Colocation Day 1: PREDICT

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Project Objectives

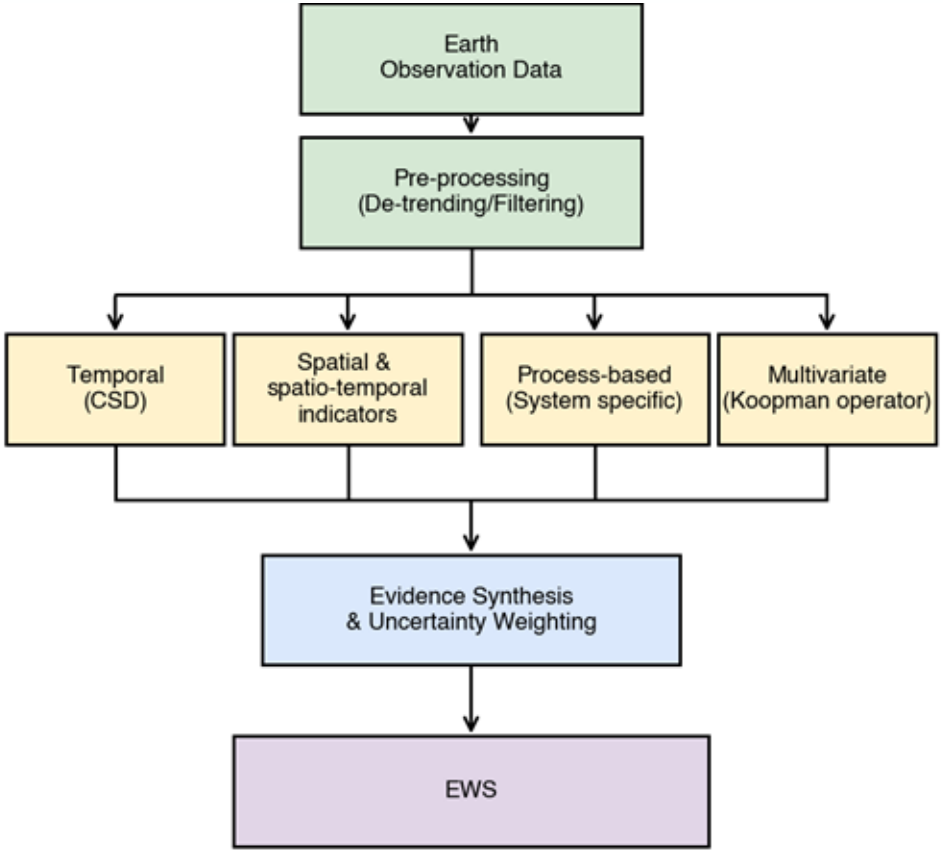
- Part of the Climate-Space Tipping Elements Activity
- Project objectives:
  - Strengthen understanding of the risk of tipping and abrupt changes in the Earth system
  - Detect patterns, trends and early warning signals of tipping points in the biosphere
  - Integrate Earth observations, models, statistics and data fusion
  - Implement robust uncertainty quantification frameworks
- Connections with wider community: ARIA Forecasting Tipping Points; CLIMTIP
- Policy activities: IPCC WG1; Global Tipping Points Report; COP31

July 2025	January 2026	July 2026	January 2027	July 2027	January 2028
Milestone 1 - Science Requirements - Inventory	**Milestone 2** -Scientific methodology	**Milestone 3** - Tipping Elements scientific analyses	**Milestone 4** - Uncertainty analysis	**Milestone 5** - Publications published	**Milestone 6** - Roadmap for ESA

Skeleton overview of the approach

01	Advance understanding of biosphere tipping elements and abrupt changes	• Identify key driving processes, feedback mechanisms, and parameter sensitivities • Amazon forest dieback, dryland vegetation and permafrost thaw
02	Detect patterns, trends, and EWS of approaching tipping points in the biosphere	• Long-term ECV datasets and other observational data • Develop statistical and ML methods that can extract signals from noisy and heterogeneous data
03	Integrate EO, models, statistics, and data fusion	• Extend proven methods for detecting EWS • Derive new indicators coupled to observable quantities • Harmonise multi-sensor datasets through advanced data fusion techniques
04	Implement robust uncertainty quantification frameworks	• Assess parametric, structural, and scenario uncertainties • Data assimilation, Monte Carlo methods and cross-model comparisons

Skeleton overview of the approach



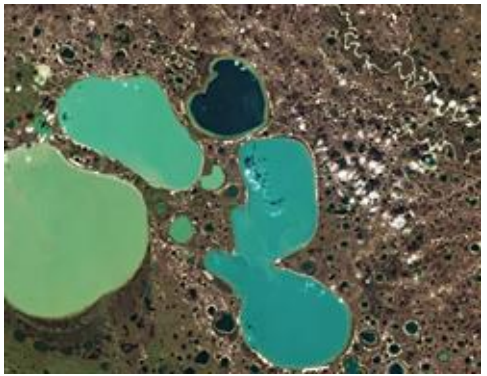
Essential Climate Variables being used

Rainforest Dieback

- Above-ground biomass
- Fire
- High Resolution Land cover
- Land Surface Temperature
- Vegetation parameters (LAI)
- Water vapour

Dryland Vegetation

- Above-ground biomass
- Fire
- High Resolution Land Cover
- Soil moisture

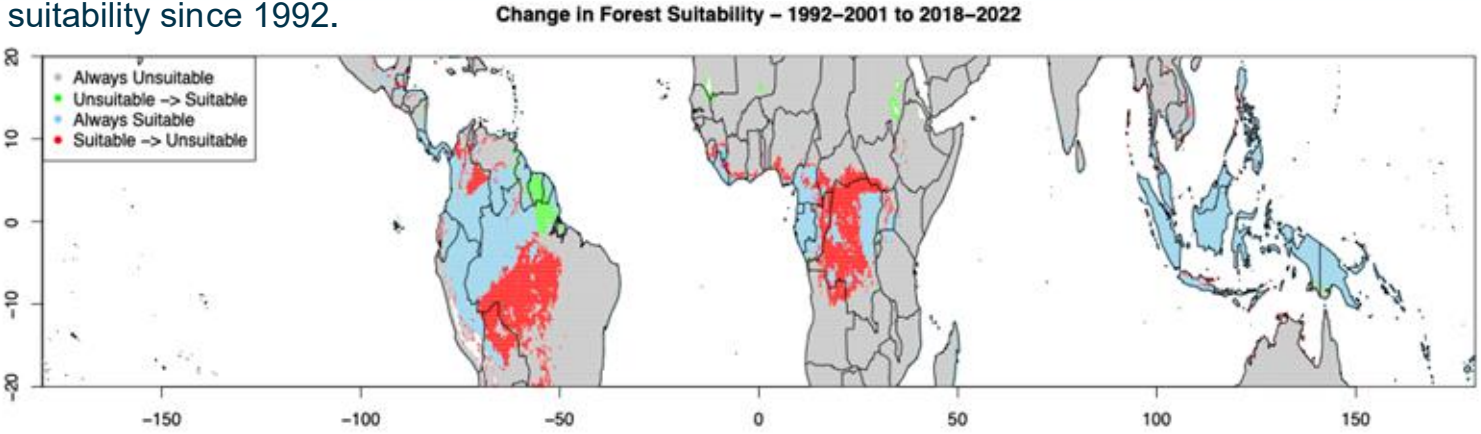


Permafrost

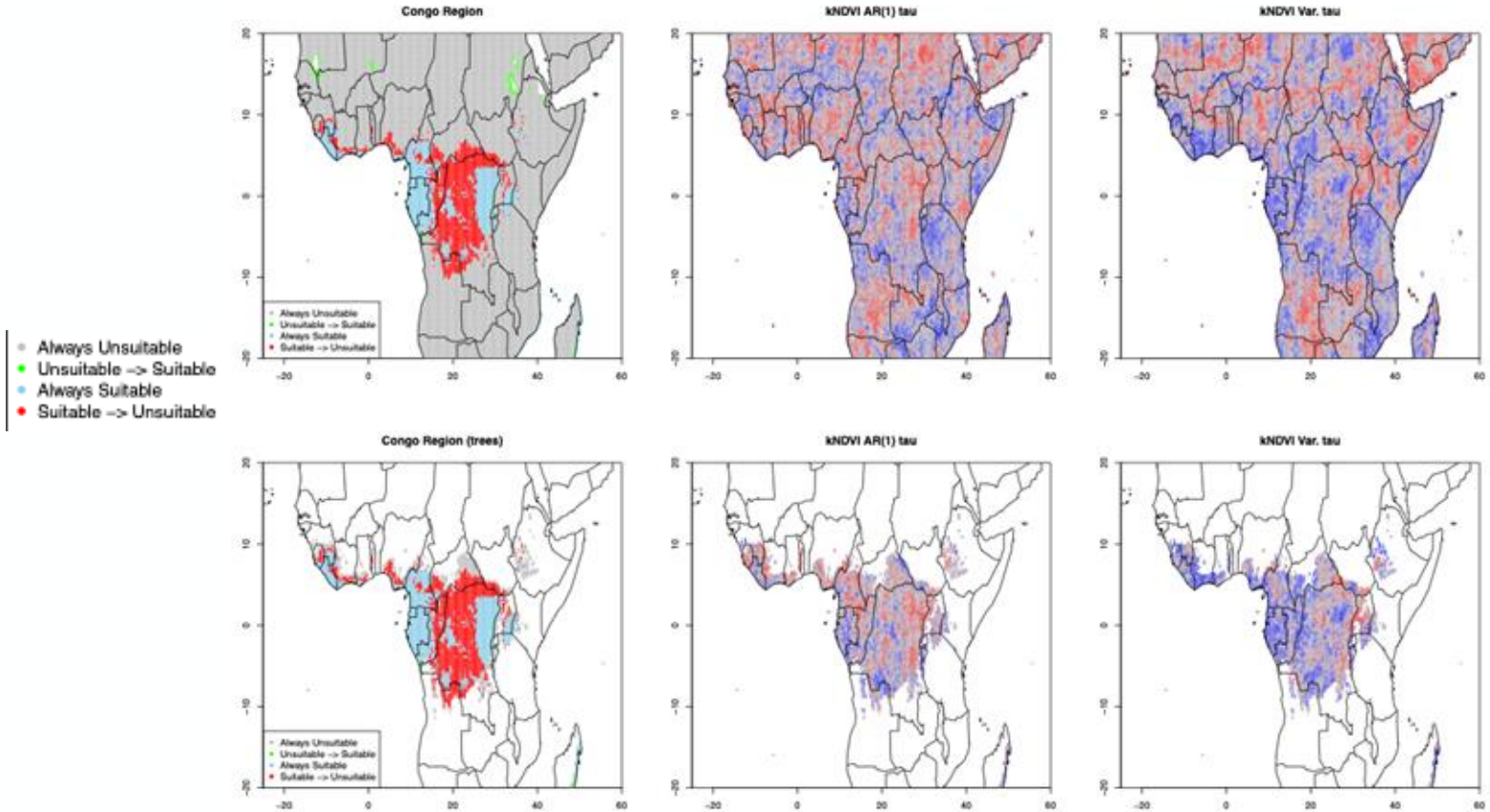
- Fire
- Lakes
- Soil moisture
- Permafrost (obviously!)

Results & relevance to the CCI community

- Initial approach is to assess changes in suitability of tropical rainforests based on climatological conditions.
- Previous evidence from GCMs of a climate niche for rainforest viability as a function of dry-season length and temperature (Boulton et al., 2017).
- Changes in this niche could be linked to the resilience of these rainforests.
- We have used ERA5 temperature and precipitation data to identify regions that have undergone changes in suitability since 1992.



Results & relevance to the CCI community



Results & relevance to the CCI community

Lead Author Name	Title	Journal	Status
Valerio Lucarini	Linear Response and Optimal Fingerprinting for Nonautonomous Systems	Reports on Progress in Physics	Submitted
Sergei Petrovskii	Tipping points in complex ecological systems	Nature Reviews Physics	Submitted
Sergei Petrovskii and Valerio Lucarini	Geometric early warning indicator from stochastic separatrix structure in a random two-state ecosystem model	Physica D	Submitted
Joseph Clarke	Conditions for Skilful Spatial and Temporal Tipping Point Early Warning Signals	Journal of Physics: Complexity	Submitted
Jesse Abrams	Science Needs for a Terrestrial Biosphere Tipping Point Early Warning System: Maximizing the Value of Earth Observation Data	Reviews of Geophysics	In review
Jesse Abrams	Integrating Tipping Point concepts across diverse systems	Communications Sustainability	In review
Valerio Lucarini	A Mathematical Framework for Linear Response Theory for Nonautonomous Systems	Communications in Mathematical Physics	Submitted