STACK CONFIGURATION AND METEOROLOGICAL INFLUENCES ON THE SIMULATION OF A LARGE POWER PLANT PLUME

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ABSTRACT

The application of CALMET/CALPUFF modelling system is well known, and several validation tests were performed until now. However, most of them were based in specific experiments with a large compilation of surface and aloft meteorological measurements, not always available. In addition, the use of an operational large smokestack as tracer source is not so usual. In this work, CALPUFF model is applied to simulate the local dispersion of SO_2 (as tracer) from the smokestack (356.5 m height) of a large coal-fired power plant in NW of the Iberian Peninsula. Considering: both different stack configurations and meteorological inputs, as follows: (1) This stack includes four independent liners in the same structure, so either a single virtual point source or four point sources at the same location were tested. (2) As CALMET input, the use of surface and aloft meteorological measurements vs. WRF meteorological model outputs are compared.

CASE STUDY: AS PONTES POWER PLANT

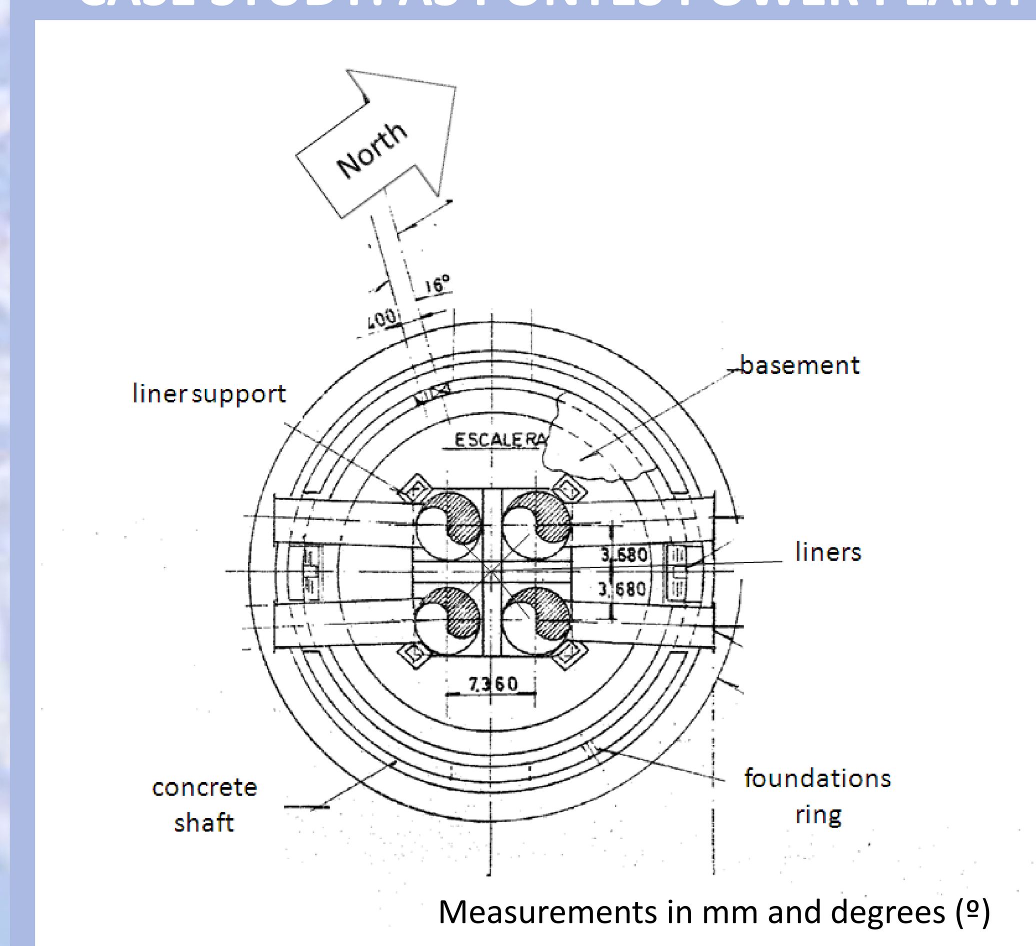


Figure 1. Stack top view, with the four liners inside it.

As Pontes Power Plant is a 1400 MWe coal-fired power plant located in the Northwest of the Iberian Peninsula, at the Southwest of Europe. Until year 2006, this facility burnt a mix of local lignite (2% in S) and foreign subbituminous coal (0.1% in S) (Dios et al., 2013) with a typical 70:30 weight ratio. Its smokestack (356.5-m height) is composed by four liners (one per boiler) in the same concrete shaft (Figure 1). As the largest source in this area, SO_2 pollutant can be considered as a tracer of this power plant emissions. An air quality network with 17 glc sites (Figure 2) monitors the power plant emissions impacts, as these sites are distributed considering the most frequent winds combined to sporadic stability conditions which are favorable to fumigation episodes.

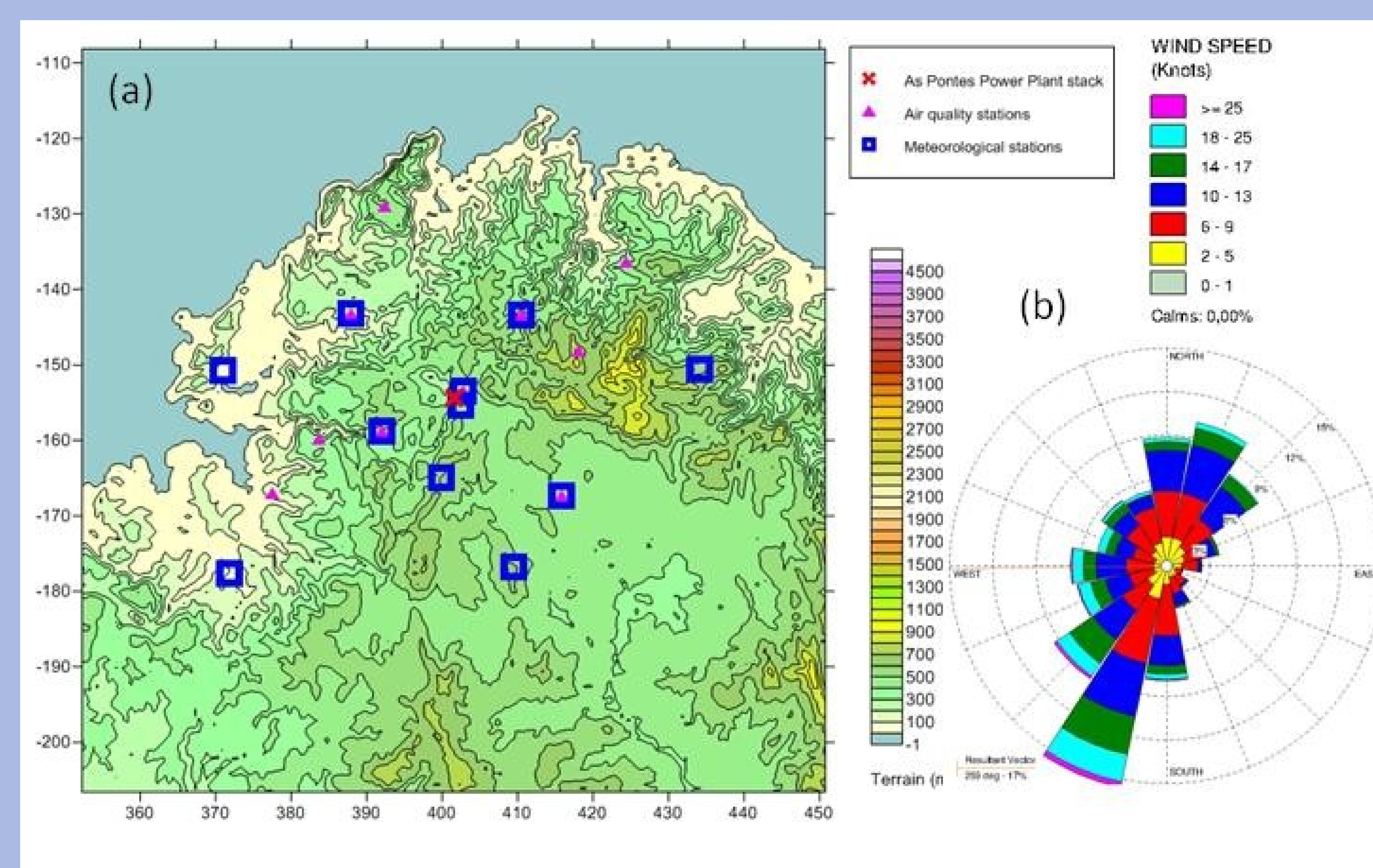


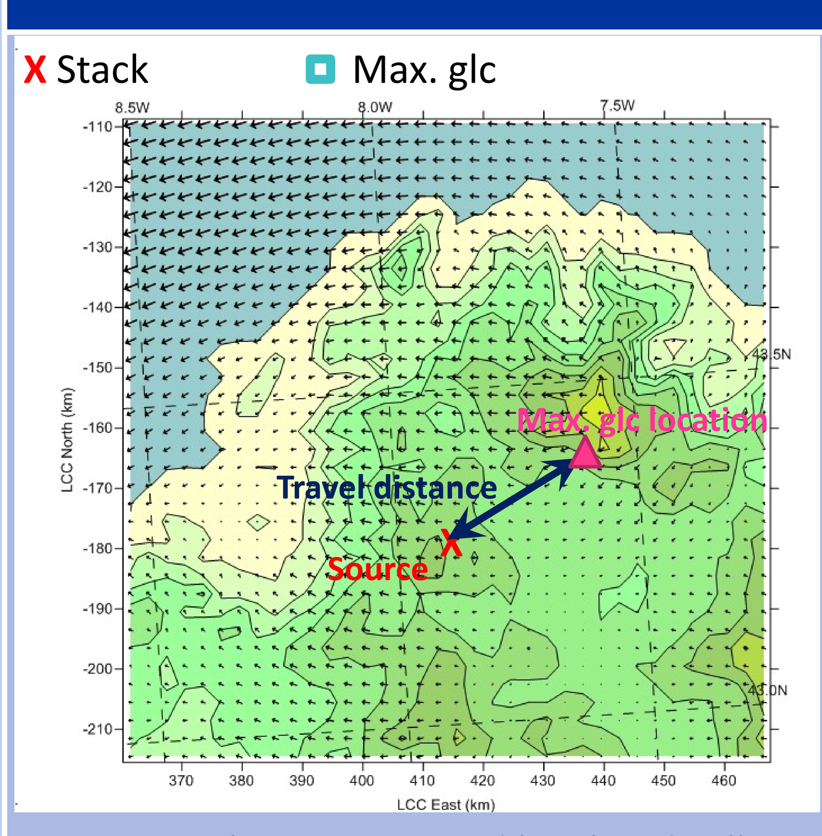
Figure 2. (a) Simulation domain around As Pontes Power Plant stack, where CALMET 0.5 km² grid resolution is applied; (b) typical annual wind rose in this region.

MODELS AND METHODS

CALPUFF (Scire et al., 2000)	CALMET (Scire et al., 2000) METEOROLOGICAL INPUTS to 0.5 km² grid resolution	
	WRF MODEL	METEOROLOGICAL MEASUREMENTS
CALPUFF model was applied, specially for two processes: (1) Entrainments, very usual in large stack plumes with significant plume rise. (2) Complex terrain (land use/topography) over this coastal region with changeable weather.	WRF model (Skamarock et al., 2008) simulations (3 km² grid resolution), with GFS 1º reanalysis as initial and boundary conditions (Hernández et al., 2012).	Surface and aloft meteorological measurements from eleven surface meteorological sites (Figure 2), and one rawinsonde (twice-a-day) at the West part of the simulation domain.

RESULTS

COMPARISON METHOD (De Castro, 2001)



Maximum glc at any ground level grid cell:
(a) Simulated: From CALPUFF results
(b) Interpolated: From glc measurements (De Arellano et al., 1993)

$$c(j) = \frac{\sum_{1}^{ns} c_n \times \exp\left[\frac{1}{r_n(j)}\right]}{\sum_{1}^{ns} \exp\left[\frac{1}{r_n(j)}\right]}$$

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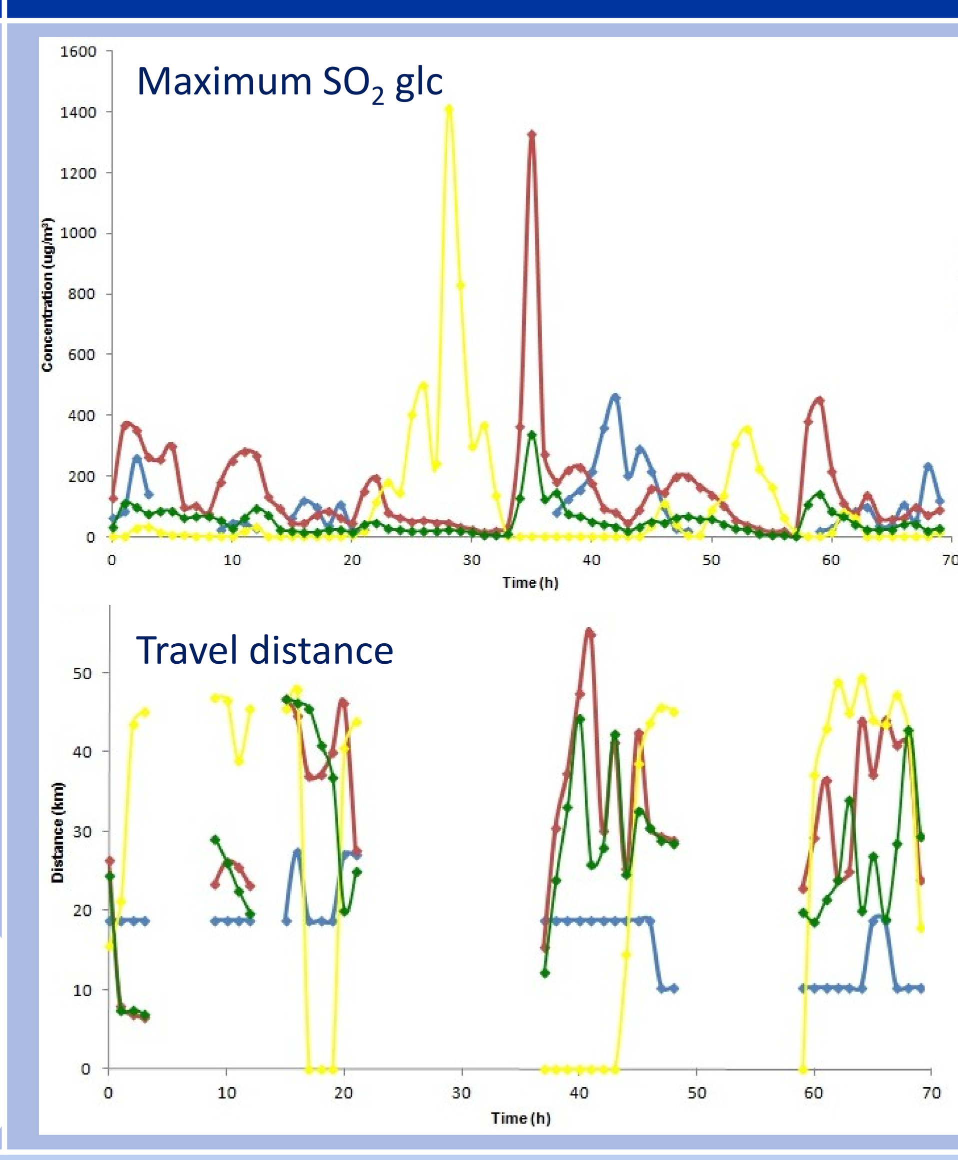
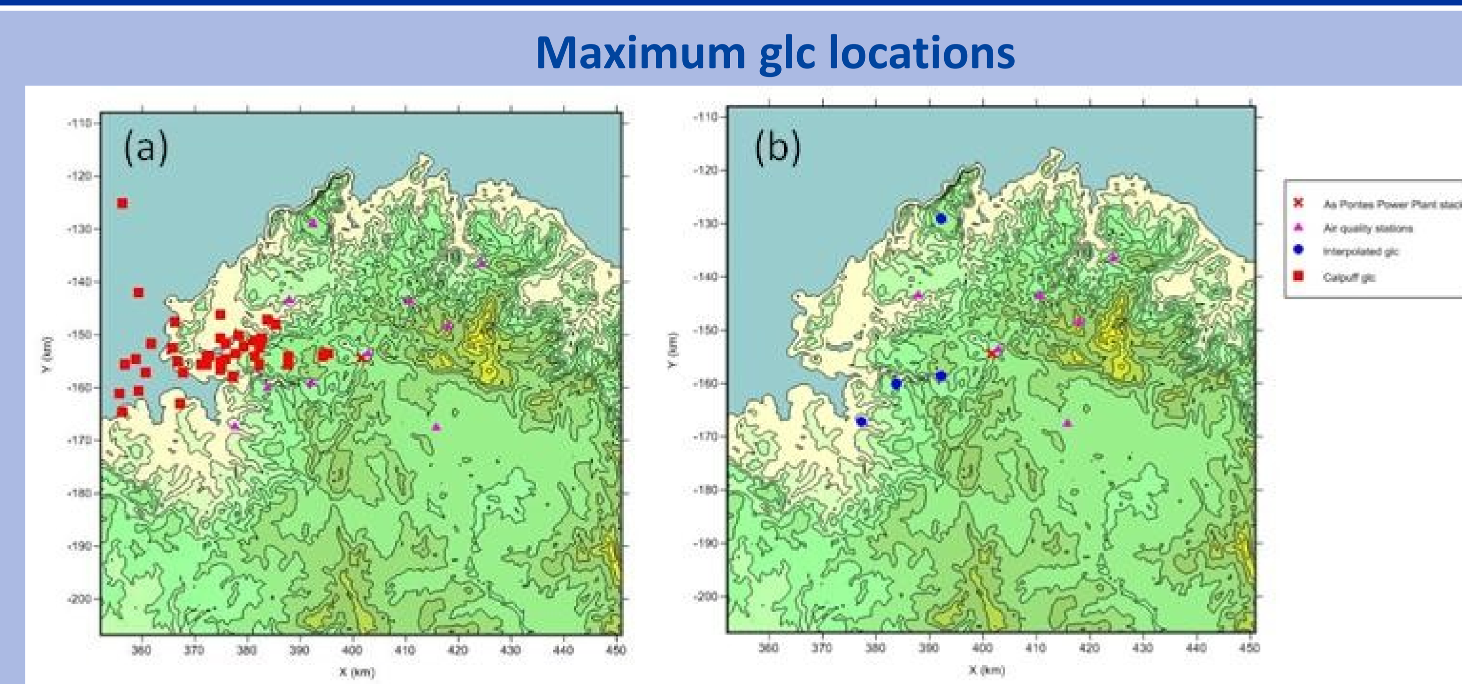


Maximum glc locations



(a) Calculated using Calpuff_1 (b) Interpolated from glc measurements

TIME SERIES COLORS

Interpolation: From glc measurements
Calpuff_1: WRF data with 4 liners ← **BETTER AGREEMENT**
Calpuff_2: Meteorological measurements with 4 liners
Calpuff_3: WRF data with 1 virtual liner

CONCLUSIONS

Results of CALPUFF model using different configurations for the simulation of a large smokestack emission show that CALMET meteorological output based in a regional numerical meteorological simulation, using WRF, provides better glc results than using a limited meteorological measurements dataset input; especially, due to the limited aloft measurements available. In addition, a more realistic smokestack (which is actually divided in four independent liners) provides higher and more realistic glc than a virtual one liner-chimney; although some simulated glc peaks could not be detected, due to the limited air quality network area. This better agreement is more apparent comparing the travel distance values to the maximum glc locations, which are usually higher using CALPUFF results that applying glc measurements interpolation; this result enforces the possibility of none detected SO_2 peaks.

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