Evaporative cold pools enhance air-sea fluxes in DYNAMO

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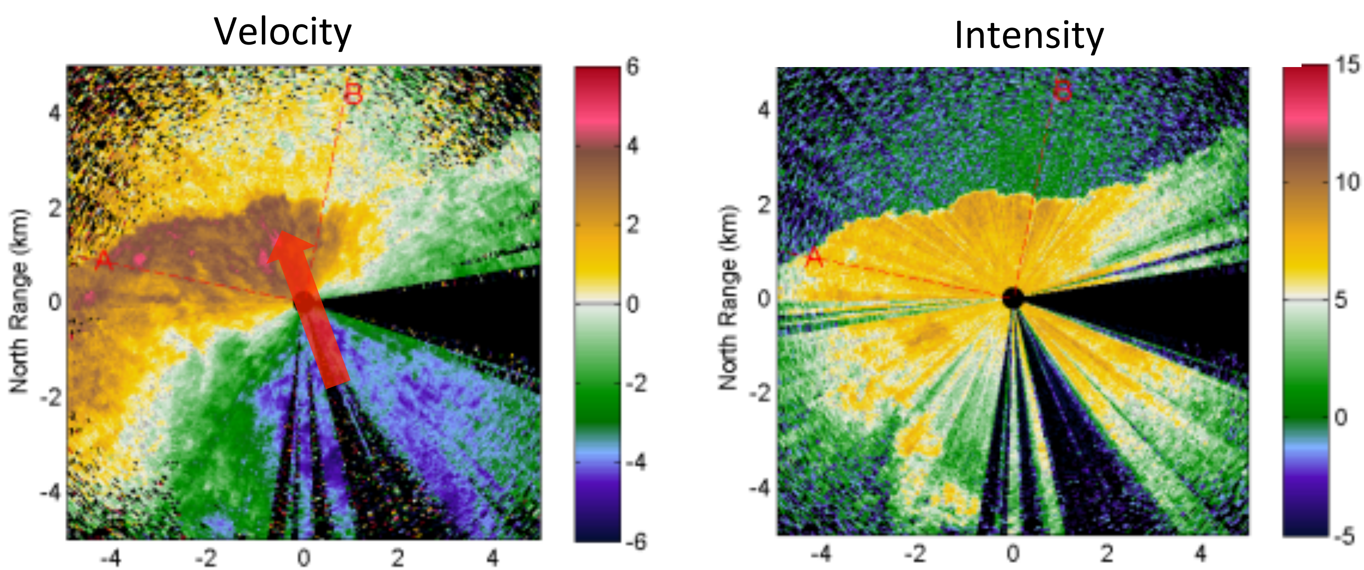
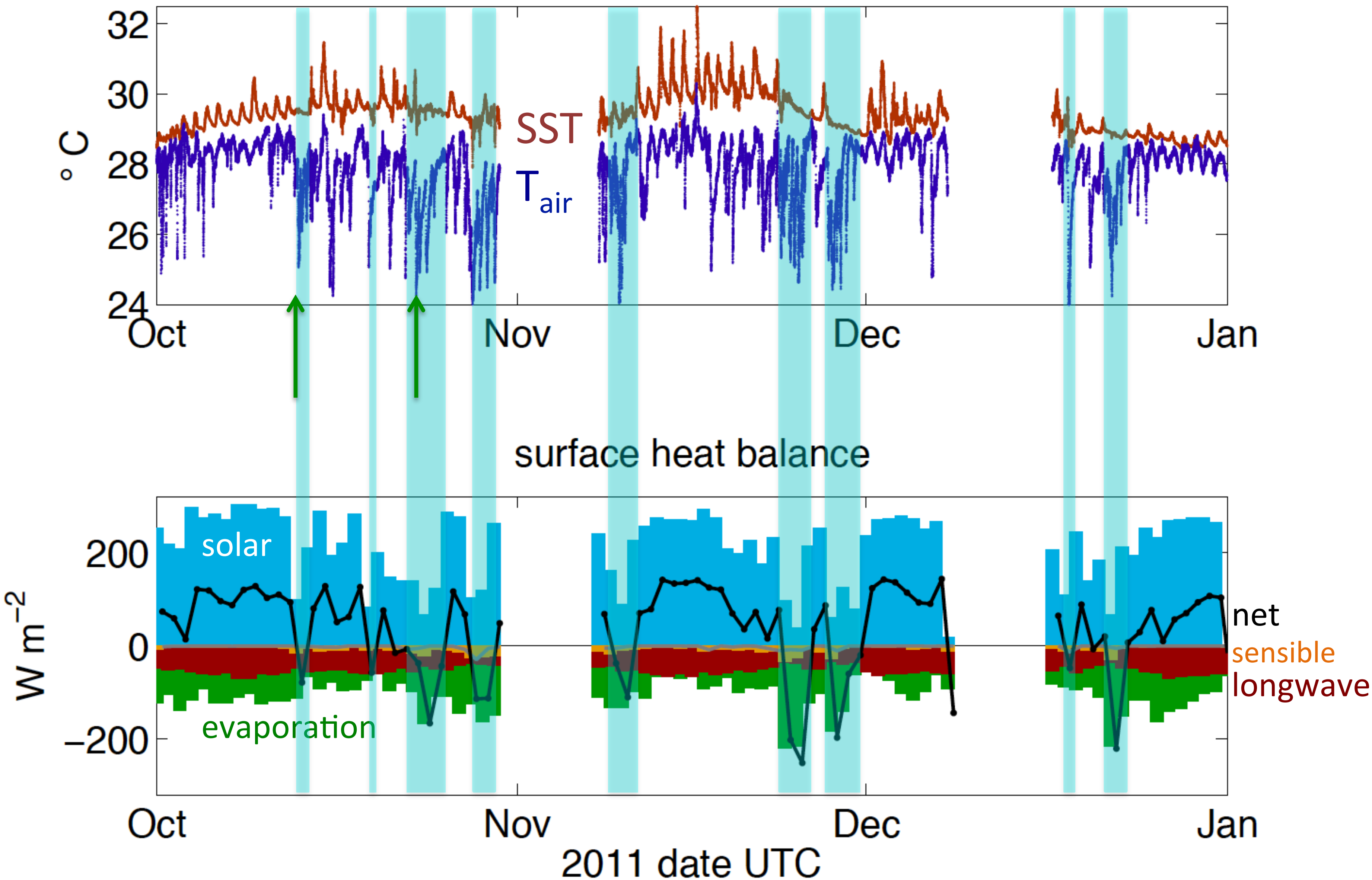
2011-Oct-13 NOAA HRDL plan images

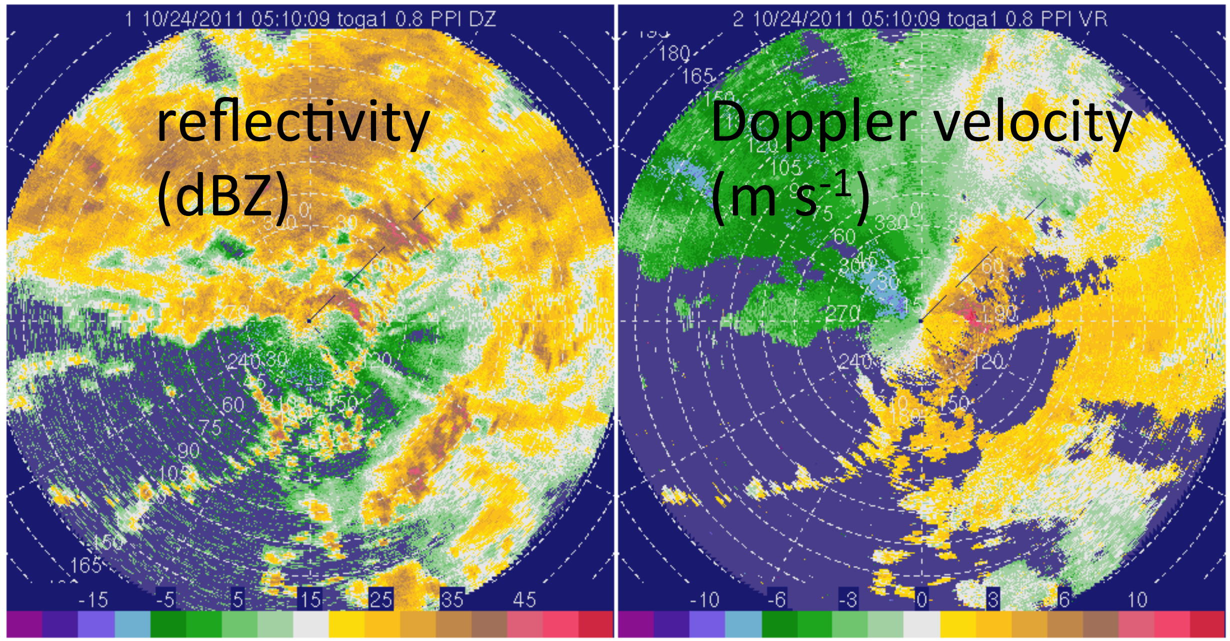


AGU Fall 2012

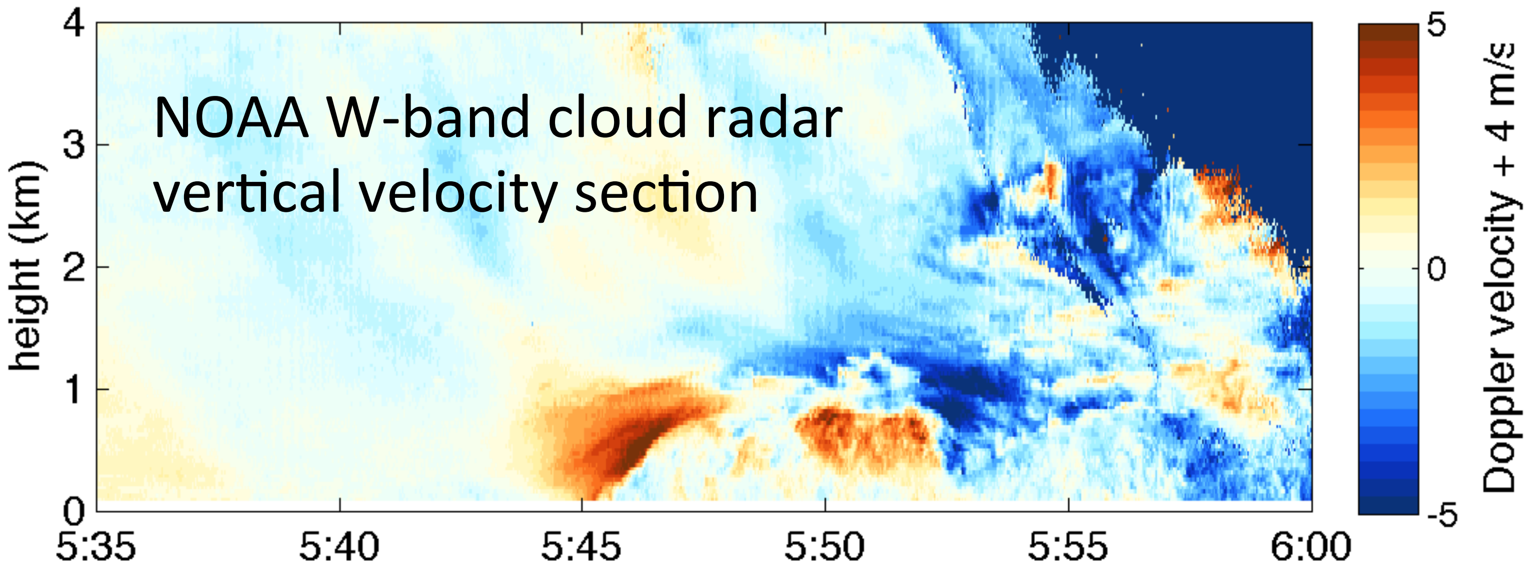
80E, equator *Revelle* ship observations

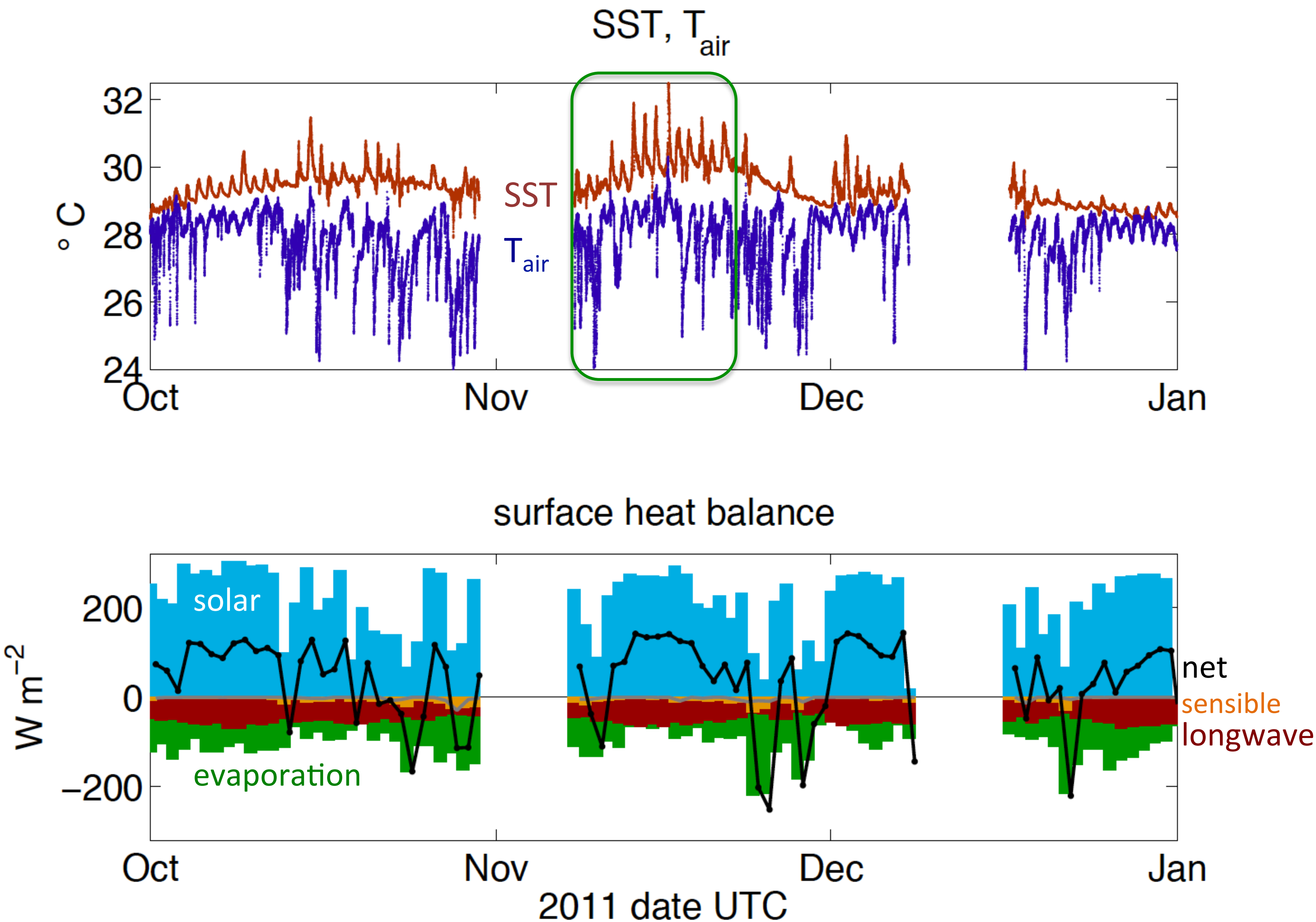


TOGA C-band precipitation radar

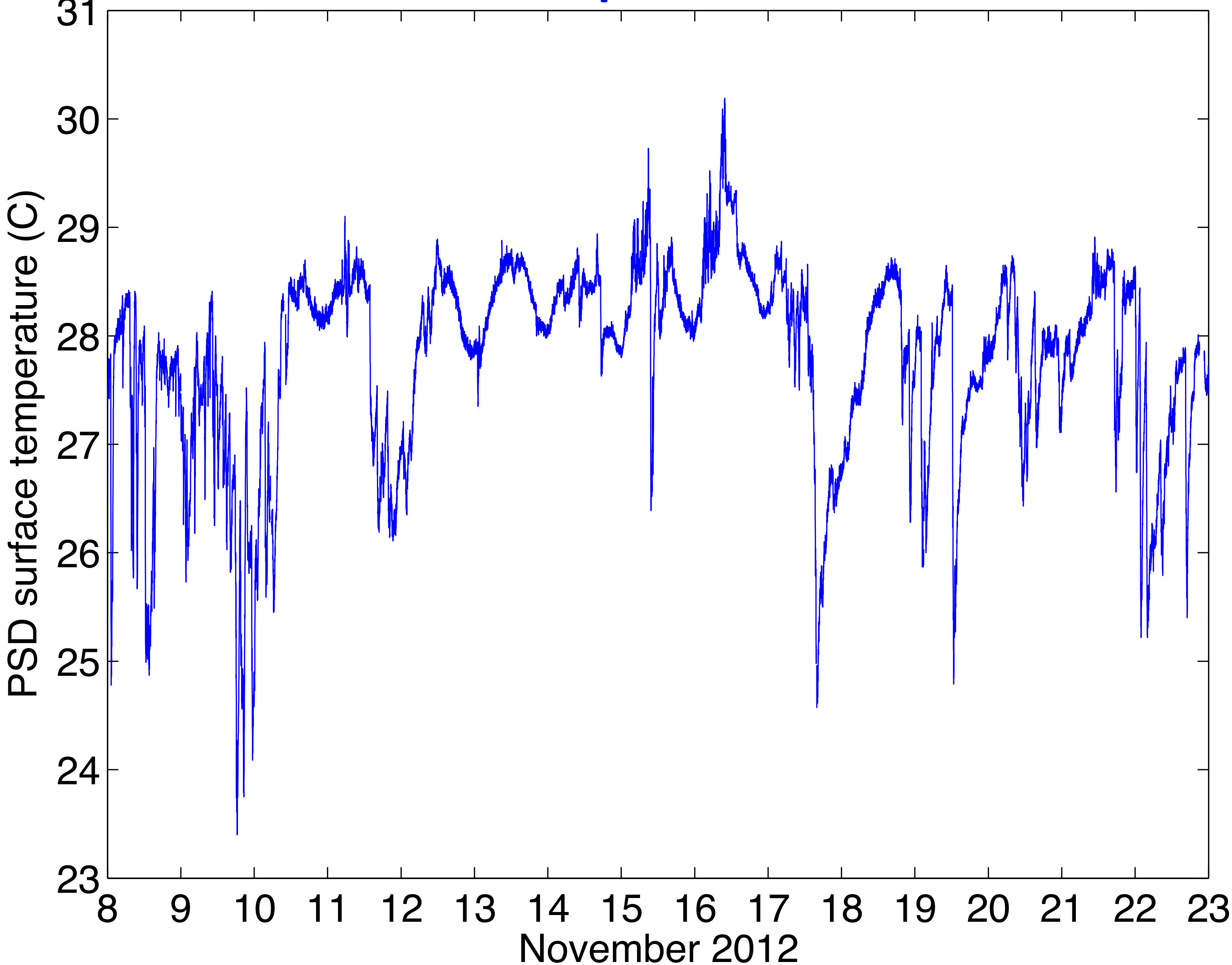


Colorado State U.

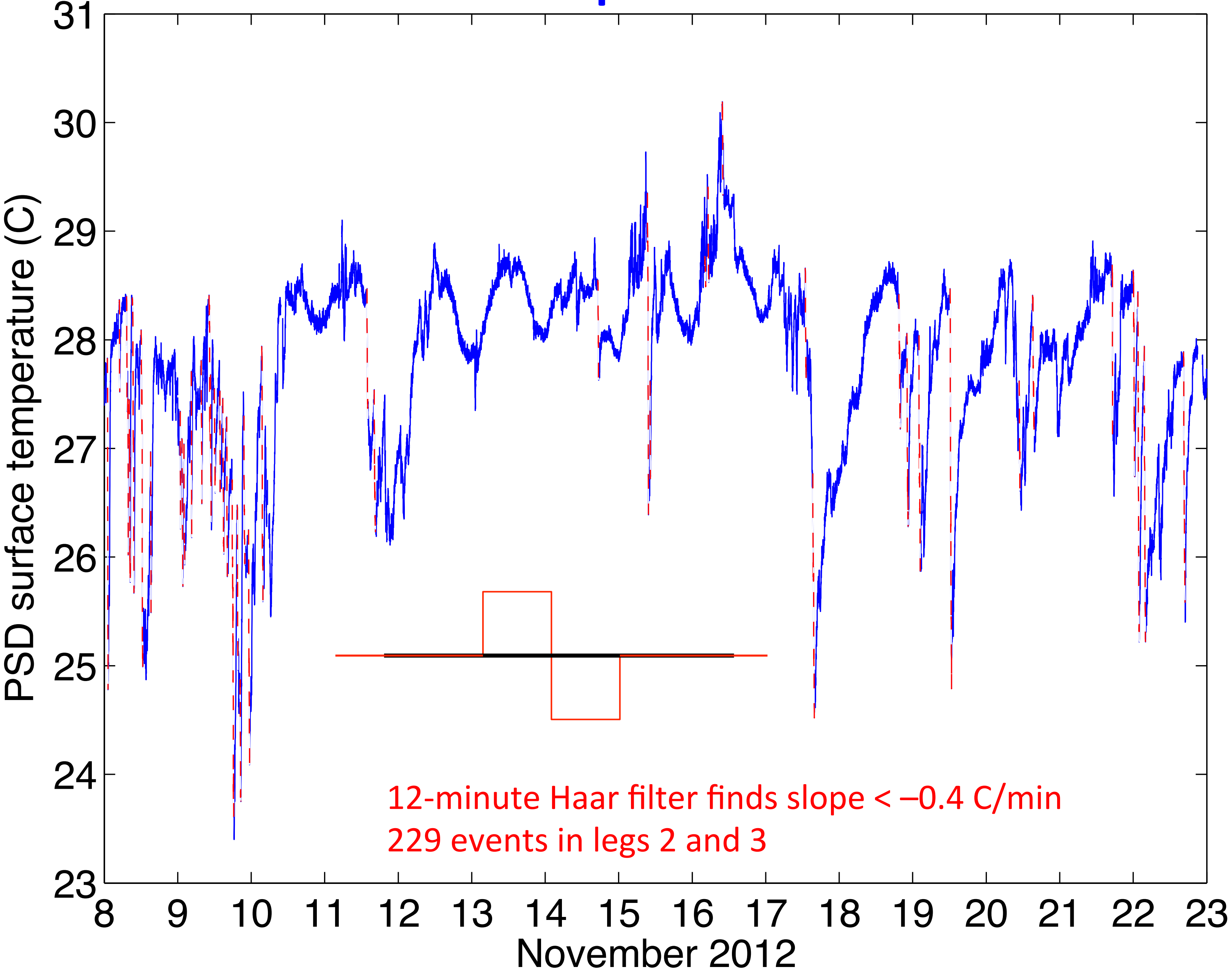



SST, T_{air}
32
30
28
26
24
°C
SST
T_{air}
Oct
Nov
Dec
Jan
surface heat balance
200
0
−200
W m^{-2}
solar
evaporation
net
sensible
longwave
Oct
Nov
Dec
Jan
2011 date UTC

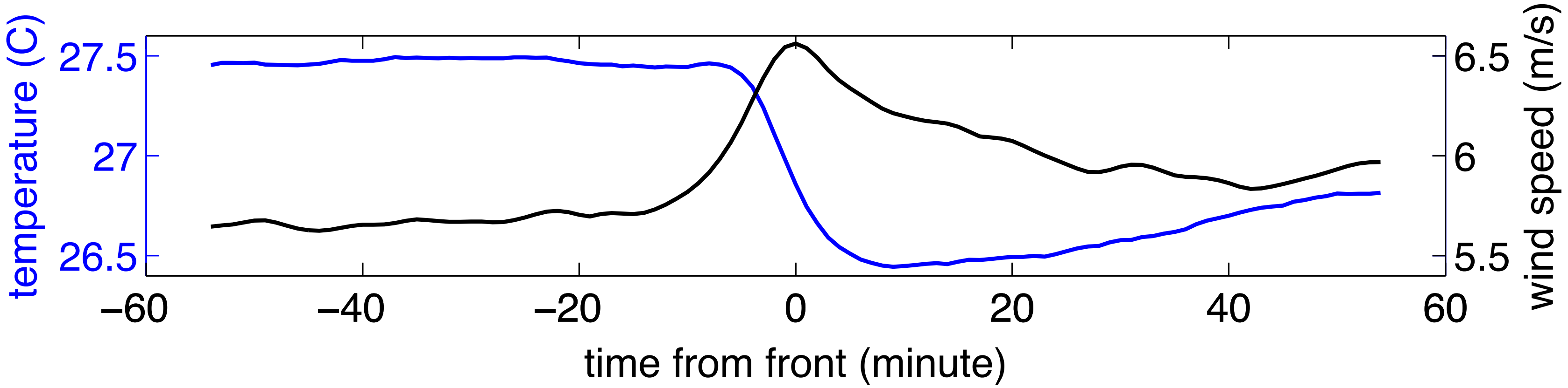
air temperature



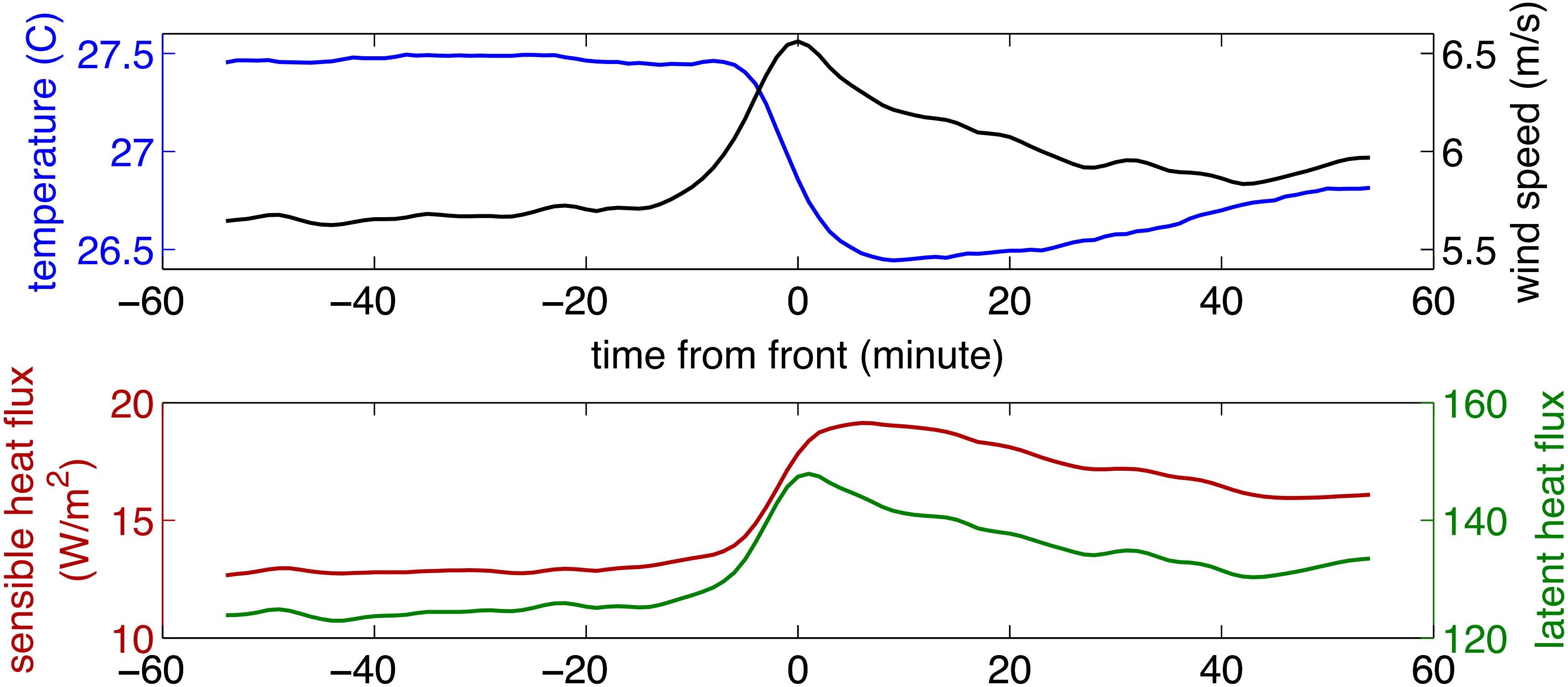
air temperature



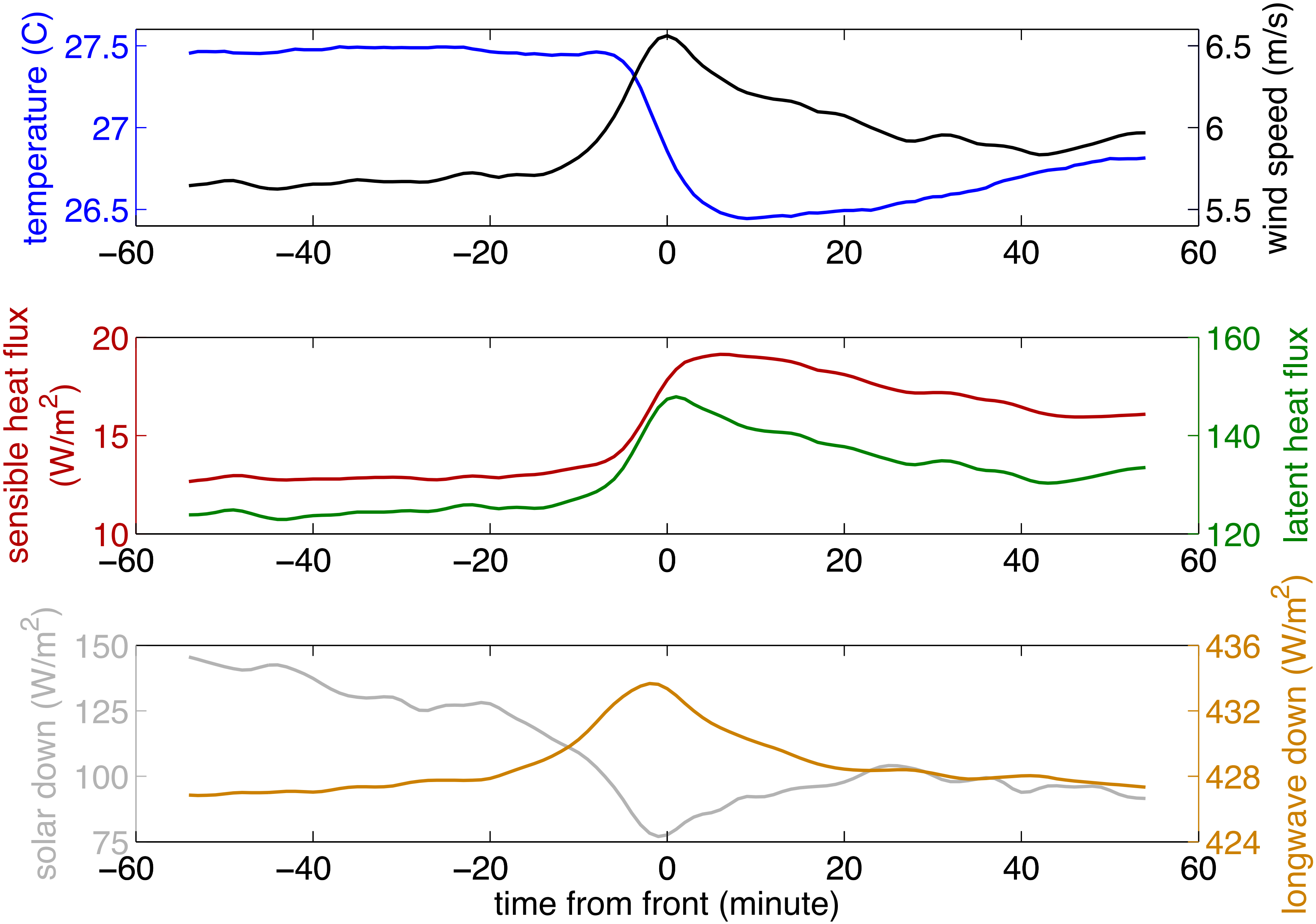
composite cold pool front



composite cold pool front



composite cold pool front

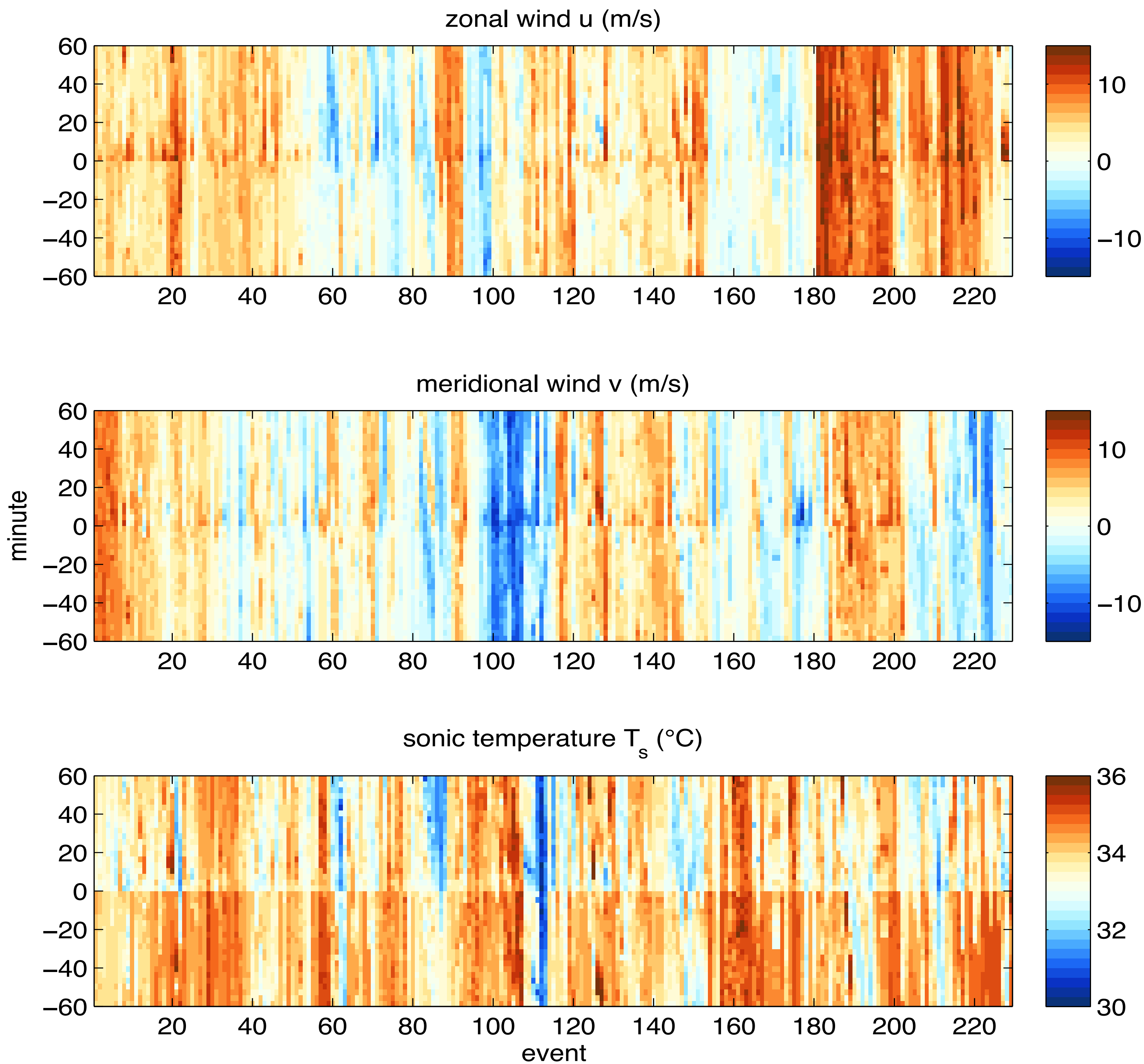


Cold front turbulence method

- Using **229 unique cold pools** from 1-min temperature time series:

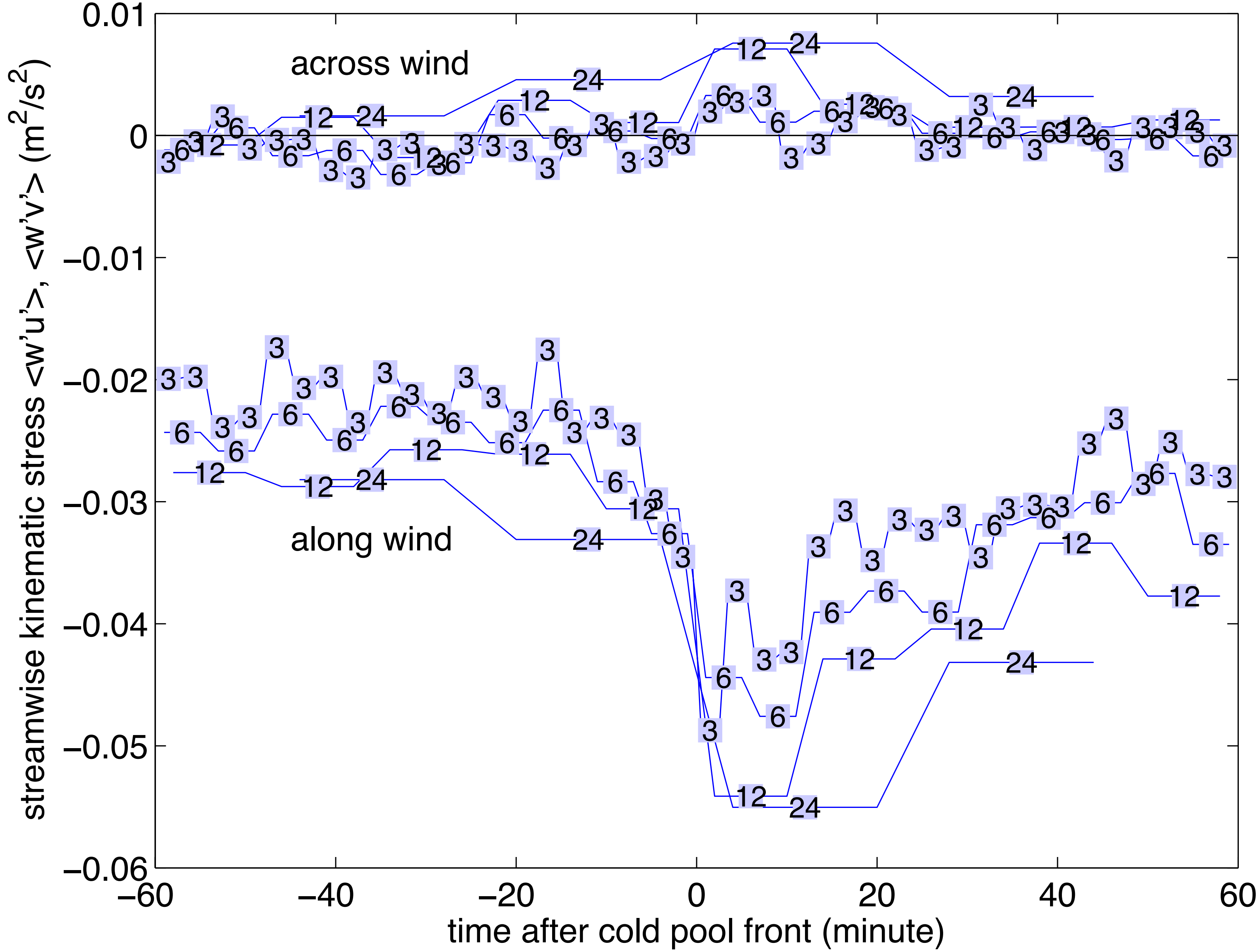
  12-minute Haar gradient filter <–0.4 C/min

- Composite turbulence ±2 hours from front
  - u, v, w, T_s
  - covariance $<w'u'>$, $<w'v'>$, $<w'T_s'>$

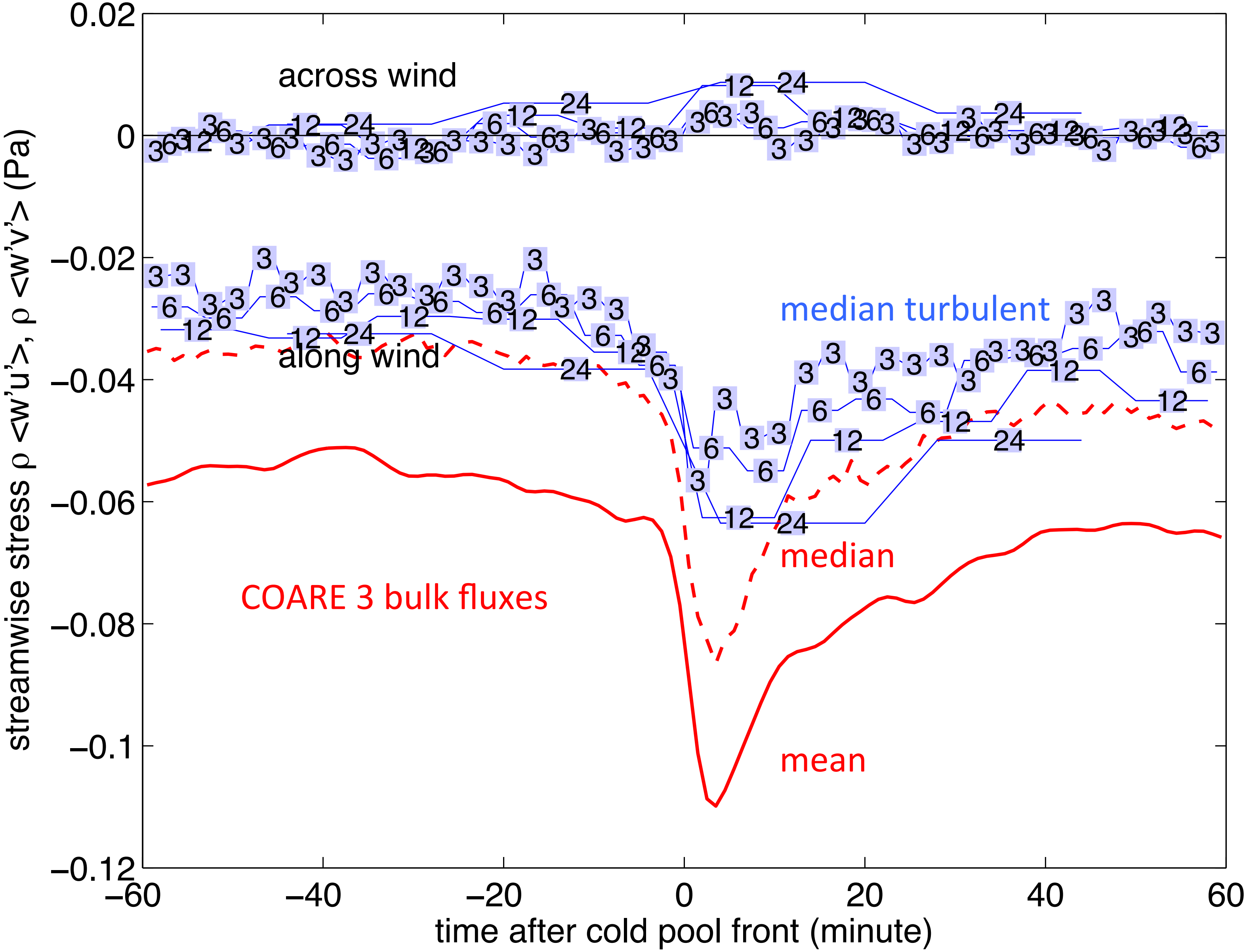


zonal wind u (m/s)
meridional wind v (m/s)
sonic temperature T_s (°C)
minute
event
60
40
20
0
−20
−40
−60
20
40
60
80
100
120
140
160
180
200
220
10
0
−10
36
34
32
30

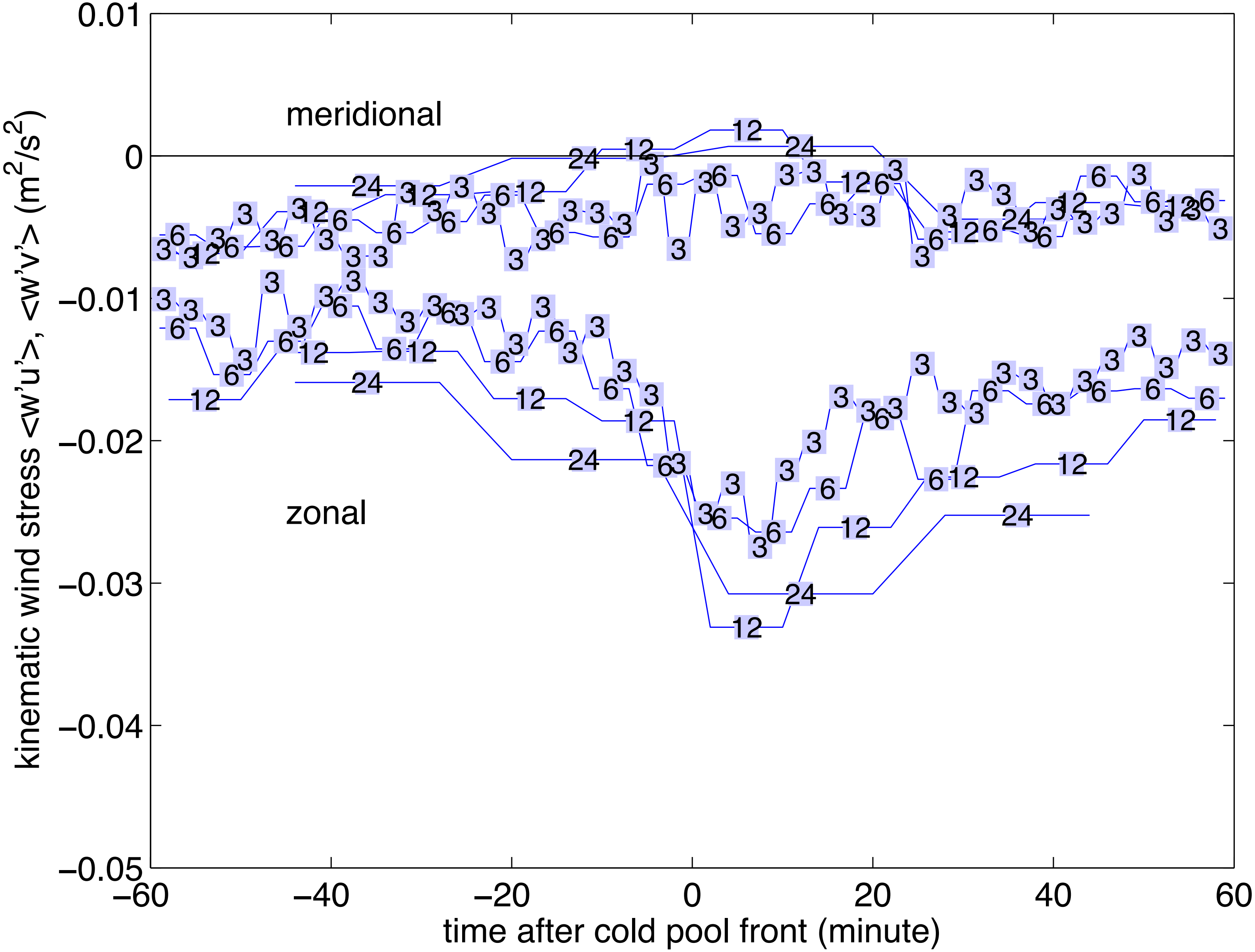
stream-wise stress



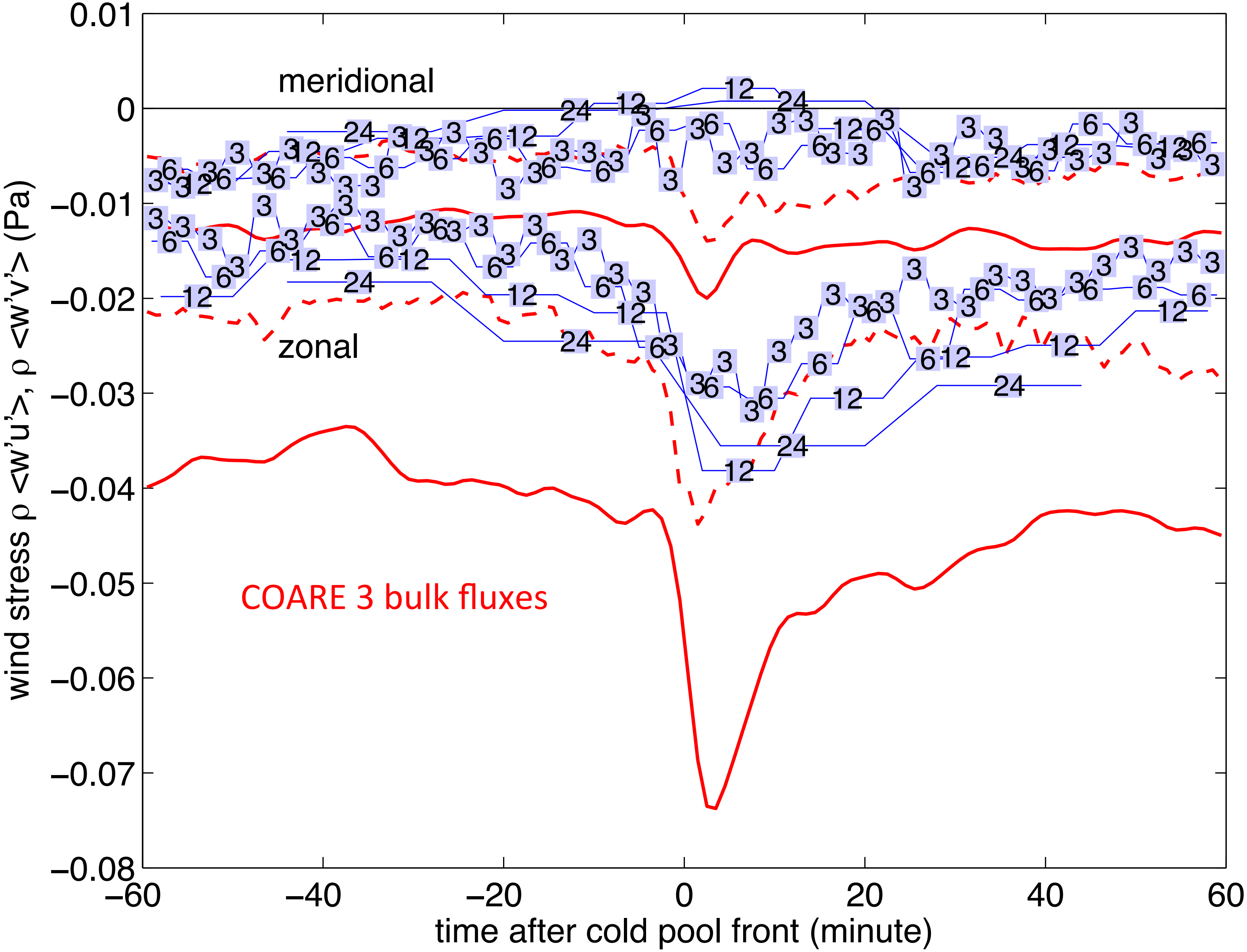
stream-wise stress



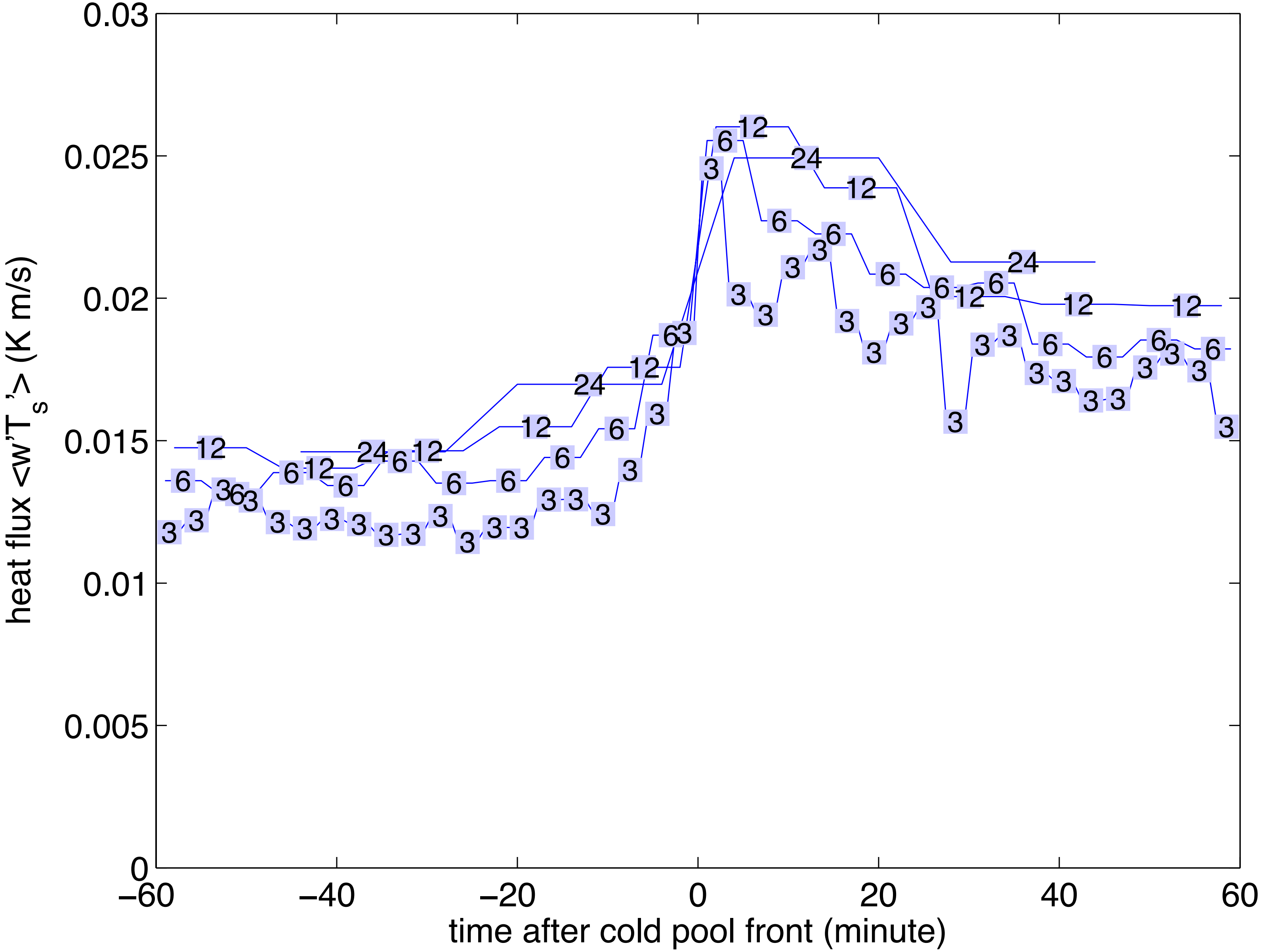
zonal and meridional stress



zonal and meridional stress

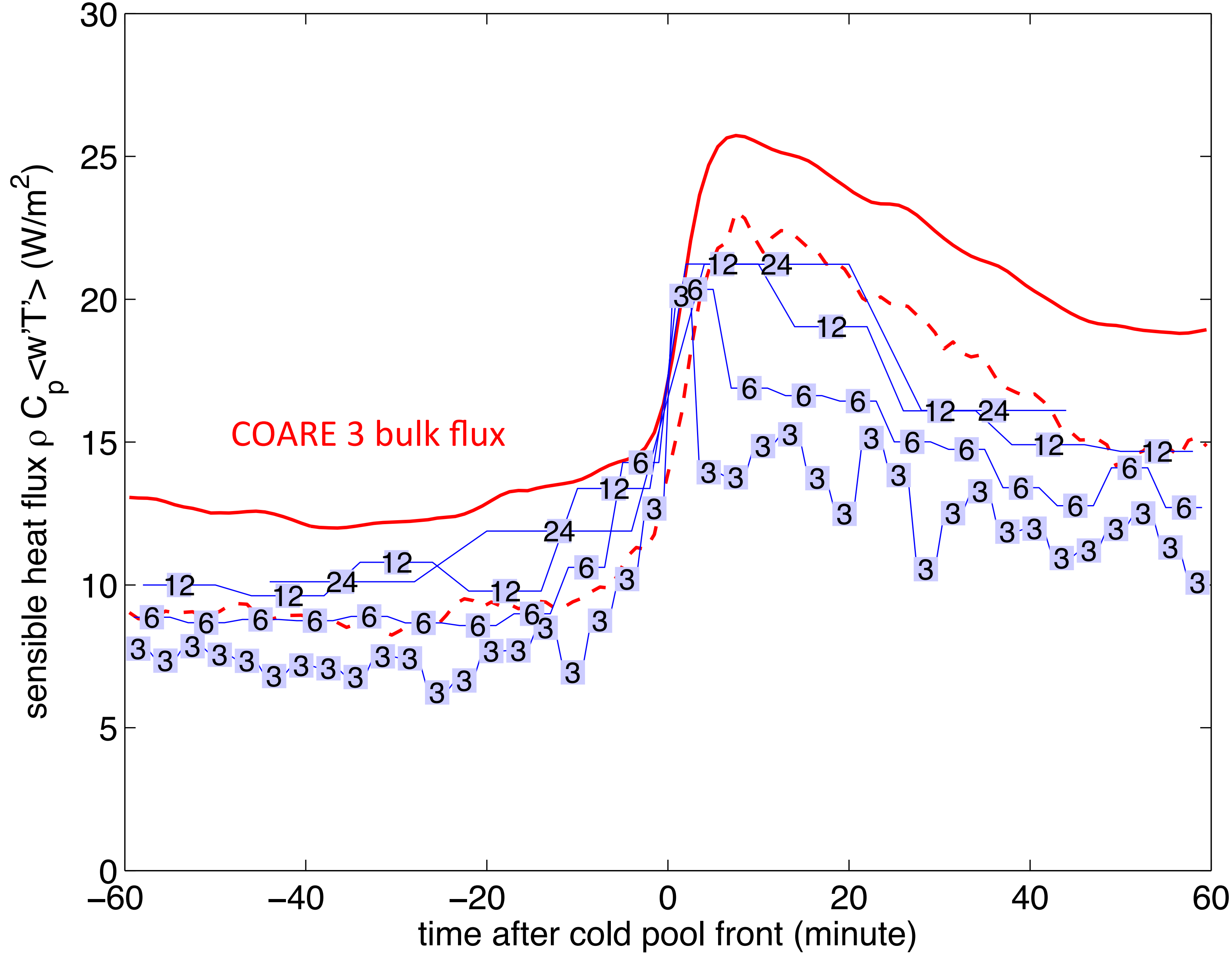


heat flux

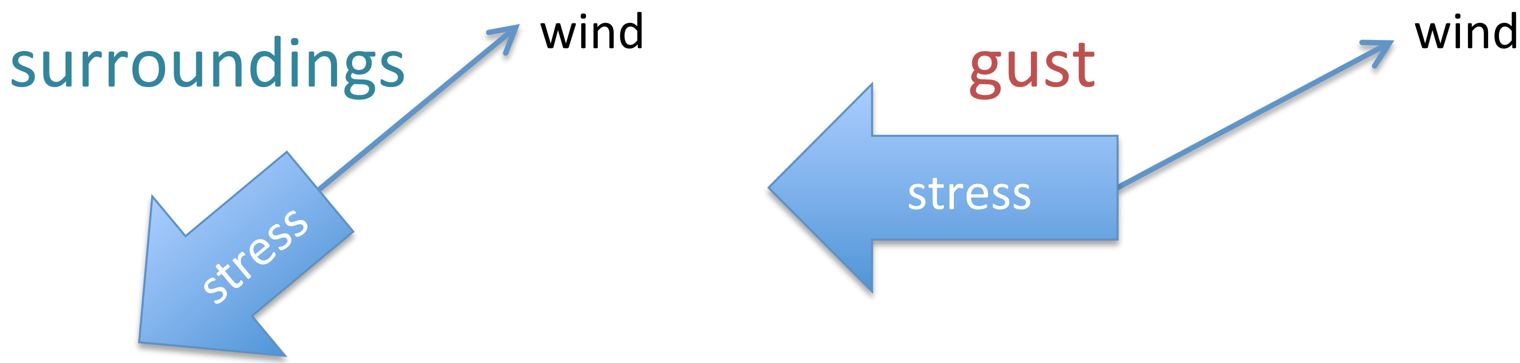


0.03
0.025
0.02
0.015
0.01
0.005
0
−60
−40
−20
0
20
40
60
heat flux <w'T$_s$'> (K m/s)
time after cold pool front (minute)

heat flux


COARE 3 bulk flux
sensible heat flux ρ C_p<w'T'> (W/m^2)
time after cold pool front (minute)
0
5
10
15
20
25
30
−60
−40
−20
0
20
40
60

Effect of cold-pool gusts: summary



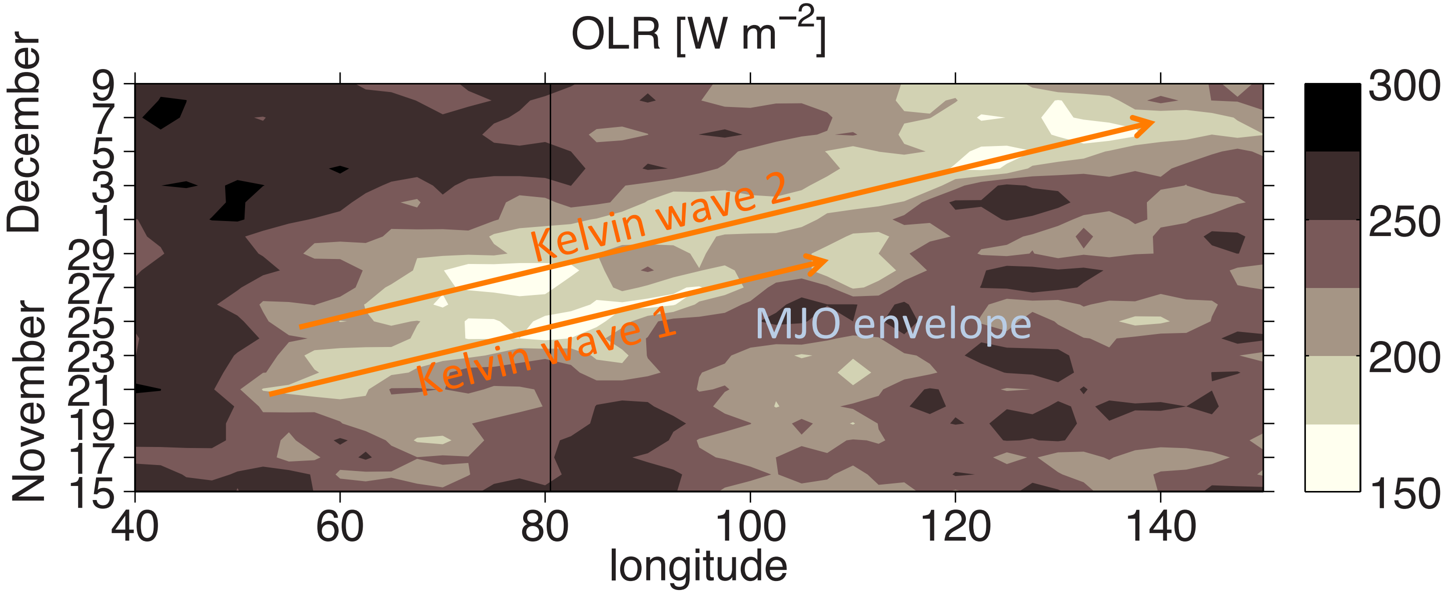
- Median cold pool front *doubles stress and sensible heat flux* for 20 minutes.
- 12-24 minute windows capture more covariance than shorter windows.
- COARE bulk fluxes are consistent with turbulence fluxes.
  - Near cold pool fronts, anomalously strong wind gusts are disproportionately responsible for mean stress/flux.
  - Sea swell could reduce along-wind stress.

large-scale setting

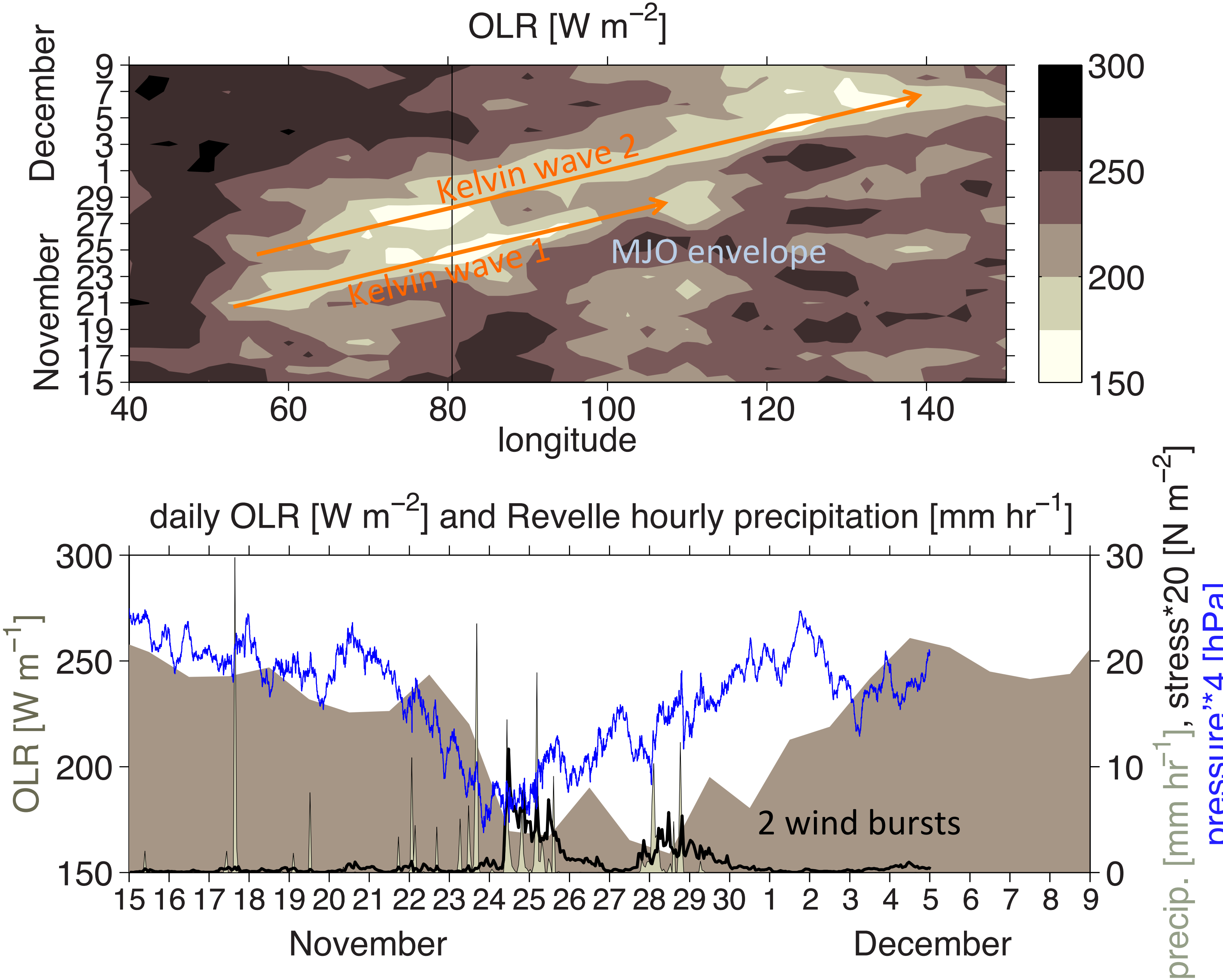
- Hovmoller
- time series
- Distinct structures at multiple scales in atm. and ocean:
  - MJO
  - wind bursts (Kelvin waves)
  - convective complexes
  - evaporative cold pools
  - turbulence
  - waves, fluxes, air-sea interaction
  - stratification and mixing
  - Wyrtki/Yoshida jet acceleration
  - Equatorial undercurrent

  (*BAMS* proposal, Moum et al.)

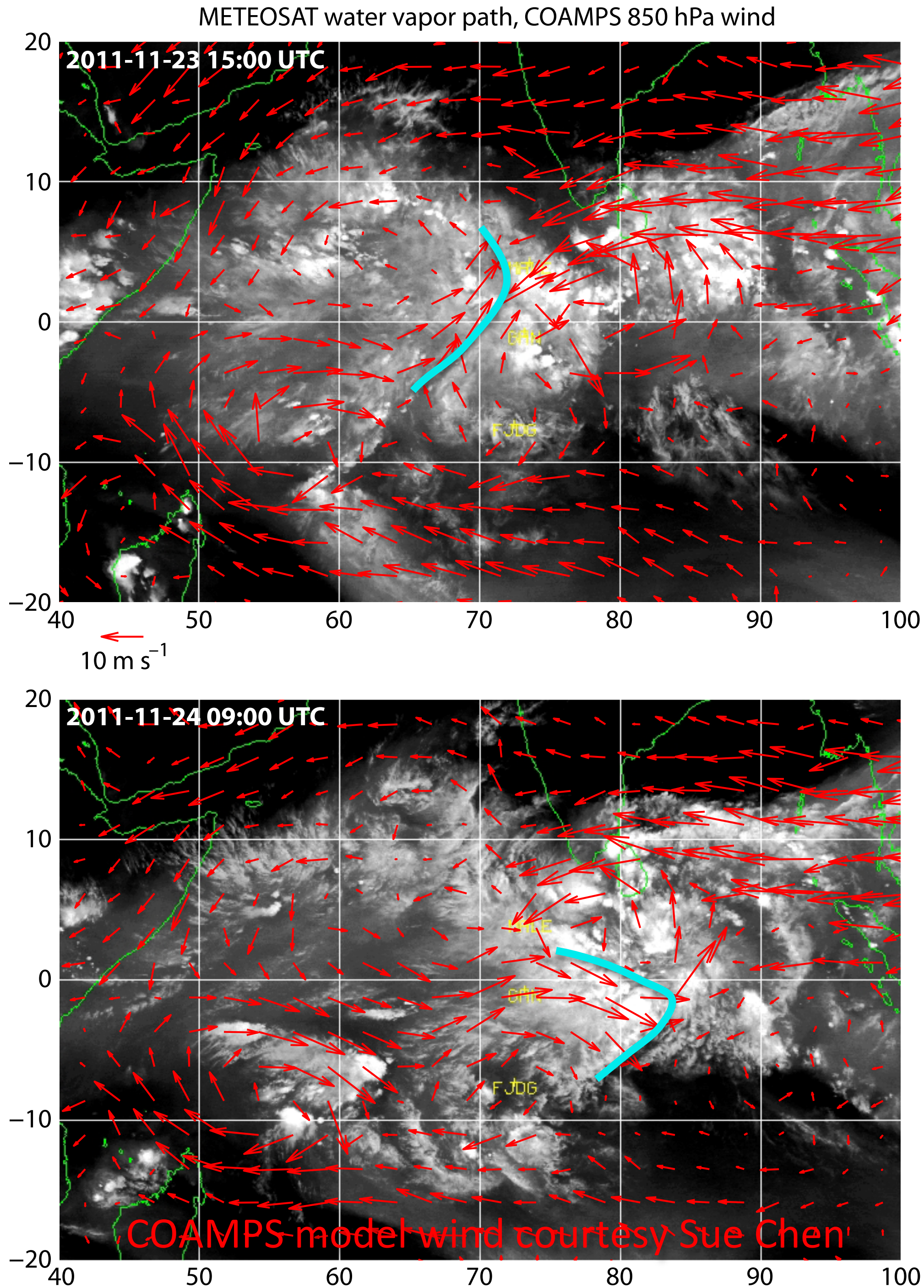
MJO, Kelvin wind bursts, rain showers



MJO, Kelvin wind bursts, rain showers



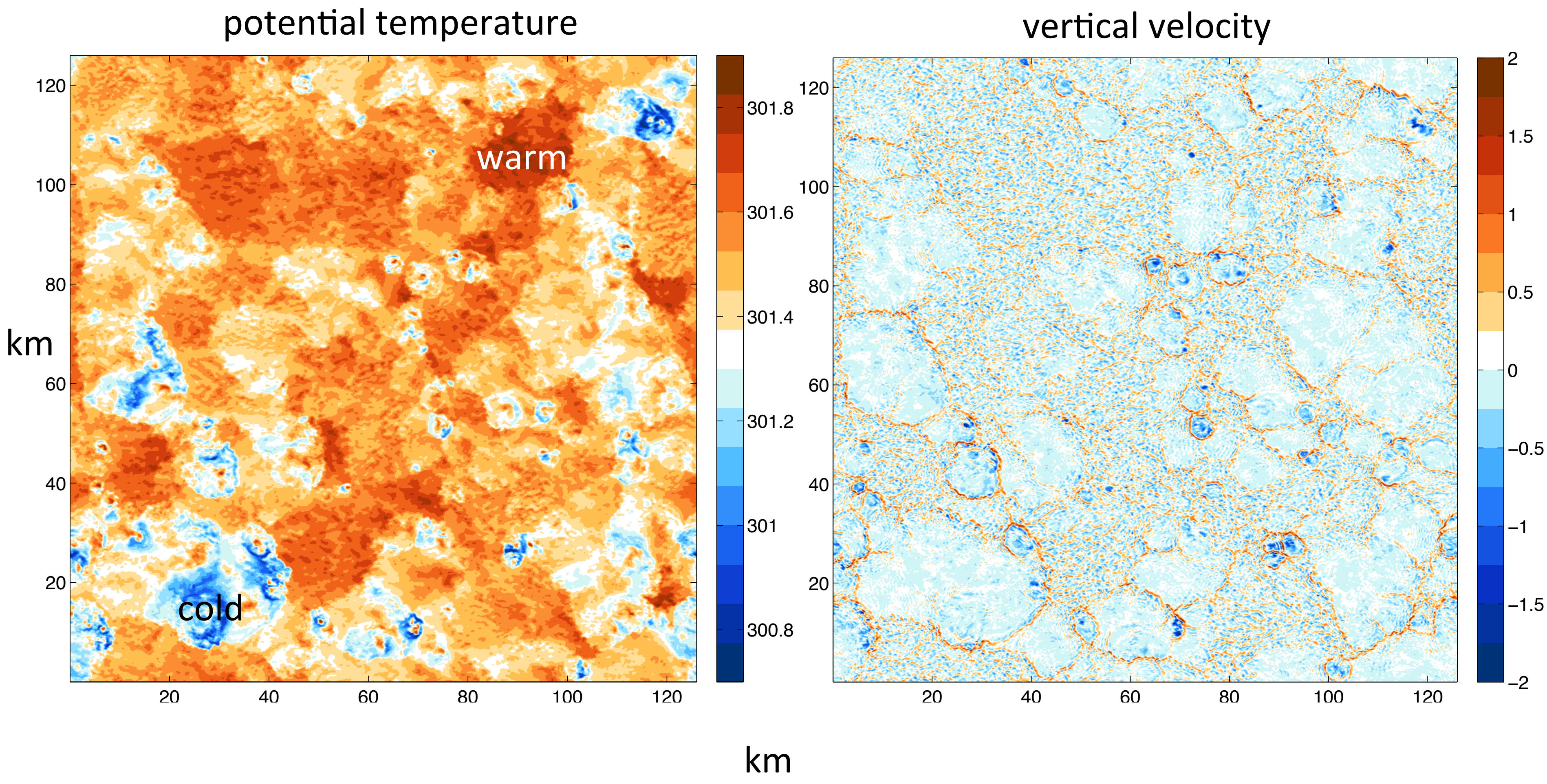
Development of 1st Westerly Wind Burst



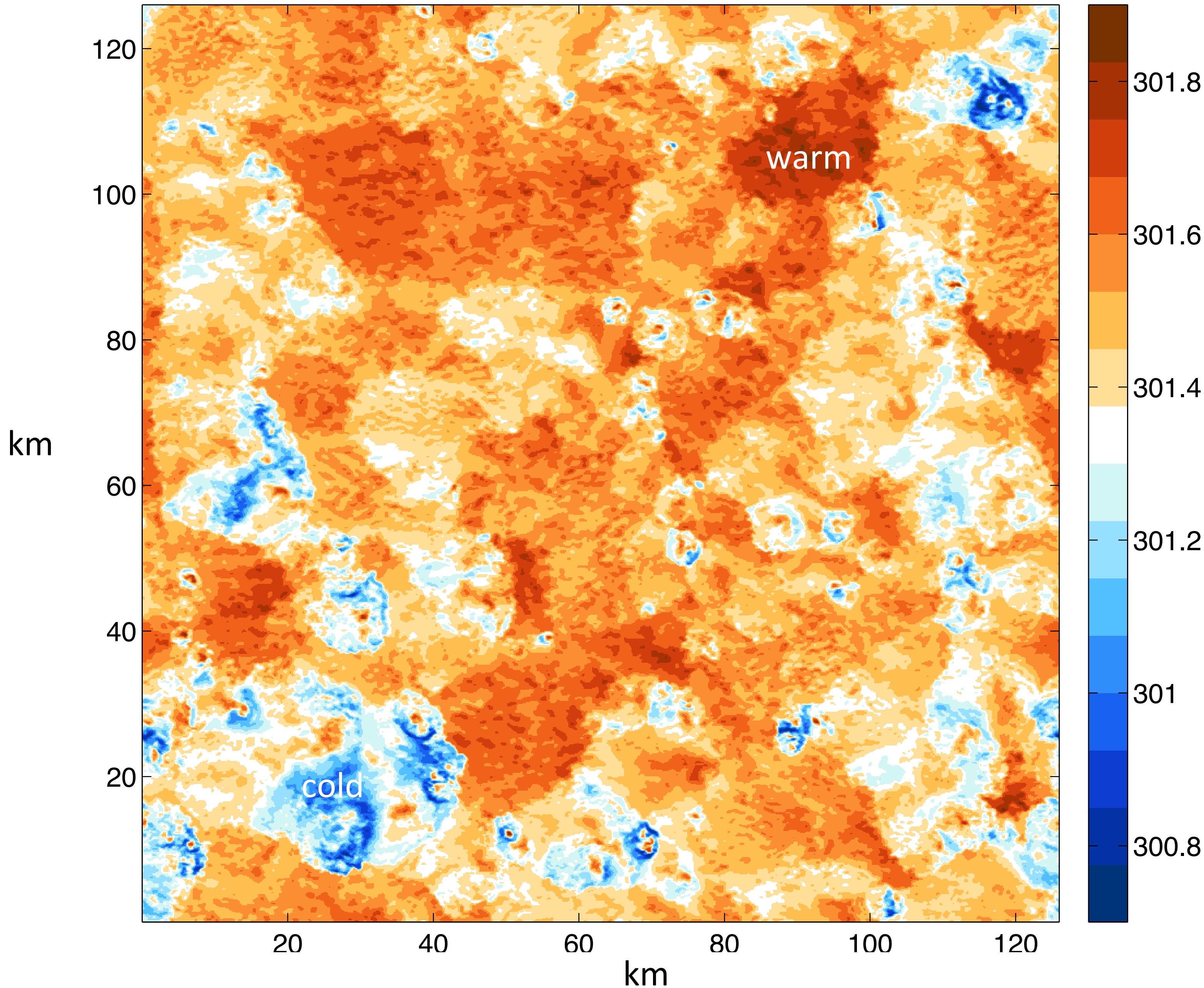
Nov 23 15 UTC

Nov 24 09 UTC

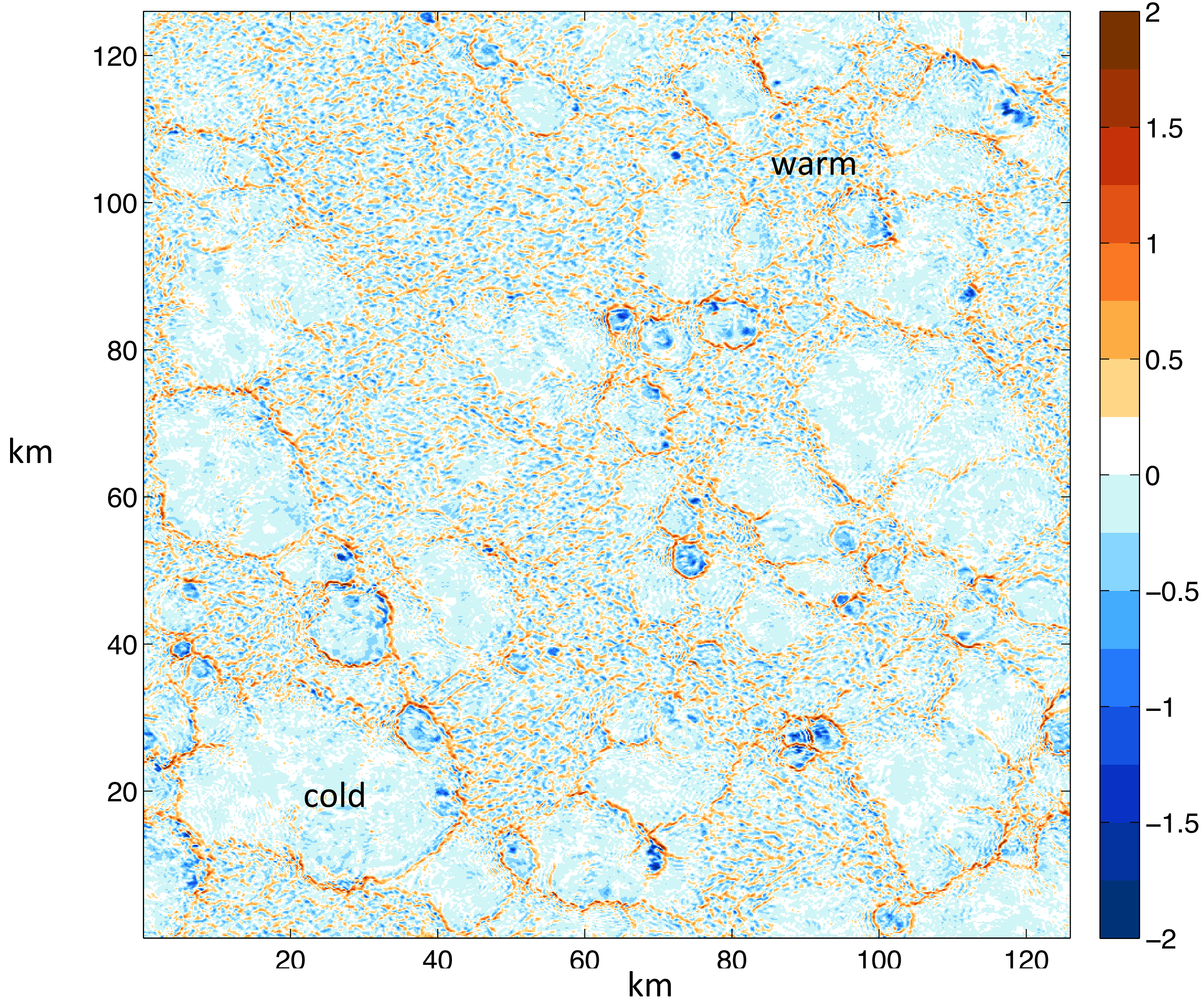
Large-eddy simulation
lowest model level



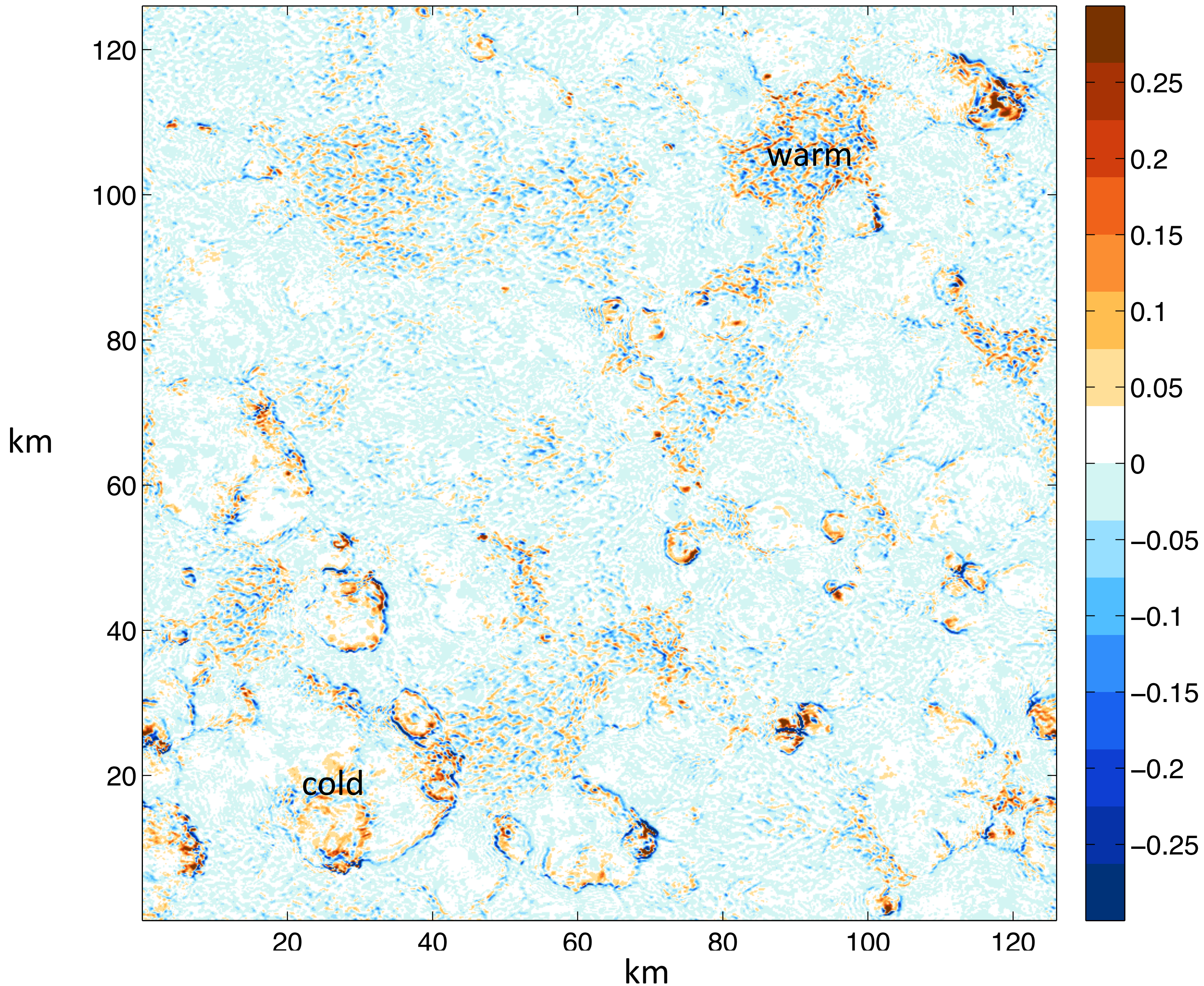
model potential temperature at lowest level (150 m)



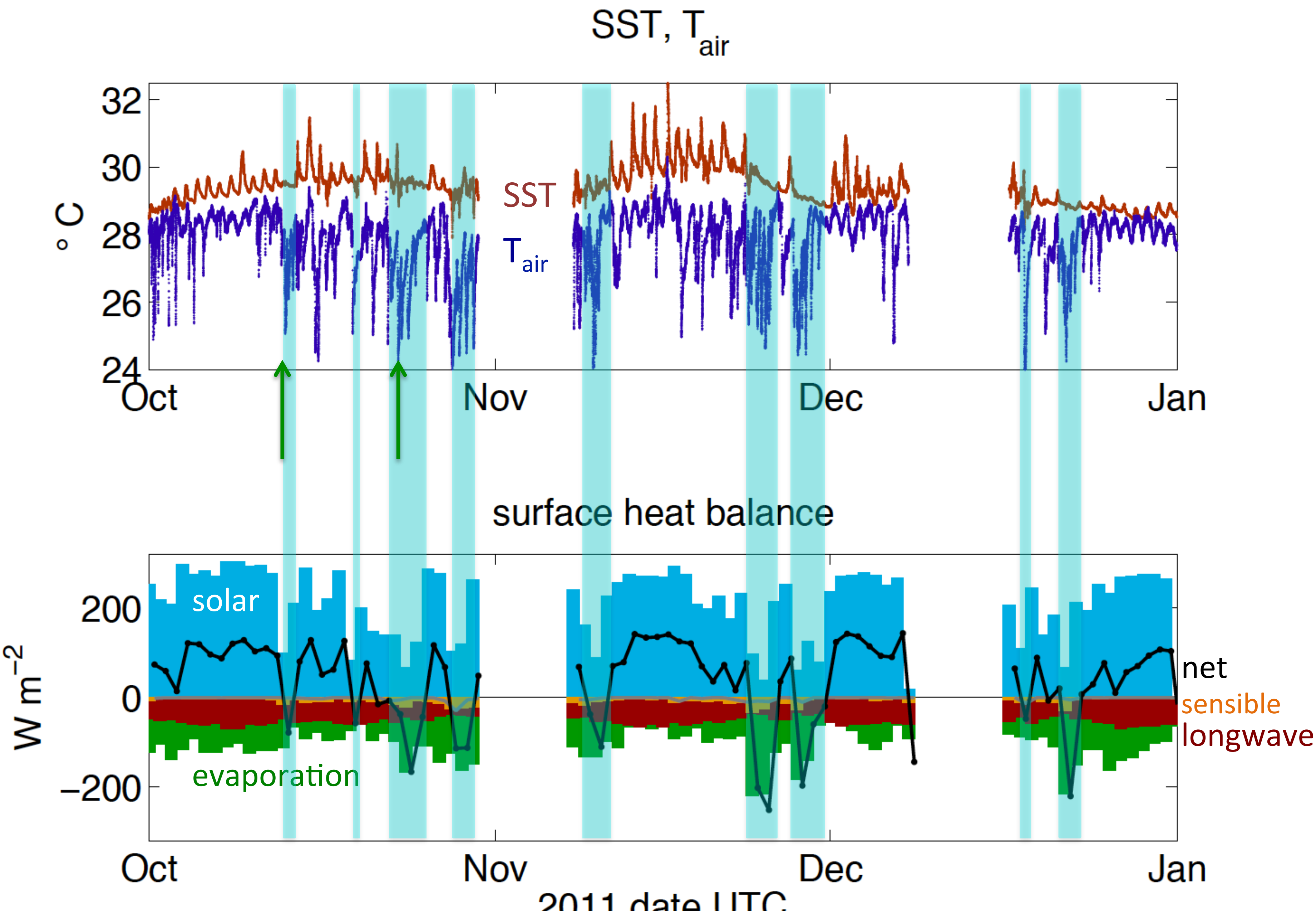
vertical velocity



w'θ' at 150 m

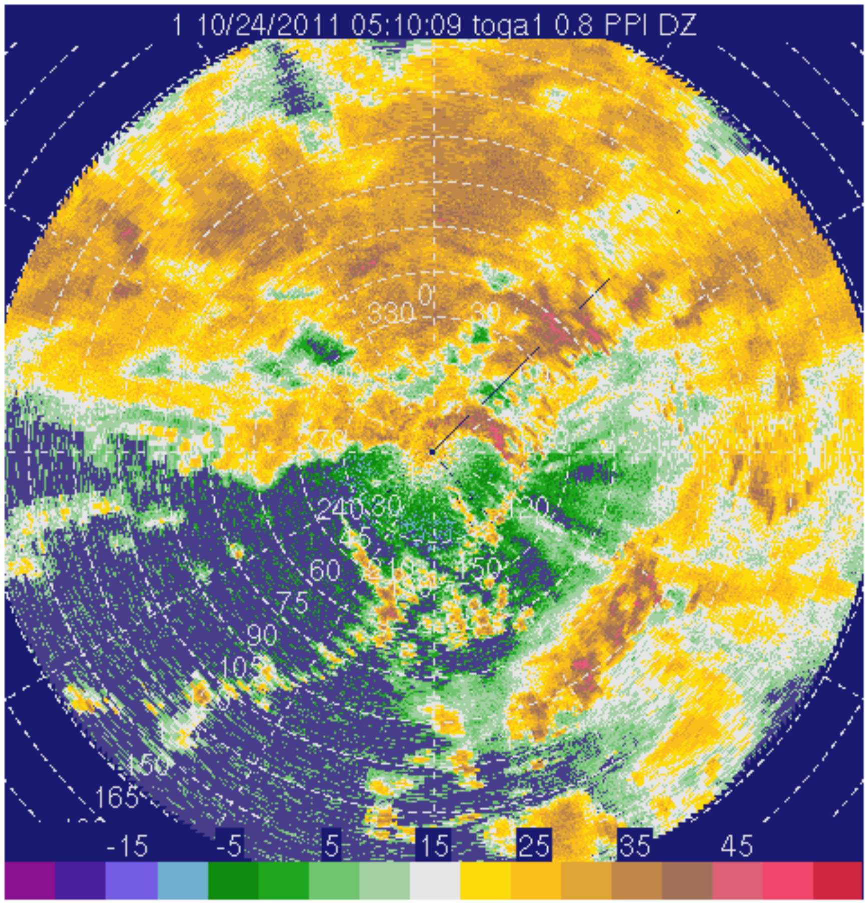


warm
cold
km
km
120
100
80
60
40
20
20
40
60
80
100
120
0.25
0.2
0.15
0.1
0.05
0
−0.05
−0.1
−0.15
−0.2
−0.25

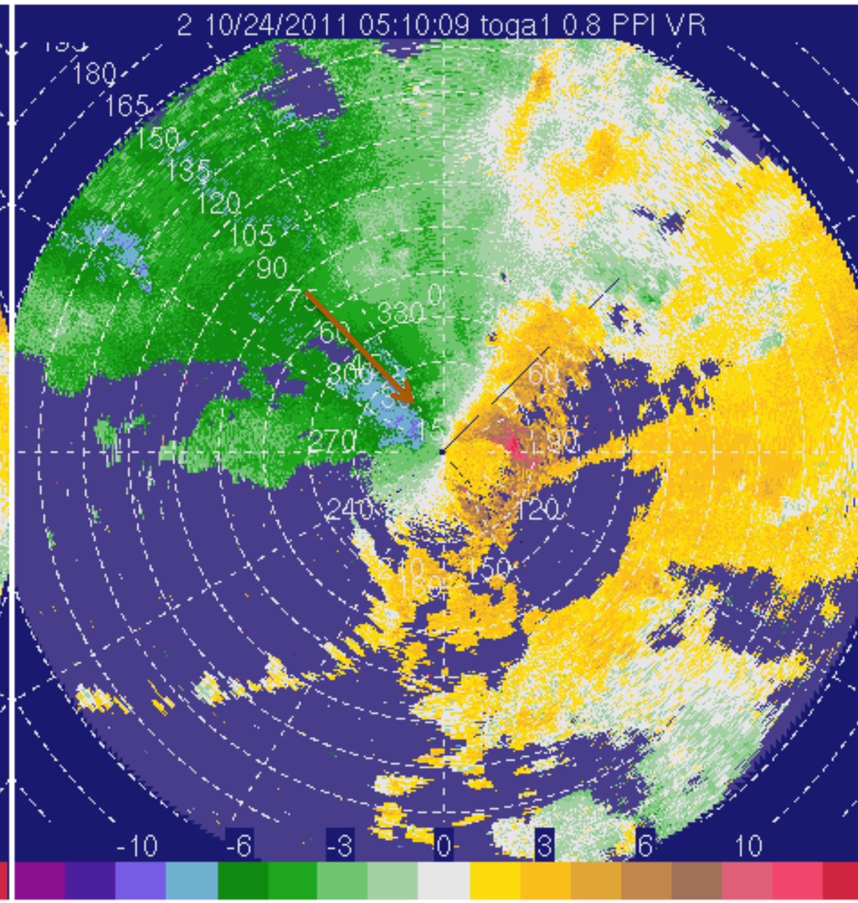


SST, T_{air}
32
30
28
26
24
°C
SST
T_{air}
Oct
Nov
Dec
Jan
surface heat balance
200
0
−200
$W\ m^{-2}$
solar
evaporation
net
sensible
longwave
Oct
Nov
Dec
Jan
2011 date UTC

Outflow boundary in TOGA radar October 24 5:10 UTC



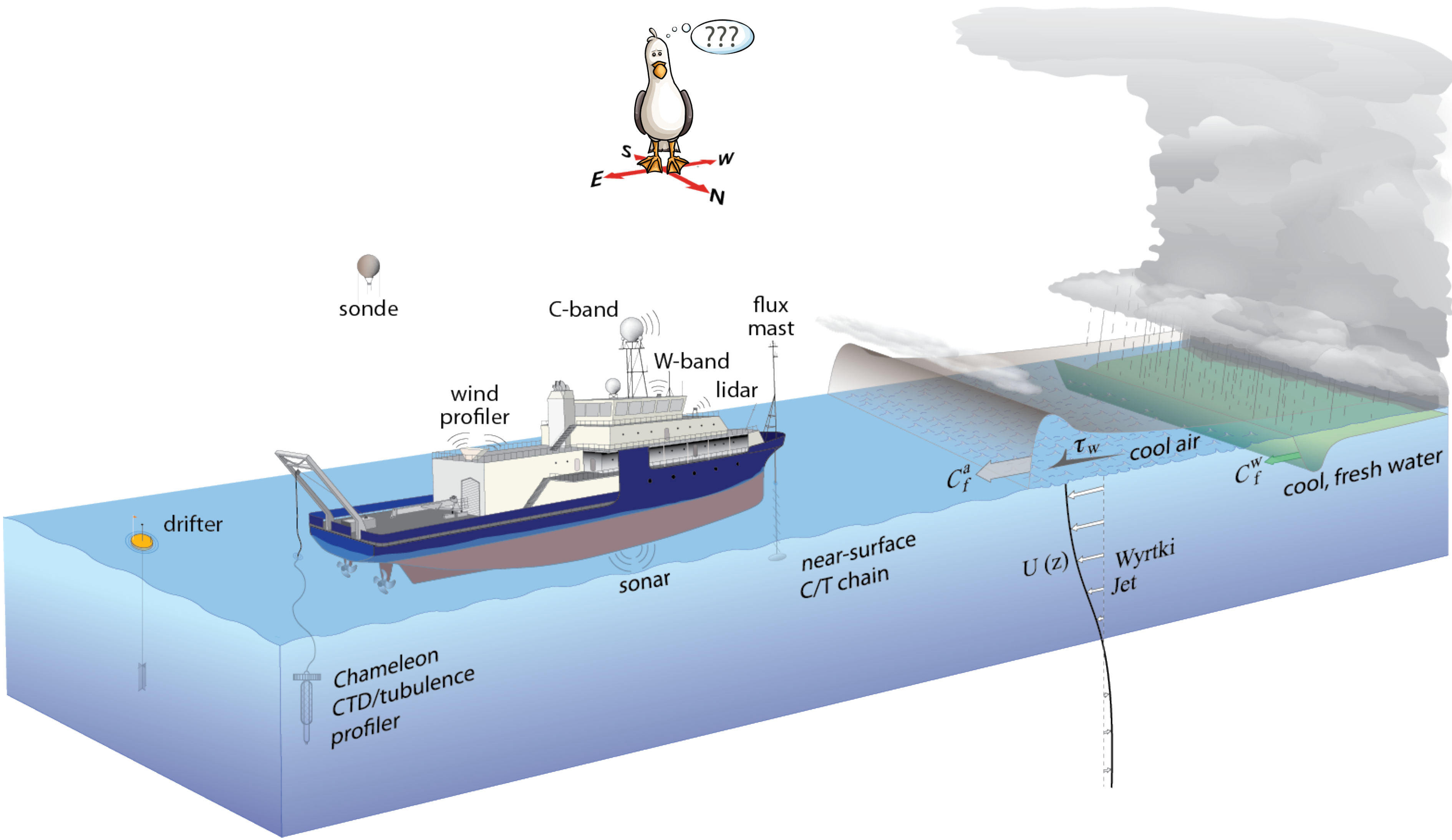
reflectivity (dBZ)



Doppler velocity (m s^{-1})

Angela Rowe, Colorado State U.

Effect of convection on surface fluxes



Clouds on the density current, 2011 October 24, 10 local
NOAA W-band cloud radar