دانشگاه رازی

Synoptic Meteorology 1

Lecture 4

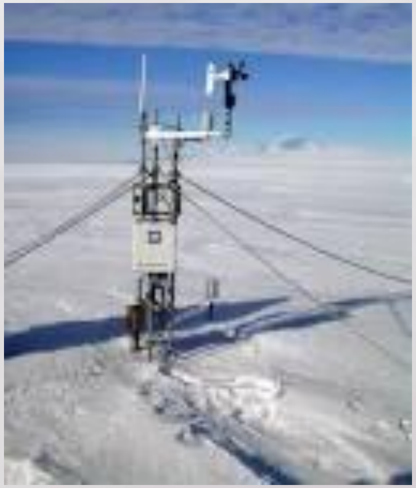
Sahraei

Physics Department
Razi University

The Weather Station

Before we can start to forecast the weather, we need a set of data describing the condition of the atmosphere at a given time.
In forecasting circles, such data is referred to as **initial conditions.**

We need observations of temperature, pressure, humidity, cloud cover, cloud type, wind speed and many other quantities, ideally at as many points on the Earth's surface as possible, and sampled throughout the depth of the atmosphere. Of course, it is impractical to observe the entire atmosphere at quite this level of detail.



Even so, the modern global weather observation network consists of over 10,000 land-based weather sites, thousands of automatic weather stations mounted on buoys and ships at sea, hundreds of sites that monitor the conditions aloft, and an array of weather satellites in constant orbit around the Earth.

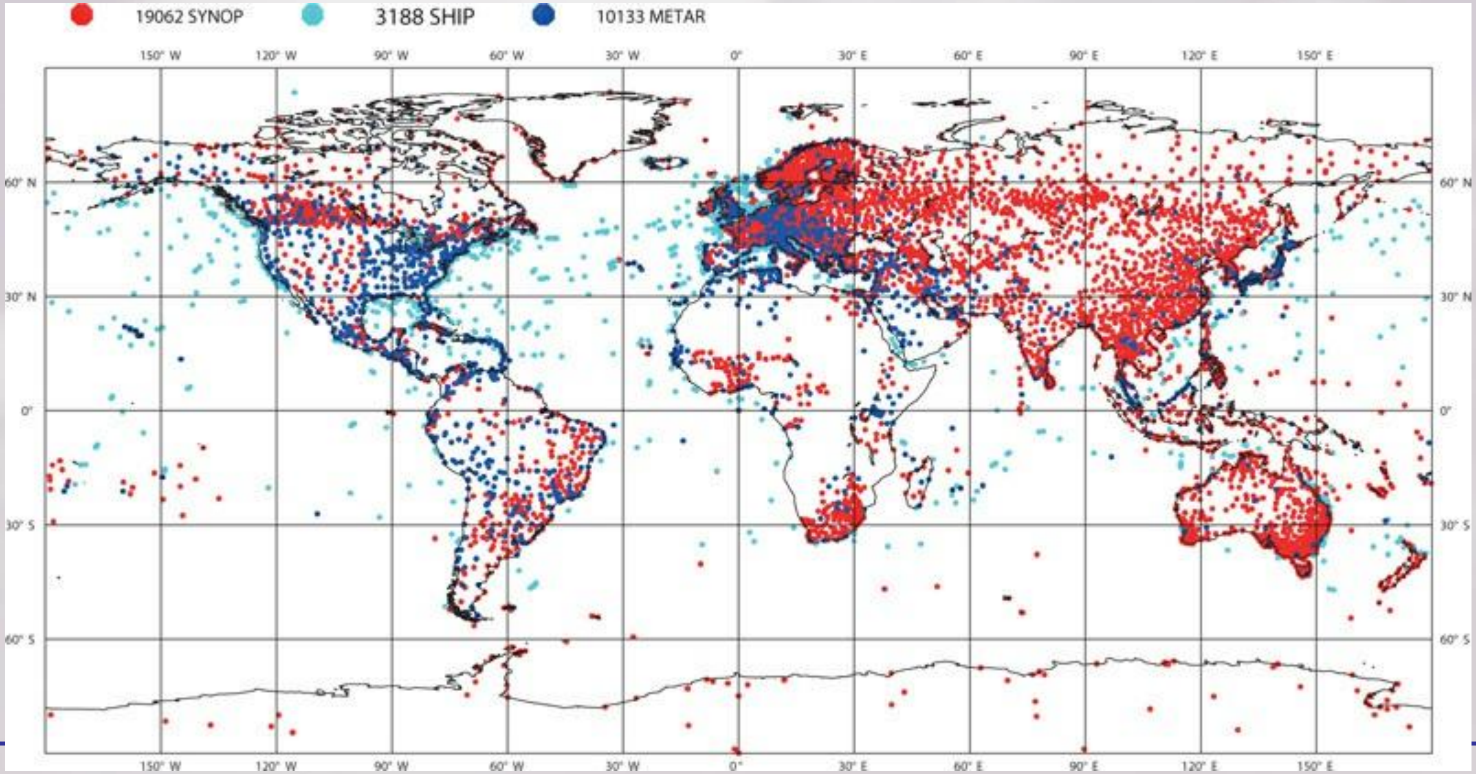
Using data from all of these sources, we have adequate information to initialise our forecast. We begin our tour of the global observation network on the ground at the meteorological observation station.

Surface Observations

A great number of countries in the world now have networks of surface observation stations.

Figure indicates the typical global coverage of surface observations.

But, if the data they report is to be useful, it is important that international standards are set so that data from one country is consistent with data from the next.



The World Meteorological Organization (WMO), a branch of the United Nations, defines these standards.

For a global set of weather observations to be useful to a forecaster, it is much better if they are all made at exactly the same time.

Therefore, irrespective of time zone, the meteorological world sets its clocks to Universal Time Coordinated (UTC), chosen by convention to be synchronised with Greenwich Mean Time.

That way, making observations worldwide at 00:00, 06:00, 12:00 and 18:00 UTC gives global snapshots of the weather every six hours.

Often, however, weather observations are made much more frequently than six-hourly.

In operational stations, readings are normally made every hour throughout the day.

These include readings of temperature, pressure, humidity, wind speed, wind direction and many more.

Such observations are referred to as synoptic obse rvations. Some stations also make climatic obse rvations.

These are measurements that are made once a day (usually at 09:00 local time) and summarise the weather over the course of the preceding 24-hour period.

Climatic observations include maximum and minimum temperatures, total rainfall accumulation and hours of sunshine.

Weather Instruments

A) Thermometer

B) Barometer

C) Psychrometer

D) Wind Vane

E) Rain Gauge

F) Anemometer

G) Radiosondes

H) Maps

I) Supercomputers

Inside the Stevenson Screen

Ideally, they need to be as far away as possible from any obstacles that may affect the background meteorological conditions certainly nowhere near buildings or trees that can block the wind or shelter the site from rain.

A signature feature of many a weather station is the Stevenson screen – a ventilated box to shelter instruments from sunlight while still allowing air to freely pass over them.

The standard height of a Stevenson screen, as determined by the WMO, is 1.5 m above the ground.

A Stevenson screen usually contains four thermometers:

1- a dry-bulb thermometer (mounted vertically to the left)

2- a wet-bulb ermometer (mounted vertically to the right)

3- a maximum thermometer (mounted horizontally, top)

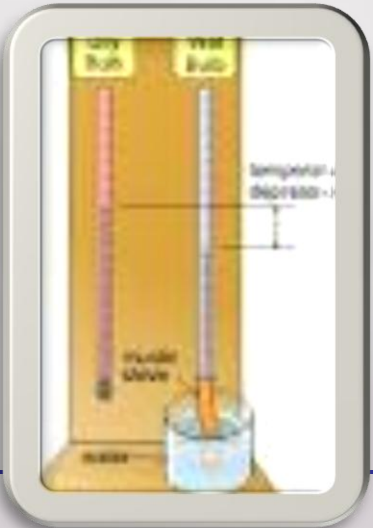
4- a minimum thermometer (mounted horizontally, bottom)

Measures humidity in the air

Modern humidity measurements usually use a psychrome te r. This consists of a pair of thermometers, one of which has its bulb exposed to the air, the other of which has its bulb kept continually moist.

As air passes over the wet bulb, it evaporates water from the bulb, causing it to cool. Comparison of the temperatures measured by the dry-bulb and wet-bulb thermometers can then be converted to humidity using a slide rule or a set of psychrometric tables.

Humidity is expressed in terms of relative humidity the amount of water vapour in the air as a fraction of the maximum water vapour that the air can hold at a given temperature, usually expressed as a percentage.



Wet- and Dry Bulb Psychrometer Psychrometric Chart.

	Dry Bulb Temperature in Degrees Fahrenheit							
Difference Between Dry Bulb and Wet Bulb Temperatures in Degrees Fahrenheit	60	64	68	72	76	80	84	88
1	90	91	91	92	92	92	93	93
2	80	82	83	83	84	85	86	86
3	71	73	74	76	77	78	79	80
4	61	65	66	68	69	71	72	73
5	53	57	59	61	62	65	66	67
6	44	49	51	54	56	58	60	61
7	36	41	44	47	49	52	54	56
8	27	34	37	40	43	47	49	51
9	20	27	31	34	37	41	43	45

If the difference between wet and dry bulb is 6° F and the temperature is 72° F (dry bulb), then the RH is 54%.

Psychrometer for Dewpoint

Dewpoint Temperatures (°C)

Dry-Bulb Temperature (°C)	Difference Between Wet-Bulb and Dry-Bulb Temperatures (C°)															
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
-20	-20	-33														
-18	-18	-28														
-16	-16	-24														
-14	-14	-21	-36													
-12	-12	-18	-28													
-10	-10	-14	-22													
-8	-8	-12	-18	-29												
-6	-6	-10	-14	-22												
-4	-4	-7	-12	-17	-29											
-2	-2	-5	-8	-13	-20											
0	0	-3	-6	-9	-15	-24										
2	2	-1	-3	-6	-11	-17										
4	4	1	-1	-4	-7	-11	-19									
6	6	4	1	-1	-4	-7	-13	-21								
8	8	6	3	1	-2	-5	-9	-14								
10	10	8	6	4	1	-2	-5	-9	-14	-28						
12	12	10	8	6	4	1	-2	-5	-9	-16						
14	14	12	11	9	6	4	1	-2	-5	-10	-17					
16	16	14	13	11	9	7	4	1	-1	-6	-10	-17				
18	18	16	15	13	11	9	7	4	2	-2	-5	-10	-19			
20	20	19	17	15	14	12	10	7	4	2	-2	-5	-10	-19		
22	22	21	19	17	16	14	12	10	8	5	3	-1	-5	-10	-19	
24	24	23	21	20	18	16	14	12	10	8	6	2	-1	-5	-10	-18
26	26	25	23	22	20	18	17	15	13	11	9	6	3	0	-4	-9
28	28	27	25	24	22	21	19	17	16	14	11	9	7	4	1	-3
30	30	29	27	26	24	23	21	19	18	16	14	12	10	8	5	1

Psychrometer for Relative Humidity

Relative Humidity (%)

Dry-Bulb Tempera-ture (°C)	Difference Between Wet-Bulb and Dry-Bulb Temperatures (C°)															
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
−20	100	28														
−18	100	40														
−16	100	48														
−14	100	55	11													
−12	100	61	23													
−10	100	66	33													
−8	100	71	41	13												
−6	100	73	48	20												
−4	100	77	54	32	11											
−2	100	79	58	37	20	1										
0	100	81	63	45	28	11										
2	100	83	67	51	36	20	6									
4	100	85	70	56	42	27	14									
6	100	86	72	59	46	35	22	10								
8	100	87	74	62	51	39	28	17	6							
10	100	88	76	65	54	43	33	24	13	4						
12	100	88	78	67	57	48	38	28	19	10	2					
14	100	89	79	69	60	50	41	33	25	16	8	1				
16	100	90	80	71	62	54	45	37	29	21	14	7	1			
18	100	91	81	72	64	56	48	40	33	26	19	12	6			
20	100	91	82	74	66	58	51	44	36	30	23	17	11	5		
22	100	92	83	75	68	60	53	46	40	33	27	21	15	10	4	
24	100	92	84	76	69	62	55	49	42	36	30	25	20	14	9	4
26	100	92	85	77	70	64	57	51	45	39	34	28	23	18	13	9
28	100	93	86	78	71	65	59	53	47	42	36	31	26	21	17	12
30	100	93	86	79	72	66	61	55	49	44	39	34	29	25	20	16

Anemometer

It is a device for measuring wind speed

The cups catch the winds, turning a dial attached to the instrument.

Wind vane and Cup Anemometer

Instruments for measuring wind: a traditional cup anemometer (left), a wind vane (centre) and a sonic anemometer (right).

The sonic anemometer measures wind speed by emitting pulses of sound waves and timing their journey from transmitter to receiver.

Barometer

An instrument used to measure atmospheric pressure

Atmospheric pressure is the pressure at any point in the Earth's atmosphere.

Air pressure is reported in he ctopascals (hPa) or millibars (mb), where 1 hPa equals 1 mb.

Some home barometers measure pressure in inches or millimetres of mercury (inHg or mmHg) the height of mercury that could be supported by the atmospheric pressure in a mercury barometer.

Barograph

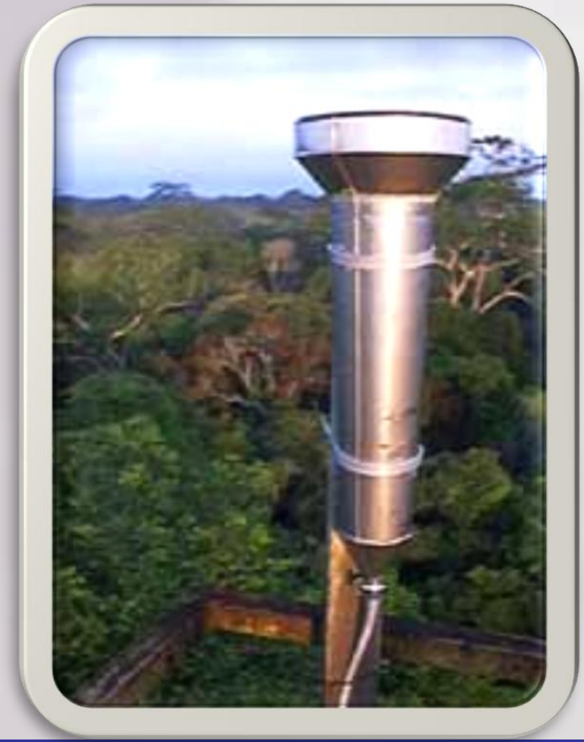
This barograph measures pressure using an aneroid capsule, which is linked mechanically to an arm with a pen on the end.

The drum on the left rotates slowly, allowing the pen to trace out changes in pressure on the chart.

Rain Gauge

Used to gather and measure the amount of liquid precipitation over a set period of time

Most rain gauges generally measure the precipitation in millimeters

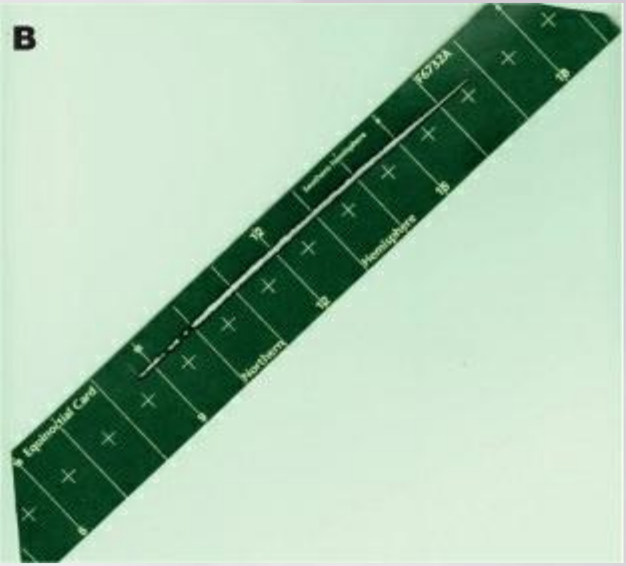


(A) A standard rain gauge assembly.

(B) The top of the gauge is a copper funnel (right), which directs water into a glass container inside (left).

The rainfall collected in the container is measured using the calibrated cylinder (bottom).

Watching the Skies



(A) A Campbell–Stokes sunshine recorder is a glass sphere that focuses the Sun's rays onto a card at the back.

(B) The burn card from a mostly sunny day (03 October 2011)

(A) cirrus, often referred to as mare's tails;

(B) a layer of stratocumulus viewed from above

(C) a layer of altostratus partially obscuring the Sun, with scattered altocumulus below

(D) contrail cirrus, a type of mcloud that forms in the wake of jet aircraft

(E) stratus enveloping the top of a hill

(F) towering cumulus

Automatic Weather Stations

Gauging the Atmosphere

Surface observations are, of course, only part of the observational story

Measuring the Upper Air

Modern radiosondes now fit in the palm of a meteorologist's hand – much more compact than earlier designs.
The large radiosonde at the back dates from the 1970s.

A radiosonde launch. The assembly consists of a radiosonde (the small white box at the bottom), a parachute (the red piece of plastic) and a helium balloon, which usually measures about 2 m across at launch.

The typical mass of a radiosonde is about 200 g,although much lighter ones are available.

Packed into this small space are three instruments: a thermometer, a hygrometer and a barometer.

More advanced radiosondes also contain Global Positioning System (GPS) sensors that allow the location of the radiosonde to be tracked, giving information about wind speed and direction.

Nowadays, they are launched twice a day at 00:00 and 12:00 UTC from a network of upper air stations across the world (some places launch four a day).

To lift its payload, the balloon needs to be large enough weather balloons are typically 2 m in diameter when fully inflated before launch.

A balloon of this size can carry the launched radiosonde up to heights of 25 km to 30 km.