The Future Workforce of Numerical Weather Prediction

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Topics:

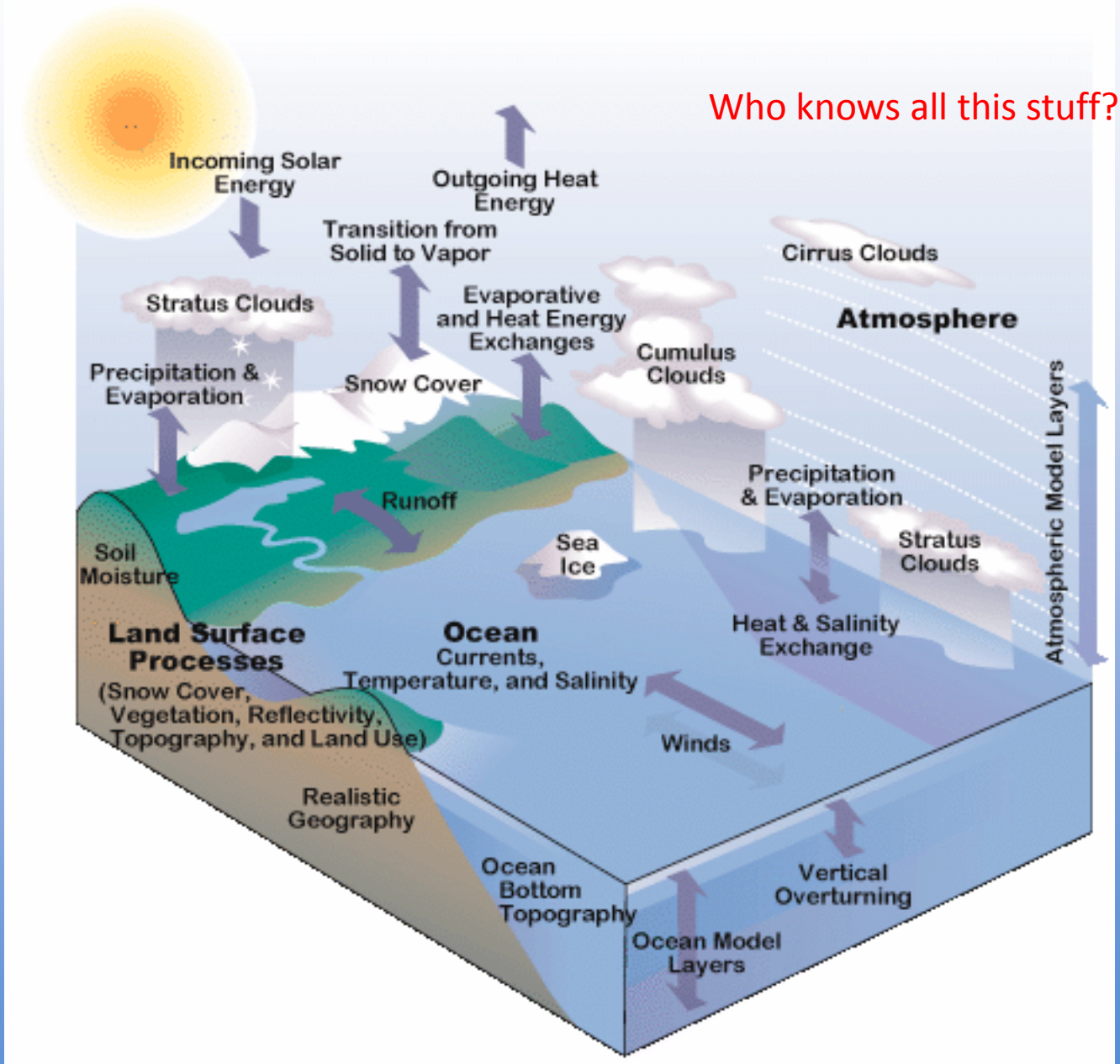
Depth vs. Breadth

Knowledge vs. Skill

One vs. Many

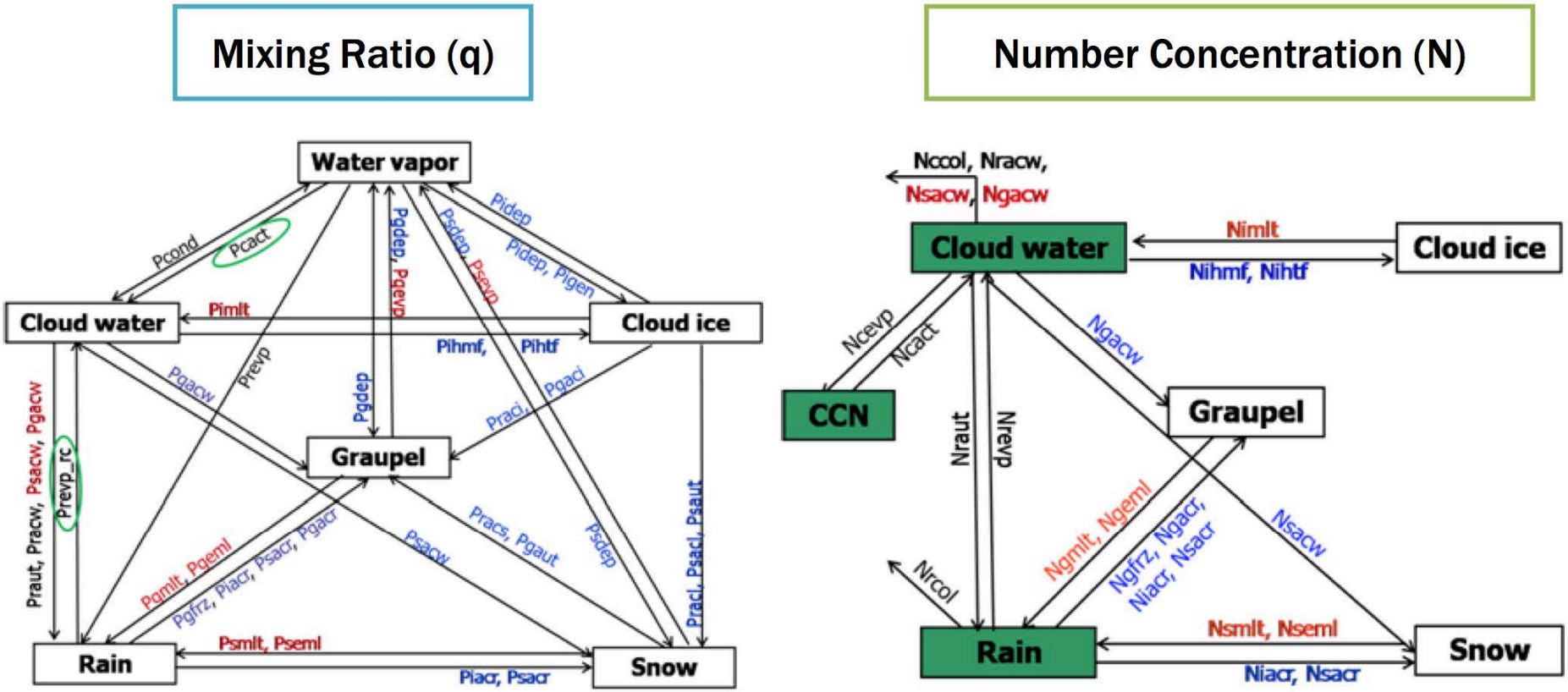
Diversity

Complexity of Models



A Simple Microphysics Scheme

Flowchart of the microphysics processes in the WDM6



Model Errors

- The problem with models is that they are nearly as complicated as the real atmosphere (earth system) but models may be totally wrong.
- Figuring out the source of errors
  - Reductionist approach: reproduce the essence of the error in a simple framework (Sherlock Holmes)
  - Expansionist approach: collect truckloads of data to improve signal to noise and increase the “obviousness factor” (EarthCube)
- Assertion: Graduates (Ph. D.s) often lack the skills to get at the root of model errors.

Simple Approach to Model Diagnostics

1. The cumulus parameterization is always wrong
2. If you think the cumulus parameterization is not the problem, see above
3. If you are not running a cumulus scheme, substitute “microphysics”; goto 1

Knowledge vs. Skill

- Workforce must:
  - Have an “investigative intuition” about how to interrogate a model and find its weakness.
  - Requires advanced knowledge of a range of physical processes and numerical treatments.
  - Not the same as computer science skills needed to run models.
  - Does Ph. D. emphasize model investigation enough? EarthCube should enable this.

Data Assimilation

- Highly technical field; difficult to find people with knowledge of both modeling and data assimilation
- Need to attract talent from other fields; meteorologists want to do meteorology
- Combined with complex models, signifies the need for a “team” approach; how does the Ph. D. student fit into this?

One “versus” Many

- The unit of science recognition is “one”
  - Ph. D.
  - Tenure/promotion
  - Professional societies shun team awards
- The practical implementation takes “many”
- Early-career atmospheric scientists are generally not used to working in teams
- How can we maintain individual satisfaction in the reality of an increasingly team-oriented enterprise? Can EarthCube help?

Depth vs. (and?) Breadth

- Modeling and data assimilation each require exceptional knowledge base: breadth
- Ph. D. usually requires deep knowledge of a small subset: depth
- How can we ensure these are complementary?
- Apprentice or scholar?

Software Engineering Expertise

- Crucial for any large problem
- Fixed or reduced budgets: tradeoffs in hiring
- University departments (often) have minimal access to expertise
- Labs: difficulty of attracting talent away from private sector
- How much does a physical scientist need to know?
- What do we do with all this Fortran?

Tapping a Diverse Population

TABLE 1. Federal scientists and engineers, by sex and race/ethnicity: 2000–09

(Percent)

Year	All federal scientists and engineers (number)	Sex		Race/ethnicity					
		Female	Male	White	Asian/Pacific Islander	Black	Hispanic	American Indian/ Alaska Native	Unknown
2000	187,396	21.2	78.8	82.0	7.7	5.8	3.7	0.9	0.1
2001	193,448	22.0	78.0	81.5	7.8	5.9	3.7	0.9	0.1
2002	206,182	22.9	77.1	80.8	8.1	6.2	3.9	0.9	0.1
2003[a]	206,620	23.9	76.1	80.5	8.3	6.1	3.9	0.9	0.2
2004[a]	209,994	24.5	75.5	80.2	8.4	6.3	4.0	0.9	0.1
2005[a]	209,747	24.9	75.1	79.8	8.6	6.4	4.2	0.9	0.1
2006	215,929	25.7	74.3	79.3	8.8	6.8	4.1	0.9	0.1
2007	219,383	26.2	73.8	78.7	8.8	7.2	4.3	0.9	0.1
2008	223,189	26.8	73.2	78.2	9.1	7.5	4.3	0.9	0.1
2009	235,110	27.2	72.8	77.7	9.1	7.8	4.4	0.9	0.1

[a] Data for 2003 to 2005 were obtained from two sources—the Defense Manpower Data Center for Department of Defense agencies and from the Central Personnel Data File (CPDF) of the Office of Personnel Management—and may not be strictly comparable to data for other years. Total includes unknown sex not shown separately.

NOTE: Percentages may not add to 100% due to rounding.

SOURCE: National Science Foundation/Division of Science Resources Statistics, tabulations from data provided by the Office of Personnel Management.

Tapping a Diverse Population

Hispanic or Latino origin and race	2010		Change 2000-2010
	Number	Percentage of total population	Percent
HISPANIC OR LATINO ORIGIN AND RACE			
Total population	**308,745,538**	**100.0**	**9.7**
Hispanic or Latino	50,477,594	16.3	43.0
Not Hispanic or Latino	258,267,944	83.7	4.9
White alone	196,817,552	63.7	1.2
RACE			
Total population	**308,745,538**	**100.0**	**9.7**
One Race	299,736,465	97.1	9.2
White	223,553,265	72.4	5.7
Black or African American	38,929,319	12.6	12.3
American Indian and Alaska Native	2,932,248	0.9	18.4
Asian	14,674,252	4.8	43.3
Native Hawaiian and Other Pacific Islander	540,013	0.2	35.4
Some Other Race	19,107,368	6.2	24.4
Two or More Races[1]	9,009,073	2.9	32.0

Growth in Fed science < 20%

Summary

- Increasingly complex modeling systems
  - Require vastly more broad knowledge
  - Potentially limit deep understanding
  - This is where EarthCube can and should help
- Team approach
  - Analogy with particle physics?
  - Individual goals versus large-problem realities
- Diversity: some gains; many shortcomings