3D RAMS Simulations

- $\Delta x=\Delta y=100$ km over North America
- Nested grid $\Delta x=\Delta y=20$ km centered WLEF
- 1 year simulation (year 2000)
- Weather on lateral boundaries nudged to observational analysis (NCEP) @ 6 hrs
- Release “particles” from WLEF, follow backward in time to quantify influence function and travel times

Influence functions for the WLEF tower (z=400m) for the June, July, August and September 2000

Simulation:

RAMS v4.3 with two nested grids (Δx=100km and 20 km) + LPD (Lagrangian Particle Dispersion) model in a receptor-oriented mode. The 2nd finer grid covers the domain around the WLEF tower used for dispersion calculations.

Concentration sampling:

The influence functions, travel time and influence frequency are presented for selected 2 hour sampling periods during the day during the August 2000. The 00-24 hour period represents the results for all samplings during the month. All sampling times are local (GMT-6h). The results can be plotted for any additional 2 hour sampling periods. The influence frequency is derived in reference to the sampling period (i.e., how often the signal from a given source area is observed at the receptor during the sampling period).

Travel distance is derived from the presented influence functions but averaged over 45° sectors and shown in polar coordinates.

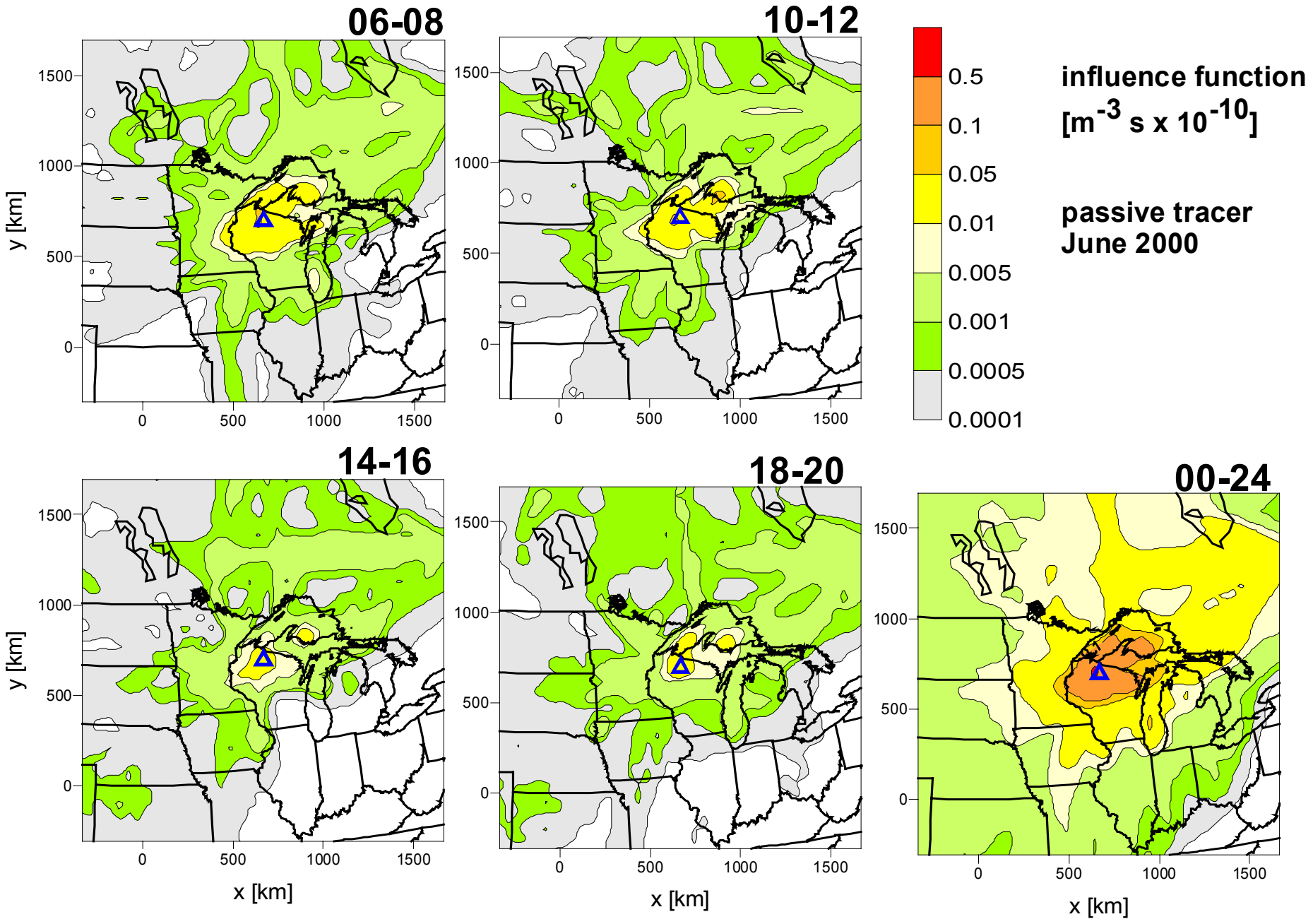
Tracers:

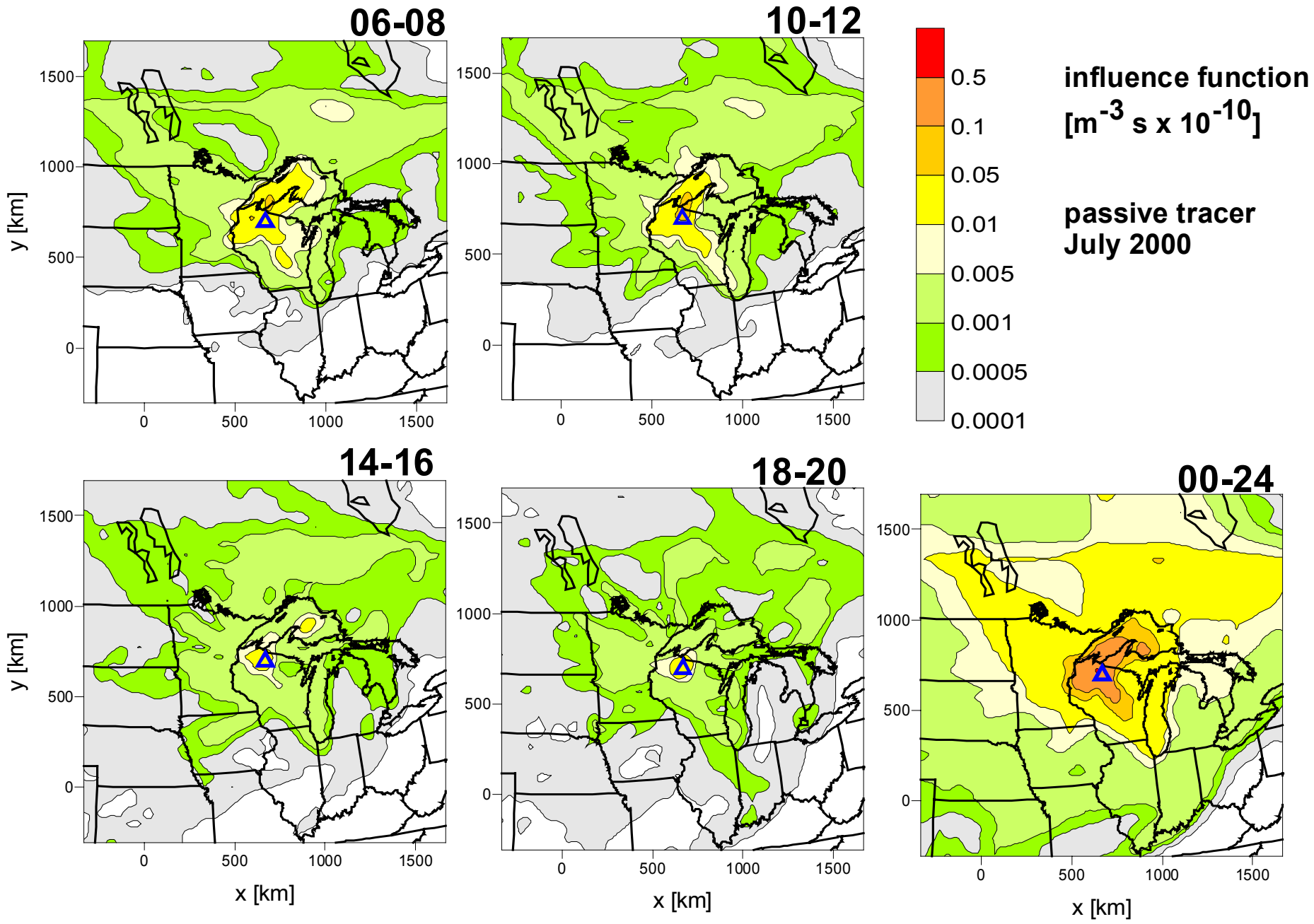
1. Passive tracer with a constant flux – the spatial distributions are the same as for the respiration flux including dependence on the soil temperature.
2. A-tracer (assimilation tracer) with a daytime flux driven by shortwave radiation

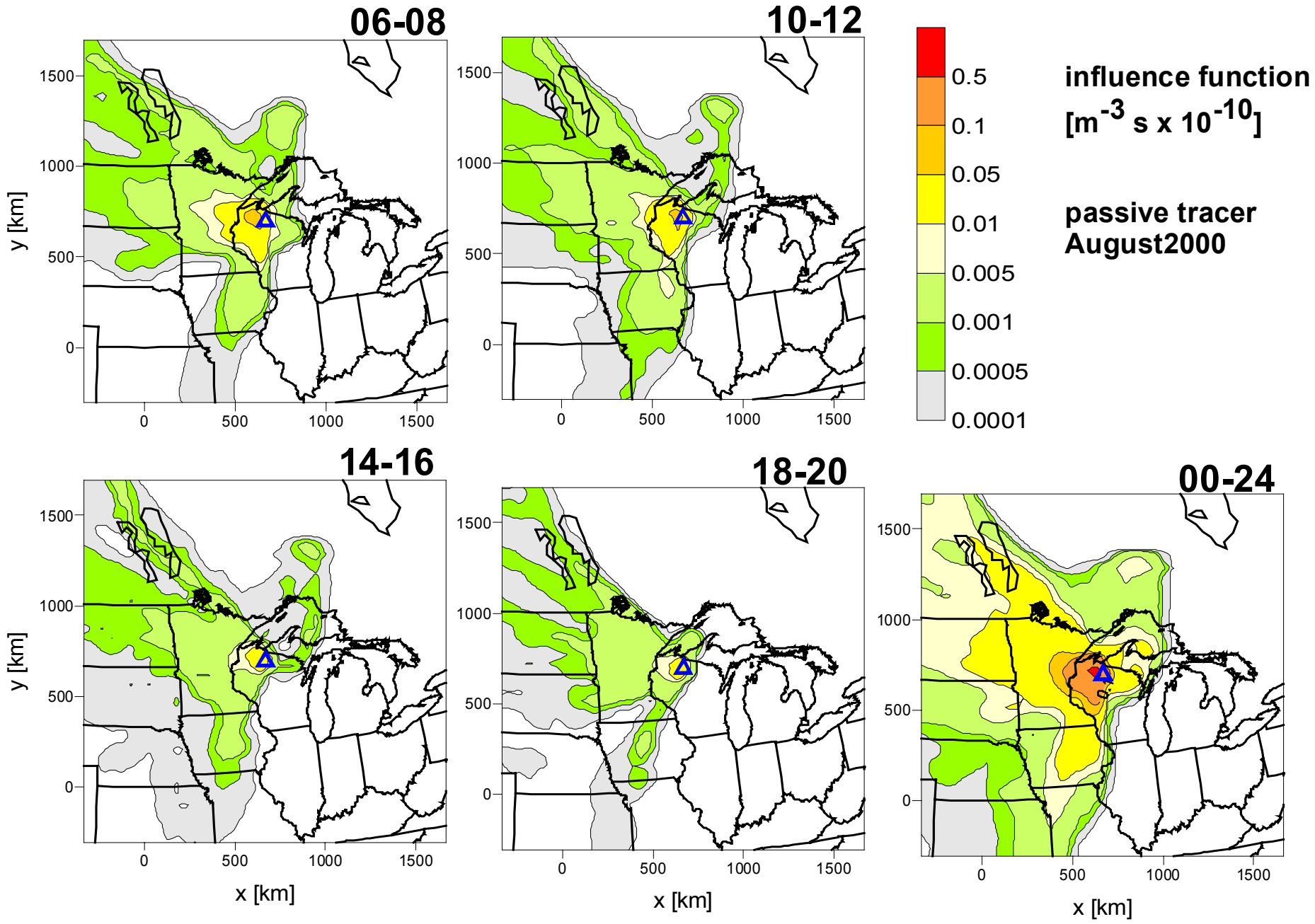
Reference:

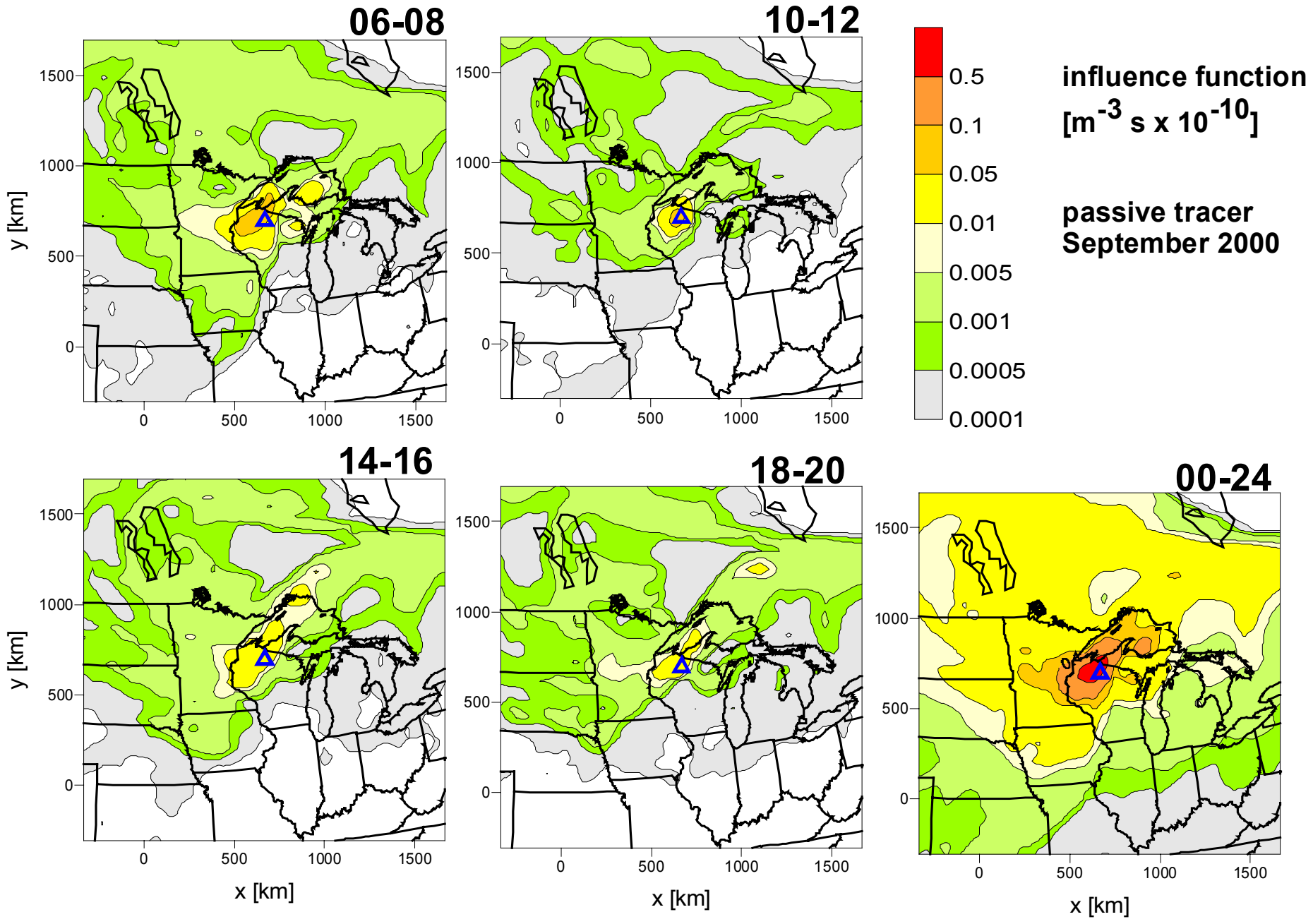
Uliasz, M. and A. S. Denning, 2002:
Deriving mesoscale surface fluxes of trace gases from concentration data.
submitted to: *J. Appl. Meteor.*
Download: http://biocycle.atmos.colostate.edu/~marek/research/publications.htm

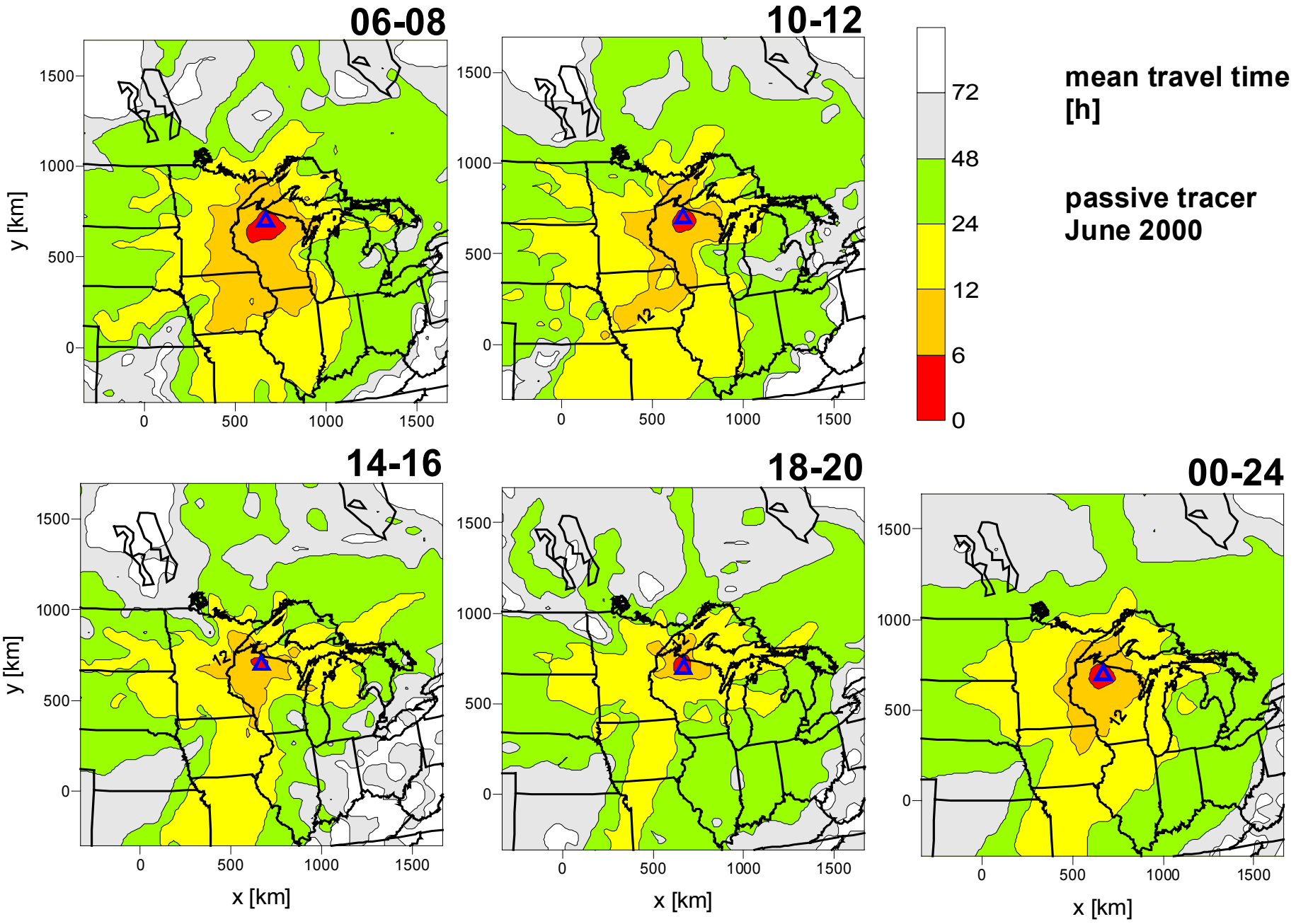
Influence function climatology

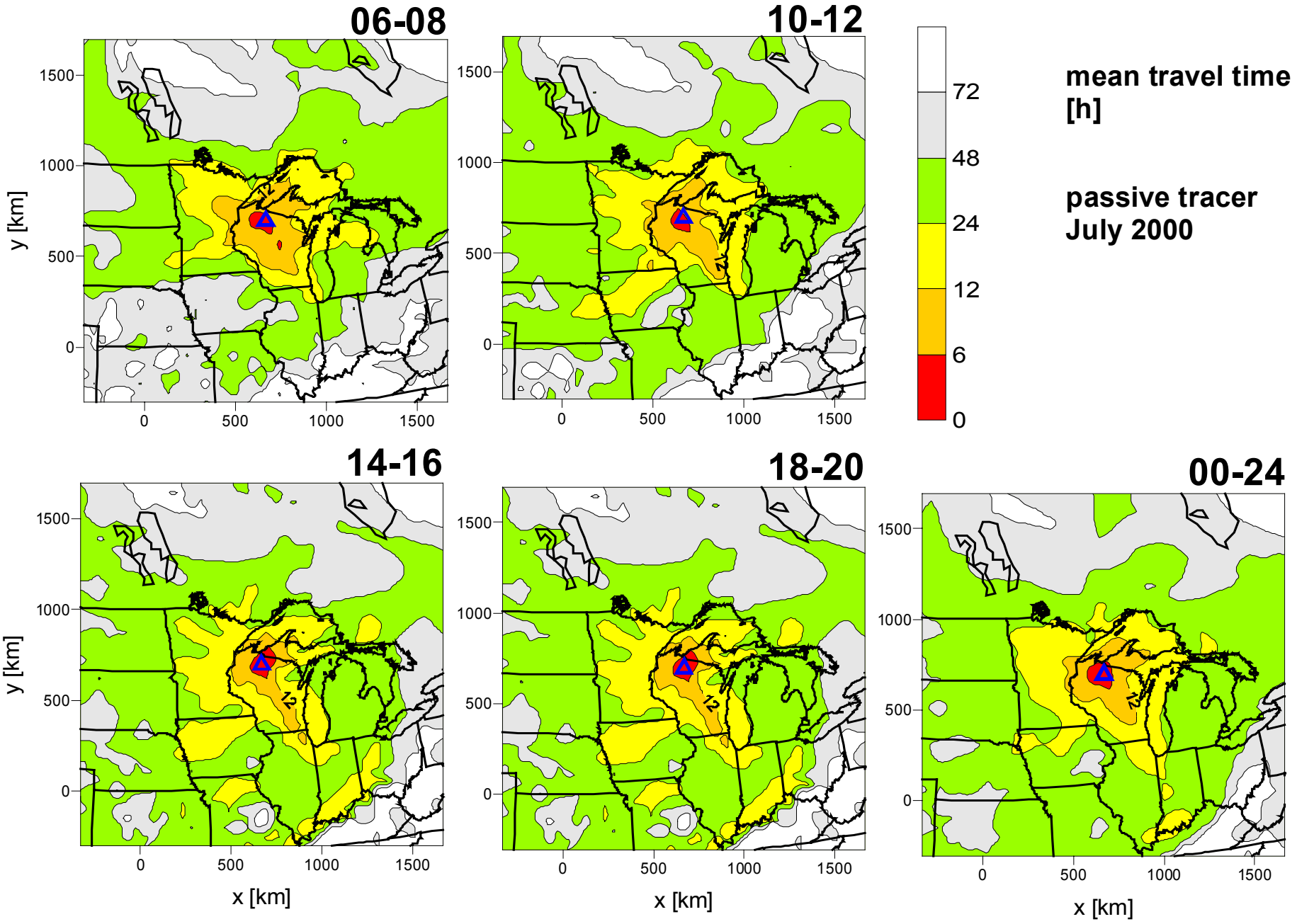

06-08
10-12
14-16
18-20
00-24
y [km]
x [km]
0
500
1000
1500
0.5
0.1
0.05
0.01
0.005
0.001
0.0005
0.0001
influence function
[m-3 s x 10-10]
passive tracer
June 2000

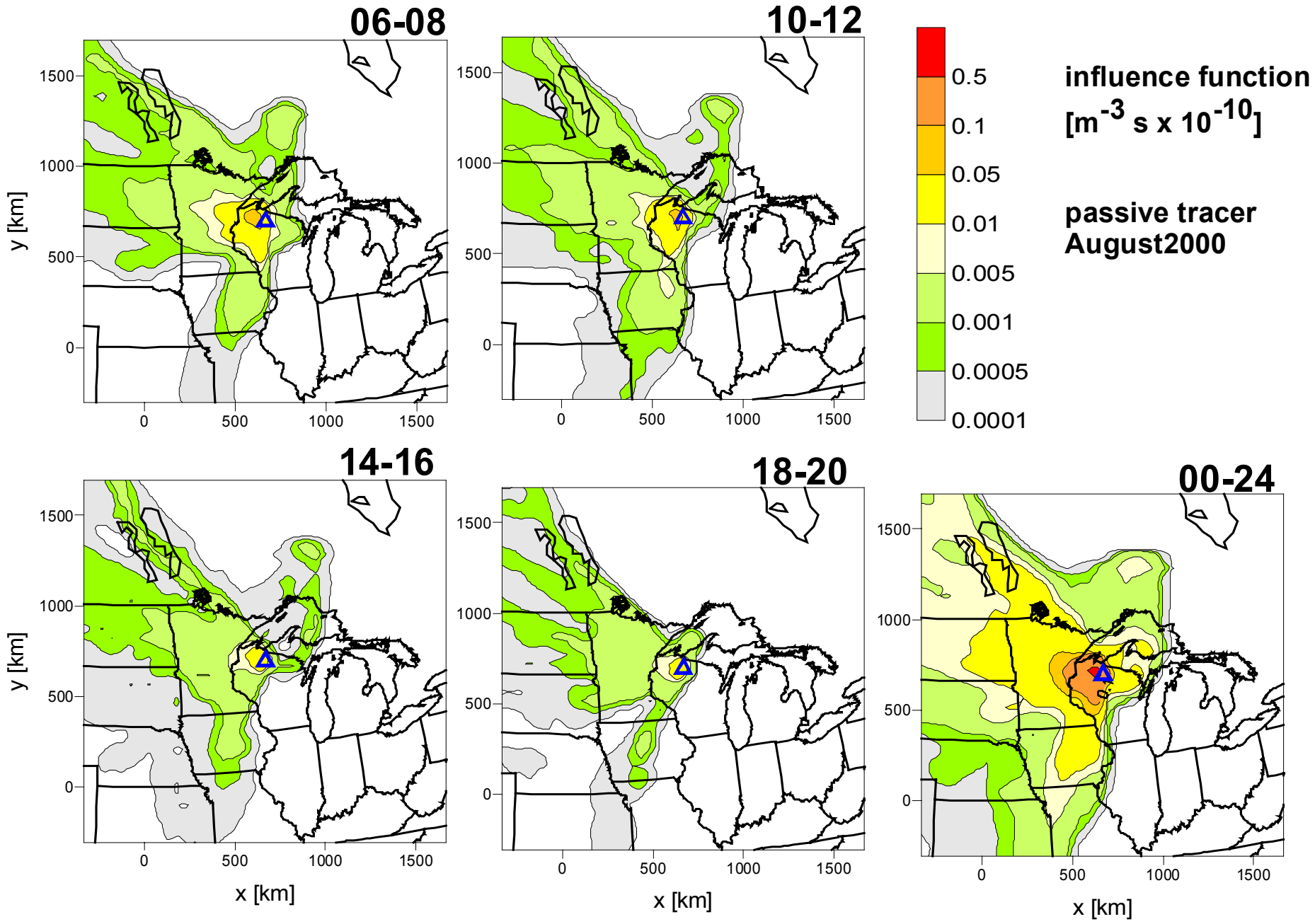

06-08
10-12
14-16
18-20
00-24
y [km]
x [km]
0
500
1000
1500
0.5
0.1
0.05
0.01
0.005
0.001
0.0005
0.0001
influence function
[m-3 s x 10-10]
passive tracer
July 2000

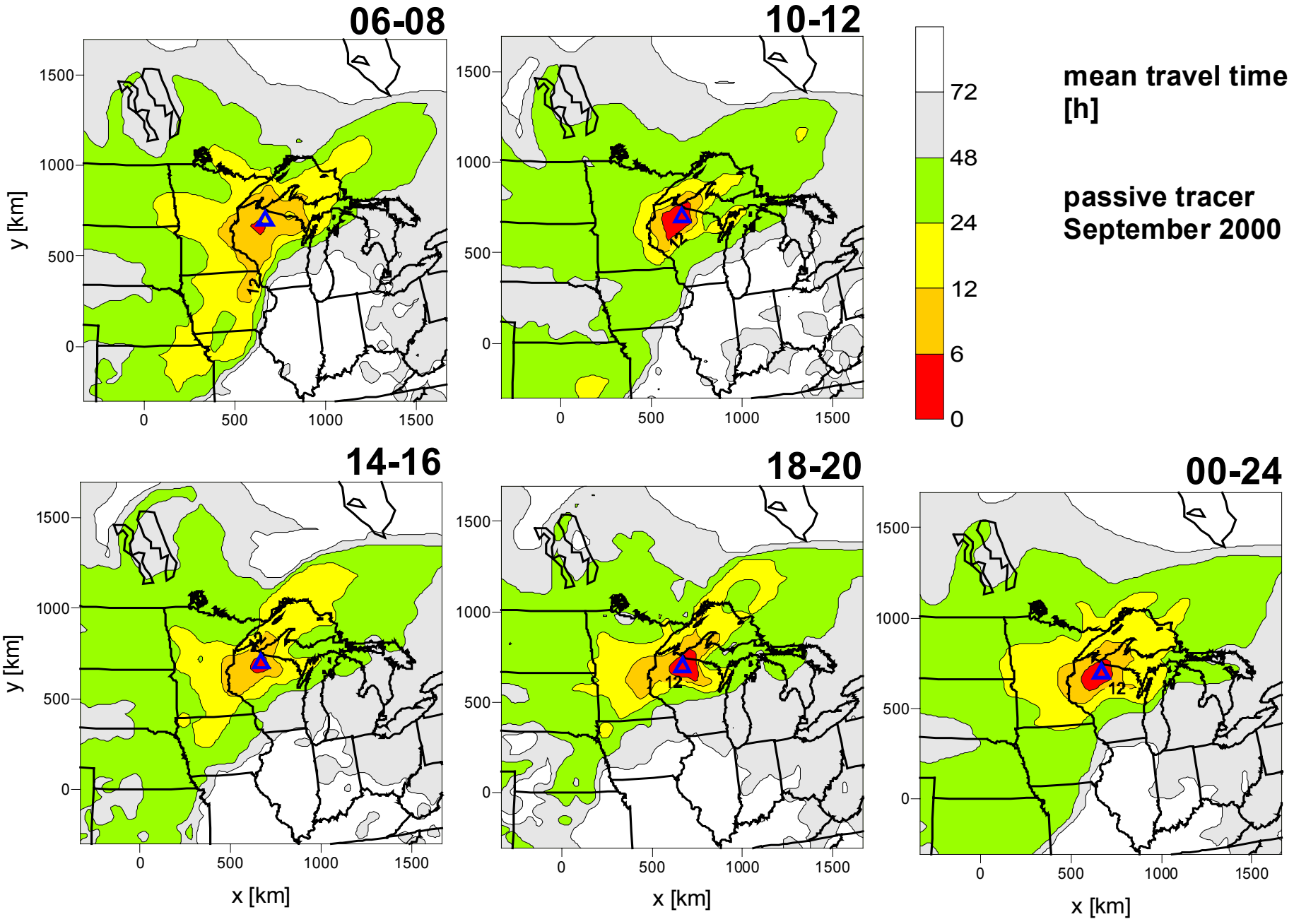

06-08
10-12
14-16
18-20
00-24
y [km]
x [km]
0
500
1000
1500
0.5
0.1
0.05
0.01
0.005
0.001
0.0005
0.0001
influence function
[m-3 s x 10-10]
passive tracer
August2000

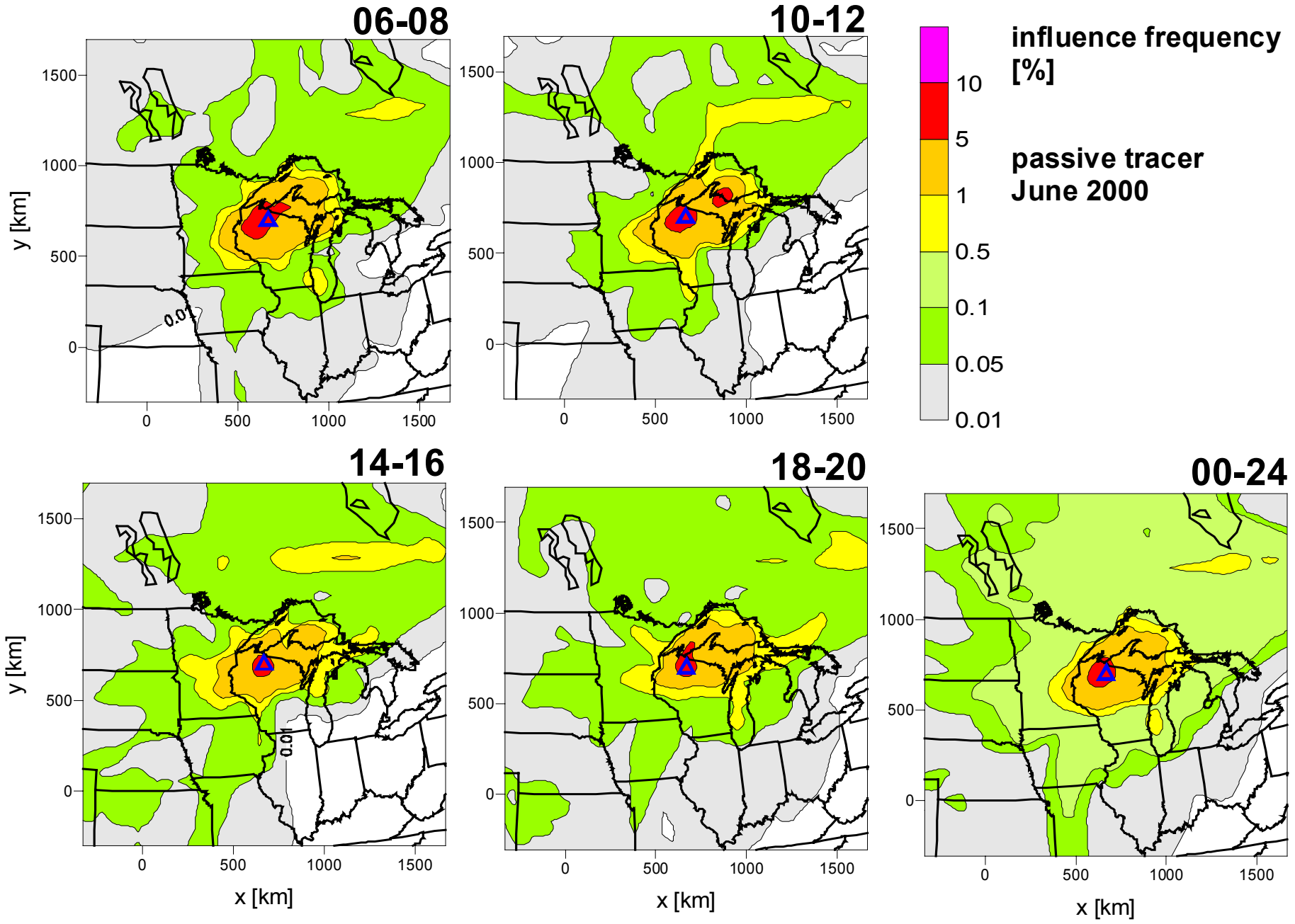

06-08
10-12
14-16
18-20
00-24
0.5
0.1
0.05
0.01
0.005
0.001
0.0005
0.0001
influence function
[m-3 s x 10-10]
passive tracer
September 2000
y [km]
x [km]
0
500
1000
1500

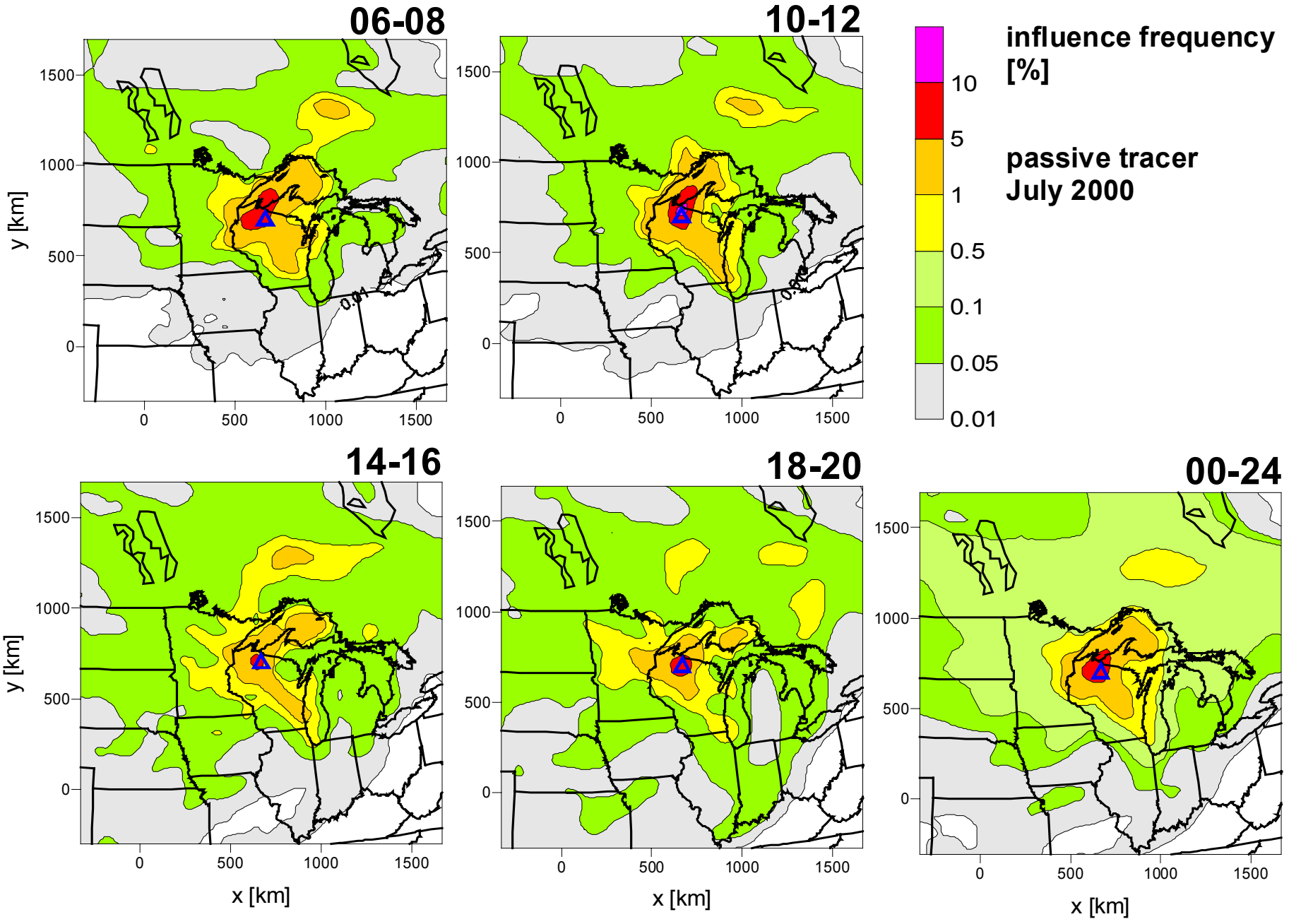

06-08
10-12
14-16
18-20
00-24
mean travel time [h]
passive tracer June 2000
72
48
24
12
6
0
y [km]
x [km]
0
500
1000
1500

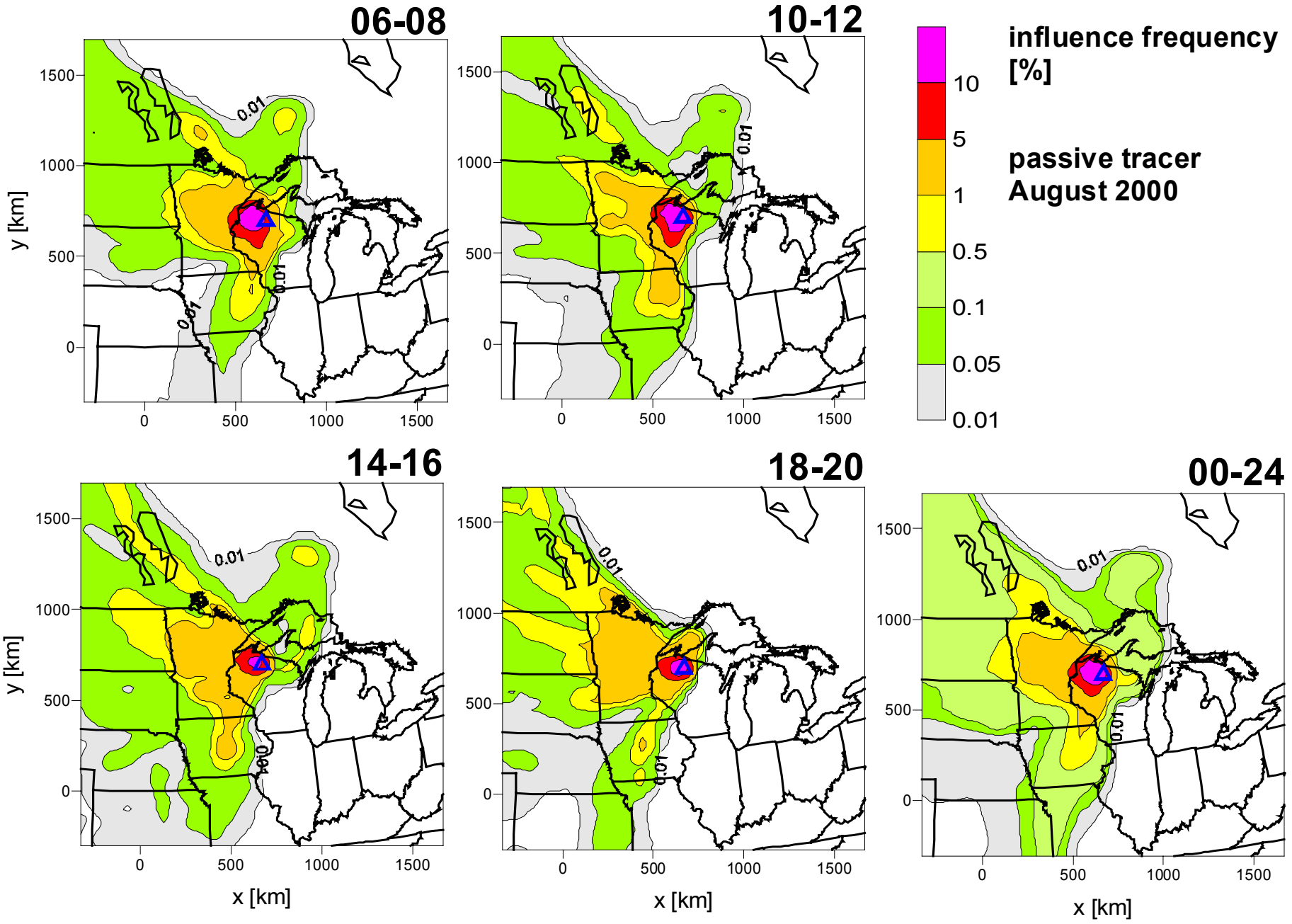

06-08
10-12
14-16
18-20
00-24
mean travel time [h]
passive tracer July 2000
72
48
24
12
6
0
y [km]
x [km]
0
500
1000
1500

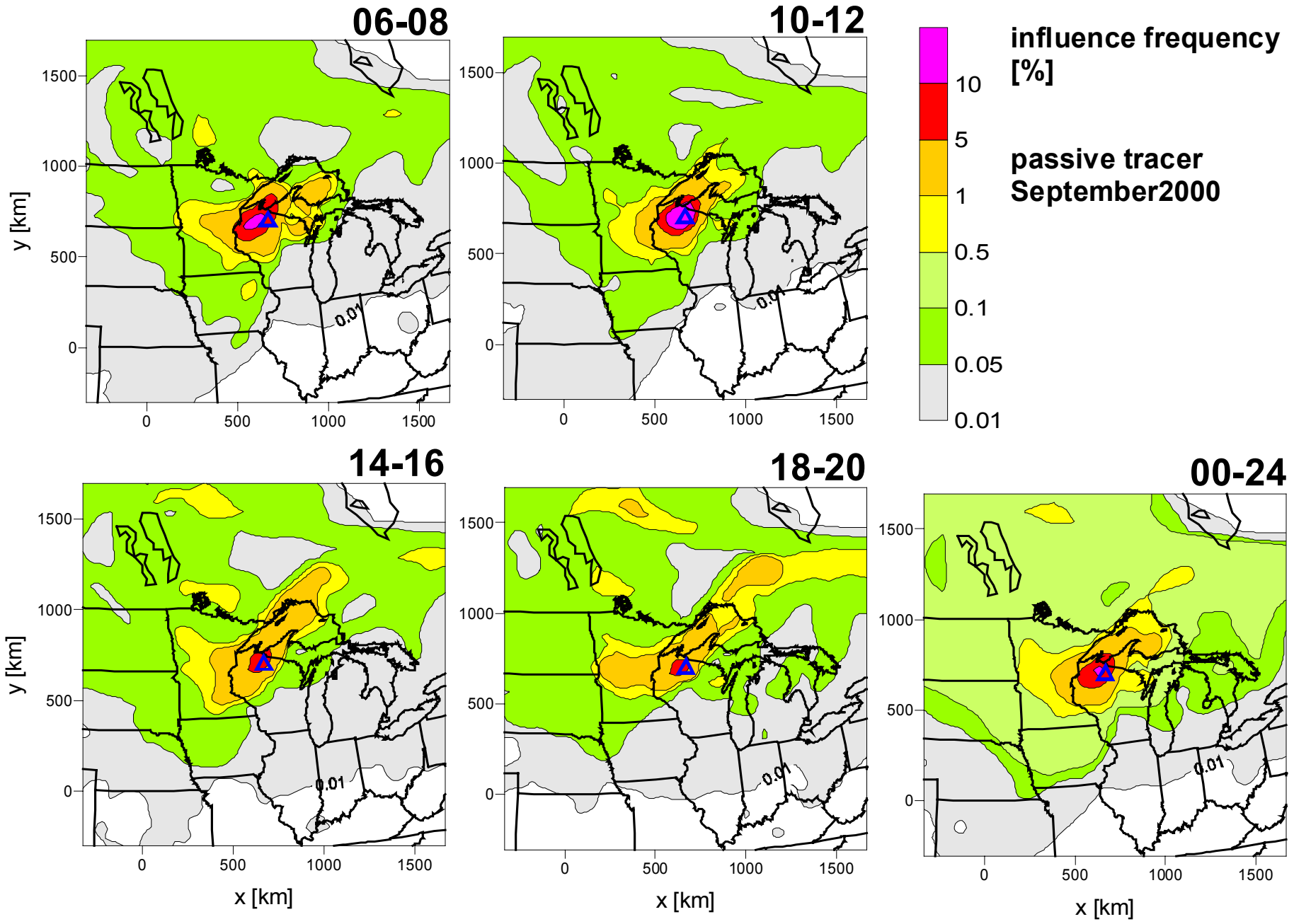

06-08
10-12
14-16
18-20
00-24
y [km]
x [km]
0
500
1000
1500
0.5
0.1
0.05
0.01
0.005
0.001
0.0005
0.0001
influence function
[m-3 s x 10-10]
passive tracer
August2000


06-08
10-12
14-16
18-20
00-24
y [km]
x [km]
0
500
1000
1500
12
72
48
24
12
6
0
mean travel time
[h]
passive tracer
September 2000


06-08
10-12
14-16
18-20
00-24
influence frequency [%]
10
5
1
0.5
0.1
0.05
0.01
passive tracer
June 2000
y [km]
x [km]
0
500
1000
1500
0.01


06-08
10-12
14-16
18-20
00-24
influence frequency [%]
passive tracer July 2000
10
5
1
0.5
0.1
0.05
0.01
y [km]
x [km]
0
500
1000
1500


06-08
10-12
14-16
18-20
00-24
influence frequency [%]
10
5
1
0.5
0.1
0.05
0.01
passive tracer
August 2000
y [km]
x [km]
0
500
1000
1500
0.01


06-08
10-12
14-16
18-20
00-24
influence frequency [%]
10
5
1
0.5
0.1
0.05
0.01
passive tracer September2000
y [km]
x [km]
0
500
1000
1500
0.01

Daily variability of transport patterns

Influence functions derived for each day during the period June-September 2000 were integrated in polar coordinates Within 8 sectors (45^o) up to 1000 km upwind from the WLEF tower. For each day the dominant sector was selected (next figure) .

Daily variability of atmospheric transport patterns were evaluated as the difference between the dominant sector at the current and previous days, i.e., 0 – no change in dominant transport, 1- 45^o change in direction of dominant transport, 4 – change of the dominant transport to the opposite direction (2^{nd} next figure). Information on direction of changes (clockwise or counterclockwise) was not taken into account. The time periods with 0-1 had rather stable transport pattern while the period with 3-4 highly variable transport patterns.

The dominant sectors and transport variability are somewhat sensitive to the sampling time during the day.

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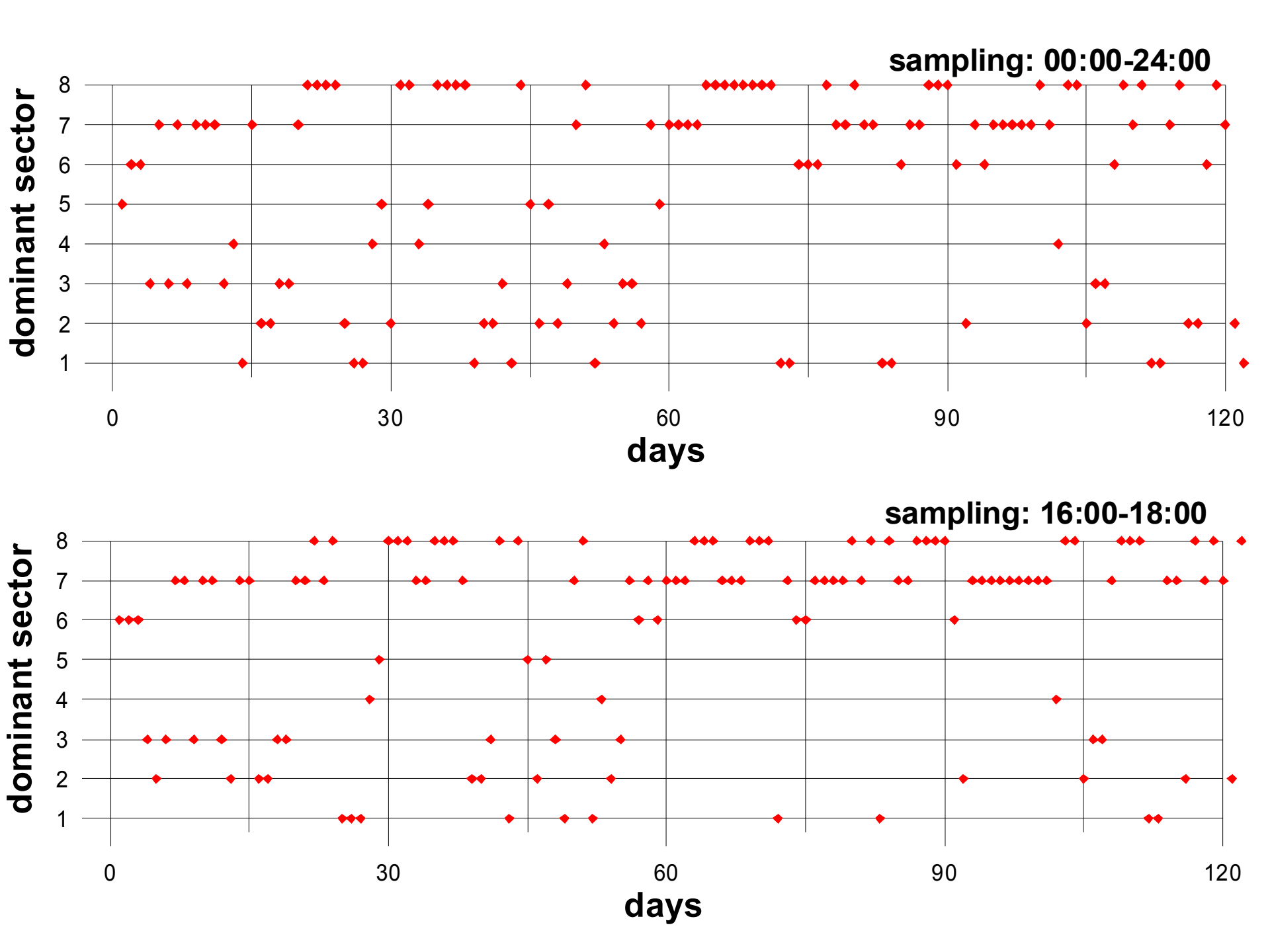
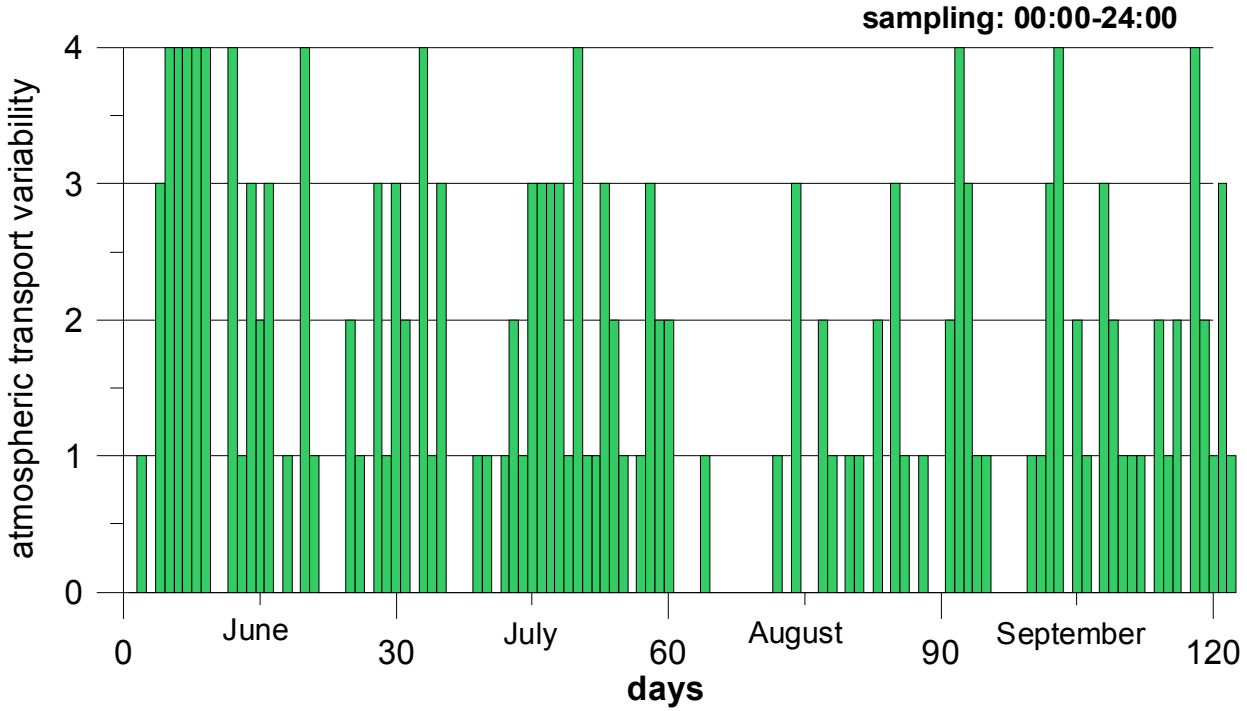
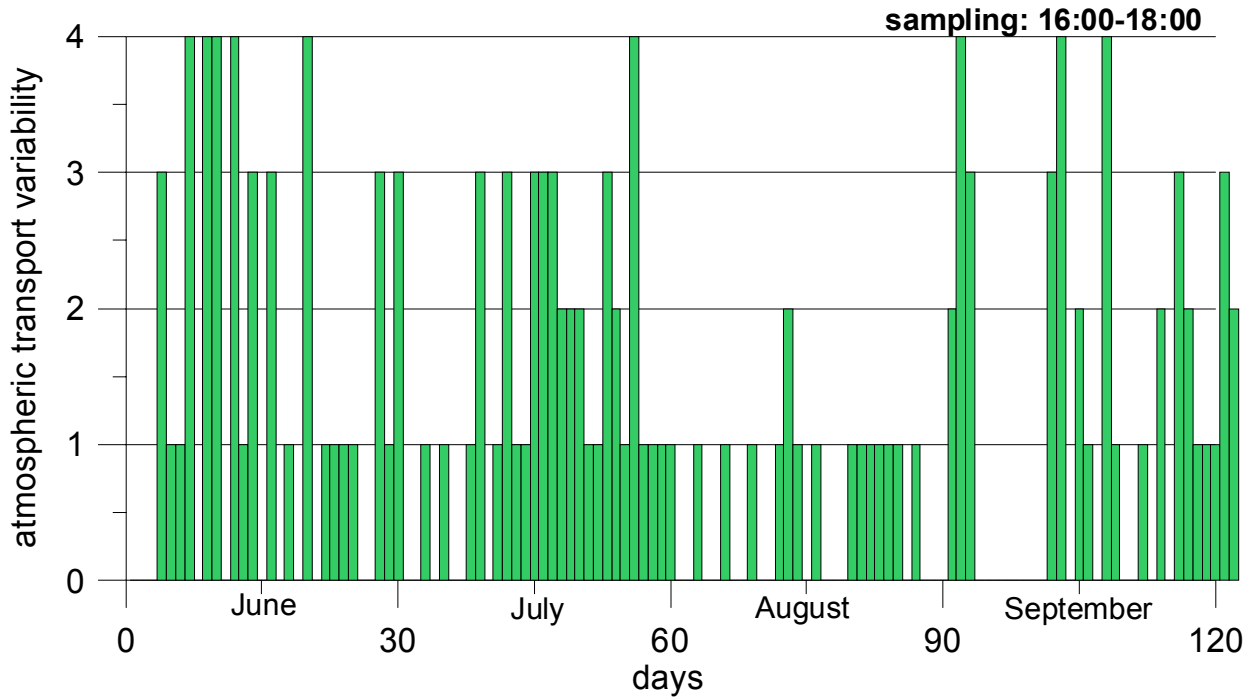
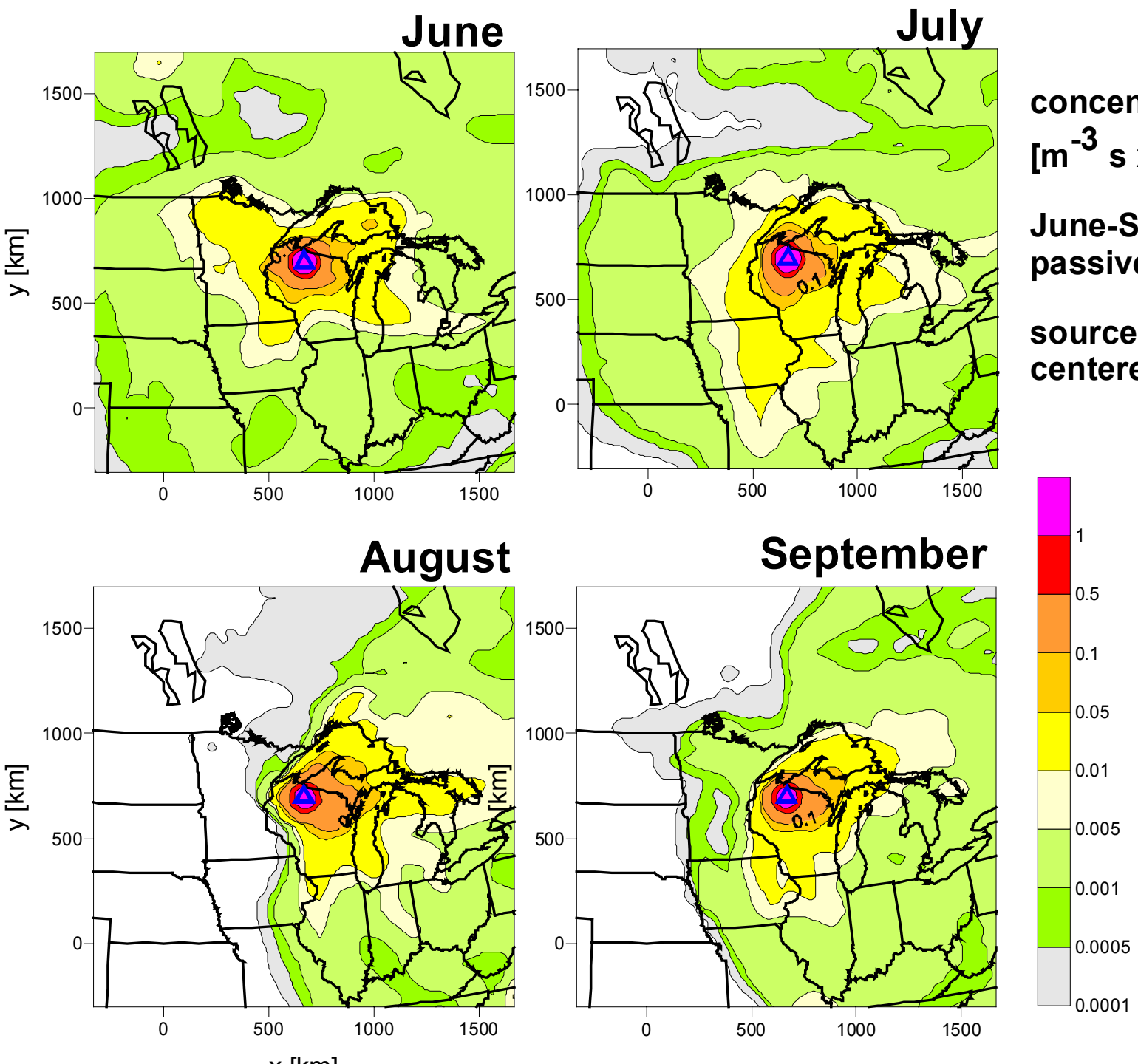

sampling: 00:00-24:00
dominant sector
8
7
6
5
4
3
2
1
0
30
60
90
120
days
sampling: 16:00-18:00
dominant sector
8
7
6
5
4
3
2
1
0
30
60
90
120
days


sampling: 00:00-24:00
atmospheric transport variability
0
1
2
3
4
June
July
August
September
0
30
60
90
120
days


sampling: 16:00-18:00
atmospheric transport variability
0
1
2
3
4
June
July
August
September
0
30
60
90
120
days

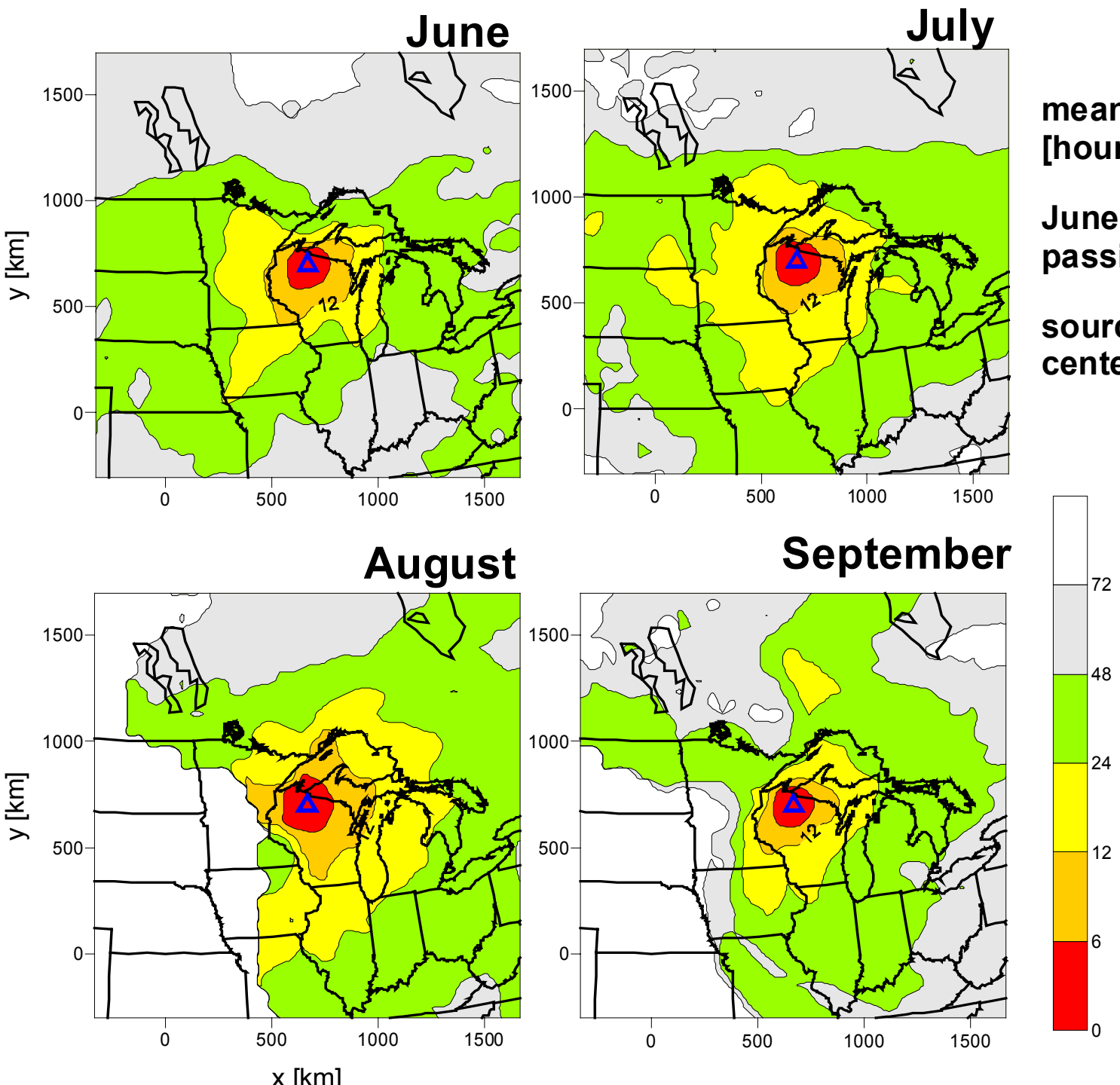
WLEF source plume climatology



concentration / flux
[m^{-3} s x 10^{-10}]

June-September 2000
passive tracer

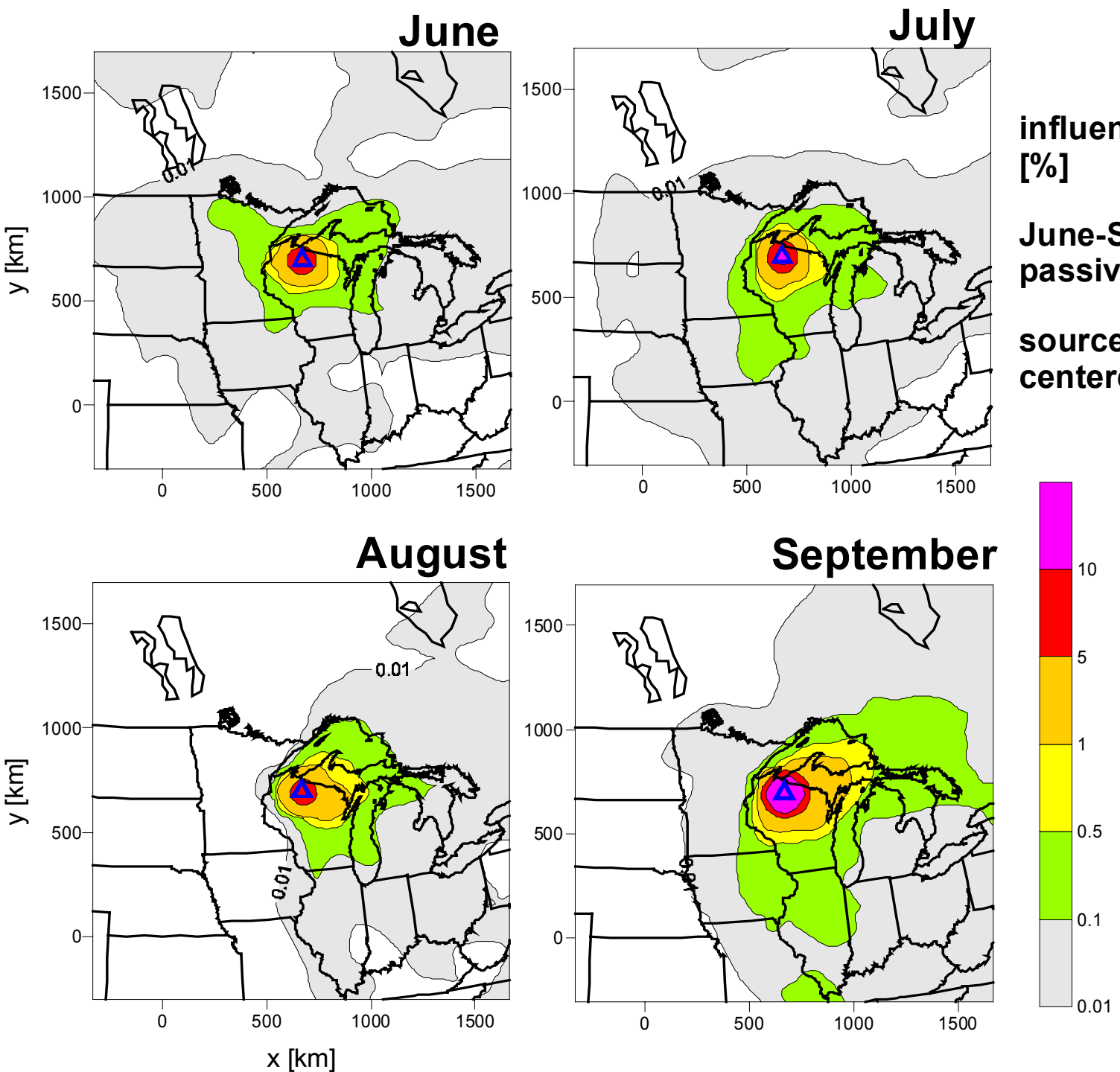
source: 100x100km
centered at WLEF



mean travel time [hours]

June-September 2000 passive tracer

source: 100x100km centered at WLEF



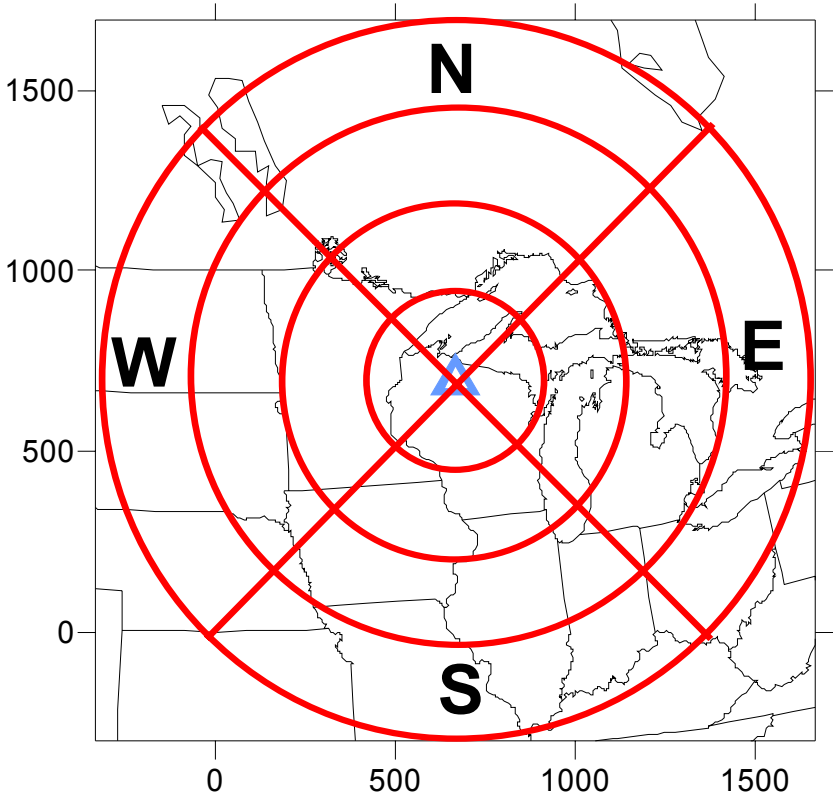
influence frequency [%]

June-September 2000 passive tracer

source: 100x100km centered at WLEF

Regional inversions

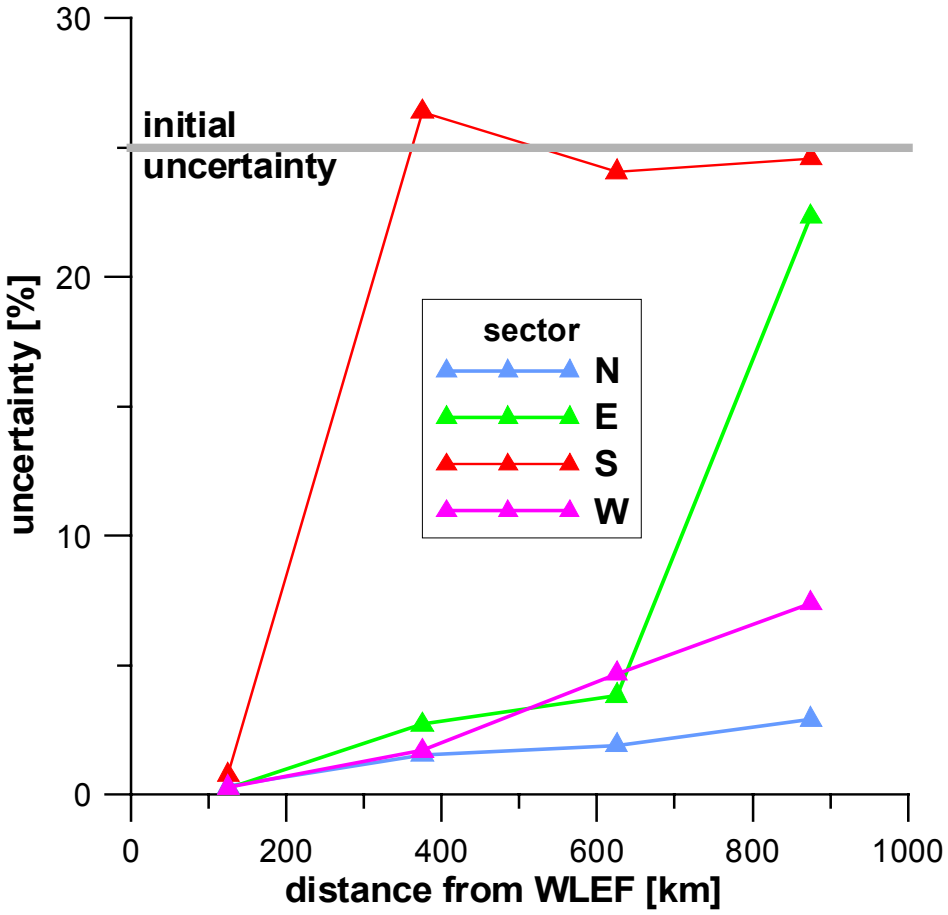
Regional inversions



Separate estimation of
A(PAR), R(T), FF

- Bayesian inversion technique
- source areas defined in polar coordinates centered at the WLEF tower
  - a better coverage by atmospheric transport
- [RAMS->LPD] long term simulations
  - derivation of influence functions for concentration samples
- data: concentration time series from the WLEF tower and additional towers
- CO_2 flux decomposed into respiration and assimilation fluxes:
  $R=R_0$ f(soil temperature, vegetation class)
  $A=A_0$ f(shortwave radiation, vegetation class)
- CO_2 **inflow** fluxes from a **larger scale model**
  - a priori estimations to be improved in in version calculations

Example of regional inversion



- **passive tracer** with a flux constant in time
- **16 source areas in 4 sectors**
- inflow fluxes assumed to be known
- estimation of averaged flux for August 2000
- model generated data:
  concentration time series from 5 levels
  of the WLEF tower
- uncertainty=σ/flux [%]
- very accurate estimations close to the tower
- poor estimations for distant source areas
in sectors with infrequent atmospheric transport
- **less accurate results expected for the net CO_2 flux**