Drought Monitoring and Early Warning Systems

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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.

World Meteorological Organization
Weather • Climate • Water

WORLD CLIMATE CONFERENCE - 3

Geneva, Switzerland

31 August–4 September 2009

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
- Proceedings will be published

- Compendium from July 2011 Workshop revised as HMNDP Science Document

Recommendations

Develop national drought policies and preparedness plans that place emphasis on risk management rather than crisis management;

Establish scientifically sound, comprehensive and integrated drought Early Warning Systems;

Formulate networks/collaborations to enhance knowledge and information sharing to improve public understanding and preparedness to drought;

Develop research and monitoring to improve drought forecasting on the seasonal scale.

www.hmndp.org

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

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

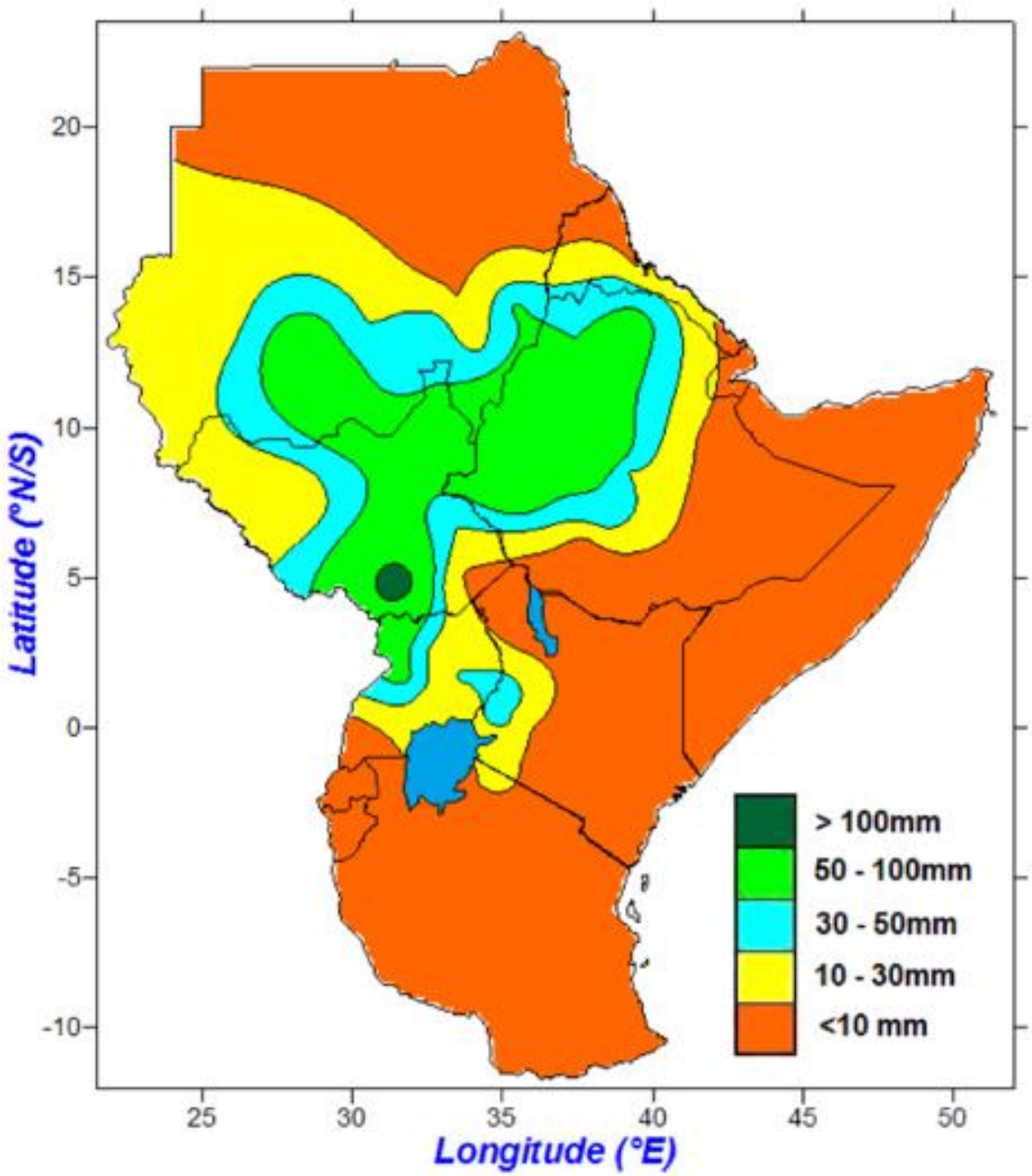


Figure 1: Spatial distribution of observed rainfall during dekad 20 (11 – 20 July) of 2014

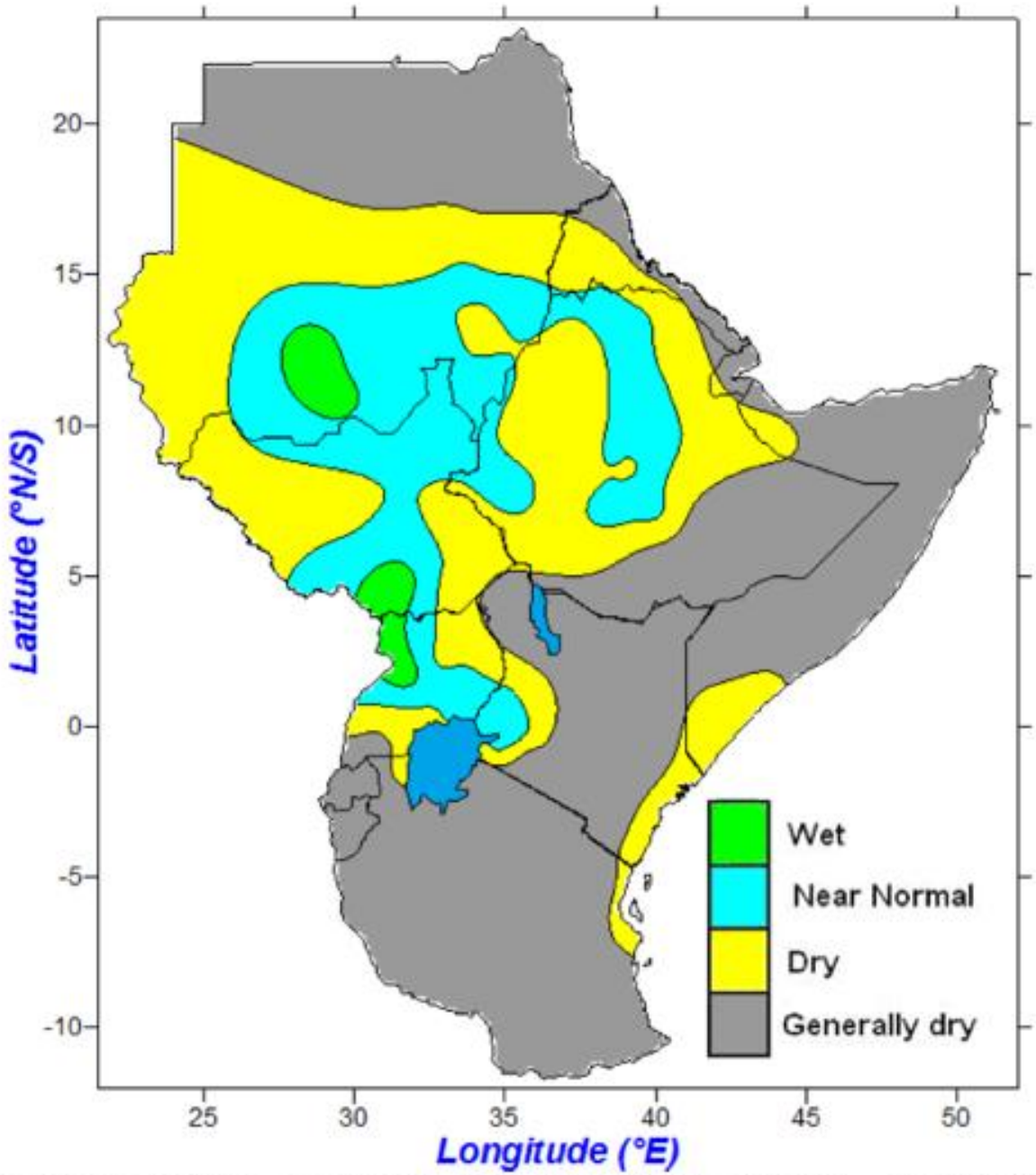


Figure 2: Rainfall Stress Severity Index for dekad 20 (11 – 20 July) of 2014

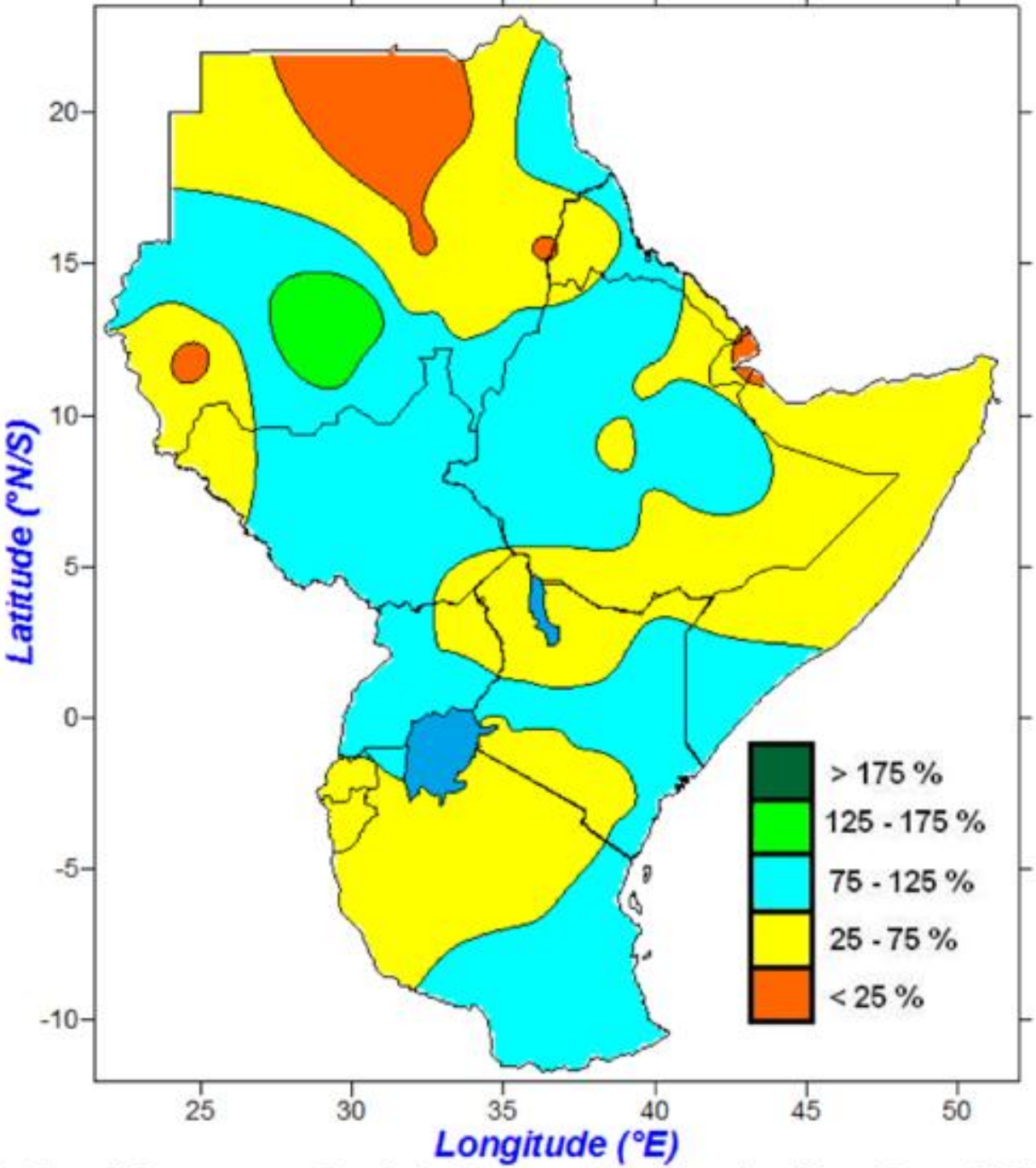


Figure 4: Spatial pattern of rainfall anomalies for April to June 2014 period

Figure 3a: Cumulative rainfall series for Nekemte

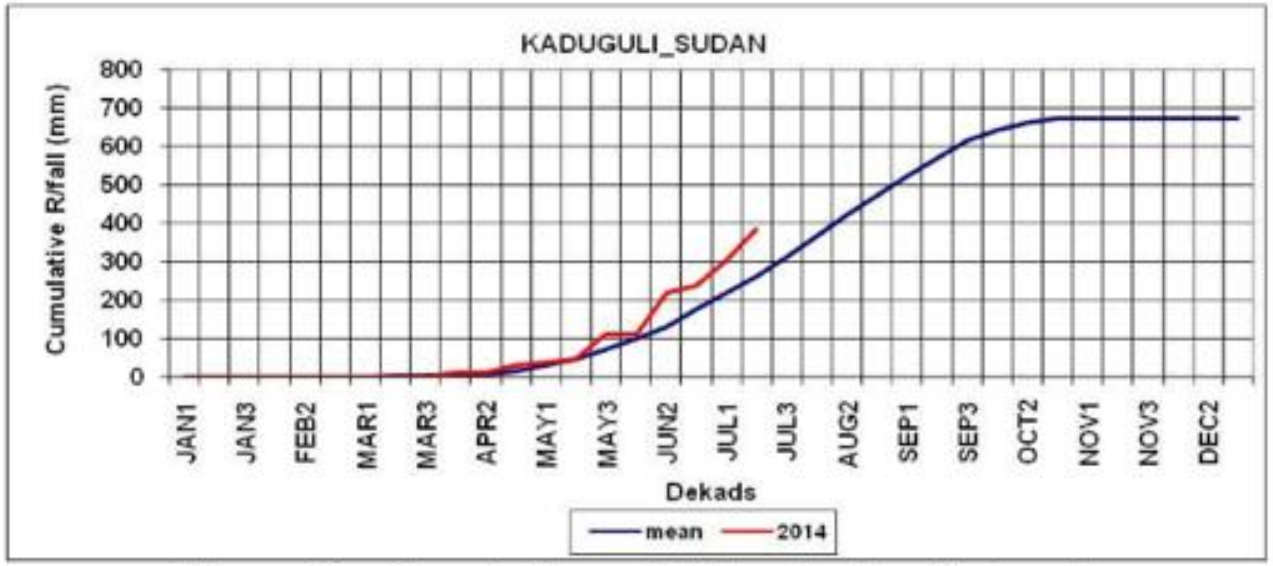


Figure 3b: Cumulative rainfall series for Kaduguli

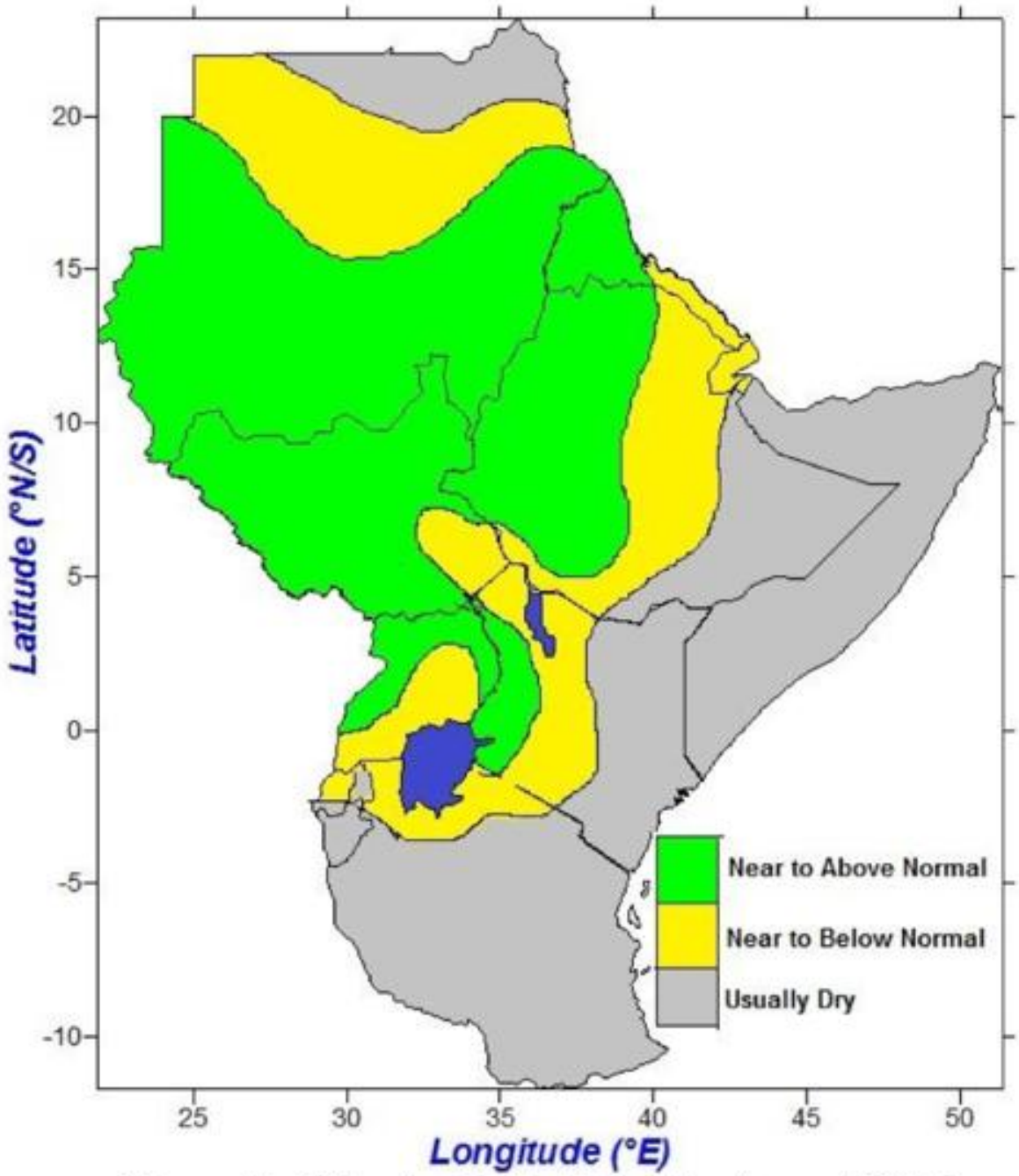
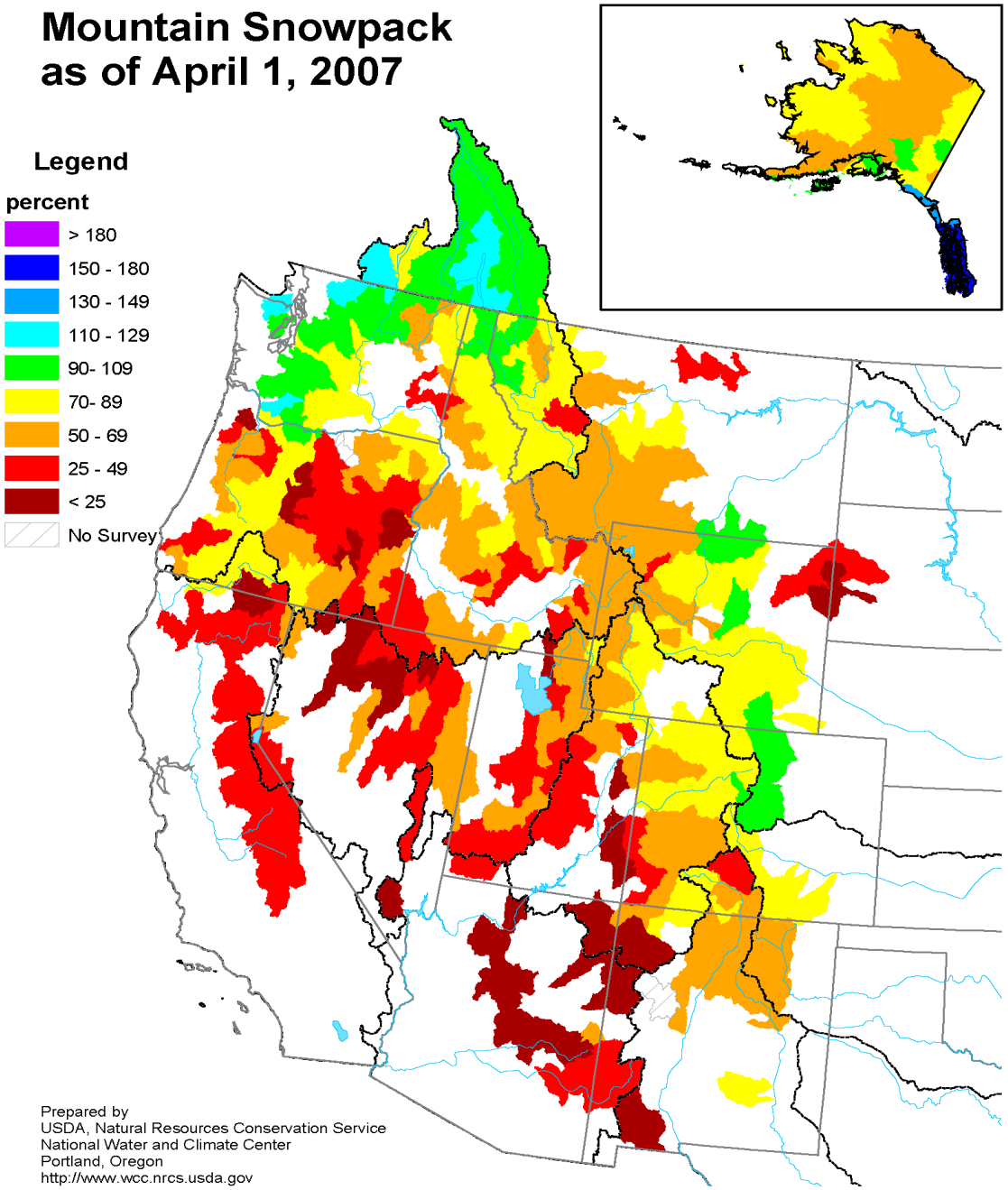


Figure 7: Climate Outlook for the August 2014

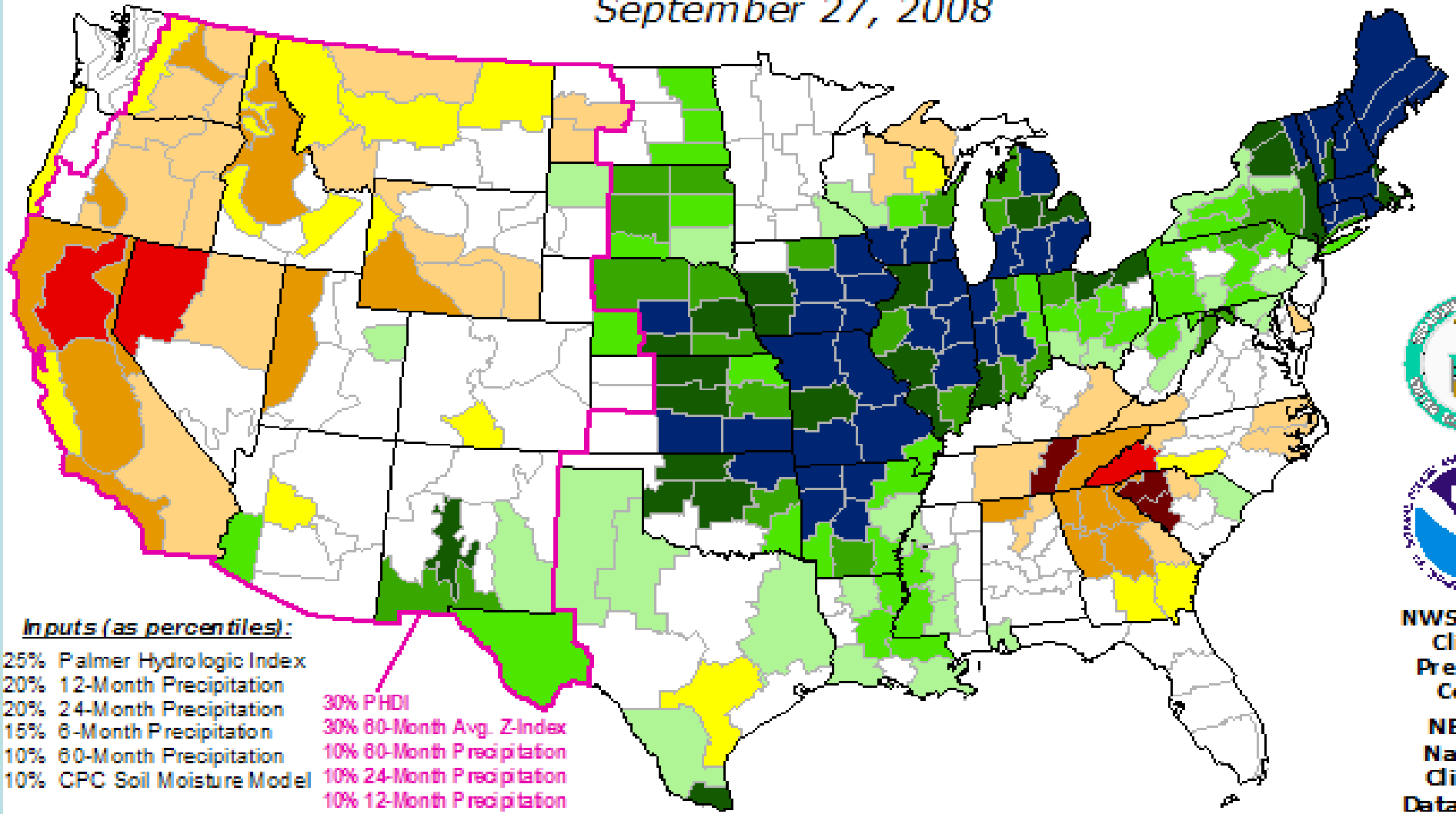
Mountain Snowpack as of April 1, 2007



Prepared by
USDA, Natural Resources Conservation Service
National Water and Climate Center
Portland, Oregon
http://www.wcc.nrcs.usda.gov

Objective Long-Term Drought Indicator Blend Percentiles

September 27, 2008



Inputs (as percentiles):

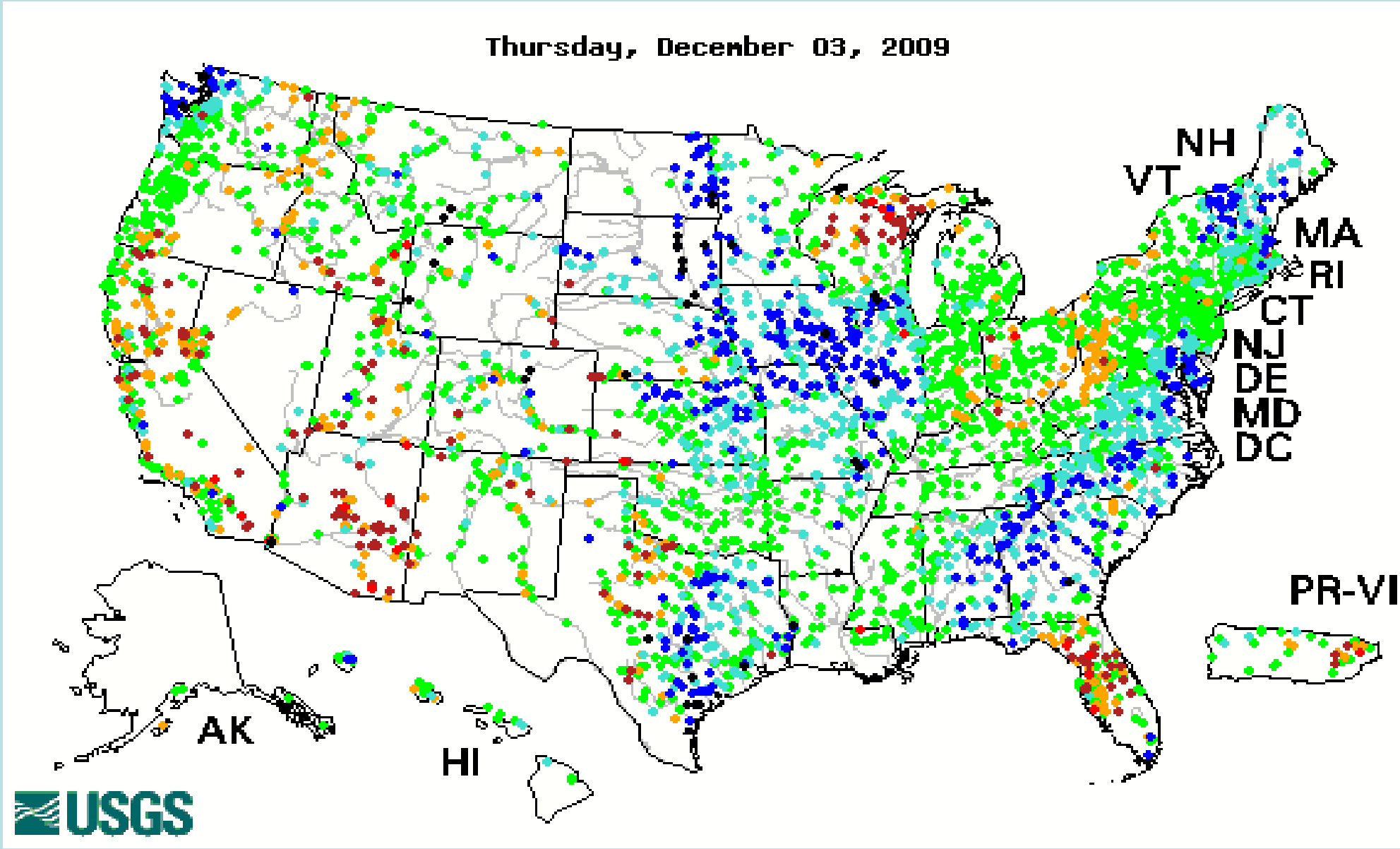
25% Palmer Hydrologic Index
20% 12-Month Precipitation
20% 24-Month Precipitation
15% 6-Month Precipitation
10% 60-Month Precipitation
10% CPC Soil Moisture Model

30% PHDI
30% 60-Month Avg. Z-Index
10% 60-Month Precipitation
10% 24-Month Precipitation
10% 12-Month Precipitation
10% CPC Soil Moisture Model

NWS / NCEP
Climate Prediction Center

NESDIS National Climatic Data Center

The short-term map (top) approximates impacts that respond to precipitation over the course of several days to a few months, such as agriculture, topsoil moisture, unregulated streamflows, and most aspects of wildfire danger. The long-term map (bottom) approximates impacts that respond to precipitation over the course of several months to a few years, such as reservoir content, groundwater depth and lake levels. HOWEVER, the relationship between indicators and impacts can vary significantly with location and season. THIS IS PARTICULARLY TRUE OF WATER SUPPLIES, which are additionally affected by source, and management practices.


Thursday, December 03, 2009
NH
VT
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USGS

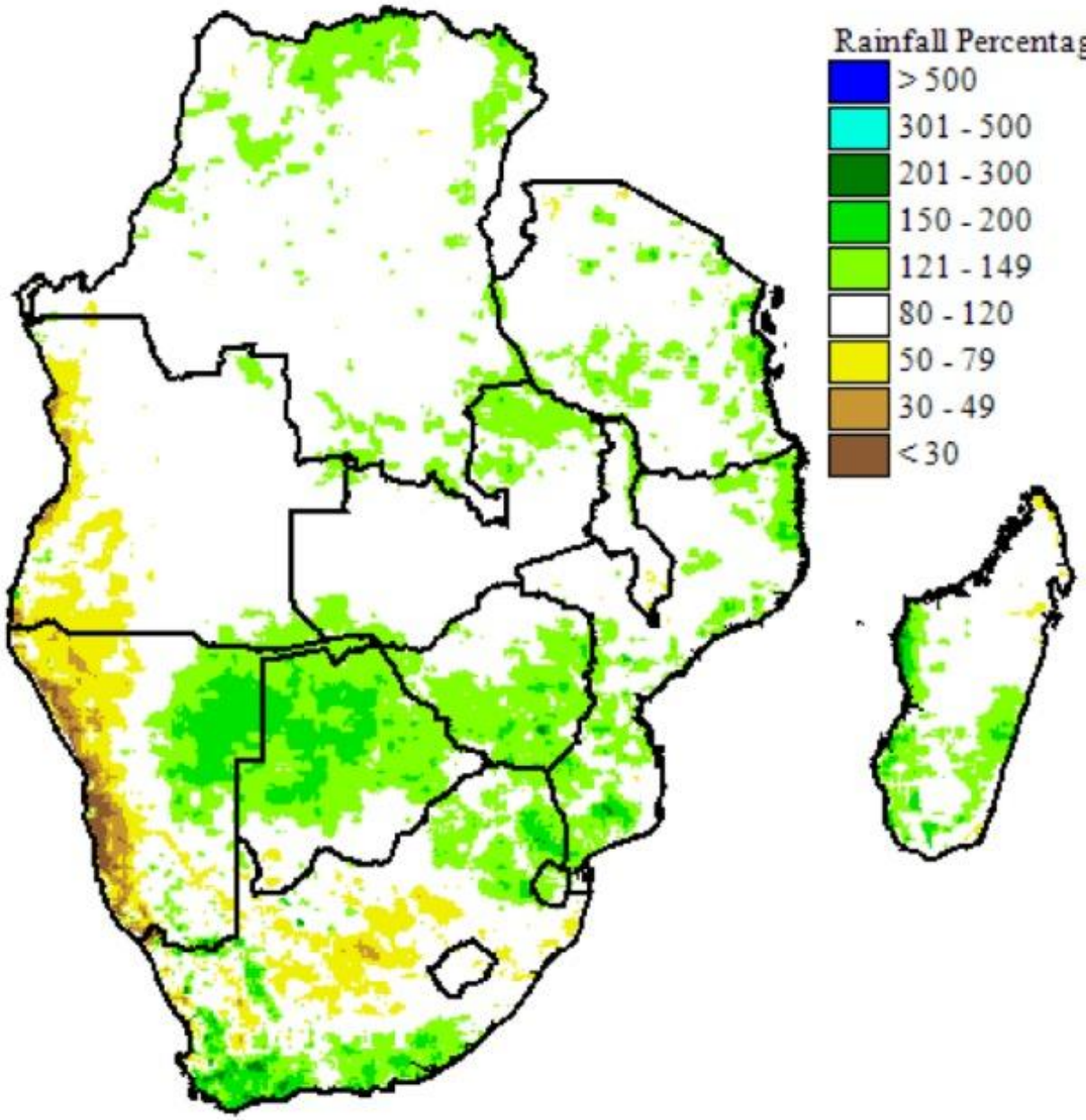


Figure 1. Rainfall for 1 Oct 2013 to 30 April 2014 as percent of average. *Source: USGS/FEWSNET*

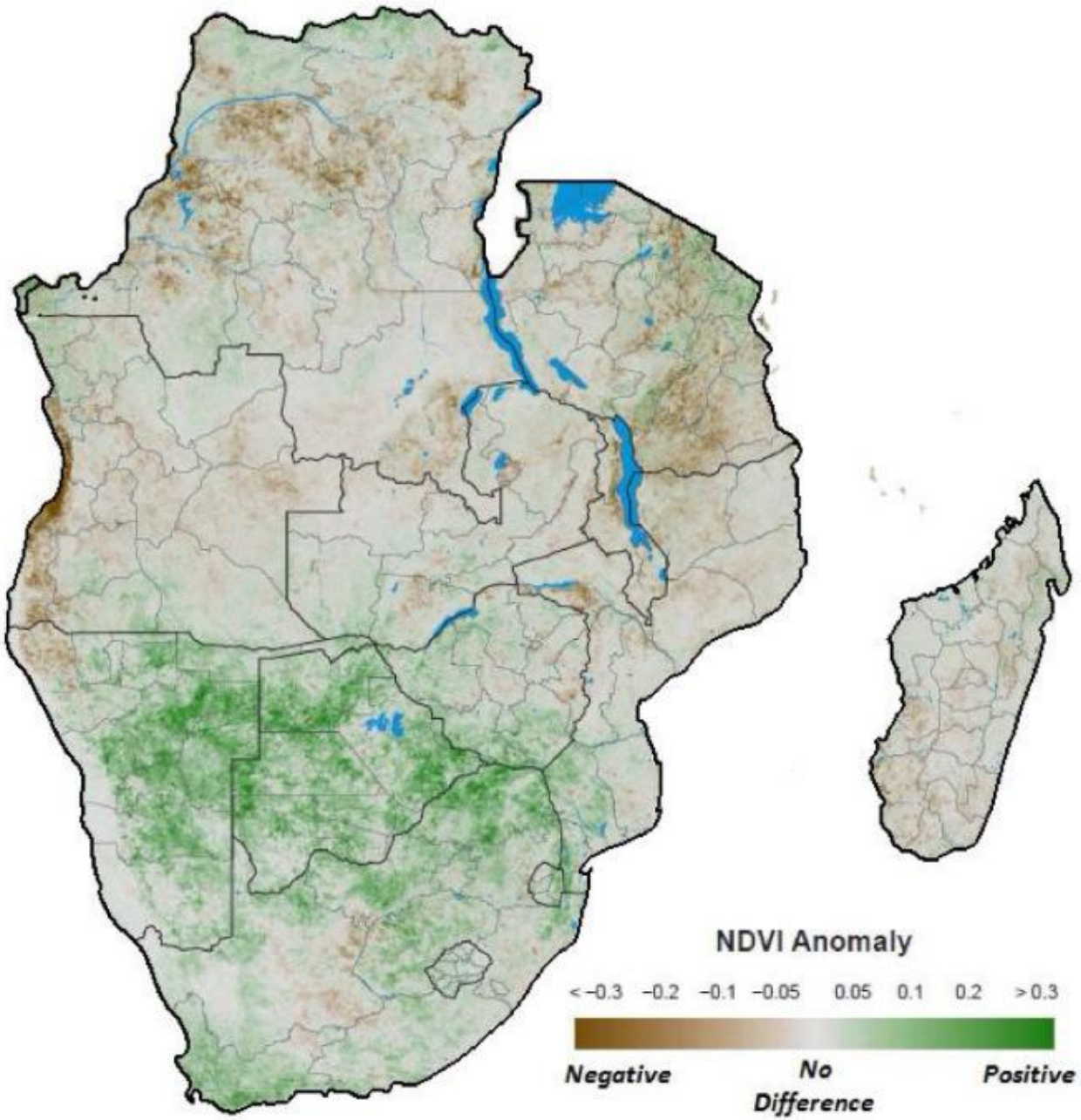


Figure 2. Vegetation Index (NDVI) compared to average conditions for 11-20 April 2014 *Source: USGS/FEWSNET*

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

FAO WATER

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 ≤ -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

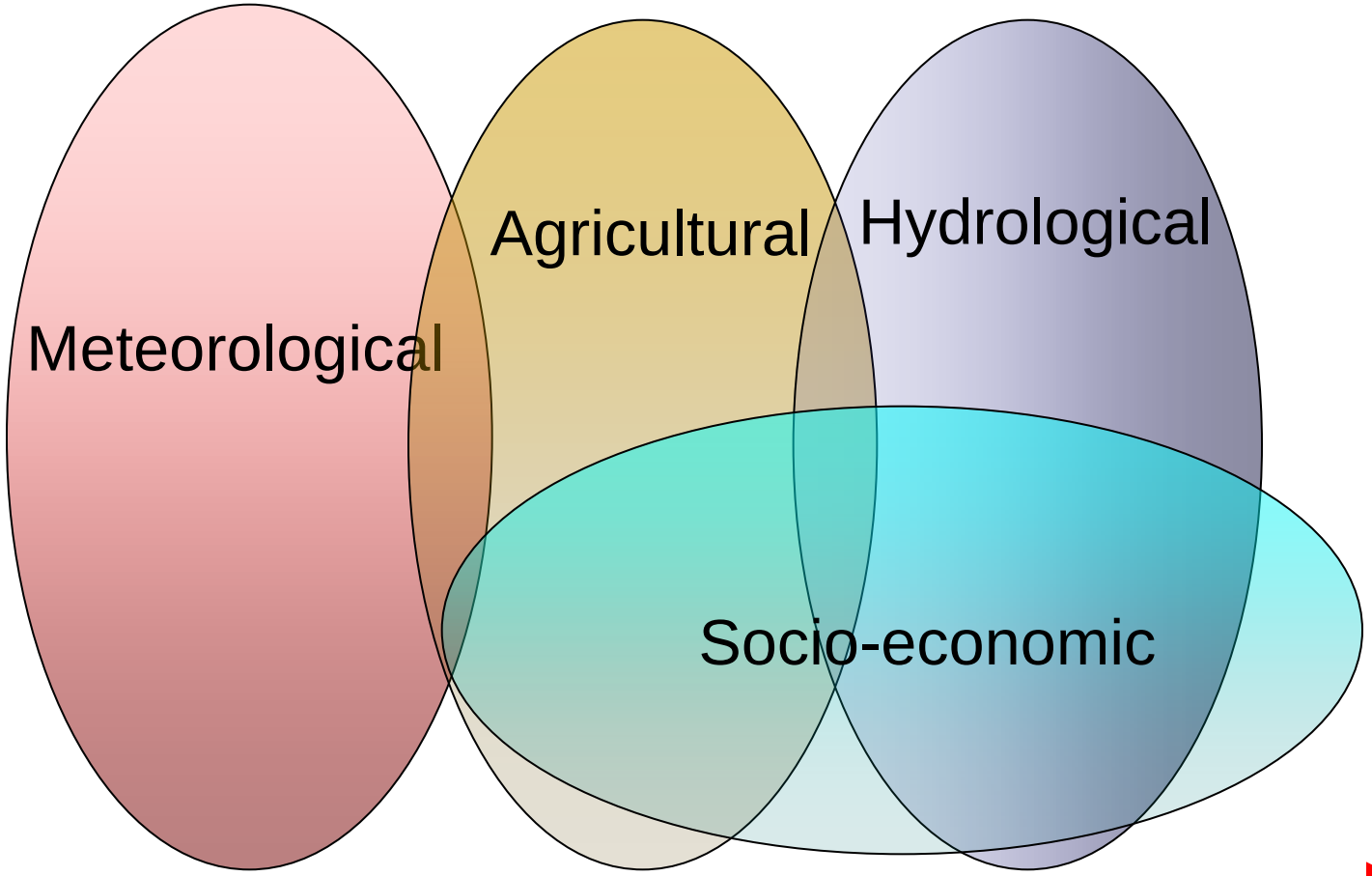
- To review and assess drought indices currently used around the world for the three types of drought (meteorological, agricultural, and hydrological);
- To review and assess the strengths, weaknesses and limitations of existing drought indices and early warning systems;
- To develop a consensus standard 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



Time/Duration of the event

Source: Wilhite 2006

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.

Outcomes

- The recommendation to use the SPI was approved by the WMO Congress in June 2011.
- The UN International Strategy for Disaster Risk Reduction (ISDR) provided funding for the meetings of the working groups on agricultural (June 2010 - Spain) and hydrological (Sept 2011 - Geneva) drought indices.
- With these recommendations, WMO contributed to ISDR on chapter on drought risks for the 2011 UN Global Assessment Report on Disaster Risk Reduction.

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

Recommendations from Murcia

- Use more than rainfall data in computation of indices for description of agricultural droughts and their impacts.
- Important to use more comprehensive data on rainfall, temperature, and soils in computing drought indices.
- Greater cooperation is required between different ministries/ agencies responsible for addressing drought issues at the sub-national, national, and regional levels.
- Recommends that all countries examine the use of a composite approach (such as the U.S. Drought Monitor).

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**

HMNDP Science & Policy Documents

www.hmndp.org

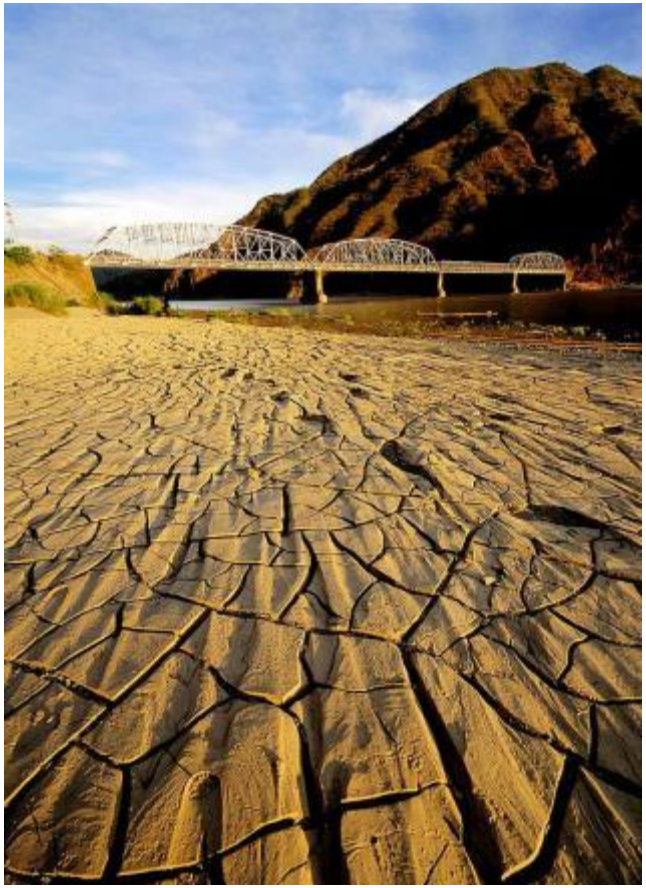
See items 18-26

Ongoing Initiatives

Integrated Drought Management Programme (IDMP)

WMO/GWP IDMP Areas of Work

1) Development of Tools
2) Capacity Building
3) Demonstration Projects
4) Responding to Regional and National Needs
5) Development of Drought HelpDesk



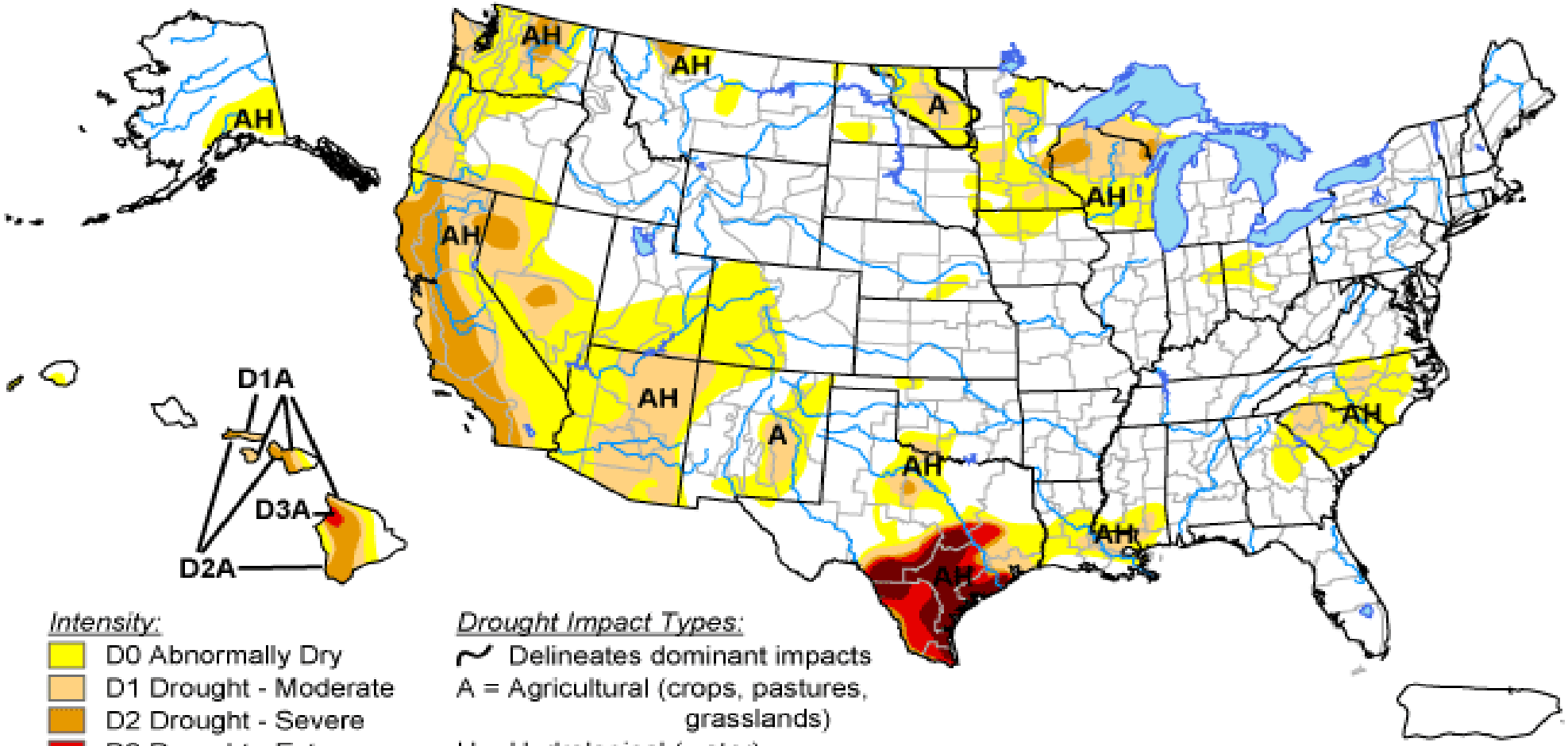
Current Actions - IDMP

- Established at HMNDP – March 2013
- Donor funding to IDMP
- Technical Support Unit created Jul-Aug 2013
- Seconded GWP expert to WMO – July 2013
- WMO Project Officer – Aug 2013
- Advisory Committee Meeting to implement work plan – October 2013
- 1st IDMP regional project - Central and Eastern Europe
- IDMP webpage: droughtmanagement.info

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:

In collaboration with:

Presented by: Oscar Rojas (FAO)

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

Vegetation condition index (VCI)

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

Temperature condition index (TCI)

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

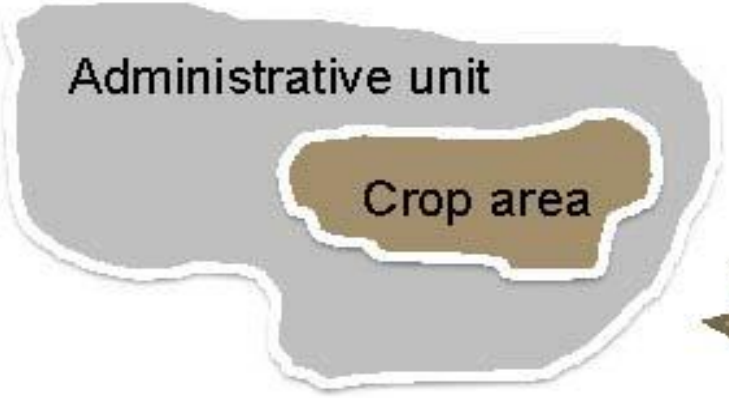
Vegetation Health Index (VHI)

VHI = a*VCI + (1-a)* TCI

low VHI

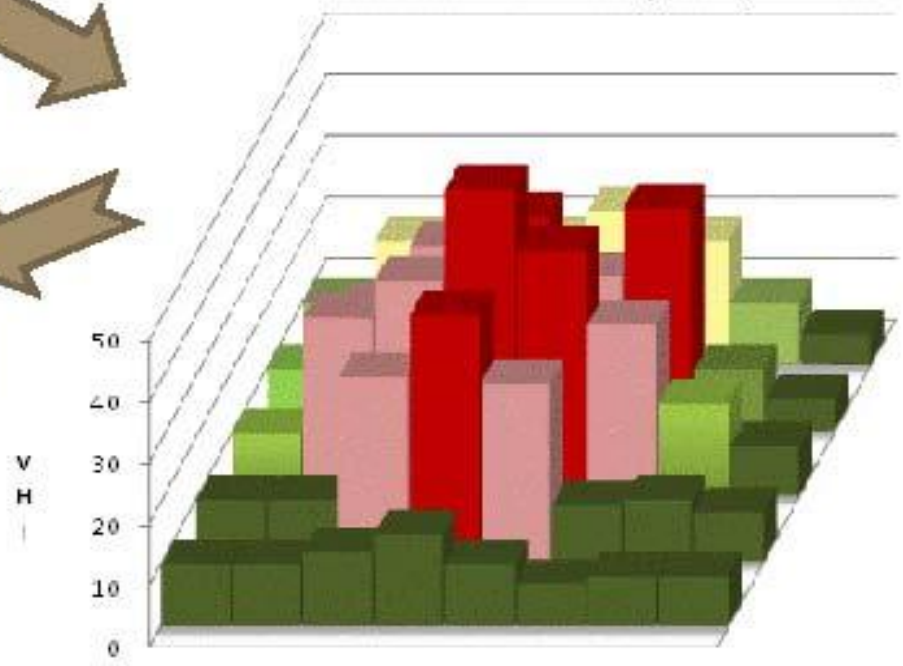
high VHI

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



Percentage of the agriculture areas with VHI below 35

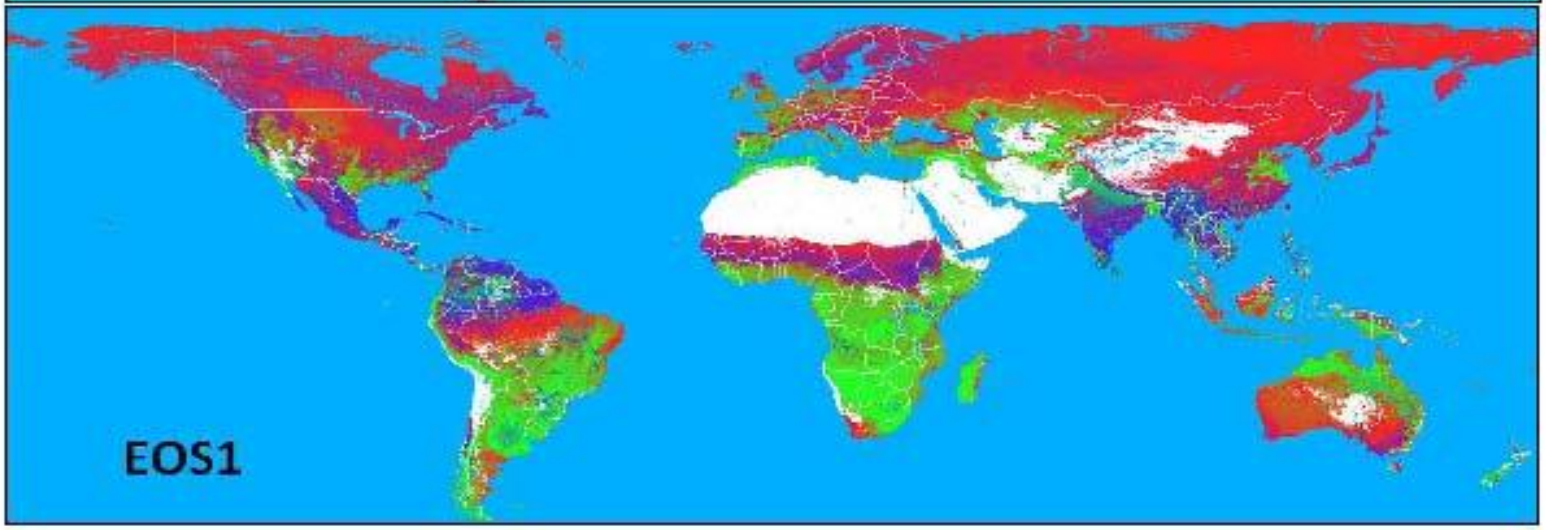
0 - 10
11 - 29
30 - 49
50 - 65
66 - 75
76 - 85
86 - 100



VHI temporal average value

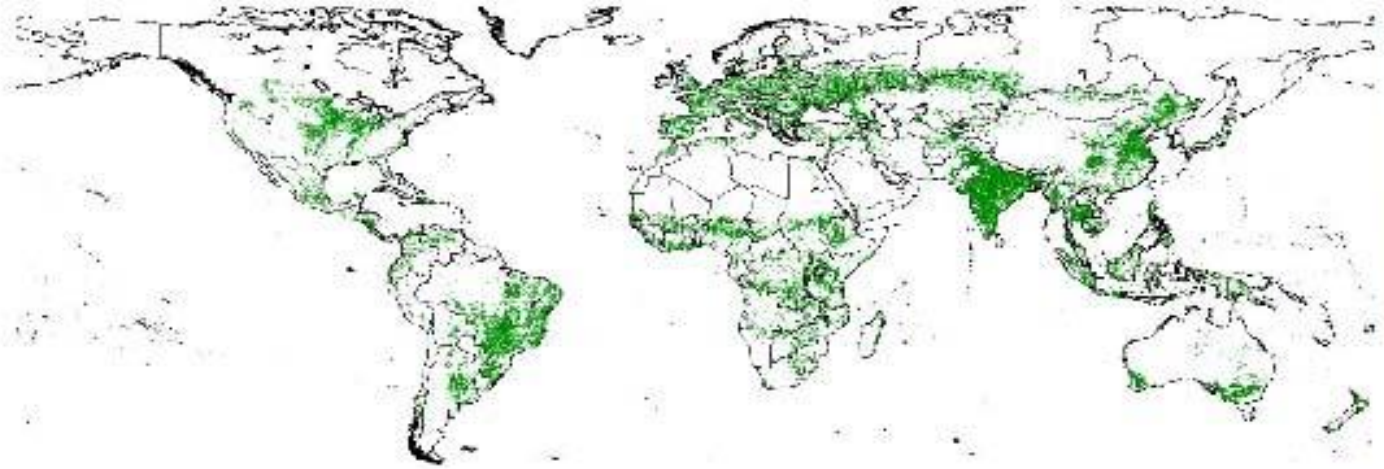
0- 10
10-20
20-25
25-35
>35

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).*

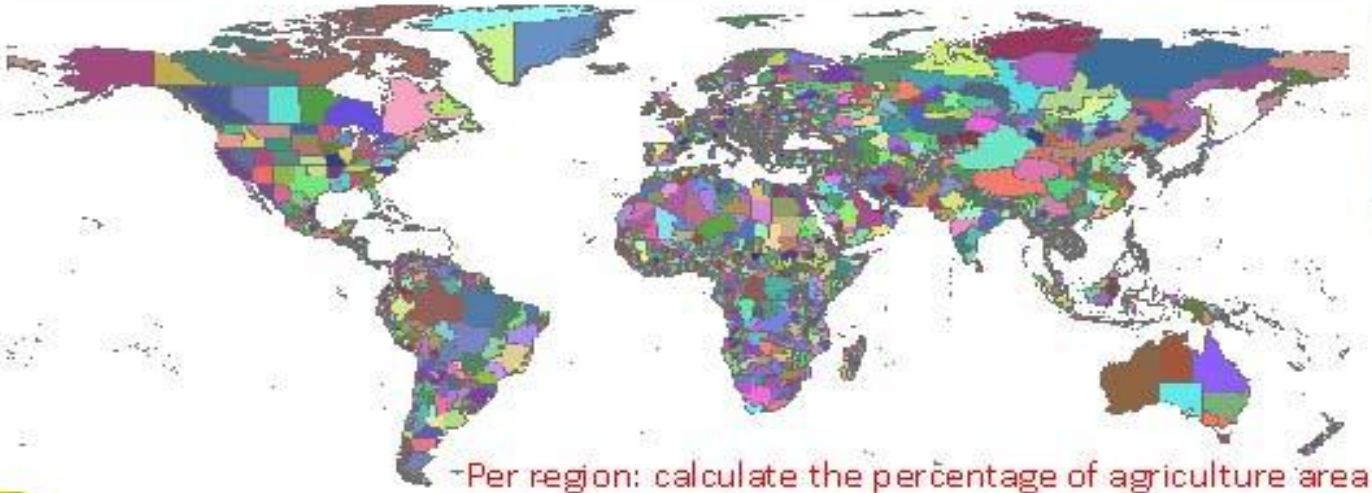
ii. Only crop pixels → Crop Mask



Compiled by JRC-FoodSec from:

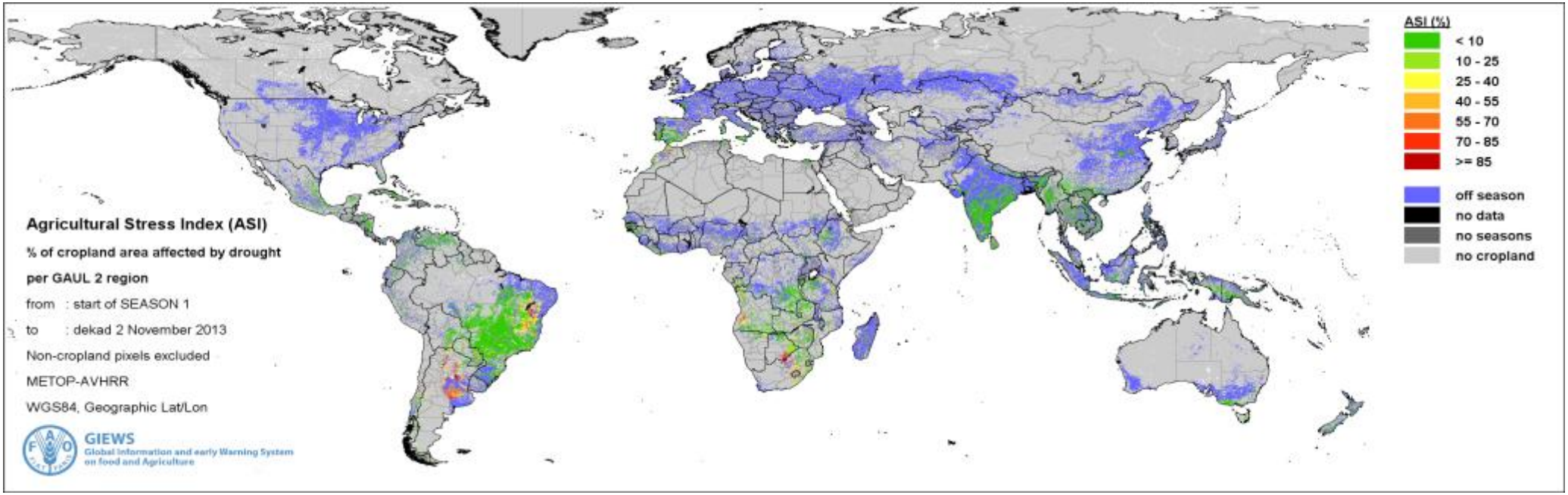
- GlobCover V2.2
- Corine-2000
- AfriCover
- …

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 %


Agricultural Stress Index (ASI)
% of cropland area affected by drought
per GAUL 2 region
from : start of SEASON 1
to : dekad 2 November 2013
Non-cropland pixels excluded
METOP-AVHRR
WGS84, Geographic Lat/Lon
GIEWS
Global Information and early Warning System on food and Agriculture
ASI (%)
< 10
10 - 25
25 - 40
40 - 55
55 - 70
70 - 85
>= 85
off season
no data
no seasons
no cropland

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