The Global Historical Climatology Network (GHCN) hourly, daily and monthly datasets

Progress towards a harmonized database of weather station observations over global land areas

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NOAA
National Satellite and Information Service

September 19, 2024

Outline

- The datasets (data sources, partnerships, etc)
- Some challenges
- Future development

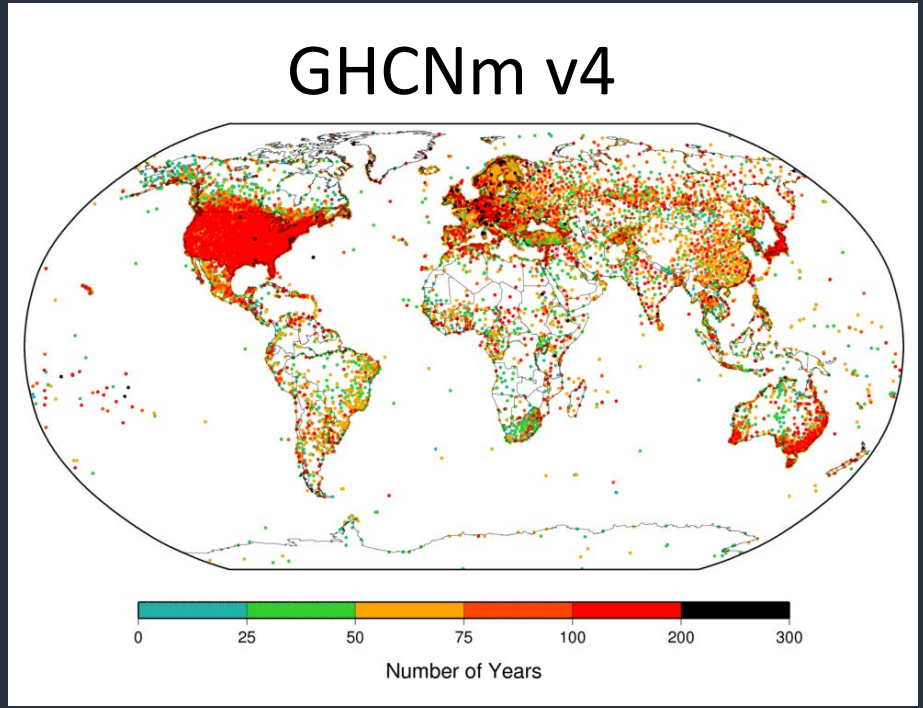
Monthly Data: Two Main Products

GHCNm (temperature and precipitation)

- Many dozens of input sources, but
- Main source is GHCNd
- Used in NOAAGlobalTemp

Global Summary of the Month (GSOM)

- More elements
- Based entirely on GHCNd
- Includes derived parameters such as heating/cooling degree days
- Shared with C3S for land component
- “Official” monthly product for NOAA stations



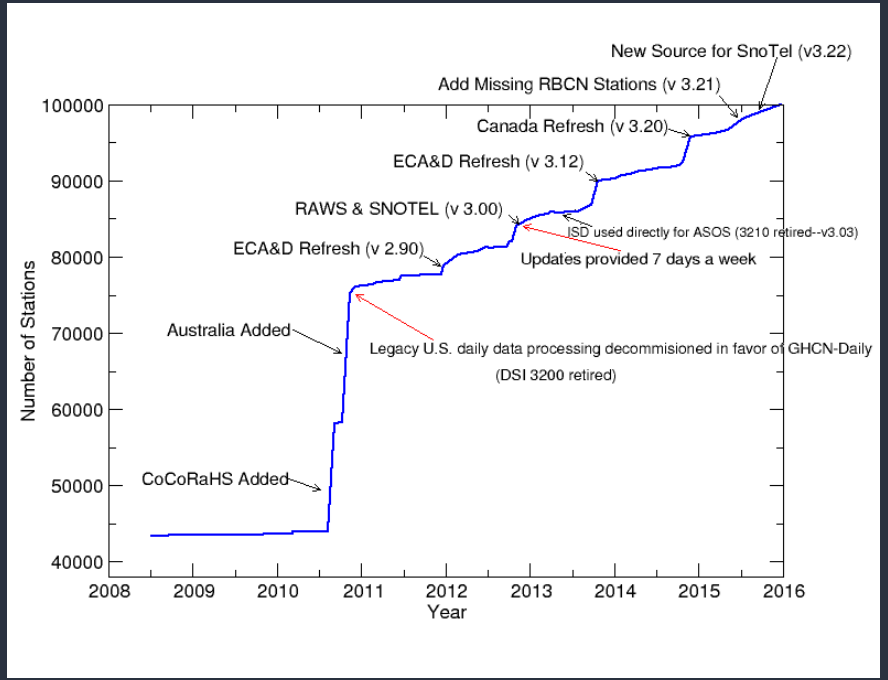
Daily Data - Also two main products

GHCNd

- 30+ input datasets via several partnerships (NOAA, USDA, KMNI, BoM, Env. Canada etc.)
- Very large user base with many downstream dependencies Observation times are network and country dependent
- “Official” daily data for NOAA Stations

Synoptic Summary of the Day (SSOD) (replacing “Global Summary of the Day”)

- derived from hourly/synoptic reports
- based on a UTC calendar day worldwide



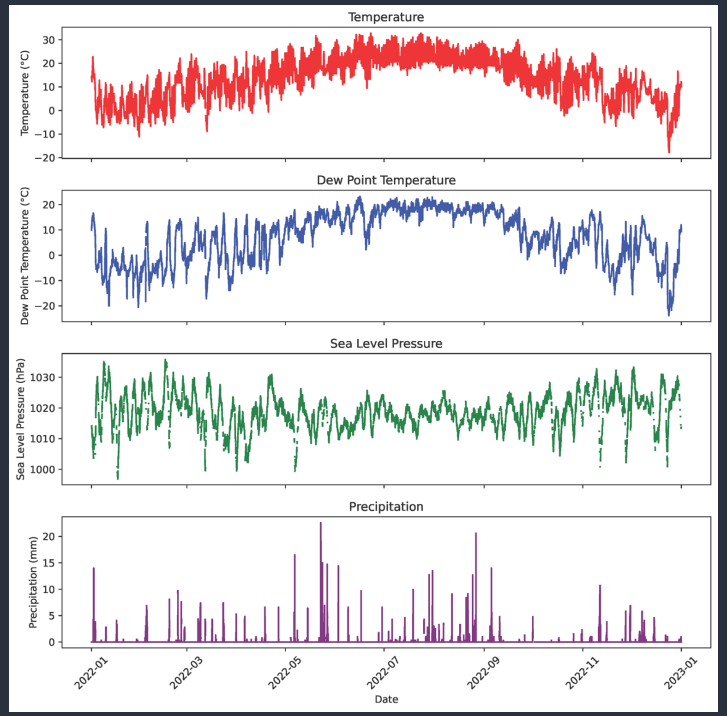
Hourly Data: New Product!

Latest addition to the GHCN family

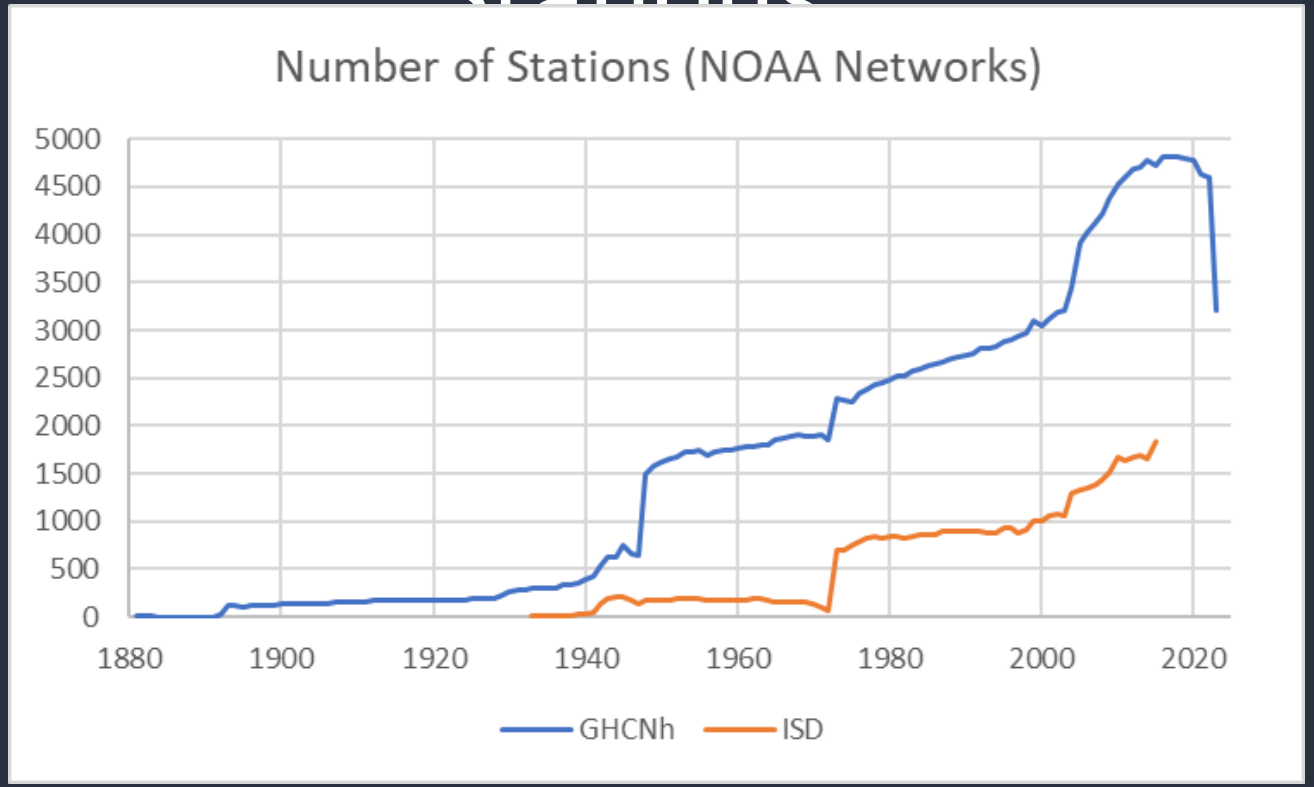
GHCNh

- Replaces NCEI's core dataset – the Integrated Surface Data (ISD)
- Co-developed with the European Union's Copernicus Climate Change Service and the US Air Force's 14th Weather Squadron
- Much more closely aligns hourly data with (GHCNd)
- Adds data sources (130+) and extends station periods of record compared to ISD
- "Official" Hourly data for NOAA Stations

Hourly Data for 2022: Asheville Regional Airport



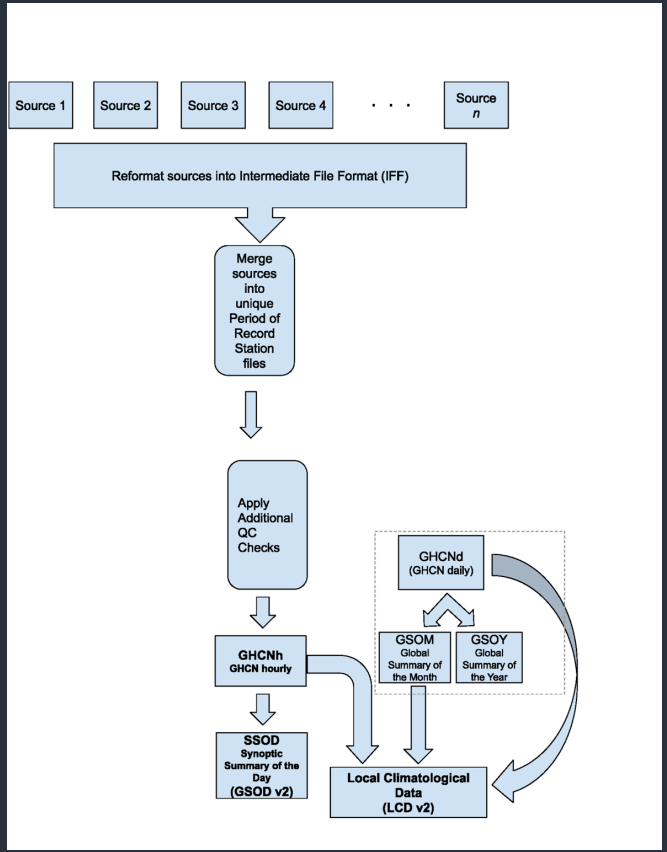
Hourly Data for NOAA Managed Stations



Local Climatological Data Version 2 (LCDv2)

The Local Climatological Data version 2 (LCDv2)

- Provides a synopsis of hourly+daily and monthly summaries for a single weather station and for specific month
- Includes departures from normal and degree day calculations
- Flagship product for NCEI



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U.S. Department of Commerce
National Oceanic & Atmospheric Administration
National Environmental Satellite, Data, and Information Service
Current Location: Elev: 2118 ft. Lat: 35.4318° N Lon: -82.5379° W
Station: **ASHEVILLE REGIONAL AIRPORT, NC US WBAN: 72315003812 (Unknown)**

Local Climatological Data
Daily Summary
December 2022

Generated on 01/26/2023

National Centers for Environmental Information
151 Patton Avenue
Asheville, North Carolina 28801

Date	Temperature (F)							Degree Days (base 65F)		Sun (LST)		Weather	Precipitation (in)			Pressure (inHg)		Wind	Maximum Wind Speed = MPH / Direction = Degrees			
	Max	Min	Avg	Dep	ARH	ADP	AWB	Heat	Cool	Rise	Set	Weather Type	TLC	Snow Fall	Snow Depth	Avg Stn	Avg SL	Avg Speed	Peak Speed	Peak Dir	Sust. Speed	Sust. Dir
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
01	53	28	41	-1.9				24	0	0721	1717		0.00	0.0	0	28.07		8.9	35	340	24	340
02	56	26	41	-1.6				24	0	0722	1717		0.00	0.0	0	28.12		6.6	36	190	23	170
03	64*	46	55	12.6				10	0	0722	1717	RA	0.03	0.0	0	28.01		10.0	29	180	22	190
04	50	33	42	-0.1				23	0	0723	1717		0.00	0.0	0	27.92		2.8	16	340	14	340
05	43	38	41	-0.8				24	0	0724	1717	RA BR	0.32	0.0	0	27.84		6.4	15	160	10	150
06	55	40	48	6.4				17	0	0725	1717	RA BR	0.30	0.0	0	27.88		5.2	13	160	10	160
07	63	49	56	14.7				9	0	0726	1717	RA FG BR	0.41	0.0	0	27.95		2.5	13	340	9	340
08	61	55	58	16.9				7	0	0727	1717	RA BR	0.45	0.0	0	27.92		2.2	13	110	9	140
09	56	46	51	10.2				14	0	0727	1717	RA BR	0.11	0.0	0	27.87		4.3	15	170	12	140
10	49	44	47	6.4				18	0	0728	1718	BR	0.00	0.0	0	27.91		5.8	13	130	12	170
11	50	44	47	6.7				18	0	0729	1718	BR	T	0.0	0	27.85		3.5	12	140	8	330
12	58	45	52	11.9				13	0	0730	1718		0.00	0.0	0	27.83		4.1	13	150	9	160
13	46	37	42	2.1				23	0	0730	1718		0.00	0.0	0	27.92		5.7	14	150	10	150
14	42	37	40	0.3				25	0	0731	1718	RA BR	0.76	0.0	0	27.79		7.3	16	170	13	200
15	48	37	43	3.5				22	0	0732	1719	RA BR	0.81	0.0	0	27.53		4.6	15	180	12	340
16	50	31	41	1.7				24	0	0732	1719		0.00	0.0	0	27.58		6.1	25	290	17	300
17	50	27	39	-0.1				26	0	0733	1719		0.00	0.0	0	27.60		4.3	23	310	17	330
18	40	28	34	-4.9				31	0	0734	1720		0.00	0.0	0	27.76		9.3	26	350	21	340
19	46	21	34	-4.8				31	0	0734	1720		0.00	0.0	0	28.02		3.4	15	330	13	330
20	40	28	34	-4.6				31	0	0735	1721		0.00	0.0	0	28.05		2.3	13	190	10	180
21	47	29	38	-0.4				27	0	0735	1721	RA BR UP	T	0.0	0	27.99		5.3	17	170	14	180
22	45	33	39	0.7				26	0	0736	1722	RA BR	0.14	0.0	0	27.70		5.2	22	170	17	170
23	41	2	22	-16.1				43	0	0736	1722	RA	0.10	0.0	0	27.48		15.0	42	300	33	300
24	24	0*	12	-26.0				53	0	0737	1723		0.00	0.0	0	27.73		13.9	34	350	26	330
25	31	12	22	-15.9				43	0	0737	1723		0.00	0.0	0	27.79		12.2	27	340	21	320
26	34	12	23	-14.8				42	0	0738	1724		0.00	0.0	0	27.88		3.8	19	340	15	340
27	45	24	35	-2.6				30	0	0738	1725		0.00	0.0	0	27.93		4.6	17	350	14	340
28	52	19	36	-1.5				29	0	0738	1725		0.00	0.0	0	27.97		2.0	15	170	12	160
29	62	23	43	5.6				22	0	0739	1726		0.00	0.0	0	28.04		3.4	20	210	16	210
30	53	28	41	3.7				24	0	0739	1727	RA FG BR UP	0.03			27.96		2.9	12	160	9	180
31	54	46	50	12.7				15	0	0739	1727	RA FG BR	0.13	0.0	0	27.75		3.2	14	110	9	120
	48.6	31.2	39.9							Monthly Averages | Totals			3.59			27.86	30.16	5.8				
	-0.9	1.9	0.5							Departure from Normal (1981-2010)			0.00s									

Degree Days

	Monthly		Season-to-date	
	Total	Departure	Total	Departure
Heating	777	-17	1697	
Cooling	0	0	991	

Number of days with...

	Temperature				Precipitation		Snow	Weather	
	Max		Min						
	>=90°	<=32°	<=32°	<=0°	>=0.01"	>=0.1"	>=1"	T-Storms	Heavy Fog
	0	2	16	1	12	10	0		2

Date of 5-sec to 3-sec wind equipment change	Sea Level Pressure			Greatest...		
		Date	Time	24-Hr...		Snow Depth
				Precip	Snowfall	
2008-10-16	Maximum 30.52	02	0801	1.57		
	Minimum 29.50	23	0319	Date		
				14-15		

Station Augmentation

Name:ASHEVILLE FIRE STATION Lat: N/A Lon: N/A Elevation: N/A Distance: 0.25mi N Elements: SNOW Equipment: SNOWBOARD

U.S. Department of Commerce
National Oceanic & Atmospheric Administration
National Environmental Satellite, Data, and Information Service
Current Location: Elev: 2118 ft. Lat: 35.4318° N Lon: -82.5379° W
Station: **ASHEVILLE REGIONAL AIRPORT, NC US WBAN: 72315003812 (Unknown)**

Local Climatological Data
Hourly Observations
December 2022

Generated on 01/26/2023

National Centers for Environmental Information
151 Patton Avenue
Asheville, North Carolina 28801

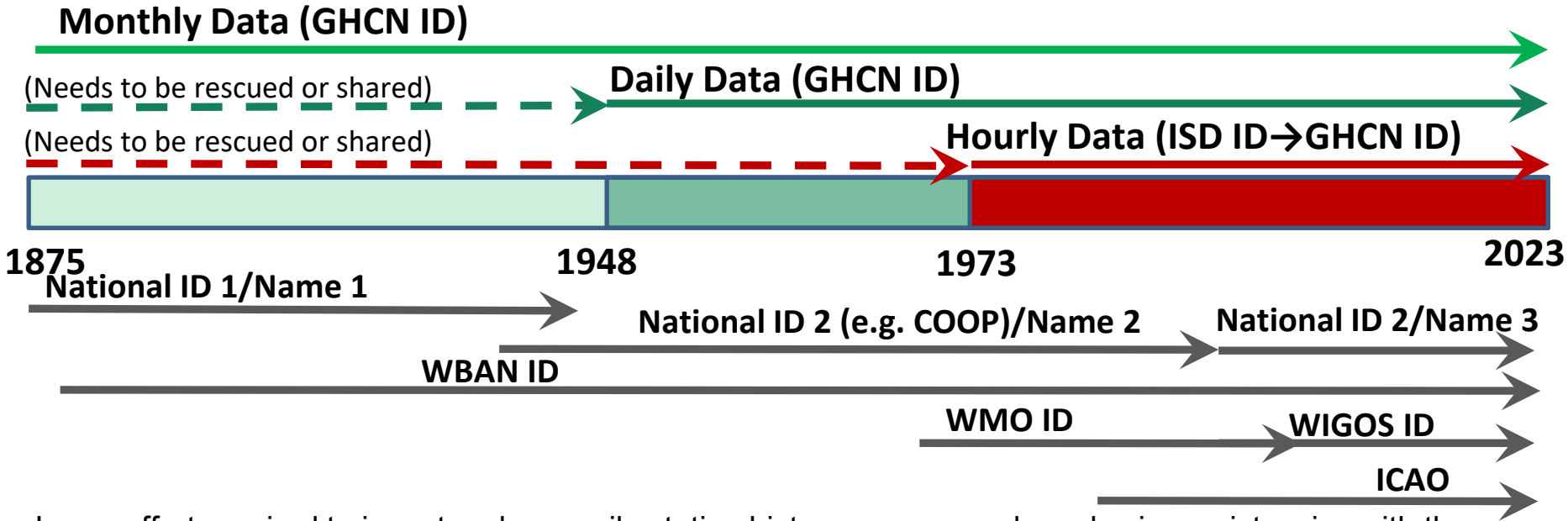
Date	Time (LST)	Station Type	Sky Conditions	Visibility	Weather Type (see documentation)	Dry Bulb Temp		Wet Bulb Temp		Dew Point Temp		Rel Hum	Wind Speed (MPH)	Wind Dir (Deg)	Wind Gusts (MPH)	Station Press (inHg)	Press. Tend	Net 3-Hr Change (inHg)	Sea Level Press. (inHg)	Report Type	Precip Total (in)	Altimeter Setting (inHg)
					AU | AW | MW	(F)	(C)	(F)	(C)	(F)	(C)	%										
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
01	0054	7	CLR:00	10.00		33	0.6	27	-2.8	16	-8.9	49	14	340	25	27.96	3	-0.03	30.25	FM-15	0.00	30.26
01	0100	4		9.94		33	0.6	27	-2.8	16	-8.9	49	14	340		27.94	3	-0.03	30.25	FM-12		
01	0154	7	CLR:00	10.00		32	0.0	26	-3.3	15	-9.4	50	14	340	25	27.99			30.28	FM-15	0.00	30.28
01	0254	7	CLR:00	10.00		31	-0.6	26	-3.3	15	-9.4	52	11	340		28.02			30.32	FM-15	0.00	30.32
01	0354	7	CLR:00	10.00		30	-1.1	25	-3.9	15	-9.4	54	11	340	23	28.05	3	-0.08	30.36	FM-15	0.00	30.35
01	0454	7	CLR:00	10.00		30	-1.1	25	-3.9	15	-9.4	54	13	340	21	28.06			30.38	FM-15	0.00	30.36
01	0554	7	CLR:00	10.00		29	-1.7	24	-4.4	15	-9.4	56	16	340	25	28.09			30.41	FM-15	0.00	30.39
01	0654	7	CLR:00	10.00		29	-1.7	24	-4.4	15	-9.4	56	17	340	26	28.09	0	-0.04	30.42	FM-15	0.00	30.39
01	0700	4		9.94		29	-1.7	24	-4.4	15	-9.4	56	17	340		28.06	9	+0.04	30.42	FM-12		
01	0754	7	CLR:00	10.00		28	-2.2	24	-4.4	15	-9.4	58	21	340	33	28.10			30.42	FM-15	0.00	30.40
01	0854	7	CLR:00	10.00		30	-1.1	25	-3.9	15	-9.4	54	16	340	29	28.12			30.44	FM-15	0.00	30.42
01	0954	7	CLR:00	10.00		34	1.1	27	-2.8	13	-10.6	42	13	010	20	28.15	3	-0.06	30.48	FM-15	0.00	30.45
01	1054	7	CLR:00	10.00		40	4.4	30	-1.1	9	-12.8	28	14	340	22	28.15			30.47	FM-15	0.00	30.45
01	1154	7	CLR:00	10.00		46	7.8	33	0.6	5	-15.0	18	10	350	21	28.12			30.44	FM-15	0.00	30.43
01	1254	7	CLR:00	10.00		49	9.4	35	1.7	7	-13.9	18	8	010		28.12	8	+0.03	30.43	FM-15	0.00	30.42
01	1300	4		9.94		49	9.4	35	1.7	7	-13.9	18	8	010		28.09	8	+0.03	30.43	FM-12		
01	1354	7	CLR:00	10.00		51	10.6	35	1.7	4	-15.6	14	8	350		28.10			30.41	FM-15	0.00	30.40
01	1454	7	CLR:00	10.00		52	11.1	36	2.2	8	-13.3	17	3	VRB		28.10			30.40	FM-15	0.00	30.40
01	1554	7	CLR:00	10.00		52	11.1	36	2.2	8	-13.3	17	3	010		28.10	5	+0.02	30.41	FM-15	0.00	30.40
01	1654	7	CLR:00	10.00		50	10.0	36	2.2	10	-12.2	20	0	000		28.10			30.42	FM-15	0.00	30.40
01	1754	7	CLR:00	10.00		46	7.8	35	1.7	18	-7.8	32	7	VRB		28.12			30.44	FM-15	0.00	30.42
01	1854	7	CLR:00	10.00		42	5.6	33	0.6	17	-8.3	36	6	180		28.15	3	-0.05	30.47	FM-15	0.00	30.45
01	1900	4		9.94		42	5.6	33	0.6	17	-8.3	36	6	180		28.12	3	-0.05	30.47	FM-12		
01	1954	7	CLR:00	10.00		39	3.9	31	-0.6	17	-8.3	41	0	000		28.15			30.49	FM-15	0.00	30.46
01	2054	7	CLR:00	10.00		36	2.2	30	-1.1	19	-7.2	50	3	150		28.15			30.49	FM-15	0.00	30.46
01	2154	7	CLR:00	10.00		32	0.0	28	-2.2	22	-5.6	66	3	170		28.15	0	-0.01	30.49	FM-15	0.00	30.46
01	2254	7	CLR:00	10.00		31	-0.6	28	-2.2	22	-5.6	69	0	000		28.16			30.49	FM-15	0.00	30.47
01	2354	7	CLR:00	10.00		29	-1.7	27	-2.8	22	-5.6	75	0	000		28.15			30.47	FM-15	0.00	30.46
02	0054	7	CLR:00	10.00		28	-2.2	26	-3.3	22	-5.6	78	0	000		28.14	8	+0.01	30.46	FM-15	0.00	30.44
02	0100	4		9.94		28	-2.2	26	-3.3	22	-5.6	78	0	000		28.10	8	+0.01	30.46	FM-12		
02	0154	7	CLR:00	10.00		27	-2.8	25	-3.9	22	-5.6	81	0	000		28.14			30.46	FM-15	0.00	30.44
02	0254	7	CLR:00	10.00		27	-2.8	25	-3.9	22	-5.6	81	3	180		28.14			30.45	FM-15	0.00	30.44
02	0354	7	CLR:00	10.00		26	-3.3	25	-3.9	22	-5.6	84	0	000		28.15	3	0.00	30.46	FM-15	0.00	30.45
02	0454	7	CLR:00	10.00		28	-2.2	26	-3.3	23	-5.0	81	0	000		28.15			30.47	FM-15	0.00	30.45
02	0554	7	CLR:00	10.00		29	-1.7	27	-2.8	23	-5.0	78	6	140		28.15			30.48	FM-15	0.00	30.46
02	0654	7	FEW:02 120	10.00		30	-1.1	28	-2.2	24	-4.4	79	0	000		28.16	3	-0.02	30.49	FM-15	0.00	30.47
02	0700	4		9.94		30	-1.1	28	-2.2	24	-4.4	79	0	000		28.13	3	-0.02	30.49	FM-12		
02	0754	7	SCT:04 120	10.00		32	0.0	29	-1.7	24	-4.4	73	3	150		28.18			30.51	FM-15	0.00	30.49
02	0854	7	BKN:07 120	10.00		37	2.8	32	0.0	25	-3.9	62	3	170		28.17			30.50	FM-15	0.00	30.48
02	0954	7	OVC:08 100	10.00		38	3.3	33	0.6	24	-4.4	57	7	180		28.17	1	-0.01	30.51	FM-15	0.00	30.48
02	1054	7	OVC:08 110	10.00		42	5.6	34	1.1	22	-5.6	45	8	160		28.16			30.49	FM-15	0.00	30.47
02	1154	7	BKN:07 110	10.00		44	6.7	36	2.2	24	-4.4	45	7	170		28.12			30.45	FM-15	0.00	30.43
02	1254	7	CLR:00	10.00		49	9.4	38	3.3	22	-5.6	35	7	140		28.10	8	+0.07	30.42	FM-15	0.00	30.40
02	1300	4		9.94		49	9.4	38	3.3	22	-5.6	35	7	140		28.07	8	+0.07	30.42	FM-12		
02	1354	7	BKN:07 120	10.00		53	11.7	46	7.8	39	3.9	59	16	180	26	28.07			30.39	FM-15	0.00	30.37
02	1454	7	BKN:07 120	10.00		54	12.2	47	8.3	40	4.4	59	17	180	26	28.06			30.37	FM-15	0.00	30.36
02	1554	7	BKN:07 120	10.00		54	12.2	48	8.9	43	6.1	67	15	170	22	28.07	5	+0.03	30.38	FM-15	0.00	30.37

Harmonized Land Station Data

- Must be built from multiple source archives
  - Requires reformatting native formats to a common format (not trivial!)
  - Requires some mechanism for ongoing integration of newly available historical sources (from data rescue and relaxed data sharing restrictions)
- Requires a system for documenting, tracking and addressing errors
- Fulfill the need to provide short time-delay updates for climate monitoring and other applications
- Management of station histories & other metadata (e.g., multiple identifiers and aliases often with overlaps and changes over time)

Hypothetical Station Record

Station X



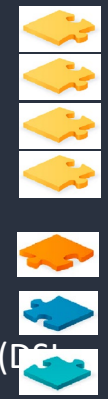
- Large effort required to ingest and reconcile station history sources and resolve inconsistencies with the station histories and digital data record
- HOMR is the “glue” that binds the data together and controls membership in NCEI’s in situ data access systems

Common Issues

Stations move…

..and are indexed differently across data sources.

Station ID	Source ID	Data Source
999999-94728	343	(NOAA SWO)
725060-94728	343	(NOAA SWO)
725053-94728	343	(NOAA SWO)
725033-94728	343	(NOAA SWO)
999999-94728	335	(DSI 3280)
725033-94728	335	(DSI 3280)



GHCN ID

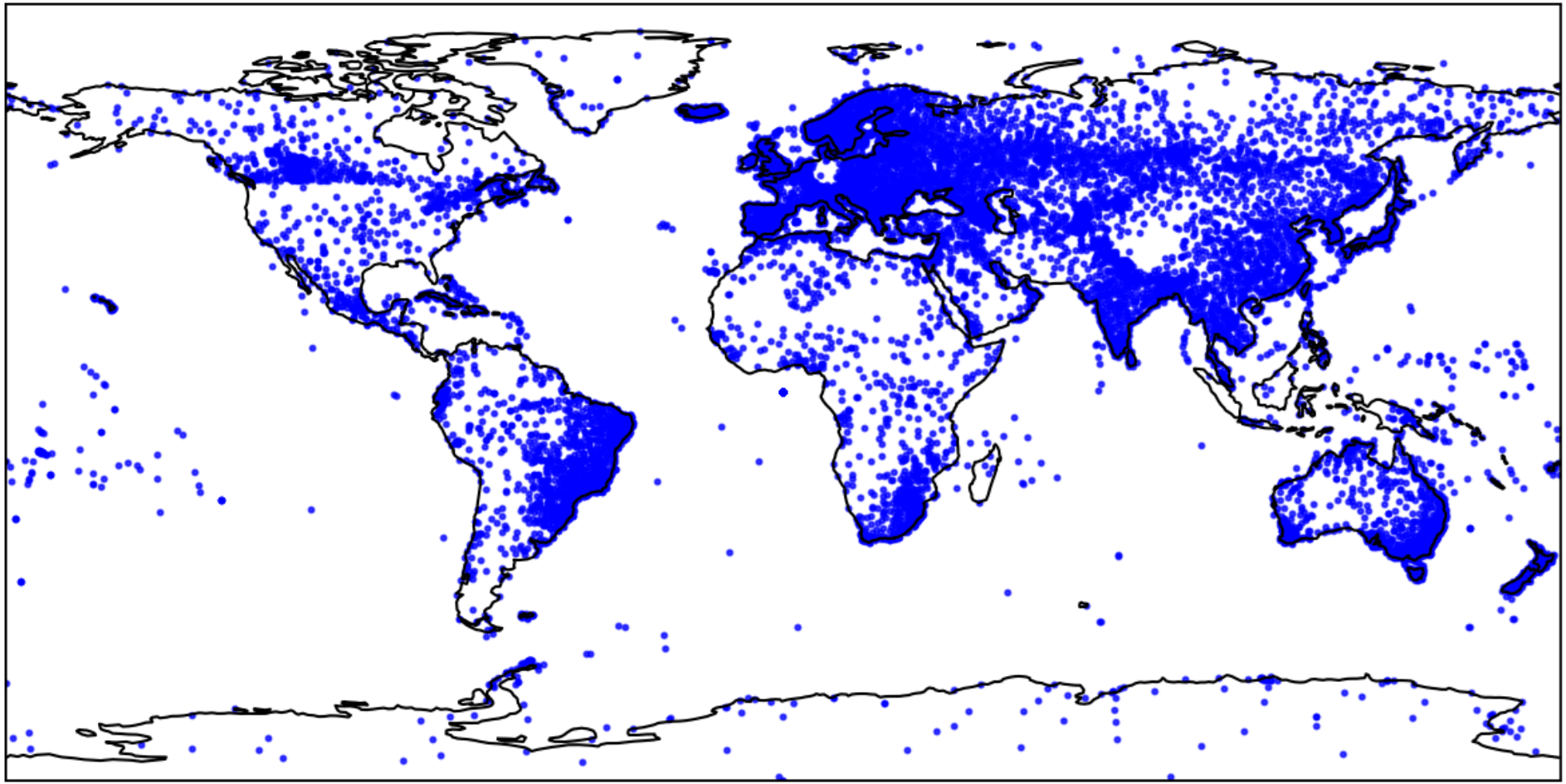
USW00094728

..change names…

ASHEVILLE REGIONAL AIRPORT, NC
1961-04-10 to Present

ASHEVILLE HENDERSONVILLE AP, NC
1941-06-26 to 1961-04-09

Station Locations for Data Source 220



Challenges

- Data Access tools
- Adding sources with regular/routine updates
- Obtaining and managing station metadata for non-NOAA stations
- Operations and Maintenance
- Fit for purpose computing platforms
- Answering user inquiries!

Compute issue: Hourly Data Flow

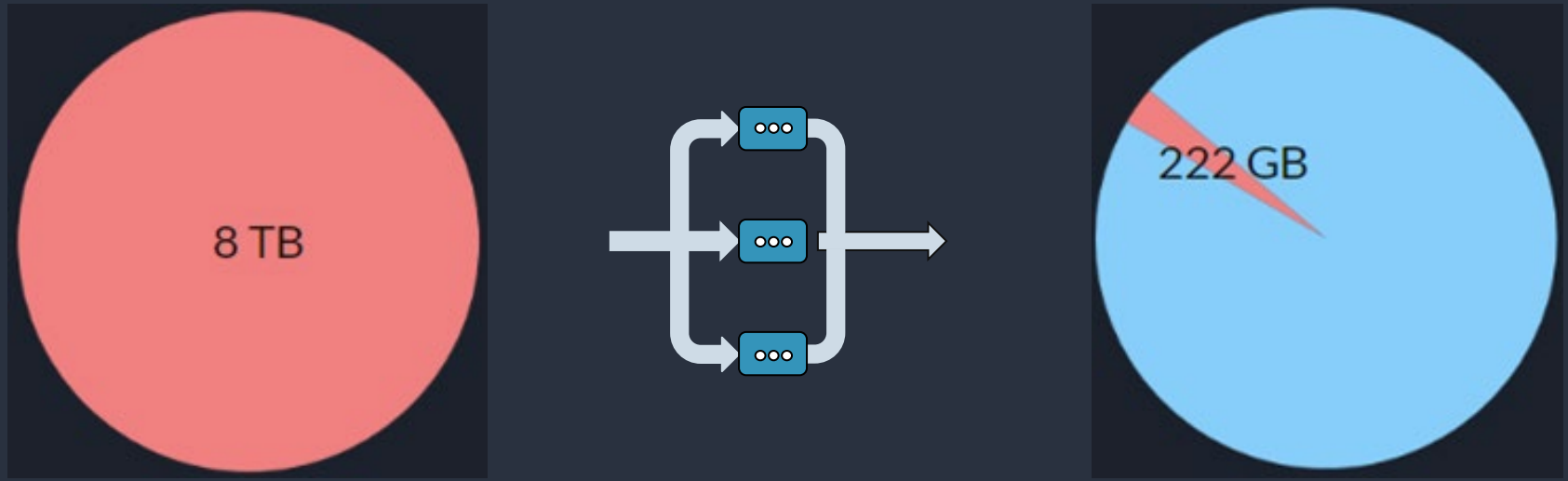
- 130+ sources
- Each contains 1 - 10,000 stations
- Stored on HPC

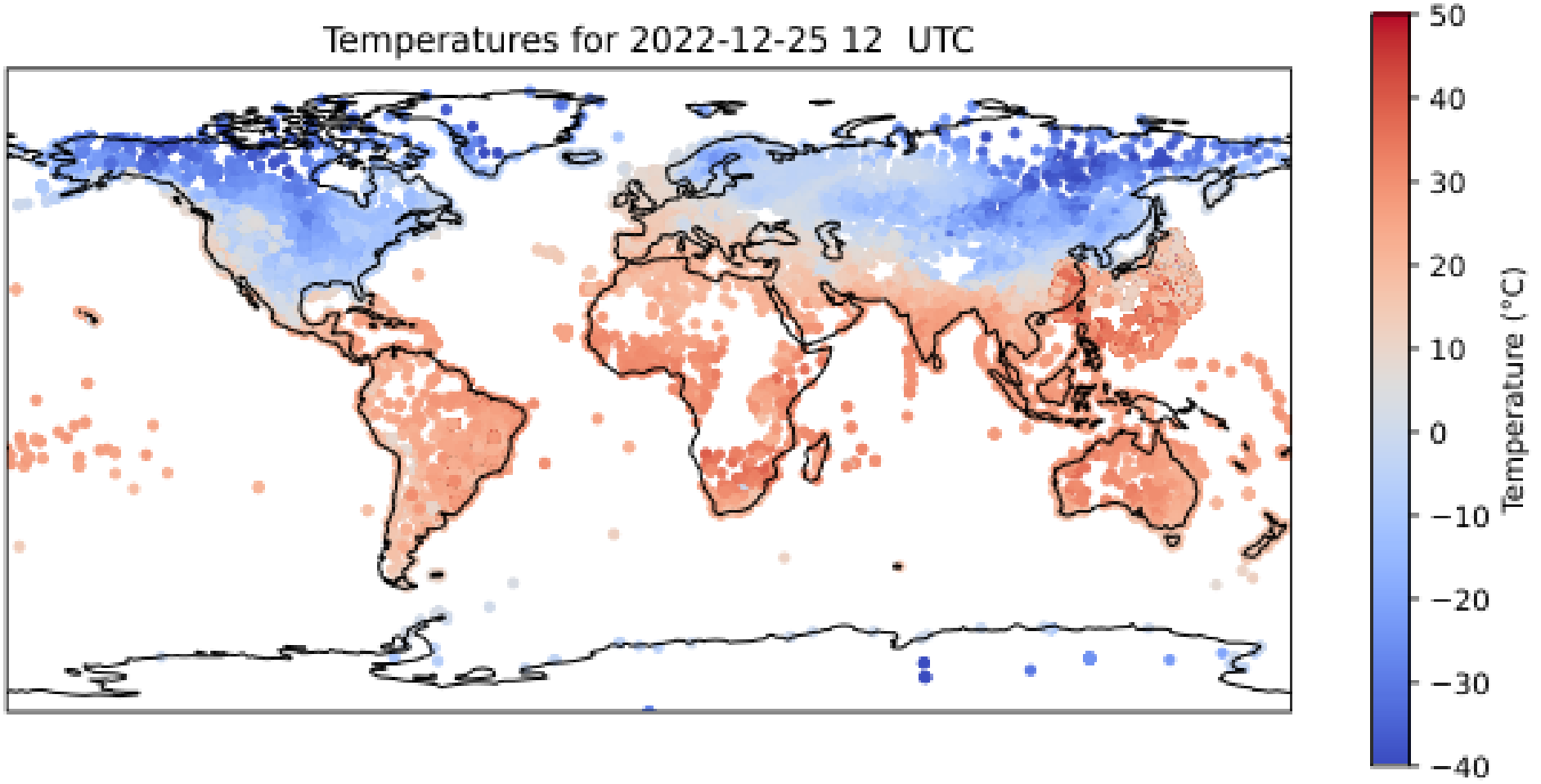
- 1 million intermediate files
- 8 terabytes of flat text
- 100+ billion observations

- 30,000 unique stations
- Parquet stored in S3

Moving To Cloud-Native Format

Parquet Conversion of Intermediate Files
Multi-Processing on AWS EC2




Temperatures for 2022-12-25 12 UTC
50
40
30
20
10
0
−10
−20
−30
−40
Temperature (°C)

The Future

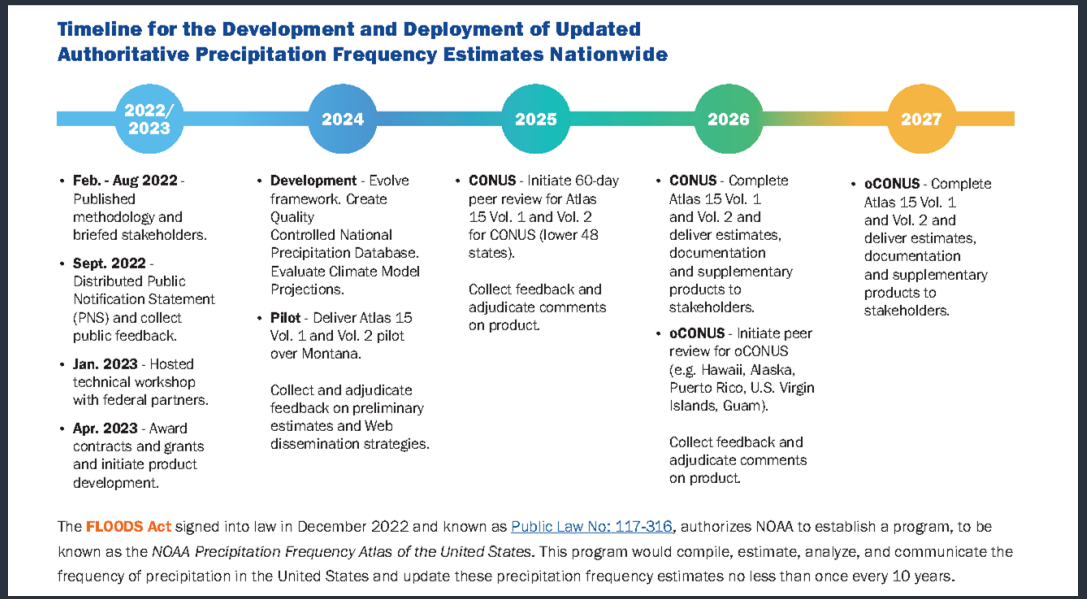
- Integration of additional sources once per year according to between C3S and NCEI
- Alignment of data and station histories at the margins where necessary
- Enhanced connection to WMO's Oscar Surface and use of WIGOS identifiers
- More API based updates
- Cloud access for hourly data
- QC across time resolutions

Atlas 15/BIL funding

Goal 1: Stewardship of U.S. Hourly and Sub-hourly precipitation observations in GHCNh

- On track to add Cooperative Observer Hourly Precipitation Data (active and historic hourly and 15-minute data)
- ASOS High resolution (5-minute totals)
- U.S. Climate Reference Network High resolution data (all variables)
- Some HADS data
- Data rescue and QC information collected by Atlas 14/15 team

Goal 2: Enhanced data access



Wrap up

- GHCN now part of larger effort that ties into more systematic data rescue and data sharing partnerships through C3S
- Need to take the long view of continuous reconciliation of data/station history issues and addition of new sources
- The plan is for GHCHh to be loaded into xmACIS

Thank You!

GHCNh format

Station_ID|Station_name|Year|Month|Day|Hour|Minute|Latitude|Longitude|Elevation|

temperature|temperature_Measurement_Code|temperature_Quality_Code|temperature_Report_Type|temperature_Source_Code|temperature_Source_Station_ID|...

USW00003812|ASHEVILLE AP|1940|11|01|12|00|35.4317|-82.5378|645.6|10.6||5|SAO-Airway|

314|723150-03812|9.4||5|SAO-Airway|...

Replaces ISD Format…

0276723150038121940110112 00G+35433-082483SAO +0639KAVL
99991585900365002445EN001600599+01065+00945101695ADDGA1999+002445999GD14995+99999999GF11818599999999999999999MA1999999093745MW1805EQDN01