	LOUISIANA STATE UNIVERSITY **College of Agriculture** **School of Plant, Environmental, and Soil Sciences** **AGRO 7076 HTP in Plant Breeding**	

Enviromics

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Prediction-based model

$$RS = \frac{i.r_{aP}.\sigma_a}{T} \qquad r_{aP} = \sqrt{h_a^2}$$

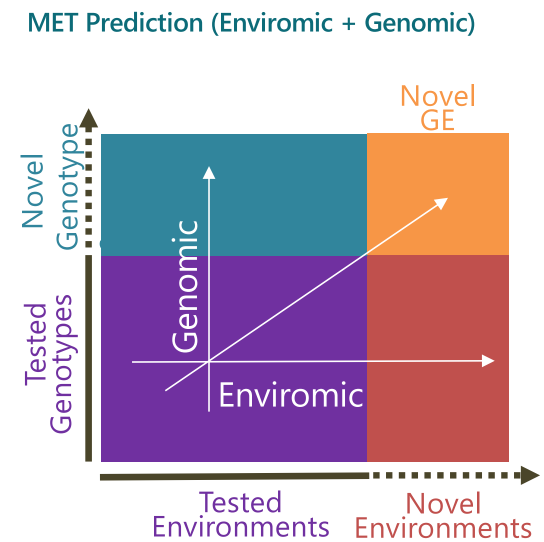
$$y = u + X\beta + Zg + Wge + \varepsilon$$

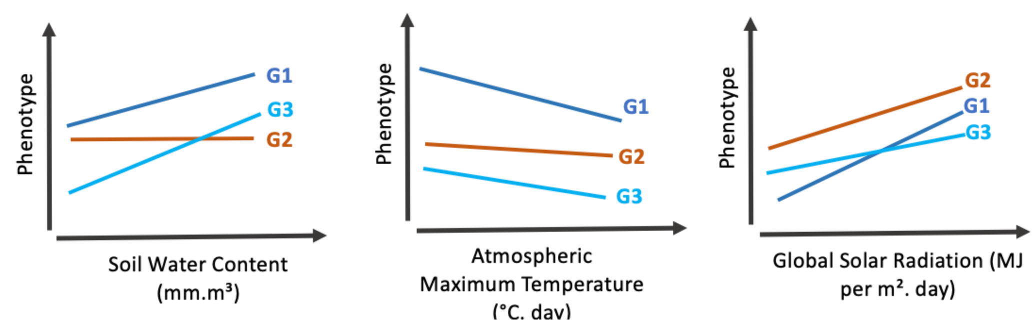
Envirotyping (W):

- Virtually increase the MET
- Allows to better predict gxe
- Optimize cultivar recommendation
- Thus, increase h

Current challenges:

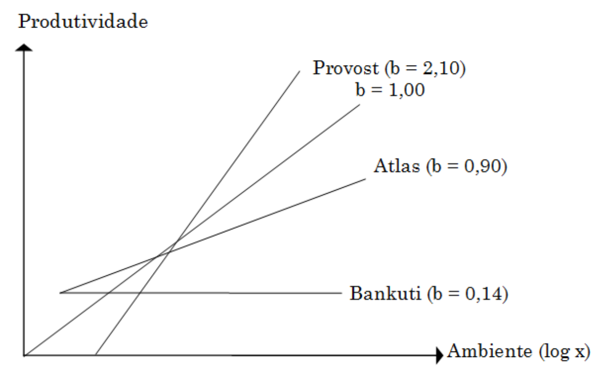
1. Obtain high resolution data
2. Translate information





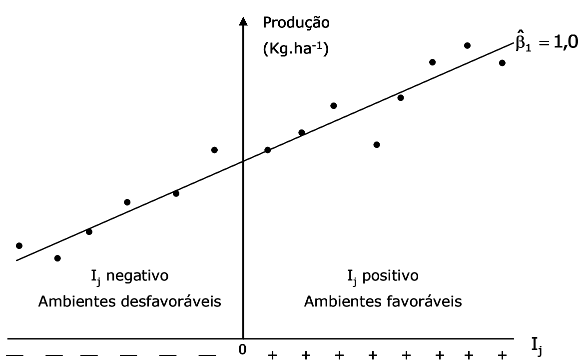
Adaptability and stability – Regression methods

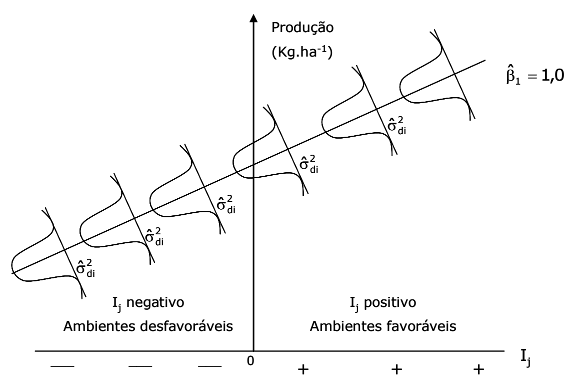
- **Adaptability:** **ability to take advantage of environmental variations**
- **Stability:** **predictable behavior in the face of variations in the environment**
- **Finlay K, Wilkinson G (1963):** **Linear regression coefficient and the variance of the regression deviations**



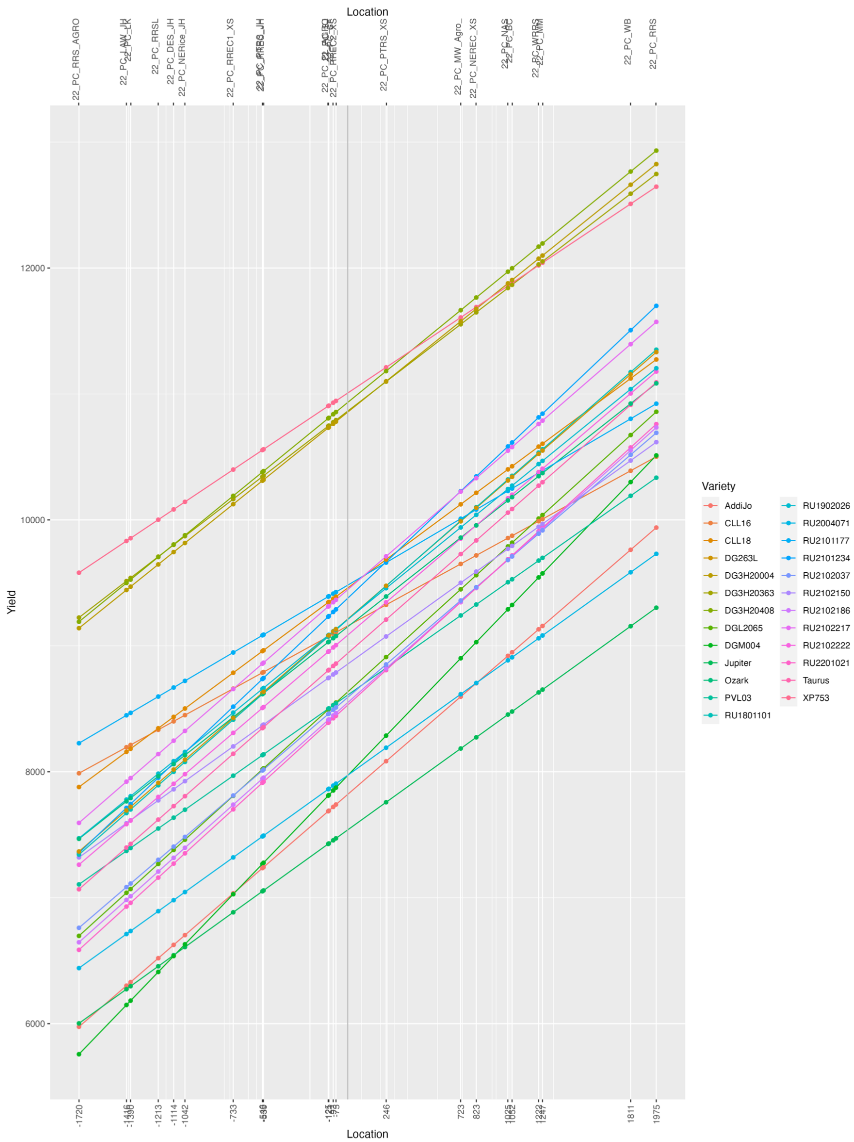
$$I_j = \bar{I}_{.j} - \bar{Y}_{..}$$

$$Y_{ij} = m_i + b_i I_j + d_{ij}$$

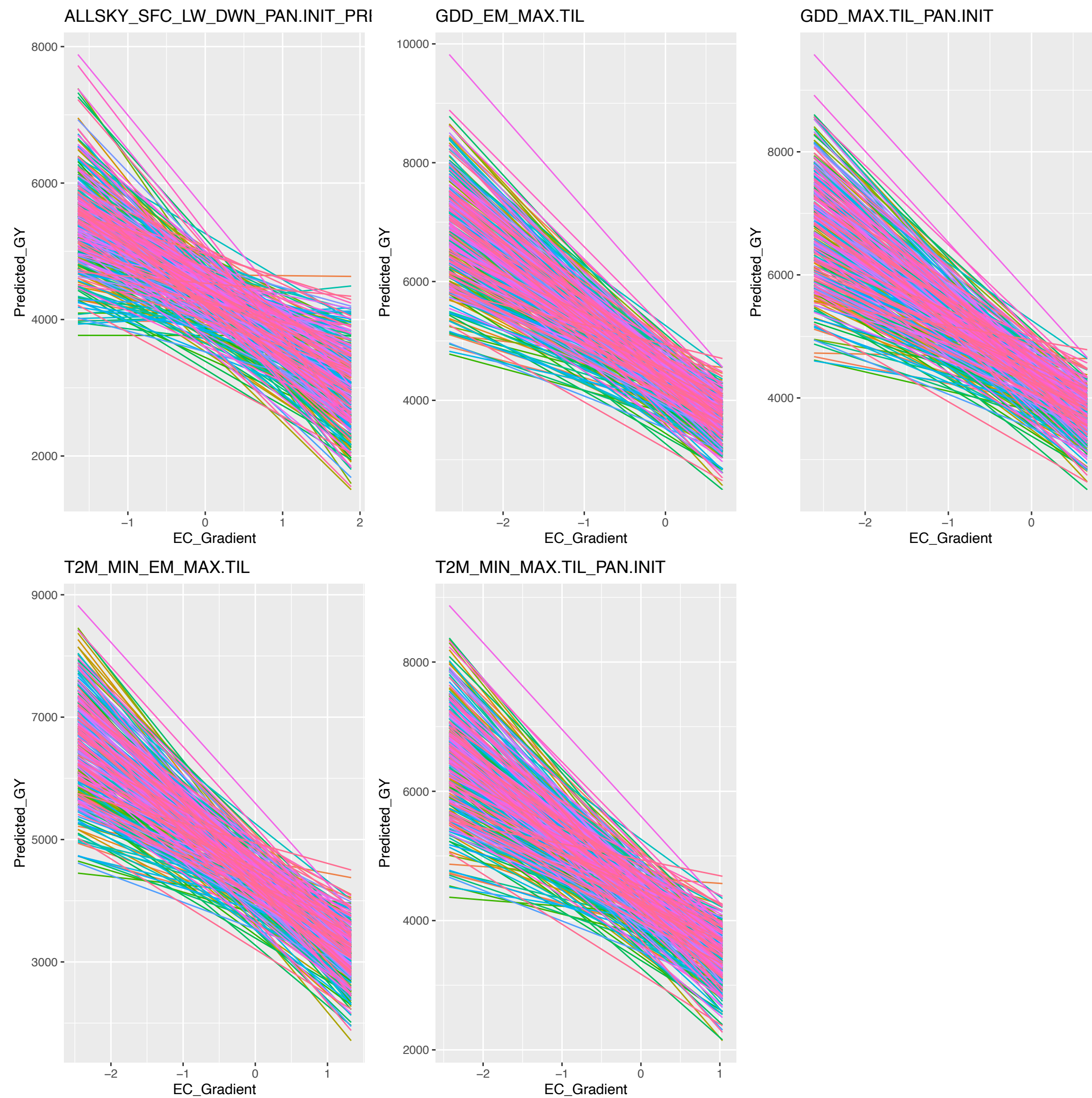




- ***d_{ij}: regression deviations predictability (stability)***
- ***What would be the ideal cultivar?***
- ***Y_{ij}: high overall performance***
- ***b_i =1.0***
- ***d_{ij}= 0***



Location
22_PC_RRS_AGRO
22_PC_RRSL
22_PC_DES_JH
22_PC_NERce_JH
22_PC_RREC1_XS
22_PC_PTRS_XS
22_PC_NEREC_XS
22_PC_WB
22_PC_RRS
Yield
12000
10000
8000
6000
-1720
-1213
-1114
-1042
-733
246
723
823
1811
1975
Location
Variety
AddiJo
CLL16
CLL18
DG263L
DG3H20004
DG3H20363
DG3H20408
DGL2065
DGM004
Jupiter
Ozark
PVL03
RU1801101
RU1902026
RU2004071
RU2101177
RU2101234
RU2102037
RU2102150
RU2102186
RU2102217
RU2102222
RU2201021
Taurus
XP753



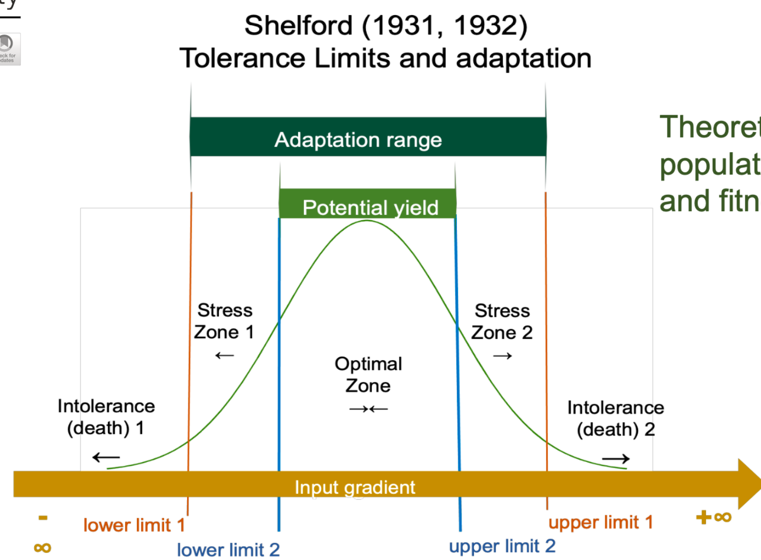
ALLSKY_SFC_LW_DWN_PAN.INIT_PRI
GDD_EM_MAX.TIL
GDD_MAX.TIL_PAN.INIT
T2M_MIN_EM_MAX.TIL
T2M_MIN_MAX.TIL_PAN.INIT
Predicted_GY
EC_Gradient

Heredity
https://doi.org/10.1038/s41437-020-00353-1
the geneticssociety

ARTICLE

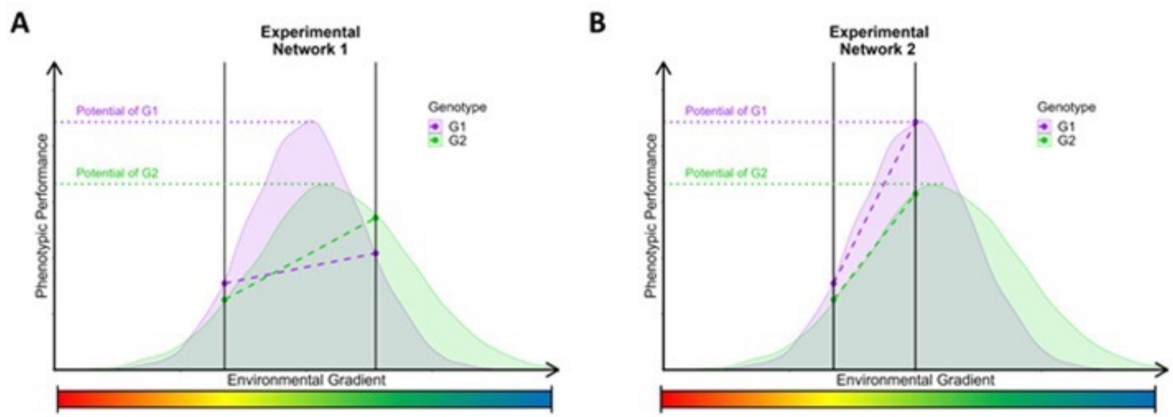
Nonlinear kernels, dominance, and envirotyping data increase the accuracy of genome-based prediction in multi-environment trials

Germano Costa-Neto[1] · Roberto Fritsche-Neto[1] · José Crossa[2]



Theoretical population diversity and fitness

Theoretical gradient of some continuous environmental factor



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ORIGINAL RESEARCH
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Enviromic Assembly Increases Accuracy and Reduces Costs of the Genomic Prediction for Yield Plasticity in Maize

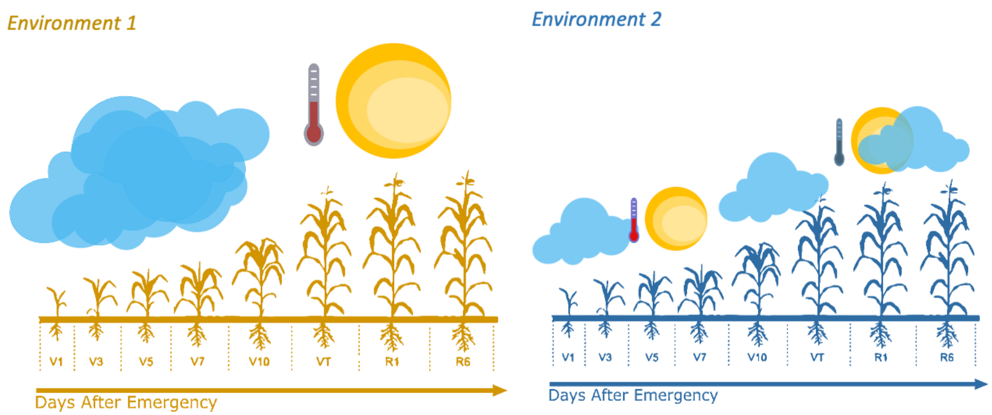
Germano Costa-Neto[1,2*], Jose Crossa[3,4†] and Roberto Fritsche-Neto[1,5]

- Cardinals must weight EC
- Not all EC are important:

- for all traits or

- during the whole cycle

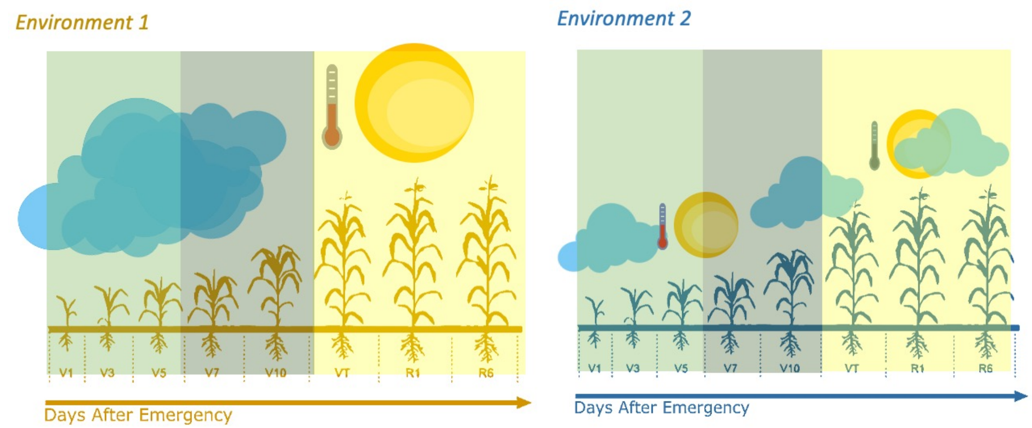
Cumulative values per croplife (poor description)



Environment 1:
- Precipitation: 560 mm/cycle
- Temperature: 962 °C/cycle
- Radiation: 724 MJ m2/ cycle

Environment 2:
- Precipitation: 560 mm/cycle
- Temperature: 962 °C/cycle
- Radiation: 724 MJ m2/ cycle

Cumulative values per stage (better)



Environment 1:
- Precipitation (mm): 300 (T1); 260 (T2); 0 mm (T3)
- Temperature (°C): 150 (T1); 100 (T2); 712 (T3)
- Radiation (MJ/m2): 144.8 (T1); 115.8 (T2); 463.4 (T3)

Environment 2:
- Precipitation (mm): 224 (T1); 168 (T2); 168 (T3)
- Temperature (°C): 150 (T1); 100 (T2); 712 (T3)
- Radiation (MJ/m2): 144.8 (T1); 115.8 (T2); 463.4 (T3)

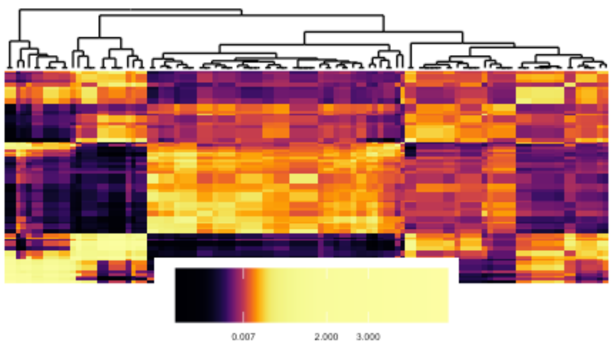
- **Crop-specific tune**
- Tbase1 = 12,
- Tbase2 = 24,
- Topt1 = 33,
- Topt2 = 37,
- Alt = 540

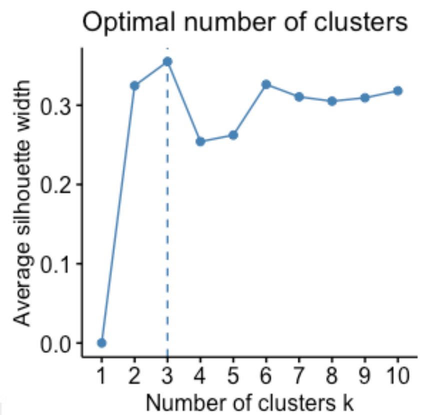
- **Temporal variations**

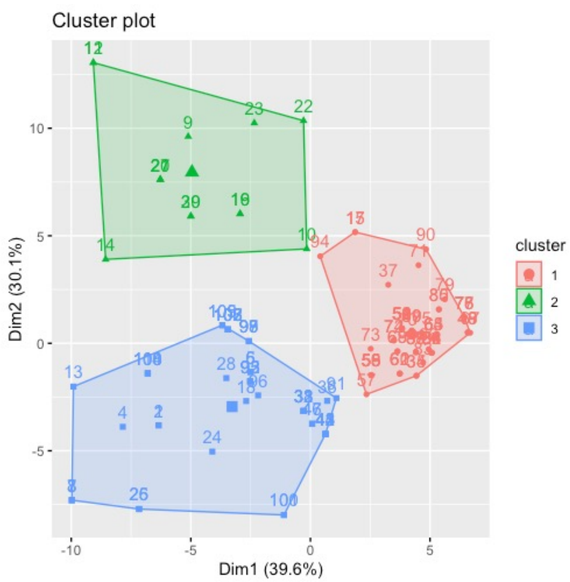
- From 0 DAE (emergence day) to 14 DAE (appearance of the first leaf, V1).
- From 15 DAE (V1) to 35 DAE (appearance of the fourth leaf, V4).
- From 36 DAE (V4) to 65 DAE (tasseling stage, VT).
- From 66 DAE (VT) to 90 DAE (kernel milk stage, R3).
- From 91 DAE (R3) to 120 DAE (physiological maturity).

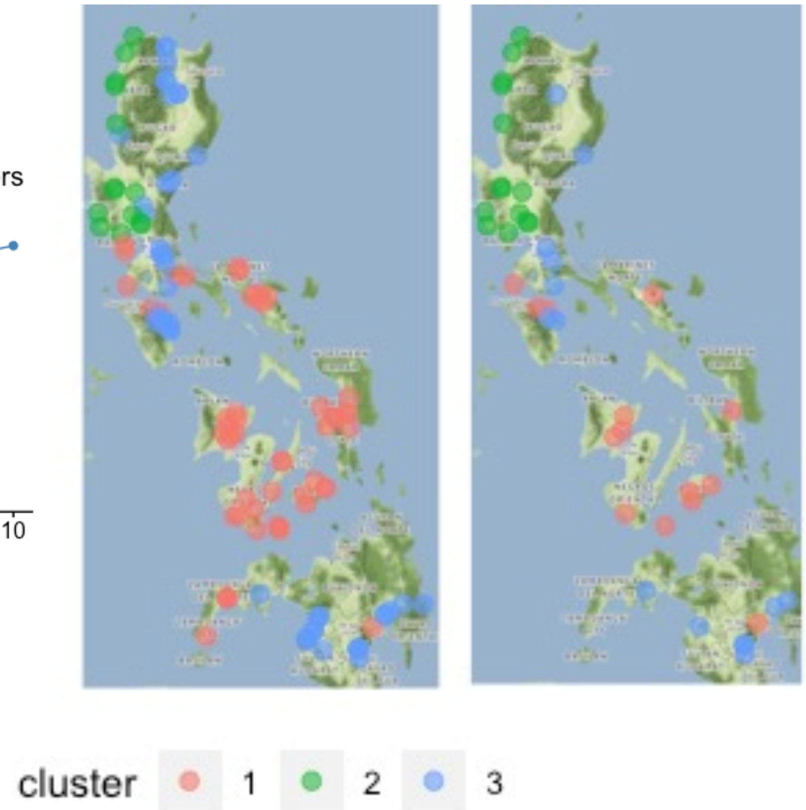
Source	Environmental factor	Unit
NASA Power	Top-of-atmosphere insolation	MJ m^{-2} d^{-1}
	Average insolation incident on a horizontal surface	MJ m^{-2} d^{-1}
	Average downward longwave radiative flux	MJ m^{-2} d^{-1}
	Wind speed at 10 m above the surface of the earth	m s^{-1}
	Minimum air temperature at 2 m above the surface of the earth	°C d^{-1}
	Maximum air temperature at 2 m above the surface of the earth	°C d^{-1}
	Dew-point temperature at 2 m above the surface of the earth	°C d^{-1}
	Relative air humidity at 2 m above the surface of the earth	%
	Rainfall precipitation (P)	mm d^{-1}
Calculated[a]	Effect of temperature on radiation-use efficiency	–
	Evapotranspiration (ETP)	mm d^{-1}
	Atmospheric water deficit P-ETP	mm d^{-1}
	Deficit of vapor pressure	kPa d^{-1}
	Slope of saturation vapor-pressure curve	kPa C° d^{-1}
	Temperature range	°C d^{-1}
	Global solar radiation based on latitude and Julian Day	MJ m^{-2} d^{-1}

E.g., DS in The Philippines









45 14 51

OXFORD G3 Genes | Genomes | Genetics

G3, 2021, 11(4), jkab040
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Software and Data Resources

EnvRtype: a software to interplay enviromics and quantitative genomics in agriculture

Germano Costa-Neto [1,*] Giovanni Galli, [1] Humberto Fanelli Carvalho [1] José Crossa [2] and Roberto Fritsche-Neto [1,3]

EnvRtype

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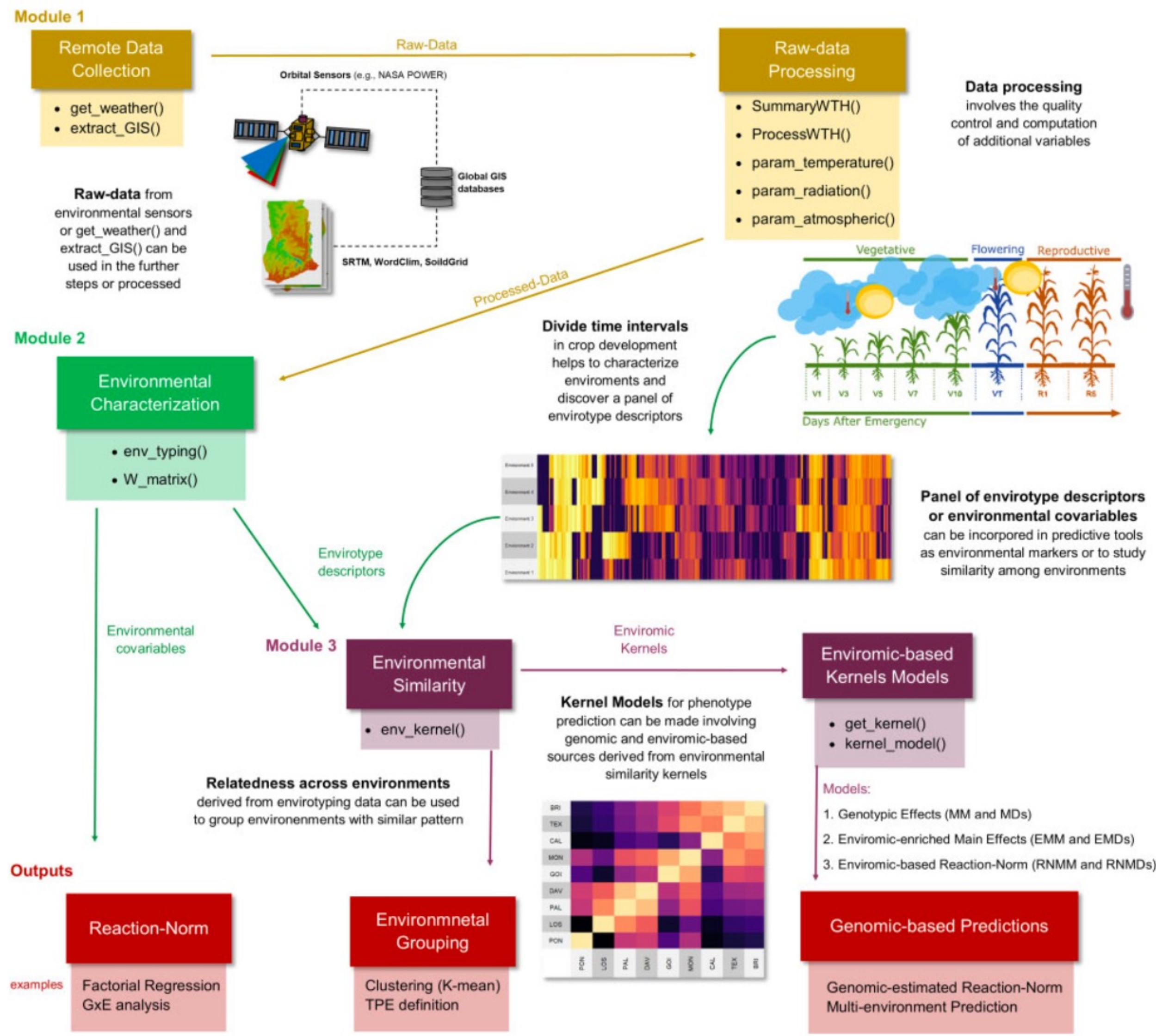
Agronomy Journal

SPECIAL SECTION: MACHINE LEARNING IN AGRICULTURE

SoilType: An R package to interplay soil characterization in plant science

Roberto Fritsche-Neto

SOIL TYPE



Using enviromics, we can:

- **Study reaction norms – how a genotype reacts to changes in an environmental component gradient**
- **Brings more resolution to GxE studies**
- **It may reduce the total number of trials and cost - better allocate resources**
- **Define the optimal MET in advance**
- **Identify genomic regions associated with EC responsiveness**
- **Help to develop models to select more resilient genotypes for future scenarios**
- **Develop models for epidemiology – predict the disease progress**
- **The limit is your imagination…**