The University of Reading

CloudNET Model Conversion Software: Model Variables

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History

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2004−06−23	AO	First version.

Contents

1. Introduction

This document provides information on the models and variables the conversion software recognizes.

It is recommended that the document *CloudNET Model Conversion Software: Overview* is read before reading this, in particular, table 1.1 in section 1.1.

Section 2 summarizes all the variables that are recognized by the software.

Section 3 contains information on the variables available from the models.

2. Model variables

The netCDF FC (forecast) datasets conform to the CF−1.0 conventions for netCDF (ref: NetCDF Climate and Forecast (CF) Metadata Convention).

Table 2.1 is a list of all the variables that are recognized by the conversion software. A FC dataset will contain some or all of these variables.

Name	***Standard Name***
Units	***Long Name***
pressure	air_pressure
Pa	Pressure
height	height
m	Height above ground
height_amsl	
m	Height above mean sea level
uwind	eastward_wind
m s−1	Zonal wind
vwind	northward_wind
m s−1	Meridional wind
wwind	upward_wind
m s−1	Vertical wind
omega	omega
Pa s−1	Vertical wind in pressure coordinates
temperature	air_temperature
K	Temperature
q	specific_humidity
1	Specific humidity
rh	relative_humidity
1	Relative humidity
ql	mass_fraction_of_cloud_liquid_water_in_air
1	Gridbox−mean liquid water mixing ratio
qi	mass_fraction_of_cloud_ice_in_air
1	Gridbox−mean ice water mixing ratio
ls_cloud_fraction	large_scale_cloud_area_fraction
1	Large scale cloud fraction
conv_cloud_fraction	convective_cloud_area_fraction
1	Convective cloud fraction
total_cloud_fraction	cloud_area_fraction
1	Total cloud fraction

Name	***Standard Name***
Units	***Long Name***
flx_height	
m	Height above ground
flx_height_amsl	
m	Height above mean sea level
flx_net_sw	net_downward_shortwave_flux_in_air
W m−2	Net shortwave flux
flx_net_lw	net_downward_longwave_flux_in_air
W m−2	Net longwave flux
flx_down_sens_heat	
W m−2	Sensible heat flux
flx_turb_moist	
kg m−2 s−1	Turbulent moisture flux
flx_ls_rain	large_scale_rainfall_flux
kg m−2 s−1	Large−scale rainfall flux
flx_ls_snow	large_scale_snowfall_flux
kg m−2 s−1	Large−scale snowfall flux
flx_conv_rain	convective_rainfall_flux
kg m−2 s−1	Convective rainfall flux
flx_conv_snow	convective_snowfall_flux
kg m−2 s−1	Convective snowfall flux
flx_turb_mom_u	downward_eastward_momentum_flux_in_air
kg m−1 s−2	Zonal turbulent momentum flux
flx_turb_mom_v	downward_northward_momentum_flux_in_air
kg m−1 s−2	Meridional turbulent momentum
sfc_height_amsl	
m	Surface height above mean sea level
sfc_pressure	surface_pressure
Pa	Surface pressure
sfc_temperature	surface_temperature
K	Surface temperature
sfc_net_sw	surface_net_downward_shortwave_flux
W m−2	Surface net downward shortwave flux
sfc_net_lw	surface_net_downward_longwave_flux
W m−2	Surface net downward longwave flux
sfc_down_sw	surface_downwelling_shortwave_flux
W m−2	Surface downwelling shortwave flux

Name	***Standard Name***
Units	***Long Name***
sfc_down_lw	surface_downwelling_longwave_flux
W m−2	Surface downwelling longwave flux
sfc_cs_down_sw	surface_downwelling_shortwave_flux_in_air_assuming_clear_sky
W m−2	Clear sky downwelling shortwave flux
sfc_cs_down_lw	surface_downwelling_longwave_flux_in_air_assuming_clear_sky
W m−2	Clear sky downwelling longwave flux
sfc_down_lat_heat_flx	surface_downward_latent_heat_flux
W m−2	Latent heat flux
sfc_down_sens_heat_flx	surface_downward_sensible_heat_flux
W m−2	Sensible heat flux
sfc_ls_rain	large_scale_rainfall_amount
kg m−2	Large−scale rainfall amount
sfc_ls_rain_flx	large_scale_rainfall_flux
kg m−2 s−1	Surface large−scale rainfall flux
sfc_conv_rain	convective_rainfall_amount
kg m−2	Convective rainfall amount
sfc_conv_rain_flx	convective_rainfall_flux
kg m−2 s−1	Surface convective rainfall flux
sfc_ls_snow	large_scale_snowfall_amount
kg m−2	Large−scale snowfall amount
sfc_ls_snow_flx	large_scale_snowfall_flux
kg m−2 s−1	Surface large−scale snowfall flux
sfc_conv_snow	convective_snowfall_amount
kg m−2	Convective snowfall amount
sfc_conv_snow_flx	convective_snowfall_flux
kg m−2 s−1	Surface convective snowfall flux
sfc_ls_precip_fraction	
1	Large−scale precipitation fraction
sfc_ls_cloud_fraction	
1	Surface large−scale cloud fraction
sfc_conv_cloud_fraction	
1	Surface convective cloud fraction
sfc_total_cloud_fraction	
1	Surface total cloud fraction
sfc_bl_height	
m	Boundary layer height

Name	***Standard Name***
Units	***Long Name***
sfc_albedo	surface_albedo
1	Surface albedo
sfc_temp_2m	
K	Temperature at 2m
sfc_q_2m	
1	Specific humidity at 2m
sfc_rough_mom	
m	Surface roughness for momentum
sfc_rough_heat	
m	Surface roughness for heat
sfc_skin_temp	
K	Skin temperature
sfc_wind_u_10m	
m s−1	Zonal wind at 10m
sfc_wind_v_10m	
m s−1	Meridional wind at 10m
sfc_geopotential	geopotential
m2 s−2	Geopotential
sfc_geopotential_height	geopotential_height
m	Geopotential height
gas_atten	
dB	Two−way attenuation from the ground due to atmospheric gases
specific_gas_atten	
dB km−1	Specific one−way attenuation due to atmospheric gases
specific_sat_gas_atten	
dB km−1	Specific one−way attenuation due to atmospheric gases for saturated air (saturated with respect to ice below 0 degrees C)
specific_dry_gas_atten	
dB km−1	Specific one−way attenuation due to atmospheric gases for dry air (no water vapour)
K2	
dB km−1	Dielectric parameter (|K|^2) of liquid water
specific_liq_atten	
(dB km−1)/(g m−3)	Specific one−way attenuation due to liquid water, per unit liquid water content

Table 2.1. Variables used by the CloudNET conversion software. Each entry in the table has four fields beginning with the shaded box which contains the name of the

variable as it appears in a FC dataset. The box to the right contains the CF standard name for the variable, if there is one and the bottom left box contains the CF compatible units for the variable. The bottom right box is the long name used for the variable.

3. The models

Currently, the conversion software can convert data from five sources

1. ECIFS − ECMWF Integrated Forecast System (IFS);
2. MFARP − Meteo France ARPEGE;
3. KNRAC − KNMI RACMO;
4. MOUMM − UK Met Office Unified Model mesoscale output;
5. MOUMG − UK Met Office Unified Model global output.

Table 3.1 is a summary of which variables are availabe from each model.

Variable	***ECIFS***		***MFARP***		***KNRAC***		***MOUMM***		***MOUMG***	
pressure	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
height[1]	N	Y	Y	Y	N	Y	Y	Y	Y	Y
height_amsl	N	N	N	N	N	N	N	N	N	N
uwind	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
vwind	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
wwind[3]	N	Y	N	Y	N	Y	Y	Y[2]	Y	Y
omega	Y	Y	Y	Y	Y	Y	Y[2]	Y	N	N
temperature	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
q	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
rh[4]	Y	Y	Y	Y	N	Y	Y	Y	N	Y
ql	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
qi	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
ls_cloud_fraction	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
conv_cloud_fraction	N	N	N	N	N	N	Y	Y	Y	Y
total_cloud_fraction[5]	N	N	N	N	N	N	N	Y	N	Y
flx_height[6]	N	Y	Y	Y	N	Y	N	Y	N	Y
flx_height_amsl	N	N	N	N	N	N	N	N	N	N
flx_net_sw	Y	Y	Y	Y	N	N	N	N	N	N
flx_net_lw	Y	Y	Y	Y	N	N	N	N	N	N
flx_down_sens_heat	Y	Y	Y	Y	N	N	N	N	N	N
flx_turb_moist	Y	Y	Y	Y	N	N	N	N	N	N
flx_ls_rain[7]	Y	Y	Y	Y	N	Y	N	Y	N	Y
flx_ls_snow[7]	Y	Y	Y	Y	N	Y	N	Y	N	Y
flx_conv_rain	Y	Y	Y	Y	N	N	N	N	N	N
flx_conv_snow	Y	Y	Y	Y	N	N	N	N	N	N
flx_turb_mom_u	Y	Y	Y	Y	N	N	N	N	N	N

Variable	***ECIFS***		***MFARP***		***KNRAC***		***MOUMM***		***MOUMG***	
flx_turb_mom_v	Y	Y	Y	Y	N	N	N	N	N	N
sfc_height_amsl[8]	N	Y	N	N	N	N	Y	Y	N	N
sfc_pressure	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
sfc_temperature	N	N	N	N	N	N	N	N	Y	Y
sfc_net_sw	Y	Y	Y	Y	N	N	Y	Y	N	N
sfc_net_lw	Y	Y	Y	Y	N	N	Y	Y	N	N
sfc_down_sw	Y	Y	N	N	N	N	Y	Y	Y	Y
sfc_down_lw	Y	Y	N	N	N	N	Y	Y	Y	Y
sfc_cs_down_sw	Y	Y	N	N	N	N	N	N	N	N
sfc_cs_down_lw	Y	Y	N	N	N	N	N	N	N	N
sfc_down_lat_heat_flx	Y	Y	Y	Y	Y	Y	N	N	Y	Y
sfc_down_sens_heat_flx	Y	Y	Y	Y	Y	Y	N	N	Y	Y
sfc_ls_rain	Y	Y	Y	Y	N	N	N	N	Y	Y
sfc_ls_rain_flx	N	N	N	N	N	N	Y	Y	N	N
sfc_conv_rain	Y	Y	Y	Y	N	N	N	N	Y	Y
sfc_conv_rain_flx	N	N	N	N	N	N	Y	Y	N	N
sfc_ls_snow	Y	Y	Y	Y	N	N	N	N	Y	Y
sfc_ls_snow_flx	N	N	N	N	N	N	Y	Y	N	N
sfc_conv_snow	Y	Y	Y	Y	N	N	N	N	Y	Y
sfc_conv_snow_flx	N	N	N	N	N	N	Y	Y	N	N
sfc_ls_precip_fraction	Y	Y	N	N	N	N	N	N	N	N
sfc_ls_cloud_fraction	N	N	N	N	N	N	Y	Y	Y	Y
sfc_conv_cloud_fraction	N	N	N	N	N	N	N	N	N	N
sfc_total_cloud_fraction	Y	Y	Y	Y	Y	Y	N	N	N	N
sfc_bl_height	Y	Y	N	N	N	N	N	N	Y	Y
sfc_albedo	Y	Y	N	N	N	N	N	N	N	N
sfc_temp_2m	Y	Y	N	N	N	N	Y	Y	Y	Y
sfc_q_2m	Y	Y	N	N	N	N	N	N	Y	Y
sfc_rough_mom	Y	Y	N	N	N	N	N	N	N	N
sfc_rough_heat	Y	Y	N	N	N	N	N	N	N	N
sfc_skin_temp	Y	Y	N	N	N	N	N	N	N	N
sfc_wind_u_10m	Y	Y	N	N	N	N	N	N	Y	Y
sfc_wind_v_10m	Y	Y	N	N	N	N	N	N	Y	Y
sfc_geopotential	Y	Y	N	N	N	N	N	N	N	N
sfc_geopotential_height	N	N	N	N	N	N	N	N	N	N
gas_atten[9]	N	Y	N	Y	N	Y	N	Y	N	Y

Variable	***ECIFS***		***MFARP***		***KNRAC***		***MOUMM***		***MOUMG***	
specific_gas_atten[9]	N	Y	N	Y	N	Y	N	Y	N	Y
specific_sat_gas_atten[9]	N	Y	N	Y	N	Y	N	Y	N	Y
specific_dry_gas_atten[9]	N	Y	N	Y	N	Y	N	Y	N	Y
K2[9]	N	Y	N	Y	N	Y	N	Y	N	Y
specific_liq_atten[9]	N	Y	N	Y	N	Y	N	Y	N	Y

Table 3.1. Variables available from each model and variables available in the FC datasets. The lighter shaded column indicates whether the variable is availabe from the model and the darker shade indicates whether the variable is in the FC datasets.

Notes:

1. See Appendix A for the calculation of level heights.

2. For MOUMM either wwind or omega is given, but not both.

3. Vertical wind w in m s^{-1} can be calculated from Ω in Pa s^{-1} using

$$w=\Omega\frac{dz}{dp}$$

where dz is the thickness of the level and dp is the change in pressure across the level.

4. See Appendix B for the calculation of relative humidity.

5. Total cloud fraction C_{tot} can be calculated from

$$C_{tot}=C_{conv}+(1-C_{conv})C_{ls}$$

where C_{conv} is the convective cloud fraction and C_{ls} is the large scale cloud fraction.

6. Flux heights can be calculated from level heights as the mid−point between levels.

7. The large scale rain and large scale snow fluxes can be calculated using pressure, temperate, height, large scale cloud fraction, specific humidity, liquid water content and ice contents.

8. Surface height can be calculated by dividing the geopotential by g, the acceleration due to gravity.

9. The microwave propagation parameters can be calculated using the pressure, temperature, height and specific humidities.

The following subsections summarize the variables available from each model.

3.1. ECMWF

See Appendix C for the original documentation.

Data from ECMWF is available in five file types:

- *var* − variables available at each level. Table 3.2.
- *flx* − flux variables available at half−levels. Table 3.3.
- *sfc* − surface variables. Table 3.4.
- *sfc2* − surface variables. Table 3.5.
- *sfce* − surface variables. Table 3.6.

The *Column* column in the following tables refers to the name at the head of each column in the original model output ASCII data files.

Column	***Description***	***Variable***
`P HIST`	pressure	pressure
`U HIST`	zonal wind component	uwind
`V HIST`	meridional wind component	vwind
`T HIST`	temperature	temperature
`Q HIST`	specific humidity	q
`L HIST`	specific cloud liquid water content	ql
`I HIST`	specific cloud ice content	qi
`A HIST`	cloud fraction	ls_cloud_fraction
`R HIST`	relative humidity	rh
`W HIST`	omega=vertical velocity in pressure coordinates	omega

Table 3.2. Variables available from ECMWF *var* data files.

Column	***Description***	***Variable***
`T FSWR`	net shortwave flux	flx_net_sw
`T FLWR`	net longwave flux	flx_net_lw
`T FVDF`	sensible heat flux	flx_down_sens_heat
`Q FVDF`	turbulent moisture flux	flx_turb_moist
`Q FCVR`	convective rain flux	flx_conv_rain
`Q FCVN`	convective snow flux	flx_conv_snow
`Q FLSR`	large−scale rain flux	flx_ls_rain
`Q FLSN`	large−scale snow flux	flx_ls_snow
`U FVDF`	turbulent momentum flux − u component	flx_turb_mom_u
`V FVDF`	turbulent momentum flux − v component	flx_turb_mom_v

Table 3.3. Variables available from ECMWF *flx* data files.

Column	***Description***	***Variable***
`SFSSLHF`	Surface latent heat flux	sfc_down_lat_heat_flx

Column	***Description***	***Variable***
SFSSSHF	Surface sensible heat flux	sfc_down_sens_heat_flx
SFSSW	Surface solar radiation	sfc_net_sw
SFSLW	Surface thermal radiation	sfc_net_lw
SFSWC	Surface csky solar radiation	sfc_cs_down_sw
SFLWC	Surface csky thermal radiation	sfc_cs_down_lw
SFLSR	Large−scale rainfall	sfc_ls_rain
SFSCR	Convective rainfall	sfc_conv_rain
SFLSF	Large−scale snowfall	sfc_ls_snow
SFSCF	Convective snowfall	sfc_conv_snow
SFSTCC	Total cloud cover	sfc_total_cloud_fraction
SFSLSPF	Large−scale precipitation fraction	sfc_ls_precip_fraction
SFSSWDO	Downward Solar	sfc_down_sw
S HIST	Surface pressure	sfc_pressure

Table 3.4. Variables available from ECMWF *sfc* data files.

Column	***Description***	***Variable***
SFSLWDO	Downward thermal radiation	sfc_down_lw
SFSZ	Orography as a geopotential	sfc_geopotential
SFSLF	Land fraction	
S HIST	Surface pressure	sfc_pressure

Table 3.5. Variables available from ECMWF *sfc2* data files.

Column	***Description***	***Variable***
SFST2M	2 m temperature	sfc_temp_2m
SFSQ2M	2 m specific humidity	sfc_q_2m
SFS10U	10 m zonal wind	sfc_wind_u_10m
SFS10V	10 m meridional wind	sfc_wind_v_10m
SFSZ0M	Surface Roughness for momentum	sfc_rough_mom
SFSZ0H	Surface Roughness for heat	sfc_rough_heat
SFSAL	Surface albedo	sfc_albedo
SFSBLH	Boundary layer height	sfc_bl_height
SFSTSK	Skin temperature	sfc_skin_temp

Table 3.6. Variables available from ECMWF *sfce* data files.

3.2. Meteo−France

See Appendix D for the original documentation.

Data from Meteo−France is available in three file types:

- *var* − variables available at each level. Table 3.7.
- *flx* − flux variables available at half−levels. Table 3.8.
- *sfc* − surface variables. Table 3.9.

The *Column* column in the following tables refers to the name at the head of each column in the original model output ASCII data files.

Column	***Description***	***Variable***
`H LEVEL`	height above ground	height
`P HIST`	pressure	pressure
`U HIST`	zonal wind component	uwind
`V HIST`	meridional wind component	vwind
`T HIST`	temperature	temperature
`Q HIST`	specific humidity	q
`L HIST`	specific cloud liquid water content	ql
`I HIST`	specific cloud ice content	qi
`A HIST`	cloud fraction	ls_cloud_fraction
`R HIST`	relative humidity	rh
`W HIST`	omega=vertical velocity in pressure coordinates	omega

Table 3.7. Variables available from Meteo−France *var* data files.

Column	***Description***	***Variable***
`H LEVEL`	height above ground	flx_height
`T FSWR`	net shortwave flux	flx_net_sw
`T FLWR`	net longwave flux	flx_net_lw
`T FVDF`	sensible heat flux	flx_down_sens_heat
`Q FVDF`	turbulent moisture flux	flx_turb_moist
`Q FCVR`	convective rain flux	flx_conv_rain
`Q FCVN`	convective snow flux	flx_conv_snow
`Q FLSR`	large−scale rain flux	flx_ls_rain
`Q FLSN`	large−scale snow flux	flx_ls_snow
`U FVDF`	turbulent momentum flux − u component	flx_turb_mom_u
`V FVDF`	turbulent momentum flux − v component	flx_turb_mom_v

Table 3.8. Variables available from Meteo−France *flx* data files.

Column	***Description***	***Variable***
SFSSLHF	Surface latent heat flux	sfc_down_lat_heat_flx
SFSSSHF	Surface sensible heat flux	sfc_down_sens_heat_flx
SFSSW	Surface solar radiation	sfc_net_sw
SFSLW	Surface thermal radiation	sfc_net_lw
SFLSR	Large−scale rainfall	sfc_ls_rain
SFSCR	Convective rainfall	sfc_conv_rain
SFLSF	Large−scale snowfall	sfc_ls_snow
SFSCF	Convective snowfall	sfc_conv_snow
SFSTCC	Total cloud cover	sfc_total_cloud_fraction
S HIST	Surface pressure	sfc_pressure

Table 3.9. Variables available from Meteo−France *sfc* data files.

3.3. KNMI RACMO

See Appendix H for the original documentation.

Data from the KNMI RACMO is available in two file types:

- *multi−level* − variables available at each level. Table 3.10.
- *single−level* − surface variables. Table 3.11.

The column numbers are 1−based.

Column	***Description***	***Variable***
4	Pressure	pressure
5	Temperature	temperature
6	Zonal wind component	uwind
7	Meridional wind component	vwind
8	Vertical wind speed	wwind
9	Turbulent Kinetic energy	
10	Specific Humidity	q
11	Specific Liquid Water	ql
12	Specific Ice Content	qi
13	Cloud fraction	ls_cloud_fraction
14	Short Wave In−Cloud Optical Thickness	
15	Long Wave In−Cloud Emissivity	
16	Liquid Precipitative Flux at lower interface	

Column	*Description*	*Variable*
17	Solid Precipitative Flux at lower interface	

Table 3.10. Variables available from KNMI RACMO *multi−level* data files.

Column	*Description*	*Variable*
3	Surface Pressure	sfc_pressure
4	Sensible heat flux at surface	sfc_down_sens_heat_flx
5	Latent heat flux at surface	sfc_down_lat_heat_flx
6	Momentum flux at surface	
7	Downward SW−flux at surface	
8	Upward SW−flux at surface	
9	Downward LW−flux at surface	
10	Upward LW−flux at surface	
11	Downward SW−flux at TOA	
12	Upward SW−flux at TOA	
13	Upward LW−flux at TOA [W/m2]	
14	Precipitation Convective	
15	Precipitation Large Scale	
16	Precipitative Fraction in GridBox	
17	Total Cloud Cover	sfc_total_cloud_fraction

Table 3.11. Variables available from KNMI RACMO *single−level* data files.

3.4. UK Met Office Mesoscale

See Appendix E for the original documentation.

Data from the Met Office UM (mesoscale) is available in two file types:

- *profile* − variables available at each level. Table 3.12.
- *surface* − surface variables. Table 3.13.

The *Column* column in the following tables refers to the name at the head of each column in the original model output ASCII data files.

Column	*Variable*
`H(km)`	height
`P(hPa)`	pressure
`ff(m/s)`	
`ddd`	
`u(m/s)`	uwind

Column	***Variable***
`v(m/s)`	vwind
`T(deg C)`	temperature
`RHw(%)`	
`RHi(%)`	
`q(g/kg)`	q
`qcl(g/kg)`	ql
`qcf(g/kg)`	qi
`CF(%)` OR `LCF(%)`	ls_cloud_fraction
`CCF(%)`	conv_cloud_fraction
`W(m/s)` OR `Om(Pa/s)`	wwind OR omega

Table 3.12. Variables available from
Met Office UM Mesoscale *profile* data files.

Column	***Variable***
`Orog (m)`	sfc_height_amsl
`pstar (Pa)`	sfc_pressure
`Net Surf SW`	sfc_net_sw
`TOA In SW`	
`TOA Out SW`	
`Tot Surf SW`	sfc_down_sw
`Net Surf LW`	sfc_net_lw
`Tot Surf LW`	sfc_down_lw
`Surf H`	
`Ustar(x)`	
`Ustar(y)`	
`U10`	
`V10`	
`T 1.5m`	sfc_temp_2m
`q 1.5m`	
`RH 1.5m`	
`TD 1.5m`	
`Mix Ht`	
`Stable BL`	
`Sc/Stable`	

Column	*Variable*
`Well Mixed`	
`Dec Sc`	
`Dec Sc/Cu`	
`Cu`	
`LSR kg/m2/s`	sfc_ls_rain
`LSS kg/m2/s`	sfc_ls_snow
`Cnv R kg/m2/s`	sfc_conv_rain
`Cnv S kg/m2/s`	sfc_conv_snow
`Tot R kg/m2/s`	
`CCA`	
`Tot C Rnd`	
`Tot C Mx/rnd`	sfc_ls_cloud_fraction
`WB Fz Lv (m)`	
`PMSL (Pa)`	

Table 3.13. Variables available from
Met Office UM Mesoscale *surface* data files.

3.5. UK Met Office Global

See Appendix F for the original documentation.

Data from the Met Office UM (global) is available in a single file type known as a MOLTS (Model Output Time Series) file. From these files, both multi−level and surface variables can be obtained. See tables 3.14 and 3.15 below. A list of GRIB codes is given in Appendix I.

GRIB code	*Description*	*Variable*
		height
001	P on theta levs	pressure
033	Zonal wind *(rho levels)*	uwind
034	Meridional wind *(rho levels)*	vwind
040	Vertical velocity dz/dt *(theta levels)*	wwind
011	Temperature *(theta levels)*	temperature
051	Specific Humidity *(theta levels)*	q
076	Cloud water content *(theta levels)*	ql
058	Cloud ice content *(theta levels)*	qi
149	LS Cloud Fraction *(theta levels)*	ls_cloud_fraction

GRIB code	***Description***	***Variable***
150	Convective cloud fraction *(rho levels)*	conv_cloud_fraction

Table 3.14. Multi−level variables available from MOLTS files.

GRIB code	***Description***	***Variable***
144	Surface Pressure	sfc_pressure
145	Surface Temperature	sfc_temperature
152	1.5m Temperature	sfc_temp_2m
153	1.5m Spec.Humidity	sfc_q_2m
155	10m U − wind	sfc_wind_u_10m
156	10m V − wind	sfc_wind_v_10m
137	Planetary BL Height	sfc_bl_height
133	TotSW down surf	sfc_down_sw
135	TotLW down surf	sfc_down_lw
121	Latent Ht Flux	sfc_down_lat_heat_flx
122	Sensible Ht Flux	sfc_down_sens_heat_flx
062	LS rainfall	sfc_ls_rain
063	CU rainfall	sfc_conv_rain
079	LS snowfall	sfc_ls_snow
078	CU snowfall	sfc_conv_snow
071	Total Cloud Frac.	sfc_ls_cloud_fraction

Table 3.15. Surface variables available from MOLTS files.

4. References

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Wilson, D.R. 2004 Notes for MOLTS from UK Met Office (UKMO). Personal communication.

WMO code table 2. URL: http://www.ecmwf.int/publications/manuals/libraries/gribex/wmoCodeTable2.html [2004−06−04]

Appendix A. Calculating the height of each level in a profile

The height of a level, if not given explicitly, can be calculated using the pressure, temperature and specific humidity.

If *n* is the number of levels with the level numbers running from $0 \ldots n-1$ and level 0 being the lowest in the atmosphere (closest to the surface) then the height of the lowest level *H*[0], in metres, is

$$H[0]=\frac{R_G}{g}\left(\frac{1}{\sigma_0}-1\right)\frac{T[0]}{(1+\epsilon_f Q[0])}$$

the height for each level above level 0 is

$$H[i]=H[i-1]+\frac{R_G}{g}\frac{(P[i-1]-P[i])(T[i]+T[i-1])}{(P[i]+P[i-1])(1+\epsilon_f(Q[i-1]+Q[i])/2)} \quad ,$$

for $i=1 \ldots n-1$

where $R_G = 287\,\mathrm{J\,kg^{-1}K^{-1}}$ is the gas constant for dry air, $g = 9.87\,\mathrm{m\,s^{-2}}$ is the mean acceleration due to gravity, $\sigma_0=\frac{P[0]}{P_{surface}}=0.998812\,\text{[default]}$ is the ratio of the pressure of the first level above the surface to the pressure at the surface, *T* is the absolute temperature in K, *Q* is the specific humidity, $\epsilon_f=1-\frac{1}{\epsilon}$, $\epsilon=\frac{R}{R_v}=0.622$ where *R* is the gas constant for a perfect gas and R_v is the gas constant for water vapour.

Appendix B. Calculating the relative humidity

The relative humidity can be calculated using the following technique.

The Goff−Gratch formula for saturated vapour pressure is

$$\begin{aligned}\mathrm{SVP} = 10 \wedge (\, & 10.79574(1-T_0/T) - 5.028\log_{10}(T/T_0) \\ & + 1.50475\times10^{-4}(1-10^{-8.2969(T/T_0-1)}) \\ & + 0.42873\times10^{-3}(10^{4.76955(1-T_0/T)}) + 0.78614 + 2\,)\end{aligned}$$

where $T_0 = 273.16\,\mathrm{K}$ and $223 \leq T \leq 373$.

For ice $223 < T < 273$

$$\mathrm{SVP}_{\mathrm{ice}} = 611\exp\left(\frac{21.874(T-T_0)}{(T-7.66)}\right) .$$

Mixing ratio is

$$\text{mixing ratio} = 0.62198\left(\frac{\mathrm{SVP}}{P-\mathrm{SVP}}\right) .$$

The relative humidity is calculated using the mixing ratio from the model divided by the mixing ratio as calculated above.

Appendix C. ECMWF−IFS model output files

(From: ECMWF DDH Data Format)

The data for each CloudNET site consist of five ASCII files per day, with names of the form `cloudnet_YYYYMMDD_AAA_BB`, where YYYYMMDD is the date, BB is a numerical code that identifies the site and AAA is one of `var` (variables on model levels), `flx` (fluxes between levels), or `sfc`, `sfc2` and `sfce` (surface and single−level fields).

Each file has a three line header, with each line beginning with "#". The first line explains the second. The first four parameters on the second line are model internal parameters and are irrelevant for the user. The next two numbers mark model point for which the data was extracted.

The third line contains the variable names for each of the columns of data that follow. The first four columns are common to all files: `idat` and `itim` are the initial date and time of the forecast from which the data was retrieved. `vdat` and `vtim` are the verifying date and time of the data meaning date and time which it is valid for. Hence the difference to the initial date and time indicates the forecast range used. The next column (`lev`) is the model level of the data. The columns that follow these are specific to the file type:

var

These files contain the model variables on the 60 model levels. Level 1 is the top full level of the model (10 hPa), level 60 is the lowest full level. The order of the variables is:

- `P HIST` − pressure (Pa)
- `U HIST` − zonal wind component (m/s)
- `V HIST` − meridional wind component (m/s)
- `T HIST` − temperature (K)
- `Q HIST` − specific humidity (kg/kg)
- `L HIST` − specific cloud liquid water content (kg/kg)
- `I HIST` − specific cloud ice content (kg/kg)
- `A HIST` − cloud fraction (percent/100.)
- `R HIST` − relative humidity (percent/100.)
- `W HIST` − omega=vertical velocity in pressure coordinates (Pa/s)

flx

These files contain the radiative, turbulent, and precipitation fluxes throughout the atmosphere. The fluxes are averages over the last hour. They are archived on the so−called flux levels of the model (often referred to as half−levels). The full levels on which the variables are stored are placed between two flux levels. Hence, level 61 represents the surface and level 1 the top of the atmosphere. Full level k is between half level k and k+1. The fluxes in level 61 are the surface fluxes. The order of the fluxes is:

- `T FSWR` − net shortwave flux (W/m2)
- `T FLWR` − net longwave flux (W/m2)
- `T FVDF` − sensible heat flux (W/m2)
- `Q FVDF` − turbulent moisture flux (kg/kg * kg/(m2*s))
- `Q FCVR` − convective rain flux (kg/(m2*s) = mm/s)
- `Q FCVN` − convective snow flux (mm/s)
- `Q FLSR` − large−scale rain flux (mm/s)
- `Q FLSN` − large−scale snow flux (mm/s)
- `U FVDF` − turbulent momentum flux − u component (m/s * kg/(m2*s))
- `V FVDF` − turbulent momentum flux − v component (m/s * kg/(m2*s))

sfc

These files contain surface/single−level variables and fluxes. The level number is set to 1. The order is:

- `SFSSLHF` − Surface latent heat flux (W m−2)
- `SFSSSHF` − Surface sensible heat flux (W m−2)
- `SFSSW` − Surface solar radiation (W m−2)
- `SFSLW` − Surface thermal radiation (W m−2)
- `SFSWC` − Surface csky solar radiation (W m−2)
- `SFLWC` − Surface csky thermal radiation (W m−2)
- `SFLSR` − Large−scale rainfall (kg m−2)
- `SFSCR` − Convective rainfall (kg m−2)
- `SFLSF` − Large−scale snowfall (kg m−2)
- `SFSCF` − Convective snowfall (kg m−2)
- `SFSTCC` − Total cloud cover
- `SFSLSPF` − Large−scale precipitation fraction
- `SFSSWDO` − Downward Solar (kg m−2)
- `S HIST` − Surface pressure (Pa)

sfc2

These files also contain surface variables and fluxes (there are too many to fit in one file). The order is:

`SFSLWDO` − Downward thermal radiation (W m−2)

`SFSZ` − Orography as a geopotential (m2 s−2)

`SFSLF` − Land fraction

`S HIST` − Surface pressure (Pa)

sfce

Yet more surface variables and fluxes:

`SFST2M` − 2 m temperature (K)

`SFSQ2M` − 2 m specific humidity (g/kg)

`SFS10U` − 10 m zonal wind (m/s)

`SFS10V` − 10 m meridional wind (m/s)

`SFSZ0M` − Surface Roughness for momentum (m)

`SFSZ0H` − Surface Roughness for heat (m)

`SFSAL` − Surface albedo (%)

`SFSBLH` − Boundary layer height (m)

`SFSTSK` − Skin temperature (K)

Note:

Very small numbers ($<10^{-10}$ for precipitation and $<10^{-1}$ for radiation) and small negative numbers in solar radiation and precipitation are due to packing and unpacking mechanisms and do not represent model problems.

Appendix D. Meteo−France ARPEGE model output files

(From: Meteo−France Data Format)

The format is very similar to the ECMWF format, with the following exceptions: height above the ground is included, `var`, `flx` and `sfc` files are provided, there are fewer vertical levels, and the extraction code runs on the midnight model run (i.e. at 00h, and data are extracted for the model forecasts +12h to +36h).

The data for each CloudNET site consists of three ASCII files per day, with names of the form `cloudnet_AAA_NNN_YYYYMMDD`, where YYYYMMDD is the date, NNN is the name of the site and AAA is either `var` (variables on model levels), `flx` (fluxes between levels) and `sfc` (some surface fluxes).

Each file has a four line header, with each line beginning with "#". The first three are self−explanatory. The fourth line contains the variable names for each of the columns of data that follow. The first four columns are common to all files: `idat` and `itime` are the initial date and time of the forecast from which the data was retrieved. vdate and vtime are the verifying date and time of the data meaning date and time which it is valid for. Hence the difference to the initial date and time indicates the forecast range used. The next column (`lev`) is the model level of the data. The columns that follow these are specific to the file type:

var

These files contain the model variables on the 41 model levels. Level 1 is the top full level of the model, level 41 is the lowest full level. The order of the variables is:

- `H LEVEL`− height above ground (m)
- `P HIST` − pressure (Pa)
- `U HIST` − zonal wind component (m/s)
- `V HIST` − meridional wind component (m/s)
- `T HIST` − temperature (K)
- `Q HIST` − specific humidity (kg/kg)
- `L HIST` − specific cloud liquid water content (kg/kg)
- `I HIST` − specific cloud ice content (kg/kg)
- `A HIST` − cloud fraction (percent/100.)
- `R HIST` − relative humidity (percent/100.)
- `W HIST` − omega=vertical velocity in pressure coordinates (Pa/s)

flx

These files contain the radiative, turbulent, and precipitation fluxes throughout the atmosphere. The fluxes are averages over the last hour. The order of the variables is:

`H LEVEL` − height above ground (m)

`T FSWR` − net shortwave flux (W/m2)

`T FLWR` − net longwave flux (W/m2)

`T FVDF` − sensible heat flux (W/m2)

`Q FVDF` − turbulent moisture flux (kg/kg * kg/(m2*s))

`Q FCVR` − convective rain flux (kg/(m2*s) = mm/s)

`Q FCVN` − convective snow flux (mm/s)

`Q FLSR` − large−scale rain flux (mm/s)

`Q FLSN` − large−scale snow flux (mm/s)

`U FVDF` − turbulent momentum flux − u component (m/s * kg/(m2*s))

`V FVDF` − turbulent momentum flux − v component (m/s * kg/(m2*s))

sfc

These files contain some surface/single−level fields and fluxes. The level number is set to 42. The order is:

`SFSSLHF` − Surface latent heat flux (W/m2)

`SFSSSHF` − Surface sensible heat flux (W/m2)

`SFSSW` − Surface solar radiation (W/m2)

`SFSLW` − Surface thermal radiation (W/m2)

`SFLSR` − Large−scale rainfall (kg/m2)

`SFSCR` − Convective rainfall (kg/m2)

`SFLSF` − Large−scale snowfall (kg/m2)

`SFSCF` − Convective snowfall (kg/m2)

`SFSTCC` − Total cloud cover

`S HIST` − Surface pressure (Pa)

Appendix E. UK Met Office Mesoscale model output files

(From: Met Office Data Format)

UK Data have been extracted from the new Non−hydrostatic Unified Model (UM) since 14/08/2002, in this the version running at approximately 12 km horizontal resolution, every 6 hours to T+36

Data have been made available for three sites:

Site ID	***Lat***	***Lon***
00200110	51.120	−1.480
00200215	52.200	5.200
00200216	51.100	−1.400

The file naming convention is obvious appart from the `MES04` prefix which indicates the choice of variables and only has significance to the extraction software.

The site IDs are unique to Met Office system and have no international significance. (NB there is a small error in the first location, Chilbolton. This error is not regarded as significant.)

The non−hydrostatic UM uses a terrain−following height−based co−ordinate system with Charney−Philips vertical staggering. Data have been supplied at the actual height of the model level with the exception of u and v which have been interpolated to the theta levels. NB Cloud liquid water and ice are from the layer cloud scheme. The equivalent from the convection scheme is not available.

```
Variable                            STASH   FC   VC  LEV Levels
----------------------------------------------------------------
SPECIFIC HUMIDITY AFTER TIMESTEP       10   95   65    1 1−38
U WIND                                  2   48   65    1 1−38
V WIND                                  3   48   65    1 1−38
OROGRAPHY                              33    1  129 9999
W COMPNT OF WIND AFTER TIMESTEP       150   42   65    1 1−38
BULK CLOUD FRACTION IN EACH LAYER     266  220   65    0 1−38
SURFACE PRESSURE AFTER TIMESTEP       409    8  129 9999
PRESSURE AT RHO LEVELS AFTER TS       407    8   65    1 1−38
PRESSURE AT THETA LEVELS AFTER TS     408    8   65    1 1−38
NET DOWN SURFACE SW FLUX: SW TS ONLY 1201  186  129 9999 1
INCOMING SW RAD FLUX (TOA): ALL TSS  1207  200  133 8888 1
OUTGOING SW RAD FLUX (TOA)           1208  201  133 8888 1
TOTAL DOWNWARD SURFACE SW FLUX       1235  203  129 9999 1
NET DOWN SURFACE LW RAD FLUX         2201  187  129 9999 1
DOWNWARD LW RAD FLUX: SURFACE        2207  205  129 9999 1
SURFACE HEAT FLUX W/M2               3217  178  129 9999 1
```

```
X-COMP OF SURF & BL WIND STRESS N/M2 3219   61   65    1 1
Y-COMP OF SURF & BL WIND STRESS N/M2 3220   62   65    1 1
10 METRE WIND U-COMP B GRID          3225   48    1 9999 1
10 METRE WIND V-COMP B GRID          3226   49    1 9999 1
TEMPERATURE AT 1.5M                  3236   16    1 9999 1
SPECIFIC HUMIDITY  AT 1.5M           3237   95    1 9999 1
RELATIVE HUMIDITY AT 1.5M            3245   88    1 9999 1
DEWPOINT AT 1.5M (K)                 3250   17    1 9999 1
TURBULENT MIXING HT AFTER B.LAYER m  3304 1534 1534 8888 1
STABLE BL INDICATOR                  3305 1535 1535 8888 1
STRATOCUM. OVER STABLE BL INDICATOR  3306 1536 1536 8888 1
WELL_MIXED BL INDICATOR              3307 1537 1537 8888 1
DECOUPLED SC. NOT OVER CU. INDICATOR 3308 1538 1538 8888 1
DECOUPLED SC. OVER CU. INDICATOR     3309 1539 1539 8888 1
CUMULUS-CAPPED BL INDICATOR          3310 1540 1540 8888 1
LARGE SCALE RAINFALL RATE    KG/M2/S 4203   99  129 8888 1
LARGE SCALE SNOWFALL RATE    KG/M2/S 4204  118  129 8888 1
CLOUD LIQUID WATER AFTER LS PRECIP   4205   79   65    1 1-38
CLOUD ICE CONTENT AFTER LS PRECIP    4206   78   65    1 1-38
CONVECTIVE RAINFALL RATE     KG/M2/S 5205   98  129 8888 1
CONVECTIVE SNOWFALL RATE     KG/M2/S 5206  119  129 8888 1
CONV. CLOUD AMOUNT ON EACH MODEL LEV 5212   34   65    0 1-38 every 3h
TOTAL PRECIPITATION RATE     KG/M2/S 5216   90  129 8888 1
2D CONVECTIVE CLOUD AMOUNT           5262   34    0 8888 1
TOTAL CLOUD AMOUNT - RANDOM OVERLAP  9216   30    0 8888 1
TOTAL CLOUD AMOUNT MAX/RANDOM OVERLP 9217   30    0 8888 1
WET BULB FREEZING LEV HEIGHT (M)     9221  139  132 8888 1
TEMPERATURE ON MODEL LEVELS         16004   16   65    1 1-38
PRESSURE AT MEAN SEA LEVEL          16222    8  128 8888 1
```

Appendix F. UK Met Office Global model output files

(From: Wilson, 2004)

The data files contain the MOLTS (Model Output Time Series) data in ASCII format. The manner in which the data is stored is outlined below.

The data from assimilation is the T+0, T+3 and T+6 output from runs at 00Z, 06Z, 12Z and 18Z. The data from the free forecast is the T+0 to T+36 at 3 hour intervals from runs at 00Z and 12Z.

Missing data indicator is −999.99 for information in the site header and −9.999999e+30 for the actual data.

Each file is set up as follows −

The first line contains 6 integer numbers, in order these represent

- Number of data output times (usually 13 for forecast data and 3 for data assimilation)
- Number of levels for the pressure level data (currently 18)
- Number of levels for the model level data (currently 38)
- Number of time series variables output (currently 14)
- Number of variables stored on pressure levels output (currently 8)
- Number of variables stored on model levels output (currently 11).

The next 2 lines contain a rudimentary header containing data validation date/time.

The rest of the file is the data. It can be split into 4 sections.

a) Header

This is 7 lines containing the data below. The first 37 characters in the line are just an explanation of the data and can be skipped when reading.

- Site name
- Site location (longitude/latitude/elevation)
- Gridpoint location of nearest neighbour in global model
- Longitude/latitude/elevation of the nearest neighbour
- Distance between the site and nearest neighbour
- Land/Sea mask value − 1 for land, 0 for sea
- Sea−ice cover at grid point.

b) Single Level (2D) Data

The first line in the single level data is the validation times for the data, this is presented in the form AAZ+BB, where AA is the cycle start time and BB is the time since start of cycle. So, for example, for the assimilated data this line would appear as

00Z+00, 00Z+03, 00Z+06.

The following lines contain the data, it has been set out as below

Field_code Fieldname units averaging_period data_time_1 data_time_2 etc.

The field_code is the identifying code used in the GRIB files for each field type and is an integer of length 3. The fieldname is a character string of 25 characters, the units is a character string of length 5, the averaging period is an integer of length 1 − set to either 0 for instantaneous or 3 for 3 hour averaging (accumulations). The data is in scientific format of length 13 including 6 decimal places. This will the same for all data in the file.

c) Pressure Level Data (3D_PL)

Data is stored in much the same way as above except there are several levels for each field, the first row for a field contains the field code, field name, units and averaging period (as defined above). The following rows contain the data in the following format

pressure_level data_time_1 data_time_2 etc.

There are 18 pressure levels for which the data has been output, there are 1000, 950, 925, 900, 850, 700, 600, 500, 400, 300, 250, 200, 150, 100, 70, 50, 30 and 10 hPa.

d) Model Level Data (3D_ML)

Almost identical to the pressure level data, except that each level is defined by height above surface. Therefore

$$\text{z(distance above sea level of data point)} = \text{orographic height} + \text{level height above surface}$$

The rows containing the data are in the form

level_index height_above_surface data_time_1 data_time_2 etc.

There are 38 model levels for all the data in this section. However they are split into two types, half levels and full levels. The full levels include the top of the model atmosphere and the surface (if there were a level zero included). The half levels lie in between the full levels. The exact height (in metres) of where the data is valid is in the data set as already mentioned.

Appendix G. KNMI HIRLAM model output files

(From: HIRLAM Model Data Format (KNMI))

Each data file consists of the output over each of the three CloudNET sites for one run of the model. The model is run every six hours, so there are four files per day, and each run produces forecasts every three hours from T+0 to T+48.

In addition to the variables at the nearest gridpoint to each site, the variables from the eight nearest gridpoints are also reported, in the form of a 3x3 grid.

The filenames are of the form `cloudnet.YYYYMMDDHH`, where YYYYMMDD is the date and HH is the forecast time. They are zipped up into monthly archives with names of the form `HIRLAM_YYYYMM.zip`.

The format is summarized here (this makes sense on examination of an actual data file):

```
                HIRLAM [analysis time of forecast]
                                 -------------
                                 | 1 | 2 | 3 |    Layout
                                 -------------      of
                                 | 4 | 5 | 6 |
                                 -------------     the
                                 | 7 | 8 | 9 |    area
                                 -------------
For forecast period 00 03 06 09 12 15 18 21 24 27 30 33 36 39 42 45
        Forecast [forecast period]
        CHIBOLTON [latitude longitude]
        single level data
    6 105   0   Geopotential of the surface     m2/s2
   83 105   0   Roughness length of surface     m
    1 105   0   Pressure at surface             Pa
    1 103   0   Pressure at mean sea level      Pa
   11 105   0   Skin temperature of surface     K
   11 105   2   2 meter temperature             K
   31 105  10   Wind direction at 10 meter      degree w.r.t. true N
   32 105  10   Wind speed at 10 meter          m/s
   51 105   2   Specific humidity at 2 meter    g/g
   17 105   2   Dew point temperature at 2 m    K
   62 105   0   Large scale precipitation       kg/m2
   63 105   0   Convective precipitation        kg/m2
   71 105   0   Cloud cover                     0 .. 1
        multilevel data
        For level 31 .. 1
```

```
11      Pressure   Pa      temperature             K
   For level 31 .. 1
31      Pressure   Pa      wind direction  degree w.r.t. true N
   For level 31 .. 1
32      Pressure   Pa      wind speed              m/s
   For level 31 .. 1
39      Pressure   Pa      vertical velocity       Pa/s
   For level 31 .. 1
51      Pressure   Pa      specific humidity       g/g
   For level 31 .. 1
76      Pressure   Pa      cloud water             g/g
   PALAISEAU [latitude longitude]
   [idem]
   CABAUW [latitude longitude]
   [idem]
```

The 9−square indicates the correspondence between column number and sub−area; column 5 always corresponds with the subarea in which the given lat/lon coordinates fall.

The multilevel data need a pressure coordinate, because the height of the coordinate surface varies with ground level (so called eta coordinates).

Note also:

- The horizontal model resolution is around 22 km; thus the position of the adjacent gridpoints can be calculated.
- The division between liquid and ice water content is internal to the model, so it is not possible to extract them separately.
- The model does not report cloud fraction at each level.

For more information on the cloud scheme, read pages 28 and 29 of the HIRLAM scientific documentation.

Appendix H. KNMI RACMO model output files

(From: Setup model evaluation CLIWANET).

Single−level parameters

Surface pressure is assumed instantaneous. All other values should be averaged (fluxes, cloud cover) or accumulated (precip) over the past temporal interval.

1. Verifying date [yyyymmdd]
2. Verifying time [hhmn]
3. Surface Pressure [Pa]
4. Sensible heat flux at surface [W/m2]
5. Latent heat flux at surface [W/m2]
6. Momentum flux at surface [Pa] (rho <u'w'>)
7. Downward SW−flux at surface [W/m2]
8. Upward SW−flux at surface [W/m2]
9. Downward LW−flux at surface [W/m2]
10. Upward LW−flux at surface [W/m2]
11. Downward SW−flux at TOA [W/m2]
12. Upward SW−flux at TOA [W/m2]
13. Upward LW−flux at TOA [W/m2]
14. Precipitation Convective [m/s]
15. Precipitation Large Scale [m/s]
16. Precipitative Fraction in GridBox [0..1]
17. Total Cloud Cover [0..1]

Multi−level parameters

All multi−level values are assumed instantaneous.

1. Verifying date [yyyymmdd]
2. Verifying time [hhmn]
3. Model layer value
4. Pressure [Pa]
5. Temperature [K]
6. Zonal wind component [m/s]
7. Meridional wind component [m/s]
8. Vertical wind speed [Pa/s]

9. Turbulent Kinetic energy [m2/s2]
10. Specific Humidity [kg/kg]
11. Specific Liquid Water [kg/kg]
12. Specific Ice Content [kg/kg]
13. Cloud fraction [0..1]
14. Short Wave In−Cloud Optical Thickness [..]
15. Long Wave In−Cloud Emissivity [0..1]
16. Liquid Precipitative Flux at lower interface [W/m2]
17. Solid Precipitative Flux at lower interface [W/m2]

File Structure

All time series are formatted as ASCII. The principle rule is that all information within one record refers to a single verifying time (apart from the general information). To avoid (too) long records there are more records (typically nlev+1) referring to the same verifying time.

All files must start with the following header lines.

If any of the header information changes, repeat the entire header before adding new information to the same file.

Header lines

line 1: ’#’,A16 ... name institute

line 2: ’#’,A16 ... name participant

line 3: ’#’,A16 ... name model

line 4: ’#’,A16 ... name experiment

line 5: ’#’,I10,I6.4 ... initial date[yyyymmdd]/time[hhmn] model run

line 6: ’#’,A16 ... name or acronym CLIWANET station

line 7: ’#’,2F8.2 ... longitude/latitude receptor point

line 8: ’#’,E16.5 ... surface geopotential height [m2/s2]

line 9: ’#’,E16.5 ... land sea mask gridbox

FORMAT FILE WITH SINGLE−LEVEL FIELD INFO:

line 10: ’# `vdate vhrm PSURF SENF LATF MOMF SWSD SWSU LWSD LWSU SW0D SW0U LW0U PRECCONV PRECLS PRECFRAC TOTCOV’`

Loop over time−index

line 11 ... : data with FORMAT: I9,I5.4,E14.6,14E13.5

FORMAT FILE WITH MULTI LEVEL FIELD INFO:

(next 2 lines form one record ...)

line 10: ’# `vdate vhrm lev PRES TEMP`
`UU VV WMEGA TKE QVAP`
`QLIQ QICE CLFRAC SWCLTAU LWCLEMIS`
`PRFLLIQ PRFLICE`’

OUTER Loop over time−index

INNER Loop over level−index

line 11 ... : data with FORMAT: I9,I5.4,I4,14E13.5

Appendix I. GRIB Codes

(From: WMO code table 2)

Code	*Field Description*	*Units*
000	Reserved	
001	Pressure	Pa
002	Pressure reduced to MSL	Pa
003	Pressure tendency	Pa/s
004	Potential vorticity	K m2 /kg /s
005	ICAO standard atmospheric reference height	m
006	Geopotential	m2/s2
007	Geopotential height	Gpm
008	Geometric height	M
009	Standard deviation of height	M
010	Total ozone	Dobson
011	Temperature	K
012	Virtual temperature	K
013	Potential temperature	K
014	Pseudo−adiabatic potential temperature	K
015	Maximum temperature	K
016	Minimum temperature	K
017	Dew point temperature	K
018	Dew point depression (or deficit)	K
019	Lapse rate	K/m
020	Visibility	M
021	Radar Spectra (1)	
022	Radar Spectra (2)	
023	Radar Spectra (3)	
024	Parcel lifted index (to 500 hPa)	K
025	Temperature anomaly	K
026	Pressure anomaly	Pa
027	Geopotential height anomaly	Gpm
028	Wave Spectra (1)	
029	Wave Spectra (2)	

Code	***Field Description***	***Units***
030	Wave Spectra (3)	
031	Wind direction	Deg. true
032	Wind speed	m/s
033	u−component of wind	m/s
034	v−component of wind	m/s
035	Stream function	m2/s
036	Velocity potential	m2/s
037	Montgomery stream function	m2/s2
038	Sigma coord. vertical velocity	s /s
039	Pressure Vertical velocity	Pa/s
040	Geometric Vertical velocity	m/s
041	Absolute vorticity	/s
042	Absolute divergence	/s
043	Relative vorticity	/s
044	Relative divergence	/s
045	Vertical u−component shear	/s
046	Vertical v−component shear	/s
047	Direction of current	Deg. true
048	Speed of current	m/s
049	u−component of current	m/s
050	v−component of current	m/s
051	Specific humidity	kg/kg
052	Relative humidity	%
053	Humidity mixing ratio	kg/kg
054	Precipitable water	kg/m2
055	Vapor pressure	Pa
056	Saturation deficit	Pa
057	Evaporation	kg/m2
058	Cloud Ice content	kg/m2
059	Precipitation rate	kg/m2/s
060	Thunderstorm probability	%
061	Total precipitation	kg/m2
062	Large scale precipitation	kg/m2

Code	***Field Description***	***Units***
063	Convective precipitation	kg/m2
064	Snowfall rate water equivalent	kg/m2s
065	Water equiv. of accum. snow depth	kg/m2
066	Snow depth	M
067	Mixed layer depth	M
068	Transient thermocline depth	M
069	Main thermocline depth	M
070	Main thermocline anomaly	M
071	Total cloud cover	%
072	Convective cloud cover	%
073	Low cloud cover	%
074	Medium cloud cover	%
075	High cloud cover	%
076	Cloud water	kg/m2
077	Best lifted index (to 500 hPa)	K
078	Convective snow	kg/m2
079	Large scale snow	kg/m2
080	Water Temperature	K
081	Land−sea mask (1=land;0=sea)	Fraction
082	Deviation of sea level from mean	M
083	Surface roughness	M
084	Albedo	%
085	Soil temperature	K
086	Soil moisture content	kg/m2
087	Vegetation	%
088	Salinity	kg/kg
089	Density	kg/m3
090	Water run off	kg/m2
091	Ice concentration (ice=1;no ice=0)	Fraction
092	Ice thickness	M
093	Direction of ice drift	deg. true
094	Speed of ice drift	m/s
095	u−component of ice drift	m/s

Code	***Field Description***	***Units***
096	v−component of ice drift	m/s
097	Ice growth rate	m/s
098	Ice divergence	s
099	Snow melt	kg/m2
100	Significant height of combined wind waves and swell	m
101	Direction of wind waves	deg. true
102	Significant height of wind waves	m
103	Mean period of wind waves	s
104	Direction of swell waves	deg. true
105	Significant height of swell waves	m
106	Mean period of swell waves	s
107	Primary wave direction	deg. true
108	Primary wave mean period	s
109	Secondary wave direction	deg. true
110	Secondary wave mean period	s
111	Net short−wave radiation (surface)	W/m2
112	Net long wave radiation (surface)	W/m2
113	Net short−wave radiation (top of atmos.)	W/m2
114	Net long wave radiation (top of atmos.)	W/m2
115	Long wave radiation	W/m2
116	Short wave radiation	W/m2
117	Global radiation	W/m2
118	Brightness temperature	K
119	Radiance (with respect to wave number)	W /m /sr
120	Radiance (with respect to wave length)	W /m /sr
121	Latent heat net flux	W/m2
122	Sensible heat net flux	W/m2
123	Boundary layer dissipation	W/m2
124	Momentum flux, u component	N/m2
125	Momentum flux, v component	N/m2
126	Wind mixing energy	J
127	Image data	
128...254	Reserved for use by originating center	

Code	***Field Description***	***Units***
255	Missing	

These are from the Met Office MOLTS files:

Value	***Parameter***	***Units***
128	TotSW down TOA	W/m2
129	TotSW up TOA	W/m2
130	TotLW up TOA	W/m2
131	Clrsky SW up TOA	W/m2
132	Clrsky LW up TOA	W/m2
133	TotSW down surf	W/m2
134	TotSW up surf	W/m2
135	TotLW down surf	W/m2
136	TotLW up surf	W/m2
137	Planetary BL Height	m
138	U BL wind stress	N/m2
139	V BL wind stress	N/m2
140	CU cloud base	Pa
141	CU cloud top	Pa
142	CU cloud base	kft
143	CU cloud top	kft
144	Surface Pressure	Pa
145	Surface Temperature	K
146	Horizontal KE	m2/s2
147	KE+CpT	m2/s2
148	KE+CpT+gZ	m2/s2
149	LS Cloud Fraction	%
150	Convective cloud fraction	%
151		
152	1.5m Temperature	K
153	1.5m Spec.Humidity	kg/kg
154	1.5m Rel.Humidity	%
155	10m U − wind	m/s

Value	***Parameter***	***Units***
156	10m V − wind	m/s

Appendix J. Status of numerical models

(From: Status of numerical models)

An overview of current numerical models

Numerical models will never be able to represent individual clouds, so the atmosphere is split up into boxes, of typical size 50 to 200 km in the horizontal and 1 km in the vertical, and clouds within the box are represented by prognostic variables such as:

(i) Cloud fraction

(ii) Average water content (liquid and ice)

and within a decade

(iii) Mean liquid and ice particle size.

Size is currently prescribed, with different liquid droplet size for marine and continental clouds, and an ice particle size which varies with temperature. Cloud overlap affects radiation and precipitation efficiency. A vertical stack of grid boxes partially filled with cloud which is continuous in the vertical is assumed to be maximally overlapped, but if they are separated by cloud free layers then overlap is assumed to be random. A further issue not yet addressed is the degree of overlap of cloud inhomogeneities within a grid box.

In the project the following variables will be observed and compared with values held in the operational models or values diagnosed from the model variables:

- Macroscopic Variables
  - (i) Cloud fractional cover
  - (ii) Cloud overlap and the overlap of cloud inhomogeneities Liquid
- Water Cloud
  - (iii) Liquid water content
  - (iv) Droplet size
  - (v) Optical depth and emissivity
- Ice Cloud
  - (vi) Ice water content
  - (vii) Ice particle size
  - (viii) Optical Depth
  - (ix) Emissivity
- Mixed Phase Cloud
  - (x) Occurrence
  - (xi) Ice water content

(xii) Liquid Water content

Key issues

At the ECMWF seminar on Key Sub−grid parameterisation issues in NWP, 3−8 September 2001, the issue of sub−grid cloud variability was identified as the major difficulty needing attention if forecasts are to be improved.

To this we may add the representation of layers of supercooled clouds. These are quite common, have an important radiative effect and yet most models cannot represent them. For example, the ECMWF model represents the liquid water fraction in clouds by a simple temperature function, so that all clouds at 0°C, and the fraction falls monotonically to zero at −22°C.

Currently we have virtually no observations of ice water content of clouds and yet this variable is crucial for the earth's radiative balance and for the production of precipitation. Very little is known about the frequency or characteristics of mixed phase clouds.

Each site is equipped with radar, lidar and a suite of passive instrumentation. The observations will be used in the evaluation of four operational numerical models, and to demonstrate the role that could be played by an operational network of cloud remote sensing stations. We will also be exploiting the extensive existing datasets from numerous observational campaigns that have already taken place.

Clouds in the operational Met Office mesoscale model

[Damian Wilson 18/3/03]

This web page provides a summary of the way cloud and condensate is diagnosed or predicted in the Met Office mesoscale model. I have assembled this for the CloudNet project although it may be a useful reference source for others.

I have assembled the information in the form of a summary table, with links to papers and more complete summaries, which should supply required information at three levels of depth.

PLEASE NOTE: SOME OF THE REFERENCE DOCUMENTS HAVE NOT BEEN PUBLISHED.

PERMISSION FROM THE MET OFFICE MUST BE OBTAINED BEFORE THESE PAPERS CAN BE QUOTED FROM.

To access these documents, Email Nicolas Gaussiat, n.gaussiat@reading.ac.uk, for the password.

Cloud Fraction:

- Large−scale: The diagnostic produced for Cloud−Net is the volume cloud fraction (of any phase).
    - Liquid cloud fraction: Based on a diagnostic PDF of q+l−qsat.
        - Basic scheme: Smith 1990 with the RHcrits below.

        - Modifications: Only used for liquid cloud fraction (Wilson and Ballard 1999). Empirically adjusted cloud fraction increases cloud fraction (Cusack, based on the work of Wood and Field)
    - Ice cloud fraction: Based on a diagnostic from ice water content (Wilson and Ballard, 1999)
        - Basic scheme: Wilson and Ballard (1999) with the RHcrits below.
        - Modifications: Empirically adjusted cloud fraction increases cloud fraction (Cusack, based on Wood and Field)
    - Overlap of ice and liquid phases: Assumed to be minimum overlap within the same gridbox.
    - Area cloud fraction: Cloud area parametrization (used for radiation) splits model levels into 3 sub−levels (Cusack).
- Convective cloud fraction: Based on a diagnostic relationship from the convective cloud condensate
    - Basic scheme:
        - Modifications: Anvil scheme of J. Gregory with these parameters
    - Combined convective and large−scale cloud: The radiation scheme assumes that the convective cloud amount (CCA) occupies its parametrized volume of the gridbox and the large−scale cloud amount occupies (1−CCA) times its parametrized volume.

Condensed water:

- Large−scale:
    - Liquid water content: Based on a diagnostic PDF of q+l−qsat.
        - Basic scheme: Smith 1990 using the RHcrits below.
        - Modifications: Only used for liquid cloud fraction (Wilson and Ballard 1999).
    - Ice water content: A prognostic from the microphysics scheme of Wilson and Ballard 1999.
        - Modifications: No modifications.
    - Overlap of ice and liquid phases: maximum overlap, so as much mixed phase cloud as possible.
- Convective condensed water: Based on a mass−flux convection scheme.
    - Basic scheme: D. Gregory and Rowntree
        - Modifications: Substantial!

References:

Cusack, 2002: The Empirically Adjusted Cloud Fraction modification to the cloud scheme. THIS NOTE HAS NOT BEEN PUBLISHED.

Gregory, D. and Rowntree, P.R., 1990. A mass flux convection scheme with representation of cloud ensemble characteristics and stability−dependent closure. Mon Weather Rev., 118, 1483−1506.

Gregory J, 1999. Hadley Centre Technical Note 7 (paper only). THIS NOTE HAS NOT BEEN PUBLISHED.

Smith, R.N.B., 1990. A scheme for predicting layer clouds and their water content in a general circulation model. Q.J.R. Meterol. Soc., 116, 435−460.

Wilson, D.R. and Ballard, S.P., 1999. A microphysically based precipitation scheme for the UK Meteorological Office Unified Model. Q.J.R. Meteorol. Soc., 125, 1607−1636.

Wood, R. and Field, P.R., 2000. Relationships between total water, condensed water and cloud fraction in stratiform clouds examined using aircraft data. J. Atmos. Sci., 57, 1888−1905.

Area Cloud: Unified Model Documentation paper 29, appendix E.

Microphysics: Unified Model Documentation Paper 26 (parts 4−6 for the 3B scheme).

Convection scheme: Unified Model Documentation Paper 27. See sections 1.8 for condensate and 1.9 for cloud amount.

RHcrits:

Level	*RHcrit*
1	0.91
2	0.9
3	0.88
4	0.86
5	0.84
6	0.82
7−38	0.8

Anvil parametrization parameters:

Anvil factor 3.0

Tower factor 0.25

Summary of q+l−qsat PDF method:

Here we assume that, within a gridbox, there exists a known distribution, *G*, of a variable *s*, where

$$s=a_L(q_T'-q_{sat}') \quad .$$

q_T is the sum of the vapour plus the liquid water content and q_{sat} is the saturation specific humidity with respect to liquid water at temperature T_L .

$$a_L=\frac{1}{(1+\alpha L/cp)}$$

where $\alpha=dq_{sat}/dT$ at constant pressure, *L* is the latent heat of vaporization of water and *cp* is the heat capacity of air.

$$T_L=T-I\ L/cp \quad .$$

The $'$ symbol represents deviations from grid box means. The distribution of *s* is a symmetric triangle (about $s=0$) where the width (where the function goes to zero) is parameterized by $\pm a_L(1-RH_{crit})q_{sat}$. The water content of a point in the distribution is given by

$$I=a_L(q_T-q_{sat})=Q_c+s$$

where

$$Q_c=a_L(q_{T\_mean}-q_{sat\_mean})$$

and q_{T_mean} and q_{sat_mean} are gridbox means. Hence the liquid cloud fraction can be given simply by the integral of *G(s)* above the limit where $s=-Q_c$. The liquid water content is given by the first moment of this integral. Further details are in the Smith 1990 paper and UM documentation paper 29.

Summary of empirically adjusted cloud fraction method:

This is an adjustment to the Smith scheme in order to increase the cloud fractions which it produces, in order to better match observations. This code will replace the Q_c used in the Smith scheme calculations of cloud fraction with an increased value of Q_c , to produce increased liquid cloud fractions. It does this with the linear mapping:

$$Q_c'/b_s=(Q_c/b_s+K_2)/K_1$$

where $K_1=1-K_2$ and $K_2=0.184$ for levels 1−13 and 0.0955 for levels 14 and above.

The liquid water content is not adjusted. A similar modification is done to the ice cloud fraction diagnostic: an equivalent Q_c is calculated, consistent with the Smith scheme, this is modified as above, then the cloud fraction is recalculated. Again, this will increase the cloud fraction. Further details are in the Cusack 2002 note.

Summary of area cloud fraction method:

This parametrization aims to better produce thin stratocumulus cloud where the vertical resolution is not sufficient to resolve it. Each model layer is split into three sub layers, and values of q_T and T_L interpolated from the the full model layer (and those surrounding it) into the sub layer. The interpolation method depends on whether there are strong jumps in temperature across the full model layers, thus suggesting the presence of a sharp inversion, the sharpness of which needs to be maintained. The cloud fraction in each of the sub−layers is then calculated as above and averaged to produce the bulk cloud fraction (hence this may be greater than the bulk cloud fraction calculated using the full model layer). The radiation will see an area cloud fraction, ade up of the maximum of the fraction in each of the sub−layers. Further details are in UM documentation paper 29.

Summary of ice cloud fraction method:

The ice cloud fraction cannot be calculated using a PDF formulation since the assumption of instantaneous condensation is not applied to ice. Instead we invert the implicit relationship that exists in the Smith 1990 scheme between cloud fraction and condensed water content (using saturation specific humidity with respect to liquid water). This provides a diagnostic relationship for ice cloud fraction as a function of ice content, q_{sat} and RH_{crit} . It is NOT a function of vapour content. The functional form is given in Wilson and Ballard, 1999. This ice fraction is then modified by the empirically adjusted cloud fraction formulation.

Summary of convective cloud fraction method:

This is a straightforward diagnostic.

$$\text{convective cloud} = 0.7873 + 0.06 \ln(TCW)$$

where *TCW* is the total cloud water content before convective precipitation is applied in kg m−2. Further details are in UM documentation paper 27.

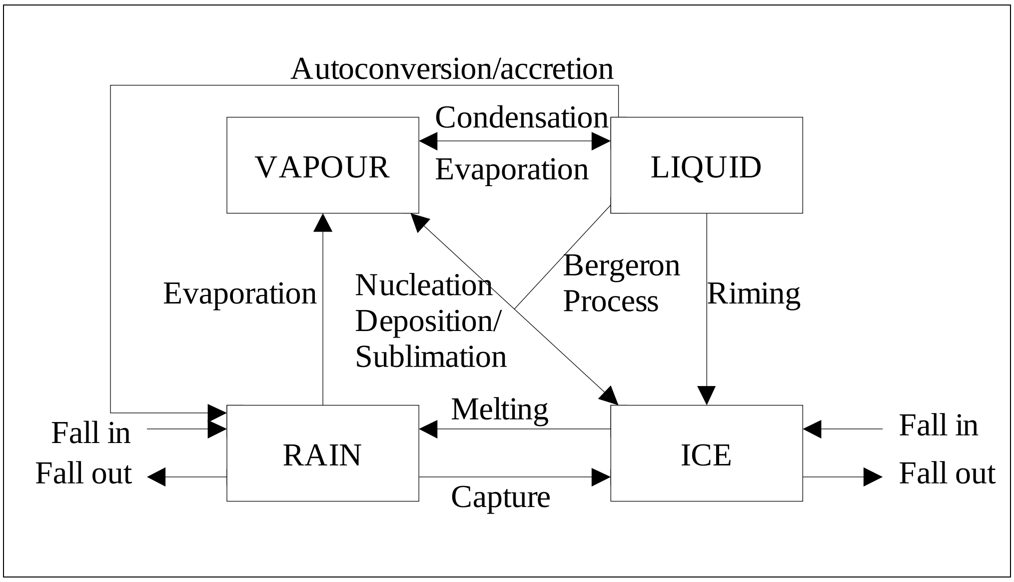
Summary of anvil cloud:

This scheme modifies the shape of the convective cloud fraction so that it is not a single, uniform value from cloud base to cloud top, but has a more anvil shape associated with it. Details will follow when I have located them!

Summary of microphysics scheme:

This scheme considers transfer processes which act between vapour, liquid water, ice and rain. The processes which are parametrized are: fall of ice; nucleation of ice; deposition and sublimation of ice; riming; capture of rain by snow; melting of ice; evaporation of melting snow; evaporation of rain; accretion; autoconversion. Rain is parameterized as a diagnostic and is assumed to fall out in a single timestep.

A transfer diagram is shown below. Further details are in UM documentation paper 26 and in Wilson and Ballard 1999.


Autoconversion/accretion
VAPOUR
Condensation
Evaporation
LIQUID
Evaporation
Nucleation
Deposition/
Sublimation
Bergeron
Process
Riming
Melting
Fall in
Fall out
RAIN
Capture
ICE
Fall in
Fall out