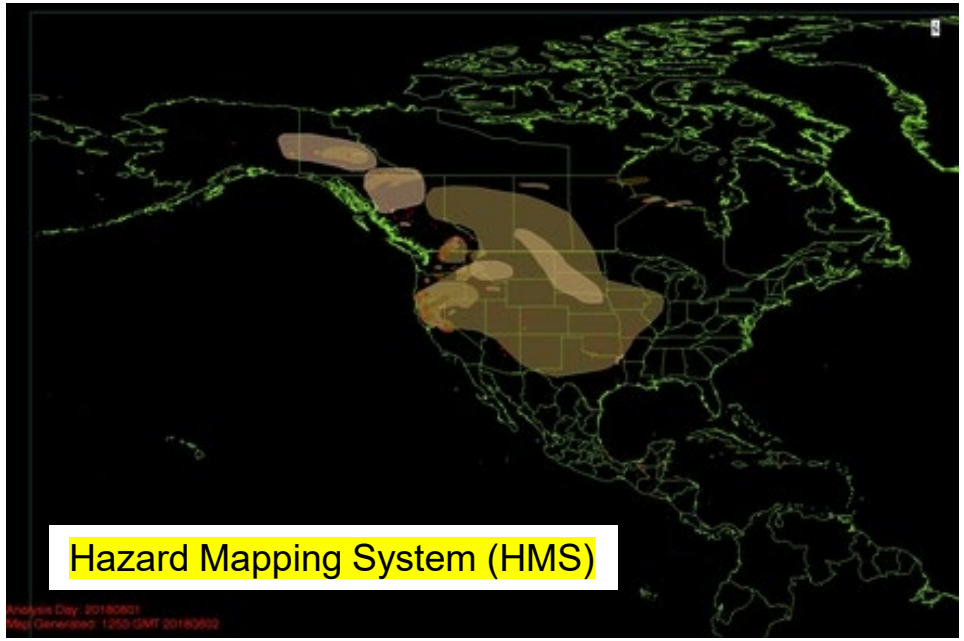
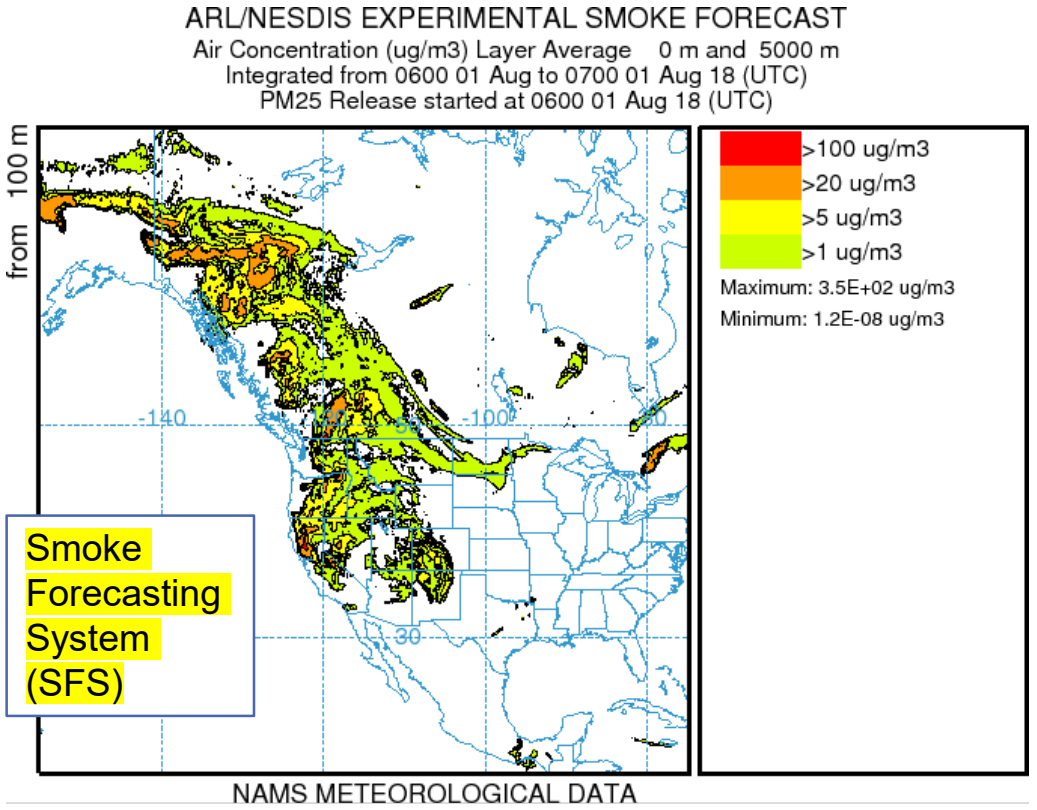
Smoke Forecast System

- **The Smoke Forecasting System (SFS), based on HYSPLIT, USFS Blue Sky emissions model, and the NOAA-NWS Hazard Mapping System, has been operated since 2007.**
- **Continuing to improving fire emissions estimates and forecast smoke air quality impacts remains an important goal.**





Fire smoke simulation using HYSPLIT

- **HYSPLIT smoke run**
  - EMITIMES
- **Fire emission information – need to know location, height & amount**
  - Wildfire emissions
    - Hazard Mapping System (HMS)
    - Blue Sky (USDA FS)
  - Prescribed fire
    - Blue Sky (USDA FS)
- **Future addition**
  - More plume rise options
  - Fire Radiative Power (FRP)
  - HEIMS

Improving smoke plume rise schemes

- **Briggs schme**

$$BF = a\,HEAT$$

$$H_p = \begin{cases} b\,BF\,U^{-1}\,u_*^{-2} & \textit{neutral, unstable} \\ c\,(BF\,U^{-1}\,s^{-1})^{\frac{1}{3}} & \textit{stable},\ U > 0.5\ \mathrm{m\ s^{-1}} \\ d\,BF^{\frac{1}{4}}\,s^{-\frac{3}{8}} & \textit{stable},\ U \le 0.5\ \mathrm{m\ s^{-1}} \end{cases}$$

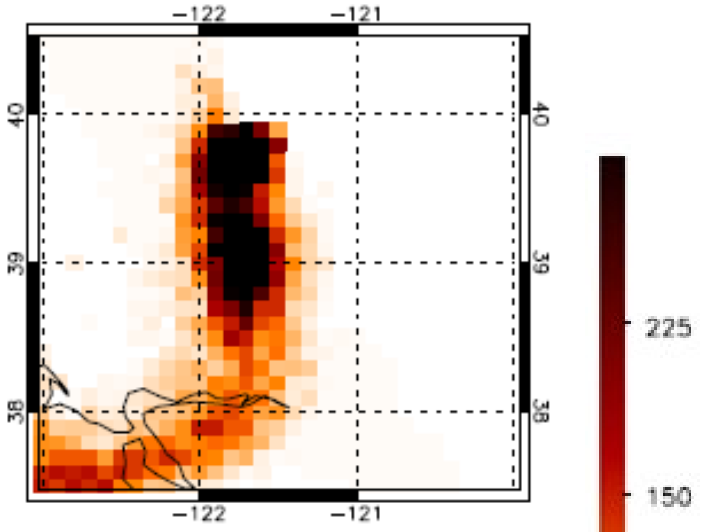
where *BF* is the buoyancy flux (m4/s3), *HEAT* is the heat released (W), *Hp* is the injection height (m), *U* is the horizontal wind speed (m/s) at 10-m elevation, *u** is the friction velocity (m/s), *s* is the static stability (1/s2), and *a*, *b*, *c*, and *d* are constants.

- **Sofiev scheme**

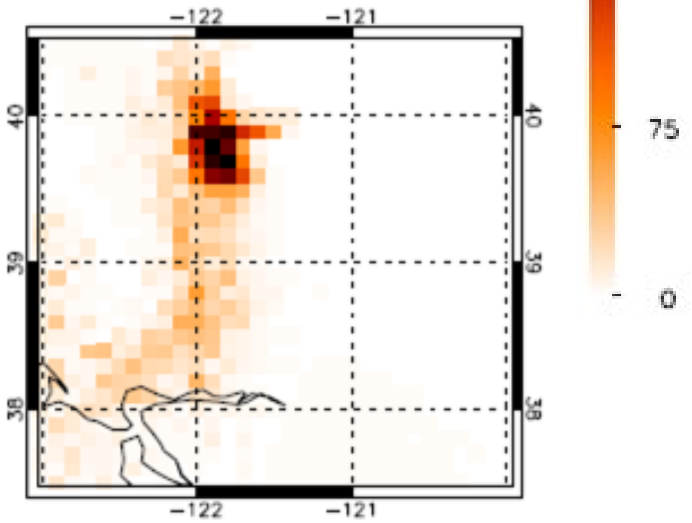
$$H_p = \alpha H_{PBL} + \beta\left(\frac{FRP}{FRP_0}\right)^{\gamma} \exp\left(-\frac{\delta BV_{FT}^2}{BV_0^2}\right)$$

HPBL is the PBL height (m), *FRP* is fire radiative power (W), *FRP*0 is the reference fire power which equals to 106 W, *BVFT* is the Brunt-Vaisala frequency in the free troposphere (FT, calculated at 500 hPa), *BV0* is the reference Brunt-Vaisala frequency which equals 2.5 × 10−4 s−2, and *α*, *β*, *γ,* and *δ* are constants.

Briggs



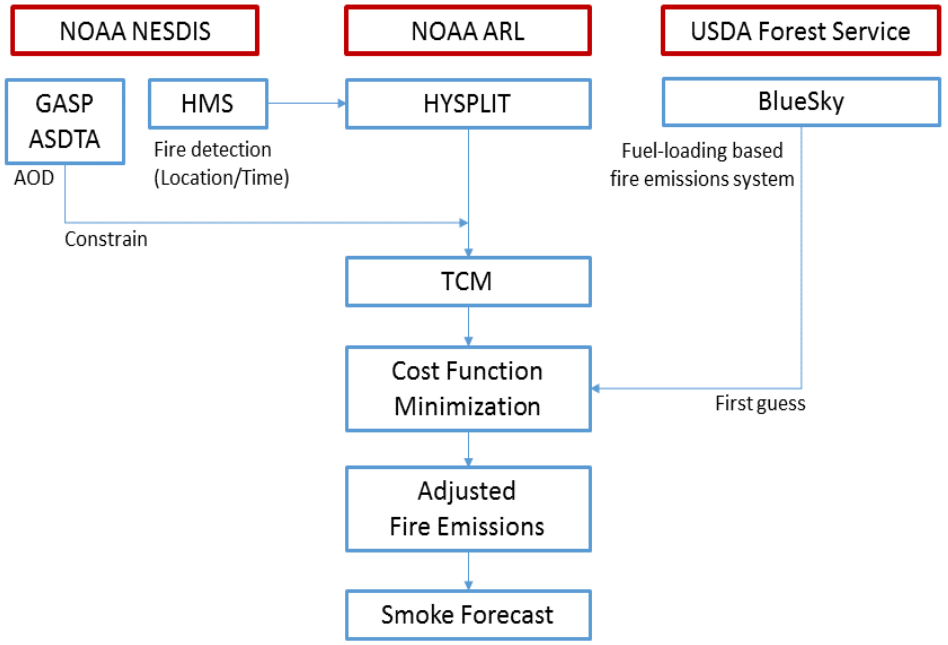
Sofiev



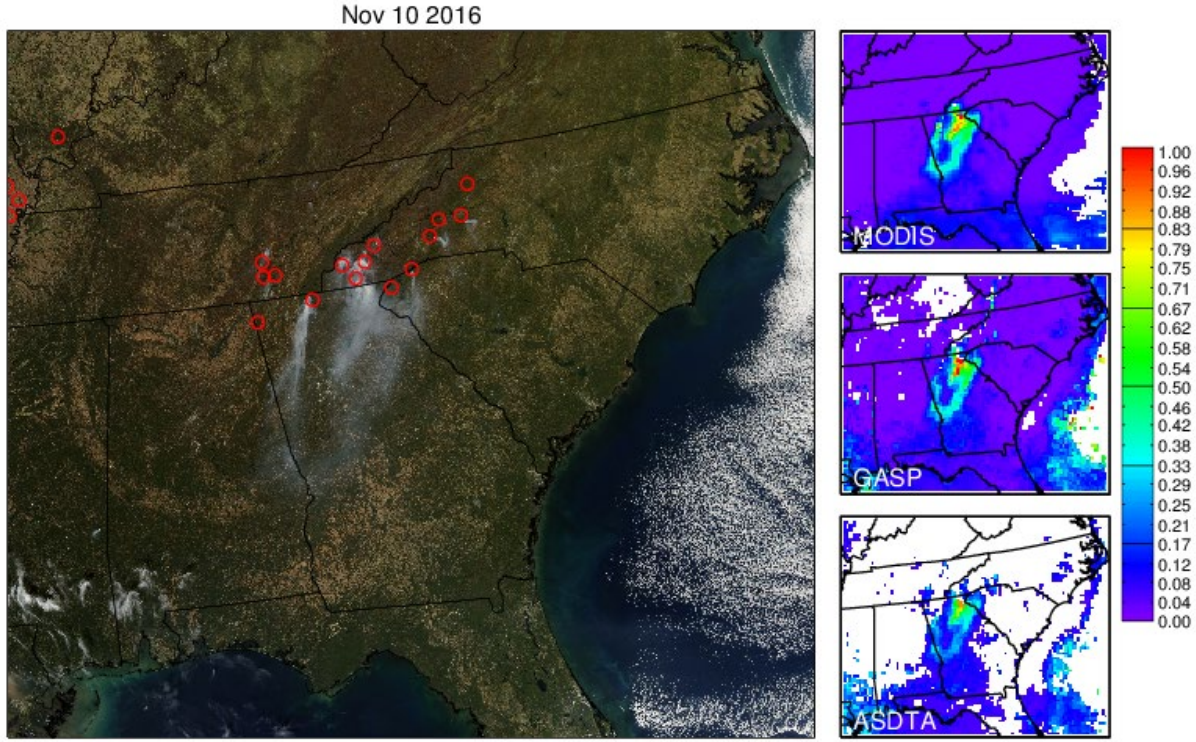
(Li et al., 2020 JGR)
PLRISE=1 plume rise option 1-Briggs; 2-Sofiev) used when heat/fire radiative power is nonzero in emissions input file

HYSPLIT-based Emission Inverse Modeling System for wildfires

- The HEIMS-fire system has been developed to estimate wildfire emissions constrained by space-born satellite observations



Schematic diagram of the HYSPLIT-based Fire Emission Inverse Modeling System.



Detection of fires over the southeastern region of the United States on November 10, 2016. True-color image from MODIS (left), MODIS AOD (top right), GASP AOD (middle right), and ASDTA AOD (bottom right) are shown.

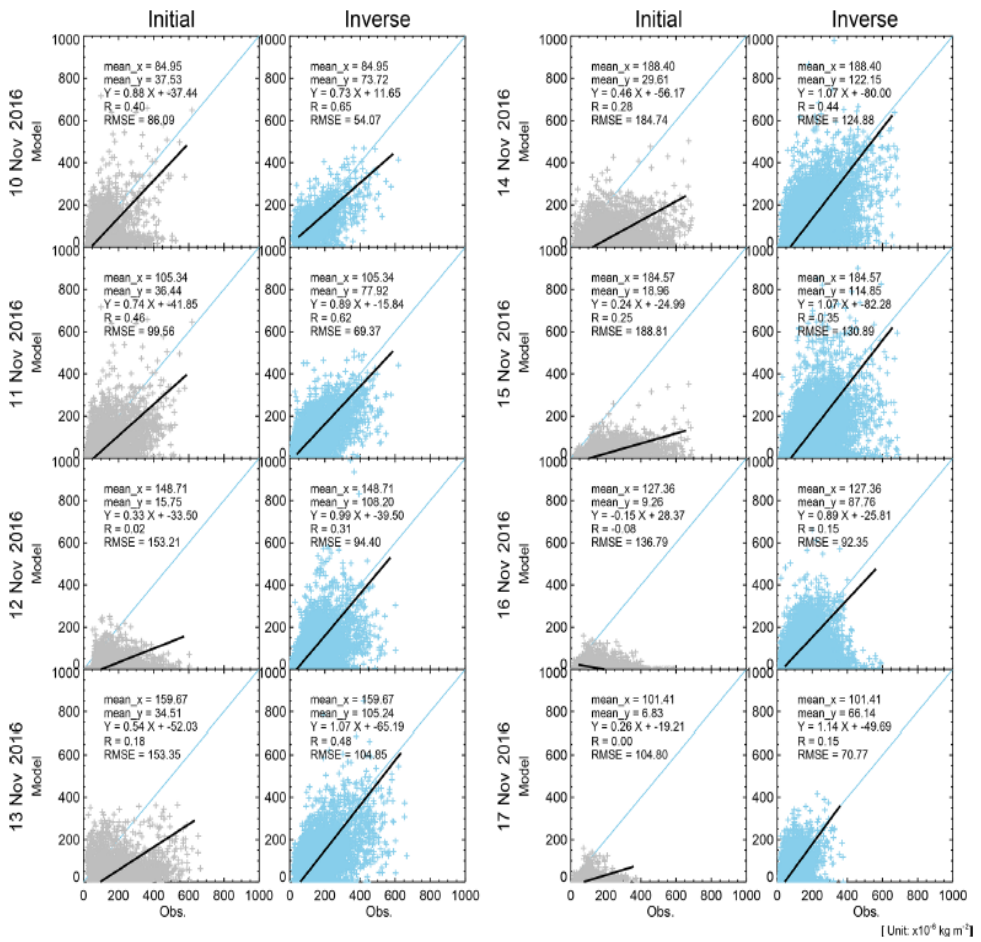
Inverse modeling of fire emissions

- **An independent HYSPLIT simulation starting at each HMS fire location with given starting time and duration is run with a unit source, at several possible release height to generate a *Transfer Coefficient Matrix (TCM)*.**

- **Source terms are solved by minimizing a cost function based primarily on the differences between model predictions and observations, following a general data assimilation approach.**

$$\mathcal{F} = \frac{1}{2}\sum_{i=1}^{N}\sum_{k=1}^{Z}\frac{(q_{ik}-q_{ik}^{b})^2}{\sigma_{ik}^2} + \frac{1}{2}\sum_{m=1}^{M}\frac{(c_m^h - c_m^o)^2}{\epsilon_m^2} + \mathcal{F}_{other}$$

First guess — HYSPLIT — GASP



Scatterplot comparison between initial and assimilated smoke mass loading using adjusted fire emissions.