Modeling Airborne Emissions from Agricultural Fumigants

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Two Steps to Modeling Exposures

- Emissions assessment
  - **On-field profiles**
  - Flux chambers
  - Ambient networks
- Dispersion modeling
  - **FEMS**
  - PERFUM

Emissions Assessment

Based on IHF Method

Integrated Horizontal Flux Method

Basic IHF equation:

$$Q_i = \frac{1}{x}\int_{z_o}^{z_p} \left(\bar{u}_z \bar{\chi}_{z\,dw}\right) dz$$

IHF equation with regression coefficients inserted:

$$Q_i = \frac{1}{x}\int_{Z_O}^{z_p} (A_i * Ln(Z) + B_i) * (C_i * Ln(Z) + D_i) dz$$

Equation to compute top of plume for trapezoid rule integration:

$$z_p = e^{\left(\frac{(0.1-D)}{C}\right)}$$

Design Considerations

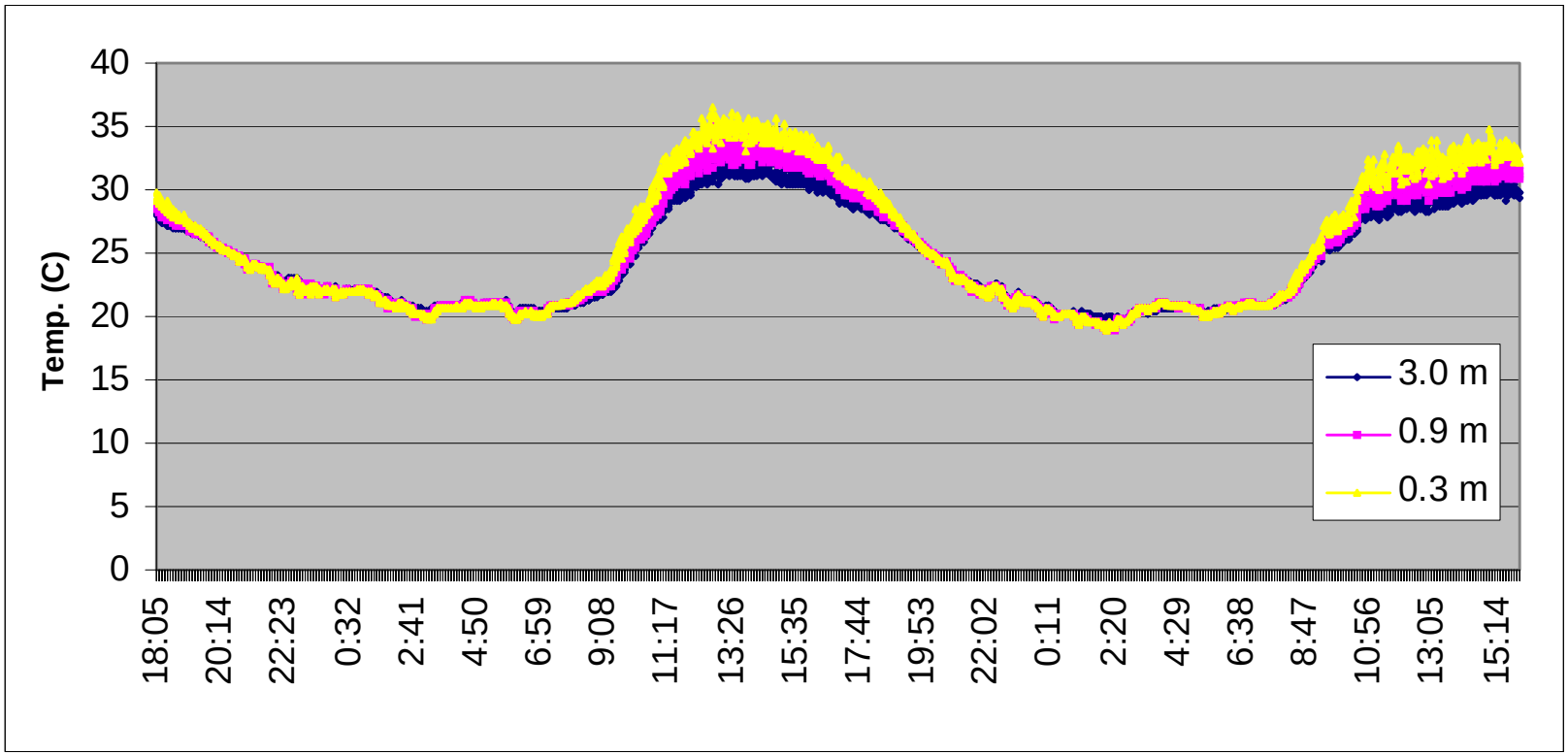
Reference	Field Size	Fetch or Recommended Fetch (m)		# Sampling heights	Height of Highest sampler (m)
		IHF	AD		
Beauchamp et. al., 1978	0.4 hectare	**36**		4	1.5
Das, 2003	135 hectares		500	2	2.5
Denmead, Freney, & Simpson, 1977	24 m fetch	**24**		4	2.24
Freney & Simpson, 1983		**30**	100	5	0.1 x fetch
Majewski, 1999			100	4-8	2
Majewski et al, 1990	1 hectare		100H	5	1.5 m
McInnes. et. al., 1985		**20**		5	2.4
Phillips, 2004			NA	2	6
Summer, 2004	7.5 m^2		NA	5	2.4
Wilson, 1982			300		
Wilson, 1992		**20**	200	5	
Yates et al., 1996b	3.5 hectares		100	6	1.6
Yates et al., 1997	3.5 hectares			9	2.6

Complicating Factors to Consider

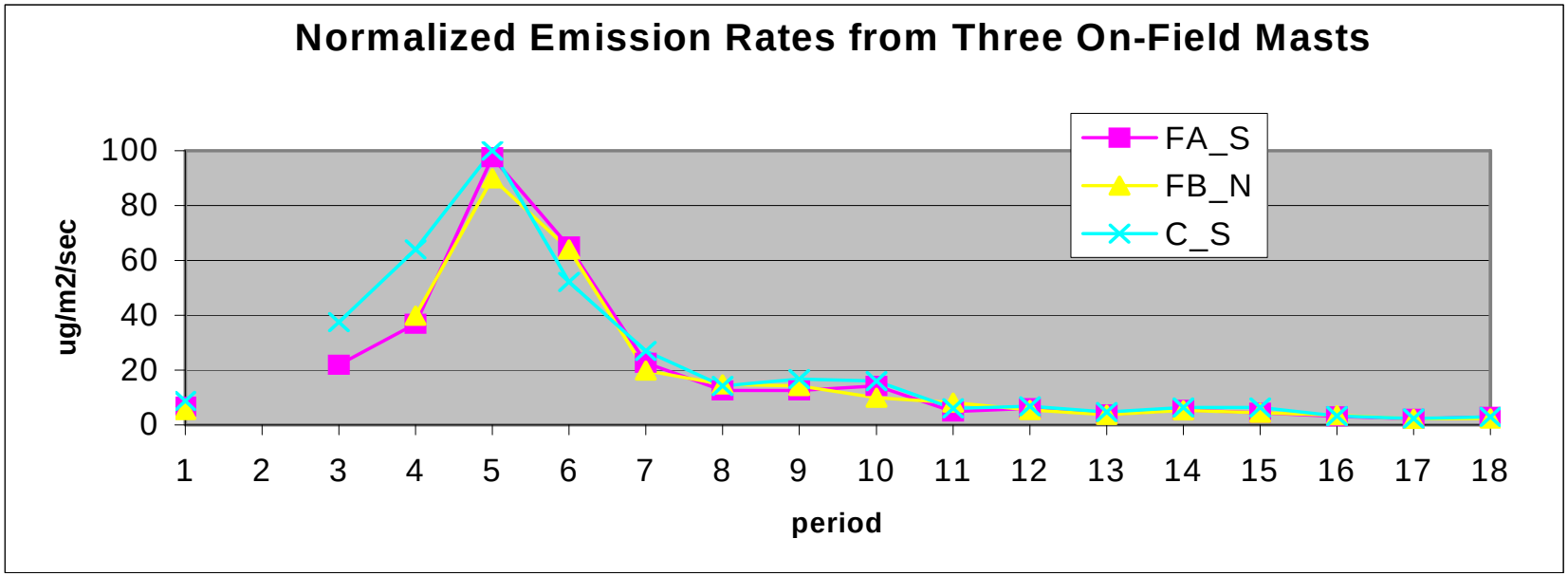
- IHF Limitations Involved with Simplification of Dropping the **Fluctuating Term**:
  - $\overline{u_z \chi_{z\,dw}} = \bar{u}_z \bar{\chi}_{z\,dw} + u_z' \chi_z'_{dw}$
  - < 5% understatement (50m fetch; <=0.01m z_o
- IHF Limitations Involved with Varying **Saturation Deficits** with Fetch - - potential for overstatement
  - Fetch > 25-30 m relatively small factor

Complicating Factors to Consider (Cont.)

Simplifying assumptions of profile shape are complicated by modification to surface by irrigation and tarped surfaces



Precision

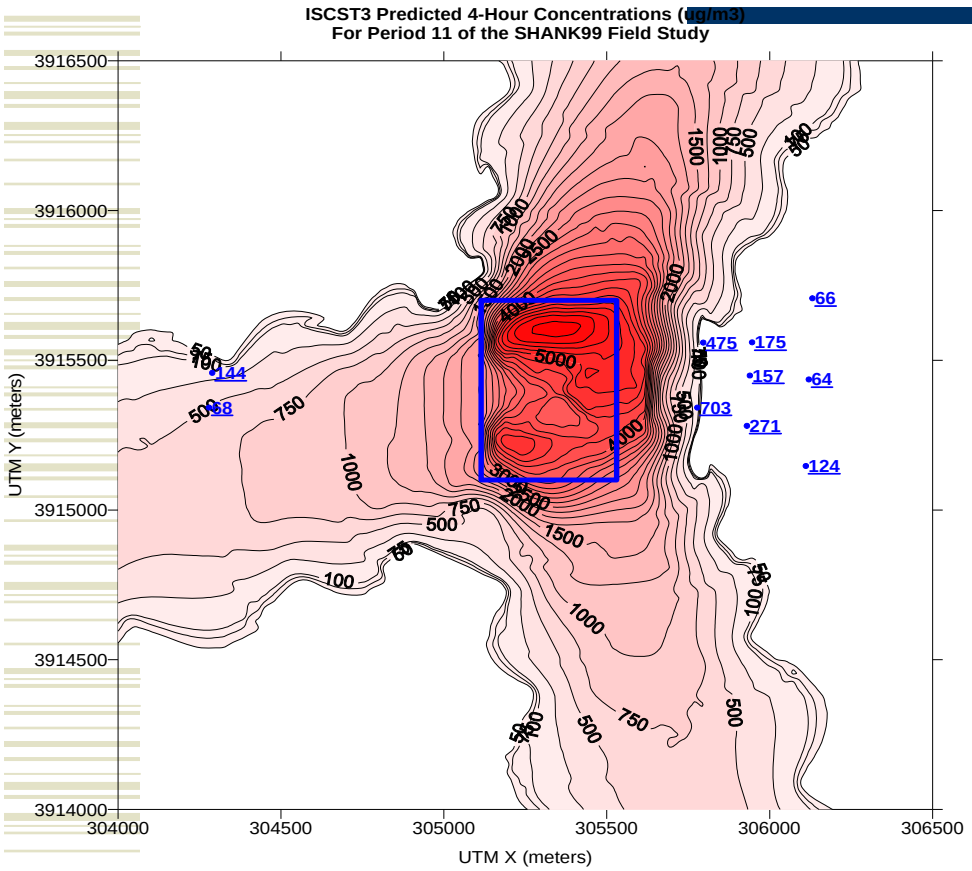


High level of precision based on multiple masts, with Low coefficient of variation of ~ 0.1

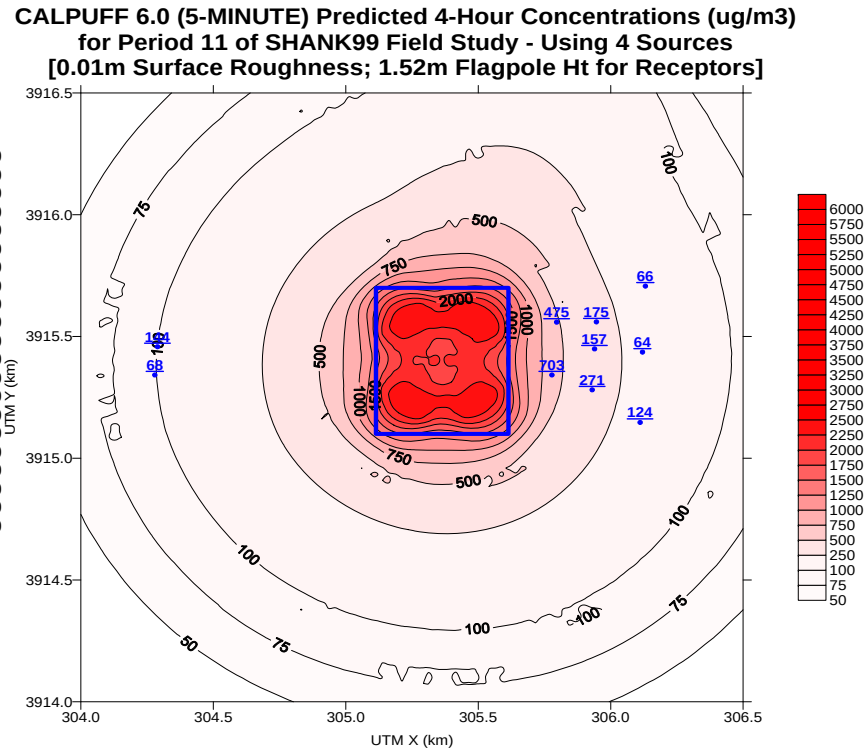
Caution: No Model Calibration with On-Field Flux - - Use Unbiased Dispersion Model

- Ambient method costly and limiting in terms of coverage, but self-correcting
- Models such as ISCST3 with substantial nocturnal bias can be a mismatch with independent IHF data
- CALPUFF 6 with 5-minute time steps is recommended

Example: Nocturnal Period with Light Wind Speeds



ISCST3 cannot replicate Measured concentration field



CALPUFF 6 can replicate Measured concentration field

Dispersion Modeling

Based on FEMS / CALPUFF 6

Why FEMS / CALPUFF 6?

- EPA recommended model of choice for complex winds (which are limited factor for agricultural fumigants) = CALPUFF 6
- Shown to replicate measured concentration fields while ISCST3 alternative cannot
- ISCST3 has been delisted by EPA in 2006 as obsolete model

How Can CALPUFF 6 Be used if CALPUFF 5 is Regulatory Version?

- For simple area sources such as used in FEMS, CALPUFF 6 and CALPUFF 5 with matched to hourly time steps are **equivalent**
- If CALPUFF 6 = CALPUFF 5 at 1-hour, physics are the same for 5 minute steps
- Alternative of ISCST3: model has no regulatory status at this time

Current Benefits of FEMS / CALPUFF 6

- Only alternative to realistically represent critical nocturnal concentrations
- State-of-the-art Monte Carlo treatment of uncertainty as approved by SAP
  - Emission rates
  - Meteorological factors
- Suitable for modeling large PNW fields (> 40 acres)

Benefits in Development at this Time

- Seasonal emissions scalars per Chain 2D relative scaling
  - Improved accuracy for non-summer periods
  - Lower buffer zones (non-summer)
- More realistic simulations of center pivot applications - - wedge-by-wedge sequence

End