Atmospheric G2

Atmospheric G2 Hourly Gridded data update

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Product Overview

The Atmospheric G2 Gridded dataset delivers hourly weather parameters derived from ECMWF's 5th Generation reanalysis (ERA5, Hersbach et al 2020), which is a state-of-the-art reanalysis that has been shown to have high accuracy in surface temperature representation within the continental U.S., outperforming NOAA's 20th century reanalysis, NASA's MERRA2 reanalysis, and NOAA's regional reanalysis of North America (Ibebuchi et al 2024). Data is available on a global 15km grid at the surface, at wind turbine nacelle heights, for full-atmosphere columns, and for four soil depth levels. Data is available from 1991 to present and is updated in real time four times a day.

Historical Data

Finalized data using ERA5 is available from January 1st 1991 to 7 days prior to present.

ERA5

Reanalyses datasets are series of full atmospheric states, usually covering many decades, calculated using a consistent numerical system. These have a wide range of uses, including providing lengthy consistent catalogues of historical weather data, data for climate studies and diagnostics of weather prediction systems. These reanalyses produce optimum atmospheric states given a set of observations by combining them with a atmospheric model via data assimilation techniques. Large volumes of observation data are assimilated from satellites, weather stations, aircraft, ships, buoys and radiosondes.

Reanalysis System

ERA5 combines ECMWF's IFS Cy41r2, which is a spectral atmospheric model, with a 4DVAR assimilation scheme. This scheme nudges the model towards each observation within a 12h assimilation window (two cycles per day) dependent on each atmospheric observation's geographical location and time. The weight to each observation relative to the background numerical model is determined via estimates of observation error variance and background model error variance. In a traditional assimilation scheme, the background model error variance is represented by tuned static values, but in ERA5, these are derived from an ensemble of perturbed numerical forecast models valid in the assimilation window. This allows for variation in the background model error variance with atmospheric conditions appropriate for the window of interest.

Boundary Conditions and Resolution

ERA5's lower boundary conditions are defined as follows: over land a special scheme combining optimal interpolation and Kalman filtering is used to produce an analysis of soil moisture and temperature (including snow temperature). Over ocean a specially designed merged gridded product defines sea surface temperature and ice coverage. This product is a union of the UK Met Office Hadley Centre HadISST2 product, the EUMETSAT OSI-SAF reprocessed product, and the UK Met Office OSTIA dataset.

ERA5 is produced at a horizontal resolution of roughly 31km and has 137 atmospheric levels to a height of 80km. The upper boundary assumes a zero rate of vertical change for most prognostic model variables, but includes radiative forcings.

Data Period

ERA5 data is continuously produced with about 7 days latency behind real time and extends back to 1940.

Therefore there is potential for the Atmospheric G2 Gridded dataset to be extended backward beyond 1991 if there is sufficient interest.

Near-Real-Time Data

To bridge the gap between ERA5 availability (7 day latency) and real time, provisional data is provided primarily from NCEP's Global Forecasting System.

GFS

GFS is a numerical model which provides forecasts of weather parameters. The model is initialized with an analysis derived using a similar data assimilation technique as ERA5. Since GFS is an operational forecast system it does not contain model consistency and aspects of the system are expected to be changed from time to time. Because forecast models run assimilation in real time, they assimilate fewer observations with less quality control than reanalyses.

Boundary Conditions and Resolution

Currently, GFS uses a finite volume model with a horizontal resolution of roughly 13km and 127 atmospheric levels to a height of 90km. Like ERA5, the upper boundary assumes no vertical change for most prognostic variables. Ocean surface data is defined by a near sea surface temperature model coupled to the atmospheric model, Li and Derber 2008. Soil moisture and temperature are taken from the previous forecast cycle with a nudging towards climatology for deeper soil depths and a daily update to snow depth, Draper 2021.

Data Availability Times

A data source parameter indicates for each grid point and time if the data are finalized (ERA5) or provisional (GFS). Provisional data from the Atmospheric G2 is produced in six hour cycles available twenty minutes prior to the end of each cycle - 00UTC to 05UTC is available at 04:40UTC, 06UTC to 11UTC is available at 10:40UTC, 12UTC to 17UTC is available at 16:40UTC and 18UTC to 23UTC is available at 22:40UTC. A full day of finalized data is produced at 08:20UTC daily with a 7-day latency.

Parameters

Static Parameters

Five static parameters have been interpolated from ERA5 onto the Atmospheric G2 15km grid. These are elevation, land sea mask (0-1), soil type and low and high vegetation type. Soil type and vegetation type use a nearest neighbor interpolation. Land sea mask and elevation use a spherical spline. These static parameters are fixed and do not vary throughout the 30+ years of data.

Vegetation type codes are defined by Grib2 code table 4.234

Type	SubType 1	Code 1	SubType 2	Code2
Crops	Standard	1	Irrigated	10
Grass	Short	2	Tall	7
Needle Lf Trees	Evergreen	3	Deciduous	4
Broad Lf Trees	Evergreen	6	Deciduous	5
Desert	Full	8	Semi	11
Water	Ocean	15	Inland	14
Shrubs	Evergreen	16	Deciduous	17
	Ice	12	Marsh	13
	Tundra	9	Missing	255

Soil type codes are defined by Grib2 code table 4.213

Sand is 1, Loamy sand 2, Organic 5, missing 255 and other values are given in the below table.

	Standard	Sandy	Silty
Loam		3	4
Clay Loam	8	6	7
Clay	11	9	10

Surface Parameters

Most surface parameters are interpolated using a spherical spline from direct output fields of ERA5 to the Atmospheric G2 15km grid. These are geopotential height, temperature, dew point temperature (2m), wind U component, wind V component, wind gust (10m), runoff, convective inhibition, convective available potential energy, friction velocity, potential evaporation, surface roughness, sea ice coverage, snow depth and snow melt. The broader scale surface parameters mean sea level pressure, surface pressure and mean (actual) evaporation are interpolated from ERA5 output fields to the Atmospheric G2 15km grid using linear interpolation.

In addition to hourly surface (mean) temperature, the maximum and minimum sub hourly temperatures (2m) across the previous hour are also provided, also interpolated using a spherical spline.

The land skin temperature and sea surface temperature over ocean are combined into a single parameter and then interpolated to the 15km grid using a spherical spline.

At 2m, relative humidity is derived from temperature and dew point using the standard definition of the ratio of the actual partial pressure of water vapor (derived from dewpoint temperature) to the saturation pressure of water (derived from temperature). The result is clipped to be between 0 and 100%. Likewise specific humidity is derived from dewpoint temperature and surface pressure, following Bolton, 1980. The water mixing ratio is defined by its relationship to specific humidity. ($w = q / (1 - q) \times 1000$) and visibility is calculated as a function of relative humidity, following Cao et al (2014).

Heat Index is calculated as a function of temperature and relative humidity following the NWS algorithm that is diagrammed in Anderson et al 2013. The wind chill calculation follows FCM-R19-2003. Apparent Temperature is a combination of heat index and wind chill - calculated as equal to heat index when the temperature is at least 26.67C, to wind chill when the temperature is at or below 10C and equal to the temperature otherwise.

The wet bulb temperature at 2m is estimated by equation 1 of Knox et al 2017.

Air density at 2m is derived from temperature, pressure and the surface mixing ratio using Hobbs 2006.

The wind speed and direction at 10m are derived by simple combination of U and V components.

The lightning flash rate is assumed to be directly proportional to CAPE times precipitation rate following Romps et al. 2014. Sea ice thickness is estimated as 1.5m times the coverage.

In total 34 surface parameters are available from Atmospheric G2 Gridded dataset

Mean evaporation and snow melt are not available in GFS. Therefore, for near real time, these parameters are derived from other variables, as follows. Mean evaporation is assumed to be a proportion of potential evaporation based on a scale of near surface soil moisture from wilting point (0) to field capacity (1), with capping when the value exceeds these extremes. Snow melt is calculated by computing the difference in the liquid equivalent snow depth since the previous hour. No sub-hourly temperatures are output from GFS, so for the provisional maximum sub hourly temperature is estimated via the maximum of the temperature at the current hour and the previous hour. There's a similar estimate for the provisional sub hourly minimum temperature. Geopotential height at the surface is also not available in GFS, but a persistent value from the last finalized data day with the same hour is assumed to be a good estimate for near real time. Run off is available in the GFS, but as an accumulation since the start of the cycle, so a simple calculation is necessary to derive the hourly value.

Precipitation

A nearest neighbor scheme is used to interpolate the accumulation of precipitation for the previous hour. This avoids further smoothing out of extreme variables or increasing spurious low value precipitation. The precipitation type code is also mapped to the 15km grid using nearest neighbor and is translated from ECMWF's code table to

	Rain	Snow	Freezing Rain	Ice Pellets
Rain & …	1	3	5	9
Snow & …	3	2	6	10
Freezing Rain & …	5	6	4	12
Ice Pellets & …	9	10	12	8
Snow & Freezing Rain & …	7	6	6	14

Or

	Snow	Freezing Rain	Ice Pellets
Rain & Snow & …	3	7	11
Rain & Freezing Rain & …	7	5	13
Rain & Ice Pellets & …	11	13	9
Rain & Snow & Freezing Rain & …	7	7	15

Rain and freezing rain are calculated as equal to the precipitation for the previous hour when active and zero otherwise. Snow and ice pellet accumulations are calculated as a function of temperature and liquid precipitation amount, using Atmospheric G2 own formulae. When multiple categories are active, the liquid precipitation is divided equally between the categories.

Trace values indicate where a small unmeasurable amount of precipitation has fallen. Precipitation, rain and freezing rain values of less than 0.05mm are indicated with the arbitrary small value of 0.0254mm (or 0.01in). For snow and ice pellets values of less than or equal to 0.254mm are indicated with the value of 0.254mm (0.1in).

For provisional data from GFS, precipitation is output as accumulation since the start of the cycle. It is a simple calculation to derive the hourly accumulation. Precipitation type is derived from individual binary indicators of each of the four precipitation types.

Radiation and Cloud

Most radiation parameters are available as output fields from ERA5 and are interpolated onto the 15km grid. These include sensible heat flux, latent heat flux, horizontal direct normal irradiance and albedo, interpolated using a spherical spline, and net solar radiation, net thermal radiation, downward solar radiation, downward thermal radiation using a linear interpolation. For near-real-time, albedo is not available in GFS. This parameter varies slowly day to day and so a persistent value from the last finalized data day with the same hour is assumed to be a good estimate for near real time.

Diffuse horizontal irradiance is calculated as the global horizontal irradiance minus the horizontal component of direct normal irradiance, both of which are direct ERA5 outputs. Similarly ground heat flux is calculated by considering the surface energy budget: net solar radiation plus net thermal radiation minus sensible heat flux and latent heat flux.

Direct Normal Irradiance is obtained directly from the horizontal component of direct normal irradiance, using the solar zenith angle, which is obtained from time, location, temperature and pressure.

Cloud parameters cloud coverage, cloud cover (Low), cloud cover (Middle), cloud cover (High) and cloud base height are ERA5 output fields interpolated to the 15km grid using a spherical spline.

Atmospheric Column Parameters

Atmospheric column parameters planetary boundary layer height, zero degrees height, total column liquid cloud and total super cool liquid cloud, are ERA5 output fields interpolated to the 15km grid using a spherical spline. Total ozone and total column water vapor are interpolated to the 15km grid using linear interpolation.

Wind Turbine Nacelle Height Parameters

Eleven weather parameters are provided at each of two wind turbine nacelle heights - 80m and 100m. The 100m wind components are output fields from ERA5 interpolated to the 15km grid using a spherical spline. The U and V wind components at 80m are derived from the 100m components, together with the surface roughness, using a simplified version of Monin–Obukhov similarity theory. Direction and speed are then derived from the wind components using the standard formulae. Temperatures at the nacelle heights are scaled from the 2m temperature using the standard atmosphere lapse rate of -0.0065C/m. Pressures are derived from surface pressure using the barometric formula. Relative humidity is assumed to be equal to that at 2m. Specific humidity is derived from temperature, pressure and relative humidity following Bolton 1980 and the water mixing ratio is estimated from the result. Then the dewpoint temperature is derived using the specific humidity, temperature and pressure following Bolton 1980.

As at 2m, air density at 80m and 100m is derived from temperature, pressure and the surface mixing ratio using Hobbs 2006.

Soil Level Parameters

Soil level parameters are soil moisture and soil temperature. These are across four depths - 0 to 7cm, 7 to 28cm, 28 to 100cm and 100 to 289cm. Moisture is obtained on the Atmospheric G2 15km grid using a spherical spline interpolation and temperature is obtained using a linear interpolation. These are combined into an overall 0 to 289cm version of each parameter. In addition to soil level parameters, leaf area indices (0-1) are interpolated using spherical spline interpolation at low and high levels. Leaf area indices are not available in GFS. These values vary slowly and so a persistent value from the last finalized data day with the same hour is assumed to be a good estimate for near real time. Input near real time soil levels are slightly different - 0 to 10cm, 10 to 40cm, 40 to 100cm and 100 to 289cm, but are considered sufficiently close for provisional data.

All in, the Atmospheric G2 Gridded dataset offers 101 weather parameters every hour.

Time Scales

As well as hourly data, data is available daily (local or UTC), monthly (local only) or annual (local only).

Precipitation type is only available at the hourly time scale, but for each other parameter daily/monthly/annual minima, maxima and means are calculated from the hourly data.. For surface temperature minima and maxima calculations use the sub hourly parameter and the mean calculation uses the hourly value. For all other parameters the hourly values are used to calculate all three statistics.

For appropriate parameters the sum over day/month/year is also calculated. These include precipitation parameters, all radiation parameters, evaporation parameters, CAPE, convective inhibition, total column water vapor, total column cloud liquid, total column supercool cloud, total column ozone and snowmelt.

Ways to Query

The endpoint(s) can be queried by:

1. Latitude/longitude coordinate – data from the grid point will be returned
2. SiteId – the numeric identifier for a particular grid point

Future functionality may include the ability to select data by country, state, province etc.

API Specs

Request Parameters

Request parameters applicable to all weather data endpoints:

- **userKey** – required – supplied by Atmospheric G2, this key identifies and authorizes the account issuing the request.
- **startDate** – required – in format MM/DD/YYYY
  - Could be any date from 01/01/1991 to today for gap-filled data
- **endDate** – required – in format MM/DD/YYYY
  - Could be any date from 01/02/1991 to tomorrow for gap-filled data
- **location** can be either **lat** / **lon** pair or **siteId**, depending on endpoint – required.
  - lat and lon are coordinates of a location – we calculate the distance and return data from the closest grid point
  - siteId is a numerical identifier for a particular grid position.
- **interval** – optional – one of hourly, daily, monthly, annual – default is hourly.
- **time** – optional – one of gmt, lwt – default is gmt.
- **units** – optional - one of metric, imperial – default is metric.
- **format** – optional – one of json, xml, csv – default is json.
- **fields** – optional – can be used to query for specific variables

HTTP Status Codes

HTTP status codes and error reporting will remain consistent with the existing V3 endpoints.

References

Anderson, G. Bell, M.L. and Peng, R.D. 2013 Methods to Calculate the Heat Index as an Exposure Metric in Environmental Health Research Environmental Health Perspectives 121:10 CID: https://doi.org/10.1289/ehp.1206273

Bolton, D. 1980 The Computation of Equivalent Potential Temperature Monthly Weather Review Vol 108 1046-1053 http://wwwdca.iag.usp.br/material/hallak/AGM-5716/Artigo_Bolton1980/Bolton-MWR-1980.pdf

Cao, X.C.; Shao, L.M.; Li, X.D. Research on parameterization scheme of visibility in Fog Model.

In Proceedings of the 31st Annual Meeting of the Chinese Meteorological Society, Beijing, China, 3 November 2014; 2014; pp. 1–5.

Draper, C. S., 2021: Accounting for Land Model Uncertainty in Numerical Weather Prediction Ensemble Systems: Toward Ensemble-Based Coupled Land–Atmosphere Data Assimilation. J. Hydrometeor., 22, 2089–2104, https://doi.org/10.1175/JHM-D-21-0016.1.

FCM-R19-2003 2003 Wind Chill Temperature And Extreme Heat Indices: Evaluation and Improvement Projects http://weather.missouri.edu/gcc/OFCMWindchillReport.pdf

Hersbach H, Bell B, Berrisford P, et al. The ERA5 global reanalysis. Q J R Meteorol Soc. 2020; 146: 1999–2049. https://doi.org/10.1002/qj.3803

Hobbs, P. V., and J. M. Wallace, 2006: Atmospheric Science: An Introductory Survey. 2nd ed. Academic Press, 504 pp.

Ibebuchi, C., Lee, C., Silva, A. and Sheridan, S. 2024 Evaluating Apparent Temperature in the Contiguous United States From Four Reanalysis Products Using Artificial Neural Networks. JGR: Machine Learning and Computation vol 1, issue 2 2993-5210 https://doi.org/10.1029/2023JH000102

Knox, J. A., Nevius, D. S., & Knox, P. N. 2017. Two Simple and Accurate Approximations for Wet-Bulb Temperature in Moist Conditions, with Forecasting Applications, Bulletin of the American Meteorological Society, 98(9), 1897-1906.

Li, X. and Derber, J. 2008. Near sea surface temperatures (NSST) analysis in NCEP GFS. 6th JCSDA Workshop http://data.jcsda.org/Workshops/6th-workshop-onDA/Session-4/JCSDA_2008_Li.pdf

Romps, D.M. et al. ,Projected increase in lightning strikes in the United States due to global warming.Science346,851-854(2014).DOI:10.1126/science.1259100