



Cambios climáticos en el sistema de Monzón Sudamericano durante el último milenio en base a registros de espeleotemas

J. Apaéstegui, F. Cruz, JL Guyot, M. Vuille, A. Sifeddine, JC Espinoza, N. Strikis

PALEO 
TRACES

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Precipitation changes over the eastern Bolivian Andes inferred from speleothem ($\delta^{18}\text{O}$) records for the last 1400 years



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^g UMR LOCEAN (IRD/UPMC/CNRS/MNHN), Paris-Jussieu, France

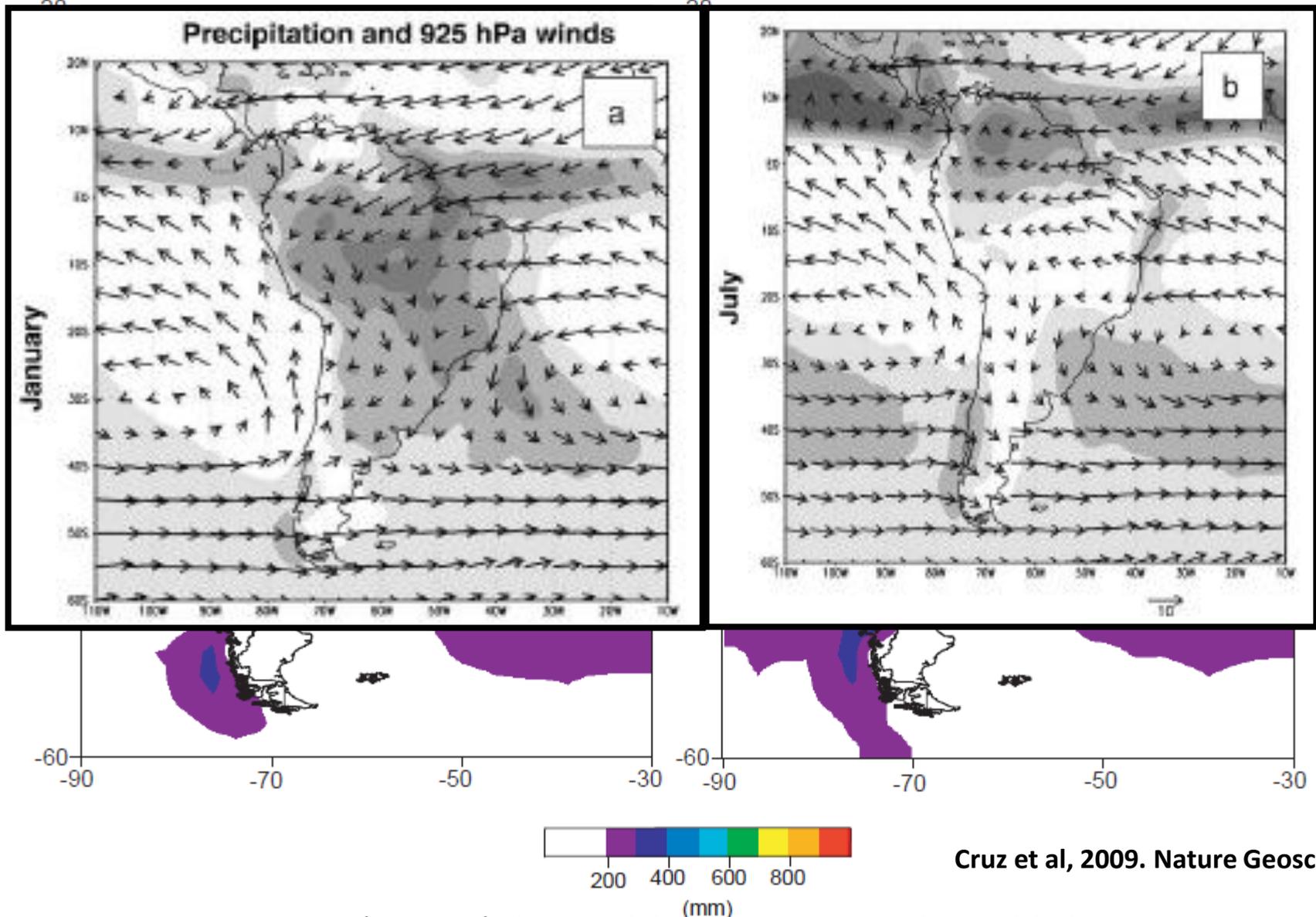
^h Departamento de Geoquímica, Universidade Federal Fluminense, Niterói, RJ, Brazil

ⁱ UMR GET (IRD) Géosciences Environnement Toulouse, CNRS-IRD-UPS, OMP, Toulouse, France

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^k Institute of Global Environmental Change, Xi'an Jiaotong University, Xi'an, China

^l Department of Geology and Geophysics, University of Minnesota, Twin Cities, Minneapolis, MN, USA

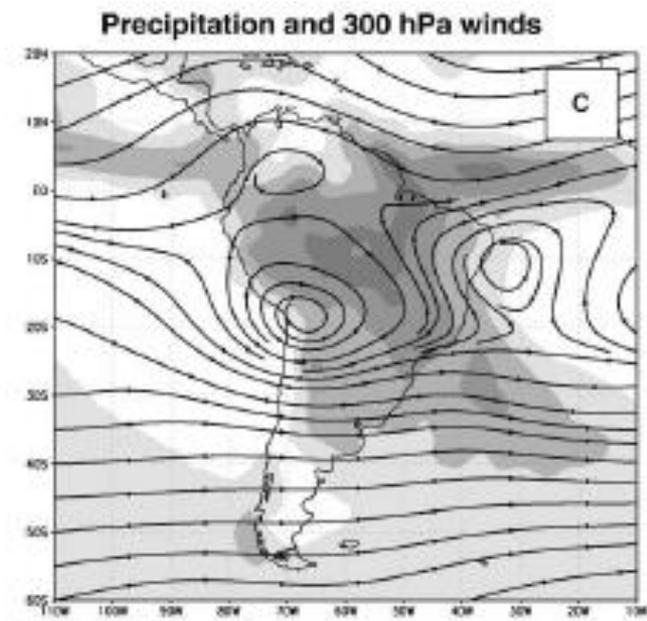
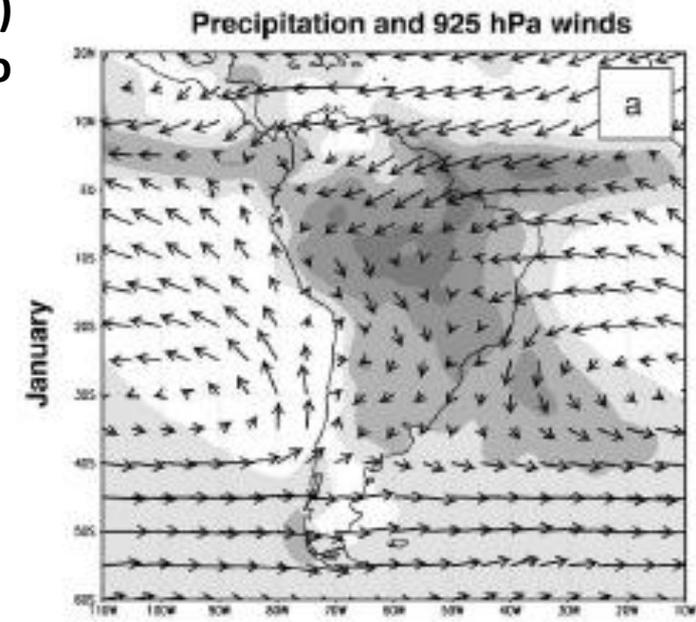
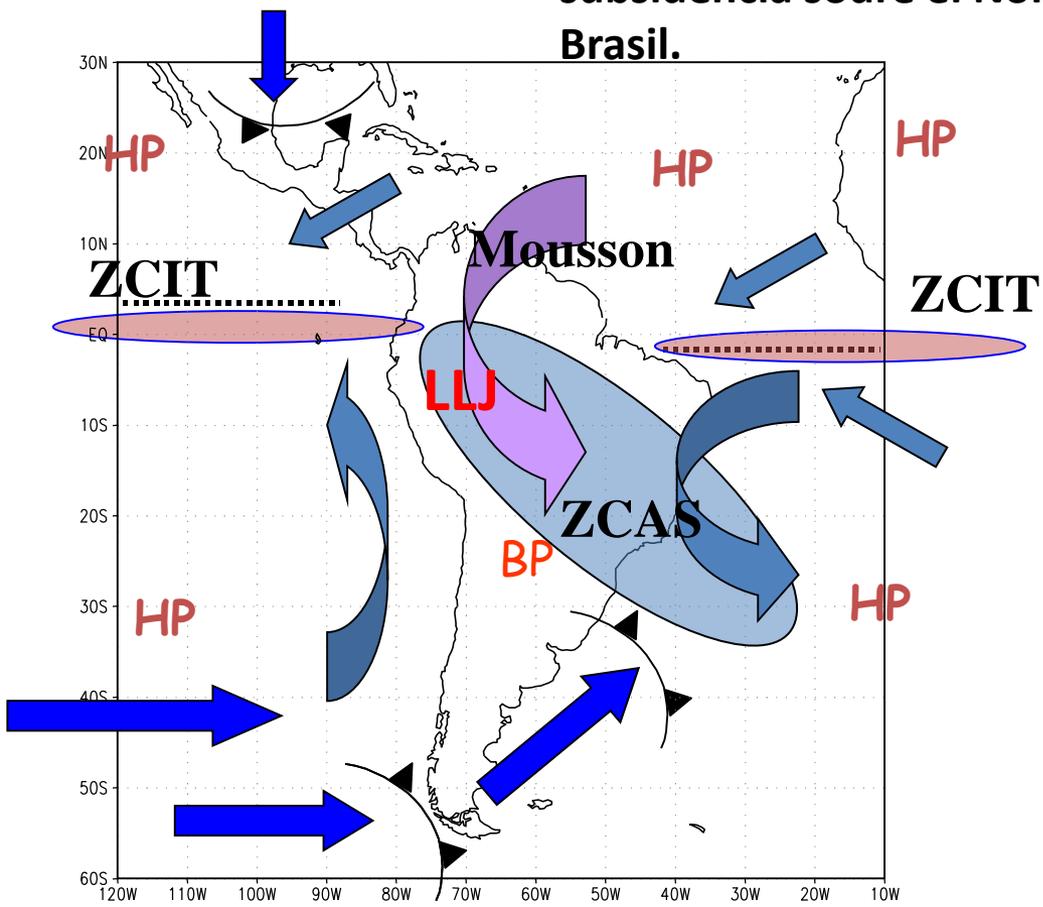


Cruz et al, 2009. Nature Geosciences

Long-term mean (1979–2000) Climate Prediction Center Merged Analysis of Precipitation seasonal precipitation totals (in mm) for December–February (left) and March–May (right).

Circulación y Precipitaciones

Calor liberado = zona de altas pressões (Alta de Bolivia ~12 km) subsidencia sobre el Nordeste do Brasil.

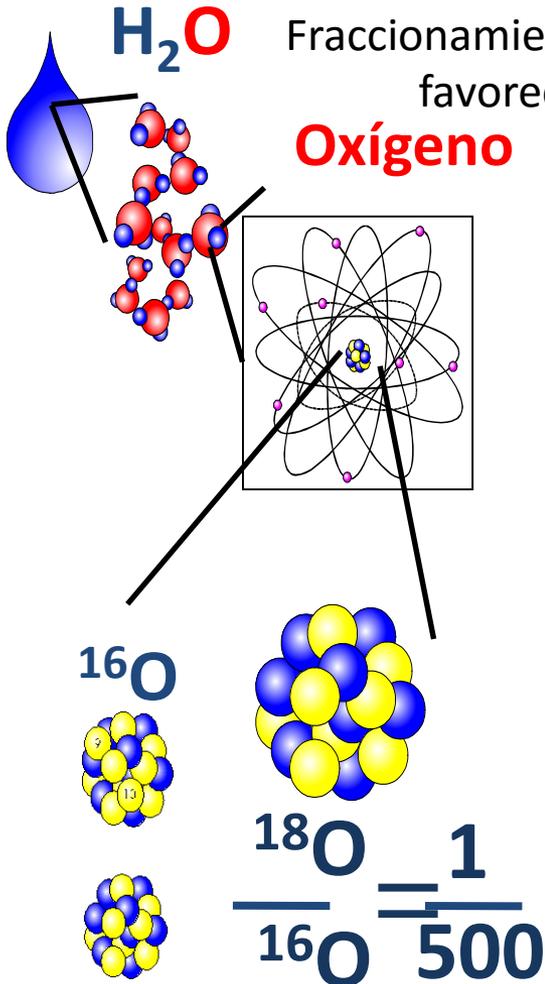


/IGES

2003-03-13-11:09

-  Circulation extra-tropical
-  Alizés
-  Mousson

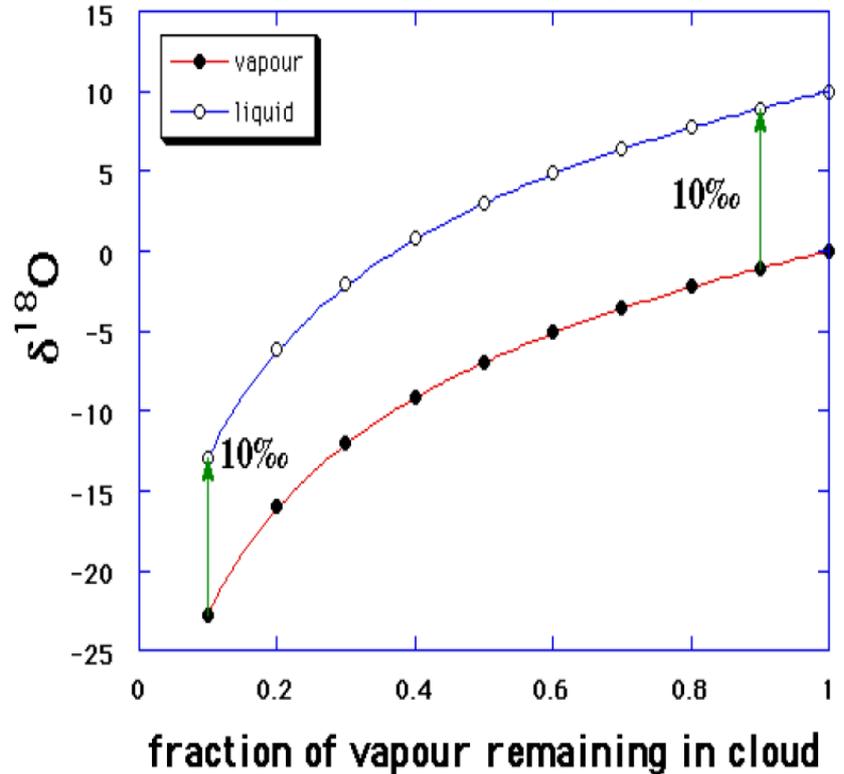
Como interpretamos estos registros?



Vienna Pee Dee Belemnite (VPDB)

Viena Standard mean ocean water. (VSMOW)

Destilación Rayleigh



Sudamerica: la señal isotopica del agua de lluvia esta influenciada por efectos del nivel de conveccion de la nube a traves de su paso por el continente.

Como interpretamos estos registros en el tiempo?

Enriquecido em ^{18}O

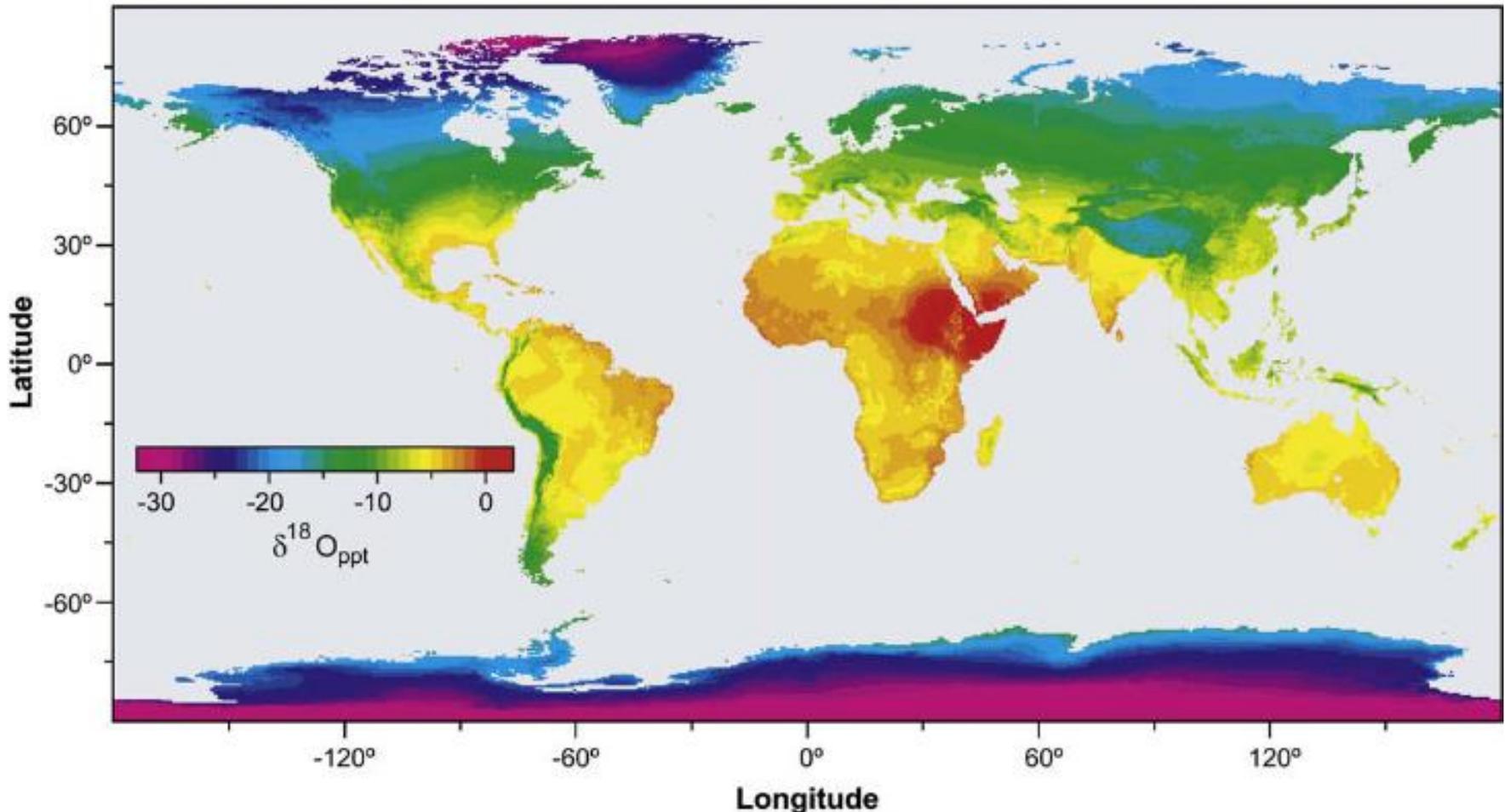
δ

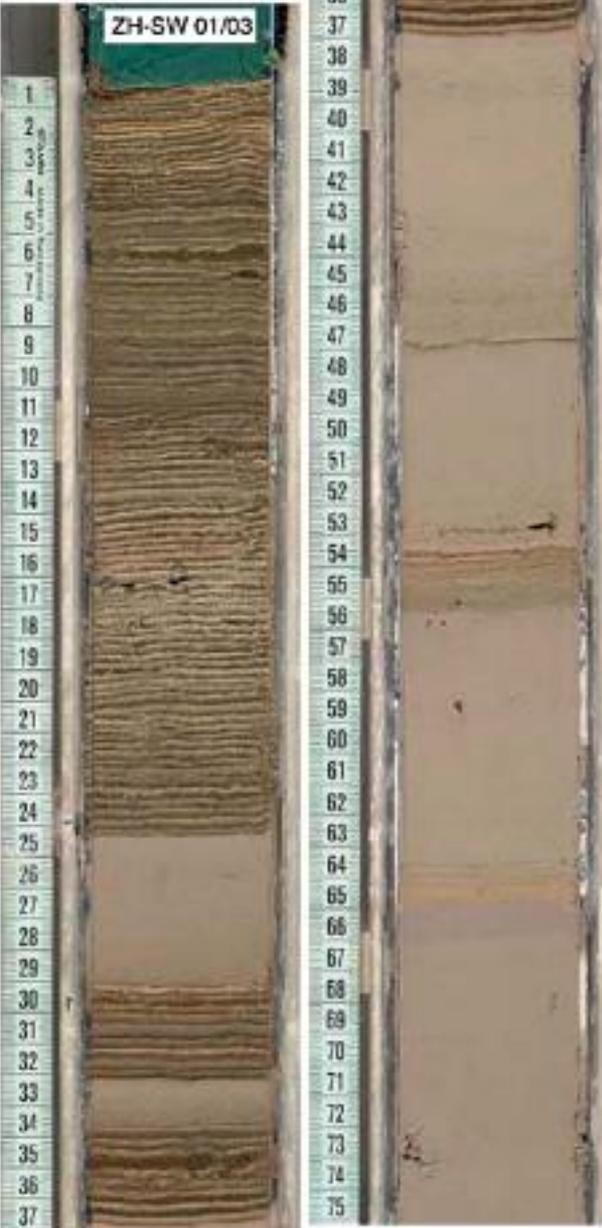
Empobrecido em ^{18}O



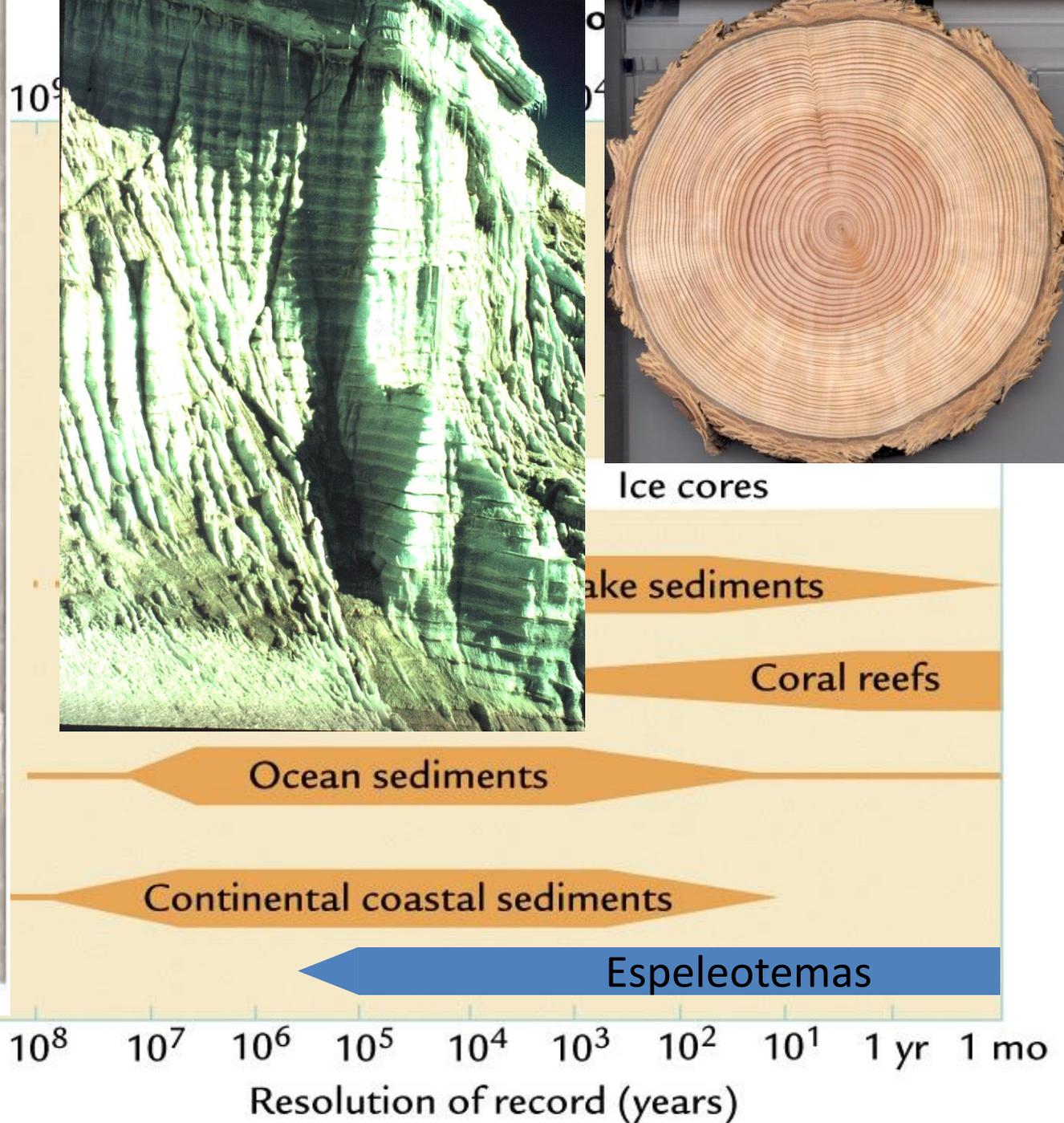
→ Periodos de atenuación en la actividad convectiva
(Poca llluvias)

→ Periodos de incrementos en la actividad convectiva
(Aumento de llluvias)

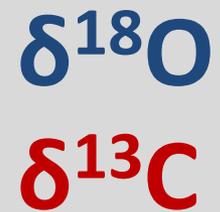
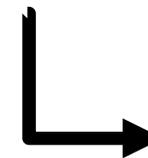
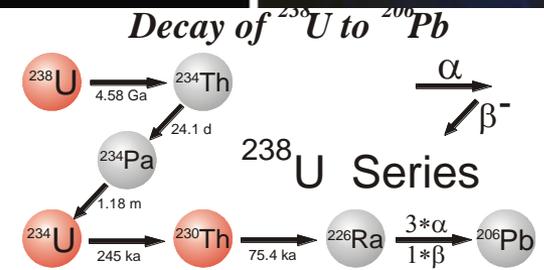
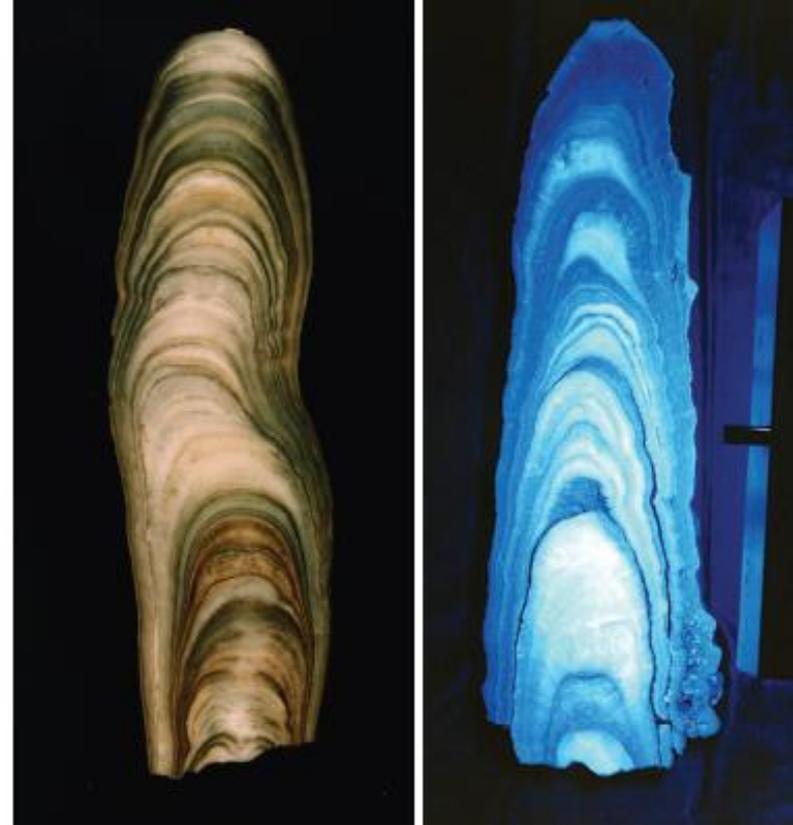
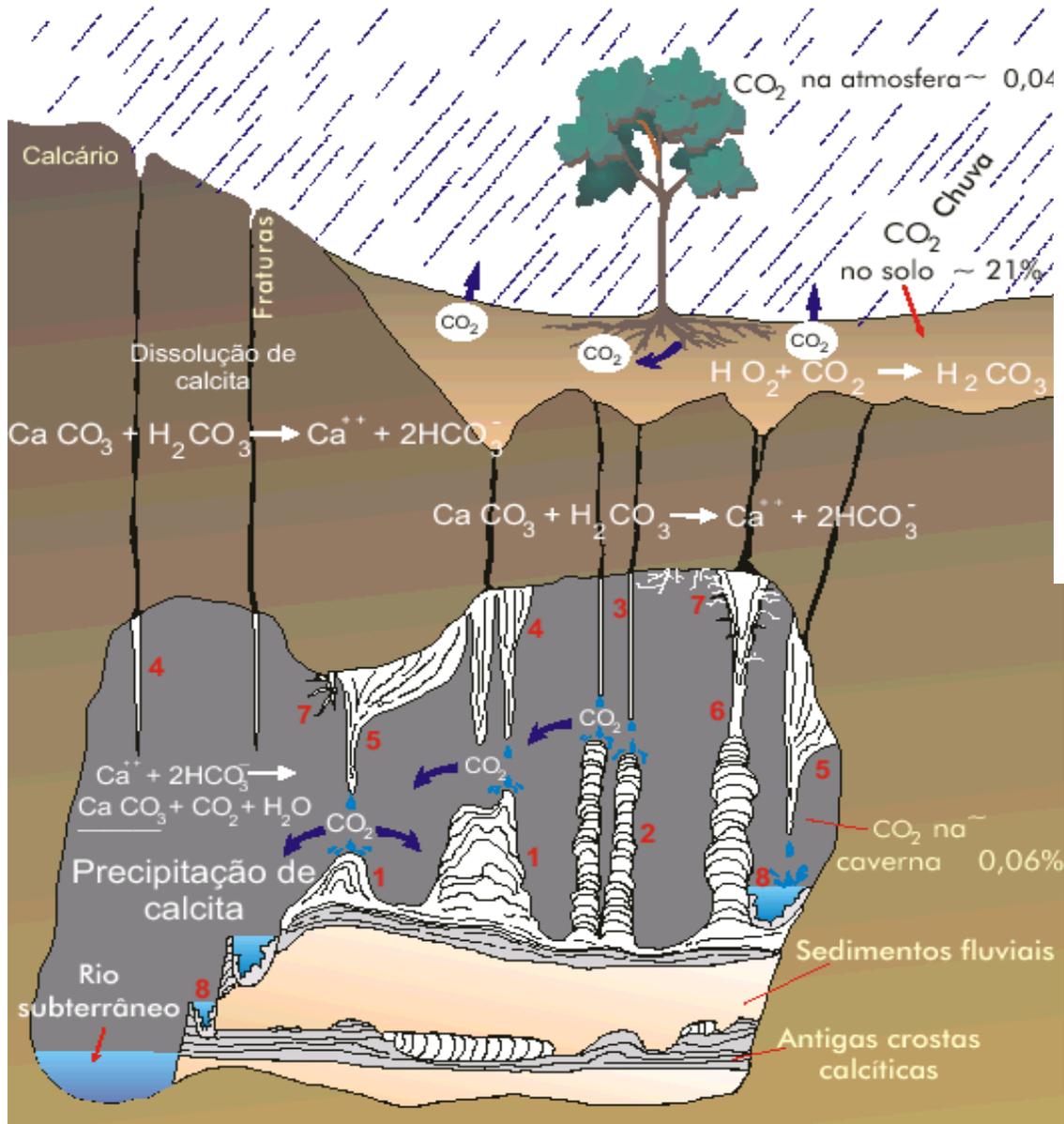




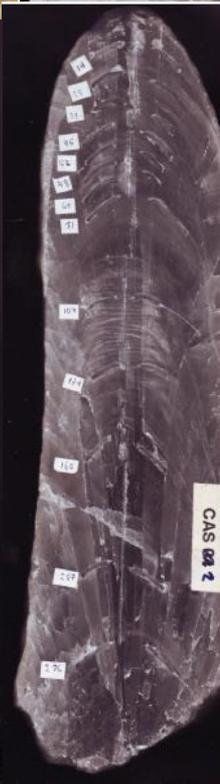
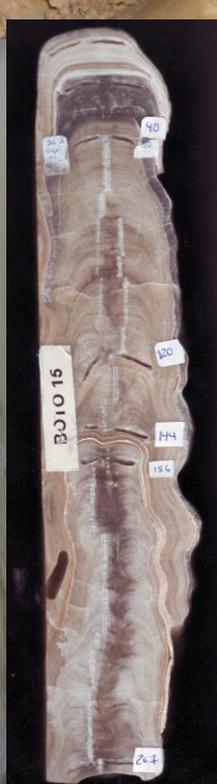
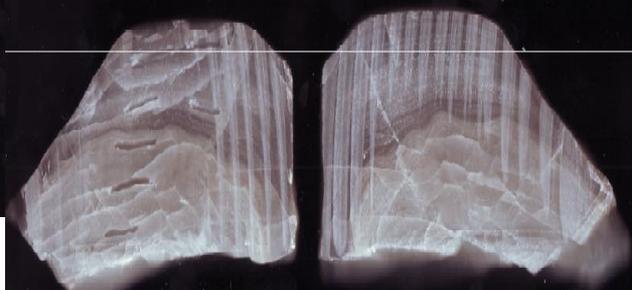
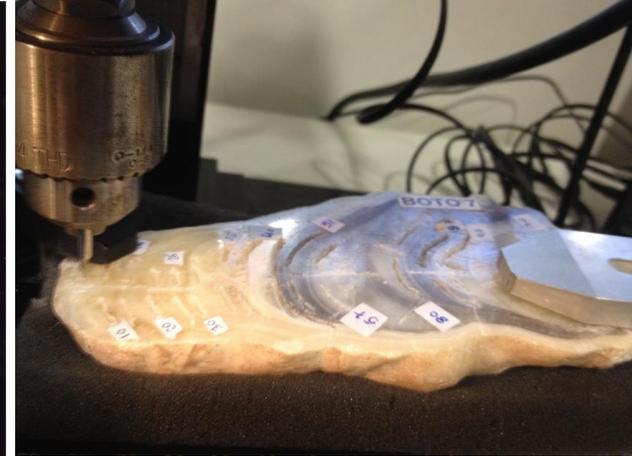
Bernasconi & McKenzie



Espeleotemas como indicador paleoclimático e paleoambiental



Colectas



Caverna Palestina

Fuera de la Caverna

- T °C, HR %
- Precipitaciones: regimen e isotopia
- Aforos de los rios
- Quimica e isotopia del agua del rio Superficial.





CUEVA DE PALESTINA

District de Nueva Cajamarca
 Province de Rioja
 Département de San Martín

Pérou

Coordonnées GPS (WGS84) (décimal) : Latitude : -5,9269 Sud
 Longitude : -77,3519 Ouest
 Altitude : 870 m

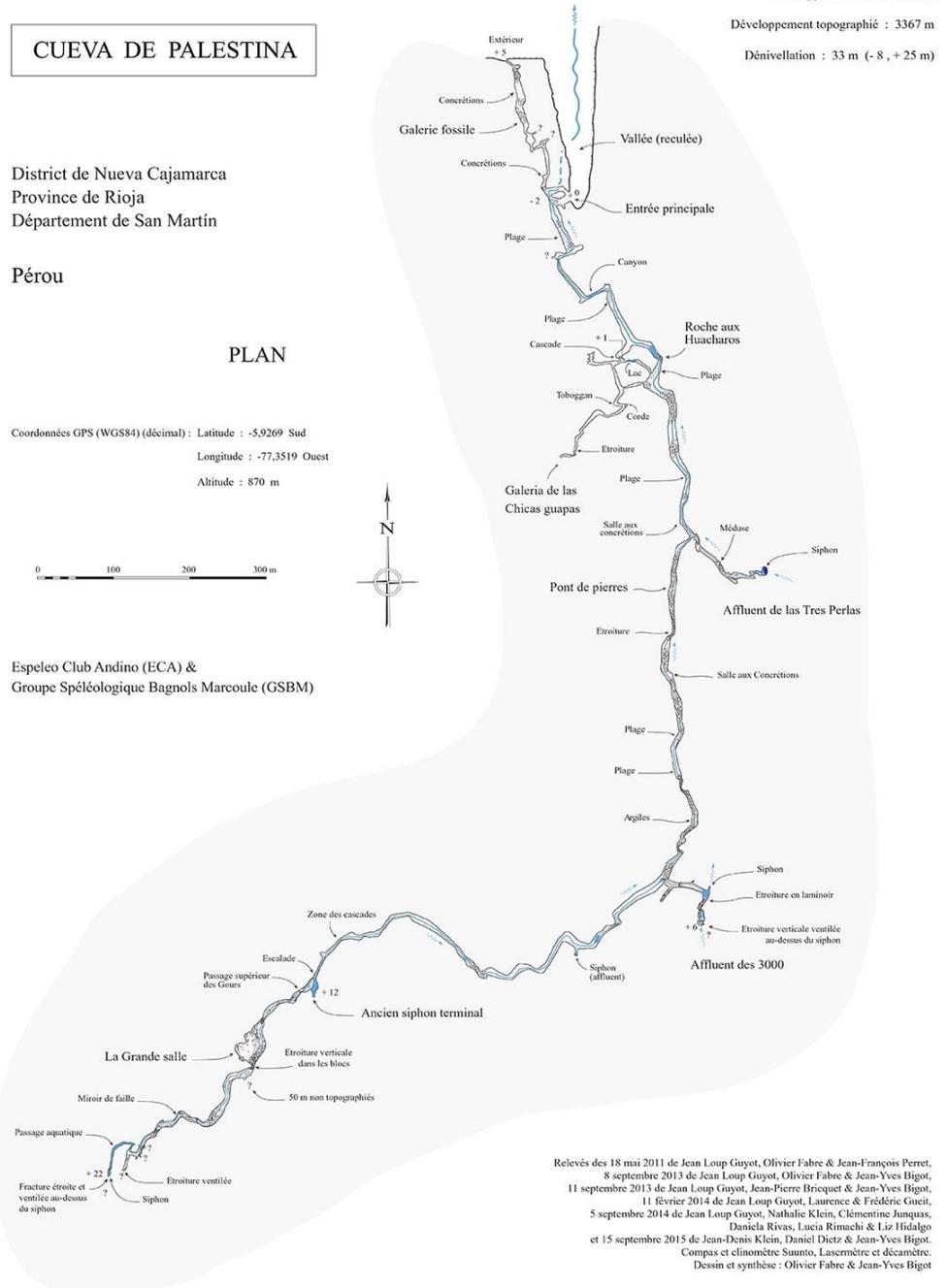


PLAN

Espele Club Andino (ECA) &
 Groupe Spéléologique Bagnols Marcoule (GSBM)



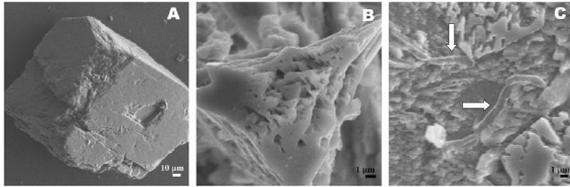
Développement total : 3390 m
 Développement topographique : 3367 m
 Dénivellation : 33 m (- 8 , + 25 m)



Relevés des 18 mai 2011 de Jean Loup Guyot, Olivier Fabre & Jean-François Perret,
 8 septembre 2013 de Jean Loup Guyot, Olivier Fabre & Jean-Yves Bigot,
 11 septembre 2013 de Jean Loup Guyot, Jean-Pierre Briquet & Jean-Yves Bigot,
 11 février 2014 de Jean Loup Guyot, Laurence & Frédéric Guell,
 5 septembre 2014 de Jean Loup Guyot, Nathalie Klein, Clémentine Jumeaux,
 Daniela Rivas, Lucia Rimachi & Liz Hidalgo
 et 15 septembre 2015 de Jean-Denis Klein, Daniel Dietz & Jean-Yves Bigot.
 Compas et clinomètre Suunto, Lasermetre et décamètre.
 Dessin et synthèse : Olivier Fabre & Jean-Yves Bigot

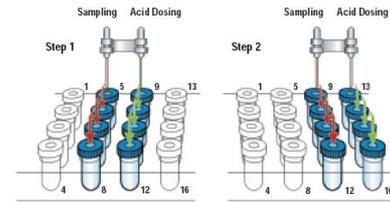
Geocronología

$^{234}\text{U}/^{230}\text{Th}$



Análisis de Isótopos estables

- Isótopos de Oxígeno ($\delta^{18}\text{O}$)
- Isótopos de Carbono ($\delta^{13}\text{C}$)



Como ev

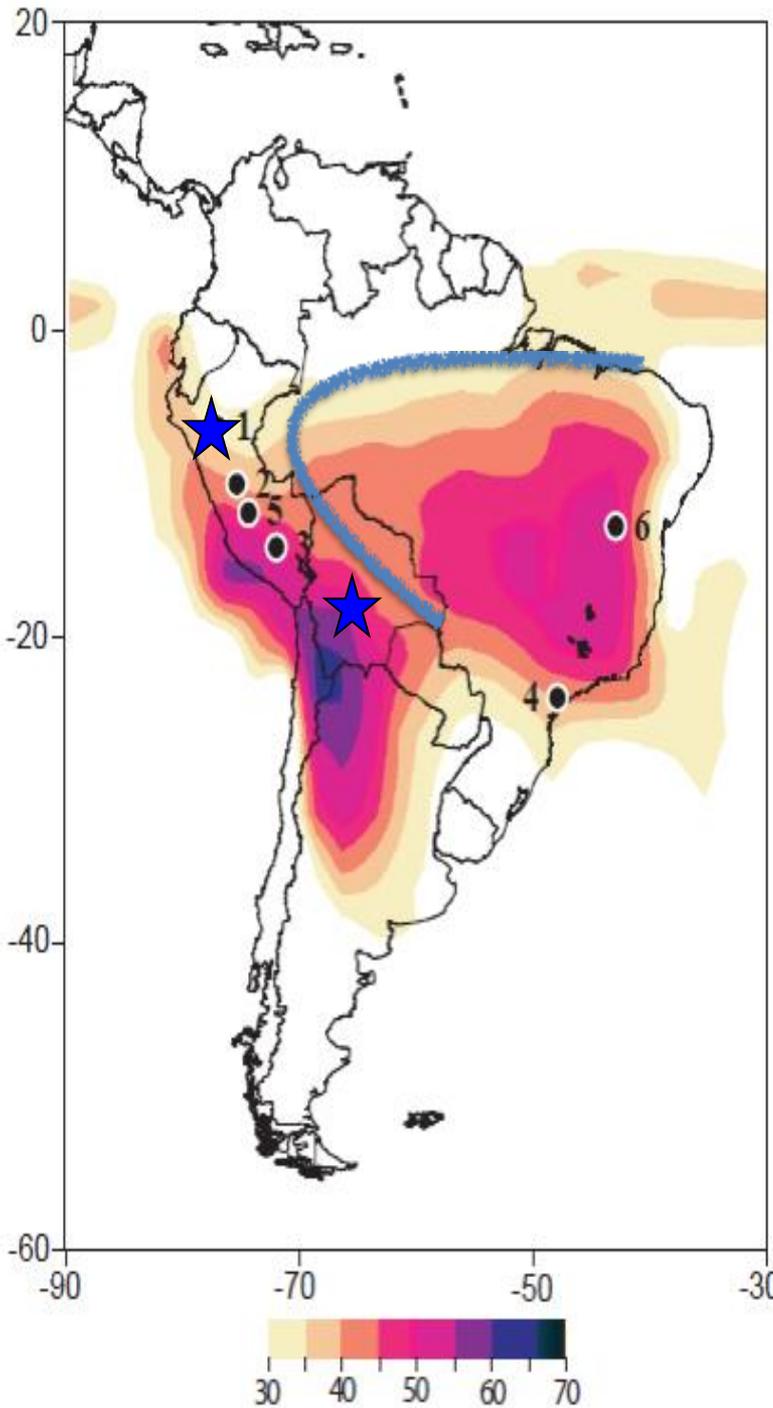
Los ultimos 2

A
Collapse of Class
Related to Mode
in Precipitation

Martín Medina-Elizalde and Eelco J. Rohlf



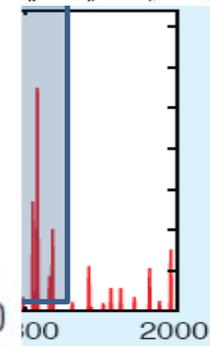
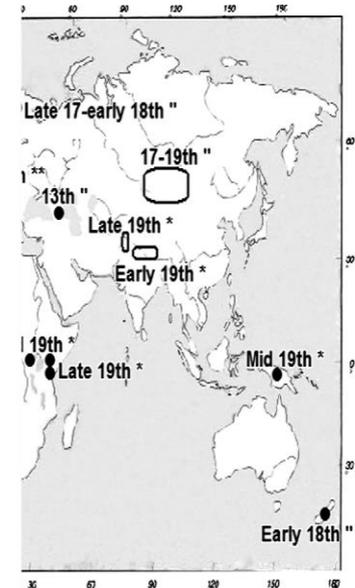
B)



Andino -

1 /MCA) 900 – 1200

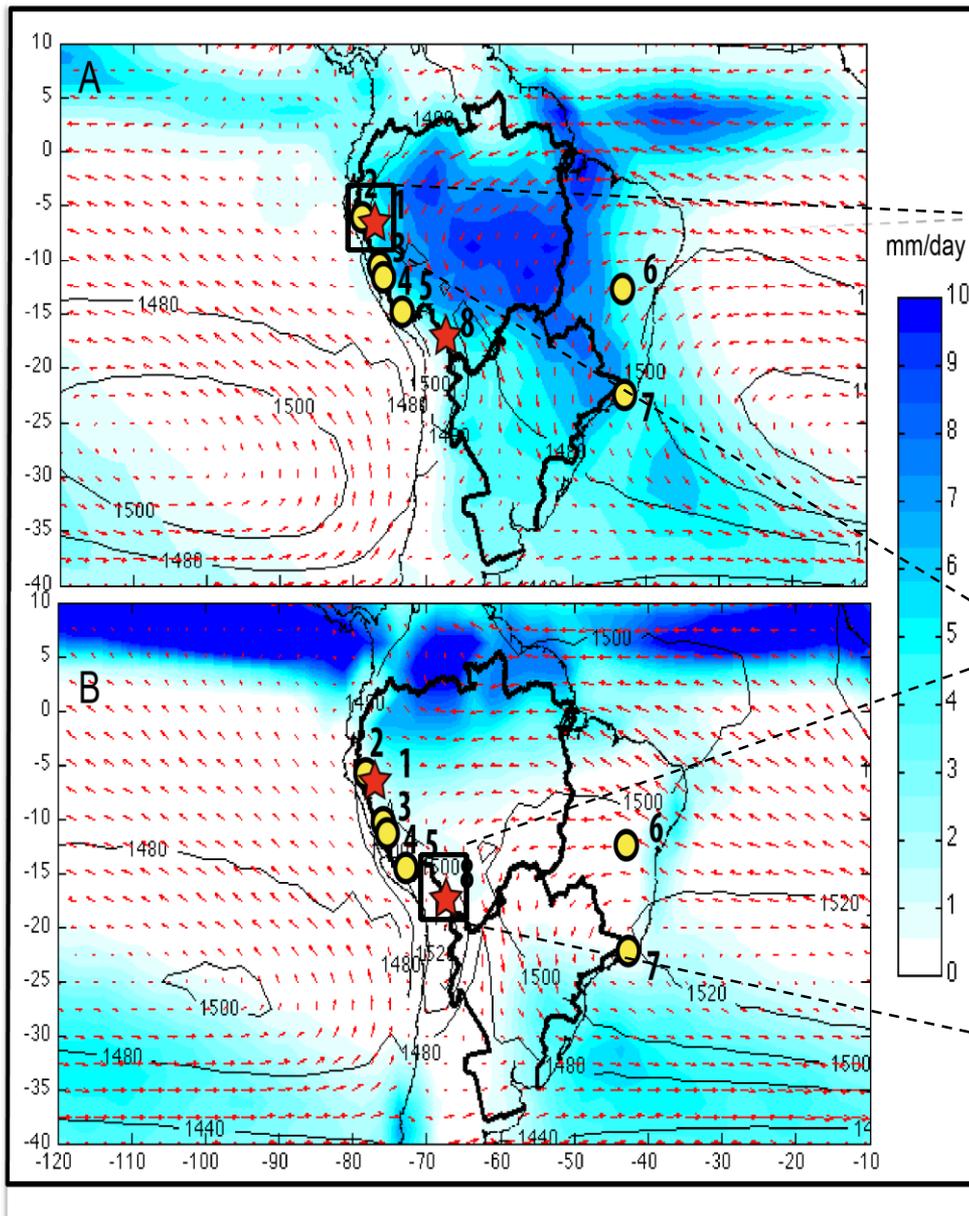
1400– 1850 A.D.



2000).

ao et al, 2008)

Areas de Estudio



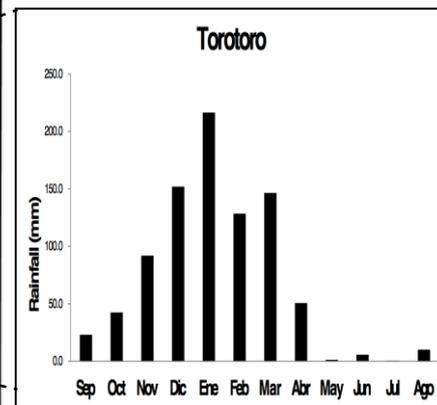
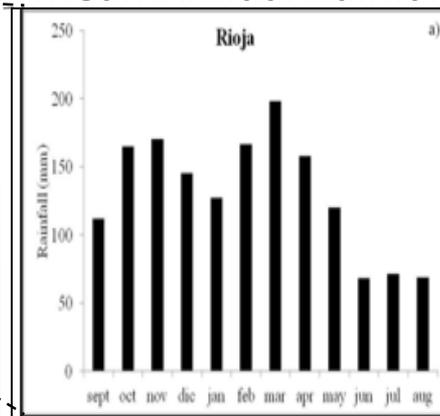
Perú

Caverna Cascayunga.

Caverna Palestina

Valor Actual do $\delta^{18}O\text{‰} = -7.4 \text{‰}$

Mean Annual Rainfall = 1520 mm



Bolivia

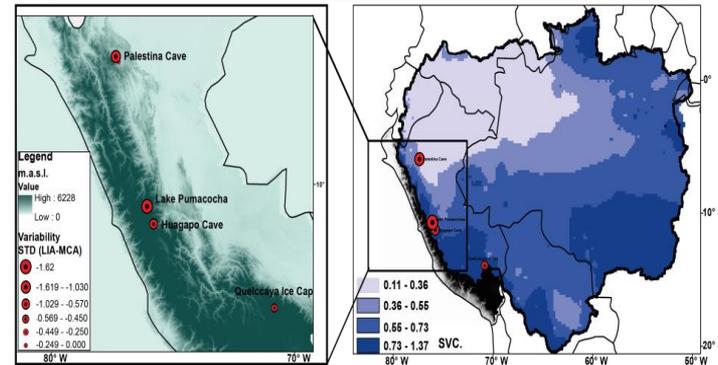
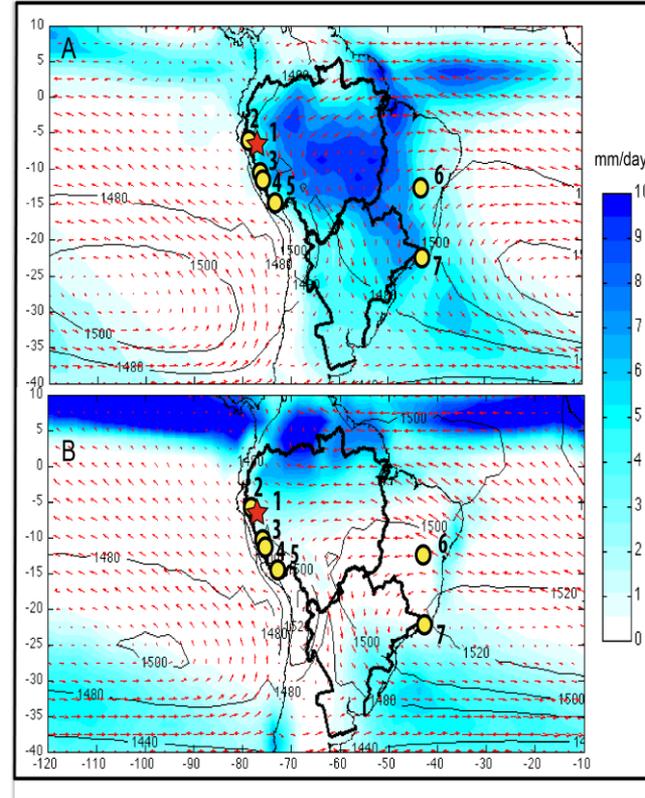
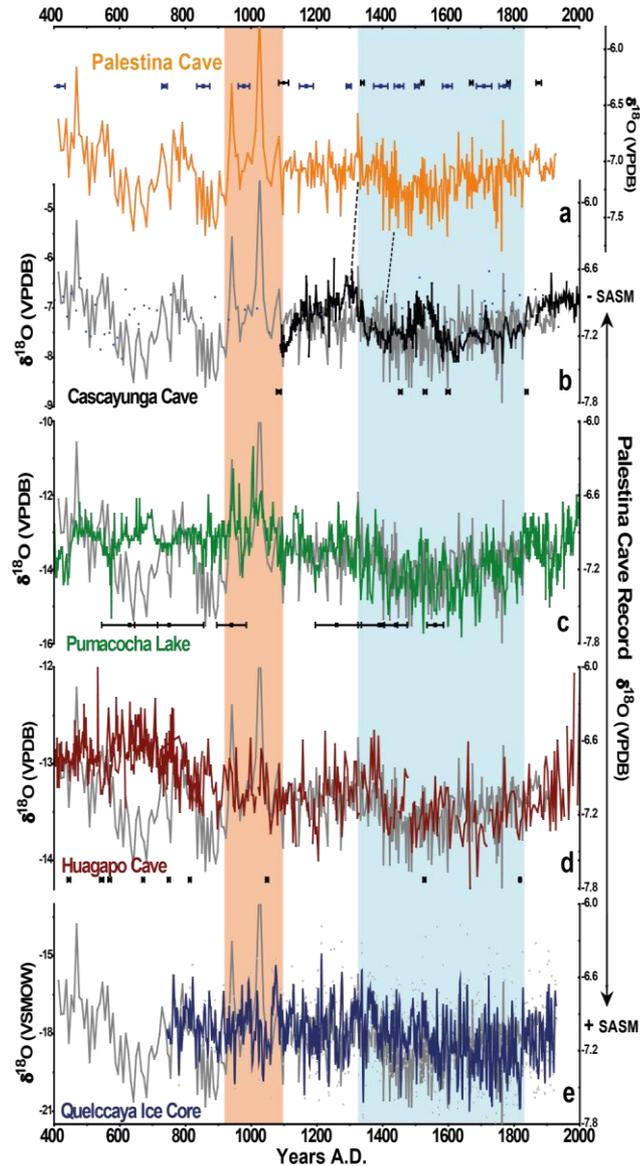
Caverna Chiflonkhak
ha

Valor Actual do $\delta^{18}O\text{‰} = -10.3 \text{‰}$

Mean Annual Rainfall = 860 mm.

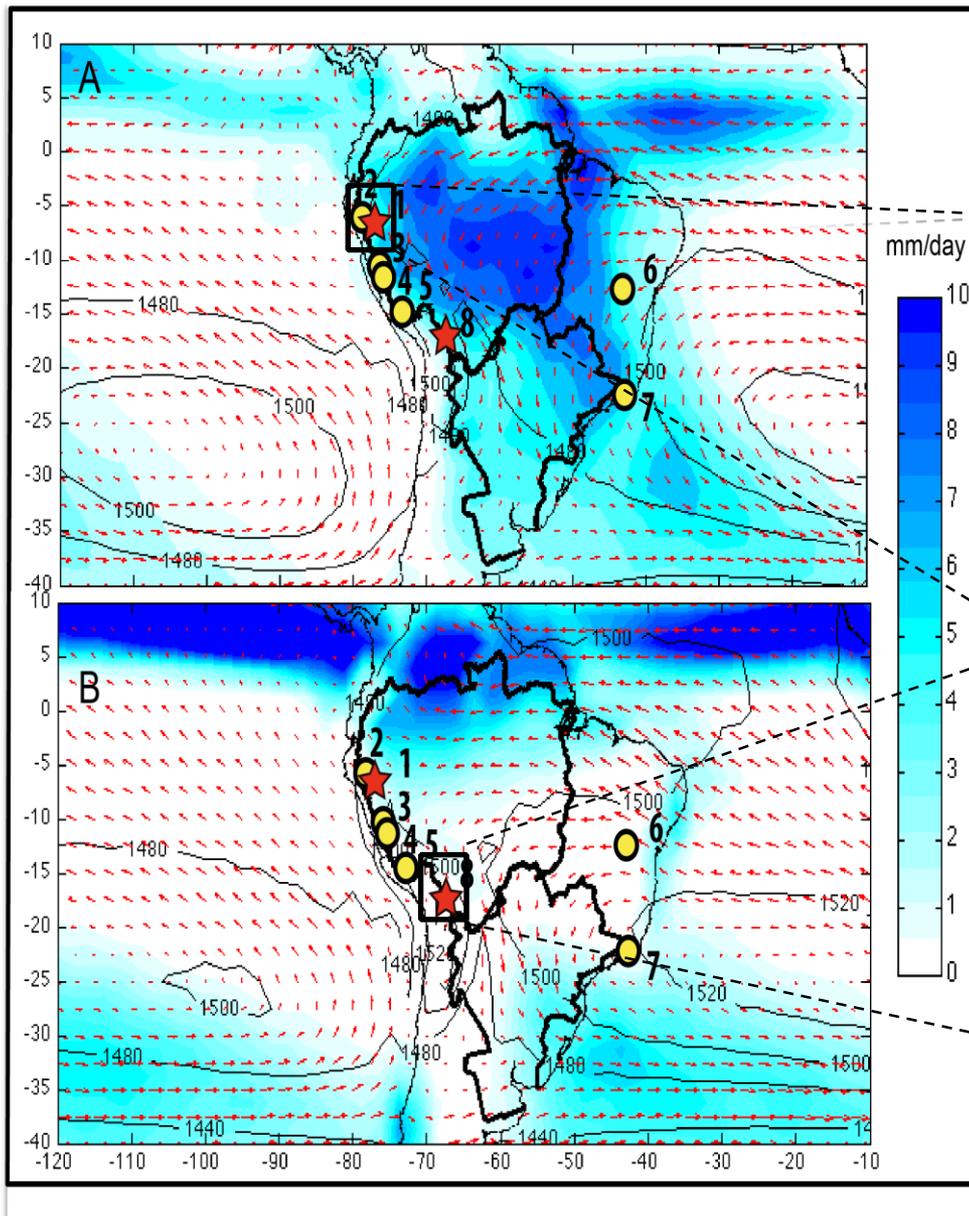
Como evolucionó el clima en la region Andino - Amazonica?

Los ultimos 2 milenios



Apaestegui et al.,

Areas de Estudio



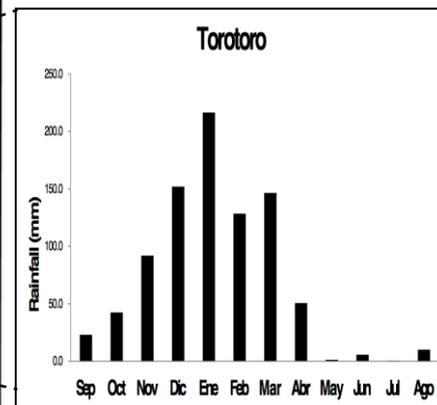
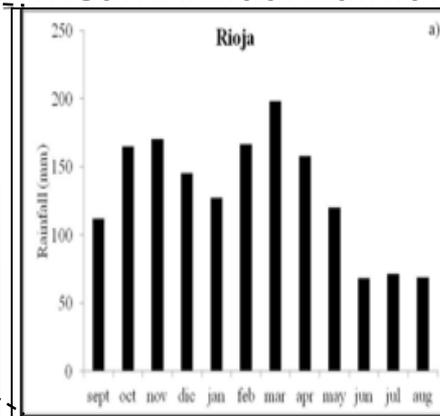
Perú

Caverna Cascayunga.

Caverna Palestina

Valor Actual do $\delta^{18}O\text{‰} = -7.4 \text{‰}$

Mean Annual Rainfall = 1520 mm



Bolivia

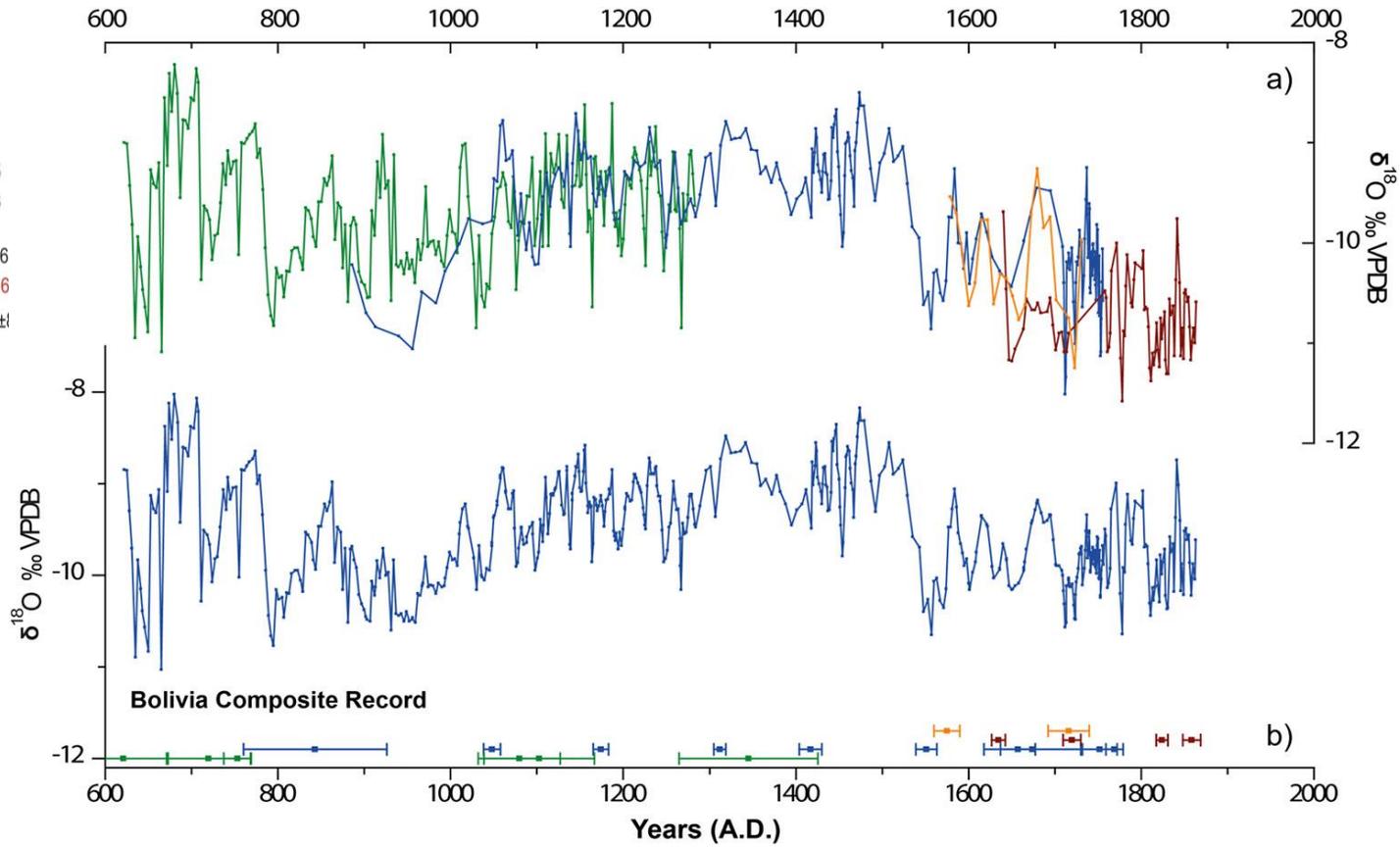
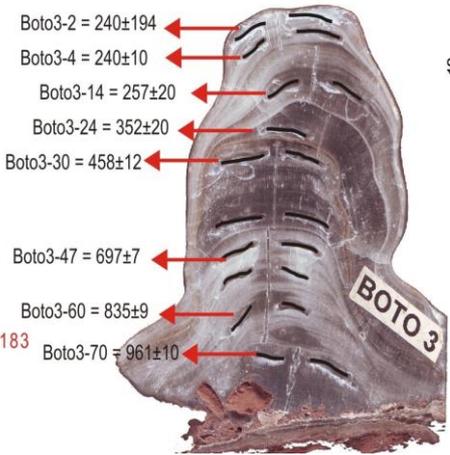
Caverna Chiflonkhak

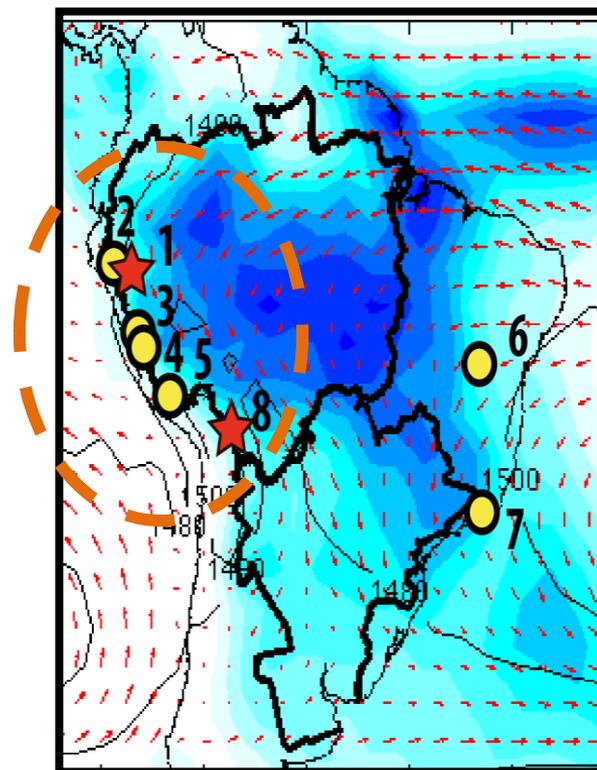
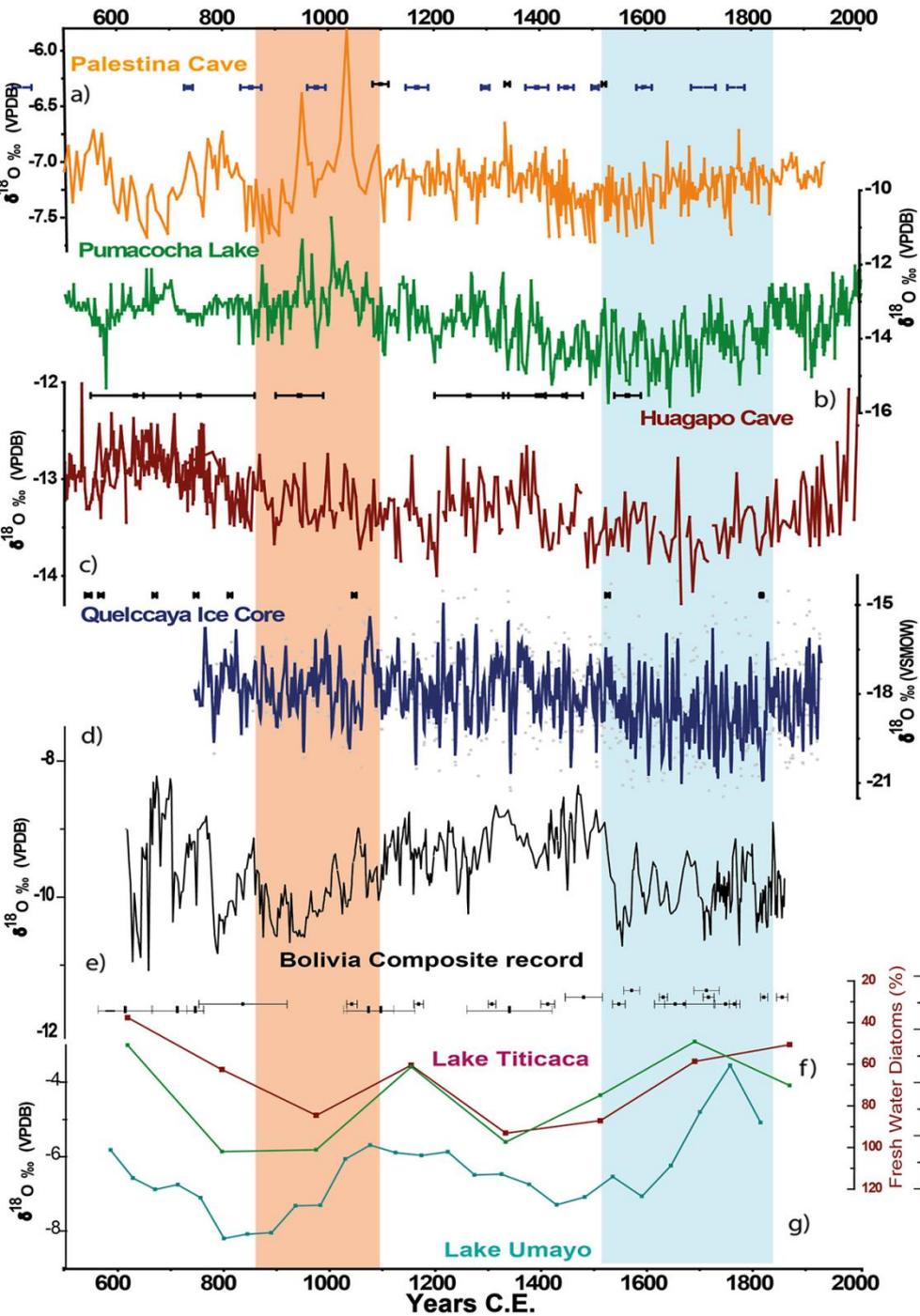
ha

Valor Actual do $\delta^{18}O\text{‰} = -10.3 \text{‰}$

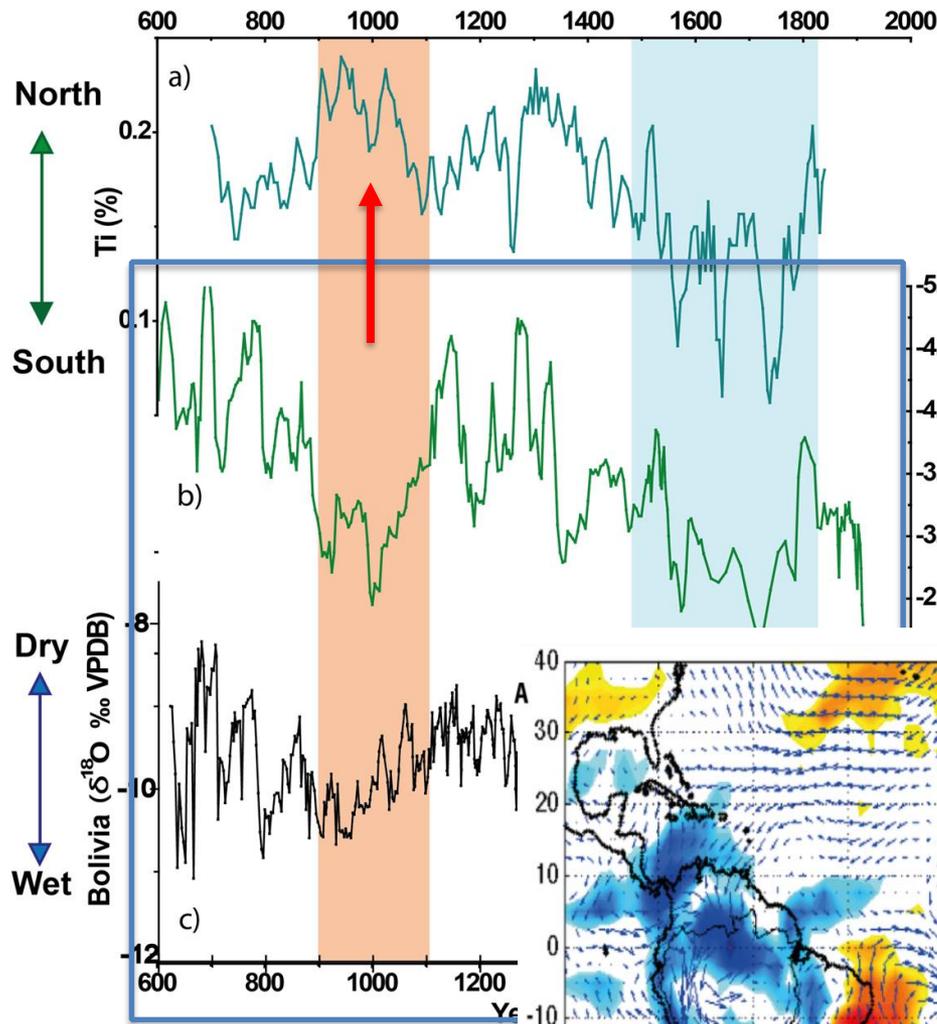
Mean Annual Rainfall = 860 mm.

Bolivian Cave Records

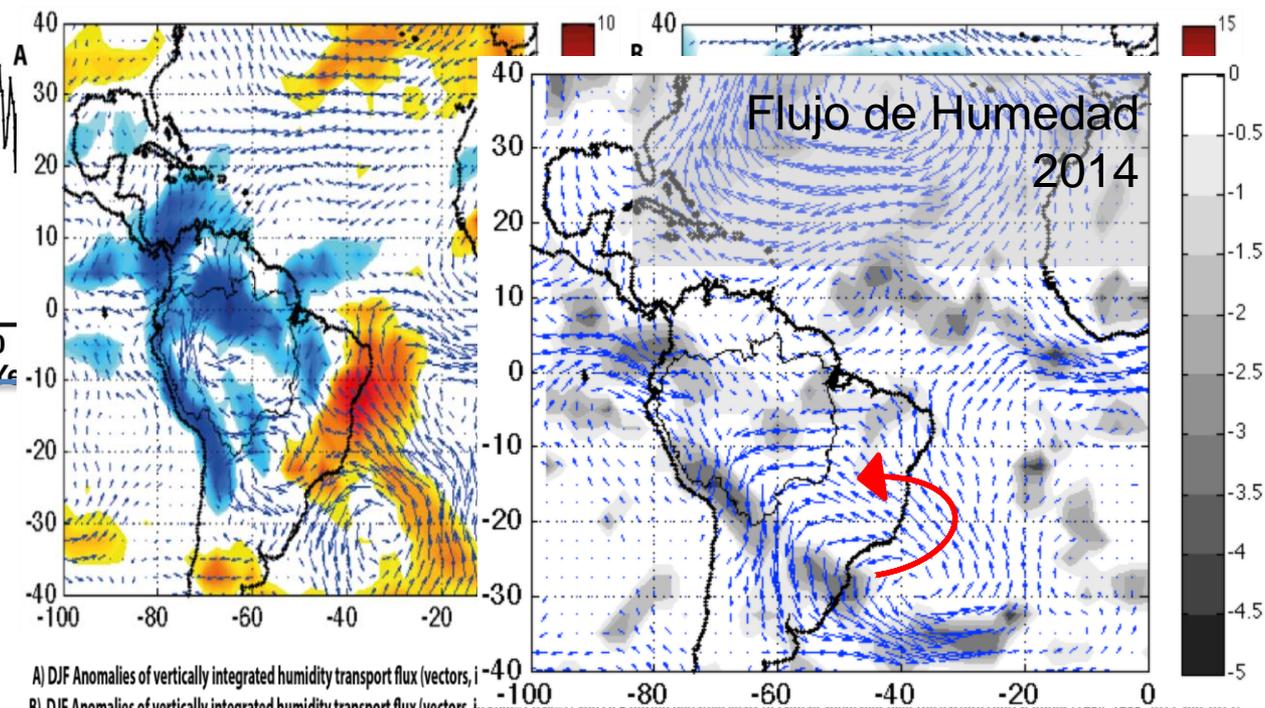
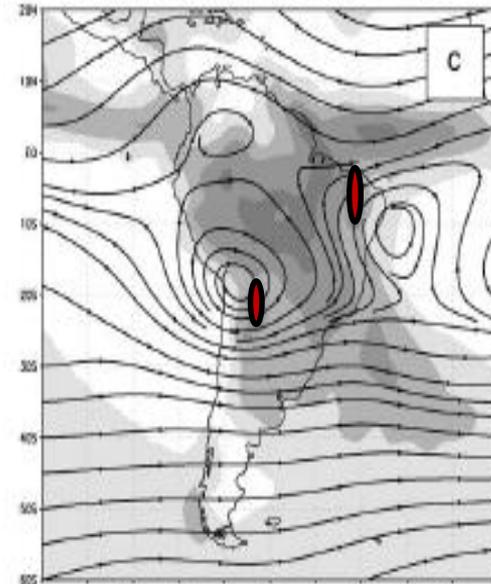




1. **Palestina Cave** (Apaéstegui et al, 2014) (CP)
2. **Pumacochas Lake** (Bird et al, 2011) (PNAS)
3. **Huagapo Cave** (Kanner et al., 2012)(EPSL)
4. **Quelccaya Ice Cap** (Thompson et al, 1984) (Science)
6. **Diva de Moura Cave** (Novello et al. 2012) (GRL)
7. **Cristal Cave** (Vuille et al., 2012) (CP).
8. **Bolivian Composite Record**; Apaéstegui et al., 2018. EPSL.

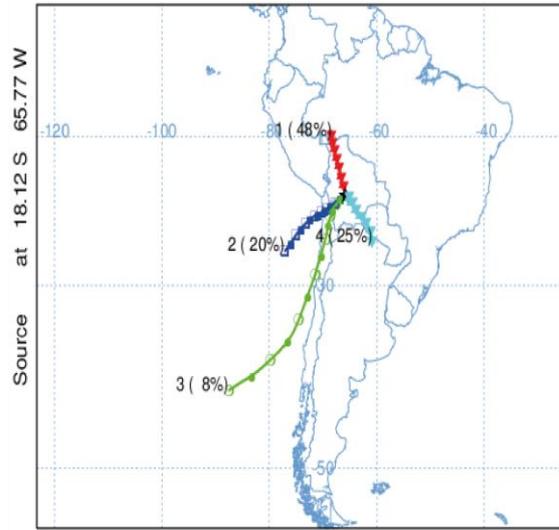


Precipitation and 300 hPa winds

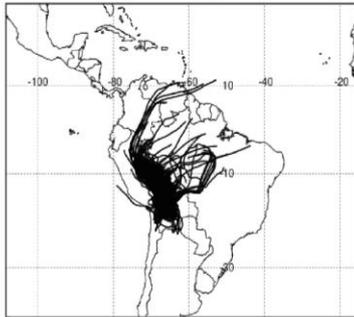


A) DJF Anomalies of vertically integrated humidity transport flux (vectors, g s^{-1})
 B) DJF Anomalies of vertically integrated humidity transport flux (vectors, g s^{-1})
 Climatology is computed using the 1980-2013 period. Espinoza et al., 2014

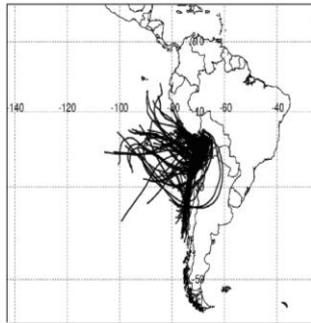
Cluster means - Standard
1252 backward trajectories
ECMG Meteorological Data



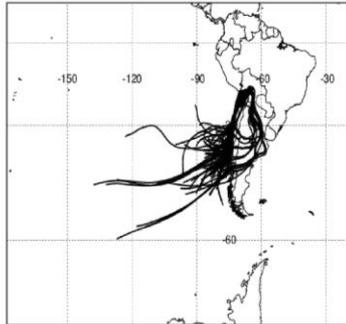
Cluster 1 of 4 - Standard
600 backward trajectories ending at various times
ECMG Meteorological Data



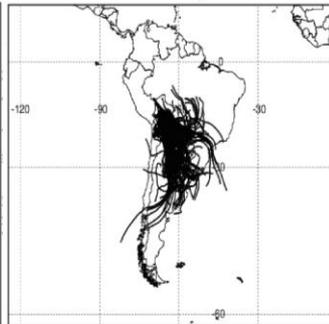
Cluster 2 of 4 - Standard
245 backward trajectories ending at various times
ECMG Meteorological Data



Cluster 3 of 4 - Standard
100 backward trajectories ending at various times
ECMG Meteorological Data

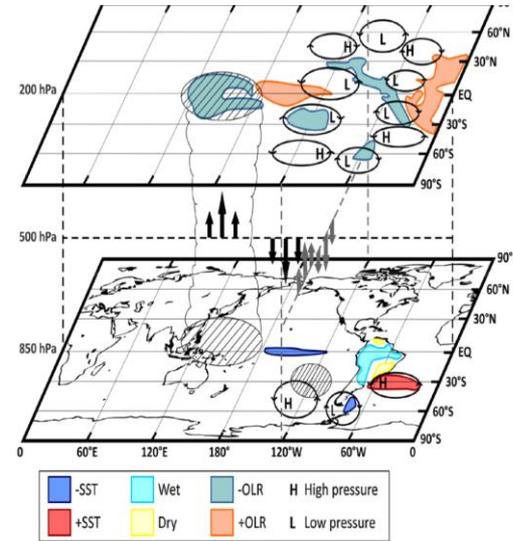


Cluster 4 of 4 - Standard
307 backward trajectories ending at various times
ECMG Meteorological Data



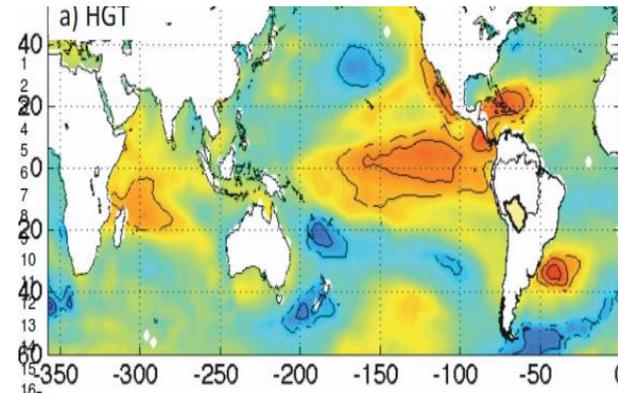
The 2014 southeast Brazil austral summer drought: regional scale mechanisms and teleconnections

Caio A. S. Coelho¹ · Cristiano Prestrelo de Oliveira² · Tércio Ambrizzi² · Michelle Simões Reboita³ · Camila Bertolotti Carpenedo² · José Leandro Pereira Silveira Campos² · Ana Carolina Nóbile Tomaziello² · Luana Albertani Pampuch² · Maria de Souza Custódio² · Lívia Marcia Mosso Dutra² · Rosmeri P. Da Rocha² · Amanda Rehbein²

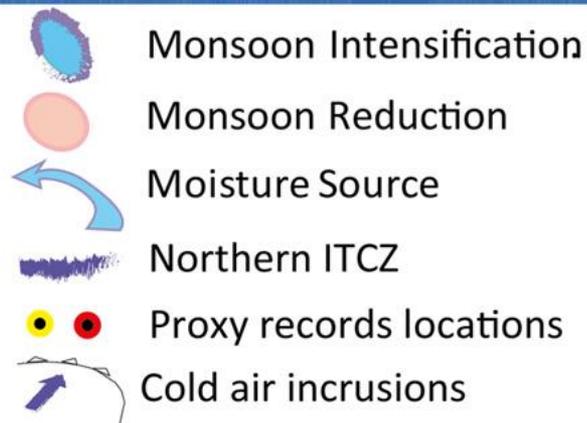
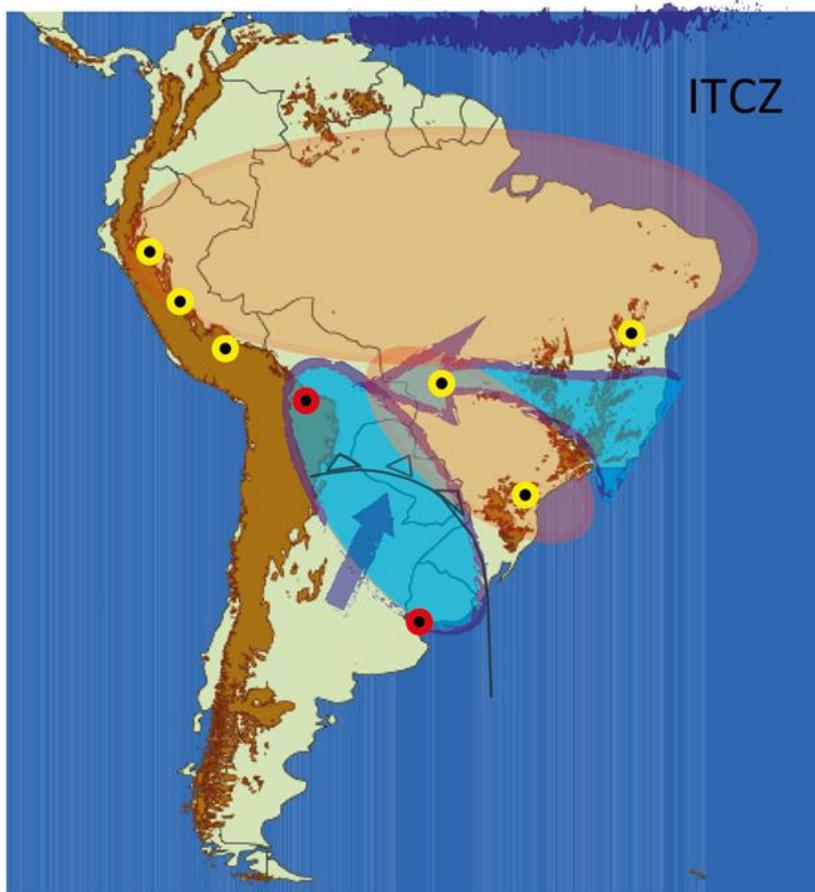


The extreme 2014 flood in south-western Amazon basin: the role of tropical-subtropical South Atlantic SST gradient

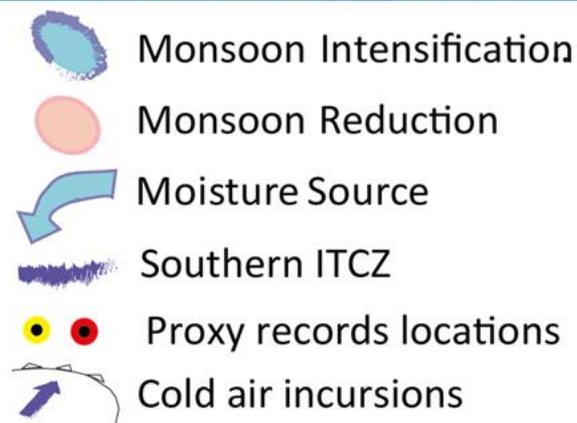
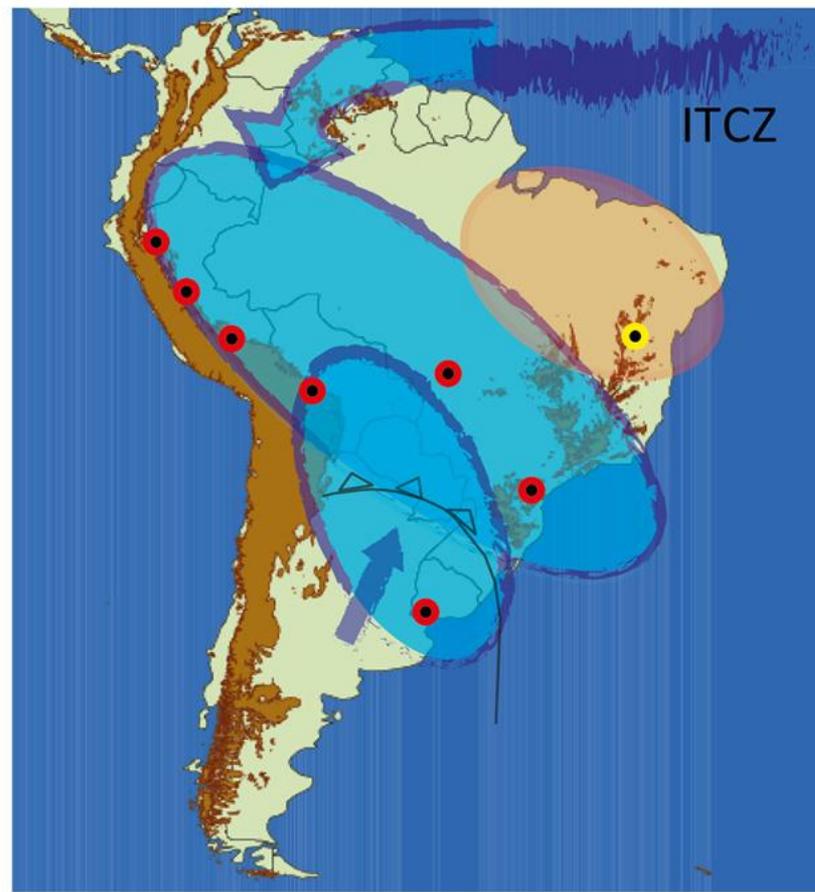
Jhan Carlo Espinoza¹ · José Antonio Marengo² · Josyane Ronchail³ · Jorge Molina Carpio⁴ · Luís Noriega Flores⁵ · and Jean Loup Guyot⁶



MCA Scenario



LIA Scenario



Algunas conclusiones del ultimo reporte del Panel Inter gubernamental para el Cambio Climático.

It is *virtually certain* that orbital forcing will be unable to trigger widespread glaciation during the next 1000 years. Paleoclimate records indicate that, for orbital configurations close to the present one, glacial inception only occurred for atmospheric CO₂ concentrations significantly lower than pre-industrial levels. Climate models simulate no glacial inception during the next 50,000 years if CO₂ concentrations remain above 300 ppm. {5.8.3, Box 6.2}

Confidence in the link between changes in North Atlantic climate and low-latitude precipitation patterns has increased since AR4. From new paleoclimate reconstructions and modelling studies, there is *very high confidence* that reduced AMOC and the associated surface cooling in the North Atlantic region caused southward shifts of the Atlantic Intertropical Convergence Zone, and also affected the American (North and South), African and Asian monsoon systems. {5.7}

With *high confidence*, floods larger than those recorded since 1900 occurred during the past five centuries in northern and central Europe, western Mediterranean region and eastern Asia. There is *medium confidence* that modern large floods are comparable to or surpass historical floods in magnitude and/or frequency in the Near East, India and central North America. {5.5.5}

There is *high confidence* for droughts during the last millennium of greater magnitude and longer duration than those observed since the beginning of the 20th century in many regions. There is *medium confidence* that more megadroughts occurred in monsoon Asia and wetter conditions prevailed in arid Central Asia and the South American monsoon region during the Little Ice Age (1450 to 1850) compared to the Medieval Climate Anomaly (950 to 1250). {5.5.4 and 5.5.5}



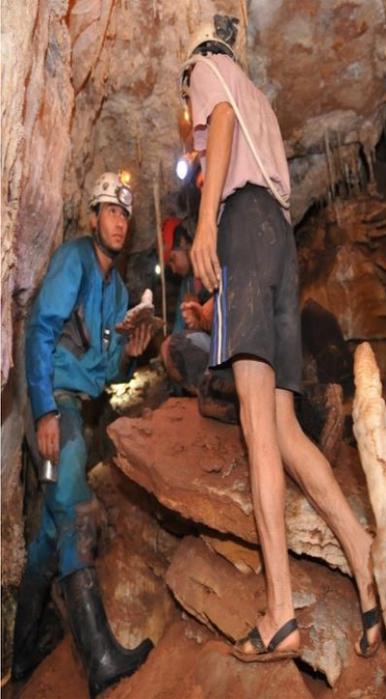
Los registros paleoclimáticos nos enseñan sobre cambios en el clima que no han sido detectados por los registros instrumentales tales como eventos extremos y sus variabilidades.

Es importante incrementar nuestro conocimiento sobre la evolución del clima y la respuestas de los ecosistemas en base a este tipo de indicadores. (espeleotemas, sedimentos lacustres, etc.)

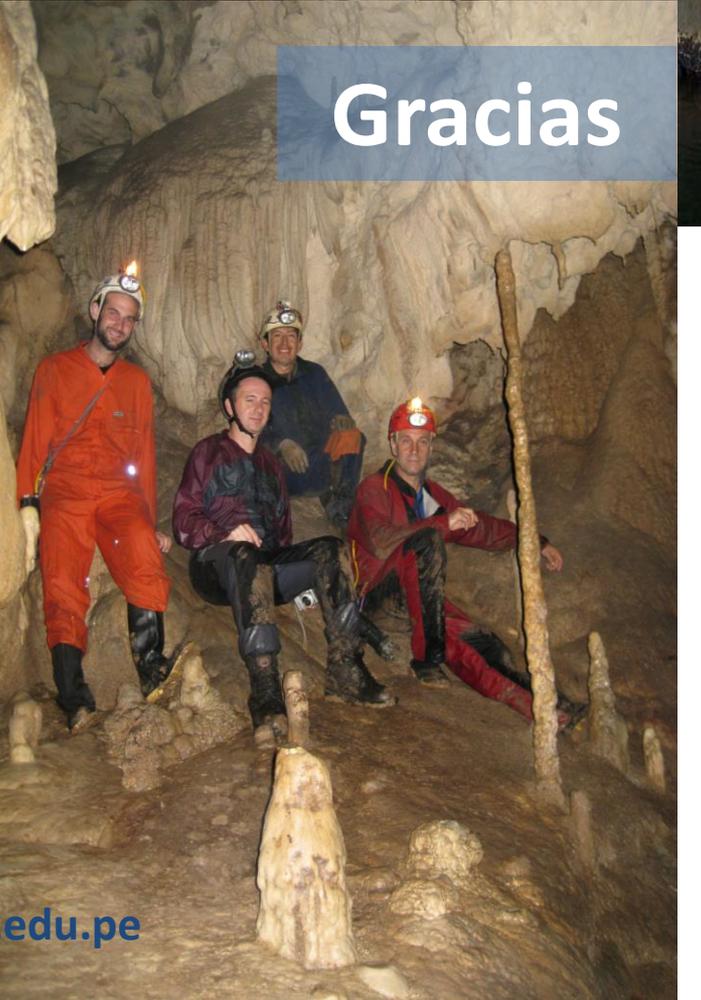
Existe una variación Norte -Sur en los registros paleoclimáticos que sugieren una modulación latitudinal de las señales relacionadas con la estacionalidad y la fuente de humedad en diferentes periodos de tiempo que deben ser tomadas en cuenta para la correcta interpretación de los registros.

Existen un cambio en las fuentes de humedad durante la MCA, esto podría ser forzado por variaciones de temperatura en la región del Indo – Pacífico, como se ve en el periodo actual.





Gracias



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