Use of new spatially refined satellite remote sensing fire detection data in support of advanced wildfire mapping and modeling

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Main Objectives

• Promote new and improved Earth Observation capabilities
  – Develop spatially refined fire information
    • Stand alone NRT fire mapping products formatted to meet user requirements (e.g., GIS-ready)
    • Bridge gap between available tactical and strategic fire management data
  – Explore & Integrate NASA and other International Assets
    • Implement new VIIRS, Landsat-8, DLR/FireBird, ESA/Sentinel-2a&b fire data sets

• Assimilate new remote sensing fire data into cutting-edge coupled weather-fire model
  – Support model initialization and verification using remotely sensed fire perimeters and intensity (FRP) data
    • Bridge gap between fire remote sensing and modeling – promote new applications
    • Enable simulation of long-duration events by assimilating frequently updated satellite fire information (previously unattainable application due to accumulating model error)
New VIIRS 375 m Active Fire Data

Built on proven MODIS fire algorithm [Kaufman et al., 1998; Giglio et al., 2003]
Day & nighttime detections providing 2-4 daily images at mid-latitudes
Improved sampling characteristics resulting in enhanced routine fire mapping performance
(plus fire intensity retrievals using complementary 750m data)

Taim Ecological Reserve – Southern Brazil, March 2013

Terra/MODIS (1 km)  
NPP/VIIRS (375 m)  
Aqua/MODIS (1 km)

Schroeder et al., 2013
Routine fire monitoring using VIIRS 375 m active fire data
Rim Fire, CA 2013
Demand for higher resolution IR data has systematically increased over the last five years aside from fluctuations in fire activity – trending fire management policies ("let it burn") require improved monitoring and mapping of fires.

USFS operates two manned aircrafts in support IR imaging for the entire CONUS plus Alaska.

1,000+ airborne missions fulfilled each year.
Further assessing the complementarity between satellite and airborne using near-coincident co-located data sets
Improved small fire detection capabilities

Small fire detection resulting in potential $10\times$ factor reduction in minimum detectable fire size $\Rightarrow$ improved response time

2.5 m diameter bonfire detected by VIIRS night data
Improved small fire detection capabilities

Subset of VIIRS L1B data
08 July 4:23 UTC (1:23am local time)
Coinciding with bonfire

Single pixel detection
Pixel fraction containing active fire: 0.004%

Image response: +10K pixel temperature increase relative to background – minimum detection limit satisfied!
Improved small fire detection capabilities

Subset of VIIRS L1B data
08 July 4:23 UTC (1:23am local time)
Coinciding with bonfire
New Landsat-8 30 m Active Fire Data

Built on proven ASTER/Landsat (5&7) fire algorithms [Giglio et al., 2008; Schroeder et al., 2008]
Day & nighttime detections 16/8-day revisit (day/night)
Spatial resolution providing detailed fire perimeter information (plus area estimate)
Coupled Fire-Weather Modeling

Apply the Coupled Atmosphere-Wildland Fire Environment (CAWFE) to simulate wildfires

- Well-proven and documented modeling framework
- Successful application to historic fire events using supporting airborne data (Coen & Riggan, 2013)

Assimilate frequently-updated spatially refined remote sensing active fire data to initialize model fire perimeter

- Spaceborne and airborne fire data sets serving as initial condition as well as reference data to assess/validate model outputs
Coupled Fire-Weather Modeling

Little Bear Fire, New Mexico June 2012

InciWeb Fire Growth Map
Coupled Fire-Weather Modeling

Little Bear Fire, New Mexico June 2012

VIIRS Fire Growth Map

Coen and Schroeder [2013]
ANIMATION IN SEPARATE FILE
Yellow perimeter: VIIRS fire perimeter used for model initialization
Red perimeter: VIIRS fire perimeter 12 h later
Coupled Fire-Weather Modeling

Little Bear Fire
Purple: VIIRS Fire detection polygon
Red: simulated fire perimeter

Sequence of model simulations

Time

Jun 8 2031 UTC  Jun 9 0857 UTC  Jun 9 2014 UTC  Jun 10 0833 UTC

Coen and Schroeder [2013]
Applications Derived from Refined Spatial Resolution Satellite Fire Data

- New satellite fire detection data provide significantly improved (>10×) performance compared to current operational products (MODIS, GOES)
  - Fire detection envelope approaching the “smallest fire of interest” – it’s not in the interest of government agencies to achieve <10m spatial resolution fire mapping capabilities. Minimum detectable fire using current algorithms equal to 0.01<>0.1% pixel fraction (≈ meter resolution requirement ✓)
  - Temporal frequency still lacking, although our results suggest otherwise – fire behavior modeling could be well qualified to fill in the gap using frequently updated satellite input data (≈ sub-hourly resolution requirement ✓)

- Refined spatial resolution satellite data leading to improved relationship between instantaneous fire size x number of detected pixels
  - Higher quality fire information, frequently updated, readily available (web-based map servers)
  - Improved characterization of radiant heat flux using complementary FRP retrievals ➔ potential application in support of plume injection height parameterization and derived air quality retrievals
Applications Derived from Coupled Fire-Weather Modeling

- Configured as a retrospective analyses tool, coupled fire-weather model will advance fire managers’ application of tactical fire suppression resources
  - Relating modeled fire growth potential versus actual growth (observed) as a function of suppression efforts
  - Advance understanding of fuel treatment and forest disease impact on fire behavior

- Configured as a predictive analyses tool, model can be applied using operational cycled weather forecasts such as NCEP’s Rapid Refresh (RAP) and High-Resolution Rapid Refresh (HRRR) and frequently updated VIIRS fire perimeters as initialization data to monitor and predict fire growth during several days from first detection until containment
  - Previously unattainable goal due to accumulation of model error
  - Model can be used to address multiple wildfire scenario and help determine priority areas for resource allocation
Supplementary Information:

VIIRS data: http://viirsfire.geog.umd.edu/map/index.html

Fire model animations: http://www.mmm.ucar.edu/people/coen/files/newpage_m.html

Use of spatially refined satellite remote sensing fire detection data to initialize and evaluate coupled weather-wildfire growth model simulations

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