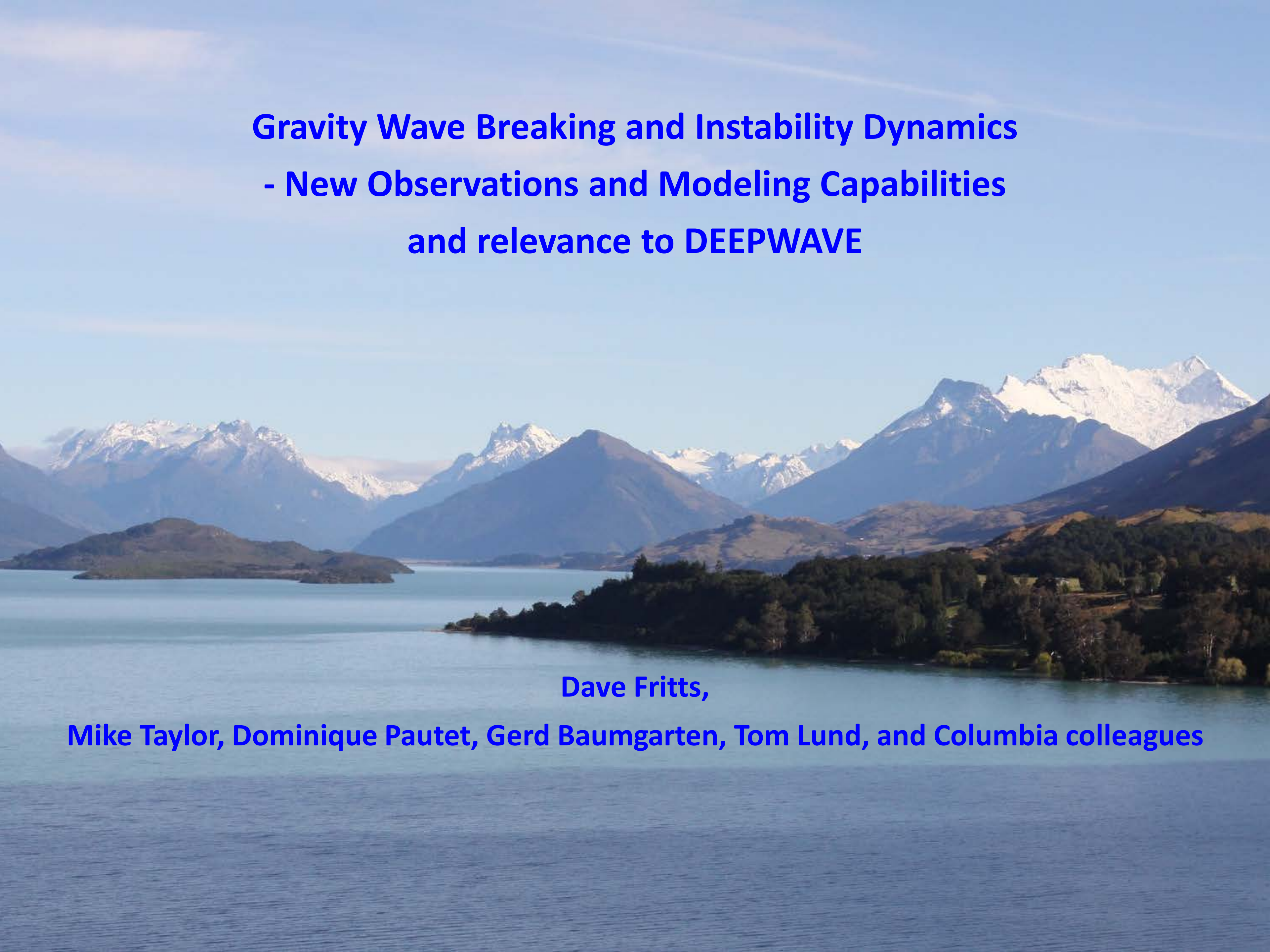


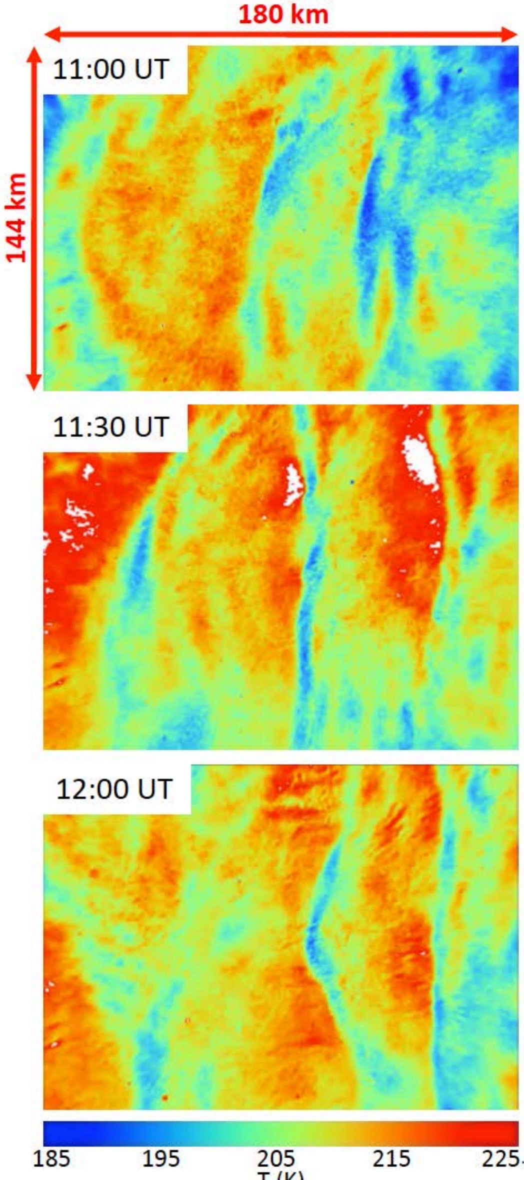
Gravity Wave Breaking and Instability Dynamics - New Observations and Modeling Capabilities and relevance to DEEPWAVE

Dave Fritts,

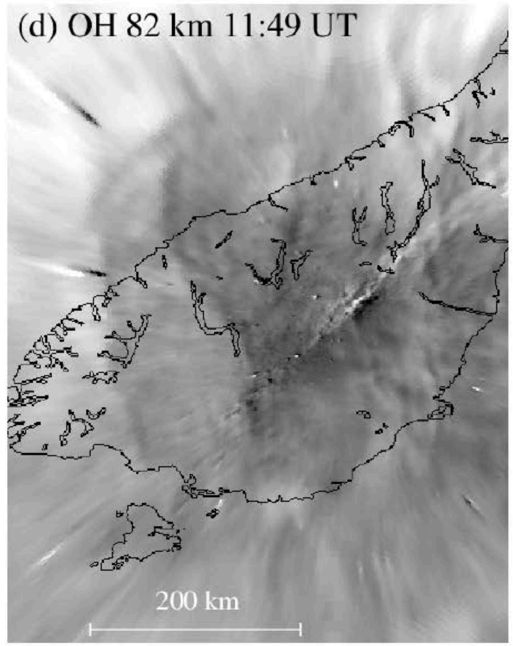
Mike Taylor, Dominique Pautet, Gerd Baumgarten, Tom Lund, and Columbia colleagues

21 June – Large-Amplitude MWs 12 UT

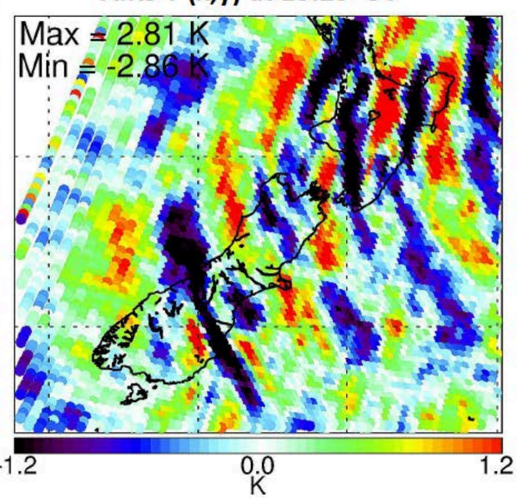
Lauder AMTM T(x,y) at 11-12 UT



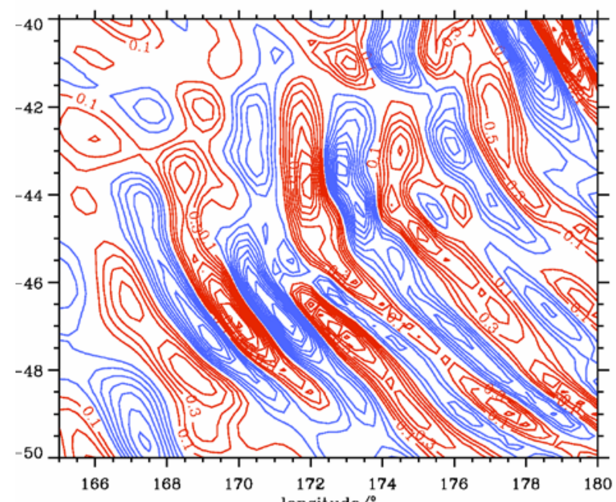
Lauder OH imager 11:49 UT



AIRS T'(x,y) at 13:25 UT



- scales vary from ~12 to 80 km
- "sawtooth" T(x) => strong overturning at ~87 km
- dominant MWs at ~85 km have δz >2km, T' ~20K, T ~210K, N ~0.02s^{-1}, λ_h ~65km, λ_z ~20-32 km
  =>
  <u>$<u'w'>$ ~400 m^2s^{-2} or greater</u>
- MWs seen by AIRS for ~4 days
- MW response is larger than NZ
- MW structure predicted by ECMWF



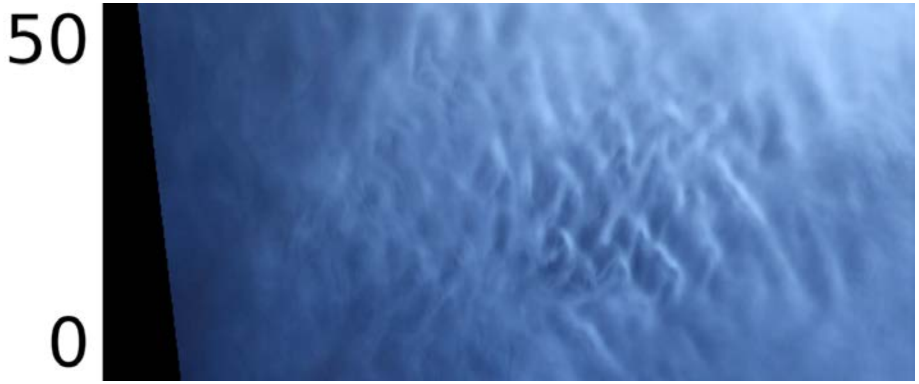
21 June Lauder – MWs at ~87 km, λ_h ~12-80 km

180 km

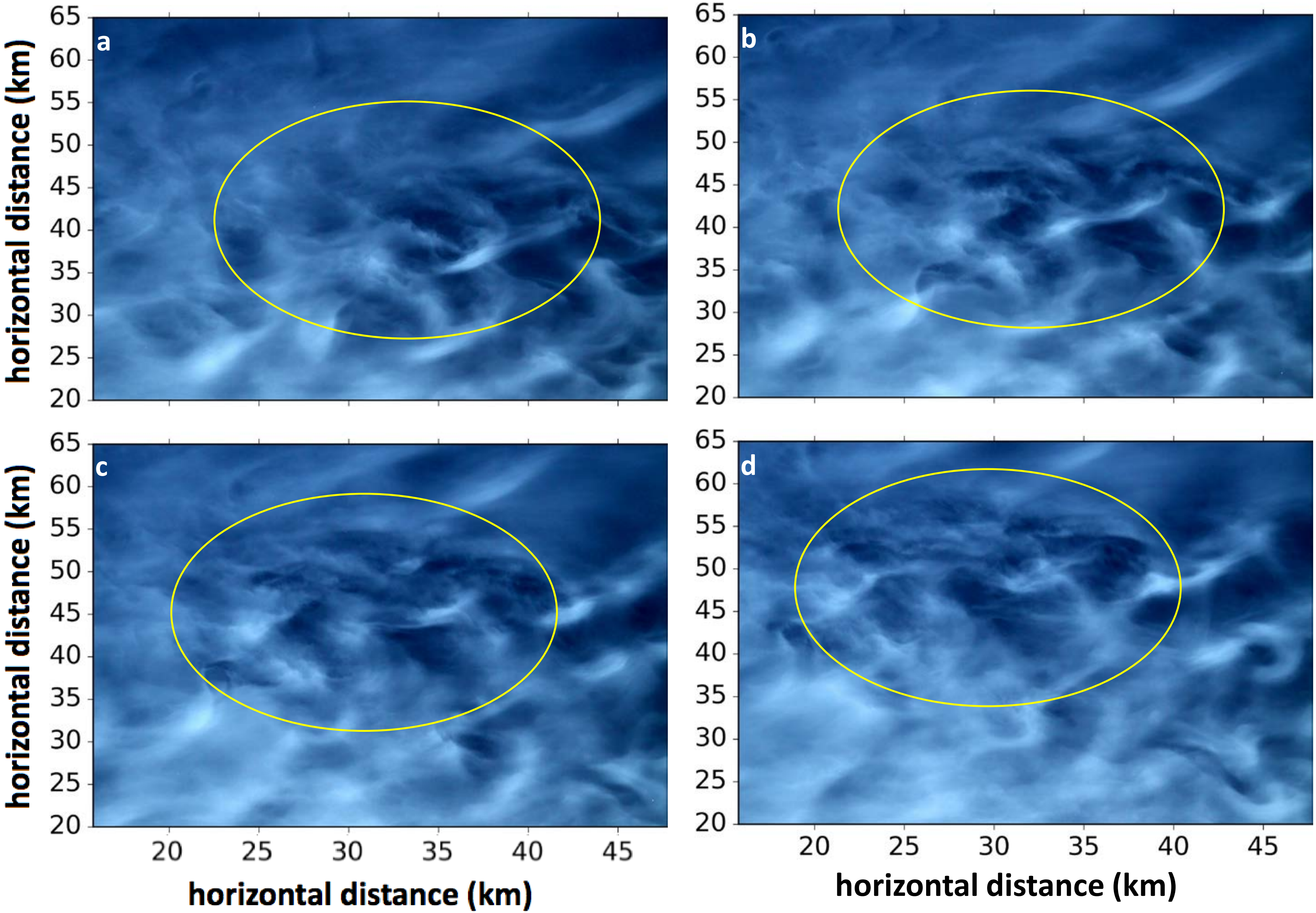
GW breaking and instabilities over Scandinavia (viewed in PMCs)

G. Baumgarten

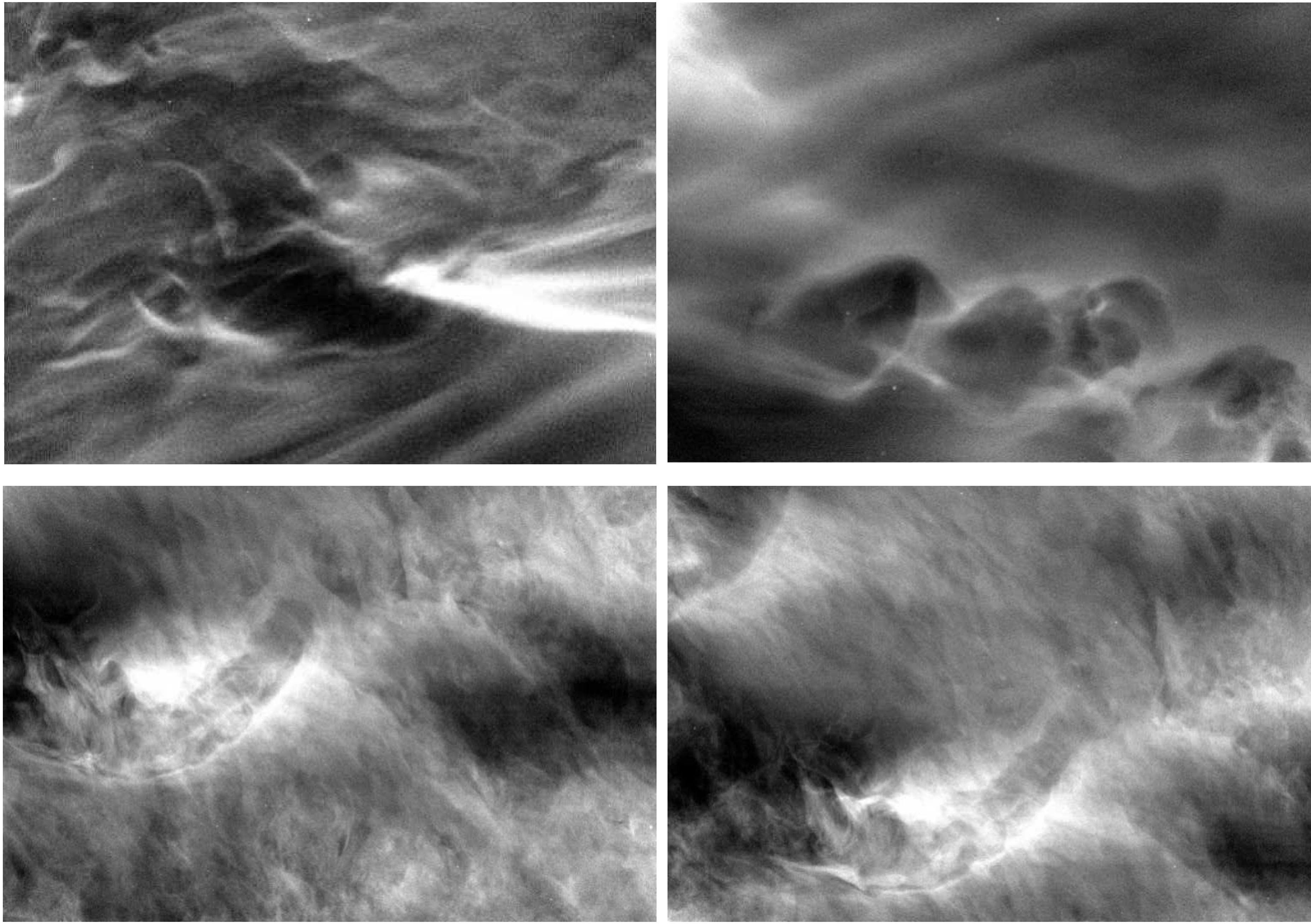
- instabilities are closely tied to specific phases of the larger-scale GW field



GW breaking via vortex rings over Scandinavia – G. Baumgarten



PMCs exhibiting vortex rings over Antarctica – Miller et al. (2015)



Idealized GW breaking

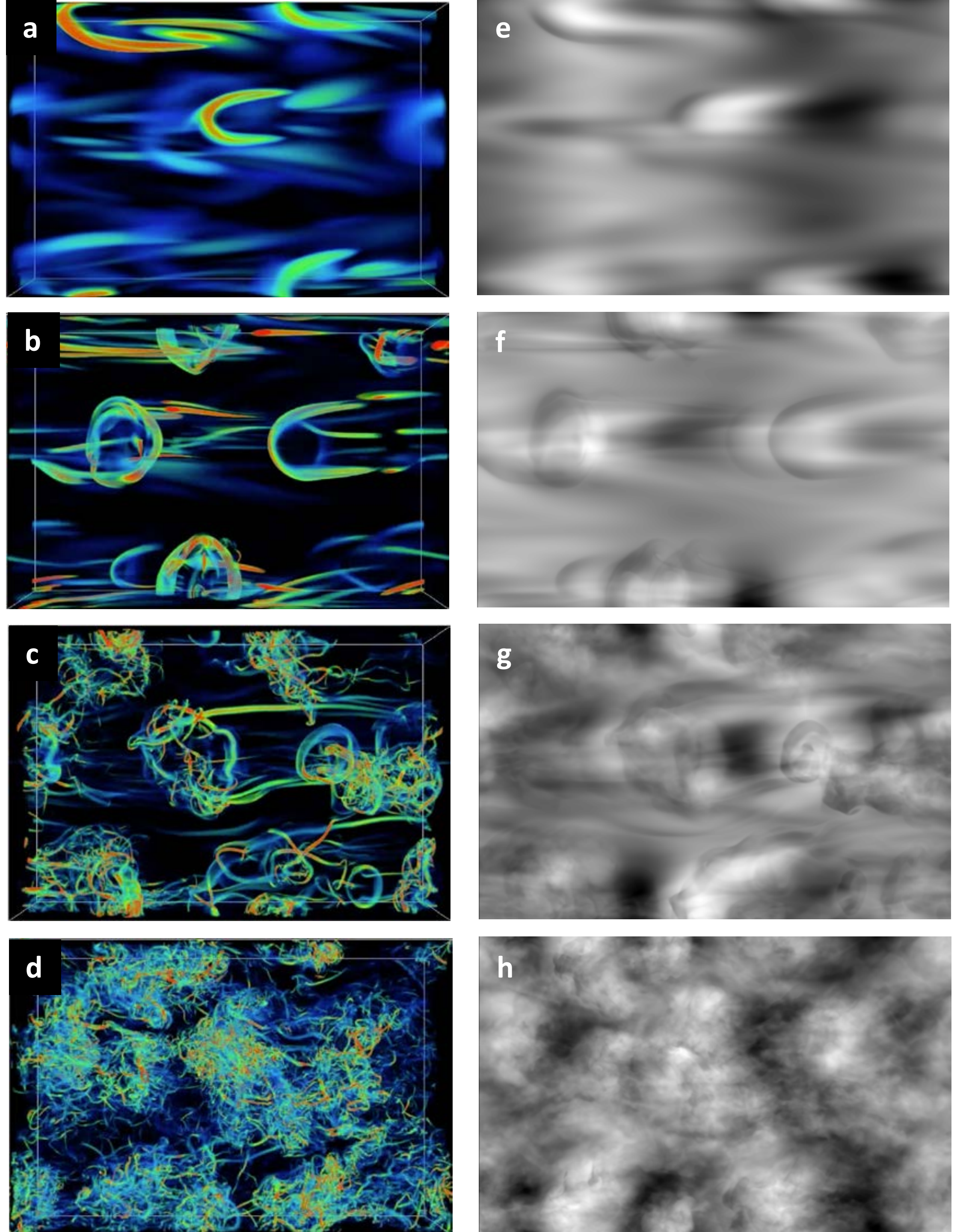
$\omega = N/3.2$

$a = u'/(c-U) = 0.9$

formation & breakdown of streamwise vortices and vortex rings (left)

airglow signatures (right)

$\Delta t = 1\ T_b$



Idealized GW breaking

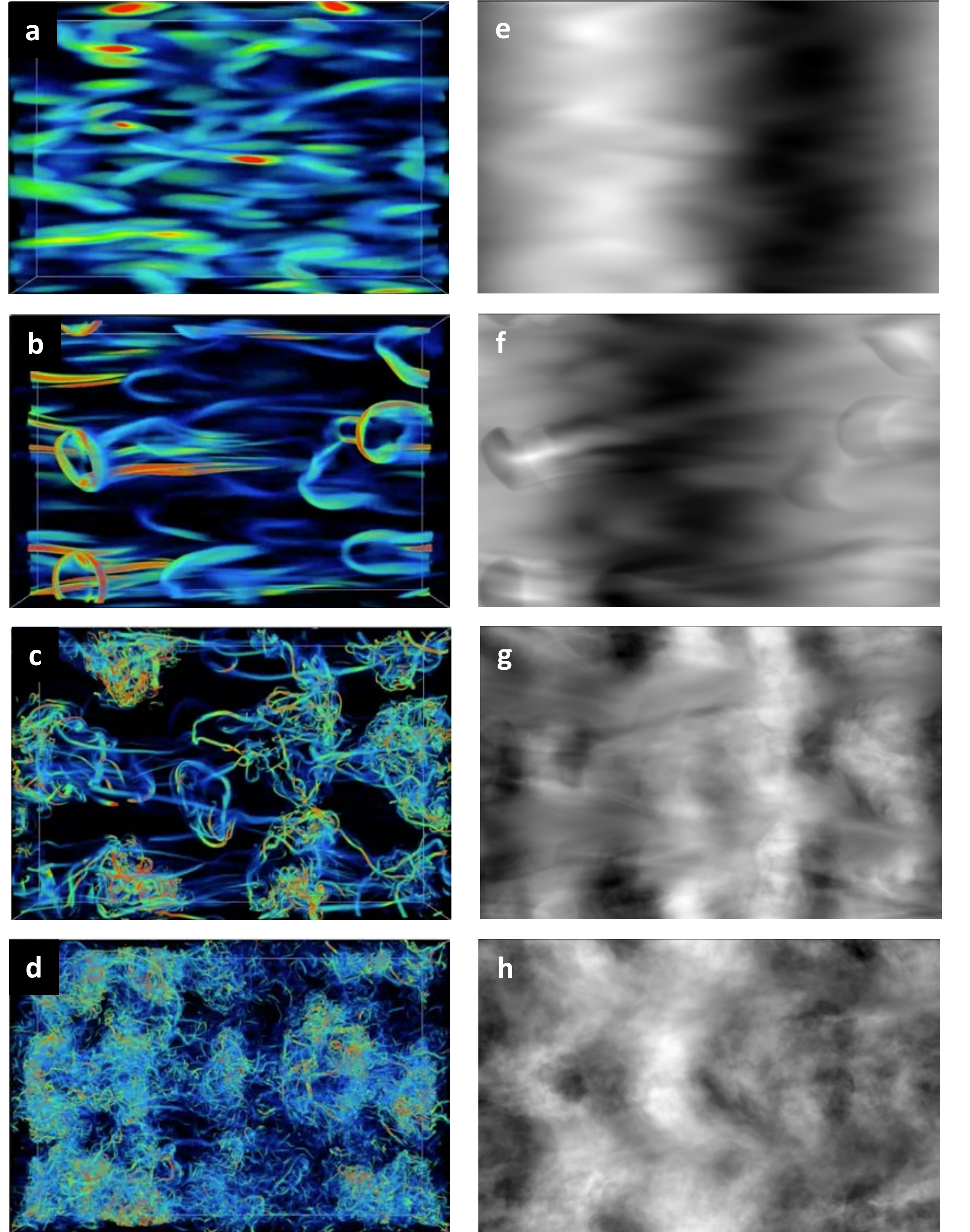
$\omega = N/3.2$

$a = u'/(c-U) = 1.1$

formation & breakdown of streamwise vortices and vortex rings (left)

airglow signatures (right)

$\Delta t = 1\ T_b$

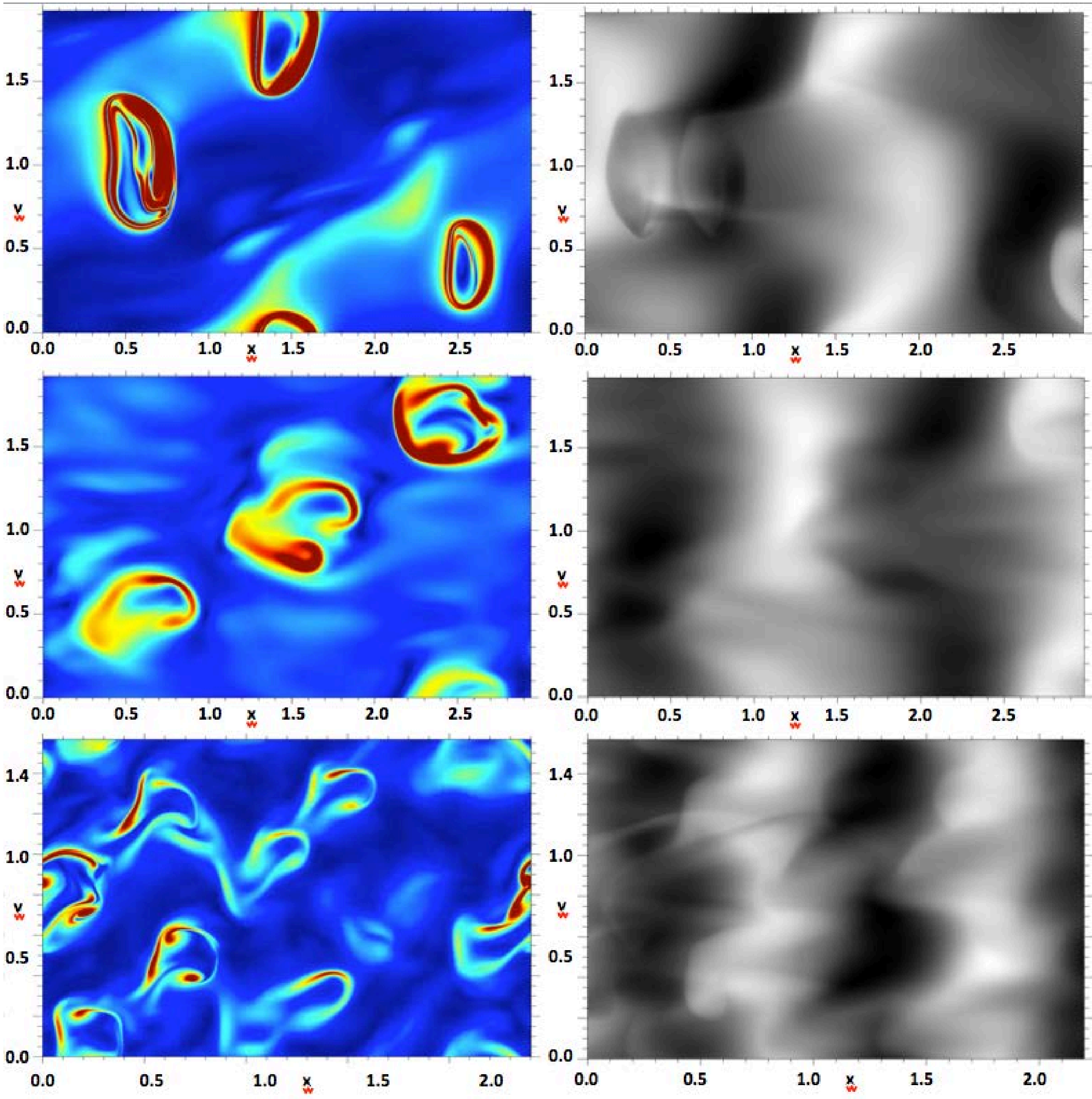


Idealized GW breaking

$\omega = N/2$
$a = u'/(c-U) = 0.9$

$\omega = N/2$
$a = u'/(c-U) = 1.1$

$\omega = N/1.4$
$a = u'/(c-U) = 0.9$



Idealized GW breaking

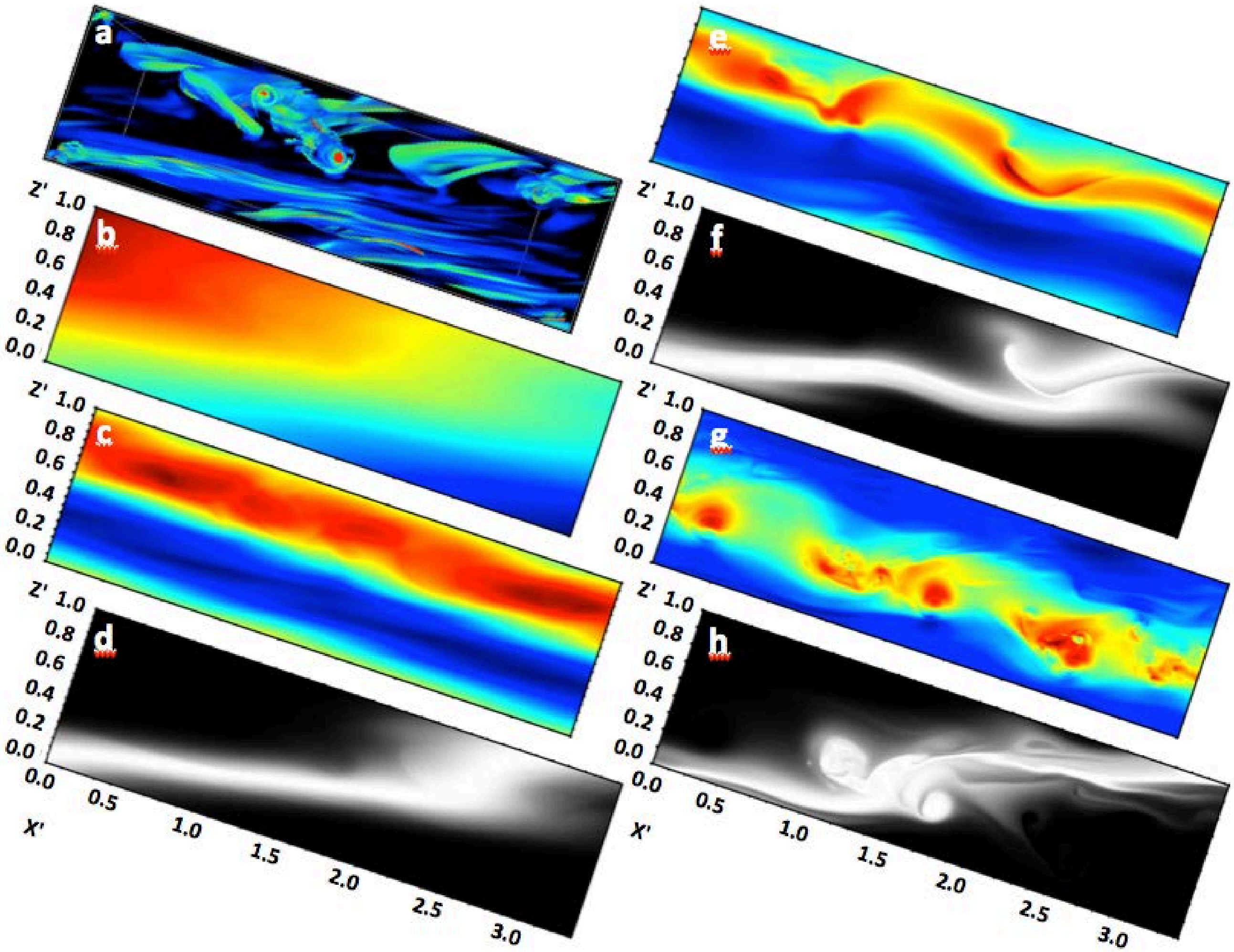
ω ~ N/3.2, a = 0.9

3D vortices

T(x,z) mean

u(x,z) mean

I(x,z) mean



T' (x,z) slice
t=22 T_b

I'(x,z) slice

T' (x,z) slice
t=23 T_b

I' (x,z) slice

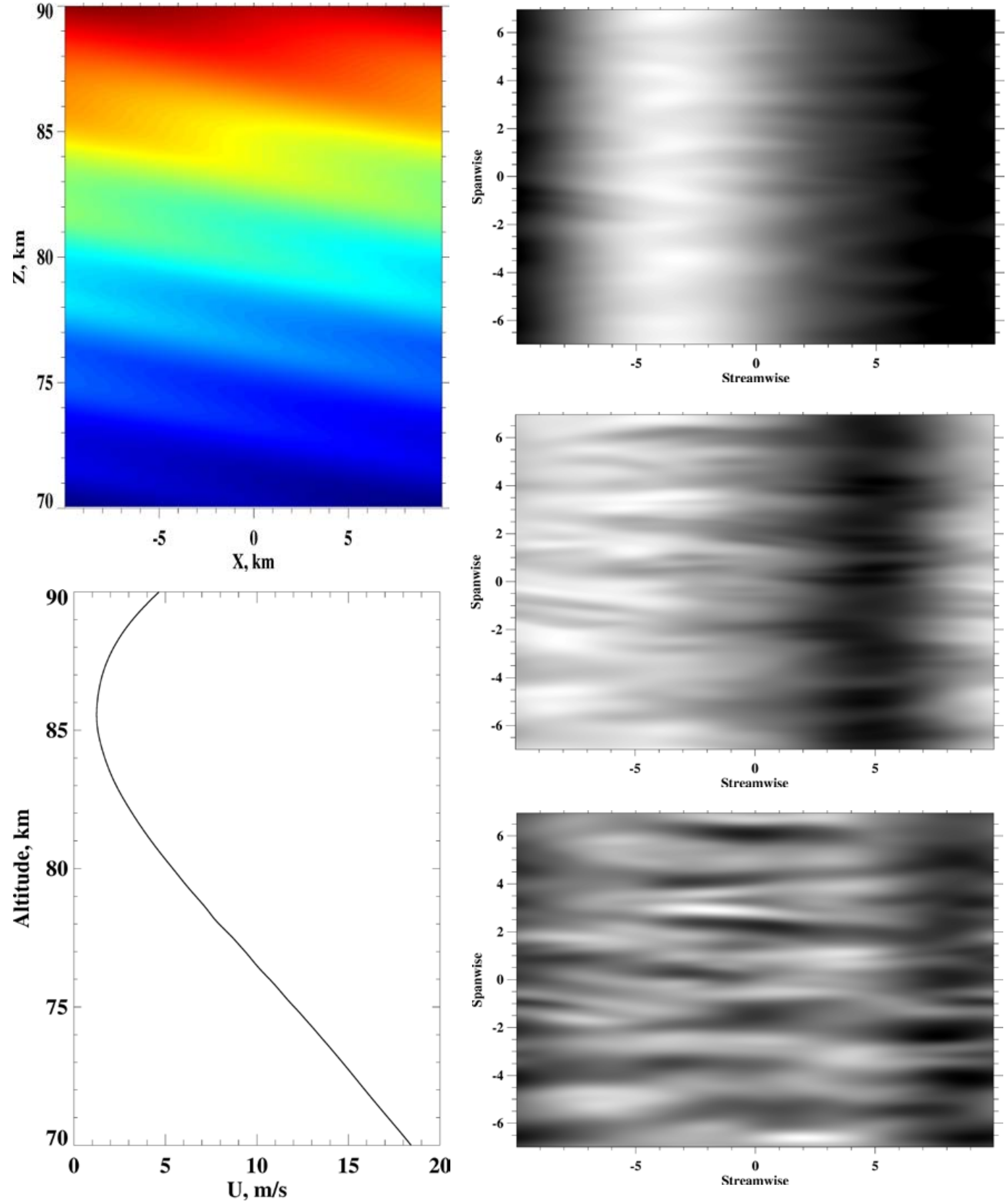
GW in shear

ω = N/7

A > 1

- dynamics also include vortex rings,

but also strong spanwise modulation at warmest phase

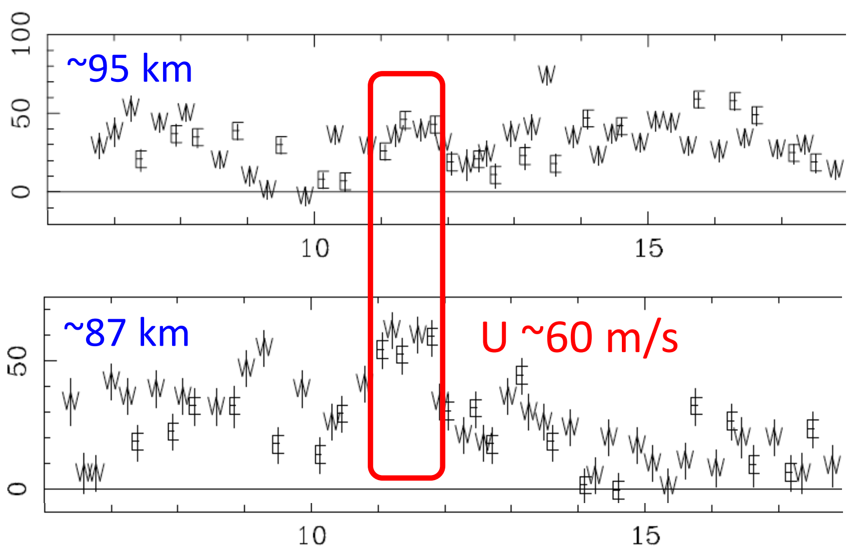


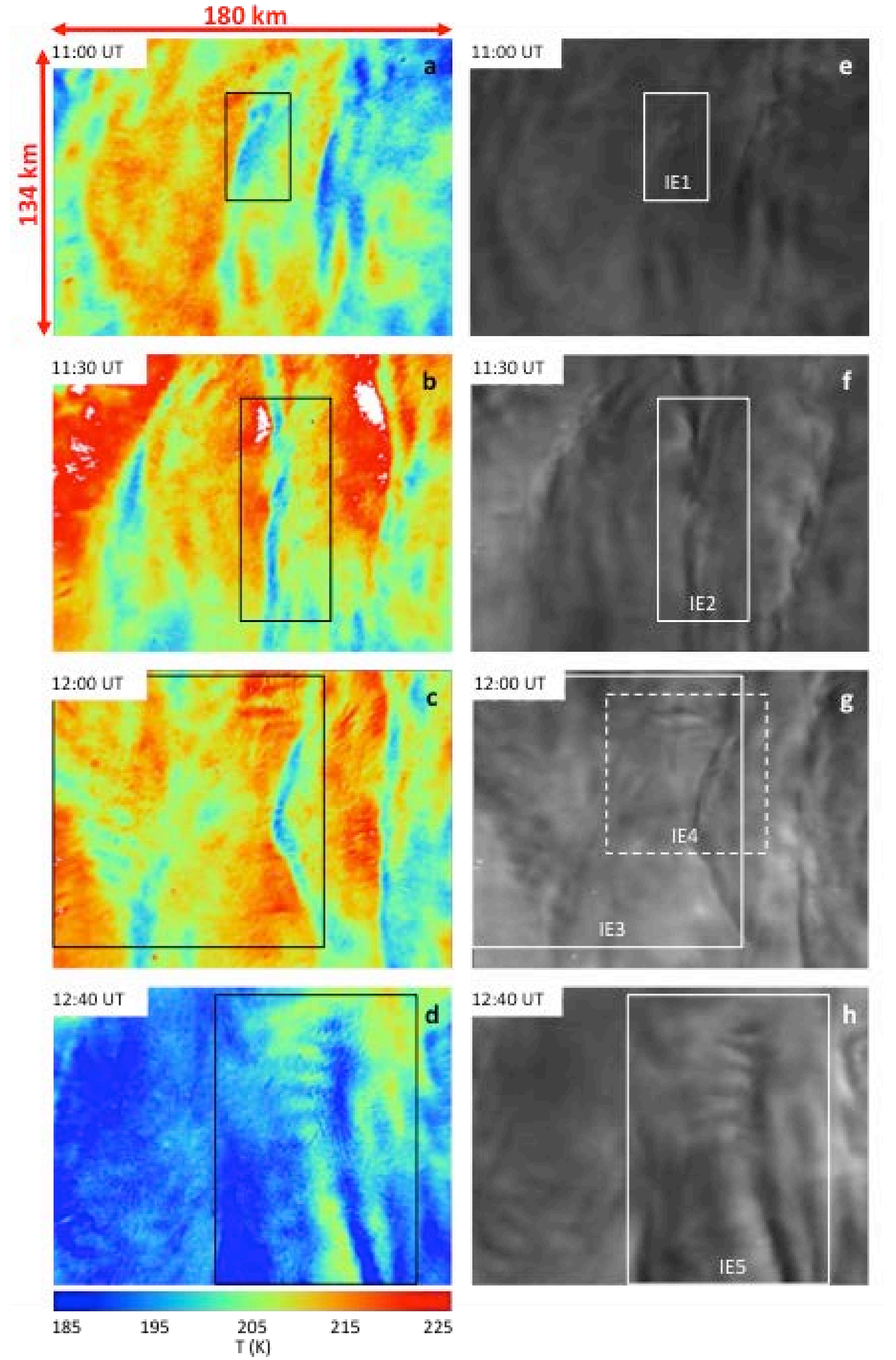
DEEPWAVE Lauder AMTM

- captures the same GW breaking dynamics

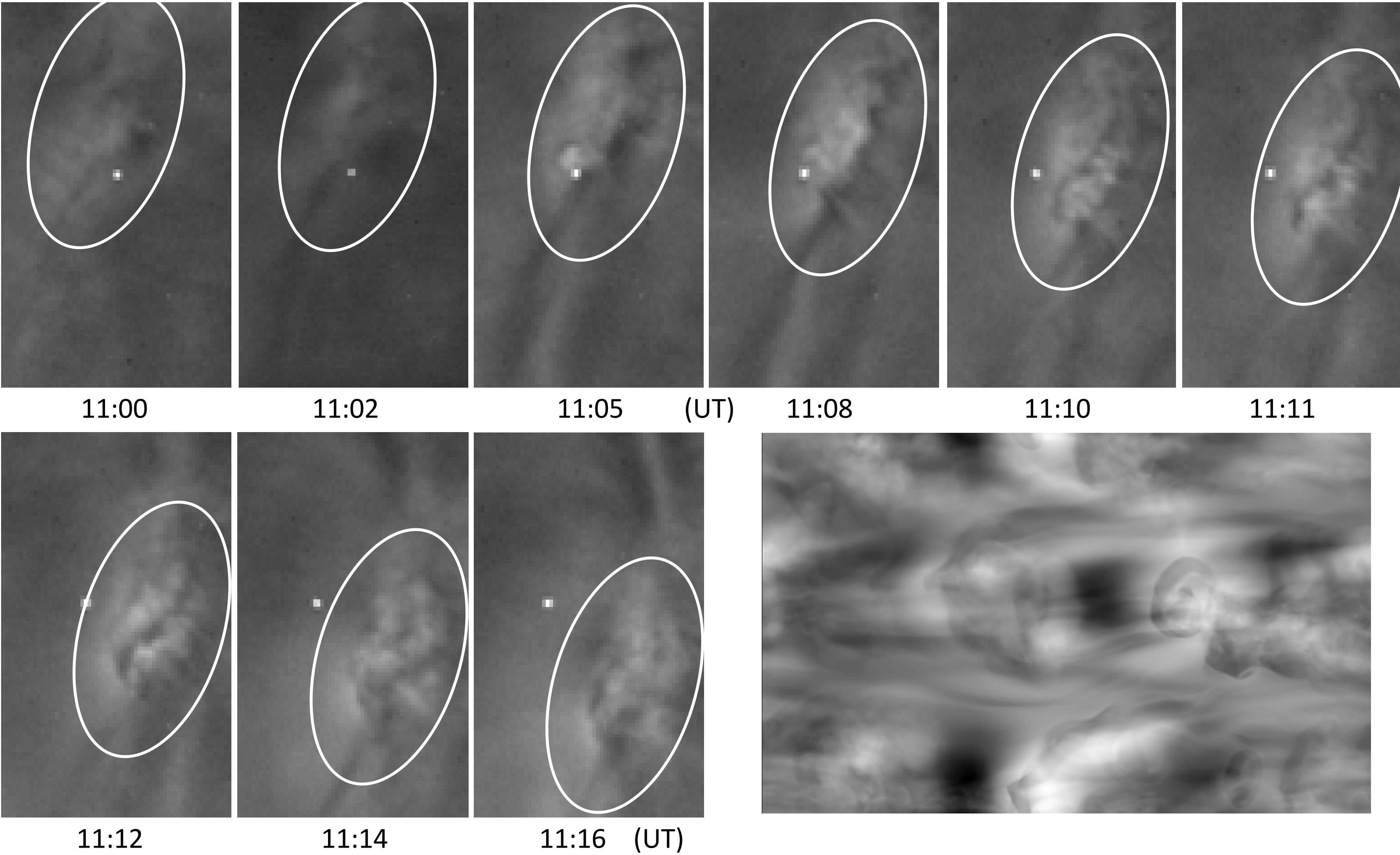
- with a more accurate sky projection, but coarser resolution

- and with much better knowledge of atmospheric structure





DEEPWAVE - Lauder 21 June – Instability Event 1

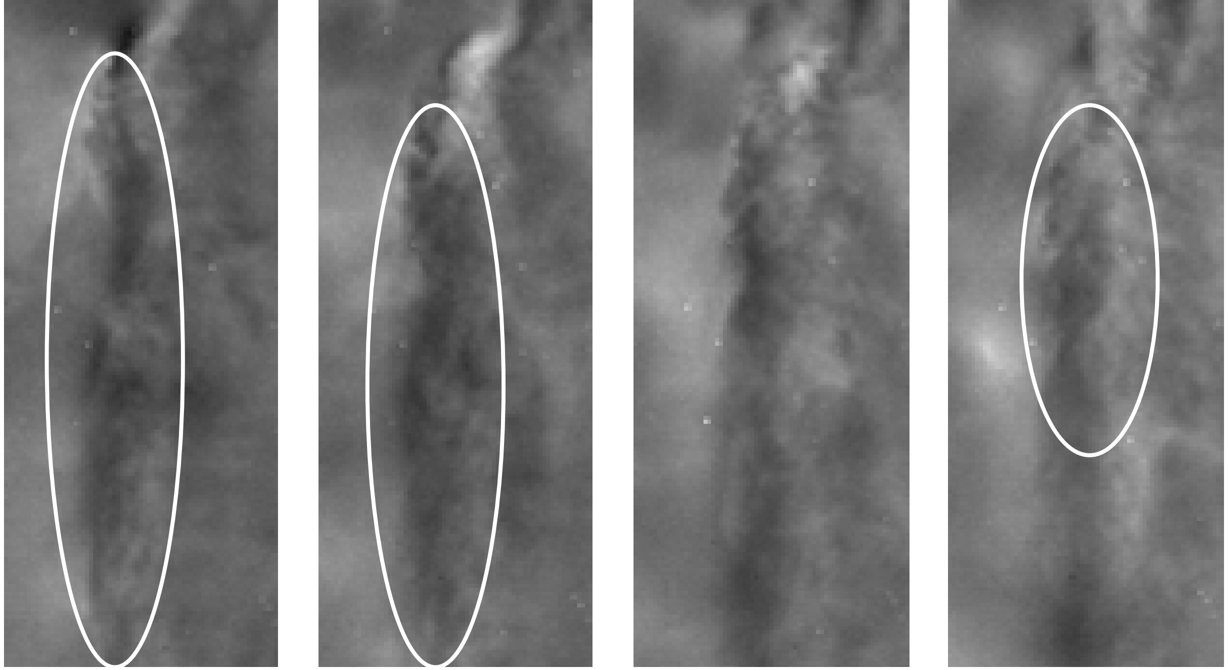


11-11:22 UT, FOVs 30x50 km, warm phase, likely MW superposition

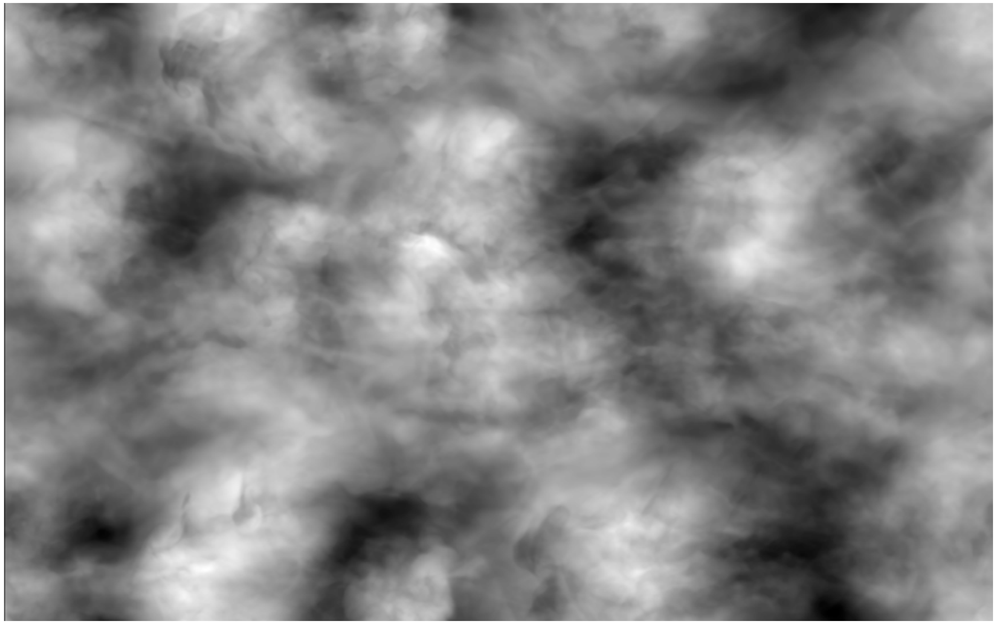
DEEPWAVE
- Lauder 21 June
- Instability Event 2

40x100 km

11:34-11:40 UT



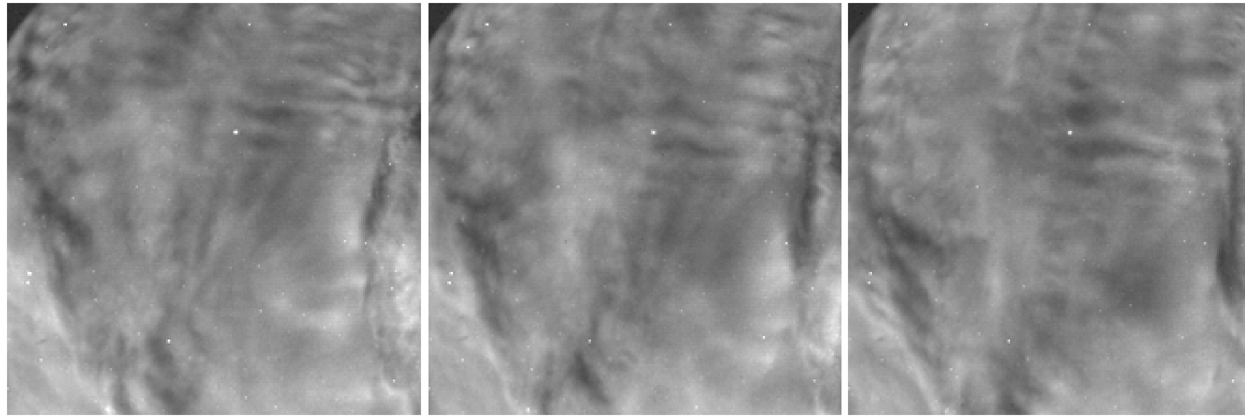
11:34 11:36 (UT) 11:38 11:40



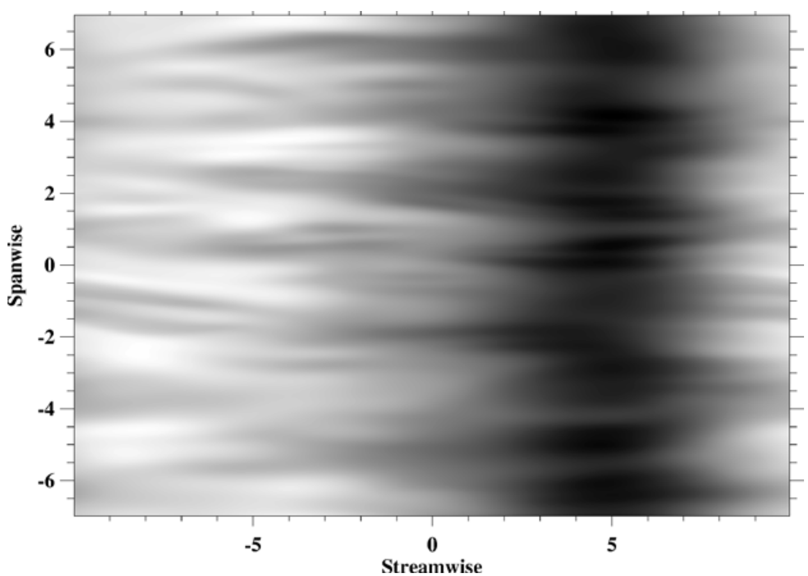
DEEPWAVE
- Lauder 21 June
- Instability Event 3

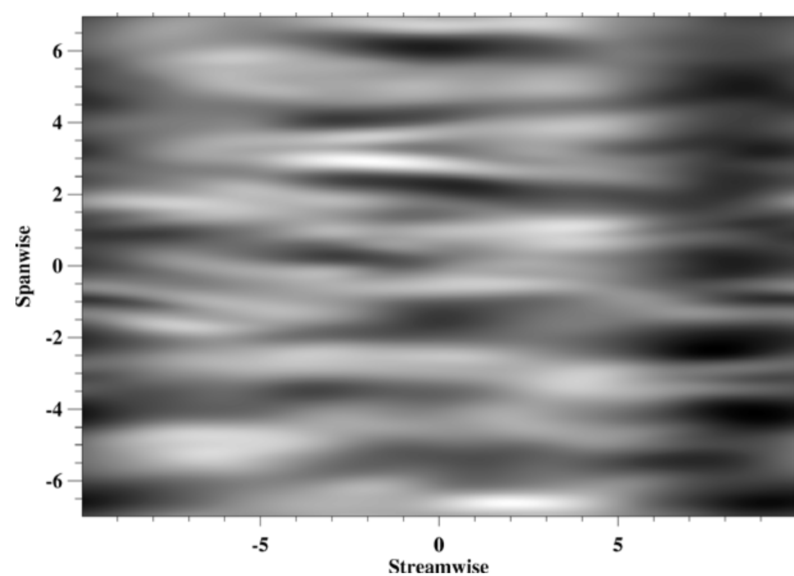
120x120 km

12:06-12:10 UT

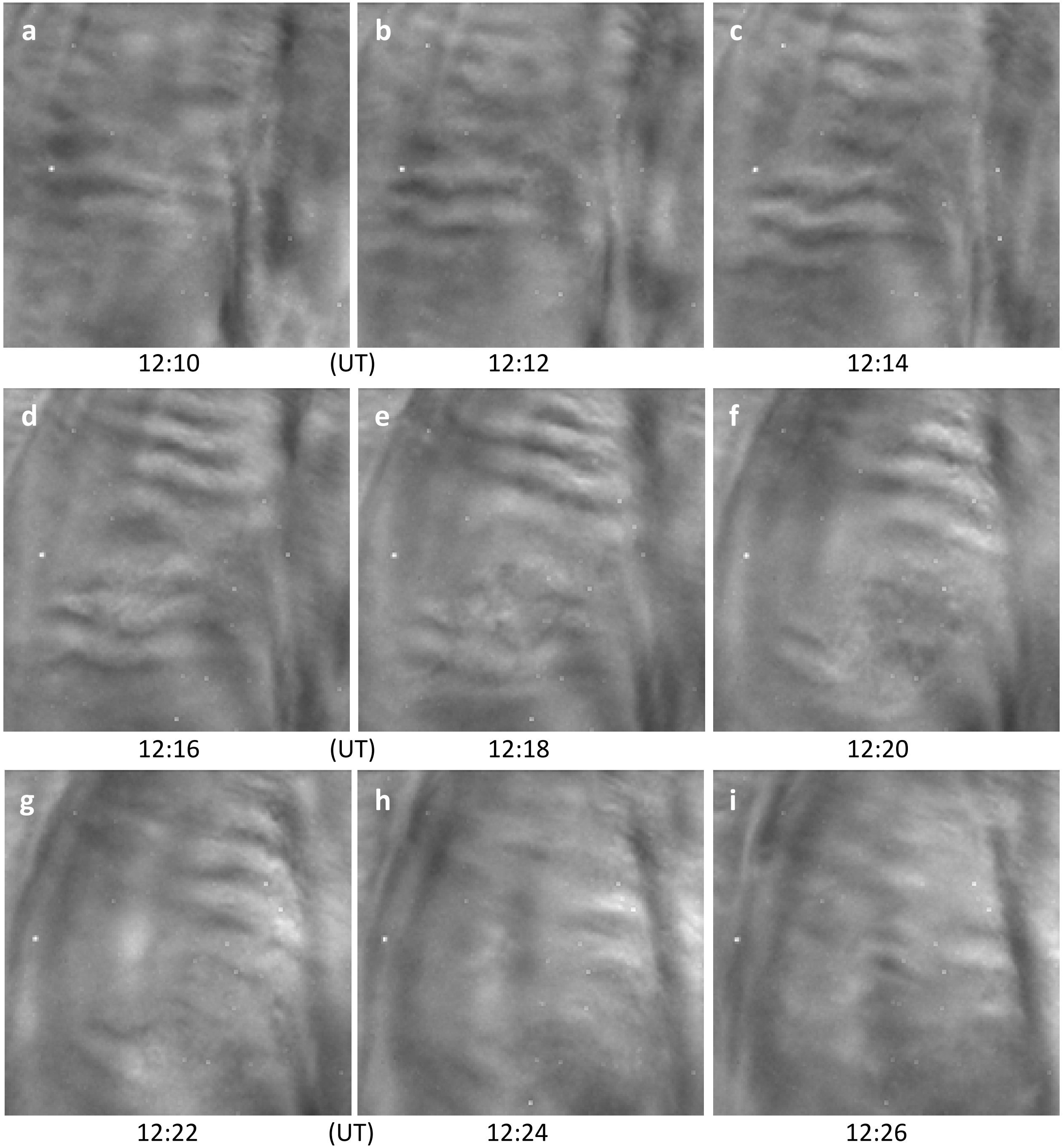


12:06 (UT) 12:08 12:10





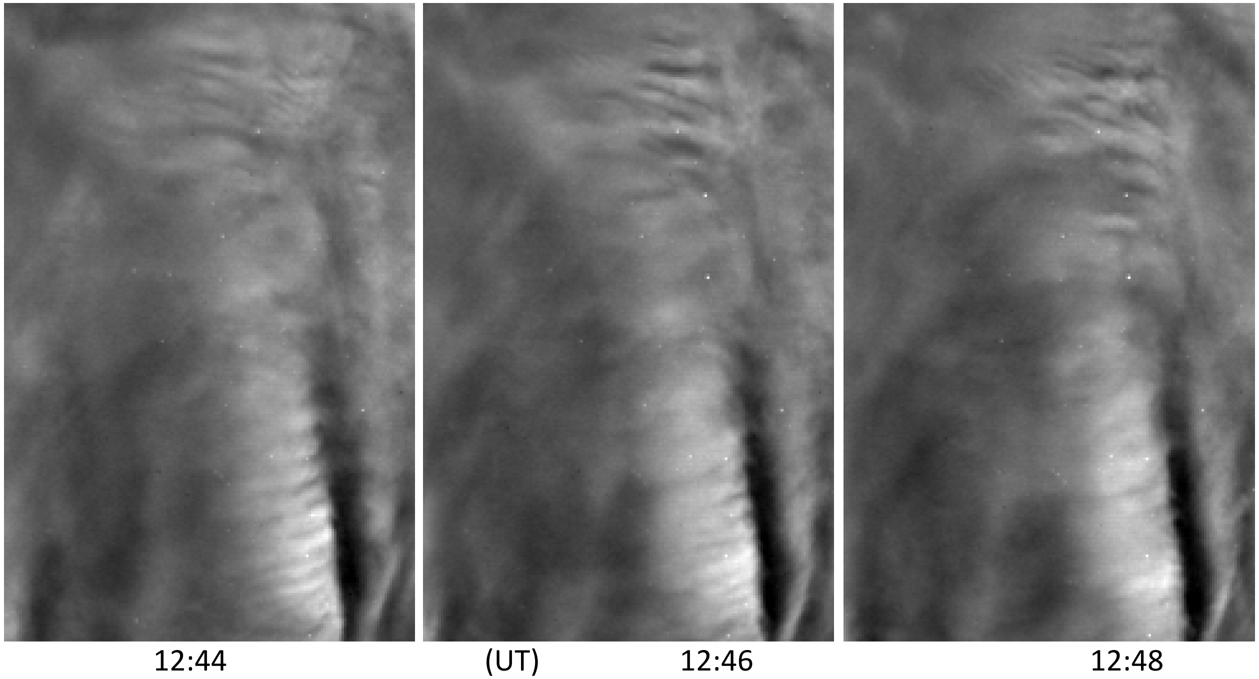
DEEPWAVE
- Lauder 21 June
- Instability Event 4



75x75 km

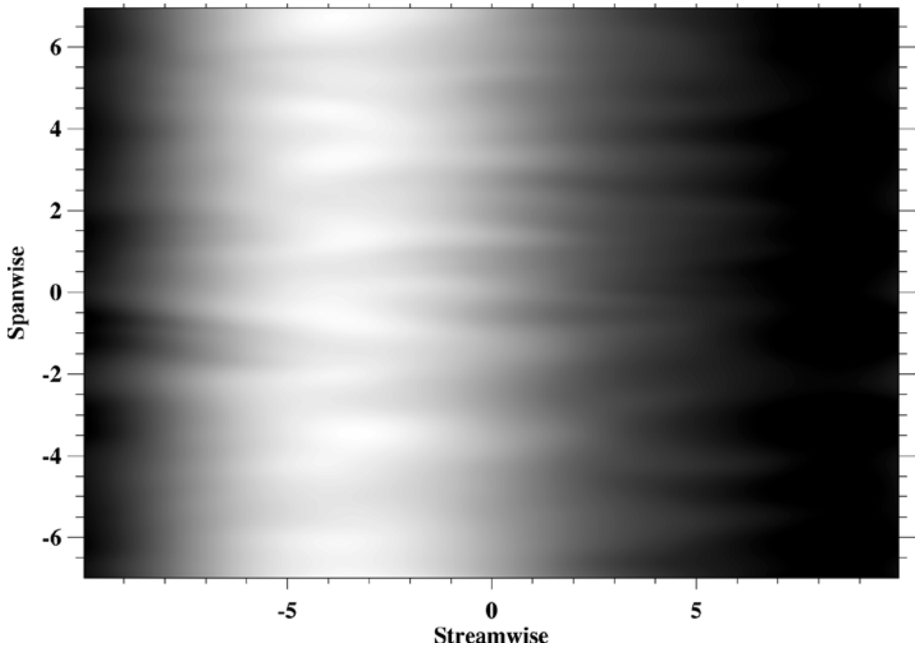
12:10-12:26 UT

DEEPWAVE
- Lauder 21 June
- Instability Event 5



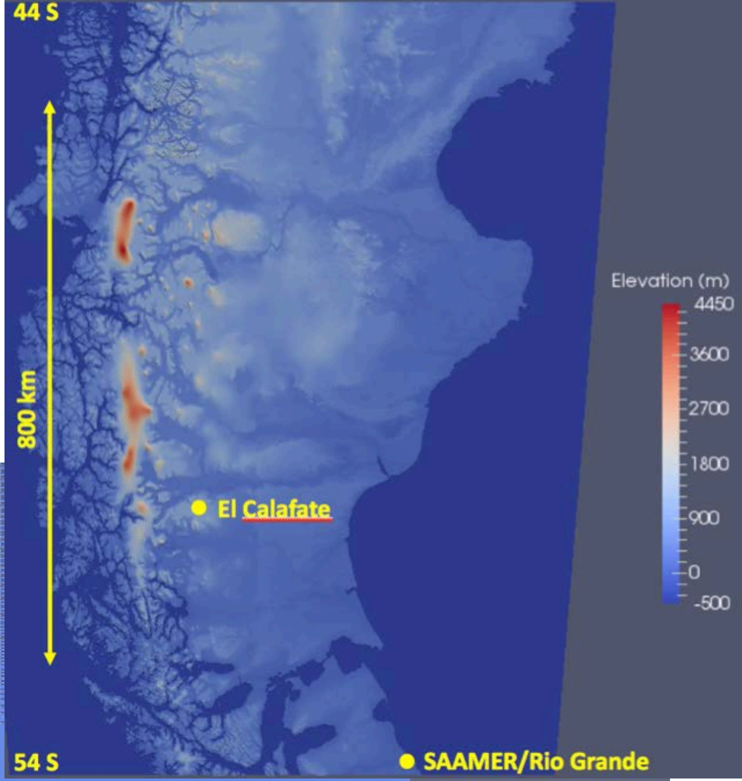
80x130 km

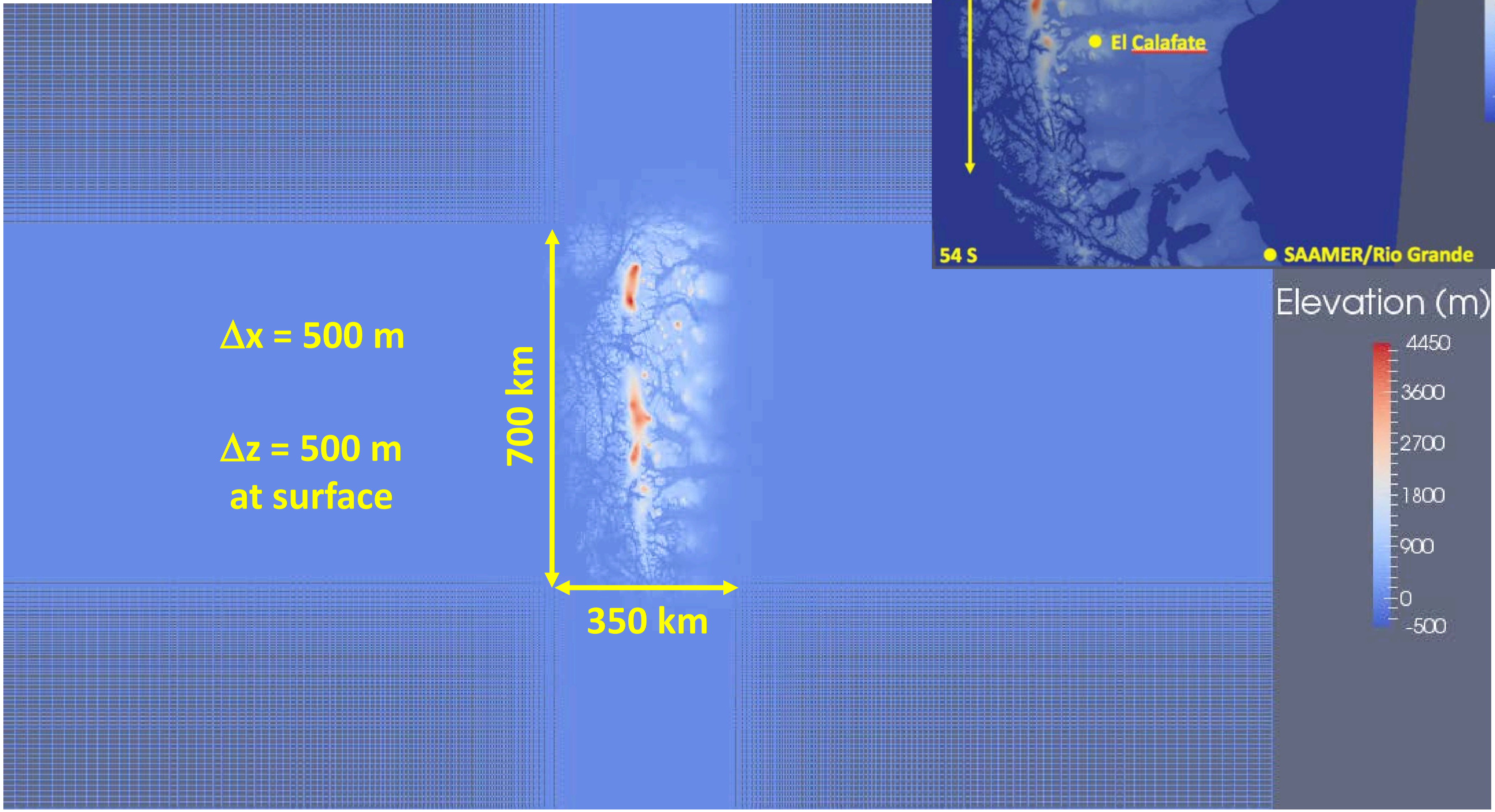
12:40,44,46,48,
50,52 UT



New compressible, large-domain modeling applications (developed by Tom Lund)

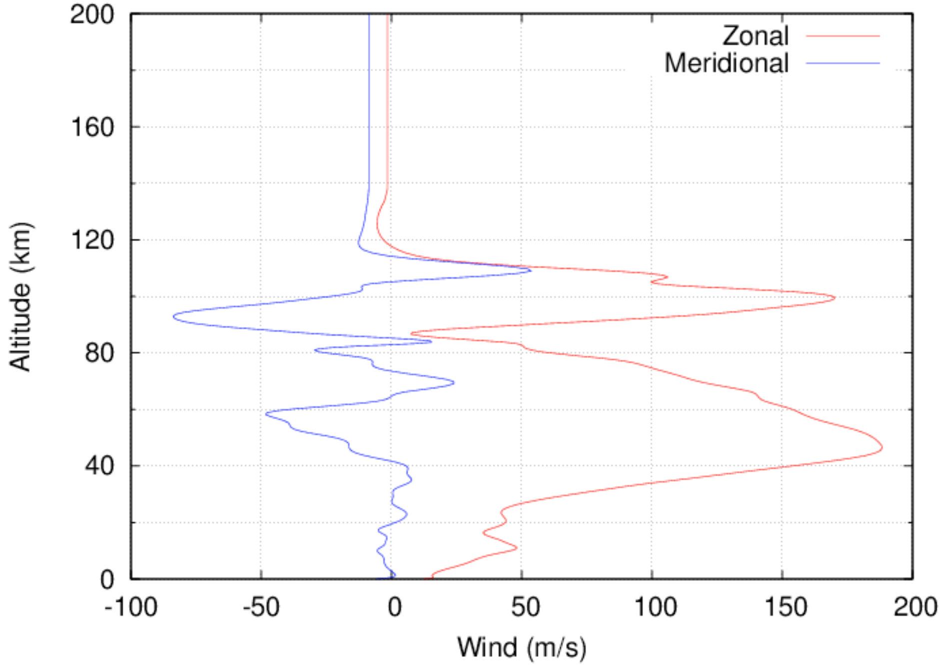
- 2500x1600x200 km domain
- initial Southern Andes app.

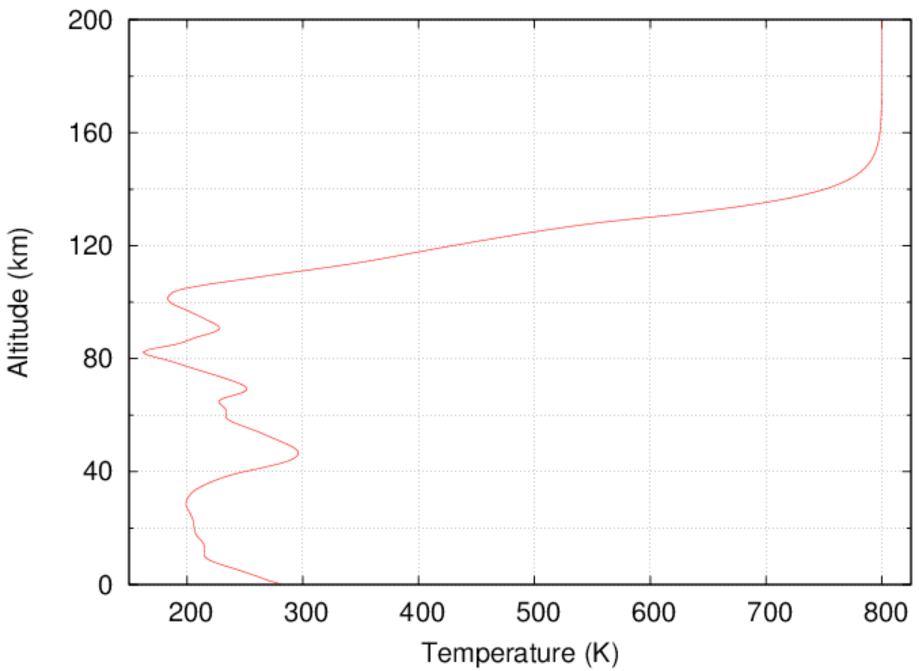


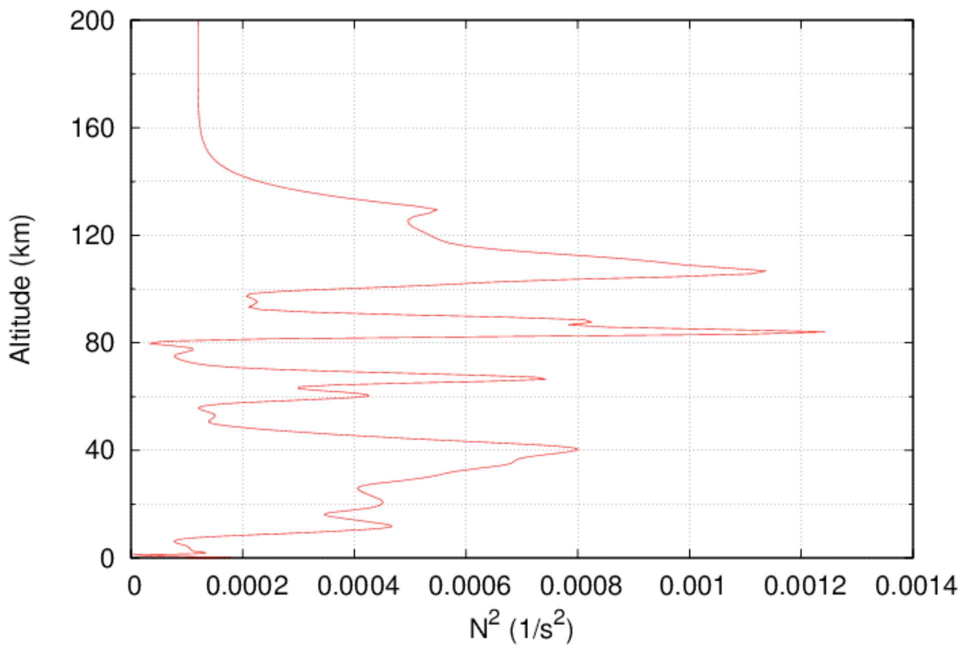


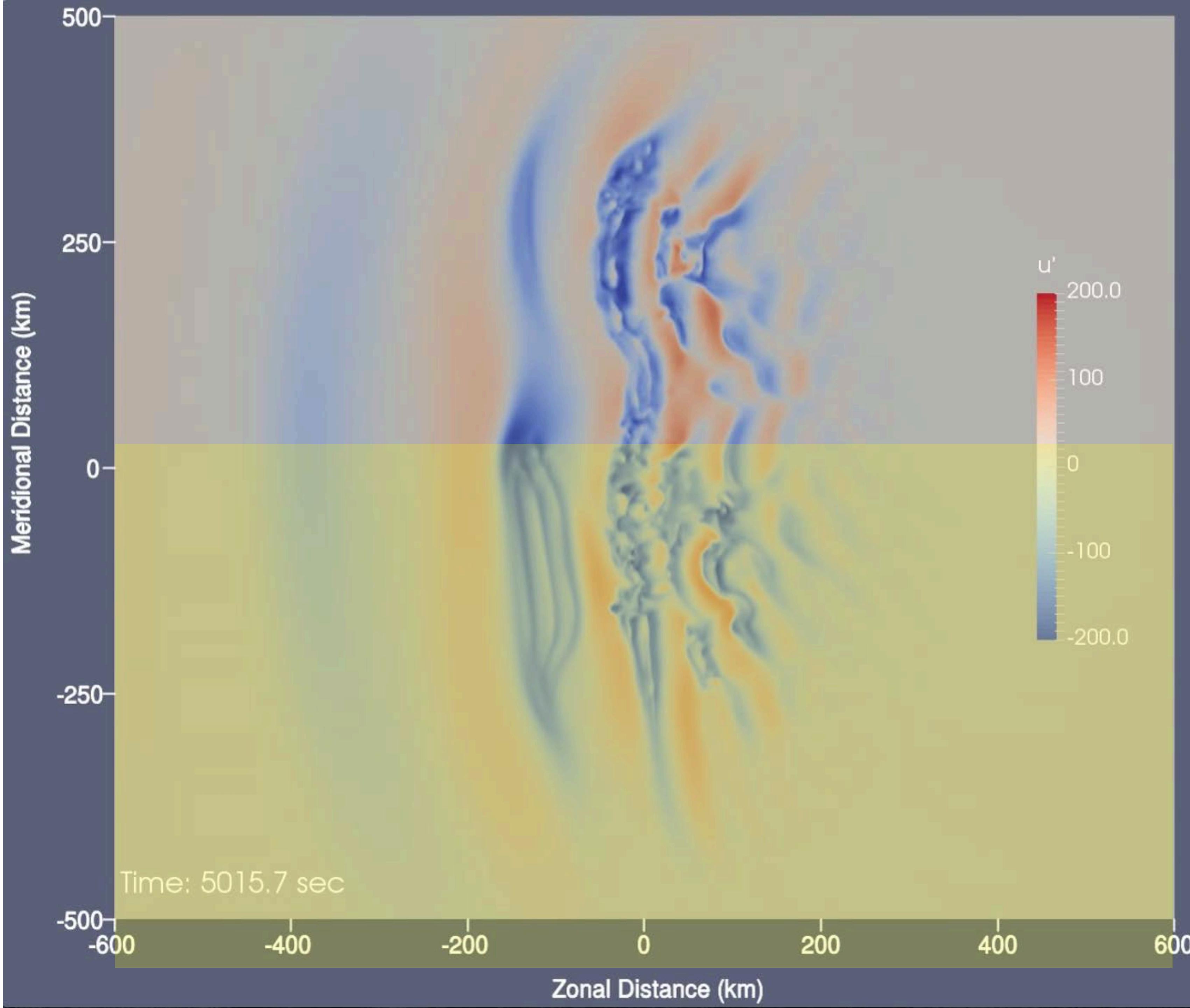
winds and temperatures from WACCM

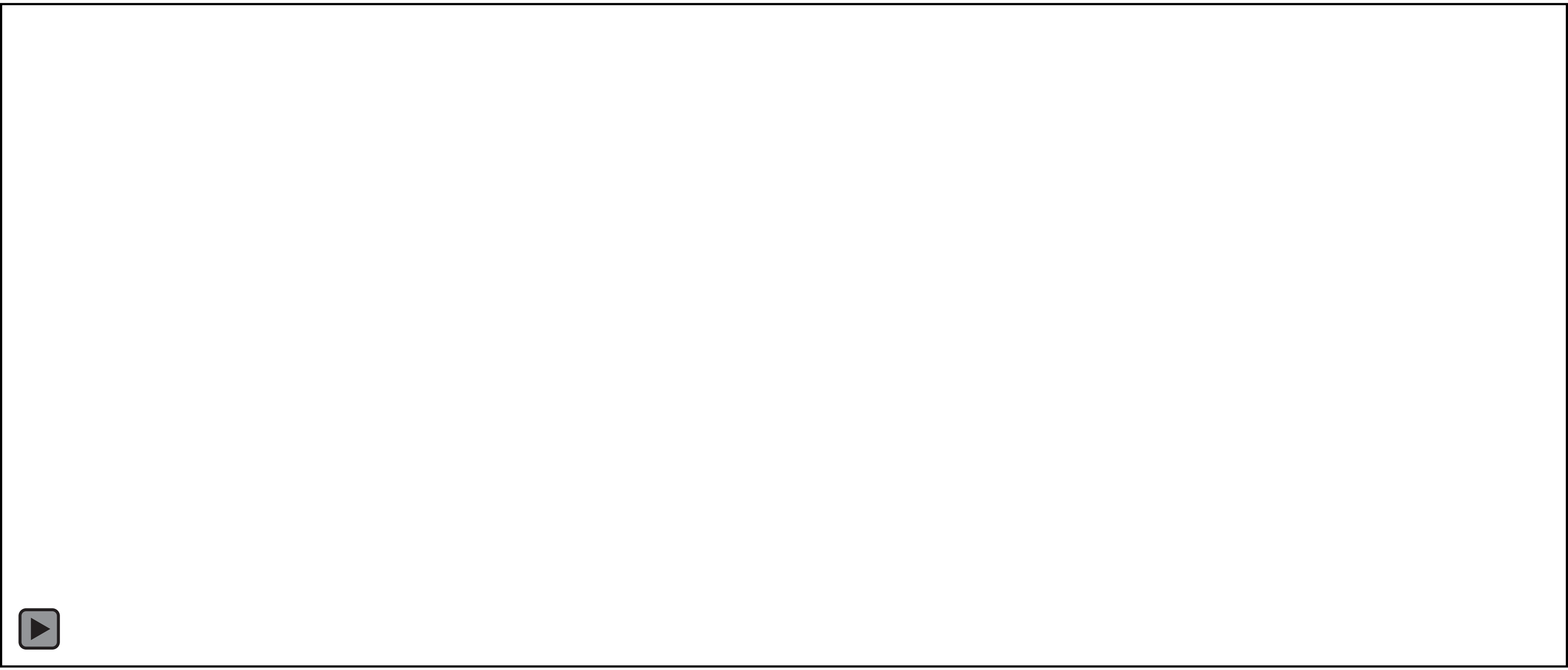
- strong SD tide ~60 m/s








500
250
0
-250
-500
Meridional Distance (km)
-600
-400
-200
0
200
400
600
Zonal Distance (km)
u'
200.0
100
0
-100
-200.0
Time: 5015.7 sec



Summary

- high-resolution PMC observations & model comparisons appear to have revealed the major instability pathways to GW dissipation, and mean wind/tidal interactions

- DEEPWAVE applications will include high-resolution, simulations of multiple cases where MW breaking or secondary GW generation appear to occur in the AMTM imaging or lidar curtains

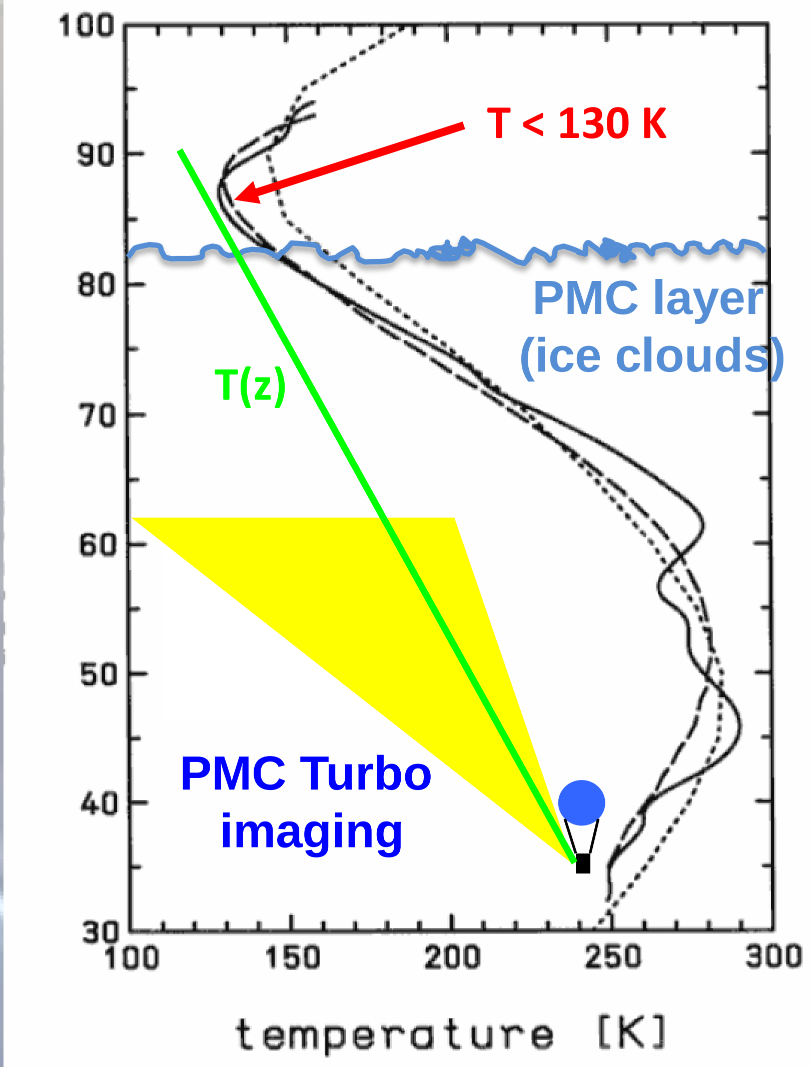
PMC Turbo – an LCAS Antarctic stratospheric balloon mission
- to study turbulence best where it is least accessible

- PMC Turbo motivated by EBEX star camera images that revealed spectacular turbulence structures

- PMCs occur where gravity wave dissipation and turbulence are strong

=> PMC are sensitive tracers of turbulence morphologies spanning 4 decades of scales

- without including correlative CIPS observations



PMC Turbo flight requirements:

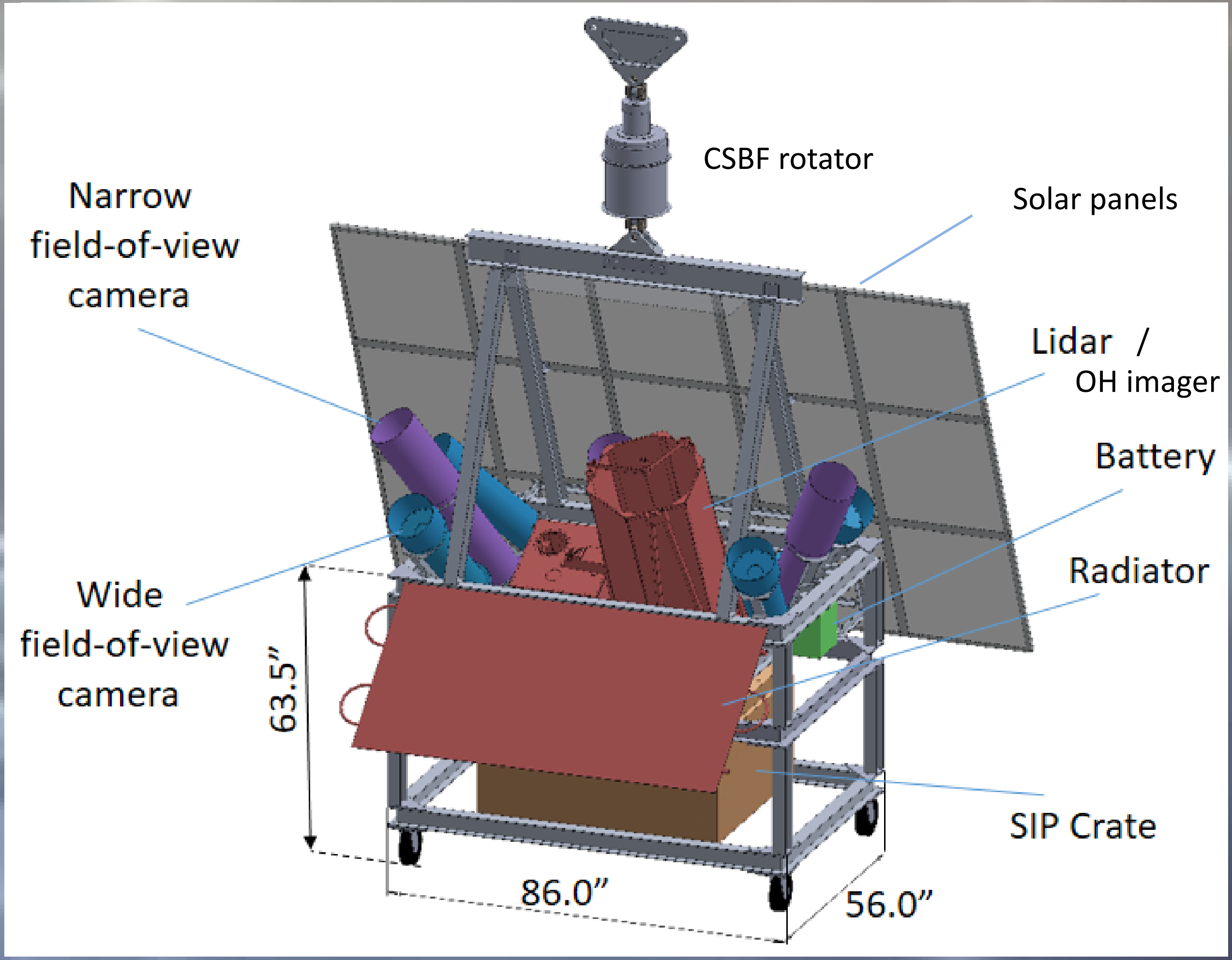
- desired altitude: ~35-38 km (higher is better)
- balloon specification: 29 MCF
- minimum duration: ~10-15 days
- number of orbits: 1 (possibly 2 if an early launch)

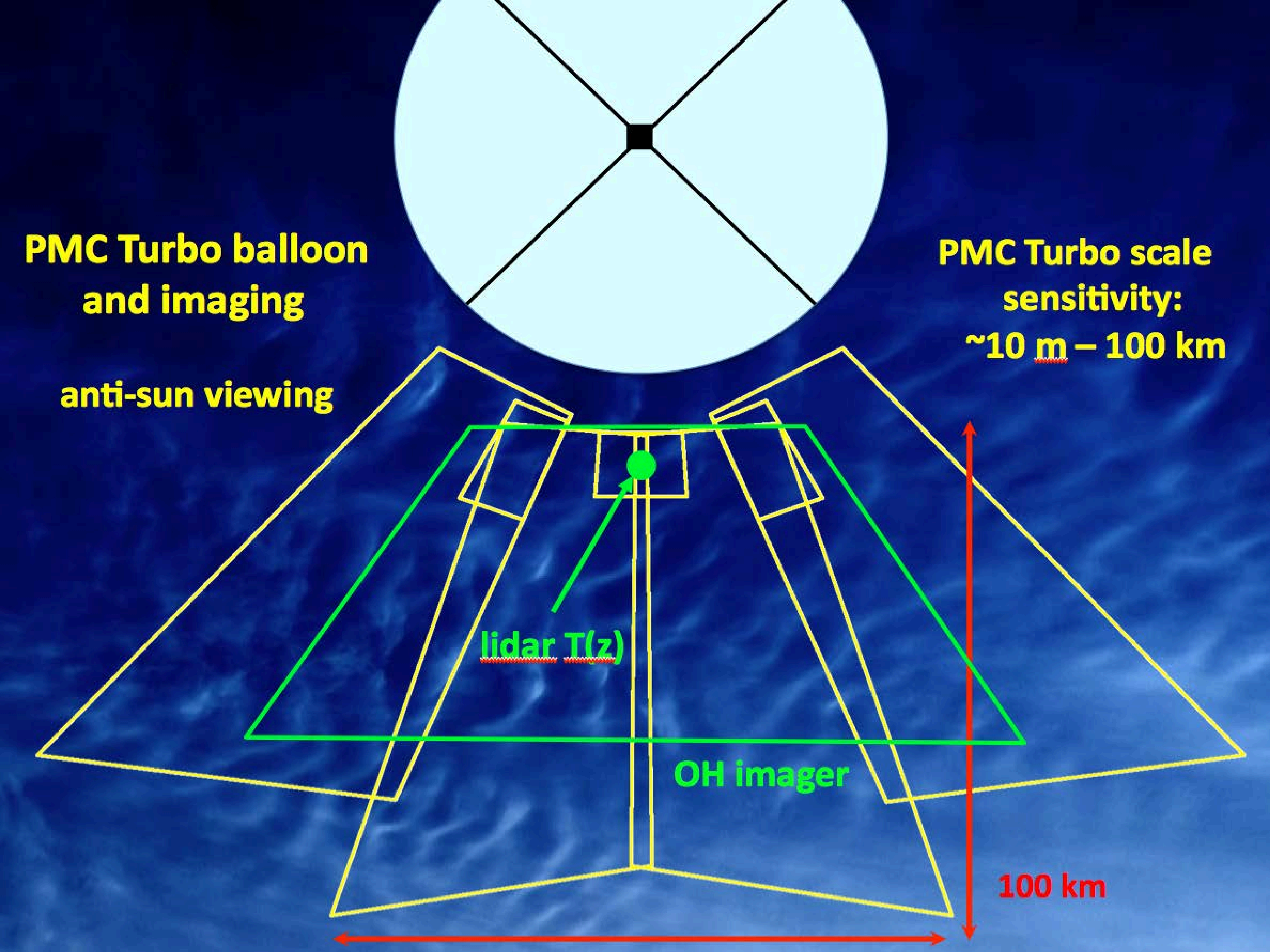
Payload components

- cameras, wide FOVs (4)
- cameras, narrow FOVs (3)
- Rayleigh lidar
- OH camera
- power system
- SIP Crate
- CSBF Rotator

Payload specifications

- weight 1600 lb
- power system 1.3 kW
- average power ~940 W




PMC Turbo balloon
and imaging
anti-sun viewing
PMC Turbo scale
sensitivity:
~10 m – 100 km
lidar T(z)
OH imager
100 km