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M. Hantel

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Preface

The key selection criteria of this handbook were discussed between the authors and the editorial team of Springer during a 3-day workshop in Vienna in September 2001. The workshop was organized jointly by the *University of Vienna* and the *Austrian Academy of Sciences*; it was funded by the Academy and by the *Federal Ministry for Education, Science and Culture*. Authors and publisher agreed that the book should comprise a set of all relevant climate budget quantities in a maximally standardised form mandatory for all climate subsystems. The format of the edition should be a one-volume printed book plus a DVD. The DVD should carry the data, all original articles in un-abbreviated form, specifically all figures in original colours, plus additional material like animations of the most important climate parameters and selected non-standard quantities.

A first draft version of book and DVD was circulated between authors, editor and publisher in December 2002 for internal review and for the purpose of overall balancing. A second draft has been available through internet since December 2003 for the same purpose and has been widely used by the community of authors.

The global climate system is represented in this book by arranging the data around the budget principle. This principle is basic for the entire climate system. A correct budget alone explains nothing. However, an advanced dynamic theory with an incorrect budget is of no use either. Thus budget climatology is the indispensable minimum upon which any deeper understanding of the system must rest. What we hope to demonstrate with this collection is that budgeting is not only a useful principle but also that “budget-thinking” has practically become state of the art in modern quantitative climatology.

The acknowledgements of the editor go to all persons who, next to the distinguished international authors of the various chapters, have made this edition possible, most notably: to the former and present chairpersons of the Clean Air Commission of the *Austrian Academy of Sciences*, Prof. Dr. Othmar Preining and Prof. Dr. Annemarie Popp; to the team from Springer-Verlag: Prof. Dr. Werner Martienssen (Editor in Chief of Landolt-Börnstein), Dr. Rainer Poerschke (Editorial Director Landolt-Börnstein), and Dr. Christian Meier (Editorial Office Landolt-Börnstein); and finally to my colleagues Dr. Leopold Haimberger, Mag. Markus Kottek and Dipl.-Hydr. Corinna Huhle who in innumerable ways have helped to transform chaotic ideas into coherent arguments, fine coloured pictures and eventually into printed text.

19 March 2005

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3 Data management

3.1 Introduction

The major goal of the data management is to collect and archive a consistent data set of the most important climate elements specifying the present state of the climate. Further, an essential component of the data management was to develop and apply a visualisation-software for the generation of standardised maps, presented as both pictures and animations. All data sets, pictures and animations are part of the digital data archive described in section 3.2.

Emphasis is placed on observational data of established global data sets carefully selected by the authors of the particular chapters on climate elements. Climate elements not observable on a global scale are represented by monthly mean short-range forecast fields from the European Centre for Medium Range Weather Forecast (ECMWF) ERA-40 Reanalysis project ([03Upp]).

Main focus lies on climatologically relevant state and flux quantities at the earth's surface, bottom of atmosphere (BOA), and at the top of atmosphere (TOA) that fulfil the requirements of the budget equations. But also secondary and complex climate elements have been collected. The authors agreed to present monthly climate elements for the 5-year reference period 1991-1995, whenever possible. This reference period has been chosen as a compromise between the fast availability of satellite data from recent sensors, and ground measurements which need a couple of years until they have been collected and archived. Also some climate parameters are not available on a monthly basis.

These parameters are presented here in form of mean annual and seasonal fields derived from all available measurements. The spatial resolution of the fields is 1° in latitude and longitude. Some climate elements are only available with a coarser resolution, usually of 2.5° . The data sets presented in this Landolt-Börnstein issue on *Observed Global Climate* have been provided by the Alfred-Wegener Institut (AWI), the Department of Natural Sciences of the University of Veterinary Medicine Vienna (BioUVR), the Climate Research Unit (CRU) of the University of East Anglia, the Consortium on Estimating the Circulation and Climate of the Ocean (ECCO), the ECMWF (ERA-40), the Global Aerosol Climatology Project (GACP), the Global Precipitation Climatology Center (GPCC), the Global Precipitation Climatology Project (GPCP-V2), the Max-Planck-Institut for Meteorology in Hamburg (HOAPS), the International Satellite Cloud Climatology Project (ISCCP), the International Satellite Land Surface Climatology Project (ISLSCP-2), the Potsdam Institute of Climate Impact Research (LPJ), the University of New Hampshire and the Global Runoff Data Center (UNH/GRDC), the Vienna University of Technology (VUT), the Center for Environmental Systems of the University of Kassel (WaterGAP) and the World Ocean Circulation Experiment (WOCE). The NASA provides several satellite estimates, data from the Moderate Resolution Imaging Spectroradiometer (MODIS), the NASA Water Vapor Project (NVAP), the Total Ozone Mapping Spectrometer (TOMS) and TIROS Operational Vertical Sounder (TOVS). A description of these 20 data sets is given in section 3.2 and a selection of the most important climate maps is presented in Chapter 17. In section 3.3 some selected features of the global climate depicted in the animated data on the DVD are described.

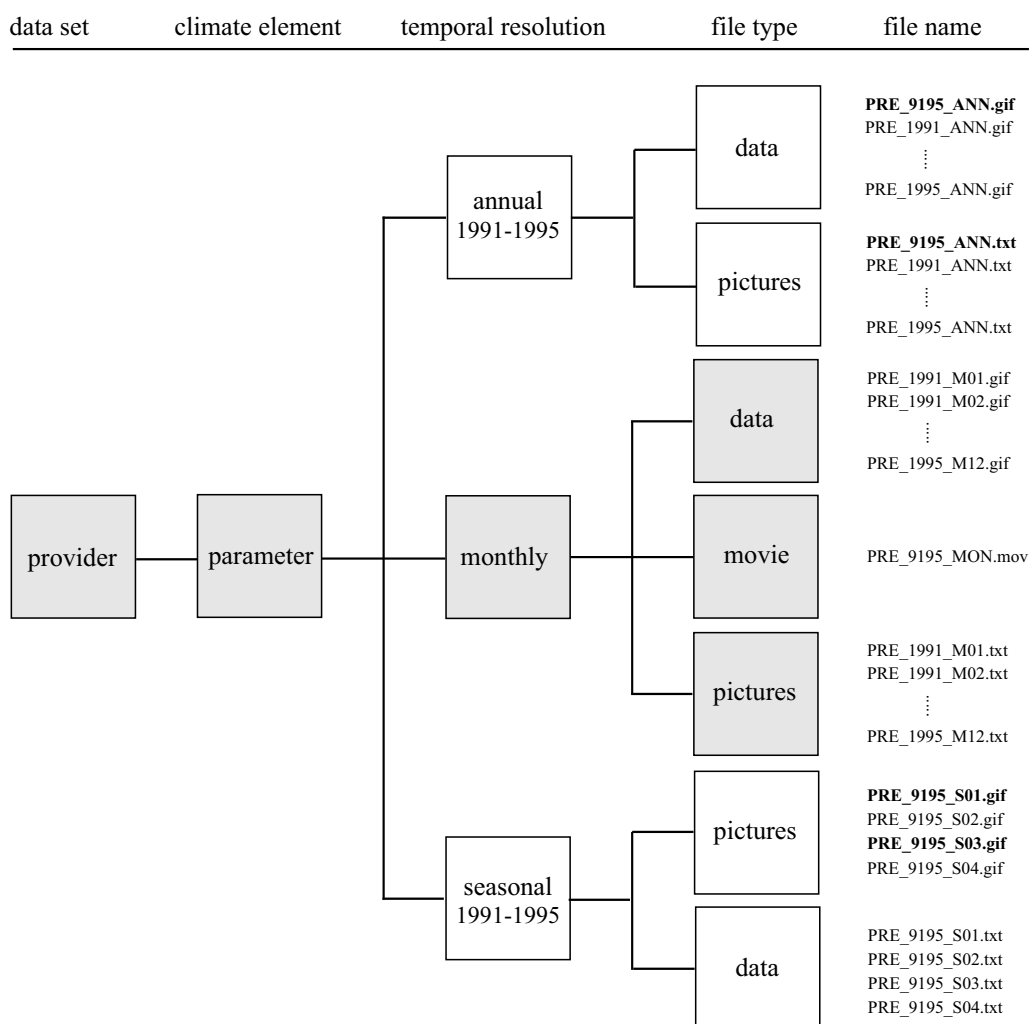


Fig. 3.1. Flow chart of the Landolt-Börnstein data archive. The data are archived by data set, climate element, temporal resolution and file type, respectively. Grey shaded boxes indicate the basic data set stored as time series of monthly fields and pictures. Additionally these pictures have been animated and are available as a movie. White boxes indicate the annual and seasonal averages for the period 1991-1995. The right column depicts as an example the file names for a precipitation data set (PRE). The file names distinguish between annual (ANN), monthly (MON, M01, M02, ..., M12) and seasonal (S01, S02, ..., S04) files for the entire period 1991-1995 (9195) or single years (1991, 1992, ..., 1995). Here M01, M02, ..., M12 denotes the month (J)anuary, (F)ebuary, ..., (D)ecember; S01, S02, ..., S04 denotes the seasons DJF, MAM, JJA and SON. The extension refers to either the ASCII text format (.txt), the picture format (.gif) or the movie format (.mov, QuickTime Player recommended). These data formats are readable on all computer platforms and may be adapted for all common operation systems (Linux, MacOS and Windows). Note that the bold marked files (pictures) are also printed in the maps of Chapter 17 as contour plots. The other pictures are exclusively presented in digital form on the DVD.

3.2 The digital data archive

The complete data archive compiled for the present issue is exclusively available in digital form on the enclosed DVD. It contains a collection of 20 data sets provided by international climate centres and/or international research projects with a total of more than 100 climate elements. The majority of these is defined at BOA, some are defined at TOA, some are also defined on a 3-dimensional grid. A selection of the data archive is provided in Chapter 17.

The structure of the digital data archive is explained in Fig. 3.1. The highest level of organisation contains the climate data sets, termed by their short names. They have been alphabetically arranged and will be discussed in the next section. Each of these data sets contains sub-directories for the climate elements provided by this specific data set. At the next level the temporal resolution is represented by sub-directories for annual, seasonal and monthly data sets. The final level of organisation contains the data, picture and movie files. The pictures and movies have been visualised using two different projections, the equal area ($\lambda, \sin\varphi$)-projection for the globe and the equal area Lambert projection for the polar caps (not explicitly depicted in Fig. 3.1).

In the following sections the data sets archived on the DVD (section 3.2.1), the files of the climate elements (section 3.2.2), the pictures and movies compiled from these files (section 3.2.3) and the global climate maps (section 3.2.4) are introduced.

3.2.1 Description of the data sets

In this section the climate data sets archived on the DVD are tabled and discussed in detail. Both the climate data sets as well as the selection presented as maps in the print version have been chosen in accordance with all authors involved. Thereby the priority has been given to comparability, that is the reference period 1991-1995 and the spatio/temporal resolution respectively. Some climate elements are not observable, they are taken from model calculations.

The digital climate data sets are listed alphabetically. The first data set description refers to the provider, often identical with the name of the data set. Approximately half of the original data archived for this issue on Landolt-Börnstein are available free of charge via the internet. For that reason, the next point describing the data set is the internet address where potential users may download the original data. If the data set is not available via the internet, then the internet address of the research project or the organisation generating the data is given. Further, the main references for the data set is given.

The next specification refers to the data. This is the period for which the data are available. The criterion for selection of data sets to be archived was firstly the coverage of the reference period 1991-1995. This time series criterion was given highest priority although quite a few of the data sets is available for a much longer time period as indicated by this description.

The next criterion for selection was the resolution. The authors tried to present data sets with a minimal resolution of 1 degree/monthly. For some data sets, it was not possible to fulfil both of these criteria, reference period and resolution. In these cases it was decided to select those data sets that are available for the reference period rather than those with the required resolution. Examples are the GPCP-V2 and the ISCCP data sets which have a resolution of 2.5 degree/monthly.

Of all data sets archived, the ERA-40 data set takes an exceptional position. The ERA-40 data are available partly as spherical harmonics coefficients with a triangular truncation up to wavenumber 159 (T159, comparable with 1.125 degrees horizontal resolution) and partly on a reduced Gaussian grid corresponding to the T159 spectral resolution (see Chapter 9). The spectral coefficients can be transformed exactly to a 1.0 degree regular grid. However, most surface data are originally defined on the Gaussian grid and have been interpolated linearly to a 1 degree regular latitude/longitude grid, knowing that the real horizontal resolution is slightly coarser. Further, for each of the data sets a description of coverage (global, land areas, sea areas, with or without Antarctica, etc.) is given.

The final specification listed concerns the parameters of each data set. Some data sets, e.g. GPCC, contain only one climate element, others contain a lot of climate elements, e.g. ERA-40 provides 32 parameters. Further, for each parameter a 3 digit short name (e.g. IBF for ice balance flux), corresponding to those used in the printed maps (Chapter 17), as well as the physical unit is given.

Table of global climate data sets selected for the digital archive

AWI - Alfred-Wegener-Institut Greenland and Antarctica Ice Data

Provider	Alfred-Wegener-Institut für Polar und Meeresforschung, Germany
Internet	http://www.awi-bremerhaven.de/
References	[00Huy], [02Huy]
Period	1950 - 2000
Resolution	20 km/annual
Coverage	Greenland and Antarctica
Parameters	Ice balance flux (IBF), unit 10^{-3} km ² /year Ice flow direction (IFD), unit ° Ice thickness (ITH), unit m Surface mass balance (SMB), unit m/year

BioUVR - The Biologically-effective UV Radiation data set

Provider	Department of Natural Sciences, University of Veterinary Medicine Vienna, Austria
Internet	http://i115srv.vu-wien.ac.at/uv/uv_online.htm/
References	[02Sch]
Period	01.11.1978 - 06.05.1993
Resolution	1.0 degree/daily
Coverage	Global
Parameters	Erythemat ultraviolet radiation daily dose (UV ₋), unit kJ/m ² d Erythemat ultraviolet radiation daily maximum (UVI), unit W/m ²

CRU05 - The Climate Research Unit data set

Provider	Climate Research Unit, University of East Anglia, UK
Internet	http://www.cru.uea.ac.uk/
References	[95Hul], [00New]
Period	1901 - 1998
Resolution	0.5 degree/monthly
Coverage	Land areas without Antarctica
Parameters	Cloud cover (CLD), unit Oktas Diurnal temperature range (DTR), unit K Precipitation (PRE), unit mm/d Wet day frequency (WDF), unit days/month Temperature (T2M), unit °C Vapour pressure (VAP), unit hPa Permafrost thawing depth (PER), unit m

ECCO - The consortium on Estimating the Circulation and Climate of the Ocean

Provider	ECCO Consortium
Internet	http://www.ecco-group.org
References	[02Sta1], [02Sta2]
Period	1992 - 2002
Resolution	1.0 degree/monthly
Coverage	Sea areas
Parameters	Zonal barotropic velocity (UBT), unit 10^{-2} m/s Meridional barotropic velocity (VBT), unit 10^{-2} m/s Zonal Ekman velocity (UEK), unit 10^{-2} m/s Meridional Ekman velocity (VEK), unit 10^{-2} m/s Zonal mass flux (MFU), unit 10^3 kg/(m s) Meridional mass flux (MFV), unit 10^3 kg/(m s) Sea surface height (SSH), unit m Sea surface temperature (SST), unit $^{\circ}\text{C}$ Sea surface salinity (SSS), unit psu

ERA-40 - The ECMWF Re-Analyses

Provider	European Centre for Medium-Range Weather Forecasts, UK
Internet	http://www.ecmwf.int/research/era/
References	[00Sim], [03Upp]
Period	September 1957 - August 2003
Resolution	Spectral resolution T159, 60 vertical levels/6-hourly Linear Gaussian grid corresponding to T159 (1.125 degrees)
Coverage	Global
Parameters	Surface albedo (ALB), unit % 2 m dewpoint (D2M), unit $^{\circ}\text{C}$ 2 m dewpoint spread (S2M), unit $^{\circ}\text{C}$ 2 m temperature (T2M), unit $^{\circ}\text{C}$ 2 m specific humidity (Q2M), unit g/kg 10 m zonal wind speed (U10), unit m/s 10 m meridional wind speed (V10), unit m/s Zonal wind stress (WSU), unit 10^{-2} N/m ² Meridional wind stress (WSV), unit 10^{-2} N/m ² Cloud cover (TCC), unit % Cloud cover of high clouds (HCC), unit % Cloud cover of midlevel clouds (MCC), unit % Cloud cover of low clouds (LCC), unit % Surface sensible heat flux (SH.), unit W/m ² Surface latent heat flux (LH.), unit W/m ² Evaporation (EVA), unit mm/d Energy flux divergence (EFD), unit W/m ² Moisture flux divergence (WFD), unit 10^{-6} kg/(m ² s) Sea level pressure (MSL), unit hPa Surface pressure (PSU), unit hPa Total ozone (O3.), unit DU Sea ice fraction (SIF), unit % Snow cover depth (SND), unit % Sea surface temperature (SST), unit $^{\circ}\text{C}$ Total column water (TCW), unit kg/m ² Total energy (TOE), unit 10^8 J/m ² Zonal mass flux (MFU), unit 10^3 kg/(m s)

Meridional mass flux (MFV), unit $10^3 \text{ kg}/(\text{m s})$
 Zonal energy flux (EFU), unit 10^8 W/m
 Meridional energy flux (EFV), unit 10^8 W/m
 Zonal moisture flux (WFU), unit $\text{kg}/(\text{m s})$
 Meridional moisture flux (WV), unit $\text{kg}/(\text{m s})$

GACP - The Global Aerosol Climatology Project data set

Provider NASA Goddard Institute for Space Studies, USA
 Internet <http://gacp.giss.nasa.gov/>
 References [99Mis]
 Period July 1983 - September 2001
 Resolution 1.0 degree/monthly
 Coverage Sea areas
 Parameters Aerosol optical thickness (AOT), unit 1

GPCC - The Global Precipitation Climatology Center full data product

Provider Global Precipitation Climatology Center, German Weather Service
 Internet <http://gpcc.dwd.de>
 References [03Rud]
 Period 1951 - 2004
 Resolution 0.5 degree/monthly
 Coverage Land areas
 Parameters Precipitation (PRE), unit mm/d

GPCP-V2 - The Global Precipitation Climatology Project Version 2 product

Provider Laboratory for Atmospheres, NASA Goddard Space Flight Center, USA
 Internet <http://precip.gsfc.nasa.gov/>
 References [97Huf]
 Period 1979 - 2004
 Resolution 2.5 degree/monthly
 Coverage Global
 Parameters Precipitation (PRE), unit mm/d

HOAPS - The Hamburg Ocean Atmosphere Parameters and Fluxes from Satellite Data

Provider Max-Planck-Institut für Meteorologie Hamburg, Germany
 Internet <http://www.hoaps.zmaw.de/>
 References [00Gra], [02Jos]
 Period July 1987 - December 2002
 Resolution 1.0 degree/monthly
 Coverage Sea areas, excluding Arctic and Antarctic regions
 Parameters Evaporation (EVA), unit mm/d
 Fresh water flux (FWF), unit mm/d
 Latent heat flux (LH.), unit W/m^2
 Precipitation (PRE), unit mm/d
 Sea surface temperature (SST), unit $^{\circ}\text{C}$
 Sensible heat flux (SH.), unit W/m^2

Surface terrestrial radiation (STR), unit W/m^2
 Specific humidity (Q2M), unit g/kg
 Specific humidity at sea surface temperature (QST), unit g/kg
 Wind speed (WSP), unit m/s

ISCCP - The International Satellite Cloud Climatology Project data set

Provider NASA Goddard Institute for Space Studies, USA
 Internet <http://isccp.giss.nasa.gov/>
 References [04Ros], [04Zha]
 Period July 1983 - September 2001
 Resolution 2.5 degree/monthly
 Coverage Global
 Parameters Surface downward solar radiation (SDS), unit W/m^2
 Surface upward solar radiation (SUS), unit W/m^2
 Surface net solar radiation (SSR), unit W/m^2
 Surface downward terrestrial radiation (SDT), unit W/m^2
 Surface upward terrestrial radiation (SUT), unit W/m^2
 Surface net terrestrial radiation (STR), unit W/m^2
 Surface net radiation (SNR), unit W/m^2
 Surface solar albedo (ALB), unit 1
 TOA downward solar radiation (TDS), unit W/m^2
 TOA upward solar radiation (TUS), unit W/m^2
 TOA net solar radiation (TSR), unit W/m^2
 TOA upward terrestrial radiation (TUT), unit W/m^2
 TOA net terrestrial radiation (TTR), unit W/m^2
 TOA net radiation (TNR), unit W/m^2
 TOA solar albedo (TAL), unit 1
 Photosynthetically active radiation (PAR), unit W/m^2
 Net radiation flux divergence (RFD), unit W/m^2
 Cloud amount (CA_), unit %
 Cloud amount of low clouds (CAL), unit %
 Cloud amount of midlevel clouds (CAM), unit %
 Cloud amount of high clouds (CAH), unit %
 Cloud top pressure (CTP), unit hPa
 Cloud top temperature minus surface temperature (TCS), unit K

ISLSCP 2 - The International Satellite Land Surface Climatology Project, Initiative II data archive

Provider ISLSCP scientific community, NASA Goddard Space Flight Center, USA
 Internet http://islsdp2.sesda.com/ISLSCP2_1/html_pages/islsdp2_home.html
 References [03Hal]
 Period 1986 - 1995
 Resolution 1.0 degree/monthly
 Coverage Global
 Parameters Snow cover extent (SCE), unit %
 Sea ice concentration (SIF), unit %

LPJ - The Lund-Potsdam-Jena Dynamic Global Vegetation Model data set

Provider	Potsdam Institute of Climate Impact Research, Germany
Internet	http://www.pik-potsdam.de/lpj/
References	[01Cra], [03Sit], [04Ger]
Period	1901 - 2000
Resolution	0.5 degree/monthly (except NEP: 0.5 degree/yearly)
Coverage	Land areas, excluding Arctic and Antarctic regions
Parameters	Evapotranspiration (ETR), unit mm/d Soil water content (SWC), unit mm Net primary production (NPP), unit g C/m ² d Net biome production (NBP), unit g C/m ² d Simulated runoff (RUN), unit mm/d

MODIS - The Moderate Resolution Imaging Spectroradiometer data set

Provider	NASA Goddard Space Flight Center, USA
Internet	http://modis.gsfc.nasa.gov/
References	[02Fri]
Period	15. Oct 2000 - 15. Oct 2001
Resolution	1.0 degree
Coverage	Global
Parameters	Land cover (COV), unit 1

NVAP - The NASA Water Vapor Project data set

Provider	NASA Langley Research Center, USA
Internet	http://www.stcnet.com/projects/nvap.html
References	[96Ran]
Period	1988 - 1999
Resolution	1.0 deg/monthly
Coverage	Global
Parameters	Precipitable water above surface (VAP), unit mm Precipitable water from surface to 700 hPa (VL1), unit mm Precipitable water from 700 hPa to 500 hPa (VL2), unit mm Precipitable water from 500 hPa to 300 hPa (VL3), unit mm

TOMS - The Total Ozone Mapping Spectrometer data set

Provider	NASA Goddard Space Flight Center, USA
Internet	http://jwocky.gsfc.nasa.gov/
References	[98McP], [93Her]
Period	01.11.1978 - 06.05.1993 (Nimbus-7), 22.08.1991 - 24.11.1994 (Meteor-3)
Resolution	1.25x1.0 degree/monthly
Coverage	Global
Parameters	Ozon(O3-), unit DU, Nimbus-7 Erythemal ultraviolet radiation (UV-), unit kJ/m ² d, Meteor-3

TOVS Path B - The TIROS Operational Vertical Sounder Path B data set

Provider	NASA Goddard Space Flight Center, USA
Internet	http://www.ozonelayer.noaa.gov/action/tovs.htm
References	[99Sco]
Period	December 1986 - June 1995
Resolution	1.0 degree/monthly
Coverage	Global
Parameters	Cloud top pressure (CTP), unit hPa Cloud top temperature minus surface temperature (TCS), unit K Effective cloud amount (ECA), unit % Effective cloud amount of low clouds (ECL), unit % Effective cloud amount of midlevel clouds (ECM), unit % Effective cloud amount of high clouds (ECH), unit % Total column water vapor content (VAP), unit cm Surface to 700 hPa column water vapor content (VL1), unit cm 700 hPa to 500 hPa column water vapor content (VL2), unit mm 500 hPa to 300 hPa column water vapor content (VL3), unit mm Above 300 hPa column water vapor content (VL4), unit 10^{-1} mm

UNH/GRDC - The University of New Hampshire / Global Runoff Data Center Composite Runoff Fields V 1.0

Provider	University of New Hampshire, USA Global Runoff Data Center, Koblenz, Germany
Internet	http://www.grdc.sr.unh.edu/
References	[99Fek]
Period	All available measurements
Resolution	0.5 degree/longtime monthly means
Coverage	Land areas without Antarctica
Parameters	Observed discharge (RUN), unit mm/d

VUT - The Vienna University of Technology Soil Moisture Data Set

Provider	Institute of Photogrammetry and Remote Sensing, Vienna University of Technology, Austria
Internet	http://www.ipf.tuwien.ac.at/radar/ers-scat/
References	[99Wag], [03Wag]
Period	1992 - 2000
Resolution	50 km/weekly
Coverage	Land areas without Antarctica
Parameters	Soil water index (SWI), unit %

WaterGAP - The Water Global Analysis and Prognosis data set

Provider	University of Kassel, Center for Environmental Systems Research, Germany
Internet	http://www.usf.uni-kassel.de/grid/projects/watergap.htm
References	[03Doe], [03Alc]
Period	1901 - 1998
Resolution	0.5 degree/yearly
Coverage	Land areas without Antarctica
Parameters	Simulated River Discharge (SRD), unit 10^7 m ³ /year

WOCE - The World Ocean Circulation Experiment data set

Provider	WOCE International Project Office, UK
Internet	http://www.woce.org/
References	[01Lin]
Period	1990 - 2002
Resolution	0.5 degree/annual average
Coverage	Sea areas
Parameters	Sea surface salinity (SAL), unit psu 30 m, 500 m, 1500 m, 2500 m, bottom oxygen (OXY), unit ml/l 30 m, 500 m, 1500 m, 2500 m, bottom potential density (PDE), unit kg/m ³ 30 m, 500 m, 1500 m, 2500 m, bottom salinity (SAL), unit psu 30 m, 500 m, 1500 m, 2500 m, bottom silicate (SIL), unit umol/kg 30 m, 500 m, 1500 m, 2500 m, bottom temperature (TMP) Geostrophic velocity (GV-), unit 10 ⁻² m/s Meridional geostrophic velocity (GVM), unit 10 ⁻² m/s Zonal geostrophic velocity (GVZ), unit 10 ⁻² m/s Ocean depth (ODE), unit m Steric height anomaly (SHA), unit m

Note: We recommend the application of the data sets presented above for educational and scientific studies, respectively. However, for scientific applications the users should be sure to apply the latest version of the data sets. Especially, climate data sets based on satellite measurements are being updated in short time intervals. The HOAPS data for example have been updated during the final stage of this book and will be available soon as an improved version (status January 2005). Further all data sets should be cited by the references given above.

3.2.2 Description of the digital data files

It is the basic concept of the Landolt-Börnstein issue on *Observed Global Climate* to print only a limited selection of climate elements but to store a much more comprehensive material as digital data files. Therefore the reader has easy access to an extensive data base and may compile his own graphics or computations (budget calculations, verifications of climate models, etc.). To facilitate this, the data have been stored in a simple to read format. Fig. 3.2 shows such a file, a precipitation field stored in ASCII file format. It consists of a 6 line header and, separated by a blank line, the matrix of the values.

```
Precipitation
10**(-8) mm/d
1993_JUN06
360x180x 1
GPCP-V2 - resolution 1.0 deg/monthly
STATISTICS: MEAN= 2.63, RMS= 3.85, STD= 2.81, MIN= 0.00, MAX= 30.41

1.18 1.18 1.36 1.54 1.54 1.14 1.14 0.94 0.75 0.75
0.87 0.87 0.91 0.94 0.94 1.13 1.13 1.13 1.13 1.13
1.39 1.39 1.14 0.88 0.88 1.35 1.35 1.28 1.21 1.21
1.33 1.33 1.25 1.18 1.18 0.83 0.83 0.83 0.82 0.82
1.26 1.26 1.19 1.11 1.11 0.96 0.96 0.98 1.00 1.00
0.84 0.84 0.87 0.90 0.90 1.04 1.04 0.93 0.82 0.82
1.07 1.07 1.00 0.94 0.94 0.93 0.93 0.98 1.03 1.03
1.52 1.52 1.47 1.42 1.42 0.94 0.94 0.94 0.94 0.94
0.81 0.81 0.74 0.68 0.68 0.84 0.84 0.71 0.57 0.57
1.08 1.08 0.79 0.51 0.51 0.47 0.47 0.66 0.84 0.84
0.28 0.28 0.36 0.45 0.45 0.48 0.48 0.49 0.50 0.50
0.53 0.53 0.58 0.62 0.62 0.77 0.77 0.68 0.59 0.59
0.22 0.22 0.34 0.45 0.45 0.28 0.28 0.34 0.39 0.39
0.42 0.42 0.41 0.39 0.39 0.21 0.21 0.30 0.40 0.40
0.53 0.53 0.43 0.32 0.32 0.55 0.55 0.49 0.43 0.43
0.49 0.49 0.36 0.23 0.23 0.41 0.41 0.36 0.30 0.30
0.48 0.48 0.41 0.33 0.33 0.61 0.61 0.44 0.27 0.27
0.31 0.31 0.31 0.32 0.32 0.13 0.13 0.37 0.61 0.61
0.29 0.29 0.21 0.13 0.13 0.11 0.11 0.14 0.18 0.18
0.24 0.24 0.30 0.36 0.36 0.12 0.12 0.20 0.29 0.29
```

Fig. 3.2. Cut from a data file of the digital archive. Each file consists of a header (6 lines plus a blank line) and the matrix of the values (6.480 lines for a 360 x 180 x 1 dimensional field). This example depicts the monthly precipitation field from the GPCP-V2 data set in units mm/day for June 1993. Basic statistical measures are given to simplify identification and comparison.

The following information is given in the header: The 1st line contains the name of the parameter. In the example depicted in Fig. 3.2 this is **Precipitation**. The 2nd line contains the order of magnitude and the unit, respectively (here **10⁰ mm/d**). The 3rd line indicates the date and the accumulation or averaging period in accordance with the short cuts described by the flow chart (Fig. 3.1). In Fig. 3.2 this is **1993_M06**, which denotes the monthly accumulated precipitation field of June 1993. The dimension of the field is described in the 4th line. The normally used field dimension is **360x180x1**, corresponding to a 1° latitude/longitude field with one level in the vertical as provided by the GPCP-V2 product (see also the information in the 5th line). The last line within the header provides statistical measures of the field, a useful information for comparison of different fields e.g. of the same quantity. The linear algebraic mean (**MEAN**), root mean square value (**RMS**), standard deviation (**STD**), minimum (**MIN**) and maximum (**MAX**) value is given.

Missing values are denoted by **9999.99** and have been excluded from the statistics. If, for example, a climate element is defined only for sea areas, then the grid points over the land areas are marked by **9999.99** and also the statistical quantities are only valid for the sea areas. To calculate for example the MEAN, the following formula has been applied:

$$MEAN = \frac{\sum_{i=1}^n x_i \cdot \cos(\varphi_i)}{\sum_{i=1}^n \cos(\varphi_i)} \quad (3.1)$$

where x_i is a climate quantity at grid point $i = 1, 2, \dots, n$ and φ_i is the corresponding latitude. Therefore, the statistics takes care of the convergence of meridians. Similar formulae have been applied to calculate the RMS and STD values:

$$RMS = \sqrt{\frac{\sum_{i=1}^n x_i^2 \cdot \cos(\varphi_i)}{\sum_{i=1}^n \cos(\varphi_i)}} \quad (3.2)$$

$$STD = \sqrt{\frac{\sum_{i=1}^n (x_i - MEAN)^2 \cdot \cos(\varphi_i)}{\sum_{i=1}^n \cos(\varphi_i)}} \quad (3.3)$$

The matrix of values of the climate elements has been written line by line beginning with the lower left corner (geographical coordinate of the first grid point 179.5° W/89.5° S). The Fortran command *Format(10F8.2)* was used. As depicted in Fig. 3.2 the precipitation value at coordinate 179.5° W/89.5° S is **1.18 mm/d**. The second precipitation value (1.18 mm/d) is located at 178.5° W/89.5° S, the third precipitation value (1.36 mm/d) is located at 177.5° W/89.5° S, and so on. The nominal spatial resolution is one degree¹. Data sets with the higher resolution of 0.5° have been averaged to the coarser resolution of 1°. Again area convergence of the earth's surface has been considered. This means that four 0.5° grid point values, weighted with $\cos(\varphi)$, have been averaged to one new 1° grid point value (equivalent to Eq. 1).

In the other case, namely for data which are only available at the coarser resolution of 2.5°, first a 0.5° field was developed by simply determining for each grid cell a 5x5 matrix with the same amount. Again considering the area convergence of earth's surface this 0.5° field was then averaged to the coarser resolution of 1°.

Note: The original resolution of the data sets archived has been listed in the description of the data sets as given in the previous section. Data archived with 1° resolution do not necessarily contain the corresponding information, except they have been originally estimated for that resolution.

¹ Due to its anomalous resolution of 1.25° x 1° the TOMS data set is archived in original resolution

3.2.3 Description of the pictures and movies

All data files described in the previous section have been visualised using both the equal area ($\lambda, \sin\varphi$)-projection for a global view and the equal area Lambert projection for a polar view. These colour pictures (see for example Fig. 3.3) include all information on climate element, the order of magnitude, the units, the statistics and the source as described in the previous section for the data files. Additionally, all pictures from climate elements available at a monthly resolution have been animated in form of computer loops and movies. These demonstrate the dynamic of the climate system. The movies can be viewed using free software on all major PC operating systems (Linux, Mac OS, Windows).

3.2.4 Description of the global climate maps 1991-1995

A selection of the digital colour pictures has also been realised in black and white for Chapter 17 of the print version of the Landolt-Börnstein issue on *Observed Global Climate*. The maps depicted in these black and white pictures are based on the same data as the maps provided on the DVD, but mostly smoothed contour line graphics have been applied for a better presentation.

3.3 Selected features of the global climate depicted in the animated data

The goal of this section is to demonstrate some climate features visible only in the animated pictures of monthly data. This should motivate the reader to use the digital data archive, which contains a large amount of supplemental material. All pictures and movies of the supplemental material are coloured. The increase of information due to the visualisation by colour pictures is substantial for climate elements that are highly variable in space and time (e.g. global oceanic precipitation, see Fig. 3.3).

The movies provide a quick look on the dynamics of the global climate and specific climate features, respectively. To demonstrate the movie material archived on the DVD, three well known features of the global climate have been selected. These are the South Pacific convergence zone, depicted in the oceanic precipitation fields from the HOAPS data set (section 3.3.1), the sea ice concentration of the Northern Hemisphere provided by the ISLSCP 2 consortium (section 3.3.2) and the annual cycle of the Gulf Stream as seen in the fields of latent heat fluxes from the ECMWF re-analyses (section 3.3.3).

3.3.1 The South Pacific convergence zone (SPCZ)

The SPCZ ([94Vin]), linked to the Inter-Tropical Convergence Zone (ITCZ), is one of the most significant climate features of the subtropical southern hemisphere, first described by Kornfield and Hasler (1969). It is associated with maxima of the sea surface temperature (see the SST fields of the HOAPS and ECCO data sets), cloudiness (e.g. cloud top temperature minus surface temperature (TCS) of the ISCCP data set) and precipitation. Here the location of the SPCZ is depicted in the HOAPS precipitation fields (Fig. 3.3). The SPCZ tends to be most active during the northern hemispheric winter (November to April). Beside this interannual variability the SPCZ is displaced northeast during El Niño events and southwest during La Niña events. Also the 15-30 year time scale fluctuation of the Interdecadal Pacific Oscillation causes a change in the mean location of the SPCZ ([02Fol]).

An equivalent of the SPCZ in the Indian Ocean is the convergence maximum of the surface horizontal wind field at about 10° S described by Hantel (1971) on basis of sailing ship observations. This convergence maximum of the wind field is also depicted by the precipitation maximum in Fig. 3.3.

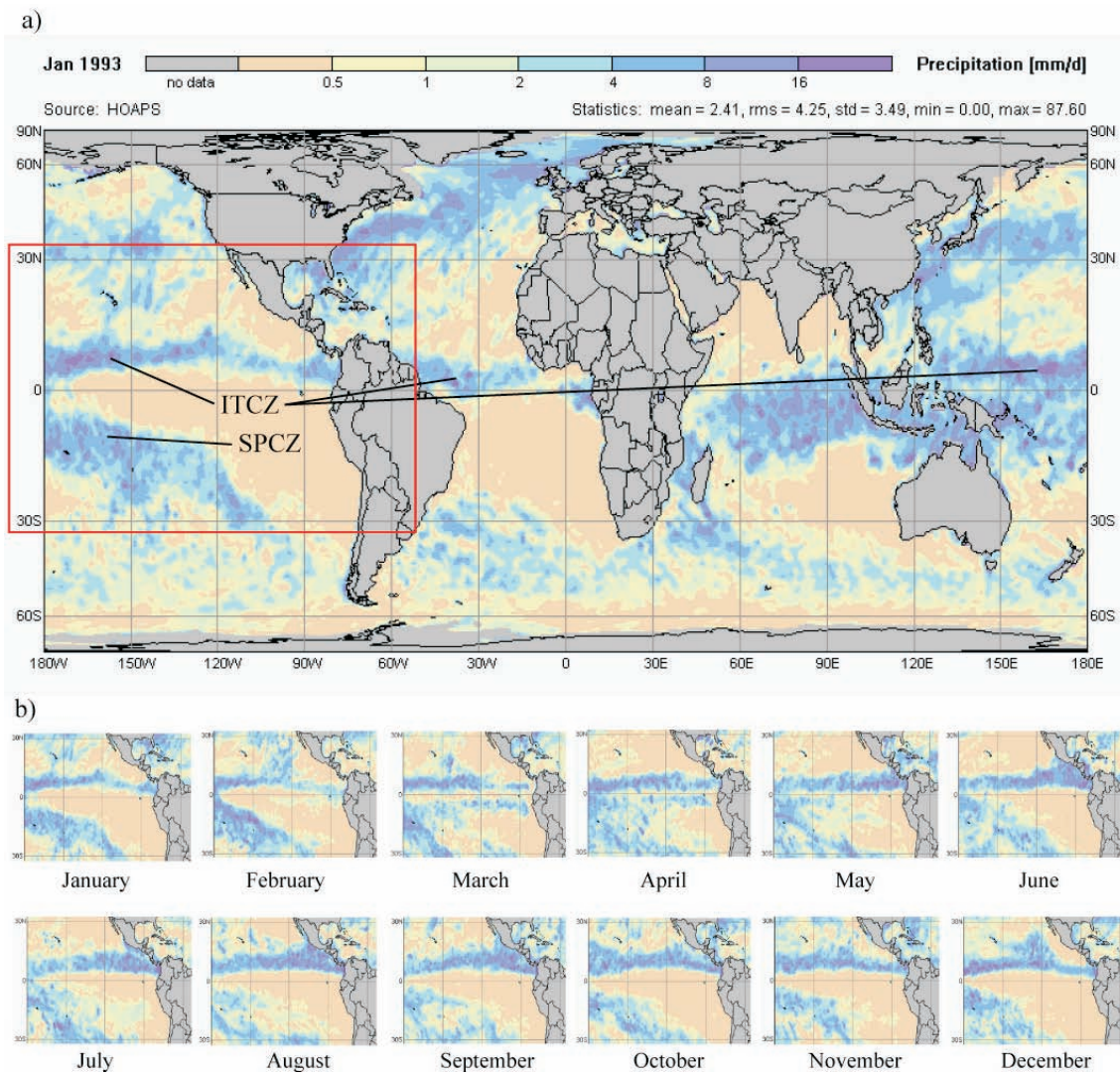


Fig. 3.3. Interannual variability of the intertropical convergence zone (ITCZ) and the South Pacific convergence zone (SPCZ). (a) Global HOAPS precipitation field for January 1993, (b) HOAPS precipitation estimates for January-December 1993 in the central and eastern Pacific Ocean region. Units mm/day.

3.3.2 The northern hemisphere sea ice concentration

As an example for the view of polar regions the northern hemisphere sea ice concentration - the fraction of grid cell area which is covered by sea ice, expressed in percent - is chosen. Provided from the International Satellite Land Surface Climatology Project Initiative II (ISLSCP 2) data collection its interannual variability for January-December 1993 is shown in Fig. 3.4. An ice concentration of 15 % typically corresponds to the ice edge. Values less than that are normally weather contamination. A 38 % concentration corresponds to the main body of the ice pack. Beside its interannual variability the northern hemisphere sea ice achieves its maximum extent from January to February and has its minimum in September. On the southern hemisphere sea ice concentration follows the equivalent annual cycle, shifted by 6 months. This can be seen on the enclosed DVD and compared with the sea ice fraction provided from the ECMWF Re-Analyses.

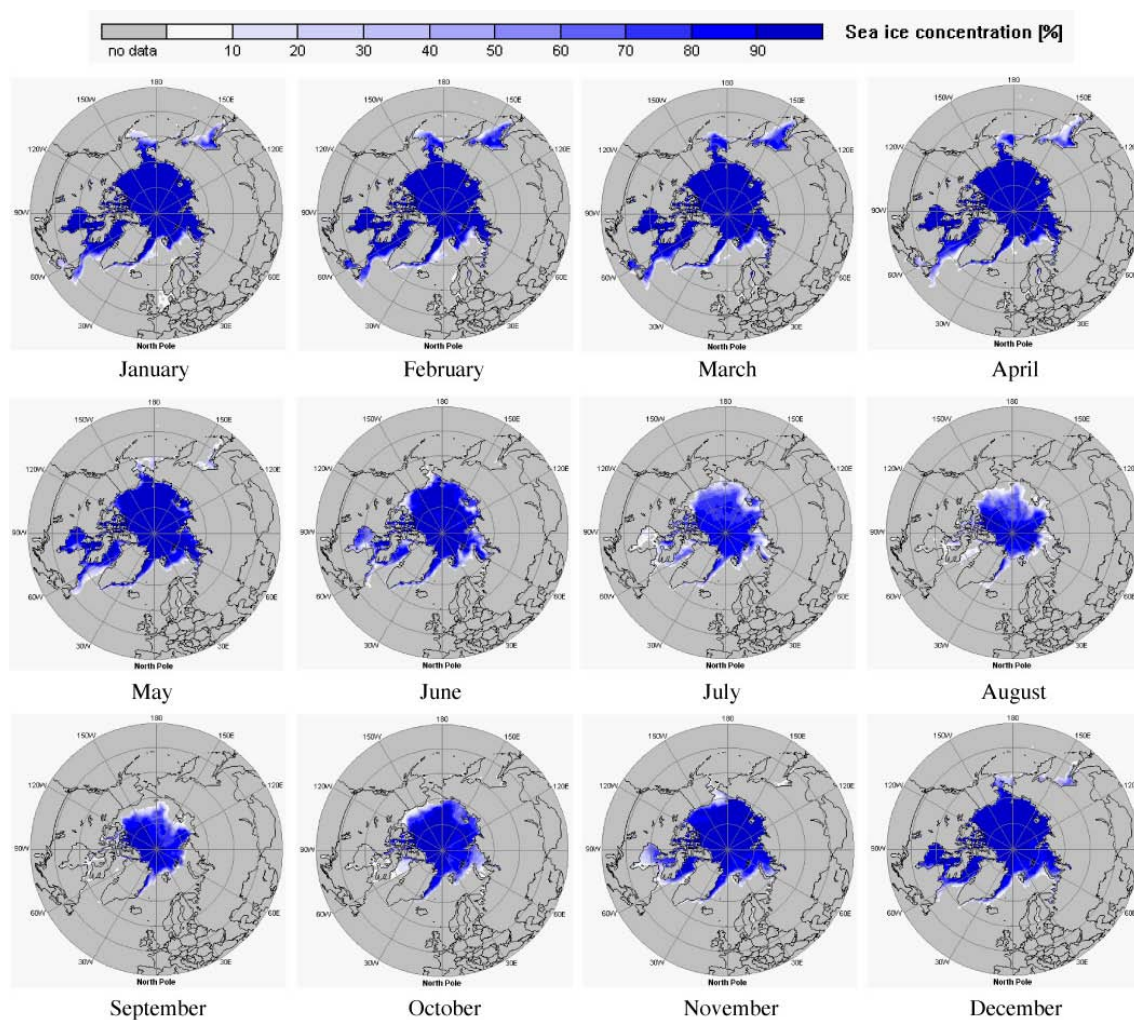


Fig. 3.4. Interannual variability of the sea ice concentration for January to December 1993. Units: percent.

3.3.3 The Gulf Stream as depicted by the latent heat flux

The latent heat flux, the major source of energy for the atmosphere, is upward practically everywhere on the globe except for quite limited regions over the polar ice sheets. Its monthly mean for January 1993, provided from the ECMWF Re-Analyses (ERA-40), is shown in Fig. 3.6(a), where its maxima can be found in the Kuroshio and the Gulf Stream regions. Fig. 3.6(b) depicts the appropriate inter-annual variability in the Gulf Stream region for January to December 1993. It shows a strong latent heat flux from the ocean to the atmosphere in the northern hemisphere winter months, whereas it is quite weak in August. Over the oceans it can be directly compared with the latent heat flux from the Hamburg Ocean Atmosphere Parameters and Fluxes from Satellite Data (HOAPS), to find on the enclosed DVD.

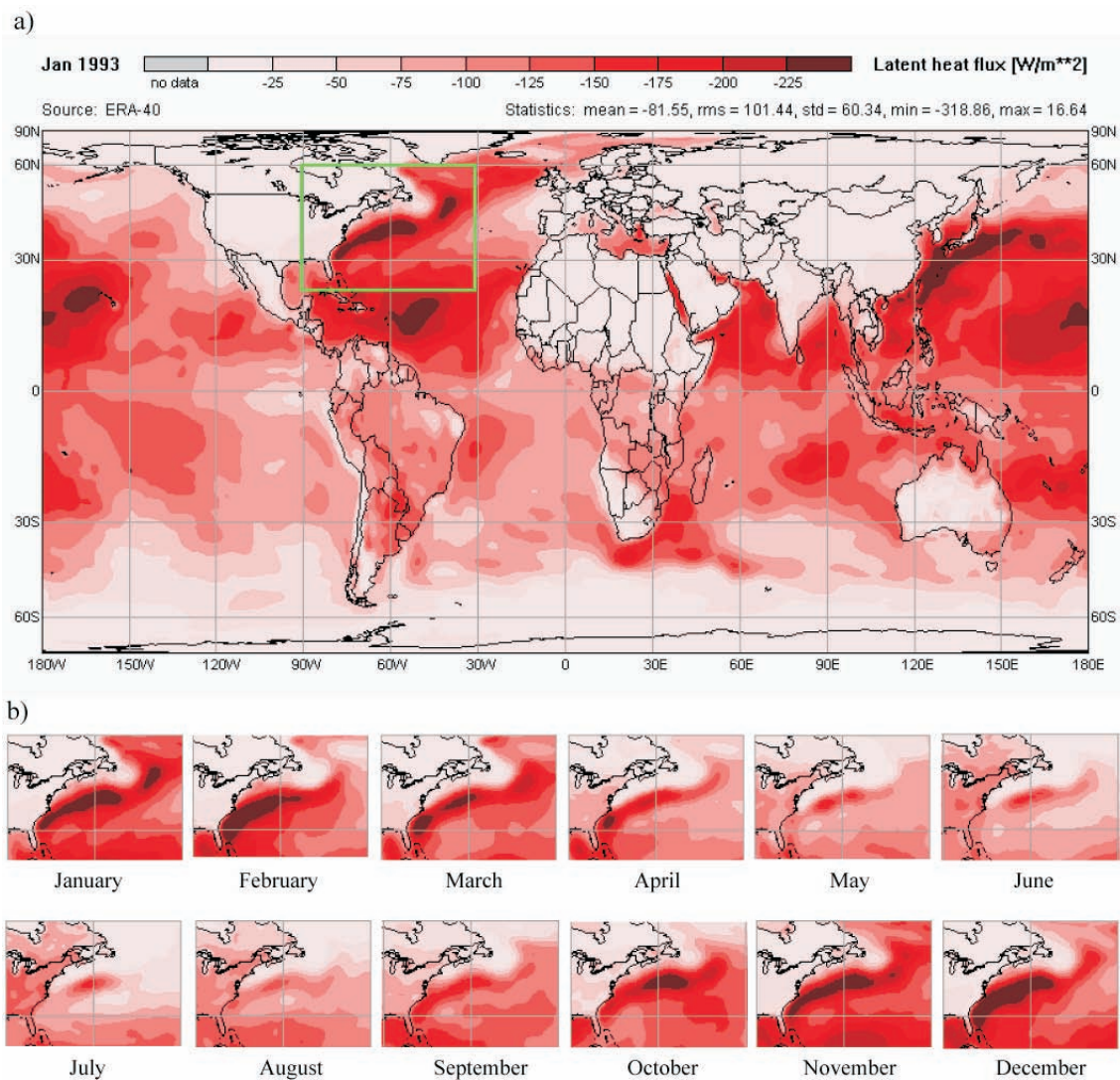


Fig. 3.5. Interannual variability of the latent heat flux density across the earth's surface. (a) Global ERA-40 latent heat flux field for January 1993, (b) ERA-40 latent heat flux for January to December 1993 depicting the Gulf Stream region. Units: W/m^2 (negative upward).

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