



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

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Doctorant 2019-2022

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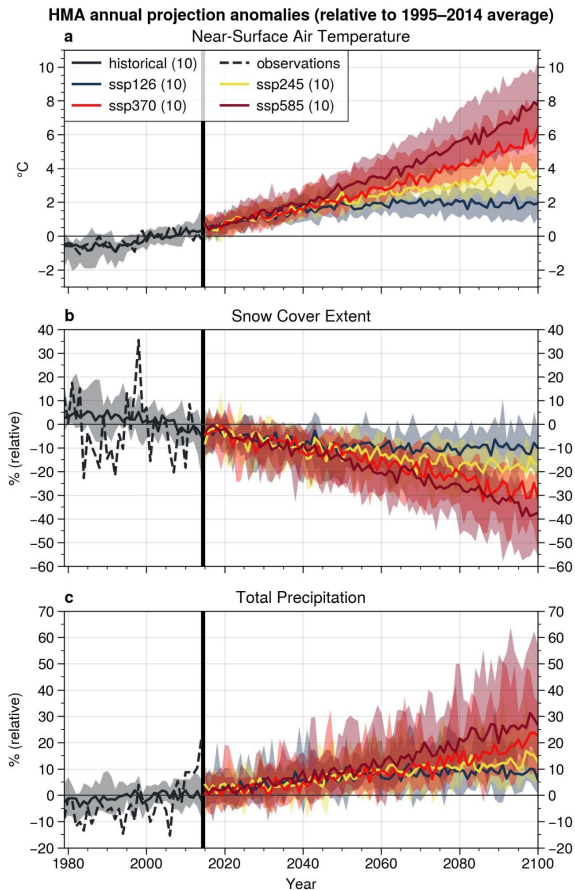
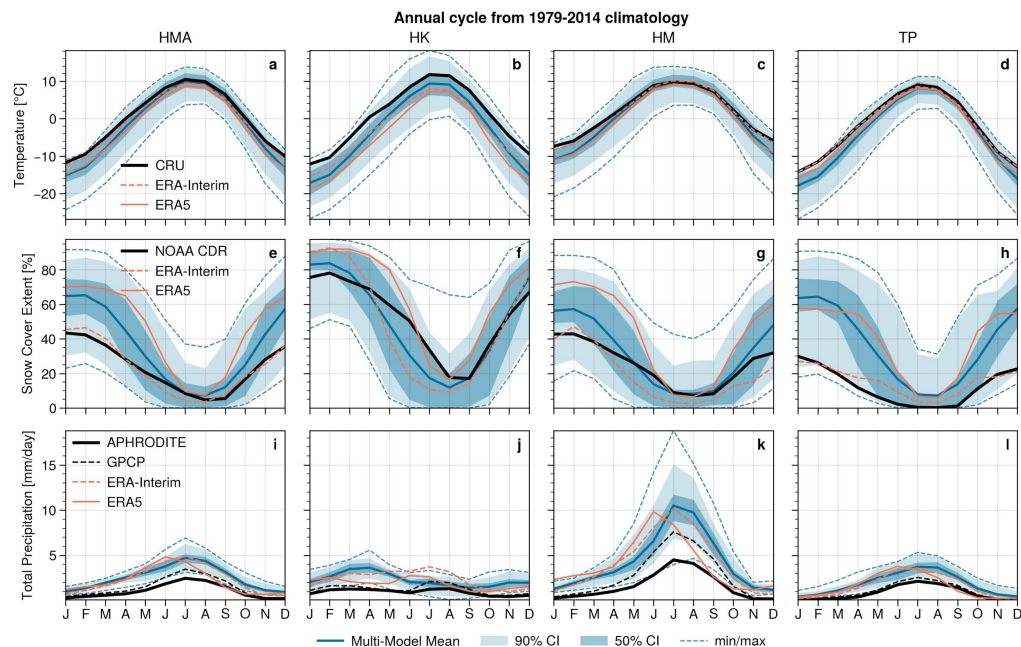
PEDALONS neige — 12/04/2021

# Climate change in the High Mountain Asia simulated with CMIP6 models

vEGU21

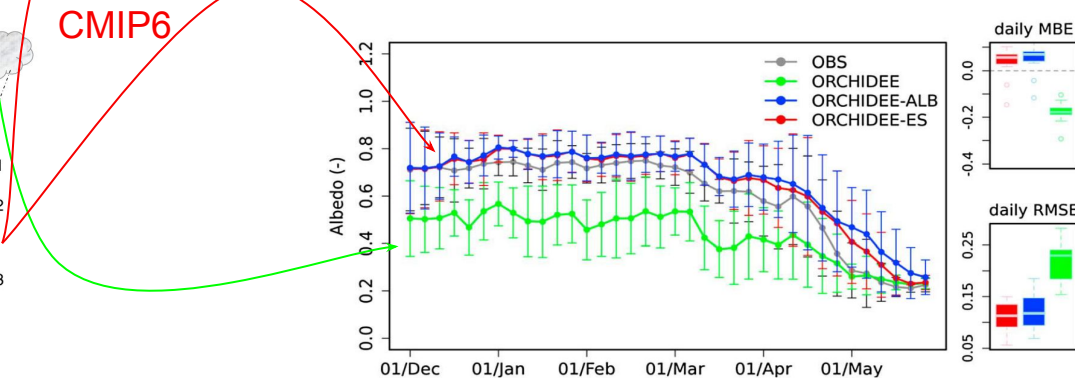
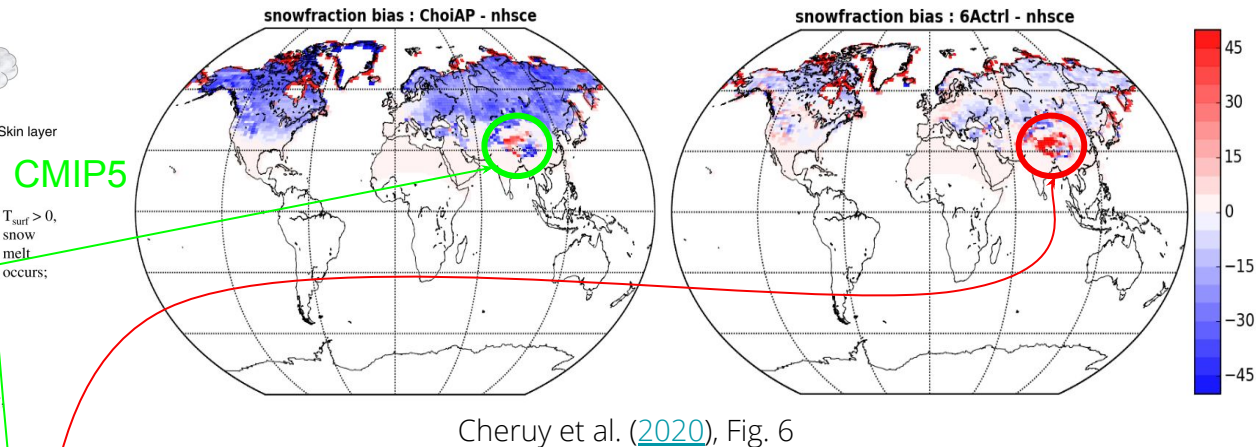
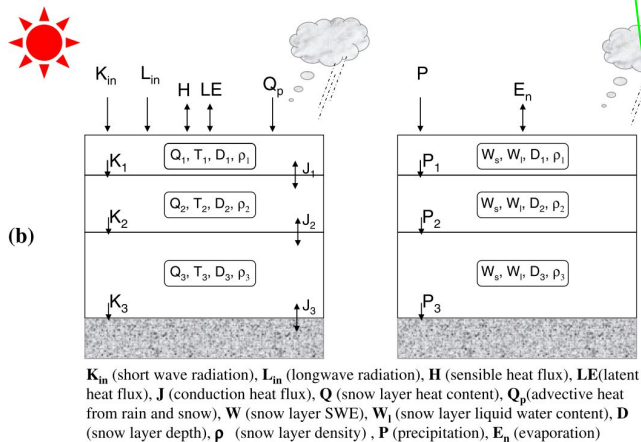
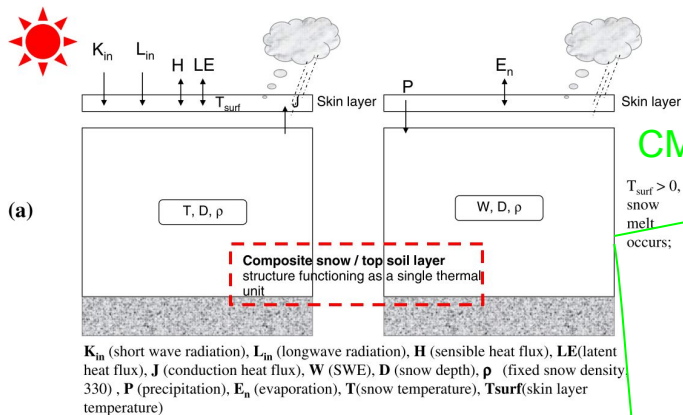
<https://meetingorganizer.copernicus.org/EGU21/EGU21-8365.html>

Tue, 27 Apr 09:00–09:10



# Biais de neige dans le modèle IPSL CMIP5 versus CMIP6

WANG ET AL.: ORCHIDEE SNOW MODEL EVALUATION



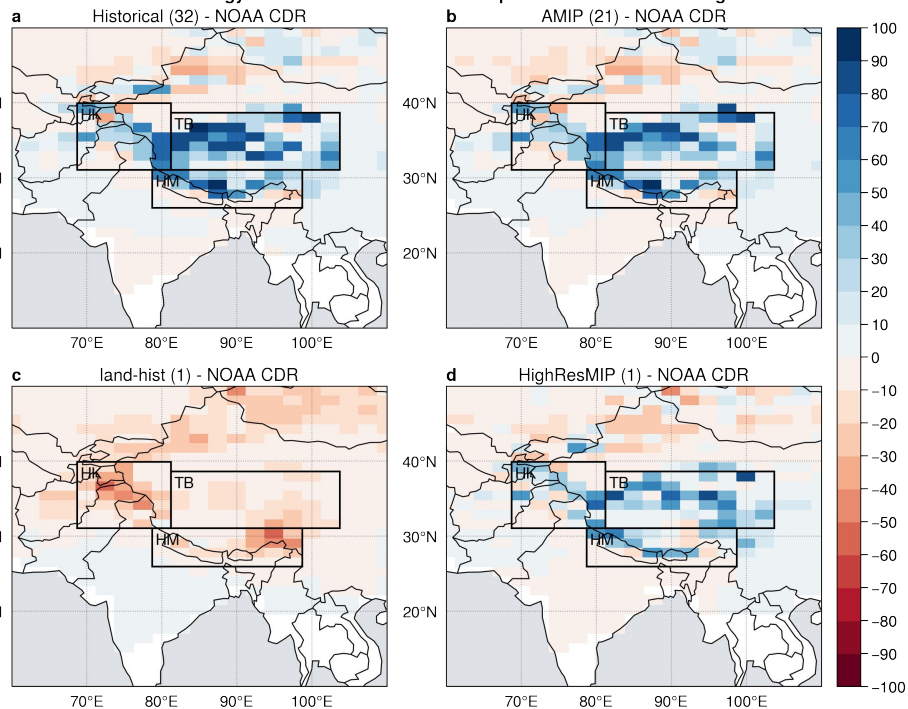
Wang et al. (2013), Fig. 1

Wang et al. (2013), Fig. 5

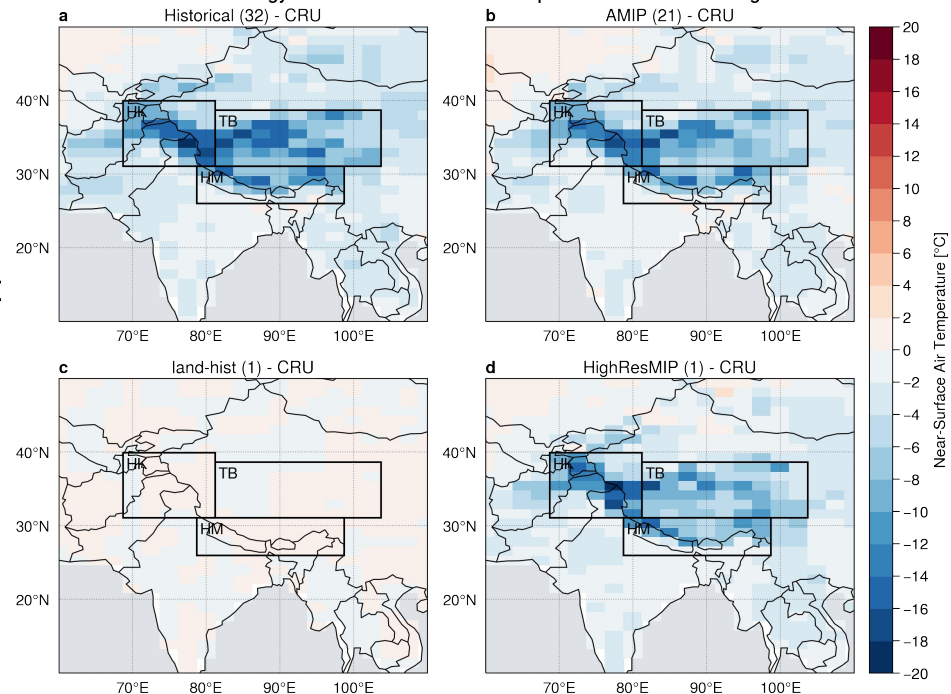
## Snow cover bias

## Temperature bias

Annual climatology bias: 1981-2014 / Bilinear interpolation towards 143x144 grid

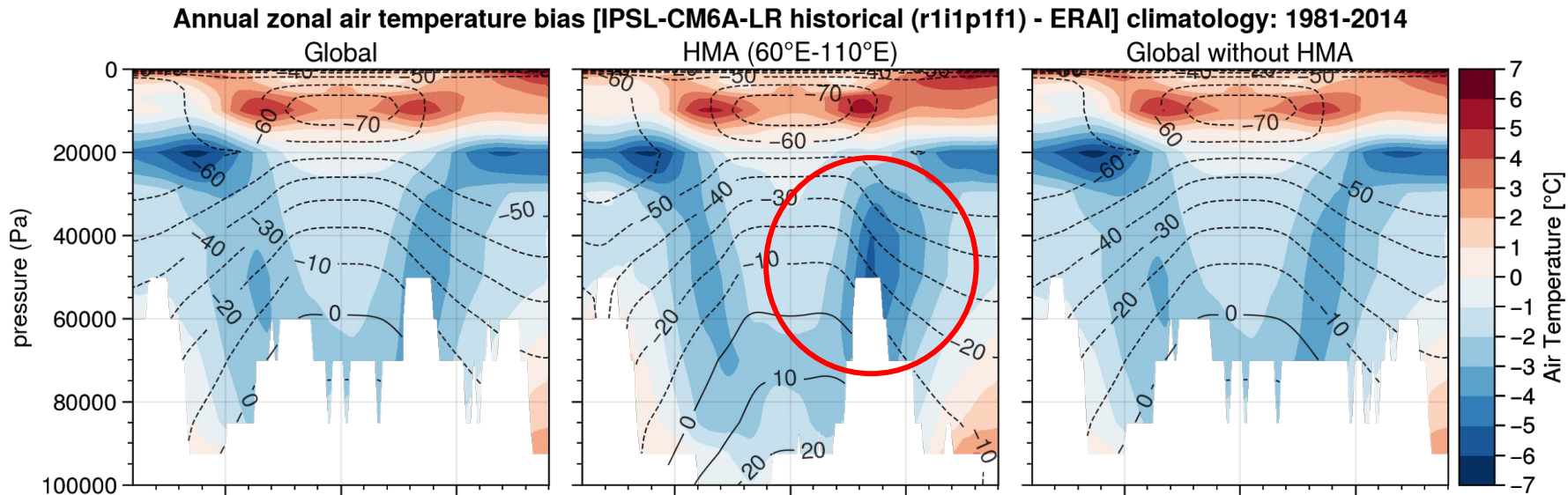


Annual climatology bias: 1981-2014 / Bilinear interpolation towards 143x144 grid





# Air Temperature zonal means bias global versus HMA

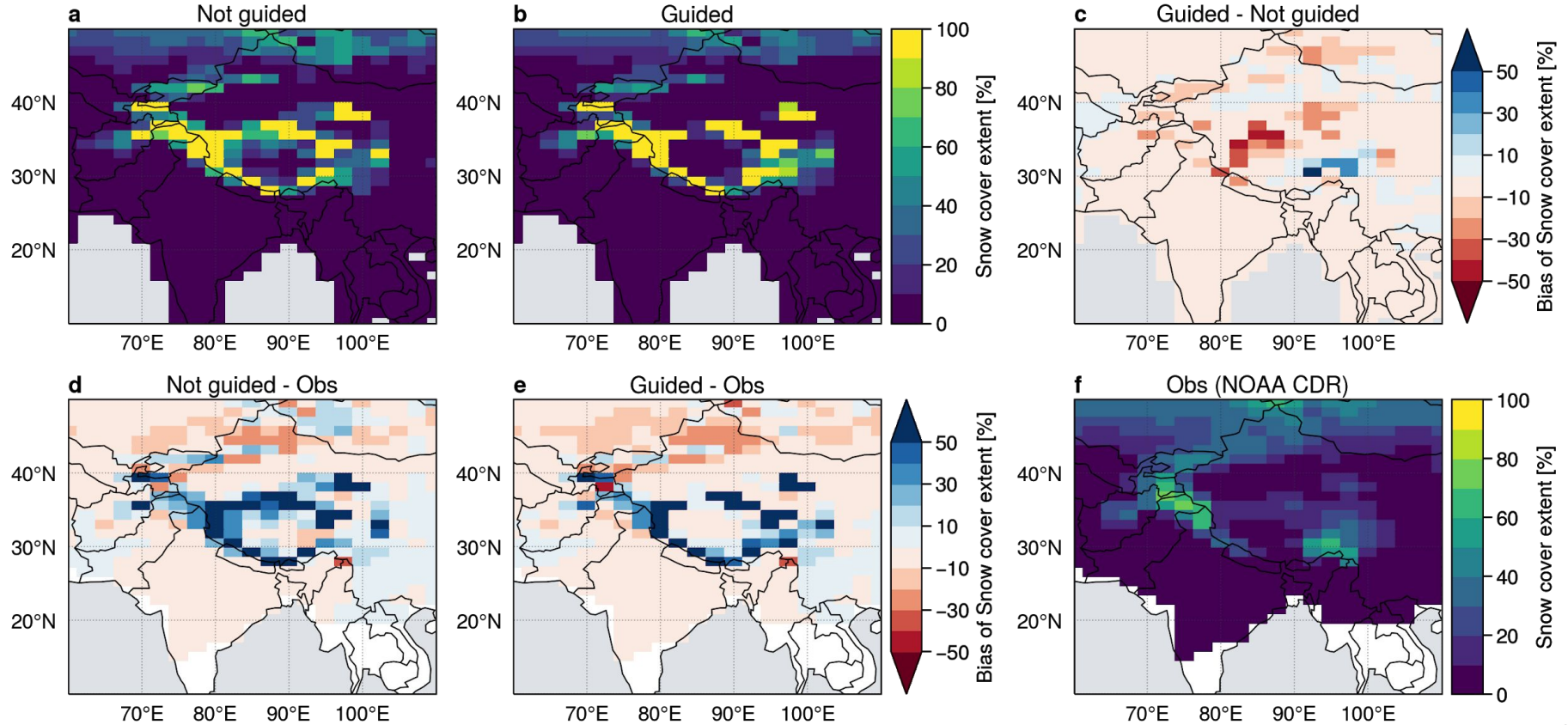


- Cold bias in troposphere and hot bias in stratosphere
- Cold bias of air temperature **not restricted to HMA!**
- HMA seems to **amplify** this bias
- The bias is **reduced in HighResMIP**

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

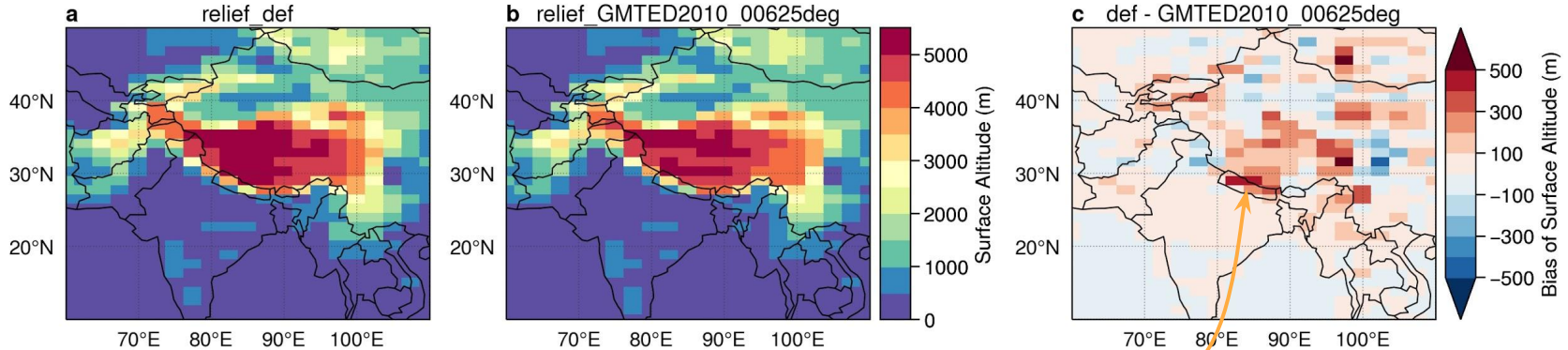
# Nudged versus not nudged: snow cover\* ([tropo bias](#))

Snow cover extent annual climatology: 1999-2008 (CM6012-LR-amip-G-02)



\* Simulation: Frédérique Cheruy

# Problem with elevation?

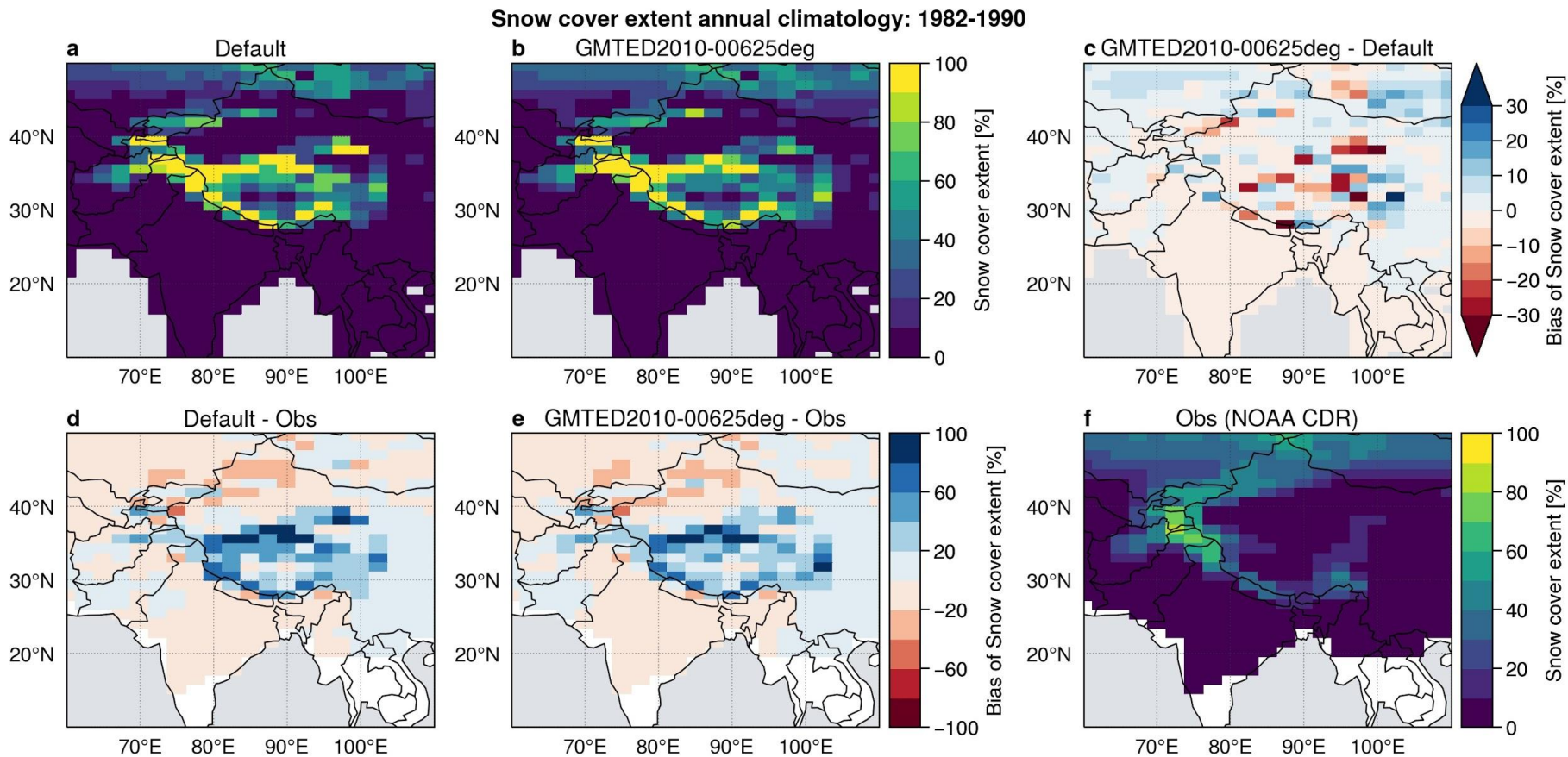


Original file of elevation has more than 500 m differences locally!

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?

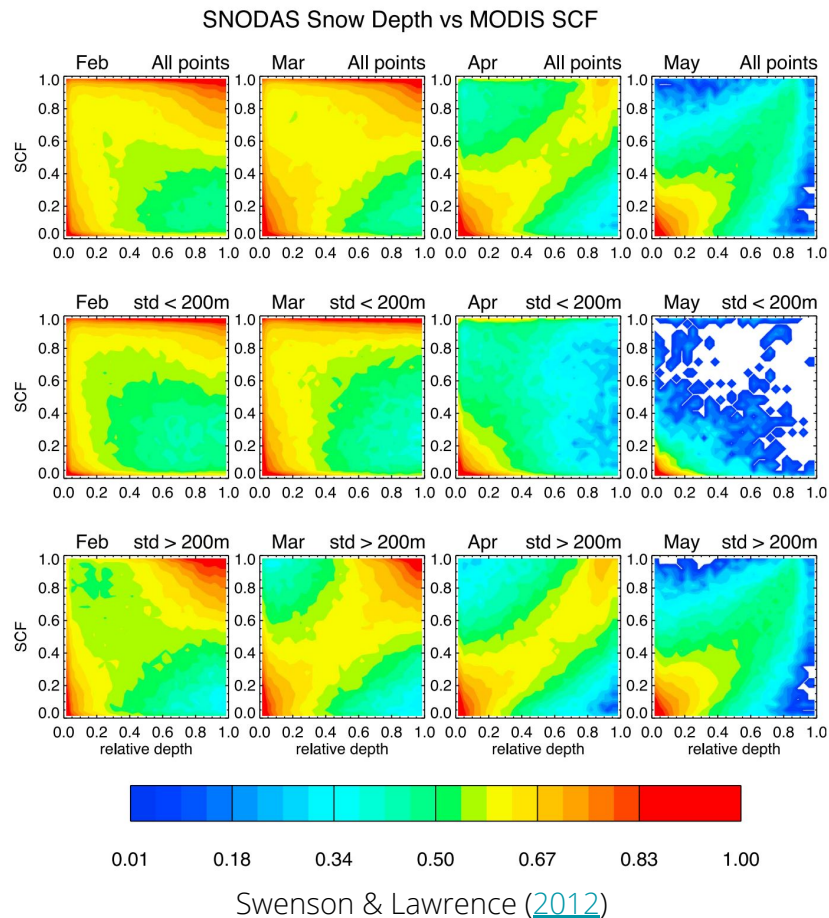
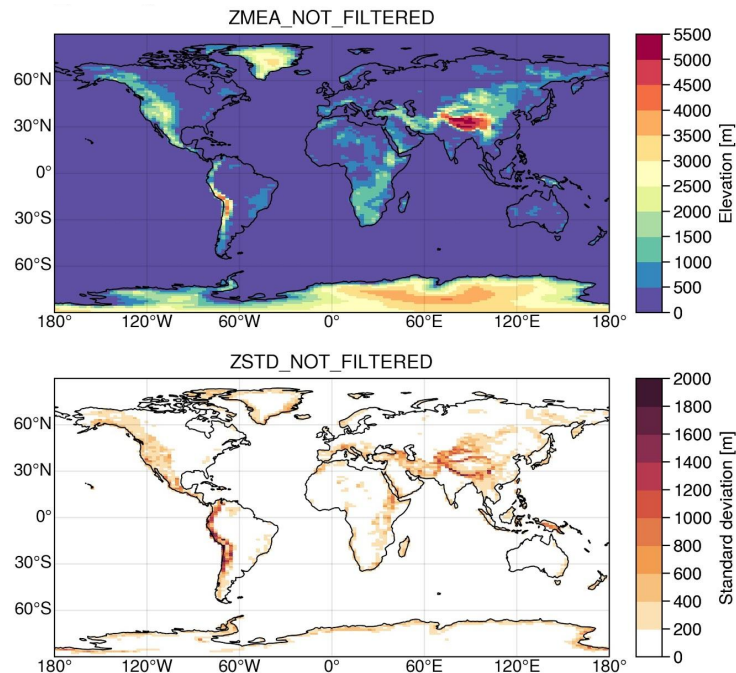




# Snow cover in mountainous area

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

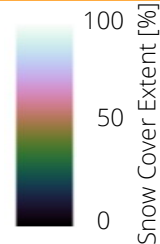
-> but we decided to focus on **topography**





# Couverture de neige

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



MEaSURES

IPSL-CM6A-ATM-HR

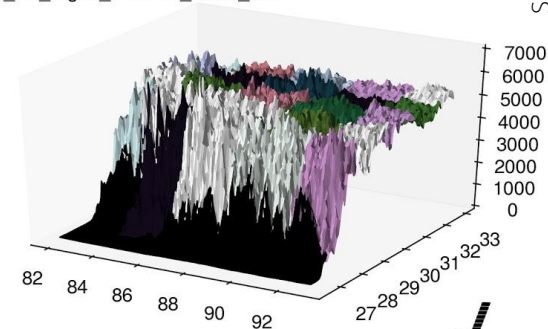
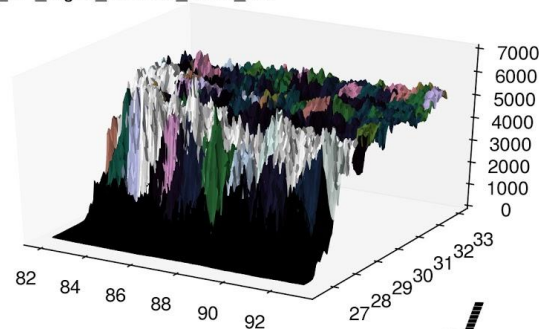
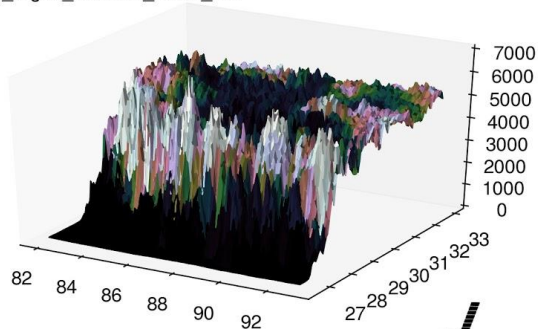
IPSL-CM6A-LR

obs\_regrid\_GMTED\_zoom\_DJF

da\_HR\_regrid\_GMTED\_zoom\_DJF

da\_LR\_regrid\_GMTED\_zoom\_DJF

Hiver

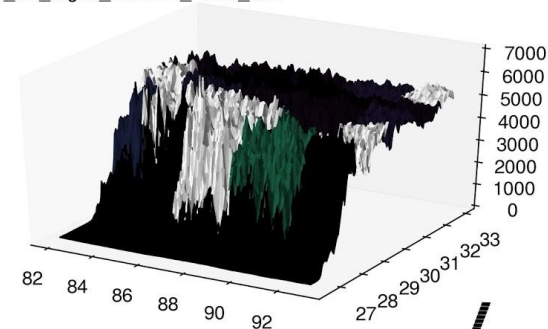
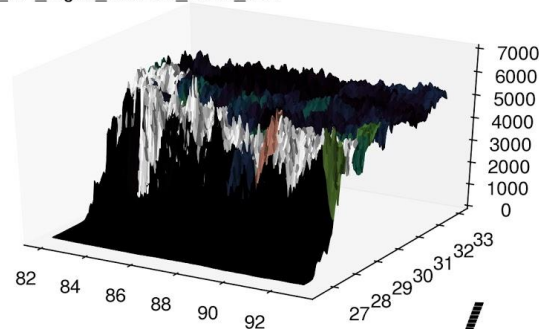
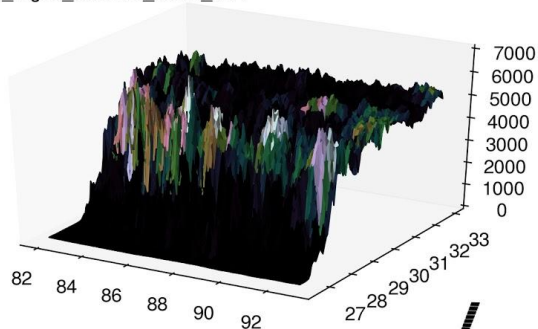


obs\_regrid\_GMTED\_zoom\_JJA

da\_HR\_regrid\_GMTED\_zoom\_JJA

da\_LR\_regrid\_GMTED\_zoom\_JJA

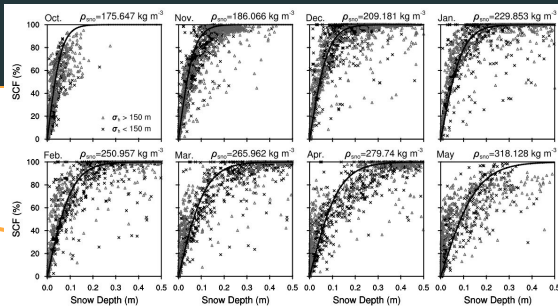
Été



# Snow cover parameterizations

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

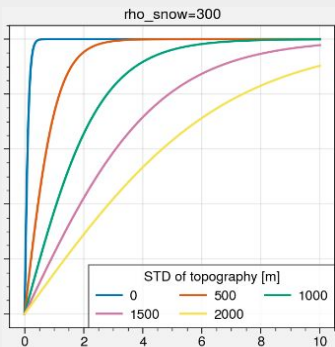
$$F = \tanh\left(\frac{d}{2.5z_{0g}(\rho_{snow}/\rho_{new})^m}\right)$$



STD impact  
not visible  
(monthly)

Niu and Yang (2007) custom

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

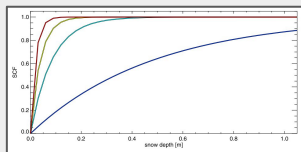


STD  
topo

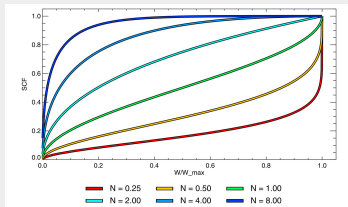
See more: [notebook](#) / [code](#)

Swenson and Lawrence (2012)

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



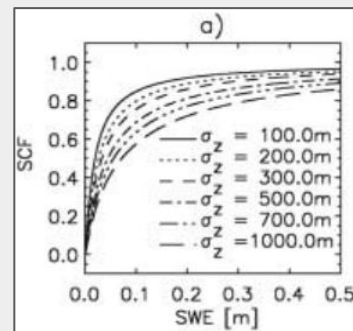
$$F = 1 - \left[\frac{1}{\pi} \arccos\left(2 \frac{W}{W_{max}} - 1\right)\right]^{N_{melt}} \quad N_{melt} = \frac{200}{\sigma_{topo}}$$



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

Roesch et al. (2001)

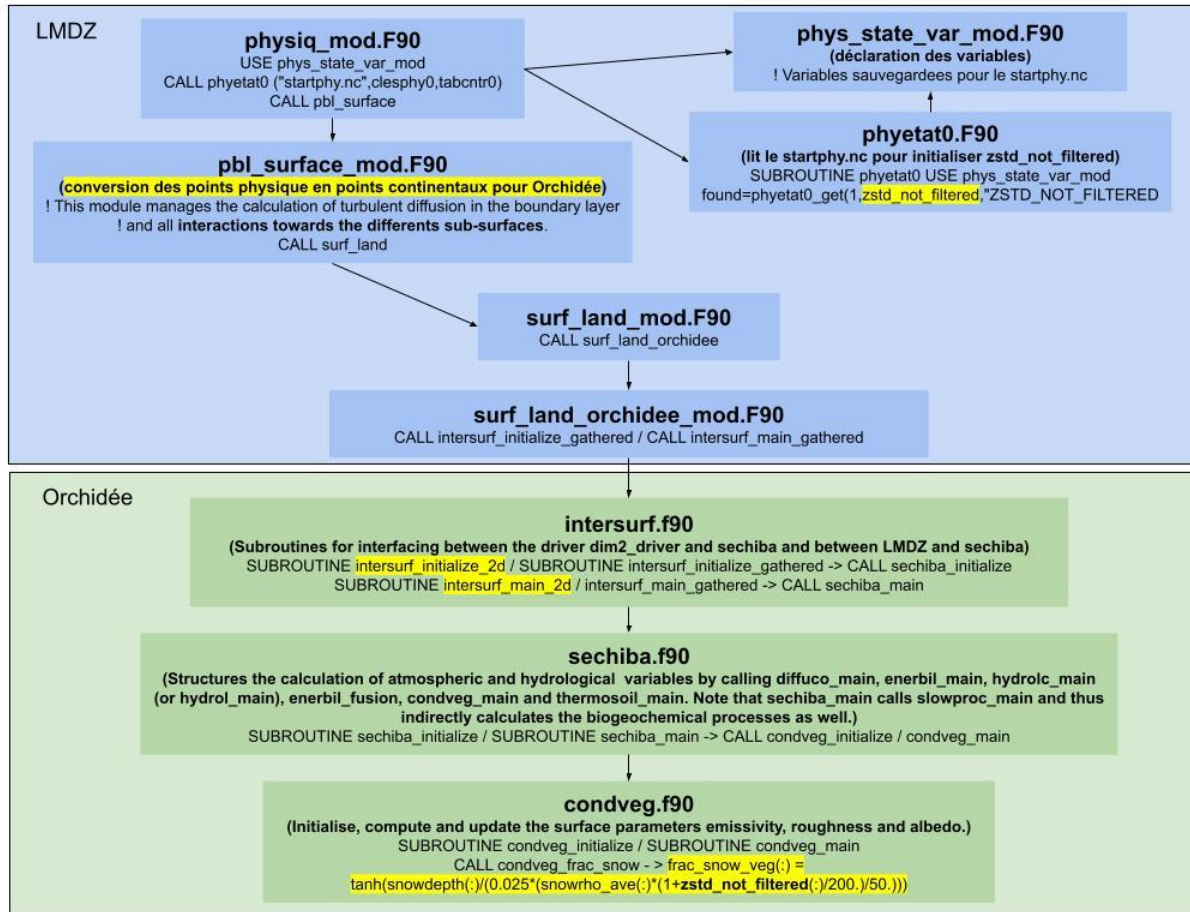
$$f_s = 0.95 \cdot \tanh(100 \cdot S_n) \sqrt{\frac{1000 \cdot S_n}{1000 \cdot S_n + \epsilon + 0.15\sigma_z}}$$



+ vegetation areas (not done)

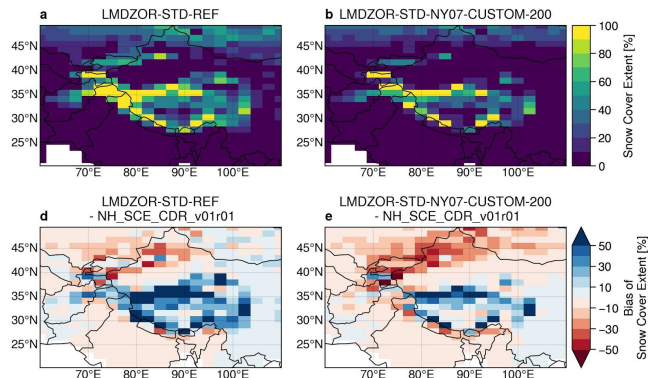
See more: [notebook](#) / [code](#)

# Éléments de code + [Google Doc](#)

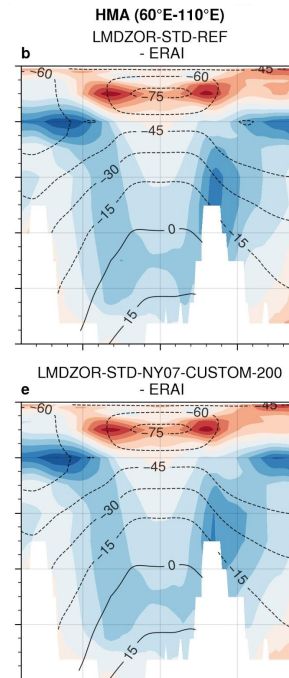
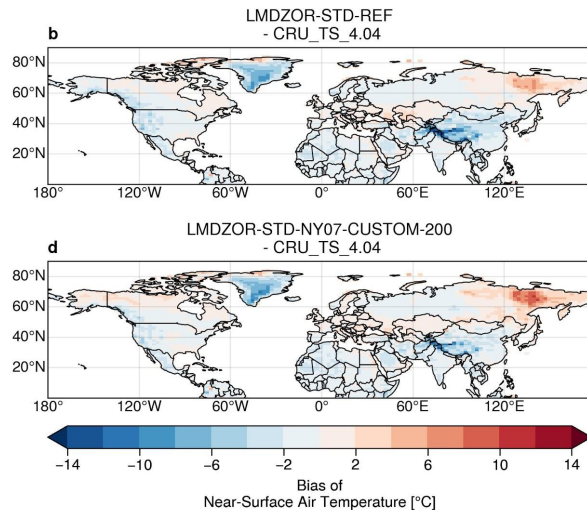
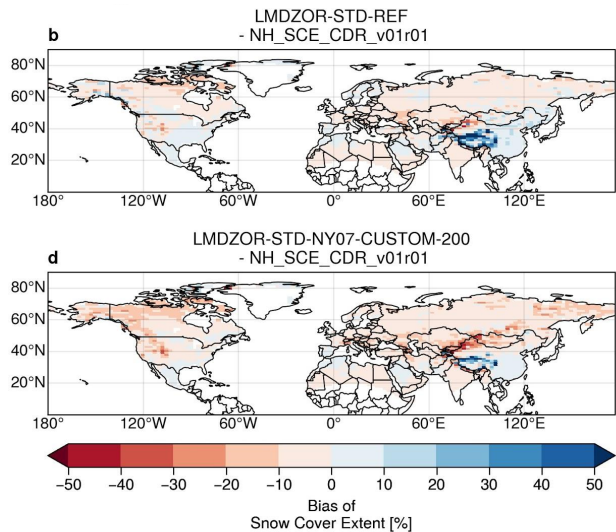
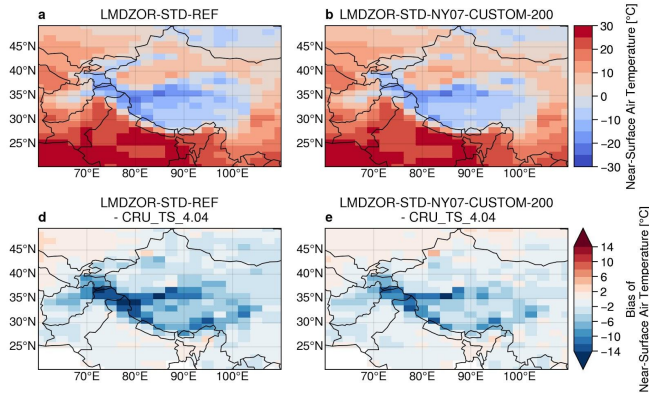


# Niu and Yang (2007) custom: [commit](#), [thredds](#)

Snow Cover Extent annual climatology: 1981-1989



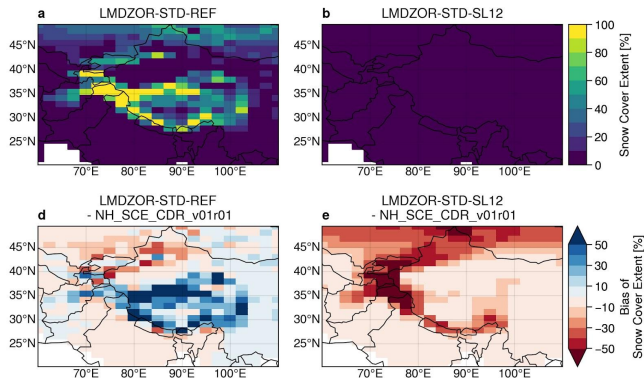
Near-Surface Air Temperature annual climatology: 1981-1



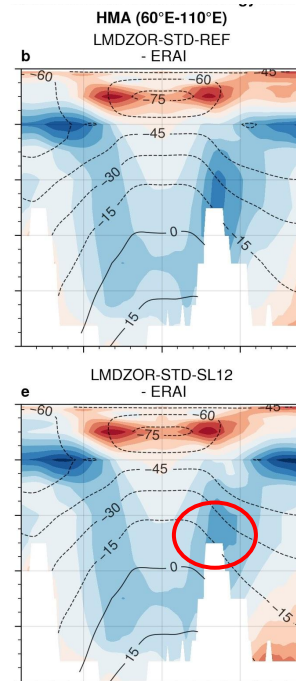
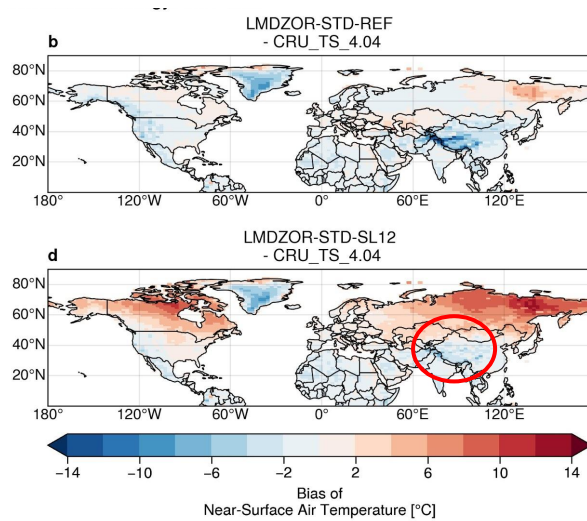
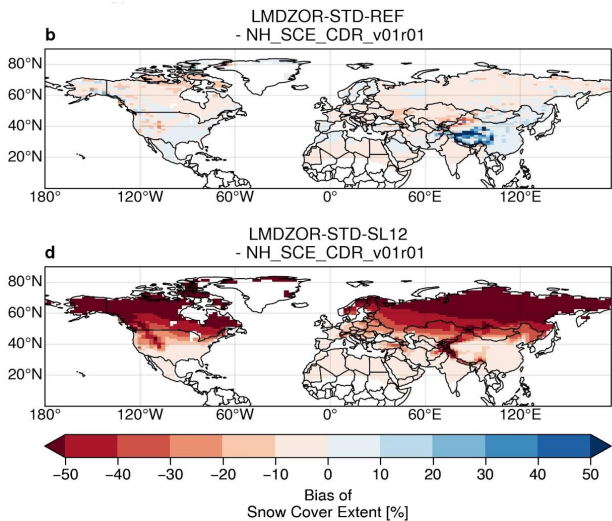
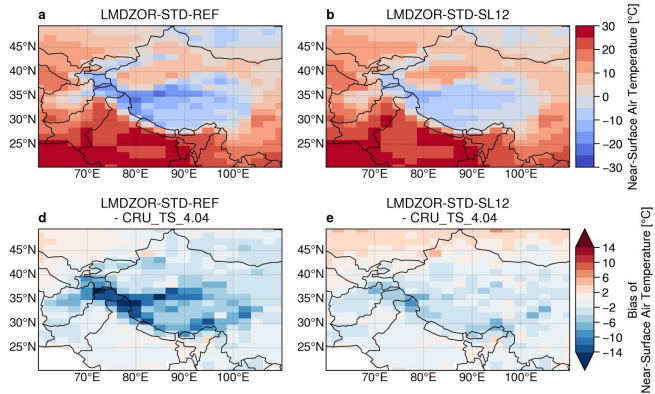


# ????????? -> no snow: [commit](#), [thredds](#)

Snow Cover Extent annual climatology: 1981-1989



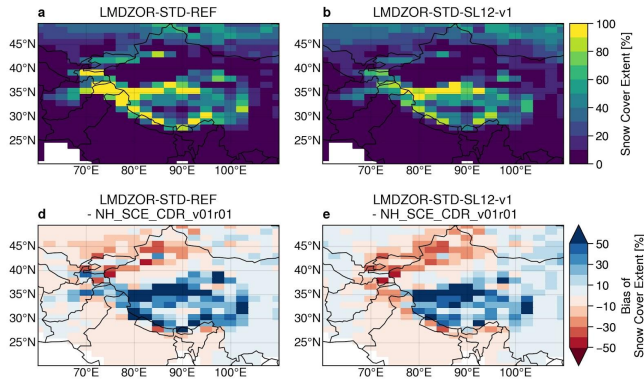
Near-Surface Air Temperature annual climatology: 1981-1



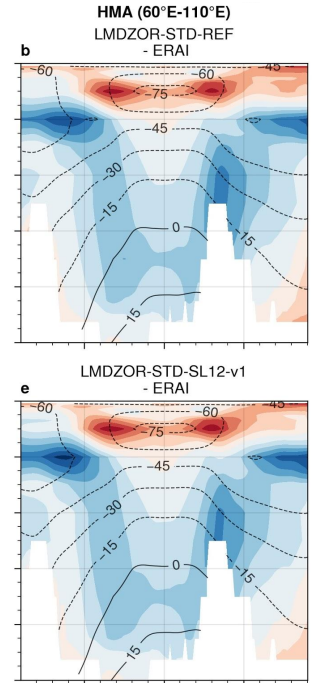
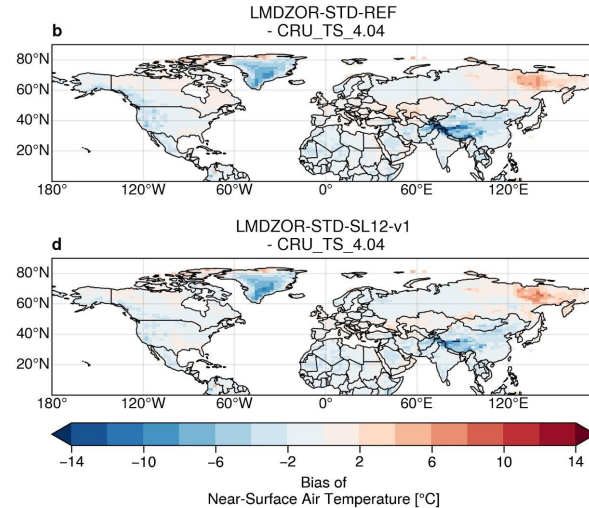
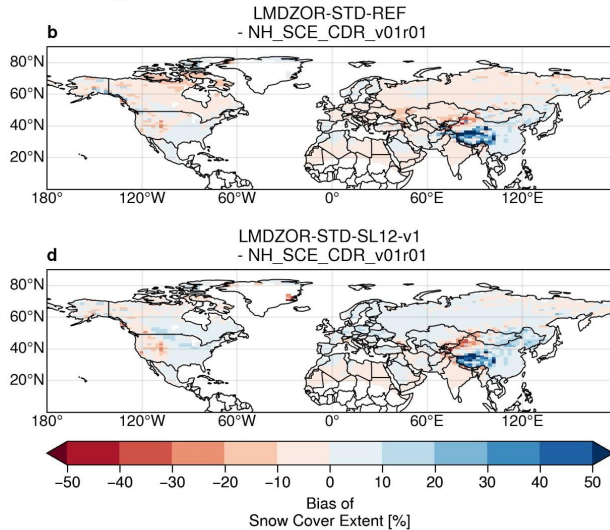
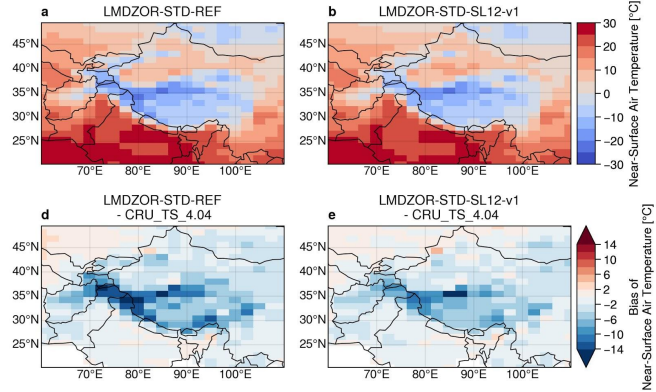


# Swenson and Lawrence (2012): commits [1](#), [2](#), [3](#), [4](#), [thredds](#)

Snow Cover Extent annual climatology: 1981-1989

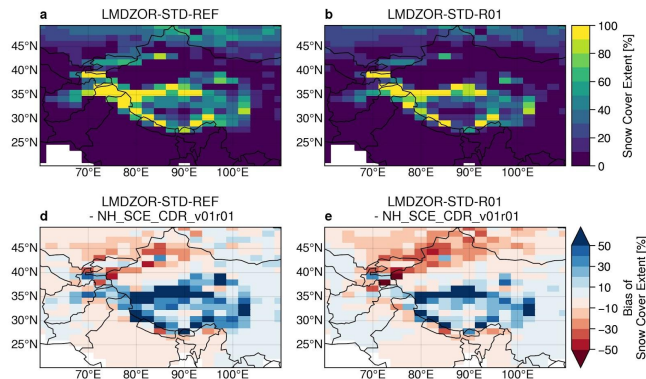


Near-Surface Air Temperature annual climatology: 1981-7

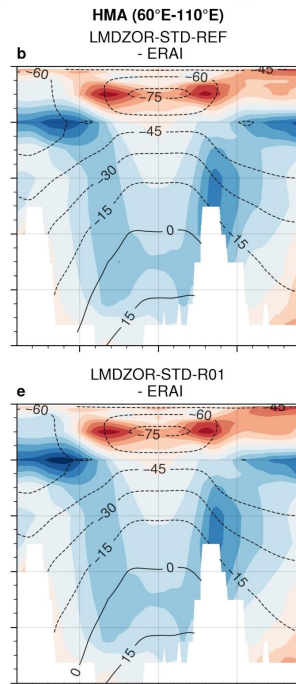
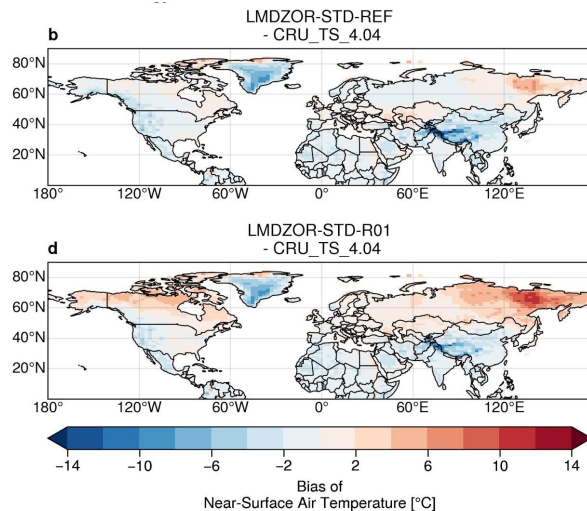
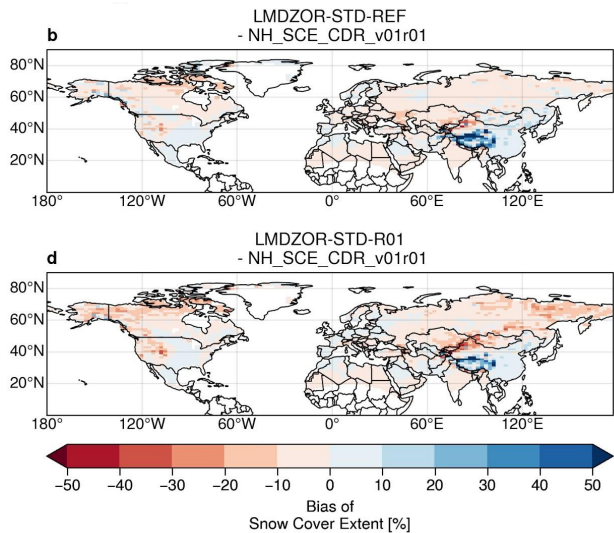
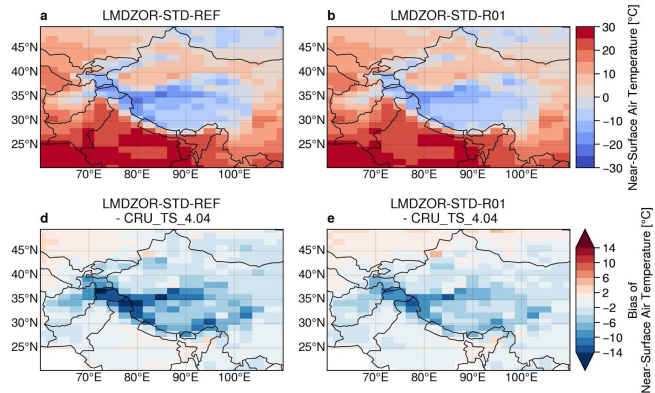


# Roesch et al. (2001) without veget: [code](#), [thredds](#)

Snow Cover Extent annual climatology: 1981-1989

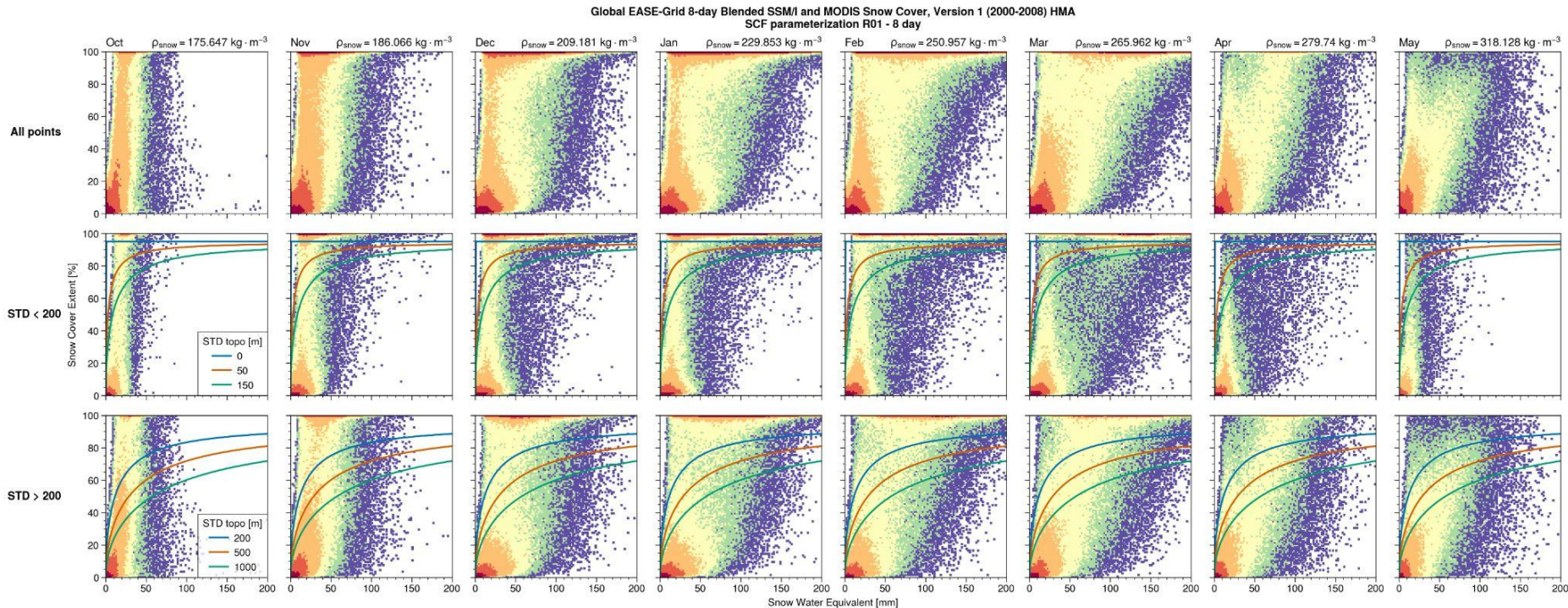


Near-Surface Air Temperature annual climatology: 1981-1





# 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'autres 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 (autres problèmes: aérosols, couche limite, etc.)

# Bibliographie

---



# References

- Cheruy, F., Ducharne, A., Hourdin, F., Musat, I., Vignon, E., Gastineau, G., ... Zhao, Y. (2020). Improved near surface continental climate in IPSL-CM6A-LR by combined evolutions of atmospheric and land surface physics. *Journal of Advances in Modeling Earth Systems*, 2019MS002005, submitted. <https://doi.org/10.1029/2019MS002005>
- 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>

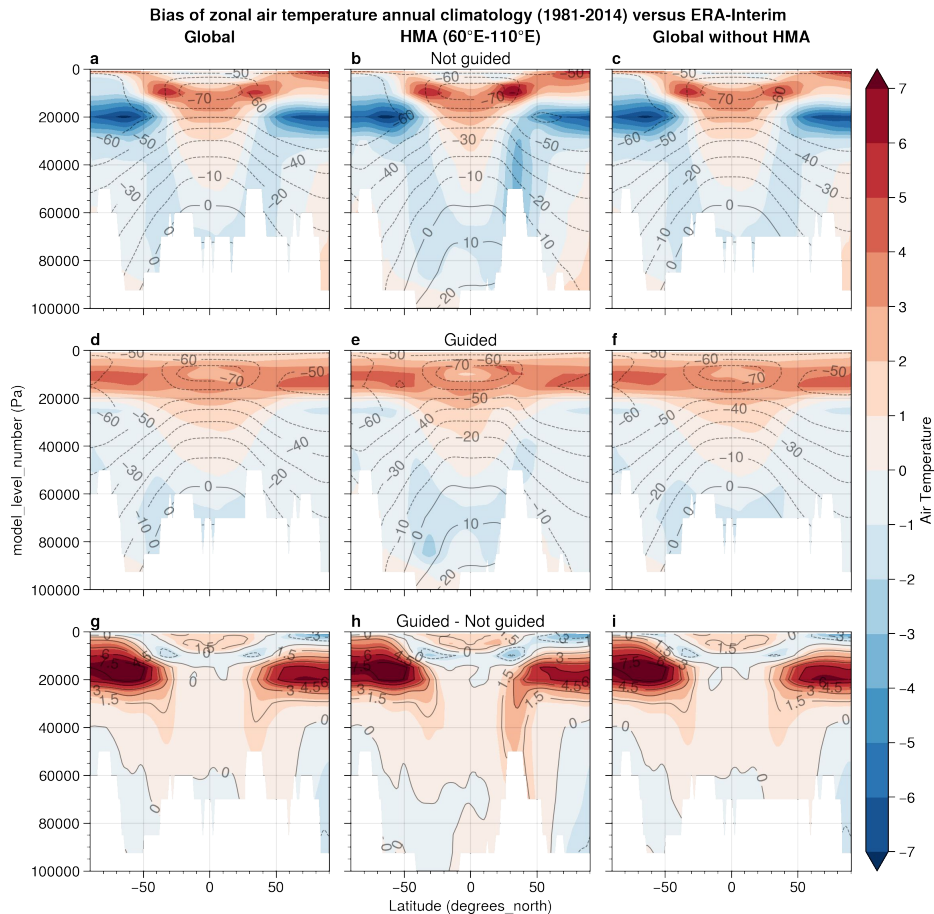
## Slides complémentaires

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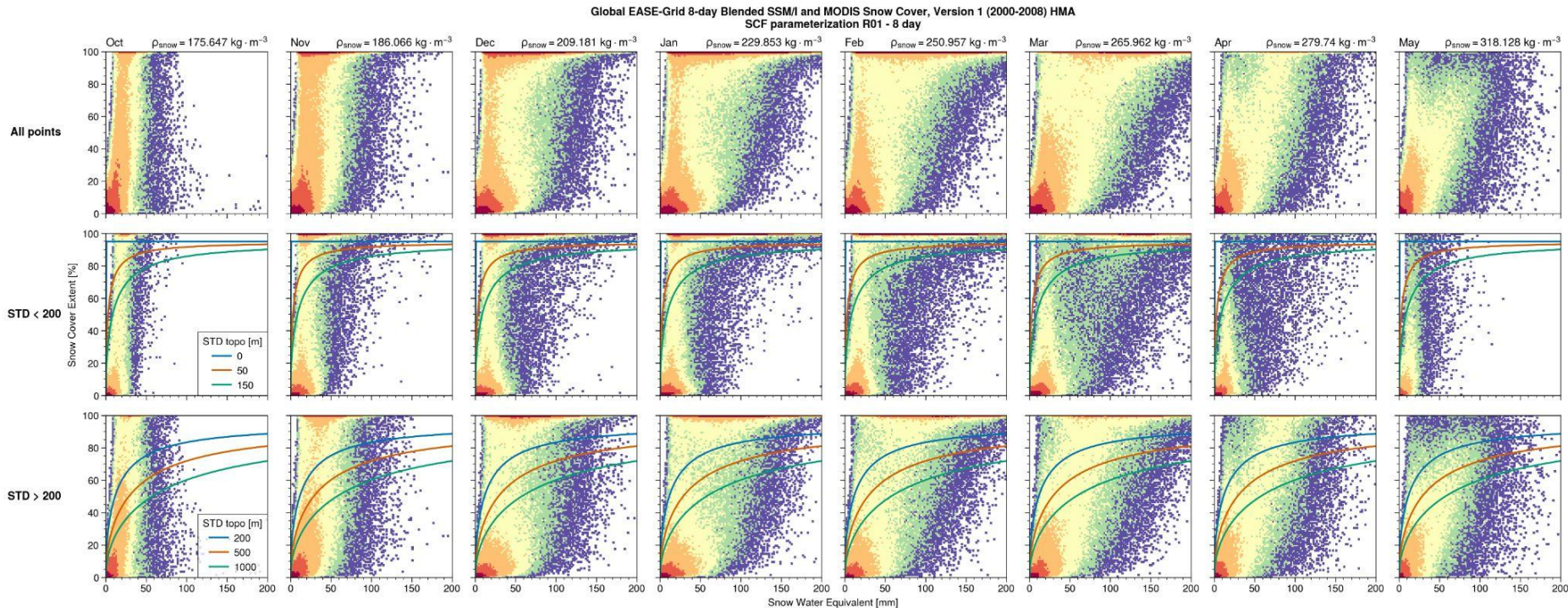
# Nudged versus not nudged

More:  
<https://docs.google.com/document/d/1SpVViaGEyB9KQbkgC4U2hC-graRfaE-ojLayZcDGPU/edit?usp=sharing>

[Back](#)



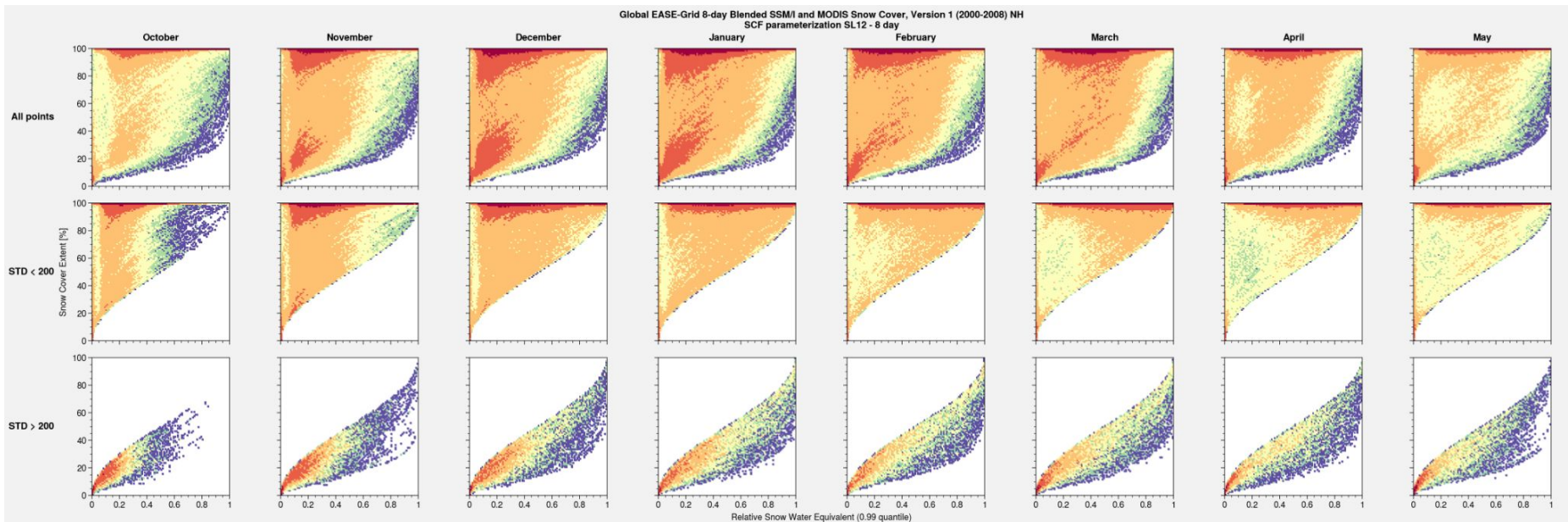
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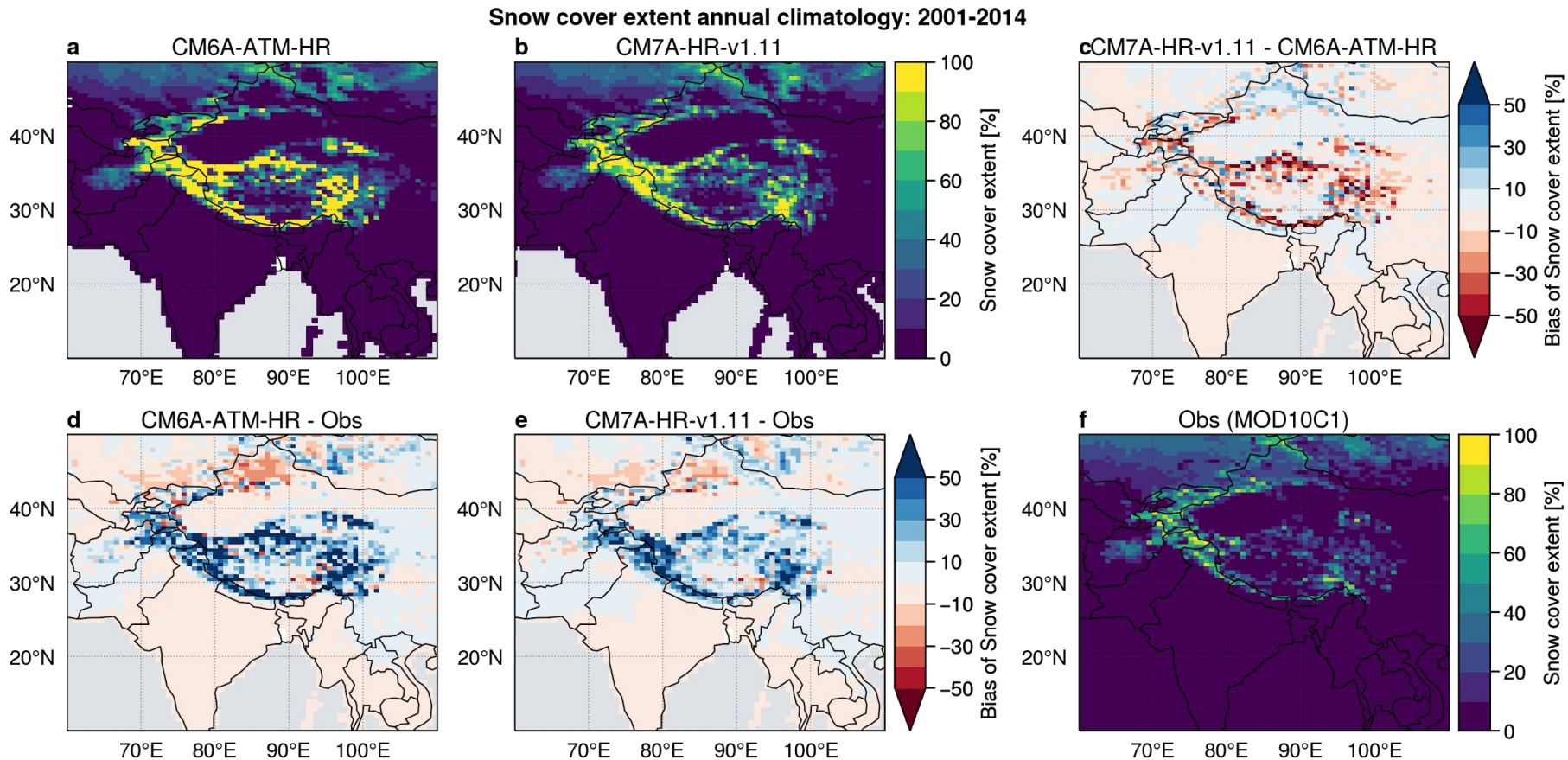
# Swenson and Lawrence (2012) “theoric” depletion curves (see more: [github](#))



A voir dans le modèle avec la courbe d'accu



# Dynamico versus HighResMIP: snow cover\*



# 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/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/condveg.f90)
- [http://forge.ipsl.jussieu.fr/orchidee/browser/branches/ORCHIDEE\\_2\\_2/ORCHIDEE/src\\_sechiba/enerbil.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/phyldm/grid\\_noro\\_m.F90](http://trac.lmd.jussieu.fr/LMDZ/browser/LMDZ6/trunk/libf/phyldm/grid_noro_m.F90)

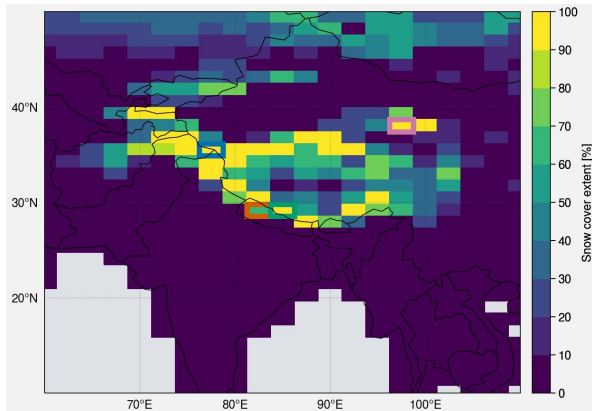
```
REAL, INTENT(OUT) :: zmea(:, :) !--- MEAN OROGRAPHY (imar+1, jmar)
REAL, INTENT(OUT) :: zstd(:, :) !--- STANDARD DEVIATION (imar+1, jmar)
REAL, INTENT(OUT) :: zsig(:, :) !--- SLOPE (imar+1, jmar)
REAL, INTENT(OUT) :: zgam(:, :) !--- ANISOTROPY (imar+1, jmar)
REAL, INTENT(OUT) :: zthe(:, :) !--- SMALL 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.
```

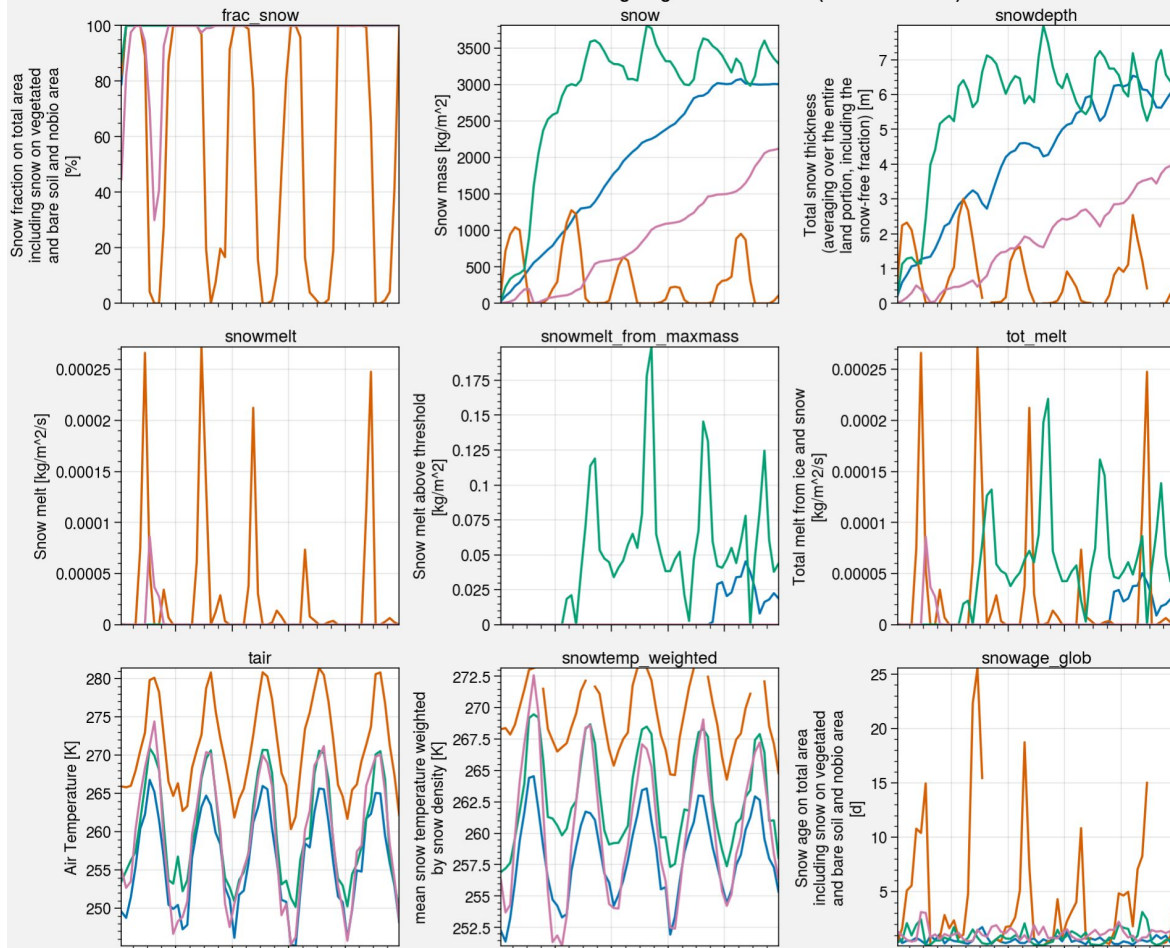
```
!-----
zphi(:, :) = zmea(:, :) ! GK211005 (CG) UNSMOOTHED TOPO
```

```
CALL MVA9(zmea); CALL MVA9(zstd); CALL MVA9(zpic); CALL MVA9(zval)
CALL MVA9(zxtzx); CALL MVA9(zxtzy); CALL MVA9(zytzy)
```

# Snow evolution

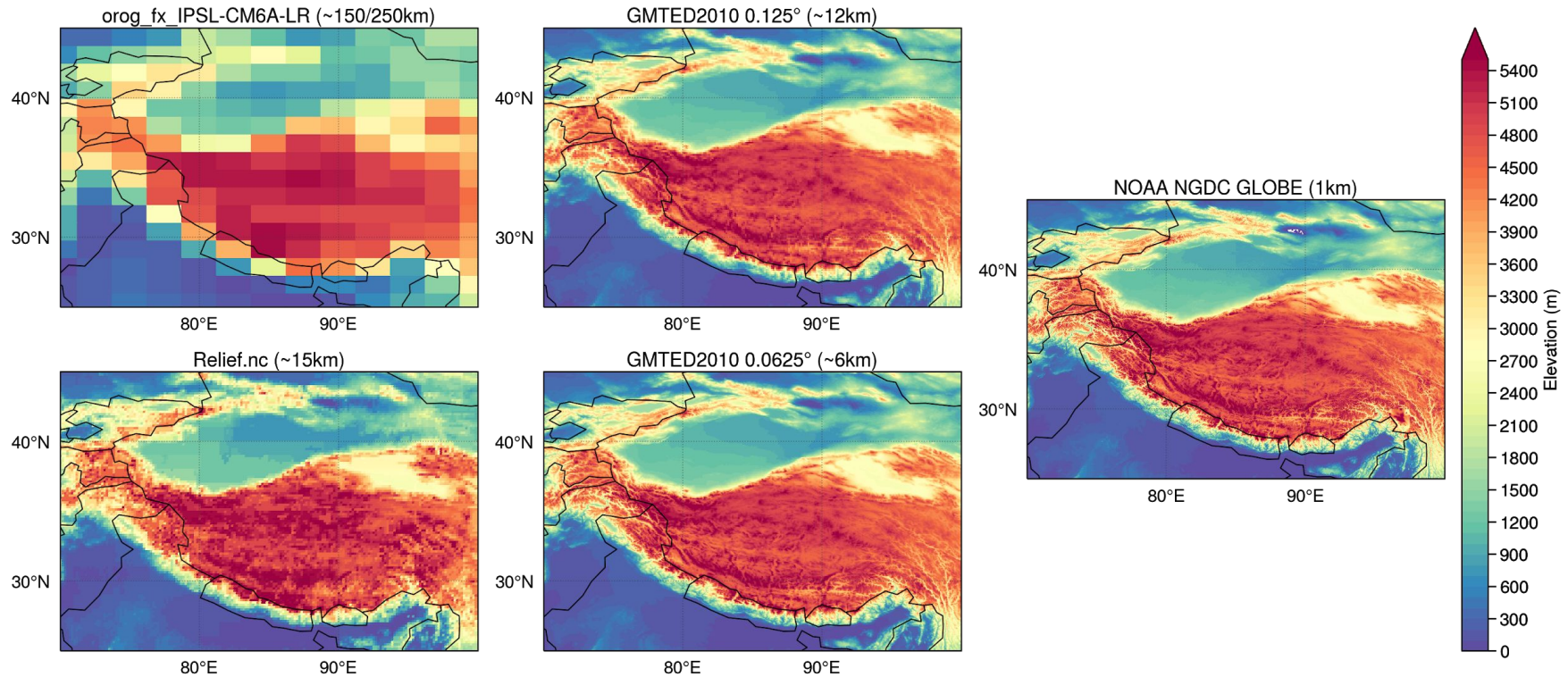


Snow related variables from the beginning of the simulation (default Relief.nc)





# Paramétrisation sous-maille de la topographie





# Paramétrisation sous-maille de la topographie

