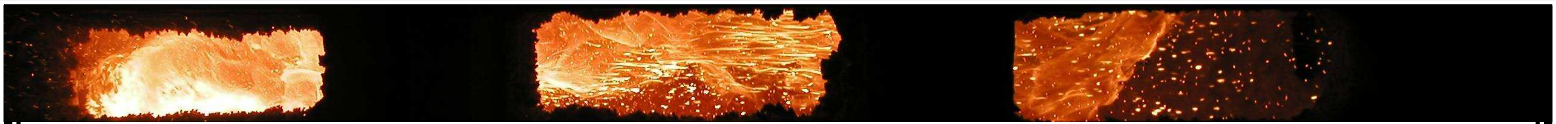
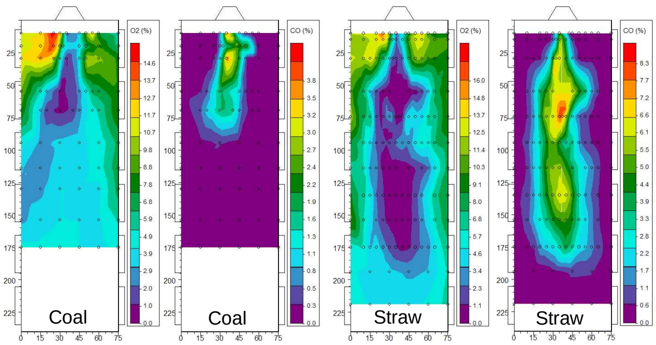


Comparison of Two Mixing Models with Experimental Solid-Fuel, Swirl-Stabilized Flame Data

Brad Damstedt, Justin Jones, Craig Christensen, Chris Johnson, Tom Jones, Mads Muff, Dale Tree, Larry Baxter
Brigham Young University – 2007

Objective: Compare relative merits of the assumed form Gaussian pdf mixing model with a newly formulated model using dual-delta functions

Experimental Data



Experimental data maps showing O_2 and CO fields for coal and straw low-NO_x flames. Other data, including CO_2, H_2O, CH_4, C_2H_2, C_2H_4, NO, NH_3, and HCN, as well as similar data sets for other fuels can be found at: http://etd.byu.edu

Flame vs. Flamelet

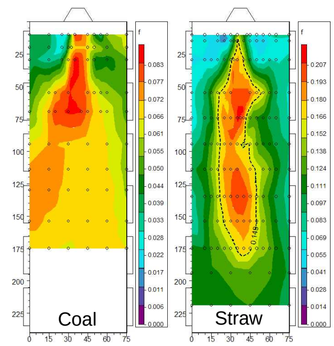
Flamelet: Individual reacting eddy. Fuel particles and volatile off-gases surrounded by a thin, reacting membrane (flame sheet).

Flame: Ensemble of many flamelets.

Flamelets intermittently fluctuating through a sampling volume give rise to super-equilibrium CO/O_2 mixtures.

How to model this?

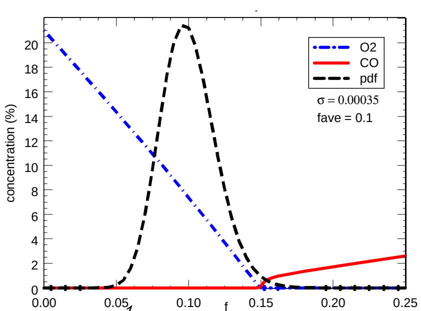
Mixture fraction



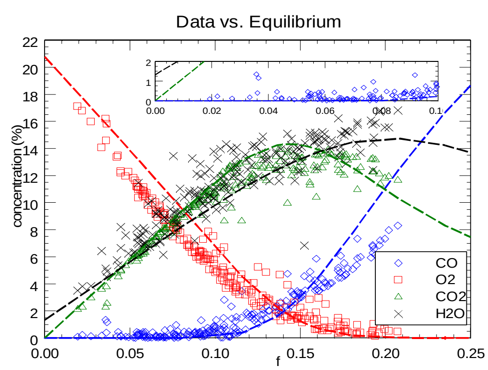
$$\bar{f} = \frac{m_f}{m_{tot}} = \frac{MW_c \cdot \sum x_i \cdot \xi_i}{MW_{tot} \cdot y_c}$$

Model Formulation

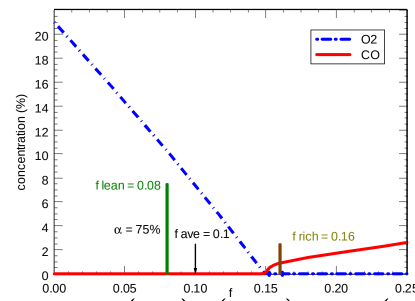
Assumed form Gaussian pdf



$$\bar{x}_i = \int_0^1 pdf(f,\sigma) \cdot x_{equil}(f)\, df$$



Dual Delta Function (DDF)

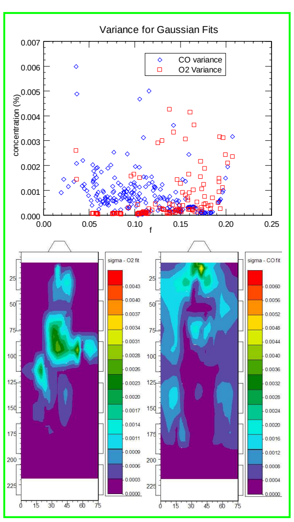


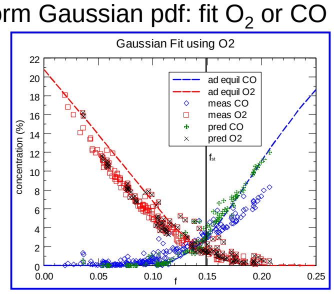
$$\bar{x}_i = \alpha \cdot x_{i,equil}(f_{lean}) + (1-\alpha) \cdot x_{i,equil}(f_{rich})$$

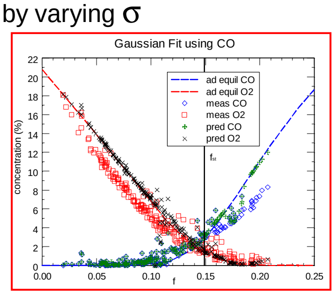
$$\bar{f} = \alpha \cdot f_{lean} + (1-\alpha) \cdot f_{rich}$$

Approach: Fit the experimental data by varying the model parameters

Assumed form Gaussian pdf: fit O_2 or CO by varying σ







O_2 fit gives poor CO estimates – no intermittency

CO fit gives poor O_2 estimates

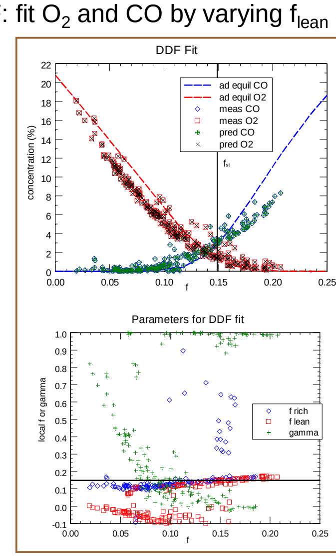
σ_{O2} and σ_{CO} are different, show different spatial trends

DDF fits O_2 and CO well, but uses physically impossible parameters

Both models are unsatisfactory in estimating intermittency

Recommendations: Vary off-gas composition and temperature, incorporate solid carbon (soot) effects

DDF: fit O_2 and CO by varying f_{lean} and f_{rich}



Acknowledgements: DONG Energy