

# **RE-ANALYSIS at ECMWF:**

**Status of ERA-40**

**Conclusions to date from ERA-40**

**Plans**

**Graeme Kelly, Adrian Simmons, Sakari Uppala and the ERA-40 team**

## **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**

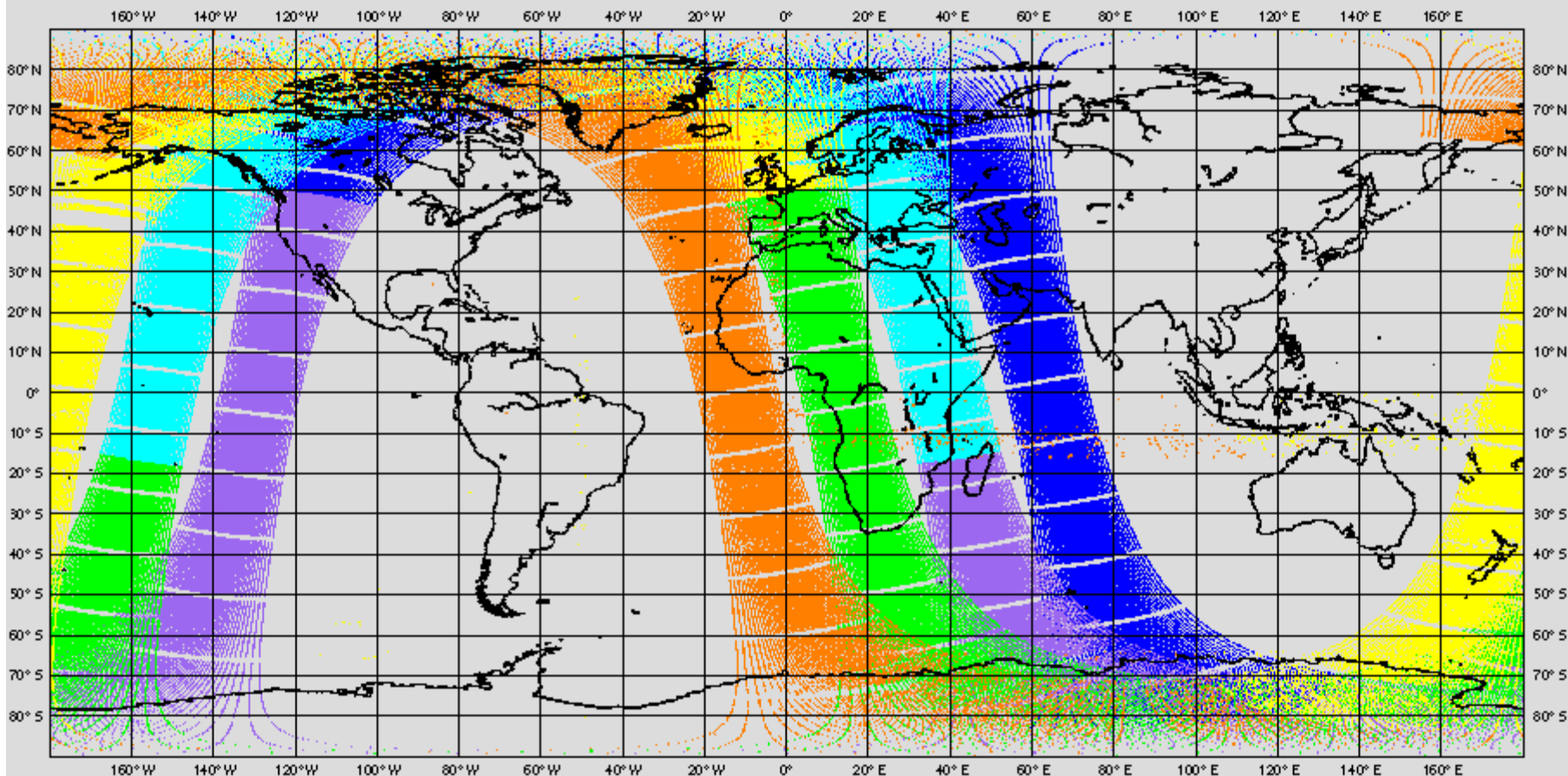
# Conclusions from ERA-40 – Observations

- 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)

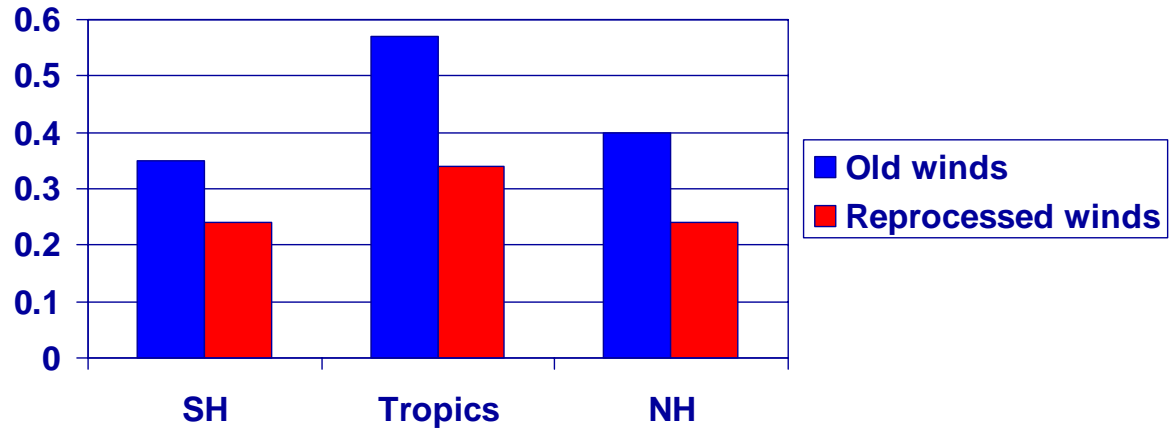
HIRS1C\_BUFR\_19810729\_18\_NOAA-6

■ 15 - 15.99 ■ 16 - 16.99 ■ 17 - 17.99 ■ 18 - 18.99 ■ 19 - 19.99 ■ 20 - 20.99

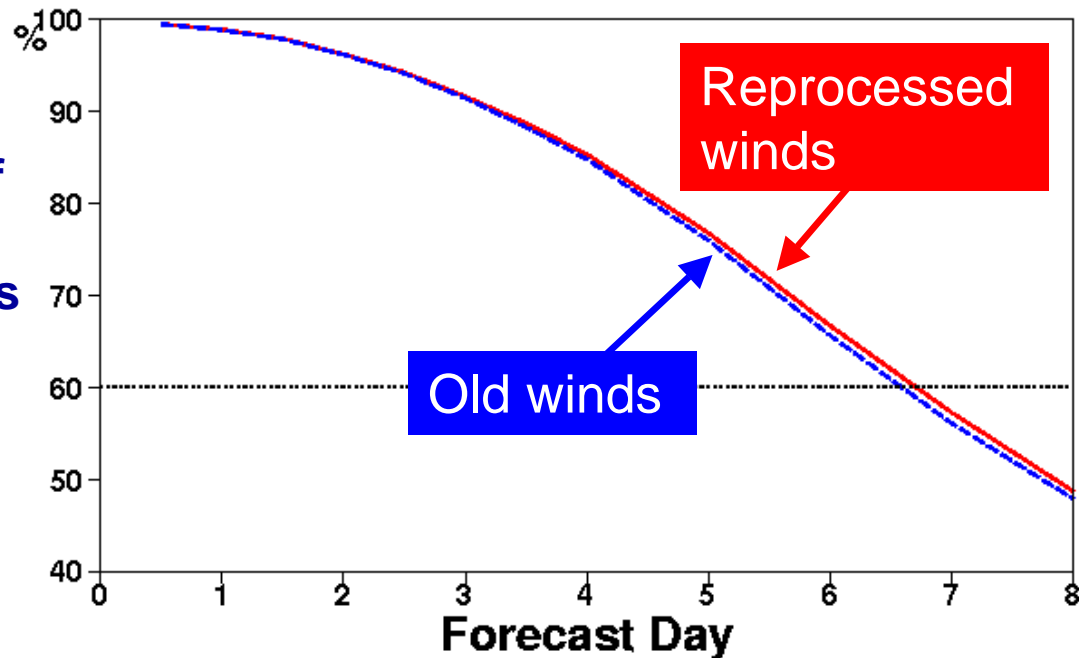


# Impact of reprocessed Meteosat-2 winds

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



Anomaly correlation of southern hemisphere 500hPa height forecasts

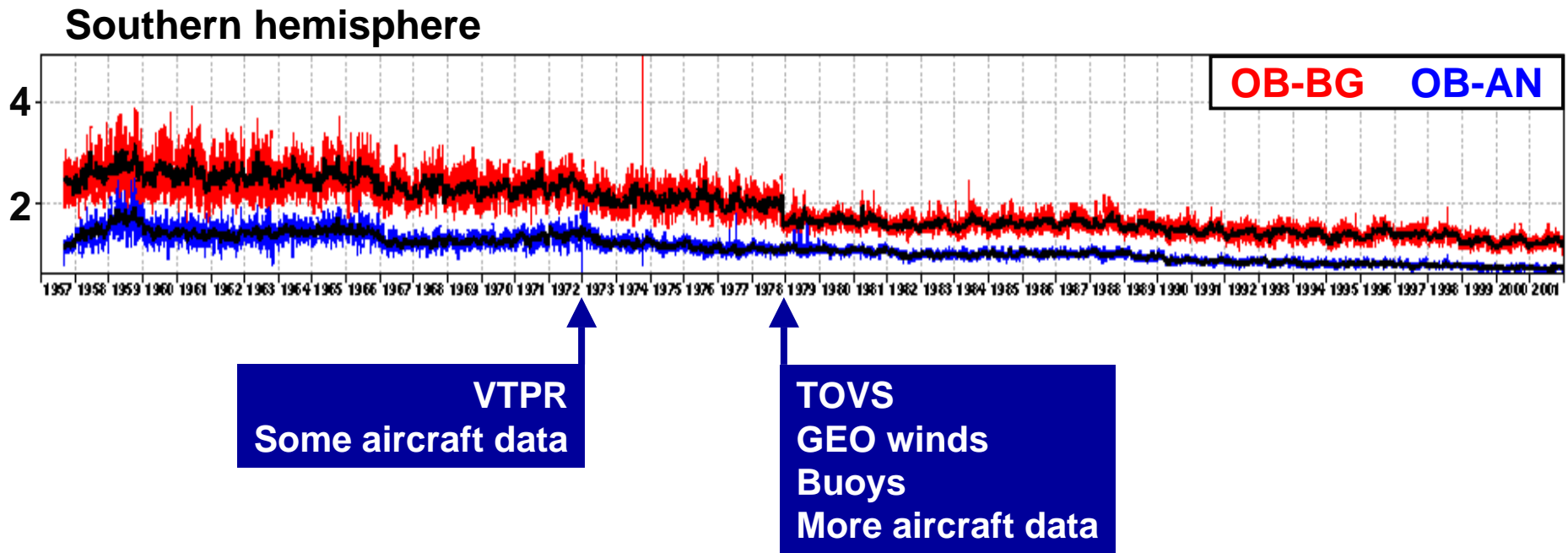


# Conclusions from ERA-40 – General synoptic quality of analyses

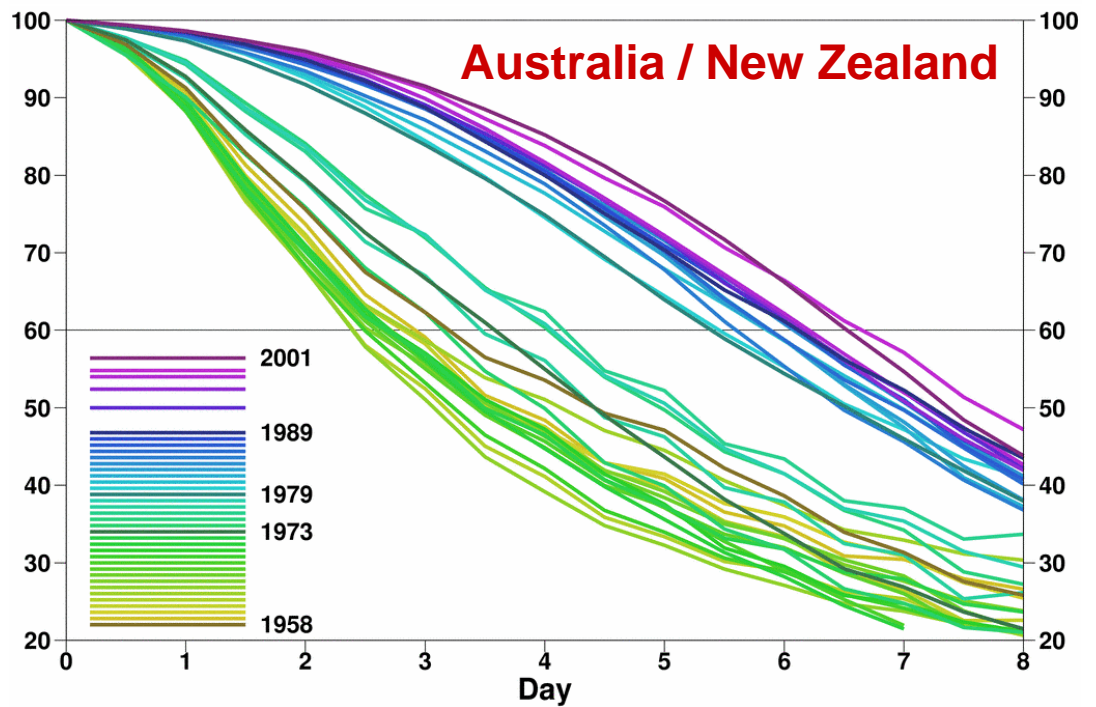
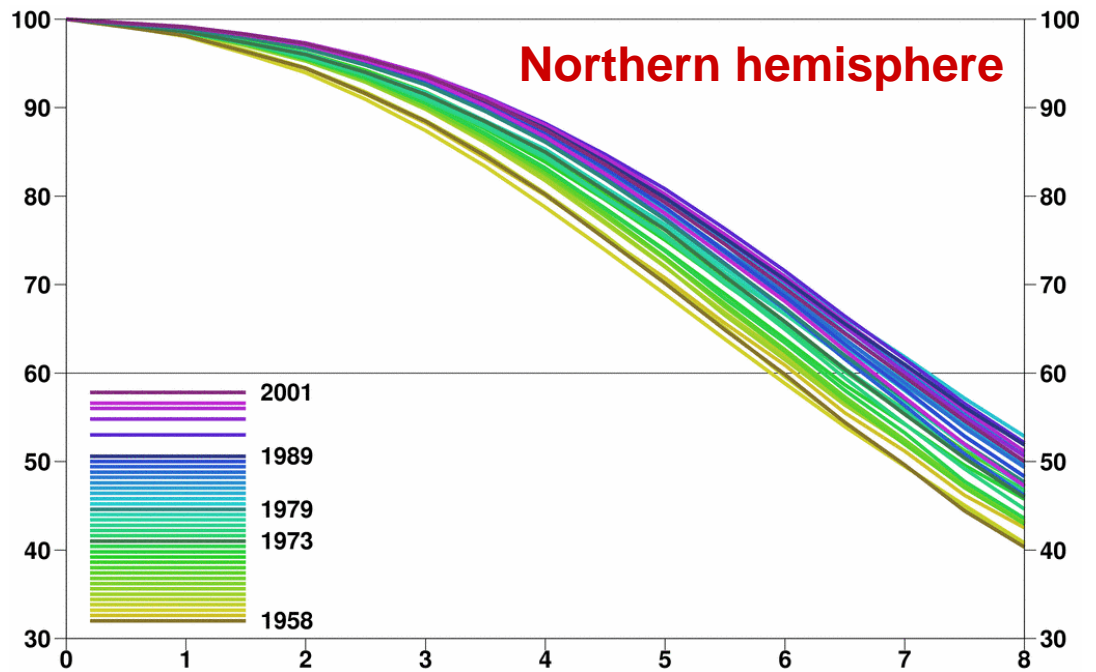
- **Best for most recent years**
- **Quite good throughout for northern hemisphere troposphere and lower stratosphere**
- **Poor in southern hemisphere in early years**
  - **Some improvement in early 1970s**
  - **Big improvement in 1979**



# R.m.s background and analysis fits to SYNOP pressure observations (hPa)



# Anomaly correlations (%) of 500hPa height forecasts

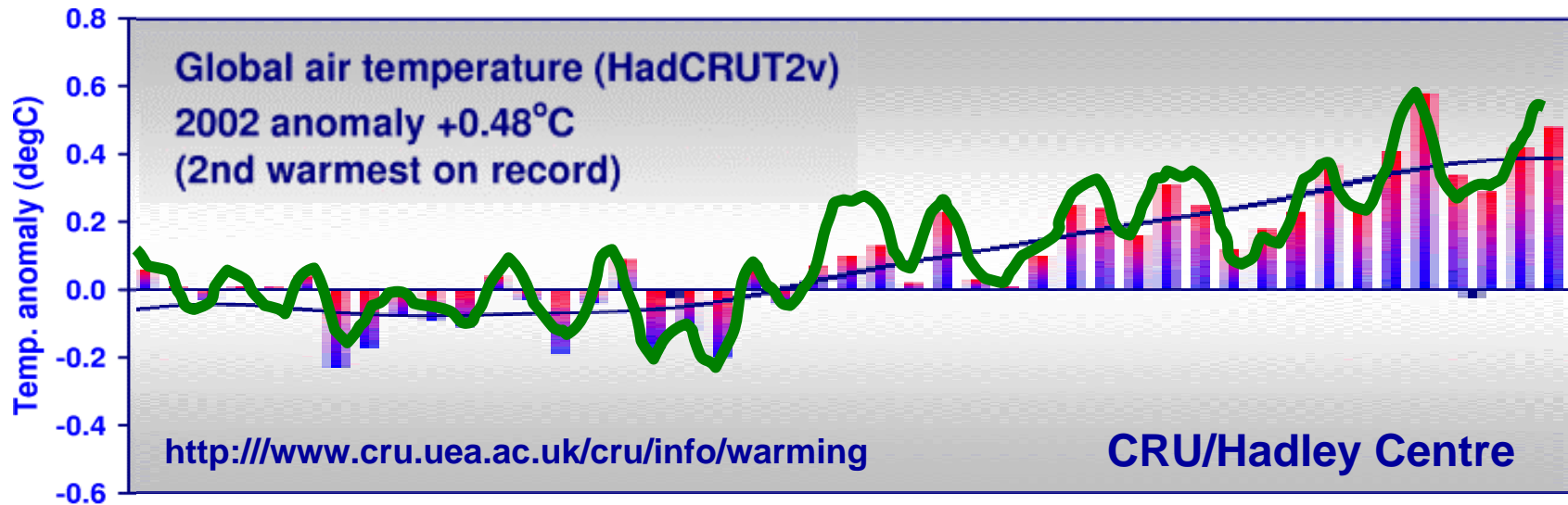
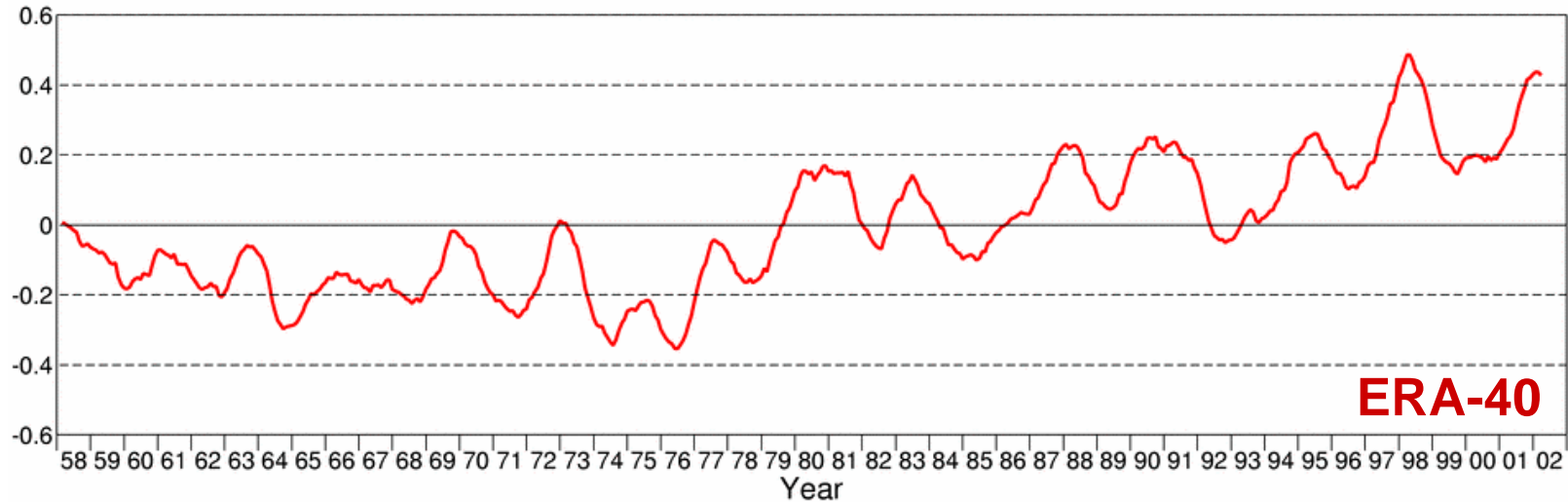


# Trends and interannual variability

- **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

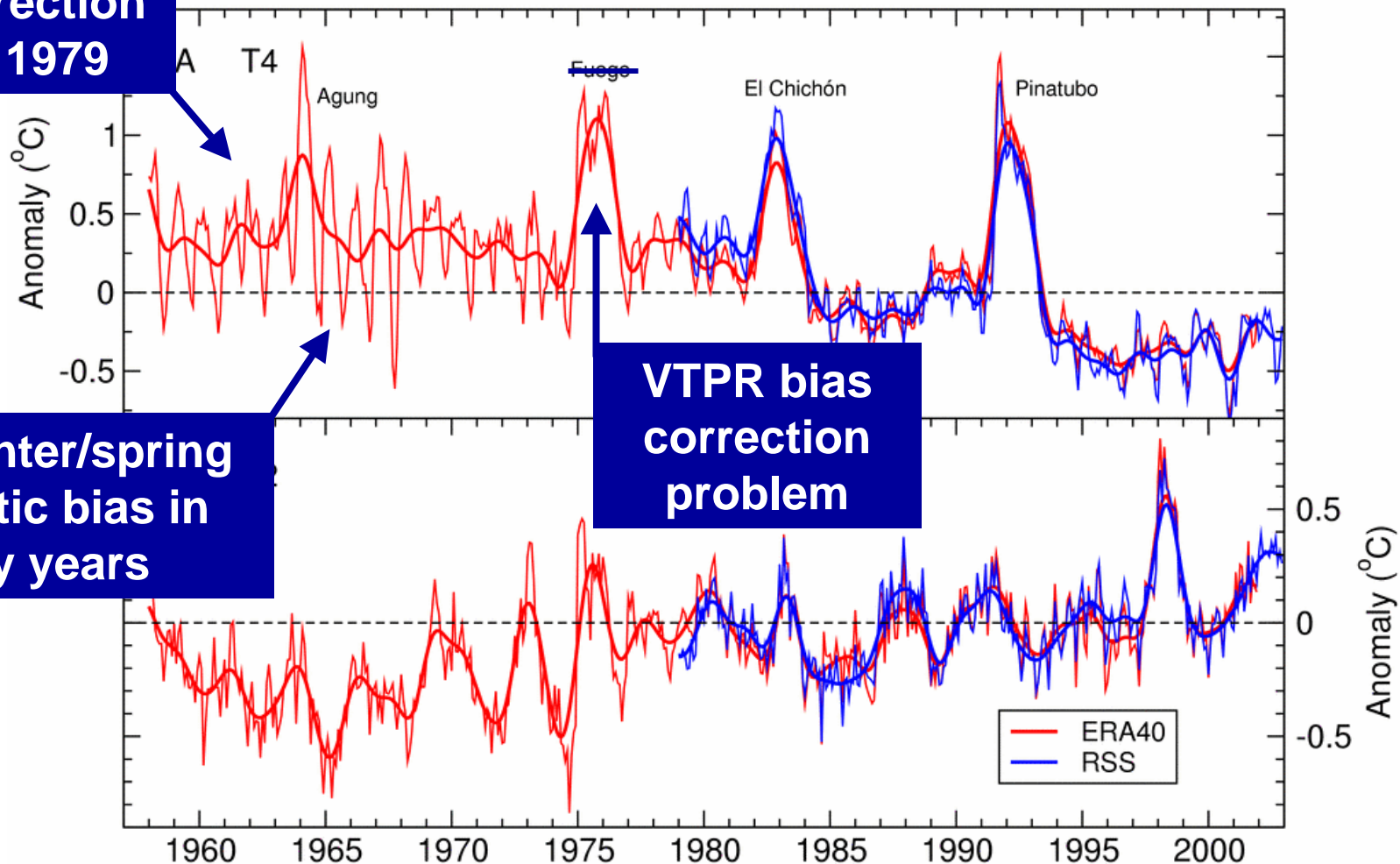
Global-mean two-metre temperature anomaly (Deg C)  
Annual running mean



# Trends and interannual variability (from Ben Santer)

## Changes in Actual and Equivalent MSU Temperatures

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



No sonde bias correction before 1979

Cold winter/spring Antarctic bias in early years

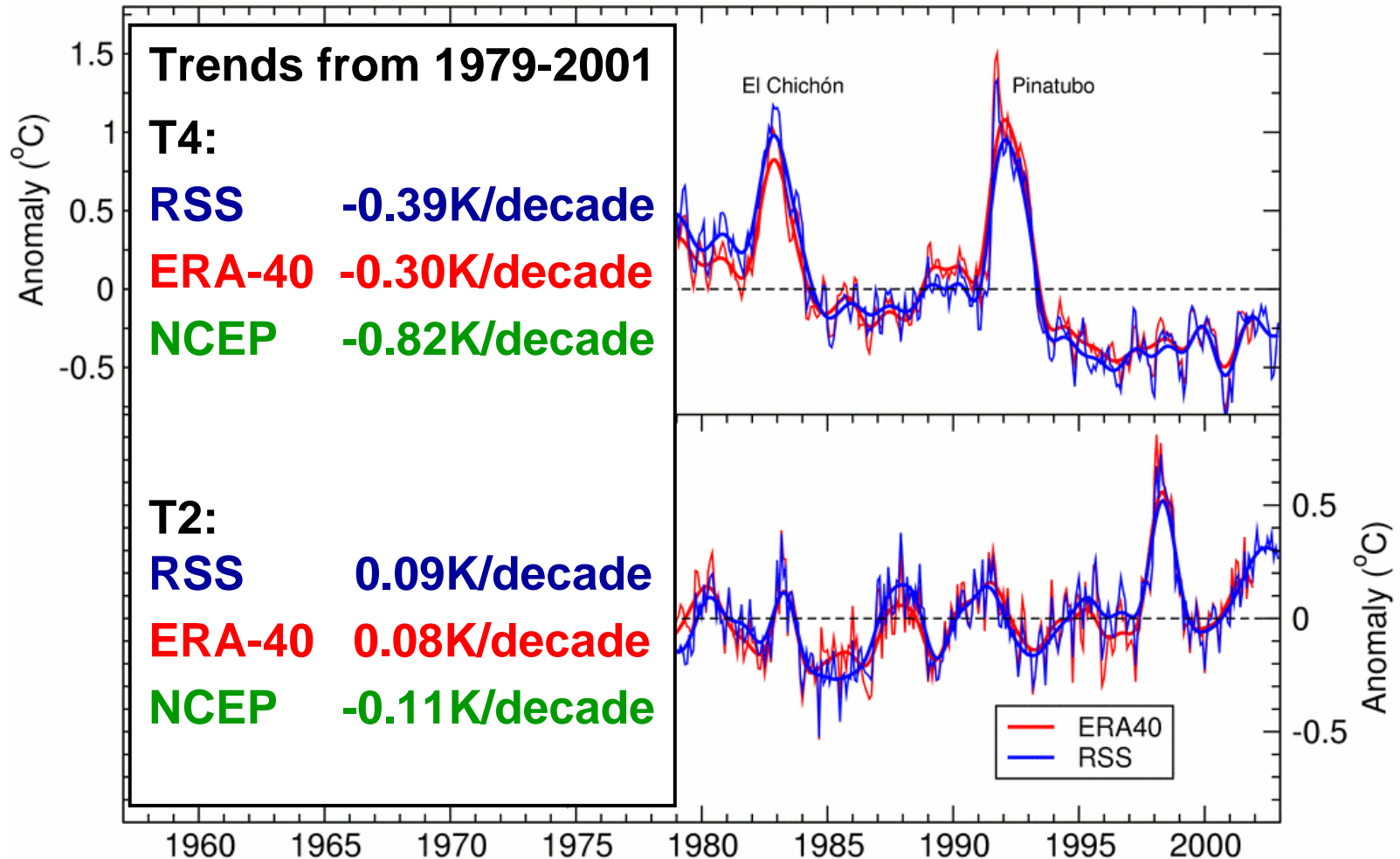
VTPR bias correction problem

ERA40  
RSS

# Trends and interannual variability (from Ben Santer)

## Changes in Actual and Equivalent MSU Temperatures

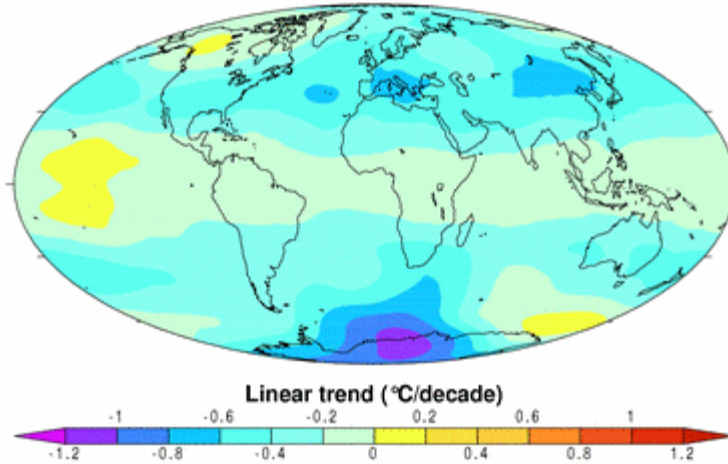
Anomalies w.r.t. 1979-2001. Bold = low-pass filtered



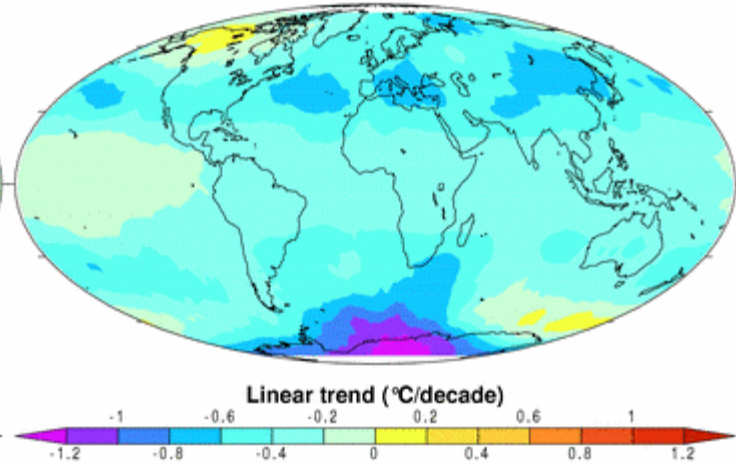
# Trends (from Ben Santer)

T4

A ERA40 linear trend (1979–2001)

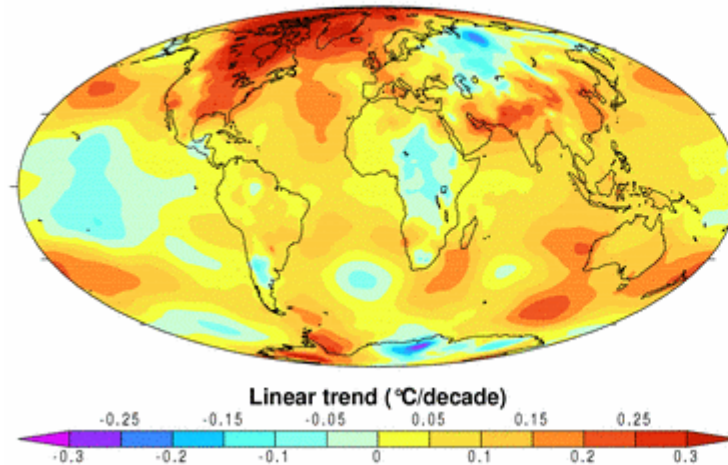


B RSS linear trend (1979–2001)

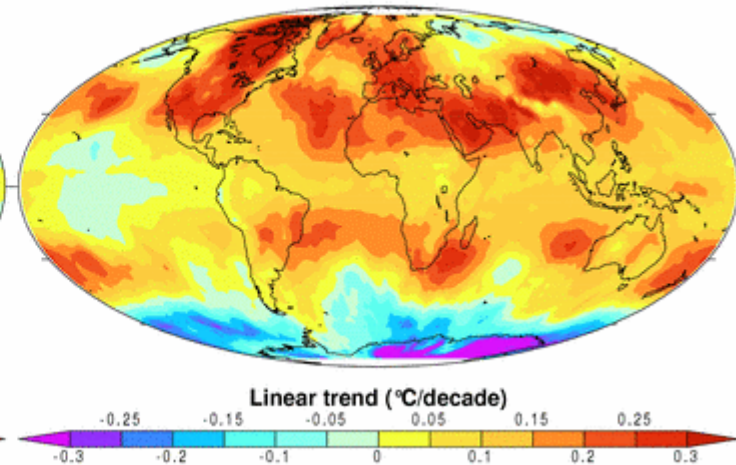


T2

A ERA40 linear trend (1979–2001)



B RSS linear trend (1979–2001)



# 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

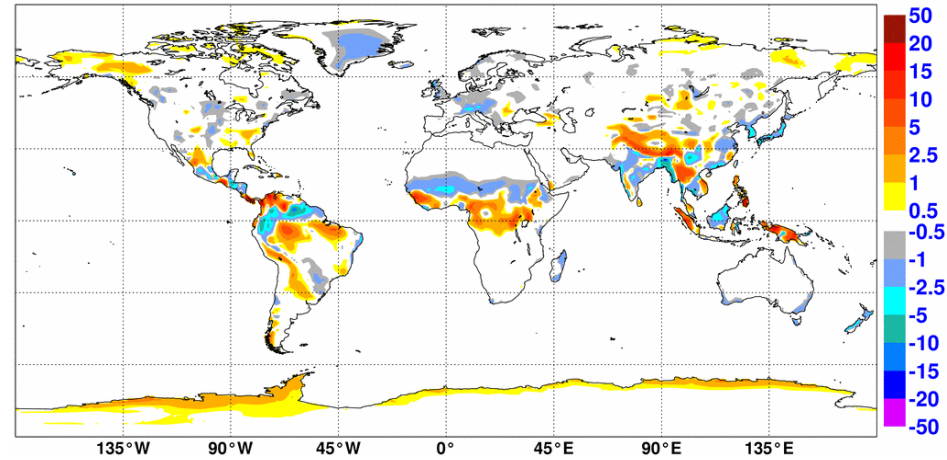
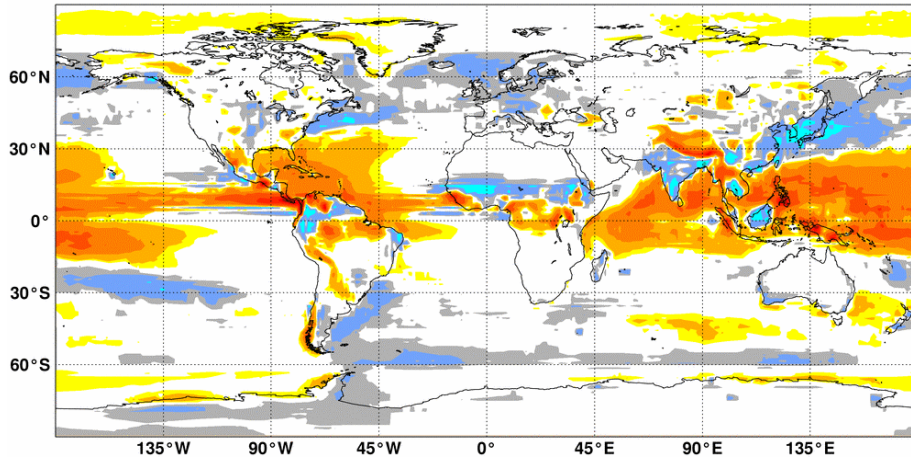


# 0-6h ERA-40 precipitation forecasts (mm/day)

## ERA-40 - GPCP

## JJA, 1986-1995

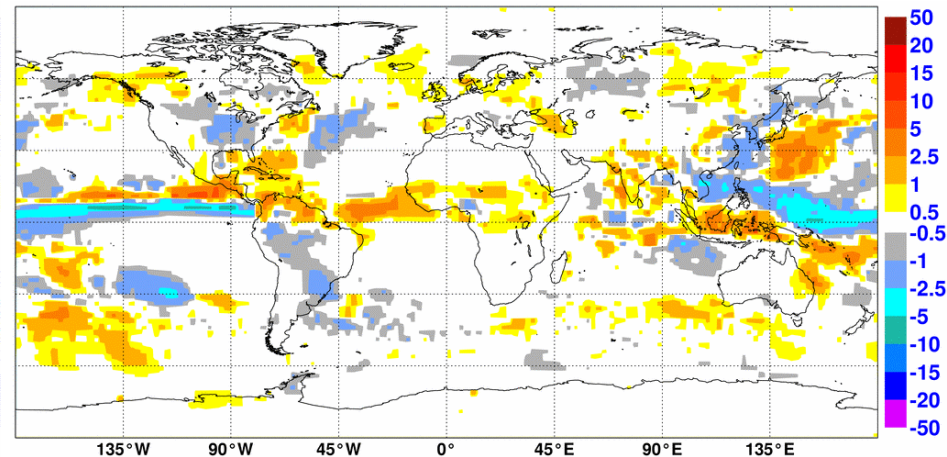
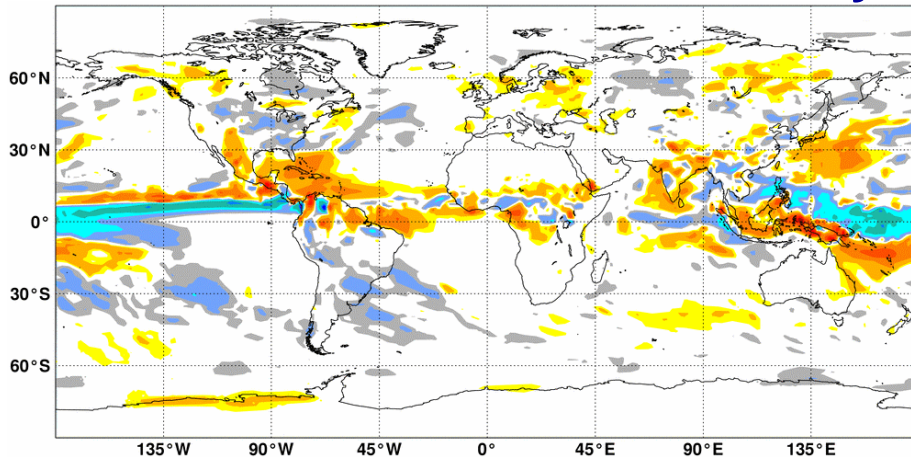
## ERA-40 - CRU



## ERA-40

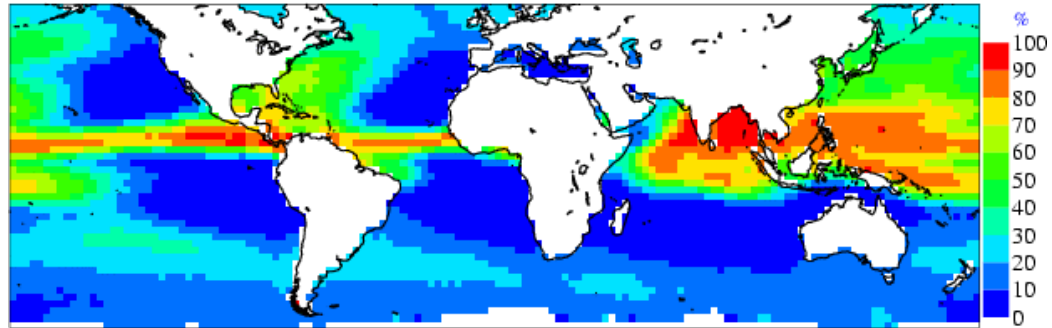
## Anomaly: JJA, 1988

## GPCP

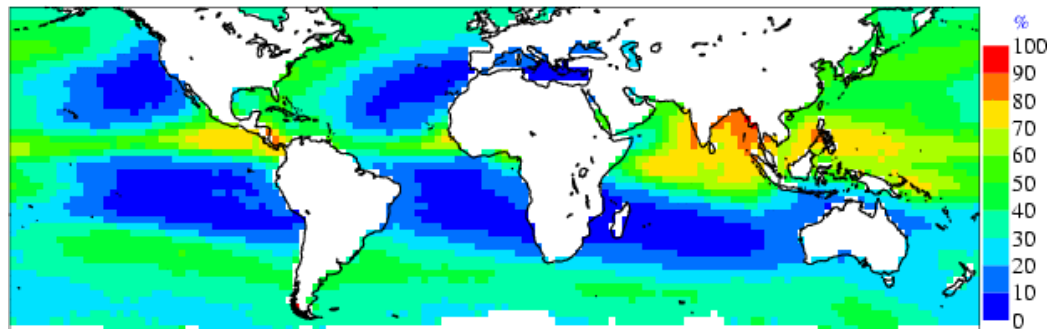


# High cloud occurrence – July

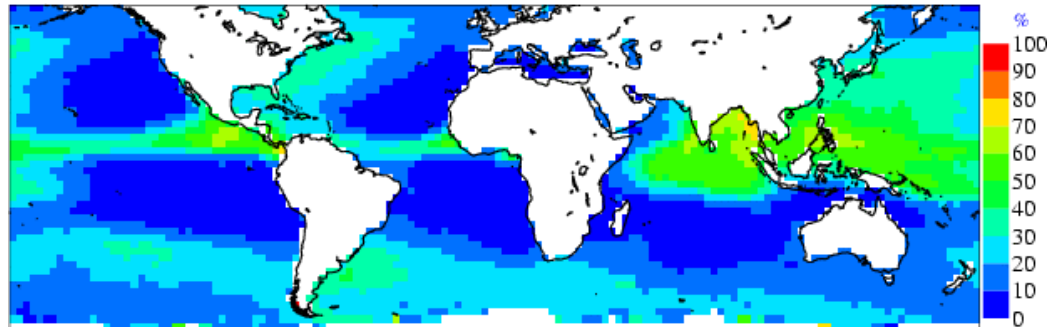
From CO<sub>2</sub>-slicing  
using simulated  
ERA-40 HIRS radiances



From CO<sub>2</sub>-slicing  
using HIRS radiances



ISCCP



*ISCCP detects less thin cirrus than HIRS*

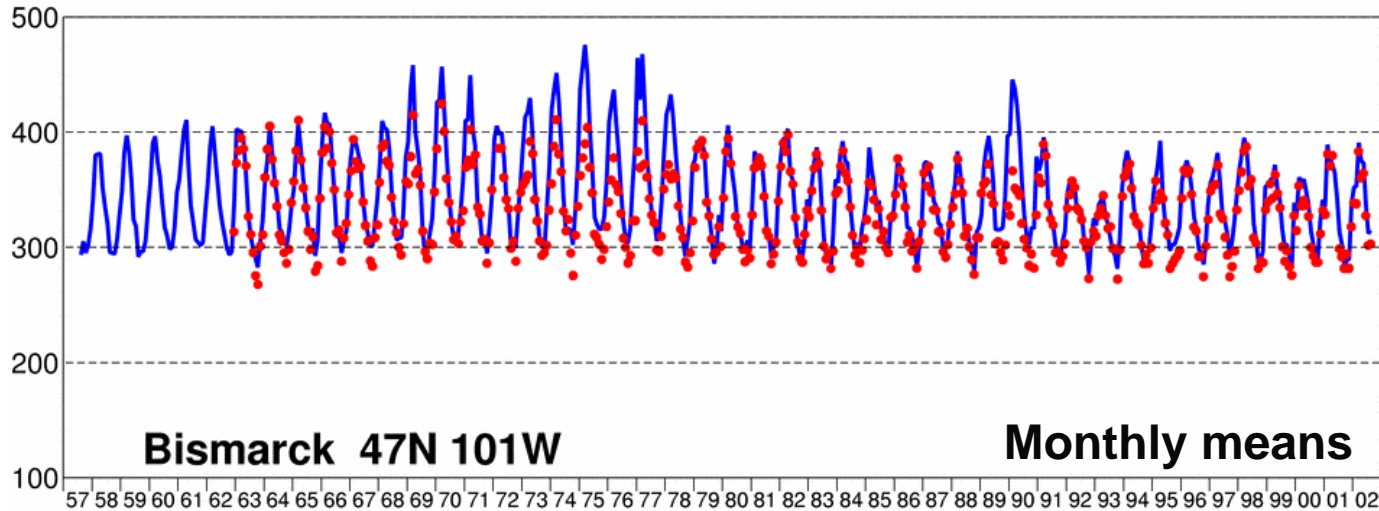
# Stratosphere

- **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

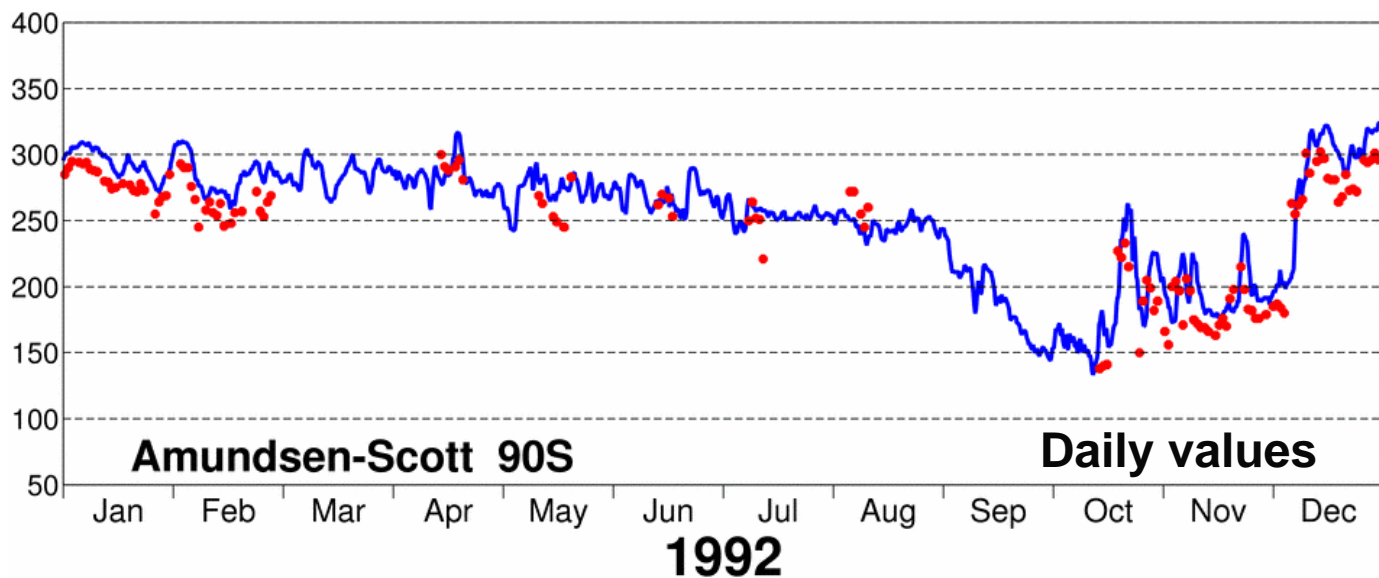
# Monitoring composition: Ozone

(following Pascal Simon, Météo-France)

### Total ozone (Dobson units)



**Blue: ERA-40  
(TOMS and SBUV  
data assimilated  
1979-1988 and  
1991-2002)**



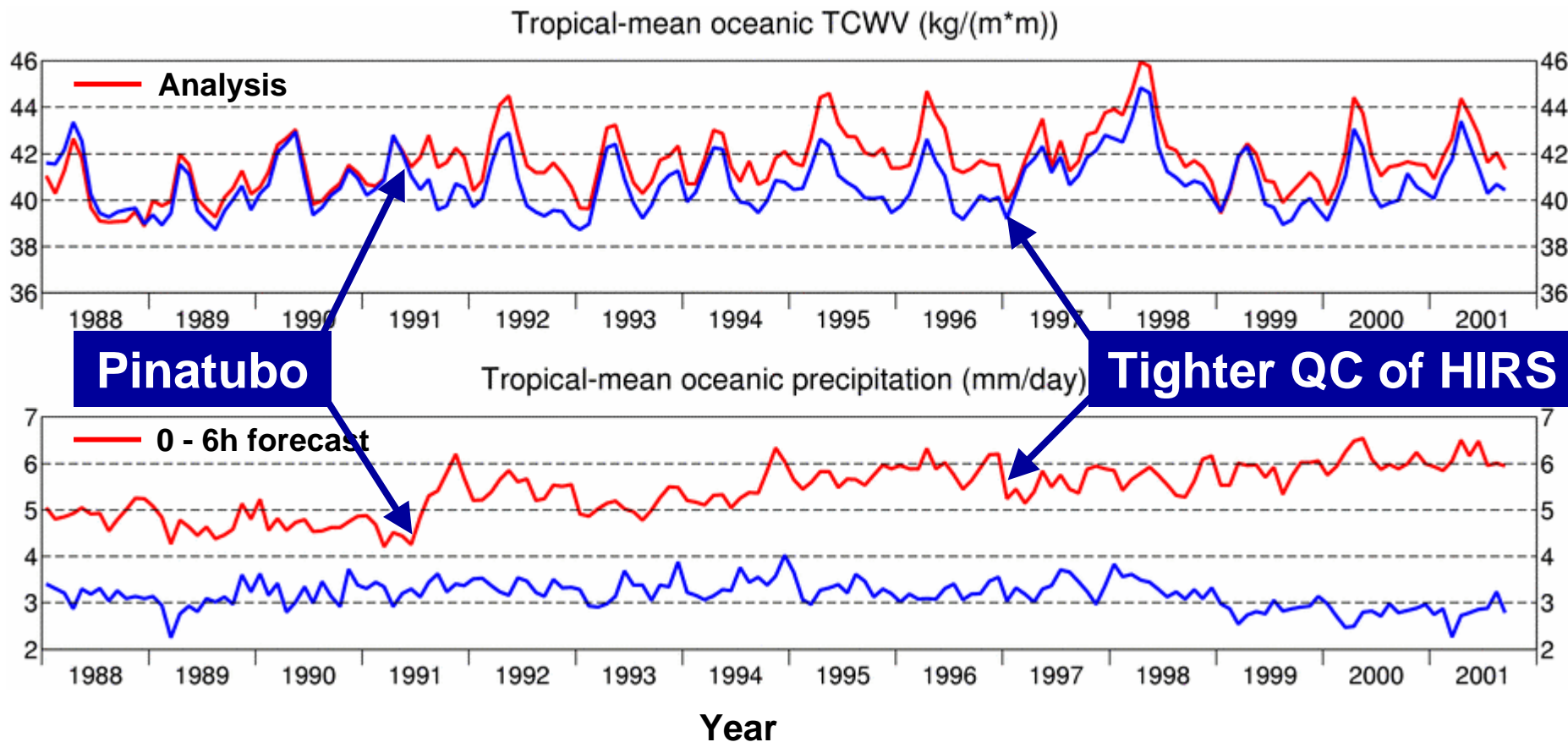
**Red: Ground-based  
measurements  
(NOAA/CMDL)**

# 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

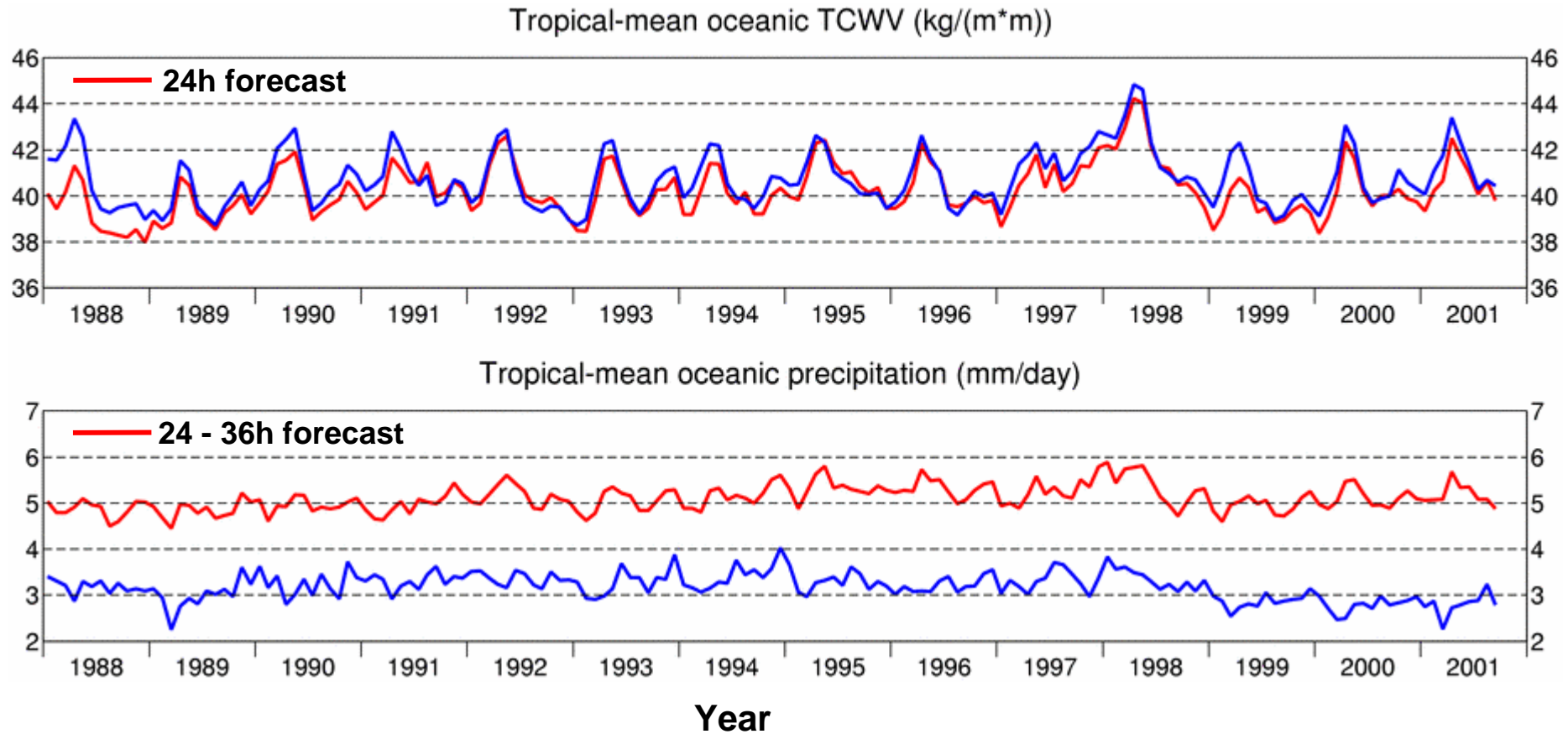
— ERA-40                      — SSM/I retrievals from Remote Sensing Systems



# Short-range forecasts over the tropical oceans

— ERA-40

— SSM/I retrievals from Remote Sensing Systems

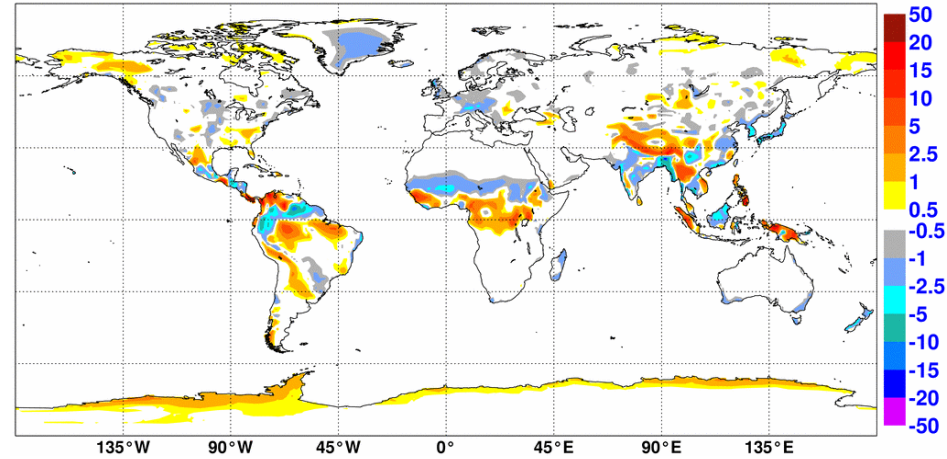
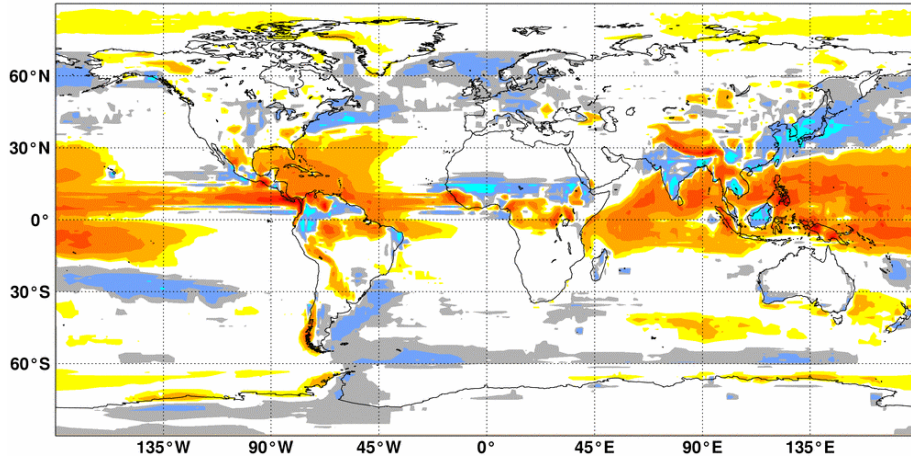


# ERA-40 precipitation JJA, 1986-1995 (mm/day)

## ERA-40 - GPCP

## 0-6h forecasts

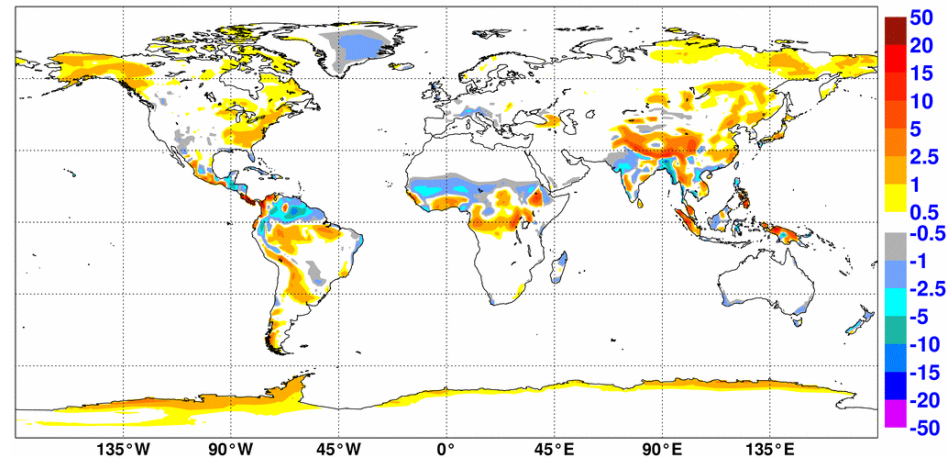
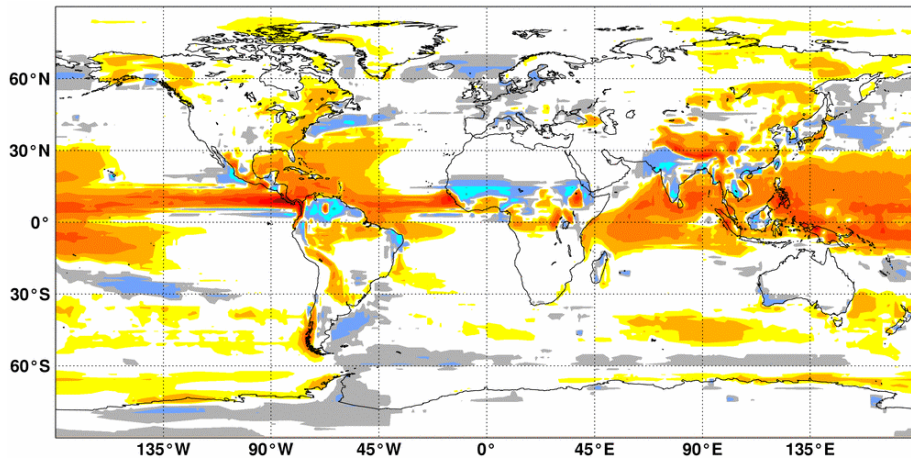
## ERA-40 - CRU



## ERA-40 - GPCP

## 24-36h forecasts

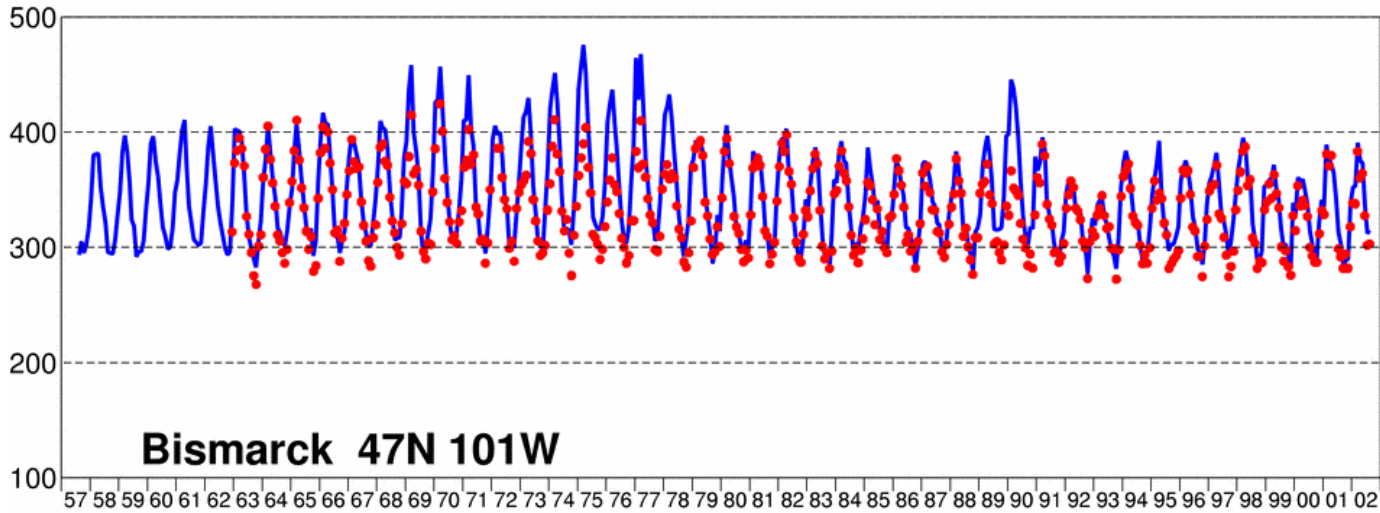
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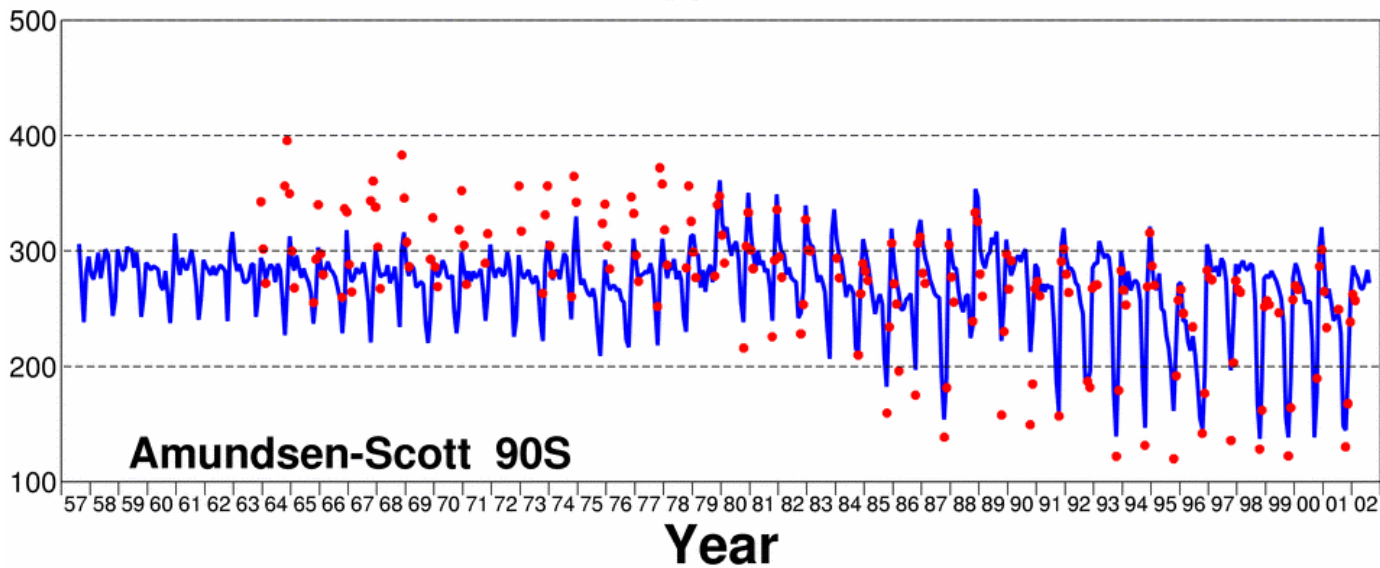


# Total Ozone (Monthly means from 1957 to 2002)

Total ozone (Dobson units)



**Blue: ERA-40  
(TOMS and SBUV  
data assimilated  
1979-1988 and  
1991-2002)**



**Red: Ground-  
based  
measurements  
(NOAA/CMDL)**