REGIONAL TIPPING POINTS & EARTH SYSTEM RESPONSE

Experiences from the South Andes and the South-East Pacific

SBSTA 18th Research Dialogue · Breakout Discussion 3: Climate risks, impacts and tipping points

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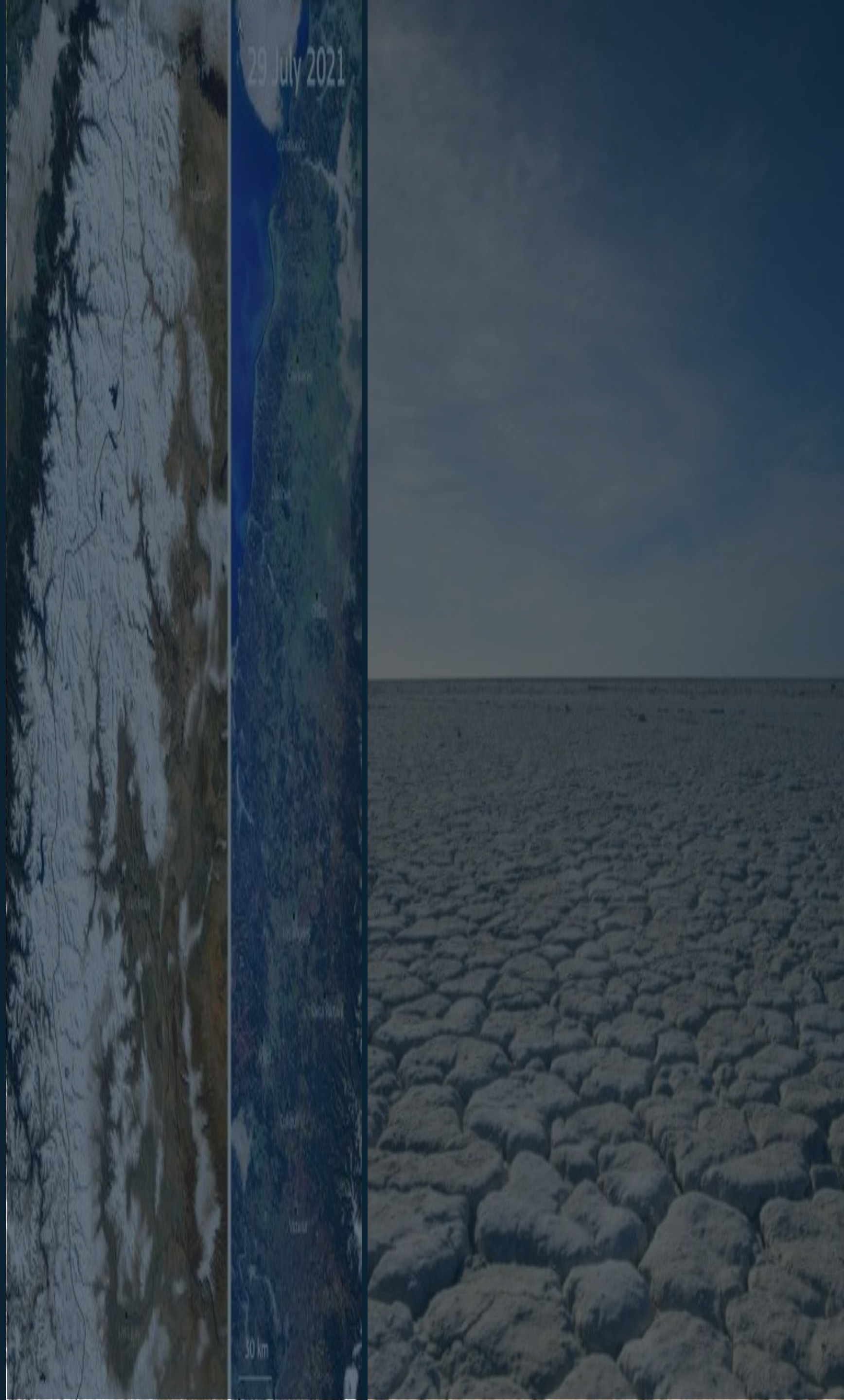

The South Andes–South-East Pacific as a coupled risk system

— Mountain water balance change propagates through water, sediments, energy, agriculture and infrastructure.
— Ocean change affects precipitation patterns upwelling, productivity, fisheries, coastal livelihoods and food systems.
— The regional risk is systemic: physical, ecological, economic and institutional.

Cryosphere
glaciers, snowpack, periglacial systems

→

Forests & vegetation
native forests, shrublands, soils, fire regimes

→

Watersheds
runoff, aquifers, water allocation, sediment

→

Cities & energy
demand, infrastructure, hydropower, heat

→

Coast & ocean
coastal exposure and land–sea interactions

Cross-system feedbacks

- water security
- fire risk
- food systems
- health
- territorial equity
- productive sectors

INTERPRETATION

A regional “tipping point” may appear first as loss of coupling stability: the weakening of mountain, vegetation, hydrological or coastal buffers that previously absorbed variability.

Tipping-like dynamics: when regional buffers degrade

At regional scale, tipping-like behaviour often emerges as the loss of natural buffering capacity — before a system crosses a globally defined tipping element threshold.

Buffer	Function	Risk under warming and extremes
Glaciers & snowpack	seasonal and interannual water storage	storage depletion; altered runoff timing
Aquifers & soils	drought buffering and baseflow support	overdraft, salinization and soil-moisture loss
Native forests & vegetation	hydrological regulation and carbon sink	drought stress, mortality and fire; sink can become source
Ocean & coastal ecosystems	carbon uptake, productivity and livelihood support (carbon storage system)	marine heat, oxygen loss, acidification and range shifts

“Thresholds” become policy-relevant when natural and institutional buffers stop absorbing shocks.

Natural buffers

Institutional buffers

FOREST-SPECIFIC IMPLICATION The native forest of central–southern is both a buffer and a system at risk. More intense heat, drought and fires can erode its hydrological role and shift carbon balance from sink toward source.

- Armstrong McKay et al., 2022: Assessment of 16 tipping elements, showing that even 1°C of warming (already exceeded) risks triggering some CTPs, and that several may activate between 1.5–2°C.
- Global Tipping Points Report 2023, 2025: Assessment of interactions and cascades across cryosphere, biosphere and ocean/atmosphere circulation. Includes a section on science-policy engagement for tipping point governance directly relevant to SBSTA
- Wunderling et al., 2024: Review of CTP cascades. Most interactions between tipping systems are destabilising, meaning tipping one system increases the probability of tipping another.

Cascading risks: from climate signal to systemic impact

Climate signal
warming, drought, ENSO, extremes

→

Buffer stress
snowpack, glaciers, forests, aquifers, Loss of Carbon cycling in the coastal ocean
Loss of diversity

→

Sector disruption
water, energy, agriculture, fisheries

→

Social impact
health, livelihoods, inequality, displacement

→

Adaptation limit
irreversibility, maladaptation or failure

Illustrative cascade

Persistent drought + lower snow/glacier buffering + forest fire risk → water allocation stress → hydropower and agricultural pressure → rural water insecurity, health effects and territorial inequity.

The operational question is when a hazard becomes a cascade — and which institutional trigger should activate before adaptation limits are reached.

Policy translation: cascading risks require integrated portfolios, not isolated sector responses.

ENSO and compound events: phase-conditioned amplification

EL NIÑO TENDENCY

Greater probability of intense rainfall episodes in parts of central Chile; flood, landslide and infrastructure risks; coastal/ocean anomalies may also intensify during particular events.

LA NIÑA TENDENCY

Greater probability of dry conditions in central Chile; amplified water stress, drought persistence, vegetation stress and fire-weather risk, especially when combined with warming.

Important qualification

ENSO is not deterministic. Impacts depend on season, latitude, atmospheric circulation, antecedent drought, land conditions and ocean state. Under warming, the same ENSO phase can produce higher-impact compound events.

—ENSO–climate change interactions and teleconnections as a research contribution.
— Compound events require attribution and projection tools that capture co-occurrence, persistence and spatial dependence.
— Decision-makers need early-warning information that is seasonal, territorial and sector-specific.

Breakout relevance: risk assessment should be conditional on climate variability, not only on mean warming.

Cordero et al., 2024: El Niño boosts wildfire weather in Chile. 1.7 million ha burned in last decade because or co-occurrence of El Niño, drought, and heatwaves.
Stuecker et al., 2025: Global warming may trigger an abrupt shift toward stronger and more predictable ENSO cycles within 30–40 years, today's extreme wildfire/drought seasons could become more regular

South-East Pacific: ocean risks and land–sea interactions

Mechanisms, indicators and decision relevance for the Humboldt Current and the South-East Pacific.

MARINE HEATWAVES
thermal stress, species redistribution, aquaculture and fisheries risk

UPWELLING DYNAMICS
productivity, nutrient supply, coastal cooling and ecosystem variability

DEOXYGENATION
habitat compression, benthic stress and food-web reorganization

ACIDIFICATION
shellfish, calcifiers and cumulative ecosystem pressure

— Marine heatwaves, upwelling variability, deoxygenation and acidification are not isolated ocean indicators.
— They interact with coastal infrastructure, fishery productivity, livelihoods and food systems.
— **We need an** integrated land–ocean observing systems and ocean carbon uptake / upwelling research.

Integrated land–sea observations

- Connect mountain runoff, sediment, coastal water quality, upwelling, oxygen, pH, fisheries productivity and social vulnerability.
- Move from monitoring single variables to tracking compound ocean–climate–society risk.

Overshoot scenarios: where reversibility may fail regionally

GLACIERS

Lost ice volume and altered hydrological timing may not return on human planning horizons.

FORESTS

Fire, mortality, soil carbon loss and species replacement can create new ecosystem states.

OCEAN ECOSYSTEMS

Species range shifts, oxygen stress and food-web changes may show long recovery lags.

COASTAL SYSTEMS

Erosion, wetland loss and infrastructure exposure can lock in damage and relocation needs.

Implication for adaptation planning

Overshoot increases the value of early action because some regional losses are path-dependent: delaying protection, restoration or relocation can close options permanently.

What science is needed for decision-making?

The submission emphasizes strengthening research capacities in developing countries, explicit funding requirements, data governance, repositories, and implementation capacities.

OBSERVATION

Integrated land–ocean observing systems; long-term records; GBON-type public goods.

DATA STEWARDSHIP

Interoperable repositories, standards, quality control and continuity of historical records.

ATTRIBUTION & MODELLING

Compound event attribution, regional climate–impact models, overshoot scenarios and early-warning signals.

TRANSDISCIPLINARY EVIDENCE

Indigenous and local knowledge, social vulnerability, health, youth and community resilience.

— Explicit funding for research capacities in developing countries is part of the adaptation and implementation agenda.
— Data governance, repositories, quality, access and continuity are not technical side issues; they determine whether early warning is possible.
— Capacity building should support integrated climate planning and resilience scenarios.

Research capacity is itself climate infrastructure.

From tipping-point science to implementation pathways

For countries, tipping-point science is useful only when it becomes operational: thresholds, triggers, responsibilities, finance and institutional learning.

Decision thresholds	What indicators trigger adaptation, protection, restoration or relocation?
Planning instruments	How are risks reflected in NDCs, NAPs, long-term strategies and GST follow-up?
Implementation capacity	Which institutions, NDEs, scientific committees and local actors own the response?
Financeable portfolios	How do early warning, water resilience, adaptive infrastructure and restoration become project pipelines?
REGIONAL COOPERATION	Shared mountain, ocean, fisheries, river-basin and observing-system challenges require cooperation platforms that connect research, technology priorities, finance and policy implementation.

Governance mechanism

— Collaborative regional platforms for countries facing similar challenges.
— Structured channels for scientific committees, NDEs and advisory bodies.

Operational technology areas identified

— Climate information platforms and early warning systems.
— Water resilience technologies and adaptive infrastructure.
— Renewable integration, grid resilience, circular/bioeconomy and decision-support tools.