Agroclimatic Seasonal Limitations by 2100: North Dakota and the World

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ND Space Grant Student Symposium and Affiliates Meeting

April 7-9 2022

NORTH DAKOTA SPACE GRANT CONSORTIUM

UNIVERSITY OF NORTH DAKOTA

AgMIP

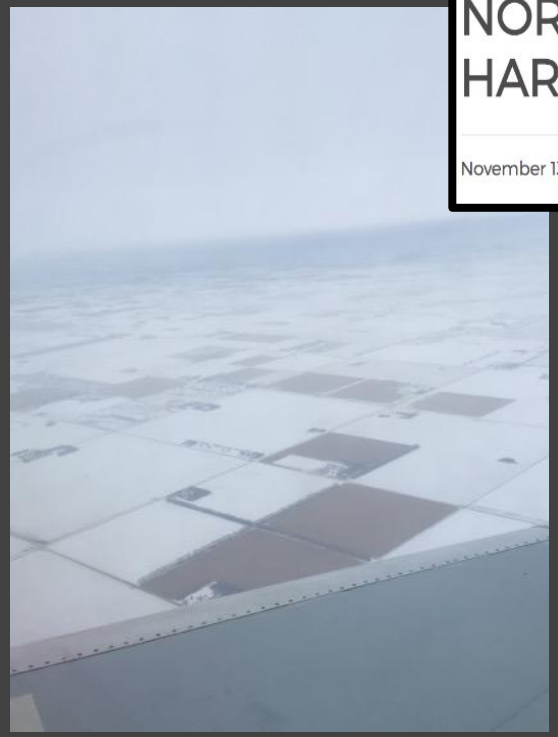
NASA

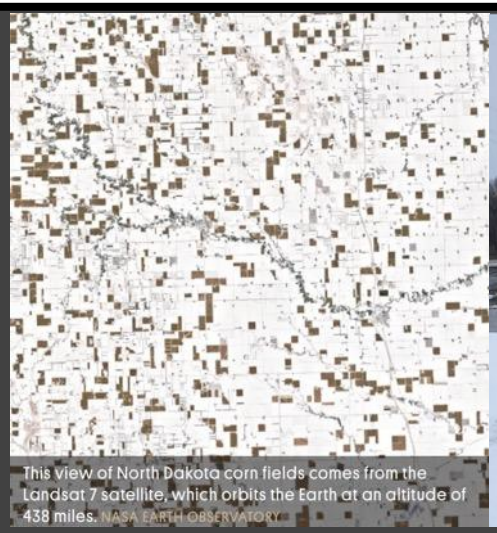
Historic amount of corn acres in North Dakota still in the field

Written By: Ann Bailey | Dec 2nd 2019 - 4pm.

NORTH DAKOTA CORN HARVEST ONLY 15% DONE

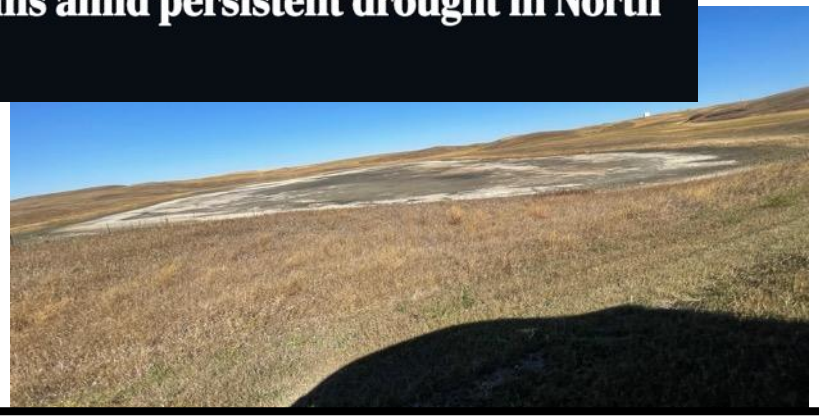
November 13, 2019 By Mark Dorenkamp Filed Under: Crops, News





Extreme Shifts in ND 2019-2021: Floods 2019

Wildfires, livestock are concerns as spring begins amid persistent drought in North Dakota



Ending one of the driest 'water years' in N.D. with extreme drought continuing

Extreme Shifts in ND 2019-2021: Drought 2021

There were 2,442 wildfires in North Dakota last year, burning 125,664 acres,

Wildfire in Medora nearly contained

Extreme Shifts in ND 2019-2021: Wild Fires 2021

More than 100,000 acres burned across North Dakota in 2021

Grasshoppers Finish off North Dakota Crops, Pastures Already Plagued by Drought, Farmers Say

Crops/ Crop Damage 2019-2021

USDA Offers Disaster Assistance to North Dakota Farmers and Livestock Producers Impacted by Drought

SCIENTIFIC QUESTIONS

1. **How are shifts in season hazards from a changing climate affecting agricultural systems/regions?**
2. **How will we adapt to these changes in the future?**
3. **How do changes projected for ND compare to rest of the world?**

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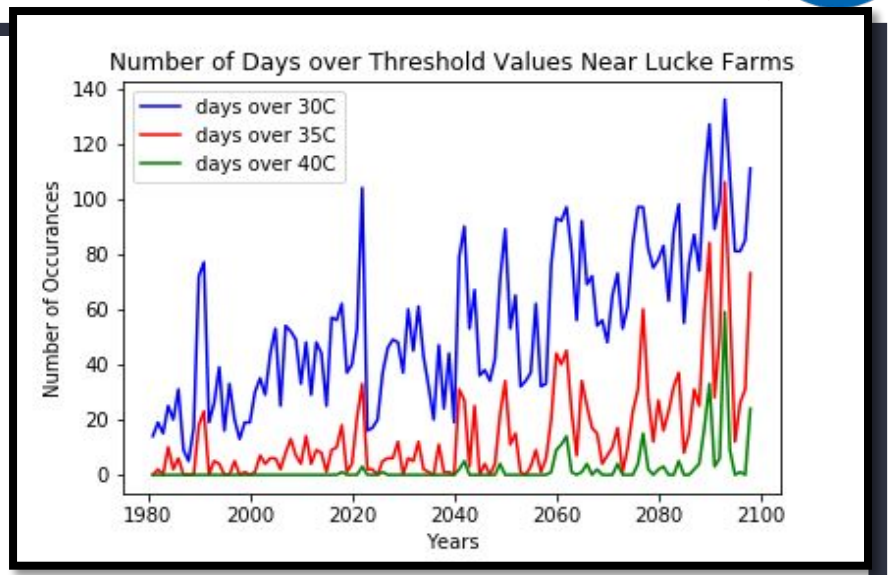
METHOD:

UNDERSTANDING AG-CLIMATE IMPACTS



- **Different Thresholds:** ex. Above 30°C, 35°C, 40°C
- **Different Hazard Characteristics:**
  - Seasonal timing, duration, frequency, spatial extent, intensity
- **Different Time Slices:** beginning, middle, end of century
- **Different Scenarios:** RCP 2.6, 4.5, 8.5
- **Different Models/Datasets:** NASA GISS Model E, GFDL, AGMIP, GGCMI, IPSL, MPI, MRI…
- **Other Metrics:** Intense rainfall, low humidity, Tmax, Tmin, frost, wet bulb temp
- **Different Regions:** North America, Northern Great Plains, ND, Field

Built a framework code for rapidly evaluating all variations

Extreme Heat: maximum temp usually over 35 °C (crops/humans/animals)

Frost Limits: when minimum temp is below 0°C (crops)

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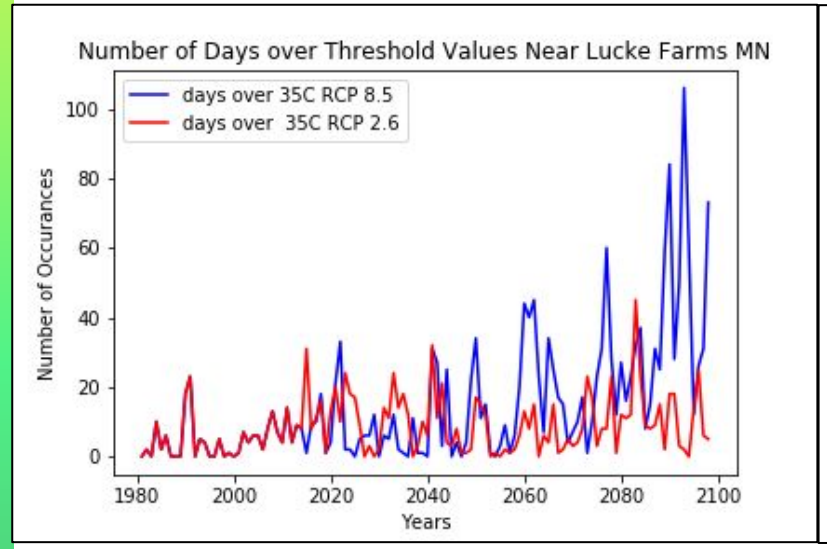
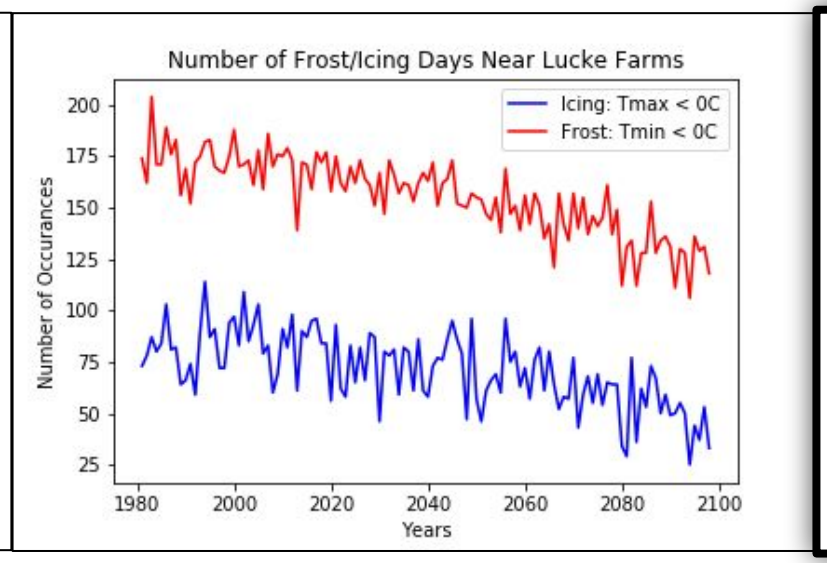
RESULTS: CLIMATE CHANGES ON LUCKE FARMS NEAR FARGO ND

Climate change is happening everywhere and affecting everyone

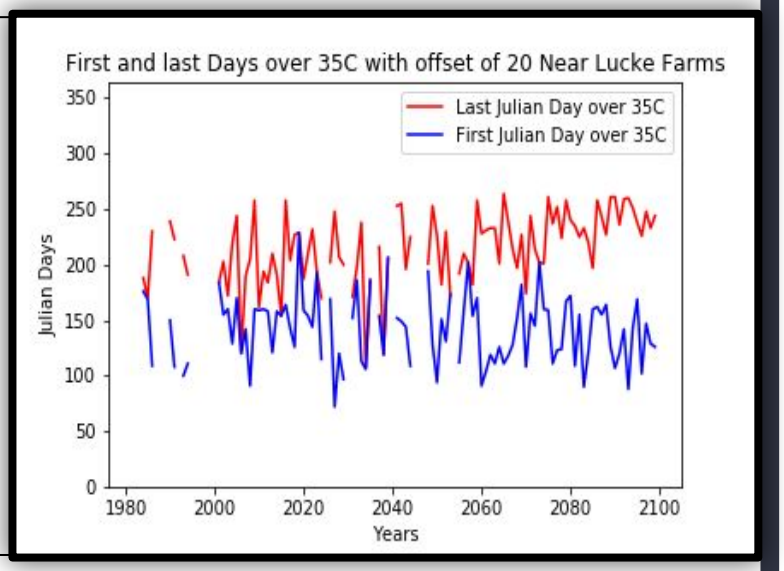
Days Tmax > 35°C



Days Tmax/Tmin < 0°C



First and Last Day Tmax > 35°C



- First day of heat each year is occurring earlier, last day is happening later

Length of extreme heat season and growing season are increasing

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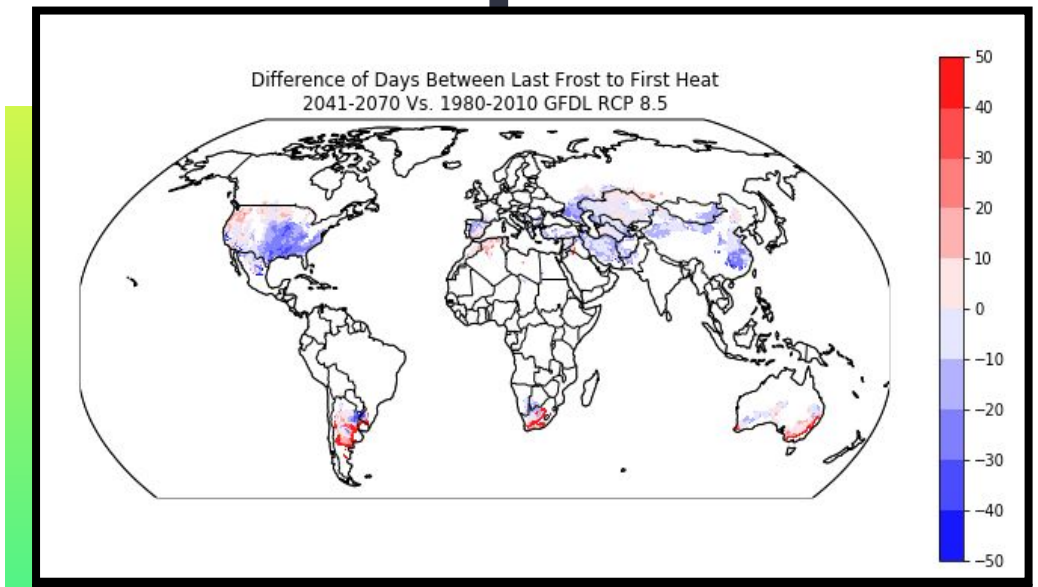
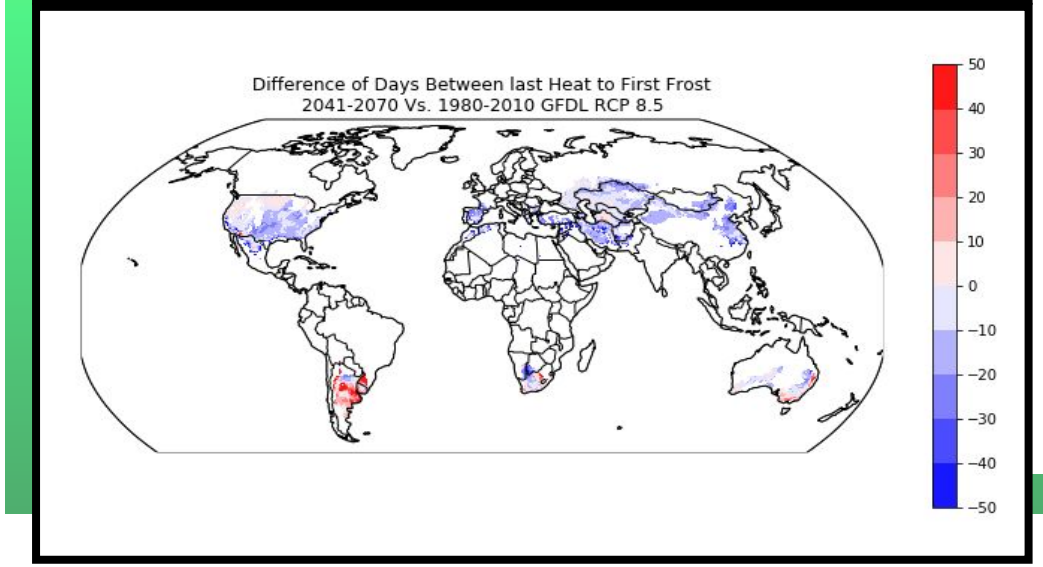
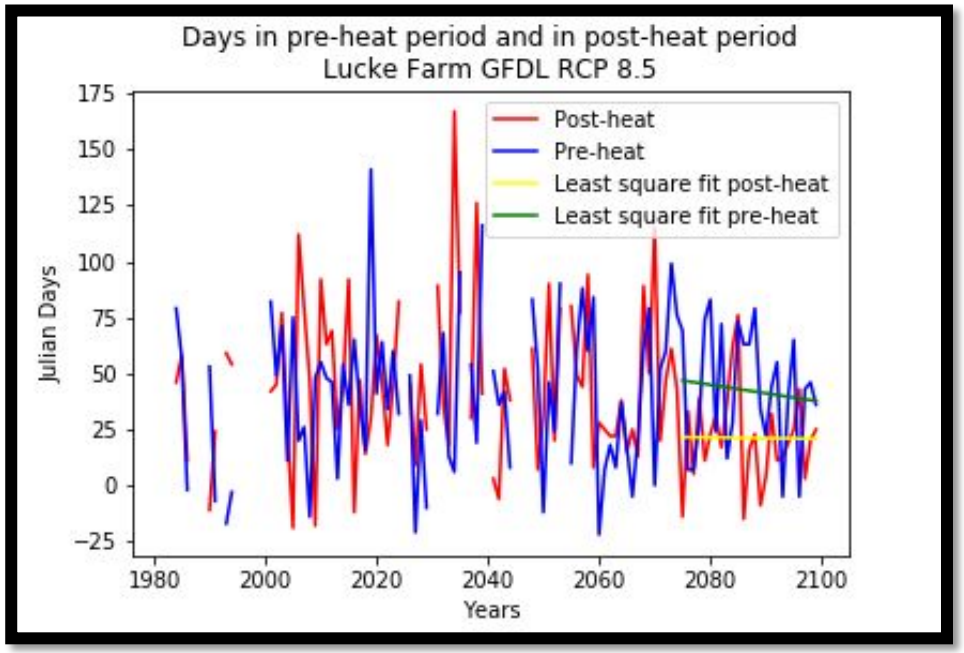
RESULTS:

CHANGE IN PRE AND POST-HEAT PERIODS







- **Length of pre-heat/post-heat is slowly decreasing**
- Indicates more rapid transitions between winter and summer hazards in future

Preheat affects crops in spring, post heat fall

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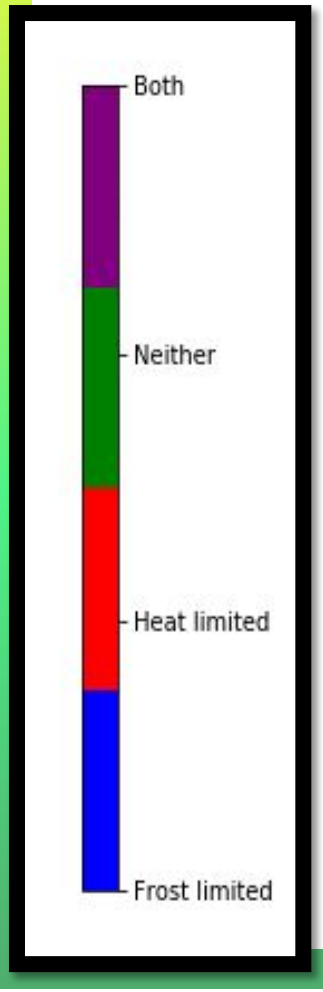
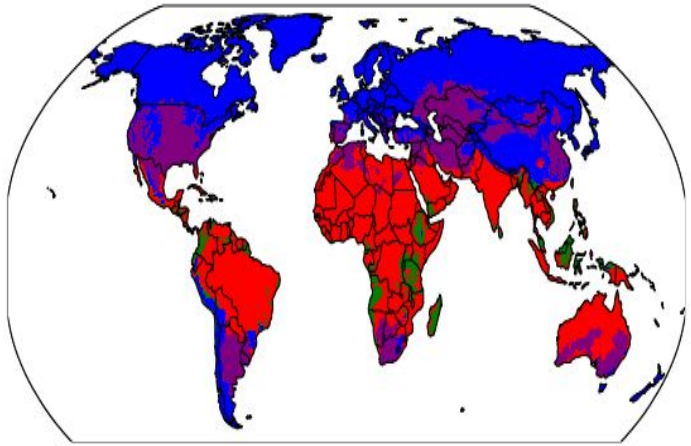
RESULTS:

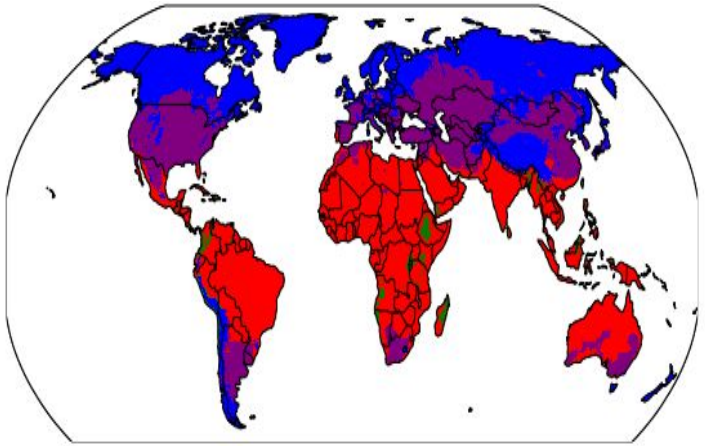
REGIONAL HAZARD EXPOSURE LIMITATIONS

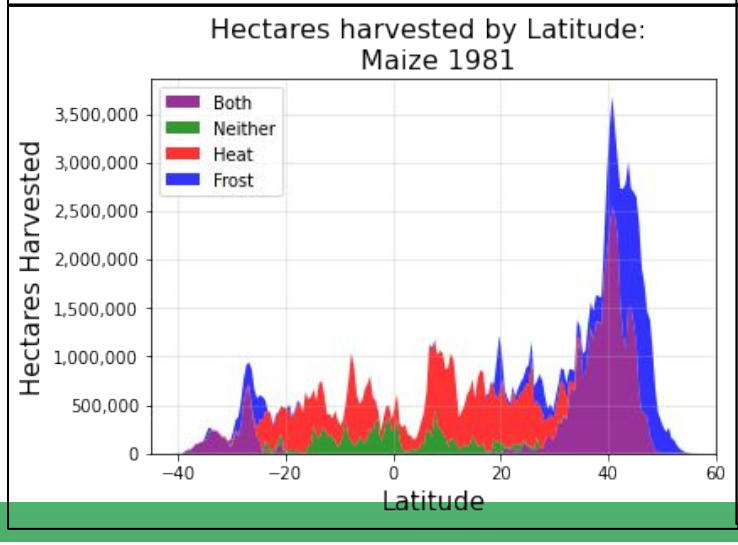


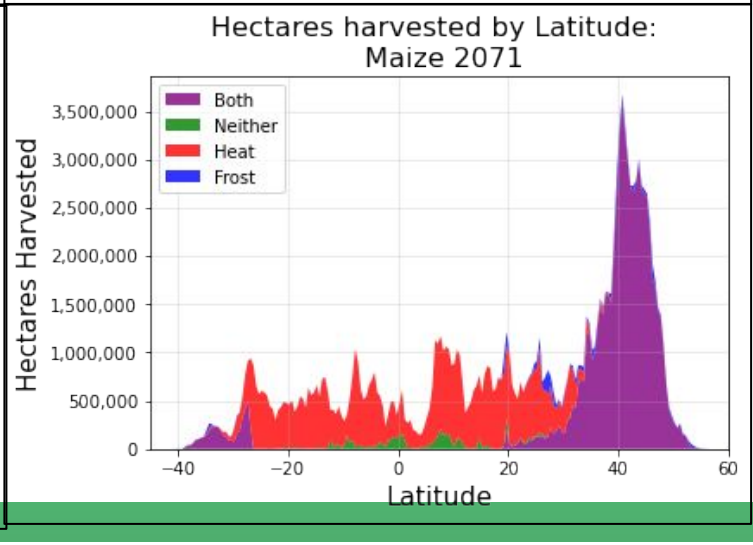
Historical



Projected 2070s







- Frost only and both heat and frost limited regions of most interest for future
- Easily see that purple overtakes blue over time

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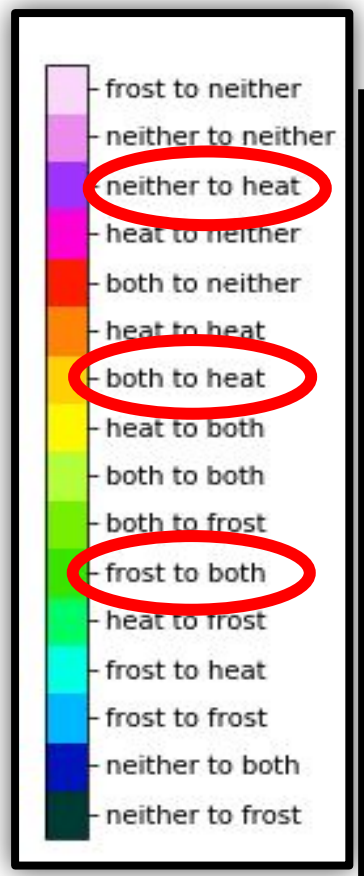
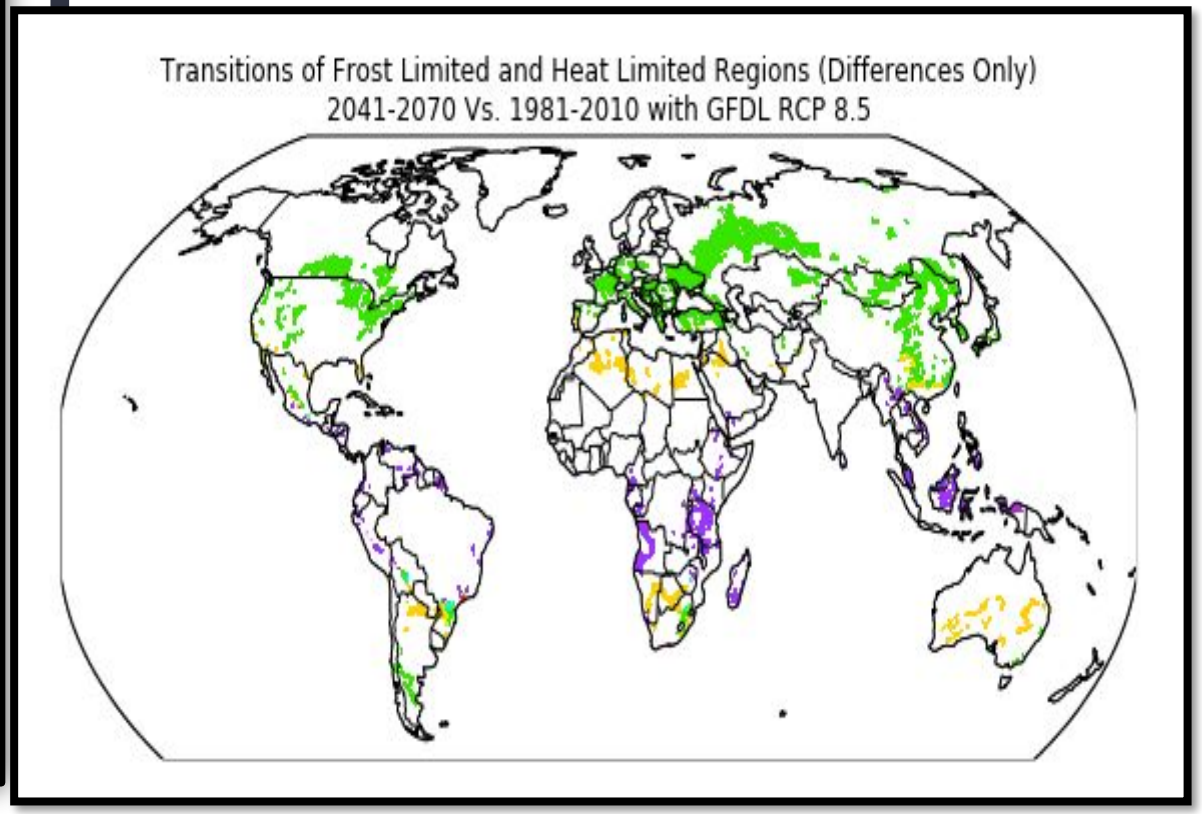
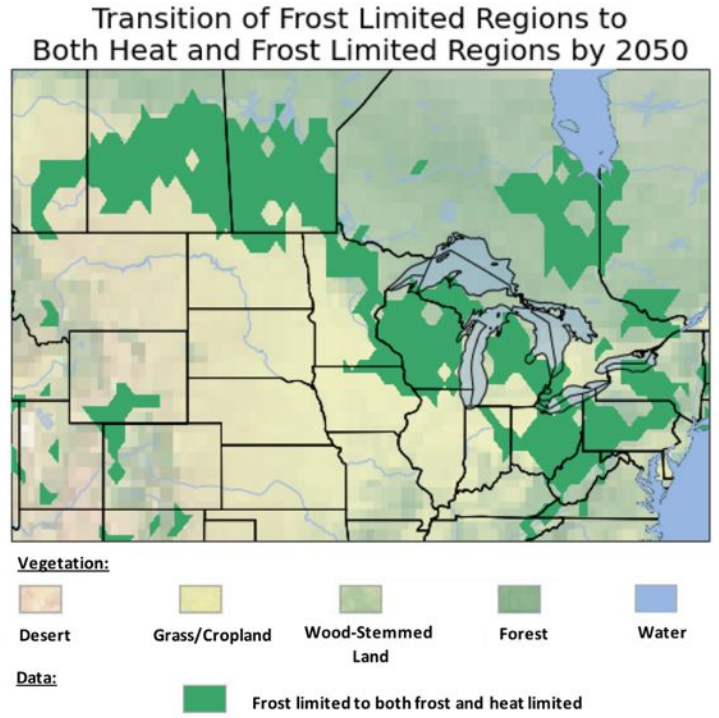
RESULTS:

TRANSITIONS IN GROWING SEASON LIMITATIONS







- **Frost limited areas are decreasing and heat limited areas are increasing**
  - Agricultural regions that are not accustomed to heat will have to adapt to extreme heat days in the future.
  - Fewer lower latitude areas are eliminating frost threats as these are changing less rapidly

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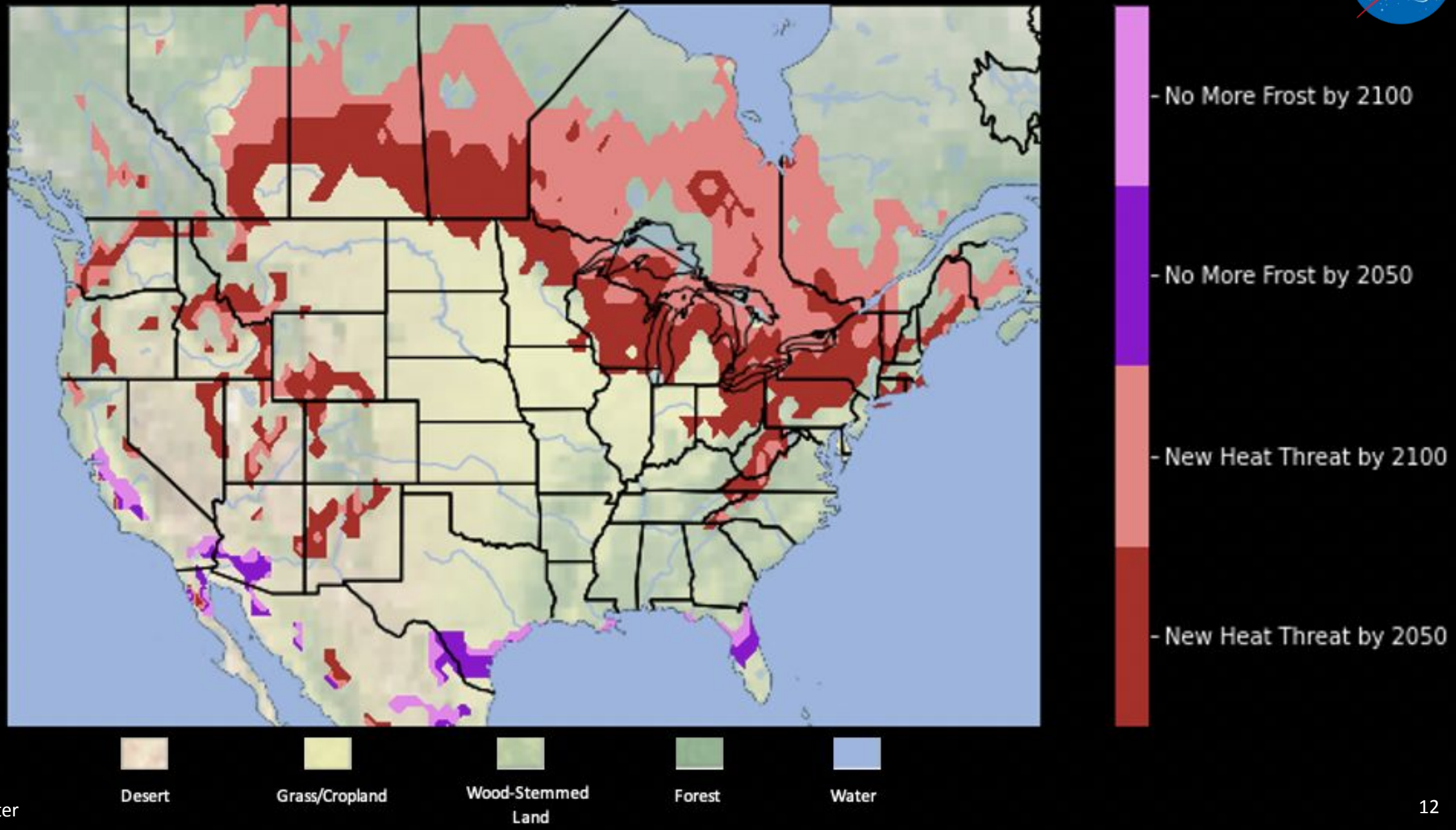
New Seasonal Hazards by 2050 and 2100

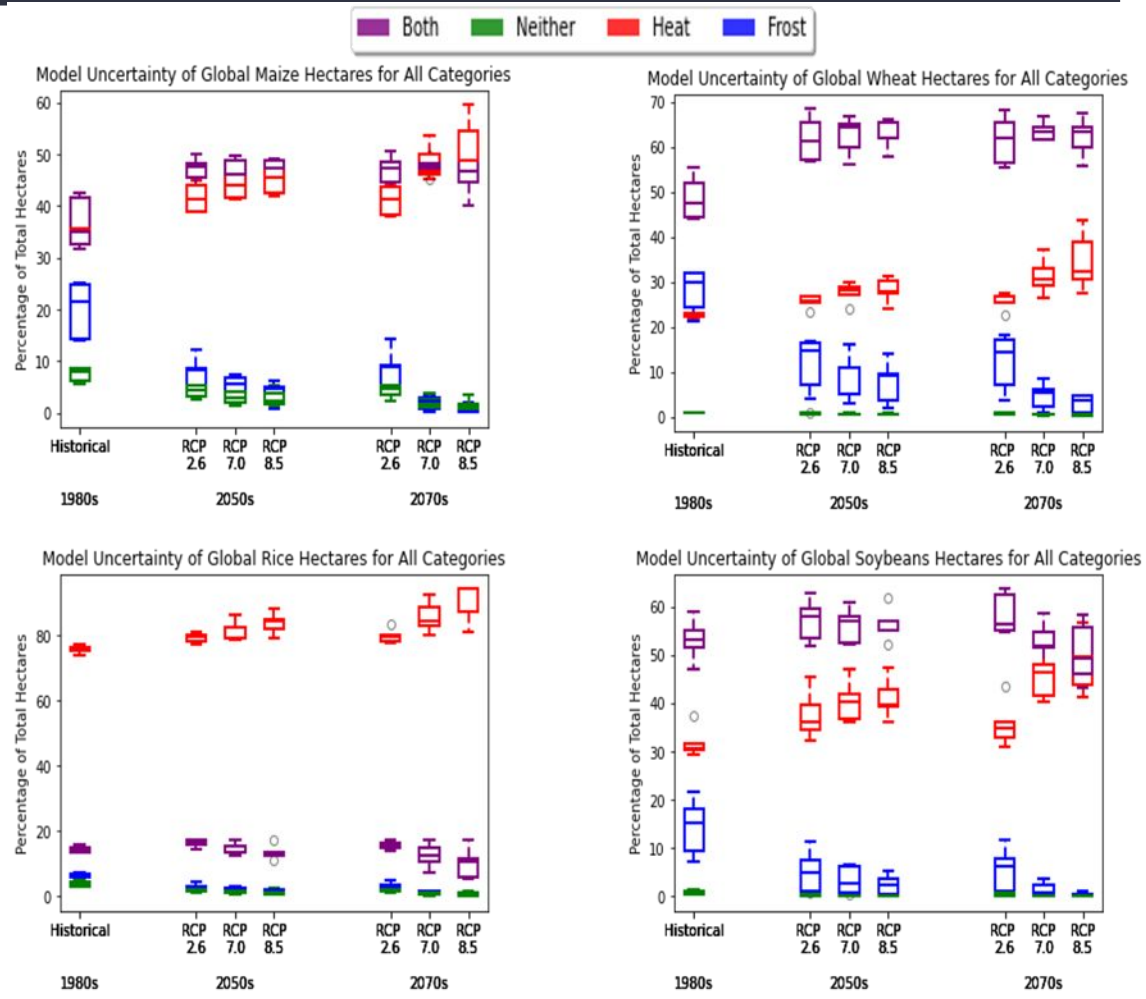


CONCLUSIONS:

OVERVIEW CHANGES IN LIMITATIONS

RCP:		Models:	Crops:
	8.5 (ssp585)		
	7.0 (ssp370)	GFDL	Maize
	2.6 (ssp126)	MRI	Wheat
Time Slices:		IPSL	Soybeans
	1981-2010	MPI	Rice
	2041-2070	UKESM1	
	2071-2100		

1. Frost limited regions are transitioning to heat limited
2. Farmers that are not accustomed to heat will have to adapt to extreme heat in the future
3. The growing season is increasing over time
4. Advanced notice of challenges will aid in future adaption, mitigation and risk management



Blue turns purple, purple turns red

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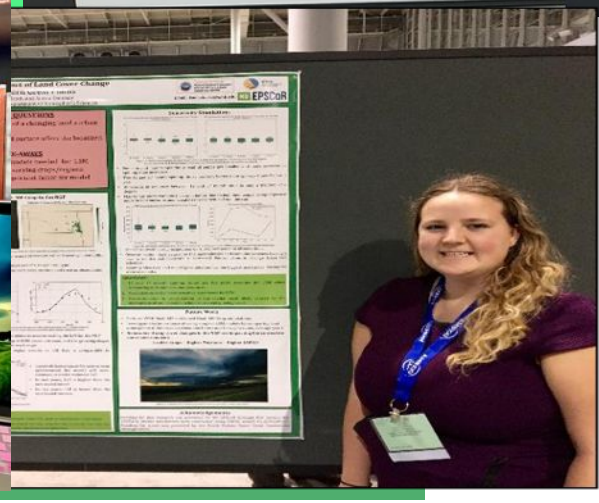
EXPERIENCE, OUTREACH AND COLLABORATIONS

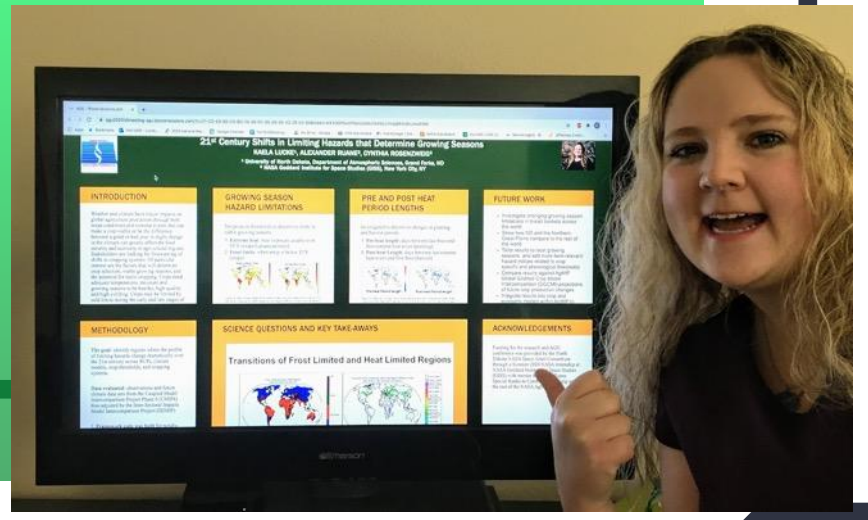
- **Meet** Weekly with AgMIP, model e, climate impacts group and my mentor.
- **NASA Outreach:** NASA Astrocamp, ND/MN High School's,
- **Presentations:** AGU, AMS, AgMIP, Climate Impacts, GISS Seminar series, UND scalar series
- **Asked** to be apart of the NASA hyperwall @ farmers commodity classic
- **Asked** to be feature in the **Art and Science COVID Museum Project:** Movie, pictures and live exhibit
- **NASA GISS Calendar, ND Magazine**
- **Collaborations** with USDA, Office of STEM engagement



EXPERIENCE, OUTREACH AND COLLABORATIONS

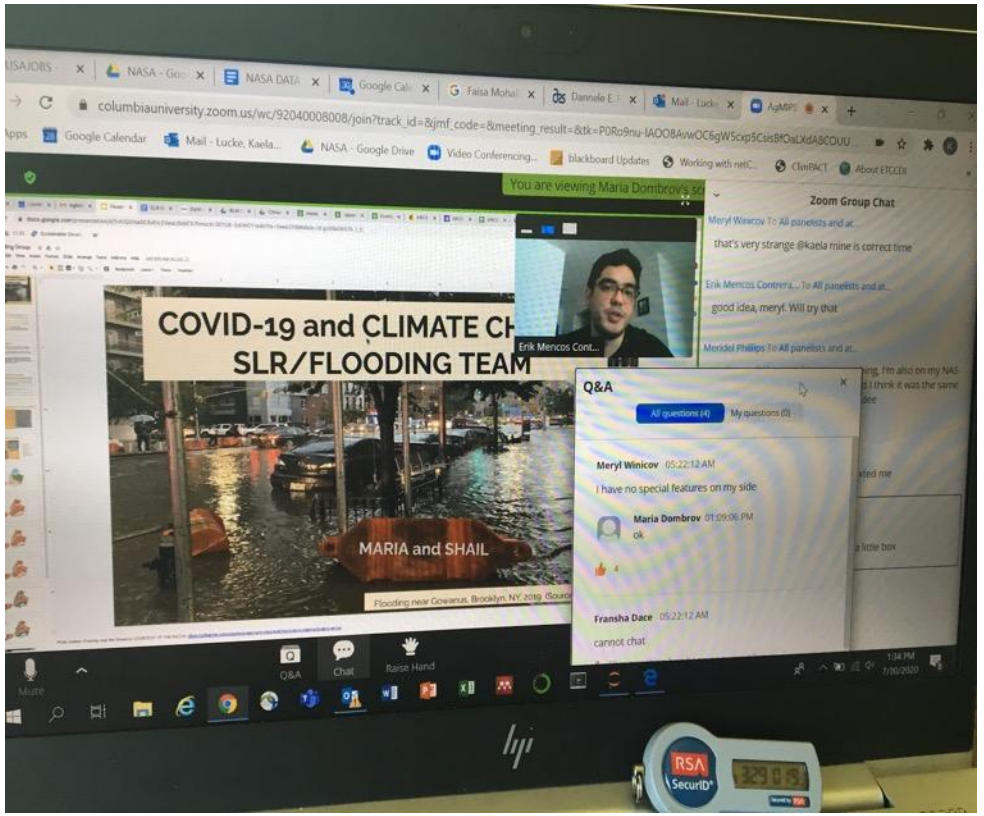
NASA Astrocamp 2020 – (FREE)

On July 15th GISS NASA Intern and UND Atmospheric Sciences master student Kaela Lucke will be educating kids on the atmosphere, climate, the 5 major gases on earth and on ways to help live an environmentally friendly lifestyle. This talk will be geared towards kids in grade 3-6 and a fun activity will follow the presentation. This whole event will last **1 hr on July 15th from 1-2pm via zoom**. Please sign up for this event at https://gflibrary.beanstack.com.



CHALLENGES AND LESSONS LEARNED

- **Virtual Challenges:**
  - IT, zoom, NASA security Issues
- **Storage Challenges:**
  - Climate models/ outputs = TBs of Data
- **Personal Challenges:**
  - Imposter Syndrome
  - Bad Autoimmune Disease Flare ups



FUTURE WORK AND CAREER GOALS

- Split into per decade time periods to find exact time transitions occur
- Add farm-relevant hazard indices like precip and wet bulb globe temp

- **This projects results:** will be integrated into crop and economic models within AgMIP to identify key vulnerabilities in food systems for the future

- **Peer Reviewed Journal to be published this fall**
- **Live Exhibit:** To open this Summer at NASA museum w/ my own little section
- **Seminar Series Speaker** for Goddard and GISS and UNDs ScalAR seminar series
- **Future Career:** NASA Extension Position or PhD w/ NASA @ Columbia

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ACKNOWLEDGEMENTS

- Fellowships, travel grant, past NASA internship and future mini grant for publishing were funded by the ND Space Grant Consortium

- Research was conducted with NASA Climate Impacts, AgMIP, and model e groups at (virtually) NASA Goddard Institute of Space Studies (NASA GISS).

- Special thanks to my mentor and advisors:
  - Alex Ruane, Cynthia Rosenzweig, Matthew Pearce

Questions?

- Growing season is increasing
- Rapid season changes (winter/summer) in future
- Extreme heat season is increasing
- Frost free season is increasing
- Higher latitudes changing faster than lower latitudes
- Climate change will shift the profile of hazards for ag

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