Agronomy 406
World Climates

March 1, 2018

A world tour of climates, including extremes (finish).

Team 1 Climate News next Thursday, March 8

Review:

- Kottek et al. (2006): World map of the Köppen-Geiger climate classification updated.
- World Meteorological Organization Weather and Climate Extremes archive

Reading: WMO summaries on maize and wheat (you can skip the parts on irrigation scheduling).

Koeppen classification of world climates

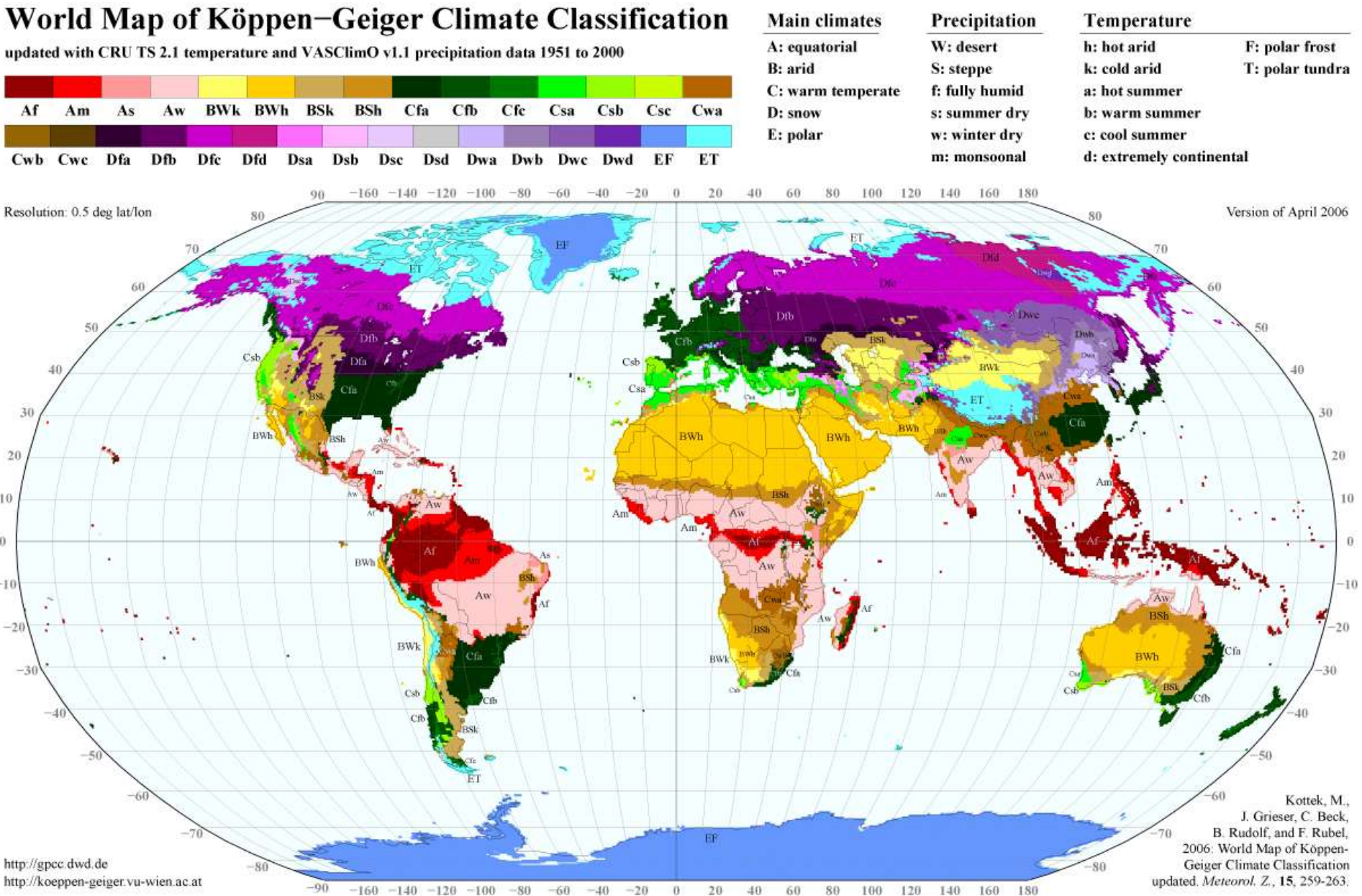
The Koeppen classification method uses **average monthly temperature and precipitation.** These are the variables for which we have the most complete observational record.

The classifications use thresholds of temperature and precipitation associated with different plant types.

Five primary classifications. Each has sub-classifications that can be used to give more detail.

Classification	Description
A	Tropical (warm all year)
B	Dry (desert or steppe)
C	Mild mid-latitude
D	Cool/cold mid latitude
E	Polar

Global Koeppen classifications



Tropical climates (Koeppen classification A)

Warm all year:

Each month has an average temperature at least 18°C (64.4°F).

Not necessarily wet all year! Has three sub-types based on precipitation variability: **Am, Aw, Af**

f = no pronounced dry season (each month has at least 6 cm of rainfall on average)

m = "monsoon-like" (based only on precipitation)

w = pronounced wet and dry seasons

Dry climates (B classification)

Two sub-types based on a **temperature dependent threshold** that is meant to reflect potential evapotranspiration:

BS = precip between 50-100% of threshold (steppe)

BW = precip < 50% of threshold (desert)

Steppe climates (BS) are dry grasslands. Agriculture typically is possible (grazing, some grains, others).

Desert climates (BW) may have some vegetation (cacti, some types of trees and bushes).

Deserts are not always hot!

Mild mid-latitude (C classification)

The coldest winter month has an average temperature above -3°C (26.6°F). Sometimes 0°C is used.

At least one month has an average temperature of 10°C (50°F) or above.

Secondary classification depends on whether there is a dry season:

f = no pronounced dry season

s = summer dry

w = winter dry

Mid-latitude cool or severe climates (D classification)

The coldest winter month has an average temperature -3°C or below (sometimes 0°C is used).

At least one month has an average temperature of 10°C (50°F) or above.

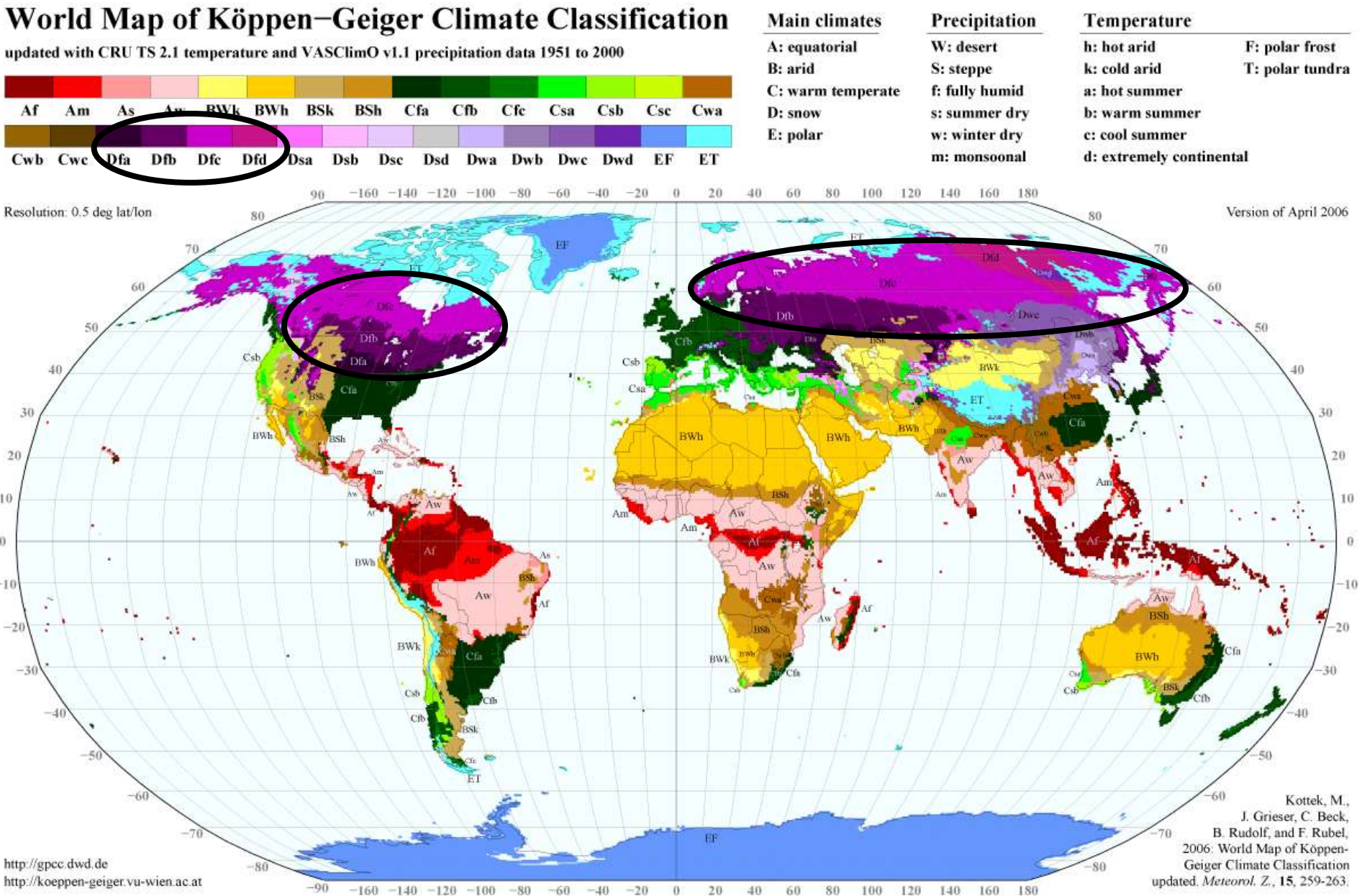
Secondary classifications same as for C types:

f = no pronounced dry season

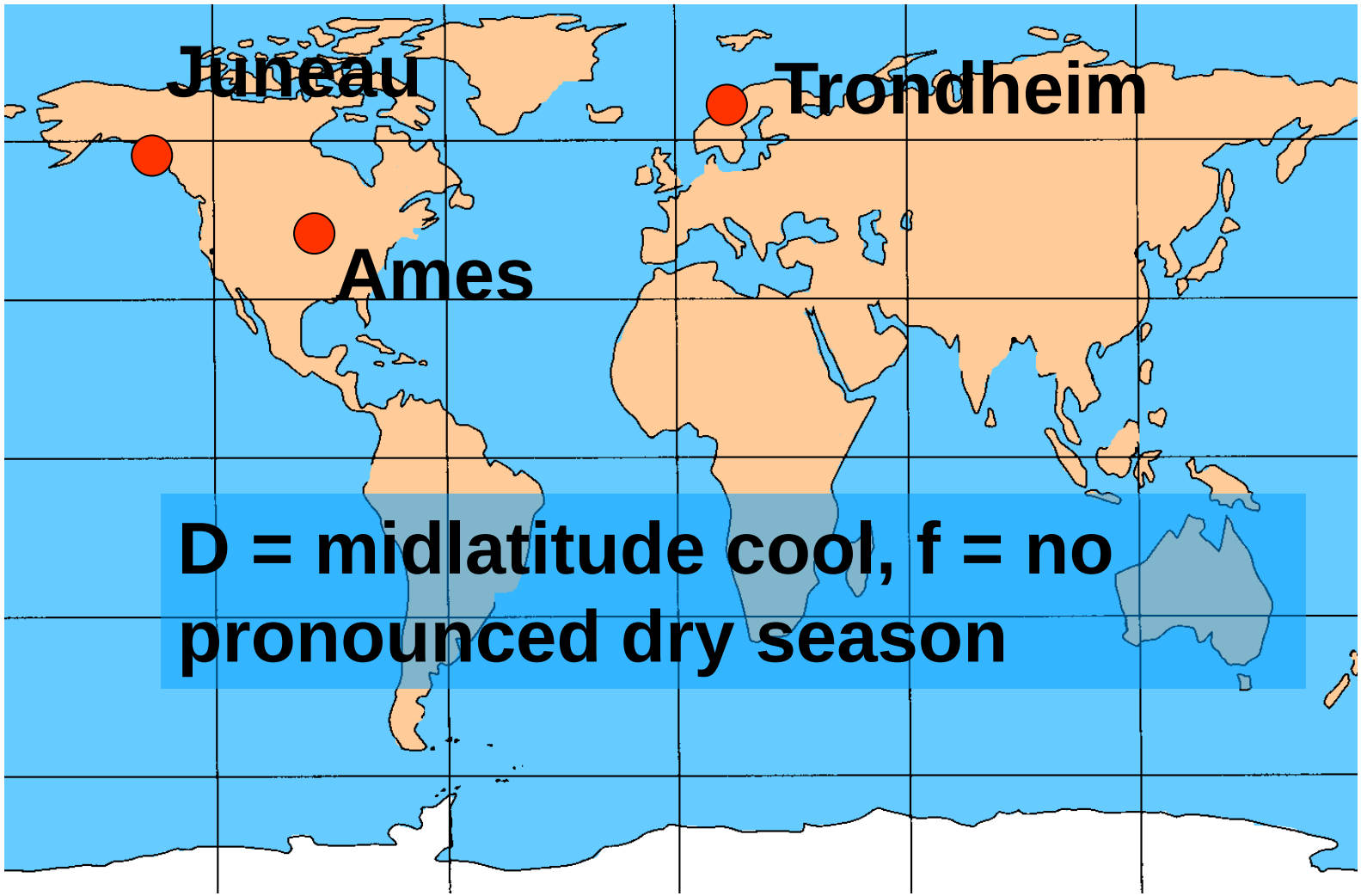
s = summer dry

w = winter dry

Df climates (mid-latitude cool)



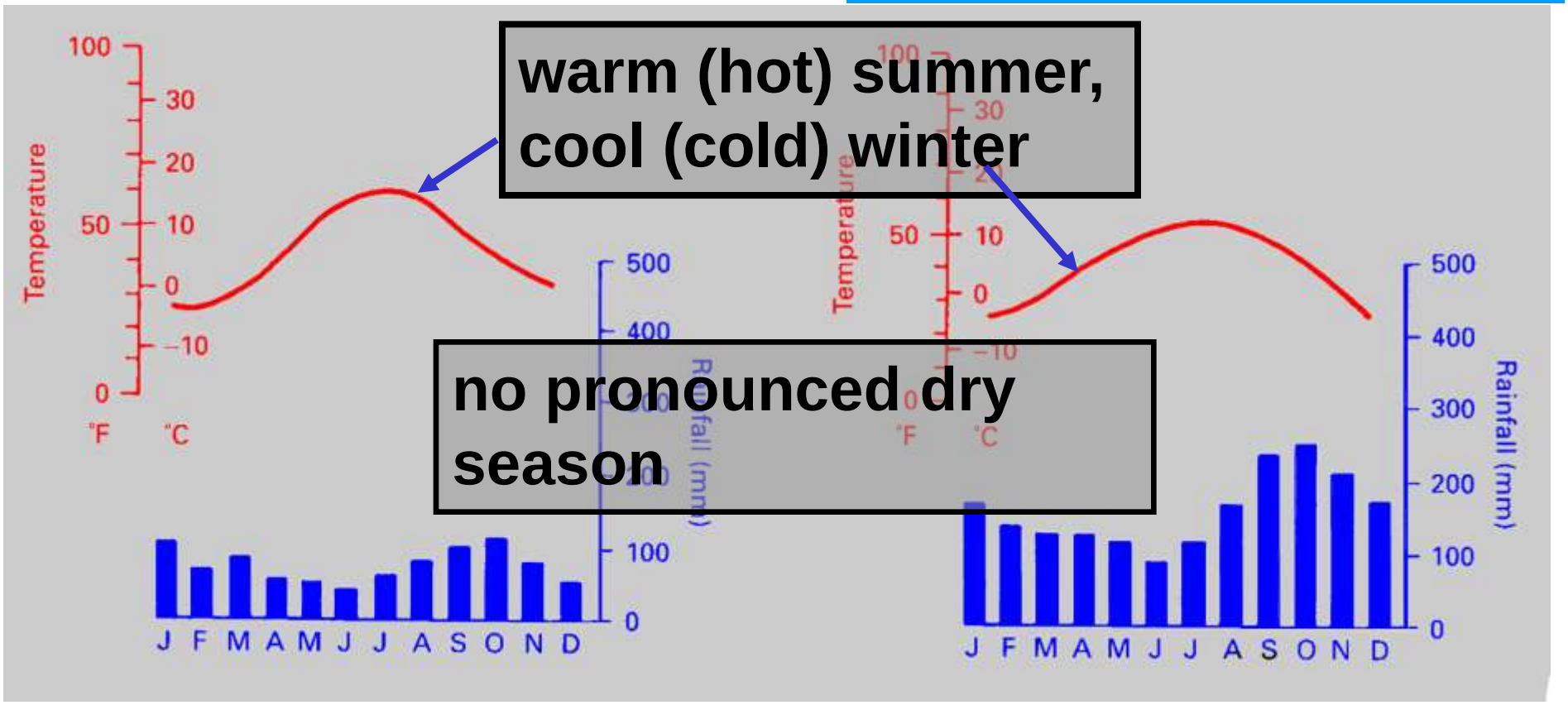
Df climates


Juneau
Trondheim
Ames
D = midlatitude cool, f = no pronounced dry season

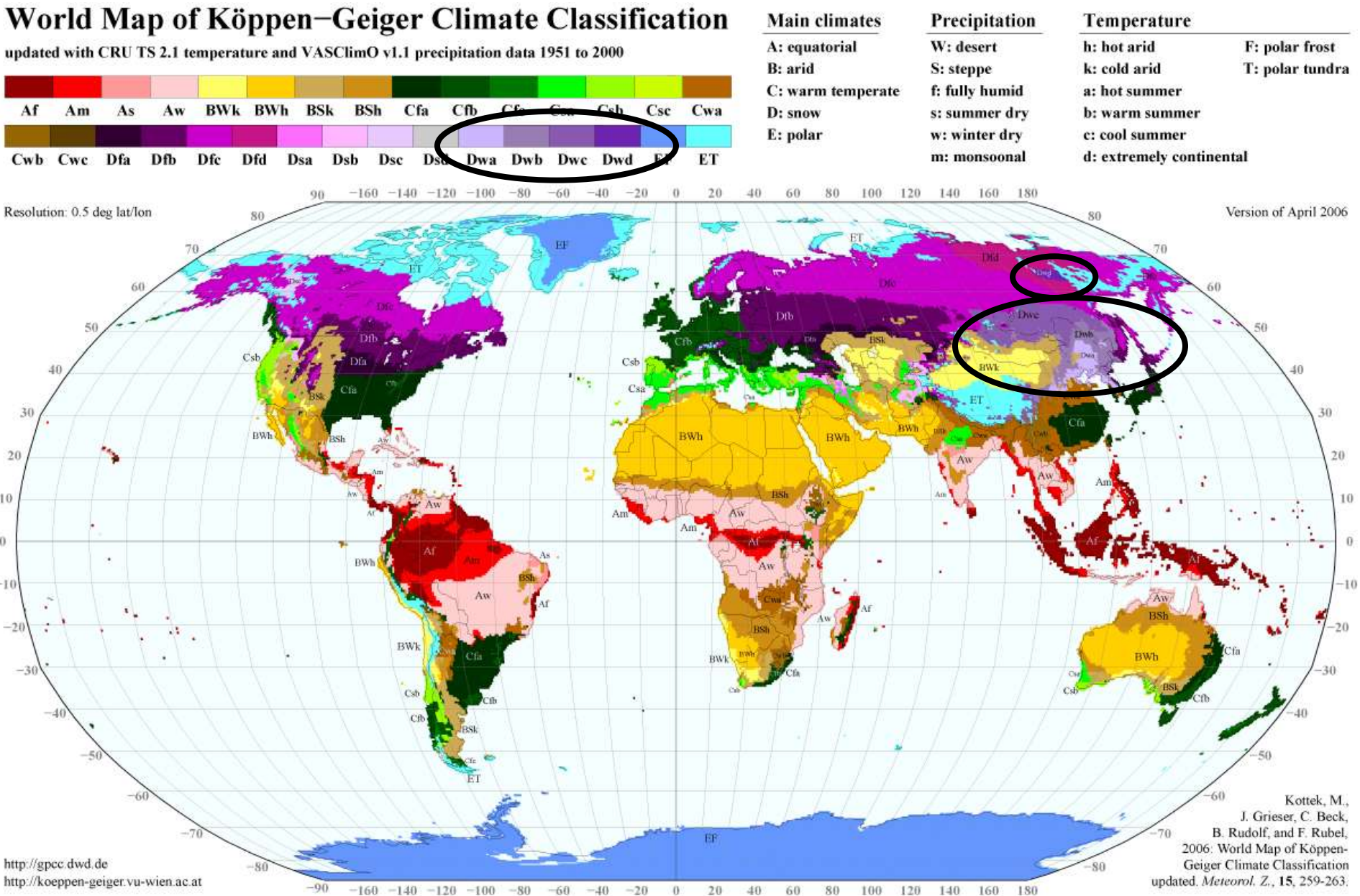
Temperature and precipitation in Df climates

Juneau (Alaska)

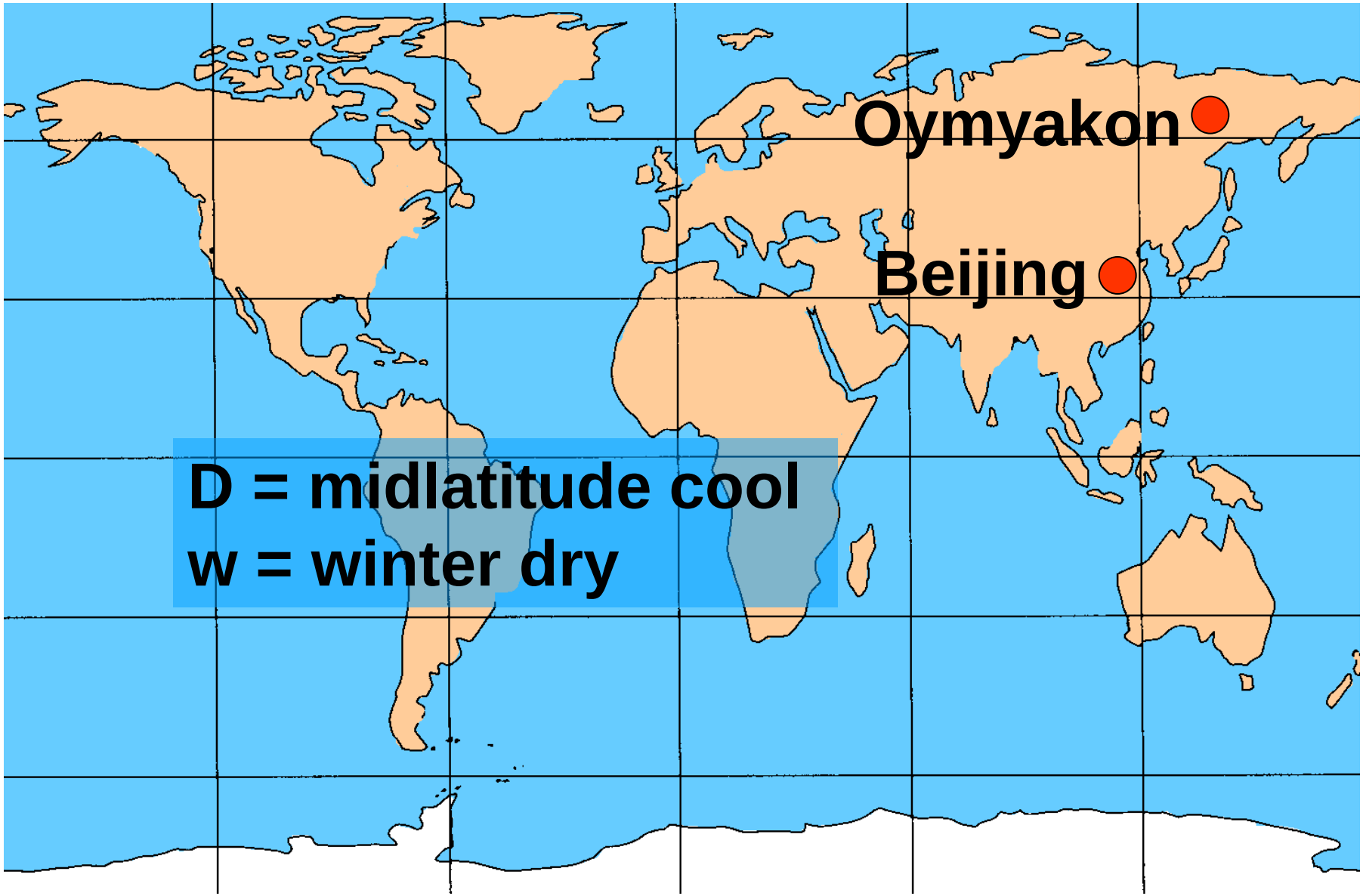
Trondheim (Norway)



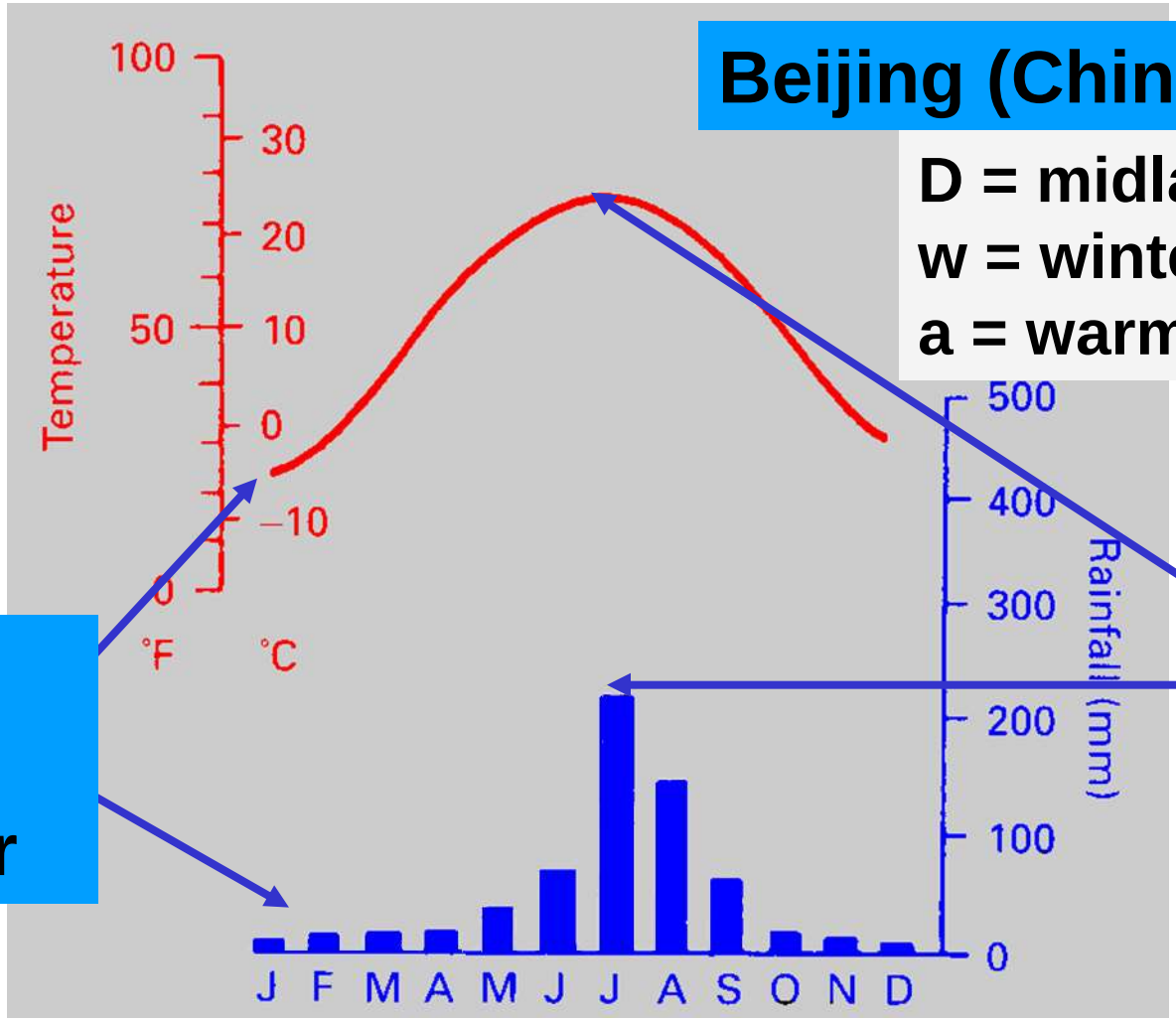
Dw climates (cool/cold, with dry winter)



Dw climates

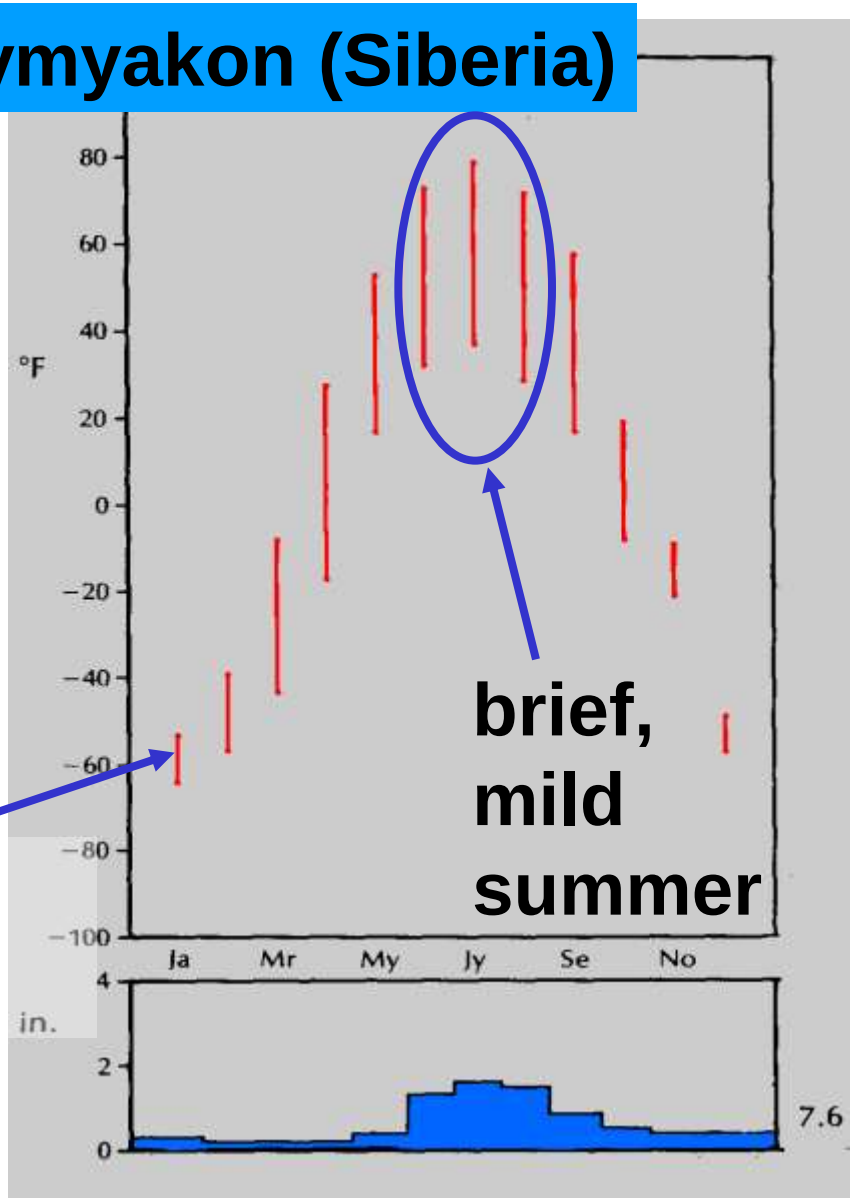


Temperature and precipitation in Dwa climate



Classification Dwd:
The most severe climate with continuous human habitation.

Oymyakon (Siberia)



D = midlatitude cool

w = winter dry

d = very cold winter (coldest month averages -38°C (-36.4°F) or colder)

brief, mild summer

average January temperature is -53°F

7.6 inches of precipitation per year

Exercise: Build a climate classification scheme

- Decide on a **purpose** for your scheme: could be a human activity, or natural features such as ecosystem types.
- Choose the **variables** that are most important. For now, limit yourself to temperature and/or precipitation since they have by far the best record of observations.
- Establish **thresholds** of your variables: could be annual averages, could also vary by month (as in Koeppen) or season. May need to look up info.
- Find **places** where your thresholds are satisfied based on what we have learned about climate so far.

Climate extremes

Extremes can be hard to define:

- Extremes of averages, or all-time records?
- Extremes usually occur in sparsely populated areas. **(Why?)** Such locations may not have continuous, long-term measurements.

Extremes are especially prone to measurement errors:

- Extremes may be outside the usual range of an instrument.
- Extreme readings may result from improper installation (e.g., poor ventilation of a thermometer) or errors made by an untrained observer.
- Some records have been questioned almost since they were announced.

World's wettest climates

Cherrapunji, India is often cited as the wettest place:

Average annual precipitation is 11,430 mm.

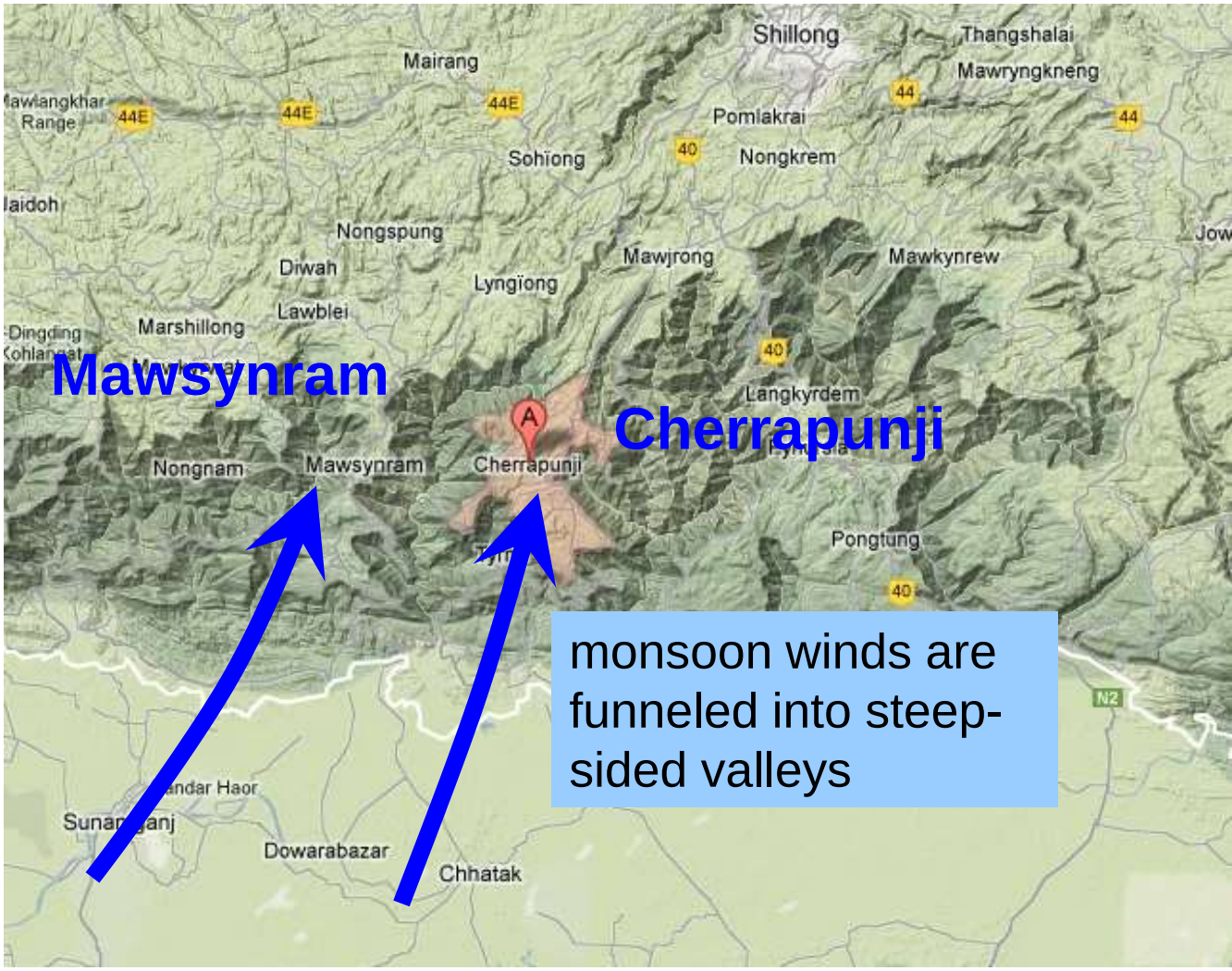
Has the record wettest year (1860-61, 26,470 mm) but may not be the wettest place on average.

About how many inches of rainfall is 26,470 mm?
Do not use a calculator.

The nearby village of Mawsynram (in the next valley to the west, about 15 km / 9 miles away) also claims to be the world's wettest place.

Highest **average** annual precipitation, 11,872 mm.

Geographical setting of Mawsynram and Cherrapunji



monsoon winds are funneled into steep-sided valleys

Google Maps

World's wettest climates

Mt. Waialeale, on the Hawaiian island of Kauai has average annual precipitation of 11,640 mm.

- What is the percentage difference from Mawsynram (11,872 mm)? Do you think this difference is large enough to be meaningful?

World's wettest climates

Difference between Mt. Waialeale and Mawsynram:

$$\frac{11{,}872 \text{ mm} - 11{,}640 \text{ mm}}{11{,}640 \text{ mm}} = 0.02 = 2\%$$

This may be smaller than measurement error. Raingage "undercatch" due to winds is often 5% or more.

World's driest climates

The driest continent is Antarctica.

- Precipitation is difficult to measure but probably around 150 mm/year averaged over the continent.

The driest region is the Atacama Desert of northern Chile:

- Core of the Atacama is sometimes called a "hyperarid" zone.
- Several stations in the Atacama report average precipitation < 1 mm/year.
- Arica (Chile) holds the record for longest stretch with no rain: 173 months (almost 15 years), November 1903 to January 1918.

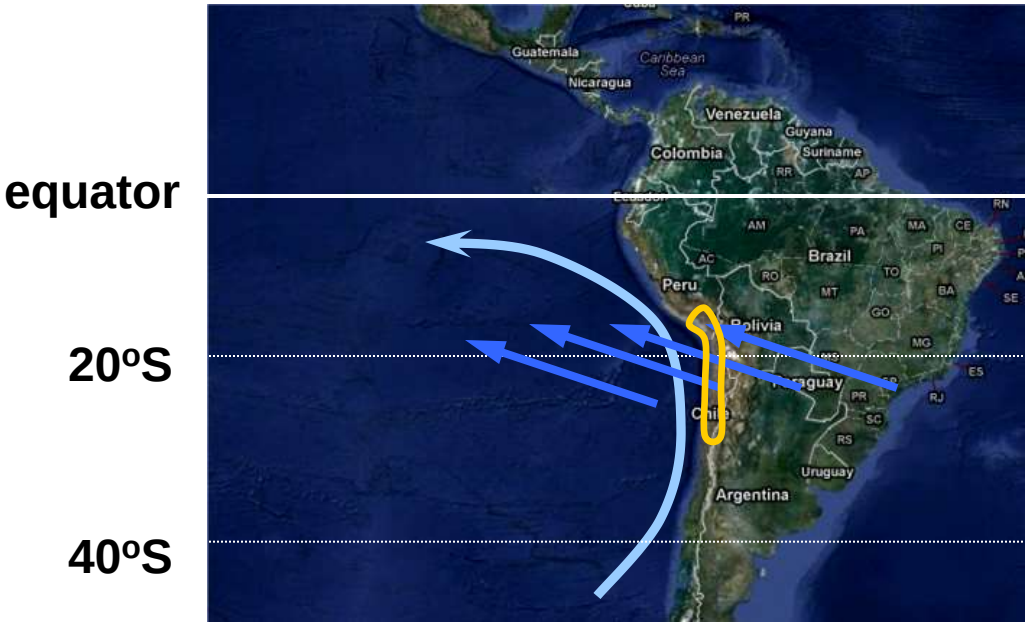
Why is the Atacama so dry?

Given your knowledge of large-scale circulation, ocean currents, and other factors affecting climate, why do you think the Atacama Desert is so dry?

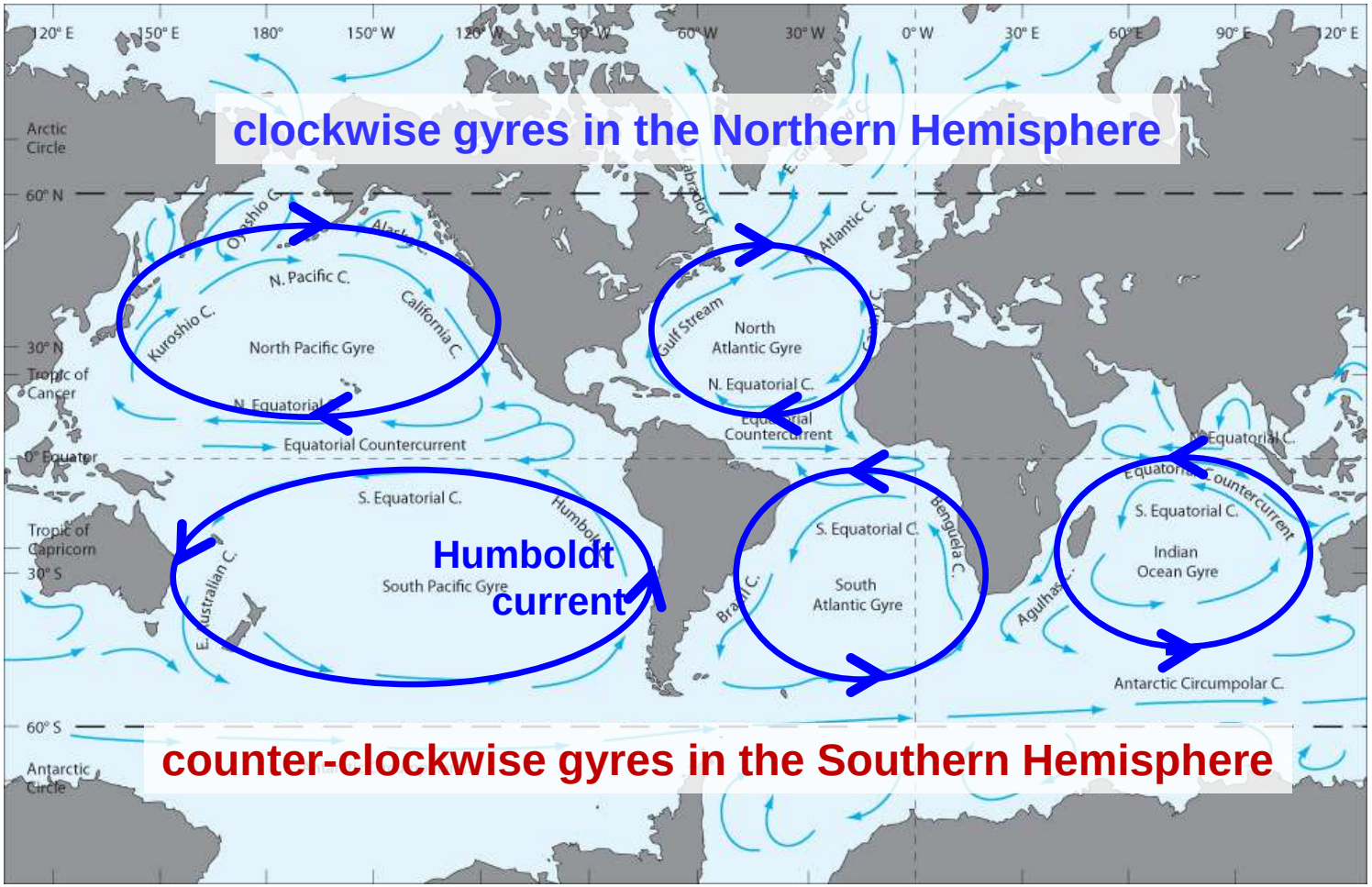
Why is the Atacama so dry?

Several causes for dry climate:

- Rain shadow: west of the Andes Mountains, and tropical winds are southeasterly in the Southern Hemisphere.
- The cold Humboldt Current (Peru Current) is offshore.
- Other reasons are related to atmospheric dynamics.



Ocean gyres


clockwise gyres in the Northern Hemisphere
counter-clockwise gyres in the Southern Hemisphere
Humboldt current
120° E
150° E
180°
150° W
120° W
90° W
60° W
30° W
0° W
30° E
60° E
90° E
120° E
Arctic Circle
60° N
30° N
Tropic of Cancer
0° Equator
Tropic of Capricorn
30° S
60° S
Antarctic Circle
Oyashio C.
Kuroshio C.
N. Pacific C.
California C.
North Pacific Gyre
Equatorial Countercurrent
S. Equatorial C.
Humboldt
South Pacific Gyre
Australian C.
Gulf Stream
North Atlantic Gyre
N. Equatorial C.
Equatorial Countercurrent
Atlantic C.
Brazil C.
S. Equatorial C.
South Atlantic Gyre
Benguela C.
Agulhas
N. Equatorial C.
Equatorial Countercurrent
S. Equatorial C.
Indian Ocean Gyre
Antarctic Circumpolar C.

Hottest places

Some contenders for hottest place on average:

- From 1960-66 Dallol, Ethiopia average temperature was 34.4^{o}C (94^{o}F) making it the hottest inhabited place. Records are poor. (No longer inhabited.)
- Mecca (Saudi Arabia) is probably the hottest continually inhabited place. Annual temperature 30.7^{o}C (87.3^{o}F).

Record highest temperature:

- 56.7^{o}C (134^{o}F) at Furnace Creek, Death Valley, California on 10 July 1913.
- Formerly held to be 57.8^{o}C (136^{o}F) at El Azizia, Libya, 13 September 1922. Validity had long been questioned and this record was disqualified a few years ago (El Fadli et al. 2013, Bulletin of the Amer. Meteor. Soc.)


Spain
Portugal
Greece
Turkey
Turkme
Mediterranean Sea
Tunisia
Syria
Iraq
Iran
Morocco
El Aziziya
Algeria
Libya
Egypt
Western Sahara
Saudi Arabia
Mecca
Oman
Mauritania
Mali
Niger
Sudan
Yemen
Chad
Dallol
Burkina Faso
Gulf of Aden
Guinea
Nigeria
Ethiopia
Ghana
South Sudan
Gulf of Guinea
Somalia
Kenya
Gabon
DR Congo

Coldest places

Record lowest temperature: -89.2°C (-128.5°F) at Vostok, Antarctica on 21 July 1983.

Coldest inhabited place is usually considered the town of Oymyakon in eastern Siberia (Dwd climate).

Average January temperature in Oymyakon is -47°C (-53°F), coldest recorded -71.2°C (-96.2°F)

photos from wired.com and askyakutia.com

Winds and pressure

Strongest wind gust:

- 253 mph at Barrow Island, Australia during Tropical Cyclone Olivia, 10 April 1996.

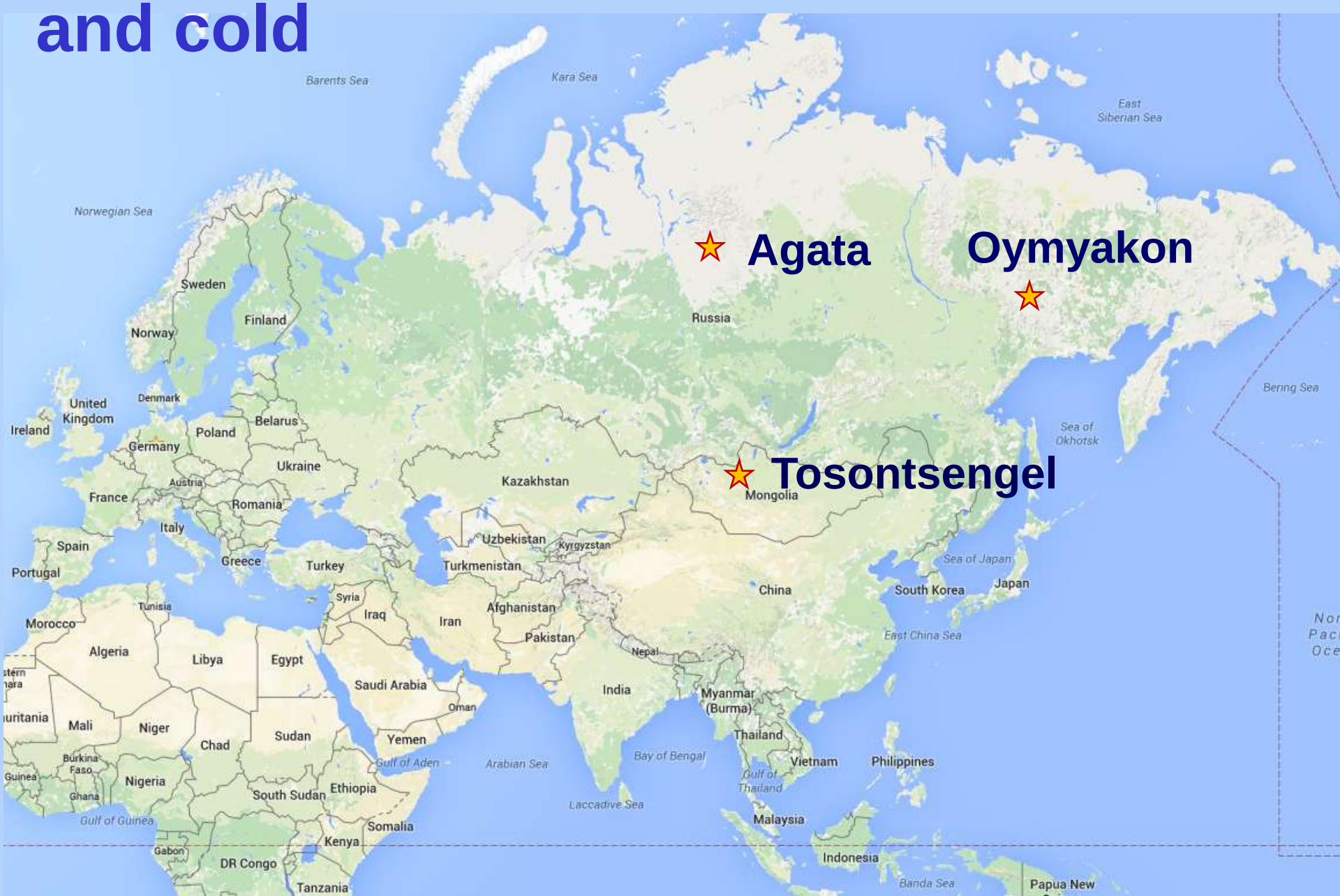
Lowest sea level pressure:

- 870 mb recorded by a dropsonde in the eye of Typhoon Tip, 10 December 1979.

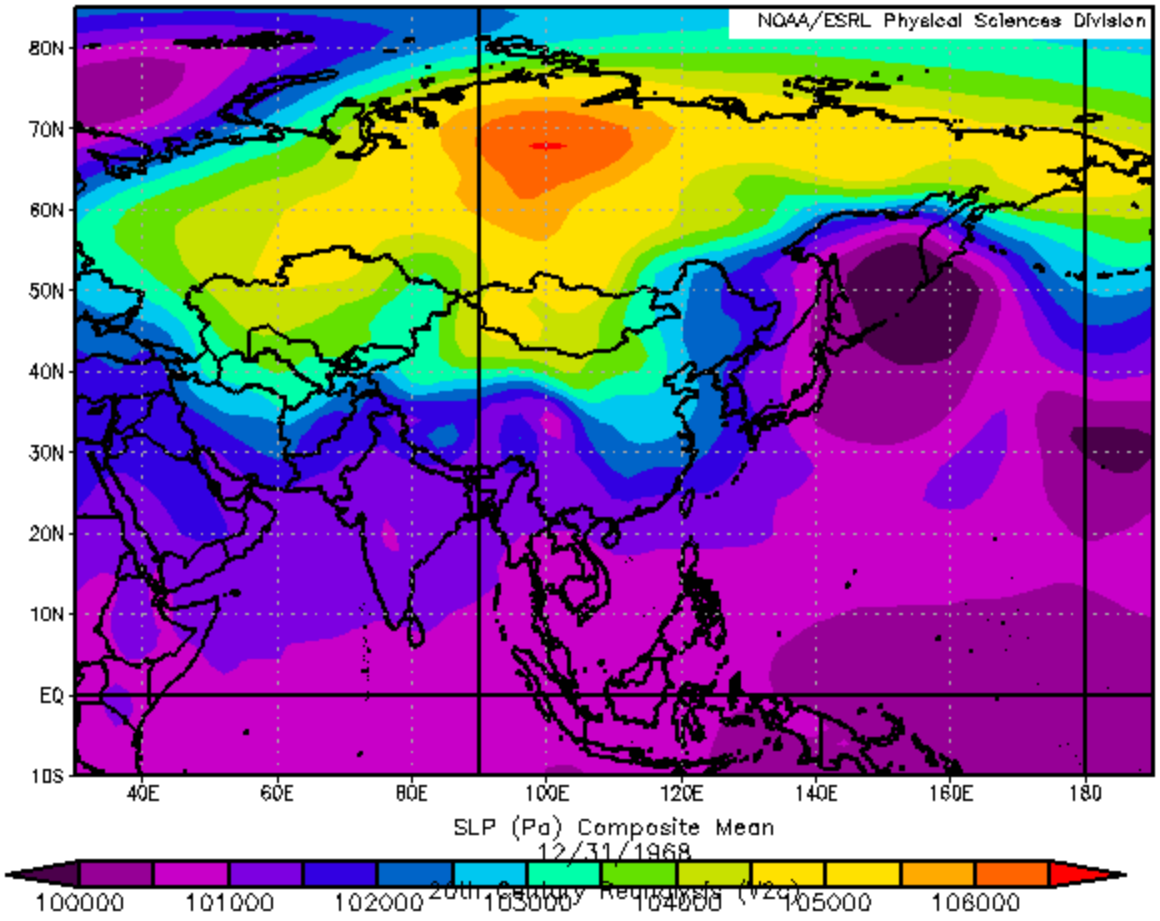
Highest sea level pressure:

- Records distinguish sites above and below 750 m due to uncertainty in converting to mean sea level. (See Purevjav et al. 2015, Int. J. Climatol. for details.)
- Below 750 m: 1083.3 mb at Agata, Russia, on 31 December 1968 (New Year's Eve).
- Above 750 m: 1089.4 mb at Tosontsengel, Mongolia on 30 December 2004.

Locations of record high pressure and cold



Surface pressure analysis for 31 December 1968



Weather analyses for any day back to 1871 can be plotted at:
http://www.esrl.noaa.gov/psd/cgi-bin/data/composites/plot20thc.day.v2.pl