

Project: **1053**

Project title: **CRC 1211 - A03: Statistical-dynamical modelling of Aeolian processes in the Atacama Desert over geological time scales and their implications to life at the dry limit**

Principal investigator: **Mark Meyers**

Report period: **2018-07-01 to 2019-06-30**

In the report period the long-term simulation for the period 1981-2017 with a horizontal resolution of 10x10 km on 80x120 gridpoints using ERA-Interim reanalysis data as boundary conditions has been completed. The model output has now been uploaded to the CRC1211 Database, and some variables are currently used by other subprojects of the CRC1211. For example, subproject C02 uses simulated precipitation to link rainfall extremes to the spatial distribution of alluvial fans in the Atacama Desert. This collaboration will result in a joint paper in a special issue of Global and Planetary Change (submission deadline: 30.04.2019).

In coordination with other subprojects of the CRC1211 different sensitivity experiments with WRF (10km resolution) have been performed for the Atacama Desert in the report period. The aim of these experiments was to figure out the impact of the sea surface temperature (SST) on fog and precipitation in the Atacama Desert. With this respect multi-year WRF simulations with present day SST conditions and with increased/decreased SSTs offshore of the Atacama Desert have been accomplished. As benchmark marine SSTs as obtained by drilling cores covering the LGM and the mid-Holocene were used. Note that in all these experiments atmospheric forcings for the present day have been used to exclude other effects. We found that in case of reduced SSTs (similar to LGM conditions) the low cloud water content is generally higher, while the cloud deck is lower compared to the simulation with present day SSTs (Figs. 1 and 2). Due to the topography of the Atacama Desert, this results in less near coastal fog in the Atacama Desert, which may have an important impact on the Tillandsia populations. Based on these results further WRF simulations with 3km resolution are planned for the remainder of the report period in collaboration with the CRC1211 subprojects B01 and D04 to explain the uncovered spatial and temporal variability of Tillandsia in the Atacama Desert.

Together with Mehdi Hamidi, who is an expert in dust modelling and visited us in late summer 2018, the WRF model has been setup such that it is suitable for simulating Aeolian processes in the Atacama Desert. To test the performance of the model we focussed on an unusual dust storm which occurred over the Atacama Desert in July 2016. Strong easterly downslope winds lead to the formation of a dust plume travelling far over the Pacific (Fig. 3, left). The dust emission and the propagation of the dust plume is simulated quite well by the WRF model (Fig. 4), although the synoptic situation was quite complex at this day (resulting in extra-ordinary high temperatures; see Fig. 3, right). We therefore conclude that the WRF model is suitable for the simulation of Aeolian processes in the Atacama Desert, which forms the basis for future research with respect to the development of a statistical-dynamical downscaling using weather types. Results of this study are published in Atmospheric Science Letters (Reyers et al., 2019).

Further, we made good progress with respect to the establishment of a weather typing approach for the Atacama region. In a study together with subproject A01 we performed a weather typing which combines an EOF analysis and a K-means clustering. Ten weather types have been identified, and the impact of these weather types on the moisture supply to the Atacama Desert was analysed using, amongst other, output variables of the long-term WRF simulation (see above). We could demonstrate that the weather typing is very useful for a wide field of applications. The study has been submitted to the special issue in Global and Planetary Change (under review).

With respect to biogenic crusts we decided to focus on the Gurbantunggut Desert in China, as for this Desert different observations are available, which enables us to evaluate some of the methods and results. Different satellite products have been used to obtain the spatial and temporal variability of crusts. By computational expensive methods the different products have now been combined to a uniform gridded crust dataset. We intend to uncover the relationship between crust and climate variability. For such an analysis highly resolved WRF simulations are required for the Gurbantunggut Desert.

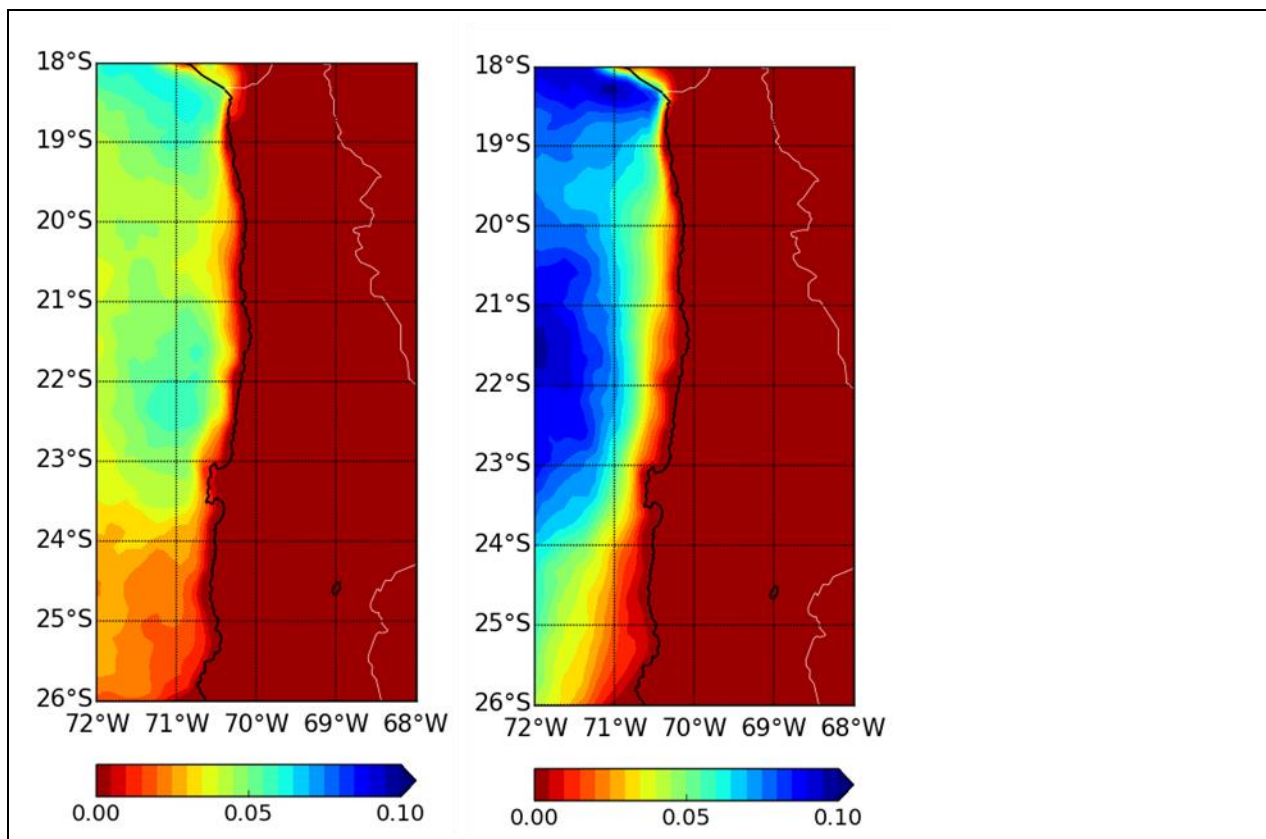


Fig. 1: Mean simulated cloud water content in the WRF simulation with present day SST conditions (left), and in the simulation with SST being reduced by 3°K (right).

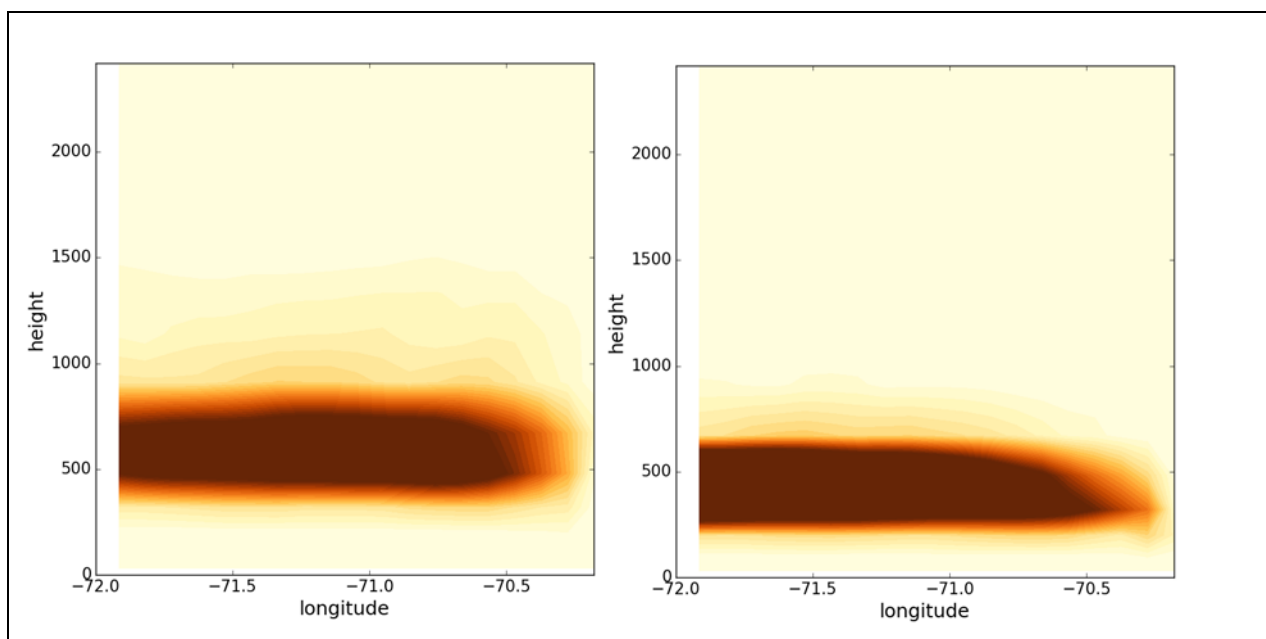


Fig. 2: Cross section of mean simulated cloud water content at 21.5°S in the WRF simulation with present day SST conditions (left), and in the simulation with SST being reduced by 3°K (right).

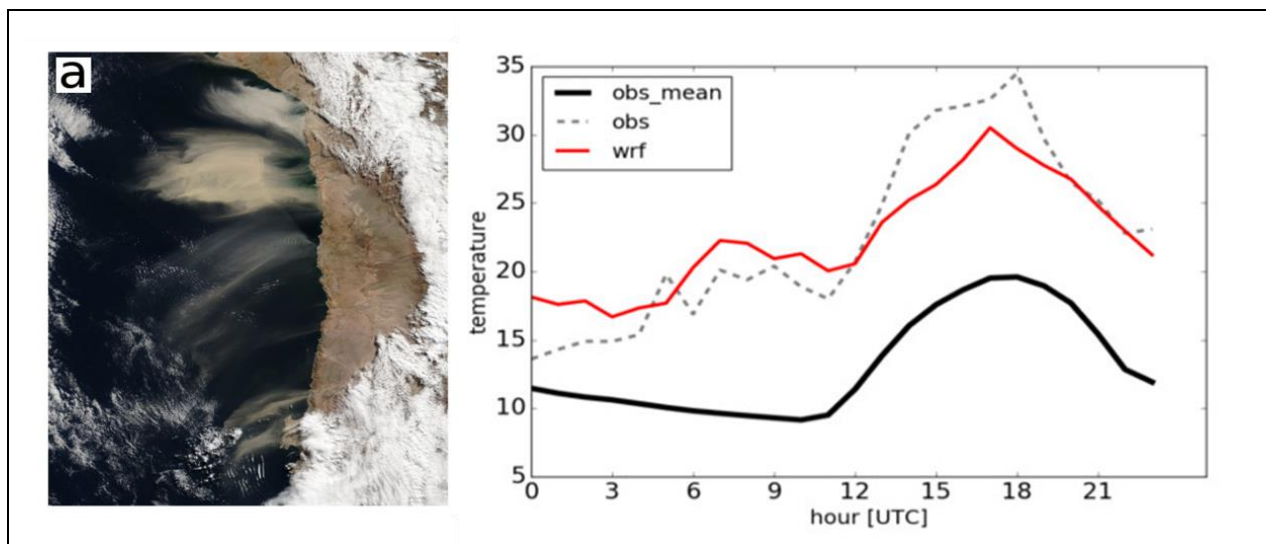


Fig. 3: (left) NASA image from the plume of the dust storm at 08 July 2016. (right) Mean daily course of observed temperature in JJA at a station in the Northern part of the Atacama Desert (black solid line), and the observed (grey stippled line) and WRF simulated (red line) temperature at the day of the dust storm.

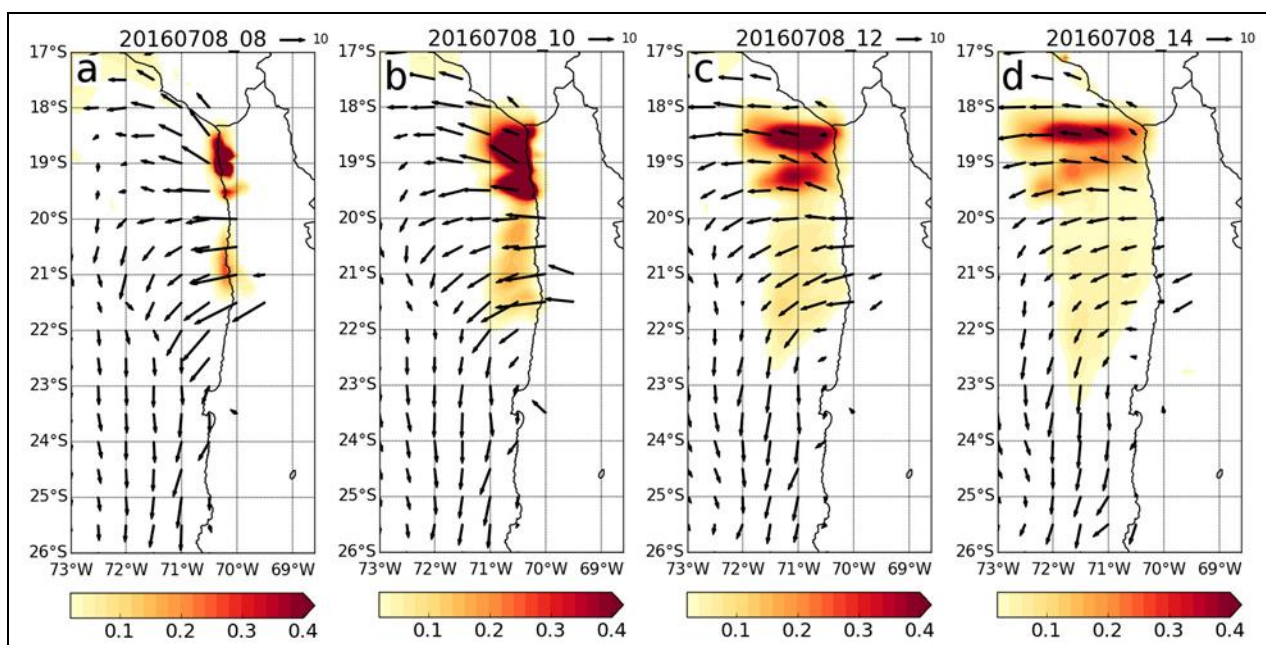


Fig. 4: WRF simulated dust plume at different time steps of 08 July 2016.

Reference:

Reyers M, Hamidi M, Shao Y, 2019: Synoptic analysis and simulation of an unusual dust event over the Atacama Desert. *Atmos. Sci. Lett.*, **e899**. doi:10.1002/asl.899