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NUMERICAL AIR QUALITY FORECASTING IN SANTIAGO DE CHILE

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Introduction

In 1997 the Metropolitan Area of Santiago de Chile was declared a saturated zone for carbon monoxide (CO), particulate matter smaller than 10µm in diameter (PM10), and Ozone (O_3). Whereas elevated concentrations of CO and PM10 can be observed during winter time, elevated ozone concentrations are frequent during summer. The Chilean ozone norm of 160 μg^{-3} is exceeded at least at one monitoring station inside the city at about 40% of the days per year. The causes of these high ozone concentrations lie in the anthropogenic emissions of the more than 5 million inhabitants of Santiago and the photochemical activity, driven by the intense global radiation at this latitude (33º27'S). Furthermore, the dispersion of contaminants is strongly influenced by the highly complex terrain surrounding the Santiago basin (Schmitz, 2005).

Air pollution forecasting started its evolution in the 1970s by the application of objective statistical methods. With time forecasting methods have improved significantly, and the most recent advances have lead to a coupling of real-time prognostic meteorological models with air quality models, keeping separate software for chemistry and meteorology ("offline", e.g. Jakobs *et al.* 2001), or using an integrated approach ("online", Grell *et al*. 2005). In this work, we present the application of a high resolution fully coupled online model for air quality forecasting in Santiago de Chile.

Model

The model used for the forecast is the Weather Research and Forecasting Model/Chemistry (WRF/Chem) (Grell *et al*., 2005). The air quality component of the model is fully consistent with the meteorological component; both use the same transport scheme (mass and scalar preserving), the same grid (horizontal and vertical components), and the same physics schemes for subgrid-scale transport. The components also use the same time step, hence no temporal interpolation is needed.

The chemistry package consists of a "flux-resistance" method for dry deposition (Wesely, 1989), biogenic emissions (as in Simpson, et al. 1995 and Guenther et al. 1994), the chemical mechanism RADM2 (Stockwell et al., 1990), a complex photolysis scheme (Madronich 1987), and a state of the art aerosol module (Ackermann et al., 1998 and Schell et al., 2001).

Table 1: The WRF model configuration used in the forecasting system

Advection scheme	5th order horizontal 3rd order vertical
Microphysics	NCEP 3-class simple ice
Longwave radiation	RRTM ()
Shortwave radiation	Dudhia 1989
Surface layer	Monin-Obukhov (Janjic)
Land-surface model	Slab scheme (??)
Boundary layer	Mellor-Yamada-Janjic
Cumulus parameterization	Kain-Fritsch (Outer and middle domain only)
Chemistry	RADM2 (Stockwell et al, 1990)
Dry deposition	Weseley 1989
Photolysis	Madronich 1987

Forecast

Nowadays, most air quality forecasts are carried out on the regional scale (e.g. Grell *et al*., 2005) using one model domain. However, in order to achieve the resolution necessary for an urban air quality forecast a nested model set-up is required. Figure 1 shows the three domains used in the forecast for Santiago. Due to computational restrictions the first two domains are run without chemistry (meteorology only) and the smallest domain is run with meteorology and chemistry. In its present version the forecast only considers gas-phase chemistry.

The forecasting system uses the standard WRF software with several add-ons, developed in house, written in PERL, MATLAB, and FORTRAN. The Table 1 shows the configuration of the model for the forecast.

Forecasts from the Global Forecast System (GFS) are used for the meteorological initialisation and boundary conditions. The air chemistry is initialised with data from the previous forecast and constant climatological values are applied at the boundaries.

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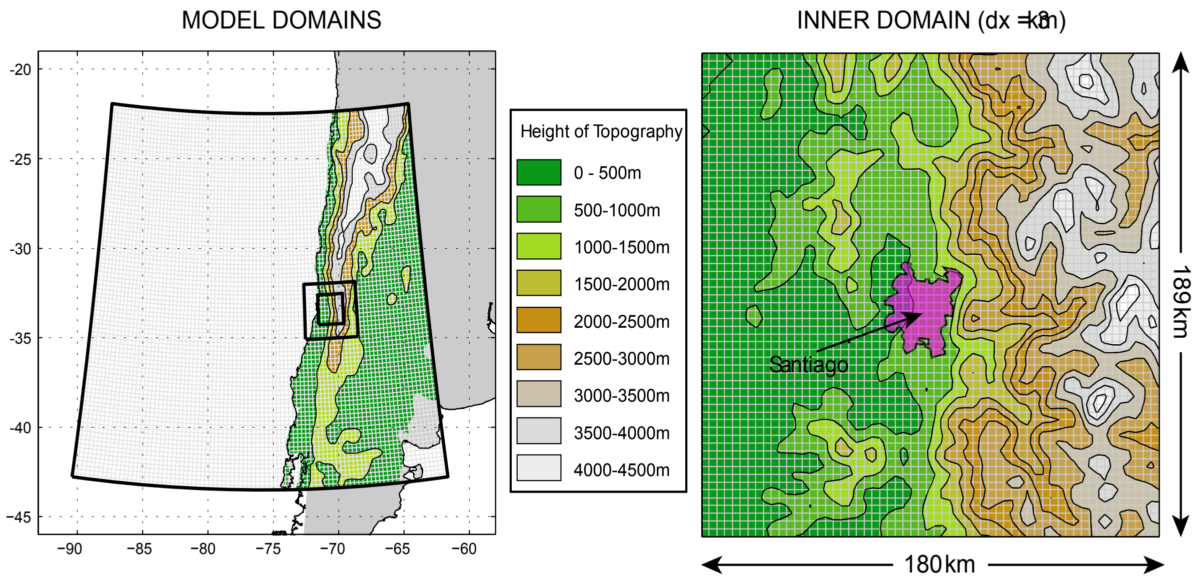

Figure 1: Configuration of the operational air quality forecasting system. The left panel shows the three nested domains, whose horizontal grid spacings are 27km, 9 km and 3 km. The right panel shows the topography of the inner domain. At this resolution, the key topographical features that play an important role in the dispersion of pollutants in the city of Santiago are well resolved. The city itself occupies a roughly square region with dimensions of about 10 x 10 grid points.

The forecast is run every 24 hours for 48 hours and published on the internet (www.ozono.dgf.uchile.cl/calidaddelaire.php).

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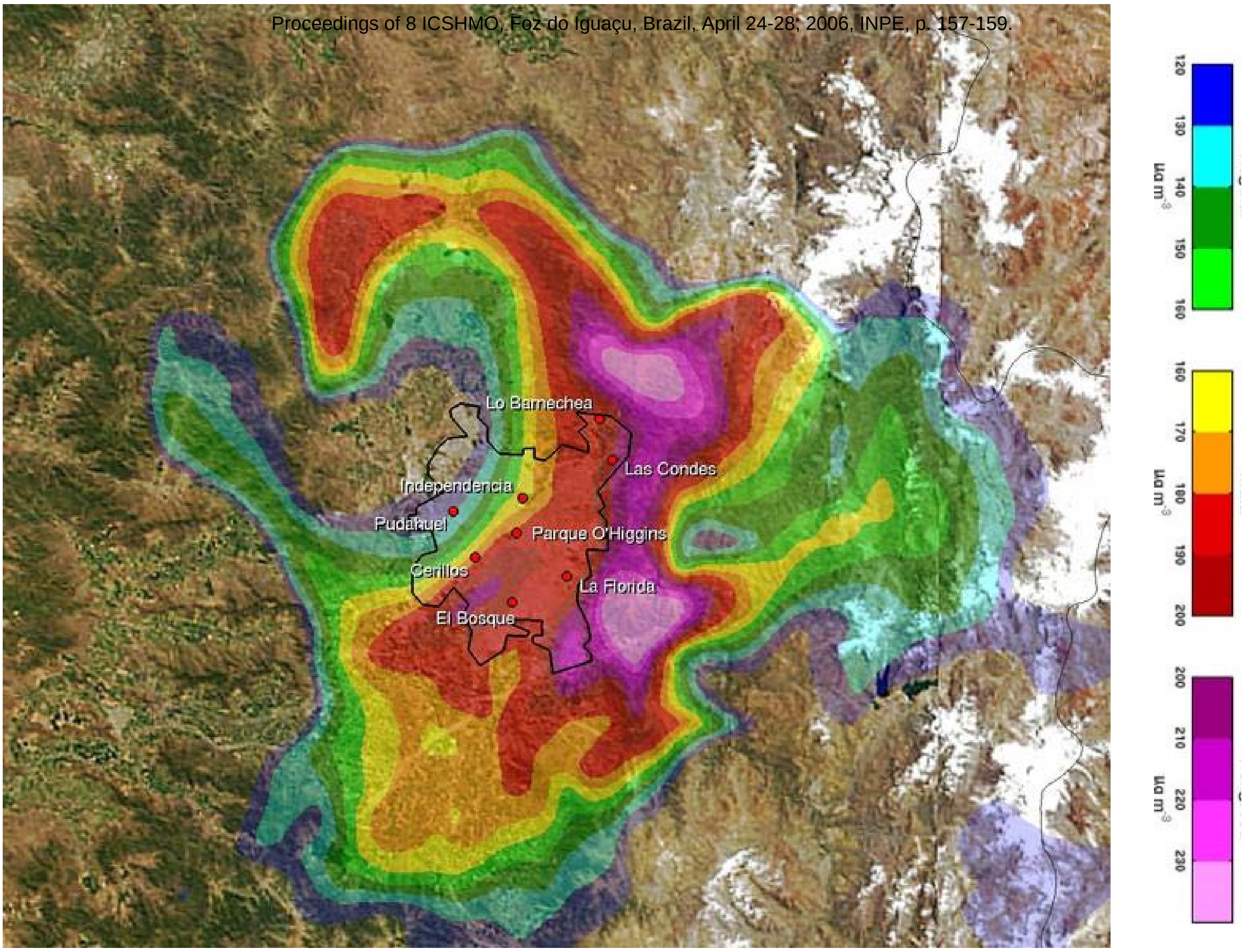

Figure 2: Forecast of near surface O3 concentration on March 16, 1600 LTC. Levels of ozone exceeding the norm are usually predicted over the higher altitude (western) side of the city where advection of precursors tends to cause peak ozone levels in the afternoon. Sharp gradients can be seen on the city scale, principally due to the complex patterns of winds within the boundary layer and the emissions within the city. Plots such as this one are produced daily and posted on the Internet.

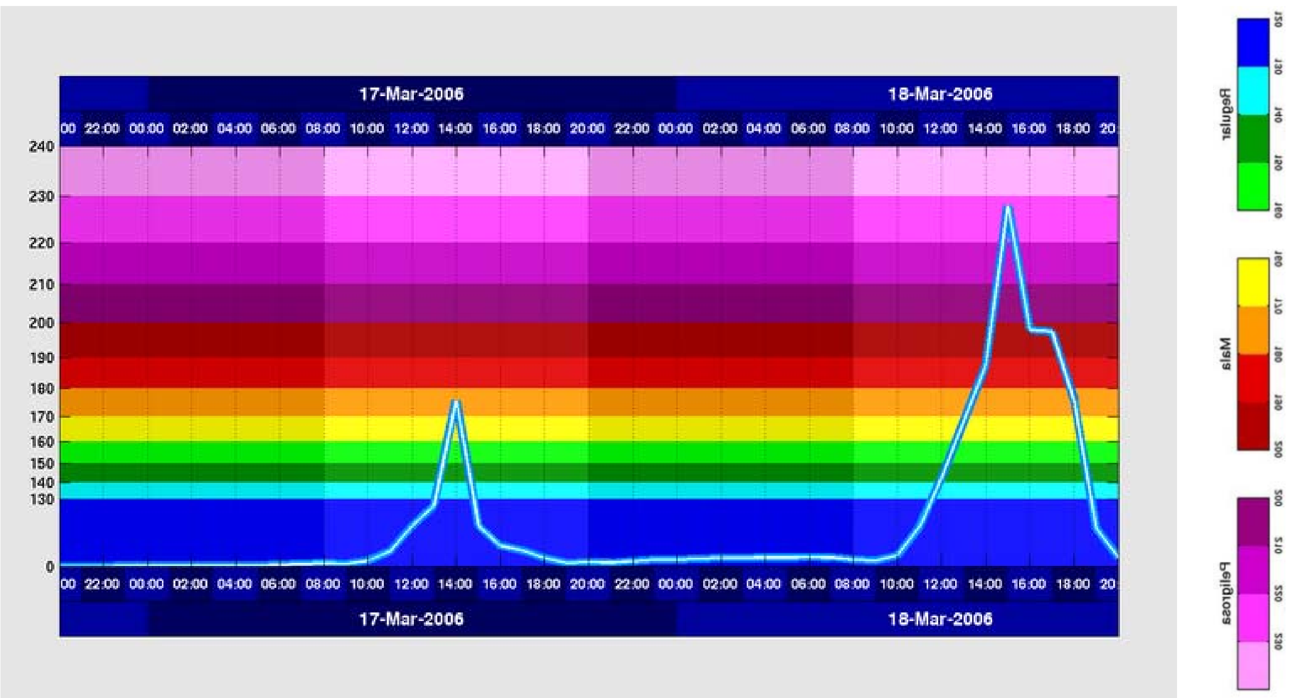

Figure 3. Time series showing the 48 hour forecast of O3 at Las Condes (Figure 2). Ozone levels regularly exceed the Chilean norm.