INPE Algorithm for Tracking Precipitating Systems

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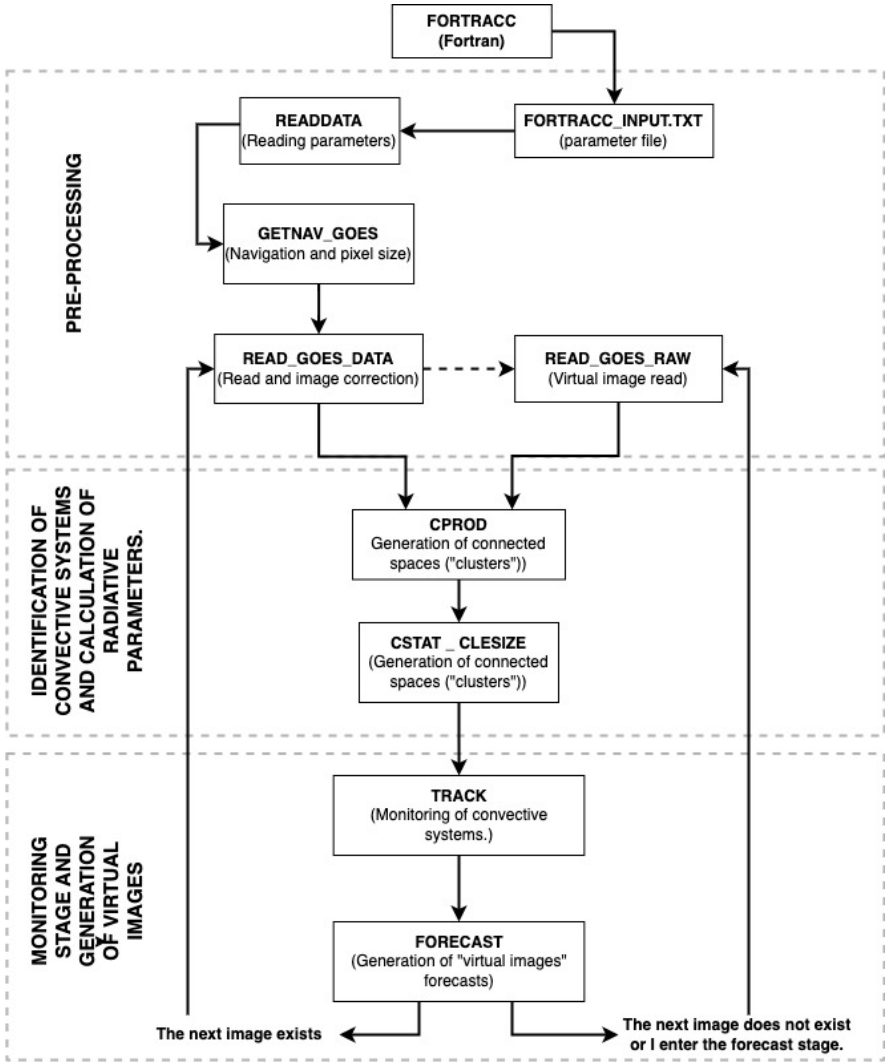
11th Workshop of International Precipitation Working Group
15-18 July 2024, Tokyo Institute of Technology, Tokyo, Japan

Background

Tracking: ForTraCC



Forecast and Tracking the Evolution of Cloud Clusters (ForTraCC) Using Satellite Infrared Imagery: Methodology and Validation

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(Manuscript received 27 December 2006, in final form 23 May 2007)

ABSTRACT

The purpose of this study is to develop and validate an algorithm for tracking and forecasting radiative and morphological characteristics of mesoscale convective systems (MCSs) through their entire life cycles using geostationary satellite thermal channel information (10.8 μm). The main features of this system are the following: 1) a cloud cluster detection method based on a threshold temperature (235 K), 2) a tracking technique based on MCS overlapping areas in successive images, and 3) a forecast module based on the evolution of each particular MCS in previous steps. This feature is based on the MCS's possible displacement (considering the center of the mass position of the cloud cluster in previous time steps) and its size evolution. Statistical information about MCS evolution during the Wet Season Atmospheric Mesoscale Campaign (WETAMC) of the Large-Scale Biosphere–Atmosphere Experiment in Amazonia (LBA) was used to obtain area expansion mean rates for different MCSs according to their lifetime durations. This nowcasting tool was applied to evaluate the MCS displacement and size evolution over the Del Plata basin in South America up to 120 min with 30-min intervals. The Forecast and Tracking the Evolution of Cloud Clusters (ForTraCC) technique's performance was evaluated based on the difference between the forecasted and observed images. This evaluation shows good agreement between the observed and forecast size and minimum temperature for shorter forecast lead times, but tends to underestimate MCS size (and overestimate the minimum temperature) for larger forecast lead times.

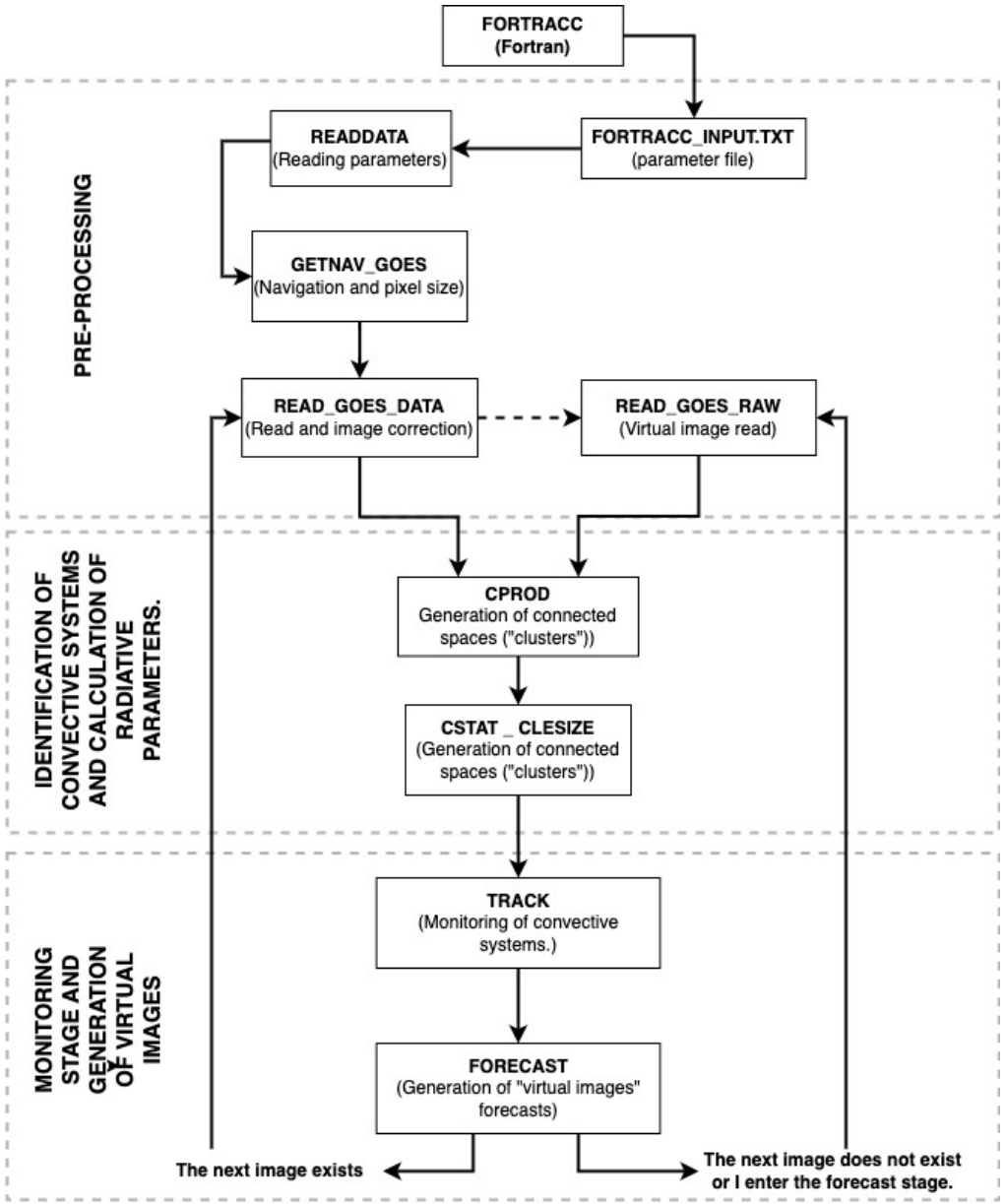
https://journals.ametsoc.org/view/journals/wefo/23/2/2007waf2006121_1.xml

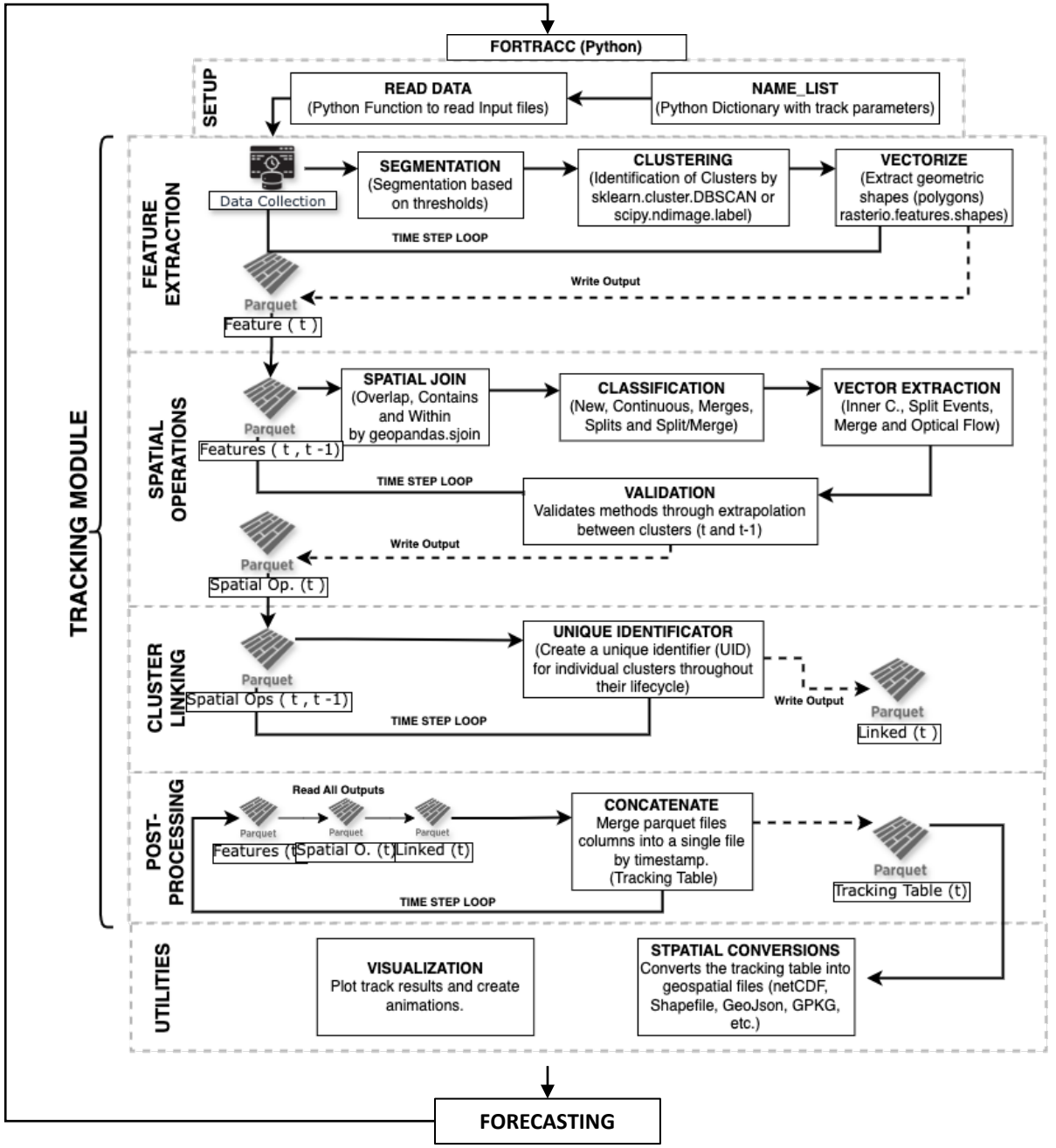
New ForTraCC

Forecasting and Tracking the Evolution of **Cloud** Clusters (ForTraCC)

A **Py**thon **For**ecasting and **Tra**cking the Evolution of **Configurable** **C**lusters (ForTraCC)

“**Configurable**” instead of “**Cloud**”: The term "**configurable**" implies that the clusters being tracked can be *adjusted or modified according to specific configurations or parameters*. This indicates flexibility in how the clusters are defined and monitored, allowing for customization based on varying criteria or user preferences.


FORTRACC
(Fortran)
PRE-PROCESSING
READDATA
(Reading parameters)
FORTRACC_INPUT.TXT
(parameter file)
GETNAV_GOES
(Navigation and pixel size)
READ_GOES_DATA
(Read and image correction)
READ_GOES_RAW
(Virtual image read)
IDENTIFICATION OF CONVECTIVE SYSTEMS AND CALCULATION OF RADIATIVE PARAMETERS.
CPROD
Generation of connected spaces ("clusters"))
CSTAT _ CLESIZE
(Generation of connected spaces ("clusters"))
MONITORING STAGE AND GENERATION OF VIRTUAL IMAGES
TRACK
(Monitoring of convective systems.)
FORECAST
(Generation of "virtual images" forecasts)
The next image exists
The next image does not exist or I enter the forecast stage.


FORTRACC (Python)
SETUP
READ DATA
(Python Function to read Input files)
NAME_LIST
(Python Dictionary with track parameters)
TRACKING MODULE
FEATURE EXTRACTION
Data Collection
SEGMENTATION
(Segmentation based on thresholds)
CLUSTERING
(Identification of Clusters by sklearn.cluster.DBSCAN or scipy.ndimage.label)
VECTORIZE
(Extract geometric shapes (polygons) rasterio.features.shapes)
TIME STEP LOOP
Write Output
Parquet
Feature (t)
SPATIAL OPERATIONS
Parquet
Features (t , t -1)
SPATIAL JOIN
(Overlap, Contains and Within by geopandas.sjoin
CLASSIFICATION
(New, Continuous, Merges, Splits and Split/Merge)
VECTOR EXTRACTION
(Inner C., Split Events, Merge and Optical Flow)
TIME STEP LOOP
VALIDATION
Validates methods through extrapolation between clusters (t and t-1)
Write Output
Parquet
Spatial Op. (t)
CLUSTER LINKING
Parquet
Spatial Ops (t , t -1)
UNIQUE IDENTIFICATOR
(Create a unique identifier (UID) for individual clusters throughout their lifecycle)
TIME STEP LOOP
Write Output
Parquet
Linked (t)
POST-PROCESSING
Read All Outputs
Parquet
Features (t)
Parquet
Spatial O. (t)
Parquet
Linked (t)
CONCATENATE
Merge parquet files columns into a single file by timestamp.
(Tracking Table)
TIME STEP LOOP
Parquet
Tracking Table (t)
UTILITIES
VISUALIZATION
Plot track results and create animations.
STPATIAL CONVERSIONS
Converts the tracking table into geospatial files (netCDF, Shapefile, GeoJson, GPKG, etc.)
FORECASTING

pyForTraCC

ForTraCC Heritage vs New Approaches

ForTraCC heritage

ForTraCC heritage or New clustering

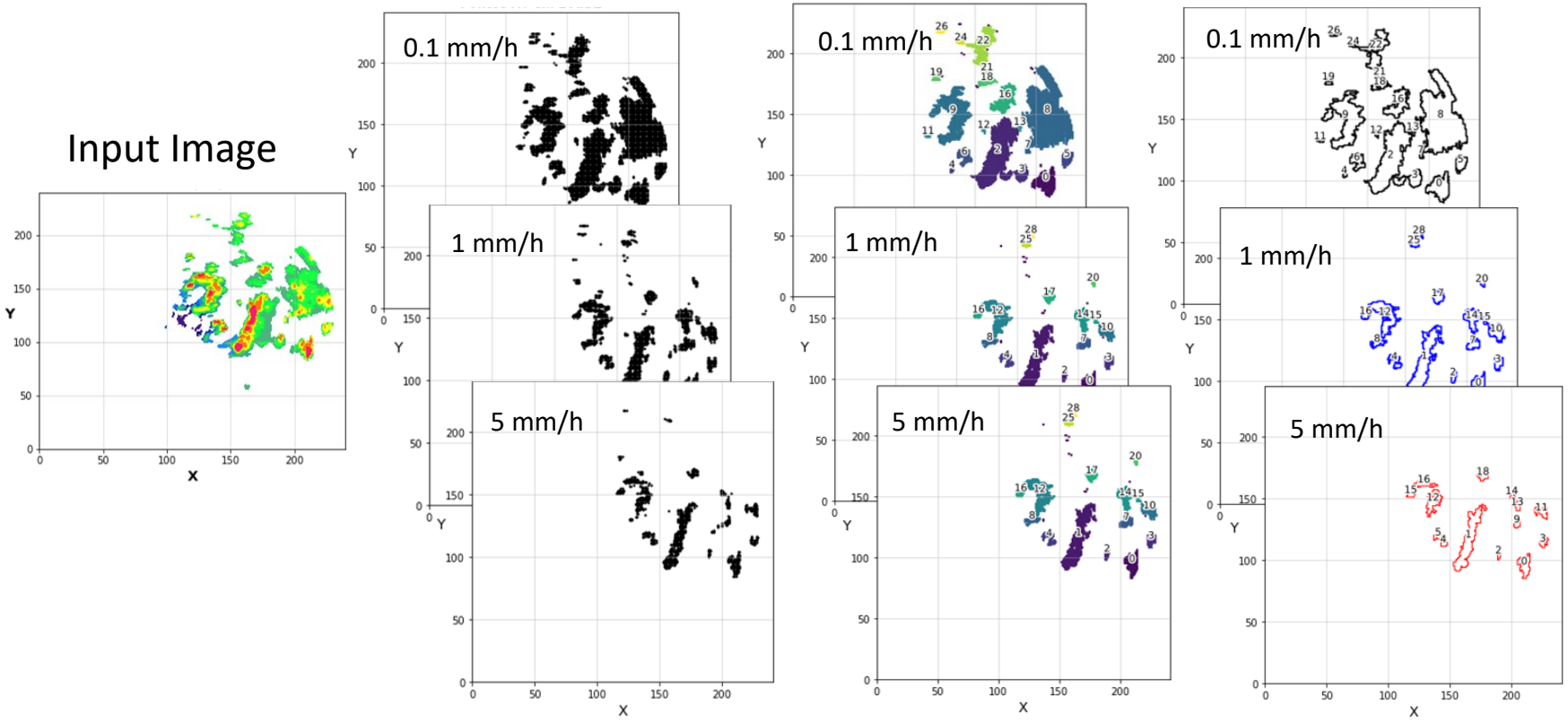
New Approach

Input Image

Thresholding

Clustering

Vectorization

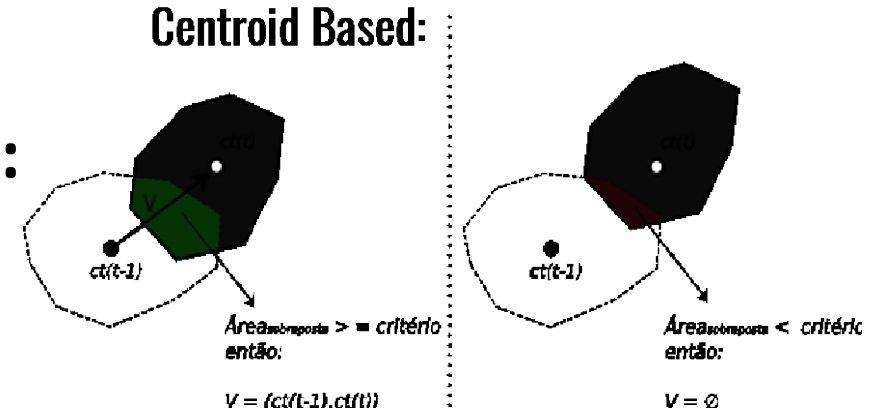


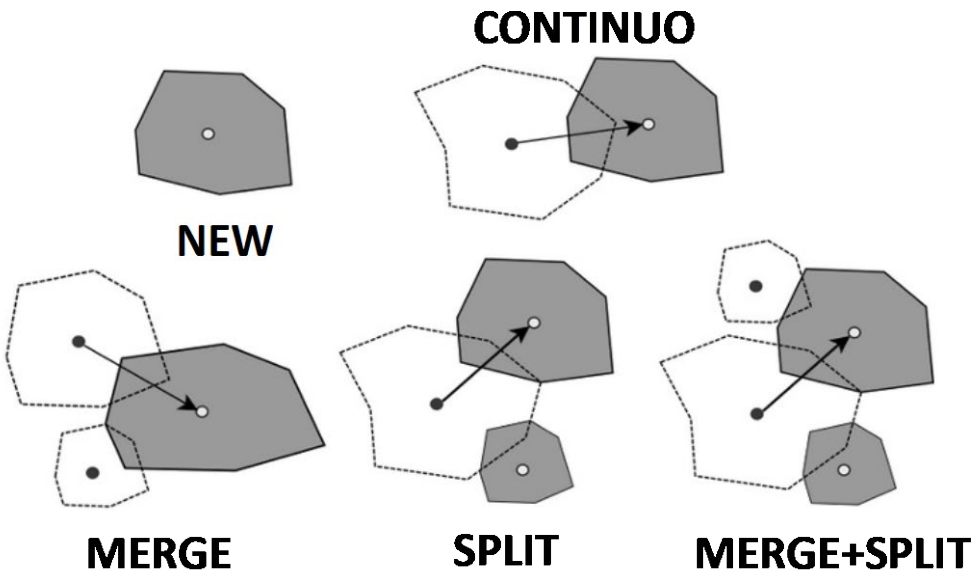
pyForTraCC

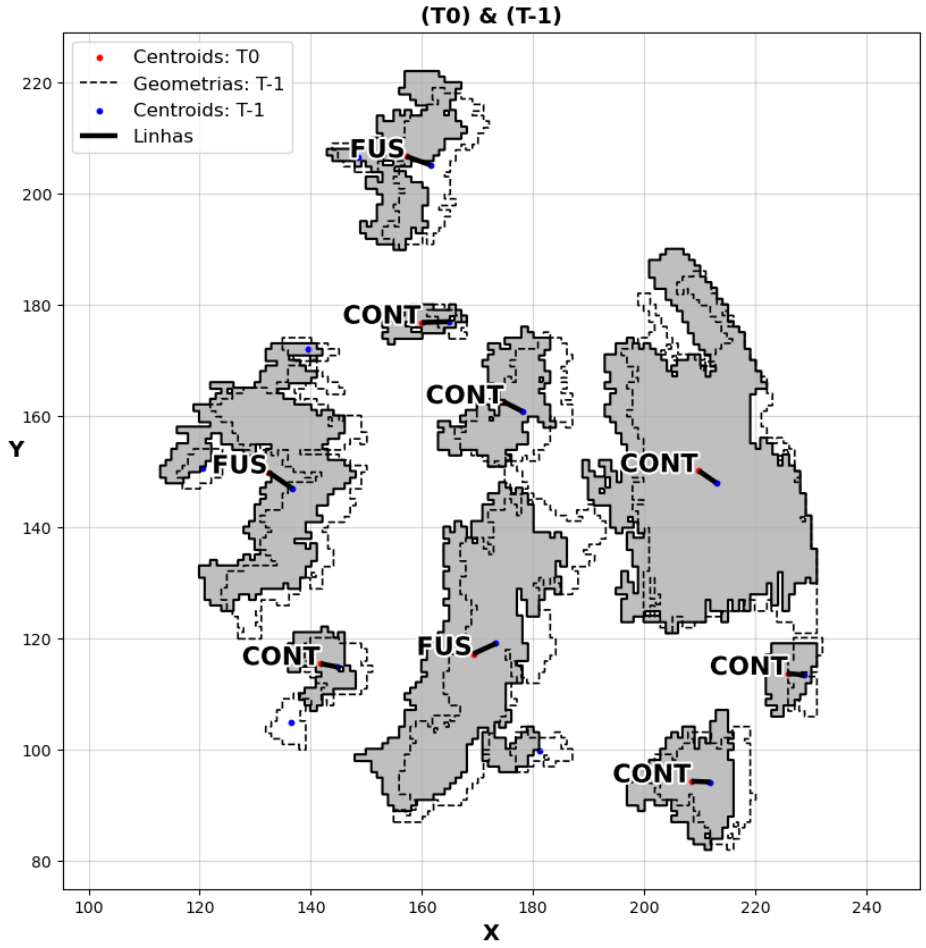
ForTraCC Heritage vs New Approaches

Overlapping:

ForTraCC heritage



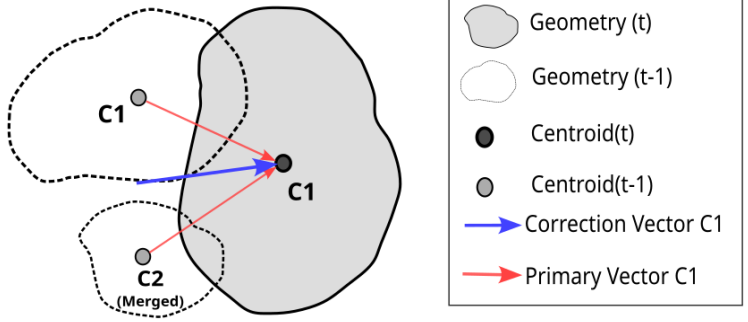




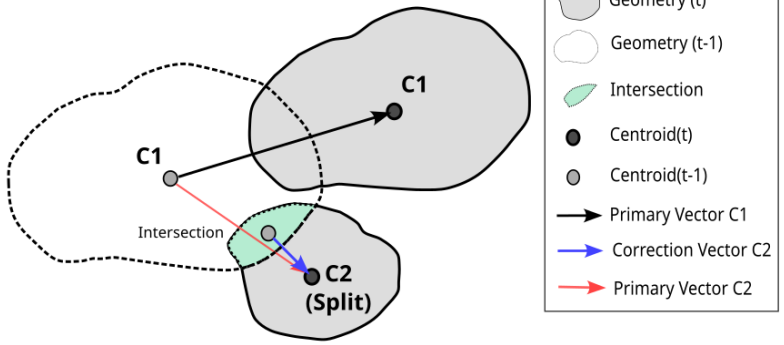
pyForTraCC

New Displacement Vector Corrections

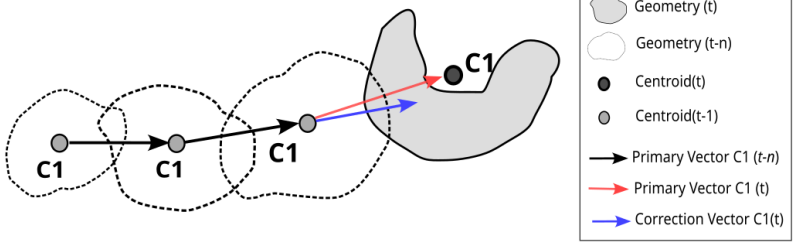
Merge Correction Method **(MCor)**



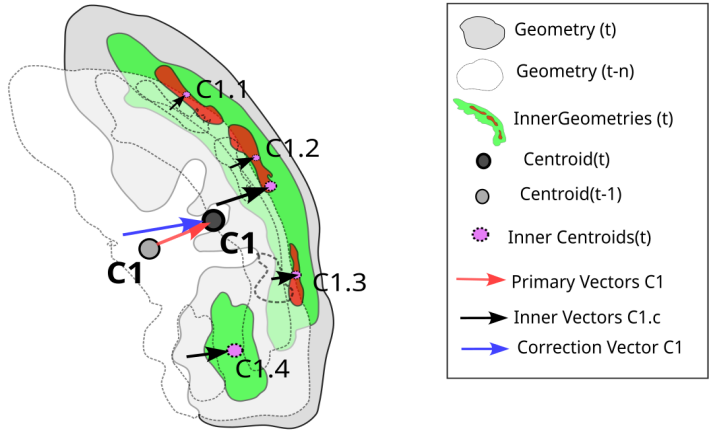
Split Correction Method **(SCor)**



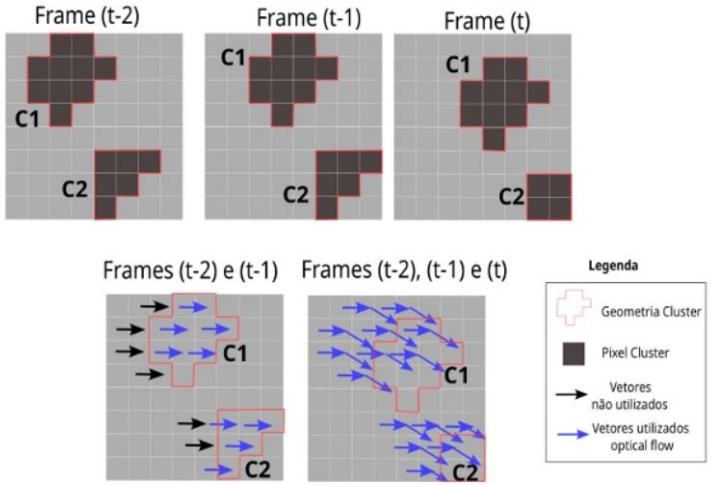
Temporal Average Correction Method **(TCor)**



Inner Cores Correction Method **(ICor)**



Optical Flow (OFCor)



More are coming...

More details in: https://doi.org/10.3390/rs14215408

pyForTraCC

Automatically validation process

POD: It is the ratio between the number of correctly predicted events and, the number of observed events.

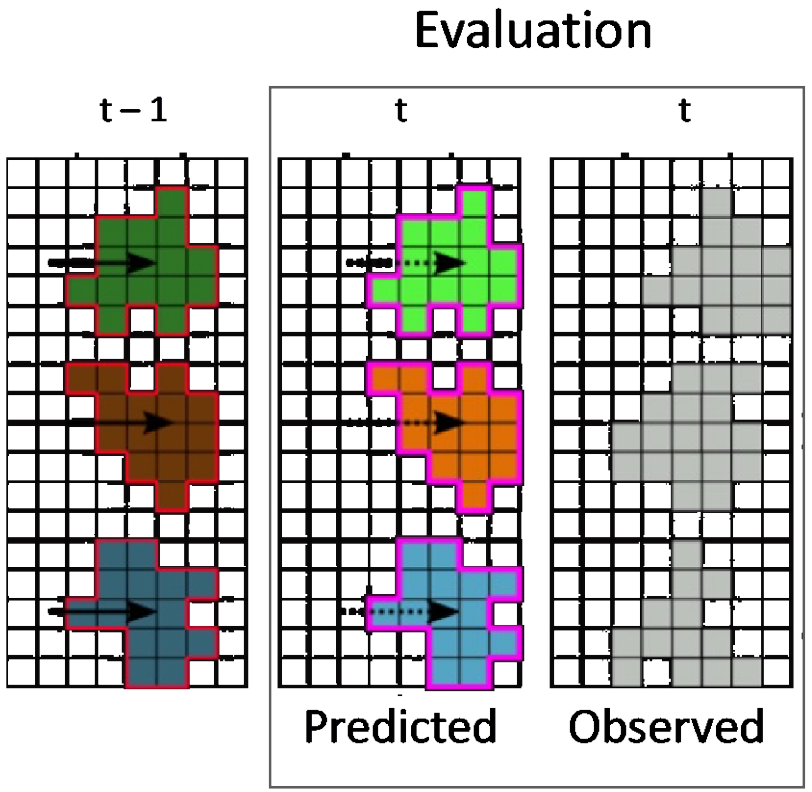
POD = *Hit / (Hit + Miss)*

FAR: A measure of the frequency of occurrence of false alarms in a reference context.

FAR = *Hit / (Hit + False Alarm)*

CSI: Measures the fraction of observed and/or forecast events that were correctly predicted.

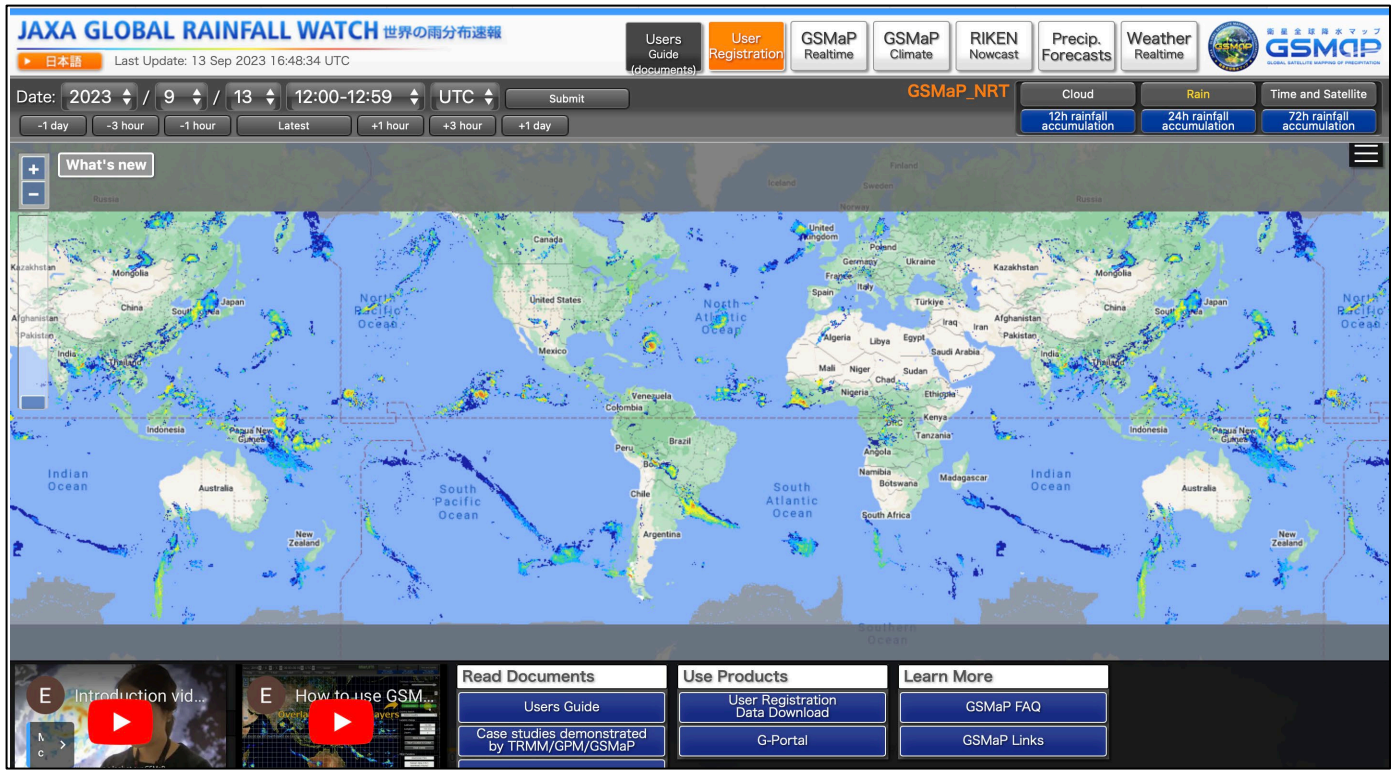
CSI = *Hit / (Hit + Miss + False Alarm)*



New Challenges

Global Precipitation projects

Thanks:
Dr. Takuji Kubota
Dr. Tomoo Ushio



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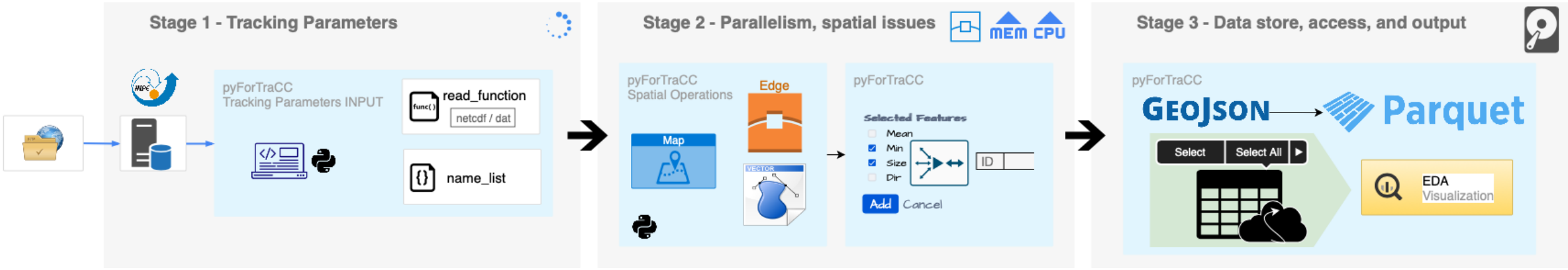
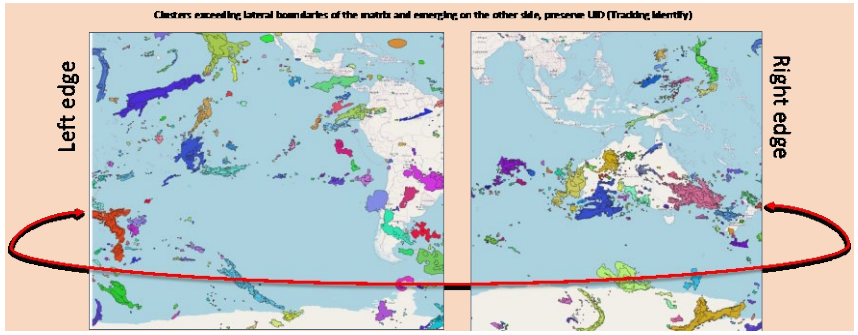
Big Data



Edge



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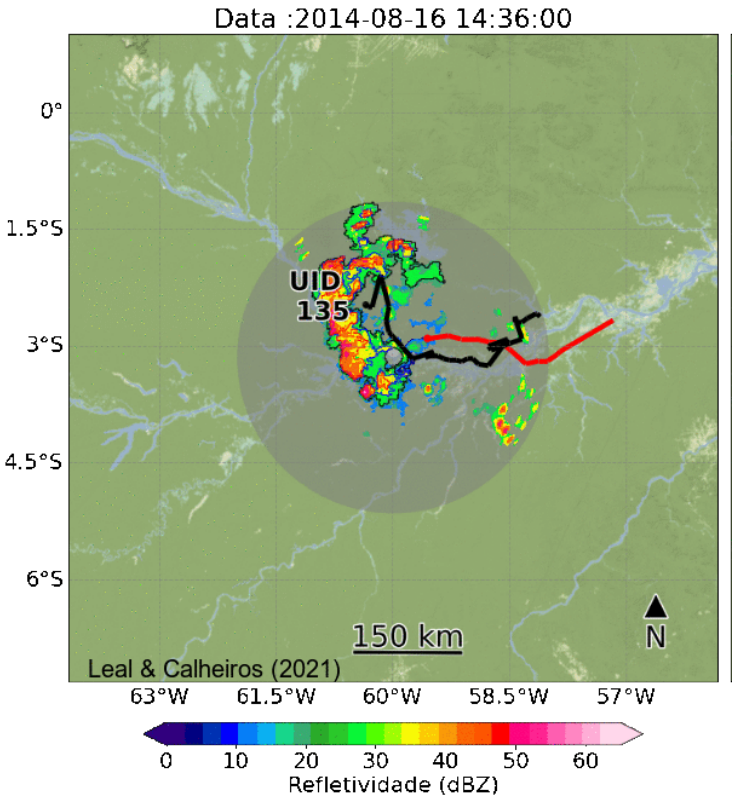
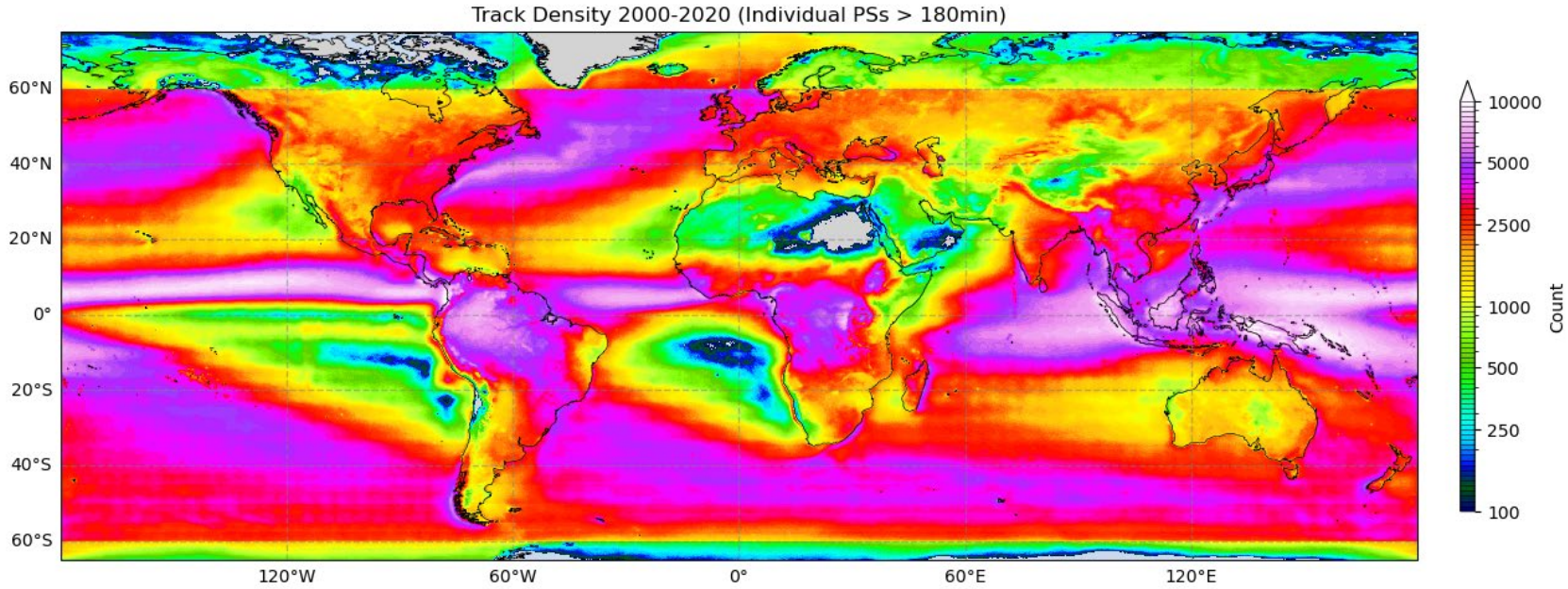
Precipitation Tracking

RADAR - dBZ



GSMaP 20 years climatology of precipitating events



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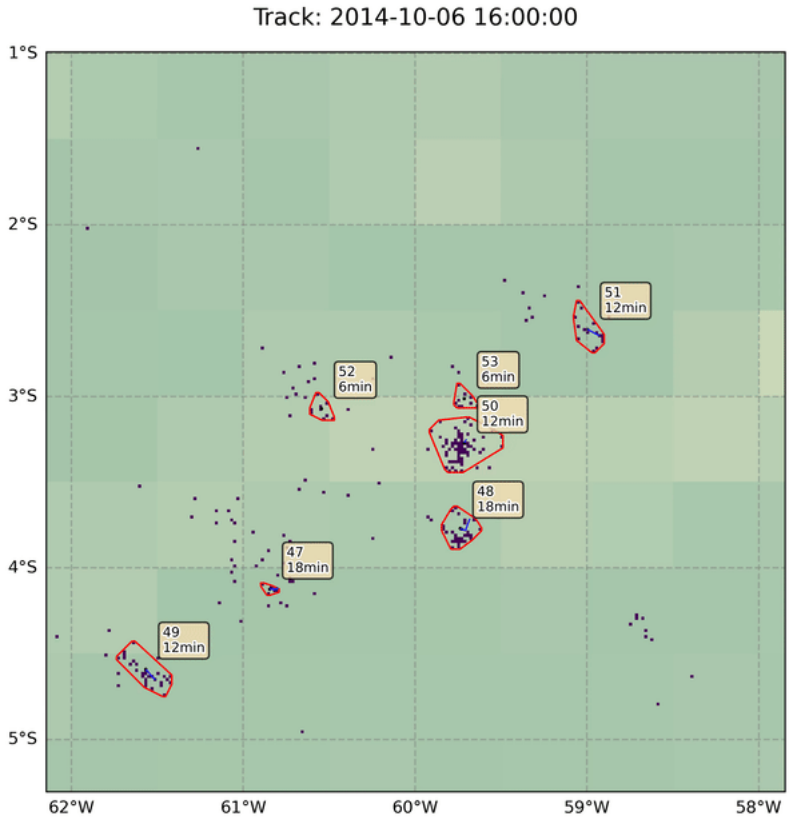
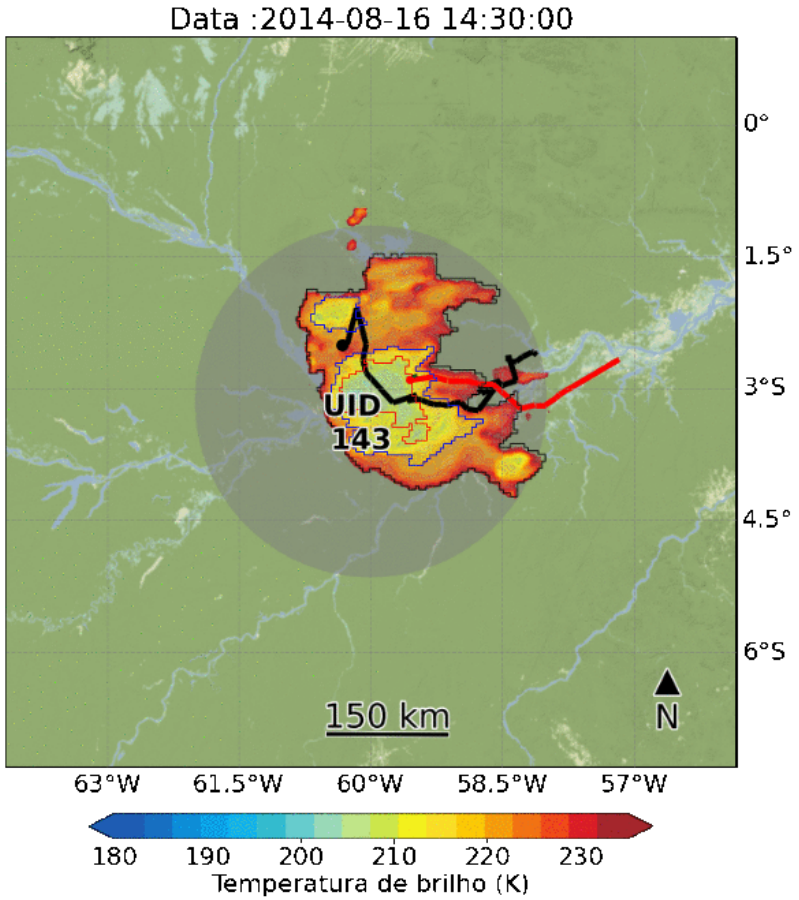
Multiple Objects (Variables)

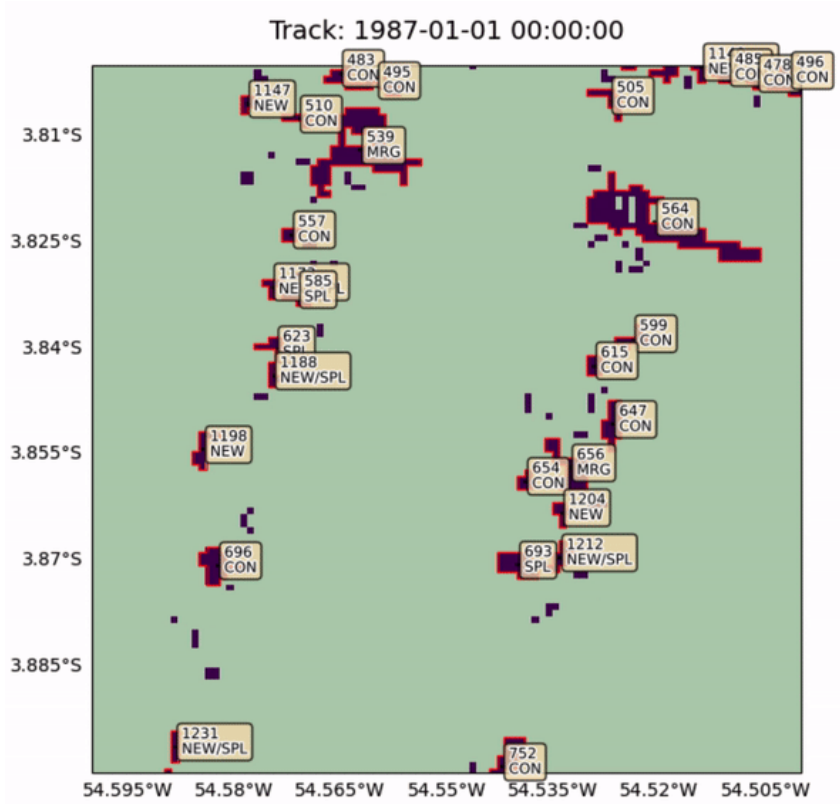
Amazon LIGHTNING Cloud-Ground (STARNET)



Amazon Satellite Infrared (GOES)



Amazon Deforestation MapBiomas



Obrigado!
Thank you!

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