RE-ANALYSIS at ECMWF:

Status of ERA-40

Conclusions to date from ERA-40

Plans

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ERA-40 – Credits

• NCAR and NCEP supplied most of the older observations

• EUMETSAT supplied reprocessed Meteosat-2 winds

• Met Office and NCEP provided SST and sea-ice analyses

• Other institutions supplied specific sets of observations

• Validation partners assessed plans and performance

• External support came from EU, Fujitsu, IAP, JMA, PCMDI, WCRP and GCOS
ERA-40 – Status

- Production *(September 1957 – August 2002)* was completed in April 2003

- Much European use of products via direct access to ECMWF archives and national data centres

- 2.5° products are available on a public data server *(http://data.ecmwf.int/data)*

- NCAR will supply products for UCAR and other US use

- Observations have been supplied to JMA for JRA-25
In-situ ("conventional") observations for ERA-40

- Radiosonde and pilot-balloon soundings 1957 - 2002
- Surface data from land stations and ships 1957 - 2002
- Flight-level data from commercial aircraft 1973 - 2002
- Surface data from ocean buoys 1979 - 2002

Satellite data for ERA-40

- NOAA VTPR radiances 1973 - 1978
- NOAA TOVS/ATOVS radiances 1979 - 2002
- Winds from geostationary orbit 1979 - 2002
- TOMS/SBUV ozone retrievals 1979 - 2002
- SSM/I radiances 1987 - 2002
- ERS scatterometer & altimeter 1991 - 2002
Conclusions from ERA-40 – Observations

- Deficiencies in SYNOP collection for early years; satellite collections fairly complete, but more possible

- More work needed on biases in radiosonde and satellite data (and model) before next time

- Various problems with old in situ observations

- One period of very bad VTPR bias correction

- Various difficulties in early TOVS period, especially with SSU

- Reprocessed Meteosat winds brought improvements
Mis-located HIRS soundings (detected by JMA)
Impact of reprocessed Meteosat-2 winds

Normalized r.m.s. vector-wind difference (obs - background) for low-level IR winds

Anomaly correlation of southern hemisphere 500hPa height forecasts

Reprocessed winds

Old winds
Conclusions from ERA-40 – General synoptic quality of analyses

• Best for most recent years

• Quite good throughout for northern hemisphere troposphere and lower stratosphere

• Poor in southern hemisphere in early years
  - Some improvement in early 1970s
  - Big improvement in 1979
R.m.s background and analysis fits to SYNOP pressure observations (hPa)

Southern hemisphere

VTPR
Some aircraft data

TOVS
GEO winds
Buoys
More aircraft data
Anomaly correlations (%) of 500hPa height forecasts
Trends and interannual variability

• Clear improvement on ERA-15 and NCEP reanalysis

• Global temperature trends reasonably well captured from surface to lower stratosphere

• Caution needed when looking at regional trends
Trends and interannual variability

Global-mean two-metre temperature anomaly (Deg C)
Annual running mean

ERA-40

Global air temperature (HadCRUT2v)
2002 anomaly +0.48°C
(2nd warmest on record)

CRU/Hadley Centre

http://www.cru.uea.ac.uk/cru/info/warming
Trends and interannual variability (from Ben Santer)

No sonde bias correction before 1979

Cold winter/spring Antarctic bias in early years

Changes in Actual and Equivalent MSU Temperatures
Anomalies w.r.t. 1979-2001. Bold = low-pass filtered

RSS: MSU data analyzed by Remote Sensing Systems and sponsored by NOAA Climate and Global Change Program
Trends and interannual variability (from Ben Santer)

Changes in Actual and Equivalent MSU Temperatures

Anomalies w.r.t. 1979-2001. Bold = low-pass filtered

**Trends from 1979-2001**

**T4:**
- RSS: $-0.39K$/decade
- ERA-40: $-0.30K$/decade
- NCEP: $-0.82K$/decade

**T2:**
- RSS: $0.09K$/decade
- ERA-40: $0.08K$/decade
- NCEP: $-0.11K$/decade

RSS: MSU data analyzed by Remote Sensing Systems and sponsored by NOAA Climate and Global Change Program
Trends (from Ben Santer)

A  ERA40 linear trend (1979–2001)  
B  RSS linear trend (1979–2001) 

T4

Linear trend (°C/decade)

T2

Linear trend (°C/decade)

RSS: MSU data analyzed by Remote Sensing Systems and sponsored by NOAA Climate and Global Change Program
Aspects of the hydrological cycle

• Extratropics
  - Reasonable agreement with GPCP precipitation, especially over land

• Tropics
  - Excessive rainfall over oceans in the satellite era
  - Problem compounded by misinterpretation of effects of Pinatubo aerosols on IR radiances
  - Model biased dry compared with IR and MW data, in cloud-free and rain-free areas respectively
  - Analyses biased moist compared with SSMI retrievals
  - Some improvement taking 24 - 36h forecasts rather than 0 - 6h
  - Low-frequency variability seems well-captured, nevertheless
0-6h ERA-40 precipitation forecasts (mm/day)
High cloud occurrence – July

From CO₂-slicing using simulated ERA-40 HIRS radiances

From CO₂-slicing using HIRS radiances

ISCCP

ISCCP detects less thin cirrus than HIRS
Stratosphere

- QBO and SAO handled well

- Several quite severe problems with temperature biases
  - due to model biases and difficulties in radiance assimilation
  - worse in ERA-40 3D-Var than in operational 4D-Var

- Too-strong Brewer-Dobson circulation
  - seen in humidity, and ozone when no data is assimilated
  - worse when model temperature biases are corrected by radiance assimilation
Monitoring composition: Ozone

(following Pascal Simon, Météo-France)


Red: Ground-based measurements (NOAA/CMDL)
Plans beyond ERA-40

• An interim reanalysis
  - Start next year, T159L60, latest version of forecasting system
  - Run from 1991 (tbd) onwards, continued in close to real time
  - Baseline for ongoing developments (e.g. constituent analysis)

• Experimentation
  - Observing system experiments
  - High-resolution 4D-Var analyses for specific cases
  - To validate new versions of forecasting system

• Development of observational data base and processing software

• An extensive new reanalysis in 2008 or beyond
Aspects of tropical humidity analysis

Tropical-mean oceanic TCWV (kg/(/m^2/m))

Year
Short-range forecasts over the tropical oceans

- **ERA-40**
- **SSM/I retrievals from Remote Sensing Systems**

### Tropical-mean oceanic TCWV (kg/(m²m))

- **24h forecast**

### Tropical-mean oceanic precipitation (mm/day)

- **24 - 36h forecast**

Year:

- 1988
- 1989
- 1990
- 1991
- 1992
- 1993
- 1994
- 1995
- 1996
- 1997
- 1998
- 1999
- 2000
- 2001
ERA-40 precipitation  JJA, 1986-1995  (mm/day)
Total Ozone  (Monthly means from 1957 to 2002)

Total ozone (Dobson units)


Red: Ground-based measurements (NOAA/CMDL)

Bismarck 47N 101W

Amundsen-Scott 90S

Year