ASSIMILATION OF AIR-BORNE AEROSOL MEASUREMENTS IN CENTRAL BRAZIL DURING THE 2007 BURNING SEASON USING THE REGIONAL CCATT-BRAMS MODEL

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INTRODUCTION

In Central Brazil every year large areas of forest, cerrado and pasture land are burned emitting primary carbonaceous aerosols and trace gases into the atmosphere. **Figure 1** shows schematically some of the effects of the aerosols released. During the South American burning season, aerosols have a significant impact on local and regional air quality affecting visibility and human health by particle inhalation causing pulmonary diseases. An improvement of the aerosol representation in atmospheric chemistry models can be achieved through data assimilation methods including available aerosol observations. In this study an assimilation system was used (Hoelzemann et al., 2010) based on the three dimensional variational data assimilation method (3D-VAR) of the Rhenish Institute for Environmental Research (RIU) / University of Cologne, Germany (Elbern and Strunk, 2005), coupled to the Coupled Chemical Aerosol-Tracer Transport – Brazilian Regional Modeling System (CCATT-BRAMS) (Freitas et al, 2009).

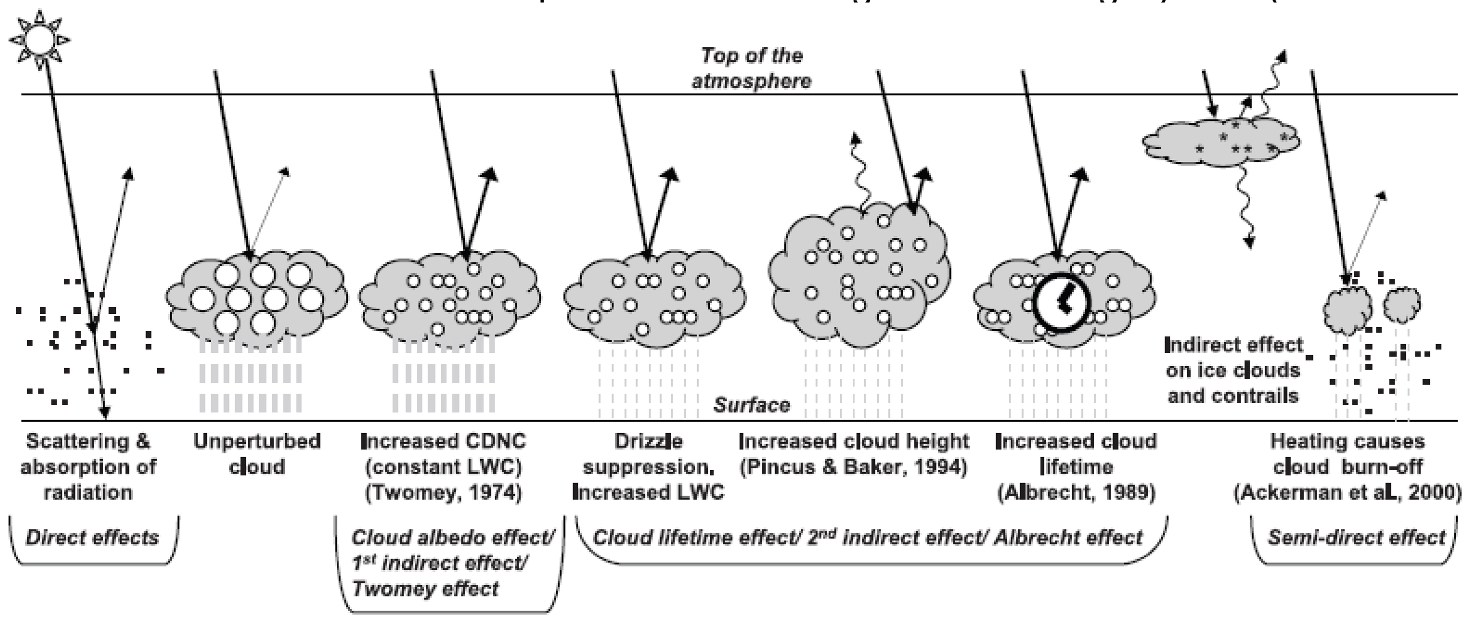

Figure 1: Schematic diagram showing the various radiative mechanisms associated with cloud effects that have been identified as significant in relation to aerosols (modified from Haywood and Boucher, 2000). FONT: IPCC (2007)

DATA

The assimilated observations are aerosol mass concentration (MC) of particular matter smaller than 2.5 μm (PM2.5). The observations were collected in October 2007, during the Cloud-Aerosol Interaction Measurements campaign (CLAIM), which took place in the region of the city Alta Floresta in the state of Mato Grosso, Brazil. The measurements of PM2.5 were collected by a DATARAM instrument aboard the aircraft that collected information with 10s or 30s frequency. During the campaign 17 flights were carried out, 13 of which could be used in this study. **Figure 2** presents the data collected during the flights 06 and 07 of the 13 flights and its paths.

For each flight one value of PM2.5 vertical column (PMINT) was calculated integrating the super-observations and its standard deviation, to estimate the PMINT error, using the equations (1), (2), (3) and (4), following Taylor (1997). The super-observations and PMINT of each flight are shown in **Figure 2**.

$$s_{obs}(k)=\frac{\sum AMC(k)}{n(k)} \quad (1)$$

$$\sigma_{S_{obs}}(k)=\frac{\sqrt{\sum\left(AMC(k)-S_{obs}(k)\right)^2}}{n(k)-1} \quad (2)$$

$$PMINT_{obs}=\sum_{k=minh}^{maxh} s_{obs}(k).rtg.\Delta Z(k).10^{-3} \quad (3)$$

$$e_{PMINT}=\sqrt{\sum_{k=minh}^{maxh}\left(\sigma_{sobs}(k).rtg.\Delta Z(k).10^{-3}\right)^2} \quad (4)$$

Where:

- **k** : model level index;
- **AMC(k)** : aerosol mass concentration observations separated according to models level k (μg/m^3);
- **n(k)**: number of observations in each model level k;
- **S_{obs}(k)**: super-observations in k level (μg/m^3);
- **σ_{Sobs}(k)**: standard deviation of S_{obs} in k level (μg/m^3);
- **$PMINT_{obs}$**: aerosol mass concentration of PM 2.5 vertical column (mg/m^2);
- **ΔZ(k)** : k model level thickness (m) ;
- **rtgt** = 1-(topography high / model top level);
- **minh**: minimum of observation altitude during all flight;
- **maxh**: maximum of observation altitude during all flight;
- **e_{PMINT}**: PMINT error.

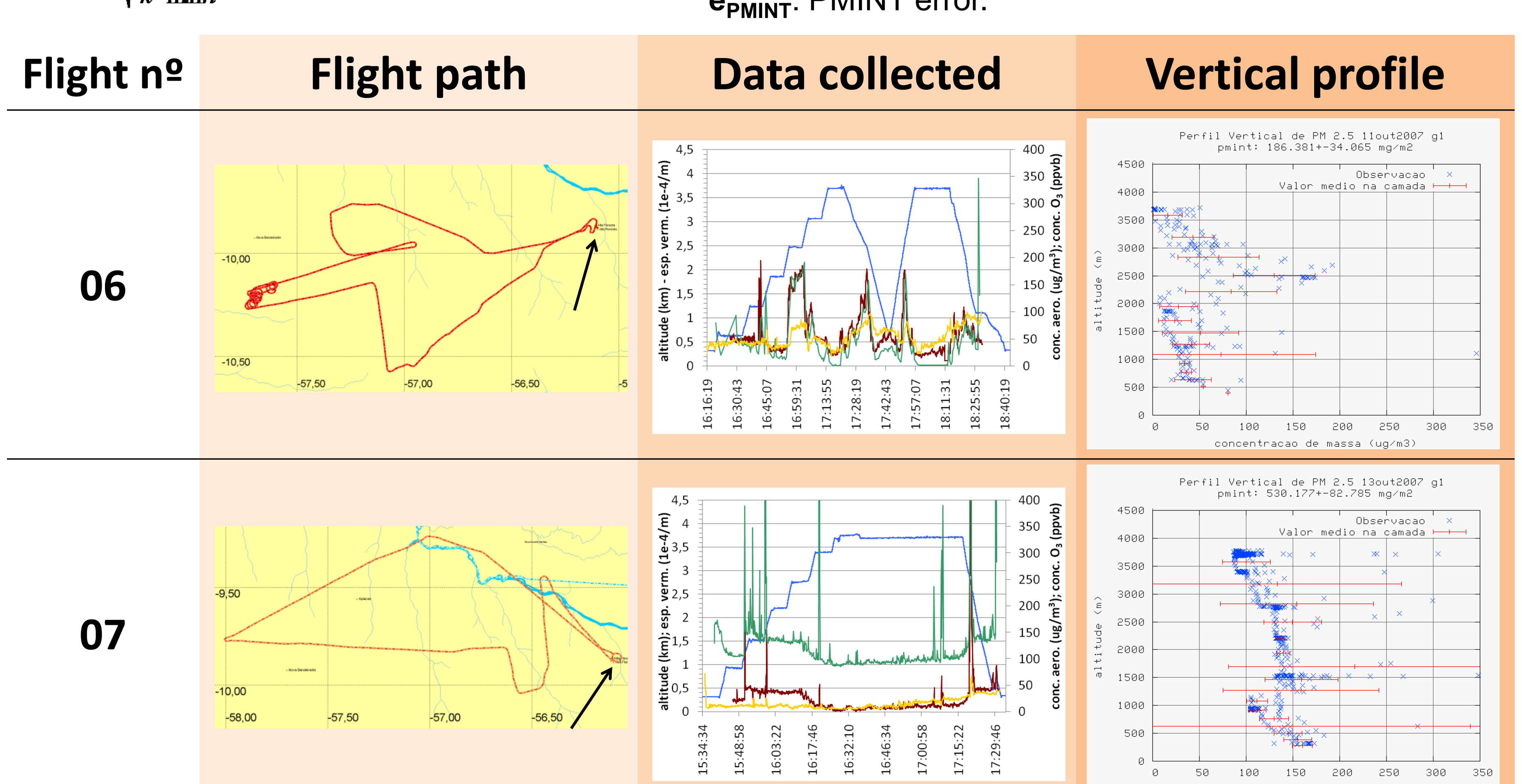

Figure 2: Flights 06 and 07 used for assimilation. The figures on the left column are the horizontal path of each flight and the black arrows points to the city of Alta Floresta. In the middle column are the data collected during the flight, where the blue line is the plain altitude, the green line is the mass concentration measured by the dataram instrument, the red line is the backscattering in the red channel measured by a nefelometer and the yellow line are the ozone measurements. The figures on the right column are the vertical distribution of the dataram data, where the blue crosses are aerosol mass concentration and the super-observations for each model level with its standard deviation are in red.

METHODOLOGY

The CCATT-BRAMS model was configured with a horizontal resolution of 30 km in the coarse grid over South America, 10 km on the nested grid over the state of Mato Grosso-Brazil and surroundings, and 38 vertical levels. As initial and boundary conditions of atmosphere the CPTEC-GCM model was used with a resolution of T126L28.

The assimilation approach is a three dimensional variational system (3D-var) developed by Elbern and Strunk (2005) and adapted to CCATT-BRAMS by Hoelzemann et al. (2010). The system is based on a diffusion equation for the background error covariances, following Weaver and Courtier (2001). **Figure 3** shows a flowchart of the assimilation system. In gray the boxes are the data necessary to run the model. In the red box are the aerosol mass concentration observations from the CLAIM Campaign. A previous field of PM2.5 is used to calculate model PMINT (mg/m^2) and used as background. The difference between the background and the PMINT calculated with the observations are minimized with the 3D-Var system and estimating a "correction factor" . This factor is multiplied to the original PM2.5 model array and which is then send back to the model to continue the simulation. The assimilations system is active in each model time step that corresponds to an observation time.

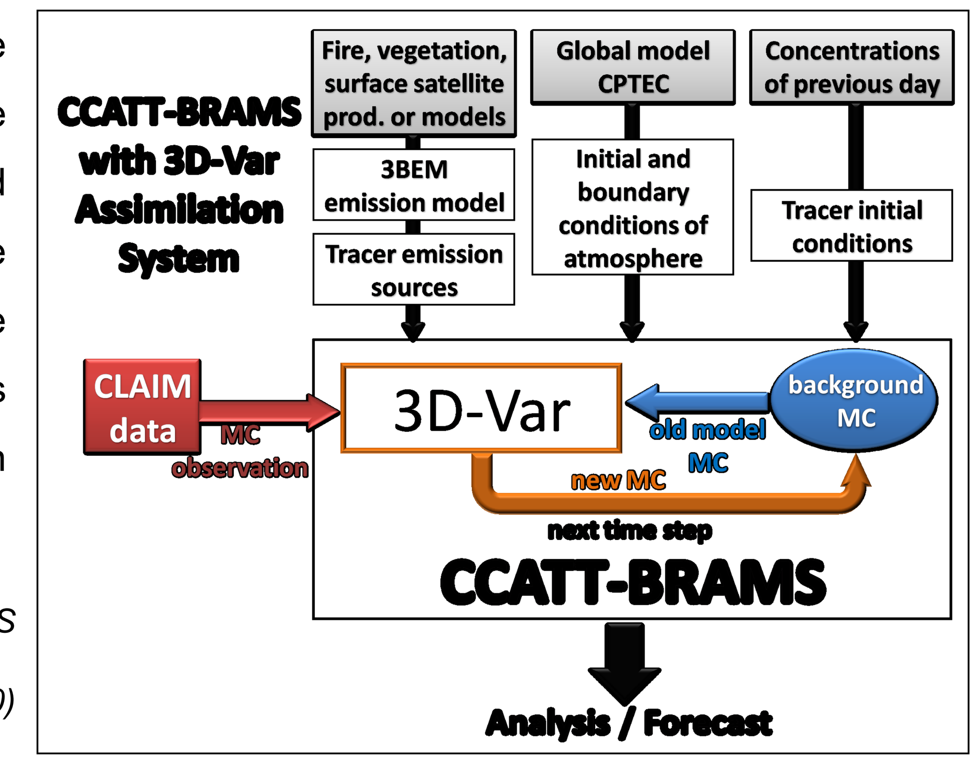

Figure 3: Flowchart of assimilation system with CCATT-BRAMS model and the data used to run the model.
Adapted from Hoelzemann (2010)

PRELIMINARY RESULTS

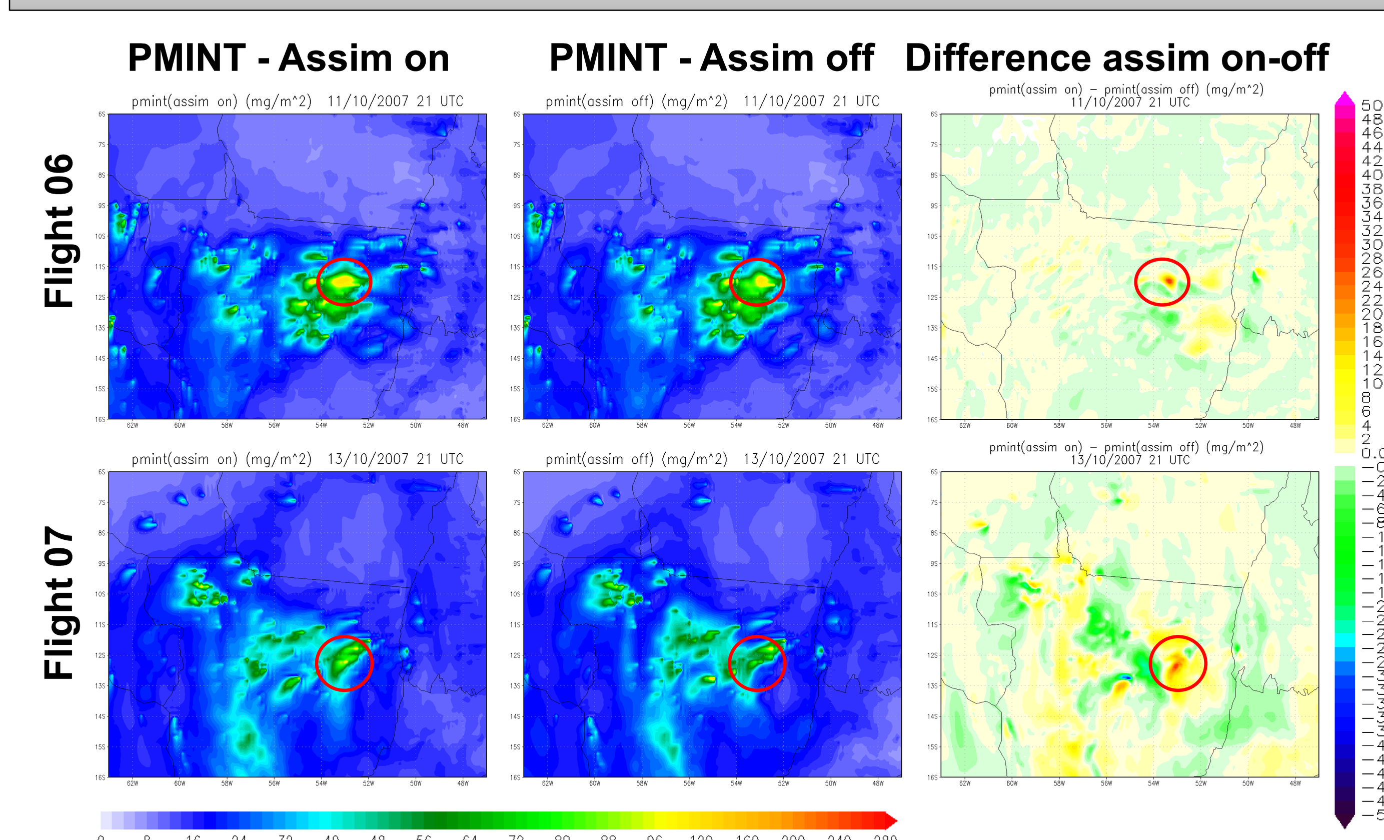

Figure 4: In the 2 first column is the field of PMINT (mg/m^2) model output with assimilation (left) and without (right) for the flights 06 and 07. On the right column the difference between PMINT with and without assimilation is shown.

As we can see in **Figure 4,** the area influenced by assimilation has a positive increment of PM 2.5 mass concentration, adding mass to the simulation. This result was expected for these observations because in all flights the model was underestimating the PM 2.5 information.

This figures are not at the exact time of assimilation. This is due the model output frequency of 3h. This means that the magnitude of the assimilation impact can be a little decreased. The figures show that the information of assimilation remains for hours in the model.

OUTLOOK

In this poster we show only the assimilation of preliminary observations. We pretend to assimilate all flights and analyze the impact of each observation and how closer the model gets to the real chemical state of the atmosphere. The upgrade of actual 2D-Var approach to an tree dimensions is under development,. This will soon allow to assimilate the observations in its exact position, eliminating the error created due to vertical integration.

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