

Universidad ECCI

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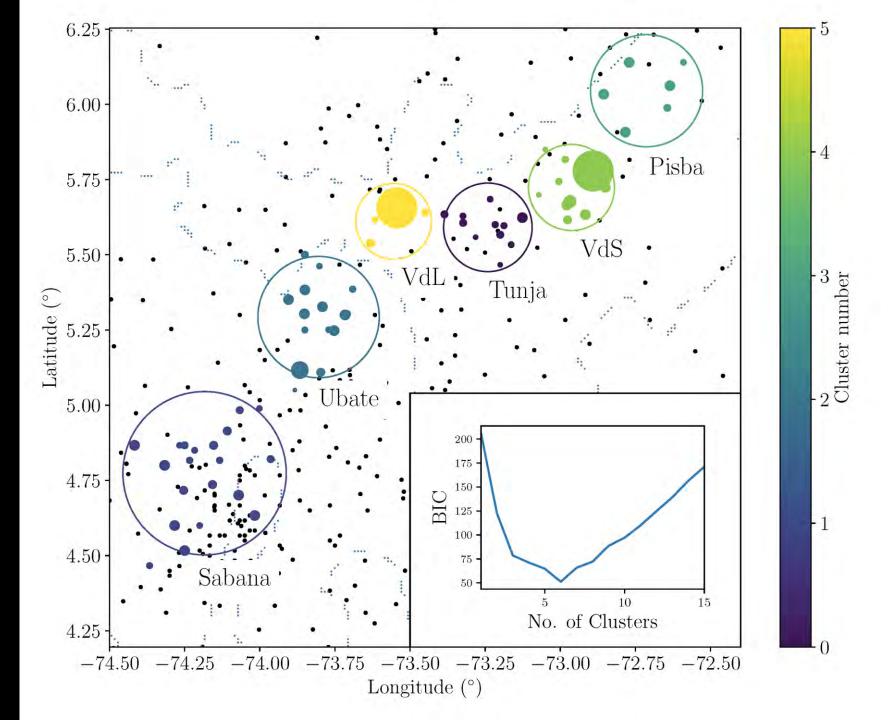
FEBRERO 16 Y 17 DE 2018

#### Radio Astronomy @ UECCI

- 3 undergraduate projects
- 1 MEng student
- 2 PhD Scholarships @ Universidad de Chile (RAIG)
   (2017+)
  - MARI-II: Antenna prototype 50-150 MHz for EOR
  - 1 m sub-mm dish at Cerro Calán– receiver refurbishment

Research and Universities Coordination (TF1)

Andean Regional Office of Astro4Dev, IAU



#### Radio Astronomía @ UECCI

- 3 trabajos de pregrado
- 1 estudiante de MEng
- 2 becas doctorales para dos estudiantes @ Universidad de Chile (RAIG) (2017+)
  - MARI-II: Prototipo antena 50-150 MHz para EOR
  - Antena Sub-mm de 1 m modernización

- Coordinación de Investigación y Universidades
   Andean Regional Office of Astro4Dev, IAU
- Coordinación Grupo de Trabajo en Radioastronomía

# SEGUNDO WORKSHOP DE

23 - 30 DE JULIO DE 2015

Universidad de Los Andes Bogotá, Colombia

#### Comité Organizador local

Jaime Forero-Romero (Uniandes, Colombia) Germán Chaparro Molano (UECCI, Colombia) Alejandro García (Uniandes, Colombia) Beatriz Sahogal (Uniandes, Colombia)

Dennis Cazar (U. San Francisco de Quito, Ecuador) Juan Carlos Muñoz-Cuartas (U. de Antioquia, Colombia) Fausto Mena (U. de Chile) Nobar Baella (Instituto Geofísico del Perú)

Fecha límite

Recepción de trabajos

29 DE MAYO

#### Invitados

Lydia Cidale Instituto Astrofísica de La Plata, Argentina U. de Antofagasta, Chile Kevin Govender Oficina de Astronomía para el Desarrollo IAU, Suráfrica José Ishitsuka Kathy Vielra Centro de Investigaciones





#### MARI: Medidor Autónomo de Radio Interferencia

(Pathfinder for redshifted 21 cm line arrays - EOR)



## MARI-II



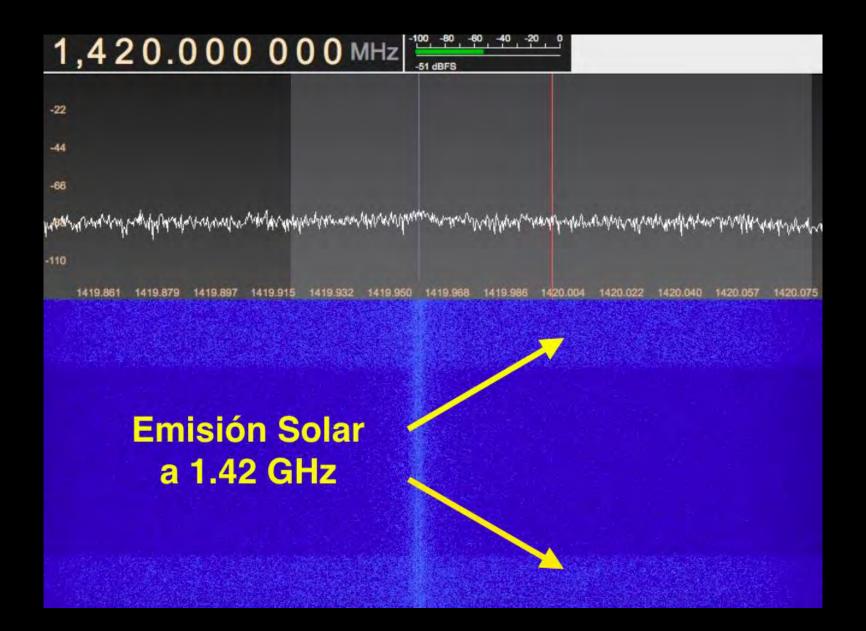
# Southern Millimeter-Wave Telescope

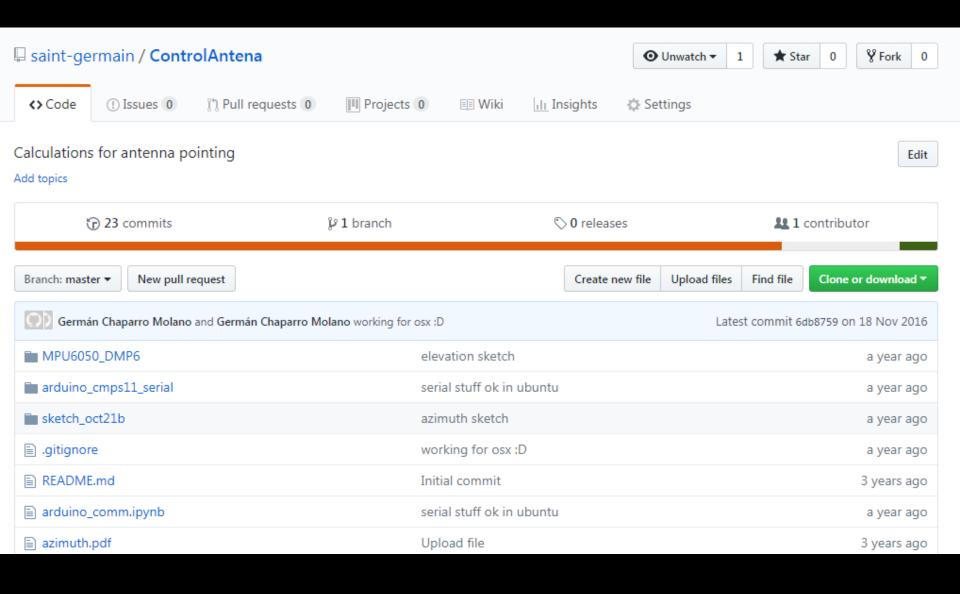


# Dish conversion 4 m radio telescope @ 1.4 GHz (21 cm) UECCI









#### Estudio de Sitio

• Estudios de viabilidad para observaciones milimétricas

Publications of the Astronomical Society of the Pacific, 129:105002 (20pp), 2017 October

https://doi.org/10.1088/1538-3873/aa83fe



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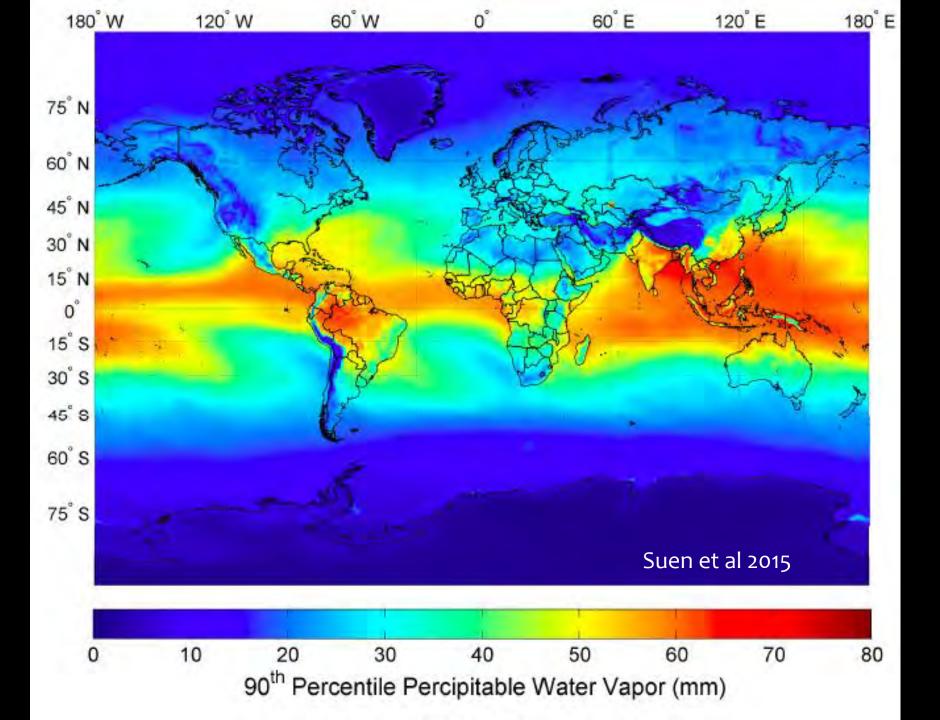
#### Low Dimensional Embedding of Climate Data for Radio Astronomical Site Testing in the Colombian Andes

Germán Chaparro Molano 100, Oscar Leonardo Ramírez Suárez 1, Oscar Alberto Restrepo Gaitán 1,2, and Alexander Marcial Martínez Mercado 1,3,4,5

<sup>1</sup> Grupo de Simulación, Análisis y Modelado, Vicerrectoría de Investigación, Universidad ECCI, Bogotá, Colombia gchaparrom@ecci.edu.co, oramirezs@ecci.edu.co

<sup>2</sup> Radio Astronomy Instrumentation Group, Universidad de Chile, Santiago de Chile, Chile; orestrepog@ecci.edu.co
<sup>3</sup> Instituto de Hidrología, Meteorología y Estudios Ambientales, Bogotá, Colombia

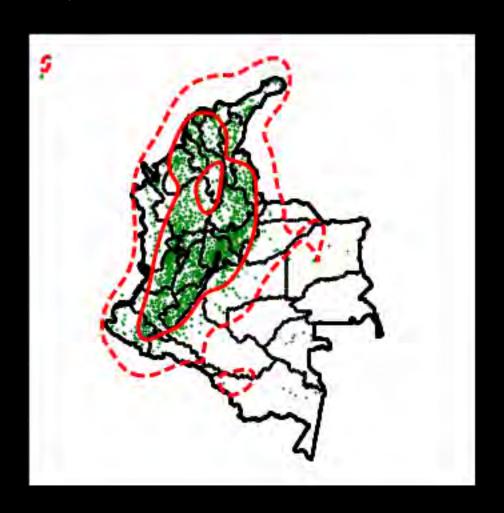
<sup>4</sup> Grupo de Simulación del Sistema Climático Terrestre, Universidad Nacional de Colombia, Bogotá, Colombia Departamento de Ciencias Básicas, Universidad ECCI, Bogotá, Colombia Received 2017 May 25; accepted 2017 July 31; published 2017 September 1





### IDEAM Climate Data (1980-2010)

- 2046 weather stations
- Precipitation, Rain Days,
   Relative Humidity, Sunshine
- Multi-annual Monthly Averages (Jan, Feb,...)
- 12-dimensional data
- Selection criteria Machine Learning

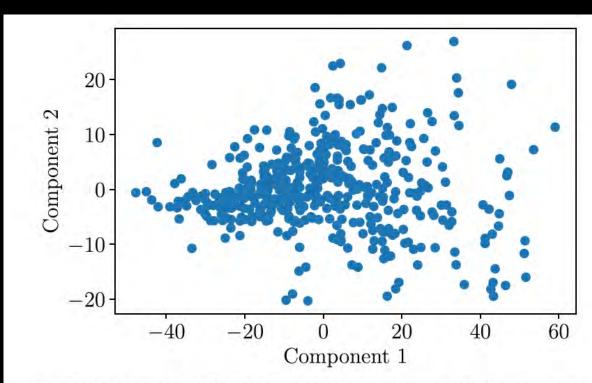


Climate data for National Meteorological Observatory, Bogotá (1971–2000)											
Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	(	

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Record high °C (°F)		25.2 (77.4)	26.6 (79.9)	24.4 (75.9)	25.0 (77)	28.6 (83.5)	25.0 (77)	23.3 (73.9)	26.0 (78.8)	25.1 (77.2)	25.6 (78.1)	24.4 (75.9)	28.6 (83.5)
Average high °C (°F)		20.3 (68.5)	19.4 (66.9)	20.1 (68.2)	19.0 (66.2)	19.2 (66.6)	18.6 (65.5)	18.8 (65.8)	19.2 (66.6)	19.5 (67.1)	19.6 (67.3)	19.9 (67.8)	19.6 (67.3)
Daily mean °C (°F)	14.3 (57.7)	14.5 (58.1)	14.9 (58.8)	14.9 (58.8)	15.0 (59)	14.5 (58.1)	14.6 (58.3)	14.1 (57.4)	14.3 (57.7)	14.3 (57.7)	14.4 (57.9)	14.6 (58.3)	14.4 (57.9)
Average low °C (°F)	7.6 (45.7)	8.4 (47.1)	9.5 (49.1)	9.7 (49.5)	9.7 (49.5)	9.5 (49.1)	9.2 (48.6)	8.9 (48)	8.7 (47.7)	9.0 (48.2)	9.2 (48.6)	8.0 (46.4)	9.0 (48.2)
Record low °C (°F)	-1.5 (29.3)	-5.2 (22.6)	-0.4 (31.3)	0.2 (32.4)	0.2 (32.4)	1.1 (34)	0.4 (32.7)	0.4 (32.7)	0.3 (32.5)	1.8 (35.2)	0.5 (32.9)	-1.1 (30)	-5.2 (22.6)
Average precipitation mm (inches)	50 (1.97)	68 (2.68)	91 (3.58)	135 (5.31)	120 (4.72)	54 (2.13)	35 (1.38)	45 (1.77)	70 (2.76)	137 (5.39)	127 (5)	81 (3.19)	1,012 (39.84)
Average rainy days (≥ 1 mm)	9	12	14	18	19	17	15	14	16	21	16	11	181
Average relative humidity (%)	75	76	75	77	77	75	74	74	75	76	77	76	76
Mean monthly sunshine hours	156	128	107	88	83	94	114	117	109	96	103	138	1,328

#### Reducción de Dimensionalidad

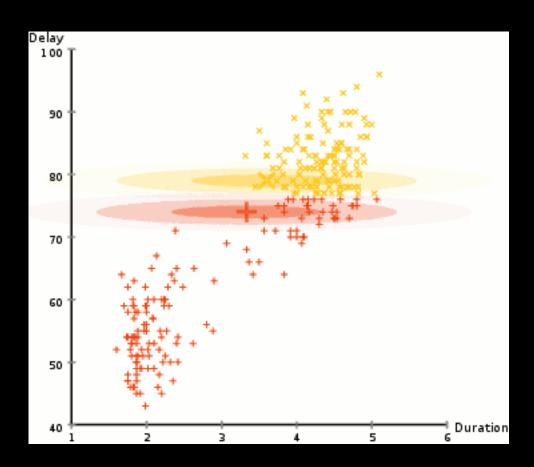
- Análisis de Componentes Principales (Eigenvalores y Eigenvectores de la matriz de covarianza)
- Preservamos 2-sigma de la varianza de los datos
- Reducimos la dimensionalidad de los vectores (datos) de 12 a 3(2)



**Figure 3.** Relative humidity data projected across two principal components. The dimensionality of the data has been reduced from 12 to two while covering 95% of the variance of the data.

#### Modelos de Mixtura Gaussiana





#### Modelos de Mixtura Gaussiana

$$p(\mathbf{x}) = \frac{1}{(2\pi)^{D/2} |\mathbf{\Sigma}|^{1/2}} \exp \left[ -\frac{1}{2} (\mathbf{x} - \boldsymbol{\mu})^{\mathrm{T}} \mathbf{\Sigma}^{-1} (\mathbf{x} - \boldsymbol{\mu}) \right] \doteq \mathcal{N}(\mathbf{x}; \boldsymbol{\mu}, \boldsymbol{\Sigma})$$

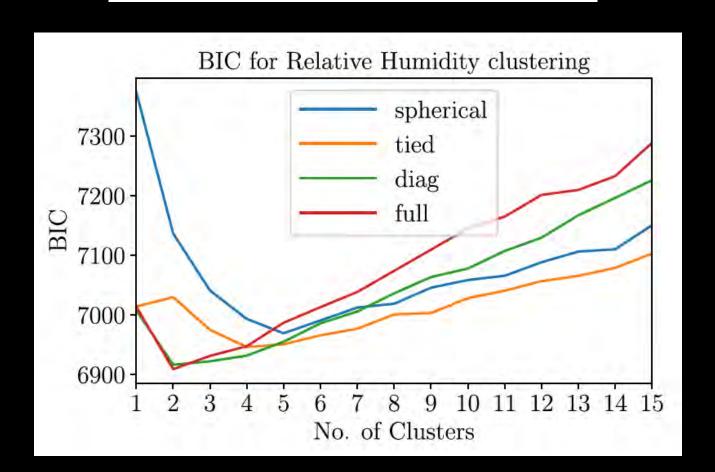
$$p(\mathbf{x}) = \sum_{m=1}^{M} \frac{c_m}{(2\pi)^{D/2} |\boldsymbol{\Sigma}_m|^{1/2}} \exp\left[-\frac{1}{2} (\mathbf{x} - \boldsymbol{\mu}_m)^{\mathrm{T}} \boldsymbol{\Sigma}_m^{-1} (\mathbf{x} - \boldsymbol{\mu}_m)\right]$$
$$= \sum_{m=1}^{M} c_m \mathcal{N}(\mathbf{x}; \boldsymbol{\mu}_m, \boldsymbol{\Sigma}_m), \quad (c_m > 0).$$

$$\boldsymbol{\Theta} = \{c_m, \boldsymbol{\mu}_m, \boldsymbol{\Sigma}_m\}$$

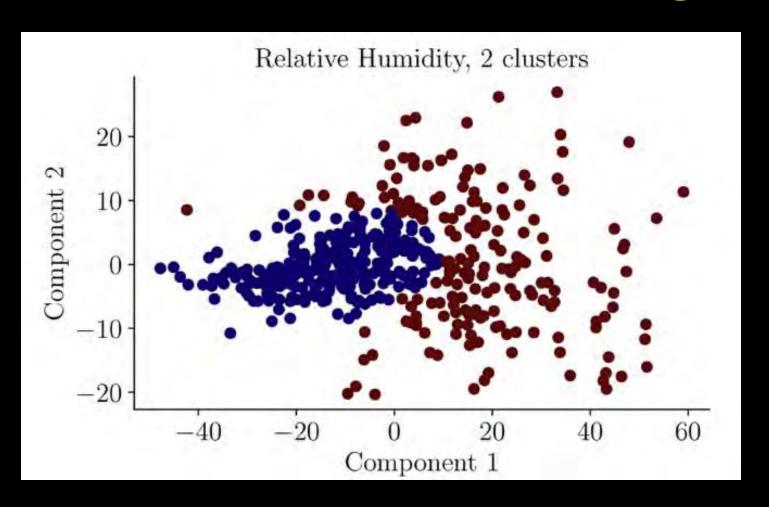
$$\mathcal{L} = \prod_i p_i(\mathbf{x}; \mathbf{\Theta})$$

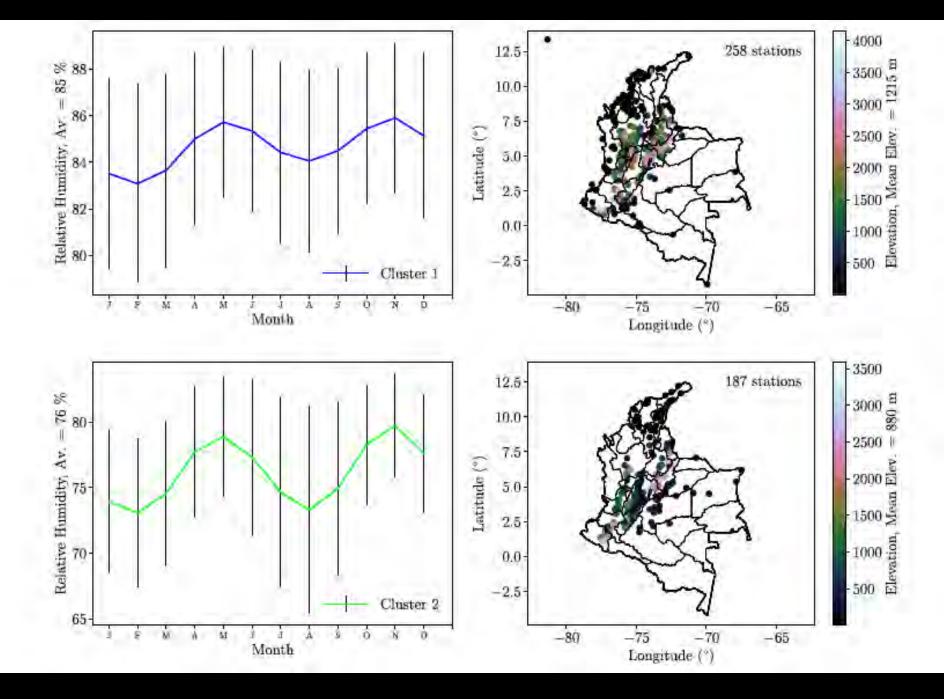
#### Criterio de Información Bayesiano

$$\mathrm{BIC} = \ln(n)k - 2\ln(\hat{L})$$

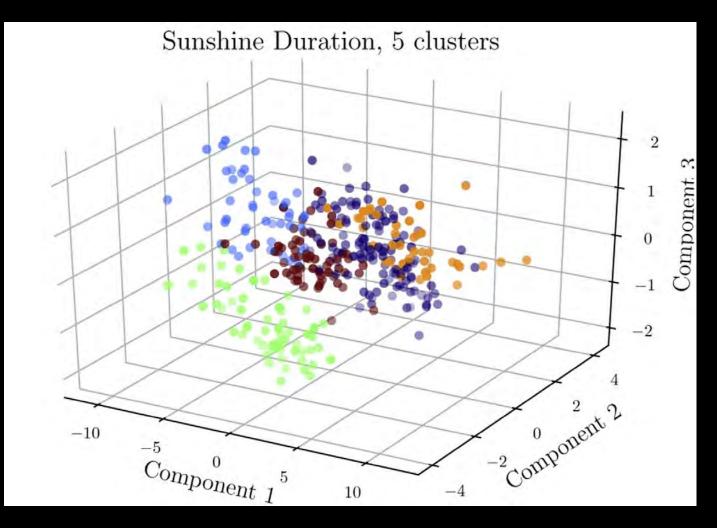


## Low Dimensional Embedding





## Low Dimensional Embedding



#### Bayesian Quality Index

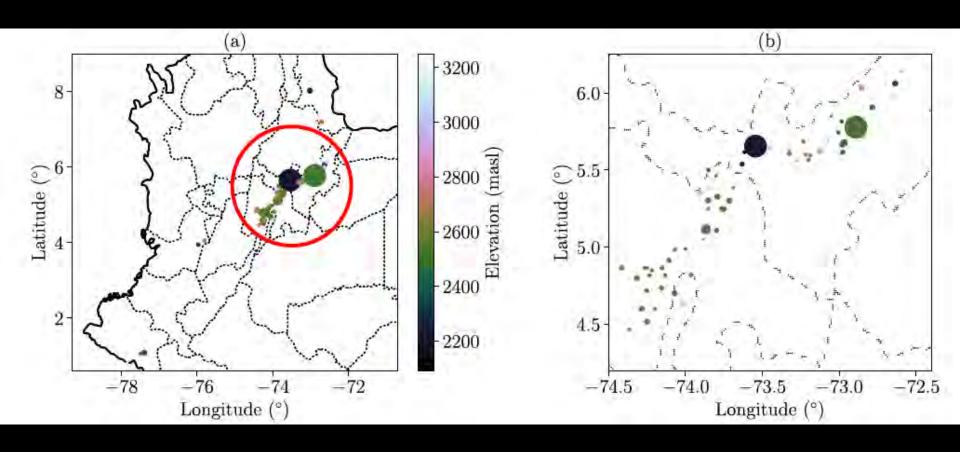
$$P_j = P(C \cap A \cap T_i \mid h)$$

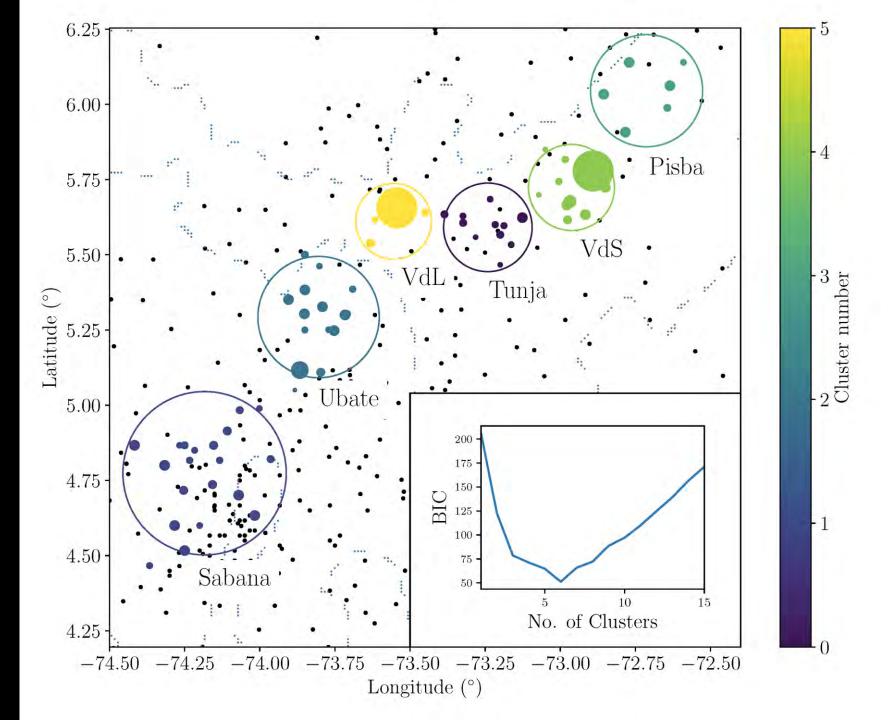
$$P_{j} = \frac{P(h \mid C \cap A \cap T_{i})}{P(h)} P(C \mid A \cap T_{i}) P(A \mid T_{i}) P(T_{i}), \quad (3)$$

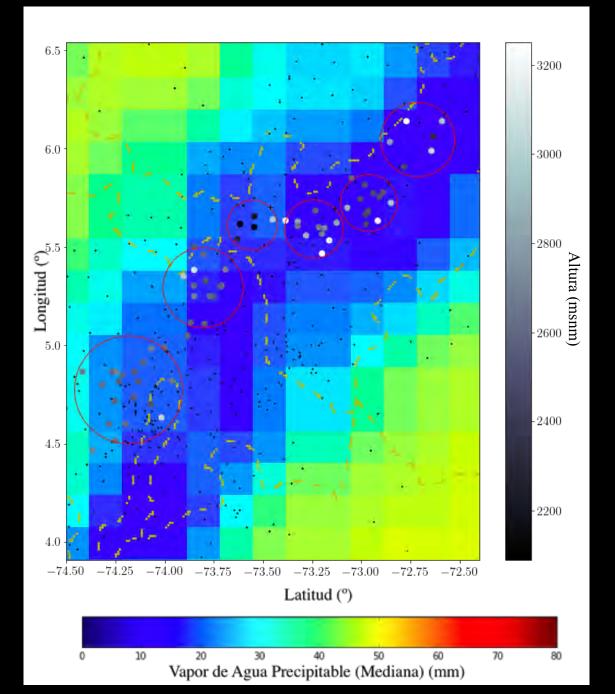
#### where

- 1.  $P(h \mid C \cap A \cap T_i)$  is the distribution of elevations for a station type  $(T_i)$  on our shortlist  $(C \cap A)$ ,
- 2.  $P(A \mid T_i)$  is the probability that a station of type  $T_i$  is in our shortlist,
- 3.  $P(T_i)$  is the probability that a station type is  $T_i$ , and
- 4.  $P(C \mid A \cap T_i)$  is the probability that a station meets all four criteria (C) given that it is in our shortlist (A) and is of type  $T_i$ .

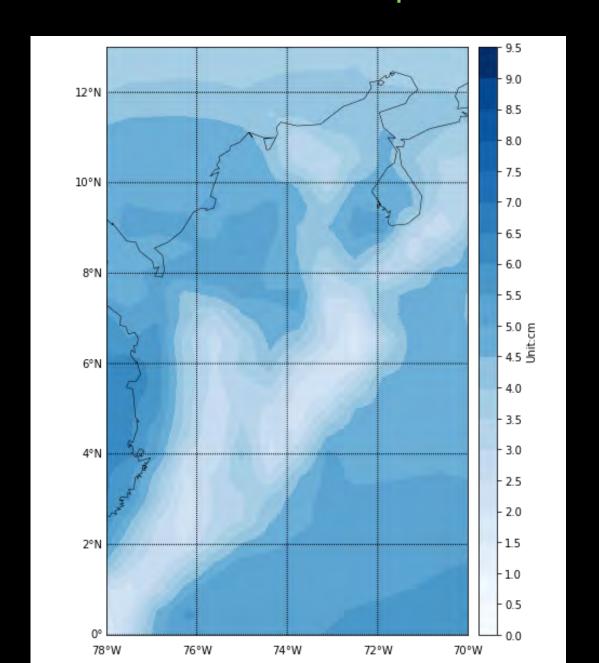
# Estaciones candidatas situadas por encima de 2000 msnm

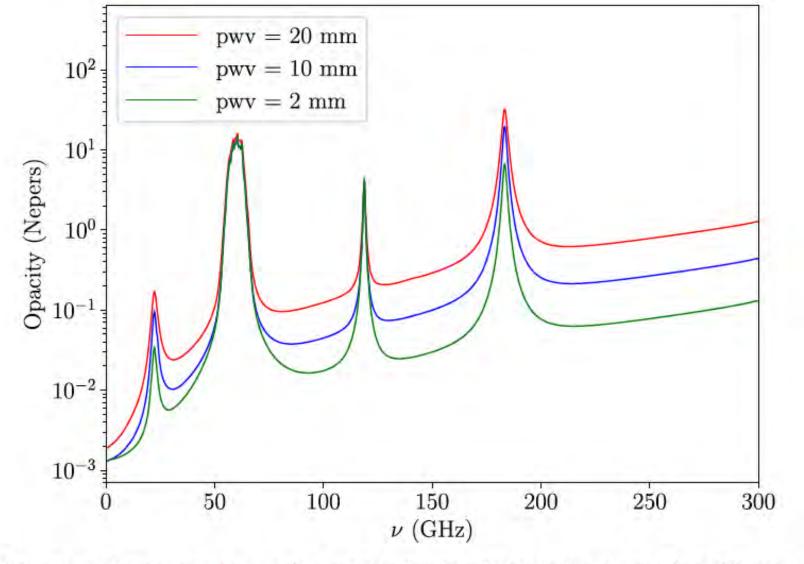






#### MODIS - satellite Water Vapor measurements





**Figure 1.** Atmospheric opacity models for the Colombian Andes for different precipitable water vapor (pwv) values corresponding to three scenarios for a 3400 masl site: red line (20 mm pwv) 90% relative humidity at 15°C, blue line (10 mm pwv) 90% relative humidity at 0°C, and green line (2 mm pwv) 30% relative humidity at 0°C.

#### Site Testing preliminary results

- 4 candidate regions for sites above 3400 msnm for mm-wave radio astronomy
  - Valle del Sol
  - Valle de Ubaté
  - Páramo de Pisba (\*)
  - Cantón de Tunja (\*)
  - Cocuy East
- Observing bands:
  - 70-115 GHz
  - 120-170 GHz
  - 120-130 GHz

#### GitHub

Estudio de Sitio: saint-germain/ideam

Control por astropy+arduino
saint-germain/ControlAntena