THE STATE OF SOLAR ENERGY RESOURCE ASSESMENT IN CHILE

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ABSTRACT

The Chilean government energy policy has determined that a renewable energy quota of the electrical energy generated must be met by 2024, which has sparked interest in the introduction of renewable energy systems to the country. Solar energy is being considered for demonstration CSP plants and for domestic water heating applications, which makes necessary an adequate resource assessment plan. We intend to review the solar energy data which is currently available in Chile. One of the databases is 20 to 40 years old, with measurements taken by pyranographs and Campbell-Stokes devices. Another database is composed by pyranometer readings, sparsely distributed along the country, with a number of these stations intermittently measuring incoming radiation. The Chilean government has contracted the formulation of a simulation model and also the deployment of a single measurement station in northern Chile. Recent efforts by the authors have resulted in a preliminary assessment by satellite image processing. Monthly mean solar energy maps are created and compared from ground measurements and satellite estimations. It is found that the solar energy levels throughout the country can be considered as high, and it is thought that they are adequate for energy planning activities, although not yet ready for power plant design and dimensioning.

1. INTRODUCTION

Chile is located in the west coast of the southern half of South America, the country being a narrow strip of land twice that stretches about 4,300 km, with an average width of about 170 km, and that may be divided into three macro zones: In the north, the Atacama Desert stands as the driest place on Earth, with characteristic sandy and rocky terrain. It is followed by a central valley where most of Chile's population lives and where productive lands are located, having a mild climate. Continuing south, a barely populated system of islands, fiords, and low mountains with a tough, cool, and damp climate is found. Sidewise, from the Pacific Ocean, about one-third of Chile is defined by a low coastal mountain chain, followed by a central valley, and then by the rugged Andes chain. This diversity of geographical features and climates makes generalizations meaningless, and has a great impact on the availability of renewable energy sources and their proper assessment. The country has limited energy resources apart from hydroelectric capacity, and the internal fossil fuel production is in permanent decline and negligible. It heavily relies on fuel imports to meet its growing energy demand, making it a growing net importer of energy. Renewable energy sources in use by the country comprise only hydroelectricity and wood-based biomass. In the best case, renewable energy sources only account for 24% of primary energy consumption, while non-renewable sources account for the other 76%. As shown in Figure 1, the consumption of primary energy (Ep) has steadily increased, and it is projected to continue doing so as the country further develops (CNE, 2008). Starting in 1997, low cost natural gas imports from Argentina have increased steadily, making the resource the second in importance, after crude oil. Since in 2004, Argentina has been unable to satisfy both its internal demand and the contracted exports to Chile. As a result, severe and frequent supply interruptions have forced industry and power generation sectors to switch to alternative fuels, mainly coal and diesel. As briefly seen, Chile depends in a great percentage (historically around 70-80%) on fossil fuels, which are almost 100% imported. Thus, the energy supply situation makes it of critical importance for the country to achieve three primary strategic goals: first, to provide adequate energy supplies in order to continue its economic growth; second, to ensure that imported energy is accessed through international markets to satisfy any requirements that cannot be met by indigenous production; and third, to ensure the development of indigenous energy sources at a sufficient rate such as needed for the substitution of imported energy resources in order to rapidly achieve energy security and a degree of energy independence with a view to align the country with the sustainable development principles.

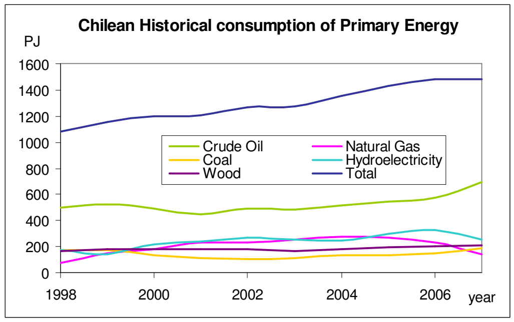

Figure 1: Historical consumption of Primary Energy

Renewable energy potential: Chile is thought to be abundantly endowed with renewable energy resources: hydro, geothermal, wind, and solar. However, no large scale renewable energy resource assessment has been conducted for wind and solar, and therefore, any energy planning effort that considers these renewable sources is seriously impeded for the time being. In what concerns to this work, solar power is used scarcely, mainly through photovoltaic panels in rural electrification and also in a growing market for solar water heating applications, which by 2009 had a cumulative surface of less than 10,000 m^2. The total contribution of solar energy to the energy mix until 2009 is therefore negligible. In contrast, the Atacama Desert in the northern part of the country is one of the best regions for solar energy, based on energy density data from several sources (Goswami et al 2000, Duffie and Beckman 2006). Unfortunately, the population in the vicinity is rather scarce, which would force the implementation of energy distribution schemes in order to make any solar-generated energy supply available to the population and industries located in the central part of the country. However, northern Chile concentrates most of the mining activities which comprise the country's main economic activity, and therefore there is ample demand growth for electricity and industrial heating and cooling, which may be possible to supply in fraction by renewable energy systems.

Solar energy resource assessment in Chile dates from the 60´s, when efforts were conducted by Universidad Técnica Federico Santa María by compiling data from around 90 pyranographs and Stokes-Campbell devices, spanning a period of about 20 years. Most of this data has a relatively large uncertainty level proper of the outdated sensors, thus making it unsuitable for energy planning at the national policy level. However, the monthly mean data is thought to be useful for solar water heating applications, and is readily available at Sarmiento (1984). A proper Chilean atlas of solar energy, with actual data of low uncertainty, is not available to the public or planning authorities, and it is part of the reasons why solar energy has not being considered in Chile as a major energy source. Moreover, no typical meteorological year (TMY) has been formulated for the county, which therefore makes it necessary to compile solar radiation data of acceptable quality in order to facilitate the development of solar energy in Chile. In what follows, we will review and analyze the available solar energy data from ground stations, compare it to satellite-derived measurements obtained by the Brazilian National institute of space research *INPE* and simulations from Universidad de Chile, and propose radiation maps that intend to serve as temporary data sources while an adequate effort is made in order to accurately assess the solar energy potential available in Chile.

2. SOLAR RADIATION MEASUREMENTS

Solar radiation data for large spatial regions can be obtained from ground station networks, which provide discrete data points from which a continuous map can be obtained by means of a proper interpolation scheme. In addition, surface radiation can be estimated by satellite data processing. The latest Brazilian Solar Atlas (Pereira et al. 2006), for example, combines both measurement techniques in order to obtain data with low uncertainty levels. Pyranometer based measurements from ground stations typically have lower uncertainty levels that satellite-derived data obtained by radiative transfer models, although this cannot be guaranteed for locations in between stations, for which data has computed by means of interpolation schemes. However, it has been shown that uncertainty levels for ground stations data are higher than satellite-derived measurements whenever the distance between stations is larger than 35 km (Perez et al, 1997).

Available ground station data: Information for this study is available from three sources: a database of ground station measurements from 89 stations along the Chilean territory, data from the Chilean Meteorological Service, and a recently deployed station at Pozo Almonte.

National Solarimetric Archive: The ground station database is under custody of the Chilean *National Solarimetric Archive*, located at Universidad Técnica Federico Santa María, Valparaiso, and kindly supplied to us by Professor Pedro Sarmiento, author of several interesting books and an excellent sort of fellow. The stations were not operated continuously, but from as much as 21 years and as low as 2 years (Cáceres, 1984), as Table 1 shows. Measurements for the stations range from complete years to incomplete years. In some cases, the station was active for as short as three months in a given place before moving to another location. According to German DLR, a minimum of 8 years data is needed in order to get an uncertainty level of 5%. Therefore, the data from the archive might have uncertainties as high as 20% associated to the measurement period, plus the uncertainty which is inherent to the use of actinographs. Details about the stations location and available years for data are shown in Table 1. In addition, there is no information about sensor calibration or expected uncertainty levels. A Kriging method (Davis, 1986) was utilized by the authors of this work for interpolation of the 89 stations data in order to create a contour map of monthly means.

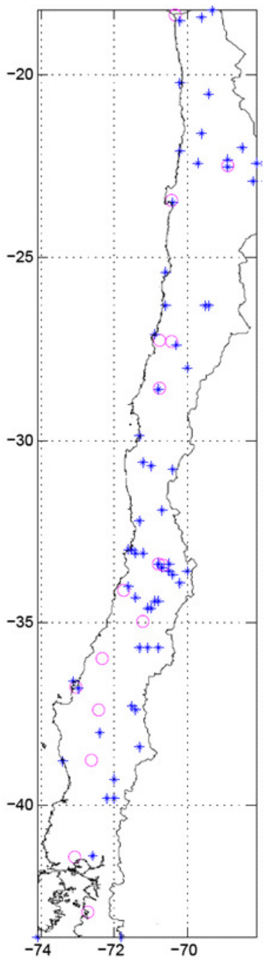

Figure 2 (left): Locations for the different ground stations. Blue: National Solarimetric Archive. Magenta: National meteorological service.

Table 1: Years for which data is available from the National Solarimetric Archive, for selected ground stations.

Table of some Solarimetric Station Location and the state of Data Series between 1961 and 1984.

	Locations	Lat	Long	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84
1	Arica	-18.50	-70.17			•	•	•	•	✓	•	✓	✓	✓	✓	✓	✓	•									
2	Iquique	-20.22	-70.15					✓	✓	•				•	✓	✓	✓	•									
3	Chuquicamata	-22.32	-68.93	•	✓	•	•																				
4	Calama	-22.47	-68.92											•	✓	✓	✓	•									
5	San Pedro de Atacama	-22.92	-68.18						•	✓	✓	✓		•	•												
6	Antofagasta	-23.47	-70.43									•	✓	✓	✓	✓	✓	•									
7	Copiapó	-27.35	-70.33			•	✓	✓	✓	✓	•	✓	✓	✓	✓	✓	✓	•									
8	Vallenar	-28.58	-70.77											•	✓	✓	✓	•									
9	La Serena	-29.90	-71.25											•	✓	✓	✓	•									
10	Ovalle	-30.57	-71.18			•	✓	•	•	•	✓	✓	•	•	✓	•											
11	Quillota	-32.17	-71.27																	•	•	•	✓	•	•	•	
12	Valparaiso	-33.03	-71.60		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	•		
13	Santiago	-33.57	-70.68				•	✓	✓	✓	•	✓	✓	✓	•												
14	San Fernando	-34.60	-71.00				✓	•						•		•	•	•									
15	Talcahuano	-36.62	-73.10					•	✓	•																	
16	Concepción	-36.83	-73.03				•	•	•	•	✓	✓	✓	✓	✓	✓	•	•									
17	Pucón	-39.27	-71.97						•	•	•	•	✓	✓	•												
18	Alto Palena	-43.62	-71.78							•	✓	•	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			

✓ **Complet** year of mesures • **Uncomplet** year of mesures

This data is available in monthly mean format for each location and can be consulted at (Sarmiento, 1984). Also, hourly data is supplied for a typical day of each month, from what seems to be a clear day model. No additional information is given in the book regarding statistical procedures utilized to construct the monthly means or the hourly data. This apparent lack of information plus the discontinuous nature of the data prevents considering it as a valid data source for energy planning and power plant dimensioning activities. However, it can still be considered as useful for the general purpose of classifying some geographical regions as having high solar radiation availability and also for solar water heating applications if the associated uncertainty is acceptable.

Meteorological service data: The *Dirección Meteorológica de Chile* (DMC, the state meteorological service) has a series of pyranometers located at meteorological stations covering the main climate regions of the country. By june 2009, a total of 18 meteorological stations with pyranometers have been reported. A number of them are already decommissioned due to maintenance costs, although 9 remain active. Table 2 displays the name, location, and period for which data is available. The data can be requested directly to the DMC at their website *www.meteochile.cl*, and is available to the public at a modest fee that covers processing costs. The data is taken in 10 minute intervals by pyranometers covering the 0.285 to 2.8 μm spectral range, and is presented as hourly-integrated irradiation (Wh/m^2) from which hourly mean irradiation (W/m^2) is easily computed, spanning complete months or years as the customer requests, and is provided in excel worksheets. The pyranometers are properly maintained and calibrated by DMC personnel following internationally-accepted guidelines.

Table 2: Location and registry periods for DMC pyranometer data.

ESTACION	UBICACIÓN			PERÍODO DE REGISTRO
	LATITUD	LONGITUD	ELEVACIÓN	
ARICA	18° 21' S	70° 19' O	58 m	Dic 1995 a May 2002/ Nov 2006 a 2008
CALAMA	22° 29' S	68° 54' O	2270 m	Ene 1996 a Dic 1999/ Oct 2004 a 2008
ANTOFAGASTA	23° 26' S	70° 26' O	135 m	Enero de 1988 a 2008
COPIAPO	27° 18' S	70° 25' O	291 m	Ene 1988 a Oct 2003
DESIERTO DE ATACAMA	27° 15' S	70° 46' O	204 m	07.Jul 2006 a 2008
VALLENAR	28° 35' S	70° 46' O	469 m	Ene 1988 a Oct 2003
SANTIAGO (PUDAHUEL)	33° 23' S	70° 47' O	475 m	Ene 1988 a Dic 2005
SANTIAGO (QTA. NORMAL)	33° 26' S	70° 40' O	520 m	04.Ene.2006 a 2008
HIDANGO	34° 06' S	71° 45' O	296 m	Jun 1989 a Mar 2004
CURICO	34° 58' S	71° 14' O	228 m	Septiembre de 1995 a 2007
CAUQUENES	35° 58' S	72° 20' O	142 m	Ene 1990 a Ene 2001
CONCEPCION	36° 46' S	73° 03' O	8 m	Ene 1992 a 2008
LOS ANGELES	37° 24' S	72° 26' O	109 m	Ene 1996 a Dic 2001
TEMUCO	38° 45' S	72° 38' O	114 m	Ene 1996 a Dic 2001
PUERTO MONTT	41° 25' S	73° 05' O	85 m	Nov 1995 a 2008
CHAITEN	42° 55' S	72° 43' O	7 m	Ene 1996 a May 2001
COYHAIQUE	45° 35' S	72° 07' O	310 m	Mar 1989 a 2008
PUNTA ARENAS	53° 00' S	70° 51' O	37 m	Ene 1998 a 2008

CNE-GTZ ground station: The Chilean *Comisión Nacional de Energía* (CNE – national energy commission) requested the German cooperation agency *GTZ* to conduct a series of renewable energy assessments, including solar energy potential. A single ground station was installed in june 2008 at Pozo Almonte, which is located approximately at (-20.25; -69.78) near the port city of Iquique in the Chilean desert. The station utilizes three Kipp&Zonnen CMP11 pyranometers, a datalogger, wind speed and temperature probes, and is operated by an independent consulting company with base in Arica, approx. 400 km to the north of the station actual location. A PV cell provides power to the station. One pyranometer measures global horizontal irradiance, and the remaining two are mounted into a ST80 solar tracker; the first measuring global irradiance in tracking mode, and the second measuring diffuse irradiance after being covered by a shadow ring. Thus, an estimation of direct normal irradiance is made by subtracting the diffuse from the global reading. The data is freely available to the public from the CNE website *www.cne.cl* in pdf format for monthly reports. The reports include hourly data for a randomly chosen day, daily-integrated data, and a monthly mean summary of all available months. Figure 3 shows a view of the station.

		Solar Radiation [kWh/m²day]			
		Global horizontal	Global-tracking	Diffuse-tracking	Estimated beam normal
2008	August	6,15	8,99	0,62	8,37
	September	7,14	10,47	0,73	9,74
	October	8,11	11,6	0,81	10,79
	November	8,41	11,95	0,88	11,06
	December	8,26	11,22	1,25	9,97
2009	January	8,37	11,67	1,08	10,59
	February	7,6	10,3	1,23	9,06
	March	7,16	10,15	0,91	9,24
	April	6,26	8,91	0,73	8,18
	Mean	7,50	10,58	0,92	9,67

Figure 3: View of the CNE-GTZ station, detailing the pyranometers used in the "tracking" mode (left). Summary of data produced by the station (right).

The station is located in a platform next to a building and a tall power transmission tower. The global horizontal pyranometer is installed on top of a small mast which also houses the datalogger and PV cell. The shadow ring being used is thick, and no correction factor is reported to account for this in the diffuse radiation reading. Additionally, no radiation shields are provided in order to block ground-reflected radiation, and the pyranometers are directly installed on top of a steel plate, without protection from excessive heating which is expected due to the high radiation levels at the Pozo Almonte location. There are therefore several shortcomings in the design, location and operation of this station that might restrict the validity of the measurements. Figure 4 also shows the available data from the station in the form of monthly means for the months of august 2008 to the most recently published of April 2009.

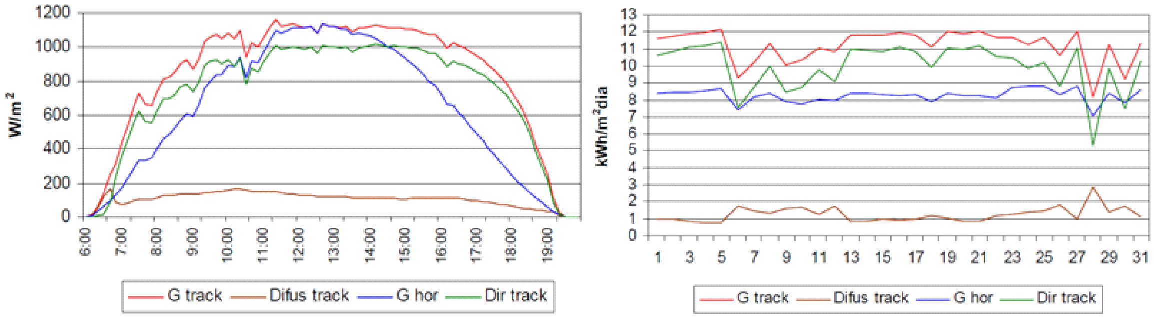

Figure 4: Data from the Pozo Almonte ground station. *Left*: Irradiance for a given day in December 2008. *Right*: Daily-integrated radiation for December 2008.

Figure 2 shows the location of the different stations in the country. Blue crosses indicate stations for which data is available at the National Solarimetric Archive. Magenta circles indicate the locations of DMC pyranometers. The CNE-GTZ station is roughly located at the blue cross right next to the -20 parallel. As can be seen, there are plenty of locations for which data is available, although the data is of varying quality and covers interrupted periods of time.

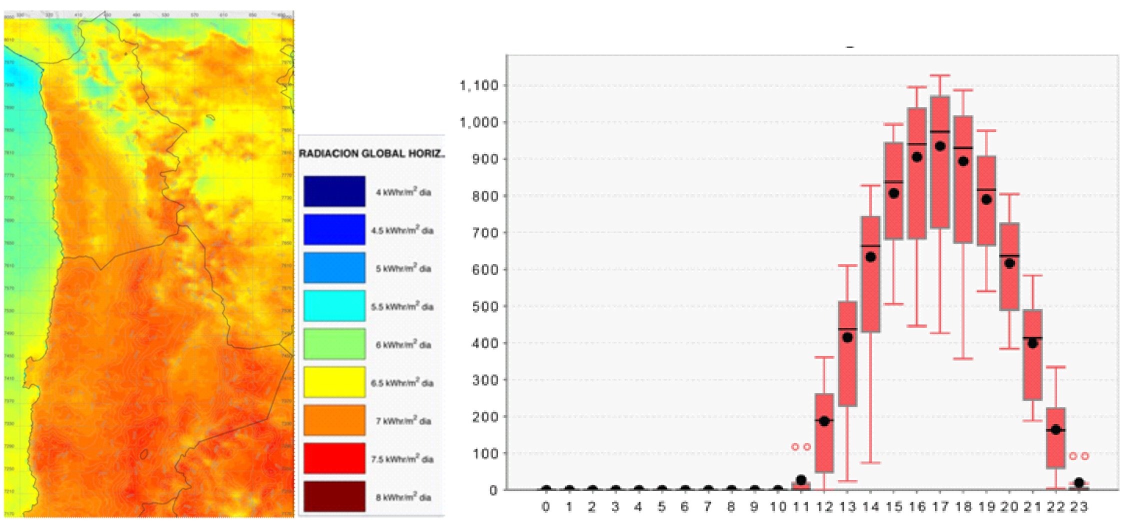

Figure 5: Contour map of annual mean of daily radiation considering the months of march, june, september and december 2006 from the WRF model (left). Daily data for the city of Antofagasta, including march, june, september and december 2006 from the WRF model (right).

Weather Simulation model: Also by request of CNE, a weather simulation model was prepared by the Geophysics department at University of Chile. The simulation utilizes the Weather Research and Forecasting Model (WRF) developed by the National Oceanic and Atmospheric Administration (NOAA), the National Center for Atmospheric Research (NCAR), and more than 150 other organizations and universities in the United States and abroad (as stated by Wikipedia entry: *Weather Research and Forecasting Model*). Information about the model can be easily found elsewhere. The model is initialized and forced by local weather conditions used as initial and boundary conditions, and generally validated by data from weather stations. The computational domain used in the simulations includes the regions of Arica and Parinacota, Tarapacá, and Antofagasta, which are the three northernmost regions of Chile. The covered area is a rectangle of roughly 1000 km long and 400 km wide, which resulted in an intensive computational effort being needed. In order to simplify the simulations, the larger domain was divided into four smaller sub-domains of approximately 60,000 km^2 each. The simulations correspond to the periods of March, June, September and December 2006, which were selected due to the availability of data from weather stations for comparison and validation purposes. However, solar radiation data was not available at all, and therefore the simulation results have been compared to the September and December 2008 data from Pozo Almonte ground station. The data provided by the simulations consists in hourly-integrated estimates of radiation, which are available in the form of pdf reports and .csv data files. The pdf report displays condensed data for a typical day of the selected month, and shows mean, maximum, minimum, median, and quartile values as shown in figure 5. The csv file includes hourly data for the period of interest (march, june, september or december).

Satellite estimation of surface radiation: We have seen from the previous sections that ground station measurements in Chile are sparse and of varying quality. This is mostly due to the characteristics of a solar radiation measurement program, which are expensive, require long term data acquisition in multiple ground stations, and are subject to issues of local validity of the data, sensor failure, and other issues such as the need for periodic cleaning of sensor surfaces if proper accuracy is to be guaranteed. In addition, it is not possible to recover data from the past. Balancing these unfavorable traits it is the high accuracy of ground station data (depending on the type of sensor selected), and the high temporal resolution of the measurements. A good alternative to ground station measurements is the use of satellite estimates, which are based on image processing. The main advantages of satellite estimations are the high spatial resolution, where a satellite image effectively covers a much larger area than could possibly be covered by ground stations, the availability of long term data, which sometimes covers more than 20 years, and the low cost of an estimation program. In addition, there are effectively no sensor failures or soiling, and no need for a proper ground site for sensor deployment. However, the temporal resolution is lower than what ground stations can offer, and the accuracy of the estimations is lower, especially at higher temporal resolutions. In what follows, we will briefly describe the methodology of satellite image processing necessary to obtain solar radiation estimations, and then describe the ongoing efforts being made by the authors in order to characterize the solar energy resource in Chile by means of satellite image processing. Finally, the satellite estimations will be compared to the ground station data in order to obtain proper conclusions.

Solar radiation is attenuated when crossing the atmosphere by diffusion and absorption, with clouds, atmospheric gases, and the surface reflecting 30% of incoming extraterrestrial radiation. The remaining 70% is absorbed by the planet in the process of surface warming and water evaporation (Pereira et al 2006). Thus, in order to properly estimate the amount of solar radiation that the earth's surface receives, it is necessary to determine the contribution of each radiative process involved in the total atmospheric transmittance. Computer models that simulate the radiative transfer processes can be classified as physical or statistical. Physical models utilize parametric data for estimating atmospheric properties. Statistical models use empirical formulations in addition to surface radiation measurements and local atmospheric conditions, and in general are valid only for the vicinity of the region under study. Physical models are valid for any region once the radiative transfer equations are solved. The main difficulty in applying physical models lies in obtaining the necessary data needed for the parameterization of solar radiation and atmospheric process interactions. This includes cloud cover information and atmospheric components such as aerosols, water vapor, ozone, and other gases (Pereira et al. 2006). The exact solution of the radiative transfer equations is very computationally intensive. Thus, alternative methods have been developed for obtaining approximate solutions in a reasonable amount of time. This way, a physical model combines the solution of approximate equations with the use of climatic information and parameters derived from satellite images. The necessary data is obtained from 6 variables: air temperature, surface albedo, relative humidity, atmospheric visibility, effective cloud cover, and surface elevation. A continental profile of atmospheric aerosols can also be used (McClatchey et al. 1972). The approximate solution for the radiative transfer equations assumes that cloud covers are the main factor in modeling the atmospheric transmittance. It also assumes that there exists a linear relation between the surface radiation and the radiation reflected by the atmosphere, considering that the extraterrestrial solar radiation is linearly distributed between the extremes of perfectly clear day and completely covered by clouds (Gambi, 1998).

Estimates of the surface radiation are obtained by applying the GL1.2 model to GOES satellite images, obtained from the Brazilian *Instituto Nacional de Pesquisas Espaciais* INPE (national institute for space research). The model was developed at the Climate studies and weather prediction center *CPTEC* of

INPE. GL1.2 predicts daily mean solar radiation for South America from visible GOES satellite images by estimating irradiance on each image pixel, and then computing an average over 3x3 pixel arrays. The data series is composed of $0,4^o$ x $0,4^o$ cells, which are available as 5-day average and divided into 5 regions that cover most of South America with a southern limit on latitude -45^o approximately. GL1.2 model details are presented in Ceballos et al. (2004). The satellite data is readily available at CPTEC by accesing http://www.cptec.inpe.br/. The *Matriz GL1.2 pentadal (versión V01 y V02 CPTEC/INPE)* data matrix is generated from GOES 8 and GOES 12 satellite images. Validation of the GL1.2 model was obtained by comparison with 80 ground stations of the Brazilian solarimetric network, and good agreement was found (Pereira et al 2006). The comparison with ground stations resulted accurate with a monthly mean deviation inferior to 10 W/m^2 and a standard deviation of monthly data of 20 W/m^2 (Ceballos and Bottino, 2004).

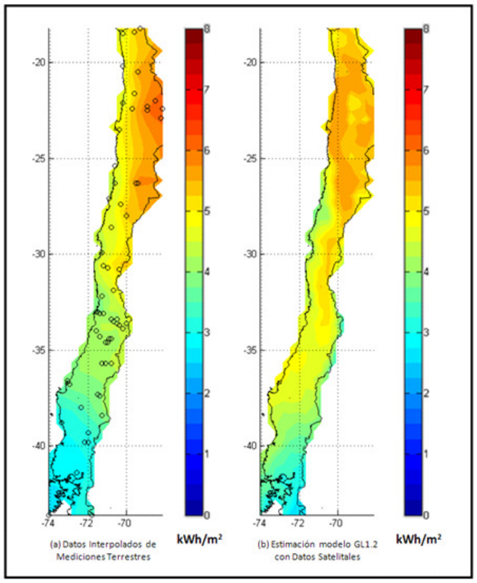

Figure 6: Yearly mean solar radiation in Chile from ground data, and satellite-derived estimations.

Figure 6 displays yearly mean solar radiation for Chile between 18^o to 40^oS, and 18^o to 44^oW, comparing satellite and ground station data. It can be observed that, in general, good agreement is found between the two databases, which display higher radiation levels in the northern part of the country, which steadily decreases in the southern direction. However, it can also be seen that the northern region presents significant disagreement between both databases, mainly related to the locations at which the highest radiation levels are available. The ground station data suggests that the highest radiation in yearly mean basis is located in the deep desert at approx. 69W and between 25S and 30S, while the satellite estimates suggest that high radiation values are available closer to the coast. The uncertainty of the interpolation results can be evaluated using Mean Bias Error MBE, Root Mean Square Error RMSE and Mean Percentage Error MPE, defined as described by (Isaaks et al, 1989). The MBE and MPE errors are computed to find the difference between ground station and satellite data. The results are divide in three zones: north (18^o to 32^oS), center (32^o to 36^oC), and south (36^o to 44^oS). The yearly mean has an error deviation inferior to 10 W/m^2, with a percentage mean error of 7%. However, monthly mean error levels are as high as 40%, most notably during winter months. This variability is thought to be a consequence of cloud covers and climatic instabilities during winter, which in turns affects the uncertainty levels of both pyranographs and satellite image processing models. It is also possible to observe that the smaller error levels are located in the northern section of the country, which being a desert located closer to the Equator line exhibits lower weather variability. Another error source for the GL1.2 model lies in its inability to distinguish reflectance due to cloud cover and reflectance due to snow covered terrain. Thus, during wintertime, the Andes mountains in central and southern Chile can be falsely interpreted as cloud cover, producing low radiation zones (Ceballos et al., 2005). Another source of uncertainty is due to the data series not overlapping in time, the satellite data being more recent. And finally, as some ground stations only measured as few as only month within a single year of climate data, it is highly probable that the database cannot represent a typical meteorological year TMY. Furthermore, there is no uncertainty analysis for each instrument or calibration reports for the ground station data.

Time Series of Radiation Data: Figure 7 shows compared time series of monthly mean data for ground measurements and satellite estimates in four different locations, displaying magnitude and statistical correlations. It can be observed that the difference in magnitude for Santiago is large throughout the year, although the data seems to correlate quite nicely. In Armerillo and Parinacota, the data displays good agreement in both magnitude and correlation. In the region of La Serena, which is characterized by cloudy mornings and clear afternoons, there is disagreement in both magnitude and correlation.

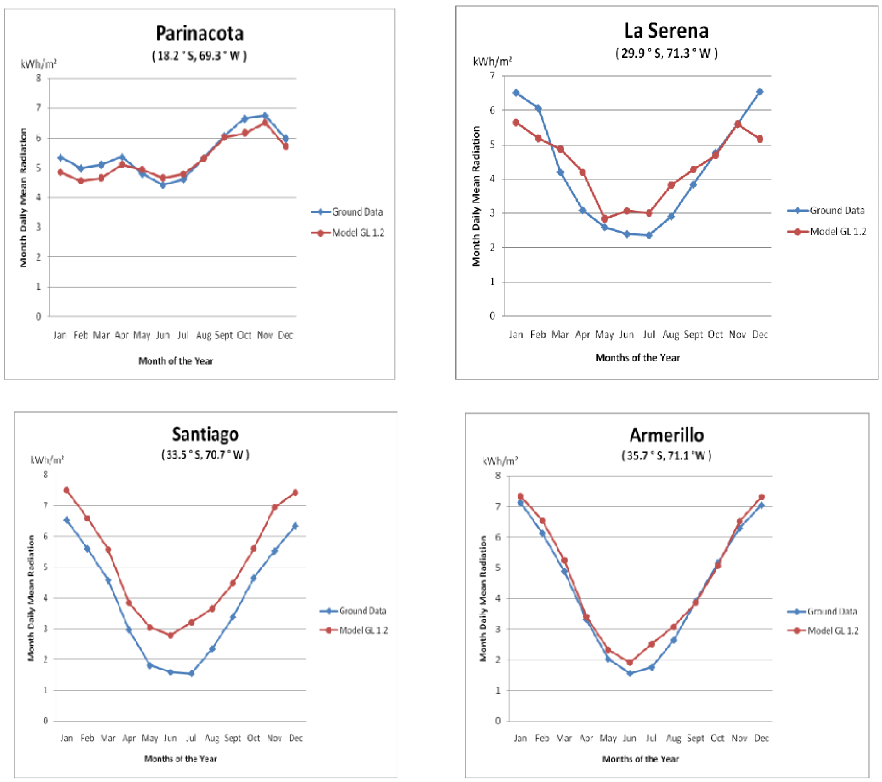

Figure 7: Time series for different locations in Chile: comparing ground station and satellite data

3. CONCLUSIONS

The Chilean energy policy intends to promote the deployment of renewable energy in Chile, including solar energy. A proper analysis and evaluation of solar energy systems makes necessary the existence of a TMY database in the form of hourly radiation data for the country. This task requires the commissioning of large scale surface radiation measurement ground station networks, and then measuring incoming radiation for a long time span with carefully controlled and calibrated instruments. In the case of Chile, there are several databases of solar radiation, but unfortunately they are not completely adequate. One database is composed of data from actinographs and Campbell-Stokes devices, with the most recent data being more than 20 years old. The data covers time periods as short as a couple of months, with several years worth of data simply not present for many of the stations, and therefore is not statistically valid. In addition, the data is reported without uncertainty levels. Another database includes pyranometer readings starting in 1988, which are properly maintained and calibrated, but are sparsely distributed along the country. Another ground station has been deployed in northern Chile by a government agency, and is reporting its data openly to the public via website with monthly frequency. This station, however, displays several shortcomings in its design and location, from which doubts about the validity of the data have arisen. A meteorological forecast simulation model has also being contracted by the government, and it is being used to simulate global horizontal radiation in northern Chile for four months in 2006. Finally, the authors have processed satellite image data from 1995 to 2005 and produced monthly means of radiation for the country. The comparison between the satellite and ground-station data is thought to be within the uncertainty levels of other South American regions. A proper uncertainty analysis is being carried out, in the hope of utilizing both databases to complement each other, and produce a Chilean solar atlas with lower uncertainty levels than those currently available to engineers and scientists. It is also thought that the adoption of satellite-derived data by a Chilean solar atlas will result in lower mean uncertainty levels. In order to acquire a properly accurate database, it is necessary to conduct a new effort of installing a network for ground station measurements. These preliminary results indicate the advantages of using satellite image processing procedures, which able to produce solar radiation estimations for South America. The adoption of a proper solar atlas will result in an enhanced ability for the analysis and design of solar energy systems, thus allowing accurate project estimations. This is perceived as the first step towards ample utilization of solar energy in Chile, for power generation, industrial, commercial and residential heat supply, and solar-assisted cooling.

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