



# L'ensemble MRCC5-CMIP6 d'Ouranos

Configuration, évaluation et changements climatiques

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**Dominique Paquin**, Olivier Asselin, Pascal Bourgault, Charles Gauthier, Michel Giguère, Marie-Pier Labonté, Dominic Matte, Christopher McCray

Simulations et analyses climatiques (SAC pour les intimes)

Session 13 : Modélisation régionale du climat

29 janvier 2025



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*Session 18*

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# Plan de la présentation

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Deqèc? Modèle et configuration

Qècékiadedan? Ensemble MRCC5-CMIP6 + Variables disponibles

Ctypapir? Évaluation : Biais structurels, totaux et autres

CC? Changements climatiques

Ouèséconsenva? Développements

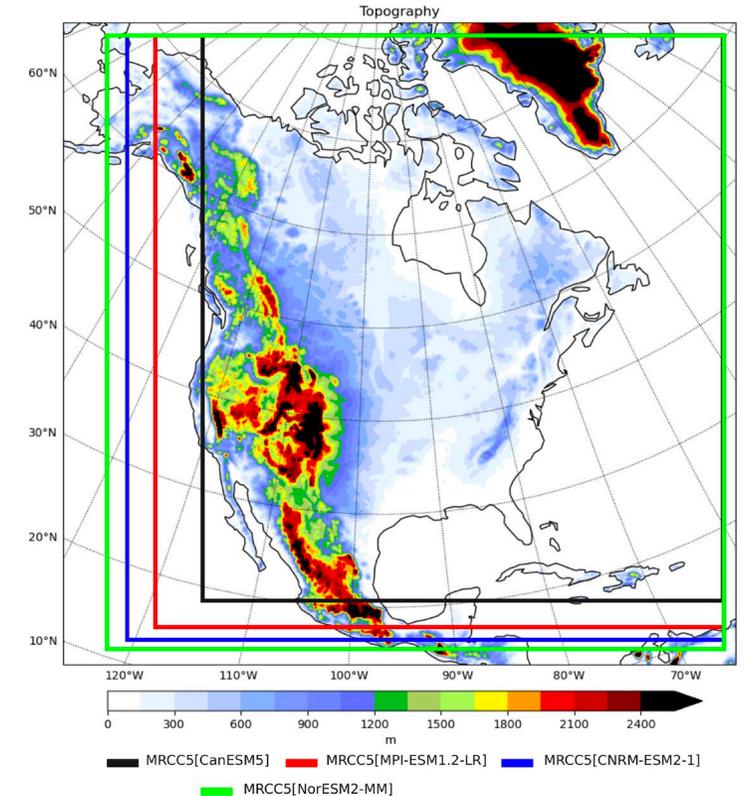
# Modèle et configuration

MRCC5 – *Modèle régional canadien du climat V5*

Modèle opérationnel utilisé à Ouranos  
Basé sur GEM3.3.3.1, modèle de prévision  
numérique du temps de ECCC  
Développé par le centre ESCER (UQAM)  
en collaboration avec ECCC

Piloté par CMIP6 – *Coupled Model  
Intercomparison Project 6th ed.*

Données archivées aux heures ou 3 heures  
selon les variables



Domaine NA-CORDEX à 0.11° -  
*WCRP Coordinated Regional  
Downscaling Experiment domaine  
Amérique du Nord*

# Ensemble MRCC5-CMIP6 d'Ouranos

pilote	ESC	période	émissions	membres
ERA-5		1979-2020	obs	2
CanESM5	5,64	1950-2014	historique	1
		2015-2100	SSP126	1
		2015-2100	SSP245	1
		2015-2100	SSP370	1
		2015-2100	SSP585	1
MPI-ESM-1-2_LR	3,0	1950-2014	historique #1	5 (3 complétés, 2 à venir)
		2015-2100	SSP126	1
		2015-2100	SSP245	1
		2015-2100	SSP370 #1	5 (2 complétés, 1 en cours, 2 à venir)
CNRM-ESM2-1	4,8	1950-2014	historique	1
		2015-2100	SSP126	1
		2015-2100	SSP245	1
		2015-2100	SSP370	1
NorESM2-MM	2,54	1950-2014	historique	1
		2015-2100	SSP126	1 en cours
		2015-2100	SSP245	1 à venir
		2015-2100	SSP370	1 en cours

# Ensemble MRCC5-CMIP6 d'Ouranos



Marie-Pier Labonté : Amélioration des données pilote pour les modèles climatiques régionaux - Impacts à l'échelle régionale

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CanESM5	5,64	1950-2014	historique	1
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		2015-2100	SSP585	1
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		2015-2100	SSP126	1 en cours
		2015-2100	SSP245	1 en cours
		2015-2100	SSP370	1 en cours

# Ensemble MRCC5-CMIP6 d'Ouranos



Dominic Matte : Sélection et analyse des modèles CMIP6 en vue d'une application à la modélisation régionale

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ERA-5		1979-2020	obs	2
CanESM5	5,64	1950-2014	historique	1
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		2015-2100	SSP126	1 en cours
		2015-2100	SSP245	1 en cours
		2015-2100	SSP370	1 en cours

# Liste des variables

Variable	Description	Frequency	Realm	Type
baresoilFrac	Bare Soil Fraction	3-hr	Land 2D	I
capei	Convective Available Potential Energy	3-hr	Atmo 2D	I
clt	Total Cloud Fraction	1-hr	Atmo 2D	M
<b>clwvi</b>	<b>Condensed Water Path</b>	<b>3-hr</b>	<b>Atmo 2D</b>	<b>I</b>
ct	Air Pressure at Cloud Top	3-hr	Atmo 2D	I
dds	Near-Surface Dewpoint Depression	3-hr	Atmo 2D	I
dedt	Tendency of Integrated Cloud Water and Ice	3-hr	Atmo 2D	M
dfq	Horizontal Divergence of Water Vapor Flux	3-hr	Atmo 2D	M
drdt	Tendency of Integrated Water Vapor	3-hr	Atmo 2D	M
ebq	Residual Term of Atmosphere Water Budget	3-hr	Atmo 2D	M
<b>evspsbl</b>	<b>Evaporation</b>	<b>1-hr</b>	<b>Atmo 2D</b>	<b>M</b>
evspsbland	Water Evaporation from Land	3-hr	Land 2D	M
<b>hfss</b>	<b>Surface Upward Latent Heat Flux</b>	<b>3-hr</b>	<b>Atmo 2D</b>	<b>M</b>
hfss	Surface Upward Sensible Heat Flux	3-hr	Atmo 2D	M
hrmax	Near-Surface Maximum Relative Humidity	3-hr	Atmo 2D	X
hrmin	Minimum Near-Surface Relative Humidity	3-hr	Atmo 2D	X
<b>hurs</b>	<b>Near-Surface Relative Humidity</b>	<b>1-hr</b>	<b>Atmo 2D</b>	<b>I</b>
hus	Specific Humidity	3-hr	Atmo 3D	I
<b>huss</b>	<b>Near-Surface Specific Humidity</b>	<b>1-hr</b>	<b>Atmo 2D</b>	<b>I</b>
lfirt	Lake Floor Temperature	3-hr	Lake 2D	I
lif	Lake Ice Fraction	3-hr	Lake 2D	I
lit	Lake Ice Thickness	3-hr	Lake 2D	I
lmlt	Lake Mixed-Layer Temperature	3-hr	Lake 2D	I
lmlthick	Lake Mixed-Layer Thickness	3-hr	Lake 2D	I
mrfl	Soil Layer Frozen Water Content	3-hr	Land 3D	I
va	Northward Wind	3-hr	Atmo 3D	I
<b>vas</b>	<b>Northward Near-Surface Wind</b>	<b>1-hr</b>	<b>Atmo 2D</b>	<b>I</b>
volmrfl	Soil Layer Volumetric Frozen Water Content	3-hr	Land 3D	I
volmrlqsl	Soil Layer Volumetric Liquid Water Content	3-hr	Land 3D	I
vqvc	Vertically Integrated North Comp. of Specific Humidity Flux	3-hr	Atmo 2D	M
zg	Geopotential Height	3-hr	Atmo 3D	I
zmla	Height of Boundary Layer	3-hr	Atmo 2D	I

mrfs0	Soil Frozen Water Content	3-hr	Land 2D	I
mrflsl	Water Content of Soil Layer	3-hr	Land 3D	I
<b>mrro</b>	<b>Total Runoff</b>	<b>3-hr</b>	<b>Land 2D</b>	<b>M</b>
mrros	Surface Runoff	3-hr	Land 2D	M
mrso	Total Soil Moisture Content	3-hr	Land 2D	I
mrso5	Moisture in Upper Portion of Soil Column	3-hr	Land 2D	I
<b>pr</b>	<b>Precipitation Flux</b>	<b>1-hr, daily</b>	<b>Atmo 2D</b>	<b>M</b>
prc	Convective Precipitation	1-hr	Atmo 2D	M
prdc	Deep Convective Precipitation	3-hr	Atmo 2D	M
<b>prfr</b>	<b>Freezing Rain</b>	<b>1-hr</b>	<b>Atmo 2D</b>	<b>M</b>
<b>prlp/prra</b>	<b>Liquid Precipitation/Rainfall Flux</b>	<b>3-hr</b>	<b>Atmo 2D</b>	<b>M</b>
prrp	Refrozen Rain	3-hr	Atmo 2D	M
<b>prsn</b>	<b>Snowfall Flux</b>	<b>3-hr</b>	<b>Atmo 2D</b>	<b>M</b>
<b>prw</b>	<b>Water Vapor Path</b>	<b>3-hr</b>	<b>Atmo 2D</b>	<b>I</b>
<b>ps</b>	<b>Surface Air Pressure</b>	<b>1-hr</b>	<b>Atmo 2D</b>	<b>I</b>
psl	Sea Level Pressure	1-hr	Atmo 2D	I
pw	Precipitable Water	3-hr	Atmo 2D	I
rhsmax	Surface Daily Maximum Relative Humidity	daily	Atmo 2D	X
rhsmin	Surface Daily Minimum Relative Humidity	daily	Atmo 2D	X
<b>rlds</b>	<b>Surface Downwelling Longwave Radiation</b>	<b>1-hr</b>	<b>Atmo 2D</b>	<b>M</b>
rls	Net LW Surface Radiation	1-hr	Atmo 2D	M
rlus	Surface Upwelling Longwave Radiation	1-hr	Atmo 2D	M
rlut	TOA Outgoing Longwave Radiation	1-hr	Atmo 2D	M
rsaa	Shortwave Radiation Absorbed by Atmosphere	1-hr	Atmo 2D	M
<b>rsds</b>	<b>Surface Downwelling Shortwave Radiation</b>	<b>1-hr</b>	<b>Atmo 2D</b>	<b>M</b>
rsdt	TOA Incident Shortwave Radiation	1-hr	Atmo 2D	M
rss	Net SW Surface Radiation	1-hr	Atmo 2D	M
rsus	Surface Upwelling Shortwave Radiation	1-hr	Atmo 2D	M
rsut	TOA Outgoing Shortwave Radiation	1-hr	Atmo 2D	M
rv	Relative Vorticity	3-hr	Atmo 3D	M
sfcWindmax	Daily Maximum Near-Surface Wind Speed	daily	Atmo 2D	X
sic	Sea Ice Area Fraction	3-hr	Ocean 2D	I
sit	Sea Ice Thickness	3-hr	Ocean 2D	I
snc	Snow Area Fraction	3-hr	Land 2D	I
snd	Snow Depth	3-hr	Land 2D	I
snm	Surface Snow Melt	3-hr	Land 2D	M
<b>snw</b>	<b>Surface Snow Amount</b>	<b>3-hr</b>	<b>Land 2D</b>	<b>I</b>
ta	Air Temperature	3-hr	Atmo 3D	I
<b>tas</b>	<b>Near-Surface Air Temperature</b>	<b>1-hr, daily</b>	<b>Atmo 2D</b>	<b>I</b>
<b>tasmax</b>	<b>Daily Maximum Near-Surface Temperature</b>	<b>daily</b>	<b>Atmo 2D</b>	<b>X</b>
<b>tasmin</b>	<b>Daily Minimum Near-Surface Temperature</b>	<b>daily</b>	<b>Atmo 2D</b>	<b>X</b>
tke	Turbulent Kinetic Energy	3-hr	Atmo 2D	I
ts	Surface Temperature	3-hr	Atmo 2D	I
tsl	Temperature of Soil	3-hr	Land 3D	I
tsmax	Maximum Near-Surface Temperature	3-hr	Atmo 2D	X
tsmin	Minimum Near-Surface Temperature	3-hr	Atmo 2D	X
tso	Sea Surface Temperature	3-hr	Ocean 2D	I
ttop	Air Temperature at Cloud Top	3-hr	Atmo 2D	I
ua	Eastward Wind	3-hr	Atmo 3D	I
<b>uas</b>	<b>Eastward Near-Surface Wind</b>	<b>1-hr</b>	<b>Atmo 2D</b>	<b>I</b>
uqvc	Vertically Integrated East. Comp. of Specific Humidity Flux	3-hr	Atmo 2D	M
uvmax	Maximum Near-Surface Wind Speed	3-hr	Atmo 2D	X



# Liste des variables

Charles Gauthier : Opérations du MRCC : base de données, accès aux données et autre sujets négligés

Variable	Description	Frequency	Realm	Type
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evspsbland	Water Evaporation from Land	3-hr	Land 2D	M
<b>hfis</b>	<b>Surface Upward Latent Heat Flux</b>	<b>3-hr</b>	<b>Atmo 2D</b>	<b>M</b>
hfss	Surface Upward Sensible Heat Flux	3-hr	Atmo 2D	M
hrmax	Near-Surface Maximum Relative Humidity	3-hr	Atmo 2D	X
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<b>hurs</b>	<b>Near-Surface Relative Humidity</b>	<b>1-hr</b>	<b>Atmo 2D</b>	<b>I</b>
hus	Specific Humidity	3-hr	Atmo 3D	I
<b>huss</b>	<b>Near-Surface Specific Humidity</b>	<b>1-hr</b>	<b>Atmo 2D</b>	<b>I</b>
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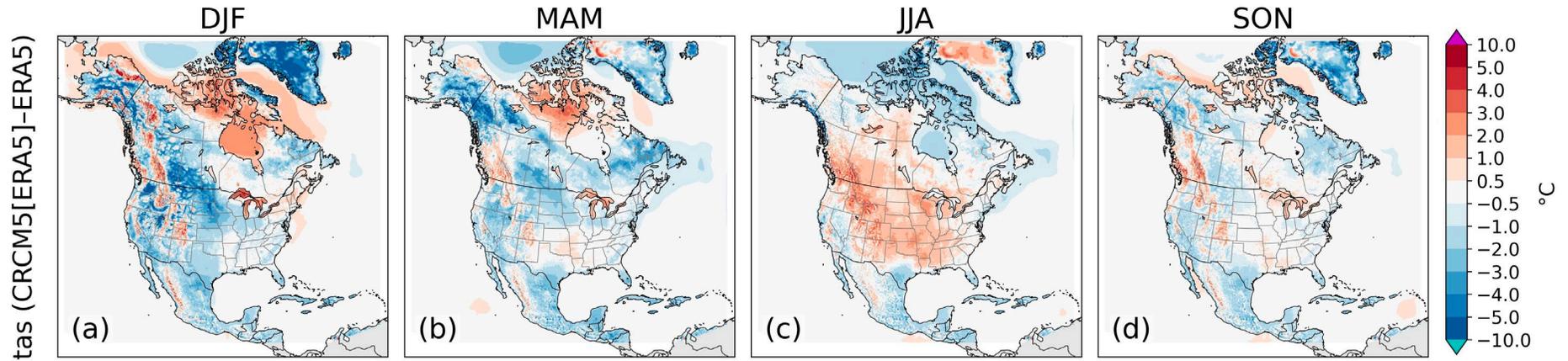
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<b>tasmax</b>	<b>Daily Maximum Near-Surface Temperature</b>	<b>daily</b>	<b>Atmo 2D</b>	<b>X</b>
<b>tasmin</b>	<b>Daily Minimum Near-Surface Temperature</b>	<b>daily</b>	<b>Atmo 2D</b>	<b>X</b>
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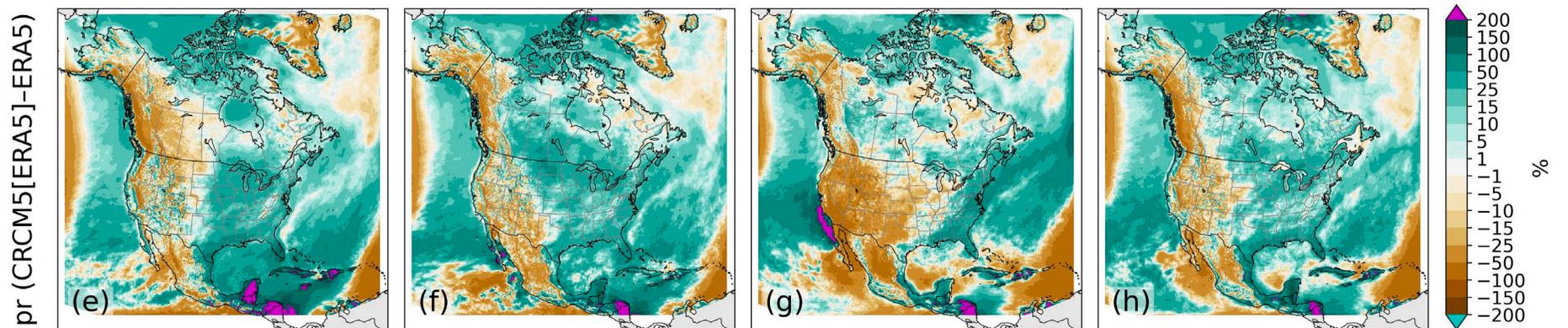
# Évaluation : biais structurels du MRCC5

*Les biais du modèle lui-même, piloté par des réanalyses et comparés aux réanalyses, le truc moche dont on ne peut se débarrasser, le niveau zéro de l'erreur*

température  
de surface  
(tas )



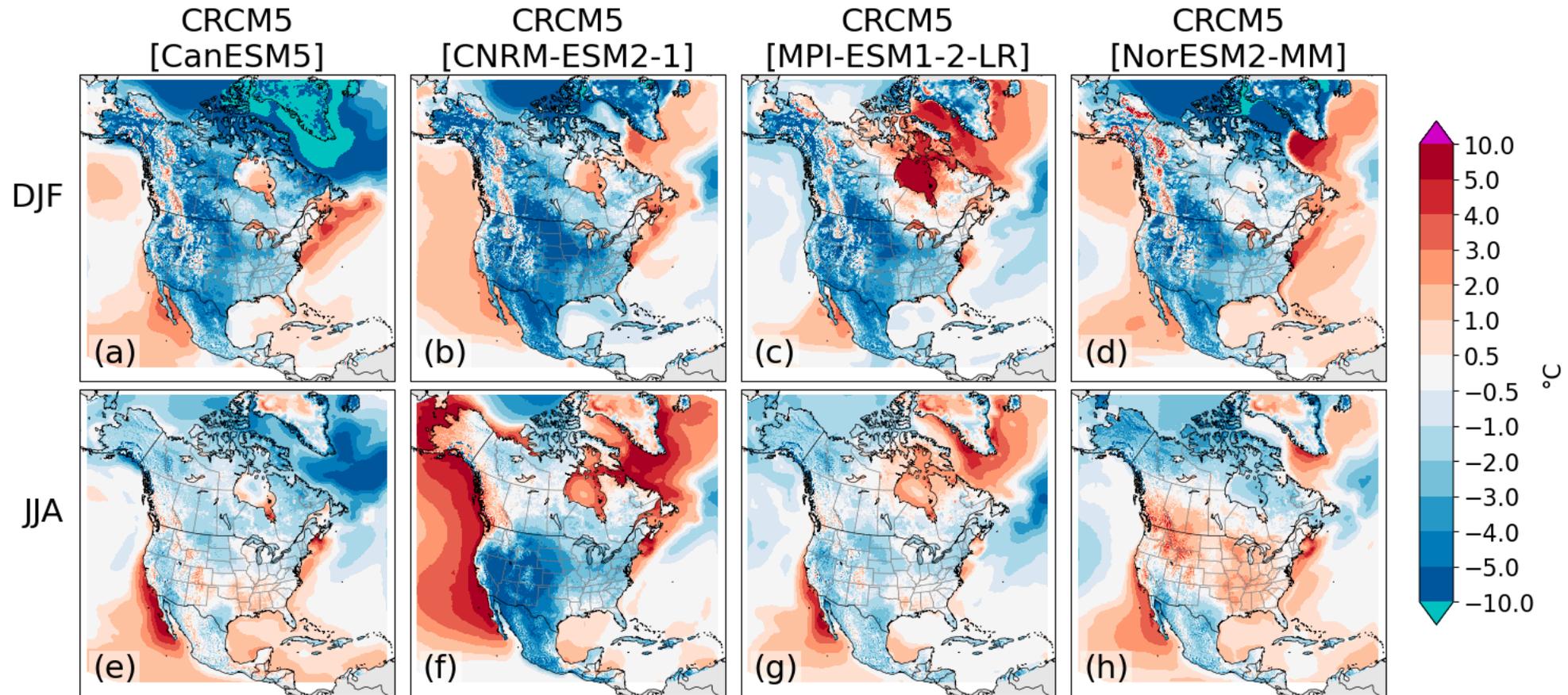
précipitation (%)



*CRCM5 structural biases for temperature (tas, a–d) (°C) and precipitation (pr, e–h) (relative changes in %) for winter (a,e), spring (b, f), summer (c, g) and autumn (d, h). Biases are calculated by subtracting 1981-2000 seasonal means from ERA5 from means from the CRCM5 simulation driven by ERA5.*

# Évaluation : biais de température à 2 m (tas °C)

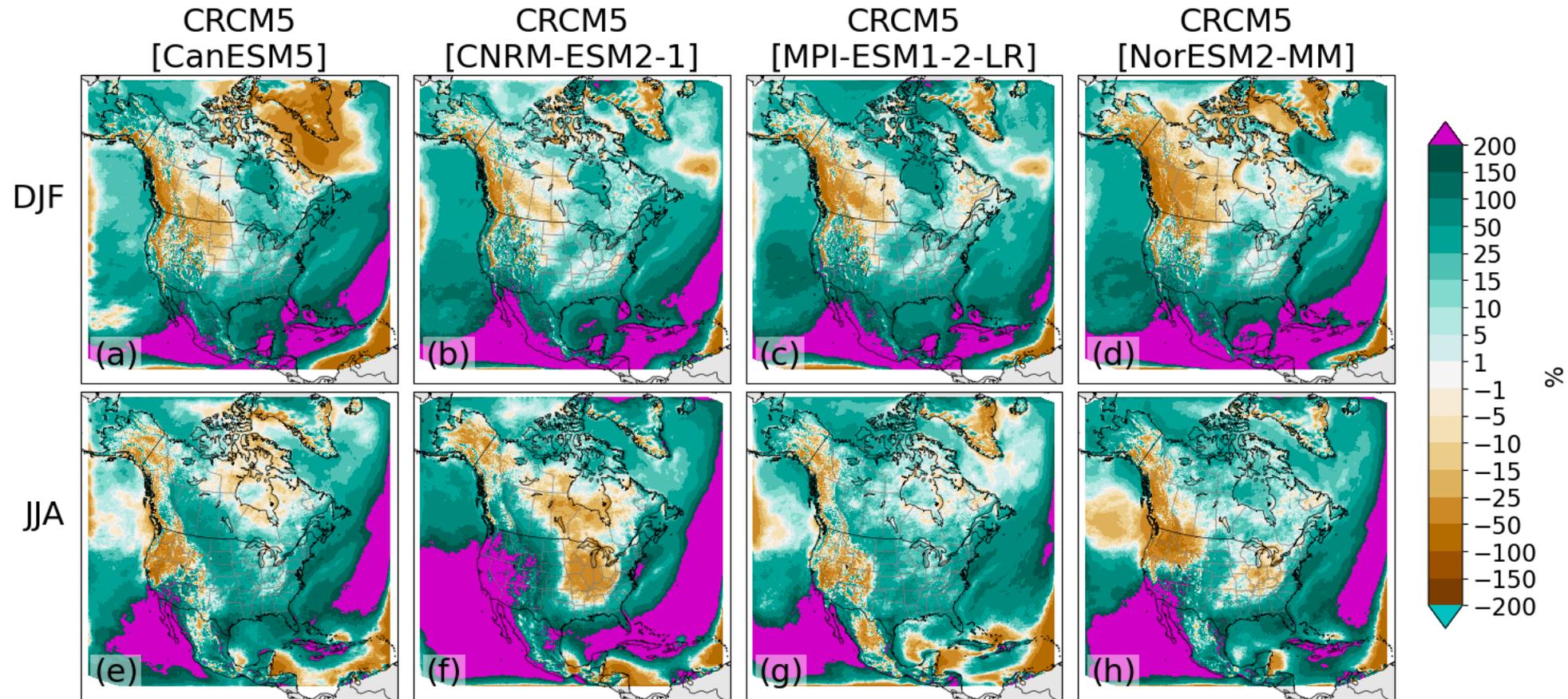
*Le biais total soit le biais structurel + ce qui provient du modèle pilote qu'on a choisi avec soin (qu'on espère pas si mal)*



*CRCM5 temperature biases (°C) for winter (a–d) and summer (e–h) for the historical climate simulations driven by CanESM5 (a), CNRM-ESM2-1 (b), MPI-ESM1-2-LR (c) and NorESM2-MM (d). Biases are calculated by subtracting 1971-2000 seasonal means from the simulation from those of ERA5.*

# Évaluation : biais de précipitation (pr %)

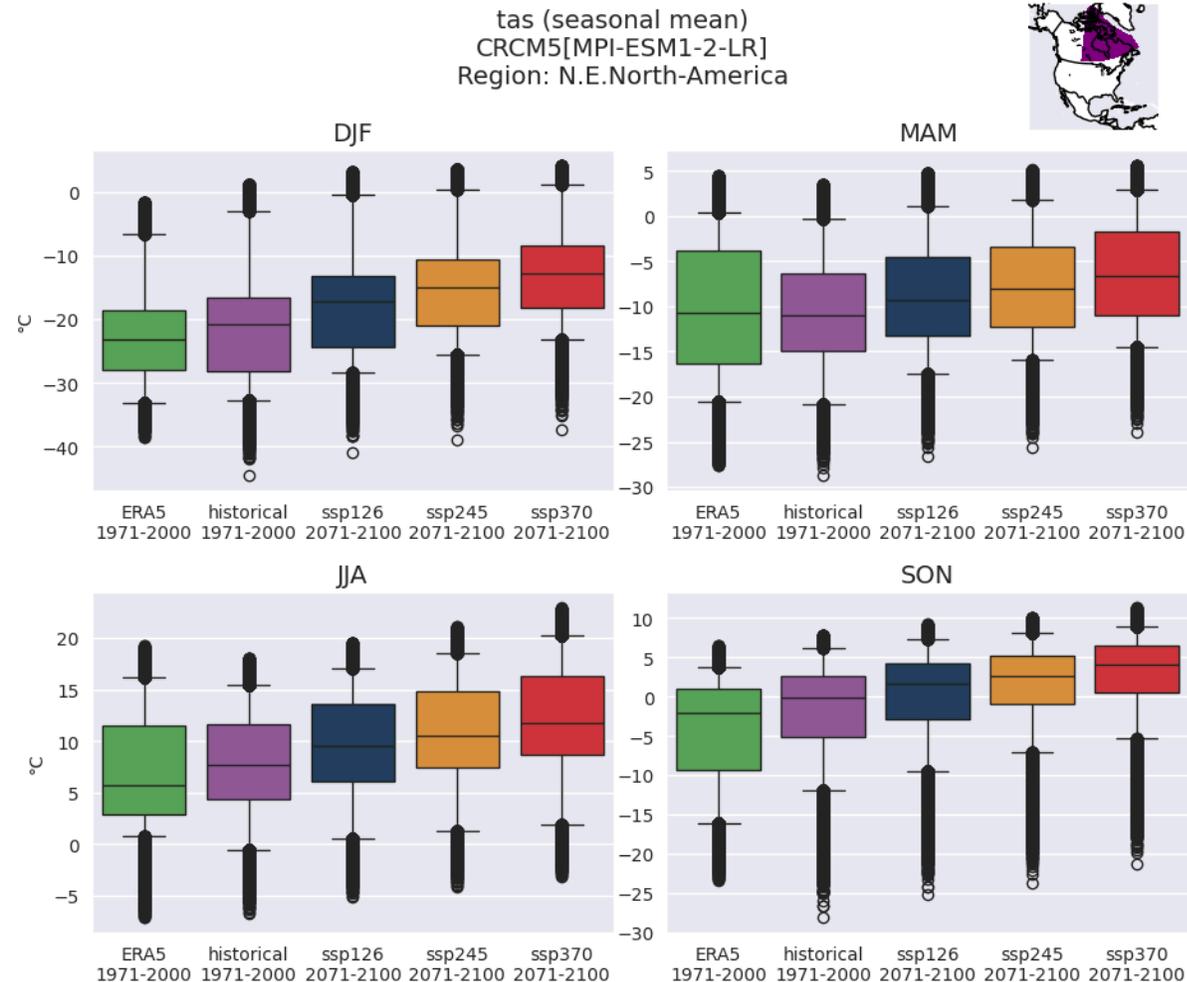
*Le biais total soit le biais structurel + ce qui provient du modèle pilote qu'on a choisi avec soin (qu'on espère pas si mal)*



*CRCM5 relative precipitation (%) for winter (a–d) and summer (e–h) for the historical climate simulations driven by CanESM5 (a), CNRM-ESM2-1 (b), MPI-ESM1-2-LR (c) and NorESM2-MM (d). Biases are calculated by subtracting 1971-2000 seasonal means from the simulation from those of ERA5.*

# Évaluation + changements climatiques

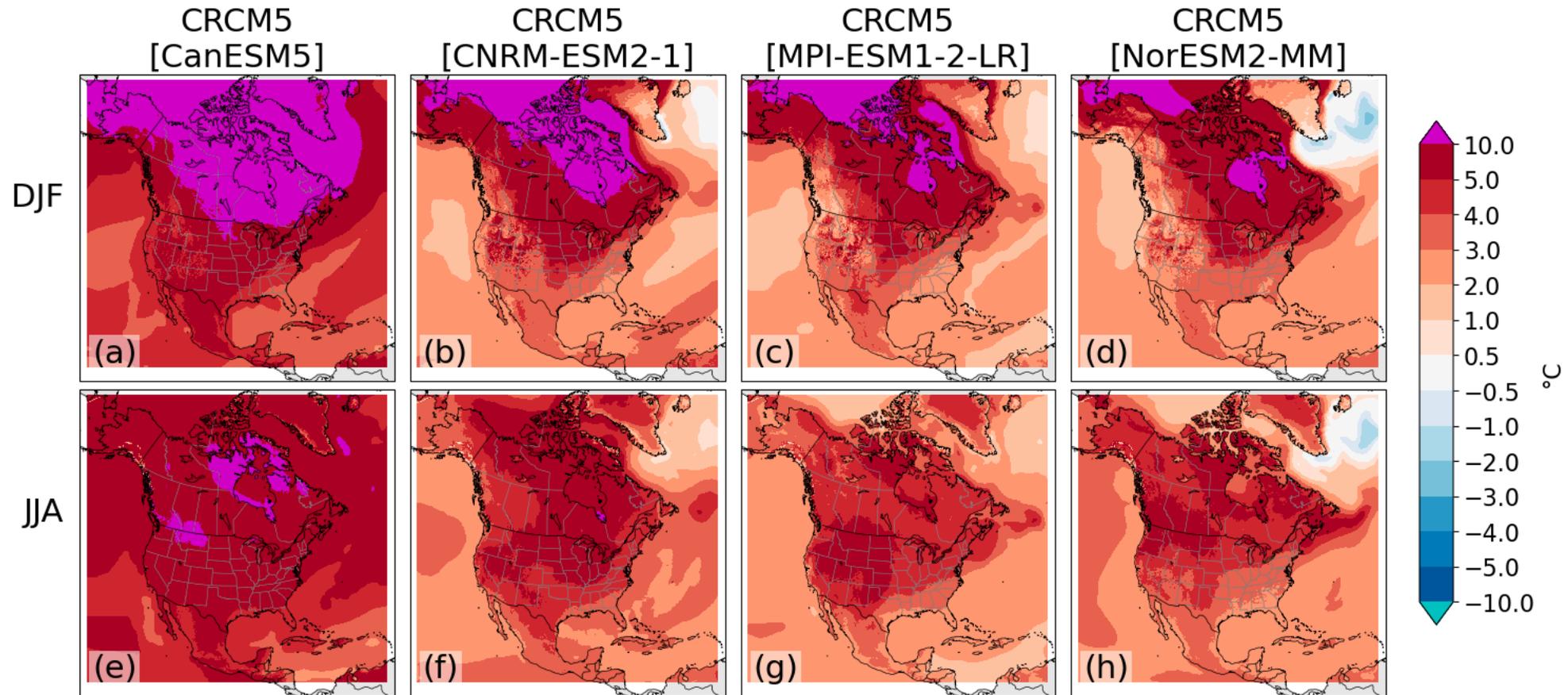
*Est-ce que les changements ont de l'allure de façon générale? Cohérents avec les scénarios d'émissions? Différences régionales?*



# Changements climatiques

## Changement de la température de surface (tas - °C)

Comment sont les changements en fonction des pilotes et de leur ECS?

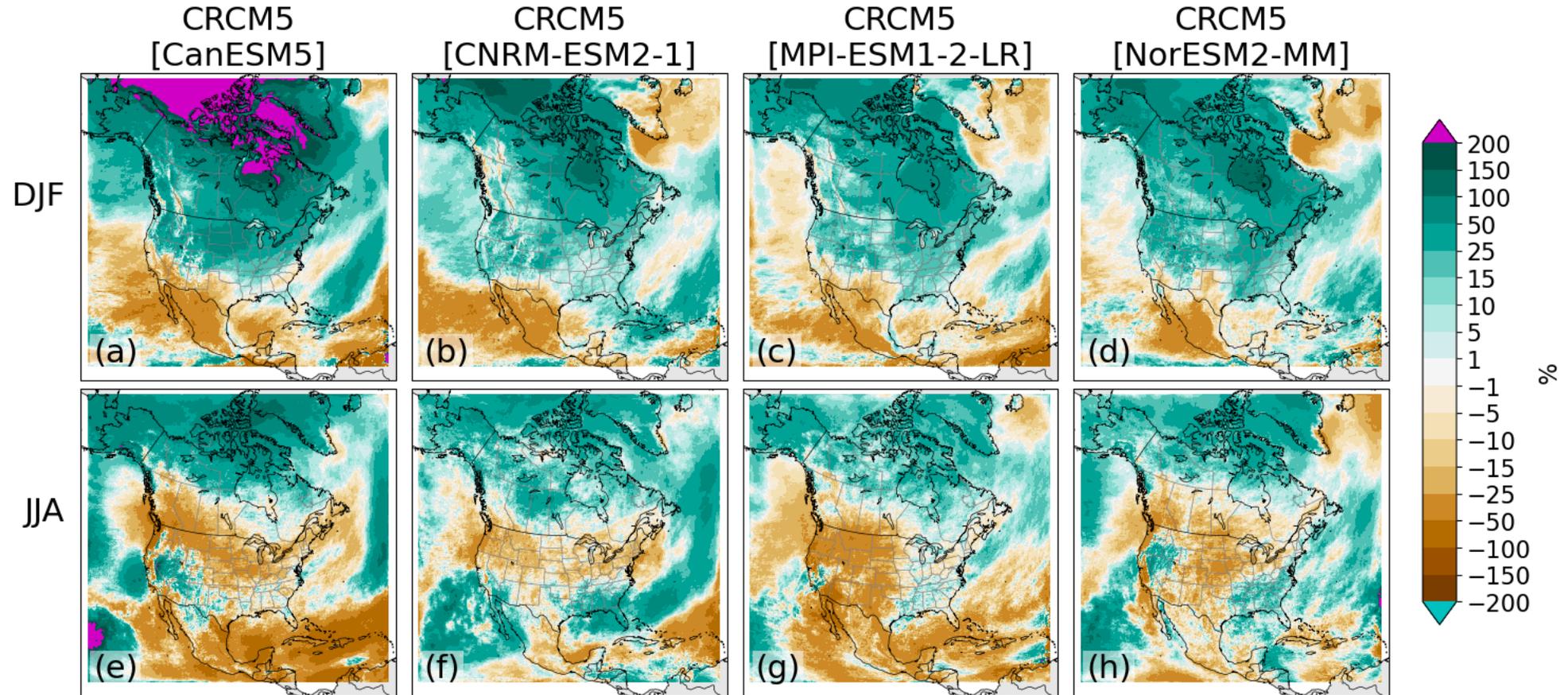


*Projected changes to tas from 1971-2000 to 2071-2100 in the SSP3-7.0 simulations for each of the driving GCMs*

# Changements climatiques

## Changement de précipitation (pr %)

Comment sont les changements en fonction des pilotes et de leur ECS?



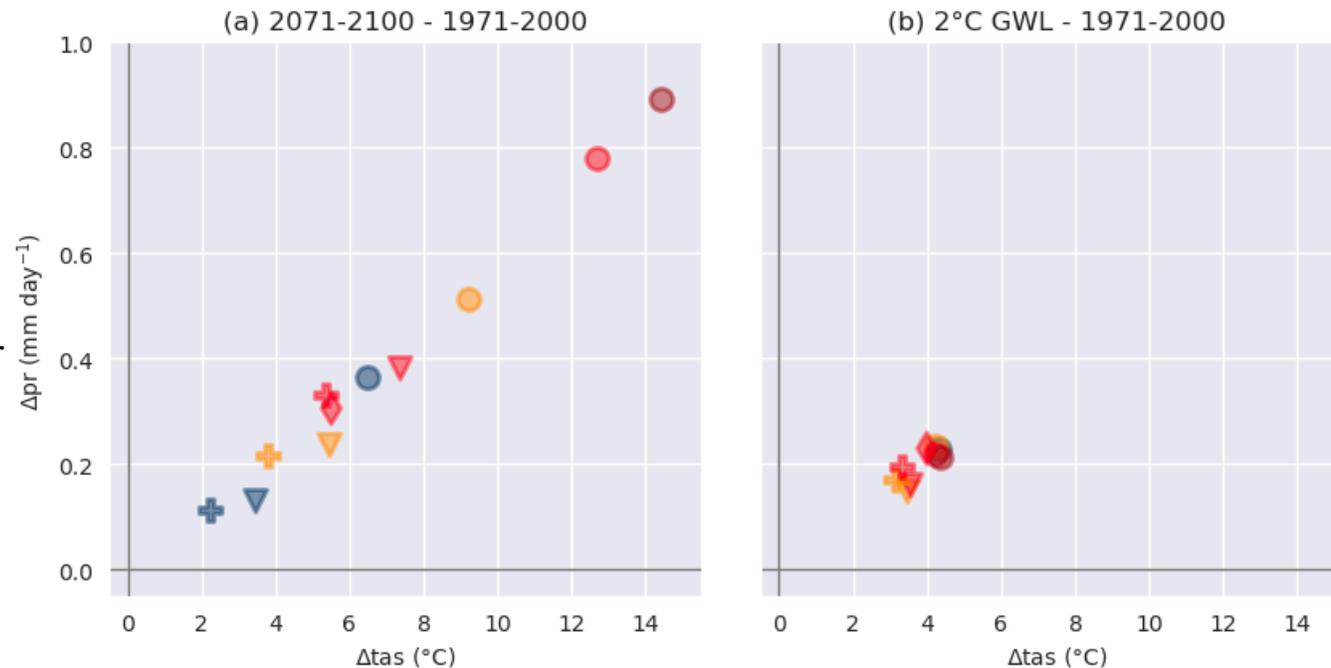
*Projected changes to precipitation from 1971-2000 to 2071-2100 in the SSP3-7.0 simulations for each of the driving GCMs*

# Changements climatiques

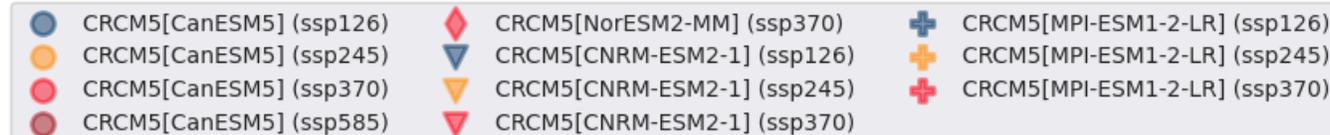
## Changement de température de surface ( $\Delta t_{as}$ °C) et précipitation (mm/jour)

*La fameuse question : par période ou par degré de réchauffement?*

**Par période**  
Incertitude sur  
les scénario  
d'émissions



**Par degré de réchauffement**  
Incertitude sur le  
moment



Scatter plots presenting regionally averaged projected changes in  $t_{as}$  (°C) and  $pr$  (mm day<sup>-1</sup>) for NEN for 1971-2000 to 2071-2000 (a) and for 1971-2000 to the time of the +2°C of global warming (b). (a) contains all completed simulations of the ensemble, while (b) includes the subset of nine simulations that attain this global warming level by 2100.

# Où se consen va?

## MRCC5

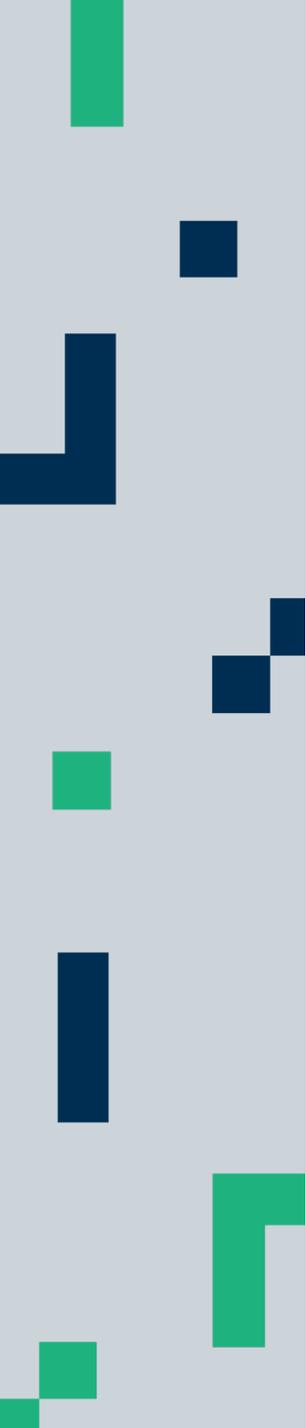
- Nouveaux diagnostics (indicateurs de verglas, cyclones, tempêtes de neige, conditions temps violent,...)
- Évaluation opérationnalisée

## MRCC6-GEM5

- Modèle en développement à UQAM (ESCER) avec ECCC et Ouranos
- Basé sur GEM5, modèle de prévision numérique du temps de ECCC

Olivier Gauthier, impacts climatiques  
hydrologiques des changements d'occupation  
du sol et méga-hydrologie

- Nouveaux champs géophysiques
- Possibilité évolution de l'utilisation de terres
- Nouveau modèle de lac – CSLM (coll ECCC)
- Mise à jour du schéma de surface – CLASSIC (coll ECCC)
- Activation modèle urbain – TEB (coll ECCC)
- Exploration impact modélisation océan-glace (coll McGill-ECCC)



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[https://pavics.ouranos.ca/index\\_fr.html](https://pavics.ouranos.ca/index_fr.html)

<https://zenodo.org/records/14008072>

Paquin, D., C. McCray, C. B. Gauthier, M. Giguère, O. Asselin, P. Bourgault, M.-P. Labonté and D. Matte. The CRCM5-CMIP6 Ouranos' ensemble : A dynamically-downscaled ensemble of CMIP6 simulations over North America. to be submitted to Scientific Data

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