

Chilean Pilot Project: Status and progress

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WMO GURME SAG Meeting
WMO Headquarters, Geneva, Switzerland
7-8 April 2017

Severe PM2.5 episodes in south-central Chile

- Produced by a combination of:
 - Complex topography
 - Episodic meteorological conditions
 - Emissions due to anthropogenic activities
- Episodes are declared to warn the public and to try to reduce the impact by invoking temporary measures



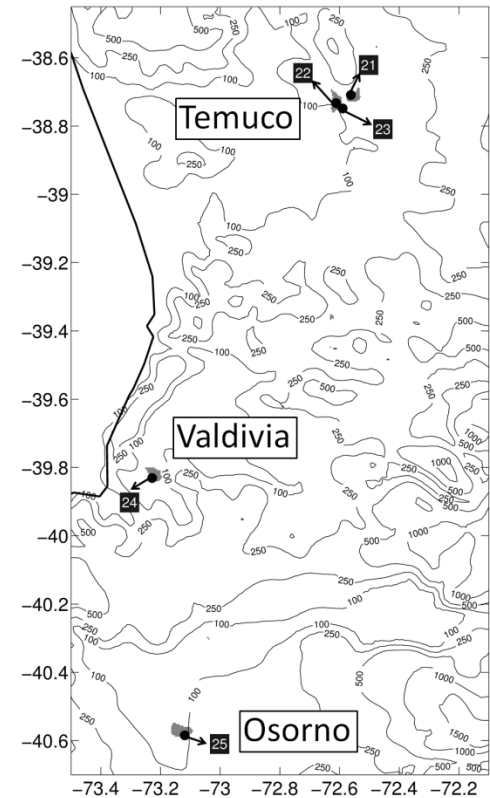
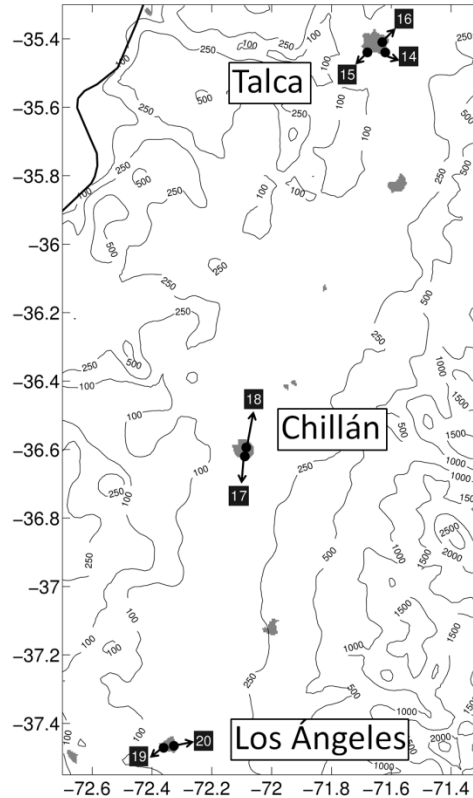
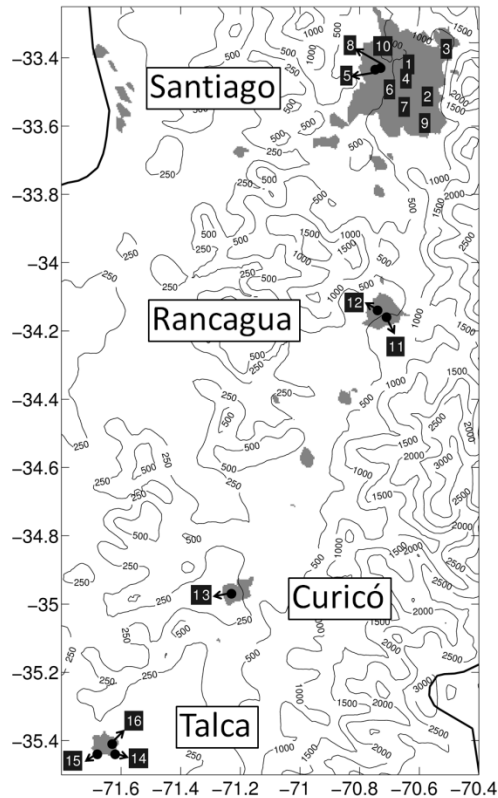
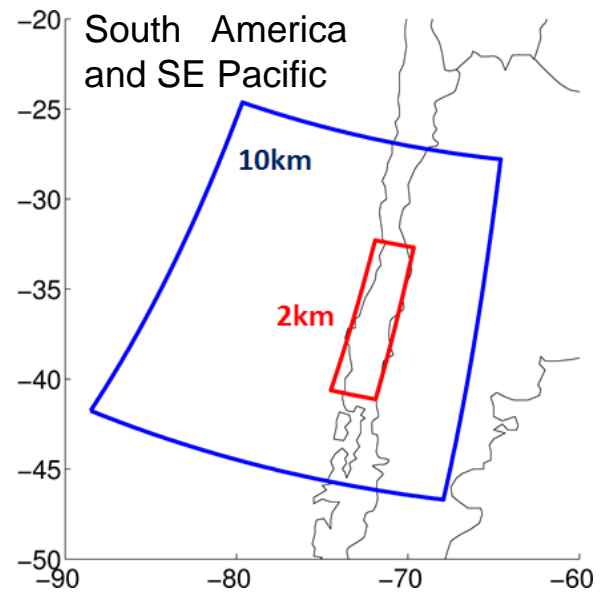
Santiago during en episode



Wood burning stoves in Temuco

Forecasting system

- WRF-Chem model at high spatial resolution to resolve met conditions, topography and emissions
- Paper under review



Summary of activities

- Presentations by the now Ministry of the Environment in IGAC and HABITAT-III
- Extending the forecast to cities in austral Chile.
- 2016 Report and website improvement by the Ministry of the Environment
- NCAR 2 month visit by Hector Jorquera
- Activities in the University of Chile
- Activities still to be developed

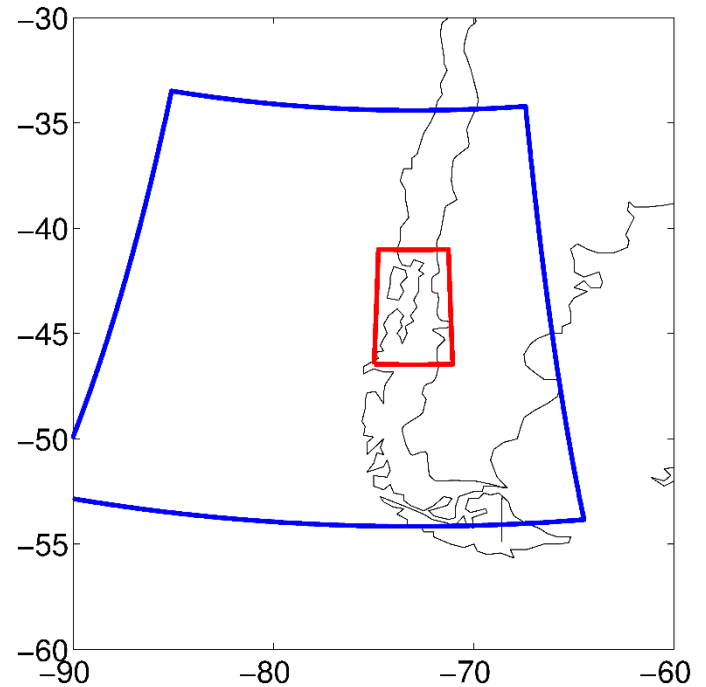
Presentations by Marcelo Mena

- Marcelo is now the Ministry for the Environment
- Gave presentations in IGAC 2016 and HABITAT-III on the forecasting system
- Caused great impact!

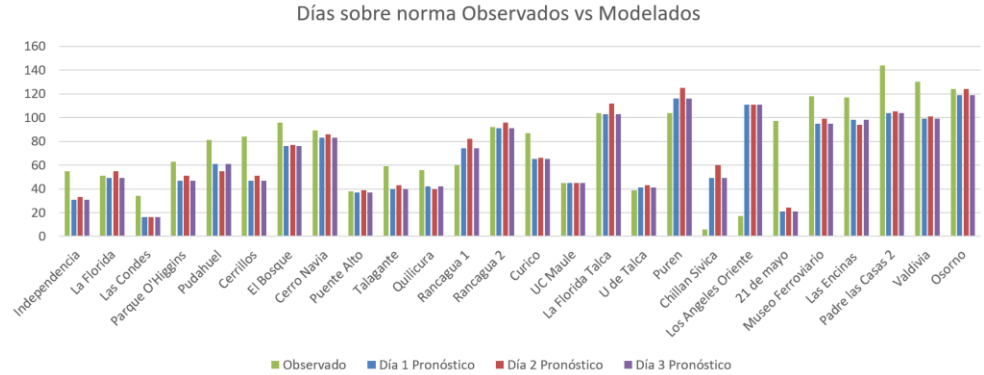
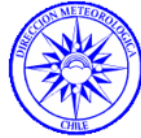


Extending the forecast to cities in Austral Chile

- Update population maps used as proxy to distribute emissions to 2014
- Emissions generated and sent to the Ministry of the Environment
- Initial testing performed in Chile
- Forecasts not yet running due to computational constraints



2016 Report by the Ministry on the Pilot project

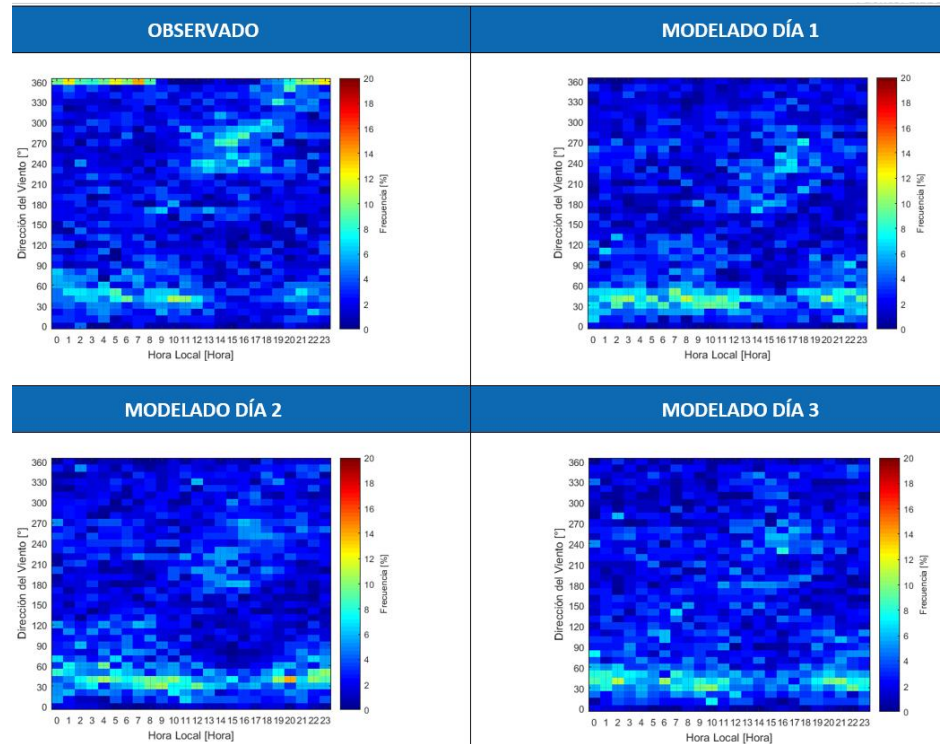


Implementación y Desempeño Sistema Nacional de Pronóstico de Calidad del Aire

Convenio de colaboración MMA – GURME - DMC

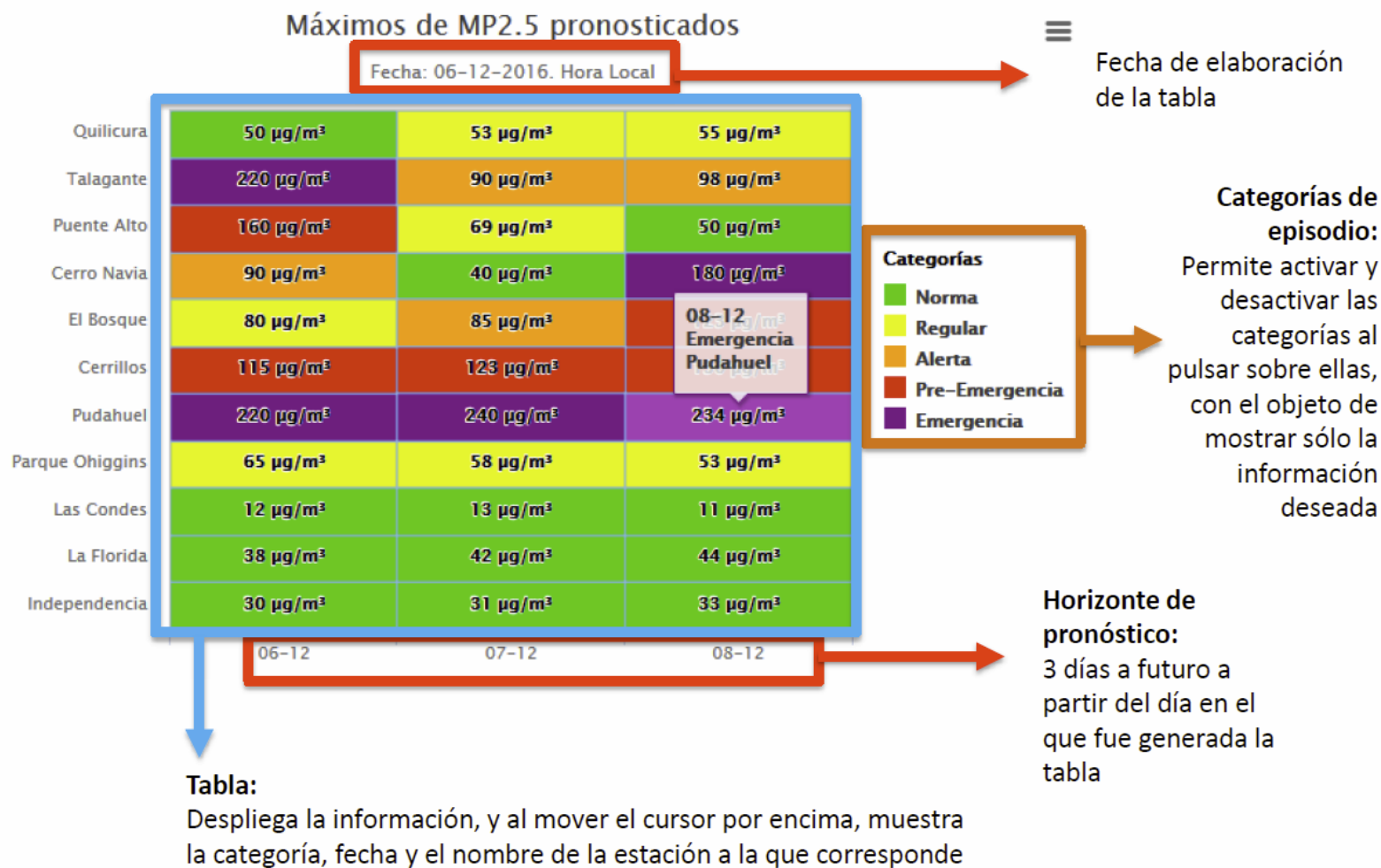
Informe Final Período 2016

Departamento de Redes de Monitoreo
División de Calidad del Aire y Cambio Climático



Improvements to the forecast website

Tabla de máximos móviles pronosticados



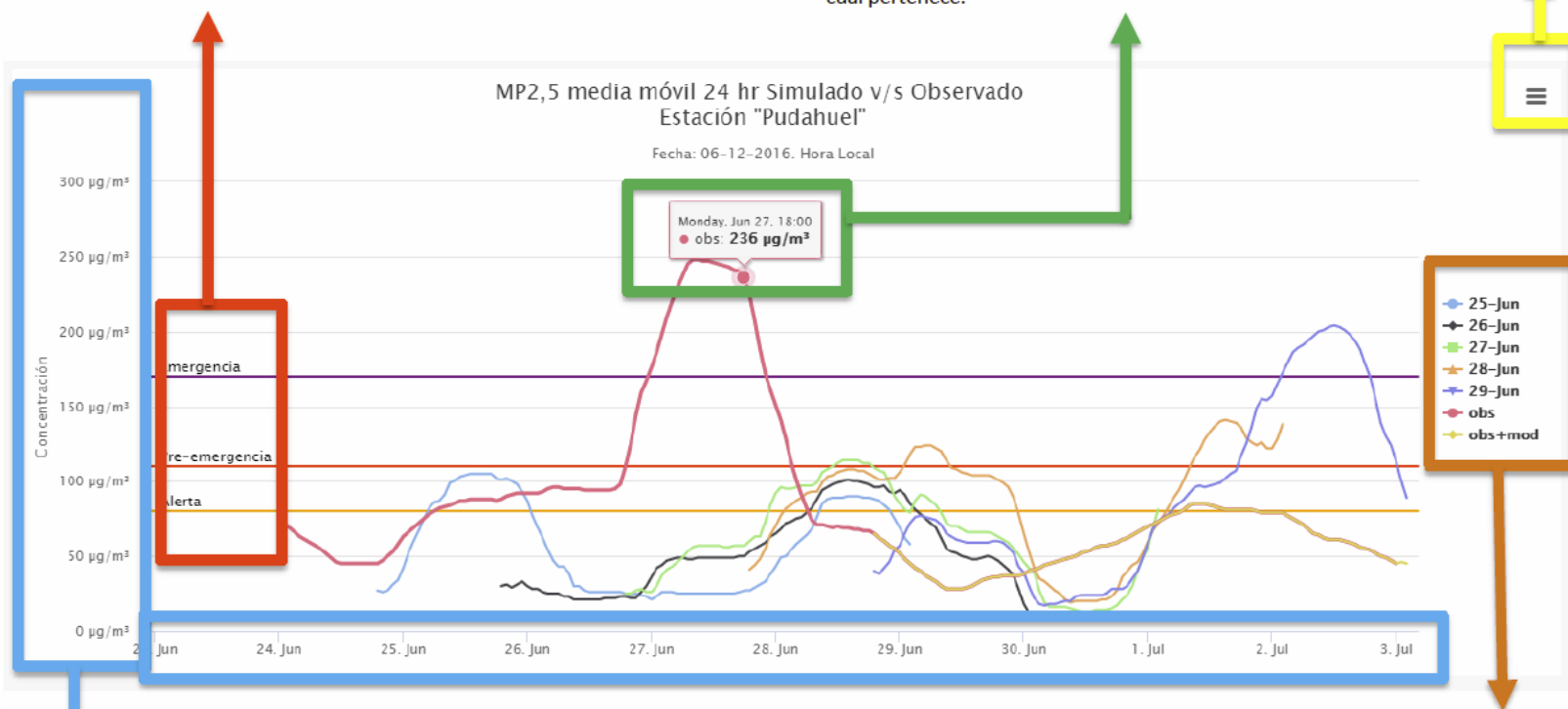
Improvements to the forecast website

Nuevo diseño de Gráficos

Categorías: Cada gráfico posee nuevas categorías que facilitan la lectura de la información desplegada

Datos: Al mover el cursor por encima, despliega la información horaria con su fecha correspondiente y la variable a la cual pertenece.

Botón de Descarga: Permite la descarga del gráfico en distintos formatos de imagen y los datos graficados en distintos formatos de texto.



Ejes automáticos:

Se ajustan automáticamente, dependiendo del rango que cubran los datos desplegados

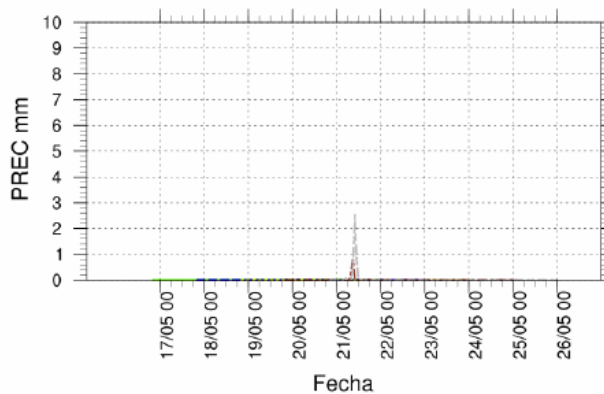
Categorías de episodio:

Permite activar y desactivar los días de modelación al pulsar sobre ellos, con el objeto de mostrar sólo la información deseada
(IMPORTANTE: Existe un pequeño bug. La primera vez que se abre un gráfico, este muestra las variables en orden aleatorio, lo cual se soluciona al cerrar el gráfico y volver a abrirlo. Estamos trabajando para solucionar este problema.)

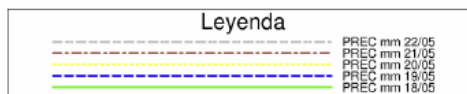
Improvements to the forecast website



Precipitacion - Simulacion CERRO_NAVIA.
Fecha: 22-05-2016. Hora local



Versión Antigua

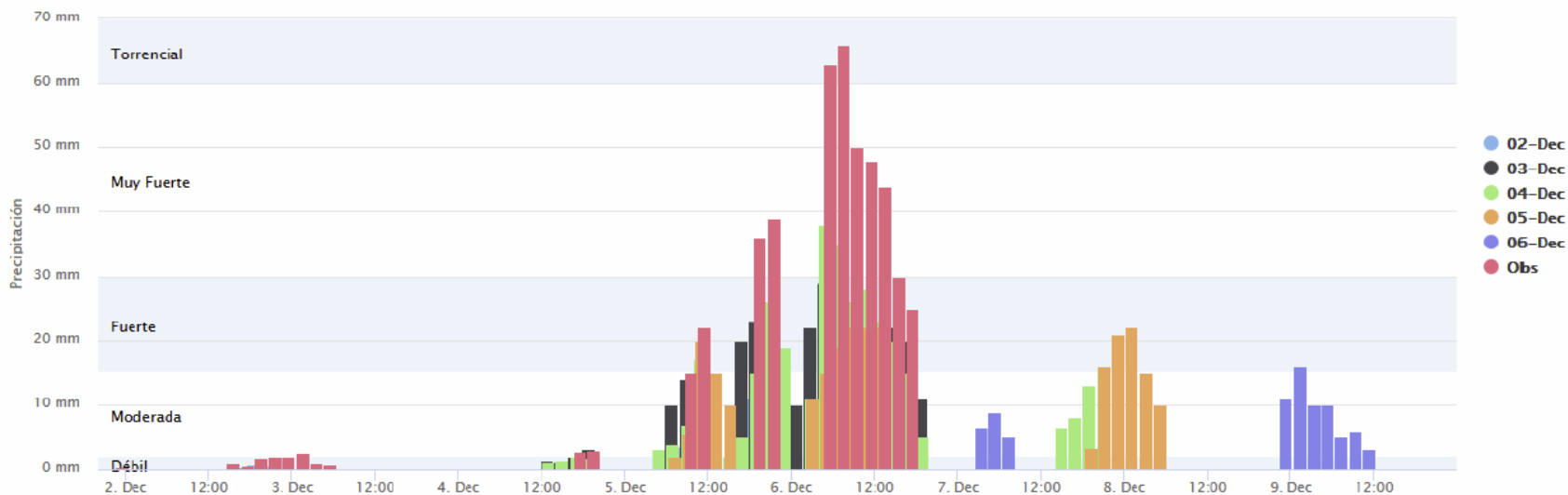


Precipitación Simulada v/s Observada
Estación "Cerrillos"

Versión Nueva



Fecha: 06-12-2016. Hora Local



Hector Jorquera visit to NCAR

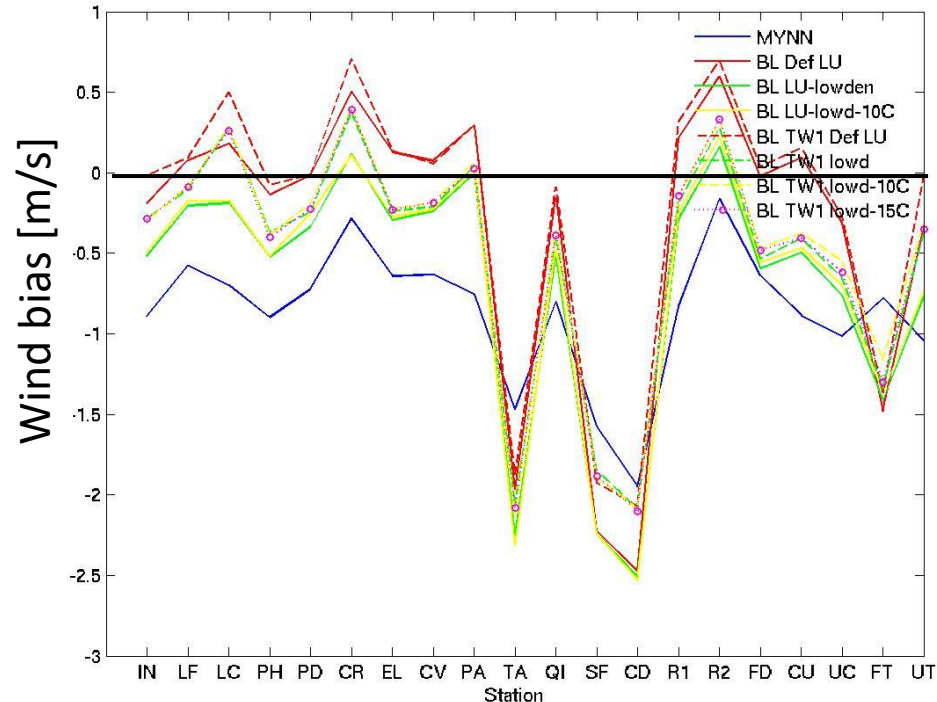
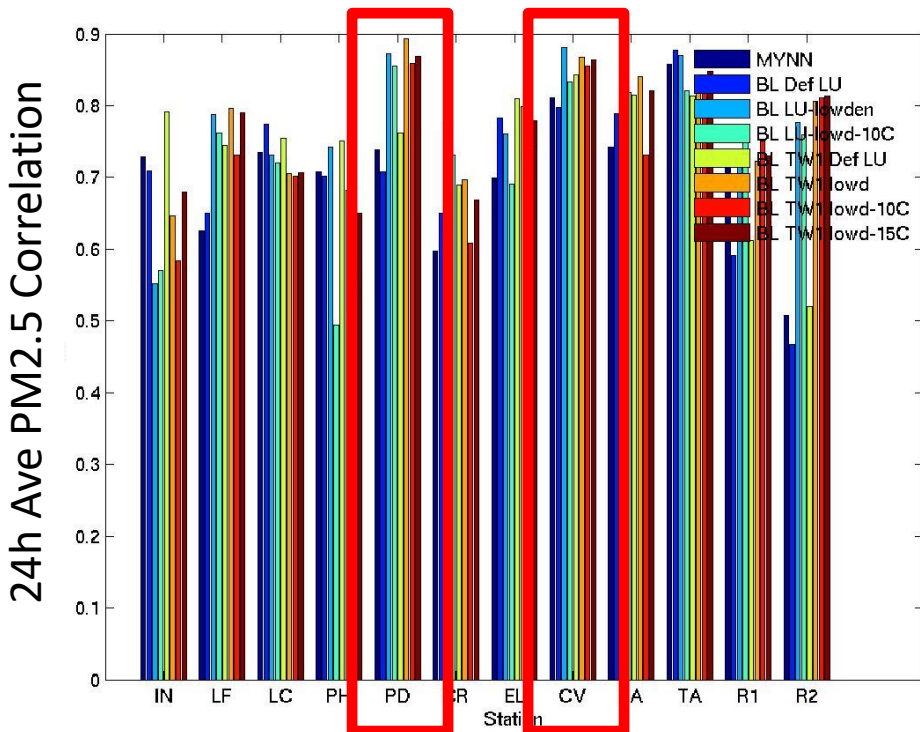


Visit to work on two main topics

- Try to improve WRF-Chem configuration for Chilean forecast system
 - Test boundary layer schemes including urban canopy parameterizations
 - Test PBL schemes that account the effects that the unresolved topographic features
- Assess AOD to PM_{2.5} relationship using high-res (1km) MODIS AOD data (MAIAC)

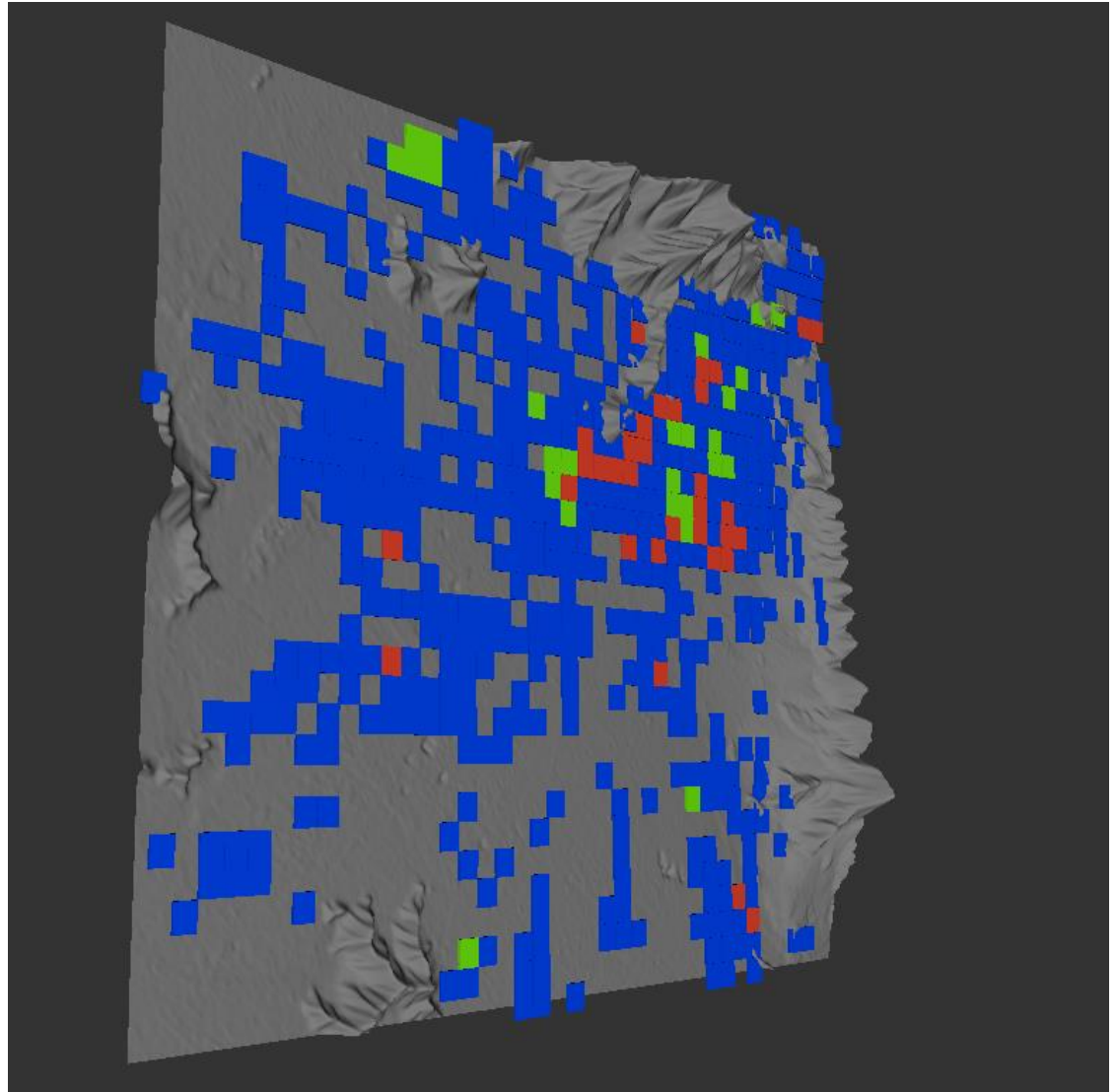
Hector Jorquera visit to NCAR

- Test case using an episode well represented
- Close work with Alberto Martilli that develops the urban canopy scheme and included topo-wind for Boulac PBL
- Sensitivity simulations include using urban canopy with default urban categories (high density urban), low-density urban, decreasing building temperature, using topo-wind option (unresolved topographic features)

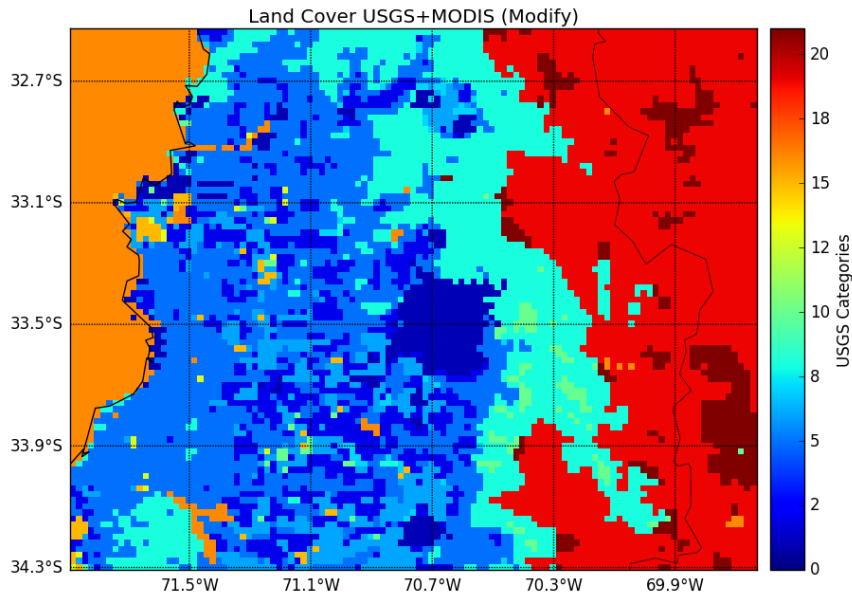


Activities in the University of Chile

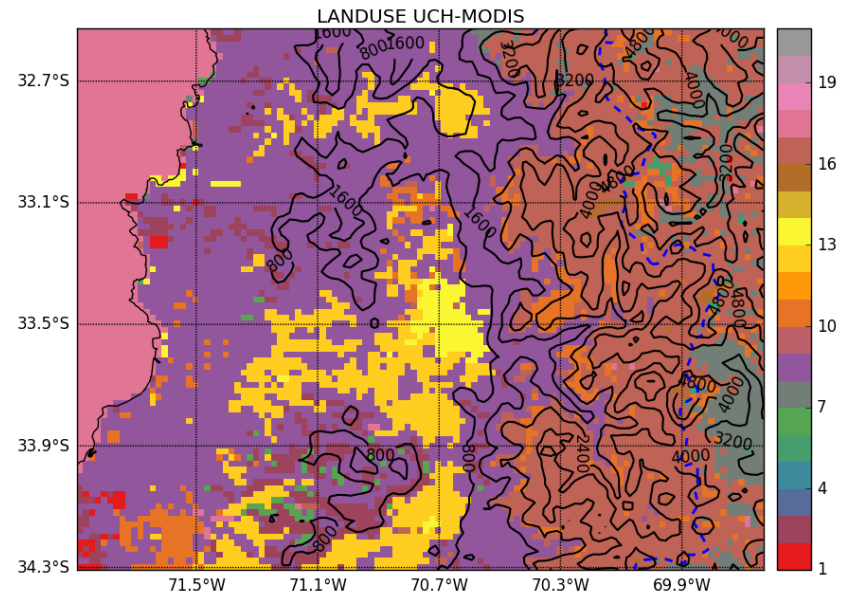
- Development of strategy to obtain urban categories using open street maps to be used by urban canopy models
- Matias Bravo Msc Thesis (Advisor: Laura Gallardo)
- Another strategy: Using WUDAPT inputs (suggested by Alberto Martilli) but not currently available



Análisis de rendimiento configuraciones WRF



Uso de suelo USGS+MODIS
(ajustando el uso de suelo a la topografía)



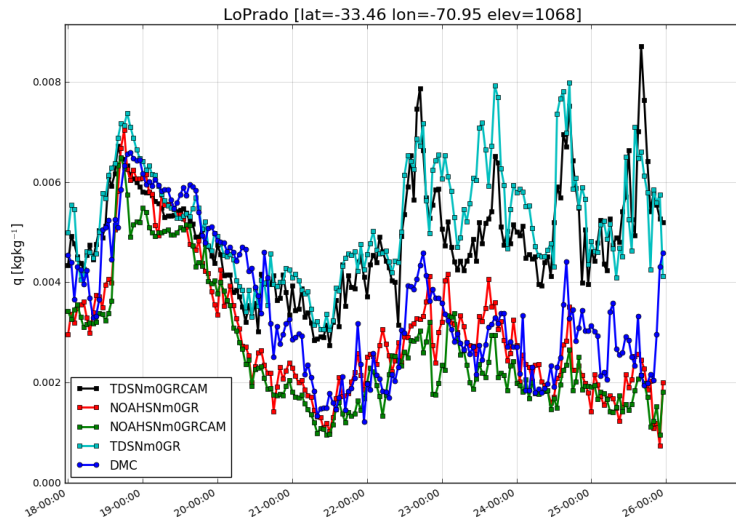
Uso de suelo generado por investigadores CR2- Uchile interpolado a 2 km (Original 30 m)

Para las simulaciones se utiliza finalmente el producto Zhao et al., (2016)

Pruebas con PBL QNSE y MYNN2

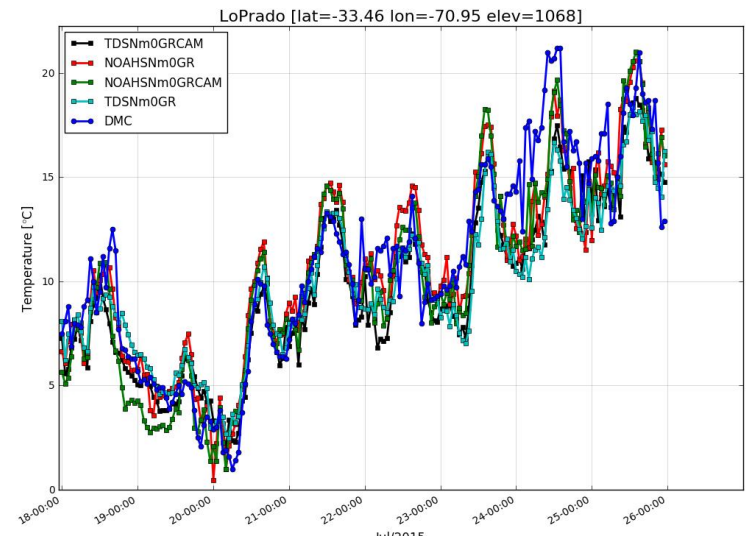
- Surface Model: TD y NOAA
- Long wave radiation: RRTM y CAM

Razón de mezcla

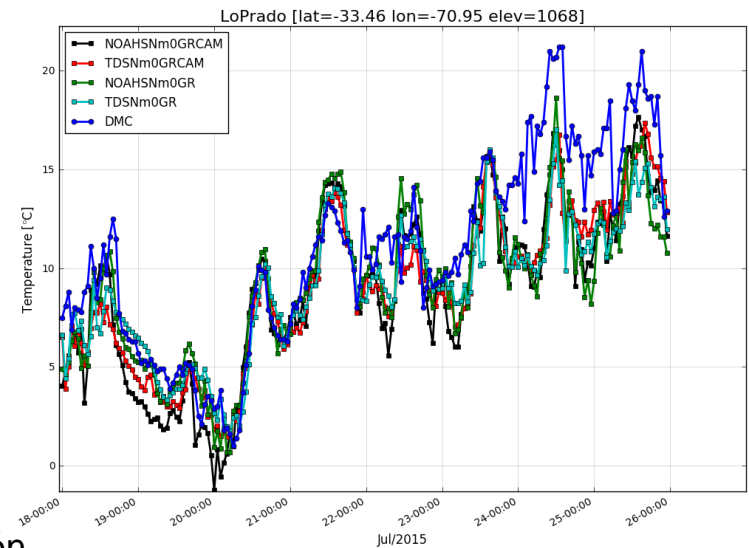
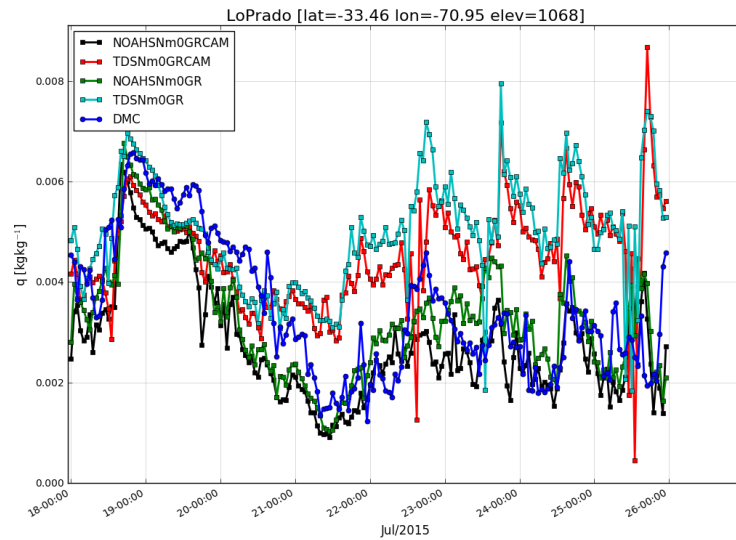


QNSE

Temperatura



MYNN2



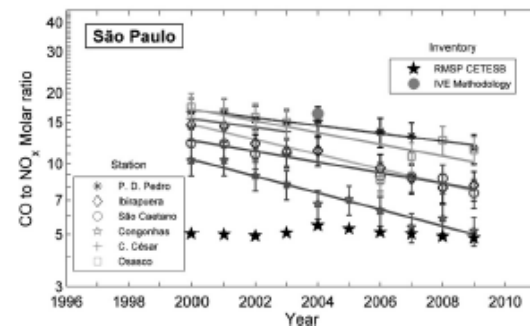
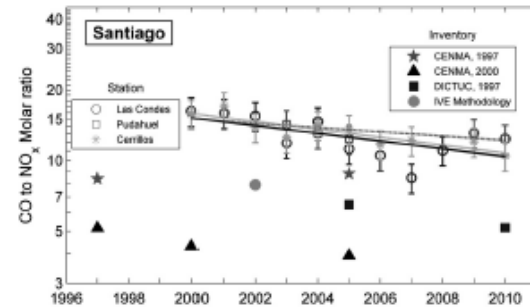
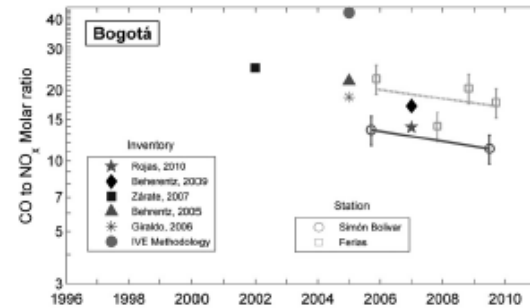
DMC=observación

Validation/Verification of emissions

2) CO/NO_x ratios

- Emission inventories for mobile sources are off!!...
- Overestimate of NO_x in Santiago and Sao Paulo by up to a factor of 3!!
- Major uncertainties linked to EF for CO and activity data for NO_x
- Learning about VOCs unfeasible due to lack of measurements ☹

Time for an extended update!!!



Gallardo, L., J. Escribano, L. Dawidowski, N. Rojas, M. de Fátima Andrade, and M. Osses (2012), Evaluation of vehicle emission inventories for carbon monoxide and nitrogen oxides for Bogotá, Buenos Aires, Santiago, and São Paulo, *Atmospheric Environment*, 47, 12-19. doi: 10.1016/j.atmosenv.2011.11.051.

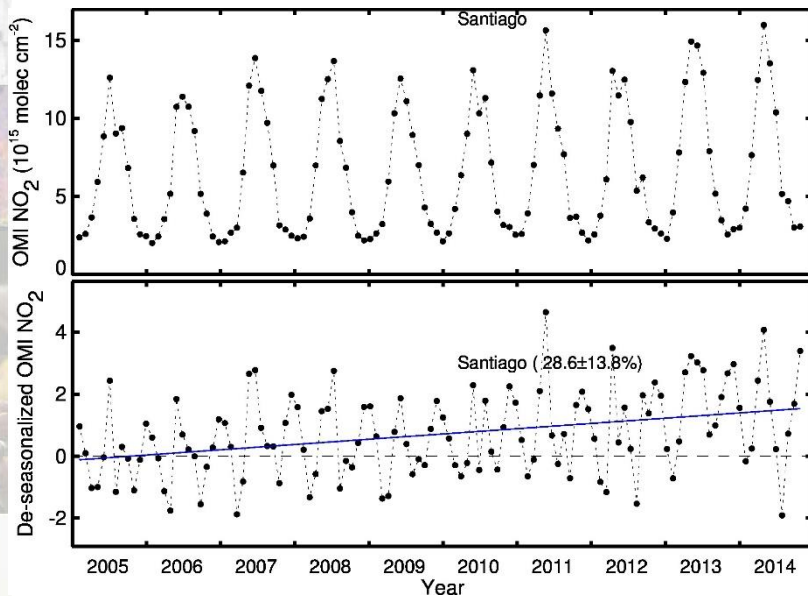
Zhu, T., M. Melamed, D. Parrish, M. Gauss, L. Gallardo Klenner, M. Lawrence, A. Konare, and C. Liousse (2013), WMO/IGAC Impacts of Megacities on Air Pollution and Climate Rep. 205, GAW Report 205, Geneva, Switzerland.

Validation/Verification of emissions

3) Satellite data

e.g., OMI NO₂

<https://airquality.gsfc.nasa.gov/>



City	Country	2014 Avg. NO ₂ *	Change (%)	Uncertainty (±%)
Bogota	Colombia	1.3	5	11.4
Buenos Aires	Argentina	4.6	-5.8	10.6
Caracas	Venezuela	2.1	10.2	10.4
Cordoba	Argentina	1.2	1.9	11.9
Iquique	Chile	0.6	-9	12.2
La Paz	Bolivia	0.4	19.2	18.1
Lima	Peru	3.2	15.7	10.3
Medellin	Colombia	1	13.1	10
Montevideo	Uruguay	1.2	11.2	14.6
Porto Alegre	Brazil	1.6	-13.8	10.2
Rio de Janeiro	Brazil	3.2	6.4	10.1
Salvador	Brazil	0.7	32.2	12.5
Santiago	Chile	5.8	28.6	13.9
Sao Paulo	Brazil	6	-8.4	10.4

Satellite retrievals are improving, however....Needs careful checking

- PM...Notice reflectivity (Escribano et al, 2014)
- SO₂... South American Anomaly
- NO₂ ... *to be explored further*

Next steps

- Make the Austral Chile forecasts operational
- Release forecast website to the public
- Integrate improvements to the model configuration and test for a pollution season

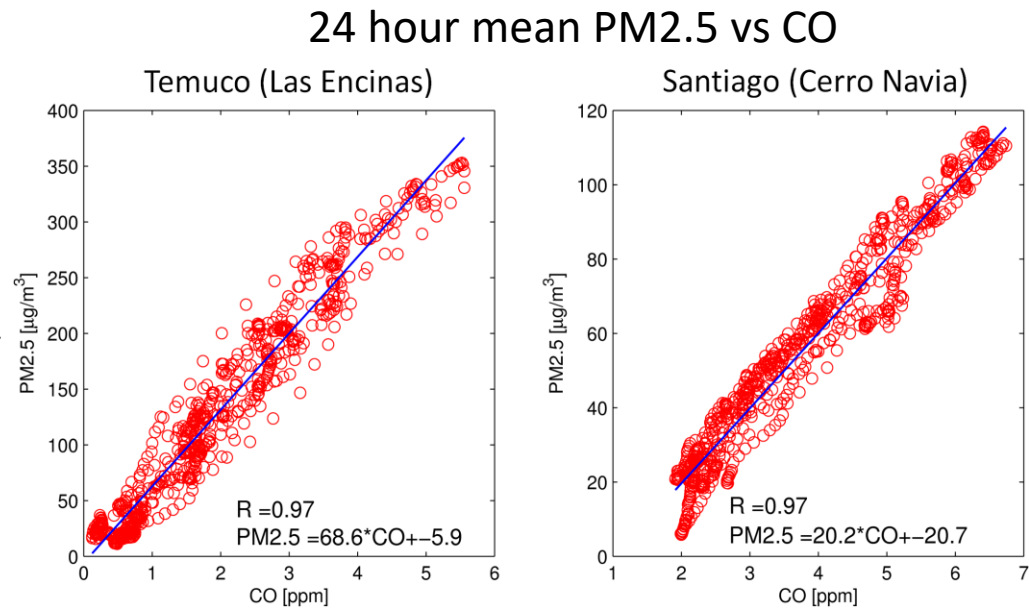
Topics yet to cover

- Improvements to emission inventories, specially to wood burning stoves
- Ensemble predictions
- Evaluation of model representation of the nocturnal boundary layer

Supporting slides

PM2.5 modeling

- CO and PM are highly correlated during episodes

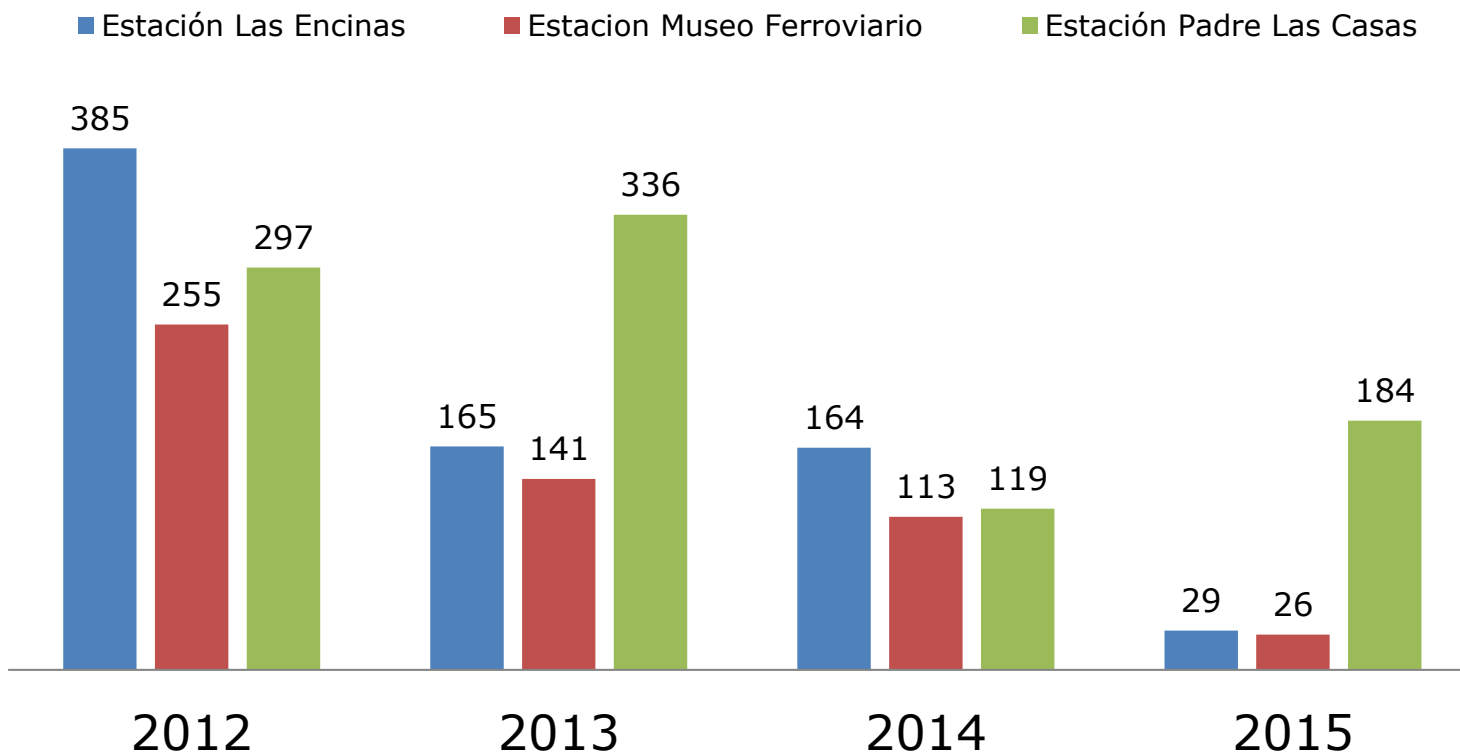


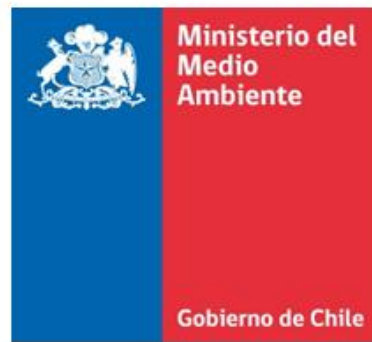
- Use CO tagged tracers (“traffic” and “wood burning stoves”) and an empirically calibration for 2014
- The conversion factors are chosen to match observed episode statistics.
- Factors are introduced to include physical processes

$$PM2.5_{t,s} = Tr_to_PM_s * A_weekend_{t,s} * \dots$$

$$\left[F_WB_s * A_WB(T_mean_{t,s}) * \left(\max_{i \in s \cup N_s} Tr_WB_{t,i} \right) + (1 - F_WB_s) * \left(\max_{i \in s \cup N_s} Tr_T_{t,i} \right) \right]$$

Número de Horas en EMERGENCIAS por MP2.5 en Temuco y Padre Las Casas





Memorándum de Entendimiento entre la Subsecretaría del Medio Ambiente, la Organización Mundial de Meteorología, a través del Global Atmosphere Watch Urban Research Meteorological and Environmental Project (GURME) y la Dirección Meteorológica de Chile

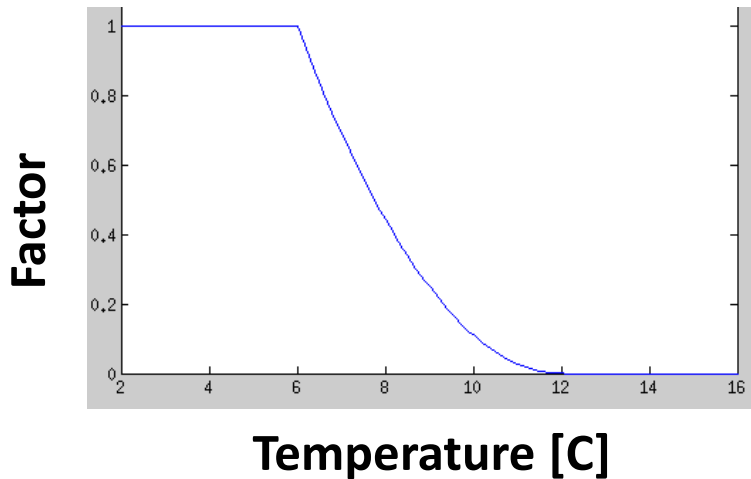
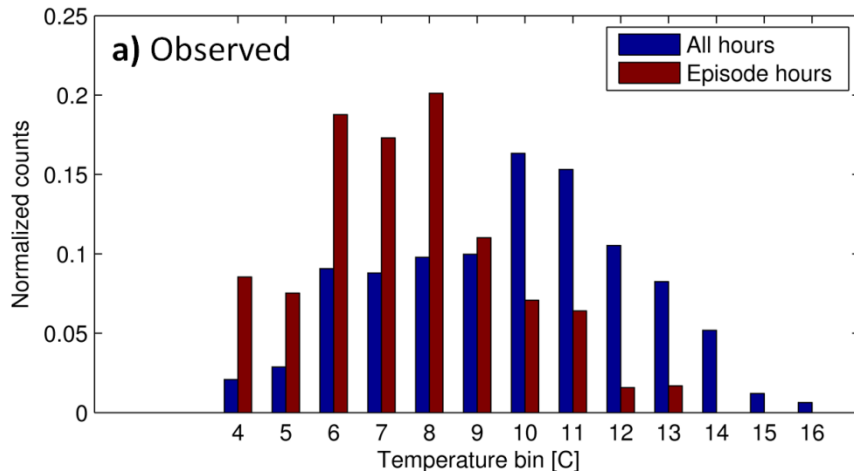
Proyecto Piloto

Mejoramiento de las Capacidades Técnicas para el seguimiento y Pronóstico Meteorológico y de la Calidad del Aire en ciudades de Chile.

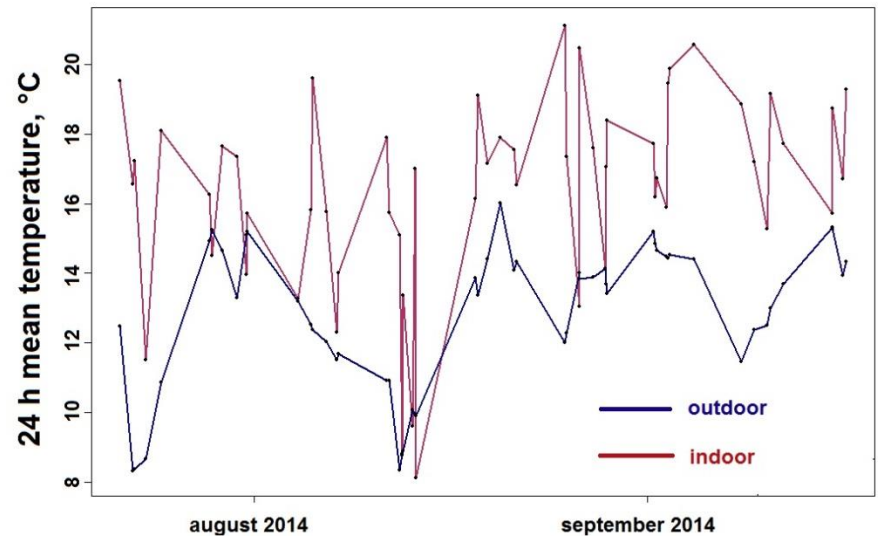
Pilot project tasks

- **Emission inventories improvement**

Temperature histograms (Temuco)

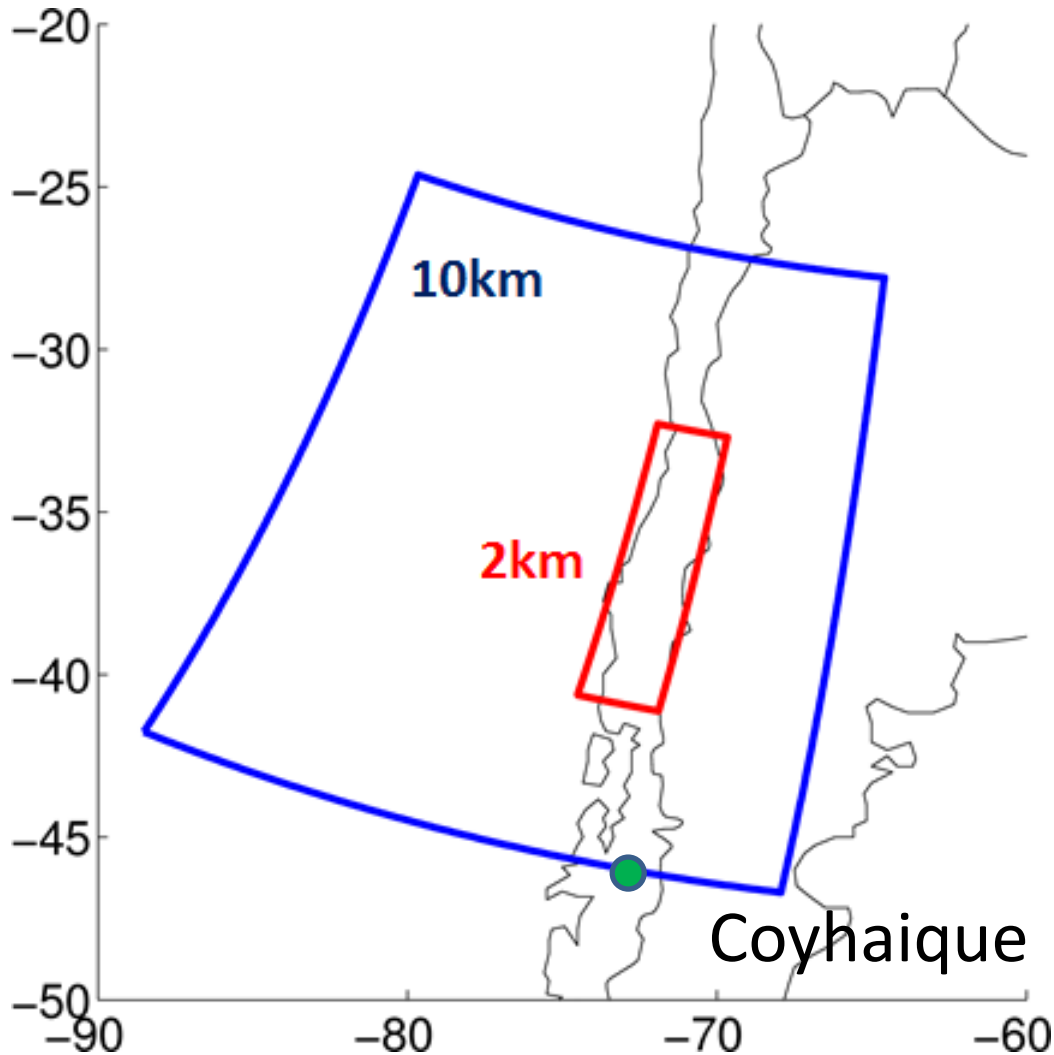


Indoor vs outdoor temperature
(Catholic University, Hector Jorquera)



Pilot project tasks

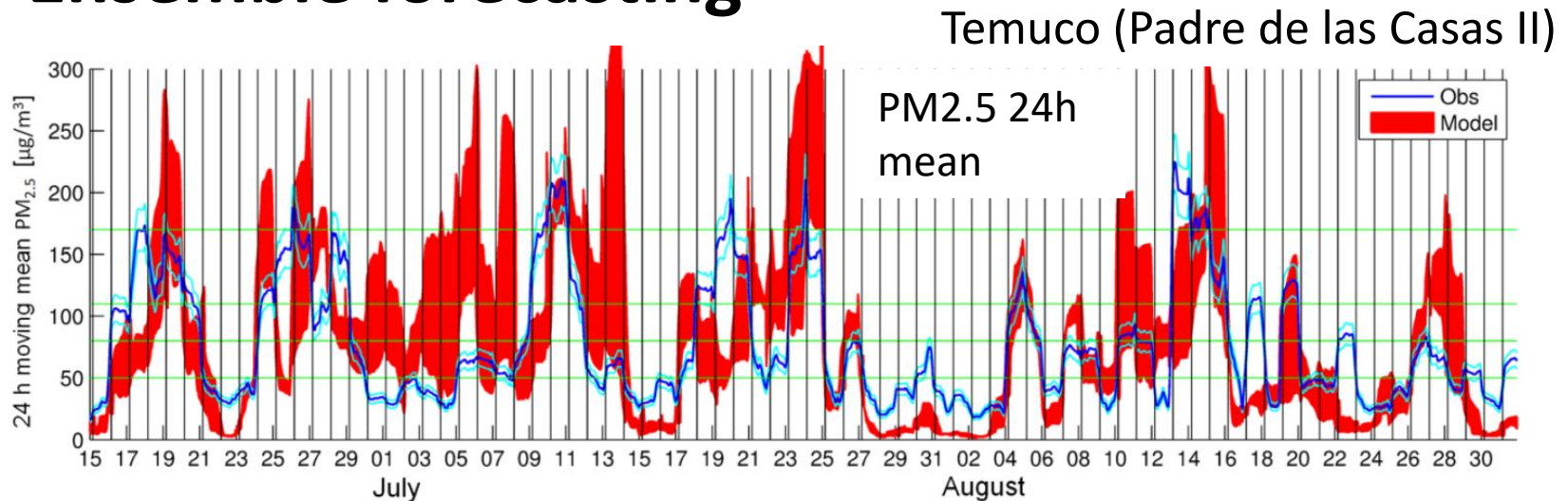
- **Extending the forecast to cities in austral Chile.**



- Coyhaique is one of the most polluted cities in Chile
- Local authorities really need (and requested) a tool as the one implemented for the other cities

Pilot project tasks

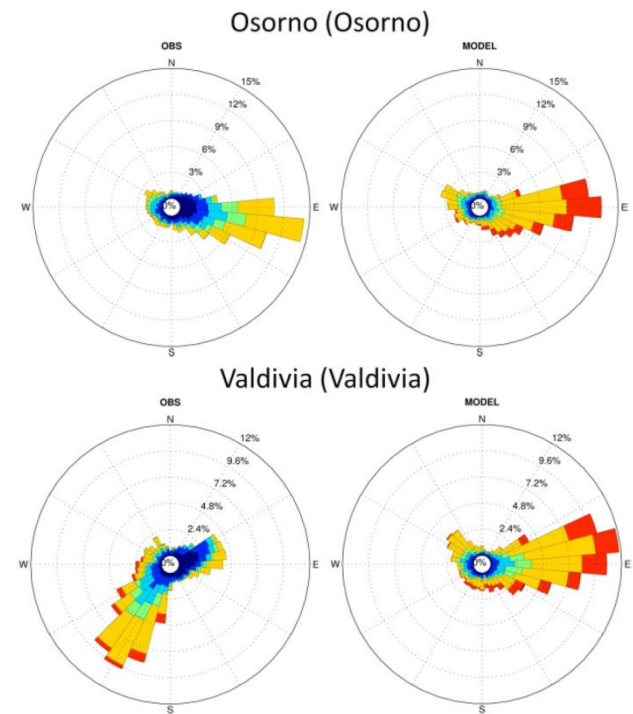
- **Ensemble forecasting**



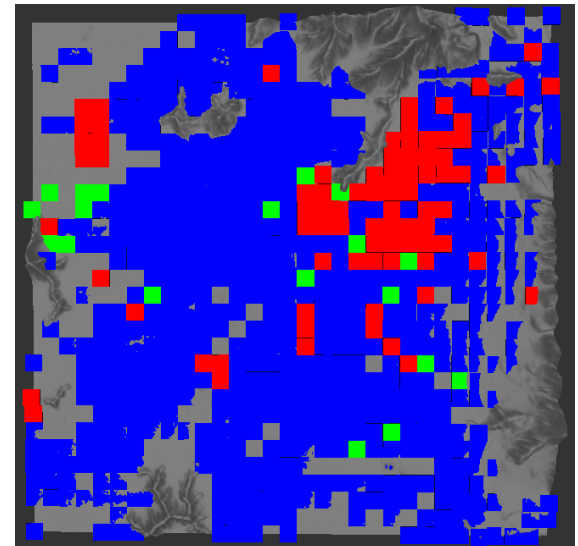
- Type of ensemble: Different global models (GFS vs ECMWF), GFS ensembles, WRF configuration
- Computing power could be an issue
 - MMA purchasing cluster (~128 cores)
 - Explore Chilean National Lab for High Performance Computing (NLHPC) <http://www.nlhpc.cl> resources
 - Chilean met office

Pilot project tasks

- Explore WRF-Chem configuration to improve forecasts
 - Refine spatial resolution for improving wind representation
 - PBL scheme that account the effects that the unresolved topographic features
 - Urban canopy models (T overestimation in Santiago)

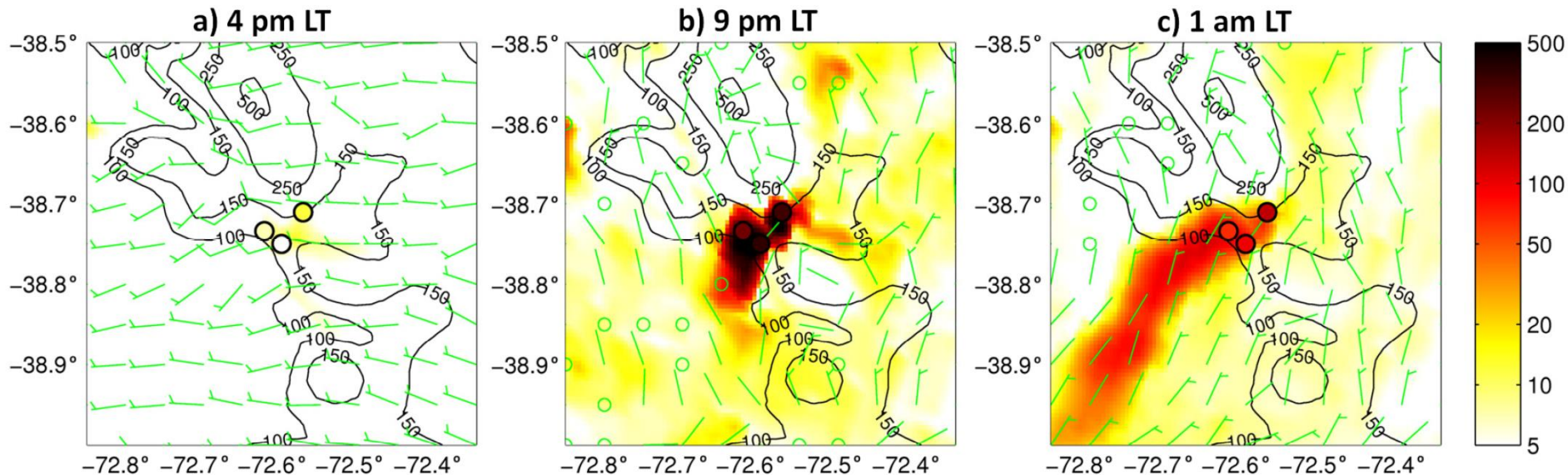


Urban Land use



Pilot project tasks

- Evaluate model representation of the nocturnal shallow boundary layer where pollutants accumulate and get further understanding of it.



Management plan

- Two working groups:
 - Scientific committee to review the research aspects
 - Survey group made of representatives of the community which will evaluate the project performance
- Specifics is lacking on who's performing what and when. Some options:
 - MMA staff. Pablo Hernandez currently checks that the forecasts runs, updates scripts, etc.
 - MMA mentioned the possibility of hiring postdocs
 - Through students in Universities (e.g., U de Chile, Catholic University)

Signing the pilot project



Signing the pilot project



Signing the pilot project

