GEO UNESCO Workshop: AfWCCI Demo Project Session

Satellite Activities and Products for Hydrological Applications: NOAA & CEOS

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Vice-Chair CEOS Working group on Capacity Building and Data Democracy

Satellite Products for Hydrological Applications

- **Satellites are particularly useful where ground measurements are:**
  - Not taken or missing
    - Examples – Sparse rain gauges and data delivery failure (maybe caused by an extreme rainfall event)
  - Of questionable quality
    - Examples – radar missing offshore rain; radar beam blockage in mountains
  - Not possible
    - Example – Open ocean
- **NOAA provides operational satellite products for each individual satellite it operates.**
  - GOES – Visible and IR based, rapid update
  - POES – Passive MW, 3 satellite, 4 hour global coverage

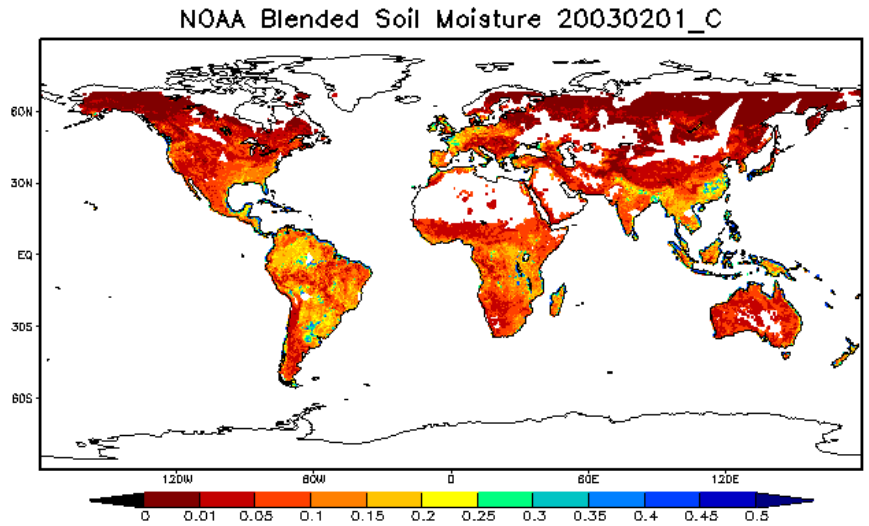
NOAA Hydrological Products

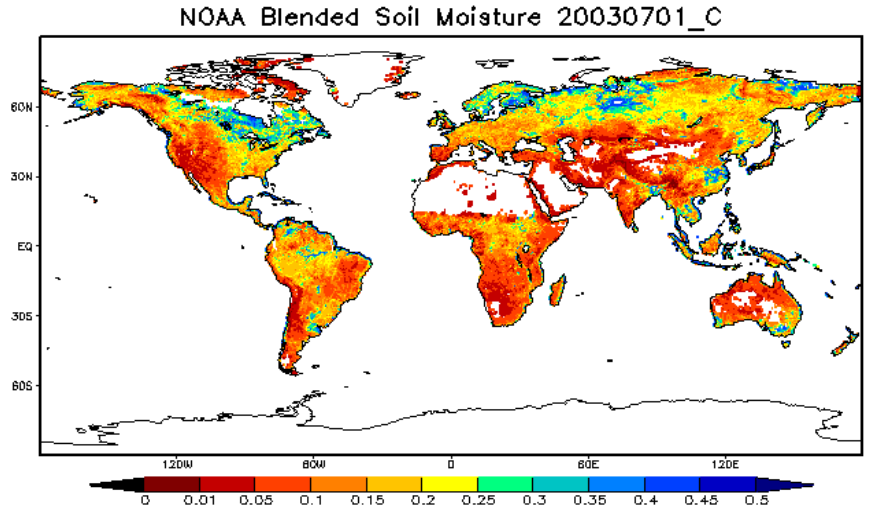
- Soil Moisture
- Vegetation Products
- Short-Term Applications (e.g., flash flood forecasting)
- Other Rainfall Products

Soil Moisture Operational Product System

SMOPS

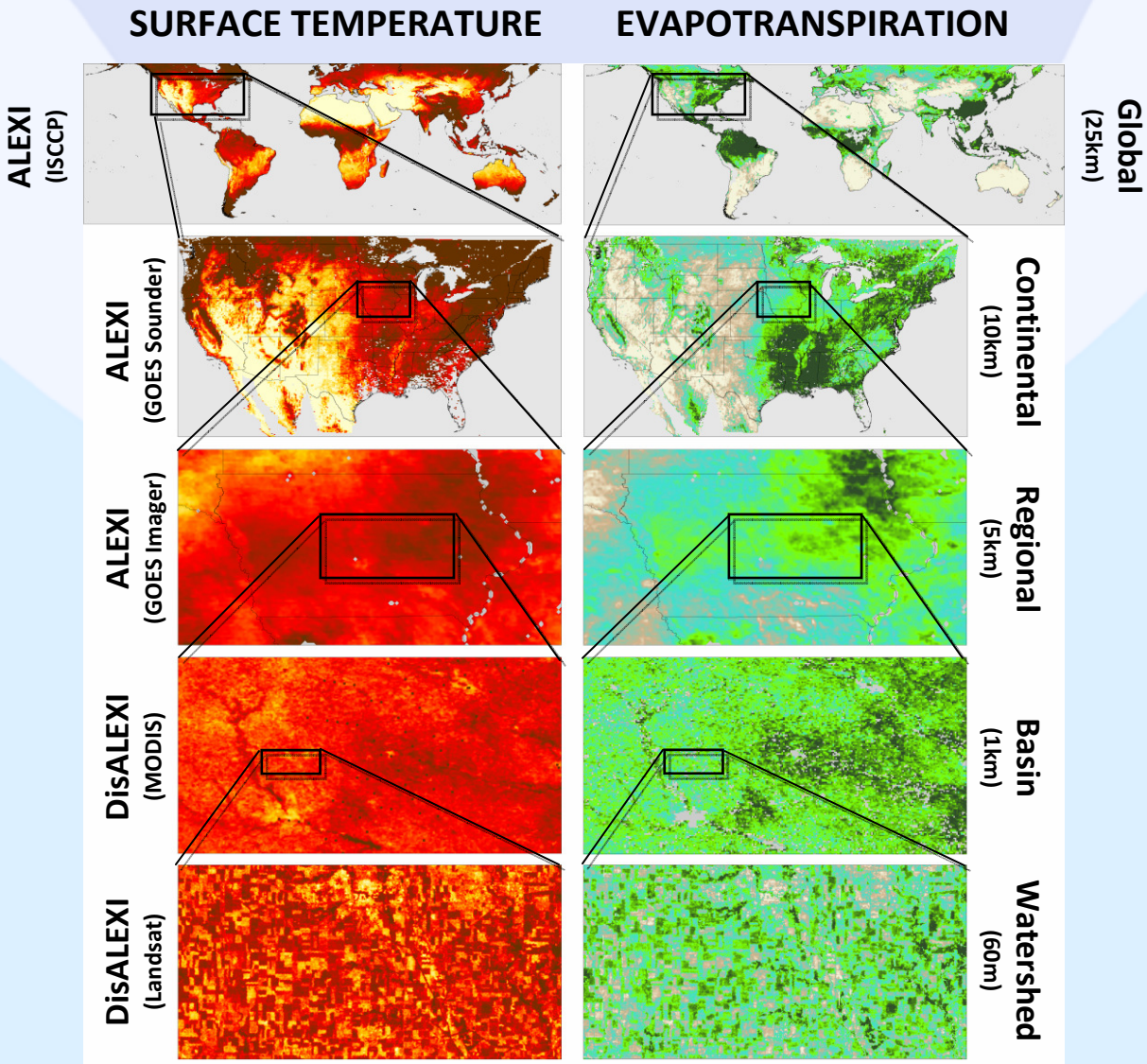
- Generates global soil moisture data sets from the best available microwave satellite sensors (AMSR-E, ASCAT, SMOS, etc) based on the sensor cross-calibration technique and the combined algorithm developed at NOAA STAR
- Serves as a friendly provider of global climatologically consistent soil moisture data provider for NCEP NWP soil moisture data needs
- Disseminates data to users via NOAA's Comprehensive Large Array-data Stewardship System (CLASS)





Atmosphere Land Exchange Inverse Model (ALEXI)

"A multi-scale (global [25 km] to field scale [60 m]) tool for monitoring ET, soil moisture and drought"

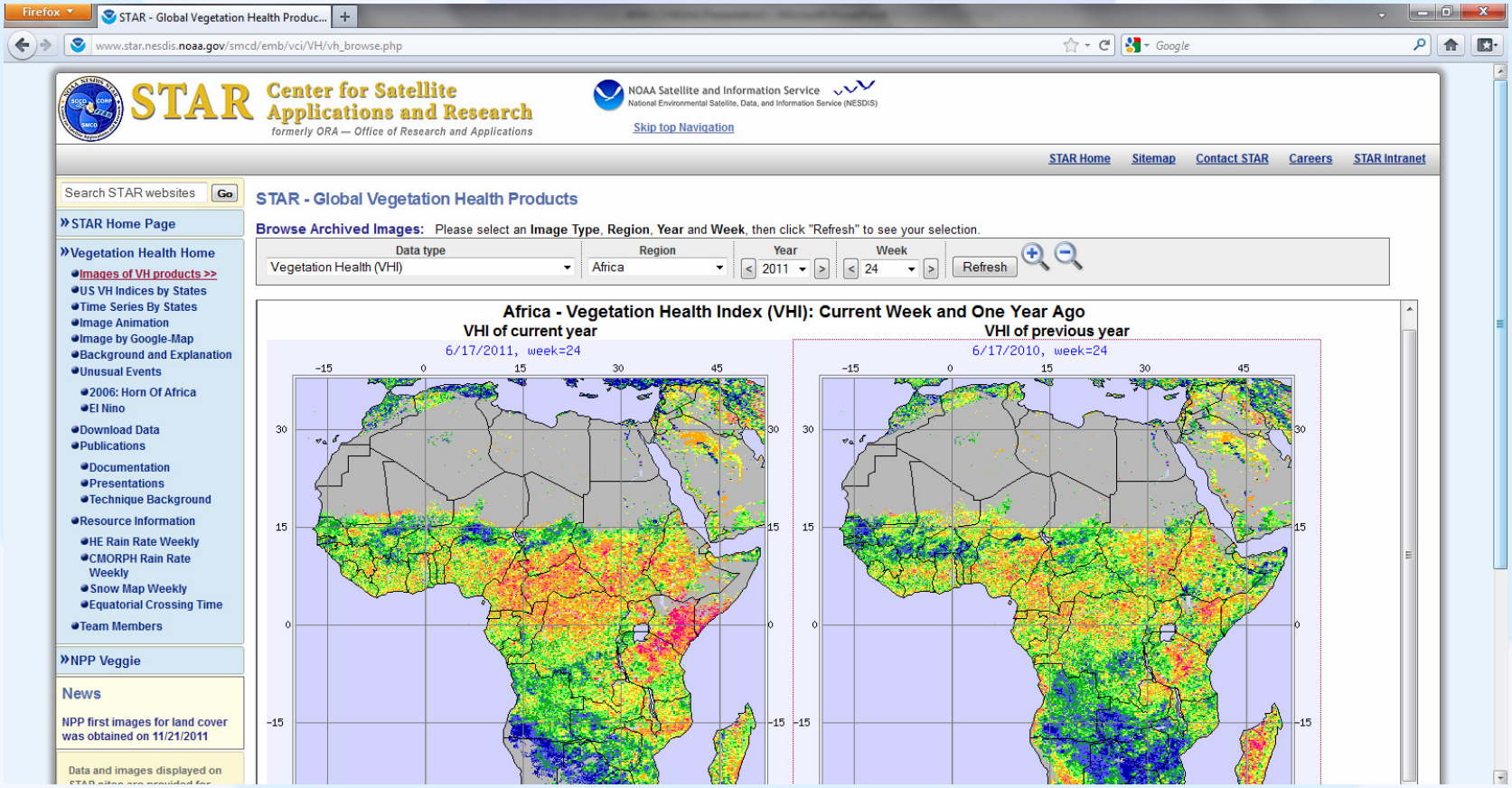


1 July 2002 – 10:30AM LST

Vegetation Products

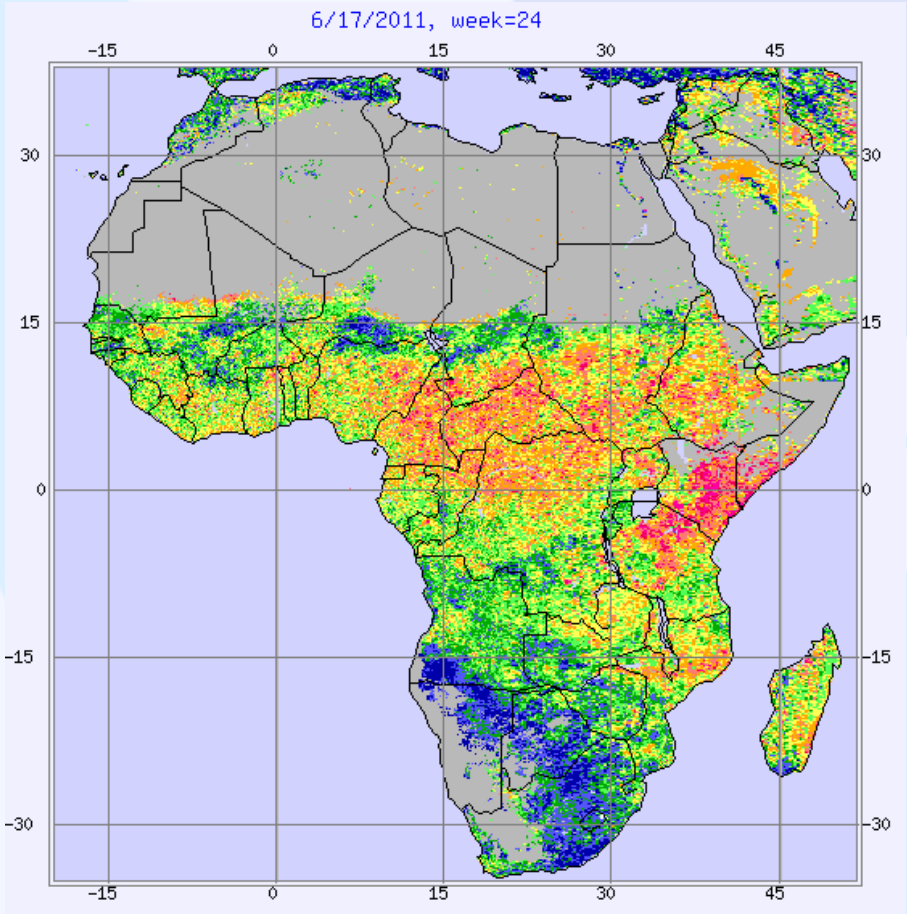
- Vegetation Health
- Vegetation Change
- Greenness
- Fire Risk
- Drought
- Drought Change
- Malaria Risk

http://www.star.nesdis.noaa.gov/smcd/emb/vci/VH/vh_browse.php

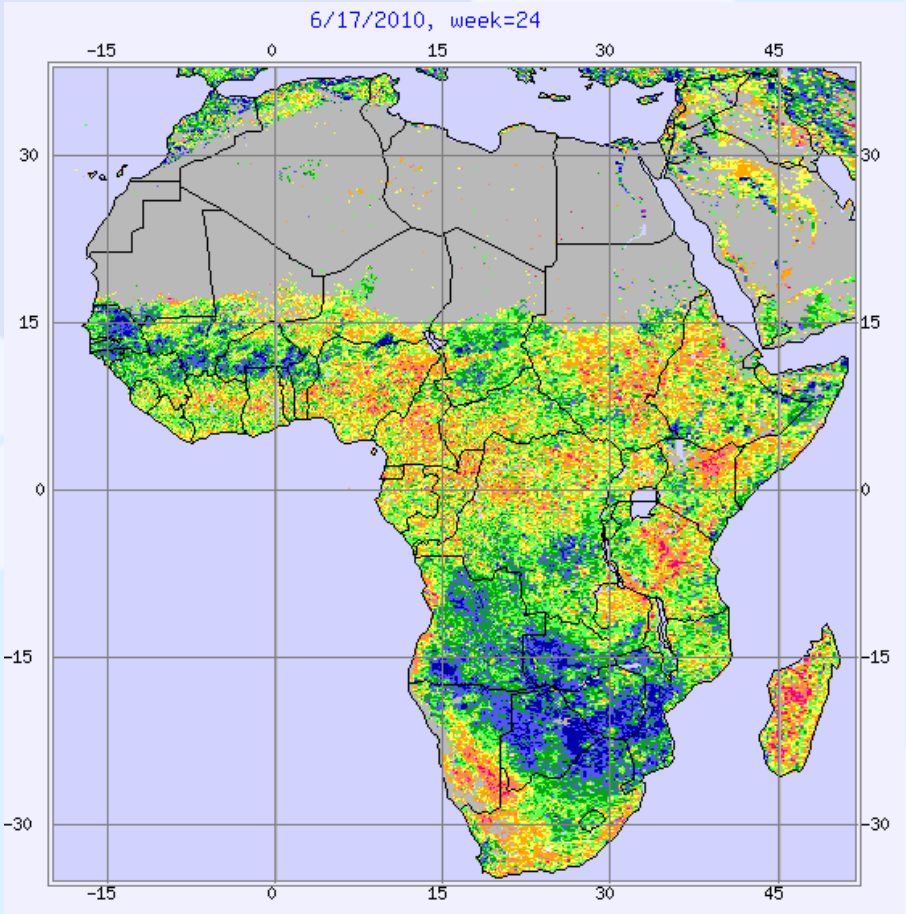


2011 East African Drought

Vegetation Health Index 2011

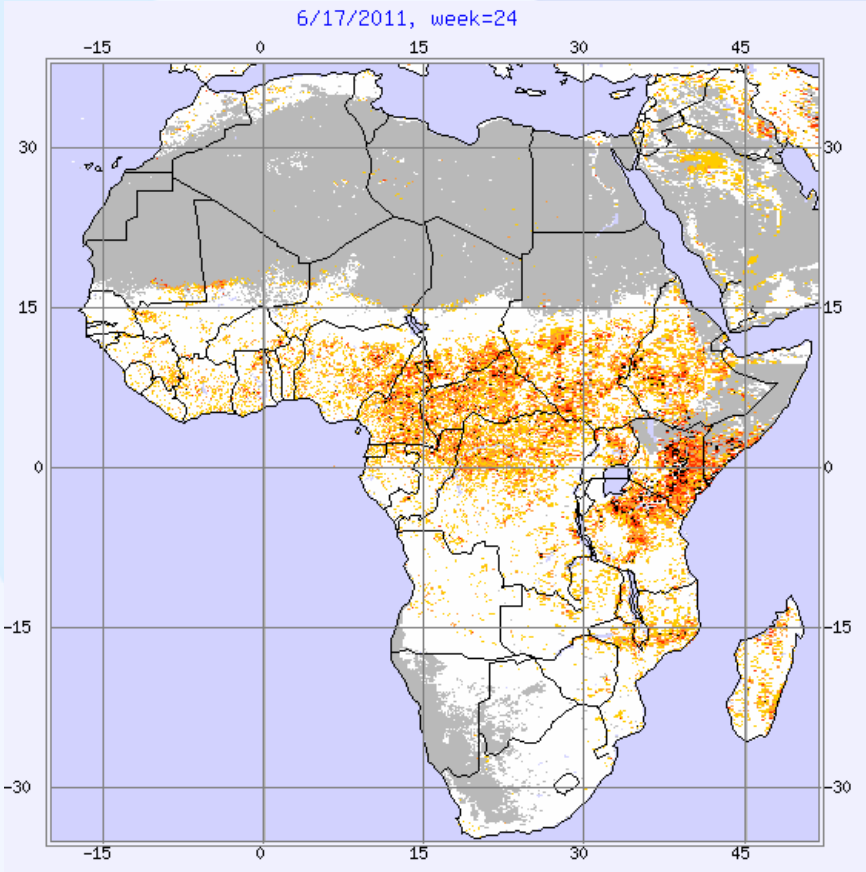


Vegetation Health Index 2010

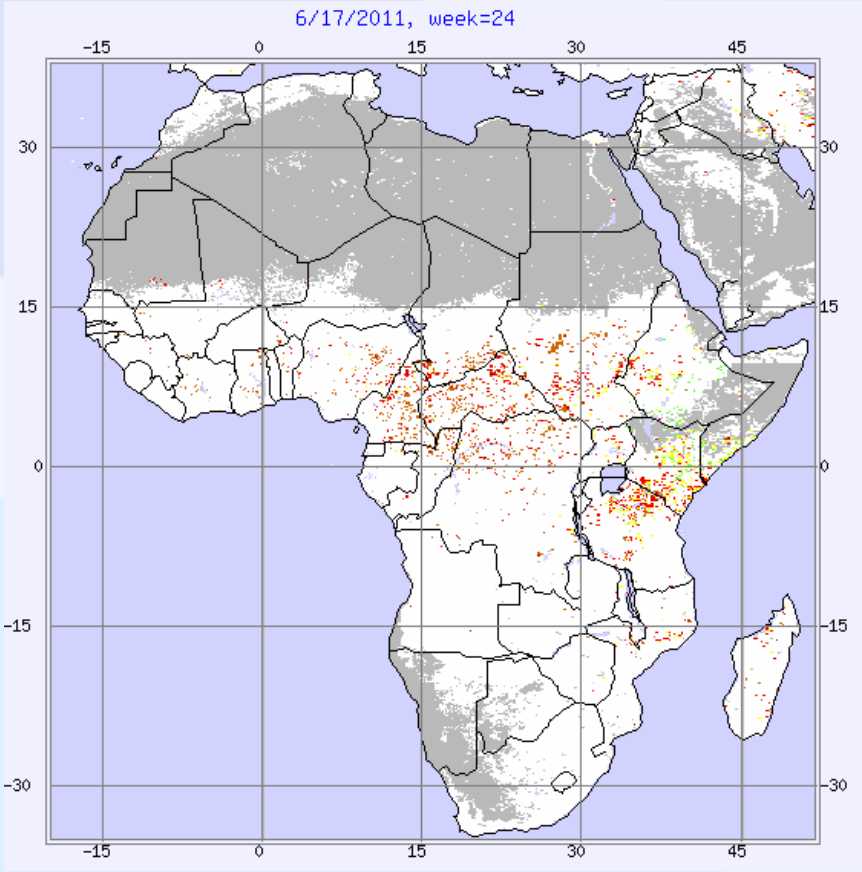


2011 East African Drought

Drought 17 June 2011



Drought Change in past 8 Weeks (Extreme to Exceptional)



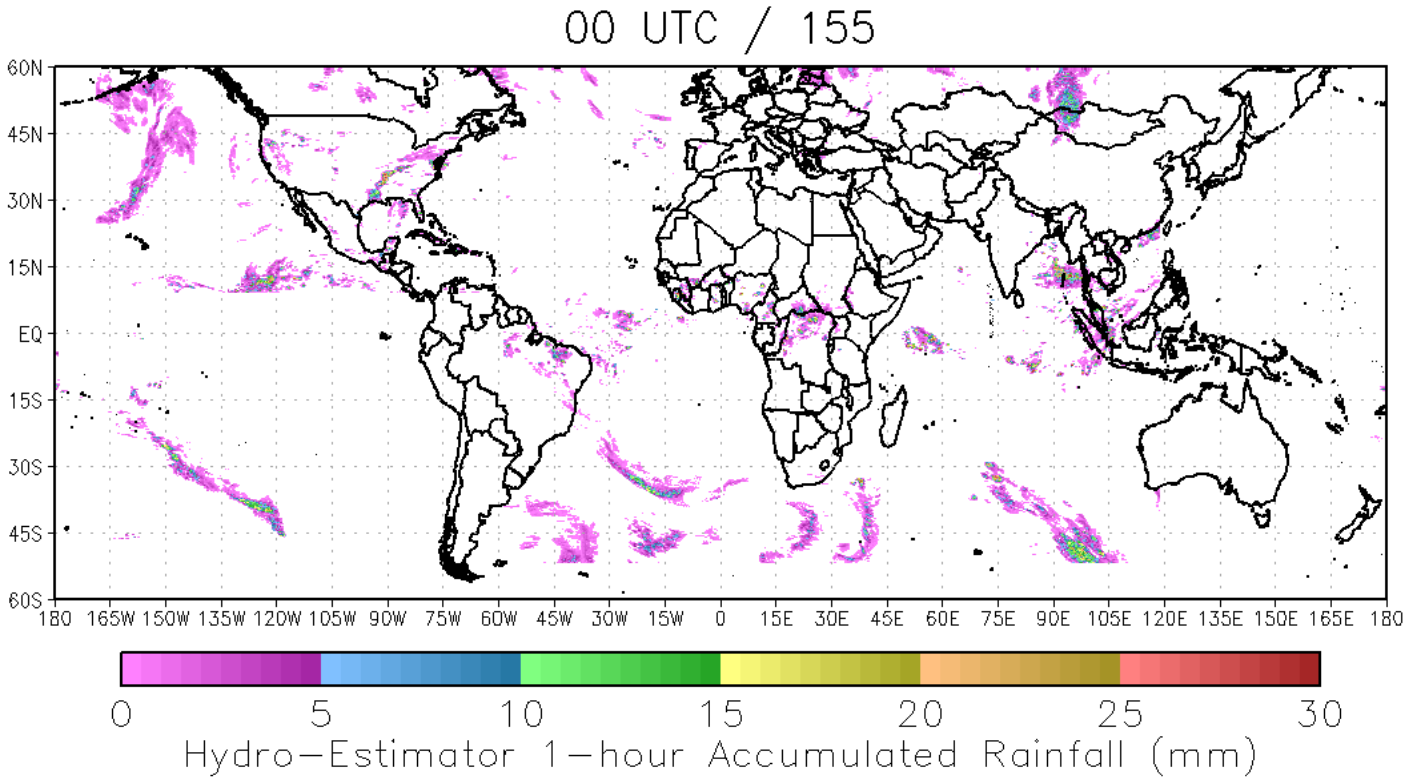
Satellite Products for Short-Term Applications

- **GOES – Visible and IR based, Rapid Update**
- **Many hydrologic applications are not very time sensitive; e.g., climate, water resources**
  - Data can be delayed by days or weeks without significant problems
- **However, some are highly time sensitive; e.g., flash flood forecasting**
  - Data may be needed within minutes for making decisions
  - Information has no value if it comes too late to make these decisions (e.g., evacuations)

Hydro-Estimator Rainfall

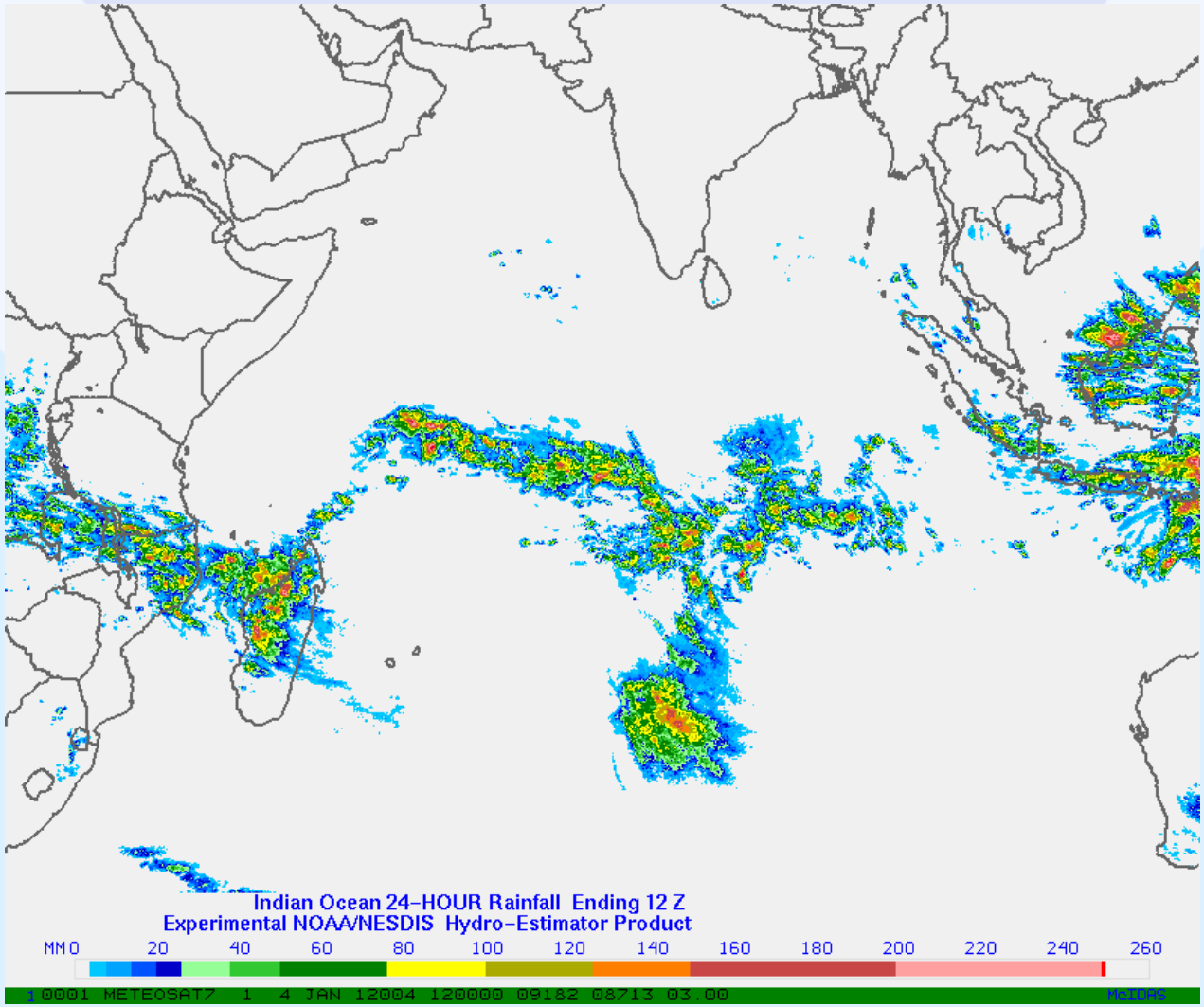
- **Based on IR data with some adjustments based on numerical weather model data**
- **Produced in real-time at NOAA for the entire globe covering 60°S to 60°N at ~4-km spatial resolution.**
  - Currently produced hourly with a latency of a few hours, but will soon be produced every 15 min (or full satellite time resolution) with 20 min latency
- **Information, real-time images, and data at http://www.star.nesdis.noaa.gov/smcd/emb/ff/HydroEst.php**

Hydro-Estimator Example



Hourly rainfall estimates for 0000-2300 UTC 4 June 2009

HE Example: East Africa / Indian Ocean



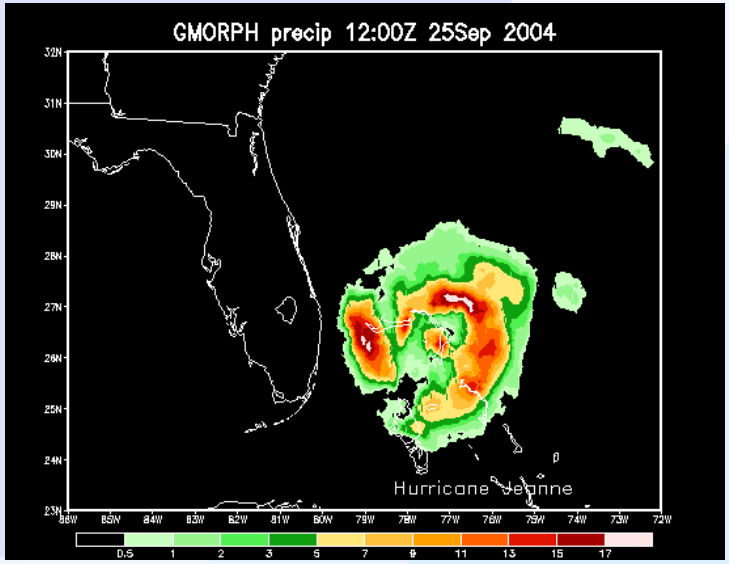
http://www.star.nesdis.noaa.gov/smcd/emb/ff/HE_World_Indian24Hr.php

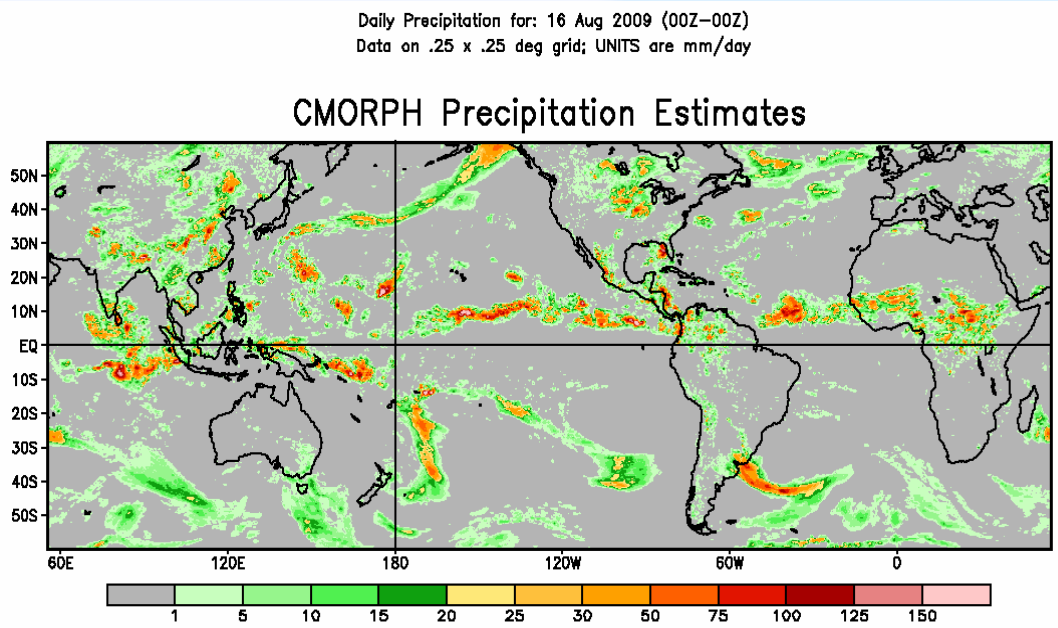
Other Rainfall Products

- POES – Passive Microwave, 3 satellite, 4 hour global coverage
- Fundamental Climate Data Records

CMORPH 3-hr Rainfall

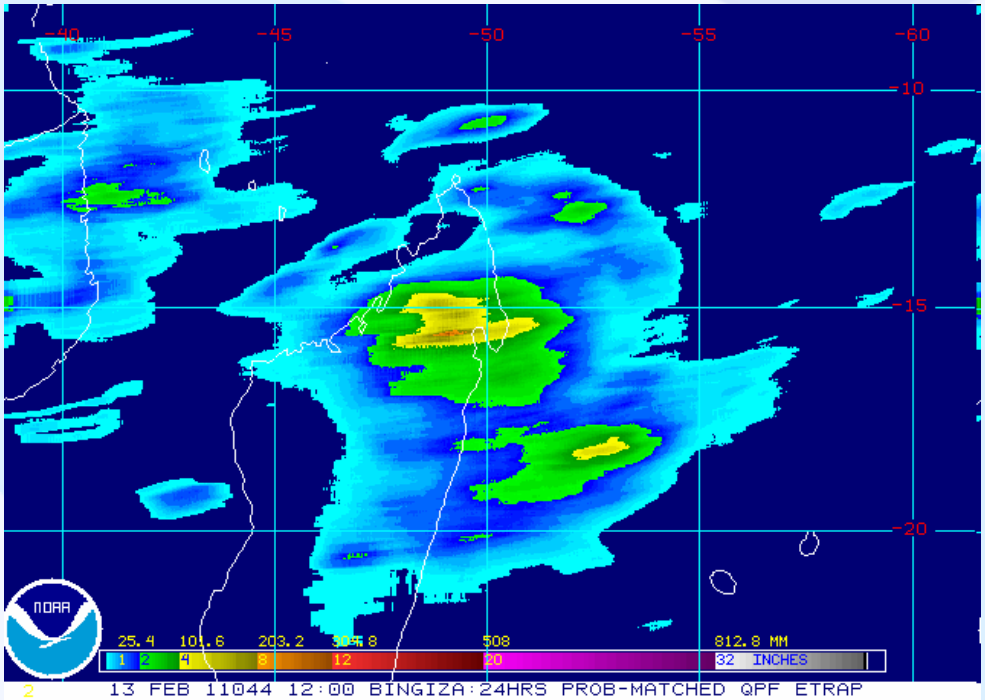
- **NOAA/CPC Cloud Morphing Product**
- **CMORPH utilizes the higher quality MW derived rain rates and combines them with the more frequent IR satellite cloud fields**
  - Global, 3-hourly rainfall
  - Validation suggests CMORPH is superior to individual satellite estimates
  - CMORPH integrated with gauges and NWP rainfall forecasts being tested





Tropical Rainfall Potential (TRaP)

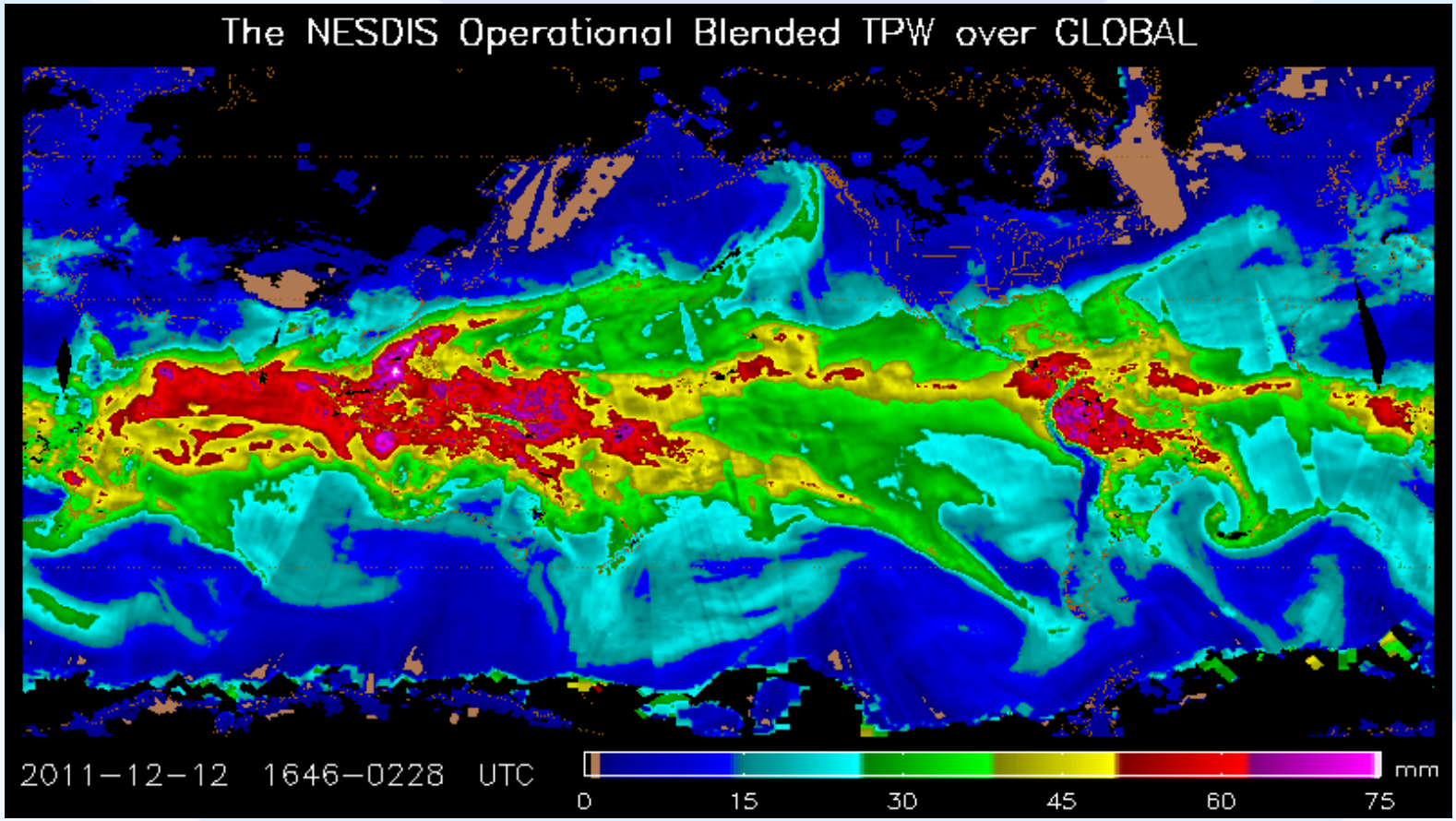
- **Provides 6 – 24 hr rainfall accumulations for tropical cyclones worldwide**
  - Uses satellite rainfall "snapshots" + storm track forecast to accumulate rainfall through "ensemble"
    - Weights accuracy of individual inputs and their latency
- **Useful for location, rainfall amounts/probabilities**



Typhoon Bingiza
13 Februay 2011

Blended TPW Product

- **TPW=Total Precipitable Water**
  - Amount of water in vapor stage (and which can be converted into rain)
- **Most sustained flooding events can be linked to "atmospheric rivers" of TPW that focus on a given location for an extended period of time**
  - Product is useful to weather forecasters



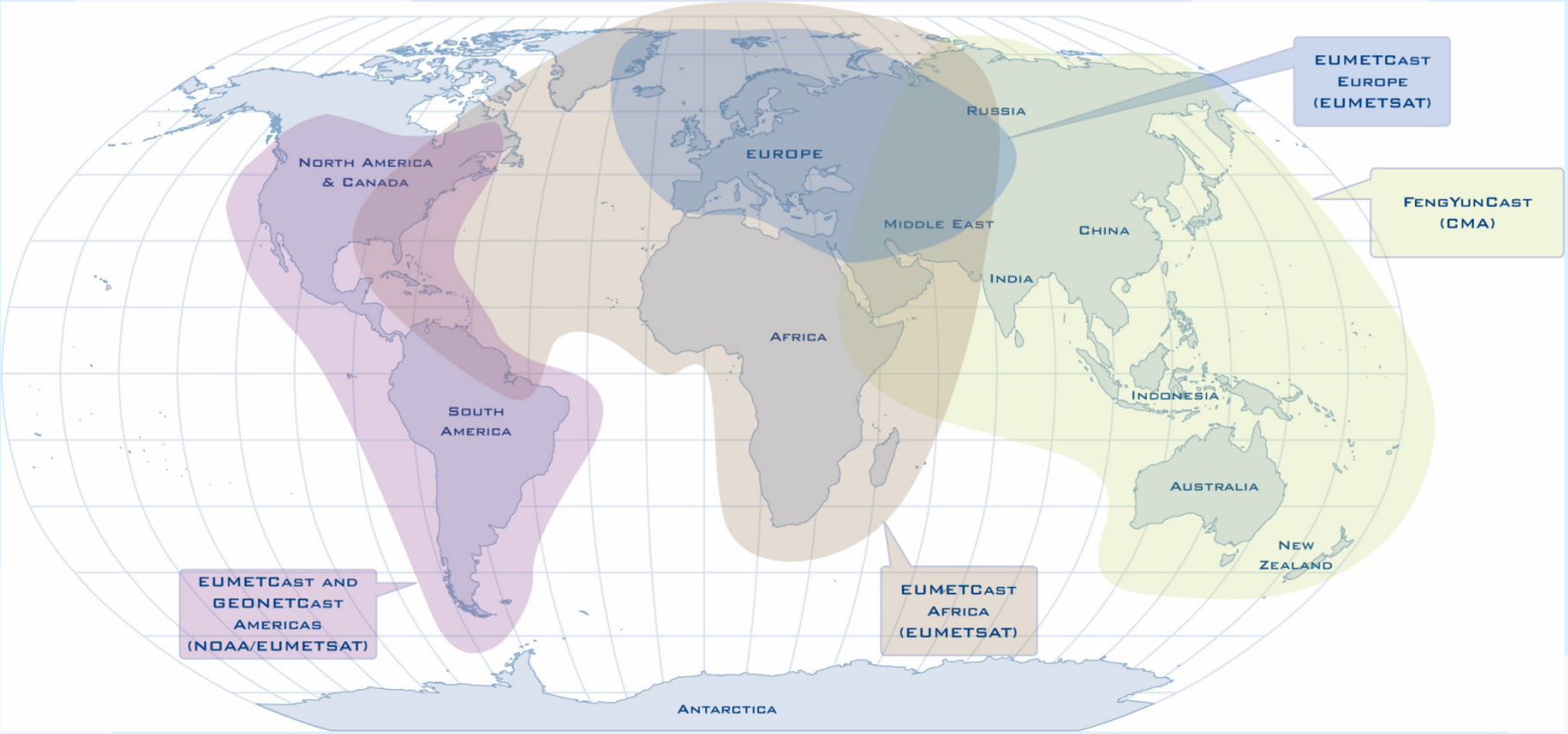
Dissemination Systems

- **Direct Readout**
- **NOAA's Comprehensive Large Array-data Stewardship System (CLASS)**
  http://www.nsof.class.noaa.gov/saa/products/welcome
- **GEOSS Common Infrastructure**
- **GEONETCast**

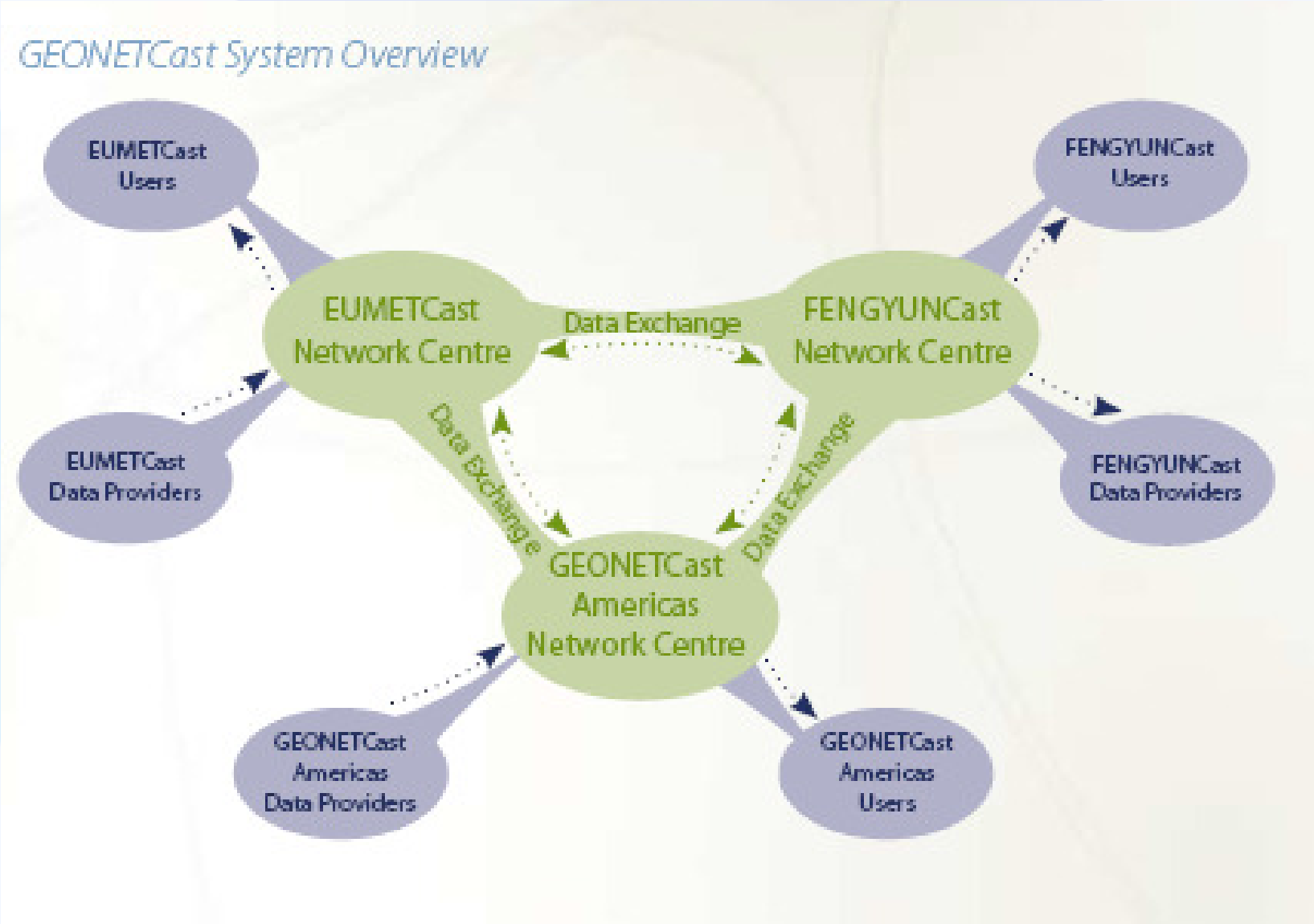
GEONETCast

- **Distribution system using communication satellites and low cost, self-contained, stand alone, off-the-shelf reception stations.**
- **Provides near-global coverage with established data exchange between regional broadcasts.**
  - CMA (FENGYUNCast, over Asia and parts of the Pacific)
  - EUMETSAT (EUMETCast, over Europe, Africa, and Americas)
  - NOAA (GEONETCast Americas, over the Americas and Caribbean)
  - Roshydromet (Mitra, Europe and Asia)
- **Access to products from all regional systems.**
- **No internet connection required by users**

GEONETCast - Global Coverage



GEONETCast Architecture



CEOS Working Group on Capacity Building and Data Democracy

- **Evolution of the former WGEdu whose mission was to facilitate activities that substantially enhance international education, training, and capacity building in the use of Earth observations to meet societal needs**
- **WGEdu Projects**
  - Eduflow
  - Remote Sensing Workshops
- **Merging of WGEdu with Data Democracy Initiative**

Data Democracy Initiative

- **Started when China and Brazil initiated their CBERS for Africa Initiative in 2007**
- **During its 2008 CEOS Chairmanship, the South African Council for Scientific and Industrial Research (CSIR) began a special initiative entitled "Data Democracy for Developing Countries"**
- **This Initiative was continued and further developed by the subsequent CEOS Chairs, Thailand's GEO-Informatics and Space Technology Development Agency (GISTDA) in 2009 and Brazil's National Institute for Space Research (INPE) in 2010**
- **CEOS Rio Statement October 2010**
  - "Provision of timely access to key data sets free of charge to build capacity worldwide,…enhanced data dissemination capabilities, sharing of software tools, increased training, and technology transfer to end users."

WGCBDD Objective and Initiatives

- **Objective**
  - Building capacity for the effective use of Earth observation data as well as providing wider and easier access to those data
- **Initiatives**
  - Coordination with Regional Partners
  - Multiagency value added projects
    - INPE sponsored E-Learning course
  - Looking to end users to help develop new initiatives
- **First WGCBDD Meeting: 29 February – 2 March, 2012, Ilhabela, Brazil**

CEOS
Committee on Earth Observation Satellites

Contacts

- **Soil Moisture Products: Jerry Zhan –** *Xiwu.Zhan@noaa.gov*
- **Vegetation Products: Felix Kogan –** *Felix.Kogan@noaa.gov*
- **Short-Term Products: Bob Kuligowski –** *Bob.Kuligowski@noaa.gov*
- **Rainfall Products: Ralph Ferraro –** *Ralph.Ferraro@noaa.gov*
- **NOAA Satellite and Information Service International Affairs: Jacob Sutherlun –** *Jacob.Sutherlun@noaa.gov*

Thank You!

Backup Slides

Committee on Earth Observations Satellites (CEOS)

- **Established in 1984 under auspices of G-7 Economic Summit of Industrialized Nations**
  - Focal point for international coordination of space-related Earth Observation (EO) activities
  - Optimize benefits through cooperation of members in mission planning and in development of compatible data products, formats, services, applications, and policies
- **Operates through best efforts of Members and Associates via voluntary contributions**
- **29 Members (Space Agencies), 21 Associates (UN Agencies, Phase A programs or supporting ground facility programs)**
- **As the space component of the Global Earth Observation System of Systems (GEOSS), CEOS is implementing high priority actions in support of Group on Earth Observation (GEO) Tasks**

CEOS Structure 2011

Troika

Past Chair	Chair	Future Chair
INPE/Brazil	ASI/Italy	ISRO/India

Systems Engineering Office (SEO)

NASA

Strategic Implementation Team (SIT)

Chair: JAXA Vice Chair: NASA

Permanent Secretariat

Chair Agency
ESA, EUMETSAT,
JAXA, NASA, NOAA

CEOS Executive Officer (CEO)

USGS (CEO) &
NOAA (DCEO)

Working Groups (WG)

WG on Calibration and Validation
- USGS/CSA

WG on Capacity Building and Data Democracy (TBC)
- INPE/NOAA

WG on Information Systems and Services
-GISTDA/JAXA

WG on Climate
- EC-JRC/NOAA

CEOS Societal Benefit Area Coordinators

- Agriculture
- Biodiversity
- Climate
- Disasters
- Ecosystems
- Energy
- Health
- Water
- Weather
- Transverse

Virtual Constellations for GEO

Atmospheric Composition
- NASA
- ESA

Precipitation
- JAXA
- NASA

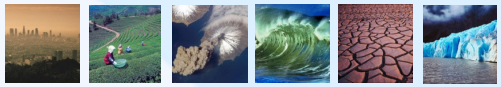
Land Imaging
- USGS
- ISRO
- INPE

Ocean Surface Topography
- NASA
- EUMETSAT

Ocean Color Radiometry
- ESA
- ISRO
- NASA

Ocean Surface Vector Wind
- NOAA
- EUMETSAT
- ISRO

CEOS
Committee on Earth Observation Satellites



CEOS Members and Associates

MEMBERS

Agenzia Spaziale Italiana (ASI)
Canadian Space Agency (CSA)
Centre National d'Etudes Spatiales (CNES), France
Centro para Desarrollo Tecnólogico Industrial (CDTI), Spain
China Center for Resources Satellite Data and Applications (CRESDA)
Chinese Academy of Space Technology (CAST)
Comisión Nacional de Actividades Espaciales (CONAE), Argentina
Commonwealth Scientific & Industrial Research Organisation (CSIRO), Australia
Deutsches Zentrum fürLuft-und Raumfahrt (DLR), Germany
European Commission (EC)
European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT)
European Space Agency (ESA)
Geo-Informatics and Space Technology Development Agency (GISTDA), Thailand
Indian Space Research Organisation (ISRO)
Instituto Nacional de Pesquisas Espaciais (INPE), Brazil
Japan Aerospace Exploration Agency/Ministry of Education, Culture, Sports, Science, and Technology (JAXA/MEXT)
Korea Aerospace Research Institute (KARI)
National Aeronautics and Space Administration (NASA), USA
National Oceanic and Atmospheric Administration (NOAA), USA
National Remote Sensing Center of China (NRSCC)
National Satellite Meteorological Center/Chinese Meteorological Administration (NSMC/CMA)
National Space Agency of Ukraine (NSAU)
National Space Research Agency of Nigeria (NASRDA)
Russian Federal Space Agency (ROSKOSMOS)
Russian Federal Service for Hydrometeorology and Environmental Monitoring (ROSHYDROMET)
South African National Space Agency (SANSA)
Scientific and Technological Research Council of Turkey (TÜBITAK)
United Kingdom Space Agency (UKSA)
United States Geological Survey (USGS)

ASSOCIATES

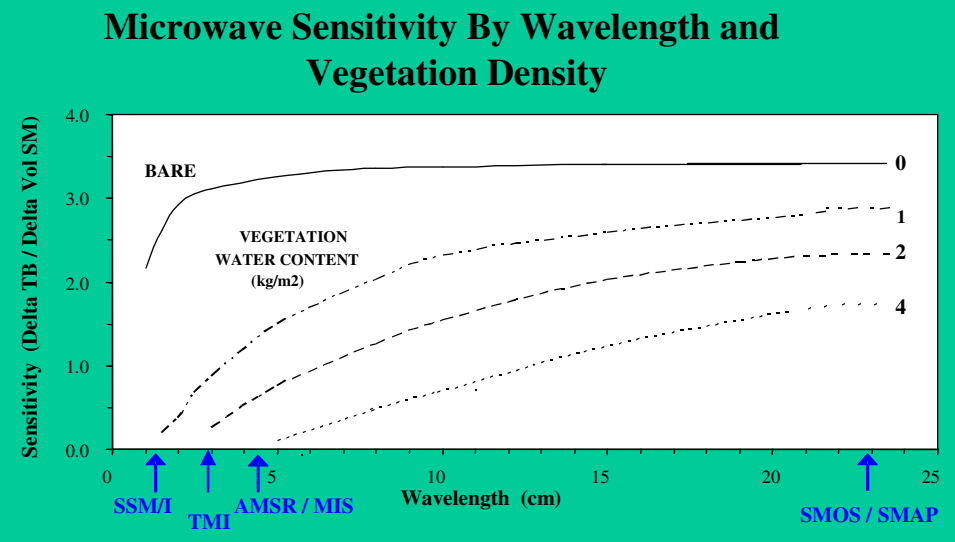
Belgian Federal Science Policy Office (BELSPO)
Canada Centre for Remote Sensing (CCRS)
Council for Scientific and Industrial Research (CSIR)
Crown Research Institute (CRI), New Zealand
Global Climate Observing System (GCOS)
Global Ocean Observing System (GOOS)
Global Terrestrial Observing System (GTOS)
Intergovernmental Oceanographic Commission (IOC)
International Council for Science (ICSU)
International Geosphere-Biosphere Programme (IGBP)
International Ocean Colour Coordinating Group (IOCCG)
International Society of Photogrammetry and Remote Sensing (ISPRS
Norwegian Space Center (NSC)
Swedish National Space Board (SNSB)
United Nations Economic and Social Commission for Asia and the Pa (ESCAP)
United Nations Educational, Scientific and Cultural Organization (UNE
United Nations Environment Programme (UNEP)
United Nations Food and Agriculture Organization (FAO)
United Nations Office for Outer Space Affairs (UNOOSA)
World Climate Research Programme (WCRP)
World Meteorological Organization (WMO)

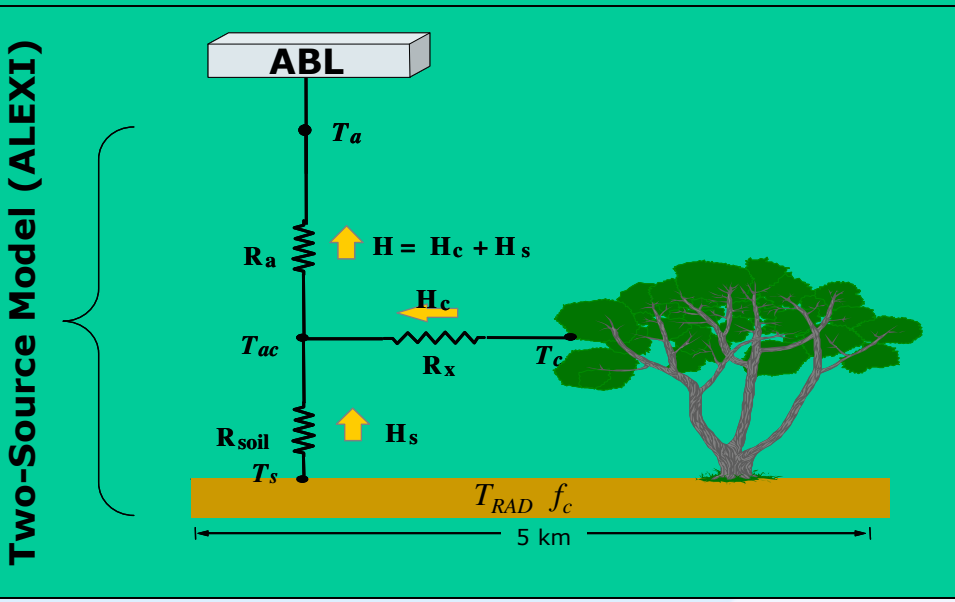
CEOS
Committee on Earth Observation Satellites

Soil Moisture Remote Sensing Science

Two ways to retrieve soil moisture from satellites:

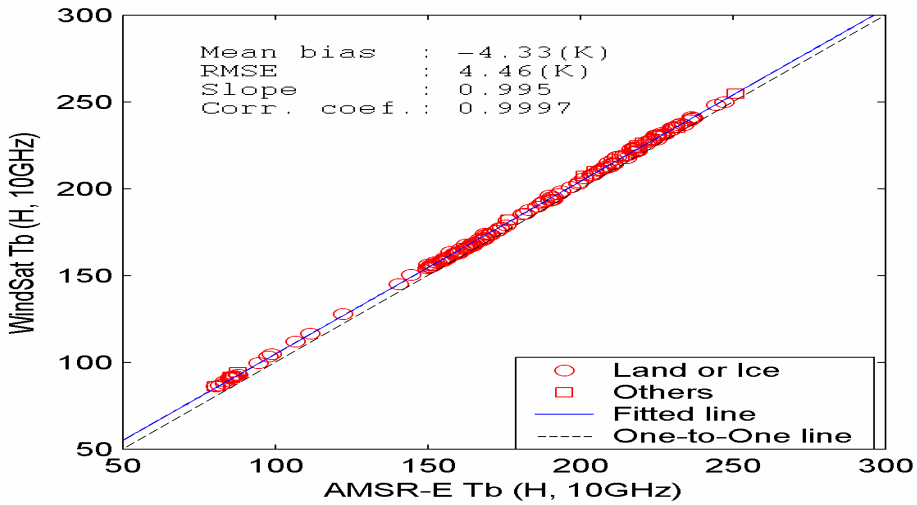
- Microwave (MW): **Observed MW brightness temperature depends on soil dielectric constant that is related to soil moisture:**
  - **Strength:** higher reliability based on direct physical relationships
  - **Weakness:** antenna technology limits spatial resolution
- Thermal Infrared (TIR): **Observed surface temperature changes result from surface energy balance that is dependent on soil moisture:**
  - **Strength:** TIR sensor could have higher spatial resolution
  - **Weakness:** relies on land surface energy balance model that is prone to input data errors.

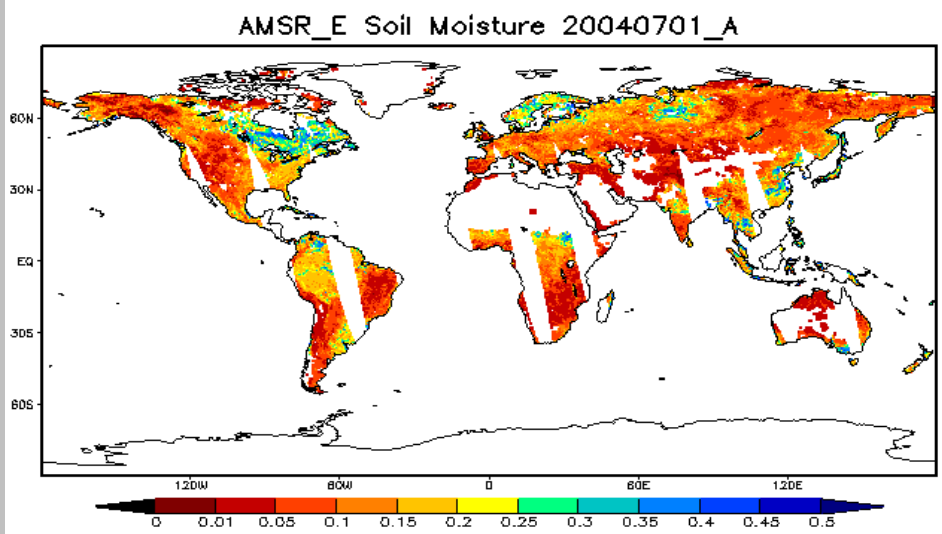




Soil Moisture Research at STAR

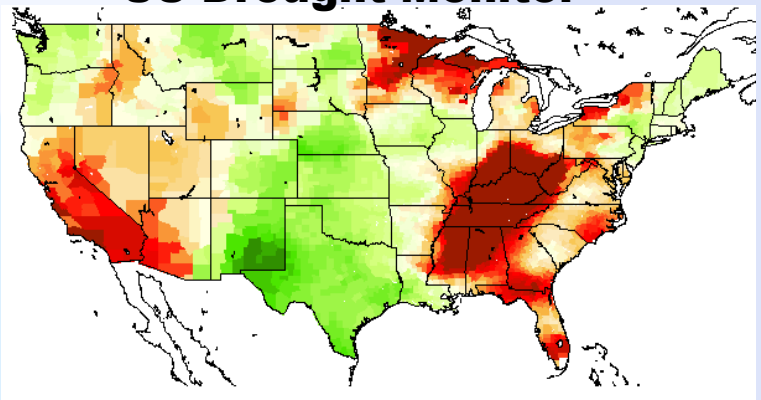
- Observations from microwave satellite sensors are found to have significant calibration differences with the Simultaneous Conical-scan Overpass (SCO) method
- Single-Channel Retrieval (SCR) algorithm is less sensitive to calibration difference while the Multi-Channel Inversion (MCI) algorithm may fail for large calibration errors
- The single-Channel Retrieval algorithm is used in NESDIS Soil Moisture Operational Product System (SMOPS)
- More robust algorithm is being tested for the soil moisture EDR from the AMSR2 of GCOM-W



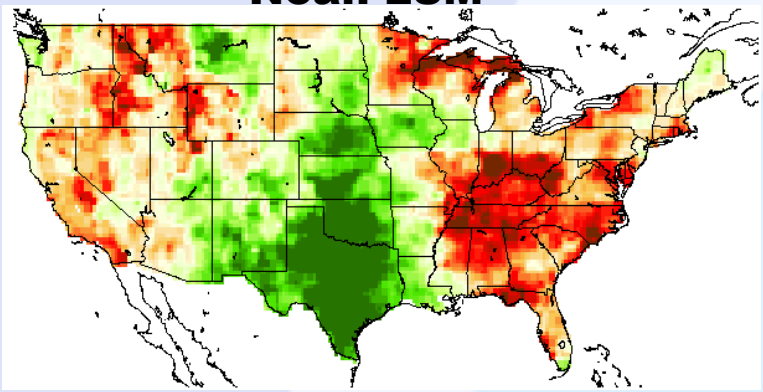


2007 Seasonal Total Profile Soil Moisture Anomalies

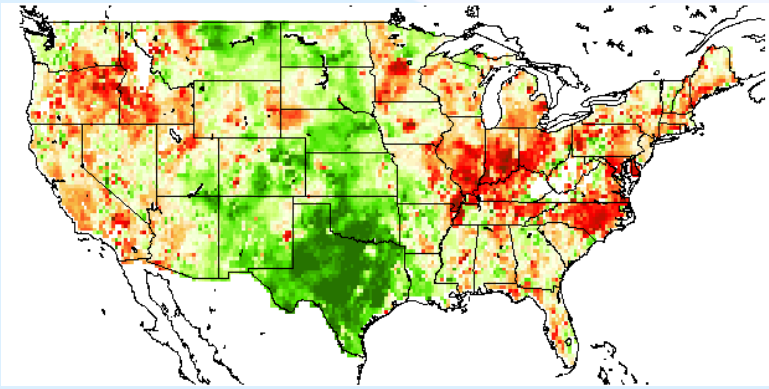
US Drought Monitor



Noah LSM

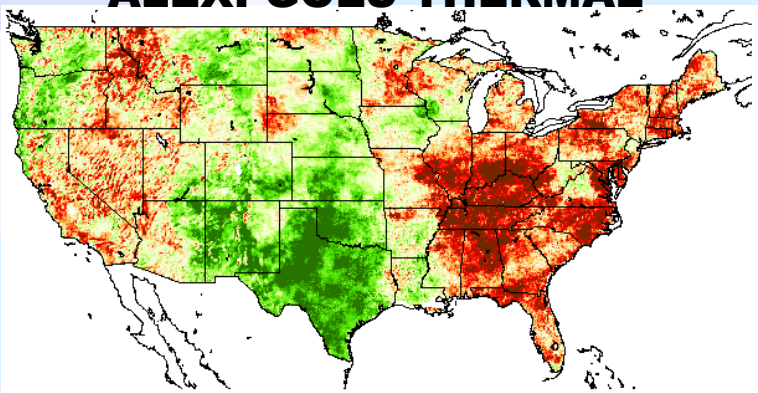


USDA AMSR-E MICROWAVE



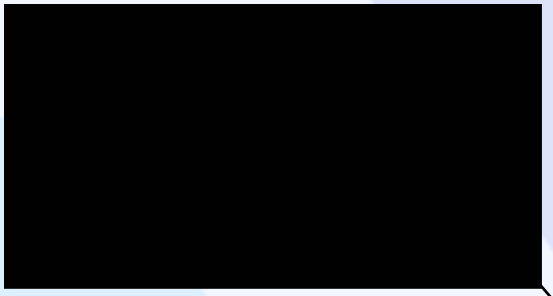
- samples 5cm layer
- 50km pixels (AMSR)
- ~2-day coverage
- light vegetation cover

ALEXI GOES THERMAL

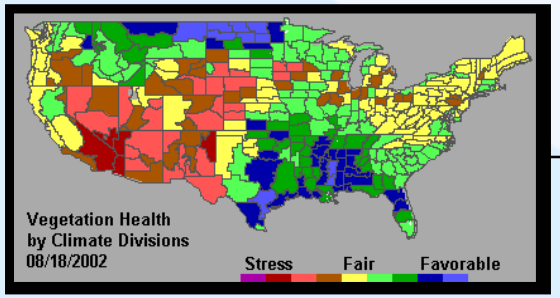


- samples ~1-2m layer
- 60m - 5km pixels (L7, GOES)
- ~15-day coverage (90%)
- low to high vegetation cover

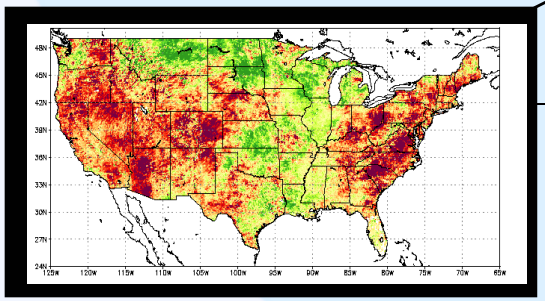
Comprehensive Drought Monitoring Concept



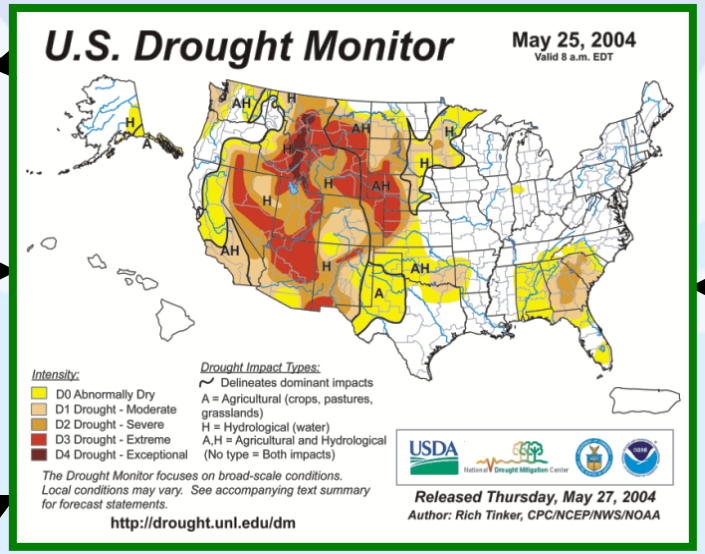
Palmer Drought Index

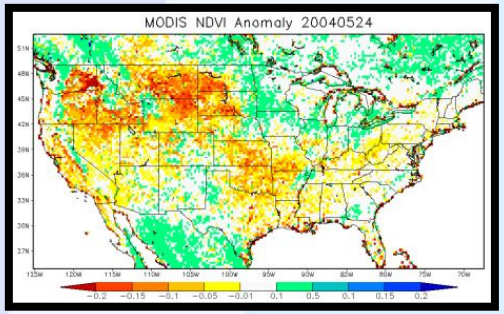


Vegetation Health Index

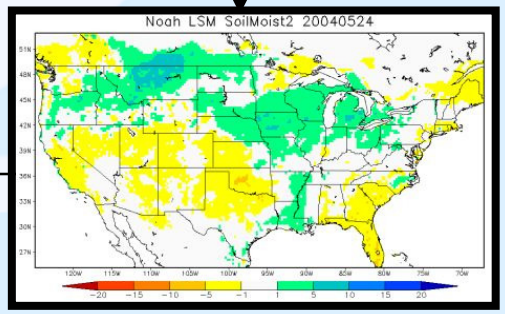


Evaporative Stress Index

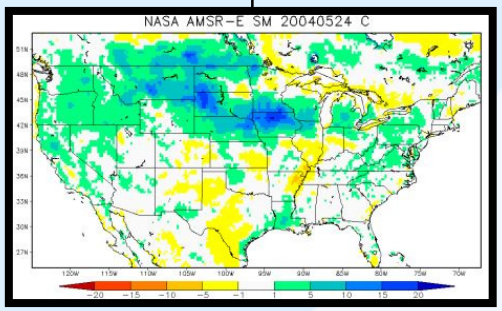




Optical VI Remote Sens.



LSM SM Output



MW SM Remote Sens.