



Paramétrisation de la couverture de neige prenant en compte la variation de topographie sous-maille dans LMDZ/Orchidée

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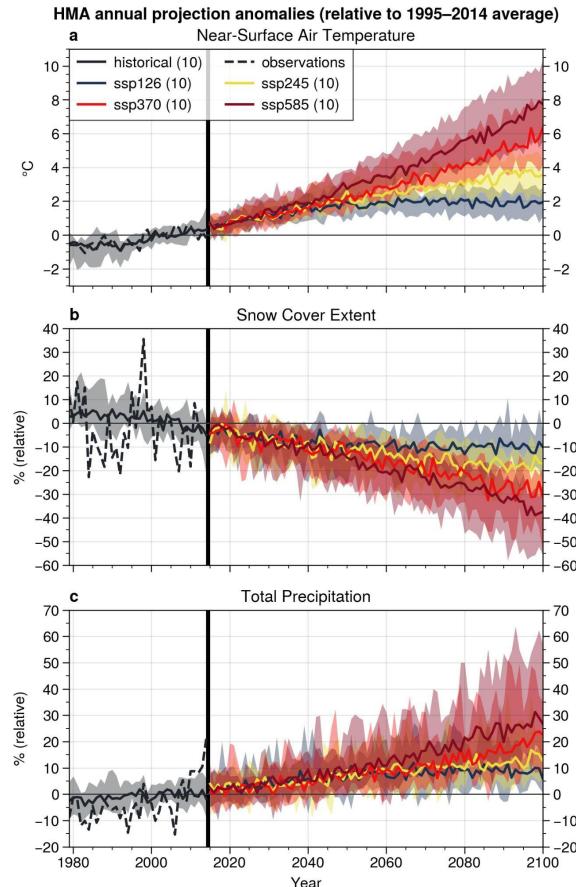
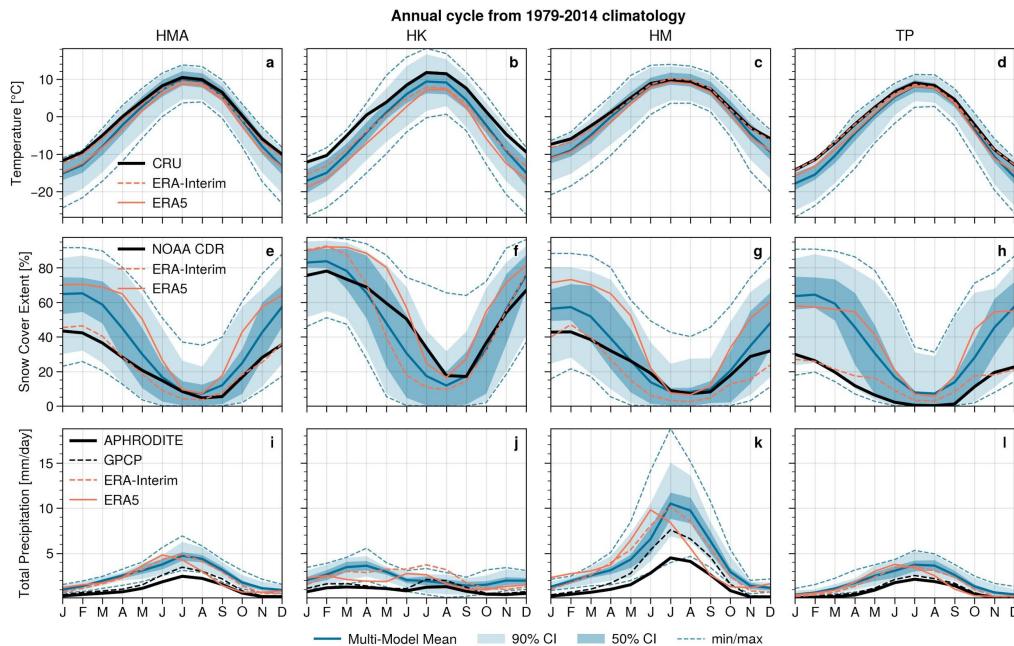
PEDALONS neige — 12/04/2021

Climate change in the High Mountain Asia simulated with CMIP6 models

vEGU21

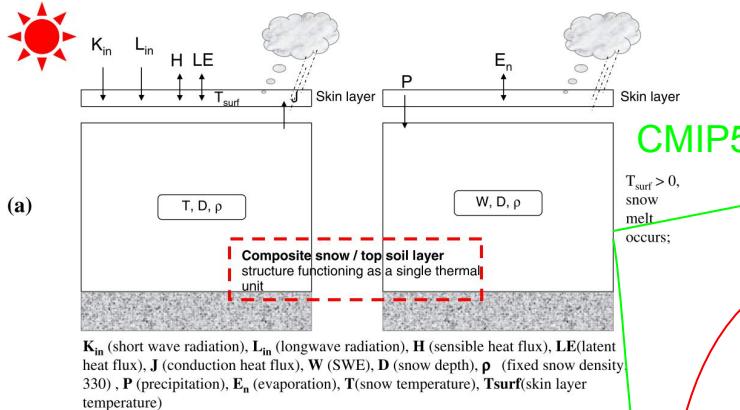
<https://meetingorganizer.copernicus.org/EGU21/EGU21-8365.html>

Tue, 27 Apr 09:00–09:10

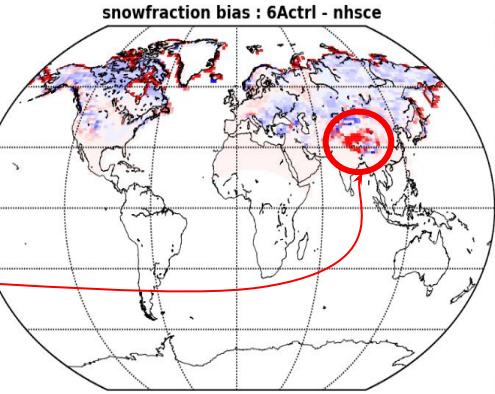
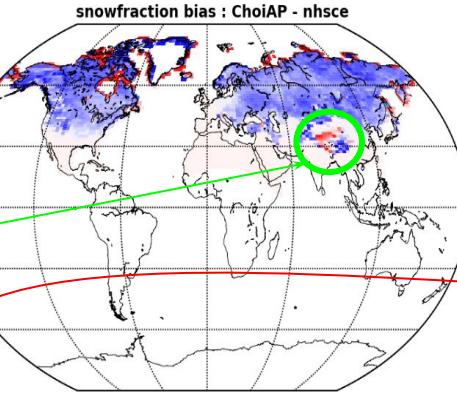


Biais de neige dans le modèle IPSL CMIP5 versus CMIP6

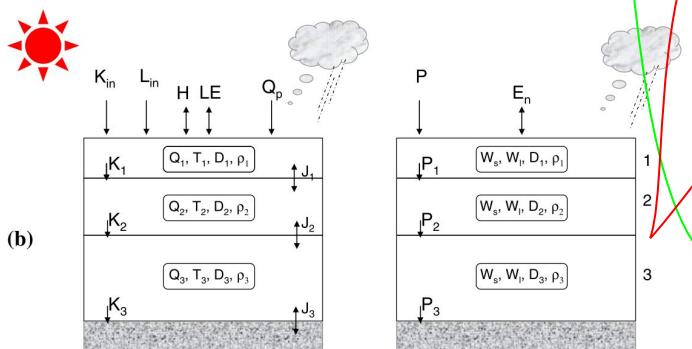
WANG ET AL.: ORCHIDEE SNOW MODEL EVALUATION



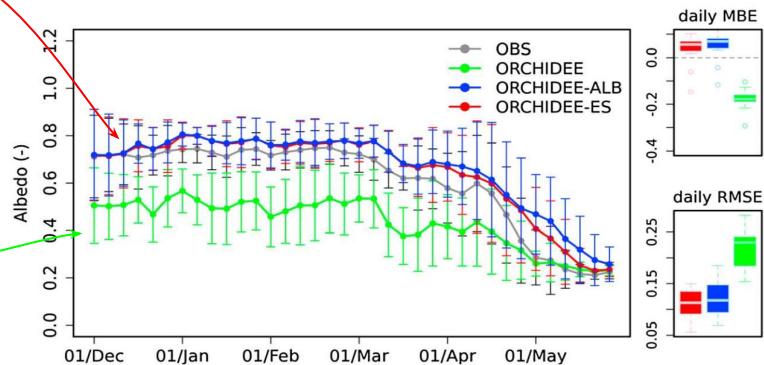
K_{in} (short wave radiation), L_{in} (longwave radiation), H (sensible heat flux), LE (latent heat flux), J (conduction heat flux), W (SWE), D (snow depth), ρ (fixed snow density 330), P (precipitation), E_n (evaporation), T (snow temperature), T_{surf} (skin layer temperature)



Cheruy et al. (2020), Fig. 6



K_{in} (short wave radiation), L_{in} (longwave radiation), H (sensible heat flux), LE (latent heat flux), J (conduction heat flux), Q (snow layer heat content), Q_p (advection heat from rain and snow), W (snow layer SWE), W_s (snow layer liquid water content), D (snow layer depth), ρ (snow layer density), P (precipitation), E_n (evaporation)

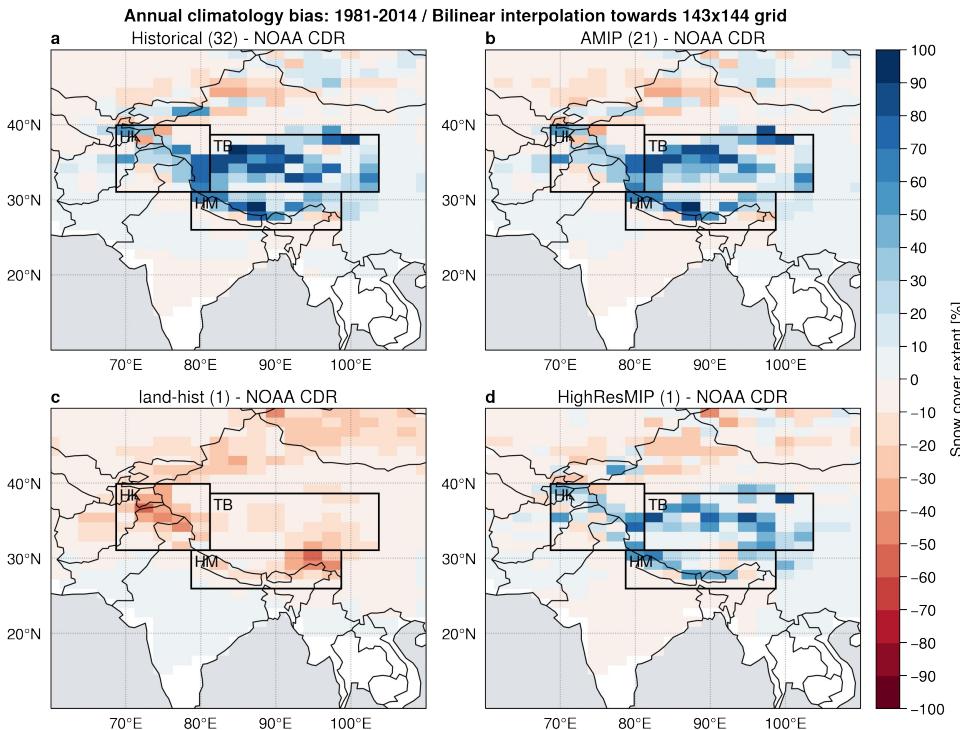


Wang et al. (2013), Fig. 1

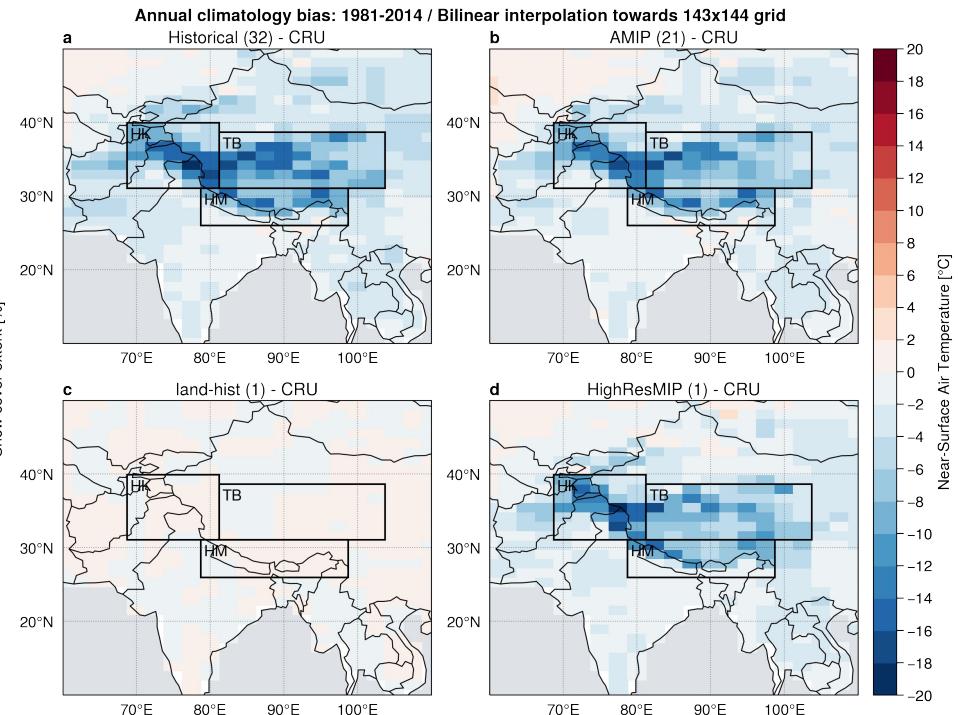
Wang et al. (2013), Fig. 5

IPSL-CM6A-LR: Historical, AMIP, land-hist / IPSL-CM6A-ATM-HR bias

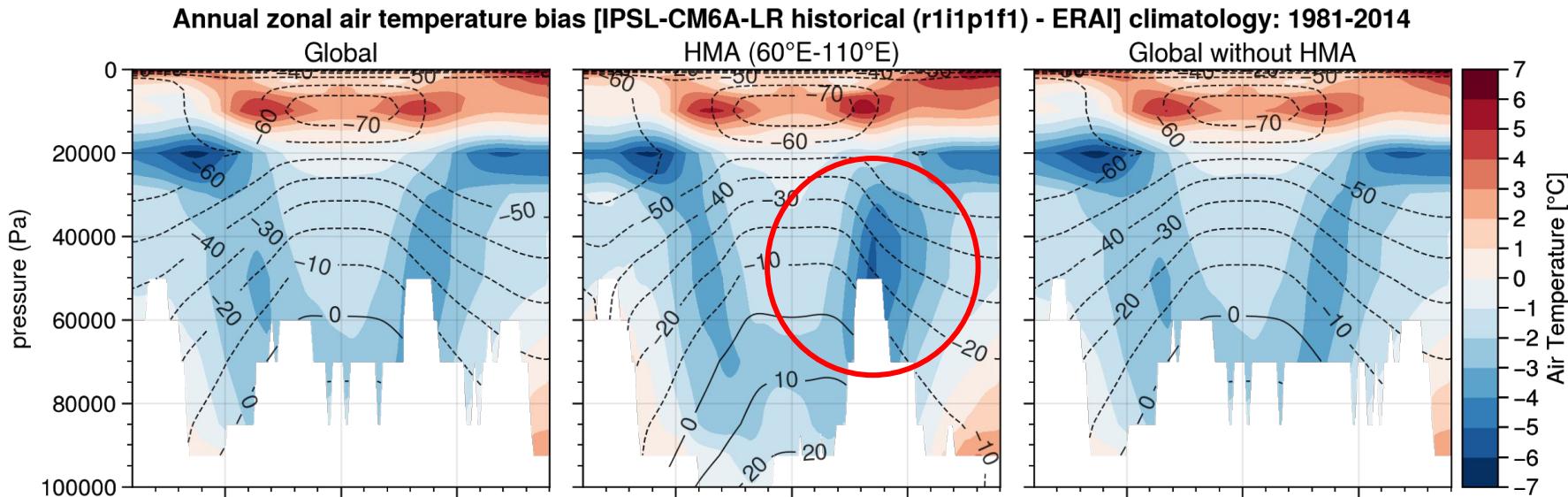
Snow cover bias



Temperature bias



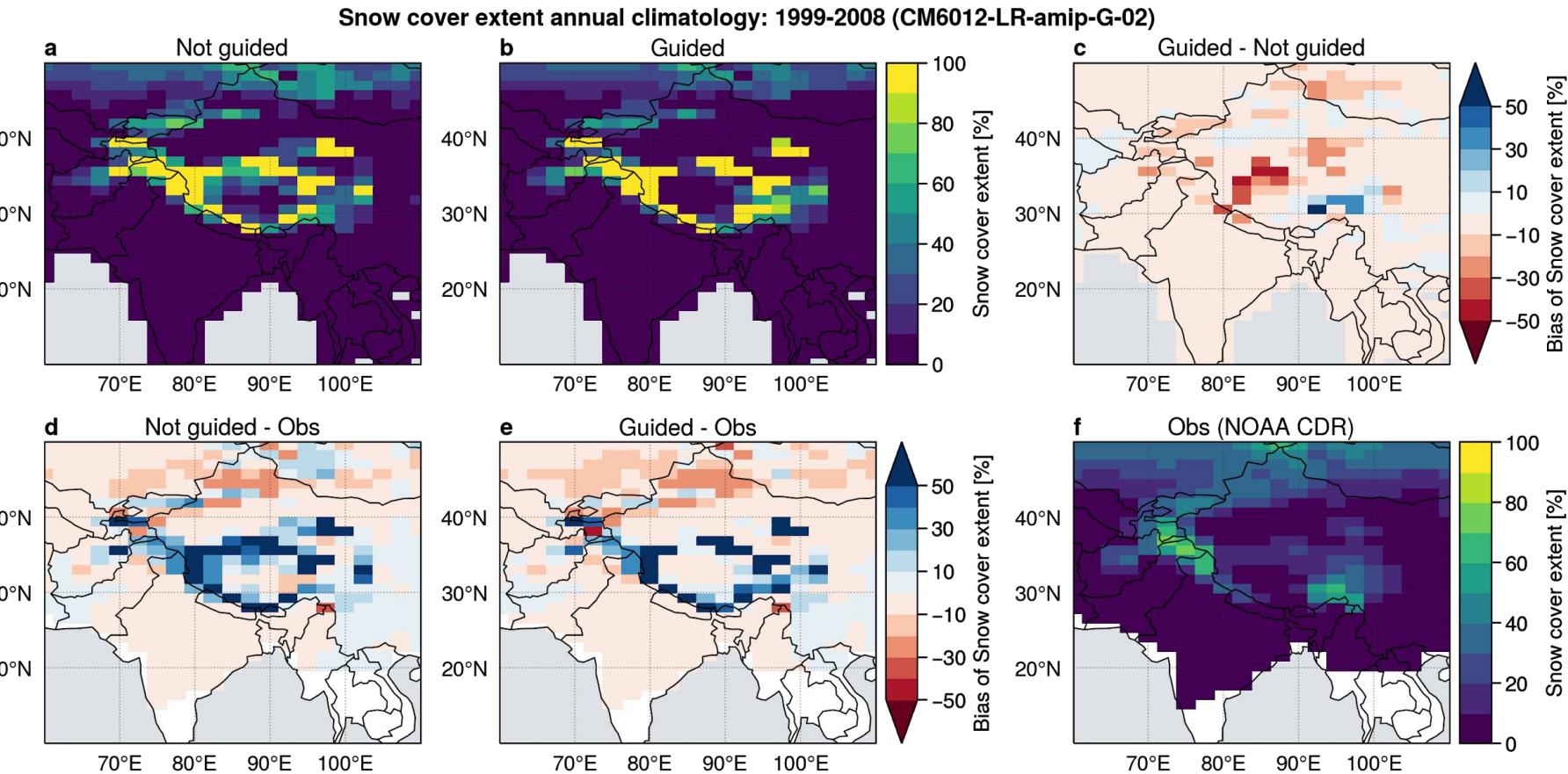
Air Temperature zonal means bias global versus HMA



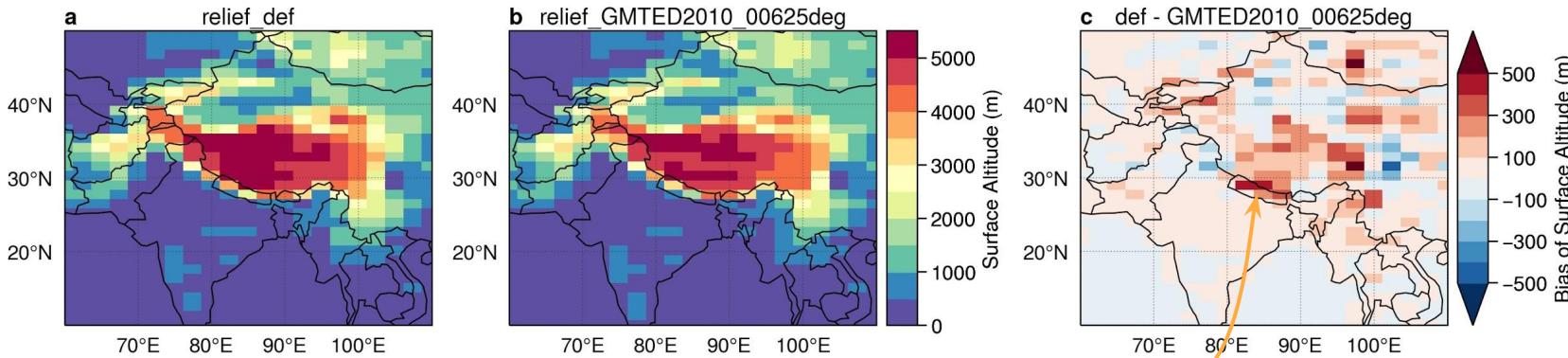
- Cold bias in troposphere and hot bias in stratosphere
- Cold bias of air temperature not restricted to HMA!
- HMA seems to amplify this bias
- The bias is reduced in HighResMIP

Adapted from Boucher et al., Fig. 3 ([2020](#))

Nudged versus not nudged: snow cover* ([tropo bias](#))



Problem with elevation?

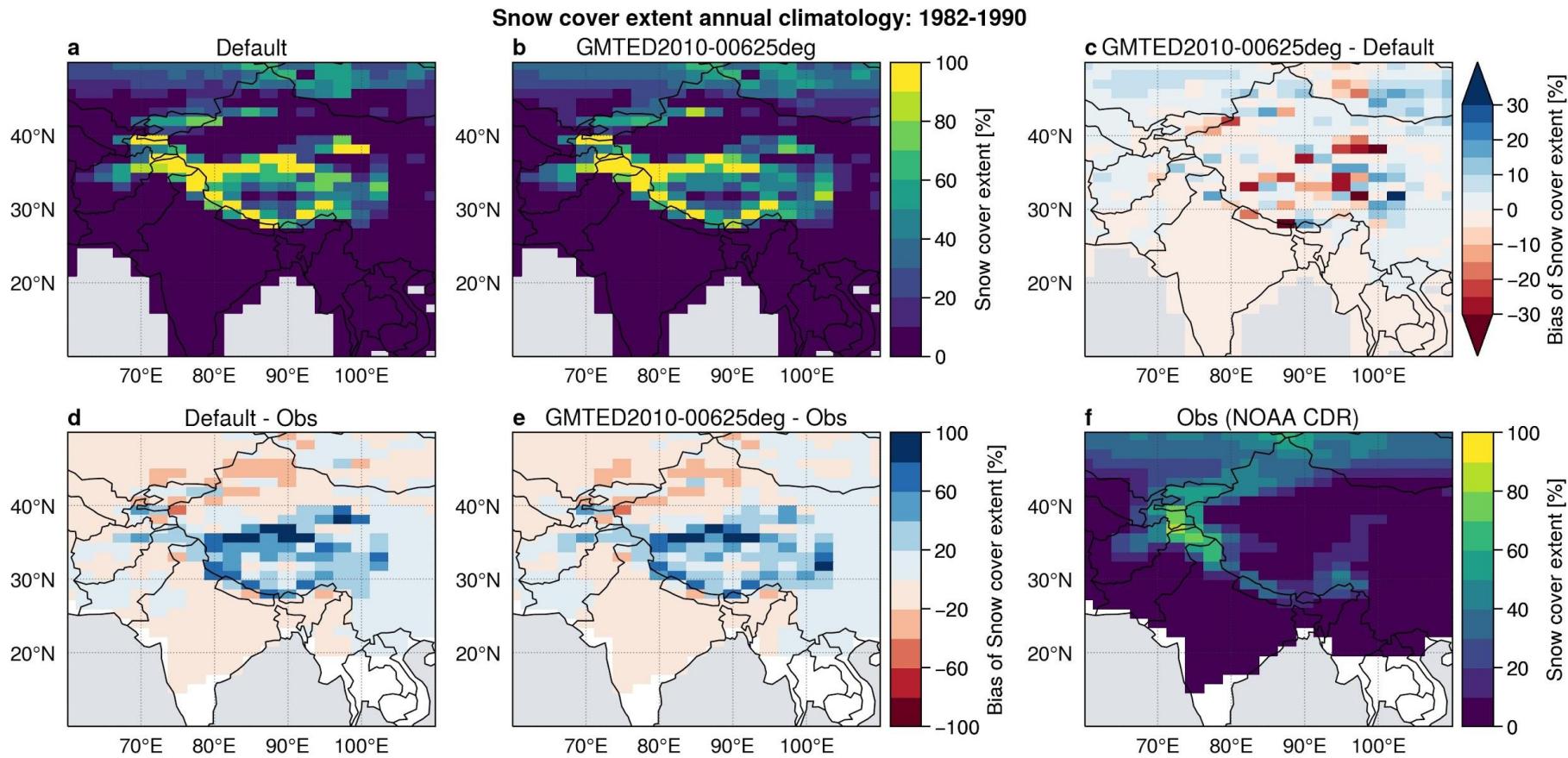


Original file of elevation has more than **500 m differences** locally!

Already targeted in 2018 : <https://lmdz.lmd.jussieu.fr/utilisateurs/reunion-utilisateurs/2018/jlmdz2018-sepulchre.pdf>

→ 2 climatological experiments of 10 years with original and new topography (GMTED2010)

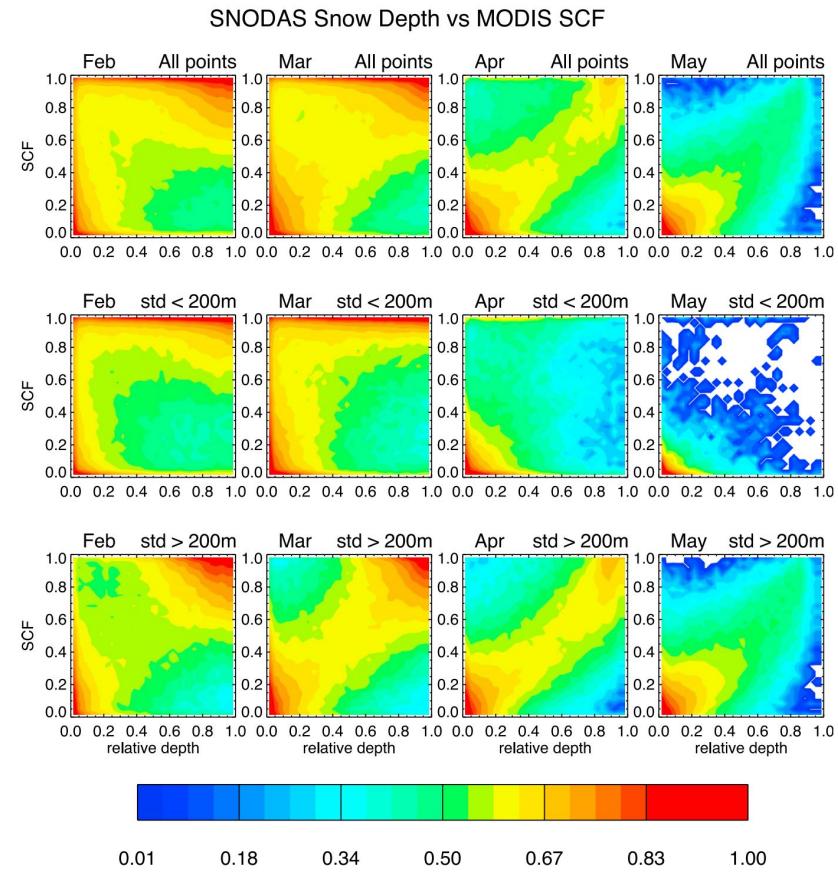
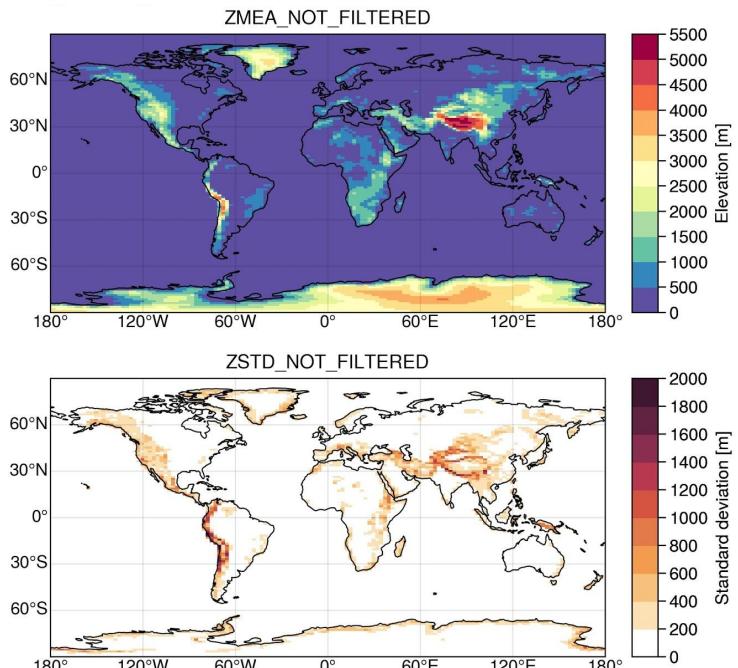
Problem with elevation?



Snow cover in mountainous area

Many other bias source possibles... aerosols, clouds, circulations, etc.

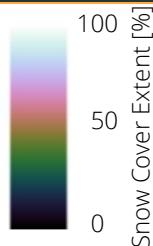
-> but we decided to focus on **topography**



Swenson & Lawrence (2012)

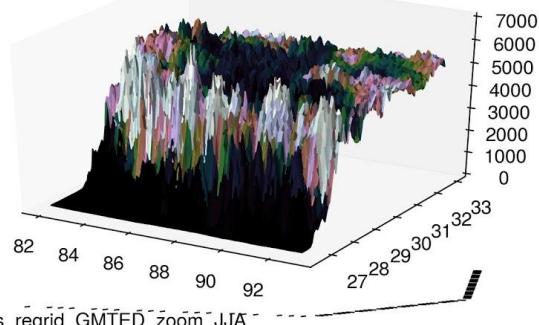
Couverture de neige

1999-2012 climatologies / Observations : [MEaSURES*](#) (25 km de résolution)
Nearest neighbor regrid towards [GMTED2010](#) grid (6km)

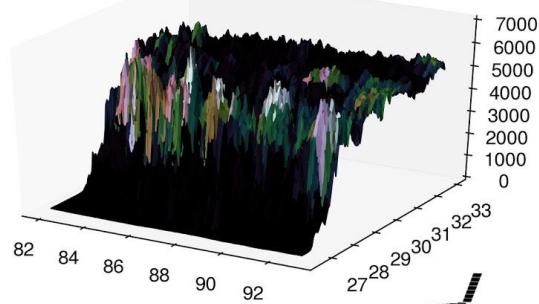


MEaSURES

obs_regrid_GMTED_zoom_DJF

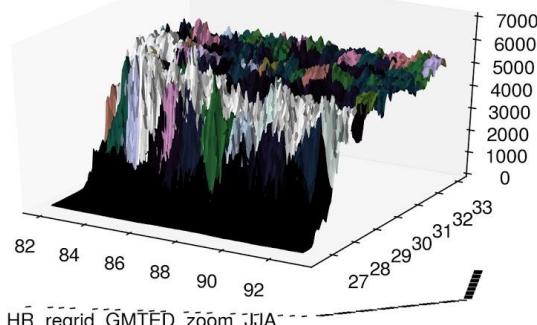


obs_regrid_GMTED_zoom_JJA

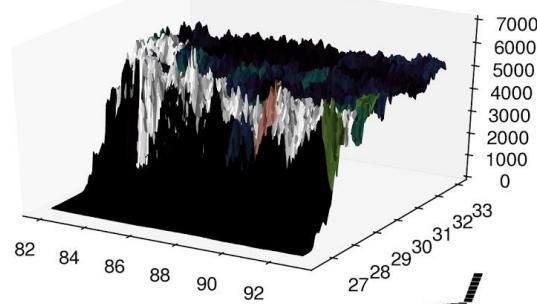


IPSL-CM6A-ATM-HR

da_HR_regrid_GMTED_zoom_DJF

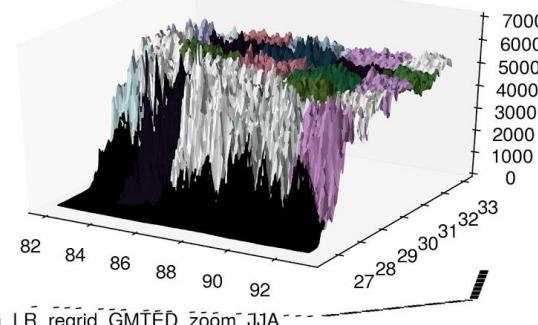


da_HR_regrid_GMTED_zoom_JJA

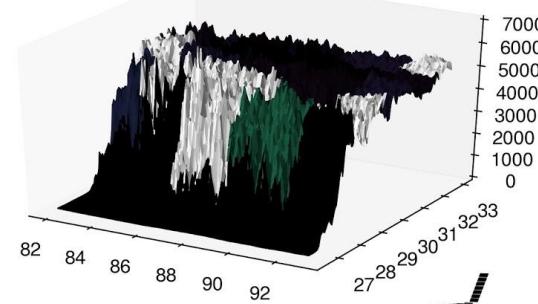


IPSL-CM6A-LR

da_LR_regrid_GMTED_zoom_DJF



da_LR_regrid_GMTED_zoom_JJA



Hiver

Été

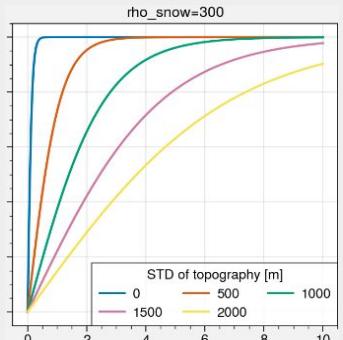
Snow cover parameterizations

Actual version in **Orchidée**: Niu and Yang (2007)

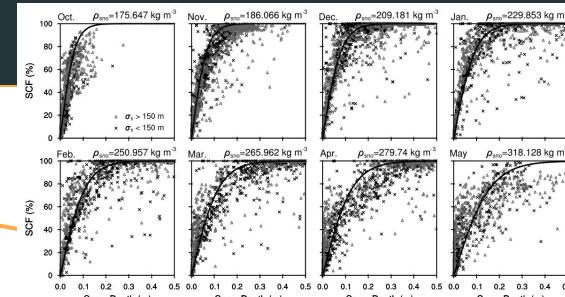
$$F = \tanh\left(\frac{d}{2.5z_{0g}(\rho_{snow}/\rho_{new})^m}\right)$$

Niu and Yang (2007) custom

$$F = \tanh\left(\frac{d}{2.5z_{0g}(\rho_{snow}/\rho_{new})^m}\right)$$



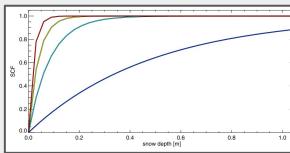
See more: [notebook](#) / [code](#)



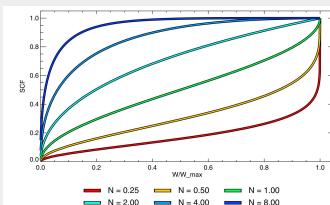
STD impact
not visible
(monthly)

Swenson and Lawrence (2012)

$$F_{N+1} = 1 - (p_{N+1})(p_N) = 1 - (1 - s_{N+1})(1 - F_N)$$



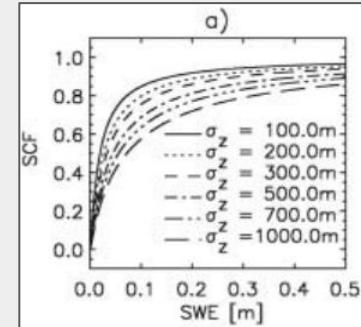
$$F = 1 - \left[\frac{1}{\pi} \arccos\left(2 \frac{W}{W_{max}} - 1 \right) \right]^{N_{melt}}$$
$$N_{melt} = \frac{200}{\sigma_{topo}}$$



See more: [notebook](#) / [code](#)

Roesch et al. (2001)

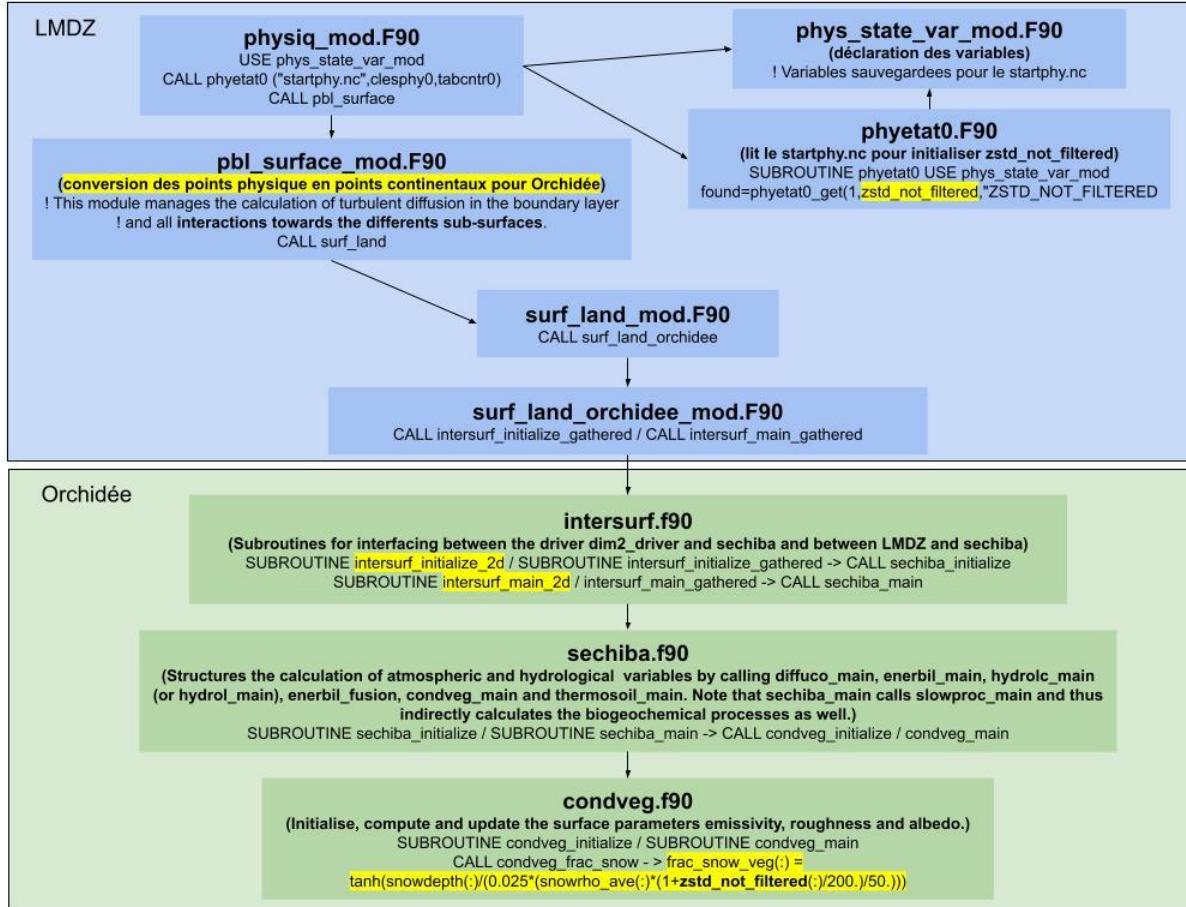
$$f_s = 0.95 \cdot \tanh(100 \cdot S_n) \sqrt{\frac{1000 \cdot S_n}{1000 \cdot S_n + \epsilon + 0.15\sigma_z}}$$



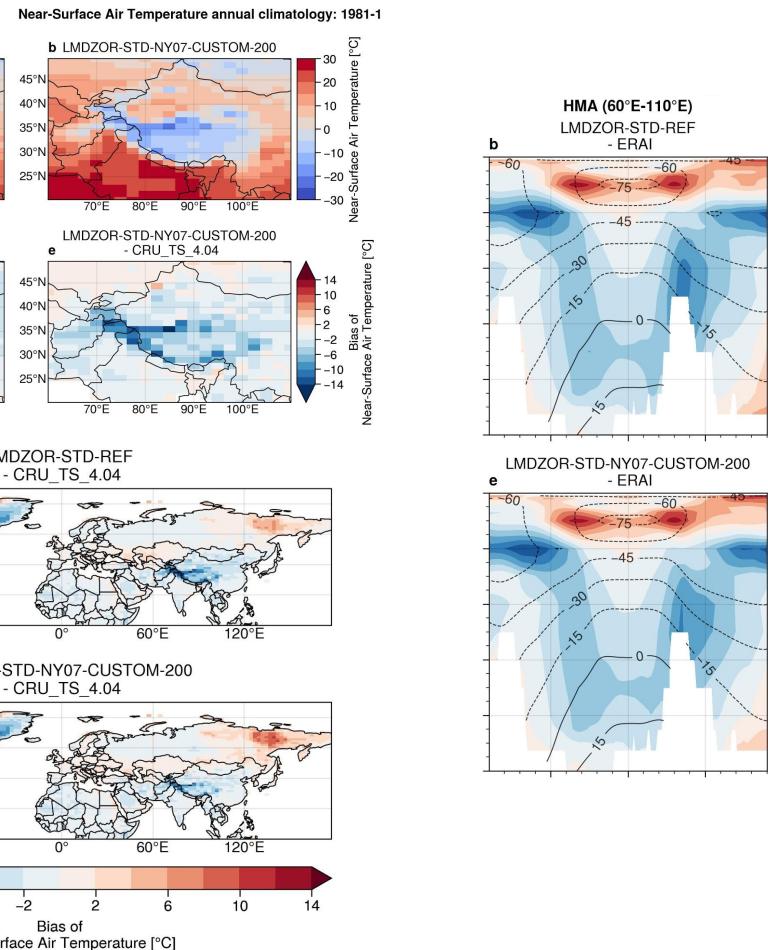
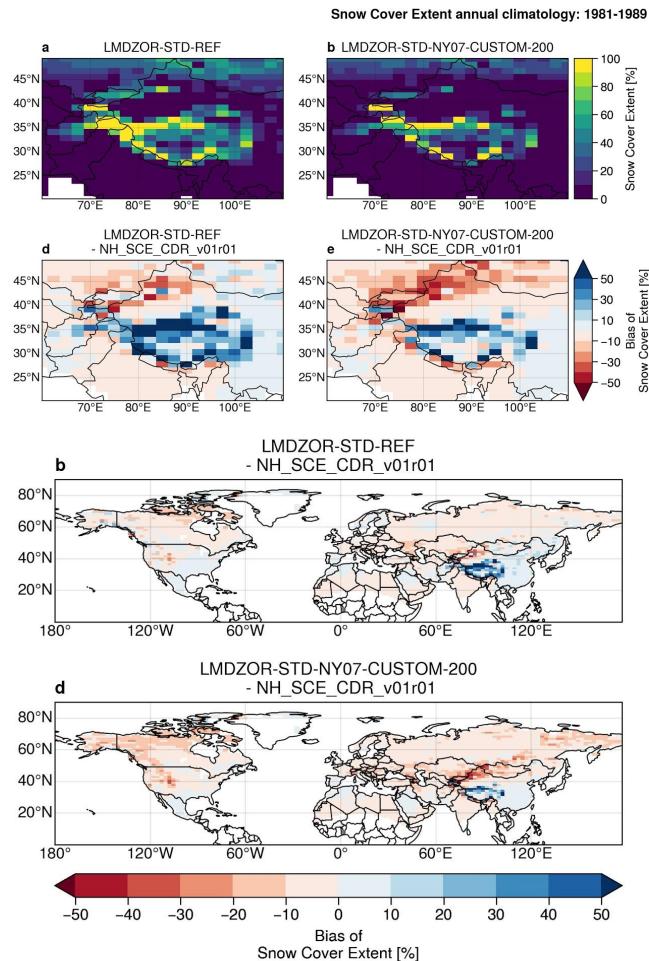
+ vegetation areas (not done)

See more: [notebook](#) / [code](#)

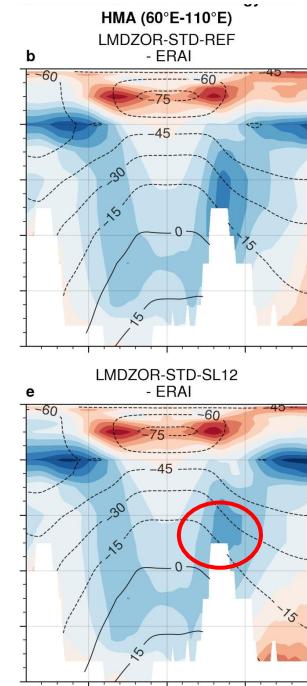
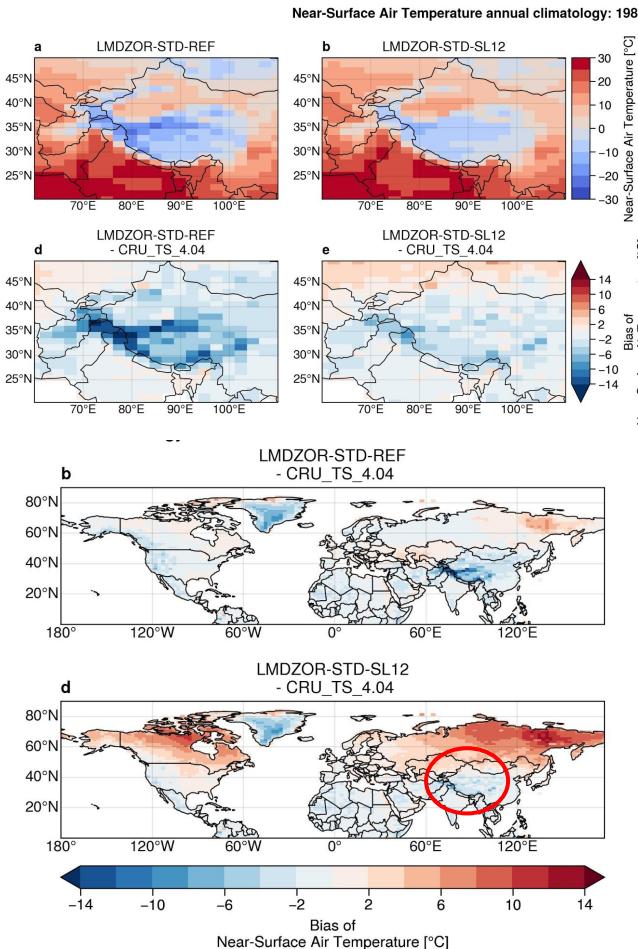
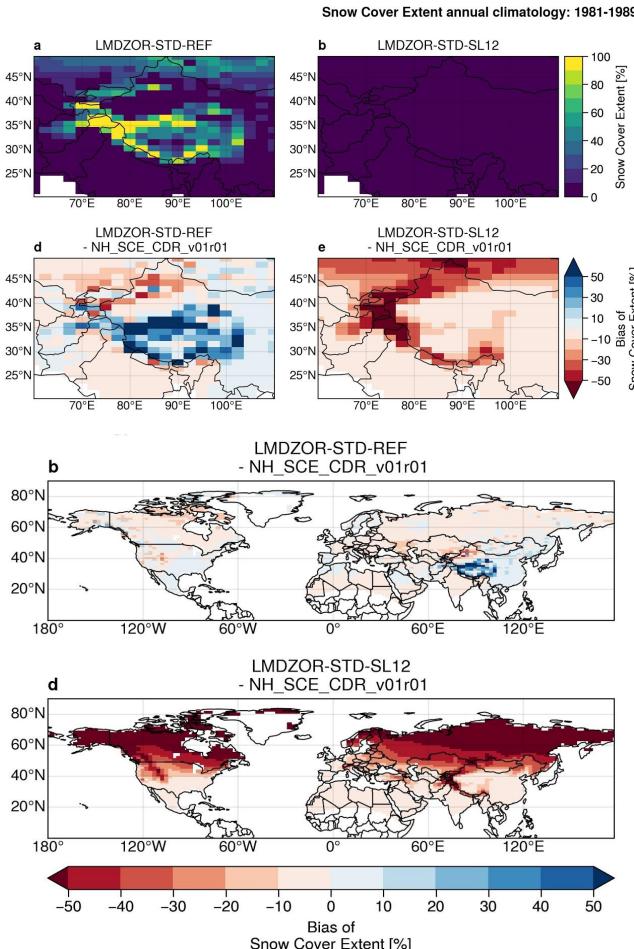
Éléments de code + Google Doc



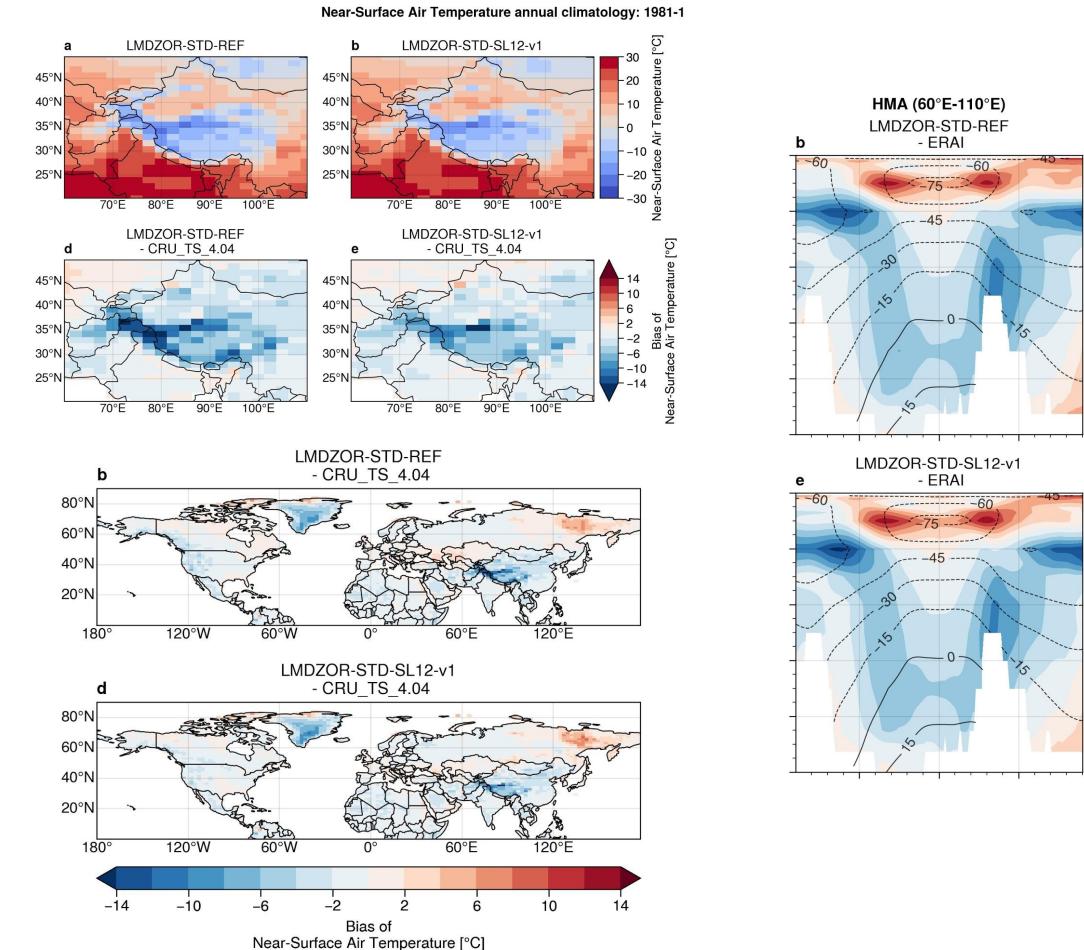
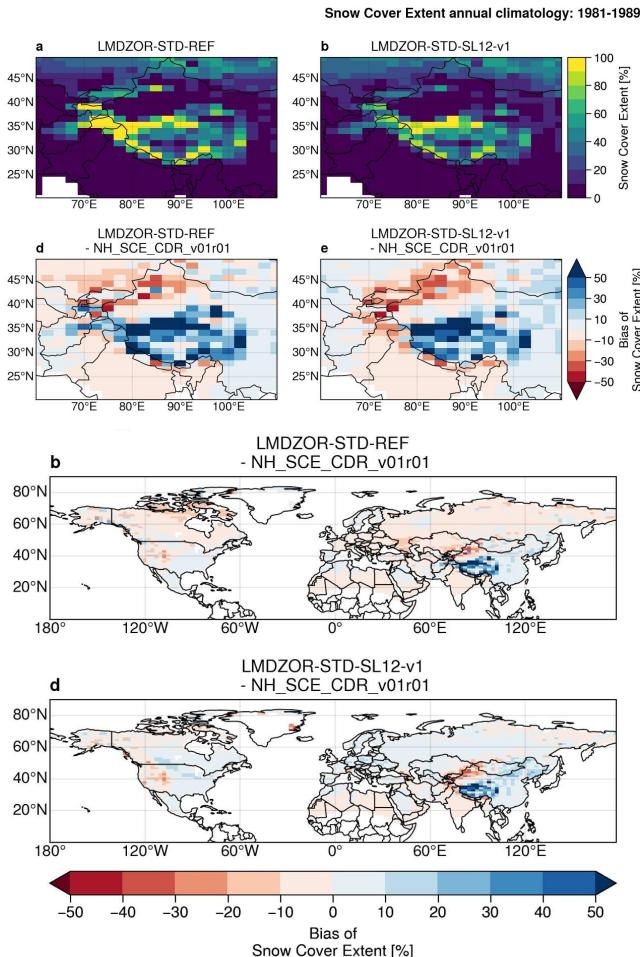
Niu and Yang (2007) custom: [commit](#), [thredds](#)



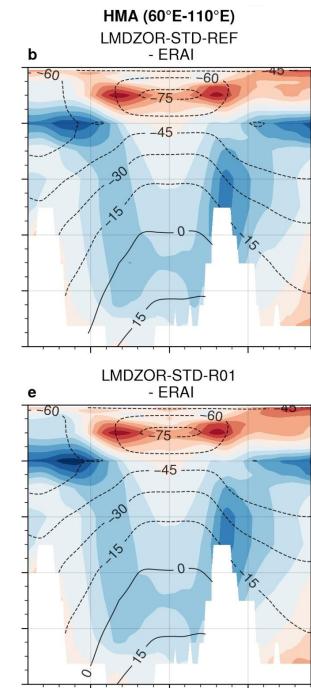
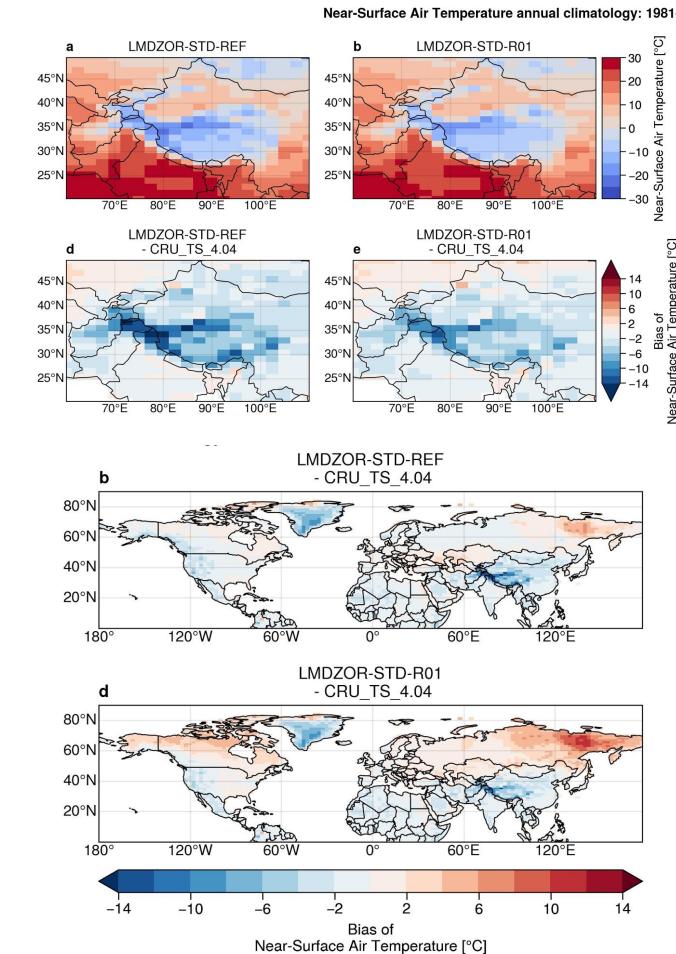
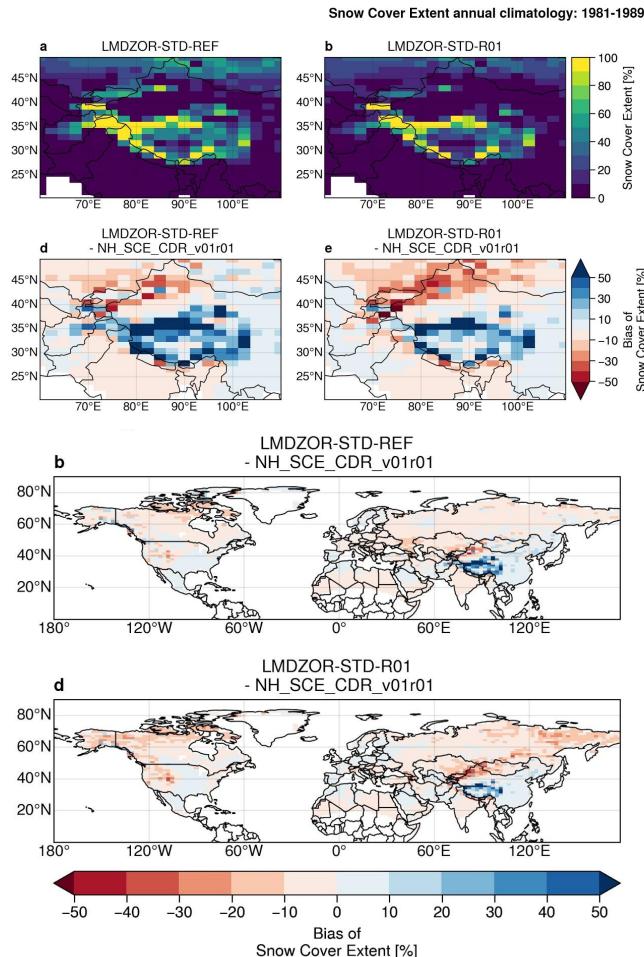
????????? -> no snow: commit, thredds



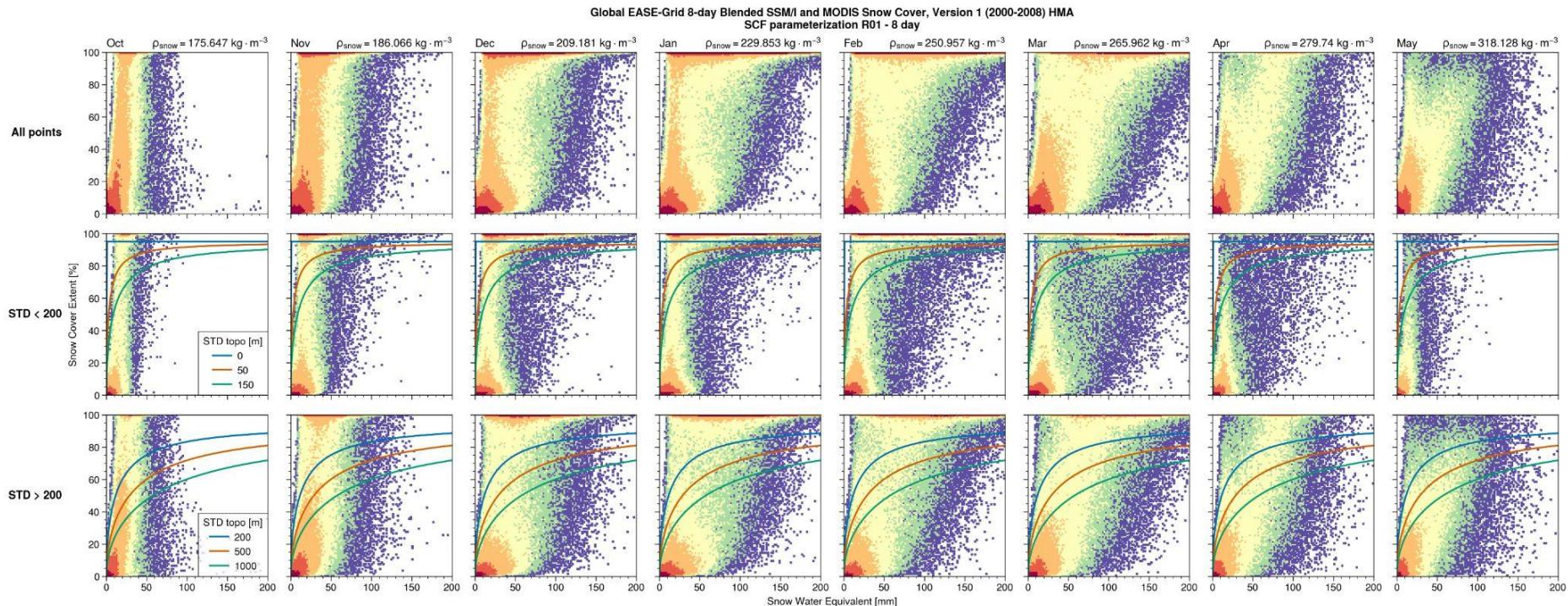
Swenson and Lawrence (2012): commits 1, 2, 3, 4, [thredds](#)



Roesch et al. (2001) without veget: [code](#), [thredds](#)



Comparison to observations (ex: Roesch et al.; see more: [github](#))



Problem : no good quality worldwide SWE/SCE observations!
(mountainous area masked in recent products...)

-> Global EASE-Grid 8-day Blended SSM/I and MODIS Snow Cover, Version 1 (<https://nsidc.org/data/NSIDC-0321/versions/1/>)

Idées de travail

- Caler les courbes par rapport aux obs (même si pas top)
- Peut-être rester sur la formule originale d'Orchidée modifiée et pourquoi pas Swenson (mais galère à implémenter et vérifier l'intérêt d'une formule d'accu et de fonte...)
- Puis faire de la validation en guidée (car le biais dans la tropo fausse complètement les résultats) mais rester en couplé AMIP pour laisser la couverture de neige "s'exprimer"
- Puis faire du zoomé guidé pour voir si cela fonctionne également à meilleure résolution
- Ajouter d'autre paramètres que seulement la STD de la topo (altitude isotherme ? autre ?)
- On ne s'attend typiquement pas à résoudre tous les biais dans cette zone mais au moins mieux représenter la couverture de neige (autre problèmes: aérosols, couche limite, etc.)

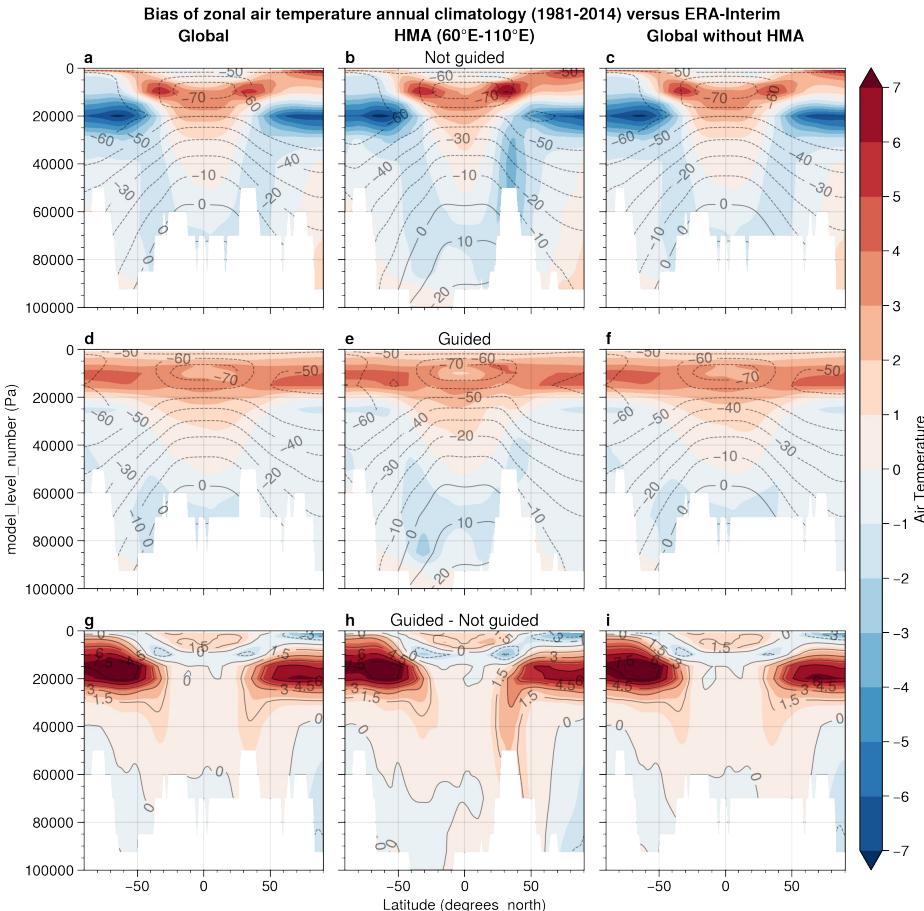
Bibliographie

References

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- Roesch, A., Wild, M., Gilgen, H., & Ohmura, A. (2001). A new snow cover fraction parametrization for the ECHAM4 GCM. *Climate Dynamics*, 17(12), 933–946. <https://doi.org/10.1007/s003820100153>
- Swenson, S. C., & Lawrence, D. M. (2012). A new fractional snow-covered area parameterization for the Community Land Model and its effect on the surface energy balance. *Journal of Geophysical Research: Atmospheres*, 117(D21), n/a-n/a. <https://doi.org/10.1029/2012JD018178>
- WALLAND, D. J., & SIMMONDS, I. (1996). SUB-GRID-SCALE TOPOGRAPHY AND THE SIMULATION OF NORTHERN HEMISPHERE SNOW COVER. *International Journal of Climatology*, 16(9), 961–982.
<http://doi.wiley.com/10.1002/%28SICI%291097-0088%28199609%2916%3A9%3C961%3A%3AAID-IOC72%3E3.0.CO%3B2-R>
- Wang, T., Ottlé, C., Boone, A., Ciais, P., Brun, E., Morin, S., ... Peng, S. (2013). Evaluation of an improved intermediate complexity snow scheme in the ORCHIDEE land surface model. *Journal of Geophysical Research: Atmospheres*, 118(12), 6064–6079.
<https://doi.org/10.1002/jgrd.50395>

Slides complémentaires

Nudged versus not nudged

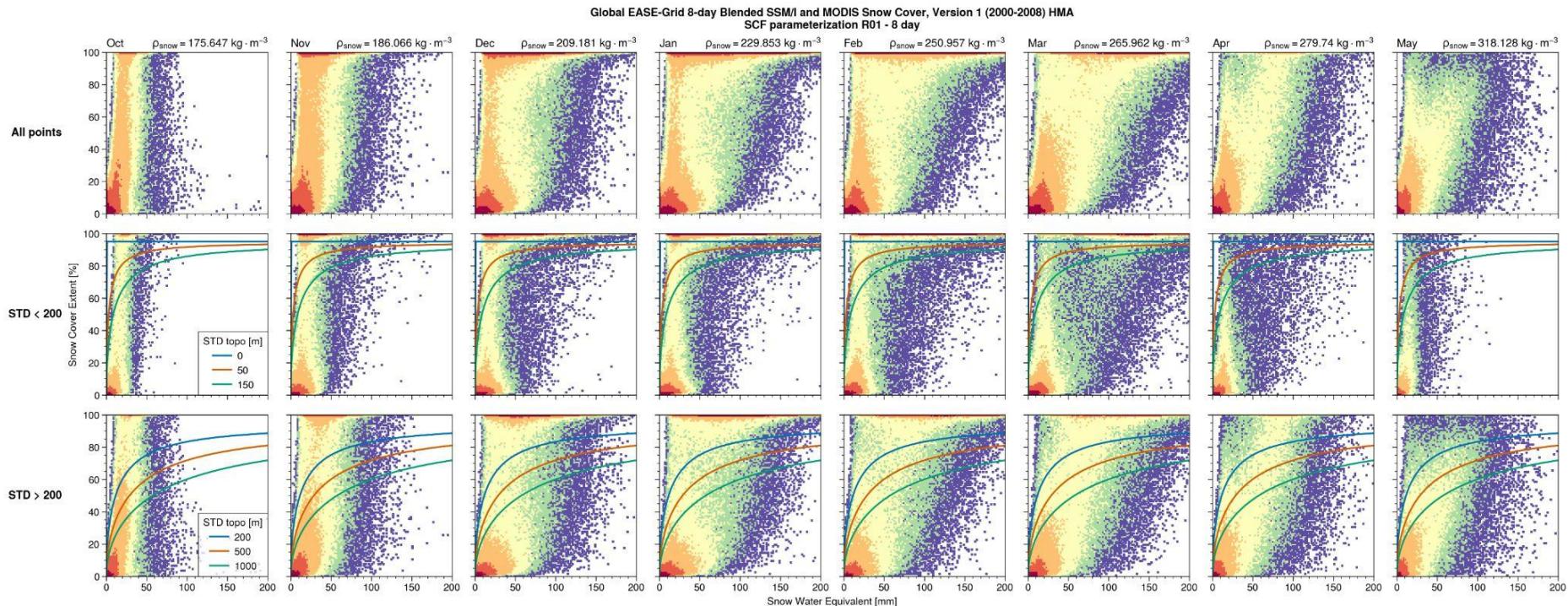


More:

<https://docs.google.com/document/d/1SpHVviaGEyB9KObkC4U2hC-qraRfaE-ojLayZcDGPU/edit?usp=sharing>

[Back](#)

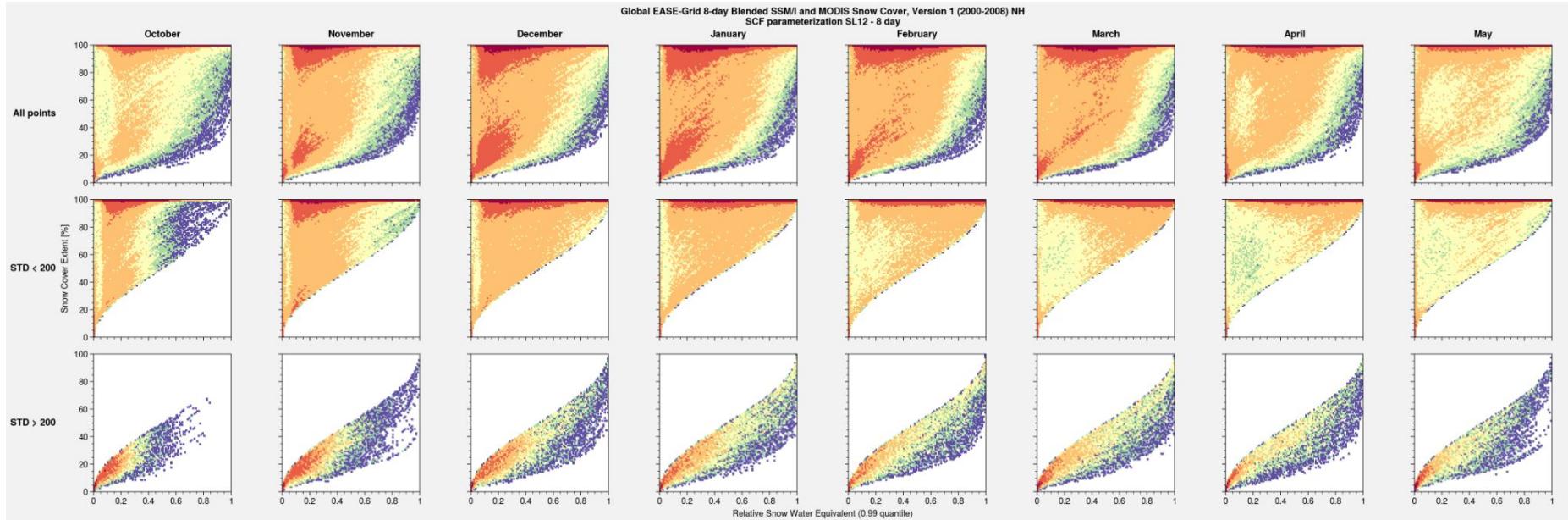
Comparison to observations (ex: Roesch et al.; see more: [github](#))



Problem : no good quality worldwide SWE/SCE observations!
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-> Global EASE-Grid 8-day Blended SSM/I and MODIS Snow Cover, Version 1 (<https://nsidc.org/data/NSIDC-0321/versions/1/>)

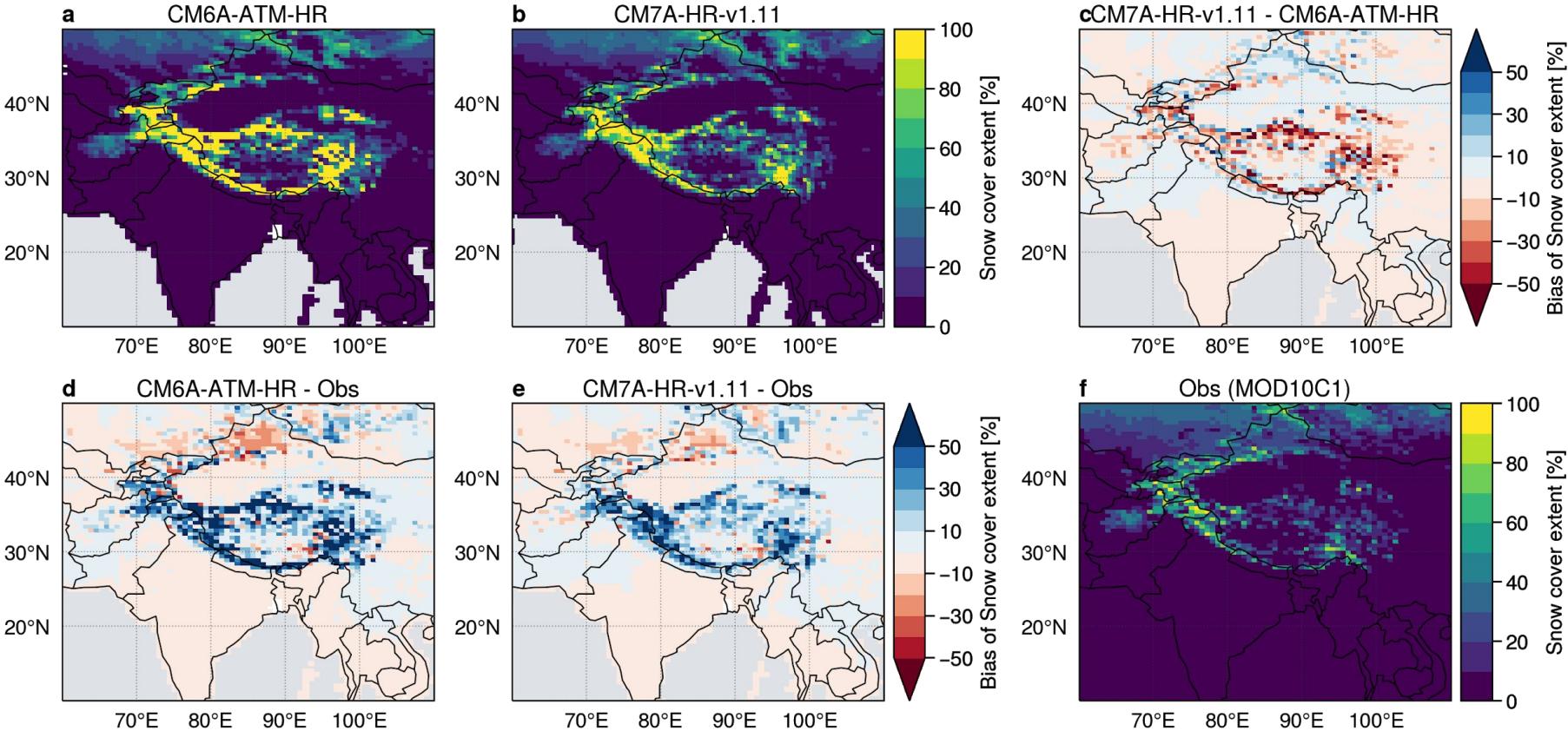
Swenson and Lawrence (2012) “theoric” depletion curves (see more: [github](#))



A voir dans le modèle avec la courbe d'accu

Dynamico versus HighResMIP: snow cover*

Snow cover extent annual climatology: 2001-2014



Éléments de code

Albedo

- <https://orchidas.lsce.ipsl.fr/dev/albedo/>

Code Orchidée

- http://forge.ipsl.jussieu.fr/orchidee/browser/branches/ORCHIDEE_2_2/ORCHIDEE/src_sechiba/explicitsnow.f90
- http://forge.ipsl.jussieu.fr/orchidee/browser/branches/ORCHIDEE_2_2/ORCHIDEE/src_sechiba/condveg.f90
- http://forge.ipsl.jussieu.fr/orchidee/browser/branches/ORCHIDEE_2_2/ORCHIDEE/src_sechiba/enerbil.f90

*"An independent hydrological budget is calculated for each soil tile, to prevent forests from exhausting all soil moisture. In contrast, **only one energy budget (and snow budget) is calculated for the whole grid cell.**"*

Boucher et al. (2020)

Code LMDZ topography

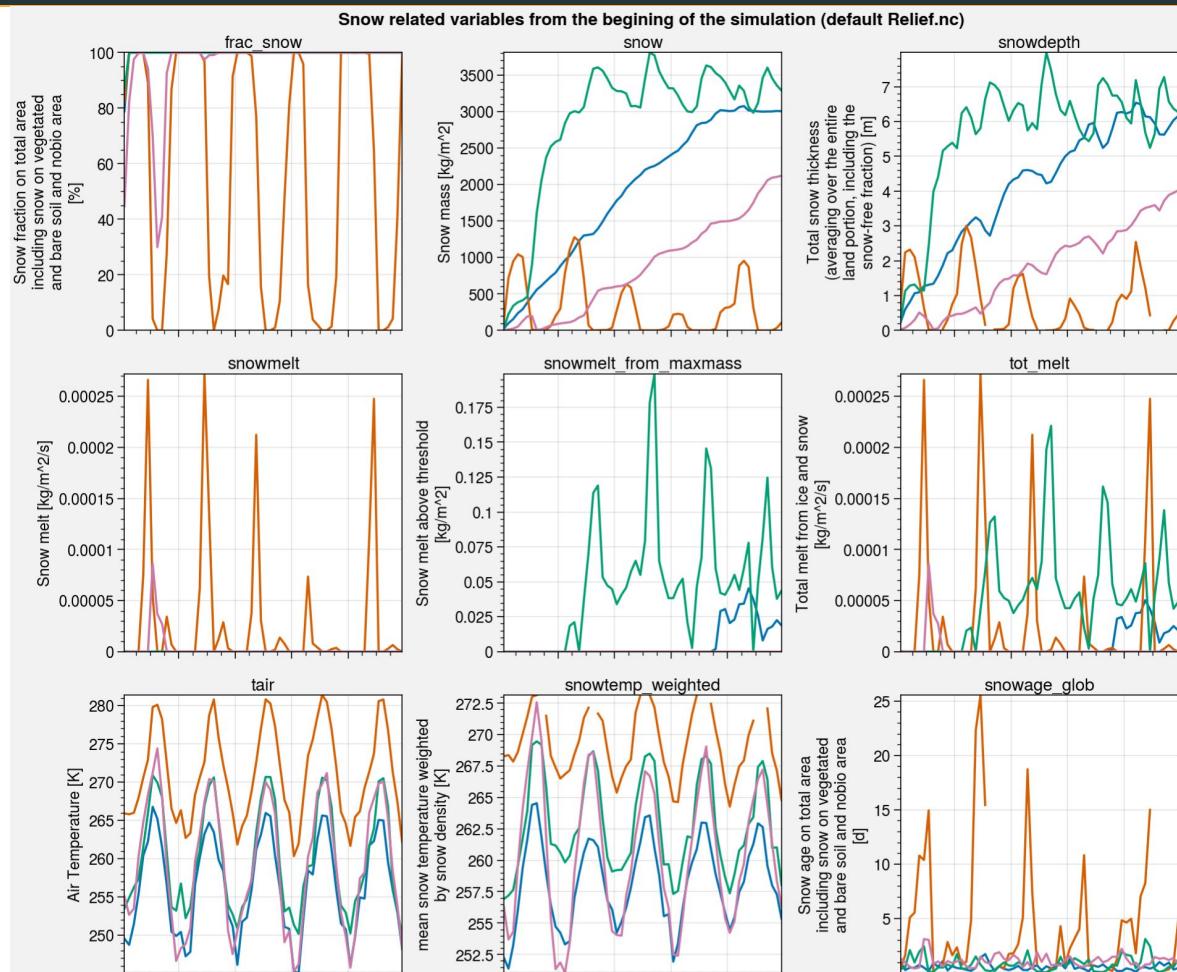
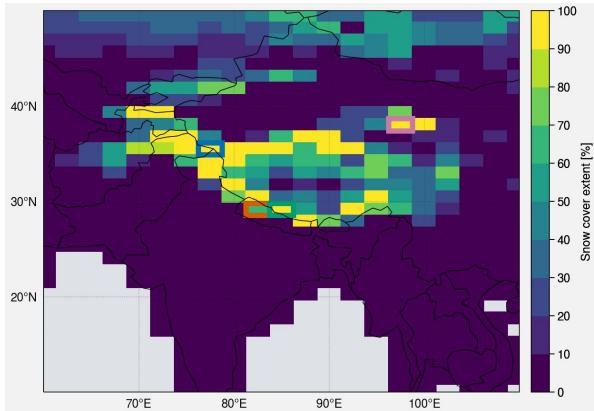
- http://trac.lmd.jussieu.fr/LMDZ/browser/LMDZ6/trunk/libf/phylmd/grid_noro_m.F90

```
REAL, INTENT(OUT) :: zmea(:,:) !--- MEAN OROGRAPHY (imar+1,jmar)
REAL, INTENT(OUT) :: zstd(:,:) !--- STANDARD DEVIATION (imar+1,jmar)
REAL, INTENT(OUT) :: zsig(:,:) !--- SLOPE (imar+1,jmar)
REAL, INTENT(OUT) :: zgam(:,:) !--- ANISOTROPY (imar+1,jmar)
REAL, INTENT(OUT) :: zthe(:,:) !--- SMALL AXIS ORIENTATION (imar+1,jmar)
REAL, INTENT(OUT) :: zpic(:,:) !--- MAXIMUM ALTITUDE (imar+1,jmar)
REAL, INTENT(OUT) :: zval(:,:) !--- MINIMUM ALTITUDE (imar+1,jmar)
```

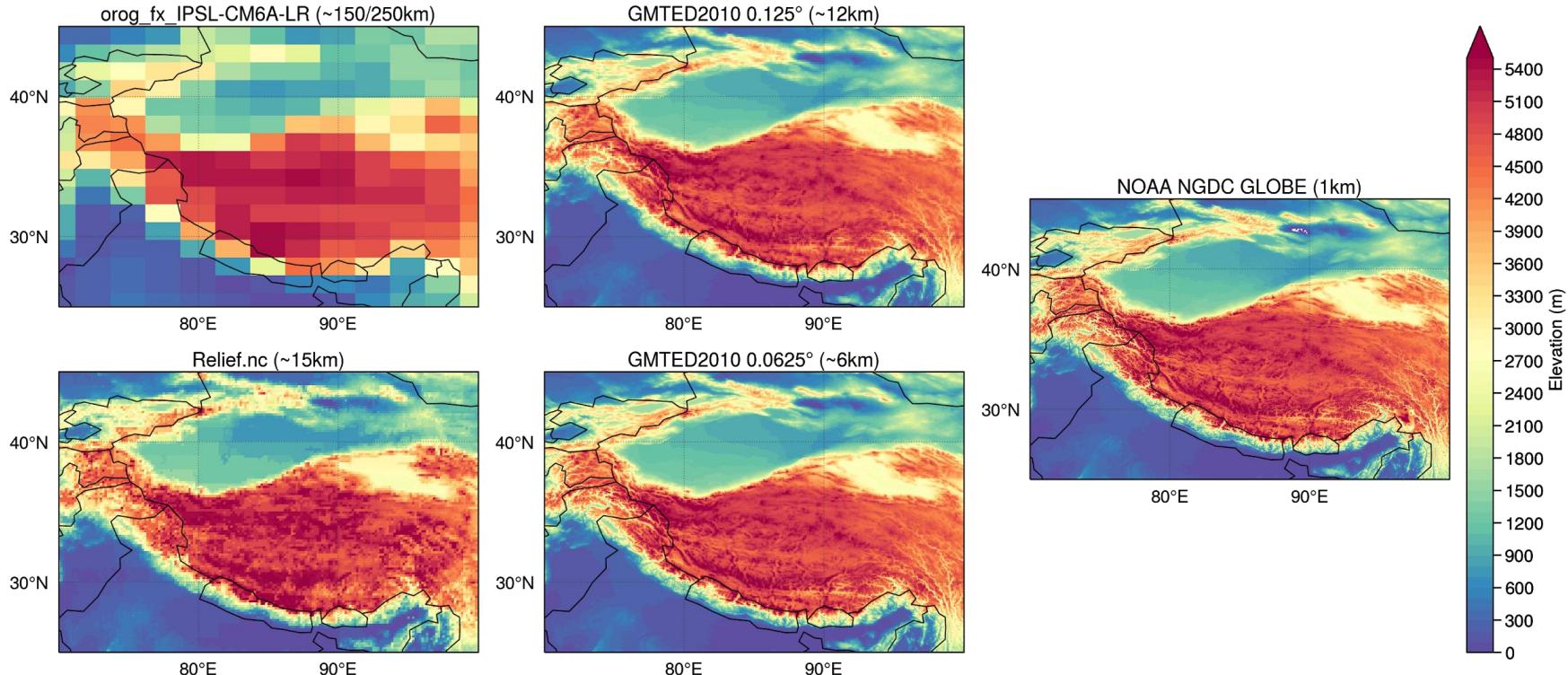
```
!==== FILTERS TO SMOOTH OUT FIELDS FOR INPUT INTO SSO SCHEME.
!---- FIRST FILTER, MOVING AVERAGE OVER 9 POINTS.
```

```
!----- ! GK211005 (CG) UNSMOOTHED TOPO
phi(:,:)=zmea(:,:)
CALL MVA9(zmea); CALL MVA9(zstd); CALL MVA9(zpic); CALL MVA9(zval)
CALL MVA9(zxtzx); CALL MVA9(zxtzy); CALL MVA9(zytzy)
```

Snow evolution



Paramétrisation sous-maille de la topographie



Paramétrisation sous-maille de la topographie

