CMUG Phase 2
WP5.6: *Snow dynamics impacts on temperate / high latitudes climate*

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Context and goals of the study

Improve the representation of snow cover dynamics in temperate and boreal zones within the IPSL climate model using the snow cover fraction (SCF) and snow water equivalent (SWE) products recently released by the CCI-snow, in order to assess the impact of snow cover dynamics and atmospheric feedback on regional to continental climate.

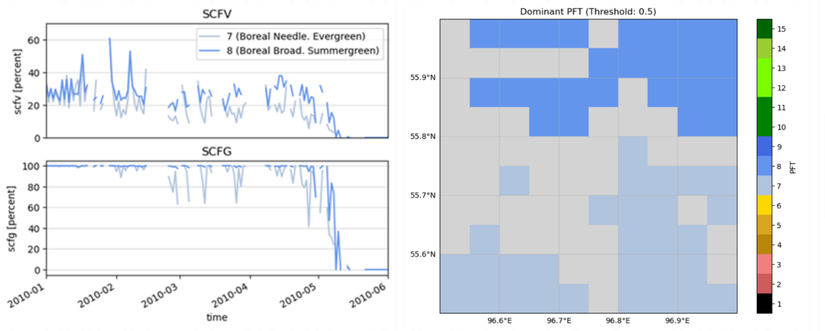
- **Improve our understanding and modelling of snow-vegetation-atmosphere feedback with the IPSL climate model (LMDZ-ORCHIDEE) and various ESA-CCI Products (especially Snow Products)**
- **Optimise the parameterisation of the snow model included in ORCHIDEE by using the CCI Snow and MODIS Albedo products**
- **Estimate the overall contribution of changes in snow cover dynamics over the past decades on high latitude climate warming amplification**

Data analysis (CCI Snow and MODIS albedo)

✓ **Analysis of the CCI Snow products and consistency checks with other products + impact of the vegetation type**

CCI-SNOW Snow Cover Fraction (SCF): MODIS (1km, 2000 - 2020) and AVHRR (5 km, 1982 - 2018)
Making use of SCFV (top of forest) versus SCFG (ground cover)

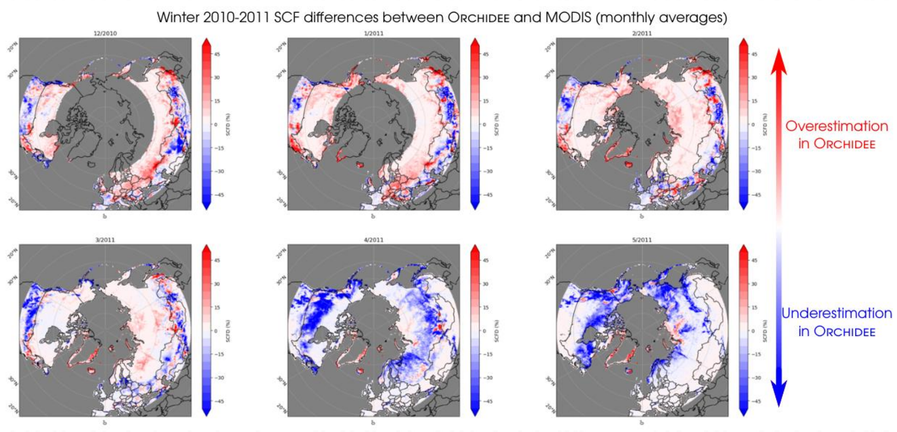
Comparison of the SCFV and SCFG extracted over two types of vegetation (boreal needleleaf evergreen and boreal broadleaf summergreen) in the same region (Siberia) (left), and repartition of the most common PFTs derived from the CCI – Medium Resolution Land Cover dataset (right)



Influence of vegetation type on snow dynamics (for instance on the Snow Cover Fraction temporal evolution)

✓ **Comparison of the CCI Snow SCF with ORCHIDEE (snow cover fraction under the vegetation – that corresponds to SCFG)**

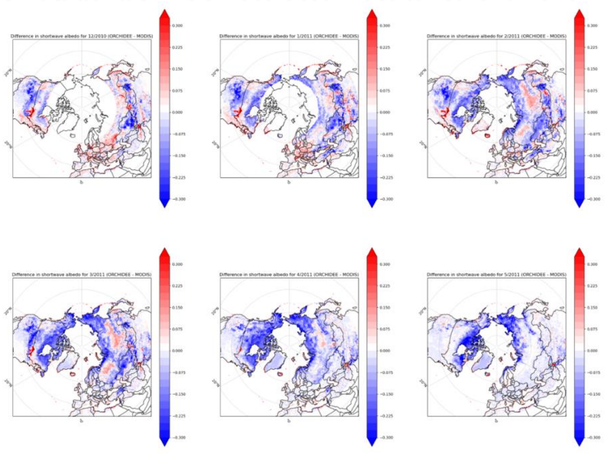
Monthly averages of the SCF differences between ORCHIDEE and the SCF product between 12/2010 and 05/2011



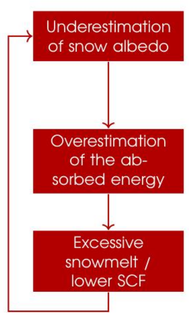
Overestimation during the accumulation period / underestimation during the ablation period

✓ **Comparison of the MODIS albedo with ORCHIDEE**

Monthly averages of the albedo differences between ORCHIDEE and the MODIS albedo product between 12/2010 and 05/2011



Feedback loop

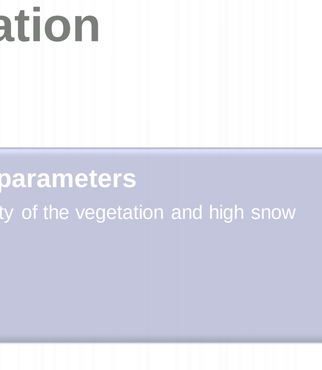


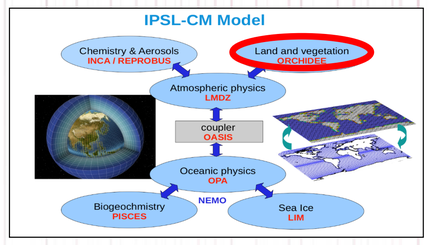
Feedback loop between SCF and albedo

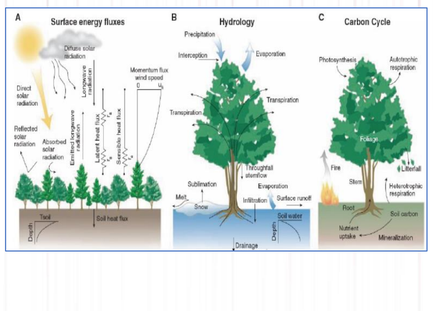
Improvement of both the albedo and SCF necessary in the model

ORCHIDEE LSM

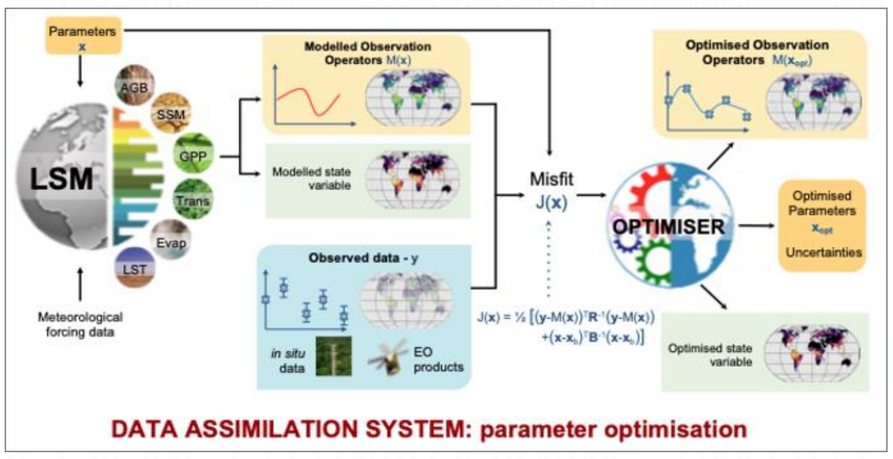
- Land component of the IPSL climate model
- Process-based model
- Energy, water, carbon and nitrogen budgets







ORCHIDAS (Data Assimilation)



Parameter optimisation

For each PFT:

Phase 1: Tuning of the snow albedo parameters

1) Selection of the most adapted sites: representativity of the vegetation and high snow cover fraction

Use of PFT maps and CCI Snow (SCFG)

2) Multi-site optimisation

Observed data: MODIS albedo

Phase 2: Tuning of the snow cover fraction parameters

New multi-site optimisation for the snow cover fraction parameters

Observed data: MODIS albedo, CCI Snow SCF and SWE

Optimised snow albedo and snow cover fraction parameters for each PFT ➔ better estimates of winter albedo and SCF, improvements in the energy budget

Performed on ORCHIDEE v3 – the methodology will be applied to the last version of ORCHIDEE with the following features:

New snow scheme, with a 12-layer discretisation (instead of 3) (Charbit et al., 2024, in press) ➔ improved snow temperature and snow depth prediction

Updated scheme for the calculation of the vegetation albedo

New PFT maps derived from the ESA CCI MRLC project (PFT V3.0 product, Harper et al., 2022)

Next steps: coupled model simulations

Analysis of the impact of improving the snow dynamics in the IPSL model on the simulated northern high latitude climate ➔ run over the historical period (past 4 decades) with fixed SST and SIC

- Analysis of the simulated surface climate over the Arctic regions and comparison with the CMIP6 version of the coupled model
- Evaluation of the coupled model simulations with the help of the CCI products
- Sensitivity experiments: turbulence in the boundary layer, insulation effect of the snow layer, snow albedo effect
- Study of the contribution of the surface – albedo feedback linked to snow dynamics

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