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A multi-scale approach for the detection and structure description of fog geo-ecosystems in the Chilean-Peruvian coastal desert

Abstract

The Chilean-Peruvian coastal desert is one of the most extreme geo-ecosystems worldwide. In its core zone, the average annual precipitation in the form of episodic rainfall events falls below 1 mm. Hence, plant growth is limited to so-called fog oases, where ecologically specialized plants, like Tillandsia spp., cover their entire water demand by combing out water from the coastal fog that regularly occurs from the Pacific Ocean during night. In consequence of their strong dependency on the coastal fog, Tillandsia spp. are highly vulnerable to changes in its frequency and intensity and may therefore serve as a bioindicator for climate change. Yet, the main dynamics of these fog geo-ecosystems, locally known as Lomas or Loma-formations, are still poorly understood on both contextual and spatial scale.

Against this background, a multi-scale remote sensing approach for the detection, analysis and monitoring of the distribution patterns of the fog geo-ecosystems in the Chilean-Peruvian coastal desert was developed. On a regional level, WorldView-3 data were used to detect the spatial extent of Tillandsia-Lomas in the study area. To obtain a quantitative description of the spatial structural dimensions, the local distribution characteristics of selected ecosystem sites in northern Chile were then examined in more detail. Data from unmanned aircraft systems were used to create orthophotos and digital surface models with a spatial resolution in the sub-decimeter range. From these products, several structural characteristics (e.g. coverage ratio, cover patterns) of the plant stands were derived, which allow a systematic and accurate spatial description.

The presented method is an integrative approach of several remote sensing products with multi-level hierarchy, complemented by in-situ observations. The results contribute to a better understanding of the interaction between atmosphere and biosphere in the Chilean-Peruvian coastal desert and may serve as the basis for protecting the fog geo-ecosystems and their endemic species. Moreover, the method allows for a systematic detection and monitoring of future changes in the distribution patterns of the Tillandsia-Lomas as an indicator for climate change.