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Towards global maps of vegetation trait change the VESTA project

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BACKGROUND

- Understanding global patterns of biodiversity and how climate change may affect them in the future is one of the main open questions in earth system science.
- Shifts in plant functional diversity are recognized as a main driver in affecting ecosystem processes such as the carbon cycle, and plant traits are intrinsically linked to vegetation function, such as photosynthesis, carbon storage and water/nutrient uptake.
- Current global maps of vegetation traits are generated by filling in the gaps from observations but are primarily based on empirical or statistical relationships between trait observations, climate and soil data, and remote sensing data. These approaches cannot embrace many traits, and are limited in their capacity to evaluate and predict trait change through time.
- EO (Earth observation)-constrained trait-based Dynamic Global Vegetation Models (DGVM) could provide multivariate, spatially and temporally complete maps of global vegetation traits.

OBJECTIVES

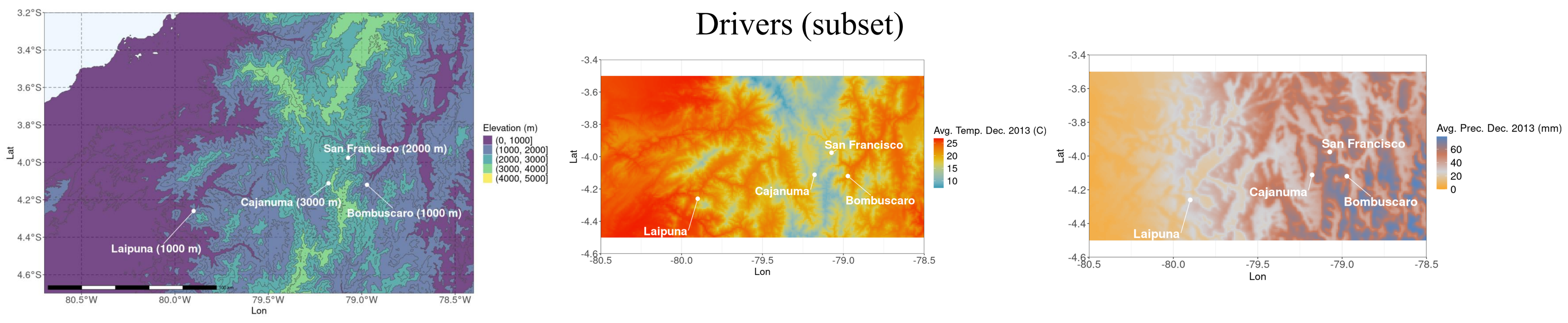
- The VESTA (Vegetation Spatialization of Traits Algorithm) project proposes the development of a workflow to produce global maps of above and belowground plant traits for the present and future through the integration of a trait-based dynamic global vegetation model (DGVM) and vegetation EO) data.

Trait Acronym	Name	Unit	Dependency
SLA	Specific Leaf Area	$cm^2\ g^{-1}$	Key
C:N	Carbon to Nitrogen Ratio	-	Dep:SLA
C:P	Carbon to Phosphorus Ratio	-	Dep:SLA
Lleaf	Leaf longevity	y	Dep:SLA
WSG	Wood Specific Gravity	$g\ cm^{-3}$	Key
MORT	Mortality Rate	y^{-1}	Dep:WSG
H	Height	m	Emergent
SRL	Specific Root Length	$cm\ g^{-1}$	Key
Droot	Root diameter	cm	Dep:SRL
Lroot	Root longevity	y	Dep:SLA
MCOL	Mycorrhiza Colonization Rate	%	Dep:SRL
L:FR	Leaf to Fine Root ratio	-	Emergent
Nr	Nitrogen resorption rate	%	Emergent
Pr	Phosphorus resorption rate	%	Emergent

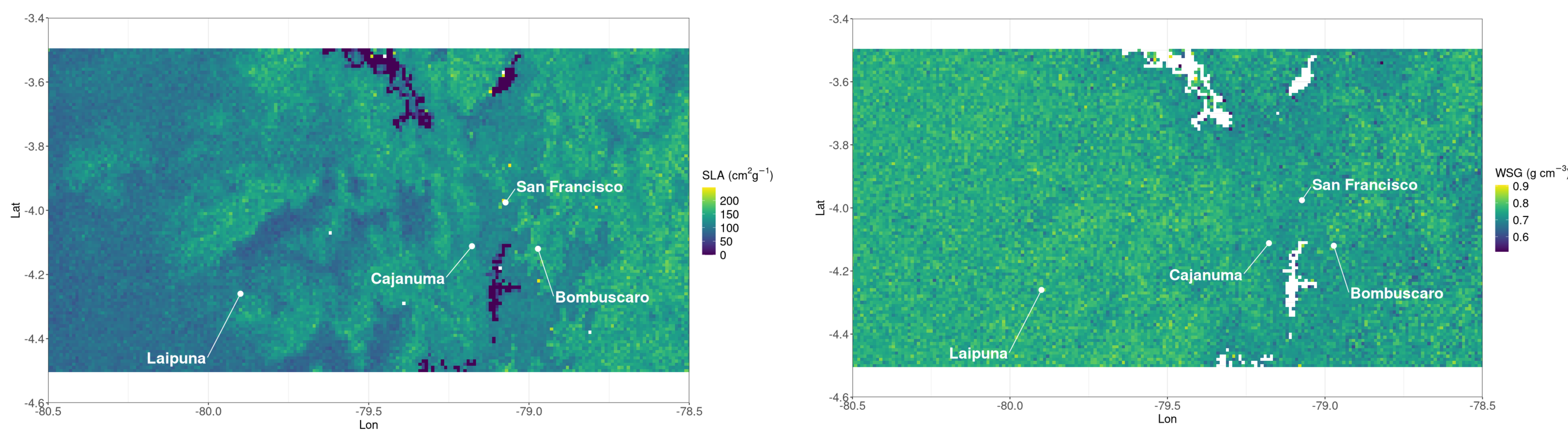
Table 1. Model trait outputs which can result in global maps.

Figure 2. Exploratory results from southern Ecuador, with model input drivers, And model output traits, carbon fluxes, stocks and trends.

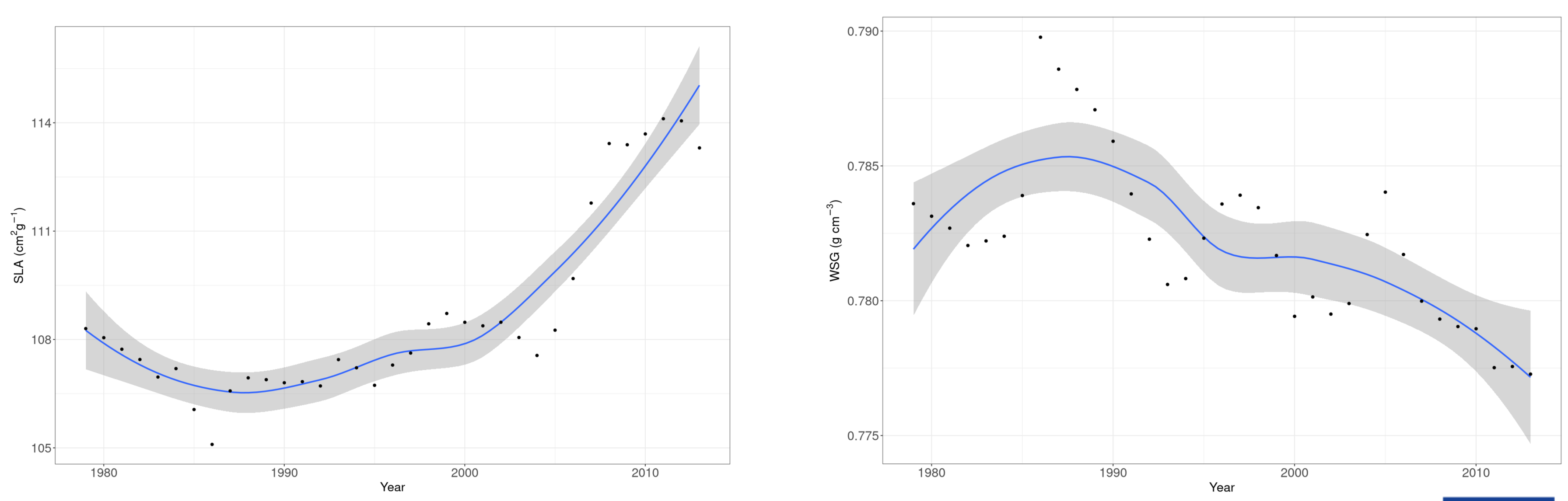
Drivers (subset)



Traits



Trait change 1979 - 2013



METHODS

- The LPJ-GUESS-NTD trait-based DGVM will be used, which draws random leaf, wood and root traits for each established individual, which competes for light, water and nutrients according to local climatic and edaphic conditions.
- Trait ranges and tradeoffs with other traits are based on relatioships from global trait databases
- Vegetation EO data (LAI, GPP) is used to optimize the model, using a calibration procedure which adjusts the trait relationship curves allowing the model to best reproduce satellite measurements of vegetation structure and productivity.
- The final map output is a temporal series, allowing a deeper understanding of the current state of functional diversity and its shift in time.

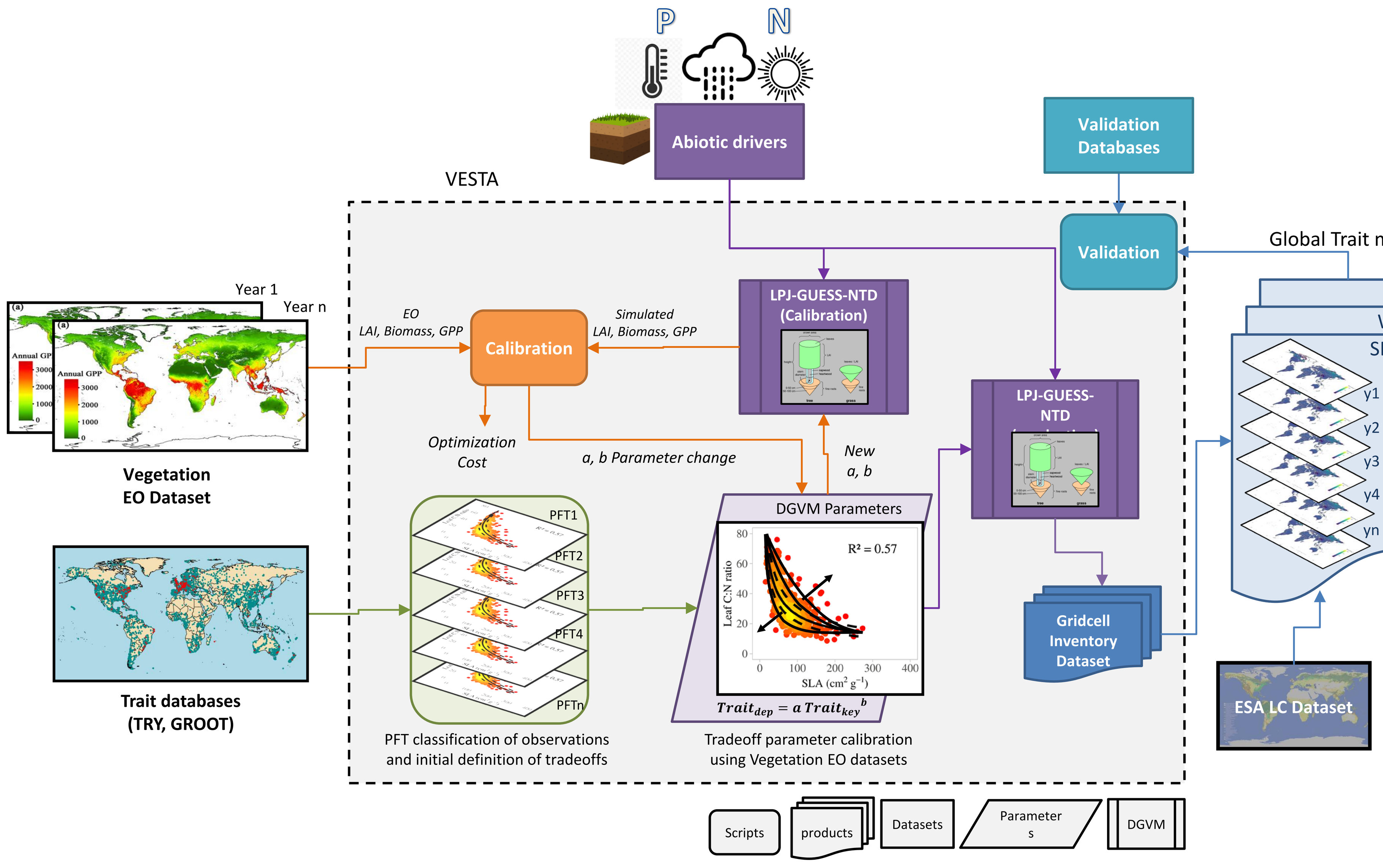
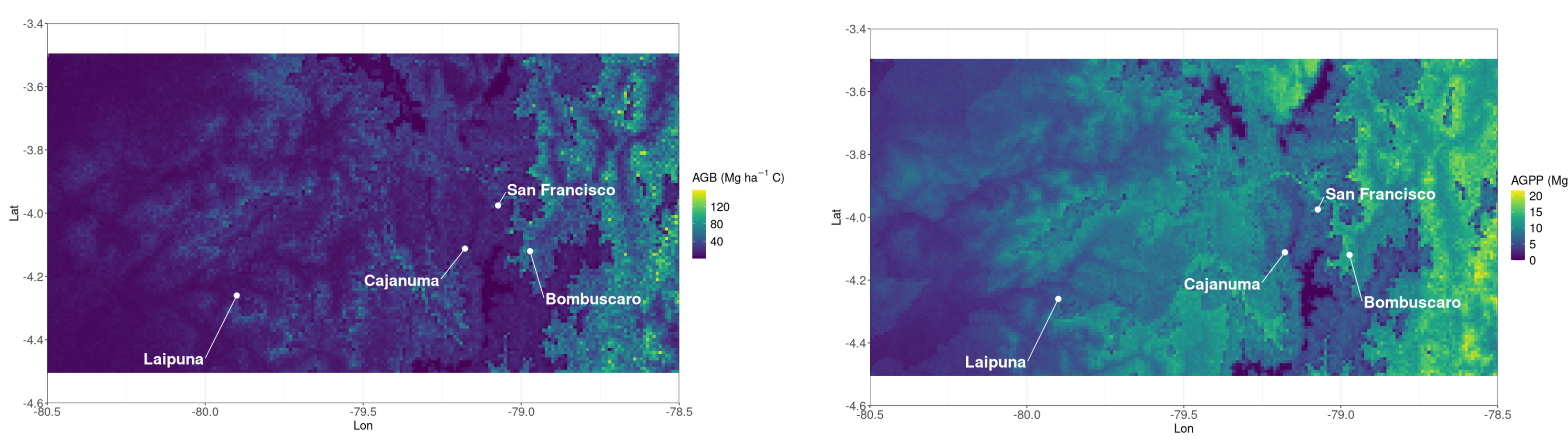


Figure 1. Project flowchart

EXPLORATORY RESULTS

- In order to test the model's trait mapping capabilities, we simulated a region in South Ecuador where ample trait data was used for model development (Figure 2).
- The simulations use climatic driving data from the CHELSA dataset (1 km resulution), which will be used in the future for global runs.
- The initial results show expected broad patterns of biomass, AGPP, SLA and WSG across the Andes mountain ranges.
- The historic trend of leaf and wood traits suggests an increase of SLA and reduction of WSG, possibly as a consequence of increasing temperatures and nitrogen deposition.

C stocks and Fluxes



OUTLOOK

- The project aims in the next 2 years to develop the VESTA algorithm and produce global yearly trait maps at a 1 km resolution.
- Using the VESTA algorithm, several simulated experiments will be carried out to test relevant hypothesis on open questions of earth system science. These include describing the project's methods and analyzing historic changes in traits, or initializing the algorithm with projected abiotic drivers instead of historic.

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