climate change initiative

→ CLIMATE MODELLING USER GROUP

# Next phase proposal: Meteo-France contribution
# # Land surface analysis #

25 October 2022

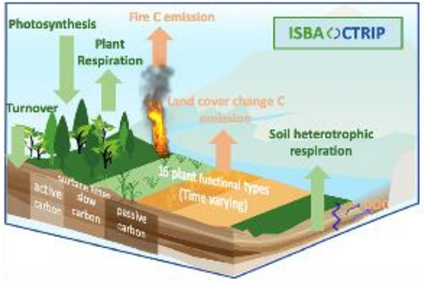
J.-C. Calvet

cmug
cci

# The SURFEX modelling platform

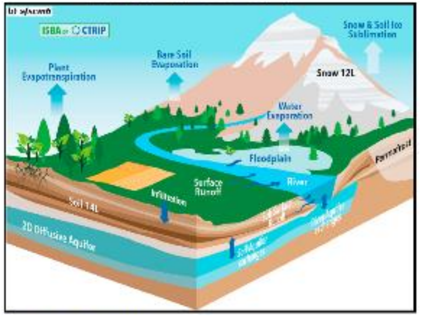
ACC≡RD
A Consortium for COnvection-scale modelling Research and Development


CARBON CYCLE




Delire et al. 2020

WATER CYCLE

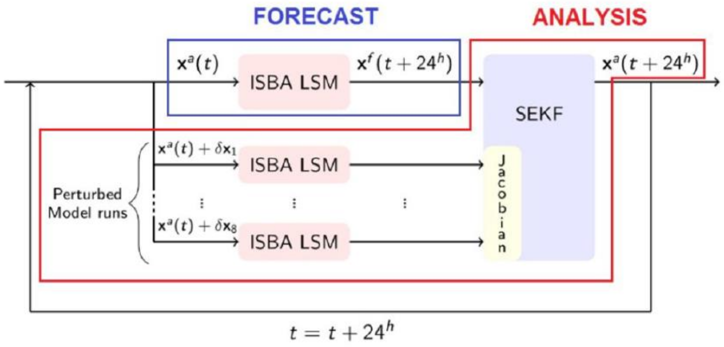



Decharme et al. 2019

| | | |
|---|---|---|
| ISBA | Soil | Force restore :<br>2 temperature, 2 or 3 layers for water, icing<br>Diffusion : multilayer (temperature, water, icing) |
| | Vegetation | Noilhan et Planton 89 (~Jarvis)<br>A-gs (photosynthesis and CO2 fluxes)<br>A-gs and interactive vegetation<br>Slow carbon processes (wood and roots) |
| | Hydrology | No subgrid process<br>Subgrid surface runoff<br>Subgrid drainage<br>Flooding and coupling with TRIP |
| | Snow | 1 layer, albedo, density variable (ARP/Climat, Douville 95)<br>1 layer, albedo, density variable (ARP/ALD, Bazile)<br>Multilayer (3, or...) albedo, density, liquid water content<br>(Boone and Etchevers 2000) |

- **LDAS-Monde**
  - Integration of satellite observations into the ISBA land surface model
  - Involves the CTRIP river discharge model
  - Sequential assimilation of LAI
    - Flexible LAI thanks to photosynthesis-driven phenology
    - Root-zone soil moisture can be analysed assimilating LAI
    - Joint LAI and SM assimilation is possible
  - Sequential assimilation of Snow Water Equivalent (SWE)

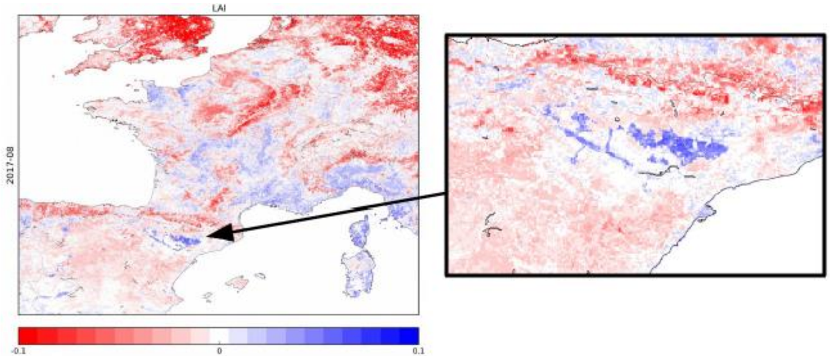
$$x^a = x^f + K(y^o - H(x^f))$$

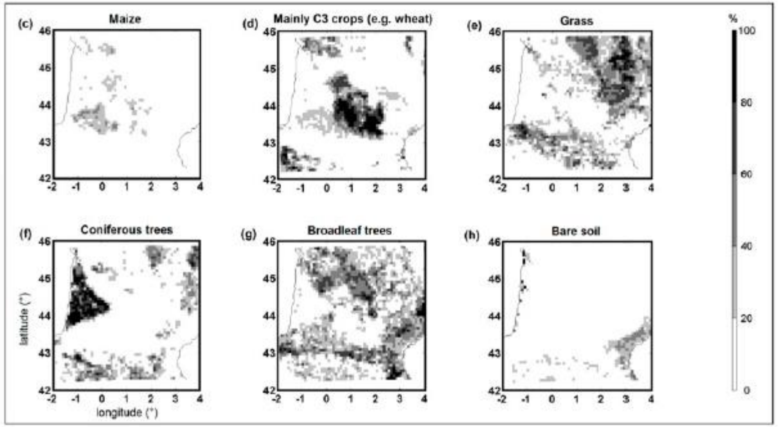


# Integration of geographical info in SURFEX

- **Sequential assimilation of satellite-derived LAI**
  - LDAS-Monde
    - e.g. LAI increments highlighting irrigated areas in Spain (August 2017)

- **Land cover and model parameter mapping**
  - ECOCLIMAP
    - e.g. surface types in southwestern France

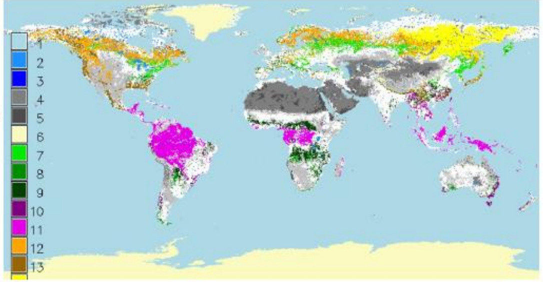


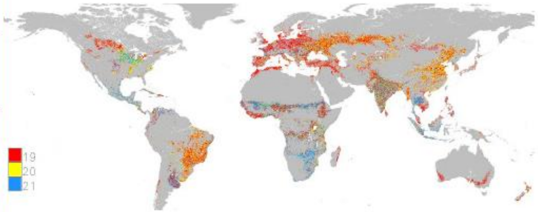
# From ECOCLIMAP to ECOCLIMAP-SG

| Geographical information | Years 2000 Ecoclimap-I | Years 2010 Ecoclimap-II | Years 2020 Ecoclimap-SG |
|---|---|---|---|
| LAI | NDVI AVHRR (1992-1993) | LAI MODIS (2000-2005) | LAI Copernicus (2014-2016) |
| Land cover (LC) | IGBP<br>Corine 1990 (Europe) | IGBP<br>Corine 2000 and GLC2000 (Europe) | ESA-CCI (2008-2012)<br>Corine 2012 (Europe) |
| Plant functional types (PFTs) | 10 | 12 | |
| LC classes (« ecosystems ») | 125 (outside Europe)<br>90 (Europe) | 125 (outside Europe)<br>273 (Europe) | 33 |
| Spatial resolution | 1 km | 1 km | 300 m |
| Primary parameters (LAI, rooting depth, tree height, etc.) | Look up tables based on LC classes | | Existing freely available databases |
| Secondary parameters - Biological (e.g. photosynthesis) | Look up tables based on PFTs | | |
| Secondary parameters - Physical (e.g. bare soil fraction, roughness, IR emissivity, albedo, etc.) | Look up tables based on PFTs and primary parameters | | |

Forest cover types




Crop cover types



# From ECOCLIMAP to ECOCLIMAP-SG

## Covers = 33 generic surface types

1. Sea and oceans (cov. 1)
2. Lakes (cov. 2)
3. Rivers (cov. 3)
4. Bare soil (veg. 1)
5. Bare rock (veg. 2)
6. Permanent snow (veg. 3)
7. boreal broadleaf deciduous (veg. 16)
8. temperate broadleaf deciduous (veg. 4)
9. tropical broadleaf deciduous (veg. 13)
10. temperate broadleaf evergreen (veg. 14)
11. tropical broadleaf evergreen (veg. 6)
12. boreal needleleaf evergreen (veg. 5)
13. temperate needleleaf evergreen (veg. 15)
14. boreal needleleaf deciduous (veg. 17)
15. shrubs (veg. 19)
16. boreal grassland (veg. 18)
17. temperate grassland (veg. 10)
18. tropical grassland (veg. 11)
19. Winter C3 crops (veg. 7)
20. Summer C3 crops (new)
21. C4 crops (veg. 8)
22. Tree cover, flooded (new)
23. Shrub or herbaceous cover, flooded (new)
24. urban LCZ1: compact high-rise (new)
25. urban LCZ2: compact midrise (new)
26. urban LCZ3: compact low-rise (new)
27. urban LCZ4: open high-rise (new)
28. urban LCZ5: open midrise (new)

29: urban LCZ6: open low-rise (new)

30: urban LCZ7: lightweight low-rise (new)

31: urban LCZ8: large low-rise (new)

32: urban LCZ9: sparsely built (new)

33: urban LCZ10: heavy industry (new)

## Primary parameter maps

- LAI (Copernicus Global Land, 2014-2016, PROBA-V, 300 m)
- Tree height (NASA IceSat 1km)
- Rooting depth (from ECOCLIMAP-2)
- Soil, vegetation, VIS, NIR, albedo (Copernicus Global Land, 1998-2014, SPOT-VGT, 1km)

**Surface parameters depending on primary parameters**

- Fraction of vegetation
- Roughness length
- Emissivity
- Total albedo

**Surface parameters depending only on surface type**
(e.g. photosynthesis parameters)

# Scientific questions

- Can
  CCI SNOW and CCI LAI products
  improve land reanalyses?

- How do
  LC – SNOW – LAI – phenology
  uncertainties propagate to the water and energy budgets?

# How do LC and SNOW uncertainties propagate?

- Assimilation of SWE with and without LC-CCI using LST and SM as a benchmark

  - Eurasia 2010-2019, 0.25 x 0.25 km
  - Experimental design
    - Open-loop with pre-existing LC
    - Open-loop with CCI LC
    - SWE assimilation with pre-existing LC
    - SWE assimilation with CCI LC.
  - Comparison of simulated LST and SM with corresponding CCI variables.
  - Products to be used
    - LC: v.1.6.1, already available
    - SNOW: SWE L3c v2.0, already available
    - SM: COMBINED v6.1, already available
    - LST: AQUA_MODIS_L3C_0.05, TERRA_MODIS_L3C_0.05, already available

# How do LC and SNOW uncertainties propagate?

- Assimilation of SWE with and without LC-CCI using LAI as a benchmark

  - Eurasia 2010-2019, 0.25 x 0.25 km
  - Experimental design
    - Open-loop with pre-existing LC
    - Open-loop with CCI LC
    - SWE assimilation with pre-existing LC
    - SWE assimilation with CCI LC.
  - Comparison of simulated LAI with corresponding CCI LAI.
  - Products to be used
    - LAI: should be available in 2024

# How do LAI uncertainties propagate?

- Assimilation of LAI using LST diurnal cycle as a benchmark
  - A region TbD in Eurasia 2010-2019, 0.25 x 0.25 km
  - Experimental design
    - LAI assimilation with CCI LC.
  - Comparison of simulated LAI with corresponding CCI LAI.
  - Products to be used
    - LAI: should be available in 2024
    - LST GEO product: should be available in 2024

# TIMELINE

- 2023-2024
    - Assimilation of SWE with and without LC-CCI using SM and LST as a benchmark
- 2024-2025
    - Assimilation of SWE with and without LC-CCI using LAI as a benchmark
    - Assimilation of LAI using LST diurnal cycle as a benchmark

# EXPECTED RESULTS

- Assessment of the impact of
    - LC on LST and SM
    - LC on LAI
    - Snow on phenology
    - Snow on LST
    - LAI on diurnal cycle of LST

Thank you for your attention