

ECMWF Re-Analysis (ERA) Project

THE RE-ANALYSIS ARCHIVE

Version 1

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European Centre for Medium-Range Weather Forecasts (ECMWF)
Shinfield Park, Reading, RG2 9AX, U.K.

The Re-Analysis Archive

1. Introduction

The goal of the ECMWF re-analysis (ERA) project is the construction of global analysis data sets of six-hourly values over the fifteen year period 1979-1993.

In addition to the use of Centre resources, funding for the project has been obtained from various sources including the University of California (PCMDI), the University of Maryland, the Japan Meteorological Agency, and the European Community.

The Project began in February 1993. During the first year a substantial programme of experimentation, closely co-ordinated with the Centre's Research and Operational activities was completed. This enabled the scientific components of the re-analysis system to be defined, and a strategy for production to be determined. The first 8 years of re-analysis are now complete.

Centre policy is to make re-analysis data available subject to the same rules of access as ECMWF Operational archives, a year at a time, once each successive year has both completed production and been sufficiently validated. The analysis and forecast results from ERA production and experimentation are stored, and may be retrieved using MARS. The purpose of this document is to provide the additional information, not yet added to the MARS User Guide, to enable MARS users to gain access to the data, and to provide a brief description of the Re-Analysis Archive.

Currently the observations used, the monthly means and statistics, and the analysis feedback information are stored within the CFS system. It is planned to move appropriate subsets of such data to the MARS system at a later date.

2. The ERA Data Assimilation System

2.1 Data Sources

The observational data for ERA includes:

- The ECMWF MARS observations archives.

- FGGE II-b data.

- ALPEX II-b data.

- 250 km TOVS cloud cleared radiance (CCR) data, augmented by NESDIS 1b data where there are gaps.

- Comprehensive Ocean Atmosphere Data Set (COADS) ships and buoys.

- Additional AIREP, TEMP and PILOT data from the JMA archive.

- The GMS cloud winds archive from JMA.

- PAOBS data from NMC Melbourne.

The sea surface temperature data for ERA comprise data from UKMO (GISST) for the early period, and from NMC (Washington) from November 1981 onwards. Sea ice cover is derived by ERA from SMMR and SSM/I data.

During FGGE a considerable number of special observations were made, particularly in the Tropics. There was also an immense effort during FGGE to collect all observations made. In December 1979, after the FGGE year, the number of radiosonde (TEMP) observations dropped significantly. In 1980, the first full year of ECMWF operations, not all potentially available observations were being acquired. From 1981 the radiosonde coverage increased, but was still below that potentially available. PILOT data amounts are fairly constant during the period; in 1980 they are almost the only upper air data source (except CCR) over the Indian Ocean. The amounts of cloud track wind (SATO) data dropped even more dramatically after FGGE; Meteosat SATO winds were not produced operationally until August 1982, and there are no reliable SATO winds from the Indian Ocean from December 1979 until this date.

Until September 1981 data from one satellite only was used in the re-analysis; from then on two satellites were usually available:

PERIOD	SATELLITES USED	COMMENTS
01.01.1979 to 31.12.1979	TIROS-N only	
01.01.1980 to 31.08.1981	NOAA-6 only	
01.09.1981 to 20.06.1983	NOAA-6 and NOAA-7	NOAA-6 not used June 1983
21.06.1983 to 12.06.1984	NOAA-7 and NOAA-8	NOAA-8 not used June 1983
13.06.1984 to 31.10.1984	NOAA-7 only	Data from some channels not available at times
01.11.1984 to 31.01.1985	NOAA-6 and NOAA-7	Data from some channels not available at times
01.02.1985 to 31.03.1985	NOAA-6 only	Data from some channels not available at times
01.04.1985 to 31.12.1985	NOAA-9 only	

2.2 The Assimilation System

The following are the specifications for the re-analysis production system:

- intermittent statistical (Optimum Interpolation) analysis with 6 hour cycling;
- one dimensional variational (1D-Var) physical retrieval of TOVS cloud cleared radiance (CCR) data;
- diabatic, non linear normal mode initialisation (five vertical modes);
- The IFS (Integrated Forecast System) forecast model with a horizontal resolution of T106 and 31 hybrid vertical levels, and a fully 3 dimensional semi-Lagrangian advection scheme;

- a physical parametrization package which includes:
 - mean orography with a compatible parametrization of sub-gridscale orography;
 - a 4 layer prognostic soil scheme, with no external soil forcing;
 - full model representation of cloud water content and cloud cover.

The analysis and forecasting system used for ERA is identical to the system used in ECMWF daily operations from 3 April 1995, except for the resolution. Full scientific documentation of the ECMWF data assimilation system is contained in Research Manual 1, published as ECMWF Meteorological Bulletin M1.5/1, while that relating to the forecast model is contained in Research Manuals 2 and 3, published as ECMWF Meteorological Bulletins M1.6/3 and M1.6/2. It should be noted that some features recently added to the ECMWF forecast model are not included within the currently available Research Manuals, but updates to these manuals are expected within the near future.

In addition the following externally produced forcing is used:

- UK Meteorological Office (GISST) 1 degree monthly sea surface temperature (SST) analyses (1978 - October 1981), NMC (Reynolds) 1 degree weekly OI SST analyses (November 1981 - 1993);
- ice limits derived by ERA from SMMR and SSM/I data.

ECMWF Technical Report No. 76 documents the work relating to global sea ice concentration carried out by Atsushi Nomura.

2.3 ERA Production Log

The following is a list of items noted during the production of the archive which may be of interest to potential users of the data.

- 1979: January - November: FGGE observations
 TIROS-N CCR all year
 IFS12r1 production checkout configuration
 01.10.79 - NOAA6 "passive"
- December: 01.12.79 - end of FGGE - MARS + JMA observations
 METEOSAT cloud winds missing; not available for the period
 01.12.79 to 01.08.82 inclusive.
- NOTE: November and December were re-run with the IFS13r1 final production system, and the above observations, as version 22
- 1980: MARS + JMA observations + COADS
 IFS13r1 production configuration
- January: COADS not used correctly
 TIROS N demoted to "passive"
 01.01.80 - NOAA6 CCR introduced "active" - no Microwave Sounding Unit channel 3 (MSU3)

01.01.80 - Radiosonde bias correction scheme introduced
01.01.80 - some data missing for 00 UTC

February: COADS used February onwards
03.02.80 - data problem for 00 UTC cycle, overcome by excluding MARS TEMP data

March: Low counts of CCR data 02.03.80 to 04.03.80
30.03.80 - data problem for 12 UTC cycle, overcome by excluding JMA data

June: 01.06.80 - TIROS N removed

July: 01.07.80 - NOAA6 MSU3 "passive" (for TOVBIAS)

August: 01.08.80 - NOAA6 MSU3 back "active"
TIROS N back "passive"
09.08.80 - data problem for 18 UTC cycle, overcome by excluding COADS data
23.08.80 - bug fix to tropopause/humidity analysis (see RD Memo R43.6/PU/70)
31.08.80 - data problem for 12 UTC cycle, overcome by excluding COADS data

September: 27.09.80 - data problem for 00 UTC cycle, overcome by excluding COADS data

October: 21.10.80 - data problem for 18 UTC cycle, overcome by excluding MARS data
(subsequently it was found that many of these "data" problems were due to the switch setting in the analysis post-processing)

1981: As for 1980, but with the "bug-fixes" fixed at IFS13r4

January: 01.01.81 - pre-release IFS13r4 binary used
NOAA6 active with MSU3

February: 01.02.81 - changed blacklist of Marion Island to exclude wind, not height (had been the wrong way round)
03.02.81 - IFS13r4 binary substituted

May: 01.05.81 - observations enhanced with new GMS data set

July: 01.07/81 - June blacklist used for July.

August: 13.08.81 - NOAA 7 used "passive"

December: 81.12.20 - 81.12.21 very few CCR data

1982:

- January: 01.01.82 - percentage vegetation, which had been incorrect (at the Greenwich meridian only), fixed.
- March: 01.03.82 - Alpex data included.
- May: 12.05.82 - data problem for 12 UTC cycle, overcome by excluding MARS data, and by reducing obs period to 11:00 through 13:00.
13.05.82 - data problem for 12 UTC cycle, overcome by excluding COADS data. These problems were later traced to ship data with MSL pressures which were obviously wrong (less than 10 hPa); a fix was subsequently introduced to correct and exclude such data.
24.05.82 to 30.05.82 - some 2.5 degree fields in the MARS archive are empty, due to a bug in MARS; these will need to be re-archived at a later date (not yet done).
- July: 29.07.82 - 12 UTC analysis run without COADS data.
- August: 10.08.82 - 12 UTC analysis run without some MARS data.
- September: 16.09.82 - 18 UTC analysis run without MARS data.
18.09.82 - 12 UTC analysis run without MARS data.

1983:

- January: 01.01.83 - postprocessing of downward components of radiation at the surface introduced (IFS CY13R4_V02)
- March: 01.03.83 - encoding problem affecting SHIP PILOT reports corrected.
- June: 01.06.83 - NOAA 6 removed.
NOAA 7 active until 20.06.83.
20.06.83 - NOAA 8 soundings used from 20th to 30th June - they should have been blacklisted.
- September: 02.09.83 onwards - SSU2 missing from NOAA 7
- October: 02.10.83 to 04.10.83 - ECMWF retrievals from NESDIS 1b; all satellite soundings above 100 hPa were blacklisted for this period. Although the system worked, lessons were learned that would enable it to be done better next time.
- November: 01.11.83 - problems generating NOAA 7 tovsbias because Stratospheric Sounding Unit channel 2 (SSU2) missing throughout, so October tovsbias for NOAA 7 used.
- December: 01.12.83 - fix used to generate tovs bias for NOAA 7 despite the still missing SSU2.

1984:

January: 01.01.84 - SSU2 channel restored for NOAA 7.
June: 20.06.84 - SSU2 channel missing from NOAA 7.
August: 01.08.84 - NOAA 8 discontinued.
September: 23.09.84 - NOAA 6 passive with MSU/SSU channels only.
November: 01.11.84 - NOAA 6 active with MSU/SSU channels only.
December: 04.12.84 - NOAA 6 discontinued (by accident - the data processing technique value changed from missing to 8).

1985:

January: 09.01.85 - NOAA 6 re-activated with MSU/SSU channels only.

3. Data Available

Data are available through the Meteorological Archive and Retrieval System (MARS). Currently the following ERA production data are available under MARS:

expver=01 - 1 January 1979 to 31 December 1987

Users of MARS should note that the ERA production data are archived in monthly files. Each archive file contains all data for one month at one synoptic hour, or, in the case of forecast data, for one timestep of the forecast based on one synoptic hour. Thus, users should try to ensure that each retrieve request relates, as far as is possible, only to one archive file. For example, where all four synoptic hours for a series of dates are required you should compose one retrieve request for each hour (all dates), making four retrieve requests rather than one. Note also that the Gaussian grid model level upper air data (January 1980 onwards) are archived in separate files from the spherical harmonic upper air data, and thus must be the subject of separate retrieve requests.

ERA data are referenced by coding:

class=er, (production version - expver=01 is the MARS default)

remaining rules being as indicated in the MARS manual. The ERA archive contains analyses (type=an) and forecasts (type=fc) only - there are no data of type=fg (first guess) or type=ia (initialised analysis). Background (first guess) forecasts are accessed using type=fc and contain initialised analysis data as step=0.

Please note the changes with respect to humidity from 1 January 1980 onwards, due to the introduction of a grid-point representation of humidity in the forecast model from that date.

The following is a summary, in MARS terms, of data currently available:

Data Assimilation Analysis and Background Forecast Production Data

1 January 1979 to 31 December 1979:

Analysis T106 model level data for 00:00, 06:00, 12:00, and 18:00

type=an, levtype=ml, repres=sh, levelist=1/to/31,
param=lnsp/t/q/w/v/d,

Analysis T106 pressure level data for 00:00, 06:00, 12:00, and 18:00

type=an, levtype=pl, repres=sh,
levelist=1000/925/850/775/700/600/500/400/300/250/200/150/100/70/50/30/10,
param=z/t/q/w/v/d,

Analysis N80 reduced Gaussian grid data for 00:00, 06:00, 12:00, and 18:00

type=an, levtype=sfc, repres=gg, levelist=off,
param=z/stl1/stl2/stl3/stl4/swl1/swl2/swl3/swl4/sd/msl/
10u/10v/2t/2d/lsm/st/al/ewov/nsov/nwov/weov/
src/veg/vso/asq/lshr/skt,

Forecast T106 model level data for forecasts based on 00:00, 06:00, 12:00, and 18:00 analyses

type=fc, levtype=ml, repres=sh, levelist=1/to/31, step=0,
param=at/lnsp/t/q/w/v/d,

(forecast step 0 only)

type=fc, levtype=ml, repres=sh, levelist=1/to/31,
param=at/lnsp/t/q/w/v/d,

(forecast steps 6, 12, 18, 24 for forecasts based on 00:00 and 12:00, step 6 only for
forecasts based on 06:00 and 18:00)

Forecast T106 pressure level data for forecasts based on 00:00, 06:00, 12:00, and 18:00 analyses

type=fc, levtype=pl, repres=sh,
levelist=1000/925/850/775/700/600/500/400/300/250/200/150/100/70/50/30/10,
param=z/t/q/w/v/d,

(forecast steps 0, 6, 12, 18, 24 for forecasts based on 00:00 and 12:00, steps 0, 6 only for
forecasts based on 06:00 and 18:00)

Forecast N80 reduced Gaussian grid for forecasts based on 00:00, 06:00, 12:00, and 18:00 analyses

type=fc, levtype=sfc, repres=gg, step=0, levelist=off,
param=z/stl1/stl2/stl3/stl4/swl1/swl2/swl3/swl4/sd/lsp/
cp/sf/bld/sshf/slhf/msl/tcc/10u/10v/2t/2d/lsm/

sr/al/ssr/str/tsr/ttr/ewss/nsss/e/ccc/lcc/mcc/hcc/
ewov/nsov/nwov/weov/lgws/mgws/gwd/
src/veg/vso/ro/iews/inss/lshf/ie/asq/lshr/skt/
csf/lst/fal/fsr/flsr,

(forecast step 0 only)

type=fc, levtype=sfc, repres=gg, levelist=off,
param=z/stl1/stl2/stl3/stl4/swl1/swl2/swl3/swl4/sd/lsp/
cp/sf/bld/sshf/slhf/msl/tcc/10u/10v/2t/2d/
ssr/str/tsr/ttr/ewss/nsss/e/ccc/lcc/mcc/hcc/
lgws/mgws/gwd/
src/ro/iews/inss/lshf/ie/asq/skt/
csf/lst/fal/fsr/flsr,

(forecast steps 3, 6, 12, 18, 24 for forecasts based on 00:00 and 12:00, steps 3, 6 only for forecasts based on 06:00 and 18:00; note that step 3 is available only for expver=01)

Analysis 2.5 degree pressure level data for 00:00, 06:00, 12:00, and 18:00

type=an, levtype=pl, repres=ll, grid=2.5/2.5,
levelist=1000/925/850/775/700/600/500/400/300/250/200/150/100/70/50/30/10,
param=z/t/u/v/q/w/r,

(NOTE param=r is missing for January 1979, expver=02)

Analysis 2.5 degree surface data for 00:00, 06:00, 12:00, and 18:00

type=an, levtype=sfc, repres=ll, grid=2.5/2.5, levelist=off,
param=z/stl1/stl2/stl3/stl4/swl1/swl2/swl3/swl4/sd/msl/
10u/10v/2t/2d/lsm/sr/al/ewov/nsov/nwov/neov/
src/veg/vso/asq/lshr/skt,

Forecast 2.5 degree pressure level data for forecasts based on 00:00, 06:00, 12:00, and 18:00 analyses

type=an, levtype=pl, repres=ll, grid=2.5/2.5,
levelist=1000/925/850/775/700/600/500/400/300/250/200/150/100/70/50/30/10,
param=z/t/u/v/q/w/r,

Forecast 2.5 degree surface data for forecasts based on 00:00, 06:00, 12:00, and 18:00 analyses

type=fc, levtype=sfc, repres=ll, grid=2.5/2.5, levelist=off, step=0,
param=z/stl1/stl2/stl3/stl4/swl1/swl2/swl3/swl4/sd/lsp/cp/
sf/bld/sshf/slhf/msl/tcc/10u/10v/2t/2d/lsm/sr/al/
ssr/str/tsr/ttr/ewov/nsov/nwov/neov/lgws/mgws/
gwd/src/veg/vso/ro/iews/inss/lshf/ie/asq/lshr/skt/
csf/lst/fal/fsr/flsr,

(forecast step 0 only)

type=fc, levtype=sfc, repres=ll, grid=2.5/2.5, levelist=off, step=0,
param=stl1/stl2/stl3/stl4/swl1/swl2/swl3/swl4/sd/lsp/cp/
sf/bld/sshf/slhf/msl/tcc/10u/10v/2t/2d/
ssr/str/tsr/tr/ewss/nsss/e/ccc/lcc/mcc/hcc/
gwd/src/ro/skt/csf/lst,

(forecast steps 6, 12, 18, 24 for forecasts based on 00:00 and 12:00, step 6 only for
forecasts based on 06:00 and 18:00)

1 January 1980 onwards:

Analysis T106 model level data for 00:00, 06:00, 12:00, and 18:00

type=an, levtype=ml, repres=sh, levelist=1/to/31,
param=lnsp/t/w/v/d,

Analysis N80 reduced Gaussian grid model level data for 00:00, 06:00, 12:00, and 18:00

type=an, levtype=ml, repres=gg, levelist=1/to/31,
param=q,

Analysis T106 pressure level data for 00:00, 06:00, 12:00, and 18:00

type=an, levtype=pl, repres=sh,
levelist=1000/925/850/775/700/600/500/400/300/250/200/150/100/70/50/30/10,
param=z/t/w/v/d/r,

Analysis N80 reduced Gaussian grid data for 00:00, 06:00, 12:00, and 18:00

type=an, levtype=sfc, repres=gg, levelist=off,
param=z/stl1/stl2/stl3/stl4/swl1/swl2/swl3/swl4/sd/msl/
sdor/isor/anor/slor/
10u/10v/2t/2d/lsm/sr/al/
src/veg/asq/lsh/skt,

Forecast T106 model level data for forecasts based on 00:00, 06:00, 12:00, and 18:00 analyses

type=fc, levtype=ml, repres=sh, levelist=1/to/31, step=0,
param=at/lnsp/t/w/v/d,

(forecast step 0 only)

type=fc, levtype=ml, repres=sh, levelist=1/to/31,
param=at/lnsp/t/w/v/d,

(forecast steps 6, 12, 18, 24 for forecasts based on 00:00 and 12:00, step 6 only for
forecasts based on 06:00 and 18:00)

Forecast N80 reduced Gaussian grid model level data for forecasts based on 00:00, 06:00, 12:00,
and 18:00 analyses

type=fc, levtype=m1, repres=gg, levelist=1/to/31, step=0,
param=q/clwc/ciwc/cc,

(forecast steps 0, 6, 12, 18, 24 for forecasts based on 00:00 and 12:00, steps 0 and 6 only
for forecasts based on 06:00 and 18:00)

Forecast T106 pressure level data for forecasts based on 00:00, 06:00, 12:00, and 18:00 analyses

type=fc, levtype=pl, repres=sh,
levelist=1000/925/850/775/700/600/500/400/300/250/200/150/100/70/50/30/10,
param=z/t/w/v/o/d/r,

(forecast steps 0, 6, 12, 18, 24 for forecasts based on 00:00 and 12:00, steps 0, 6 only for
forecasts based on 06:00 and 18:00)

Forecast N80 reduced Gaussian grid for forecasts based on 00:00, 06:00, 12:00, and 18:00 analyses

type=fc, levtype=sfc, repres=gg, step=0, levelist=off,
param=z/stl1/stl2/stl3/stl4/swl1/swl2/swl3/swl4/sd/lsp/
cp/sf/bld/sshf/slhf/msl/tcc/10u/10v/2t/2d/lsm/
sr/al/ssr/str/tsr/tr/ewss/nsss/e/ccc/lcc/mcc/hcc/
sdor/isor/anor/slors/lgws/mgws/gwd/
src/veg/ro/iews/inss/lshf/ie/asq/lshr/skt/
csf/lst/fal/fsr/flsr,

(forecast step 0 only)

type=fc, levtype=sfc, repres=gg, levelist=off,
param=z/stl1/stl2/stl3/stl4/swl1/swl2/swl3/swl4/sd/lsp/
cp/sf/bld/sshf/slhf/msl/tcc/10u/10v/2t/2d/
ssr/str/tsr/tr/ewss/nsss/e/ccc/lcc/mcc/hcc/
lgws/mgws/gwd/
src//ro/iews/inss/lshf/ie/asq/skt/
csf/lst/fal/fsr/flsr,

(forecast steps 3, 6, 12, 18, 24 for forecasts based on 00:00 and 12:00, steps 3, 6 only for
forecasts based on 06:00 and 18:00; note that step 3 is available only for expver=01)

Analysis 2.5 degree pressure level data for 00:00, 06:00, 12:00, and 18:00

type=an, levtype=pl, repres=ll, grid=2.5/2.5,
levelist=1000/925/850/775/700/600/500/400/300/250/200/150/100/70/50/30/10,
param=z/t/u/v/q/w/r,

Analysis 2.5 degree surface data for 00:00, 06:00, 12:00, and 18:00

type=an, levtype=sfc, repres=ll, grid=2.5/2.5, levelist=off,
param=z/stl1/stl2/stl3/stl4/swl1/swl2/swl3/swl4/sd/msl/
10u/10v/2t/2d/lsm/sr/al/sdor/isor/anor/slors/
src/veg/asq/lshr/skt,

Forecast 2.5 degree pressure level data for forecasts based on 00:00, 06:00, 12:00, and 18:00 analyses

```
type=an, levtype=pl, repres=ll, grid=2.5/2.5,  
levelist=1000/925/850/775/700/600/500/400/300/250/200/150/100/70/50/30/10,  
param=z/t/u/v/q/w/r,
```

Forecast 2.5 degree surface data for forecasts based on 00:00, 06:00, 12:00, and 18:00 analyses

```
type=fc, levtype=sfc, repres=ll, grid=2.5/2.5, levelist=off, step=0,  
param=z/st1/st2/st3/st4/sw11/sw12/sw13/sw14/sd/lsp/cp/  
sf/bld/sshf/slhf/msl/tcc/10u/10v/2t/2d/lsm/sr/al/  
ssr/str/tsr/tr/ewov/sdor/isor/anor/slor/  
gwd/src/veg/ro/fews/inss/ishf/ie/asq/lshr/skt/  
csf/lst/fal/fsr/flsr,
```

(forecast step 0 only)

```
type=fc, levtype=sfc, repres=ll, grid=2.5/2.5, levelist=off, step=0,  
param=st1/st2/st3/st4/sw11/sw12/sw13/sw14/sd/lsp/cp/  
sf/bld/sshf/slhf/msl/tcc/10u/10v/2t/2d/  
ssr/str/tsr/tr/ewss/nsss/e/ccc/lcc/mcc/hcc/  
gwd/src/ro/skt/csf/lst,
```

(forecast steps 6, 12, 18, 24 for forecasts based on 00:00 and 12:00, step 6 only for forecasts based on 06:00 and 18:00)