Paper-writing Workshop on the Analysis of CORDEX-CORE Climate Projections

ICTP

Variability of the subtropical winter circulation in North America and its influence in Mexico

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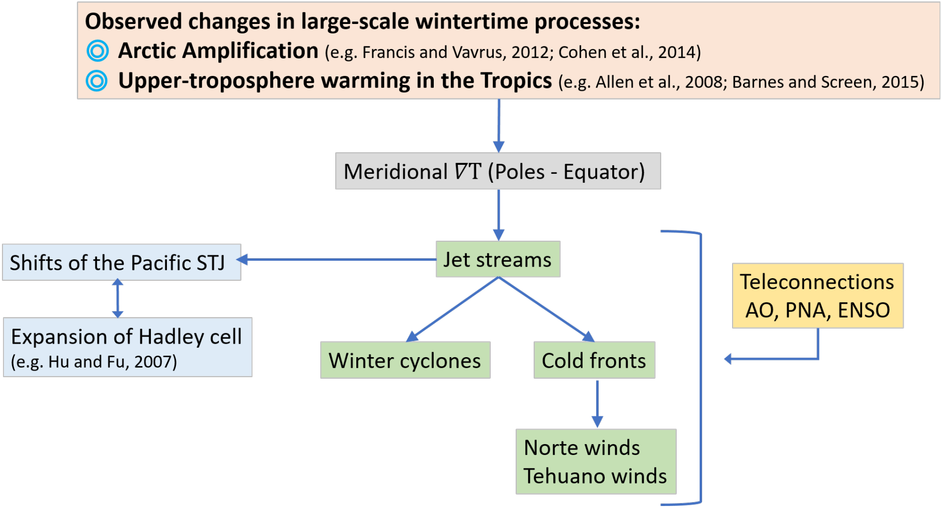
Introduction



Research questions

- Has the wintertime subtropical circulation in North America changed in the last 30 years?
- How will the subtropical winter circulation of North America change as a result of global warming?
- Will the frequency and intensity of the cold fronts and Norte winds in Mexico be different in the second half of the 21st century?

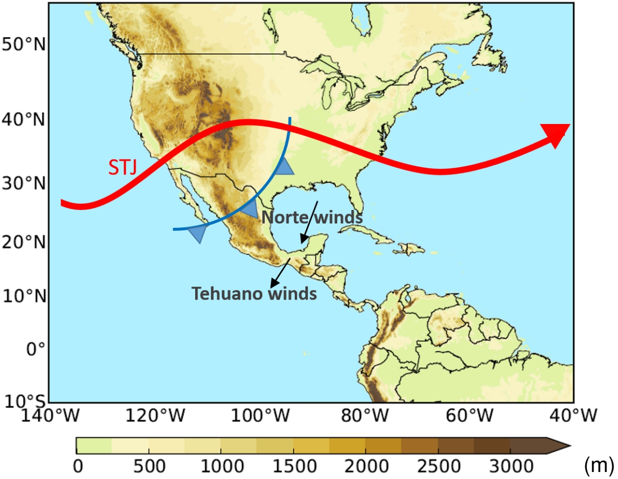
Specific objectives for the historical period

1. To evaluate the skill of RegCM4.7 and its forcing GCMs in the simulation of the boreal winter climate over the CORDEX-CAM domain.

2. To analyse the historical winter circulation at synoptic and regional scale (apply different detection methods for the subtropical jet stream, winter cyclones, cold fronts, and Norte winds).

3. To determine the possible role of large-scale teleconnections indices (AO, PDO, PNA, ENSO) on the inter-annual and decadal variability of the winter circulation.

Study region



Data for the historical evaluation (1980-2010)

- CRU Climatic Research Unit
  (Harris et al., 2014). Monthly, 50 km; temperature and precipitation

- GPCP Global Precipitation Climatology Project
  (Adler et al., 2003). Daily, 1°; precipitation

- CHIRPS Climate Hazard Group InfraRed Precipitation with Station data (Funk et al., 2015). Daily, 5.5 km; precipitation

- Livneh US-Climate Computing Project (Livneh et al., 2013).
  Daily, 6 km; temperature, precipitation and near-surface winds

- ERA-Interim (Dee et al., 2011).
  Reanalysis, 6 hrs, 0.75°; temperature, precipitation, and winds

- MERRA2 The Modern-Era Retrospective analysis for Research and Applications, Version 2 (Gelaro et al., 2017).
  Reanalysis, 6 hrs, 0.5° x 0.65°; temperature, precipitation, and winds

CMIP5 GCMs

- ◎ HadGEM2-ES Hadley Center Global Environment Model version 2. (Collins et al., 2008) 1.875° x 1.25°

- ◎ MPI-ES Max Planck Institute Earth System Model. 1.875° x 1.875°

- ◎ GFDL Geophysical Fluid Dynamics Laboratory Model. (Dunne et al., 2008) 2.5° x 2.0°

⇓

RegCM4.7 Regional Climate Model

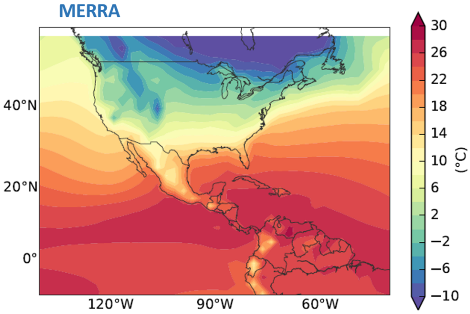
(Giorgi et al., 2012) 25 km x 25 km

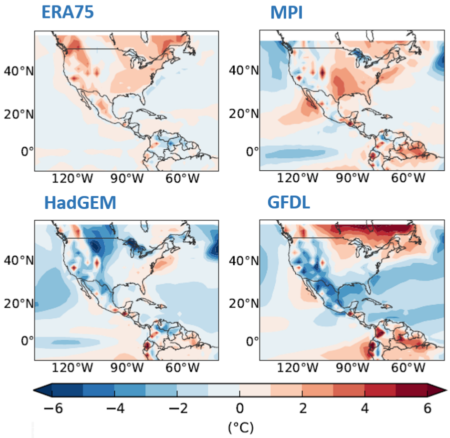
The numerical experiments are carried out by the climate modelling group of the ICTP

Evaluation of surface variables during Nov-Apr

(1980-2010)

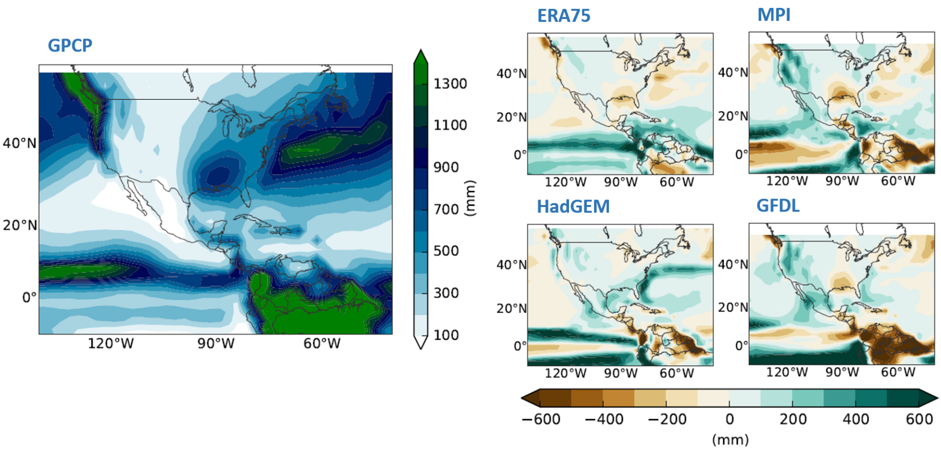
Mean winter tas bias (℃) with respect to MERRA2 (Nov-Apr, 1980-2010)





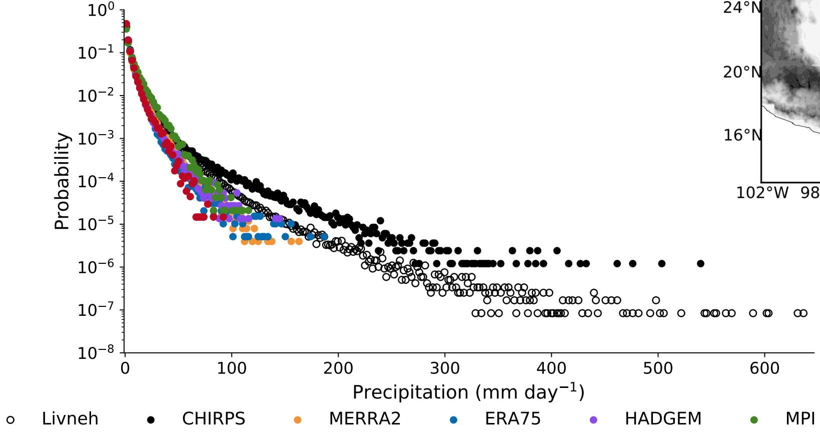
RegCM4.7 biases?

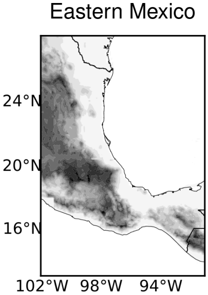
Mean winter pr bias (mm) with respect to GPCP (Nov-Apr, 1980-2010)



RegCM4.7 biases?

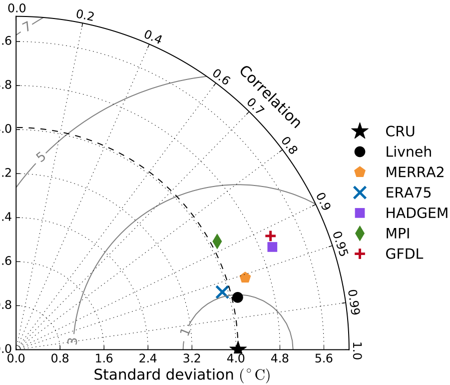
Intercomparison of the PDFs of daily winter precipitation over Eastern Mexico (Nov-Apr, 1980-2010)



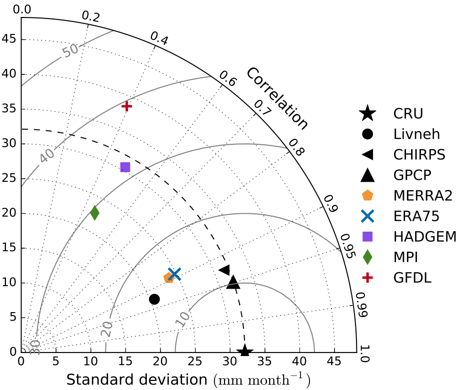


Spatial Taylor diagrams for Eastern Mexico (Nov-Apr, 1980 - 2010)

Temperature

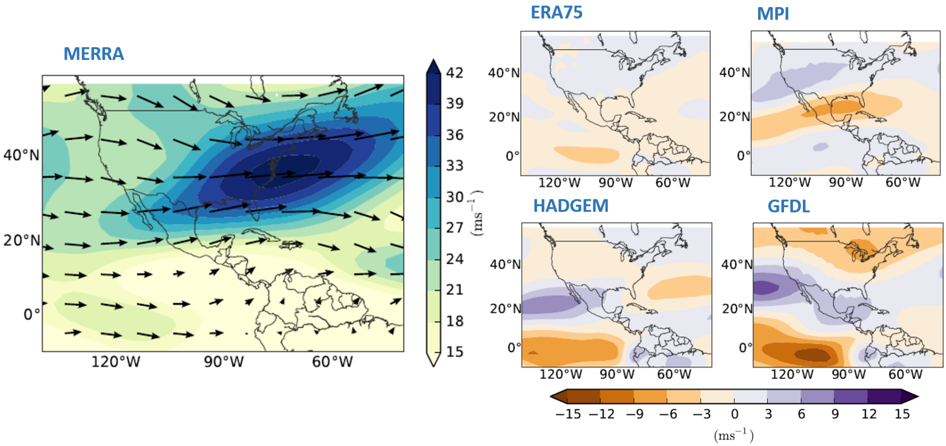


Precipitation



Detection of the position and intensity of the Subtropical Jet Stream during DJF 1980-2010

Bias of wind speed at 250 hPa during DJF (1980-2010) MERRA2 - database



RegCM4.7 biases?

Detection methods of the STJ at 250 hPa using winds from ERA75

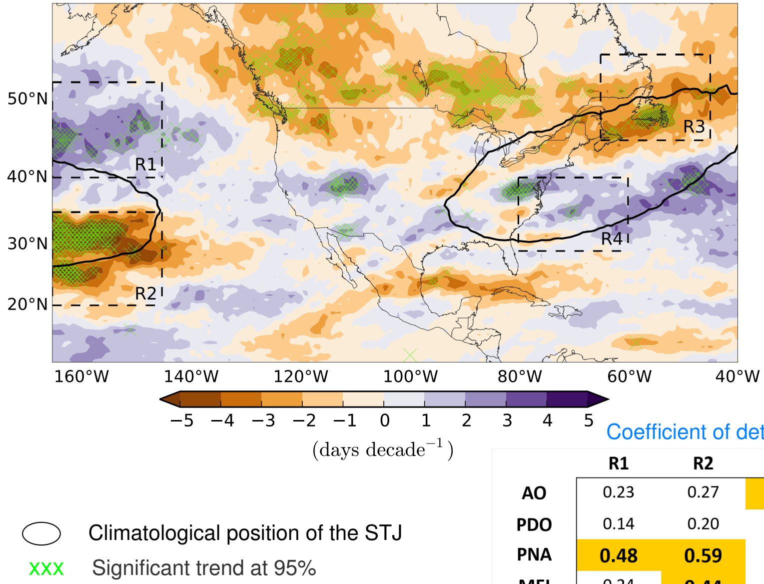
Jet core

◎ **Strong and Davis (2007)**
Relative maximum based on $\frac{\partial^2 V}{\partial y^2} < 0$ and $V \geq 25.7\ \mathrm{ms^{-1}}$ (50 kt)

Jet axis

◎ **Based on gradient of wind speed**
$\frac{\partial V}{\partial y} = 0$ and $V \geq 25.7\ \mathrm{ms^{-1}}$ (50 kt)

Trends of the jet core frequency (days decade^{-1}) at 250 hPa during winter (DJF, 1980-2010)

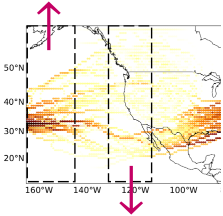


Coefficient of determination (R^2)

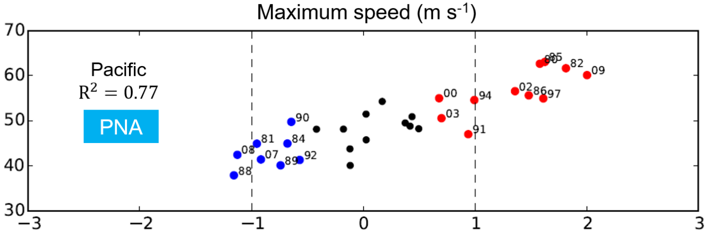
	R1	R2	R3	R4
AO	0.23	0.27	**0.48**	0.24
PDO	0.14	0.20	0.29	0.26
PNA	**0.48**	**0.59**	0.21	0.14
MEI	0.24	**0.44**	0.07	0.06

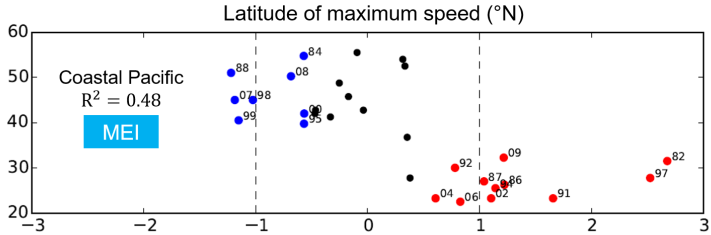
Pacific STJ axis as a function of the PNA and ENSO (DJF, 1980-2010)

Pacific

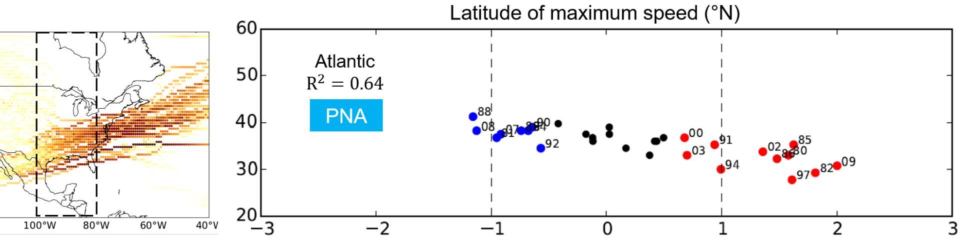


Coastal
Pacific





Atlantic STJ axis as a function of the PNA (DJF, 1980-2010)



Subtropical Jet Stream: pending activities

- Can the RegCM4.7 forced with ERA75 reproduce the trends and variability of the STJ?

Preliminary conclusions

- **The Pacific STJ is modulated mainly by the PNA and ENSO**.

  PNA^+ The jet axis is more intense over the Pacific.

  $ENSO^+$ The jet axis is further south over the coastal Pacific.

  The Pacific STJ has become less frequent in the southern part of the climatological jet suggesting a **poleward shift.**

- **The Atlantic STJ is modulated mainly by the PNA and AO**.

  PNA^+ The jet axis is farther south over the eastern United States and the Gulf of Mexico.

  The Atlantic STJ has become more frequent in the southeastern quadrant of the climatological jet suggesting an **equatorward shift**.

Next steps

- To add the regional model RegCM4.7 in the evaluation of surface variables and upper winds. To quantify the added value of RegCM4.7.
- To apply detection methods for winter processes: cyclones, cold fronts and Norte winds.
- To investigate the future changes of the winter circulation at synoptic and regional scale.

Grazie, Gracias, Thank you

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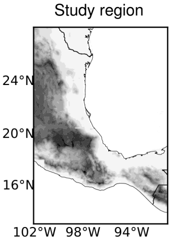
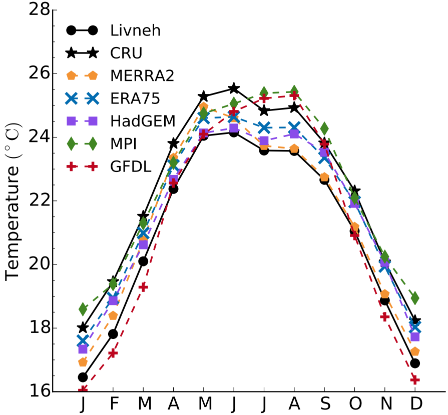
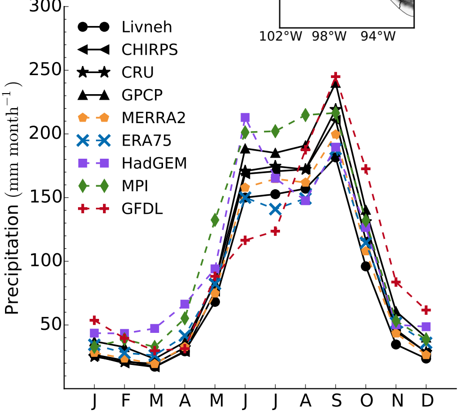
Mean annual cycle of tas (℃) and pr (mm) in the study region during 1980-2010







Jet axis

- - Based on relative vorticity

($\xi = 0$ and $V \geq 25.7\ \mathrm{ms^{-1}}$)

- - Based on wind speed gradient

($\frac{\partial V}{\partial y} = 0$ and $V \geq 25.7\ \mathrm{ms^{-1}}$)