



WMO OMM

World Meteorological Organization

Working together in weather, climate and water

Drought Monitoring and Early Warning Systems

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Climate and Water Department



Summary

- **Review of High-Level Meeting on National Drought Policies**
- **Introduction to Drought Monitoring and Early Warning Systems**
- **Different Drought Indices and Data Issues**
- **Successful examples/ongoing initiatives**



World Meteorological Organization

- United Nations agency for weather, climate, hydrology and water resources and related environmental issues.
- 191 Members from National Meteorological and Hydrological Services (NMHS) – New Member – South Sudan (Dec 2012)
- 10 major scientific & technical programmes (Secretariat)
- **8 Technical Commissions** advise & guide activities of programmes (Experts)
- 6 Regional Associations involved in implementation

Global Framework for Climate Services

- Goal:
 - Enable better management of the risks of climate variability and change and adaptation to climate change at all levels, through development and incorporation of science-based climate information and prediction into planning, policy and practice.



Priorities

- **Agriculture**
- **Disaster risk reduction**
- **Water**
- **Health**





HMNDP Main Organizers and Partners

- **World Meteorological Organization (WMO)**
- **United Nations Convention to Combat Desertification (UNCCD)**
- **United Nations Food and Agriculture Organization (FAO)**
- United Nations Educational, Scientific and Cultural Organization (UNESCO)
- United Nations Development Programme (UNDP)
- **UN-Water Decade Programme on Capacity Development (UNW-DPC)**
- United Nations International Strategy for Disaster Reduction (UNISDR)
- World Food Programme (WFP)
- Global Water Partnership (GWP)
- International Fund for Agricultural Development (IFAD)
- A total of 17 Organizations



Attendance

414 registered participants from 87 countries





Scientific Segment

- **9 substantive sessions in the Scientific Segment plus 2 synthesis/reporting sessions (regional breakout groups and summary)**
- **28 posters in three poster sessions. 16 Side events**
- **All sessions produced summaries and recommendations**
- **Compendium from July 2011 Workshop revised as HMNDP Science Document**

HMNDP Science & Policy Documents

www.hmndp.org

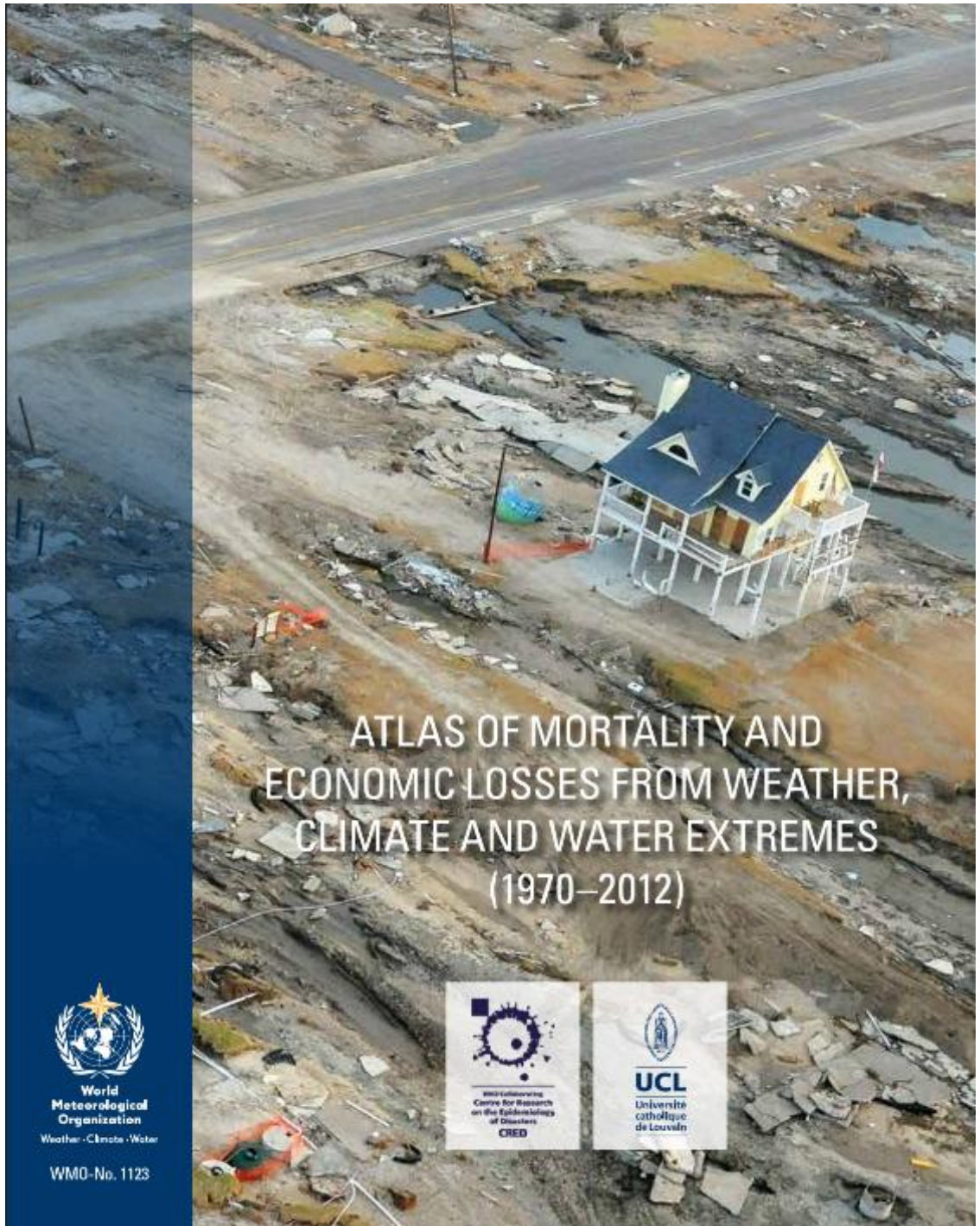
See items 18-26



Launch of initiatives

- **2013 World Day to Combat Desertification, UN Decade for Deserts and the Fight against Desertification, and UN Decade on Biodiversity**
- **Integrated Drought Management Programme (IDMP) with WMO & GWP**
- **National Drought Management Policies Initiatives (NDMP) with UNW-DCP, FAO, UNCCD, & WMO**

Introduction



ATLAS OF MORTALITY AND ECONOMIC LOSSES FROM WEATHER, CLIMATE AND WATER EXTREMES (1970–2012)



World
Meteorological
Organization
Weather · Climate · Water

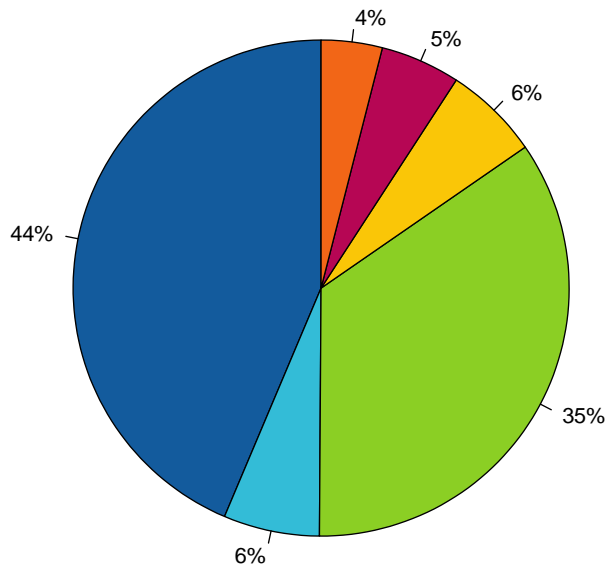
WMO-No. 1123



Global

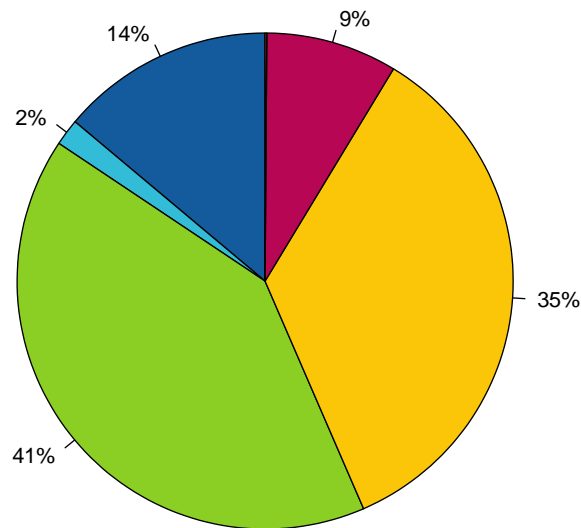
Distribution of (a) number of reported disasters, (b) reported deaths and (c) reported economic losses (1970–2012)

Total = 8 835 disasters (1970–2012)



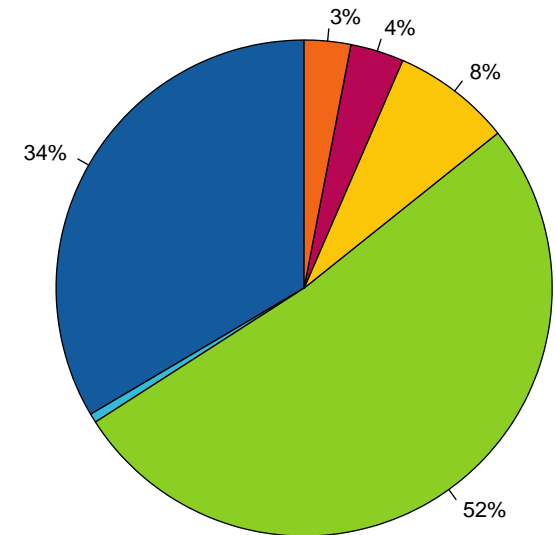
(a)

Total = 1 944 653 deaths (1970–2012)



(b)

Total = US\$ 2 390.7 billion (1970–2012)

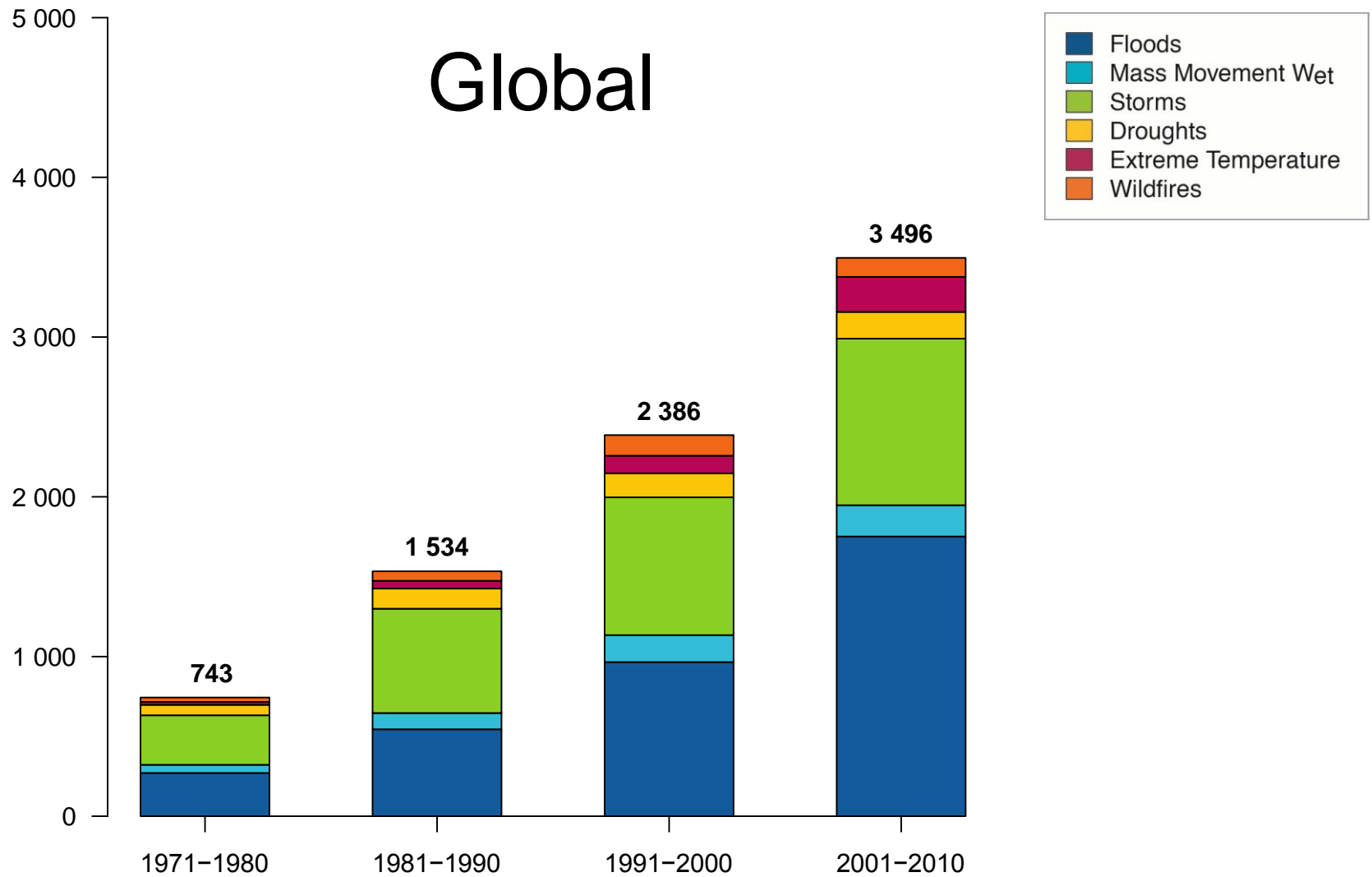


(c) (in US\$ billion, adjusted to 2012)

■ Floods
 ■ Mass Movement Wet
 ■ Storms
 ■ Droughts
 ■ Extreme Temperature
 ■ Wildfires

Source: *Atlas of Mortality and Economic Losses from Weather, Climate and Water Extremes (1970–2012)*, WMO, WMO- No. 1123

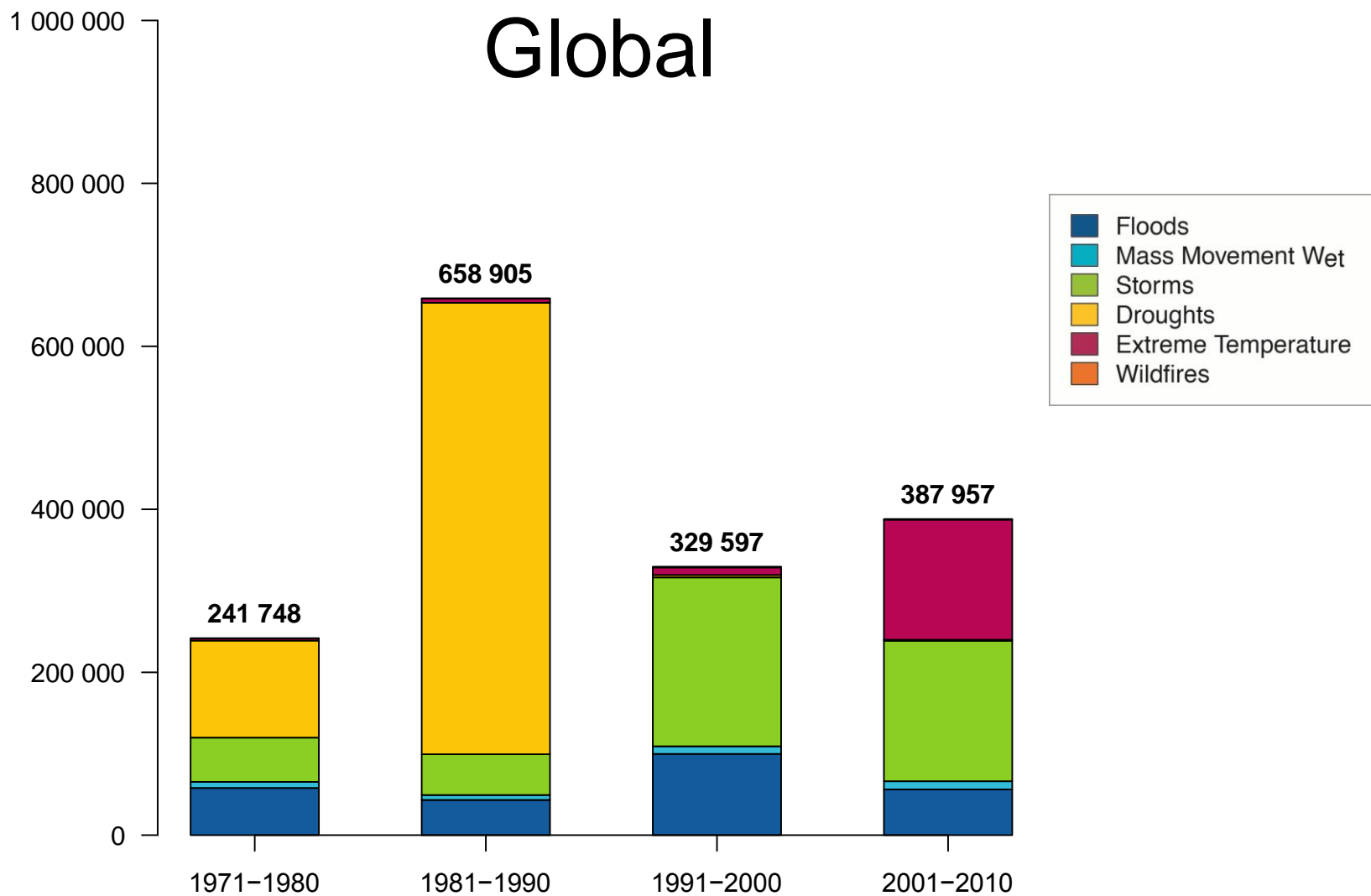
Number of reported disasters by decade by hazard type (1971–2010)



Source: *Atlas of Mortality and Economic Losses from Weather, Climate and Water Extremes (1970–2012)*,
WMO, WMO- No. 1123

Number of reported deaths by decade by hazard type (1971–2010)

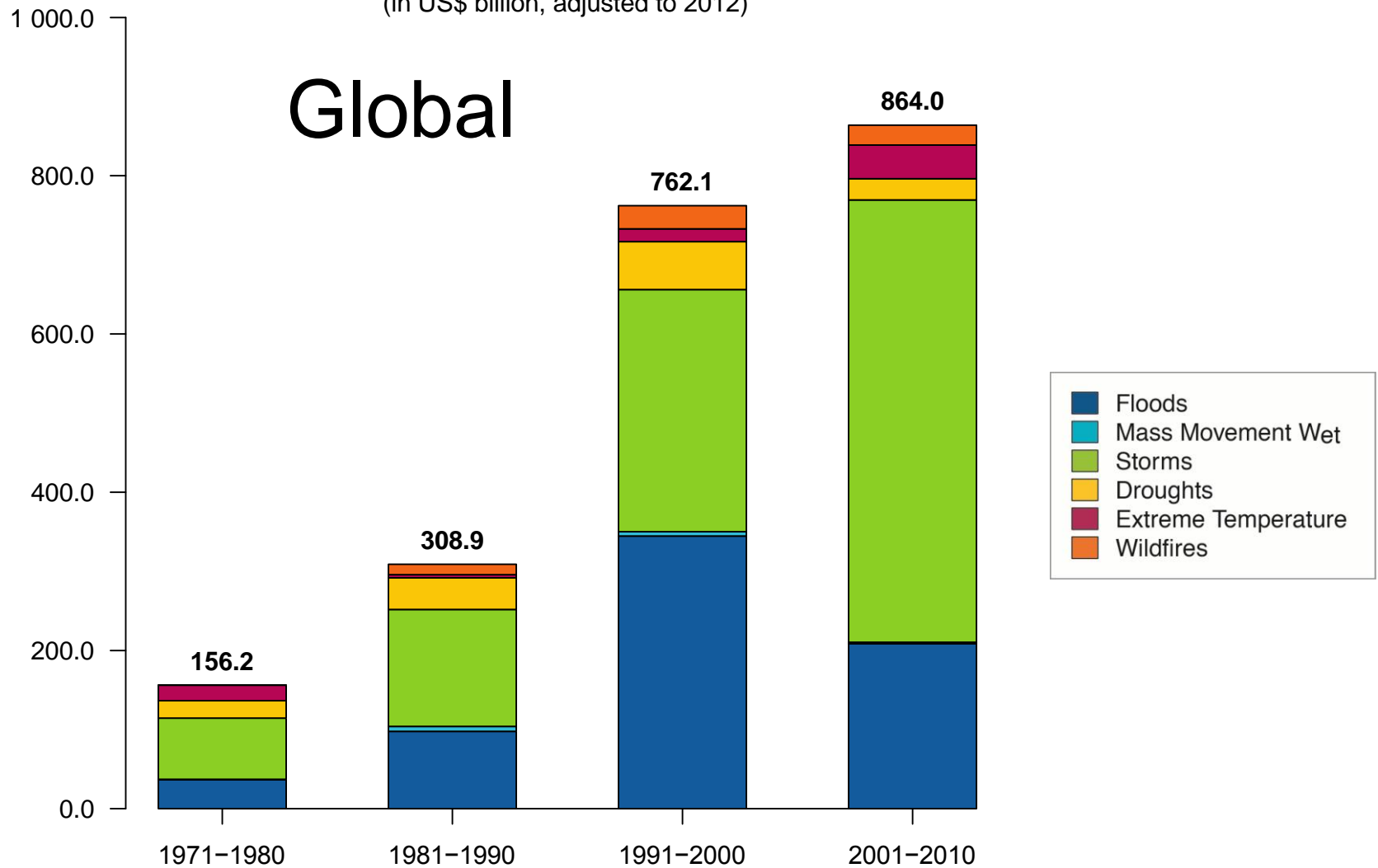
Global



Source: *Atlas of Mortality and Economic Losses from Weather, Climate and Water Extremes (1970–2012)*,
WMO, WMO- No. 1123

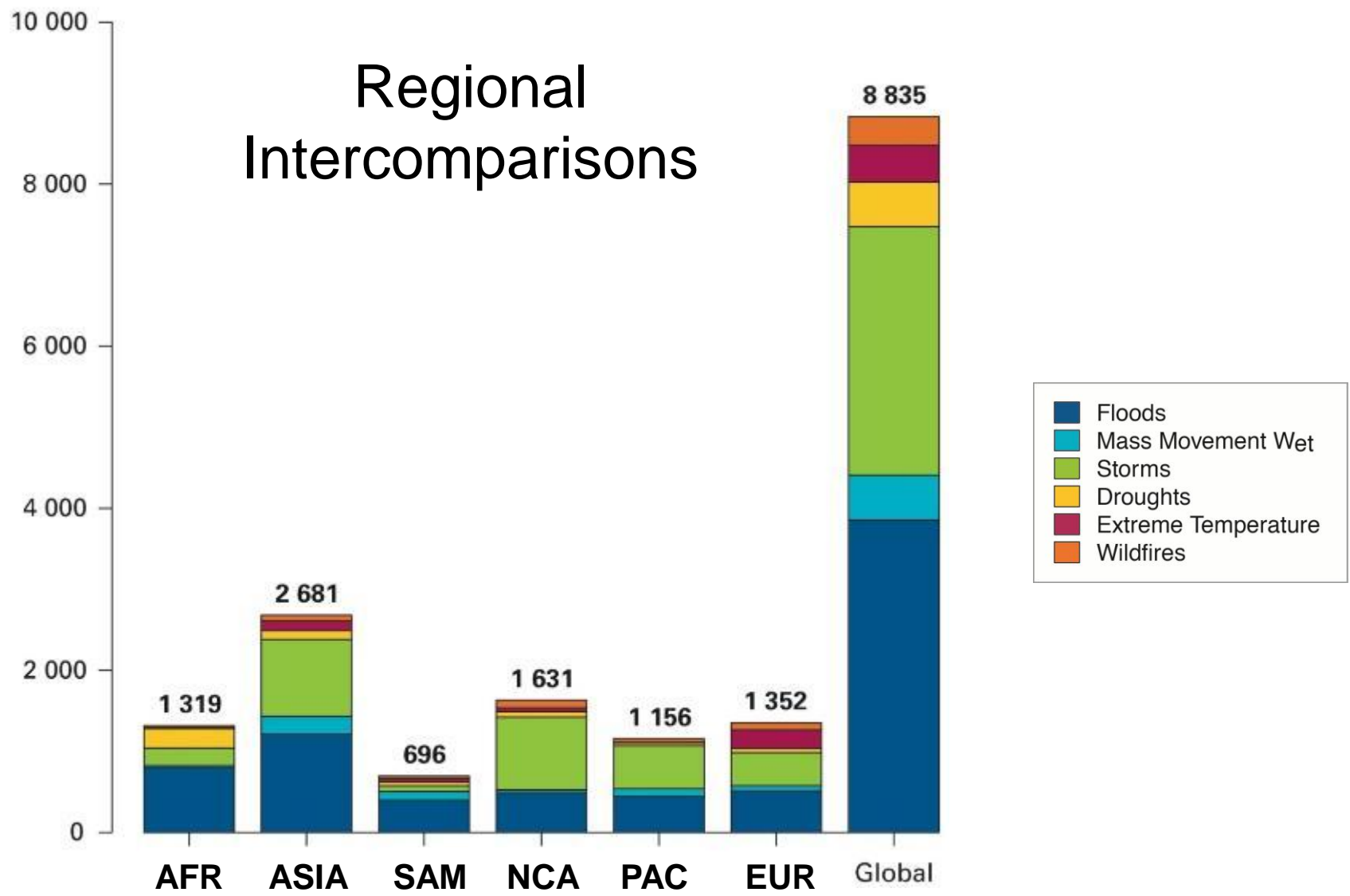
Reported economic losses by decade by hazard type (1971–2010)

(in US\$ billion, adjusted to 2012)



Source: *Atlas of Mortality and Economic Losses from Weather, Climate and Water Extremes (1970–2012)*, WMO, WMO- No. 1123

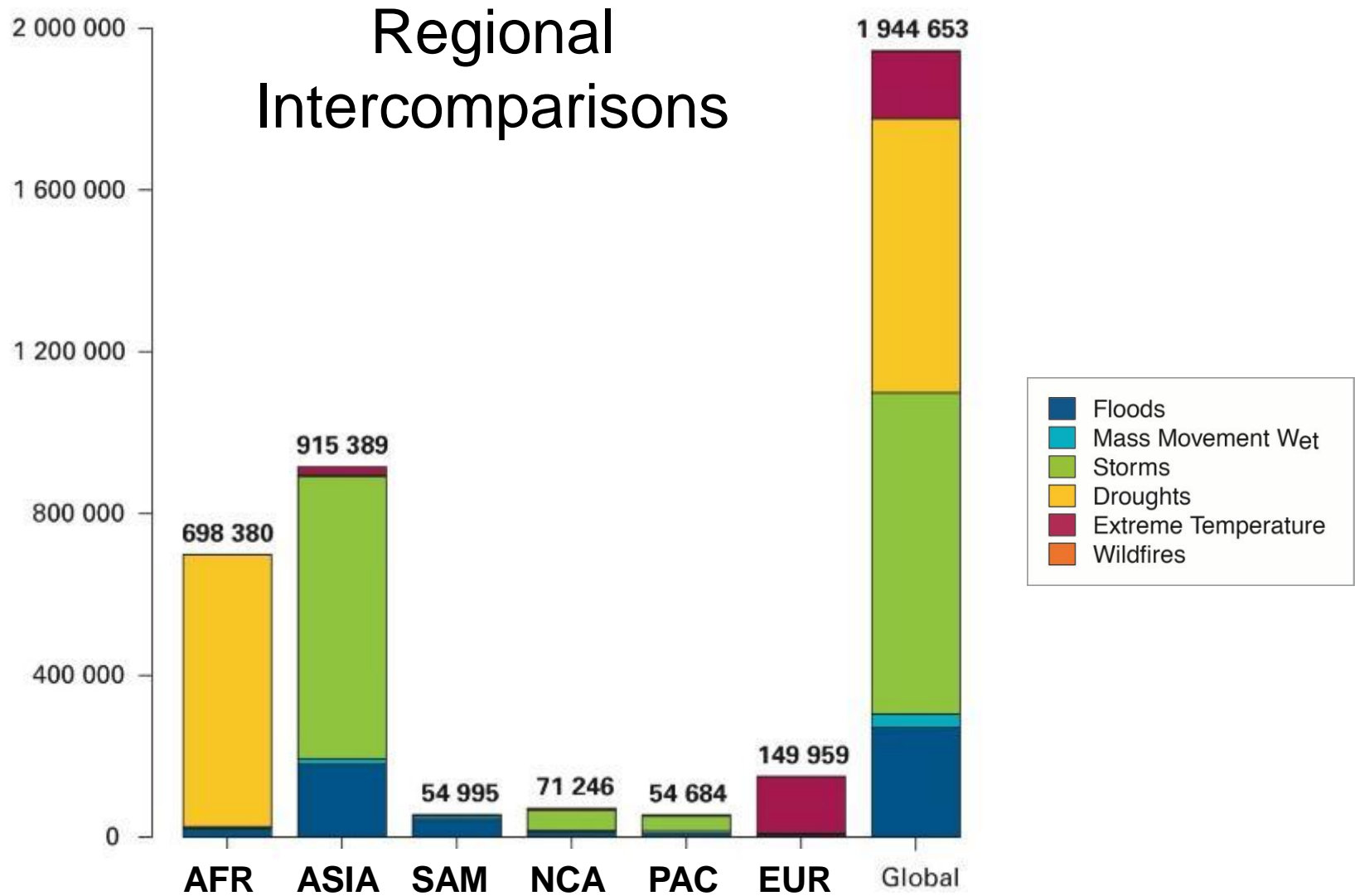
Number of reported disasters by hazard type (1970–2012)



Source: *Atlas of Mortality and Economic Losses from Weather, Climate and Water Extremes (1970–2012)*, WMO, WMO- No. 1123



Number of reported deaths by region by hazard type (1970–2012)



Source: *Atlas of Mortality and Economic Losses from Weather, Climate and Water Extremes (1970–2012)*, WMO, WMO- No. 1123



Why Monitor Drought?

- Drought is a **Normal** Part of the Climatic Cycle
- Drought **Impacts** are Significant & Widespread
- **Many** Economic Sectors Affected
- Drought is **Expensive**
 - Droughts cause more deaths and displace more people than any other kind of natural disaster.
 - Since 1980, major droughts and heat waves within the U.S. alone have resulted in costs exceeding 100 billion dollars

Source: Svoboda, 2009



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

Source: Svoboda, 2009



Components of a Drought Monitoring System

- **timely data and timely acquisition**
- **synthesis/analysis of data used to “trigger” set actions within a plan**
- **efficient dissemination network (web, media, extension, etc.)**

Source: Svoboda, 2009



Potential Monitoring System Products and Reports

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

Source: Svoboda, 2009



Components of a Drought Early Warning and Information System

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

Source: Wilhite, 2013

Indices and Data Issues



Approaches to Drought Monitoring

- **Single index or parameter**
- **Multiple indices or parameters**
- ***Composite index***

Source: Svoboda, 2009

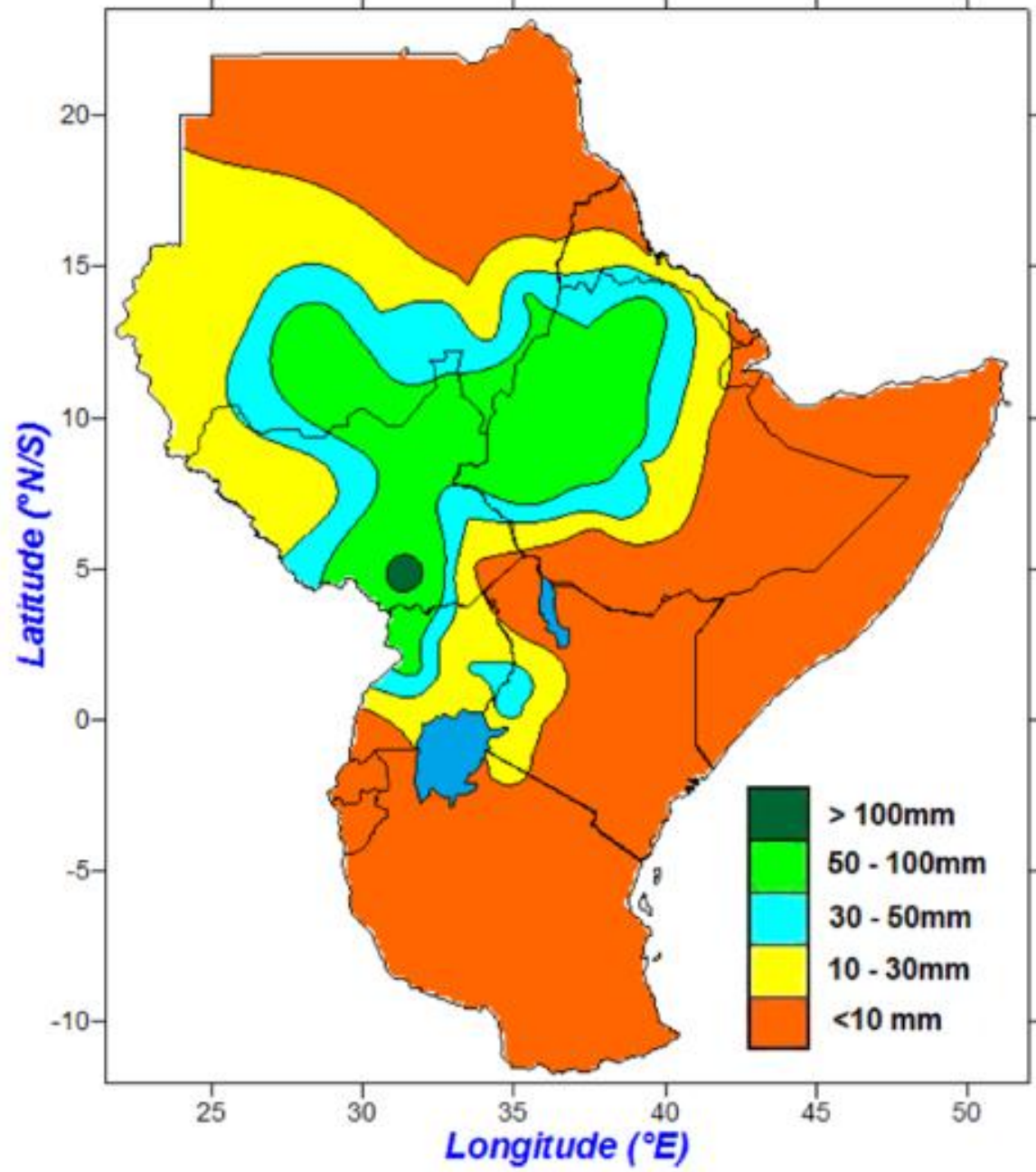
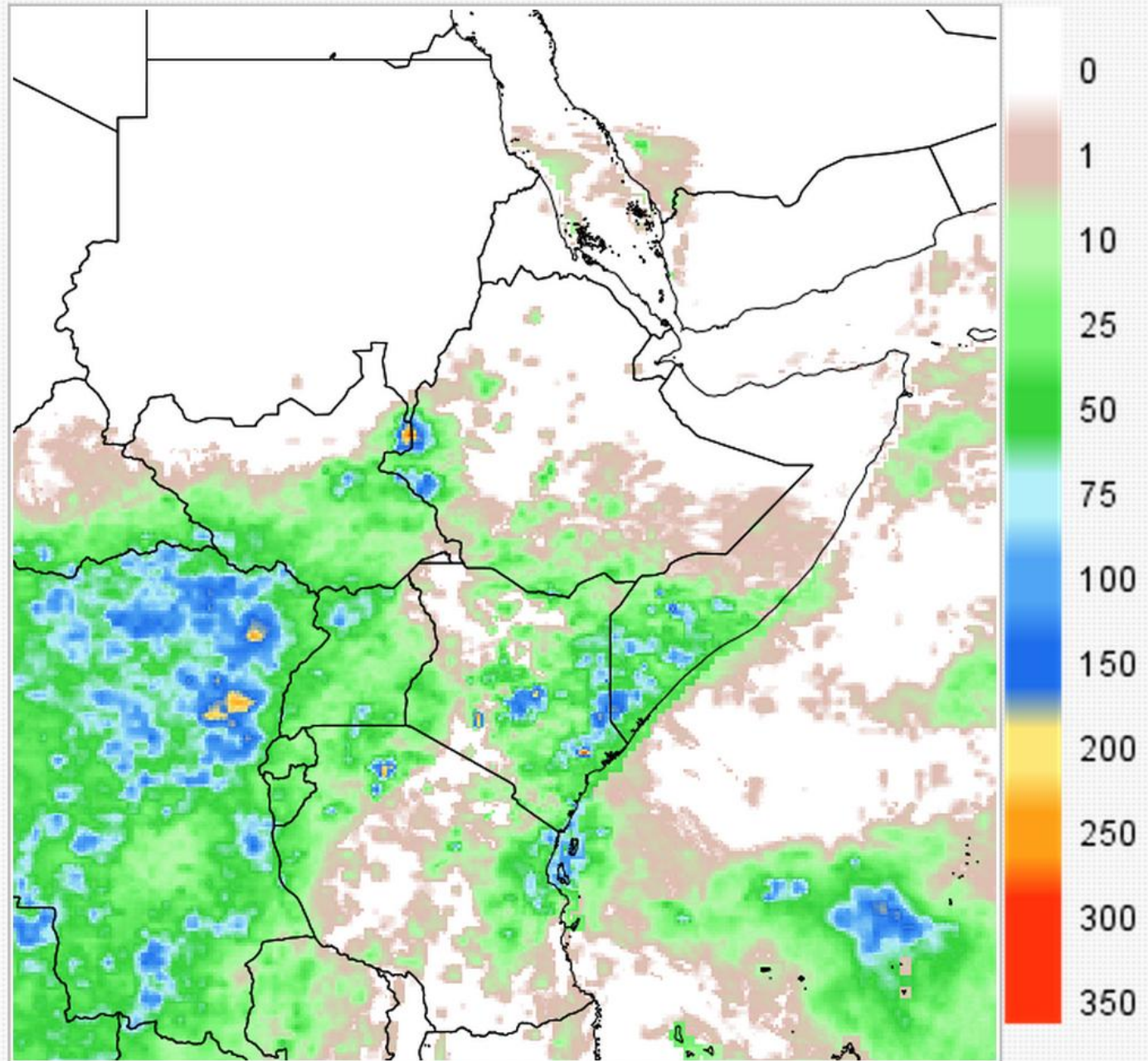


Figure 1: Spatial distribution of observed rainfall during dekad 20 (11 – 20 July) of 2014



Rainfall Estimate Nov 2014 Dekad 1 (1st - 10th)

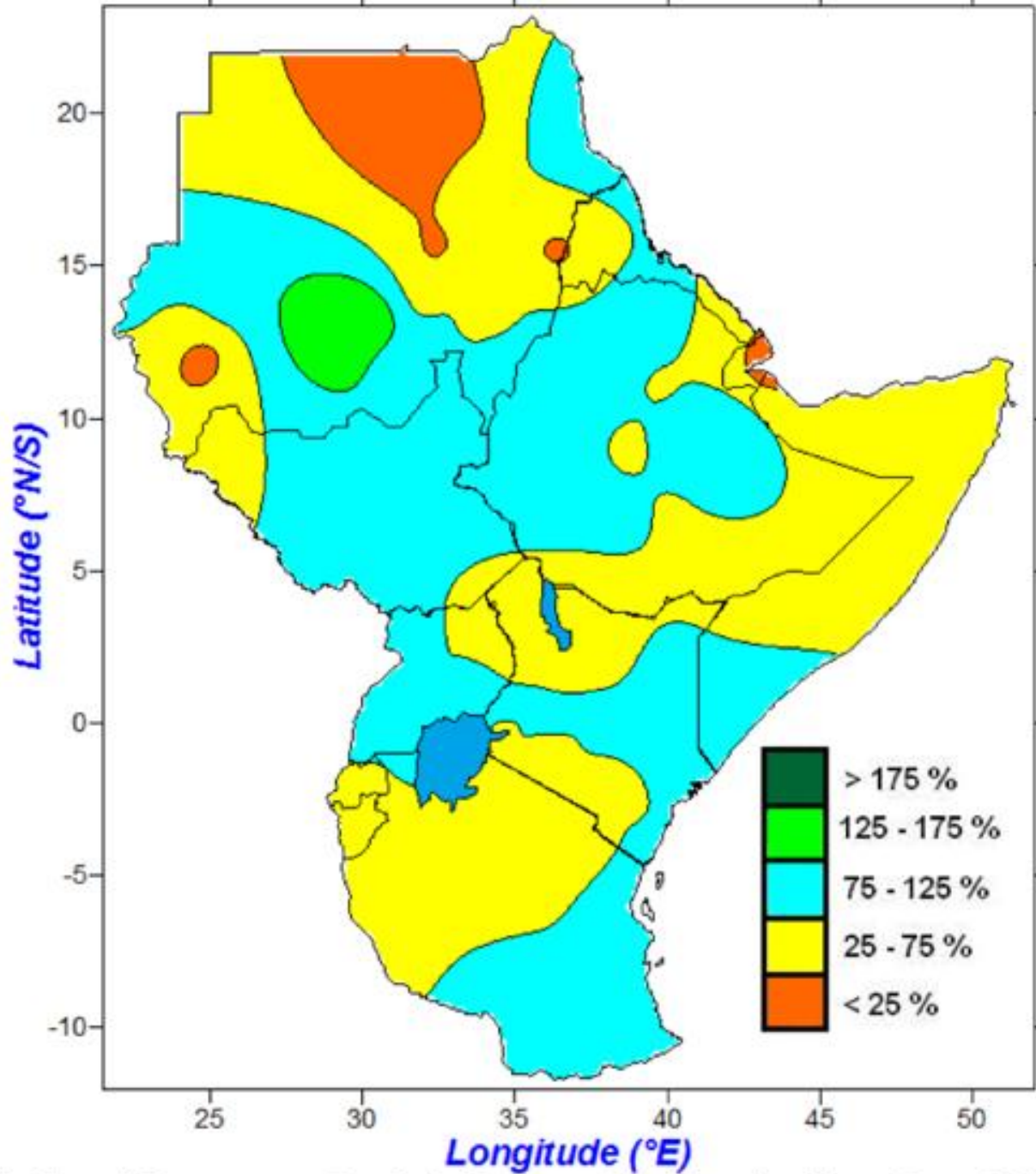


Figure 4: Spatial pattern of rainfall anomalies for April to June 2014 period



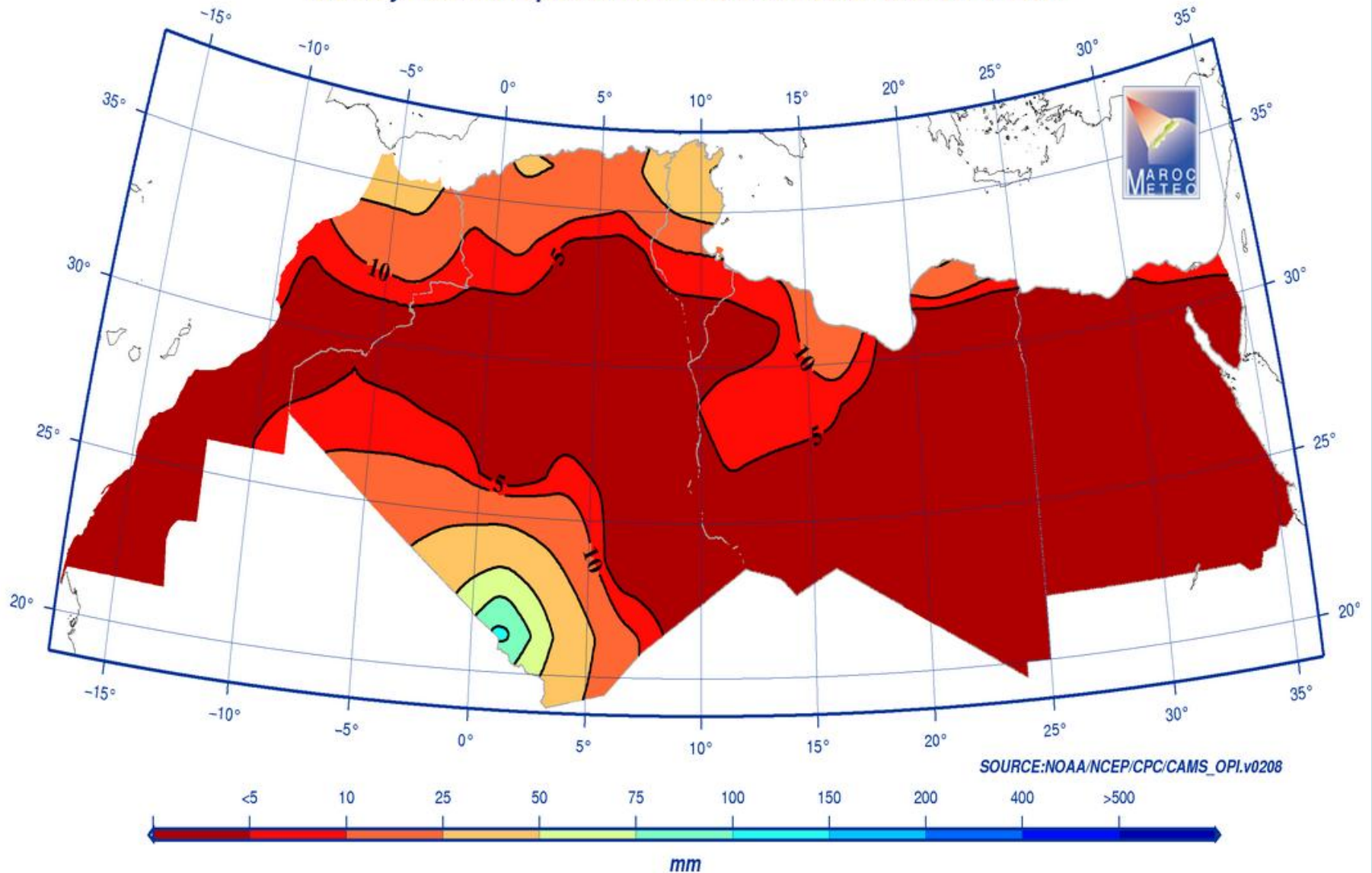
Figure 3a: Cumulative rainfall series for Nekemte



Figure 3b: Cumulative rainfall series for Kaduguli

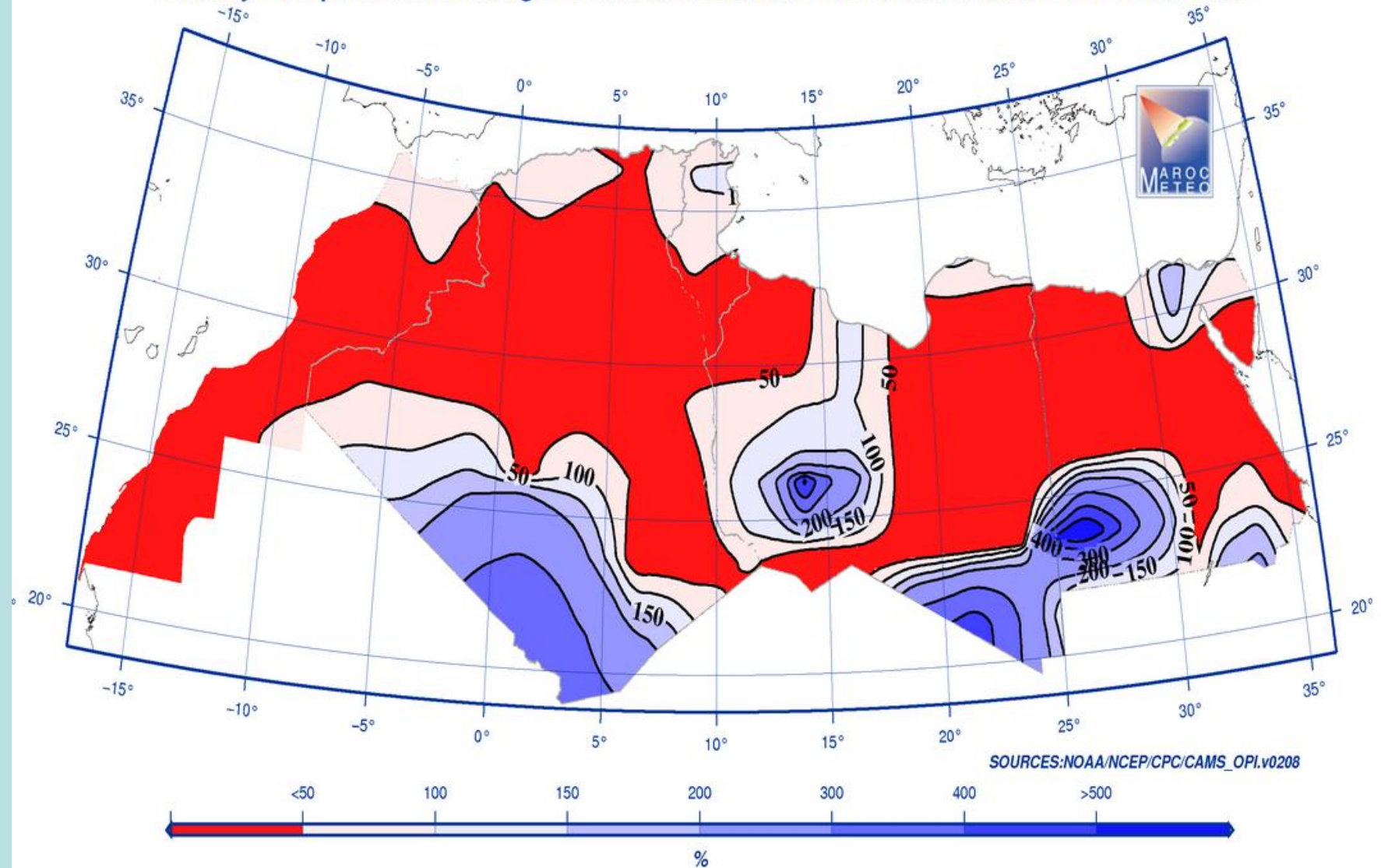
Climate RR OCT 2014

Monthly Total Precipitation over North Africa for OCTOBER 2014



Climate RR Anomaly OCT 2014

Monthly Precipitation Percentage of Normals 1981/2010 over North Africa for OCTOBER 2014



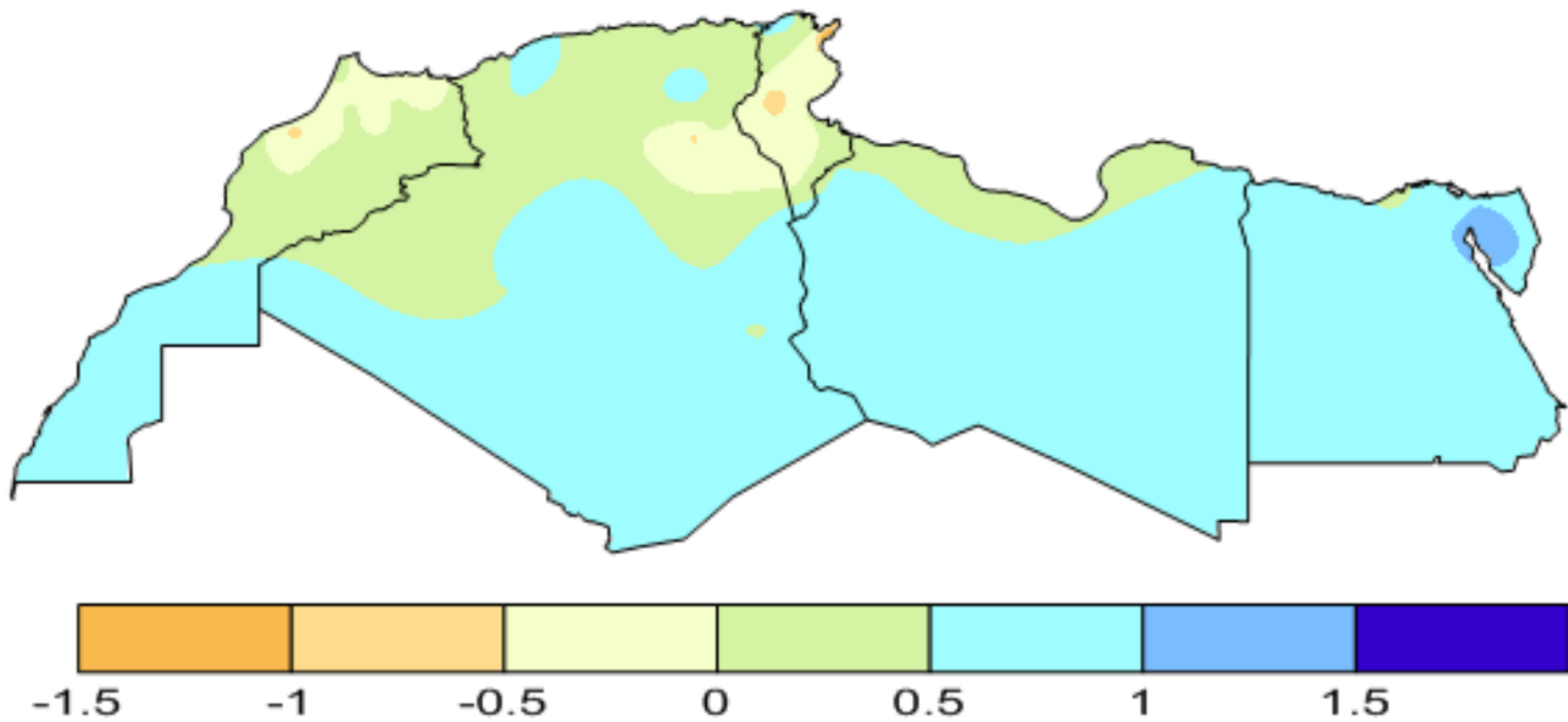


Figure 5: SPI October 2014 (3months)

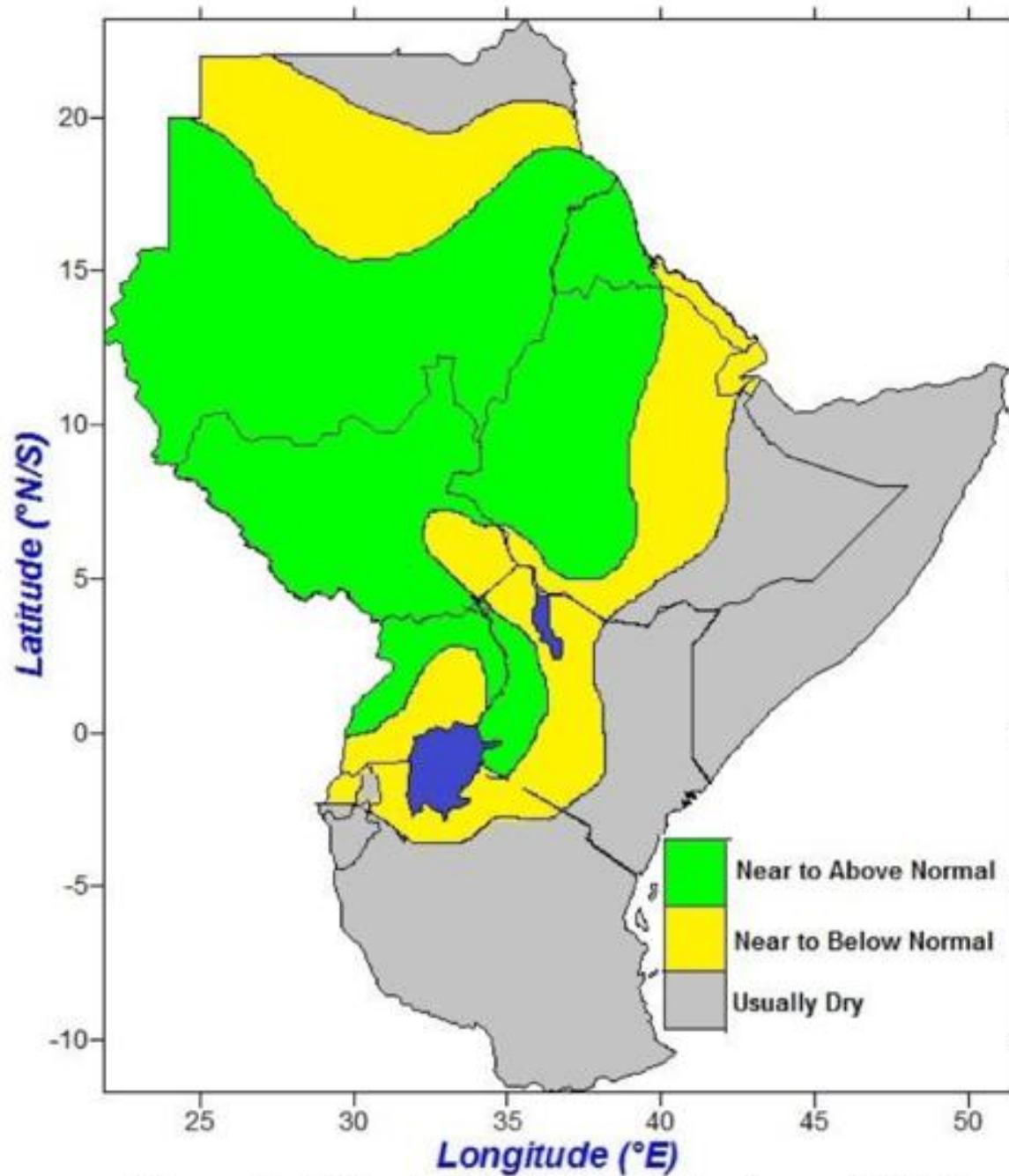
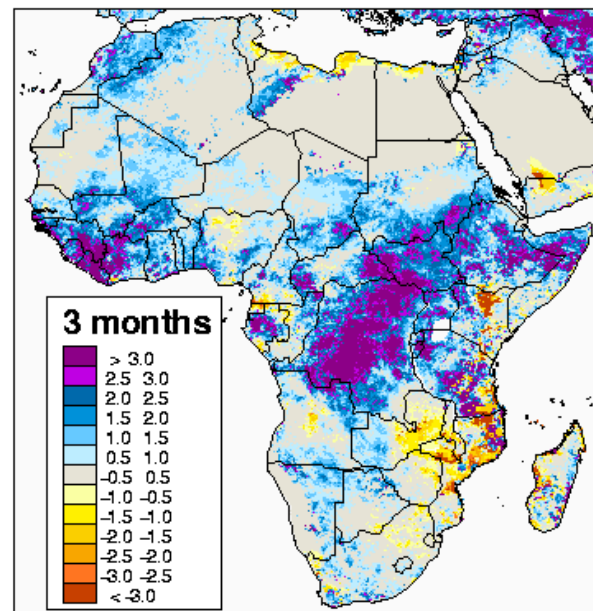
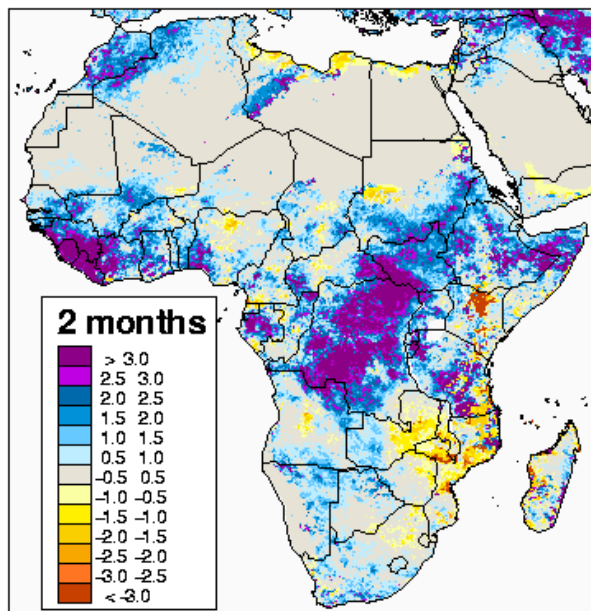
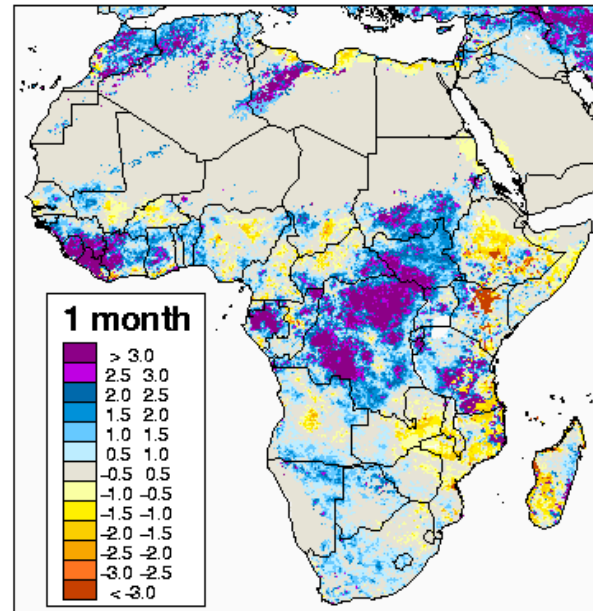
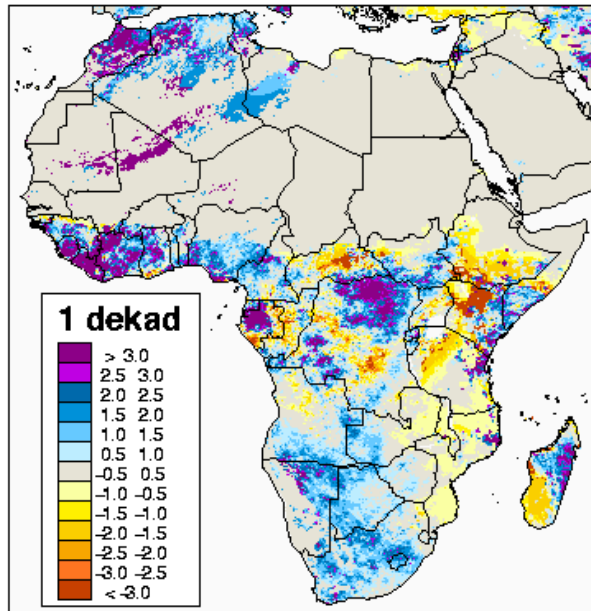


Figure 7: Climate Outlook for the August 2014

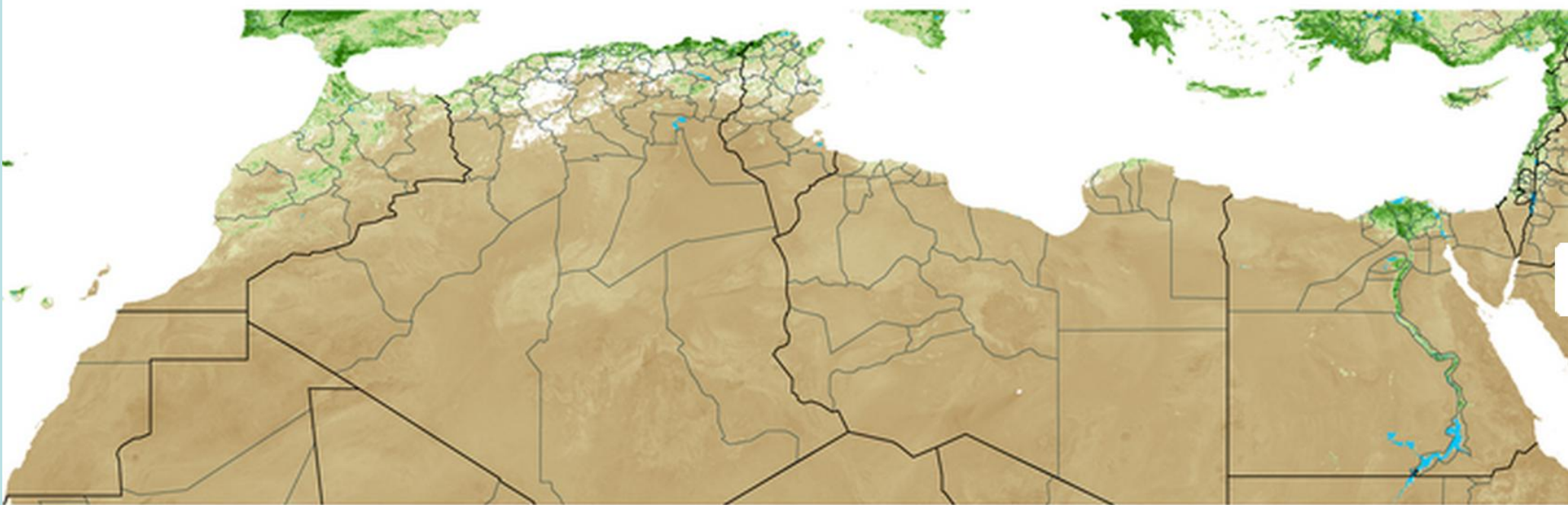
Africa Standardized Precipitation Index (SPI)

for the indicated accumulation periods
as of November 10, 2014



North Africa eMODIS 250m Temporally Smoothed NDVI

Period 63 / Nov 6 - 15, 2014



NDVI

0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9



Sparse

Moderate

Dense

Map Produced by USGS/EROS





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.

Source: Svoboda, 2009

Planned drought mitigation and response options



Time during normal conditions 

Indicators

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

Consider I-1 is SPI

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 \leq -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%

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

Source: Svoboda, 2009



Considerations in Choosing Indicators / Triggers

- **Proper and Timely Detection of Drought**
- **Spatial and Temporal Sensitivity**
- **Supplies and Demands**
- **Drought In / Drought Out**
- **Composite and Multiple Indicators**
- **Data Availability, Validity, and Clarity**
- **Ease of Implementation**

Source: Svoboda, 2009



Key Variables for Monitoring Drought

- climate data
- soil moisture
- stream flow / ground water
- reservoir and lake levels
- snow pack
- short, medium, and long range forecasts
- vegetation health/stress and fire danger
- remote sensing products
- **impacts**

Source: Svoboda, 2009



Lincoln Workshop

- **Inter-Regional Workshop on Indices and Early Warning Systems for Drought held in Lincoln, Nebraska, USA from 8 to 11 December 2009**
- **Co-Sponsors:**
 - National Drought Mitigation Center (NDMC)
 - United States Department of Agriculture (USDA)
 - United States National Oceanic and Atmospheric Administration (NOAA)
 - United Nations Convention to Combat Desertification (UNCCD)
 - University of Nebraska-Lincoln, School of Natural Resources
 - World Meteorological Organization

http://www.wmo.int/pages/prog/wcp/agm/meetings/wies09/index_en.html



Workshop Objectives

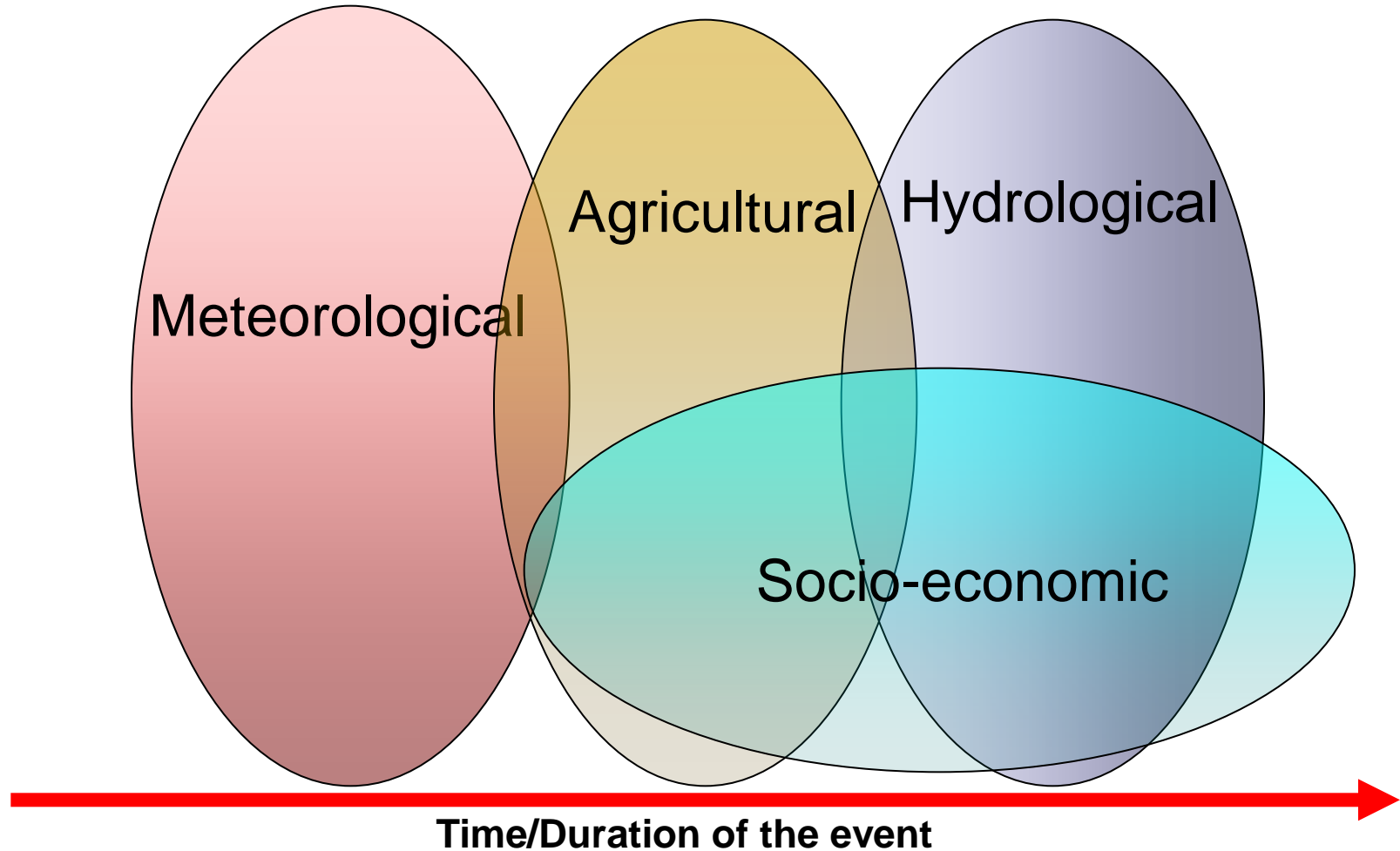
- To review and assess drought indices currently used around the world for the three types of drought (**meteorological, agricultural, and hydrological**);
- To review and assess the **strengths, weaknesses and limitations** of existing drought indices and early warning systems;
- To develop a **consensus standard index** for each of the three types of drought;
- To develop guidelines for WMO Members in implementing and improving drought early warning systems.

Natural and Social Dimensions of Drought

Decreasing emphasis on the natural event (precipitation deficiencies) 

Increasing emphasis on water/natural resource management

Increasing complexity of impacts and conflicts



Lincoln Declaration - Recommendations

- **The National Meteorological and Hydrological Services (NMHSs) are encouraged to use SPI to characterize meteorological droughts and provide this information in addition to indices currently in use.**
- **A comprehensive user manual for the SPI should be developed that describes the index, computation methods, specific examples of current use, the strengths and limitations, mapping capabilities, and how it can be used.**



Probability of Recurrence

SPI	Category	# of times in 100 yrs.	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	1 in 50 yrs.



Standardized Precipitation and Evapotranspiration Index (SPEI)

- New variation of the SPI index by Vicente-Serrano et al. (2010) includes a temperature component.
- The inputs required are precipitation, mean temperature, and latitude of the site(s) to run the program on.
- More information can be explored through obtaining the SPEI at <http://sac.csic.es/spei/index.html>.
- Vicente-Serrano, S.M., Beguería, S., and López-Moreno, J.I. (2010). A multi-scalar drought index sensitive to global warming: The Standardized Precipitation Evapotranspiration Index – SPEI. *Journal of Climate* 23(7), 1696-1718, DOI: 10.1175/2009JCLI2909.1



Data Issues I

- **Accurate and long-term weather data is needed**
- **Need at least years 30 years of rainfall data for SPI**
- **Can use fewer years but SPI will become unreliable**
- **For Agricultural and Hydrological drought need other data**
 - **Potential evapotranspiration (ETP)**
 - **Departure of ETP from normal?**
 - **Affected crops – conditions, growth stages**
 - **Soil moisture (measurement/simulation/departure from normals)**



Data Issues II

- **Gridded datasets can be used (i.e. GPCC-Global Precipitation Climatology Centre)**
- **Remotely sensed data**
- **Reanalysis of weather model data**

- **Vulnerability and impact data are limited in area and length of record**

Ongoing Initiatives

Integrated Drought Management Programme (IDMP)



IDMP Objectives



- **To support stakeholders at all levels by providing policy and management guidance and by sharing scientific information, knowledge and best practices for Integrated Drought Management.**
- Contributes to global coordination of drought-related efforts of existing organizations & agencies:
 - Better scientific understanding & inputs for drought management;
 - Drought risk assessment, monitoring, prediction and early warning;
 - Policy and planning for drought preparedness and mitigation across sectors; and
 - Drought risk reduction and response

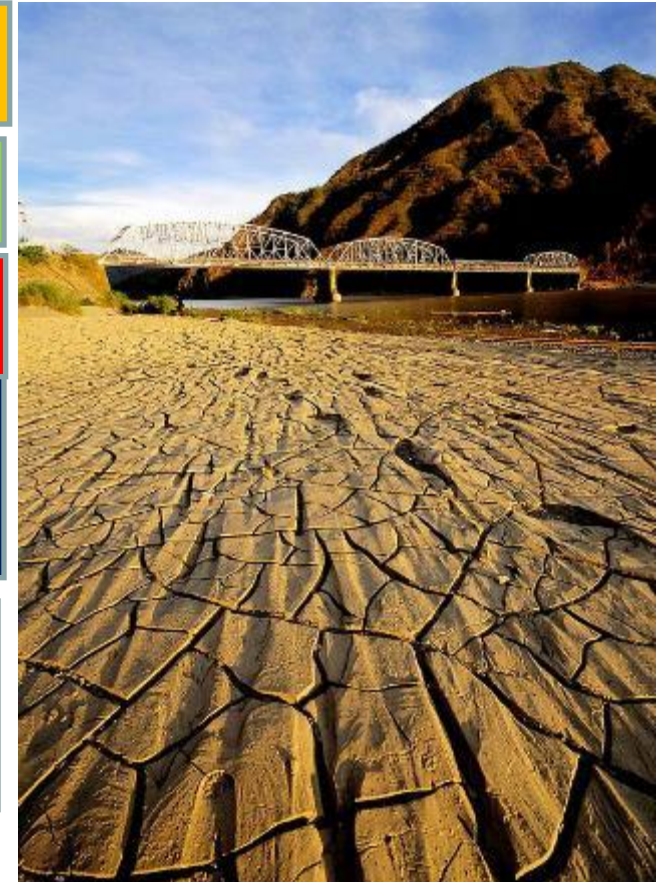
1) Development of Tools

2) Capacity Building

3) Demonstration Projects

4) Responding to Regional and National Needs

5) Development of Drought HelpDesk





Current Actions - IDMP



- **Established at HMNDP – March 2013**
- **Donor funding to IDMP**
- **Technical Support Unit created Jul-Aug 2013**
- **Advisory Committee & Management Meeting Sep 2014**
- **IDMP regional projects**
 - **Central and Eastern Europe**
 - **West Africa**
 - **East Africa**
 - **South Asia Drought Monitoring System (IWMI)**



Outcomes of Sep 2014 IDMP Meetings

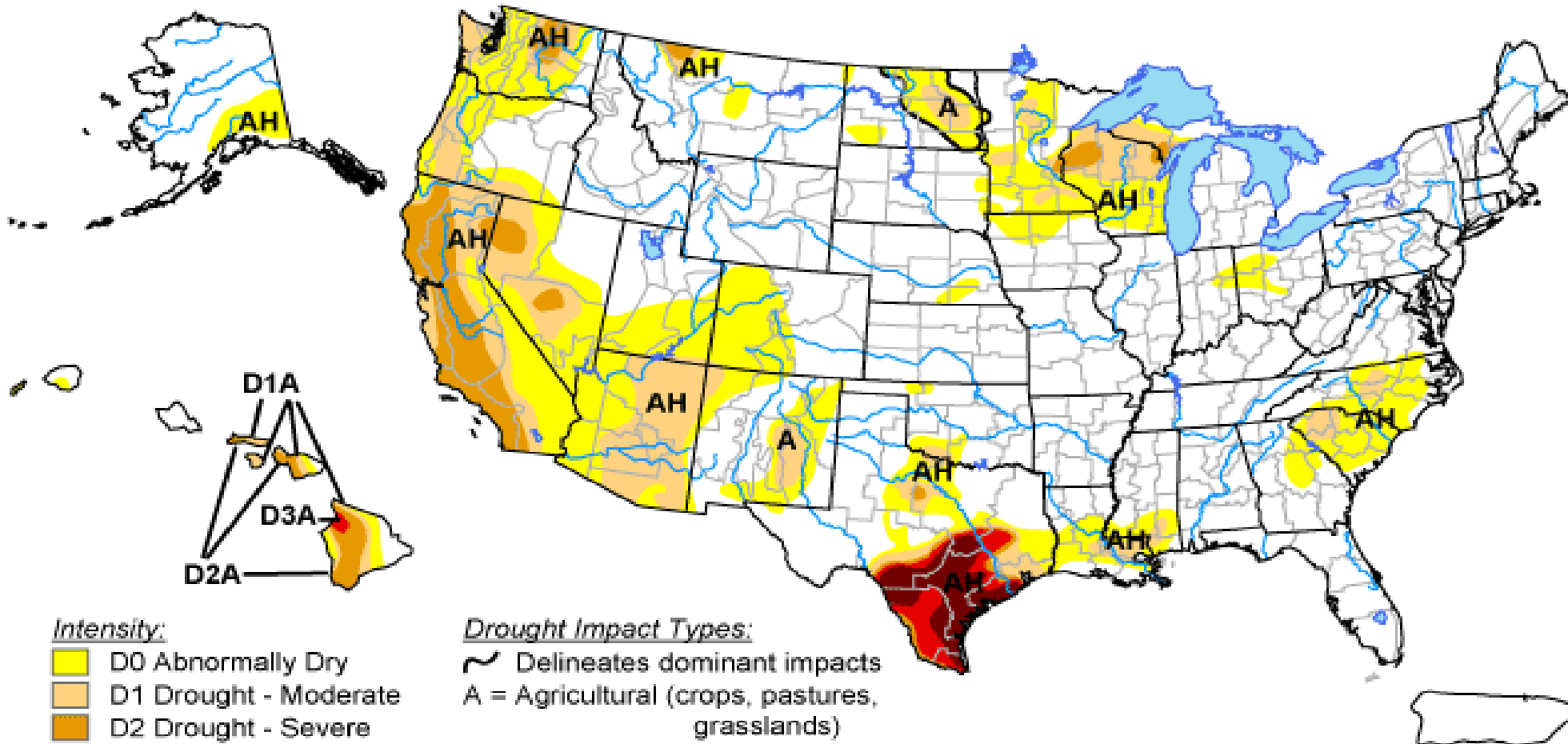
- **Proposed publications:**
 - **Integrated Drought Management Framework Document**
 - **Drought Indices Handbook**
 - **Series of Case Studies**
- **Engage with partners to exchange information on drought to further enhance HelpDesk**
- **Develop cooperation mechanism with partners to allow contributions to IDMP in consistent way avoiding duplications.**
- **Consider organizing an international conference on drought management in 2016**

Examples






U.S. Drought Monitor

September 8, 2009


Valid 8 a.m. EDT



Intensity:

-  D0 Abnormally Dry
-  D1 Drought - Moderate
-  D2 Drought - Severe
-  D3 Drought - Extreme
-  D4 Drought - Exceptional

Drought Impact Types:

-  Delineates dominant impacts
- A = Agricultural (crops, pastures, grasslands)
- H = Hydrological (water)

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

<http://drought.unl.edu/dm>



Released Thursday, September 10, 2009

Author: Rich Tinker, CPC/NCEP/NWS/NOAA



The Drought Monitor is widely used:

- *Policy: Farm Bill/IRS/USDA/NOAA DGT/State drought plan triggers*
- *~3.75M page views and ~2M visitors/year*
- *Media: The Weather Channel and all major newspapers/Internet Media/ Network News/ CNN/NPR/etc.*
- *Presidential/Congressional briefings*
- *A model of interagency/level collaboration*

Source: Svoboda, 2009



Some Examples of Decision Making Using the Drought Monitor

- USDA Dried Milk Program 2002-03
- USDA CRP Release hot spot trigger
- Numerous states use as a drought trigger (Governor's declarations)
- 2006-07 USDA Livestock Assistance
- 2006-07 IRS (tax deferral on livestock losses)
- 2008 Farm Bill
- NWS Drought Information Statements

Source: Svoboda, 2009



FAO-Agriculture Stress Index System (ASIS)

Developed by:



Presented by:

Oscar Rojas (FAO)

In collaboration with:



UNIVERSITY OF TWENTE.

Agricultural Stress Index System is based on the Vegetation Health Index (VHI) (Kogan et al. 1995)

Vegetation condition index (VCI)

Temperature condition index (TCI)

$$VCI_i = \frac{NDVI_i - NDVI_{min}}{NDVI_{max} - NDVI_{min}}$$

$$TCI_i = \frac{BT_{max} - BT_i}{BT_{max} - BT_{min}}$$



Vegetation Health Index (VHI)

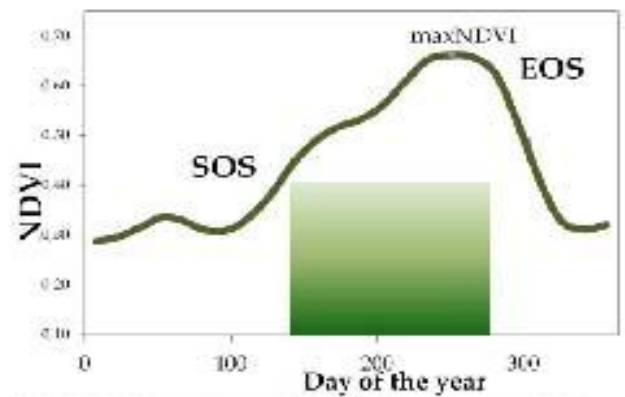
low VHI

$$VHI = a \cdot VCI + (1-a) \cdot TCI$$

high VHI

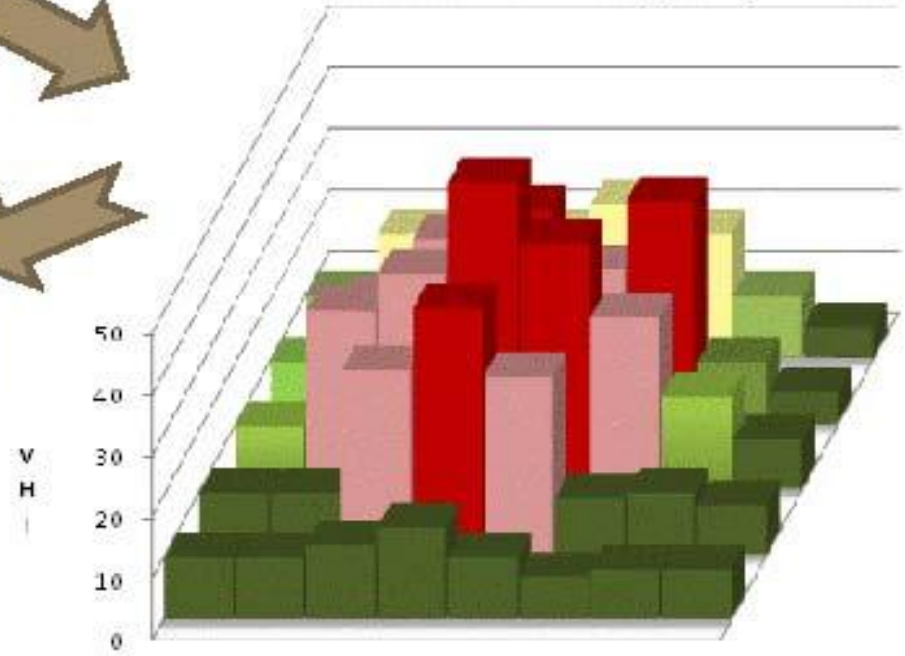


ASIS assess the severity (intensity, duration and spatial extent) of the agricultural drought



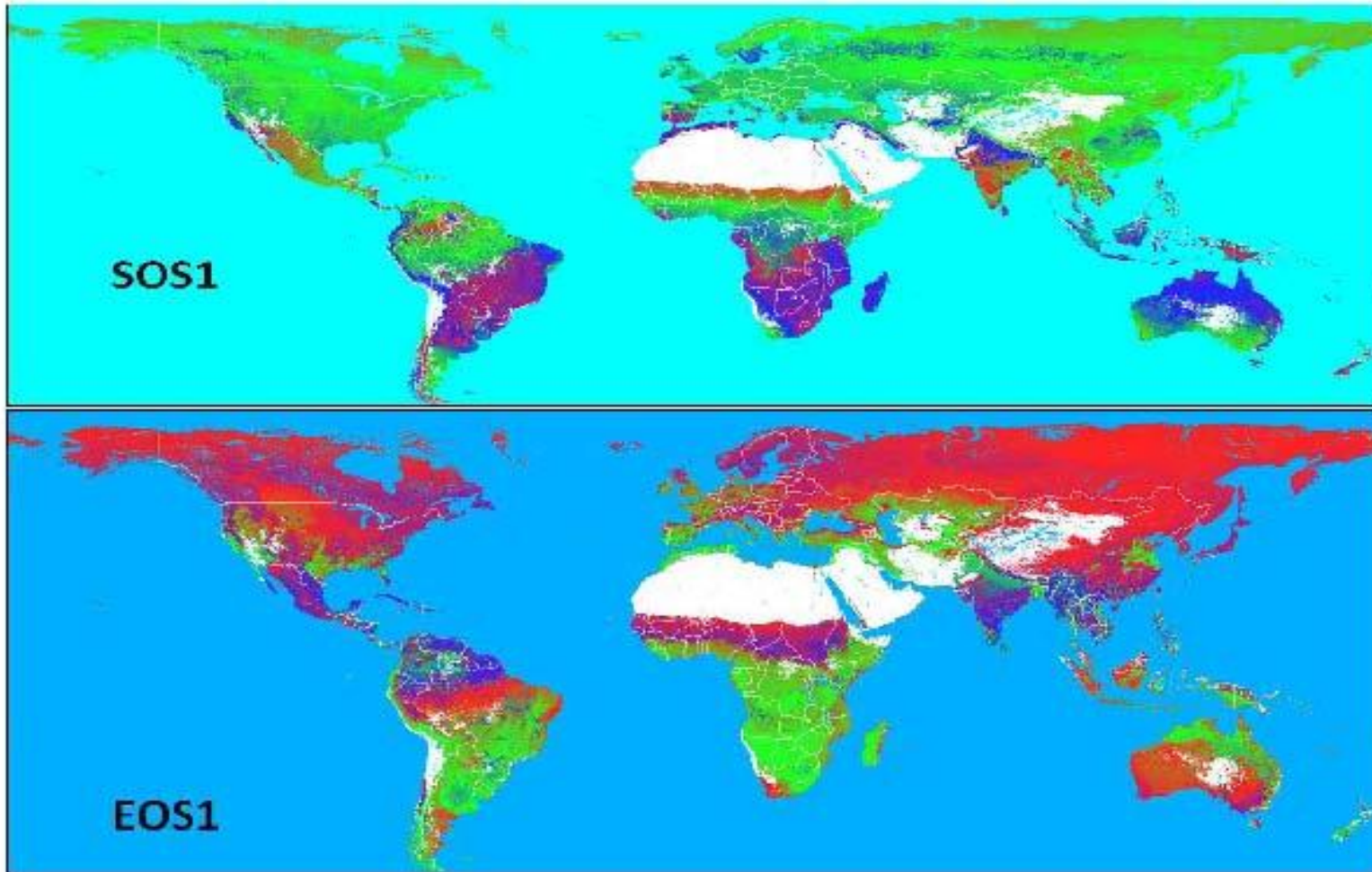
Percentage of the agriculture areas with VHI below 35

- 0 - 10
- 11 - 29
- 30 - 49
- 50 - 65
- 66 - 75
- 76 - 85
- 86 - 100



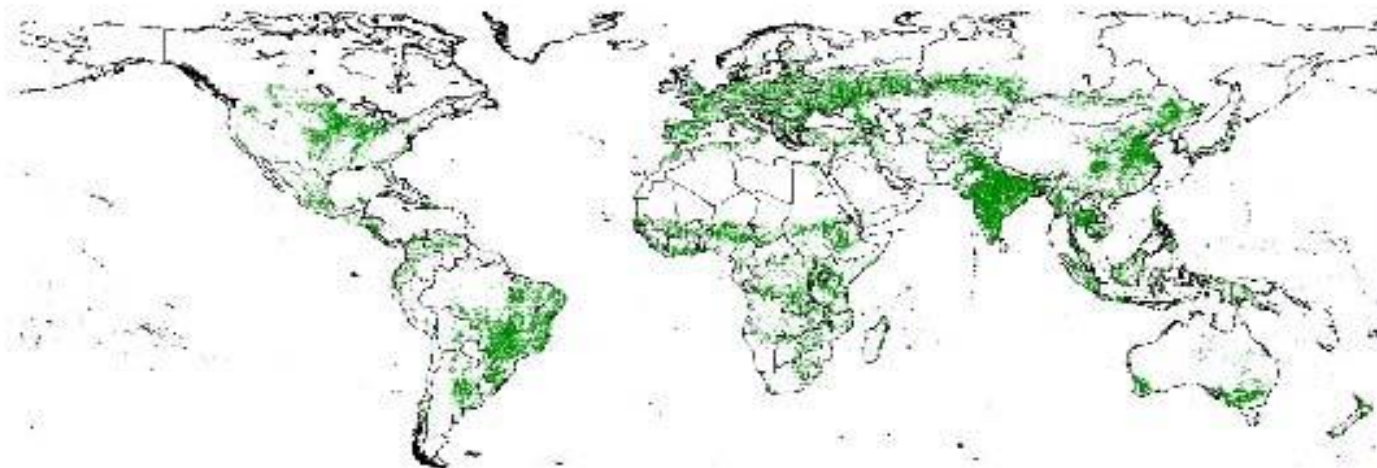
- VHI temporal average value
- 0- 10
 - 10-20
 - 20-25
 - 25-35
 - >35

i. Temporal aggregation - defining SOS (start of growing season) & EOS (end of growing season)



SOS and EOS of the first season, as derived from the long term NDVI averages of SPOT-VGT (roi GLD, 21 km resolution).

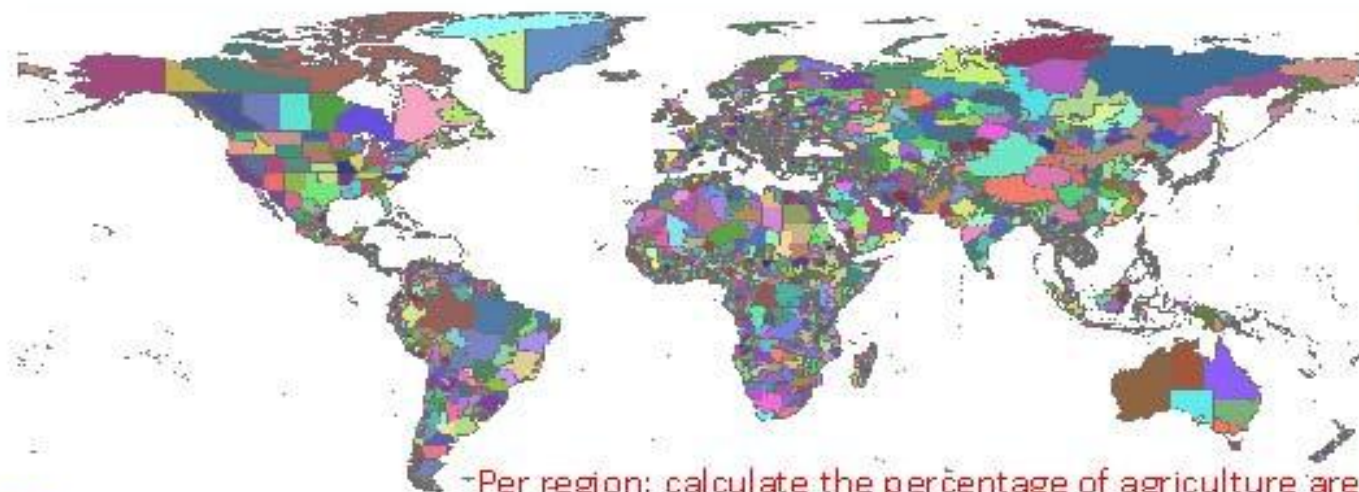
ii. Only crop pixels → Crop Mask



Compiled by JRC-
FoodSec from:

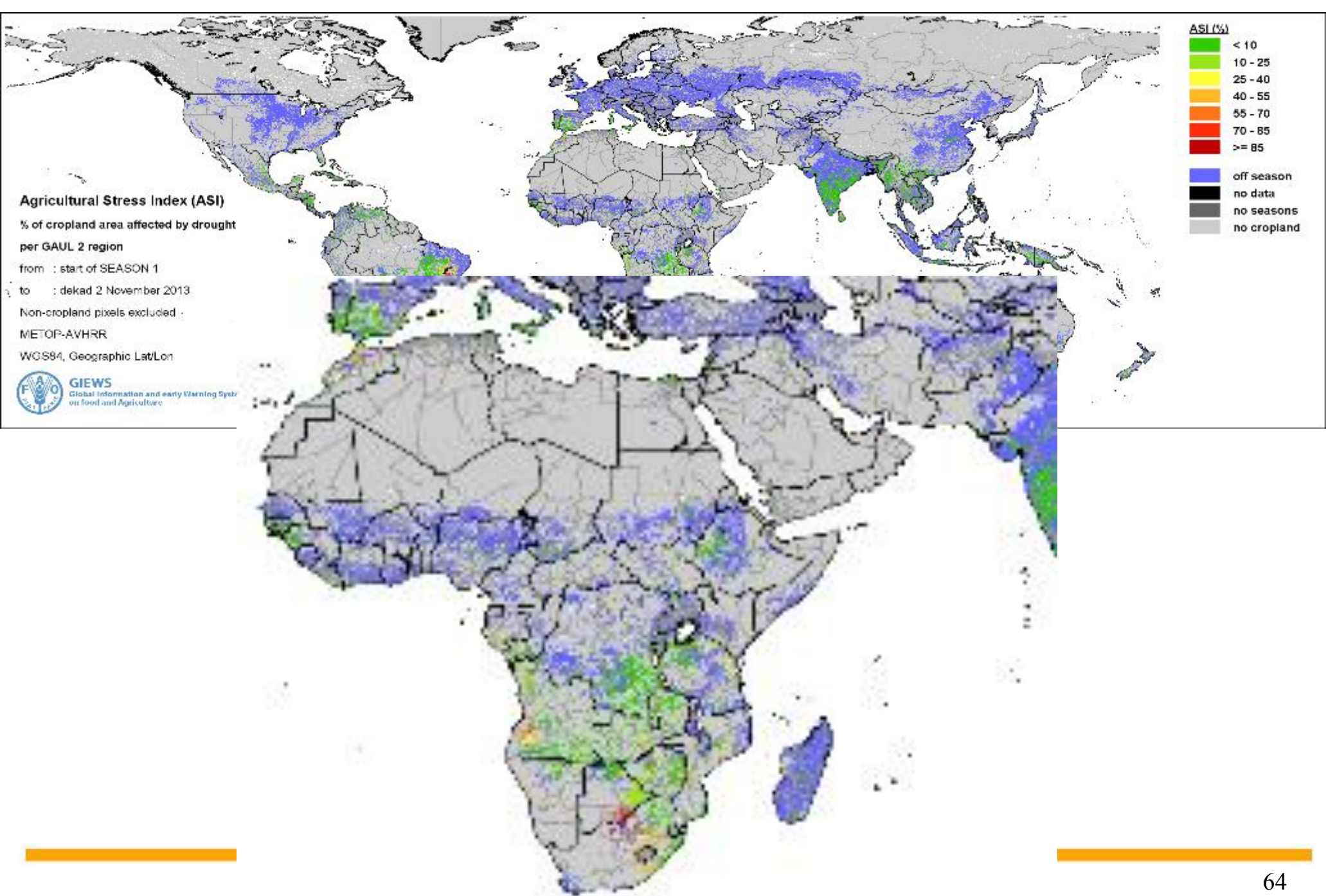
- GlobCover V2.2
- Corine-2000
- AfriCover
- ...

iii. Per administrative unit → Spatial Aggregation on GAUL1 level



GAUL1 → Global
Administrative Unit
Layers

- Per region: calculate the percentage of agriculture area affected by drought
→ Pixels with Vegetation Health Index < 35 %



Breakout Sessions



Group Questions

- **Group A:** What are the current procedures/challenges on early warning systems?
- **Group B:** What are the meteorological and hydrological networks, data quality, sustainability needed?
- **Group C:** What mechanisms are in place for communicating and liaising drought monitoring and early warning information between national institutions?



Breakout Group Guidelines

- **Each Group will have a facilitator.**
- **Group identifies leader and rapporteur.**
- **Either group leader or rapporteur makes presentation in Session 3c.**
- **Each group will spend 45 minutes on main group question and 15 minutes each on other questions**