Daily and hourly variability in global fire emissions and consequences for atmospheric model predictions of carbon monoxide

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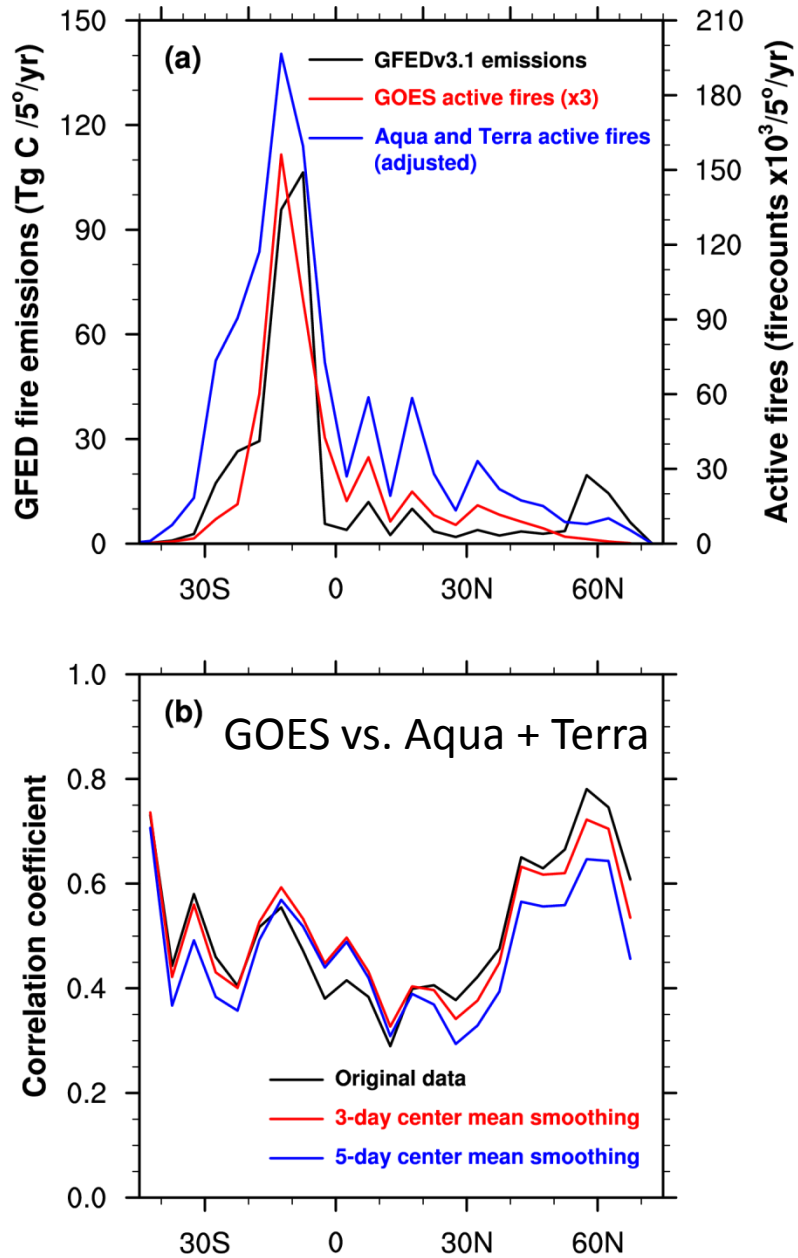
How might daily and hourly fire emissions improve our understanding of atmospheric composition?

- In some regions, atmospheric transport and fires strongly covary
- Fires have a unique temporal signature on weekly and daily timescales that may enable more efficient source attribution
- Diurnal cycle of fires is large in many tropical regions with important consequences for rapidly cycling chemical species (e.g., NO_2 as discussed by Boersma et al. 2008)

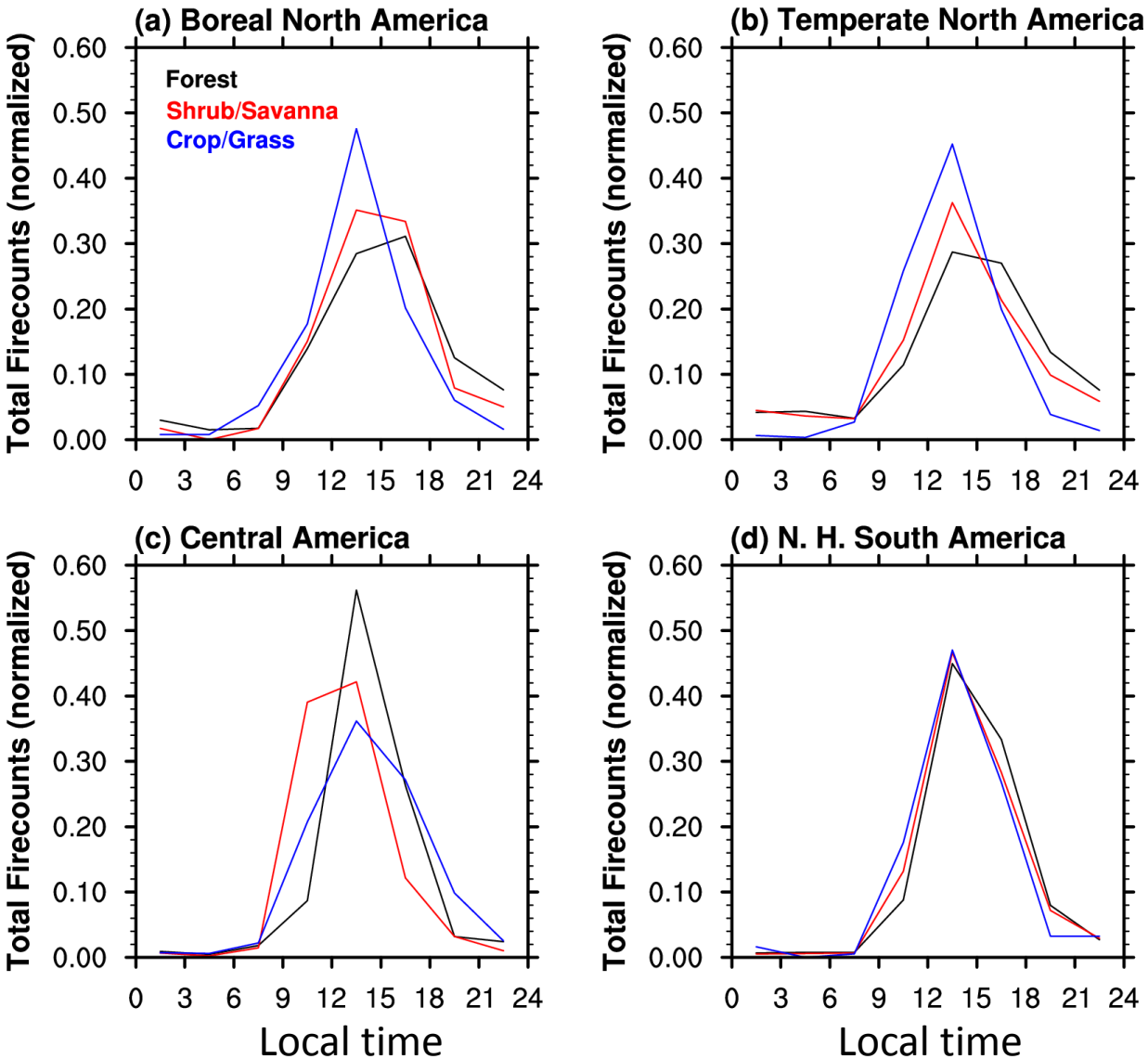
Terra 2007/296 - 10/23 at 18 :25 UTC

Approach

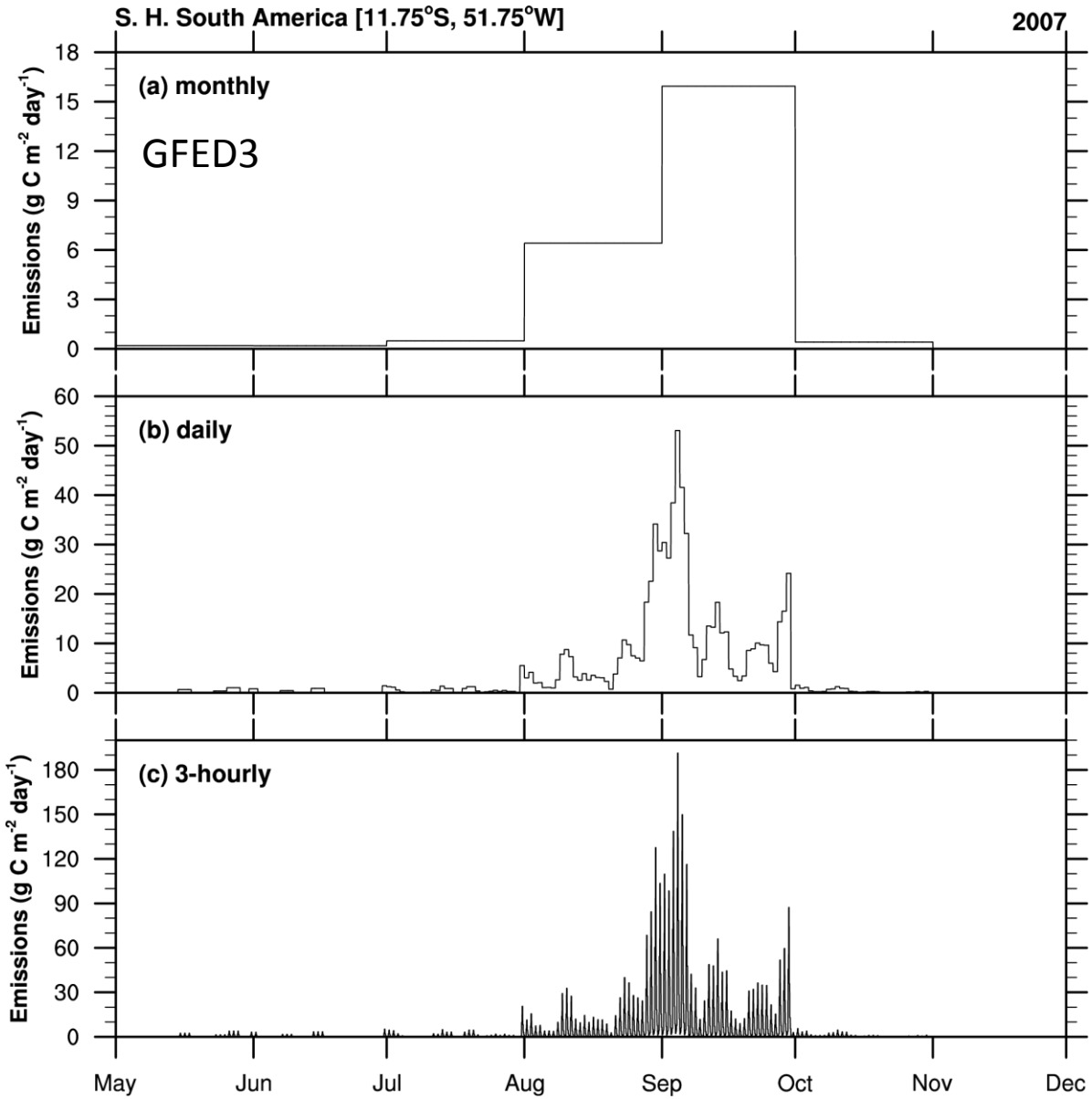
- Start with GFED3 monthly emissions (0.5°)
  - burned area derived from 500m reflectance [Giglio et al., 2010]
  - Biogeochemical model includes deforestation and peat fire components, fuel loads compared with obs. [van der Werf et al., 2010]
- Use sum of Aqua & Terra active fires to distribute emissions day by day
  - 3-day smoothing applied in tropics to account for gaps between overpasses
  - Normalize Terra to account for earlier satellite overpass (fewer fire detects)
- Diurnal cycle climatology derived from GOES active fires (ABBA v6) during 2007-2009
  - Mean diurnal cycles derived for three plant functional types in 5 regions in Western Hemisphere
  - PFT-specific diurnal cycles were linearly combined each month according to 500-m burned area
  - PFT-specific diurnal cycles in West mapped to similar continental scale regions in East



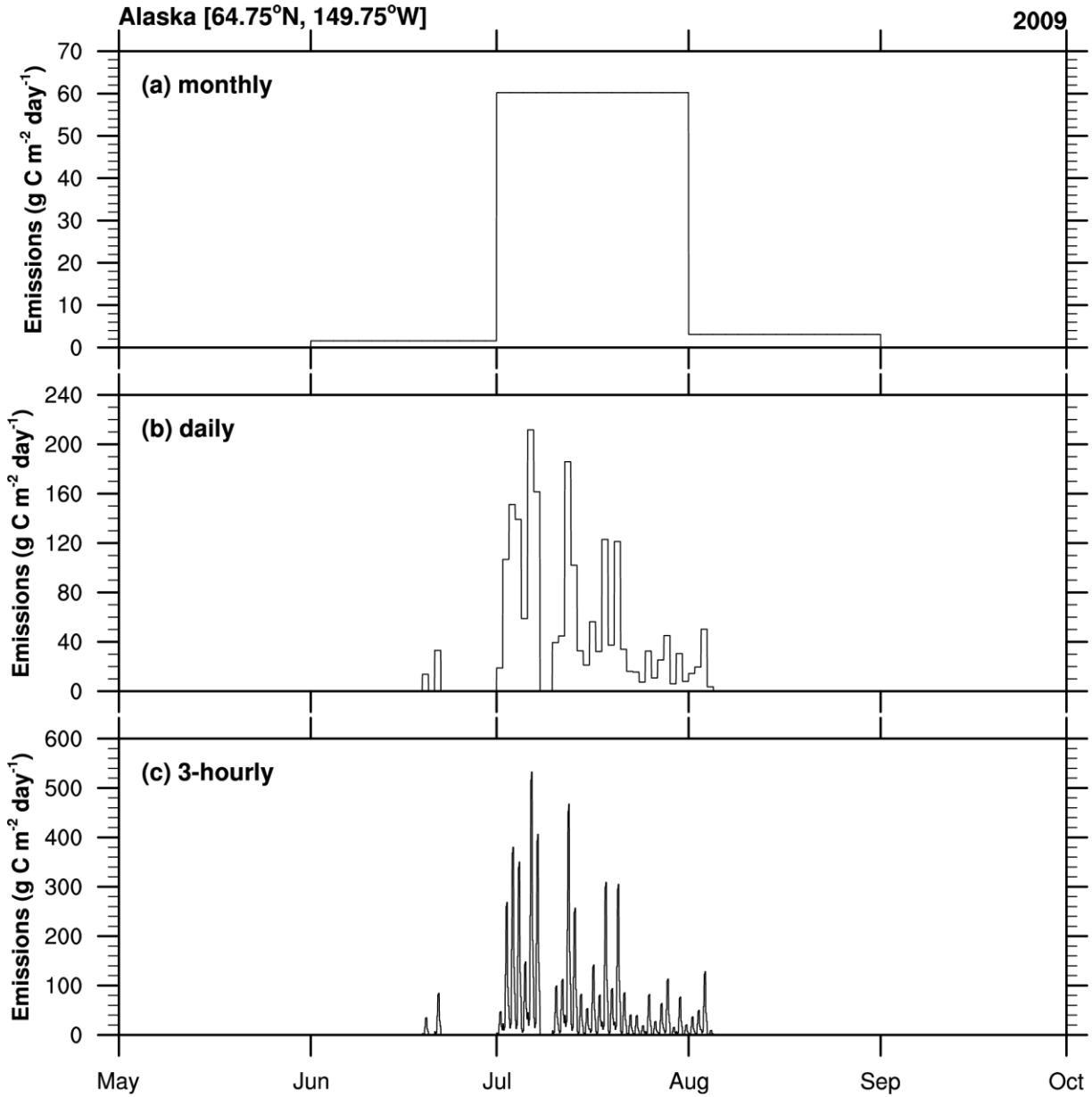
In boreal and temperate regions, forest fires have a smaller diurnal amplitude and occur later in the day compared to crop and grass fires



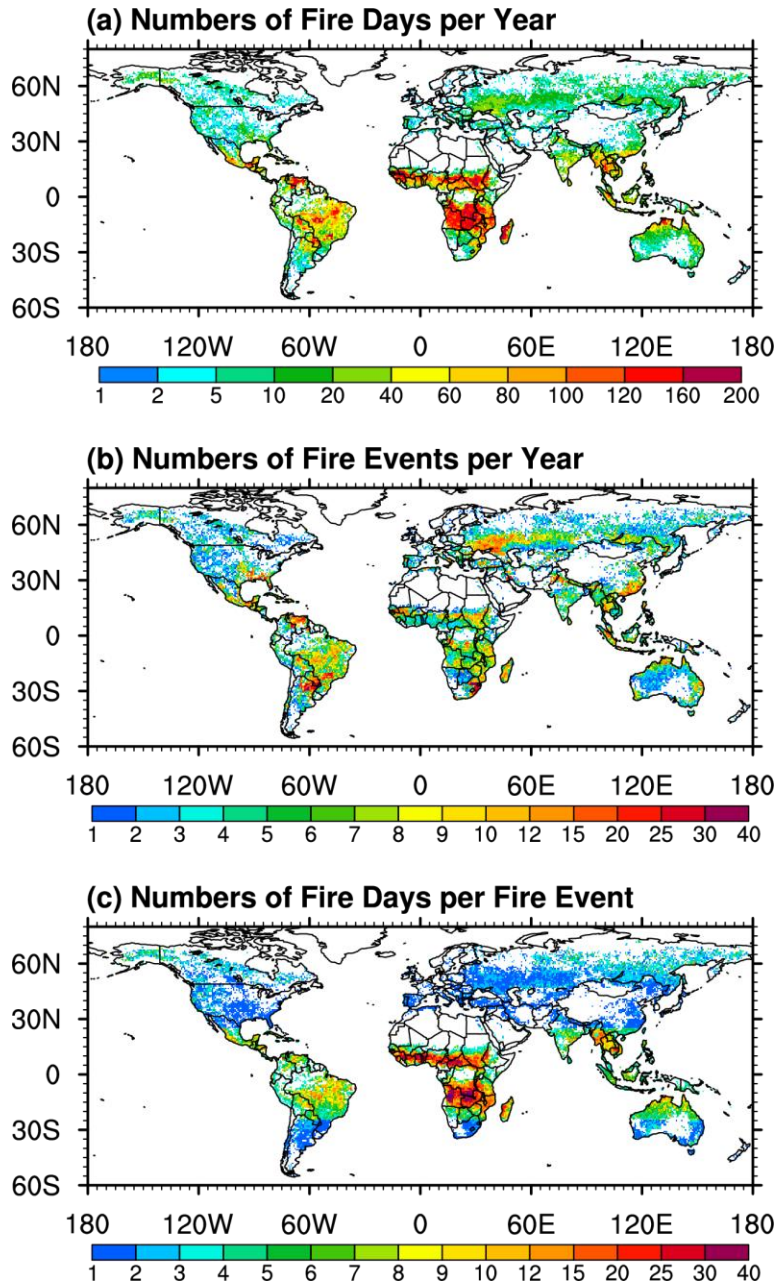
Example 0.5 °grid cell: Mato Grosso, Brazil in 2007



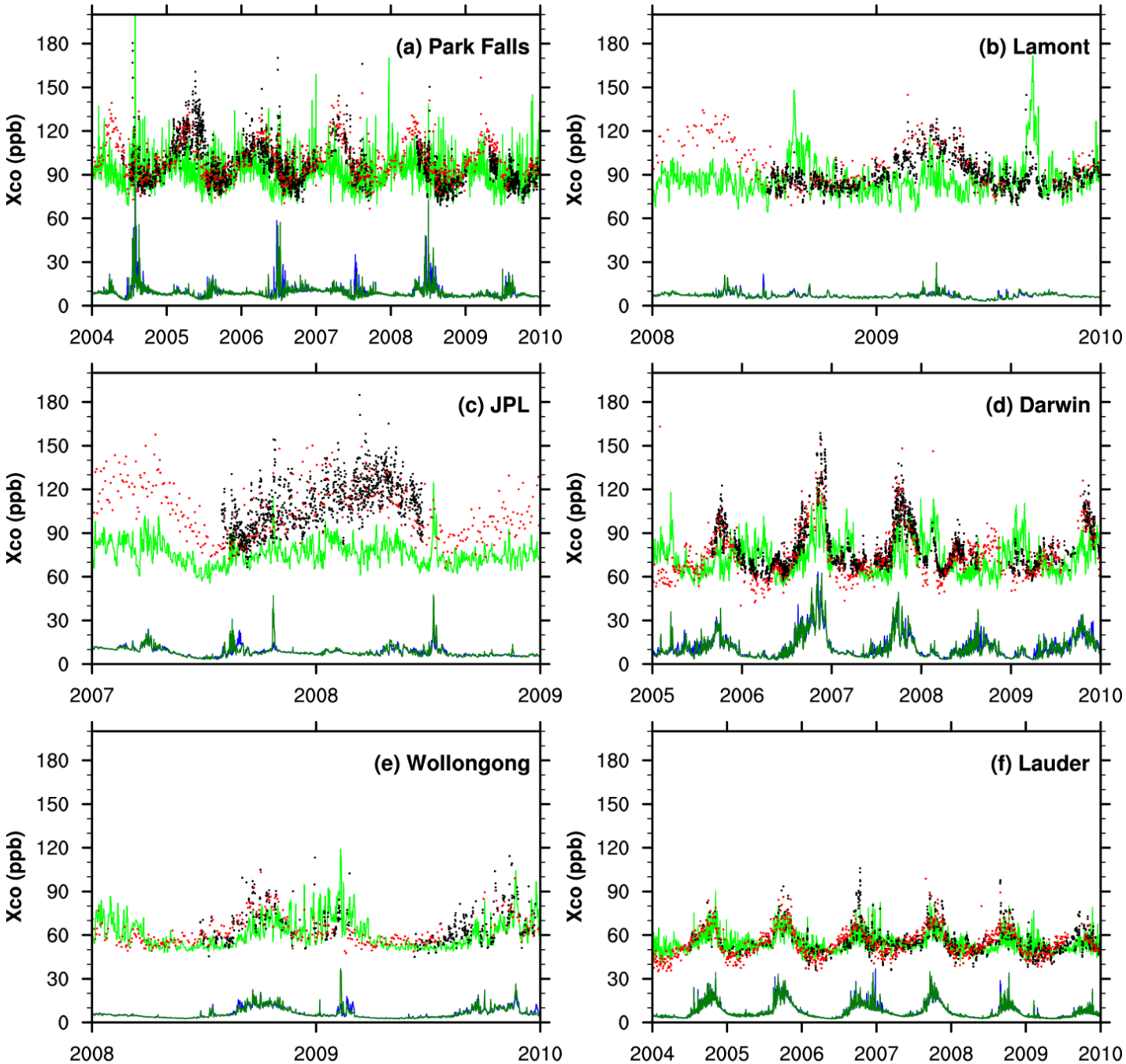
Example 0.5 °grid cell: Minto Flats, Alaska in 2009



Global patterns of daily fires



- At 0.5°, the number of fire days per year varies from 5-20 in many boreal ecosystems to over 100 in African savannas
- The number of discrete fire events is high in agricultural regions



Comparison with TCCON column CO and MOPITT 4

v 8-01-02
GEOS-5 meteorology
2° × 2.5°

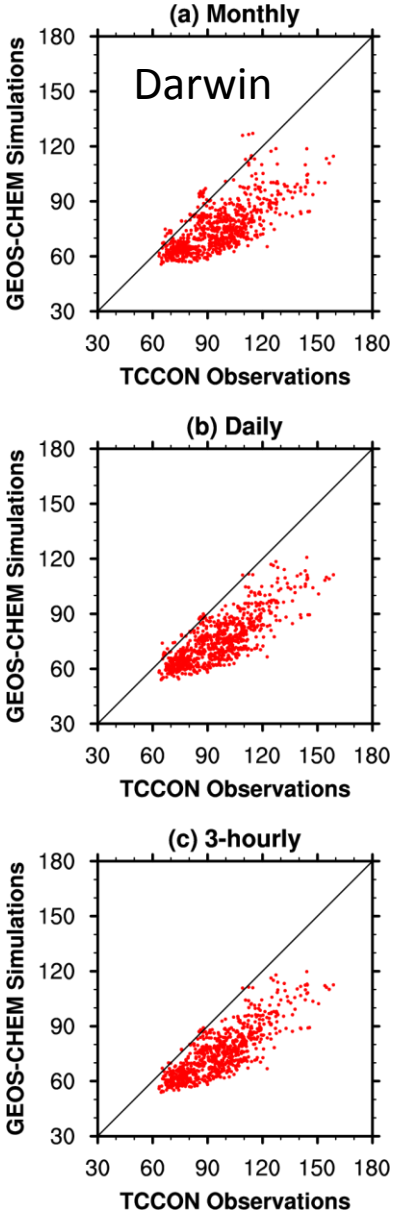
Three fire emissions simulations:

1. Monthly
2. Daily
3. Hourly

Small improvements in model agreement with TCCON obtained when using daily emissions, particularly during the fire season

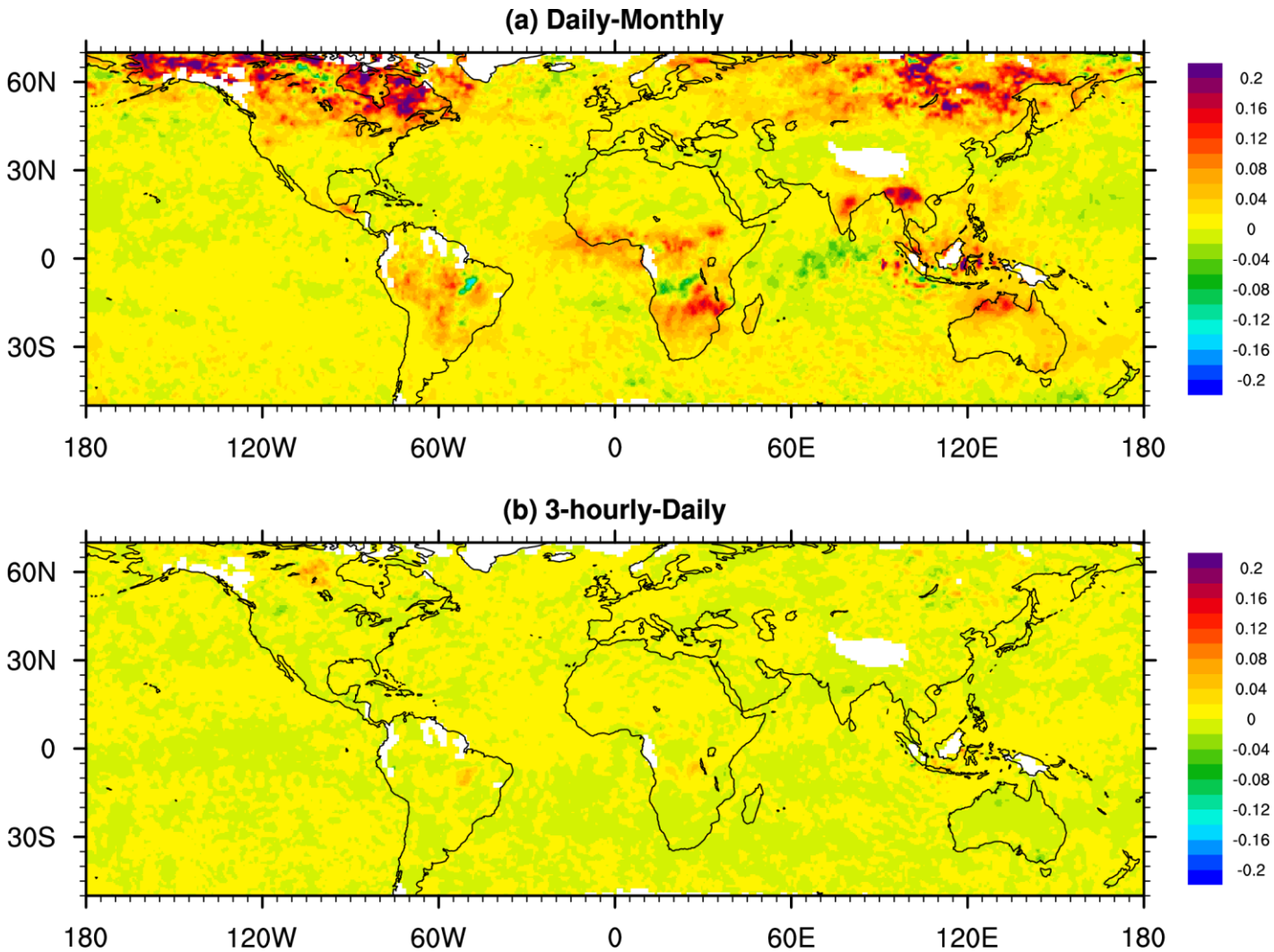
Table 1. Correlation between TCCON CO column and GEOS-Chem

TCCON station	Full time series			Peak fire season (3 months)		
	Monthly	Daily	3-hourly	Monthly	Daily	3-hourly
Park Falls, WI	0.26	0.29	0.29	0.13	0.25	0.24
Lamont, OK	0.13	0.14	0.13	0.42	0.47	0.44
JPL, CA	0.27	0.29	0.33	0.54	0.56	0.56
Darwin, AU	0.48	0.53	0.53	0.71	0.80	0.82
Wollongong, AU	0.59	0.60	0.60	0.53	0.56	0.56
Lauder, NZ	0.67	0.67	0.67	0.54	0.56	0.56



Improvements in the correlation between column CO from MOPITT 4 and GEOS-Chem:

Replacing monthly with daily, and daily with 3-hourly emissions



Conclusions and Future directions

- Forest fires have a reduced diurnal amplitude and a phase delay compared to savanna or grassland fires
- Daily fire variability may allow us to distinguish different anthropogenic controls on fire emissions
- Daily emissions lead to modest improvements in GEOS-Chem performance for CO– these are likely to be more significant for higher resolution simulations and for studies with more reactive chemistry and aerosols
- Daily and 3-hourly emissions available at http://www.globalfiredata.org/
- Currently being integrated into the standard version of GEOS-Chem by P. Kasibhatla and R. Yantosca
- Future relevant development with GFED includes quantifying emissions from small fires (< 500m) and optimizing photosynthesis and net ecosystem exchange fluxes using FLUXNET eddy covariance observations

Comparison of GOES ABBA with Aqua and Terra active fires