



JORNADA SOBRE MODELACIÓN NUMÉRICA EN INGENIERÍA DE PRESAS

MACHINE LEARNING EN INGENIERÍA DE PRESAS

F. Salazar, A. Conde, D.J. Vicente, J. Irazábal,
J. San Mauro, E. Oñate

CIMNE^R

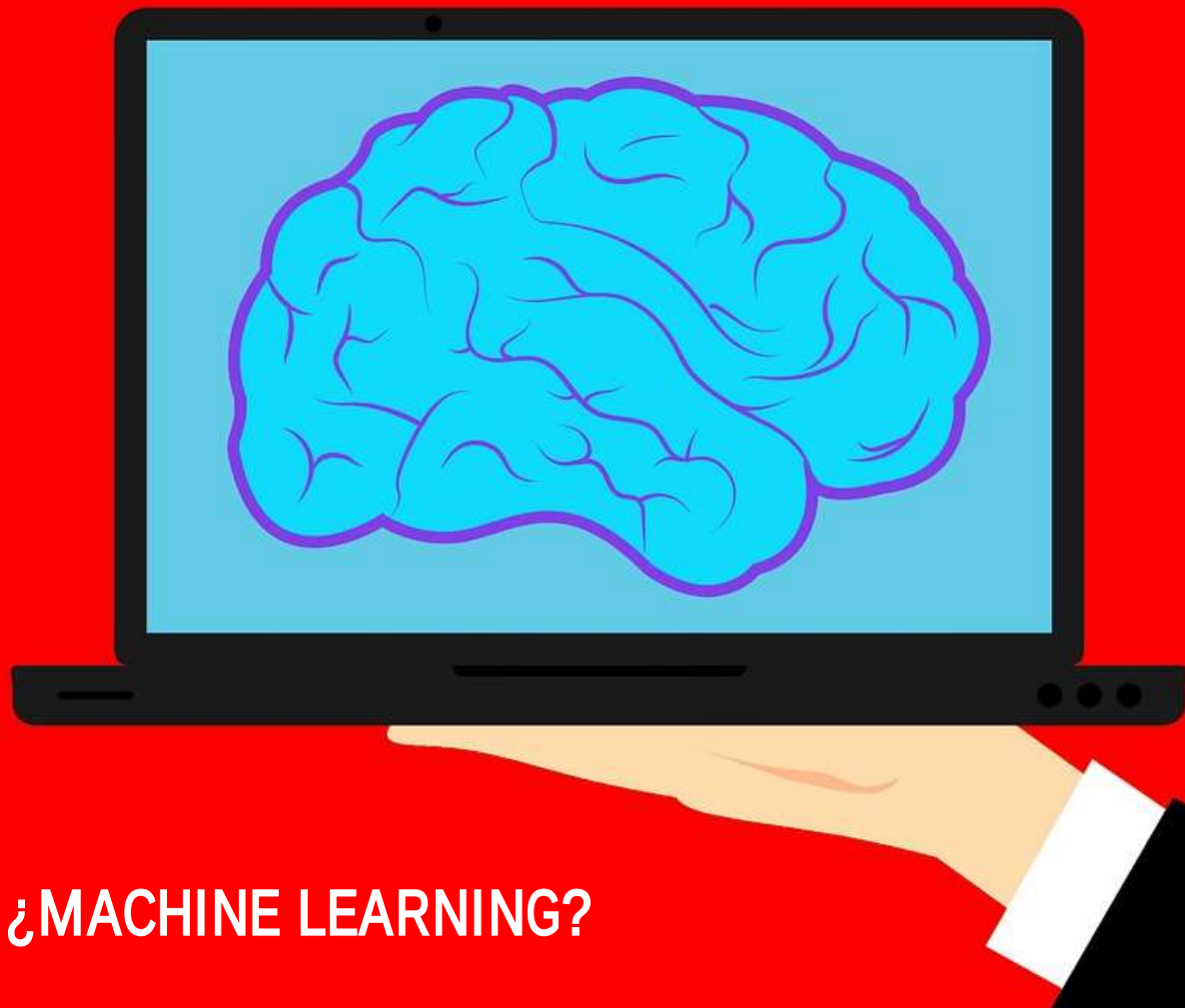


Image: Claude AI Info
<https://claudeai.wiki/category/ai-blog/>

¿MACHINE LEARNING?

DATA AS A SERVICE

DEEP LEARNING

BIG DATA

BLOCKCHAIN

DATA WAREHOUSE

TENSORFLOW

DATA MINING

SOFT COMPUTING

BIG DATA

DEEP LEARNING

EXTREME LEARNING

DATA LAKE

MACHINE
LEARNING

PETABYTE

APACHE

DATA WAREHOUSE

HADOOP

DATA MINING

ARTIFICIAL INTELLIGENCE

DATA ARQUITECTURE

SOFT COMPUTING

CLOUD COMPUTING

SQL

INTERNET OF THINGS

NEURAL NETWORK

NO-SQL

DATA ARQUITECTURE

DATA SCIENCE

TENSORFLOW

DEFINICIÓN

machine learning

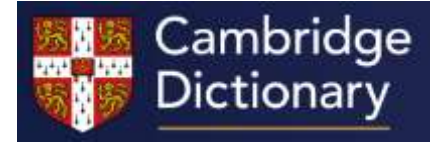
noun [U] • COMPUTING • specialized

UK /məˈʃiːn ˈlɜːnɪŋ/ US /məˈʃiːn ˈlɜːnɪŋ/



the process of computers changing the way they carry out tasks by learning from new data, without a human being needing to give instructions in the form of a program:

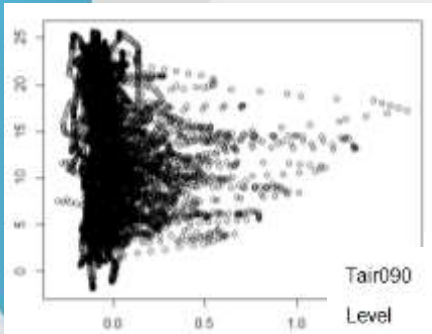
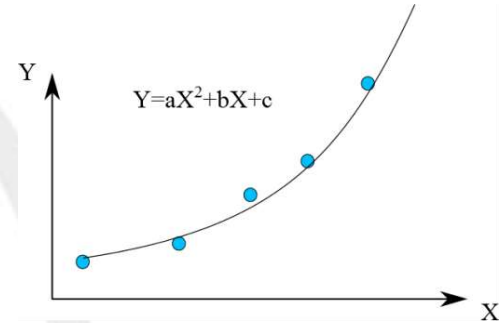
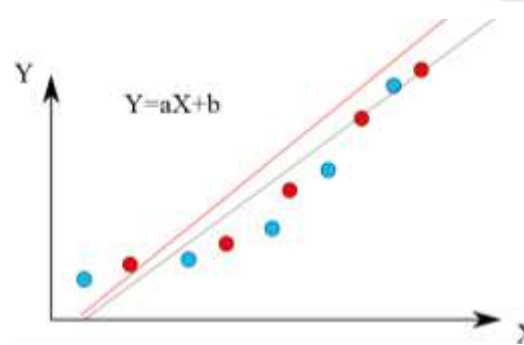
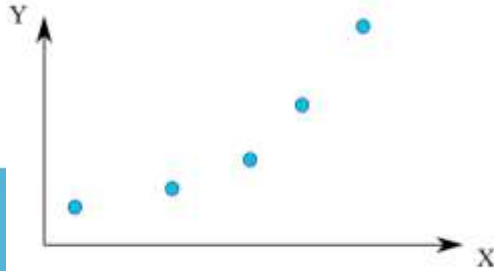
- *His research helped shape the field of machine learning, bringing computers closer to the realm of human thought.*
- *The route to genuine machine learning and artificial intelligence runs through language.*



Regresión

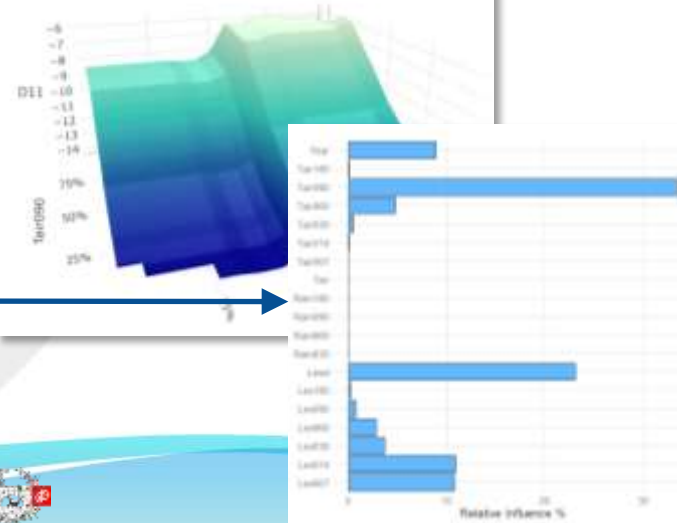


MACHINE LEARNING. REGRESIÓN



Tair090	Lev030	Lev090	Rain180
Level	Month	Tair180	Rain090
Lev014	Lev060	Lev180	Rain060
Lev007	NDay	Tair014	Rain030
Tair060	Tair030	Tair007	Rain
	Year	Tair	

**MACHINE
LEARNING**



MACHINE LEARNING



- Predicción
- Interpretación

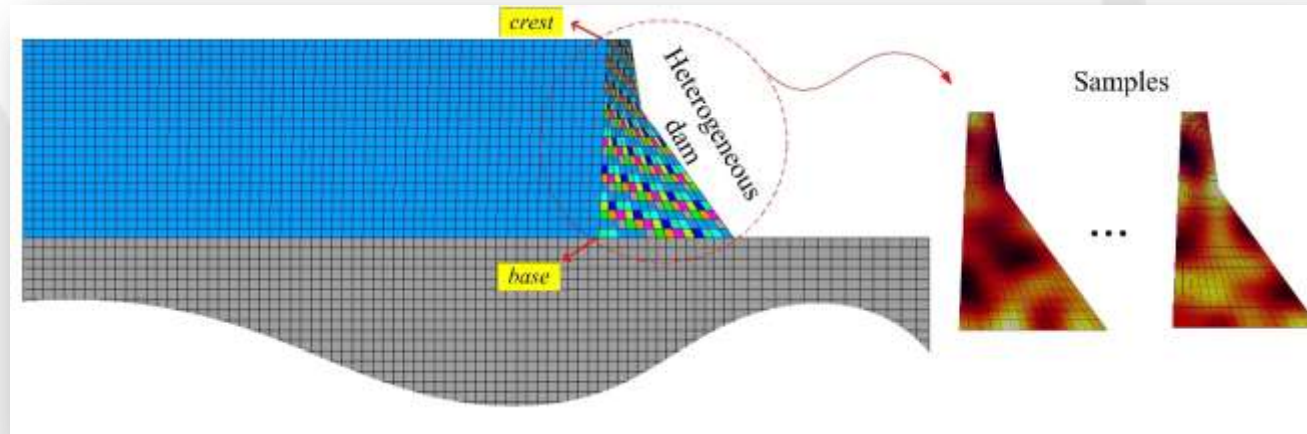
MACHINE LEARNING



Support Vector
Machines **Redes Neuronales**
Boosted Regression Trees
Multi Adaptive Random
Regression Splines Forests

CUANTIFICACIÓN DE LA INCERTIDUMBRE

- Análisis sísmico
- E_c como variable aleatoria (hormigón heterogéneo)
- 100 modelos; 1,000 pasos de tiempo cada uno



MACHINE LEARNING

Input

Material

 $\bar{X}$

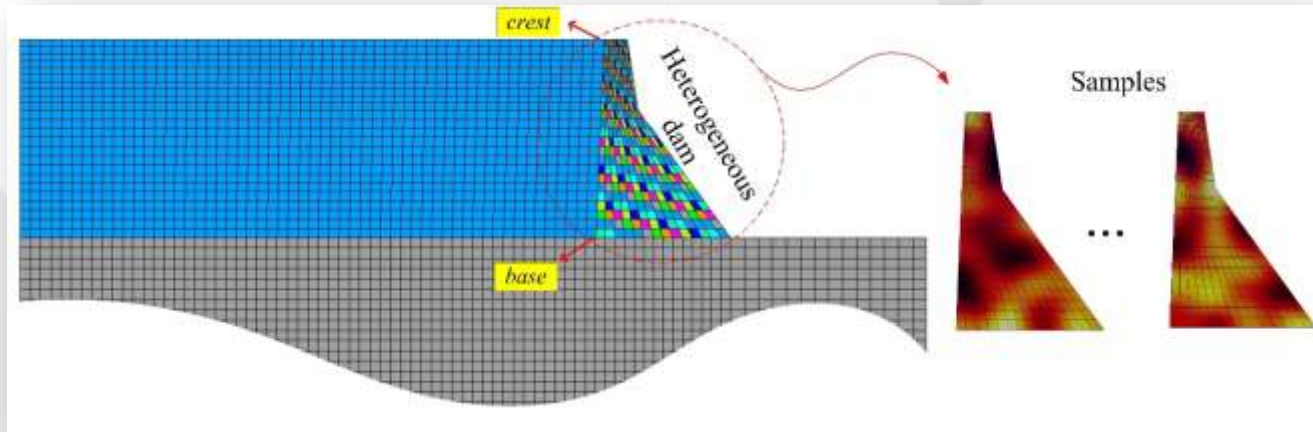
Model

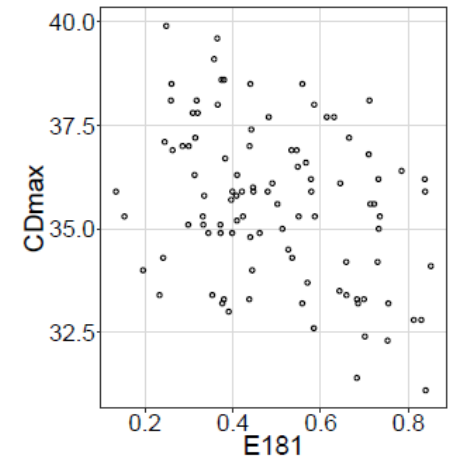
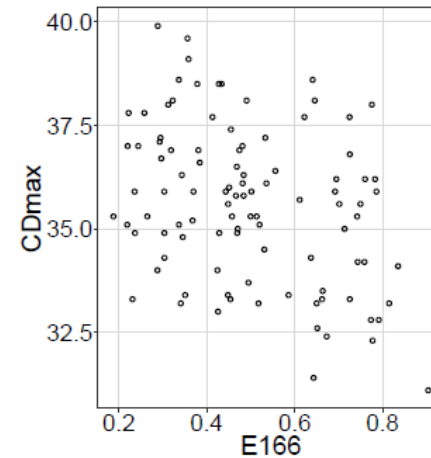
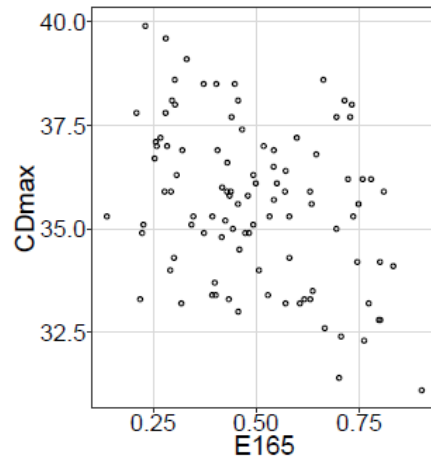
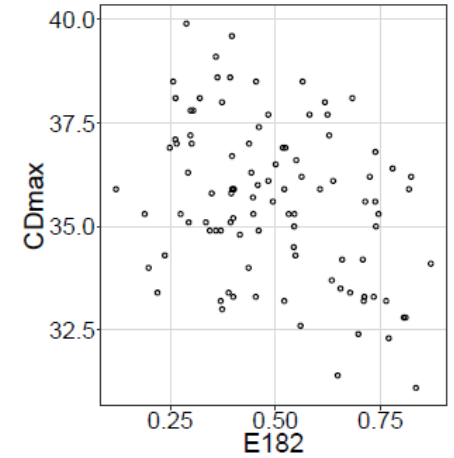
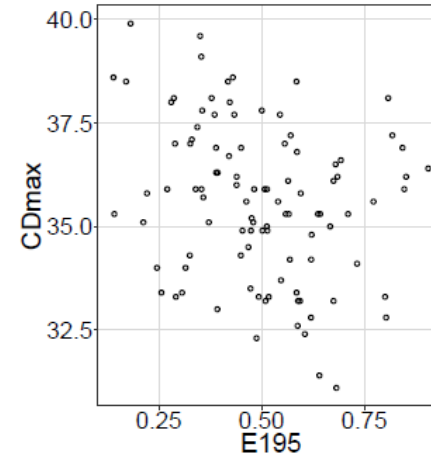
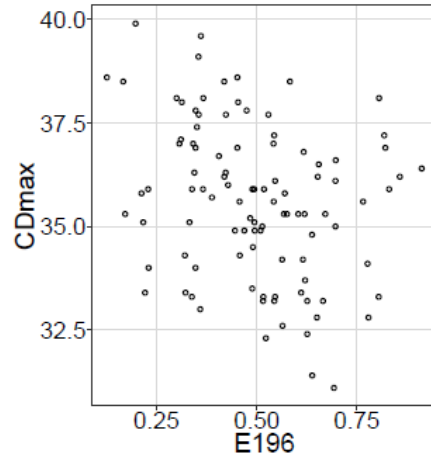
Presa

Modelo MEF

 $f()$

Output

Desplazamiento
Tracción $Y \simeq f(\bar{X})$ 



PREDICCIÓN

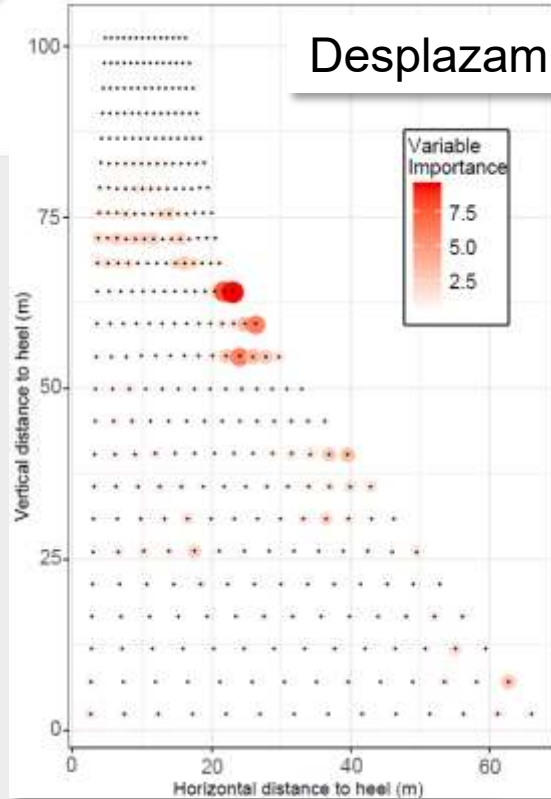
- Algoritmo: Bosques aleatorios
- Coste computacional despreciable

Output	Model ID	MAE-Train	MAE-Test	MAPE-Train	MAPE-Test
<i>CD_{max}</i> (mm)	C	0.67 (0.014)	0.66 (0.015)	1.90 (0.040)	1.82 (0.042)
<i>SB_{max}</i> (MPa)	D	8.71 (0.32)	10.71 (0.32)	0.88 (0.032)	1.11 (0.033)

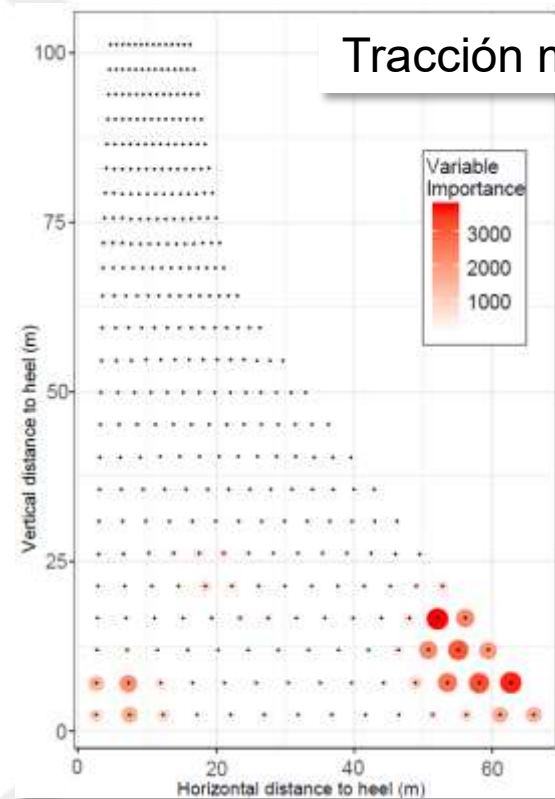
MAE: Error medio absoluto
MAPE: Error porcentual medio absoluto

INTERPRETACION

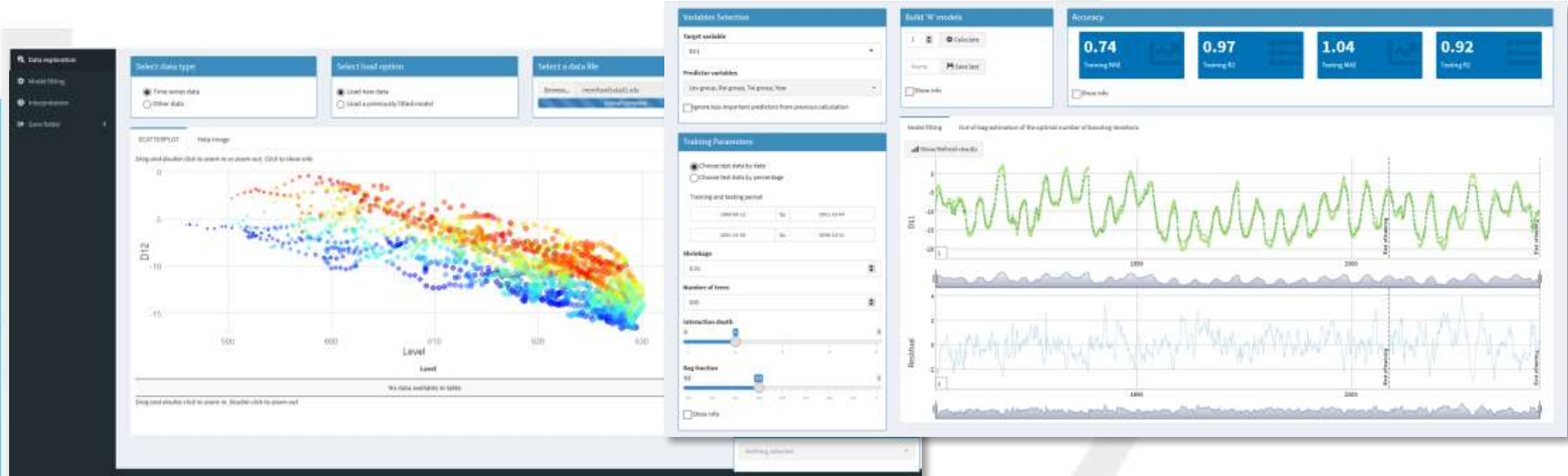
Desplazamiento máximo



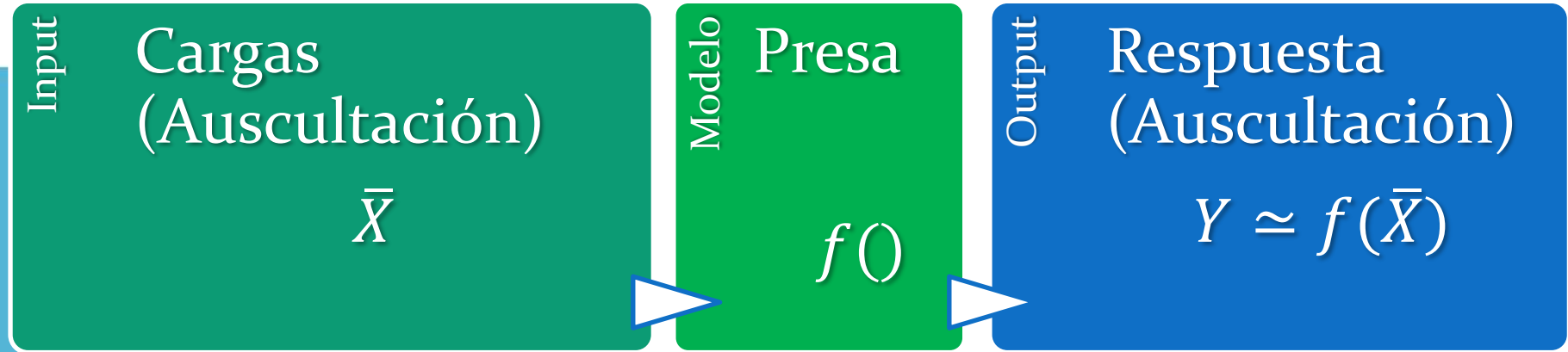
Tracción máxima



ANÁLISIS DE DATOS DE AUSCULTACIÓN



MACHINE LEARNING



MODELO ESTADÍSTICO VS MACHINE LEARNING

• Método HST

- Desplazamientos
- Función predefinida
- No cumplen hipótesis
- Fácil de interpretar

• Machine Learning

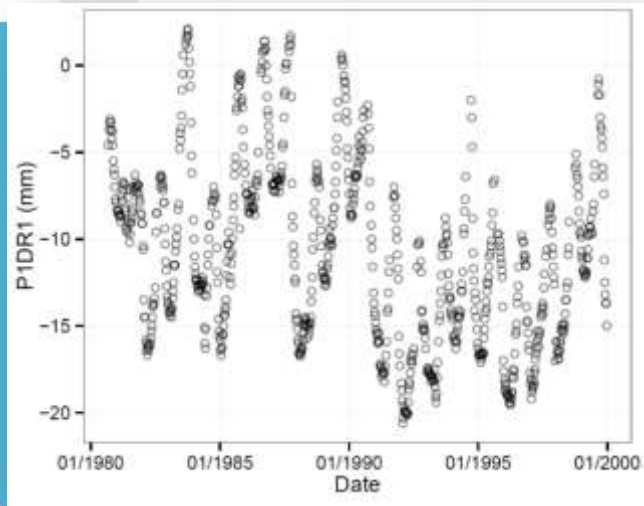
- Cualquier variable
- Flexible
- Consideran la interacción
- Interpretable
- Mayor precisión

$$\hat{f}(h, s, t) = a_0 + a_1 \cdot h + a_2 \cdot h^2 + a_3 \cdot h^3 + a_4 \cdot h^4 + a_5 \cdot e^{-t} + a_6 \cdot t + a_7 \cdot \cos(s) + a_8 \cdot \sin(s) + a_9 \cdot \sin(2s) + a_{10} \sin(s) \cos(s)$$

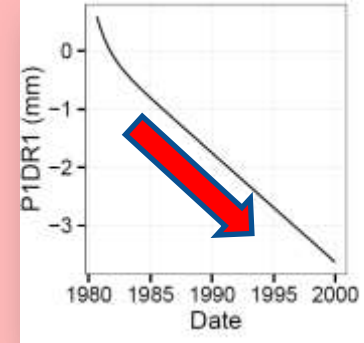
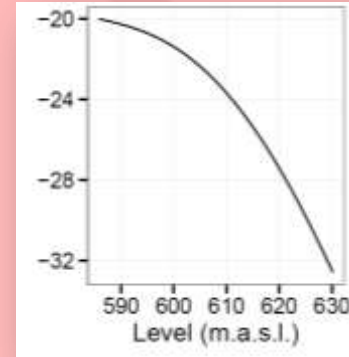
Willm, G., & Beaujoint, N. (1967, September). Les méthodes de surveillance des barrages au service de la production hydraulique d'Electricité de France, problèmes anciens et solutions nouvelles. In *IXth international congress on large dams* (pp. 529-550).

INTERPRETACIÓN

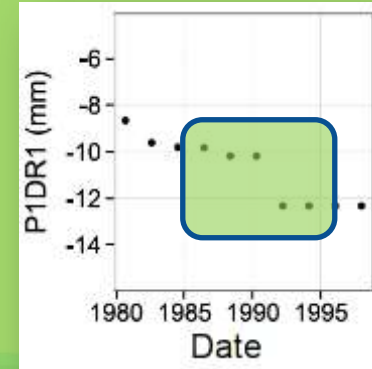
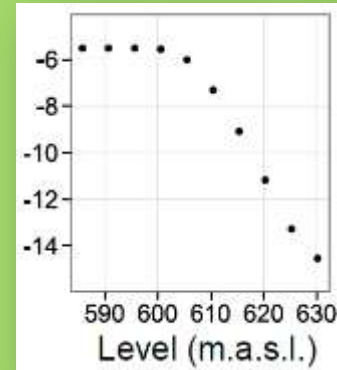
Desplazamiento radial
Presas bóveda 100 m.

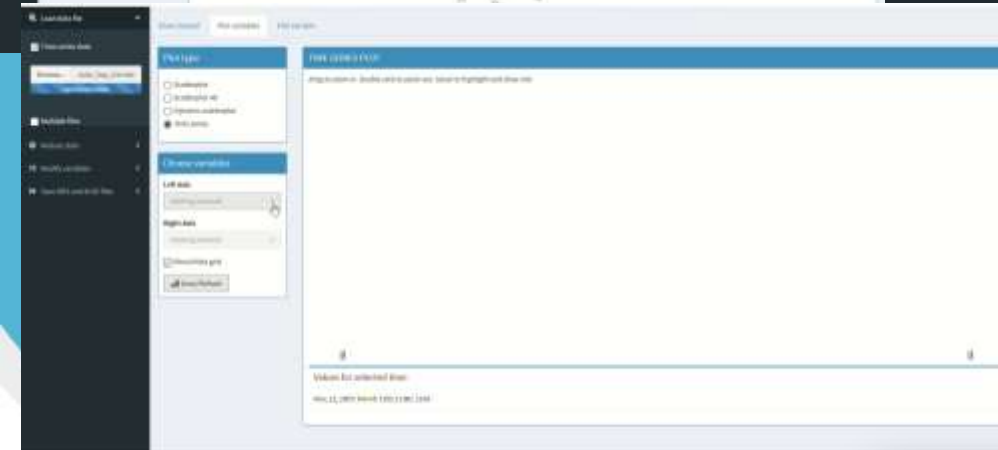
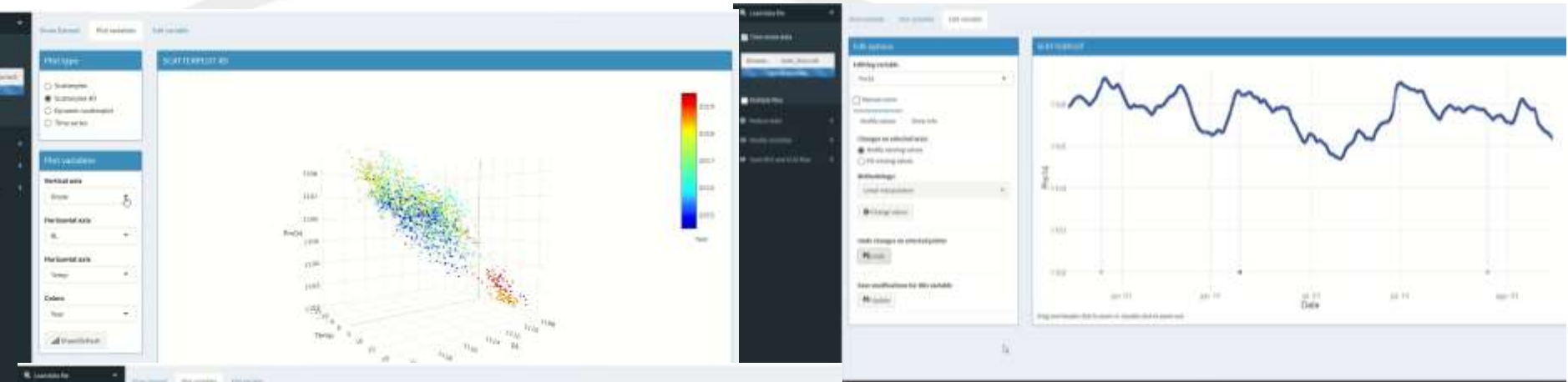


HST

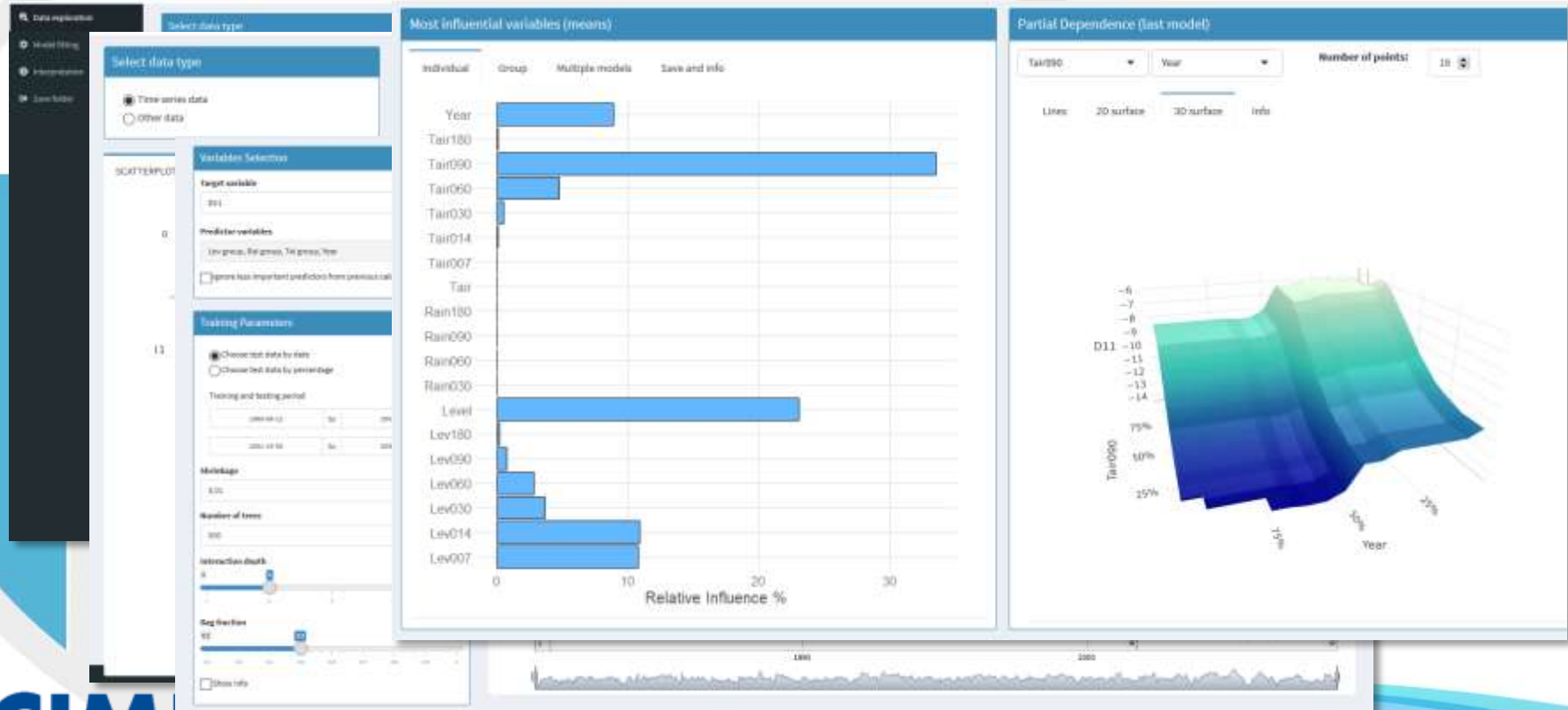


Machine
Learning



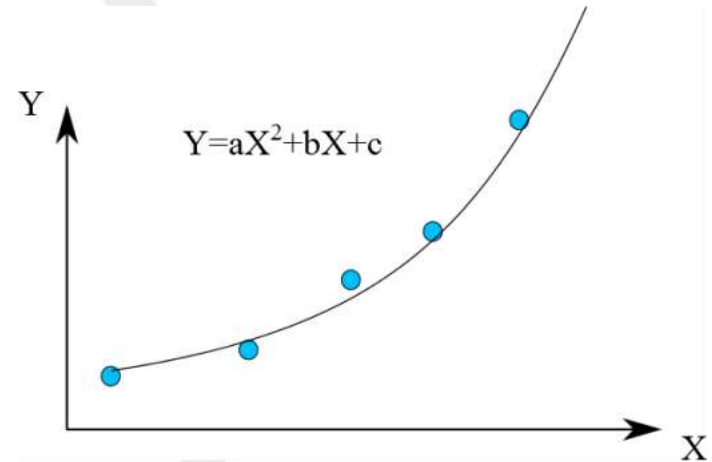


SOFTWARE. VERSIÓN LIBRE ONLINE



PRECAUCIONES Y LIMITACIONES

- ☐ Se requieren **datos**:
 - ☐ Auscultación
 - ☐ Modelos MEF
 - ☐ Experimentos
- ☐ Conocimiento de algoritmos
- ☐ ¡No extrapolar!
- ☐ Tienen base teórica
- ☐ Muchos recursos en internet
- ☐ **Juicio ingenieril**



**“If you only have a hammer,
you tend to see every problem
like a nail”**

**Abraham Maslow,
“Psychology of Science: A
Reconnaissance”, 1966**





JORNADA SOBRE MODELACIÓN NUMÉRICA EN INGENIERÍA DE PRESAS

¡GRACIAS!

fsalazar@cimne.upc.edu

CIMNE^R