Lecture 5
Introduction of WRF-HRRR and Mesonet Data

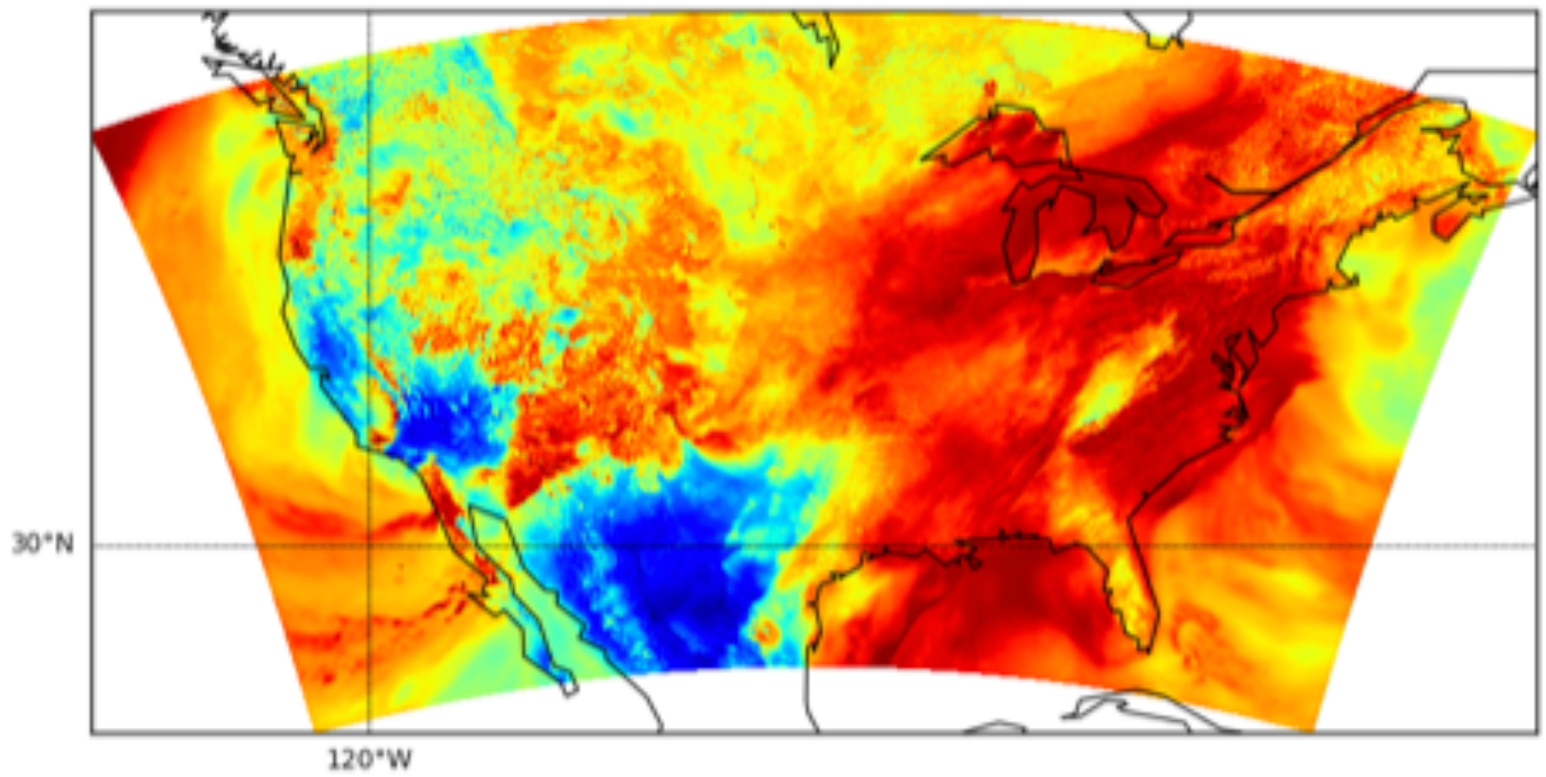
Xu Yuan
University of Louisiana at Lafayette

WRF-The Weather Research and Forecasting

- **Next generation mesoscale numerical weather prediction system**
- **It can produce simulations based on actual atmospheric conditions (i.e., from observations and analysis)**
- **It has been developed since the later of 1990's**

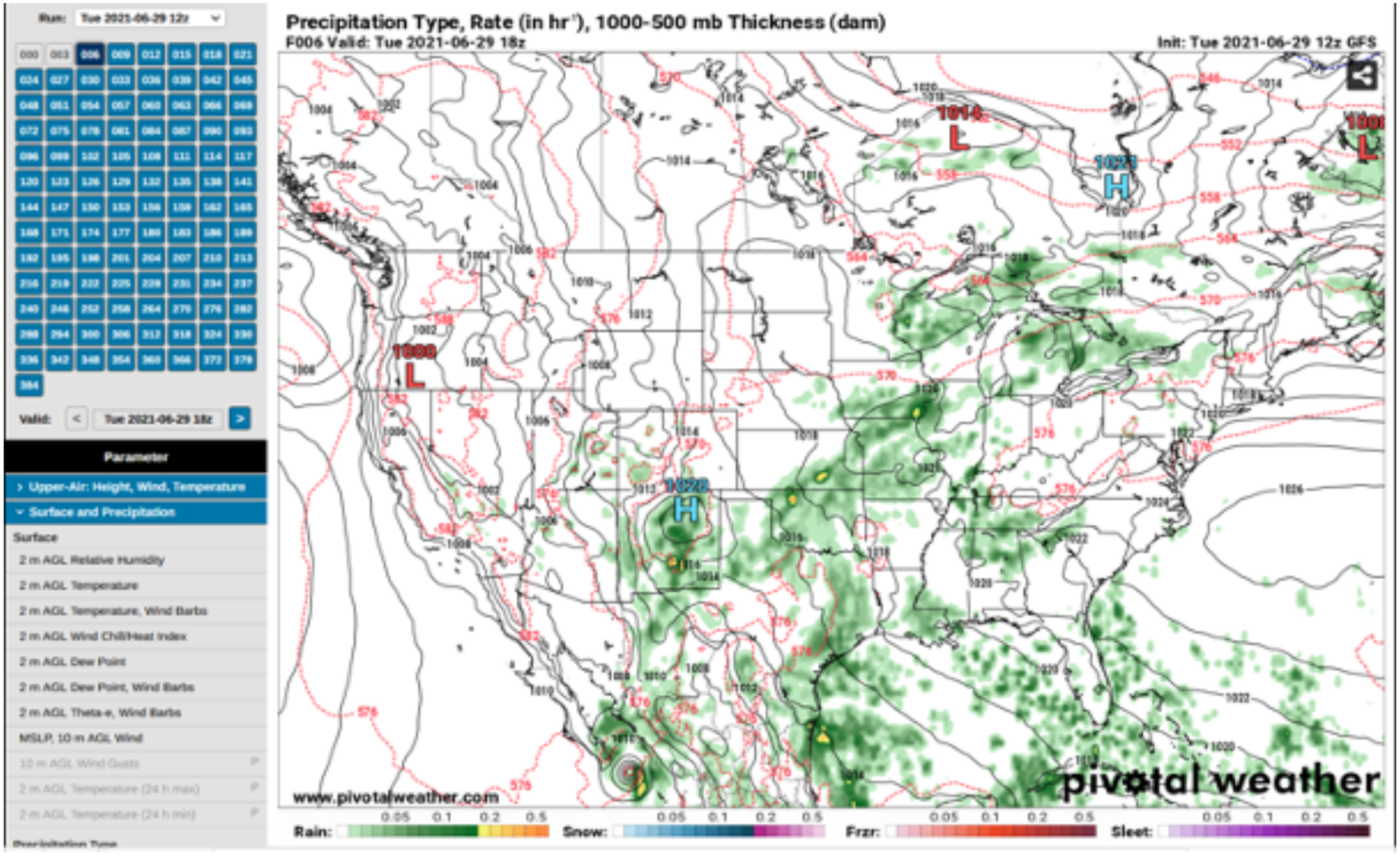
WRF-HRRR

The Weather Research and Forecasting Model with High-resolution Rapid Refresh



Predict hourly weather parameters covering US continent

WRF-HRRR: High-resolution Rapid Refresh



Source: https://www.pivotalweather.com/model.php

WRF-HRRR Data Source

- **Source: https://home.chpc.utah.edu/~u0553130/Brian_Blaylock/cgi-bin/hrrr_download.cgi**

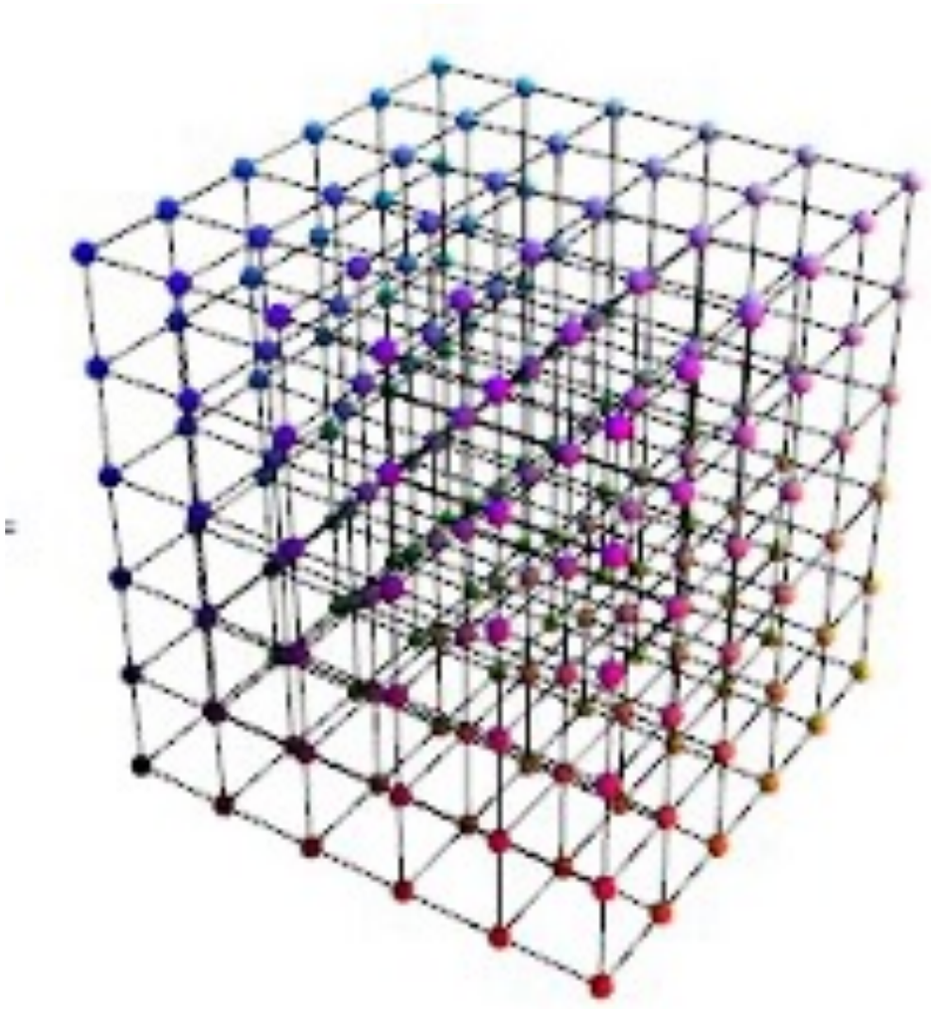
Tap to download HRRRv4 **grib2** from 2021-06-29:

Hour 00	F00	F01	F02	F03	F04	F05	F06	F07	F08	F09	F10	F11	F12	F13	F14	F15	F16	F17	F18	F19	F20	F21	F22	F23	F24	F25	F26	F27	F28	F29	F30	F31	F32	F33	F34
	F35	F36	F37	F38	F39	F40	F41	F42	F43	F44	F45	F46	F47	F48																					
Hour 01	F00	F01	F02	F03	F04	F05	F06	F07	F08	F09	F10	F11	F12	F13	F14	F15	F16	F17	F18																
Hour 02	F00	F01	F02	F03	F04	F05	F06	F07	F08	F09	F10	F11	F12	F13	F14	F15	F16	F17	F18																
Hour 03	F00	F01	F02	F03	F04	F05	F06	F07	F08	F09	F10	F11	F12	F13	F14	F15	F16	F17	F18																
Hour 04	F00	F01	F02	F03	F04	F05	F06	F07	F08	F09	F10	F11	F12	F13	F14	F15	F16	F17	F18																
Hour 05	F00	F01	F02	F03	F04	F05	F06	F07	F08	F09	F10	F11	F12	F13	F14	F15	F16	F17	F18																
Hour 06	F00	F01	F02	F03	F04	F05	F06	F07	F08	F09	F10	F11	F12	F13	F14	F15	F16	F17	F18	F19	F20	F21	F22	F23	F24	F25	F26	F27	F28	F29	F30	F31	F32	F33	F34
	F35	F36	F37	F38	F39	F40	F41	F42	F43	F44	F45	F46	F47	F48																					
Hour 07	F00	F01	F02	F03	F04	F05	F06	F07	F08	F09	F10	F11	F12	F13	F14	F15	F16	F17	F18																
Hour 08	F00	F01	F02	F03	F04	F05	F06	F07	F08	F09	F10	F11	F12	F13	F14	F15	F16	F17	F18																
Hour 09	F00	F01	F02	F03	F04	F05	F06	F07	F08	F09	F10	F11	F12	F13	F14	F15	F16	F17	F18																
Hour 10	F00	F01	F02	F03	F04	F05	F06	F07	F08	F09	F10	F11	F12	F13	F14	F15	F16	F17	F18																
Hour 11	F00	F01	F02	F03	F04	F05	F06	F07	F08	F09	F10	F11	F12	F13	F14	F15	F16	F17	F18																
Hour 12	F00	F01	F02	F03	F04	F05	F06	F07	F08	F09	F10	F11	F12	F13	F14	F15	F16	F17	F18	F19	F20	F21	F22	F23	F24	F25	F26	F27	F28	F29	F30	F31	F32	F33	F34
	F35	F36	F37	F38	F39	F40	F41	F42	F43	F44	F45	F46	F47	F48																					

WRF-HRRR Data Format

- **HRRR models store data in GRIB format (i.e., 3-D grid), which is a compressed format**

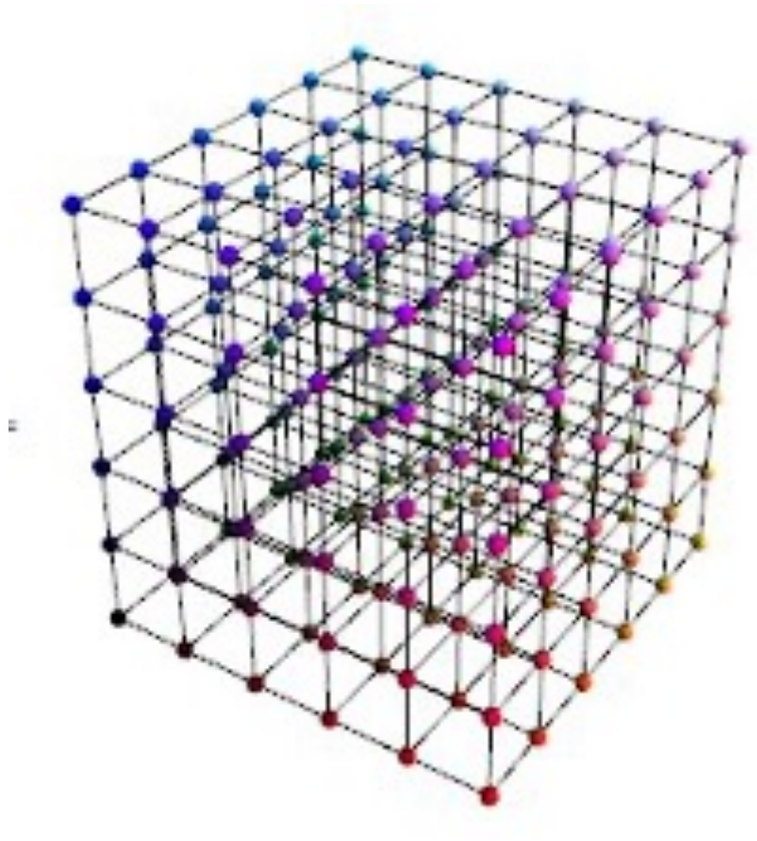
- **Each Grid is of fixed size, 3km x 3km**
  - Covering the United States continent: 1059 x1799 geo-grids



WRF-HRRR Data Format

- **Each layer in a GRIB file represents one feature (e.g., temperature), spanning throughput United States**
  - Horizon represents locations and vertical represents features

- **So all vertically aligned grid points represents the set of features for a particular location**
  - The latitude and longitude information are encoded in the GRIB file



148 Parameters = 148 Layers

Examples for Features at Some Layers

Layer	Feature
1	Maximum/Composite radar reflectivity
8	Wind speed (gust)
11	U component of wind
12	V component of wind
13	Geopotential Height
14	Temperature
15	Dew point temperature
57	Surface pressure
66	2 meter temperature
71	10 meter U wind component
72	10 meter V wind component
73	10 meter wind speed

Extracting Weather Conditions at A Location

- **The latitude and longitude of the UL Lafayette (ULL) is 30.2126 and -92.0193, respectively**
  - How to get the weather conditions at ULL?

- **We can fetch the latitude and longitude matrix from GRIB file**
  - Find the grid point that has the closest distance to ULL

Extracting Weather Conditions at ULL

```
lt_ULL = 30.2126
ln_ULL = -92.0193
gr = pygrib.open('path/to/grib/file')                    # open file
msg = gr [1]                                             # get layer-1 message (any layer no. works here).
lt, ln = msg.latlons()                                   # extract GPS coordinate
dis_mat = (lt-l_lt_ULL)**2+(ln-l_ln_ULL)**2              # compute distance between each grid point and ULL
p_lt, p_ln = numpy.unravel_index(dis_mat.argmin(), dis_mat.shape) # pick smallest distance index
data = msg.values
feature_ULL = data[p_lt,p_ln]
```

Mesonet

- **Comprising a set of automated weather stations located at some specific area in the USA**
  - Each station monitors tens of of atmospheric measurements, like temperature, rainfall, wind speed, etc., once per minute
  - South Alabama Mesonet includes a network of 26 weather stations, maintained by Dr. Sytske Kimball, Co-PI of our project
  - Kentucky Mesonet is led by Dr. Eric Rappin, Co-PIs of our project

South Alabama Mesonet

- **Data is publicly available at: http://chiliweb.southalabama.edu/archived_data.php**
  - A combination of selectable features for a given range of date is available for downloading
  - Dataset includes 60 features, excluding time, date, and location
  - Data are ion CSV format

South Alabama Mesonet

South Alabama Mesonet

South Alabama Mesonet

Temperature (soil - 5 depths and above the surface at 1.5, 2, 9.5, and 10 m).

Relative Humidity (above the surface at 2 and 10 m).

Horizontal Wind Speed and Direction (2 and 10 m).

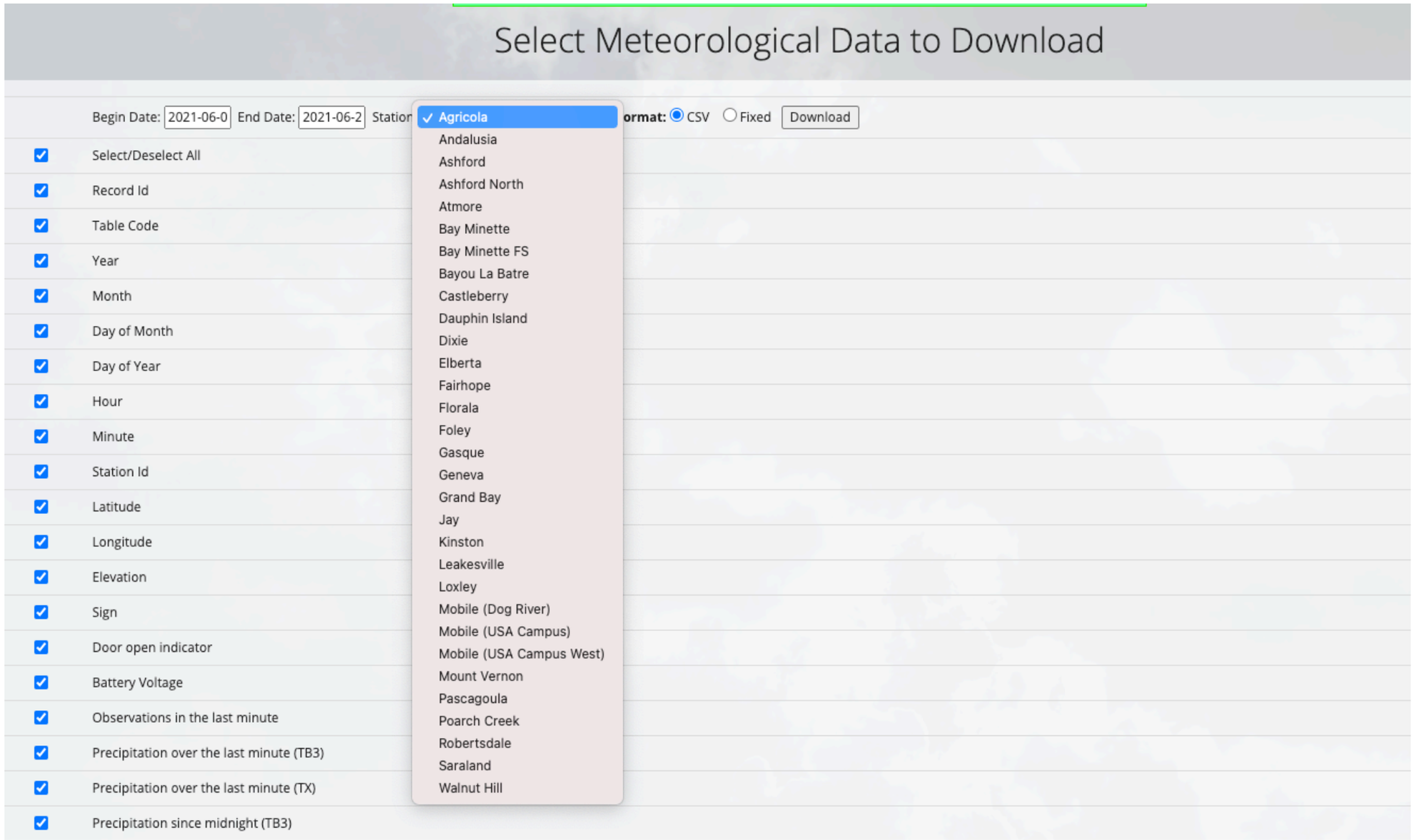
Vertical Wind Speed (10 m).

Atmospheric Pressure.

Rainfall.

Solar Radiation (Total Radiation and PAR).

Example



Source: http://chiliweb.southalabama.edu/archived_data.php

WRF-HRRR verus Mesonet

	Parameters	Resolution	Frequency	Height	Accuracy	Future Prediction
WRF with HRRR	148	3 km * 3 km	1 hour	Upper air	Low	Yes
Mesonet	60	single point	1 minute	Near-surface	High	No

We would like to …

By incorporating the two datasets, we develop Deep Learning approach to predict the future weather conditions.

The good thing here is that you don’t need to label the data.

Comparing to Twitter Data

- **Twitter Data**
  - Unstructured
  - Classification on purpose
  - Classification based on spam patterns: feature extraction
  - No ground truth
  - Binary classification

- **Weather Data**
  - Structured
  - Prediction on purpose
  - All features (weather parameters) have been provided
  - No ground truth
  - Time-series Prediction