Fire Weather Research and R2O: Where we are and What we want to do

A Presentation to the
GOFC-GOLD Meeting, Summer 2014

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Outline

- Vision and Goals
- What are the Gaps and Challenges?
- Opportunities for Meeting Gaps
- Summary

Vision and Expected Benefits

- Vision: High resolution fire weather information and services, in close collaboration with agency partners, focused on providing impact-oriented, integrated improvements of fire danger and behavior predictions that save lives and reduce impact to property

- Benefits/Outputs:
  - Improved resolution and accuracy of coupled fire weather/behavior forecasts
  - Improved decision support systems and tools
  - Extended lead time of high threat areas
  - Extension of Red Flag Warning capability to include a Watch/Advisory capability and severity levels
  - Efficient evacuation of threatened communities
  - Reduced risk of escaped prescribed burns
  - Reduced out-of-control acreage burned
  - Improved public safety (evacuations) due to reduced smoke danger in WUI

- Impacts/Outcomes: So what?
  - Minimize firefighter fatalities due to unpredicted fire behavior
  - Cost savings with more efficient use of resources (e.g., Wildland-Urban Interface (WUI))
  - Reduced time to detection of fires due to lightning to allow better preparation, resource planning
  - Better understanding of growth of existing fires to prevent loss of life and enhance evacuation procedures
  - Improvement of intra-seasonal forecasts to ensure fire assets are properly deployed well ahead of time (saving millions of dollars in avoiding day-day crisis action)

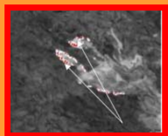
Current Satellite Products Used for Fire Detection, Tracking and Analysis

Polar Orbiter Satellite Imagery

Aqua MODIS

Greece – 08/07

BIRD



Australia – 01/02

Envisat

Australia – 02/09

NOAA AVHRR

NW U.S. – 09/08

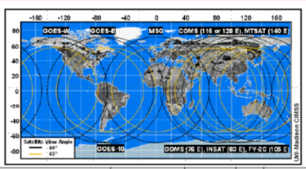
SPOT-5

Greece – 08/07

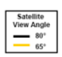
Terra ASTER

Big Sur (CA) – 06/08

Geostationary Satellite Capabilities

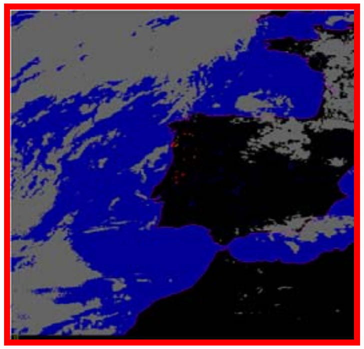


Global Geostationary Active Fire Monitoring Capabilities

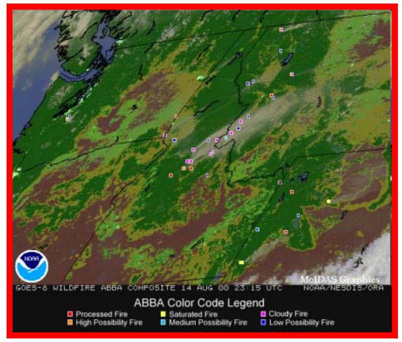


Satellite	Active Fire Spectral Bands	Resolution IGFOV (km)	SSR (km)	Full Disk Coverage	3.9 µm Saturation Temperature (K)	Minimum Fire Size at Equator (at 750 K) (hectares)
GOES-E/-W Imager (75°W / 135°W)	1 visible 3.9 and 10.7 µm	1.0 4.0	0.57 2.3	3 hours (30 min NHE and SHE)	>335 K (G-11) >335 K (G-12)	0.15
GOES-10 Imager (60°W) (Ceased operation December 2009, replaced with GOES-12 in May 2010)	1 visible 3.9 and 10.7 µm	1.0 4.0	0.57 2.3	3 hours (Full Disk) 15 min (SA)	~322 K (G-10) >335 K (G-12)	0.15
Met-8/-9 SEVIRI (9.5 °E, 0°)	1 HRV 2 visible 1.6, 3.9 and 10.8 µm	1.6 4.8 4.8	1.0 3.0 3.0	15 minutes	~335 K	0.22
FY-2C/2D SVISSR (105 °E / 86.5°E)	1 visible, 3.75 and 10.8 µm	1.25 5.0		30 minutes	~330 K	
MTSAT-1R JAMI (140°E) MTSAT-2 (HRIT) (145°E) Operational 2010	1 visible 3.7 and 10.8 µm	1.0 4.0		1 hour	~320 K (MTSAT-1R) 330 K (MTSAT-2)	0.15
INSAT-3D (83 °E ?, TBD) (Launch 2010)	1 vis, 1.6 µm 3.9 and 10.7 µm	1.0 4.0	0.57 2.3	30 minutes	?	
GOMS Elektro-L N1 (76 °E) (2010) GOMS Elektro-L N2 (14.5 °E) (2011?)	3 visible 1.6, 3.75 and 10.7 µm	1.0 km 4.0 km		30 minutes	?	
COMS (128 °E) (Launch 2010)	1 visible 3.9 and 10.7 µm	1.0 km 4.0 km		30 minutes	~350 K	

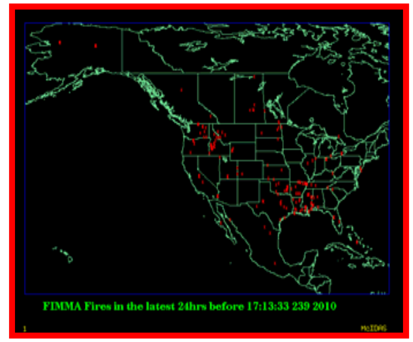
Examples of Current Operational Fire Algorithms



AFMA - Active Fire Monitoring Algorithm -
3 MSG SEVIRI channels



WF_ABBA – Wildfire Automated Biomass Burning Algorithm –
Multi-spectral GOES (vis, 3.9 µ, 10.7 µ)



FIMMA - Fire Identification Mapping and Monitoring Algorithm –
Uses 4 NOAA AVHRR channels

Incorporation of Satellite Data into Decision Support

U.S. – IMETs use in complex terrain where radar beams are blocked by mountains. IMETs use 11.9-3.9 µ IR imagery to ID areas of smoke in deep canyons/drainages, as well as to pinpoint areas of intense heat and trends in intensity. In Alaska, radar coverage is sparse…IMETs/FBANs find areas of wind shift and mesoscale convection.

Europe/Africa: Integrated System for Fire Risk Management (SEVIRI), European Forest Fire Information System (MODIS), Advanced Fire Information System (MODIS/SEVIRI)

Need for Improved, Global Data

- The NOAA SAB Report: “Fire Weather Research, A Burning Agenda for NOAA”, Oct. 2008, mentions the needs for improved satellite-derived estimates of fire radiative energy output and the exploration into satellite methods for continuous monitoring/forecasting of microscale wx and fire growth in ongoing wildfires
- Polar orbiting satellites offer the spatial resolution for fire detection and tracking, but, for true real time operations, early detection and detailed monitoring of fire activity can only be accomplished with the temporal resolution of Geostationary satellites. Geostationary satellites will be able to provide consistent global coverage as well.

Future Satellites…Addressing Fire Weather Observation Gaps

ABI: Advanced Baseline Imager

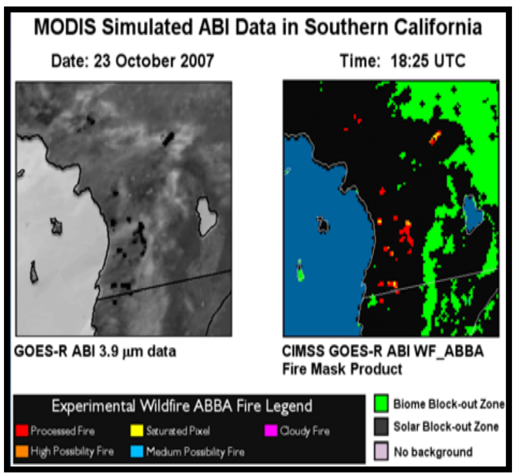
Higher temporal and spatial resolution, better navigation, lower noise (better than GOES MSG SEVIRI)

↓ ↓

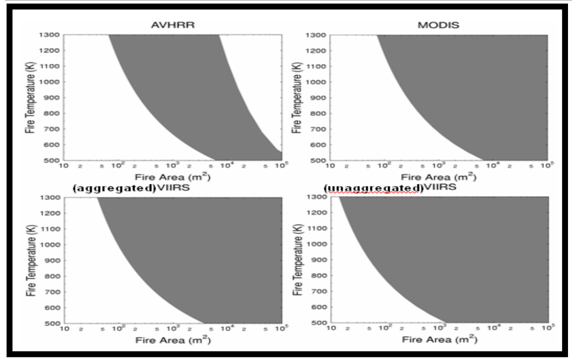
Fire Detection and Characterization Algorithm (FDCA),

↓ ↓

- **Builds on current WF_ABBA algorithm,**
- **Provides instantaneous fire size/temperature/radiative power**
- **Dynamic, multi-spectral, uses 4 channels…calculates sub pixel estimates of fire size and temperature**



VIIRS: Visible/Infrared Imager Radiometer Suite



VIIRS improves fire detection capabilities of MODIS and AVHRR (shaded area 90%)

Resolution Increase: 1.14 µm to 0.37 µm

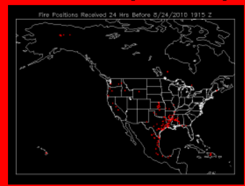
An Incident Meteorologist (IMET) Depends on Satellite Data and Algorithms to Support Many Land Management Agencies

IMETs Use Many Tools - Satellite Information Used to Detect/Track Fires

Theodolite Upper Air

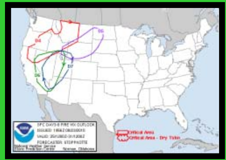
All Hazards Meteor. Response

Satellite (MODIS)

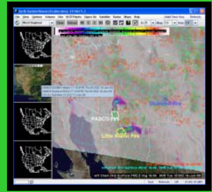


Automated Wx Stations

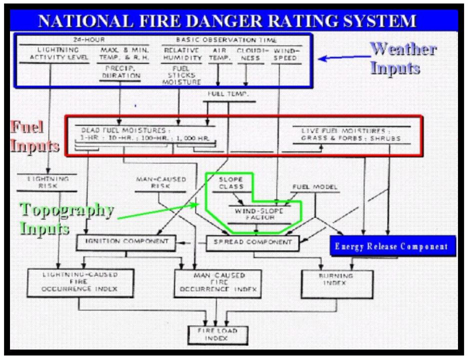
SPC Outlooks



FX-Net/NCEP Model



Weather data is a very important element for fire behavior; IMET helps customer understand complexity



IMET at a stand-up early morning brief to Incident Commander and Crews

IMET Coordination Process – Many complex links with customers

Certified IMET

Meteorologists in Charge (WFOs)

Region HQ/Centers

National Fire Wx Ops Center (NFWOC)

Land Management Agency

12 to 24 hr Response

IMET Arrival/Duties for Wildfires

- IMET coordinates with WFO
- IMET checks into payroll
- Meets w/ Plans Section Chief
- Meets w/ Fire Behavior Analyst
- Coordinate equipment needs
- Obtain/complete ops reports
- Provides briefings to IC
- Coordinate with WFO/IMETs
- Set-up/maintain equipment

IMET near the fire line talking with firefighters

Overall Goals & Issues Emerging S&T

Goal/Target	Outstanding Issues
Improved observations and measurements to initialize numerical models	Deployable surface and aerial platforms. Improved use of remote sensing tools. Real-time assimilation of data.
Development and execution of high-resolution forecasts of humidity, wind, and precipitation for fire prediction	Significant challenges with modeling weather over complex terrain and WUI. Validation to confirm adequacy.
Successful coupling of weather and fire models	Bridging disparity between resolution of fire and weather models. Integration of thermodynamics, physics over complex terrain and vegetation/soil conditions
Improved capability of IMETs to provide rapid response to incident commanders and emergency managers with fire-scale information	On demand assimilation of local data. Merging of weather with current fire information. Establishing mobile WFO; GIS-centric, intelligent agent system.

Overall Goals & Issues Emerging S&T

Goal/Target	Outstanding Issues
Improve forecasting of dry lightning and comprehension of atmospheric processes leading to CG lightning (i.e., initiation of convection)	Development of index based on lightning coverage and precipitation chances. Better understanding of ignition potential and what cloud processes lead to CG lightning for high-based thunderstorms.
On demand 90 day Red Flag WWA decision-support system with high resolution Red Flag warning lead times of 24 hours	Incorporation of NCEP models into fire danger reporting modules. Development of GIS-centric platform and training plans.
Reduced time of detection for new and existing fires	Faster detection of fire location and intensity with remote sensing devices. Examination of satellite and high altitude UAS-based technologies.

Administration/Dept Goals Charges

<u>Departmental Goal:</u> Evolve NOAA's weather services to become more effective, efficient, and agile.

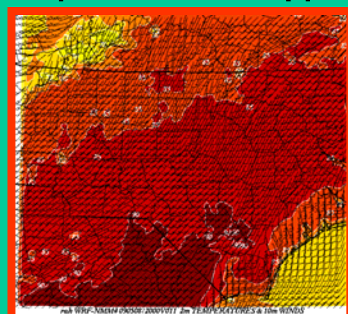
<u>Charges for Vast Improvements</u>

- Western Governors' Association charged NOAA to hasten transfer of new science and technology into fire operations and to provide *"an integrated fire weather and fire environment research program for effective management and health of US forests and rangelands*."
- Calls for action from National Wildfire Coordinating Group (2011) and National Association of State Foresters (2005) to improve data and products for support to strategic firefighting
- OFCM Fire Weather Needs Assessment report (2007)
- NOAA's Science Advisory Board chartered Fire Weather Working Group that provided 46 recommendations for NOAA to improve fire weather operations *(Fire Weather Research: A Burning Agenda for NOAA, 2008)*
- IPCC Climate Change Report: Effects of temperature increases have been documented, including…alterations in disturbance regimes of forests due to fire and pests *(IPCC Climate Change Report, April 2007)*

Overall Information Gaps

Larger, Numerous Fires

Improved Obs/Support



High Res Wx Guidance

Improved DSS Tools and information

1) Limited observations and measurements near fires
2) Real-time detection of fires
3) Improved high-res model forecast guidance
4) Fine-scale coupled model (sub 1-km, hourly)
5) Improved Red Flad ID, lead time, indexing
6) No coupled smoke behavior prediction less than 4 km res
7) Intra-seasonal prediction of fires
8) IMET capability improvements (training, customer interface)
9) Tool for debris flow prediction
10) Social science evaluation

Opportunities to Meet Gaps

There are many but need to prioritize based on SAB recommendations, SMEs and resources:

- USFS/NOAA MOU projects
- Joint Fire Science Program
- Work being accomplished at NCAR and OAR
  - Incorporates data from VIIRS, numerical models
- Object-oriented techniques (Frank Fendell et al)
- Fire and Smoke Initiative
- SOW for Social Science examination

SAB Recommendations

Recommendations:

- Assimilate output from all local observation resources (2.1)
- Explore use of remote sensing methods (2.2)
- Increase R&D of integrated fire weather modeling systems (3.1)
- Use assimilation from 2.1 to generate high res fire danger maps (5.1)
- Develop Intelligent Assistant tool for WFOs and deployed IMETs (8.1)
- Explore emerging communication and low bandwidth technologies (12.1)
- Collaborate with USGS on rainfall rate thresholds for debris flows (15.1)
- Designate lead NOAA/NWS lab for R&D, provide budget/authority (18.2)
- Team with land agencies to establish fire weather test bed (18.3)

Progress to Date

- FX-Net support and AWIPS II Thin Client transition work (12.1)
- Fire Weather Research NOAA/USFS MOU → OAR is NOAA S&T lead (18.2)
- Designated NWS fire weather research lead as OST (18.2, 18.3)
- NCEP modeling strides with 1.33 km nested fire weather model runs (2.1, 3.1)
- Wildfire/structure and downscaling research from NIST, OAR/GSD (3.1, 18.3)
- Coupled fire/atmosphere modeling research from NCAR, OAR/GSD (3.1, 18.3)
- Interagency Joint Fire Science Program funds weather forecast accuracy projects (2010 & 2012), and again in 2014 (2.1, 5.1)
- Establishment of work to build objective tool for flaming firefront (8.1)

Proposed MOU Efforts

<u>Departmental Goal:</u> MOU efforts at level comparable with USFS and other land management agencies to resolve longstanding support issues

<u>R&D Focus Areas</u> (SAB # in Red)

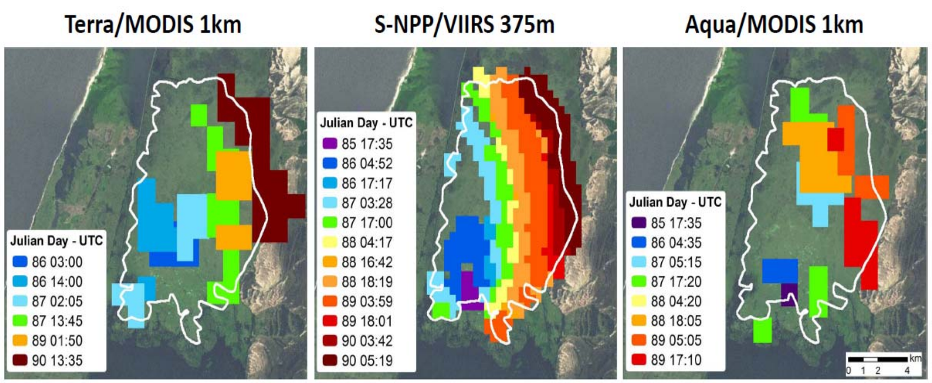
- Verify NCEP hi-res models with hi-res USFS tower observations (2.1)
- Coordinate/test interface between hi-res NCEP output and analysis systems with WFDSS and firespread models (2.1)
- Examine and expand interface of hi-res LAPS output with FSPro (2.1)
- Interface NCEP forecast climatology and ensemble output with WFDSS and FSPro to analyze improvements in risk assessment (3.1)
- Develop/execute an objective tool that will enable IMETs to make a landscape-scale forecast for next 6-7 hours with intensive data collection as cornerstone (8.1)
- Develop fire severity/fire danger model to predict fire potential out to 7 months (5.1)

2.1 (Local obs); 3.1 (Fire wx model); 5.1 (Fire danger); 8.1 (Intel asst)

VIIRS and Coupled Fire-Wx Models

- Trending fire management policies dictate improved mapping of fires
- Assimilate new remote sensing fire data into cutting-edge coupled fire-weather model

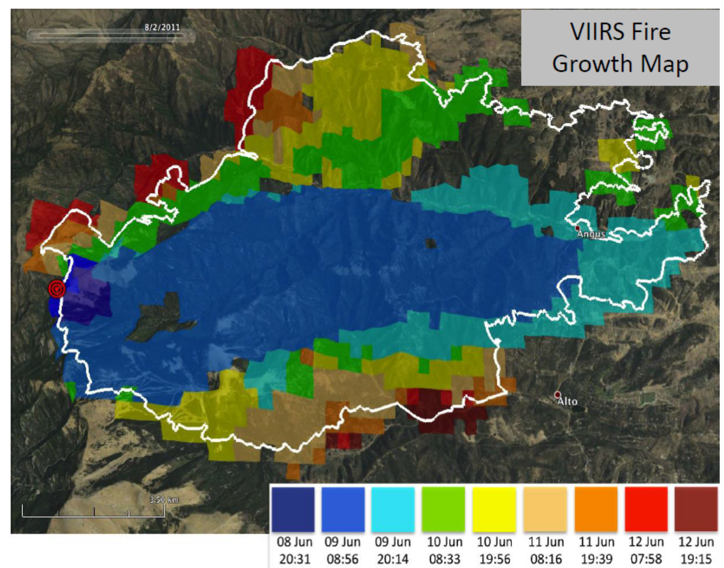
Improved Satellite Mapping of Active Fires Achieved Using VIIRS I-bands



Wildfire in southern Brazil, March/2013

Coupled Fire-Weather Modeling

Little Bear Fire, New Mexico June 2012



Coen and Schroeder [2013]

Objective Tools for IMETs

- For a demonstration NOAA project, select the central phenomenon on which most other products depend:
  Fire propagation under high-spread-rate conditions
  - Smoke/soot generation and transport, visibility reduction, air-quality deterioration, loss of watershed all depend on what vegetation will burn, when, and how completely
  - We exclude structure fires, and fires at the urban/wildland interface
  - We pose the central challenge thus:
    - *Given* where an actively flaming firefront is currently located, and given the topography, vegetation, meteorology,
    - *Find* where the actively flaming firefront will be about 7 hours in the future
    - *For* (a) no firefighting countermeasures; or (b) active intervention (treat cutting line as a fuel-loading reduction; water/retardant drops as altering moisture content of vegetation; backfiring as independent fire starts)
  - Focus on large-area fires: small start-ups are intractable and individualistic, and have small impact
  - Would like to predict far into the future, but the predictability horizon is limited for phenomena intensely corrective at 1-km scale

Social Science Examination/SOW: How Do Customers React/Feel?

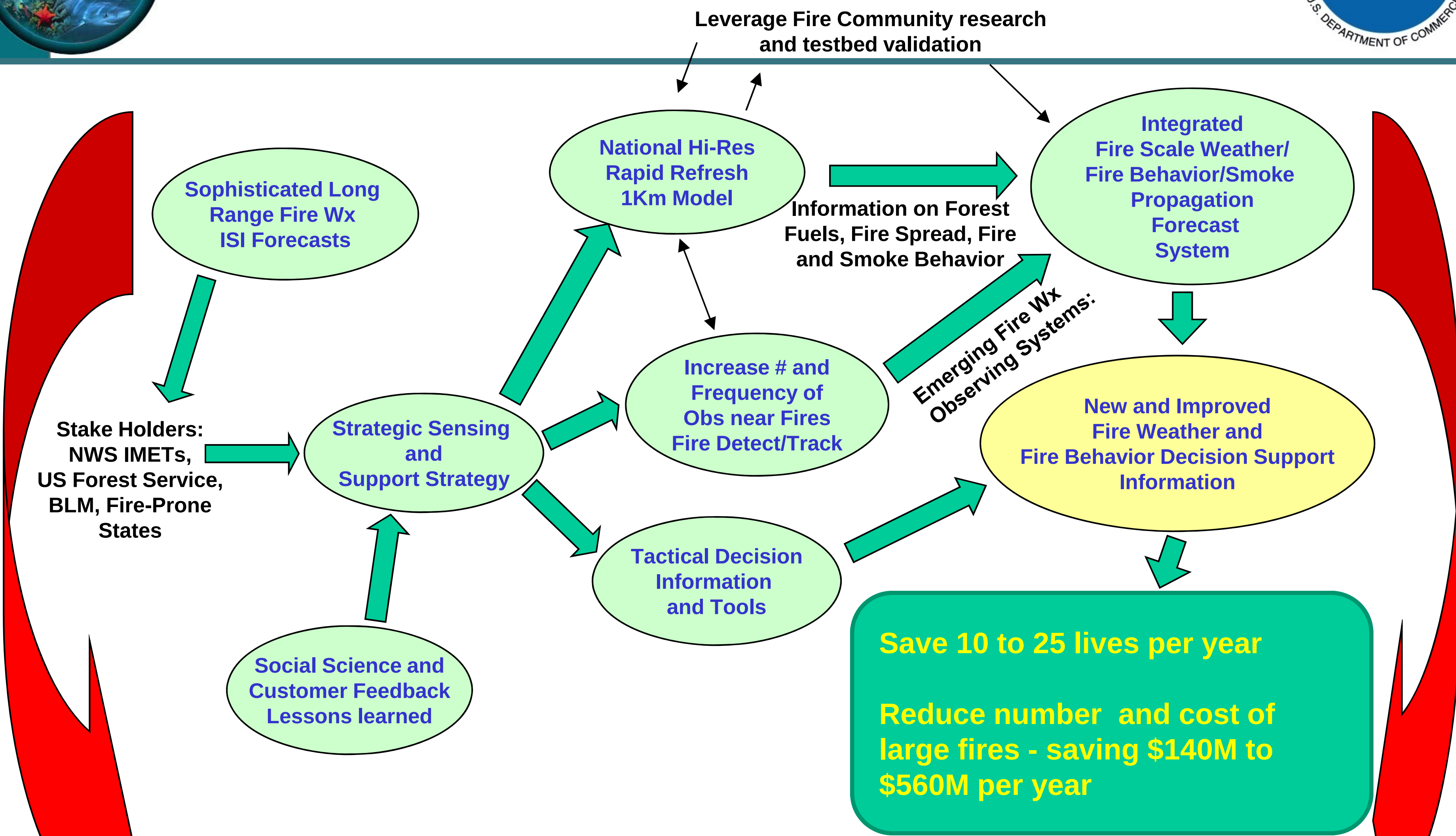
- NWS Social Science program
- Assessing Fire Weather Info…What is the Intent?
- Interactions for Major Fire Events
  - Australia Fires of Feb 2009
  - Blackhorse Fire near Roanoke VA Feb 2007
  - Esperanza Fire in Oct 2006
- Perspective on Building Trust
- Examples of Firefighter-Community interaction

Fire Weather S&T and WRN

- Fire weather should not be treated as a stove pipe as it is related to $B dollar disasters and needs similar data and models to other initiatives such as severe weather and aviation weather

- A fire-weather initiative meshes with other ongoing NOAA initiatives
  - Synoptic scale → Mesoscale → Landscape scale
  - Applying GOES-R and JPSS to detection and characterization of fire and smoke across and local and broad areas
  - Fire is the major landscape-scale natural hazard
  - Deploying/linking/standardization of local surface-weather mesonets
  - Large-area-fire monitoring is an appropriate UAV application
  - Drought monitoring (NIDIS)

Fitting into R2O Framework



Public Safety, Economic Benefit, and Hazard Resilient Communities

Proposed Way Ahead

- Short-term Field and Modeling Work
  - Determine partnership opportunities with land management agencies through JFSP
  - Allocate any available NWS and OAR funding resources to assist in obtaining local observations and conducting model validations, as well as to perform tasks under MOU umbrella
  - Utilize IMET upper air systems to advance model initialization and research-ready data sets
  - Integrate VIIRS into coupled fire-weather models being developed by UCAR/NCAR

Proposed Way Ahead

- Budget and R&D Planning
  - Look into ways of including approved fire weather research projects in NOAA budgeting process
  - Formalize NWS Fire Weather Research to Operations Plan
  - Look into potential testbed opportunities
  - Take steps to establish Fire Weather Program and Centralized Fire Weather Operations Center (possible with limited funding).
  - Support O2R paths