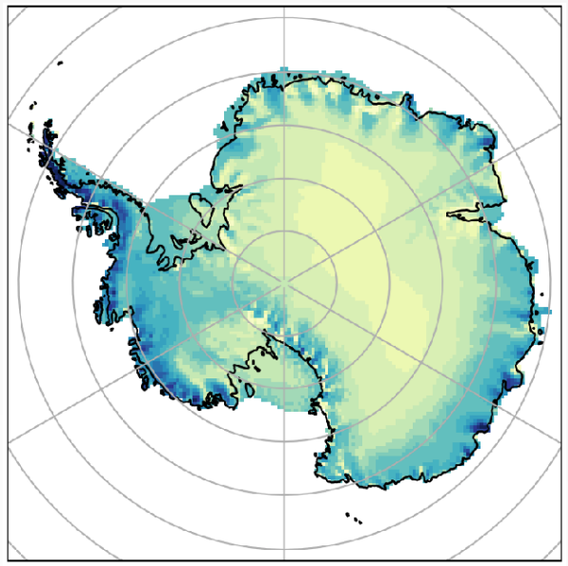
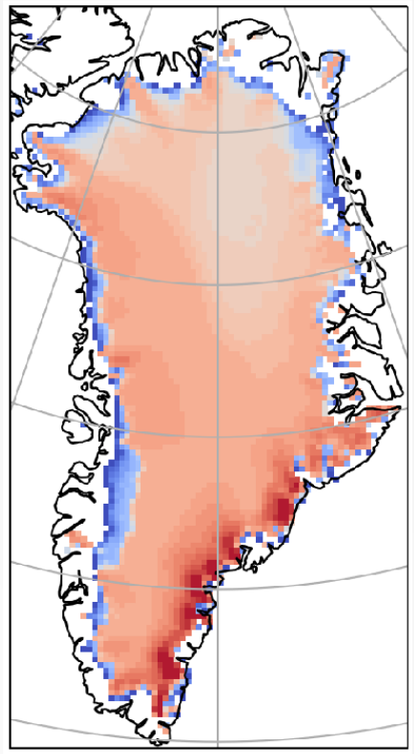




ORCHIDEE-ICE

Christophe Dumas, Sylvie Charbit, Catherine Ottle, Fabienne Maignan, Nina Raoult

Why ORCHIDEE-ICE ?

- Ice-covered surface poorly represented in ORCHIDEE : 1 snow layer, constant density, no water percolation or refreezing
- Coupling with ice-sheet in next version of IPSL ESM
- Need to update ORCHIDEE snow model over ice sheets in order to provide a surface mass balance to the ice sheet model

Explicit-Snow standard version

Atmosphere / Snow interface : Surface energy balance

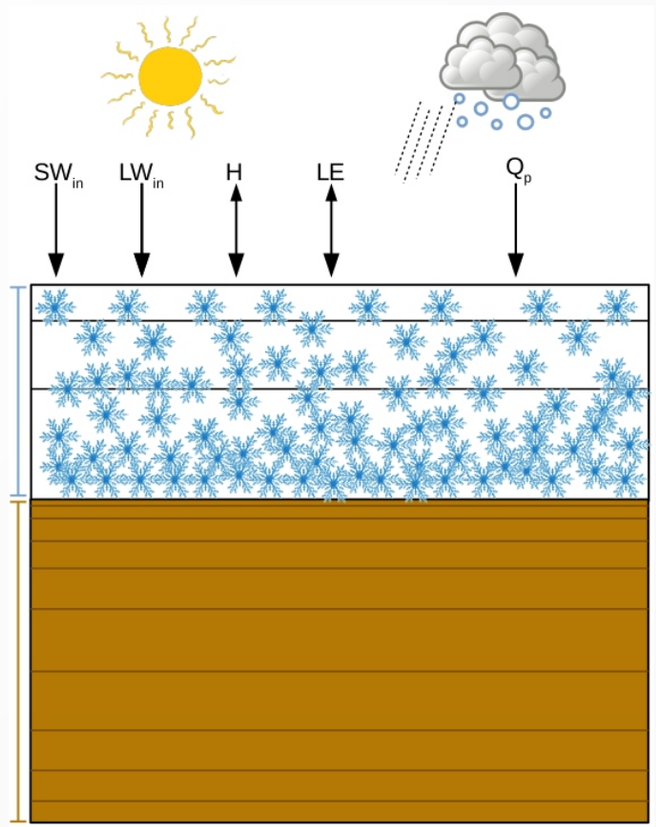
Processes represented in snow :

- snow settling
- snow compaction
- snow aging
- snow melting
- water percolation and refreezing

=> density and albedo changes

3 layers snow Module ES

18 layers soil module



Explicit-Snow in ORCHIDEE-ICE

Atmosphere / Snow interface : Surface energy balance

Processes represented in snow :

- snow settling
- snow compaction
- snow aging
- snow melting
- water percolation and refreezing

=> density and albedo changes

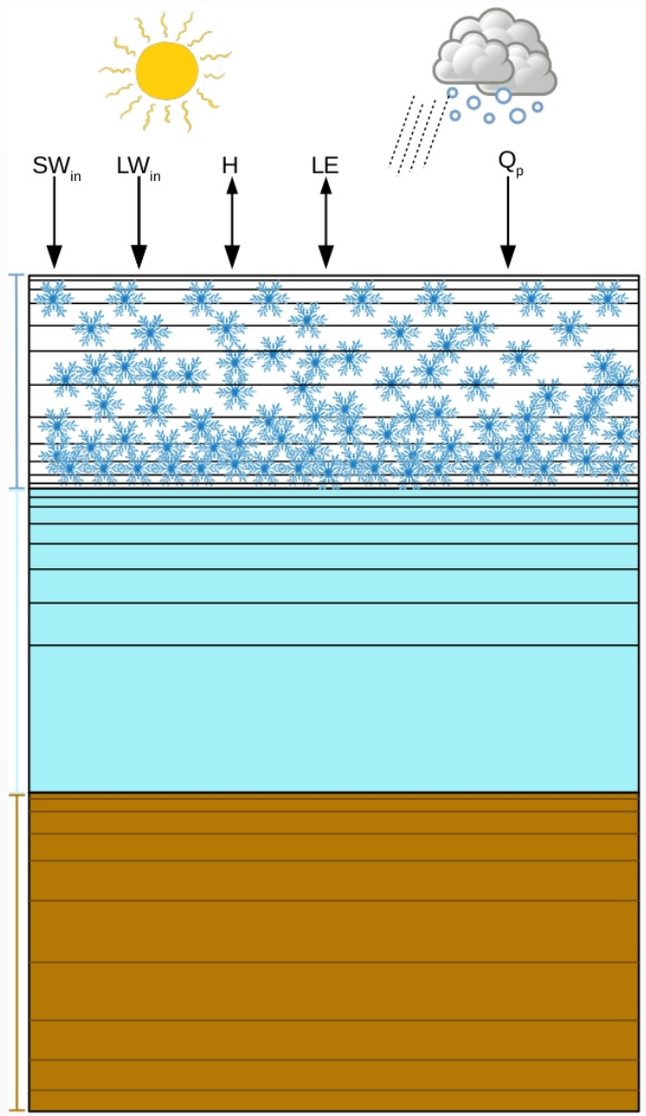
Ice module on ice sheet areas allows the computation of heat exchange between snow and ice, and ice melt :

- temperature
- melt
- no refreezing in ice

12 layers snow Module ES

8 layers ice module

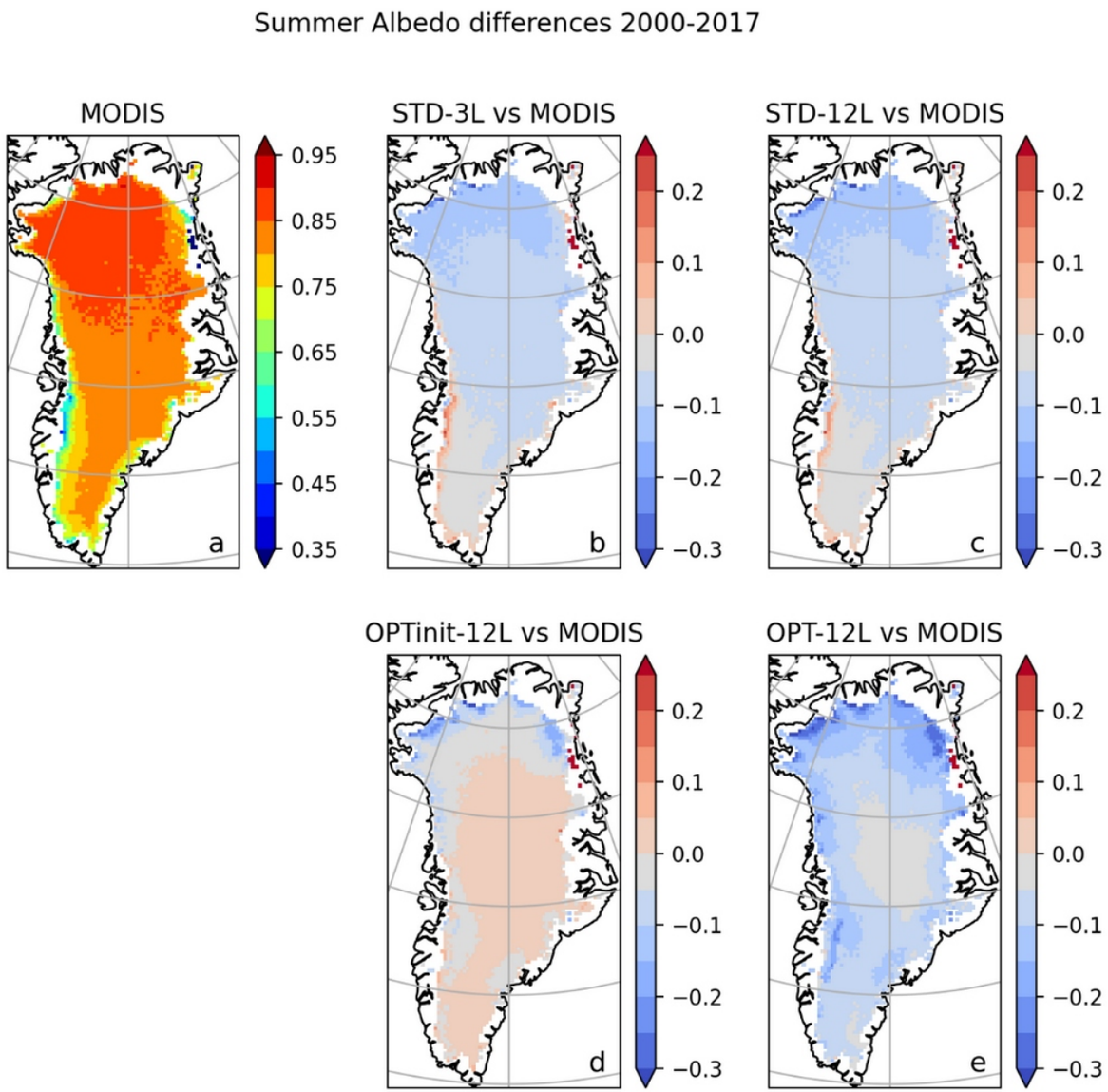
18 layers soil module



OR-ICE on Greenland

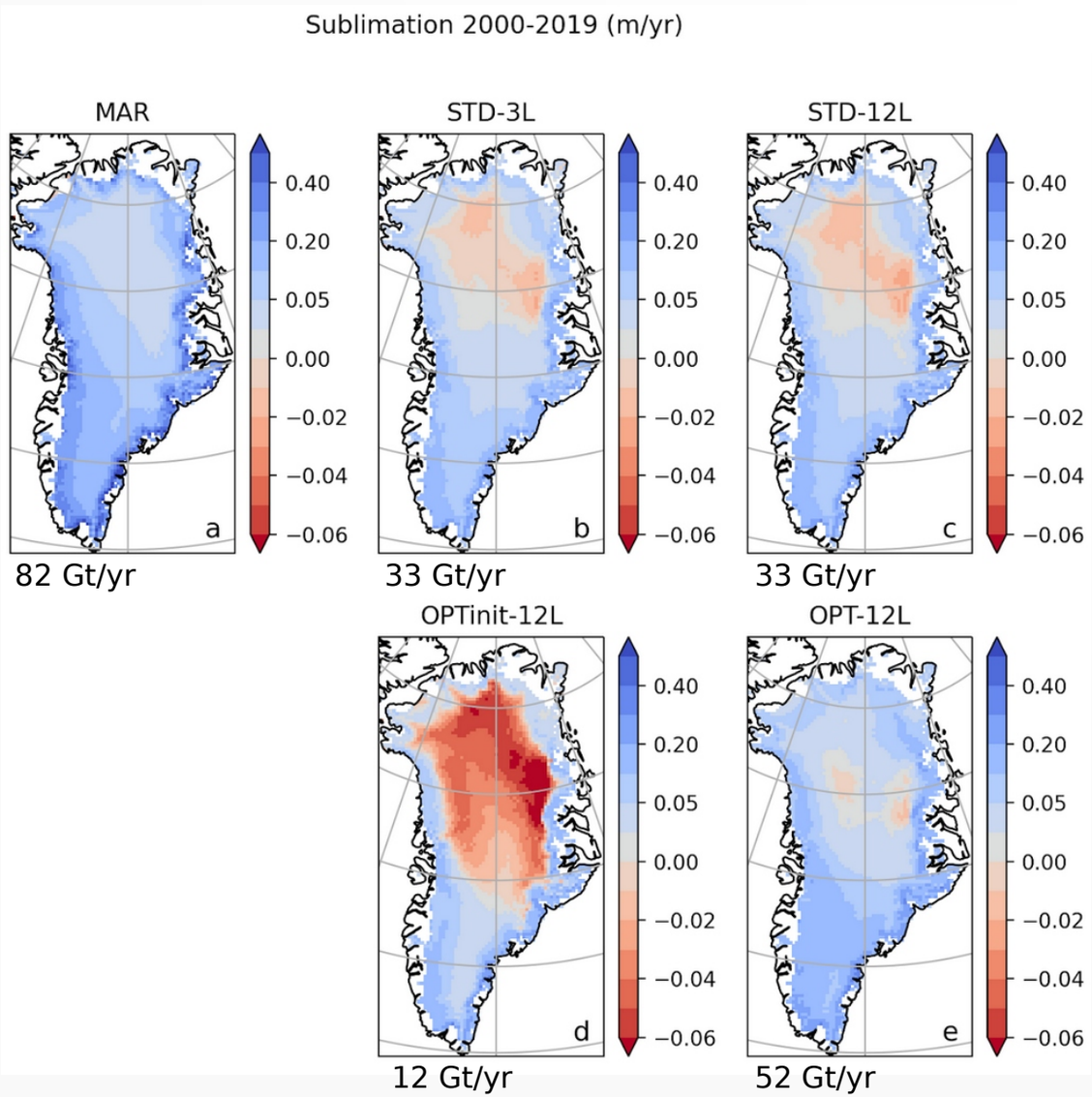
- Simulation forced by MAR ERA-Interim simulation
- Forcing : RCM MAR : LW, SW, Qair, Rainf, Snowf, Wind
- Simulations performed over 1995 – 2019 period
- Initialisation of ice temperature : 25 years spin-up simulation
- Charbit et al in prep

Evaluation on Greenland : albedo



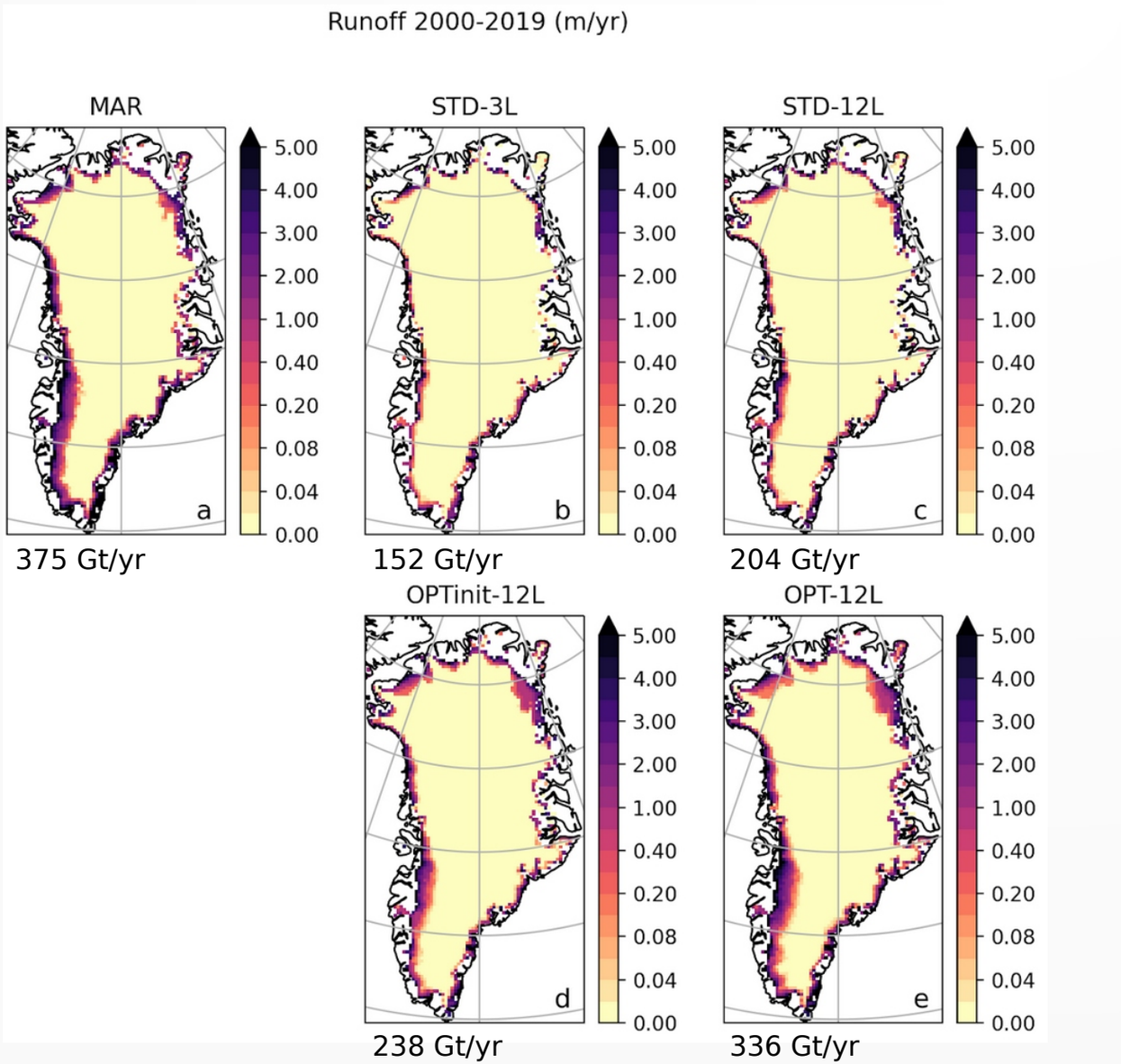
- STD-3L & STD-12L standard CMIP-6: albedo is too high in melting areas
- OPTinit-12L : albedo optimized by Nina is the best !
- OPT-12L : albedo too low espacially on margins
- South-north albedo gradient is not well represented

Evaluation on Greenland : sublimation



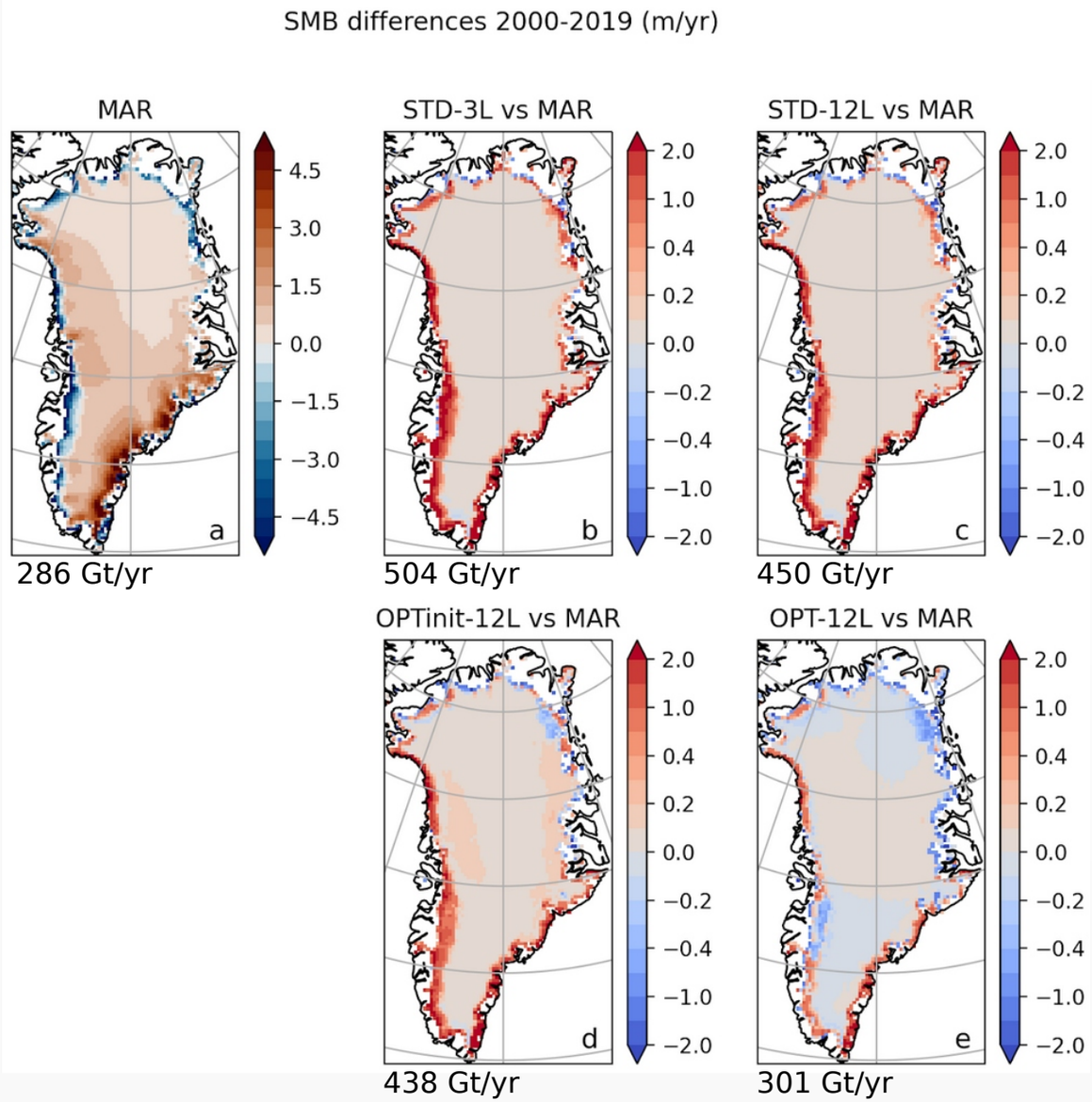
- Sublimation too low in STD-3L and STD-12L
- In central Greenland : lot of condensation with OPTinit-12L
- Sublimation is strongly influenced by albedo

Evaluation on Greenland : runoff



- MAR : runoff in peripheral areas, particularly on western edge
- OR-ICE : runoff limited in a very narrow band
- 12L favors inland expansion of the ablation areas
- Runoff integrated 60 % and 45 % lower compared to MAR with STD albedo

Evaluation on Greenland : SMB

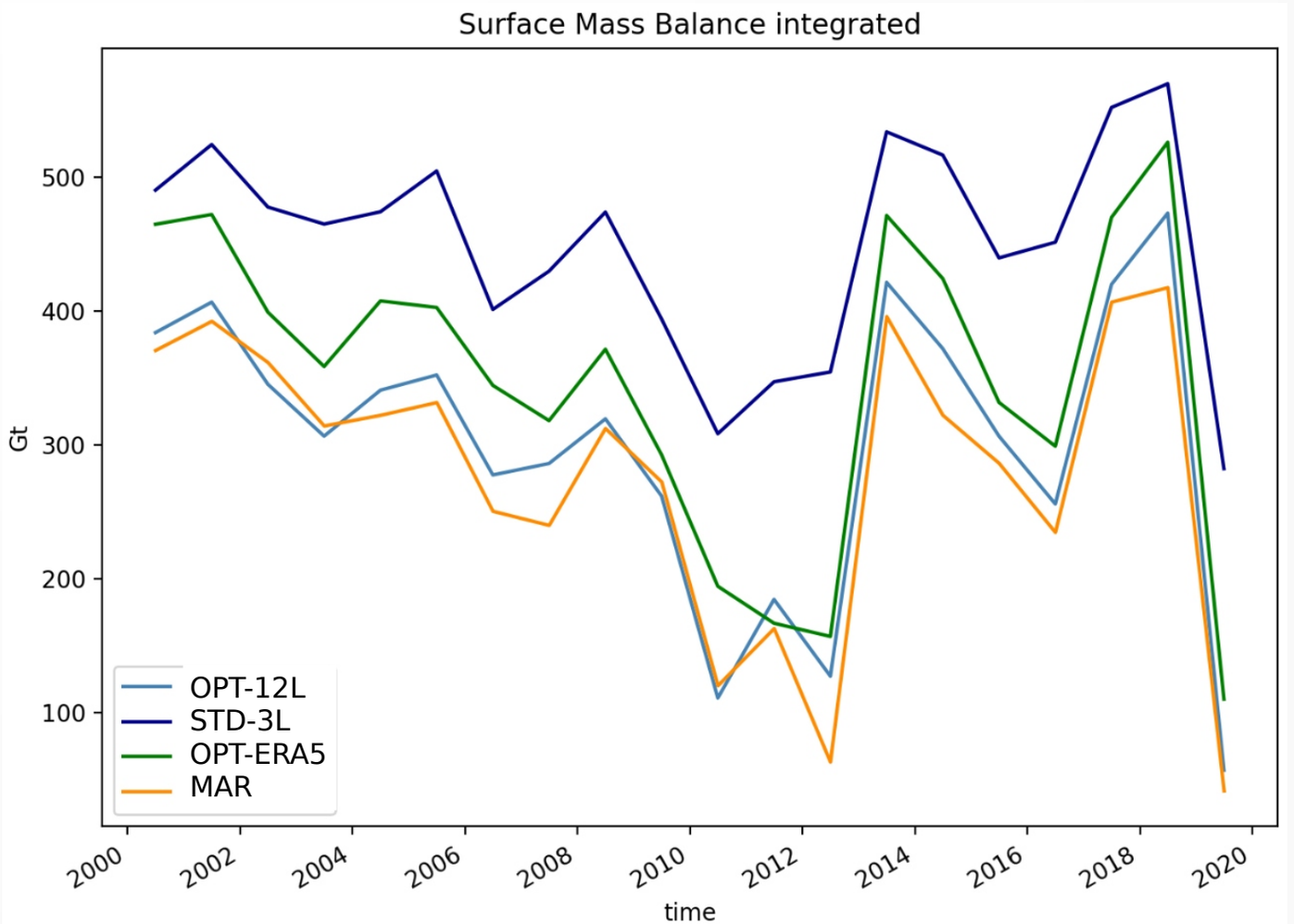


- Large positive SMB anomaly in STD-3L and STD-12L
- OR-ICE : runoff limited in a very narrow band
- 12L favors inland expansion of the ablation areas

Evaluation on Greenland : time series

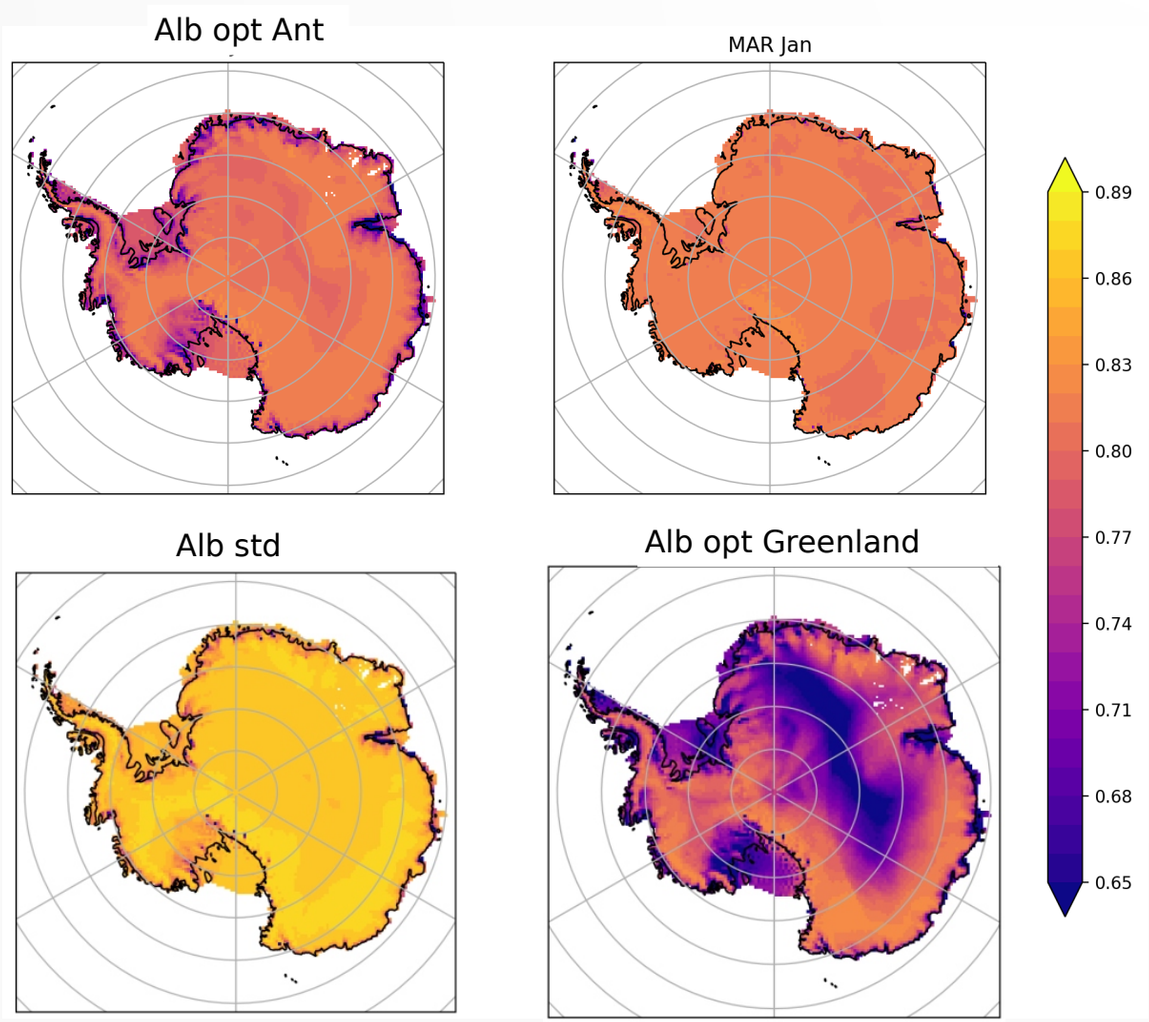
Temporal evolution of the SMB between 2000-2019

- STD-3L : SMB too high and lower annual variability
- OPT-12L : integreted SMB and variability in the same range as MAR
- Extreme melting events 2012 & 2019 are well represented
- => ORCHIDEE-ICE can now properly simulate melting over Greenland, but albedo should be optimized in the latest version.



Antarctic ice sheet : Albedo

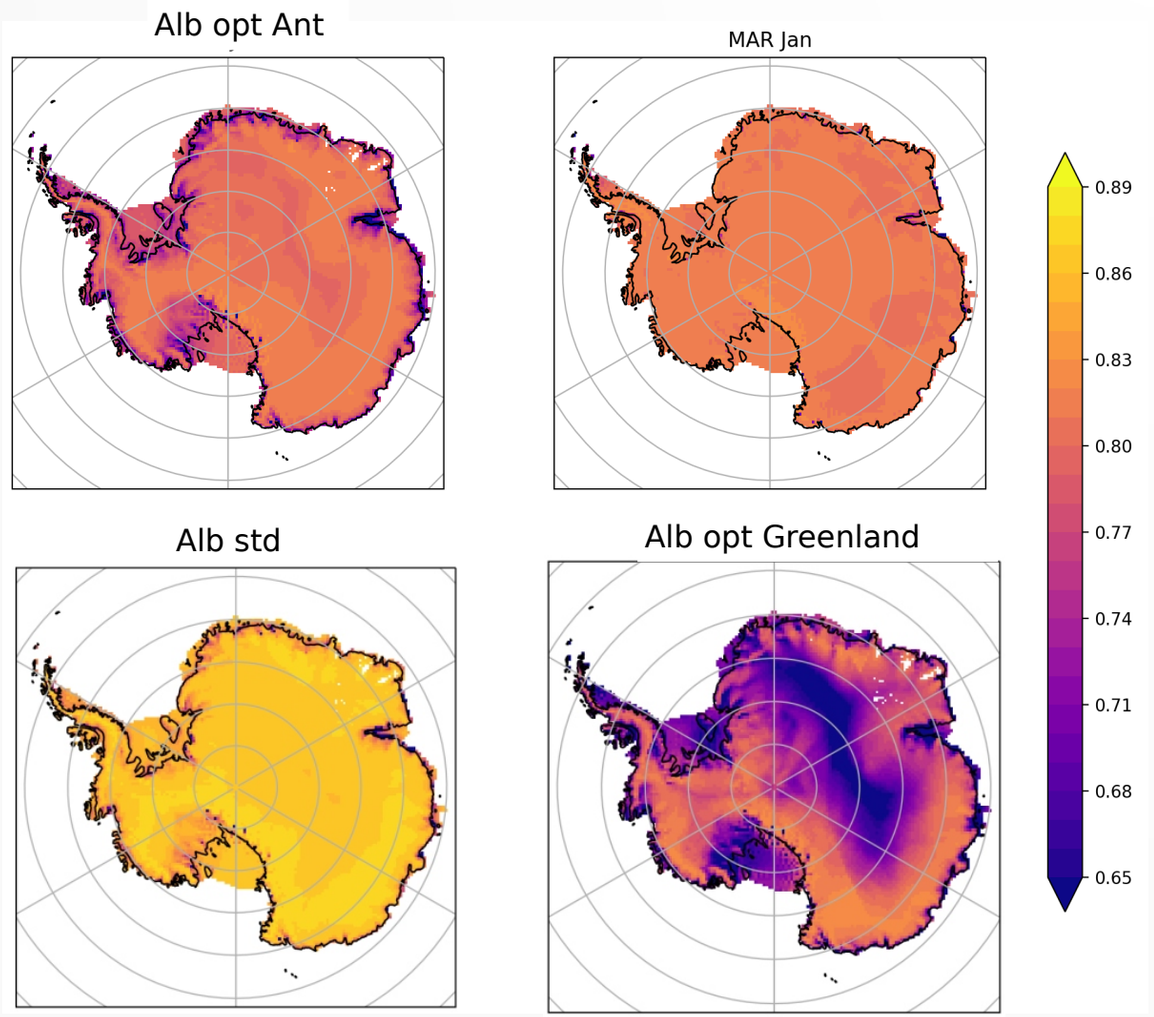
Albedo



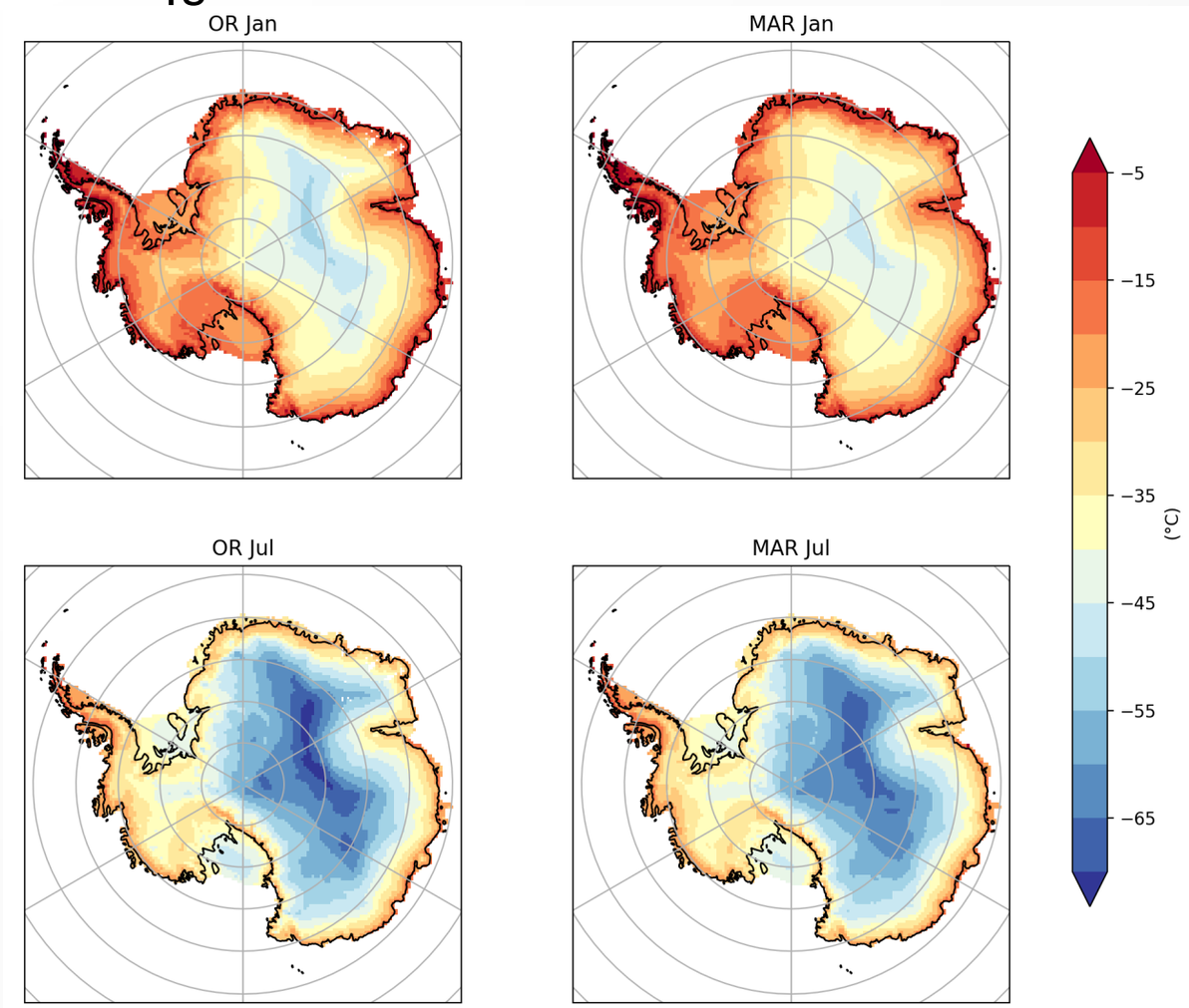
- Same type of simulation on Antarctic ice-sheet : MARv3.12 forcing
- Albedo too high with standard param
- albedo very low on the Antarctic plateau and ice-shelves with OPT-12L from Greenland
- Parameter adjustment to recover values close to MAR

Antarctic : Albedo and Ts

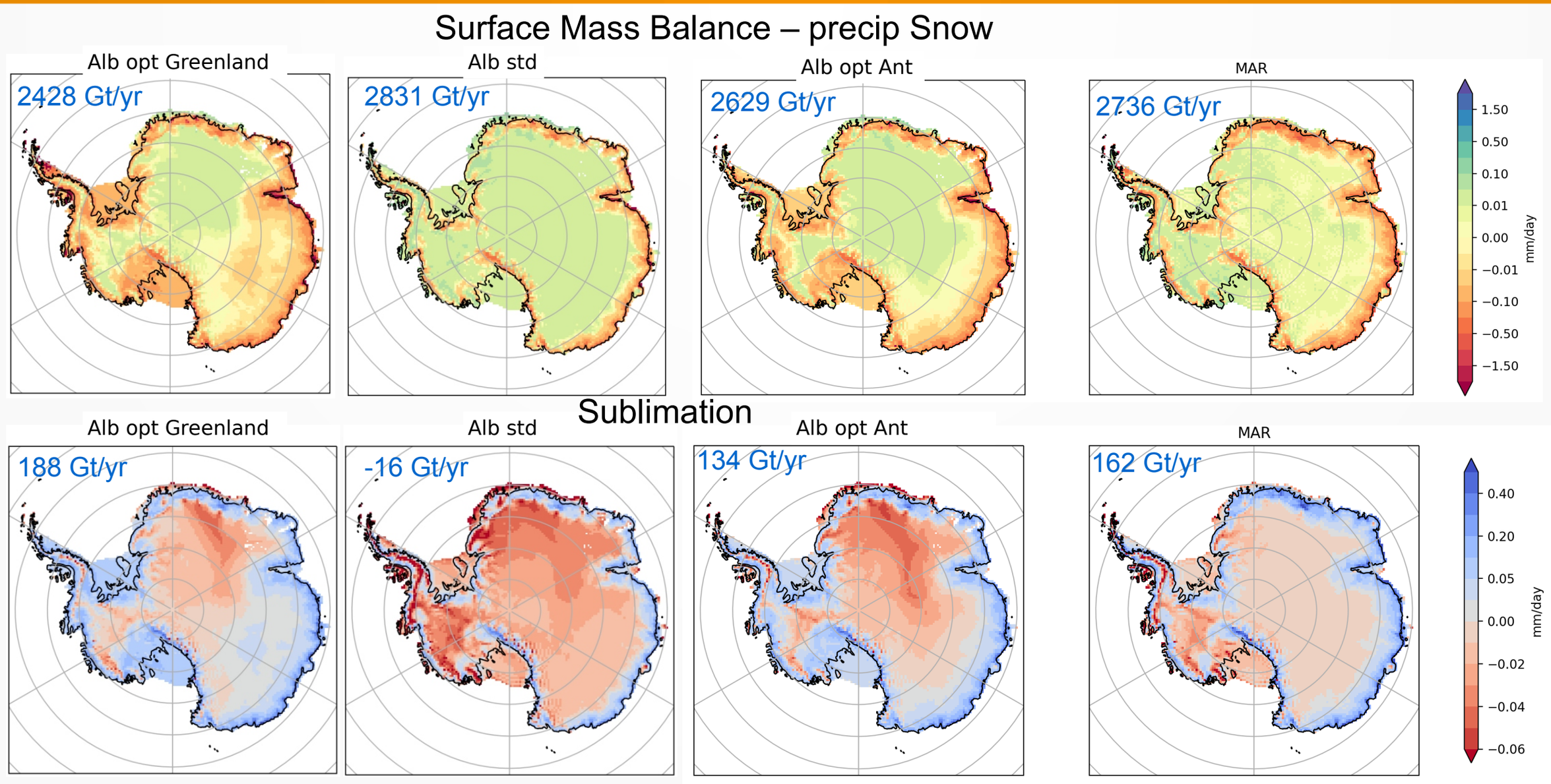
Albedo



Ts

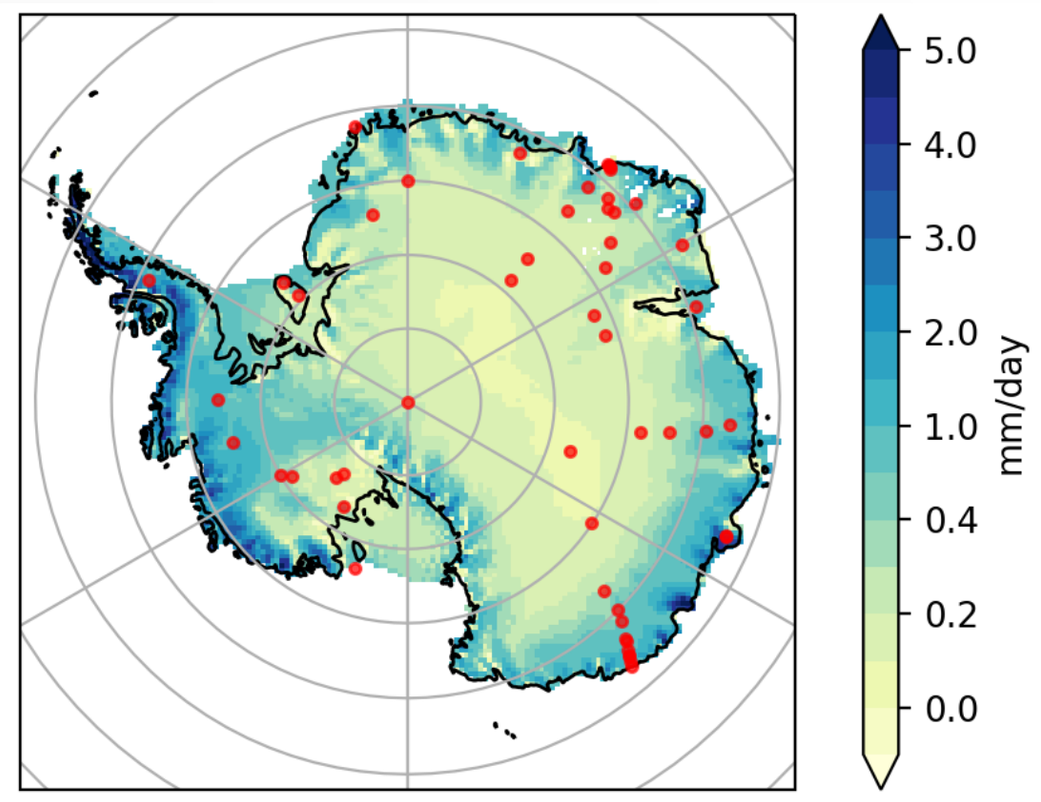


SMB and sublimation

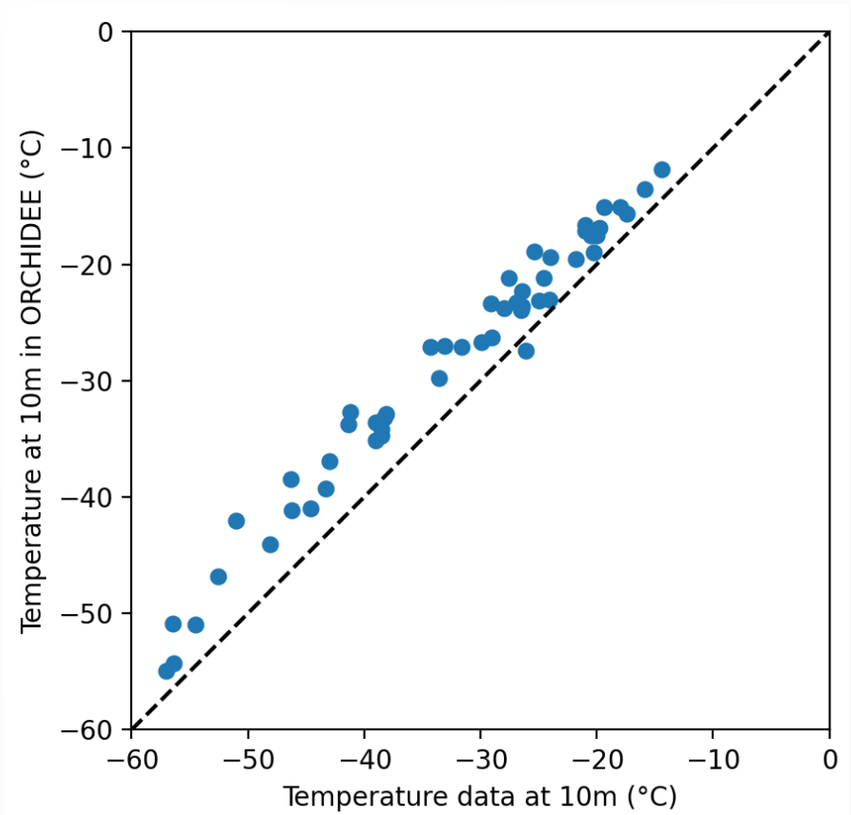


Temperature at 10m

Location of temperature data points



Temperature at 10m : model vs data



Conclusion and perspectives

- ORCHIDEE-ICE in the trunk : flag OK_ICE_SHEET and specific albedo parameters for ice covered surface
- Better runoff with 12 layers snow model
- Good agreement between the SMB computed in ORCHIDEE-ICE and MAR with updated albedo parameters
- Next step : evaluation of snow density and temperature
- Data assimilation on albedo over Greenland and Antarctic ice sheet (Raoult et al 2022)
- Philippe Conesa PhD (S. Charbit & C. Agosta): Improving snow representation to better simulate ice sheet mass balance in the IPSL climate model

Albedo Chalita Le Treut Trunk

albedo_surface.f90

```
! Bare soil use tot_bare_soil_notree
snowa_veg(ipts,ivm,ks) = tot_bare_soil_notree(ipts) / &
     fraction_veg(ipts) * &
     ( snowa_aged_tmp(1,ks)+snowa_dec_tmp(1,ks) * &
     agefunc_veg(ipts) )
```

bare soil albedo depends on tot_bare_soil_notree

L 1855 : Test for loop output if a PFT is not present : veget_max(ipts,ivm) == zero

=> In presence of snow, bare soil albedo may not be calculated whereas tot_bare_soil_notree GT 0.

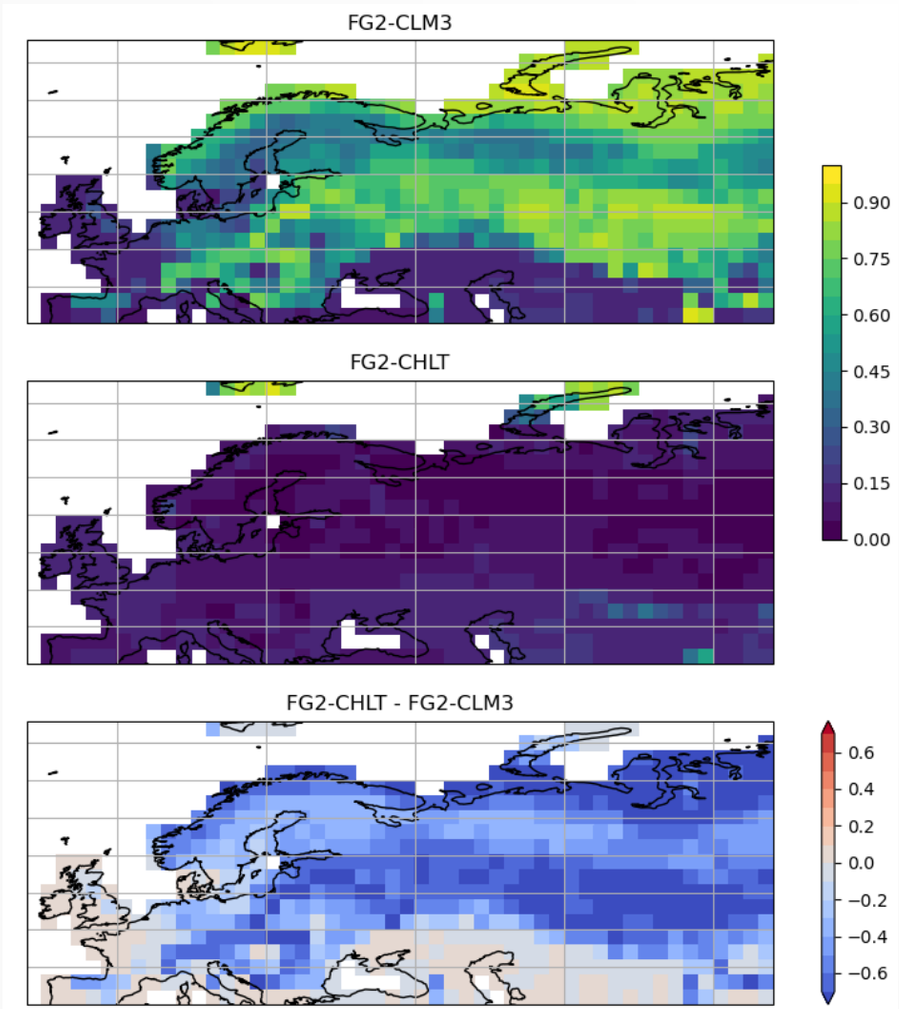
```
!cdc IF(veget_max(ipts,ivm) == zero)THEN
IF((ivm.NE.ibare_sechiba.AND.veget_max(ipts,ivm) == zero) .OR. &
   ( ivm .EQ. ibare_sechiba .AND. tot_bare_soil_notree(ipts) == zero)) THEN
     ! No vegetation or bare soil present, so no reason to do the
     ! calculation
     CYCLE
ENDIF
```

L 683

```
    !cdc bug albedo bare soil
    !   albedo(ipts,ks) = veget_max(ipts,1) * (alb_bare(ipts,ks)*&
    !        (un-frac_snow_veg(ipts)) + &
    !        frac_snow_veg(ipts)*snowa_veg(ipts,1,ks))
    albedo(ipts,ks) = veget_max(ipts,1) * (alb_bare(ipts,ks)*&
         (un-frac_snow_veg(ipts))) + &
         frac_snow_veg(ipts)*snowa_veg(ipts,1,ks)
```

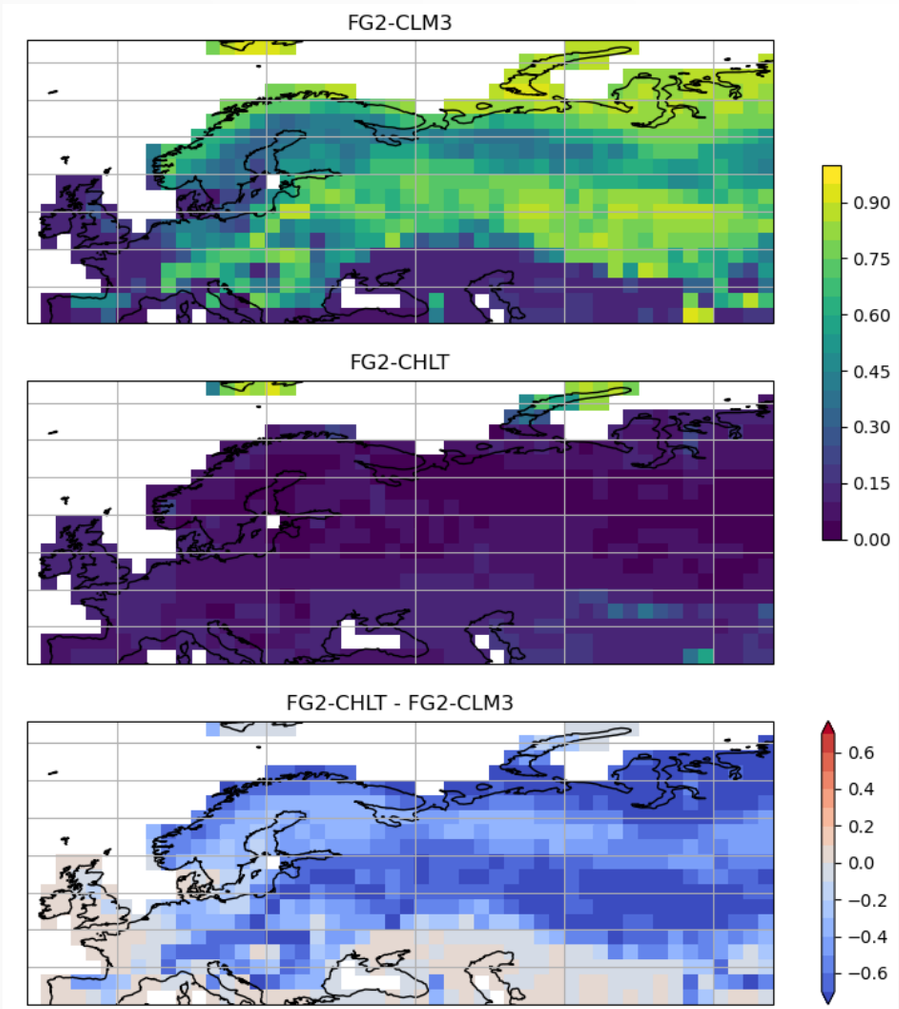
Albedo Chalita Le Treut Trunk

Albedo Trunk in winter

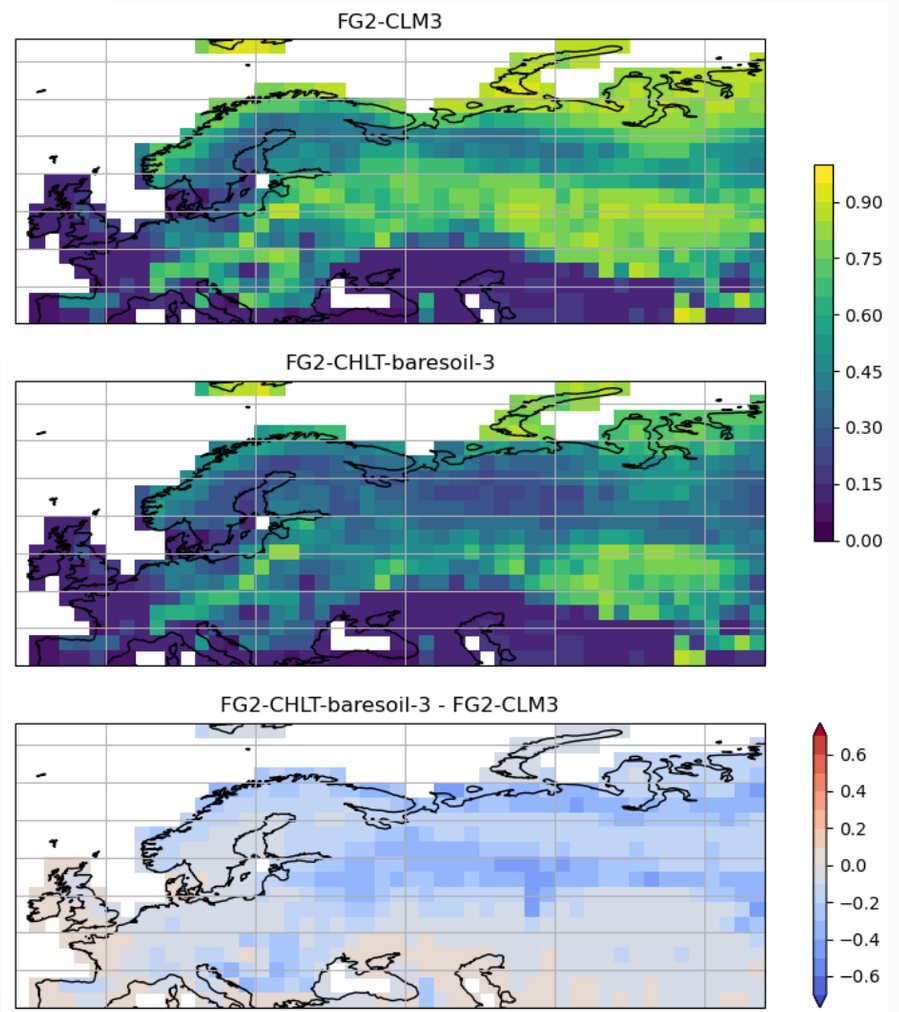


Albedo Chalita Le Treut Trunk

Albedo Trunk in winter : bug in bare soil albedo

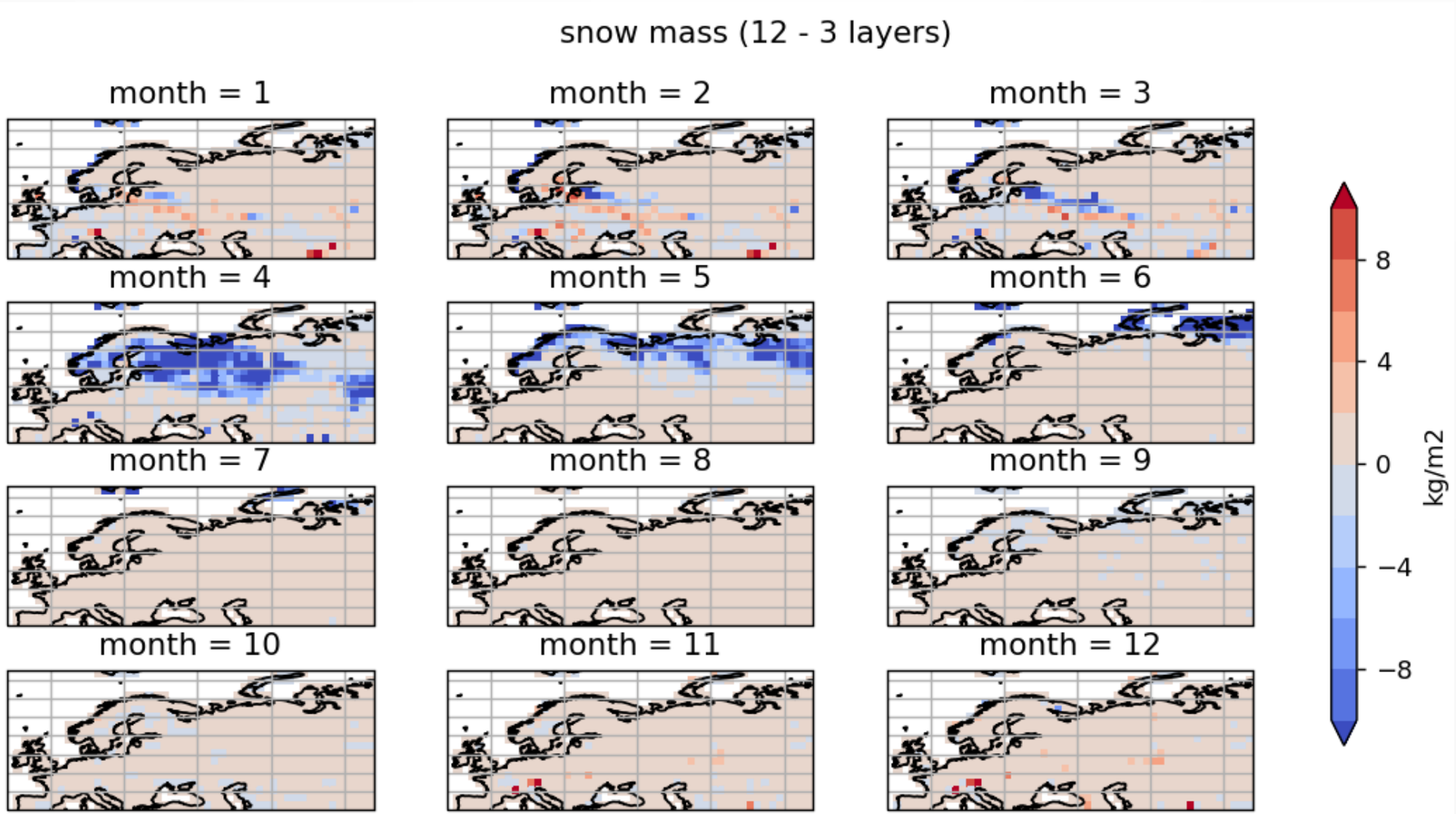


bug-fixed version



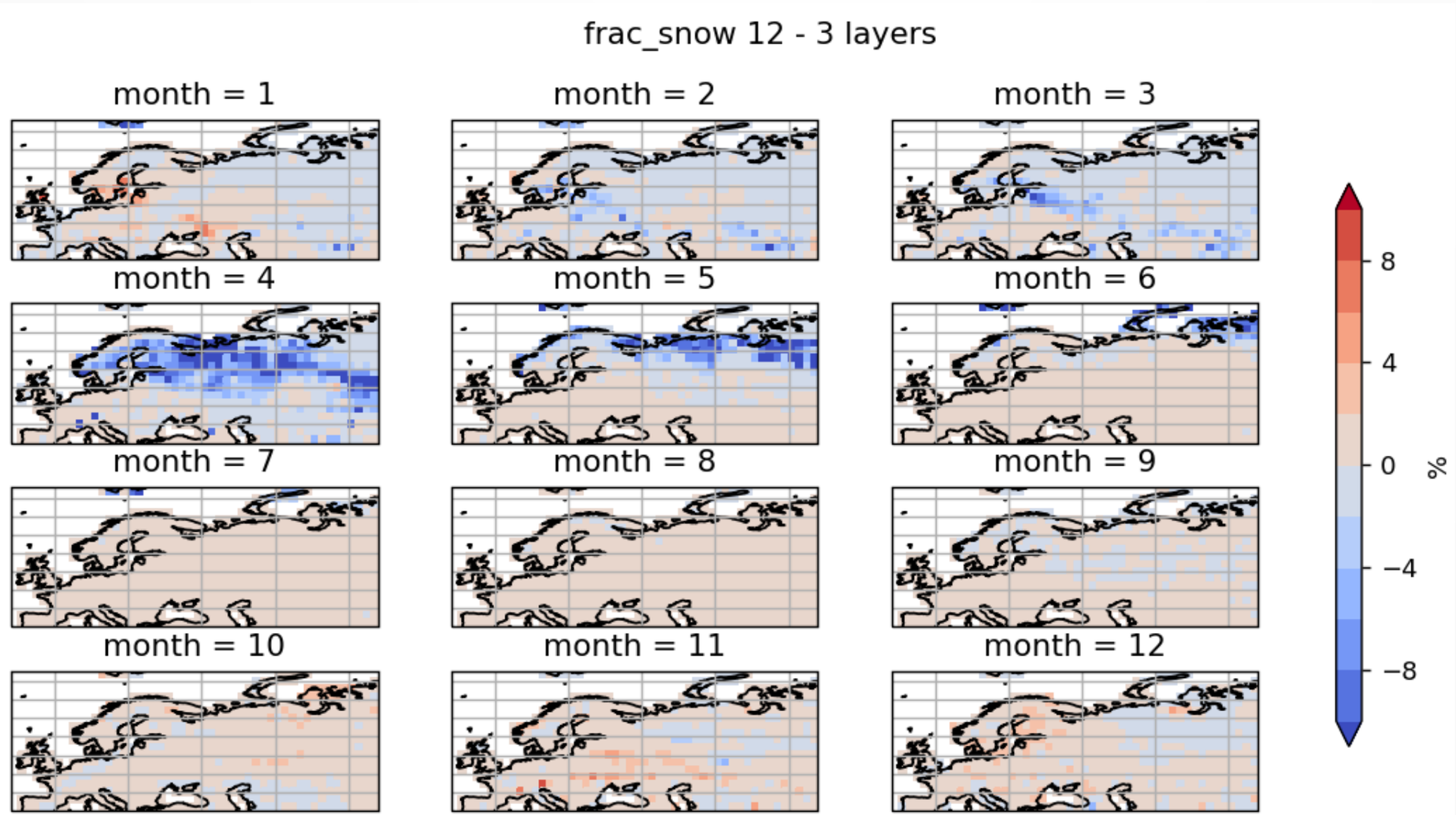
Comparison 3 vs 12 layers : snow mass

Snow mass decreases faster in spring with 12 layers



Comparison 3 vs 12 layers : frac_snow

Snow fraction is very similar except during the spring melting season



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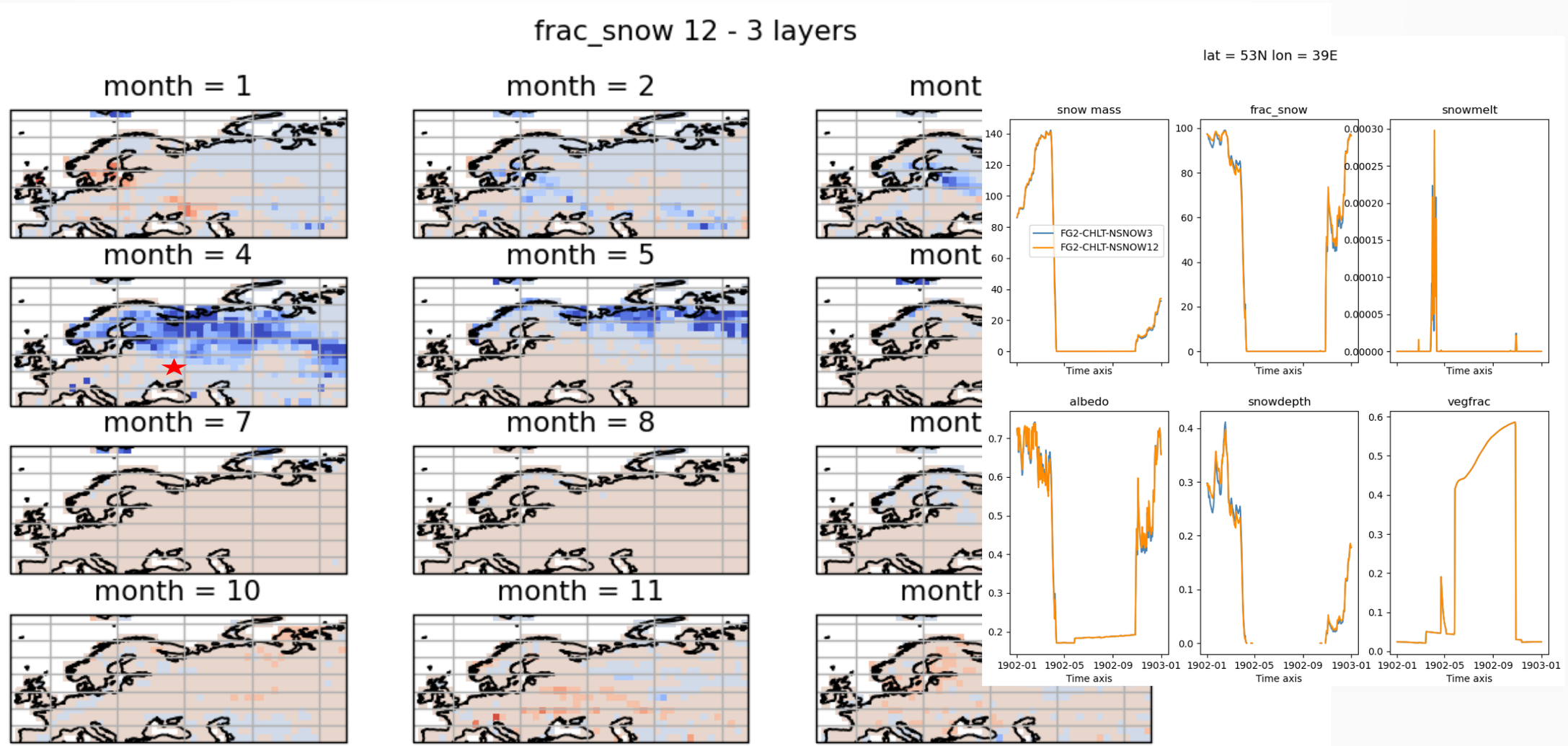

Comparison 3 vs 12 layers : frac_snow

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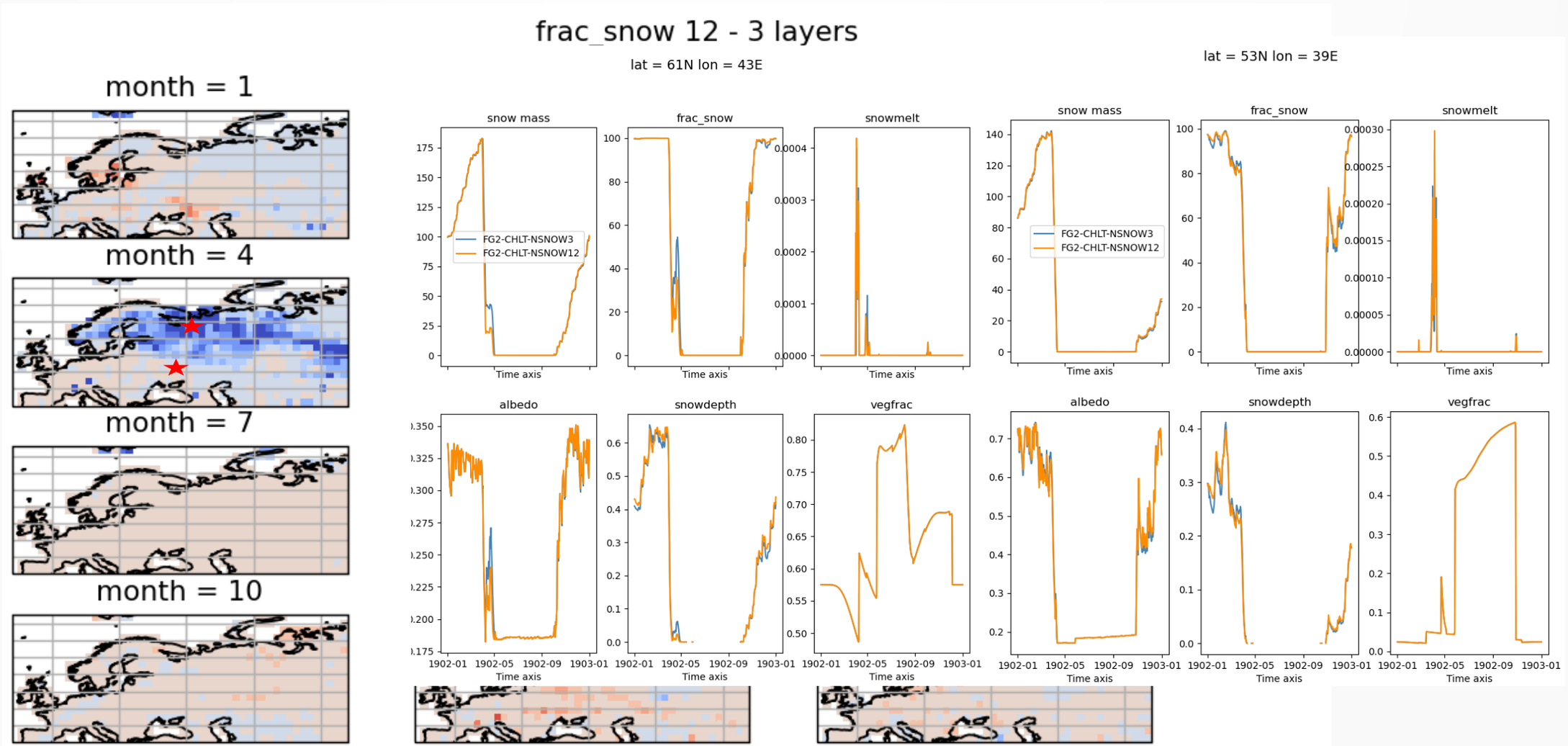
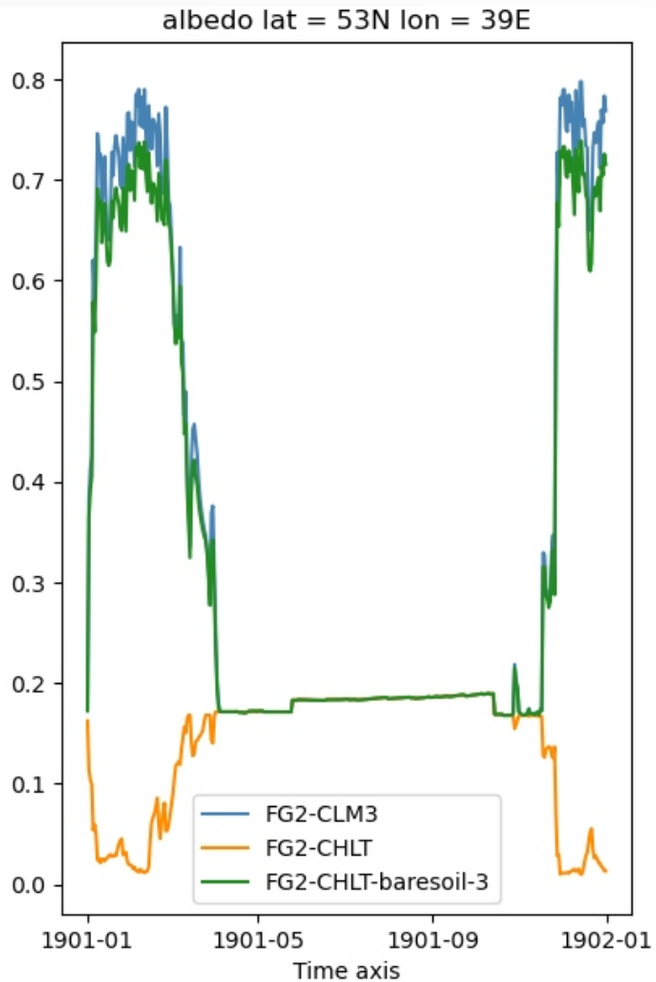
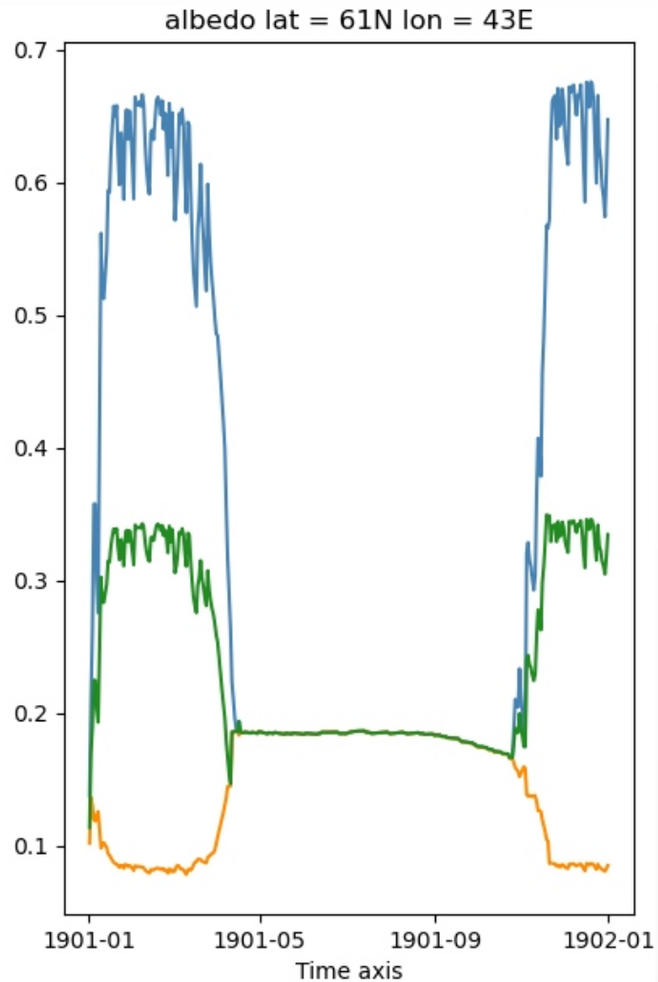


Albedo Chalita Le Treut Trunk

6 % Tree fraction



66 % Tree fraction



Albedo parameters for each PFT need to be re-evaluated with observations:

minimum snow albedo:

snowa_aged_vis, snowa_aged_nir

decay rate of snow albedo:

snowa_dec_vis, snowa_aged_nir