Dynamics and Statistics in Weather and Climate
Focus Workshop 29 – 31 July 2009

Statistical and numerical downscaling approaches over southern South America

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Outline

_Motivation

_Introduction of the climate in southern South America

_Statistical Downscaling

_Dynamical/Numerical Downscaling

_Summary and Outlook

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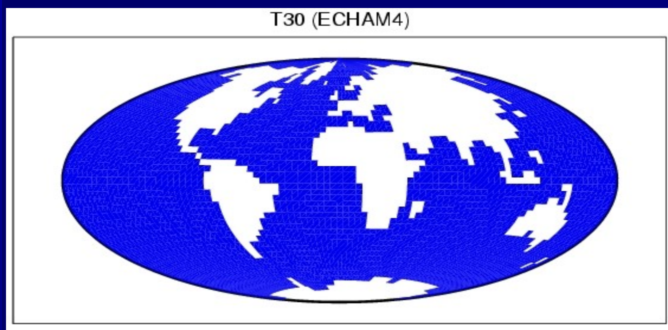
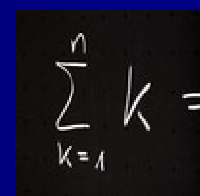
_Motivation I

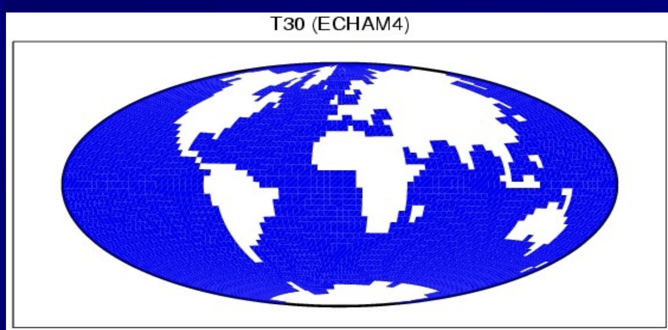
_Problem: Scale gap between skilful scale of GCM and local scale of proxy/climate impact analysis

_Solution approach: Downscaling of large scale GCM output

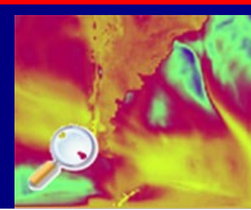


Statistical transfer function





Numerical regional model



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ASSUMPTIONS

_Motivation II

_Assumption for statistical downscaling:

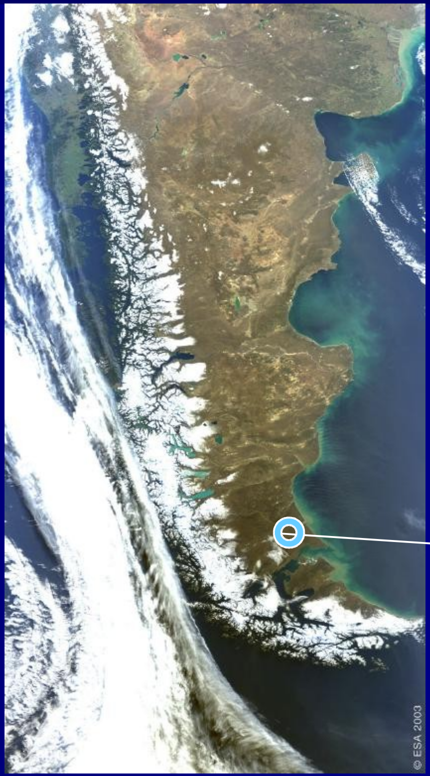
Validity of transfer function in statistical downscaling model

_How can the validity of this assumption be tested ?

1st: carry out statistical downscaling setup by observations and downscale GCM output

2nd: carry out numerical downscaling with same GCM used for 1st

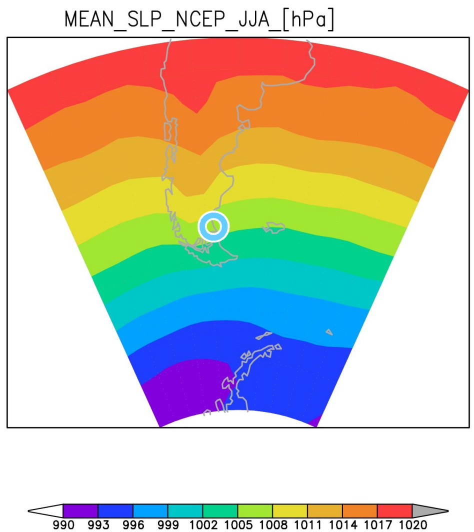
_Introduction to the climate of southern South America



Potrok Aike [PTA]
Crater Lake

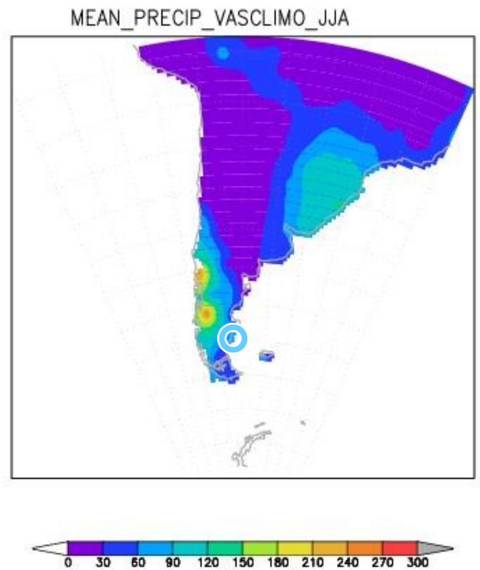
_Introduction to the climate of southern South America

Mean SLP JJA



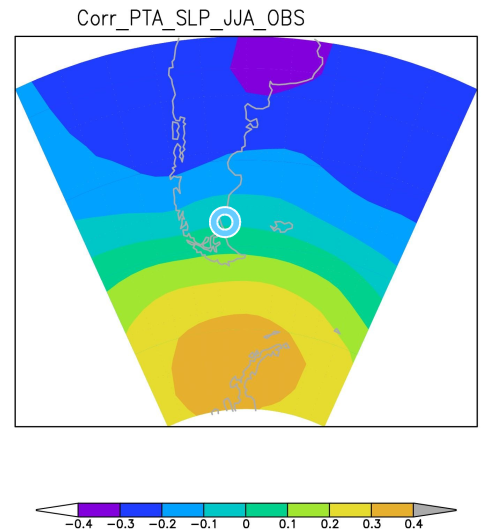
Strong mean westerly flow

Mean PRECIP JJA



Precipitation ‘hot spots’ due to rare station availability and interpolation of station precipitation

PRECIP_PTA-SLP



Precipitation–circulation relationship at Lake PTA: weakened westerlies lead to increased precipitation

_Introduction to the climate of southern South America

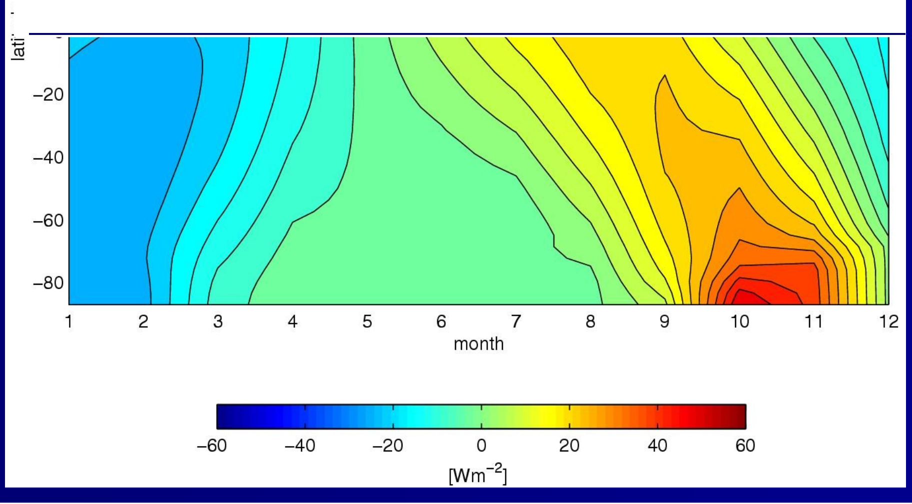
_Simulation with GCM of

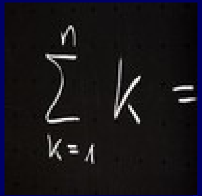
- Pre-Industrial climate [PI, 1750 AD]
- Mid-Holocene climate [MH, 6000 BP]

(orbital, solar, GHG)

Difference in shortwave insolation between Mid-Holocene and pre-industrial:

Increased seasonal insolation cycle





_Statistical downscaling

_Principal Component Regression (PCR):

$$PREC(t) = a_0 + \sum_{k=1}^{K} a_k^{SLP} c_k^{SLP}(t) + \varepsilon(t)$$

_Estimation of principal components by means of EOF

$$\vec{X} = \sum_{j=1}^{J} c_j \vec{e}^{\,j}$$

$$c_j = X^T \cdot e_j \qquad c_j \cdot c_k = 0 \mid j \neq k$$

_Estimation of GCM-modelled principal components c_j

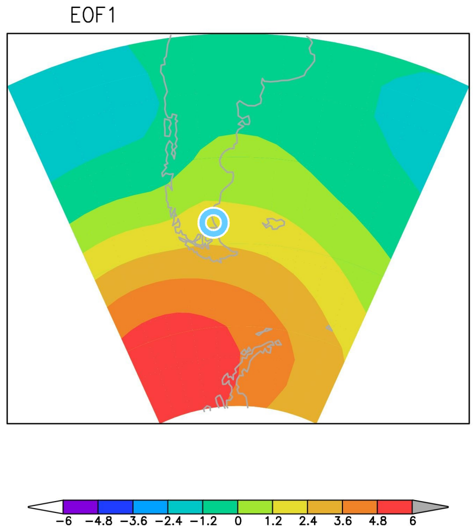
$$c_j^{mo} = X^{T,mo} \cdot e_j^{obs}$$

_Statistical downscaling

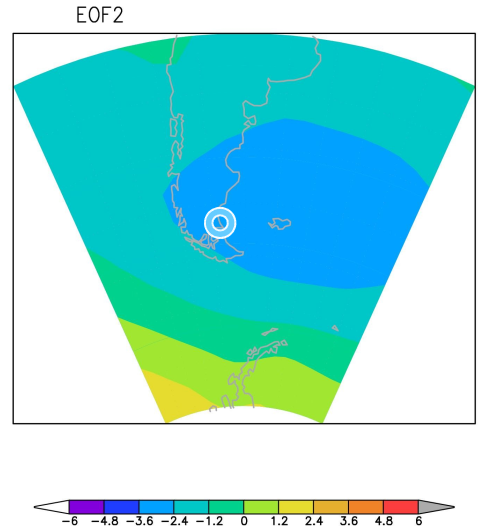
_Climate-circulation regression coefficients a_i for JJA for observations:

Physical plausibility with precipitation at Lake site PTA

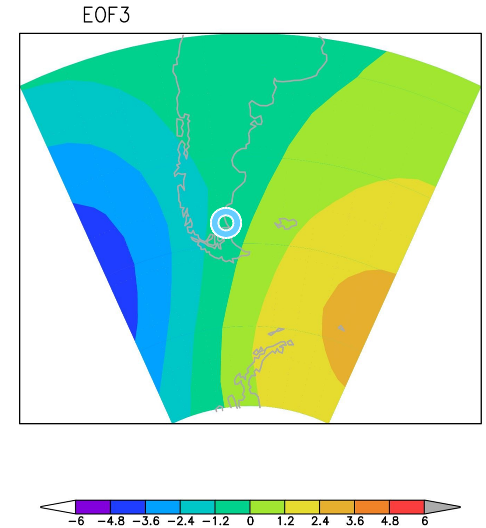
$a_1^o = +0.34$



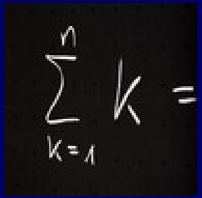
$a_2^o = +0.18$



$a_3^o = +0.13$



Model skill:	DJF	JJA
$r_{crossval}$	+0.2	+0.44

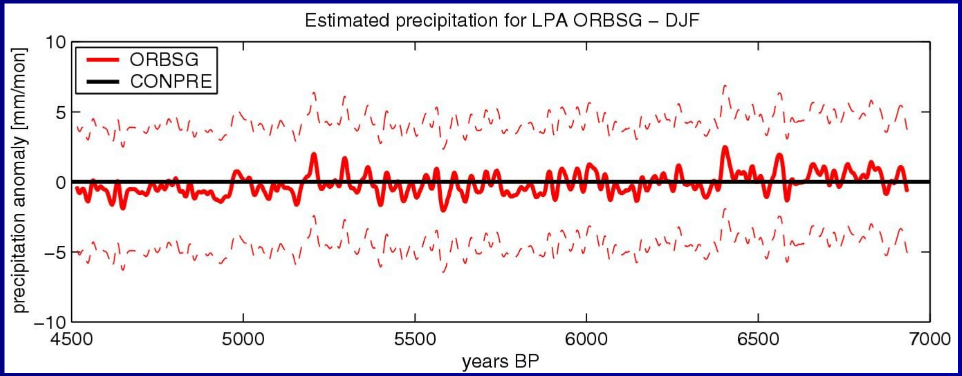


_Statistical downscaling

_Result for precipitation at Lake [PTA] in south-eastern Patagonia for difference mid-Holocene – pre-industrial:

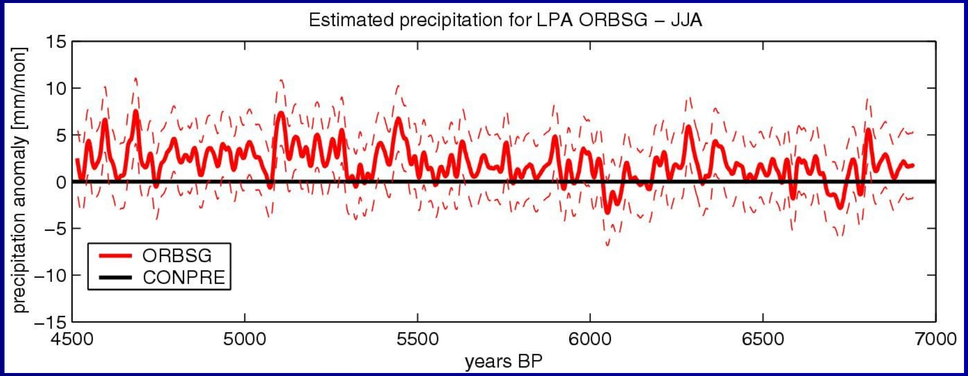
_Reduced precipitation during DJF

[mean MH-PI: -1.4%]

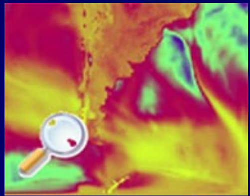


_Increased precipitation during JJA

[mean MH-PI: +7.7%]

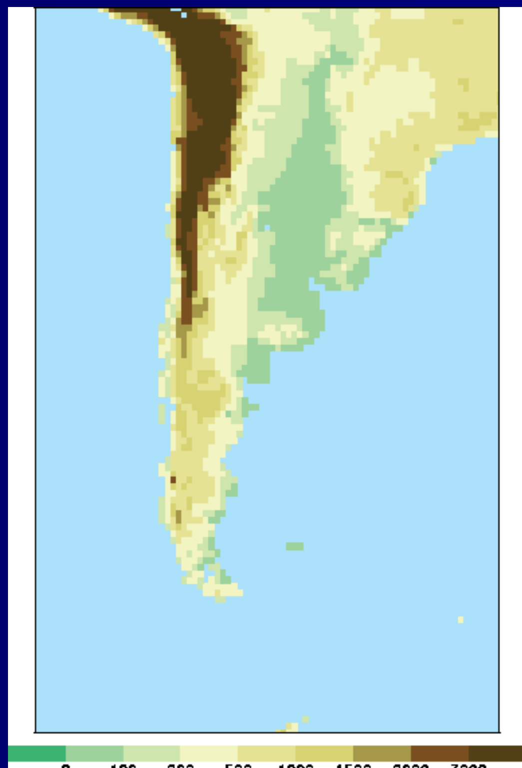


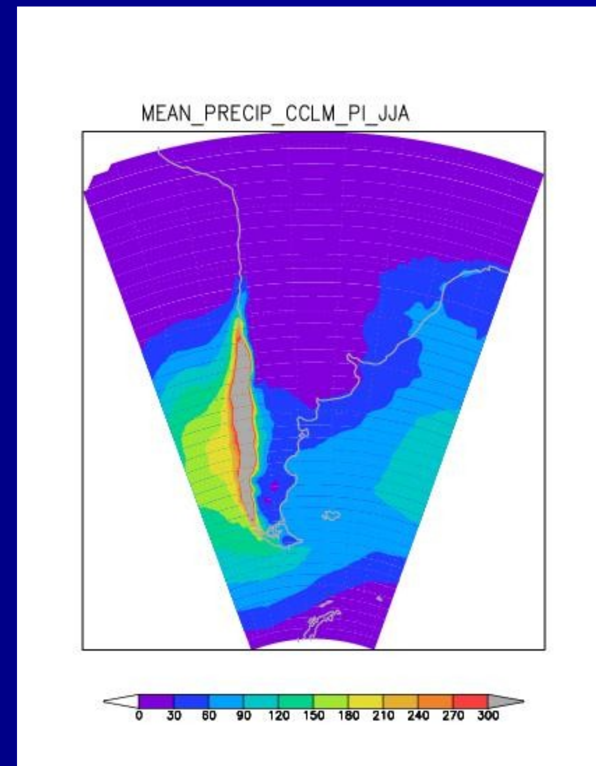
_Confidence intervals: $2\sigma = 1.98 * \sqrt{\mathrm{var}(\varepsilon)}$



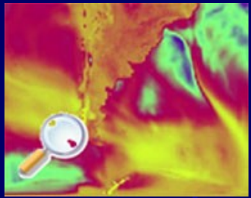
_Numerical downscaling

Orography [0.44x0.44] CCLM and mean precipitation for JJA:



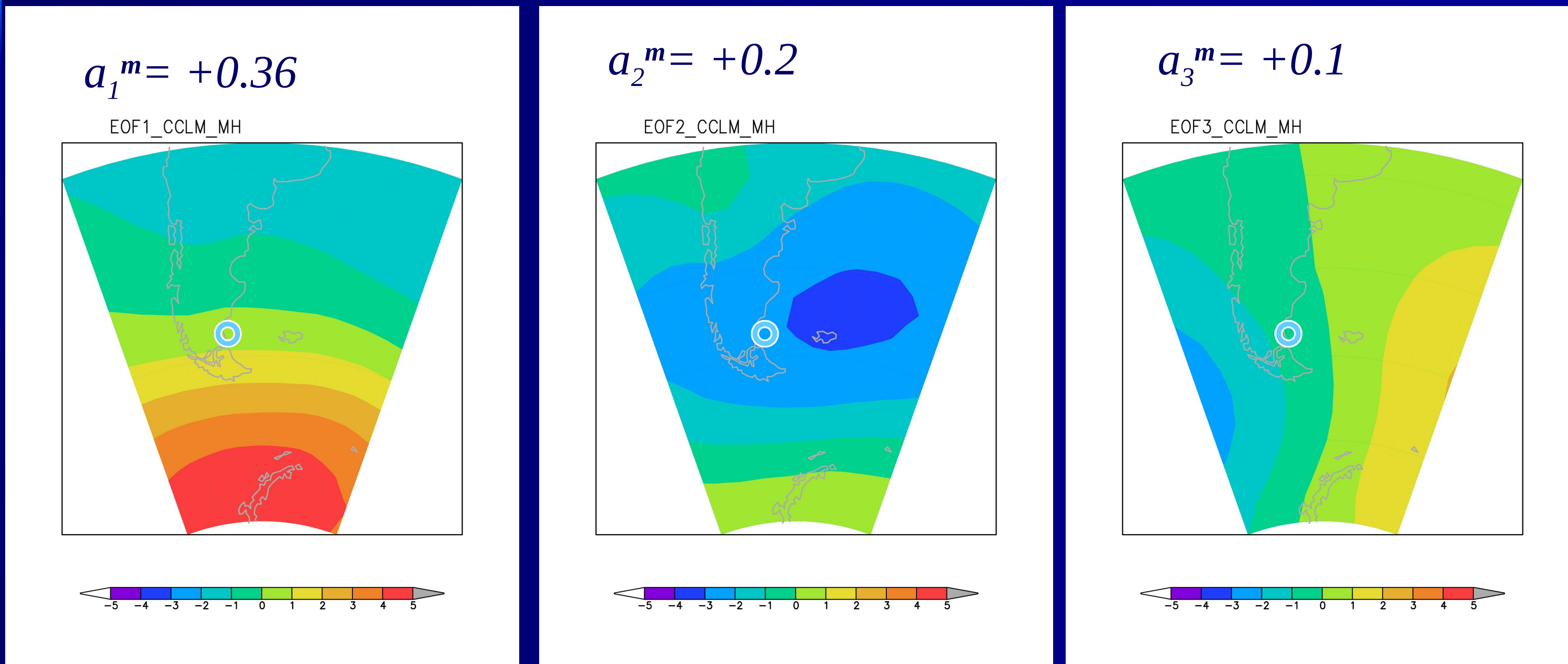


Regional model shows longitudinal band of increased precipitation along Andes mountains – difference to gridded obs. VASCLIMO data [cf. p.



_Numerical downscaling

Test of circulation-climate relationship for the mid-Holocene:



Basic atm. circ. patterns and links with precipitation at PTA are well reproduced by regional model [cf. p. 9]

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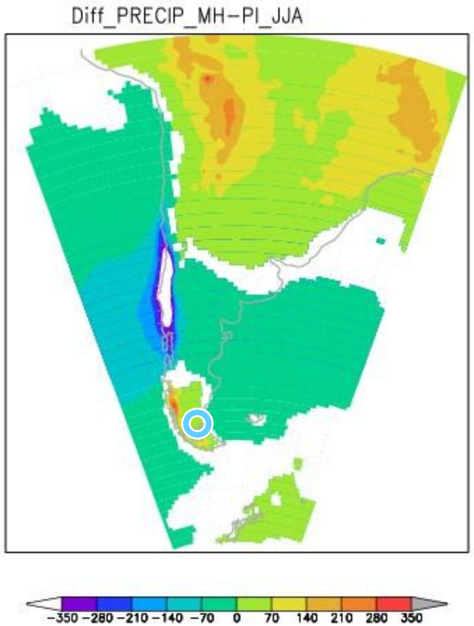
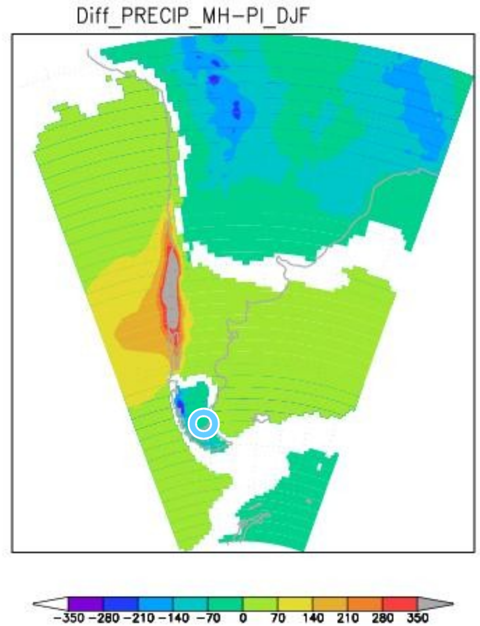
Mean precipitation differences between Precipitation MH-PI:

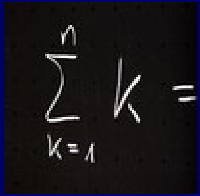


PTA: +35%



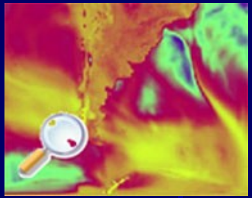
PTA: -28%

Complex spatial pattern with opposite signs for JJA and DJF



_Summary I

- _Physical plausibility of the statistical model
- _Less is more: fewer predictors but stable model
- _Residuals for estimation of uncertainty due to statistical model



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_Summary II

_Numerical regional models for estimating spatial patterns of climate change

_Validity of assumptions in the circulation-climate relationship

_Results of numerical DS are in accordance with SD

_Outlook: Quo vadis ?

_Range rather than resolution: Sensitivity to driving GCMs

_Skilful model chain: A chain is as strong as its weakest link

_Paleo-Perspective: Revisiting of hypothesis derived from proxy

Thank you for your attention!