High resolution simulations of pollution vertical stratification over Santiago and its transport to the Chilean Andes

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OVERVIEW

In spite of a clear decline in extreme events of pollution, Santiago, Chile (33.5 S, 70.5 W, 500 m.a.s.l.) still faces severe air pollution with consequences on public health, ecosystems and climate (Zhu et al., 2013; Mena-Carrasco et al., 2014). Extreme winter pollution occurs in connection with sub synoptic disturbances that intensify the prevailing subtropical subsidence (Rutllant and Garreaud, 1995). Except for an elastic LIDAR system (355 nm), a ceilometer (Muñoz and Alcafuz, 2012), and occasional meteorological soundings, the monitoring system is largely devoid of vertically resolved observations. During a few days in late August 2013, a short, multi-platform measuring campaign (DIVERSOL) took place in Santiago (Gallardo et al., 2013) providing the first measurements of vertical profiles of black carbon (BC). Here we present simulations of the dispersion and vertical mixing of carbon monoxide (CO) applying a numerical model (WRF-Chem) as described in (Saide et al., 2011). We use CO as a quasi- passive tracer for the vertical mixing of BC. This is the initial step towards assessing the fate of BC and its export to the Andean cryosphere.

PROBLEM

PISAC — Pollution and its Impact on the South American Cryosphere

Santiago basin in Chile has a quite important pollution problem, because geographical and meteorological factors usually avoid the ventilation of the basin, especially during winter time. That is why several studies has been develop about the issue, some of them about tracer dispersion with emphasis on particulate matter pollution episodes (Jorquera 2002, Olivares et al 2002, Gallardo et al 2002, Jorquera & Rappenglück 2004, Schmitz 2005, Saide et al 2011), just a few have an approach in vertical dispersion (Muñoz & Undurraga 2010, Muñoz & Alcafuz 2012) and impacts of the transport out of town (Cereceda et al 2012, Córdova et al 2016). Still we have a poor knowledge of the vertical stratification and the process that could drive pollutant toward Central Andes. This work is part of PISAC initiative.

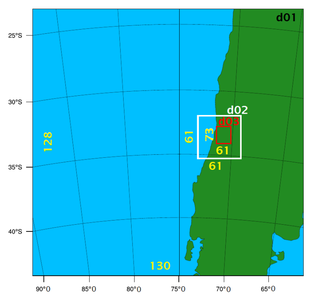
Observational Data

DIVERSOL campain took place between August 26 and 29, 2013. BC profiles were measured using a mini aethalometer on a tethered balloon. These measurements were carried out at Quinta Normal in downtown Santiago.

Weather Office of Chile (DMC) has 3 WEATHER STATIONS over Santiago. With this data we evaluated meteorological surface conditions during DIVERSOL.

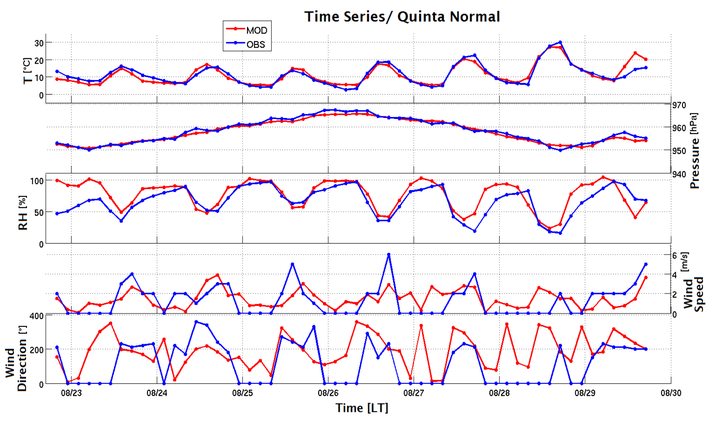
AIR QUALITY MONITORING NETWORK of Santiago consists of 11 stations that provide nearly continuous measurements of criteria pollutants since 1997. Only Las Condes station has BC measurements.

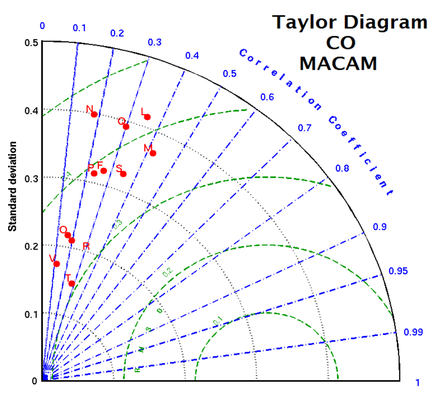
SIMULATIONS — WRF-Chem

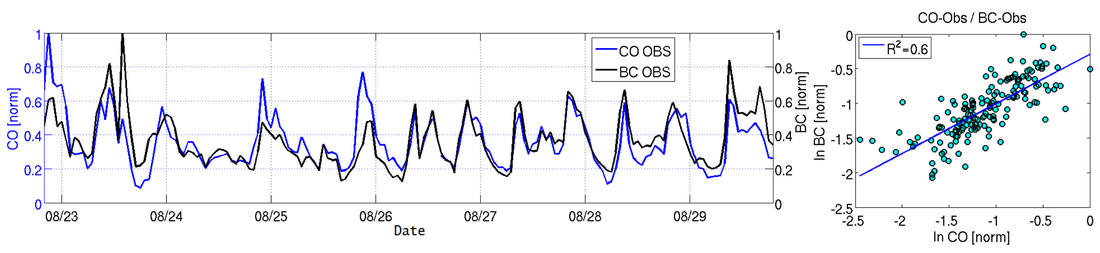


We performed a 7days simulation starting on August 23 using CO as tracer of BC. With 3 domains, 45 vertical levels and emissions inventory and configuration from Saide et al. 2011.

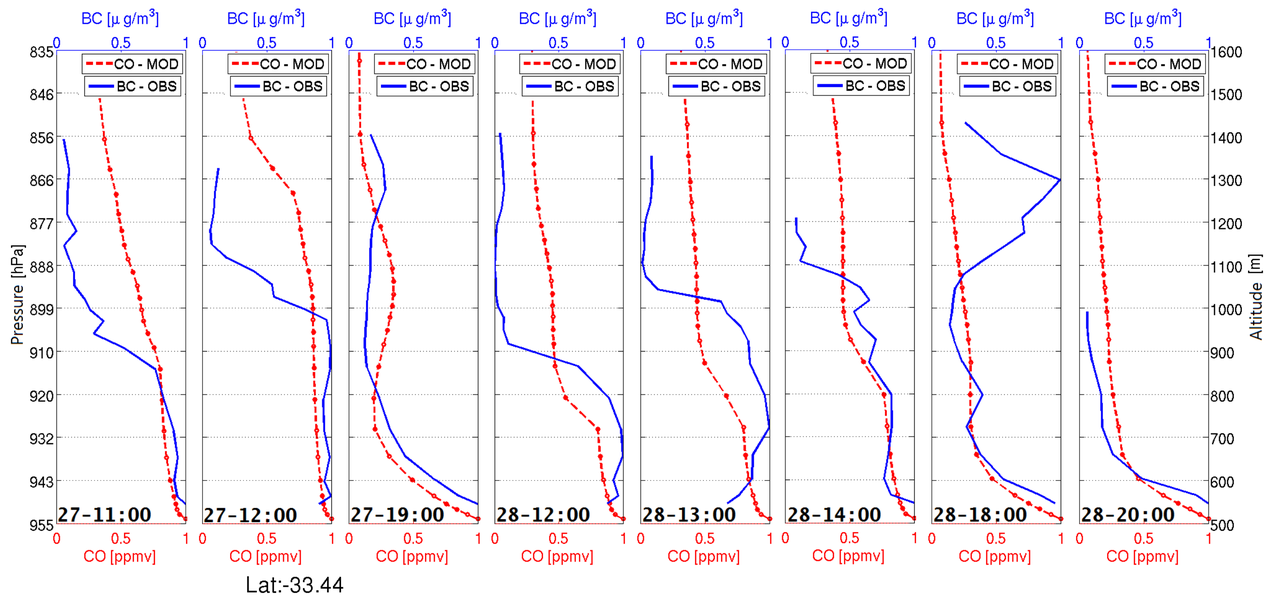
The model captures the overall variability of Surface meteorological observations. However, doesn't show this good agreement with Surface CO. Nevertheless the Surface dispersion of CO follows the characteristic mountain-valley circulation. Modeled CO has a good correlation with Surface BC, as observed CO.

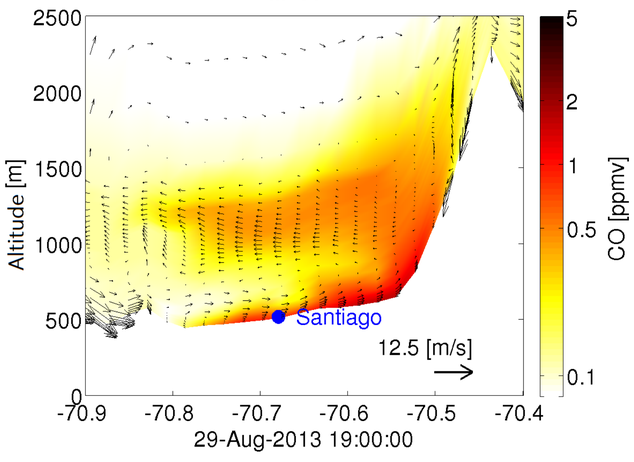






VERTICAL PROFILES & export of pollution



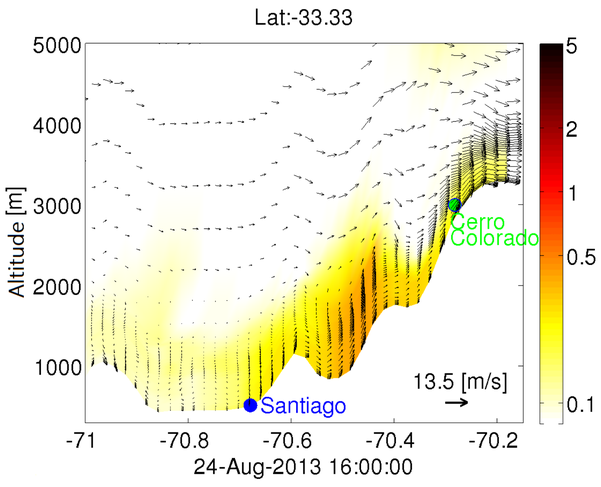


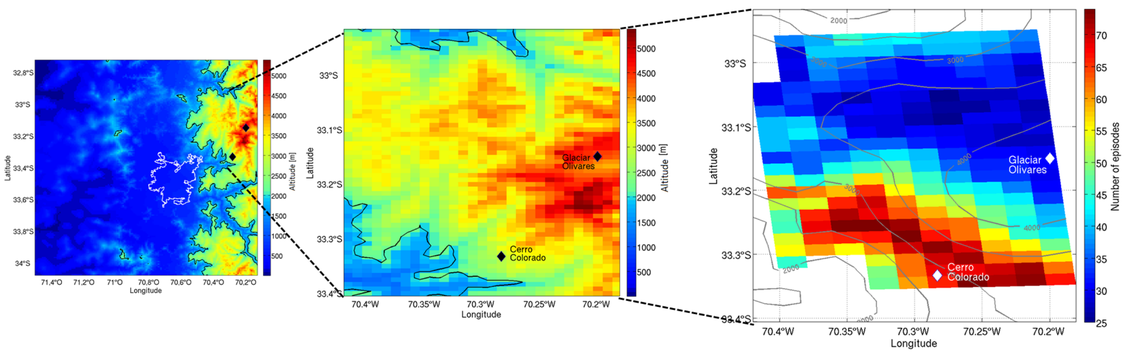
Observations indicates the presence of multiple layers within the boundary layer, and also the occurrence of upper layers of BC. These features are not captured by the model at the real occurrence times, but they show up at different moments. Seguel et al.,2013 and Escribano, 2014, among others, have suggested that these layers correspond to residual layers, the model show that this could be the effects of recirculation.

This recirculation would be product of thermal mesoscale wind circulation, mountain-valley circulation. When the flow is reverse, during the evening, downslope wind meet upslope flow at the middle of the mountain, getting back over the city.

The model suggest that windward flow, during the afternoon circulation, could transport pollutants emitted in Santiago reaching the upper Cordillera de Los Andes.

With an entire year of simulation we evaluate the occurrence of transport events, occasions when pollutants reach the glaciar zone near to Santiago.





We found that the transport of pollutants displays a seasonal signal. Most of the transport episodes are during the summer time, when the subsidence over the city is weeker and Santiago exhibit a convective boundary layer.

CONCLUSIONS

•This work is the first systematic comparison of model results with vertical profiles measurements in Chile, obtained consistent results. •Observations indicates the presence of multiple layers within the boundary layer, and also the occurrence of upper layers. These features are not captured by the model at the real occurrence times, but they show up at different moments. •The model suggest that during the afternoon circulation, pollutants emitted in Santiago could reach the upper Cordillera de Los Andes. •With an entire year of simulations, we observe transport episodes to the Andes, most of them occurring during summer. The quantification of pollutant export to the Andes cryosphere may be improved with additional measurements, as well as higher resolution simulations to describe the effects of narrow mountain valleys.

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