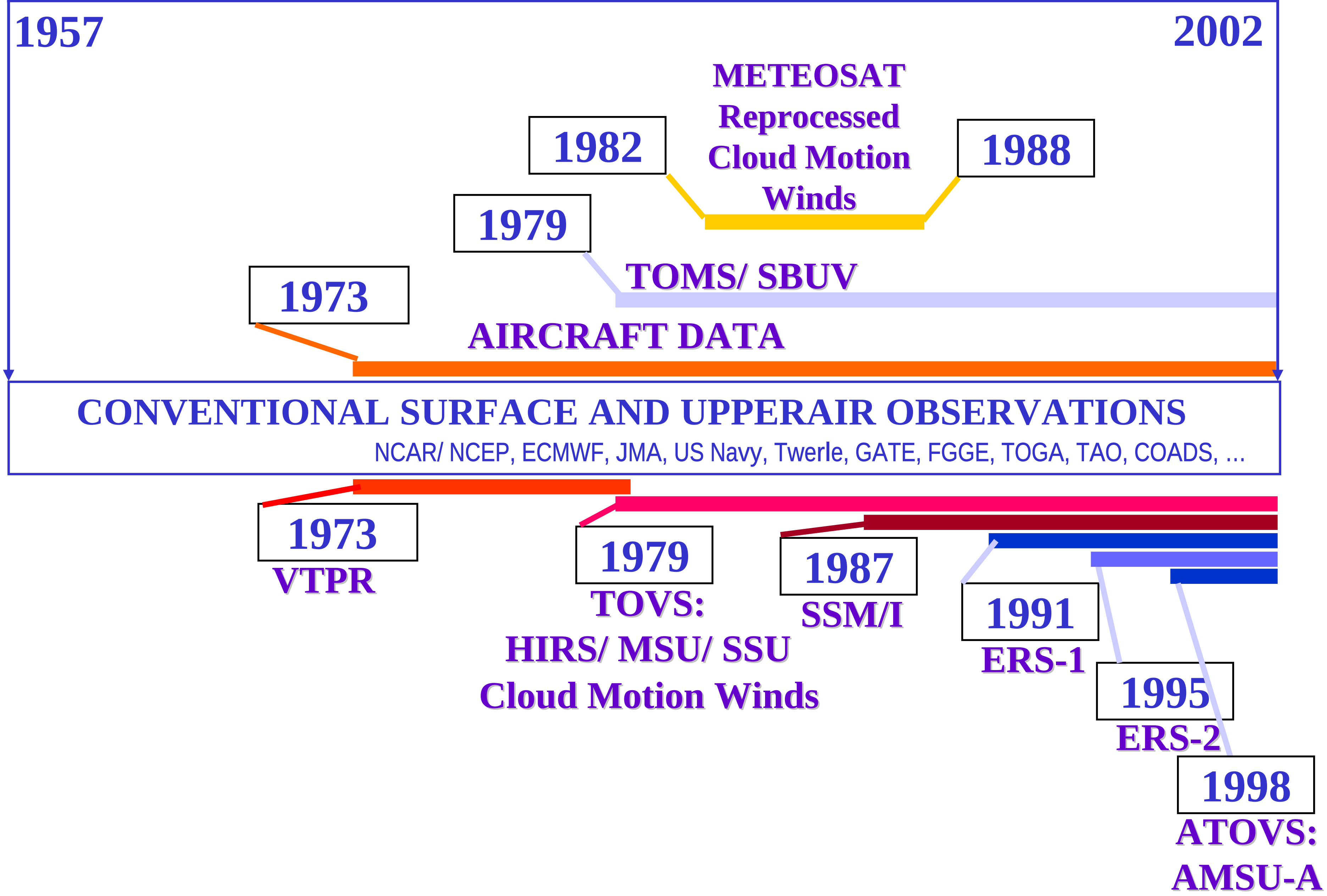
Observational requirements for future reanalyses

Sakari Uppala

ECMWF

CONTENTS

Observing Systems in ERA-40



Illustration

The number of available TEMP/ land data per year from different data sources at 00UTC

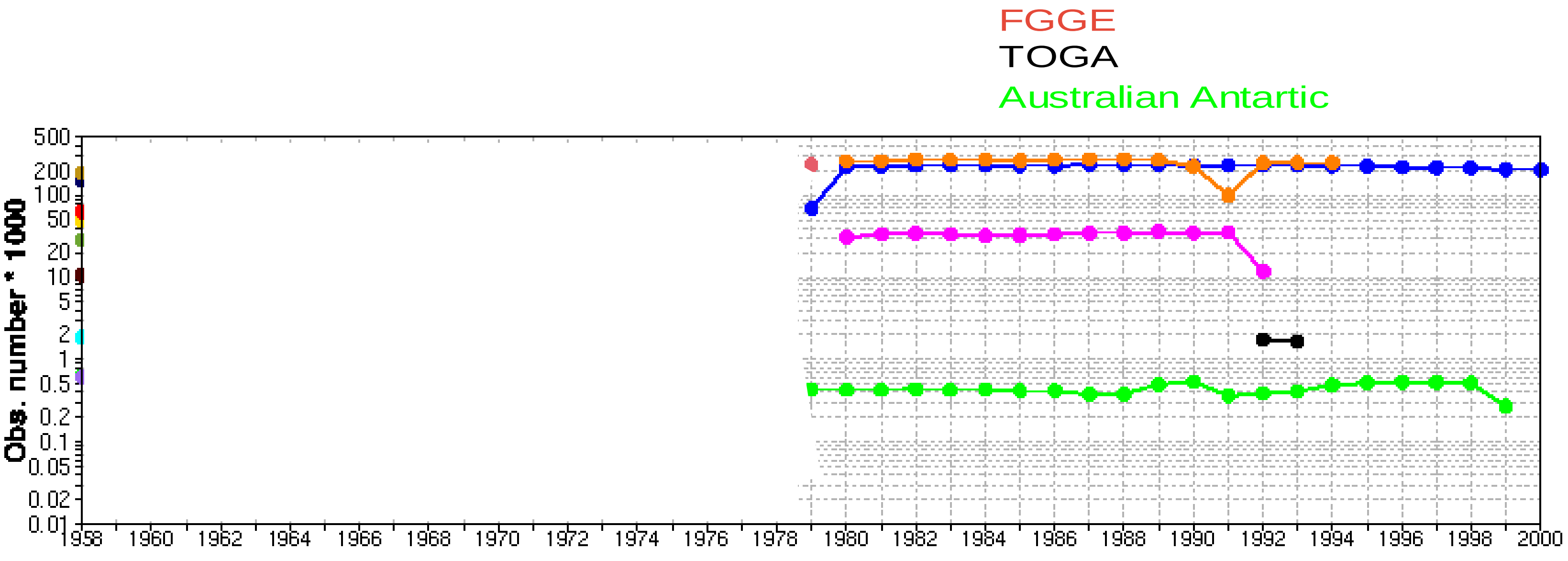
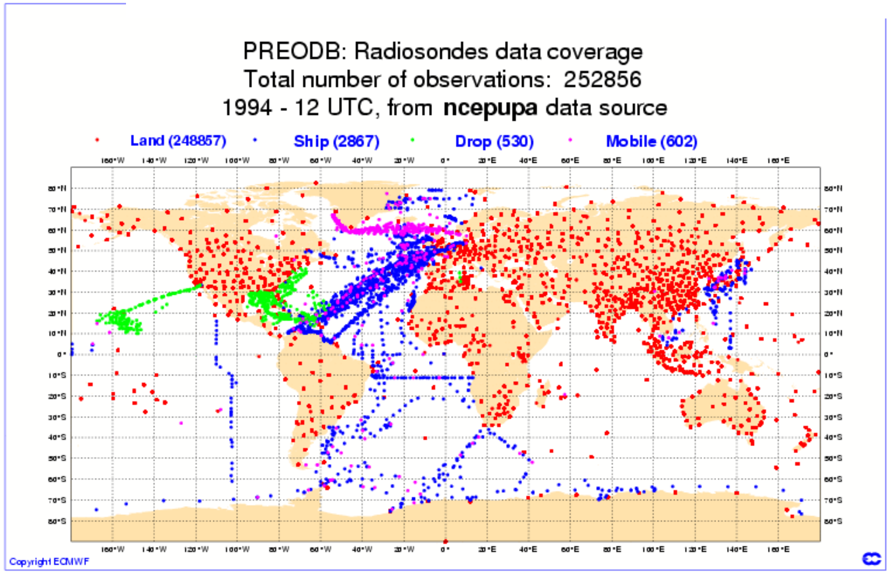
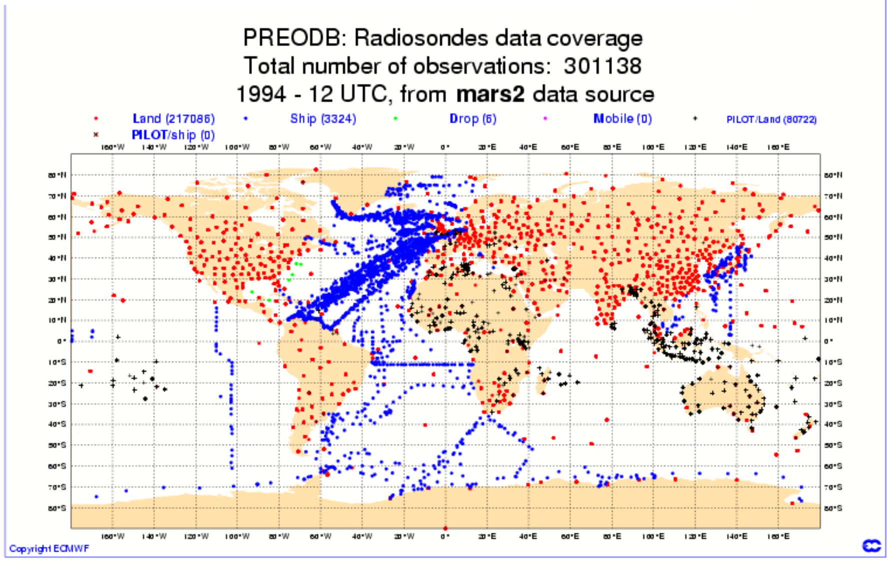
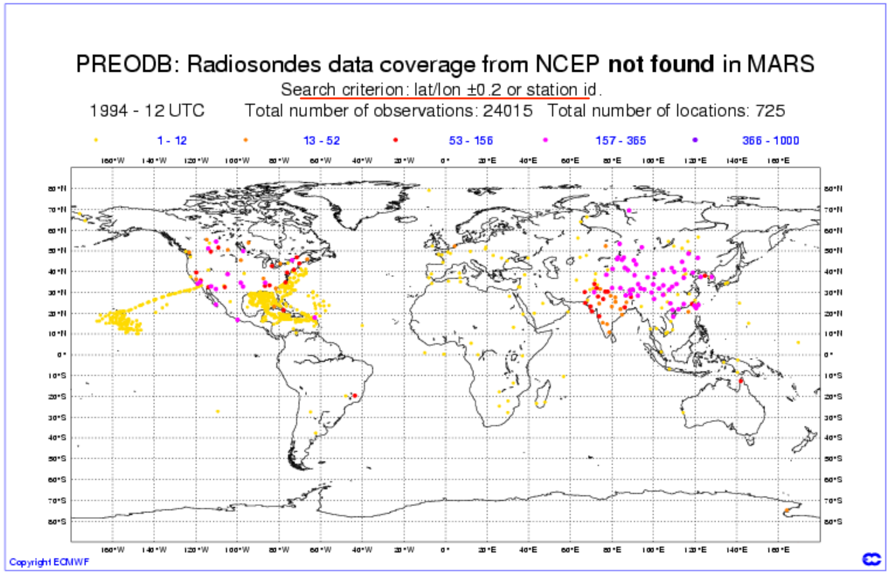
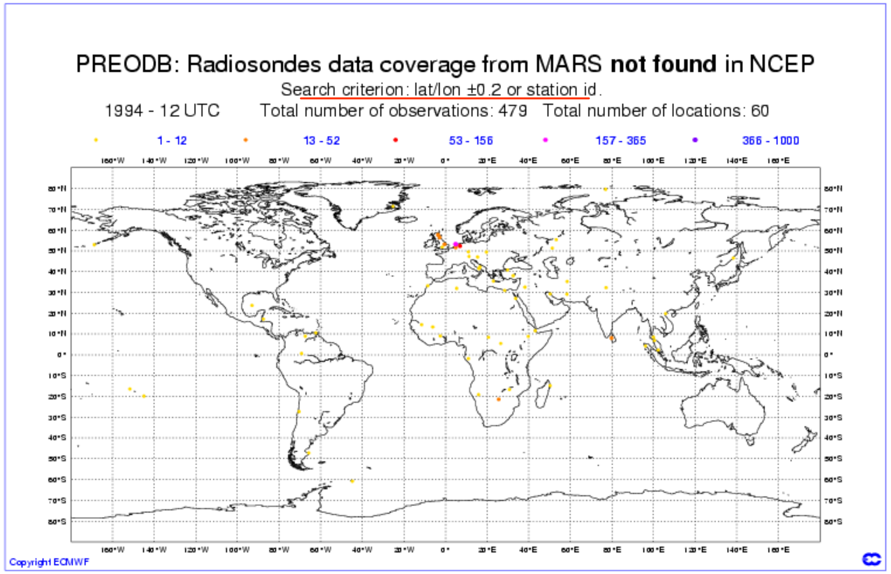


ILLUSTRATION: THE IMPORTANCE OF MERGE

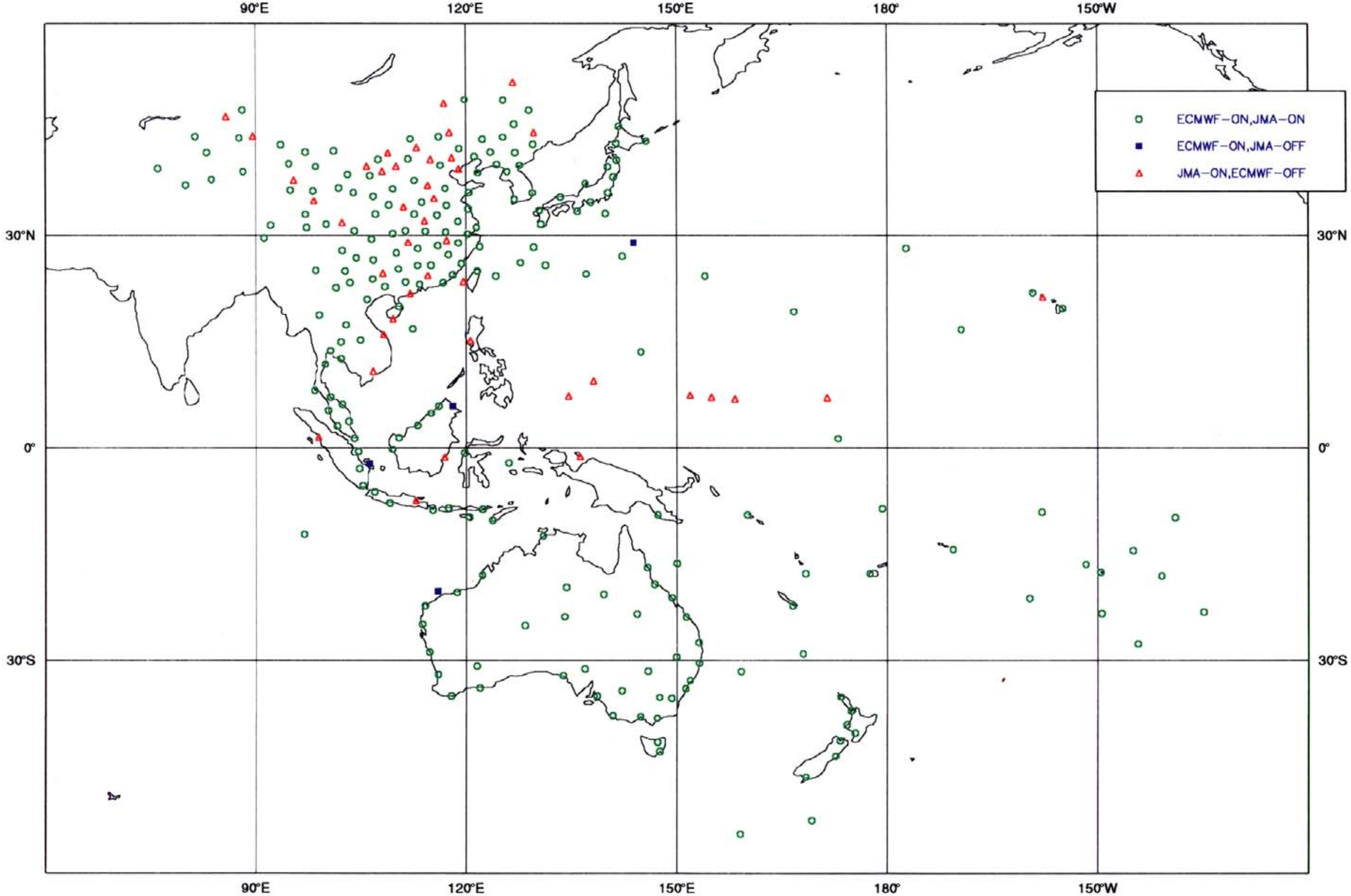






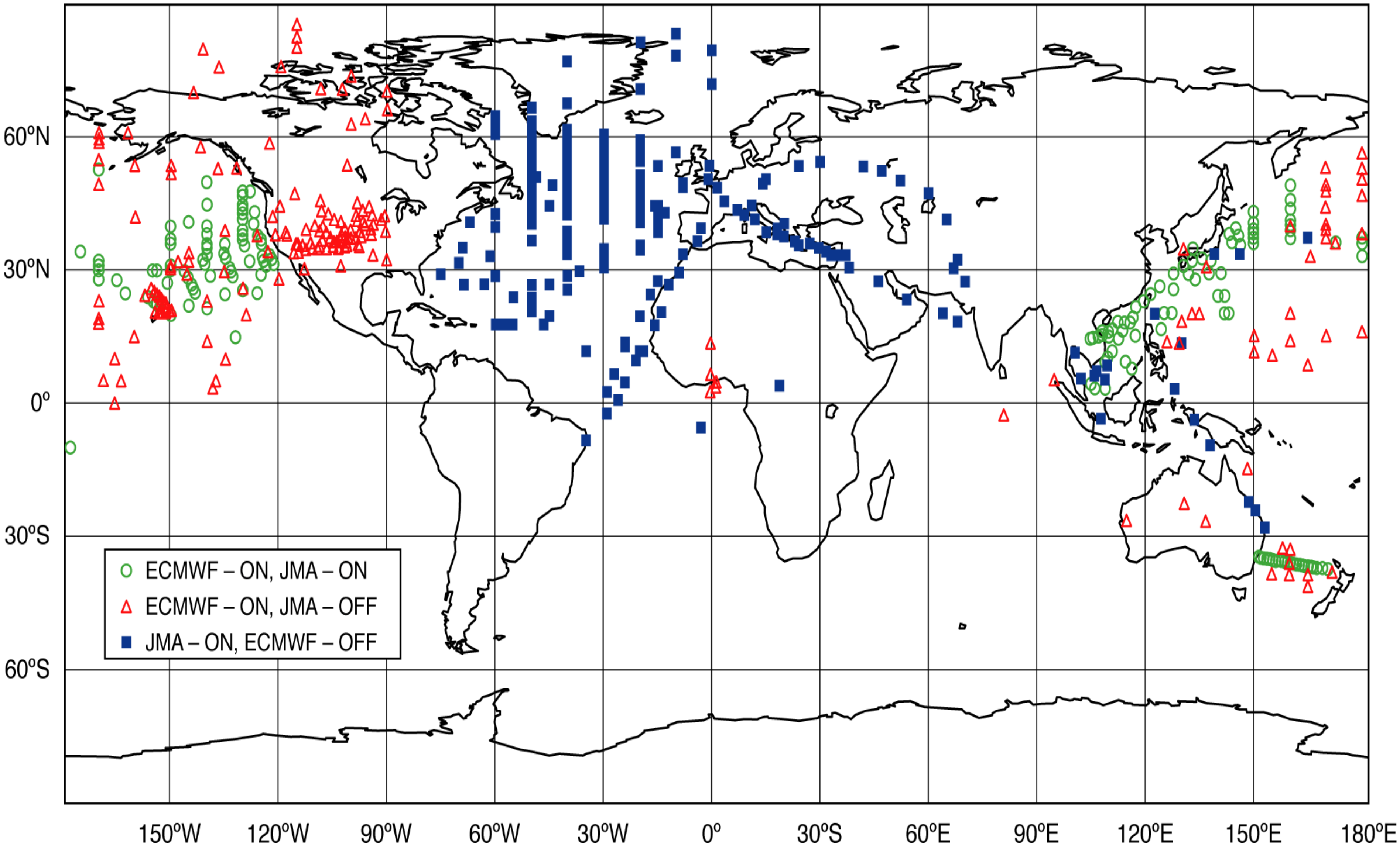


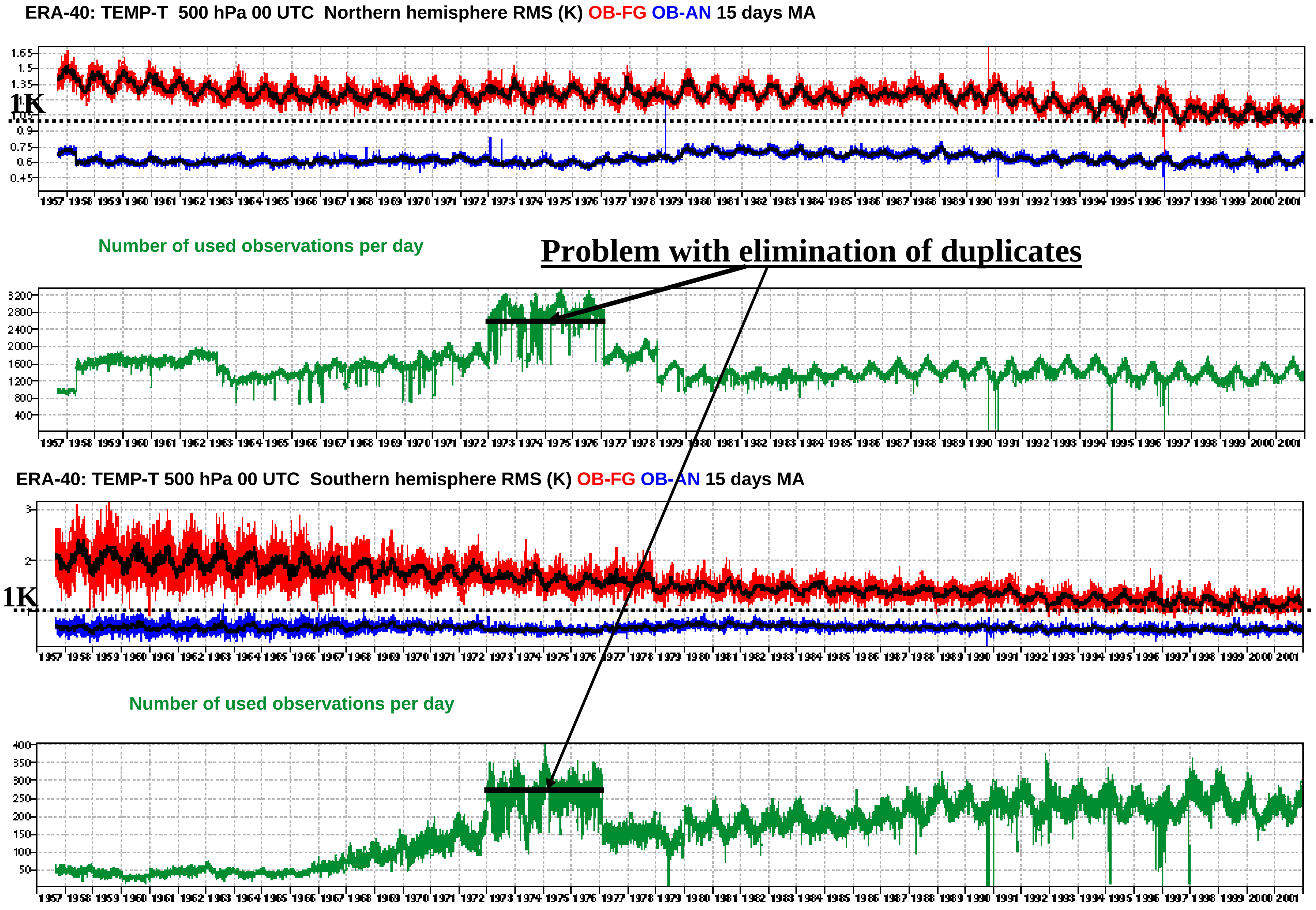
OBSERVATION POINT TEMP/PILOT
ONLY FOR 46000-59999,90000-99999 and TEMP-SHIP
TIME : 1983 6 2 10UTC - 1983 6 2 14UTC



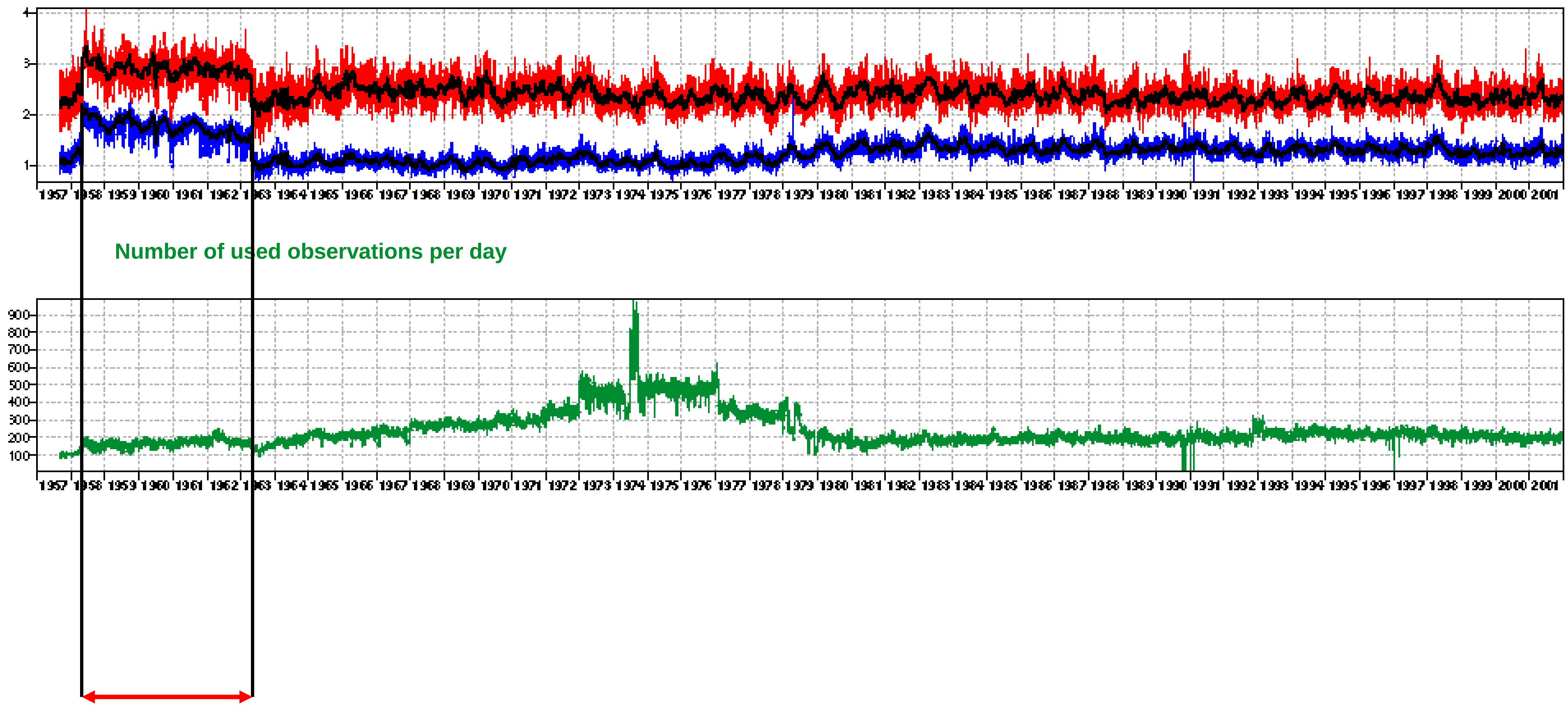
MAGICS 4.1a cray/unicos - ern 18 June 1993 10:46:28 - ERN TEMP

Observation point, AIREP
Time: 1982 2 28 18UTC – 1982 3 1 05UTC




ERA-40: TEMP-T 500 hPa 00 UTC Northern hemisphere RMS (K) OB-FG OB-AN 15 days MA
1K
Number of used observations per day
Problem with elimination of duplicates
ERA-40: TEMP-T 500 hPa 00 UTC Southern hemisphere RMS (K) OB-FG OB-AN 15 days MA
1K
Number of used observations per day

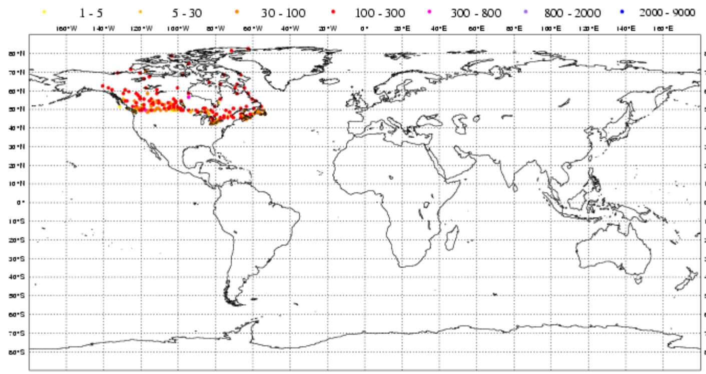
ERA-40: TEMP-Q 850 hPa 00 UTC Tropics RMS (g/kg) OB-FG OB-AN 15 days MA



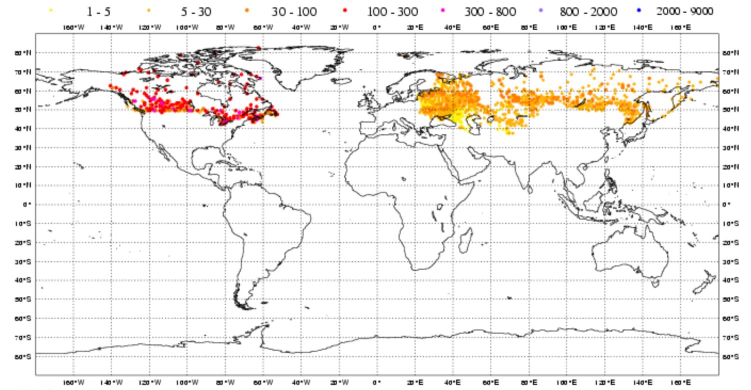
Humidity
Conversion Problem
Datasource: MIT

Snow data coverage (sdepth>0)

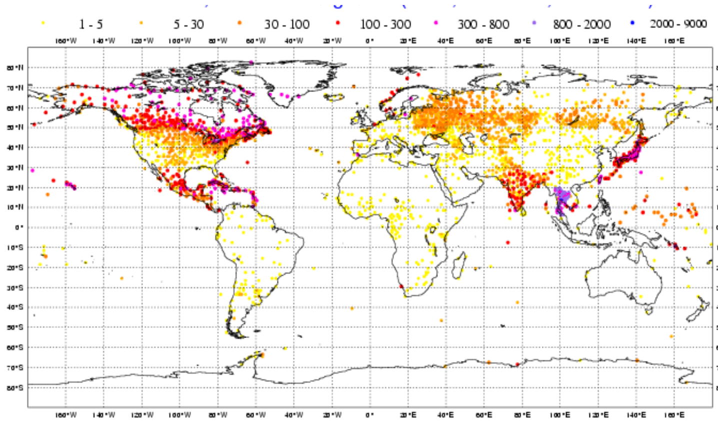
1958



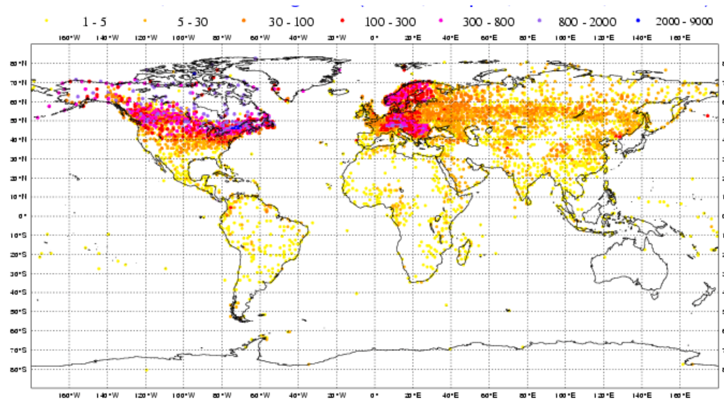
1966



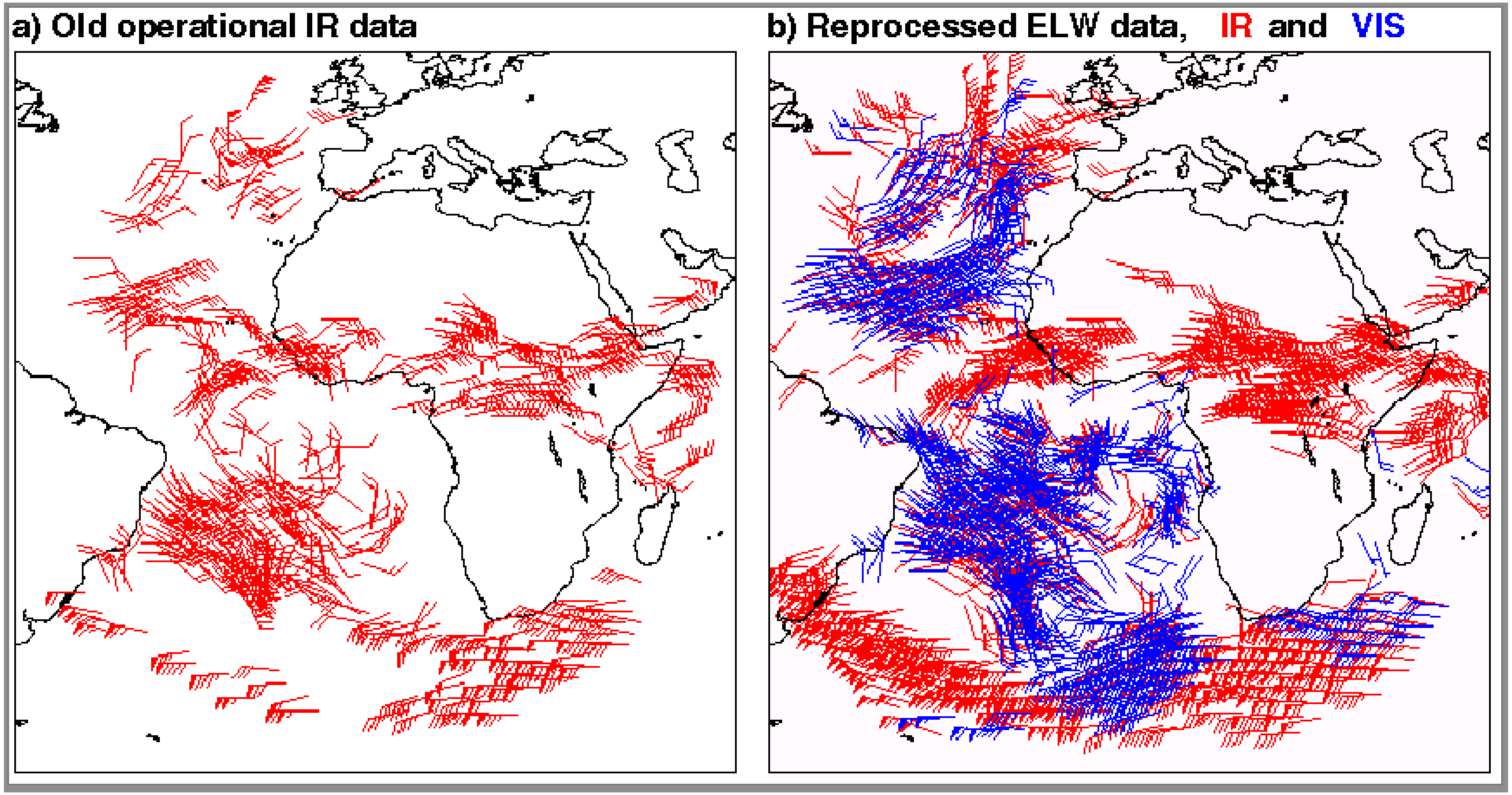
1976



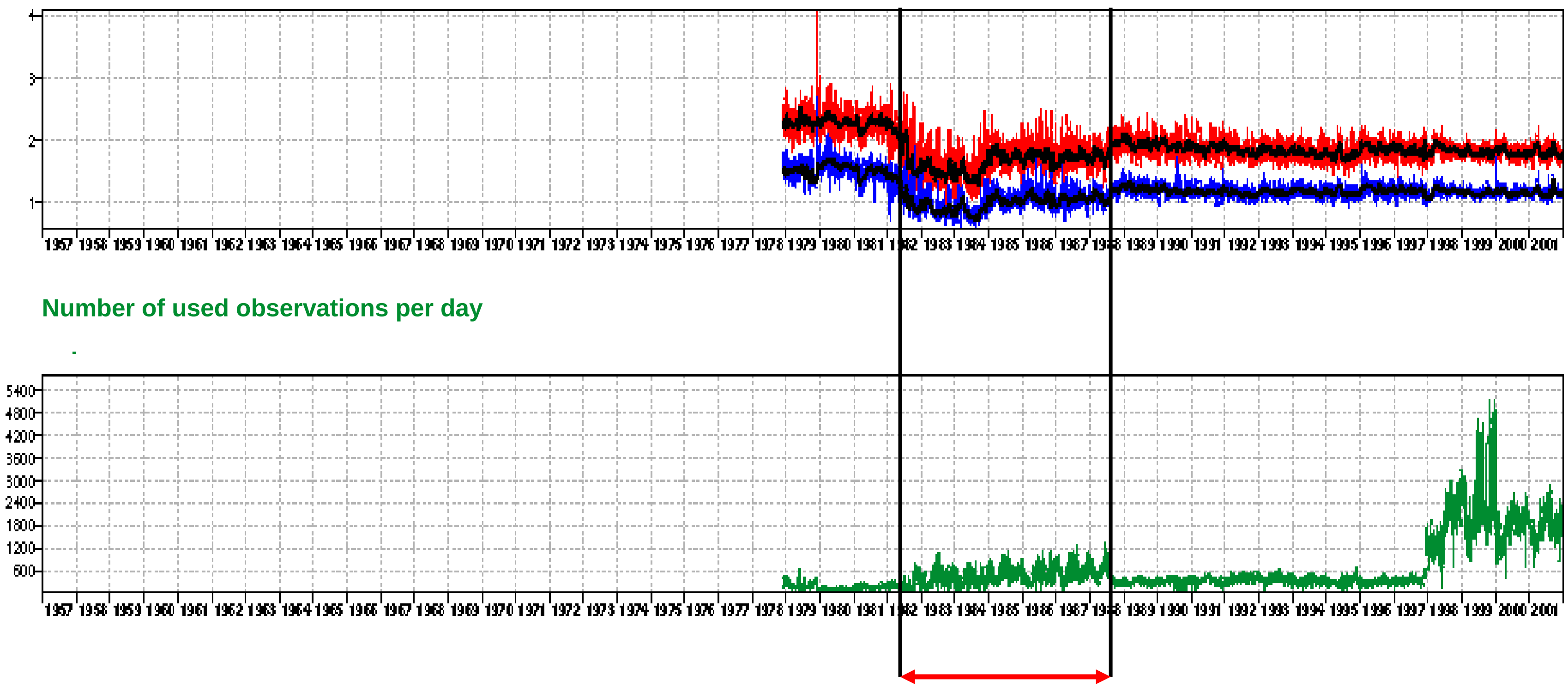
1986



METEOSAT Reprocessed Winds



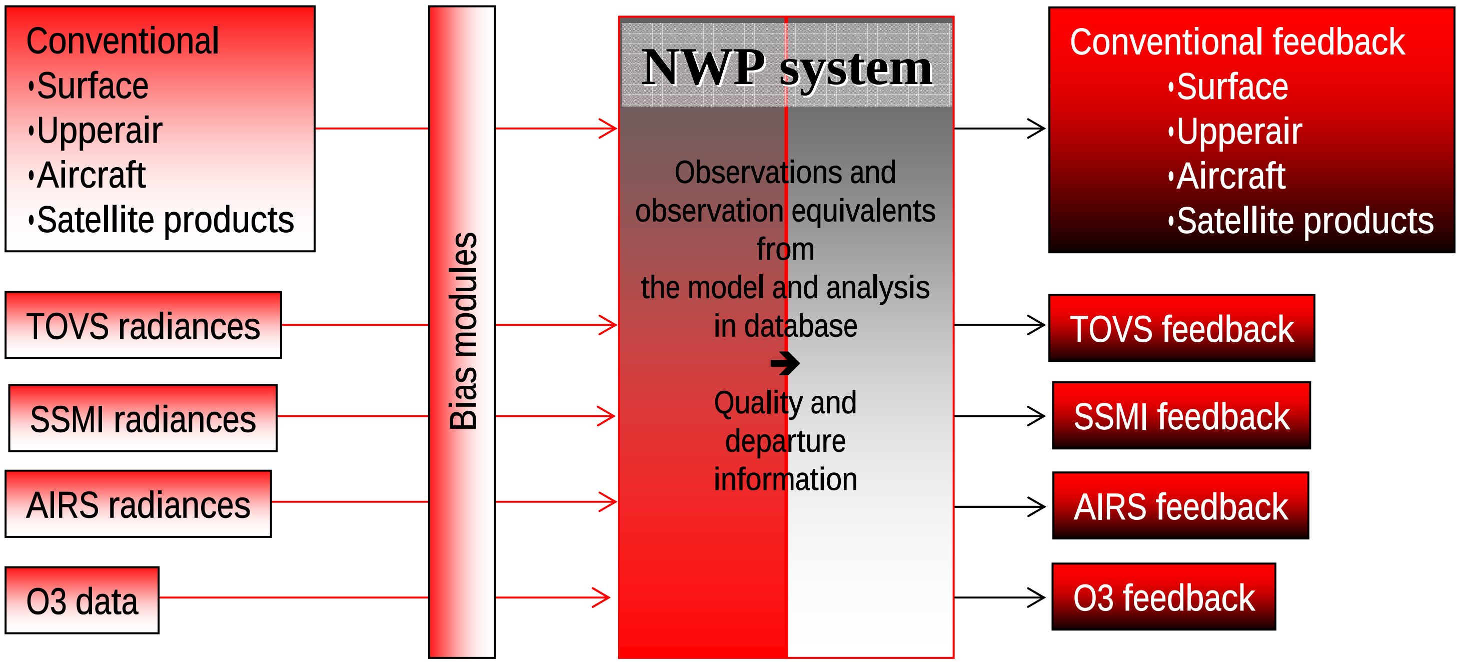
ERA-40: SATOB U- Wind 850 00 UTC Tropics RMS (m/s) OB-FG OB-AN 15 days MA



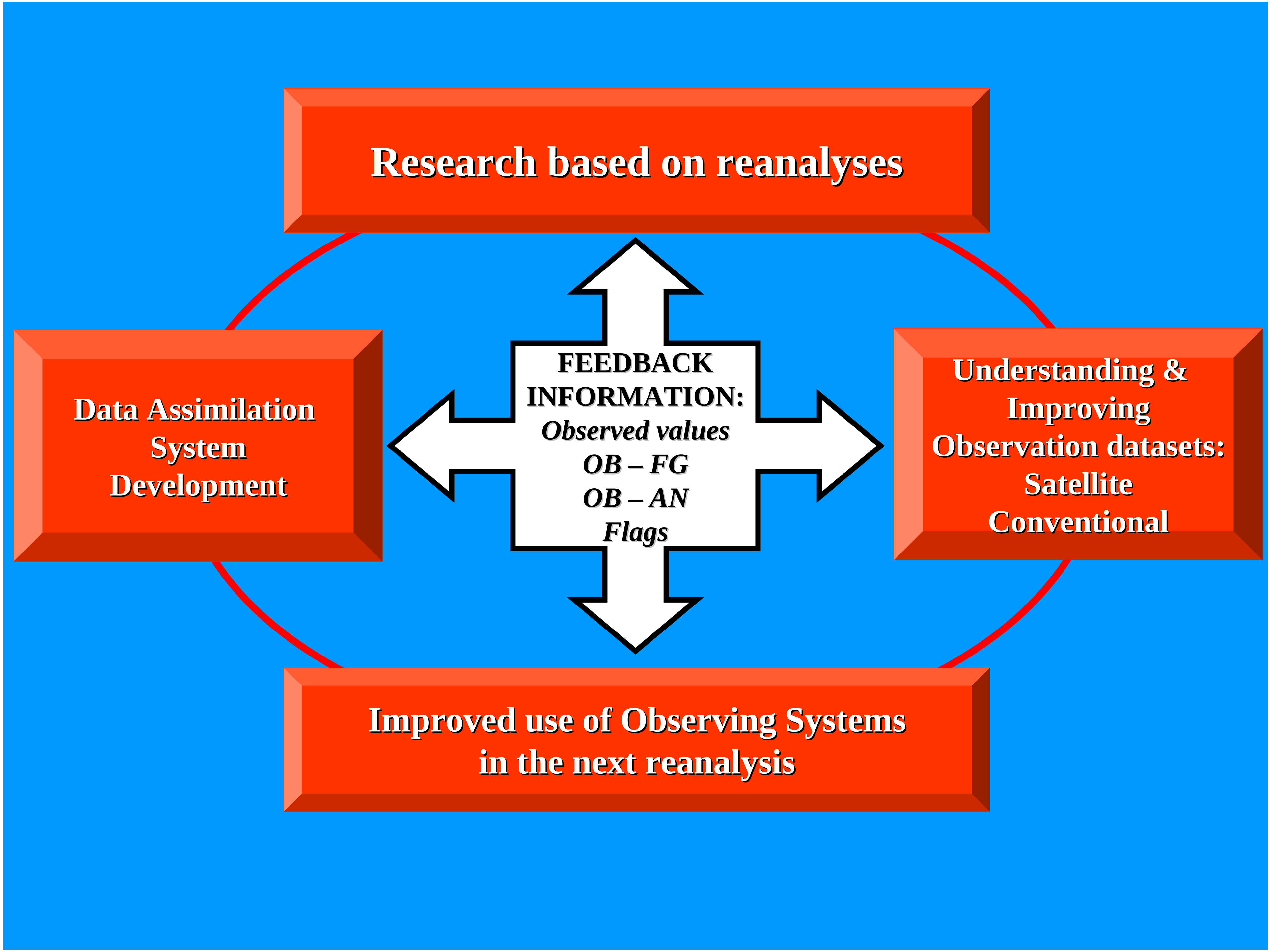
Meteosat Reprocessed winds

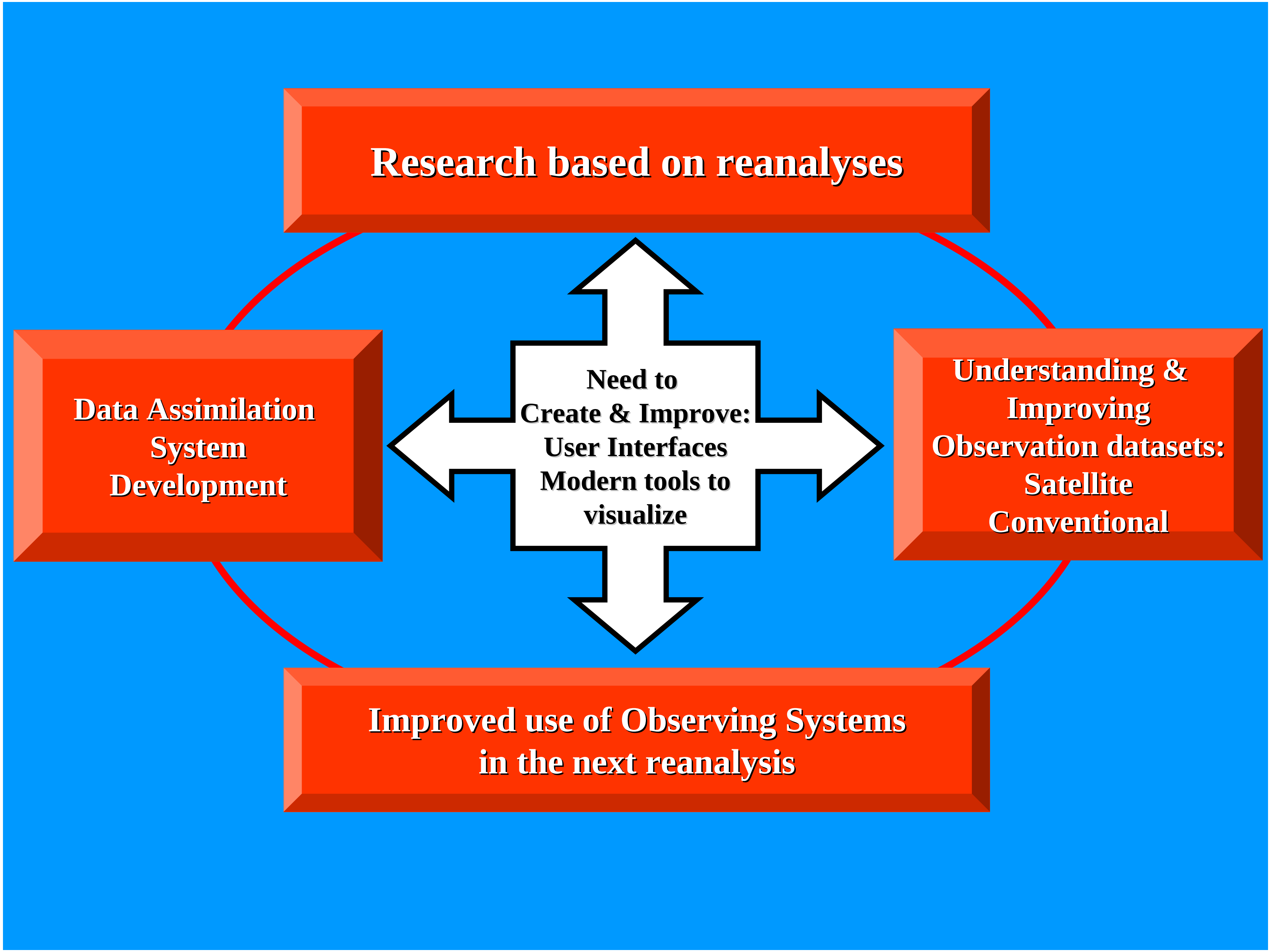
Input observations

How the observations were used in the analysis (feedback)



(Input and feedback observations in BUFR code)


Research based on reanalyses
Data Assimilation System Development
FEEDBACK INFORMATION:
Observed values
OB – FG
OB – AN
Flags
Understanding & Improving Observation datasets:
Satellite
Conventional
Improved use of Observing Systems in the next reanalysis

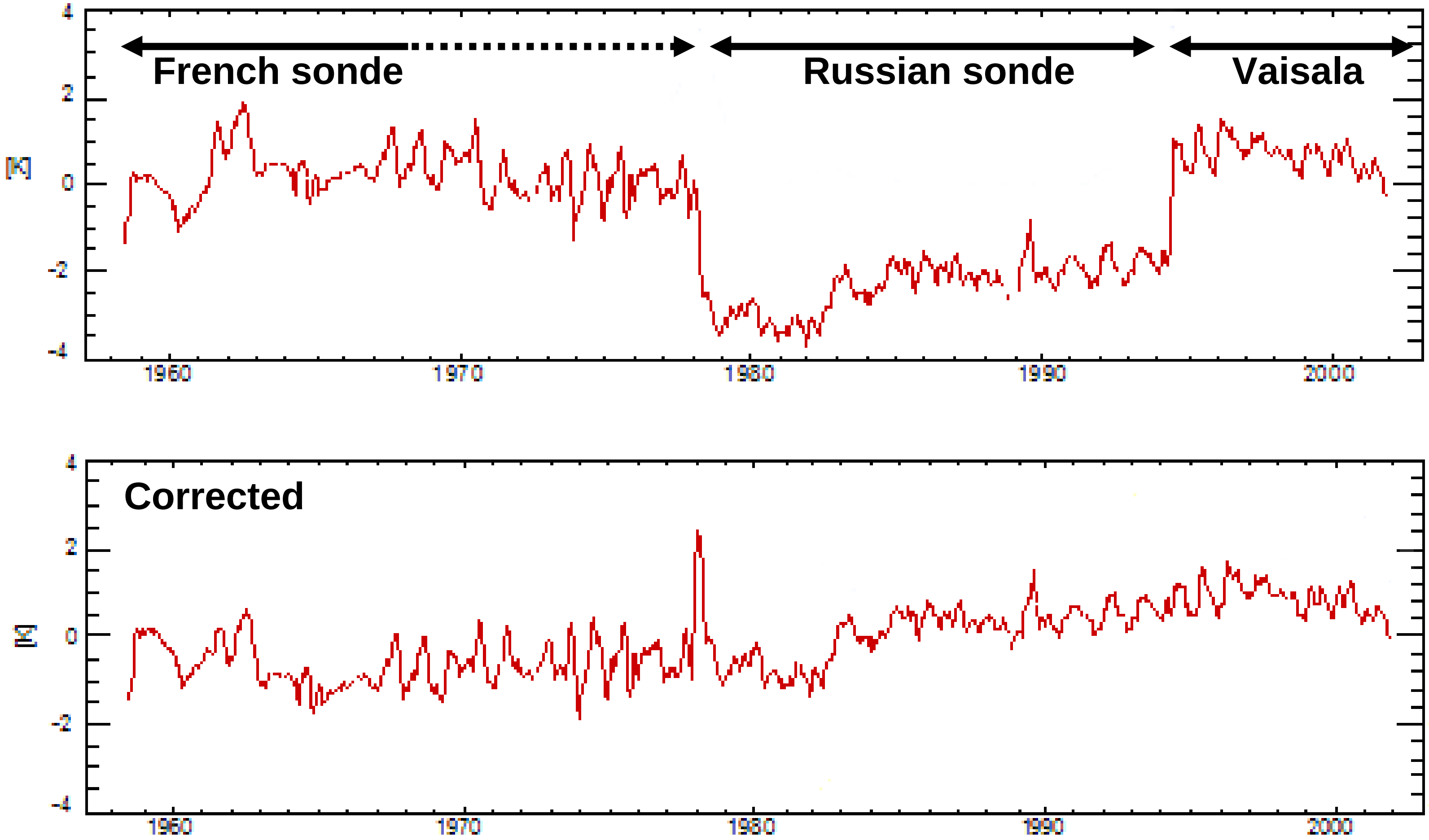

Research based on reanalyses
Data Assimilation System Development
Need to Create & Improve: User Interfaces Modern tools to visualize
Understanding & Improving Observation datasets: Satellite Conventional
Improved use of Observing Systems in the next reanalysis


Investigate the Feedback information (Ob-Fg, Ob-An) :
Statistics and time series per area/ station
Statistics of accepted/ rejected data per data source
Detailed inventories of the merged dataset and data sources
Filling the possible gaps in time and space with additional data
Insert the new data into Data Base
Merge of observations and observed values:
in the Screening step before minimization
Check/ Modify Station height and position information
Use the merged observations in reanalysis$_{(n+1)}$

Need to homogenize radiosonde biases in time

(example: Haimberger, 2005 using ERA-40 feedback data)

SAIGON / TAN-SON-NHUT 00UTC 200hPa temperature (Background – Observation)



Report of the Workshop on "The Development of Improved Observational Data Sets for Reanalysis: Lessons learned and Future Directions"

28-29 September 2005
University of MD Conference Center, College Park, MD USA
Sponsored and support by: NASA, NOAA, NSF

Organizers:

Siegfried Schubert (NASA/GMAO)
Dick Dee (ECMWF)
Sakari Uppala (ECMWF)
Jack Woollen (NOAA/NCEP)
John Bates (NCDC)
Steven Worley (NCAR)

Key contributors:

Joey Comeaux (NCAR)
Russell Vose (NCDC)

1 May 2006

Motivation and background

- Four-dimensional climate data assimilation provides

  1. The best approach to understanding climate variability and ensuring that climate models are consistent with the full range of observed climate variations.

  2. Information about the quality of the observations. ***As such, a systematic and iterative process of climate data integration based on four-dimensional data assimilation can facilitate both model development and efforts to improvement the long-term consistency and quality of the observations*.**

- The feasibility of employing data assimilation systems to reprocess past observations has been demonstrated by several reanalysis efforts

- ***The changes in the observing system have continued and WCRP has identified the need to solve the problem of these spurious changes and trends as the most important problem in reanalysis.***

… Motivation and background

- An important, but perhaps under appreciated aspect of the first generation of reanalyses is that they fostered substantial improvements to the basic input observations and databases.

- New climate analyses and reanalyses can now take advantage of observations that have been rescued into digital form, collected from previously untapped sources, corrected for obvious errors, quality controlled, and quality checked as part of previous reanalysis efforts.

- The reprocessing of observations and reanalysis are just different sides to the same coin and each must be supported, both independently and mutually, to make optimal progress.

- Issues that must be addressed include, duplication of data sets, ad hoc approach to data preparation, difficulties in taking advantage of previous reanalysis, poor traceability, and bringing in work on observations that is independent of reanalysis.

- For an ongoing reanalysis of the climate system to be successful, different reanalysis groups and data centers must collaborate on common issues.

Vision for the future

- Each new reanalysis extracts more information from observations by taking advantage of new developments in data-assimilation systems, the handling of biases in observations, and in the metadata.

- New data continue to become available from both data archeology and the current suite of operational observing systems. The importance of the stewardship increases each year, since the massive amount of new operational data has to be merged into the input streams.

- The creation of input datasets for reanalysis is an important contribution to our stewardship of global climate observations, their maintenance for future use, and the extraction of reliable information concerning climate variability and change.

  - It is a unified approach to the observing system and its history spanning both conventional and satellite data.

  - It is a major effort that needs on-going institutional support.

  - It also needs international support (e.g., WMO) to open data policies so that access to important data can be achieved worldwide.

… Vision for the future

- Scientific Data Stewardship with **four functions** to be adopted

- **<u>The first function</u>** is to provide real-time monitoring of the observing system performance for long-term applications

- **<u>The second function</u>** is generating authoritative, long-term records. This function will preserve and enhance the value of the irreplaceable historical data by conducting rigorous data analysis and research to validate and improve these authoritative records, and by reanalysis and reprocessing and enabling others to participate in these.

- **<u>The third function</u>** uses the authoritative records to assess the current state of the environment and to put it in historical perspective. Long-term trends on local, regional or global scales can be determined and estimated for the future.

- **<u>The final function</u>**, insuring complete archival and access capabilities, requires that metadata, direct observations, and fundamental records from satellite and in situ platforms be comprehensive, complete and preserved, in perpetuity. Open, efficient access to the metadata, products, and data streams must be insured, and data made available in useful formats.

...Vision for the future

- Recent technological advances have been important not only in terms of improved data storage and data handling, but also in the availability of high performance data base systems. These systems allow the maintenance of different data sources separately using version control, so that reanalysis projects can extract or enquire new merged versions from the sources.

Strategy

- *A key component of strategy must be a strong collaboration between the reanalysis and observational communities to improve our existing world-wide database of input observations.*
  - This includes efforts aimed at the identification and correction of observational bias and obvious errors
  - Improved quality control
  - The merging of various data sets
  - Rescue and organization to create more complete digital collections, improved handling of meta-data
  - Developing and testing adaptive bias-correction techniques that adjust to an ever-changing observing system.

Recommendations

The key programmatic recommendation of the workshop is:

for the **WCRP Observations and Assimilation Panel (WOAP) to appoint a working group of experts charged with developing a plan for "The On-going Development of Improved Observational Data Sets for Reanalysis", that describes the necessary resources, infrastructure, institutional commitments, and coordination on technical issues outlined in this report.**

Action: Get commitments from member countries to carry out specific tasks.

The workshop identified the need to raise the profile of activities concerning the pre, post, and bias processing of observations and the related science. It was recognized that the improved understanding of climate variability and change depends more than ever on the quality of the historical observations and their effective use in reanalyses

Recommendation 1:

All the main centers should prepare inventories of reanalysis observations (on the level of observation records)

Action 1a: Compare NCAR and NCDC inventories for surface and upper air.
Joey Comeaux will draft inventory record structure; will iterate with NCDC to reach mutual agreement. Russ Voss is the contact at NCDC

Action 1b: Draft inventory record structure for moving platforms.
Consult with ICOADS and WOB experts to assure compatibility.
Responsible individuals- Steven Worley and Joey Comeaux

Action 1c: Following Actions 1a and 1b, get inventories in established forms from JMA, ECMWF, NCEP, NASA, BoM for data not from NCDC, NCAR, or in ICOADS and WOD. Contacts, JMA – Kasutoshi Onogi, ECMWF – Sakari Uppala, NCEP – Jack Woollen, NASA – Siegfried Schubert, BMRC – Peter Steinle, CRU East Anglia Univ – Phil Jones

Recommendation 2:

A collaboration be formed that can sustain a data refresh cycle and create high quality merged datasets for reanalyses

Action 2a: Begin to collaboratively explore merging/combining activities with radiosonde data because of its vertical data structure and potentially large impact on reanalysis.

Action 2b: Add ancillary data (reanalysis feedback files – add specific fields; other expert calibration and inter-calibration information) to merged data set database.

Action 2c: Further inter-calibrate various measurements across successive generations of satellite sensors, with priority given to SSU data

Recommendation 3:

Develop improved record tracking control for observations to further improve the use of feedback data from reanalyses targeted especially for data providers/developers:

Action 3a: Provide additional details on metadata efforts and standards for in situ and satellite data, including a pilot rich metadata standard for satellite data, by spring 2006 (John Bates)

Action 3b: Establish working group to determine standard set of record header information that satisfies recording track through the reanalysis system.

Action 3c: Provide a list of web sites relevant to data quality control for reanalysis and real-time NWP analysis. Post at the WMO WOAP web site. (Glenn White).

Recommendation 4:

The observational, reanalysis, and climate communities should take a coordinated approach to further optimizing reanalysis for climate

Action 4: Set up working group (Schubert, Dee, Whittaker, Thorne, etc.) to focus on the following reanalysis issues:

- All data vs. stable observing system including reduced resolution data
- What are the highest impact set of observations (priority of, e.g., SSU data)?
- Developing and testing adaptive bias-correction techniques for reanalysis
- Enhance community participation to interact and analyze reanalysis
- What can reanalysis do toward recommending sampling distribution and supporting the need for a “reference” upper air network?
- How can new observations best be tested/ evaluated in reanalysis/ OSEs?
- Establishment of ongoing relations with major data centers

Data-assimilation requirement document?

Data-assimilation groups in the reanalysis centres could produce a document describing those observed quantities in the historical data:

1. which are important for the assimilation
2. which could potentially be used in the future e.g ((snow, T2m), (Ps, Pmsl), Tmax, Tmin, precip, clouds, daily mean values, TEMP significant levels/ standard levels, pressure tendency etc.