

# Weather Impacts on UAV Flight Availability for Agricultural Purposes in Oklahoma

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# Objectives

- Determine feasibility of drone flight during various times of the year in Oklahoma
- Determine the number of flyable periods per day for various tolerance levels
- Determine the frequency of weather conditions that made flight unfeasible



# Fixed Wing versus Rotary

	Fixed Wing	Rotary
Cruising Speed	High	Low
Coverage	Large	Small
Take Off Area	Large	Very Small
Wind Resistance	High	Low*

- Rotary wing UAVs can cover less ground in the same period of time but are faster to deploy
- Fixed wing can cover much larger areas but take more takeoff space and deployment time



\*Can be accounted for in software at the cost of decreased battery life



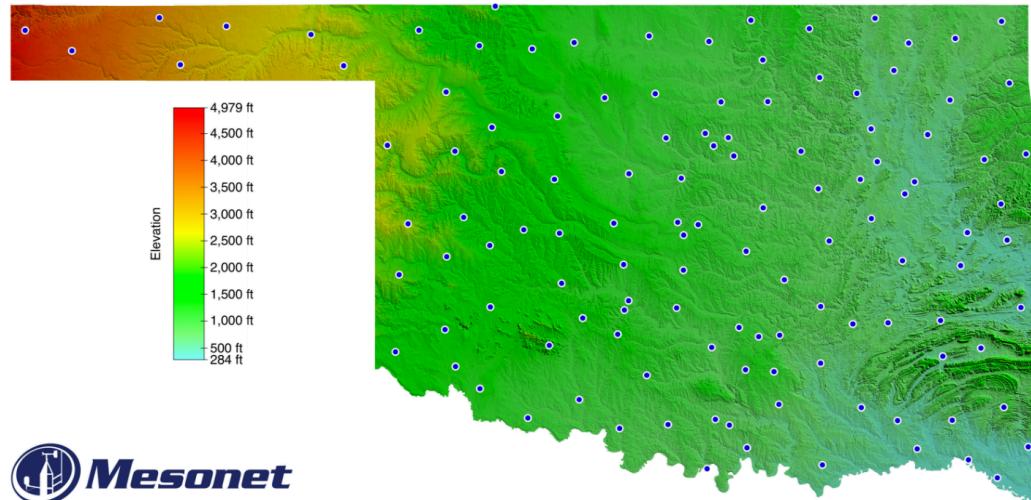
# Thresholds

Usage	Maximum Precipitation	Time from Solar Noon	Maximum Wind Speed	Maximum Wind Gust	Minimum Solar Radiation
Livestock Monitoring	0	N/A	15 mph	18 mph	150 W/M <sup>2</sup>
Color Photography	0	N/A	10 mph	15 mph	300 W/M <sup>2</sup>
Crop Consultant	0	+/- 3 Hours	10 mph	10 mph	600 W/M <sup>2</sup>
Research	0	+/- 2 Hours	5 mph	10 mph	600 W/M <sup>2</sup>



# Data Collection

- Oklahoma Mesonet
- 141 sites statewide
- 20 retired or moved, 121 active



# Data Format

- 1 file per day of observations per site
- Tab delimited
- 938,617 files
- Observations every 5 minutes, 288 per day
- 01/01/1994-12/31/2015

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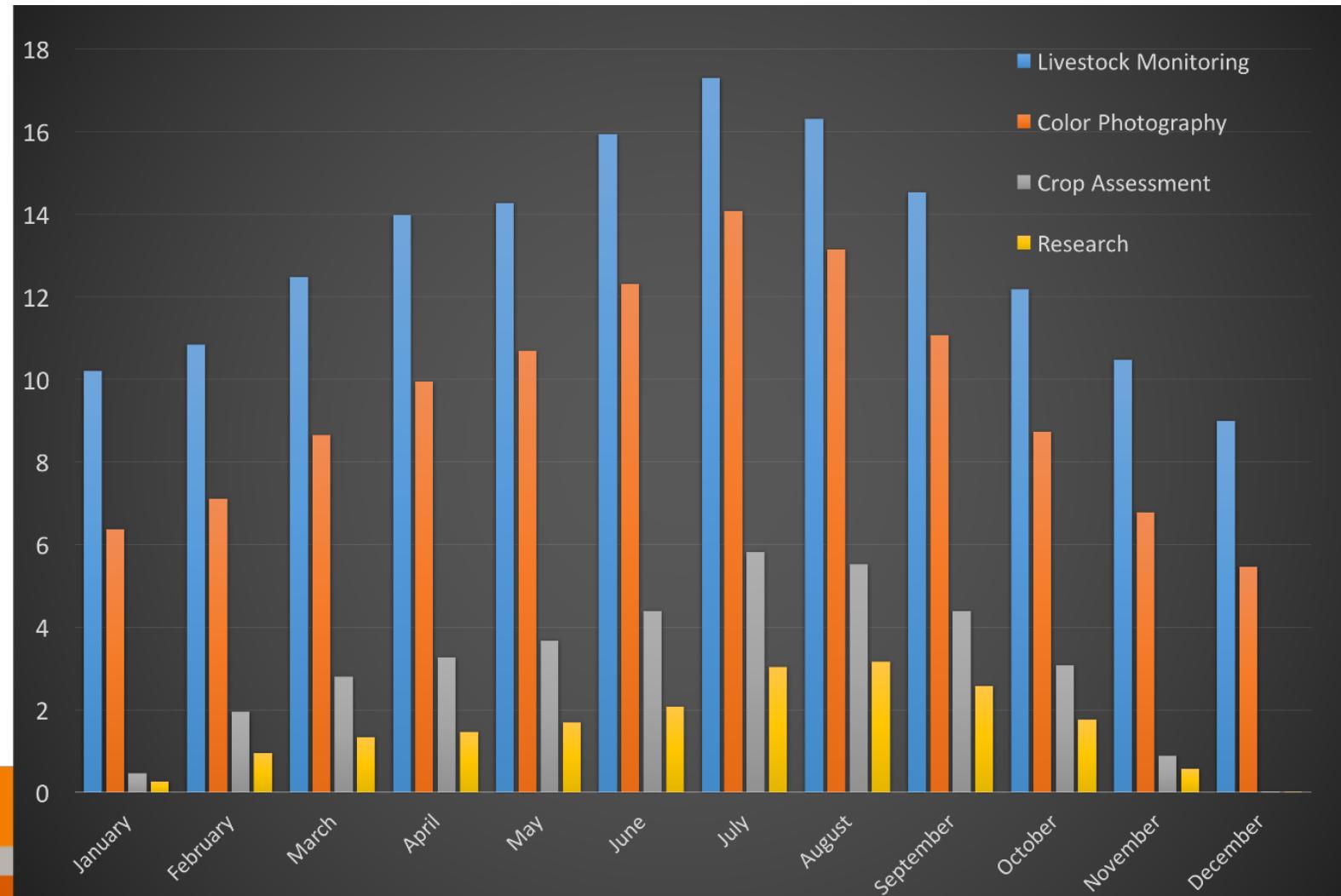
STID	STNM	TIME	RELH	TAIR	WSPD	WVEC	WDIR	WSDS	WSSD	WMAX	RAIN	PRES	SRAD	TA9M	WS2M	TS10	TB10	TS05	TS25	TS60	TR05	TR25	TR60
BIXB	10	0	59	12.7	2.3	2.3	146	5.3	0.1	2.7	0.00	988.87	0	17.6	0.1	10.4	11.5	10.3	9.9	11.3	1.52	1.43	1.48
BIXB	10	5	61	12.0	2.4	2.4	143	2.8	0.1	2.6	0.00	988.87	0	17.4	0.1	-995	-995	-995	-995	-995	-995	-995	-995
BIXB	10	10	64	11.8	2.3	2.3	141	2.6	0.1	2.6	0.00	988.83	0	16.9	0.0	-995	-995	-995	-995	-995	-995	-995	-995
BIXB	10	15	65	11.7	2.4	2.3	135	3.5	0.1	2.6	0.00	988.83	0	16.7	0.1	-995	-995	-995	-995	-995	-995	-995	-995
BIXB	10	20	67	11.5	2.4	2.4	141	4.1	0.1	2.6	0.00	988.83	0	16.7	0.1	-995	-995	-995	-995	-995	-995	-995	-995
BIXB	10	25	67	11.6	2.4	2.4	140	2.8	0.2	2.9	0.00	988.79	0	17.0	0.1	-995	-995	-995	-995	-995	-995	-995	-995
BIXB	10	30	67	11.7	2.5	2.5	137	3.8	0.2	2.9	0.00	988.79	0	16.8	0.8	10.4	11.2	10.3	10.0	11.3	1.52	1.45	1.51
BIXB	10	35	66	11.5	2.2	2.2	138	5.0	0.1	2.5	0.00	988.82	0	16.3	0.4	-995	-995	-995	-995	-995	-995	-995	-995
BIXB	10	40	66	11.4	2.0	2.0	137	4.3	0.1	2.4	0.00	988.85	0	16.0	0.0	-995	-995	-995	-995	-995	-995	-995	-995
BIXB	10	45	66	11.6	2.2	2.2	150	4.4	0.3	3.0	0.00	988.78	0	16.2	0.0	10.3	11.0	10.3	10.0	11.3	-995	-995	-995
BIXB	10	50	66	11.3	2.3	2.3	148	3.5	0.3	3.0	0.00	988.70	0	16.0	0.0	-995	-995	-995	-995	-995	-995	-995	-995
BIXB	10	55	67	11.4	2.4	2.4	151	3.4	0.3	3.3	0.00	988.69	0	16.1	0.2	-995	-995	-995	-995	-995	-995	-995	-995
BIXB	10	60	68	10.8	2.3	2.3	148	3.7	0.2	2.9	0.00	988.68	0	15.8	0.4	10.3	10.9	10.3	10.0	11.3	1.50	1.44	1.48
BIXB	10	65	69	10.3	2.9	2.8	153	3.2	0.2	3.2	0.00	988.55	0	15.9	0.8	-995	-995	-995	-995	-995	-995	-995	-995
BIXB	10	70	71	10.4	3.0	3.0	152	3.3	0.2	3.4	0.00	988.52	0	15.7	0.9	-995	-995	-995	-995	-995	-995	-995	-995
BIXB	10	75	70	10.9	2.7	2.7	152	3.6	0.2	3.2	0.00	988.60	0	15.6	0.6	10.3	10.7	10.2	10.0	11.3	-995	-995	-995
BIXB	10	80	68	11.1	2.0	2.0	145	6.1	0.2	2.8	0.00	988.81	0	15.5	0.1	-995	-995	-995	-995	-995	-995	-995	-995
BIXB	10	85	70	10.0	2.3	2.3	145	4.8	0.2	2.9	0.00	988.77	0	15.5	0.8	-995	-995	-995	-995	-995	-995	-995	-995
BIXB	10	90	70	10.3	2.9	2.9	154	5.3	0.4	4.3	0.00	988.59	0	15.5	1.0	10.3	10.5	10.2	10.0	11.3	1.52	1.45	1.49
BIXB	10	95	69	11.4	3.4	3.4	161	4.6	0.3	4.6	0.00	988.50	0	15.4	1.3	-995	-995	-995	-995	-995	-995	-995	-995
BIXB	10	100	64	12.6	3.3	3.2	167	7.1	0.4	4.2	0.00	988.59	0	15.5	1.4	-995	-995	-995	-995	-995	-995	-995	-995
BIXB	10	105	60	13.2	2.6	2.6	174	6.7	0.3	3.6	0.00	988.67	0	15.6	1.3	10.2	10.4	10.2	10.1	11.3	-995	-995	-995
BIXB	10	110	57	13.4	2.6	2.6	175	5.7	0.2	3.4	0.00	988.67	0	15.8	1.2	-995	-995	-995	-995	-995	-995	-995	-995
BIXB	10	115	57	13.4	2.6	2.6	176	5.9	0.3	3.2	0.00	988.66	0	16.0	1.1	-995	-995	-995	-995	-995	-995	-995	-995
BIXB	10	120	55	13.9	2.4	2.3	178	7.8	0.3	3.2	0.00	988.66	0	15.8	1.2	10.2	10.3	10.1	10.1	11.3	1.51	1.45	1.49
BIXB	10	125	53	13.9	2.3	2.3	181	7.2	0.4	3.8	0.00	988.66	0	15.8	1.4	-995	-995	-995	-995	-995	-995	-995	-995
BIXB	10	130	53	14.0	2.7	2.7	176	6.5	0.4	3.9	0.00	988.64	0	15.8	1.8	-995	-995	-995	-995	-995	-995	-995	-995
BIXB	10	135	54	13.8	2.6	2.6	177	6.7	0.3	3.4	0.00	988.69	0	15.8	1.6	10.2	10.1	10.1	10.1	11.3	-995	-995	-995
BIXB	10	140	53	14.1	2.5	2.4	183	5.9	0.3	3.0	0.00	988.69	0	15.8	1.5	-995	-995	-995	-995	-995	-995	-995	-995
BIXB	10	145	52	14.3	2.2	2.2	185	8.4	0.3	3.1	0.00	988.56	0	15.7	1.2	-995	-995	-995	-995	-995	-995	-995	-995
BIXB	10	150	52	14.1	2.5	2.5	182	9.0	0.4	3.8	0.00	988.49	0	15.7	1.3	10.2	10.0	10.1	10.1	11.3	1.52	1.45	1.51
BIXB	10	155	51	14.6	3.0	3.0	182	7.7	0.6	4.1	0.00	988.46	0	15.8	2.2	-995	-995	-995	-995	-995	-995	-995	-995
BIXB	10	160	52	14.3	3.5	3.5	178	7.0	0.4	4.9	0.00	988.47	0	15.7	2.5	-995	-995	-995	-995	-995	-995	-995	-995
BIXB	10	165	52	14.5	3.9	3.9	180	8.5	0.7	5.9	0.00	988.38	0	15.8	2.9	10.1	9.9	10.0	10.1	11.3	-995	-995	-995
BIXB	10	170	50	14.9	3.8	3.8	186	8.9	0.6	5.5	0.00	988.37	0	15.7	3.2	-995	-995	-995	-995	-995	-995	-995	-995
BIXB	10	175	51	14.8	3.7	3.6	188	9.2	0.5	5.1	0.00	988.41	0	15.6	2.8	-995	-995	-995	-995	-995	-995	-995	-995
BIXB	10	180	52	14.4	3.3	3.2	194	9.8	0.5	4.3	0.00	988.42	0	15.4	2.6	10.1	9.8	10.0	10.1	11.3	1.52	1.45	1.51
BIXB	10	185	53	14.1	3.3	3.3	196	10.8	0.5	5.1	0.00	988.37	0	15.0	2.7	-995	-995	-995	-995	-995	-995	-995	-995
BIXB	10	190	54	13.9	3.2	3.1	199	9.2	0.5	4.6	0.00	988.41	0	14.8	2.3	-995	-995	-995	-995	-995	-995	-995	-995
BIXB	10	195	54	13.8	3.1	3.0	200	10.3	0.4	4.1	0.00	988.44	0	14.7	2.3	10.1	9.7	10.0	10.1	11.3	-995	-995	-995
BIXB	10	200	54	13.7	2.9	2.8	202	8.6	0.4	4.0	0.00	988.45	0	14.4	2.3	-995	-995	-995	-995	-995	-995	-995	-995
BIXB	10	205	55	13.4	3.0	3.0	197	7.6	0.4	3.9	0.00	988.40	0	14.2	2.2	-995	-995	-995	-995	-995	-995	-995	-995
BIXB	10	210	56	13.1	3.1	3.1	196	8.1	0.3	3.9	0.00	988.35	0	14.1	2.2	10.1	9.6	10.0	10.1	11.3	1.52	1.45	1.49
BIXB	10	215	57	13.2	2.7	2.7	195	10.4	0.4	3.9	0.00	988.26	0	13.9	2.1	-995	-995	-995	-995	-995	-995	-995	-995
BIXB	10	220	57	13.0	2.7	2.7	197	8.5	0.4	3.7	0.00	988.27	0	13.8	2.1	-995	-995	-995	-995	-995	-995	-995	-995
BIXB	10	225	58	13.0	2.7	2.6	193	9.0	0.5	4.2	0.00	988.27	0	13.7	2.1	10.0	9.5	10.0	10.1	11.3	-995	-995	-995
BIXB	10	230	58	12.8	2.6	2.5	198	9.1	0.5	4.0	0.00	988.27	0	13.6	1.7	-995	-995	-995	-995	-995	-995	-995	-995
BIXB	10	235	58	12.8	2.6	2.5	196	9.4	0.4	3.7	0.00	988.22	0	13.6	1.8	-995	-995	-995	-995	-995	-995	-995	-995
BIXB	10	240	58	12.8	3.0	3.0	196	10.0	0.5	4.3	0.00	988.23	0	13.6	2.2	10.0	9.4	10.0	10.1	11.3	1.52	1.45	1.51
BIXB	10	245	59	12.7	2.9	2.9	195	7.3	0.4	3.9	0.00	988.18	0	13.4	2.2	-995	-995	-995	-995	-995	-995	-995	-995
BIXB	10	250	59	12.7	3.0	3.0	190	10.4	0.5	4.1	0.00	988.18	0	13.4	2.2	-995	-995	-995	-995	-995	-995	-995	-995
BIXB	10	255	59	12.8	3.1	3.0	194	11.2	0.5	4.4	0.00	988.22	0	13.4	2.3	10.0	9.4	9.9	10.1	1			

# Working with Data

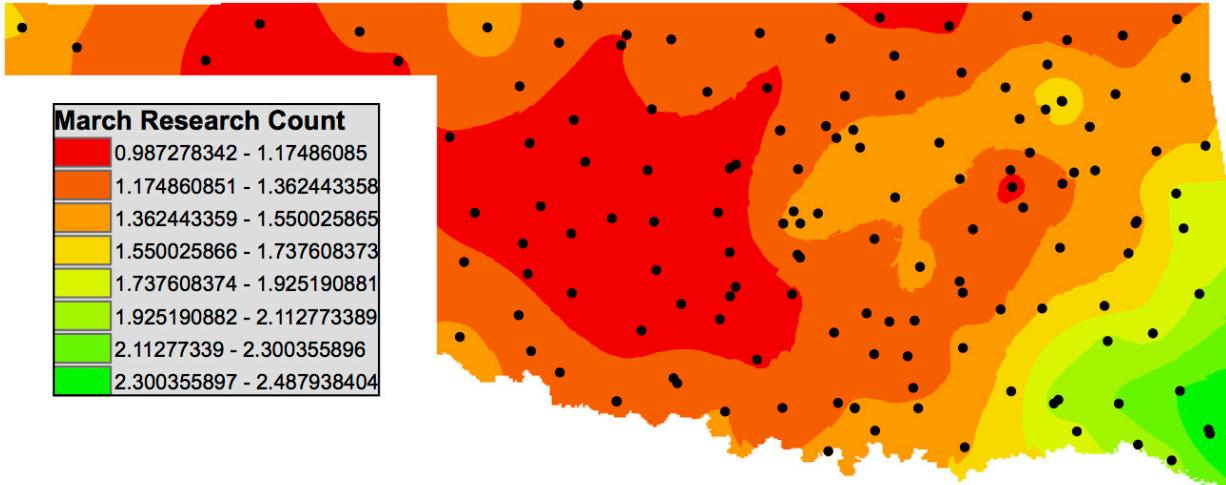
- Analyzed using R
- Removed bad data
  - -999 Flagged bad by Mesonet Quality Assurance
  - -998 Sensor not installed
  - -997 Calibration Missing
  - -996 Station did not report
  - -995 Data not reported on time interval
  - -994 Data did not fit column
- Selected data that met thresholds
- Found 6 contiguous five minute observations to make one period
- Counted total number of periods
- <https://github.com/coopermor/Mesonet-Flyable>



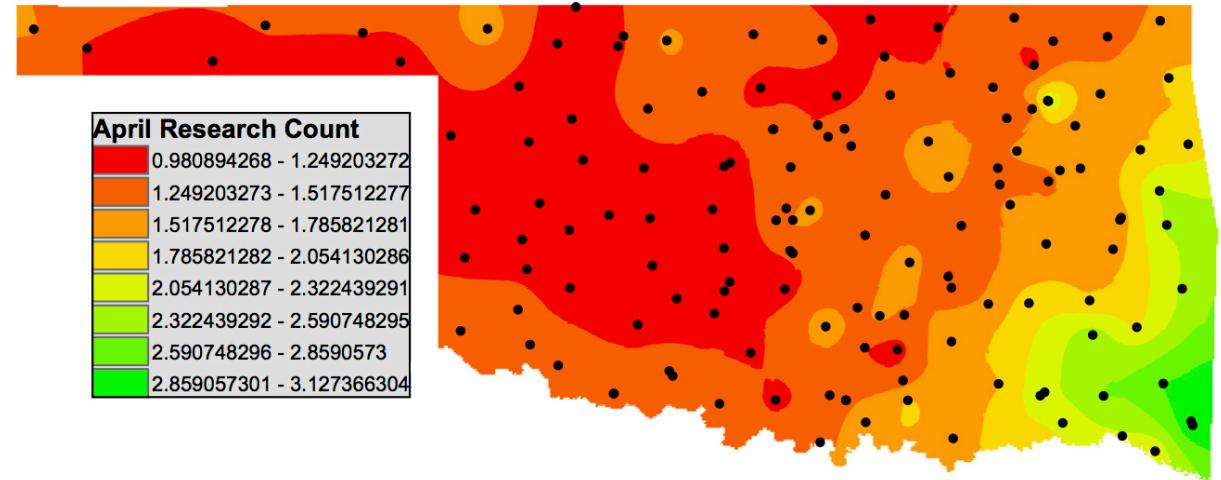
# Average Flyable Periods per Month



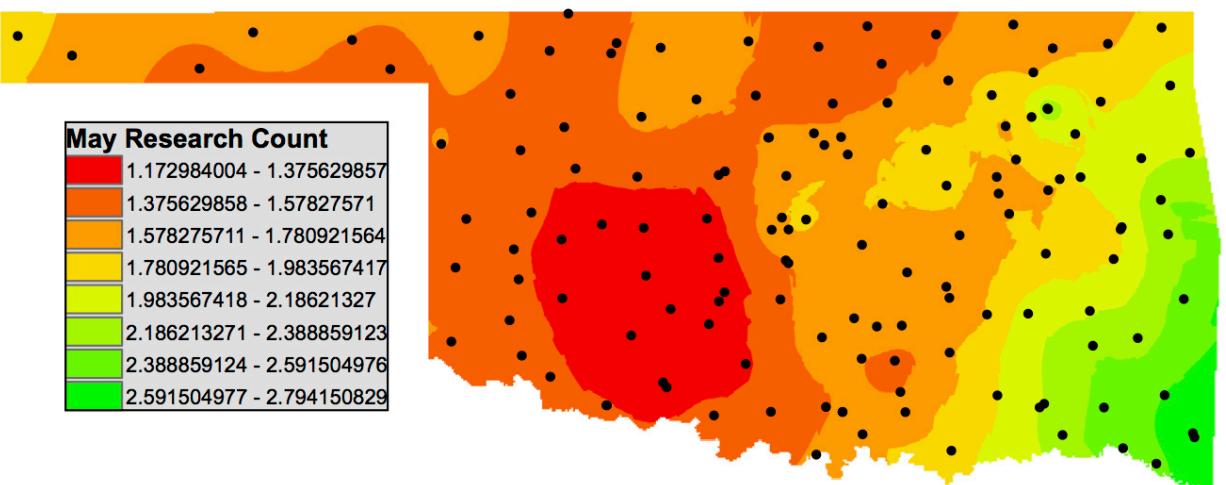
### Average Flyable Periods per Day for March



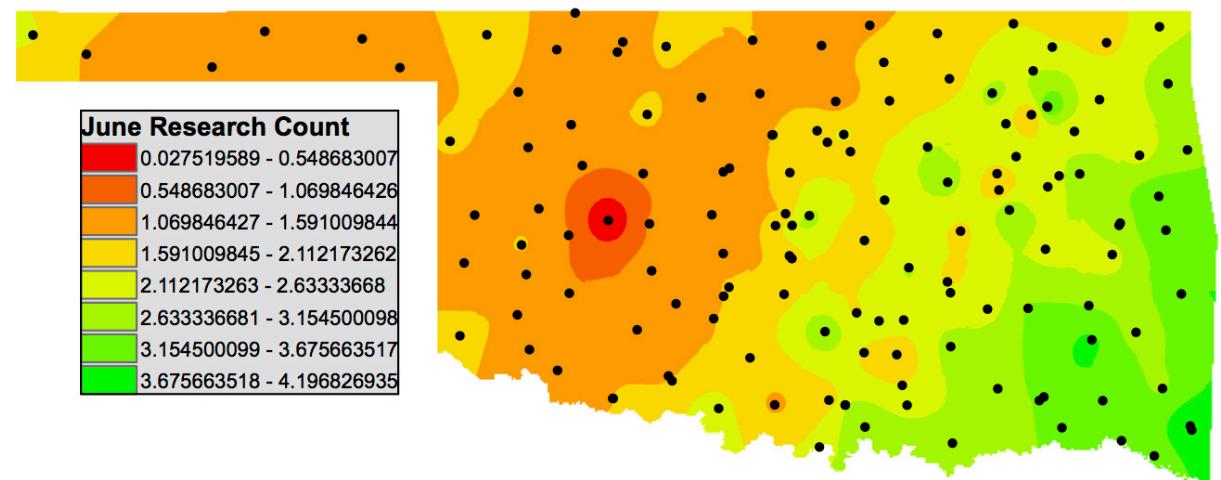
### Average Flyable Periods per Day for April



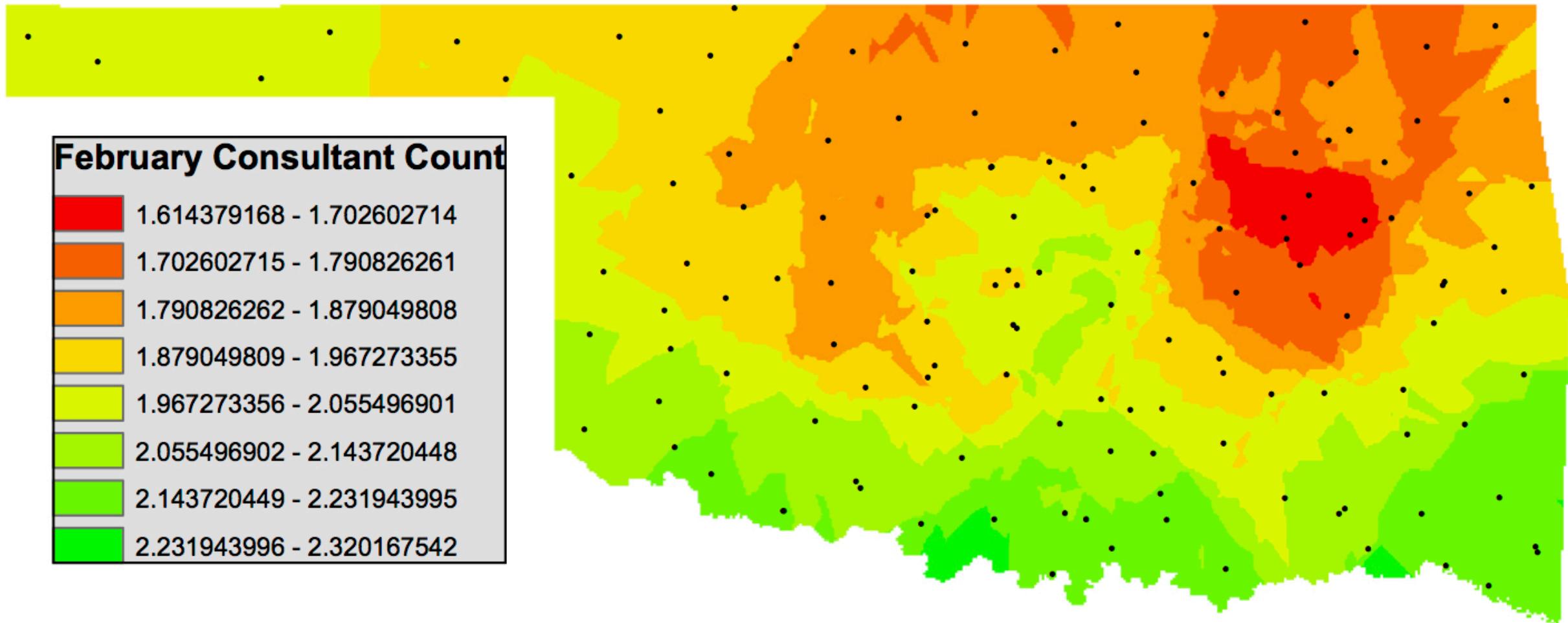
### Average Flyable Periods per Day for May



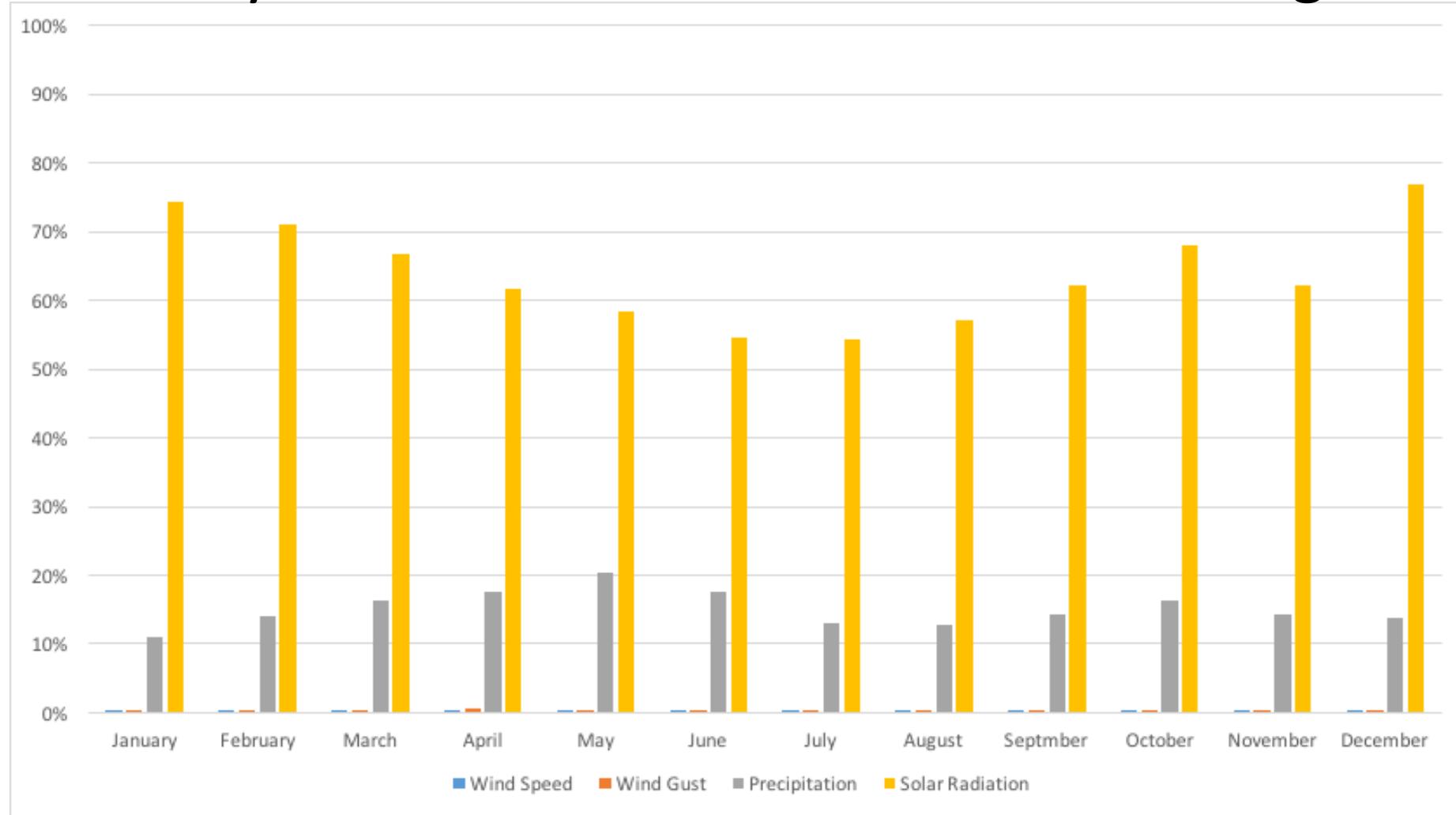
### Average Flyable Periods per Day for June



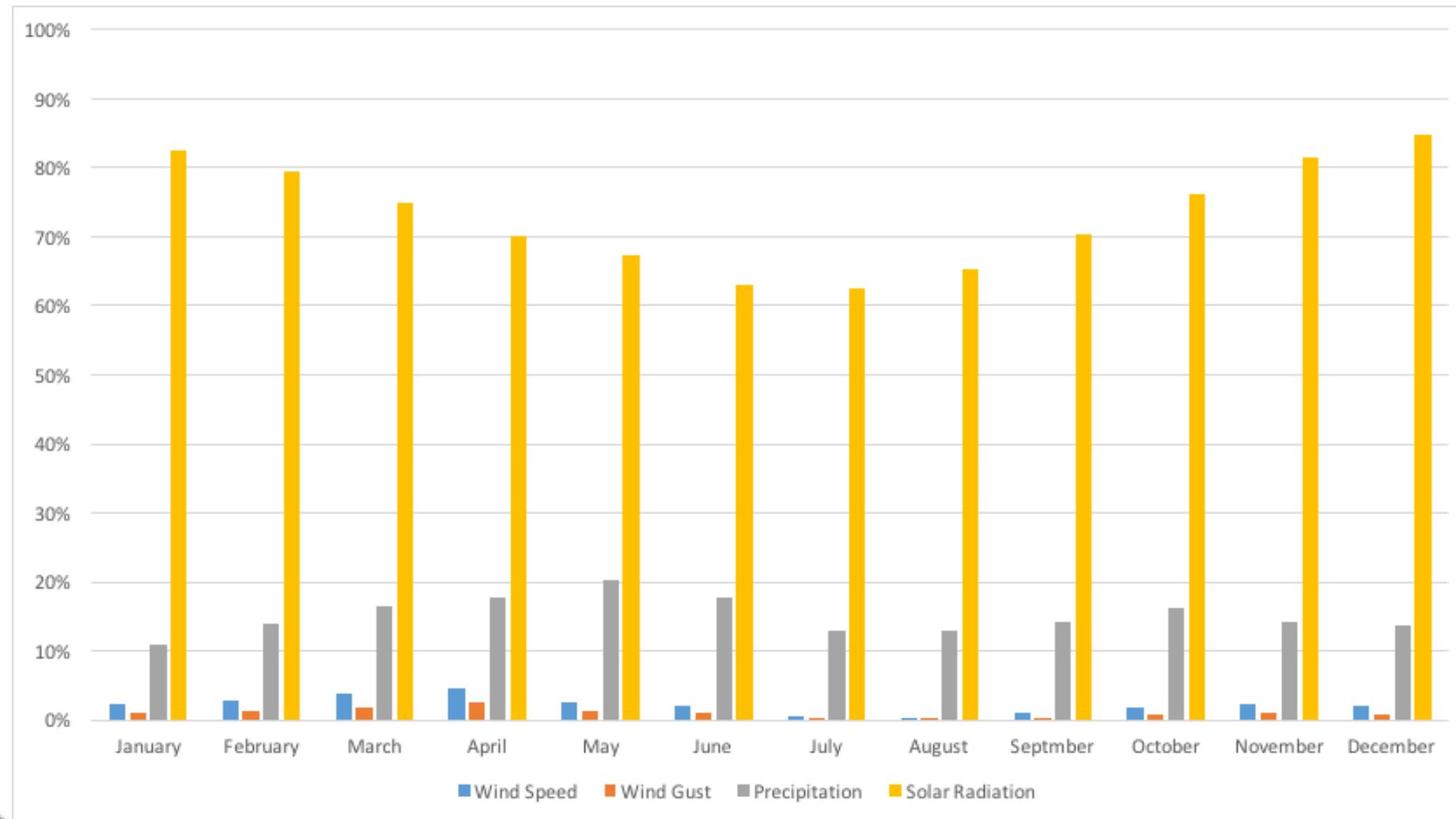
# Average Flyable Periods per Day as a Crop Consultant in February



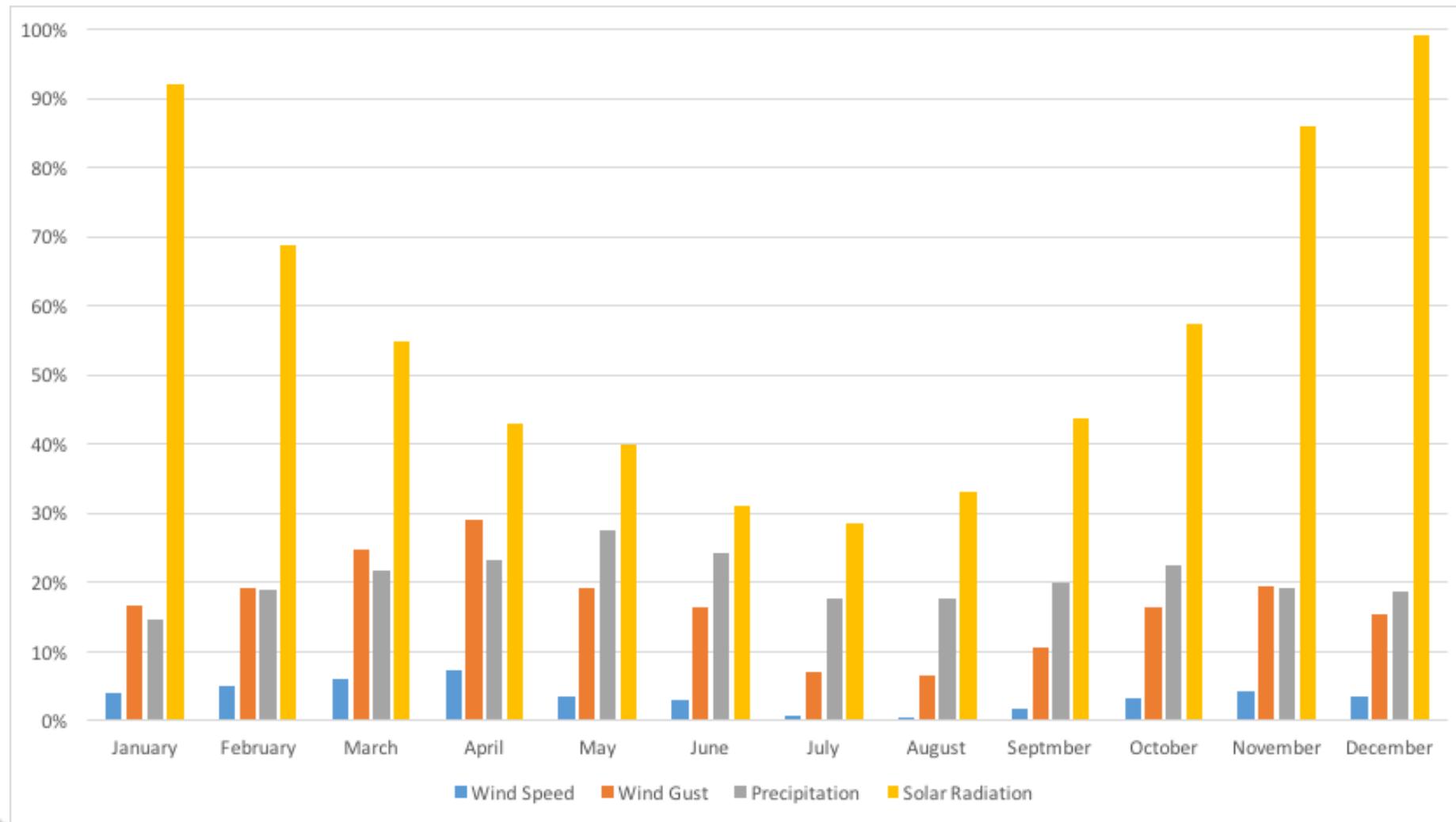
# Cause of Unflyable Periods at Livestock Monitoring Tolerance



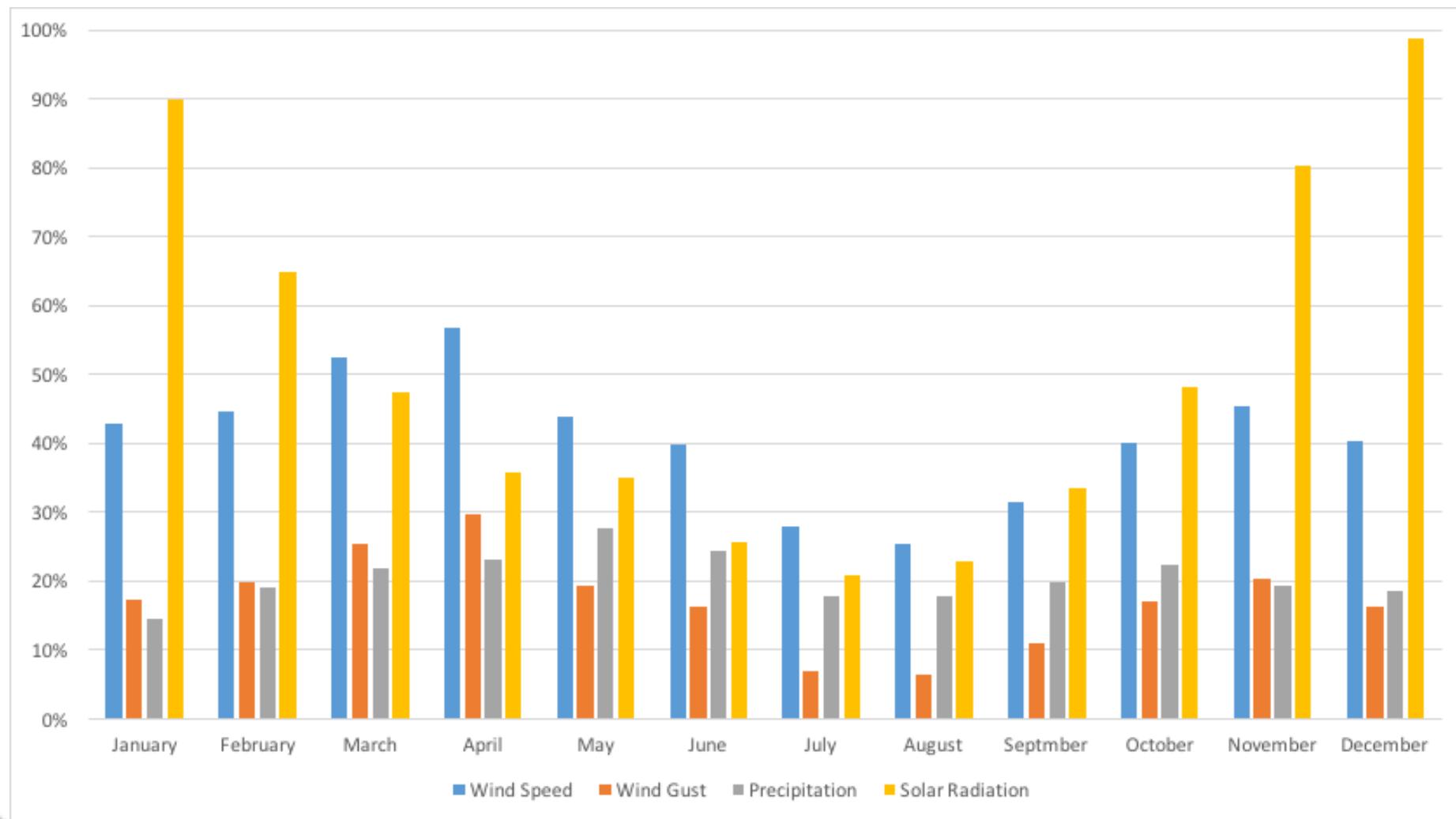
# Cause of Unflyable Periods at Color Photography Tolerance



# Cause of Unflyable Periods at Crop Consultant Tolerance



# Cause of Unflyable Periods at Research Tolerance



# Conclusions

- For livestock monitoring there is a year round average of 6.56 hours per day, making flight feasible year round
- At the strictest tolerance level, wind speed becomes the most significant factor during the late spring to early fall months
- Feasibility of UAS flight in Oklahoma varies greatly depending on the desired application and time of year that flight is required
- Agricultural UAS applications could see use up to 8.6 hours per day



# Further Reading

- *Flight characteristics of a fixed wing unmanned aircraft systems for aerial surveillance of agricultural systems* – ASABE Paper 152190195
- *Conducting Unmanned Aircraft Flight Operations Under Federal Aviation Administration Regulations* – ASABE Paper 152147654
- *Imaging from an unmanned aerial vehicle: agricultural surveillance and decision support* – doi:10.1016/j.compag.2004.02.006



- **Acknowledgements**
- Special thanks to OSU Office of Scholar Development and Undergraduate Research, Dr. W. Stephen Damron, Assistant Dean, Academic Programs, College of Agricultural Sciences and Natural Resources, the entire Oklahoma Mesonet team, as well as Oklahoma State University High Performance Computing.
- The computing for this project was performed at the OSU High Performance Computing Center at Oklahoma State University supported in part through the National Science Foundation grant OCI-1126330.



# Questions? Comments?

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