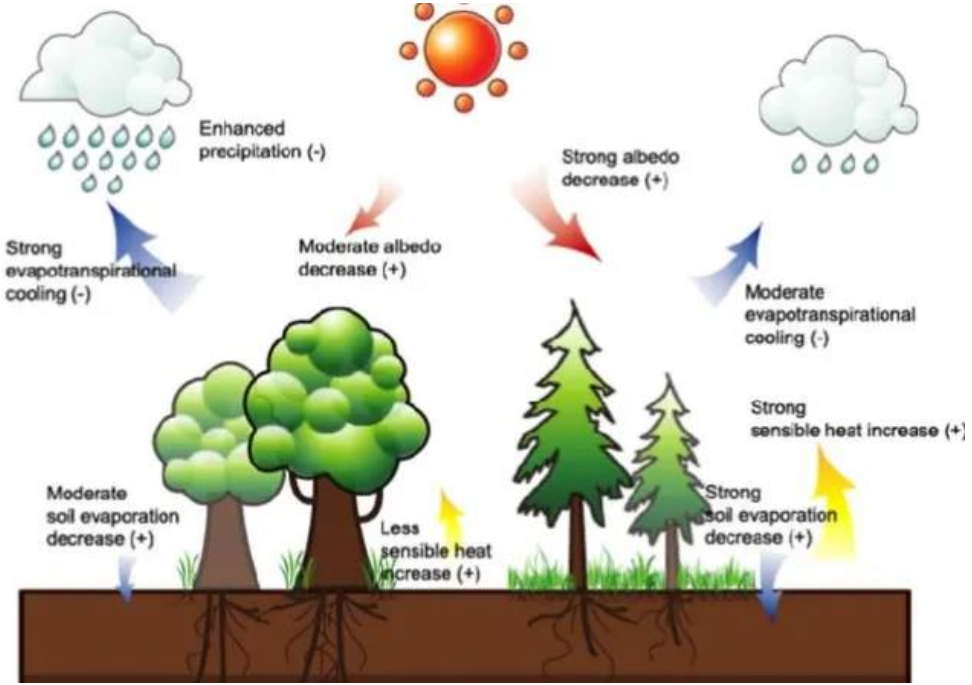
CMUG Phase 2
Role of vegetation on hydrometeorological processes

Daniele Peano (CMCC), Deborah Hemming & Rob King (MO)

CMUG Integration Meeting, Frascati, 25 October 2022

Hydrometeorological processes regulate the exchange of water and energy between the land surface and atmosphere influencing surface conditions and feedbacks



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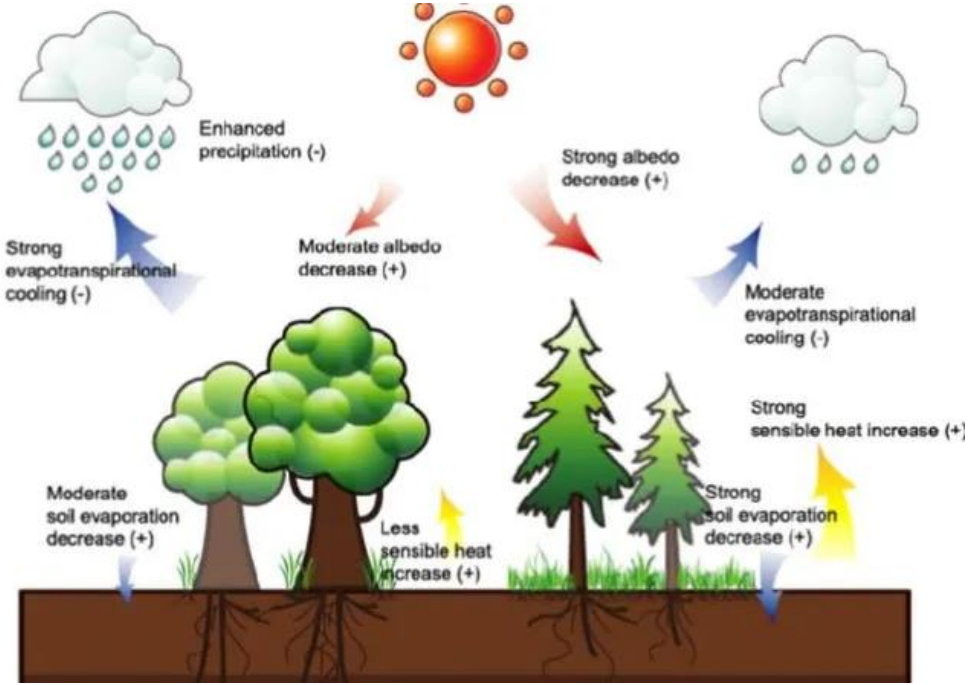

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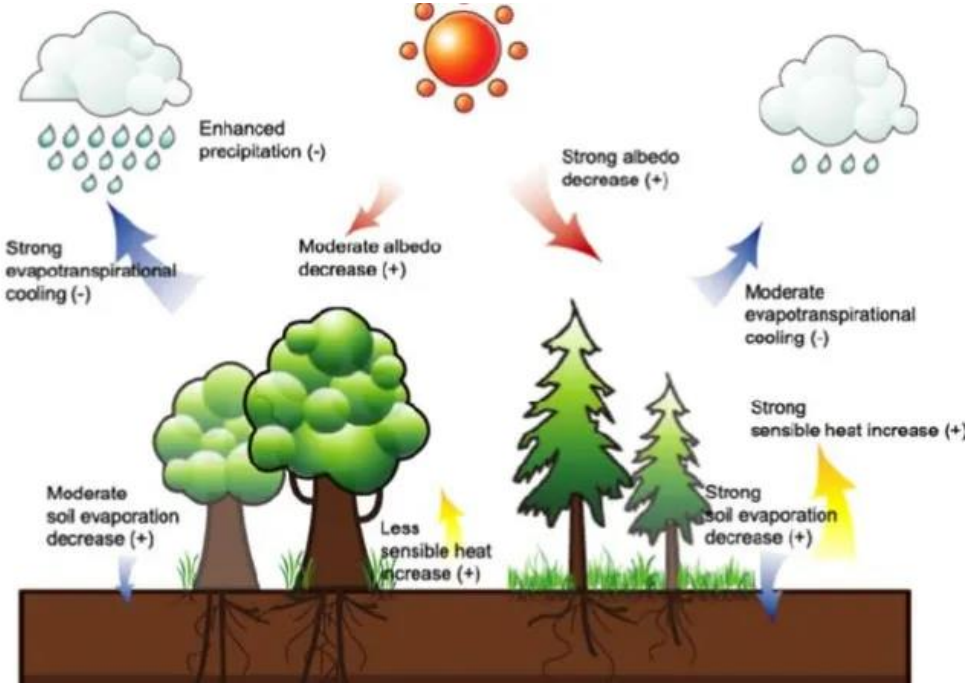
For this reason, it is important to understand these relationships and sensitivities, and how they vary across biomes and spatio-temporal scales.



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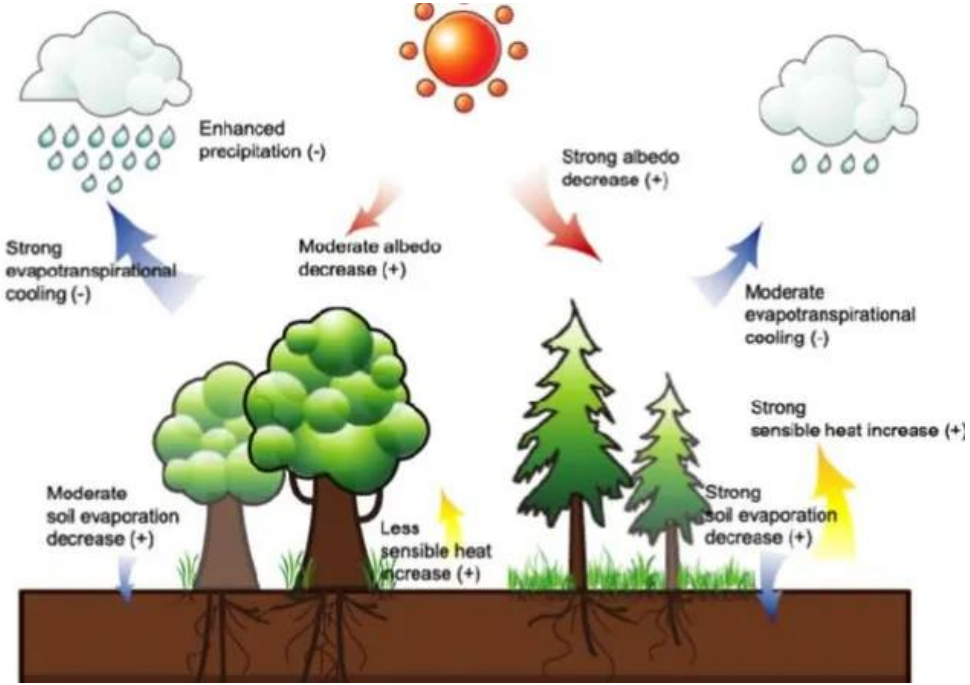
The use of observed essential climate variables (ECVs) allow to assess:

- Spatio-temporal relationships;
- Sensitivity between vegetation and hydrometeorology processes.



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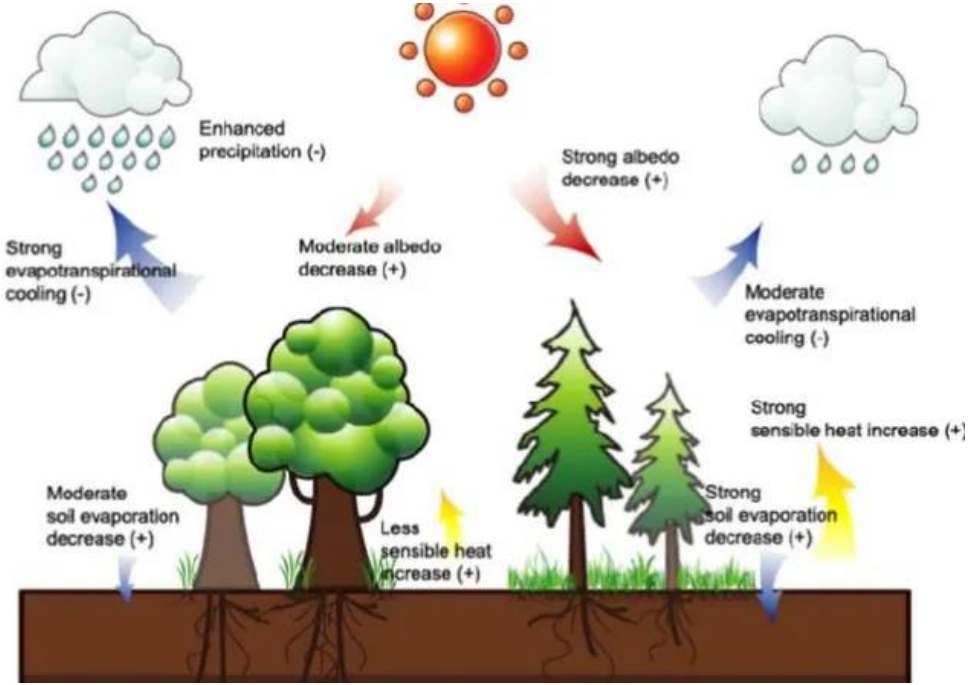
The use of observed essential climate variables (ECVs) allow to assess:

- Spatio-temporal relationships;
- Sensitivity between vegetation and hydrometeorology processes.

Focusing on specific scientific questions:

- How does vegetation influence spatio-temporal exchanges of water and energy between the land surface and atmosphere?
- Which locations and biomes exert a strong influence on these exchanges?



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CMUG Phase 2 – Role of vegetation on hydrometeorological processes

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The proposed analysis will use various ECVs datasets to represent Vegetation

Land cover and seasonality

Above ground biomass

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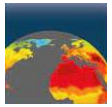
The proposed analysis will use various ECVs datasets to represent Vegetation, Soil



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Near-surface and root zone soil moisture

Land cover and seasonality

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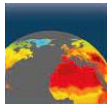

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Total Column Water vapour

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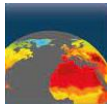

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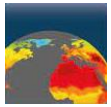

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ESMValTool
Earth System Model Evaluation Tool

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Task 1

Task 2

CMUG Phase 2 – Role of vegetation on hydrometeorological processes

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Task 1

- Identify a set of indicators to characterize spatio-temporal variations in vegetation and hydrometeorological using relevant ECV data;
- Prepare data, such as collate ECVs and other relevant datasets (e.g.,reanalysis, Fluxnet, and models), and harmonise these data to enable comparison.
- Calculate the set of indicators using the harmonized datasets

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- Calculate the set of indicators using the harmonized datasets

Task 2

- Analyse statistical relationships between vegetation and hydrometeorological indicators, using time series analyses and spatial analyses;
- Identify regions, biomes and time periods (seasonal) where vegetation has a positive and negative influence on the surface water budget. Show where and when vegetation exerts the largest influences on hydrometeorological processes.
- Submit a paper on key relationships and sensitivities between vegetation (different biomes, locations and seasonal timing) and hydrometeorological conditions and processes.

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For example previous literature focused on:

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Adv. Geosci., 17, 105–110, 2009
www.adv-geosci.net/17/105/2009/

Advances in Geosciences

Hydrometeorological and vegetation indices for the drought monitoring system in Tuscany Region, Italy

F. Caparrini[1,2] and F. Manzella[1]

[1]Centro Funzionale Regione Toscana, Pisa, Italy
[2]Eumechanos, Firenze, Italy

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Geophysical Research Letters

RESEARCH LETTER
10.1029/2021GL092856

Key Points:

- Vertically resolved soil moisture (SM) improves the understanding of large-scale vegetation productivity and yields extended water-related controls

Revisiting Global Vegetation Controls Using Multi-Layer Soil Moisture

Wantong Li[1], Mirco Migliavacca[1], Matthias Forkel[2], Sophia Walther[1], Markus Reichstein[1], and René Orth[1]

[1]Department of Biogeochemical Integration, Max Planck Institute for Biogeochemistry, Jena, Germany, [2]Technische Universität Dresden, Institute of Photogrammetry and Remote Sensing, Dresden, Germany

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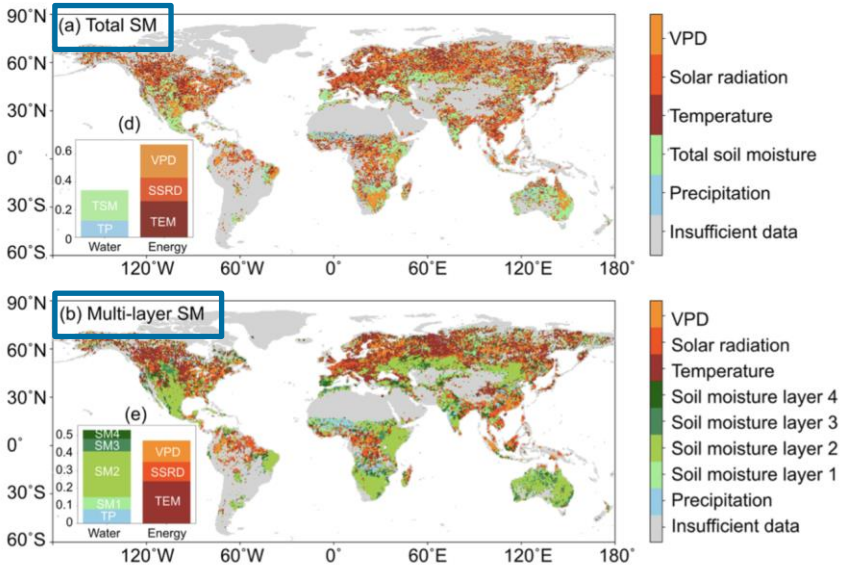

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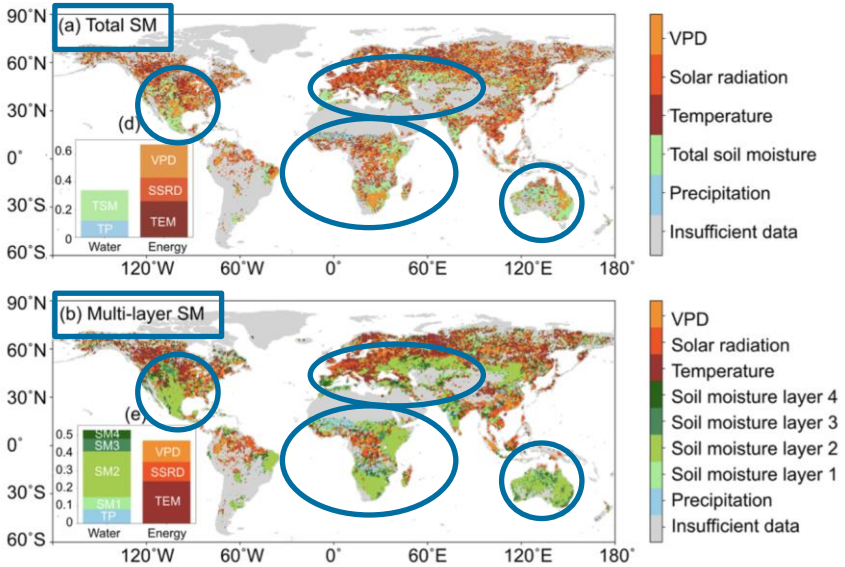

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Snowmelt Events in Autumn Can Reduce or Cancel the Soil Warming Effect of Snow–Vegetation Interactions in the Arctic

MATHIEU BARRERE

Centre d'Études Nordiques, and Department of Geography, and Takuvik Joint International Laboratory, Université Laval, Québec City, Québec, Canada, and University of Grenoble Alpes–CNRS–IRD, IGE, Grenoble, France

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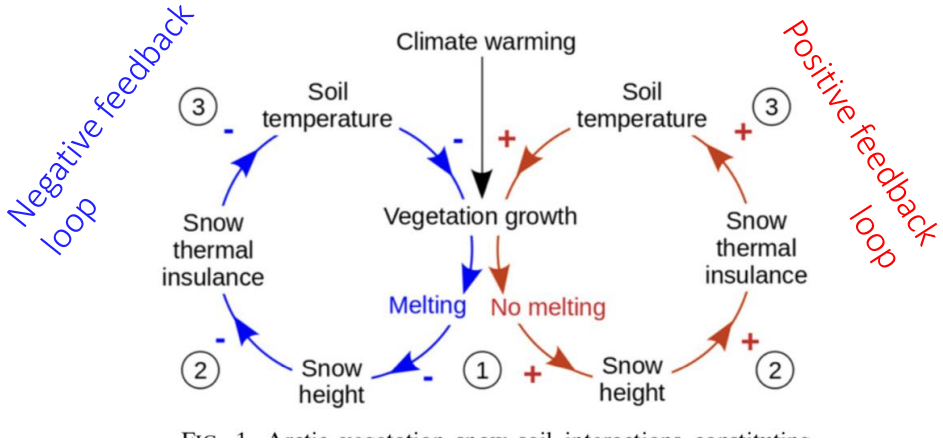

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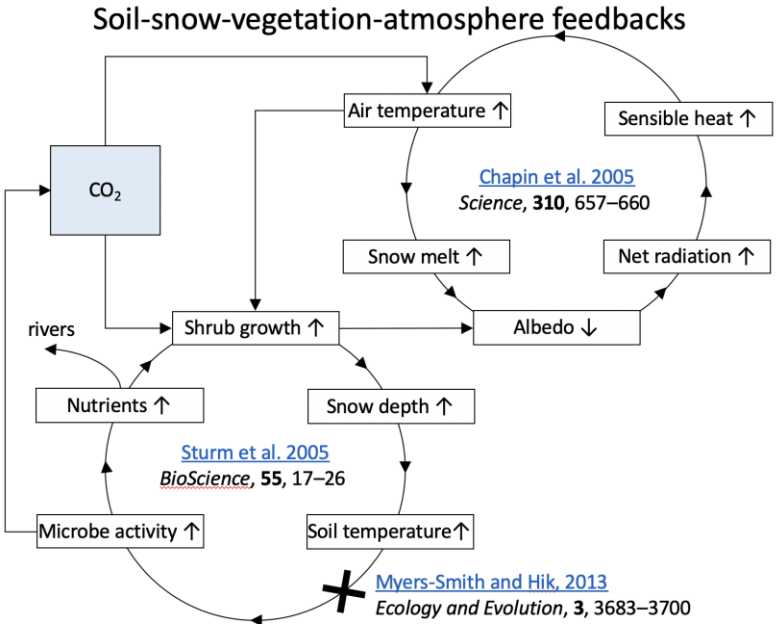

Courtesy of R. Essery

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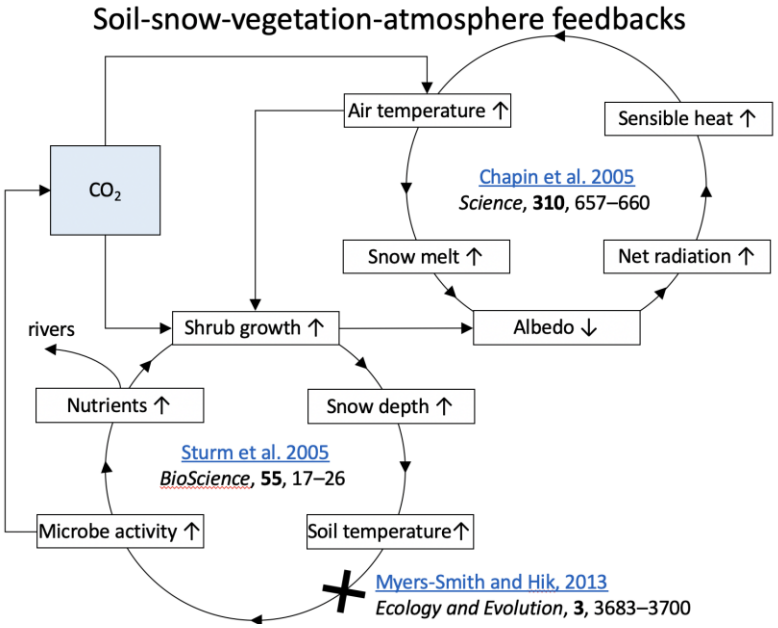
- Influence of snow melting season on soil moisture and land surface temperature in vegetated regions;



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CMUG Phase 2 – Role of vegetation on hydrometeorological processes

Deborah Hemming & Rob King (MO), Daniele Peano (CMCC)

EXTRA

CMUG Phase 2 – Role of vegetation on hydrometeorological processes

Deborah Hemming & Rob King (MO), Daniele Peano (CMCC)

CCI ECVs and other datasets	Data availability and updates
CCI Soil moisture	Near-surface soil moisture 1978 to 2020 (ESACCI-SOILMOISTURE-L3S-SSMV-COMBINED-*-fv06.1) data available on CEDA; v4.2 of CCI already implemented into ESMValTool – will be updated to version v6.1 on ESMValTool within 1st year of CMUG 2022-25 work. Root zone soil moisture product – available autumn 2022.
CCI Land cover	Land cover (ESACCI-BIOMASS-L4-AGB-MERGED-100m -2018-fv3.0) data available on CEDA; v1.6 of CCI already implemented into ESMValTool – will be updated to v2.0.7 on ESMValTool within 1st year of CMUG 2022-25 work. Land surface seasonality product.
CCI Land surface temperature	Land Surface Temperature 2003 to 2014 (Aqua) (ESACCI-LST-L3C-LST_MODISA-0.01deg_1MONTHLY_*-fv3.00) data already available on ESMValTool. Daily data is also available
CCI Biomass	Above-Ground Biomass for one of the periods, 2010, 2017 or 2018 (ESACCI-BIOMASS-L4-AGB-MERGED-100m -2018-fv3.0) data available on CEDA …also 2019 and 2020 available from CCI Biomass team.
CCI Snow	Snow water equivalent (esacci.SNOW.day.L3C.SWE.multi-sensor.multi-platform.MERGED.2-0.r1) data available via Climate Data Dashboard. Snow cover fraction – snow on ground (esacci.SNOW.day.L3C.SWE.multi-sensor.multi-platform.MERGED.2-0.r1) data available via Climate Data Dashboard; (esacci.SNOW.day.L3C.SCFG.MODIS.Terra.MODIS_TERRA.2-0.r1) data available via Climate Data Dashboard.
CCI Water vapour	Total column water vapour daily and/or monthly means from 2002 to 2017 (ESACCI-WATERVAPOUR-L3S-TCWV-*-fv3.1) data already implemented on ESMValTool.
CMIP6 model ensemble	CMIP6 (inc. LUMIP, LS3MIP) data available on ESMValTool Also available via CEDA - https://help.ceda.ac.uk/article/4801-cmip6-data
ERA5-Land reanalyses	ERA5-Land data - https://www.ecmwf.int/en/era5-land Including air temperature, Precipitation, runoff.

➢CCI Land Cover: preliminary interaction

- LC monthly mean data already available from 1992-2015 v1.6 on ESMValTool. More recent version covers 1992-2020, available on CEDA (2021 added in July 2023; 2022 added in April 2024).
- Moderate spatial resolution 150-1000m.
- 22 vegetation classes, supports conversion to Plant Functional Types used in CMIP6 models. Also PFT database for 2010 based on 14 PFTs.
- Version 2.0.7 Global Land Cover Maps available on CEDA and will be updated on ESMValTool in 1st year of CMUG 2022-25 work.
  - Use v1.6 if update to v2.0.7 not available in time for our analyses.
- The land surface seasonality products represent the average seasonal behaviour of the vegetation greenness, fire and snow cover.
- There are no gaps in the datasets (radar-based, so cloud cover is not an issue).
- 4 quality flags relating to processing, valid observations, changes.
- Regridding/re-sampling/sub-setting can be performed using "user tool 4.3" developed by CCI team.

- *Which CCI data sets are required for use in the study?*
- *Are all required data sets (CCI and external) expected to be available in time to perform the study?*
- *Are the CCI data sets technically suitable for the study? The meeting must demonstrate that the detailed characteristics and limitations of the EO data have been fully understood - e.g. differences between the geophysical meaning of the satellite product vs. the equivalent model variable, snapshot in time vs. daily average, clear sky or seasonal biases, horizontal/vertical/time resolution, gaps, stability, accuracy, etc.*
- *Risk analysis: e.g. What is the backup solution in case the CCI project fails to deliver on time?*

➢CCI Soil Moisture: preliminary interaction

- Data already available up to Dec 2021 for COMBINED product
- Root Zone product available from autumn 2022
  - Existing COMBINED product is sufficient if delay
- COMBINED product has better spatio-temporal coverage over the PASSIVE or ACTIVE only products
  - With slightly better agreement with in-situ obs
  - Coverage is better in later periods early 2000s
- Tropics have poor coverage due to dense vegetation
  - We will choose locations to study where coverage is available
- Rootzone product will allow consideration of deeper soil moisture levels from the model, not just top level
- Further discussions required to understand uncertainty propagation in SM product.
- Will engage with CCI team on horizontal regridding as this is likely the largest gridbox data we will be using.

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➢CCI Land Surface Temperature: preliminary interaction

- Use the MODIS Aqua product
  - This has daytime local overpass time of ~13:30 close to vegetation peak activity
  - Following up on best use of Day- and Night- time overpass data and how/if to combine
- Different sensors and their overpass times will 'bias' differently to model outputs
  - Keep consistent sensor, so this restricts years to 2003 onwards
- Uncertainty propagation is well supported by documentation and ESMValTool has a work on this
  - CCI team releasing a regridding tool supporting this in autumn 2022
- Daily and Monthly versions available
  - Gaps in daily data will need to be mitigated
  - Possible use of MW sensor product could help, although this has a stability issue around sensor changes.

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➢CCI Biomass: preliminary interaction

- Global forest above ground biomass density (AGBD) for 2018, 2019 and 2020 are all available from CCI-Biomass.
- No gaps in the datasets (radar-based, cloud cover not an issue).
- Current investigation on AGBD variations between years and if estimates across years should be averaged.
- AGBD data would come with an estimated precision for each grid-cell which would take account of spatial correlation.
  - The effect of AGBD errors, i.e., their propagation, depends on what is done with these data so needs dialogue with CCI team.
- Bias in the AGBD estimates is problematic.
  - CCI Biomass use methods to estimate the bias but current methods to remove it are not optimal, and this would be a good area to discuss further.
- Regridding to coarser resolution could be done by CCI Biomass
  - If regridding to a coarser resolution than the CCI AGBD estimates then the spatial correlation of the errors needs to be accounted for. These are estimated within CCI but are not supplied with the CEDA data so it would be better if the regridding was performed by the CCI team.

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➢CCI Snow: preliminary interaction

- Use of Snow Water Equivalent (SWE) and Snow Cover Fraction (SCF).
- Version 2 is already available, while version 3 is under preparation:
  - SWE covers 1979-2020 at 12.5 km;
  - AVHRR-derived SCF v2 1982-2018 (5 km)
  - MODIS-derived SCF v2 2000-2020 (1 km)
- SWE has not limitation due to cloud cover, but is not available in mountainous regions (i.e. topography std > 200m)
  - Some techniques have been applied to interpolate over mountainous areas, but only about 50% can be recovered, possible further discussion with CCI team
- SCF is derived from optical instrument and is affected by cloudiness
  - Some techniques have been applied to fill the cloud-gaps, possible further discussion with CCI team
- Previous work on CMIP6 has been performed using 0.1deg SWE monthly data.
- SWE regridding is straightforward, SCF regridding is more tricky.
- SWE and SCF uncertainties are available, but it has not yet been incorporated in any model evaluation study.

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➢CCI Water Vapour: preliminary interaction

- Use of Total Column Water Vapour (TCWV)
- Actual version covers the period 2002-2017, WV_cci phase 2 just started and will cover 2002-2023 over land and 2002-2020 globally (second half 2024)
- Over land data are:
  - Observation around 10:30;
  - Clear sky data, consequently containing gaps in daily data;
  - Use of this data, to maintain temporal stability, data limited to March 2016
  - 1km resolution
- Over ocean data are:
  - Retrieved at different time of day and night;
  - All sky data;
  - 15-25km resolution
- Uncertainties (such as std, mean uncertainty, mean squared uncertainty) are provided and can be propagated.
- Comparison between models and observation requires taking into account the effect of clouds
  - Further discussion with CCI team is required.

- *Which CCI data sets are required for use in the study?*
- *Are all required data sets (CCI and external) expected to be available in time to perform the study?*
- *Are the CCI data sets technically suitable for the study? The meeting must demonstrate that the detailed characteristics and limitations of the EO data have been fully understood - e.g. differences between the geophysical meaning of the satellite product vs. the equivalent model variable, snapshot in time vs. daily average, clear sky or seasonal biases, horizontal/vertical/time resolution, gaps, stability, accuracy, etc.*
- *Risk analysis: e.g. What is the backup solution in case the CCI project fails to deliver on time?*