A first look at assimilating carbon dioxide concentration for flux estimation:

Temporal and spatial variability and correlation structures

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CO_2 plays a major role for climate

But our knowledge of where CO_2 comes from and where it is absorbed is severely lacking

"Uncertainties inferred from tracer-transport inversions are ... greater than 100 percent for anthropogenic CO_2 fluxes at national scales"

Challenging problem because of a lack of observations of CO_2 fluxes and small signal-to-noise ratio

A way forward using data assimilation?

CO_2 concentration in the atmosphere can be used to constrain the CO_2 fluxes

We propose to use our PSU EnKF system assimilate CO_2 concentration and derive CO_2 fluxes

Essentially a parameter estimation of CO_2 fluxes, which vary in time and space

Objective

Examine the temporal and spatial variability of CO_2 concentration, and investigate the ensemble sensitivity due to uncertainties in atmospheric initial conditions

Simulate transport of CO_2

Run WRF-Chem 3.6.1 at a 27 km resolution to simulate CO_2 emissions and transport

The domain is over the contiguous United States

Focus on 2015 during summertime (July) when there is a large biological activity

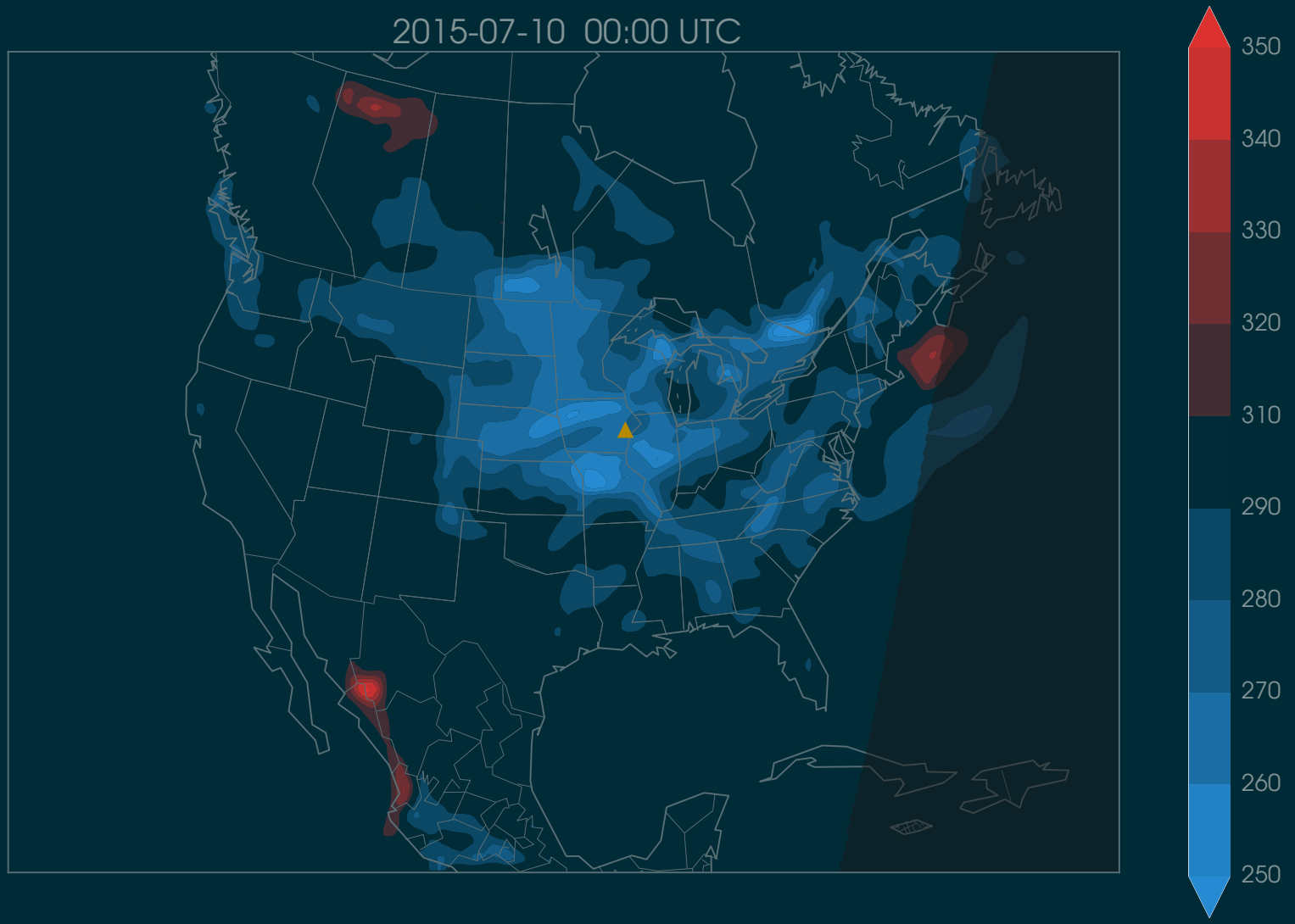
Run 40 ensemble members with different atmospheric initial conditions

Input data

Atmospheric initial conditions from ERA-Interim

CO_2 emissions from CarbonTracker (Near-Real Time)

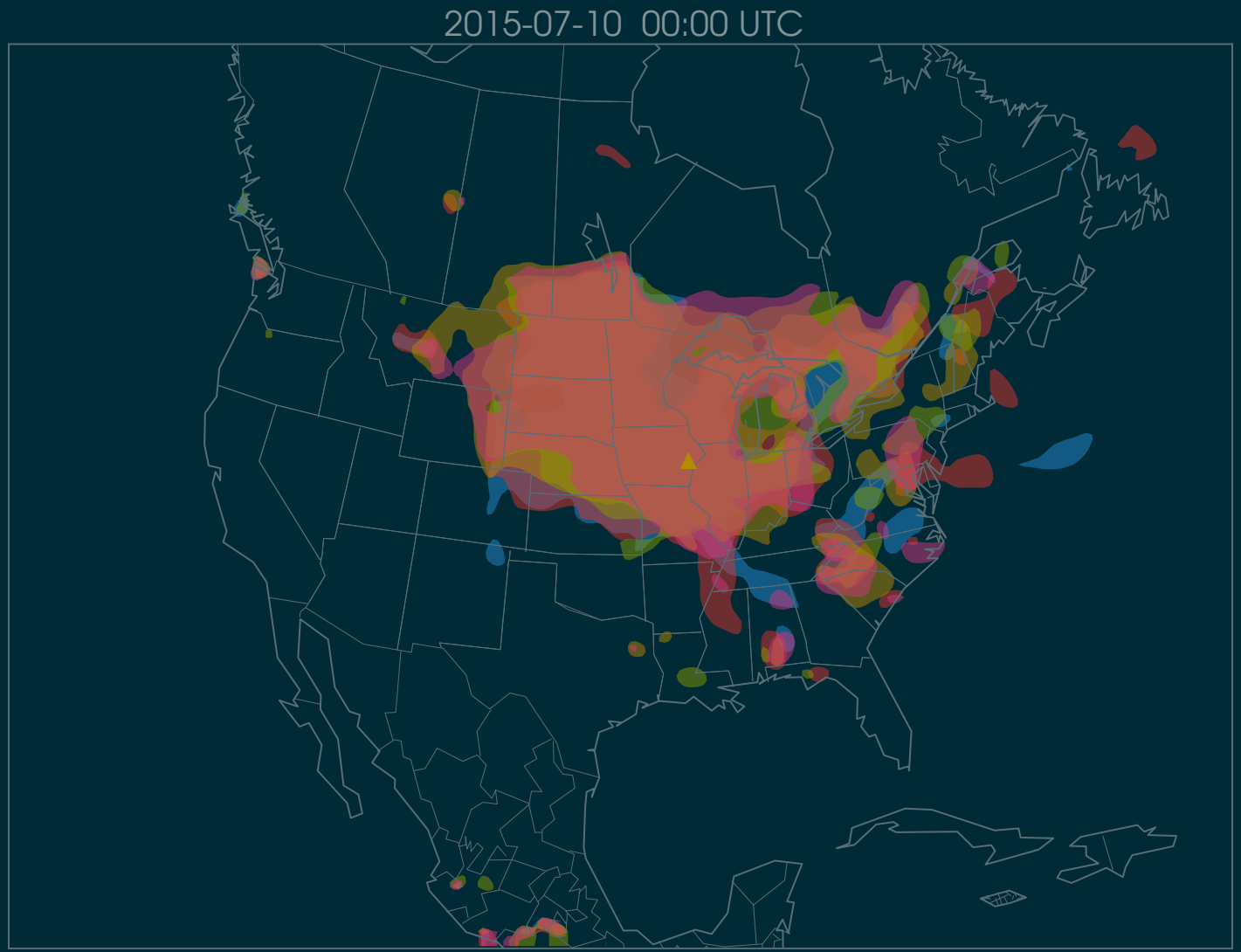
CO_2 has a large spatial variability



CO_2 concentration (ppm) at 100 m

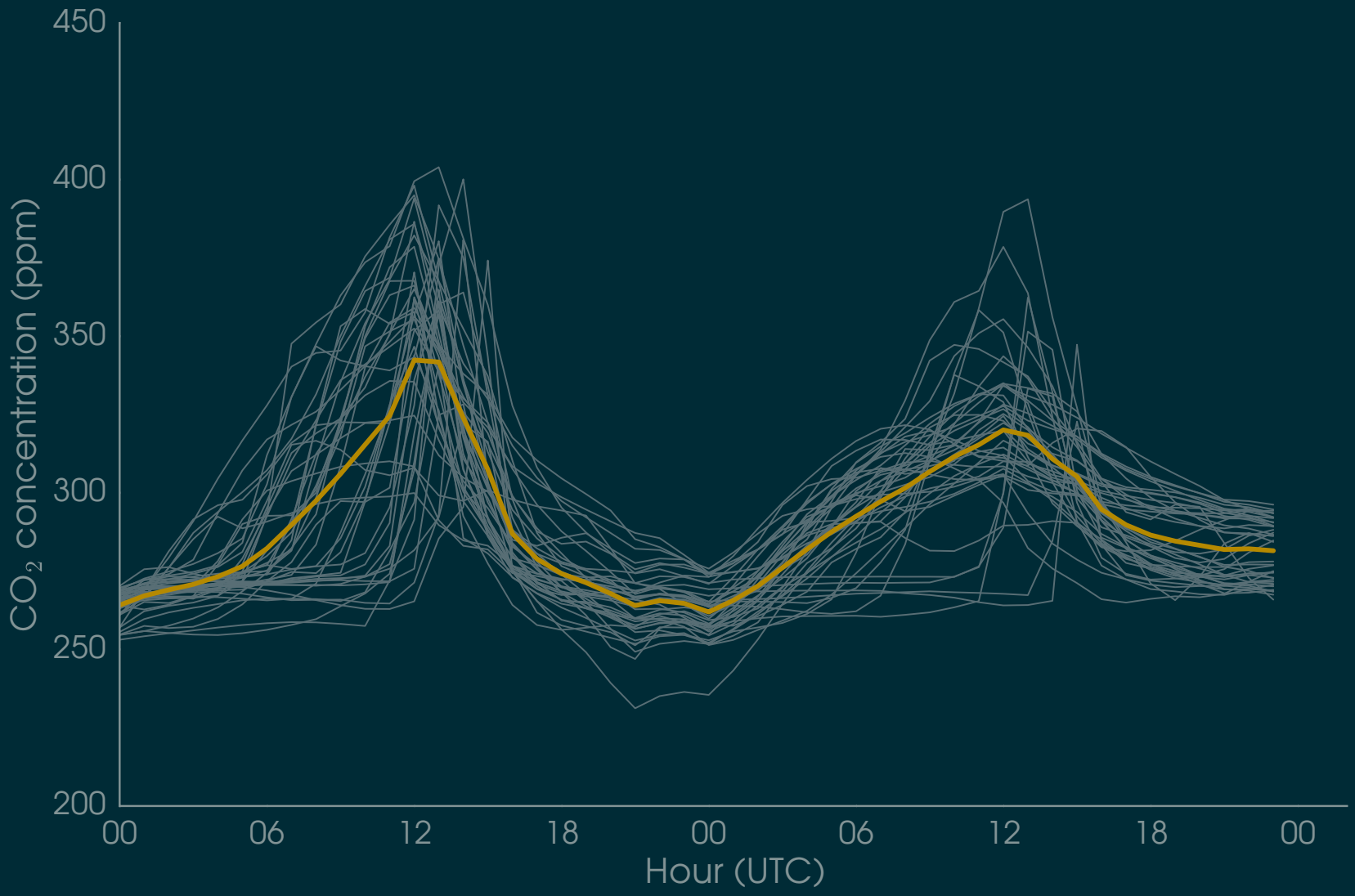
Large spread among ensemble members

Due to transport error



Paintball of $CO_2 < 280$ ppm for 5 members

Strong diurnal variability in CO_2

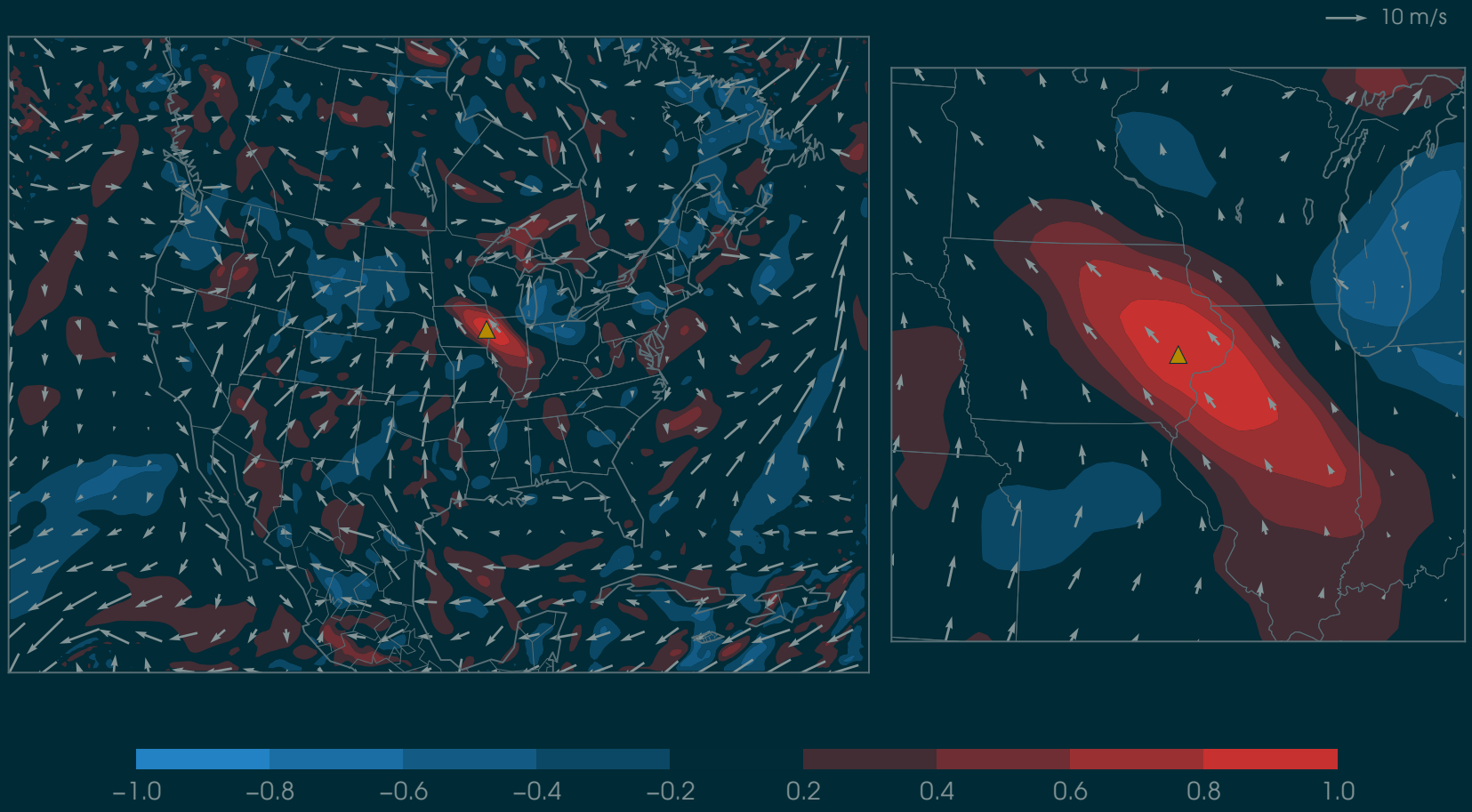


CO_2 at tower (▲) for all members and ensemble mean

Significant correlation with nearby gridpoints

2015-07-10 23:00 UTC

Time lag: 0 hours

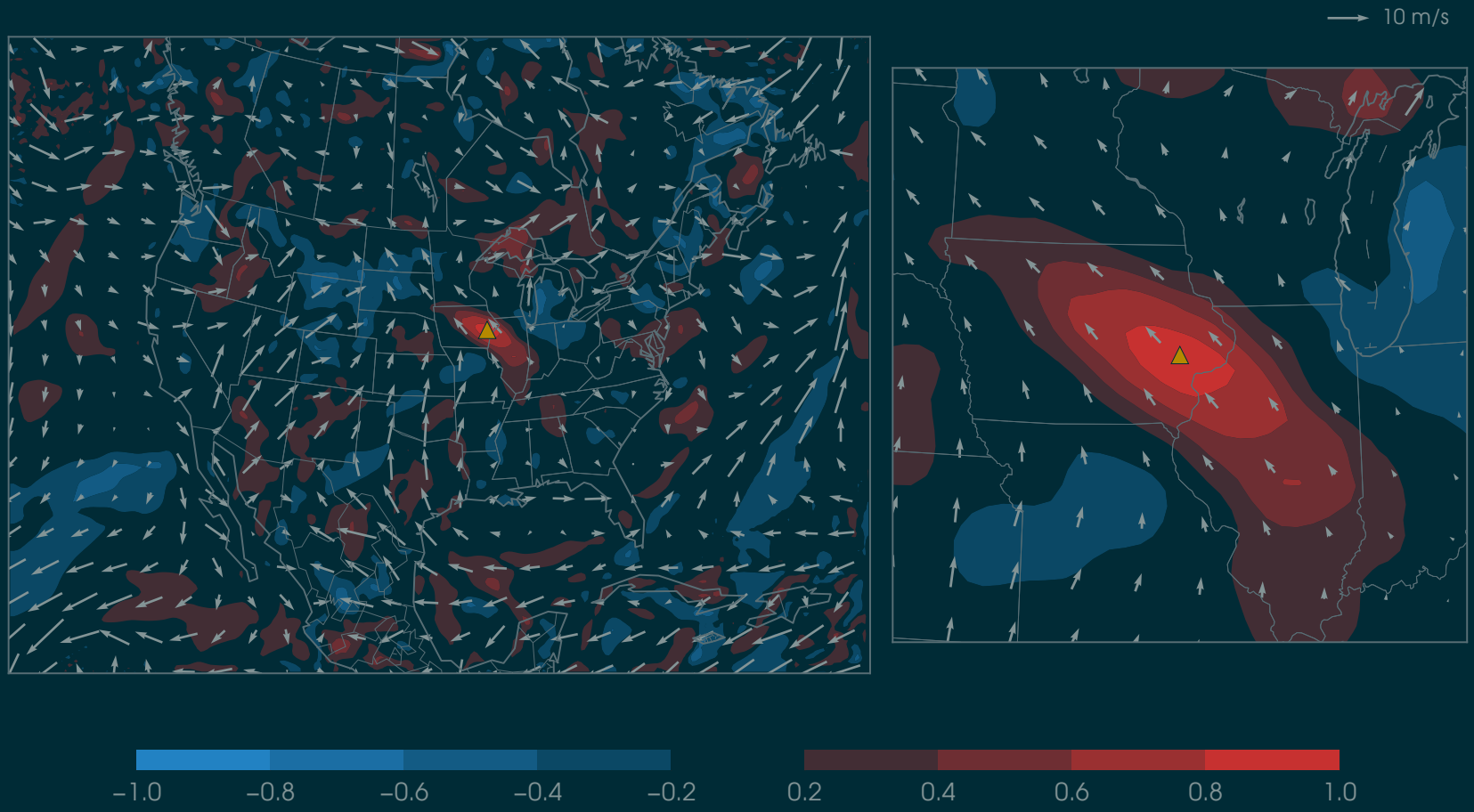


Ensemble correlation between CO_2 at ▲ and other points

Significant correlation with nearby gridpoints

2015-07-10 23:00 UTC

Time lag: −3 hours

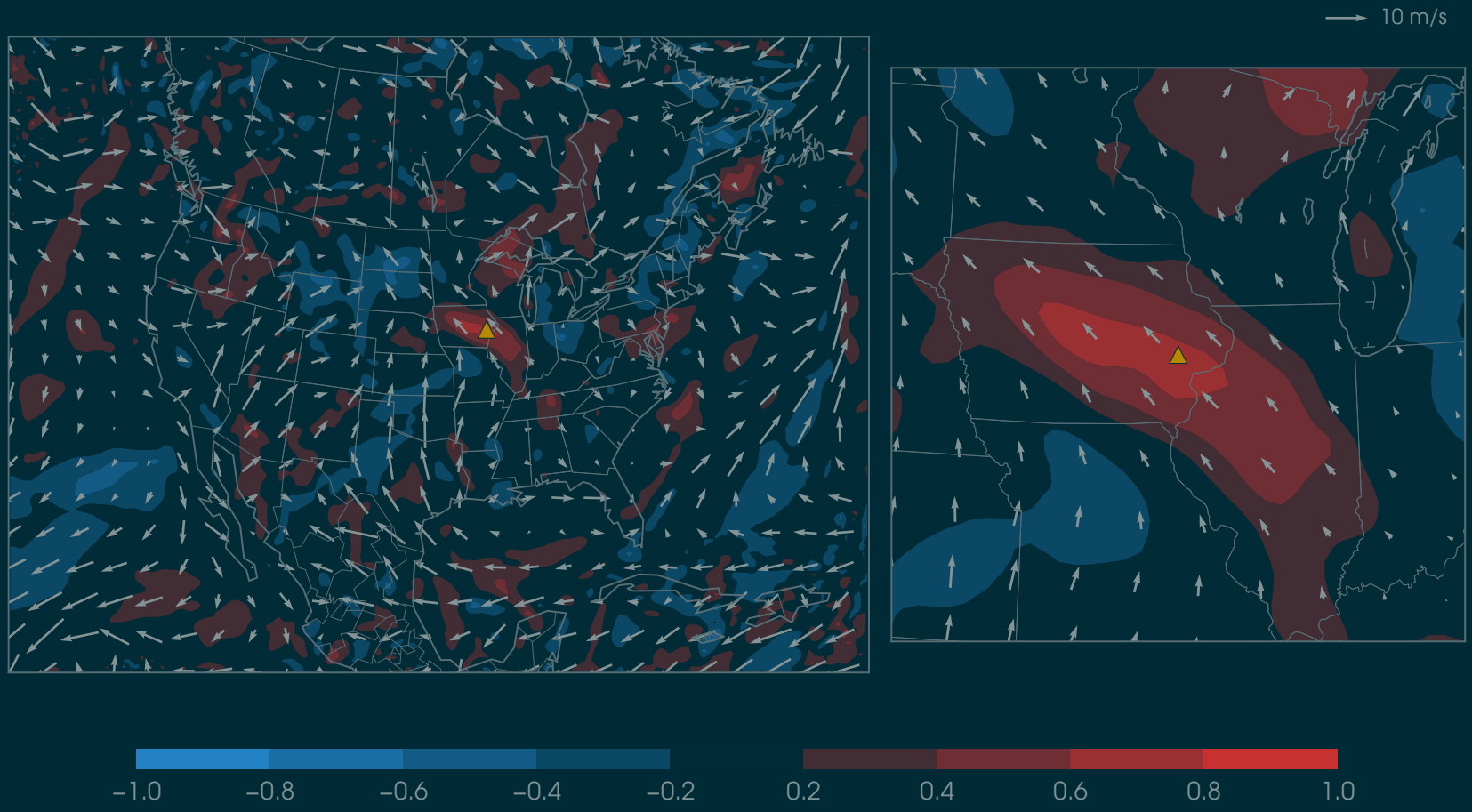


Ensemble correlation between CO_2 at ▲ and other points

Significant correlation with nearby gridpoints

2015-07-10 23:00 UTC

Time lag: −6 hours

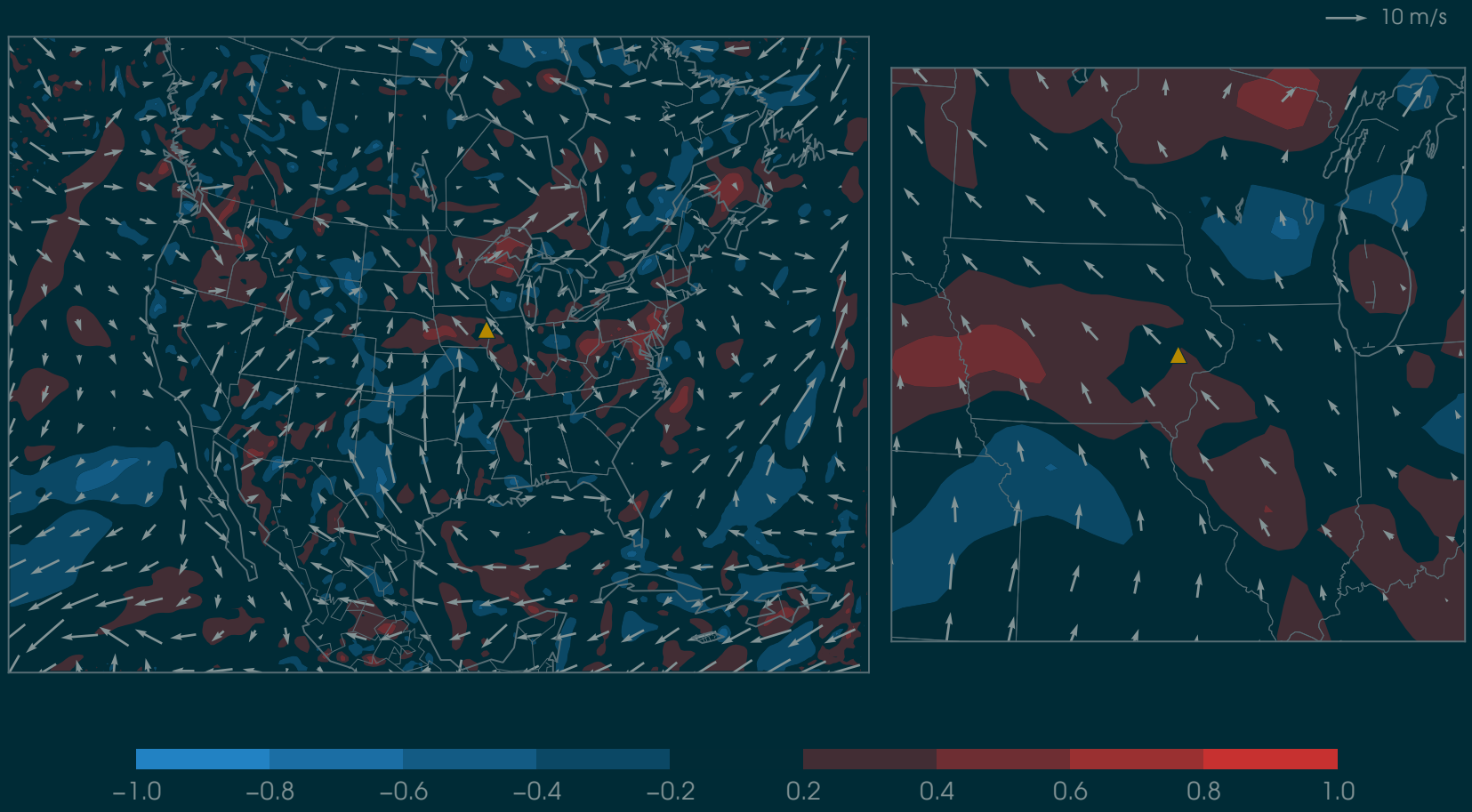


Ensemble correlation between CO_2 at ▲ and other points

Significant correlation with nearby gridpoints

2015-07-10 23:00 UTC

Time lag: −9 hours

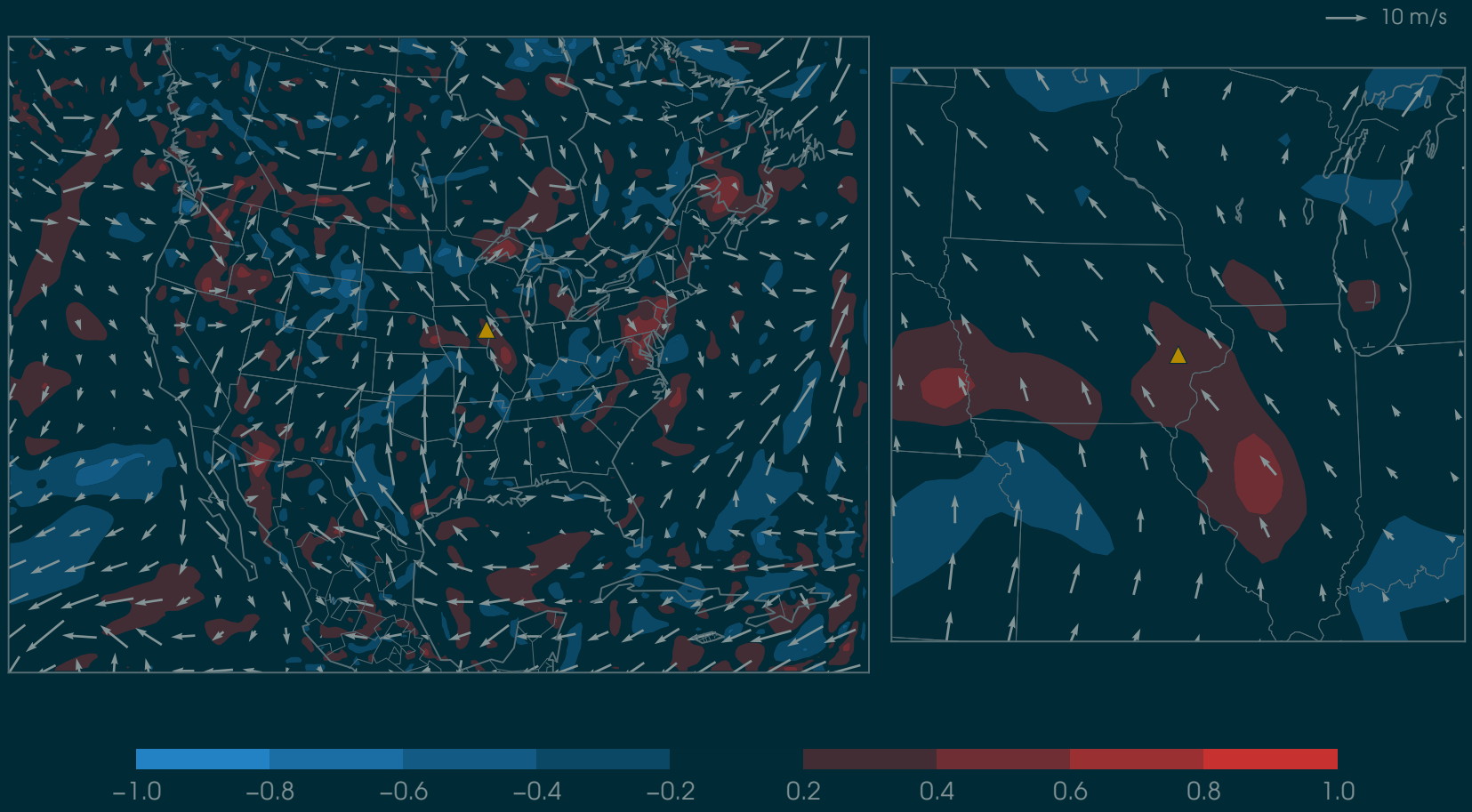


Ensemble correlation between CO_2 at ▲ and other points

Significant correlation with nearby gridpoints

2015-07-10 23:00 UTC

Time lag: −12 hours



Ensemble correlation between CO_2 at ▲ and other points

Conclusions

CO_2 concentration has a large temporal and spatial variabliity on the regional scale

Transport errors result in large uncertainties in CO_2

Ensemble correlation structures show strong dependence on wind speed and direction

Significant lagged correlations show promise for deriving CO_2 fluxes from CO_2 concentration

Future work

Create an ensemble of CO_2 fluxes

Optimize the fluxes by assimilating CO_2 concentration