GEOSS

Architecture Implementation Pilot, Phase 3 - Call for Participation - and GEO Water Tasks

Will Pozzi and George Percivall

Open Geospatial Consortium, GEO Task AR-09-01b Task POC, and GEO Task WA-06-02b, Impacts of Drought, NASA WaterNet Project Manager

Presentation before the 2010 GEO Drought Response Initiative, Winnipeg, CA, 10 May 2010

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GEO Task WA-06-02b
Impacts of Drought

- Track and analyze impacts from drought (including feedbacks such as soil drying) to provide a tangible and practical demonstration of the value of integrated water cycle observations. Develop a full and operational data cycle of environmental information from “producer-to-consumer”/“source to sink,” and explore the application of data products to Water and Agriculture.

  - http://www.grouponearthobservations.org/geoweb/geoss_wa_wpa.shtml

Two GEO Committees Have Overlapping Pilot Projects

- *First,* Call for Proposals by the GEO User Interface Committee
  - includes proposals for water (including agriculture and water)
- Second, Call for Participation by the GEO Architecture and Data Committee Architecture Implementation Pilot
  - includes pilot projects being set up within the AIP Water Working Group for agricultural drought and water quality
- Development by the Water Cycle Community of Practice (former Integrated Global Water Cycle Observations IGWCO)

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What is the real significance of having two sets of projects, within the GEO Architecture and Data Committee (ADC) and the User Interface Committee (UIC)?

GEO Task AR-09-01b
Architecture Implementation Pilot

- There has to be a way of making the results of science (and Earth Observations) available and useful to end users, such as farmers.

- Providing useful *knowledge* can be accomplished by automating the process of acquiring, processing, and presenting information to users
  - remove the drudgery, work required, and background expertise required to wade through page-after-page of forms on web sites, requiring familiarity with the details of how data are organized within each data collection

The science aspects of a societal problem area and the IT aspects are mirror images, or opposite sides, of the same problem

You need to develop the science to produce results really useful to end users (i.e., farmers)(as being carried out in the UIC projects)

You need to have an effective informatics system to make useful, critical information available to decision makers (including small individual farmers who have to decide when to schedule irrigation and how much irrigation water to apply)

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GEOSS
Web-based Services:

The Old Way:

Pre-Science

- Find data
- Retrieve high volume data
- Learn formats and develop readers
- Extract parameters
- Perform spatial and other subsetting
- Identify quality and other flags and constraints
- Perform filtering/masking
- Develop analysis and visualization
- Accept/discard/get more data (sat, model, ground-based)

DO SCIENCE

- Exploration
- Initial Analysis
- Use the best data for the final analysis
- Derive conclusions
- Write the paper
- Submit the paper

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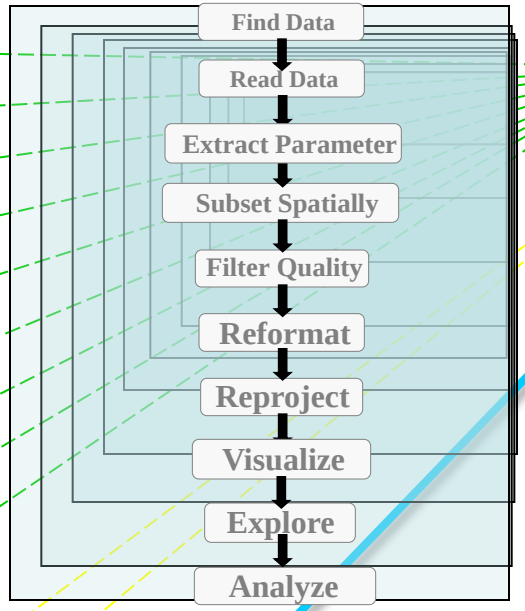

The Services Way:

Minutes

Days for exploration

Use the best data for the final analysis
Derive conclusions
Write the paper
Submit the paper

DO SCIENCE

Services "Link-Rich" Environment Provides: *discovery, access, manipulation, visualization, and analysis*.

Scientists have ***more time to do science.***

Decision makers rapid access to information

Graphic courtesy of Greg Leptoukh, NASA

GEO Task AR-09-01b
Architecture Implementation Pilot

- The work task of the Water Societal Benefit Area for drought and drought impact has been cited, GEO Task WA-06-02b

- Task AR 09-01b, in turn, is “development and testing of contributed components in a pilot setting, the leveraging of the GEOSS Common Infrastructure, portals, and clearinghouses, through interoperability arrangements and serving the SBAs (i.e., the water and agriculture tasks).”
  - http://www.earthobservations.org/documents/tasksheets/latest/AR-09-01b.pdf

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The AIP-3 Water Drought Scenario

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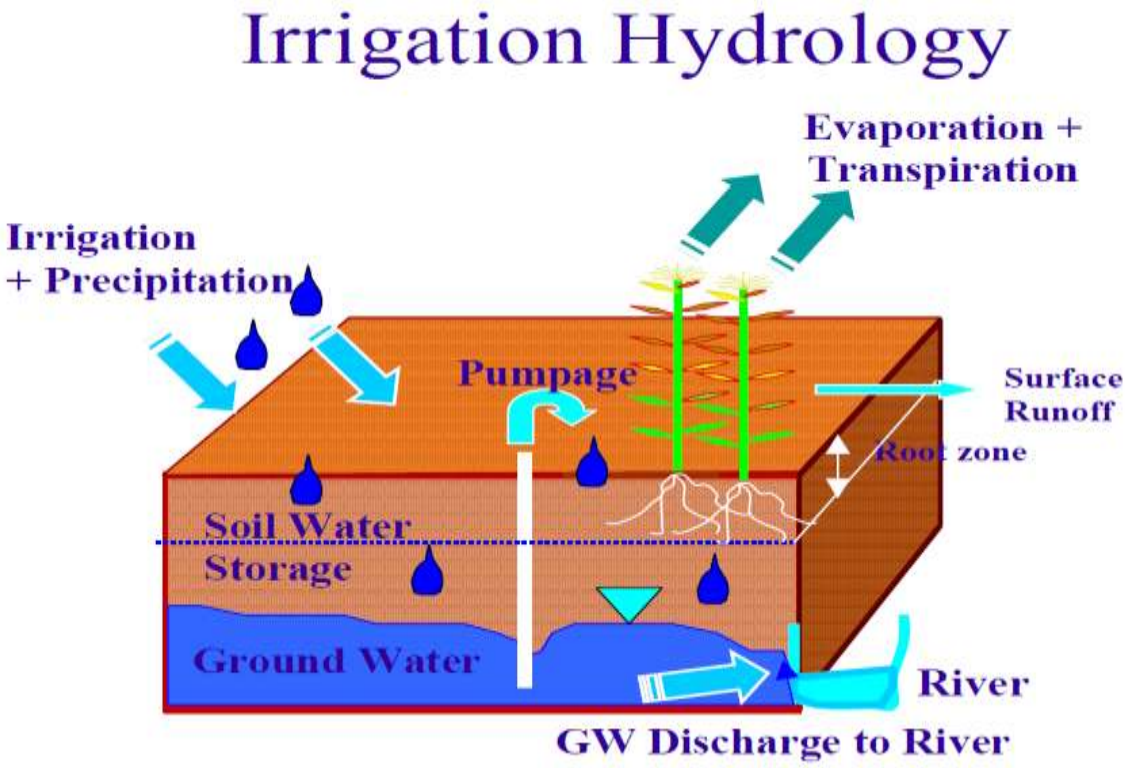
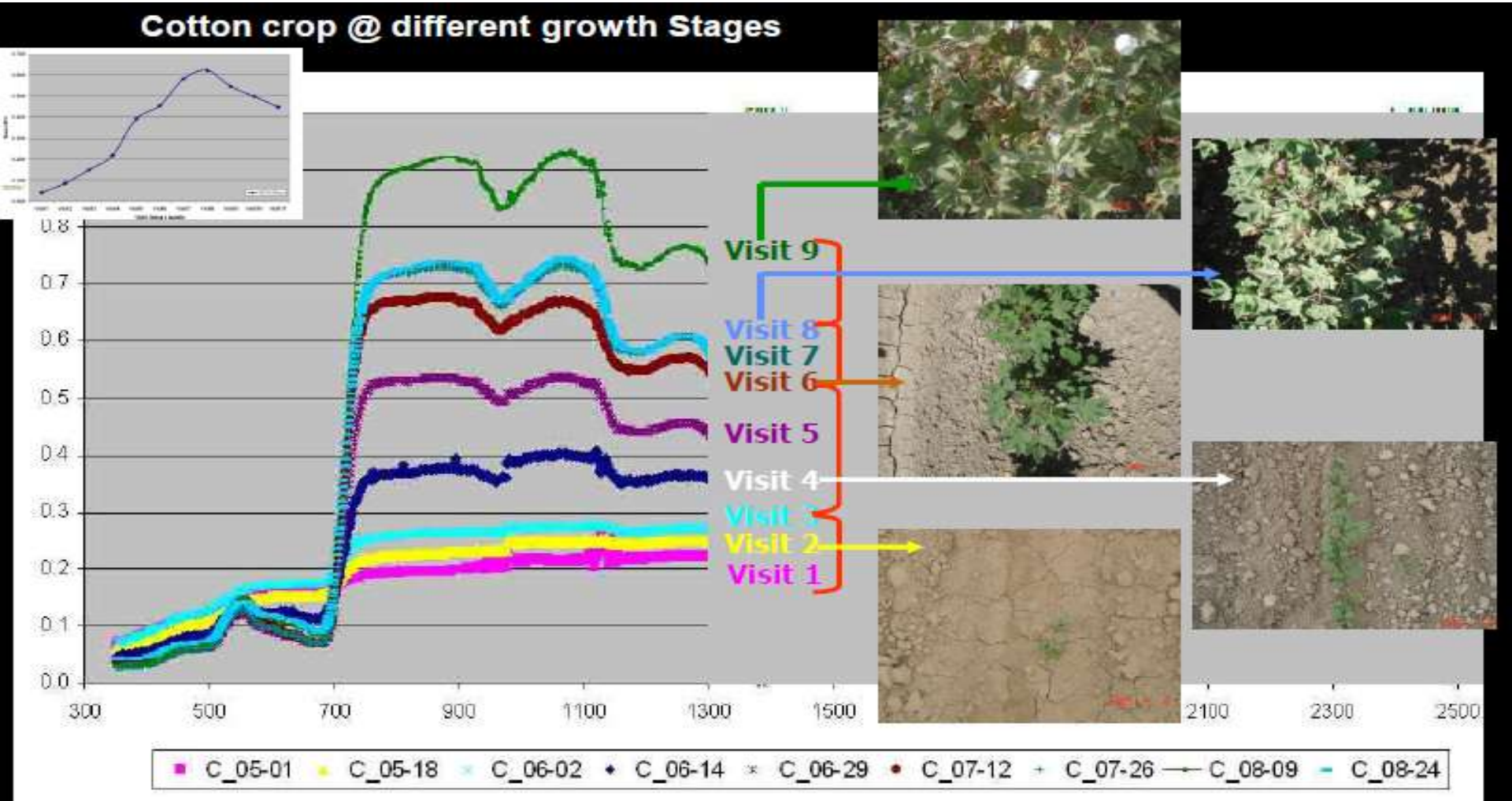
The real question that the Agriculture and Water Societal Benefit Areas need to answer: Is there enough water available to sustain growth of agriculture to feed the increasing global population?



Agro-Hydrology and Irrigation Efficiency (Allen, Clemmens, and Willardson 2005)

Different Crops have differing Water Requirements as they grow



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Soil Moisture Drought Monitoring—*the Meaning behind the Technology*

- *Soil Moisture* Drought Monitoring

  -- A model estimates soil moisture for a locality, in which Soil Moisture *anomalies* can be expressed as *deviations away from soil moisture climatology* (over a 50 year or 100 year record.

- *Agricultural* Drought Monitoring
  - Soil moisture *deficit relative to crop* or plant *water demand*

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Soil Moisture Drought Monitoring—*the Technology*

Model-Based Drought Monitoring: (E. Wood, 2006)

1) Retrospective Simulation

After: E. Wood, 2006 Princeton University

Forcings → **VIC LSM** → **Retrospective Soil Moisture**

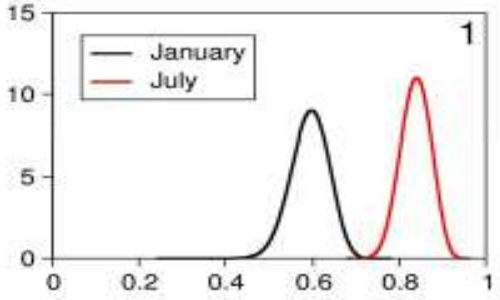
2) Calculate Soil Moisture Index

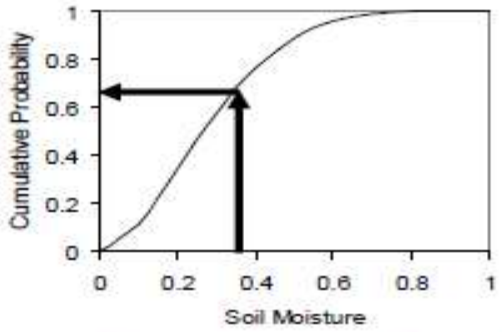
L-Moments → **Fit beta distribution** → **Calculate Index**

$$L_{mean}(\mu_s) = \lambda_1$$

$$L_{CV}(\sigma_s / \mu_s) = \frac{\lambda_2}{\lambda_1}$$

$$L_{skew}(\gamma_s) = \frac{\lambda_3}{\lambda_2}$$

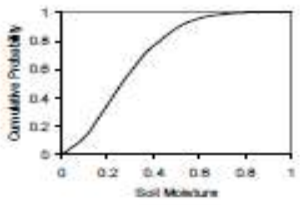


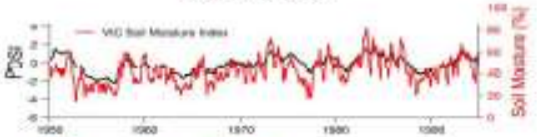


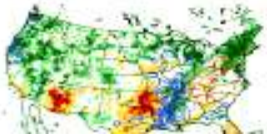
3) Drought Analysis

Historic soil moisture

Realtime soil moisture







B. Imam 2009 Water Resources for Developing Countries

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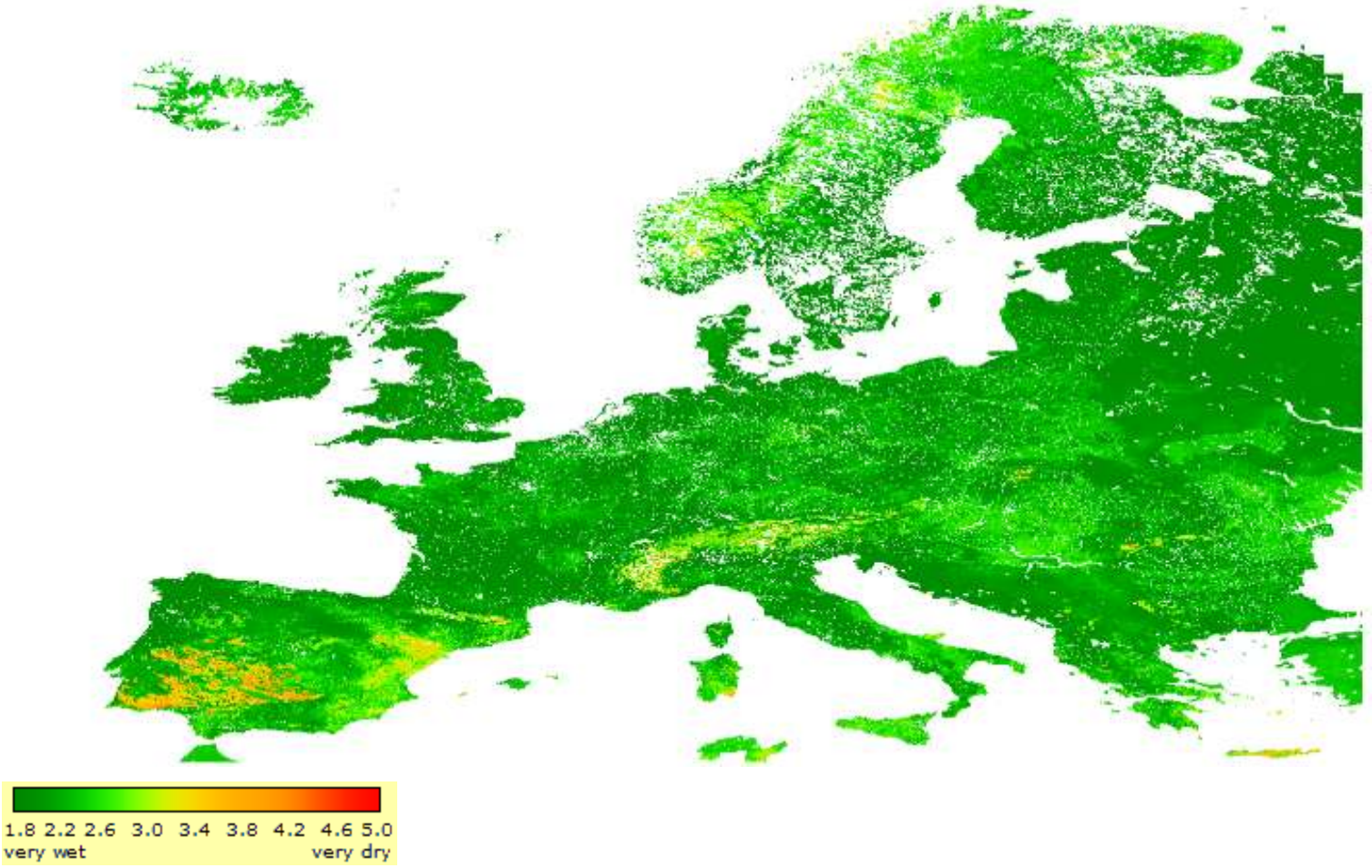
Soil Moisture Drought Monitoring—*the End Result*



Soil Moisture in the European Union Europe Drought Observatory (EDO)(http://edo.jrc.ec.europa.eu/php/index.php?action=view&id=19)

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Agricultural Drought—*Role of Vulnerability*

- Drought Risk = Intensity (Hazard)* Susceptibility (Social Factors)

  -- D. A. Wilhite and M. D. Svoboda Drought Early Warning Systems in the context of Drought Preparedness and Mitigation

- Social factors (Susceptibility):

  -- Helen Sida: Agency Approaches to Monitoring Food Security and Livelihoods

Agricultural Drought Vulnerability-- *Methodology*

- Most Agricultural Drought Vulnerability studies have examined soil texture, treated supplemental irrigation as a buffer to weather short term drought
- These studies also assign subjective weights for each of these factors, and then added each weight up from each factor to highlight drought vulnerable areas

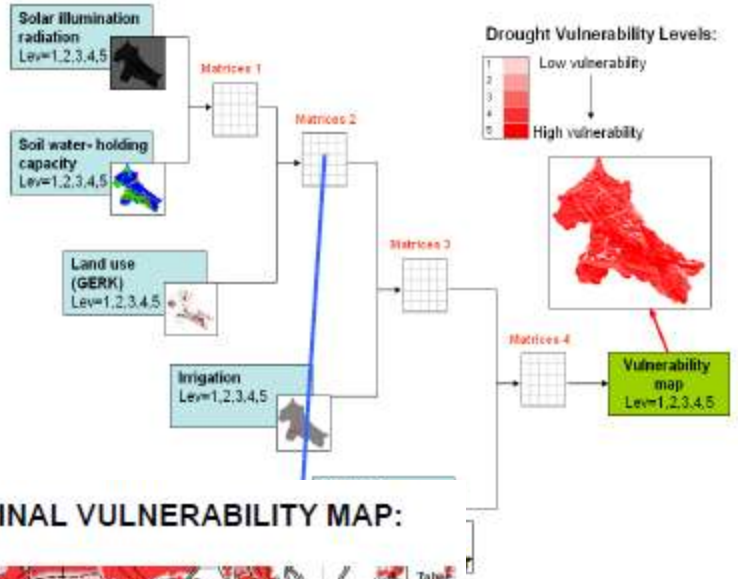
An Example--Agricultural Drought Vulnerability Slovenia-style

The technique combines an interaction matrix methodology with GIS map overlaying.

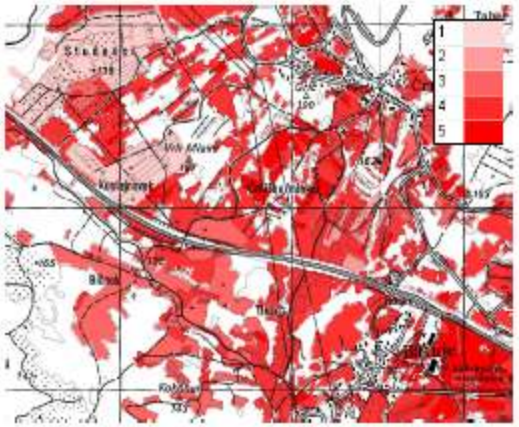
The environmental factors that were considered:

- Solar illumination radiation [MJm⁻²] — Biophysical factors
- Soil water-holding capacity [mm] — Biophysical factors
- Irrigation areas — Socio-economic factors
- Agricultural land use (GERK) — Socio-economic factors
- Reference evapotranspiration [mm] — Factors related to hazard – water balance for summer 2006

→ FINAL VULNERABILITY MAP



FINAL VULNERABILITY MAP:



Slejko, Gregoric, and Bergant 2009 Drought Vulnerability Assessment for Agriculture: a case study for west Slovenia

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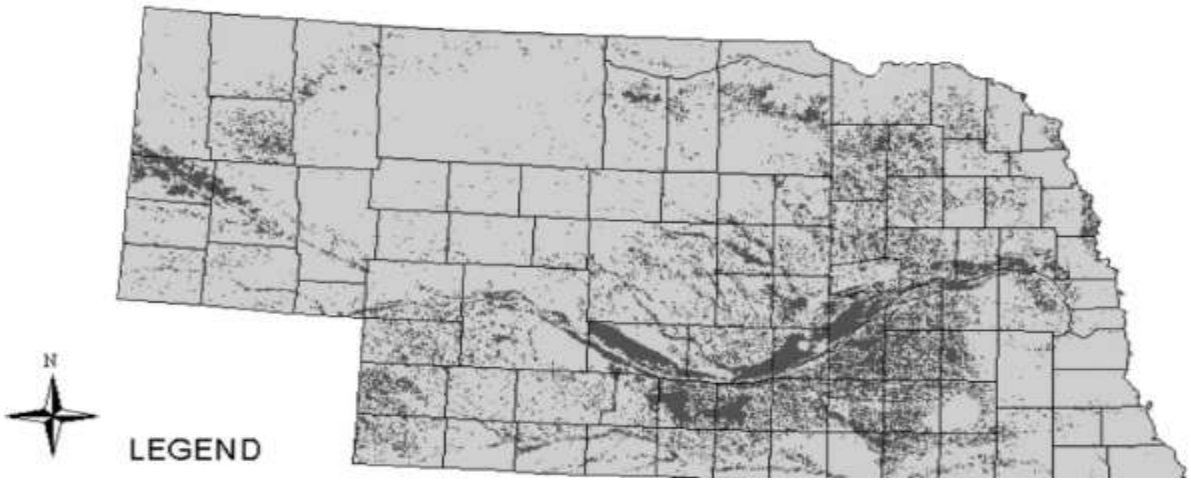
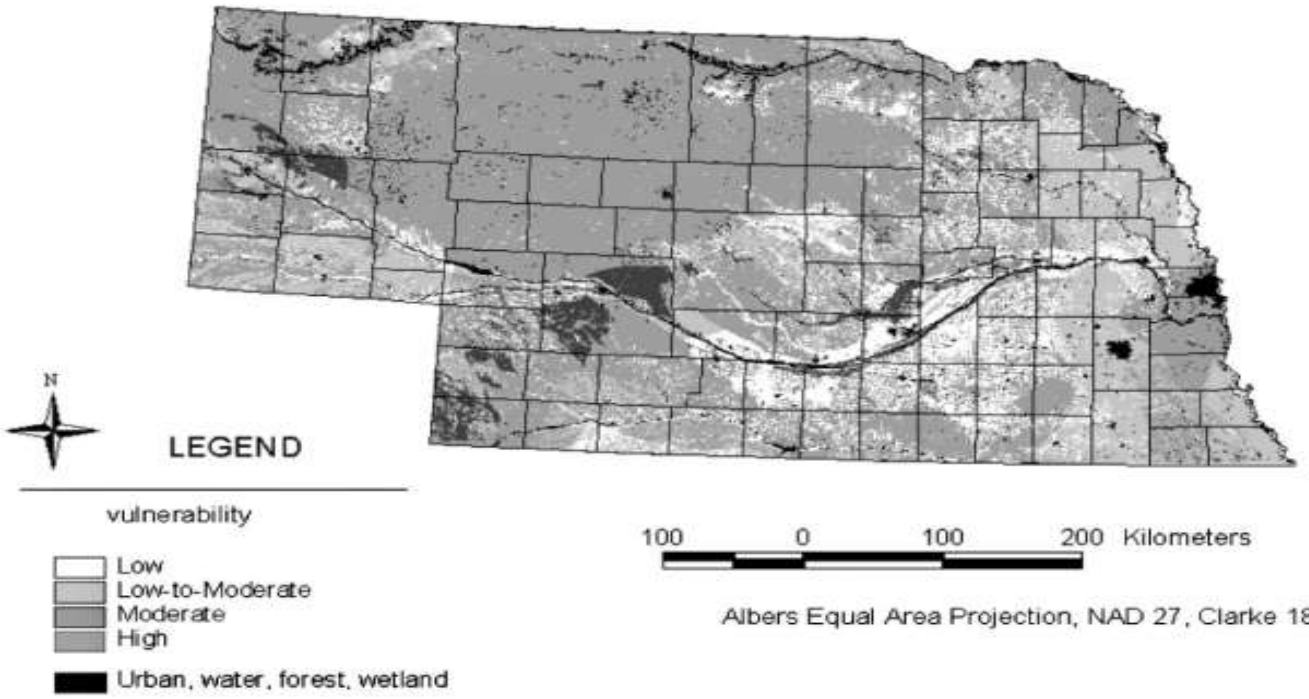
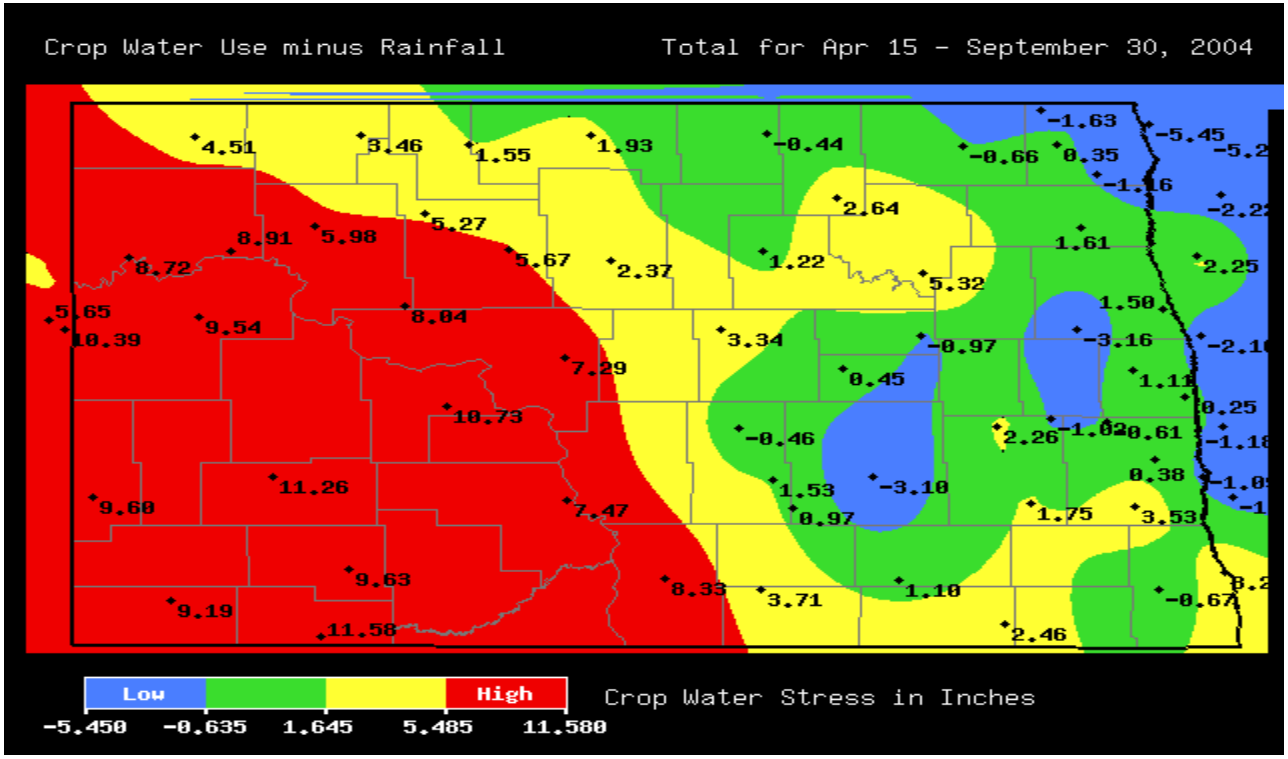


Another Example-- Agricultural Drought Vulnerability of Nebraska



Wilhelmi and Wilhite 2002

The End Result--Mapping of High-Resolution (1 km) Crop Water Deficit



An Example a coarse-scale Resolution Crop Water Deficit Map (North Dakota Agricultural Weather Network) (reference evapotranspiration is adjusted for individual crop type for 10 crops using crop coefficients **) (**http://www.ext.nodak.edu/weather/cropwater/cwdeficit-season.gif **)**

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Roll-out of GEO AIP Water Working Group Agricultural Drought Projects

- *Global-scale* Agricultural Drought Monitor
- The computer hardware requirements are still too taxing for high-resolution global monitoring: one has to resort to coarse-scale global with networks of regional high-resolution drought monitors. Alert and early warning systems are only meaningful at high-resolution, and, hence, regional-scale.
- *Regional scale* Agricultural Drought Monitors (products under development (contingent upon funding):
  - USA
  - India
  - China

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The Agricultural Drought Conclusion for AIP GEO

- ***Not*** trying to compete with US National Integrated Drought Information System (NIDIS) within USA

- **Adding and Augmenting** critical **Earth Observations** of high resolution crop information and water use information that can be shared

- Setting up information as pilot project to test whether upgraded higher scale information reduces uncertainty in quantifying water use in agriculture and improves predictability of limits of agriculture in feeding global population

GEO AIP Agricultural Drought--*implementation*

- A map layer of high resolution crop water requirement can be overlain on top of a map layer of soil moisture
- Crop water deficit between the two map layers can be highlighted, when soil moisture falls below a threshold
- An alert system would be based upon user registration to receive automated email alerts (or cell phone alerts), if soil water falls below a designated threshold
- An early warning system does not necessarily include such an alert system (users would check the GEO portlet maps to check conditions in their locale),

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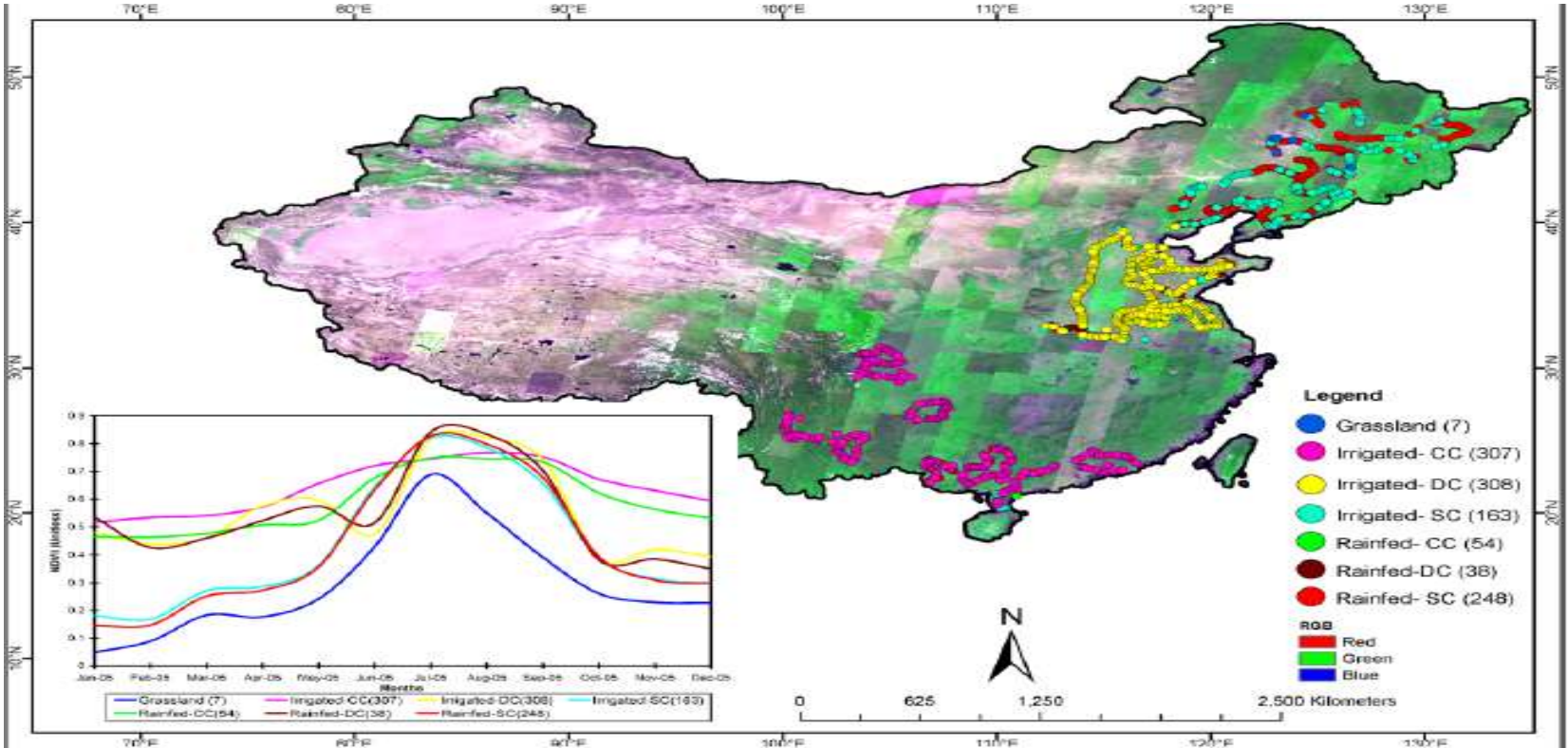
Linkage between the GEO AIP Water Working Group Agricultural Drought Projects and the GEO UIC Projects

- The UIC project GEO2010 Global Cropland Area Monitoring System (GCAMS) will generate from Landsat, Quick Bird, and Ikonos 30 m or higher crop type and precise geospatial crop acreage database—an absolutely essential requirement towards increased accuracy in high-resolution crop water requirement mapping



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Edge of the Envelope Limits in Applying Water Models to Ultra-Fine Scale Agricultural Drought Decision Support

- The routing algorithms used in the Variable Infiltration Capacity (VIC) model, along with routing used in WBM/WTM and the NASA/GSFC Land Data Assimilation System breaks down well before 30 m

- Land Surface Model (LSM) grid cells do not allow for horizontal exchanges of water from grid cell to grid cell (although routing of surface water is allowed); at 30 m, sub-surface exchanges of water are significant in some areas

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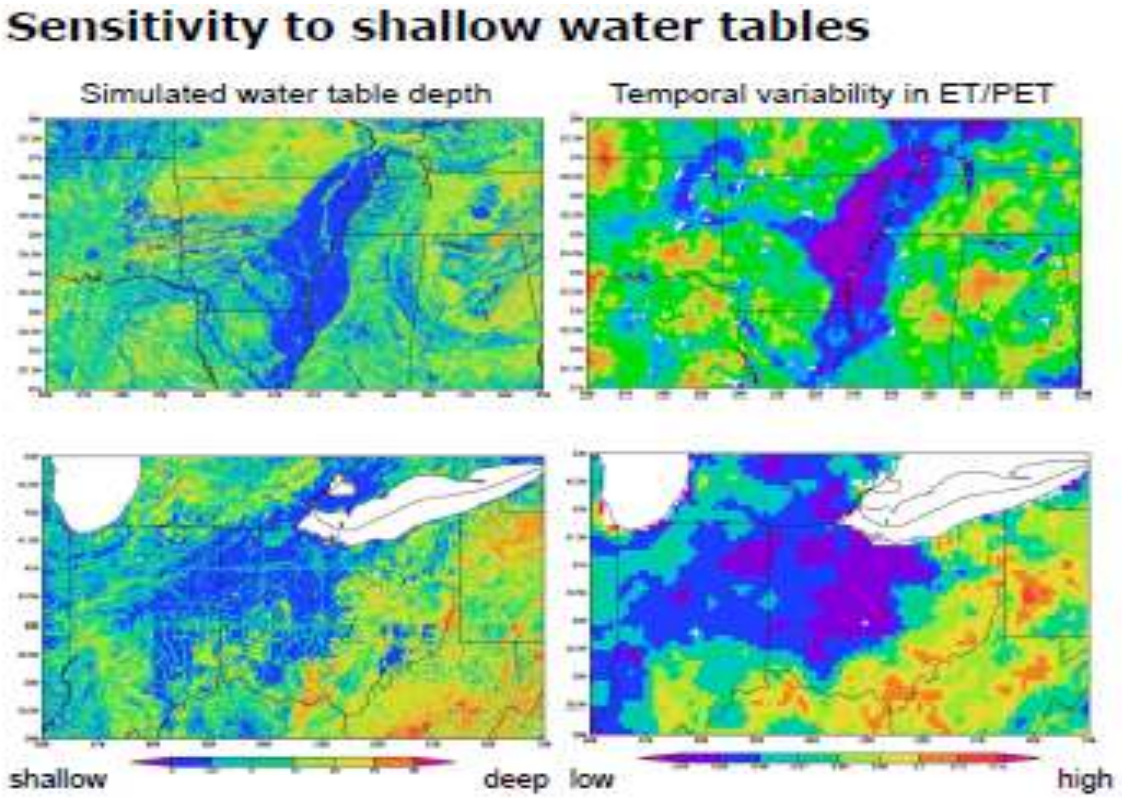
Attempting Agricultural Drought Monitoring for the first time at Application Scales

- A trade-off will have to be reached between hydrologic model scales (1 km) and the 30 m scales of the agricultural crop type and acreage inventory



Variability in evapotranspiration rates with depth to the water table, using ALEXI (courtesy of Martha Anderson)

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The AIP-3 Water Quality Scenario

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GEO AIP Water Working Group *Water Quality* Activities and Projects

- US Environmental Protection Agency (EPA) is carrying out a pilot project in the Gulf of Maine, USA

- EO2Heaven (Earth Observation2Heaven) is carrying out a pilot project on cholera in Mozambique

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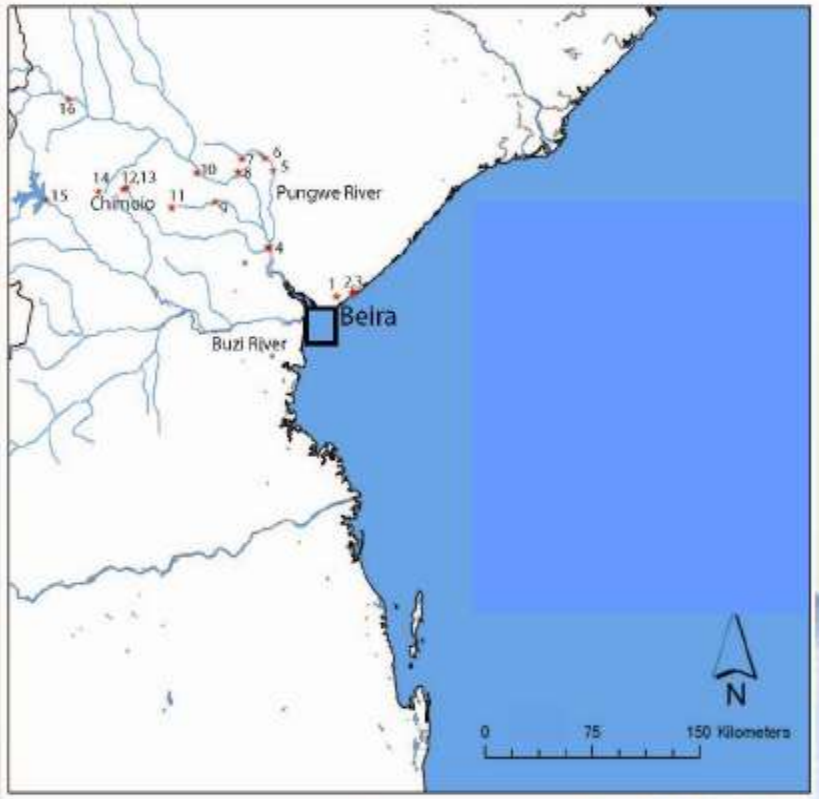
Earth Observation2Heaven (EO2Heaven) (Water Quality)

Endemic in Mozambique:

- Yearly outbreaks : hot, rainy season
- Reports about 11% of all cases on the African continent on a yearly basis
- Coastal areas always affected : epi-centre and/or affected by polluted cross-boundary inland rivers ending in the Indian ocean along the coast line



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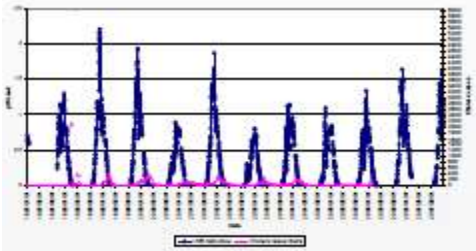
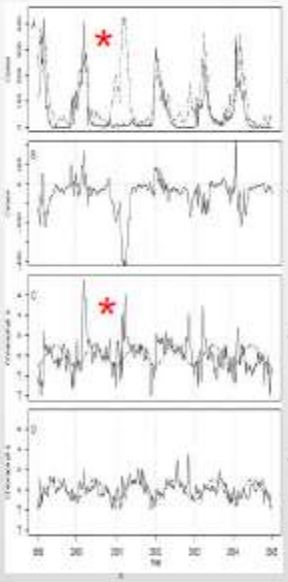
Earth Observations2Heaven (EO2Heaven) (Water Quality)



Different environmental parameters & processes

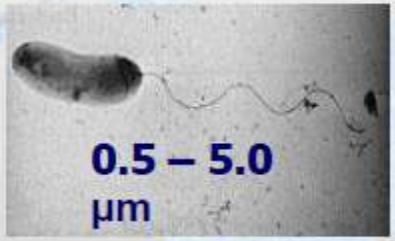


← Cholera case cycles are amplified naturally by rainfall

← Climatic drivers explain > 70% of cholera cases

← Chlorophyll a concentrations* measured close to Pungwe river mouth follows same pattern as cholera cases * → runoff effect (?)

← Chl-*a* in open sea follows seasonal pattern – Peaks during dry season compared to cholera cases that peak during rainy season



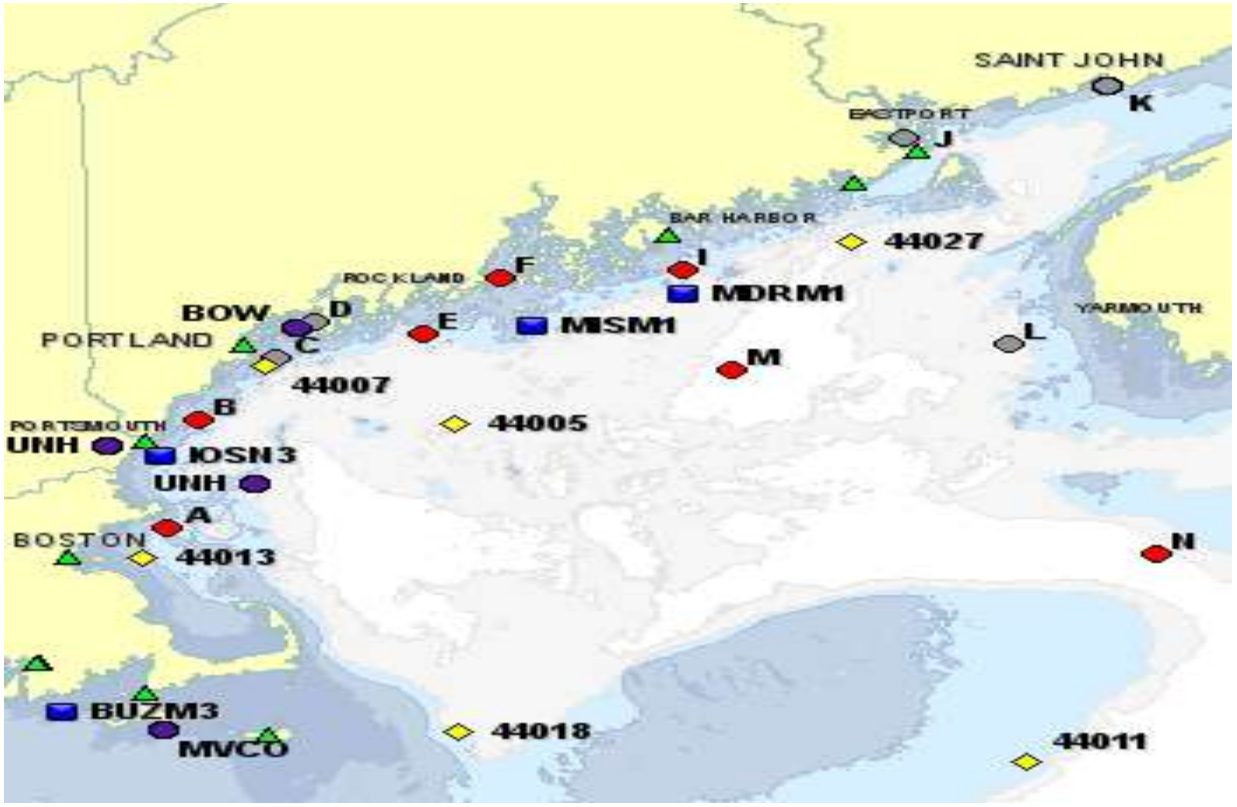
(1x10^{-6}m)

www.eo2heaven.org

Fm.nev@ntropic.fr

US Environmental Protection Agency (Water Quality)

Gulf of Maine Ocean Observatory



Looking at the Informatics-side of the Problem

- A farmer (or any decision maker, such as a water planner) can access a map on the GEO Water Societal Benefit Area Community portlet
- The farmer can draw a border around a locality on the map where he or she lives and click on “soil water deficit map”
- The spatial locations of the map are linked to the database containing both the soil moisture data, the soil moisture anomaly data, the crop water requirement for that area (based upon the high-resolution crop type information)

Looking at the Informatics-side of the Problem

- By either clicking on or typing in *soil moisture* or *crop water requirement,* these terms are actually terms in the ontology. Each ontology term is registered to cells within the database of a data collection

- Retrieval and updating of data (streamflow, etc.) can be based upon an updated WaterML (Water Markup Language) type of scheme that marks up data, as if they were documents using XML

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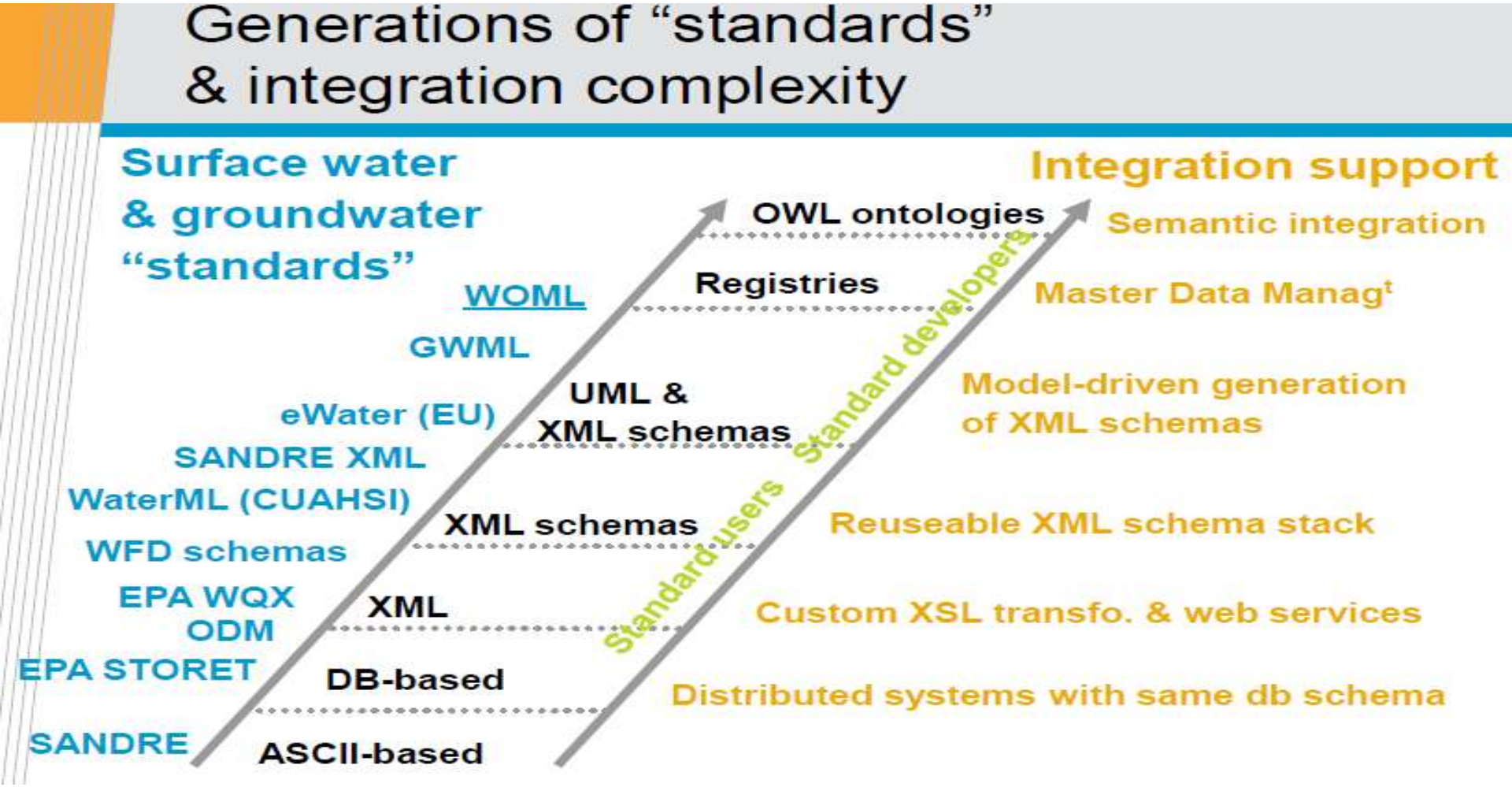
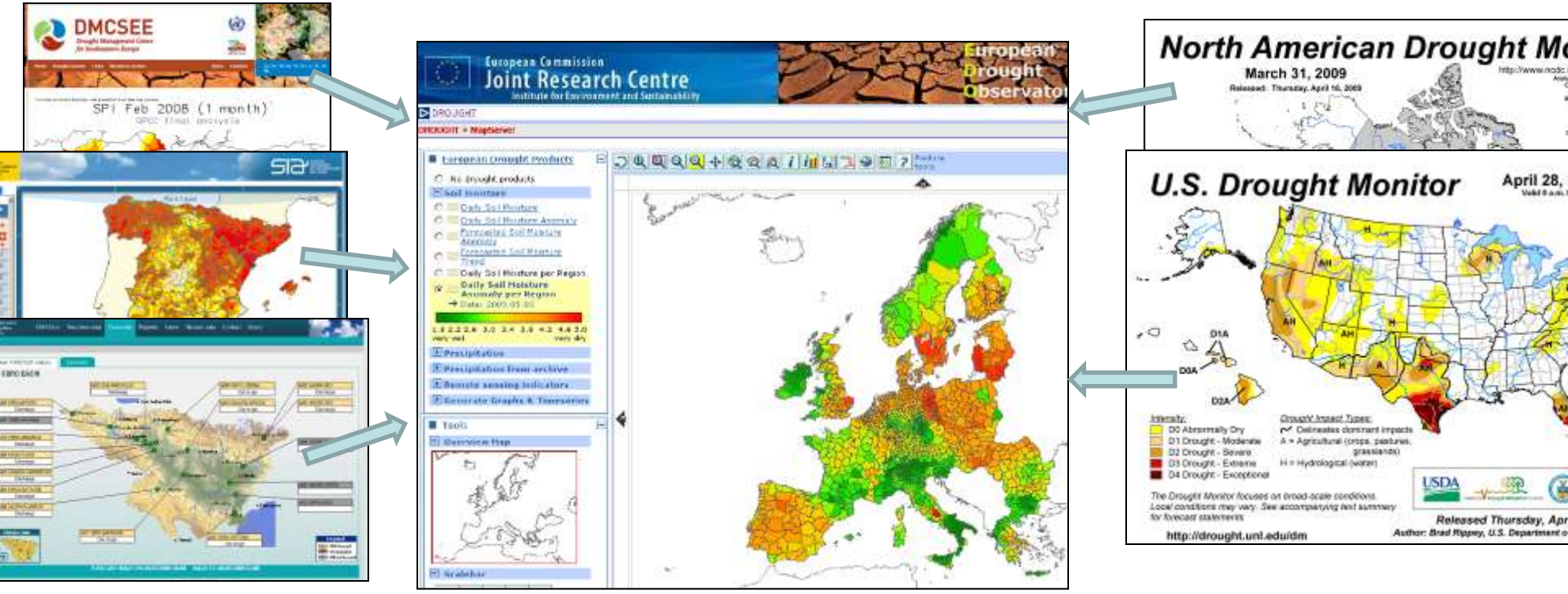
Designing an Interoperable system capable of Growth



Interoperability is required between EuroGEOSS and USA efforts—and Australia

"To develop a European Drought Observatory within the framework of INSPIRE specifications and GEOSS interoperability arrangements, fully integrated with local and national systems in Europe and international drought early warning systems as a European contribution to a Global Drought Early Warning System."



Fast access through web portal
Comparison and analysis

Seamless up and downscaling
New perspectives for R&D

International Collaboration being fostered through GEO

- The European Union is using EuroGEOSS Broker and GI-Cat, a distributed approach in order to achieve scalability and accuracy. It implements metadata querying and browsing in an asynchronous way (Nativi, et. al. 2007)(http://zeus.pin.unifi.it/cgi-bin/twiki/view/GIcat/WebHome).
- Various semantic search utilities with map user interface have under development in the USA
  - Hydroseek by CUAHSI
  - SciScope, an open software, freeware client application developed by Microsoft (Bora Beran)

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Why Bother with Ontologies and Semantics?

- GEO is multi-national; efforts should be scalable
- Each country has different database schema; such syntactic and semantic heterogeneity calls for a superstructure that will automate the drudgery and be user-friendly
- New Data collections can be added by semantic registration with terms in the ontology using the existing search utilities

The Conclusion--what does Water have to do with GEOSS Architecture? What about the User Interface Committee Call for Proposals?

- AIP-3 are also pilot projects, involving decision support tools, which are accessible through the GEOSS portal and which utilize GEOSS architectural services. Development of the scientific aspects of these pilot projects will *simultaneously* develop techniques to utilize the data streams, along with registration and improved data synthesis and processing within the GEOSS architecture.

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GEO Water Subtasks and the Goals of the GEOSS Architectural Implementation Pilot (AIP-3)

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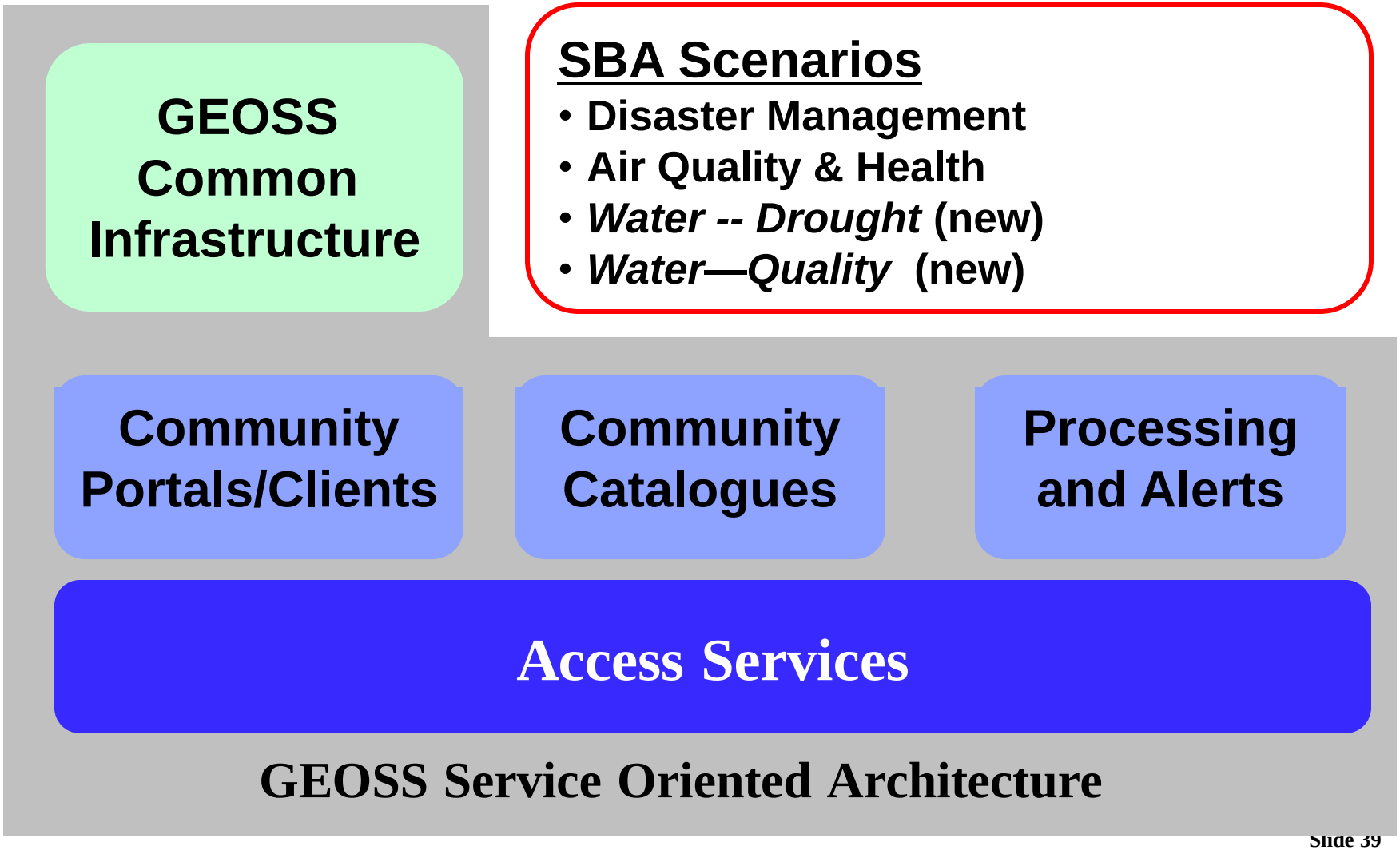
AIP-3 Components and Scenarios—Drought Alerts in Processing and Alerts



Engineering Components

GEOSS Common Infrastructure

Main GEO Web Site

GEO Web Portals

GEOSS Clearinghouses

Registries

- Components & Services
- Standards and Interoperability
- Best Practices Wiki
- User Requirements

Registered Community Resources

Client Tier

- Community Portals
- Client Applications

Business Process Tier

- Community Catalogues
- Mediation Servers
- Alert Servers
- Workflow Management
- Processing Servers
- Test Facility

Access Tier

- GEONETCast
- Product Access Servers
- Sensor Web Servers
- Model Access Servers

Knowledge Processing Improvements accompanying AIP-3 Water Pilot Project Development and Deployment

- Data integration (as in ontology-enabled semantic data integration over multiple data centers);
- Data discovery;
- Metadata design and registration;
- Data format unification; and
- Community development (as in Water Cycle Community of Practice) schemas and water cycle ontologies (Shorter and Hansen, Community Schemas, *Position*, Dec 2008-Jan 2009).

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AIP-3 Master Schedule

Post AIP-3 CFP	January 2010
Responses to AIP-3 CFP	3 March 2010
Kickoff Workshop (Europe)	11-12 March 2010
Demo Capture Workshop (US)	2nd Half of 2010
Ministerial Summit & GEO VII (China)	Nov 2010
Finalize AIP-3 deliverables	2nd Half of 2010
AIP-3 results transition to operations	2nd Half of 2010

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Thank You!

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