Automatic Weather Observational System In SENAMHI Peru

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Abstract
The National Meteorological and Hydrological Service – SENAMHI from Peru have installed an weather automatic station network around the country, that works already fourteen years, it measures the diverse weather of the country, since the coast to the amazonic forest, considering the high points in the mountains near of 4600 meters above sea level.

1. Introduction

Geographical Location

Peru is located between 0 to 18.5º S latitude, 60.5 to 81.5º W longitude in South America continent, it is conformed by a territory of a continental surface of 1.285.215, 60 km²

it has 3 regions clearly defined, divided by the Andes mountains who cross the country from south to north. The regions has distributed in:
coastal region 136.232,85 km² (10,6%) side the pacific ocean
mountain region 404.842,91 km² (31,5%) middle side
amazonic region: 754.139,84 km² (57,9%) east side

The fact that Peru is near the equatorial line would indicate that its climate would have especially to be tropical, nevertheless two factors alter remarkably the climate. In the first place the existence of the high Mountain in parallel to the Pacific Ocean and, secondly, the cold peruvian sea current or Humboldt current who flows from south pole to north of the country, until the latitude 5°. These accidents, plus the anticyclone of the South Pacific in this part of the continent, originate a diminution of the annual temperatures average of about 10° Celsius in the coast and a great variety of simultaneous climates in all the country which has located to Peru like the country with greater variety of climates in the world.

The Peruvian climate varies from warm temperate, subtropical desert with rain shortage throughout the year in the coast region (0 to 300 m asl), to a variable tropical climate in the mountain. The diverse heights of places, its reliefs that generate microclimates and the variations of the amounts of precipitations according to the zones. There are zones, like the White Mountain (6768 m asl) that its denomination due to snows with below freezing temperatures. The Amazonian forest, appears to the east of the Andean mountain, its climate rather is tempered moderate, by its own nature and away location of the influences of the coast and proximity with the equatorial line, it is a tropical climate with rains about 2800 mm to the year. The permanent heat contributes to the fast evaporation of rain.

Hidrologycal and Meteorologycal Automatic Observational Network

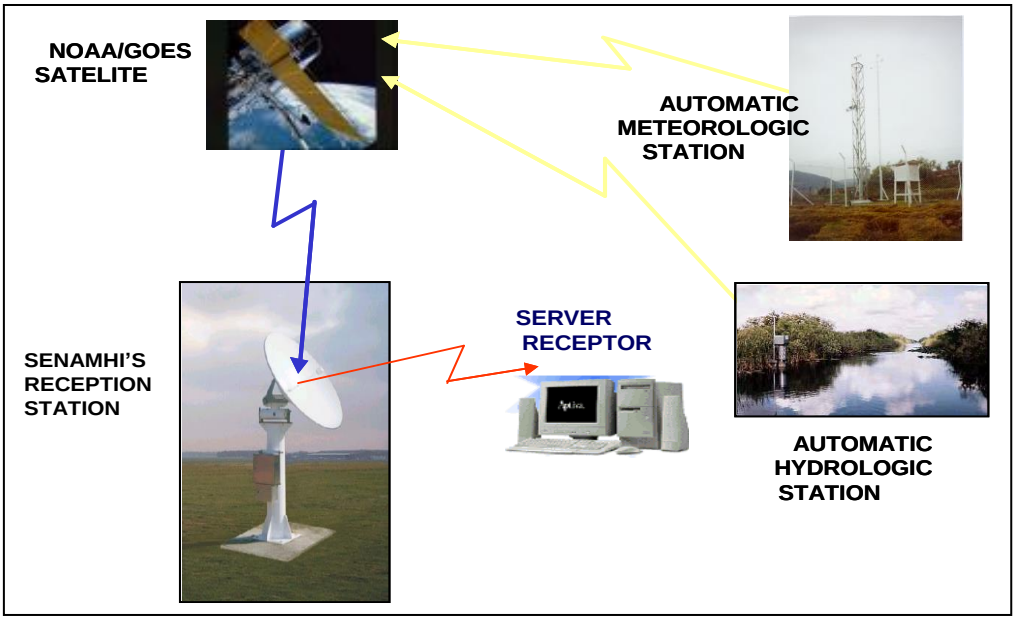
The observational network of SENAMHI consist in 751 stations, among manned, automatic and Radiosonding ground stations. The network generates hydrological and meteorological data in defined times, so the conventional network is big, and works from the 60's.

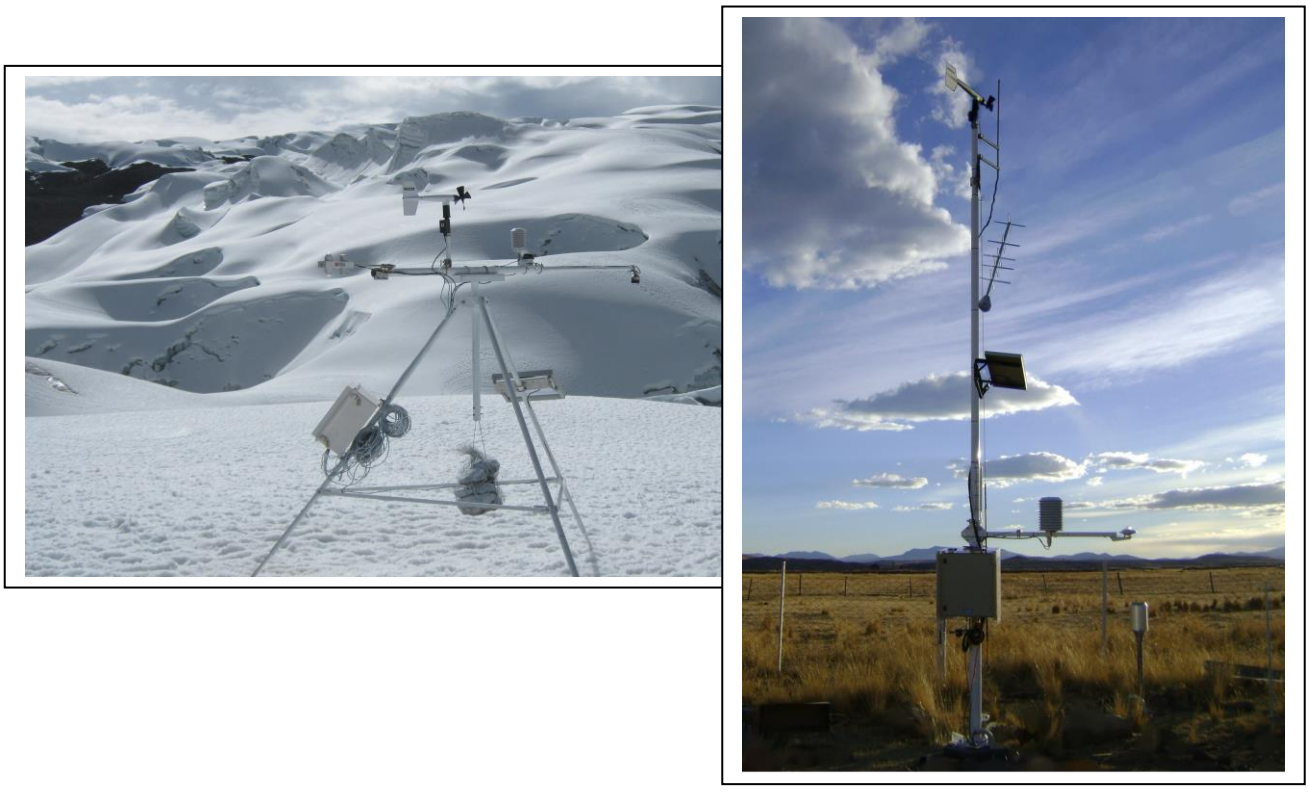
Area	Class	Types	Cantity	Totall	Measures Time
Surface	Conventional	Main Agricultural	17	701	7.00; 12.00; 19,00
		Main Climatic	46		7.00; 12.00; 19,00
		Ordinary Climatic	356		7.00; 12.00; 19,00
		Especific Propouse	18		Several
		Pluviometric	123		7,00; 19,00
		Hidrologic	141		6.00; 10.00;14,00 y 18.00
	Automatic	Meteorological	69	125	Hourly
		Hydrological	7		Hourly
		Hydro-meteorological	17		Hourly
		Agro-meteorological	32		Hourly
Upper	Semi automatic	Radiosonde	1	1	4 times a week

The automatization of the network is 16.67%.
The automatic network consist in 125 stations that works as meteorological, hydrological, hydro-meteorological and agro-meteorological stations; some automatic stations are joined to manned stations for compare data.

The operation of the automatic network started from the 2000 with 55 AWS, its communication was through GOES Satellite, there is a receptor ground station in the headquarter located in Lima.

The stations are installed in remote places of the country, so they are powered by photovoltaic system, with a month independency battery.
So the stations have a lightning system with its corresponding electric ground





The AWS have different sensors according with the types of stations: Agro-Met, Met, Hydro-Met and Hydro. The technical features of the SENAMHI's AWS are according with the WMO-Nº 8.

N°	Parameter	Agro-Met	Met	Hydro	Hydro-Met
1	Air Temperature	X	X		X
2	Air Relative Humidity	X	X		X
3	Speed and Direction Wind	X	X		X
4	Rain	X	X	X	X
5	Solar Radiation	X	X		
6	Atmospheric Pressure	X	X		
7	Leaf Wetness	X			
8	Soil Moisture	X			
9	Water Level			X	X

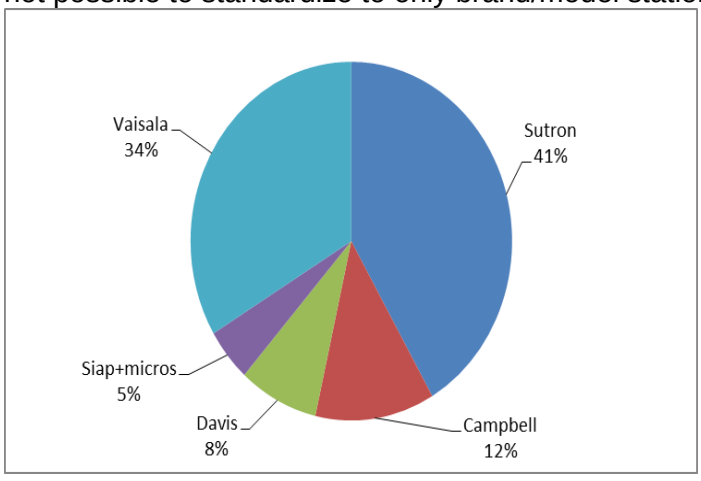
The sensor of the AWS are made by different enterprises, them features are suitable with the Peruvian Climate.

Sensor	Transductor	Range	Accuracy	Output Signal
Relative Humidity	Capacitor	0 to 100%	+/- 1.5RH%	Analogue (0 – 1 V)
Air Temperature	Termistor / PT100	-40 to + 60ºC	+/- 0.3º	Analogue (0 – 1 V) / four wires
Wind Speed & Direction	Electromagnetic Induction – Potenciometer (also ultrasonic sensor)	60 m/s	+/- 0.3 m/s to below of 20m/s	Frequency Hz / Resistor ohms
		0 to 359º	±3°	
Rain	Tipping Backet		2% in 2" per hour	Pulses
Solar Radiation	Semiconductor and thermopile	400-1100nm	±3%	Analogue (uA)
Atmospheric Pressure	Solid transductor	500 to 1100 hPa	Less tan 0.5 hPa	SDI-12
Soil Moisture	Ceramic	10 to 200 cB		Analogue (0 – 3.6V aprox.)
Leaf Wetness	Electrodes	0 to 5		Analogue (0 – 5V)
Water Level	Acoustic / Radar	0 to 15 m	0.25% of range	Analogue (4 – 20mA) SDI-12

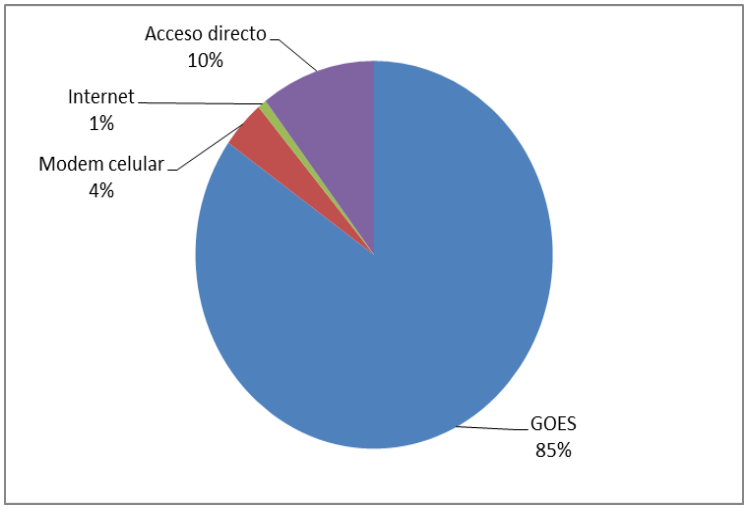
The data has hourly and daily periods

N°	Variable	Function	Hourly	Daily	Unit
1	Air Temperature	Instantaneous	X		ºC
		Maximum		X	
		Minimum		X	
2	Air Relative Humidity	Instantaneous	X		%HR
		Maximum		X	
		Mínimum		X	
3	Wind Speed	Average	X		m/s
		Chill		X	
4	Wind Direction	Average	X		Grade
		Chill		X	
5	Rain	Accumulated	X	X	mm
6	Solar Radiation	Accumulated	X		WH/m2
7	Atmospheric Pressure	Instantaneous	X		hPa
8	Leaf Wetness	Instantaneous	X		---
9	Soil Moisture	Instantaneous	X		cBar
10	Water Level	Instantaneous	X		meter
		Average	X		
		Maximum		X	
		Minimum		X	

The SENAMHI Automatic Stations Network has several brands and models, because according with the Peruvian rule, in the purchase should be plurality of bidders and does not possible to standardize to only brand/model stations.



The SENAMHI Automatic Stations Network transmits data mainly by GOES Satellite with 85% of them. The transmission period is hourly, with small windows of 5 and 10 seconds.

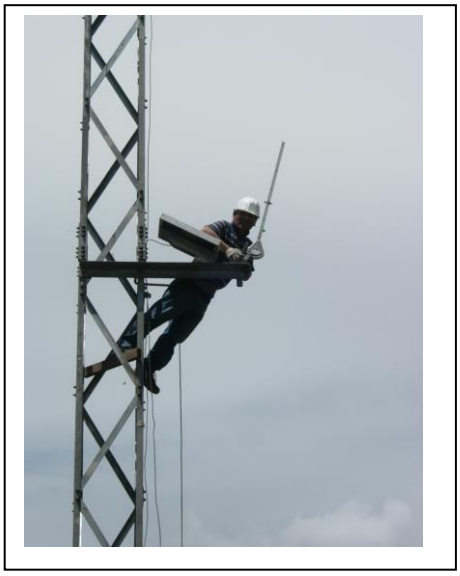


Maintenance system

The maintenance of AWS are done according the procedures
So maintenance is divided in three kinds:

- Routine maintenance: in charge of station technical
  It is basic clean of sensors, frequently cleaning to solar radiation and rain sensors.
- Preventive maintenance: according the annual program
  It is an activity where the spares are changed after its life period is end, as bearings, batteries, silice.
  Check of voltage of battery, power of transmission, clock time.
  Field verification of data using portable standards
  Cleaning of AWS
  It is in charge of technical staff from SENAMHI regional management

- Corrective maintenance:
  Repleacement of sensors, loggers, transmitters failed
  Upgrades of stations
  Repair stations
  In charge of technical electronic staff from regional management or headquarter



Calibration system

SENAMHI has a calibration laboratory

Temperature laboratory is implemented with a liquid bath, SQRT reference thermometer traceable with national metrology institute
The temperature calibration procedure are according SI

Humidity laboratory is implemented with a climatic chamber and for calibration we use reference salts.

Wind laboratory is implemented with a wind tunnel and a hot wire anemometer
SENAMHI does contrast of sensor with the reference anemometer, but still we did not implemented a procedure for calibration

Pressure atmospheric laboratory is implemented with a barometric chamber, and we use a barometer of +/- 0.1 hPa accuracy, as reference, we do contrast of sensor with reference barometer into the barometric chamber.

SENAMHI does contrast of amount of rain using pipette traceable with national metrology institute.

We do simple contrast with solar radiations sensor, so we require implement SI calibration procedure.

The Calibration is divided in two stages:

- Verification in field, it is made after the preventive maintenance, using portable standards, according a format.

- Calibration in laboratory, it is made according a calibration/contrast program.


Current Situation

The Automatic Observation Network is working into the appropriate performance, considering the very harsh environmental conditions in the amazonic forest, as near the pacific ocean, as on the high mountains.

Actually its complicated to maintenance a network with at least five brand of AWS, so they required different spares, knowledge of different setup program of each brand/model, but the staff of technician has developed great experience to keep working the network.

Since 2000 year, the network was increasing with other stations, and now there are several expectations according the economic develop of the country and the international organizations aids.

Some sensor are been upgraded progressively as the acoustic water level sensor to radar sensor; so the semiconductor solar radiation sensor to thermopile, the last temperature sensor purchased let liquid calibration, so they are metallic probes.

Challenges

Senamhi is improving the index maintenance, reducing the time response to solve the AWS fails.

The new AWS consider real time communication through internet, FTP protocol.

Continue the progressive implementation of the calibration laboratory according with SI and WMO rules

Improve the time response to solve the AWS fails

Standarize the network, at least with same sensors features, specially the same signal outputs.

Installed at least 44 new AWS during 2014.

Receive at least 116 new hydrological and meteorological automatic stations working from other government institutions.

Conclusion

- The Senamhi's Observational Network is increasing the quantity of AWS according with news project and develop of the country.

- SENAMHI is improving the knowledge of the technical staffs to be able to maintenance and calibrate the AWS Network, so the implementation of the meteorological laboratory considering the purchase of primary standars and equipment.