Creation of a Composite Drought Index using ArcGIS and satellite data

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Types of Drought:

- **Meteorological**
- **Agricultural**
- **Hydrological**
- **Socioeconomic**

- **There are *indices for all* of these types of drought**
- **There is *no one definition* of drought**
- **Thus, there is *no one-size-fits-all* drought index or indicator**

Monitoring the Drought Hazard: Many Parameters and Indices to Choose from:

Parameters (Indicators) to measure: temperature, precipitation, soil moisture, reservoir/lake levels, streamflow, ground water, snow pack, ET, vegetation health/stress, short and long-term/seasonal forecasts, ***impacts!***

Assessing Drought:

Meteorological/Agricultural Indices

- Percent of normal precipitation
- Deciles
- Standardized Precipitation Index (SPI/SPEI)
- Palmer Drought Severity Index (PDSI, scPDSI)
- Aridity Index

Hydrologic Drought Indices

- Palmer Hydrological Drought Index (PHDI)
- Surface Water Supply Index (SWSI)

Importance of Drought Indices

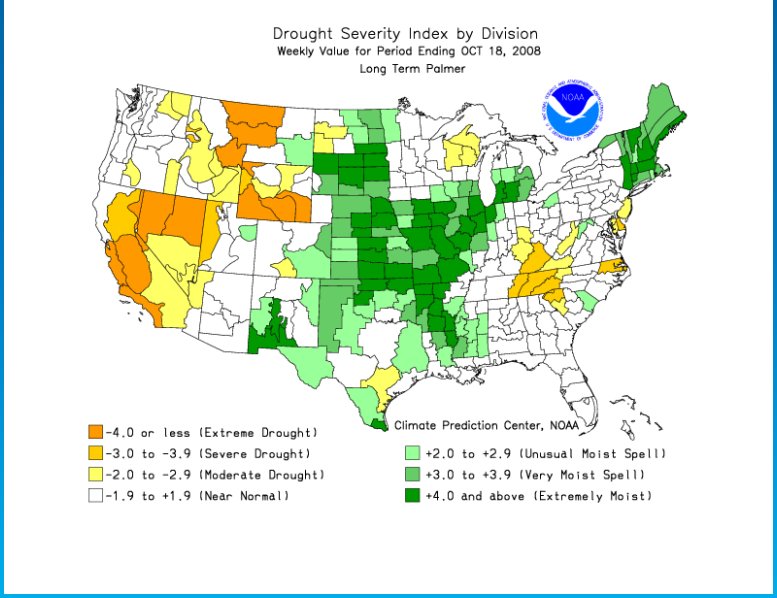
- ***Simplify*** **complex relationships and provide a good communication tool for diverse audiences/users**
- ***Quantitative*** **assessment of anomalous climatic conditions**
  - **Intensity**
  - **Duration**
  - **Spatial extent**
- ***Historical*** **reference (probability of recurrence)**
  -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

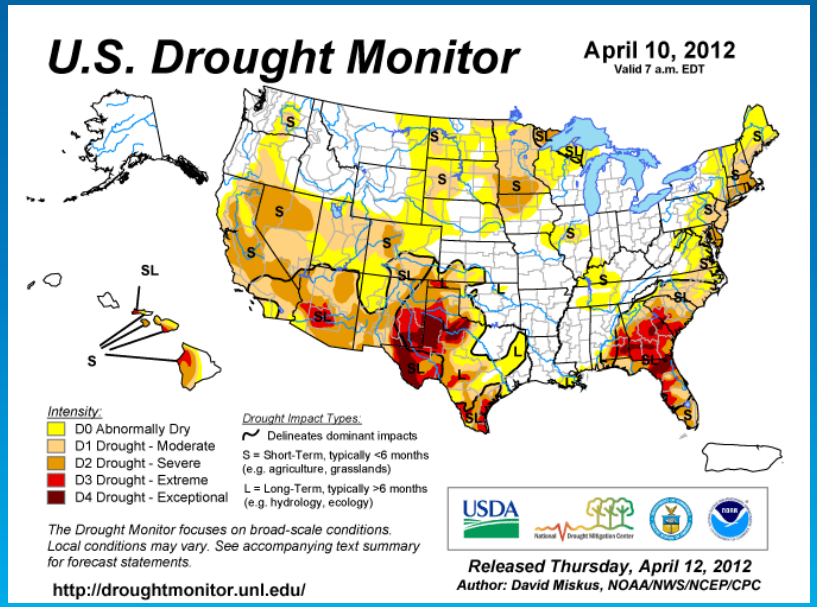
Approaches to Drought Assessment

- Single indicator or index
- Multiple indicators or indices
- *“Composite”* or “hybrid” indicators

Approaches to Drought Assessment

- **Single index or indicator (parameter)**
- **Multiple indices or indicators**
- ***Composite (or "hybrid") Indicator***
  - ***Integrates several indicators/indices***
  - ***Convergence of evidence approach***



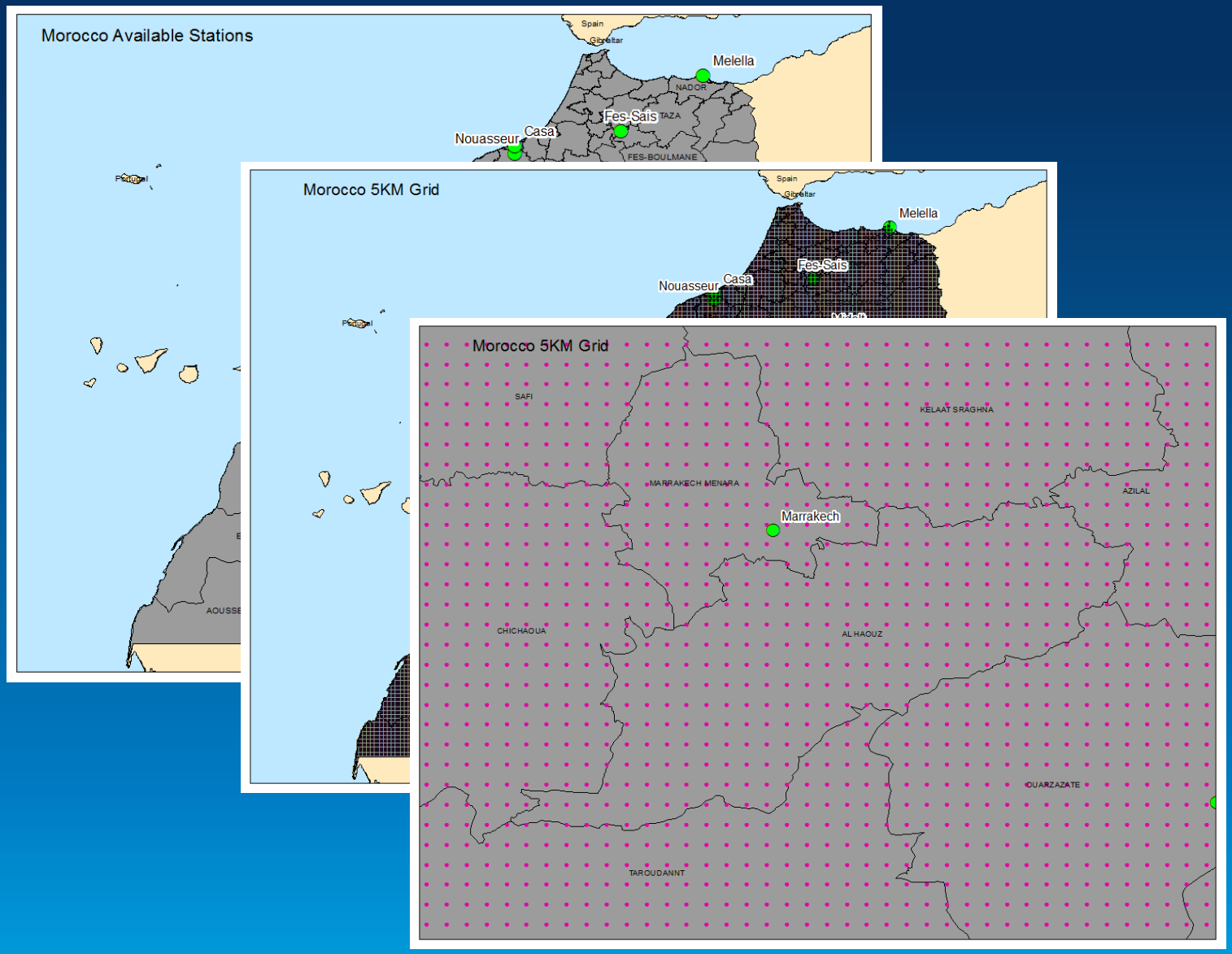


Why use a Gridded Approach?

The driving force behind the use of satellite products as inputs for the Composite Drought Index is the lack of long-term weather stations in many developing areas.

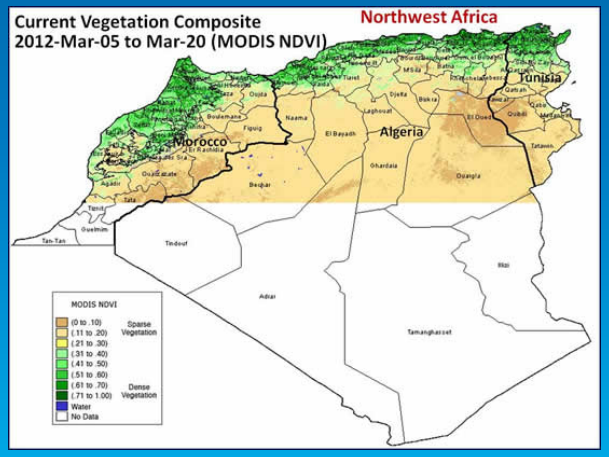
Without these records it is very difficult to calculate an of the indicators normally used in many of the more commonly used indices.

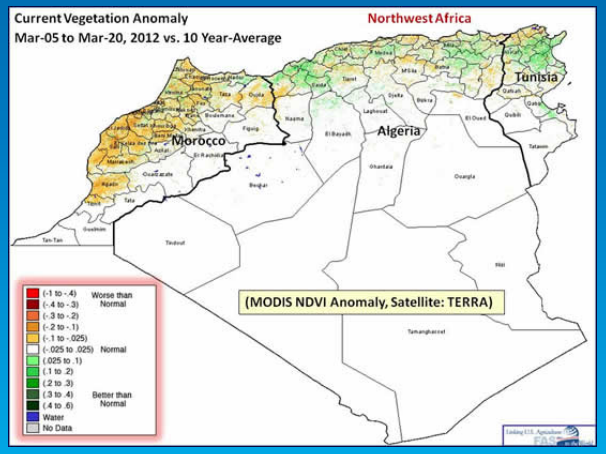
In many cases the only indicator that can be calculated is SPI. SPI alone may not accurately describe the drought conditions especially in naturally drier climates.


Morocco Available Stations
Spain
Gibraltar
Melella
NADOR
Fes-Sais
TAZA
Nouasseur
Casa
FES-BOULMANE
Morocco 5KM Grid
Spain
Gibraltar
Melella
Fes-Sais
Nouasseur
Casa
Morocco 5KM Grid
SAFI
KELAAT SRAGHNA
MARRAKECH MENARA
AZILAL
Marrakech
CHICHAOUA
AL HAOUZ
OUARZAZATE
TAROUDANNT

Key Considerations in Using Remote Sensing for 'Operational' Agricultural Drought Monitoring

1. 'Anomaly' products are needed to represent how the 'current' conditions related to historical baseline conditions for a given location and time period to establish the 'severity' of the drought conditions.
   - Examples…..'Percent of normal/average' and percentiles
   - The historical satellite data record can vary by instrument and data product, which can influence the baseline conditions that determine the magnitude of the anomaly (severity of the drought condition).



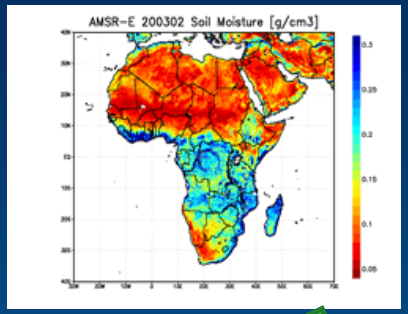


Key Considerations in Using Remote Sensing for 'Operational' Agricultural Drought Monitoring

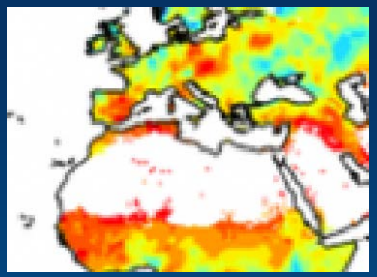
2. Data update cycle – how often are the data updated (e.g., weekly, bi-weekly, or monthly)
3. Data latency – time between the spectral remote sensing observation and the production of the data input for the composite indicator calculation (e.g., 24 hours, one-week, or one-month)
4. Operational commitment of long-term production of the remote sensing data set(s) and/or product(s) from organization providing the source data.
5. Data access – what is the data sharing policy sharing of organization producing the remotely sensed data product

- *Option can varying including:*
  - Free, open access to general public
  - Registration or special permissions registration
  - Fees required

Soil Moisture

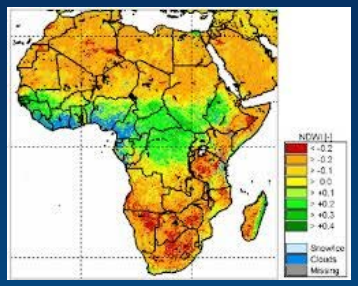


SPI/SPEI

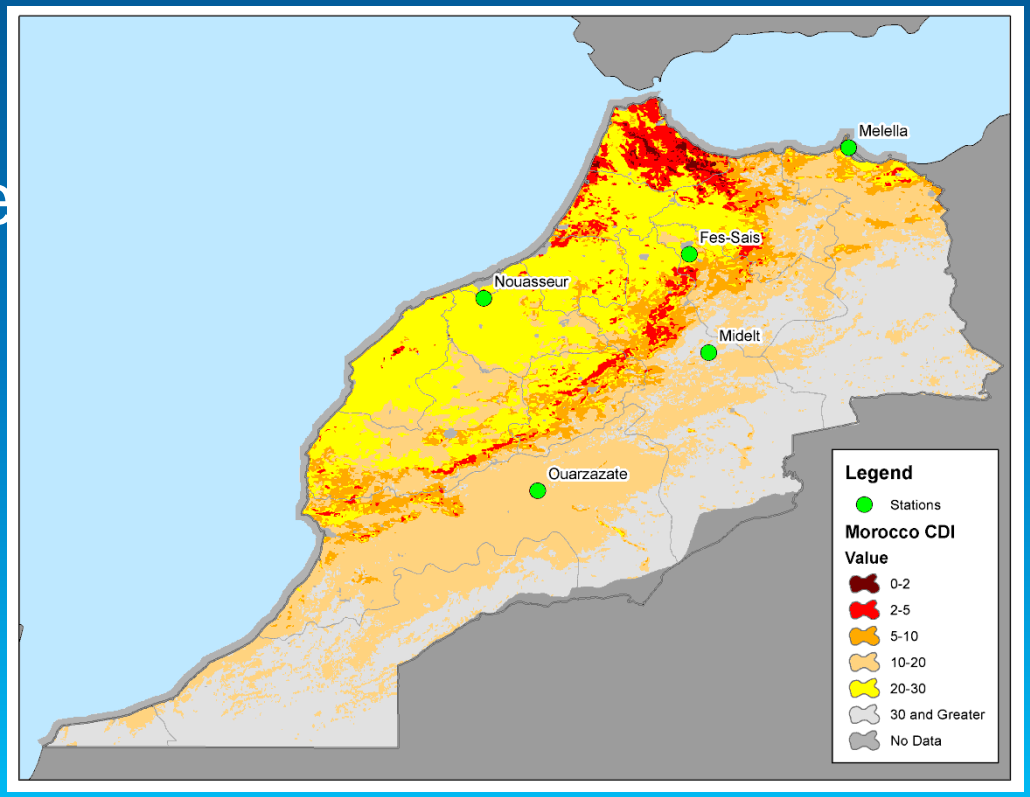


FAPAR

NDWI



Composite
Drought
Index



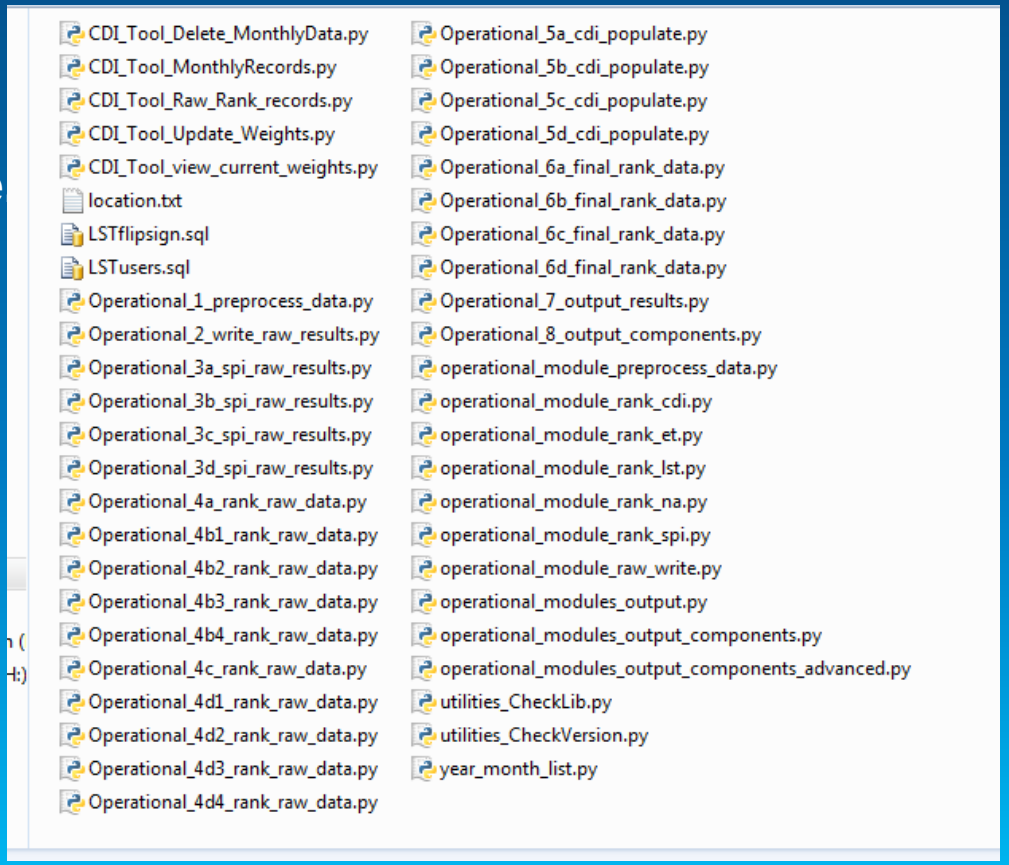
Calculating the CDI

Steps in the creation of the Gridded CDI

- A base grid will be created
  - The cell resolution will most likely be that of the coarsest input dataset
- All of the input grids need to be aggregated to match the base grid
- Each cell value will then be extracted and entered into the database.
- Once the overall history for a particular dataset is completed a stored procedure can be run on the values to rank cell's history
- When all of the datasets are complete and ranked the raw CDI can be calculated and ranked.

CDI Python Scripting

- The process was built with the intention of:
  - Run by personnel with limited GIS/database/python skills.
  - To be easily updated
  - To be easily expandable
  - To run as quickly as possible



Calculating the CDI

Updating the Gridded CDI

- Adding an additional month of values to the database is relatively simple
  - Preprocess the data input to prepare it for value extraction.
    - Aggregate the new datasets to match the base grid
  - Add the new cell values to the database
  - Run the stored procedure to re-rank the cell values to include the new data values
  - Run the stored procedure to calculate the raw CDI values and rank the results

  - All processing is accomplished with ArcGIS, Spatial Analyst the standard Python install and 2 additional open source python

Script samples

The scripts cannot be included in the slides per the IMF/CRTS/NDMC contract. I will be showing them in the IDLE editor at this time.

Gridded CDI

Comparison of the approaches

- **The Gridded approach will produce a CDI value for every cell so interpolation of the data is no required**
  - **The results can still be interpolated and will produce a much smoother surface**
- **The weighting the ranking and all of the other calculations are the same for both approaches the difference is only in the amount of data being processed.**

Gridded CDI

Issues with the Gridded Approach

- Very large datasets and huge numbers of calculations
- Production will require increasing amounts of processing power as more inputs are added or as the production is moved to decadal or weekly intervals
- Given the large amounts of data processing time may take a day or more

Gridded CDI

Positives with the Gridded Approach

- With the use of the this approach the coverage is evenly spread over the country
- Given the spacing and density of points it may be possible to create regional variations to allow better drought depiction
- With gridded datasets adding additional inputs will be relatively simple the only requirement will be that the datasets have a long enough history and cover the entire country

Gridded CDI

Requirements for production

- **A relational Database**
  - **MS SQL Server or similar**
- **A machine setup to do the processing and populate the database**
- **Python and SQL scripting experience**
  - **Only minimal experience required unless you are adding additional inputs or making other large changes to the system.**
- **GIS tools to turn the ranked CDI's into a final Monthly grid**

Any Questions?

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