Exploring water vapor and precipitation uncertainties in a warming climate
(Main supervisor: Gottfried Kirchengast)

Significant uncertainties about climate change severity, risks and potential threshold exceedances still exist today with regard to the future evolution of the climate, and especially in relation to how atmospheric water vapor and regional precipitation patterns will evolve (out to 2050, 2100, 2200). Given that the degree of future mitigation of anthropogenic greenhouse gas emissions is still highly uncertain, due to the inability to implement effective climate policies so far, the case of essentially unabated global warming is a particular concern. Analyses of future climate projections by state-of-the-art climate models, the relevant behavior of which is to be understood from retrodictions of recent climate change, may enable us to better understand uncertainties and potential thresholds related to atmospheric water vapor and precipitation during future climate change.
The work will aim to investigate climate projections and sensitivity simulations by global and regional climate models, the performance of which may be evaluated based on retrodictions of observed climate change during recent decades, to explore and better understand uncertainties and potential threshold exceedances that may induce severe changes in water vapor and precipitation during future climate change. Focus questions include, with the case of essentially unabated global warming being of primary interest: What are key uncertainties and associated feedbacks, and what are potential thresholds in the future evolution of atmospheric water vapor? Which magnitudes and types of uncertainty do these uncertainties and potential thresholds bring into our knowledge about future regional precipitation patterns?
Model results from the global CMIP5 GCM and regional CORDEX RCM climate simulation ensembles, together with conceptional modeling and sensitivity simulations with selected skillfiul models (e.g., from MPI-M Hamburg, NCAR Boulder), may be used to address these questions. The implications of changes and associated uncertainties in precipitation patterns on possible future land surface hydrology changes will be of particular intersest.

The project contributes to answering the DK research questions1 and 2

Exploring the uncertainties of land surface hydrology changes in a warming climate

(Main supervisor: Gottfried Kirchengast)

Large uncertainties still exist about the severity, risks and potential thresholds related to land surface hydrology changes under future climate change (out to 2050, 2100, 2200). For example, in a given land region (e.g., European Alpine region), or even within specific catchments therein at the more local scale (e.g., Enns, Mur, Raab catchment study areas in Styria, Austria), how will the balance of precipitation (P) and evapotranspiration (E) change? And how will the related partitioning of available water into runoff (Q) and storage as surface water (e.g., lake water, snowpack), soil moisture, and groundwater change? Furthermore, adding to the complexity, how may human-made changes in water use and management modify the climate-induced changes?

The work may start with a survey of climate change uncertainties, with focus on gathering all main influence factors of land surface hydrology changes (e.g., emission scenarios, climate forcings, climate sensitivities, climate and water cycle feedbacks, human-made nonclimatic influences of relevance). It may then explore, as possible, probability density functions (pdfs) of potential future changes, including pdf tails, as well as potential thresholds, i.e., include low probability/high risk subspaces of change in the water balance quantities like P-E-Q. Available observation and model diagnostics data (related to the climate, hydrology, and human systems), including key observation-vs-model discrepancies, may serve as further aid to cover a wide yet physically sound uncertainty space, including possible thresholds.

As a result, a representative set of storylines and (probabilistic) scenarios, accompanied by simple conceptional or intermediate-complexity system modeling, of possible future land surface hydrology changes may be obtained, first generically for diverse climate-weather-land-soil-ground conditions then specifically applied to focus catchments (Enns, Mur, Raab catchment areas). The work shall aim to discover such possible futures both for unabated global warming paths (RCP8.5 type) and mitigation paths (RCP2.6 type), respectively, and to understand the differences.

The project contributes to answering the DK research questions 1 and 2