The water, energy and food security nexus refers to the fact that the three sectors — water security, energy security and food security — are inextricably linked and that actions in one area more often than not have impacts in one or both of the others.

The nexus approach integrates management and governance across sectors and scales.

Actions should lead to improved ecosystem management that can provide multiple ecosystem services and increase overall benefits derived from them.

Hoff 2011 – Stockholm Environment Institute
CICS-MD challenges in the context of the Food-Energy-Water Nexus

- Increase in food production required to feed a world of 9 billion by 2050
- Increased dependence on food trade exposes countries to water stress impacts abroad

- Trade-offs between water and energy including integrated management of hydro and other renewables
- Regional cooperation needed to optimize hydropower in conjunction with other water uses

- Increased water demand from mushrooming cities
- Growing numbers of people and value of assets at risk from flooding

Courtesy of Fernando Miralles-Wilhelm
CICS-MD Topic areas

- Calibration / Validation
- Future Satellite Programs (JPSS and GOES-R)
- Data Fusion and Algorithm Development
- Surface Observing Networks
- Climate Research, Data Assimilation and Modeling
- Earth System Monitoring from Satellites
- Data Stewardship
- Land and Hydrology
- Climate Science to Support Policy, and Outreach

Earth System Monitoring from Satellites
CICS-MD has demonstrated its capacity to develop reliable satellite products and contribute on each of its topic areas to NOAA’s mission.

These products include components of the water, energy, and carbon cycles.

(e.g., precipitation, evapotranspiration, soil moisture, snow cover, vegetation, shortwave and longwave radiation, and much more)
Three questions three...

- What is the **consistency** of our products?
- What do we need to **monitor** the Earth System?
- How can we use our expertise to **train a workforce** that meets NOAA’s needs?
The Surface Water Balance

\[ \frac{\partial W}{\partial t} = P - E - N + RESW \]
The Surface Water Balance

(a) Residual of the surface water balance
\[ \frac{dW}{dt} = (P - E - N) \]

(b) Residual/Precipitation (%)

(c) \[ \frac{dW}{dt} = (P - E - N) \] Mississippi basin

Graphs showing spatial and temporal variations in water balance components.
The Surface Water Balance

<table>
<thead>
<tr>
<th>Basin</th>
<th>Ohio</th>
<th>Columbia</th>
<th>Colorado</th>
<th>Arkansas/Red</th>
<th>Missouri</th>
<th>Core Monsoon</th>
</tr>
</thead>
<tbody>
<tr>
<td>TSM</td>
<td>603.23</td>
<td>541.58</td>
<td>478.00</td>
<td>440.47</td>
<td>422.11</td>
<td>385.12</td>
</tr>
<tr>
<td>P</td>
<td>3.11</td>
<td>1.83</td>
<td>0.90</td>
<td>1.92</td>
<td>1.35</td>
<td>1.29</td>
</tr>
<tr>
<td>E</td>
<td>2.70</td>
<td>1.56</td>
<td>1.09</td>
<td>1.86</td>
<td>1.44</td>
<td>1.51</td>
</tr>
<tr>
<td>N</td>
<td>0.46</td>
<td>0.69</td>
<td>0.20</td>
<td>0.12</td>
<td>0.14</td>
<td>0.05</td>
</tr>
<tr>
<td>dW/dt</td>
<td>0.00</td>
<td>0.01</td>
<td>-0.01</td>
<td>0.00</td>
<td>0.00</td>
<td>-0.01</td>
</tr>
<tr>
<td>Res</td>
<td>0.05</td>
<td>0.42</td>
<td>0.39</td>
<td>0.06</td>
<td>0.23</td>
<td>0.26</td>
</tr>
<tr>
<td>E/P (%)</td>
<td>86.8</td>
<td>85.2</td>
<td>121.1</td>
<td>96.9</td>
<td>106.7</td>
<td>117.0</td>
</tr>
<tr>
<td>N/P (%)</td>
<td>14.8</td>
<td>37.7</td>
<td>22.2</td>
<td>6.3</td>
<td>10.4</td>
<td>3.5</td>
</tr>
</tbody>
</table>

mm day⁻¹
Develop a *consistent, long-term* dataset that fully represents the water cycle and hence facilitates hydro-climate research and applications.

With great potential uses for water resources, agriculture, GEWEX/WCRP ...
Ecosystems can be classified by their functional characteristics in relation to the amount and timing of the exchanges of matter and energy between the biota and the physical environment.
Ecosystem Functional Types estimated from NESDIS NDVI (16 km res)

Monitoring of EFTs is useful for:

- land management,

- estimating the anthropogenic influence on ecosystems

- as an alternative to Land Cover Types to characterize the dynamics of land surface-atmosphere interactions
Conversion from radiances to land cover types involves (Friedl et al. 2010):

- ensemble decision trees,
- sample bias correction, and
- training of results

(None of these aspects can be easily replicated.)

Friedl et al. (2010) report that the MODIS land cover data set has an overall accuracy of about 75% but “the range in class specific accuracies is large.”
The CICS-MD Summer Initiative series provides training and outreach opportunities for both graduate and undergraduate students.

It pairs students with mentors to conduct original scientific research and help train future NOAA scientists.

Students not only learn new tools but are already contributing to generate products with value to NOAA.

- About 20-25 students each summer; most UG
- 15 on-site; 9 off-site
- Also hosted a visit from the Howard University NCAS Weather Camp
- Two Hollings Scholars
• Began as a summer intern
• Continued at CICS-MD
• Graduated with a Masters degree
• Hired by Farmers Insurance as a natural catastrophe analyst

Dustin Shea
• Math student from Boston College.

• Created web displays of model/satellite data

• Recent graduate and now a DOD contractor
• Began as a summer intern
• Continued working at CICS-MD on her senior thesis
• Graduated with a Bachelors degree during Spring 2015
• Has interned at UMD for 3 years

• Studies MJO mechanisms for modulating P and T over the Americas.

• Won several awards; last summer he was a Hollings Scholar in Boulder, CO.

• Currently in Barcelona finishing his studies, and applying for Graduate Schools.
NOAA's proving grounds facilitate pre-deployment testing and operational readiness/suitability evaluation in operational proving grounds.

- **Planned Activities**
  - Receive National Weather Service feeds
  - Send and receive experimental products
  - Implement AWIPS-2, McIDAS-X, and WDSS-II
  - Train Students and Scientists on this software
  - Develop New Products and Visualizations

- **Support**
  - Support from GOES-R and JPSS Programs
  - University of Maryland Campus Visualization Partnership (CVP) Grant (Patrick Myers)
Three questions three...

- What is the consistency of our products?
- What do we need to monitor the Earth System?
- How can we use our expertise to train a workforce that meets NOAA’s needs?