CONFESS

Consistent representation of temporal variations of boundary forcings in reanalyses and seasonal forecasts

Task 1.2: Implementation in HTESSEL/SURFEX to assess interannual variability

CONFESS 1st General Assembly

Overview of activities

- ✓ Land cover/Vegetation boundary conditions and atmospheric input prepared
- ✓ Optimization of the effective cover parameterization based on Copernicus novel observational data
- ✓ Get ready for simulations
  - ➢ Set-up and configuration
  - ➢ Spin-up and CTRL simulation
- ✓ Decision and agreement about land model output (variable, frequency)

Land cover/Vegetation boundary conditions and atmospheric input prepared

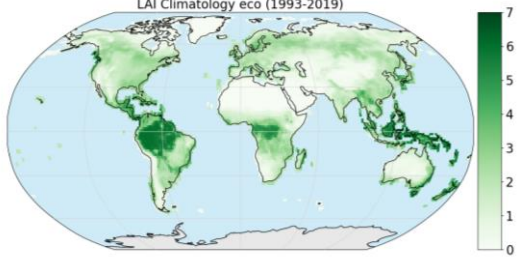
Set-up and configuration of boundary conditions for simulations

- ✓ Land cover (LC) and vegetation (LAI) boundary conditions prepared
  - ➢ From C3S/CGLS LC and LAI for HTESSEL & HTESSEL-LPJGuess (ECMWF)
  - ➢ From LUH2 Land cover and Ecoclimap LAI for SURFEX (MF)
- ✓ ERA5 hourly meteorological forcing at the land-atmosphere interface have been downloaded, interpolated and prepared separately by each partner.

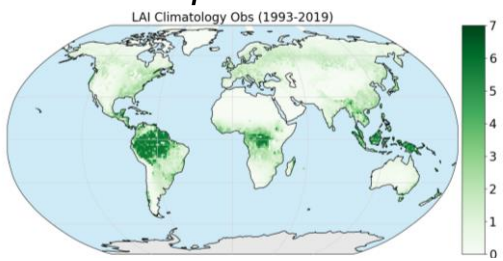
Comparison of novel Copernicus LAI vs. Ecoclimap climatology

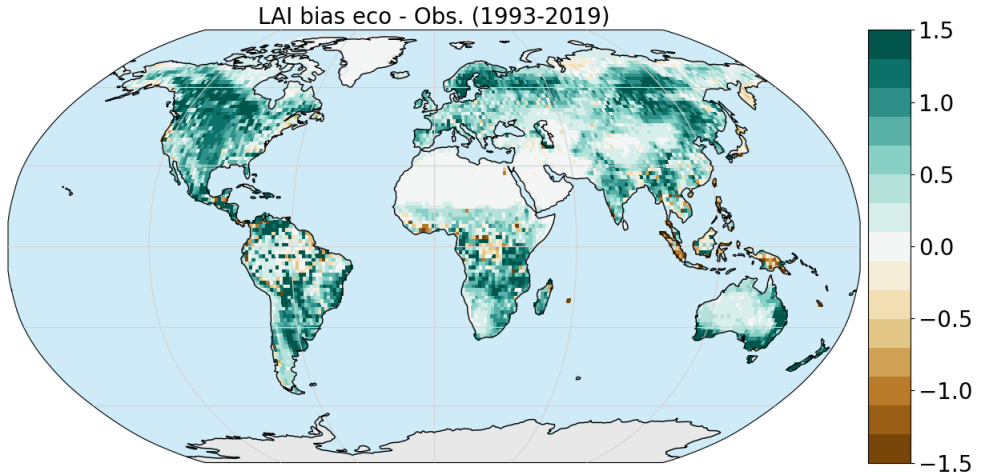
Mean LAI

Ecoclimap



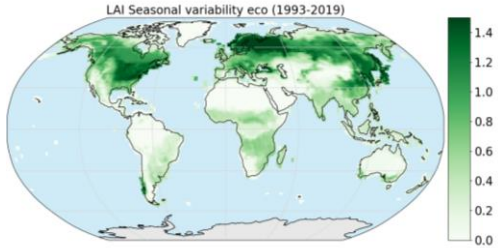
Copernicus



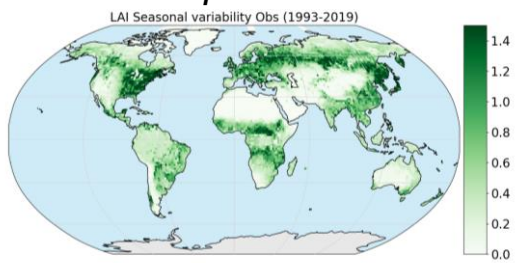


LAI standard deviation

Ecoclimap



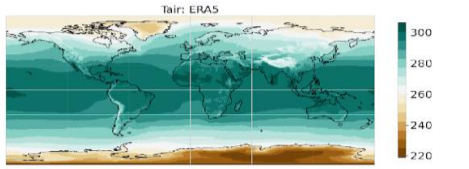
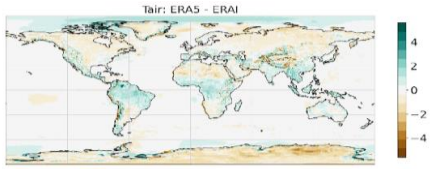
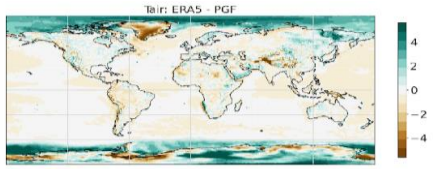
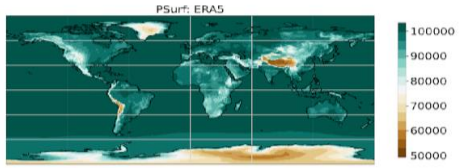
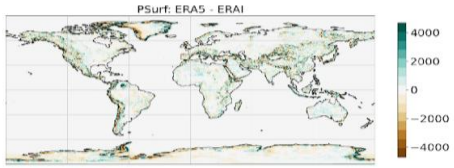
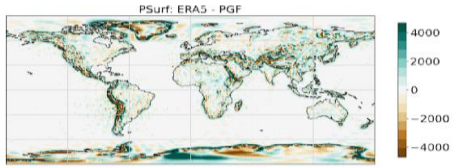
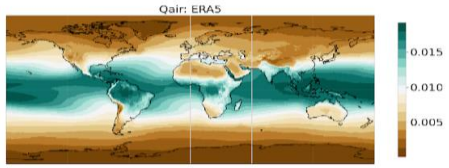
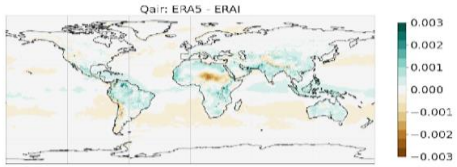
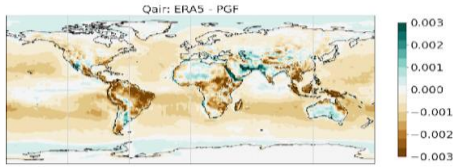
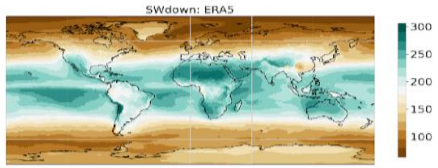
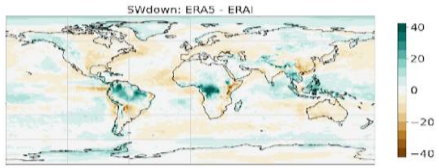
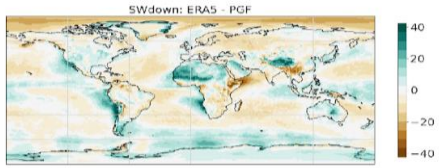
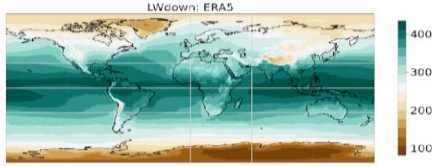
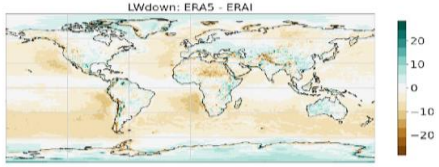
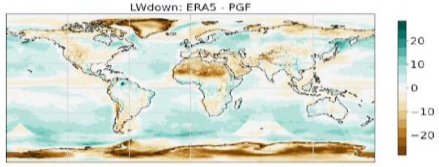
Copernicus



- Positive LAI bias over most of the globe
- LAI variance too strong in NH extratropics, too reduced over intertropics

ERA5 forcing uncertainty evaluation

Comparison with ERA-Interim and Princeton Global meteorological Forcing (PGF)

	ERA5	ERA5 - ERAI	ERA5 - PGF
T2m			
Surf. pressure			
Specific humidity			
SW downward radiation			
LW downward radiation			

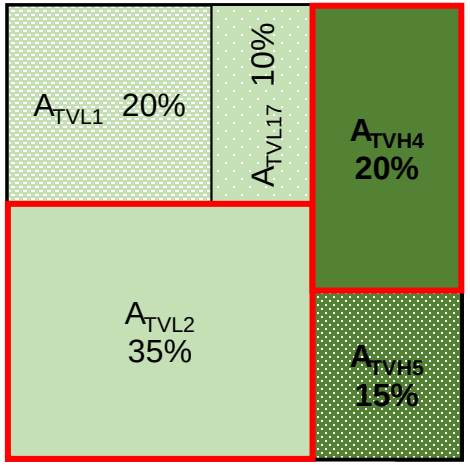
Annual mean climatology (1990-2000)

Optimization of the effective cover parameterization based on FCover and LAI and consistent with ESA-CCI Land Cover (ISAC-CNR)

Land Cover/Vegetation representation in HTESSEL

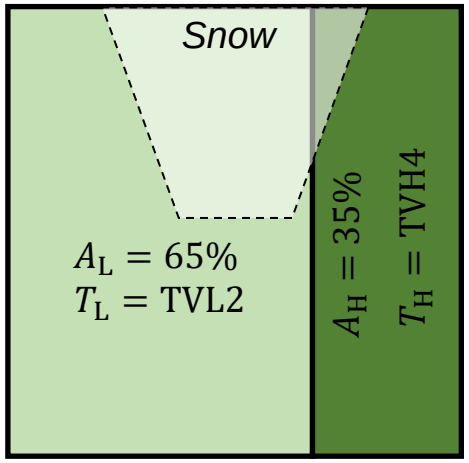
Index	Vegetation type	H/L	$Cv_{L/H}$
TVL1	Crops, mixed farming	L	0.90
TVL2	Short grass	L	0.85
TVH3	Evergreen needleleaf trees	H	0.90
TVH4	Deciduous needleleaf trees	H	0.90
TVH5	Deciduous broadleaf trees	H	0.90
TVH6	Evergreen broadleaf trees	H	0.99
TVL7	Tall grass	L	0.70
8	Desert	–	0
TVL9	Tundra	L	0.50
TVL10	Irrigated crops	L	0.90
TVL11	Semidesert	L	0.10
12	Ice caps and glaciers	–	–
TVL13	Bogs and marshes	L	0.60
14	Inland water	–	–
15	Ocean	–	–
TVL16	Evergreen shrubs	L	0.50
TVL17	Deciduous shrubs	L	0.50
TVH18	Mixed forest/woodland	H	0.90
TVH19	Interrupted forest	H	0.90
TVL20	Water and land mixtures	L	0.60

'Real' land cover

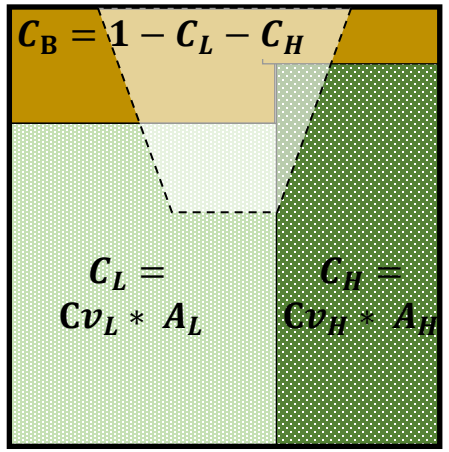


Only dominant high & low vegetation types

Model land cover



Effective vegetation cover



H = high vegetation
L = low vegetation

$A_{H,L}$ aggregated fraction of low/high vegetation
$T_{H,L}$ dominant low/high vegetation type

$Cv_{H,L}$ high/low vegetation density
$C_{H,L} = Cv_{L,H} * A_{L,H}$ effective low/high vegetation cover
$C_B = 1 - C_H - CL$ bare soil cover

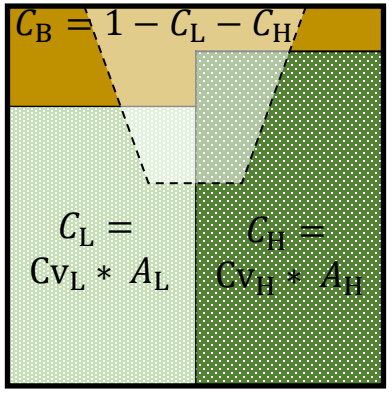
Effective vegetation cover affects:

- Evapotranspiration resistance
- Precipitation interception
- Roughness length
- Surface Albedo
- Effective root density

Cv_L, Cv_H → ??

Vegetation density Cv_L, Cv_H ?

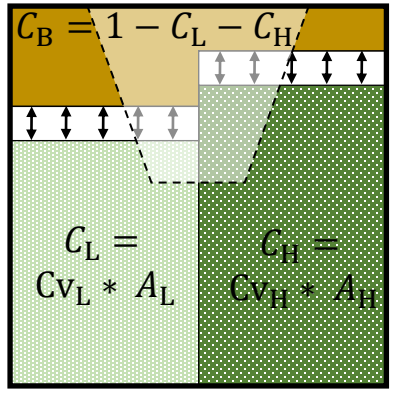
1. Fixed look-up table Cv_L, Cv_H parameters per vegetation type



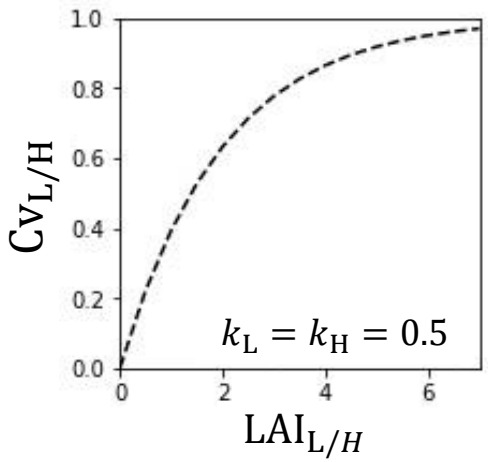
Index	Vegetation type	H/L	$Cv_{L/H}$
TVL1	Crops, mixed farming	L	0.90
TVL2	Short grass	L	0.85
TVH3	Evergreen needleleaf trees	H	0.90
TVH4	Deciduous needleleaf trees	H	0.90
TVH5	Deciduous broadleaf trees	H	0.90
TVH6	Evergreen broadleaf trees	H	0.99
TVL7	Tall grass	L	0.70
8	Desert	–	0
TVL9	Tundra	L	0.50
TVL10	Irrigated crops	L	0.90
TVL11	Semidesert	L	0.10
12	Ice caps and glaciers	–	–
TVL13	Bogs and marshes	L	0.60
14	Inland water	–	–
15	Ocean	–	–
TVL16	Evergreen shrubs	L	0.50
TVL17	Deciduous shrubs	L	0.50
TVH18	Mixed forest/woodland	H	0.90
TVH19	Interrupted forest	H	0.90
TVL20	Water and land mixtures	L	0.60

Balsamo et al. (2009)

2. Time varying Cv_L, Cv_H as a function of LAI

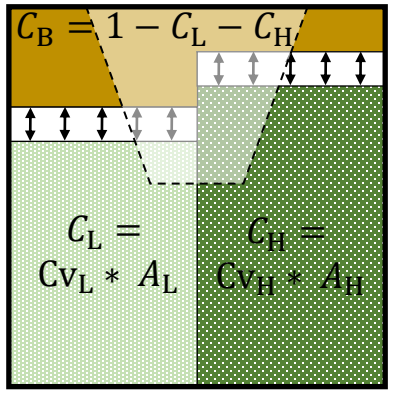


$$Cv_L = 1 - e^{-k_L * LAI_L}$$
$$Cv_H = 1 - e^{-k_H * LAI_H}$$

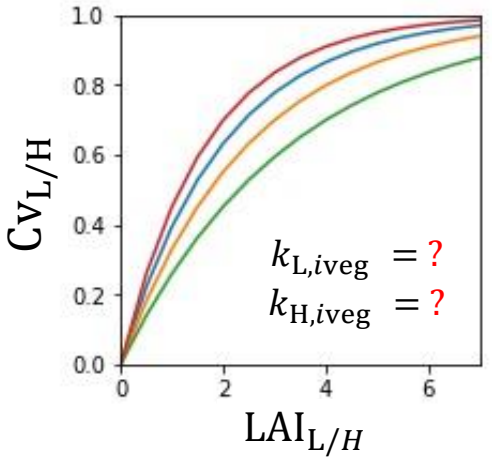


Alessandri et al. (2017)

3. Time varying Cv_L, Cv_H as function of LAI with optimized k for each vegetation type

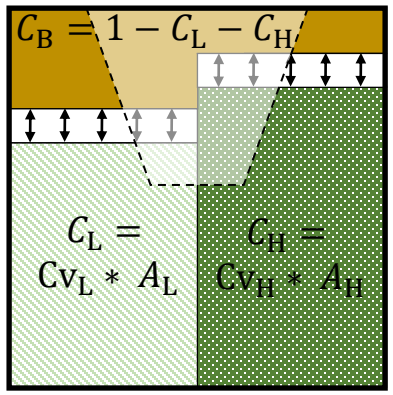


$$Cv_L = 1 - e^{-k_{L,iveg} * LAI_L}$$
$$Cv_H = 1 - e^{-k_{H,iveg} * LAI_H}$$

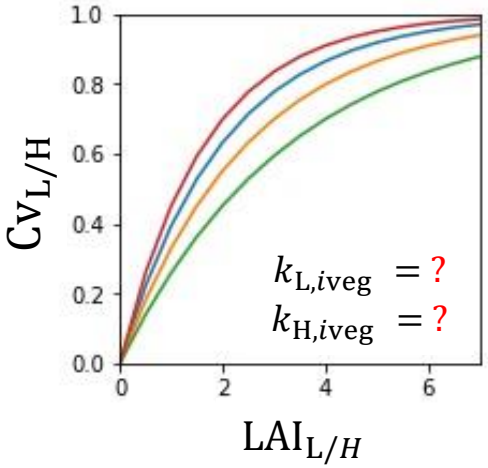


k_L, k_H varying per vegetation type $iveg$

3. Time varying Cv_L, Cv_H with LAI with optimized k per vegetation type



$$Cv_L = 1 - e^{-k_{L,iveg} * LAI_L}$$
$$Cv_H = 1 - e^{-k_{H,iveg} * LAI_H}$$



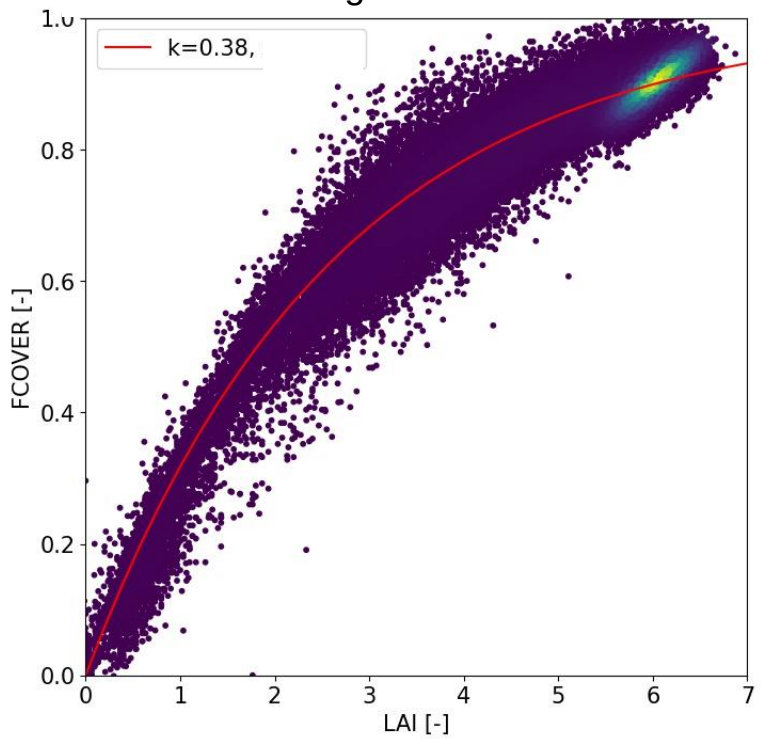
k_L, k_H varying per vegetation type $iveg$

Data
Copernicus FCOVER
Copernicus LAI
ESA-CCI land cover (ECMWF)
10-daily
1999-2019
~9km grid

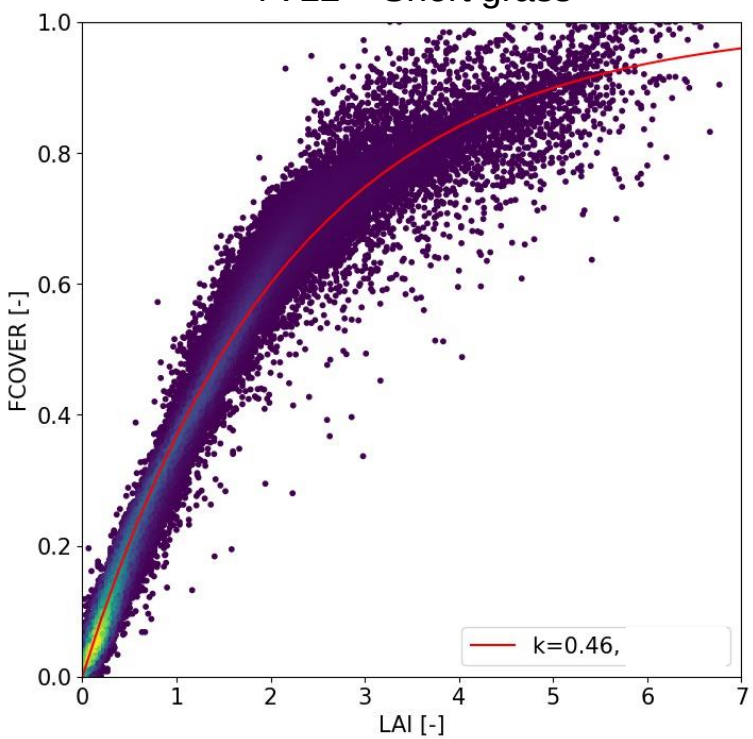
$$FCOVER = 1 - e^{-k_{L/H,iveg} * LAI_{L/H}}$$

*Non-linear least-squares minimization of **k** for each vegetation type following Chambers (1992)*
** Statistical significance of parameters tested (5%; using T-value statistics)*

TVH6 – Evergreen broadleaf trees



TVL2 – Short grass



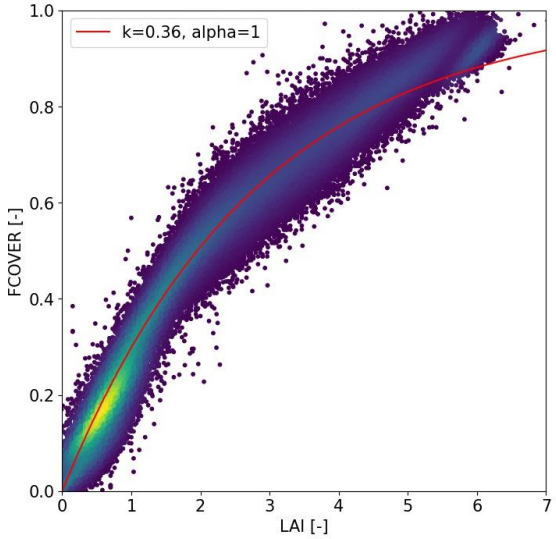
Bates, D. M. and Chambers, J. M. (1992) Nonlinear models. Chapter 10 of Statistical Models in S eds J. M. Chambers and T. J. Hastie, Wadsworth & Brooks/Cole.

Better fitting the shape of observations by adding parameter α to equation → $\mathrm{FCOVER} = \boldsymbol{\alpha}_{\mathrm{L/H},ive g}\left(1 - e^{-\boldsymbol{k}_{\mathrm{L/H},ive g} * \mathrm{LAI}_{\mathrm{L/H}}}\right)$

→ Reduction in RMSE limited (mainly for high vegetation)

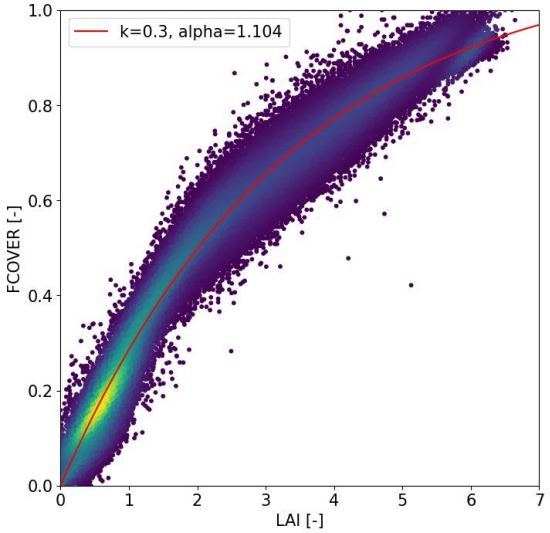
→ No comparison to literature

TVH5 deciduous broadleaf trees



Only k

$\mathrm{FCOVER} = 1 - e^{-k_{\mathrm{L/H},ive g} * \mathrm{LAI}_{\mathrm{L/H}}}$



k and α

$\mathrm{FCOVER} = \alpha_{\mathrm{L/H},ive g}\left(1 - e^{-k_{\mathrm{L/H},ive g} * \mathrm{LAI}_{\mathrm{L/H}}}\right)$

RMSE for the two fitting equations

		RMSE FCOVER fitting k (-)	RMSE FCOVER fitting k and α (-)
TVL1	Crops	0.0315	0.0314
TVL2	Short grass	0.0286	0.0284
TVL9	Tundra	0.0284	0.0282
TVL13	Bogs and Marshes	0.0286	0.0285
TVL16	Evergreen shrubs	0.0288	0.0287
TVL17	Deciduous shrubs	0.0268	0.0267
TVH3	Evergreen needleleaf trees	0.0456	0.0443
TVH4	Deciduous needleleaf trees	0.0467	0.0446
TVH5	Deciduous broadleaf trees	0.0473	0.0448
TVH6	Evergreen broadleaf trees	0.0309	0.0297

Results based on fitting only k: $\mathrm{FCOVER} = 1 - e^{-\mathbf{k}_{\mathrm{L/H},ive g} * \mathrm{LAI}_{\mathrm{L/H}}}$

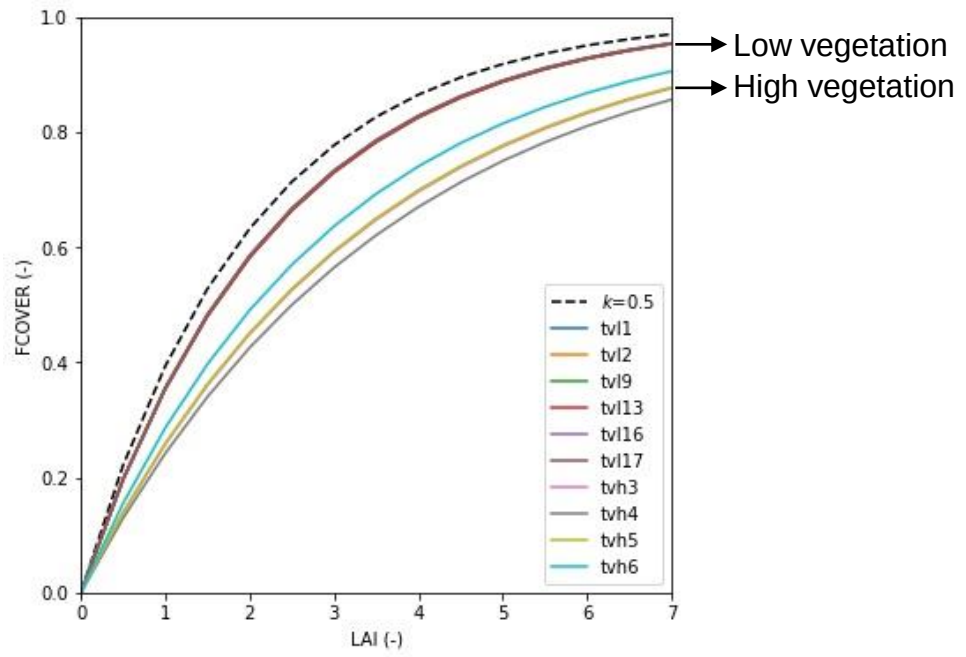
Findings:

- k=0.5 is too large, especially for high vegetation
- We find very little variation in k among low vegetation types (→mixed types?)
- Large possible ranges found in literature

Optimized k-values in relation to literature (based on satellite and in-situ data)

		k optimised (-)	Chen 2005	Chen 2021/Wei 2016	Zhang 2014
TVL1	Crops	0.458(*)		0.34 ± 0.07	0.62 ± 0.17
TVL2	Short grass	0.459(*)	0.42	0.33 ± 0.07	0.50 ± 0.15
TVL9	Tundra	0.458(*)			
TVL13	Bogs and Marshes	0.457(*)			
TVL16	Evergreen shrubs	0.457(*)	0.40	0.33 ± 0.07	0.56 ± 0.13
TVL17	Deciduous shrubs	0.456(*)	0.40		
TVH3	Evergreen needleleaf trees	0.345(*)	0.34	0.29 ± 0.05	0.45 ± 0.11
TVH4	Deciduous needleleaf trees	0.338(*)	0.39	0.30 ± 0.06	
TVH5	Deciduous broadleaf trees	0.355(*)	0.39	0.30 ± 0.06	0.59 ± 0.12
TVH6	Evergreen broadleaf trees	0.382(*)	0.34	0.29 ± 0.06	

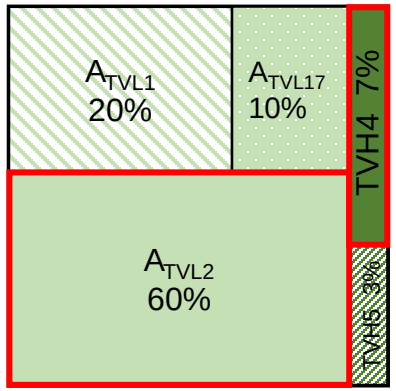
** Statistical significance of parameters verified (5%)*



Chen, J.M.; Menges, C.H.; Leblanc, S.G. Global mapping of foliage clumping index using multi-angular satellite data, Remote Sensing of Environment, Volume 97, Issue 4, 2005, Pages 447-457, ISSN 0034-4257, https://doi.org/10.1016/j.rse.2005.05.003.
Chen, B.; Lu, X.; Wang, S.; Chen, J.M.; Liu, Y.; Fang, H.; Liu, Z.; Jiang, F.; Arain, M.A.; Chen, J.; Wang, X. Evaluation of Clumping Effects on the Estimation of Global Terrestrial Evapotranspiration. Remote Sens. 2021, 13, 4075. https://doi.org/10.3390/rs13204075
Wei, S.; Fang, H. Estimation of canopy clumping index from MISR and MODIS sensors using the normalized difference hotspot and darkspot (NDHD) method: The influence of BRDF models and solar zenith angle. Remote Sens. Environ. 2016, 187, 476–491
Zhang, L., Hu, Z., Fan, J. et al. A meta-analysis of the canopy light extinction coefficient in terrestrial ecosystems. Front. Earth Sci. 8, 599–609 (2014). https://doi.org/10.1007/s11707-014-0446-7

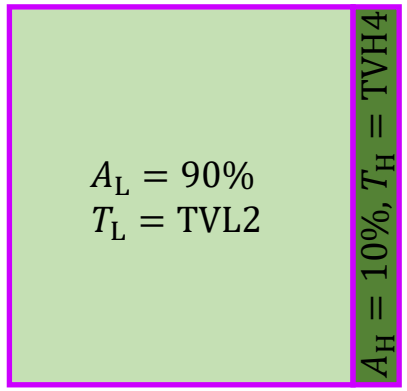
Discussion of applied methodology

'Real' land cover



Dominant high and low vegetation cover

Model land cover

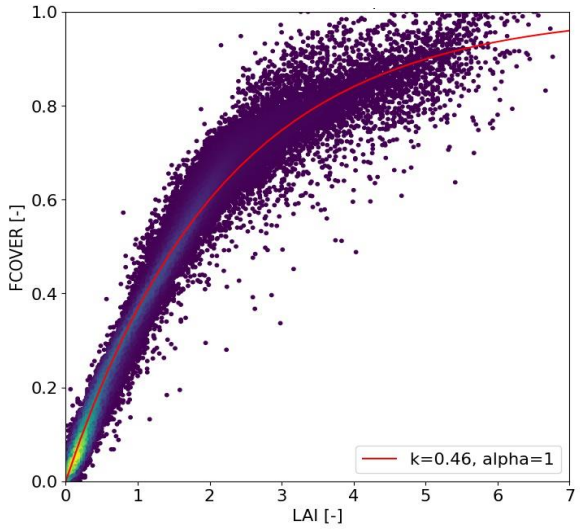


***Problem**: In the least-squares minimization procedure we had to use the aggregated fractions (e.g. AL =90% and AH=10%) instead of the actual %fractions of the dominant type (e.g. A_{TVL2} =60% and A_{TVH4}=7%), because not avalable in the data prepared by ECMWF so far.*

***Solution**: to avoid mixing of types in the fitting,* information about *the actual %fractions of the dominant types is* needed in addition to aggregated $A_{L,H}$ fractions. **Can ECMWF provide?**

Grid point selection based on **threshold coverage**: A_L**>0.90**
Vegetation type: T_L = TVL2

Fitting TVL2



Get ready for simulations

- Set-up and configuration
- Spin-up and CTRL simulation

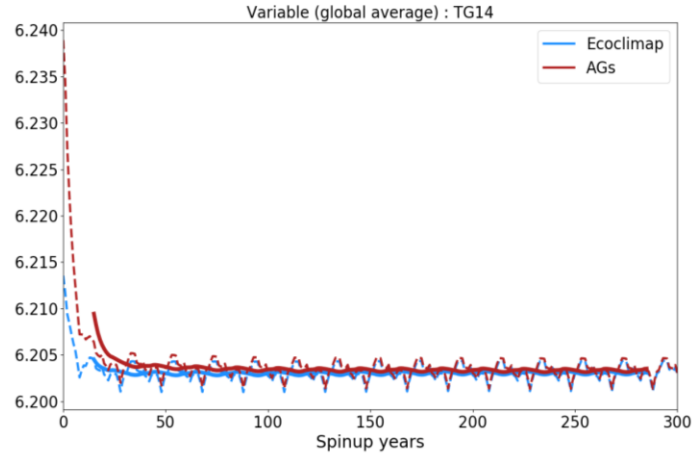
Set-up and configuration of simulations

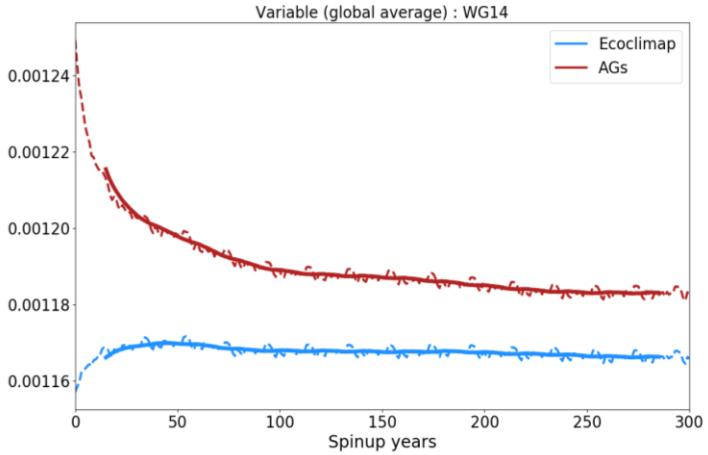
- ✓ Set-up of control (CTRL) simulation with fixed Land cover (LC) and LAI seasonal cycle (e.g. fixed to 1993 or climatological).
  - ➢ From C3S/CGLS LC & LAI for HTESSEL & HTESSEL-LPJGuess (ECMWF)
  - ➢ From Ecoclimap LC & LAI for SURFEX (MF)
- ✓ Preliminary tests performed for control simulations; spinup and CTRL simulation performed at MF.
- ✓ Preparation of the simulations with prescribed interannually varying LAI ongoing

SPINUP of Control simulation (MF)

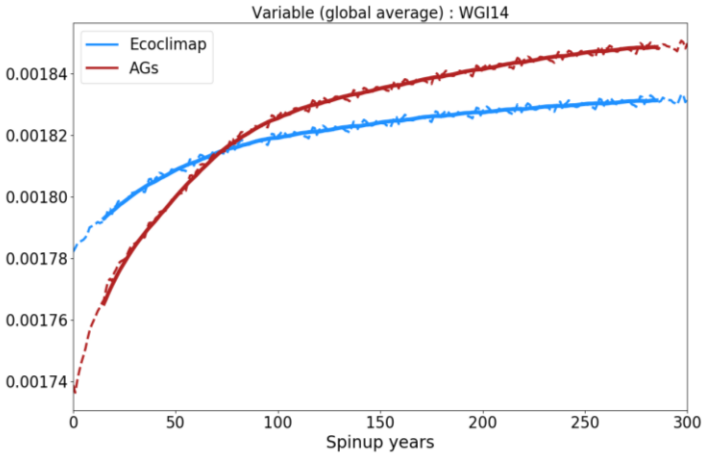
- 300-year spinup (Ecoclimap= baseline simulation, Ags=interactive vegetation)

Bottom layer temperature (K)





Bottom layer liquid water content (m^3/m^3)

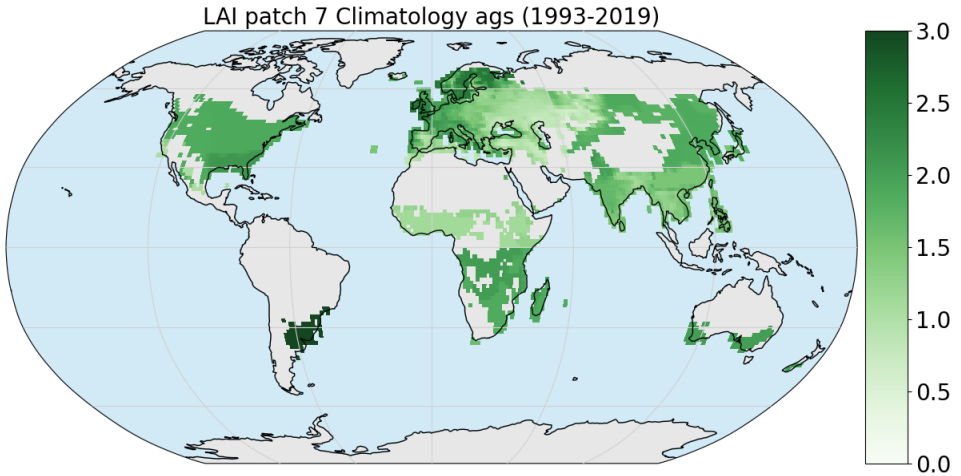


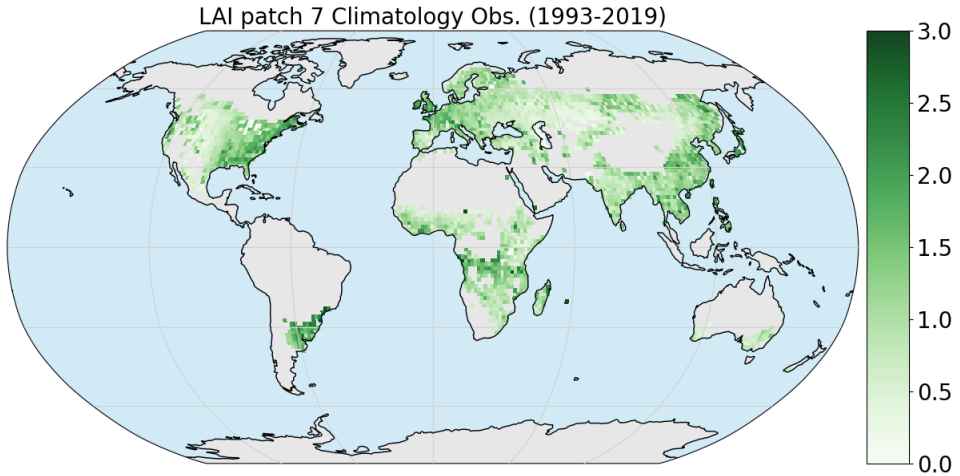
Bottom layer ice content (m^3/m^3)

PREPARATION OF THE SIMULATION WITH PRESCRIBED LAI (MF)

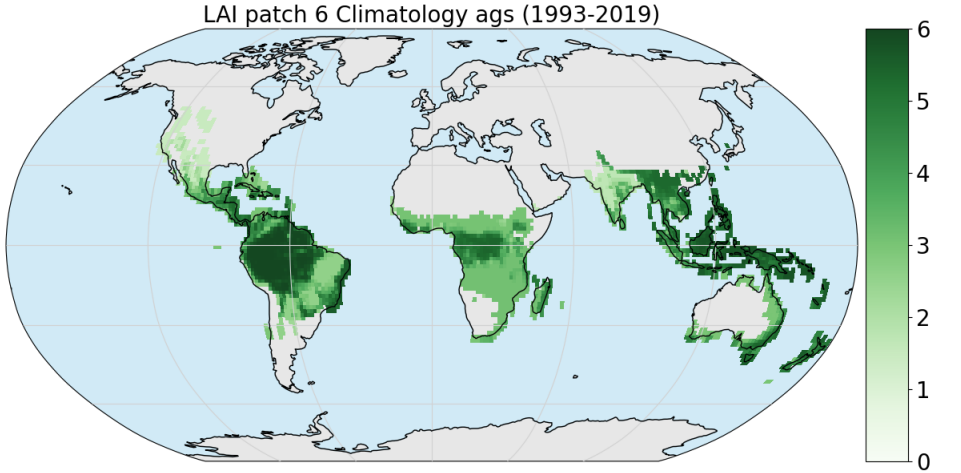
- Disaggregation of the C3S/CGLS LAI into Ecoclimap Vegetation types

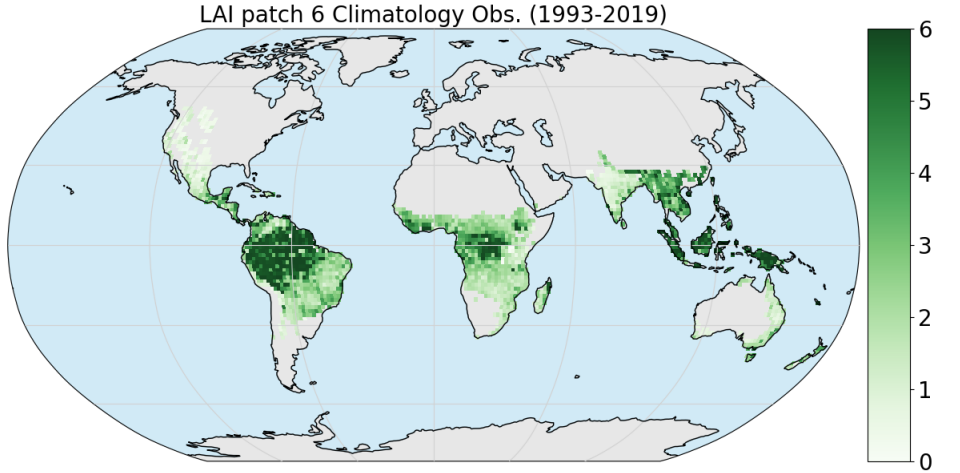
C3 crops





Evergreen broadleaf forest





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Decision and agreement about land model output (variable, frequency)

Decision and agreement about land model output (variable, frequency)

Task force was organized to collect output data requests and evaluate differences/inconsistencies among the models in the variables provided.

A list of variables with their units and frequency has been reviewed and agreed: https://docs.google.com/spreadsheets/d/1BX544q9NbXuMzBi-JKYyM5-uDLYryiT5GOvY3VBREvc/edit#gid=572339624

Concerning spatial resolution: by default, partners will provide their data on a gaussian or regular lat-lon grid close to their own model horizontal resolution.

Questions?

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The CONFESS project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101004156.