Unraveling Hail Growth in Argentina: A Multifaceted Study of hail formation through Physical-Chemical Analysis and Satellite-based Environmental Assessment

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1

2

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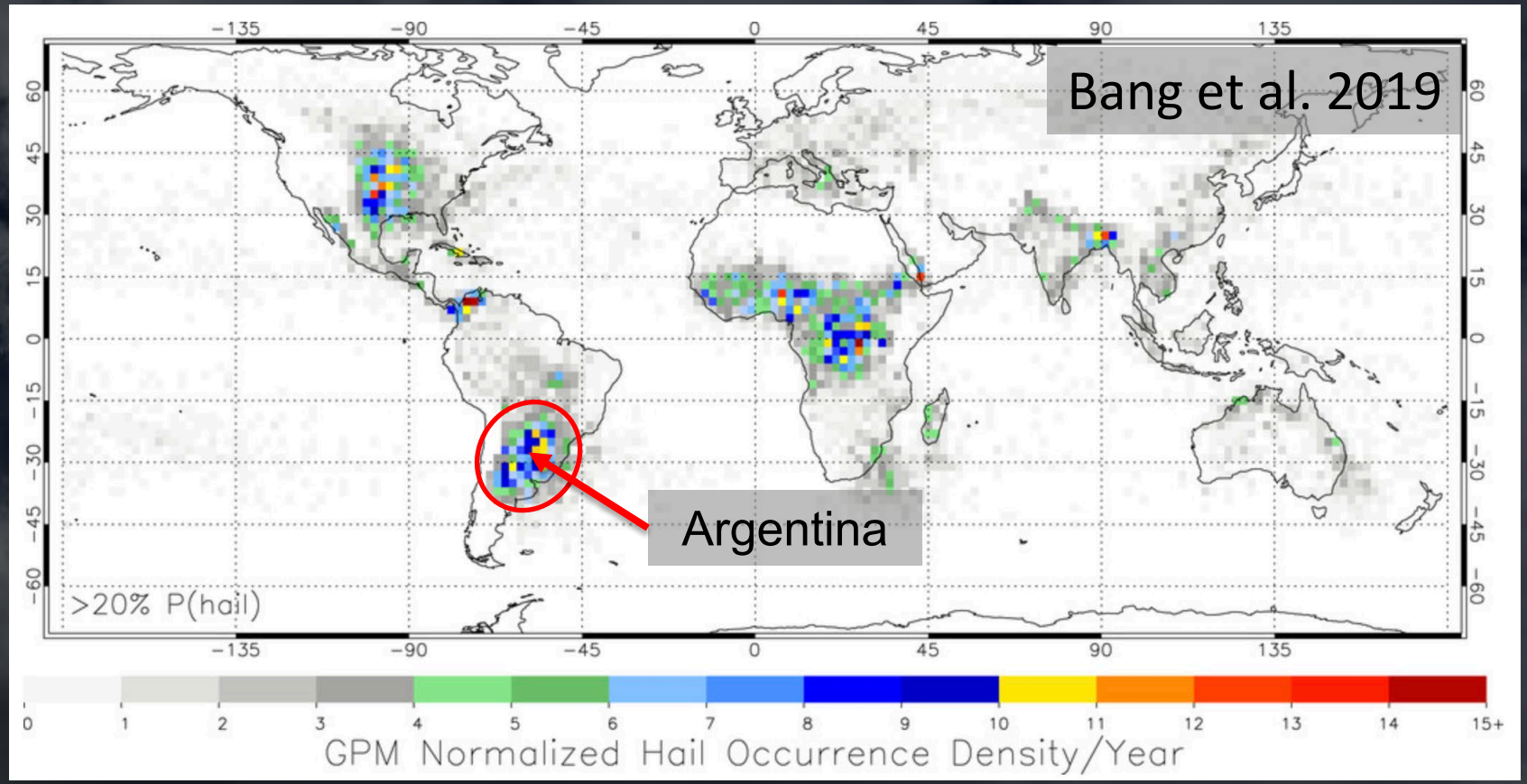
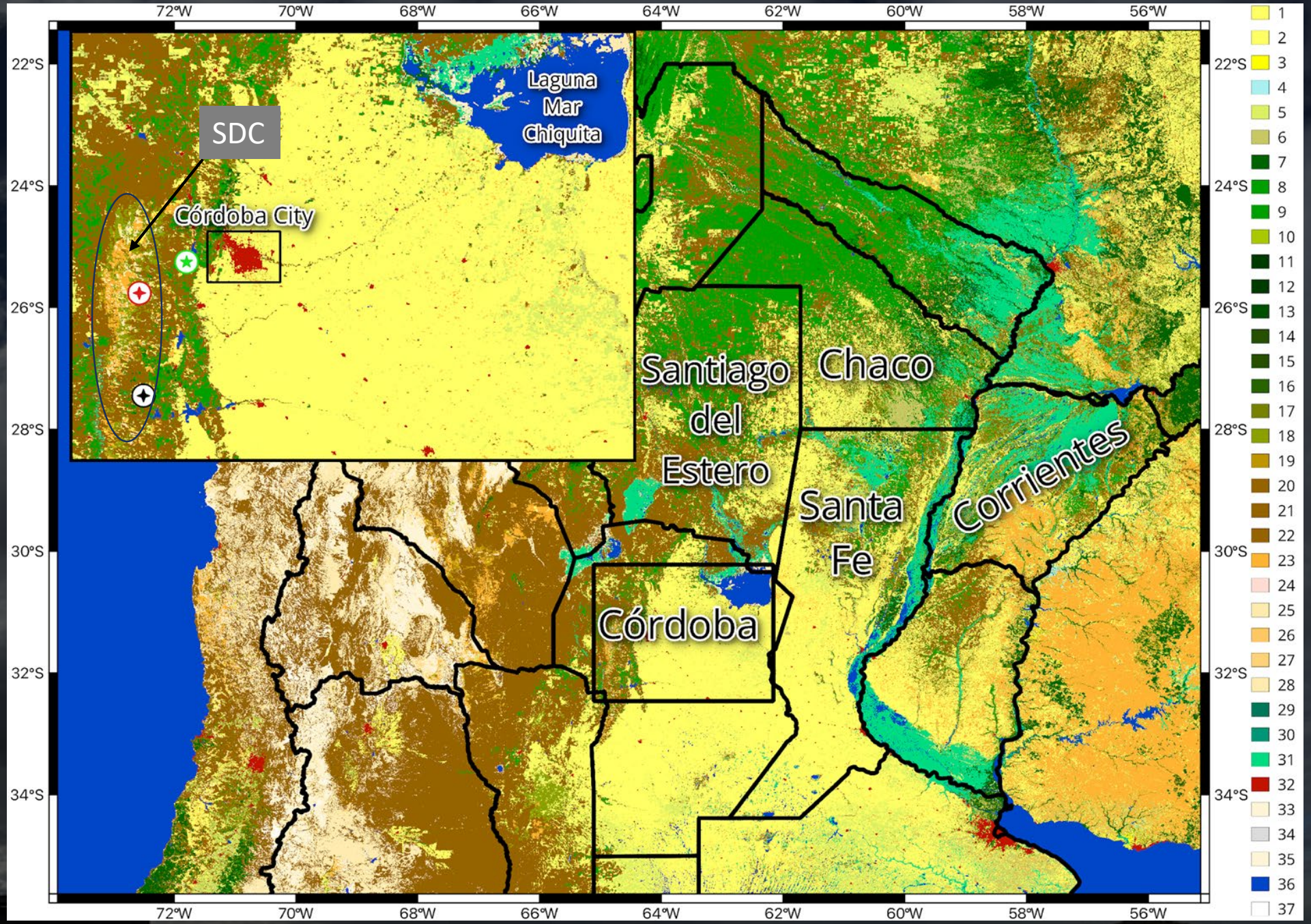
Motivation



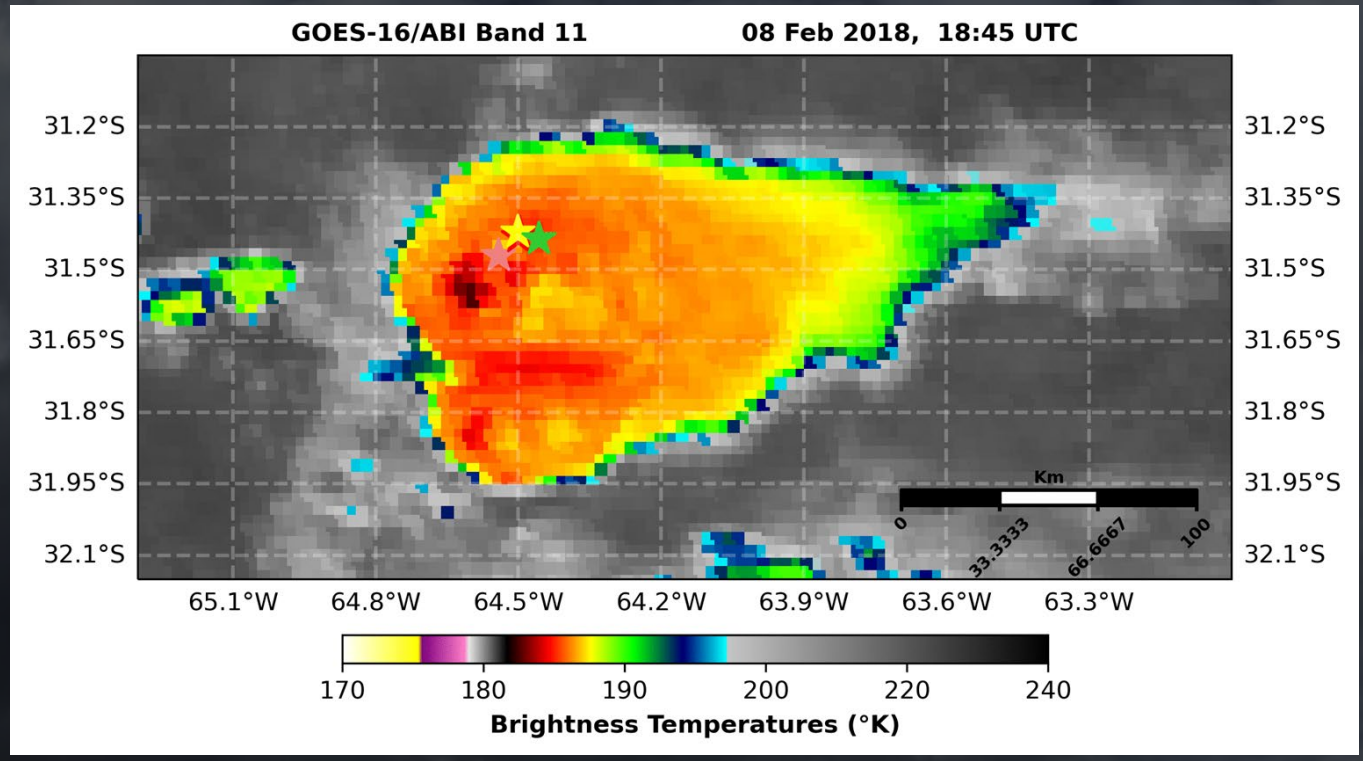
- Hailstorms are some of the most destructive and intense natural phenomena causing over $1 billion in damages in the U.S. since 1949 (Changnon 2008; Sande et al. 2013; Allen et al. 2017; Kumjian and Lebo 2019).
- Climate change projections indicate increased hailstorm damage.
- Limited understanding of convective systems and their impact on hail development globally.
- *This research aims to understand the impact of local land use on aerosol composition that potentially impacts CCN and INP production, also influencing hail formation.*

Córdoba Region



8 February 2018

- Supercell storm produced record-breaking gargantuan hail in Villa Carlos Paz (Kumjian et al. 2020; Arena 2020).
- This storm developed without large-scale forcing, suggesting a regional influence (Bernal Ayala et al. 2022).
- 4-cm hailstone collected in collaboration with the citizen science program “Cosecheros de Granizo 2018–2020”



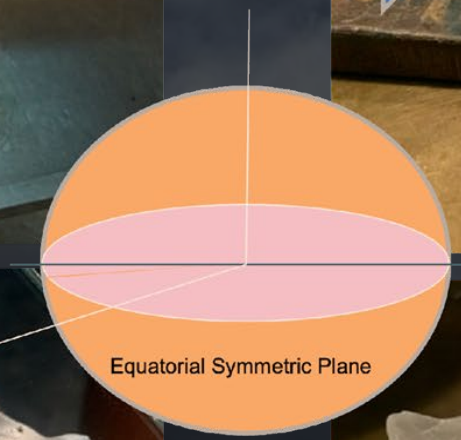
Bernal Ayala et al. 2022

Research Questions

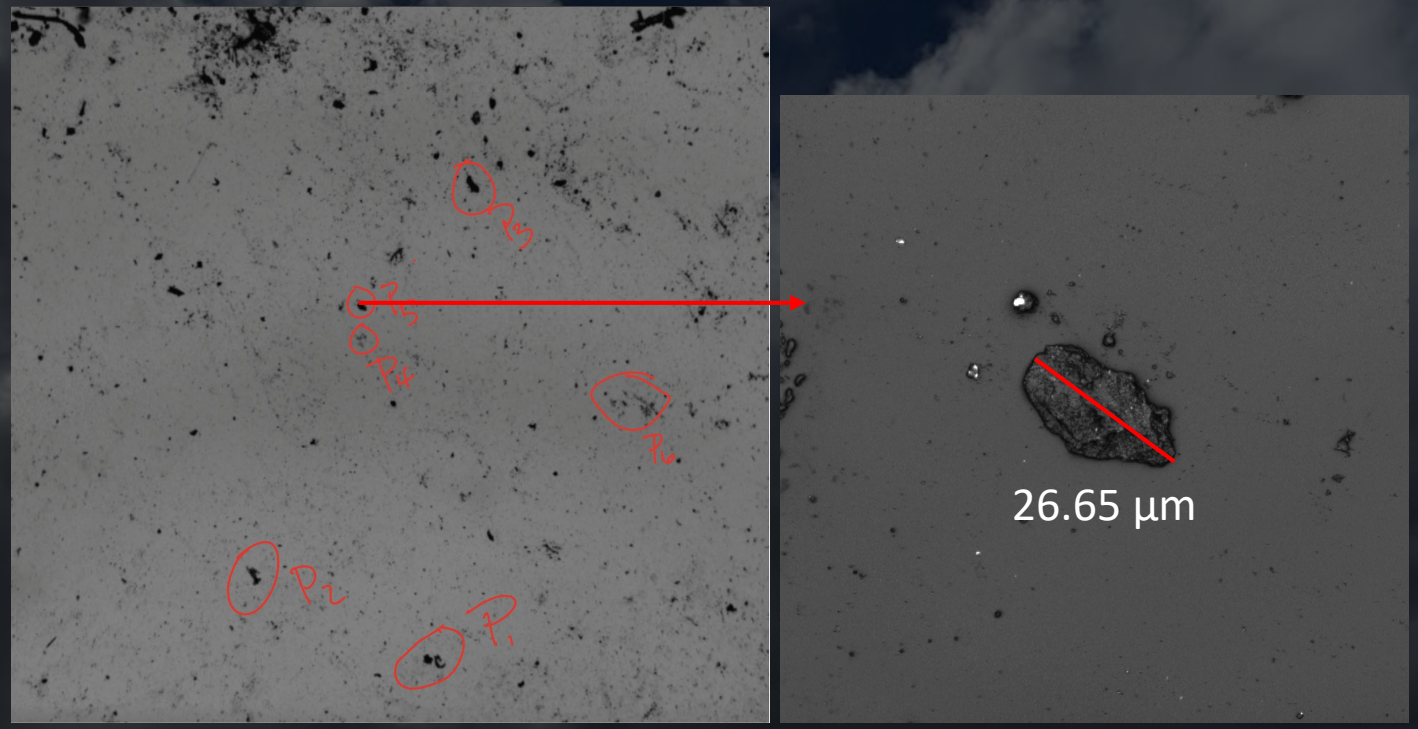
Study of the physical-chemical properties of non-soluble particles trapped in a hailstone in Cordoba, Argentina

- What is the ***spatial distribution*** with respect to the center of the hailstone and particle ***size distribution*** of non-soluble particles trapped within the hailstone sample?
- What is the ***elemental composition*** distribution of non-soluble particles collected by the hailstone during its growth in the cloud?
- Which regions are ***potential sources*** of the non-soluble particles identified in the hailstone? Are they regional or extend outside of Argentina's geographical boundary?

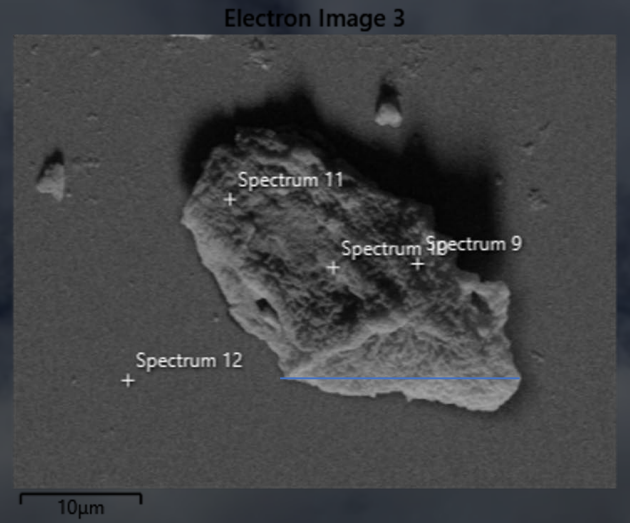
Hailstone Preparation

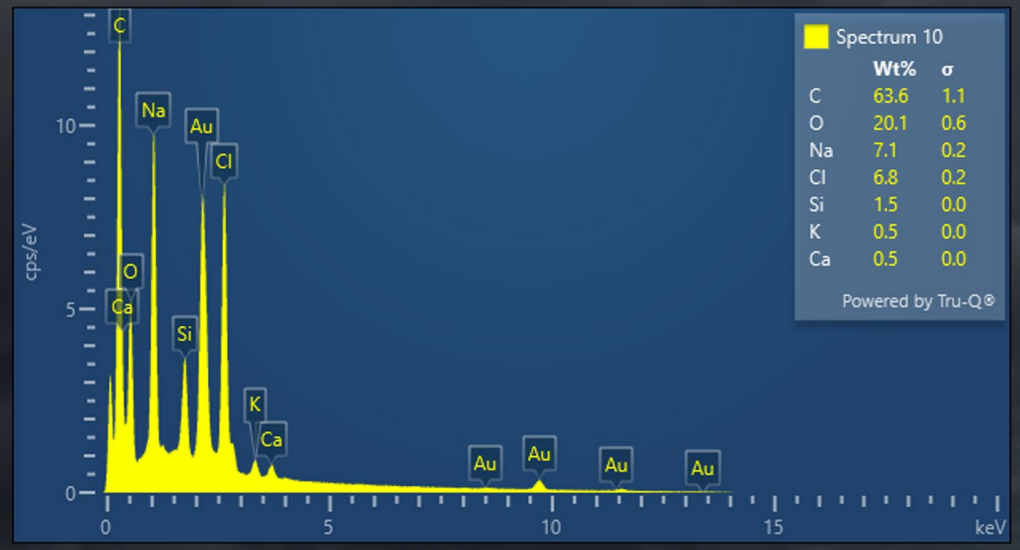


Microscopy Analysis



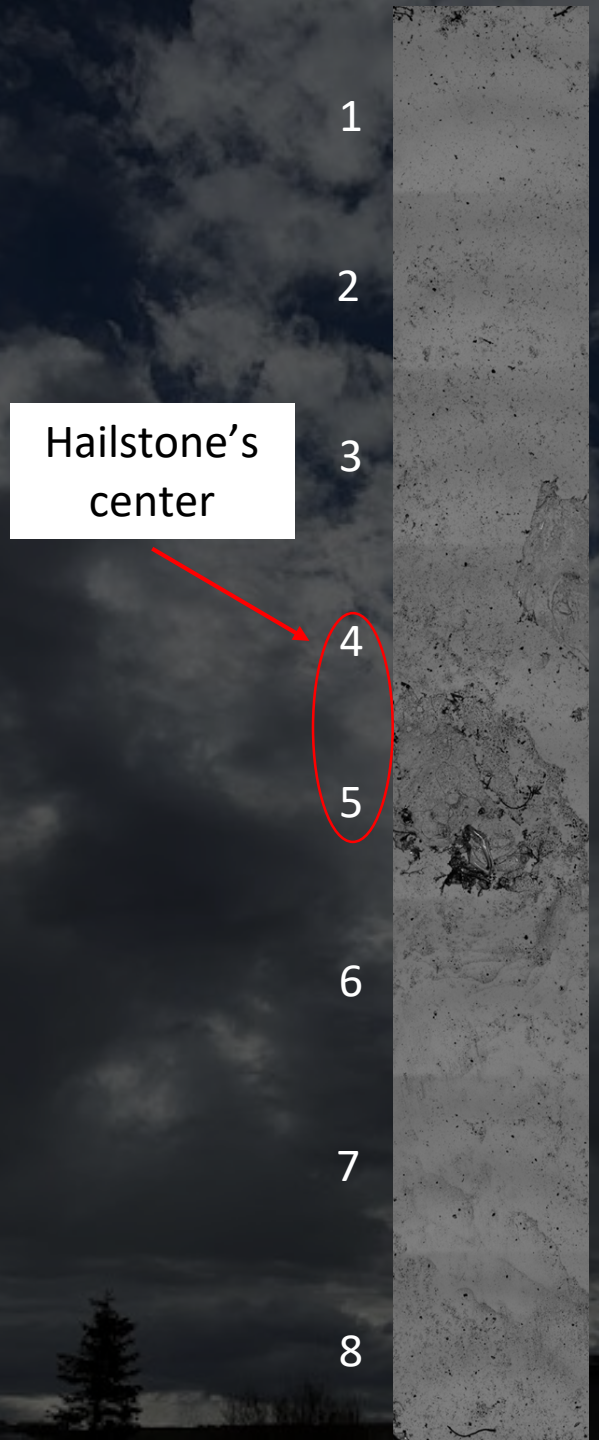
Confocal Laser Scanning Microscope (CLSM)

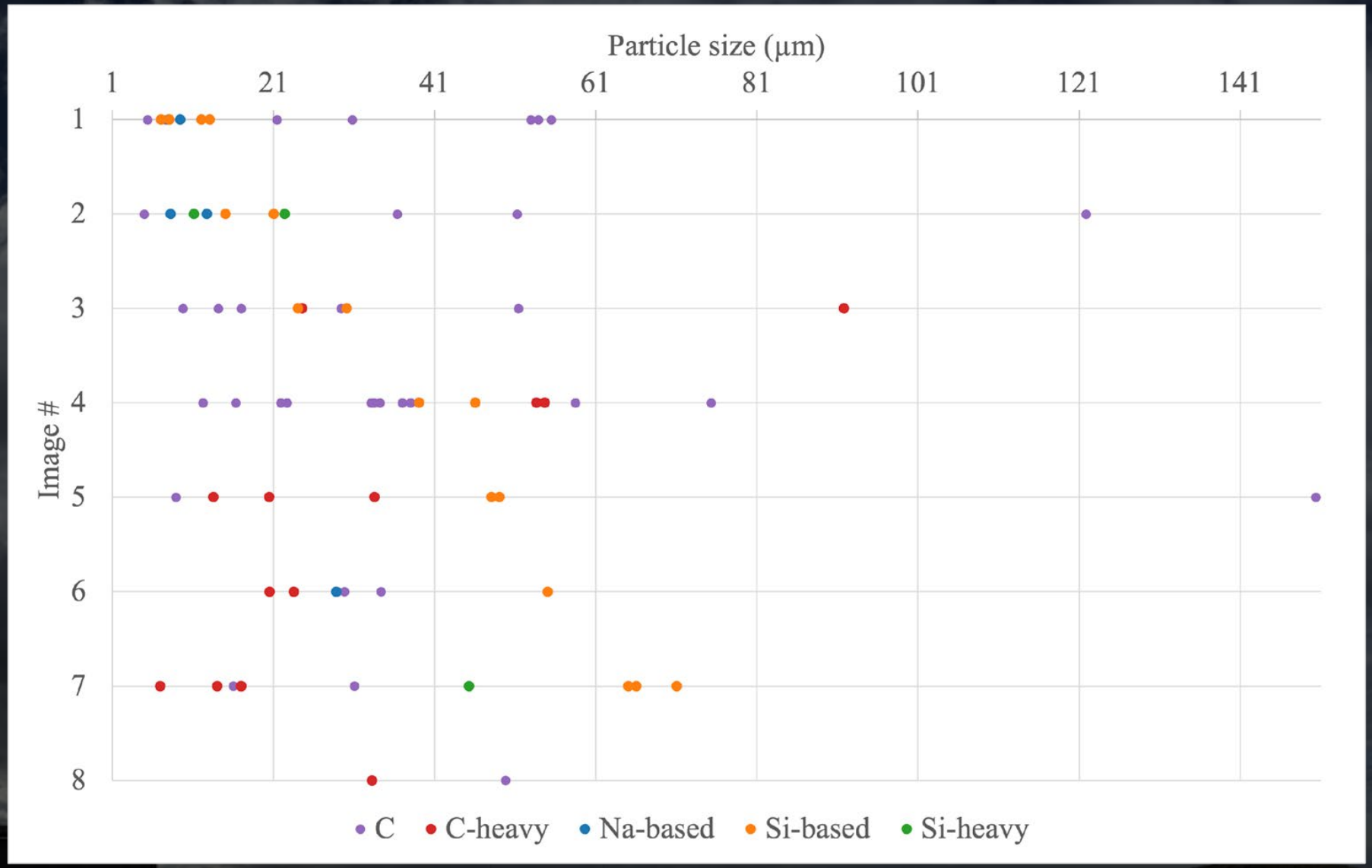




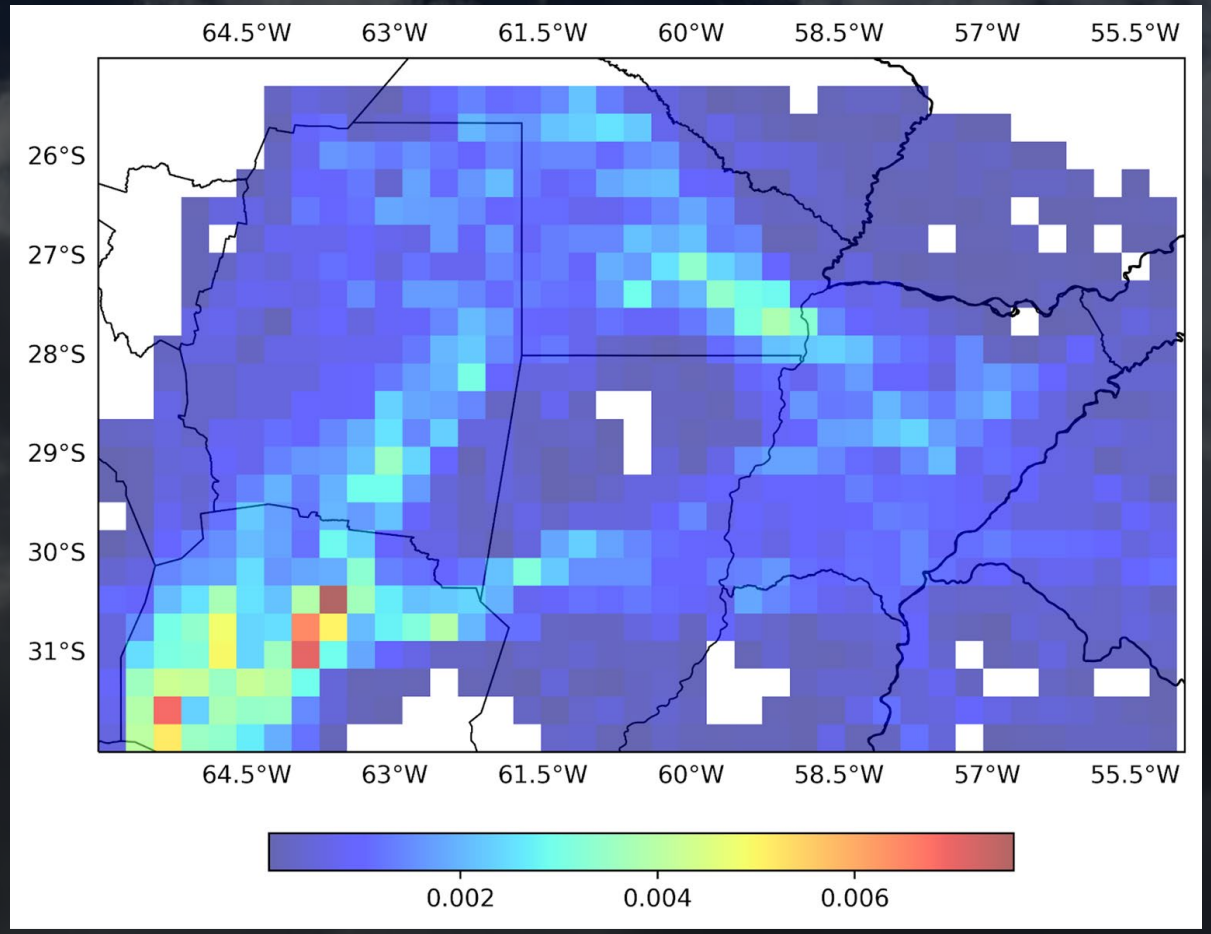
Scanning Electron Microscope – Energy Dispersive Spectroscopy (SEM-EDS)

CLSM/SEM-EDS analysis

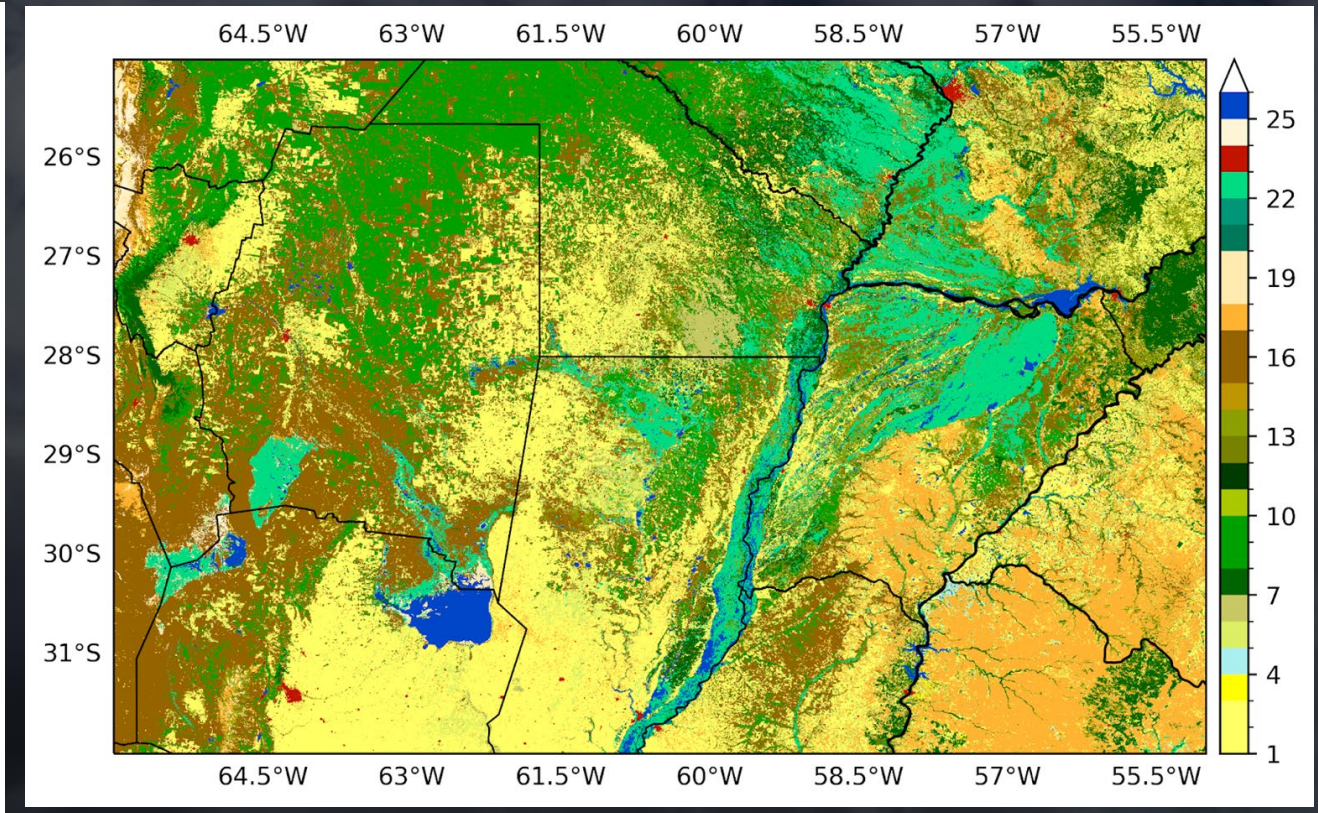




Source regions



5-day residence time coefficients



Cropland

Water

Urban

Mix Vegetation

Key Messages (8 February)

- ***Carbonaceous*** particles were the most predominant particles.

- Local strong winds likely suspended ***larger particles***, enabling them to be entrained within the updraft and influencing hail growth.

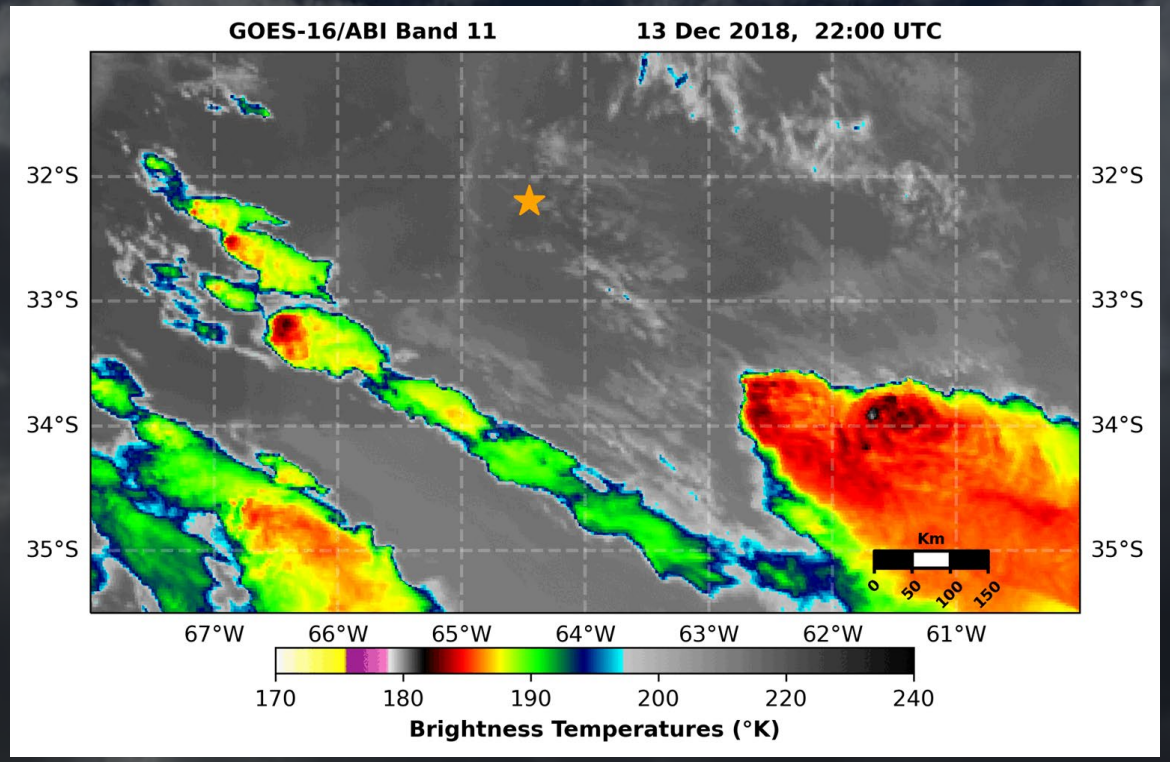
- ***Silicates*** were detected in similar places to the carbonaceous particles.

- ***Salts*** on the outer layers were detected, potentially originating from particles acting as CCN and mixing with other atmospheric particles.

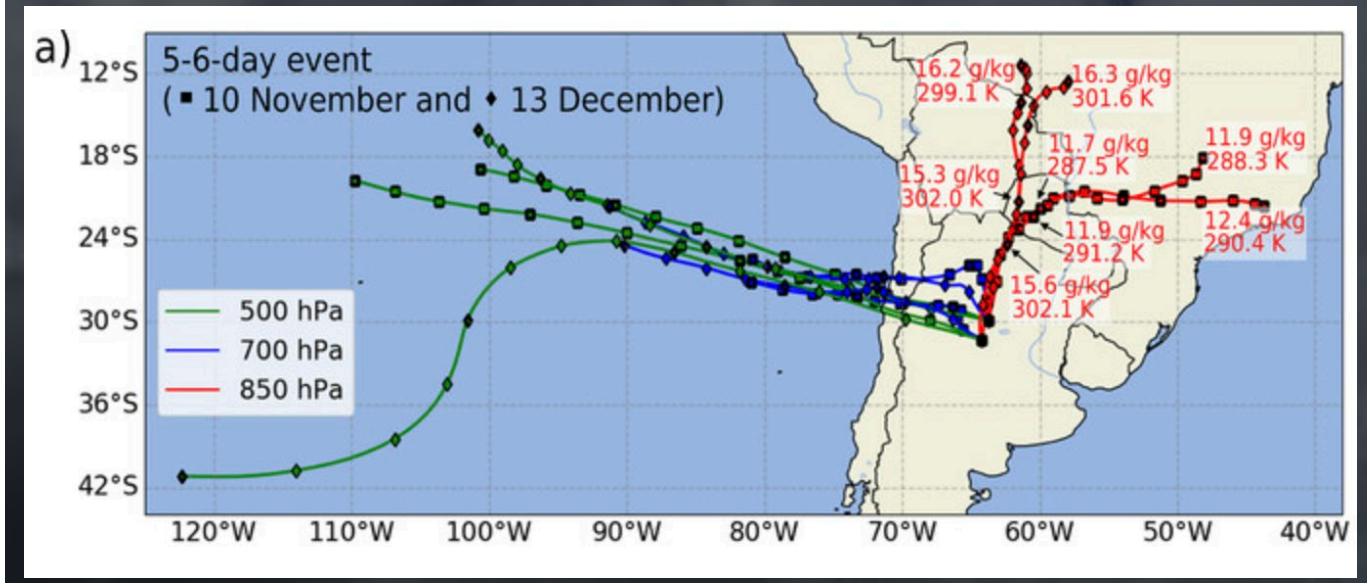
- ***Anthropogenic activities*** may contribute to the presence of heavier metals in the particles, which can affect aerosol interactions and ***ice nucleation temperatures***.

- Considering nearby urban areas and their influence on heavier metal transport and vegetation absorption is crucial in understanding ***hailstone composition*** and its implications.

Are similar results seen in the 14 December 2018 8 cm hailstone?



Bernal-Ayala et al. 2022

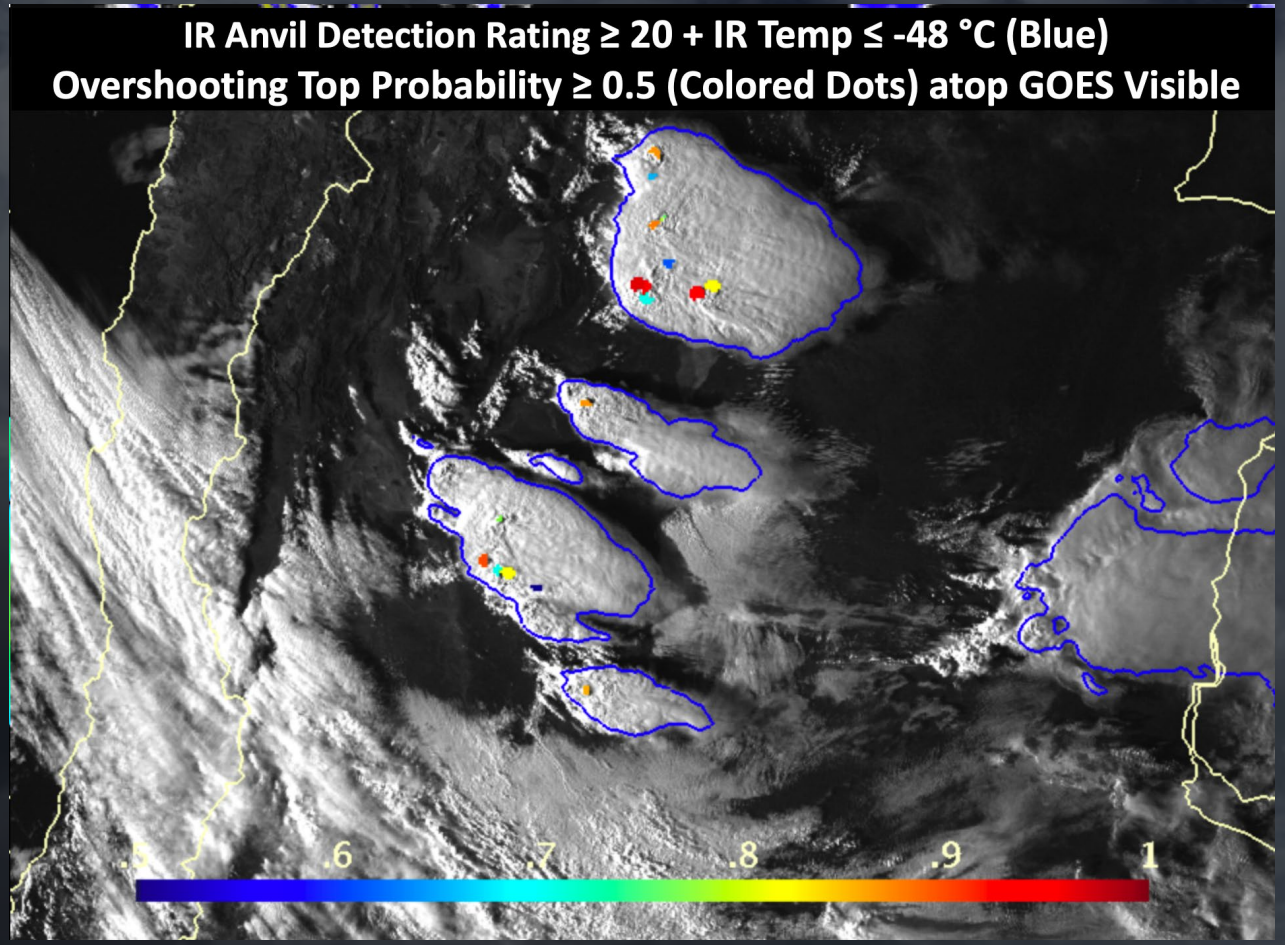


Sasaki et al. 2022

Previous studies link deep convective systems in the region to heightened moisture from the South American Low-Level Jet (SALLJ), dry air subsidence east of the Andes, and lee cyclogenesis (Rasmussen and House 2016; Bruik et al. 2019; Mullholand et al. 2018). Environmental factors conducive to hail formation were noticed in the MCS on 14 December (Bernal Ayala et al. 2022; Sasaki et al. 2022).

Future work

- Hailstorms in subtropical South America differ from those in the United States regarding diurnal cycle and storm organization.
- ***Overshooting tops (OTs)*** indicate vigorous updrafts and strong convective activity, a proxy for hail potential.
- OT areas/depth linked to hail from different storm types (Grover 2021)
- ***Objective: Associate environmental conditions with SSA deep convection systems through OTs***



Setvak et al. 2013

Thank you!

A. C. Bernal Ayala, J. J. Gerth, T. J. Schmit, S. S. Lindstrom, and J. P. Nelson III, 2023: Parallax shift in GOES ABI data. J. Operational Meteor., 11 (2), 14-23, doi: https://doi.org/10.15191/nwajom.2023.1102

Bernal Ayala, A.C.; Rowe, A.K.; Arena, L.E.; Desai, A.R. Evaluation of Satellite-Derived Signatures for Three Verified Hailstorms in Central Argentina. Meteorology 2022, 1, 183-210. https://doi.org/10.3390/meteorology1020013

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