Synergistic satellite & modeling methods for the description of biomass smoke dispersion over complex terrain. The FireHub platform.

Stavros Solomos, Vassilis Amiridis, Haris Kontoes

National Observatory of Athens
Institute for Astronomy Astrophysics Space Applications and Remote Sensing

13th International Conference on
Meteorology, Climatology and Atmospheric Physics
COMECAP Thessaloniki, 19-21 September 2016

Atmospheric impacts of biomass burning aerosol

Biomass emissions have a twofold significance for atmospheric science:

1. The dispersion of smoke towards inhabited areas consist a direct threat for human health
2. Smoke aerosol particles affect radiation and cloud processes

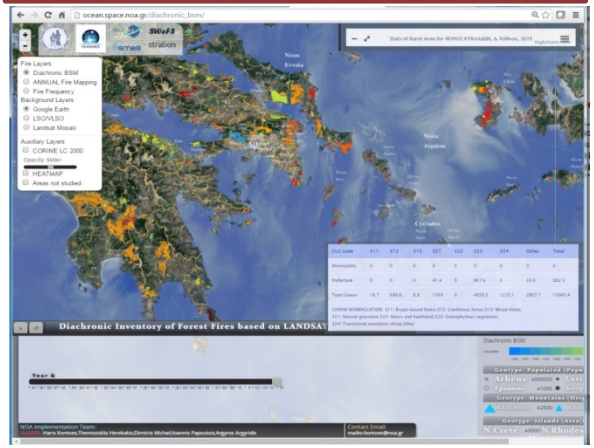
Smoke from wildfires in Los Angeles, 20 June 2016. *SOURCE: Associated Press*

Smoke From Canadian Wildfires Trapped in Clouds, *MODIS, 9 May 2016*

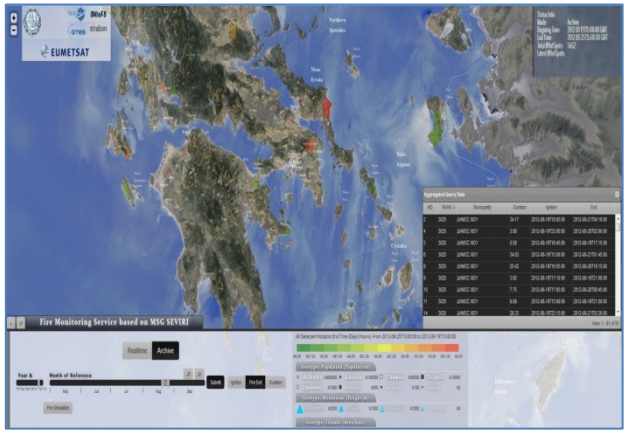
Development of a Space Based Fire Management Hub at NOA

FireHub is a synergistic satellite – modeling system developed in the frame of BEYOND project and includes 3 service pillars:

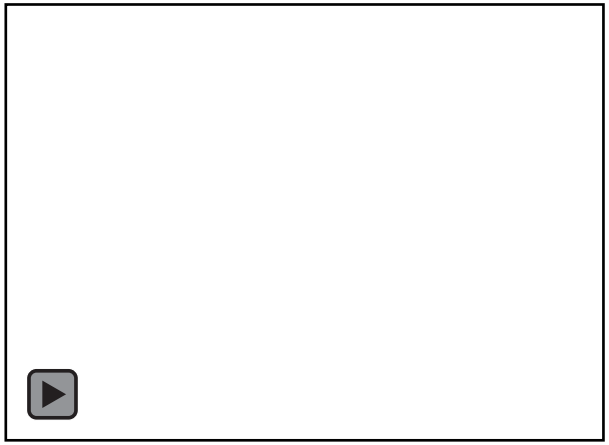
1. Diachronic Inventory of Forest Fires based on LANDSAT (1984-)



2. Real time Fire Monitoring Service based on MSG SEVIRI



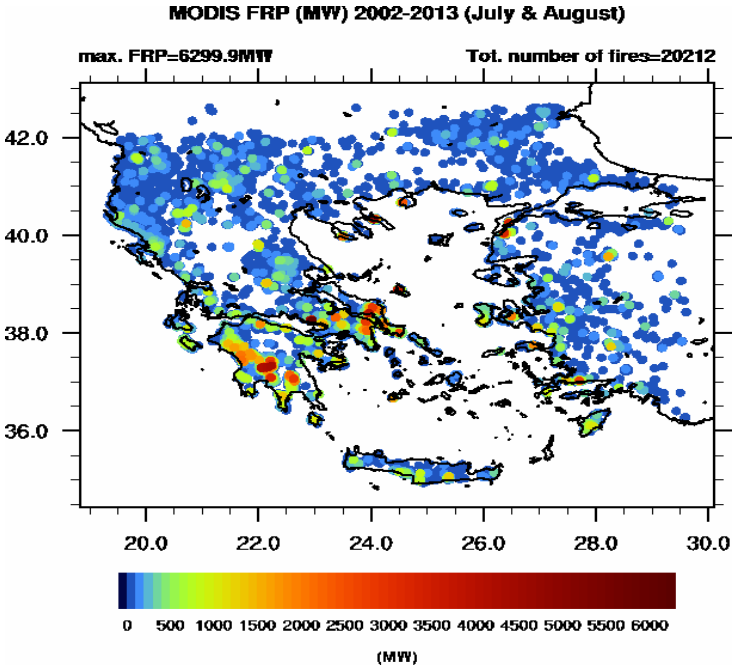
3. Smoke dispersion forecast based on FLEXPART-WRF

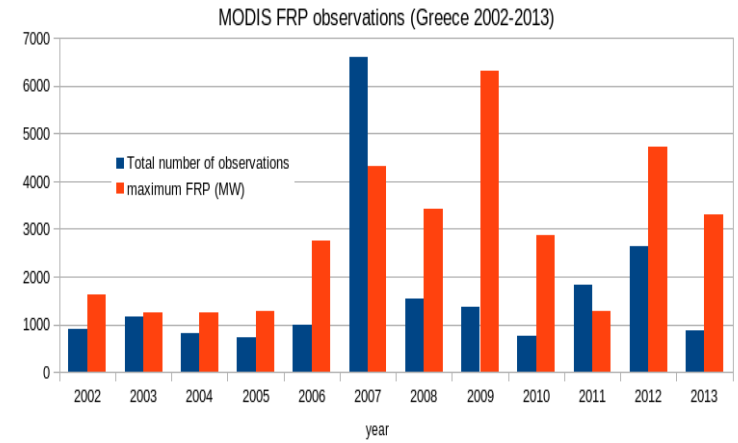


- **FireHub** has been elected as the winner of the Best Service Challenge of the Copernicus Masters 2014
- **FireHub** is integrated into the Global Fire Monitoring Center of UN for Disaster Reduction

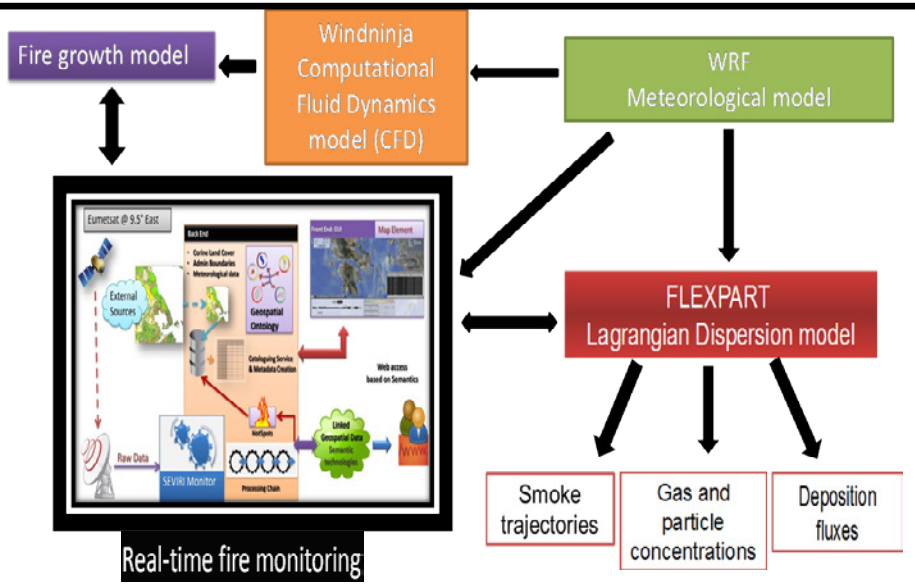
http://ocean.space.noa.gr/seviri/fend_new/index.php

MODIS Fire Radiative Power (FRP) Climatology in Greece



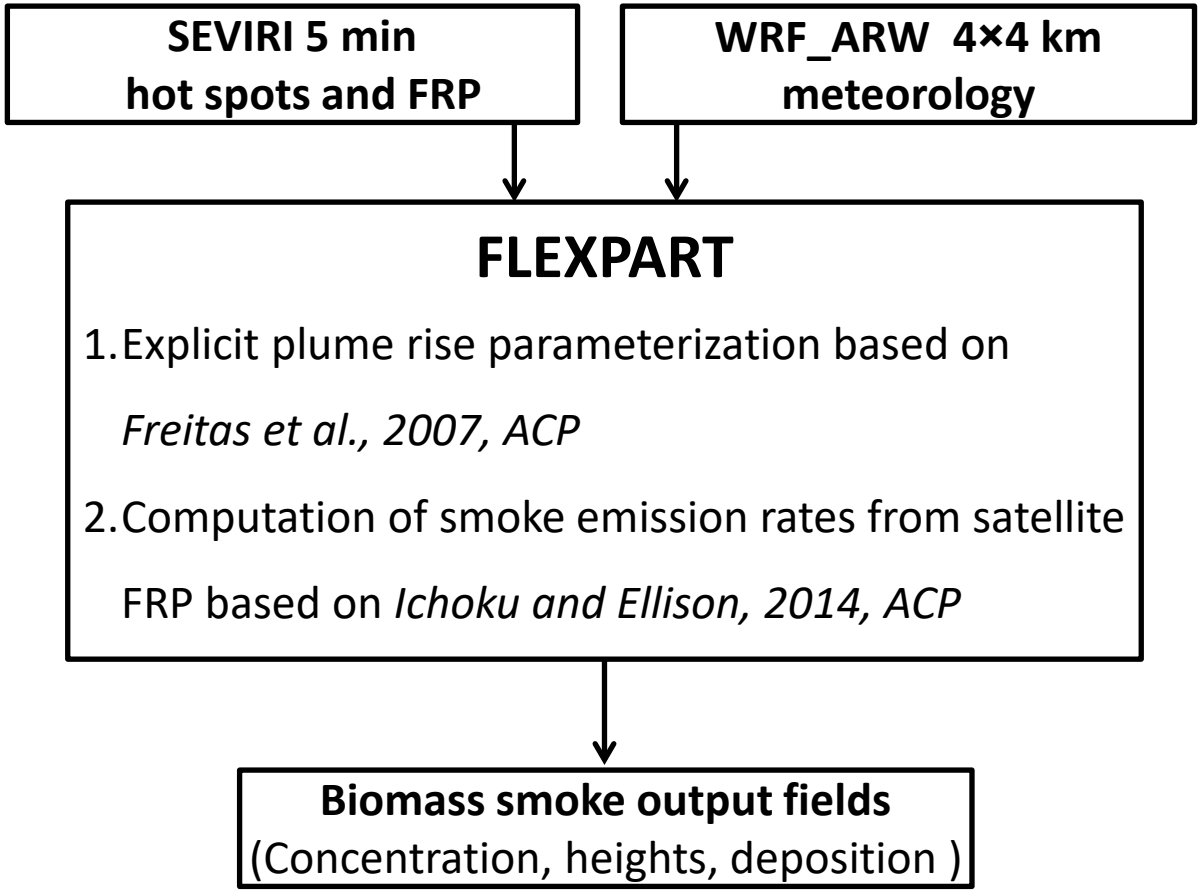


- 20212 Total number of MODIS fire detections in Greece during 2002-2013
- More than 1000 during July & August every year
- FRP often exceeds 1000 MW



- The 3.5km spatial resolution of MSG SEVIRI sensor is downscaled to 500 meters
- SEVIRI hot spot retrievals every 5 min
- FLEXPART is triggered every 1 hour

FireHub Smoke Dispersion development

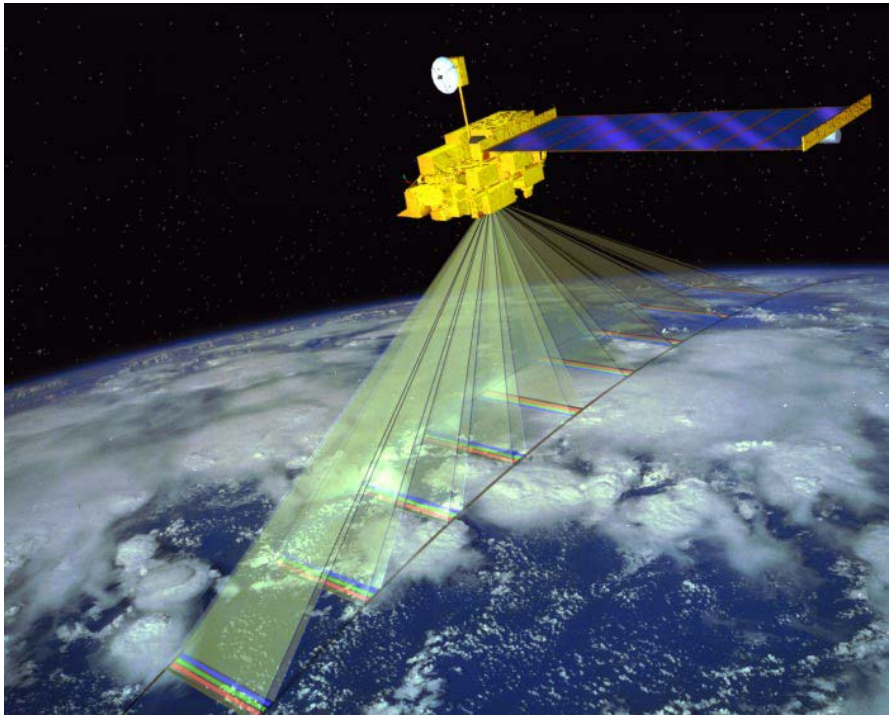


Solomos et al., 2015, Atm. Environment

MISR 3D plume detections

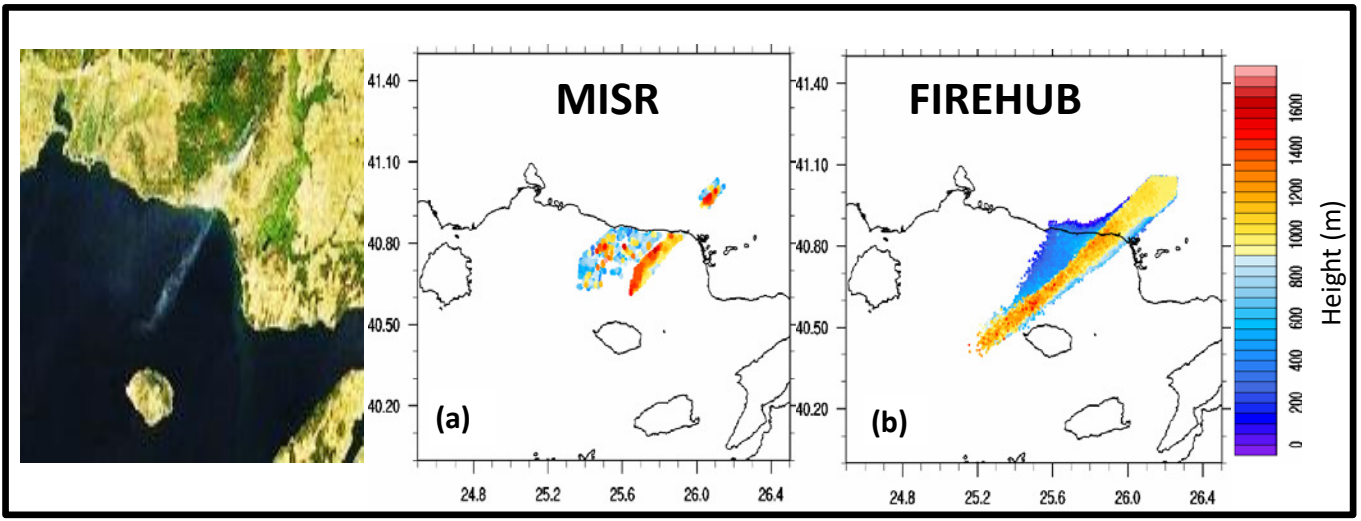
Multiangle Imaging Spectro Radiometer

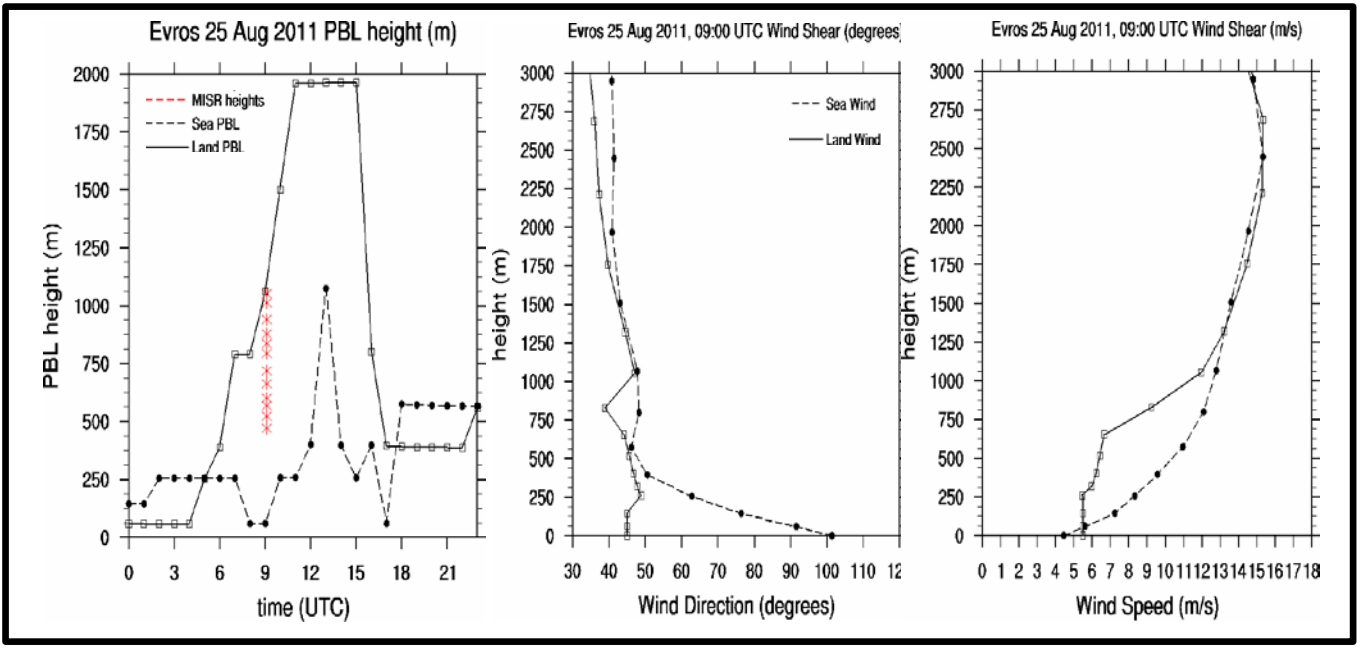
- Most satellite instruments look only straight down or toward the edge of the planet
- MISR instrument is onboard Terra and includes nine cameras pointed in nine different directions
- MISR's nine cameras, each viewing Earth at a different angle, can be used to determine the height of clouds and smoke above the surface



Evros fire, 25 August 2011

FireHub comparison with MISR and MODIS satellite retrievals



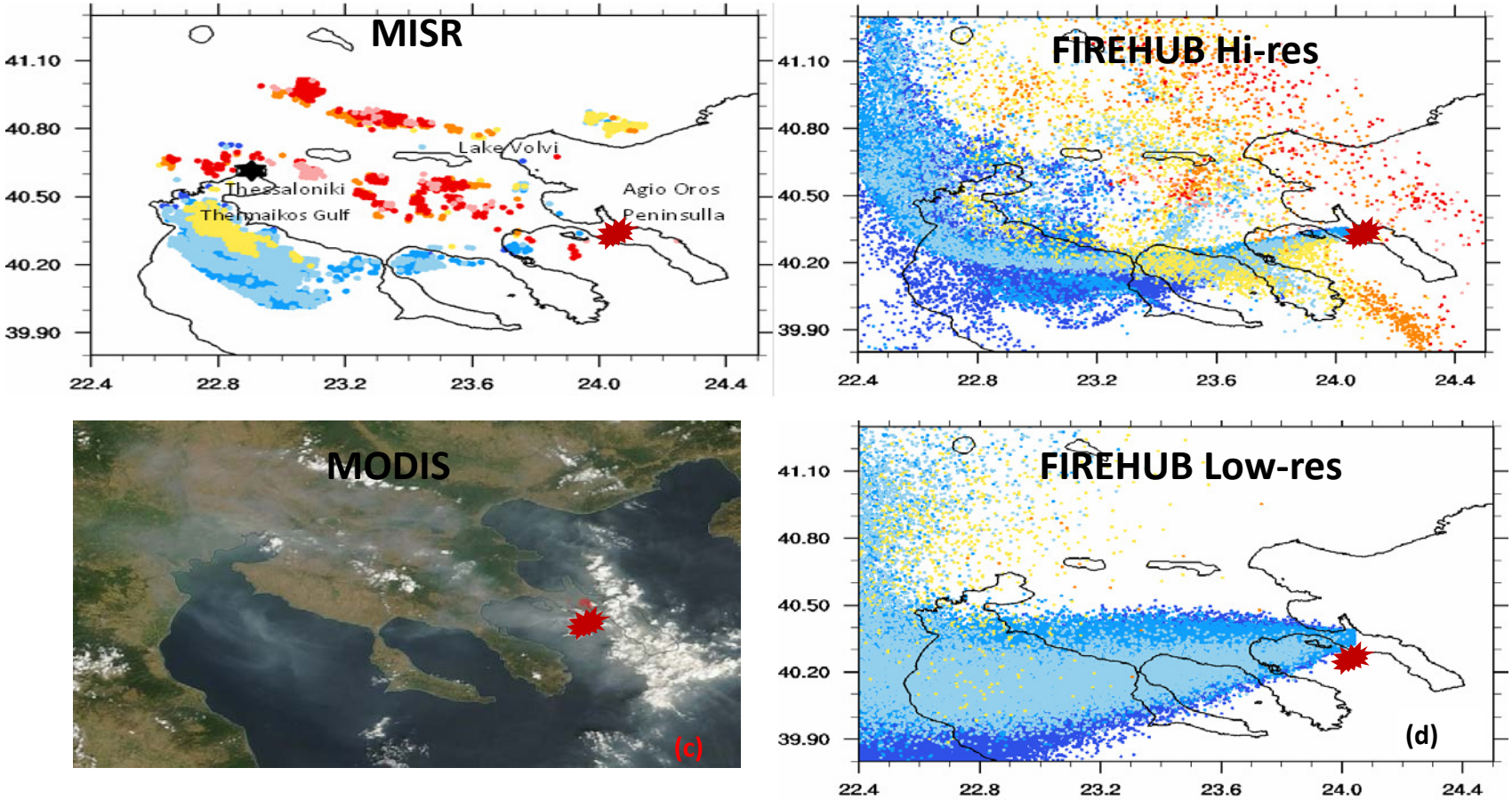


- Vertical wind shear and PBL heights determine smoke dispersion
- The interchange between deep land PBL and shallow marine PBL favors long range transport of decoupled smoke plumes

Agion Oros fire, 9 August 2012

FireHub comparison with MISR and MODIS satellite retrievals

Dispersion of smoke over complex terrain and complex meteorological conditions

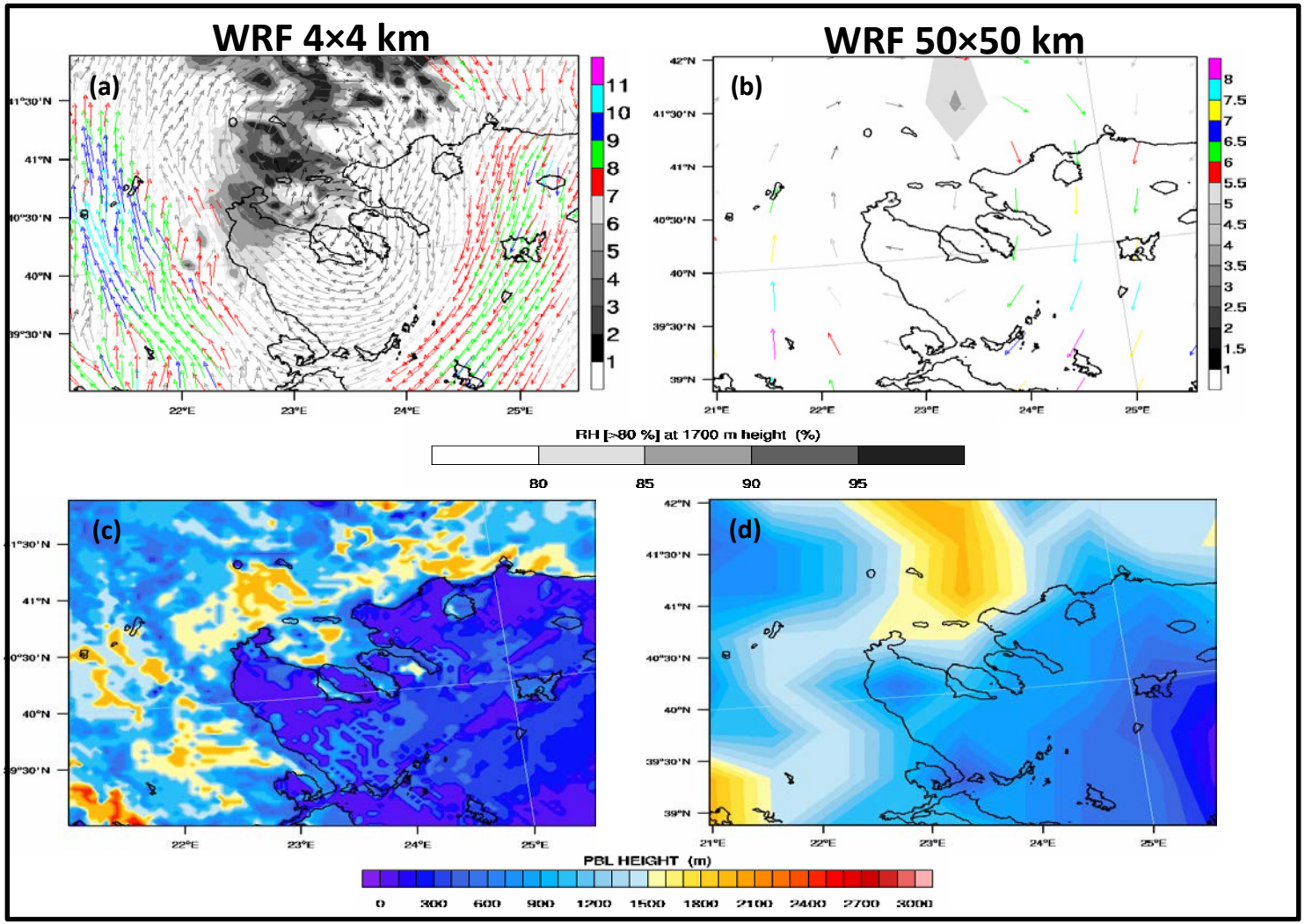


Solomos et al., 2015, Atm. Environment

Agion Oros fire, 9 August 2012

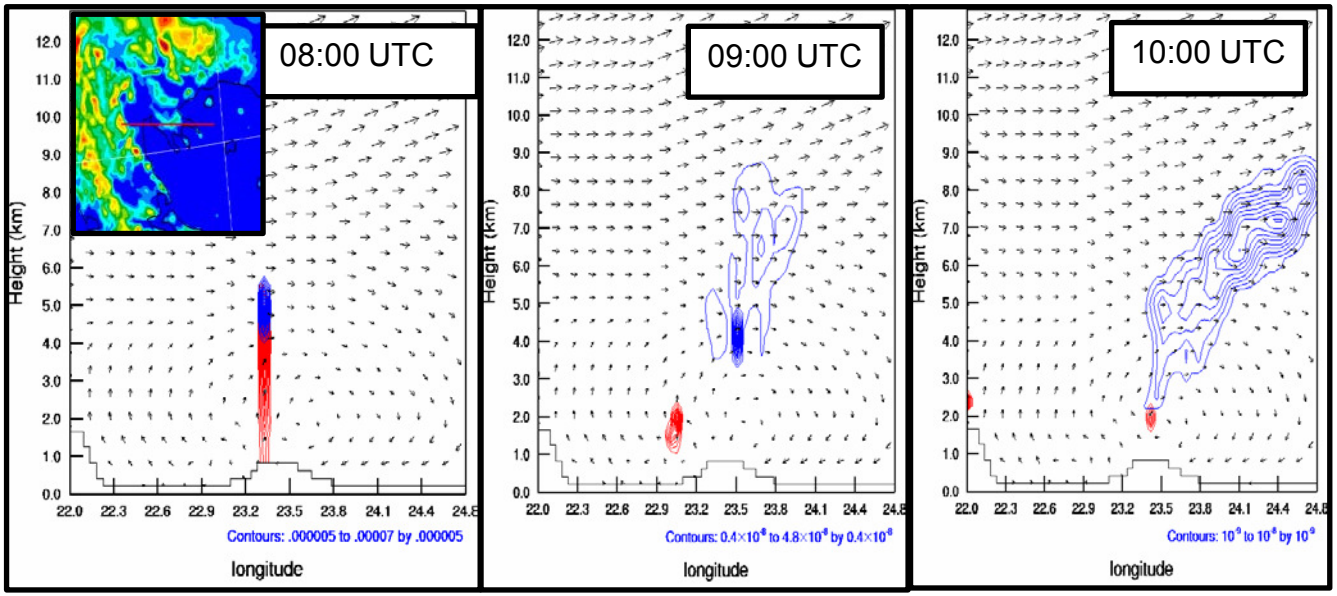
FireHub comparison with MISR and MODIS satellite retrievals

Clouds at 1.7 Km (RH >80%), Wind spead (m s^{-1}) and PBL height (m)



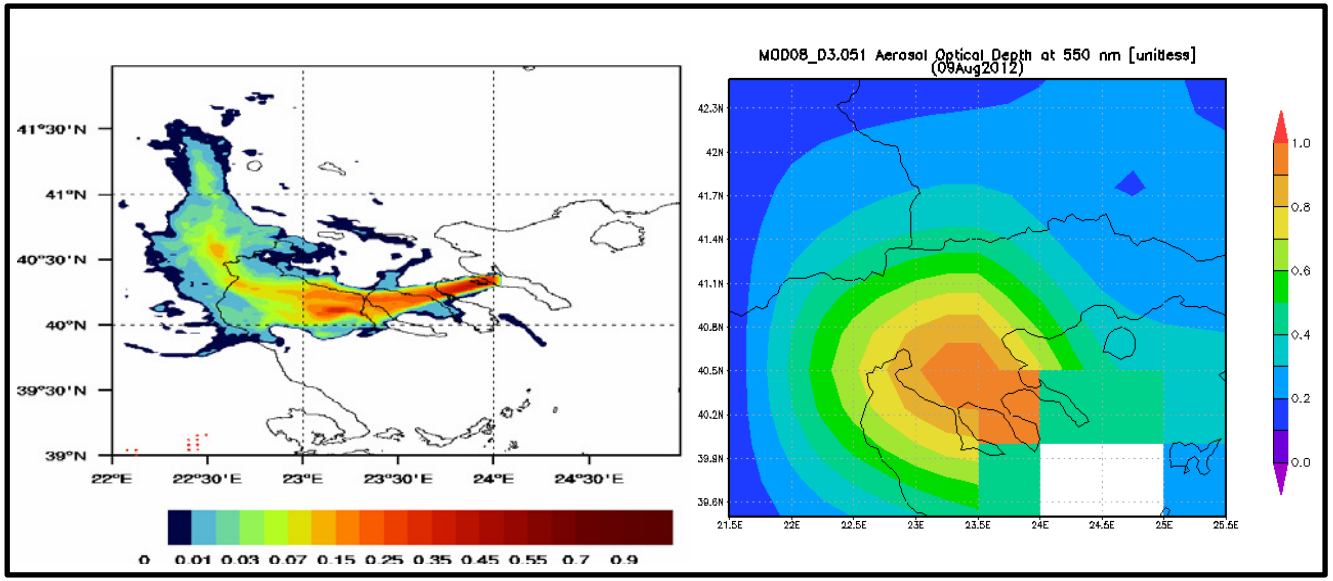
Agion Oros fire, 9 August 2012

FireHub comparison with MISR and MODIS satellite retrievals



Development of convection / recirculation

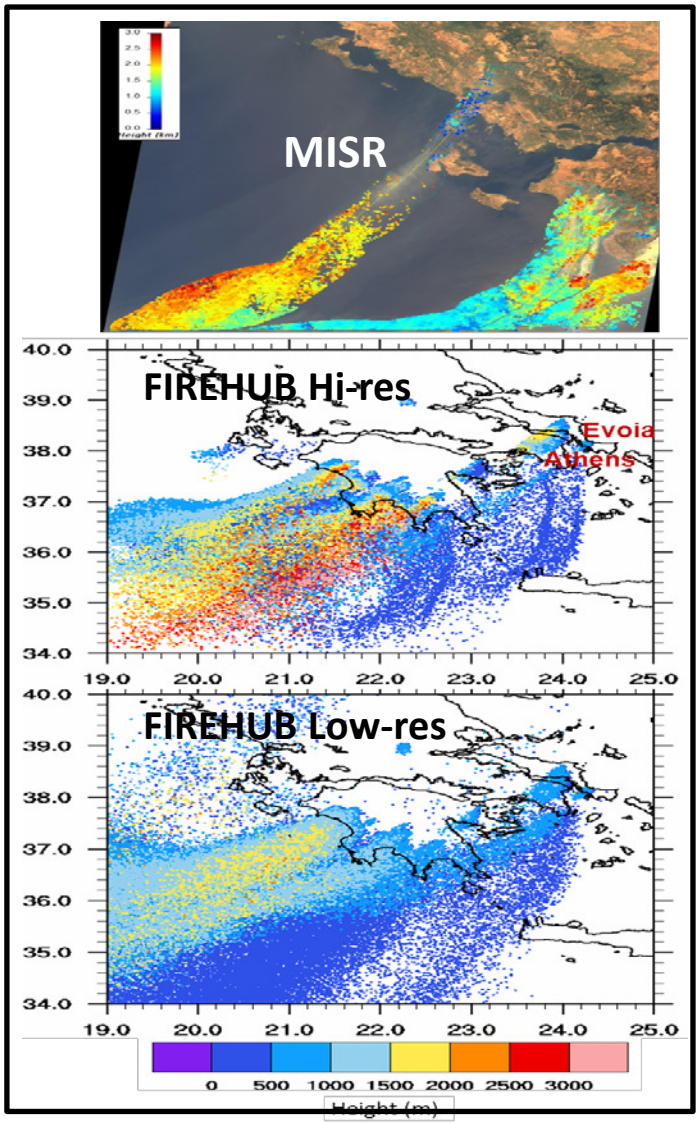
Red : Liquid condensates mix. Ratio (g kg^{-1})
Blue: Ice condensates mix. Ratio (g kg^{-1})



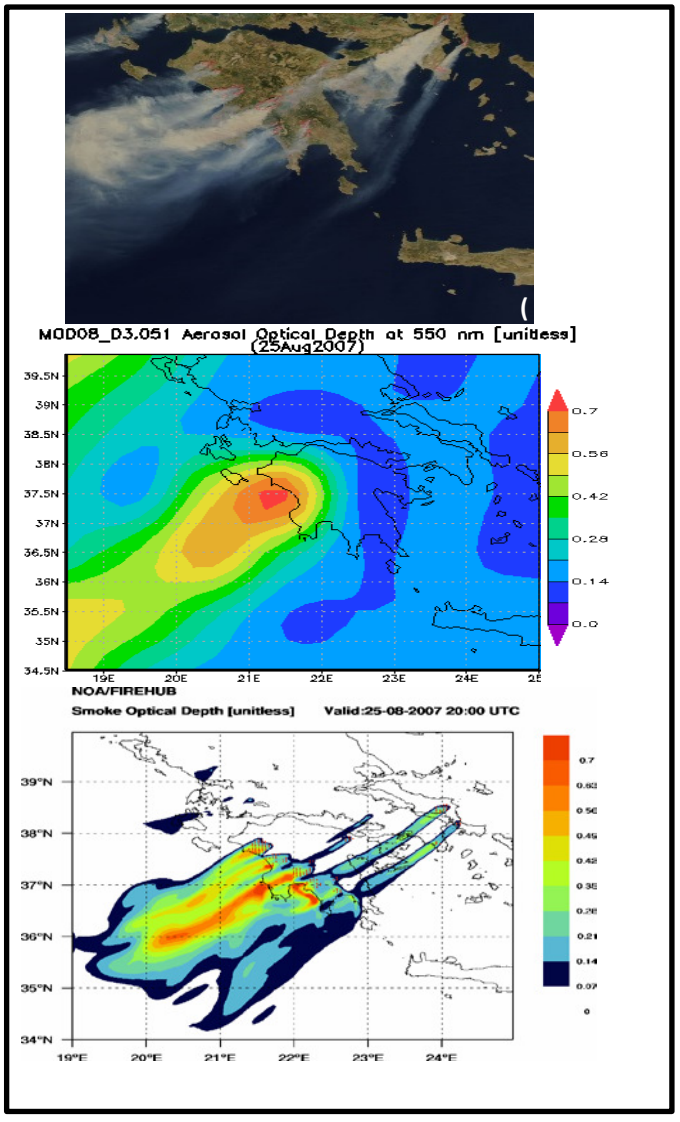
Aerosol Optical Depth at 550 nm, 9 August 2012
Left: FLEXPART (smoke AOD)
Right: MODIS AOD

Peloponnese fires, 25-26 August 2007

FireHub comparison with MISR and MODIS satellite retrievals

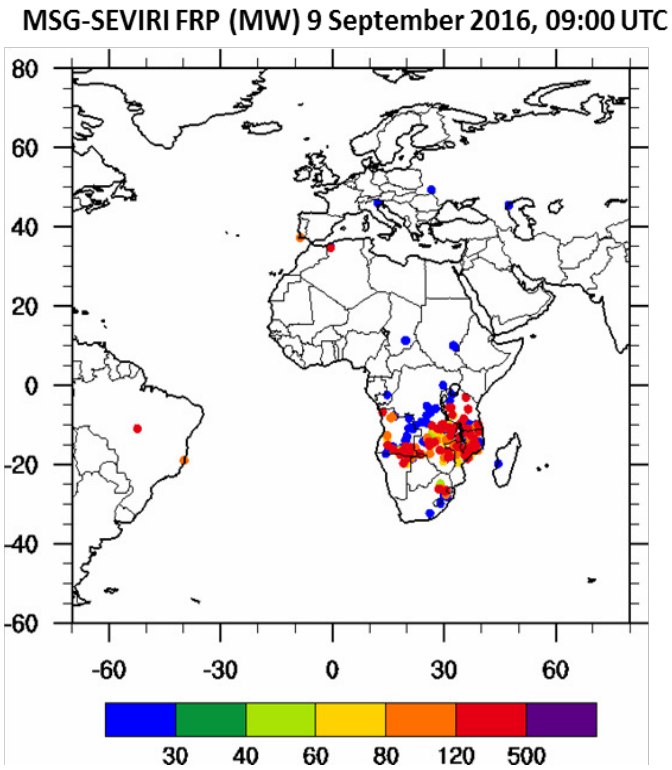


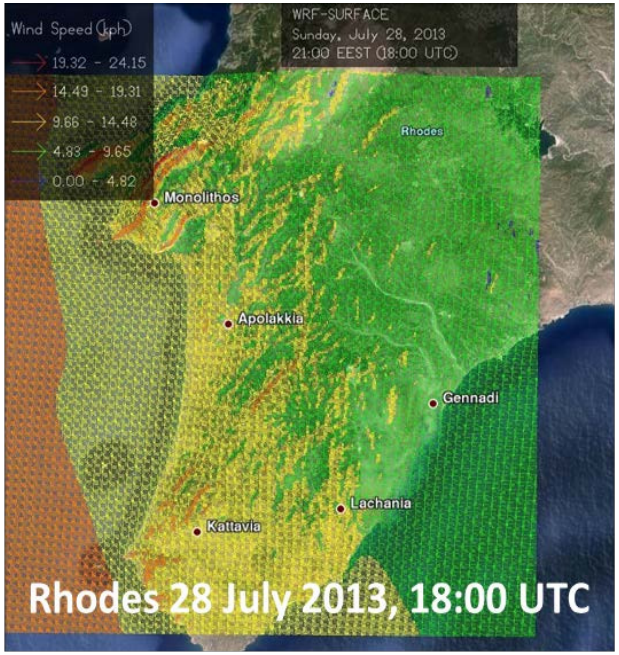
Smoke particle heights (m)

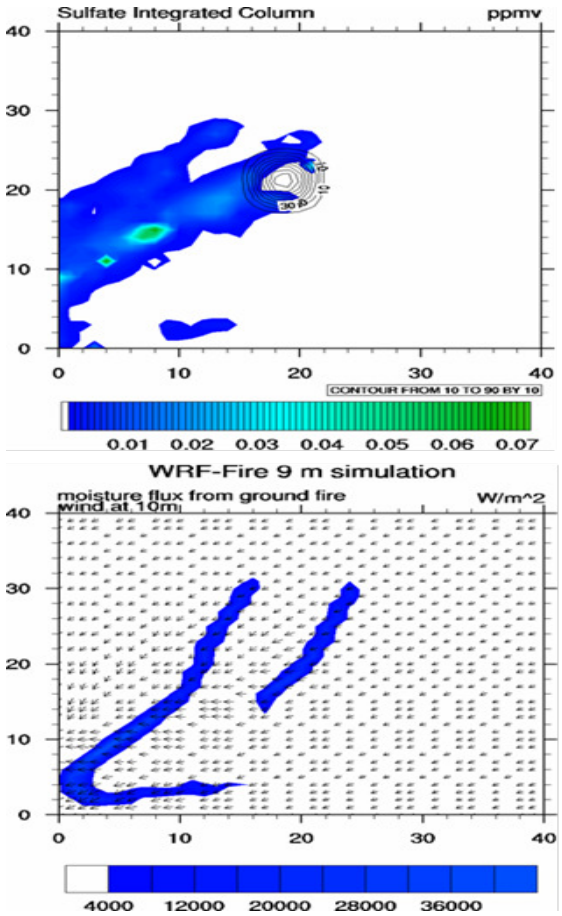


MODIS visible (top) MODIS AOD (middle) FIREHUB AOD (down)

Future Plans for FireHub developments







Extend the domain to cover the entire MSG disc

Examine the use of CFD modeling for fire propagation forecasts

Consider the use of WRF-Fire

Conclusions

- A satellite / modeling synergistic platform (FIREHUB) for open fire detection and biomass smoke dispersion forecast has been developed at NOA
- The long range transport of smoke is favored by the complex Greek coastline and the associated interchanges between land and marine PBL
- Smoke from the inland fires is quickly diluted and deposited inside the turbulent mixing layer
- Smoke plumes from coastal and island fires are decoupled and may travel several hundred kilometers downwind
- Satellite retrievals and FIREHUB simulations indicate AOD values exceeding 1 during severe smoke dispersion episodes
- Future plans include the continuous improvement of retrieval and modeling algorithms and the extension of the FIREHUB domain to cover the entire MSG-SEVIRI disc

Thank You !

BEYOND

SEVENTH FRAMEWORK PROGRAMME

GEO CRADLE

HORIZON 2020