MERRA-2 Data and Analytic Services at NASA GES DISC for Climate Extremes Study

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NASA Goddard Earth Sciences
Data and Information Services Center
(GES DISC)
https://disc.gsfc.nasa.gov/

Jul 28-Aug 2 2019 AOGS

Overview of MERRA-2 Products

MERRA-2 (Modern-Era Retrospective analysis for Research and Applications, Version-2) is a NASA reanalysis data set for the satellite era, focused on historical analyses of meteorology, atmospheric chemistry, land, ocean, and aerosol data with temporal scales ranging from weather to climate context. (**https://gmao.gsfc.nasa.gov/reanalysis/MERRA-2/docs/**

- **Temporal Coverage:** 1980-present (39+ years)
- **Temporal Resolution:** Hourly, 3-Hourly, Monthly
- **Spatial Coverage:** Global
- **Spatial Resolution:** 0.5^{o} x 0.625^{o} (361x576), L42 (pressure level), L72 (model level)
- **Number of Product Groups:** 95
- **Data Format:** NetCDF-4

Services to Obtain MERRA-2 Data

Through various available services and tools, the GES DISC provides users with data access and visual analysis for a number of science disciplines.

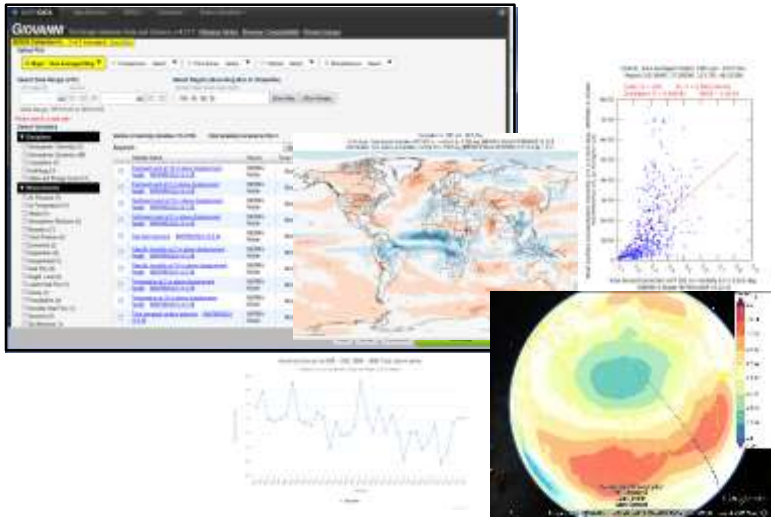
Faceted Web Interface

- Web interface to data products and services
- Search and Download mechanisms
- Dataset landing pages

https://disc.gsfc.nasa.gov/

GES DISC Subset and Regrid Service – Parameter, Spatial, Time, Vertical, daily mean, format conversion and regridding.

Giovanni–Online Data Visualization and Analysis Tool which features Level 3 and 4 gridded datasets.



OPeNDAP - Open-source Project for a Network Data Access Protocol

GDS – GrADS Data Server

HTTPS direct online access – Direct HTTPS access

Online Help Documents – FAQ and Data How-to

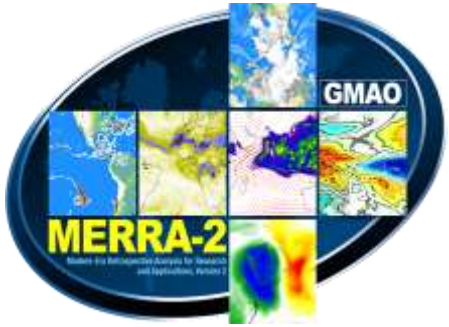
Supporting Science Research

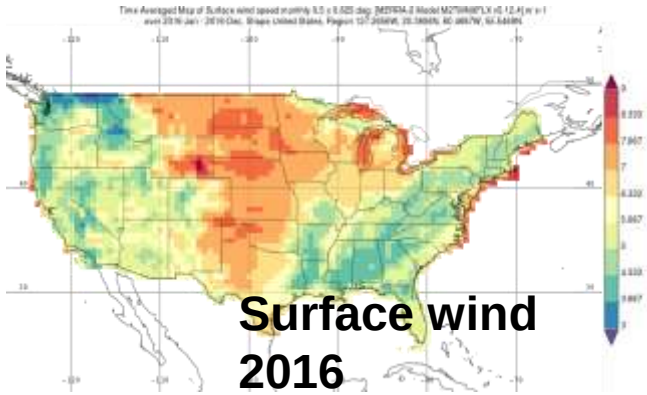
- **Climate and Weather:**

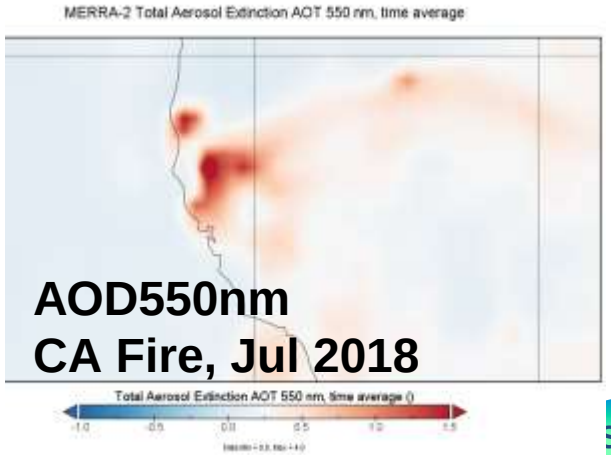
  ENSO, Monsoon, Arctic warming, …

  Hurricanes, drought, flood, heatwave, cold surge (winter blizzard), …

- **Applications:**
  - Renewable energy (wind & solar)
  - Health & Air Quality
  - Wildfire
  - Water resources
  - Landslide
  - Earthquake & Volcano
  - …

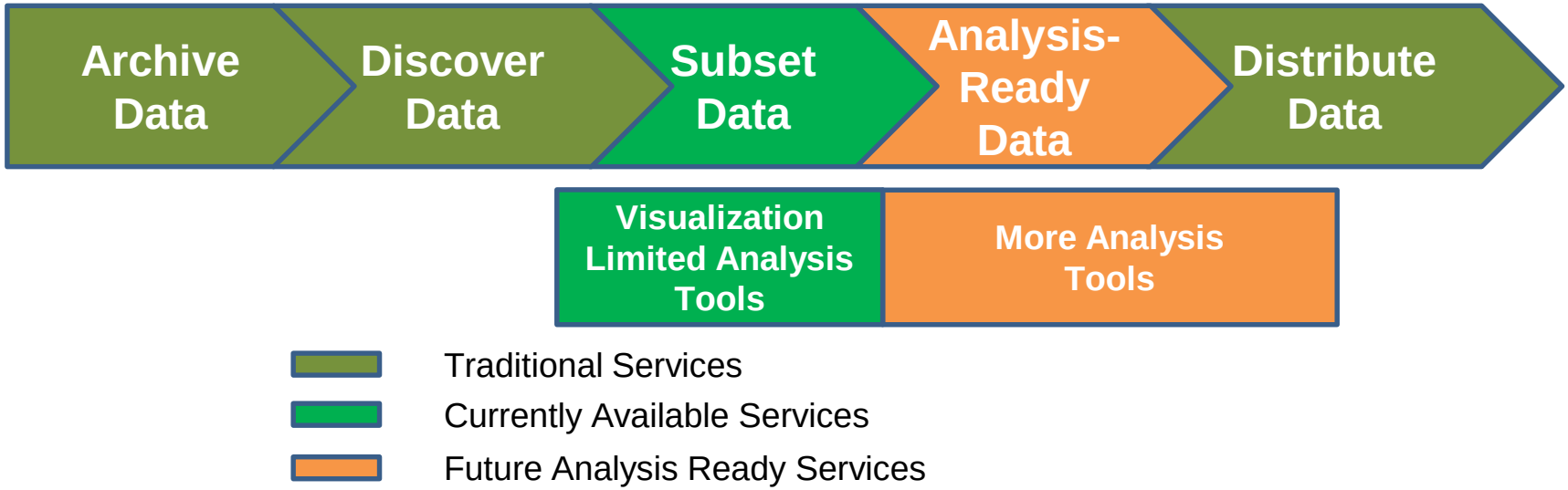






Recent activities have been under way for creating new value-added products, Data Lists, and analysis ready services

Developing Analytical Services



- ✓ Improve data downloading performance
- ✓ Download only data of interest, in preferred format and structure
- ✓ Reduce pre-processing time
- ✓ Implement selected analysis algorithms for testing scenarios on-the-fly without downloading the data

Key or Grand Challenge: Is it *fast* ?

Scientists face challenges in dealing with the native data files, such as slow processing times, timing out, system overloads, and storage capacity issues.

Data has to be conformable to the needs of the user, and be ready for analysis:

- Download in a different format, time-series at a single point, or a small area into a single file in different data format (e.g., ASCII, NetCDF, or flat binary) easy and fast;
- Compute basic statistics: for example, mean, minimum, maximum, and standard deviation, etc.
- Find extreme events, such as days of very windy, hot or cold, drought, and high aerosol load, etc.

How do we address this? By

- Reconstructing data files
- Creating value-added datasets for specific applications
- Integrating selected data into cloud environment
- Packaging data based on application areas ("Data List")

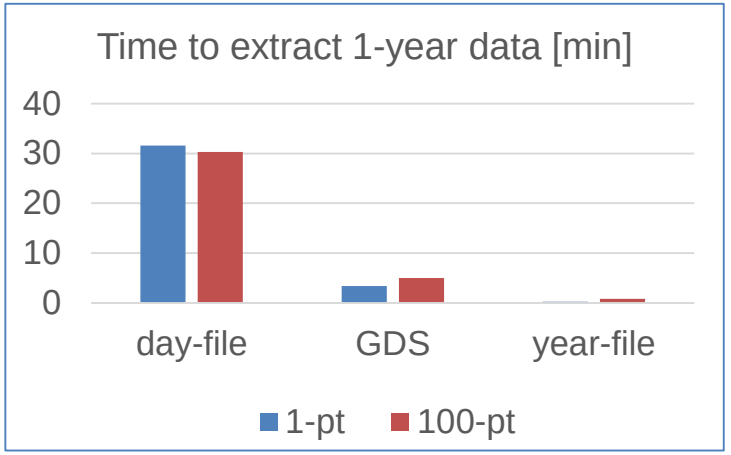


Figure (top) shows the time (unit=min) elapsed to download a **1-year** hourly time series of wind data in ASCII format of a 1x1 (single point) and 100x100 points from day (native archived), GDS (virtual time aggregation) and year (physical time aggregation restructured) files to get 1-year hourly wind analysis, such as the displayed time-series plot (bottom).

Challenges of Extreme Study

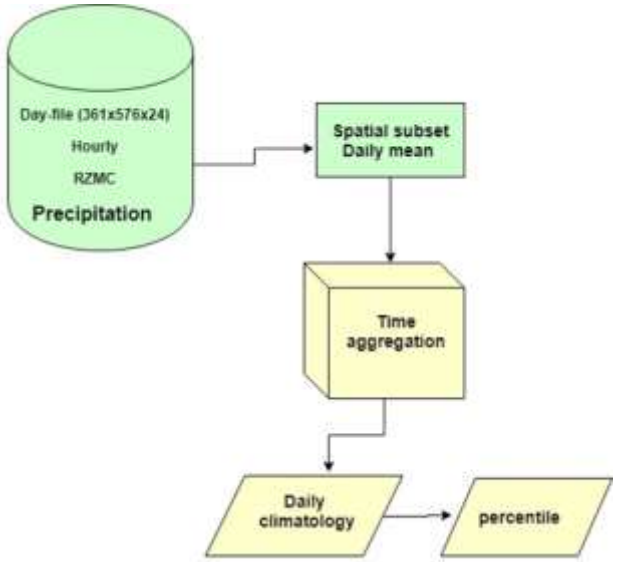
Example: Drought

Various Drought Indices

- ✓ **PDSI (**Palmer Drought Severity Index) – effective for long-term drought
- ✓ **SPI** (Standardized Precipitation Index) – meteorological drought
- ✓ **CMI** (Crop Moisture Indices)
- ✓ **SSI** (Standardized Soil moisture Index)
- ✓ **SVPD** (Standardized Vapour-Pressure Deficit)
- ✓ **MSDI** (Multivariate Standardized Drought Index)
- ✓ **SPEI** (Precipitation and Evapotranspiration Index)
- ✓ ……

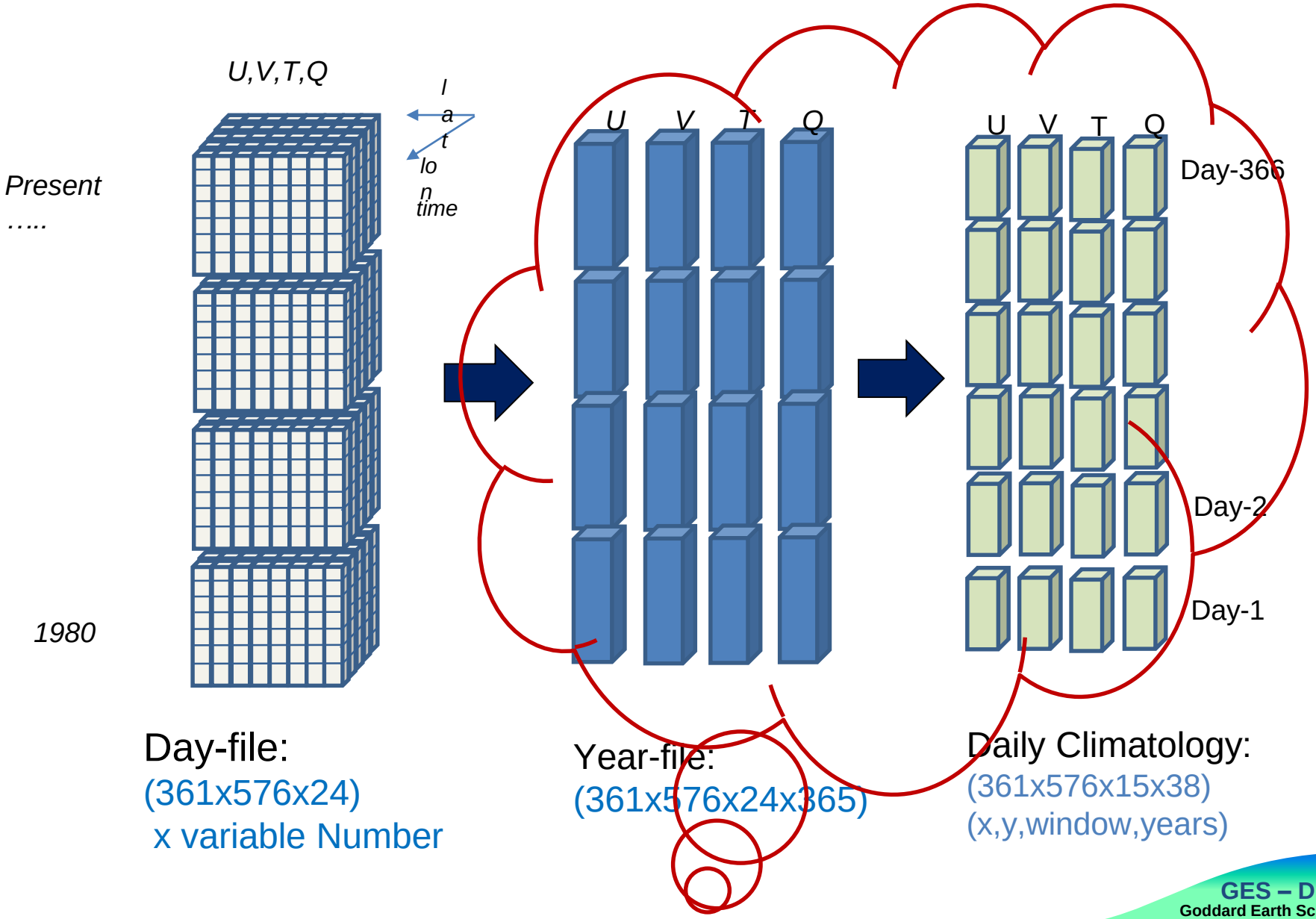
Common issue: time consuming to download and pre-process long-term daily data, or hourly data

Workflow of Percentiles Calculation



The figure above is the workflow which composes daily climatology and computes percentiles with existing services (green) and in developing analytic services (yellow).

Re-construct Data Cubes: MERRA-2 Hourly



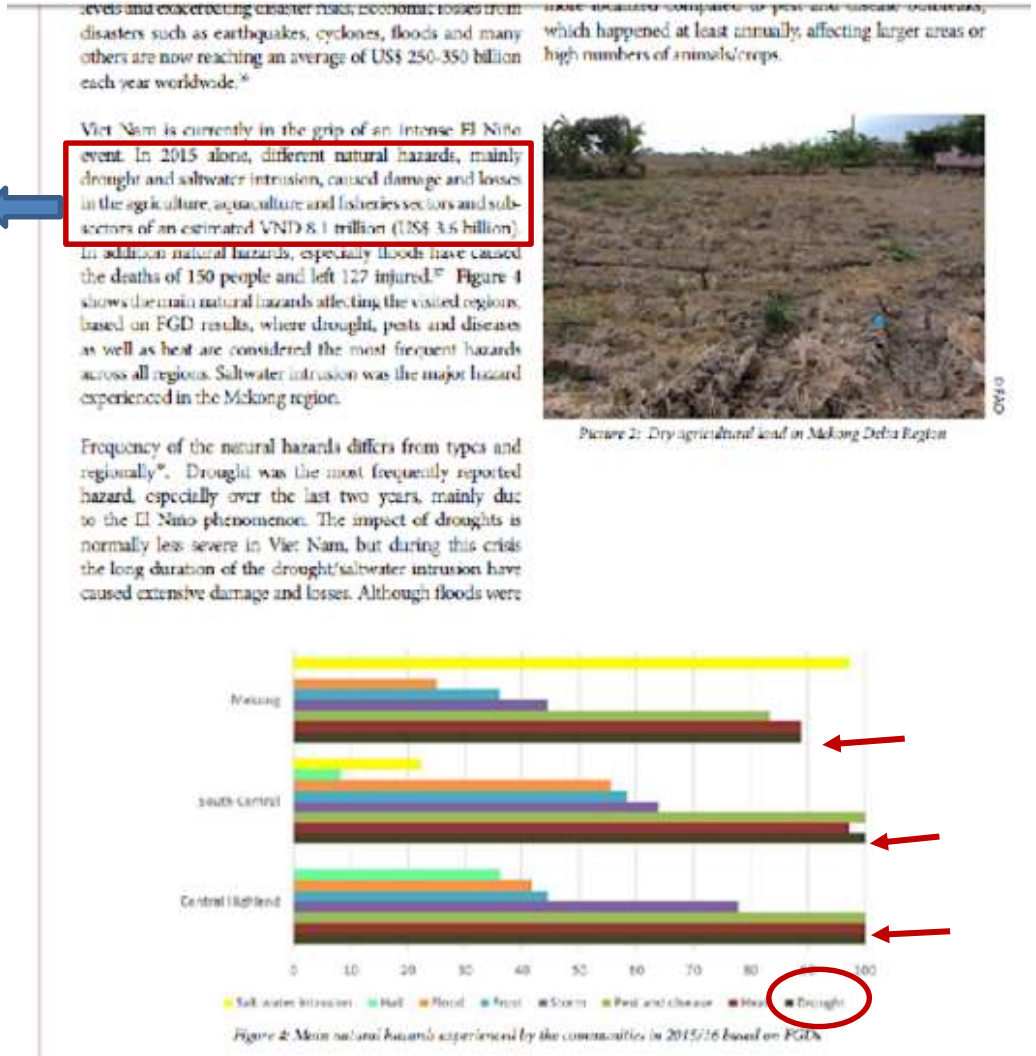
Day-file:
(361x576x24)
x variable Number

Year-file:
(361x576x24x365)

Daily Climatology:
(361x576x15x38)
(x,y,window,years)

Severe Drought in VIETNAM 2015

"In 2015 alone, different natural hazards, mainly drought and saltwater intrusion, caused damage and losses in the agriculture, aquaculture, and fisheries sectors and subsectors of an estimated VND 8.1 trillion (US$ 3.6 billion)."



disasters such as earthquakes, cyclones, floods and many others are now reaching an average of US$ 250-350 billion each year worldwide.[6]

which happened at least annually, affecting larger areas or high numbers of animals/crops.

Viet Nam is currently in the grip of an intense El Niño event. In 2015 alone, different natural hazards, mainly drought and saltwater intrusion, caused damage and losses in the agriculture, aquaculture and fisheries sectors and sub-sectors of an estimated VND 8.1 trillion (US$ 3.6 billion). In addition natural hazards, especially floods have caused the deaths of 150 people and left 127 injured.[7] Figure 1 shows the main natural hazards affecting the visited regions. based on FGD results, where drought, pests and diseases as well as heat are considered the most frequent hazards across all regions. Saltwater intrusion was the major hazard experienced in the Mekong region.

Picture 2: Dry agricultural land in Mekong Delta Region

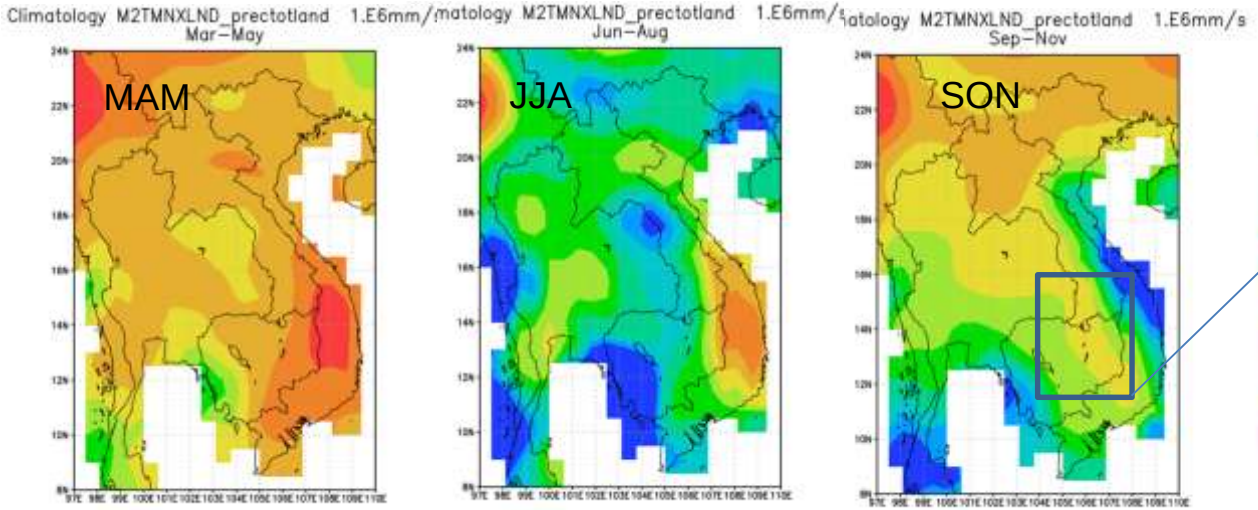
Frequency of the natural hazards differs from types and regionally[8]. Drought was the most frequently reported hazard, especially over the last two years, mainly due to the El Niño phenomenon. The impact of droughts is normally less severe in Viet Nam, but during this crisis the long duration of the drought/saltwater intrusion have caused extensive damage and losses. Although floods were

Figure 4: Main natural hazards experienced by the communities in 2015/16 based on FGDs

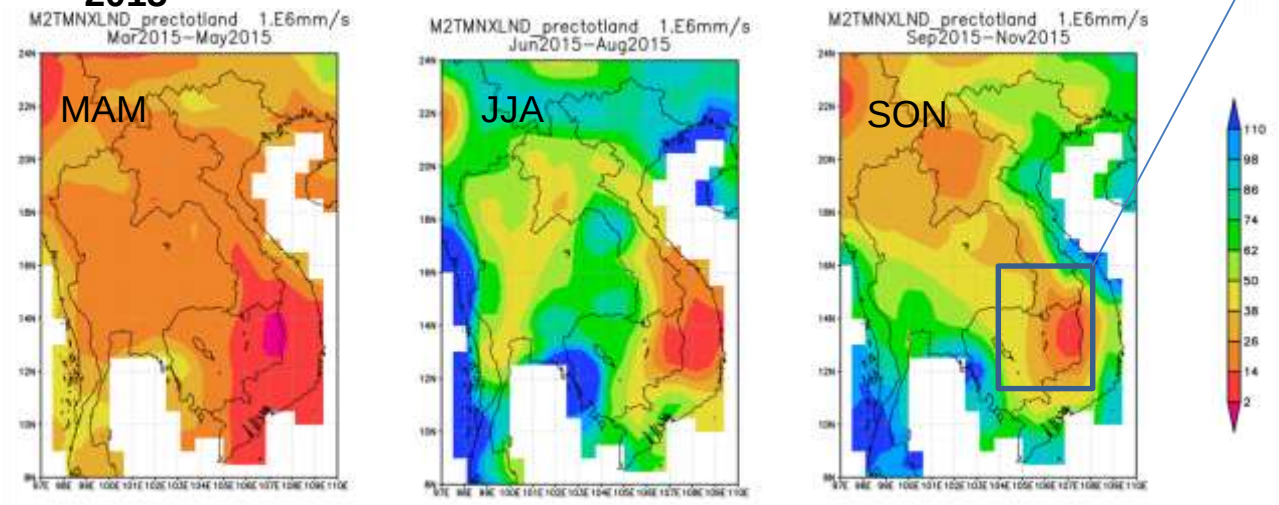
Courtesy: FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
Hanoi, 2016
https://reliefweb.int/sites/reliefweb.int/files/resources/a-i6020e.pdf

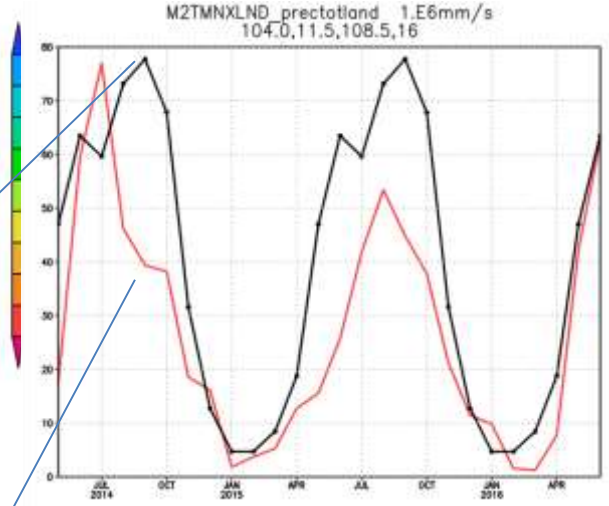
MERRA-2 Precipitation (M2TMNXLND_prectotland)

Climatology



2015

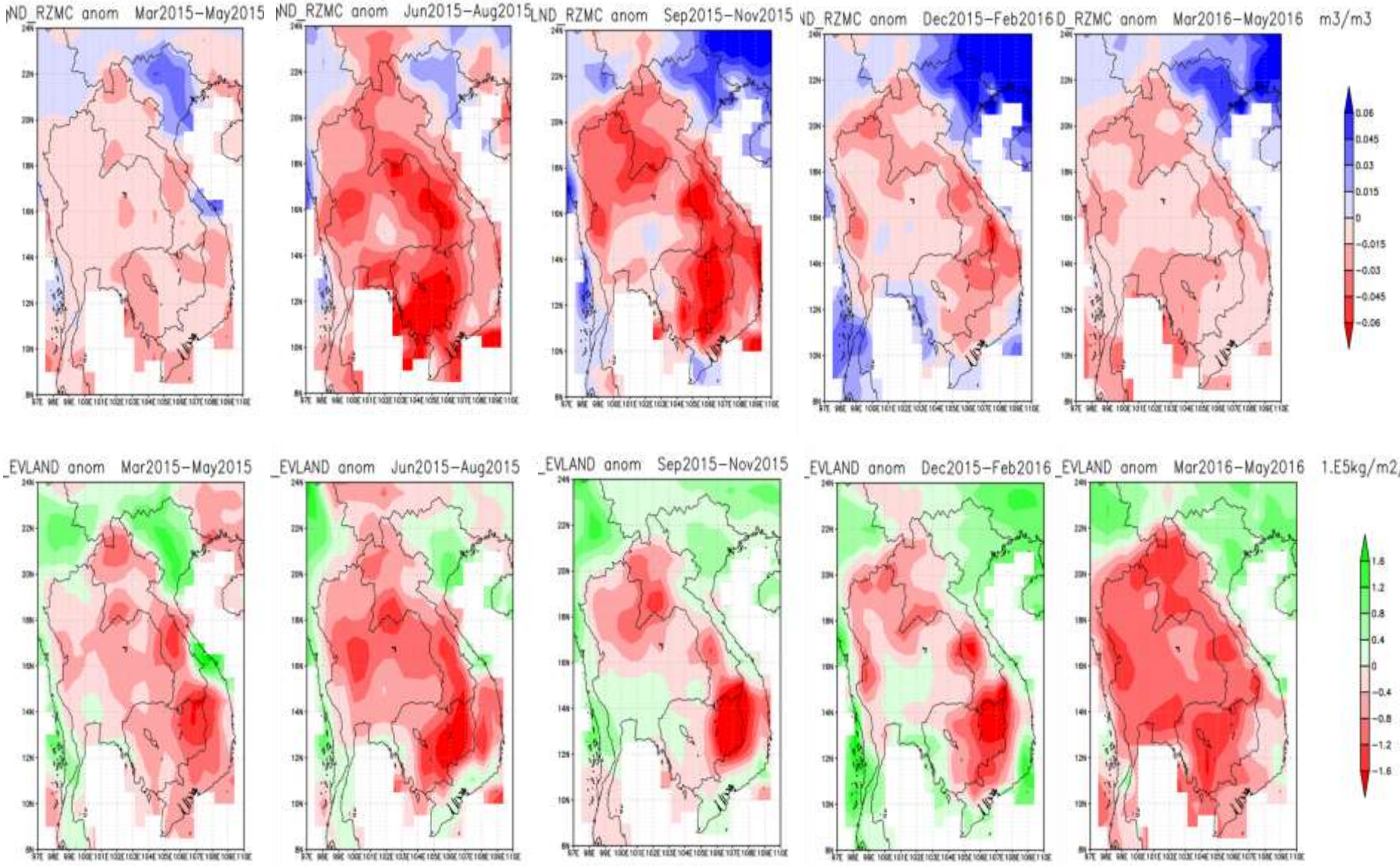




Precipitation of boxed area for climatology (black line) 2014.05-2016.06 (red line)

Map and time series may be generated with Giovanni

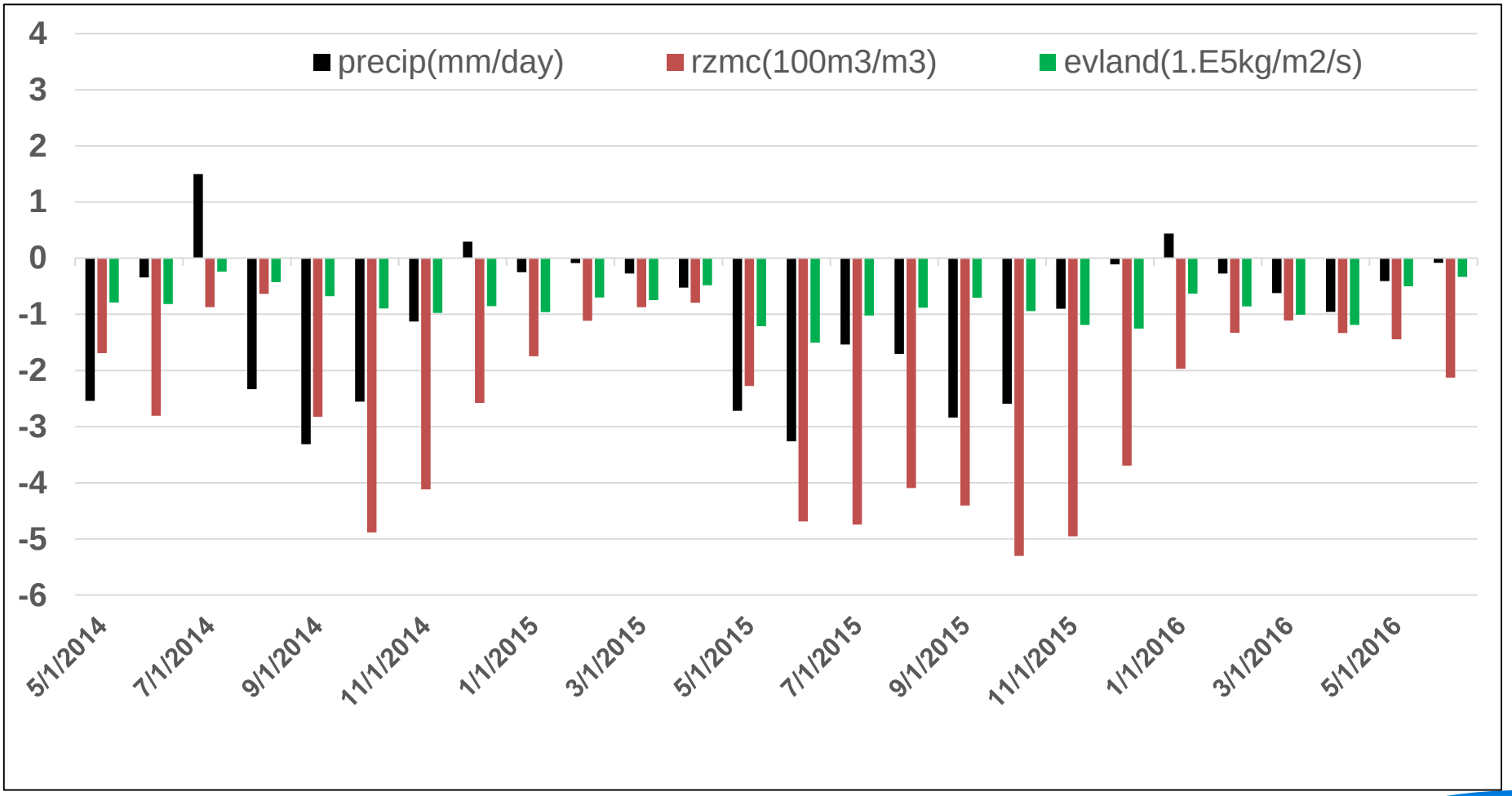
Anomaly of Soil Moisture and Evaporation, 2015 - 2016



Anomaly over Southeast Asia, 2014.05 –2016.06

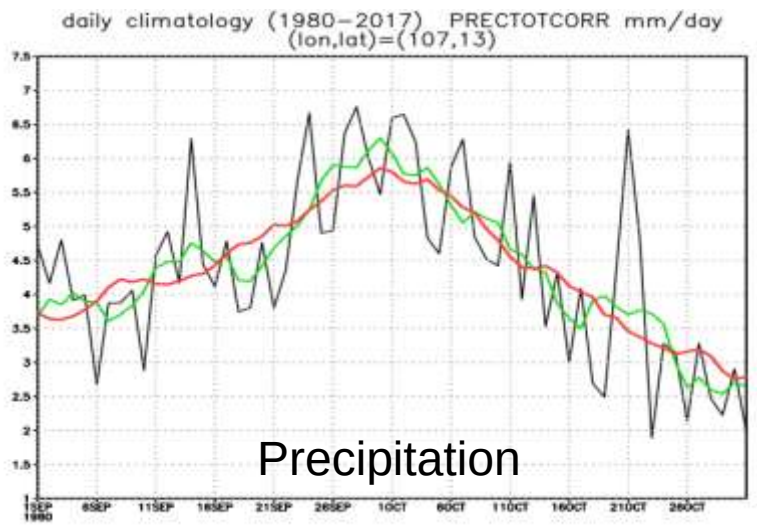
Precipitation, Soil Moisture, and Evaporation

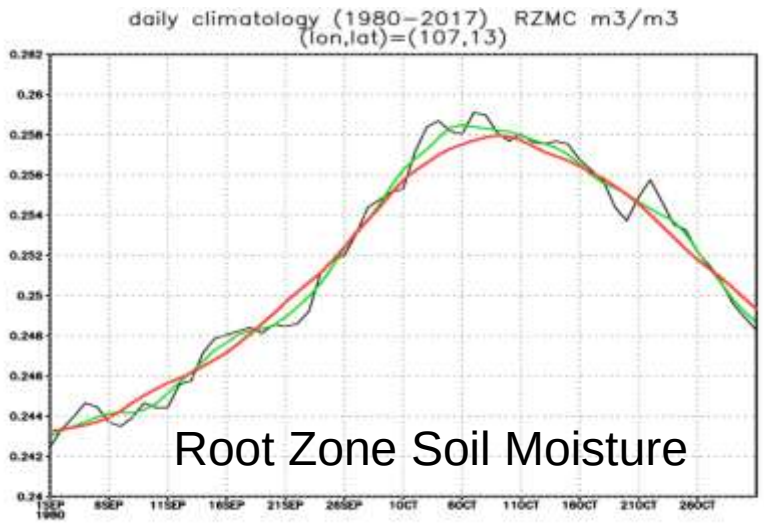
(104E-18.5E, 11.5N-16N)



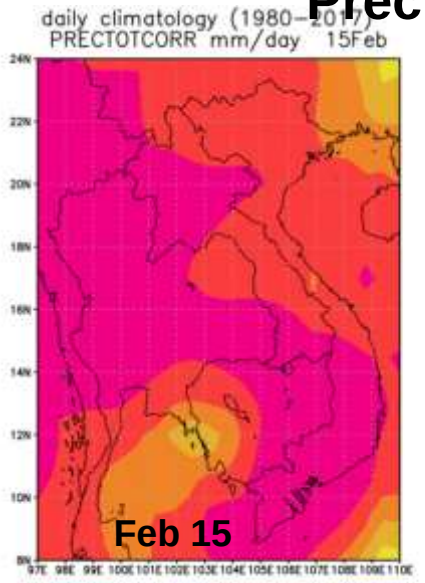
Example: Daily Climatology

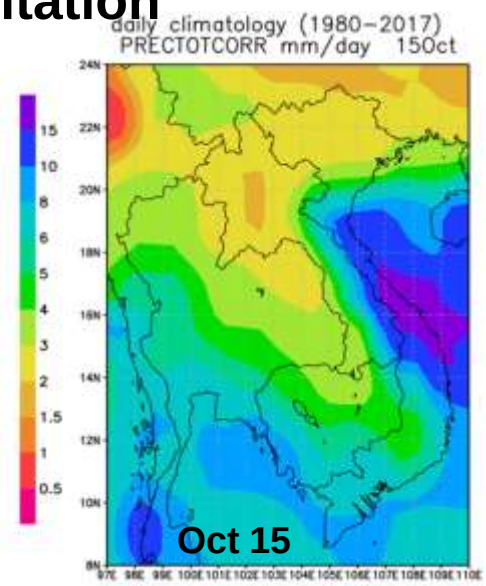
(107°E, 13°N) for window size **0, 7, 15**



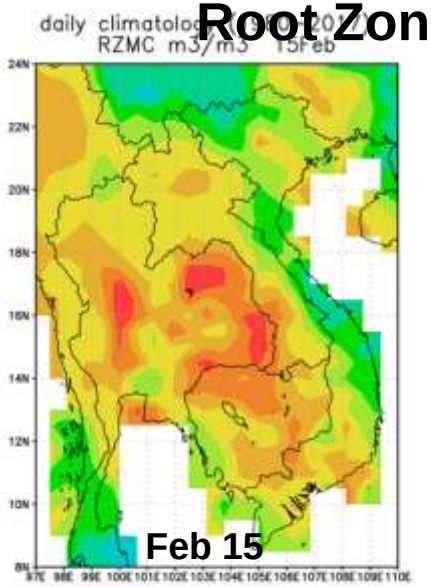


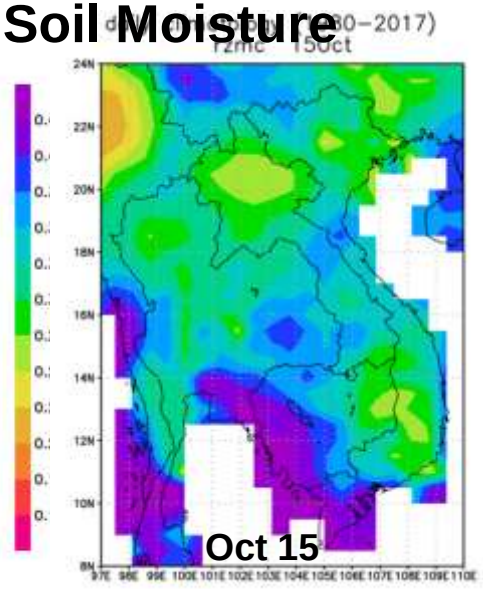
Precipitation





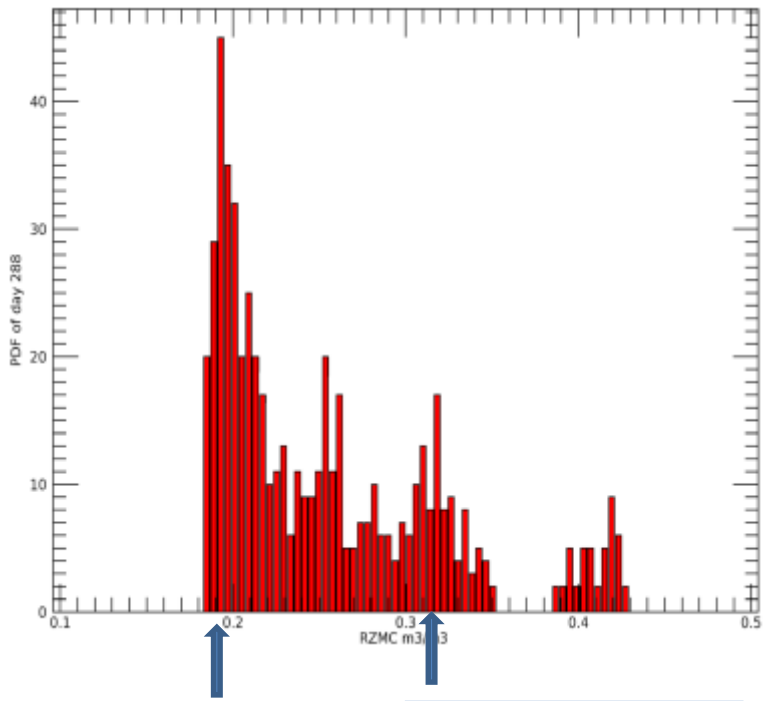
Root Zone Soil Moisture





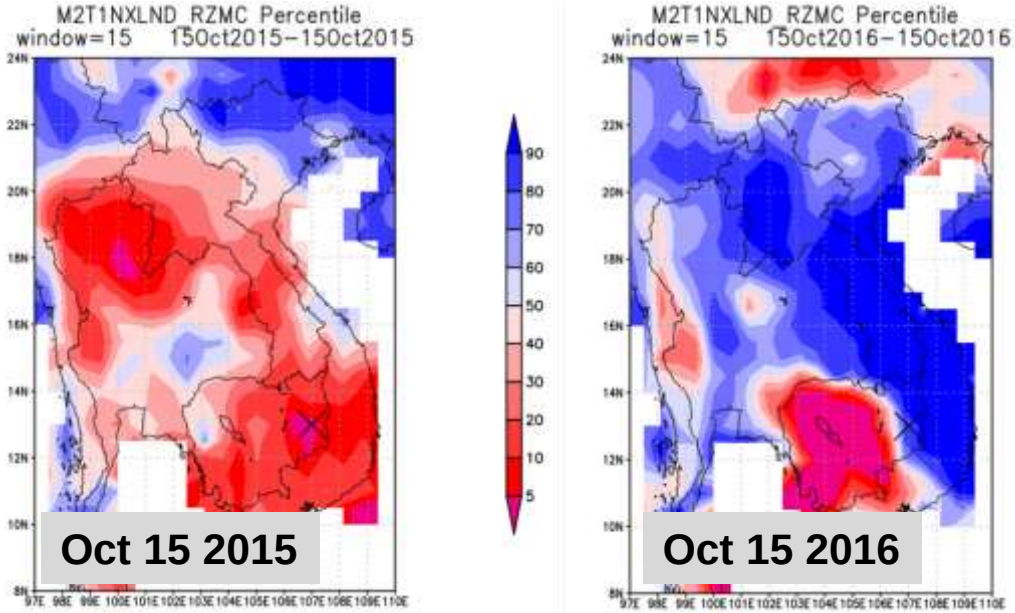
Example: Percentiles

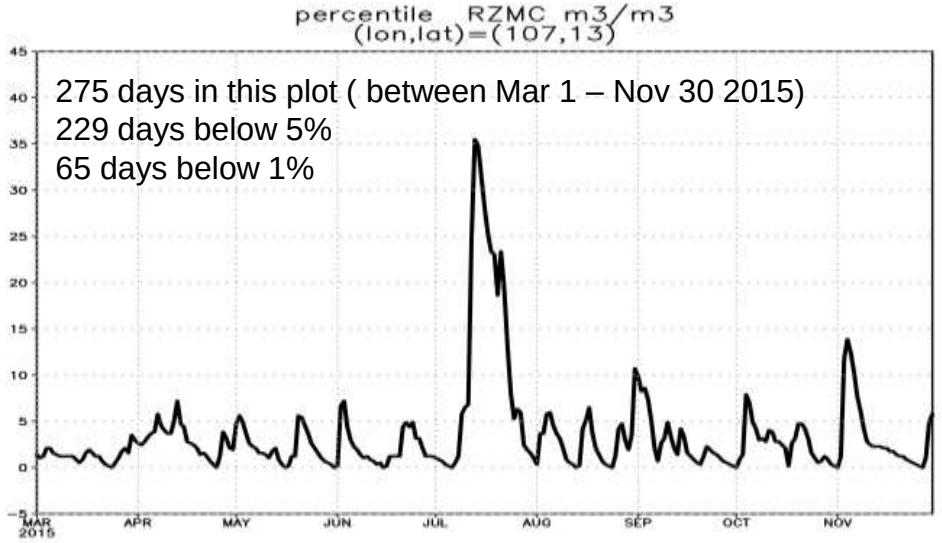
Root Zone Soil Moisture (RZMC) on Oct 15 (Window=15) **(107E, 13N)**



Oct 15 2015
RZMC = 0.187
percentile=2.5%

Oct 15 2016
RZMC = 0.316
percentile=81.2%





Future Work:

- Work closely with domain experts, learn and implement popular algorithms for finding extremes
- Provide a monthly and daily climatology database that may make it easier for scientists to to study extremes
- Develop user-friendly interface
- Create User Guide, data How-to, including Jupyter Notebook about using the system
- Move data into cloud, provide software environment for data processing

Related Data Services Resources:

From GES DISC:

GES DISC Home Page: https://disc.gsfc.nasa.gov

Data visualization and analysis: https://giovanni.gsfc.nasa.gov/

Data How-to: https://disc.gsfc.nasa.gov/information/howto

Videos on Youtube: https://www.youtube.com/user/NASAGESDISC

More NASA Data Resources:

NASA Earth Data: https://earthdata.nasa.gov

Full resolution data viewer: https://worldview.earthdata.nasa.gov

Applied Remote sensing training: https://arset.gsfc.nasa.gov

Stories with NASA data: https://earthobservatory.nasa.gov

Contact: gsfc-help-disc@lists.nasa.gov