Hydrological Impacts of Solar Radiation Management in La Plata Basin

Inés Camilloni

Centro de Investigaciones del Mar y la Atmósfera (CIMA)
University of Buenos Aires - (CONICET)
Buenos Aires, Argentina

International Symposium on Climate Geoengineering, ACB
Rio de Janeiro, 10-11 June 2019

1

01 La Plata Basin (LPB)

02 Climate Change in LPB

03 LPB DECIMALS Project: Motivation

04 LPB DECIMALS Project: Goals

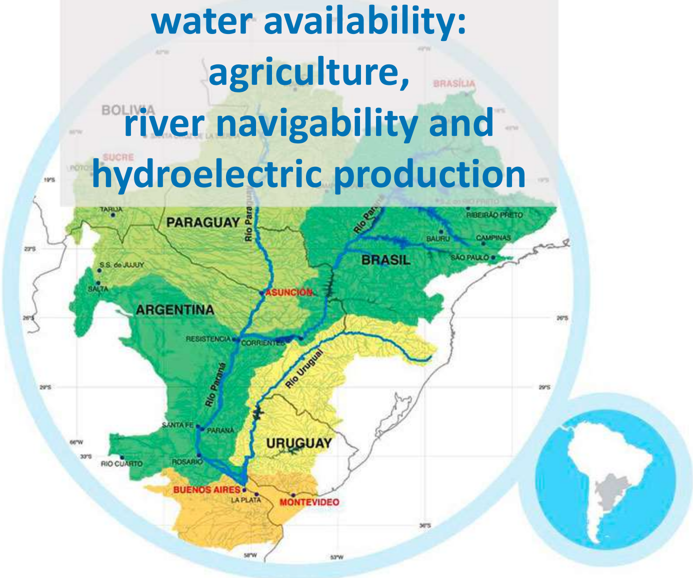
05 LPB DECIMALS Project: Preliminary results

2

01 La Plata Basin

5 Countries

Economic activities rely on water availability: agriculture, river navigability and hydroelectric production



MAIN RIVERS

Paraná ~ 17,000 m3/s
Uruguay ~ 5,500 m3/s
Paraguay ~ 4,300 m3/s

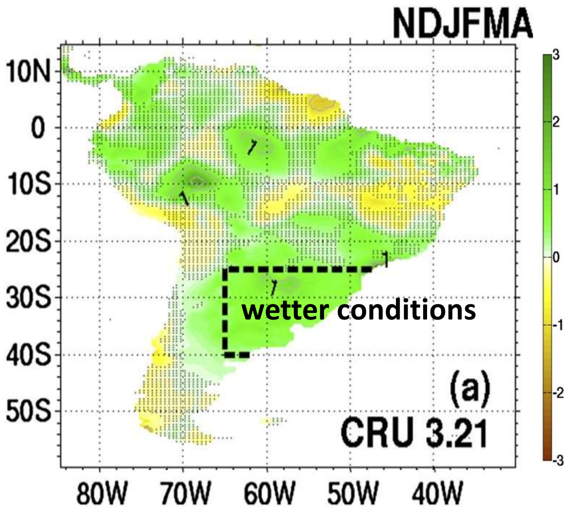
FEATURES

- 3.1 million km^2
- +150 million inhabitants
- 75 dams
- +30 large hydropower plants
- varied ecosystems

02 Climate Change in La Plata Basin

5

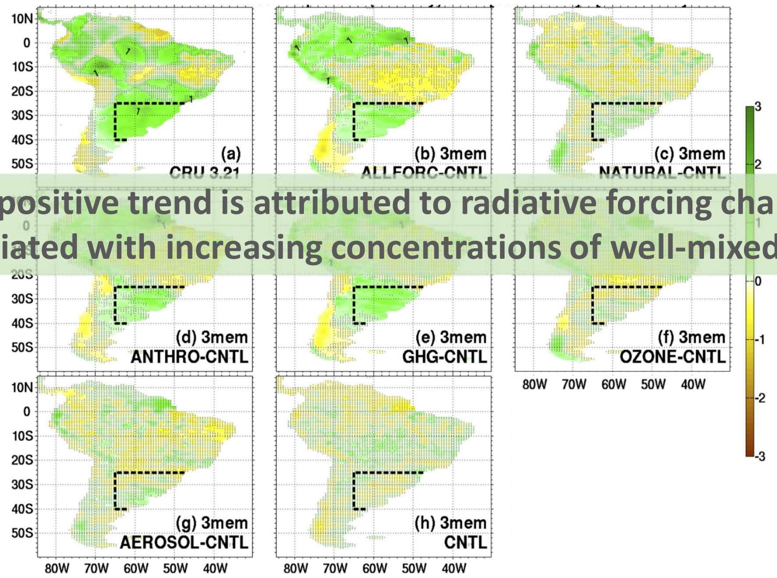
Precipitation Change (mm/day)
[1981-2010] - [1901-1950]



Zhang et al. (2016)

6

Precipitation Change (mm/day)
[1981-2010] - [1901-1950] - FORCINGS

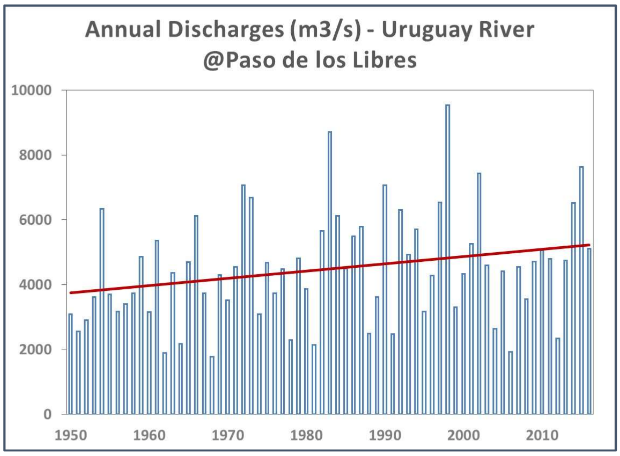


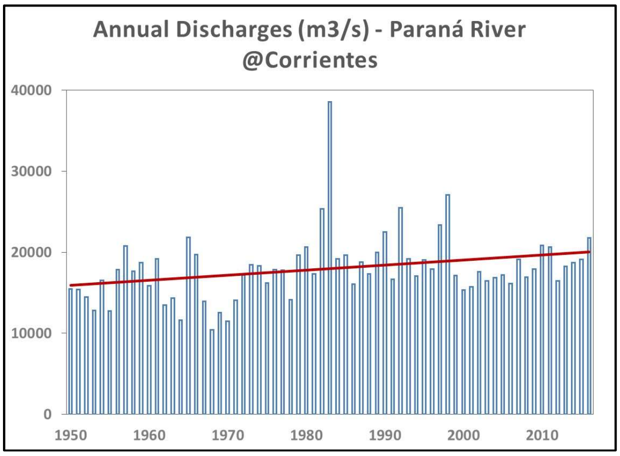
The positive trend is attributed to radiative forcing changes associated with increasing concentrations of well-mixed GHG

Zhang et al. (2016)

7

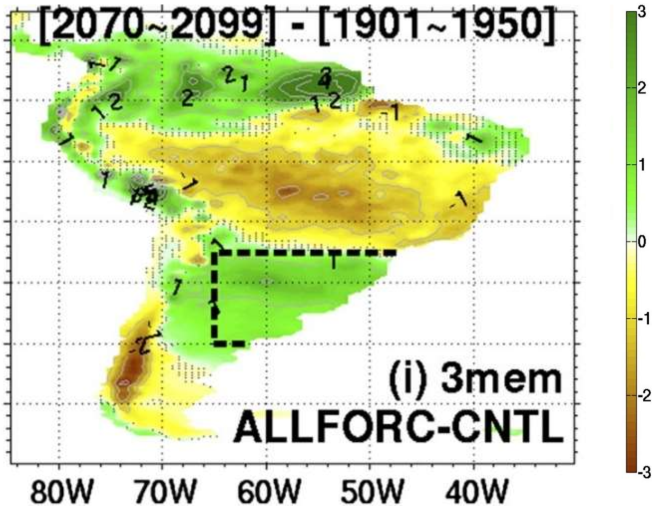
Also positive trends in many other variables relevant for socio-economic activities: river flows and floods as well as extreme temperatures.





8

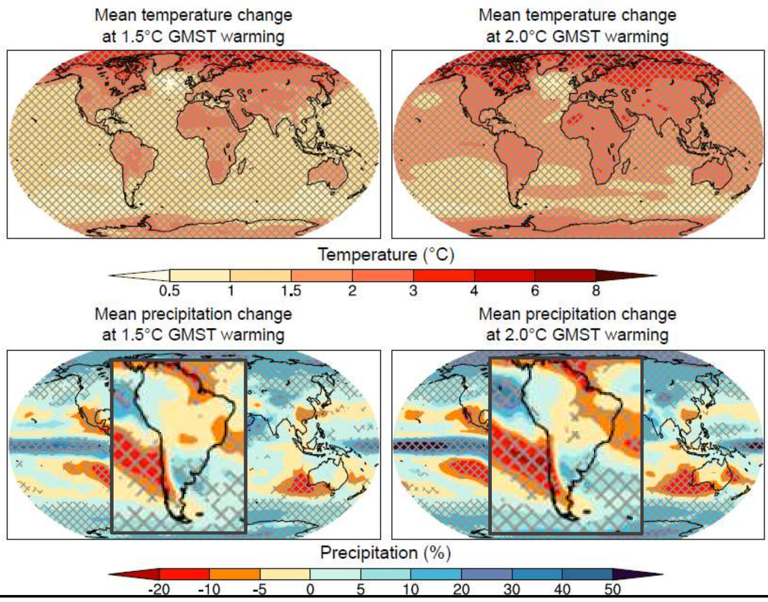
Precipitation Change (mm/day)
[2070-2100] - [1901-1950] - RCP8.5



Zhang et al. (2016)

9

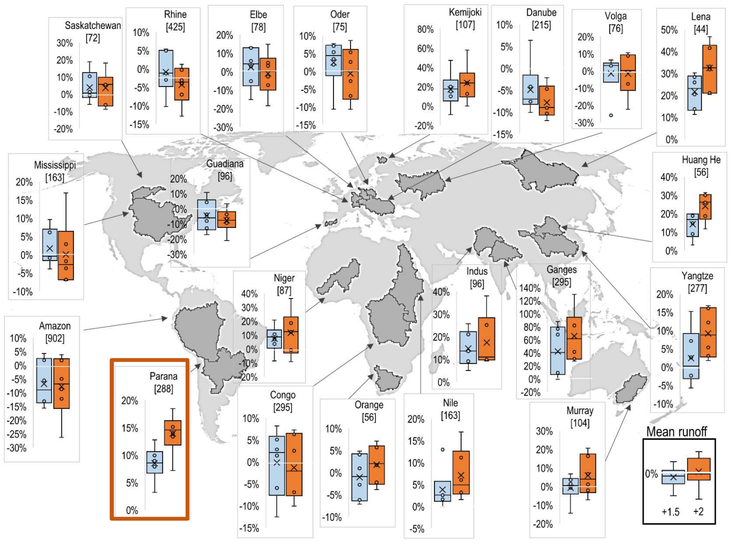
Precipitation (%) and Temperature (°C) Change
1.5°C & 2°C global warming worlds



IPCC (2018)

10

Changes in mean flows under 1.5°C and 2 °C global warming scenarios



Betts et al. (2018)

11

HOME ABOUT WHAT IS SRM? DECIMALS FUND EVENTS RESOURCES CONTACT

ARGENTINA

http://www.srmgi.org/decimals-fund/the-projects/argentina/

Hydrological impacts of solar radiation management in the La Plata Basin in South America

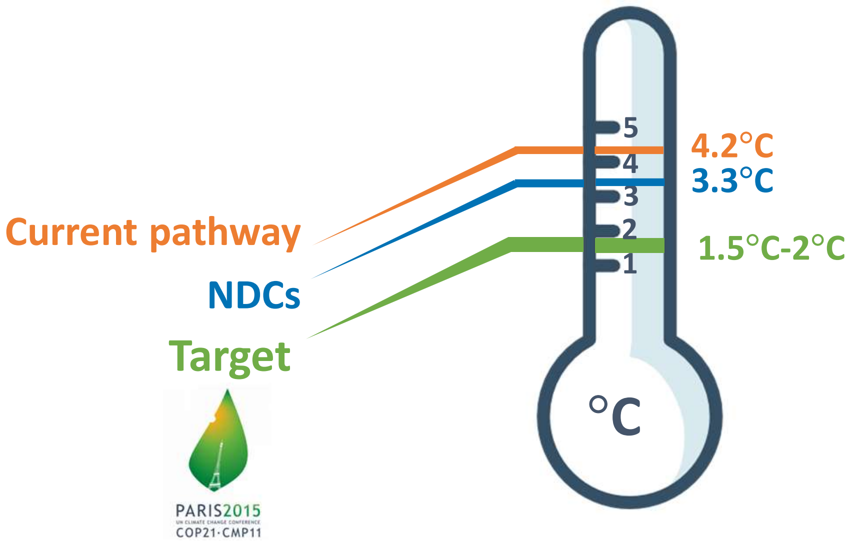
Researchers: Carla Gulizia, Natalia Montroull, Ramiro Saurral, Inés Camilloni (PI) (UBA/CONICET)
Research collaborators: Simone Tilmes (NCAR), Pete Irvine (Harvard University)

12

03 LPB DECIMALS Project:

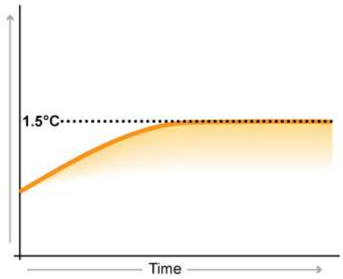
13

Projected global warming by the end of 21st century above the preindustrial period



14

Conceptual pathways to limit global warming to 1.5°C

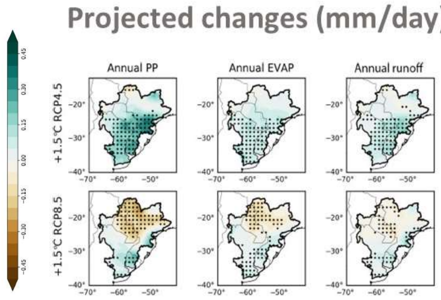


IPCC (2018)

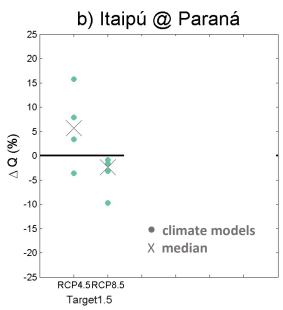
15

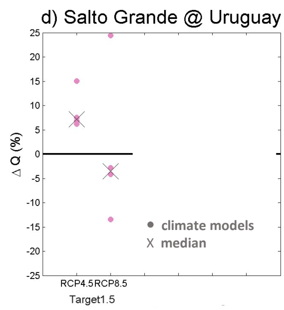
Projected regional hydrology impacts over LPB for 1.5°C global warming above the preindustrial level (no overshoot)

Projected changes (mm/day)



Projected streamflow changes (%)





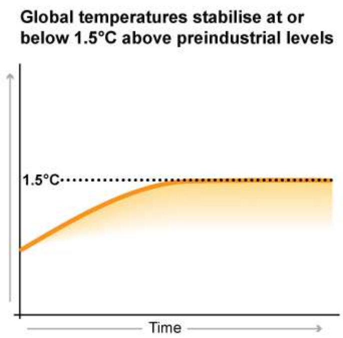
RCP4.5

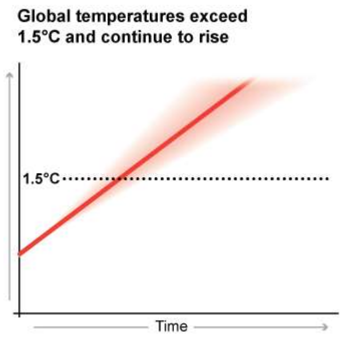
RCP8.5

Montroull et al. (2018)

16

Conceptual pathways to limit global warming to 1.5°C

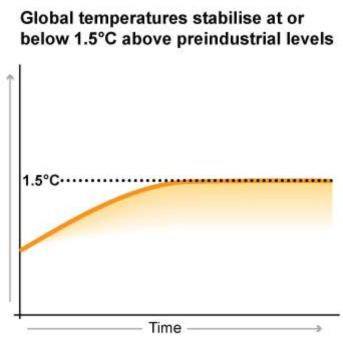


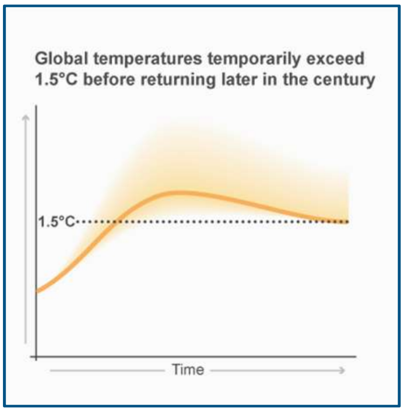


IPCC (2018)

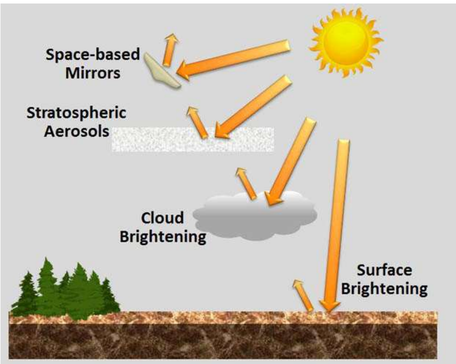
17

Conceptual pathways to limit global warming to 1.5°C



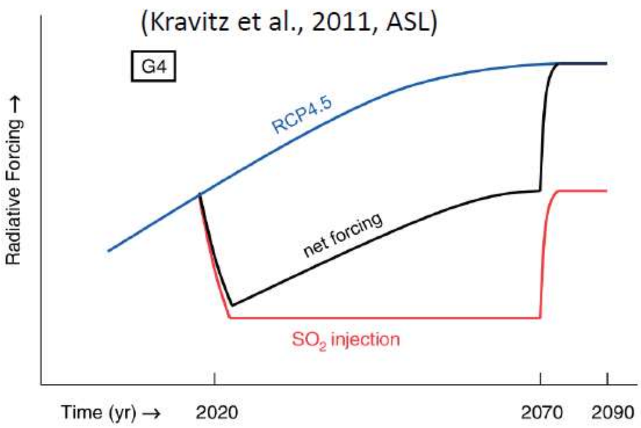


SRM?



18

GEOMIP1 – G4 Stratospheric SO2 injection



G4: Baseline: RCP4.5, **Geoeng.:** fixed aerosol injection of 5 Tg SO_2 per year, termination after 50 years

19

Changes in Precipitation (P), Evaporation (E), (P-E) and runoff between G4 and RCP4.5 for 2030-2069

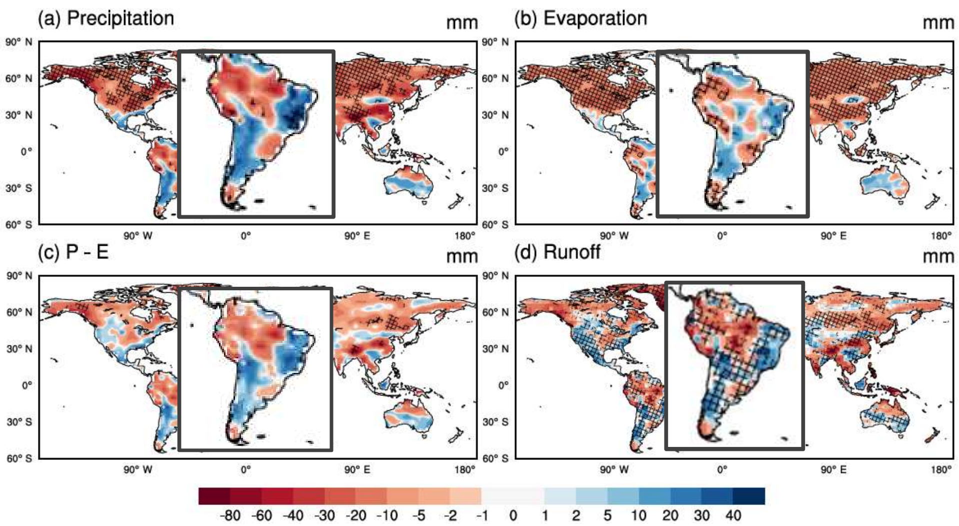
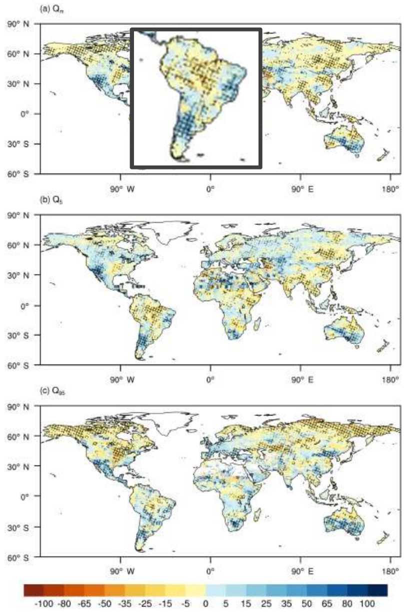


Figure 1. Changes of annual precipitation (**a**), evaporation (**b**), precipitation minus evaporation ($P-E$, **c**), and runoff (**d**) between G4 and RCP4.5 during the period of 2030–2069. Hashed areas indicate locations where the changes are significant at the 95 % level using the two-sample MW-U test. For runoff (**d**), grid cells with less than 0.01 mm day^{-1} are masked out.

Wei et al. (2018)

20

Changes in streamflow indicators between G4 and RCP4.5 for 2030-2069



Annual mean flow

Extreme high flow

Extreme low flow

Figure 2. Relative difference of three streamflow indicators between G4 and RCP4.5 during the period of 2030–2069, as percentages of RCP4.5: (G4-RCP4.5)/RCP4.5 × 100 %. **(a)** Annual mean flow (Q_m); **(b)** annual high flow (Q_5); **(c)** annual low flow (Q_{95}). For each streamflow level, grid cells with less than 0.01 mm day^{-1} are masked out. Hashed areas indicate locations where the streamflow changes are significant at the 95 % level using the two-sample MW-U test.

Wei et al. (2018)

21

04 LPB DECIMALS Project:

22

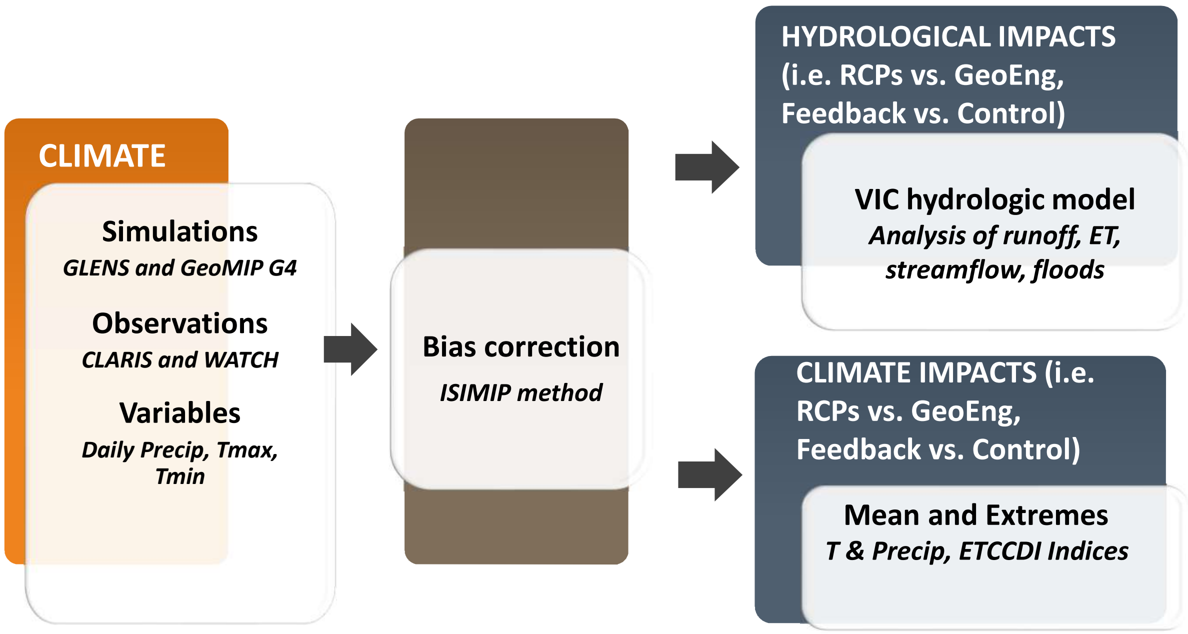
The objective of this project is to assess the possible effects of SRM in the hydroclimate of LPB:

- temperature
- precipitation
- evapotranspiration
- runoff
- river discharges

Also,

- extreme temperatures and precipitation
- extreme streamflow (flood frequency & duration)

23



24

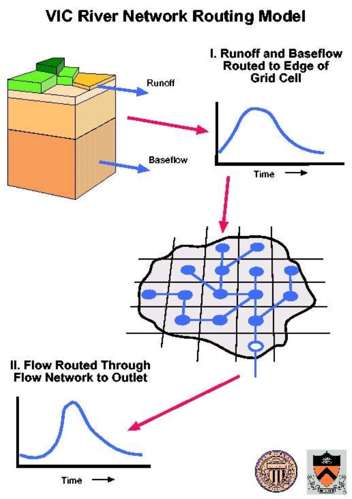
Hydrologic Impacts: Variable Infiltration Capacity (VIC) Hydrologic Model

Large-scale, semi-distributed hydrological model (University of Washington)

Resolution:
0.125° x 0.125°

Time step:
Land-atmosphere fluxes, and the water and energy balances at the land surface, are simulated at a **daily time step**

- **Grid cells are simulated independently of each other**
- **Routing of streamflow is performed separately from the land surface simulation, using a separate model**



25

INPUT

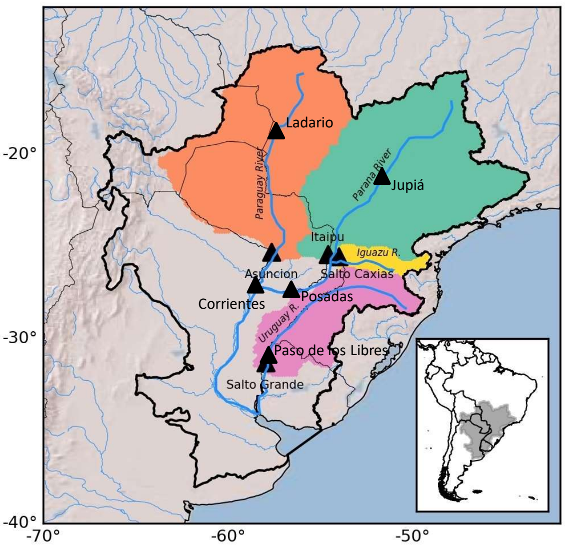
Meteorological data
- Daily gridded **precipitation**
- Daily gridded **Tmax** and **Tmin**

Soil data
- 5-min Global Soil Data Task dataset from the Distributed Active Archive Center (2000)

Vegetation data
- University of Maryland`s 1-km Global Land Cover product (Hansen et al. 2000)

OUTPUT

- Daily/monthly **streamflow** at closing points
- Daily/monthly gridded **runoff, evapotranspiration,** etc.



CLOSING POINTS

Paraguay River
- Ladario
- Asunción

Paraná River
- Jupiá
- Itaipú
- Posadas
- Corrientes

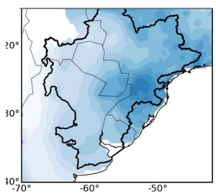
Uruguay River
- Paso de los Libres
- Salto Grande

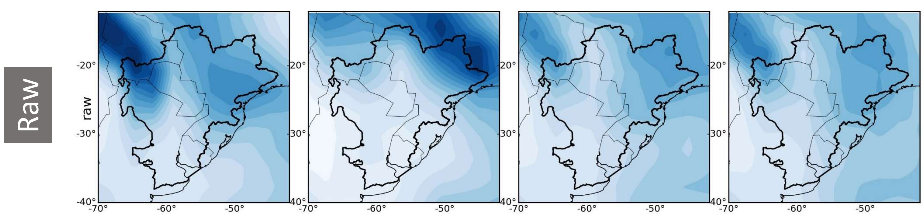
Iguazú River
- Salto Caxias

26

05 LPB DECIMALS Project: Preliminary results

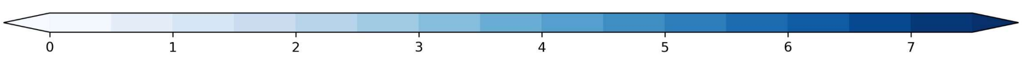
OBS.

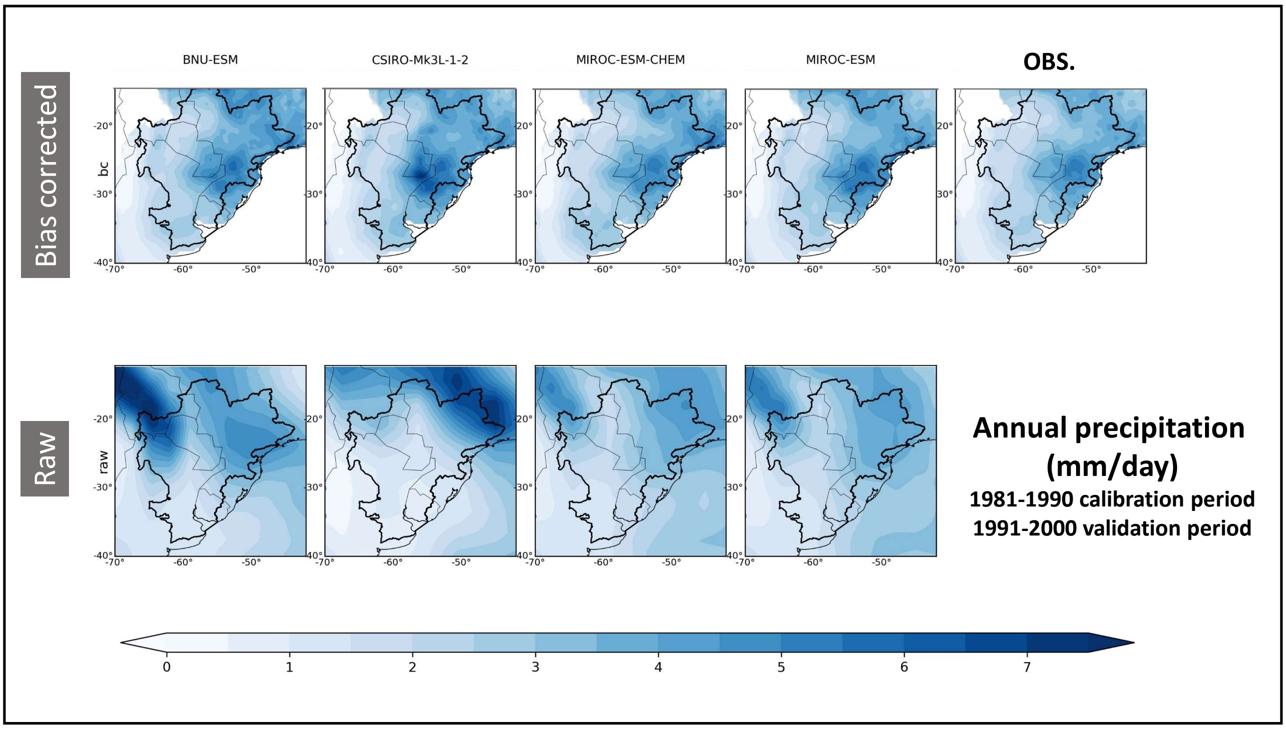




Annual precipitation (mm/day)

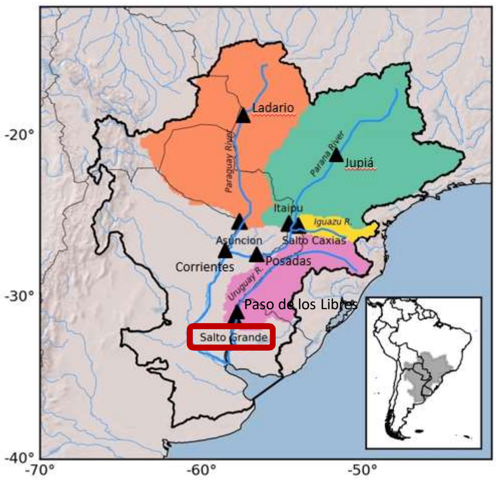
1981-1990 calibration period
1991-2000 validation period



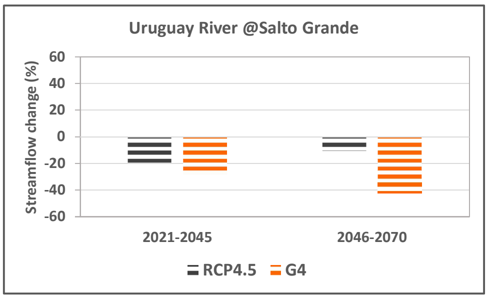


29

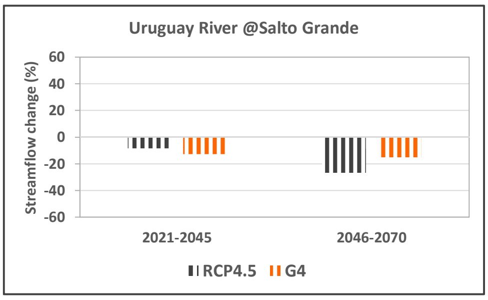
Uruguay River - Streamflow change (%) – Reference period: 1991-2000



CSIRO Mk3L-1-2



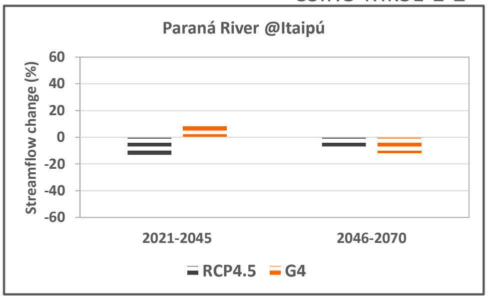
MIROC-ESM



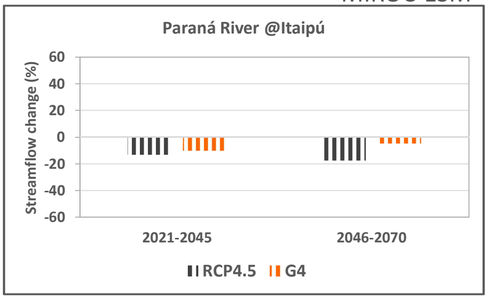
30

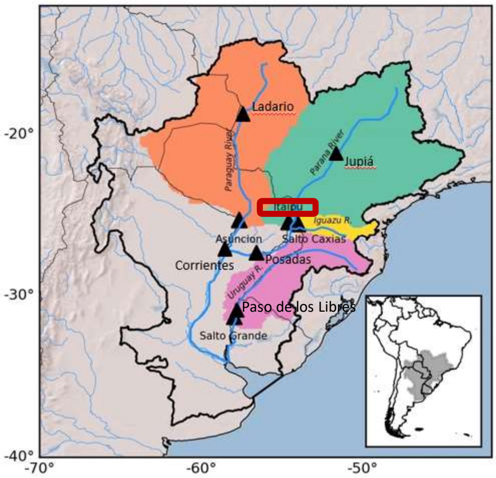
Paraná River - Streamflow change (%) – Reference period: 1991-2000

CSIRO Mk3L-1-2



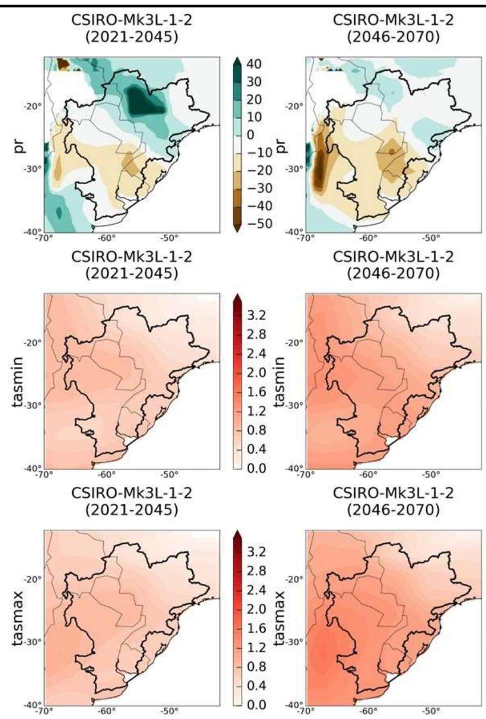
MIROC-ESM



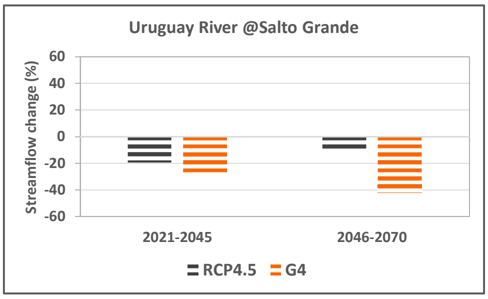


31

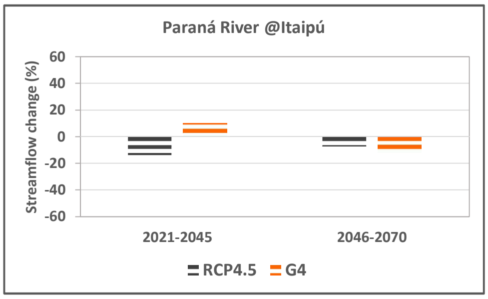
G4 Experimient vs. 1991-2000



CSIRO Mk3L-1-2

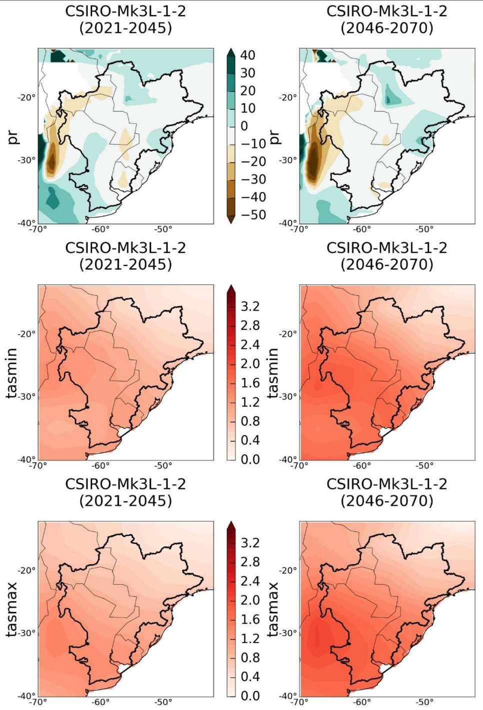


CSIRO Mk3L-1-2

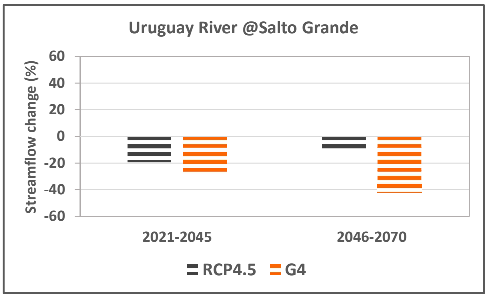


32

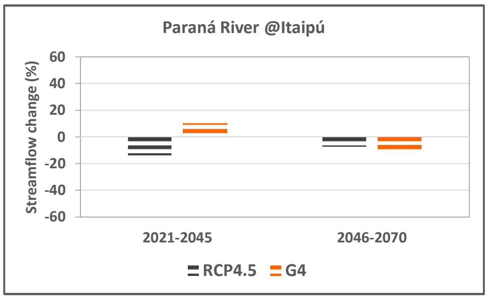
RCP4.5 vs. 1991-2000



CSIRO Mk3L-1-2

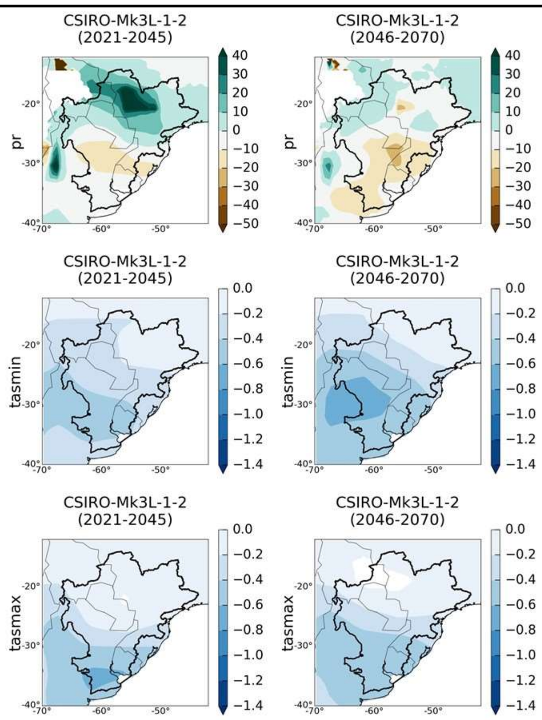


CSIRO Mk3L-1-2

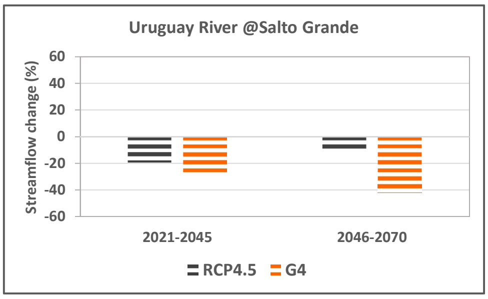


33

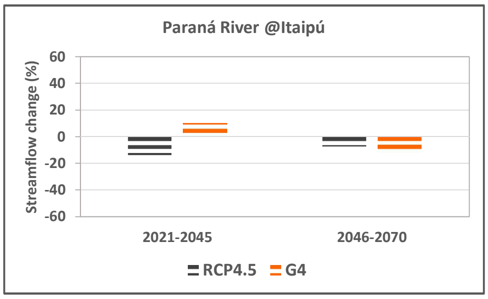
G4 Experiment vs. RCP4.5



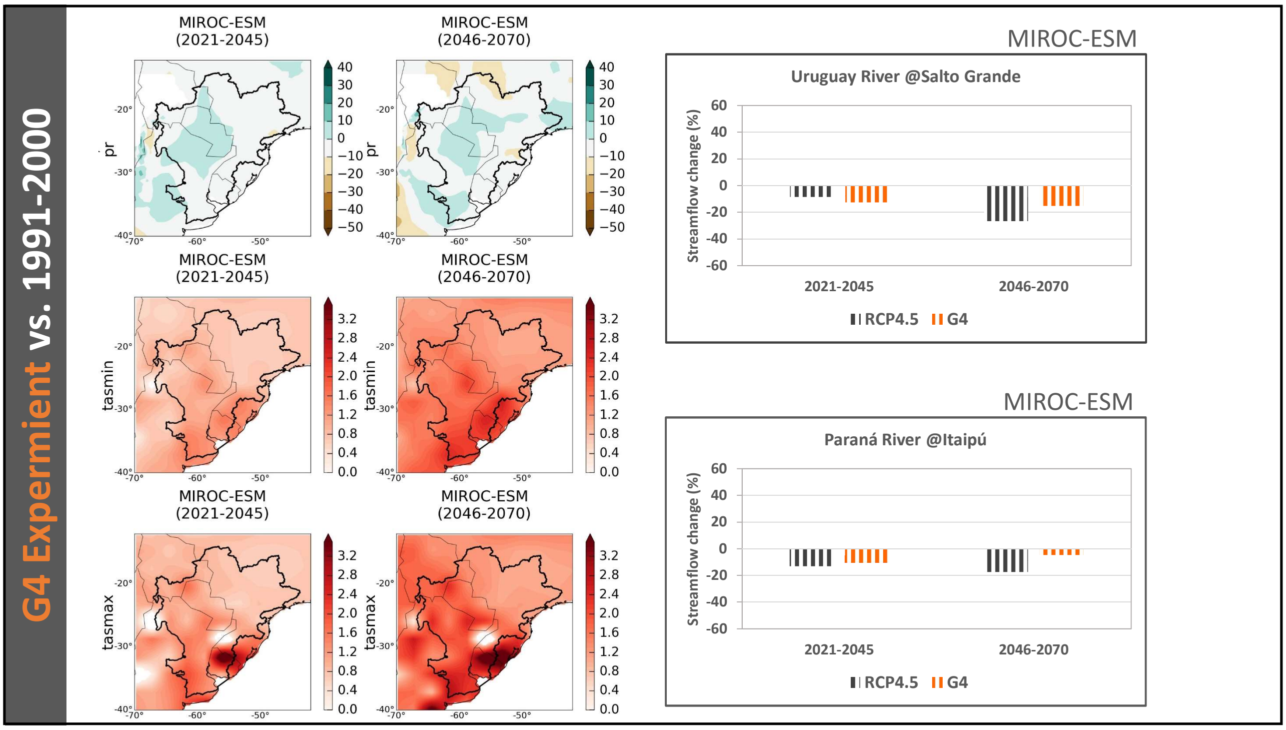
CSIRO Mk3L-1-2



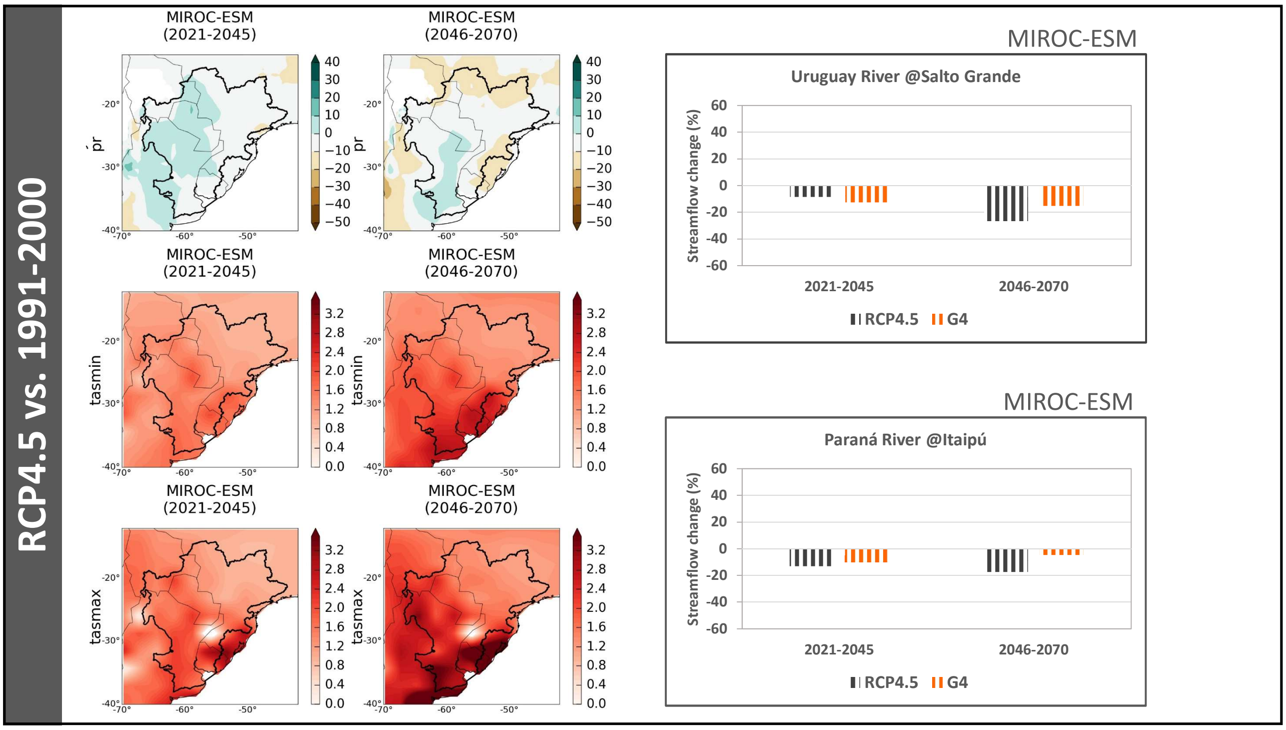
CSIRO Mk3L-1-2



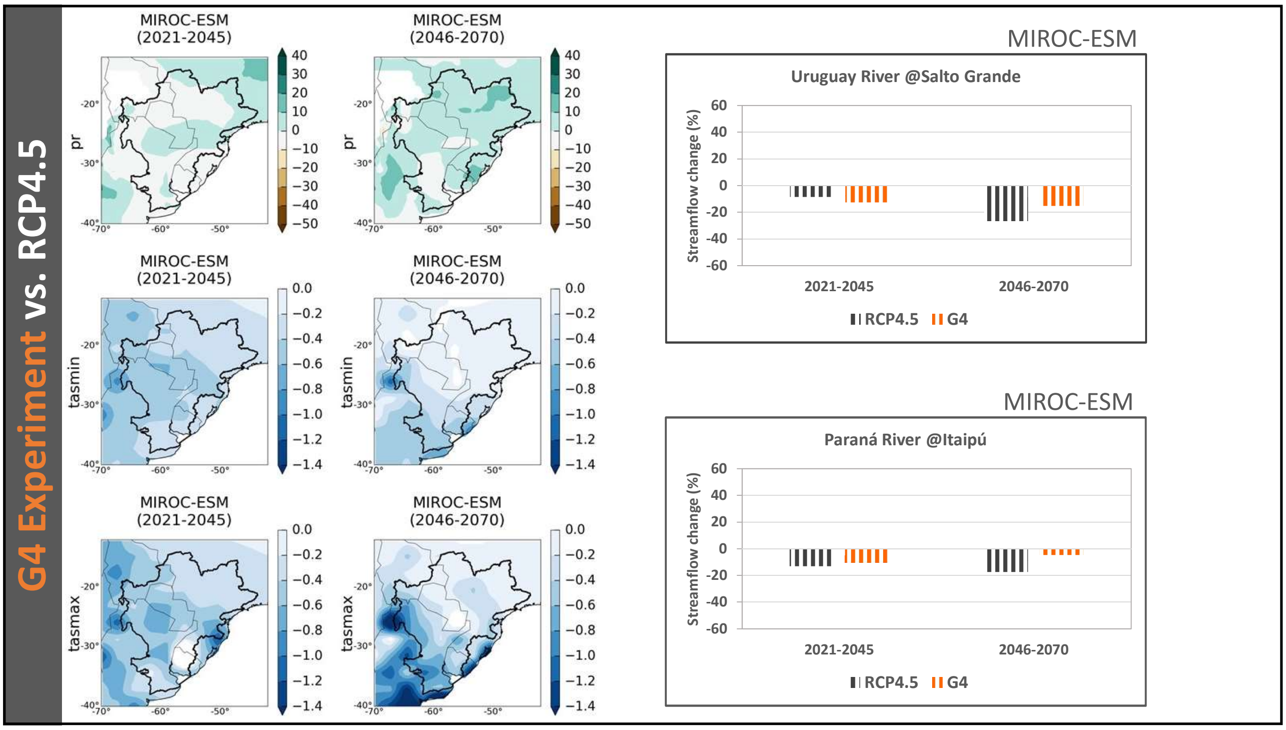
34


G4 Experiment vs. 1991-2000
MIROC-ESM (2021-2045)
MIROC-ESM (2046-2070)
pr
tasmin
tasmax
MIROC-ESM
Uruguay River @Salto Grande
Streamflow change (%)
2021-2045
2046-2070
RCP4.5
G4
MIROC-ESM
Paraná River @Itaipú
Streamflow change (%)
2021-2045
2046-2070
RCP4.5
G4

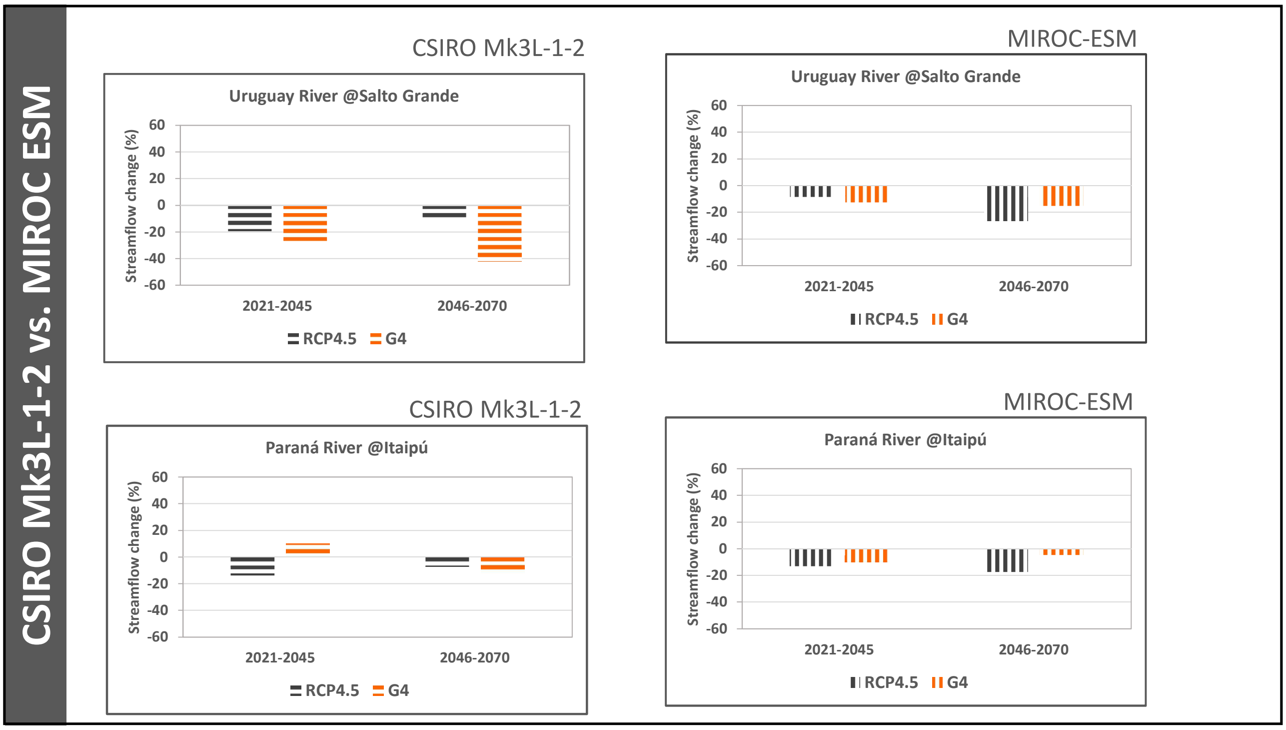
35


RCP4.5 vs. 1991-2000
MIROC-ESM (2021-2045)
MIROC-ESM (2046-2070)
pr
tasmin
tasmax
MIROC-ESM
Uruguay River @Salto Grande
Streamflow change (%)
2021-2045
2046-2070
RCP4.5
G4
MIROC-ESM
Paraná River @Itaipú
Streamflow change (%)
2021-2045
2046-2070
RCP4.5
G4

36


G4 Experiment vs. RCP4.5
MIROC-ESM
(2021-2045)
MIROC-ESM
(2046-2070)
pr
tasmin
tasmax
40
30
20
10
0
−10
−20
−30
−40
−50
0.0
−0.2
−0.4
−0.6
−0.8
−1.0
−1.2
−1.4
-20°
-30°
-40°
-70°
-60°
-50°
MIROC-ESM
Uruguay River @Salto Grande
MIROC-ESM
Paraná River @Itaipú
Streamflow change (%)
60
40
20
0
-20
-40
-60
2021-2045
2046-2070
RCP4.5
G4

37


CSIRO Mk3L-1-2 vs. MIROC ESM
CSIRO Mk3L-1-2
Uruguay River @Salto Grande
CSIRO Mk3L-1-2
Paraná River @Itaipú
MIROC-ESM
Uruguay River @Salto Grande
MIROC-ESM
Paraná River @Itaipú
Streamflow change (%)
60
40
20
0
-20
-40
-60
2021-2045
2046-2070
RCP4.5
G4

38

Thank you!

39