Determination of Isoprene Emissions from Aircraft Measurements During 4 Campaigns and Comparison with Emission Inventories

Carsten Warneke and Joost de Gouw

NOAA Earth System Research Laboratory
and
CIRES, University of Colorado
Boulder, Colorado

Compare measurements versus inventories using:
1. Mixed-boundary layer method
2. Flexpart model

Inventories used: BEIS3.12 and 3.13, MEGAN and Wiedinmyer et al. for Texas

Top-Down Evaluation of Biogenic VOC Inventories

Different methods have been used previously:

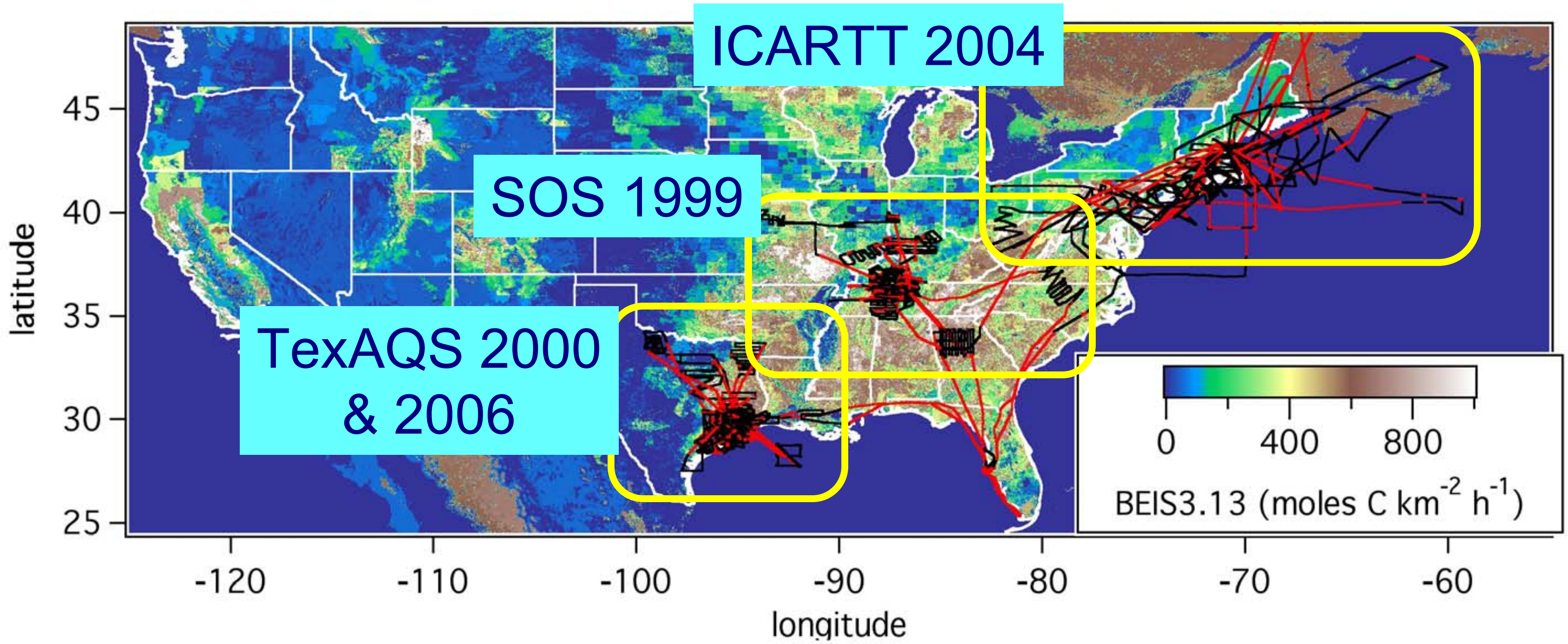
1. Eddy-covariance flux measurements
   e.g. *Guenther and Hills* [JGR 1998]
   very accurate, but only 1 location

2. Using satellite-derived formaldehyde
   e.g. *Palmer et al.* [JGR 2006]
   large scale, but indirect

3. Regional chemistry models vs. measurements
   e.g. *Mueller et al.* [ACP 2008]
   emissions, meteorology and chemistry all have to be correct

Here: use airborne measurements to estimate isoprene emissions at the aircraft location and compare with inventories

NOAA Aircraft Measurements of Biogenic VOCs in the U.S.



BEIS 3.13 Base Emissions

VOC measurements:

- Canister sampling
- Airborne GC
- Proton-Transfer Reaction Mass Spectrometry

Approach 1: Mixed Boundary Layer Method

1. Estimate Emissions from Measurements

$\left.\begin{array}{l}\text{assume well-mixed PBL}\\ \text{PBL height from aircraft data}\\ \text{estimate OH} \Rightarrow \text{VOC lifetime}\end{array}\right\}$ estimate emissions

2. Calculate Emissions from Inventory

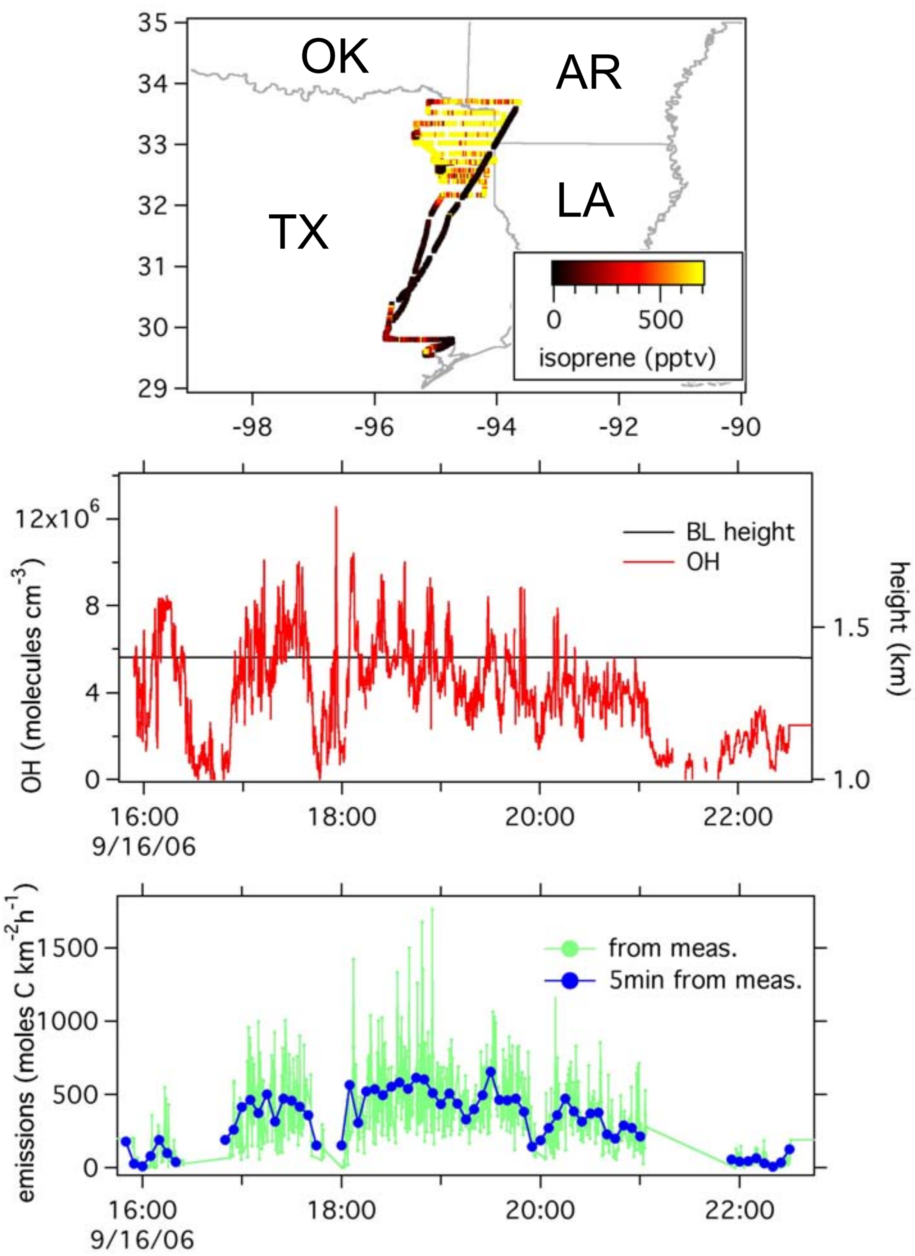
Temperature and PAR from aircraft data

3. Compare Measurements to Inventories

<u>Inventories used in this work:</u>

- BEIS3.12
- BEIS3.13
- WM2001 [*Wiedinmyer*, AE 2001] (TX only)
- MEGAN [*Guenther*, ACP 2006]

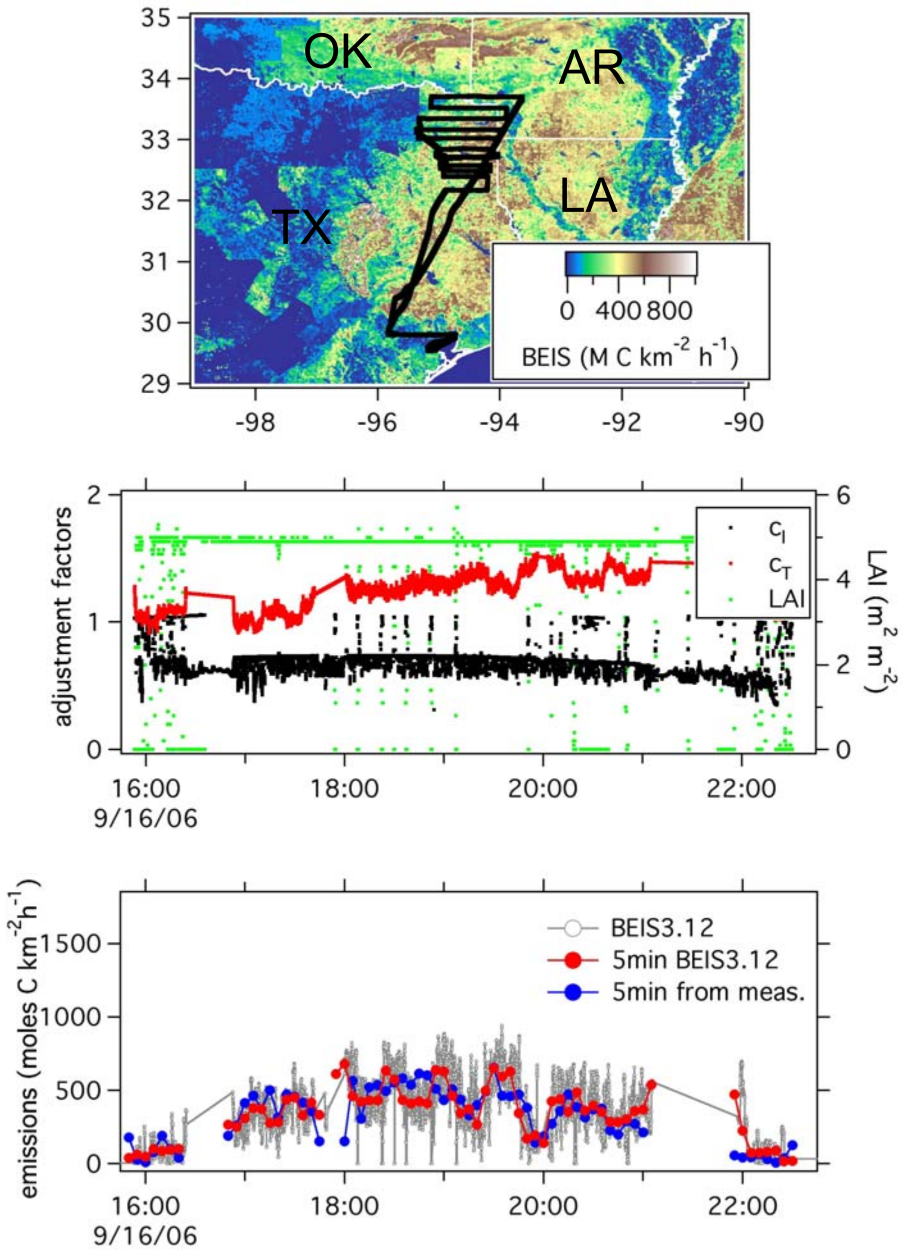
Step 1: Estimate Emissions from Measurements



isoprene emission - F_e =
measured concentration
$\times$ BL_{height} $\times$ OH $\times$ k_{OH}

- F_e = entrainment flux
- BL_{height} from aircraft data
- OH from parameterization using j_{O3}, j_{NO2}, and NO_2 [*Ehhalt*, JGR 2000]
- Uncertainty: -50%, +100%

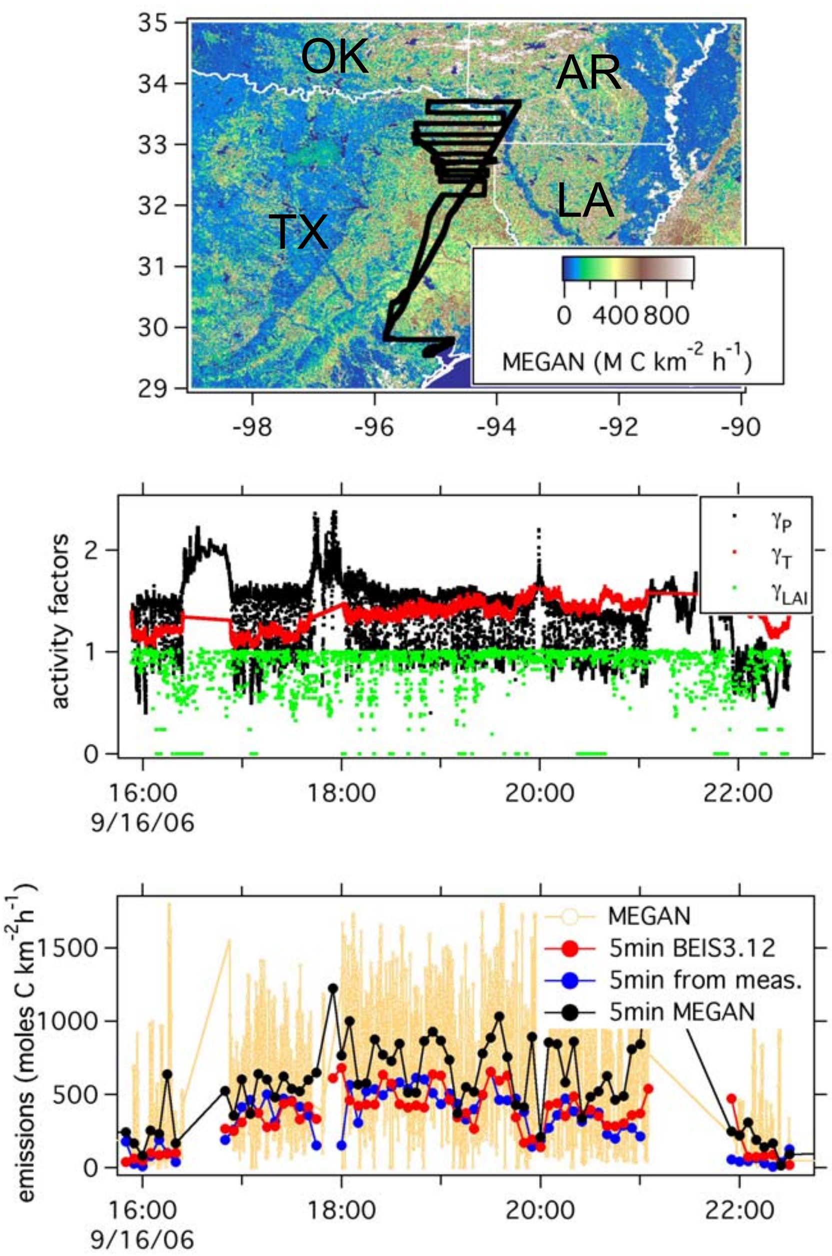
Step 2: Calculate Emissions from Inventory - BEIS



isoprene emission = base emission $\times c_t \times c_l$

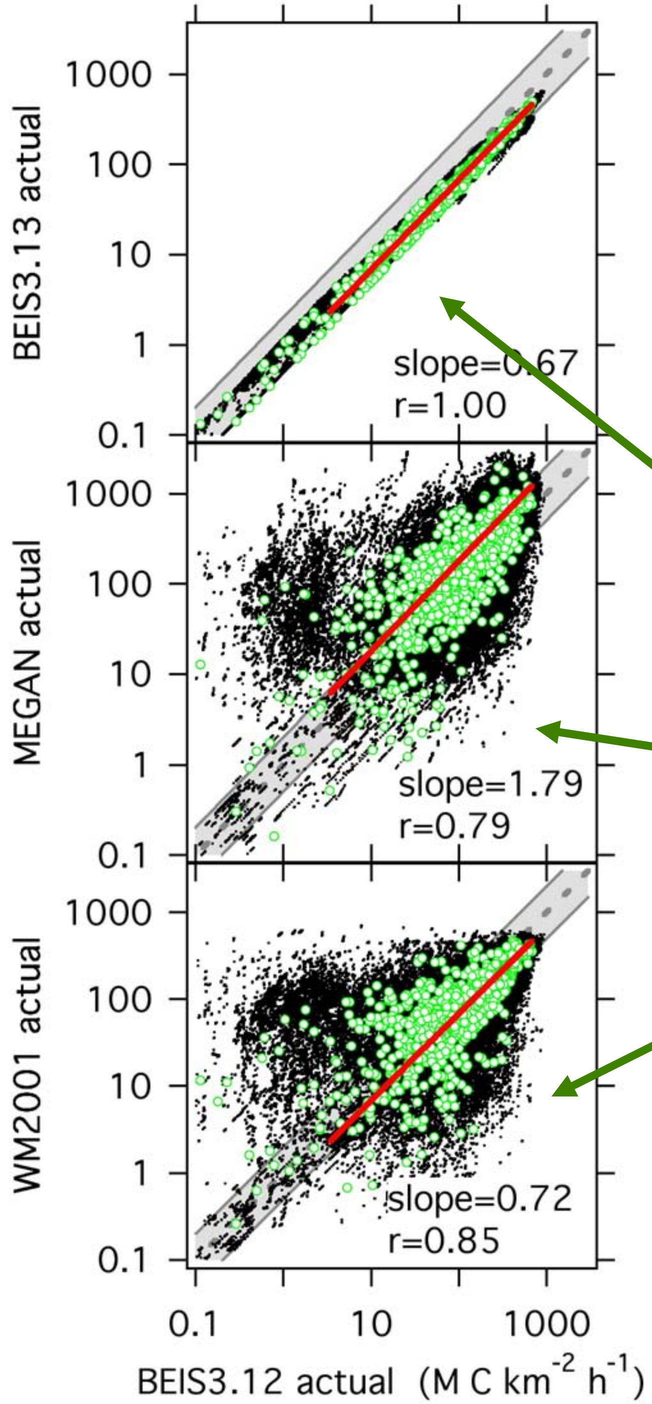
- c_t = temperature factor
  temperature from aircraft
- c_l = light factor
  PAR from aircraft
  using leaf-area index (LAI)

Step 2: Calculate Emissions from Inventory - MEGAN



isoprene emission = base emission × $\gamma_t \times \gamma_l \times \gamma_{LAI} \times \gamma_{age}$

- γ_t = temperature factor from aircraft data
- γ_l = light factor from aircraft data
- γ_{LAI} = leaf-area index factor
- γ_{age} = leaf-age factor from ECMWF past 15-day weather

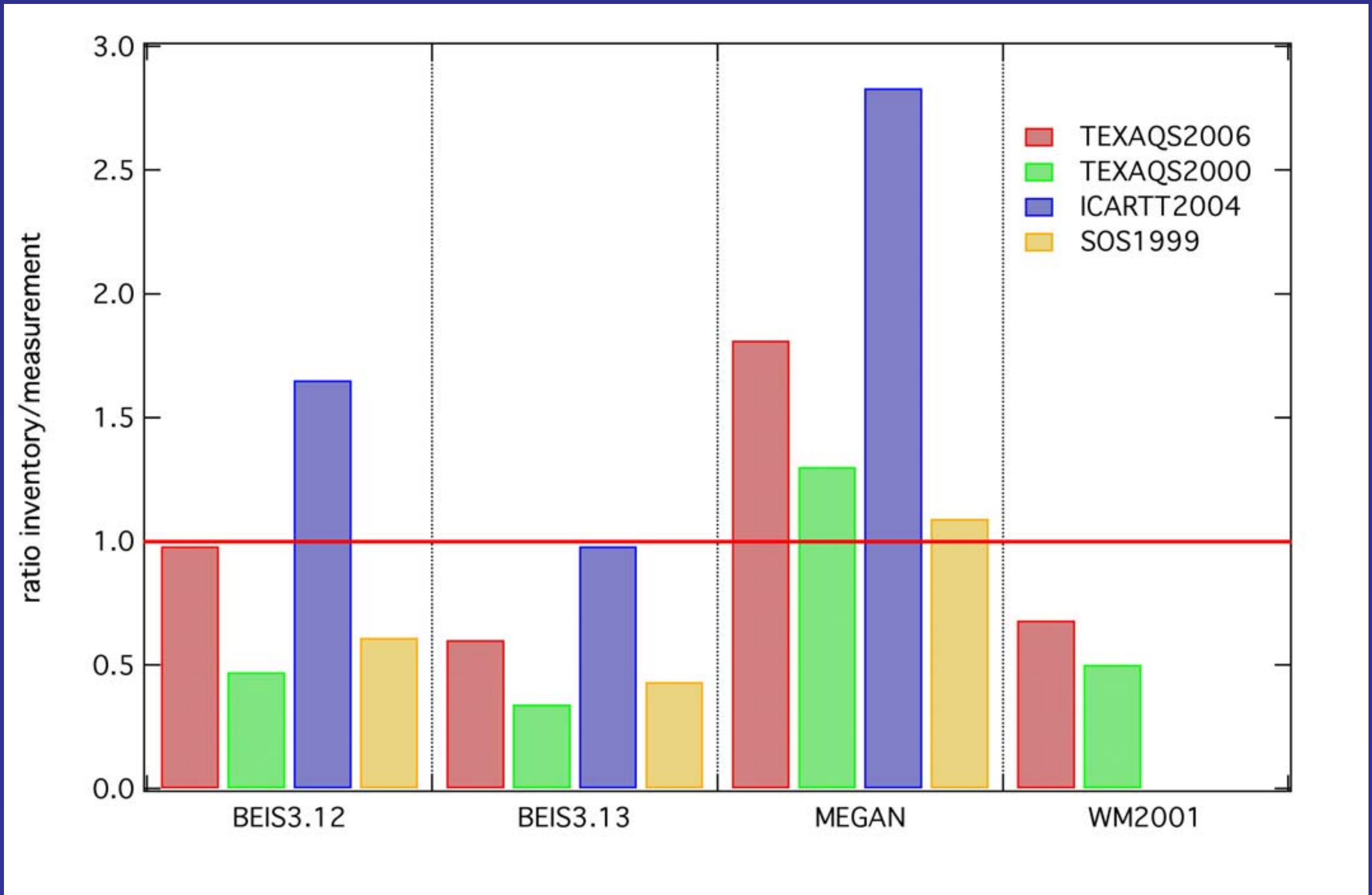


Differences Between Inventories

Actual emissions along flight tracks:

- BEIS 3.13 = 0.67 × BEIS 3.12
  different light parameterization
- MEGAN = 1.79 × BEIS 3.12
  different base emissions
- WM2001 = 0.72 × BEIS 3.12

Step 3: Compare Measurements to Inventories



- Overall agreement within factor of ~2
- MEGAN higher than most measurements; BEIS 3.13 lower
- Texas: higher emissions in 2006 than in 2000

Approach 2: Calculate Isoprene with FLEXPART - BEIS 3.12

FLEXPART

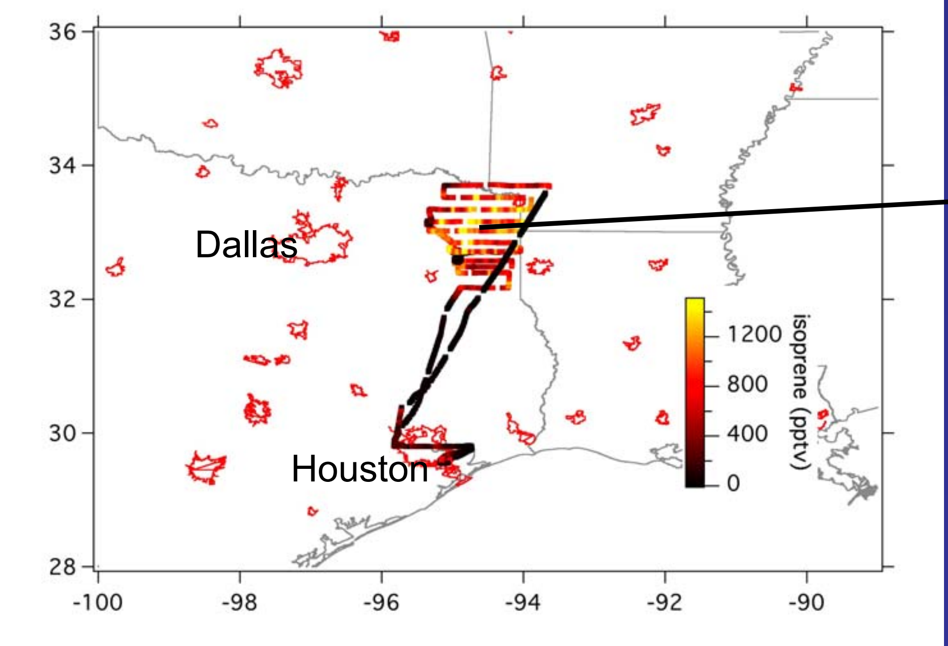
- Lagrangian transport model [*Stohl*, JGR 2003]:
- ECMWF meteorology
- No chemistry: remove isoprene after 1 hour of transport

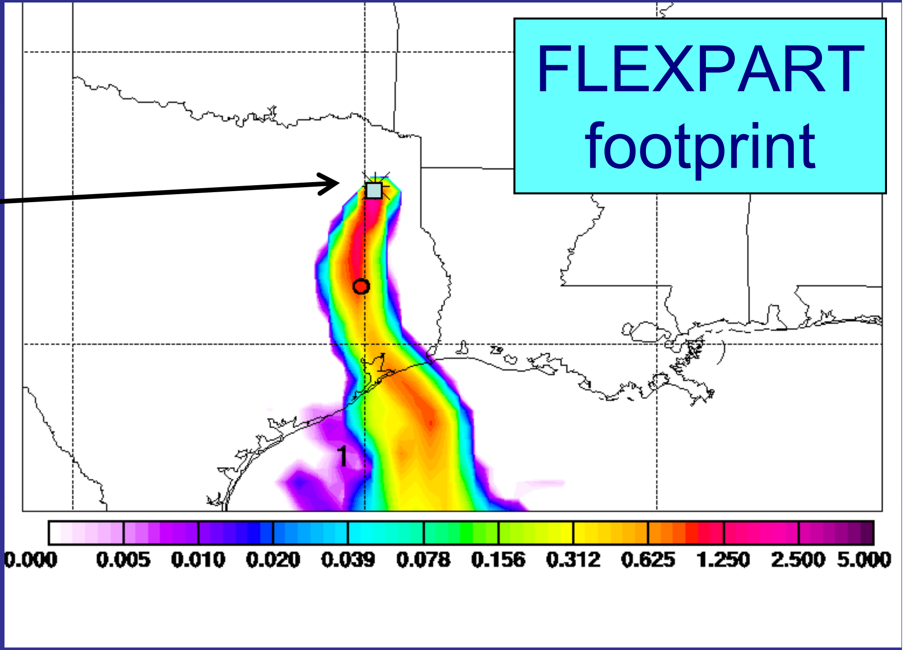
BEIS 3.12

- 0.15^0 x 0.15^0 resolution
- Temperature and light from ECMWF

Approach 2: Calculate Isoprene with FLEXPART - BEIS 3.12

Example: September 16, 2006, over NE Texas

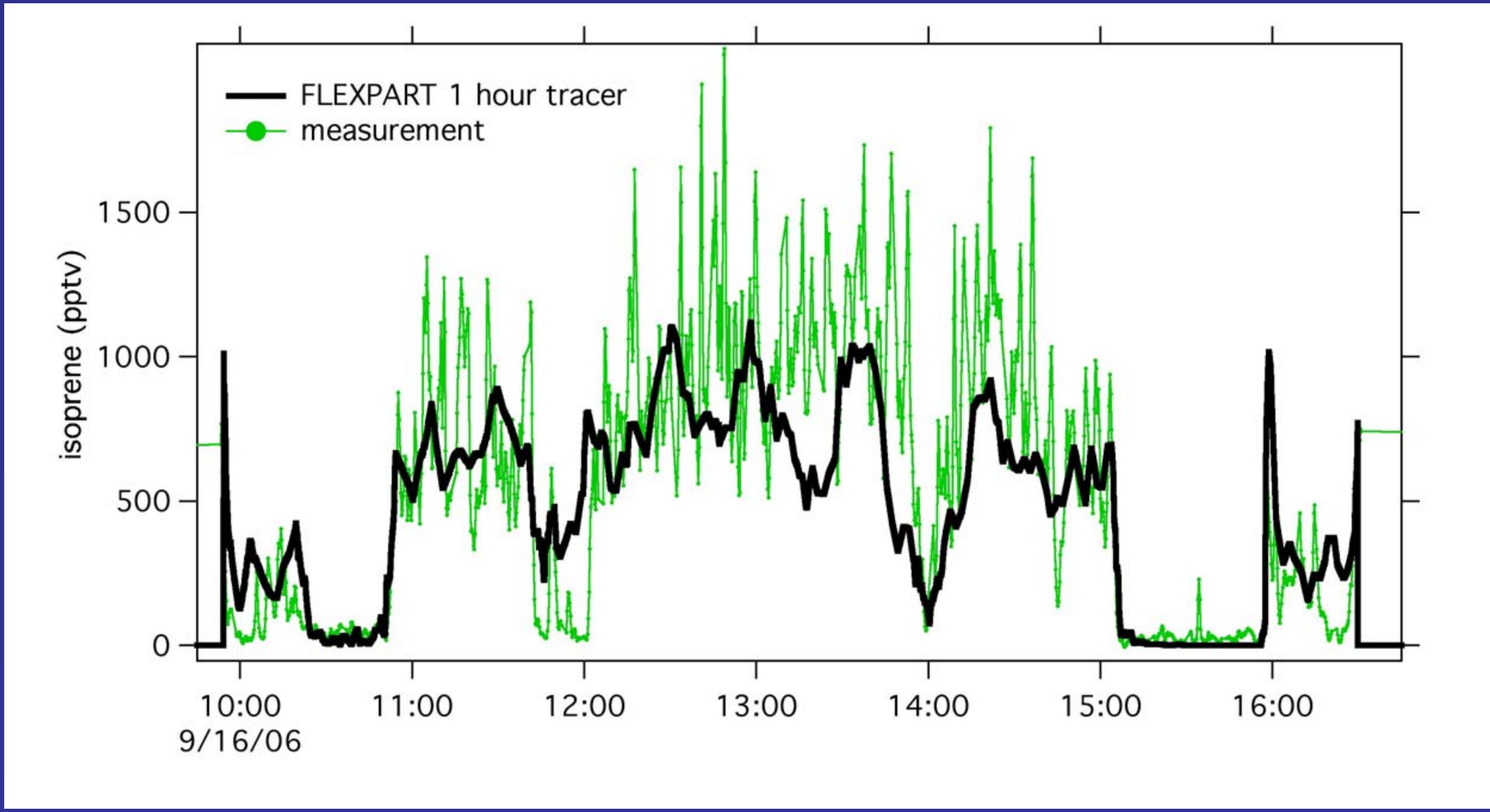




- Model releases 40,000 particle back-trajectories from each measurement location
- Footprint is BL residence time of all particles
- Isoprene concentration = footprint × emissions from BEIS 3.12
- Isoprene removed after 1 hour of transport

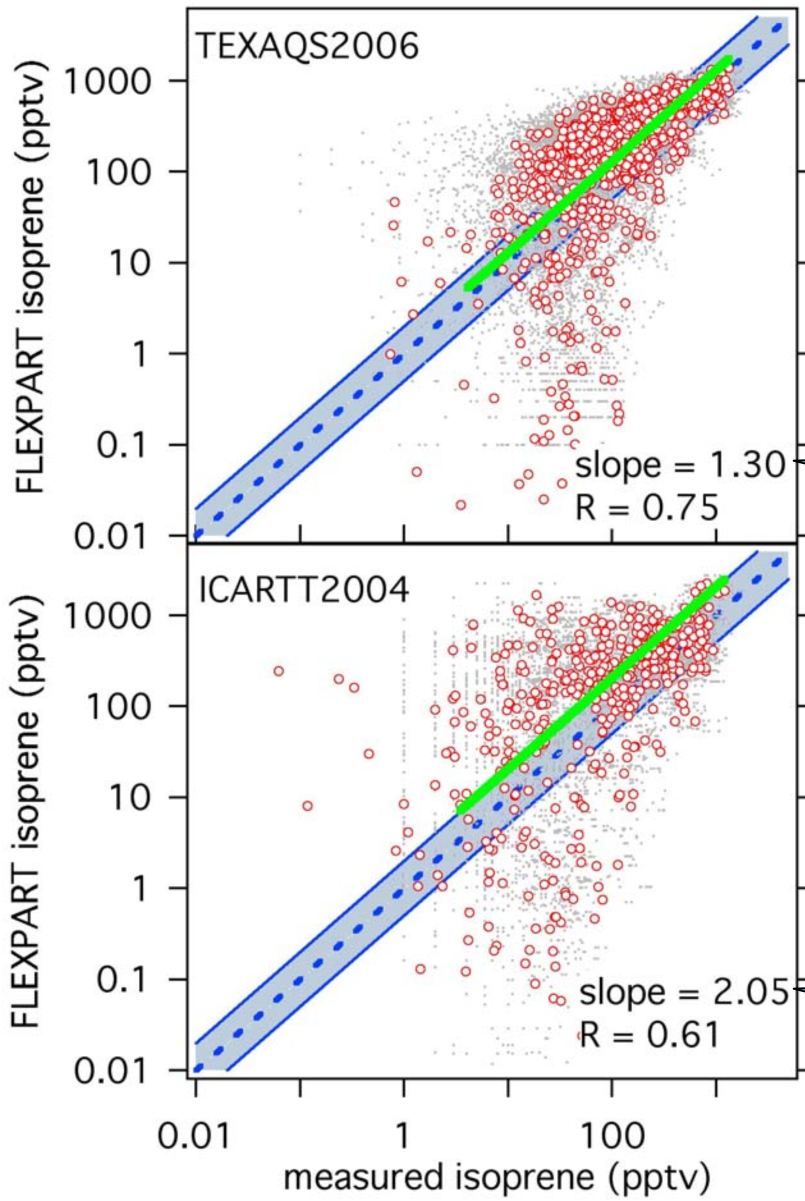
FLEXPART - BEIS 3.12 vs. Measured Isoprene

Example: September 16, 2006, over NE Texas



- ➢ Agreement within factor of ~2

FLEXPART - BEIS 3.12 vs. Measured Isoprene



- Texas: good agreement
- Northeastern U.S.: FLEXPART ≈ 2 × measured data

Slope was 0.98 in previous method

Slope was 1.65 in previous method

Summary

1. Two methods were used to compare airborne measurements of isoprene directly with inventories: overall agreement within factor of ~2 is found in both methods

2. For all areas: MEGAN > BEIS 3.12 > BEIS 3.13

No time to show:

3. Larger uncertainties for monoterpenes

4. Method allows identification of local differences

e.g. discontinuity at U.S.-Canadian border in BEIS

TX hotspot between Dallas and Houston

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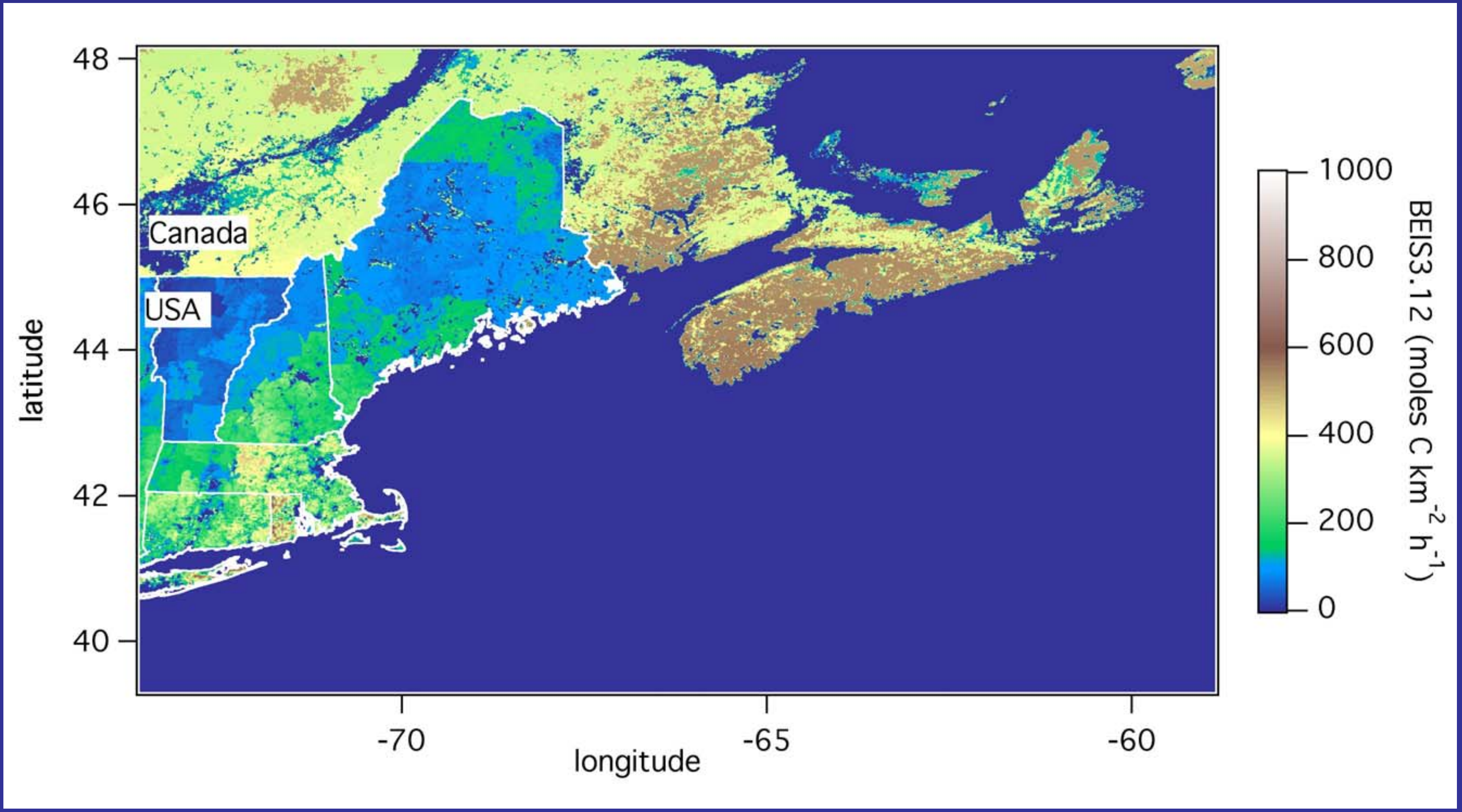
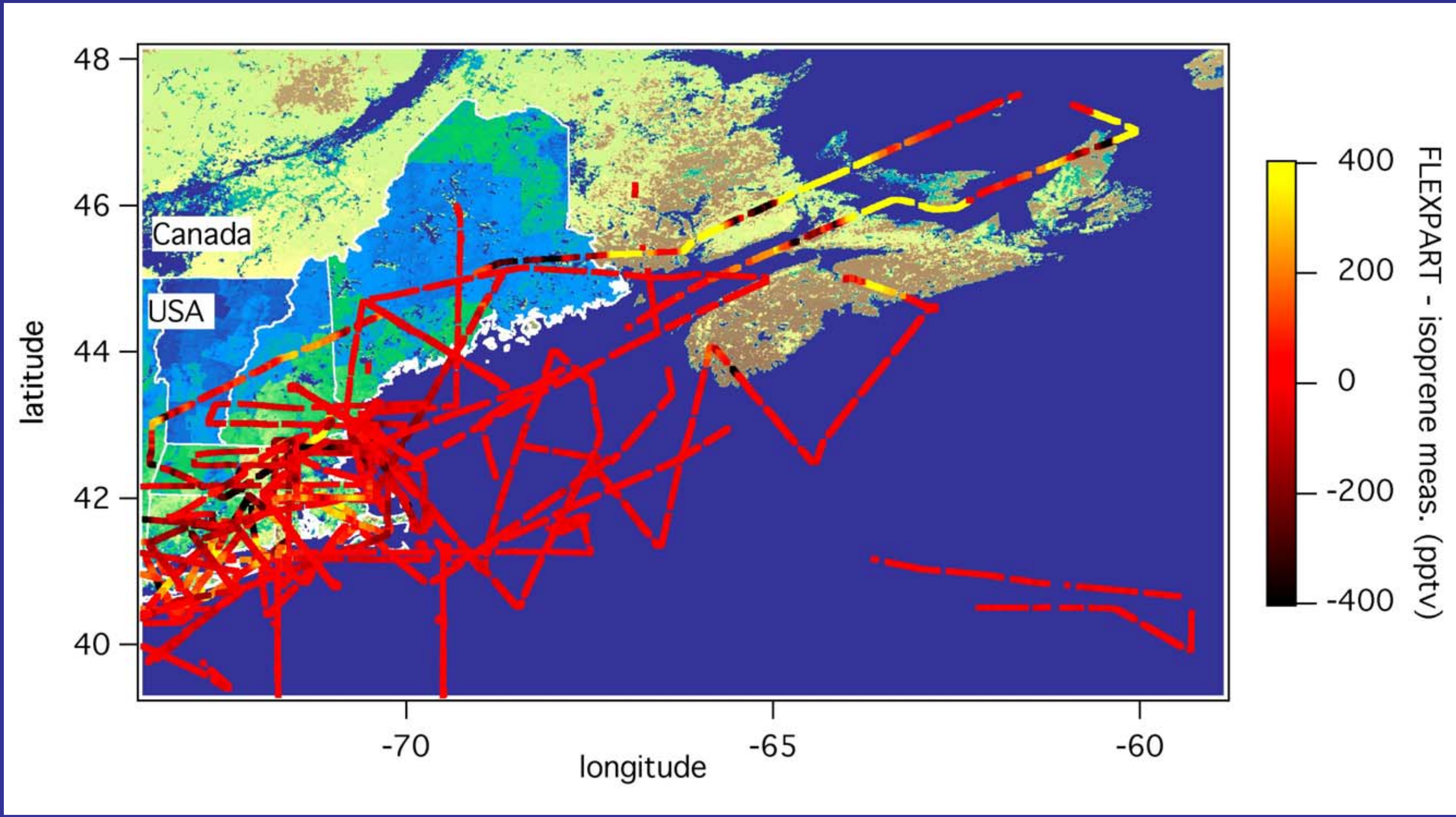
Differences by Location

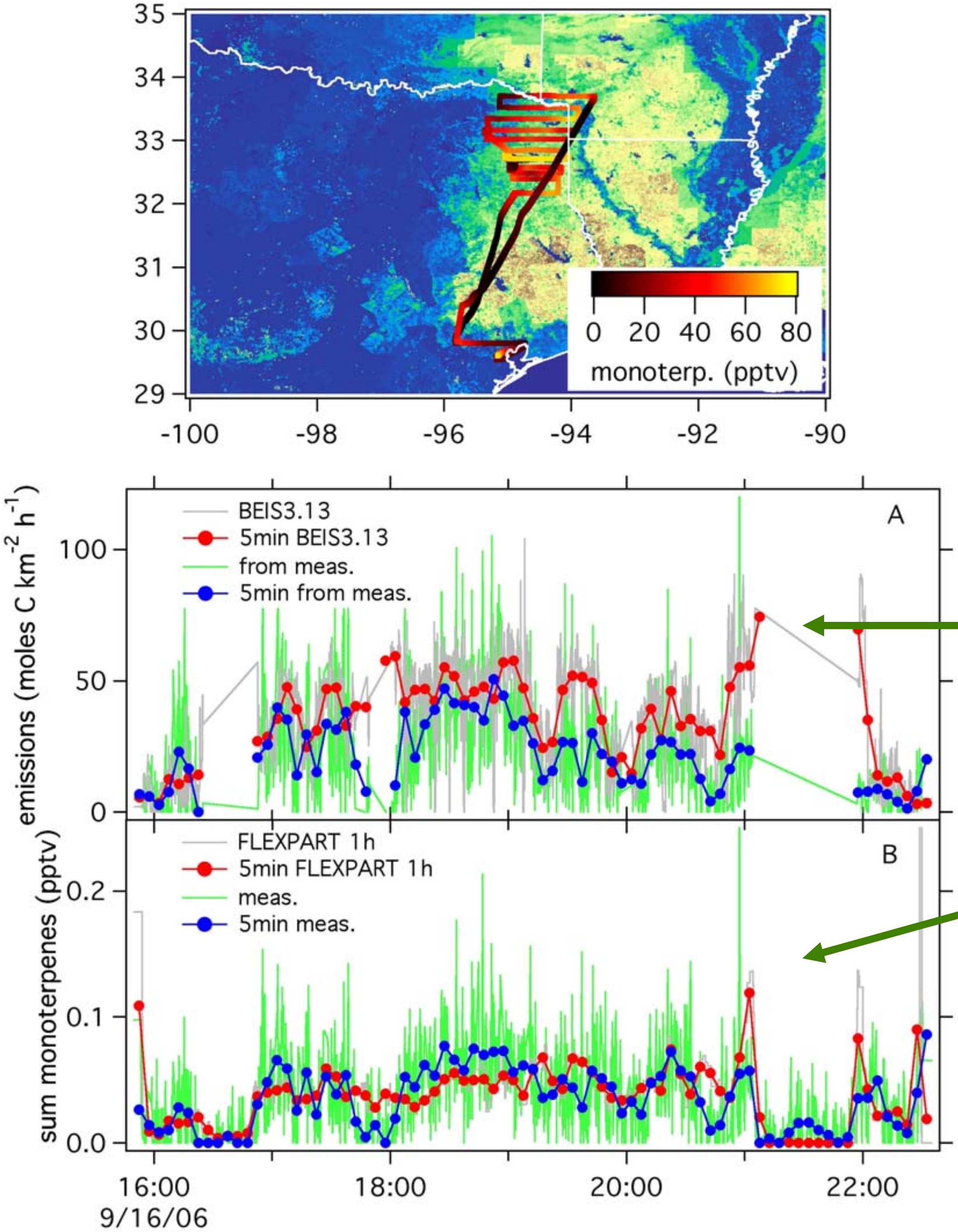


- Discontinuity at the U.S.-Canadian border
- Different land-cover data used

Differences by Location: Isoprene



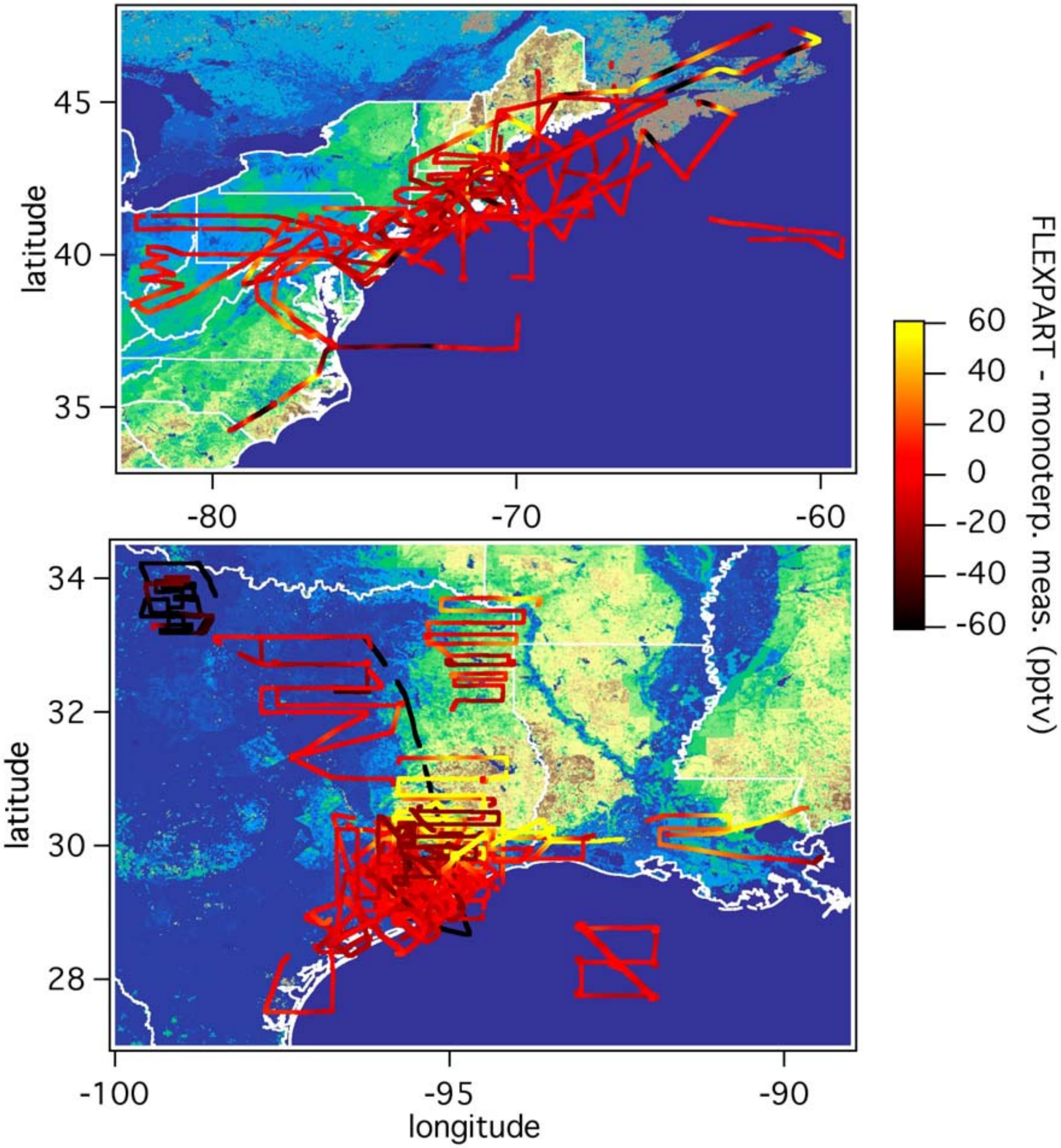
- Discontinuity at the U.S.-Canadian border
- BEIS 3.12 seems too high in Nova Scotia



Monoterpenes

- Same analysis for TEXAQS2006 and ICARTT using BEIS 3.13
- Emissions from measurements and from BEIS 3.13
- Measurements versus FLEXPART model
- Larger uncertainties than for isoprene

Differences by Location: Monoterpenes



- Same problem at the border in BEIS 3.13: different land-cover data used
- Higher emissions north of Houston and lower north of Dallas than measurements show