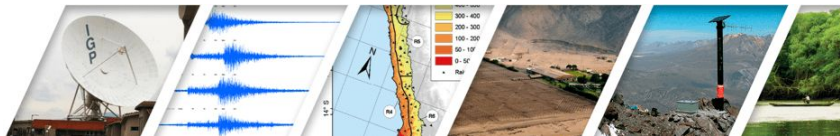
BASIC RADAR SIGNAL PROCESSING

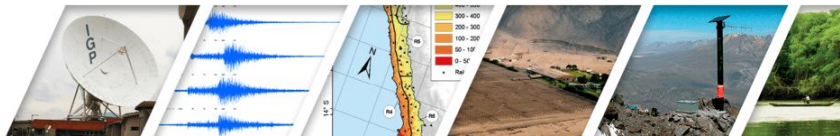
Juan C. Espinoza

Jun 2019

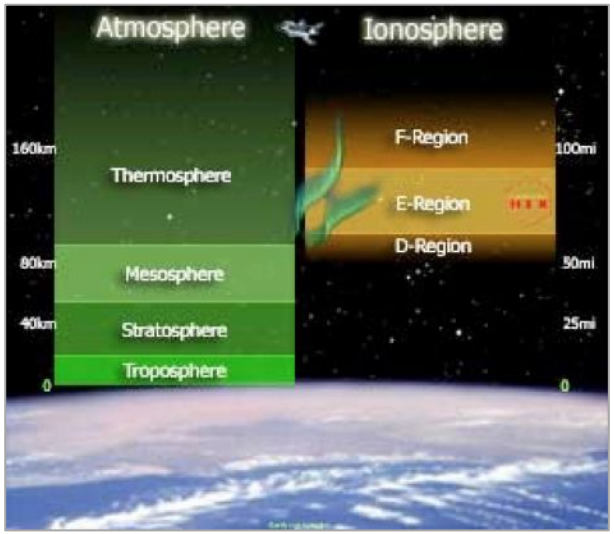


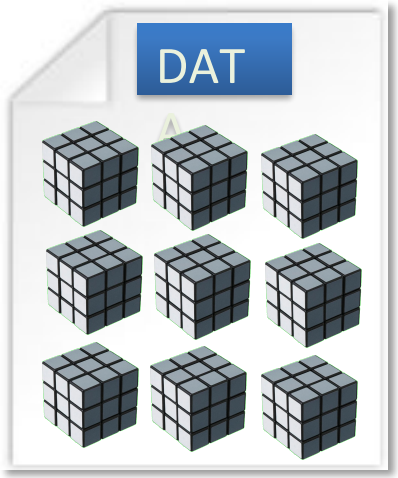
Outline

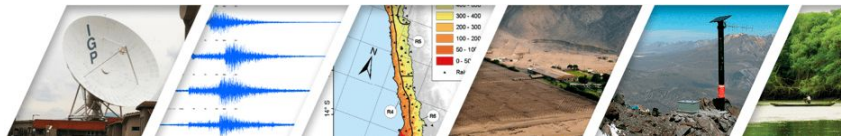
- Introduction
- Jicamarca Data Structure
- Radar Processing
- Signal Chain



Introduction

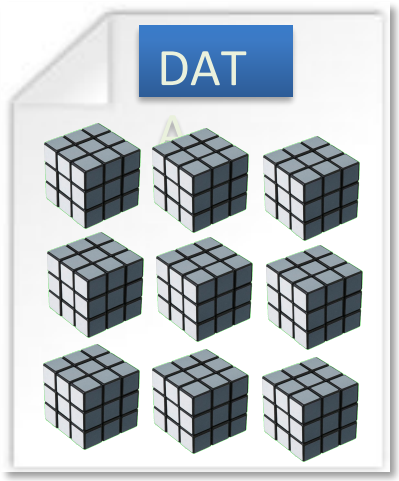




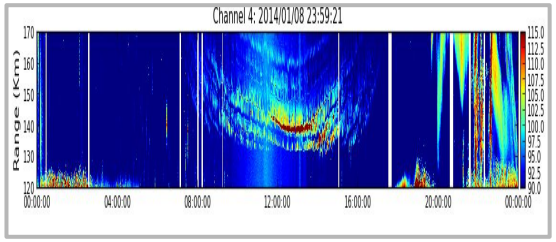


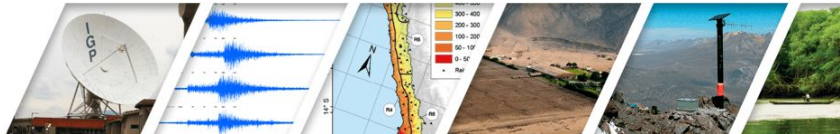
Jicamarca Data

Real-time monitoring

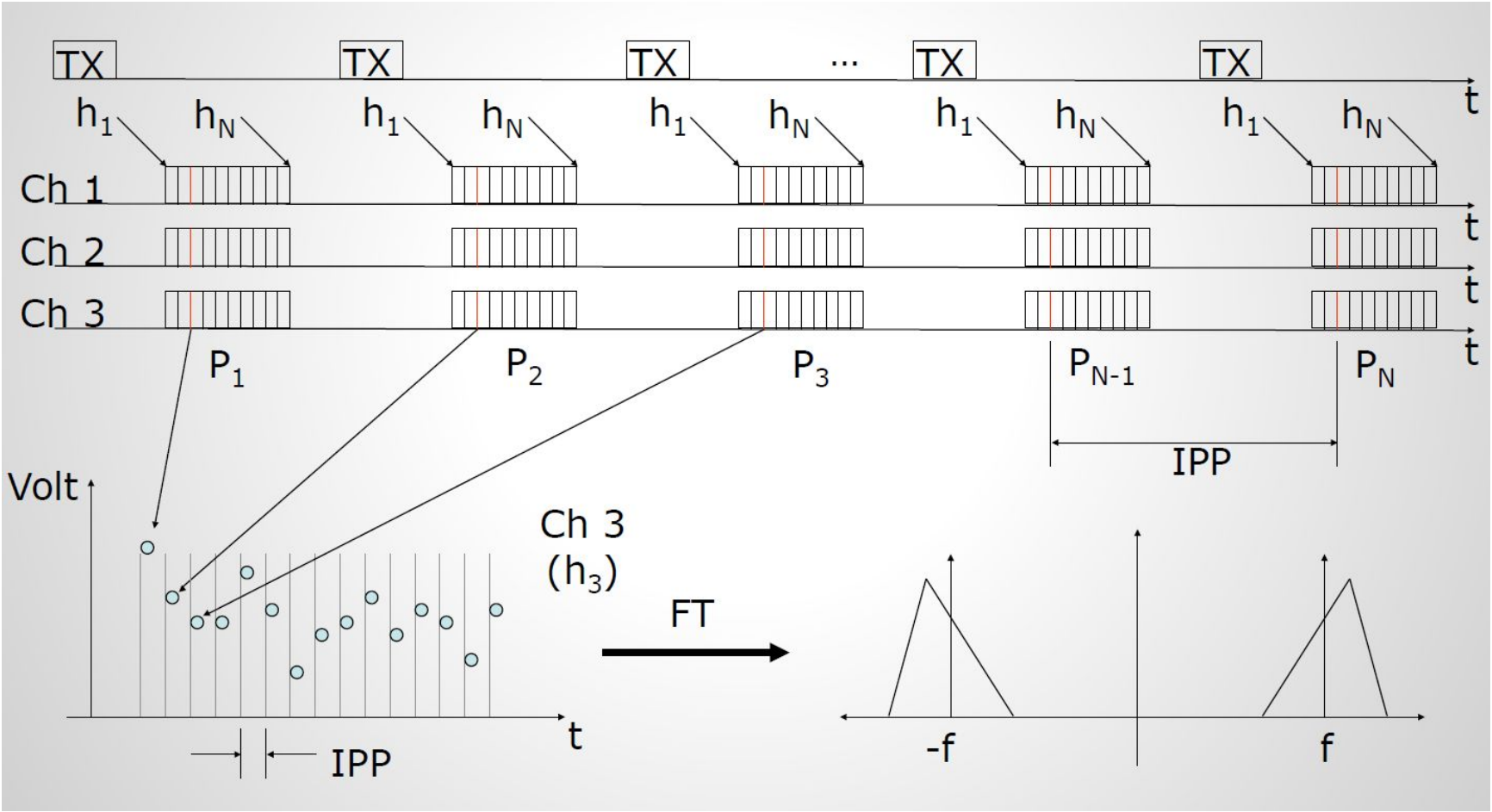


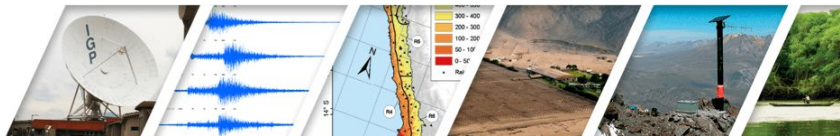
Some Magic



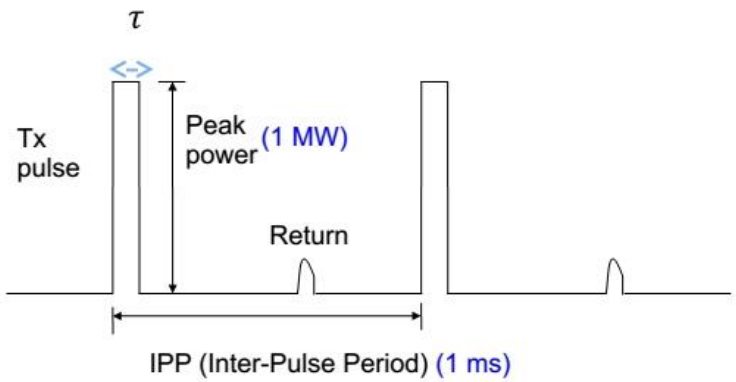


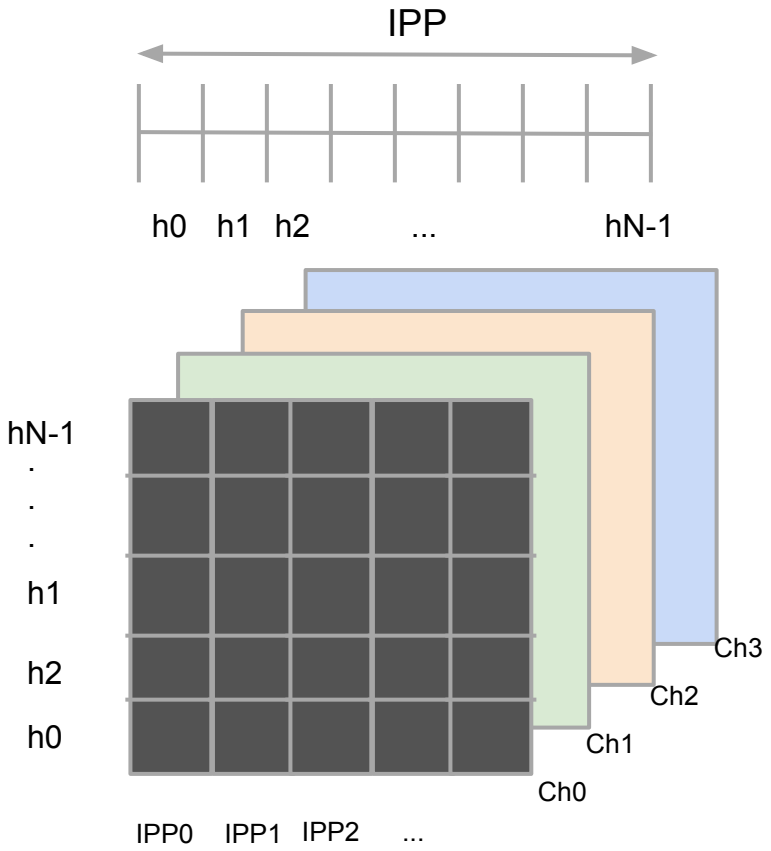
Jicamarca Data
Structure (1)

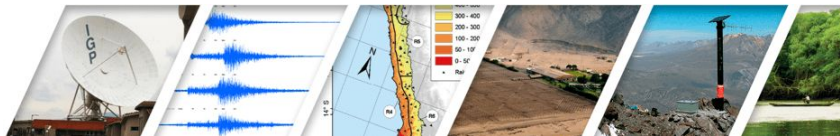




Jicamarca Data
Structure (2)

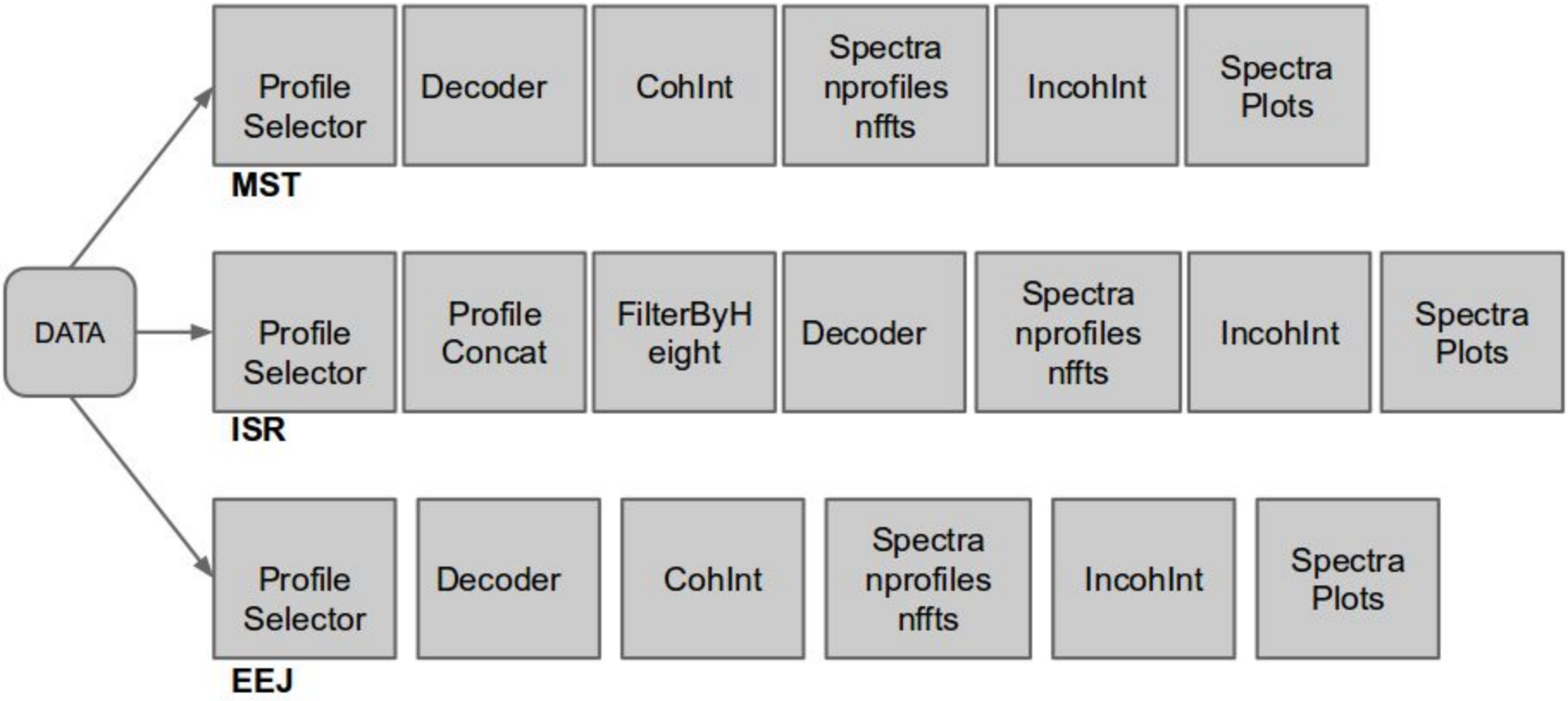


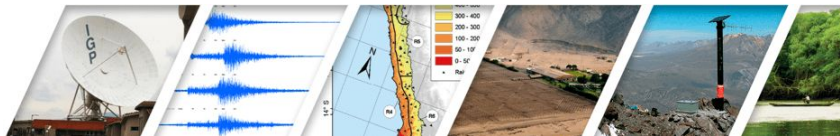




Radar Processing

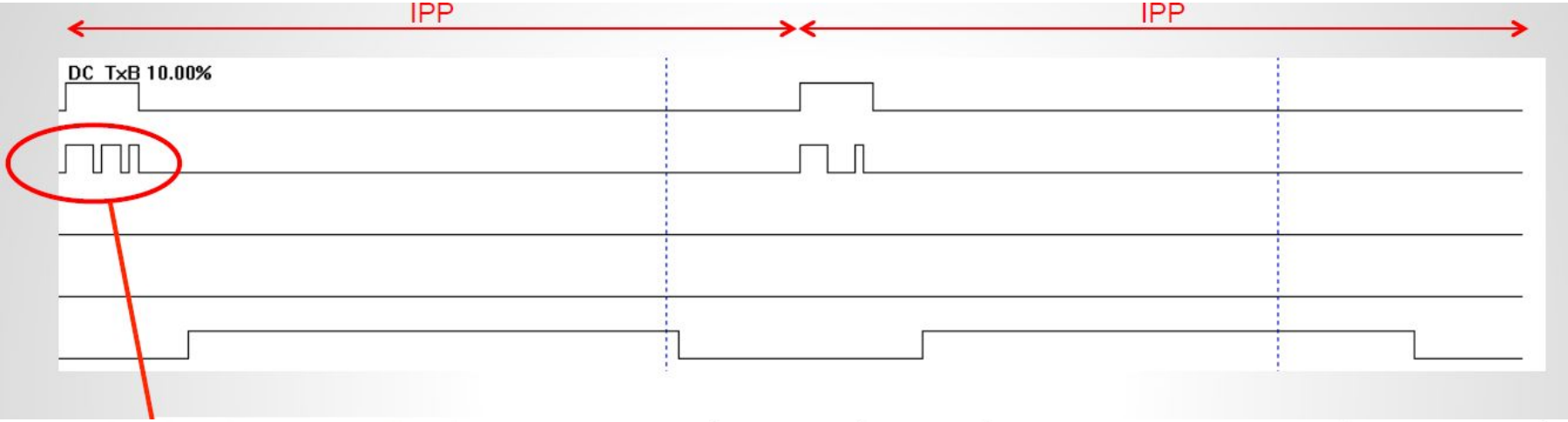
Typical experiment

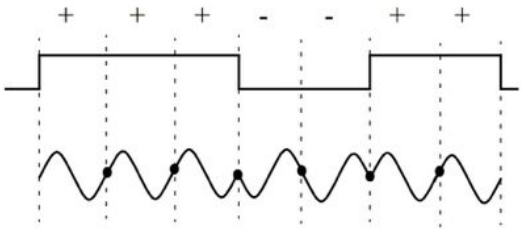


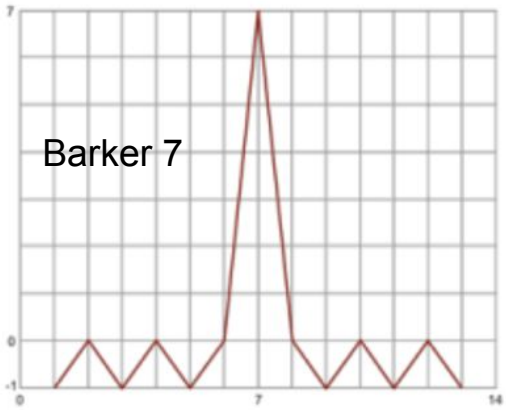


Radar Processing

Coding



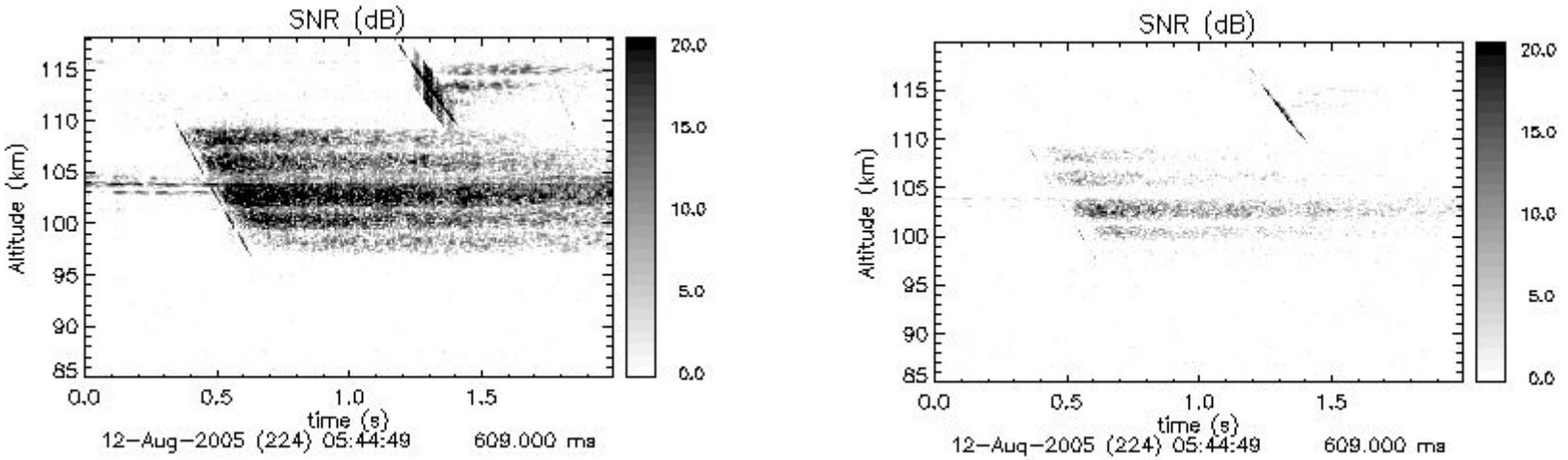




Code symbol	Code length	Code elements	Side lode reduction (dB)
B_2	2	1 -1 1 1	6.0
B_3	3	1 1 -1	9.5
B_4	4	1 1 -1 1 1 1 1 -1	12.0
B_5	5	1 1 1 -1 1	14.0
B_7	7	1 1 1 -1 -1 1 -1	16.9
B_{11}	11	1 1 1 -1 -1 -1 1 -1 -1 1 -1	20.8
B_{13}	13	1 1 1 1 1 -1 -1 1 1 -1 1 -1 1	22.3

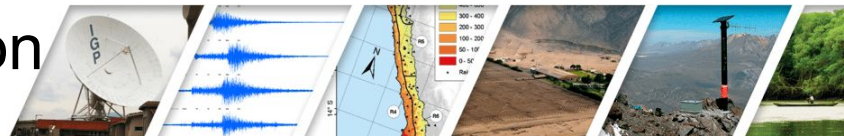
Radar Processing

Why use coding?



Meteor Detection. Left Side: PW=0.15Km, Right Side: PW=1.95Km

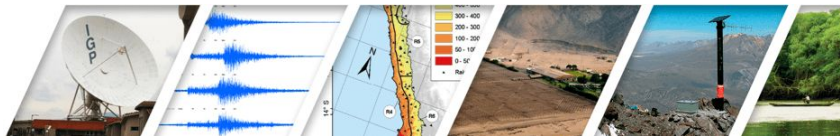
- Target resolution is limited by the amount of transmitted power.
- The transmitted power has a relationship with Pulse Width (PW)
- PW defines the target resolution



Radar Processing
Decoding

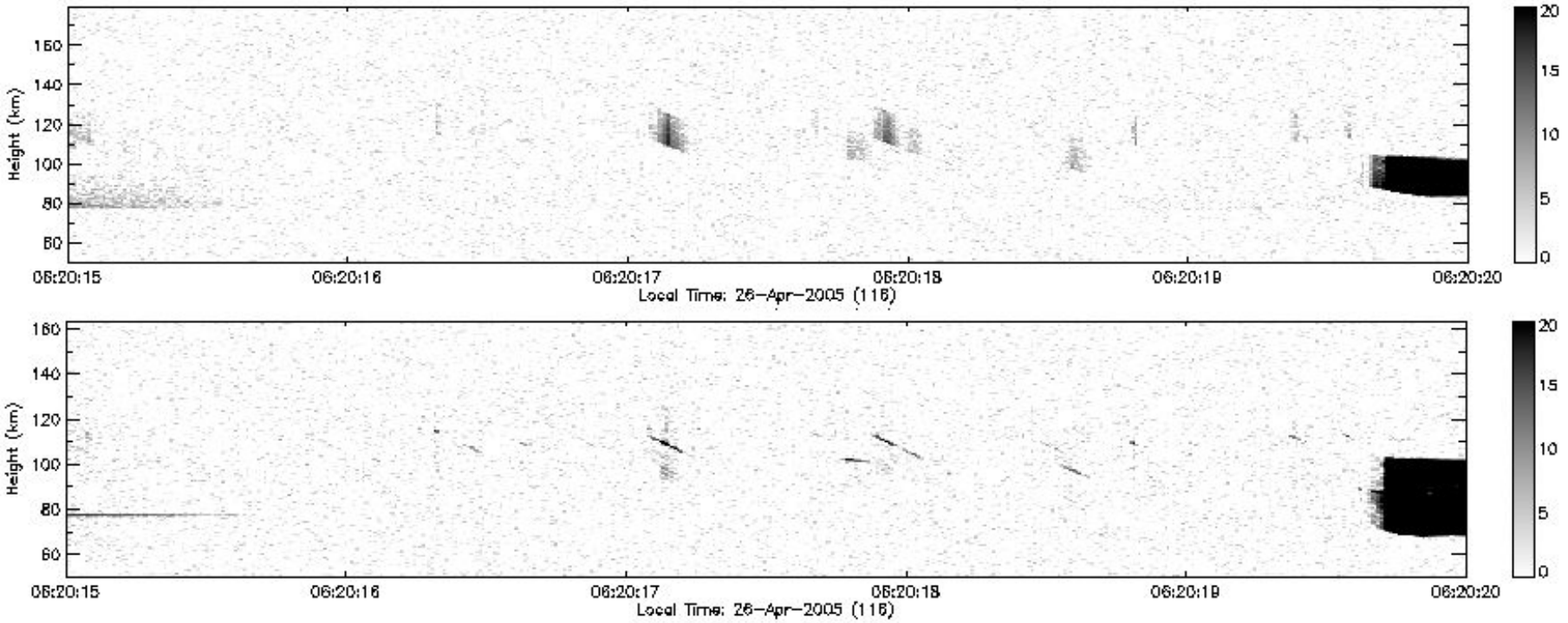
$$S_{out} = S_{rec} * C'$$

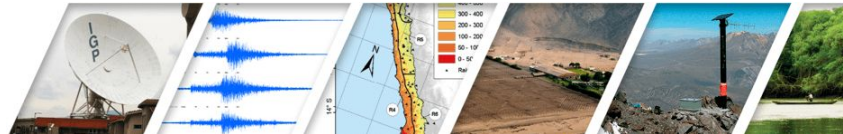
- S_{out}: Output Signal
- S_{rec}: Received Signal
- C’ : Conjugated Code
- * : Convolution



Radar Processing

Decoding

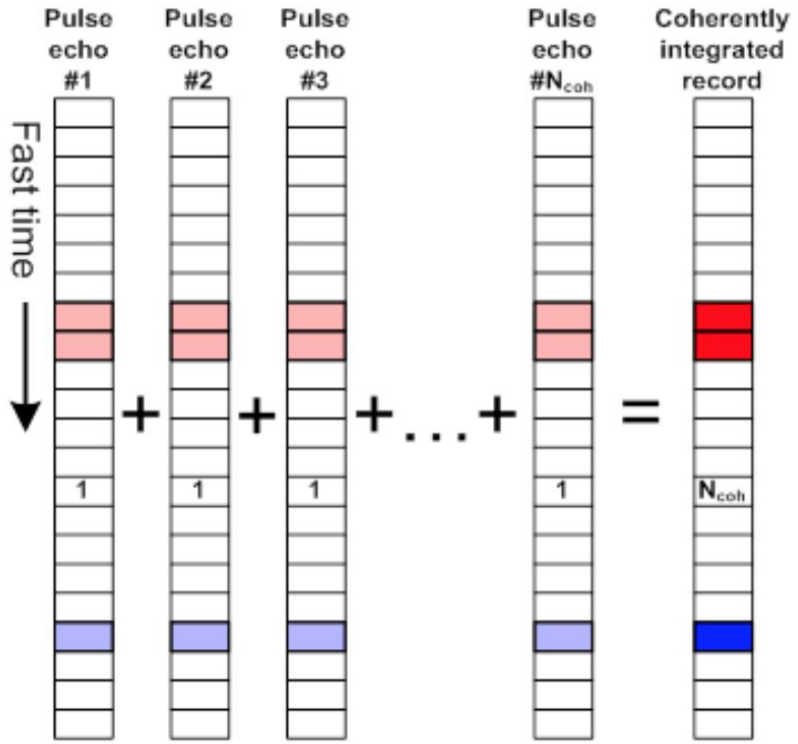


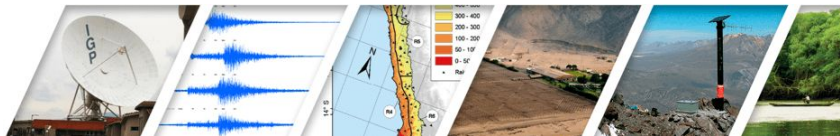


Radar Processing
Coherent Integration

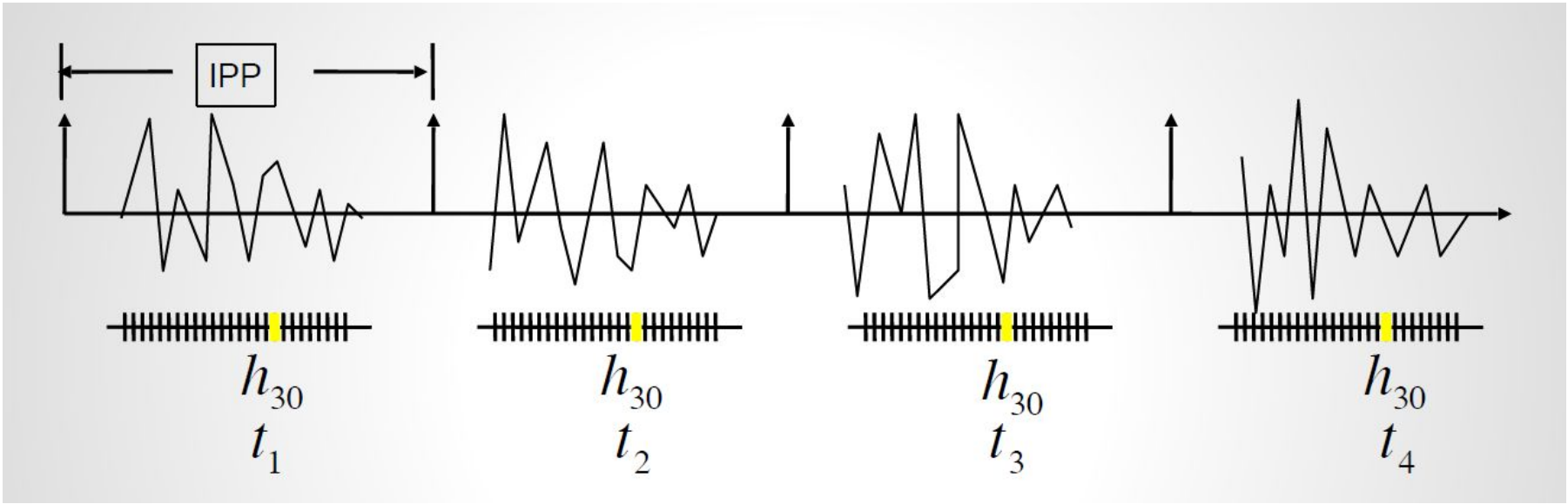
Summation (averaging) of multiple echo signals (records) in a short period of time.

- Reduce data volume
- Improve SNR
- Acts as low-pass filter

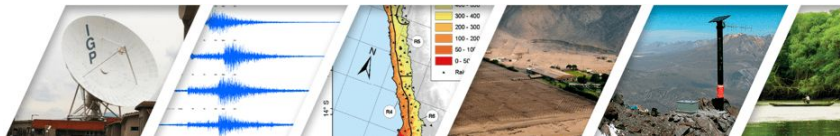




Radar Processing
Coherent Integration

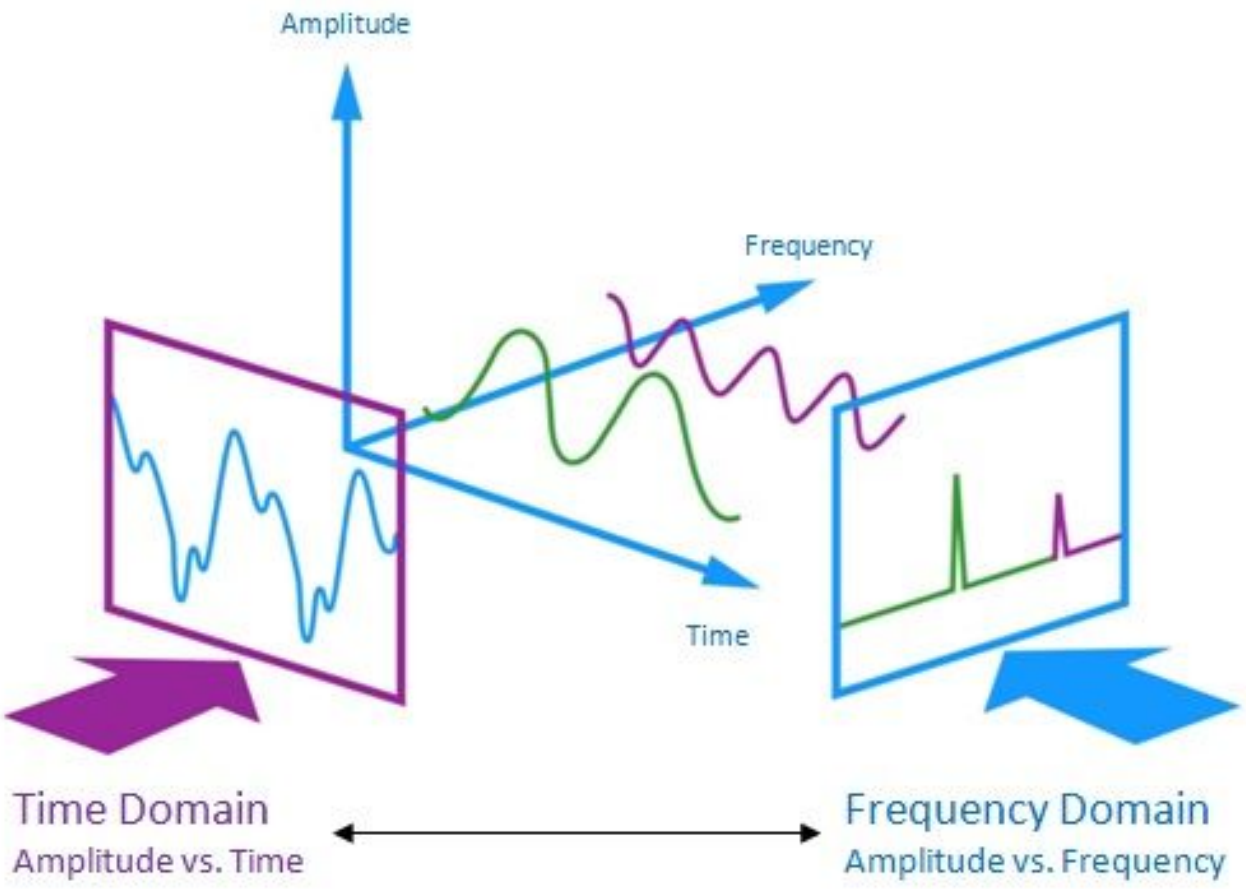


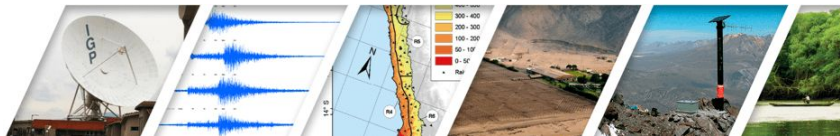
- Over heights or profiles



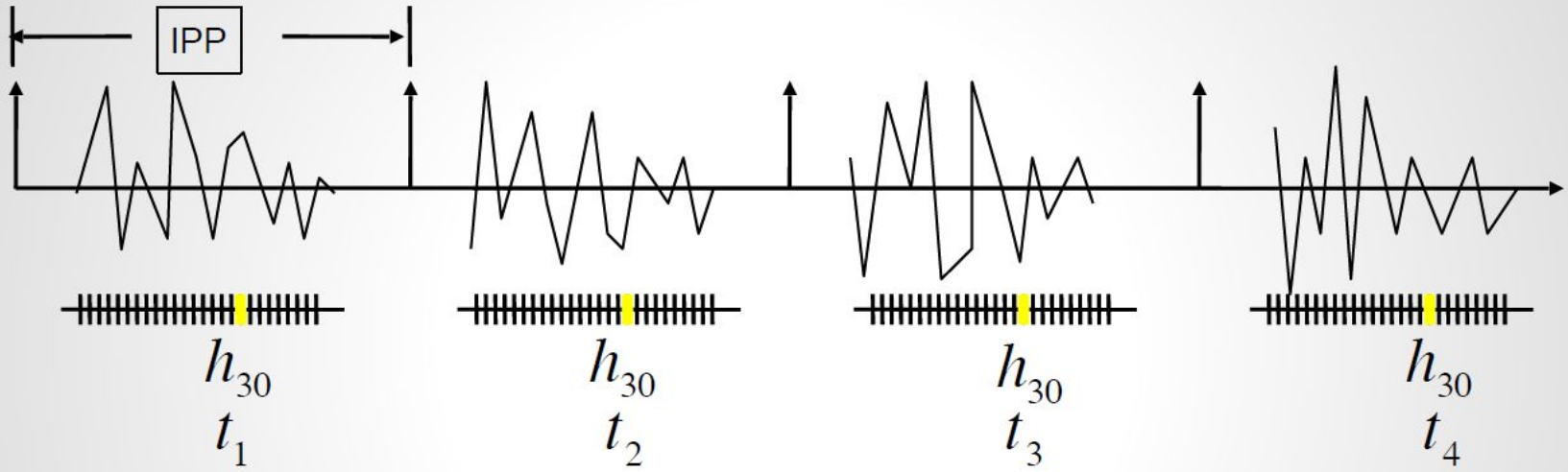
Radar Processing

Spectral Analysis



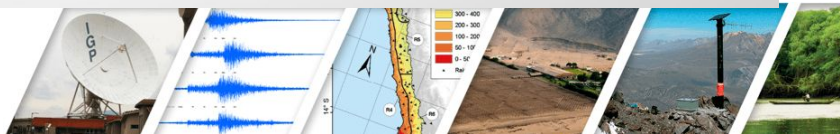


Radar Processing
Spectral Analysis



- The samples (yellow mark) at h_{30} are a complex time series of voltage $v(h_{30}, t_n)$

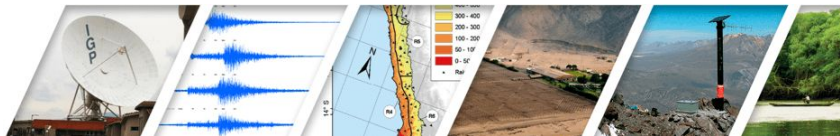
- Applying Fourier Transform: $V(h_{30}, \omega_N)$



Radar Processing
Incoherent Integration

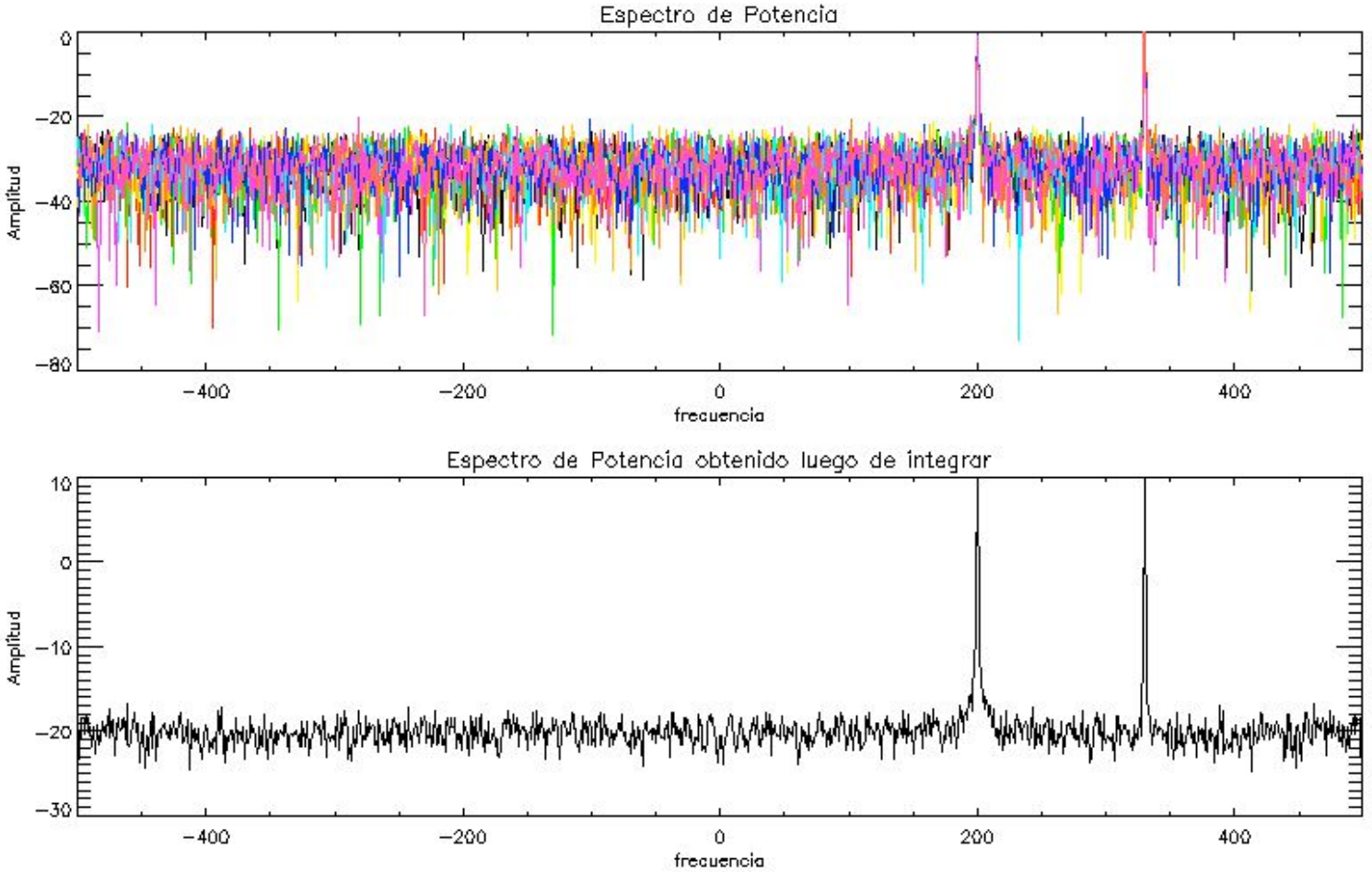
- Average in Frequency

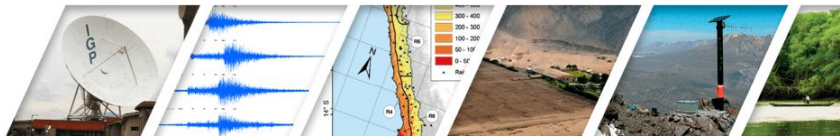
- Allows the detection of the echo signal



Radar Processing

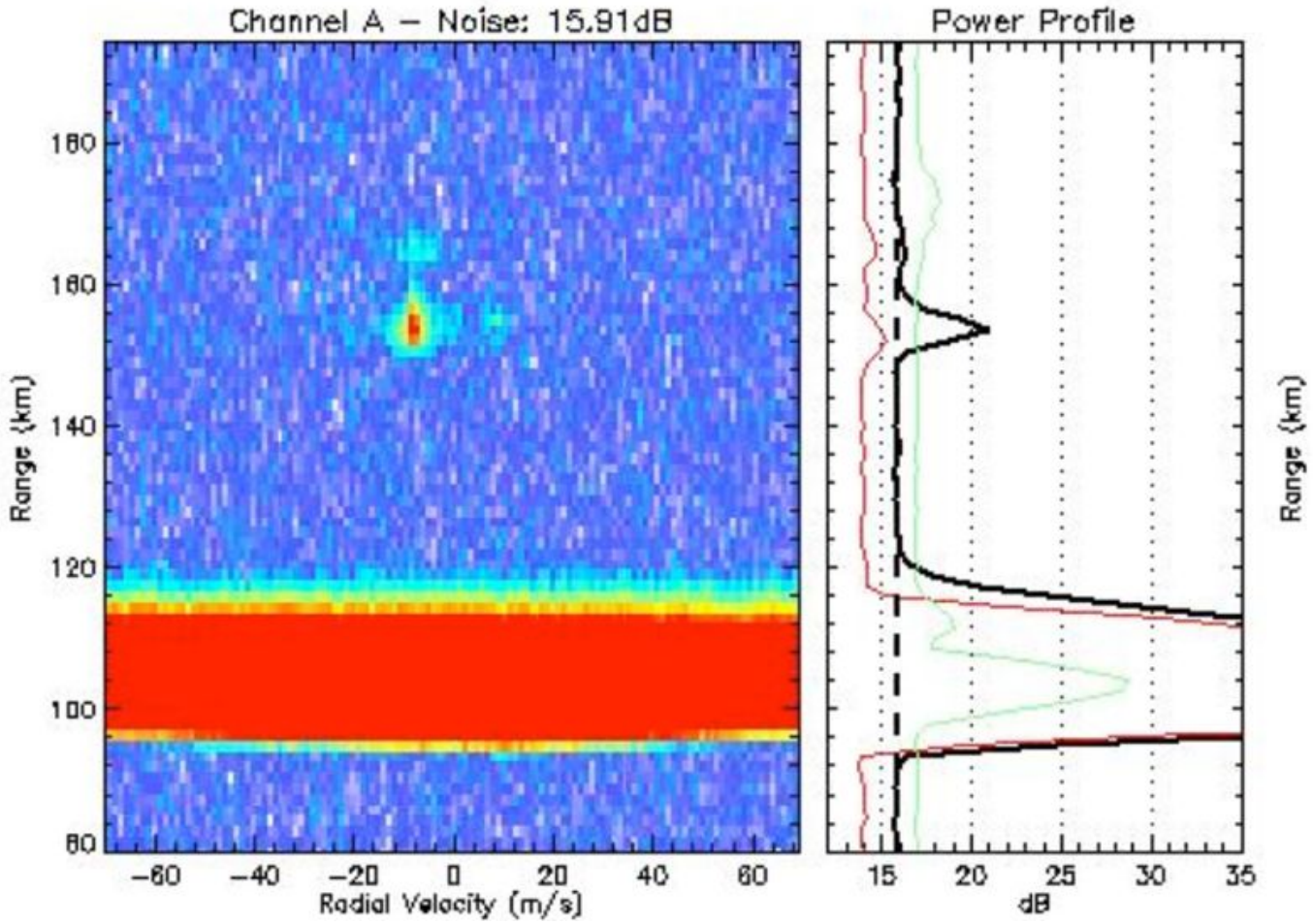
Incoherent Integration

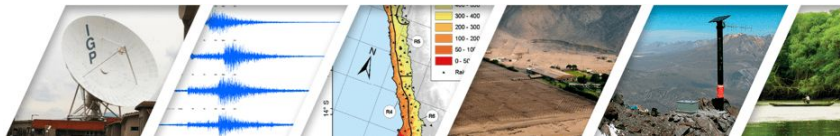




Radar Processing

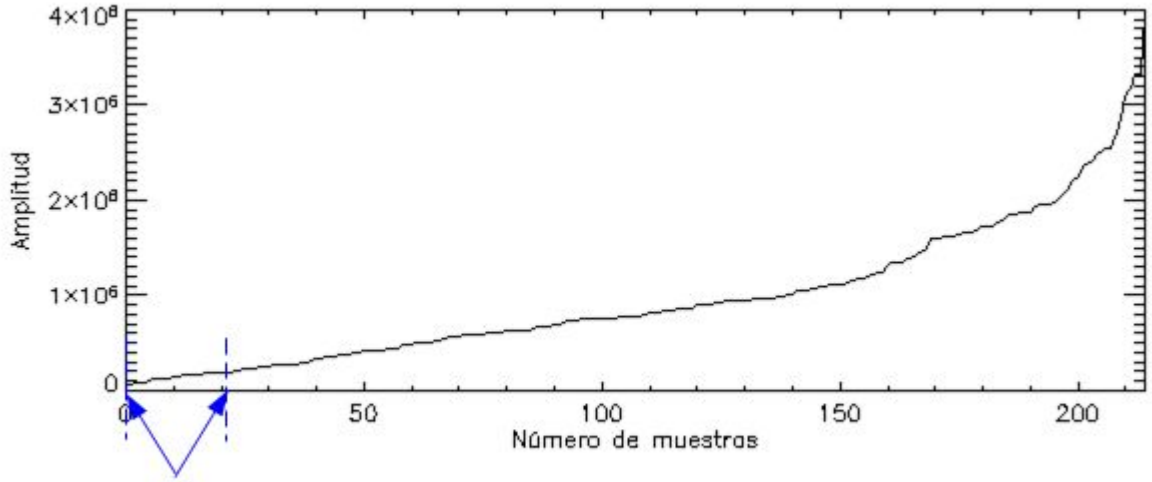
Incoherent Integration





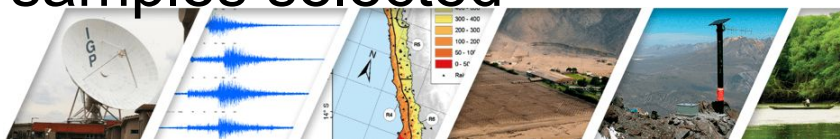
Radar Processing

Noise Estimation



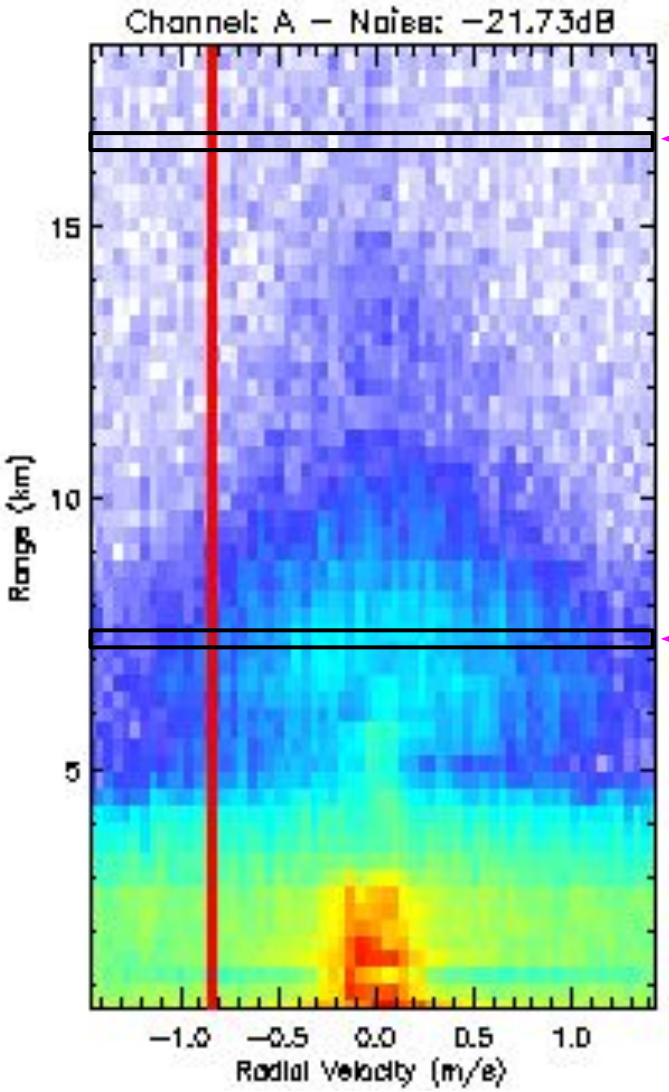
Región utilizada para calcular el nivel de ruido en la señal recibida

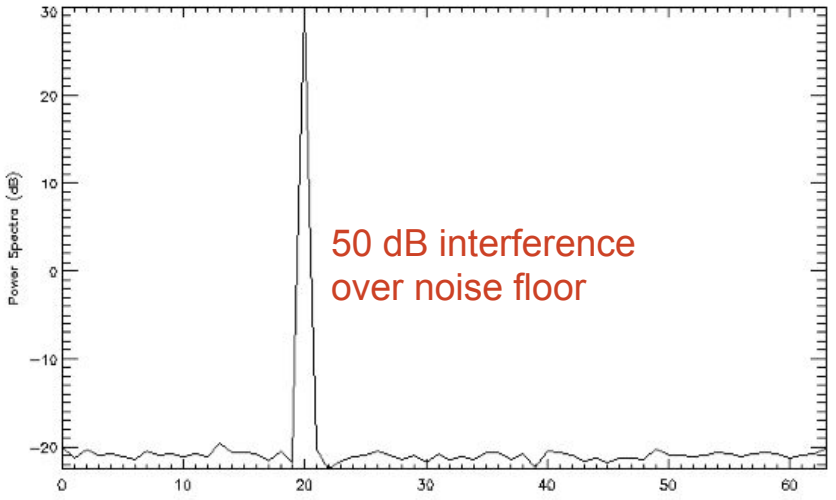
- Hildebrand and Sekon, 1974
- Sorting Power Spectrum from lowest to highest
- Select the samples with the lowest power
- Noise Estimation using the samples selected



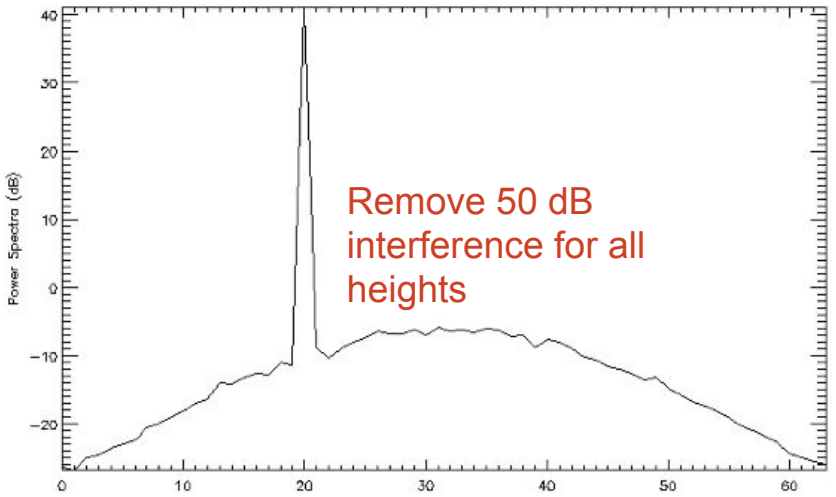
Radar Processing

Interference removal





50 dB interference over noise floor



Remove 50 dB interference for all heights

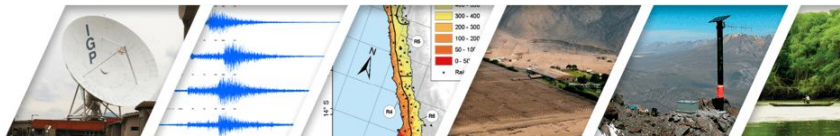
Radar Processing
Parameters

Raw Data (Voltage)

Proc Data (Spectra)

Parameters

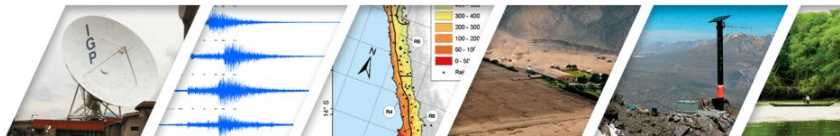
- Spectral Moments (Doppler, SNR, Spectral width)
- Winds estimation
- Faraday, Drifts



Signal Chain
What is it?

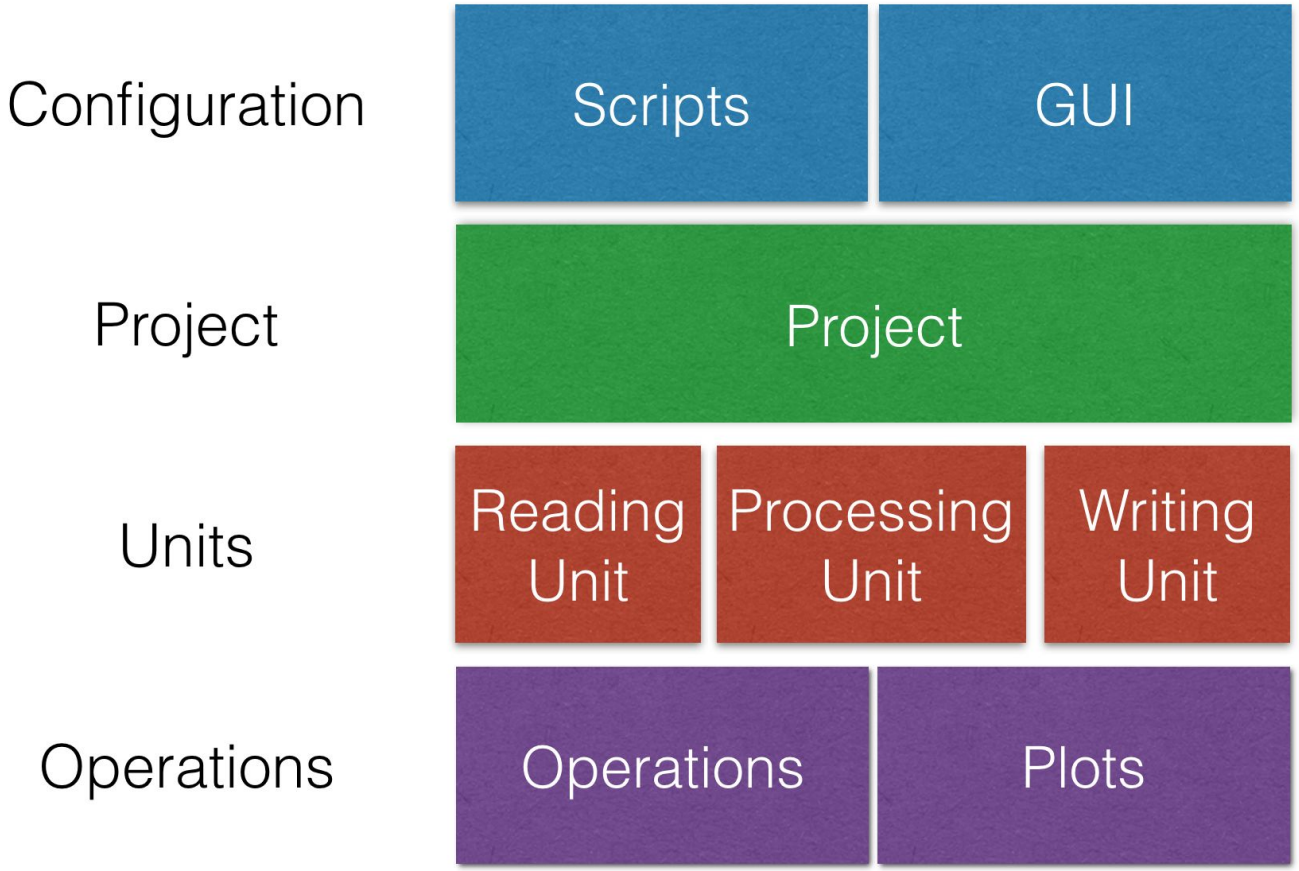
Signal Chain (SCh) is an ongoing project, which has the aim to develop open source libraries for the signal processing of the information acquired with scientific radars.

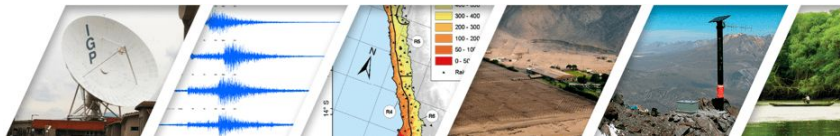
The final purpose of these libraries is to share them with the scientific community that uses these devices, in order to foster collaboration between the different institutions engaged in this field of study.



Signal Chain

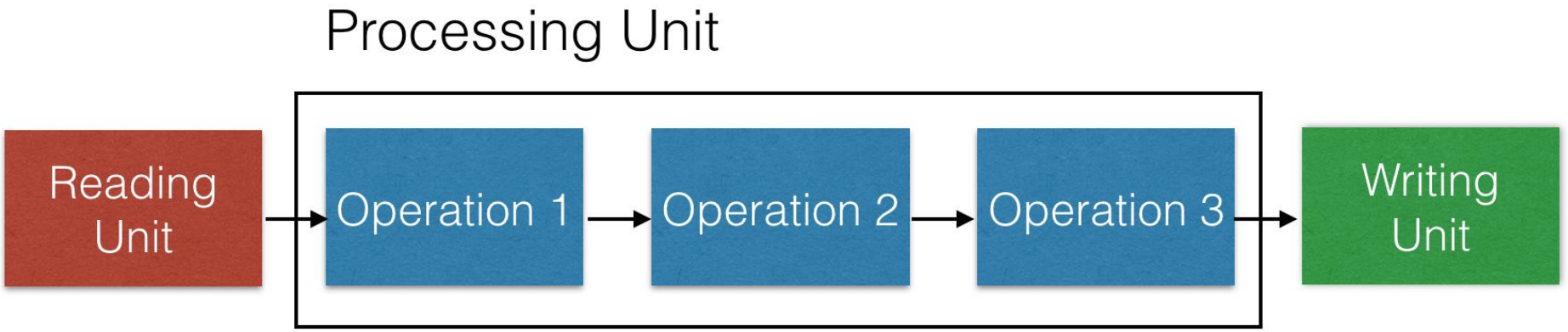
How it works?

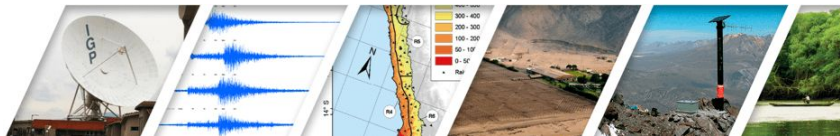




Signal Chain

How it works?

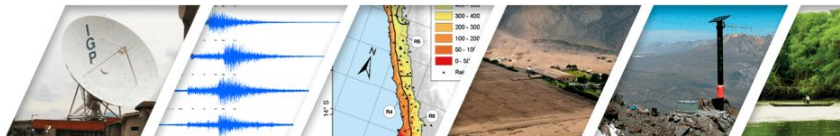




Signal Chain
How to use?

- Python library
- Versions:
  - Stable: schainpy-2.3
  - Development: schainpy-3.0

```
git clone http://jro-dev.igp.gob.pe/rhodecode/schain
cd schainpy
pip install ./
```



Signal Chain

How to use?

IGP
INSTITUTO GEOFÍSICO DEL PERÚ

```
import os, sys

path = os.path.split(os.getcwd())[0]
path = os.path.split(path)[0]

sys.path.insert(0, path)

filename = "school_test2.xml"
figpath = os.path.join(os.environ['HOME'],'Pictures')
path = os.path.join(os.environ['HOME'],'Pictures')
```

```
from schainpy.controller import Project
controllerObj = Project()
controllerObj.setup(id = '102', name='test02', description='Reader/Writer experiment')
```

PROJECT

```
readUnitConfObj = controllerObj.addReadUnit(datatype='MyReader',
                                            path=path,
                                            startTime = '00:00:00',
                                            endTime = '23:59:59',
                                            startDate = '2000/01/31',
                                            endDate = '2012/01/31')
```

READ UNIT

```
procUnitConfObj2 = controllerObj.addProcUnit(datatype='ParametersProc', inputId=readUnitConfObj.getId())

opObj21 = procUnitConfObj2.addOperation(name='ParametersPlot', optype='other')
opObj21.addParameter(name='id', value='5', format='int')
opObj21.addParameter(name='wintitle', value='Radial Velocity Plot', format='str')
opObj21.addParameter(name='save', value='1', format='bool')
opObj21.addParameter(name='figpath', value=figpath, format='str')
opObj21.addParameter(name='xmin', value='0', format='float')
opObj21.addParameter(name='xmax', value='0.5', format='float')
opObj21.addParameter(name='zmin', value='-0.25', format='float')
opObj21.addParameter(name='zmax', value='0.25', format='float')
opObj21.addParameter(name='paramIndex', value='1', format='int')
opObj21.addParameter(name='colormap', value='0', format='bool')
```

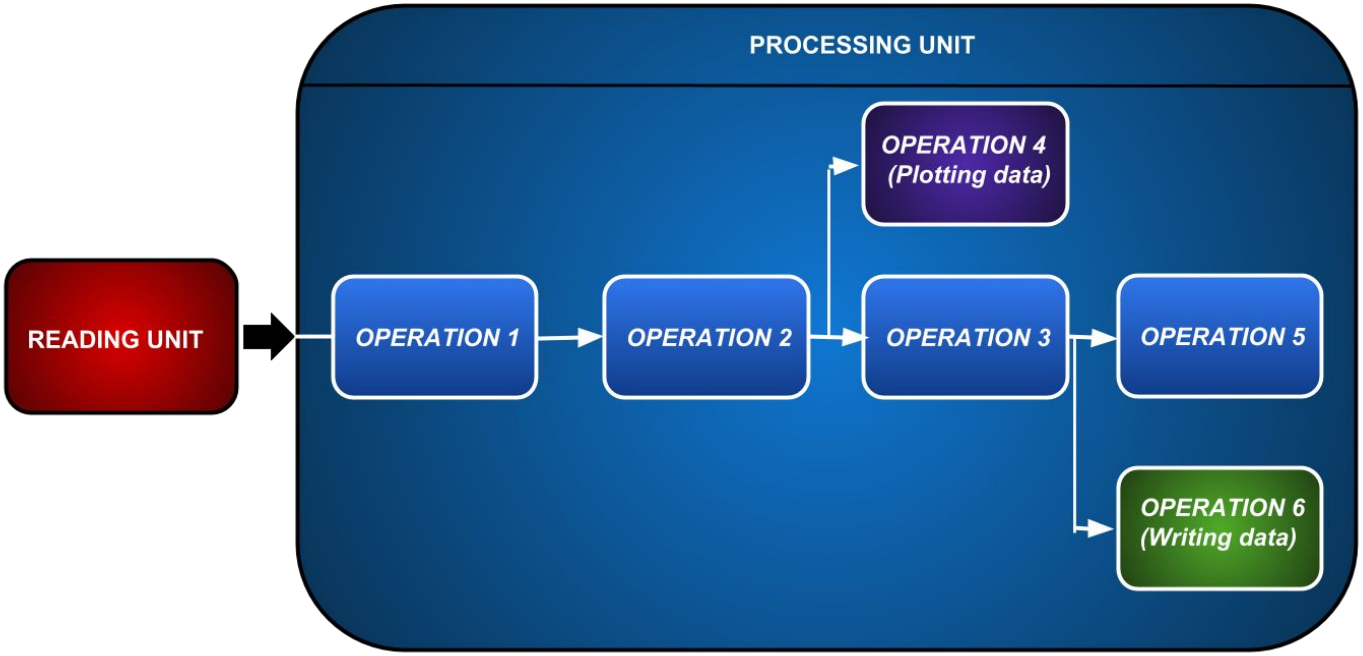
PROC UNIT

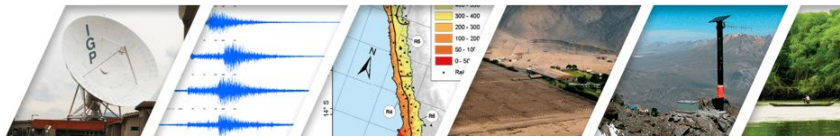
```
print "Escribiendo el archivo XML"
controllerObj.writeXml(filename)
print "Leyendo el archivo XML"
controllerObj.readXml(filename)

controllerObj.createObjects()
controllerObj.connectObjects()
controllerObj.run()
```

CONTROLLER

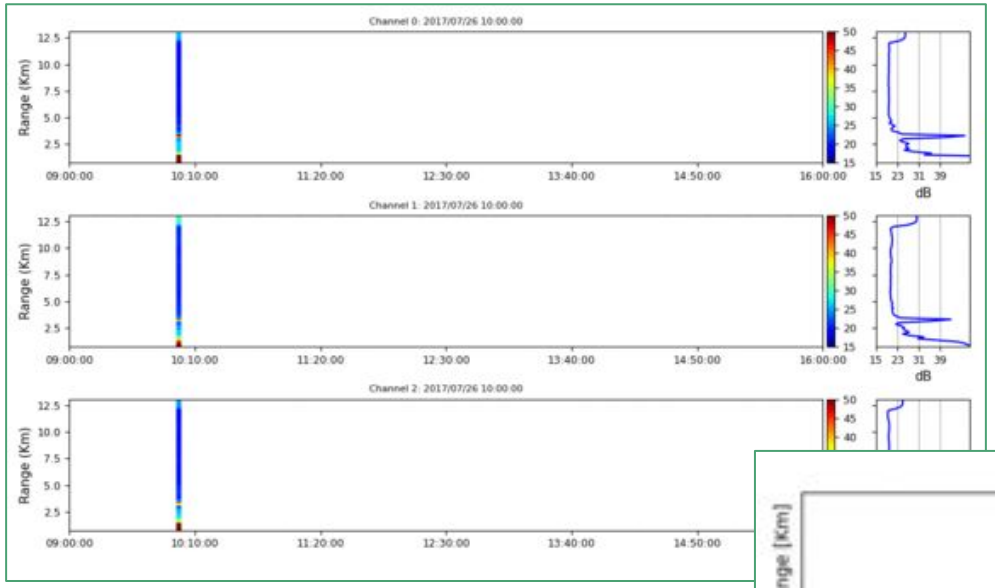
Signal Chain
Improvements v3.0

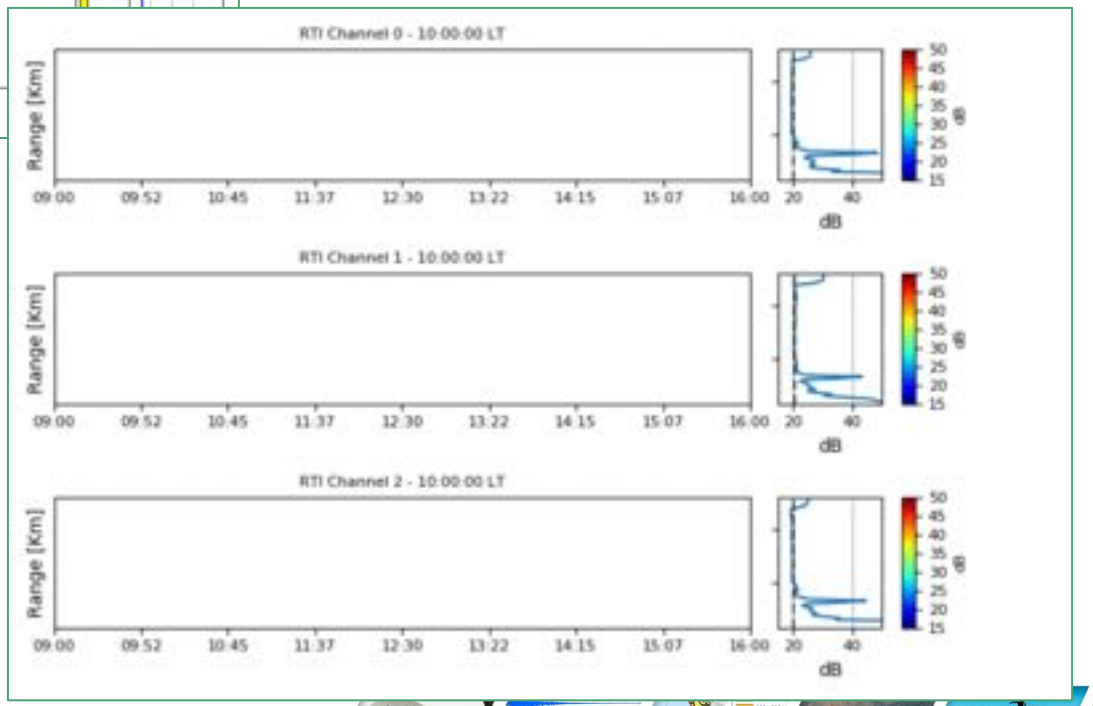
- Multiprocessing (Read Units, Proc Units, Operations)
- Decoupled operations
- Throttling functions (plots)
- Python 3 compatibility

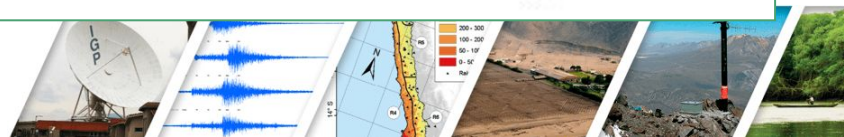




Signal Chain
Plotting







Questions?