

Assessment and evaluation of the role of vegetation on hydrometeorological processes in CMIP models - OWP 5.9



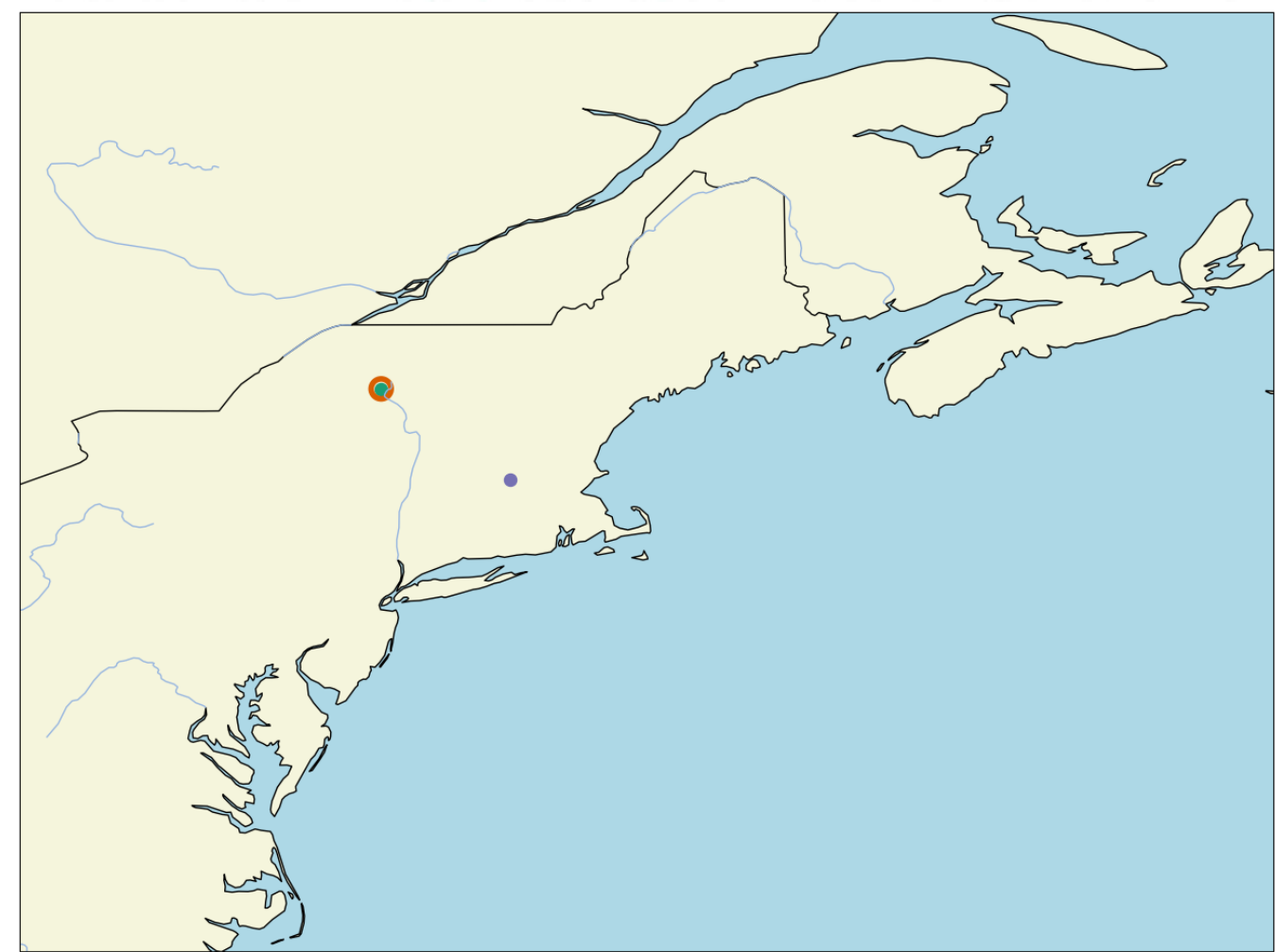
Authors: Robert King, Debbie Hemming¹ Daniele Peano, Matteo Mastropiero, Barbara Cardeli²
1: Met Office (MO), 2: Euro-Mediterranean Center on Climate Change Foundation (CMCC).

Overview

Hydrometeorological processes regulate the exchange of water and energy between the land surface and atmosphere. This work explores the relationship between vegetation phenology and hydrometeorological quantities such as soil moisture, water vapour, precipitation and surface runoff.

Phenology metrics, such as start of the growing season (vegetation onset), describe the dates plant processes occur and become observable. Calculating these from data sourced at different length scales allows for an understanding of what satellite observations are seeing and how this relates to the individual plants and sub-gridbox variability. Large scale observations are available via satellite-based products (such as CCI and C3S), and smaller length scales are observed by in-situ cameras such as deployed by the PhenoCam network. Understanding these differences in spatial scales can be applied to evaluating the phenology and their related hydrometeorological processes in CMIP6 models.

Vegetation Onset in New York state



Arbutus Lake: PhenoCam site at 43.98 N 74.23 W with deciduous broadleaf trees as the primary vegetation type.
C3S LAI: Gridbox containing Arbutus Lake. 1km and 10-day resolution.
CCI LAI: The nearest site available in version 1 is Harvard 43.53 N 72.17 W, 1km and 5-day resolution. The LAI data is cleaned and smoothed using the method developed in CMUG WP5.2.

Figure 2: New York state. (green) Arbutus Lake, (orange) gridbox of C3S LAI, & (purple) the Harvard site of CCI LAI.

Leaf Area Index & PhenoCam GCC

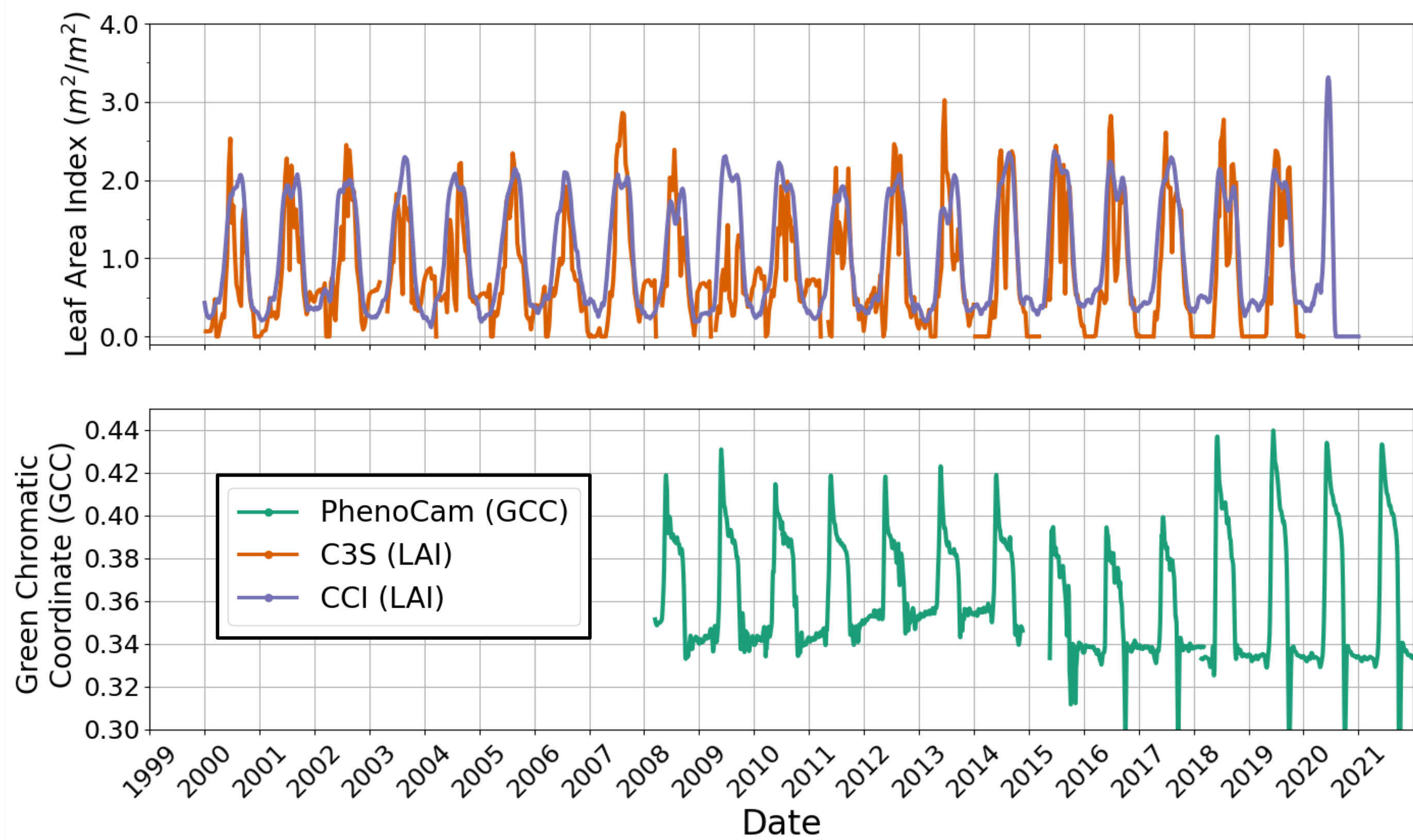


Figure 3: (top) The leaf area index data from (orange) C3S and (purple) CCI. (bottom) The green chromatic coordinate data from the Arbutus Lake (and the additional cameras at the lake inlet site) as taken from PhenoCam.

Water Vapour & Soil Moisture Relationships

Correlation TCWV-SM by Season

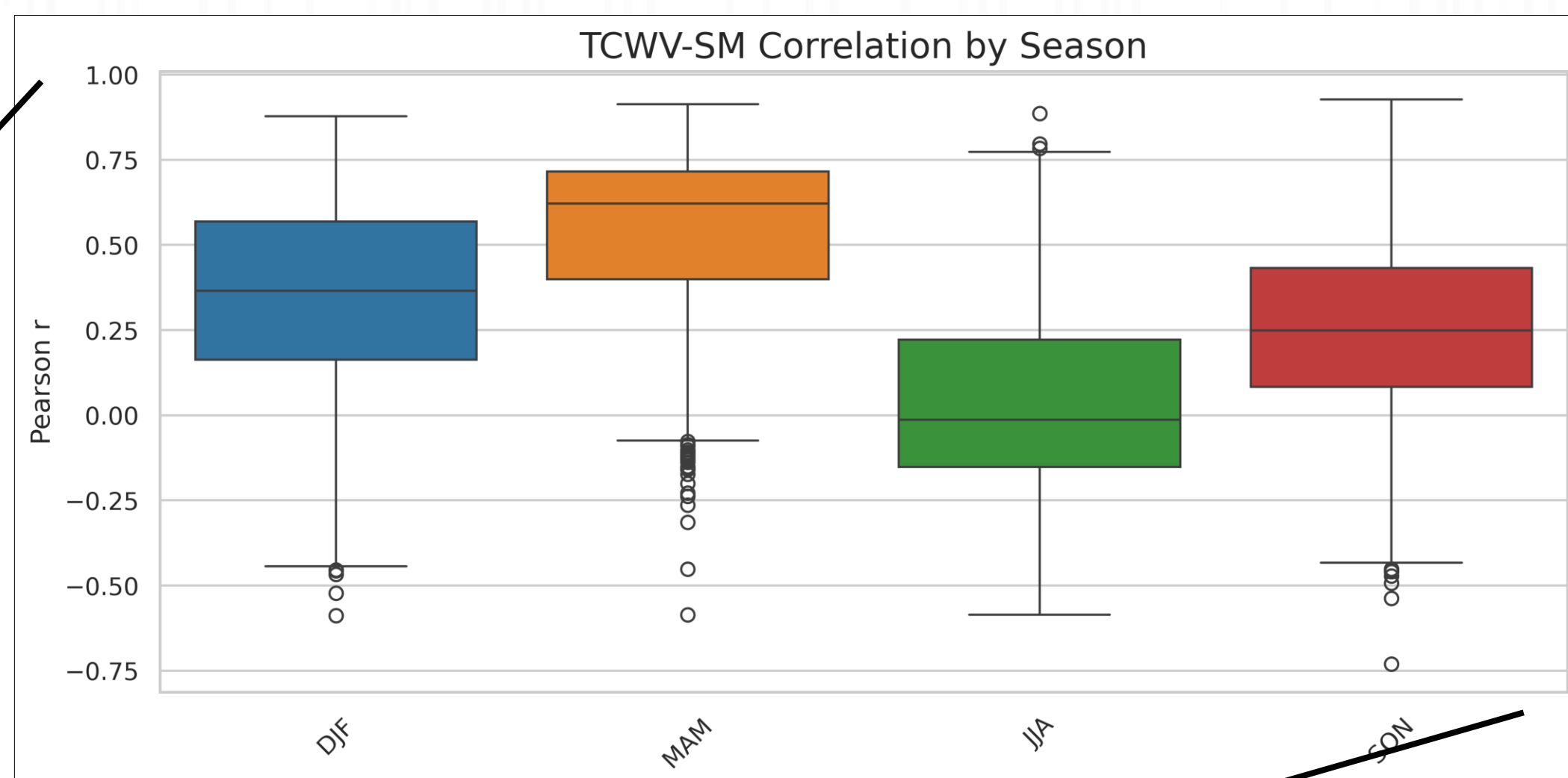
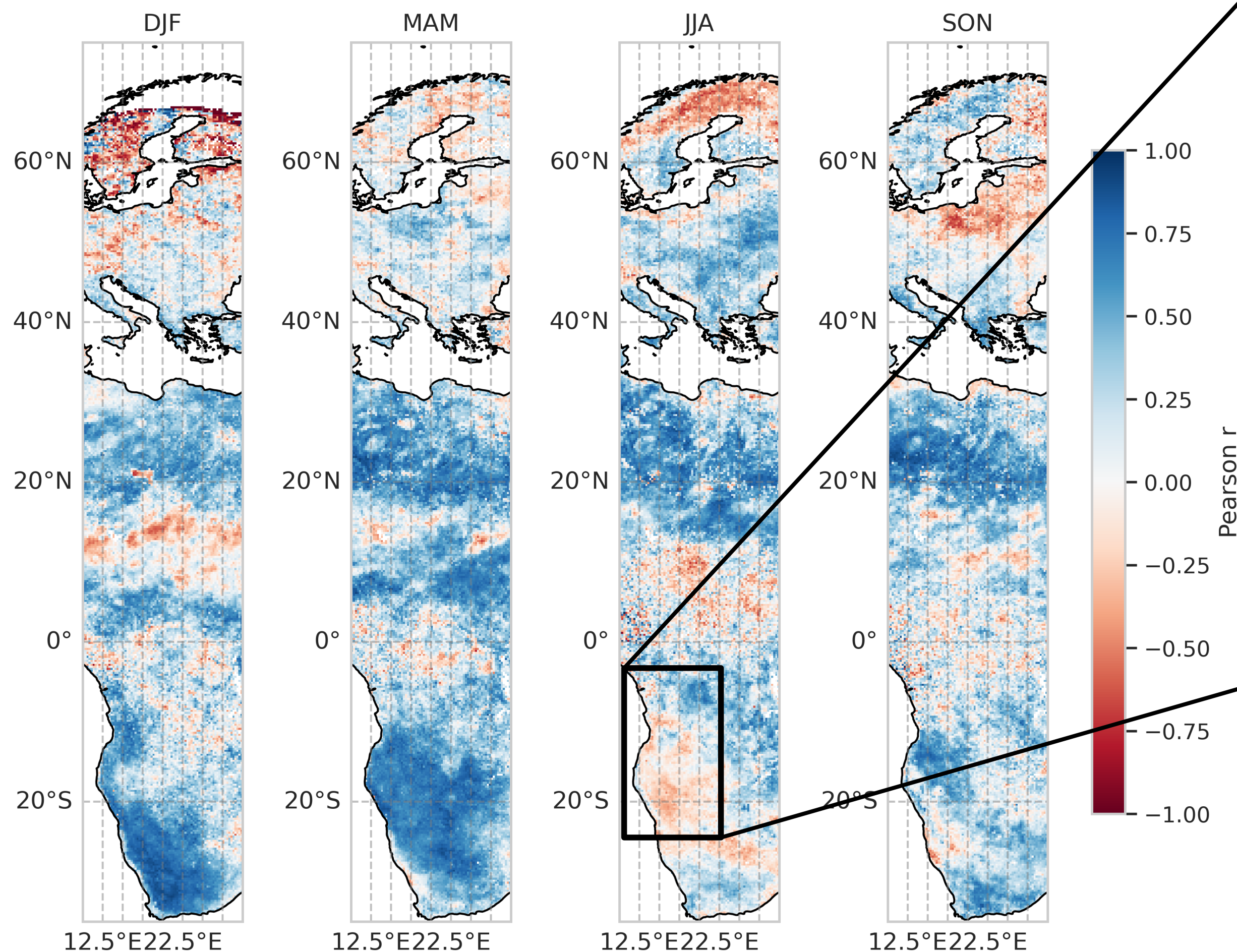


Figure 5: Seasonal correlation of monthly averaged Total Column Water Vapour and Soil Moisture, both from CCI products. The inset represents the seasonal distribution of correlation values for the grassland biomes within the black rectangle.

Total column water vapour (TCWV) data have been aggregated at monthly timescales, assessing their co-variability with soil moisture. Some regions, as in figure 5, characterized by grasslands, seem to have a marked seasonality in the soil moisture - atmospheric water content relationship, thus a stronger coupling.

Next Steps:

- Examine daily-scale hydrometeorological variability, focusing on the modulation of different vegetation types. Investigate the coupling with surface turbulent fluxes

Calculating Vegetation Onset

Vegetation onset is calculated for each year using “The Four Growing Season Type (4GST)”, Peano et al. (2019), using Leaf Area Index (LAI) data, or Green Chromatic Coordinate (GCC) data.

- Calculate the amplitude of the annual cycle
- Calculate annual minimum + 20% of the amplitude
- Date the LAI/GCC exceeds this value is the **vegetation onset**.

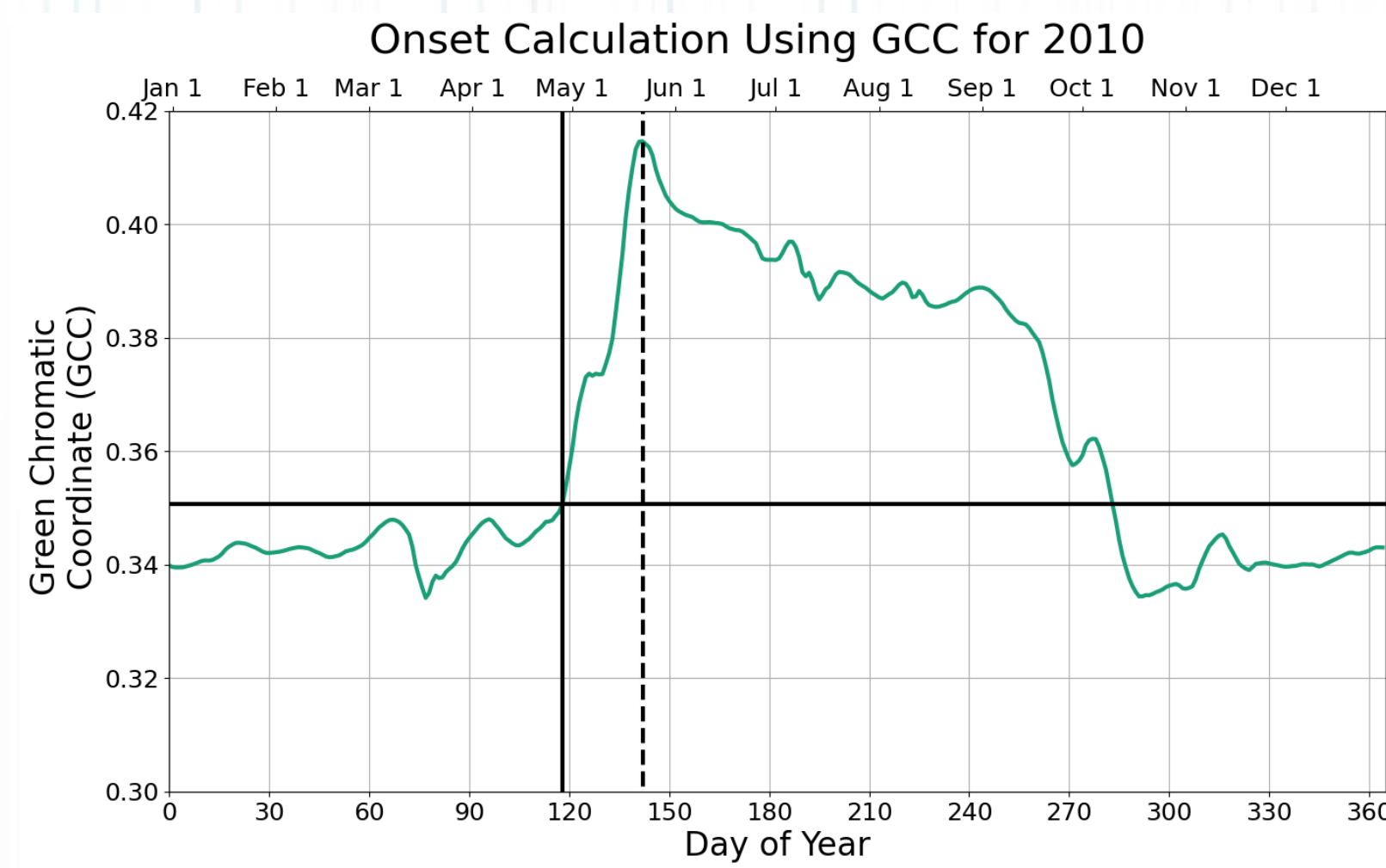


Figure 1: Calculating the vegetation onset in 2010 at Arbutus Lake, NY, USA, using the Green Chromatic Coordinate (GCC) from PhenoCam. (Green) GCC from 2010, (dashed black line) peak value, and (black crosshair) the onset date as day 119 (29th April) compared to understand the effects of using data from different length scales.

Onset Dates at Arbutus Lake:

- Figure 3 shows both CCI and C3S LAI, and GCC from Arbutus Lake.
- Differences in LAI timeseries lead to differences in vegetation onset date, figure 4.
- Onset calculated from GCC is closer to onset calculated from C3S LAI than CCI LAI.
- A similar offset in the vegetation onset dates between as calculated from GCC and CCI LAI was seen in CMUG WP5.2.

Next Steps:

- Relate the vegetation onset dates to hydrometeorological quantities such as Water Vapour, precipitation and runoff.
- Establish the vegetation onset dates from CMIP6 models, especially LS3MIP
- Evaluate similarities and differences between the onset/hydromet relationships seen in observations to the model relationships.

LAI Onset Dates

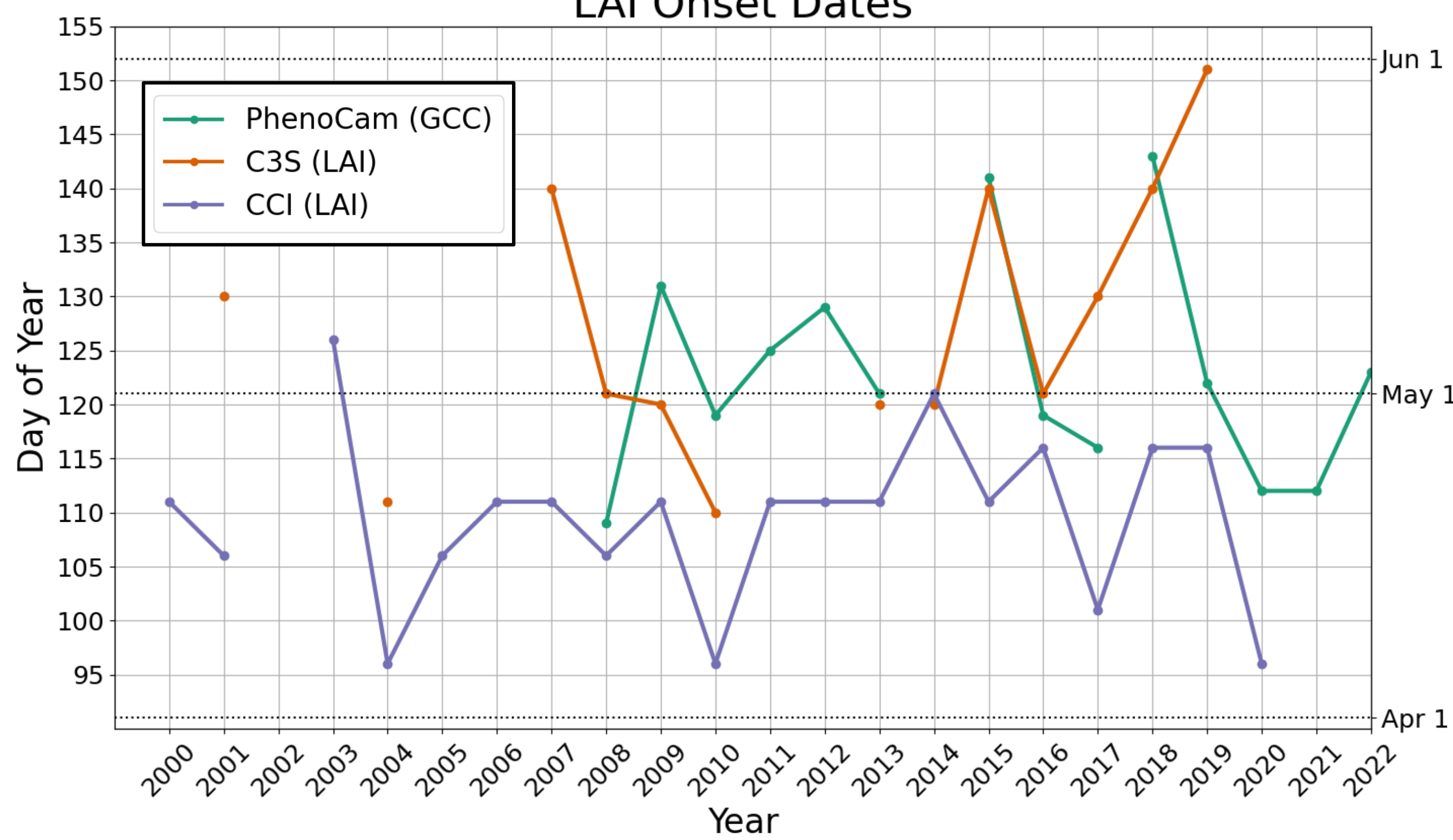


Figure 4: The vegetation onset dates calculated from (green) green chromatic coordinate data from Arbutus Lake PhenoCam data, and leaf area index (orange) C3S and (purple) CCI Vegetation. Dates before day 95 are masked because at this site are typically given by noise in the data. GCC data is only available for 2008 onward.

References

- Peano, D. et al. (2019). Global variability of simulated and observed vegetation growing season. Journal of Geophysical Research: Biogeosciences, 124, 3569–3587.
- PhenoCam <https://phenocam.nau.edu/>