Weather “Intelligence”

Observations and Forecasts

2016 PNS Snow Conference

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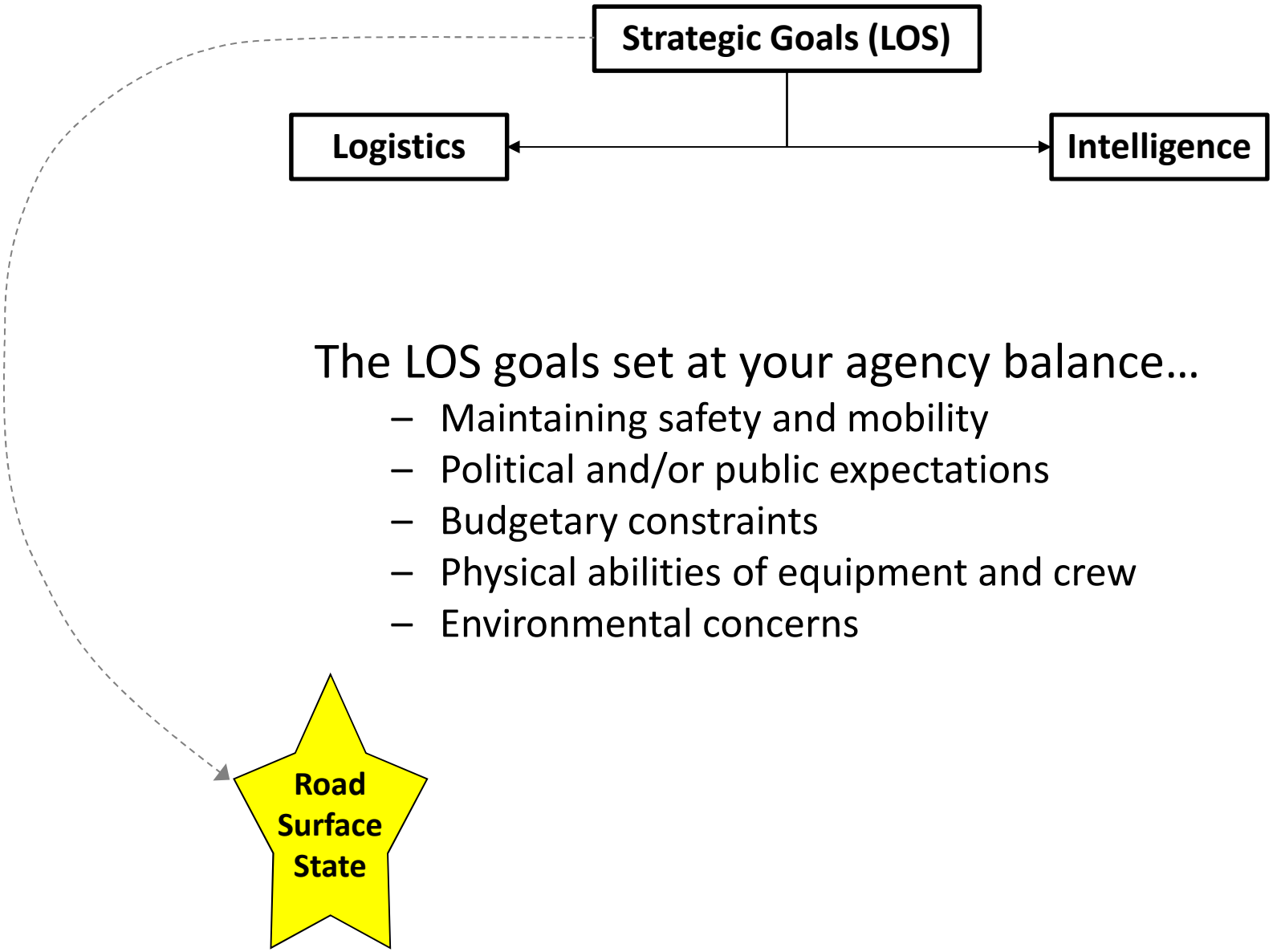
WEATHERNET

THE NARWHAL GROUP

Today's Talk

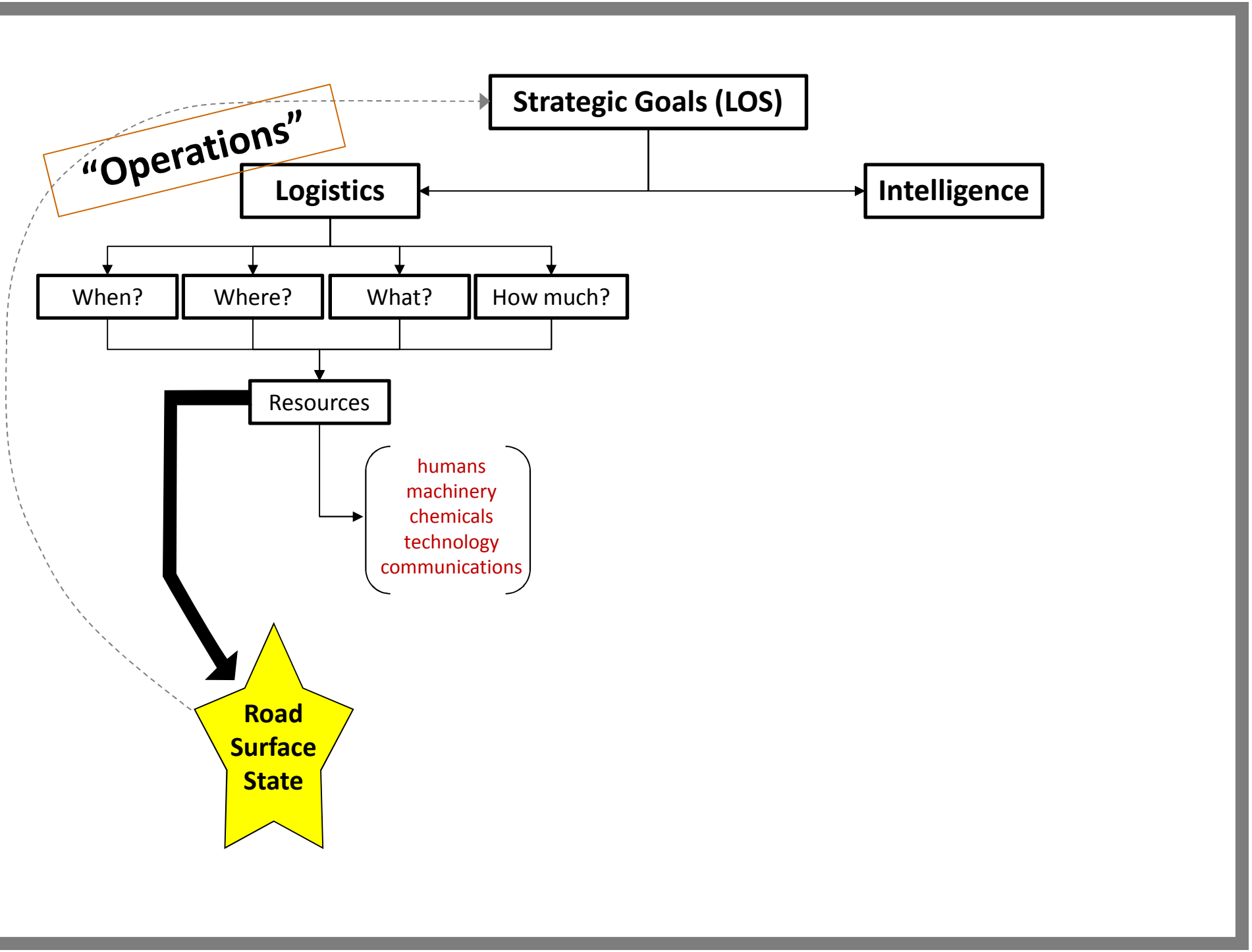
- Strategic goal: LOS
  - Logistics: Operations
  - Intelligence: Weather information
- Intro: Weather information
- Key environmental measurements
  - Air temperature
  - Humidity
  - Wind
  - Pressure
  - Visibility
  - Precipitation
  - Solar radiation
  - Soil temperature
  - Road temperature
  - Road condition

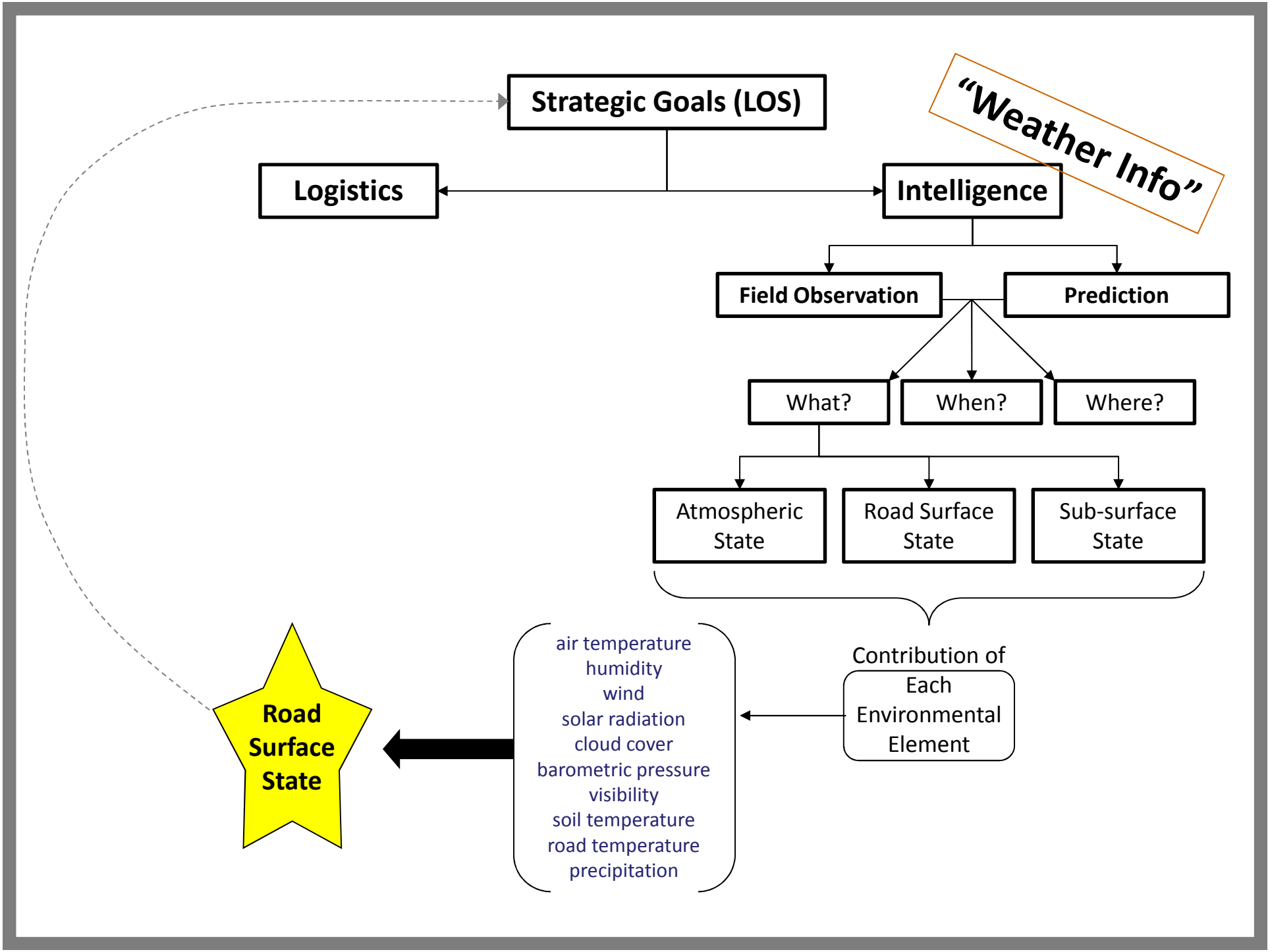
  - What it is
  - Why it matters
- Concluding thoughts



The LOS goals set at your agency balance…

- Maintaining safety and mobility
- Political and/or public expectations
- Budgetary constraints
- Physical abilities of equipment and crew
- Environmental concerns


"Operations"
Strategic Goals (LOS)
Logistics
Intelligence
When?
Where?
What?
How much?
Resources
humans
machinery
chemicals
technology
communications
Road Surface State


Strategic Goals (LOS)
"Weather Info"
Logistics
Intelligence
Field Observation
Prediction
What?
When?
Where?
Atmospheric State
Road Surface State
Sub-surface State
Contribution of Each Environmental Element
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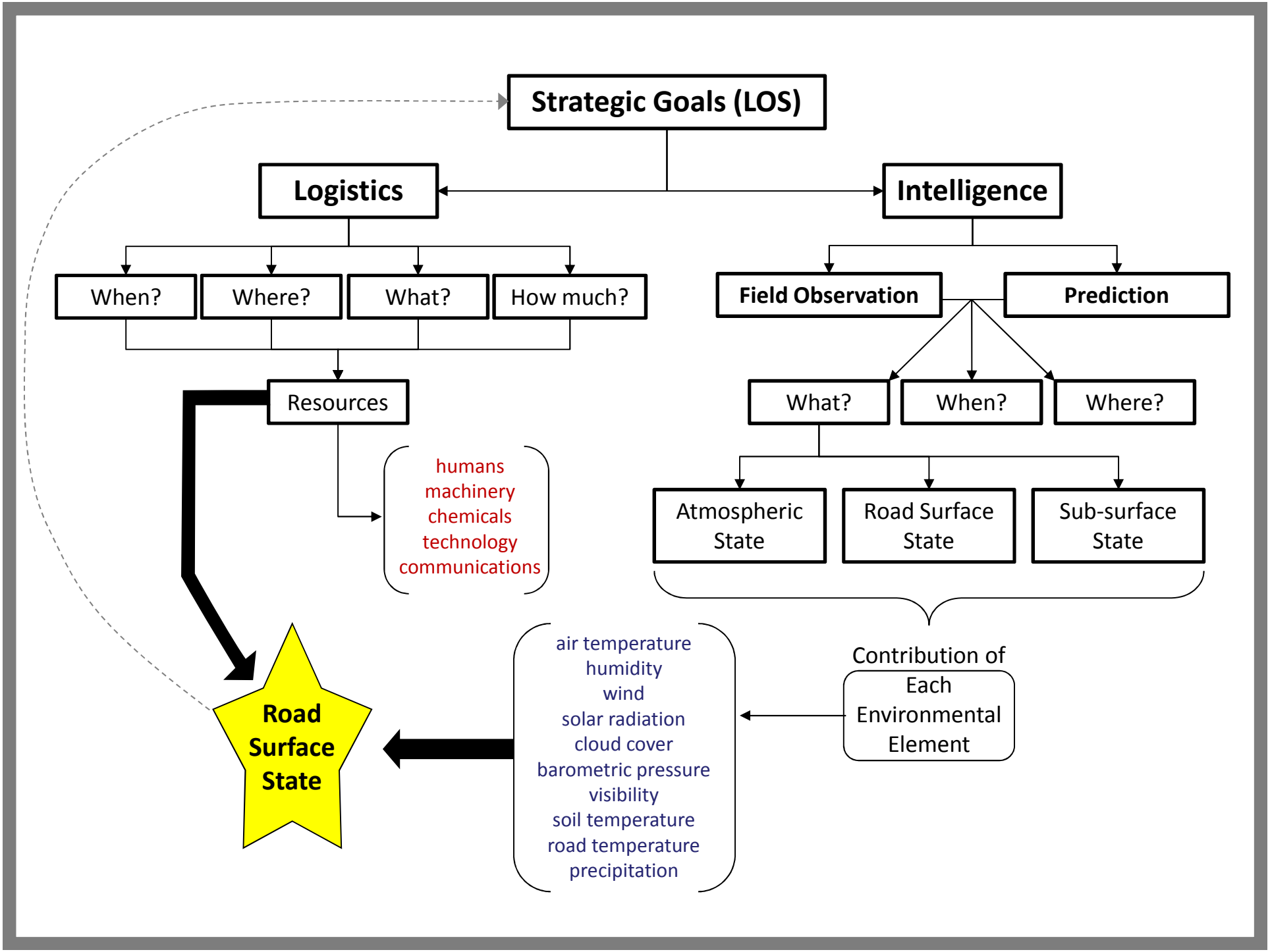
humidity
wind
solar radiation
cloud cover
barometric pressure
visibility
soil temperature
road temperature
precipitation
Road Surface State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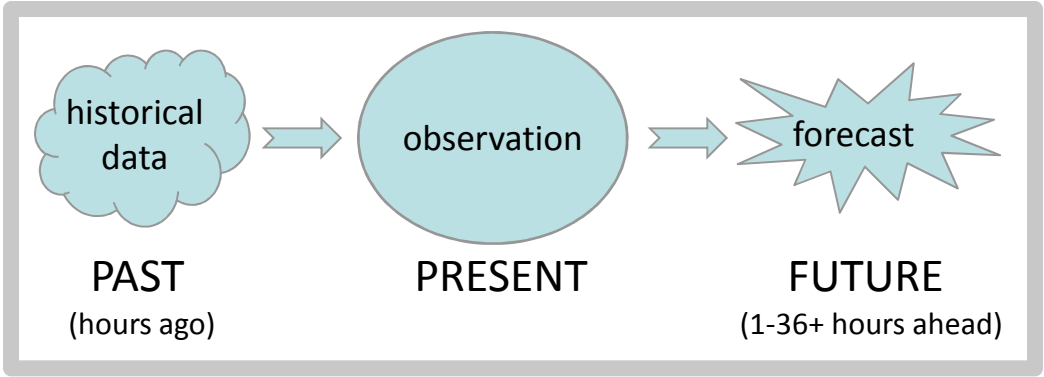
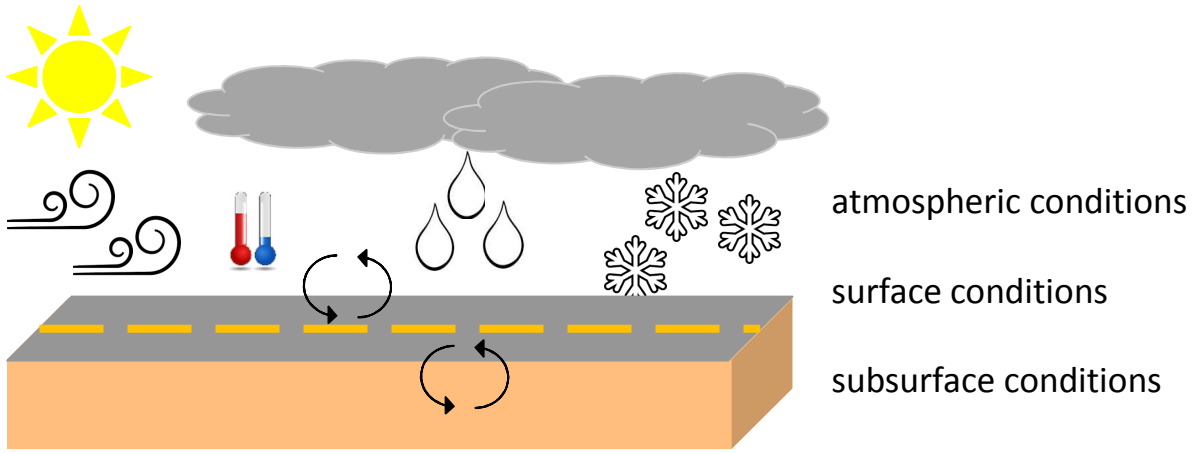
Intro:
Weather Information

Weather Information

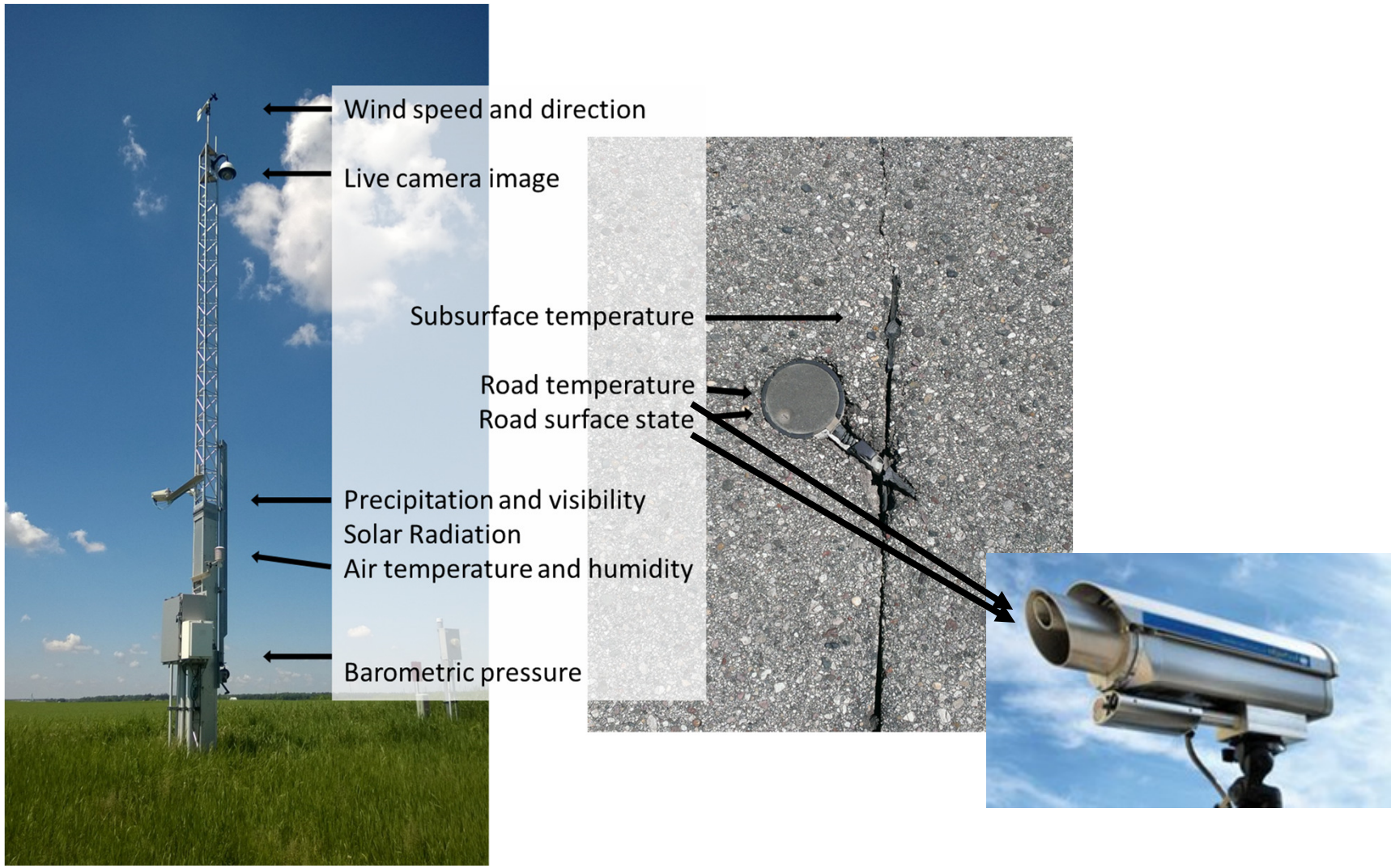
- Weather information is:
  - Field observations
    - Current and historical
  - Forecasts
    - Future state of those observations



- All environmental elements that affect road surface state must be considered

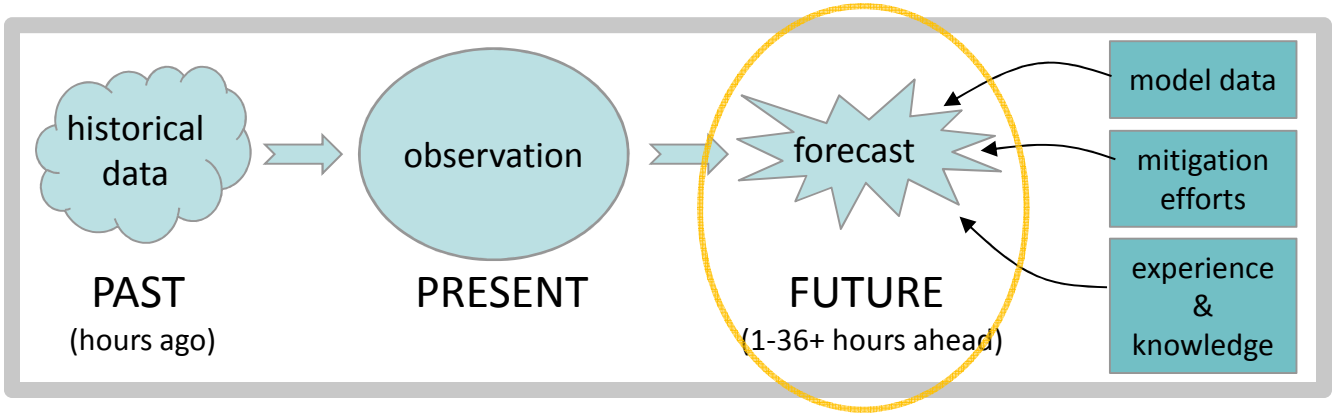


Field Observations: RWIS

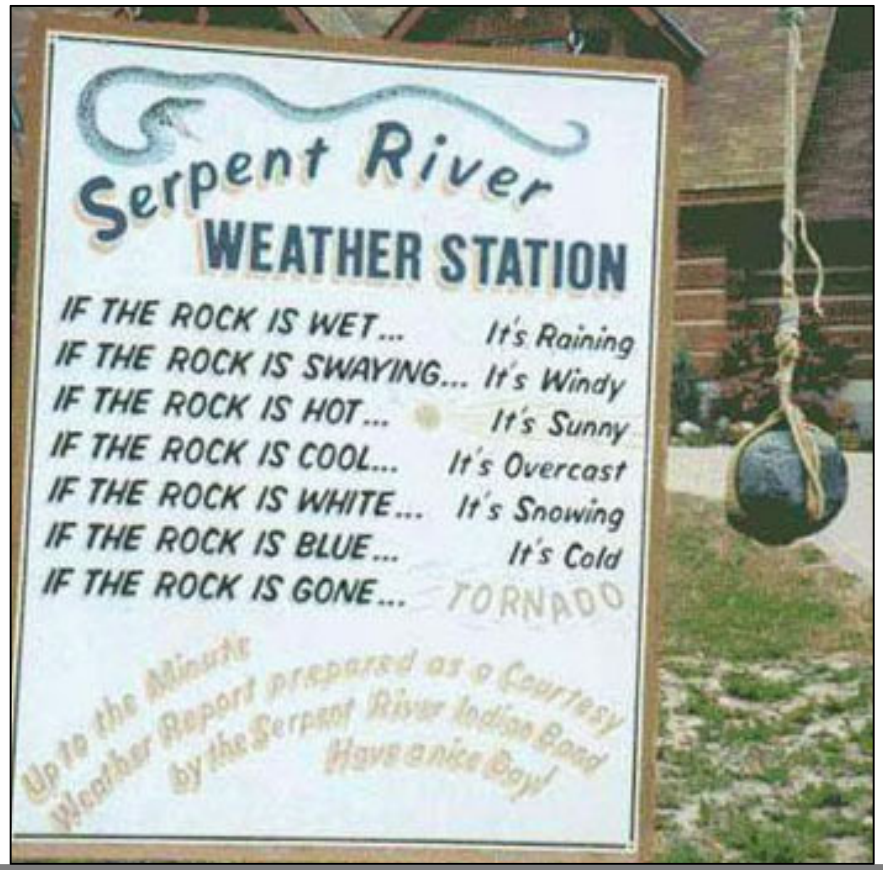


Forecasts

- Forecasters…
  1. Figure out the future state of each element,
  2. How it will affect road surface state, and
  3. Communicate the part that matters to you
- They do this by combining different inputs:
  - Past environmental conditions
  - Current environmental conditions
  - Model data
  - Mitigation efforts
  - Physical understanding of the system (knowledge and experience)

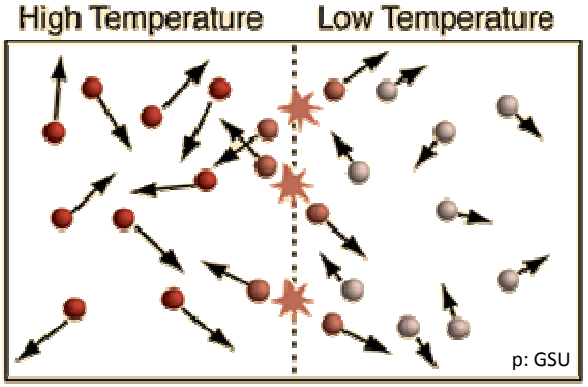


Environmental Measurements



Air Temperature

- What it is:
  - Air temperature is the average kinetic energy of molecules in the atmosphere

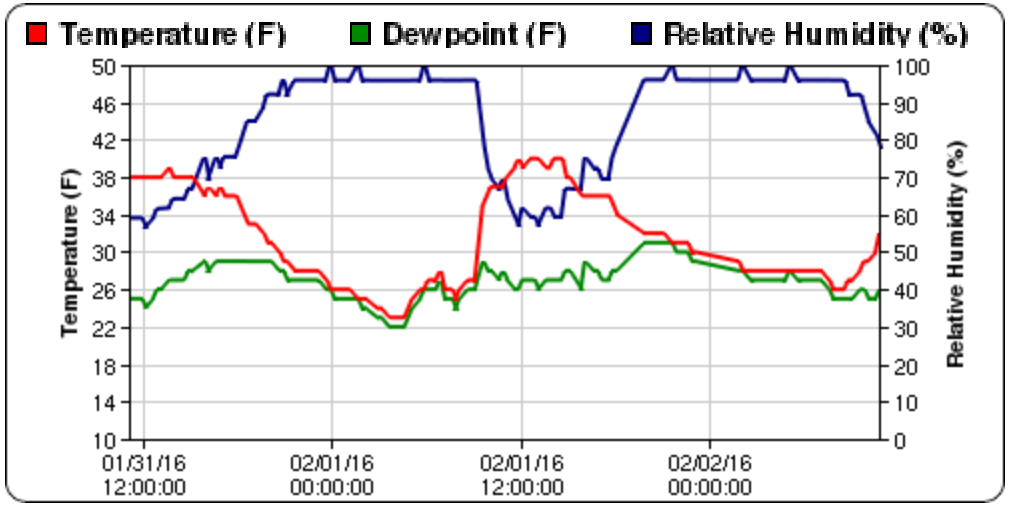


- Why it matters:
  - Affects road surface temp
  - Affects precipitation type
    - Rain-snow level
    - Rate of change through a storm
  - Warm air is less dense
  - Cold air is more dense

Humidity

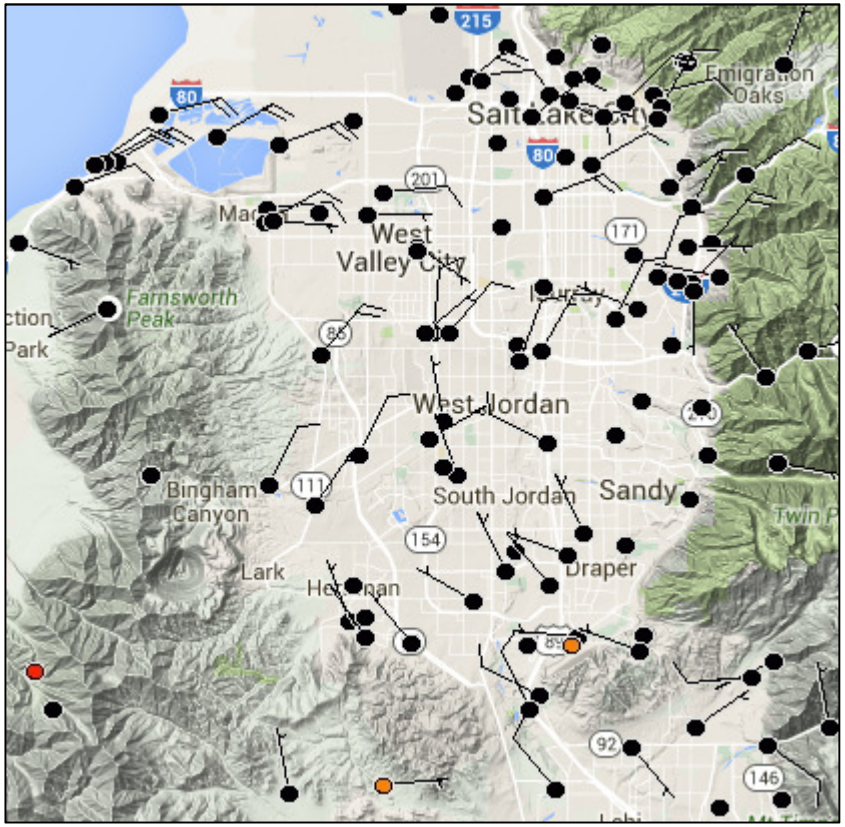
- What it is:
  - The amount of water vapor in the air
  - Relative humidity – Amount of water vapor in the air compared to the amount of water vapor the air can hold – how close the air is to *saturation* (100%)
  - Dewpoint temperature – The temperature at which the air would reach saturation

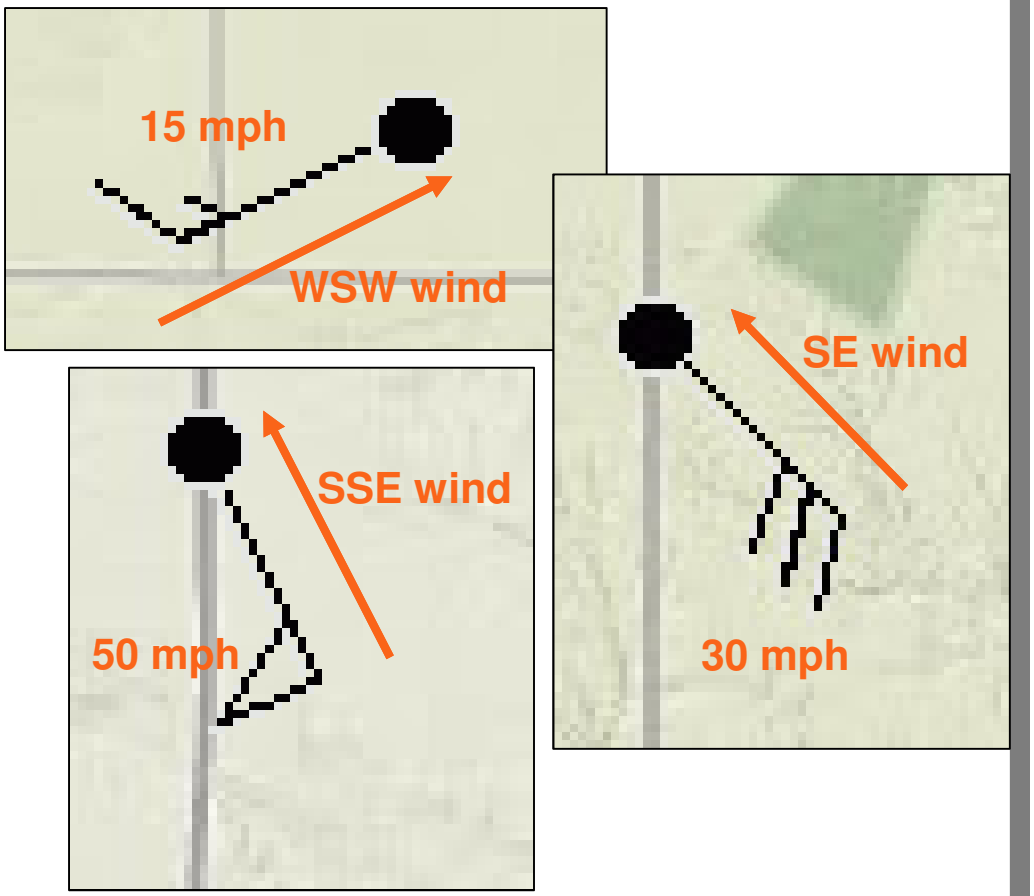
- Why it matters:
  - When used with air temperature:
    - Fog or freezing fog
    - Deposition onto roads
  - When used with road temperature:
    - Wet or frosty roads



Wind: Reading Wind Barbs

Direction and Speed

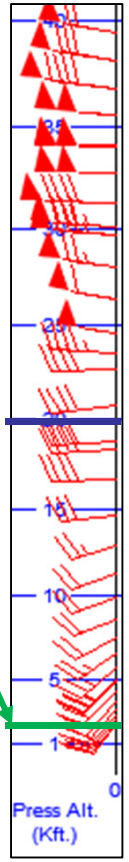




Wind

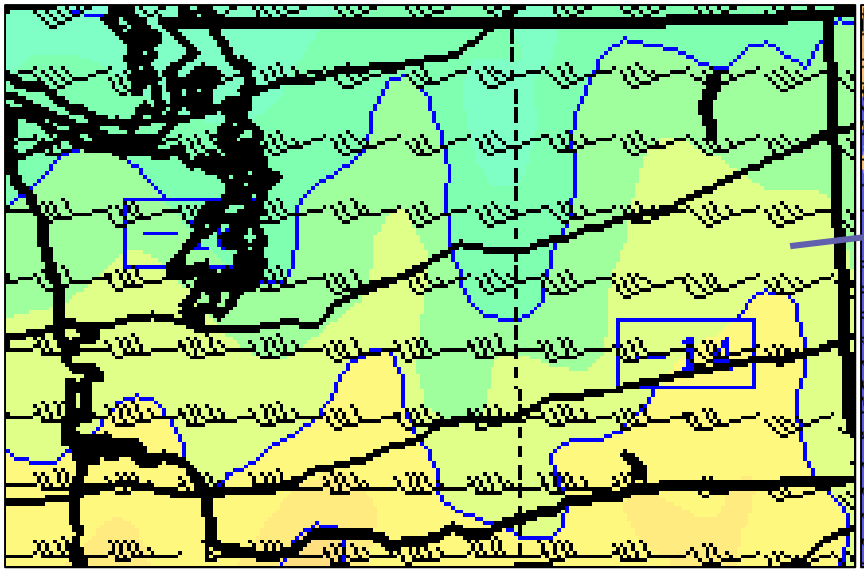
- What it is:
  - Physical motion of air
  - Caused by differences in pressure/temperature
  - Varies greatly between the surface and the upper levels

Wind profile
(Spokane)

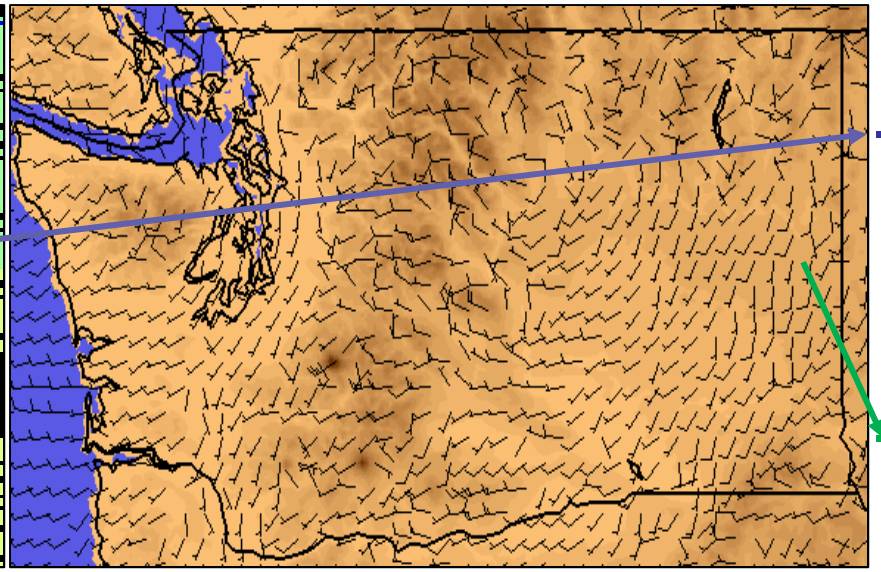


2 June 2016, 5 am

Wind @ 20,000 ft
Large-scale atmospheric waves



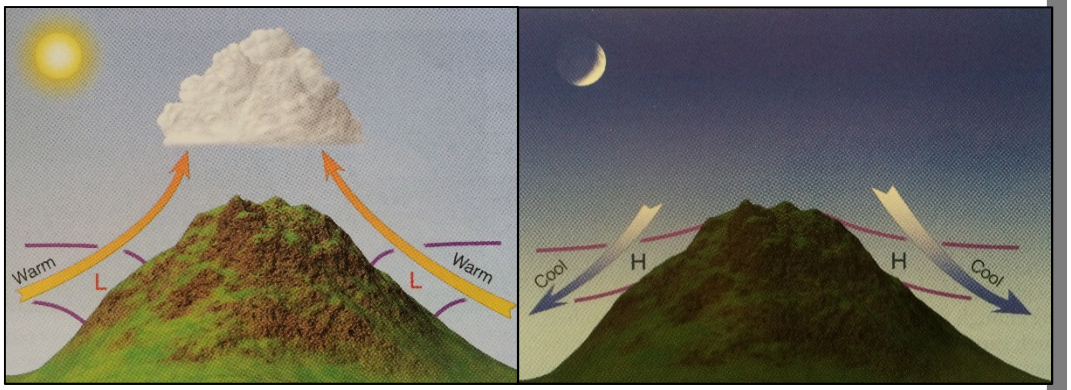
Wind @ surface
Driven by terrain, temperature differences, and large-scale weather

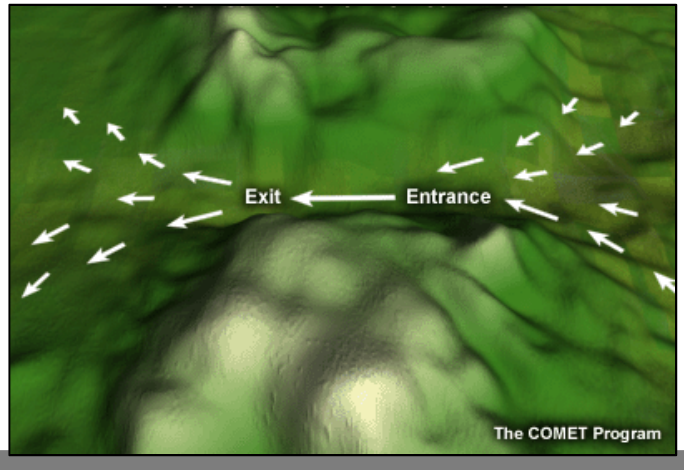


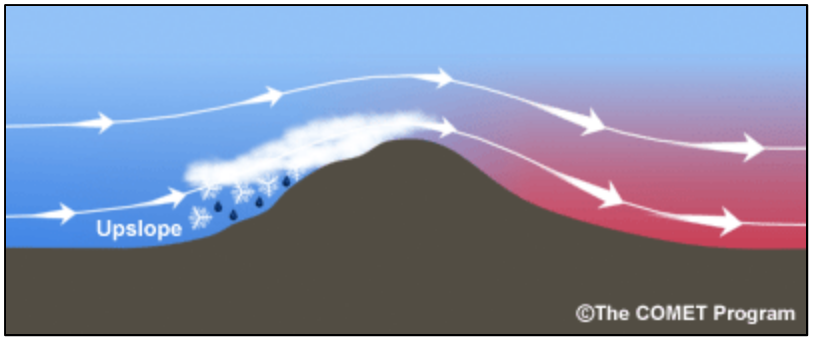
Wind

- Why it matters:
  - Blowing snow after precipitation stops
  - Reducing visibility
  - Moderates temperature at night
    - Reduces frost development

- A few specific phenomena:
  - Daily mountain/drainage
  - Gap winds
  - Downslope wind events







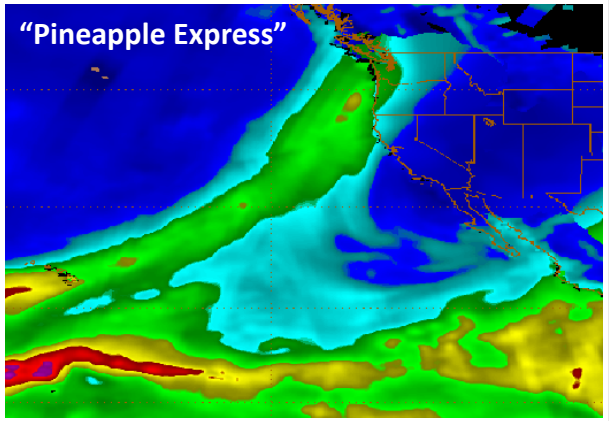
Visibility

- What it is:
  - Distance visible light is able to pass through a medium

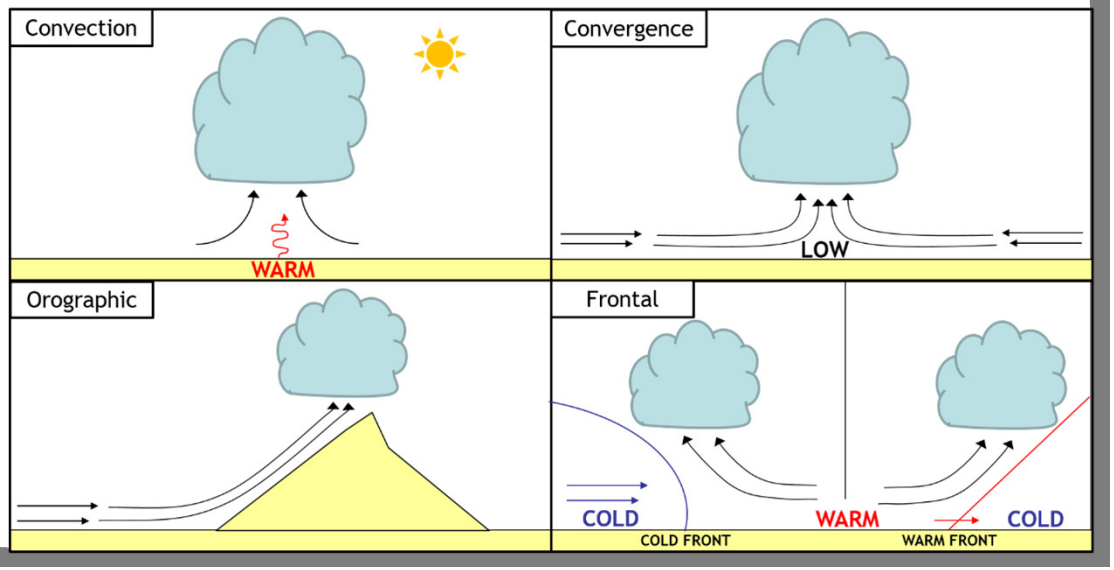
- Why it matters:
  - Can give you a *sense* of how intensely it's precipitating
  - Operational considerations:
    - How visible are your plows?
    - How visible are other obstacles?

Precipitation

- What it is:
  - Hydro*meteors*
  - Type, intensity, duration



- How we forecast it:
  - Observe moisture upstream (satellite & radar)
  - Model forecasts
  - Knowledge of precipitation forcing mechanisms



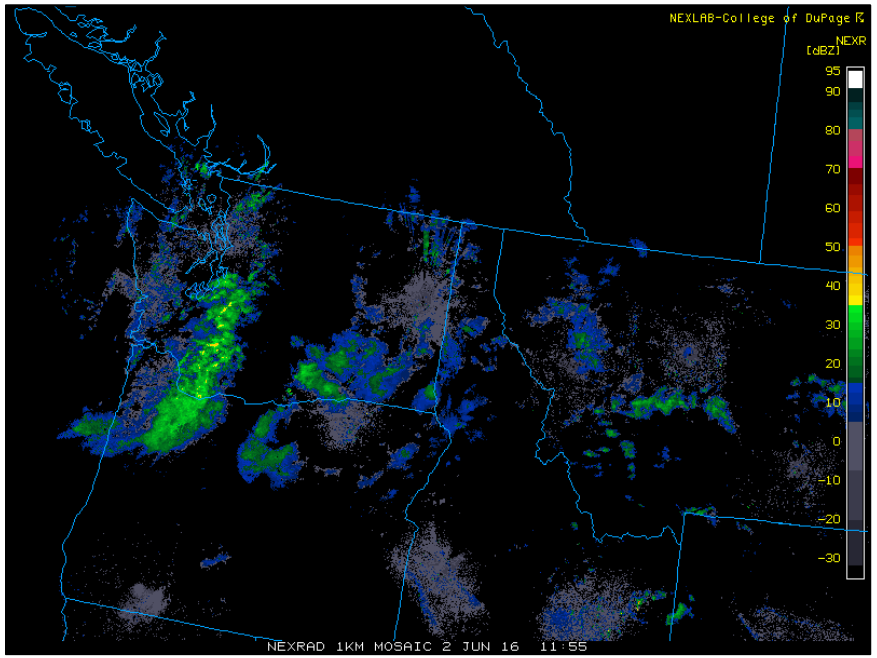
- How we measure it:
  - Radar*
  - RWIS sensors

Radar Basics

- Radars…
  1. Emit a radio beam that is reflected off of particles in the atmosphere.
  2. Use an antenna to capture the reflected signal back at the radar site.

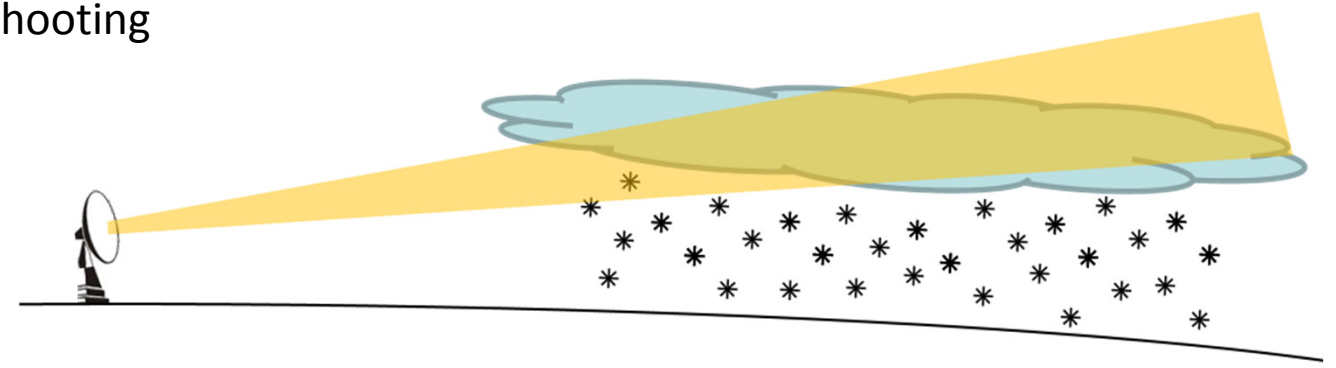
NOAA

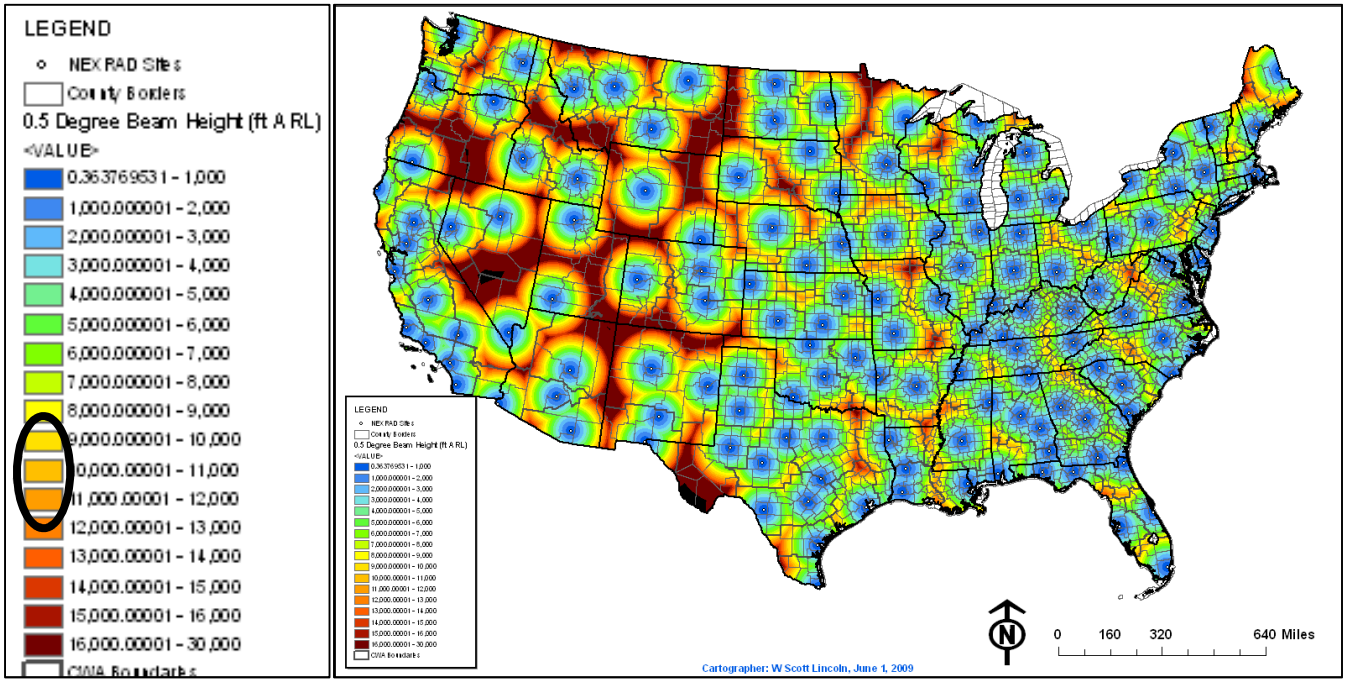
- The amount of *reflectivity* measured back at the radar represents the amount of precipitation (number and size of hydrometeors).



Radar Coverage in the West

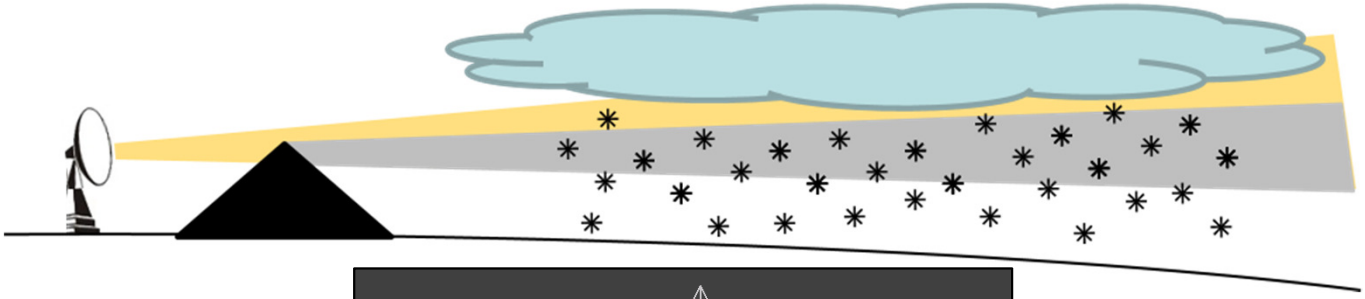
Beam Overshooting

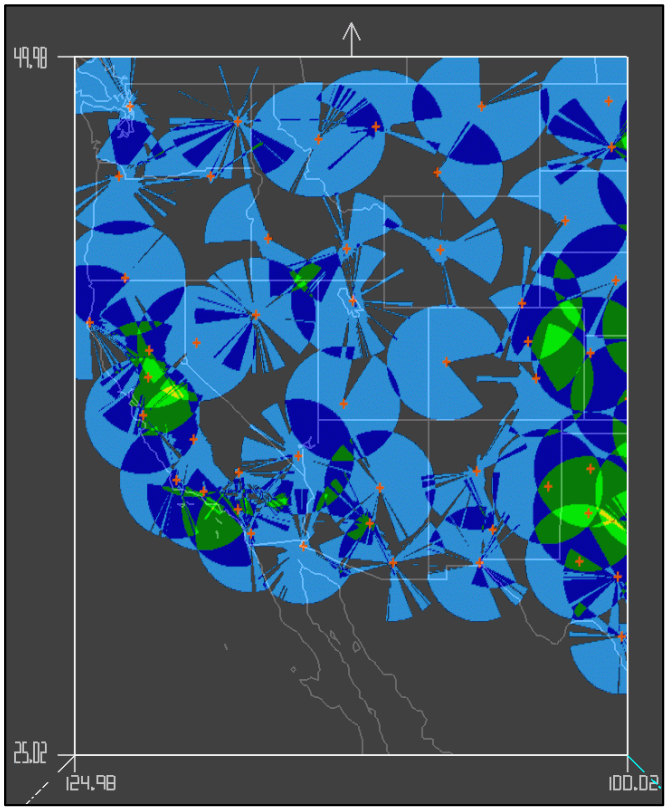




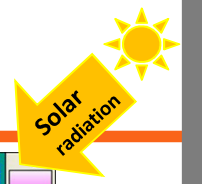
Radar Coverage in the West

Beam Blockage

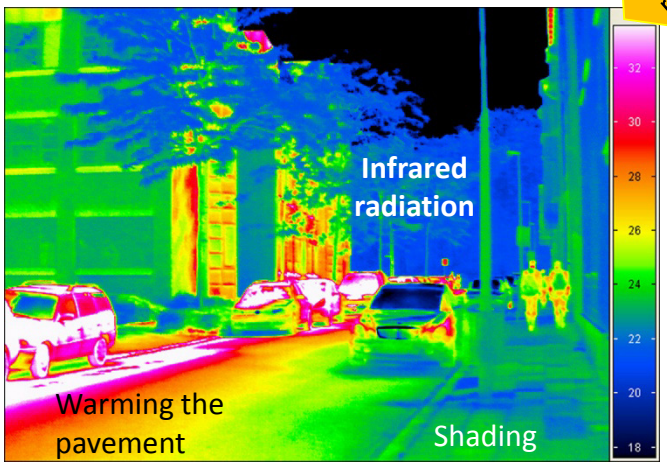




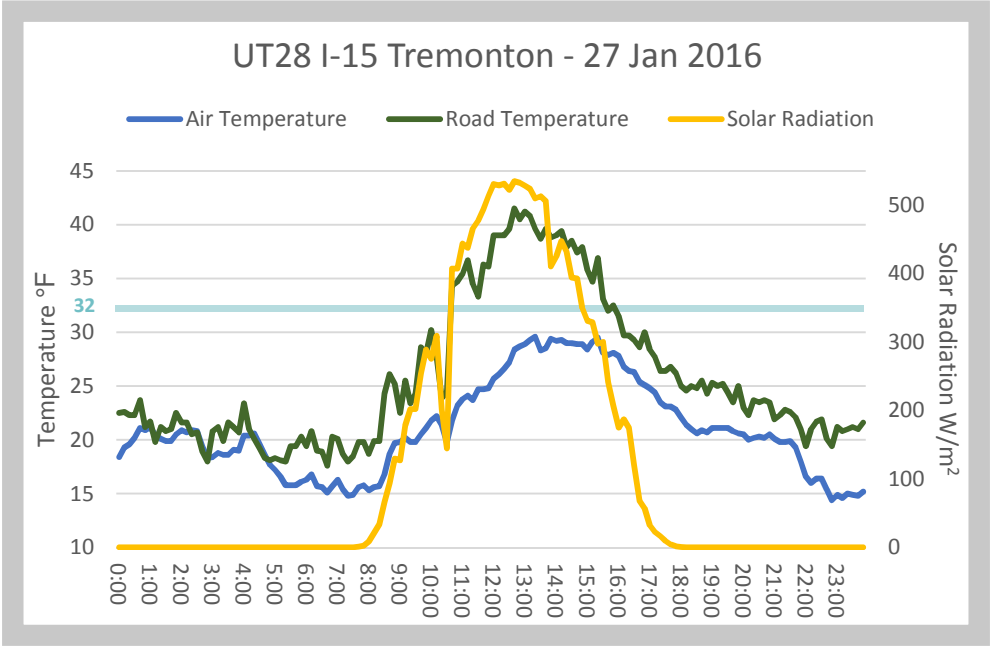
Solar Radiation



- What it is:
  - Radiation that comes from the sun
  - Solar radiation is *absorbed by* a surface; surface is heated.
  - Heated surface *emits* infrared radiation.

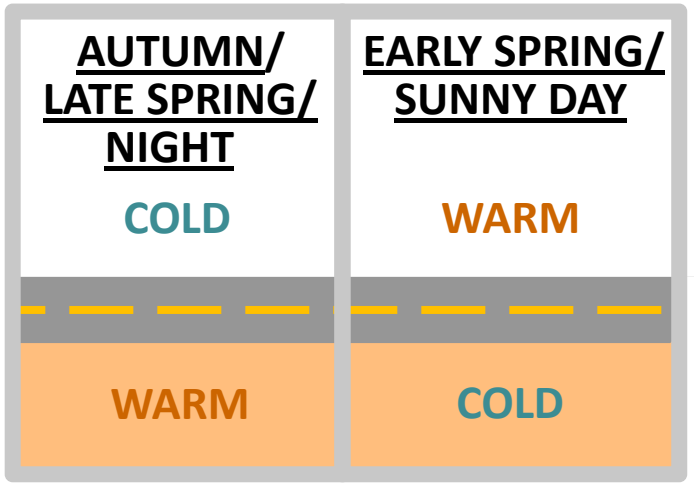


- Why it matters:
  - Road surface absorbs radiation very efficiently
  - Solar radiation is very susceptible to:
    - Angle—time of year, time of day, latitude
    - Obstacles—cloud cover, terrain, trees, buildings
  - Clouds block radiation during the day, but hold it in at night
    - Like a blanket



Soil Temperature

- What it is:
  - Temperature of the pavement's underlying structure
  - Usually measured at 18" depth

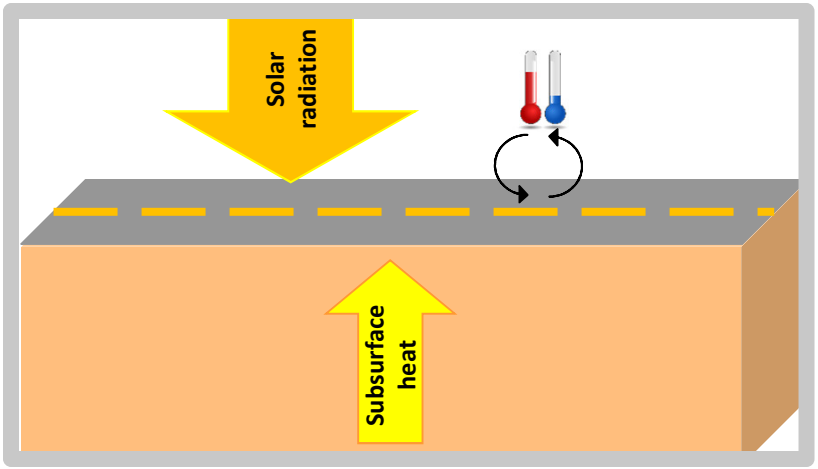


- Why it matters:
  - Heat retention and transfer to pavement surface

- Think about how not having a substrate—i.e., bridge deck—affects pavement temperature.

Road Temperature

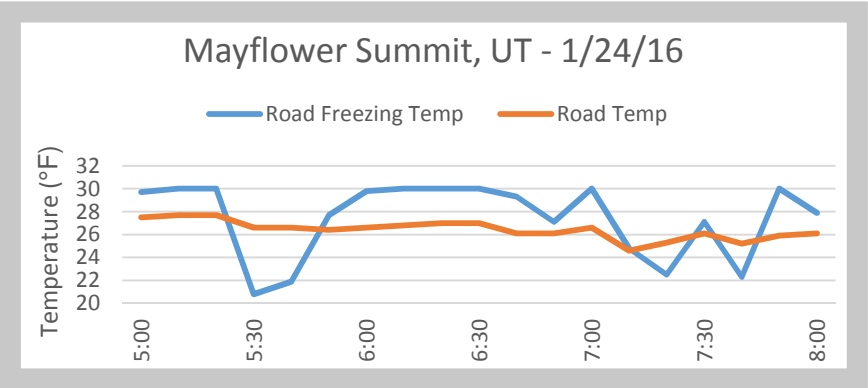
- What it is:
  - The amount of infrared radiation emitting from the pavement
  - Dependent upon **solar radiation**, **subsurface temperature**, and **air temperature**



- Why it matters:
  - Dictates road surface state:
    - How precipitation will behave when it contacts surface
    - Development of frost (when used with dewpoint)
  - Dictates which chemicals to use

Road Condition

- What it is:
  - The physical state of water on the pavement surface: none/dry, damp, wet, ice, snow, slush
  - Or the grip/friction of the surface
  - Or the eutectic (freezing) point of the water-salt solution
  - Or dry salt residual



- Why it matters
  - Being able to measure this through a storm helps to determine further mitigation efforts
  - Verify mitigation results throughout a storm
  - Informs how chemicals will/will not adhere

Camera Image

- When the camera image is helpful:
  - Helping you learn meaning of RWIS data
  - Verification of snow on roads
  - Visibility
  - Wet vs dry roads
  - Traffic congestion

Icy or wet?

- When the camera image is *not* helpful:
  - Falsely identifying icy vs wet
  - No way to determine friction
  - Lack of light at night
  - Snow-packed camera lens

So you know the road is salty, but can you tell the freezing point? Surface friction?

Concluding Thoughts

What (More) Can RWIS Do For You?

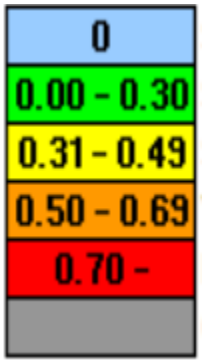
Before the RWIS is installed:

- Site RWIS in strategic locations
  - Use the right sensors for the right spot
  - Think outside the box
  - Work with partners
  - Have a 5-year plan

Good practice for operations:

- Perform twice-annual calibration and preventative maintenance(!)
- Make room for response maintenance
- Quality control the data
- Metadata…metadata…metadata
- Archive the data and make it readily accessible
  - Post-storm analyses (what went well, what didn't, and why?)
  - Use for training or performance measurement
  - Severity indices

ITD's performance scale



What (More) Can A Forecast Do For You?

- Ask yourself: Where is the human in the loop?
- Humans are important, because…
  - Forecasting the weather is still an art
  - Humans can recognize patterns and make comparisons to prior storms
  - Humans can communicate uncertainty in human terms, not just statistical or probabilistic terms
    - Humans can be descriptive and nuanced in their communication
  - If something changes, the human can relay that at that time and can describe the change to the crew
  - Can more easily adjust their biases and errors than a model
  - Mountain weather is important in the west, and models don't handle it well

Questions?

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WEATHERNET

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Supplementary Slides

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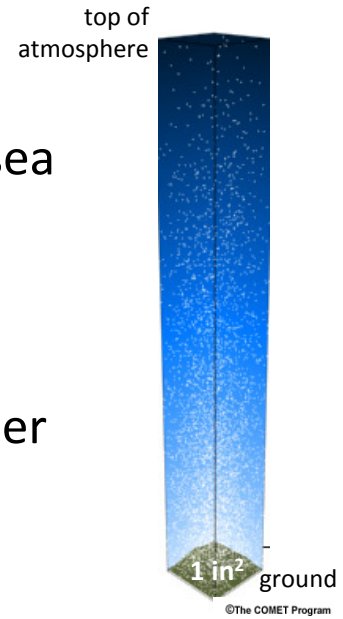
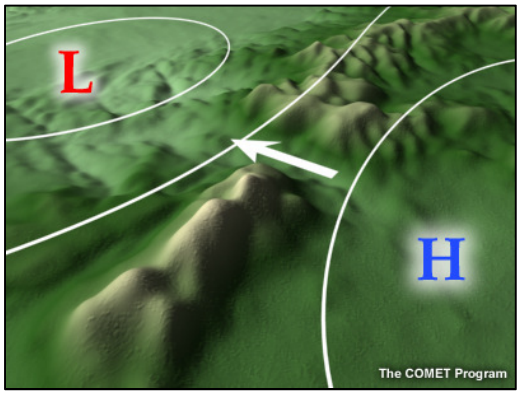
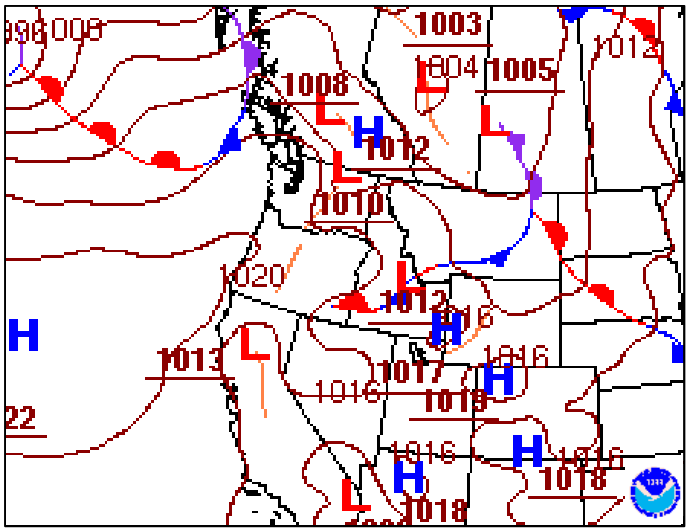
Barometric Pressure

- What it is:
  - The weight of a column of air over a given area at ground or sea level

- Why it matters:
  - Important for meteorologists denoting a change in the weather
  - Pressure, temperature and wind are all related
  - Used to forecast…
    - Wind storm development
    - Daily coastal weather
    - Strength of cyclones





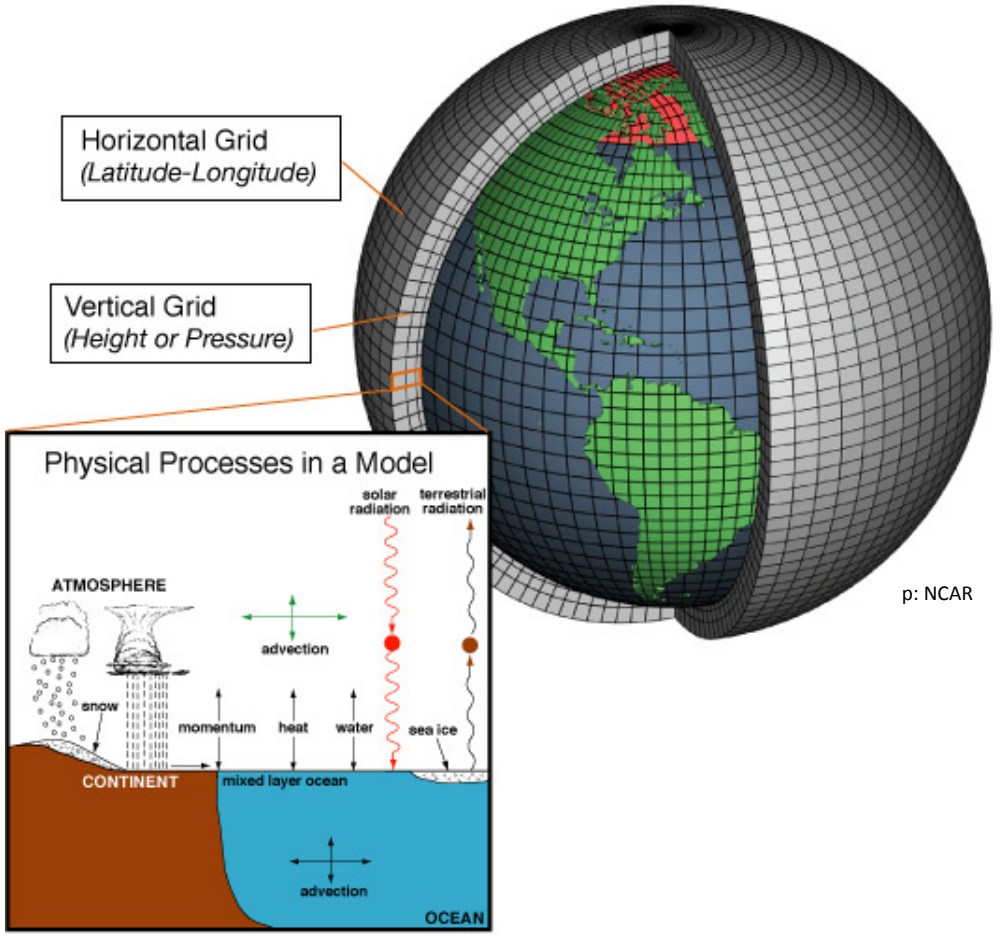


The Physics of the Forecast

- How do we estimate the future state?

- A weather model:
  1. Collects observations
  2. Builds an estimate of the current atmosphere
  3. Estimates the future of the atmosphere
     - Using physical and thermodynamical equations

- Forecasters understand the science *and* know how to communicate what matters to you



p: NCAR

Key Trouble Spots

- Low areas (cold pooling)
- Areas by water (humidity)
- Bridges
- Shady spots (solar radiation; terrain, buildings, trees)
- Gaps in terrain (wind)
- Summits and lee slopes (orographic enhancement)
- But that doesn’t necessarily mean you put your RWIS there

Seasonal Forecasts

- What you'd want to know and what they might include
- Why they should not be used to make operational plans

Summary

- Bring it back to the operational goal: good intel builds your logistical plan, helping you reach your goal efficiently