B1

IMPETUS MOROCCO

Spatial and Temporal Variability of Precipitation

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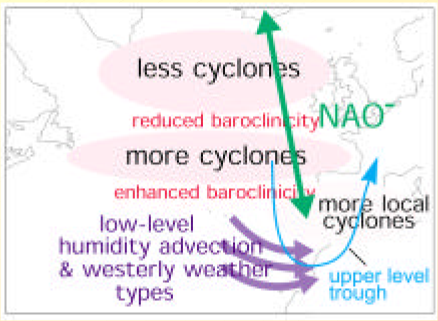
Objectives:
The principal goals of the meteorological sub-project consist of the determination of the atmospheric branch of the water budget for the Drâa catchment and the assessment of the mechanisms that control regional precipitation/ evaporation variability. These objectives are pursued by a twofold strategy based upon *diagnostic* and *model studies.*

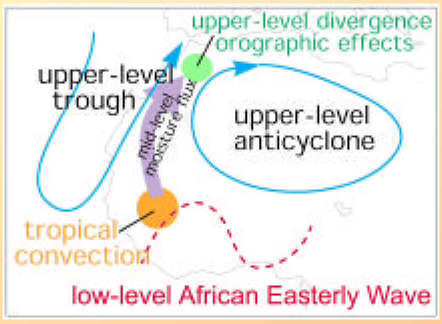
Results:
Both large-scale and regional-scale influences on precipitation and evaporation are analysed for time-scales from decades to single events in order to obtain a picture of the physical mechanisms behind Moroccan precipitation generation and its spatial and temporal variability. It is shown that precipitation south of the Atlas is to an important part determined by tropical/extratropical interactions. Wintertime precipitation is connected to the position of the North Atlantic storm track and the phase of the North Atlantic Oscillation (NAO). High resolution modelling of individual precipitation events gives further insight into the underlying mechanisms and provides an interface to the estimation of snow ablation in the High Atlas as an important freshwater source for the Drâa. Plant transpiration and soil moisture in the Drâa valley itself are decisive factors for freshwater loss due to evaporation and significantly influence regional near-ground atmospheric flow, which can even lead to modification of the isolated convective showers in the region.

Outlook:
The results of the scale-comprehensive process analysis obtained in B1 will enter the assessment of potential effects on freshwater availability in the Drâa catchment by global and regional changes.

Principal mechanisms for precipitation generation in NW Africa

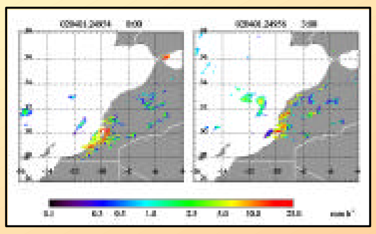


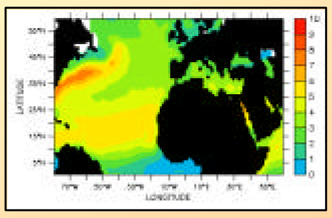
Extratropically induced rainfall (predominantly during the winter half-year)



Tropically induced rainfall (predominantly during late summer / early autumn)

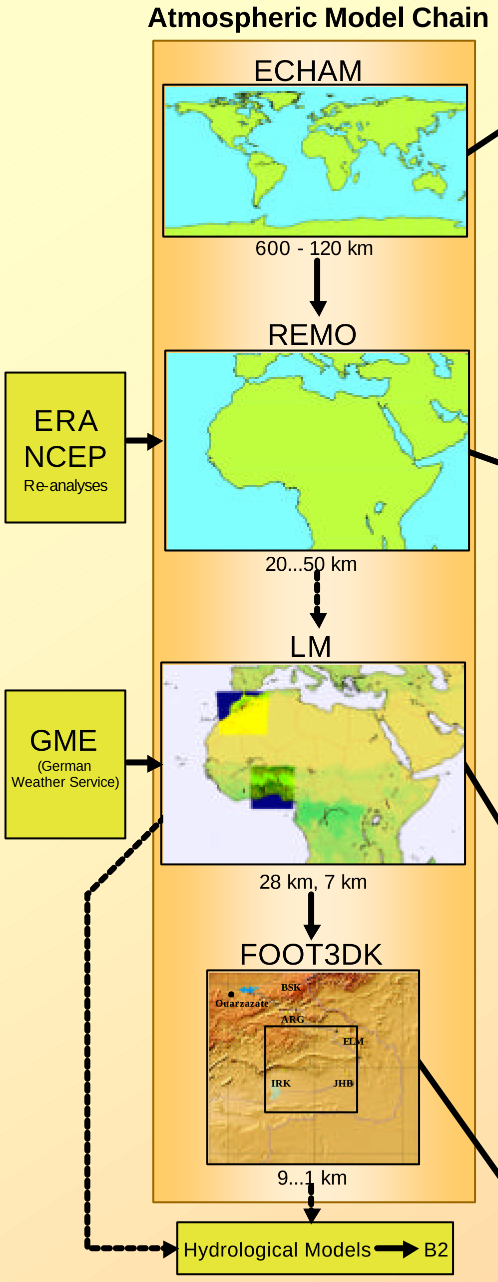
Monitoring precipitation and evaporation by satellite



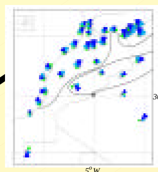


- IR image (above left) and instantaneous rain rate (above right) derived from TRMM measurements on April 1, 2002.
- Evaporation climatology over the sea surface (left) derived from infrared and microwave satellite observations during winter 1988 – 1998. Those measurements are supporting trajectory analysis of low level humidity advection (cf. schematic on far left side).

Atmospheric Model Chain



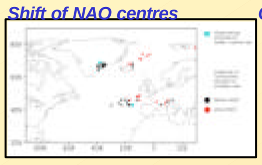
Large-scale conditions for precipitation in Morocco: present and future



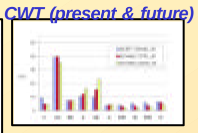
Circulation Weather Types (CWT) & precipitation (present)

- radius ~ percentage of each of the 8 directional weather types
- precipitation events with more than 1 mm in 12 hours

Shift of NAO centres



CWT (present & future)

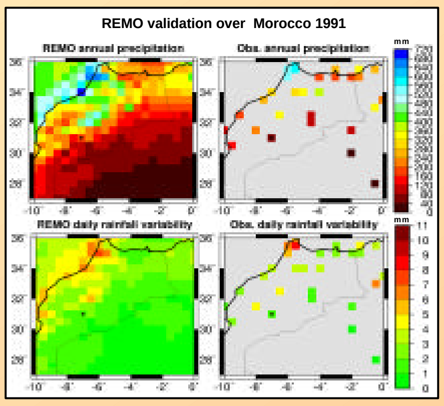


Climate signal (only large-scale aspects)

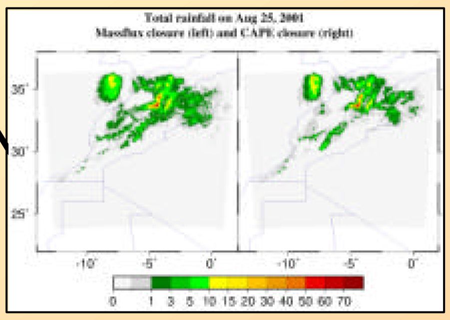
- northward shift of deep cyclones
- decrease in the number of shallow cyclones
- eastward shift of southern NAO pole
- less westerly and more easterly situations
- *decrease in precipitation for NW Morocco is likely in the future*

Generation of a rainfall climatology over Northwest Africa with *REMO*

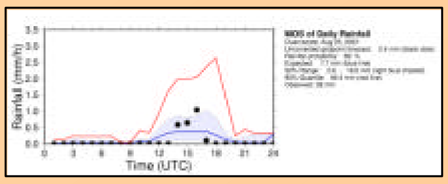
Observation data coverage is quite poor over the north-western part of Africa. Around 40 stations are located in Morocco and Algeria, whereas data density is steadily decreasing to the Saharan side of the Atlas mountains. Reanalysis products usually exist in a coarse resolution and do not allow to study synoptic-scale processes. Therefore, the regional climate model REMO has been nested over the West African continent. The model is run in 0.5° resolution and will provide 6 hourly data over several years. The resulting decadal-scale climatology of various atmospheric parameters, such as convective and large-scale precipitation, is of benefit to the other subprojects in IMPETUS, especially to the hydrological modelling and to understanding the vegetation dynamics. Moreover, REMO offers the prospect of improving our insights into the synoptic mechanisms which induce rainfall over this semi-arid part of Africa. However, the basic requirement is that REMO is able to reproduce the observed climate mean and variability. First REMO results are very encouraging: Compared with the station data, REMO is in excellent agreement in terms of the annual sums (right, top) and daily variability (right, bottom) of rainfall. The model integration is still continuing in order to provide a long-term data set to quantify the atmospheric branch of the hydrological cycle over NW Africa.



Regional scale precipitation forecasts with the *Lokalmodell* (LM)



In West Africa, rainfall often is connected with mesoscale rainfall systems. Their forcing is caused by synoptic activities like extratropical waves. To enhance our knowledge of West African weather systems, typical rainfall situations are investigated in case studies with the non-hydrostatic mesoscale model LM. Another aim is to provide spatially distributed rainfall data on horizontal scales of some kilometres to the hydrological models in B2. For this purpose, rainfall parameterisation in the LM had to be tested very carefully in the tropical and subtropical region (left figure).
Because rainfall on small scales is of a very stochastic nature, model output statistics (MOS) is absolutely necessary to generate reliable precipitation forecasts. The figure below shows a summer rainfall on August 25, 2001, where the normal model output was quite unspectacular, while MOS suggested a 5% probability of 46 mm rainfall on that day - a likely reason to broadcast storm or heavy rain warnings.



Modelling of the evapotranspiration with *FOOT3DK*

Mesoscale simulations raise the question whether the soil moisture information is sufficient to obtain realistic results. Two methods to virtually enhance plant available soil moisture are invented. Tests show strong reactions of near surface properties (temp., humidity, wind) to soil moisture. Evaporative cooling enhances stability and leads to changes in near surface flow. It can even alter position and amount of rainfall events. It is thus expected that reduced availability of water will enhance the scarcity by reducing evaporation, therefore also reducing near surface humidity which in turn leads to reduced precipitation.

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