Future of smoke science

Sim Larkin
U.S. Forest Service AirFire Team
Seattle, Washington

Smoke Forum
Halifax
October 10, 2014

photo: wildfire

What's possible in say... 10 years

IF A RESEARCHER SAYS A COOL NEW TECHNOLOGY SHOULD BE AVAILABLE TO CONSUMERS IN...

WHAT THEY MEAN IS...

THE FOURTH QUARTER OF NEXT YEAR	THE PROJECT WILL BE CANCELED IN SIX MONTHS.
FIVE YEARS	I'VE SOLVED THE INTERESTING RESEARCH PROBLEMS. THE REST IS JUST BUSINESS, WHICH IS EASY, RIGHT?
TEN YEARS	WE HAVEN'T FINISHED INVENTING IT YET, BUT WHEN WE DO, IT'LL BE AWESOME.
25+ YEARS	IT HAS NOT BEEN CONCLUSIVELY PROVEN IMPOSSIBLE.
WE'RE NOT REALLY LOOKING AT MARKET APPLICATIONS RIGHT NOW.	I LIKE BEING THE ONLY ONE WITH A HOVERCAR.

xkcd.org/678

Issues

Need to:

- Characterize fire emissions better.

Also:

- Better capture fire occurrence and fire growth
- Better resolve terrain
- Better diurnal profile models
- Better plume schemes
- Bring chemistry models into ensemble daily runs

Structural issues with smoke modeling

Garbage in, garbage out

But, there are a lot of inputs in smoke models:

- Weather forecasts
  - Vertical structure (mixing height, etc…)
  - Transport direction
- Fire information
  - Location, size and growth
- Fuels
  - Including fuel structure
  - Fuel moistures

Structural issues with smoke modeling

- People are sensitive to smoke at very low levels

- Smoke models are on large grid scales
  - Fires burn and people live in complex terrain
  - Near-field and drainage flow smoke impacts are not well-modeled

- Smoke models are *slow* (and likely to get slower)

- Bias correction is hard for event driven, spatially inhomogeneous, highly variable phenomenon

- Smoke models are hard to interpret

Modeling Steps

Fire Info

Fuels

Total Consumption

Time Rate

Emissions

Plume Rise

Dispersion / Trajectories
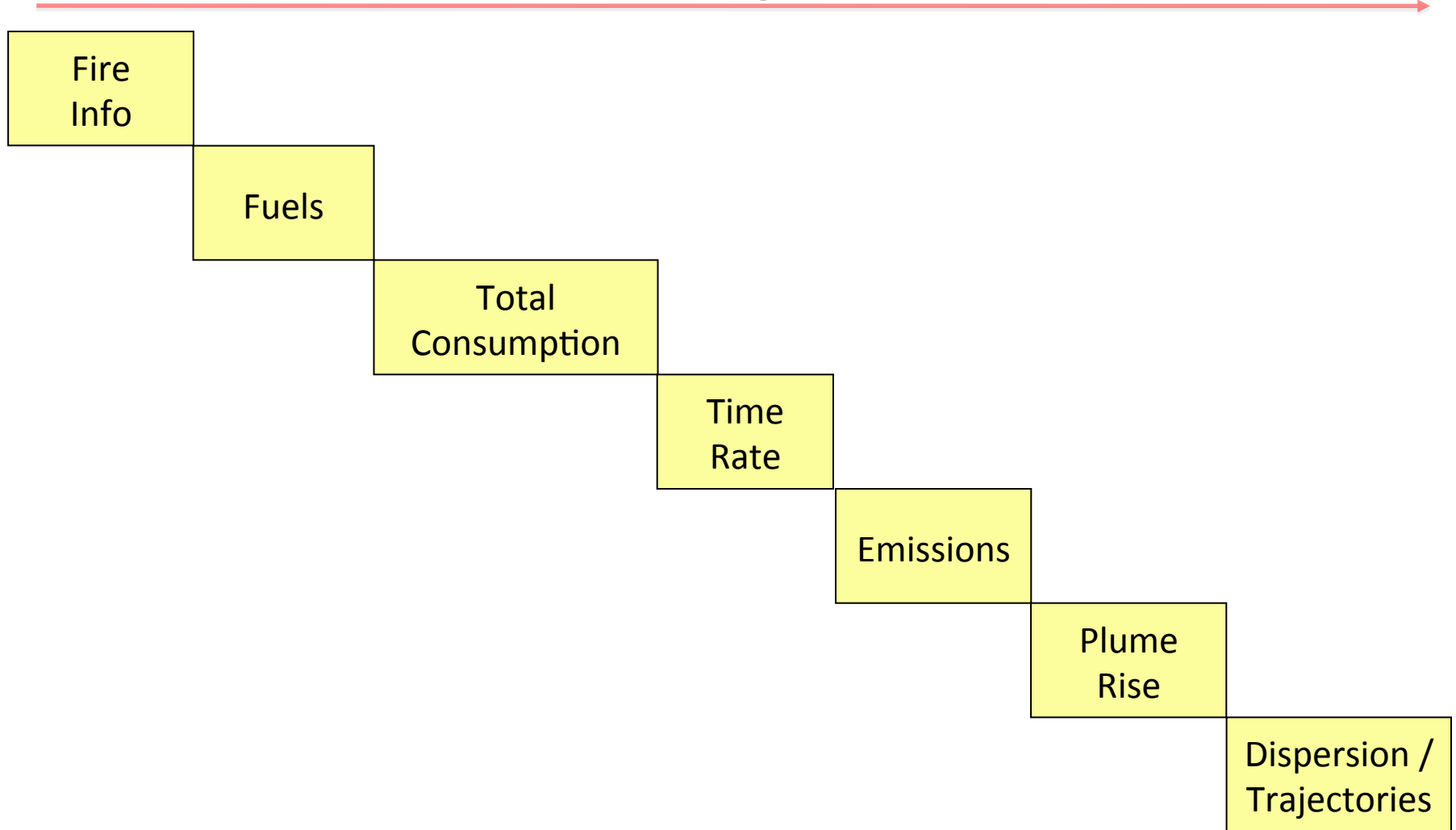
The Next Generation Smoke Model
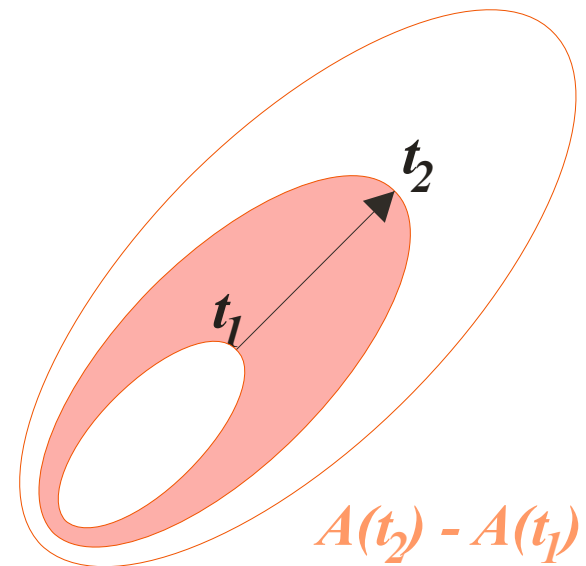
+ Enhanced fire detection / tracking

- More accurate fire sizes
- Detection of smaller fires
- Compensation for dropouts of detections (e.g. due to cloud cover)

+ Fire growth modeling

- No more persistence
- Better diurnal profile based on fire / weather / fuels interaction

t_2

t_1

$A(t_2) - A(t_1)$

courtesy K. Anderson
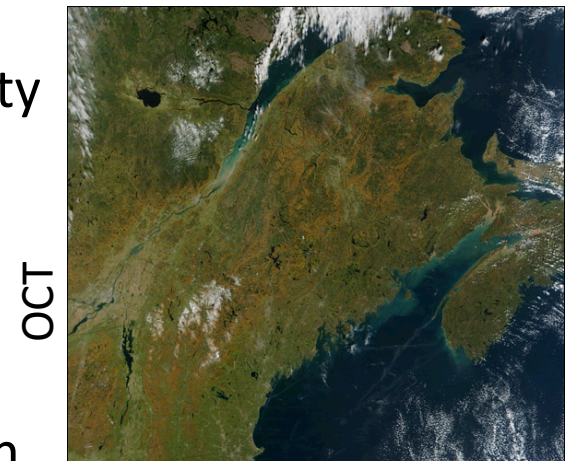
The Next Generation Smoke Model

+ Enhanced fuels
- More accurate fuel type maps
- Better fuel loading *and* fuel loading uncertainty
- Better layers for: Shrubs, Duff, Litter, Canopy

+ Dynamic fuels
- Fuels that change with the season
- Fuels that incorporate predictions of regrowth

+ Better spatially allocated fuel moistures
- Enhanced satellite tracking of rain
- Moisture dynamics for spatial allocation

OCT

October 9, 2001

SEPT

September 12, 2001

NASA MODIS

The Next Generation Smoke Model

+ Consumption algorithm improvements
  - Deep organic consumption a major issue
  - Canopy consumption currently very simplistic
  - Smoldering duration and amount

+ Emissions factors – more & better
  - By vegetation type
  - Enhanced EFs for chemically important but lesser emitted species (e.g. VOCs, BC, etc…)
  - BC / OC ratios
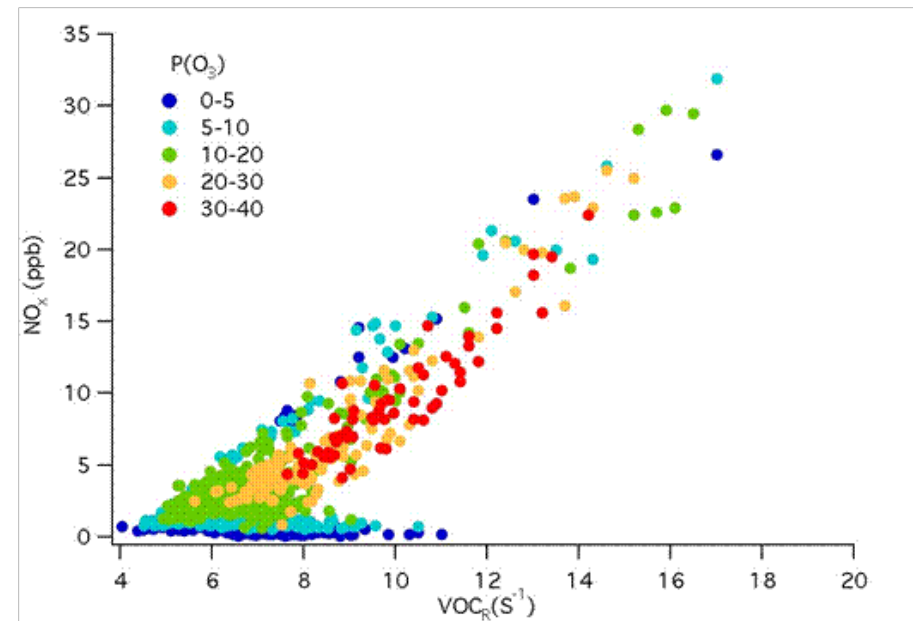
The Next Generation Smoke Model

+ Plume rise
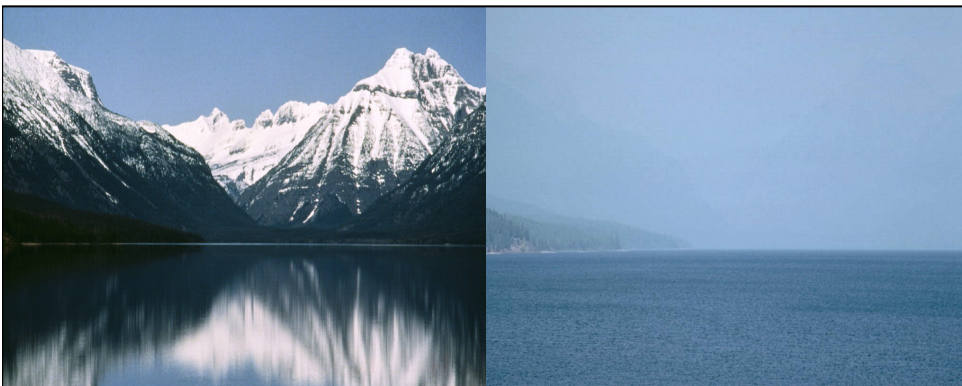 - New models needed
  - Ability to model complex fire plumes

The Next Generation Smoke Model

+ Smoke chemistry improvements

- Ozone formation
- Secondary aerosols
- Better represent aging of smoke for haze, etc...

courtesy B. Lamb

IMPROVE Network

What's possible… soonish

- Operational framework w/
  - Coupled fire / atm model
    for fire growth and plume
  - Near-field plume model (sub-grid)
  - Far-field full chemistry
  - Ensemble runs

- Explicitly treats and outputs useful results for:
  - Near-field smoke impacts
  - Drainage flow smoke impacts
  - Plume chemistry (ozone, PM, visibility)

- Provides for easier interpretation:
  - Corrects for uncertainties and errors by using time/space
    aggregation
  - Gives impacts + uncertainties
  - Probabilistic forecast 30% chance of light to moderate…
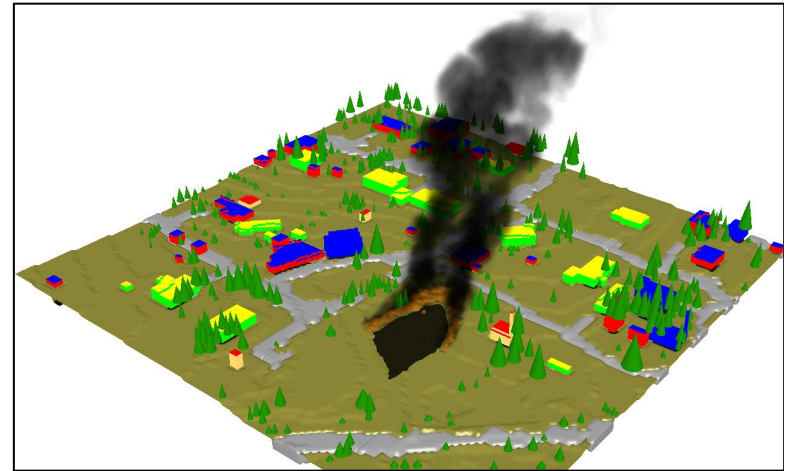
To do this,

we will need a significantly better understanding of and ability to model:

- Plume structure
- Emissions, including heat and its time-space structure
- Transport including drainage flows
- Chemistry near and far-field
- Public health relevant outputs

So, let's get to it:

- Coupled fire-atmosphere models are advancing
- New models in development
    - e., CFS fire growth and plume schemes
- Ensemble forecasts in progress in U.S.

- Above are being incorporated into experimental forecasts
- Near-term bias correction being tested
- Automated regional summaries being tested that use models + smoke obs + ancillary data

- Major new observation campaign being planned

Thank you

Special thanks to our funders in this work:
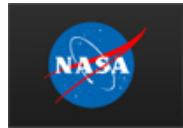
More information:

Sim Larkin
larkin@fs.fed.us
206-732-7849

http://airfire.org