EVALUATING THE IMPACTS OF POWER PLANT EMISSIONS IN MEXICO

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Outline

- Objectives
- Electricity sector in Mexico
  - Generation
  - Emissions
- Tuxpan Power Plant
- Methodology
  - Selection of modeling domain
  - Selection of modeling periods
  - Dispersion modeling
- Results
- Conclusions
- Recommendations

Objectives

- Estimate the contribution of power plant emissions to ambient concentrations of air pollutants in Tuxpan, México

- Estimate annual concentration of SO_2, $(NH_4)_2SO_4$, NH_4NO_3 and primary PM_{10}

Scope

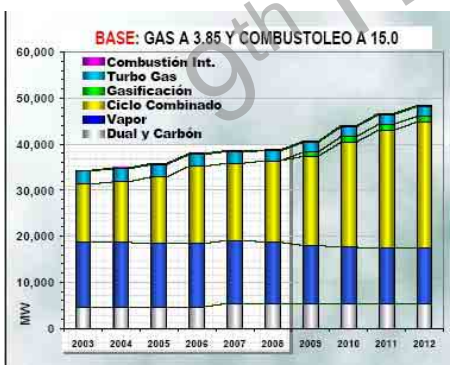
- Estimate the health effects caused by emissions from this power plant in economic terms in order to conduct cost-benefits analysis

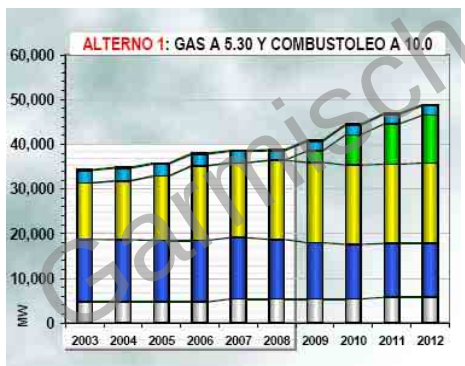
Current situation electricity generation in Mexico

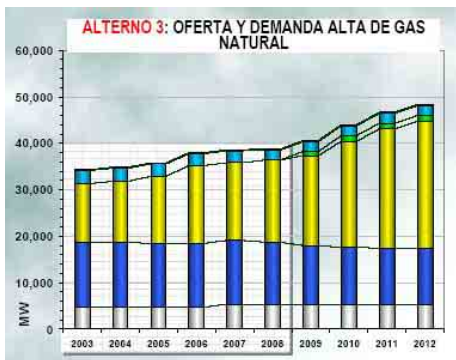
- The country's total effective installed capacity in 2003 was **42,067 MW**

- **67%** corresponds to thermoelectric power plants

  - **Energy Demand Projection (MOSDEC model)***







*Source. Institute of Electricity Research

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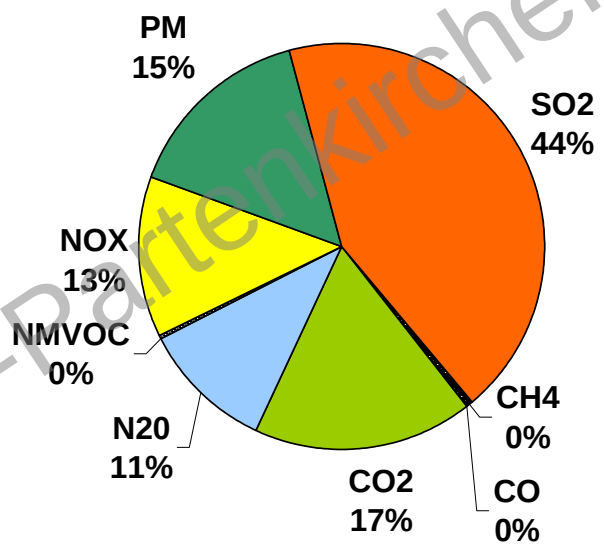
Electricity sector emissions

Share of national emissions (1999-2003)

- **GHGs:**
  17% de CO_2
  11% de N_2O

- **Criteria Pollutants:**
  44% del SO_2
  13% de NO_x
  15% de PM

Average contribution from the electricity sector (%)



Source: National Inventory of Greenhouse Gases in Mexico, National Institute of Ecology

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General features of the Tuxpan Power plant

- Located on the northern coast of the Gulf of Mexico in the state of Veracruz
- Total installed capacity of **2,100 MW**
- **6 steam** generators
- Produces approximately **15,000 GWh** of electricity per year
- Burns **3.7** million m^3 of heavy fuel oil each year
- Sulfur content of fuel oil is **3.8%***

* Source: PEMEX, Mexican Petroleum Corporation

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Emissions from the Tuxpan Power Plant

- Emissions*
  - 257,000 ton/year SO_2
  - 22,000 ton/year NO_x
  - 17,000 ton/year PM_{10}
- Emissions estimates
  - Emission factor recommended by the EPA-EU
  - Compared to emissions calculated using Annual Operations Information

* Source: SEMARNAT, Secretariat of the Environment and Natural Resources

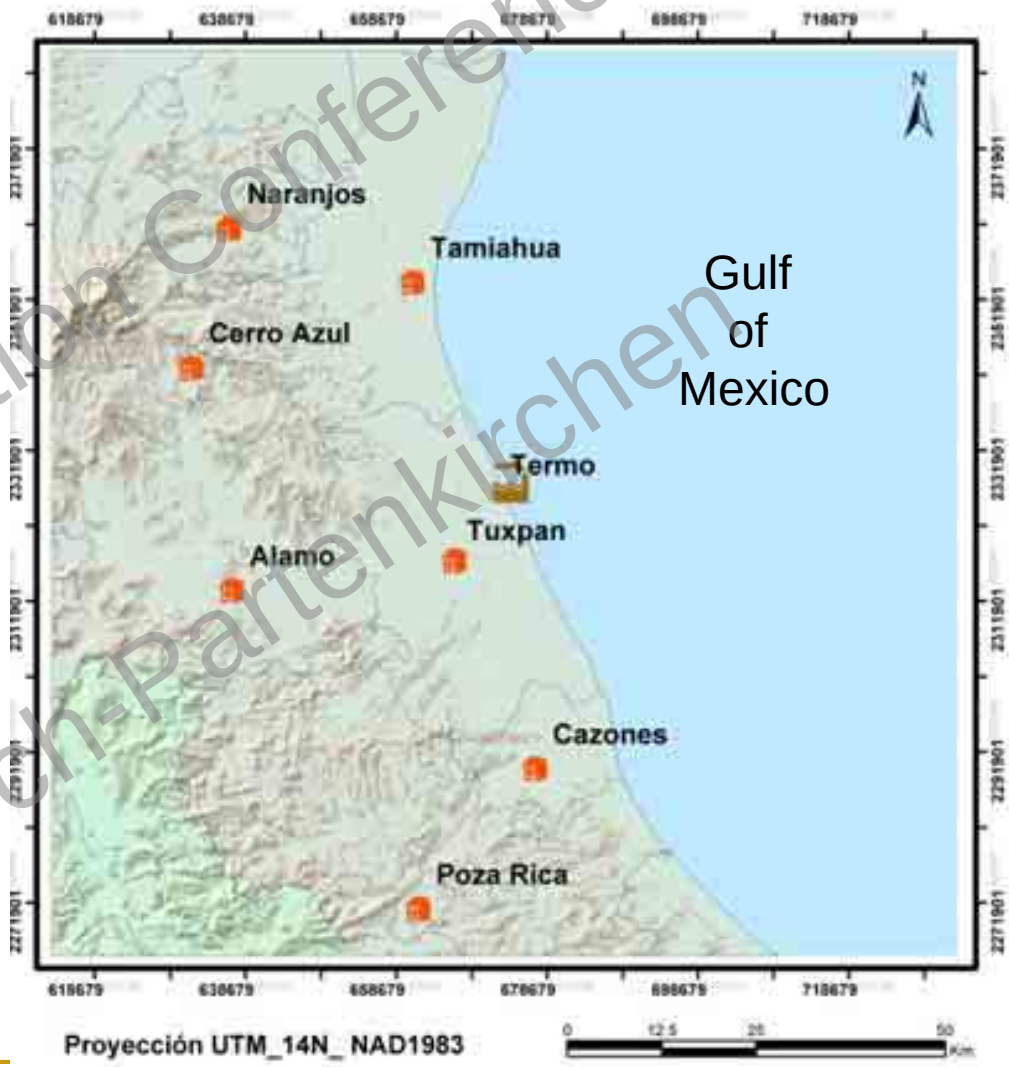
Stack parameters

Parameter	Height (m)	Diameter (m)	Temperature (K)	Velocity (m/s)	NO_x Emissions (tons/yr)	PM_{10} Emissions (tons/yr)	SO_2 Emissions (tons/yr)
Unit 1	120m	5.5m	425-428k	22-23 m/s	7,426	5,795	89,288
Unit 2	idem	idem	idem	idem	7,570	5,908	91,031
Unit 3	idem	idem	idem	idem	6,342	4,948	76,248

Modeling domain

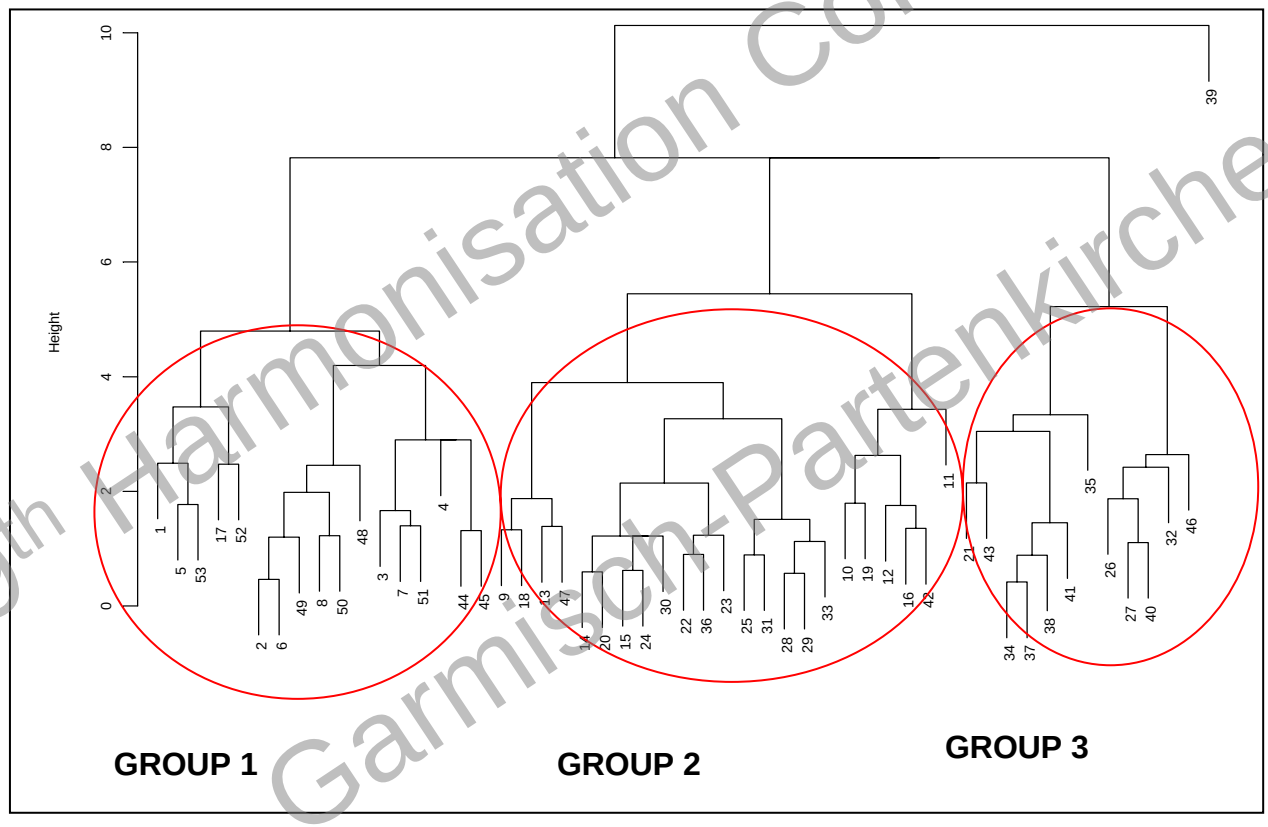
- Include populations located within a 60km radius around the power plant

- This area comprises approximately 791,000 inhabitants of both rural and urban population



Selection modeling periods

Cluster Analysis: Using 52 weeks of meteorological data from the Tuxpan station (2001)

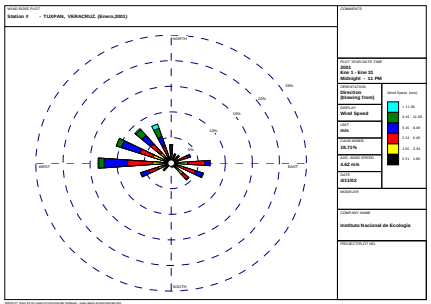


Cluster Analysis Results

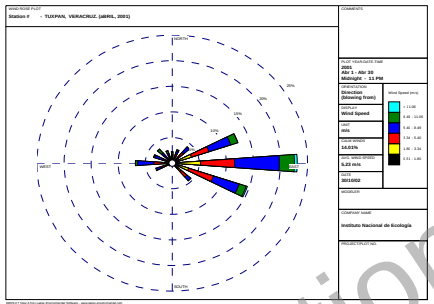
GROUP	# of Weeks	Dominant Months	Wspd (m/s)	T (°C)	RH (%)	PB (mb)	Rainfall (mm)	Representative-ness
1	16	November, December, January y february	4.8	20.3	92.1	1017.5	13.3	31 %
2	23	March, April, may, Jun and July	4.8	26.3	88.5	1012.3	5.4	44 %
3	12	August , September y October	3.9	26.4	91.8	1013.7	109.7	23 %

Wind rose analysis for the study area

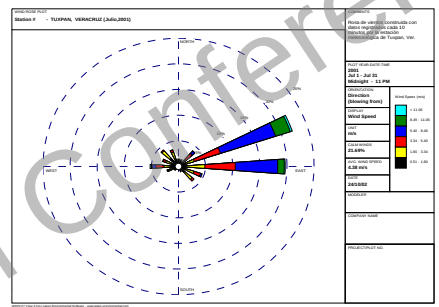
January



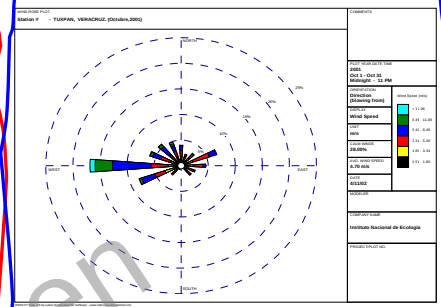
April



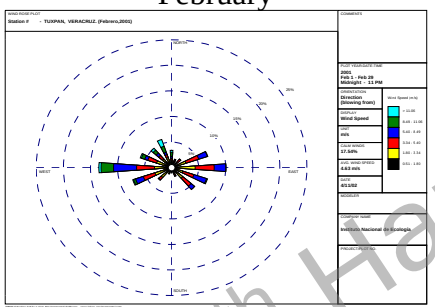
July



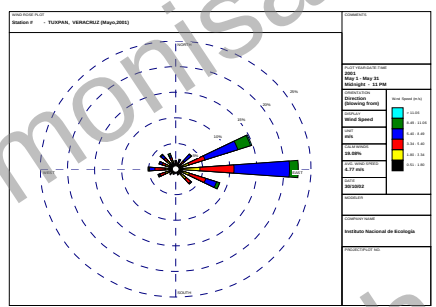
October



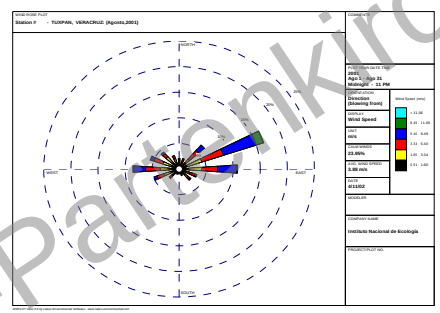
February



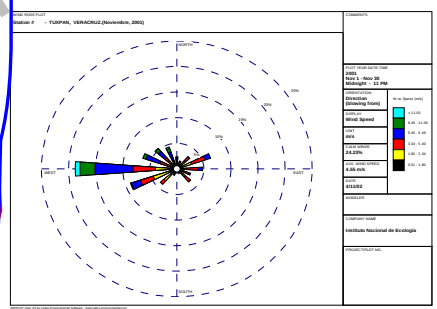
May



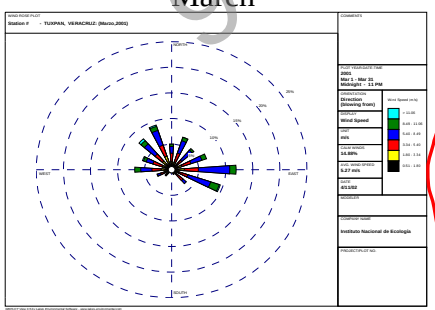
August



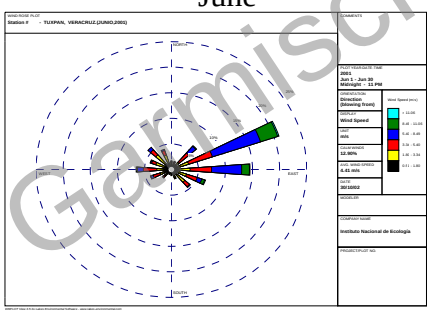
November



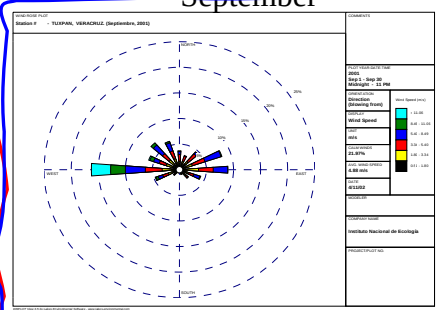
March



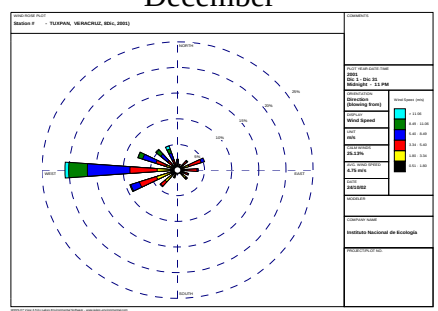
June



September



December



Source: National Meteorological Service

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Dispersion Modeling

CALMET-CALPUFF - MM5 System

- CALPUFF, a non-steady-state Lagrangian Gaussian puff model, was run for the selected weeks to determine concentrations of primary PM10, SO2, and NOx.
- To model the formation of secondary particulate matter species, SO42-, HNO3 and NO3-, we used the MESOPUFFII mechanism.
- CALPUFF default assumptions were used for wet and dry deposition parameters as well as for background concentrations of ammonia and ozone.
- The CALMET model was used to calculate wind fields and micrometeorological variables.
- The MM5 model output was used as an “initial guess field” and then adjusted for kinematical effects of terrain, slope flows, and terrain blocking by CALMET, to produce the wind fields.

Estimating annual concentration

- We ran the dispersion model for each representative week
- The annual average was calculated by weighing the concentration of each group by its frequency

$$C_{annual} = \sum c_i \times f_i$$

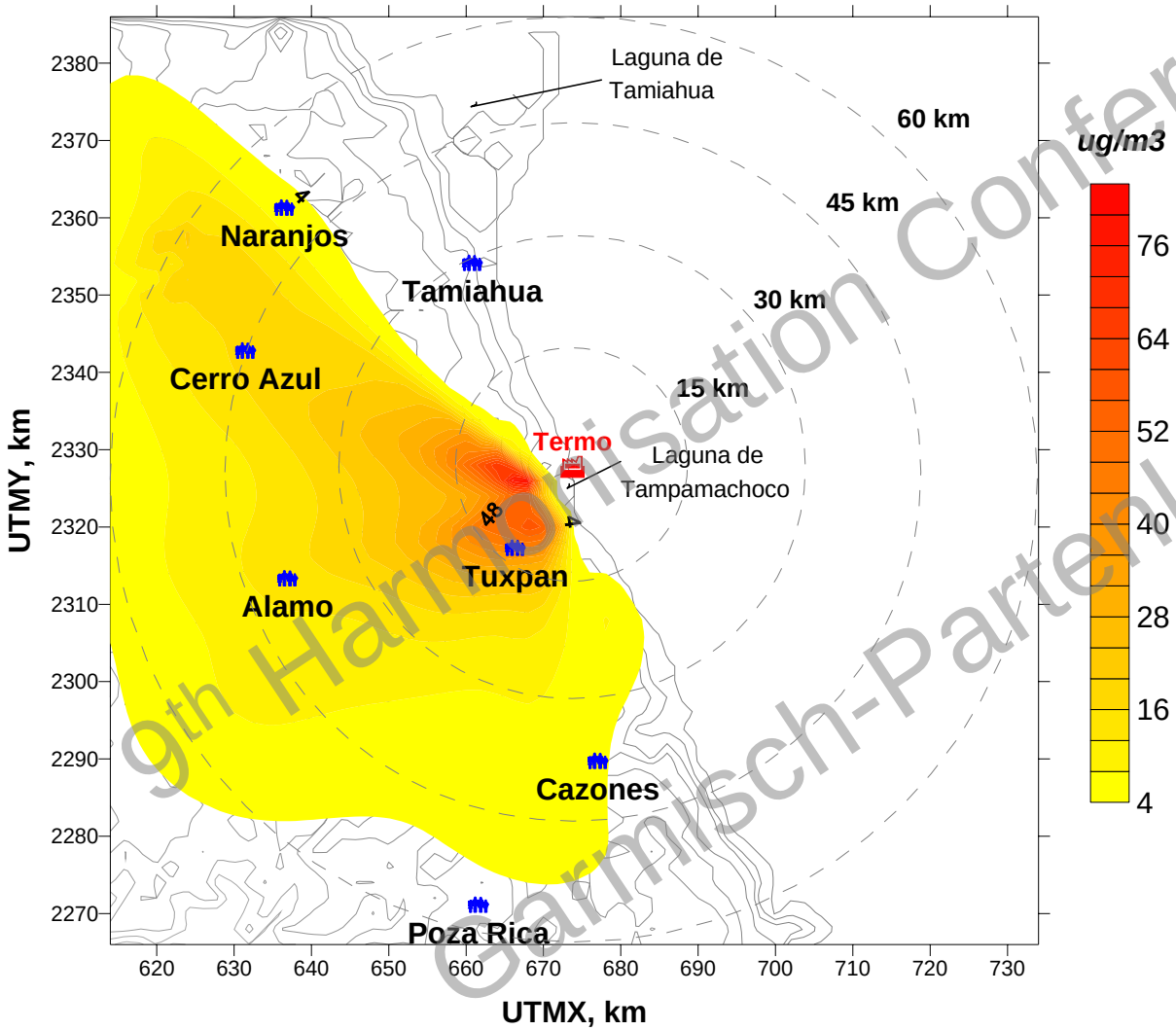
Where,

C_{annual}.- Annual average concentration

c_i .-Concentration for that meteorology

fi .- frequency of occurrence of that meteorology

Results SO_2 (June period)



Most of the effects occur to the west of the power plant

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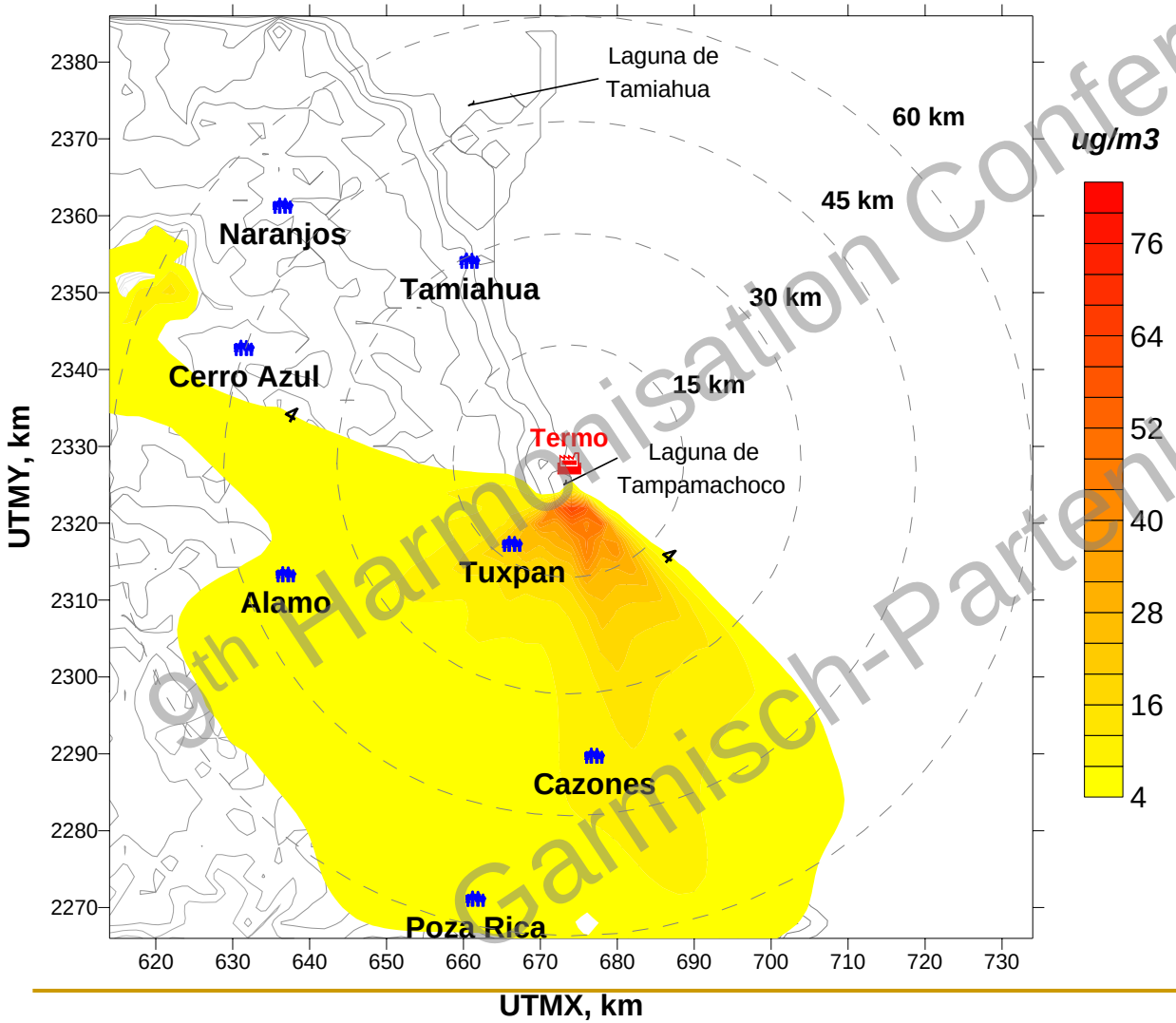
Results SO_2 (November period)



Most effects occur to the south of the power plant

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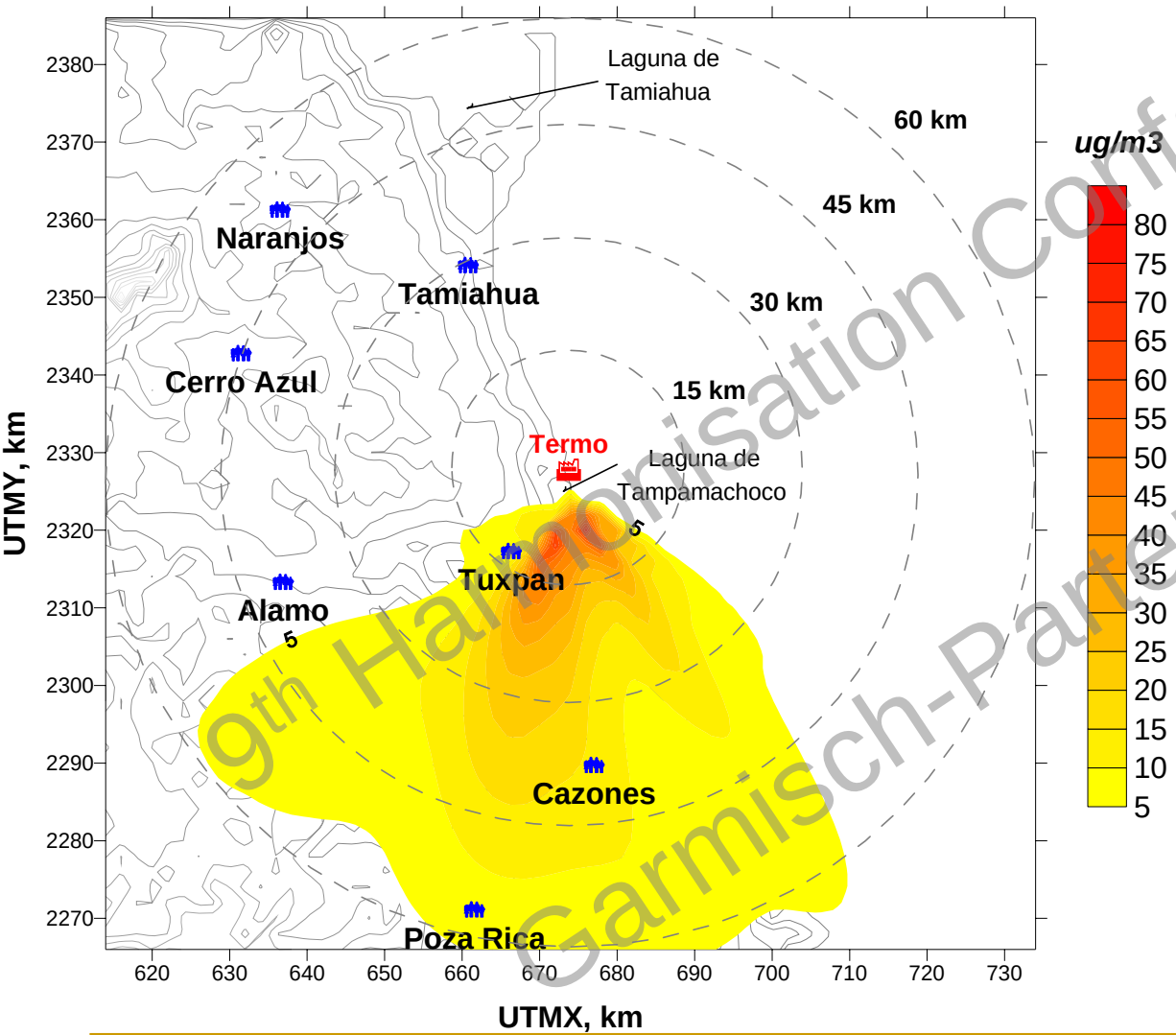
Results SO_2 (September period)



Important effects to the south of the power plant

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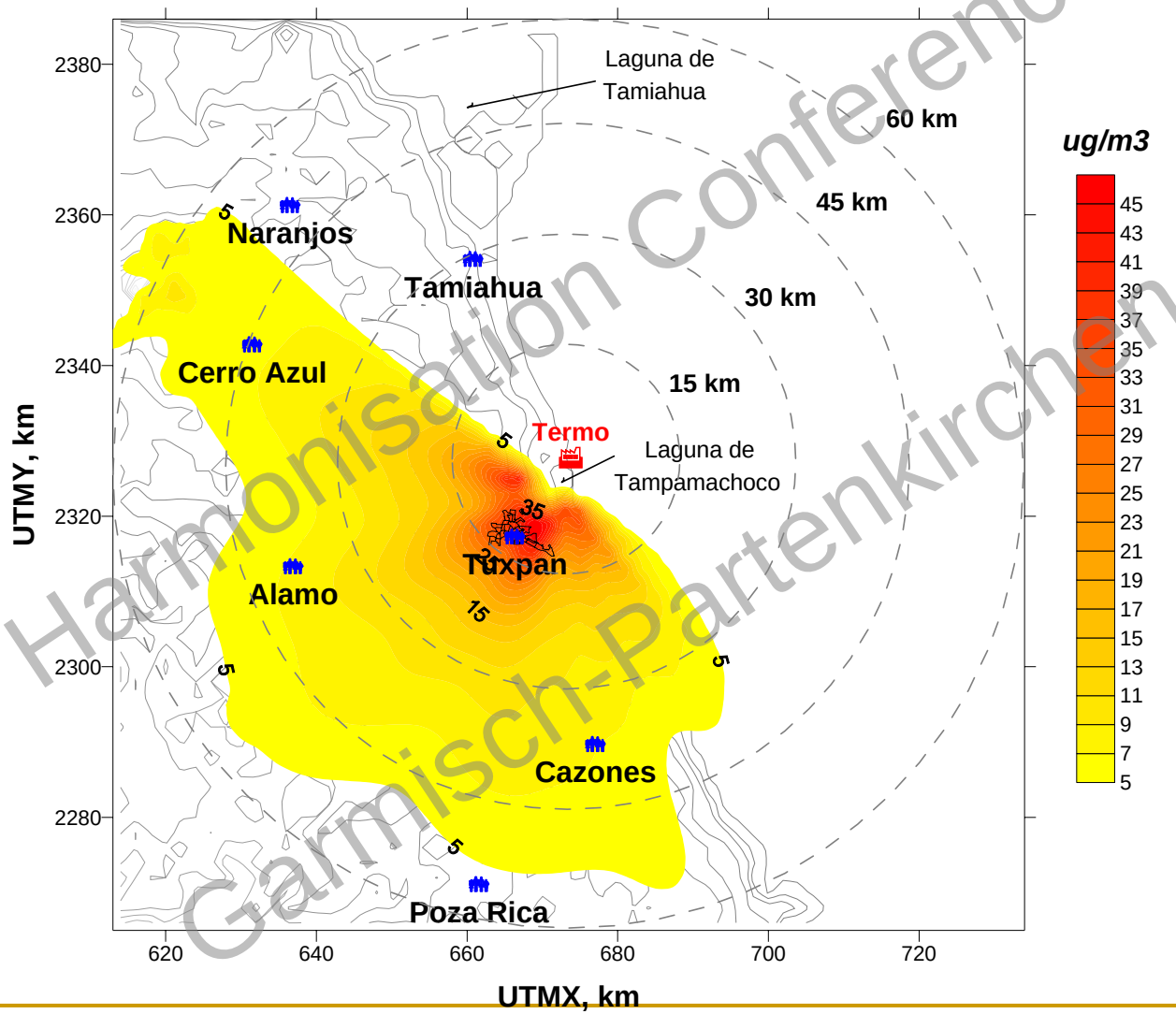
Results SO_2 (Annual concentrations)



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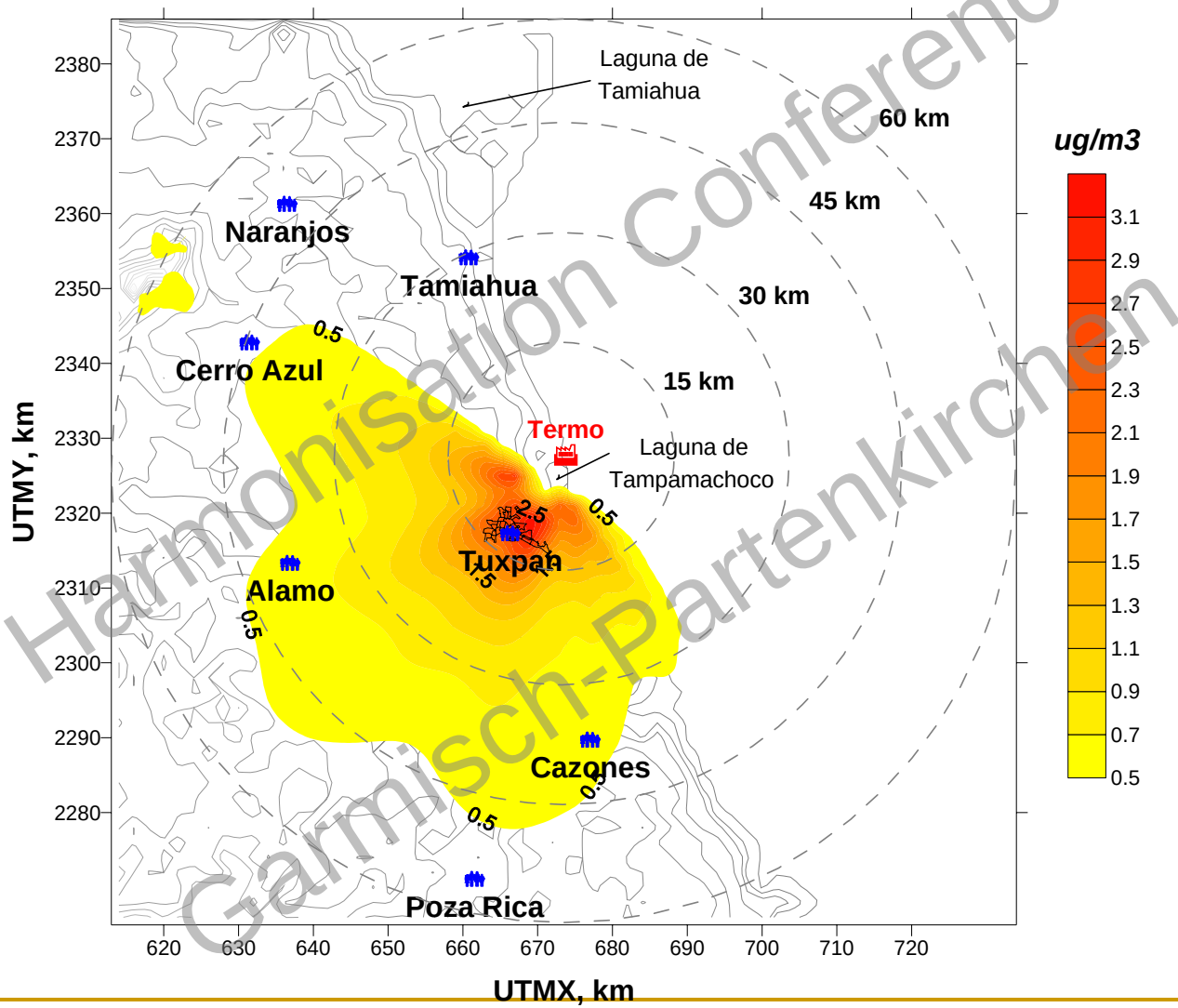
Results for Primary PM_{10} (Annual concentrations)



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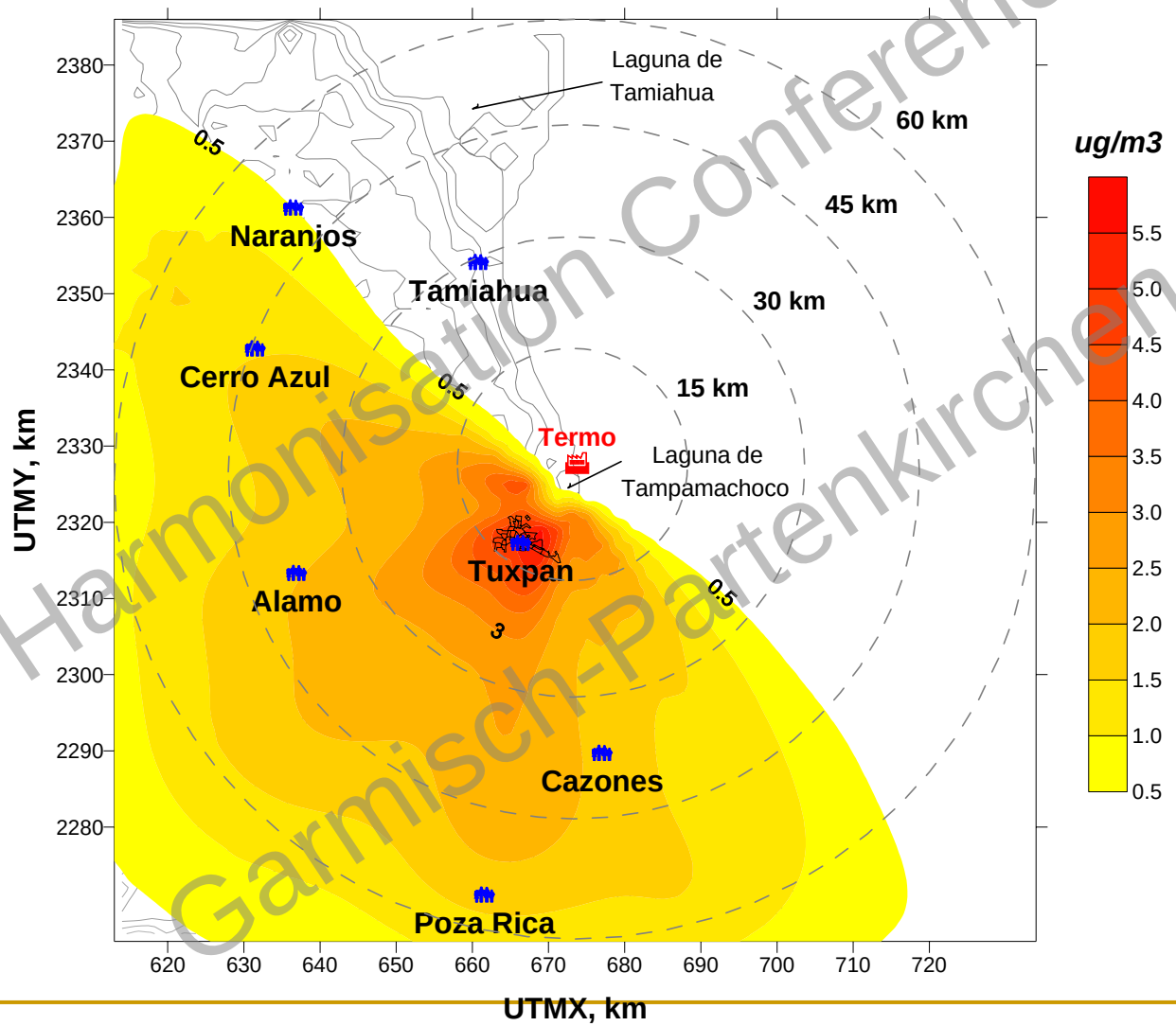
Results primary y secondary PM10

((NH4)2SO4, NH4NO3 and HNO3) (**annual concentration**)



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Conclusions

- Pollutant dispersion in the area is high, due to sea-continent interaction and stack height (120 meter).
- The three weeks selected represent 98% of the meteorological conditions for 2001.
- The June period showed the highest concentration for all pollutants, followed by November and September

Conclusions 2

- Transport of secondary PM (sulfates) extends beyond domain boundaries
- Pollutants are dispersed mainly to the south and west of the power plant.
- The population in the town of Tuxpan is the most affected community.

Recommendations for future analysis

- Expansion of the modeling domain
- Simulation over an entire year
- Incorporation of other relevant sources in the modeling area
- Comparison with air quality measurements from a field campaign
- Estimation of the health effects

Health effects (preliminary results)

- Emissions from the power plant could result in approximately 30 deaths annually (90% CI: 10 - 56).
- After applying the appropriate value of statistical life for the region, we find the total social annual cost of the power plant emissions to be approximately 25 million dollars
- Secondary particulate formation contributes approximately 70% to the mortality impacts, most of which comes from secondary sulfate formation (62% of total impacts).
- This is largely due to the high S02 emissions and the preference of ammonium to react with sulfate over nitrate, consistent with results from similar analyses (Levy and Spengler, 2002).

Thank you for your attention

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