Convective Events and Impacts to Aviation Over Western Arizona During the 2017-2022 Monsoon Seasons

> Sharon Sullivan, Meteorologist, CWSU Albuquerque Roger Smith, Meteorologist, CWSU Albuquerque

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Purpose

• Perception: Western AZ is a difficult area to forecast convection and to define its impacts

• Goal: To find a relationship between different variables (CAPE, PWAT, certain synoptic patterns, etc.) that can be used as diagnostic tools for forecasting thunderstorms in this area



Purpose

• We will address meteorological variables and impacts to this area due to rapid development and timing of storms, the high national enroute impacts of convective weather on the NAS that are not highly anticipated, and the necessity of generating accurate, trusted forecasts for use by the FAA traffic flow management specialists, air traffic controllers, and commercial airline planners.

Background

• Several sources have identified northward surges of relatively cool, maritime air from the tropical Pacific into the southwestern United States via the Gulf of California every monsoon season, with the frequency and intensity varying substantially (Strensrud 1997).

 Said to be like a giant sea-breeze (Brenner 1974, Watson 1994) coastally-trapped disturbances (Pascale 2016, Fuller 2000), or also thought to be in a phase relationship with a tropical easterly wave (Strensrud 1997), MJO (Goodrich 2008), or westerly propagation of upper-level trough.



Background



• Common characteristics of these surges: drop in temperature, rise in Td (above 60 F), southerly wind shift (135-203), rise in SLP, and light winds before sensible heating and mixing dilute the signal (Hales 1972).

• Depth of this surge said to be 8000-12,000 ft (Brenner 1974).

• Average of 3 surge events per month identified at Yuma during 1977-2001 monsoon seasons (Higgins 2004).

Challenges at ZAB

- Covers over 210,000 nautical miles
- 51% of ZAB area is military airspace
- 1,463,827 aircraft operations in 2010
- Supports the 9th busiest airport in the U.S. (PHX)
- International border
- Poor radar coverage
- Complex terrain -> turbulence/ mountain wave, LLWS (common 40-70 days/ year), icing, mountain obscurations, winter events, extreme winds, blowing dust, thunderstorms (ranks 4th busiest ARTCC for convective activity



Radar Coverage at 16,500 ft.





Enroute Air Traffic Corridors in Western AZ





Methodology

 We identified 31 events across western Arizona (2017-2022) that met the criteria for thunderstorms congesting air route corridor(s) for one or both corridors for two hours or more.

• Eliminated all events between 0355-1155z, when air traffic volume is low.

• Identified 3 types of events: Gulf surges, outflow, and easterly waves.

Methodology, continued...

• From here, we narrowed it down to 3 multi-day events (lasting 2 or 3 days each) and 17 single-day events all of which were not outflow or easterly wave events.

- We looked at:
 - Precipitable Water
 - Relative Humidity
 - Mixing Ratios
 - Mixed-Layer Convective Available Potential Energy (CAPE)
 - 850-300 mb Winds



Event Frequency

• These are relatively rare events that can be difficult to forecast

• As previously mentioned, Higgens 2004 identified 3 surge events per month

• The period from 2017-2022 twenty (20) surge events which produced thunderstorms in the corridors were identified

Precipitable Water Anomalies for All Events



A comparison of meteorological variables for two events on 7/19/2021 and 8/12/2022 three hours prior to convective initiation



Precipitable Water (-3HR) Values 1.8-2.0 Inches







700-500 mb Mean Relative Humidity (-3HR) Values between 70-80 %



20210719



100-mb Mixing Ratio (-3HR) Values between 12-13 g/kg



20210719



100 mb Mixed-Layer CAPE (-3HR) Values between 250-750 J/kg









Surface-Based Lifted Index (-3HR) Values from -1 to -3









850-300 mb Winds (-3HR) Values from 155-180 degrees







Comparing Two Multi-day Events

• We looked at average conditions (moisture, instability, steering flow) that occurred for two of the multi-day events (7/19/21-7/21/21 and 8/12/22-8/14/22)

 Now, we'll look at daily composites of 500 & 700 mb heights, precipitable water, and lifted indices for the duration of these two events from the NOAA Physical Sciences Laboratory site

H5 Composites (July 2021 vs. August 2022)





500 mb-July 19-21, 2021

500 mb-August 12-14, 2022

H7 Composites (July 2021 vs. August 2022)



700mb Geopotential Height (m) Composite Mean 07/19/21 07/20/21 07/21/17 NCEP/NCAR Reanalysis



700 mb-July 19-21, 2021

700 mb-August 12-14, 2022

Precipitable Water Composites (July 2021 vs. August 2022)



July 19-21, 2021

August 12-14, 2022

Lifted Index Composites (July 2021 vs. August 2022)



July 19-21, 2021

August 12-14, 2022



Multi- vs. Single-Day Events

• We looked at composites for the two multi-day events.

Now, we'll compare those with composites of 500 & 700 mb heights, precipitable water, and lifted indices for the 17 single-day events (and now include the 8/9/22-8/10/22 event in our multi-day composite).

500 mb Height Composites (Multi- vs. Single- Day Events)



Multi-Day

700 mb Height Composites (Multi- vs. Single- Day Events)





Multi-Day

Precipitable Water Composites (Multi- vs. Single-Day Events)



Columnar Precipitable Water kg/m²2 Composite Mean (21/18 08/08/18 08/16/18 09/02/19 09/02/19 06/30/21 08/08/21 08/04/

NCEP/NCAR Reanalysis

Multi-Day

Lifted Index (Multi- vs. Single-Day Events)



Multi-Day



Impacts to Air Traffic Operations at ZAB

• We have looked at average conditions and composites for the multi- and single-day events, but what does this mean in terms of impacts for ZAB?



NAS Impacts



Radar Image on 8/12/22 at 1625Z (MMM/UCAR)



What is the Traffic Flow Management (TFM) Convective Forecast (TCF)?

- Issued 24x7 every 2 hours (with domestic operational forecaster input March 1st October 31st)
- Forecast for 4, 6, and 8 hours for high confidence areas
- Forecasts and verification available on AWC website

Areas of convection:

- Polygon coverage
 <u>25%</u>
- <u>></u> 40 dBZ reflectivity
- Echo tops ≥ FL250
- · Highly confident this will occur

Sparse 25-39% (broken hatching) /// Medium 40-74% (solid hatching) Solid lines of convection:

- Linear coverage of
 <u>></u> 75%
- <u>></u> 40 dBZ reflectivity
- ≥ 100 nautical miles in length
- Echo tops ≥ FL250
- · Highly confident this will occur

Solid Line 75-100%

Note: Lines can stand alone or be included within areas.)





TCF

TCF Home Archive Plot Preview eTCF **TFM Convective Forecast (TCF)** 20220812_1100 ~ Issuance: Latest FRI 15Z FRI 17Z 4 hour forecast 6 hour forecast Issued Aug 12 at 11Z COVERAGE HEIGHT TOPS: 100's OF FEET MSL SPARSE 25000 - 29000 290 1111 25-39% 30000 - 34000 340 MEDIUM 35000 - 39000 390 40-74% 40000+ >400 LINES SOLID 75-100% FRI 19Z

8 hour forecast



TCF Verification









Estimating the Impacts...

• In 2021, the average cost of delays for U.S. aircraft was \$80.52/minute (DOT Form 41 data for U.S. scheduled passenger airlines).

• Cost for delays usually attributed to crew, fuel costs, maintenance, passenger delay, etc. (Kara 2013).


Estimating the Impacts on 8/12/22

• For August 12th event: 4538 total ops, 23 delays to commercial aircraft -> 2 to LAS, 20 to PHX, 1 due to TMI (Traffic Management Initiative)

• Average delay of 30 min, Total delay ~ 690 minutes

 ~\$80.52 per aircraft/minute x 690 minutes= approximately \$55,558.80 total additional expense



Conclusions

• Through this study, meteorological variables that favored these events were identified:

- → Moisture
- → Instability
- \rightarrow Mean Flow

Moisture Variables (PWAT)





Multi-Day Composite Anomaly

Single-Day Composite Anomaly



Moisture Variables (Relative Humidity)





Moisture Variables (Mixing Ratio)

100-mb Mixing Ratio (g/kg)





Instability (Mixed-Layer CAPE)





Instability (Lifted Index)

Lifted Index





Steering Flow



Conceptual model of initiation and propagation of surge events as defined by Fuller 2000

Steering Flow - Example of H7/H5 Streamlines During Surge Event 8/12/22-8/13/22



220812/1700V001 700-500 mb mean Petterssen frontogenesis (fill) 220812/1700V001 700-500 mb mean height, temperature and wind



8/13/2022 18007

8/12/2022, 1700Z



Synoptic Patterns



→ 700 mb

Mean 500 mb Pattern





500 mb Multi-Day Composite Mean

500 mb Multi-Day Climatology

Mean 700 mb Pattern





700 mb Multi-Day Composite Mean

700 mb Multi-Day Climatology

Conclusions, continued...

 Operationally, the meteorological variables that typify these events can be added to the toolbox for forecasting. This research can help boost confidence in forecasts (including TCF forecast improvements for ZAB) and improve NAS safety.

 The single vs. multi-day averages can aid in distinguishing between the two events, allowing ZAB forecasters to give better lead time for multi-day events to Operations Managers (OM's) and our Traffic Management Unit (TMU) for planning and staffing purposes.



Thank you!

Questions?

sharon.sullivan@noaa.gov

roger.smith@noaa.gov





8/9-8/10/22



500mb Geopotential Height (m) Composite Mean 08/09/22 08/10/22 NCEP/NCAR Reanalysis





700mb Geopotential Height (m) Composite Mean 08/09/22 08/10/22 NCEP/NCAR Reanalysis



3240

3210

3180



Surface Lifted Index (K) Composite Mean 08/09/22 08/10/22 NCEP/NCAP Reapplysis





Precipitable Water (-3h)









220812/1300 precipitable water (in) lowest 400 mb



1.0 1.5 2.0 220813/1800 precipitable water (in) lowest 400 mb



Precipitable Water (-6h)









220812/1000 precipitable water (in) lowest 400 mb



220813/1500 precipitable water (in) lowest 400 mb



220814/1400 precipitable water (in) lowest 400 mb

Mixed-Layer CAPE (-3h)













Mixed-Layer CAPE (-6h)













700-500 mb mean Relative Humidity (-3h)





220812/1300V001 700mb hght/wind/temp/700-500mb mean RH (fill)











700-500 mb mean Relative Humidity (-6h)















80 220812/1000V001 700mb hght/wind/temp/700-500mb mean RH (4111)

100 mb Mixing Ratio (-3h)









220812/1300 Deep layer mstr flux cyonc and 100 mb mean mixing rate







220814/1400 Deep layer mstr flux counc and 100 mb mean mixing ratio

100 mb Mixing Ratio (-6h)















laver mstr flux

850-300 mb Winds (-3h)



220814/1700V001 850 - 300 mb mean wi

850-300 mb Winds (-6h)



500 mb Height Composites



NCEP/NCAR Reanalysis



5800

5650

5600

5550

500mb Geopotential Height (m) Composite Mean 08/12/22 08/13/22 08/14/22 NCEP/NCAR Reanalysis



500mb Geopotential Height (m) Composite Mean 08/12/22 08/13/22 08/14/22 07/19/21 07/20/21 07/21/21 NCEP/NCAR Reanalysis



500mb Geopotential Height (m) Composite Mean 08/09/22 08/10/22 08/12/22 08/13/22 08/14/22 07/19/21 07/20/21 07/21/21 NCEP/NCAR Reanalysis



700 mb Height Composites

3210

3180

3120

3090

3060

3030

3000

2970



NCEP/NCAR Reanalysis



700mb Geopotential Height (m) Composite Mean 08/12/22 08/13/22 08/14/22 07/19/21 07/20/21 07/21/21 NCEP/NCAR Reanalysis



700mb Geopotential Height (m) Composite Mean 08/12/22 08/13/22 08/14/22 NCEP /NCAR Reanalysis



700mb Geopotential Height (m) Composite Mean 08/12/22 08/13/22 08/14/22 07/19/21 07/20/21 07/21/21 08/09/22 08/10/22 NCEP/NCAR Regnalysis



Lifted Index Composite Means



Surface Lifted Index (K) Composite Mean 07/19/21 07/20/21 07/21/21 NCEP/NCAR Reanalysis



16

14

10

Surface Lifted Index (K) Composite Mean 08/12/22 08/13/22 08/14/22 NCEP/NCAR Reanalysis



Surface Lifted Index (K) Composite Mean 08/12/22 08/13/22 08/14/22 07/19/21 07/20/21 07/21/21 NCEP/NCAR Reanalysis



14





Surface Lifted Index (K) Composite Mean 18 08/16/18 09/30/18 07/24/19 09/02/19 06/30/21 07/30/21 08/08/21 08/04/22

Precipitable Water Composite Means



Columnar Precipitable Water kg/m^2 Composite Mean 07/19/21 07/20/21 07/21/21 NCEP/NCAR Reanalysis



Columnar Precipitable Water kg/m*2 Composite Mean 08/12/22 08/13/22 08/13/22 NCEP/NCAR Reanalysis



50

35

30

25

Columnar Precipitable Water kg/m² Composite Mean 08/12/22 08/13/22 08/14/22 07/20/21 07/21/21 NCEP/NCAR Reanalysis







Columnar Precipitable Water kg/m*2 Composite Mean 3 08/16/18 09/30/18 07/24/19 09/02/19 06/30/21 07/30/21 08/08/21 08/04/22



2 types of events: Gulf surge (Thermodynamically driven, explosive C.I. even with discrete cells) ; outflow off the Mogollon Rim after main push of 23-03z (cold pool) :

- August 8-18th
- August 8th and 17th events eventually morphed into 2nd events from outflow from the Rim

• Average onset 19z

• Average duration = 6 hours

• Average lead time = 1.2 hours



Soundings

• Soundings: Ct near 100 degrees, Mixing ratios (peak in SPC climo around mid Aug) 925 mb avg for 15/16 and above avg for 17/18, 850 mb avg (except for abv avg 18th), 700 mb abv avg (except for avg for 15th), 500 mb (15th avg, 16th below avg, 17-18th abv avg)



1 hr before CI: MLCAPE near 2000 J/kg; PWAT near/ above 2; LR near 6-6.5; SW-SE 850-300 mb flow (veering) 8th- 14th -> from 15th counterclockwise flow , 16-18th clockwise flow

• 18th had strong westerly anvil winds, BRN, DCAPE > 1500 to the west, 250 mb divergence, weak 700-500 mb lapse rates, converging 0-2 km SR winds, mix ratio dec, 100+ CIN, sfc TD 40-50, EHI to south (shear in CO River Valley)

Cost of Delays

OPSNET : Delays : Standard Report

From B10002 Tp 8310022																						
		1		System Impi	aot Delays													System Impa	ot Delays			
							Occurred At Delays						By Class					By Cauca			Time	
							TMI From				Abre	No.										
Date	Faoility	Total Ops	Total Delays	TMI To	Dep	Abrn	Local	Non- Local	Total Ooo At	Total Local Dep	Dect To Delays	AC	AT	GA	MI	Wx	Vol	Equip	Rwy	Other	Avg (Min)	Total (Min)
08/01/2022	Z/B	4589		1. 0	0 0	1.1.1		0	11	0	0	0	1	0	0	1	0.:	0	0	0	89.00	89
08/02/2022	Z/8	4459	(0 0	0	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0
08/03/2022	Z/B	4753		1 0	0		i 0	0	1	a	0	1	0	0	0	1	0	0	0	0	21.00	21
08/04/2022	Z/B	4621	0.3	2 0	0		0	0	2	0	0	2	0	0	0	2	0	0	0	a	17.00	34
08/05/2022	Z/8	4495	1	0 0	0		0 0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0
08/06/2022	Z/B	3974		0 0	0		a a	0	0	۵	0	0	0	0	0	0	0	0	0	a	0.00	0
08/07/2022	Z//8	4341		0 0	0	ī	0 0	0	0	a	0	0	0	0	0	0	0	0	0	0	0.00	a
08/08/2022	Z/8	4428		0 0	0	- 7	0 0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0
08/09/2022	Z/B	4258		5 0	0		5 0	0	5	0	0	5	0	0	0	4	1	0	0	0	20.00	100
08/10/2022	Z/AB	4156	(0 0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0
08/11/2022	Z/8	4731		0 0	0		0 0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0
08/12/2022	Z/B	4538	28	16	0	21	5 0	ō	25	a	0	23	0	3	0	26	0	0	0	0	30.00	780
08/13/2022	Z/B	3874		0 0	0	1	a a	0	0	o	0	0	0	0	0	0	0	0	0	0	0.00	0
08/14/2022	Z/AB	4209		0 0	0		0 0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0
08/15/2022	Z/B	4748		1	0		0 0	0	0	٥	0	4	0	0	0	0	1	0	0	0	44.00	44
08/16/2022	Z/8	4326		1 6	0		0	0	1	0	0	1	0	0	0	1	0	0	0	0	34.00	34
08/17/2022	Z/B	4507	0.0	0 0	0		0 0	0	0	0	ō	0	0	0	0	0	0	0	0	0	0.00	0
08/18/2022	Z/B	4744	20	10 0	0	20	0 0	0	20	Ū.	0	20	0	0	0	20	0	0	0	0	16.00	320
08/19/2022	Z/AB	4726		1 0	0	1		0	1	0	0	1	0	0	0	0	1	0	0	0	16.00	16
08/20/2022	ZAB	3728		0 0	0		0 0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	a
08/21/2022	Z/B	4321	28	9 0	0	25	0	0	29	0	0	29	0	0	0	29	0	0	0	0	23.00	667
08/22/2022	ZAB	4398		2 0	0		2 0	0	2	D	0	0	2	0	0	0	2	0	0	0	22.00	44
08/23/2022	ZAB	4246		0 0	0	ī	0 0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0
08/24/2022	ZAB	4458		0 0	0	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0
08/25/2022	Z//B	4776	(0 0	0		0 0	0	D	0	0	0	0	0	0	0	0	0	0	0	0.00	0
08/26/2022	ZAB	4579	(0 0	0		0 0	0	0	0	ō	0	0	0	0	0	0	0	0	0	0.00	0
08/27/2022	Z/AB	3875		1 0	0		0	0	1	0	0	1	0	0	0	0	0	0	0	1	40.00	40
08/28/2022	ZAB	4352		0 0	0		0 0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	a
08/29/2022	Z/AB	4500	14	4 0	0	1	0	0	4	0	0	4	0	0	0	2	2	0	0	0	22.00	88
08/30/2022	ZAB	4306	1	11	0	11	0	0	11	۵	0	11	0	0	0	-11	0	0	0	a	29.00	319
08/31/2022	ZAB	4595		3 0	0		0	0	3	0	0	3	0	0	0	з	0	0	0	0	9:00	27
Sub-Total for ZAB		136611	108	18 2	2 0	106	5 0	0	106	D	0	102	3	3	0	100	7	0	0	1	24.29	2623
Total :		138811	10	18 2	2 0	105		0	108	0	0	102	3	3	0	100	7	0	0	1	24.29	2822

Har John - Altons AC + AC Carlor, H = 40 Tail, Hg = Average, Dep + Departure, Date = Destitution, Equip = Equipment; GA + General-Autors (MI = Million, MI =

Report created on Tue Mar 14 11:02:23 EDT 2023 Sources: The Operations Network (DPSNET) Show data notices.

OPSNET : Delays : Delay Types Report

From 811/2022 To 8/31/2022 | Facility=ZAB

									System imp	aot Delays																		
Date	Facility																		Occurred AT	Delays								
		Total				TMI To				Departure					Airborne					TMI From					Coourred At			
		Delays	Avg	Tot Min	Max Min	Delays	Avg	Tot Min	Max Min	Delays		Avg Min	Tot Min	Max Min	Delays	Avg		Tot Min	Max Min	Delays		Avg Min	Tot	Max Min	Delays	Avg Min	Tot Min	Max Min
08/01/2022	ZAB		89	89	89	0	0	0	0		0	0	0	0		1	89	89	89		0	0	0	0	1	89	89	9 89
08/03/2022	ZAB		21	21	21	0	0	0	0		0	0	0	0		1	21	21	21		0	0	0	0	1	21	21	1 21
08/04/2022	ZAB	2	17	33	17	0	0	0	0		0	0	0	0		2	17	33	17		0	0	0	0	2	17	33	3 17
08/09/2022	ZAB	5	5 20	101	27	0	0	0	0.		0	0	0	0		5	20	101	27		0	.0	0	0	5	20	101	1 27
08/12/2022	ZAB	26	30	792	52	1	19	19	19		0	0	0	0		15	31	773	52		0	0	0	0	25	31	773	3 52
08/15/2022	ZAB		44	44	44	1	44	44	44		0	0	0	0		0	0	0	0		0	0	0	0	0	0	0	0 0
08/16/2022	ZAB		34	34	34	0	0	0	0		0	0	0	0		1	34	34	34		0	0	0	0	1	34	34	4 34
08/18/2022	ZAB	20	16	320	31	0	0	0	0		O	0	0	0		20	16	320	31		0	0	0	a	20	16	320	31
08/19/2022	ZAB		16	16	16	0	0	0	0		O	0	a	0		1	16	15	15		0	0	0	0	1	16	16	5 16
08/21/2022	ZAB	29	23	670	46	0	0	0	0		0	0	0	0		19	23	670	46		0	0	0	0	29	23	670	46
08/22/2022	ZAB	2	22	43	24	0	0	0	0		0	0	0	0		2	22	43	24		0	0	0	0	2	22	43	3 24
08/27/2022	ZAB		40	40	40	0	0	0	0		0	0	0	0		1	-40	40	40		0	.0	0	0	1	40	40	0 40
08/29/2022	ZAB	4	22	88	41	0	0	0	0		0	0	0	0		4	22	88	41		0	0	0	0	4	22	88	8 41
08/30/2022	ZAB	11	29	324	66	Π	0	0	0		0	0	0	0		H	29	324	66		0	0	0	0	11	29	324	4 66
08/31/2022	ZAB	3	9	27	11	0	0	0	0		0	0	0	0		3	9	27	11		0	0	0	0	3	9	27	7 11
Sub-Total for ZAB		108	24	2642	89	2	32	63	44		0	0	0	0	1	16	24	2579	89		0	0	0	0	105	24	2579	9 89
Total :		103	24	2642	89	2	82	63	44		0	0	0	0	1	8	24	2679	39		0	0	0	0	108	24	2679	8 89

Mare information about this report.

Report created on Tue Mar 14 1858 17 EDT 2023 Scenae: The Operations Network (DPSNET) Show data notices.

1.	1) 20170803/04,	1855Z-0055Z	
2.	2) 20180710,	0025Z-0355Z	
3.	3) 20180816/17,	1855Z-0025Z	
4.	4) 20190724,	1155Z-1455Z	
5.	5) 20190902,	0055Z-0355Z	
6.	6) 20220804,	1155Z-1725Z	
7.	7) 20220810/11	1955Z-0155Z	
8.	8) 20220813/14	2125Z-0255Z	
9.	9) 20220814/15	2025Z-0355Z	
10.	1) 201708, 10/11	2125Z-0255Z	
11.	2) 201709, 8/9	2355Z-0355Z	
12.	4) 201807, 21	1155Z-1655Z	
13.	1) 202107, 20/21	2225Z-0055Z	
14.	2) 202107, 21/22	2225Z-0325Z	
15.	3) 202107, 29/30	2125Z-0155Z	
16.	5) 202108, 8,	.9 2225Z-0125Z	
17.	9) 2	202208, 121555Z01855Z (Outside of the morning/evening pushes)	
18.	10) 202208, 17/18	2255Z-0255Z	
19.			
20.	1 Outflow) 20170716,	0150Z-0350Z	
21.	2 Outflow) 202108	811, 0055Z-0355Z (This one was a monster!)	
22.	4) 202107, 30	1525Z-1825Z (Outside of the morning/evening pushes)	
23.	3) 201807, 11	1755Z-2155Z (Outside of the morning/evening pushes)	
24.	11) 202208, 24	0055Z-0355Z (Outflow Event)	
25.	12) 202209, 23	1825Z-2055Z (Outside of the morning/evening pushes)	
26.	8) 202208, 9	1855Z-2255Z (Outside of the morning/evening pushes)	
27.	13) 202209, 29/30	1955Z-2325Z (Outside of the morning/evening pushes) *	
28.	5) 201809, 30	1825Z-2225Z (Outside of the morning/evening pushes)	
29.	7) 202107, 19	1955Z-2255Z (Outside of the morning/evening pushes)	
30.	6) 202107, June30, July	/ 1 2225Z-0125Z * tropical	
31.	6) 202108, 30/31	2025Z-0355Z * tropical	
32.	7) 202108, Aug31/Sep1	1 18257-00257 * tropical	


• Tops generally under-forecast on TCF verification

- talked to dan / pete (impacts to LAS/SAN traffic and sometimes LAS, there was a day last year for storms stretching from Mex to LAS that resulted in aircraft holding for several hours. Date? Last August? -> BZA and BXK both blocked (holding)
 SAN departures through BZA to PHX and BXK (merger) -> arrivals and departures (compression at FL250 can also cause issues), have ot go up through DRK (aka BRUSR arrivals) → operationally relevant to PSP
- If all 3 blocked, LAS may delay (around Peach Springs)
- Size of gaps? Pete . Estimate costs, diversions, fuel . How to assess impactful? Gates blocked for 2 hours?
- Perception: this is a difficult area to fcst for (impacts)
- Goal: correlation between different variables, cape, pw's -> null case ; diagnostic tool , certain synoptic patterns
- American AL? Cost
- unpredictability, rapid development (timing) -> high national enroute, impacts, not highly anticipated
- Operational impacts -> if we see this, then X
- present her research on convective weather to the American Meteorological Society. Her research boosted confidence in forecasts, helped operators avoid convective weather, and improved safety.
- research has identified <u>TCF</u> accuracy improvements, boosted confidence in the forecasts, helped operators avoid convective weather, and improved NAS safety.
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• discussion addressed the unpredictable impacts and risks of convective weather on the NAS and the necessity of generating accurate, trusted forecasts for use by FAA traffic flow management specialists, air traffic controllers, and commercial airline planners.

Talking Points

- 2 different patterns (Gulf moisture*-> explosive CI, outflow from Rim-> after main push, cold pool)
- Consistent surface pattern from June 24th-August 25th (500 mb high over Great Basin, 700 mb high over SW U.S.)
- PWAT's over 2", MLCAPE > 1000 J/kg (week of August 13-20th)
- Soundings: Ct near 100 degrees, Mixing ratios (peak in SPC climo around mid Aug) 925 mb avg for 15/16 and above avg for 17/18, 850 mb avg (except for abv avg 18th), 700 mb abv avg (except for avg for 15th), 500 mb (15th avg, 16th below avg, 17-18th abv avg)
- 18th had strong westerly anvil winds, BRN, DCAPE > 1500 to the west, 250 mb divergence, weak 700-500 mb lapse rates, converging 0-2 km SR winds, mix ratio dec, 100+ CIN, sfc TD 40-50, EHI to south (shear in CO River Valley)
- 2 hr lead time on case on 18th
- Aug 8-18th Avg onset shortly aftr 19z, duration 6 hours, avg lead time about 1.2 hours
- Tops generally under-forecast on TCF verification
- How big is area?

1 hr before CI: MLCAPE near 2000 J/kg ; PWAT near/ above 2 ; LR near 6-6.5 ; SW-SE 850-300 mb flow (veering) 8th-14th -> from 15th counterclockwise flow , 16-18th clockwise flow

Thermo driven 2 types of events: gulf surge (explosive Ci), , off rim (after main push, cold pool) 2011 -> lingering for 8+ hours , shear in CO River Valley Lead time *

8th - 12z from 00z night before, 00-06z \rightarrow Gulf then Rim 22-01z

9th - 00z -12z 10th \rightarrow 00-05z (Gulf)

10th - 12z-15z, 18z-06z \rightarrow 19-01z Gulf

11th - 18z -05z 12th \rightarrow 20-05z Gulf

12th - 15z med -06z \rightarrow 20-06z Gulf

13th - 12z-15z, 18z (med) -12z 14th \rightarrow 21-03z (Gulf)

14th - 18z (med) -05z 15th \rightarrow 21-02z (Gulf)

15th- 18z -03z \rightarrow 21-00z (Gulf)

16th - 18z-03z \rightarrow 20-04z (Gulf)

17th - 19z (03z med) -10z 18th \rightarrow 20-07z (Gulf then Rim)

18th - 00z-12z \rightarrow 22-02z (Gulf)

Avg onset 19z, avg duration 6 hours , avg lead time (1.2 hrs)

https://www.spc.noaa.gov/publications/dial/wafmode.pdf

- For instance, strong linear low-level convergence often contributes to rapid upscale linear growth, especially if the boundary motion relative to the mean cloud-layer wind prevents storms from moving away from the boundary shortly after initiation
- the thermodynamic environment is often in a state of transition,

- "Dryline" boundary outlined on SPC surface maps (BIG discovery for 3/9/23) *
- Discrete



ZAB Overview

NEXRAD 1KH HOSAIC 21 AUG 16 03 2







STATISTICS FOR SW AZ 2018-2021



SW AZ Verified Event And Mogollon Rim Verified Event 12Z HREF Sfc Dewpoint Forecast at 18Z 20190923 Vs. 20180728



