THE GREEN OCEAN AMAZON EXPERIMENT (GOAMAZON2014/5) OBSERVES POLLUTION AFFECTING GASES, AEROSOLS, CLOUDS, AND RAINFALL OVER THE RAIN FOREST

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The susceptibility of air quality, weather, terrestrial ecosystems, and climate to human activities was investigated in a tropical environment.

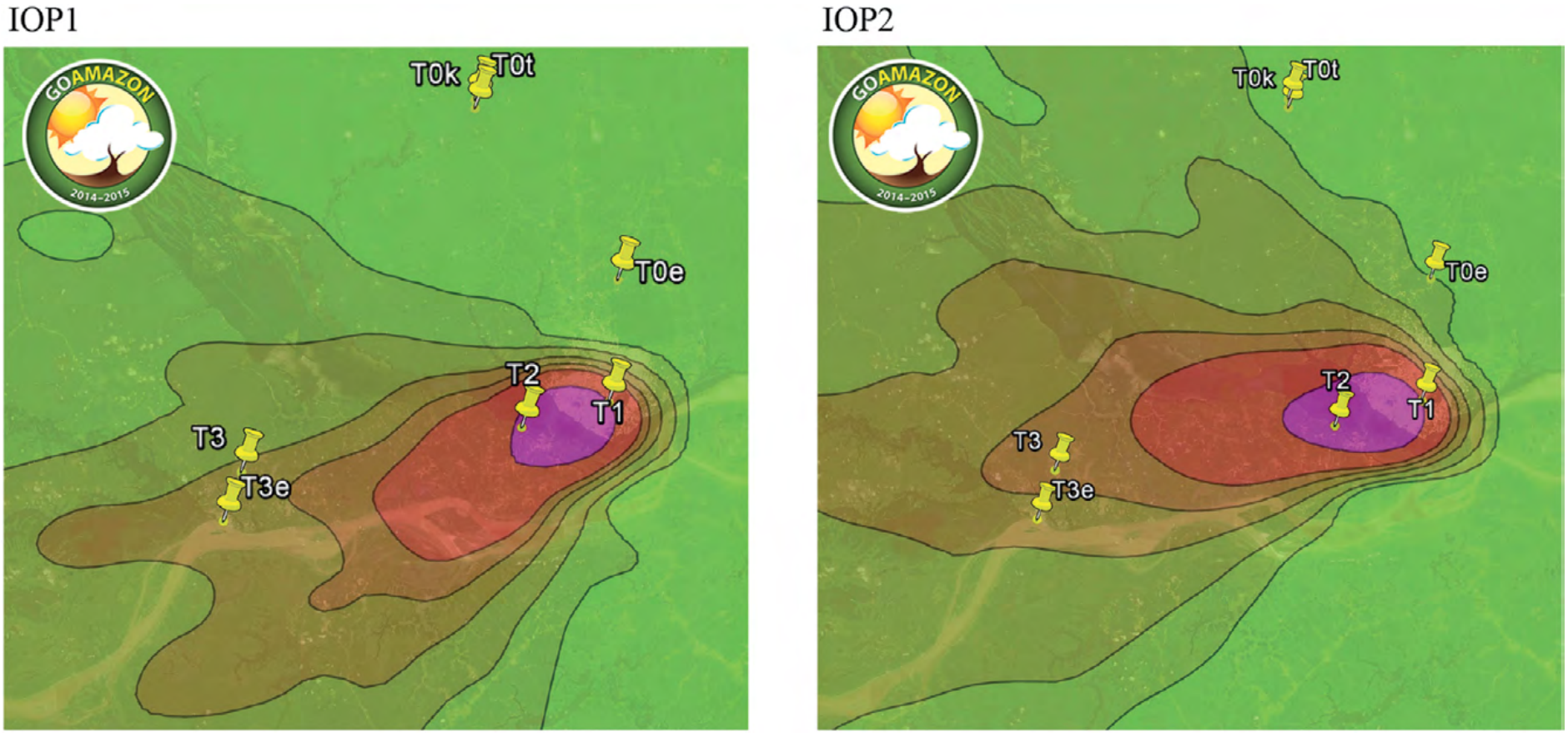
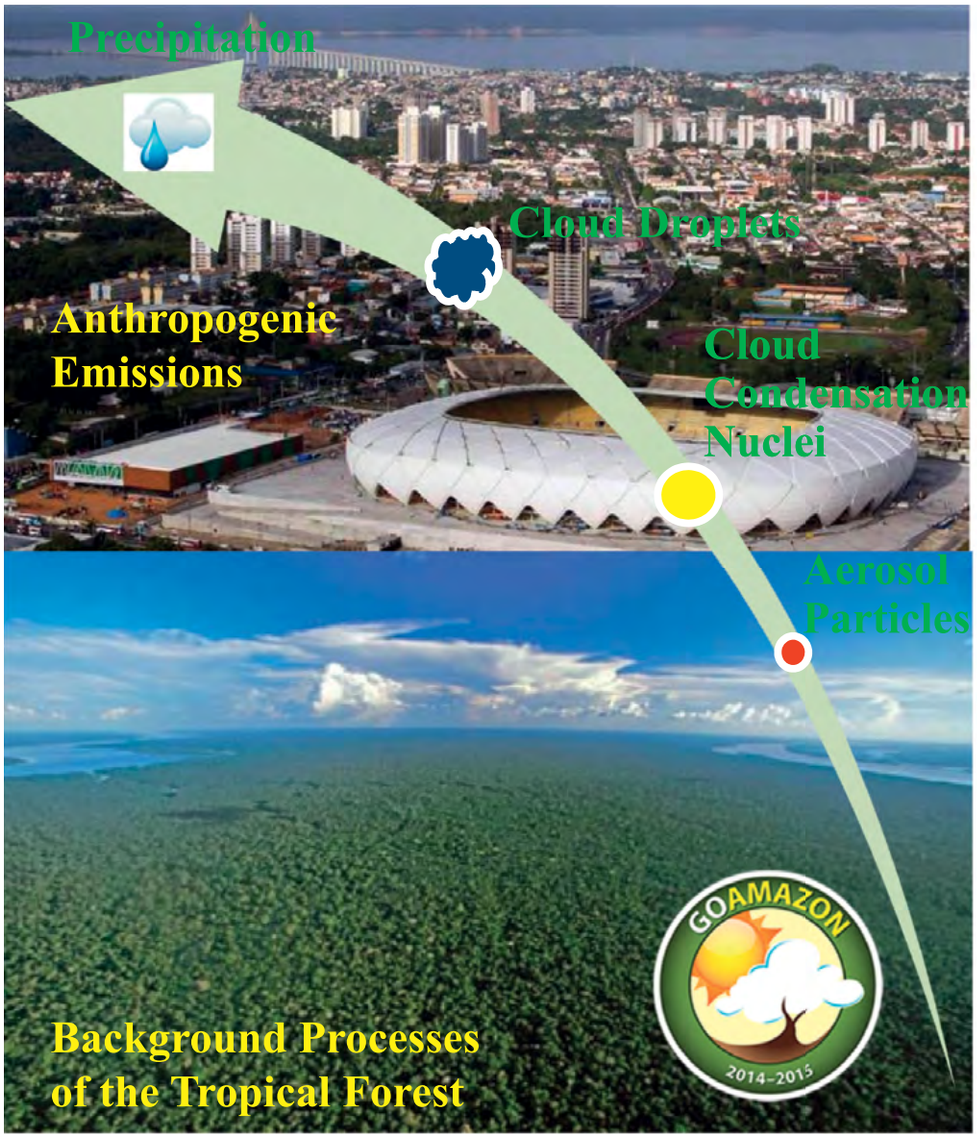


FIG. 2. Statistical composite of forward trajectories launched 500 m above site T1 in Manaus at 0000, 0600, 1200, and 1800 UTC for (left) the 59 days of IOP1 (1 Feb–31 Mar 2014) and (right) the 60 days of IOP2 (15 Aug–15 Oct 2014). Easterlies associated with trade winds normally swept the urban pollution plume westward toward the downwind research sites. The intensity of the contour coloring represents the frequency for trajectories that passed nearby the latitude–longitude position represented by the map. Contours are drawn at 2%, 5%, 10%, 15%, 20%, and 40% frequency on a grid size of 0.1° × 0.1°. Yellow pins indicate the locations of some of the GoAmazon2014/5 research sites (cf. Fig. 3). These results are produced by the Meteorologia Aplicada a



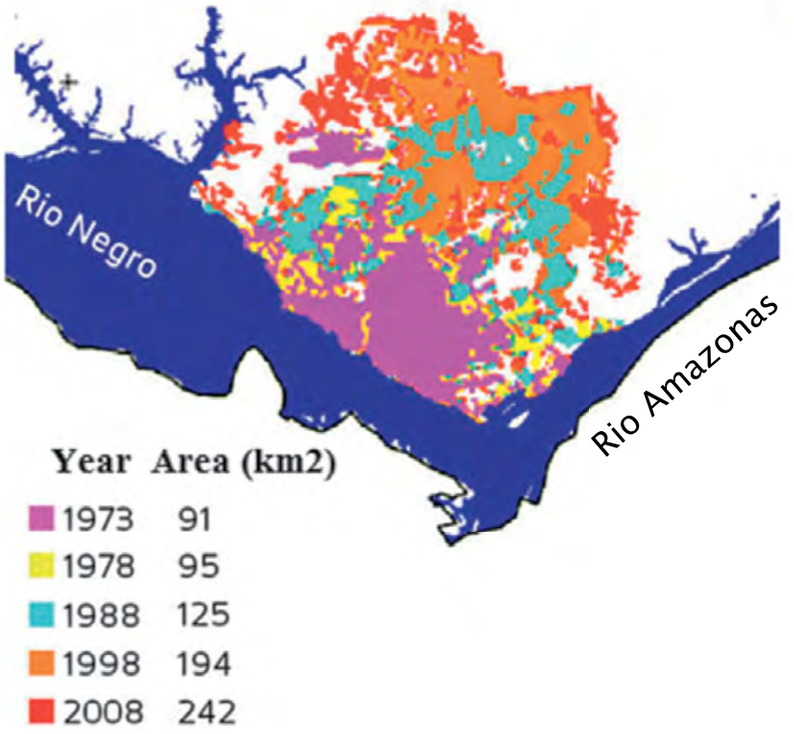
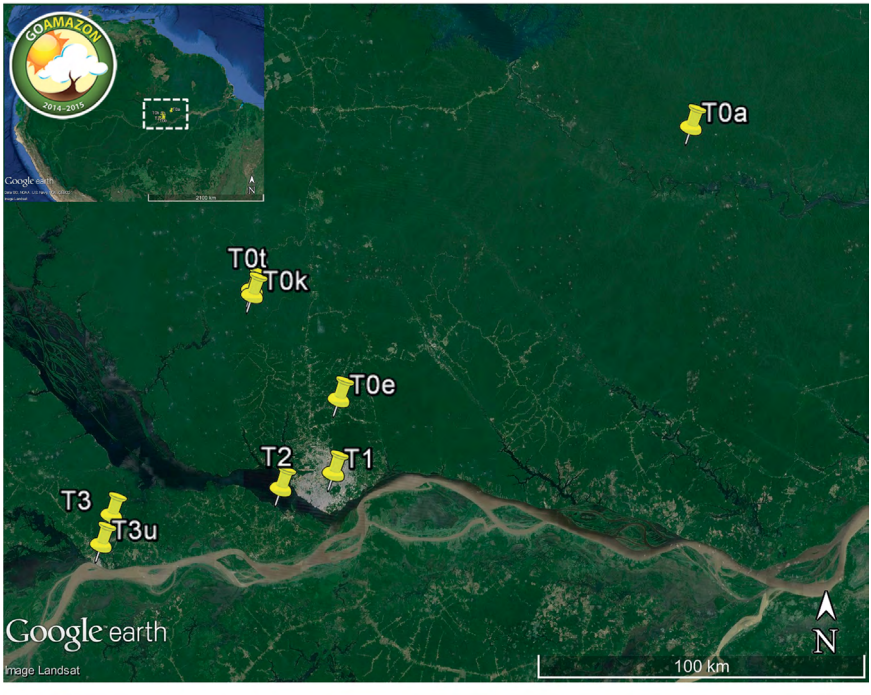
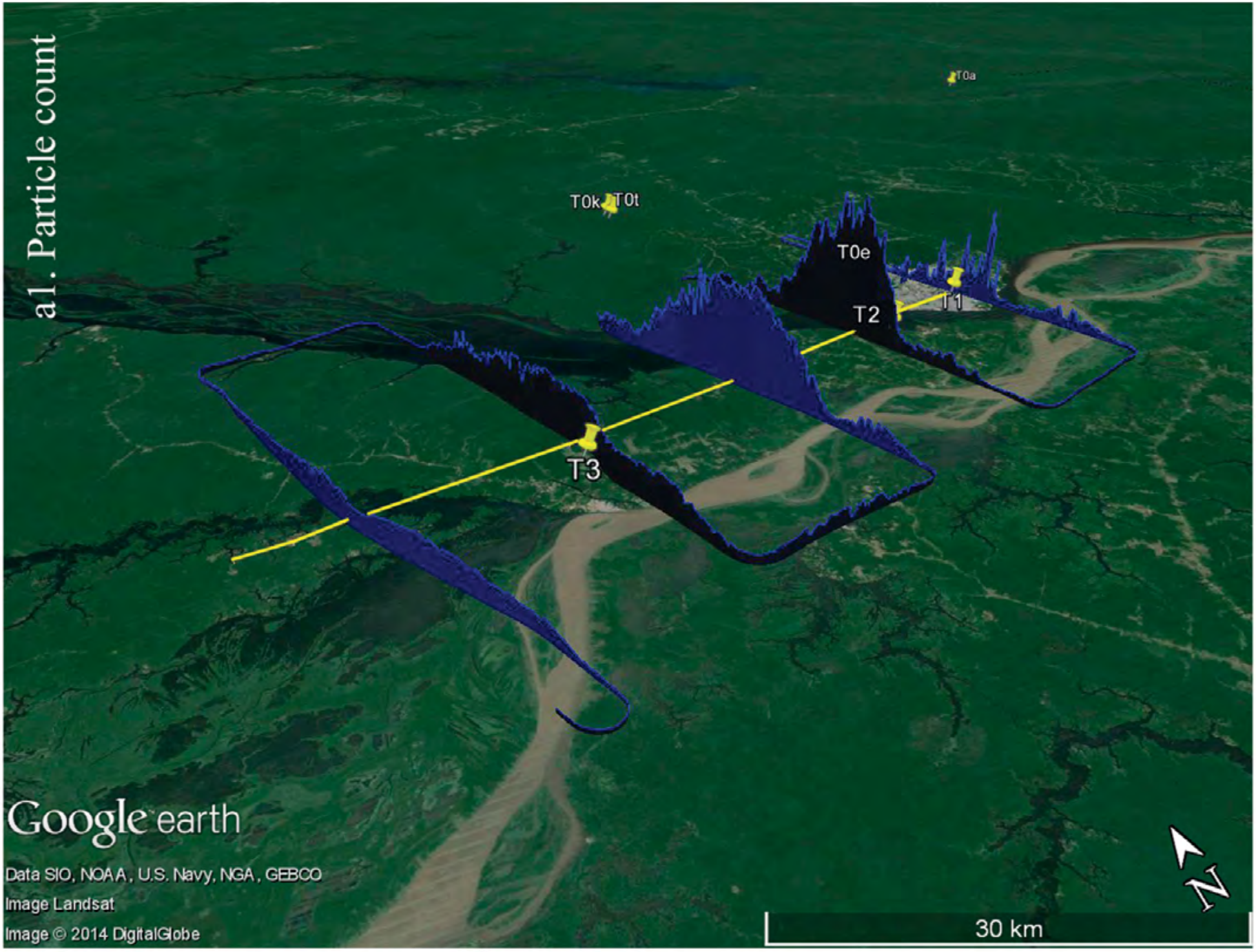


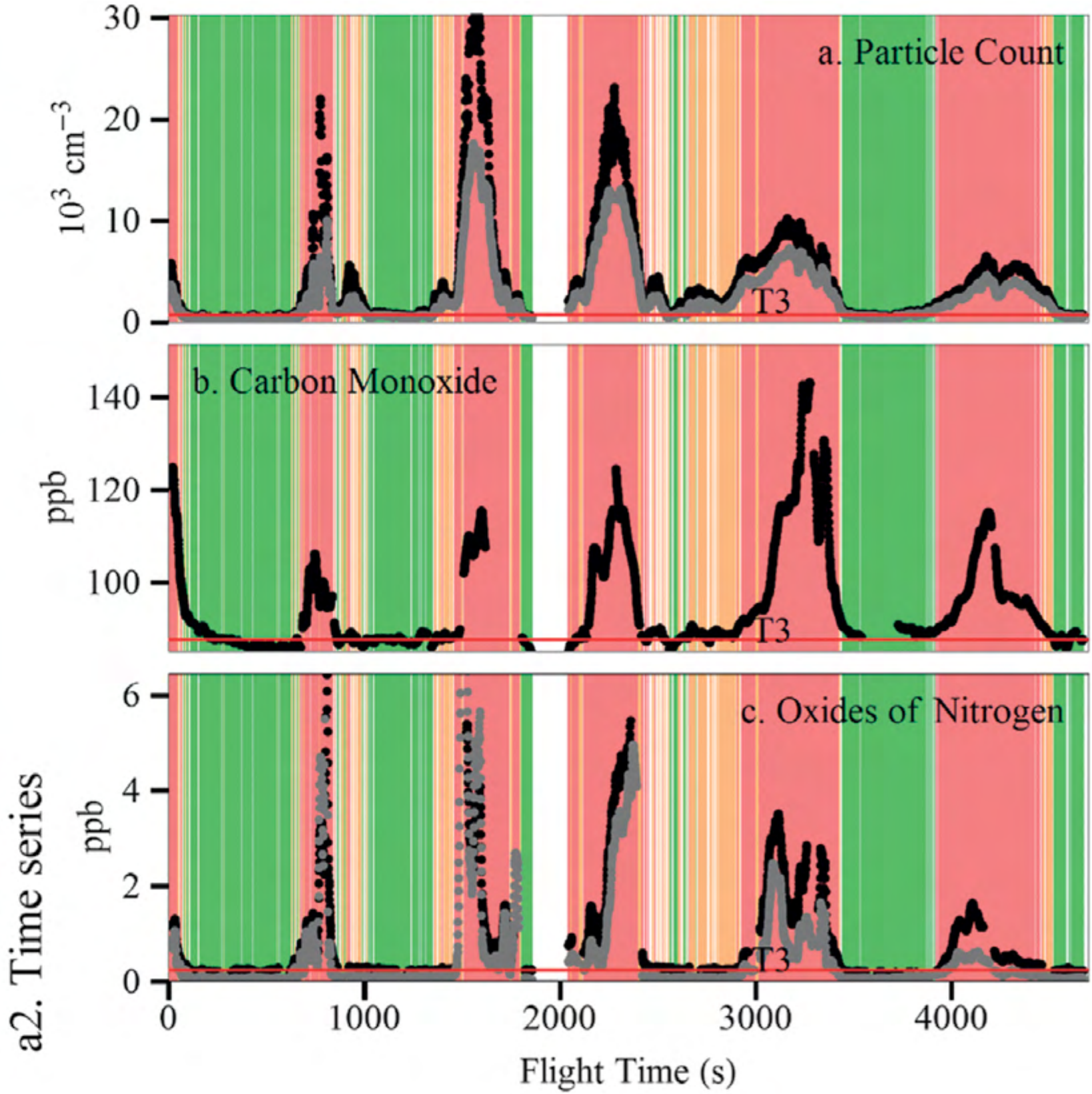
Fig. 1. The GoAmazon2014/5 experiment in concept. (left) The advection by wind of a background air mass into Manaus, emissions into this air mass while over the city, and the transformation of atmospheric species as the air mass continues downwind of the urban region. The air mass is laden with biogenic volatile organic carbon compounds (BVOC) emitted by the forest both upwind and downwind of the city. These BVOCs are transformed by the atmospheric oxidant cycle into aerosol particles. The prevailing chemical reactions are altered by pollution. The particulate matter serves as CCN. As a result, cloud properties and possibly rainfall can be modified in response to different levels of pollution over the tropical rain forest. (right) As a surrogate for scaled anthropogenic emissions, the

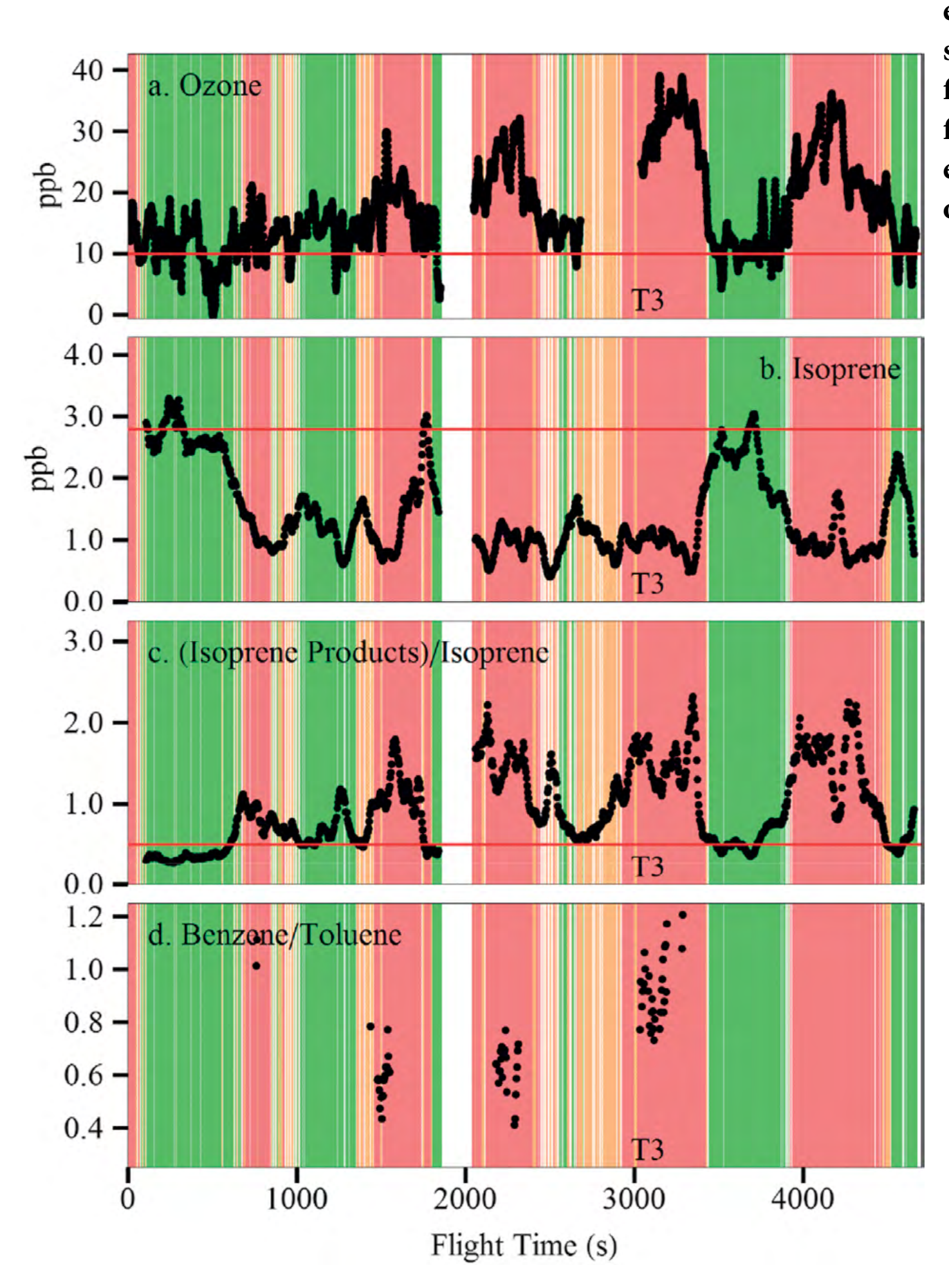

GOAMAZON
2014-2015
T0a
T0t
T0k
T0e
T2
T1
T3
T3u
Google earth
Image Landsat
100 km
N

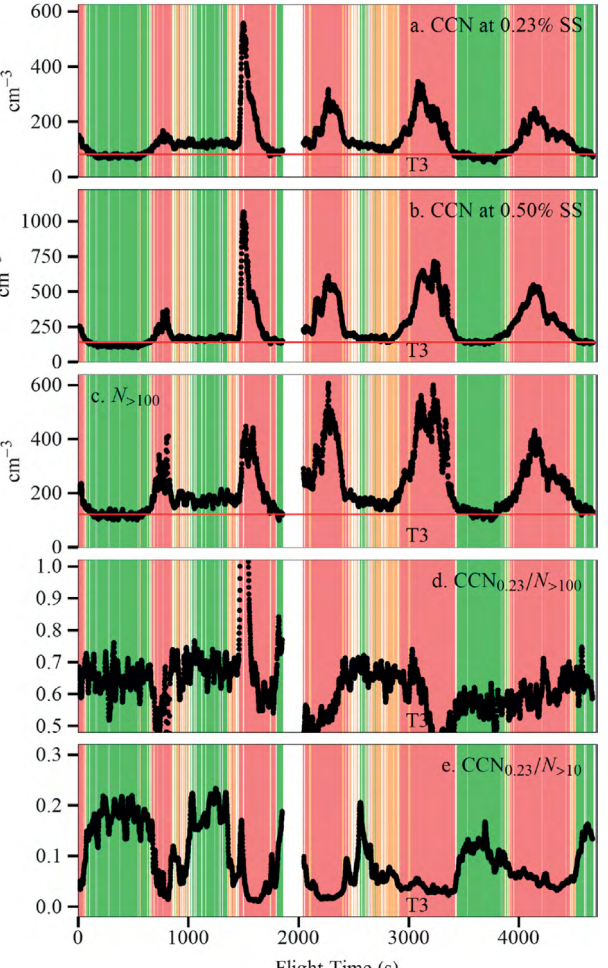
OBSERVATIONS. The organization of GoAmazon2014/5 results, as presented herein, follows the origins-to-effect sequence represented in the left panel of Fig. 1. In origin, there are natural and anthropogenic emissions of both gaseous compounds and aerosol particles (Martin et al. 2010a). In sequence, important chemical transformations occur for some of the gaseous compounds, ultimately affecting the aerosol particles because of gas-to-particle conversion processes (Martin et al. 2010b). These aerosol particles serve as cloud condensation nuclei (CCN; Poschl et al. 2010). The physicochemical properties

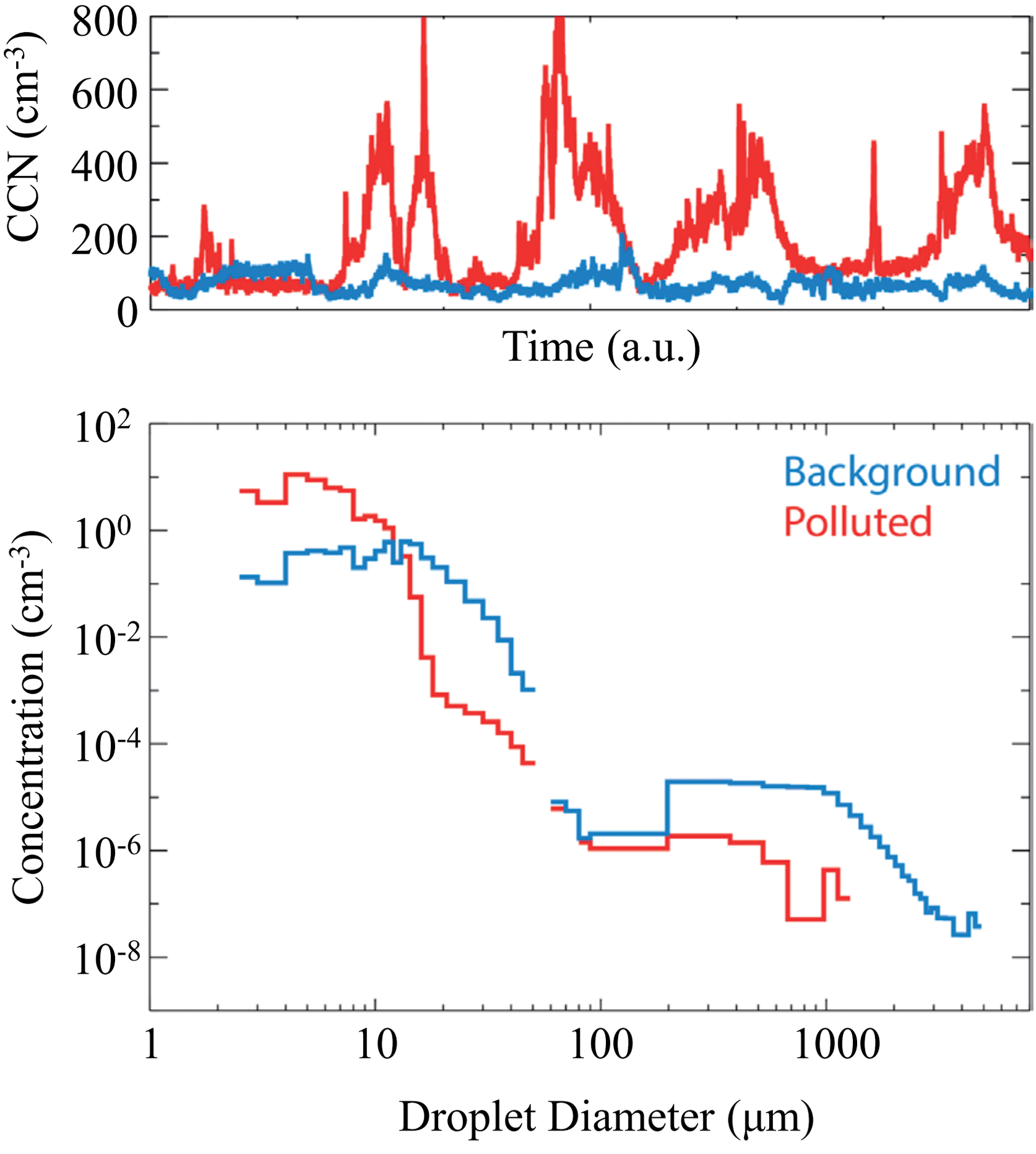
of this CCN population differ significantly between background and polluted conditions (Andreae and Rosenfeld 2008). In net effect, cloud microphysics, droplet size distributions, droplet lifetime, and rainfall can be altered by this sequence of events (Rosenfeld et al. 2008). The large arrow in Fig. 1 represents the sweep of these species and associated processes through Manaus and then westward in the prevailing direction of the urban plume across the Rio Negro (Black River). Based on measurements obtained from

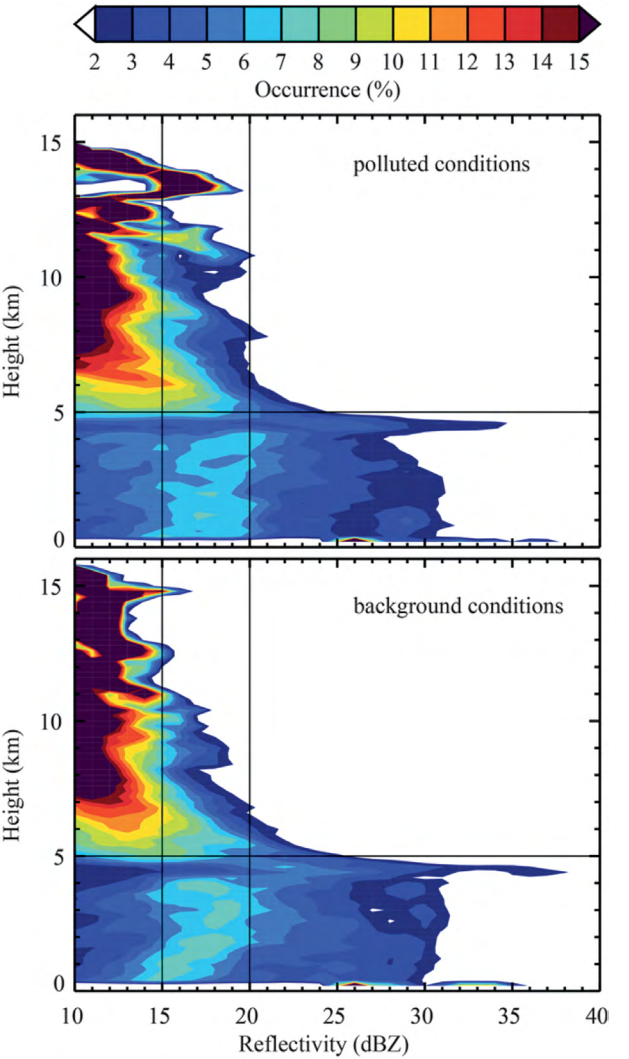

a1. Particle count
T0a
T0k
T0t
T0e
T1
T2
T3
Google earth
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image Landsat
Image © 2014 DigitalGlobe
N
30 km


a. Particle Count
10^3 cm^{-3}
30
20
10
0
T3
b. Carbon Monoxide
ppb
140
120
100
T3
c. Oxides of Nitrogen
ppb
6
4
2
0
T3
0
1000
2000
3000
4000
Flight Time (s)
a2. Time series


a. Ozone
ppb
40
30
20
10
0
T3
b. Isoprene
ppb
4.0
3.0
2.0
1.0
0.0
T3
c. (Isoprene Products)/Isoprene
3.0
2.0
1.0
0.0
T3
d. Benzene/Toluene
1.2
1.0
0.8
0.6
0.4
T3
0
1000
2000
3000
4000
Flight Time (s)


a. CCN at 0.23% SS
b. CCN at 0.50% SS
c. $N_{>100}$
d. $CCN_{0.23}/N_{>100}$
e. $CCN_{0.23}/N_{>10}$
cm^{-3}
T3
Flight Time (s)
0
1000
2000
3000
4000


800
600
400
200
0
CCN (cm-3)
Time (a.u.)
102
100
10-2
10-4
10-6
10-8
Concentration (cm-3)
Background
Polluted
1
10
100
1000
Droplet Diameter (μm)


2 3 4 5 6 7 8 9 10 11 12 13 14 15
Occurrence (%)
polluted conditions
background conditions
Height (km)
0
5
10
15
10 15 20 25 30 35 40
Reflectivity (dBZ)

human activities. At the present time, however, tropical deep convection in a natural state is poorly understood and modeled, with insufficient observational data sets for model constraint. Furthermore, future climate scenarios resulting from human activities globally show the possible drying and the eventual possible conversion of rain forest to savanna in response to global climate change. Based on our current state of knowledge, the governing conditions of this catastrophic change are not defined. Human activities locally, including the economic development activities that are growing the population and the industry within the Basin, also have the potential to shift regional climate, most immediately by an increment in aerosol number and mass concentrations, and the shift is across the range of values to which cloud properties are most sensitive. The ARM Climate Research Facility in the Amazon Basin seeks to understand aerosol and cloud life cycles, particularly the susceptibility to cloud aerosol precipitation interactions, within the Amazon Basin.

13 March 2015, de Mello Dias Machado

Observations and Modeling of the Green Ocean Amazon: LIDAR Comparison
5 October 2014, Barbosa

Observations and Modeling of the Green Ocean Amazon: Oxidation Flow Reactor 2
15 August 2014, Palm

See more (+22)

The ARM Mobile Facility will be located downwind of the city of Manaus, Brazil (3 6' 47" S, 60 1' 31" W) near Manacapuru from January 2014 to November 2015. The site is situated so that it experiences the extremes of (i) a pristine atmosphere when the Manaus pollution plume meanders and (ii) heavy pollution and the interactions of that pollution with the natural environment when the plume regularly intersects the site. The central Amazon where this site is located is only weakly influenced by biomass burning emissions in the dry season. The city of Manaus uses high-sulfur oil as its primary source of electricity; the city is also an industrial zone of 3 million people and has high emissions of soot. Particle number and mass concentrations are 10 to 100 times greater in the pollution plume compared to the times when pristine conditions prevail. The deployment will enable the study of how aerosol and cloud life cycles, including cloud-aerosol-precipitation interactions, are influenced by pollutant outflow from a tropical megacity.

ADDITIONAL INFORMATION

- GoAmazon2014/5 results appear in an interjournal Special Issue of Atmospheric Chemistry Physics (ACP), Atmospheric Measurement Techniques (AMT), Geoscientific Information (GI), and Geoscientific Model Development (GMD).
- Please find information on how to do acknowledgments, including special notes related to the Brazilian scientific licenses under which the data sets were collected.

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