Building a Better Scientist

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Microsoft Research

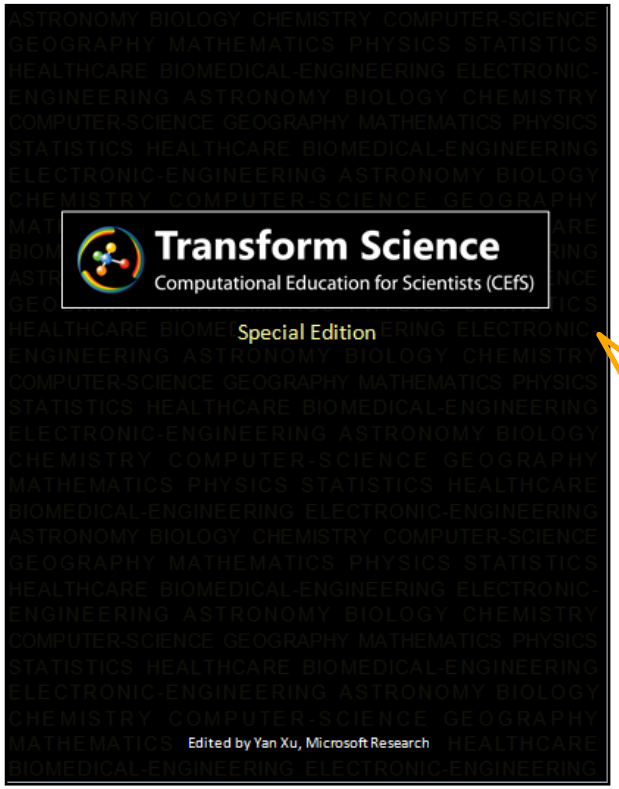
Microsoft Research (MSR)

- Founded in 1991
  - Staff of 750+ in over 55 disciplines
- International research teams
  - MSR Redmond, Cambridge, Asia, Silicon Valley, India, New England
- A "Safe house" for incubating technologies/ideas
  - Not bound to product cycles
  - Support long-term research in computer-science and eScience
- A environment for research collaboration
  - Sabbaticals, New Faculty Fellowships, Post-docs, interns
  - **External Research – collaborate with academia worldwide**

External Research at MSR

- Initiate collaborations with academia
  - Invest in emerging areas of research and education
    - Computational science
    - Socially relevant computing
    - Gender equality
  - Collaborate with universities worldwide
  - Cultivate next-generation academic thought leaders
- Transfer established research/education innovations
  - User community
  - Productization
  - Institution

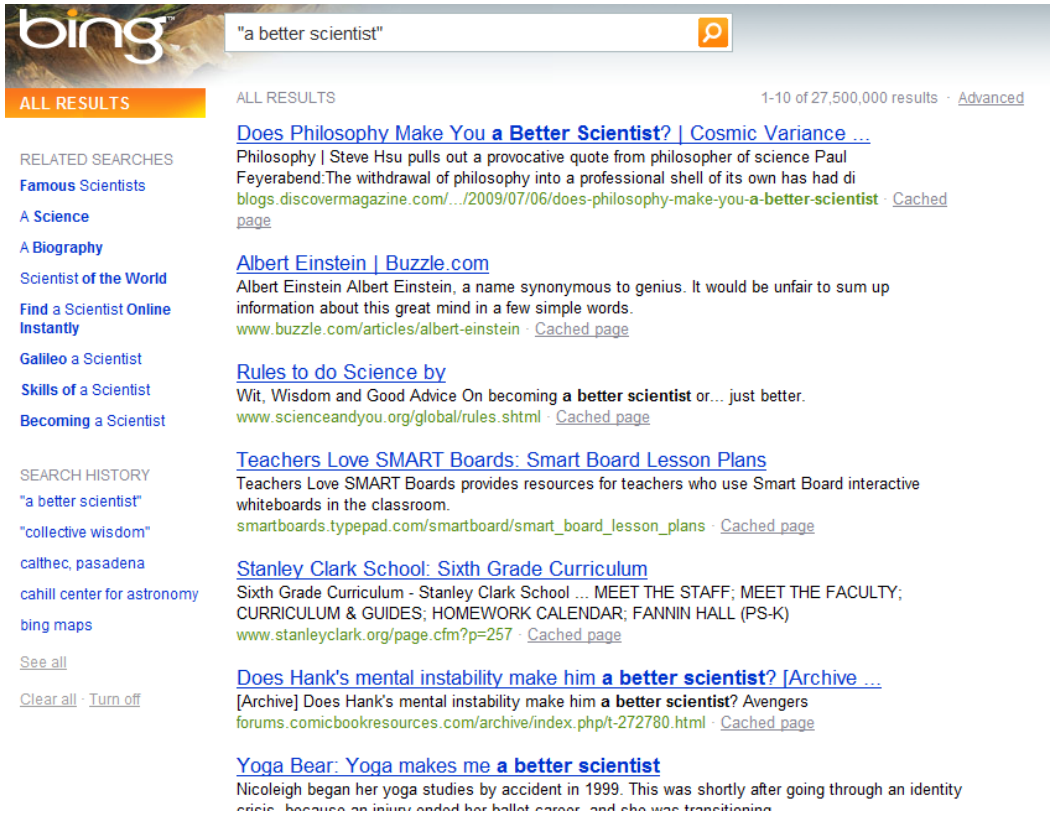
Building a Better Scientist - Computational Education for Scientists



A collective wisdom from 45+ scientists & educators in 15+ different disciplines

http://research.microsoft.com/transformscience/

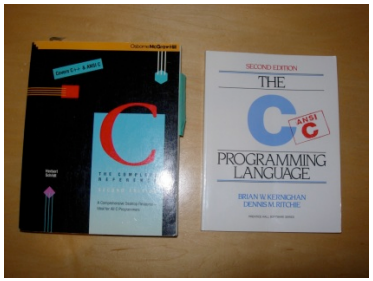
What makes a better scientist?



Knowing how to take advantage of computing technologies

What mindsets are out there?

- “My (science) students write computer programs themselves …”
- “I write lots of C code for my thesis work …”
- “I do script to test my models on computer …”
- “Do I have to care for performance? Not really…”
- “Our Fortran program works pretty well for the purpose…”
- “They are creating tomorrow’s dinosaurs!”
- “Their computational approach is to use us as their IT…”
- …



Computational Education for Scientists (CEfS)

– a Microsoft Research Initiative (2007)

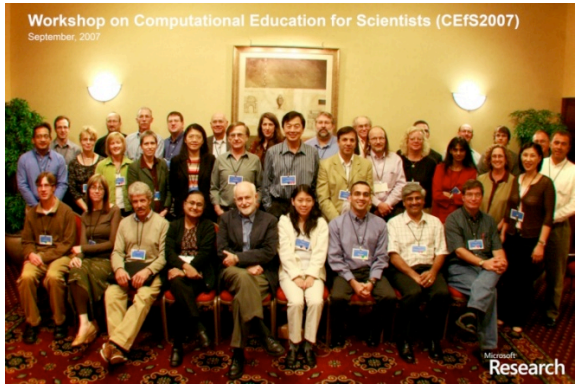
- **Vision**: Infuse computational skills into creating the new-generation scientists
- **Goals**:
  - Facilitate effective engagement of science education with Computer Science
  - Identify common computational education components
  - Set forth pedagogical strategies for curriculum innovation
- **Focus**
  - Build the missing link
    - Computationally challenged scientific research vs. Traditionally developed science curricula
  - Change mindset
    - this is not about teaching scientists how to code
    - This is about effective engagement of scientific research with Computer Science
  - Help decision makers to see the value in order to adopt
    - Assessment in curriculum innovation

Computational Education for Scientists

- **Pilot Projects**:
  - Problem-Based Learning (PBL) of Image Processing
    - Prof. May Wang, Biomedical Engineering, GaTech
    - Class of ~20: half from CS
    - Two students projects resulted in papers accepted by IEEE BIBE
  - Xbox Science – Xbox platform to teaching biology system visualization
    - Prof. Leonard McMillan, CS, UNC
  - Body sensor network for healthcare
    - Mario Gerla and Majid Sarrafzadeh, CS, UCLA
  - Defense Against the Dark Arts – Phoenix for anti-virus
    - Jack Davidson, UVA
    - Mark Bailey, Hamilton College
    - Jeff Zadeh, Virginia State University
  - .NET for Physics 111
    - Physics 111 lab, UC Berkeley, for all sciences and high school science teacher training

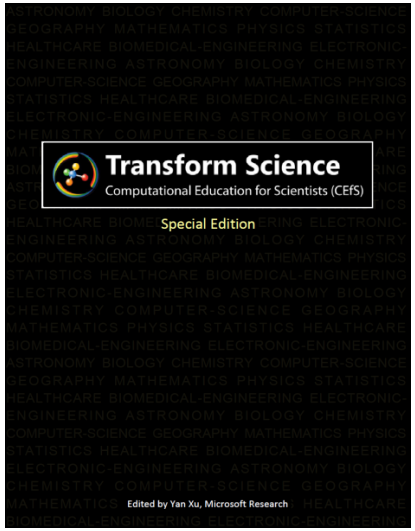
Computational Education for Scientists

- The Workshop on Computational Education for Scientists
  http://research.microsoft.com/workshops/CEfS2007
  - September 27-28, 2007, Redmond
  - Ground breaking event of CEfS
  - Position papers
  - 40+ attendees from 10+ disciplines
  - CS and non-CS pairs
  - Topics:
    - What to Teach – Computational thinking vs. Computing…
    - How to Teach – Pedagogical strategies…
    - How to Assess – Curriculum innovation & education assessment…



Computational Education for Scientists

- Call for Paper: CEfS – What to Teach?
  - 14 reports:
    - ✓ Vision v.s. practice
    - ✓ Collaborative teaching
    - ✓ Problem-based learning
    - ✓ Socially relevant education



		D0	D1.1	D1.2	D2.1	D2.2	D2.3	D2.4	D3	D4	D5.1	D5.2	D6	D7	D8
		(All Disciplines)	Astronomy	Physics	Biology	Biomedicine	Healthcare	Life Science	Chemistry	Earth Science	Mathematics	Statistics	(others)	Social Science	Liberal Arts
A1	Database Design		3	2	2	2		2	1	1			1	1	
A2	Data Mining		3	2	4	3		3	2	1			1	1	
A3	Digital Signal Processing			2	2	2	2					1		1	
A4	Embedded System						1						1		
A5.1	HPC		3	3	2	2	2	2	2	2				2	
A5.2	Parallel Programming		**5**	**5**	**5**	4	3	4	4	3			2		
A6	Machine Learning		3	3	4	3	1	2	2	1			1	1	
A7	Modeling/Simulation		**6**	4	**7**	3	2	4	4	2	1		1	2	1
A8.1	Software Security		1	1	1	1	1	1	1	1			1		
A8.2	Privacy														
A9	Visualization		3	4	**6**	3	1	3	1	1	1		1	1	
A10	Workflow Management		3	3	2	3	1	2	2	2			1	2	1
A11	*Com. Complexity ...	1													
A12	Interaction Design		1		1			1			1			1	1
A13	Web/Grid Services		1												
A14	(others)		1	1	1	1	1	1	1	1			1		
A15	CS Pedagogy		1	1	1			1			1			1	1
		7													
A16	CEfS Investigation		1	1				1			1				
		4													

Computational Education for Scientists

- Call for Paper: CEfS – What to Teach?
  - A compelling example:

Quantitative MRI Reconstruction

Wen-mei Hwu (UIUC) & David Kirk

http://courses.ece.illinois.edu/ece498/al/textbook/Chapter7-MRI-Case-Study.pdf

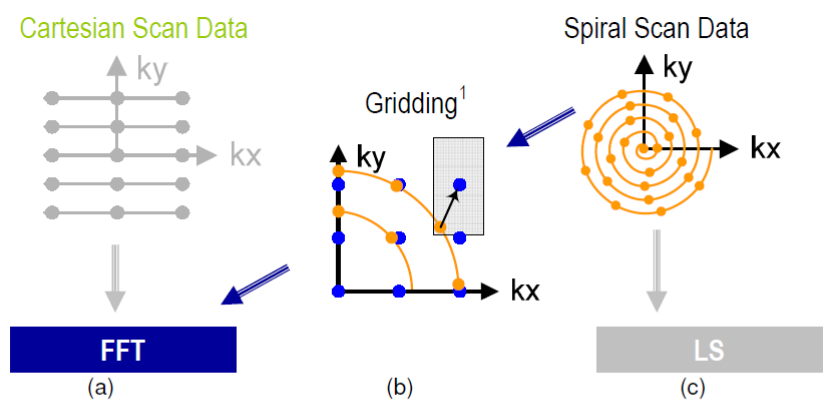


Figure 7.1. Scanner k-space trajectories and their associated reconstruction strategies: (a) Cartesian trajectory with FFT reconstruction, (b) Spiral (or non-Cartesian trajectory in general) followed by gridding to enable FFT reconstruction, (c) spiral (non-Cartesian) trajectory with linear solver based reconstruction.

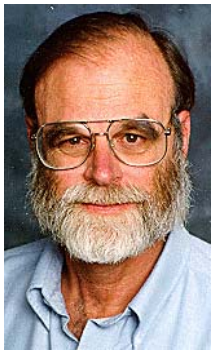
Computational Education for Scientists

- an example of problem & solution

Astronomy & Computing

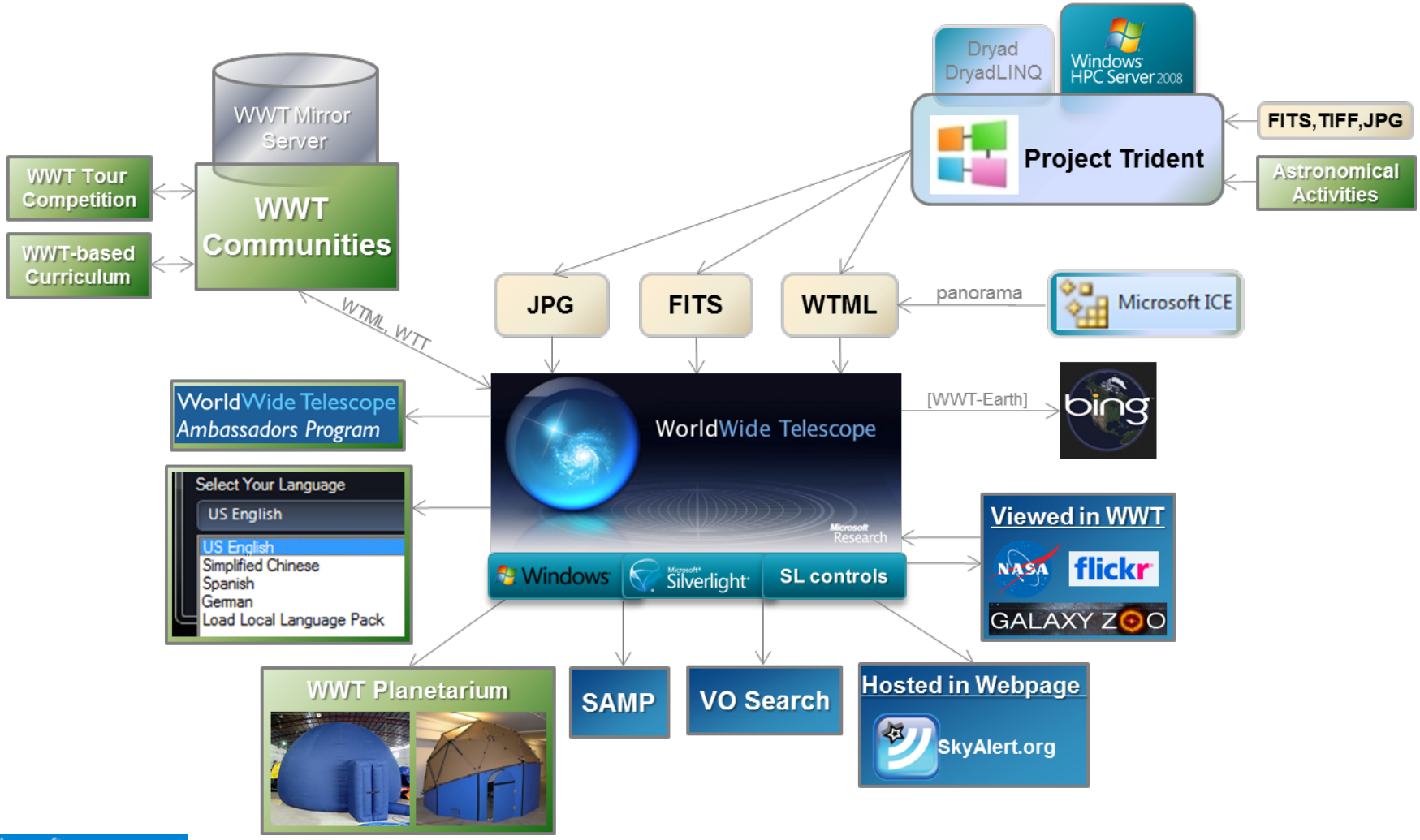
- Transforming from Observational to experimental
- Facing exponential growth of data volume and complexity
- Engaging with computer-science (VO, digital sky survey, etc.)
  - Provided a stage for computing innovation, such as

WorldWide Telescope



- Microsoft Research WorldWide Telescope (WWT)
  - A computational science innovation
    - Started 10 years ago Jim Gray and scientists at JHU
    - Enables a PC to function as a virtual telescope
    - Sets a new standard in presenting large data sets
  - A one-stop research/education platform
    - Aggregate scientific data from major telescopes, observatories, and institutions.
    - Make temporal and multi-spectral studies available through a single cohesive Internet–based portal
    - Enhance connections among professional astronomers, educators, and the amateurs.
    - Facilitate historical and cultural astronomy research and science outreach
  - A giant case study of CS collaborating with domain science
    - Implement computational challenges in real-world (universe)
    - Leverage the power of virtualization - extending science to the beyond

WorldWide Telescope

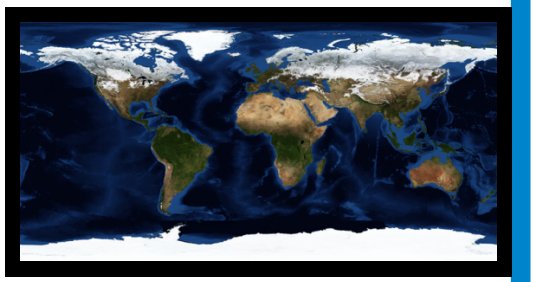


WorldWide Telescope

An end-to-end data process/visualization example

NASA Blue Marble Images:

- From a collection of satellite-based observations
- With terrestrial, oceanic, and atmospheric features of the Earth
- The most detailed true-color images of the entire Earth
- Monthly images of 2004: 500m/pixel, 20k x 10k pixel



WWT (Microsoft Research WorldWide Telescope)

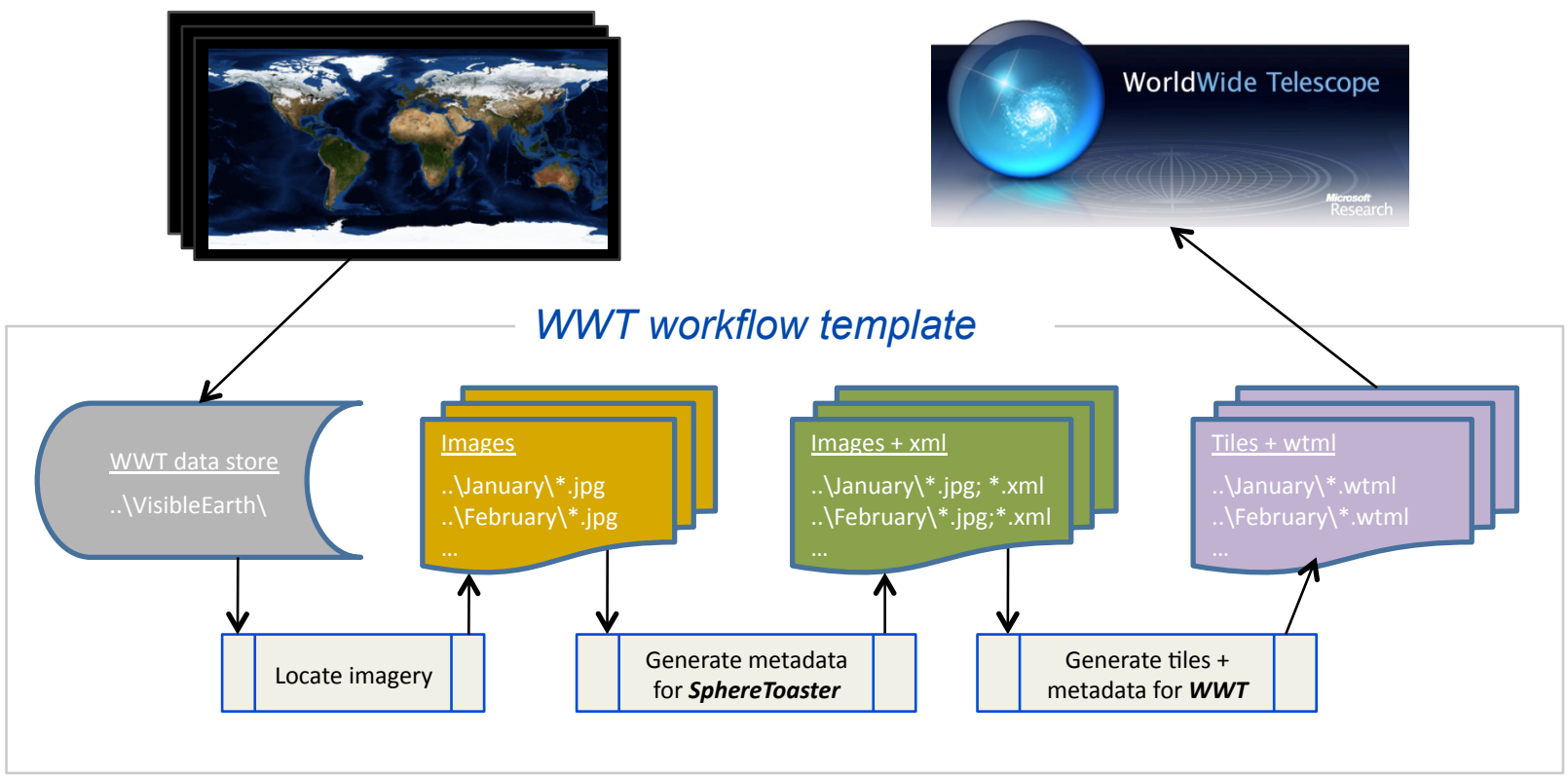
- Enabling a computer to function as a telescope
- 3D views of sky objects
- Knowledge-base behind visualization
- XML based tools for integration
- Free for non-commercial use

  http://www.worldwidetelescope.org

WorldWide Telescope

An end-to-end data process/visualization example (cont.)

Data Process



WorldWide Telescope

- Stimulate computational practice in Astronomy
- Bridge the gas between astronomical research and education
  - Revolutionize astronomical information authoring and publishing
  - Enhance Astronomy 101
  - Bring planetarium into classroom
  - Provide a gateway to introduce students to other technologies
- Outreach to international communities
  - e.g. WWT at the total Solar eclipse 2009
- In classrooms
  - WWT-based teaching & Learning at CCNU

"I think WorldWdie Telescope is an example of where science and science education should be going" Alyssa Goodman

Computational Education for Scientists

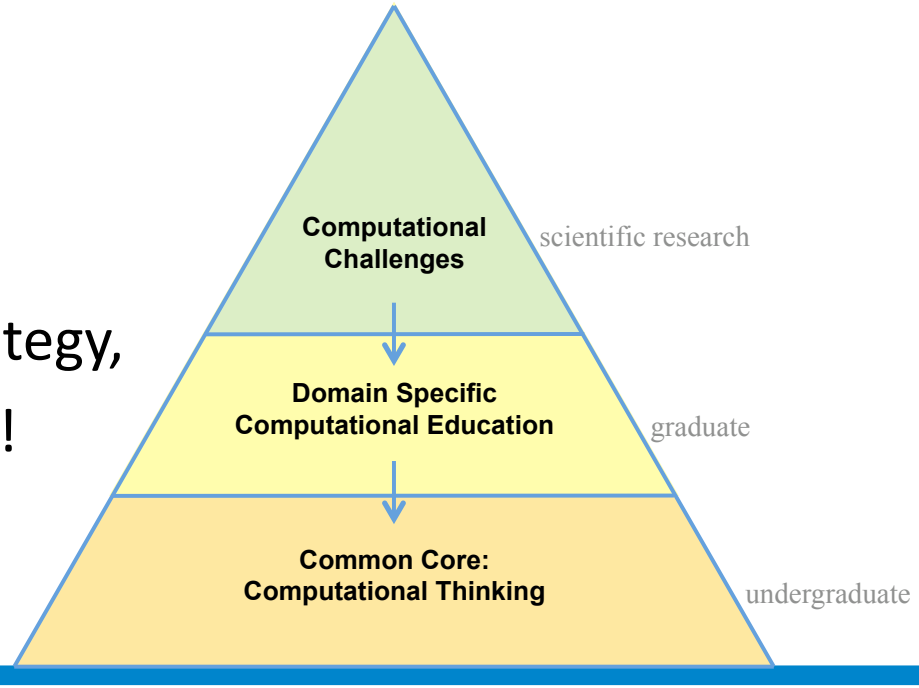
What's next?

Original agenda:

- What to Teach – Computational thinking vs. Computing…
- How to Teach – Pedagogical strategies…
- How to Assess – Curriculum innovation & education assessment…

A Top-Down Strategy,

a long-way to go!



Questions?