Instituto de Hidráulica
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Knowledge gaps and relevance, potential activities and expected outcomes

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Knowledge gaps

Conjoint Analysis of Surface and Atmospheric Water Balances in the Andes-Amazon System

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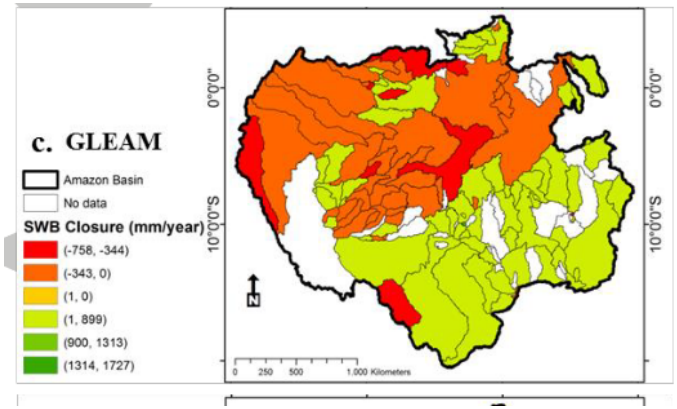
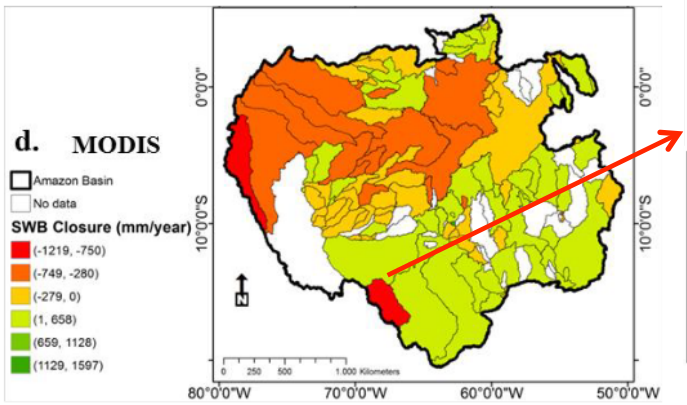
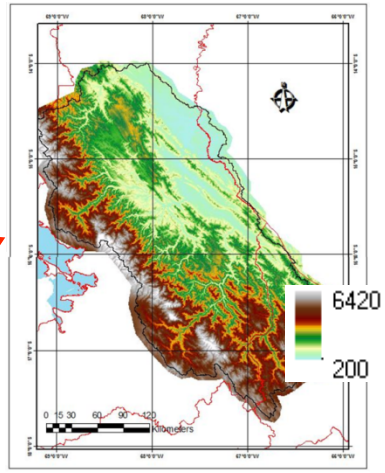
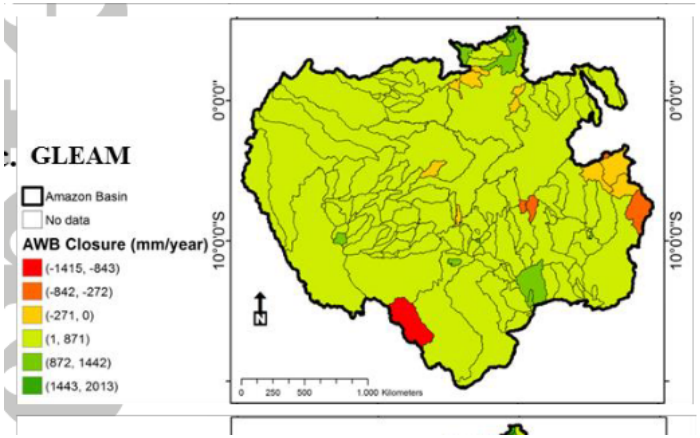
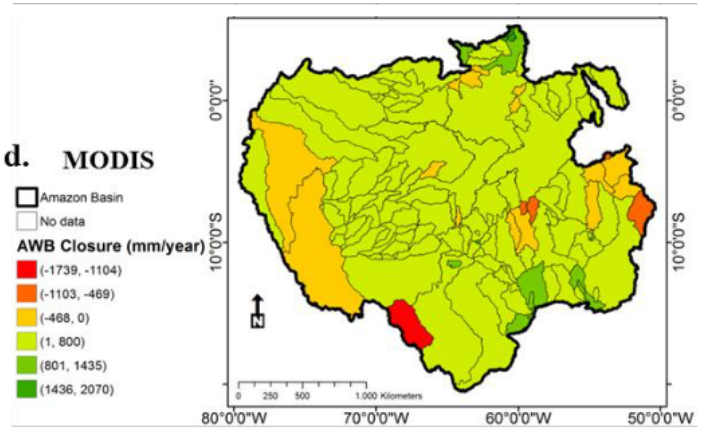






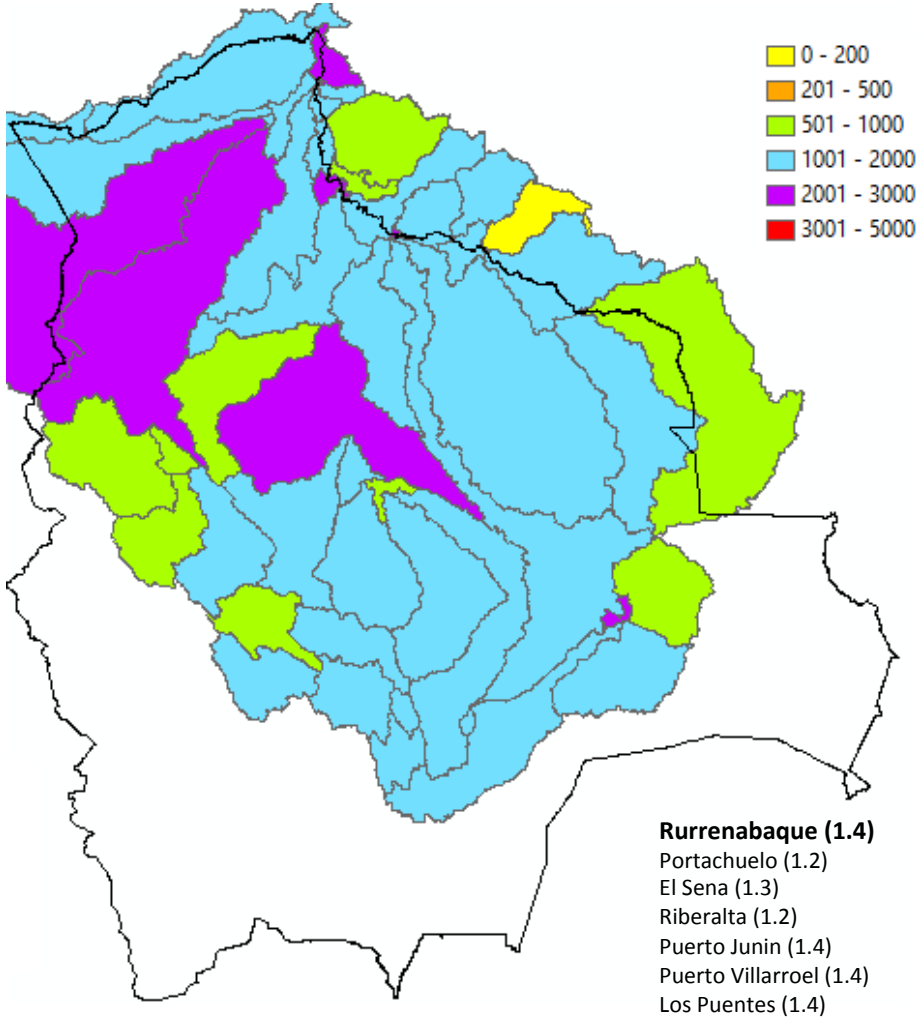
SWB negative residuals (P-E-R < 0) prevail in the Andes and are strong in two Andean sub-catchments, Borja and Rurrenabaque (Upper Beni River basin)





Negative AWB residuals are observed over the Rurrenabaque basin

Anual precipitation (mm/year)
in hydrological units



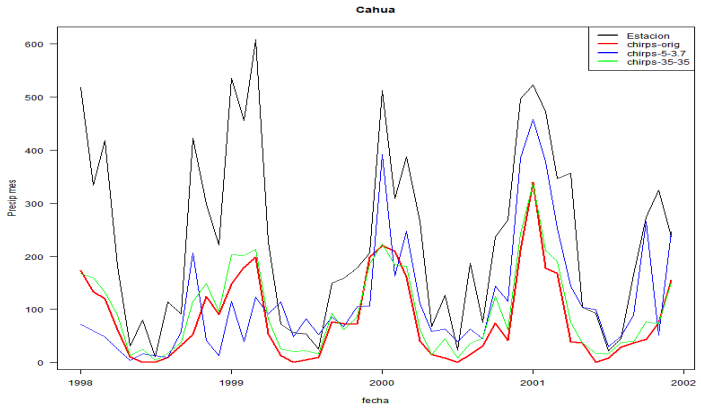
A coefficient was used to “correct” precipitation in many Andean basins in order to close the water balance with the hydrological model (WEAP)

Data gaps and relevance

- SWB imbalance in these basins reflects mainly the **low density** of ground meteorological networks in a context of extreme spatiotemporal gradients of precipitation P and evaporation E (particularly the former)
- Data quality and record length issues also play a role
- AWB imbalance (both internally and related to SWB) reflects the uncertainties in the reanalysis data source
- Ground data are still essential for the calibration of satellite products, particularly precipitation.
- Sub-daily time scale data are needed to study spatial variability, extreme events and climate change

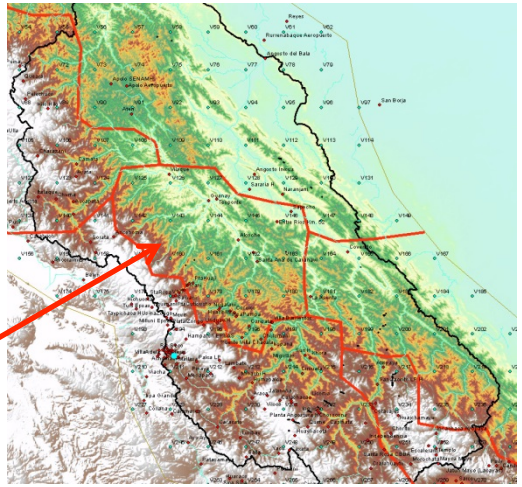
- Water balance components (P and E) are not adequately represented in satellite-based observations: complex topography and algorithm issues

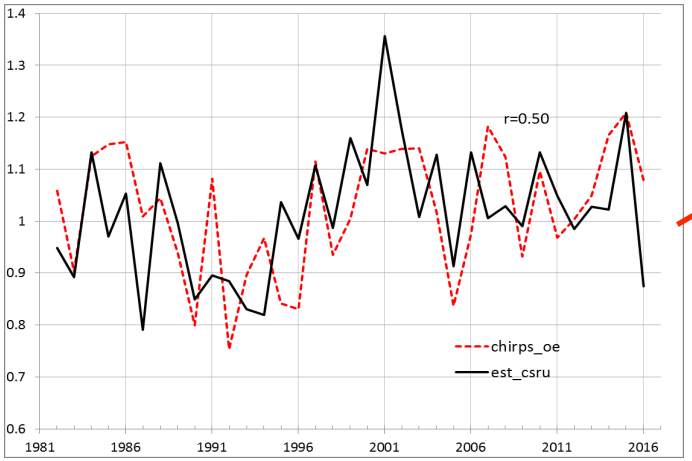
Both magnitude (Bias) and temporal variability could be misrepresented



Cahua station

TRMM and Chirps have strong limitations in reproducing rainfall variability over the Andes





Yungas vector

- Evaporation spatial variability at low latitudes is largely unknown (and few studies explored its effect on water balance)

Most measures of evapotranspiration are indirect or modelled

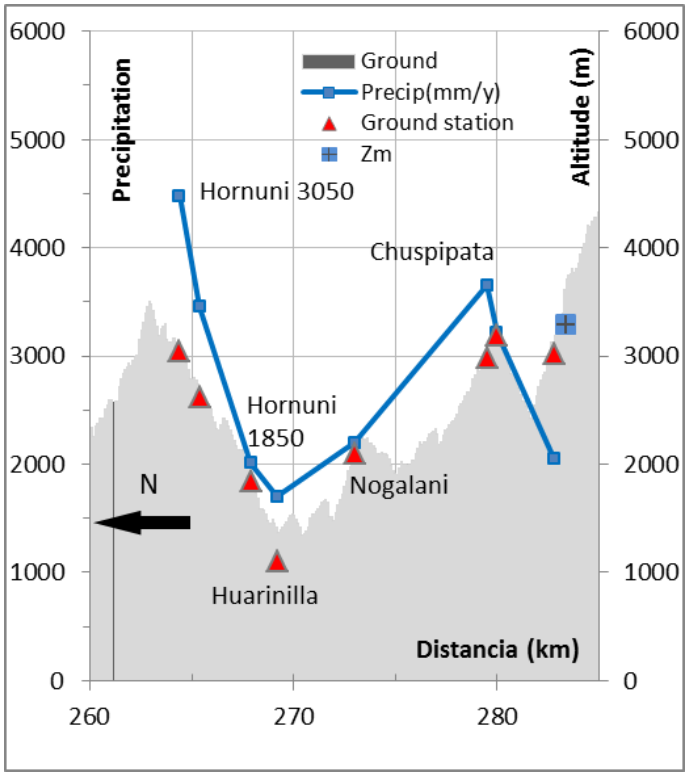
Estación	Altitud m	Temp C	Hum Rel %	Viento m/s	Insolac hr/dia	Rad. Neta W/m2	Rad.incid. W/m2	ETP mm/año
			Periglaciar					
Ore Zongo	5050	0.8	68	3.0		250		1380
Mevis Zongo	4750	2.0	64	1.9		225		1350
			Altoandino húmedo					
Hornuni3050	3050	10.0	95	1.0		58	116	420
Chuspipata	3000	10.4	93	1.0			135	560
Hornuni2600	2600	12.7	94	0.6		67	134	495
			Yungas					
Hornuni1850	1850	16.8	82	0.4		111	177	1100
Chulumani	1752	20.3	75	0.6				1127
Coroico	1750	19.0	78	0.5	5.3			1120
			Subandino					
Sta Ana Caran	980	21.8	80	0.6	5.7			1200

Altiplano (3600-4200 masl): From 900 to more than 2000 mm/year

Incomplete process understanding

Major hydrological processes are still understudied:

- Role of the atmospheric dynamics on water resources in high-mountain river basins, in particular through (a) local orographic mechanisms and (b) climate teleconnection processes acting at global, regional and local scales



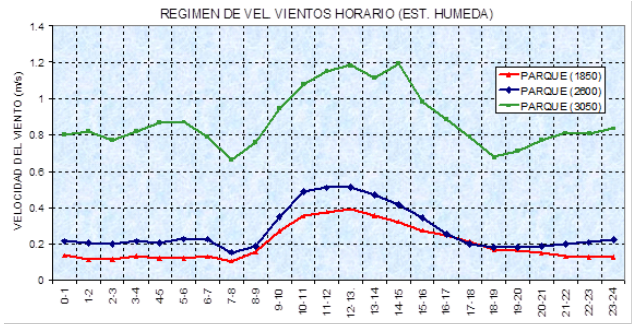
Huarinilla valley transect

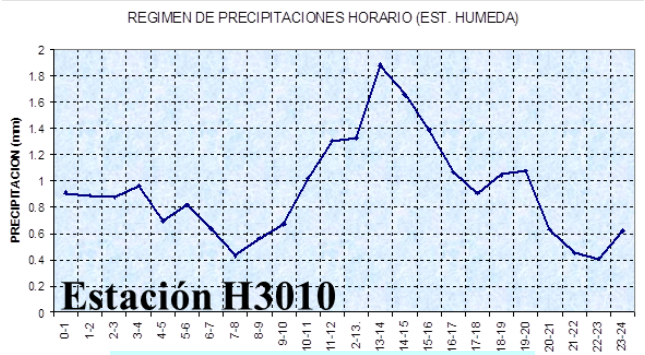
What is the moisture pathway?
The understanding of the orographic precipitation gradients, and pluviometric optimum in terms of dynamic and thermodynamic processes are insufficient

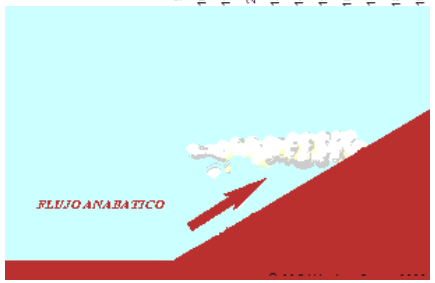
Incomplete process understanding

- What is the relationship between diurnal variability and spatial variability?

Moisture transport: the role of evapotranspiration on valley floors to rainfall across the slopes?

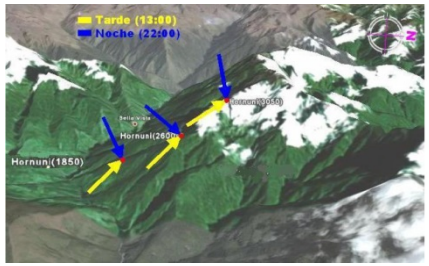


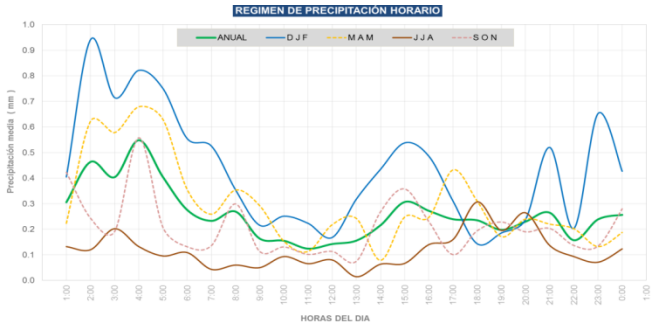




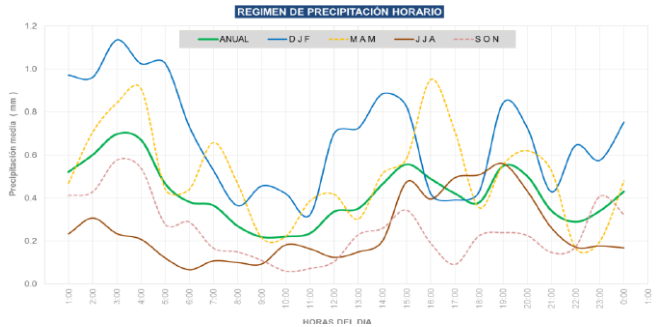
At 3000 masl upslope winds in early afternoon and daily rainfall peak afterwards

But downslope… at 1800 masl





At 2600 masl



Incomplete process understanding

- What are the linkages between vegetation and precipitation and evapotranspiration? Can vegetation be used as a co-variable to improve P and E estimates?
- What are the Interactions between hydrology and vegetation in the Andes?
- Most of the still existing Andean glaciated basins are in a transient state. How to assess runoff in the short and long term? What will be the fate of the wetlands below?
- What are the combined effects of different phases of ENSO, NAO, PDO, AMO? on river flows?
- What are the impacts of mining activities and urban pollution on water quality? And the cost of remediation?

Change

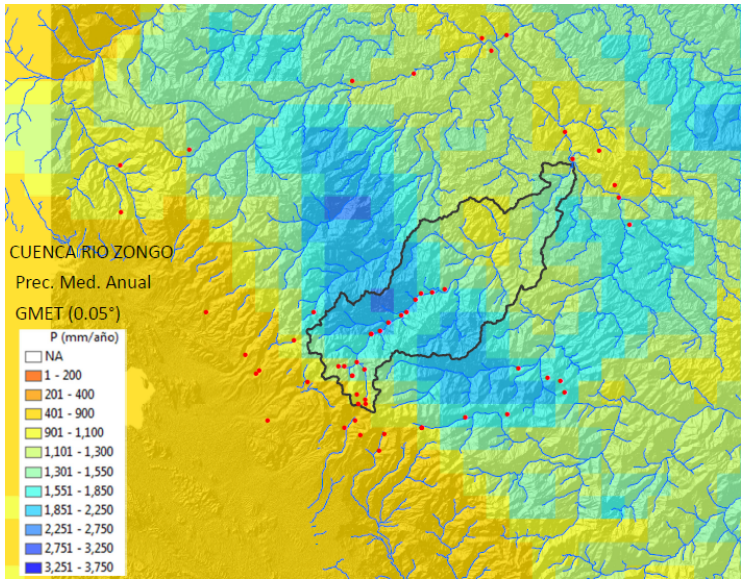
- Prediction of hydroclimatic changes induced by land use change (i.e deforestation) and infrastructure building (i.e. dams) at the Amazon scale is required.
- What are the combined-synergic environmental impacts of the many dams planned for the Andes-Amazon region on water and sediment river flows?
- What is the role of increasing water diversion and climate change on the Altiplano rivers´ discharge and Lakes Titicaca and Poopo levels on water resources?
- Are there hydrological trends in the Andean rivers? Causes?
- How the main drivers of hydroclimatic variability may change in the future?
- GCM models (IPCC-AR5) predict divergent precipitation changes in the tropical Central Andes. How to deal with these uncertainties from a water management perspective?

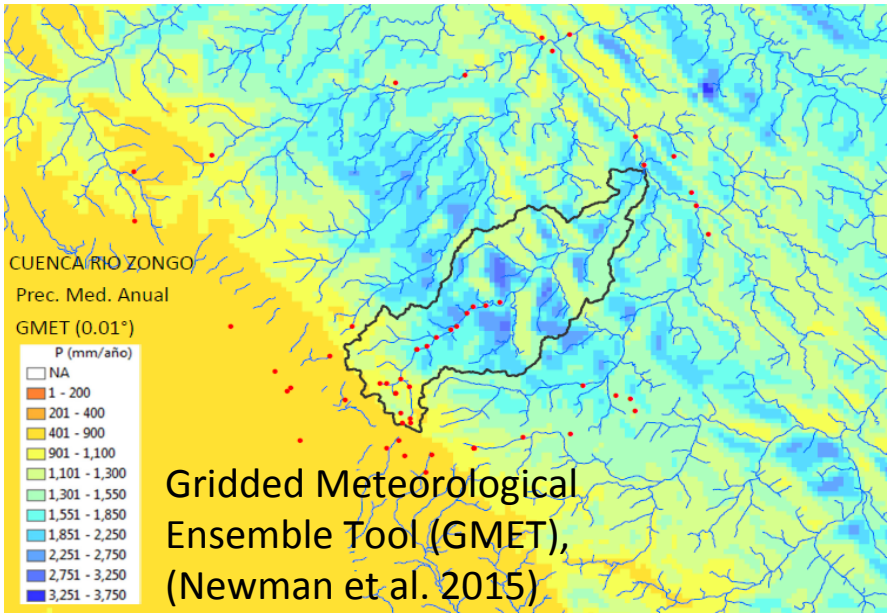
Summary

- What is the spatiotemporal variability of water balance terms at the basin level?
- What are the linkages and interactions between vegetation and P, E and R?
- What is the role of local orographic mechanisms and climate teleconnection processes at different spatiotemporal scales on the water cycle?
- What is the effect of data scarcity and quality issues on the study of hydrological variability and trends? On hydrological modelling and regionalization? How to fill the gap?
- Glaciated basins´ hydrology in the short and long term? What will be the fate of the wetlands and paramos below?
- How to elucidate/quantify the impact of water diversion, deforestation and climate change on the hydrological cycle at different time scales? Mitigation, adaptation?
- What are the synergic environmental effects of Andean dams on water and sediment flows? Of mining and urban effluents on water quality?

Potential activities

- High resolution (vertically, horizontally and sub-daily) regional atmospheric modelling (i.e. WRF) to improve understanding of orographic mechanisms and spatiotemporal variability of "climatically available water "(P-E) terms.
- Review water balance modeling and tools (i.e. GMET, use of vegetation as co-variable) to improve spatiotemporal resolution of water balance terms.





Gridded Meteorological Ensemble Tool (GMET), (Newman et al. 2015)

Potential activities

- Improve seasonal weather and river flow forecasting by studying climate teleconnection processes.
- Explore standardization of data quality control and homogenization of the observation data
- Use of (preferably) standardized hydrological models to be linked to water resource models (i.e. WEAP, MikeBasin) and use the latter to assess human impacts.
- Development and use of indices (i.e. Latrubesse et al. 2017) to assess the effects of dams/reservoirs and water pollution.
- Revisit the past evolution of climate and its consequences on Andean civilizations.
- Study the current (transient state) and future hydrologic behavior of glaciated basins.

Expected outcomes

- Better understanding of orographic mechanisms effects (i.e. diurnal and spatial variability) and hydroclimatological functioning of Andean basins
- Better water balances of Andean basins linking them to water resource models to assess natural and/or anthropogenic changes in the water cycle
- Enhancement of seasonal weather and river flow forecasting
- Capacity building: develop regional collaboration through ANDEX

Thanks


Andes-Amazon: The Bala gorge near Rurrenabaque


Uyuni salt pan – southern Altiplano
Willy Kenning


La Paz and Illimani
E. Cuba