Reducing Uncertainties in National Smoke Emissions Modeling as Applied in the BlueSky Framework

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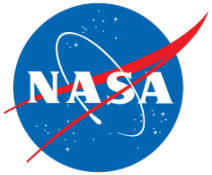
For presentation at the
Public Health and Air Quality Applications Program Review
Newport, Rhode Island

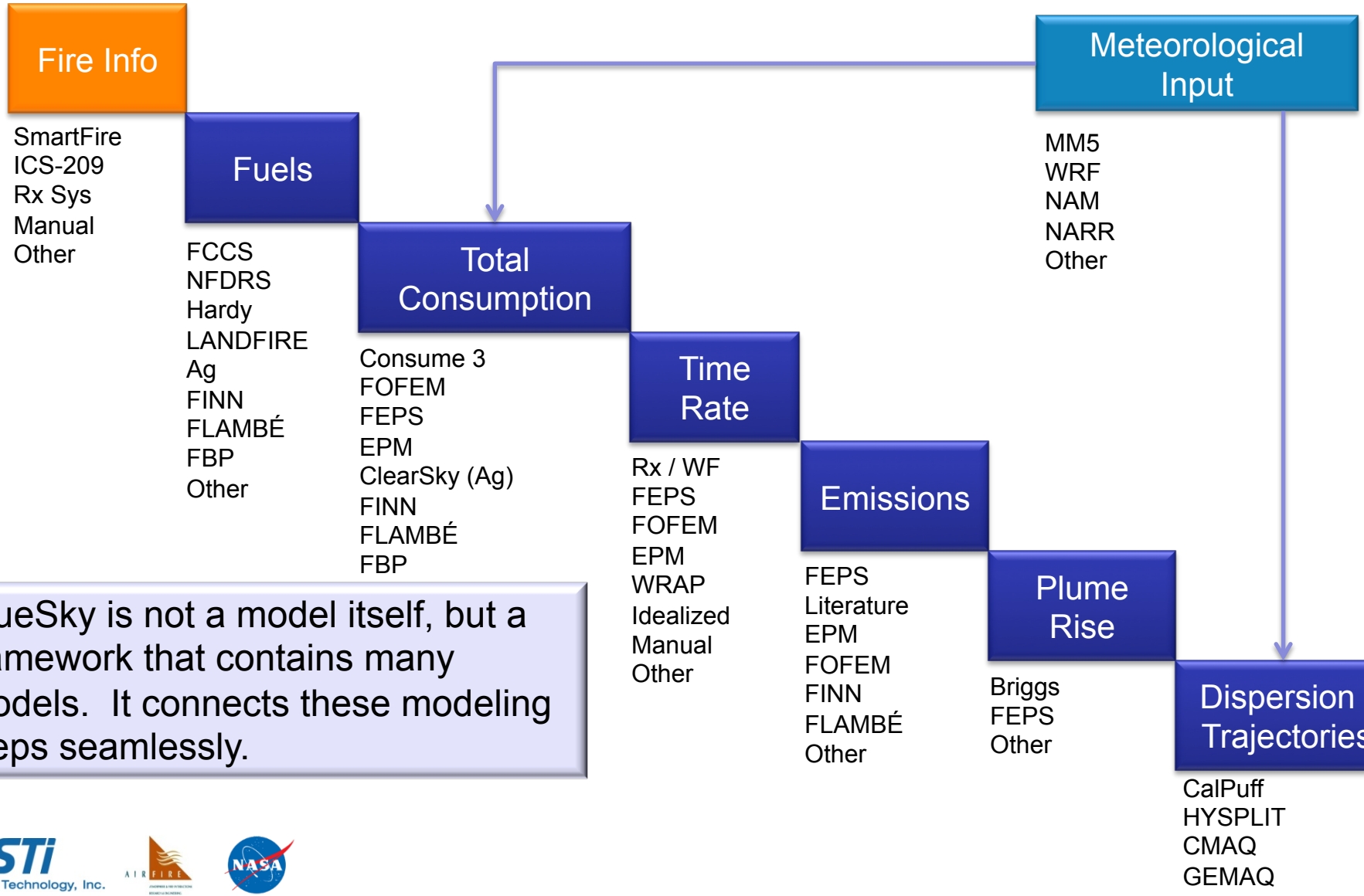
September 19, 2012



What Are the BlueSky Systems?

- BlueSky Framework and SmartFire
  - Decision-support systems (DSS): (1) a modeling framework and (2) a fire information processing and reconciliation system
  - Function: facilitate modeling of the air quality and climate impacts of smoke and fire
- Examples of decisions supported include
  - Air quality management (prescribed burning: burn/no-burn)
  - Air quality forecasting (public health: air quality alerts)
  - Forest management (prescribed burn mid- to long-range planning)
  - National emissions inventory (climate change, National Ambient Air Quality Standards [NAAQS])
  - And others: research, incident command, interdisciplinary collaboration with other DSS

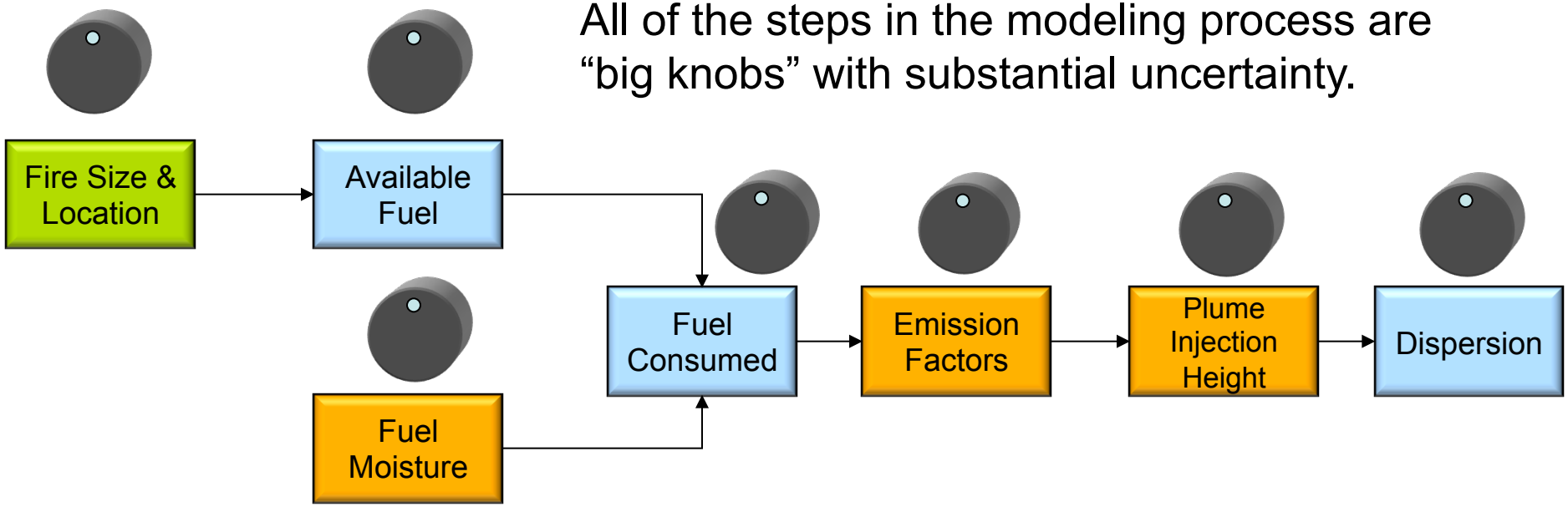
The BlueSky Smoke Modeling Framework



BlueSky is not a model itself, but a framework that contains many models. It connects these modeling steps seamlessly.

Project Objective: Reduce Key Uncertainties and Information Gaps

All of the steps in the modeling process are "big knobs" with substantial uncertainty.



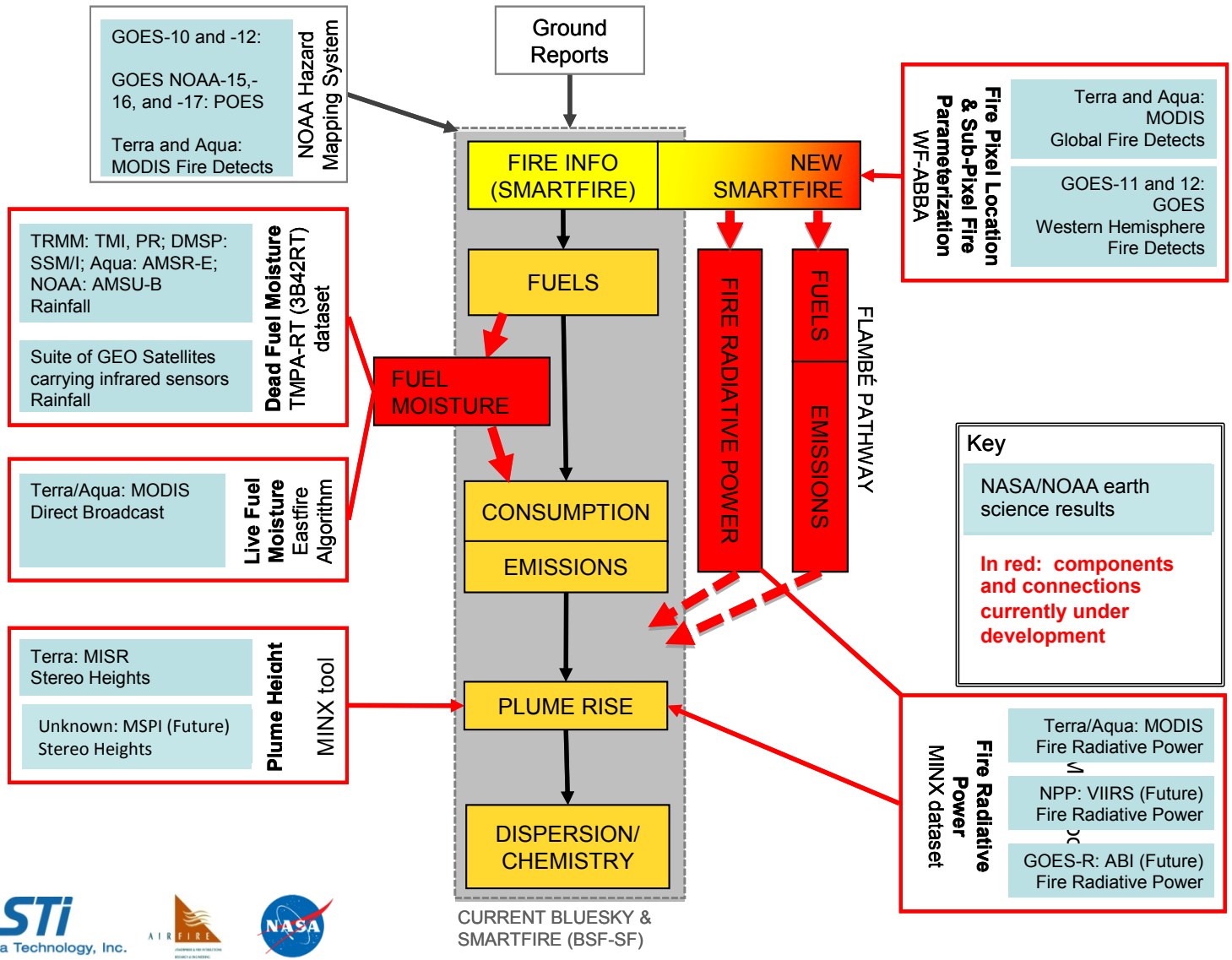
Addressed by previous NASA ROSES (2006–2009)

Addressed by current project (new or improved modules)

Other modeling steps

ROSES: NASA's Research Opportunities in Space and Earth Sciences program

Overview of NASA Earth Science in BlueSky



TRMM (Tropical Rainfall Measuring Mission)

MODIS (Moderate Resolution Imaging Spectroradiometer)

MISR (Multi-angle Imaging Spectroradiometer)

MINX: MISR Interactive Explorer

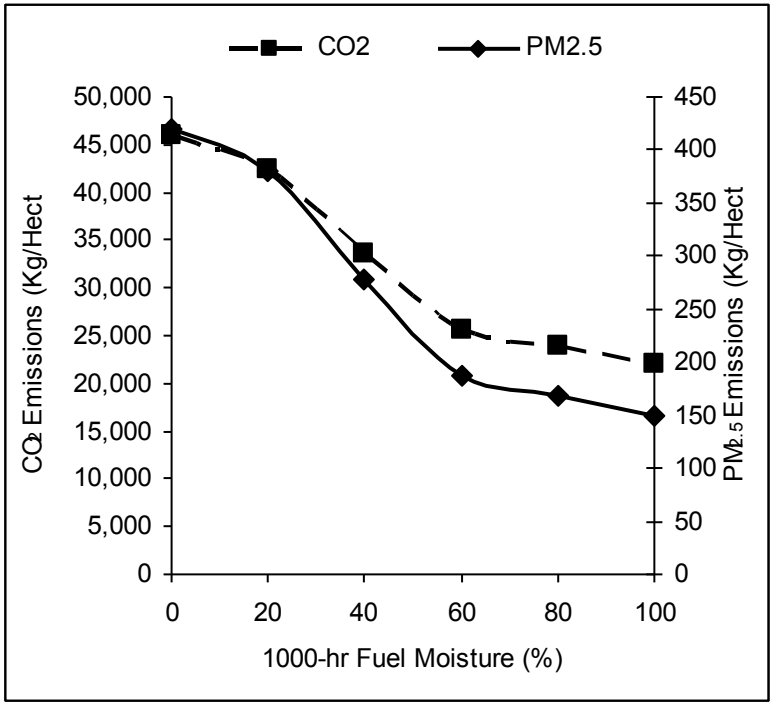
Follow-on:

- NPP–VIIRS
- GPM

Earth Science Data Sources and Expert Collaborators

- TRMM Multisatellite Precipitation Analysis (TMPA)
  - Dead fuel moisture
  - George Huffman (NASA), collaborator
- EastFIRE live fuel moisture content retrieval data set
  - Live fuel moisture
  - John Qu and Xianjun Hao (George Mason University), co-investigators
- MINX
  - Plume injection height
  - David Diner (NASA), collaborator
- Fire Locating and Modeling of Burning Emissions (FLAMBÉ)
  - Emission factors
  - Ed Hyer (Naval Research Laboratory), collaborator

Dead Fuel Moisture

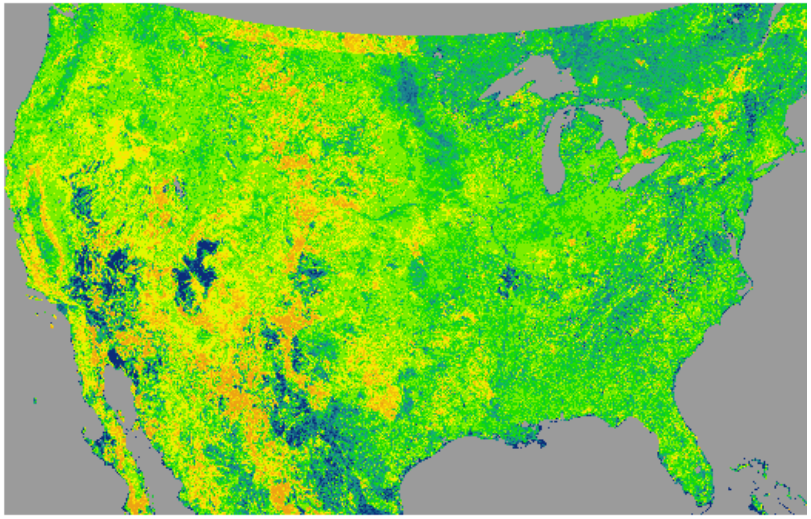


- Dead fuel moisture content (DFMC) directly influences modeled emissions (i.e., greenhouse gases, fine particulate matter [$PM_{2.5}$]).
- BlueSky previously defaulted to static DFMC (absent user-supplied values).

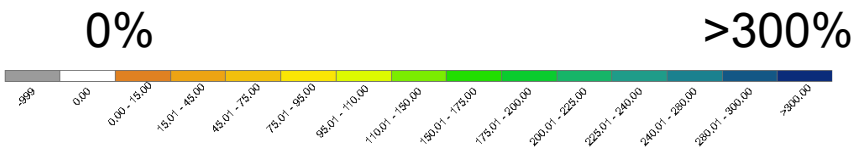
Improvement

- Calculate dynamic DFMC default values over contiguous United States using daily real-time precipitation data from **TMPA** real-time data set.

Live Fuel Moisture



Example: daily LFMC image for July 4, 2008.



- Live fuel moisture content (LFMC) affects fire intensity, rate of spread, and duration, all of which affect pollutant concentrations and transport.
- BlueSky previously defaulted to the static DFMC for large woody fuels (absent user-supplied LFMC).

Improvement

- Use **EastFIRE Lab's** data products to provide dynamic estimation of LFMC at 1-km spatial resolution.

Plume Injection Height

- Plume rise models were designed for industrial sources (e.g., Briggs equation).
- A high degree of uncertainty arises when applying these models to smoke plumes from fires.

Improvement

- MINX and MODIS data were used to develop a plume-rise data set (continuous from 2000). That data set was used to develop adjustments to the plume rise models used in BlueSky.

  Analyses led by Fok-Yan Leung, Washington State University (WSU).

Alternative Emissions Models

- BlueSky lacked fuelbed data outside the United States.
- Methods to calculate smoke emissions outside the United States will facilitate North American emissions inventories and modeling of transboundary smoke transport.

Improvements

- Implement parts of the FLAMBÉ program to estimate emissions globally:
  - WF_ABBA (area burned)
  - Global fuels database
  - FLAMBÉ emissions pathway
- Incorporate MODIS Fire Radiative Power (FRP) pathway.

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Image source: http://trendsupdates.com/wp-content/uploads/2009/04/forest-fires-smoke.jpg

Summary Status Assessment

- Analyses of plume rise and fire radiative power were challenging, but are being wrapped up.
- Despite delays, project goals are still on track to be met by the end date.
- Key accomplishment: development of modules.
- New modules developed under current NASA ROSES project will be integrated with existing BlueSky systems at Technology Readiness Level for Applications (TRL-A) Levels 7–9 by project conclusion:
  - Fuel moisture modules (9)
  - Plume rise algorithm (9)
  - FLAMBÉ emissions model (9)
  - FRP emissions (7 or 8)

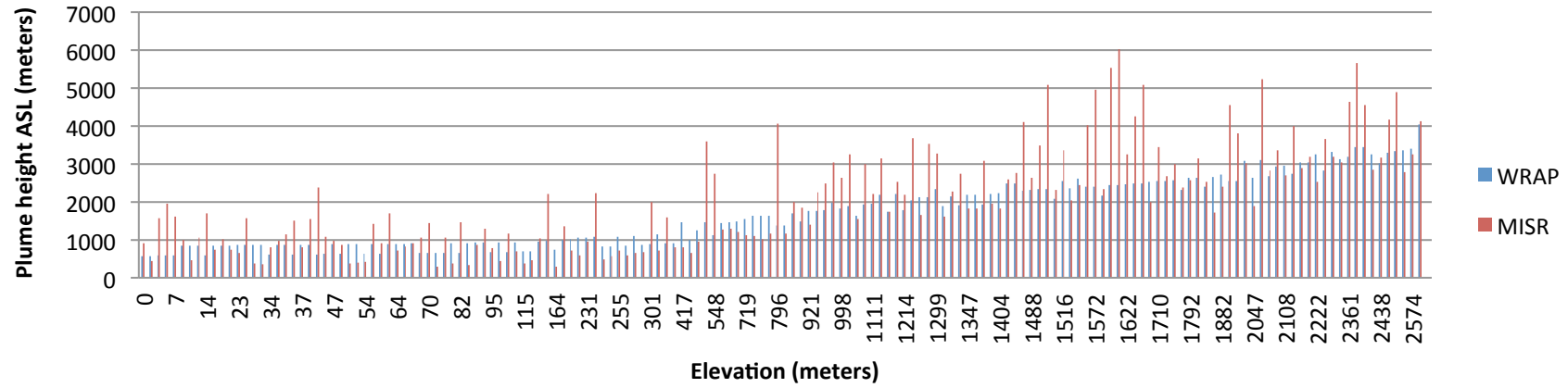
Technology Readiness Level for Applications (TRL-A)

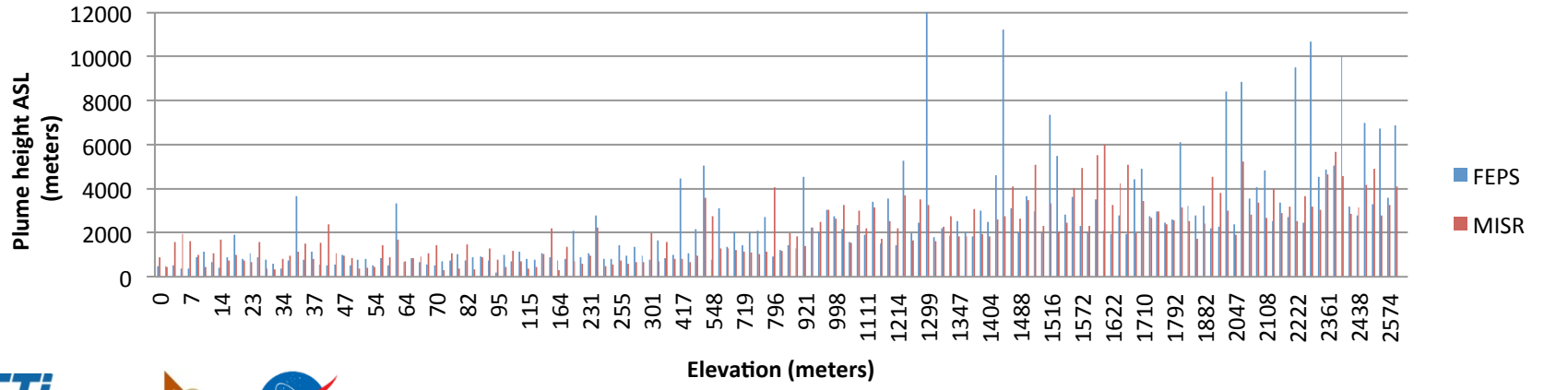
- BlueSky Framework and SmartFire were at TRL-A Level 9 before project start—i.e., approved, in operational deployment, and in use for decision making (by U.S. Environmental Protection Agency [EPA], USDA Forest Service [USFS], other agencies).
- The new modules and algorithms for BlueSky, developed under the current ROSES project, began at various TRL-A Levels:
  - Fuel moisture modules — Level 3: Proof of Concept
  - Plume rise algorithm — Level 3: Proof of Concept
  - FLAMBÉ emissions model — Level 6: Demonstration in Relevant Environment
  - FRP emissions model — Level 3: Proof of Concept
- Currently, new modules are at TRL-A levels 5–7 and are projected to be at levels 7 (prototyped), 8 (completed and qualified), or 9 (approved and deployed) by the project end (September 2013).

Summary Status Assessment

Quantifiable improvements to modeling results were made.

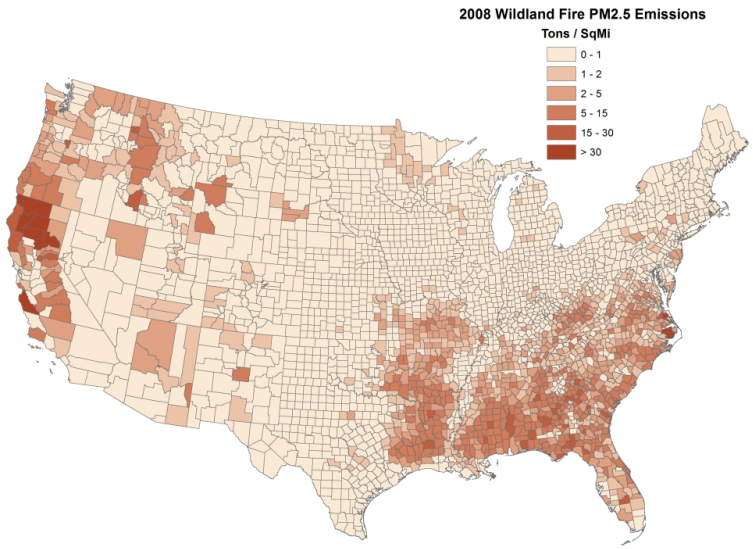
Sample illustration: Comparison of observed (MISR) and plume heights as previously modeled (WRAP or FEPS).



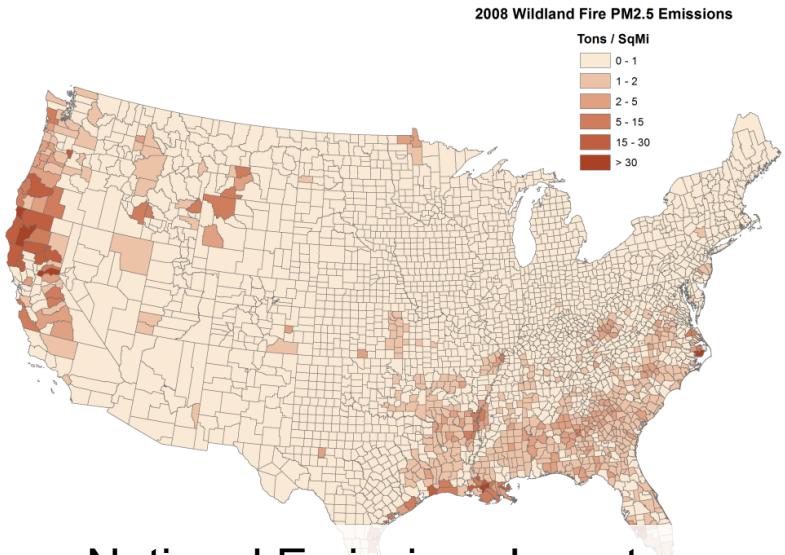


Summary Status Assessment

Sample illustration: Results from new emissions pathways vary from prior methods, but within the range of uncertainty that is typical for the present time (a factor of 5 to 10) and with the ability to cover new regions.



FLAMBÉ Emissions Pathway



National Emissions Inventory (NEI) Emissions Pathway

Year	Area (acres)			PM2.5 (tons)		
	NEI Path	FLAMBE	Ratio (%)	NEI Path	FLAMBE	Ratio
2008	14,814,841	14,473,993	98%	2,597,043	5,937,409	2.3
2009	17,326,747	17,291,675	100%	1,376,974	5,446,343	4.0

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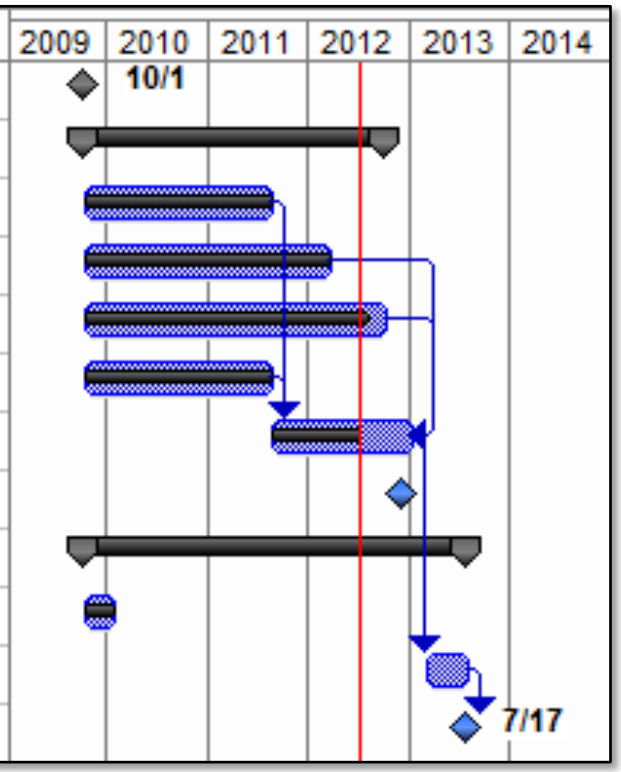
Schedule

Key next steps: benchmarking and socioeconomic benefits studies.

Task Name
Project Initiation
Analyses
Task 1: Dead Fuel Moisture Content
Task 2: Live Fuel Moisture Content
Task 3: Plume Rise and Fire Radiative Power
Task 4: Incorporate Flambe' with BlueSky
Implementation & Quantitative Benchmarking
Systems Documentation
Qualitative Benchmarking (Surveys)
Initial Measurement
Final Measurement
Benchmark Final Report



Budget Status

PY12					
Institution	Budget	Obligated	Unobligated	Costed	Uncosted
Sonoma Technology, Inc.	54,937	-	54,937	-	54,937
George Mason University	-	-	-	-	-
Washington State University	35,000	-	35,000	-	35,000
Population Research Systems	-	-	-	-	-
USFS	21,348	-	21,348	-	21,348

PY11					
Institution	Budget	Obligated	Unobligated	Costed	Uncosted
Sonoma Technology, Inc.	271,812	271,812	-	120,516	151,296
George Mason University	-	-	-	-	-
Washington State University	116,745	116,745	-	36,838	79,907
Population Research Systems	90,000	90,000	-	-	90,000
USFS	83,740	83,740	-	-	83,740

PY10					
Institution	Budget	Obligated	Unobligated	Costed	Uncosted
Sonoma Technology, Inc.	115,657	115,657	-	115,657	-
George Mason University	43,000	43,000	-	43,000	-
Washington State University	102,554	102,554	-	102,554	-
USFS	102,936	102,936	-	90,000	12,936

PY09					
Institution	Budget	Obligated	Unobligated	Costed	Uncosted
Sonoma Technology, Inc.	159,563	159,563	-	159,563	-
George Mason University	29,000	29,000	-	29,000	-
Washington State University	84,633	84,633	-	84,633	-
USFS	99,045	99,045	-	99,045	-

Thank You

Our Co-Investigators: Fok-Yan Leung (WSU); John Qu and Xianjun Hao (EastFIRE Lab, George Mason University)

Funding from National Fire Plan, USDA Cooperative State Research, Education, and Extension Service's (CSREES) National Research Initiative, USFS, Joint Fire Science Program, EPA, U.S. Department of the Interior, and NASA.

Our many collaborators and partners, including Mark Ruminski (National Oceanic and Atmospheric Administration's Hazard Mapping System); Amber Soja (National Institute of Aerospace); Tom Pace (EPA); Pete Lahm (USFS); Susan O'Neill (Natural Resources Conservation Service); and Tweak Software.

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