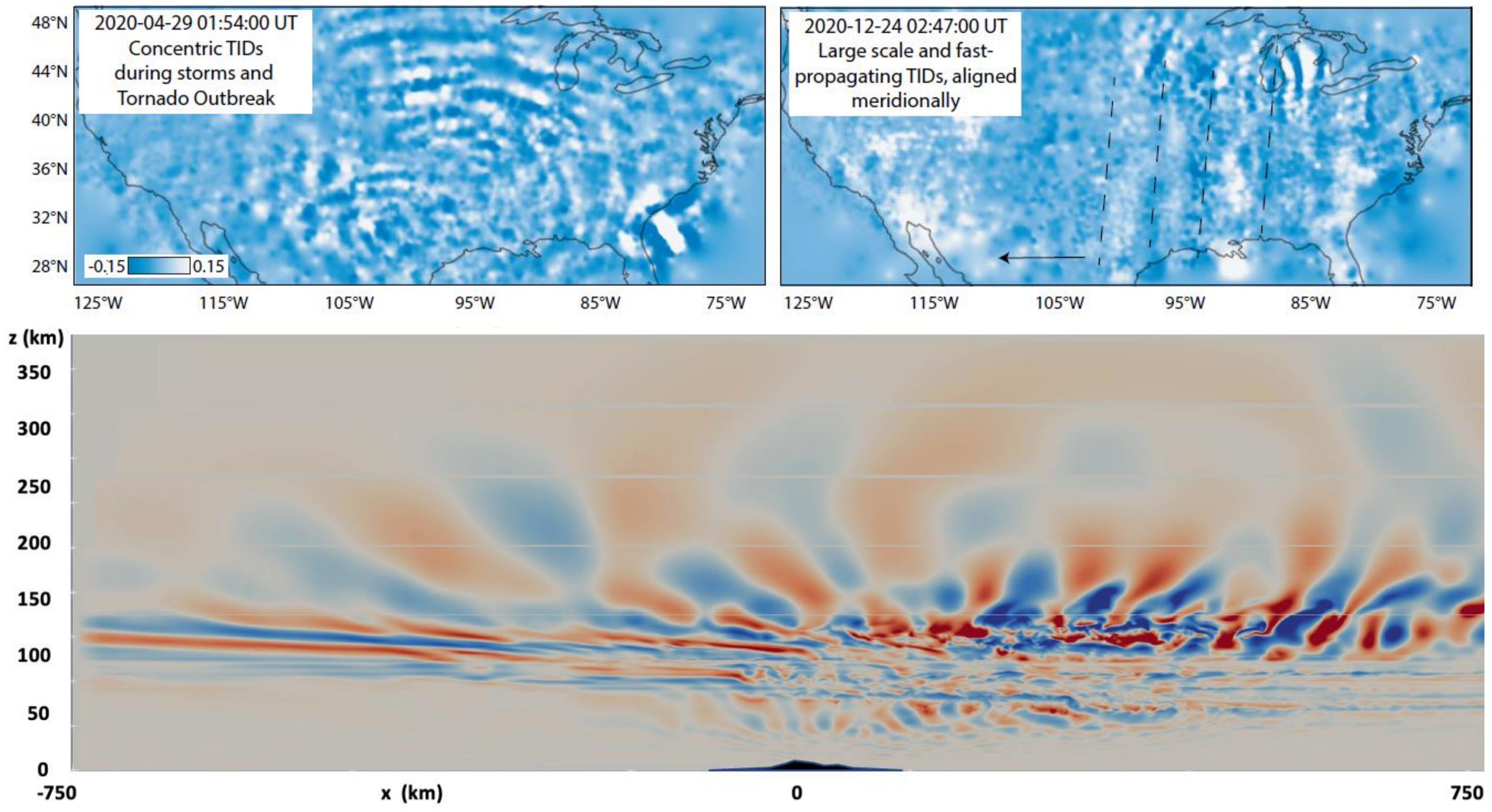
The role of gravity waves in the mesosphere, thermosphere and ionosphere cross-scale coupling and irregularities: Observations and numerical simulations

Titus Yuan, Mike Taylor, Sharon Vadas, Erich Becker, Hanli Liu, Jonathan Makela,
Brian Harding, Jonathan Snively, Christopher Heale, Cesar Valladares

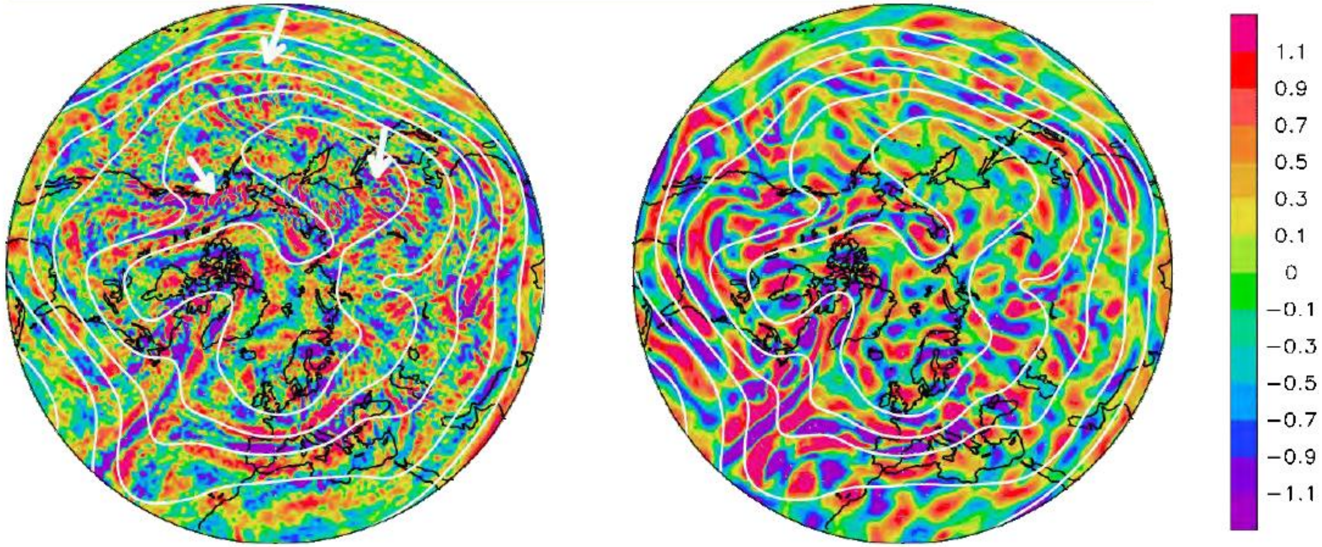


2020-04-29 01:54:00 UT
Concentric TIDs
during storms and
Tornado Outbreak
-0.15
0.15
2020-12-24 02:47:00 UT
Large scale and fast-
propagating TIDs, aligned
meridionally
48°N
44°N
40°N
36°N
32°N
28°N
125°W
115°W
105°W
95°W
85°W
75°W
z (km)
350
300
250
200
150
100
50
0
-750
x (km)
0
750

Resolved GWs: Nudged HIAMCM versus MERRA-2, 12 Jan. 2016, 12UT

T' (K) and horiz. streamf. at 200 hPa

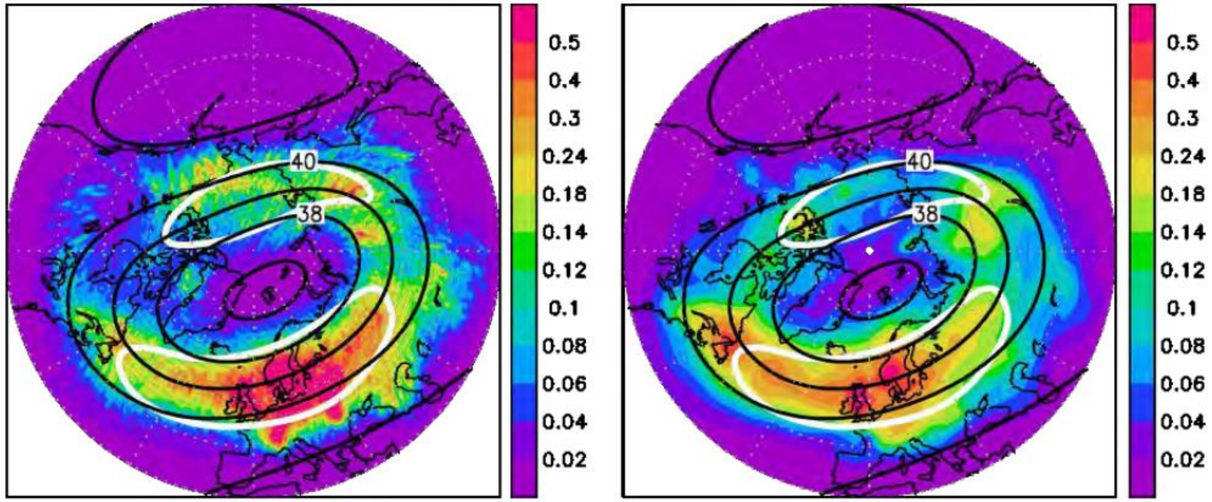
HIAMCM **MERRA-2**



GWs in the stratosphere: Nudged HIAMCM versus AIRS, 1-31 Jan. 2016

T variance (K²), z @ 2.4 hPa (km), |v| (80 m/s)

HIAMCM **AIRS**



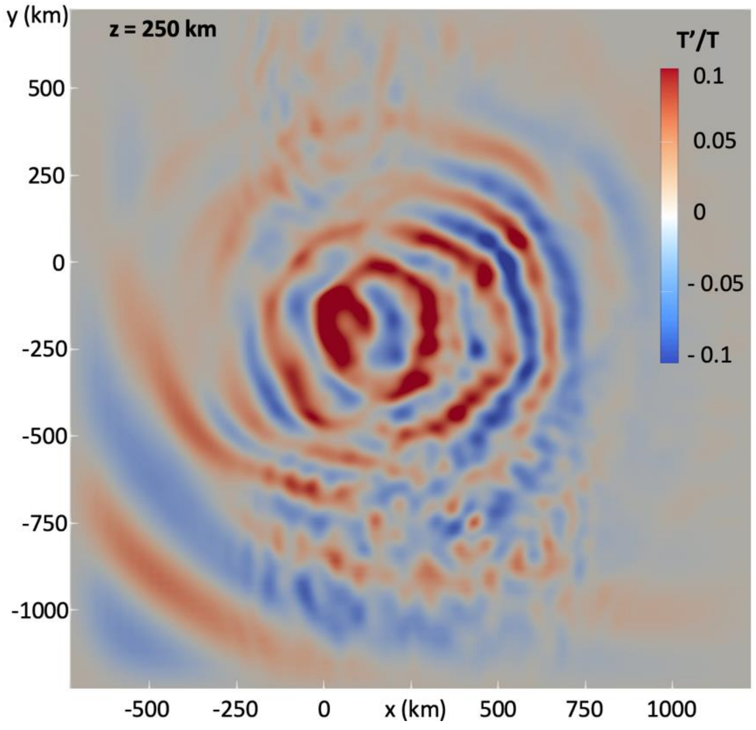
(Becker, Vadas, et al., 2022, JGR-A)

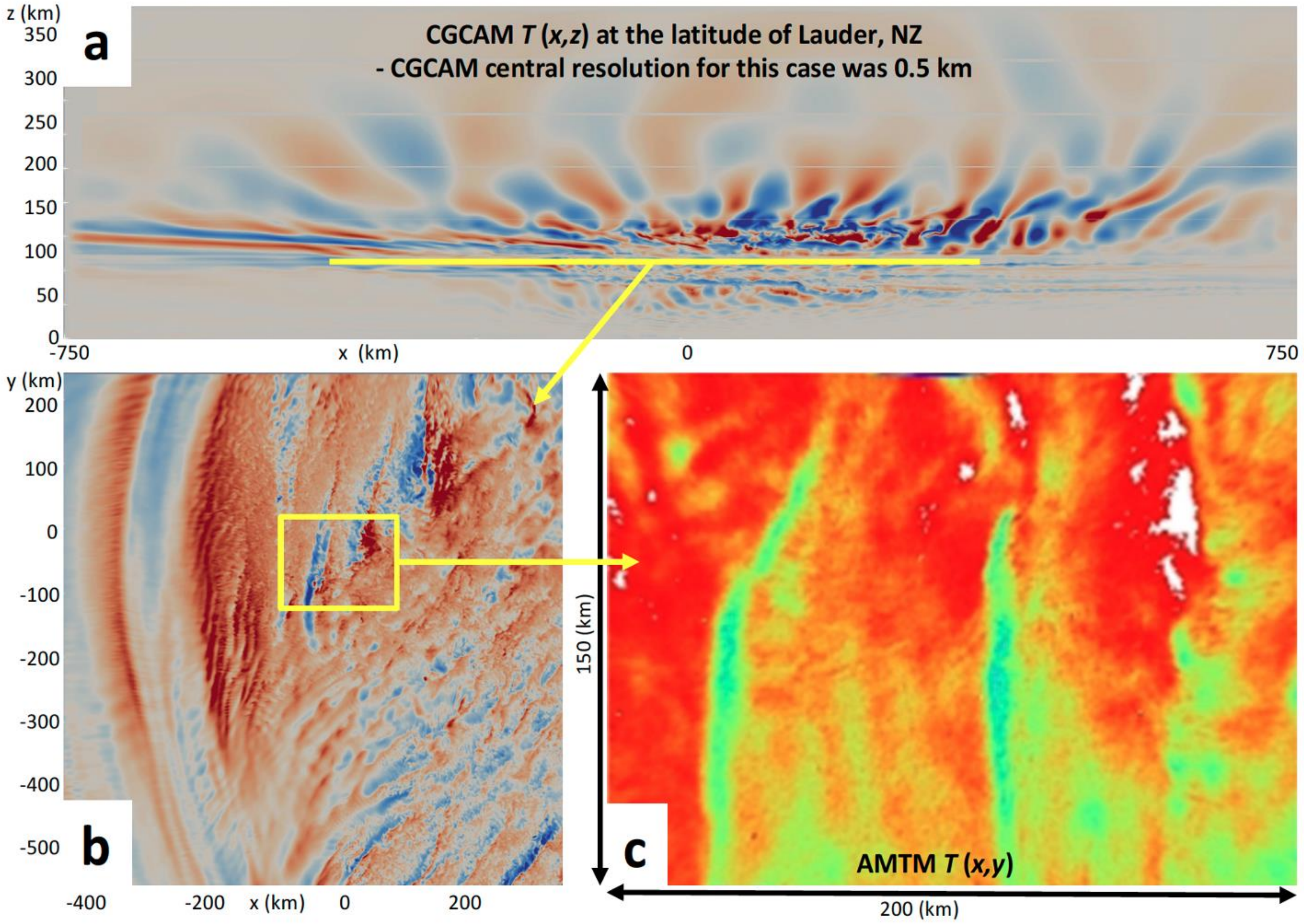
Mountain Waves simulated with CGCAM that closely approximate DEEPWAVE AMTM observations

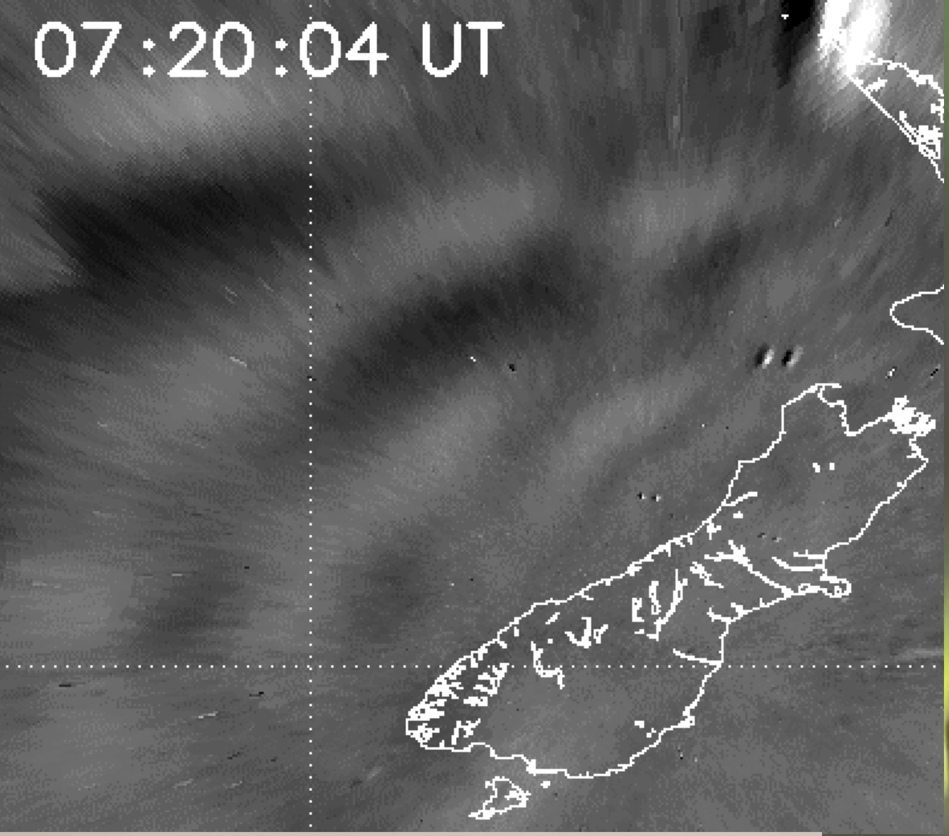
- **Environmental specification was provided by NAVGEM DA and reanalysis**

- **CGCAM at 1-km resolution closely approximated the AMTM imaging**

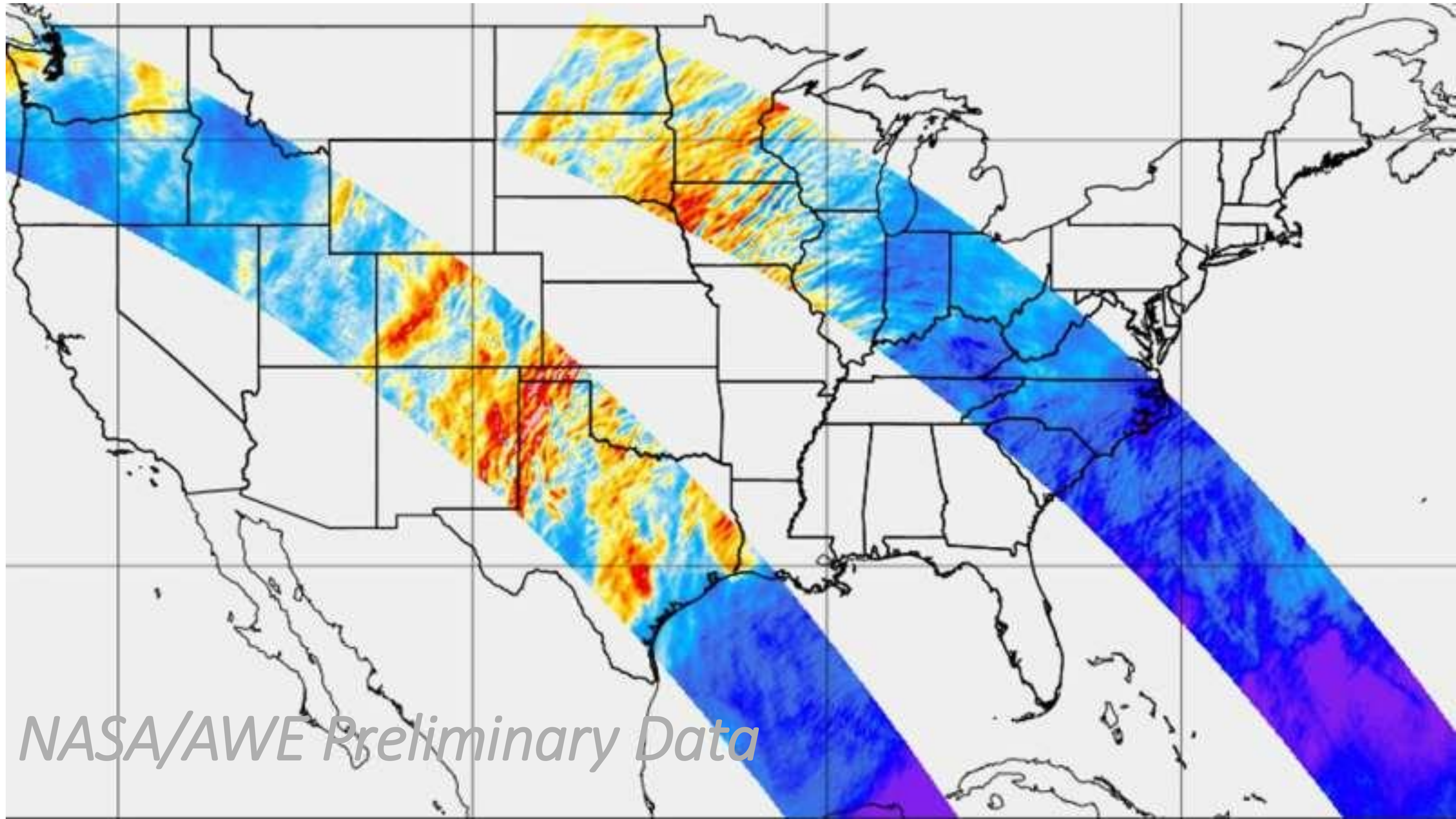
- **SGWs at 250 km quickly followed initial MW breaking**



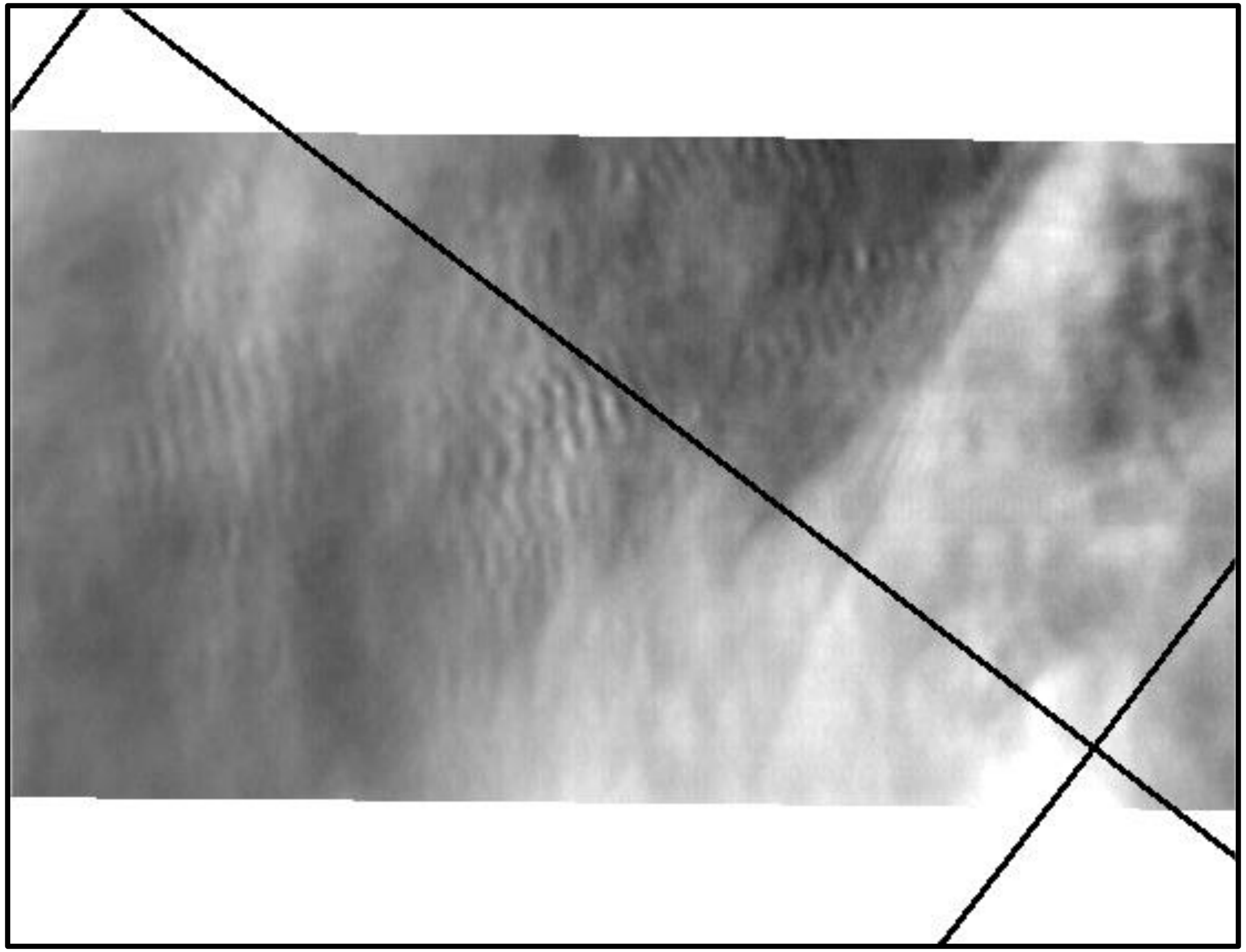



07:20:04 UT

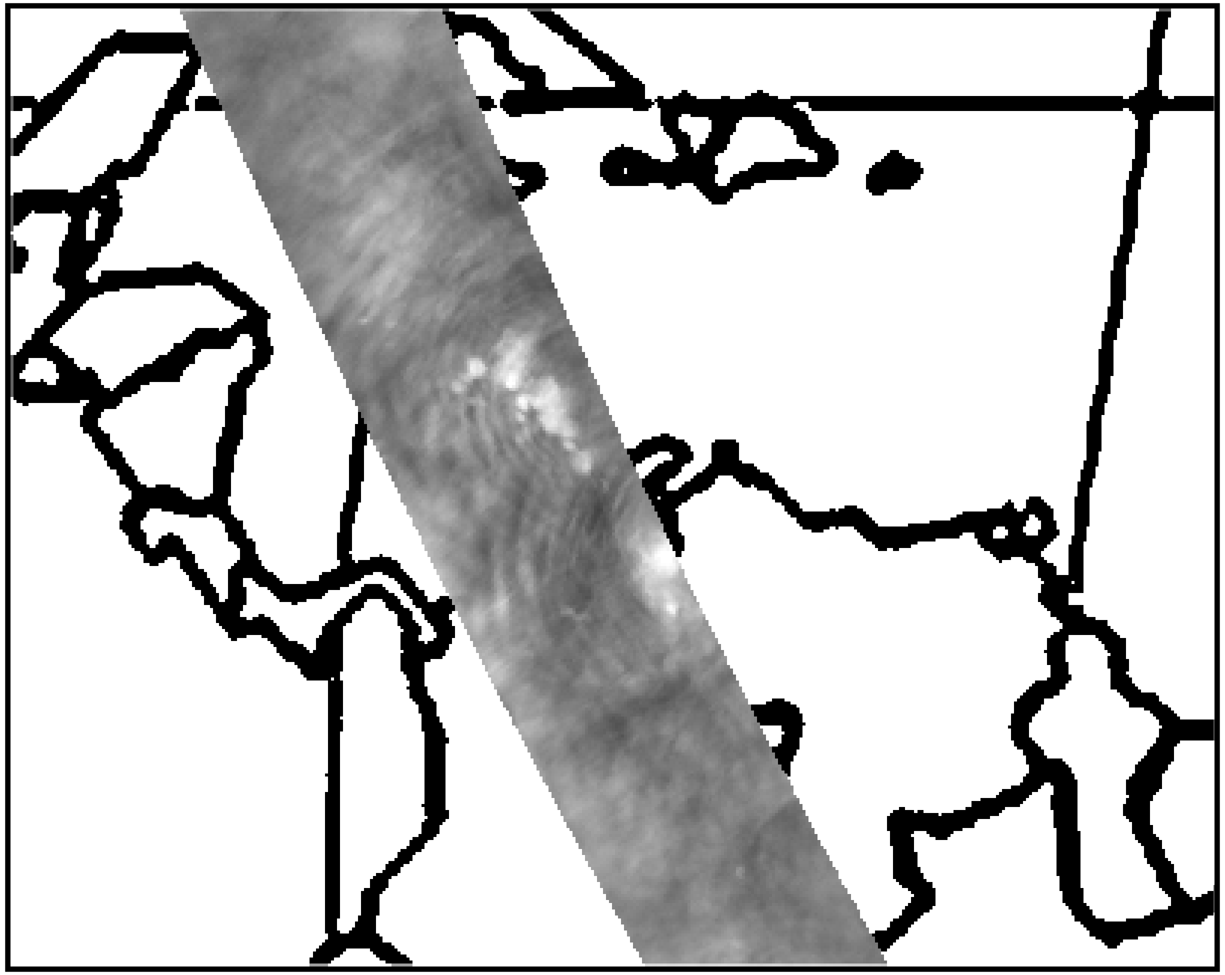

Xenics


NASA/AWE Preliminary Data

NASA/AWE Preliminary Data

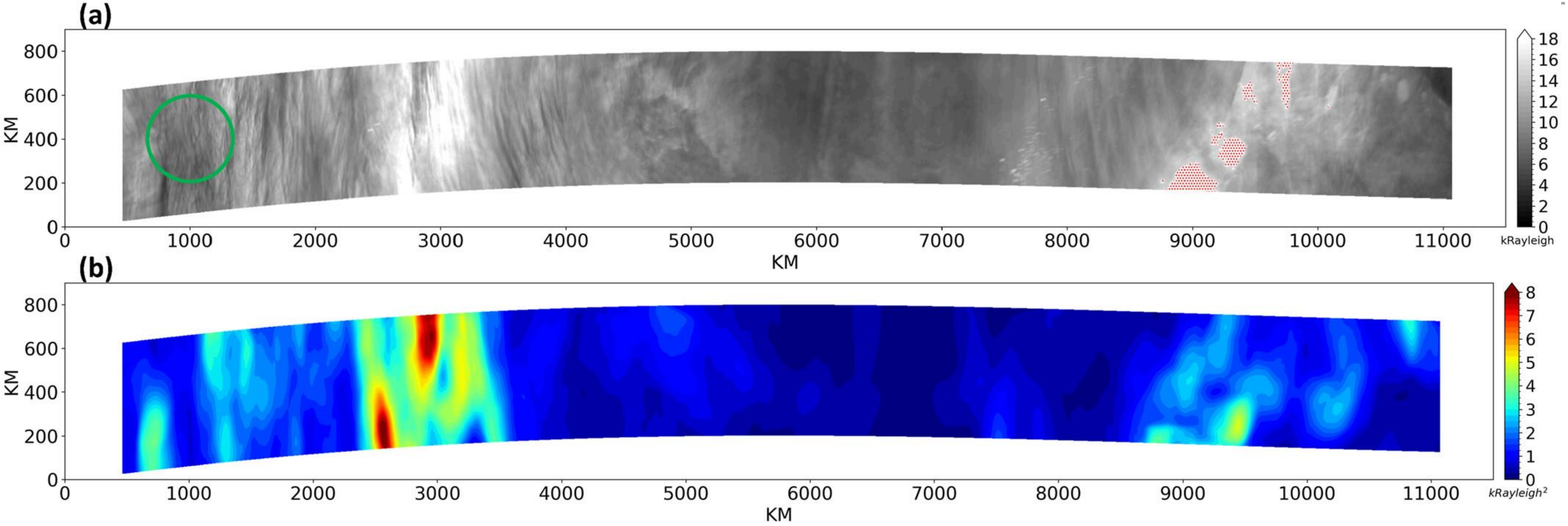


Example of multiple short-scale gravity wave packets



AWE measurements over a convective region

AWE $Q_1(1)$ Radiance Variance to study AGW variations during SSW



Radiance data for the first orbit of the AWE $Q_1(1)$ emission line on 22 November 2023. (a) Radiance, and (b) radiance variance, computed based on surrounding pixels within a 200 km radius, as indicated by the green circle. The red dots in panel (a) represent pixels potentially impacted by high-altitude clouds, identified by values within 20°S–20°N that exceed two standard deviations of the entire swath (Zhang et al., 2025).

GC Year 2 Summary & Conclusions

- AGWs have significant impacts on whole mesosphere thermosphere-ionosphere system

- The latest development of general circulation models and local/regional high resolution physics models are greatly advancing the understanding of AGW in the community

- Major challenges are the high quality and high resolution observations, covering both broad AGW spectrum and the background atmospheric condition, in the critical regions with global coverage.

- The NASA/AWE team presented the first scientific results of global coverage high resolution AWG observations in the mesopause region

- There is surely a wide diversity of enticing opportunities for new correlative observational and modeling studies addressing these dynamics in our CEDAR community