Convective Influence Calculations for INTEX

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Introduction

Convection plays an important role in the composition of the upper troposphere during the North American Summer. Lightning generated by convection produces NO and subsequent byproducts, and the convective motions themselves move trace constituents from lower levels well into the upper troposphere. Thus, the inhomogeneity of constituents at the surface across the continent can be reproduced in the upper troposphere by numerous convective systems in different locations.

This poster examines several upper tropospheric transects by the DC-8 during INTEX, where "upper tropospheric" is defined as altitudes above 29000 feet. The approach is to examine the convective history of air parcels sampled by the DC-8 by: (1) calculating 10 day back trajectories from a grid of parcels surrounding the transect; and (2) locating the most recent convective encounter of each back trajectory based on hourly infrared satellite imagery. A convective encounter is said to occur if the altitude of a cloud exceeds the altitude of the air parcel.

This approach has advantages and disadvantages. Its main advantage is that it uses direct observations to locate convective systems (as opposed to a model calculations). Its disadvantages are: (1) quantitative information is limited to an integrated convective exposure along a back trajectory; and (2) it will not handle situations where the convective detrainment occurs above the altitude of a parcel (a "false positive" for convective encounters). calculated).

The figures show plots of the most recent convective encounters for several of the upper tropospheric passes during INTEX. On each plot we have: (1) the flight track of the DC-8 in black; (2) the outline of the region for which back trajectories were calculated (black rectangle); (3) the colored squares indicating (by the color) the time since the most recent convection; (4) similarly colored crosses indicating the locations of the convective systems; and (5) dotted trajectories connecting the convective locations (crosses) to the parcel locations (squares). The colored diamonds indicate values of a trace constituent (usually NO) along the flight track. The middle of the color range is the deployment average for that altitude, so one can tell if there are enhancements or "dehancements" along the track. There is a brief discussion for each figure.

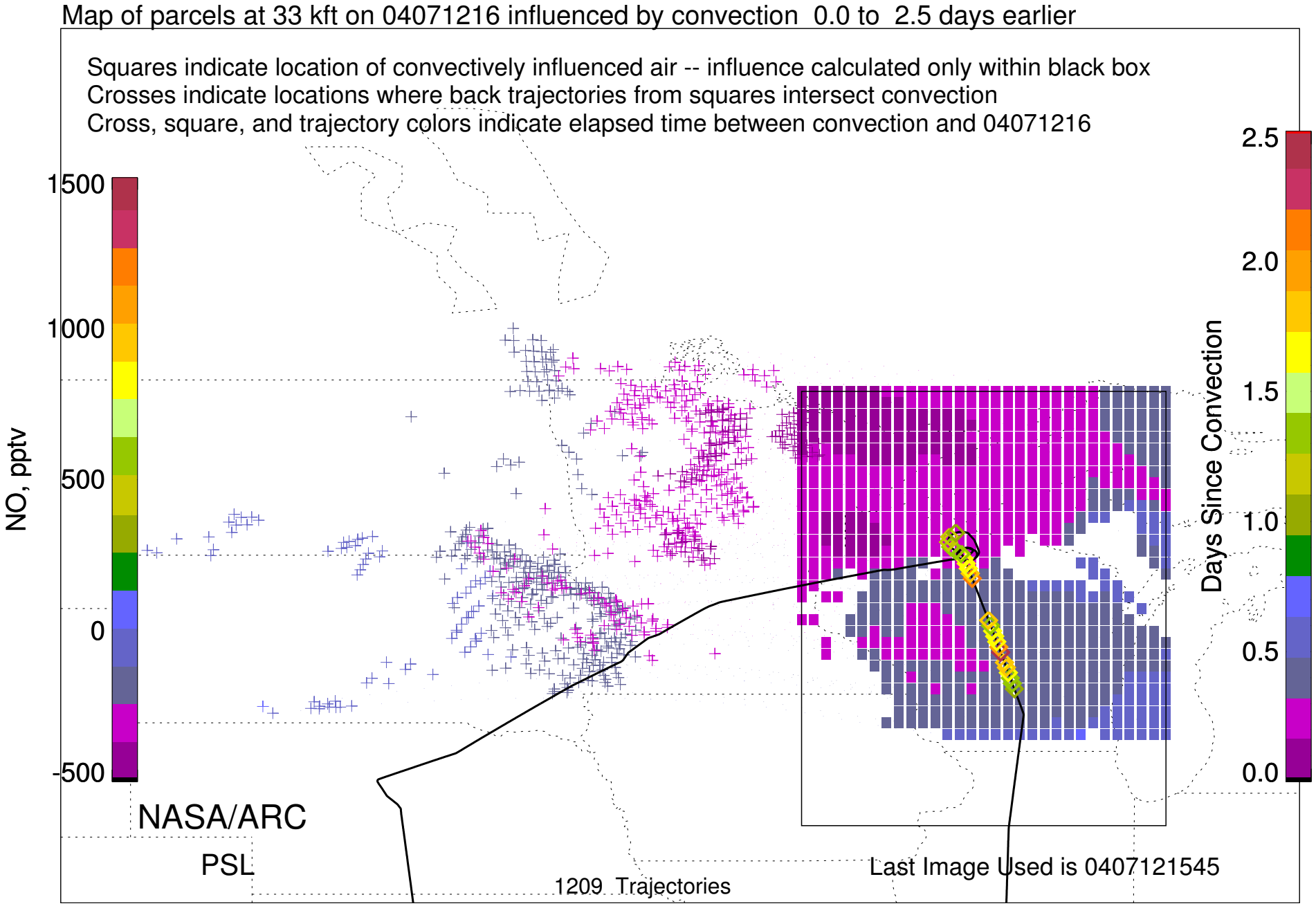
Discussion

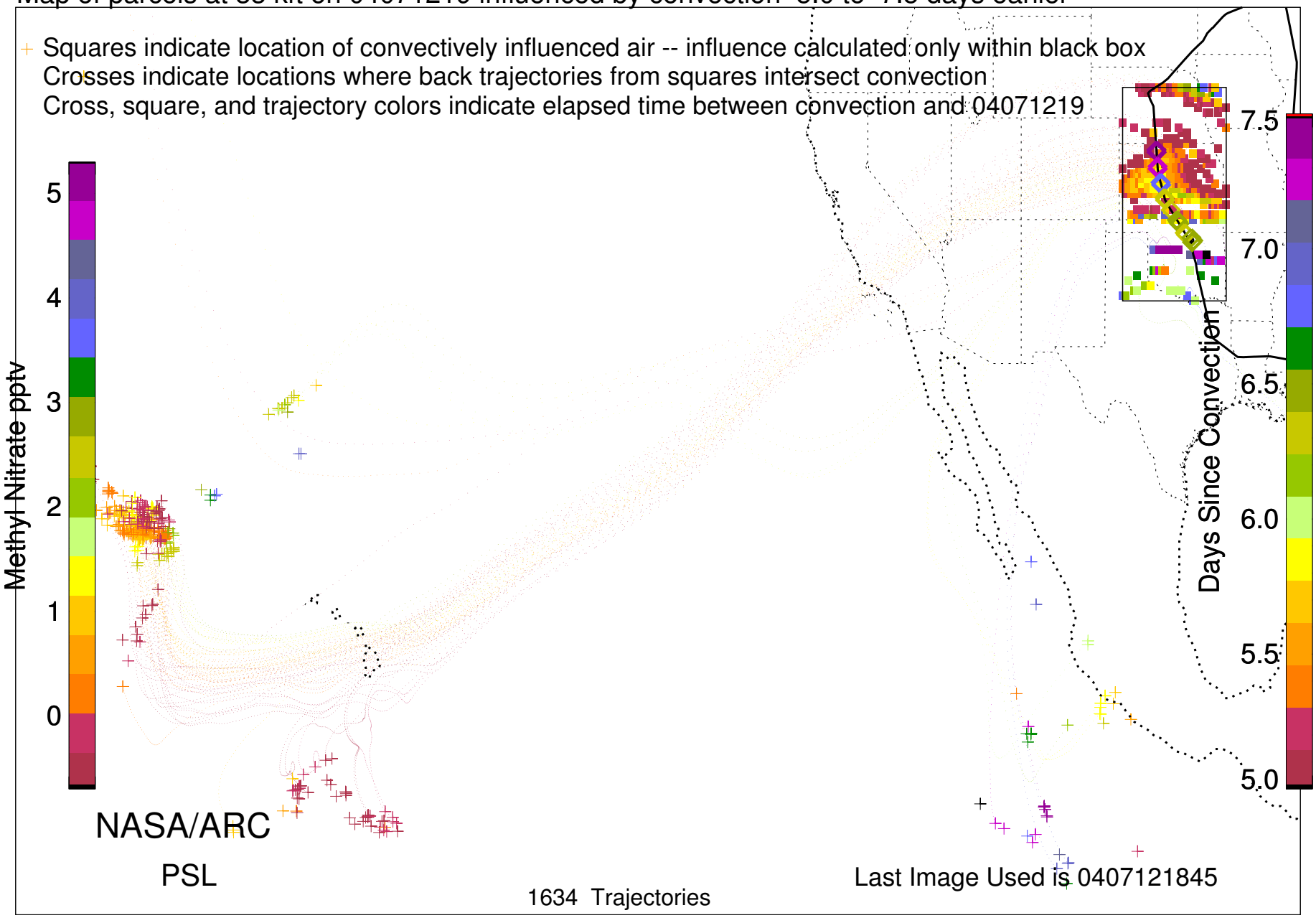
THE DISCUSSION PROCEEDS FROM THE UPPER LEFT COUNTER-CLOCKWISE AROUND THE POSTER

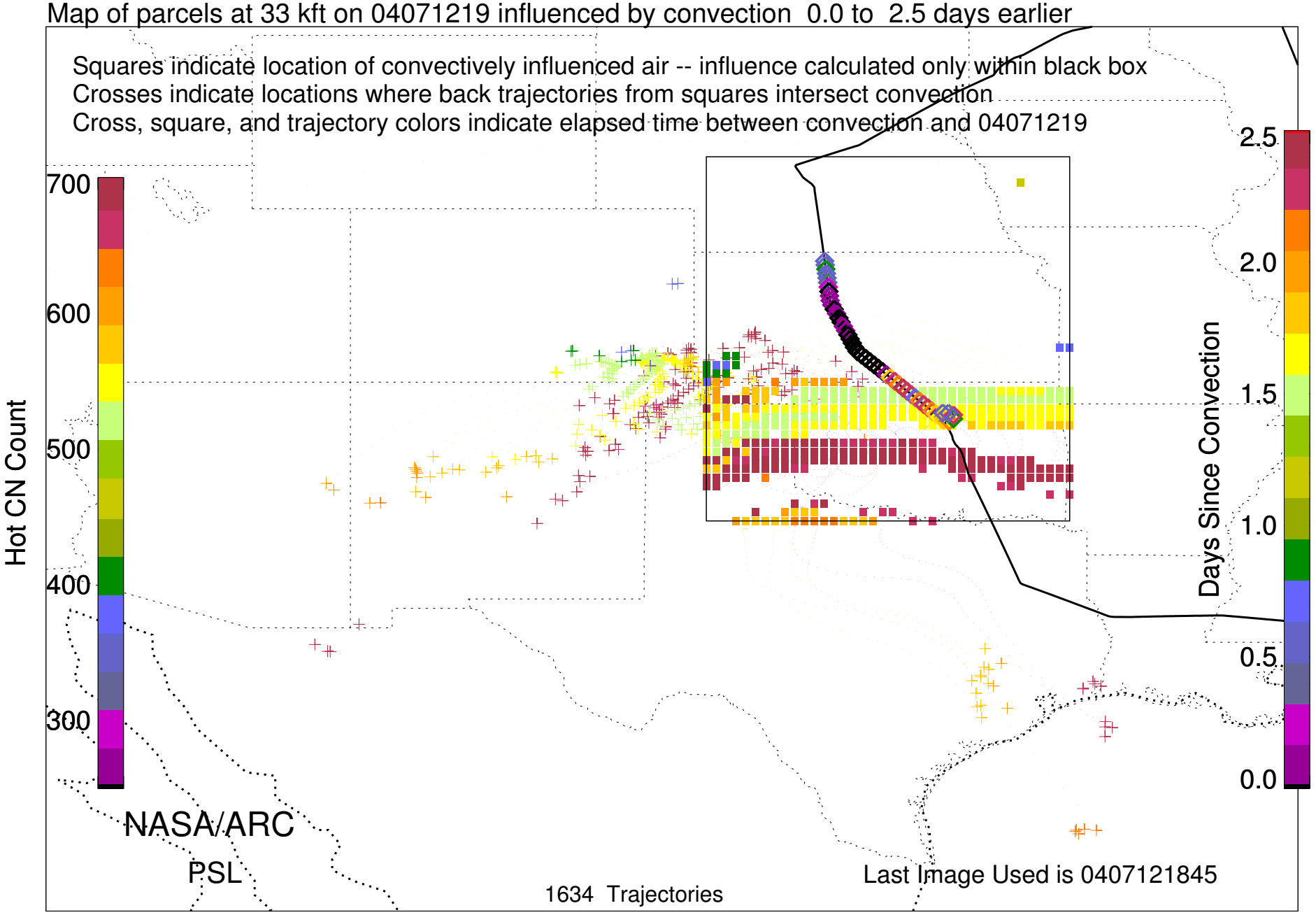
Pass at 16Z on July 12 (04071216) at 33000 feet: Calculated convective influence is dominated by systems occurring a half day or less before the time of observation (essentially the previous night – this region does have a nighttime max in convection during the summer). The systems' locations are indicated by the crosses. Air from these two systems is advected eastward into the region of observation. Data shows NO enhanced above its deployment mean of 500pptv at 33000 feet. Formaldehyde (200-600 pptv) and NOx/NOy (.6-.85) are also elevated above their mean values at this altitude. Heated CN is depressed. The diagnostic seems to explain this pass reasonably well.

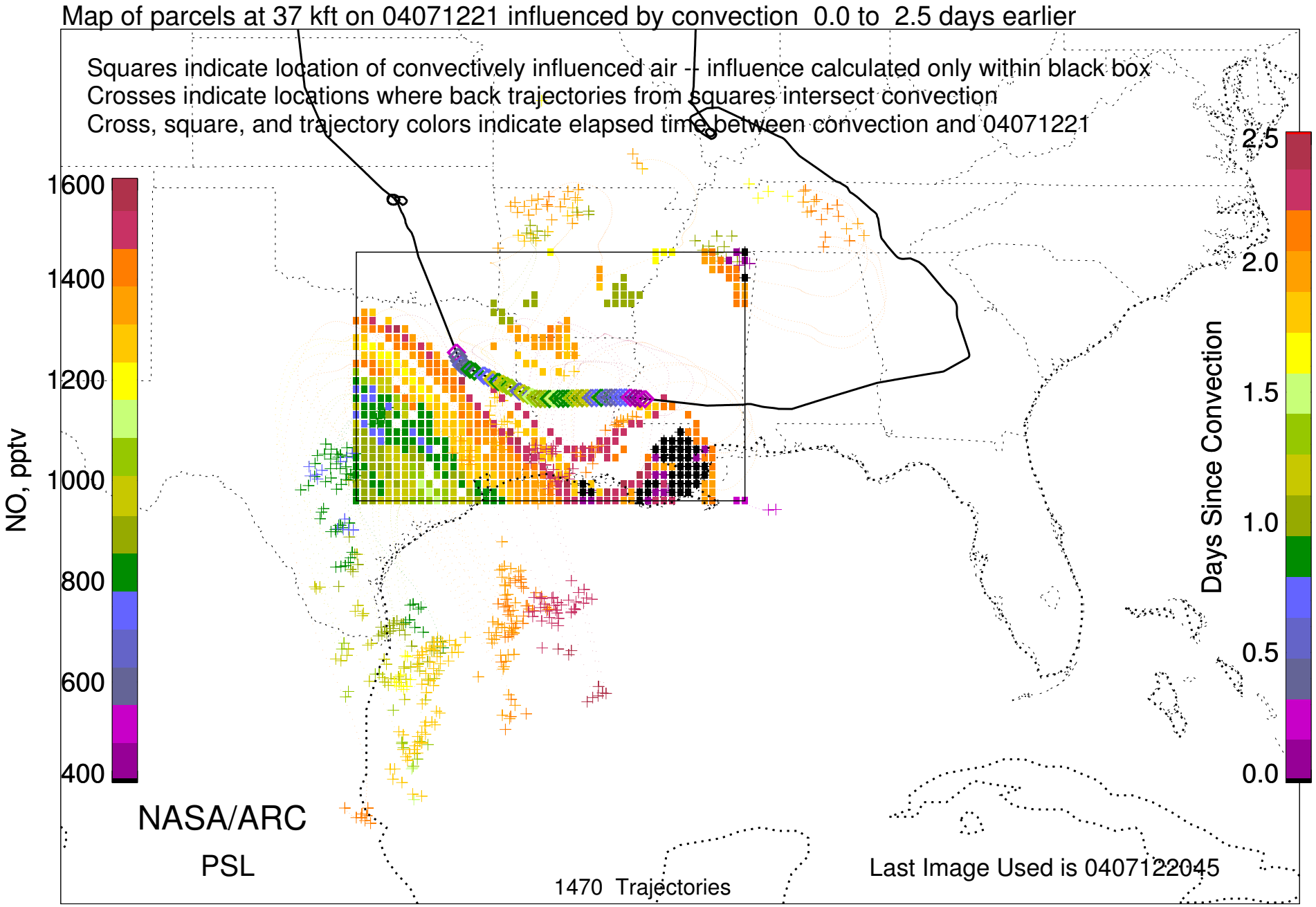
Pass at 19Z on July 12 (04071219) at 33000 and 35000 feet (two figures): Parcels in the northern section of this pass have not encountered convection for 5-6 days, and that convection is out in the Pacific. Ozone and CO are quite low(about 35 and 75 ppbv respectively) and methyl nitrate (plotted) is enhanced. The southern portion is more complex. Particularly at 35000 feet, formaldehyde and heated CN (plotted) are enhanced, coinciding with the region influenced by convection over Kansas and New Mexico about 1.5 days old. NO is marginally enhanced. In the middle of the 33000 foot portion (where there is no recent convective influence), ozone and CO jump, but heated CN do not and NO is of only average value. Ask the presenter for more discussion.

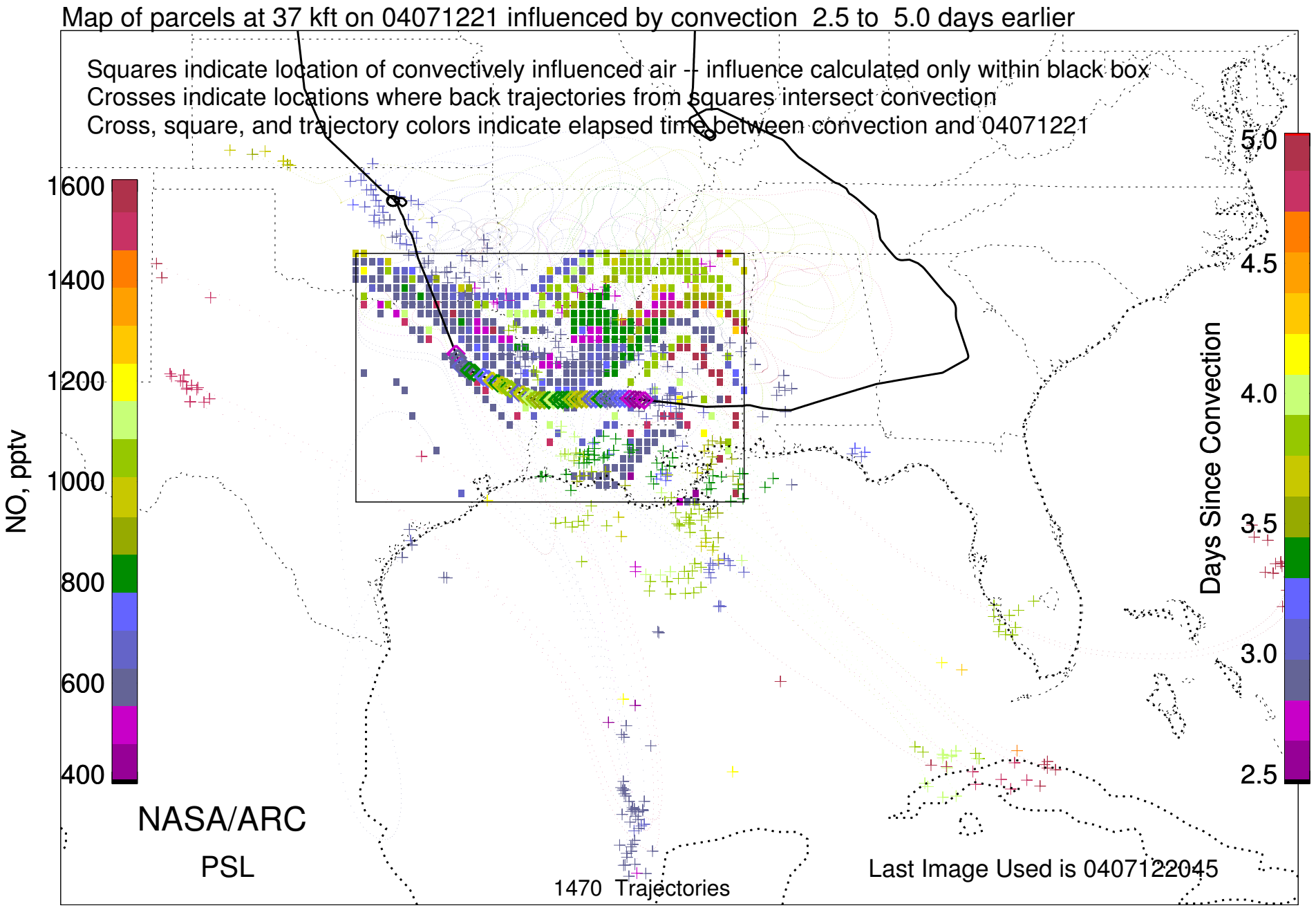
Pass at 21Z on July 12 (04071221) at 35000 and (mostly) 37000 feet (two figures):Based on the trajectory calculations, the aircraft is marginally north of air parcels influenced by Gulf convection about 2 days old and marginally south of the major portion of continental convective influence about 3 days old. NO is about average value for this altitude, and ozone is high. There are some interesting fluctuations in heated CN, with a big spike early in the pass, low values for about half the pass, jumping to high values in the latter half of the pass. The diagnosis of no substantial recent convective influence seems reasonably consistent with the observations.


Map of parcels at 33 kft on 04071216 influenced by convection 0.0 to 2.5 days earlier
Squares indicate location of convectively influenced air -- influence calculated only within black box
Crosses indicate locations where back trajectories from squares intersect convection
Cross, square, and trajectory colors indicate elapsed time between convection and 04071216
NO, pptv
1500
1000
500
0
-500
Days Since Convection
2.5
2.0
1.5
1.0
0.5
0.0
NASA/ARC
PSL
1209 Trajectories
Last Image Used is 0407121545


Map of parcels at 33 kft on 04071219 influenced by convection 5.0 to 7.5 days earlier
Squares indicate location of convectively influenced air -- influence calculated only within black box
Crosses indicate locations where back trajectories from squares intersect convection
Cross, square, and trajectory colors indicate elapsed time between convection and 04071219
Methyl Nitrate pptv
5
4
3
2
1
0
Days Since Convection
7.5
7.0
6.5
6.0
5.5
5.0
NASA/ARC
PSL
1634 Trajectories
Last Image Used is 0407121845


Map of parcels at 33 kft on 04071219 influenced by convection 0.0 to 2.5 days earlier
Squares indicate location of convectively influenced air -- influence calculated only within black box
Crosses indicate locations where back trajectories from squares intersect convection
Cross, square, and trajectory colors indicate elapsed time between convection and 04071219
Hot CN Count
700
600
500
400
300
Days Since Convection
2.5
2.0
1.5
1.0
0.5
0.0
NASA/ARC
PSL
1634 Trajectories
Last Image Used is 0407121845


Map of parcels at 37 kft on 04071221 influenced by convection 0.0 to 2.5 days earlier
Squares indicate location of convectively influenced air -- influence calculated only within black box
Crosses indicate locations where back trajectories from squares intersect convection
Cross, square, and trajectory colors indicate elapsed time between convection and 04071221
NO, pptv
1600
1400
1200
1000
800
600
400
Days Since Convection
2.5
2.0
1.5
1.0
0.5
0.0
NASA/ARC
PSL
1470 Trajectories
Last Image Used is 0407122045


Map of parcels at 37 kft on 04071221 influenced by convection 2.5 to 5.0 days earlier
Squares indicate location of convectively influenced air -- influence calculated only within black box
Crosses indicate locations where back trajectories from squares intersect convection
Cross, square, and trajectory colors indicate elapsed time between convection and 04071221
NO, pptv
1600
1400
1200
1000
800
600
400
Days Since Convection
5.0
4.5
4.0
3.5
3.0
2.5
NASA/ARC
PSL
1470 Trajectories
Last Image Used is 0407122045

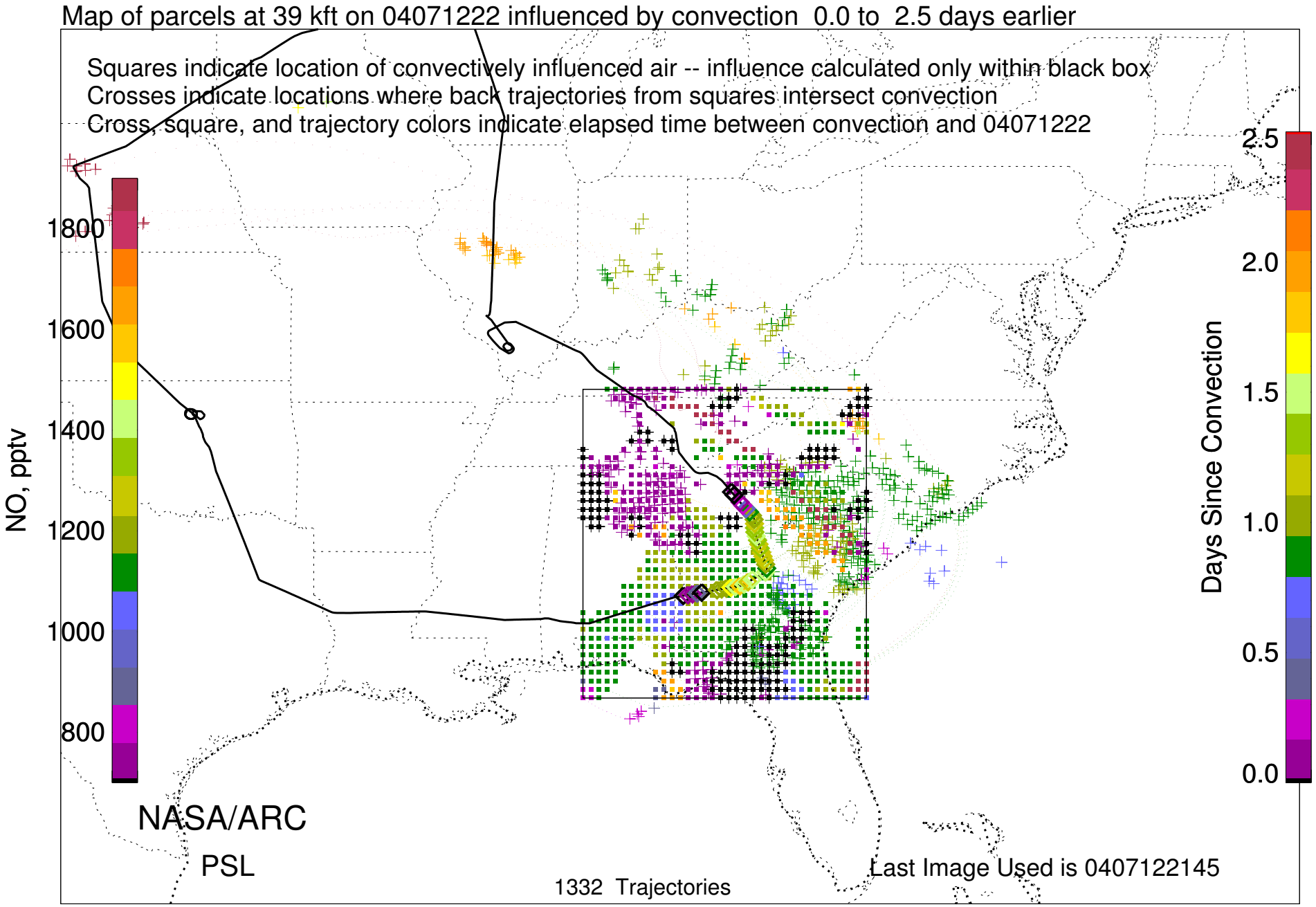
Discussion (continued)

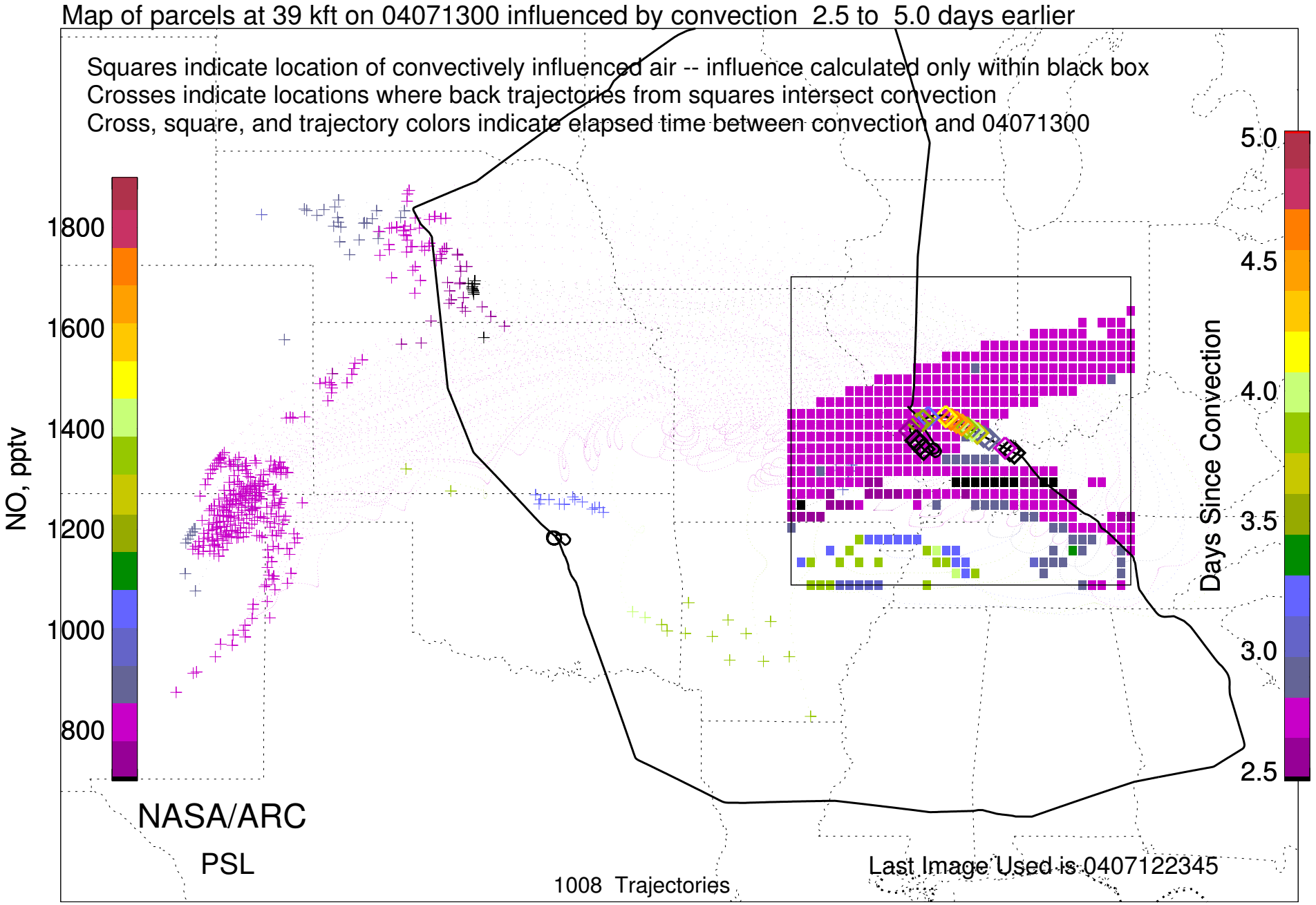
Pass at 22Z on July 12 (04071222) at 39000 feet: Convective influence from a south Carolina system occurring about a day before observation time is present in the first part of this pass. There is marginally more NO in this first section than the second section, and values are slightly elevated above average for this altitude. Formaldehyde ranges from 190 to 400 pptv, and there is a jump to 700 pptv on the ascent at about 34000 feet. It appears that the recent convection may be contributing to, but not dominating, the air mass on this pass.

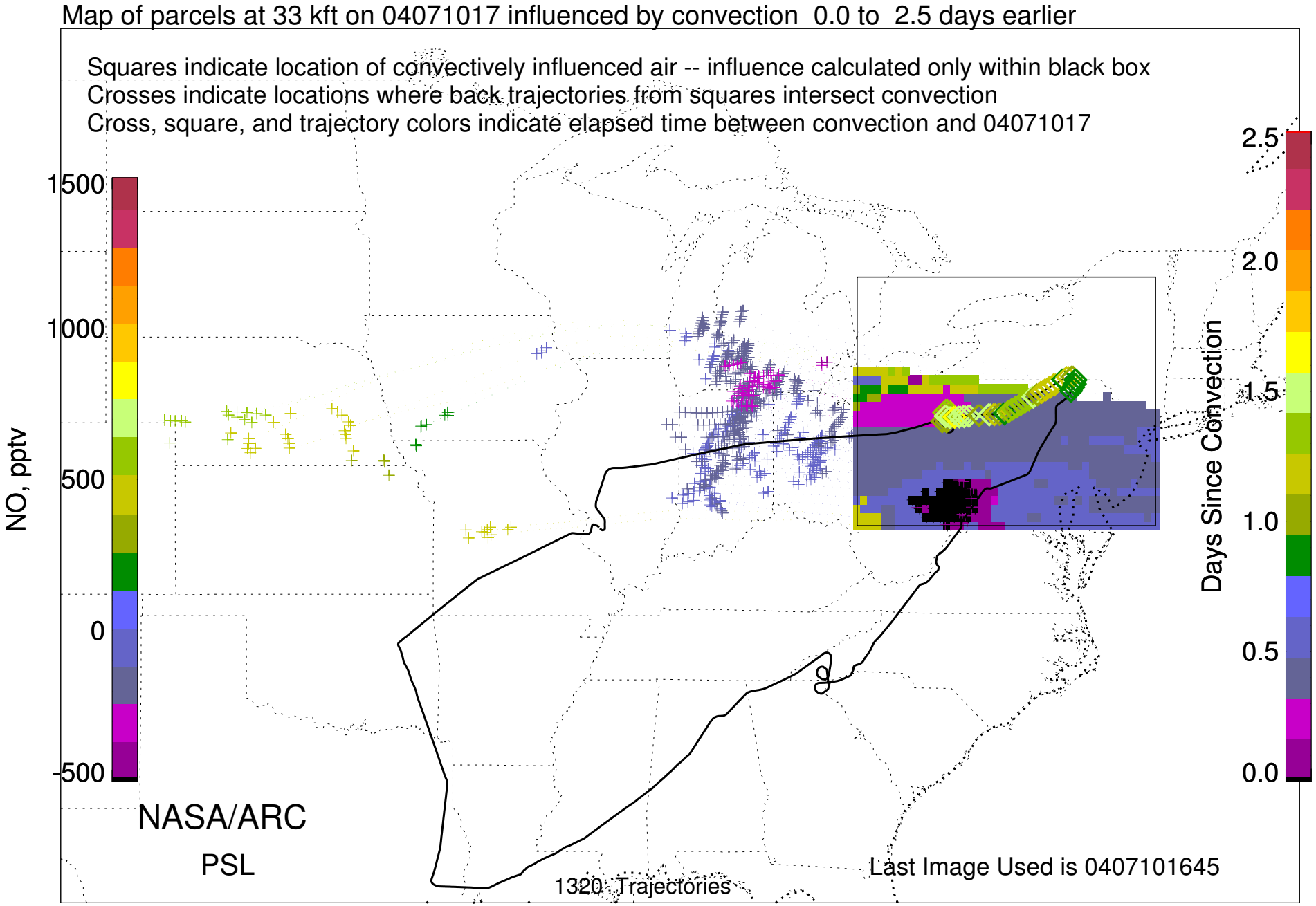
Pass at 0Z on July 13 (04071300) at 39000 feet (tail end of July 12 flight: Significant enhancements in NO over the mean for this altitude are found on this pass, and it does coincide with the location of enhanced convective influence from a system over northeastern New Mexico.

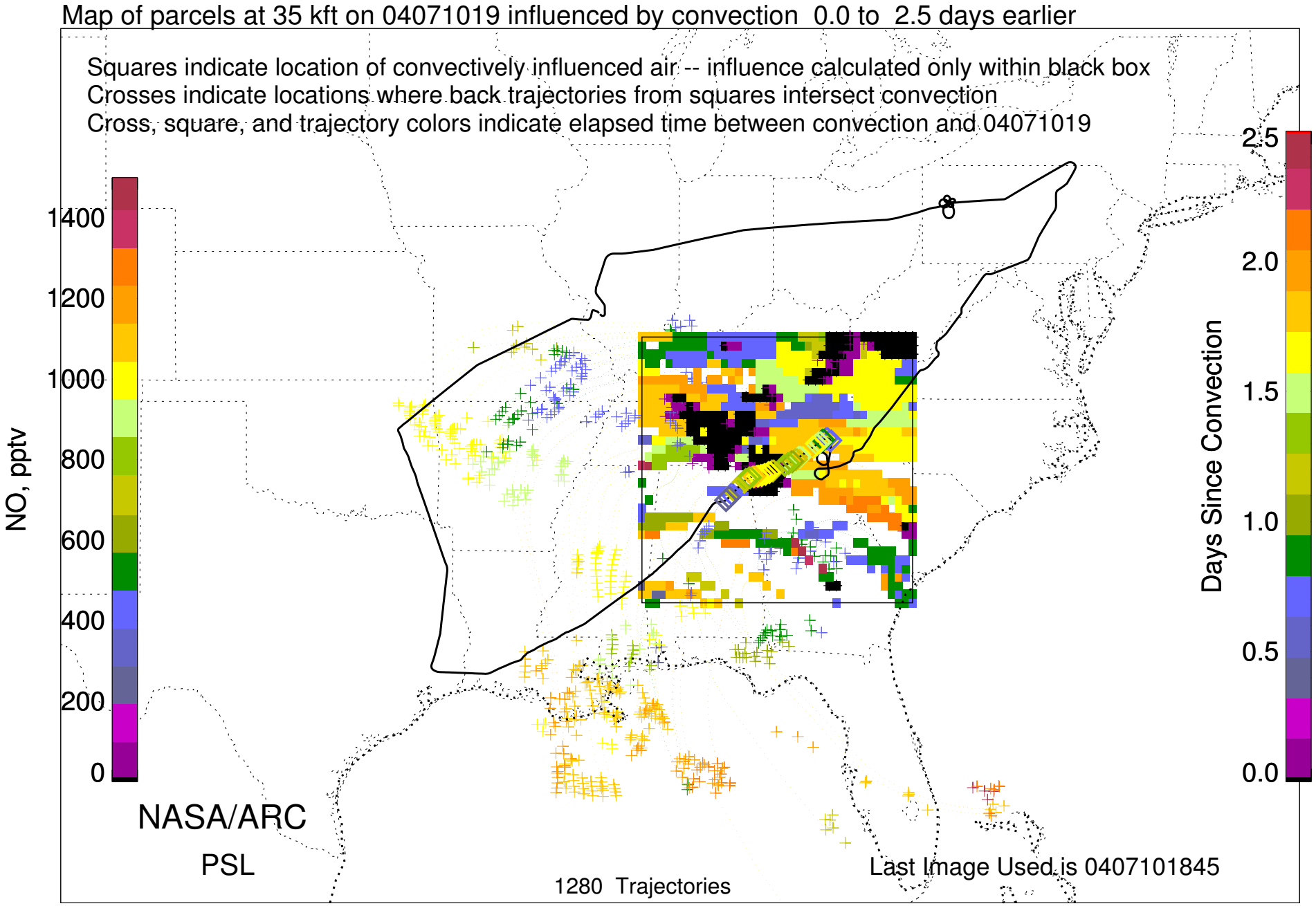
Pass at 17Z on July 10 (04071017) at 33000 feet: Calculations suggests that a large system over Indiana the previous night (and, to a lesser extent an even larger system over Nebraska about 1-1.5 days old) have extensively influenced the air along the flight track. Yet, NO is only marginally enhanced. The NOx/NOy ratio is also about average for this altitude. Methyl Iodide (!) is about double the mean value for this altitude. This may be one of those cases where the convection has detrained above the altitude of the sampled parcels.

Pass at 19Z on July 10 (04071019) at 35000 feet: The calculated picture indicates influence from two-day old convection from the Gulf of Mexico in the first half of the pass, and passage near a cloud on the second half. There are some enhancements over the average of NO that correspond to these two areas of influence. The ratio of NOx to NOy is also slightly enhanced. Methyl Iodide is enhanced relative to the average (but most prominently at the boundary between the two areas of influence and between the two areas of enhanced NO). Formaldehyde is also enhanced in the same spot. Heated CN are low in the area of Gulf influence.


Map of parcels at 39 kft on 04071222 influenced by convection 0.0 to 2.5 days earlier
Squares indicate location of convectively influenced air -- influence calculated only within black box
Crosses indicate locations where back trajectories from squares intersect convection
Cross, square, and trajectory colors indicate elapsed time between convection and 04071222
NO, pptv
1800
1600
1400
1200
1000
800
Days Since Convection
2.5
2.0
1.5
1.0
0.5
0.0
NASA/ARC
PSL
1332 Trajectories
Last Image Used is 0407122145


Map of parcels at 39 kft on 04071300 influenced by convection 2.5 to 5.0 days earlier
Squares indicate location of convectively influenced air -- influence calculated only within black box
Crosses indicate locations where back trajectories from squares intersect convection
Cross, square, and trajectory colors indicate elapsed time between convection and 04071300
NO, pptv
1800
1600
1400
1200
1000
800
Days Since Convection
5.0
4.5
4.0
3.5
3.0
2.5
NASA/ARC
PSL
1008 Trajectories
Last Image Used is 0407122345


Map of parcels at 33 kft on 04071017 influenced by convection 0.0 to 2.5 days earlier
Squares indicate location of convectively influenced air -- influence calculated only within black box
Crosses indicate locations where back trajectories from squares intersect convection
Cross, square, and trajectory colors indicate elapsed time between convection and 04071017
NO, pptv
1500
1000
500
0
-500
Days Since Convection
2.5
2.0
1.5
1.0
0.5
0.0
NASA/ARC
PSL
1320 Trajectories
Last Image Used is 0407101645

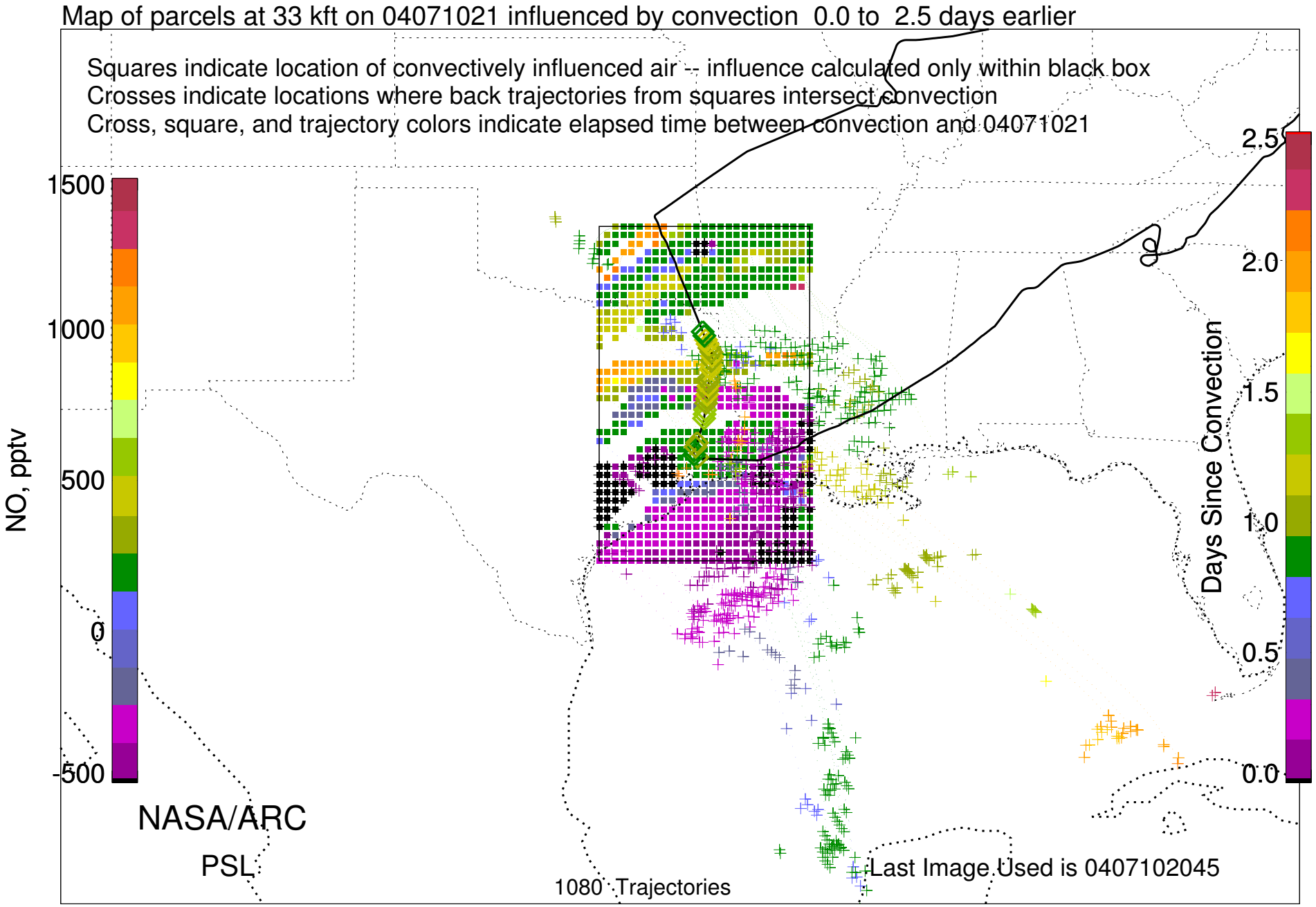

Map of parcels at 35 kft on 04071019 influenced by convection 0.0 to 2.5 days earlier
Squares indicate location of convectively influenced air -- influence calculated only within black box
Crosses indicate locations where back trajectories from squares intersect convection
Cross, square, and trajectory colors indicate elapsed time between convection and 04071019
NO, pptv
1400
1200
1000
800
600
400
200
0
Days Since Convection
2.5
2.0
1.5
1.0
0.5
0.0
NASA/ARC
PSL
1280 Trajectories
Last Image Used is 0407101845

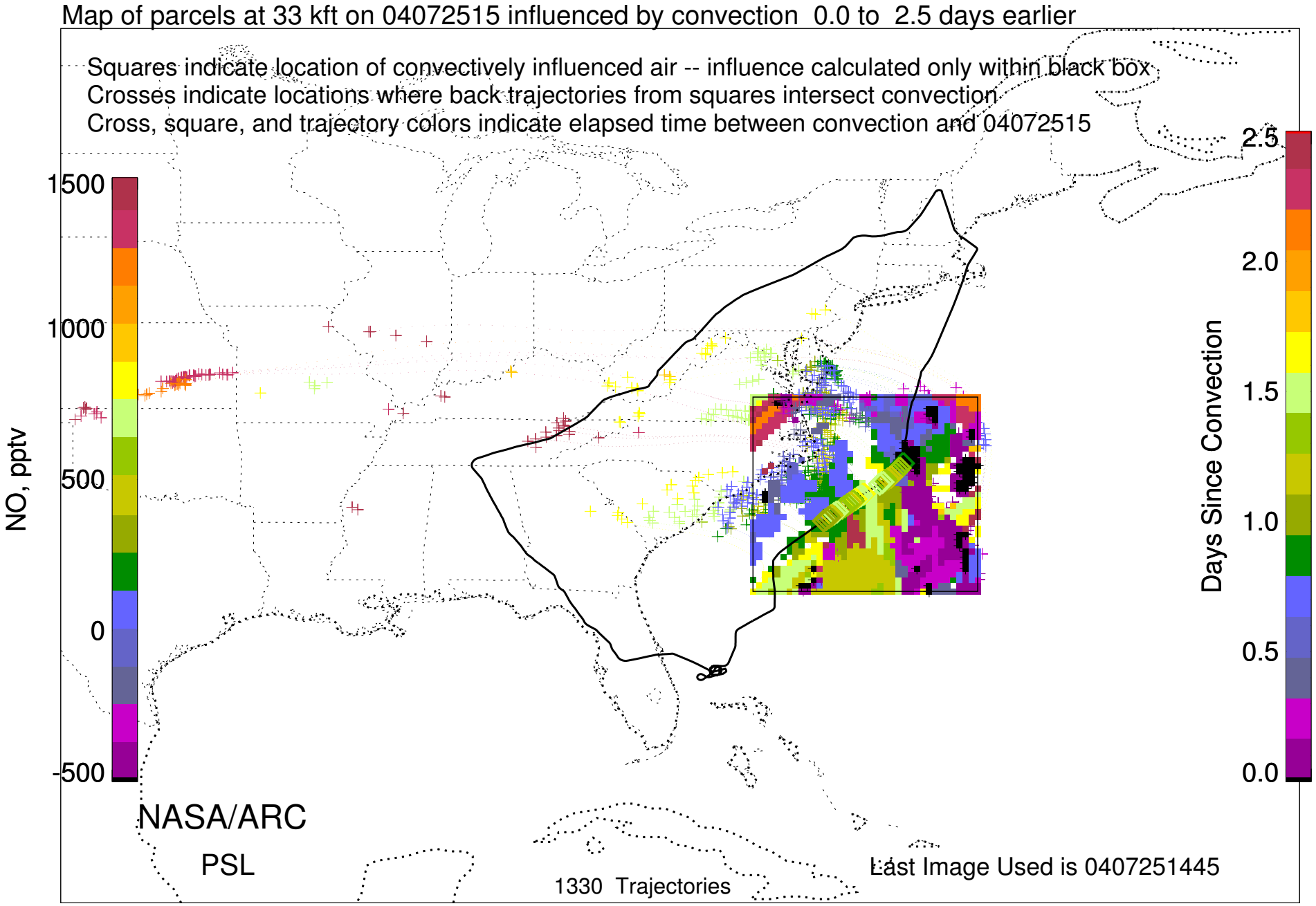
Discussion (continued)

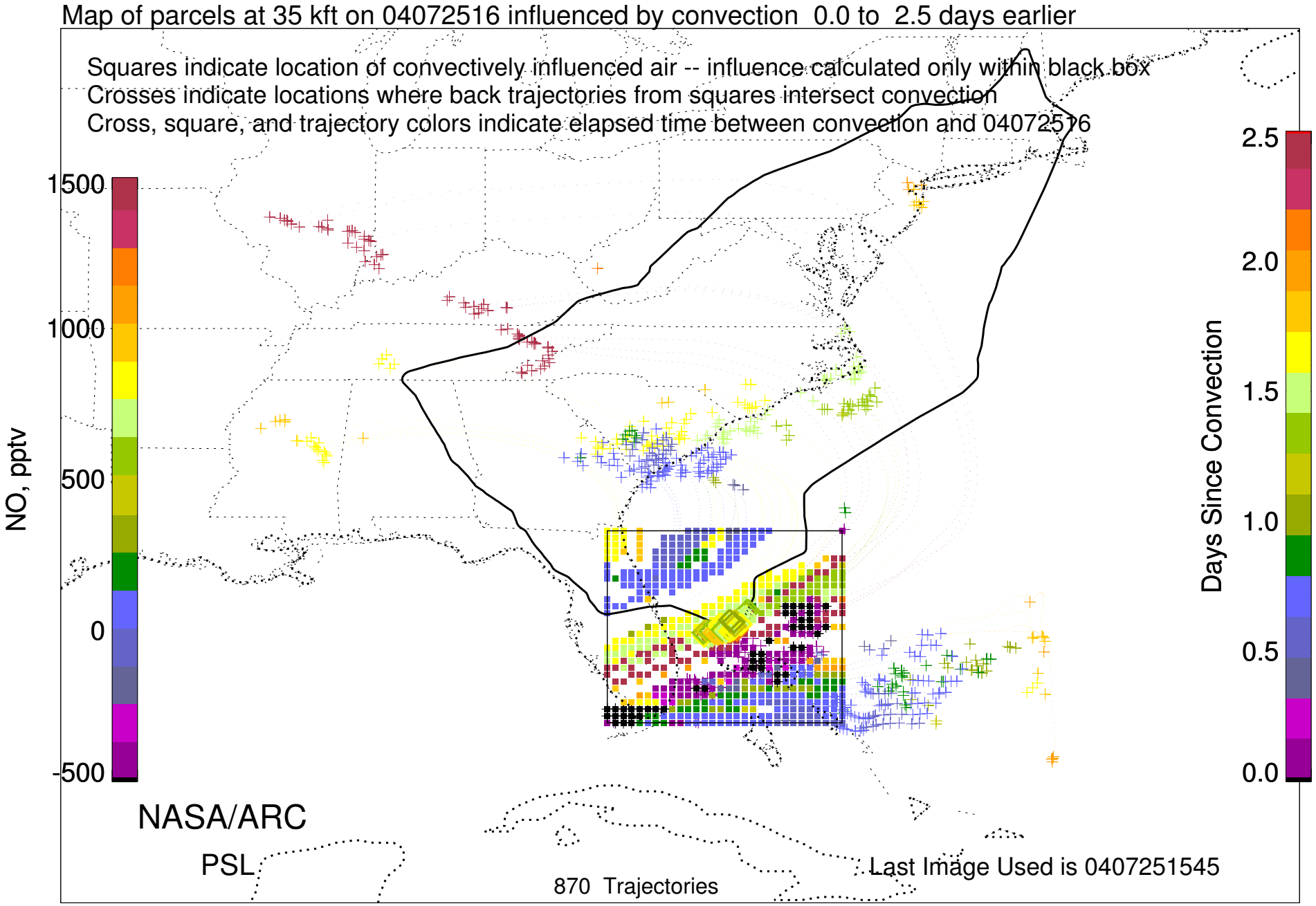
Pass at 21Z on July 10 (04071021) at 33000 feet: Calculations show a region in the middle of the pass that is influenced by convection near the Gulf coast and convection over Louisiana. This is bracketed by regions of no recent (0-2.5 day) influence. The data suggest below average or average values of the convective indicators (NO, NOx/NOy, heated CN, formaldehyde). The implication is that the clouds at these low latitudes are detraining at altitudes above the aircraft (33000 feet).

Pass at 15Z on July 25 (04072515) at 33000 feet: The diagnostic shows that the flight track is near the boundary between air influenced by coastal convection (North Carolina and Virginia coasts) and convection in inland Virginia about 1 day old. NO is elevated (max value of 800 pptv vs average of 500 pptv for this altitude), and NOx/NOy is average. Heated CN jumps up to double the altitude average value of 300 in spots. No other convective indicators are remarkable.

Pass at 16Z on July 25 (04072516) at 35000 feet: The convective influence calculation suggests that air masses detrained by convective systems over Tennessee/Kentucky (red 2.5 days old), the Carolinas (yellow, 1.6 days old), and the North Carolina coast (green, 1-1.5 days old) have been elongated and strung next to each other by the anticyclonic flow near the DC-8's level spiral survey. There may be some issues with exhaust sampling on this leg (?). NO shows some significant enhancements (up to 1200 pptv vs an altitude average of 750 pptv). Heated CN is generally slightly above altitude average, with some excursions to double the altitude average. Methyl Iodide also has some excursions to well above average values. The NOx/NOy ratio is about average.


Map of parcels at 33 kft on 04071021 influenced by convection 0.0 to 2.5 days earlier
Squares indicate location of convectively influenced air -- influence calculated only within black box
Crosses indicate locations where back trajectories from squares intersect convection
Cross, square, and trajectory colors indicate elapsed time between convection and 04071021
NO, pptv
1500
1000
500
0
-500
Days Since Convection
2.5
2.0
1.5
1.0
0.5
0.0
NASA/ARC
PSL
1080 Trajectories
Last Image Used is 0407102045


Map of parcels at 33 kft on 04072515 influenced by convection 0.0 to 2.5 days earlier
Squares indicate location of convectively influenced air -- influence calculated only within black box
Crosses indicate locations where back trajectories from squares intersect convection
Cross, square, and trajectory colors indicate elapsed time between convection and 04072515
NO, pptv
1500
1000
500
0
-500
Days Since Convection
2.5
2.0
1.5
1.0
0.5
0.0
NASA/ARC
PSL
1330 Trajectories
Last Image Used is 0407251445


Map of parcels at 35 kft on 04072516 influenced by convection 0.0 to 2.5 days earlier
Squares indicate location of convectively influenced air -- influence calculated only within black box
Crosses indicate locations where back trajectories from squares intersect convection
Cross, square, and trajectory colors indicate elapsed time between convection and 04072516
NO, pptv
1500
1000
500
0
-500
Days Since Convection
2.5
2.0
1.5
1.0
0.5
0.0
NASA/ARC
PSL
870 Trajectories
Last Image Used is 0407251545