How stable or variable is the climate of Amazonia?

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Glacial-interglacial climate change

• The last glacial period
• The Holocene
• High-frequency oscillations & teleconnections
• Temperature
• Carbon dioxide
• Precipitation

• Temporal patterns
• Spatial patterns
• Drivers

Palaeoclimate proxies

- Diatoms
- Pollen
- Ice-cores
- Stalagmites/stalactites
- Charcoal
Last Glacial Maximum (LGM)

- 21,000 years ago
- Sea-level 120 m below present
- CO₂ 180 ppm

Temperature
Modified ecoregion map Olson et al., 2000

LGM ca. 5°C colder

Andean taxa move downslope 800 – 1500 m
Podocarpus
Drimys
Alnus
Weinmannia
Hedyosmum

Reduced greenhouse effect due to low atm CO₂?

More frequent polar incursions associated with expanded ice-sheets?

Was cooling synchronous across Amazonia?

Only 2 records from Amazon interior!

Precipitation
Modified ecoregion map Olson et al., 2000

Precipitation during the LGM

- Much higher than present
- Similar to present
- Lower than present

Only 2 records from Amazon interior!

Forested Amazon Basin
(Haffer was wrong!)

Amazon Fan

Pata

Porto Velho

Chaplin

Speleothems

Modified ecoregion map Olson et al., 2000
Precipitation during the LGM

Lake Titicaca

Modified ecoregion map Olson et al., 2000

Similar to present

Much higher than present

Lower than present
Salar de Uyuni drill core sedimentology

Salts (halite)  Lacustrine Muds

Courtesy of Sheri Fritz
Salar de Uyuni
Wet – dry cycles

130 m deep lake at the LGM

Gamma Radiation

0 20 40 60 80 100

0 20 40 60 80 100

Calendar Years BP (x 1000)

Lake
Salt pan

Precipitation during the LGM

Similar to present
Much higher than present
Lower than present

Modified ecoregion map Olson et al., 2000

Courtesy of Sheri Fritz
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Laguna Chaplin

Noel Kempff Mercado National Park, NE Bolivia
Speleothems & travertines, caatinga, NE Brazil

Wang et al., 2004
Nature, 432

Auler et al., 2004
JQS, 19

Ice-Age Amazonia was both wet and dry!
But Amazon remained forested!

• 20,000-yr periodicity
• correlates with the precession orbital cycle
• change in seasonal amplitude of insolation
• change in strength of South American summer monsoon
The Holocene

- Arid episode between 9 & 3 ka BP
- Ecotonal areas

Early-Mid Holocene aridity
Lake Titicaca

Mid-Holocene lowstand
ca. 8,000 to 3,000 yrs ago
90 m below present
6,000 years ago
(shown by seismic data)
Early-mid Holocene aridity

Biomass burning
21,000 yr BP to present

Northern Bolivia, Sep 14th 2004

Courtesy of Yadovinder Malhi
High-frequency climatic oscillations & inter-hemispheric teleconnections

Holocene record of Lake Titicaca
Baker et al., 2005, JQS, 20

- Centennial-scale fluctuations in organics
- Correlate with North Atlantic SST fluctuations

Tipping points??
Salar de Uyuni
Wet – dry cycles

Tipping points??

Synchronous with North Atlantic sea-surface temp oscillations

• Millennial-scale glacial pluvial phases
• Synchronous with:
  – Cold episodes in Greenland & North Atlantic
  – Decreased river runoff in Cariaco Basin
  – Weak East Asian summer monsoon

Speleothems
caatinga, NE Brazil
Wang et al., 2004, Nature, 432

Courtesy of Sheri Fritz
Salar de Uyuni
Glacial-Holocene transition

Wet period synchronous with North Atlantic Younger Dryas cold period?

Laguna La Gaiba
Correlative with European Younger Dryas cooling?

Courtesy of Sheri Fritz
Conclusions

• The orbital 20-kyr precession cycle drives long-term Amazon climate change
  – via changes to seasonal amplitude of insolation
  – contrasts with 100-kyr eccentricity cycle in mid-high latitudes
• Short-term (centennial/millennial-scale) climatic variations
  – inter-hemispheric connections
• Amazonia’s climate has never been stable!!
  – Stable Holocene climate in Oxford but high amplitude climate change during Holocene in Amazonia
• Mid-Holocene aridity
  – best analogue for future mid-21st C Amazon??

Questions please