

climate change initiative

→ HIGH RESOLUTION LAND COVER

CCI+ High Resolution Land Cover ECV

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- (4) University of Genova, Italy; (5) Polytechnic University of Milan, Italy; (6) UCLouvain, Belgium;
- (7) e-Geos, Italy; (8) Planetek Italia, Italy; (9) Geoville, Austria; (10) LSCE, France; (11) CREAM, Spain



high resolution
land cover
cci



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POLITECNICO
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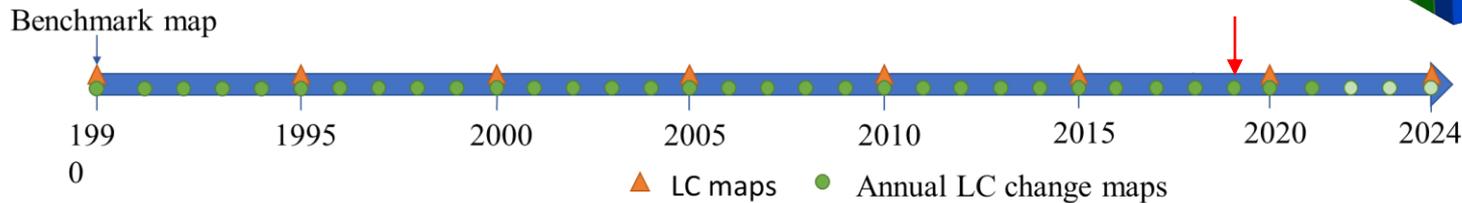
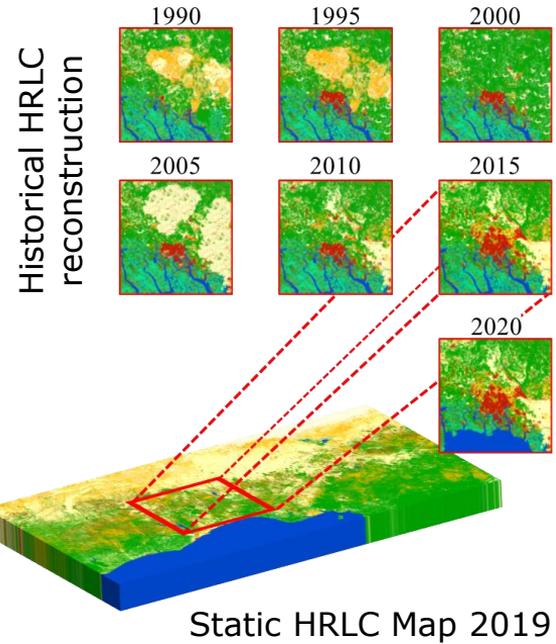




Main Products

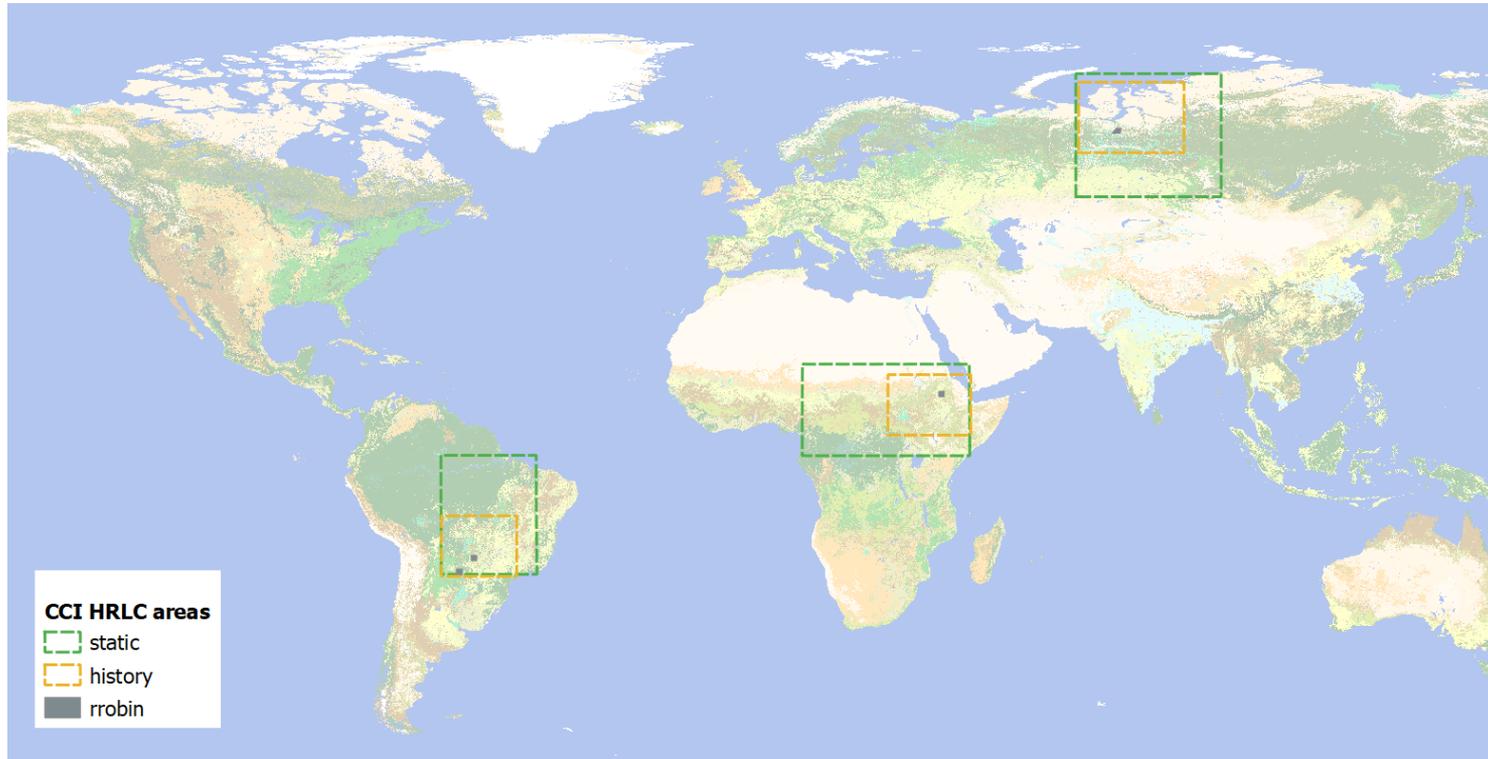


- ✓ A **HRLC map** at subcontinental scale for 2019 at **10m** as reference **static** input to the climate models.
- ✓ A **long-term historical record of regional HR maps at 30m** in sub-regions of the static input for historical reconstruction of **LC** every 5 years.
- ✓ The **change** information at **30m** on a **yearly scale** (only when feasible from data availability) coherent with the updates of the HRLC maps.



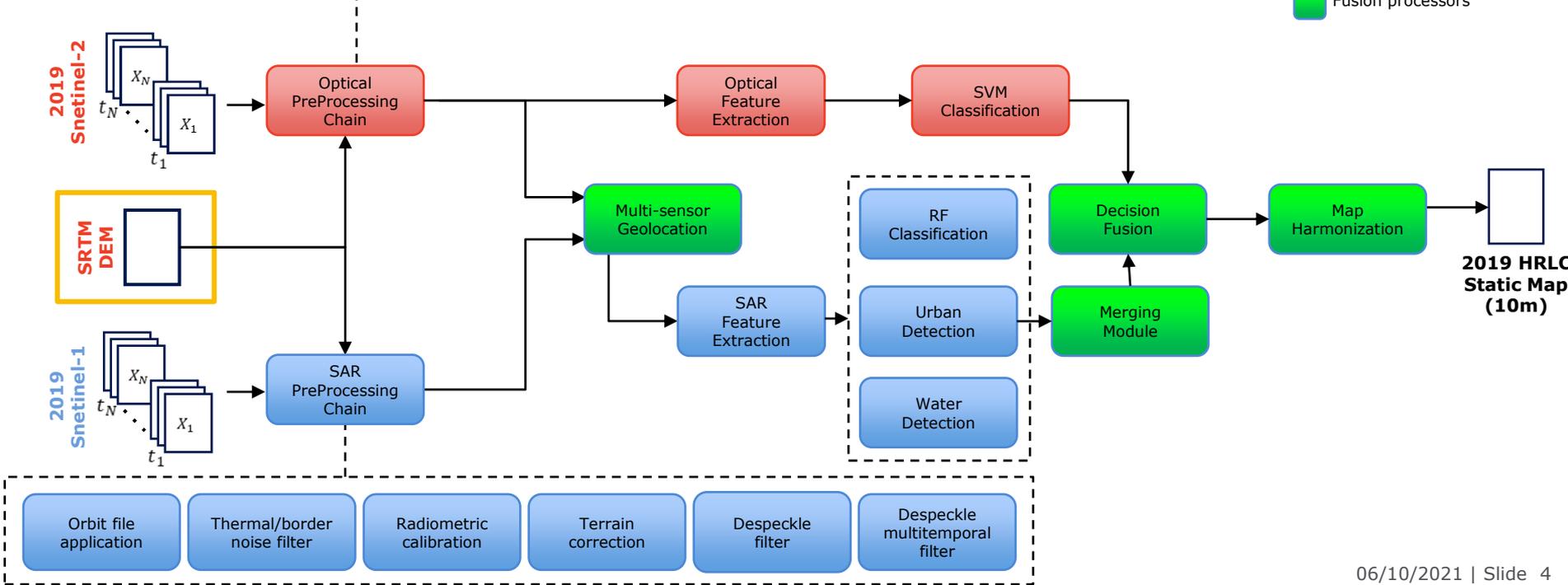
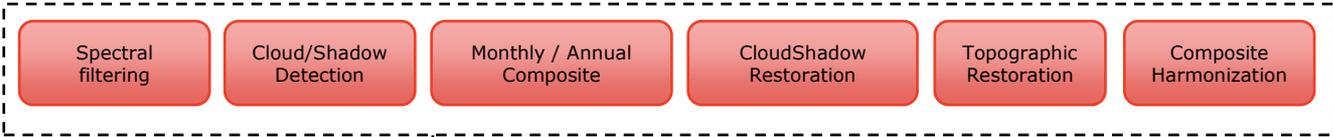


Study Areas



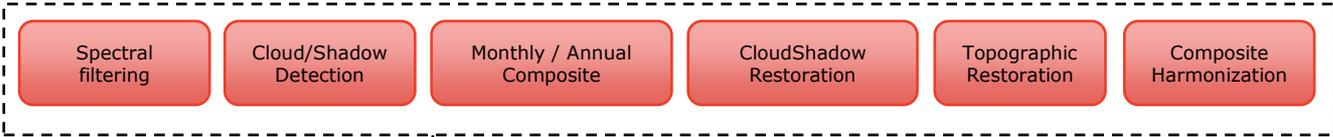


Processing Chain – Static Maps

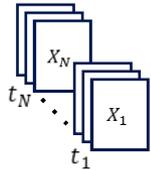




Processing Chain – Historical Maps



Landsat 5-8



Optical PreProcessing Chain

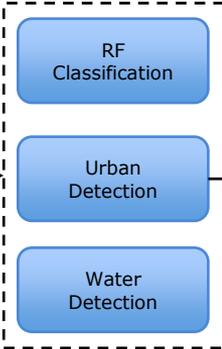
Optical Feature Extraction

SVM Classification



Multi-sensor Geolocation

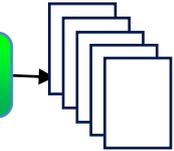
SAR Feature Extraction



Decision Fusion (with cascade)

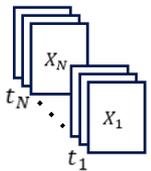
Merging Module

Map Harmonization



5 years Regional HRLC Maps (30m)

ASAR / ERS 1-2

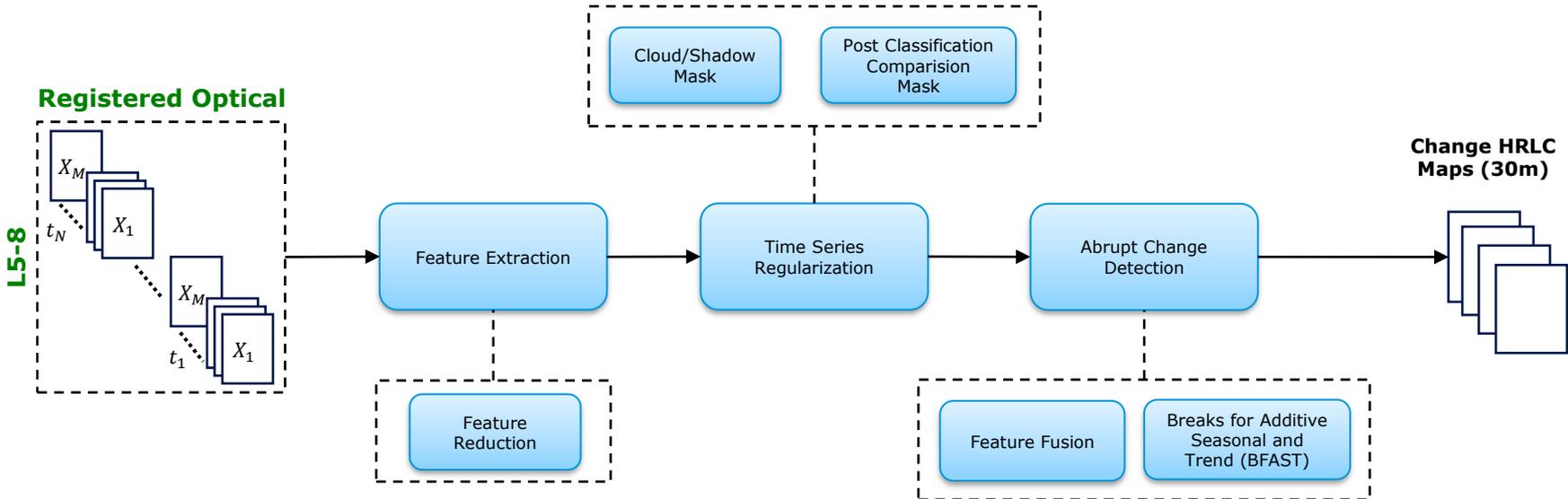


SAR PreProcessing Chain



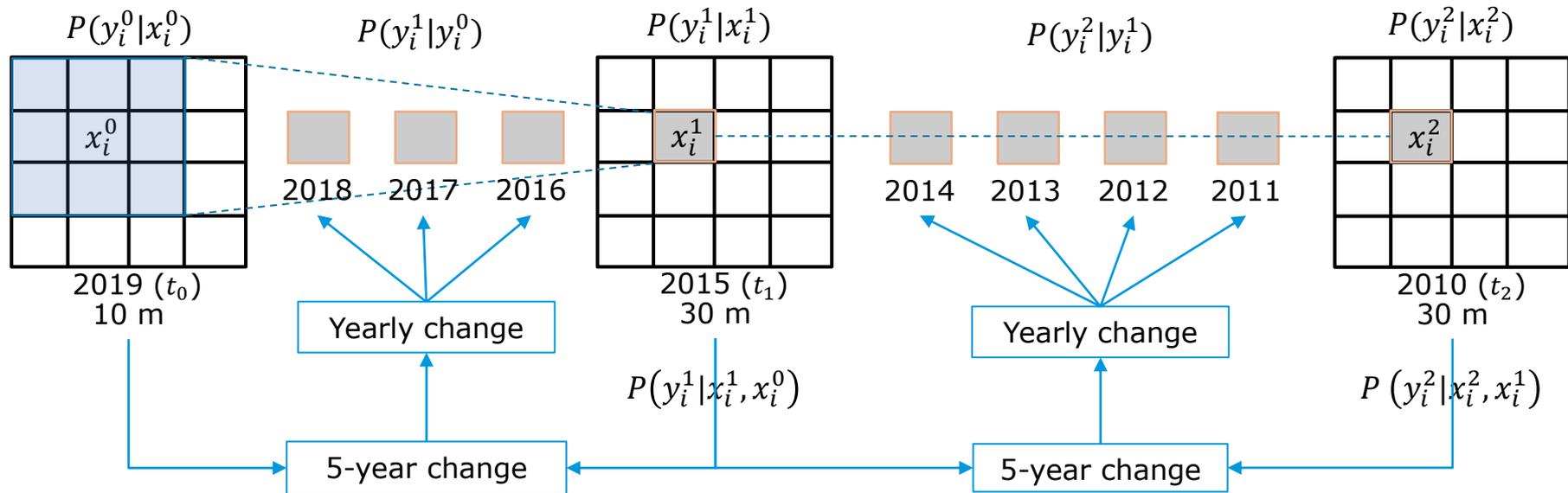


Processing Chain – Land Cover Change Maps



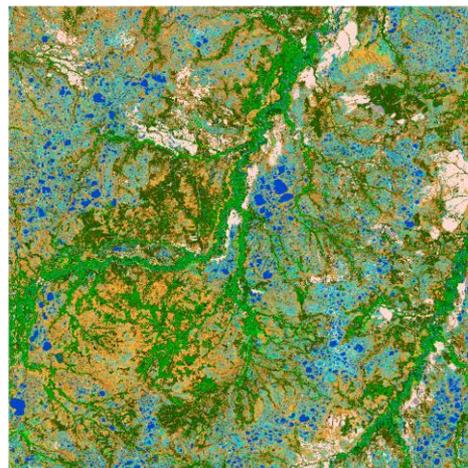


Processing Chain: Cascade Paradigm





Example: Static Maps



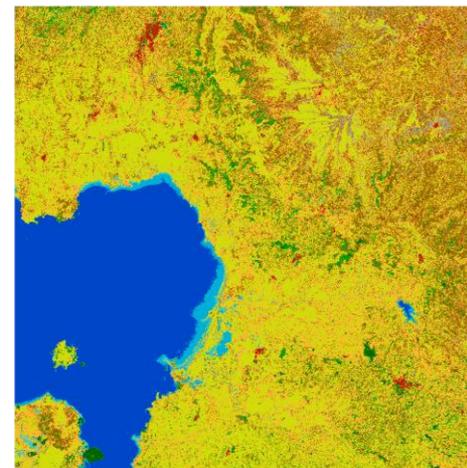
Siberia



Amazonia



Amazonia



Africa

- | | | | | |
|----------------------|-----------------|--|--------------------|----------------------|
| Evergreen broadleaf | Shrub evergreen | Woody Vegetation aquatic or regularly flooded | Lichens and mosses | Open water seasonal |
| Evergreen needleleaf | Shrub deciduous | Herbaceous Vegetation aquatic or regularly flooded | Bare areas | Open water permanent |
| Deciduous broadleaf | Grassland | Built-up areas | Snow and/or ice | |
| Deciduous needleleaf | Cropland | | | |

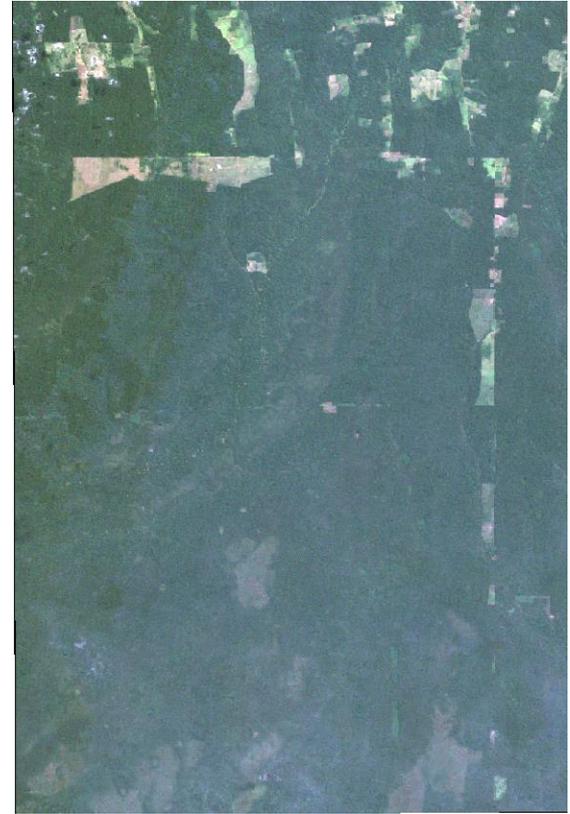
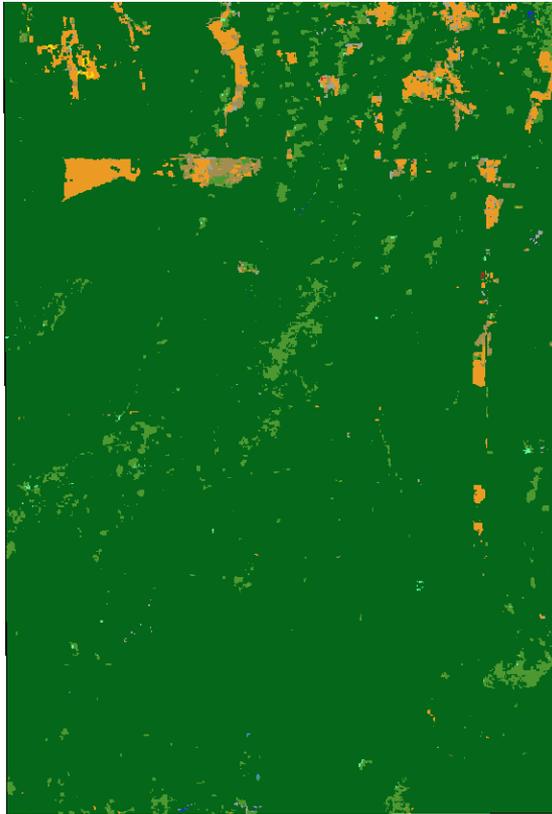




Example: Historical Maps Amazon 1990



-  Evergreen broadleaf
-  Evergreen needleleaf
-  Deciduous broadleaf
-  Deciduous needleleaf
-  Shrub evergreen
-  Shrub deciduous
-  Grassland
-  Cropland
-  Woody Vegetation aquatic or regularly flooded
-  Herbaceous Vegetation aquatic or regularly flooded
-  Bare areas
-  Build-up
-  Open water permanent



06/10/2021 | Slide 9

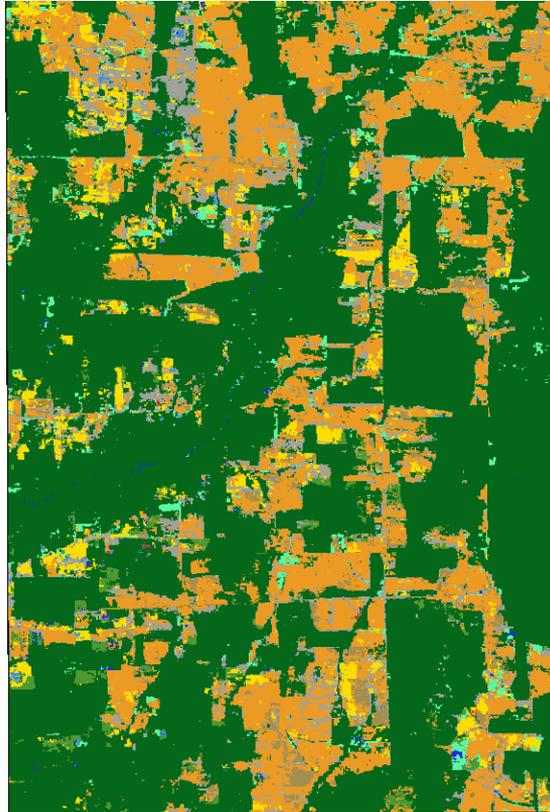




Example: Historical Maps Amazon 2005



- Evergreen broadleaf
- Evergreen needleleaf
- Deciduous broadleaf
- Deciduous needleleaf
- Shrub evergreen
- Shrub deciduous
- Grassland
- Cropland
- Woody Vegetation aquatic or regularly flooded
- Herbaceous Vegetation aquatic or regularly flooded
- Bare areas
- Build-up
- Open water permanent



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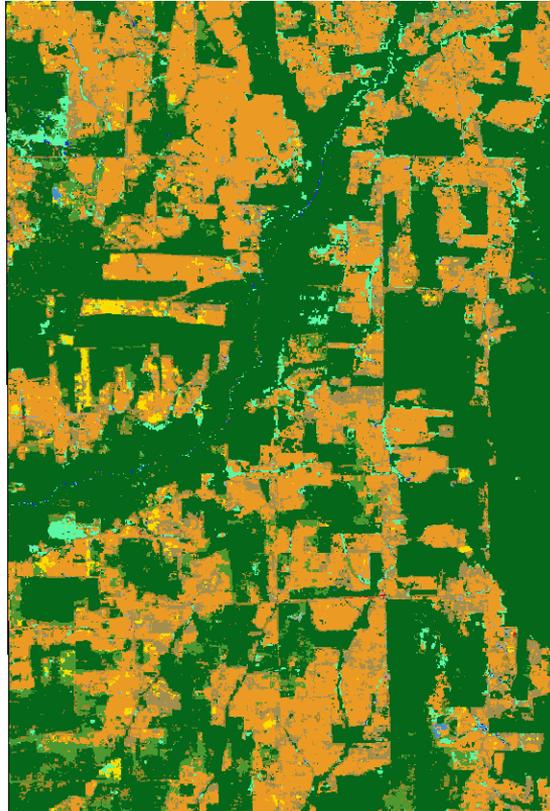




Example: Historical Maps Amazon 2010



- Evergreen broadleaf
- Evergreen needleleaf
- Deciduous broadleaf
- Deciduous needleleaf
- Shrub evergreen
- Shrub deciduous
- Grassland
- Cropland
- Woody Vegetation aquatic or regularly flooded
- Herbaceous Vegetation aquatic or regularly flooded
- Bare areas
- Build-up
- Open water permanent



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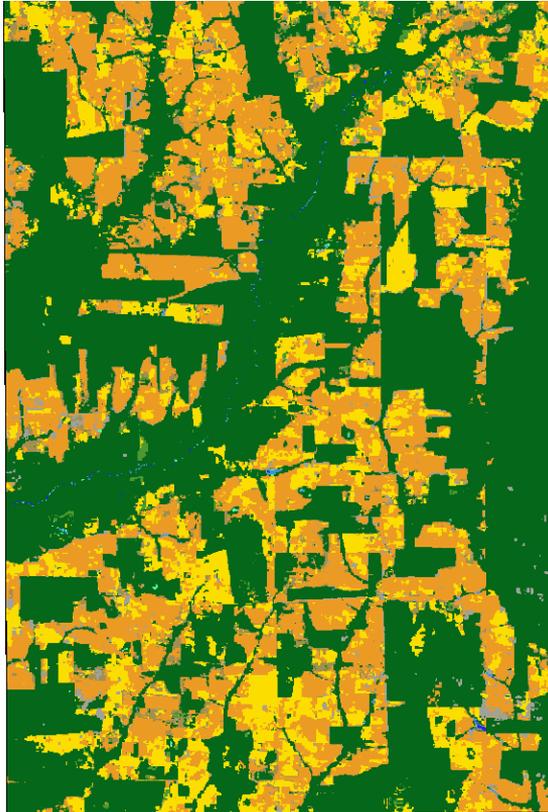




Example: Historical Maps Amazon 2015



- Evergreen broadleaf
- Evergreen needleleaf
- Deciduous broadleaf
- Deciduous needleleaf
- Shrub evergreen
- Shrub deciduous
- Grassland
- Cropland
- Woody Vegetation aquatic or regularly flooded
- Herbaceous Vegetation aquatic or regularly flooded
- Bare areas
- Build-up
- Open water permanent

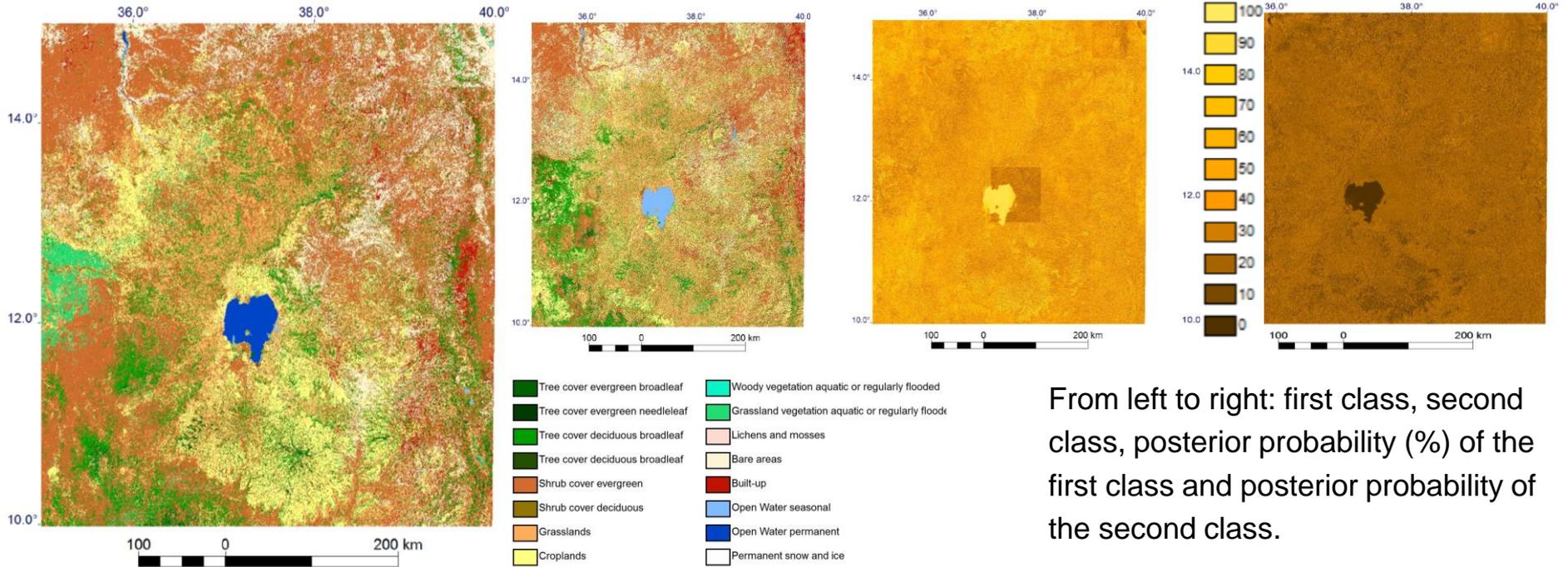


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Collection of products at sub-region of Sahel (2005)



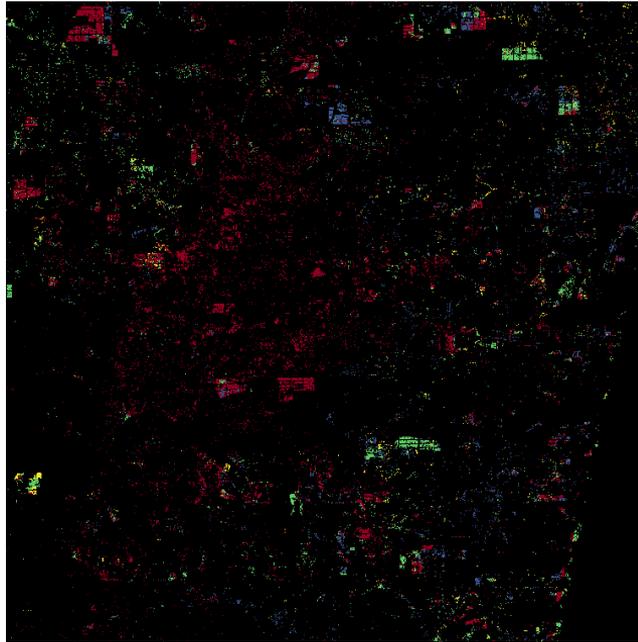
From left to right: first class, second class, posterior probability (%) of the first class and posterior probability of the second class.



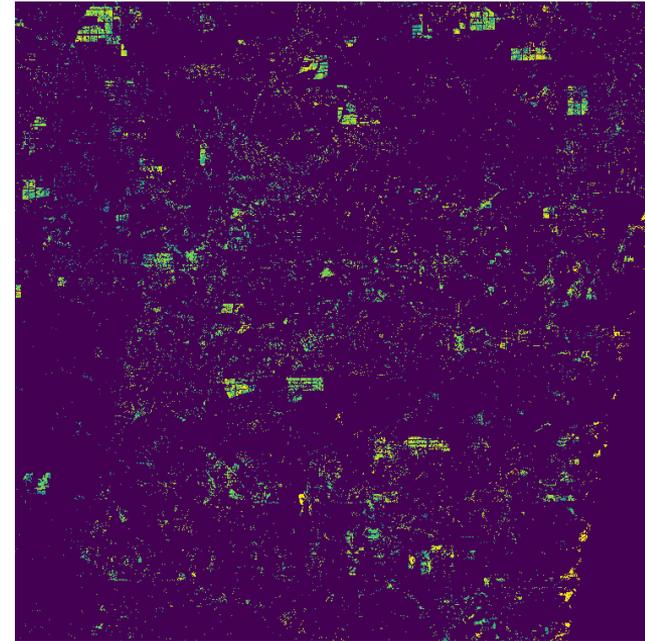
Land Cover Change Products



Land Cover Change Map (2019 – 2015)



Probability of Change

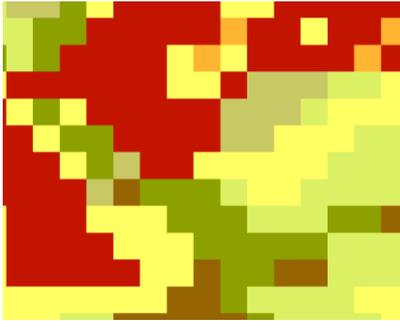




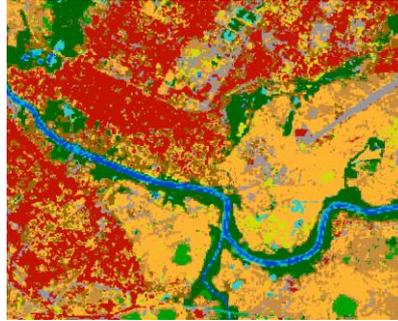
HRLC vs MRLC



- Tree cover broadleaved
- Tree cover deciduous
- Shrubland
- Mosaic tree and shrub
- Shrub or herbaceous cover
- flooded herbaceous cover
- Mosaic natural vegetation
- Grassland
- Cropland
- Urban areas
- Water bodies



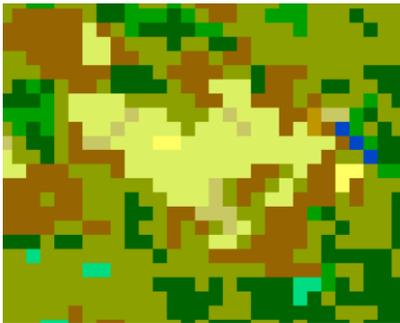
CCI medium resolution



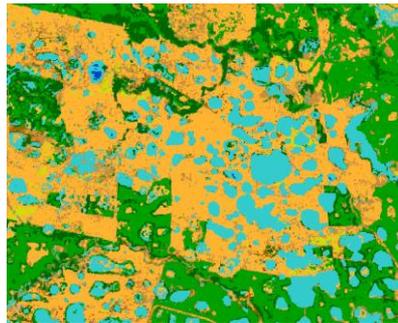
CCI high resolution



Google Image



CCI medium resolution



CCI high resolution



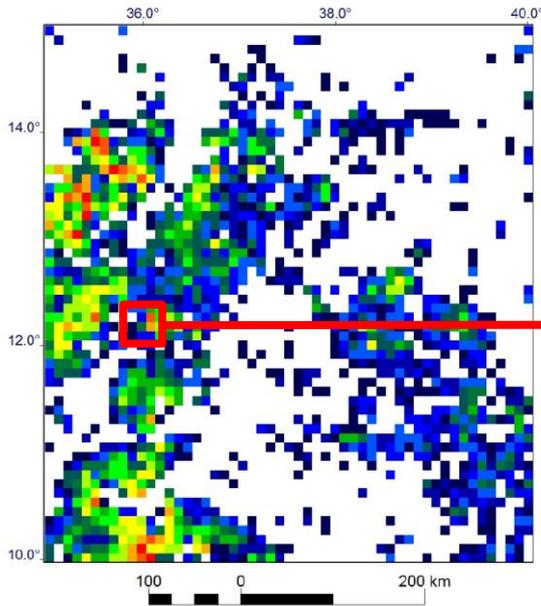
Google Image

- Evergreen
- broadleaved
- Deciduous
- Shrubland
- evergreen
- Shrub deciduous
- Grassland
- Cropland
- Herbaceous
- Vegetation aquatic or regularly flooded
- Bare areas
- Build up
- Open water seasonal
- Open water permanent

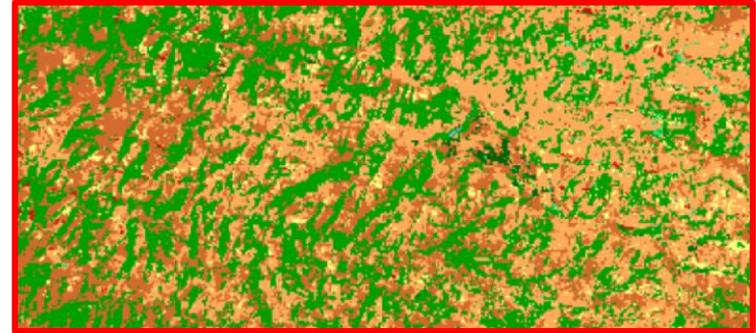




KPI: landscape metrics for HR vs MR LC product comparison



HR



Zoom to high diversity
difference at $36^{\circ}5' 13.50''$ E,
 $12^{\circ}10' 20.23''$ N.

An homogeneous dominant
mixed class for the MR point of
view. A fragmented and
diversity area by HR.

MR



Tree cover, broadleaved, deciduous, open (15-40%)

Differences HR – MR regionalized (10 km
grid) Shannon diversity index 10km HR-MR



Land Cover Classes to ORCHIDEE Plant Functional Types



New Cross-Walking Table (CWT) adapted to HRLC classes and spatial resolution (interpretation of the LC classes depend on the resolution, refinement of the climate zones and C3/C4 mapping)

HRLC classes		→	ORCHIDEE PFTs
TREES	Broadleaved Evergreen		PFT1 : Bare Soil
	Broadleaved Deciduous		PFT2 : Tropical Evergreen
	Needleleaved Evergreen		PFT3 : Tropical Raingreen
	Needleleaved Evergreen		PFT4 : Temperate Needleleaf Evergreen
SHRUBS	Broadleaved Evergreen		PFT5 : Temperate Broadleaf Evergreen
	Broadleaved Deciduous		PFT6 : Temperate Broadleaf Summergreen
	Needleleaved Evergreen		PFT7 : Boreal Needleleaf Evergreen
	Needleleaved Evergreen		PFT8 : Boreal Broadleaf Summergreen
GRASSES	Natural Grasses		PFT9 : Boreal Needleleaf Deciduous
	Crops		PFT10 : Temperate Natural Grassland (C3)
Bare Soil			PFT11 : Natural Grassland (C4)
Water			PFT12 : Crops (C3)
Snow and Ice			PFT13 : Crops (C4)
Urban			PFT14 : Tropical Natural Grassland (C3)
No Data			PFT15 : Boreal Natural Grassland (C3)

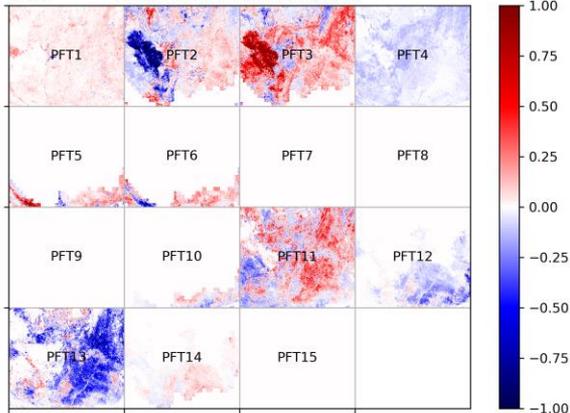




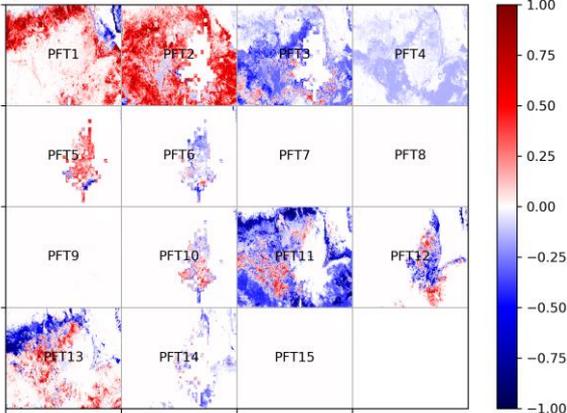
PFT Generation: Comparison HRLC vs MRLC



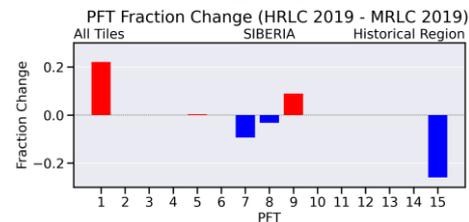
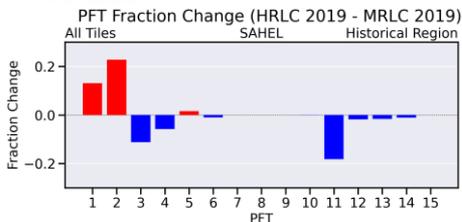
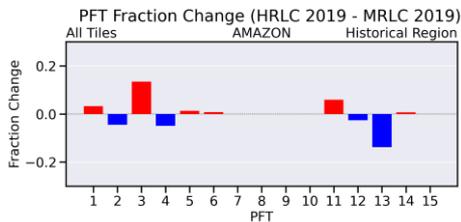
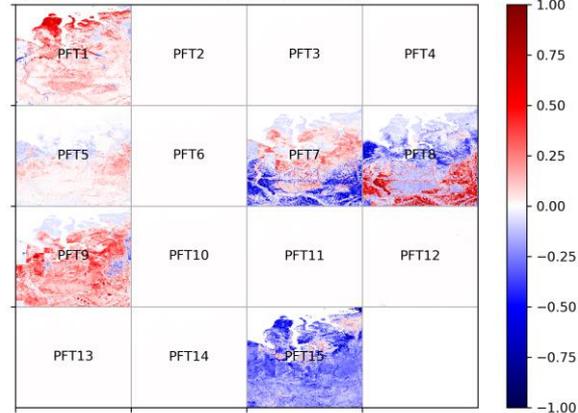
2019 Amazon HRLC vs MRLC (0.025)



2019 Africa HRLC vs MRLC (0.025)



2019 Siberia HRLC vs MRLC (0.025)



- PFT 1: Bare Soil
- PFT 2: Tropical Evergreen
- PFT 3: Tropical Raingreen
- PFT 4: Temperate Needleleaf Evergreen
- PFT 5: Temperate Broadleaf Evergreen
- PFT 6: Temperatre Broadleaf Summergreen
- PFT 7: Boreal Needleleaf Evergreen
- PFT 8: Boreal Broadleaf Summergreen
- PFT 9: Boreal Needleleaf Deciduous

- PFT 10: Temperate Natural Grassland (C3)
- PFT 11: Natural Grassland (C4)
- PFT 12: Crops (C3)
- PFT 13: Crops (C4)
- PFT 14: Tropical Natural Grassland (C3)
- PFT 15: Boreal Natural Grassland (C3)

More trees/shrubs and less crops in Amazonia
Different partition of broadleaf/evergreen species
More shrubs, less grasslands in Ethiopia
More bare soil and less grasslands in Siberia

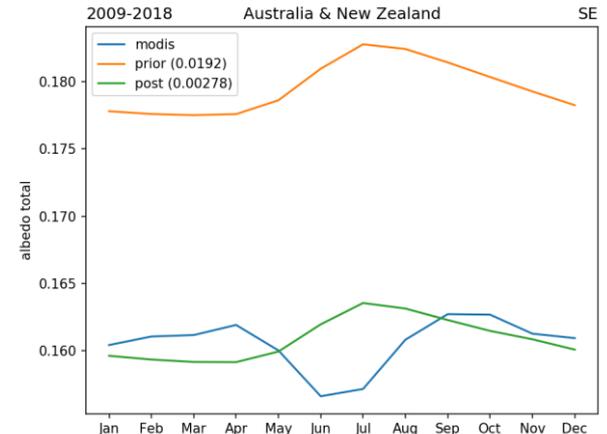
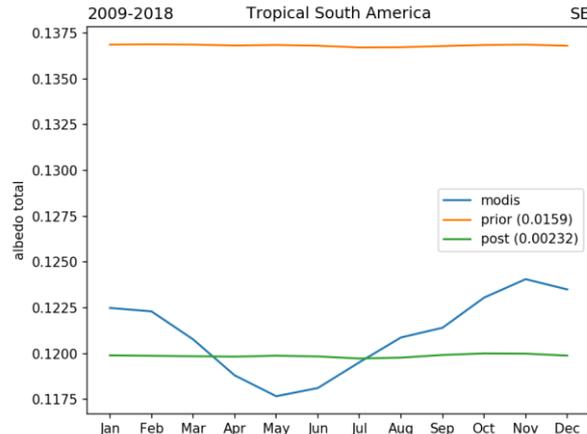


Albedo revisions in ORCHIDEE



- ✓ **Albedo biases were found in ORCHIDEE:** HRLC allowed to diagnose the origin of these errors (whether they were linked to LC mapping errors or to albedo parameterization deficiencies).
- ✓ **MODIS and GlobAlbedo products** used to diagnose and revise the albedo modeling.
- ✓ **New model is in better agreement with the observations,** especially in the semi- arid zones (sparse vegetation with significant bare soil fraction).

Albedo evaluation against MODIS data (average annual cycles).

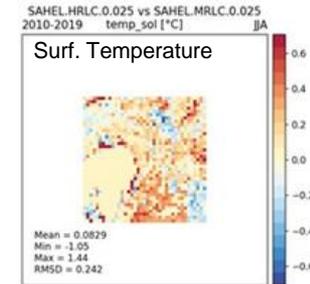
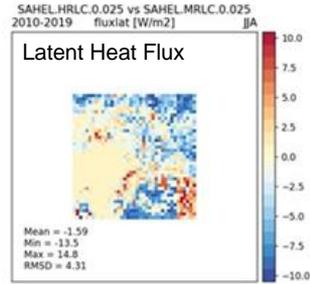
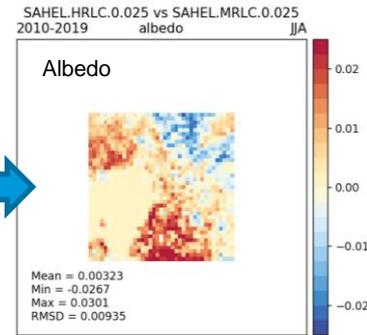
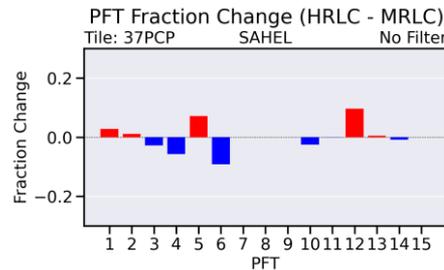




ORCHIDEE simulations: CRU-JRA reanalysis, (1992-2018), 0.5° , downscaled at 0.025°
 Simulations based on MRLC are compared to the ones based on HRLC on the period 2010-2019, on a small domain in Ethiopia

Higher fractions of grasslands in the South result in higher surface albedo values.

This means less energy available for evapotranspiration and higher surface temperatures when soil water content is limiting





Conclusions



- ✓ The final production is in progress and the final products will be used for updating all the climate modeling activities.
- ✓ Validated products will be available at the end of the year. Each product will be associated with data modeling the uncertainty estimated in the production process.
- ✓ The use of HR data poses challenges in the definition of the processing chains related to the very different conditions on data availability (and quality) going back in time and to the computation requirements.
- ✓ HRLC allows to capture high relevance regional/local patterns that cannot be recognized with MRLC and to improve modeling capabilities also towards a better use of MRLC products.



- ✓ C. Paris, L. Orlandi, L. Bruzzone, "A Strategy for an Interactive Training Set Definition based on Active Self-Paced Learning," IEEE Geoscience and Remote Sensing Letters, Vol. 17, In press, 2021. DOI: 10.1109/LGRS.2021.3114611.
- ✓ L. Bruzzone, F. Bovolo, P. Defourny, P. Gamba, L. Agrimano, A. Amodio, M. A. Brovelli, M. Corsi, C. Lamarche, G. Moser, C. Ottlé, P. Peylin, P. Pistillo, M. Riffler, C. Domingo, L. Pesquer, "CCI Essential Climate Variables: High Resolution Land Cover," ESA Living Planet Symposium, Milan, Italy, 13-17 May 2019.
- ✓ L. Pesquer, C. Domingo-Marimon, J. Cristóbal, C. Ottlé, P. Peylin, F. Bovolo, L. Bruzzone. "Comparison of ecosystem functional type patterns at different spatial resolutions in relation with FLUXNET data." In Remote Sensing for Agriculture, Ecosystems, and Hydrology XXI, vol. 11149, p. 1114908. International Society for Optics and Photonics, 2019.
- ✓ I. Podsiadlo, C. Paris, L. Bruzzone, "A study of the robustness of the long short-term memory classifier to cloudy time series of multispectral images," SPIE 2020, SPIE Conference on Image and Signal Processing for Remote Sensing XXVI, Virtual Meeting, 21-25 September 2020.
- ✓ Y.T. Solano-Correa, K. Meshkini, F. Bovolo, L. Bruzzone, "A land cover-driven approach for fitting satellite image time series in a change detection context," SPIE 2020, SPIE Conference on Image and Signal Processing for Remote Sensing XXVI, Virtual Meeting, 21-25 September 2020.



- ✓ L. Maggiolo, D. Solarna, G. Moser and S. B. Serpico, "Automatic area-based registration of optical and SAR images through generative adversarial networks and a correlation-type metric," IGARSS 2020 - 2020 IEEE International Geoscience and Remote Sensing Symposium, Waikoloa, Hawaii, USA, 2020, DOI: 10.1109/IGARSS39084.2020.9323235.
- ✓ I. Podsiadlo, C. Paris, L. Bruzzone, "An Approach Based on Low Resolution Land-Cover-Maps and Domain Adaptation to Define Representative Training Sets at Large Scale," IEEE 2021 Int. Geoscience and Remote Sensing Symposium, (IGARSS '21), Brussels, Belgium - Virtual Meeting, 12-16 July 2021.
- ✓ B. Pinel-Puyssegur, L. Maggiolo, M. Roux, N. Gasnier, D. Solarna, G. Moser, S. B. Serpico, F. Tupin, "Experimental comparison of registration methods for multisensor SAR-optical data," IEEE 2021 Int. Geoscience and Remote Sensing Symposium, (IGARSS '21), Brussels, Belgium - Virtual Meeting, 12-16 July 2021.
- ✓ D. Marzi, P. Gamba, "Wide-scale Water Bodies Mapping Using Multi-temporal Sentinel-1 SAR Data", IEEE 2021 Int. Geoscience and Remote Sensing Symposium, (IGARSS '21), Brussels, Belgium - Virtual Meeting, 12-16 July 2021.
- ✓ A. Sorriso, D. Marzi, P. Gamba, "A General Land Cover Classification Framework for Sentinel-1 SAR Data." in Proc. of the 2021 IEEE 6th International Forum on Research and Technology for Society and Industry (RTSI), Napoli, Sept. 2021.