Multi-model Analysis For CEOP (MAC): A model data product supporting CEOP science objectives and the GEWEX Roadmap

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All model contributors and any contributors to the plan will be added with concurrence, including reviews/contributions from GRP and GMPP

A plan to synthesize the gridded model contributions to the CEOP data archives to facilitate their use in GEWEX science and operational objectives and research the uncertainty of models.

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1. Background

Early in the formulation of the Coordinated Enhanced Observing Period (CEOP), the need for model data to support science objectives became apparent. Additionally, the observations being developed for CEOP would be very useful to the validation of model analyses and forecasts. Invitations were sent to the major international Numerical Weather Prediction and data assimilation Centers (NWPCs). Ten centers responded favorably, and by the end of 2007, seven centers provided 27 months' worth of data for the CEOP EOP-3 and -4 (Oct 2002 – Dec 2004). Two separate model contributions from ECPC gave a total of 8 (eight) analyses. NASA/GSFC GMAO's GEOS-5 reanalysis data is currently under development, and is not included within these 8 analyses. The EOP-3/4 period is an excellent timeframe for testing the model data, as tremendous amounts of global remotely-sensed data are also available for verification.

Comparing the analyses from the NWPCs has primarily been through the single-point Model Output Location Time Series (MOLTS) co-located with CEOP reference sites (Yang et al. 2007; Chou et al. 2007; Rikus 2007 and Bosilovich et al. 2007). To get at the comparison of global grids, an ensemble of the analyses is proposed. This ensemble serves several purposes. First, the variance of the analyses can provide a measure of uncertainty in analyses. It also provides a range of the state-of-the-art analyses. Second, this ensemble may make a better benchmark for comparing individual analyses than simply differencing one against another. The veracity of the ensemble can be tested against global independent observations (e.g., GPCP, ISCCP, SRB, etc.). Lastly, it is hoped that these datasets will demonstrate the benefit of such a multi-model analysis for global atmospheric data assimilation systems, for future longer-term studies. The GSWP-2 multi-model analysis provides encouraging results showing that the ensemble average can be a high-quality data product (Dirmeyer et al, 2006).

The purpose of this paper is to outline the methods and procedure for developing a Multi-model Analysis for CEOP (MAC). Input from the GEWEX community (GMPP, GRP, and others) is crucial to develop a dataset useful beyond the interest of the modeling groups. This paper will contain descriptions of the regridding method, common grid, variables to be ensembled, and any special considerations. An accompanying spreadsheet (see Appendix) will provide additional details of the CEOP MAC data. This document contains the description of the first version of the MAC. Subsequent versions may include different variables, methods or new data.

2. Data

The data contributed to CEOP consists of analysis and forecast cycles. Few requirements were placed on the contributing NWPCs; thus, the length of the forecasts, frequency of output, variables and units were left to the individual center (see Tables 1 and 2 in the Appendix). While the archive of data is perfectly useable, these issues need careful consideration for users intending on applying these data to a validation exercise or scientific evaluation.

The CEOP MAC data will synthesize a subset of high-priority variables (see Appendix), ensure that units are consistent, and grids are made common. Each NWPC's system has its own topography and land/water mask. All centers did not provide a mask and topography for their system, so these will not factor into this initial pilot study of ensembling analyses. Also, the dataset does not synthesize data beyond the first 6-hourly forecast period available past the analysis time. Most of the centers do not provide data beyond the 6-hour forecast, and thus the number of members drops at longer forecast times. However, CPTEC data is only available daily beyond a 12-hour forecast; thus, the daily CPTEC data is from a 12-hour to 36-hour forecast. Also, MSC data is only provided from a single daily run at 12Z; thus, the daily data is from 0-hour to 24-hour forecast. The 6-hourly analysis and forecast cycles will be averaged into monthly and daily averages, as these will be well-posed frequencies in the individual time series.

The centers that have provided global gridded analyses to the project are:

- Bureau of Meteorology Research Centre (BMRC)
- Centro de Previsão de Tempo e Estudos Climáticos (CPTEC, The Center for Weather Forecasts and Climate Studies)
- Experimental Climate Prediction Center (ECPC)
- Japan Meteorological Agency (JMA)
- Meteorological Services of Canada (MSC)
- National Centers for Environmental Prediction (NCEP)
- United Kingdom Meteorological Office (UKMO)

The raw model data from the NWPCs participating in CEOP is stored (in Grib1 format) and archived by the Model & Data group at the Max Planck Institute (MPI) for Meteorology in Hamburg, Germany. Only those data files containing the subset of high-priority variables and the minimum-available forecast times described above were downloaded to a workstation at NASA/GSFC GMAO. Because these files typically contained additional variables and forecasts beyond what was desired, often at very high resolution, the amount of data downloaded to data has to date exceeded 1.13 Tb. A significant portion of this data was transferred over a high-speed optical network that was configured during the development of the CEOP MAC. This optical path used end-to-end communication over the University of Illinois-Chicago's TeraFlow Testbed network, which included support from NASA/GSFC's Software Integration and Visualization Office.

3. Methods and Plan

The procedure for generating the Multi-model Analysis for CEOP (MAC) is as follows:

1. Generate a 6-hourly dataset for all centers, using consistent units and time-frames
2. Regrid the 6-hourly data from each center to a common grid (1.25 deg. by 1.25 deg.)
3. Create an ensemble mean of the 6-hourly data; also create a 6-hourly standard deviation (Figure 1)
4. Create daily-averages and monthly-averages from the 6-hourly ensemble mean (Figures 2 and 3)
5. Create daily- and monthly-averages of the individual centers (Figures 2 and 3)
6. Create daily and monthly standard deviations between the individual centers averages
7. Write the re-gridded data for all centers, the mean, and the standard deviation at the 6-hourly, daily, and monthly times in the final formats of NetCDF and grib1 with consistent units and variable names.

The steps listed above provide a broad outline of the procedure. Many decisions and problems needed to be overcome along the way, and are discussed in further detail below.

a. 6-hourly dataset (Step 1)

For each NWPC dataset, a Grib table was used to identify and locate the subset of high-priority variables listed in the Appendix. The minimum forecast time available for each variable of the center was then pulled from the raw model data using "wgrib". The minimum forecast time available typically was the analysis (0-hour forecast) for the instantaneous variables, and the 0-6 hourly forecast for the average/accumulation (ave/acc) variables. Some major exceptions include the CPTEC data, the MSC data, and some variables from the ECPC data. The CPTEC data at 00Z is a 12-hourly forecast, at 06Z an 18-hr forecast, at 12Z a 24-hr forecast, and at 18Z a 36-hr forecast. Similarly, the ave/acc variables from 00Z to 06Z are a 12-18 hourly forecast, and so on. The MSC instantaneous surface variable data at 12Z is an analysis/0-hr forecast, at 18Z a 6-hr forecast, at 00Z a 12-hr forecast, and at 06Z an 18-hr forecast. The upper air data, however, was not available at 06Z and 18Z; the 12Z data is an analysis/0-hr forecast and the 00Z data is a 12-hr forecast. The MSC ave/acc variables from 12Z to 18Z are a 0-6 hourly forecast, and so on. Several ECPC RII and SFM instantaneous surface variables are a 6-hr forecast rather than an analysis/0-hr forecast. Further details, including descriptions of any missing times and variables, are available in the spreadsheet and the Appendix (see Tables 1 and 2).

b. Regridding (Step 2)

In order to produce an ensemble, a common grid must be defined. Since most operational analyses are near or going to ~100km spatial scales, a grid on the order of 1 degrees latitude and longitude was desirable. Also, many data products (GPCP and the reanalyses data) use a regular latitude-longitude coarse grid (2.5 degrees). Thus, a regular latitude-longitude grid that is near the spatial scale of the observational analyses, but also can be related easily to the reanalyses coarse grid, was chosen. The resolution is 1.25º longitude by 1.25º latitude (288×144 gridpoints), with the 1,1 center point located at 179.375W, 89.375S.

The native grid from each of the NWPCs supplied to CEOP was interpolated to the common grid using the OpenGrADS re() command (http://opengrads.org/). In the cases where the native grid is finer than 1.25ºx1.25º, box averaging was used. In the cases where the native grid is coarser than 1.25ºx1.25º, bilinear interpolation was be used. No other filtering or screening of the gridded data was applied (except for some below-ground heights – details in Sections 3c-f). At the end of this step, the data from each NWPC was on the common grid at a 6-hourly timestep, with common variable names and units. A list of the available variables for each center can be found in Table 1.

c. Ensemble Average (Step 3)

The ensemble average is the straight average of all of the available variables from each NWPC at each 6-hourly timestep. As all centers did not provide all variables, the ensemble averaging was done with those centers that did provide the given variable. If any data was missing from one or more of the NWPCs at a given time, the ensemble average was the average of the remaining data available. For the upper-air data at 850hPa and 700hPa, a masking to the MAC ensemble was applied for areas where the surface pressure at the given time was less than the pressure of the level (less than 850hPa or than 700hPa). This masking was also performed for the BMRC 6-hourly data, but not for the other individual NWPCs. The flowchart decisions used for each variable during the creation of the MAC ensemble at each of the 3292 6-hourly times is shown in Figure 1.

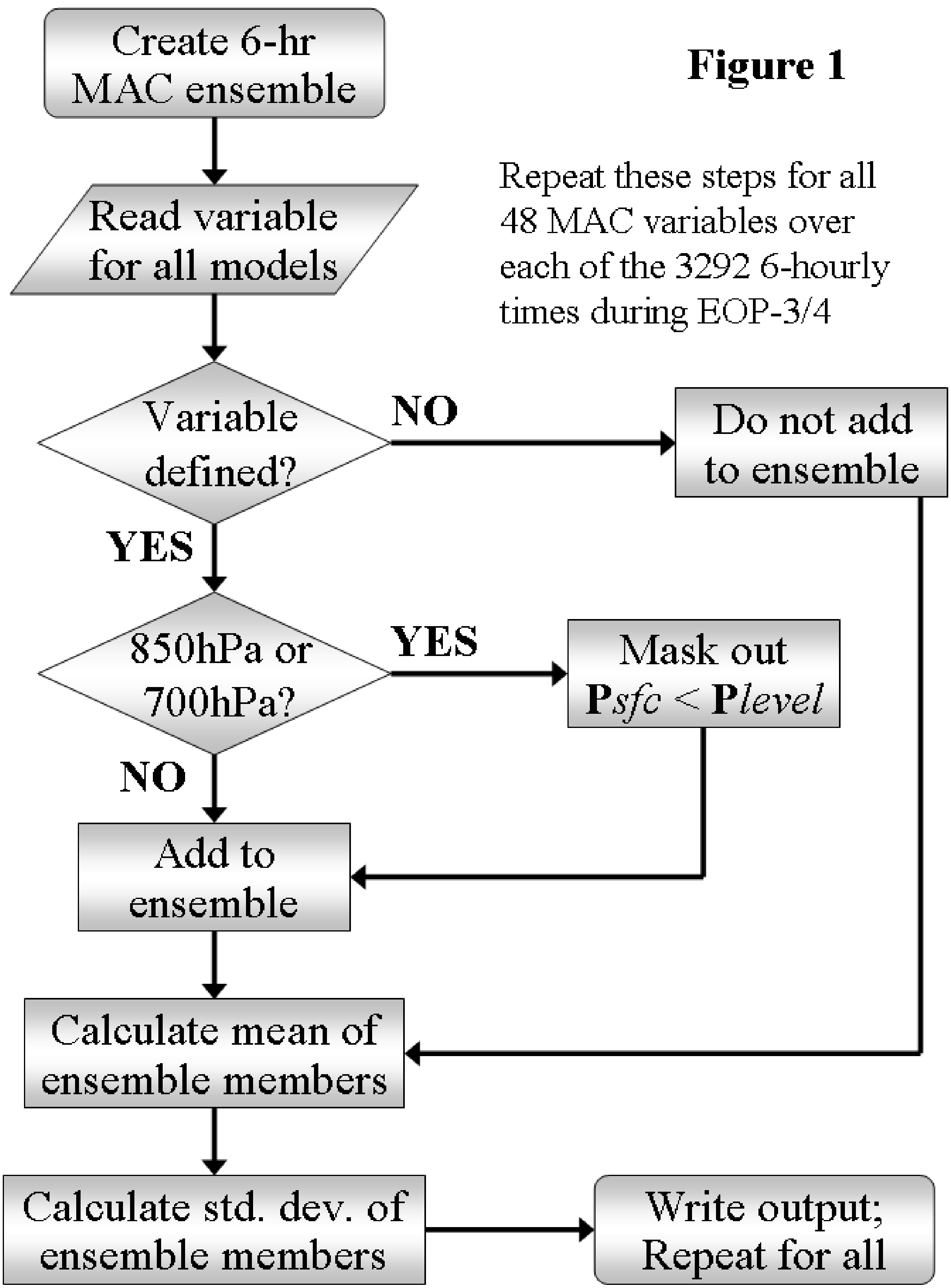

Figure 1: Flowchart of the creation of the 6-hourly ensemble mean and standard deviation.

The individual center's regridded variable is also provided with the MAC, so that it will be apparent when data is included in the ensemble average or not. Also, a separate dataset is provided that enumerates the number of ensemble members for each variable for each time. Similarly, the standard deviation at each 6-hourly timestep was computed from the available data that made up the ensemble average. The ensemble mean and standard deviation are provided as separate datasets on the same grid and same format as the individual NWPCs described at the end of Section 3b (Step 2).

d-f. Daily- and Monthly-Averages (Steps 4, 5, and 6)

The daily average of the ensemble mean was the simple average of the 00Z, 06Z, 12Z, and 18Z data on the given date. For the individual NWPCs, the daily average was the same, except that if an individual variable was missing or unavailable for at least one time during the date, that variable was considered to be undefined for that center on that day. The one exception to this is the MSC upper-air data, which was only available at 00Z and 12Z, and the daily average is just the average of these two times. Also, for each dataset, if at least one of the four times of the day had a point masked out because the surface pressure was less than the pressure of the upper-air level, then that point was also masked out for the entire day. The flowchart for the daily averages is shown in Figure 2. The daily standard deviation was then calculated between the centers that had valid daily averages for each variable. Note that the daily ensemble mean may include more data/centers than the daily ensemble standard deviation. An example of this is to suppose the 500 hPa heights was missing for 12Z only for one center. The 6-hourly ensemble means will include the 00Z, 06Z, and 18Z times for this center, and thus the daily ensemble mean will proportionally include this data. However, the daily mean for this center/variable will be considered undefined, and will not be included in the daily ensemble mean.

The monthly average of the ensemble mean was the simple average of all times in the month. For the individual NWPCs, the monthly average was calculated differently. First, all the 00Z times during the month were averaged, then the 06Z times, the 12Z times, and then the 18Z times. Next, these four times were summed and divided by four (4). This method was done to minimize the effect of an individual missing time on the monthly average. For example, if a 06Z time was missing for a variable such as downward surface radiation on a single date, this missing time would have a noticeable effect on the monthly average. If the similar times were averaged first, this problem is reduced, but does give a little extra weight to the other dates where the variable was available. No more than 6 times during the month were allowed to be undefined (out of a typical 120 or 124 6-hourly periods). If more than 6 times were undefined, the variable for that month was undefined. Similarly, if a given point had more than 6 times masked because the surface pressure was less than the pressure of the upper-air level, the point was also masked. The exceptions to this were for the UKMO data (numerous missing times, see Appendix), for the CPTEC data (only for May 2003, due to missing data), and for the MSC data (only 00Z and 12Z data available). The flowchart for the monthly averages is shown in Figure 3. The monthly-average standard deviation was then calculated between the individual centers' monthly averages. Again, because of the different methods of the monthly-average calculations, the monthly-average standard deviation will not be exactly centered about the ensemble mean monthly-average.

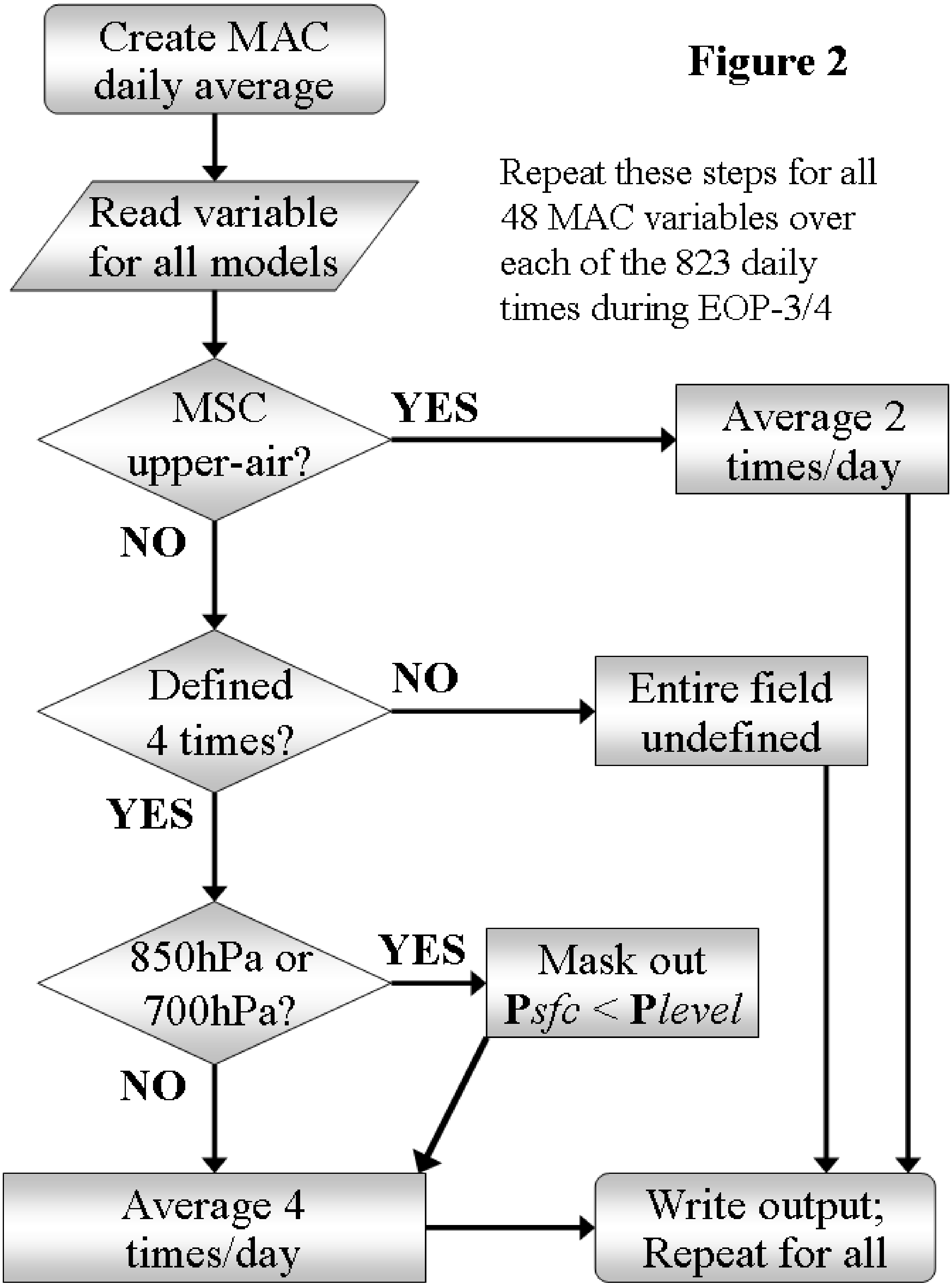

Figure 2: Flowchart of the creation of the daily average for ensemble mean and individual models.

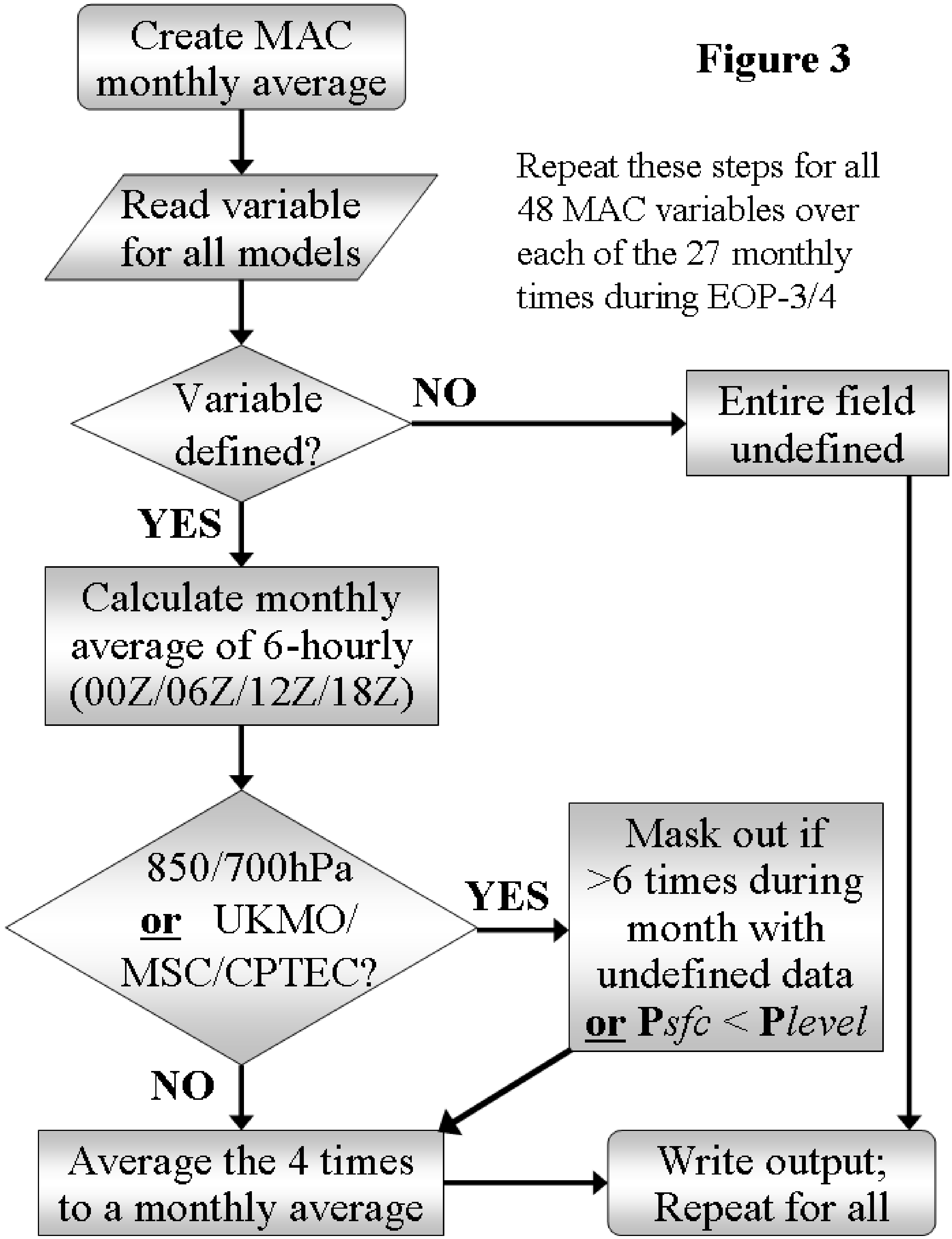

Figure 3: Flowchart of the creation of the monthly average for ensemble mean and individual models.

g. Write the gridded data out for the MAC (Step 7)

Data were written to binary output, then were converted to the NetCDF and Grib1 formats (using the public GrADS script LATS4d) for release to the contributors and community. The resulting binary (or NetCDF) output size is roughly 284Gb (about 134Gb in Grib1). Each file contains each variable listed in Table 1 (with the common naming convention). Common utilities, ncdump and wgrib, can be used to identify the vital information needed to access the data. A grib table common to all processed centers and the MAC is also provided. The data will be sent to the NASA Goddard Data Information Services Center (DISC) and the MPI Model and Data Center (others can be included if interested).

4. Summary and next steps

The global gridded analyses contributed to CEOP have been modified to fit a common framework to facilitate comparisons among the analyses and make the access to the data easier for science efforts. The eventual goal is to quantify the uncertainty among operational analyses. Preliminary results and evaluation of the MAC ensemble have been favorable, so the data should be returned to the contributing centers, and made available to the scientific community. These results were presented at the AMS annual meeting (http://ams.confex.com/ams/88Annual/techprogram/paper_131182.htm) and the WCRP 3rd International Reanalysis Conference (http://jra.kishou.go.jp/3rac_en.html).

Two major tasks are nearing completion. First, make the data accessible to the contributing centers and CEOP science efforts. Possibly, some review of the data and results could be available by the annual CEOP meeting in September 2008. Second, we would like to invite the data contributors to collaborate on an overview paper of the data set. The eventual manuscript would go to peer review, but perhaps a more broad distribution, for example, Bulletin of the AMS. Lastly, the documentation on each of the system is quite variable. It would be useful to researchers/users to have some basic information and citations for the systems' model and data assimilation methods.

Acknowledgments

We would like to express sincerest appreciation for the numerical prediction centers contributing time and model data to the CEOP archives, without which this study could not have been easily accomplished. In addition, MPI Model and Data center's effort in hosting and serving the data provided a critical resource. The NASA/GSFC SIVO branch is thanked for the development of a high-speed optical path for quicker downloads between GSFC and MPI. The effort to compile the CEOP model data was funded by the NASA Model, Analysis and Prediction program.

5. Appendix 1: Summary of available model data used in the MAC

		Centers							
Description	**Units**	**BMRC**	**CPTEC**	**ECPCRII**	**ECPCSFM**	**JMA**	**MSC**	**NCEP**	**UKMO**
Surface Pressure	Pa	SURFPsfc	PRESsfc	PRESsfc	PRESsfc	PRESsfc	SURFPsfc	PRESsfc	SURFPsfc
Mean Sea Level Pressure	Pa	MSLPsfc		PRMSLmsl	PRESmsl				PRMSLmsl
Surface Air Temperature	K	TMP2m	TMP2m	TMP2m	TMP2m	TMP2m	TTSUsfc	TMP2m	LOWT2m
Surface Skin Temperature	K	SURFTsfc	SURFTsfc	TMPsfc	TMPsfc		SURFTsfc	TMPsfc	SURFTsfc
Surface Air Moisture	kg kg^{-1}	SPFH2m	RH2m	SPFH2m	SPFH2m	SPFHhbl	HUSUsfc	SPFH2m	LOWSH2m
Surface Eastward Wind	m s^{-1}	UGRD10m	UGRD10m	UGRD10m	UGRD10m	UGRD10m	UUSUsfc	UGRD10m	TENUS10m
Surface Northward Wind	m s^{-1}	VGRD10m	VGRD10m	VGRD10m	VGRD10m	VGRD10m	VVSUsfc	VGRD10m	TENVS10m
Precipitation	kg m^{-2} s^{-1}	APCPsfc	APCPsfc	PRATEsfc	PRATEsfc	PRATEsfc	PRsfc	PRATEsfc	APCPsfc
Convective Precipitation	kg m^{-2} s^{-1}			CPRATsfc	CPRATsfc				ACPCPsfc
Surface Runoff	kg m^{-2}		WATRsfc	WATRsfc	WATRsfc		N0sfc	WATRsfc	WATRsfc
Liquid equivalent snow depth	kg m^{-2}	SNODsfc		WEASDsfc	WEASDsfc		I5sfc	WEASDsfc	
Latent Heat Flux	W m^{-2}	LHTFLsfc	LHTFLsfc	LHTFLsfc	LHTFLsfc	LHTFLsfc	AVsfc	LHTFLsfc	LHTFLsfc
Sensible Heat Flux	W m^{-2}	SHTFLsfc	SHTFLsfc	SHTFLsfc	SHTFLsfc	SHTFLsfc	AHsfc	SHTFLsfc	SHTFLsfc
Surface Incoming Shortwave	W m^{-2}	DSWRFsfc	DSWRFsfc	DSWRFsfc	DSWRFsfc	DSWRFsfc	N4sfc	DSWRFsfc	TDSWSsfc
Surface Incoming Longwave	W m^{-2}	DLWRFsfc	DLWRFsfc	DLWRFsfc	DLWRFsfc	DLWRFsfc	ADsfc	DLWRFsfc	TDLWSsfc
Surface Reflected Shortwave	W m^{-2}	USWRFsfc	USWRFsfc	USWRFsfc	USWRFsfc	USWRFsfc	N4sfc-ASsfc	USWRFsfc	TUSWSsfc
Surface Outgoing Longwave	W m^{-2}	ULWRFsfc	ULWRFsfc	ULWRFsfc	ULWRFsfc	ULWRFsfc	ADsfc-AIsfc	ULWRFsfc	TULWSsfc
TOA Longwave Outgoing	W m^{-2}		ULWRFtoa	ULWRFtoa	ULWRFtoa	ULWRFtoa	ARsfc	ULWRFtoa	TULWTtoa
TOA Shortwave Incoming	W m^{-2}			DSWRFtoa	DSWRFtoa	DSWRFtoa	ABsfc		TDSWTtoa
TOA Shortwave Outgoing	W m^{-2}		USWRFtoa	USWRFtoa	USWRFtoa	USWRFtoa	AUsfc	USWRFtoa	TUSWTtoa
Total Cloud Cover	(0-1)		TCDCclm	TCDCclm	TCDCclm	TCDCsfc	TCDCsfc	TCDCclm	TCDCsfc
Total Column Water Vapor	kg m^{-2}	PWATclm	PWATclm	PWATclm	PWATclm		IHsfc	PWATclm	
Total Column Condensed Water	kg m^{-2}					CWATprs	IEsfc	CWATclm	
Q850	kg kg^{-1}	SPFHprs	SPFHprs	SPFHprs	SPFHprs		SPFHprs	RHprs	RHprs
T850	K	TMPprs	TMPprs	TMPprs	TMPprs	TMPprs	TMPprs	TMPprs	TMPprs
U850	m s^{-1}	UGRDprs	UGRDprs	UGRDprs	UGRDprs	UGRDprs	UGRDprs	UGRDprs	UGRDprs
V850	m s^{-1}	VGRDprs	VGRDprs	VGRDprs	VGRDprs	VGRDprs	VGRDprs	VGRDprs	VGRDprs
H850	m	HGTprs	HGTprs	HGTprs	HGTprs	GPprs	HGTprs	HGTprs	GPprs
Q700	kg kg^{-1}	SPFHprs	SPFHprs	SPFHprs	SPFHprs		SPFHprs	RHprs	RHprs
T700	K	TMPprs	TMPprs	TMPprs	TMPprs	TMPprs	TMPprs	TMPprs	TMPprs
U700	m s^{-1}	UGRDprs	UGRDprs	UGRDprs	UGRDprs	UGRDprs	UGRDprs	UGRDprs	UGRDprs
V700	m s^{-1}	VGRDprs	VGRDprs	VGRDprs	VGRDprs	VGRDprs	VGRDprs	VGRDprs	VGRDprs
H700	m	HGTprs	HGTprs	HGTprs	HGTprs	GPprs	HGTprs	HGTprs	GPprs
Q500	kg kg^{-1}	SPFHprs	SPFHprs	SPFHprs	SPFHprs		SPFHprs	RHprs	RHprs
T500	K	TMPprs	TMPprs	TMPprs	TMPprs	TMPprs	TMPprs	TMPprs	TMPprs
U500	m s^{-1}	UGRDprs	UGRDprs	UGRDprs	UGRDprs	UGRDprs	UGRDprs	UGRDprs	UGRDprs
V500	m s^{-1}	VGRDprs	VGRDprs	VGRDprs	VGRDprs	VGRDprs	VGRDprs	VGRDprs	VGRDprs
H500	m	HGTprs	HGTprs	HGTprs	HGTprs	GPprs	HGTprs	HGTprs	GPprs
Q300	kg kg^{-1}	SPFHprs	SPFHprs	SPFHprs	SPFHprs		SPFHprs	RHprs	RHprs
T300	K	TMPprs	TMPprs	TMPprs	TMPprs	TMPprs	TMPprs	TMPprs	TMPprs
U300	m s^{-1}	UGRDprs	UGRDprs	UGRDprs	UGRDprs	UGRDprs	UGRDprs	UGRDprs	UGRDprs
V300	m s^{-1}	VGRDprs	VGRDprs	VGRDprs	VGRDprs	VGRDprs	VGRDprs	VGRDprs	VGRDprs
H300	m	HGTprs	HGTprs	HGTprs	HGTprs	GPprs	HGTprs	HGTprs	GPprs
Q200	kg kg^{-1}	SPFHprs	SPFHprs	SPFHprs	SPFHprs			RHprs	RHprs
T200	K	TMPprs	TMPprs	TMPprs	TMPprs	TMPprs		TMPprs	TMPprs
U200	m s^{-1}	UGRDprs	UGRDprs	UGRDprs	UGRDprs	UGRDprs		UGRDprs	UGRDprs
V200	m s^{-1}	VGRDprs	VGRDprs	VGRDprs	VGRDprs	VGRDprs		VGRDprs	VGRDprs
H200	m	HGTprs	HGTprs	HGTprs	HGTprs	GPprs		HGTprs	GPprs

Table 1: List of variables, descriptions/names, and availability by center of data used in the MAC.

Description	Units	BMRC	CPTEC	ECPCRII	ECPCSFM	JMA	MSC	NCEP	UKMO
Surface Pressure	Pa	analysis	12hr fcst+	6hr fcst	6hr fcst	analysis	anl/6hr fcst+	analysis	analysis
Mean Sea Level Pressure	Pa	analysis		analysis	analysis				analysis
Surface Air Temperature	K	analysis	12hr fcst+	6hr fcst	6hr fcst	analysis	anl/6hr fcst+	6hr fcst	analysis
Surface Skin Temperature	K	analysis	12hr fcst+	6hr fcst	6hr fcst		anl/6hr fcst+	6hr fcst	analysis
Surface Air Moisture	kg kg^{-1}	analysis	12hr fcst+	6hr fcst	6hr fcst	analysis	anl/6hr fcst+	6hr fcst	analysis
Surface Eastward Wind	m s^{-1}	analysis	12hr fcst+	6hr fcst	6hr fcst	analysis	anl/6hr fcst+	6hr fcst	analysis
Surface Northward Wind	m s^{-1}	analysis	12hr fcst+	6hr fcst	6hr fcst	analysis	anl/6hr fcst+	6hr fcst	analysis
Precipitation	kg m^{-2} s^{-1}	0-6hr ave	12hr fcst+	0-6hr ave	0-6hr ave	6hr fcst	3hr fcst+	0-6hr ave	0-6hr acc
Convective Precipitation	kg m^{-2} s^{-1}			0-6hr ave	0-6hr ave				0-6hr acc
Surface Runoff	kg m^{-2}		12hr fcst+	0-6hr ave	0-6hr ave		3hr fcst+	0-6hr acc	0-6hr acc
Liquid equivalent snow depth	kg m^{-2}	analysis		6hr fcst	6hr fcst		anl/6hr fcst+	6hr fcst	
Latent Heat Flux	W m^{-2}	0-6hr ave	12hr fcst+	0-6hr ave	0-6hr ave	0-6hr ave	3hr fcst+	0-6hr ave	0-6hr ave
Sensible Heat Flux	W m^{-2}	0-6hr ave	12hr fcst+	0-6hr ave	0-6hr ave	0-6hr ave	3hr fcst+	0-6hr ave	0-6hr ave
Surface Incoming Shortwave	W m^{-2}	0-6hr ave	12hr fcst+	0-6hr ave	0-6hr ave	0-6hr ave	3hr fcst+	0-6hr ave	0-6hr ave
Surface Incoming Longwave	W m^{-2}	0-6hr ave	12hr fcst+	0-6hr ave	0-6hr ave	0-6hr ave	3hr fcst+	0-6hr ave	0-6hr ave
Surface Reflected Shortwave	W m^{-2}	0-6hr ave	12hr fcst+	0-6hr ave	0-6hr ave	0-6hr ave	3hr fcst+	0-6hr ave	0-6hr ave
Surface Outgoing Longwave	W m^{-2}	0-6hr ave	12hr fcst+	0-6hr ave	0-6hr ave	0-6hr ave	3hr fcst+	0-6hr ave	0-6hr ave
TOA Longwave Outgoing	W m^{-2}		12hr fcst+	0-6hr ave	0-6hr ave	0-6hr ave	3hr fcst+	0-6hr ave	0-6hr ave
TOA Shortwave Incoming	W m^{-2}			0-6hr ave	0-6hr ave	0-6hr ave	3hr fcst+		0-6hr ave
TOA Shortwave Outgoing	W m^{-2}		12hr fcst+	0-6hr ave	0-6hr ave	0-6hr ave	3hr fcst+	0-6hr ave	0-6hr ave
Total Cloud Cover	(0-1)		12hr fcst+	0-1hr ave	0-1hr ave	analysis	anl/6hr fcst+	0-6hr ave	analysis
Total Column Water Vapor	kg m^{-2}	analysis	12hr fcst+	6hr fcst	6hr fcst		anl/6hr fcst+	analysis	
Total Column Condensed Water	kg m^{-2}					analysis	anl/6hr fcst+	analysis	
Q850	kg kg^{-1}	analysis	12hr fcst+	analysis	analysis		anl/12hr fcst	analysis	analysis
T850	K	analysis	12hr fcst+	analysis	analysis	analysis	anl/12hr fcst	analysis	analysis
U850	m s^{-1}	analysis	12hr fcst+	analysis	analysis	analysis	anl/12hr fcst	analysis	analysis
V850	m s^{-1}	analysis	12hr fcst+	analysis	analysis	analysis	anl/12hr fcst	analysis	analysis
H850	m	analysis	12hr fcst+	analysis	analysis	analysis	anl/12hr fcst	analysis	analysis
Q700	kg kg^{-1}	analysis	12hr fcst+	analysis	analysis		anl/12hr fcst	analysis	analysis
T700	K	analysis	12hr fcst+	analysis	analysis	analysis	anl/12hr fcst	analysis	analysis
U700	m s^{-1}	analysis	12hr fcst+	analysis	analysis	analysis	anl/12hr fcst	analysis	analysis
V700	m s^{-1}	analysis	12hr fcst+	analysis	analysis	analysis	anl/12hr fcst	analysis	analysis
H700	m	analysis	12hr fcst+	analysis	analysis	analysis	anl/12hr fcst	analysis	analysis
Q500	kg kg^{-1}	analysis	12hr fcst+	analysis	analysis		anl/12hr fcst	analysis	analysis
T500	K	analysis	12hr fcst+	analysis	analysis	analysis	anl/12hr fcst	analysis	analysis
U500	m s^{-1}	analysis	12hr fcst+	analysis	analysis	analysis	anl/12hr fcst	analysis	analysis
V500	m s^{-1}	analysis	12hr fcst+	analysis	analysis	analysis	anl/12hr fcst	analysis	analysis
H500	m	analysis	12hr fcst+	analysis	analysis	analysis	anl/12hr fcst	analysis	analysis
Q300	kg kg^{-1}	analysis	12hr fcst+	analysis	analysis		anl/12hr fcst	analysis	analysis
T300	K	analysis	12hr fcst+	analysis	analysis	analysis	anl/12hr fcst	analysis	analysis
U300	m s^{-1}	analysis	12hr fcst+	analysis	analysis	analysis	anl/12hr fcst	analysis	analysis
V300	m s^{-1}	analysis	12hr fcst+	analysis	analysis	analysis	anl/12hr fcst	analysis	analysis
H300	m	analysis	12hr fcst+	analysis	analysis	analysis	anl/12hr fcst	analysis	analysis
Q200	kg kg^{-1}	analysis	12hr fcst+	analysis	analysis			analysis	analysis
T200	K	analysis	12hr fcst+	analysis	analysis	analysis		analysis	analysis
U200	m s^{-1}	analysis	12hr fcst+	analysis	analysis	analysis		analysis	analysis
V200	m s^{-1}	analysis	12hr fcst+	analysis	analysis	analysis		analysis	analysis
H200	m	analysis	12hr fcst+	analysis	analysis	analysis		analysis	analysis

Table 2: Location in the forecast cycle of each NWPC's variables included in the MAC.

CEOP GRID 6-hourly Datasets

Center	Data Status (should be 3292 6-hourly files)	Dimensions	Experiment: Dataset	Key Variables
JMA	No times missing	X by Y: 288 by 145 Lon/Lat: 1.25 by 1.25 Levels: 22 pressure levels	CEOP_JMA_GRID_RAW: CEOP_JMA_GRID_1	T, U/V, ω, Φ (22 levels) Cloud liquid water (12 levels) Total cloud cover % (column) 2-m T, 10-m U/V
		X by Y: 640 by 320 Lon/Lat: 0.5625 by ~0.5625 Levels: 1 surface level	CEOP_JMA_GRID_RAW: CEOP_JMA_GRID_2	TOA/surface LW/SW ↑/↓ radiation Sensible/Latent heat flux Precip/Pressure/Roughness/ TKE Momentum & Water Vapor flux
		X by Y: 320 by 160 Lon/Lat: 1.125 by ~1.125 Levels: 40 eta levels	CEOP_JMA_GRID_RAW: CEOP_JMA_GRID_3	T, U/V, P, q (40 levels) Local time tendency of T (40 levels)
UKMO	278 times missing: (by month) *2002*: 4, 3, 70 *2003*: 27, 5, 4, 2, 10, 26, 4, 24, 8, 9, 11, 1 *2004*: 5, 5, 5, 0, 4, 9, 5, 9, 9, 4, 9, 8	X by Y: 288 by 145 Lon/Lat: 1.25 by 1.25 Levels: 1 surface level	CEOP_UKMO_GRID_RAW: CEOP_UKMO_GRID_DA_all_2D	TOA/surface LW/SW ↑/↓ radiation Sensible/Latent heat flux Precip w/ Convective/Large-scale Pressure/Roughness/PBL height Total/High/Mid/Low cloud cover % Convective cloud base/top Snow fall/depth/melt Runoff/Soil moisture 2-m T/q, 10-m U/V
		X by Y: 288 by 145 Lon/Lat: 1.25 by 1.25 Levels: 18 pressure levels	CEOP_UKMO_GRID_RAW: CEOP_UKMO_GRID_DA_all_3D	T, U/V, RH, Φ (18 levels) KE/Enthalpy (18 levels)
BMRC	2 times missing: 12Z2003Dec12 18Z2003Dec12	X by Y: 480 by 240 Lon/Lat: 0.75 by ~0.75 Levels: 15 pressure levels	CEOP_BMRC_GRID with corrections in: CEOP_BMRC_GRID_18Z CEOP_BMRC_GRID_NEWSFC CEOP_BMRC_GRID_SPHUM (data obtained direct from BMRC)	T, U/V, ω, Φ (15 levels) Surface LW/SW ↑/↓ radiation Sensible/Latent heat flux Precip/Pressure Precipitable water Snow depth Surface albedo Soil moisture & temp 2-m T/q, 10-m U/V

NCEP	1 time missing: 12Z2003Aug26	X by Y: 360 by 181 Lon/Lat: 1.0 by 1.0 Levels: 26 pressure levels	CEOP_NCEP_GRID_RAW: NCEP_GR_FORC_06__00H NCEP_GR_FORC_06__06H NCEP_GR_FORC_06__12H NCEP_GR_FORC_06__18H	T, U/V, Φ (26 levels) Cloud water, RH, ω (21 levels) TOA/surface LW/SW ↑/↓ radiation (no TOA SW↓, however) Sensible/Latent/Ground heat flux Precip/Pressure/PBL height Total cloud cover % (column) Precipitable & Cloud water (column) Snow depth Surface albedo Runoff/Soil moisture & temps 2-m T/q, 10-m U/V
ECPC RII	No times missing	X by Y: 192 by 94 Lon/Lat: 1.875 by ~1.915 Levels: 1 surface level	CEOP_ECPCRII_GRID_RAW: ECPCRII6_flx_ft00_MUL (analysis) ECPCRII6_flx_ft03_MUL (00-03 hour forecast average) ECPCRII6_flx_ft06_MUL (03-06 hour forecast average)	TOA/surface LW/SW ↑/↓ radiation Sensible/Latent/Ground heat flux Precip w/ Convective Pressure/Roughness/PBL height Momentum flux/Gravity wave stress Total/High/Mid/Low cloud cover % Cloud base/top/ temperature/CWF Snow fall/depth/melt Surface albedo Runoff/Soil moisture & temps 2-m T/q, 10-m U/V
		X by Y: 144 by 73 Lon/Lat: 2.5 by 2.5 Levels: 17 pressure levels	CEOP_ECPCRII_GRID_RAW: ECPCRII6_pgb_ft00_MUL (analysis)	T, U/V, RH/q, ω, Φ, η (17 levels) Precipitable water/RH (column) Lifted index Max wind level T, U/V, Pressure Tropopause T, U/V, Pressure, Shear

ECPC SFM	2 times missing: 12Z2003Aug22 12Z2003Aug25	X by Y: 192 by 94 Lon/Lat: 1.875 by ~1.915 Levels: 1 surface level	CEOP_ECPCSFM_GRID_RAW: ECPCSFM6_flx_ft00_MUL (analysis) ECPCSFM6_flx_ft03_MUL (00-03 hour forecast average) ECPCSFM6_flx_ft06_MUL (03-06 hour forecast average)	TOA/surface LW/SW ↑/↓ radiation Sensible/Latent/Ground heat flux Precip w/ Convective Pressure/Roughness/PBL height Momentum flux/Gravity wave stress Total/High/Mid/Low cloud cover % Cloud base/top/ temperature Snow fall/depth/melt Surface albedo Runoff/Soil moisture & temps 2-m T/q, 10-m U/V
	No times missing	X by Y: 144 by 73 Lon/Lat: 2.5 by 2.5 Levels: 17 pressure levels	CEOP_ECPCSFM_GRID_RAW: ECPCSFM6_pgb_ft00_MUL (analysis)	T, U/V, RH/q, ω, Φ, η (17 levels) Precipitable water (column)
MSC	No times missing	X by Y: 800 by 600 Lon/Lat: 0.45 by 0.3 Levels: 1 surface level & 4 upper-air levels (upper-air only 12-hourly)	CEOP_MSC_GRID_RAW: CEOP_MSC_GRID_RAW_xxxx (xxxx = variable name)	T, U/V, q, Φ (4 levels) TOA/surface LW/SW ↑/↓ radiation Sensible/Latent/Ground heat flux Precip/Pressure 1.5-m T/q, 10-m U/V Total cloud cover % (column) Precipitable & Cloud water (column) Snow depth/SWE Surface albedo Runoff/Soil moisture
CPTEC	35 times missing: (by month) *2002*: 0, 1, 0 *2003*: 1, 1, 1, 0, 14, 2, 1, 0, 1, 0, 0, 3 *2004*: 0, 0, 0, 1, 4, 0, 0, 0, 1, 0, 4, 0	X by Y: 384 by 192 Lon/Lat: 0.9375 by ~0.9375 Levels: 15 pressure levels	CEOP_MSC_GRID_RAW: CPTEC_GR_gposnmc_fct_12_MUL CPTEC_GR_gposnmc_fct_18_MUL CPTEC_GR_gposnmc_fct_24_MUL CPTEC_GR_gposnmc_fct_30_MUL	T, U/V, q, ω, Φ, diverg. (15 levels) TOA/surface LW/SW ↑/↓ radiation (no TOA SW↓, however) Sensible/Latent heat flux Precip/Pressure/Roughness Runoff/Soil moisture 2-m T/RH, 10-m U/V Total cloud cover % (column) Precipitable water (column)

JMA

Experiment name at MPI:	CEOP_JMA_GRID_RAW
Dataset name at MPI:	CEOP_JMA_GRID_1
Spatial resolution:	288x145 (1.25 lon. X 1.25 lat.)
Vertical resolution:	22 pressure levels
Temporal resolution:	6-hourly (3292 total files)
Missing data:	None
Key variables:	T, U/V, ω, Φ (22 levels) Cloud liquid water (12 levels) Total cloud cover % (column) 2-m T, 10-m U/V
Dataset name at MPI:	CEOP_JMA_GRID_2
Spatial resolution:	640x320 (0.5625 lon. X ~0.5625 lat.)
Vertical resolution:	1 surface level
Temporal resolution:	6-hourly (3292 total files)
Missing data:	None
Key variables:	TOA/surface LW/SW ↑/↓ radiation Sensible/Latent heat flux Precipitation/Pressure/Roughness/TKE Momentum & Water Vapor flux Land/Sea/Ice Mask, Deep soil T
Dataset name at MPI:	CEOP_JMA_GRID_3
Spatial resolution:	320x160 (1.125 lon. X ~1.125 lat.)
Vertical resolution:	40 eta model levels
Temporal resolution:	6-hourly (3292 total files)
Missing data:	None
Key variables:	T, U/V, P, q (40 levels) Local time tendency of T (40 levels)
Pull binary data from grib:	~/CEOP/JMA/pull_grid1.bash ~/CEOP/JMA/pull_grid2.bash ~/CEOP/JMA/pull_grid3.bash
Re-grid 6-hourly binary:	~/CEOP/JMA/mma_regrid.gs
Daily average creation:	~/CEOP/MAC/daily_average.gs
Daily average description:	“lats4d” average of 00Z, 06Z, 12Z, and 18Z times
Monthly average creation:	~/CEOP/MAC/monthly_average.gs
Monthly average description:	“lats4d” average of 00Z (day 1) to 18Z (last day of month)

UKMO

Experiment name at MPI:	CEOP_UKMO_GRID_RAW
Dataset name at MPI:	CEOP_UKMO_GRID_DA_all_2D

Spatial resolution:	288x145 (1.25 lon. X 1.25 lat.)
Vertical resolution:	1 surface level
Temporal resolution:	6-hourly (3014 total files)
Missing data:	278 times missing (by month):
	2002: 4, 3, 70
	2003: 27, 5, 4, 2, 10, 26, 4, 24, 8, 9, 11, 1
	2004: 5, 5, 5, 0, 4, 9, 5, 9, 9, 4, 9, 8
Key variables:	TOA/surface LW/SW ↑/↓ radiation
	Sensible/Latent heat flux
	Precip w/ Convective/Large-scale
	Pressure/Roughness/PBL height
	Total/High/Mid/Low cloud cover %
	Convective cloud base/top
	Snow fall/depth/melt
	Runoff/Soil moisture
	2-m T/q, 10-m U/V

Dataset name at MPI:	CEOP_UKMO_GRID_DA_all_3D
Spatial resolution:	288x145 (1.25 lon. X 1.25 lat.)
Vertical resolution:	18 pressure levels
Temporal resolution:	6-hourly (3014 total files)
Missing data:	278 times missing (by month):
	2002: 4, 3, 70
	2003: 27, 5, 4, 2, 10, 26, 4, 24, 8, 9, 11, 1
	2004: 5, 5, 5, 0, 4, 9, 5, 9, 9, 4, 9, 8
Key variables:	T, U/V, RH, Φ (18 levels)
KE/Enthalpy (18 levels)	

Pull binary data from grib:	~/CEOP/UKMO/pull_da2d.bash
	~/CEOP/UKMO/pull_da3d.bash
Re-grid 6-hourly binary:	~/CEOP/UKMO/mma_regrid.gs
Daily average creation:	~/CEOP/MAC/daily_average.gs
Daily average description:	"lats4d" average of 00Z, 06Z, 12Z, and 18Z times
Monthly average creation:	~/CEOP/MAC/monthly_average.gs
Monthly average description:	"lats4d" average of 00Z (day 1) to 18Z (last day of month)

BMRC

Experiment name: CEOP_BMRC_GRID
(obtained directly from BMRC)

Dataset names:	N/A
Spatial resolution:	480x240 (0.75 lon. X ~0.75 lat.)
Vertical resolution:	15 pressure levels & 1 surface level
Temporal resolution:	6-hourly (3290 total files)
Missing data:	2 time missing: 12Z2003Dec12 & 18Z2003Dec12
Key variables:	T, U/V, ω, Φ (15 levels)

	Surface LW/SW ↑/↓ radiation
	Sensible/Latent heat flux
	Precip/Pressure
	Precipitable water
	Snow depth
	Surface albedo
	Soil moisture & temp
	2-m T/q, 10-m U/V
Pull binary data from grib:	~/CEOP/BMRC/pull_grid.bash
Re-grid 6-hourly binary:	~/CEOP/BMRC/mma_regrid.gs
Daily average creation:	~/CEOP/MAC/daily_average.gs
Daily average description:	"lats4d" average of 00Z, 06Z, 12Z, and 18Z times
Monthly average creation:	~/CEOP/MAC/monthly_average.gs
Monthly average description:	"lats4d" average of 00Z (day 1) to 18Z (last day of month)

NCEP

Experiment name at MPI:	CEOP_NCEP_GRID_RAW
Dataset names at MPI:	NCEP_GR_FORC_06__00H
	NCEP_GR_FORC_06__06H
	NCEP_GR_FORC_06__12H
	NCEP_GR_FORC_06__18H
Spatial resolution:	360x181 (1.0 lon. X 1.0 lat.)
Vertical resolution:	26 pressure levels & 1 surface level
Temporal resolution:	6-hourly (3291 total files)
Missing data:	1 time missing: 12Z2003Aug26
Key variables:	T, U/V, Φ (26 levels)
	Cloud water, RH, ω (21 levels)
	TOA/surface LW/SW ↑/↓ radiation (no TOA SW↓, however)
	Sensible/Latent/Ground heat flux
	Precip/Pressure/PBL height
	Total cloud cover % (column)
	Precipitable & Cloud water (column)
	Snow depth
	Surface albedo
	Runoff/Soil moisture & temps
	2-m T/q, 10-m U/V
Pull binary data from grib:	~/CEOP/NCEP/pull_grid.bash
Re-grid 6-hourly binary:	~/CEOP/NCEP/mma_regrid.gs
Daily average creation:	~/CEOP/MAC/daily_average.gs
Daily average description:	"lats4d" average of 00Z, 06Z, 12Z, and 18Z times
Monthly average creation:	~/CEOP/MAC/monthly_average.gs
Monthly average description:	"lats4d" average of 00Z (day 1) to 18Z (last day of month)

ECPC RII

Experiment name at MPI:	CEOP_ECPCRII_GRID_RAW
Dataset names at MPI:	ECPCRII6_flx_ft00_MUL (analysis)
	ECPCRII6_flx_ft03_MUL (00-03 hour forecast average)
	ECPCRII6_flx_ft06_MUL (03-06 hour forecast average)
Spatial resolution:	192x94 (1.875 lon. X ~1.915 lat.)
Vertical resolution:	1 surface level
Temporal resolution:	6-hourly, with forecast data 3-hourly (3292 total files)
Missing data:	None
Key variables:	TOA/surface LW/SW ↑/↓ radiation
	Sensible/Latent/Ground heat flux
	Precip w/ Convective
	Pressure/Roughness/PBL height
	Momentum flux/Gravity wave stress
	Total/High/Mid/Low cloud cover %
	Cloud base/top/temperature/CWF
	Snow fall/depth/melt
	Surface albedo
	Runoff/Soil moisture & temps
	2-m T/q, 10-m U/V
Dataset names at MPI:	ECPCRII6_pgb_ft00_MUL (analysis)
Spatial resolution:	144x73 (2.5 lon. X 2.5 lat.)
Vertical resolution:	17 pressure levels
Temporal resolution:	6-hourly, with forecast data 3-hourly (3292 total files)
Missing data:	None
Key variables:	T, U/V, RH/q, ω, Φ, h (17 levels)
	Precipitable water/RH (column)
	Lifted index
	Max wind level T, U/V, Pressure
	Tropopause T, U/V, Pressure, Shear
Pull binary data from grib:	1) ~/CEOP/ECPC-RII/pull_analysis.bash
	2) ~/CEOP/ECPC-RII/pull_6hourly.bash
	3) ~/CEOP/ECPC-RII/combine_3hourly.gs
Re-grid 6-hourly binary:	~/CEOP/ECPC-RII/mma_regrid.gs
Daily average creation:	~/CEOP/MAC/daily_average.gs
Daily average description:	"lats4d" average of 00Z, 06Z, 12Z, and 18Z times
Monthly average creation:	~/CEOP/MAC/monthly_average.gs
Monthly average description:	"lats4d" average of 00Z (day 1) to 18Z (last day of month)

ECPC SFM

Experiment name at MPI:	CEOP_ECPCSFM_GRID_RAW

Dataset names at MPI: ECPCSFM6_flx_ft00_MUL (analysis)
ECPCSFM6_flx_ft03_MUL (00-03 hour forecast average)
ECPCSFM6_flx_ft06_MUL (03-06 hour forecast average)
Spatial resolution: 192x94 (1.875 lon. X ~1.915 lat.)
Vertical resolution: 1 surface level (with 3 soil moisture/temperature levels)
Temporal resolution: 6-hourly, with forecast data 3-hourly (3292 total files)
Missing data: 2 times missing: 12Z2003Aug22 & 12Z2003Aug25
Key variables: TOA/surface LW/SW ↑/↓ radiation
Sensible/Latent/Ground heat flux
Precip w/ Convective
Pressure/Roughness/PBL height
Momentum flux/Gravity wave stress
Total/High/Mid/Low cloud cover %
Cloud base/top/temperature/CWF
Snow fall/depth/melt
Surface albedo
Runoff/Soil moisture & temps
2-m T/q, 10-m U/V

Dataset names at MPI: ECPCSFM6_pgb_ft00_MUL (analysis)
Spatial resolution: 144x73 (2.5 lon. X 2.5 lat.)
Vertical resolution: 17 pressure levels
Temporal resolution: 6-hourly, with forecast data 3-hourly (3292 total files)
Missing data: None
Key variables: T, U/V, RH/q, ω, Φ, h (17 levels)
Precipitable water/RH (column)

Pull binary data from grib: 1) ~/CEOP/ECPC-SFM/pull_analysis.bash
2) ~/CEOP/ECPC-SFM/pull_6hourly.bash
3) ~/CEOP/ECPC-SFM/combine_3hourly.gs
Re-grid 6-hourly binary: ~/CEOP/ECPC-SFM/mma_regrid.gs
Daily average creation: ~/CEOP/MAC/daily_average.gs
Daily average description: “lats4d” average of 00Z, 06Z, 12Z, and 18Z times
Monthly average creation: ~/CEOP/MAC/monthly_average.gs
Monthly average description: “lats4d” average of 00Z (day 1) to 18Z (last day of month)

MSC

Experiment name at MPI: CEOP_MSC_GRID_RAW

Dataset names at MPI: CEOP_MSC_GRID_RAW_xxxx
(xxxx = variable name)
Spatial resolution: 800x600 (0.45 lon. X 0.3 lat.)
Vertical resolution: 1 surface level (with 4 upper-air levels used)
Temporal resolution: 24-hourly, with forecast data 3-hourly (823 total files)
Upper-air forecast data 12-hourly only

Missing data:	2 times missing: 00Z2002Oct01 & 06Z2002Oct01
Key variables:	T, U/V, q, Φ (4 levels) TOA/surface LW/SW ↑/↓ radiation Sensible/Latent/Ground heat flux Precip/Pressure 1.5-m T/q, 10-m U/V Total cloud cover % (column) Precipitable & Cloud water (column) Snow depth/SWE Surface albedo Runoff/Soil moisture
Pull binary data from grib:	1) ~/CEOP/MSC/pull_analysis.bash 2) ~/CEOP/MSC/pull_3hourly.bash
Re-grid 6-hourly binary:	~/CEOP/MSC/mma_regrid.gs
Daily average creation:	~/CEOP/MAC/daily_average.gs
Daily average description:	"lats4d" average of 00Z, 06Z, 12Z, and 18Z times
Monthly average creation:	~/CEOP/MAC/monthly_average.gs
Monthly average description:	"lats4d" average of 00Z (day 1) to 18Z (last day of month)

CPTEC

Experiment name at MPI:	CEOP_CPTEC_GRID_RAW
Dataset names at MPI:	CPTEC_GR_gposnmc_fct_12_MUL CPTEC_GR_gposnmc_fct_18_MUL CPTEC_GR_gposnmc_fct_24_MUL CPTEC_GR_gposnmc_fct_30_MUL
Spatial resolution:	384x192 (0.9375 lon. X ~0.9375 lat.)
Vertical resolution:	15 pressure levels & 1 surface level
Temporal resolution:	6-hourly, with forecast data from 12- to 30-hourly (3293 total files)
Missing data:	35 times missing (by month): 2002: 0, 1, 0 2003: 1, 1, 1, 0, 14, 2, 1, 0, 1, 0, 0, 3 2004: 0, 0, 0, 1, 4, 0, 0, 0, 1, 0, 4, 0
Key variables:	T, U/V, q, ω, Φ, diverg. (15 levels) TOA/surface LW/SW ↑/↓ radiation (no TOA SW↓, however) Sensible/Latent heat flux Precip/Pressure/Roughness Runoff/Soil moisture 2-m T/RH, 10-m U/V Total cloud cover % (column) Precipitable water (column)
Pull binary data from grib:	~/CEOP/CPTEC/pull_grid.bash
Re-grid 6-hourly binary:	~/CEOP/CPTEC/mma_regrid.gs

Daily average creation:	~/CEOP/MAC/daily_average.gs
Daily average description:	"lats4d" average of 00Z, 06Z, 12Z, and 18Z times
Monthly average creation:	~/CEOP/MAC/monthly_average.gs
Monthly average description:	"lats4d" average of 00Z (day 1) to 18Z (last day of month)

6. References

Bosilovich, M. G., J. D. Radakovich, A. da Silva, R. Todling and F. Verter: Skin Temperature Analysis and Bias Correction in a Coupled Land-Atmosphere Data Assimilation System. JMSJ, Vol. 85A, 205-228.

Chou, S. C., J. A. Marengo, C. P. Dereczynski, P. V. Waldheim and A. O. Manzi, 2007: Comparison of CPTEC GCM and Eta Model Results with Observational Data from the Rondonia LBA Reference Site, Brazil". JMSJ, Vol. 85A, 25-42.

Dirmeyer, P. A. and co-authors, 2006: Multi-model Analysis and Implications for our perception of the land surface, Bull. Amer. Met. Soc., 87, 1381-1395.

Rikus, L., 2007: Validating Basic Surface Variables in the Australian Bureau of Meteorology Model with CEOP EOP3 In-situ Data. JMSJ, Vol. 85A, 73-97.

Yang, K. and co-authors, 2007: Initial CEOP-based Review of the Prediction Skill of Operational General Circulation Models and Land Surface Models. JMSJ, Vol. 85A, 99-116.

7. Acronyms