NEURAL INFORMATION PROCESSING SYSTEMS

Proposal:

A Multi-source, End-to-End Solution for Tracking Climate Change Adaptation in Agriculture

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Proposal track - Climate Change AI NeurIPS 2020 workshop

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Context

The impact of climate change on tropical agri-food systems will depend on the direction and magnitude of climate change, and on the agricultural sector's adaptive capacity.

By extending SEIRS, a Satellite Remote Sensing (SRS) based system, this research proposes the development and deployment of a scalable AI-based platform exploiting free-of-charge SRS data that will enable the agri-food sector to monitor a wide range of climate change adaptation (CCA) interventions in a timely, evidence-driven and comparable manner.

N. Palmer / CIAT

A **massive amount of investments** are required and needed to be deployed to **adapt agri-food systems to climate change**

The proposed system aims to answer:

Is the money spent by my government in implementing adaptation actions in the agri-food sector really contributing to be better prepared for climate change impacts?

How can I compare different adaptation outcomes?

Previous work - SEIRS

Input data

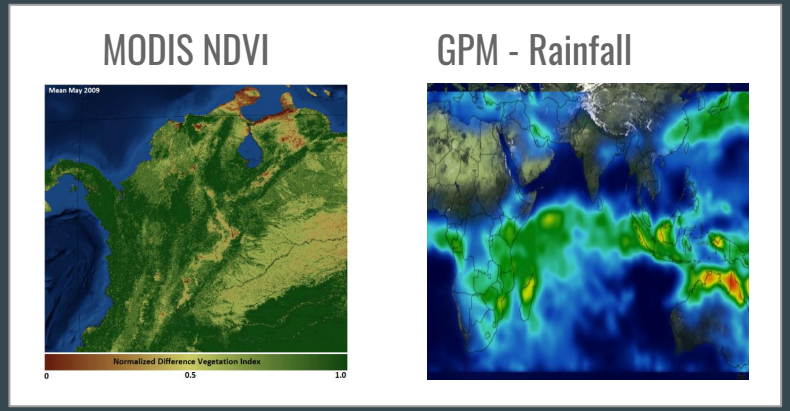


Figure 1. Satellite input data ingested into SEIRS.

Modelling using CNNs

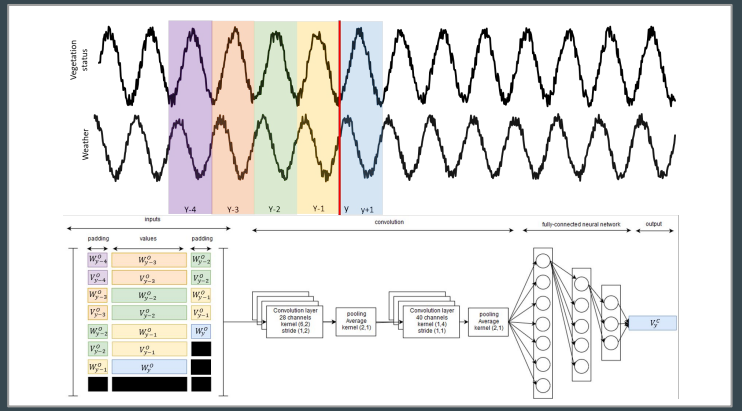
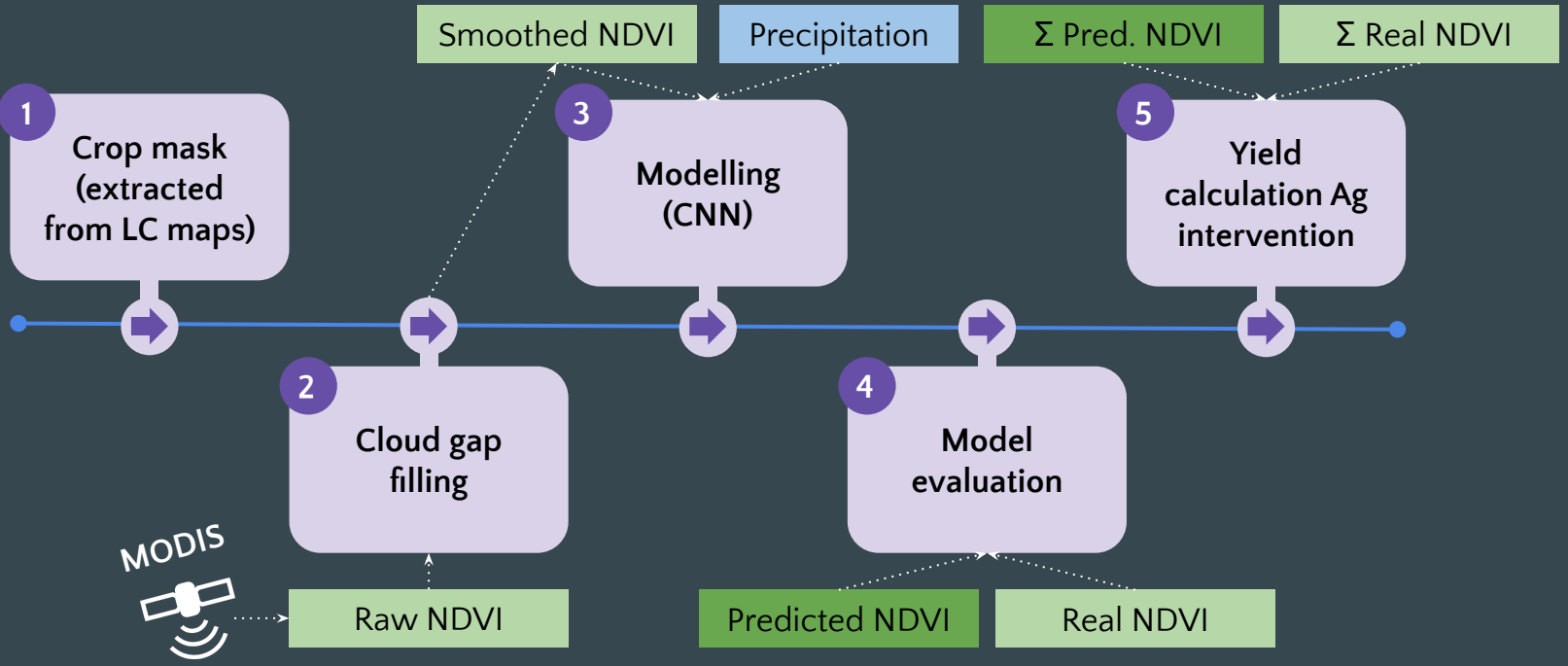


Figure 2. Overview of the CNN model used in SEIRS.

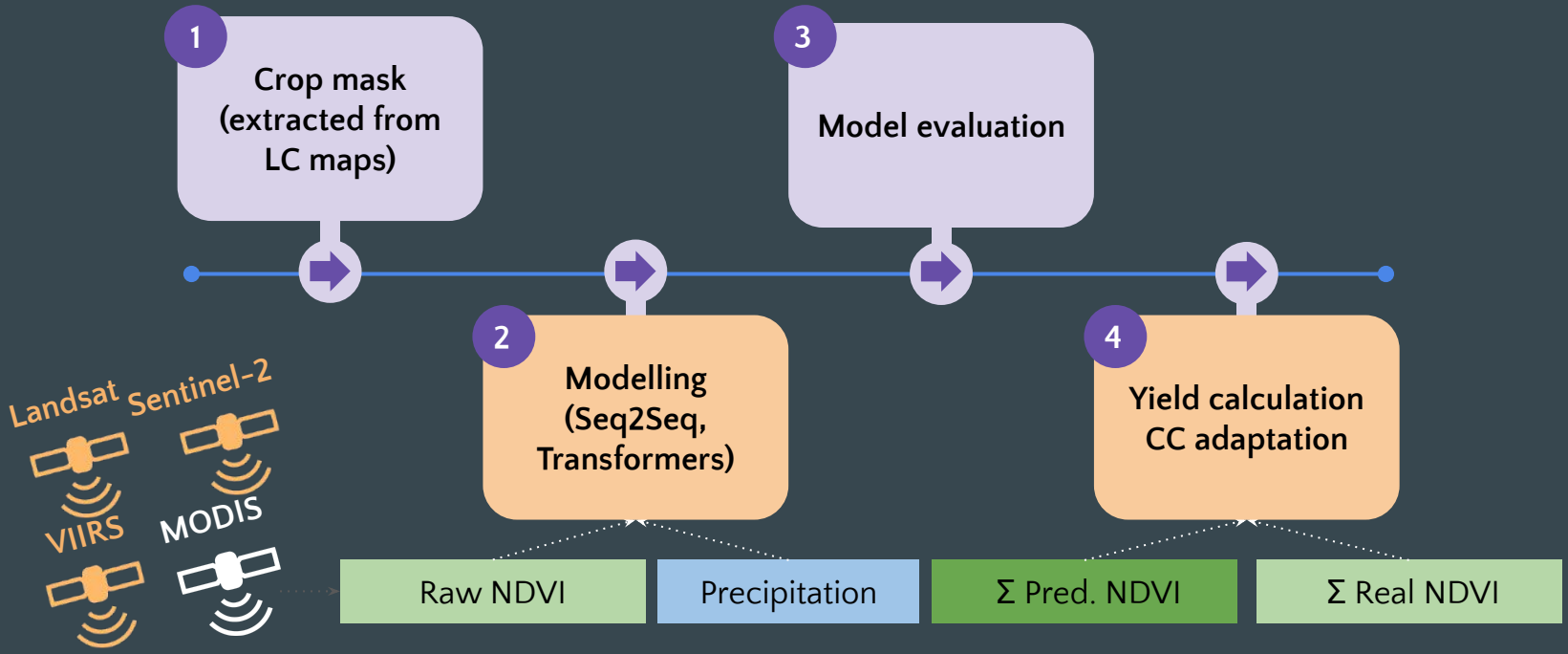
CIAT's System for Evaluation of Impact Using Remote Sensing (SEIRS) models are calibrated using only historical, pre-development intervention EO data.

SEIRS has monitored U.S. Government-funded development programs particularly those involving interventions across cropping areas in Sub-Saharan Africa.

SEIRS: Original modelling framework



Proposed modelling framework (new components)



Which are the major contributions of the proposed system?

Input data

- Explore additional sources of satellite image time series (SITS) e.g. optical (VIIRS, Sentinel-2, Landsat 8) as MODIS instruments have exceeded their design lifetime

Machine learning

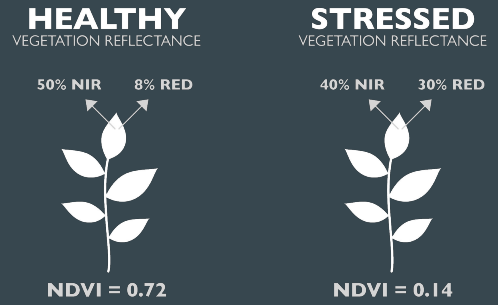
- Implement SoA deep neural nets architectures suited to the extraction of spatio-temporal attributes from SITS data

Climate change

- Propose new NDVI-derived products (proxies of crop yield) suited to the needs of the proposed system

Input data: SRS products to derive vegetation greenness NDVI

Product	Ground sample distance (resolution)	Temporal coverage	Frequency
MODIS (MOD13Q1)	250-m	2000-to present	16-day composite
VIIRS (VNP13) VNP 13	500-m	2012-to present	16-day composite
Landsat legacy (1-8)	30-m (red, NIR)	1975-to present	Revisit, 8-day
Sentinel-2	10-m (red, NIR)	2015-to present	Revisit, 10-day



$$NDVI = \frac{(NIR-red)}{(NIR+red)}$$

Whilst MODIS data provides consistent and regular observations (every 16-days), other SRS instruments such as Landsat and Sentinel can be complementary.

Machine Learning:

- Different to MODIS products, which have a defined number of images per year, Landsat and Sentinel datasets contain different number of images available per year i.e. irregular SITS
- The CNN model in SEIRS cannot handle irregular SITS and variant length inputs. The following strategies are then proposed:
  - Replace fully connected layers within the CNN model by ResNET
  - Explore RNN-based models e.g. Seq2Seq using LSTM/GRU
  - Explore self-attention and transformer models

Complexity ↓

Climate change

For SEIRS, a series of NDVI-derived products were developed according to the needs of the project, in this case to measure interventions.

For the proposed system, it is expected to adjust new outputs informing climate change adaptation e.g. NDVI/price synthetic index, drought index

Examples of NDVI-derived information in SEIRS

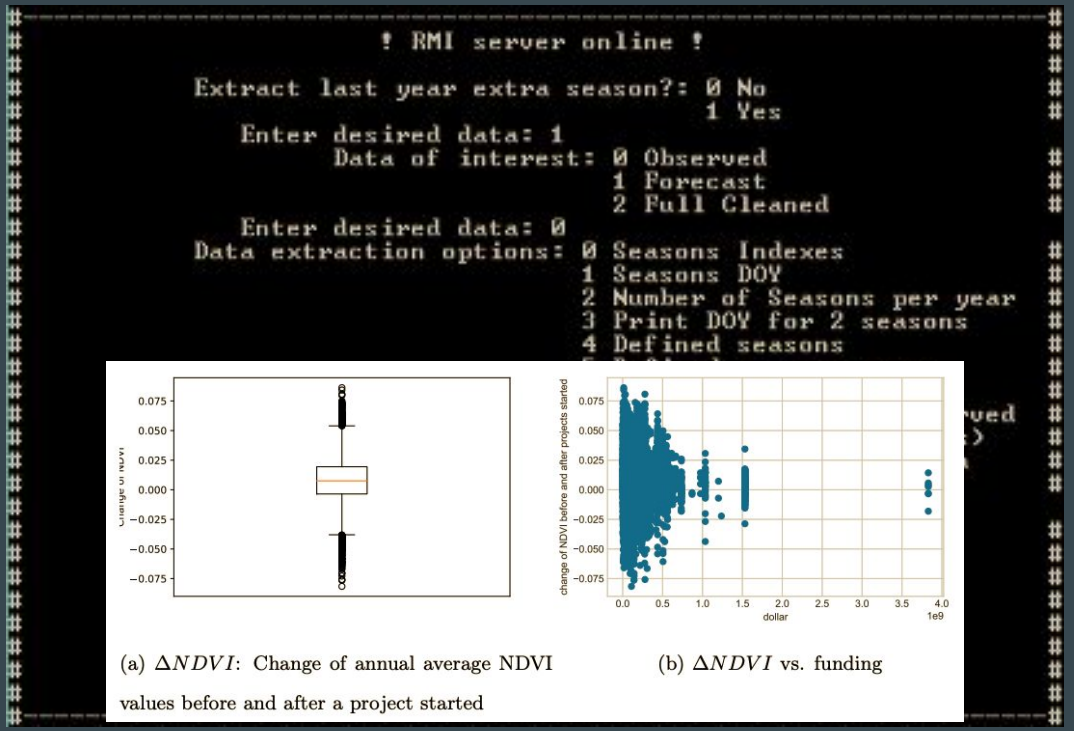


Figure 1. NDVI-derived information obtained in SEIRS. Source: CIAT.

Pilot area: Senegal river valley

Why?

Benchmark area where SEIRS was implemented (baseline) and can be compared against proposed models.

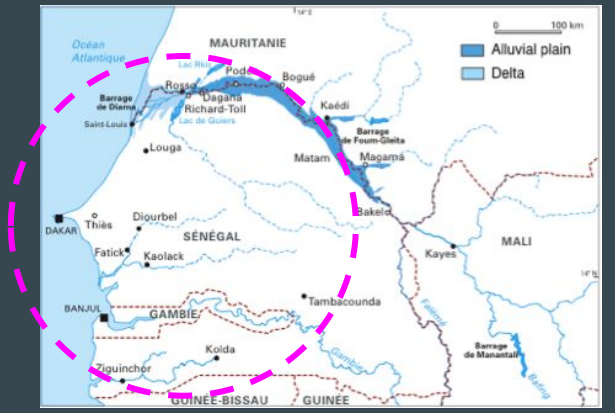


Figure 1. Location of the Senegal River Valley.

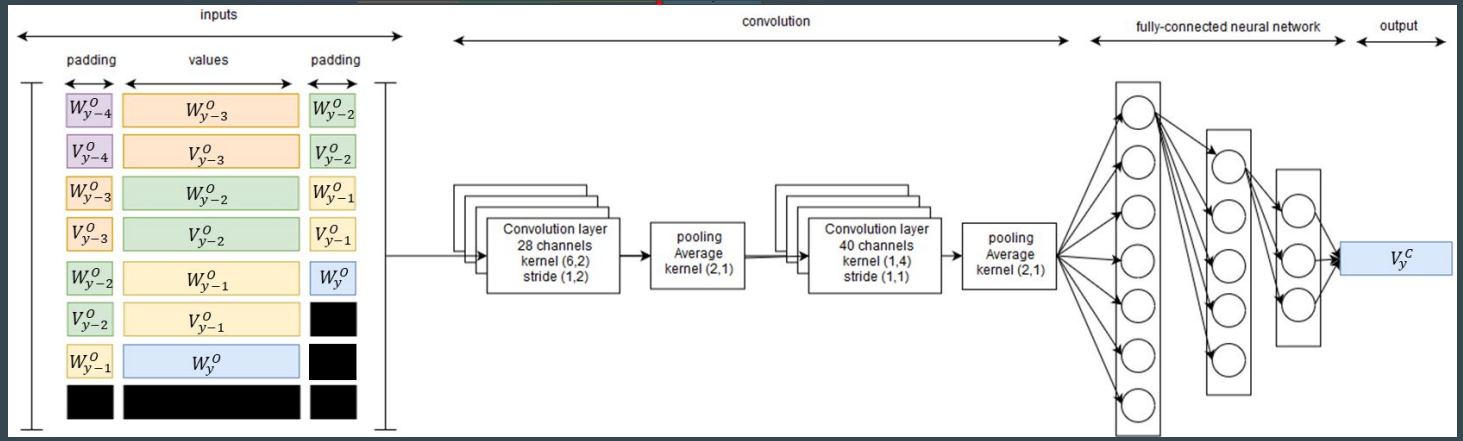


Figure 2. Overview of the CNN architecture used in SEIRS accessed through CIAT..

Implementation

Deep Learning Framework

SEIRS was implemented and deployed in Java and Eclipse Deeplearning4j library.

For the proposal, we will keep the same framework as it offers a wide variety of models, including those targeted in this proposal, Seq2Seq and Transformers.

Hardware:

Experiments will be implemented by using Azure cloud credits granted through the TAPAS project, a transdisciplinary project working on CCA tools for Agriculture.

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