# Corrections de biais dans et/ou pour des projections régionales avec LMDZ (et/ou autre)

**Gerhard Krinner**

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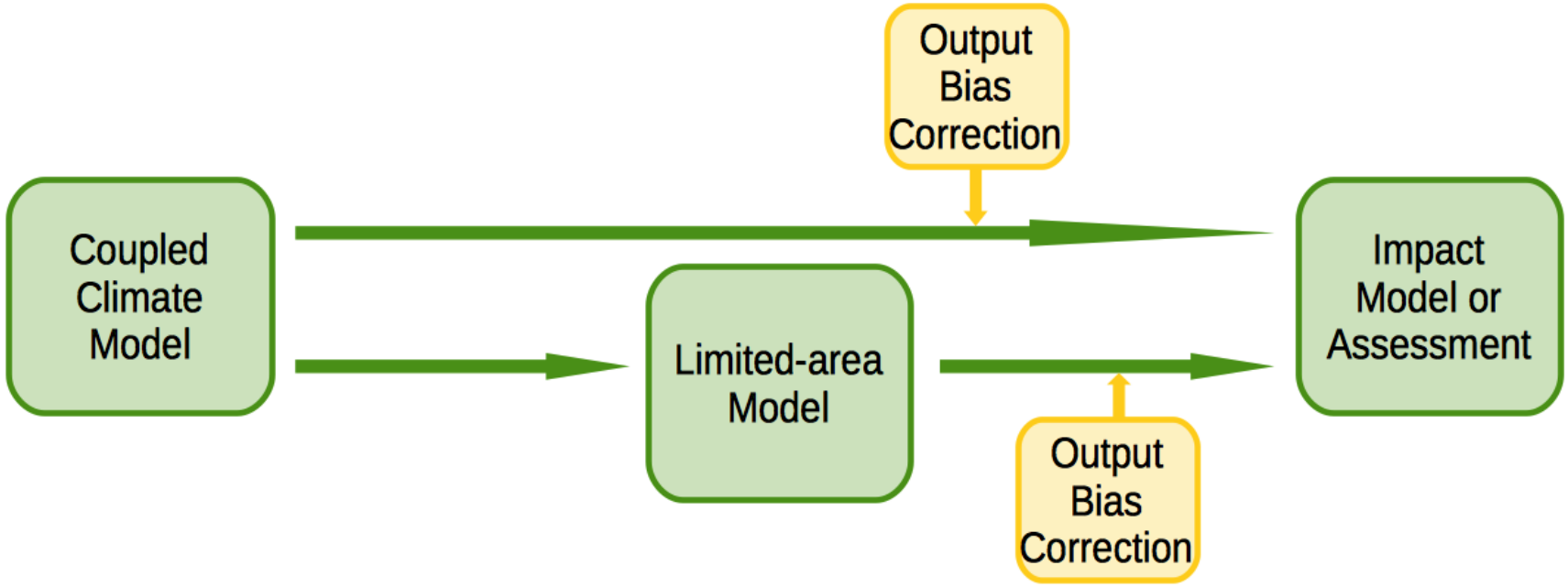
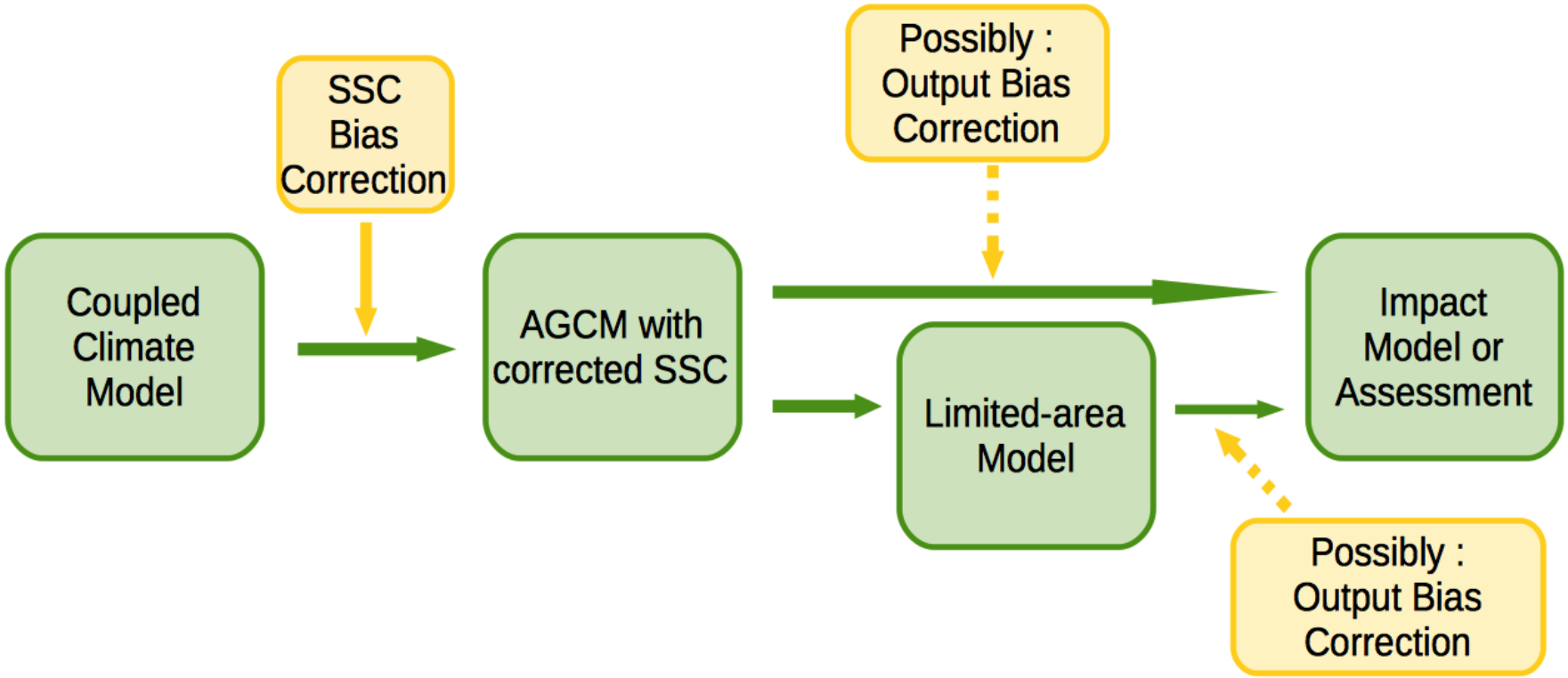
# Usual modeling chain from coupled climate models to impact assessment




Somebody will apply some bias correction at some point

Can we do anything better?

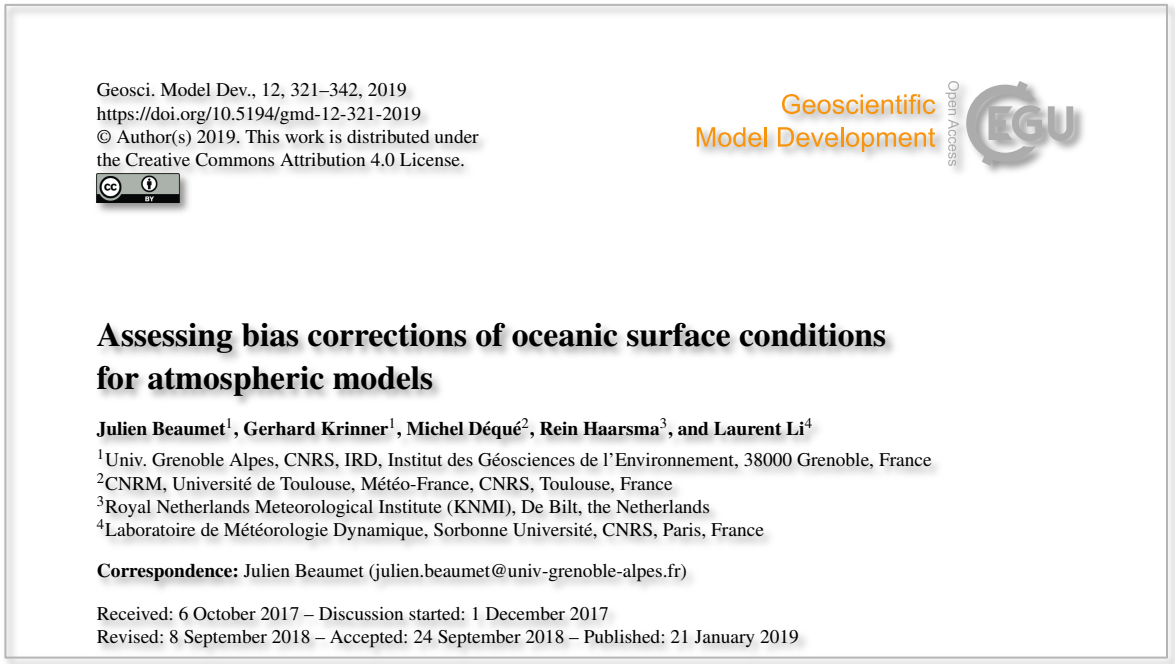
# First step:
# AGCM with corrected sea-surface conditions (SSC)




SSC: Sea-surface boundary conditions (SST, sea ice)

# Simple idea

- Use observed SST+SIC for reference AGCM run (present)
- Take SST+SIC change signal from a coupled model, add to observed SST+SIC, use this in AGCM projection run (future)
- Effectively imports TCR & ECS from coupled model
- Similar approach frequently used in paleoclimate studies
- Sea ice a bit tricky
- Lots of papers on this: Asfaq et al., Clim. Dyn., 2011; Haarsma et al., GMD, 2016; Hernández-Díaz et al., Clim. Dyn., 2017; Krinneret al., 2008, 2014; Beaumet et al., GMD, 2019



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**Assessing bias corrections of oceanic surface conditions for atmospheric models**

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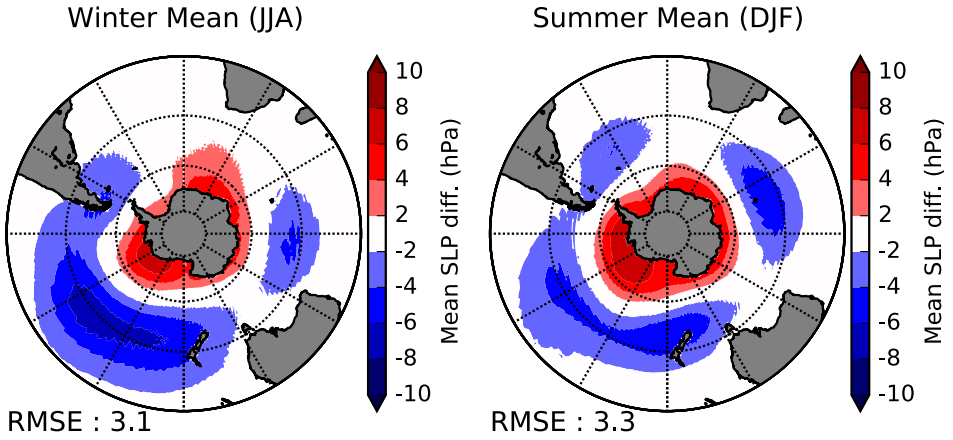
# Better present-day climate, of course

Arpège T255, 35 km over Antarctica

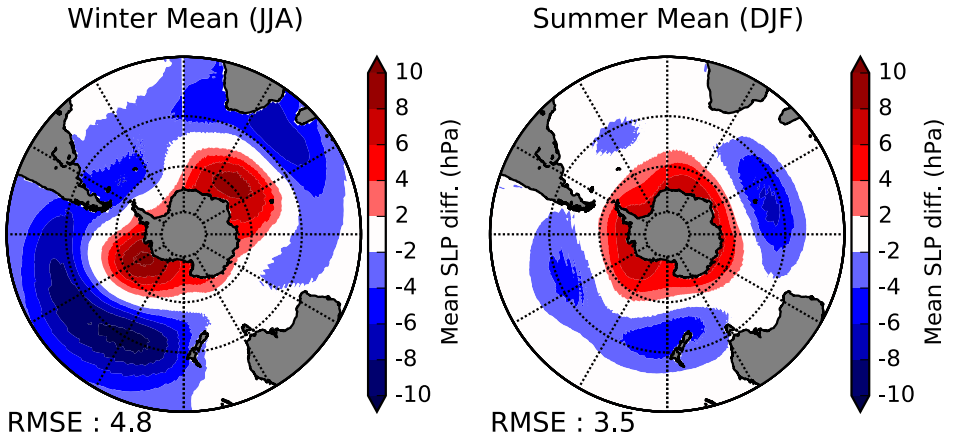
**SLP biases**

Observed SST & SIC




(a) ARP-AMIP

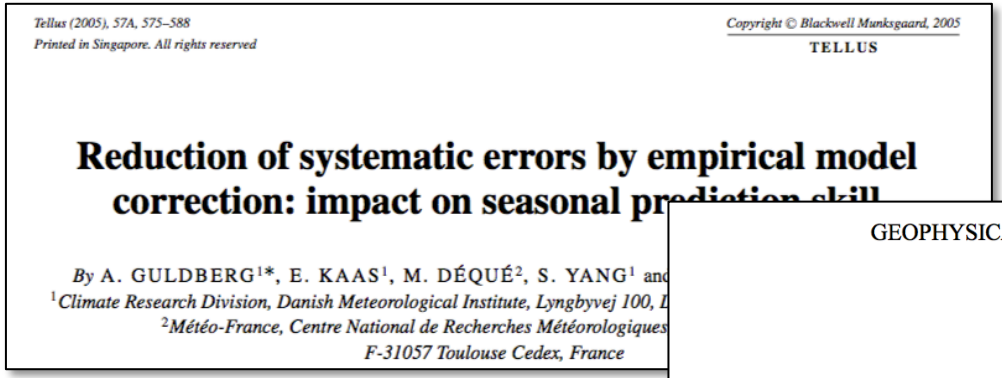
SST & SIC from coupled model (NorESM)




(b) ARP-NOR-20

(Beaumet et al., The Cryosphere, 2019)

# Empirical bias correction of atmospheric models



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TELLUS

**Reduction of systematic errors by empirical model correction: impact on seasonal pr**

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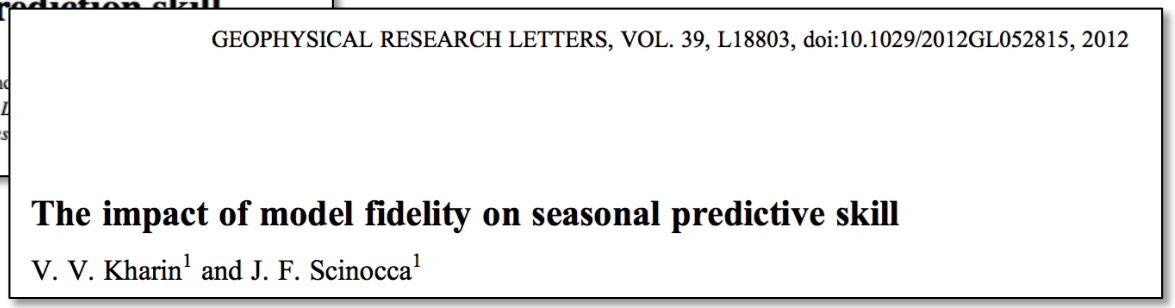


GEOPHYSICAL RESEARCH LETTERS, VOL. 39, L18803, doi:10.1029/2012GL052815, 2012

**The impact of model fidelity on seasonal predictive skill**

V. V. Kharin[1] and J. F. Scinocca[1]

*Normal prognostic equations*

*Nudging term*

Nudging:

$$\frac{\partial X}{\partial t} = F(X) - \frac{1}{\tau}(X - X_R)$$

Bias correction:

$$\frac{\partial X}{\partial t} = F(X) + G$$

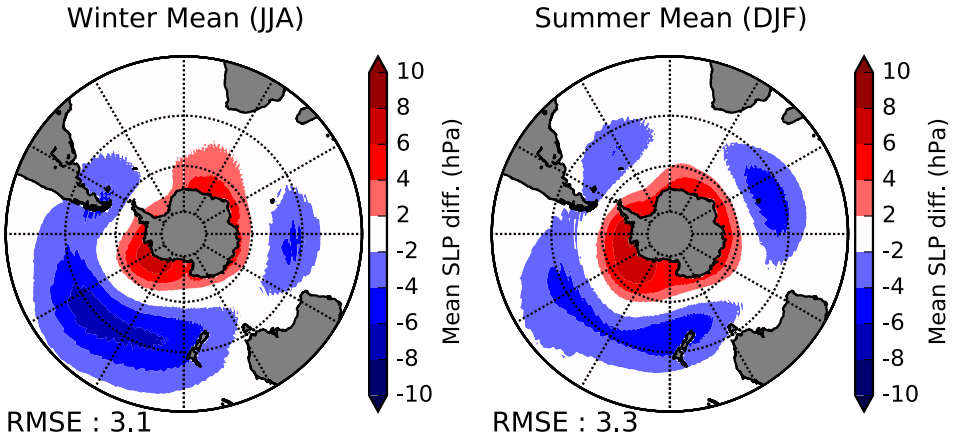
where $G$ is the empirical bias correction

$$G = -\frac{1}{\tau}\overline{(X - X_R)}^{AC}.$$

# Better representation of present mean climate, by construction

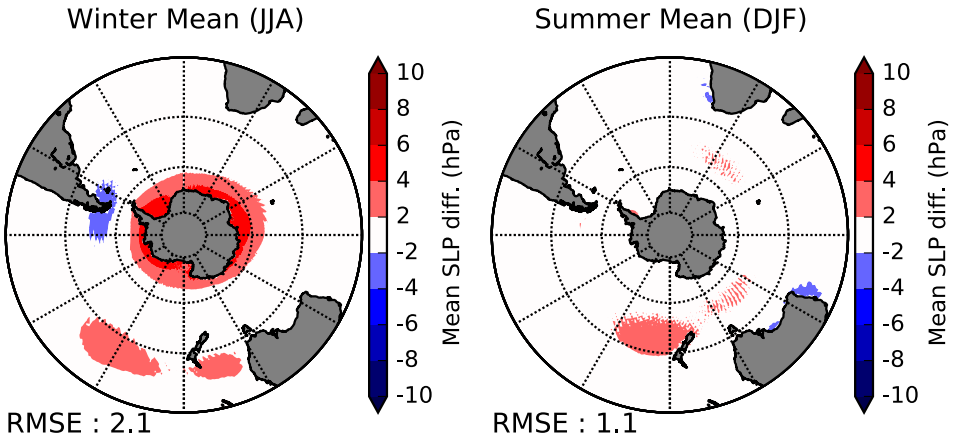
**SLP biases**

Uncorrected AMIP-type run




(a) ARP-AMIP

Corrected AMIP-type run

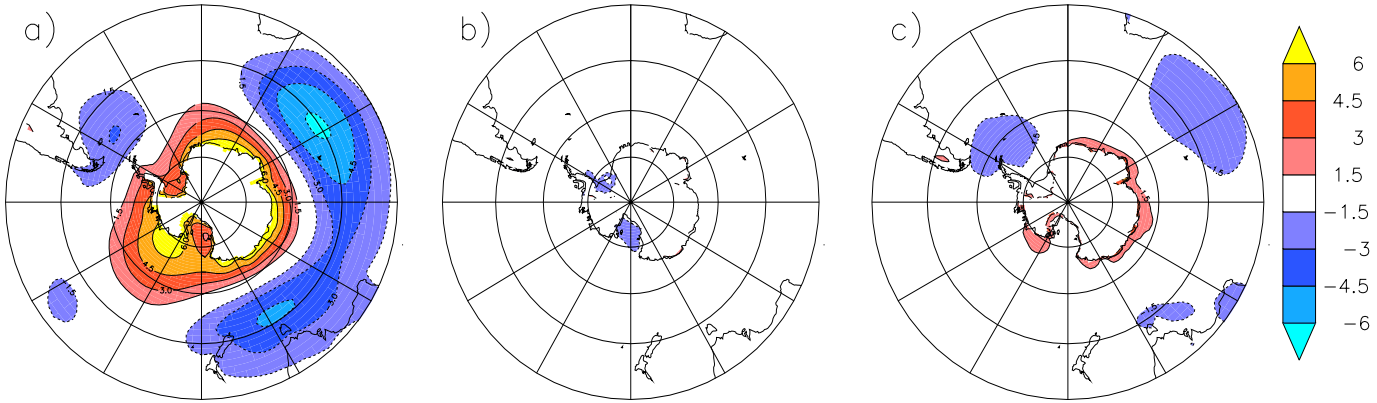



(b) ARP-AMIP-AC

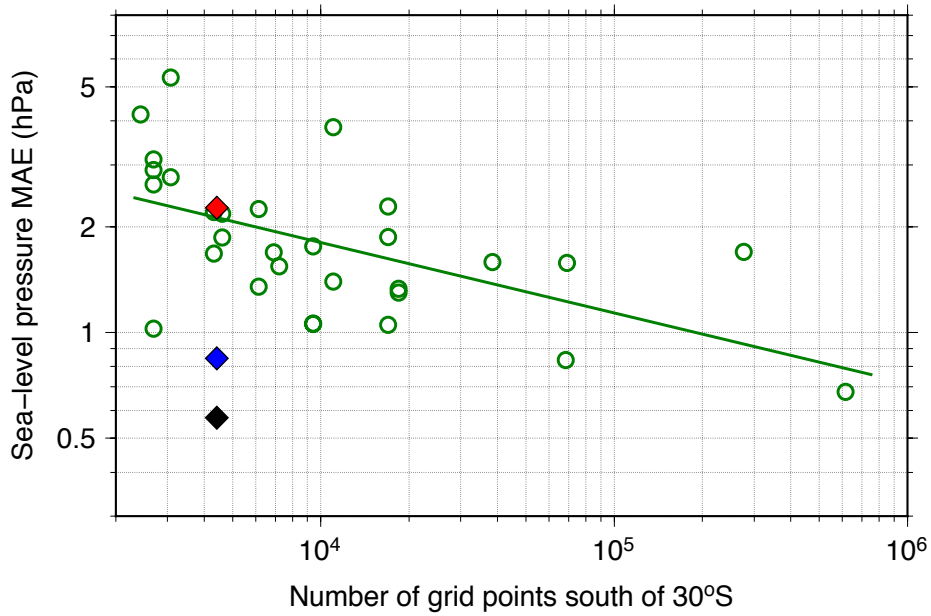
(Beaumet et al., in preparation)

LMDZ, 100 km over Antarctica

**SLP biases**



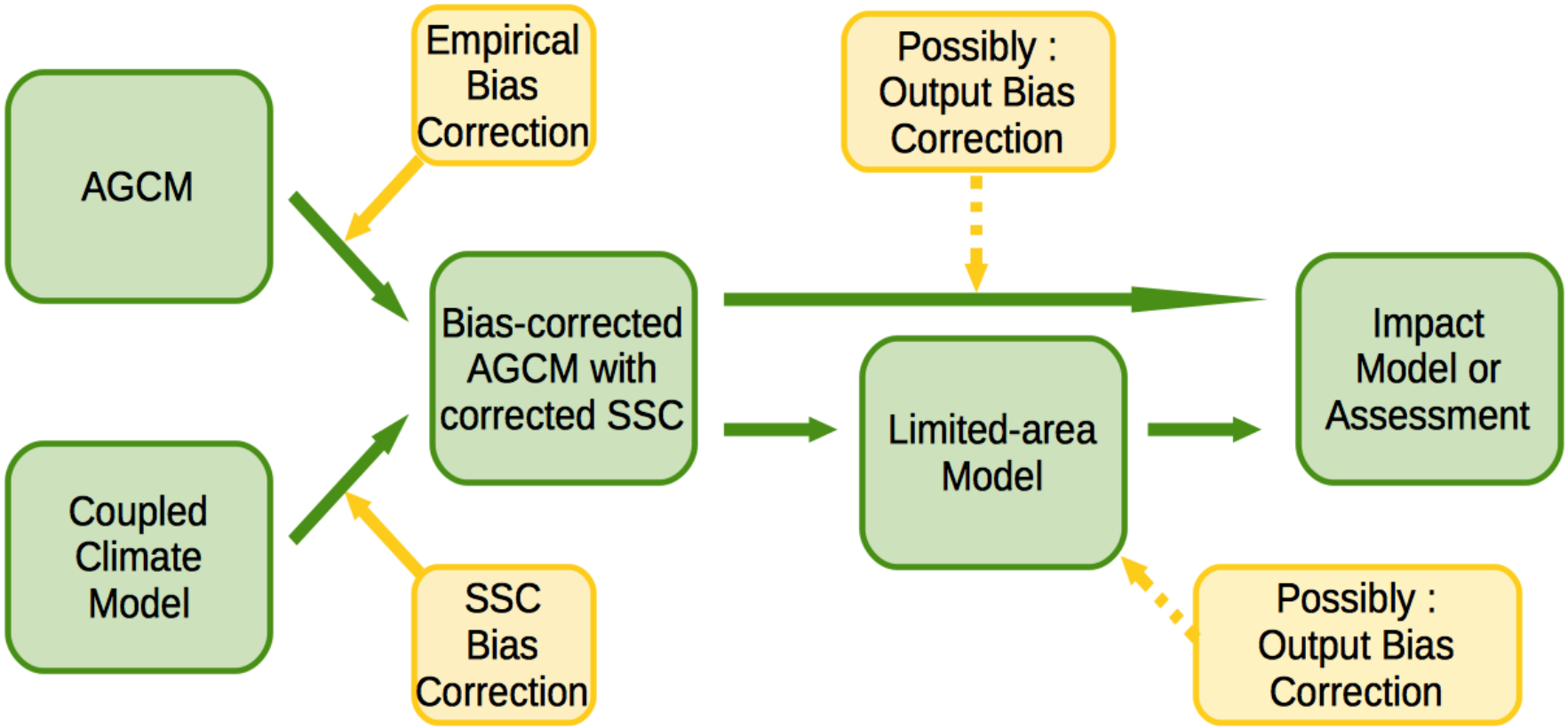

Free Nudged Corrected




CMIP5 AMIP
Free LMDZ
Corrected LMDZ
Nudged LMDZ

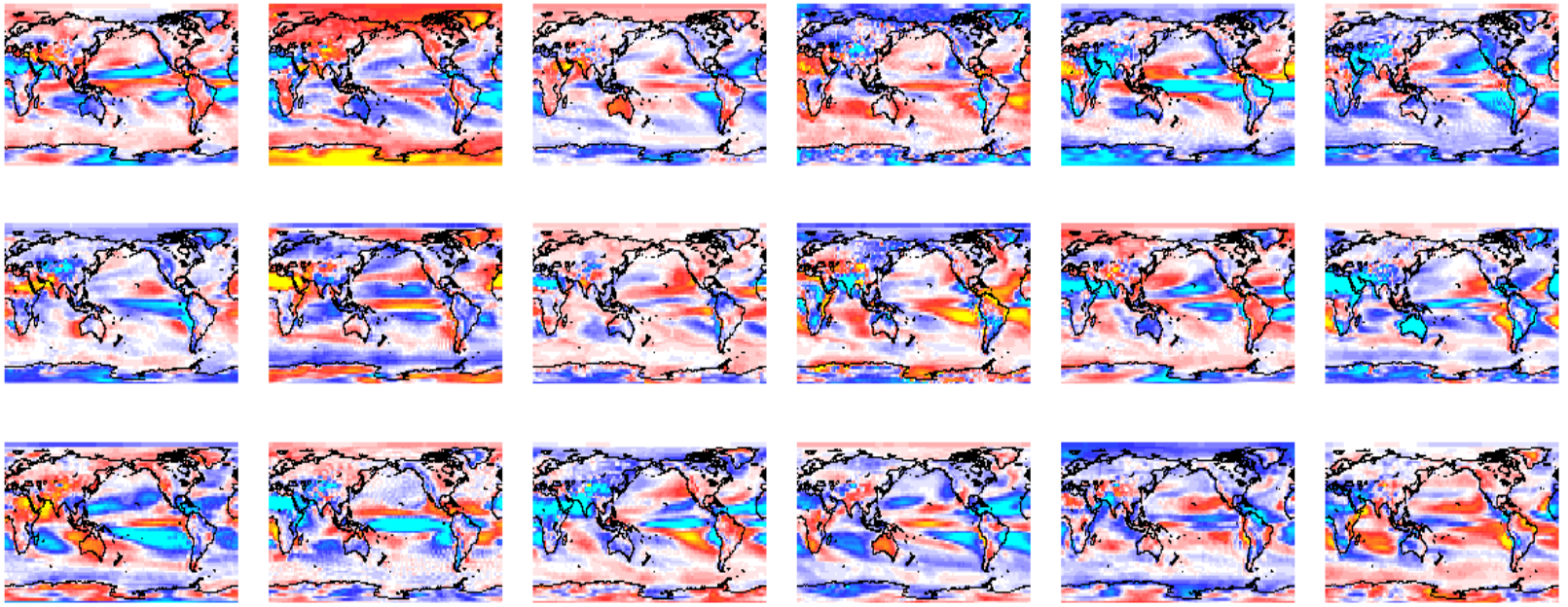
(Krinner et al., JAMES, 2019)

**Idée : combiner les corrections atmosphériques et à la surface de l'océan pour des projections**



# Necessary condition for projections: Bias stationarity

- CMIP3 & 5 : Mean model > any individual (global scale)
- Simulations: picontrol and abrupt4x$CO_2$
- Variables : p, $P_0$, $T_{2m}$, $T_{500}$, $u_{200}$, $v_{200}$, $u_z$, $v_z$, $z_{500}$,…
- Compare individual model's bias w/ ensemble mean for both periods



piControl

(Krinner and Flanner, PNAS, 2018)

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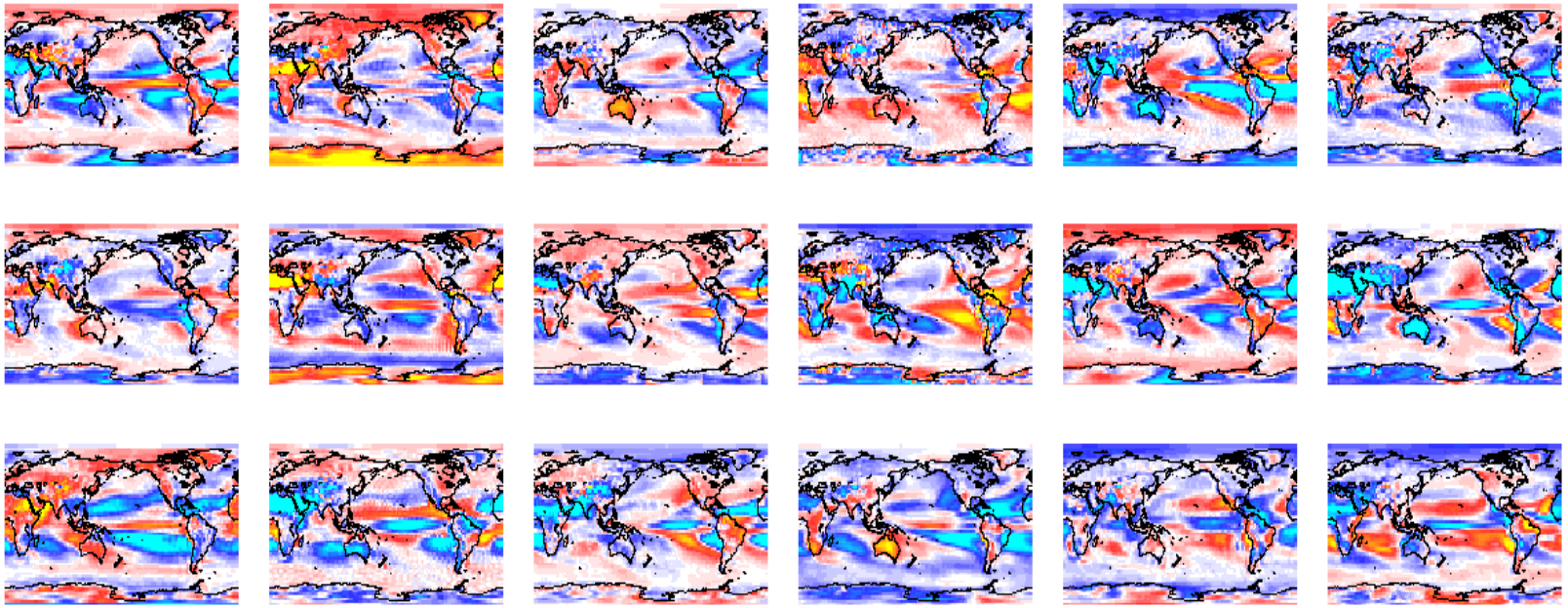


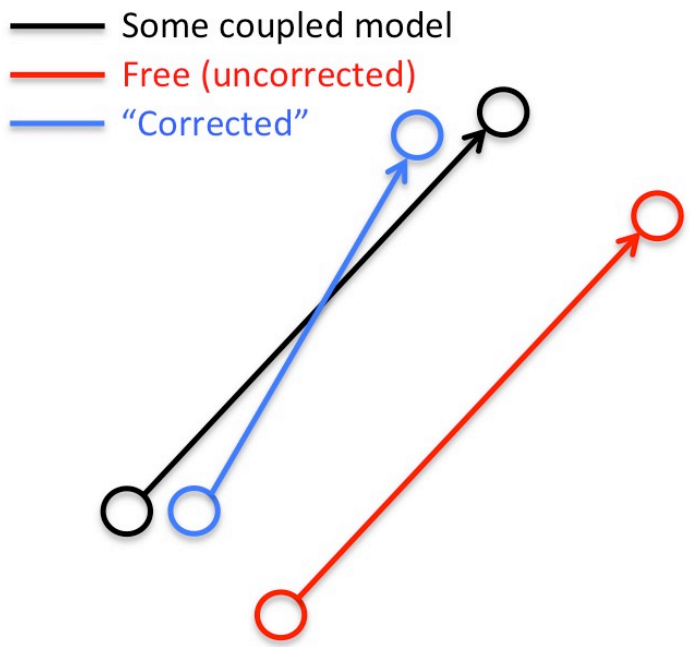
abrupt4x$CO_2$

(Krinner and Flanner, PNAS, 2018)

# A stringent test in a pseudo-reality framework

- We want to know whether the corrected model really simulates a more realistic future climate (not necessarily a more realistic climate *change*)

- But we do not know the future climate (yet)




**"Pseudo-reality" (aka "perfect model") test: Use another coupled model as a surrogate for the observable climate**

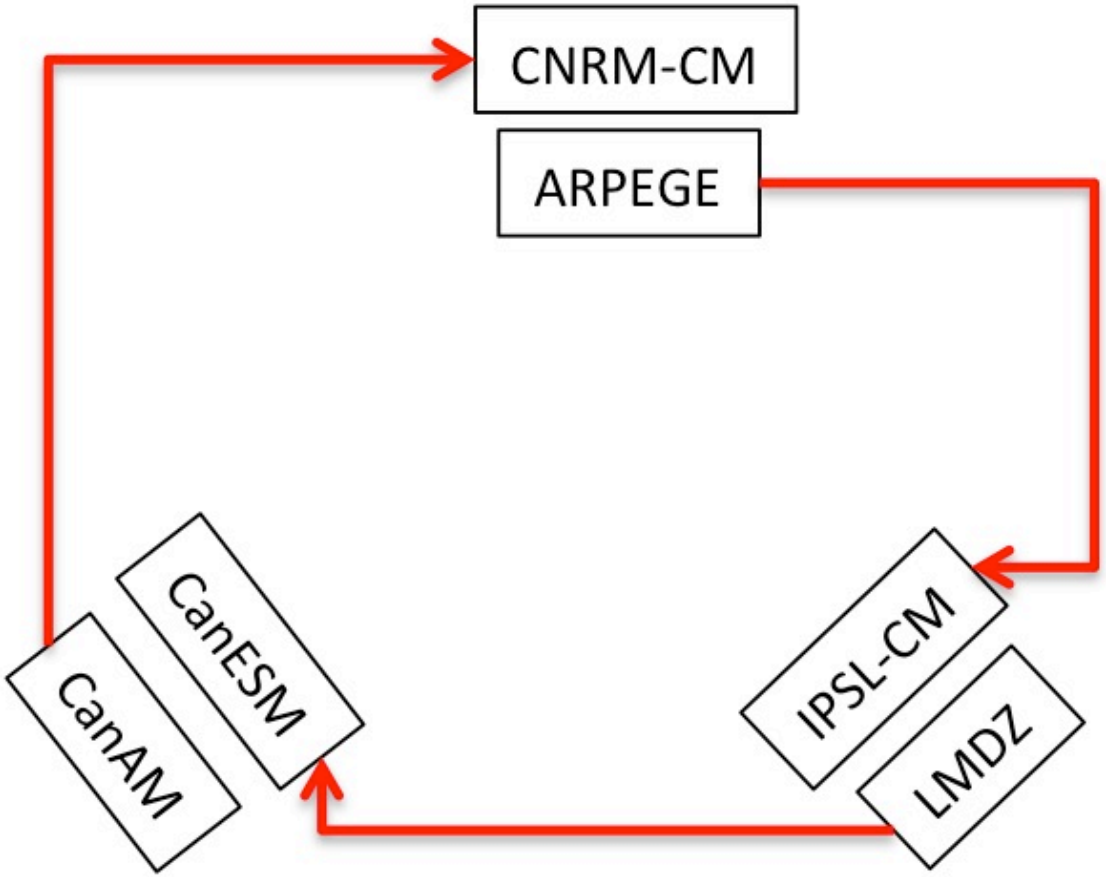
- Our AGCM has been trained to emulate the *present* "perfect model" climate

- In the "perfect model" world, we do know the future climate

- Test whether our "corrected" AGCM can simulate that future climate

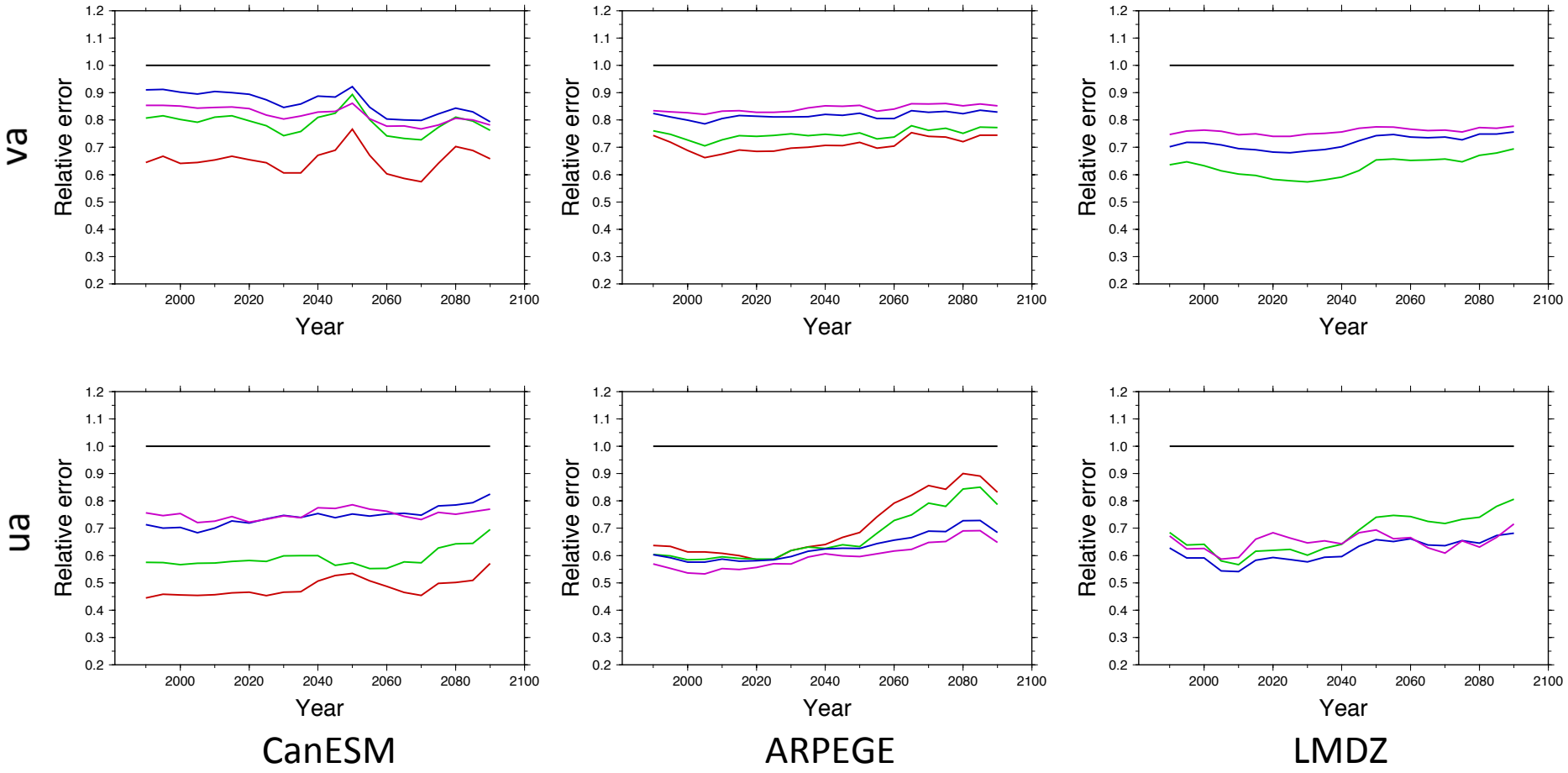
**3 AGCMs tested in CMIP5 coupled model pseudo-realities**

- RCP8.5: very strong climate change
- LMDZ uses present-day CanESM SST + IPSL-CM5 anomalies (similar for CanAM and ARPEGE)
- Check whether LMDZ correctly represents CanESM future climate (similar for CanAM and ARPEGE)



## RMSE over time, corrected model relative to uncorrected model

- Here, meridional and zonal wind speed at various tropospheric levels (RMSE uncorrected = 1)
- Benefit of bias correction mostly preserved well into the future
  ➔ **bias correction remains valid**



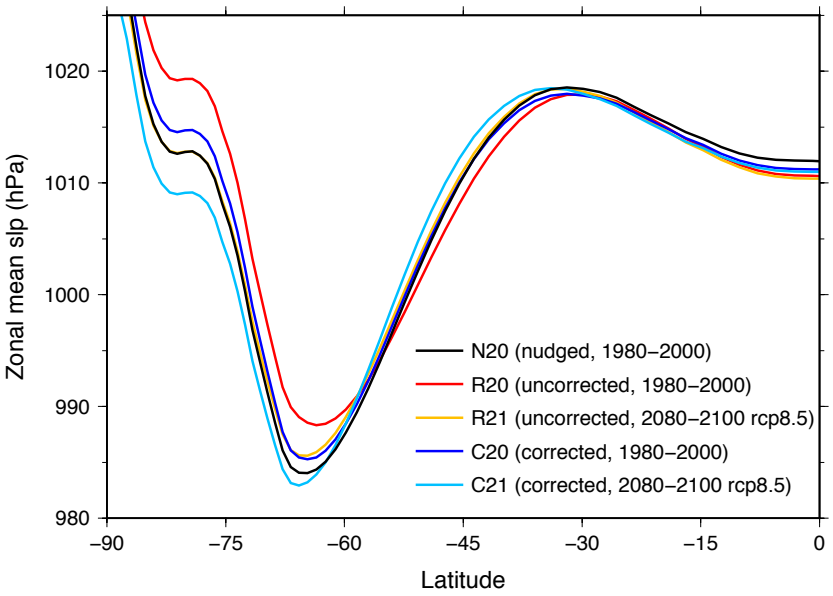
# Some applications

## Comparing corrected and uncorrected regional climate projections

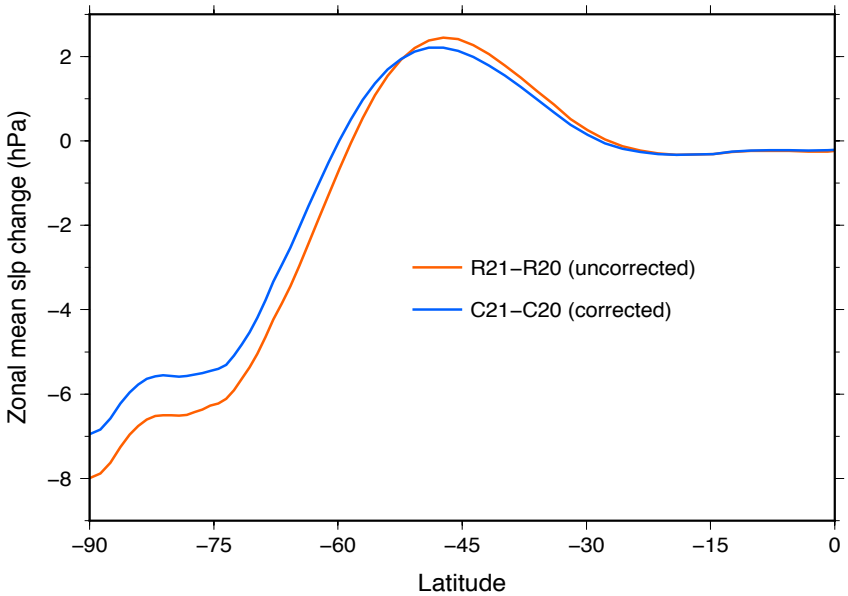
LMDZ, 100 km, using SST & SIC change from IPSL-CM5 (RCP8.5), period 2071-2100

**Simulated change of the SH westerlies (here: zonal mean slp trough):**
Similar but not identical southward displacement + deepening in both configurations

a) Annual mean zonal mean sea level pressure




b) Annual mean zonal mean sea level pressure change



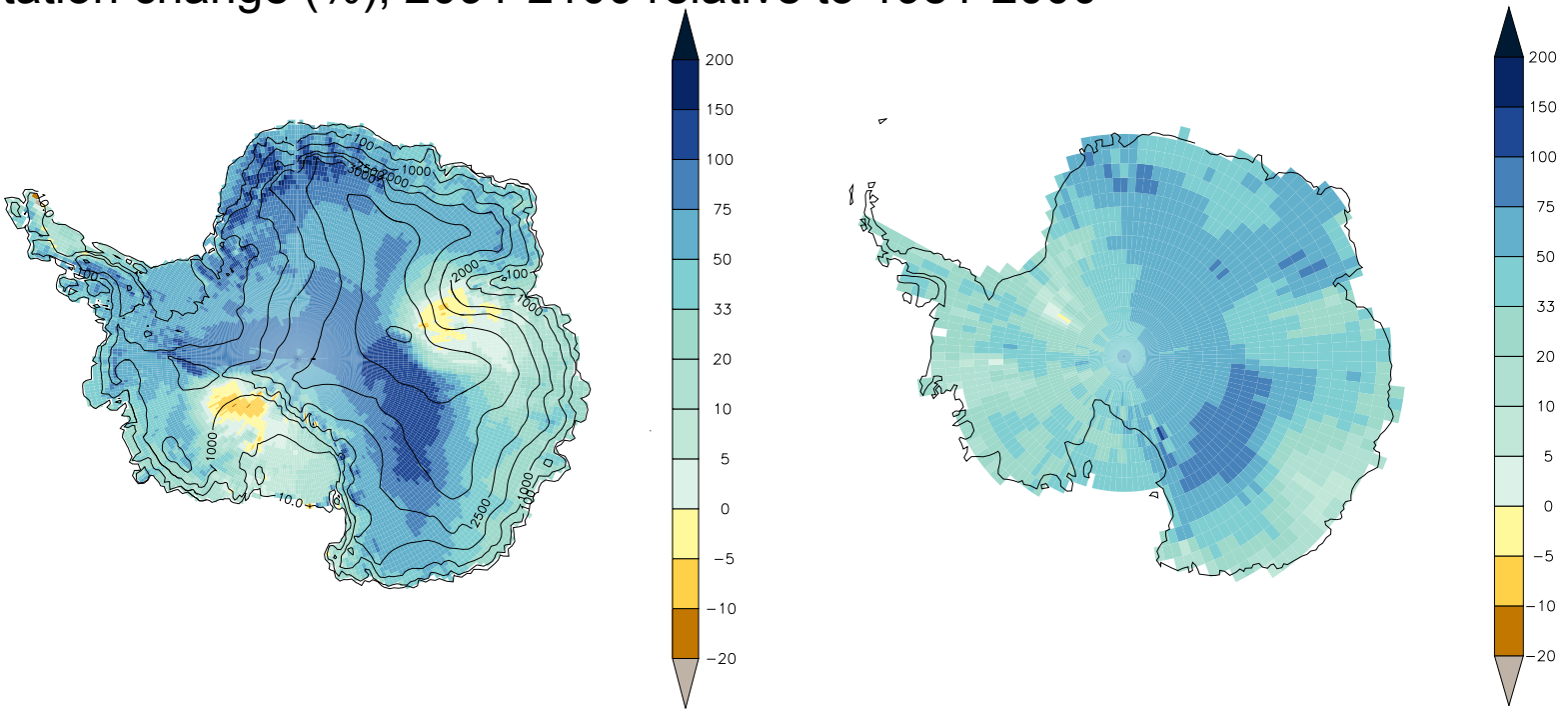

(Krinner et al., JAMES, 2019)

# Downscaling CMIP6

## Ongoing (1):

LMDZ6, run-time bias-corrections (ERA-I), 45 km over Antarctica, IPSL-CM6 ssp585

Precipitation change (%), 2091-2100 relative to 1981-2000




LMDZ6

IPSL-CM6

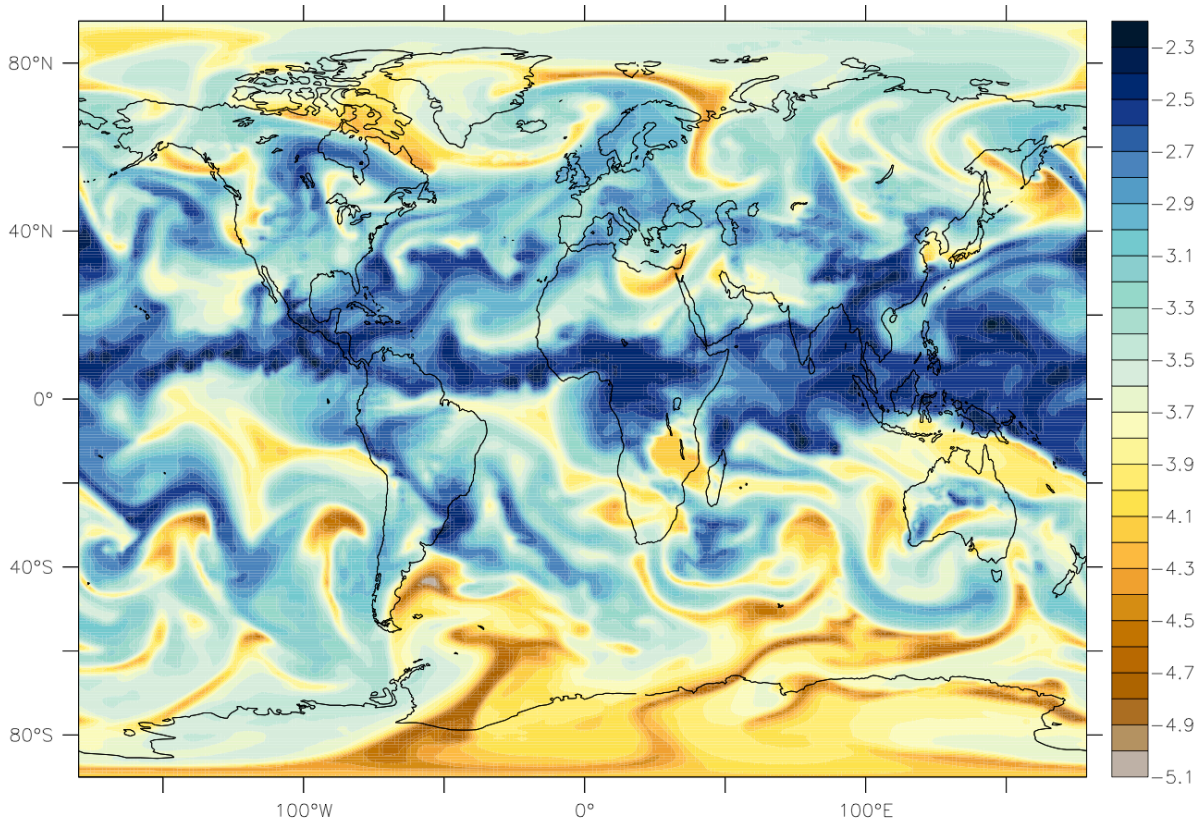
**Ongoing (2):**

LMDZ6 256x256x79 (“MR”: 1.4°x0.7°, 79 levels) w/ run-time bias-corrections (ERA5)

Scenario: IPSL-CM6 ssp585? (pattern scaling!)

Purpose: Bias-corrected climate change projection for

- RCMs: Antarctica, Greenland, Andes, Himalaya, West Africa, Arctic, Europe ?
- Land-surface models
- Ice sheet models
- Ocean models



# En résumé

- Correction de biais dans l'atmosphère et à la surface de l'océan pour AGCM
- Semble valide pour des projections climatiques
- Simulations LMDZ (en grille régulière) comme CL pour modèles régionaux
- Simulations LMDZ zoom: avec correction, ou guidées par simulations régulières débiaisées
- Bien sûr on préférerait avoir un GCM sans erreurs dès le départ…