EGU General Assembly 2020

Terrestrial CO_2 Fluxes, Concentrations, Sources and Budget in Northeast China: Observational and Modeling Studies

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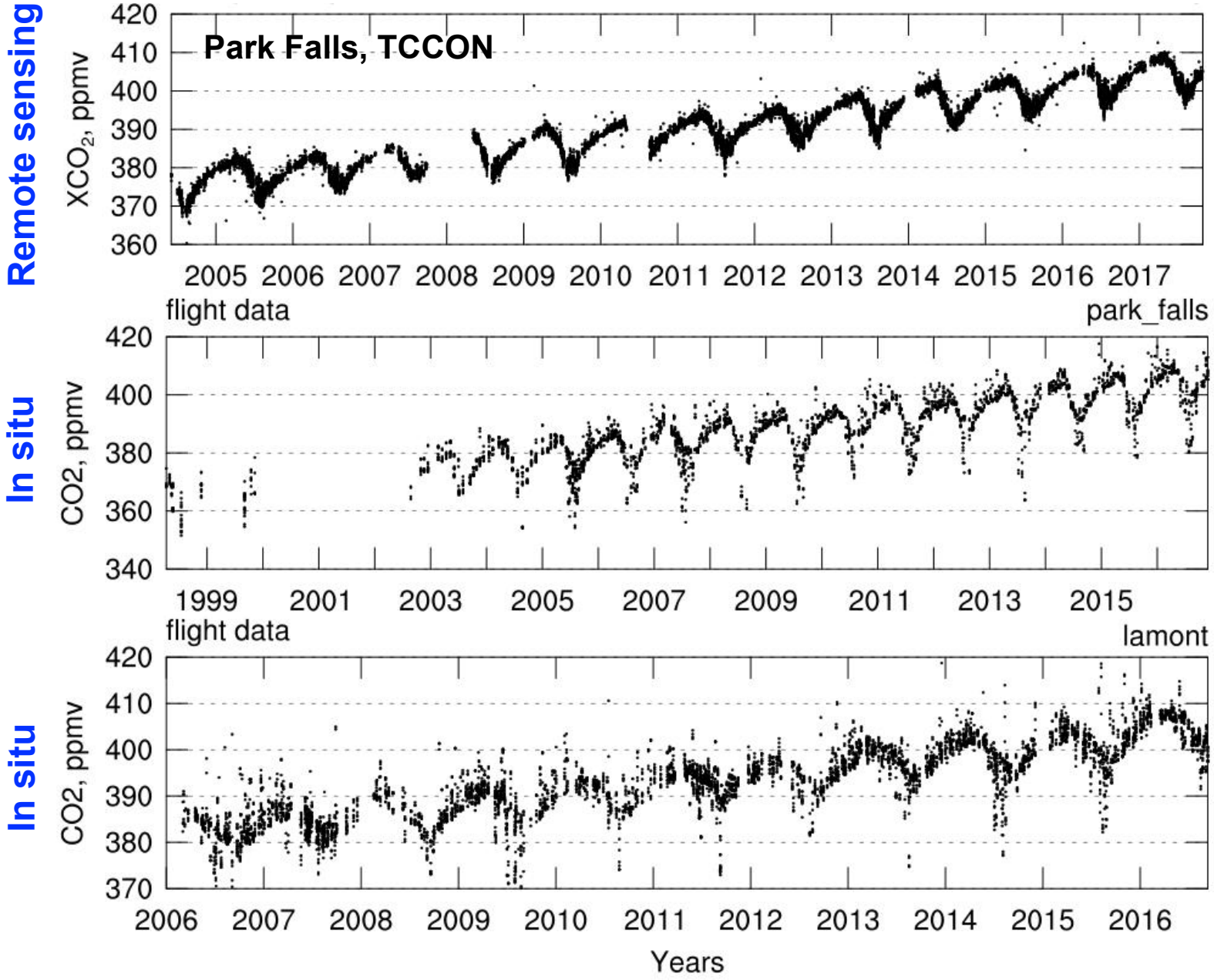
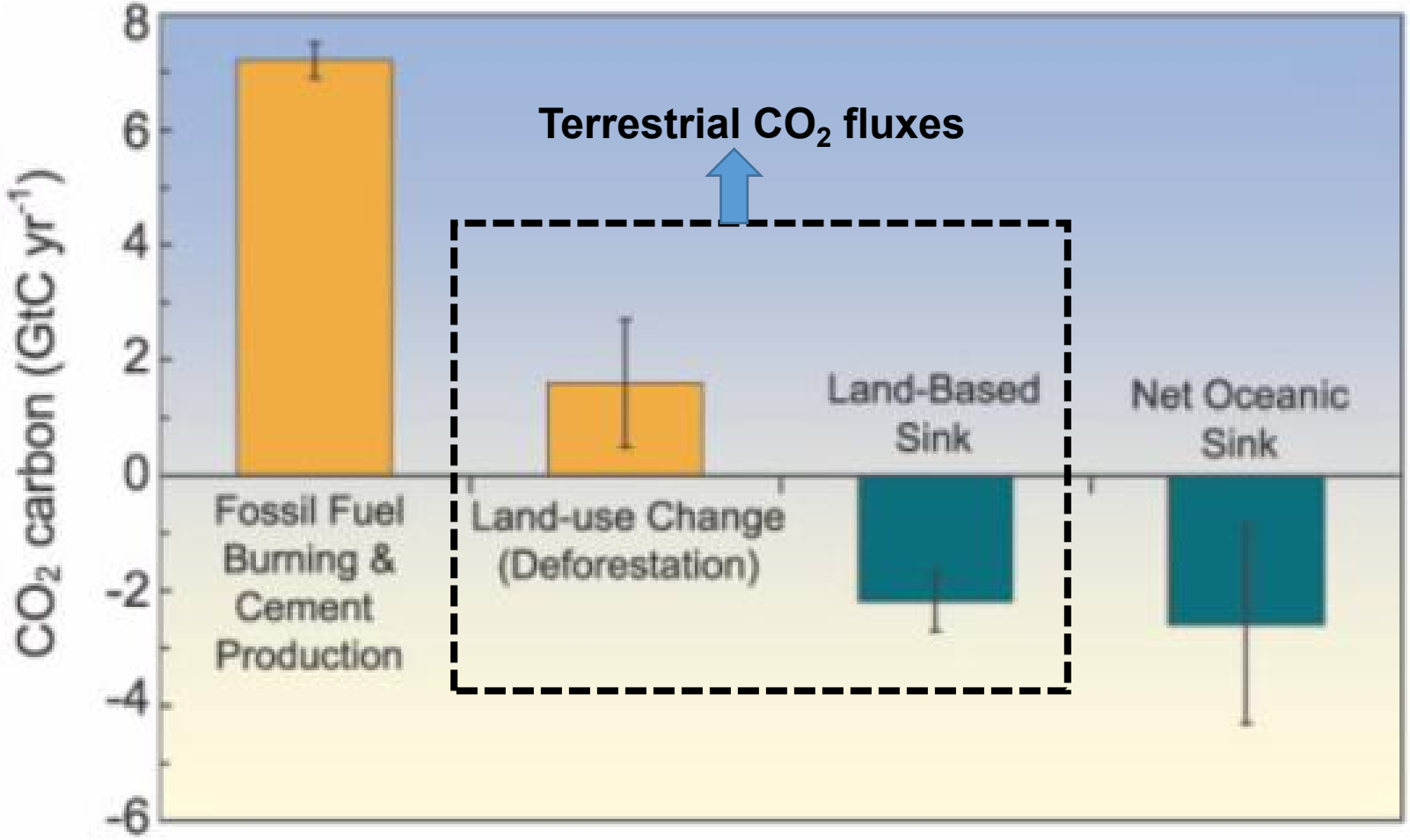
April 20, 2020

Trend of CO_2 concentration



Global warming!!

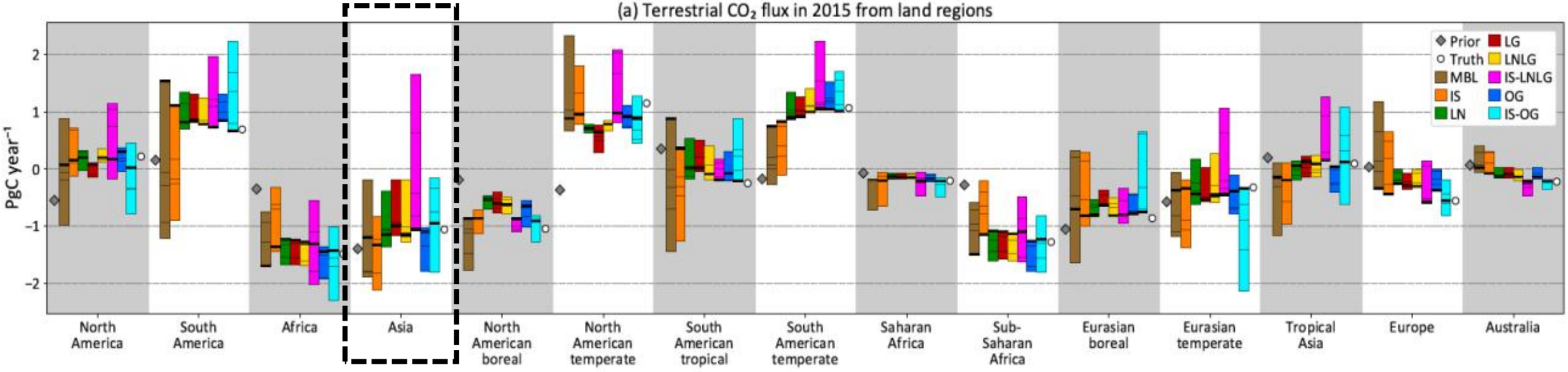
Global CO_2 sources and sinks



IPCC (2007)

Uncertainties of terrestrial CO_2 fluxes are large

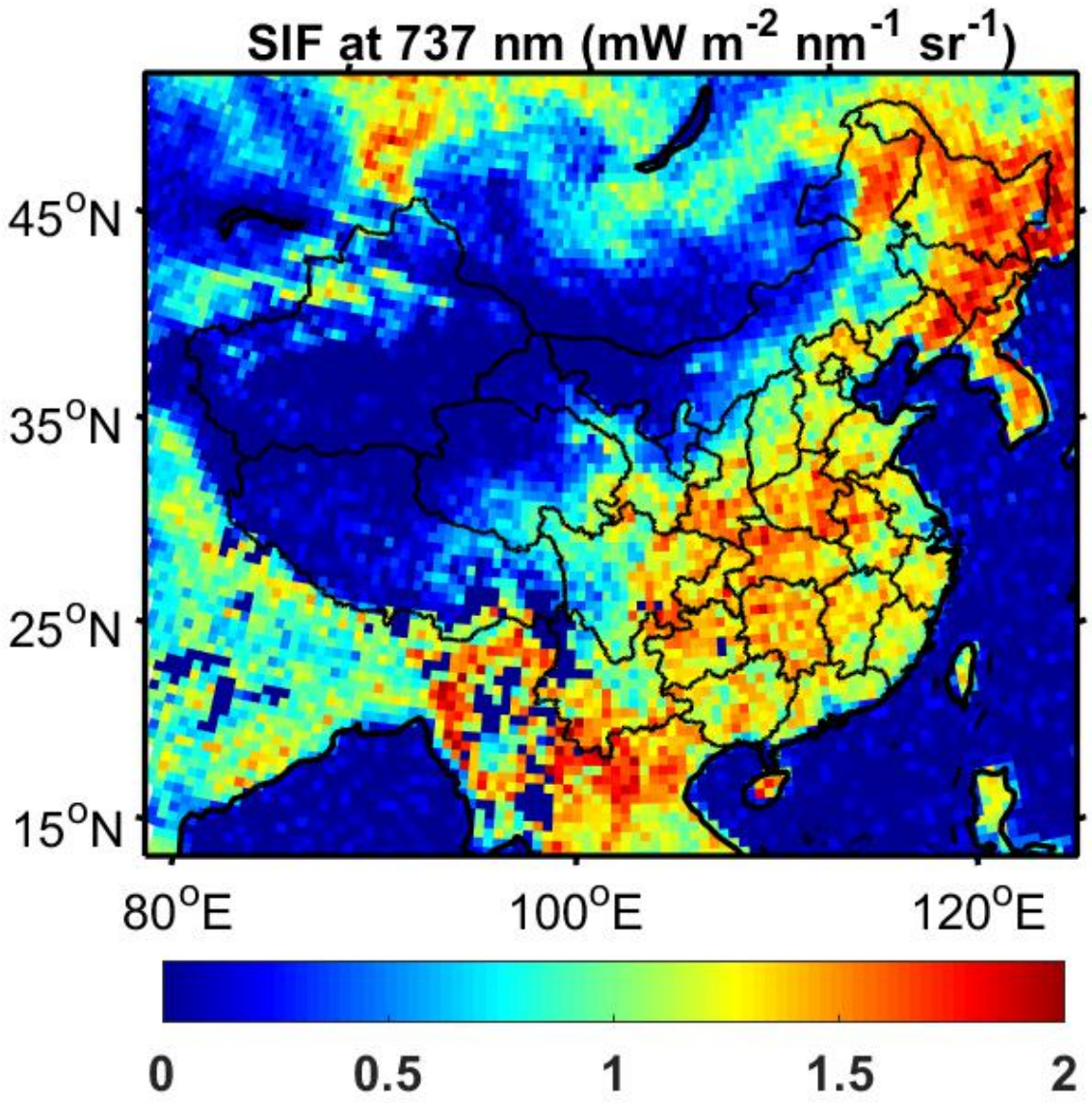
Terrestrial CO_2 fluxes in different regions

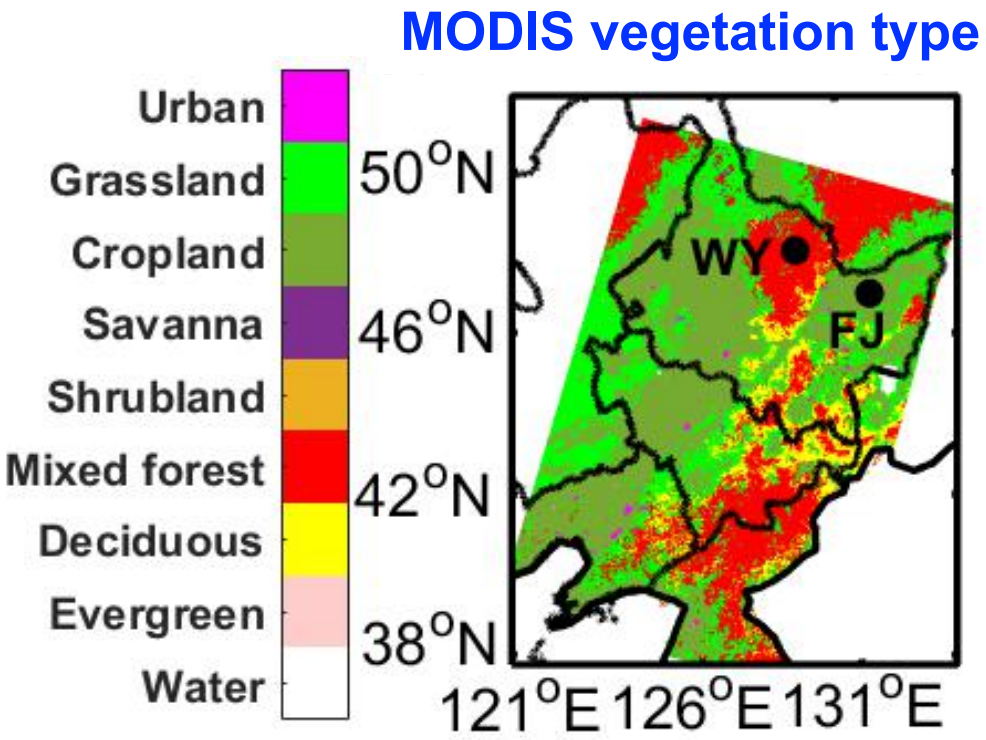


(Sourish Basu et al., 2018)

Uncertainties in each region are large too.
Asia is CO_2 sink!!

Northeast China: a major CO_2 sink in summer

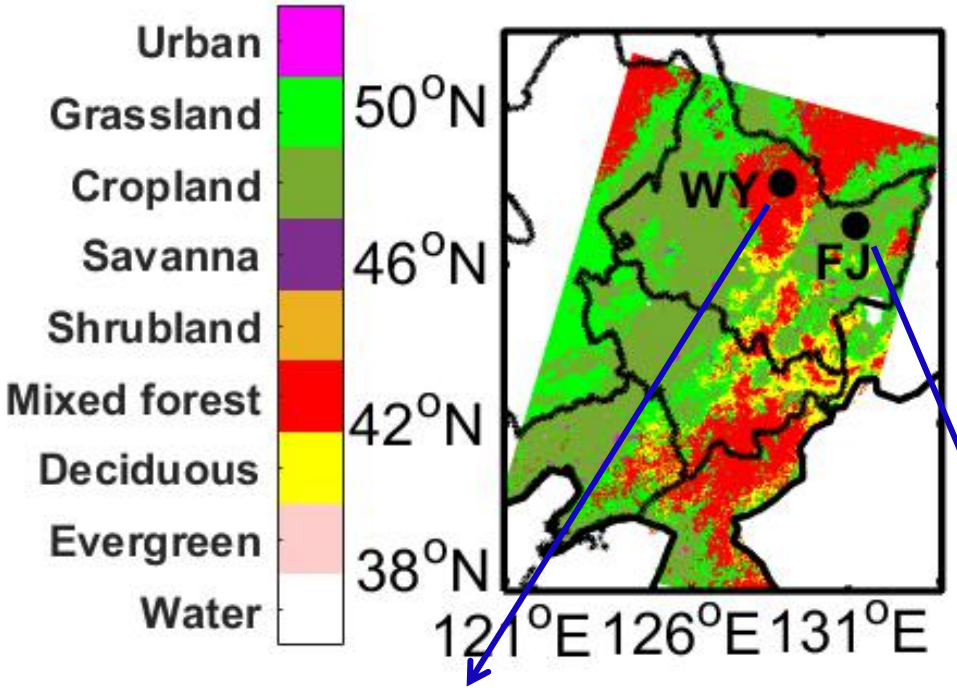




Mixed forest and cropland dominate in Northeast China
Crop area is still increasing!!

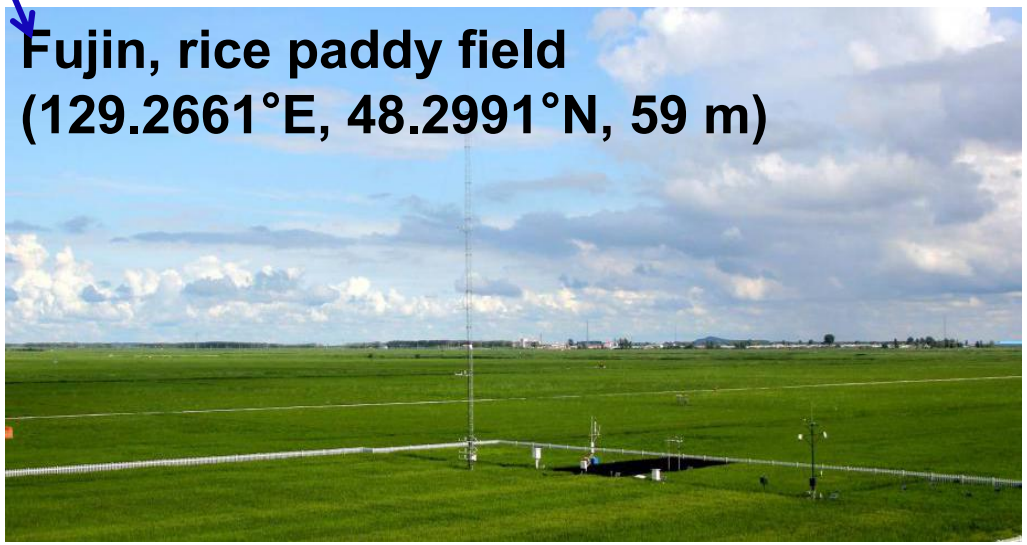
SIF: Sun-induced Fluorescence, proportional to photosynthesis

Long-term tower measurements, focusing on 2016

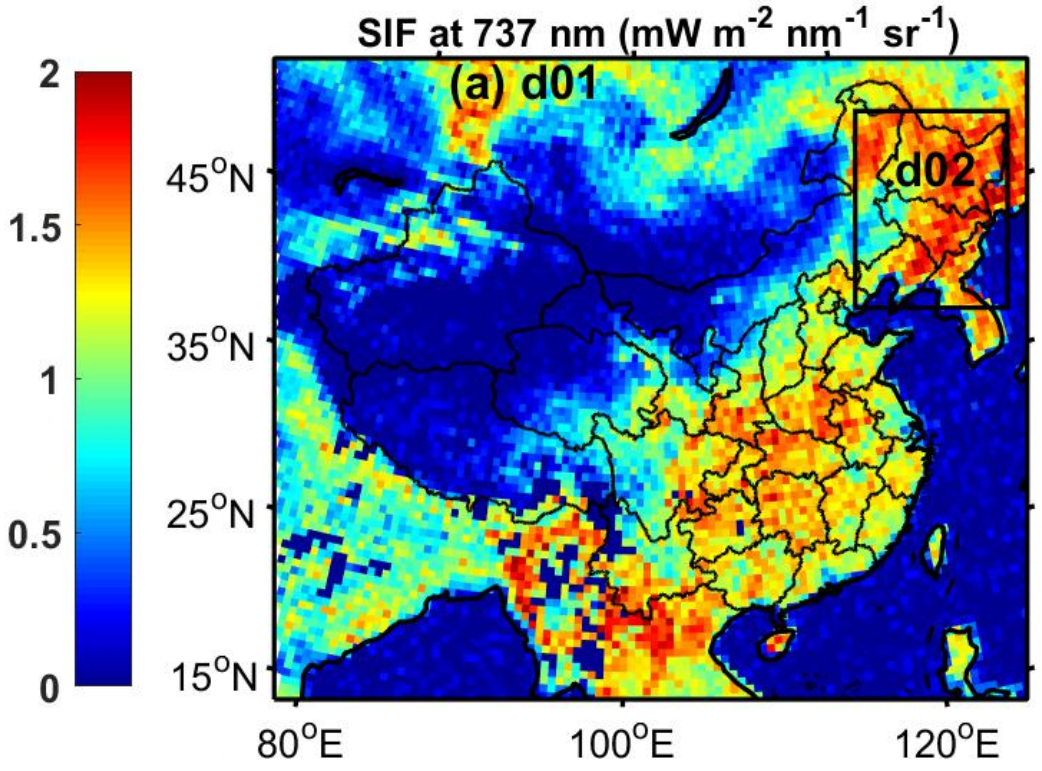


- **Observational parameters:**
  1) Hourly mean CO_2 fluxes and concentrations
  2) wind speed and direction, air temperature
  3) Photosynthetically active radiation PAR (only at Fujin)

- **Observational period:**
  Fujin: since 2012
  Wuying: since 2014



2016 downscaling using WRF-VPRM: a weather-biosphere-online-coupled model



VPRM: Vegetation Photosynthesis and Respiration Model

$$NEE = ER + GEE$$

$$ER = (\alpha \times T) + \beta$$

$$GEE = -\lambda \times T_{scale} \times W_{scale} \times P_{scale} \times \frac{1}{1 + \frac{PAR}{PAR_0}} \times FAPAR_{PAV} \times PAR$$

- λ: maximum light use efficiency
- W_{scale}: water stress scale
- P_{scale}: phenology scale
- W_{scale} and P_{scale}: Related to land surface water index (LSWI)
- $FAPAR_{PAV}$: Roughly equal to enhanced vegetation index (EVI)
- PAR: photosynthetically active radiation

- **Resolution:** 20 km in d01; 4 km in d02
- **Meteorology initial/boundary conditions:** NECP/DOE R2
- **CO_2 initial/boundary conditions:** 3°×2° CarbanTracker 2017
- **Anthropogenic emissions of CO_2:** ODIAC

	Crops	Mixed forest	Evergreen forest	Deciduous forest	Shrub	Savanna	Grass
α	0.1300	0.2000	0.1247	0.0920	0.0634	0.2000	0.0515
β	0.5420	0.27248	0.2496	0.8430	0.2684	0.3376	-0.0986
λ	0.085	0.100	0.130	0.100	0.180	0.180	0.115
PAR_0	1074.9	419.50	745.306	514.13	590.7	600.0	717.1

Following Hu et al. (2019) based on Hilton et al. (2013)

The sensitivity of simulated CO_2 flux to VPRM parameters

multiparameter experiment

single-parameter experiment

Ensemble Simulation	α	β	λ	PAR_0
ES1	[0.12, 0.30]	[0.50, 1.20]	[0.09, 0.14]	[350, 600]
	-40 ~ 50%*	-50 ~ 20%*	-10 ~ 40%*	-16.57 ~ 43.03%*
ES2	[0.12, 0.30]	1	0.1	419.5
ES3	0.2	[0.50, 1.20]	0.1	419.5
ES4	0.2	1	[0.09, 0.14]	419.5
ES5	0.2	1	0.1	[350, 600]

$$NEE_{ES1}(i,t) = f\{\alpha(i), \beta(i), \lambda(i), PAR_0(i), t\}$$

***i*=1, 2, ..., 100,**
***t*: hours during the growing season**

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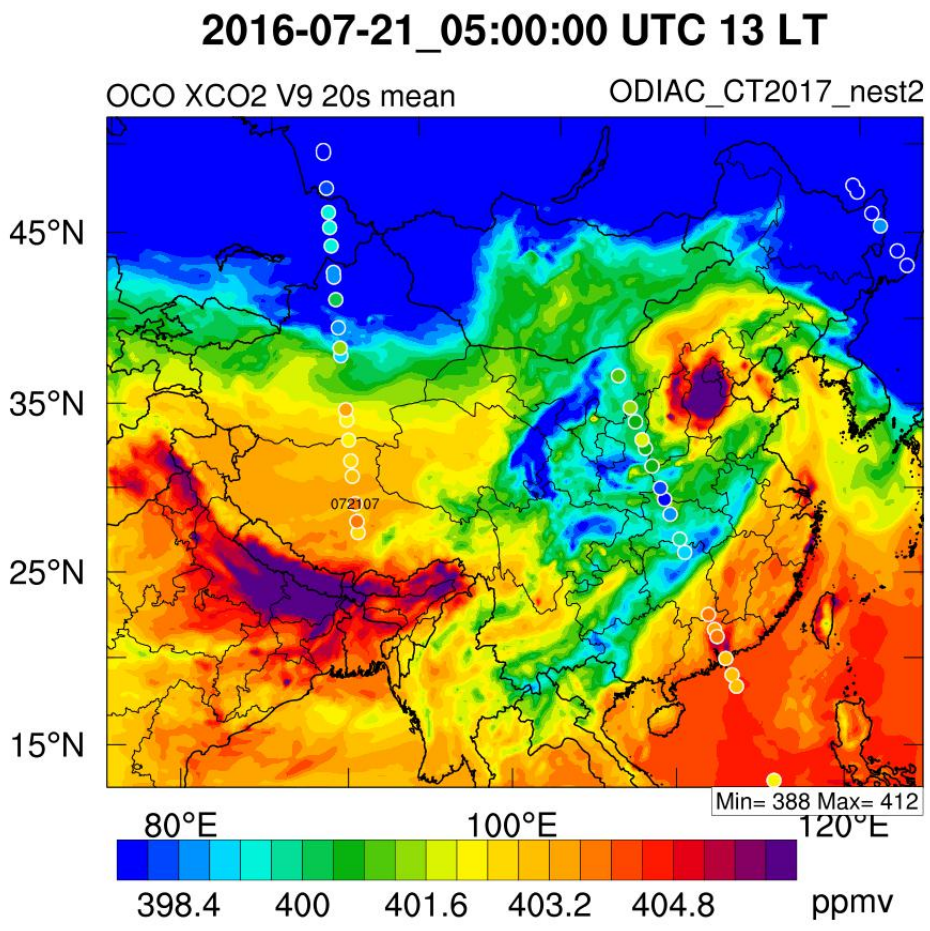
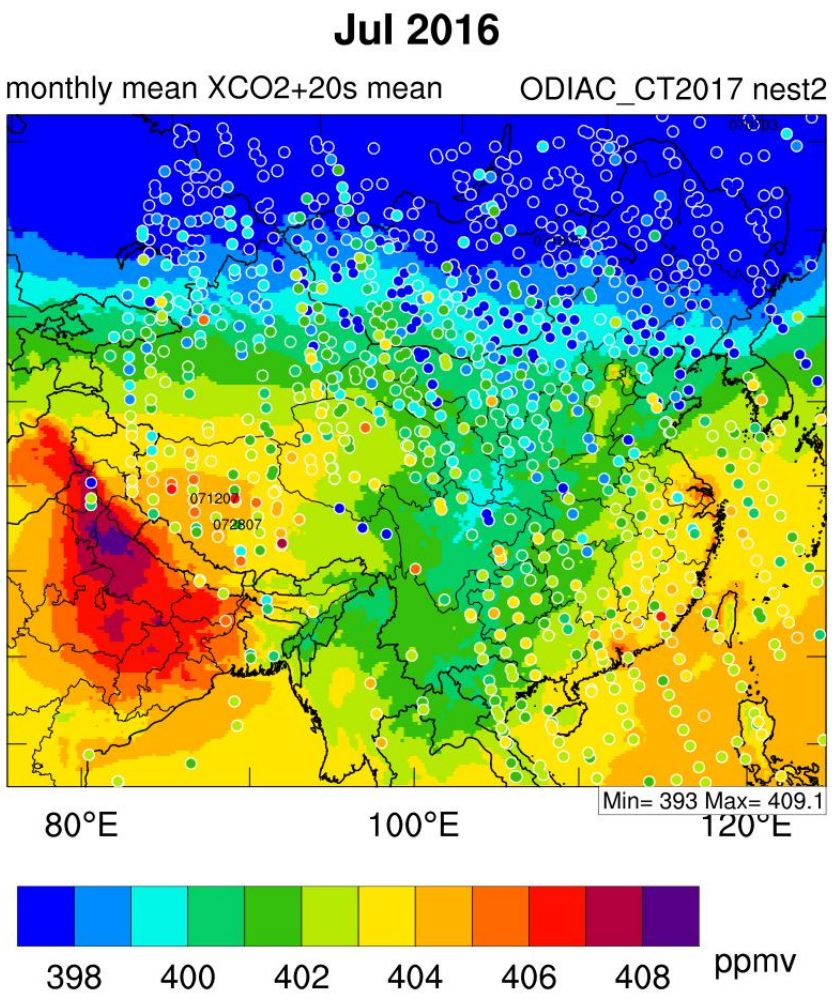
OCO-2 satellite-retrieved XCO_2 (L2 Lite Version 9)

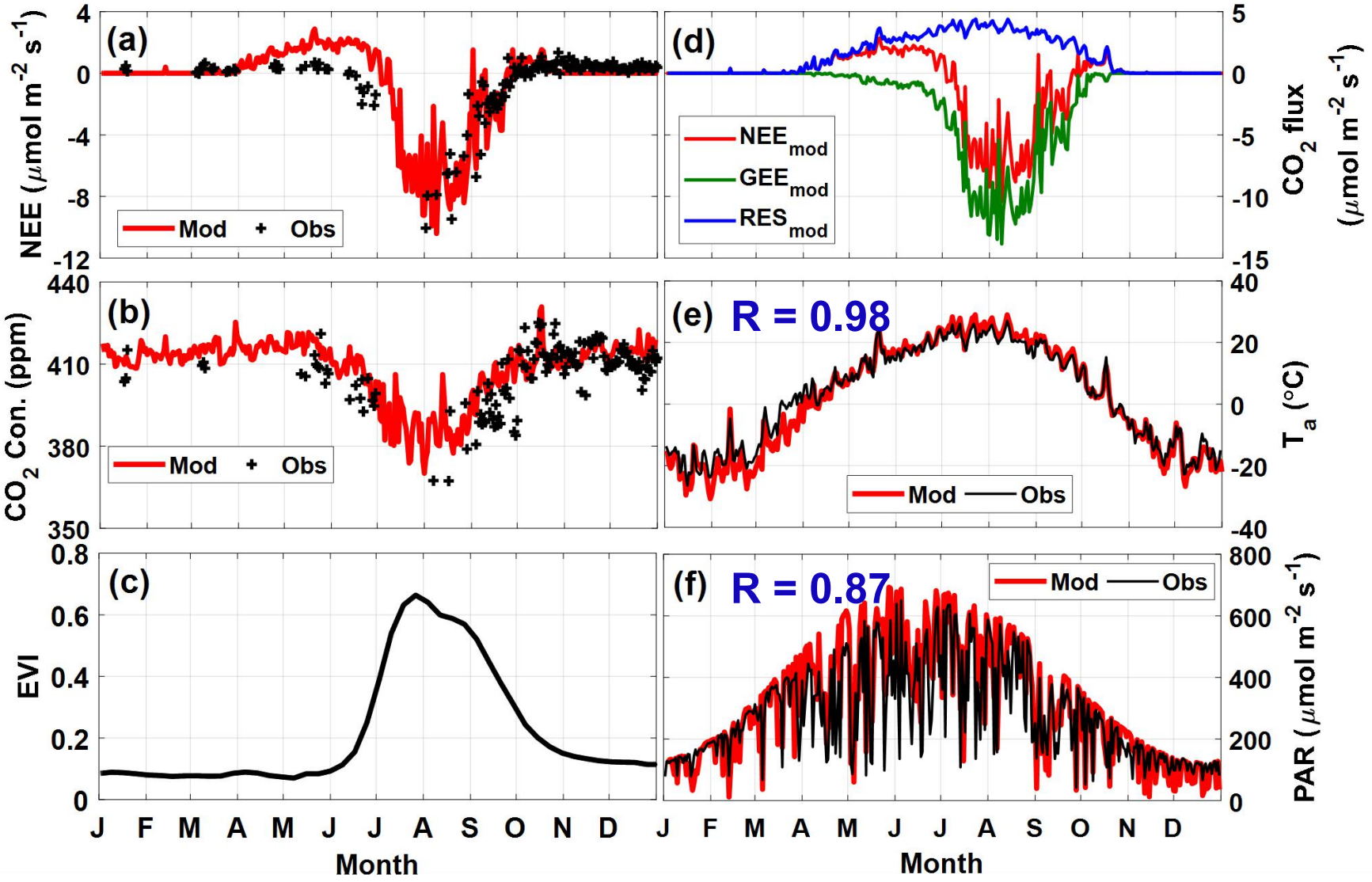




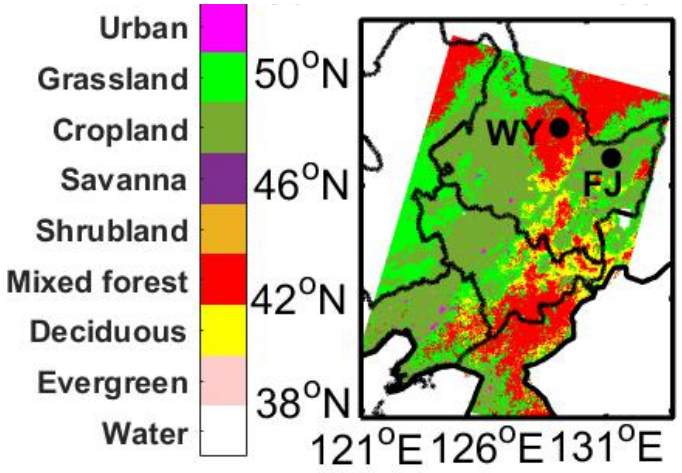
Advantage: spatiotemporal coverage
Disadvantage: interfere with cloud and haze pollution!!

Seasonal variaitons of CO_2 fluxes and concentrations

Fujin (cropland, rice paddy)

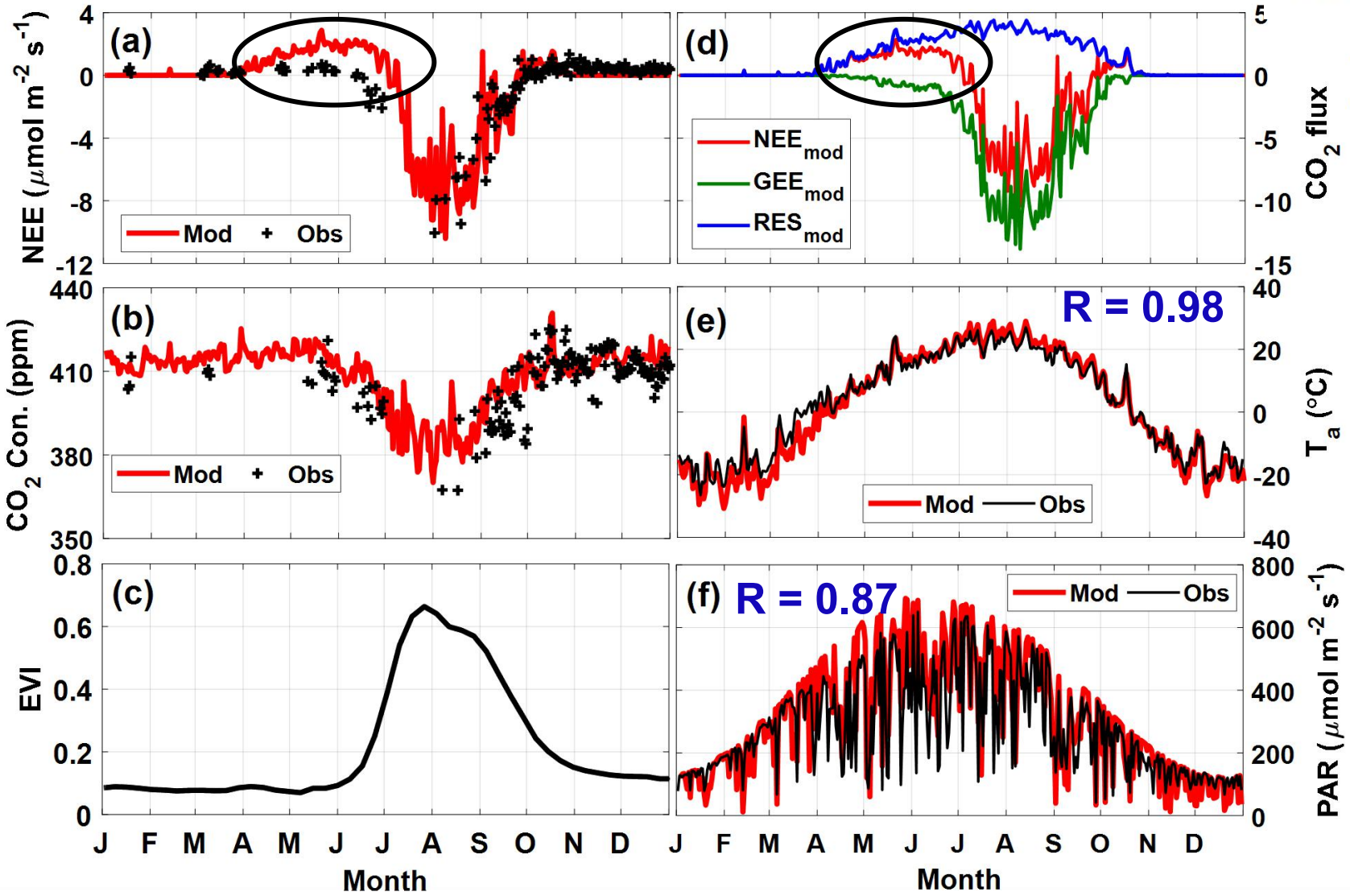


MODIS vegetation type



Bias of terrestrial respiration

Fujin (cropland, rice paddy)



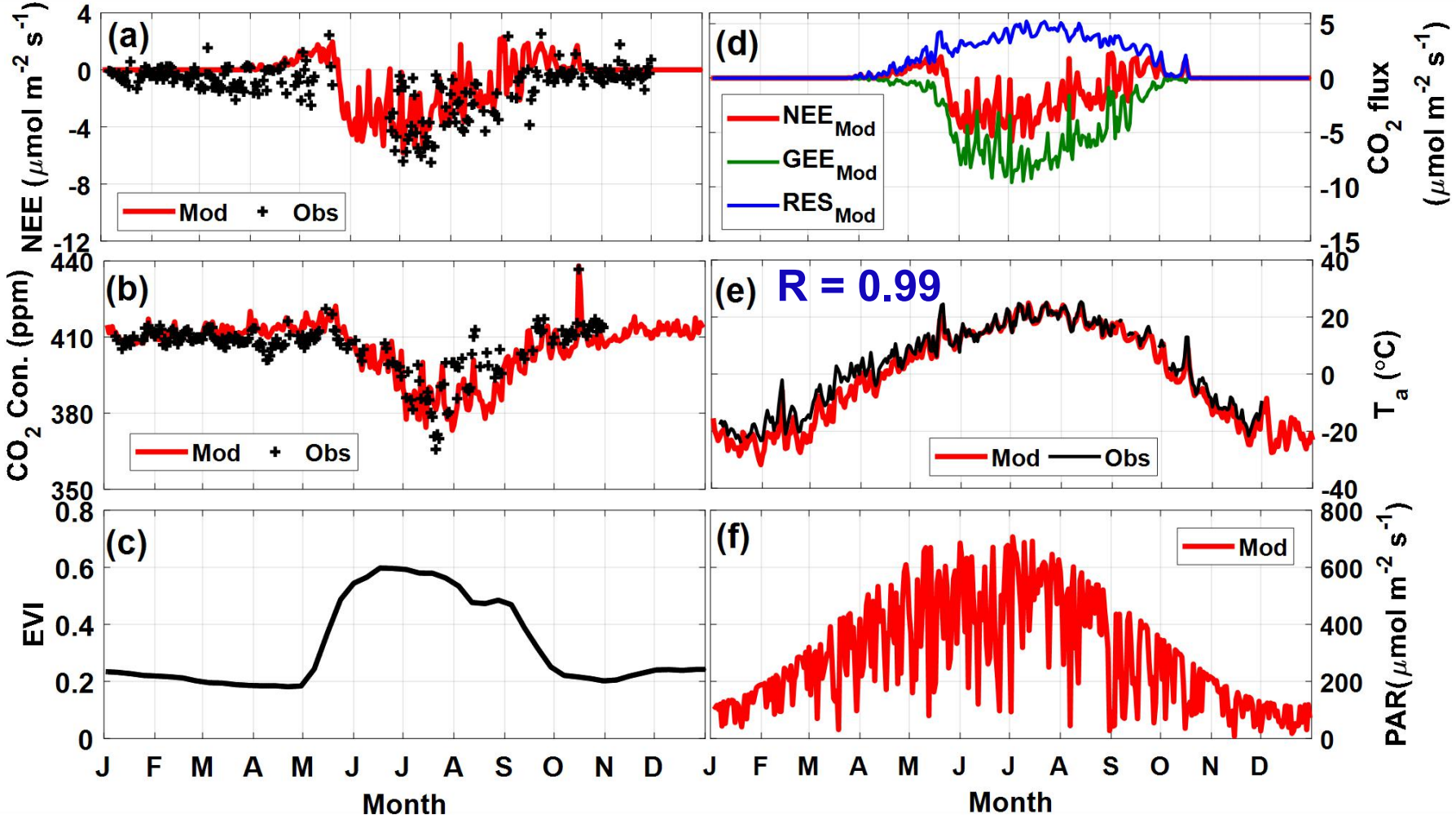
$$NEE = (\alpha \times T + \beta) + GEE$$

largely subjected to the EVI

Ignores leaf mass, involves EVI?

Seasonal variation of CO_2 fluxes and concentrations

Wuying (mixed forest)



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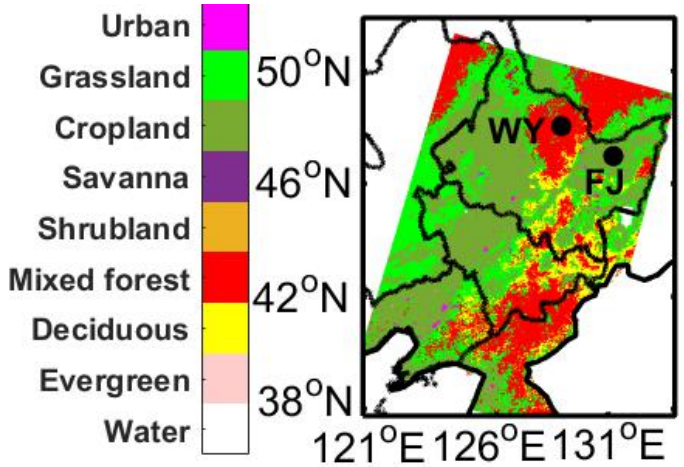
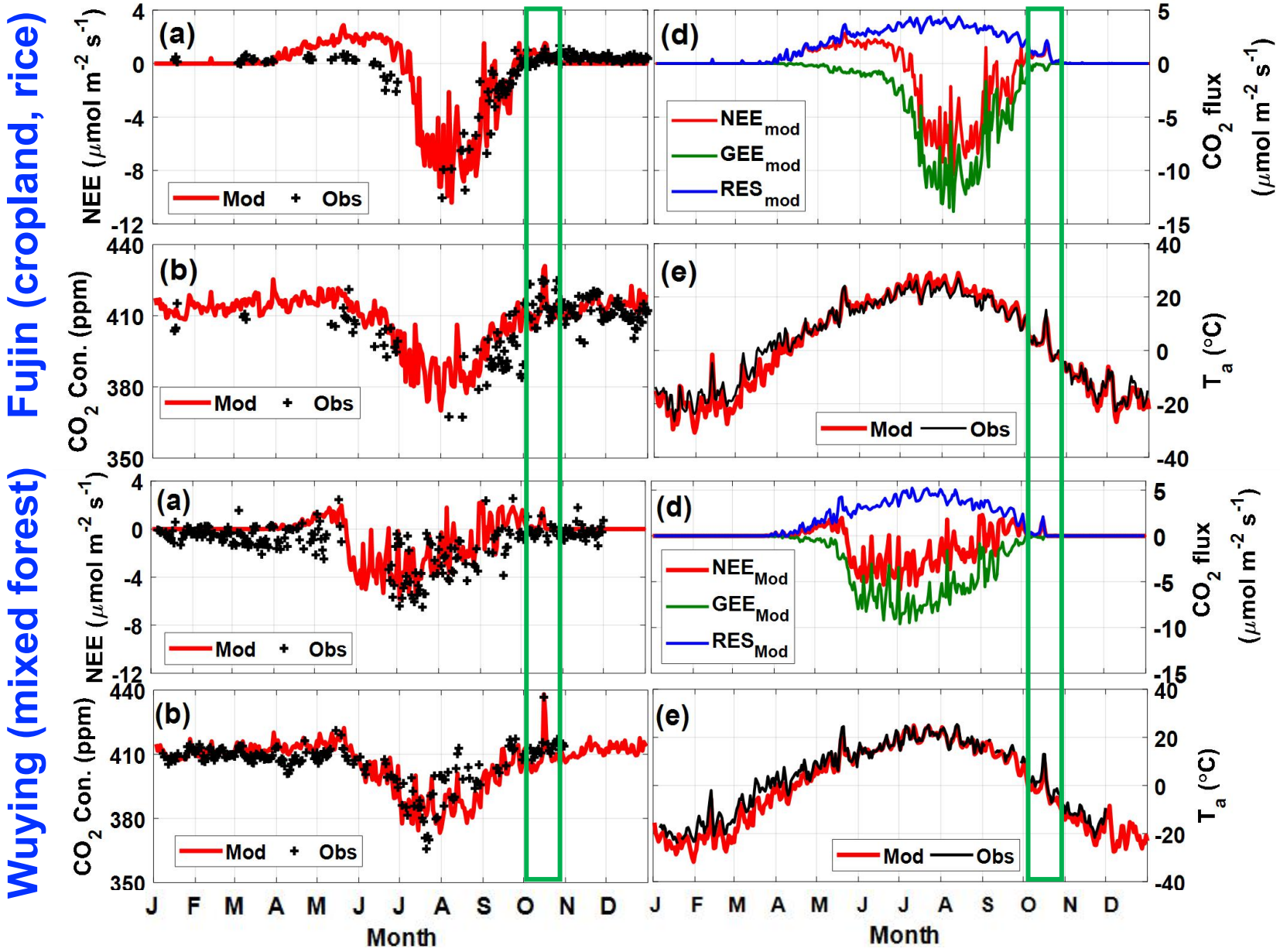
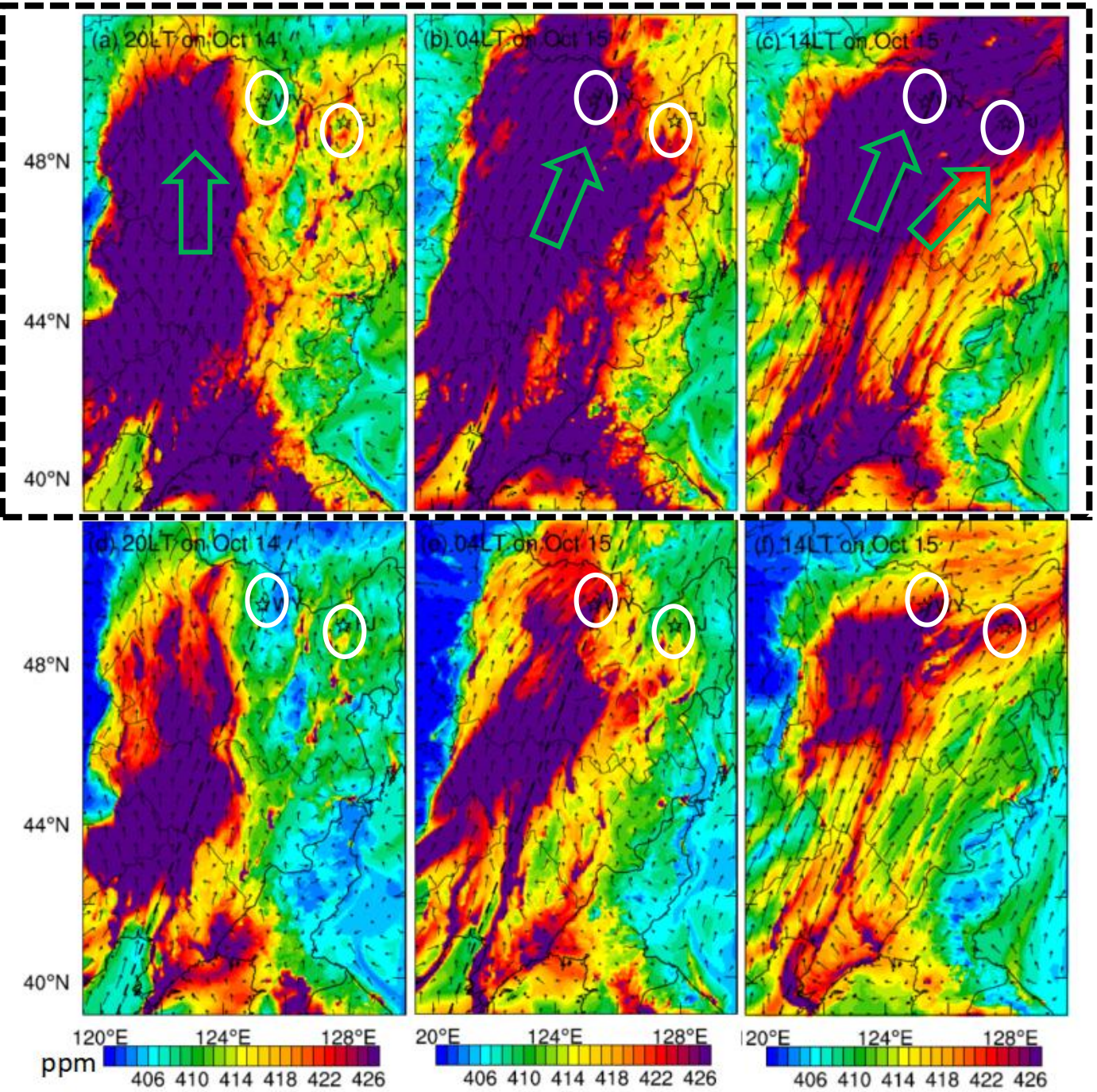


Episodic variation on October 15, 2016



Regional transport on October 15

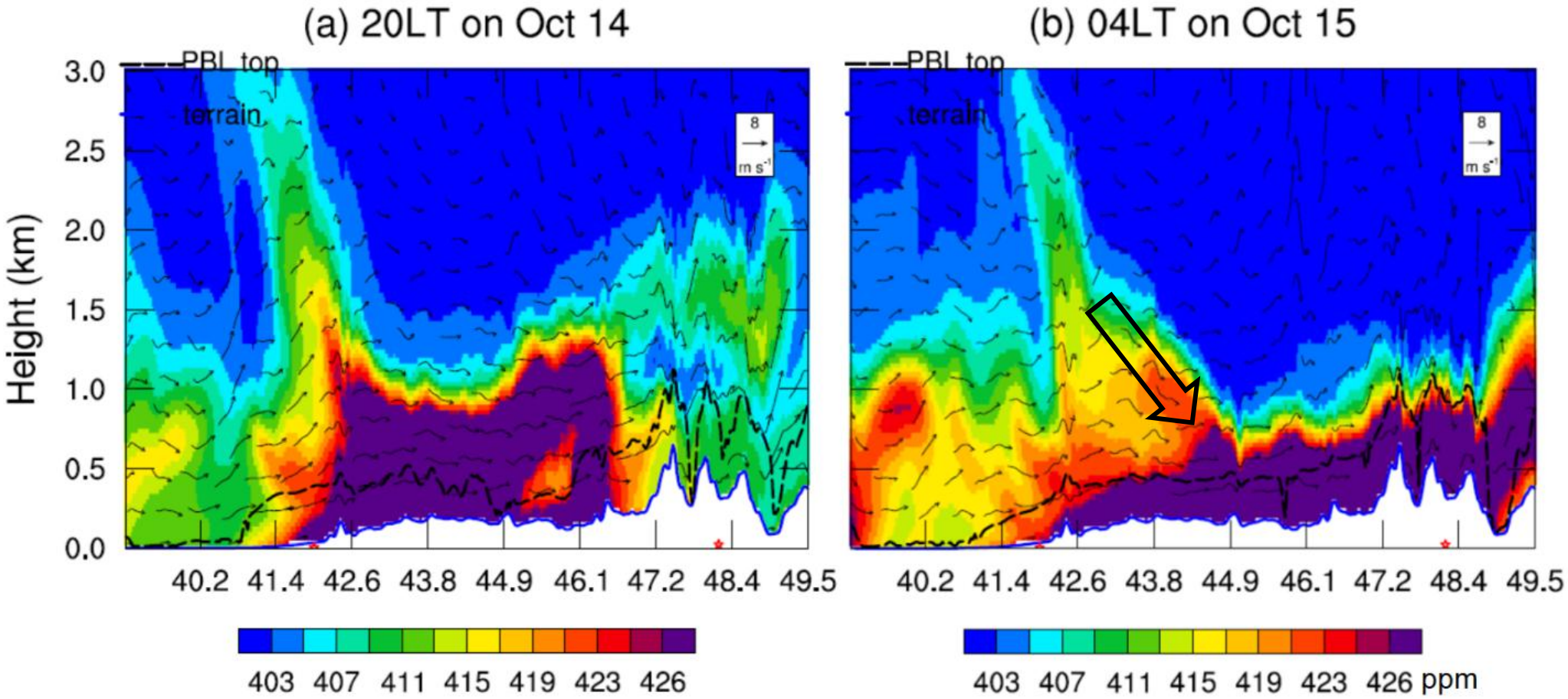


Anthropogenic emissions & biogenic contribution

Anthropogenic emissions only

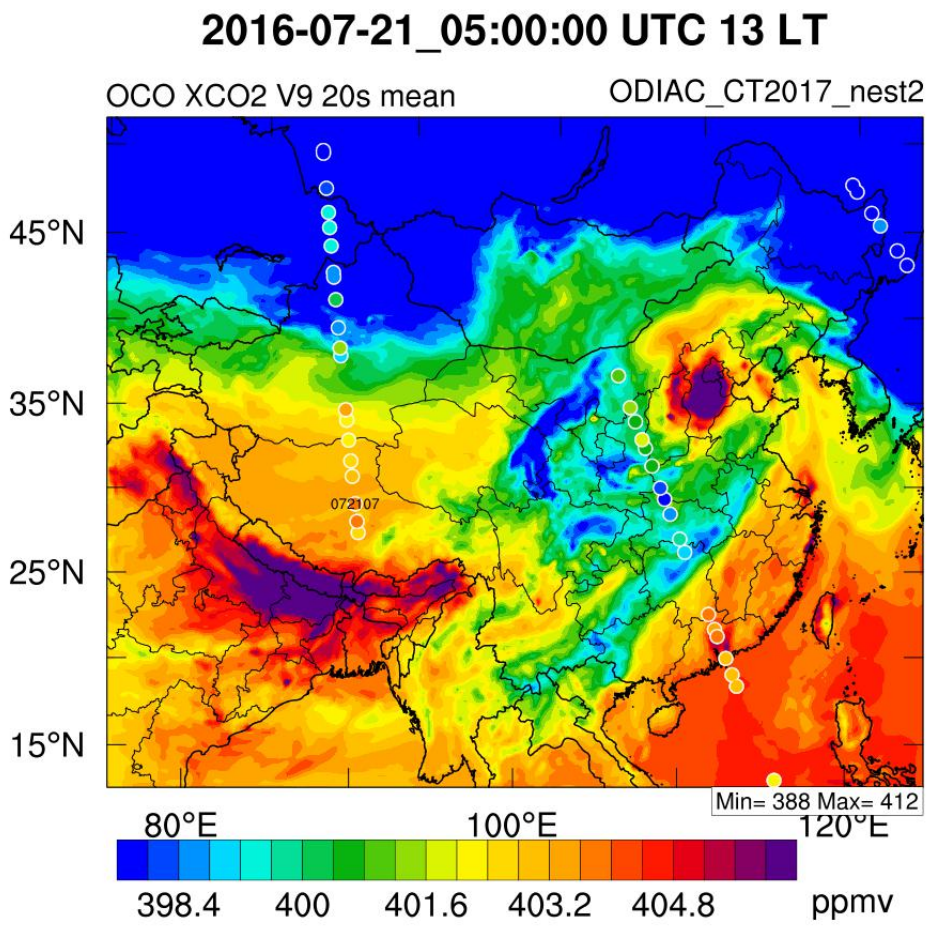
Anthropogenic contribution: 59.4 ± 5.9%
Biogenic contribution: 40.6 ± 5.9%

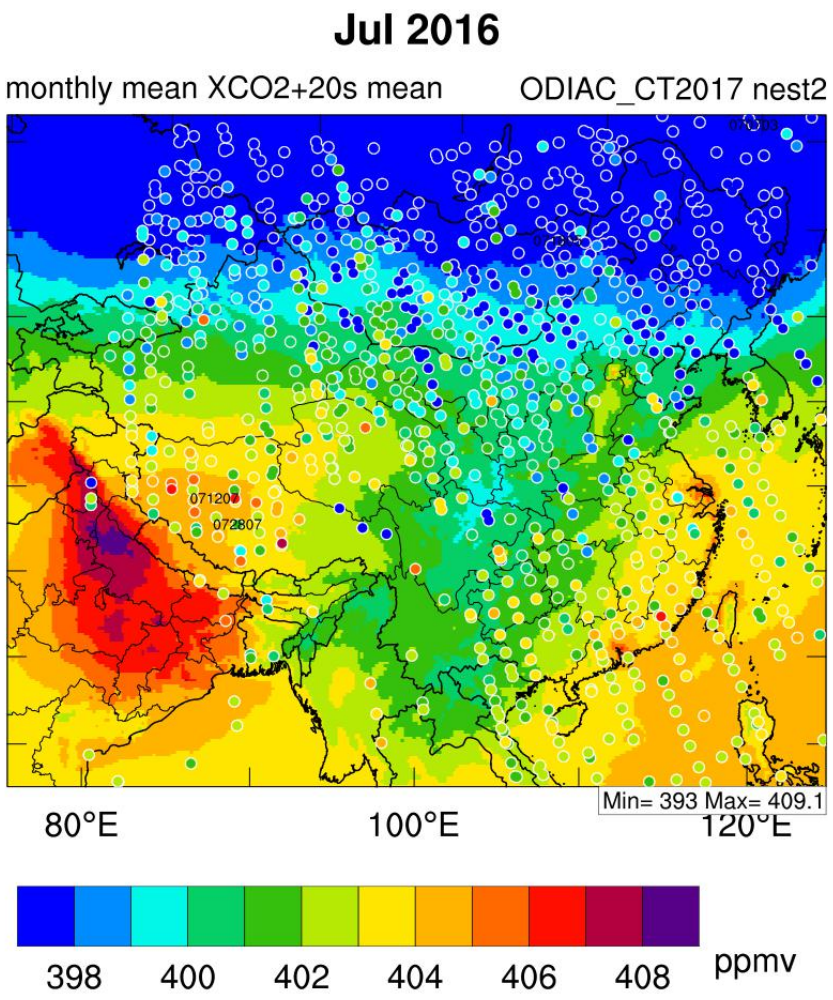
Vertical cross-section on October 15



Regional transport as well as subsidence?

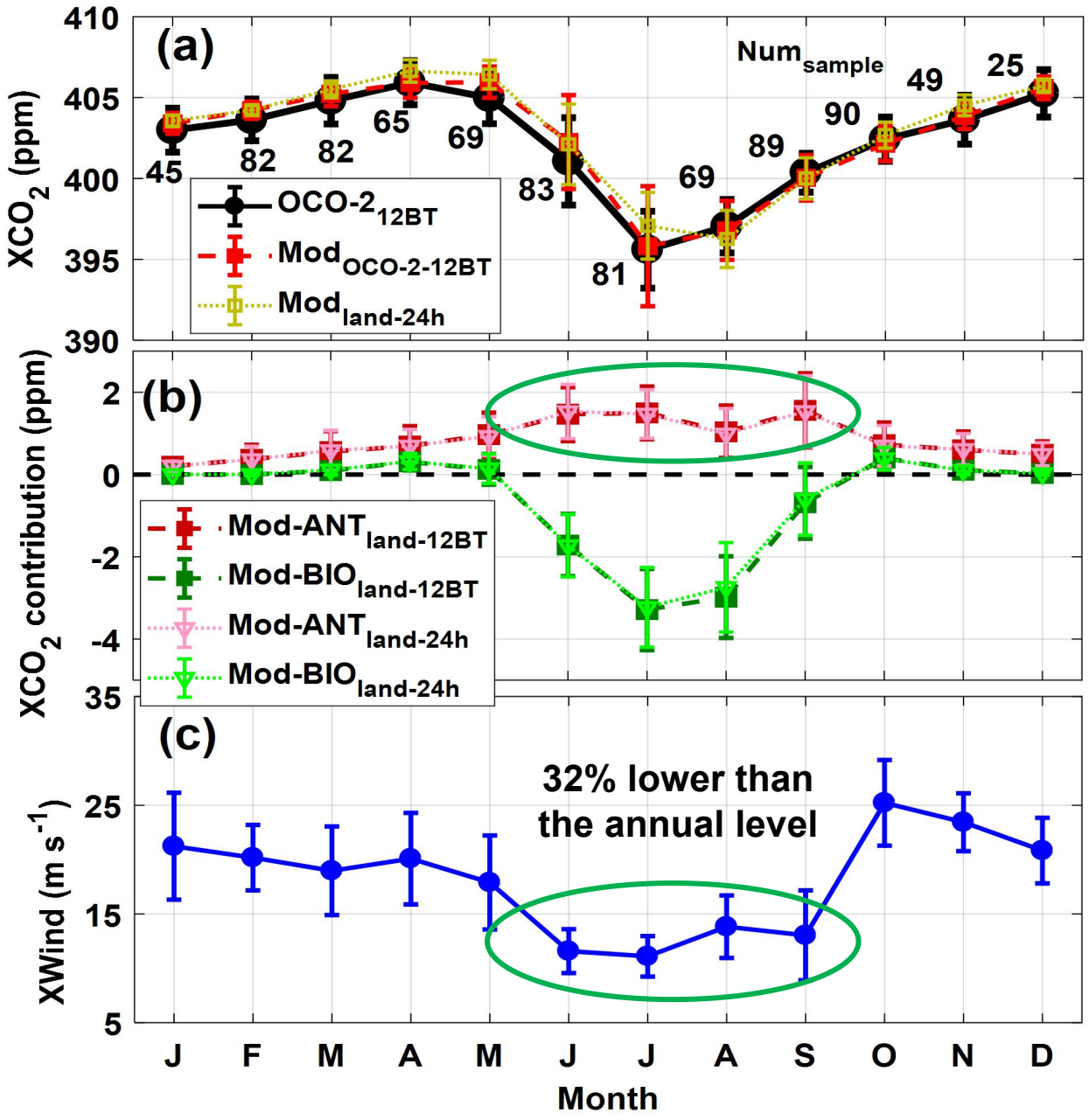
OCO-2 retrieved XCO_2 (L2 Lite Version 9)





Advantage: spatiotemporal coverage
Disadvantage: interfere with cloud and haze pollution!!

Seasonal variation of XCO_2 over Northeast China



Monthly variation range: 10 ppmv

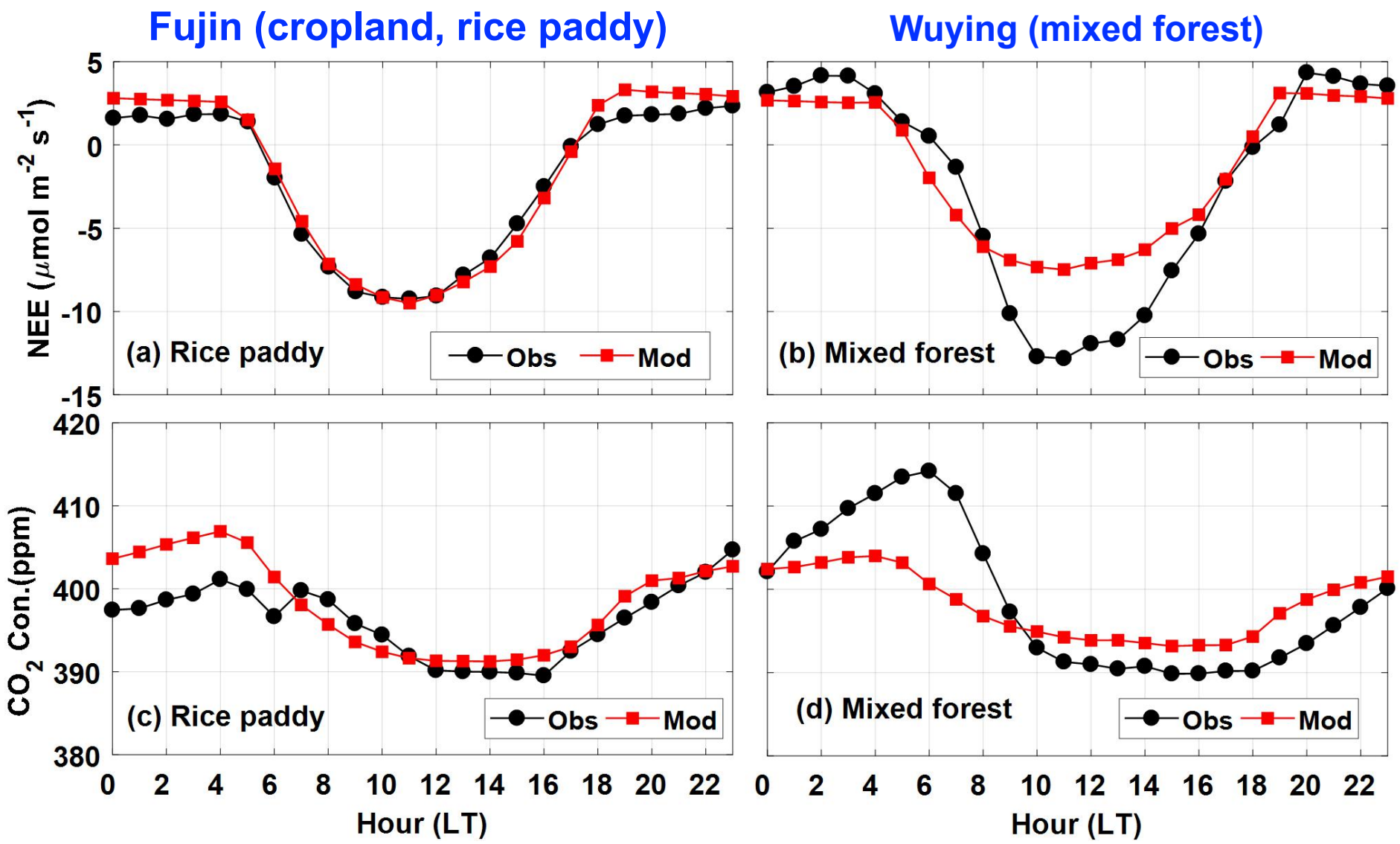
Annual mean contribution:

- **anthropogenic: 0.84 ppmv**
- **biogenic: -0.60 ppmv**

Weak winds favors the large anthropogenic contribution of XCO_2 in summer

Mean diurnal variation of CO_2 fluxes and concentrations in growing season

(May through September)



WRF-VPRM underestimates diurnal variation range over mixed forest

Ensemble offline VPRM simulations over mixed forest, predictability of CO_2 fluxes

Table 3 Range of VPRM parameters in five groups of ensemble simulations, with * representing relative variation to the default values

Ensemble Simulation	α	β	λ	PAR_0
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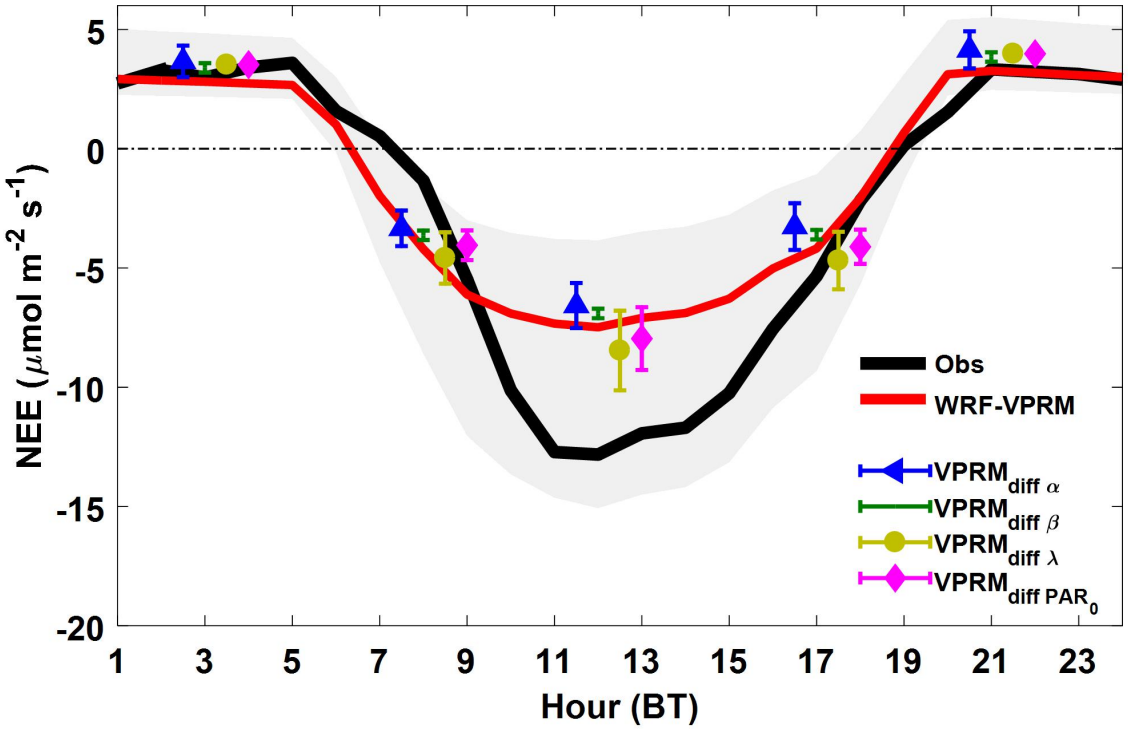

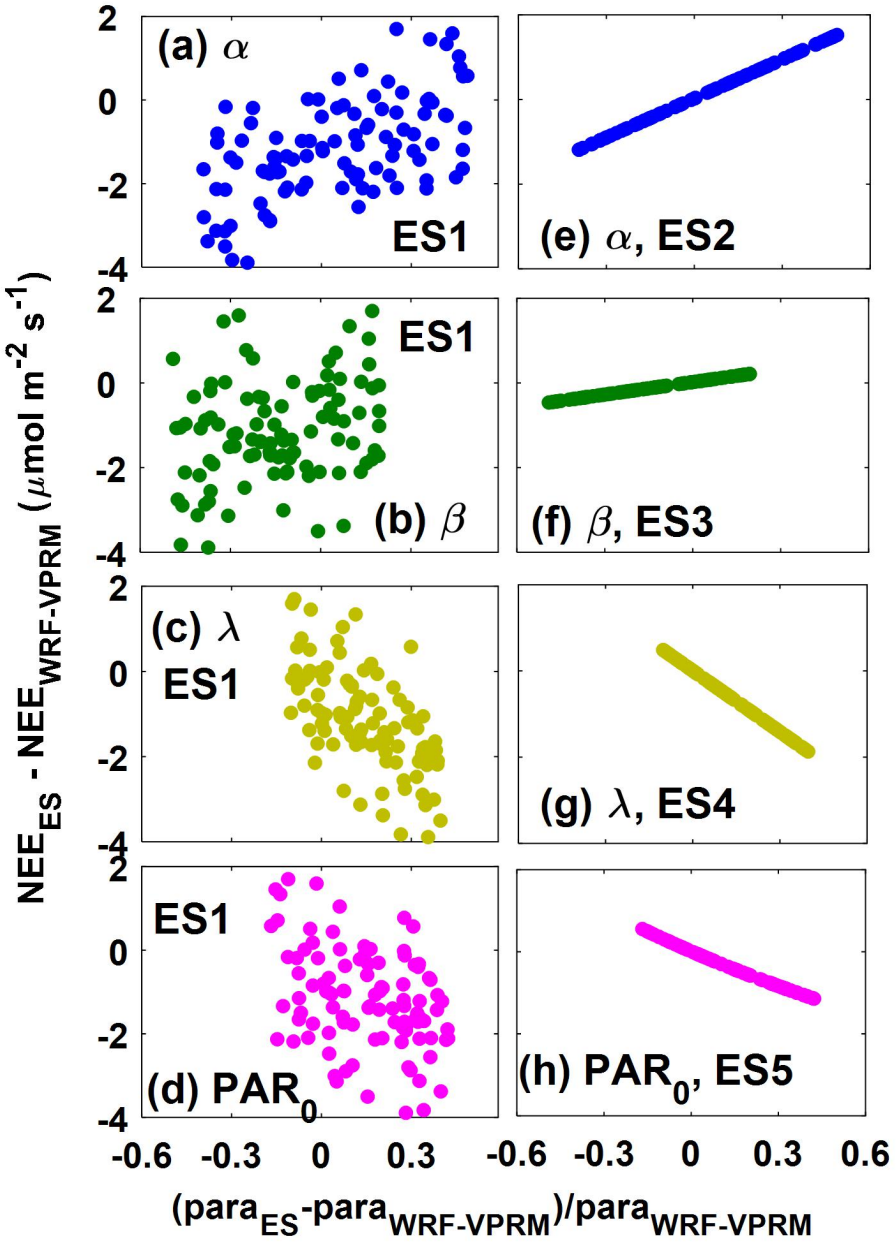

Conclusions

- **Mixed forest is observed as a stronger CO_2 sink/source than rice paddy on average in 2016;**
- **Negative biogenic contribution offset about 70% of anthropogenic contribution of XCO_2 over Northeast China in 2016;**
- **The uncertainty of NEE simulation largely depends on four VPRM parameters, especially the maximum light use efficiency λ.**

Please refer to: Li, X., Hu, X.- M., Cai, C., Jia, Q., Zhang, Y., Liu, J., et al. (2020). Terrestrial CO2 fluxes, concentrations, sources and budget in Northeast China: Observational and modeling studies. Journal of Geophysical Research: Atmospheres, 125, e2019JD031686. https://doi.org/10.1029/2019JD031686