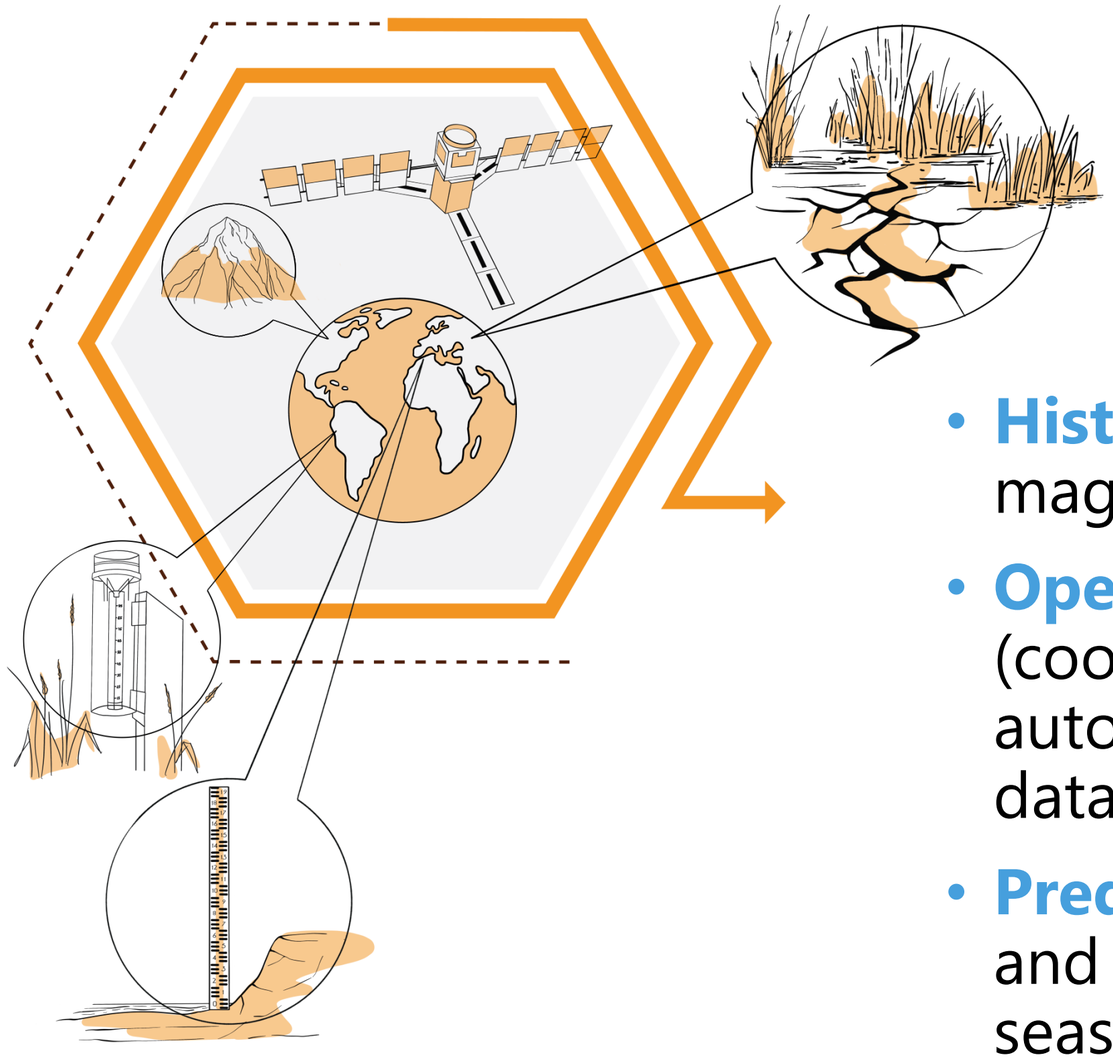
Drought Forecasting is building on the Monitoring

Monitoring Products linked and building on Drought Forecasts



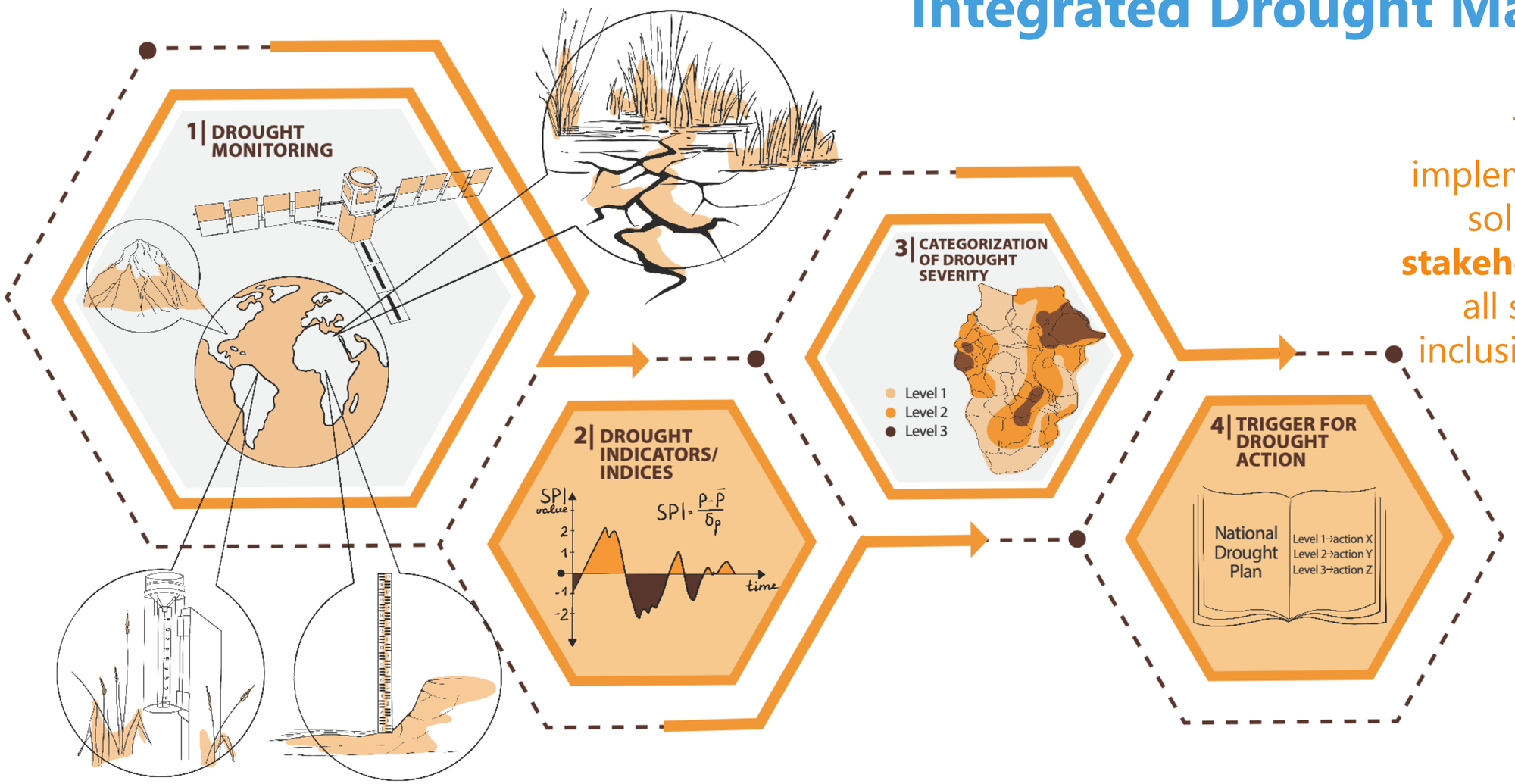


Potential Monitoring System Products and Reports



- **Historical analysis** (climatology, impacts, magnitude, frequency)
- **Operational assessment/Early Warning** (cooperative data, SPI and other indices, automated networks, satellite and soil moisture data, media and official requests)
- **Predictions/Projections /Early Warning** (SPI and other indices, soil moisture, streamflow, seasonal forecasts, SST's)

Drought monitoring for Integrated Drought Management



The design and implementation of technical solutions is based on **stakeholder engagement** at all steps and using an inclusive **whole-of-society approach**

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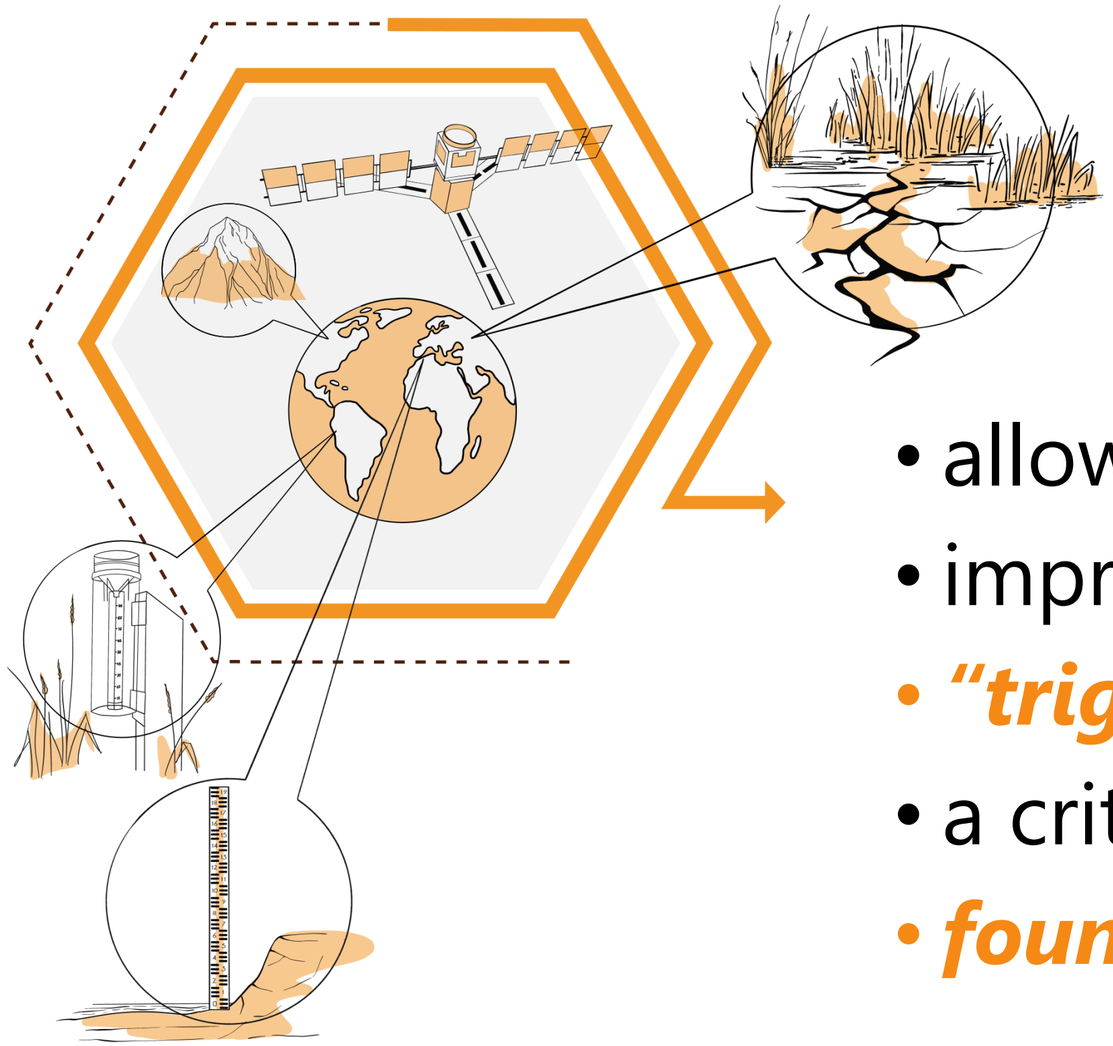
INTEGRATED DROUGHT MANAGEMENT PROGRAMME

Global Water Partnership

Importance of a Drought Monitoring System



- allows for ***early*** drought detection
- improves response (***proactive***)
- ***"triggers"*** actions within a drought plan
- a critical ***mitigation*** action
- ***foundation*** of a drought plan

Planned drought mitigation and response options

Another example

Indicators

I-1
I-2
I-3
I-4

Consider I-1 is SPI

Time during normal conditions

Triggers

I-1
Level 1 (SPI 0.0 to -0.99)
Level 2 (SPI -1.0 to -1.49)
Level 3 (SPI -1.5 to -1.99)
Level 4 (SPI ≤ -2.0)

Consider Level 2 ; SPI = -1.25
(Moderate drought)

Actions

Level 2
Action 1
Action 2
Action 3

Consider Action 1: Ban watering lawns
Consider Action 2: Dig extra wells for livestock and wildlife in area
Consider Action 3: Reduce irrigation of annual crops by 50%

Monitoring, Early Warning & Information Delivery Systems

Monitored variables

- Precipitation
- Temperature
- Surface water supplies
  - Stream flow
  - Soil Moisture
  - Reservoir levels
  - Snow pack
  - Water use
- Ground water
- Remotely-sensed data (e.g., plant water stress)

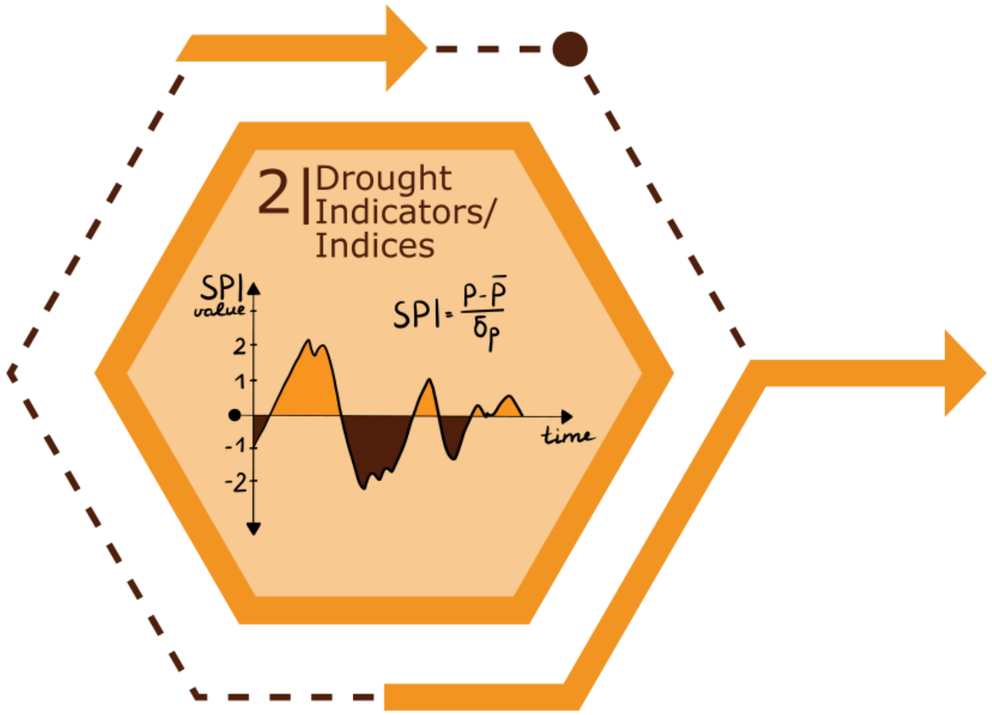
Impacts

- By sector, area

Agencies, Ministries, Organizations

- Water
- Meteorological & Hydrological Services
- Agriculture, Forestry & Fisheries
- Environment
- Health
- Energy
- Transportation
- Commerce
- Social Services
- NGOs
- Others

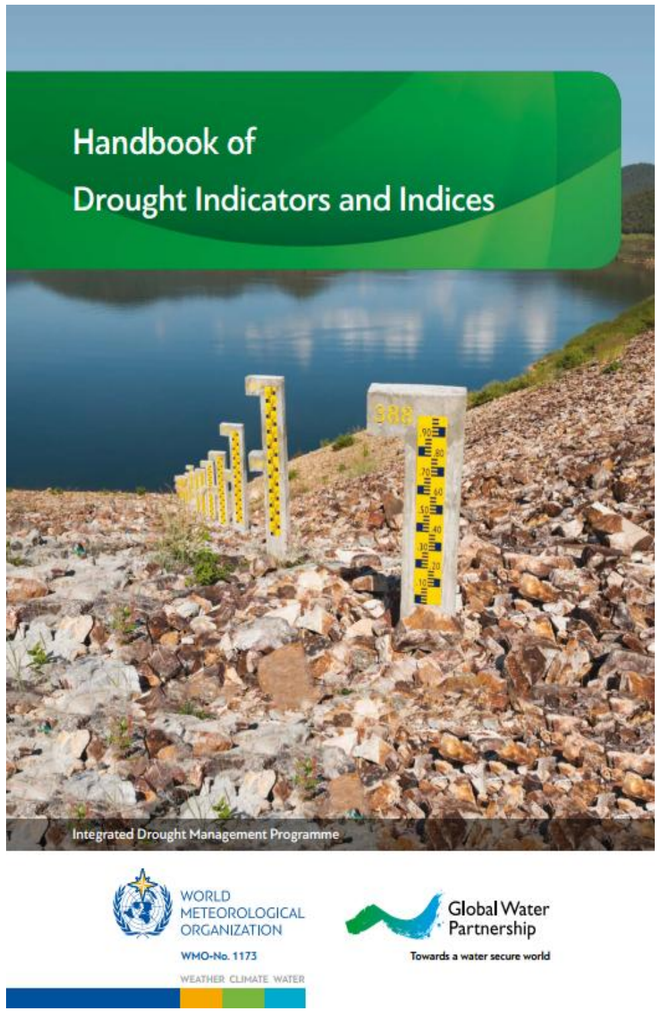
Importance of Drought Indices



- **Simplify** complex relationships and provide a good communication tool for diverse audiences
- ***Quantitative*** assessment of anomalous climatic conditions
  - Intensity
  - Duration
  - Spatial extent
- ***Historical*** reference (probability of recurrence)
  - Planning and design applications

Handbook of Drought Indicators and Indices

- Handbook is a resource to cover most commonly used drought indicators/indices
- A starting point to describe and characterize the most common indicators and indices and their applications
- Does not recommend a "best" set of indicators and indices, given research requirements for appropriate application in location in question.



Development of indices in a national context: example of Afghanistan

	Description	Possible Impact	Indices >>>>>Thresholds											Triggered Actions
			SPI	SPEI	NDVI	VHI	SRSI	SSFI	Market Prices	ASI	IDPs	VegDRI	Other (TBD)	
D1	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												
D2	Moderate Drought	• Rainfall / snowfall less than average for the fortnight / month • Some damage to crops, pastures • Streams, reservoirs, or wells low, some water shortages developing or imminent • Reduced water levels (ground water etc)												
D3	Severe Drought	• Crop or pasture losses High • Water shortages common • Water restrictions imposed (use of water ground water etc.)												
D4	Extreme Drought	• Major crop/pasture losses • Widespread water shortages or restrictions												
D5	Exceptional Drought	• Exceptional and widespread crop/pasture losses • Shortages of water in reservoirs, streams, and wells creating water emergencies												
D0	No Drought or cessation of Drought	• returning of average / normal rainfall and snowfall; or normal / adequate snowpack formation • crop production at decadal average/ livestock prices at average levels, etc.												

Indicators & Triggers Definitions

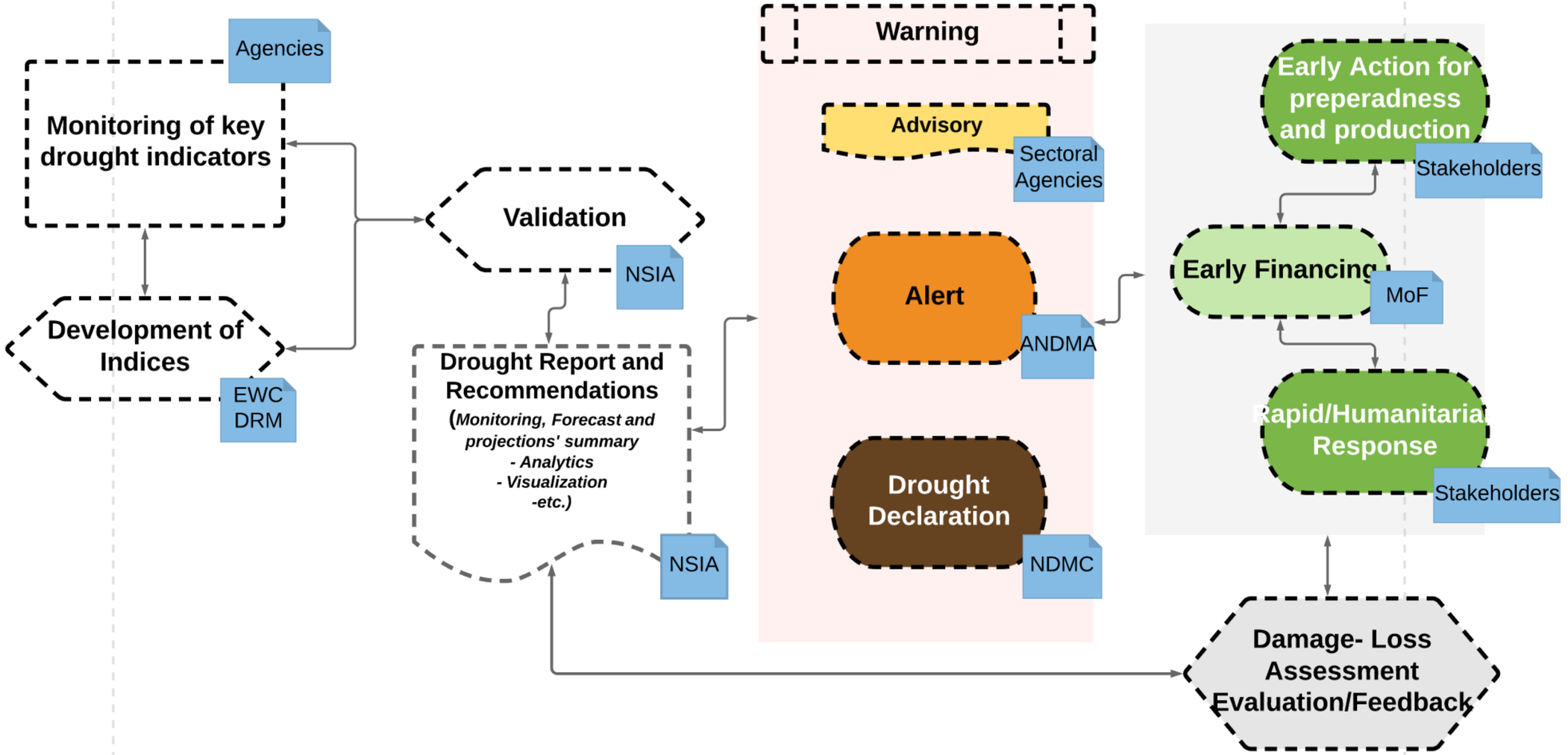
- **Indicators: Variables to describe drought conditions.**

Examples: precipitation, streamflows, groundwater, reservoir levels, soil moisture, Palmer indices, …

- **Triggers: Specific values of the indicator that initiate and terminate each level of a drought plan, and associated management responses.**

Example: precipitation below the 5th percentile for two consecutive months is a Level 4 Drought.

Early Warning, Early Action, Early Finance example from Afghanistan



Drought Monitoring and Early Warning Systems (DEWS)

Regional Drought Monitors

ICPAC – East Africa
CIIFEN Drought Monitor
Meso American Drought Monitor
NorthEast Brazil Drought Monitor
North American Drought Monitor
Caribbean Drought Bulletin
Pacific Island Climate Update
European Drought Observatory
Drought monitor for Central Europe
Drought Watch (South Eastern Europe)

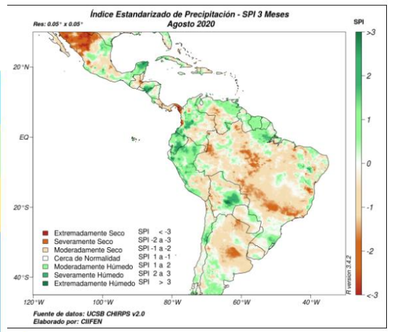
Three Pillars of Integrated Drought Management

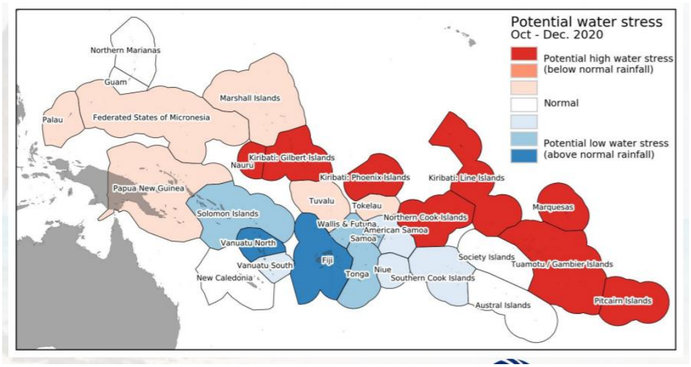
1) **Monitoring and early warning systems**
2) **Vulnerability and impact assessments**
3) **Drought preparedness, mitigation and response**

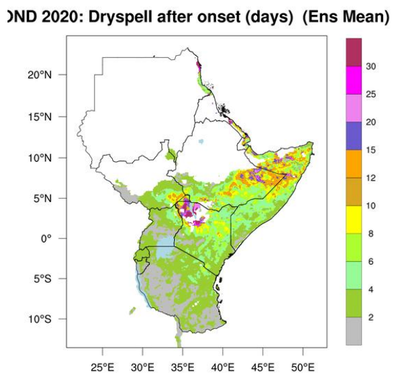
All are need for successful drought plans/polices

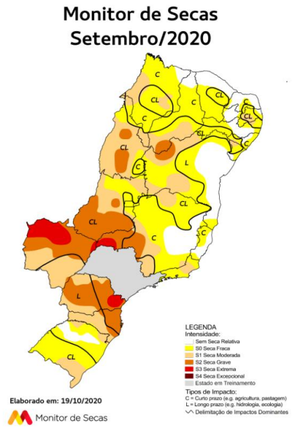
Components of DEWS

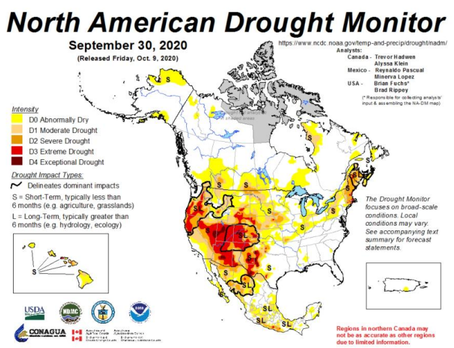
- Monitoring **AND** Forecasting
- **Tools** or decision makers
- Drought risk assessment and planning
- **Education** and awareness





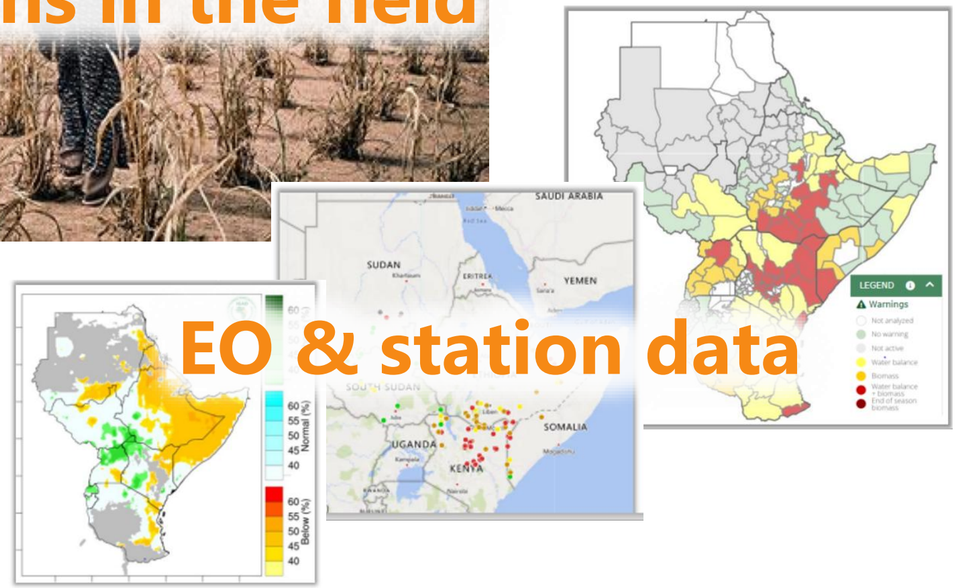


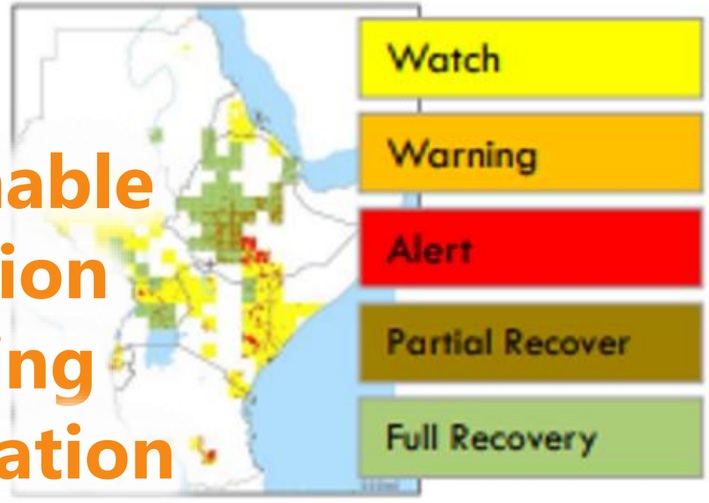




East African Drought information system: DROUGHTWATCH.ICPAC.NET

- **Service operated by ICPAC and JRC**
- **adopted as prototype by the project: Strengthening Drought Resilience for Smallholder Farmers and Pastoralists in the IGAD Region (DRESS-EA)**
- **Public online near-real time system**
- **Provides automatic 10-day warnings**
- **Covering the whole drought cycle: developing, actual and recovery from drought conditions**
- **Tailored approach crucial: Not “one fits all”**





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INTEGRATED DROUGHT MANAGEMENT PROGRAMME

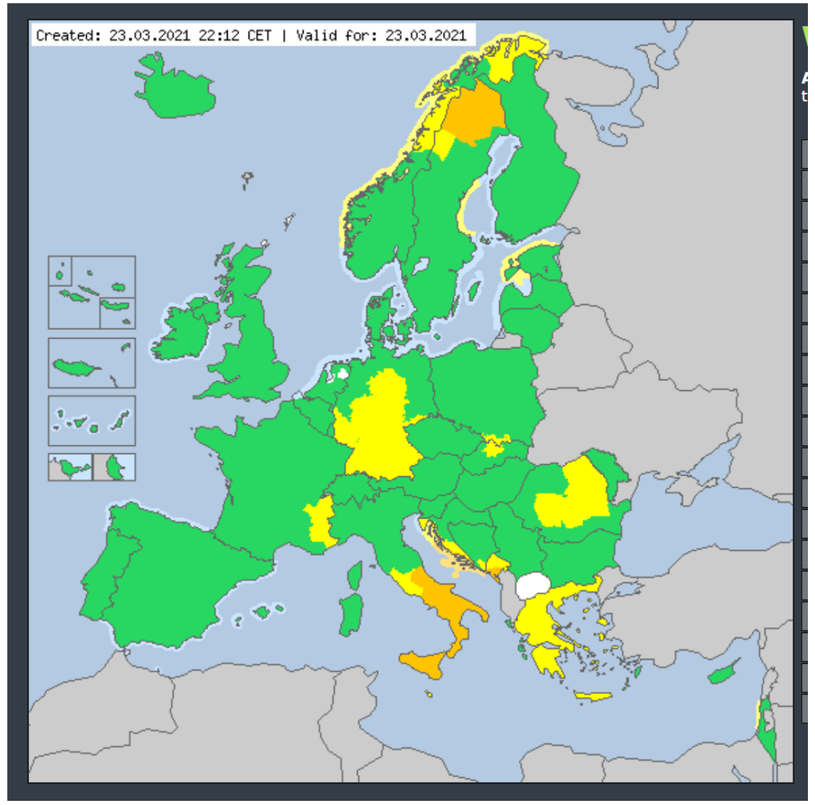
Global Drought Classification System (GDCS)

WMO SPI Manual (WMO No. 1090)

Table 2. Probability of recurrence

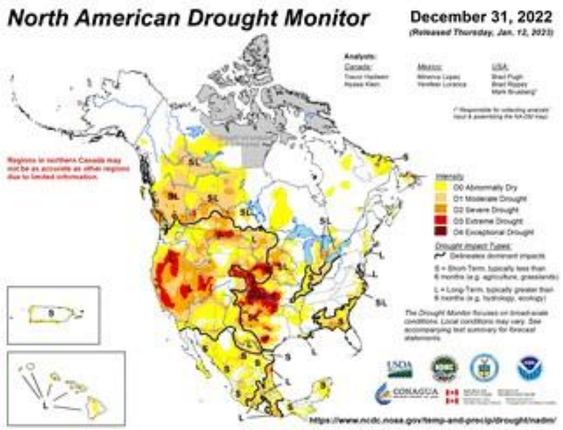
SPI	Category	Number of times in 100 years	Severity of event
0 to -0.99	Mild dryness	33	1 in 3 yrs.
-1.00 to -1.49	Moderate dryness	10	1 in 10 yrs.
-1.5 to -1.99	Severe dryness	5	1 in 20 yrs.
< -2.0	Extreme dryness	2.3 2.5	1 in 50 yrs.

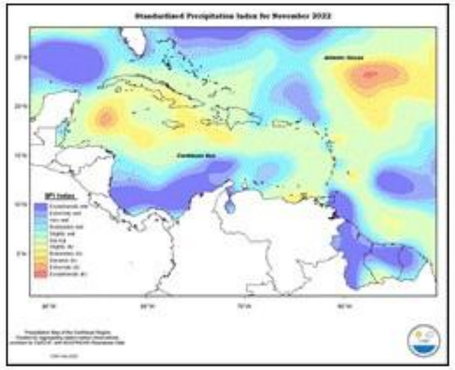
METEOALARM

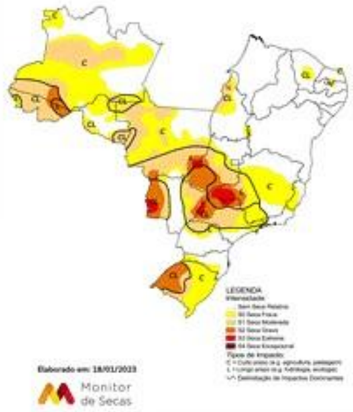


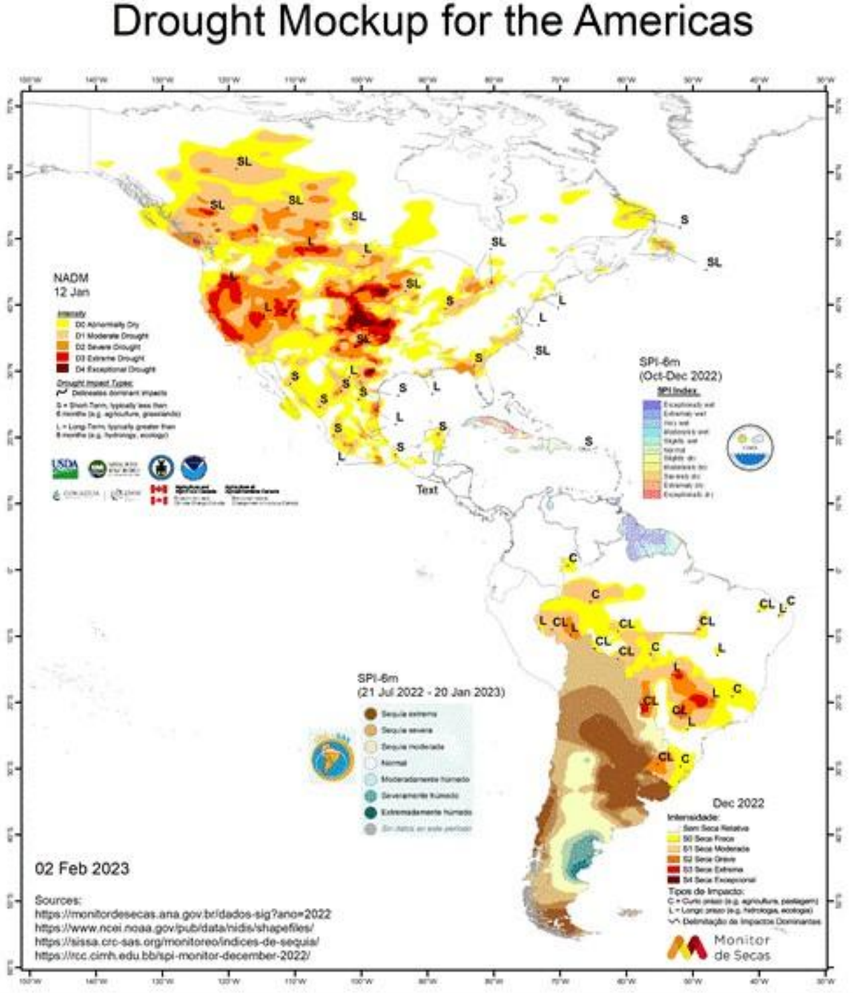
https://www.meteoalarm.org/en/

National Drought Products - Americas









Prototype of merging 4 national and regional drought products Into one GIS map

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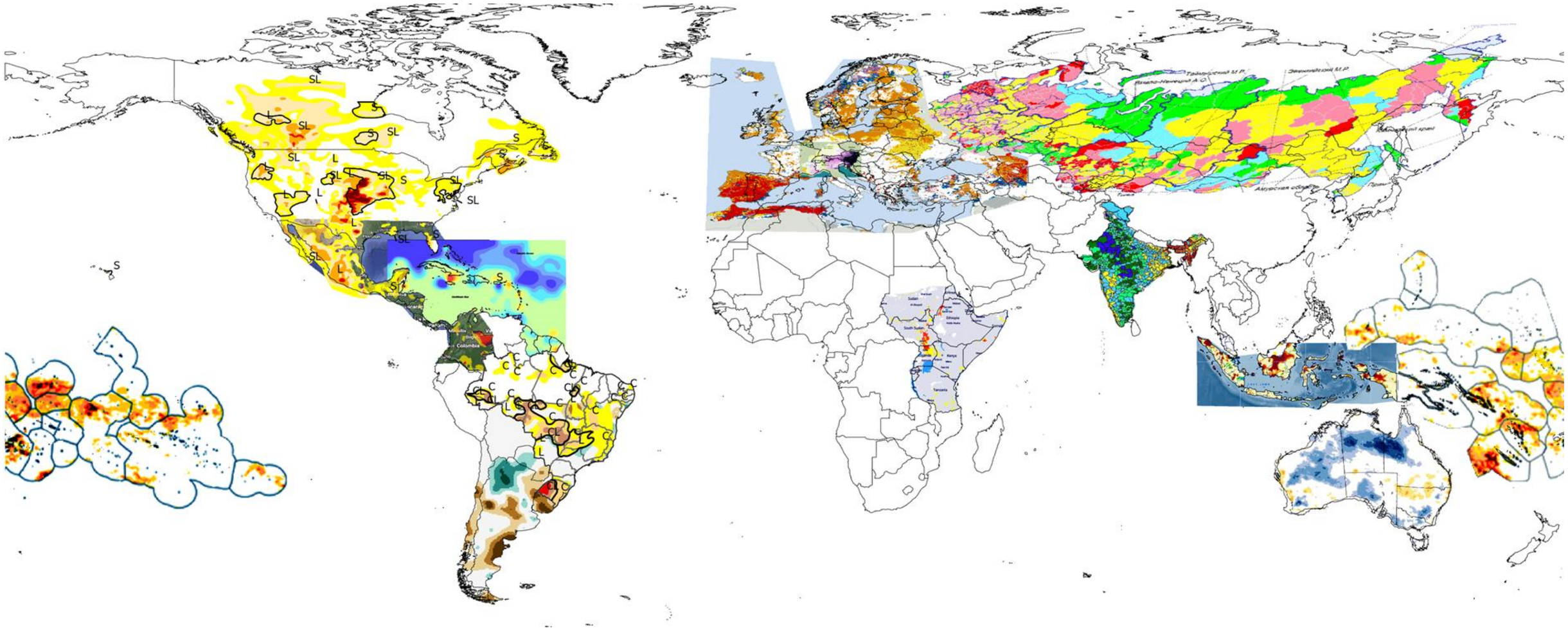
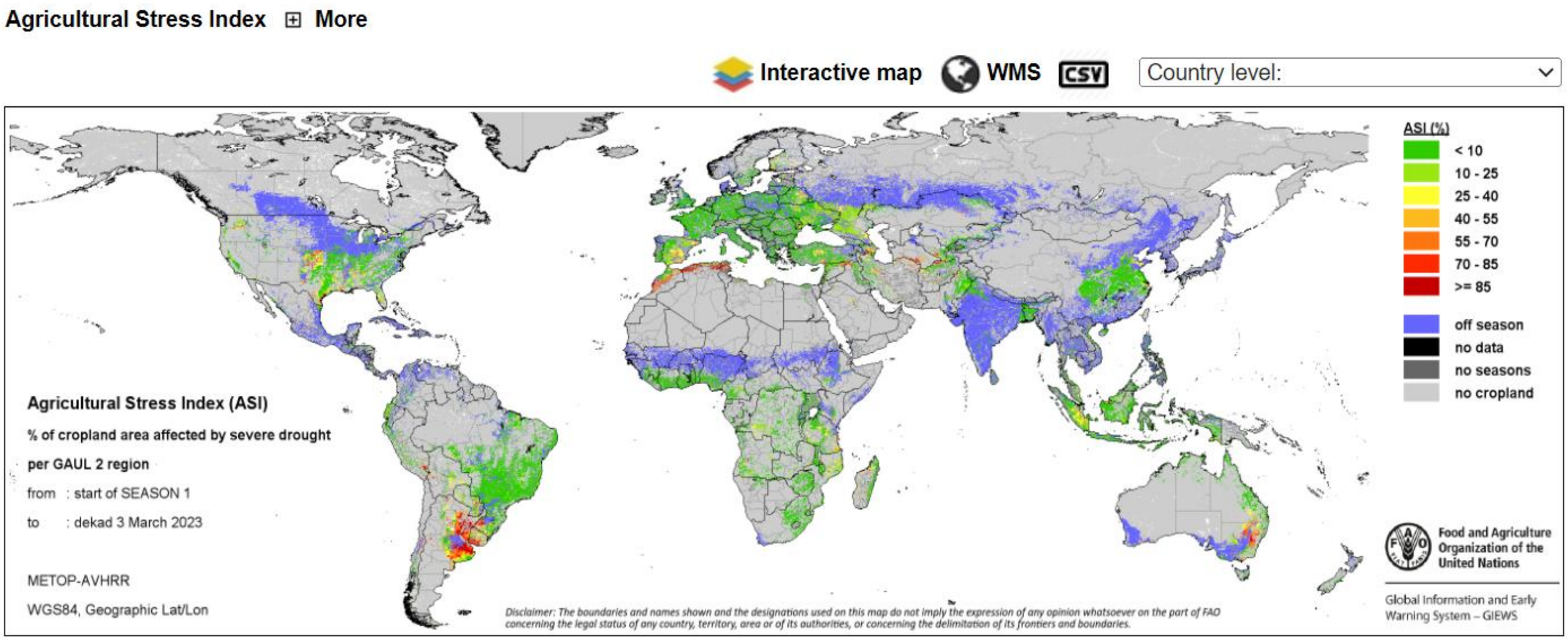
Global Water Partnership

National Drought Products

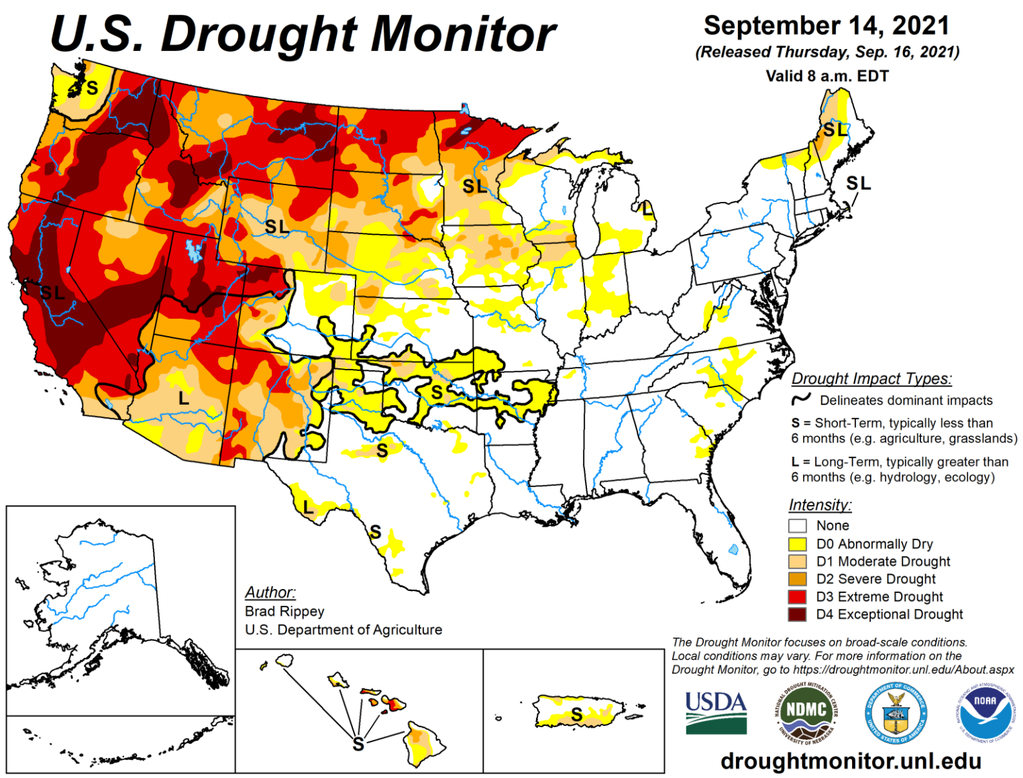


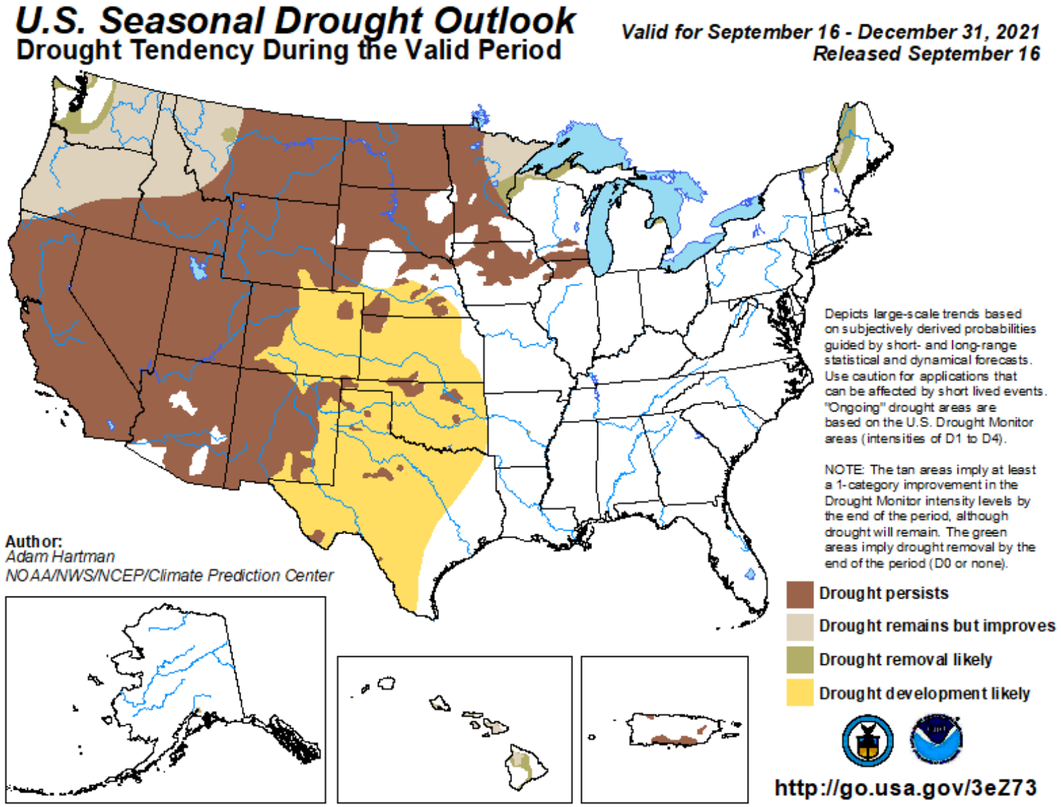
Drought Impact Monitoring

Agricultural Stress Index System (ASIS)



Monitoring Products linked and building on Drought Forecasts



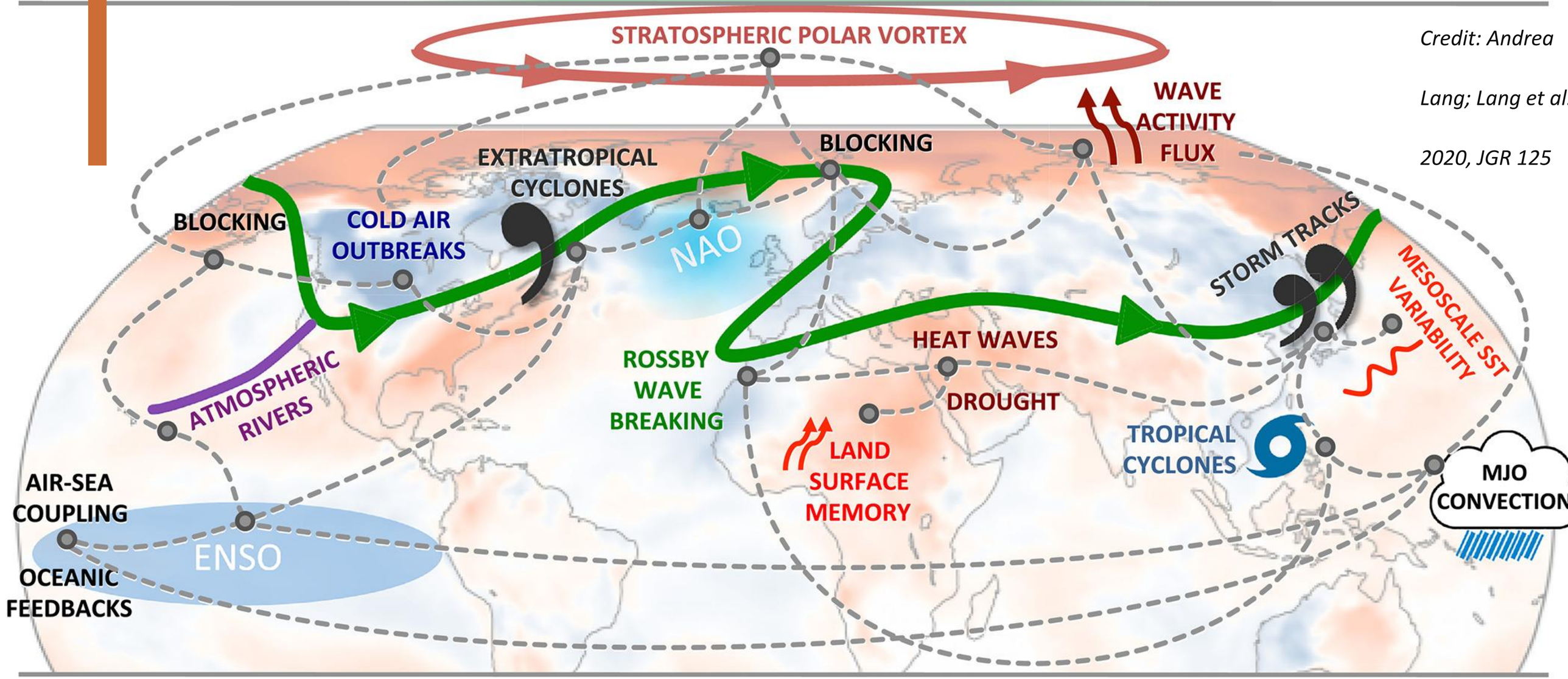


Weather Prediction
Initial Conditions
Data Assimilation

Bridging Weather and Climate:
Subseasonal–to–Seasonal (S2S) Prediction

Climate Prediction
Boundary Conditions
Coupled Earth System

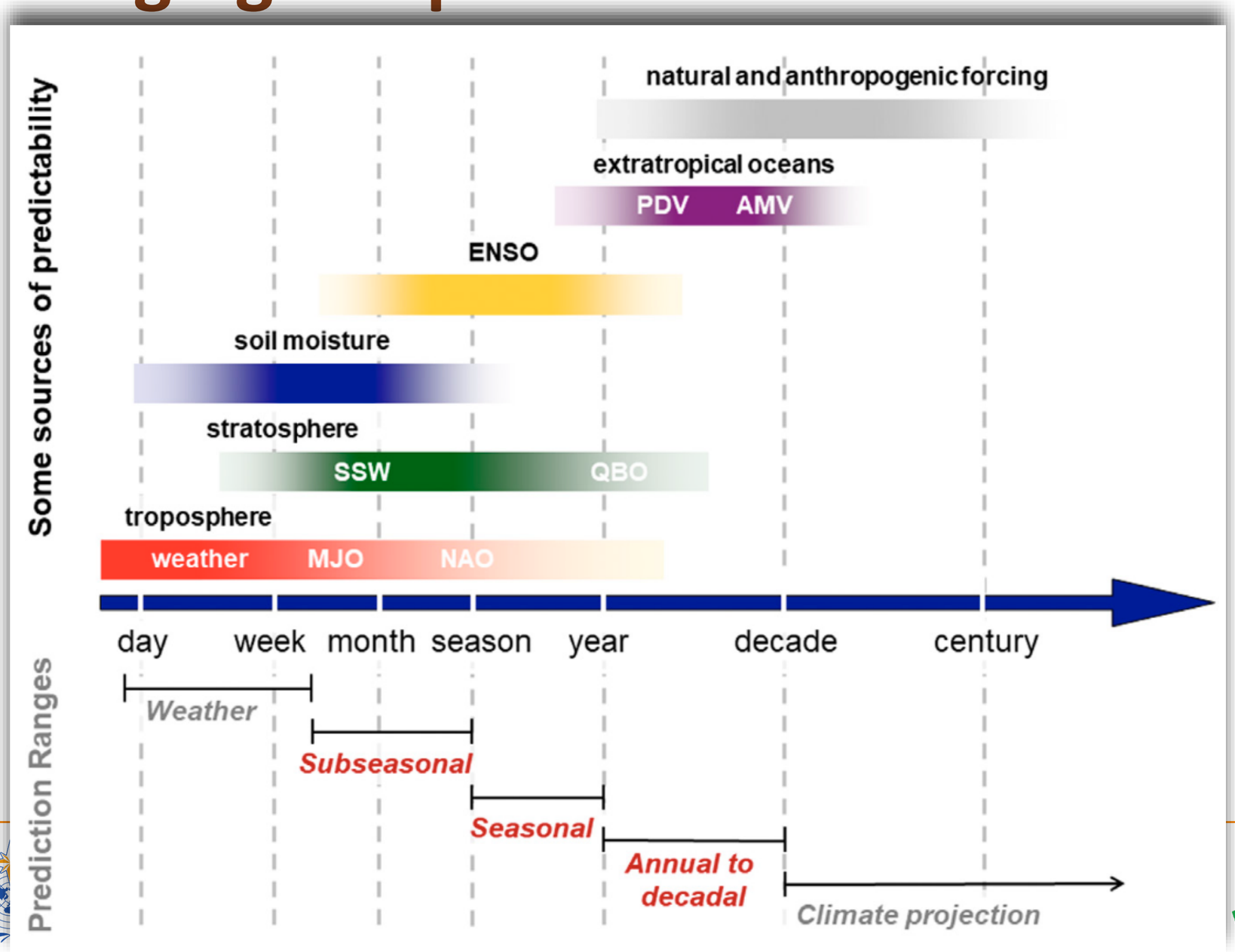
← Day | Week | Month | Season | Year →



Credit: Andrea Lang; Lang et al 2020, JGR 125

Scale interaction | Ensemble generation | Resolution | Systematic biases | Teleconnections | Physical Processes | Applications | Extremes

Bridging temporal scales

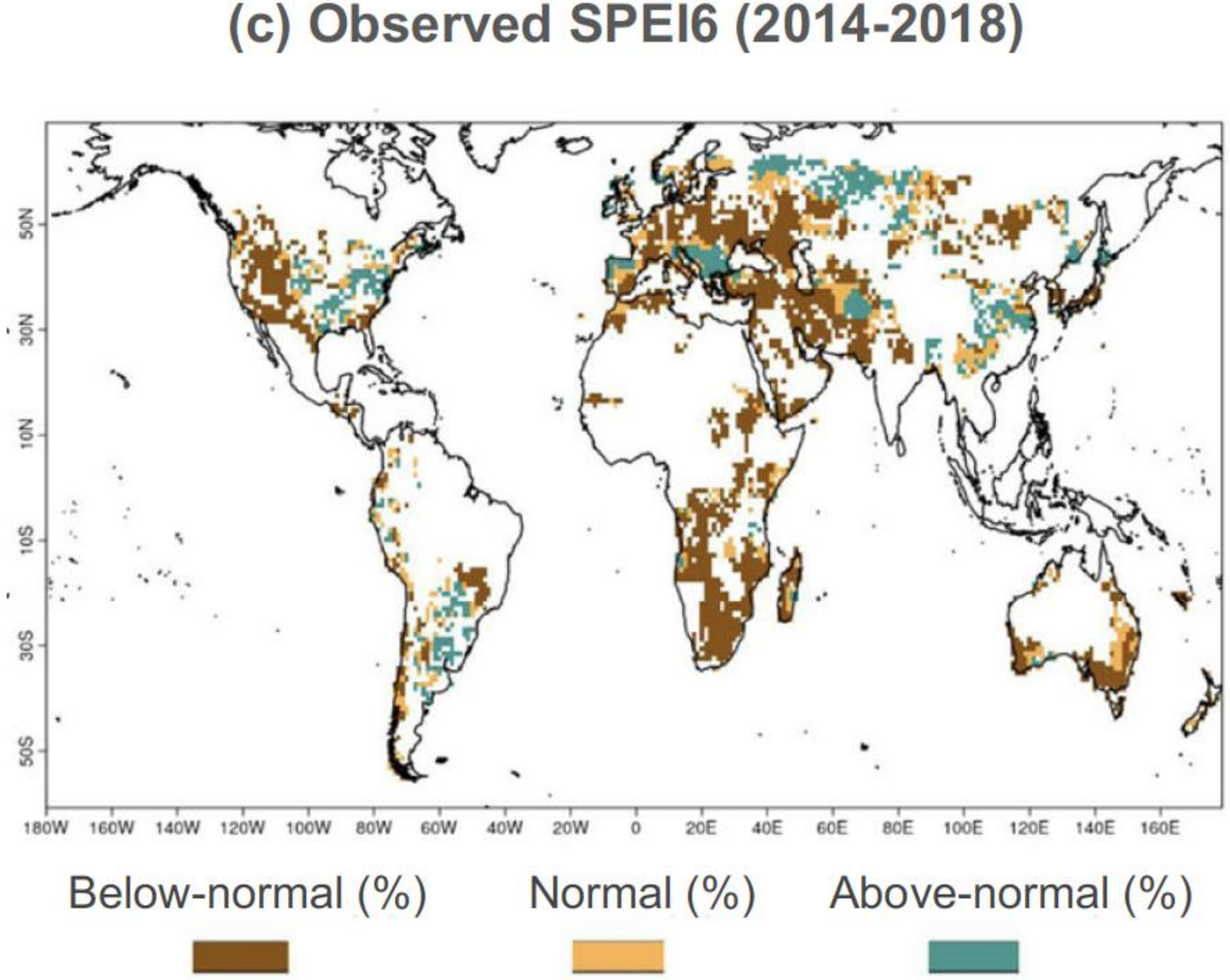


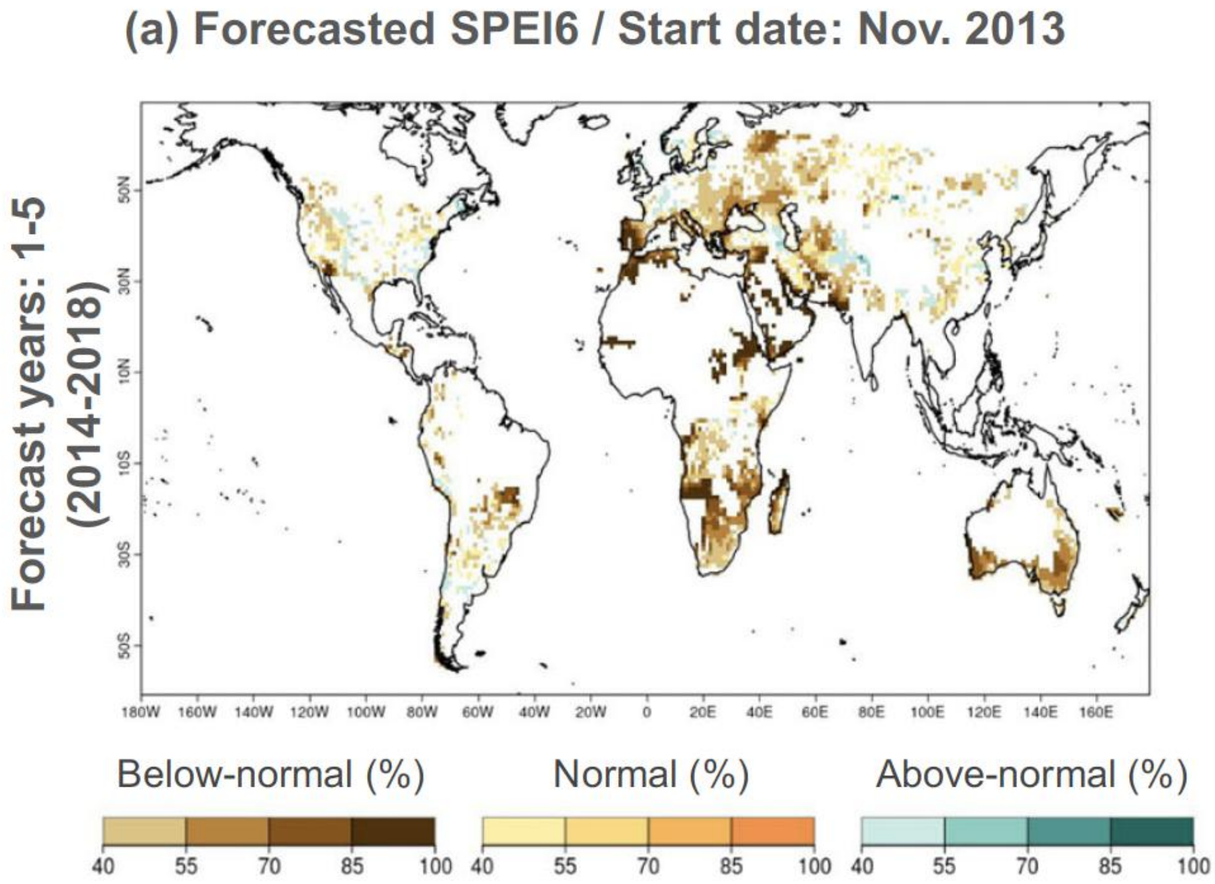
Merryfield et al. 2020

BAMS

Global Water Partnership

Bridging temporal scales





Adapted from: Solaraju-Murali et al. 2021, NPJ 34

Future directions

Courtesy Andrea Toreti, JRC

- ***Dynamics*** *- modulation mechanisms; interactions*
- ***Dynamics*** *- land-atmosphere; stratosphere-troposphere coupling*
- ***Dynamics*** *- exploring teleconnections*
- ***Modelling*** *- processes' representation; assimilation*
- ***Modelling*** *- human factors*
- ***Modelling*** *- ensembles; longer time scales*
- ***Modelling*** *- improving hydrological models (calibration, snow-related processes, water use, groundwater)*
- ***Data*** *- optimal integration of available data sources; high-res data*
- ***Use*** *- varying skill, uncertainty, and coherence*
- ***Hybrid*** *- AI exploitation*
- ***Hybrid*** *- Digital Twins*
- ***Seamless*** *- bridge time scales from monthly to decadal*
- ***Impacts*** *- integrated strategies to provide impact predictions*
- ***Impacts*** *- combine different tools to support actions and reduce drawbacks*

Importance of Capacity Building for Drought Monitoring and Forecasting

>2000

Participants

MORE INFO HERE

- Collaboration with UNEP-DHI Centre and CapNet
- Free, online and self-paced course was launched

ENGLISH & FRENCH COURSE

Online courses (and training)