

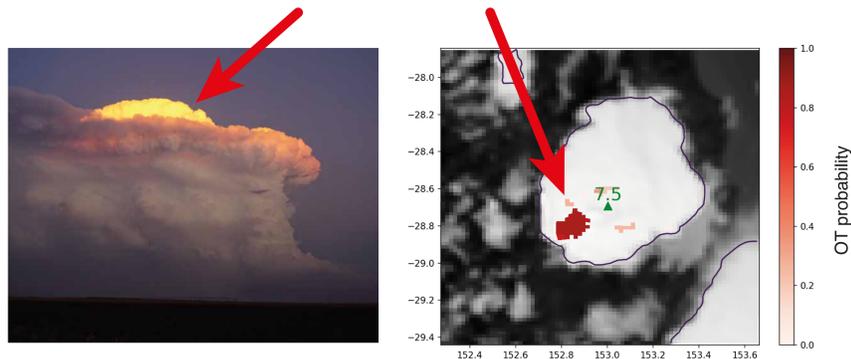
Hail Climatology, Trend, and Hazard Models for South America and Australia

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Climatology

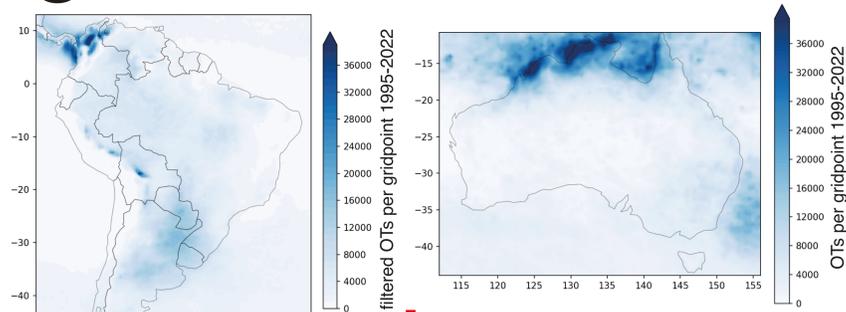
Overshooting cloud tops (OTs) indicate intense updrafts (the OT detection algorithm of [1] was used on GOES/MTSAT/himawari satellite with OT probability > 0.5)



Example Supercell with OT and 7.5cm hail

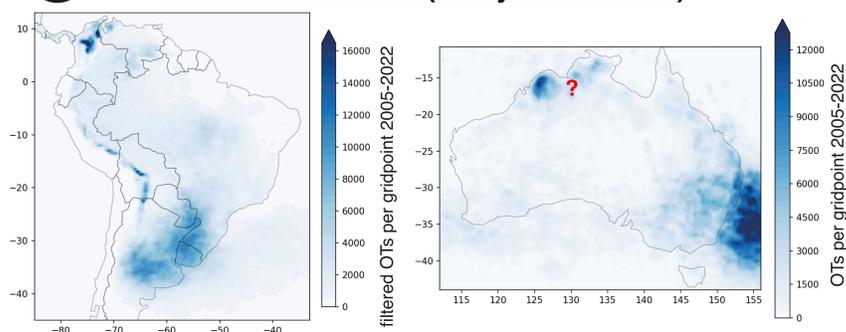
- 1 Counting the OTs for South America (1995-2022) and Australia (2005-2022) gives a thunderstorm climatology
- 2 To only include hailstorms, ERA5 Reanalysis was used to filter out OTs in environments where hail is unlikely to reach the ground [2,3], yielding a hail climatology.
Hail is most likely in South central S. Am., locally along the Andes mountains, and in Southeast Australia
- 3 OTs give limited hail size info but filtering for strong OTs or supercells [4,5] or hazard modeling (below) can estimate large hail

1 Total OT count (intense thunderstorms)

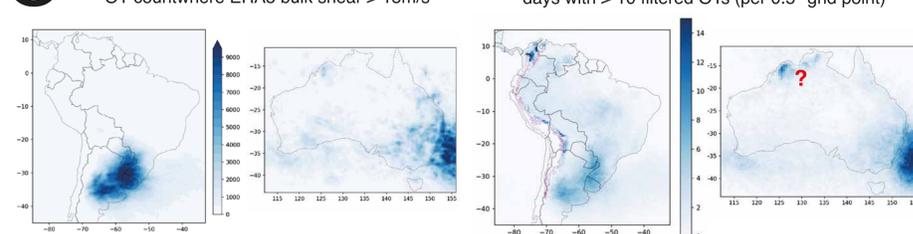


ERA5 filter
 (CAPE>100J/kg, bulk shear>1.5m/s,
 1800m<melting level<4845m)

2 Filtered OT count (likely hailstorms)

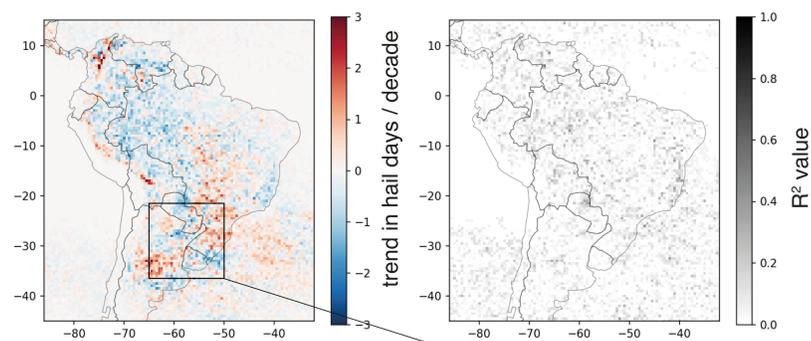


3 OTs in supercell environments only



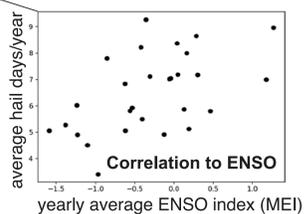
hail days per year
 days with > 10 filtered OTs (per 0.5° grid point)

Trend over South America



The long S. Am. dataset allows to assess trends via linear regression of the hail days (see hail days Climatology above) per year per gridpoint.

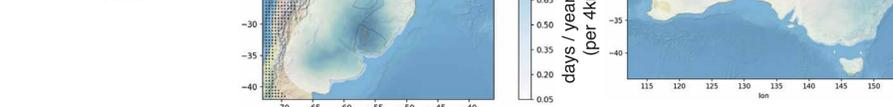
Some trends are visible, but natural year to year variability is large (low R²) and there is a link to ENSO, so deeper statistical analysis is required.



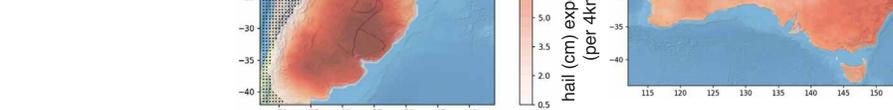
Hazard modeling

Based on OT tracks and reports, hail swaths are modeled stochastically (left example) for 25000 years [2]. This hazard model can be used in insurance risk models or to estimate return frequencies of hail (below).

yearly severe hail



200 year return size



References:
 [1] Khlopenkov, K. V., Bedka, K. M., Cooney, J. W., & Iltterly, K. (2021). Recent Advances in Detection of Overshooting Cloud Tops From Longwave Infrared Satellite Imagery. *Journal of Geophysical Research: Atmospheres*, 126(14), 1–25. <https://doi.org/10.1029/2020-JD034359>
 [2] Punge, H. J., Bedka, K. M., Kunz, M., Bang, S. D., and Iltterly, K. F.: Characteristics of hail hazard in South Africa based on satellite detection of convective storms, *Nat. Hazards Earth Syst. Sci.*, 23, 1549–1576, <https://doi.org/10.5194/nhess-23-1549-2023>, 2023
 [3] Bedka, K. M., Allen, J. T., Punge, H. J., Kunz, M., & Simanovic, D. (2018). A long-term overshooting convective cloud-top detection database over Australia derived from MTSAT Japanese Advanced Meteorological Imager Observations. *Journal of Applied Meteorology and Climatology*, 57(4), 937–951. <https://doi.org/10.1175/JAMC-D-17-0056.1>
 [4] Scarino, B., Iltterly, K., Bedka, K., Homeyer, C. R., Allen, J., Bang, S., & Cecil, D. (2023). Deriving Severe Hail Likelihood from Satellite Observations and Model Reanalysis Parameters Using a Deep Neural Network. *Artificial Intelligence for the Earth Systems*, 2(4), 1–30. <https://doi.org/10.1175/aies-d-22-0042.1>
 [5] Blair, S. F., and Coauthors, 2017: High-Resolution Hail Observations: Implications for NWS Warning Operations. *Wea. Forecasting*, 32, 1101–1119, <https://doi.org/10.1175/WAF-D-16-0203.1>.