Convective TAF and AWW Enhancements in Phoenix for the 2019 Monsoon

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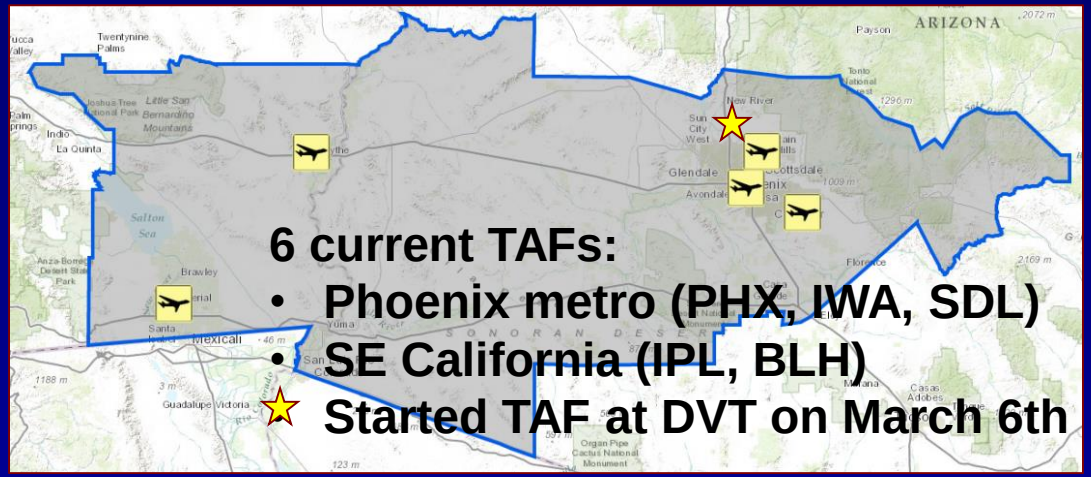
Aviation Focal Point | National Weather Service Phoenix, AZ

8th Southwest Aviation Safety Awareness Workshop
June 8, 2019 | Tempe, AZ

NWS Phoenix (PSR) Aviation Program

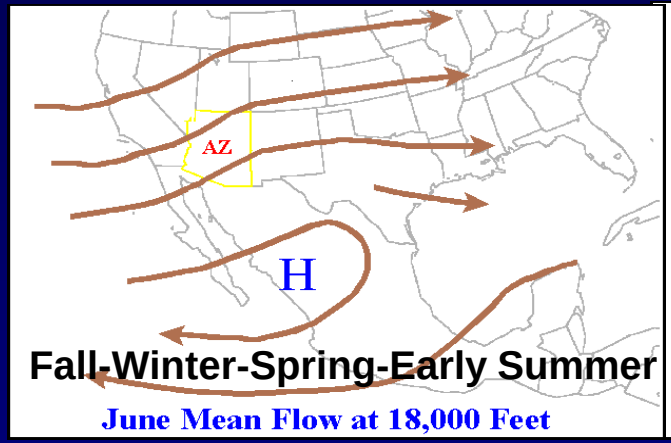
- **Forecasts and Watch/Warning/Advisories**
  - **Terminal Aerodrome Forecasts (TAFs)**
  - **Airport Weather Warnings (AWWs)**
  - ***Started new TAF and AWW at DVT in March!***
- **Specialized Decision Support (e.g., Super Bowl)**
- **Local Research and Outreach (monthly exercises)**

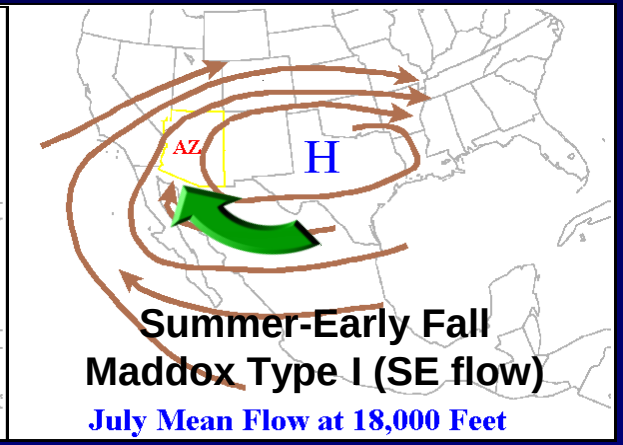


- **4 of 36 busiest airports in U.S. (by FY17 Ops):**
  - **12. PHX (455k; 1246 p/day)**
  - **19. DVT (384k; 1052 p/day)**
  - **34. IWA (291k; 796 p/day)**
  - **36. FFZ (289k; 792 p/day)**

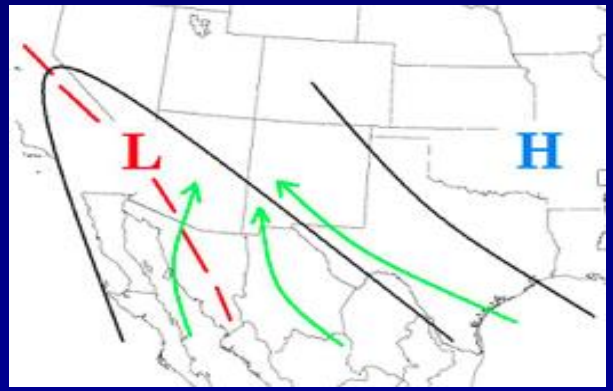
What causes Monsoon Season?

- Seasonal reversal in the prevailing wind flow patterns





- Officially June 15 to Sept 30 (varies in reality)
- Typical surface moisture surge lasting 2-4 days helps trigger t-storms



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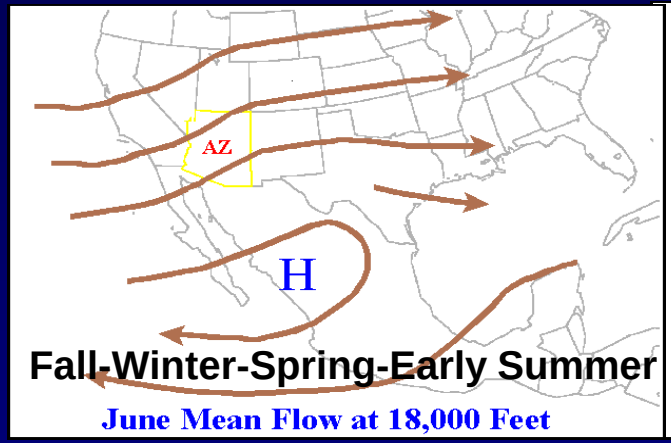
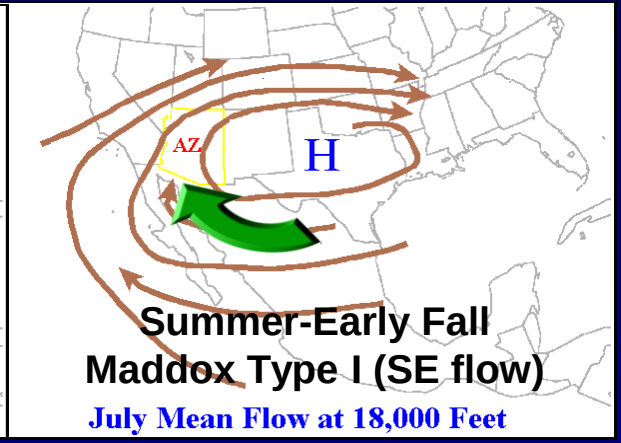


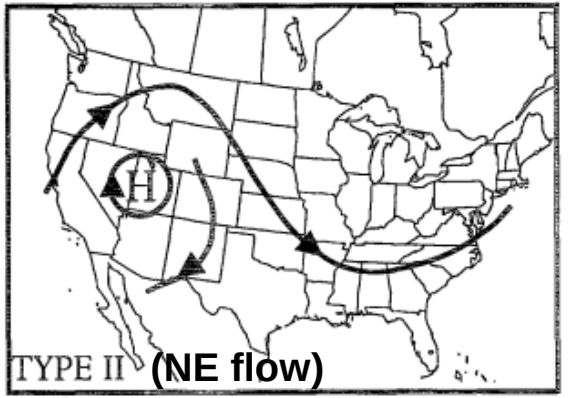
Fall-Winter-Spring-Early Summer

June Mean Flow at 18,000 Feet



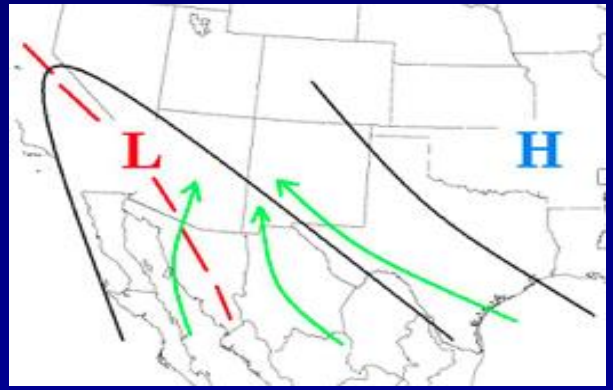
Summer-Early Fall
Maddox Type I (SE flow)

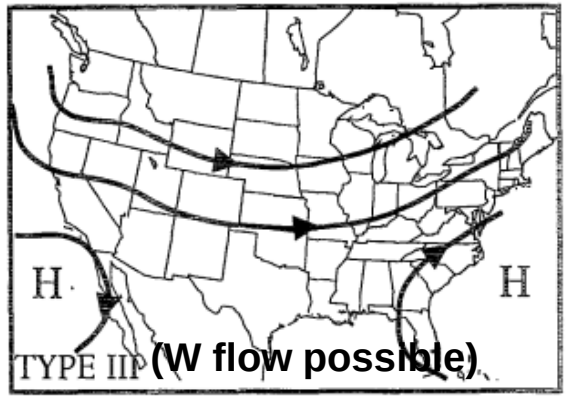
July Mean Flow at 18,000 Feet



(NE flow)

- SE and NE flow aloft most common
  - Occasional westerly events (fringes)



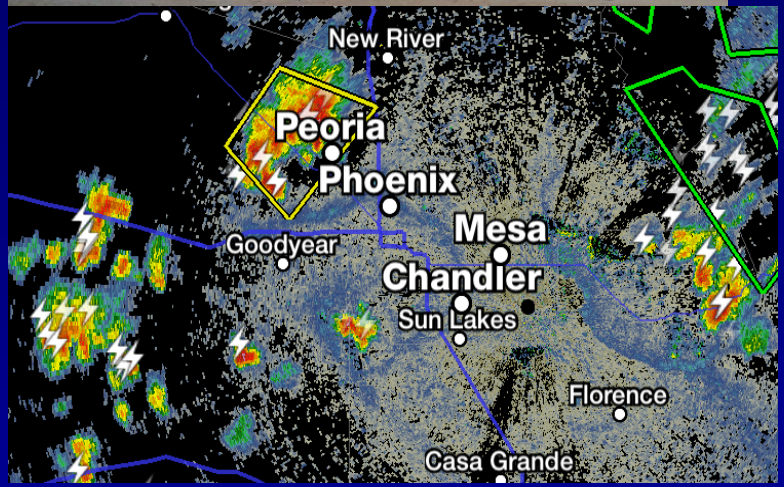


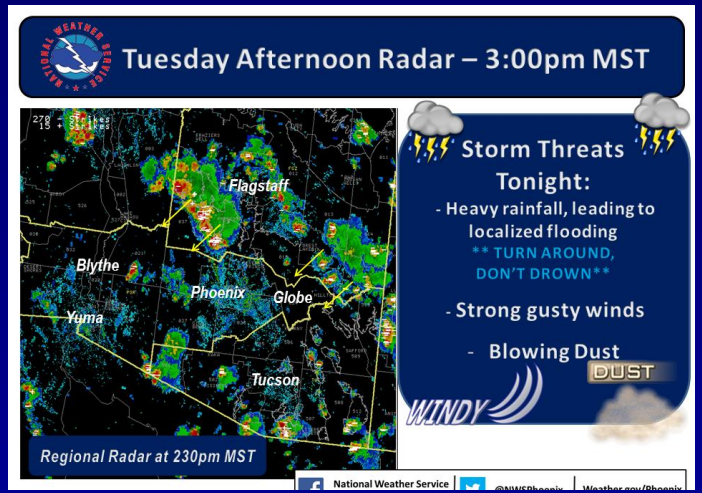
(W flow possible)

- *Objective monsoon climatology (ASU grant?)*

Typical Monsoon Day in our Office

- **Radar forecaster** tracks storms and issues warnings
- **Aviation forecaster** tracks wind shifts/ outflows to issue AWWs and amend TAFs
- **Additional staff** handles calls, social media, interviews, public products, etc.





Terminal Aerodrome Forecasts (TAFs)

```
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      TEMPO 1301/1303 06025G40KT 2SM TSRA BKN050CB
     FM130300 06012KT P6SM VCSH BKN100 BKN150
     FM130600 12010KT P6SM BKN100 BKN150
     FM131900 27012KT P6SM FEW120 SCT250=
```

- We strive to write **"practically perfect TAFs"** in 6 lines or less by:
  - Writing to flight categories first and establishing trends
  - Adding specific details for the first 12 hours (especially first 3-6 hrs)
  - Highlighting specific events past 12 hours for planning

- 30-hour TAFs at PHX (updated every 3 hours); 24-hours at other sites
  - Amendments issued if conditions causing categorical changes have been (or will be) met and persist for ≥ 30 min *(call TRACON for major changes)*

Aviation Forecast Discussions (AFDs)

- **We give details, confidence, and uncertainty in AFDs:**

.AVIATION...
South-Central Arizona including KPHX, KIWA, and KSDL:
A broken line of strong to severe thunderstorms has pushed into eastern Maricopa County. These storms should affect KIWA and KSDL within the next hour and KPHX around 01Z. Wind gusts up to 45 knots appear to be possible with these storms, with at least isolated severe wind gusts to 50-55 knots. Although blowing dust does not currently appear to be a major threat for the terminals, this threat may increase if an outflow boundary is able to push ahead of the storms. At the current moment, it appears that the wind shift will be closely tied to the broken convective line of storms, so visibility decreases will most likely be caused by brief heavy rain. Thunderstorms and wind gusts above 20 knots should end between 02-03Z with this relatively fast-moving line, with all showers ending by 6Z. E-SE winds should return after 06Z with a typical early afternoon shift to westerly tomorrow.

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```

- ***WFO Phoenix now issuing regularly by 00/06/12/18Z***

"TEMPO" Groups

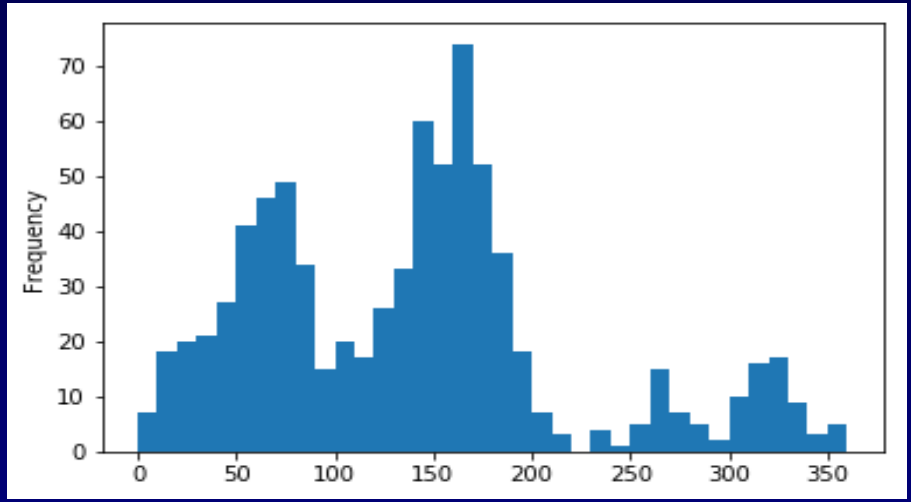
```
KPHX 122334Z 1300/1406 29009G18KT P6SM SCT100 SCT250
     FM130045 06020G30KT 4SM BLDU VCTS BKN080CB BKN150
     TEMPO 1301/1303 06025G40KT 2SM TSRA BKN050CB
     FM130300 06012KT P6SM VCSH BKN100 BKN150
     FM130600 12010KT P6SM BKN100 BKN150
     FM131900 27012KT P6SM FEW120 SCT250=
```

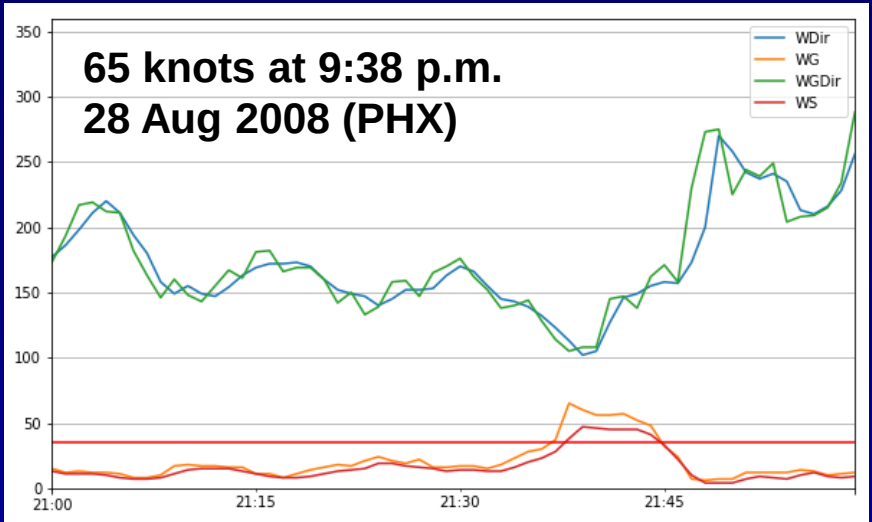
- **What does a "TEMPO" group technically indicate?**
  - ***High confidence (≥ 50% probability)*** **of**
  - ***Temporary fluctuations (≤ 1 hr p/instance)*** **to forecast conditions**
  - ***Covering less than half of the period*** **(should prevail if longer)**

- **TEMPO groups not allowed beyond 9 hours or for more than 4 hours**
  - **"Vicinity" groups (e.g., VCTS) and LLWS groups are not included**

Climatology of wind gusts ≥ 35 knots at PHX*

- 775 separate occurrences during monsoon (Jun-Sep) since 2000
  - SSE (140-170º) and ENE (50-80º) headings most common
  - 47 events ≥ 40 knot max gust
  - 12 events ≥ 50 knot max gust

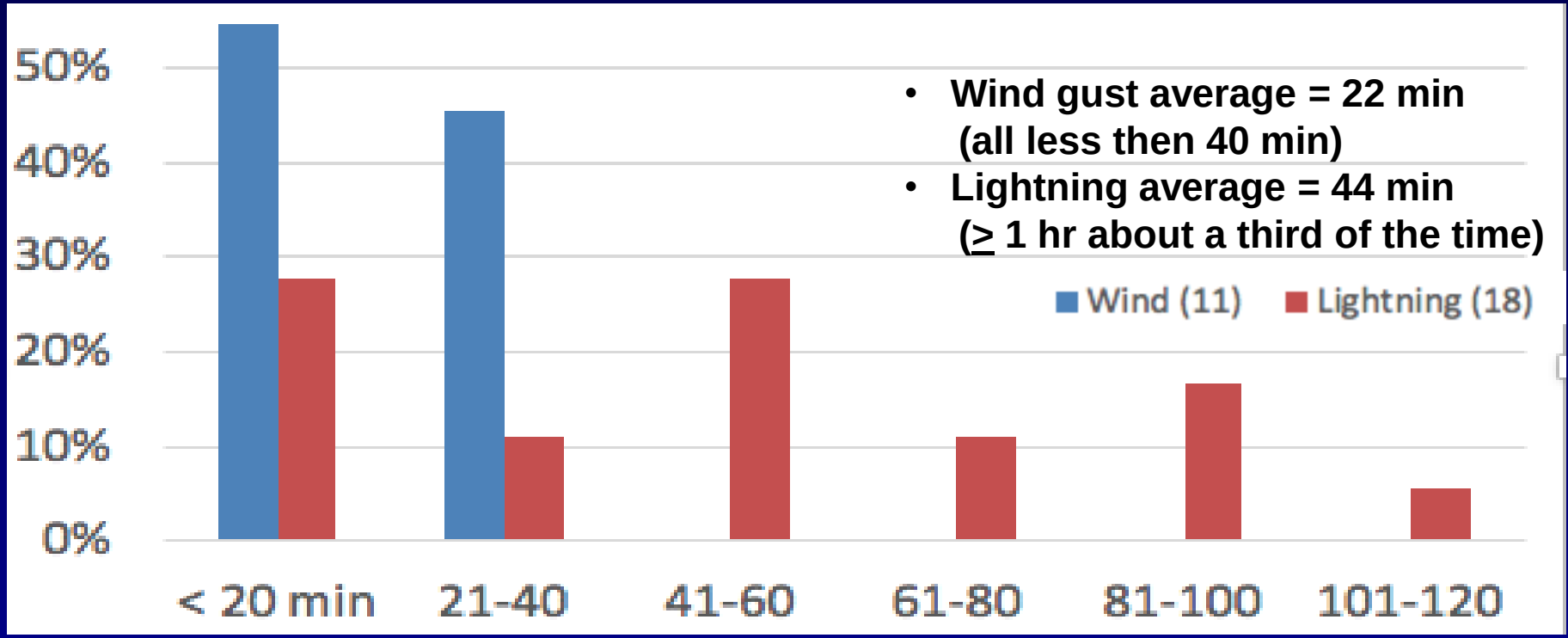




- Short-lived (86% single 1-min ob)
  - 29 gusts lasted 5-10 min
  - 7 gusts lasted 10-30 min
  - 3 gusts lasted 30-45 min
  - Two events with 65 and 62 knot gusts both lasted less than 10 min

*Courtesy Paul Iniguez; Based on 1-min ASOS data

Wind Gust vs. T-storm Duration at PHX in 2018



- **Wind gust average = 22 min (all less then 40 min)**
- **Lightning average = 44 min (≥ 1 hr about a third of the time)**

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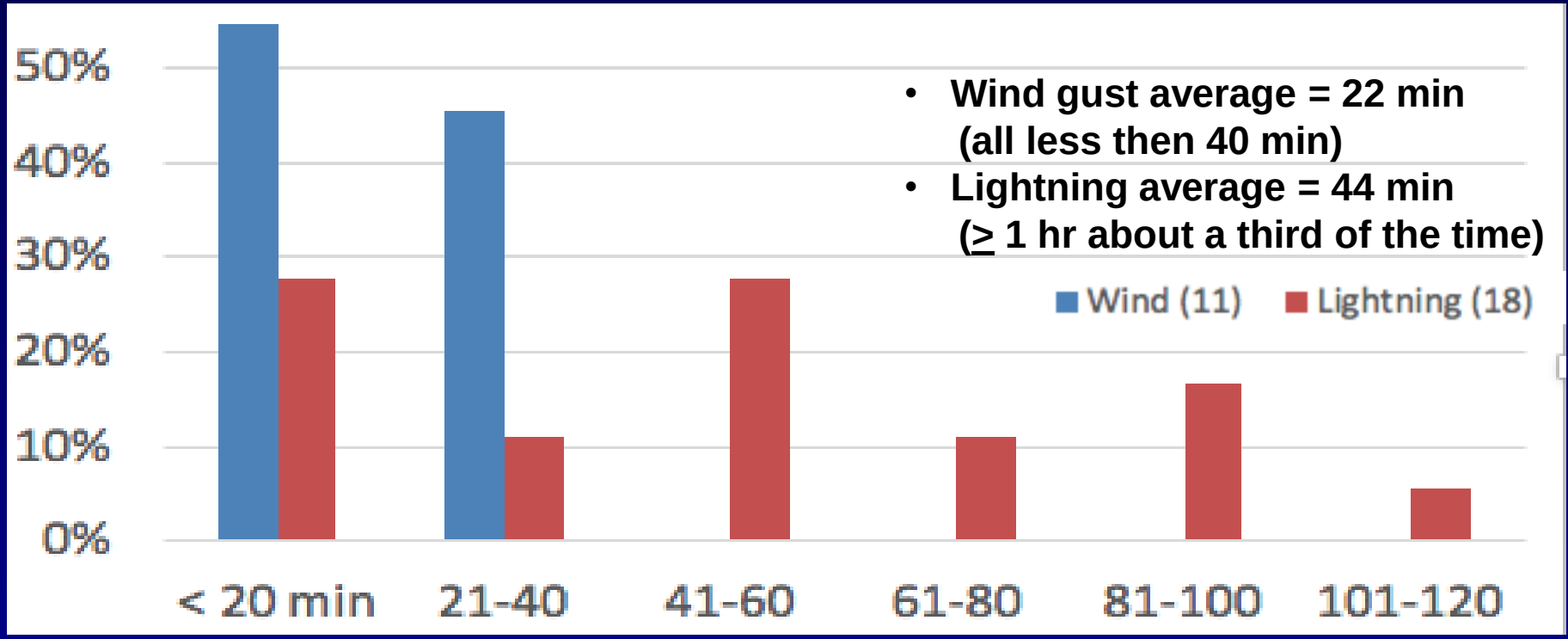

- **Wind gust average = 22 min (all less then 40 min)**
- **Lightning average = 44 min (≥ 1 hr about a third of the time)**

- ***Limit TEMPO TS groups and AWW duration for lightning to 2 hours***
  - ***Should generally not exceed one hour for wind gusts ≥ 35 knots***

“Vicinity” Groups (It’s back…..)

```
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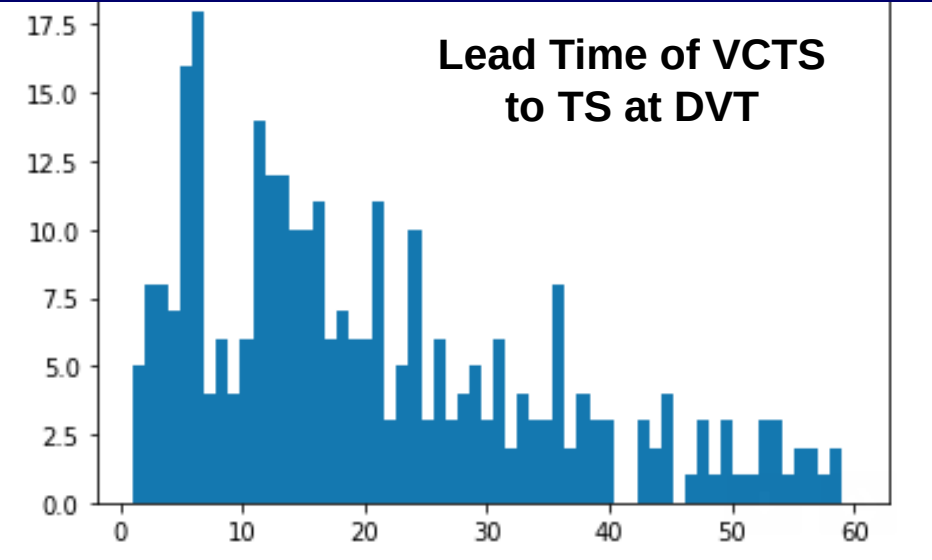
     FM130300 06012KT P6SM VCSH BKN100 BKN150
     FM130600 12010KT P6SM BKN100 BKN150
     FM131900 27012KT P6SM FEW120 SCT250=
```

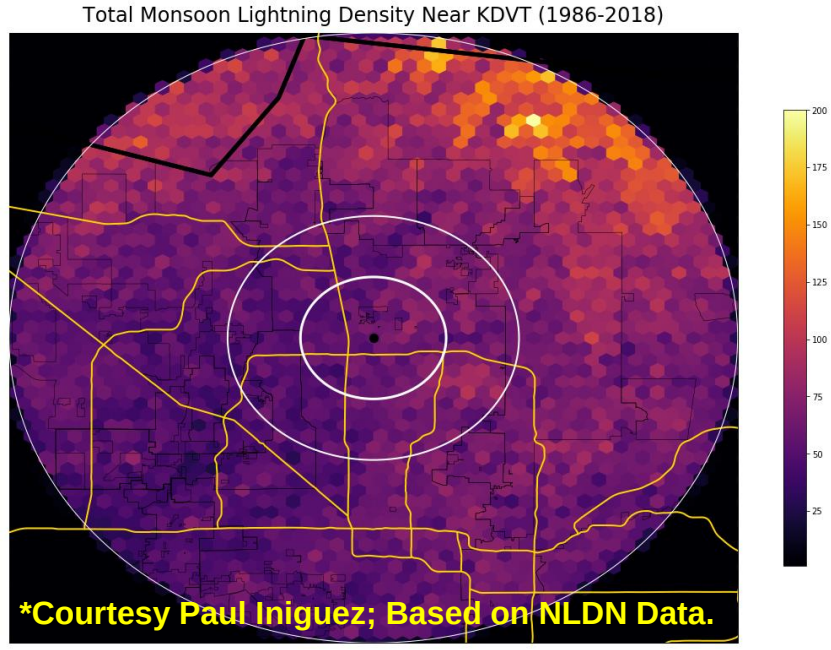
- What does a “Vicinity” group technically indicate?
  - *High confidence (≥ 50% probability)* of
  - Significant weather in the *donut-shaped area 5-10 SM from airport*
  - *Covering more than half of the period* (it’s prevailing; not a TEMPO)

- “Vicinity” groups only allowed for thunderstorms, showers, and fog
  - Not allowed in TEMPO or PROB30 groups;

Monsoon Climatology of VCTS vs. TS at DVT*

- 83% of storms producing lightning in 5-10 SM annulus first:
  - Remain VCTS 69% of the time
  - Become TS 31% of the time with a 27 min average lead time





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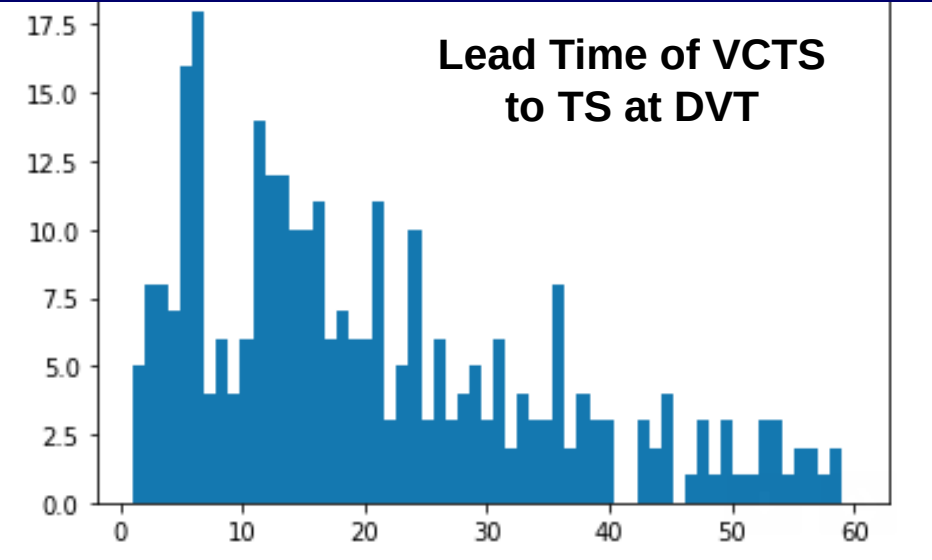
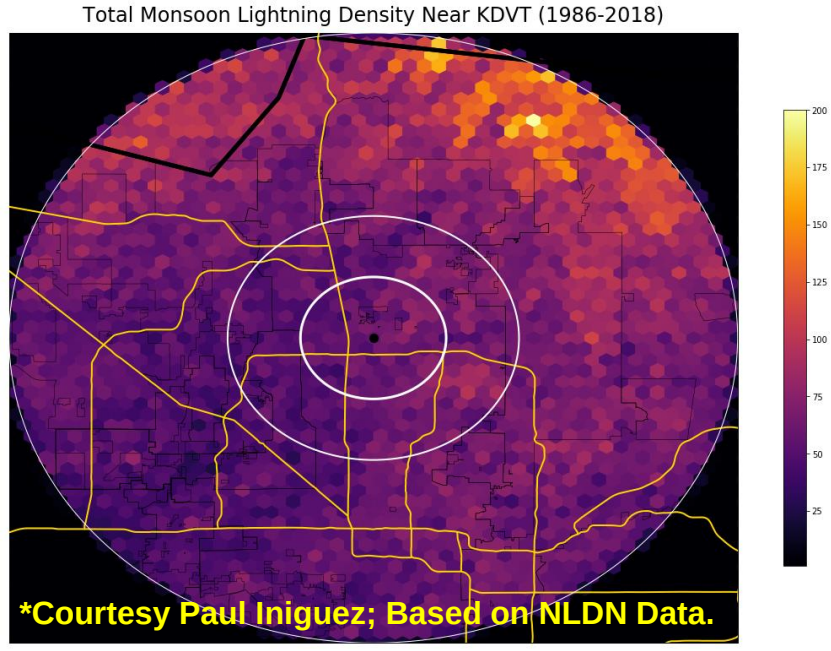




- ***VCTS is more likely than TS…..***
- ***Issuing AWWs for lightning anticipated within 5 miles (not just observed within 10 miles)***

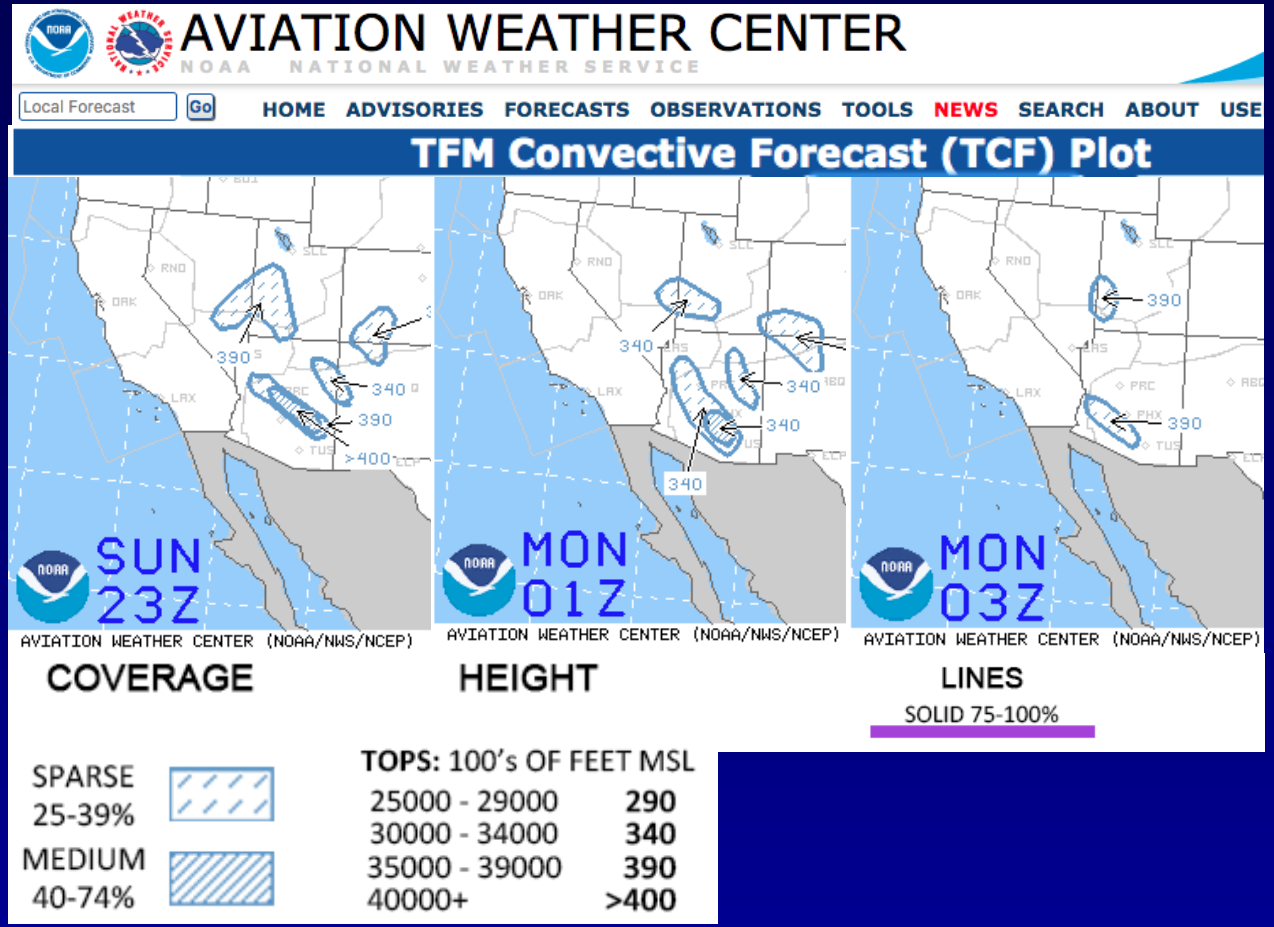
Local Convective TAF Guidelines

Time to Convection (in hours)	Probably of TS at airport		
	Slight (10-24%) or Isolated Coverage	**Chance (25-54%) or Scattered Coverage**	**Likely/Categorical (≥55%; any coverage)**
0-3 hours	Prevailing VCTS & CB **OR** Prevailing VCSH^	Prevailing VCTS & CB (TEMPO impacts?)	***Prevailing TS & CB**** (TEMPO impacts?)
3-9 hours	Prevailing VCSH^ **OR** No Mention	Prevailing VCTS & CB	***Prevailing TS & CB**** **OR** ***TEMPO TS & CB****
9-24/30 hours	No Mention	Prevailing VCTS & CB (or VCSH^), PROB30 TS & CB, **OR** No Mention	Prevailing VCTS & CB

^Use VCSH for shallow convection that will impact aircraft operations, but less than TS.

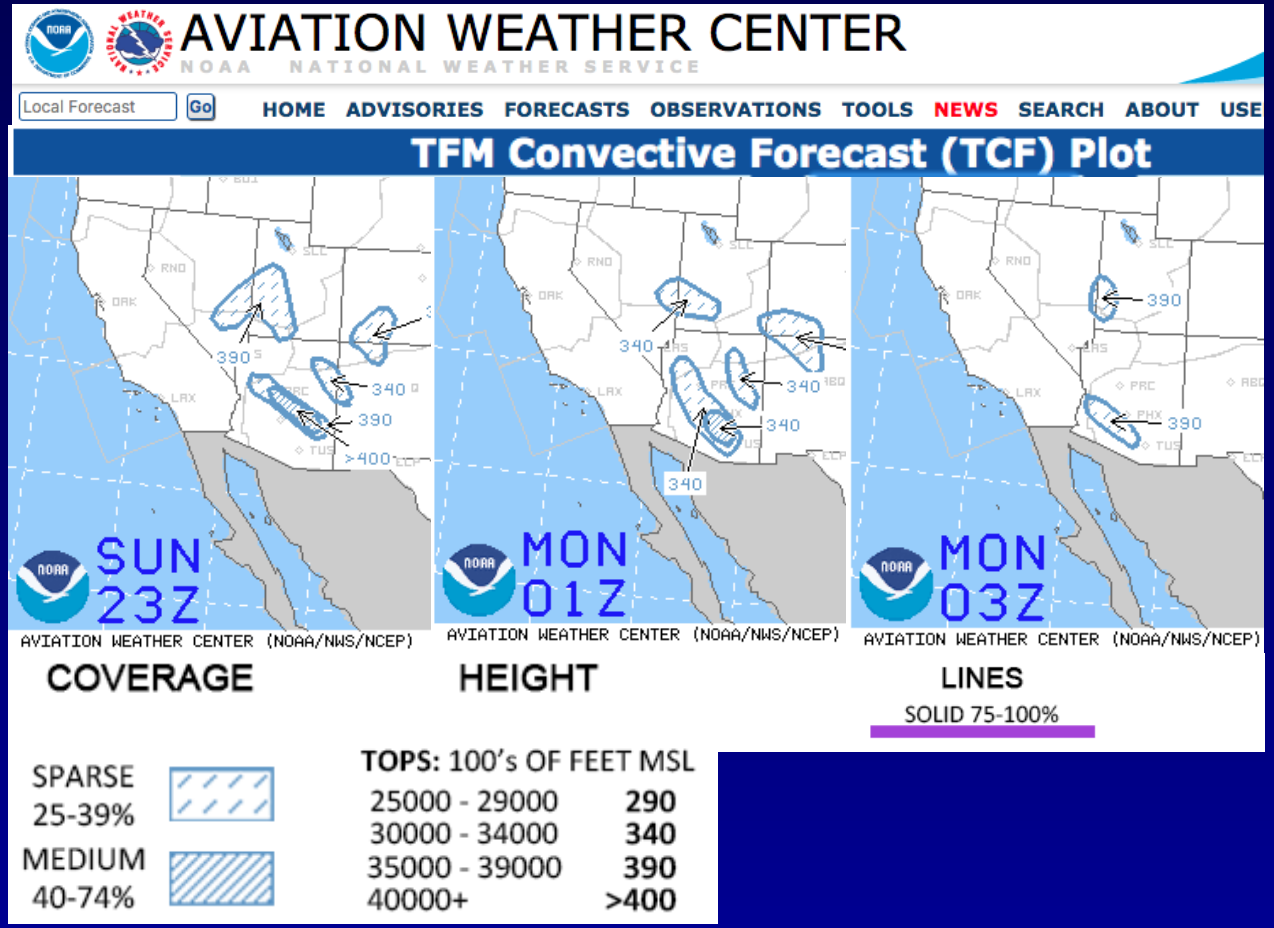
- ***Blending national DAS philosophies with the need for flexibility here in the short-term for handling isolated or slight chance convection.***

TCF Forecast and AWC/CWSU Collaboration



- High confidence (≥ 50%) forecast for areas and lines of convection
- AWC issues every 2 hrs valid at 4, 6, and 8 hrs

TCF Forecast and AWC/CWSU Collaboration



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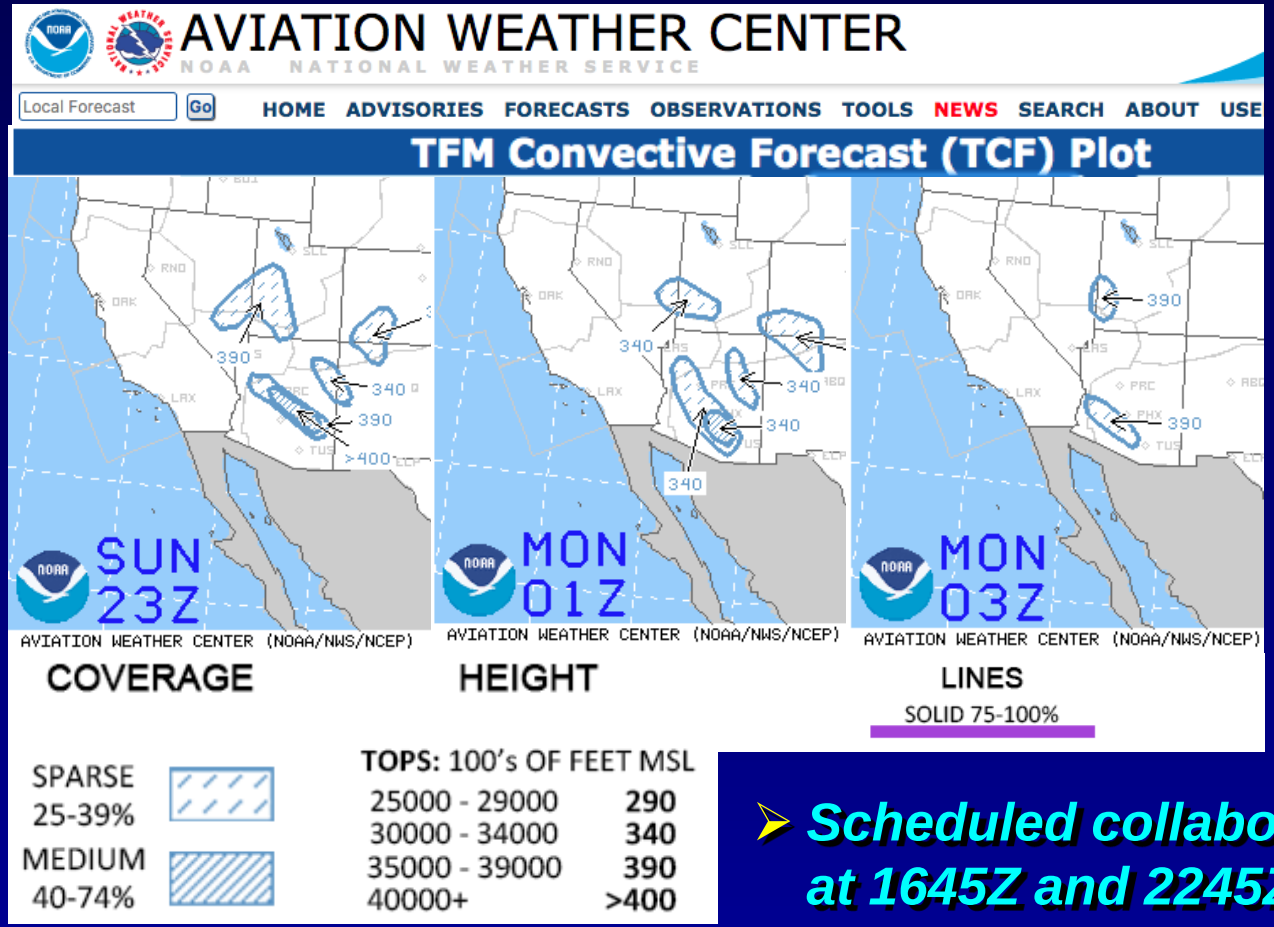

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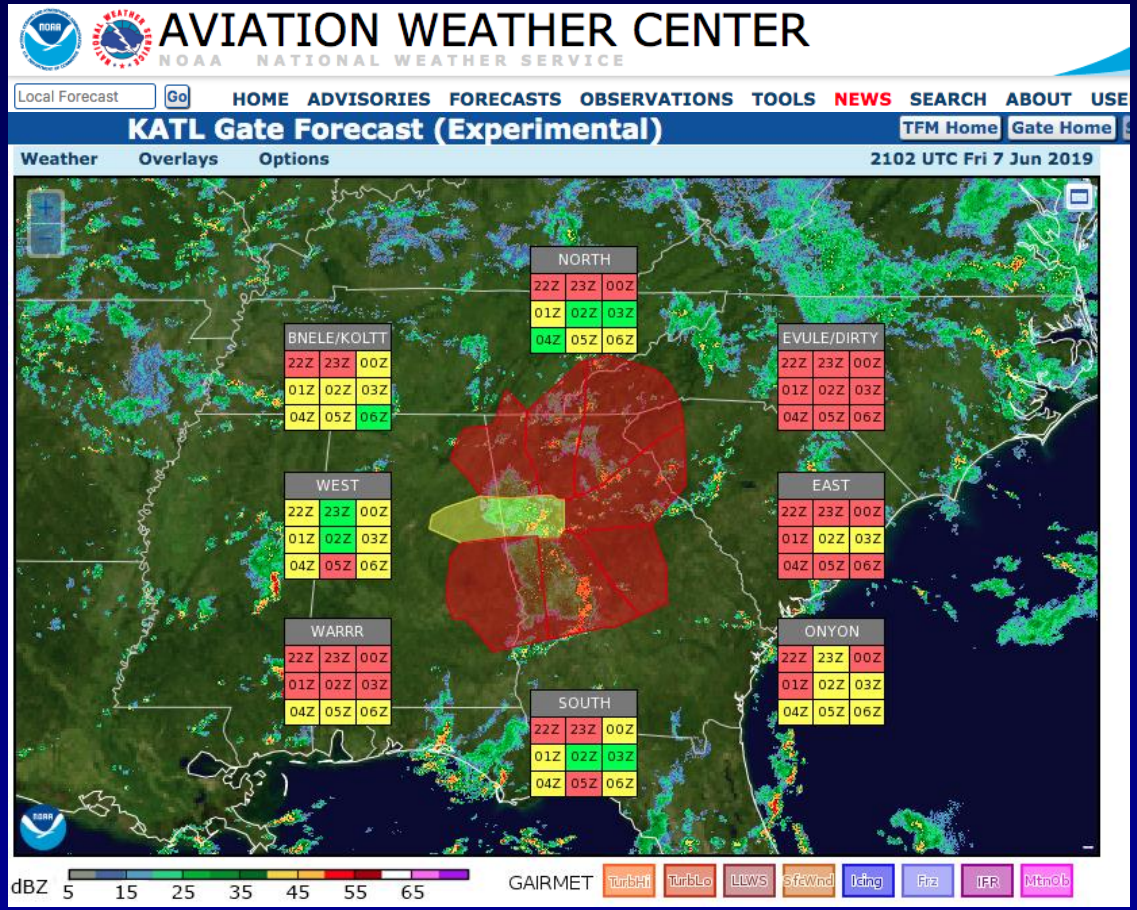
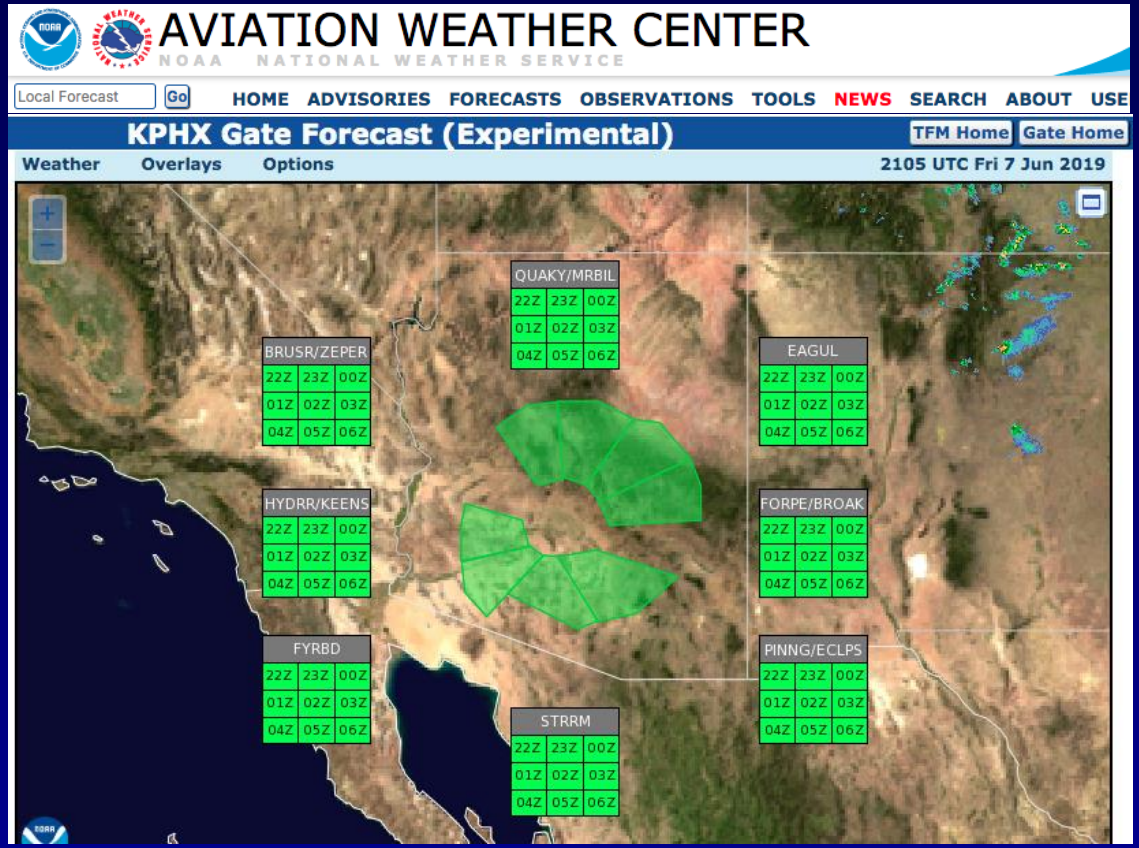
- *Locally requiring VCTS or TEMPO TS for "medium" coverage (VCTS/SH for "sparse")*
- ***Scheduled collaboration with CWSU ZAB at 1645Z and 2245Z for 18Z and 00Z TAFs***

Experimental TFM Gate Forecast



- 9-hr forecast of hourly potential for t-storm activity in each gate
  - Uses composite reflectivity from last three HRRR runs
- "Stoplight" approach:
  - Green: No sig weather
  - Yellow: ≥ 1% coverage of 25-60% TS chance
  - Red: ≥ 4% coverage of 60% TS chance

Experimental Phoenix TFM Gate Forecast



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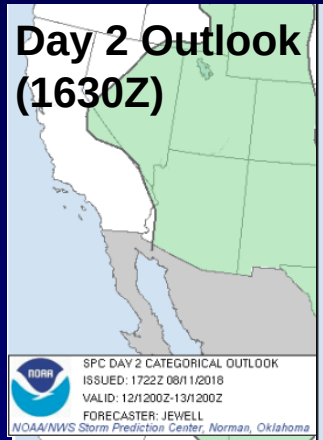
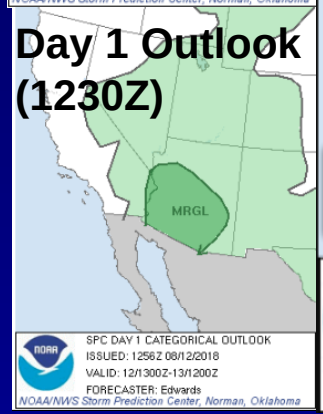
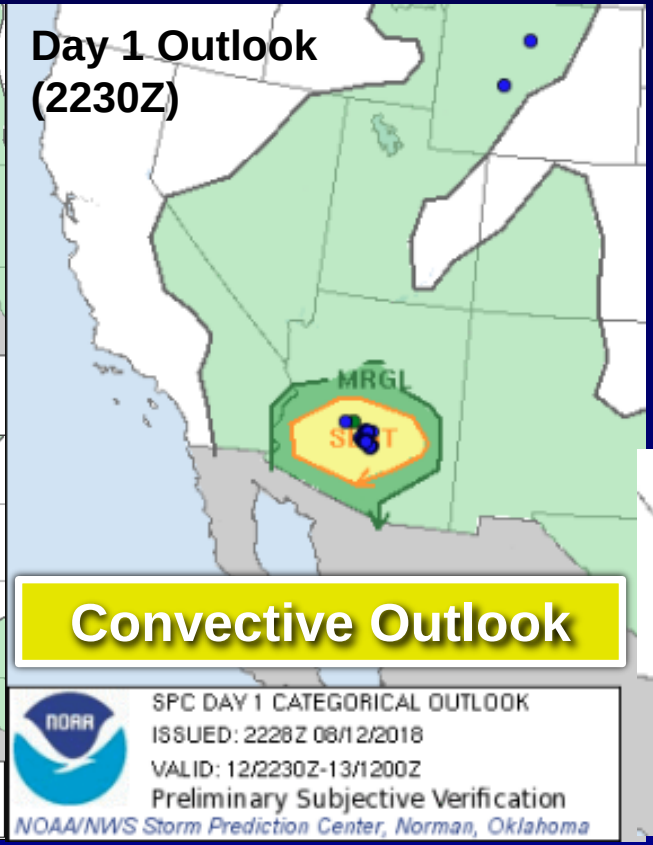
- *Resolve timing inconsistencies by amending TAF or contacting CWSU*

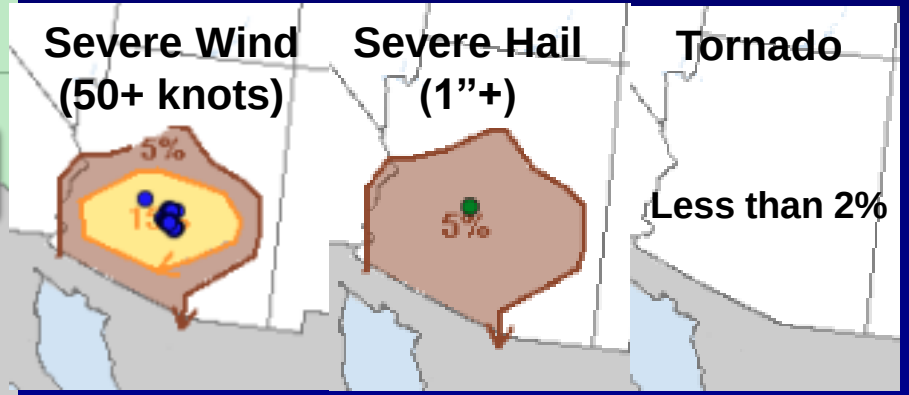
Storm Prediction Center Convective Outlooks





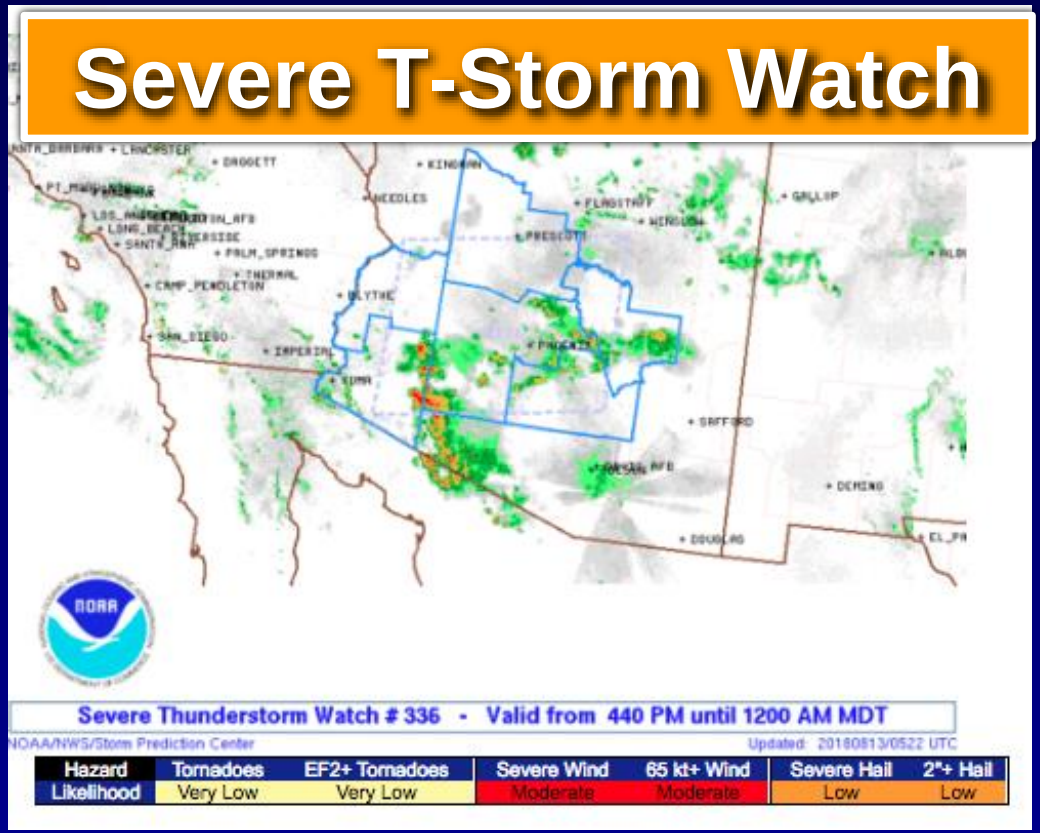


- SPC issues daily (12-12Z) convective outlooks to Day 3
  - "Marginal" Risk common (5% severe threat within 25 mi)
  - "Slight" Risk (15%) few times p/yr; → Proxy for potential WATCH



- *Recommending more aggressive outlook-watch product collaboration.*

Severe T-Storm Watch and SPC Collaboration



- Severe thunderstorm (and tornado) watches issued by SPC collaborating with WFOs
- High confidence of severe storms in effect for 4-8 hours
- Typically not issued before Severe T-Storm Warnings in Arizona, so take notice of it!
  - One last year (8/12) compared with 4 Flash Flood Watches

- *Will experiment with tools to help with identifying watch days!*

Convective Warning Products

BULLETIN - IMMEDIATE BROADCAST REQUESTED
Severe Thunderstorm Warning
National Weather Service Phoenix AZ
556 PM MST SUN AUG 12 2018

The National Weather Service in Phoenix has issued a

* Severe Thunderstorm Warning for...
  Maricopa County in south central Arizona...

* Until 645 PM MST.

* At 556 PM MST, a severe thunderstorm was located near Scottsdale Airport, or near Paradise Valley, moving west at 20 mph.

  HAZARD...60 mph wind gusts.

  SOURCE...Radar indicated.

  IMPACT...Expect damage to roofs, siding, and trees.

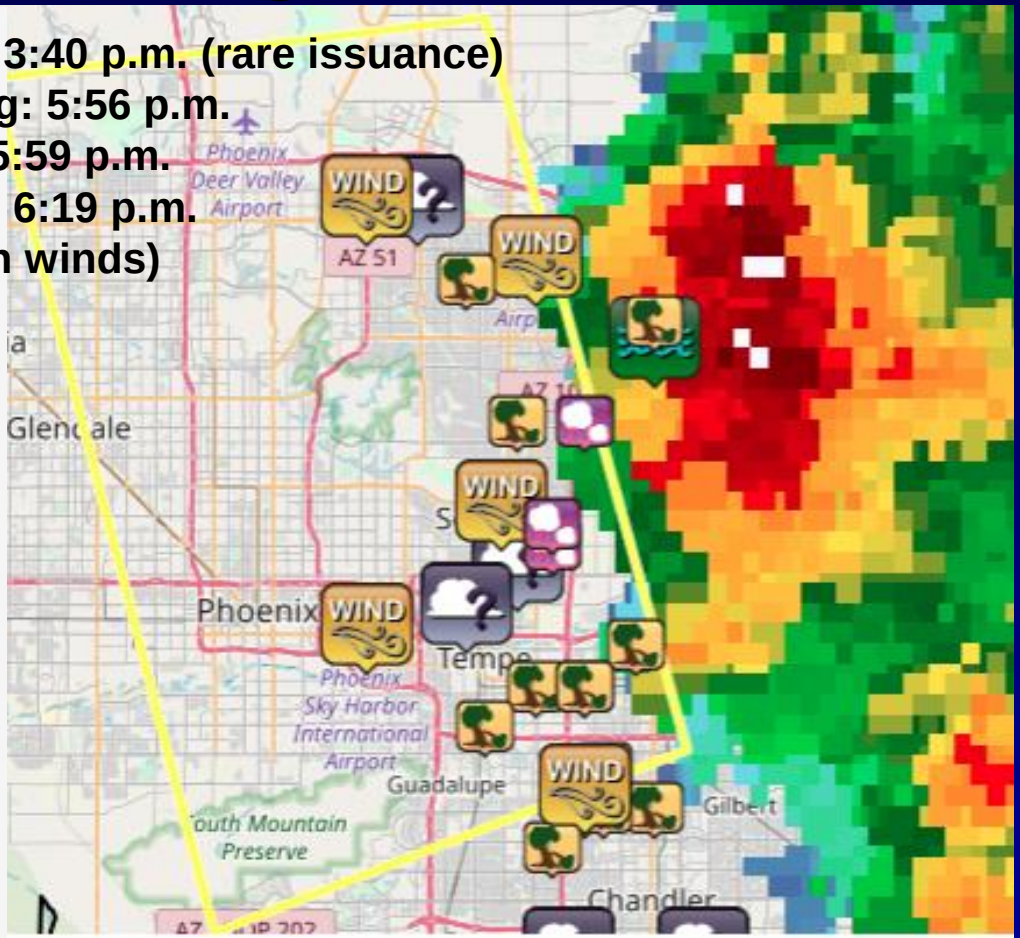
* Locations impacted include...
  Phoenix, Mesa, Glendale, Scottsdale, Tempe, Paradise Valley, Laveen, Tempe Marketplace, Papago Park, Piestewa Peak Park, Deer Valley Airport, Salt River Indian Community, North Mountain Park, South Phoenix and Arizona State Fairgrounds.

* This includes the following highways...
  AZ Interstate 10 between mile markers 141 and 159.
  AZ Interstate 17 between mile markers 195 and 218.
  AZ Route 51 between mile markers 1 and 15.

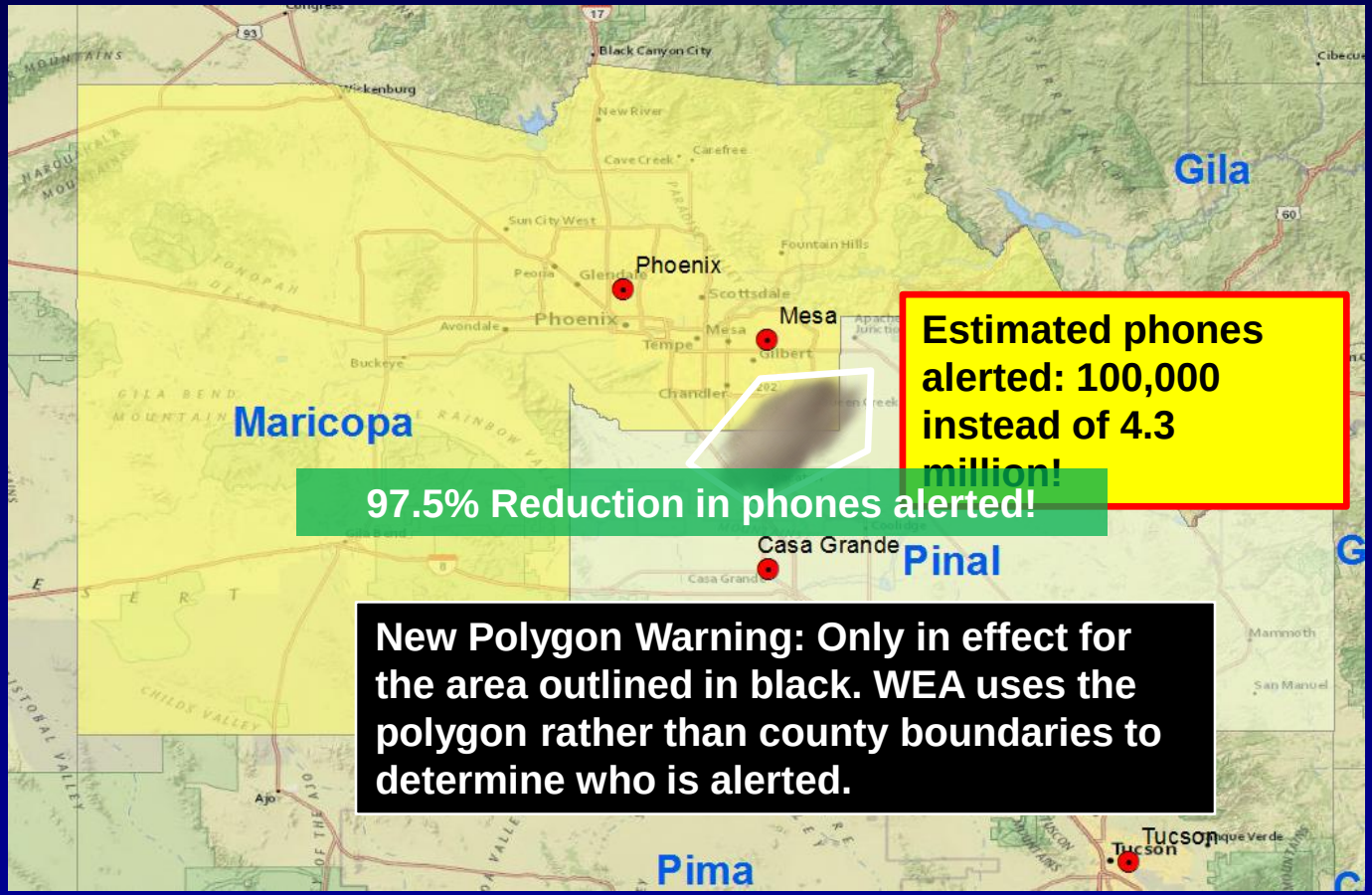
PRECAUTIONARY/PREPAREDNESS ACTIONS...

For your protection move to an interior room on the lowest floor of a building.

Watch: 3:40 p.m. (rare issuance)
Warning: 5:56 p.m.
AWW: 5:59 p.m.
Impact: 6:19 p.m.
(58 mph winds)



2nd Year of Polygon Dust Storm Warnings!



Convective Warning Products

BULLETIN - EAS ACTIVATION REQUESTED
Dust Storm Warning
National Weather Service Phoenix AZ
603 PM MST Sun Aug 12 2018

AZC013-021-130145-
/O.NEW.KPSR.DS.W.0043.180813T0103Z-180813T0145Z/
Maricopa AZ-Pinal AZ-
603 PM MST Sun Aug 12 2018

The National Weather Service in Phoenix has issued a

* Dust Storm Warning for...
  Maricopa County in south central Arizona...
  Pinal County in southeastern Arizona...

* Until 645 PM MST.

* At 603 PM MST, a wall of dust was along a line extending from New River to near Chandler Fashion Center Mall, moving west at 45 mph.

  HAZARD...Less than a quarter mile visibility.

  SOURCE...Doppler radar.

  IMPACT...Dangerous life-threatening travel.

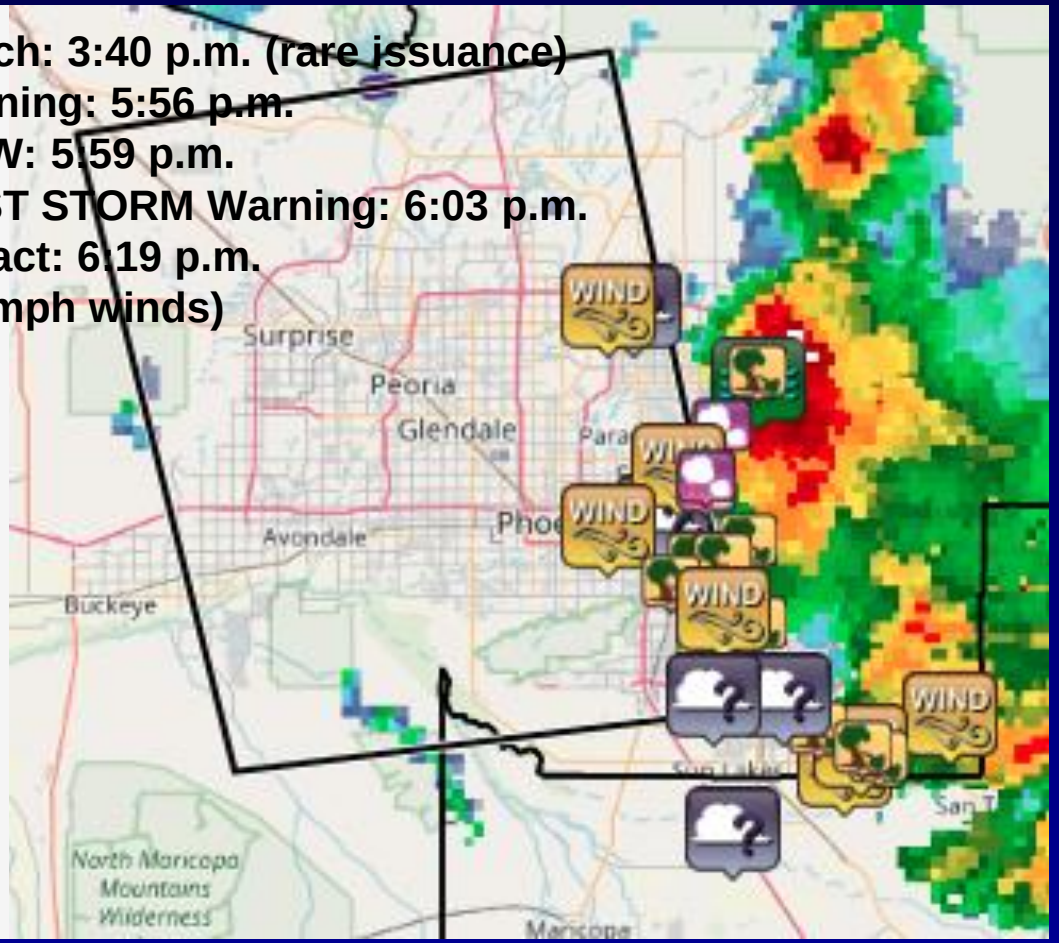
* This includes the following highways...
  AZ Interstate 10 between mile markers 120 and 164.
  AZ Interstate 17 between mile markers 195 and 229.
  AZ Route 51 between mile markers 1 and 15.

Locations impacted include...
Phoenix, Chandler, Glendale, Scottsdale, Tempe, Peoria, Surprise, Avondale, Goodyear, Buckeye, El Mirage, Paradise Valley, Tolleson, Youngtown and Waddell.

PRECAUTIONARY/PREPAREDNESS ACTIONS...

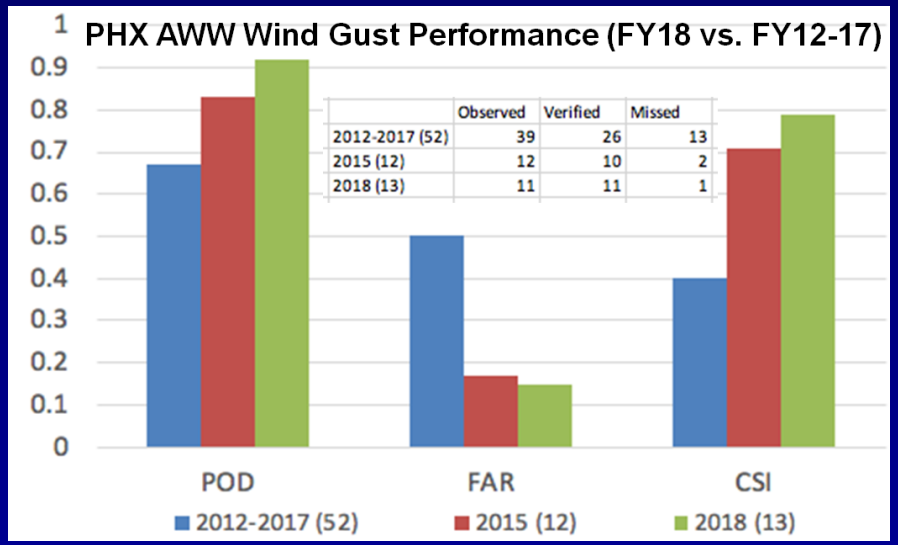
Dust storms lead to dangerous driving conditions with visibility reduced to near zero. If driving, avoid dust storms if possible. If caught in one, pull off the road, turn off your lights and keep your foot off the brake.

Watch: 3:40 p.m. (rare issuance)
Warning: 5:56 p.m.
AWW: 5:59 p.m.
DUST STORM Warning: 6:03 p.m.
Impact: 6:19 p.m.
(58 mph winds)

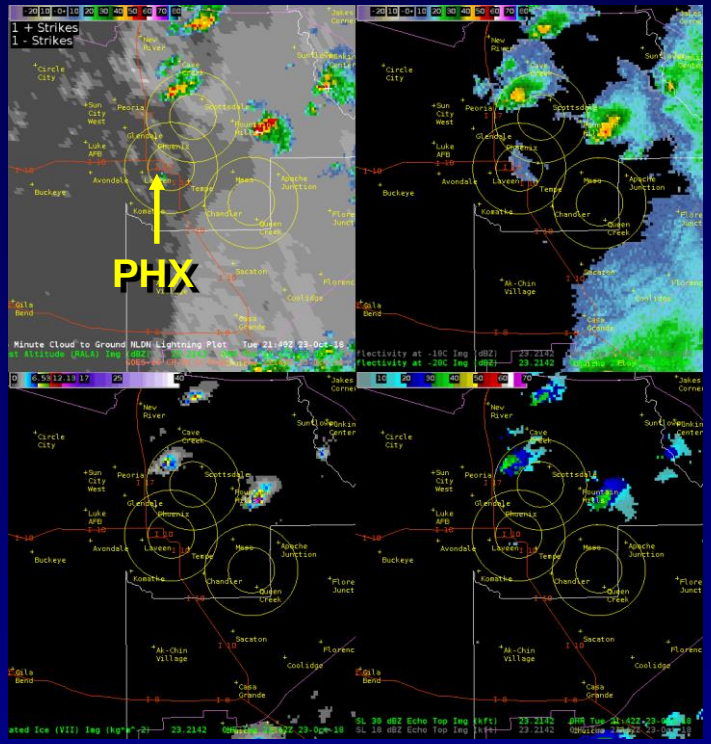


Airport Weather Warnings (AWWs)

- **Issued for PHX and DVT if:**
  - Lightning is observed within 10 miles *OR* ***anticipated within 5 miles***;
  - Winds ≥ 35 knots; and/or
  - Dust storm w/visibility ≤ ¼ mi



	Observed	Verified	Missed
2012-2017 (52)	39	26	13
2015 (12)	12	10	2
2018 (13)	11	11	1



- **Improved skill at PHX in 2018**
  - 0.92 POD vs. 0.15 FAR (0.79 CSI)
  - Average lead time 16 min

New Text Format of AWW Product and Other Changes

```
Airport Weather Warning For Sky Harbor Airport
National Weather Service Phoenix AZ
559 PM MST Sun Aug 12 2018

...AIRPORT WEATHER WARNING FOR SKY HARBOR AIRPORT IN EFFECT UNTIL
700 PM MST...

The National Weather Service in Phoenix has issued an Airport Weather
Warning for Sky Harbor Airport for strong gusty winds. Winds from the
east-northeast in excess of 35 knots are expected. Wind gusts of 45-55
knots will be possible.

Blowing dust with reduced visibility under 2 miles is also expected.
In addition, cloud to ground lightning should begin within 10 miles of
the terminal within the next 15 minutes.
```

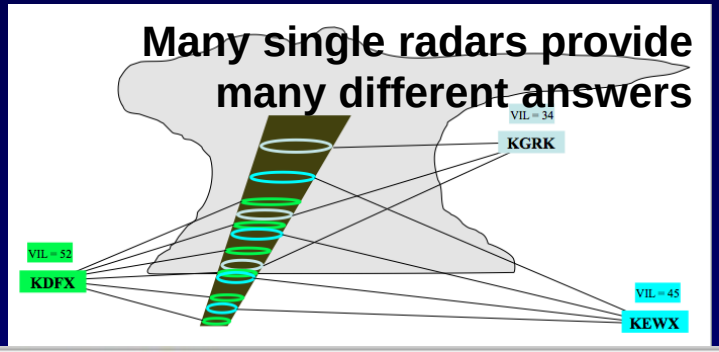
```
...Airport Weather Warning for Deer Valley Airport until 700 PM MST for
strong gusty winds and lightning...

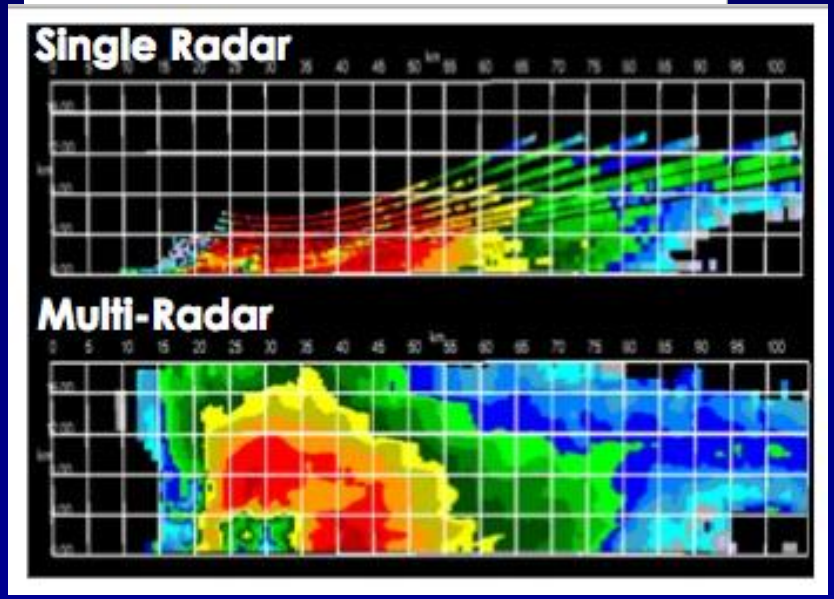
.Wind Potential...
East-Northeast winds sustained at 30-40 knots with gusts in excess of 50
knots.

.Dust Potential...
Blowing dust will reduce visibilities below 1 mile.

.Other Threats/Remarks...
Lightning has been observed within 10 miles of the airport.
```

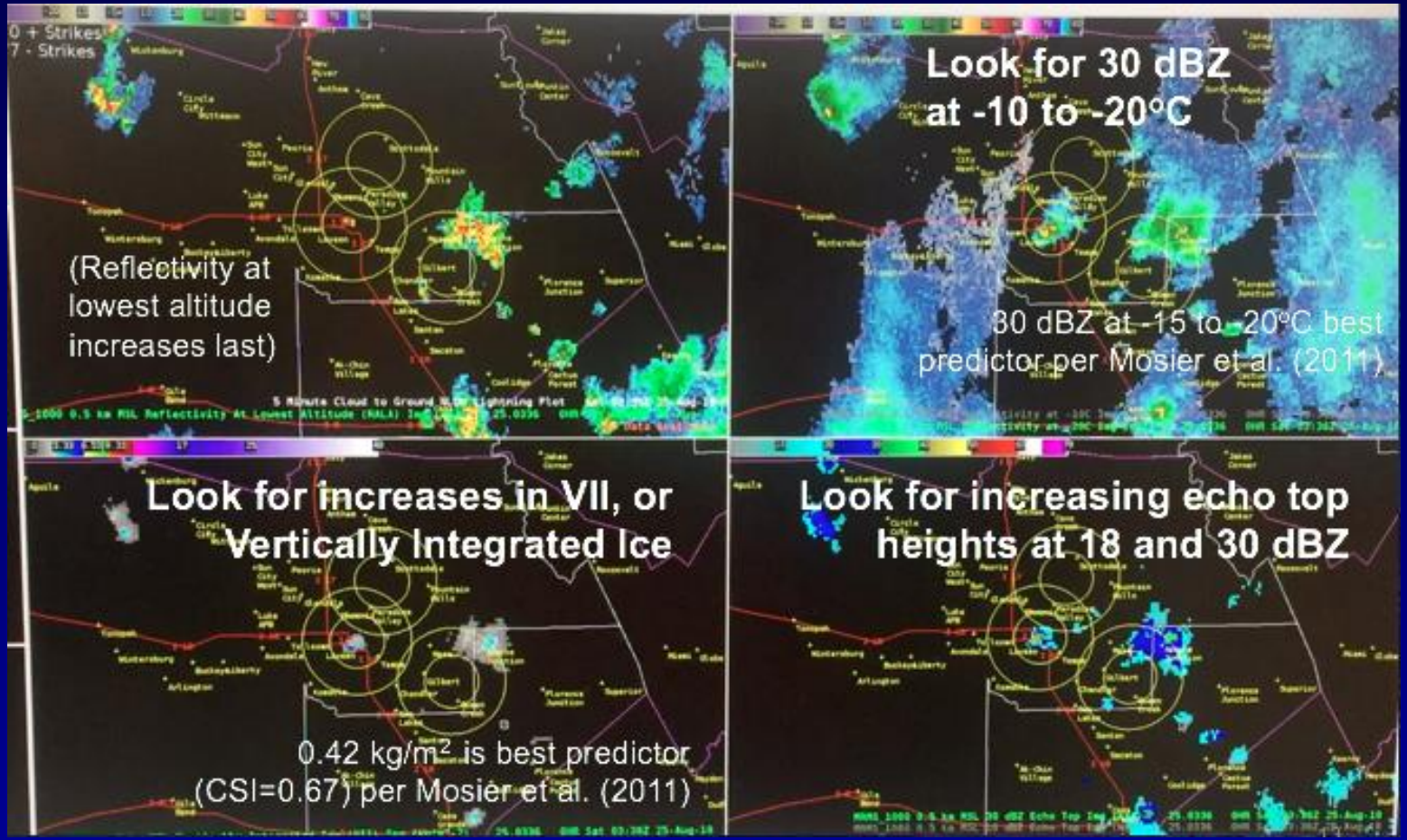
Multi-Radar, Multi-Sensor (MRMS) Products





- Used operationally since 2016
- Sources: WSR-88D and Canadian radar networks, CG lightning, RAP model, and GOES-R satellite data
- Strengths:
  - Overlapping coverage
  - Higher sampling frequency
  - Mitigates terrain blockage
- Still must analyze multiple radars for small signatures
- *More widespread adoption at WFO*

MRMS Tools for Issuing AWWs for Lightning



Southwest Aviation Weather Safety Workshop:

June 7-8, 2019 at Residence Inn Tempe Downtown/University

https://www.weather.gov/psr/saws

Questions?

Contact Information:

602-275-7004 (aviation line)

larry.hopper@noaa.gov

weather.gov/Phoenix

TAFs from 12 August 2018

```
KPHX 120907Z 1209/1312 09008KT P6SM SCT150 BKN250
     FM122000 27008KT P6SM SCT120 BKN250
     FM130300 07012G18KT P6SM SCT080 BKN150 BKN200
     FM130600 20008KT P6SM SCT100 BKN180=
```

```
KPHX 120948Z 1210/1312 13013KT P6SM SCT120 BKN250
     FM122100 28008KT P6SM SCT120 SCT250
     FM130000 02015G30KT P6SM VCTS BKN080CB BKN150 BKN200
     FM130700 10008KT P6SM SCT100 BKN180=
```

```
KPHX 121120Z 1212/1318 12008KT P6SM SCT120 BKN250
     FM122100 28008KT P6SM SCT120 SCT250
     FM130000 02015G30KT P6SM VCTS BKN080CB BKN150 BKN200
     FM130700 10008KT P6SM SCT100 BKN180=
```

```
KPHX 121502Z 1215/1318 12005KT P6SM FEW100 BKN250
     FM121900 VRB04KT P6SM FEW100 SCT250
     FM122000 28008KT P6SM SCT100 SCT250
     FM130100 03015G30KT P6SM VCTS BKN080CB BKN150 BKN200
     FM130300 10008KT P6SM SCT100 BKN180=
```

```
KPHX 121720Z 1218/1324 VRB04KT P6SM FEW100 SCT250
     FM121900 28008KT P6SM FEW100 SCT250
     FM130000 03015G30KT P6SM VCTS BKN080CB BKN150
     FM130200 28010KT P6SM BKN100 BKN150
     FM130600 11008KT P6SM SCT100 BKN200
KPHX 122056Z 1221/1324 24008KT P6SM FEW100 FEW150 SCT250
     FM130000 04020G35KT P6SM VCTS BKN080CB BKN150
     FM130200 30008KT P6SM BKN100 BKN150
     FM130600 11008KT P6SM SCT100 BKN200
     FM131900 27012KT P6SM FEW120 SCT250=
```

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KPHX 122334Z 1300/1406 29009G18KT P6SM SCT100 SCT250
     FM130045 06020G30KT 4SM BLDU VCTS BKN080CB BKN150
      TEMPO 1301/1303 06025G40KT 2SM TSRA BKN050CB
     FM130300 06012KT P6SM VCSH BKN100 BKN150
```

```
KPHX 130057Z 1301/1406 06020G35KT 3SM BLDU VCTS BKN080CB
      TEMPO 1301/1302 06030G45KT 2SM TSRA BKN050CB
     FM130230 06012KT P6SM VCSH BKN100 BKN150
```

```
KPHX 130102Z 1301/1406 06020G35KT 1/2SM BLDU VCTS BKN080CB
      TEMPO 1301/1302 06030G45KT 2SM TSRA BKN050CB
     FM130230 06012KT P6SM VCSH BKN100 BKN150
```

```
KPHX 130123Z 1301/1406 06030G50KT 1SM TSRA SCT009 BKN080CB
     FM130200 06015G30KT P6SM SHRA VCTS BKN080CB
     FM130230 06012KT P6SM VCSH BKN100 BKN150
```

```
KPHX 130133Z 1302/1406 06030G50KT 3SM TSRA BLDU SCT009 BKN080CB
     FM130210 06015G30KT P6SM SHRA VCTS BKN080CB
     FM130230 06012KT P6SM VCSH BKN100 BKN150
```

```
KPHX 130203Z 1302/1406 13015G22KT P6SM SHRA VCTS BKN090CB
     FM130230 11012KT P6SM VCSH BKN100 BKN150
     FM130300 12010KT P6SM BKN100 BKN150
```

```
KPHX 130216Z 1302/1406 13011KT P6SM -RA SCT050 BKN090 BKN120
     FM130230 11012KT P6SM VCSH BKN100 BKN150
     FM130300 12010KT P6SM BKN100 BKN150
```

Monsoon Outlooks: Hot! Maybe Wet?

- Odds strongly tilted towards a warmer than normal summer, with possibly a slight tilt towards above normal rain late monsoon