# Use of Radio Spectrum for Meteorology: Weather, Water and Climate Monitoring and Prediction:

## ***Transition of U.S. Radiosonde Operations Due to Commercialization of Spectrum***

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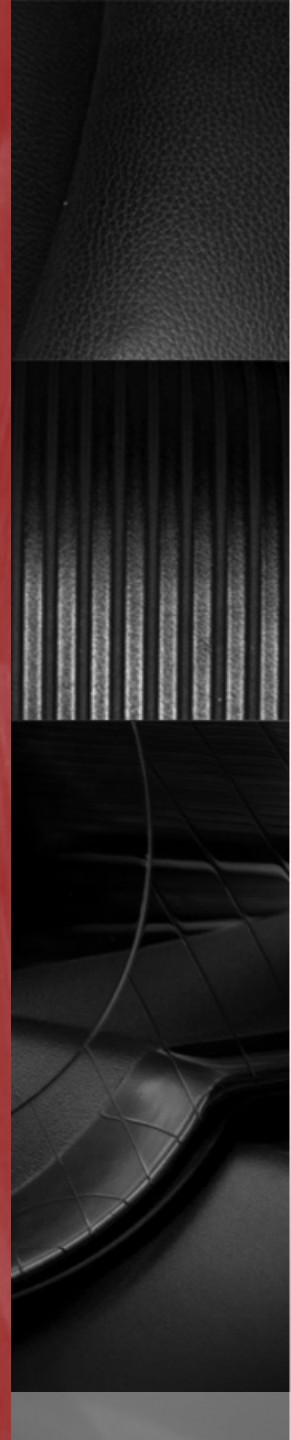
National Oceanic and Atmospheric Administration



# Background

- The Transition of U.S. Radiosonde Operations was initiated in response to the U.S. spectrum of the 1695 – 1710 MHz band for shared use with Advanced Wireless System-3
- This initiative required a redesign of the Geostationary Operational Environmental Satellite – R-Series (GOES-R) into a lower operational frequency band
  - This redesign shifted the GOES-R operational frequencies lower in the band, such that the lower edge of the signal overlapped with frequencies used by radiosondes (1679–1683 MHz)
- To avoid interference with GOES-R signals, radiosondes operations required relocation to operate in the another band, 400.15 – 406 MHz
  - The GOES-R Satellite was launched in November of 2016, is completing calibration and validation testing, and is expected to become operational in January of 2018
  - Relocation of radiosonde operations at eight sites located near GOES earth station receivers has already been completed before the launch to ensure no operational conflicts

# A Brief History *

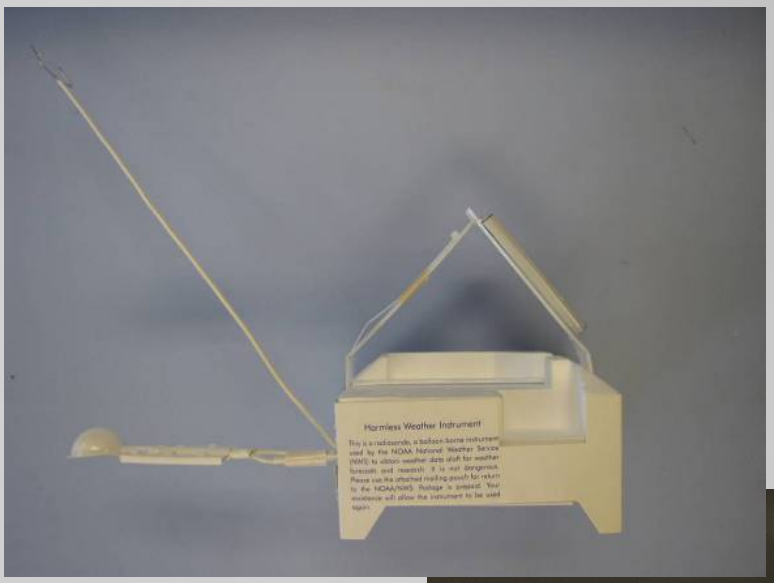
- In 1892 two French scientists used a balloon to fly a meteograph, leading to the discovery of the Tropopause six years later by Léon Teisserenc de Bort
- In 1924 the US Signal Corps first experimented with using the temperature dependence of electrical circuits as a temperature measurement instrument
- The first modern radiosonde, sending precise encoded telemetry from weather sensors, was also invented in France by Robert Bureau
  - Bureau coined the name "radiosonde" and flew the first instrument in 1929
  - "Sonde" translates to "Probe" in English
- The NOAA National Weather Service (NWS) has been making atmospheric observations using radiosondes since the late 1930's

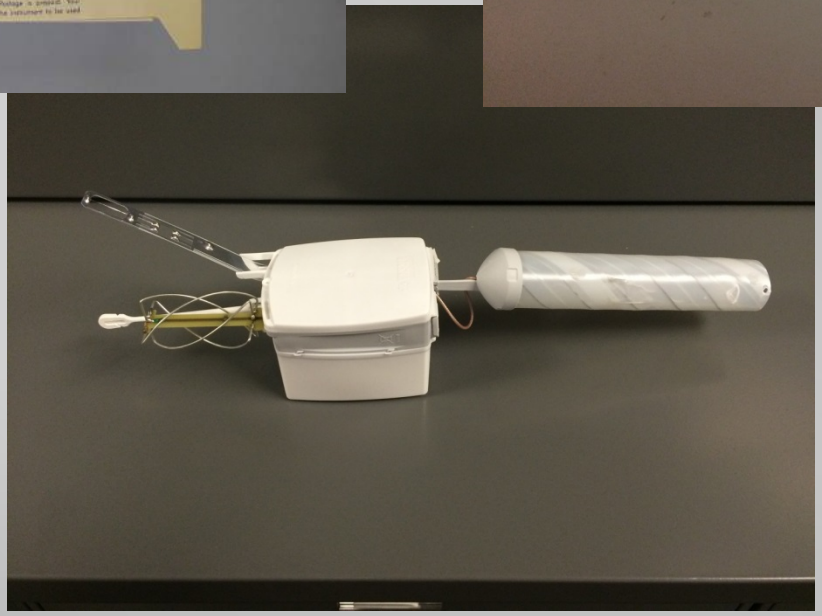
* Source: Wikipedia

# The Radiosonde

- A radiosonde is a meteorological instrument used to make in-situ observations of the atmosphere, from the surface to 30,000 meters altitude
- Radiosondes are launched daily around the world, at synoptic hours of 00:00 and 12:00 UTC
- Data is used in weather forecasting and climate research, including numerical weather prediction models
- The U.S. Radiosonde Network consist of 92 radiosonde observing stations located throughout the Continental U.S, Alaska, Hawaii, Puerto Rico, and Pacific Islands
  - The U.S. also supports and supplies 10 Cooperative Hurricane Upper Air Stations (CHUAS) in the Caribbean
    - These stations were not affected by the commercialization of spectrum
- U.S. Radiosondes currently operate in two radio-frequency bands
  - 1675 – 1683 MHz, and
  - 400.15 – 406 MHz

# The Radiosonde



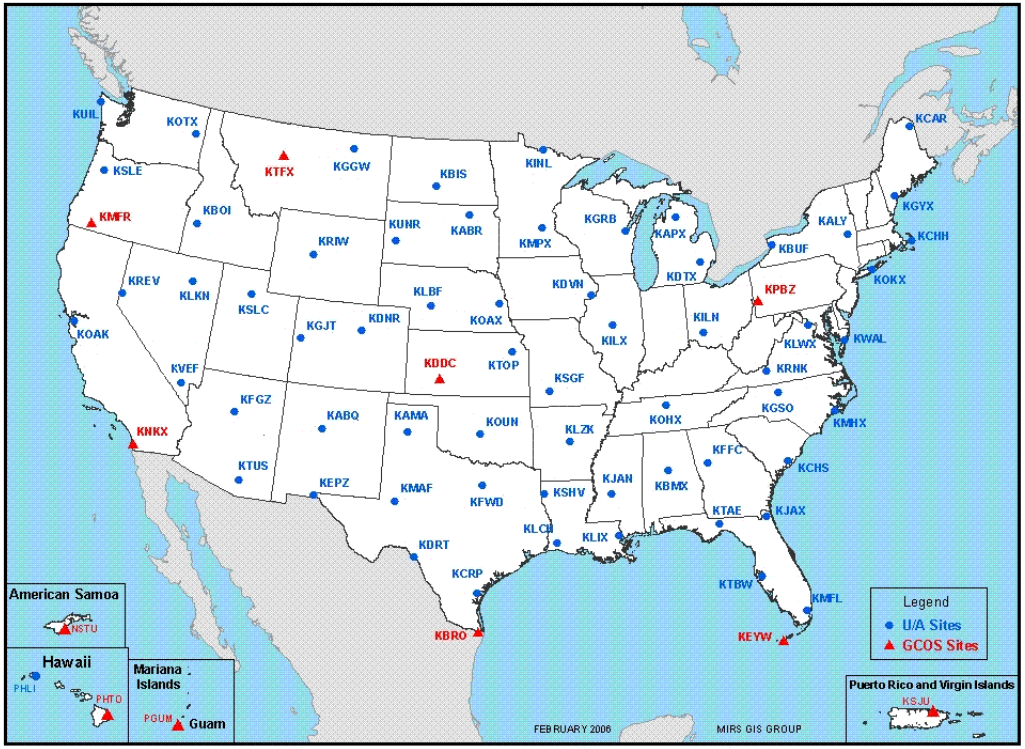
# U.S. Radiosonde Network

- The U.S. Radiosonde Network is primarily operated by the National Oceanic & Atmospheric Administration's (NOAA) National Weather Service (NWS) of the U.S. Department of Commerce
- Consists of 92 upper air stations:
  - 67 Stations in Continental U.S. *
  - 13 Stations in Alaska **
  - 9 Stations in the Pacific Islands
  - 2 Stations in Hawaii
  - 1 Station in the Caribbean (San Juan, Puerto Rico)
- U.S. Radiosonde operations are part of the World Weather Watch Programme

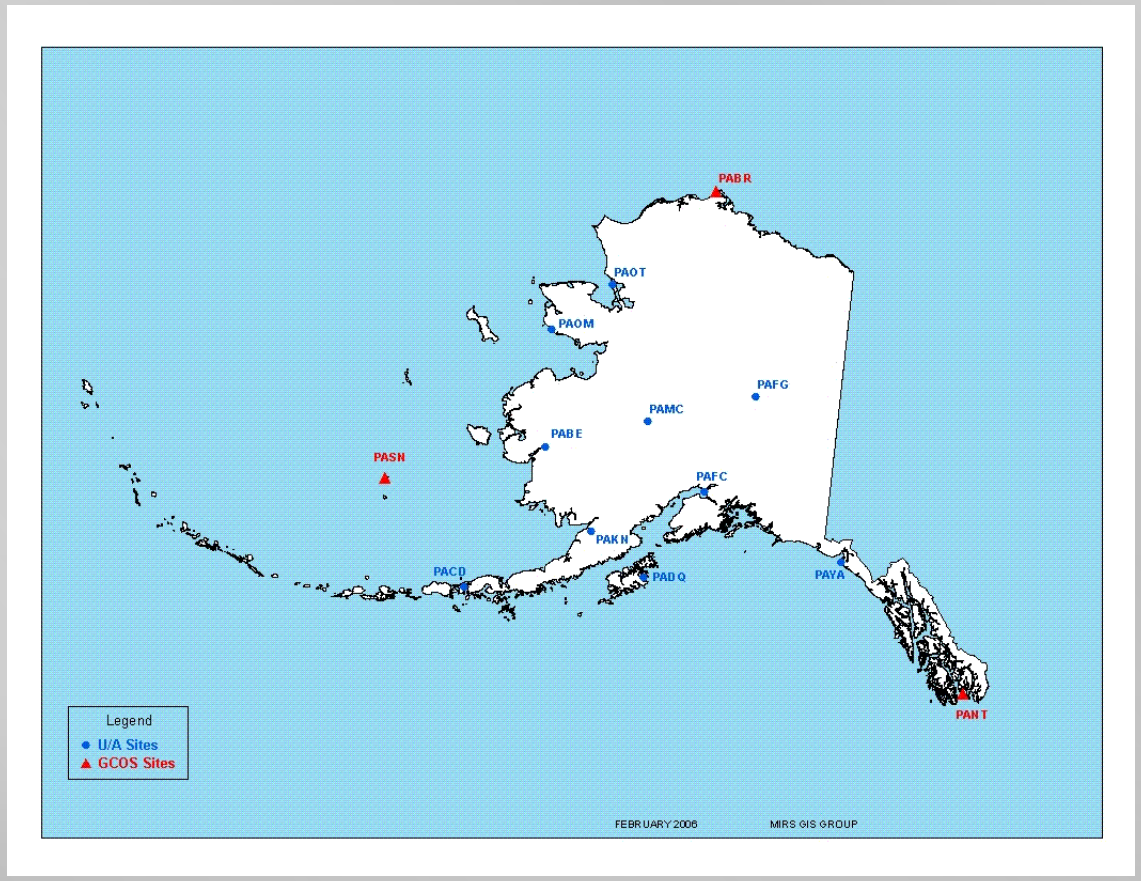
* Wallops Island, Virginia site operated by NASA

** Barrow, Alaska is operated by the Department of Energy

# Lower 48 States & Puerto Rico



# Alaska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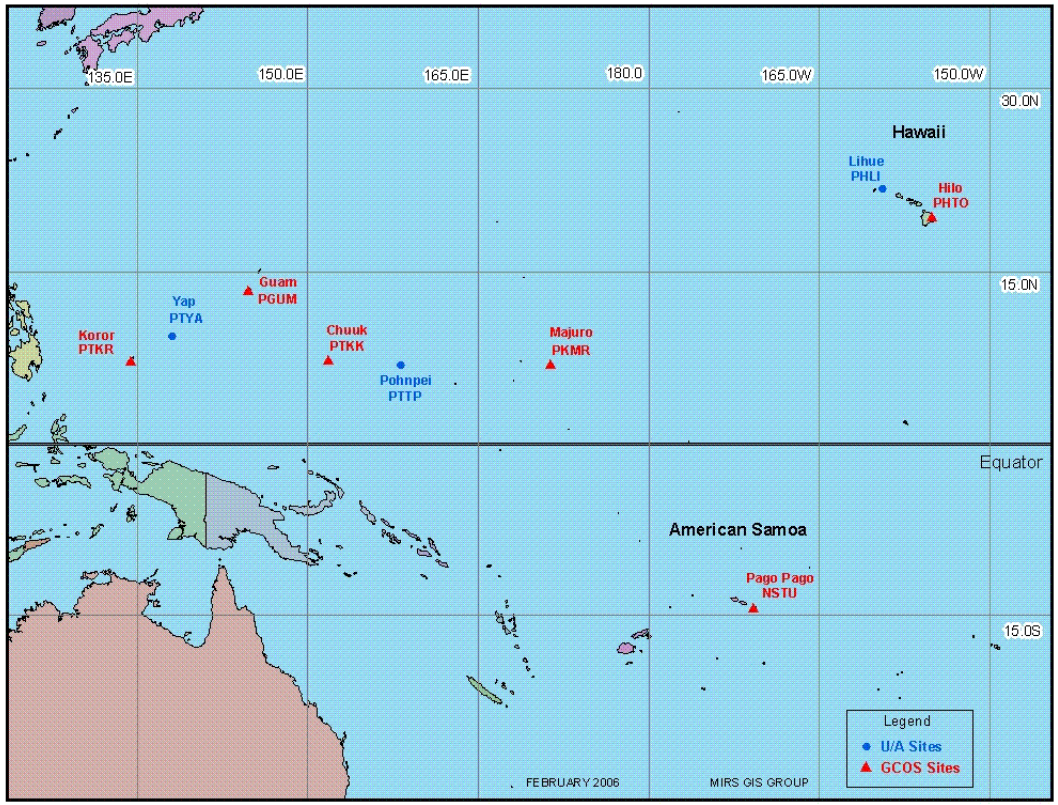
# Pacific Islands



# Radiosonde Function

- NWS radiosonde sensors measure profiles of pressure, temperature, relative humidity, and wind speed and direction with a relatively high degree of accuracy and precision
- The radiosonde uses a radio transmitter to transmit sensor measurements to a ground-based receiving and data processing system
- Wind speed and direction aloft are also obtained by tracking the position of the radiosonde using Global Positioning System (GPS)
- Received signals are converted to meteorological values to derive significant levels using computer processing, put into a special code form, and then disseminated to data users via the Advance Weather Interactive Processing System (AWIPS)
- High vertical resolution flight data, among other data, are also archived and sent to the NOAA's National Center for Environmental Information (NCEI)
- Today's radiosondes are small, expendable instrument packages typically weighing between 100 and 307 grams

# Radiosonde Observations

- The radiosonde rises at about 300 meters per minute to obtain a thermodynamic 'profile' of the atmosphere
- A typical observation "weather balloon sounding" is collected in approximately two hours
- The radiosonde can ascend to over 35 km and drift more than 300 km from the point of release
- The radiosonde is suspended 25 to 35 meters below the balloon to minimize contamination of the temperature measurements due to solar, radiant heat being shed from the balloon skin
- During the flight, the radiosonde is exposed to temperatures from –90ºC to +50ºC and an air pressure less than 1 percent of what is found on the Earth's surface (10 hecto-Pascals)
- If the radiosonde enters a strong jet stream it can travel at speeds in excess of 400 km/hr.
- The NWS uses approximately 74,460 radiosondes per year
- Less than 20% of radiosondes are returned to the NWS for reconditioning
  - These rebuilt radiosondes are used again at a significant cost reduction

# Radiosonde Data Use

**Understanding and accurately predicting changes in the atmosphere requires adequate observations of the upper atmosphere**

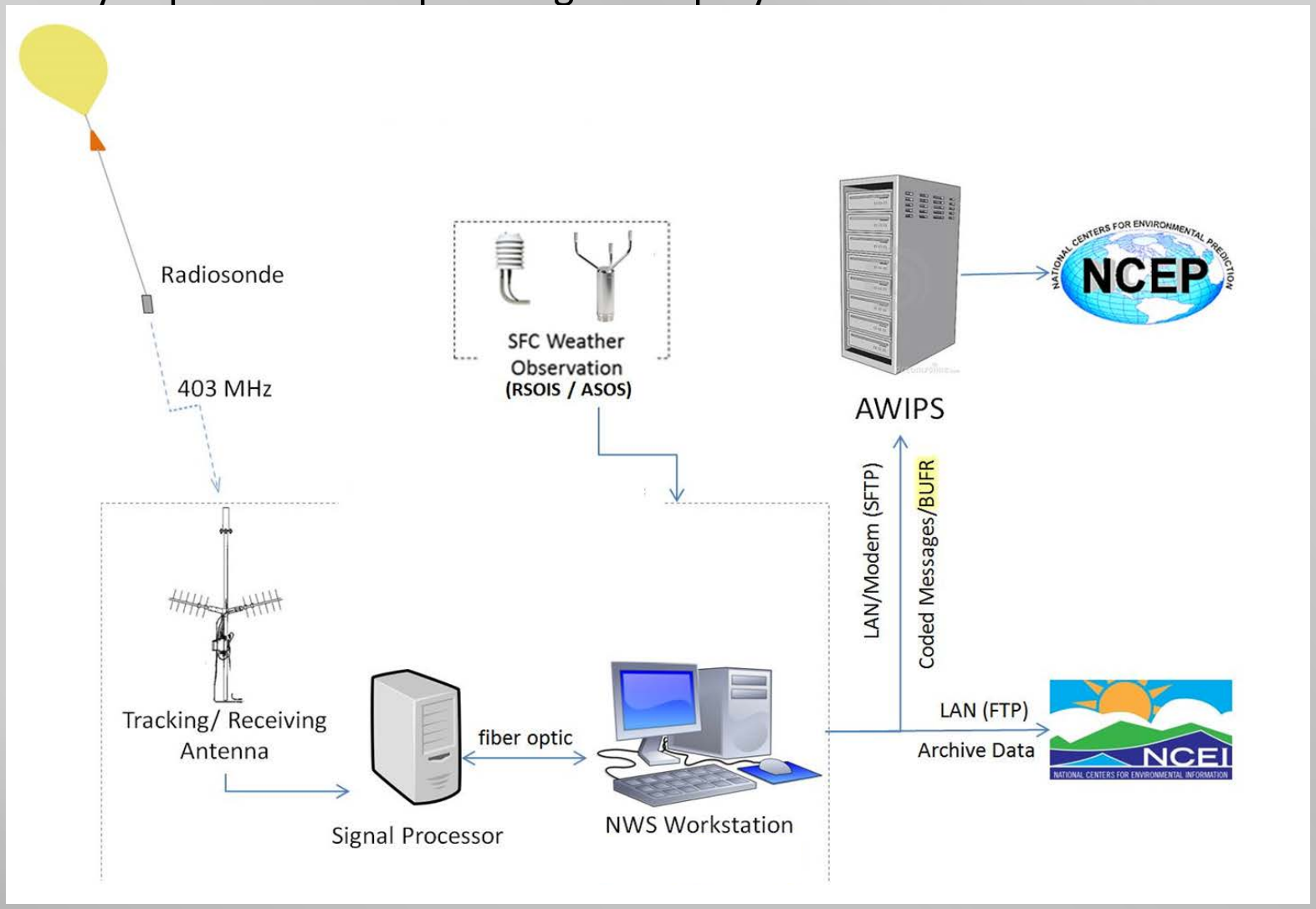
- Radiosondes provide a significant source of upper-air observations data and will remain so into the foreseeable future
- Data applications include:
  - Input for computer-based weather prediction models
  - Local severe storm, aviation, fire weather, and marine forecasts
  - Weather and climate change research
  - Input for air pollution model
  - Ground truth for satellite data

# Typical Radiosonde Launch

NWS Sterling Field Support Center,  Sterling, VA

# 403 MHz Standard System

Currently in procurement planning for deployment to most locations



# Transition Progress

- Procured one system in 2015 for operational evaluation at Field Support Center
- Installed eight Transition Radiosonde Observing Systems at sites most likely to cause interference to meteorological satellite operations
- A second system was installed in Kodiak, Alaska station in 2016 and placed into operation in 2017
- Contracts have been awarded to begin site preparations and install four additional systems in Alaska in 2018
- Preparing requirements for standard systems to be deployed to upper-air stations that are not remote from NWS Forecast Offices
- One-year pre-award testing program is planned for systems, before awarding contracts to supply new ground systems and radiosonde instruments
- Expect Transition to be complete in 2022

# QUESTIONS?