Potential and limits of satellite data for climate issues

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In the framework of the Virtual Institute EXTROP of the Helmholtz Association of German Research Centers, the issue of the added value, which satellite products may provide in climate studies, has been taken up.

Climate research goes beyond meteorology (and oceanography) in that it deals with (changing) statistics of parameters characterising weather; that is, apart of modeling and theoretical work it deals to large extent with the inference of characteristic parameters such as spatial disaggregated mean values or average occurrences of certain phenomena, extreme values, spatial correlations, spectra and characteristic patterns, and sensitivities. To do proper inference the data need to fulfill some properties. A major requirement is that the data must be representative of the considered statistical ensembles, i.e., the time series must be long enough; at least many decades if not a century and more. Second, the data should be homogeneous, i.e., the informational content should be the same through the entire time series; thus improved observational technology may introduce artificial “signals” into the data series, which may compound with existing climate signals (i.e., statistical parameters changing over time). These two conditions limit the applicability of satellite data in climate studies.

We examine two examples, which illustrate the potential and limit of using satellite data – the first deals with scrutinizing the skill of a climate model, and the other with the number of samples and accuracy needed to infer extreme value statistics from satellite soundings.

In the first case, the task/aim is to determine the variability of the occurrence of polar lows in the sub-polar Atlantic in the past decades. Eventually this enables an assessment if recent trends in frequency, spatial distribution or intensity are consistent with climate change scenarios or not. Obviously, in situ data for this purpose are not available; (passive or active) satellite data are available only for a limited time. On the other hand, downscaling strategies, involving a limited area atmospheric model (LAM) suitably embedded in global atmospheric re-analysis, are able to generate mesoscale disturbances in climate mode simulations. We demonstrate the quality of the LAM simulation by comparing the model simulation with the HOAPS climatology for a limited time period, when these high-quality satellite data are available. It turns out that the model does a reasonable job, even if significant differences remain. Additionally, sporadic satellite products may help to further validate the performance of the models during periods when no regular coverage of modern satellite data existed.

The second case deals with the problem, how many data of which accuracy are needed to derive good estimates of extreme wave heights in the North Atlantic. Here, in regular overpasses, a radar satellite infers significant wave height in pixels with irregular temporal sampling. The question is, how long these efforts have to be continued before useful estimates of very high percentiles or expected maxima per time period can be made. This is examined in the framework of a multi-year wave simulation, run with realistic wind fields, and a crude model describing the estimation errors, when the ground signal is monitored by the satellite.