**Point-to-Point Reply to Referee #1 (RC C688,** received and published: 27 November 2012**)**

**We thank all reviewers for their thoughtful and important comments. In the following the citation of our modifications in the manuscript are related to the new, revised version.**

The paper by Wulfmeyer et al. deals with an important topic, namely the carbon storage potential on degraded land in coastal arid and semi-arid areas using desalinated sea water for irrigation. It is an interdisciplinary study showing that in a global emission trading scheme irrigation of such degraded lands might be an economic option and could offset a considerable portion of carbon dioxide emissions due to the burning of fossil fuels. The main strength of the paper is the high resolution modeling of the regional circulation in coastal semi-arid areas that is more realistic than the earlier estimates by others. It shows that a 100x100km2 area leads to a positive feedback on precipitation reducing in parts the need for irrigation. The paper is well written but has one major weakness.

Despite talking about rehabilitating degraded land, it does not discuss in enough detail the main reason for this degradation: inadequate irrigation either by not using enough irrigation water to establish regularly contact to the groundwater table or by using irrigation water with too high mineral content. In both cases the result is salt layers in the upper layers of the soil.

**We agree that this topic should be addressed in more detail. We are focusing on arid coastal zones, which are deserts since a long time due to lack of precipitation or natural water sources. Therefore, in most of these regions, irrigation was absent and these landscapes became arid by natural processes in the land-surface-atmosphere system.**

**The main reasons for the degradation of the land are lack of precipitation or natural water sources over a long amount of time. The very low precipitation amounts are due to large-scale suppression of convection, e.g., by Hadley cell subsidence, or local suppression of convection either by upwelling of cold air by ocean currents or by atmospheric divergence caused by increasing land friction. Therefore, land degradation by high salinity of the soil due to poor agricultural practices such as inadequate irrigation is not the main reasons. We added a corresponding statement on p.7, section 2, par. 1st par.:" The dry coastal areas have been degraded over a long period of time due to lack of precipitation or natural water sources. The very low precipitation amounts are caused by large-scale suppression**

**of convection, e.g., by Hadley cell subsidence, or local suppression of convection either by upwelling of cold air by ocean currents or by atmospheric divergence caused by increasing land friction. Therefore, in these “natural deserts” land degradation caused by poor agricultural practises such as inadequate irrigation leading to high salinity of the soil is hardly an issue. However, strategies for minimizing contamination of the soil must certainly be taken into account and are discussed in sections 3.2 and 4.”**

**Furthermore, we extended the sentence on p.4, 2nd par.: “However, carbon farming must not compete with food production so that afforestation measures should concentrate on already degraded land areas such as desert *regions that are not likely used for conventional farming and which are not salinated by previous unsustainable agricultural practises.”***

**In cases where salinity or the accumulation of soluble contaminants is likely to be a problem (e.g., our test plantation in Luxor, Egypt that uses sewage water as the sole source of irrigation) we recommend that only one crop of carbon fixing trees is grown and then the land is left fallow. Even this ‘one shot’ approach would still fix large amounts of carbon for a period of decades to centuries. The literature is unclear in the sensitivity of *Jatropha* on salination. We added three references on this. Please see p. 10, 2nd par.: “The extensive use of sewage water would also not be recommended in very dry areas because of salination. In the literature, mixed results are found with respect to the sensitivity of Jatropha to salinity. Whereas Tal et. (1979) found a very low sensitity of plant growth on salinity and Silva et al. (2010) found adaptive physiological processes reducing salination-induced stresses; in contrast, Rajaona et al. (2012) observed that salt stress influenced Jatropha’s canopy development and the CO2 assimilation rate. Without extensive flushing, it is unlikely that more than one crop of Jatropha curcas could be grown before the build-up of salt in the soil prevented further growth, in which case carbon sequestration could be done only once. However, long-term experience is lacking and there is a need for more experiments and analyses on large-scale plantations.”**

**Furthermore, we added on p. 26-27 three new pars., which are discussing the limits and optimization of irrigation.**

Further weaknesses are, firstly, the use of modelled soil moisture without validation by observed soil moisture from irrigated land in hot climates in the modeling exercise. Data from irrigated land in Arabian countries or in Arizona should be used for the case studies presented

**In principle, it is a very good idea to use observations for driving the model and for its verification. Unfortunately, at the time of the simulations, data in the two regions of interest (Oman, Sonora) were not available. This is essential, as the measurements depend critically on local soil properties (texture, hydraulic coefficients), which are highly variable and thus certainly differ between Arizona and Sonara as well as other Arabian countries and Oman. We see these effects in a variety of observational studies, e.g., within WESS ([www.wess.info](www.wess.info)) and the DFG FOR 1695 ([https://klimawandel.uni-hohenheim.de/home](https://klimawandel.uni-hohenheim.de/home)). Therefore, even if these data were available, comparisons with model results are likely not promising. Of course, we may use data from irrigation simulations in the model. However, at the time of this experiment, a sophisticated irrigation model for NOAH was not available. Sophisticated irrigation schemes apply subsurface water supply (current practice e.g. in Israel) with demand dependent amounts of water. Further irrigation is applied at the location of the single plants and not uniformly across the plantation. To implement such a model will take a significant amount of time and require verification studies at sites of measurements. Instead, as described in the manuscript, we set the soil moisture above the wilting point. We are convinced that this leads to realistic model simulations, as is discussed on p. 20-21. This is due to the fact that the irrigation amounts derived in section 3.2 (100 mm/year now used as reasonable estimate) lead to a low upper limit of evapotranspiration (about 16 W/m2, see p. 21, 2nd par.) Therefore, even if large errors occur in the assumption of soil properties, this translates in small errors in the energy balance closure, which is the main driver of land-surface-atmosphere exchange. We extended a sentence on p. 21, 2nd par.: "It turns out that irrigation has a negligible effect on the evapotranspiration, *as long as the irrigation amounts derived in section 3.2 are realistic."* We added the following sentences on the same page, 2nd par: "Furthermore, the low resulting latent heat flux minimizes potential errors with respect to the assumption in soil properties such as hydraulic conductivity."**

and secondly, I cannot understand the neglect of evapo-transpiration by vegetation in the boundary layer modeling, although plants evaporate strongly in dry climates.

**We agree that this points needs quite a bit of research. Many plant transpiration properties are still not know to date, observations are sparse, and the simulations in the model are of limited quality. However, we are convinced that all these challenges play a minor role in our simulations here. This is for the following reasons: Plants can only transpire, if a significant amount of water is provided due to irrigation. Furthermore, stomata close with increasing temperature. The soil evaporation can be neglected, as the upper soil layer is quickly drying out. The low amount of transpiration is calculated on p. 21, 2$^{nd}$ par with 16 W/m2. There is just not more water from the soil available, which can be transpired, so that this is the maximum limit of transpiration, if the irrigation value is set to about 100 mm per year. Consequently, even if considerable errors are made in vegetation dynamics, soil properties, and irrigation amounts, the main exchange flux is given by sensible heat. We added the following paragraph on p. 21, 2$^{nd}$ par., to point this out: "This result may be modified, if further data concerning vegetation dynamics and irrigation amounts become available. However, even if errors of around 100 % are made, the partitioning of fluxes in the energy balance closure remains mainly driven by the sensible heat flux, which amounted to more than 500 W m-2 during daytime both in Oman and Sonora."**

**Plants can indeed withstand very low precipitation and irrigation rates. A famous example is the famous Yatir pine forest in Israel surviving precipitation values of < 100 mm per year.**

Also irrigation type differences are not discussed

**This is correct but we consider this as not critical, as the overall irrigation amount resulted in a small latent heat flux. Therefore, we decided neither to include nor to compare detailed irrigation models during this simulation. The energy balance closure is mainly driven by the sensible heat flux, which gives us good confidence that land-surface-atmosphere exchange is properly represented. We are currently working on the incorporation of an irrigation scheme in NOAH but this will still take some time.**

**We modified the following sentence on different irrigation schemes on p. 21, 2$^{nd}$ par.: "Consequently, area averaged irrigation of the soil in the grid cell could be neglected and details of irrigation techniques did not have to be altered so that the soil moisture was kept the same as the initial values specified in the ECMWF driving data. Furthermore, the**

**resulting low latent heat flux minimizes potential errors with respect to the assumptions made as to soil properties such as hydraulic conductivity."**

no CDM project of a similar kind is named

**We added some references on p.5, 2$^{nd}$ par.**