USACE, ERDC, and CRREL Interests and Capabilities Relative to High Latitude Regions and Beyond

John Eylander, Jeanne Roningen, Michael Shaw

CRREL

11/13/2015

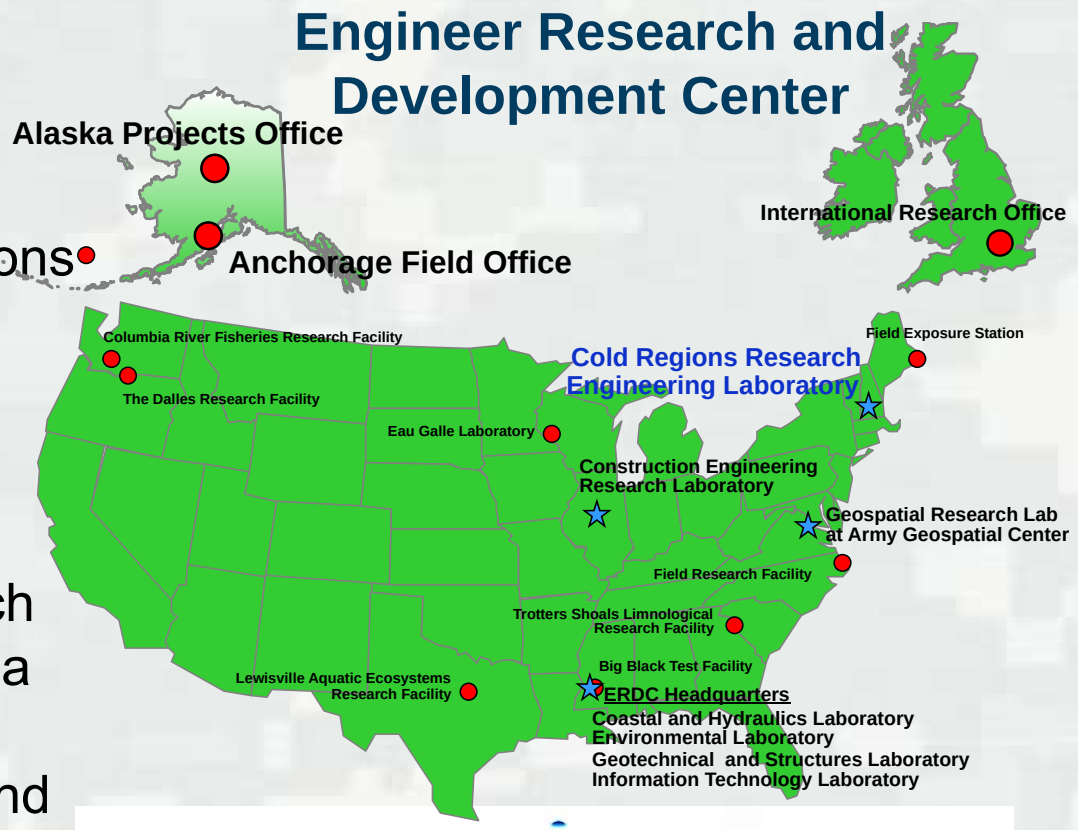
U.S.ARMY

US Army Corps of Engineers.

ERDC
Engineer Research and Development Center

USACE, ERDC, CRREL

- USACE (United States Army Corps of Engineers) is one of world's largest civil works and project management organizations
- ERDC (Engineer Research and Development Center) is the USACE R&D organization; comprised of 7 labs
- CRREL (Cold Regions Research and Engineering Laboratory) is a facility recognized as a national center of expertise in RS/GIS and cold regions



CCAWWG

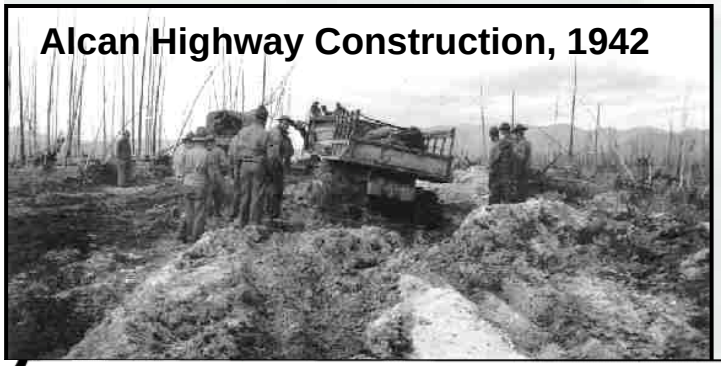
Climate Change and Water Working Group

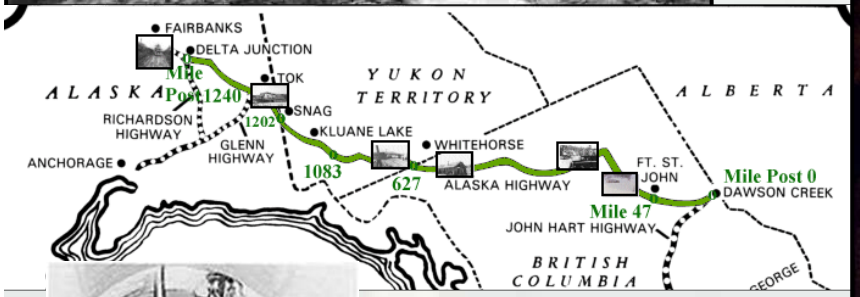
ERDC

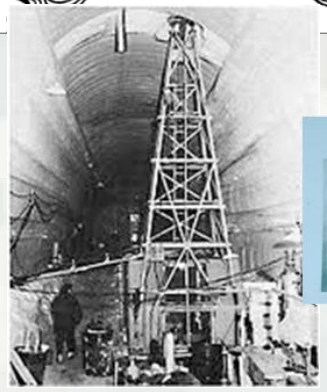
U1 Engineer instead of Engineering

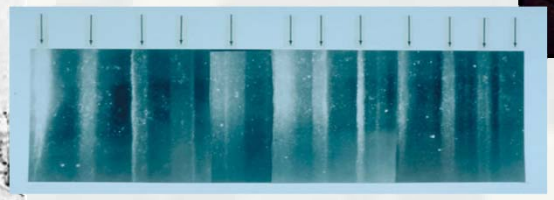
U4PAZSCL, 12/17/2015

Army Cold Regions History

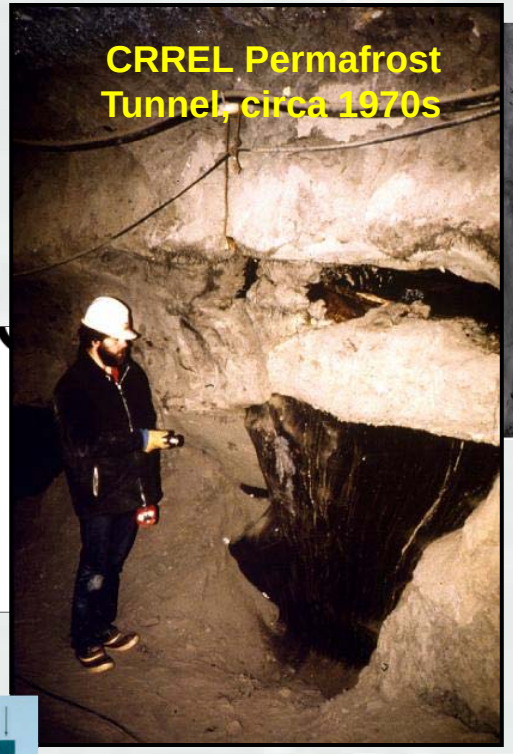


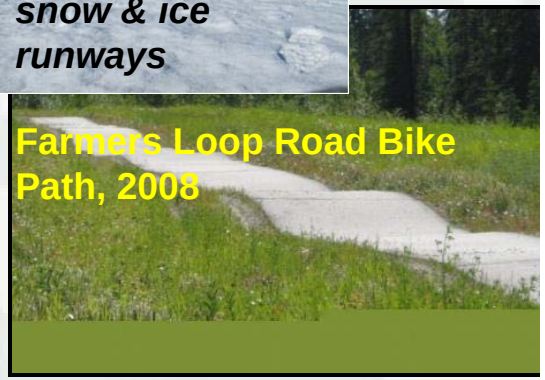


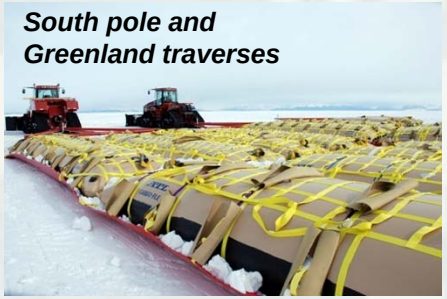




Ice core drilling on Greenland (Camp Century) and Antarctica (Byrd Station) providing a climate record of past 120,000 plus years.







US Physical Presence
Importance of Alaska

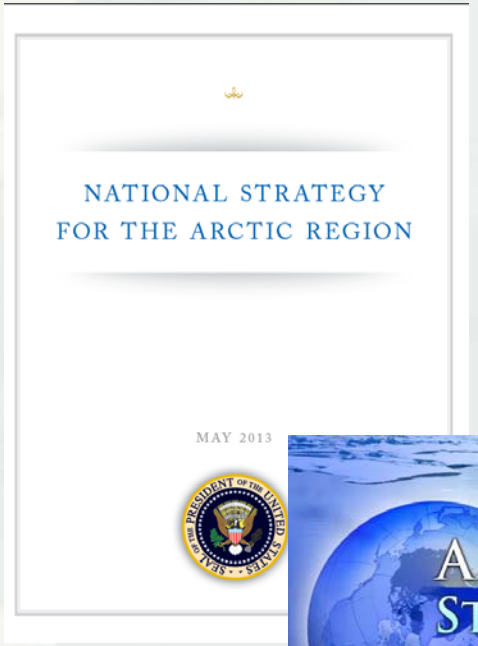
- Only Arctic State
- 33,900 miles of coastline
- 20% of US land
- 40% of US surface water
- 50% of US wetlands
- Half is underlain by permafrost
- remote communities w/o highway infrastructure
- 229 communities of native peoples
- 50% of US seafood
- 25% of US crude oil

Hartig, Commissioner, Alaska Dept. of Env. Conservation, 2009

Alaska serves as a test bed for how we adapt to climate change

We're Attentive to U.S. Arctic Strategy Doctrine

- **National Strategy for the Arctic, May 2013**
  - Advance security interests, pursue responsible stewardship, strengthen international cooperation
- **U.S. Coast Guard Arctic Strategy, May 2013**
  - Improving awareness, modernizing governance, broadening partnerships
- **DoD Arctic Strategy, November 2013**
  - Secure/stable region, interests safeguarded, homeland protected, nations work cooperatively to address challenges
- **U.S. Navy Arctic Roadmap (2014 – 2030), February 2014**
  - Ensure security, support safety, promote defense cooperation, prepare for a wide range of challenges/contingencies
- **NOAA's Arctic Action Plan, April 2014**
  - Research aligned with National Strategy: weather and sea ice forecasts, foundational science toward stewardship/management, national/international partnerships



ERDC

The Importance of Climate Change to *DoD*

Quadrennial Defense Review, 2010

- *Climate change will reshape the operating environment and impact our facilities and mission*
- *Climate change will stress already stressed systems*
- *Some ecosystems/regions are more vulnerable than others*
- *Conduct assessment of installations to determine the potential impacts of climate on mission and how to adapt*

Strategic Sustainability Performance Plan, 2010

- *Sustain operation into the future without decline of mission or environment*
- *Maintain readiness in the face of climate change*

Policy Guidance

National Strategy for the Arctic Region

Guiding Principles:

- Safeguard Peace and Stability
- Make Decisions Using the Best Available Information
- Pursue Innovative Arrangements
- Consult and Coordinate with Alaska Natives

Approach:

- Foster Partnerships with Arctic Stakeholders
- Coordinate and Integrate Activities across Federal Government

Department of Defense Arctic Strategy

Objectives:

- Ensure security, support safety, and promote defense cooperation
- Prepare to respond to a wide range of challenges and contingencies

Implementation Plan Activities:

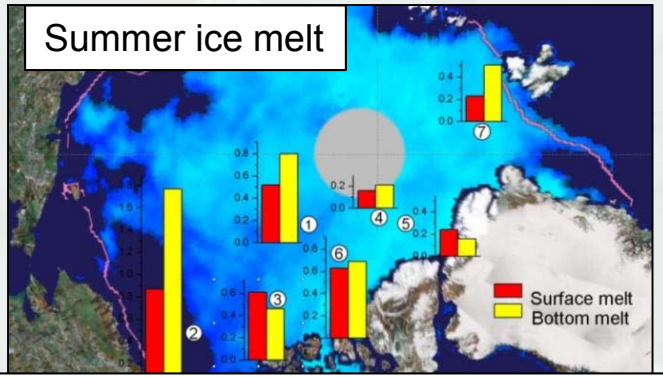
- *Evolve Arctic Infrastructure and Strategic Capabilities**
- *Enhance Arctic Domain Awareness**
- *Preserve Arctic Region Freedom of the Seas*
- *Provide for Future US Energy Security*
- *Protect the Arctic Environment and Conserve Arctic Natural Resources**
- *Use Integrated Arctic Management to Balance Economic Development, Environmental protection, and Cultural Value**
- *Increase Understanding of the Arctic through Scientific Research and Traditional Knowledge**
- *Chart the Arctic Region*
- *Pursue Arrangements that Promote Shared Arctic State Prosperity, Protect the Arctic Environment, and Enhance Security**
- *Cooperate with other Interested Parties**

Arctic Intelligence Workshops

- Semi-annual, sponsored by NORAD\NORTHCOM
- Increased maritime activity
  - Commercial, military, and recreation
- Putin's order for Arctic military build-up in 2014
  - Revival of military infrastructure from Cold War
- China's interest in becoming an "Arctic" player
- Long lead items:
  - Intelligence, Surveillance, and Reconnaissance
  - Arctic-ready ships, vessels, and vehicles
  - Infrastructure

Arctic Interests

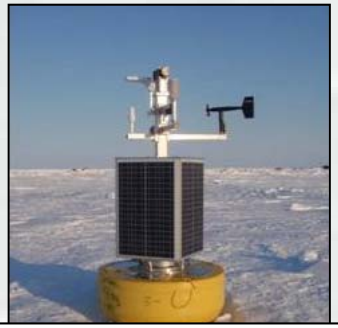
- Climate Change
  - Observing and understand Arctic change to enhance predictive capabilities
    - Sea-ice characteristics and spatial variation
    - Autonomous Platforms

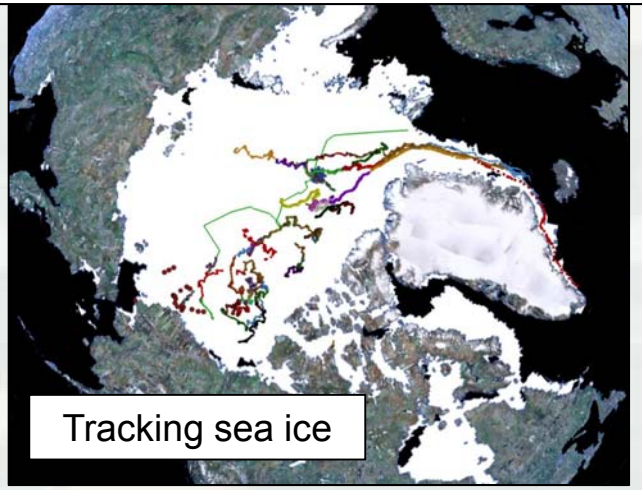


Summer ice melt

IMB-buoy: ice drift, mass balance, meteorological obs


Autonomous Sensors


O-buoy: atmospheric chemistry

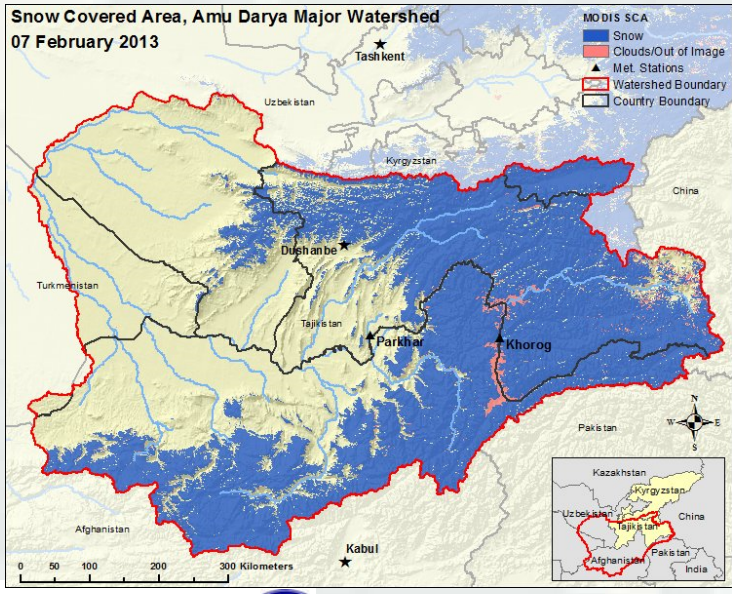

Tracking sea ice

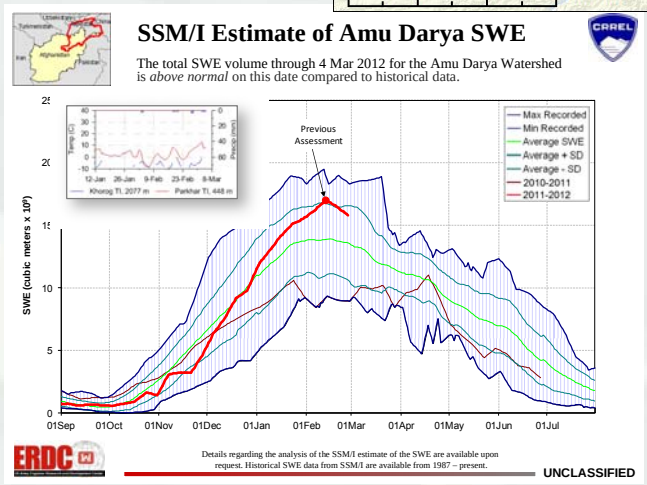
Observe, understand, and respond

STUDY OF ENVIRONMENTAL ARCTIC CHANGE

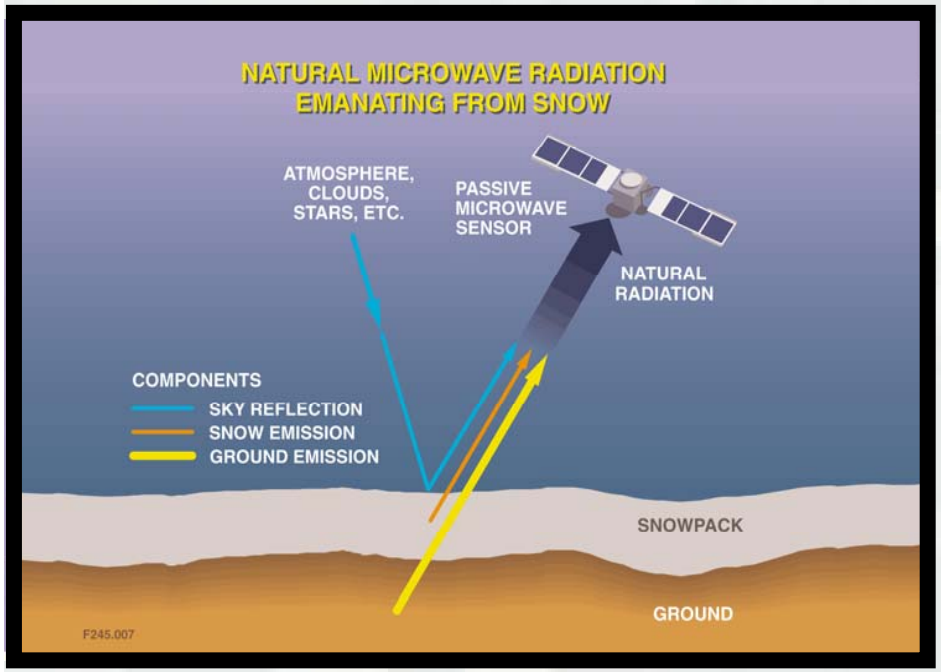
Satellite-based Snow Products

- CRREL Snow Water Equivalent (SWE) products
  - "Operational" bi-weekly products generated for USACE Reachback Operations Center
  - Relies on remotely sensed observations as primary source of data
  - Satellite-SWE estimates combined with satellite-based climatology and previous year records for reference purposes
  - CRREL transitioned this remote sensing technology and product capability to Air Force 557th WW





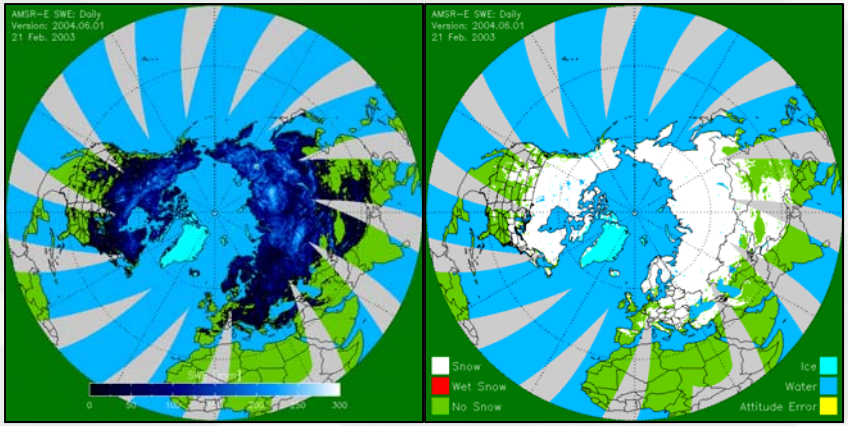
Snow Situational Awareness w/ Remote Sensing



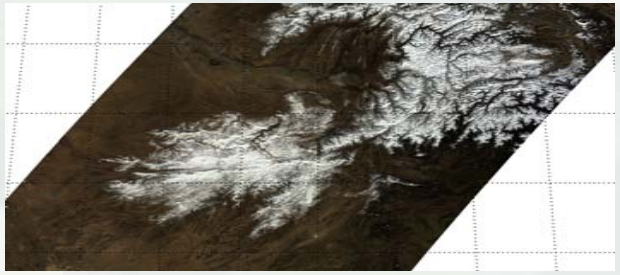
T_B is inversely related to snow depth

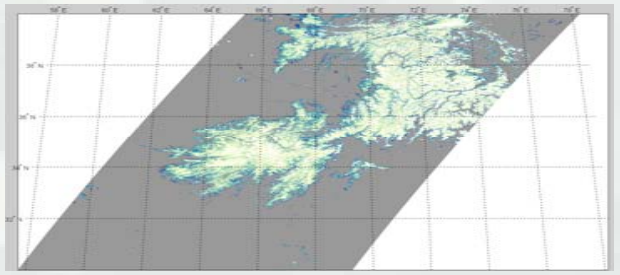
AMSR-E daily, gridded, global SWE estimate (left) and snow cover map (right) example from Feb 21, 2003

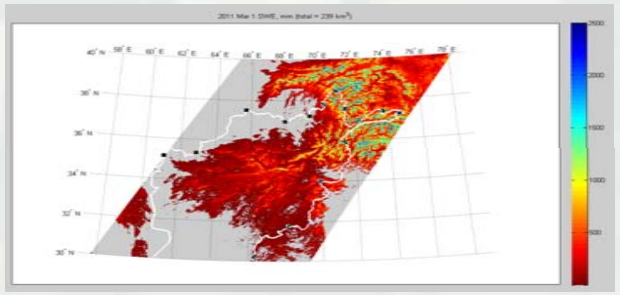
- Current operational methods use passive microwave spectral differencing to diagnose SWE
  - Comparing brightness temperatures (Tb's) of 18/19, 36/37, 10, 22, and 89 GHz frequencies
  - Heritage algorithms (SSMIS) limited to 19 GHZ and 37 GHz comparison
    - Limited detection of both thin snow and deeper snow packs



Snow Situational Awareness w/ Remote Sensing



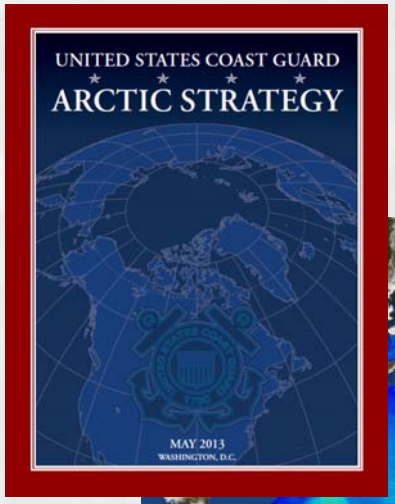




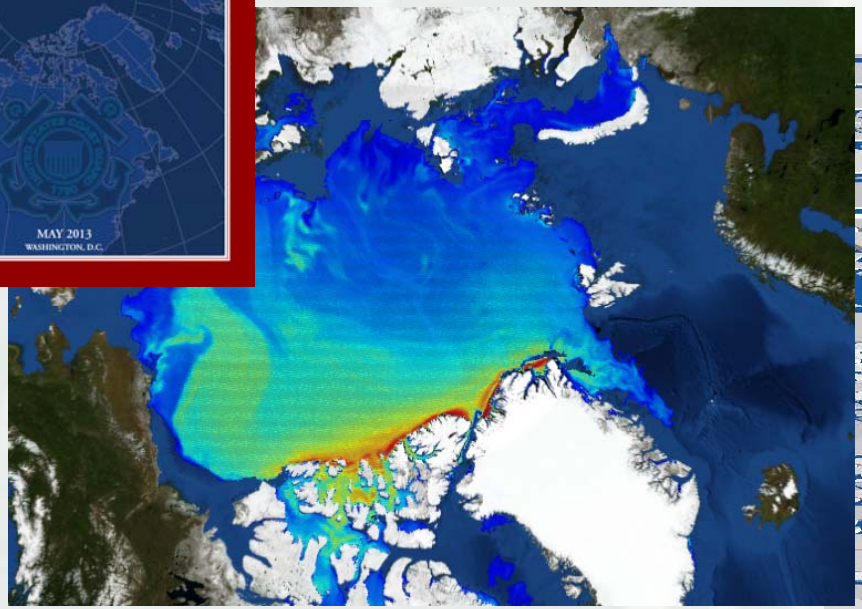
In many regions, snow is critical source of water & stability

- CRREL & UCSB collaboration – improve snow pack remote sensing science
- Snow depth, snow water estimates produced operationally, distributed through DOD channels
- Primary interest has been to estimate water resources impacts of snow depth (some mobility concerns)
- Snow Reconstruction Project – use EO/IR (NASA MODIS, JPSS VIIRS) sensors to measure snow depth/water retrospectively versus using AMSR-E
  - EO/IR sensors provide higher resolution products

Discrete Element Sea Ice Modeling

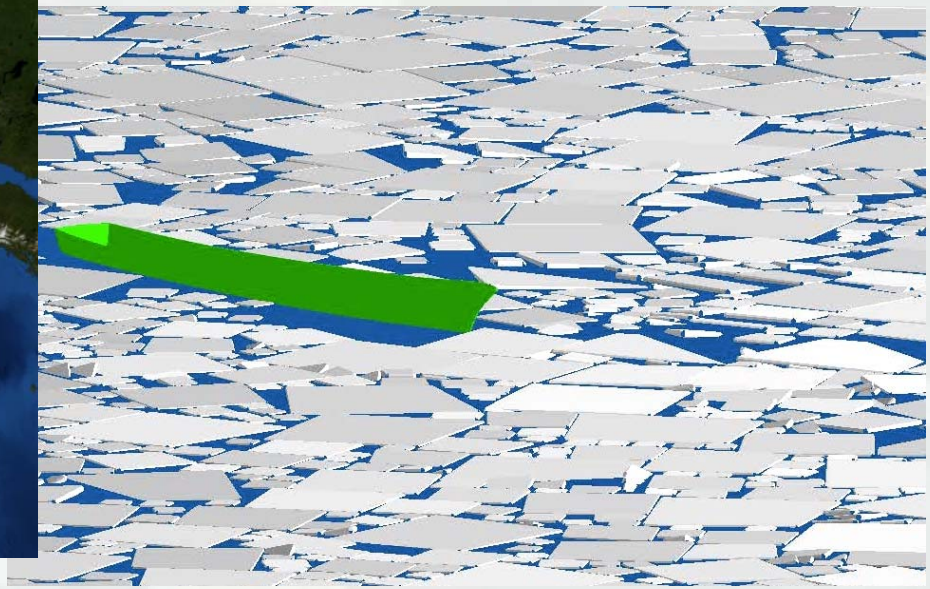


- *Enhance awareness*
- *Achieve effective presence*



High resolution regional forecast model
- Routing
- Operations planning
- Oil spill dispersion

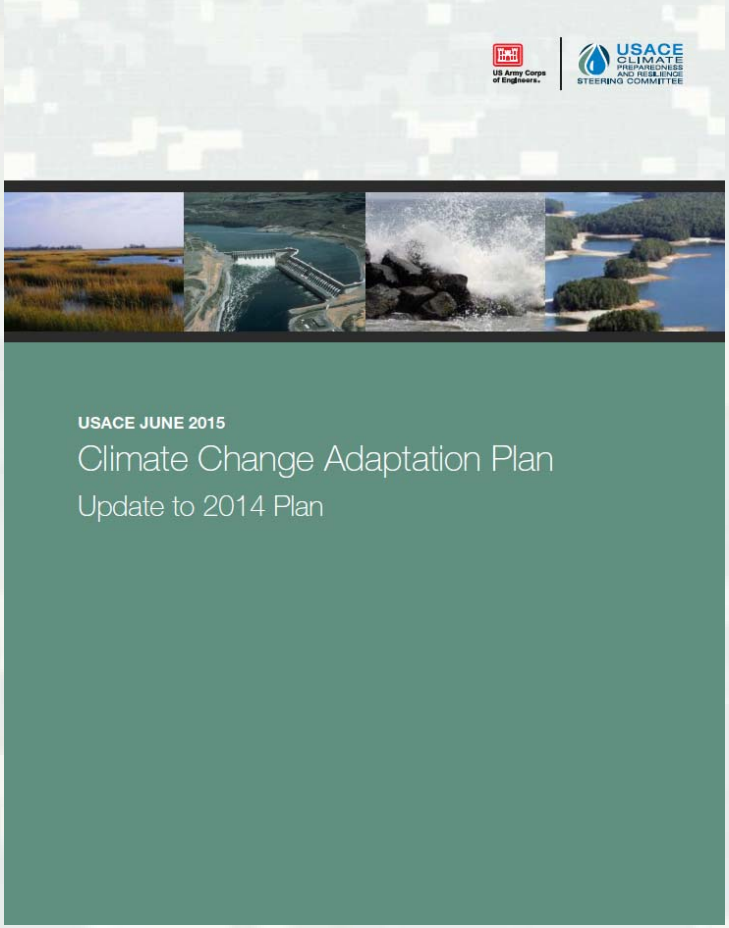
Courtesy Arnold Song, CRREL



Ice-ship/structure interaction model
- Estimate ice loads
- Safe speeds through ice guidance
- Ice management

USACE 2015 Climate Change Adaptation Plan

- Focus on specific areas
  - Infrastructure Resilience
  - Vulnerability Assessments
  - Risk-Informed Decision-Making for Climate Change
  - Nonstationarity
  - Portfolio of Approaches
  - Metrics and Endpoints
- Engage in meaningful external collaboration
- Improve USACE knowledge for water resources management and infrastructure resilience
- Develop policy and guidance for Infrastructure resilience



http://www.corpsclimate.us/adaptationpolicy.cfm

ERDC

Interests and Implications Beyond – Albeit Connected to – the Cryosphere…..

(OR, Beyond Domain Awareness and Physical Presence)

- Implications, interests, concerns, and efforts across disciplines, scales, and latitudes
- Consider statistical, multi-scale, multidisciplinary implications….
  - from hydrologic, to coastal, to supply chain, to socioeconomic and ecological, to adaptations…and implications w.r.t. cornerstones of civilization and security; food, water, energy
  - *all of interest under the USACE/ERDC/CRREL missions*
- "How can we collaborate towards better data/access, better understanding, better science and engineering, better decision making……?"

Regional Security & Stability

"*The best way to win the war is through non-military means."*

-Sun Tzu, The Art of War, 512 BC

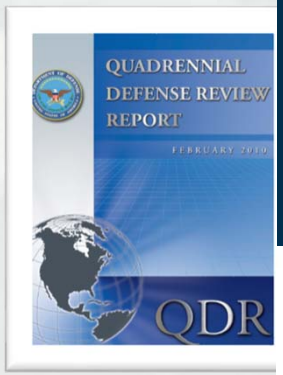
"We have not yet learned to use technology to reduce the cost of stability operations as we have for combat operations. But, technology has significantly amplified the capabilities of insurgents to disrupt U.S. operations"

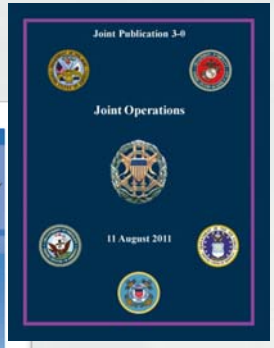
-Defense Science Board Task Force on Institutionalizing Stability Operations within DoD

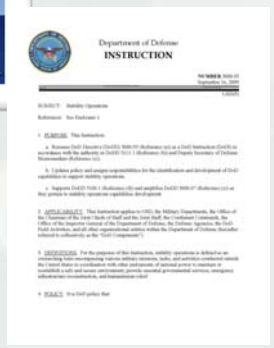
Why Do We Care?

DOD Stability Operations

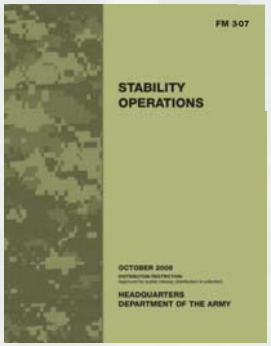
STRATEGIC GUIDANCE

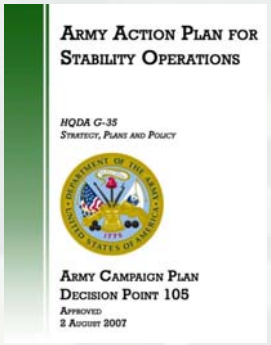




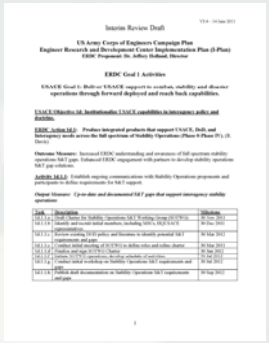


DOD





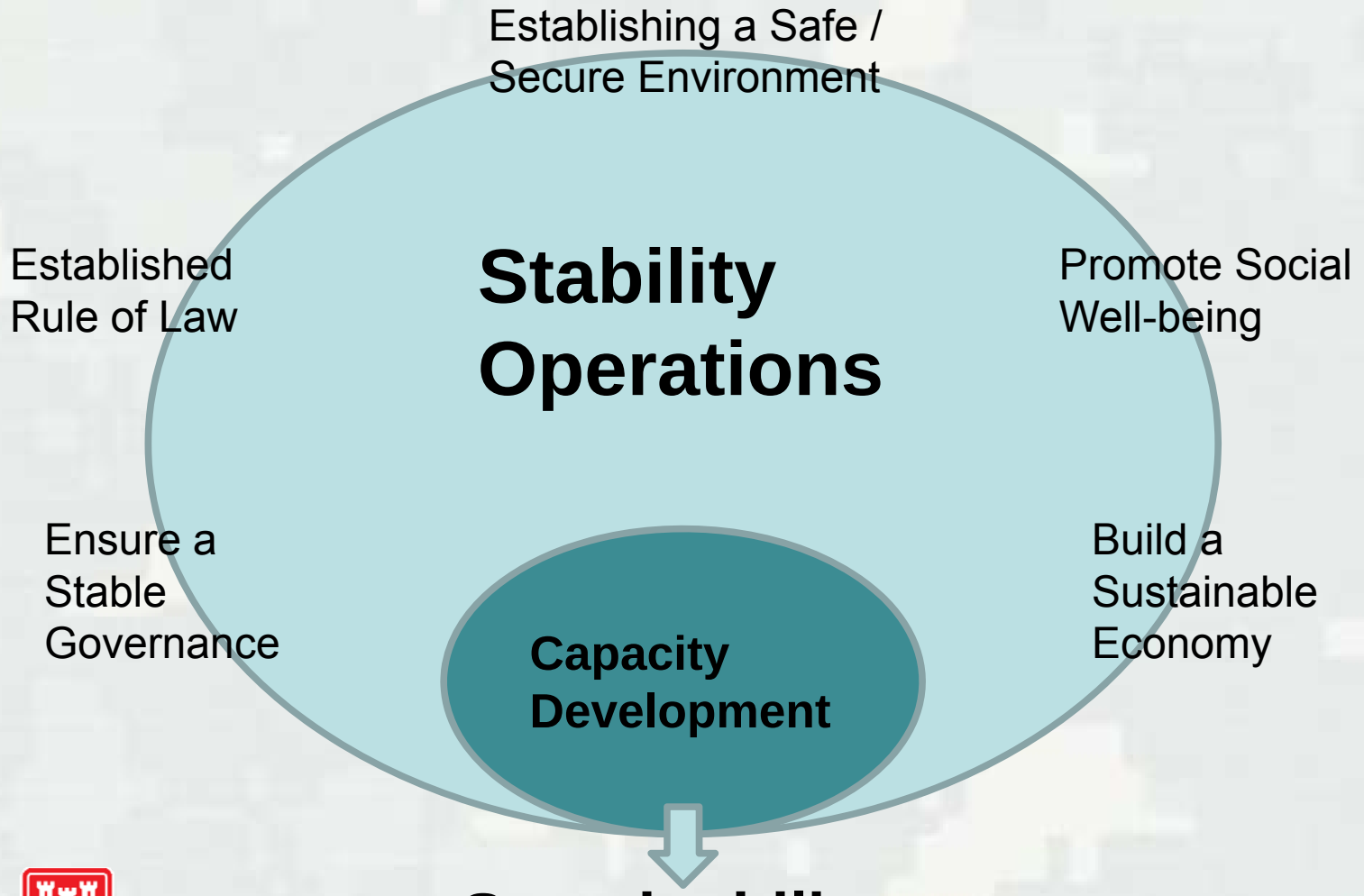
Army



USACE

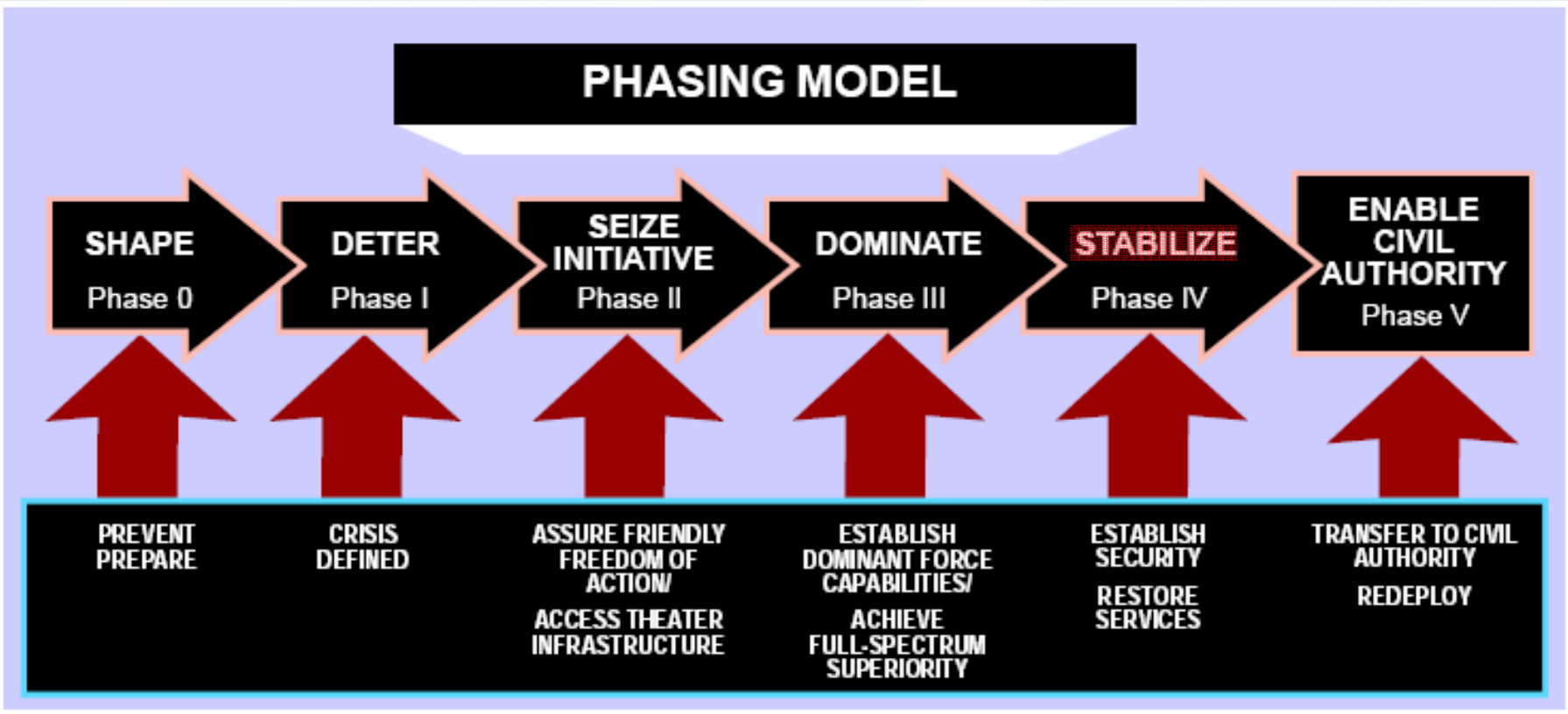
STRATEGIC RESPONSE

Common Definition



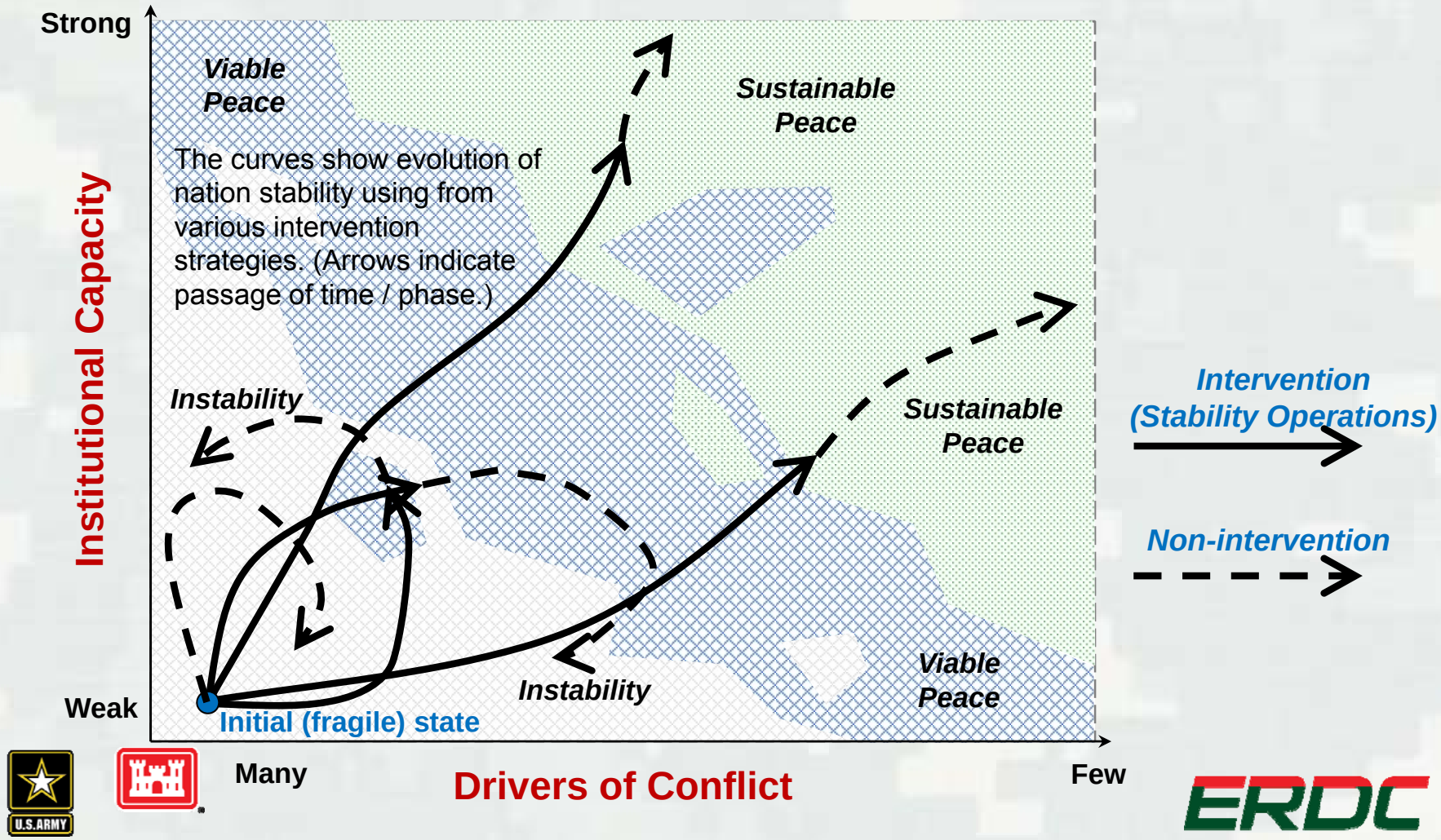
Stability Operations in Context:

Phases of Conflict



It's not just "Phase IV" activities

Generalized Model for State Stability



Drivers of Conflict: Causes

The x-axis (previous slide)

Changing demographics

- Urbanization
- Refugee migration
- Globalization patterns

Resource demands

- Lack of resources (e.g., water, food)
- Emerging energy technologies
- Residual territorial claims (e.g., physical, cyber)
- Technology access/change
- Competition

Governance and participation

- Social well-being
- Internal security
- Political instability
- Justice and reconciliation

Economic well-being

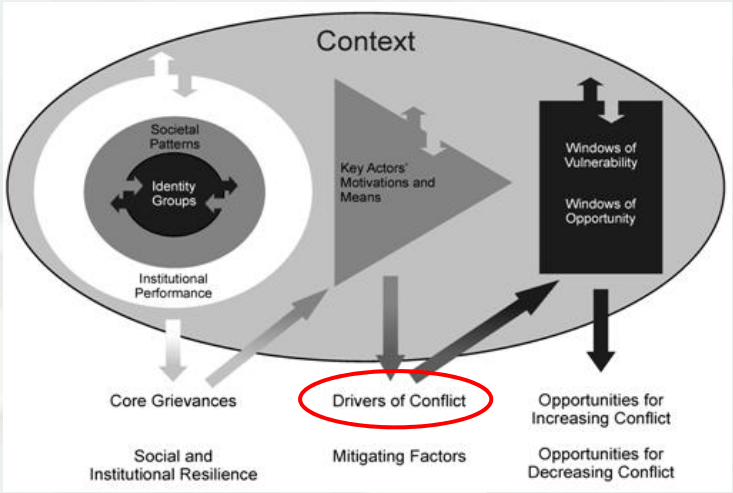
- Shifting patterns
- Lack of economic systems
- Bimodal social classes
- High unemployment rates
- Lack of upward mobility paths

Natural / Anthropogenic events

- Climate Change
- Pandemics
- Proliferation of WMDs
- Mass atrocities

Ideology

- Elitism / Greed
- Religious fanaticism
- Ethnic tension
- Violent extremist orgs (VEOs)



Institutional Capacity: State Stabilizers

The y-axis

Assist / Establish civil security and control

-Regional security
-Police reform
-Build security forces
-Strengthen/establish Judicial systems
-Provide humanitarian assistance

Assist governance and participation

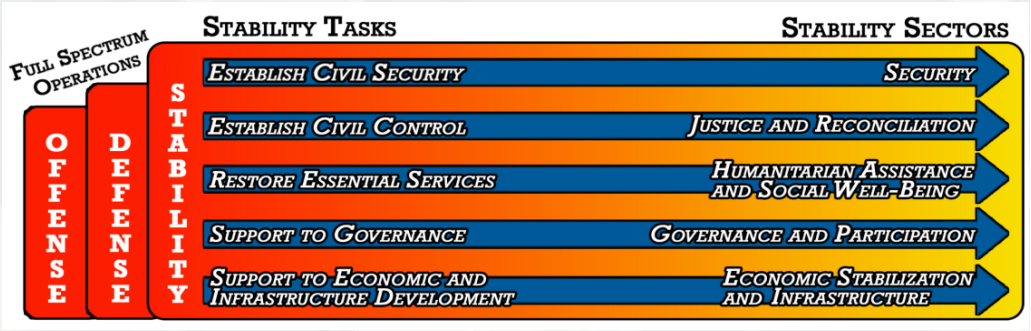
-Transparency
-Power sharing among ethnic / religious groups
-Promote peace / freedom
-Facilitate political development
-Establish Democratic institutions (e.g., elections)
-Establish Rule of Law
-Strengthen governance
-Public information engagement
-Combat corruption

Restore / Provide Essential Services

-Develop physical infrastructure
-Repair critical infrastructure
-Develop indigenous essential services
-Develop an effective labor force
-Establish viable market economy

Cultural considerations

-Social reconciliation
-Strengthen educational, religious, cultural, and recreational Institutions
-Understand personal behaviors
-Understand social norms
-CU2munity development



Slide 22

U2 Added bullets here and changed the text so that it all reads the same promote, build, establish instead of promoting, build, combating, etc.

U4PAZSCL, 12/17/2015

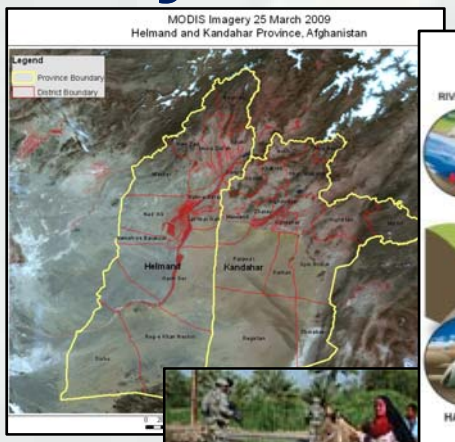
Trends: Regional Stability & Sustainability Science

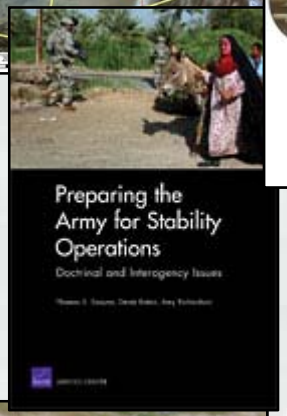
- Disruptive Technologies: New ways of looking at natural and anthropogenic features.

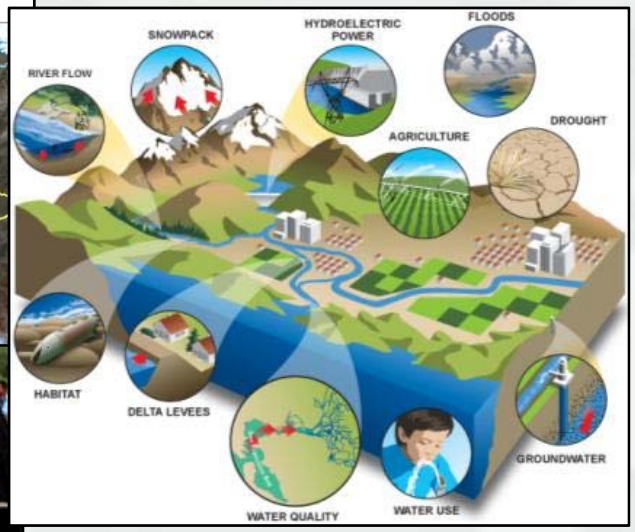
- Short-term: Discover new thresholds that, when reached, lead to regional instability.

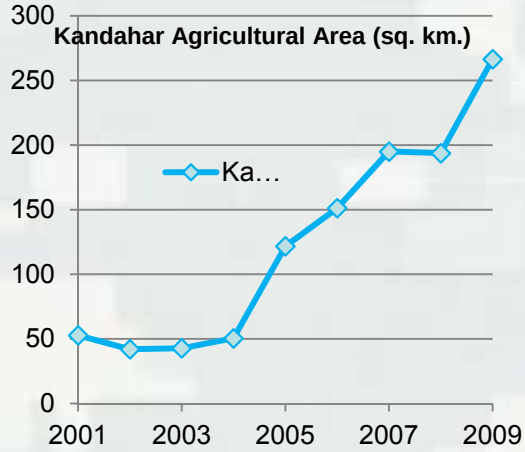
- Long-term: Science-based methodologies for measuring and creating sustainability.

- Integrate with the Social Sciences: Anthropology, Economics, History, etc.



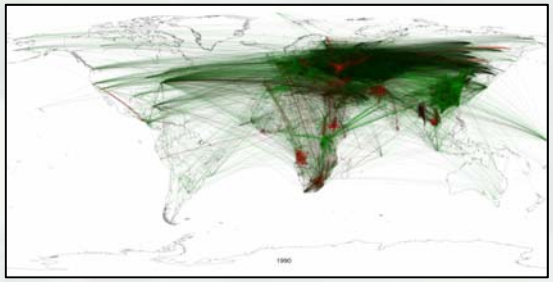






A Spatial-Temporal Problem

Adding additional axes

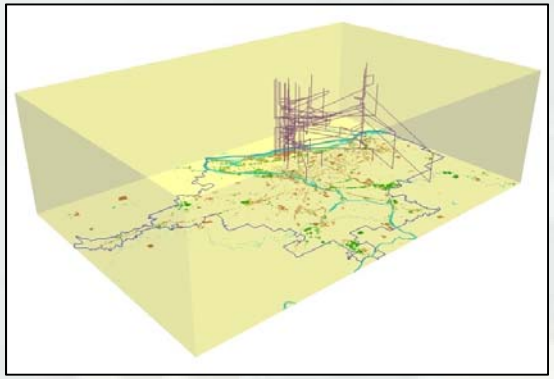


Leetaru, K.H. 2011. "Culturomics 2.0: Forecasting Large–Scale Human Behavior Using Global News Media Tone in Time and Space," First Monday, v. 16, n. 9.

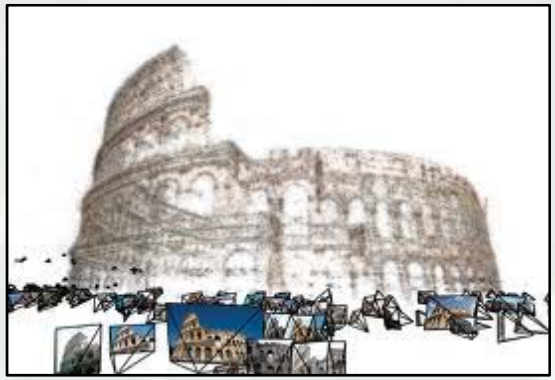
Culturomics – The study of human behavior and cultural trends through the quantitative analysis of digitized texts.

New knowledge discovery paths

Geonarratives – The study extending current GIS capabilities for the analysis and interpretation of narrative materials such as oral histories, life histories, and biographies.



Mei-Po Kwan. 2004. "GIS Methods in Time-Geographic Research: Geocomputation and Geovisualization of Human Activity Patterns" *Geografiska Annaler. Series B, Human Geography* , v. 86, n. 4.



Sameer Agarwal, Yasutaka Furukawa, Noah Snavely, Ian Simon, Brian Curless, Steven M. Seitz and Richard Szeliski. 2011. "Building Rome in a Day ," *Communications of the ACM*, v. 54, n. 10.

Crowdsourcing – The practice of obtaining needed services, ideas, or content by soliciting contributions from large groups of people rather than from individuals.

USACE Resilience Definition

- "resilience means the ability to **anticipate, prepare for**, and **adapt** to **changing conditions** and **withstand**, respond to, and **recover** rapidly from **disruptions**."

Presidential Executive Order 13653, Preparing the U.S. for Impacts of Climate Change (NOV 2013)

Courtesy of USACE Climate Preparedness and Resilience CoP

Drought: Intelligence and DoD interests

Egyptians up in arms as Ethiopia builds giant hydro dam on Nile River; minister rules out war

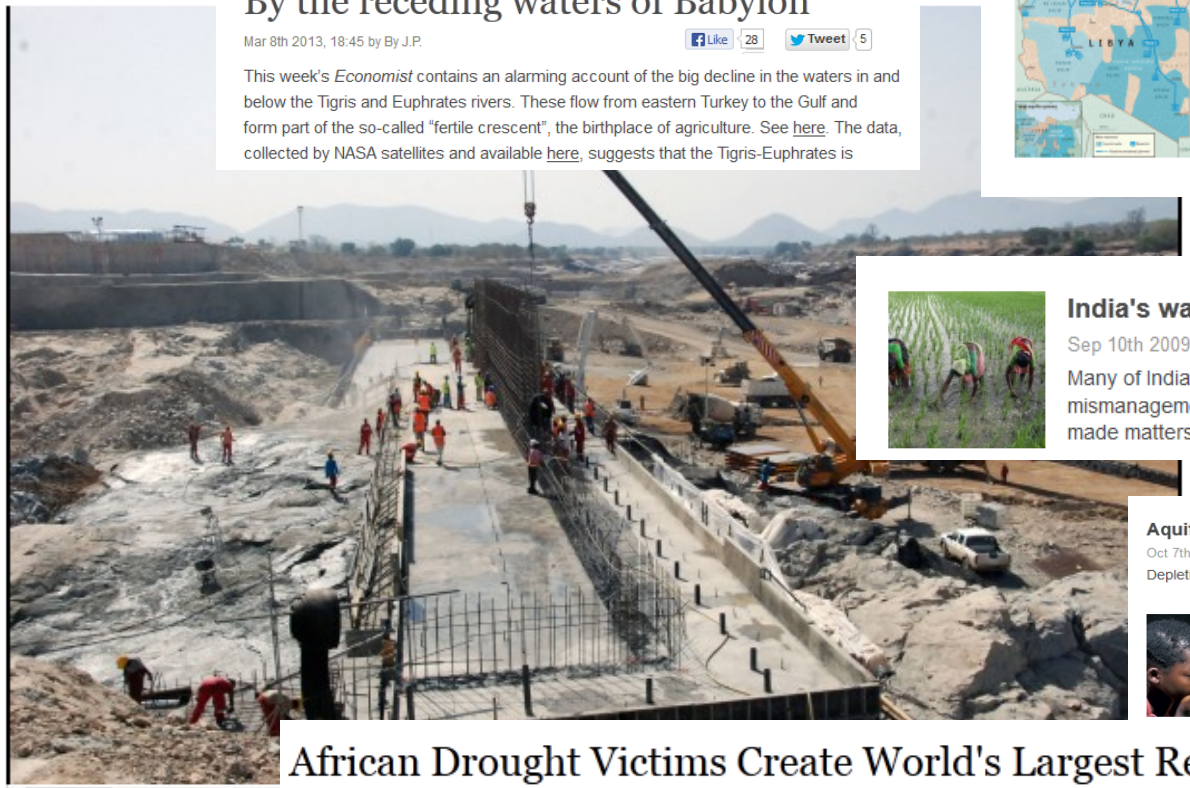
Feeding the Middle East

By the receding waters of Babylon

Mar 8th 2013, 18:45 by By J.P.

Like 28 Tweet 5

This week's *Economist* contains an alarming account of the big decline in the waters in and below the Tigris and Euphrates rivers. These flow from eastern Turkey to the Gulf and form part of the so-called "fertile crescent", the birthplace of agriculture. See here. The data, collected by NASA satellites and available here, suggests that the Tigris-Euphrates is



Libya's water supply: Plumbing the Sahara

Mar 11th 2011, 2:46 from **Graphic detail**

Libya's water is pumped from deep under the desert 7

India's water crisis: When the rains fail

Sep 10th 2009, 10:37 from **Print edition**

Many of India's problems are summed up in its mismanagement of water. Now a scanty monsoon has made matters much worse 53

Aquifers: Deep waters, slowly drying up

Oct 7th 2010, 11:04 from **Print edition**

Depletion of aquifers is a looming tragedy. New agreements offer hope 3

For want of a drink

May 20th 2010, 1:25 from **Print edition**

Finite, vital, much wanted, little understood, water looks unmanageable. But it needn't be, argues John Grimond (interviewed here) 40

African Drought Victims Create World's Largest Refugee Camp

By LISA FRIEDMAN of ClimateWire

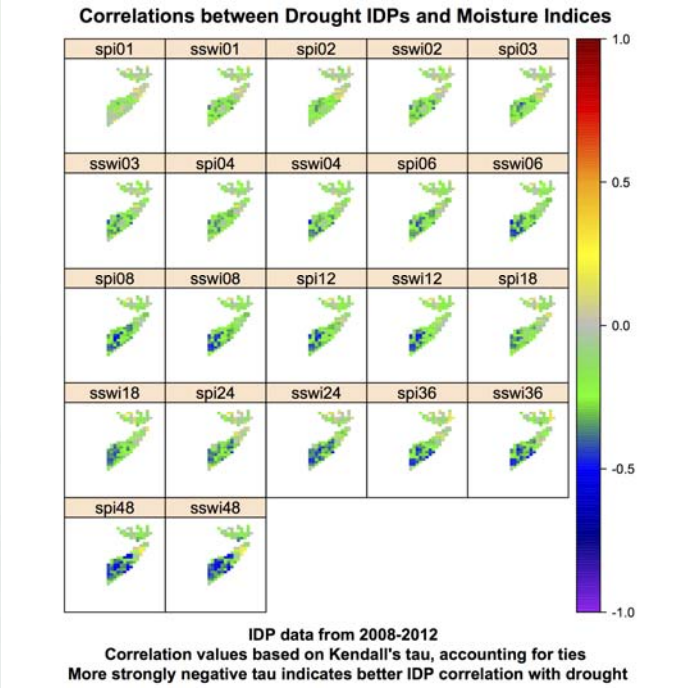
Published: August 22, 2011

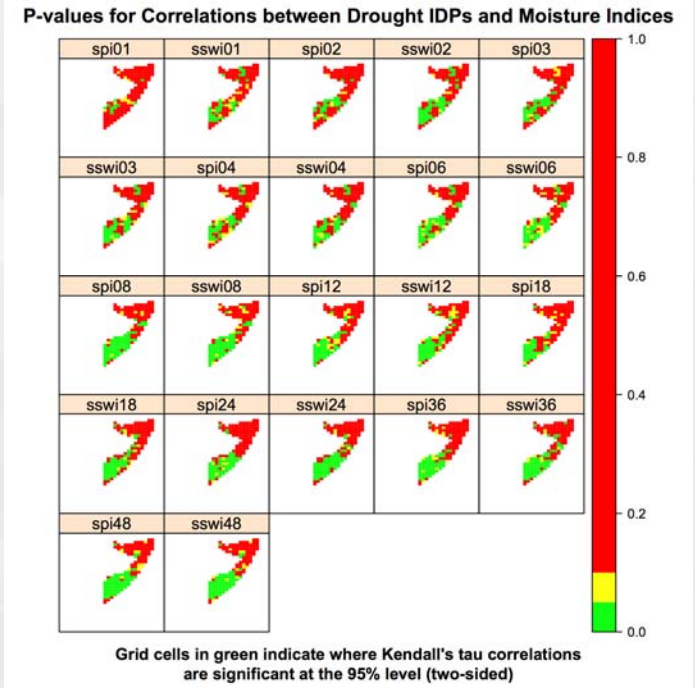
U.S.ARMY

ERDC

Drought in Horn of Africa

Combining Remote Sensing with in situ knowledge





- Drought indices based on MERRA-Land output generally are correlated with drought-induced population movements
- Correlations are consistently statistically significant in southern Somalia for cumulative 8-month or longer drought indices
- The region around Mogadishu where correlations are consistently not significant for indices up to 6-months suggests a sphere of influence of aid/commerce as opposed to subsistence

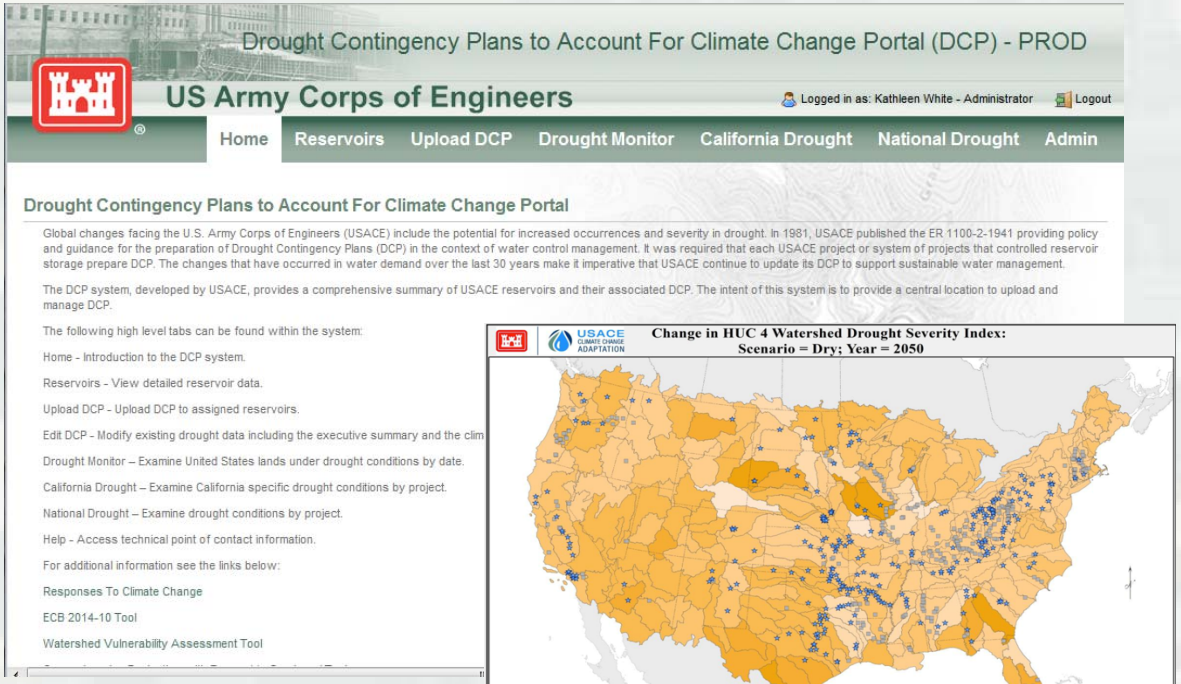
Courtesy Jeanne Roningen, CRREL

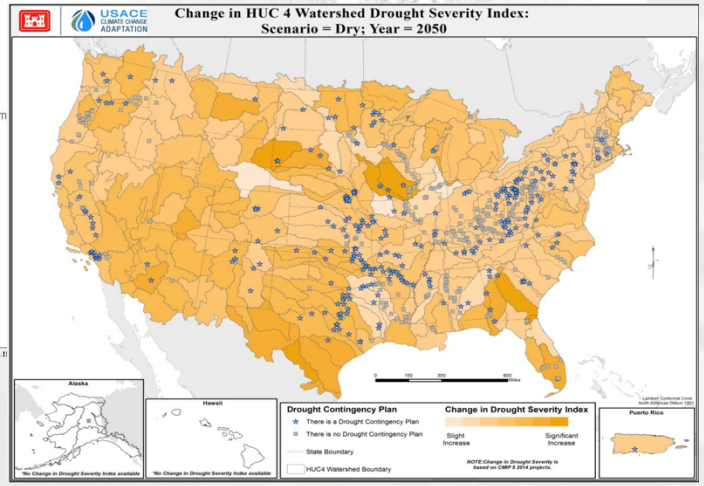
Basic Climate Preparedness and Resilience Concepts

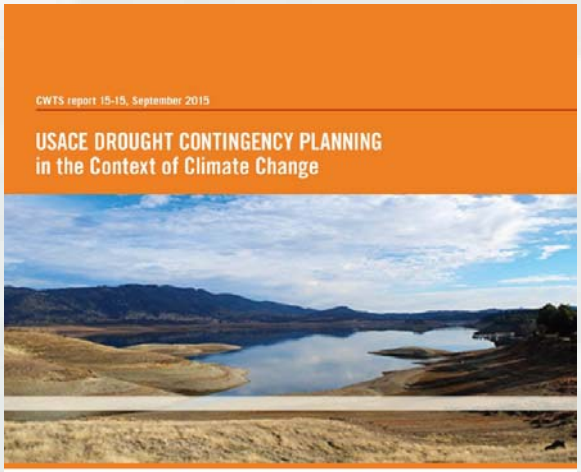
- Considerations for adaptation measures
  - Implications of approaches
  - Adaptation continuum
  - Long-range planning and implementation
- It's not all about extremes
  - Continued development in vulnerable areas
  - Potential changes in sea level and storm conditions
  - Constrained economic conditions
- Full portfolio of measures
  - Natural and Nature-Based
  - Nonstructural
  - Structural
  - Combinations

Adaptation Implementation: Updating Drought Contingency Plans to Account for Climate Change

- US National Climate Assessment : Increases in summer drought are likely across the northern tier, including the Northeast, Northwest and Alaska, while increases in drought are likely in the southern Plains, Southeast and Hawaii







Slide 29

U3 in or is? Changed to in

U4PAZSCL, 12/17/2015

Investigating Effects of Long-term Hydro-climatic Trends on Midwest Ice Jam Events

(Carr and Vuyovich 2014)

Under a changing climate:

- river ice regime will have increased risk and uncertainty
- studies have found that in temperate regions climate may exacerbate problems
- In recent years, communities in the Midwest U.S. have experienced long duration ice jam events that have resulted in flooding, damages and evacuations
- Found statistically increasing trends in discharge and precipitation, with no corresponding increase in winter period temperature
- Found a statistically significant increase in frequency of freezeup jams for most sites
- Future emergency management plans need to prepare to respond to the risk and impact of freezeup jams in areas where breakup jams were the norm

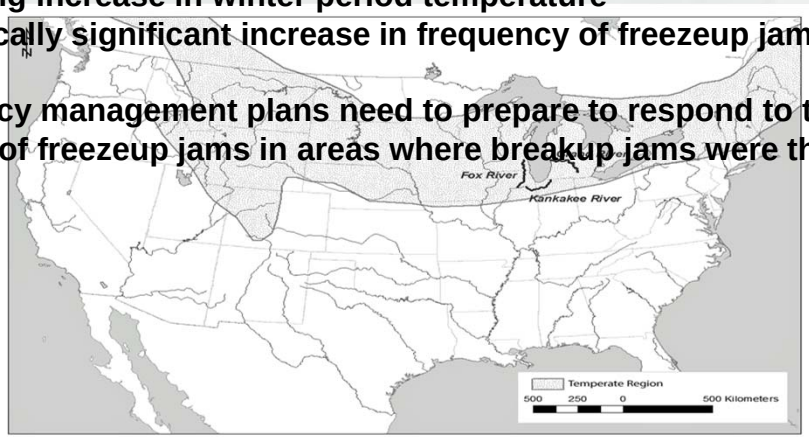


Fig. 1. Midwest study rivers. Temperate region shown in gray (based on Prowse et al., 2002).

Fox River at Dayton, IL

Kankakee River at Wilmington, IL

Grand River at Grand Rapids, MI

Questions?