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AN OPTIMIZATION OF A REGIONAL RAOB NETWORK BY MAXIMIZING OF THE INFORMATION CONTENT A CASE STUDY: RA I - AFRICA.

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Summary and Purpose of Document

The purpose of the document is to inform the Expert Team on the progress in optimization of the BSRN RAOB (site number and its location) in RA-I to provide the maximum information content with regard to NWP and climate monitoring tasks.

ACTION PROPOSED

The meeting is invited to take into account information presented in this document and discuss issues related to evolving of BSRN RAOB site distribution in RA-I and preliminary proposal on its redistribution to maximize information content.

BSRN RAOB site distribution for maximum information content

1. Introduction

1.1. The global meteorological observing system is extremely expensive and in the present economical situation some conventional observations such as RAOB (radiosondes) begin to be severely reduced. But in some regions with high spatial and temporal variability of major meteorological variables, a priority role of RAOB still remains. Most part of RA I (Africa) is located within ITZC (intra-tropical zone of convergence). Therefore, air mass field and, as well as air temperature, humidity and geopotential fields in contrast to those in the moderate and high latitudes have smaller scales of horizontal disturbances. Thus, here a role of the wind velocity components in numerical weather prediction (NWP) is a more significant than in other latitude belts. On the other hand, ITZC has an advantage in satellite data availability. Located here, the geo-stationary platforms (GMS, METEOSAT, MSG) provide a more detailed in time and in space information on all meteorological variables than outside of this area. But, there is some uncertainty in simultaneous acquisition of height and wind fields in ITZC. Wind field components are retrieved from cloudiness movement tracing by instruments boarding at GMS and other satellites. But, having any cloudiness in the field of radiometer view, we are restricted in accuracy of the temperature and humidity profile retrievals. It is known that radiances coming from surface-atmosphere system to satellite radiometer are contaminated by cloudiness impact even in microwave domain. That is a cause of degrading in accuracy of height profile retrieval. Vice versa, wind satellite is not available in cloudless conditions. Thus, RAOB data in this area cannot be replaced by satellite information in full size.

1.2. The current state of RAOB network in RA I might be characterized as partly satisfactory because of non-uniform coverage of Africa by stations. Some regions (North, North-West and South Africa) are sufficiently provided by RAOB data. But there are many missing ranges in some others. The aim of this study is to define some statistically homogeneous ranges within RA I, estimate information weights of existed stations with respect to major meteorological variables H500, T500, U700, V700, Q850 used in NWP models and to reveal the priority synoptic sites, which might be used to extend ourday RAOB network. The recommendations, contained in this report are based on information model developed for RA I RAOB network and related information content estimations. The above approach was developed in early author papers [2-6]. This approach is based on multiple variance statistical analysis [1]. In this study, we used the daily re-analysis dataset of NCEP/NCAR for 1990-1999. The total sample size was 3650 realizations for each meteorological variable.

2. Information content estimation

2.1. Theoretical background. Shannon information theory and its generalization (Gelfand, Yaglom, 1957) to the case of multidimensional fields is implemented to quantity evaluate of the measurement data information content.

2.2. Information model of observing system. This model was developed to establish a relationship between measurement data and estimated variables (meteorological fields) by means of operator, which depend on observing system parameters – control variables: number and site locations, measurement error statistics: magnitudes and correlation features.

2.3. Regionning. Spatial range allocated for the analysis and the forecast of meteorological fields should be split into a set of homogeneous regions (HR) in such a way that within each of them usual assumptions on stationary and isotropy of meteorological fields are approximately valid.

2.4. Optimization problem for observational system. To state this problem, it is necessary to select a qualitative criterion and develop some search technique to minimize a cost functional. We applied a criterion of minimum of the root mean square approximation of meteorological fields by set of measurements delivered by observing system. As the information model is a regression equation with coefficients depending on network configuration our task is to minimize the residual, which compose a cost function. To minimize the cost functional we implied Boolean function minimization technique, which requires several tens of iterations to achieve an optimal solution.

3. Implication to BSRN RAOB network optimization in RA-I

3.1. Missing data areas with respect to BSRN operational RAOB station list for RA-I are very significant. Only 46 from nominal 262 sites carried out measurements in January-April, 2004. Therefore, error fields corresponding to major meteorological variables reveal many gap regions, where the relative errors of meteorological field representation reach 0.7-0.8 levels. Highest errors are achieved in objective analysis of wind velocity component fields. Similar is valid for GUAN. Only 12 from nominal 17 GUAN stations provide measurement data in RA-I.

3.2. Search of statistically homogeneous areas (SHA) in RA-I useful for optimal interpolation permits to find several of them, which are not supported by any of operational RAOB stations. Methodology of SHA considering as homogeneous random fields allows us to find SHA and geographic areas, which are now missing data and should be provided with RAOB data to reduce uncertainty in grid fields used in NWP. This step might be considered as search of hints to determine an optimal RAOB network configuration.

3.3. Error field performance is an important step in order to estimate an impact of missing data areas on input data accuracy for NWP. Our finding proofs that many regions of Central Africa are provided by low quality data on wind and height fields if only operational RAOB data are used because of network degrading in these areas.

3.4. Information weights of particular sites give a helpful estimate of BSRN RAOB station contribution in reduction of the meteorological field uncertainty. These values permit to find out that the most informative stations are located in regions with lowest site density, at ocean islands and at coast areas.

3.5. Search algorithm allows us to develop a scenario for existed operational RAOB network extension from 46 to 59 stations by recover measurements at 13 stations, which provide a substantial improvement of error fields for all meteorological variables in missing data areas. Analysis of information weights showed that recovering stations have maximal contribution in reduction of the error fields with respect to many of other sites, which belong to both: existing and nominal WMO networks.

3.6. The existing GUAN network has some gaps in Central Africa, which are a reason of anomaly in objective analysis error fields. An alternative set of ten GUAN sites provides more uniform information coverage of Africa with respect to monthly fields. Maximal error magnitudes are decreased at 15-20%.

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