CONFESS (CONsistent representation of temporal variations of boundary Forcings in Earth System)

Towards observation-constrained representation of land cover and vegetation/hydrology processes in CONFESS

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www.confess-h2020.eu

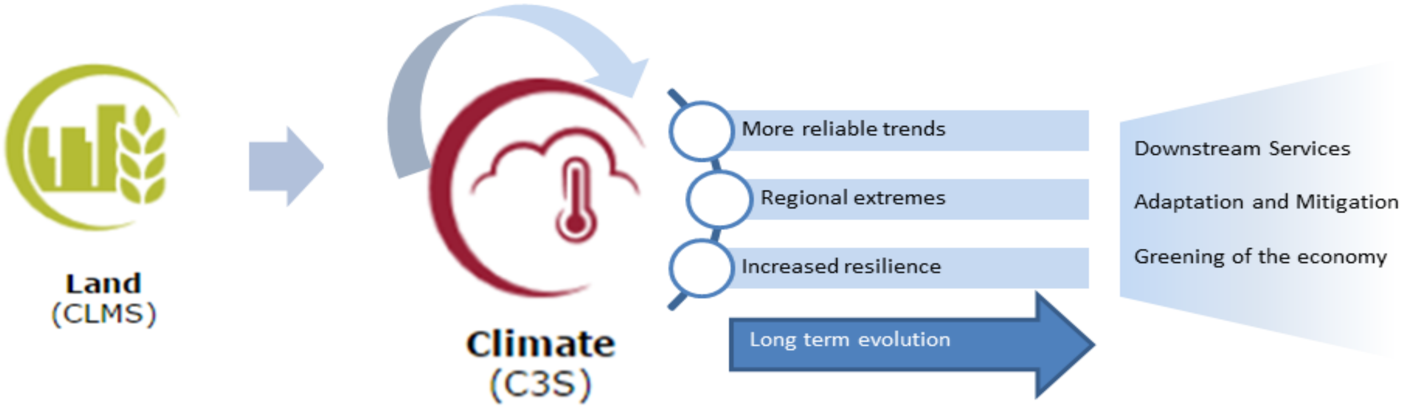
H2020-LC-SPACE-18-EO-2020
Project Start: 1 November 2020

Outline

- CONFESS overview and motivation
- Planned Land Cover, vegetation and hydrology development: land only mode (ERA5-land setup)
    - ➢ Obtain improved seasonal to decadal predictions
- Summary and Discussion - Q&A

CONFESS (CONsistent representation of temporal variations of boundary Forcings in Earth System)

One of the main objectives: integrate the unprecedented land cover/use & vegetation information from latest satellite campaigns (Copernicus) in the land surface models used for reanalysis and initialization of the seasonal to decadal prediction systems.



CONFESSION

Land Cover/Use and Vegetation in reanalysis and seasonal forecasts are represented by climatological values. Suboptimal.

OPPORTUNITY

New data records of Land Cover/Use/Vegetation delivered by Copernicus Services.
Advances in vegetation/ABL effecs from previous FP7 & H2020 projects.

EXPECTED IMPACT

Improved processes representation in land models (including reanalysis for consitent initialization) to enhance forecasting capabilities.

ECMWF ISAC METEO FRANCE BSC Barcelona Supercomputing Center Centro Nacional de Supercomputación

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Unprecedented Land cover & vegetation observations being provided by Copernicus Land Monitoring Sercvice

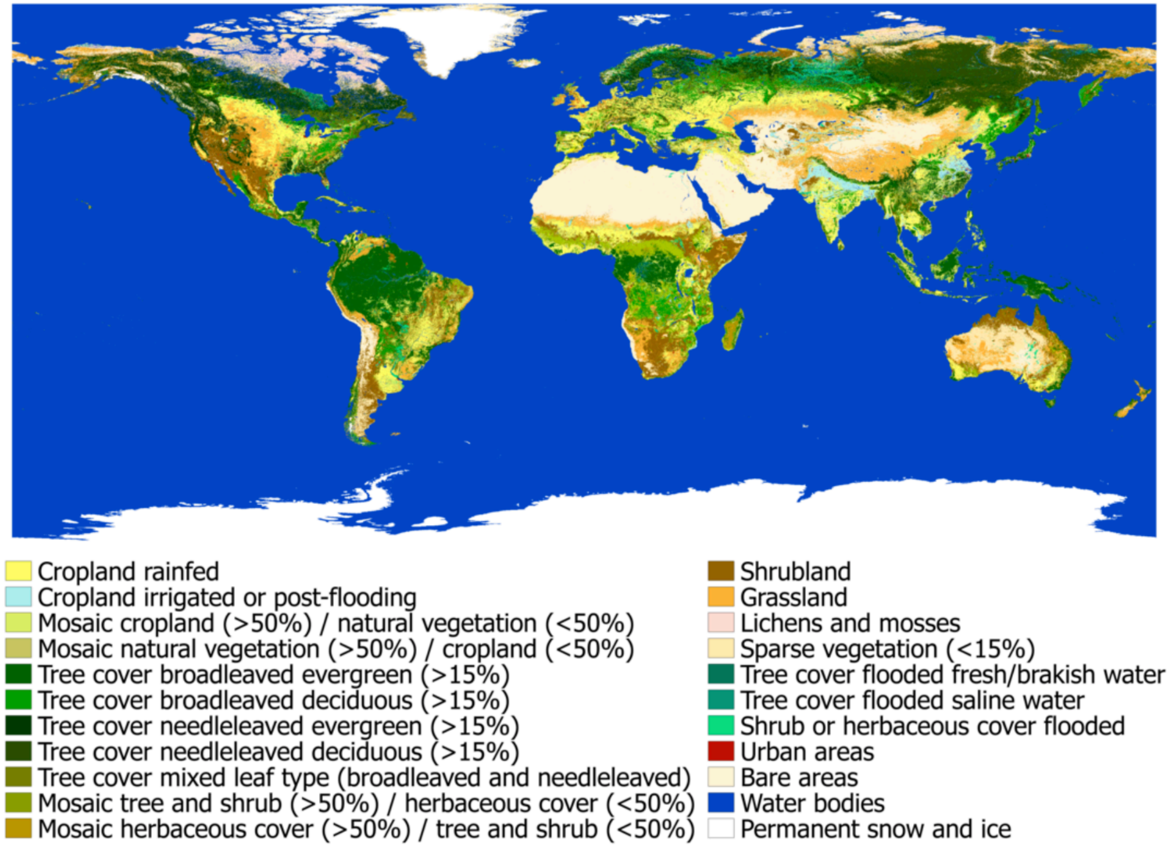
Unprecedented latest-generation Land-vegetation Satellite ECV are being delivered:

1) Land Cover (1993-present) from C3S based on ESA-CCI LC – yearly time resolution
2) Leaf Area Index (1993-present) from C3S based on CGLS LAI – 10-daily time resolution
3) Fraction of green Vegetation Cover (FCOVER; 1999-present) from CGLS – 10-daily time resolution

Latest Generation ESA-CCI Land Cover (1993-present) to replace static GLCC in HTESSEL

Latest Generation Land Cover (1993-present) in HTESSEL

Annual global land cover mapping at 300m from 1992 to present

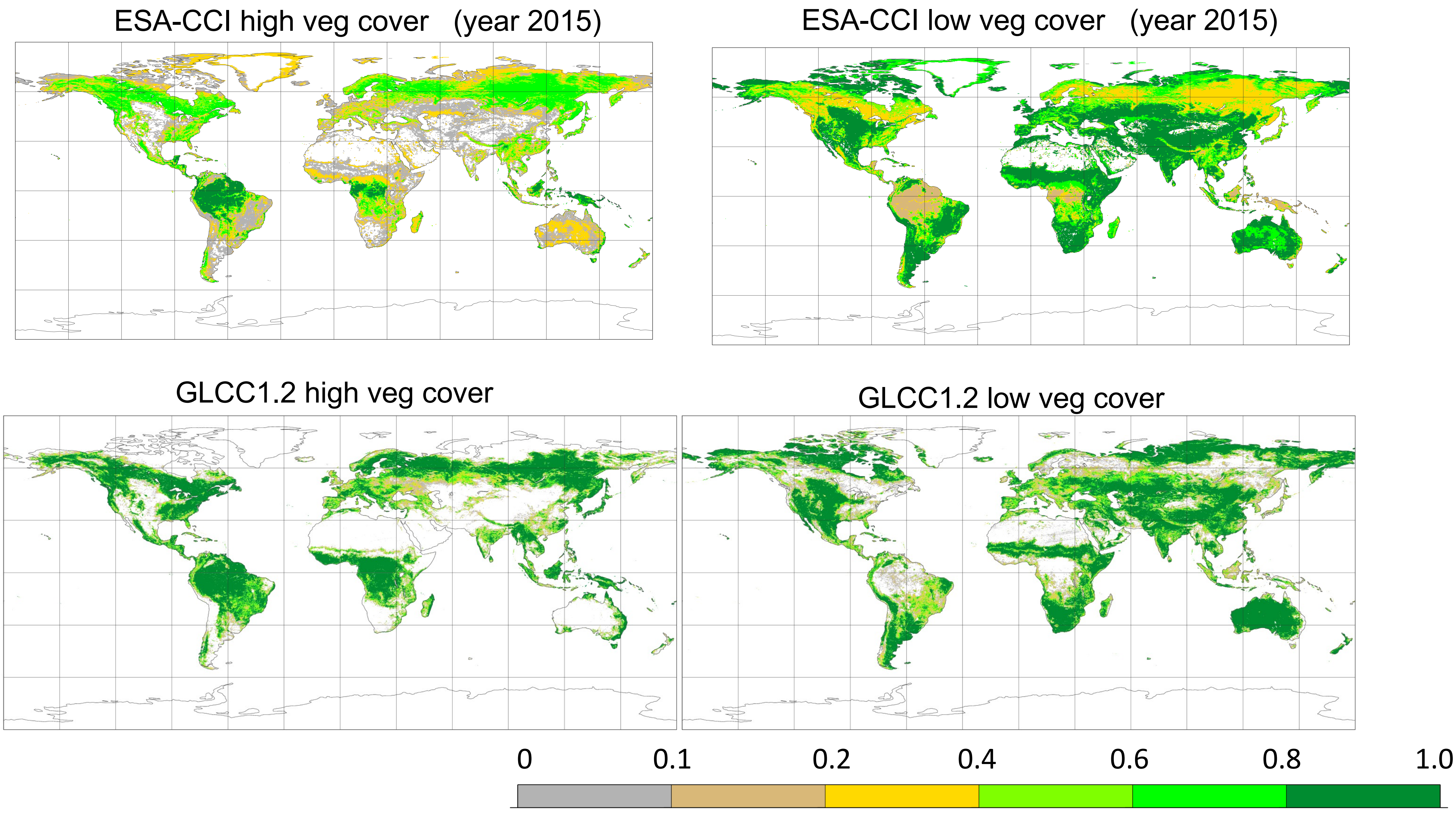


Static GLCC Land Cover (representing a snapshot in early 1990's) in HTESSEL is replaced with the latest generation CGLS/ESA-CCI yearly LC product (1993-present)

Work being done by ECMWF team (S. Boussetta et Al)

More details shown by Nils Wedi presentation yesterday

Latest Generation Land Cover (1993-present) in HTESSEL



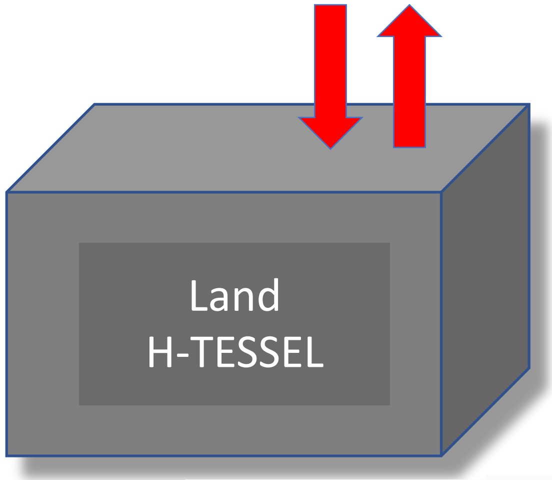
Observation-constrained representation of effective vegetation cover

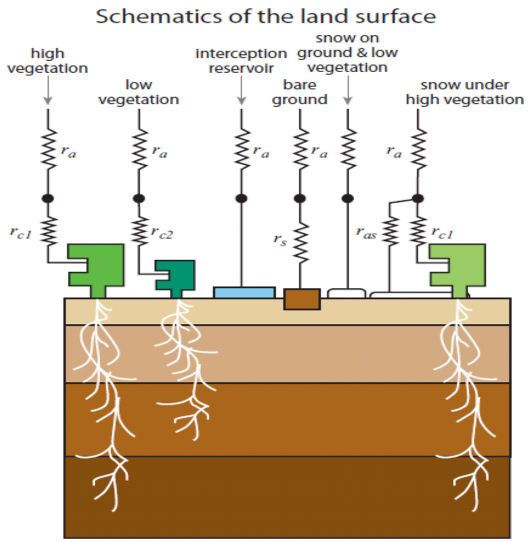
Land surface coupling in EC-Earth

Coupling biophysics

IFS

Climate
radiation, temperature, precip,…





Vegetation effective cover affects coupling parameters:

- -roughness length,
- -albedo,
- -field capacity,
- -evapotranspiration resistance

rc Canopy resistance to transpiration

$$r_c(LAI) = \frac{r_{s,\min}}{LAI} f_1(Rs) \cdot f_2(\bar{\omega}) \cdot f_3(D_a)$$

Rs downward shortwave radiation
ω soil moisture content
Da atmospheric water vapor deficit

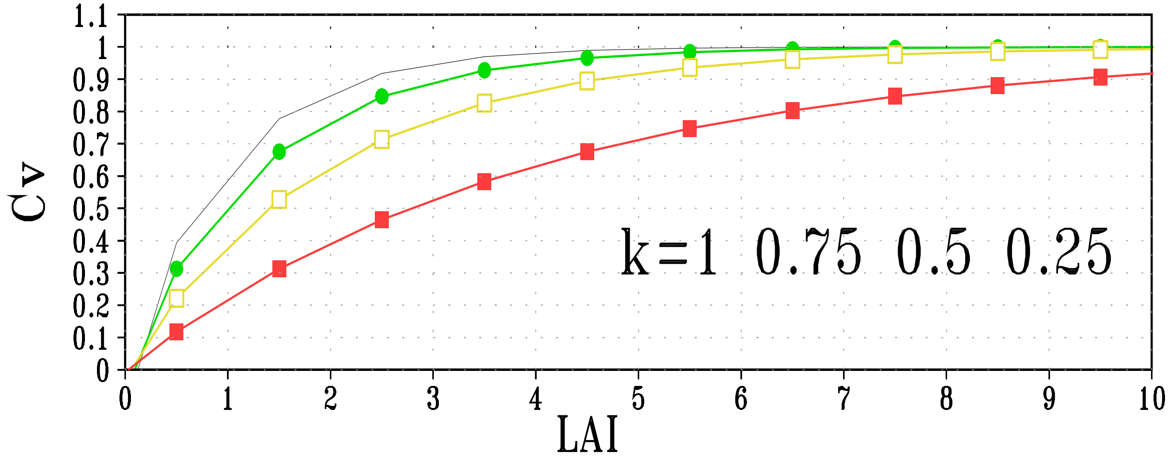
From Observations
or
LPJ-Guess

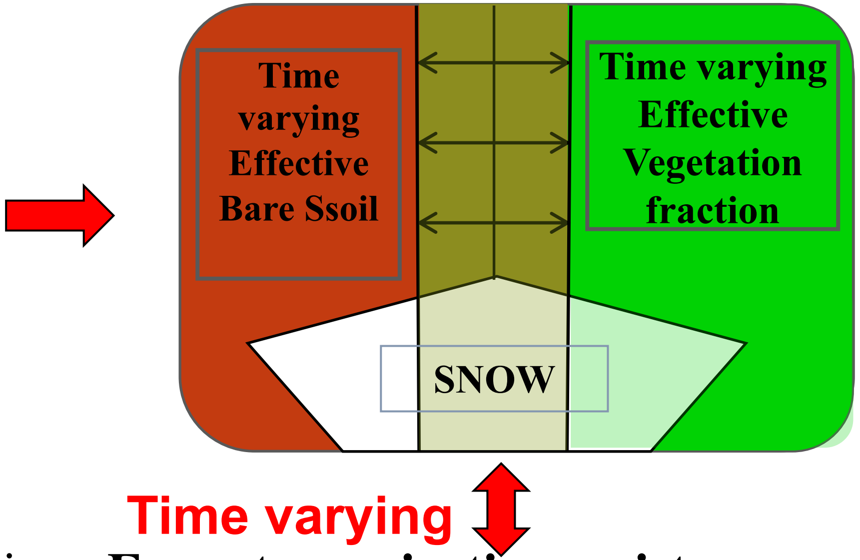
Vegetation
LAI (High/Low veg.)
Land cover (High/Low veg)

Alessandri et al 2017

Implementation of effective vegetation cover (Ceff) as a function of vegetation Leaf Area index

$$Ceff(t) = Cv_L(LAI[t]) \cdot A_L + Cv_H(LAI[t]) \cdot A_H$$





LAI and vegetation density (Cv) Time varying & interactively coupled

$$Cv_{L,H}(t) = f(LAI_{L,H}) = (1 - e^{-K_{L,H} \cdot LAI_{L,H}})$$

$_{L,H}$ low, high vegetation

A_L, A_H *Max fractional Land Cover*

C_L, C_H Vegetation density

$k_{L,H} = 0.5$

i. **Evapotranspirating resistance**

ii. **Roughness length**

iii. The contribution of root density of each vegetation-type to the **Field Capacity**

iv. Surface **Albedo**

Alessandri et al 2017

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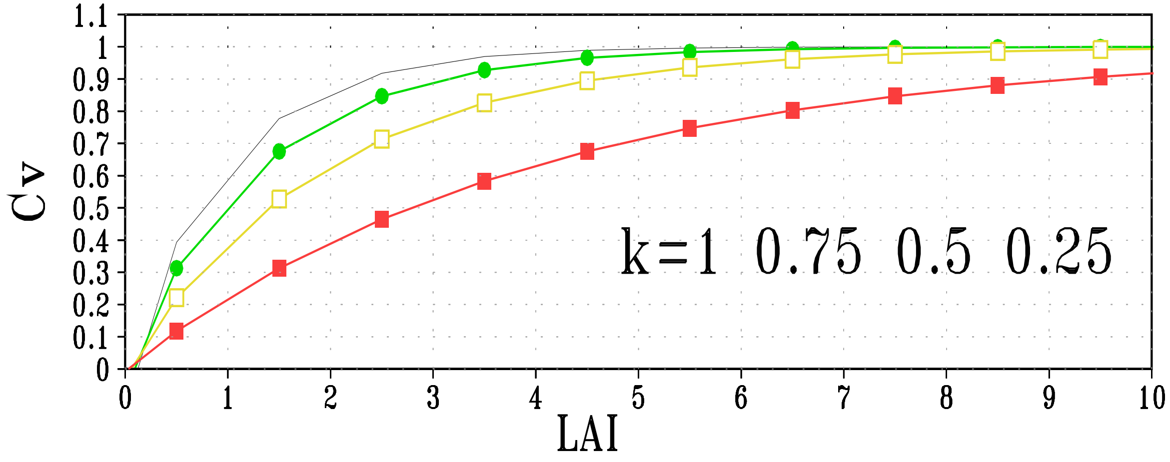

LAI and vegetation density (Cv) Time varying & interactively coupled

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C_L, C_H Vegetation density

In CONFESS we'll estimate $\boldsymbol{K_{L,H}}$ for each of the vegetation types in the land model (ESA-CCI land cover) using inverse modelling and based on available **FCOVER** observational data from **Copernicus**:

$$K_{H.L} = f\left(D_{H,L}\right) = \text{minimization problem}$$

$$D_{H,L} = \textit{dominant vegetation type}$$

for High and Low vegetation

The effective vegetation cover directly relates to the modelled water uptake by vegetation's roots using the **Memory method** for root zone parameterization.

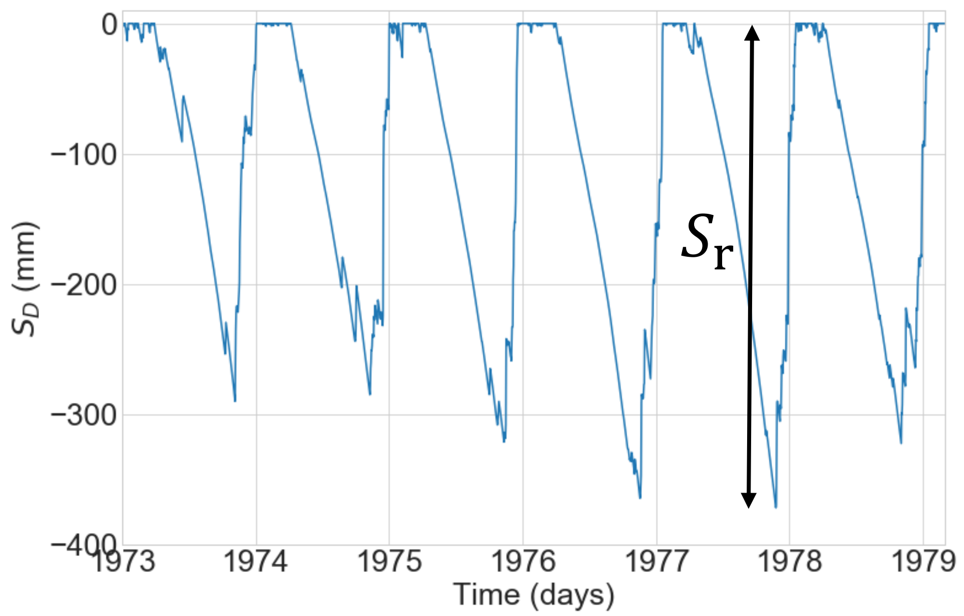
Climate controlled root zone parameterization

F. van Oorschot (PhD Udelft) see her presentation later

"Memory method" to size Root zone storage capacity

Root zone storage capacity $\boldsymbol{S_r}$

- Maximum subsurface water volume that is accessible to roots → includes both root depth and vertical and lateral root density
- Vegetation develops its S_r in a way to try avoiding water shortages
- Climate controlled approach: S_r estimated on river catchment scale based on the max cumulative water storage deficits (S_D) of which vegetation keeps memory.

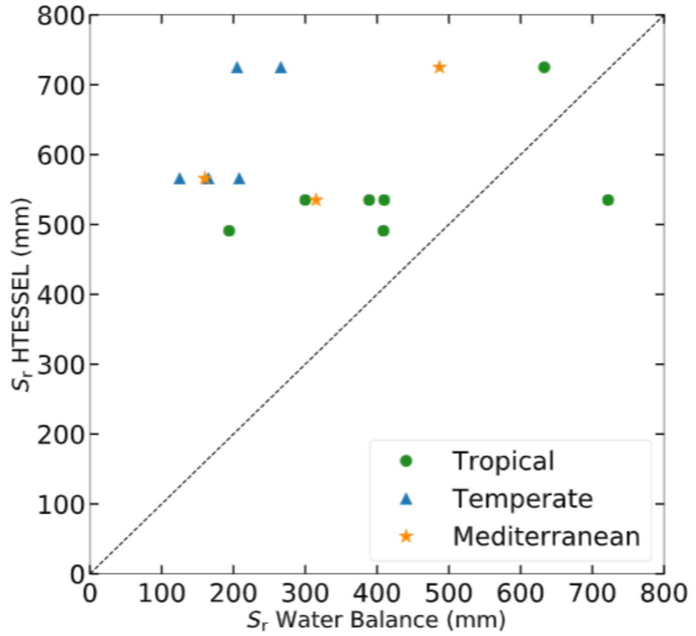


$$S_D = \int P - E_t \, dt$$

$$S_r = \max(S_D)$$

Return periods to account for non-survival of vegetation

S_r in Australian river catchments



De Boer-Euser et al. (2016), Nijzink et al. (2016) and Wang-Erlandsson et al. (2016)

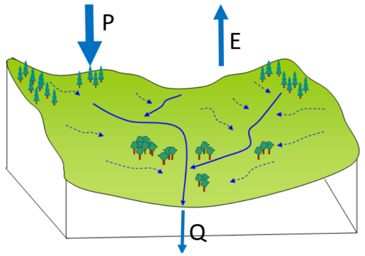
See next presentation by F. van Oorschot (PhD Udelft)

Hydrological reference data for modelling and verification

Precipitation data from reanalysis (ERA-5; GSWP-3)

Evaporation and discharge data

- Discharge observations (Global Runoff Data Centre)
  - Reliable station observations of river discharge from a catchment (daily or monthly timescales)
- Water balances
  - Analyses of the closure of long term water balances at catchment scales
    (0 = P – E – Q)



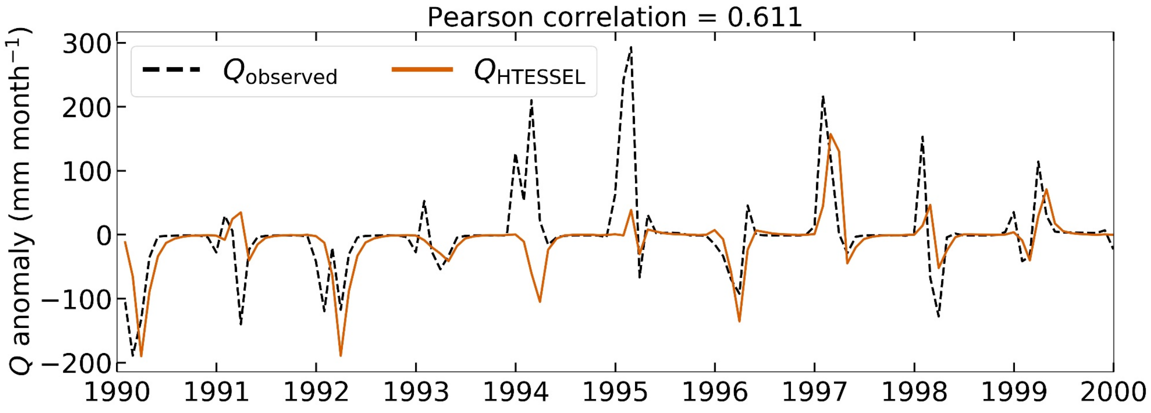
- FLUXNET towers
  - Point scale energy fluxes based on eddy-covariance tower measurements as a reference for single grid cell analyses (Pastorello et al., 2020)
- FLUXCOM energy fluxes (Jung et al., 2019)
  - Latent and sensible heat fluxes based on machine learning algorithms using FLUXNET towers, satellite observations and meteorological data
  - Monthly time scales
  - 0.5 x 0.5 degree resolution

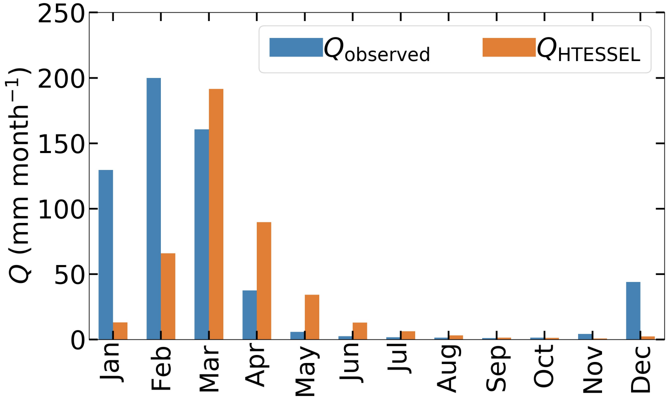
References
Global Runoff Data Centre, River Discharge Data, https://www.bafg.de/GRDC/EN/02_srvcs/21_tmsrs/riverdischarge_node.html
Pastorello, G., Trotta, C., Canfora, E. *et al.* The FLUXNET2015 dataset and the ONEFlux processing pipeline for eddy covariance data. *Sci Data* **7,** 225 (2020). https://doi.org/10.1038/s41597-020-0534-3
Jung, M., Koirala, S., Weber, U., Ichii, K., Gans, F., Camps-Valls, G., Papale, D., Schwalm, C., Tramontana, G., Reichstein, M. (2019). The FLUXCOM ensemble of global land-atmosphere energy fluxes. Scientific Data, 6: 74. doi:10.1038/s41597-019-0076-8.

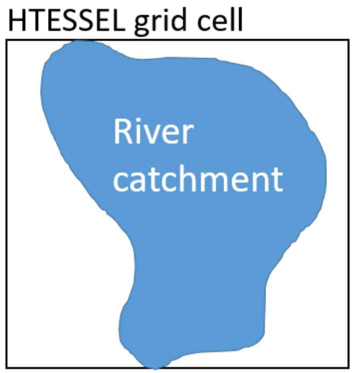
Discharge and Evapotranspiration analysis

HTESSEL performance

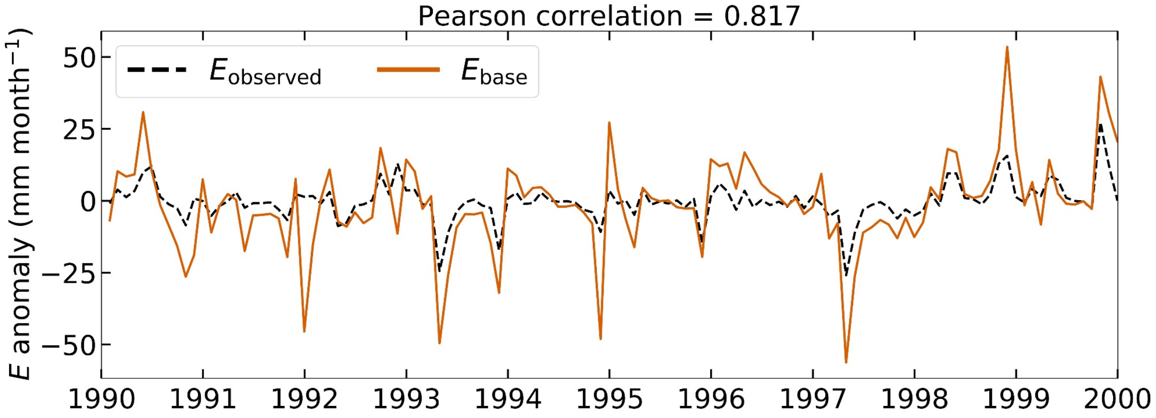
*Discharge in a **tropical** river catchment in Australia*

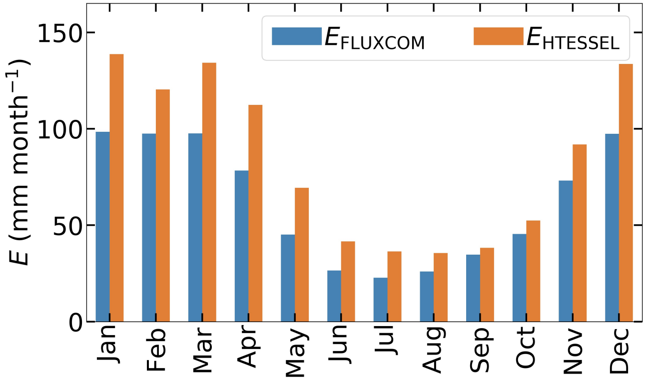






*Evaporation in a **tropical** river catchment in Australia*





See next presentation by F. van Oorschot (PhD Udelft)

Summary and Discussion

- CONFESS will exploit the latest-generation Land-vegetation Satellite ECV from Copernicus to obtain better-constrained representation of land cover and effective vegetation/hydrology processes in HTESSEL-LPJGuess
- Developments will be first tested in land only (ERA5-land setup) that will deliver an improved set of ICs.
- Then an improved set of hindcasts will be performed:
  - at seasonal time-scale with ECMWF SEAS5
    [1993-2016, ≥4 months, 51 members, May and November starts]
  - at decadal time-scale with EC-Earth3/4
    [*1993-2016, ≥5 years, 10 members, 1st November starts*]
- How the improved representation of land cover-vegetation translates into changes in seasonal to multi-annual forecast quality at a global and regional scale will be assessed.

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