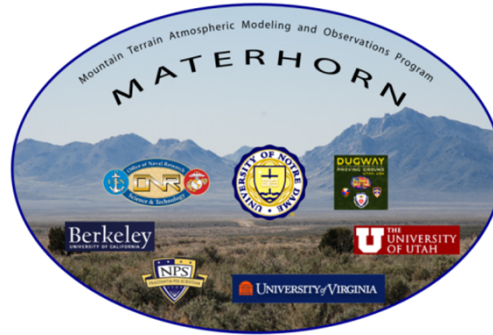
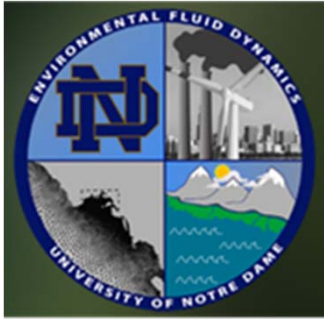


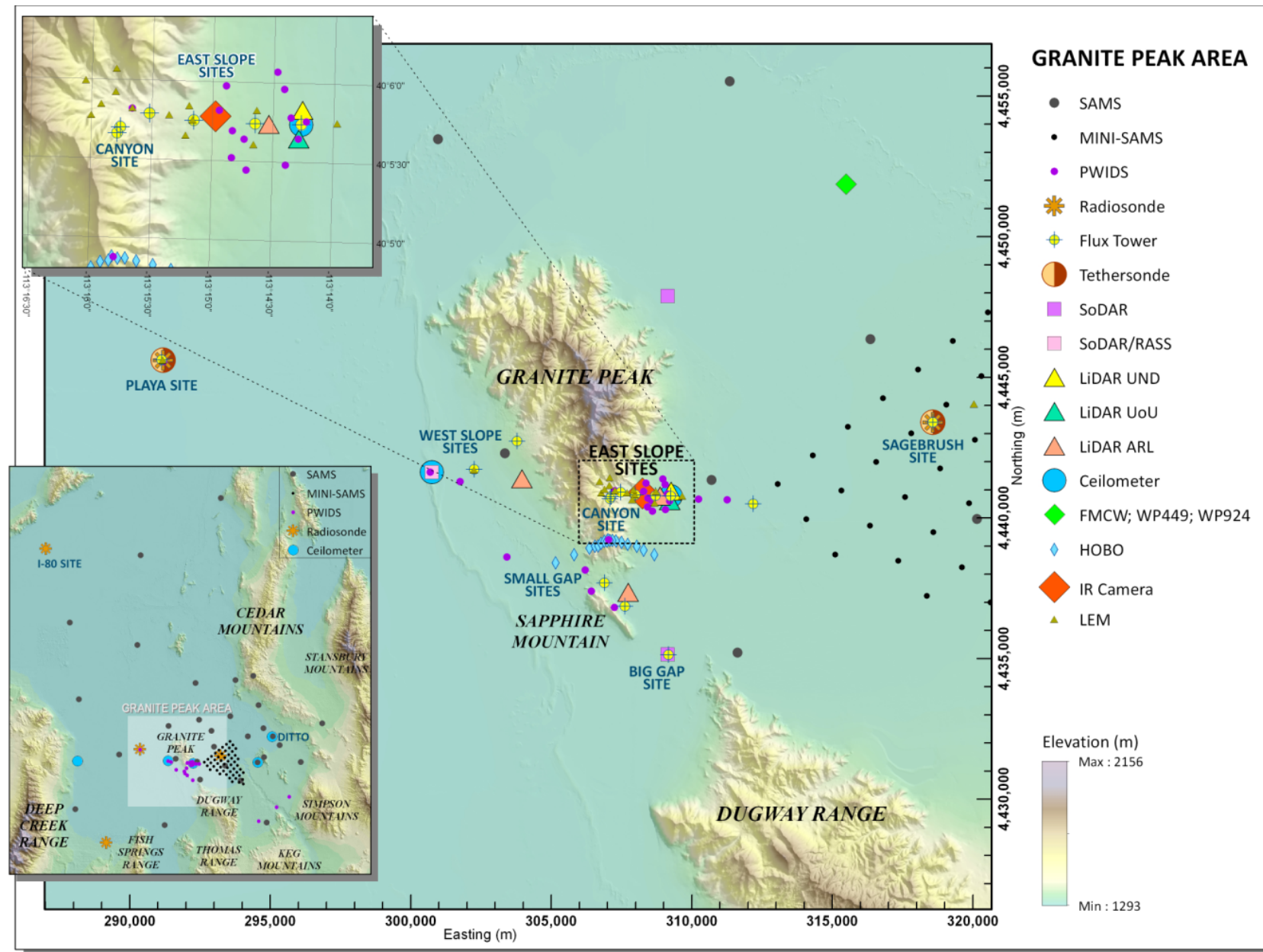


# Waves in Katabatic Flows

**Laura S. Leo <sup>(1)</sup> and Silvana Di Sabatino <sup>(1, 2)</sup> & Materhorn Team**

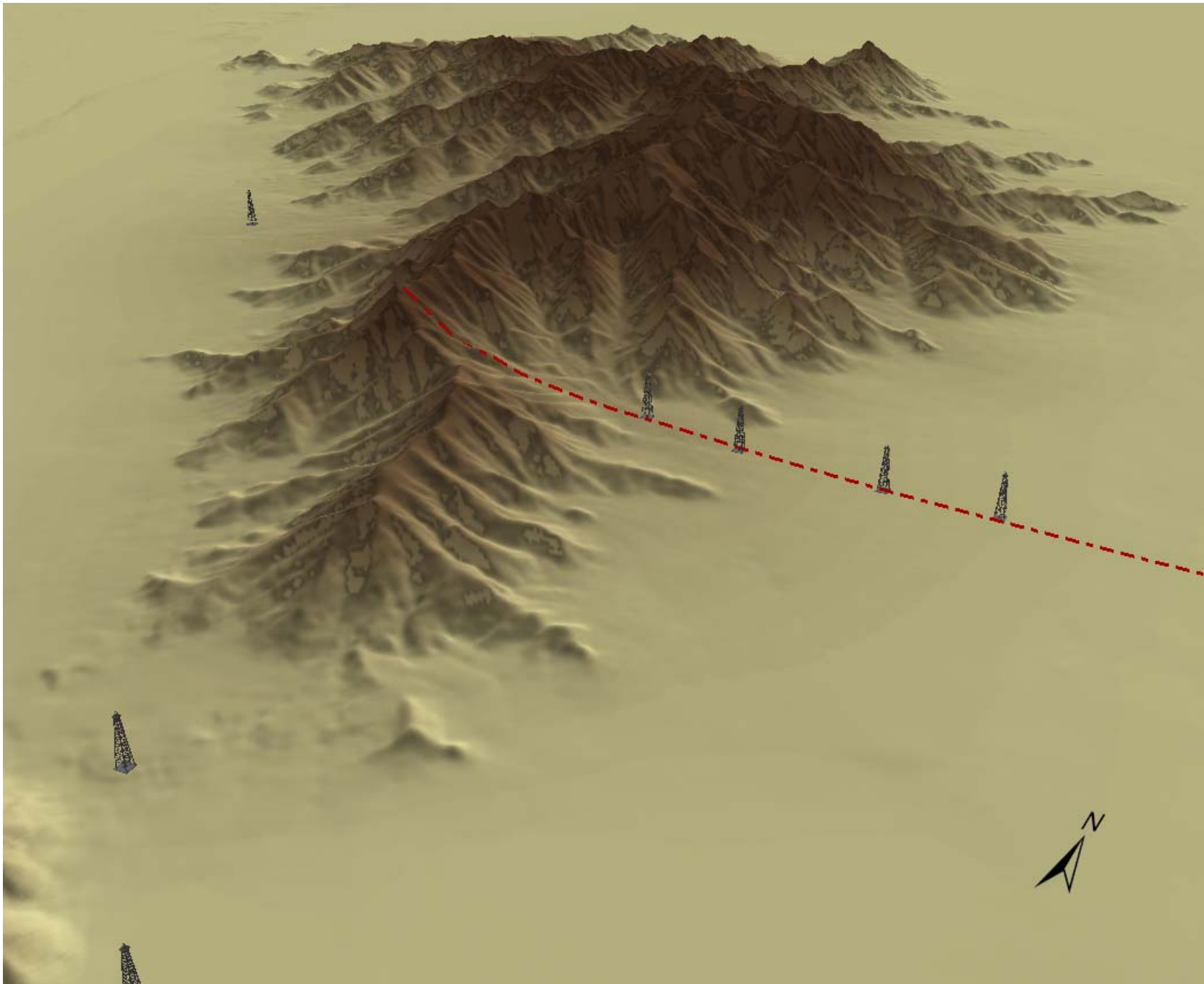
*<sup>(1)</sup> Environmental Fluid Dynamics Laboratories, Civil Engineering & Geological Sciences,  
University of Notre Dame, Notre Dame, IN, USA*

*<sup>(2)</sup> Micrometeorology Lab, University of Salento, Via Monteroni, Lecce, Italy*



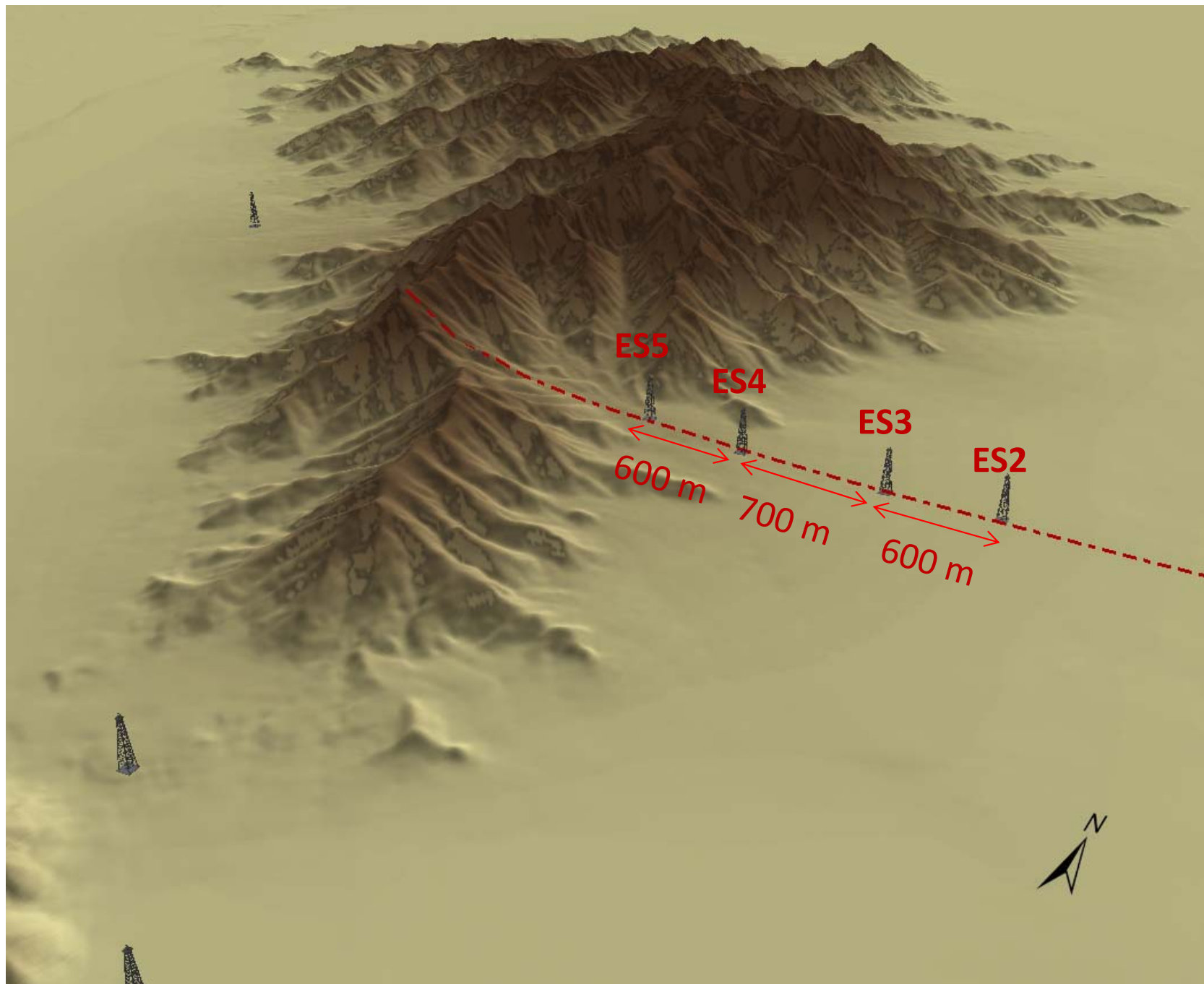
**Materhorn X-1** : 30-day intense field campaign during **September 25-October 25, 2102** conducted at the **Granite Mountain Atmospheric Science Testbed (GMAST)** of the US Army Dugway Proving Grounds (DPG).

## East Slope of Granite





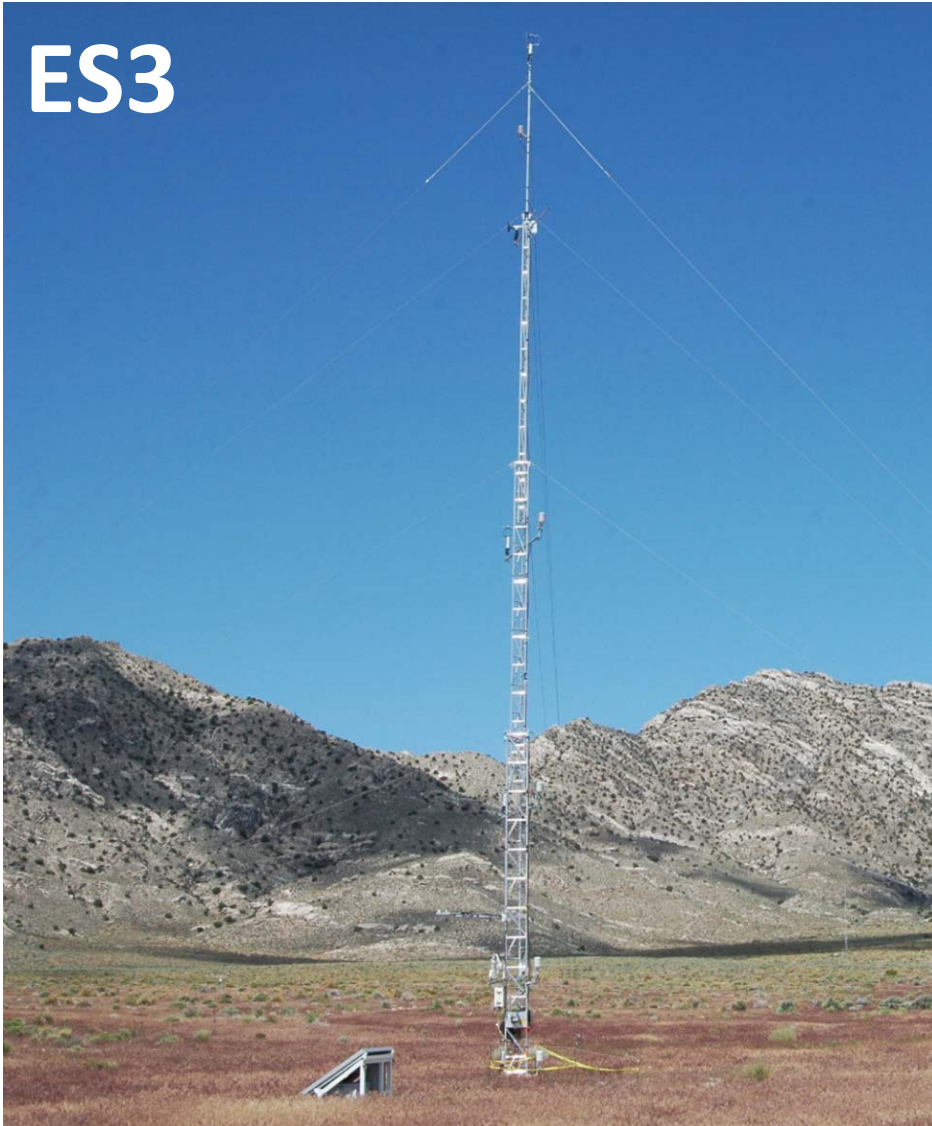
## East Slope of Granite





## **Towers - East Slope of Granite**

**ES3**

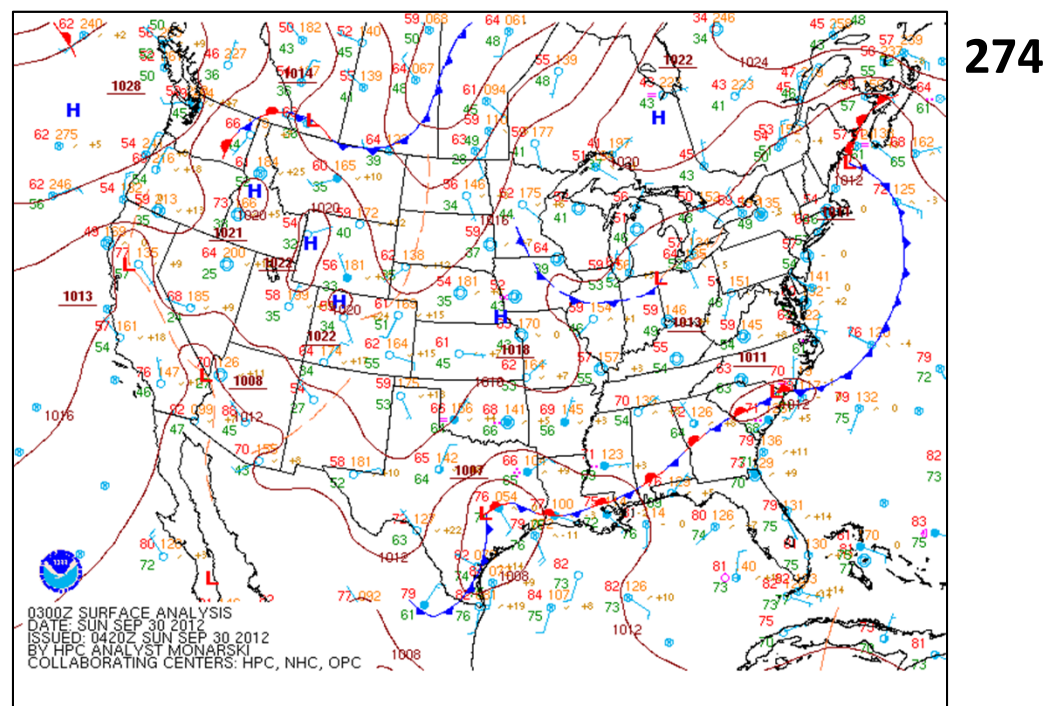
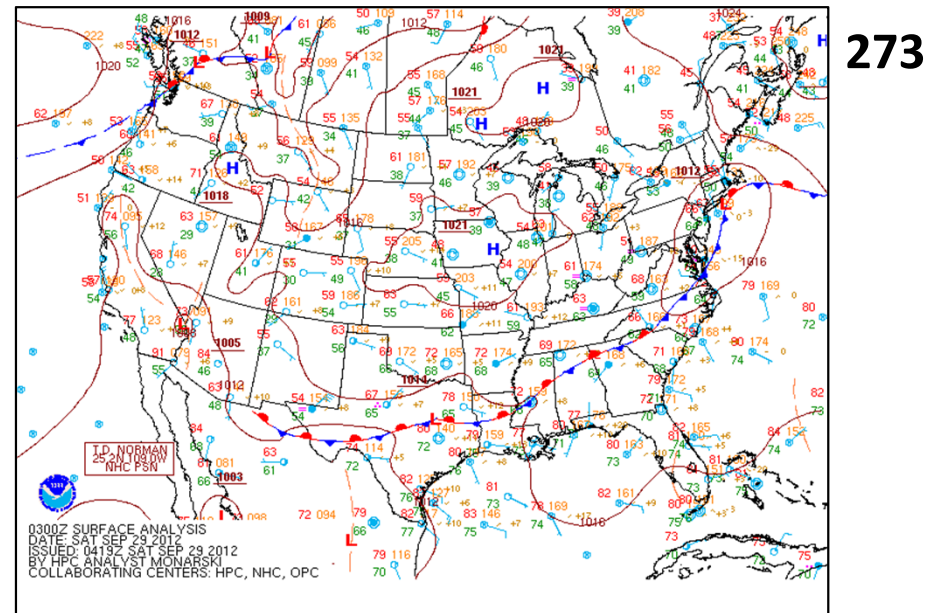
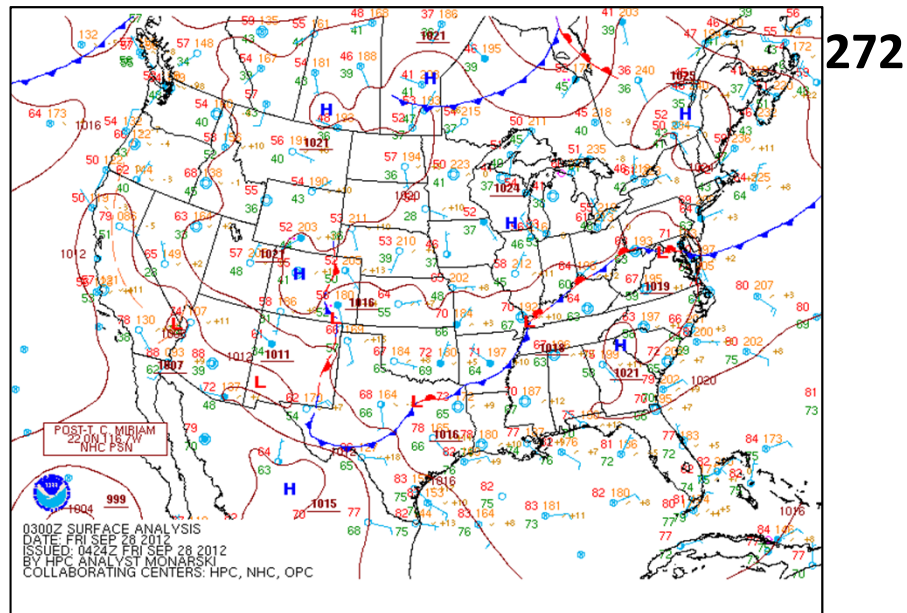


*Ultrasonic Anemometers (20 Hz)  
Temperature and Relative Humidity  
Probes (0.5Hz-1 Hz)*

- ES5 - 20 m tower  
Levels 0.5m , 2m, 5m, 10m, 20m
- ES4 – 28 m tower  
Levels 0.5m , 2m, 5m, 10m, 20m, 28 m
- ES3 – 20 m tower  
Levels 0.5m , 2m, 5m, 10m, 20m
- ES2 – 28 m tower  
Levels 0.5m , 4m, 10m, 16m,20m, 25m, 28 m



# Surface weather maps for Jdays 272-273-274 in the evening (03:00 UTC)



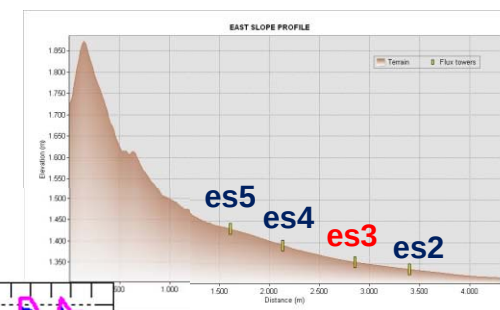
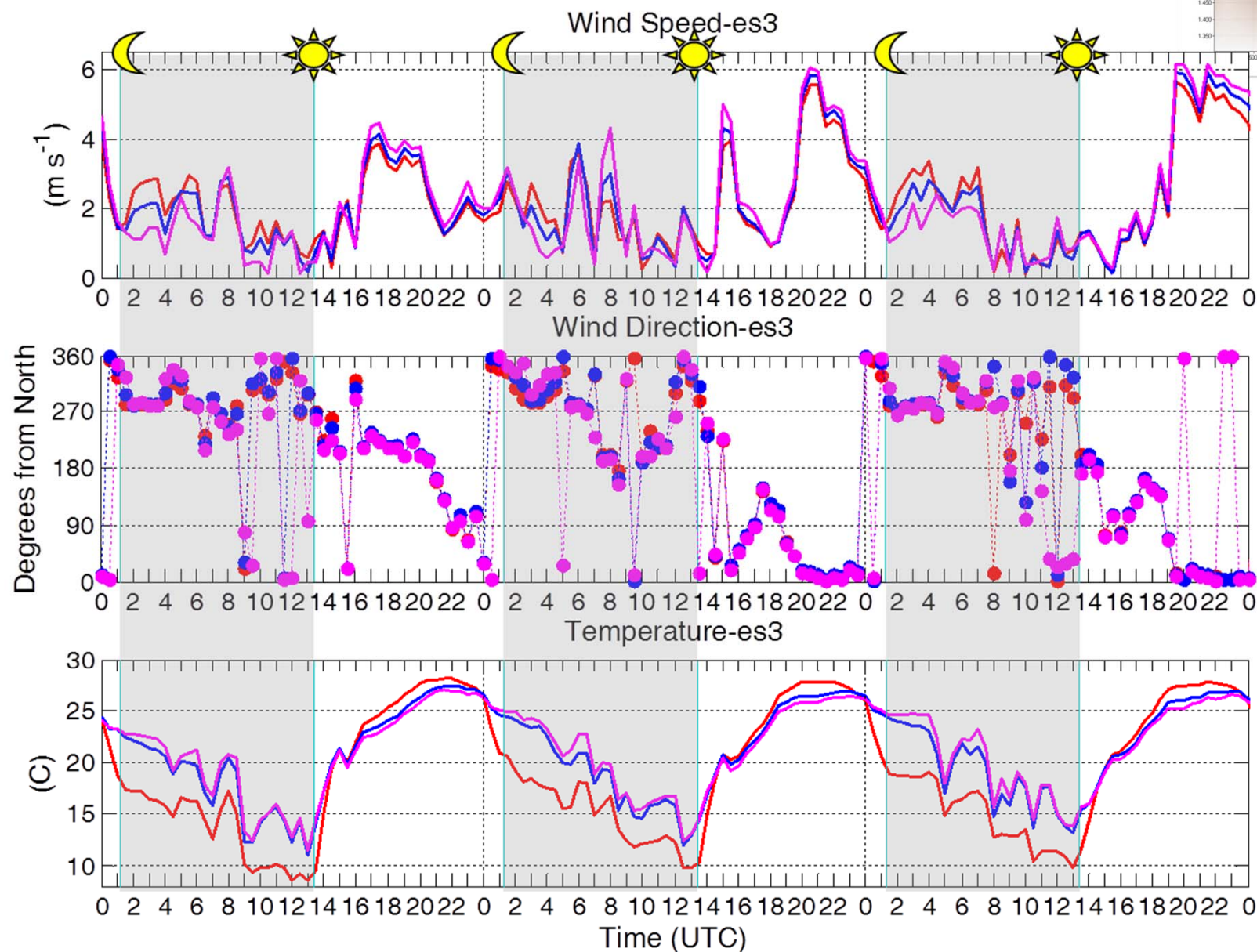
**Sunset** 🌙  
**01:17 UTC**  
**(19:17 LC)**

**Sunrise** ☀️  
**13:25 UTC**  
**(07:25 LC)**



# 30 min avg timeseries

ES3 Tower  
Jday 272-273 -274



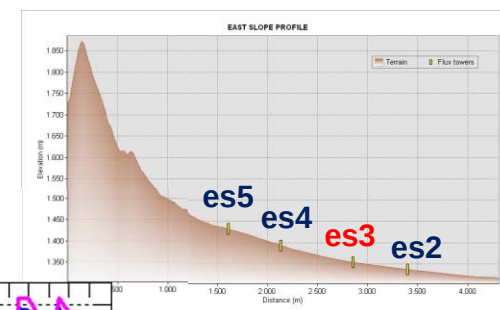
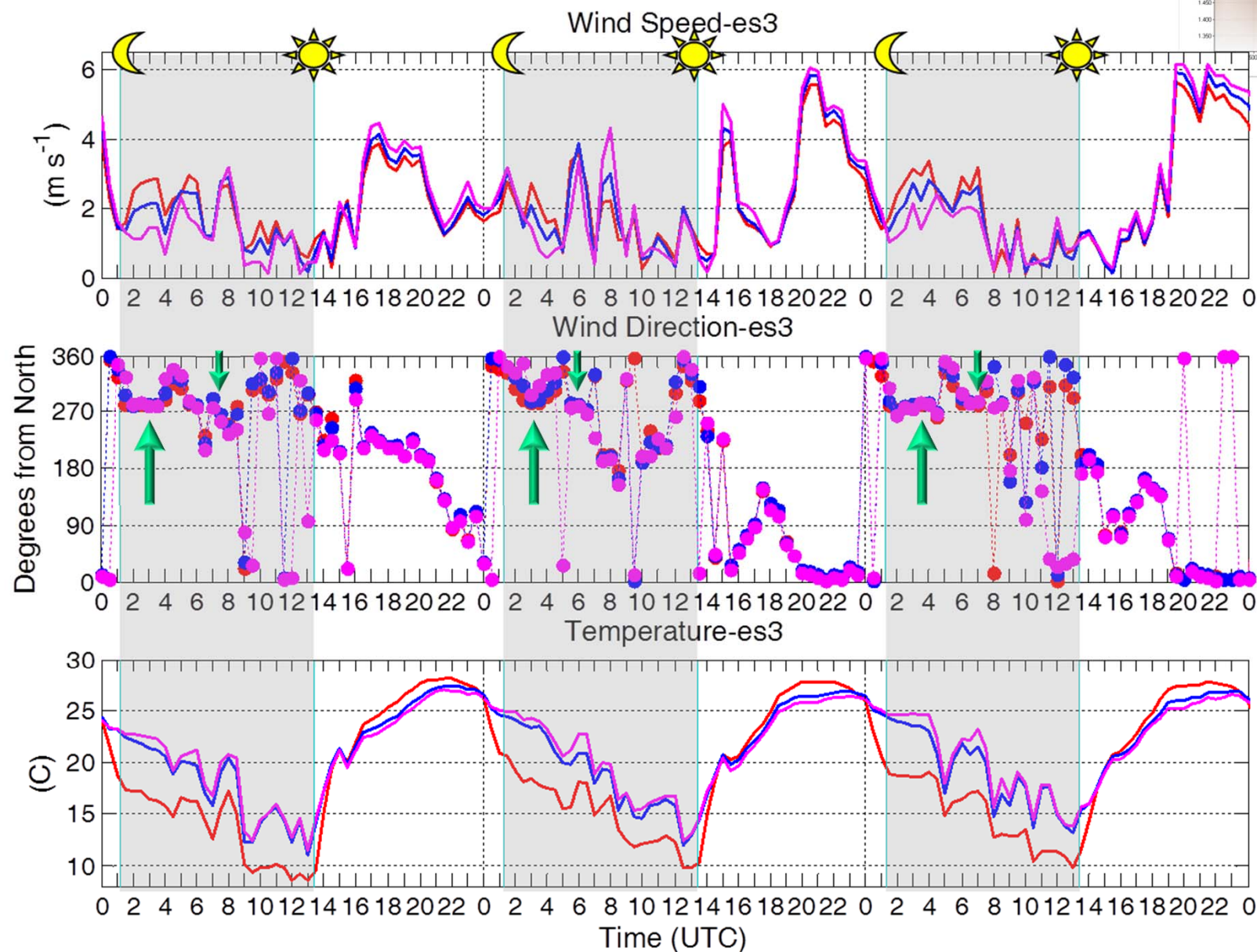
Sunset 🌙  
01:17 UTC  
(19:17 LC)

Sunrise 🌞  
13:25 UTC  
(07:25 LC)



# 30 min avg timeseries

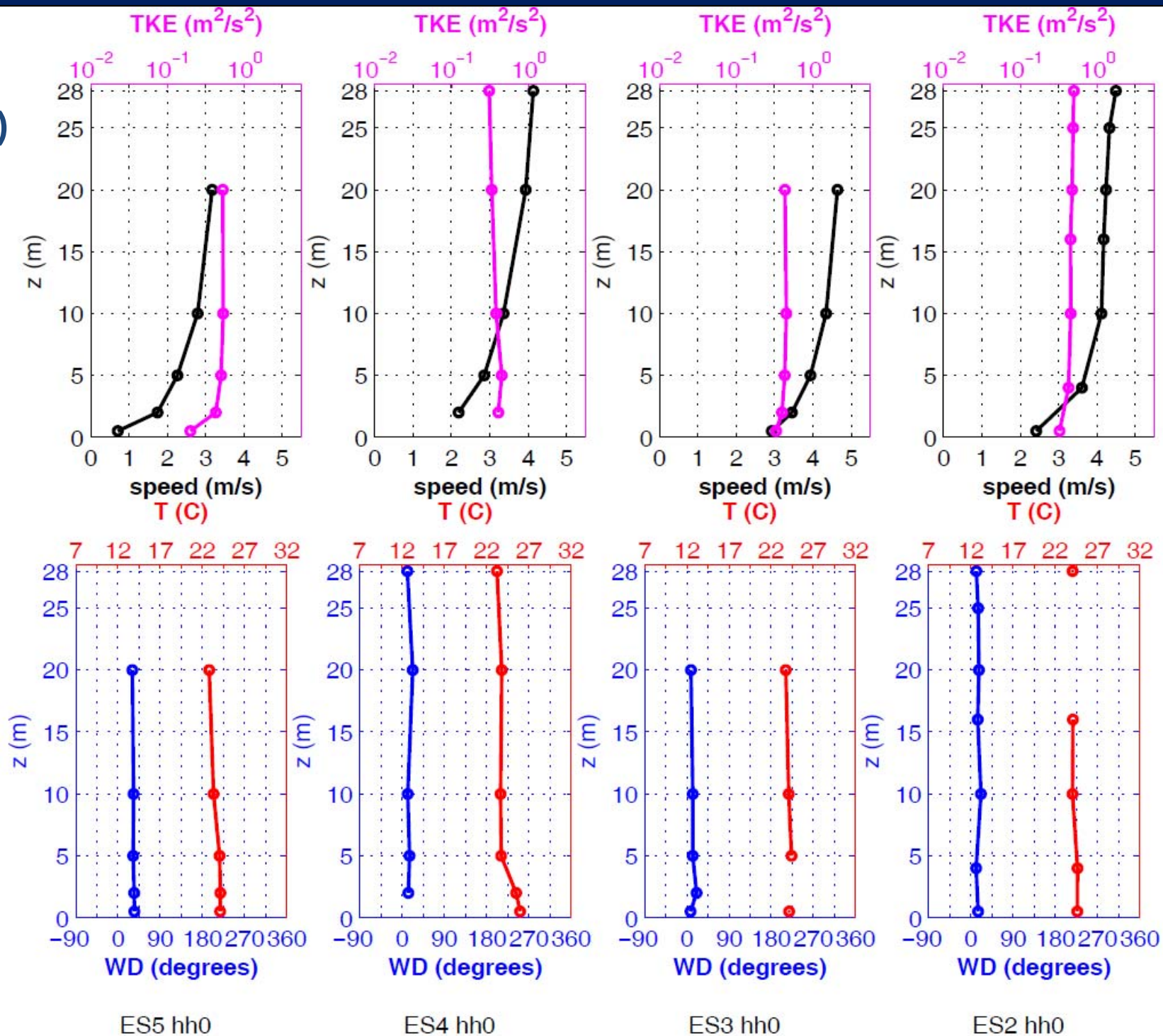
## ES3 Tower Jday 272-273 -274



**Sunset** 🌙  
01:17 UTC  
(19:17 LC)

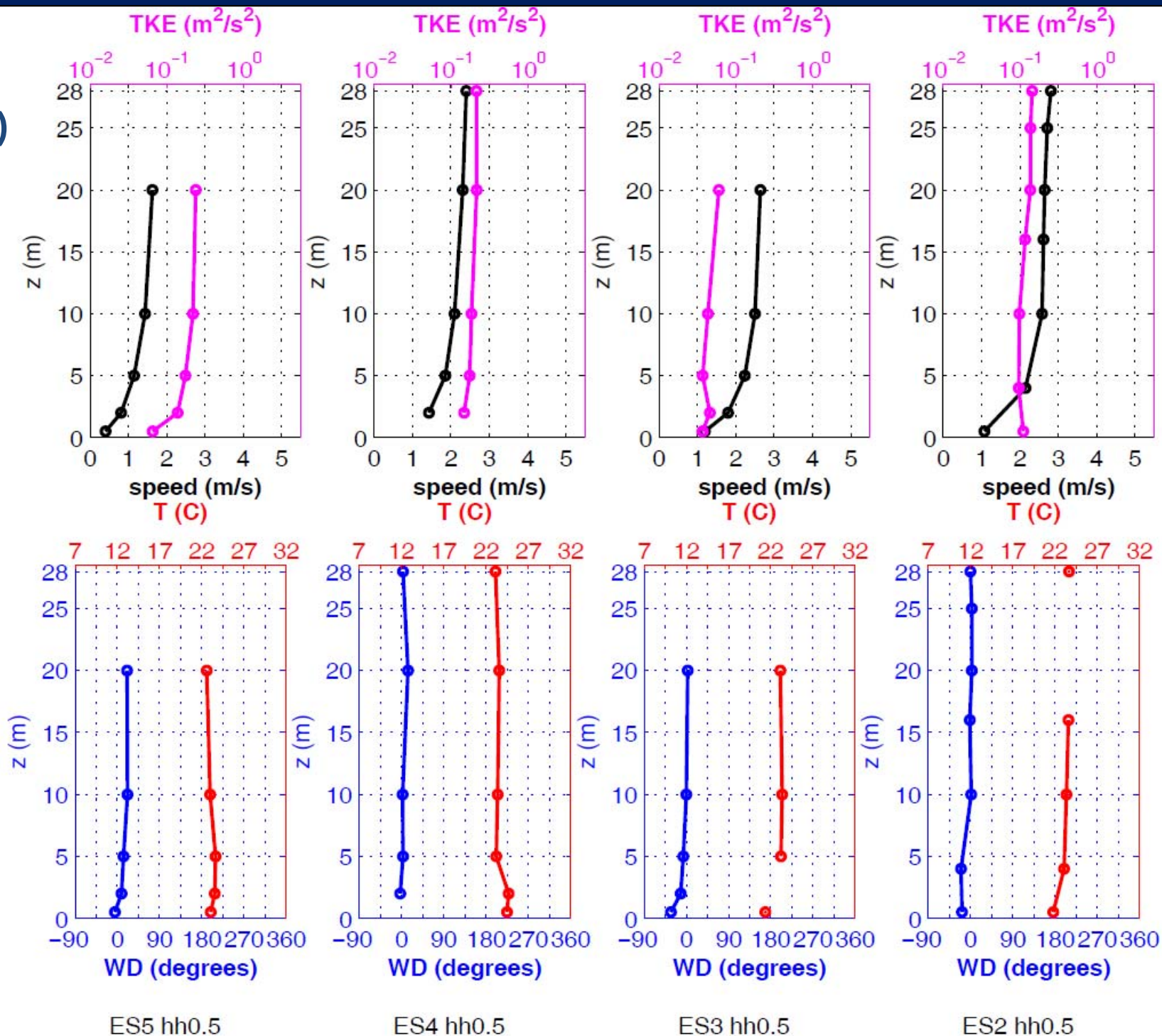
**Sunrise** ☀️  
13:25 UTC  
(07:25 LC)

Jday 272  
(30 min avg)

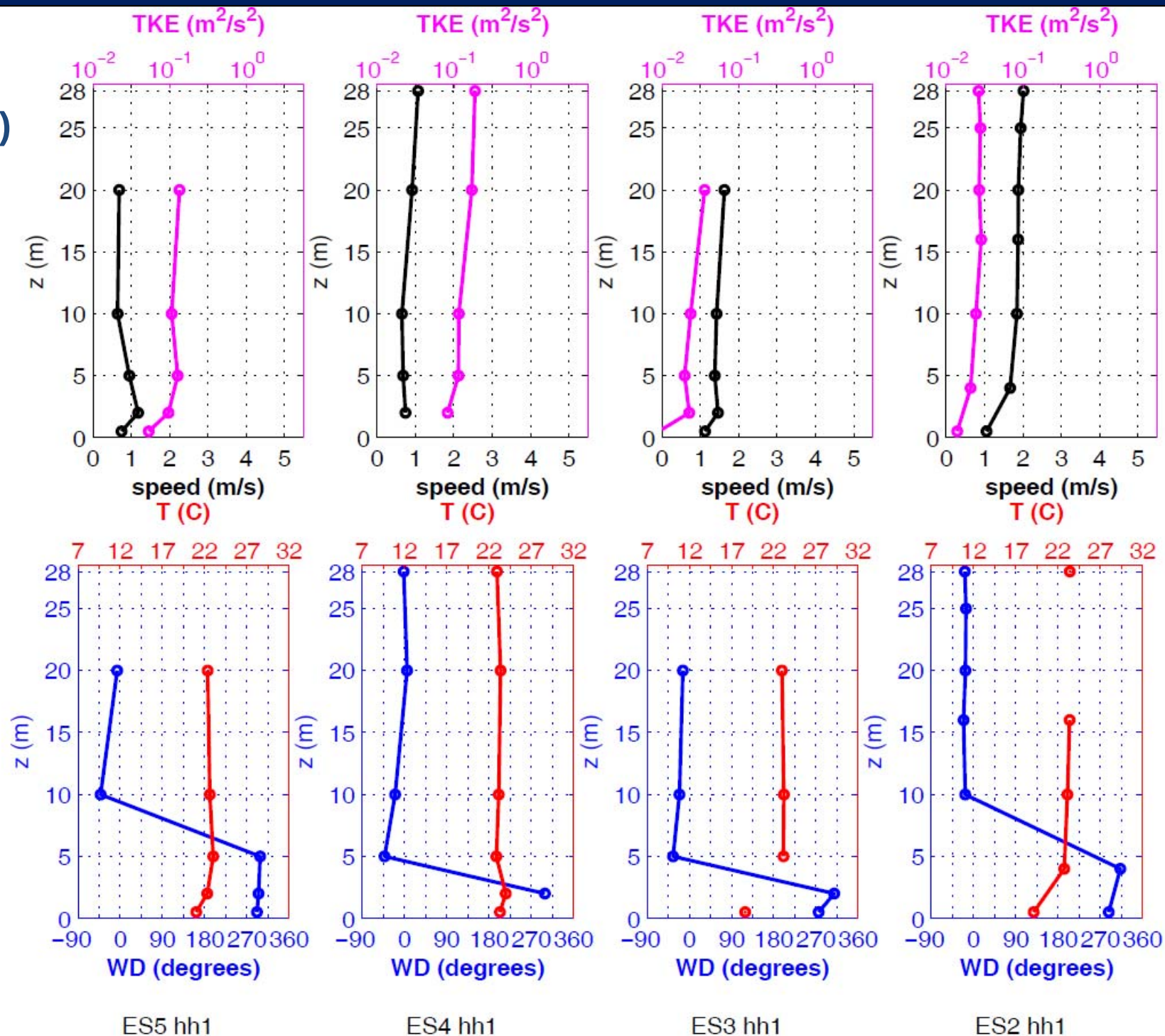




Jday 272  
(30 min avg)

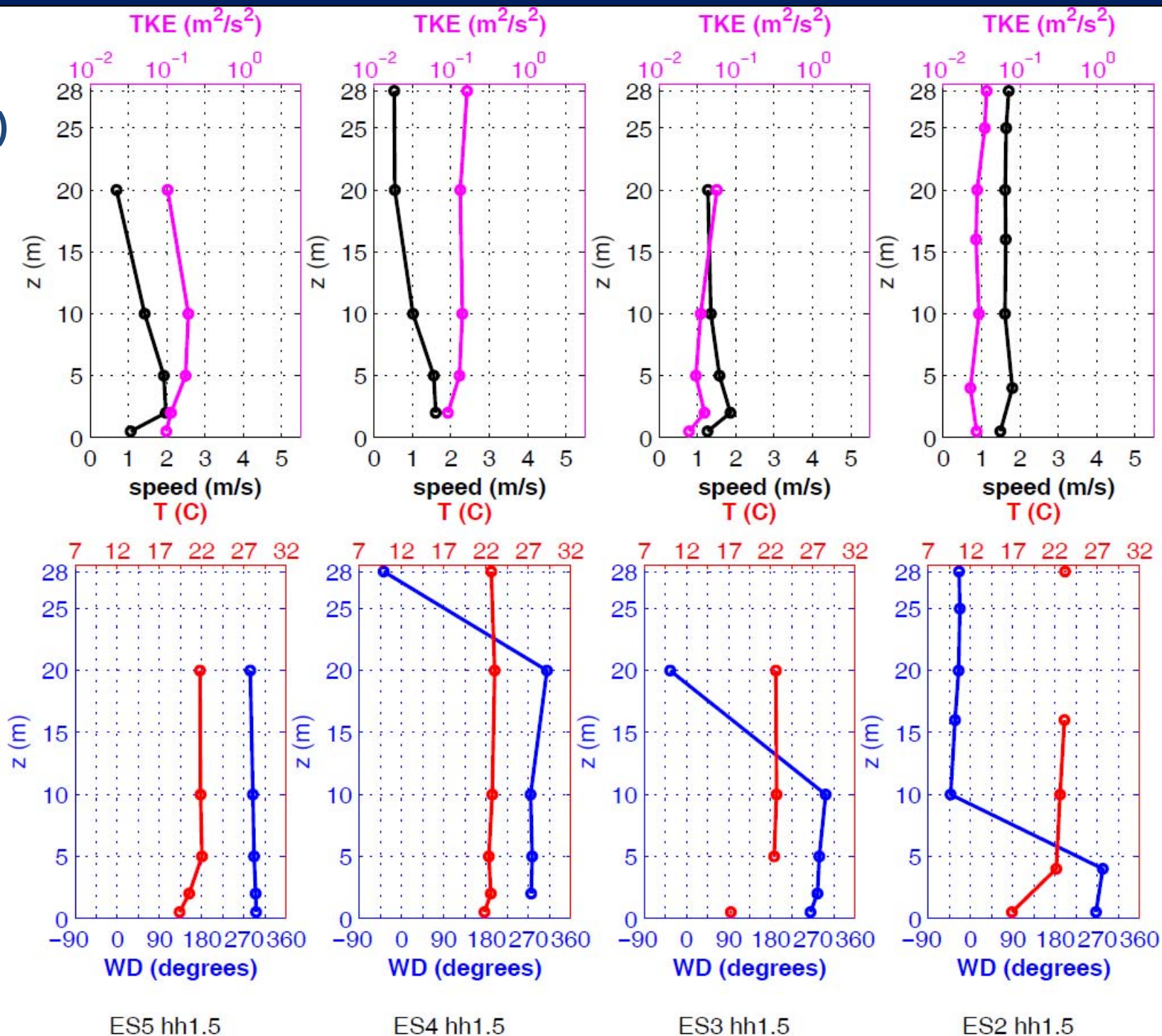


Jday 272  
(30 min avg)

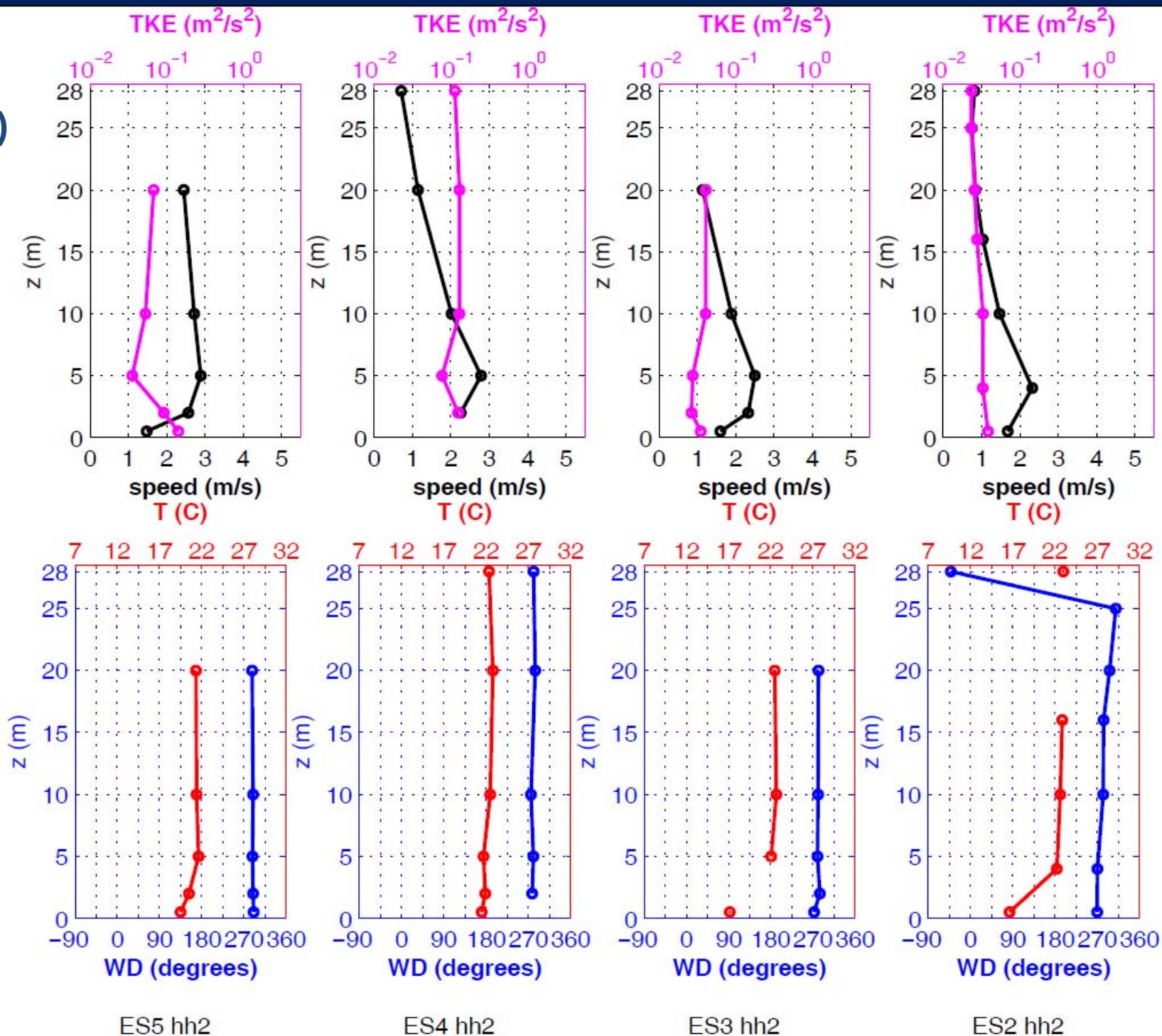




Jday 272  
(30 min avg)

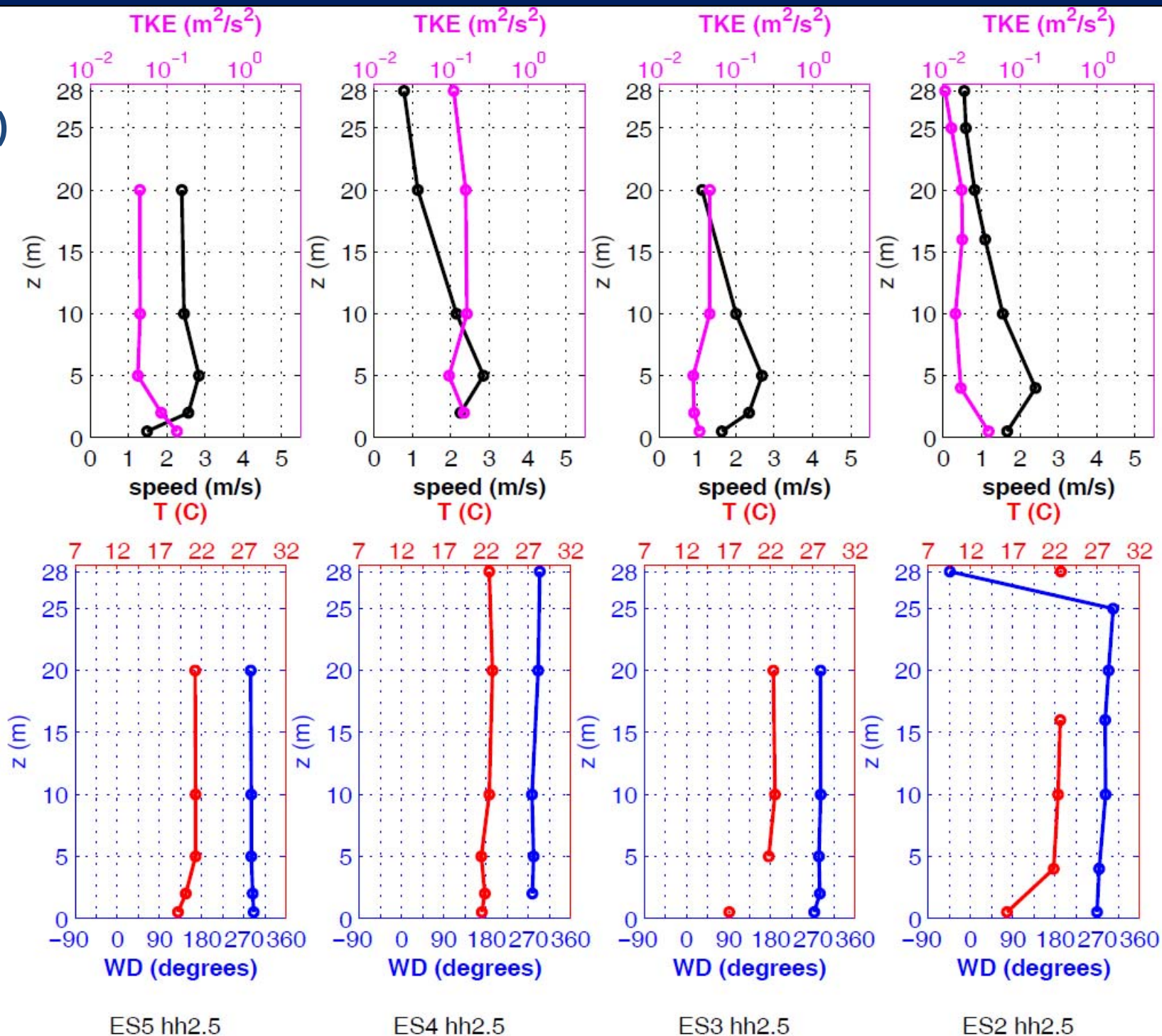


Jday 272  
(30 min avg)

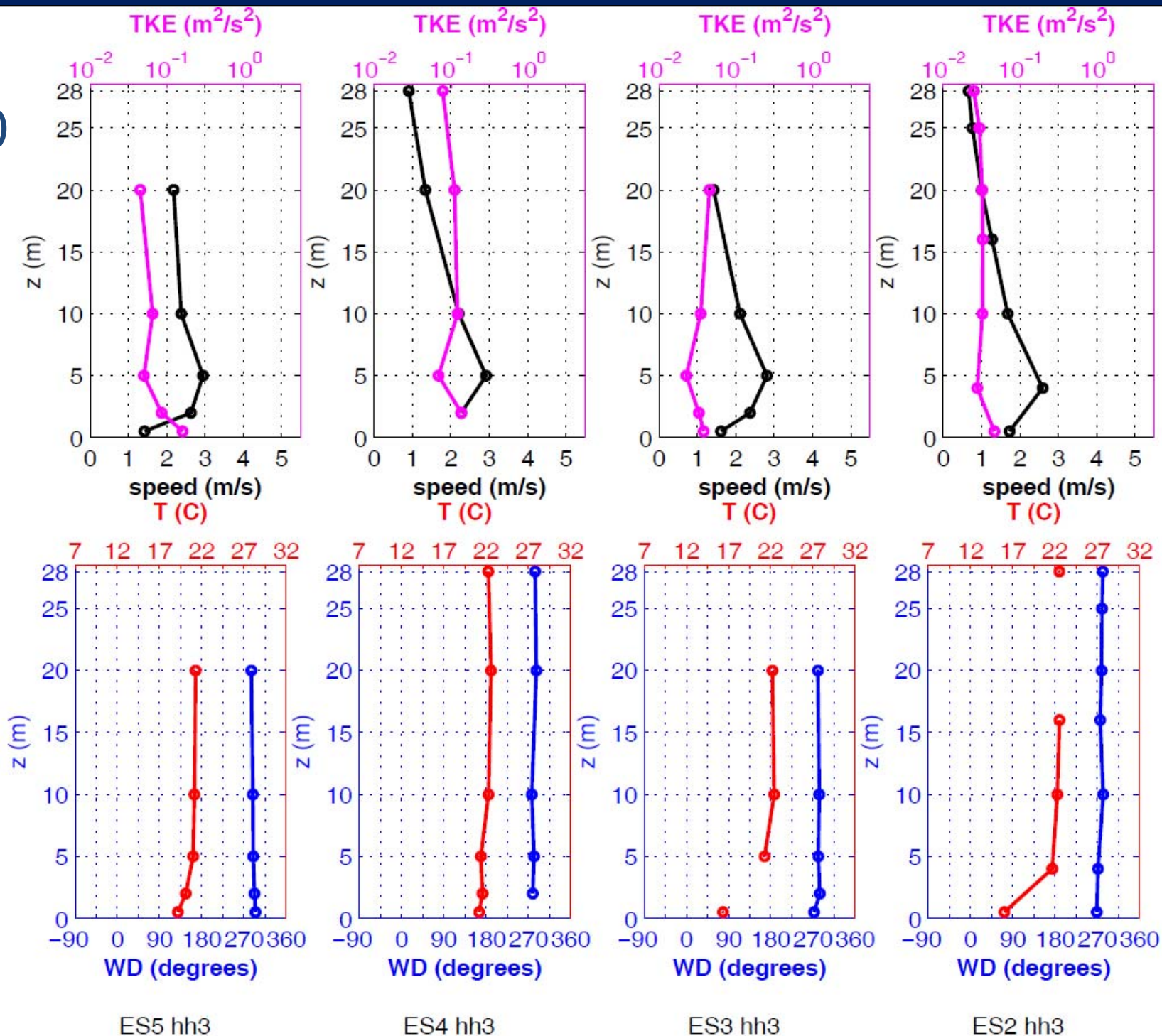




Jday 272  
(30 min avg)

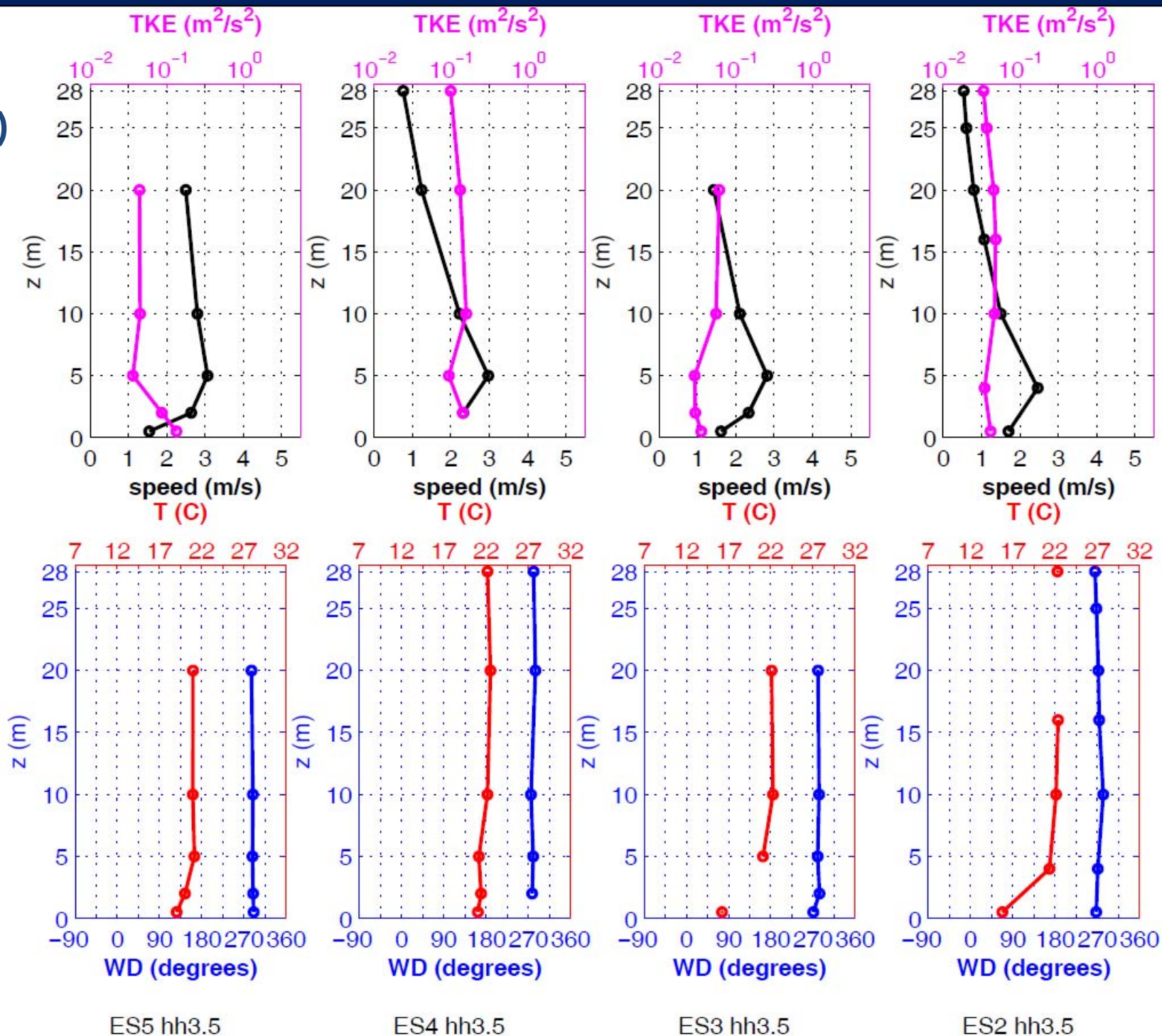


Jday 272  
(30 min avg)

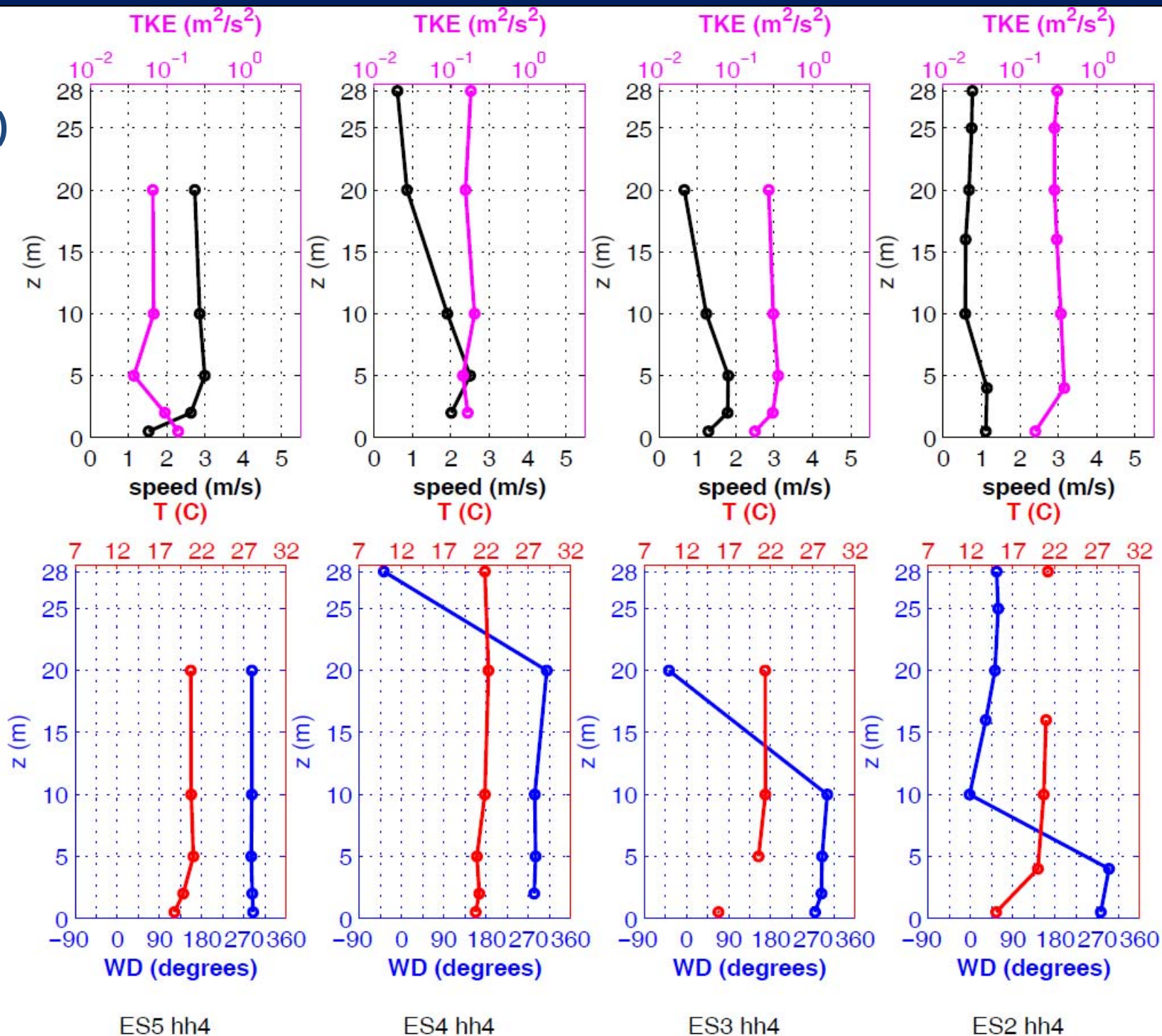




Jday 272  
(30 min avg)

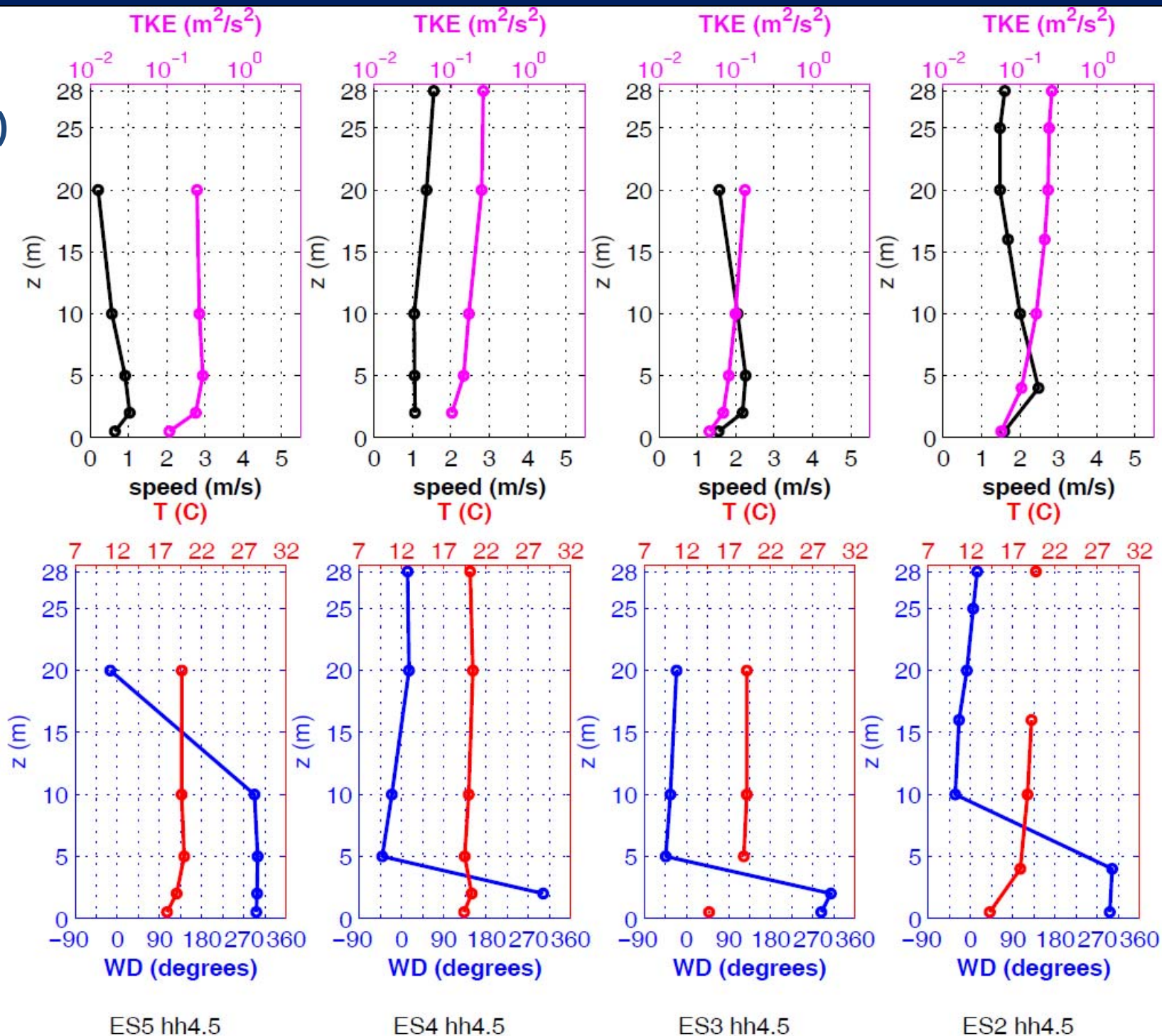


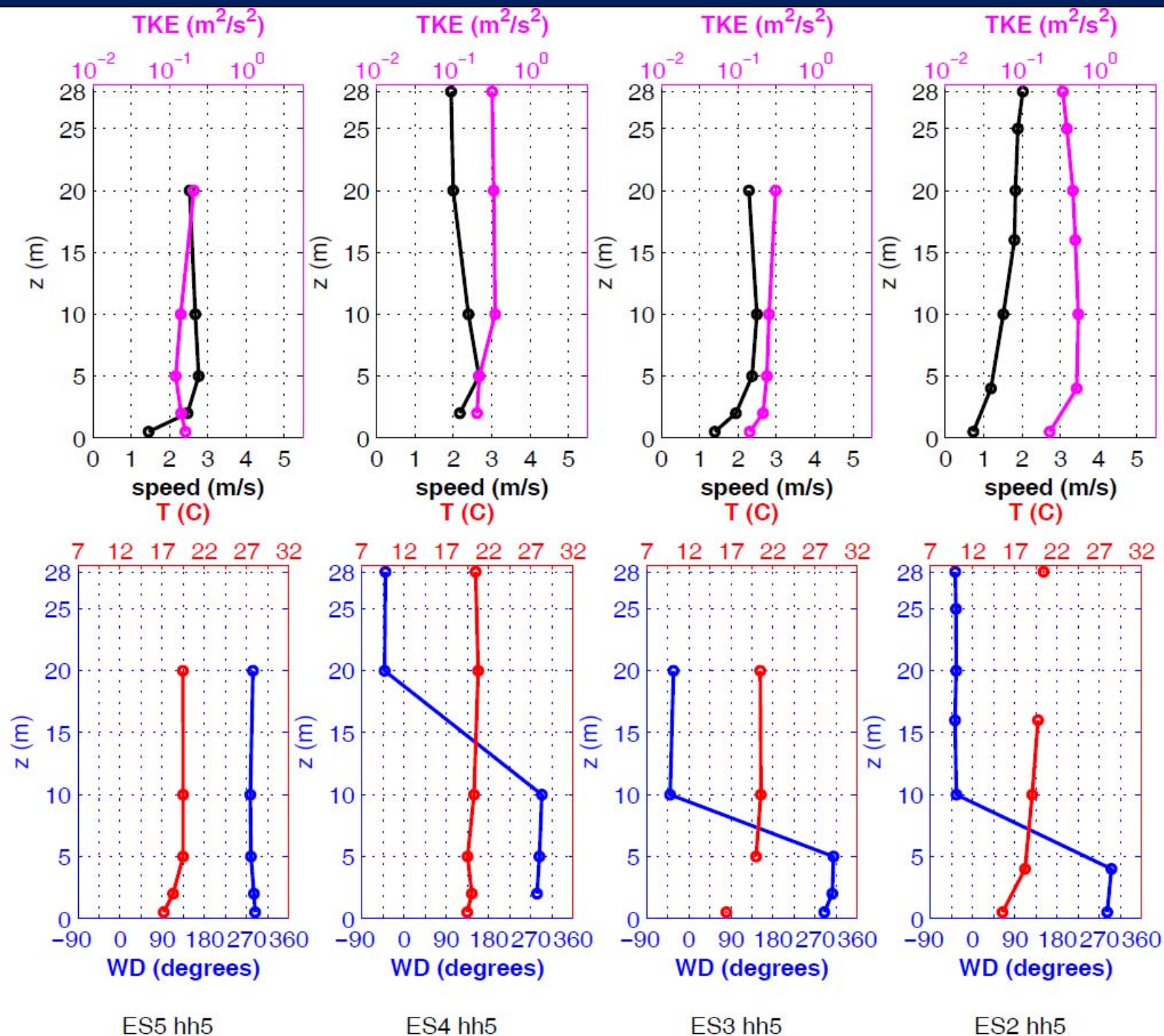
Jday 272  
(30 min avg)





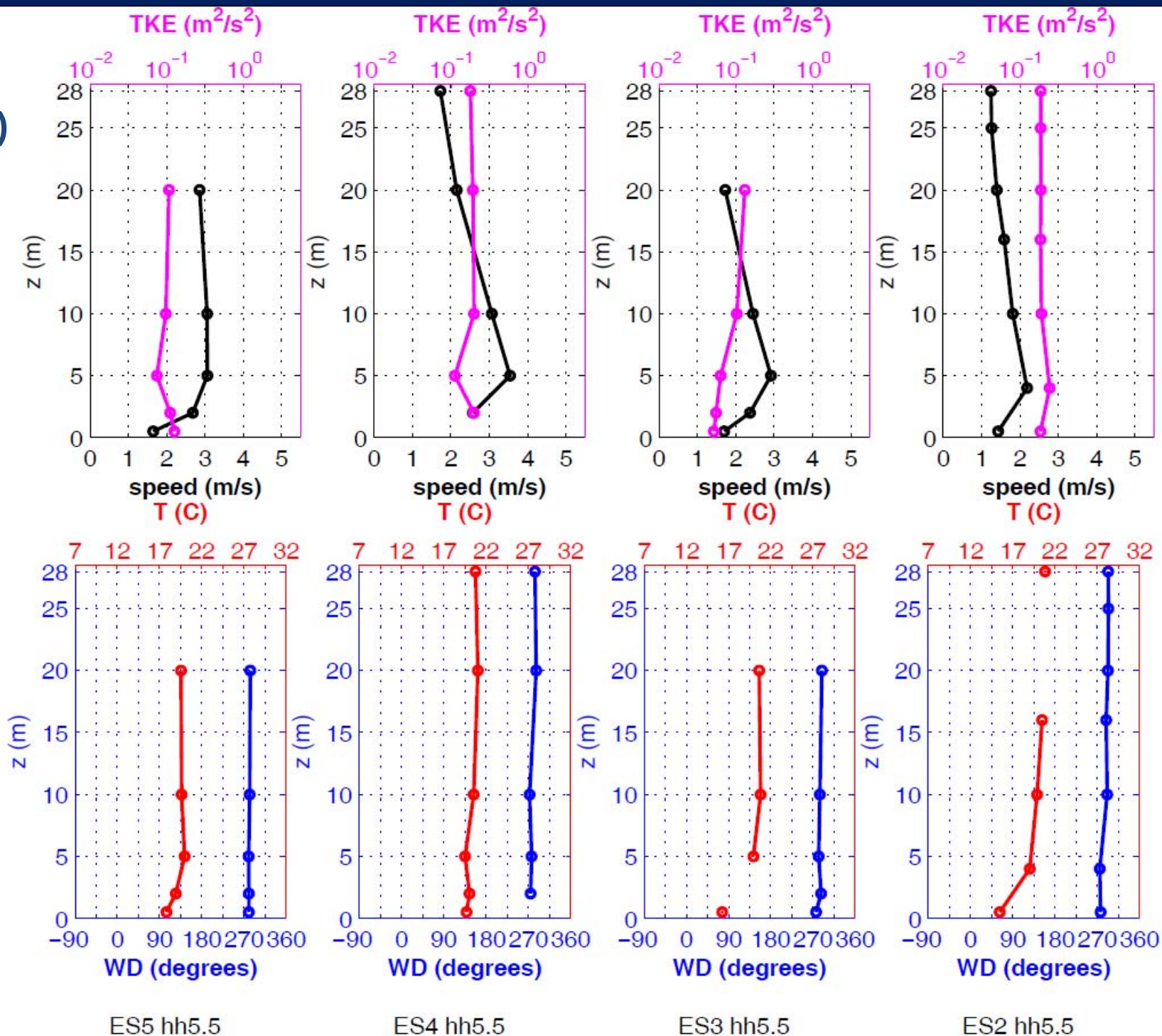
Jday 272  
(30 min avg)



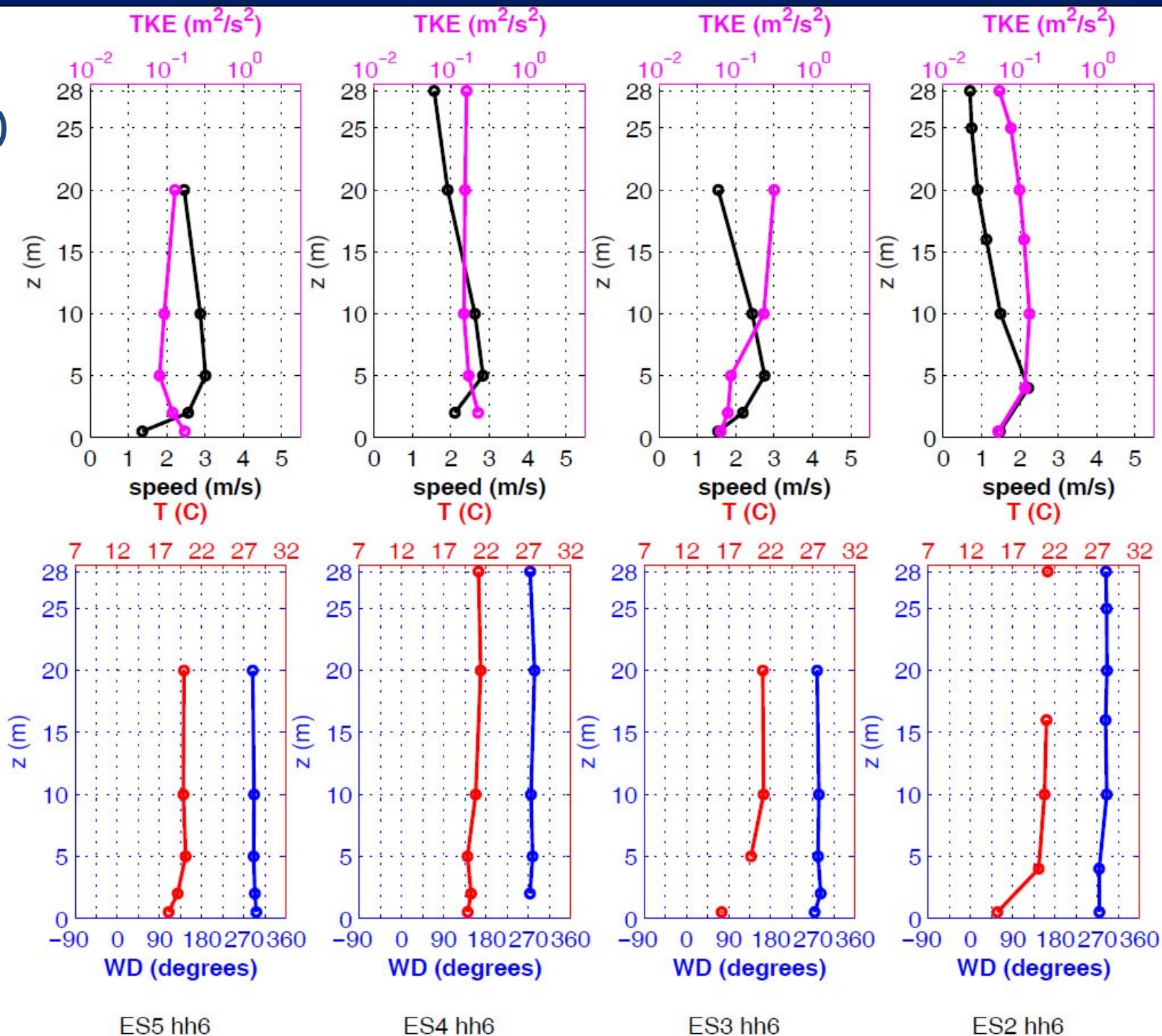




Jday 272  
(30 min avg)

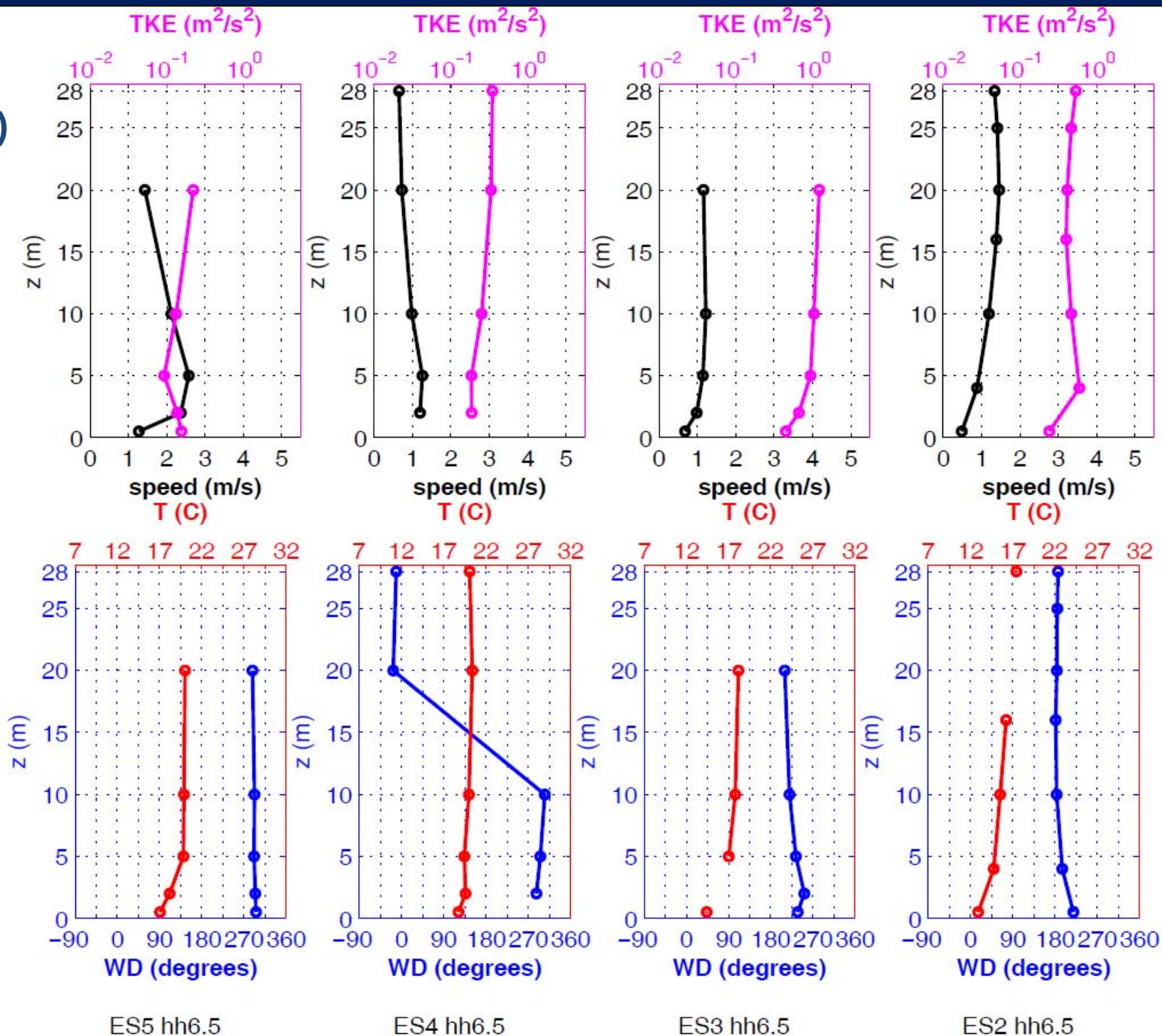


Jday 272  
(30 min avg)

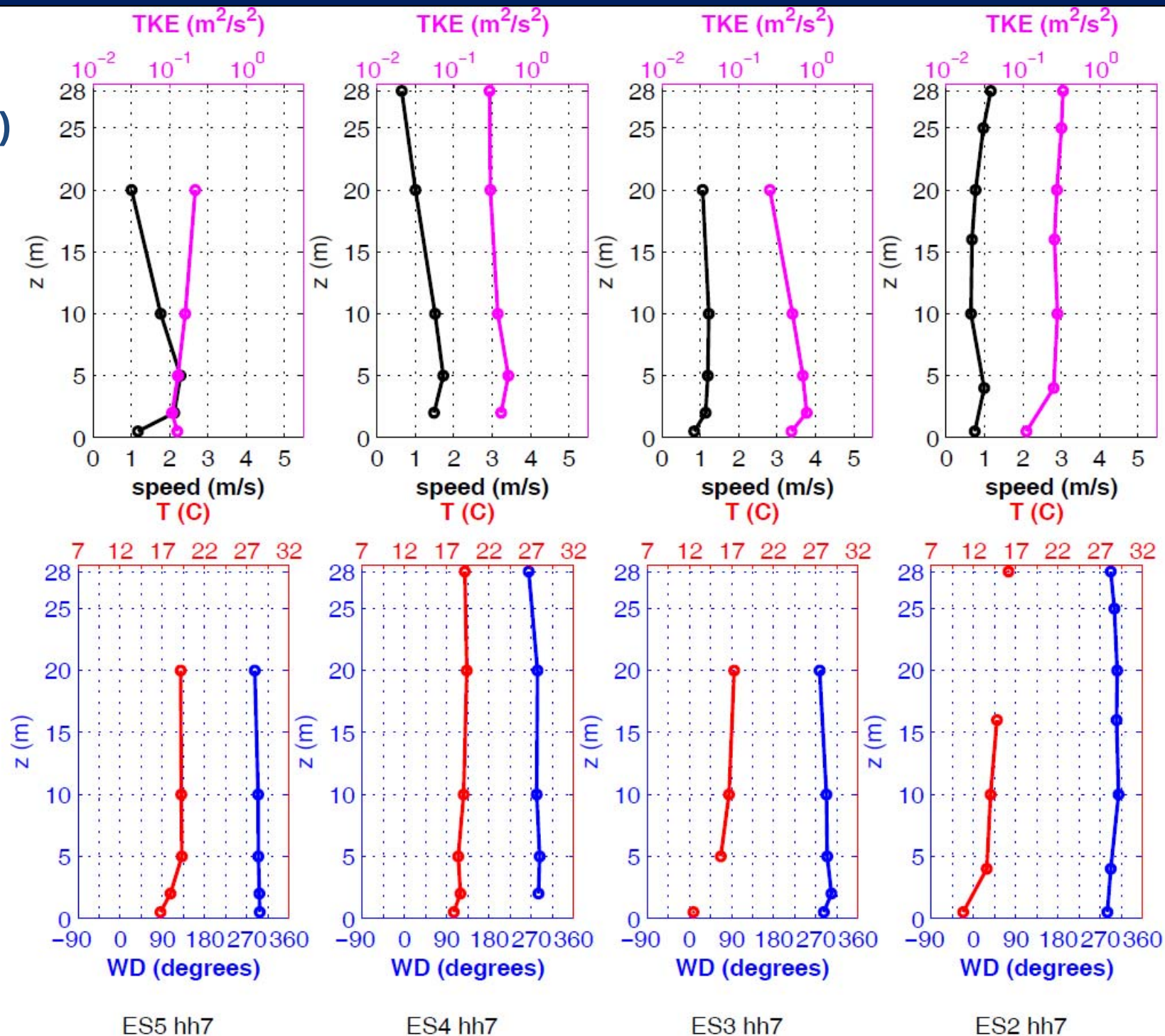




Jday 272  
(30 min avg)

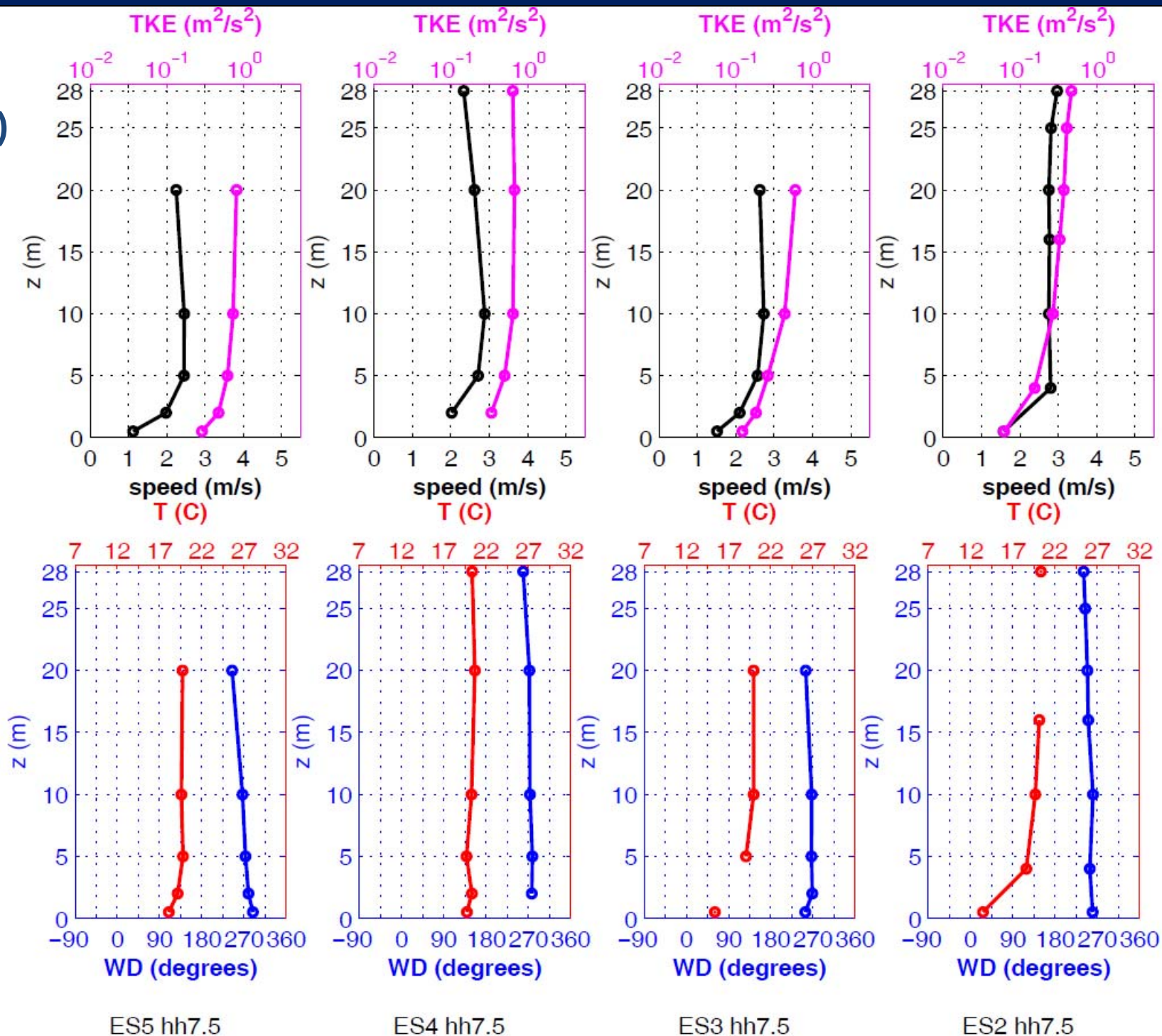


Jday 272  
(30 min avg)

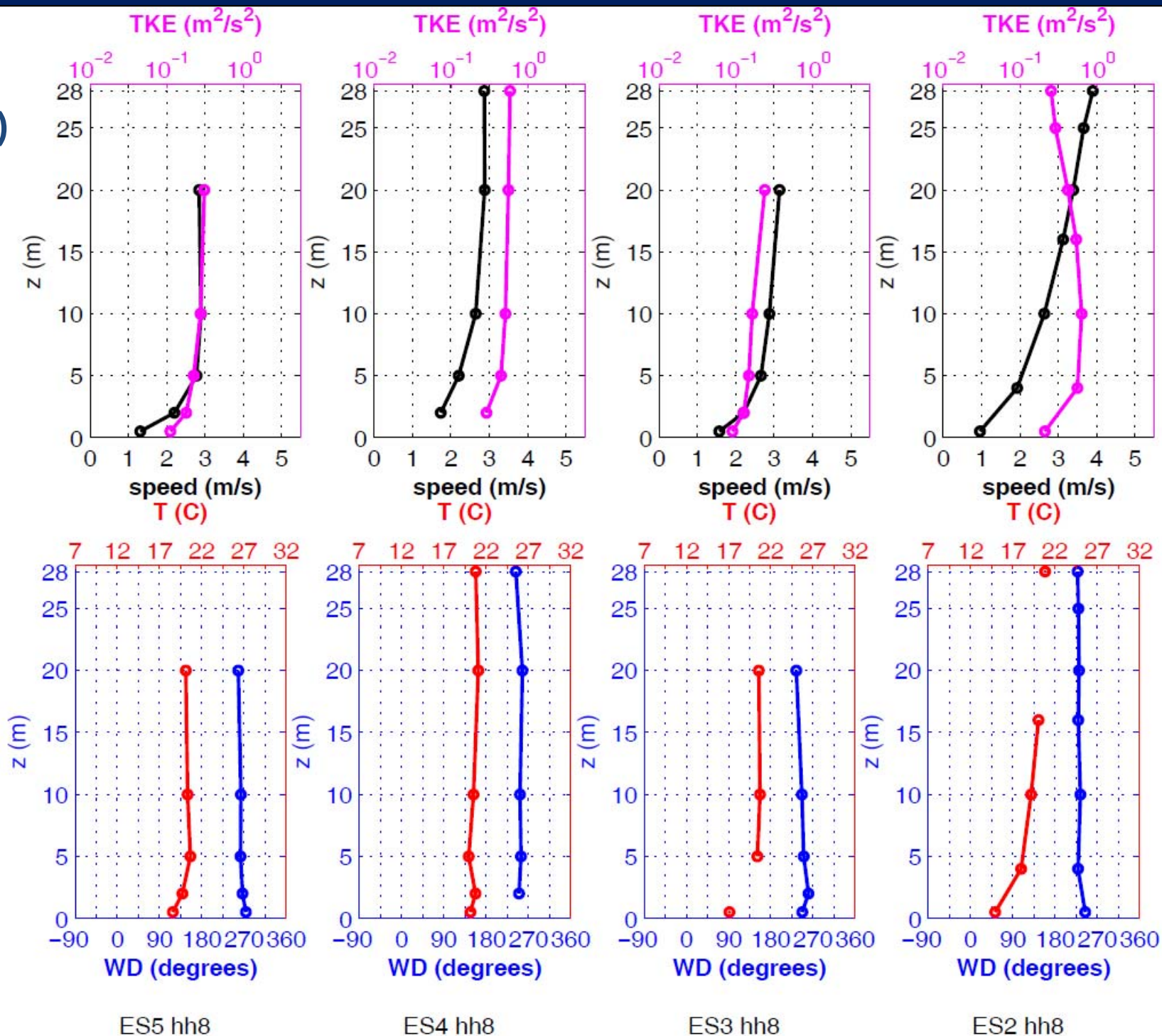




Jday 272  
(30 min avg)

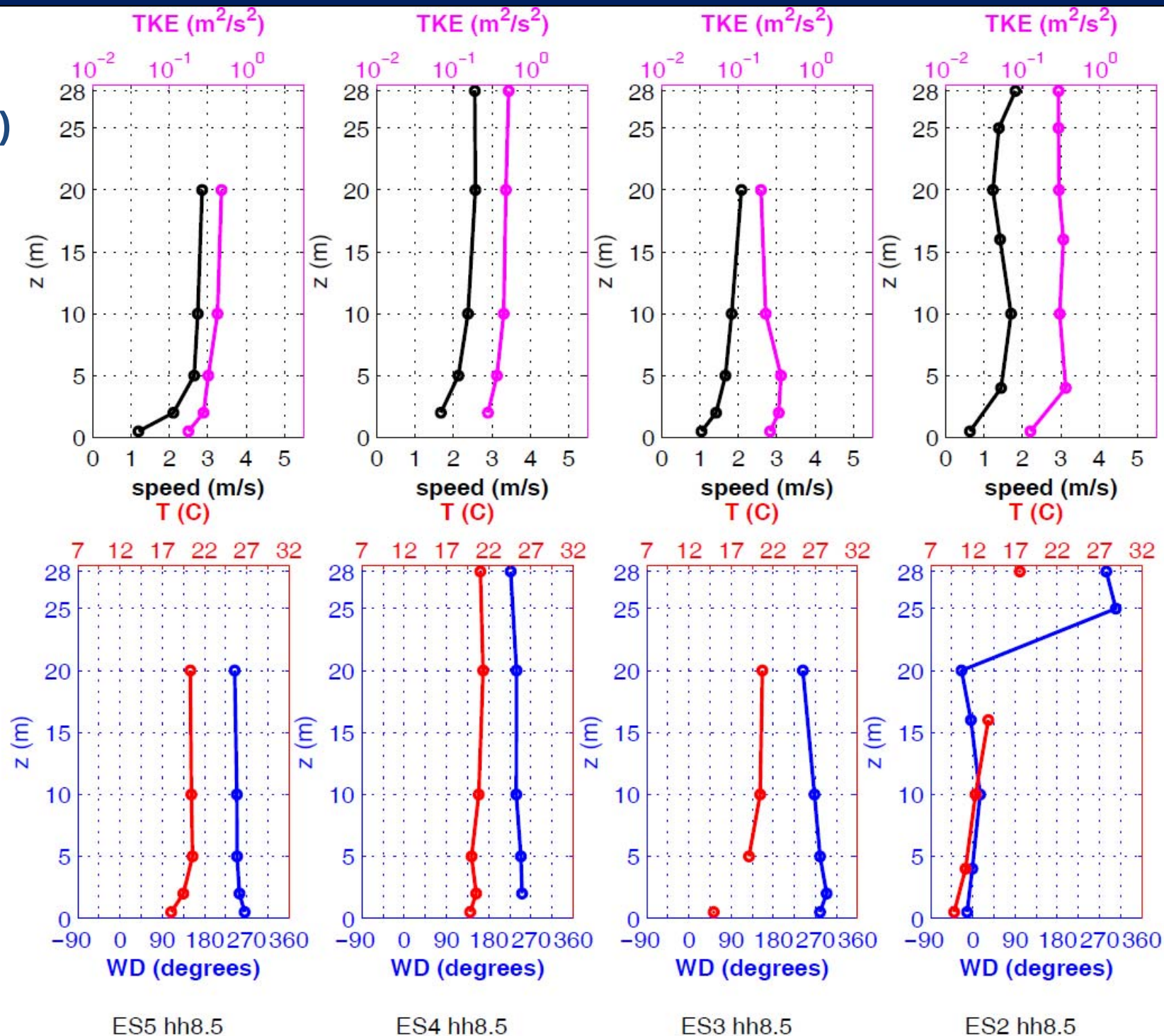


Jday 272  
(30 min avg)

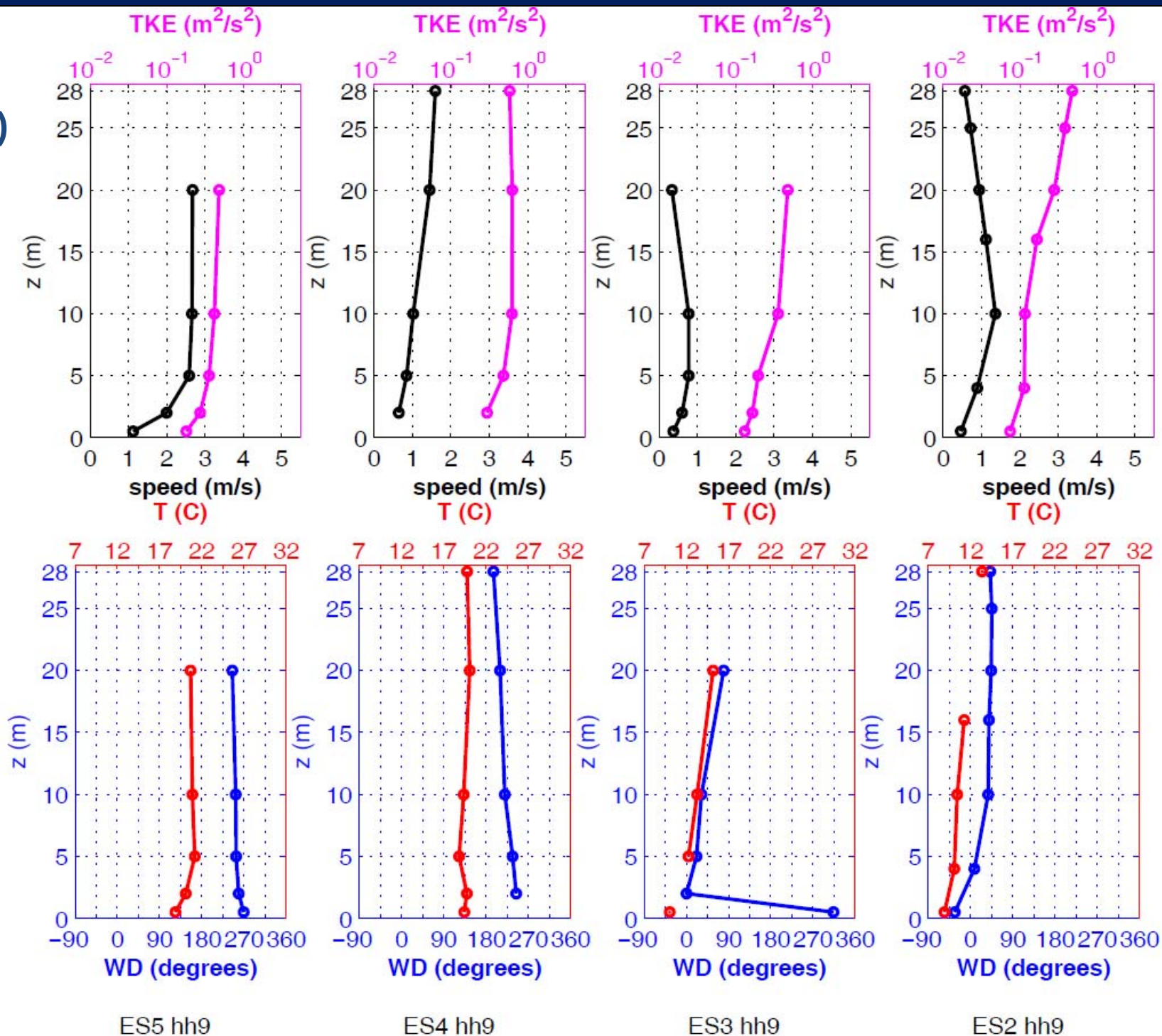




Jday 272  
(30 min avg)

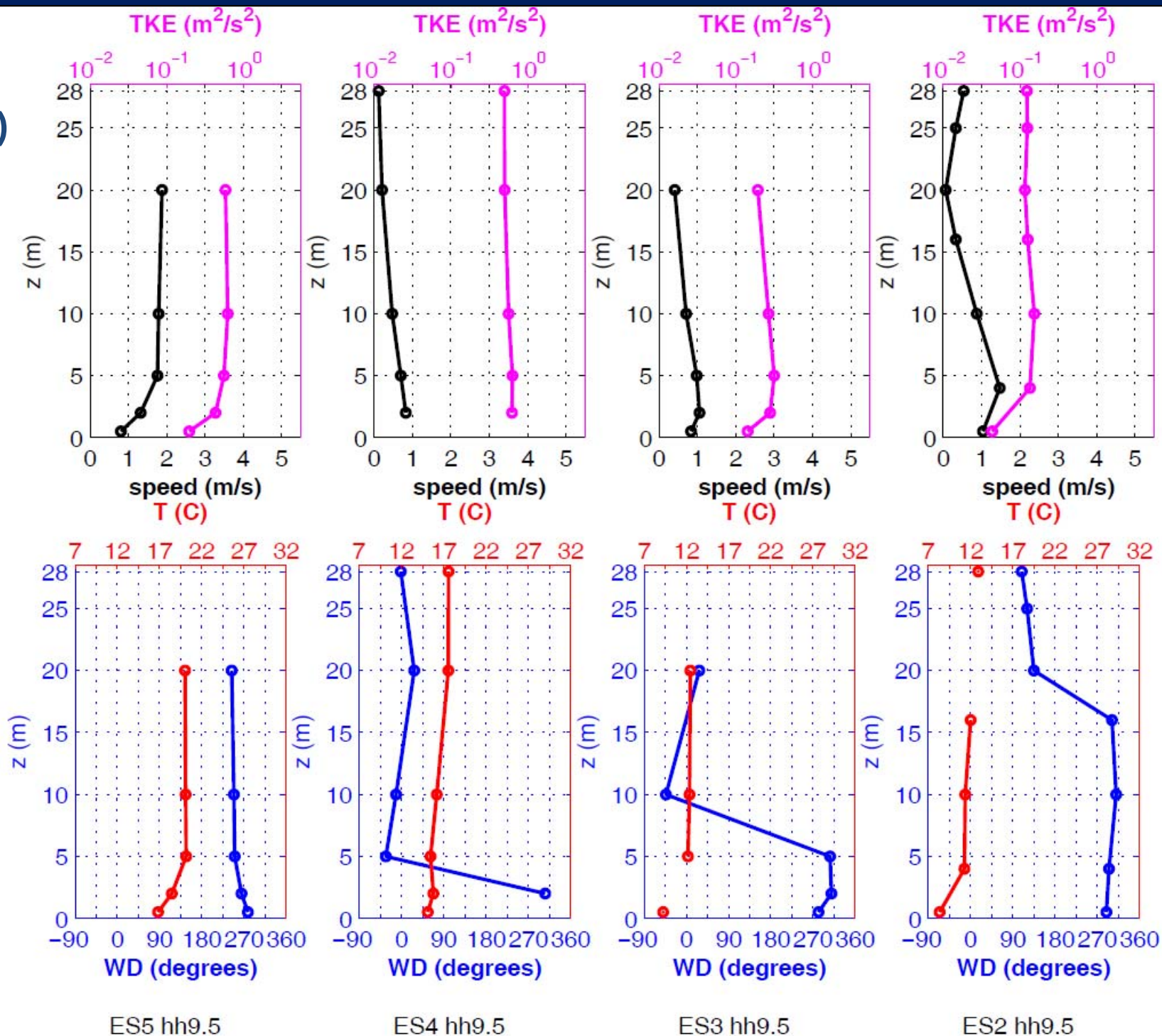


Jday 272  
(30 min avg)

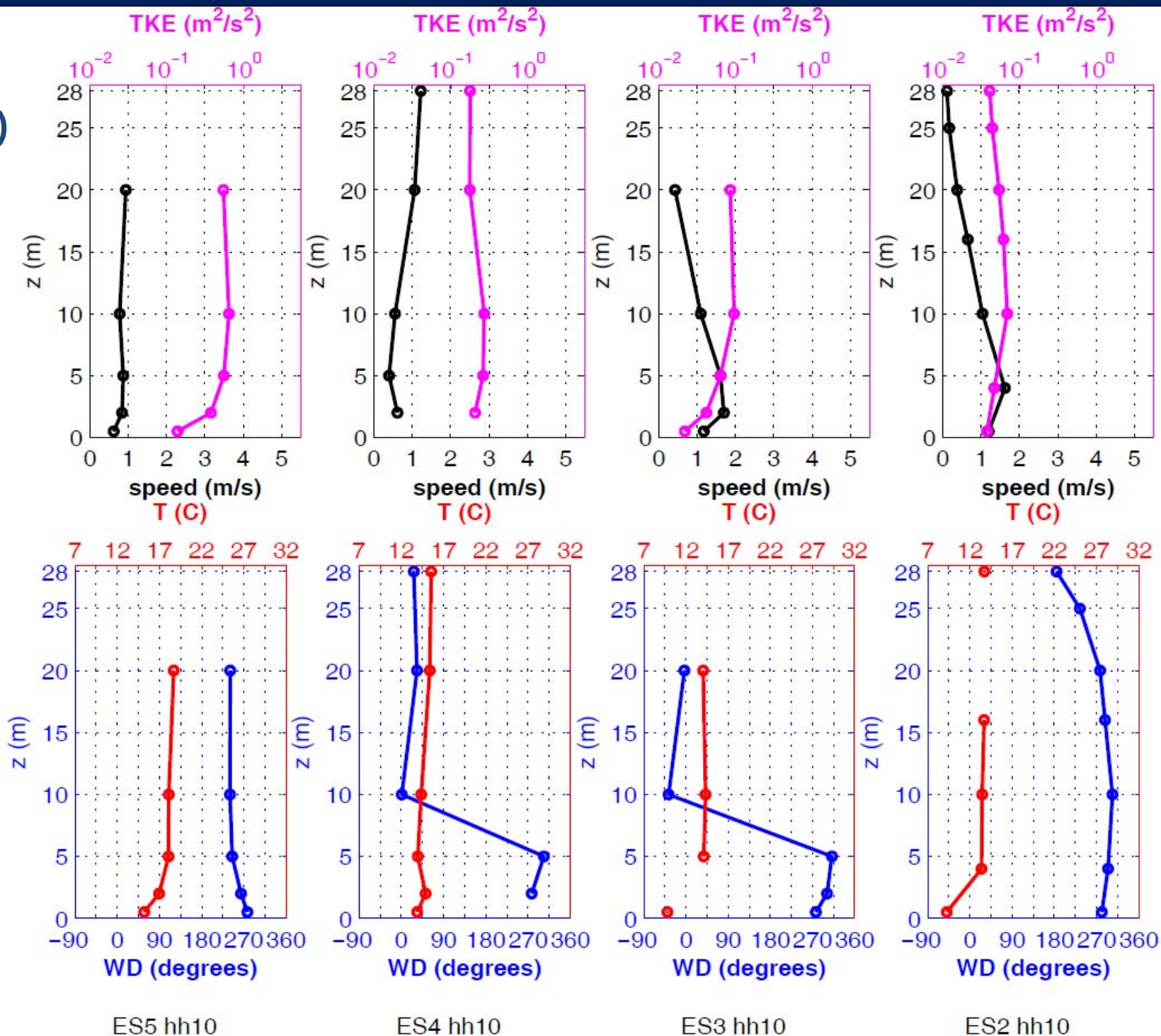




Jday 272  
(30 min avg)

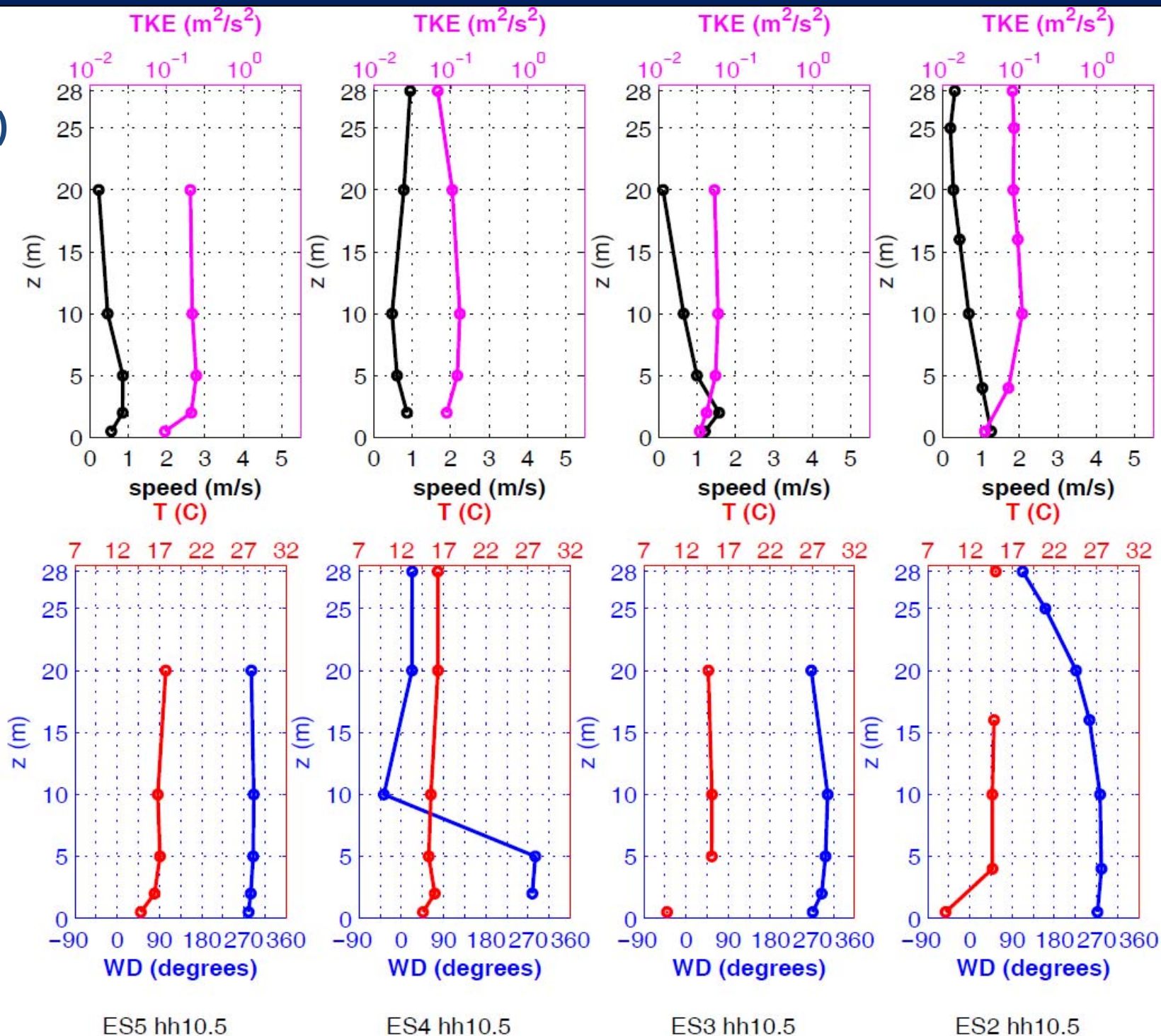


Jday 272  
(30 min avg)

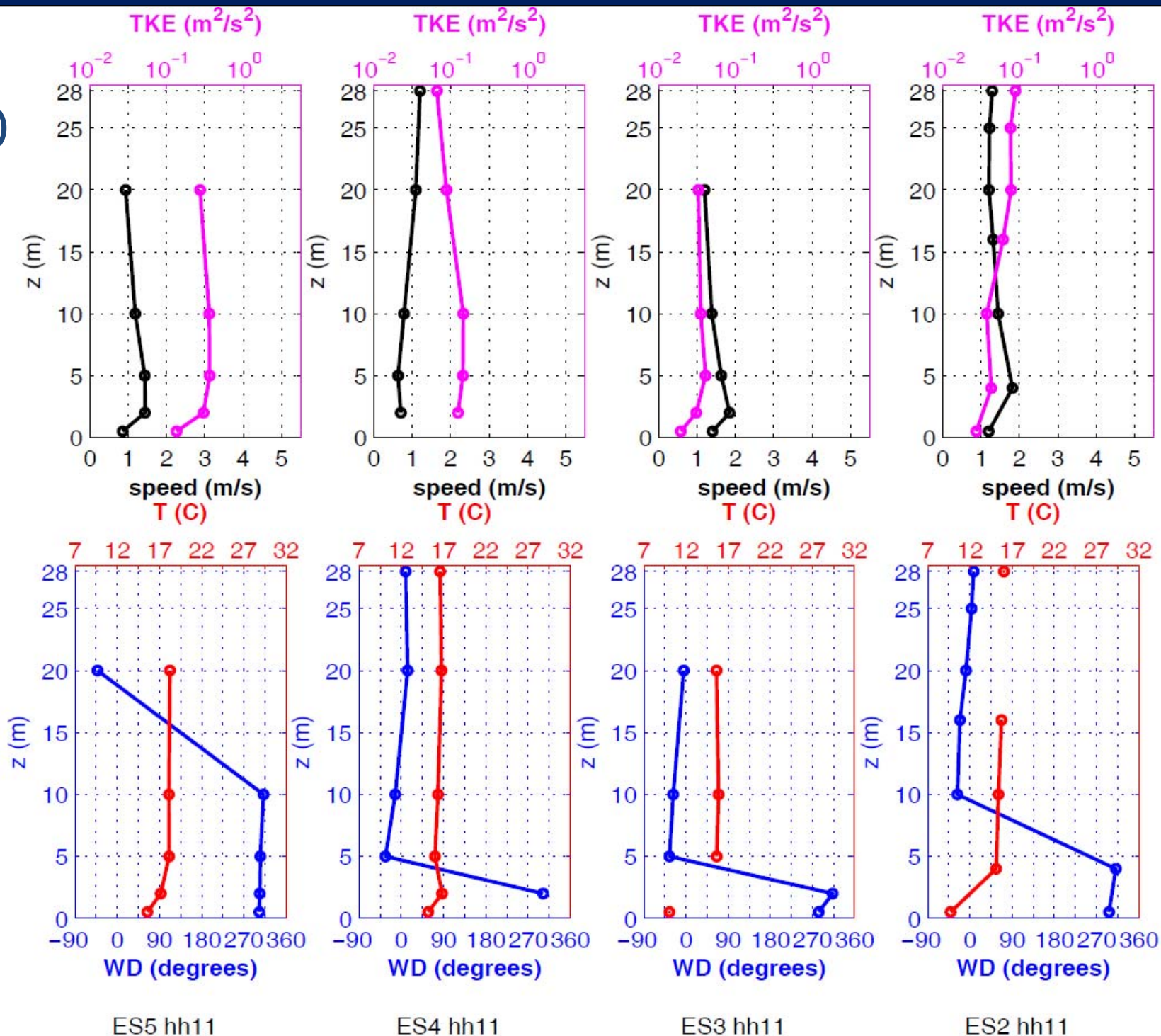




Jday 272  
(30 min avg)

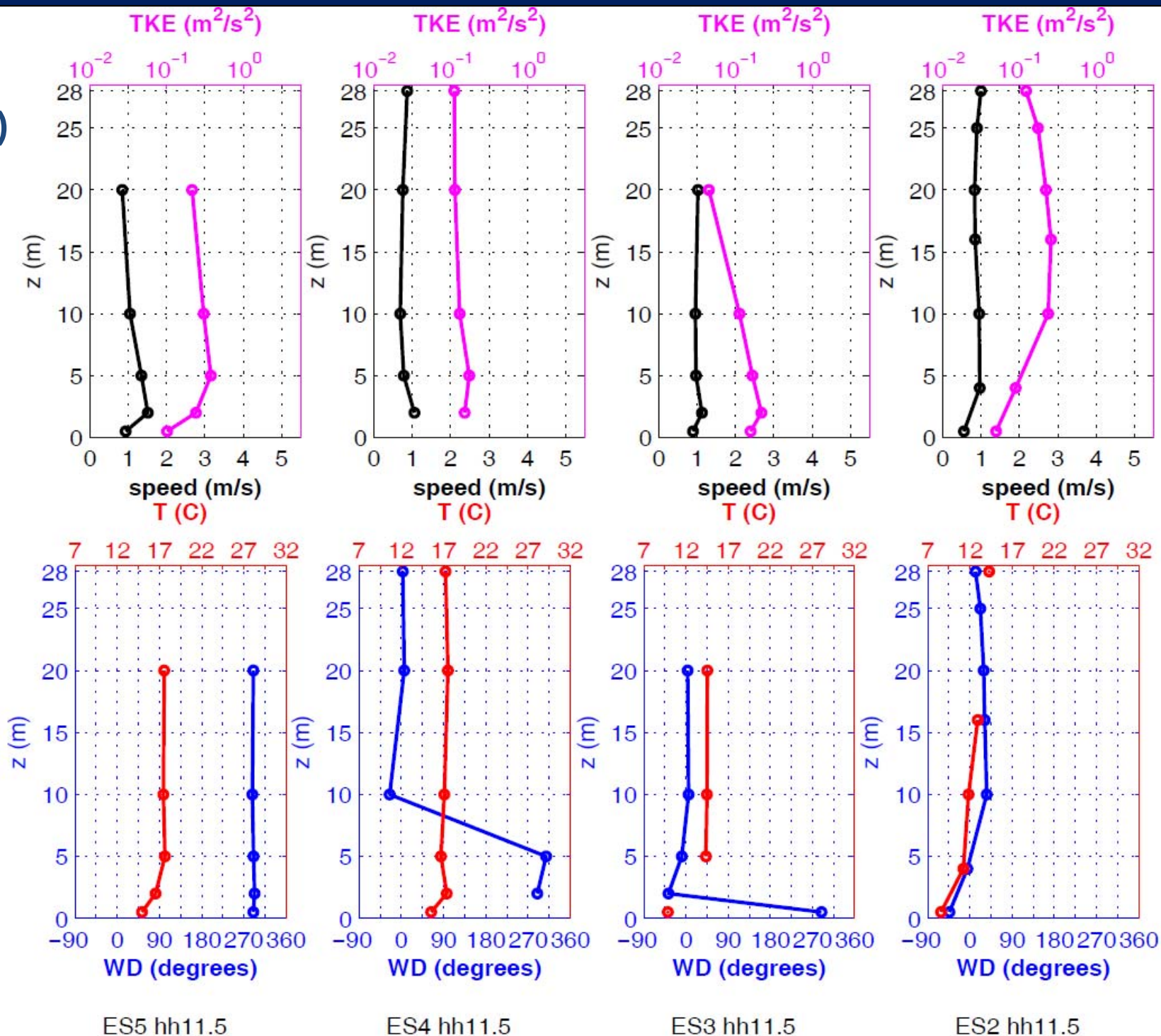


Jday 272  
(30 min avg)

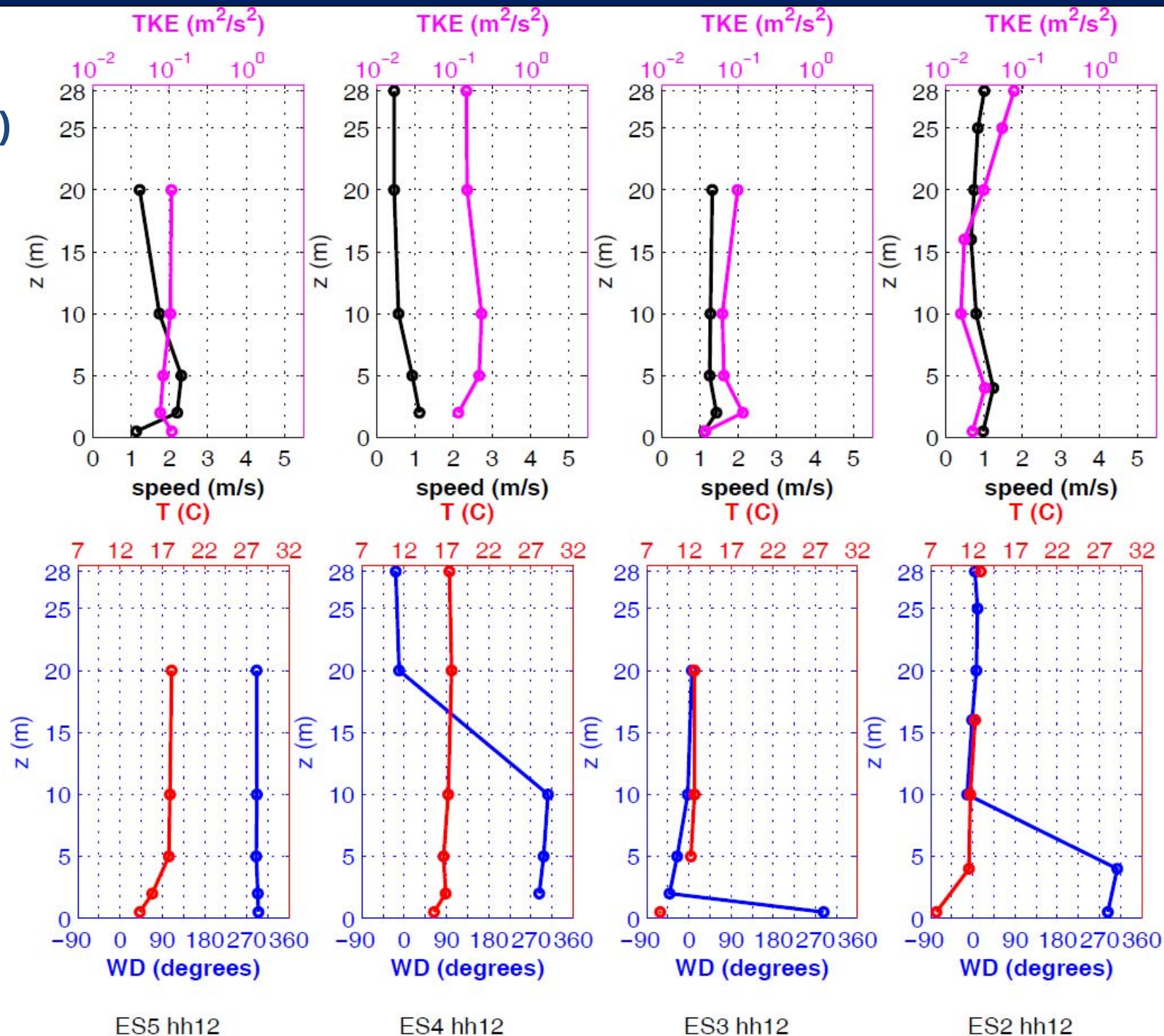




Jday 272  
(30 min avg)

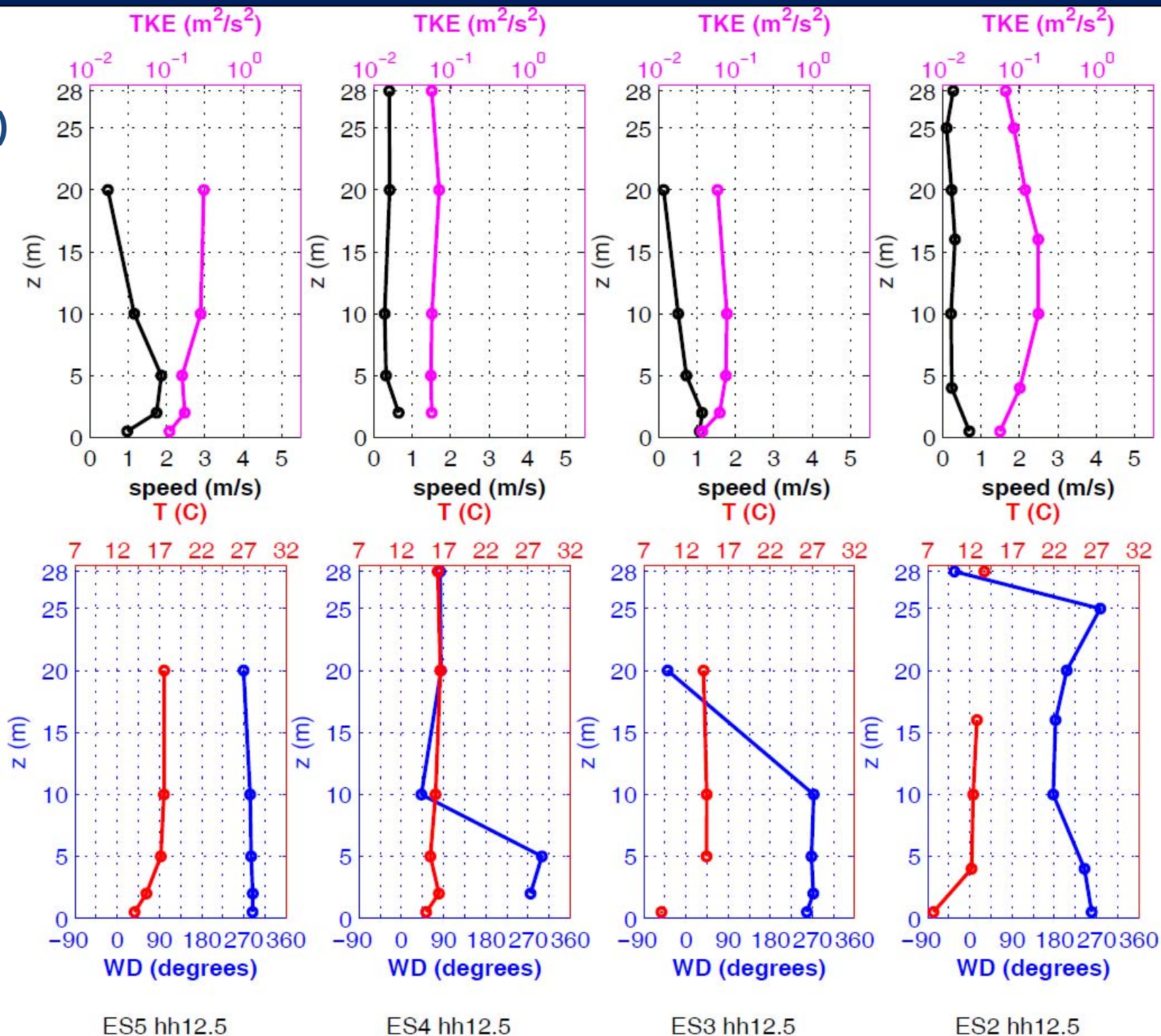


Jday 272  
(30 min avg)

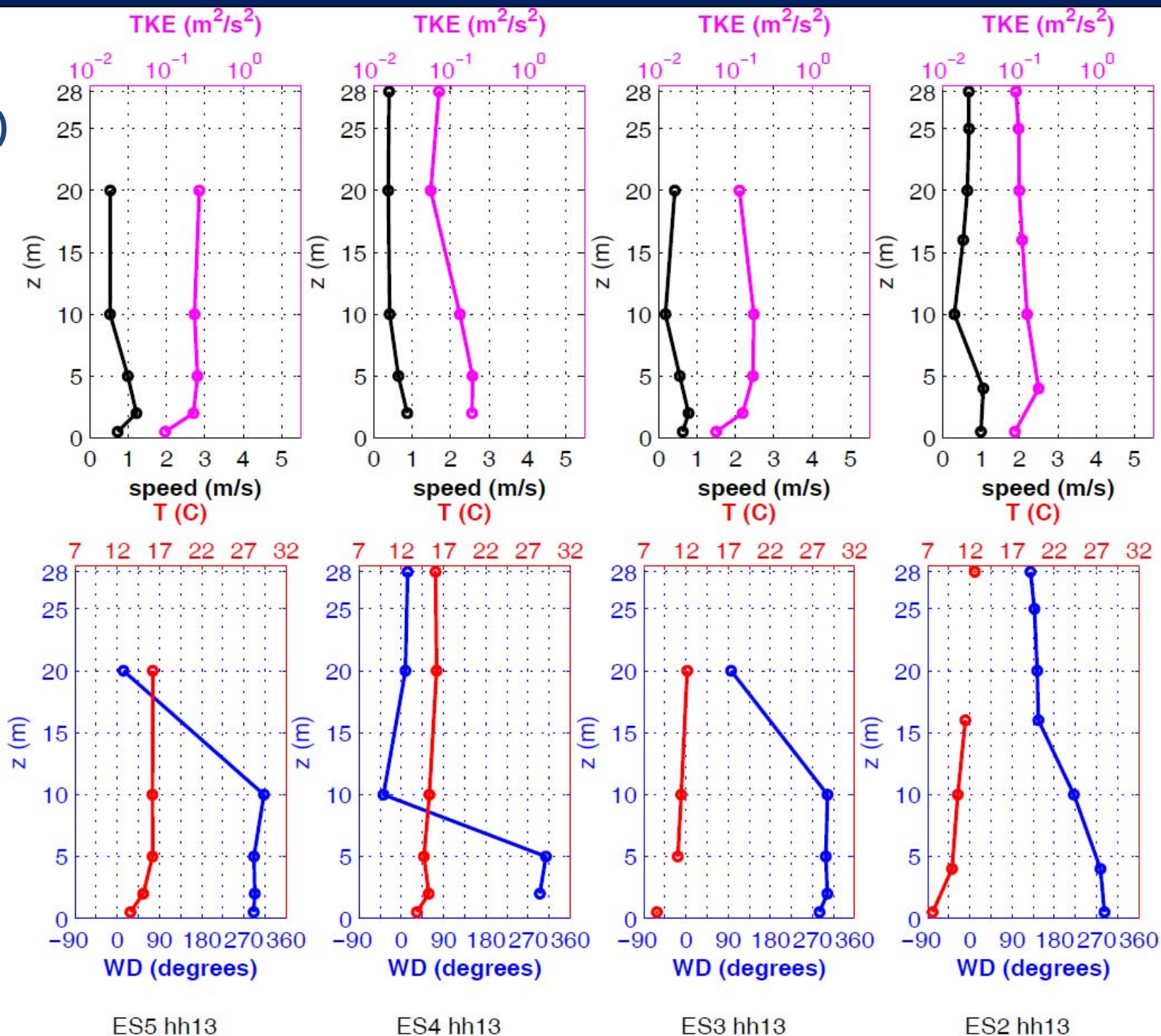




Jday 272  
(30 min avg)

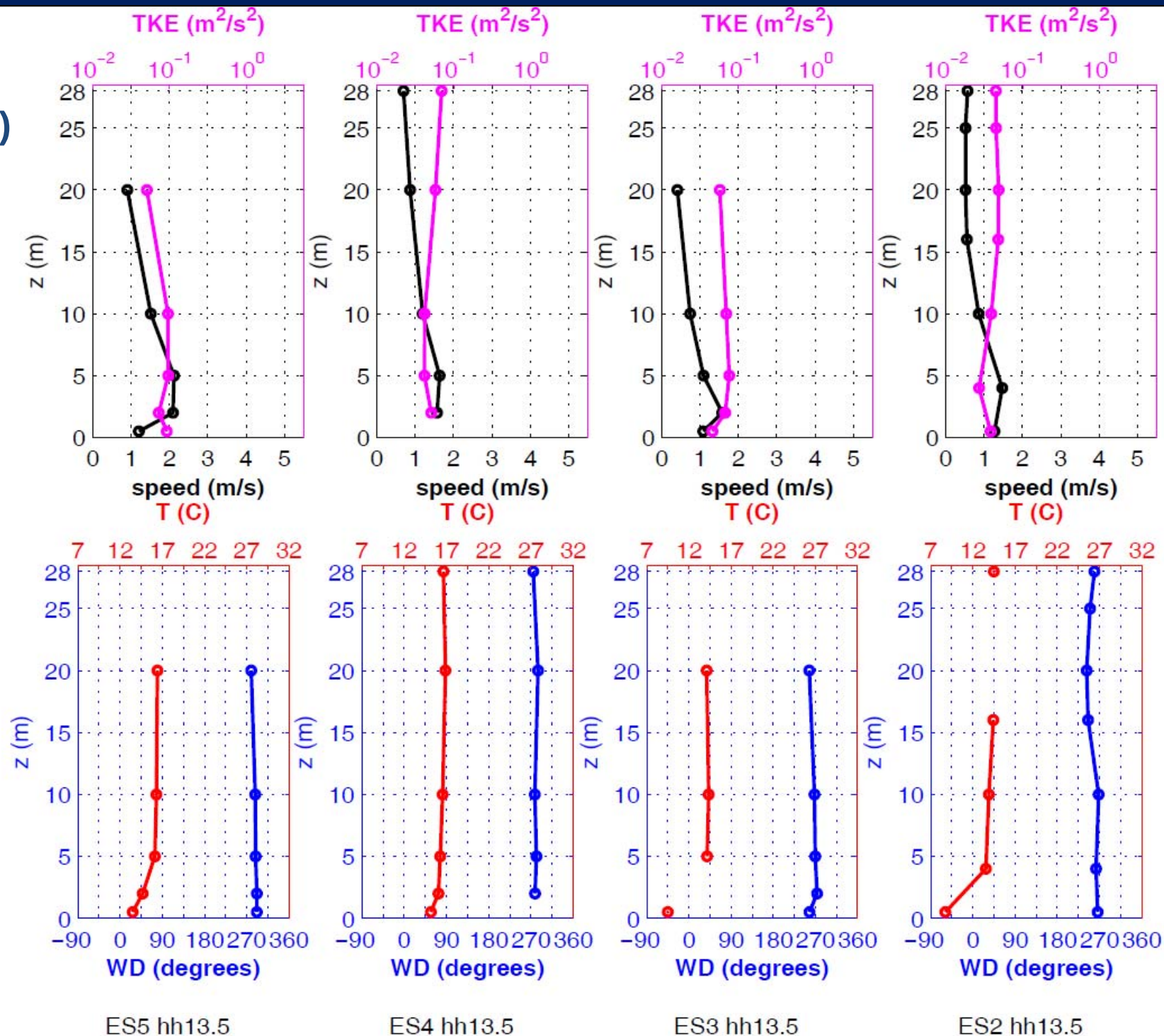


Jday 272  
(30 min avg)

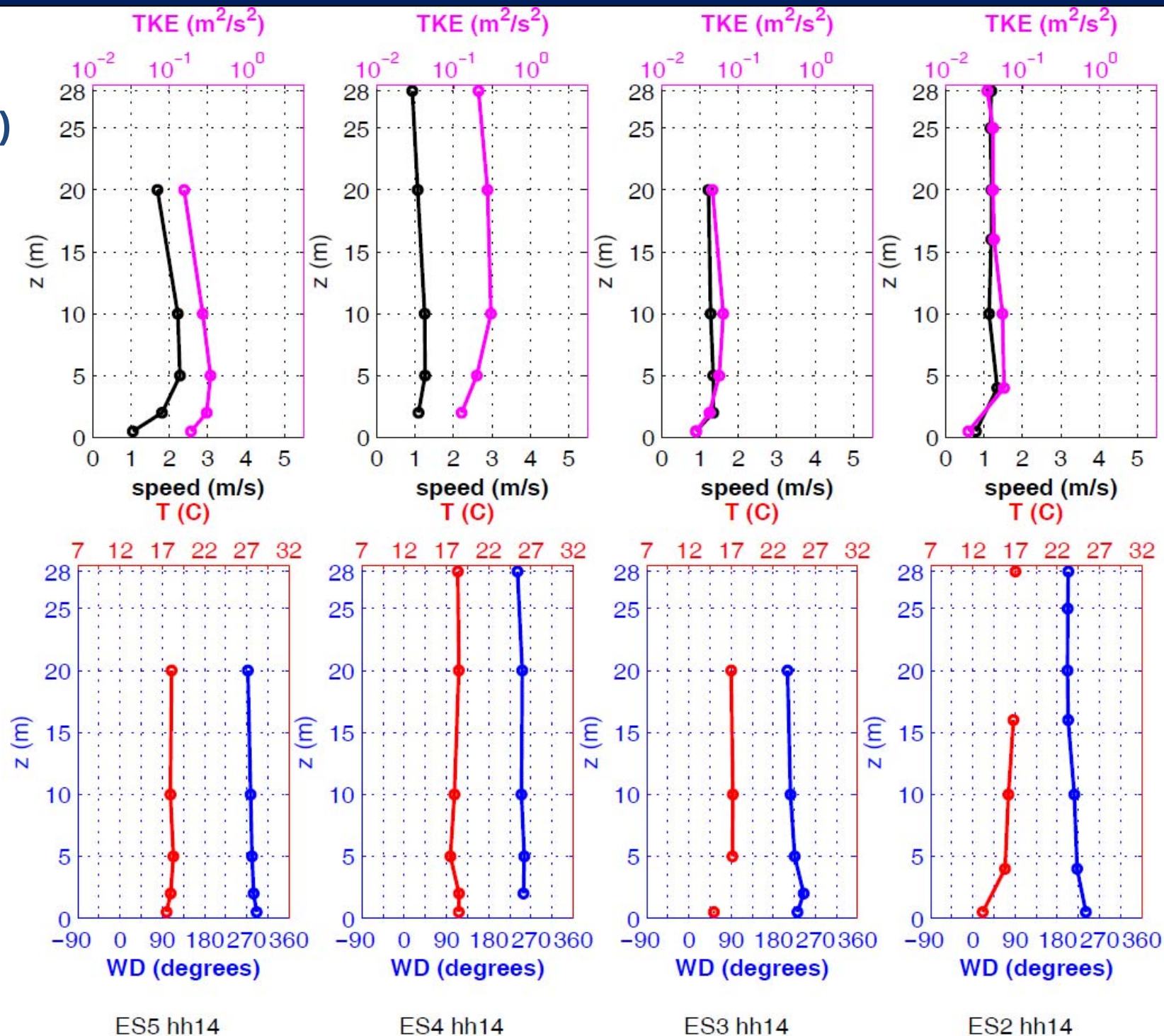




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(30 min avg)

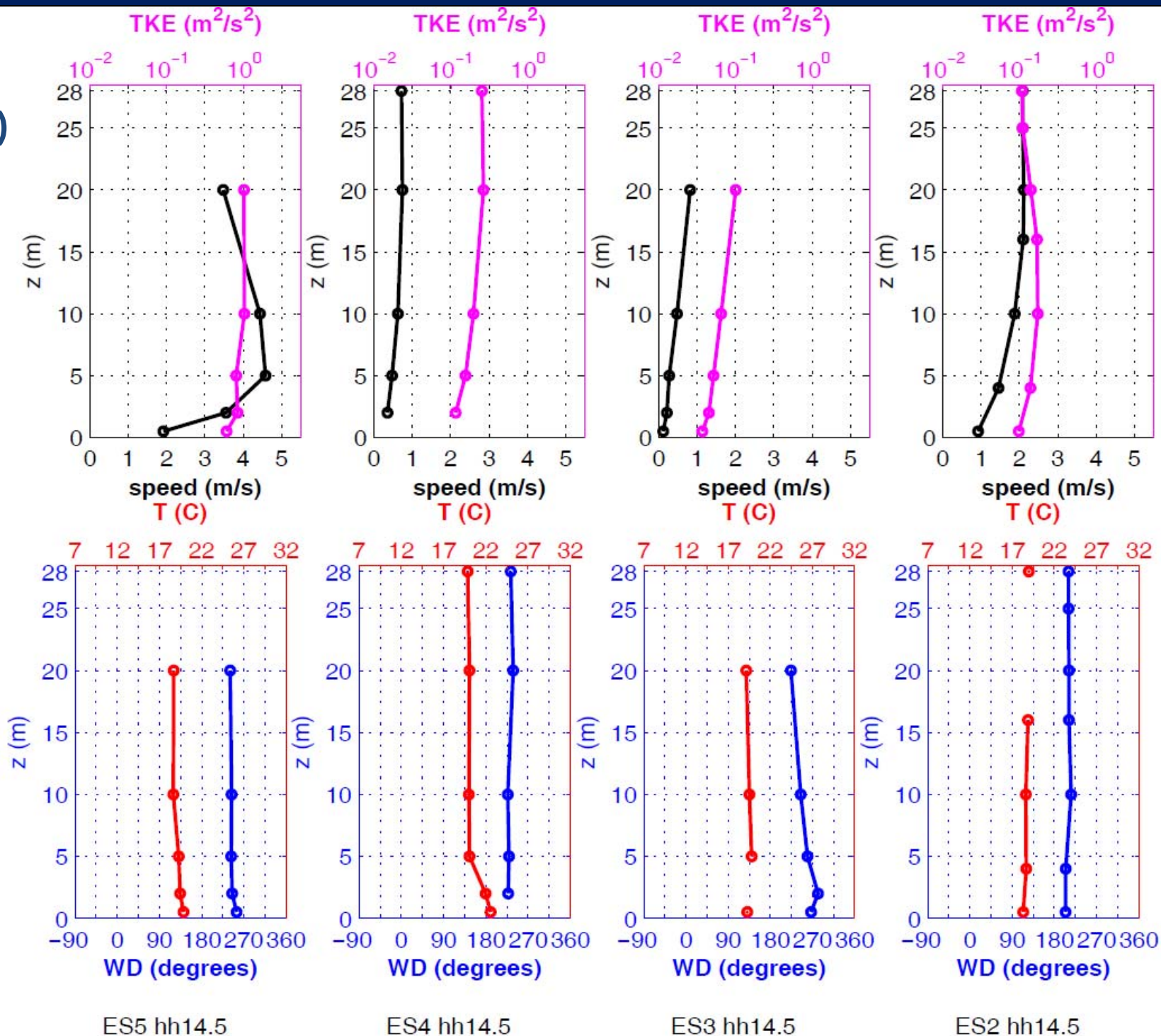


Jday 272  
(30 min avg)

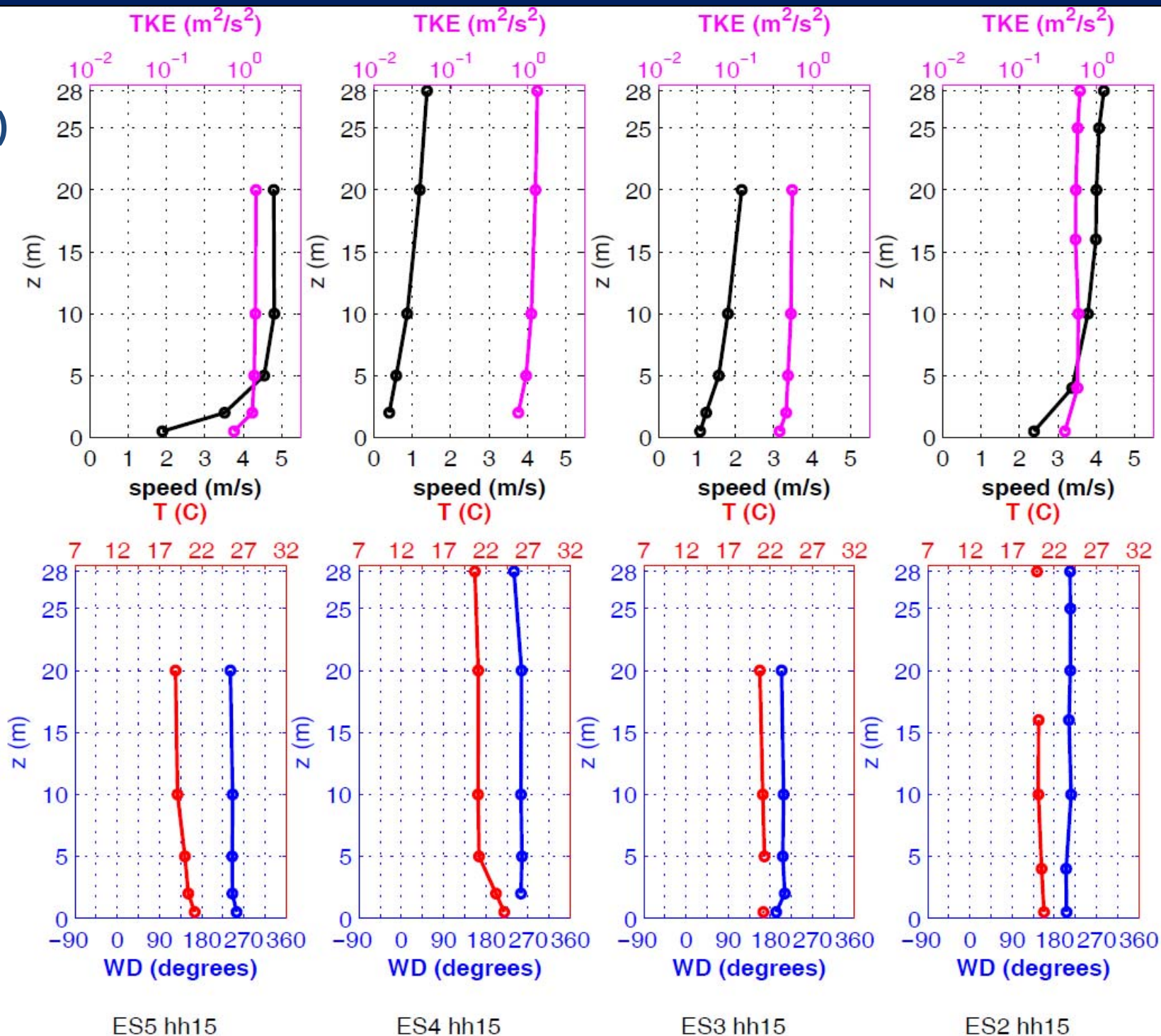




Jday 272  
(30 min avg)



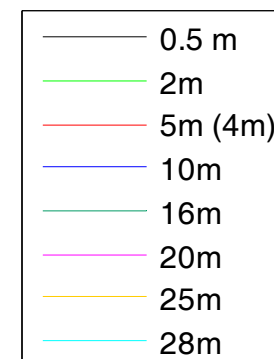
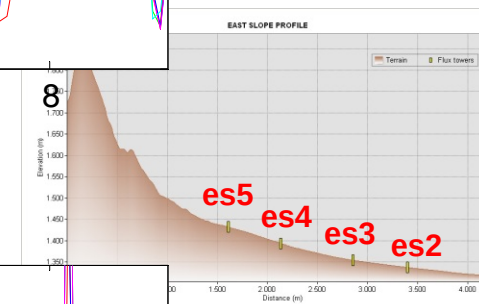
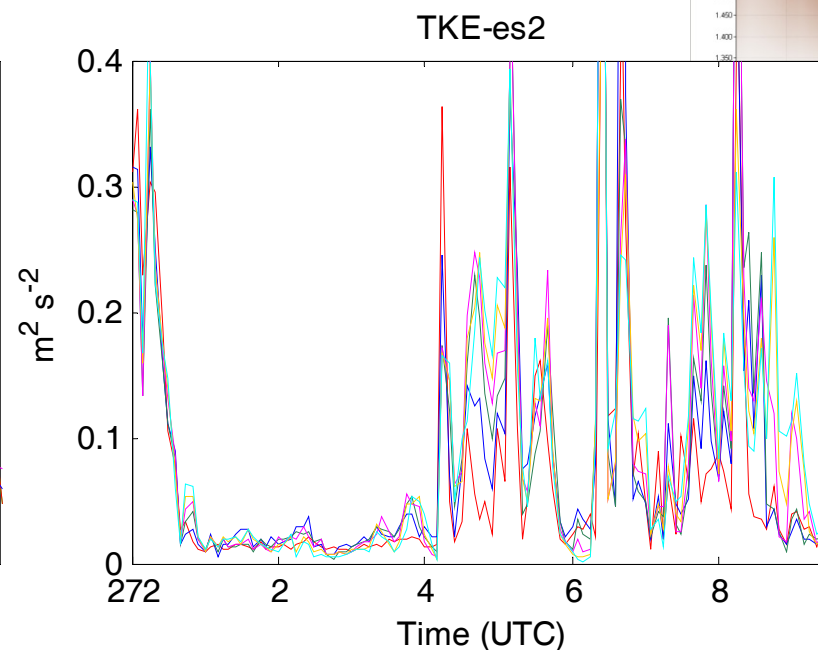
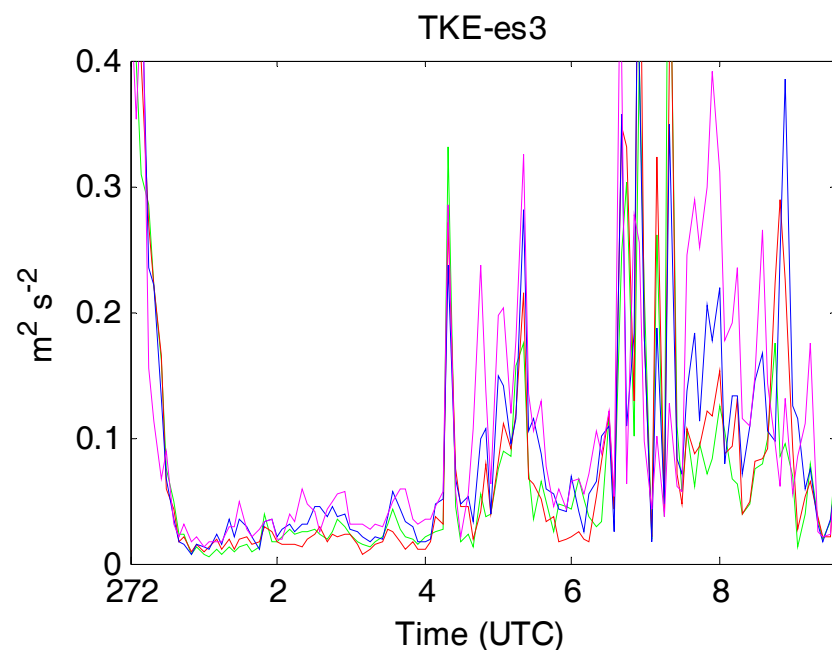
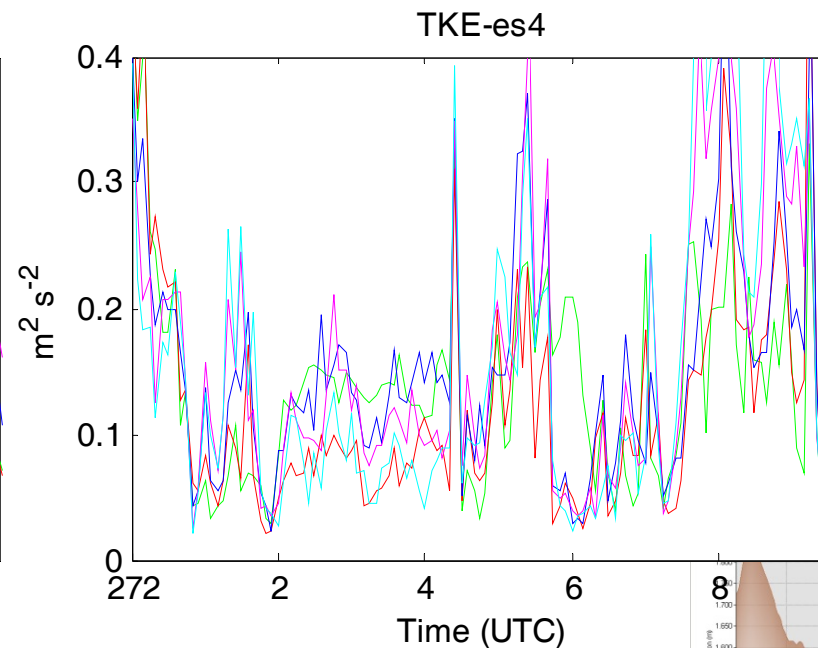
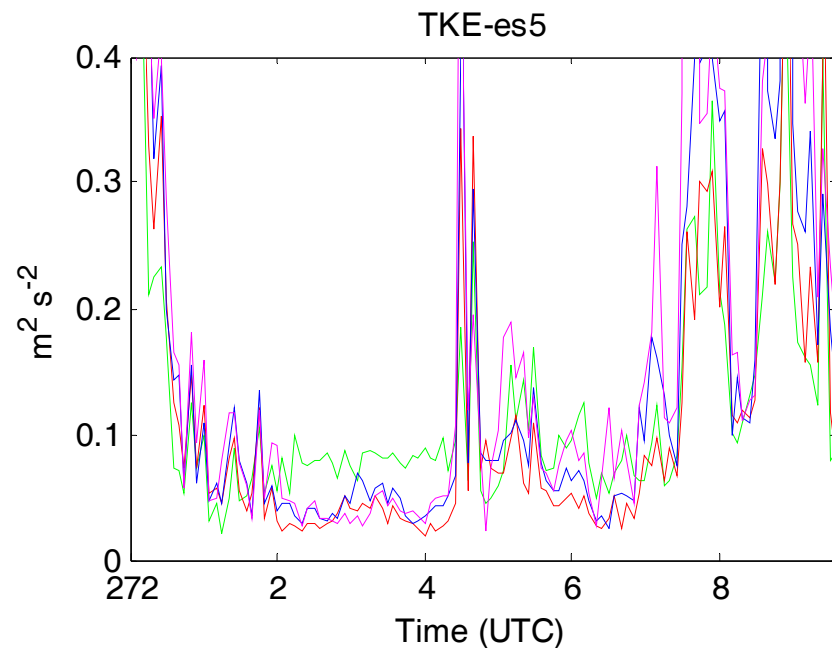
Jday 272  
(30 min avg)





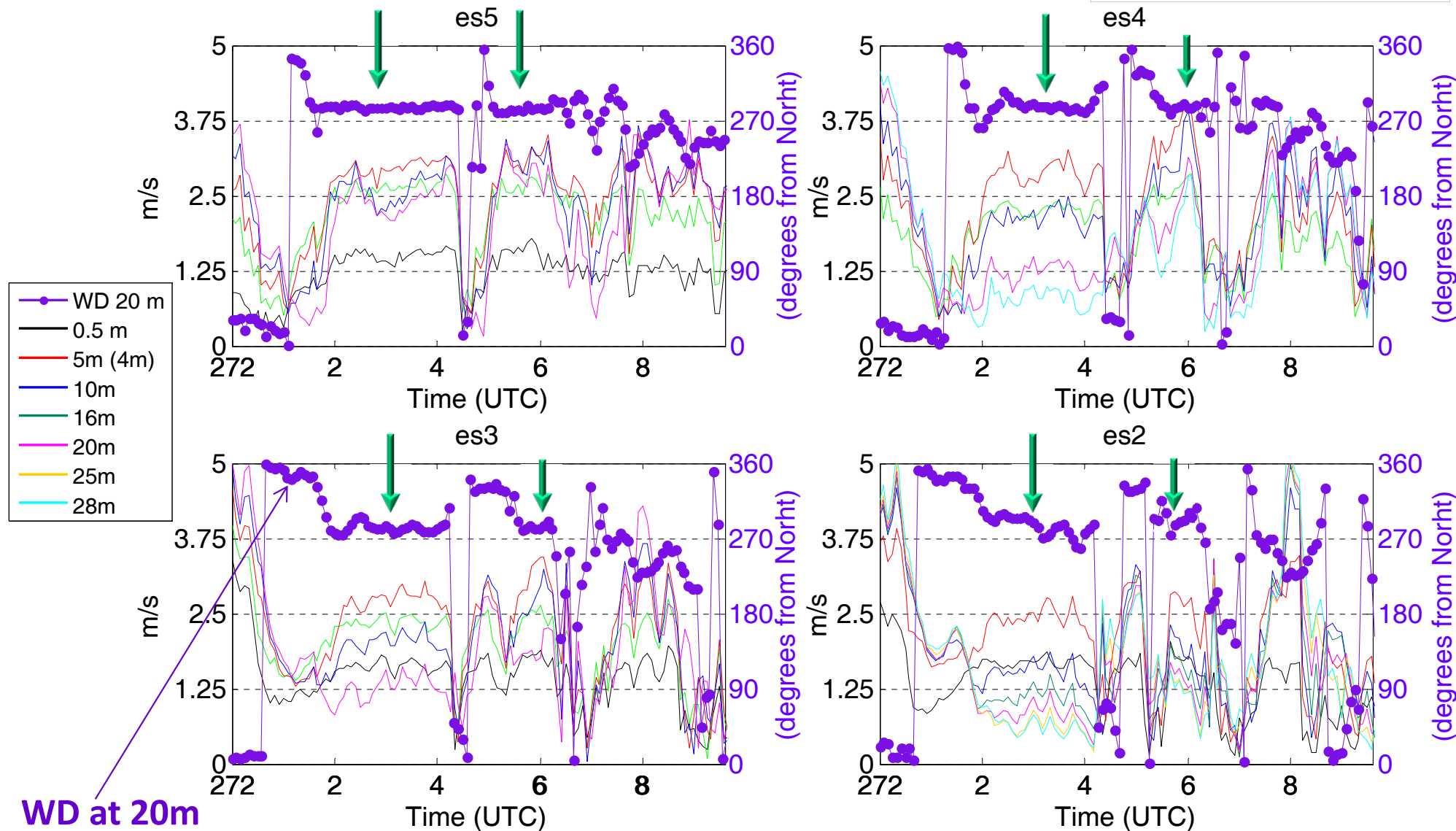
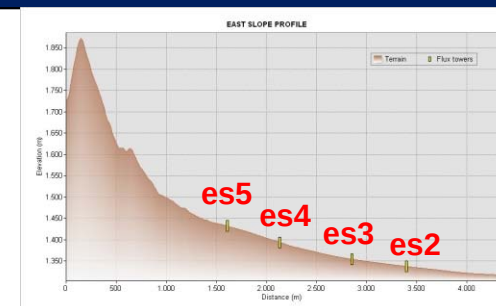
# TKE timeseries (5 min avg) along the East Slope

(Jday 272)



# Wind speed timeseries (5 min avg) along the East Slope

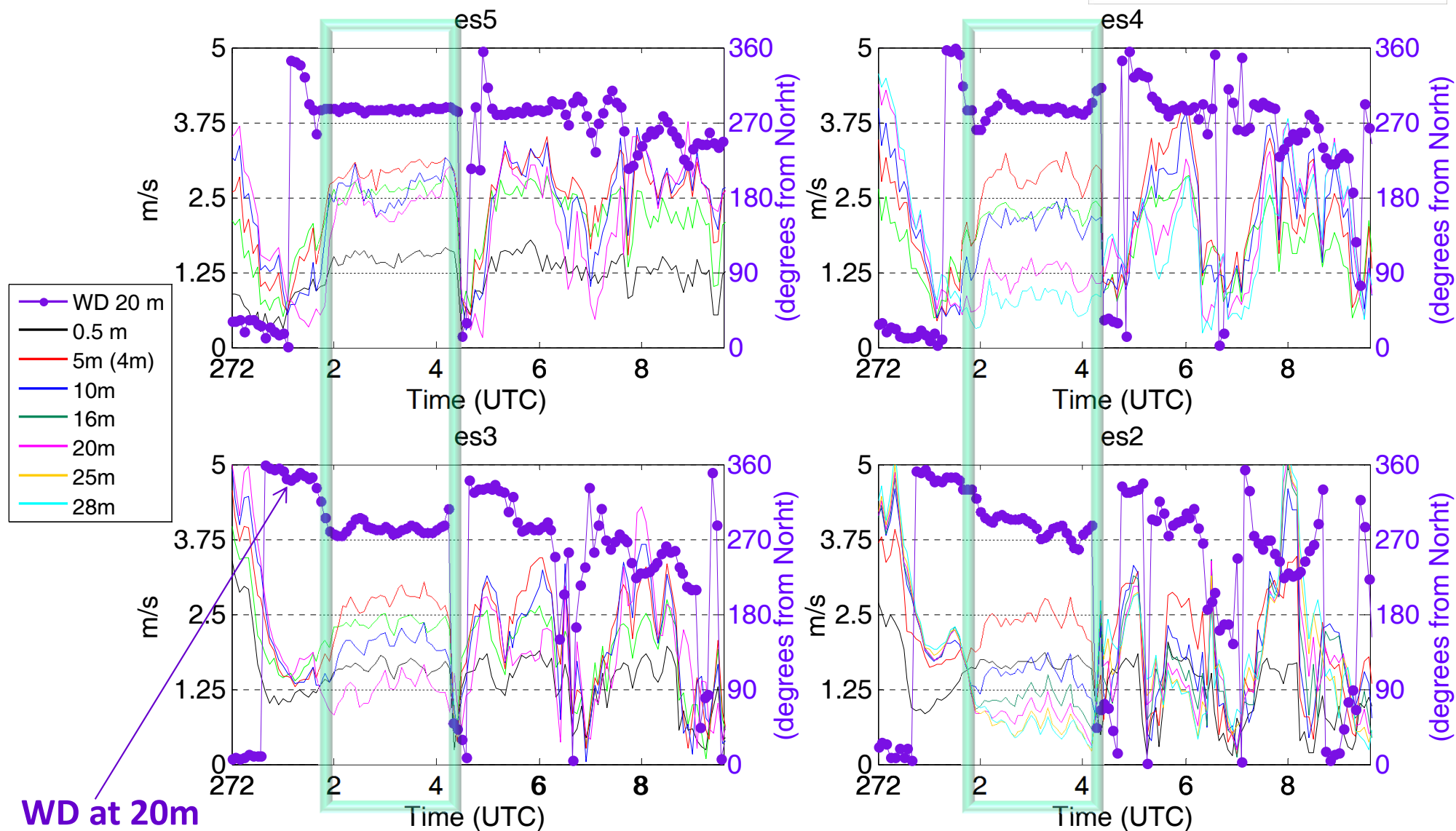
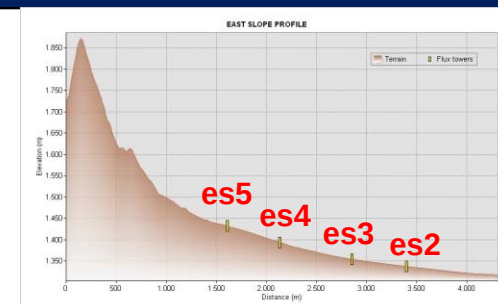
Jday 272 -- hh 0:00-10:00 UTC





# Wind speed timeseries (5 min avg) along the East Slope

Jday 272 -- hh 0:00-10:00 UTC

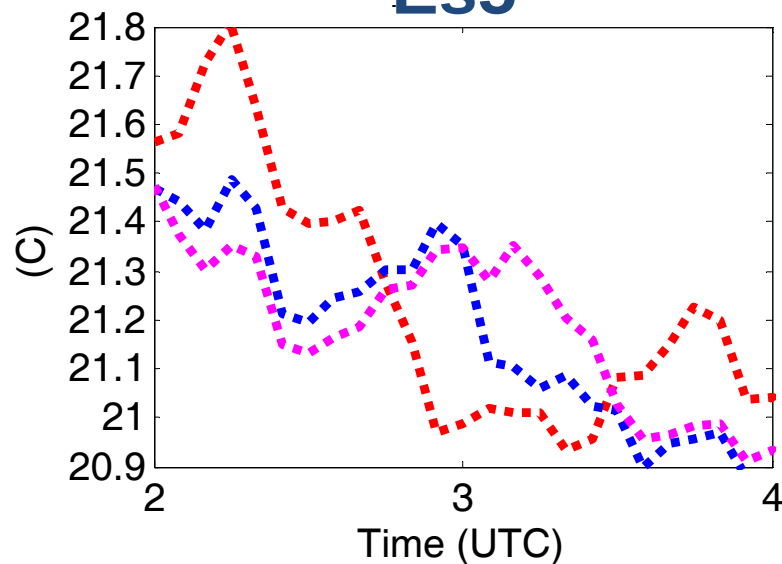


# Temperature timeseries (5 min avg) along the East Slope

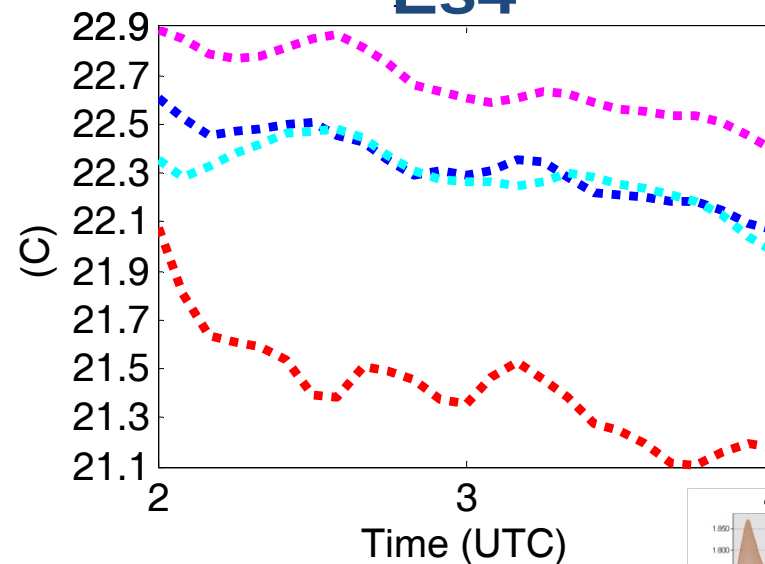
Jday 272

hh 2:00-4:00 UTC

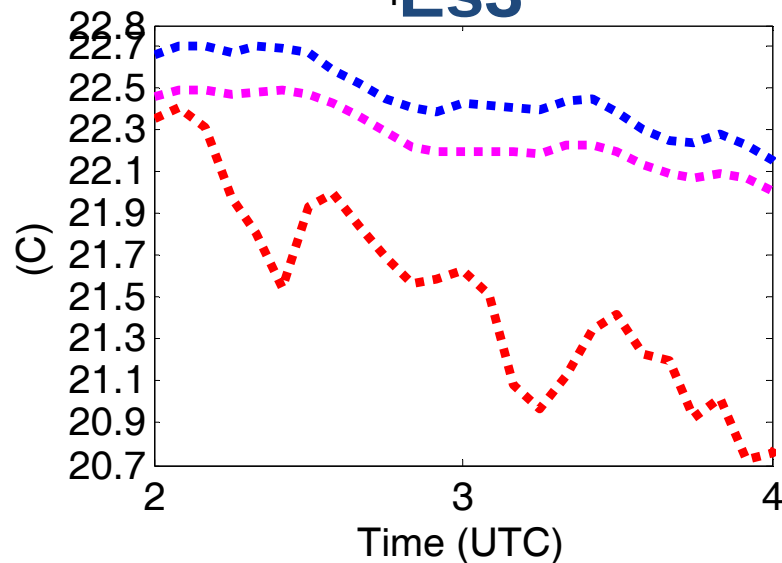
**Es5**



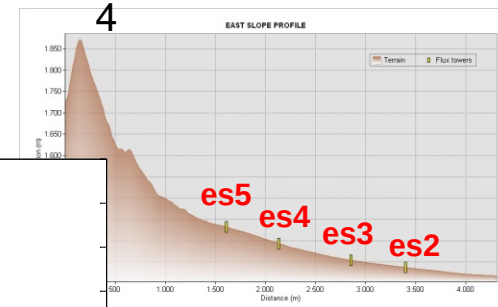
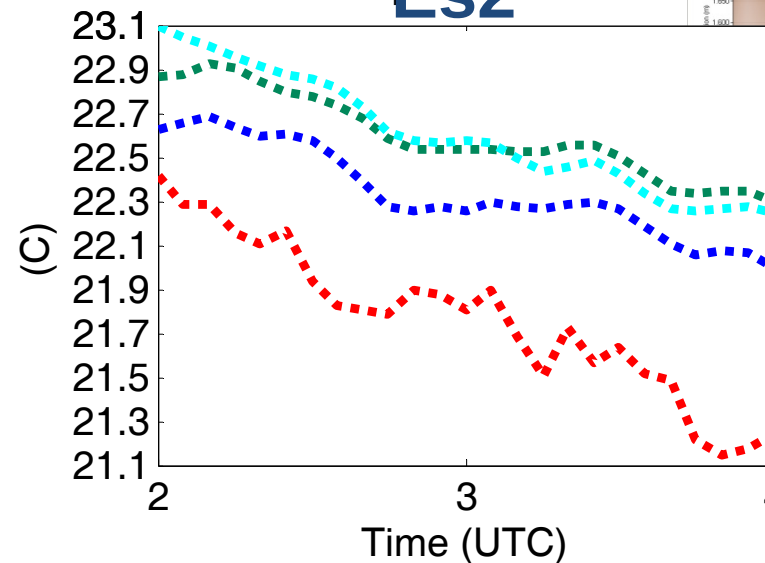
**Es4**



**Es3**

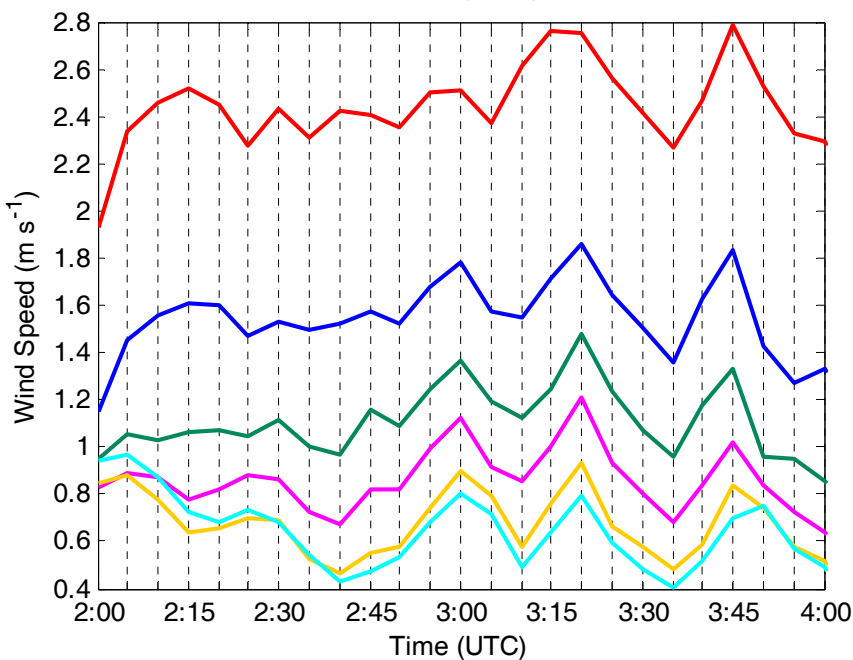
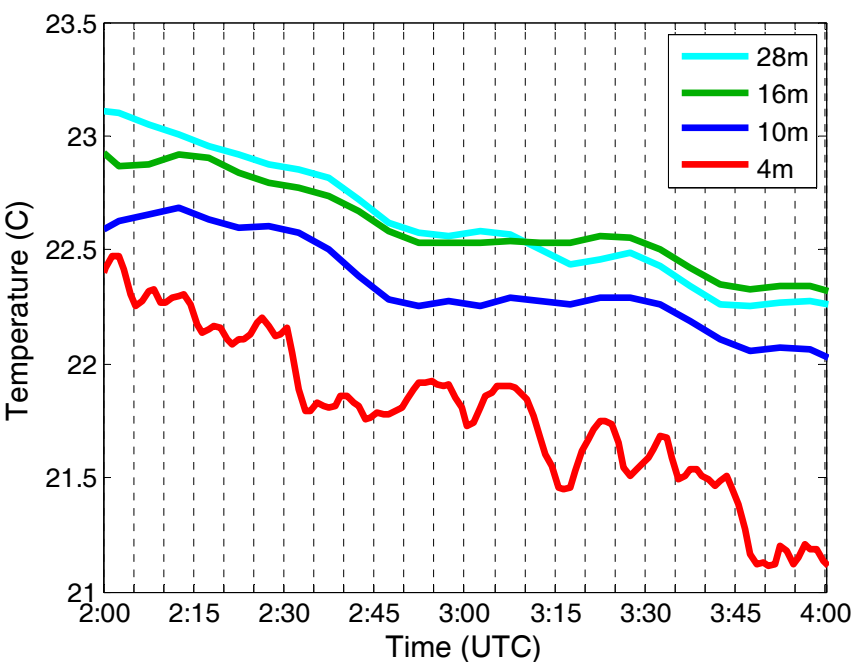


**Es2**

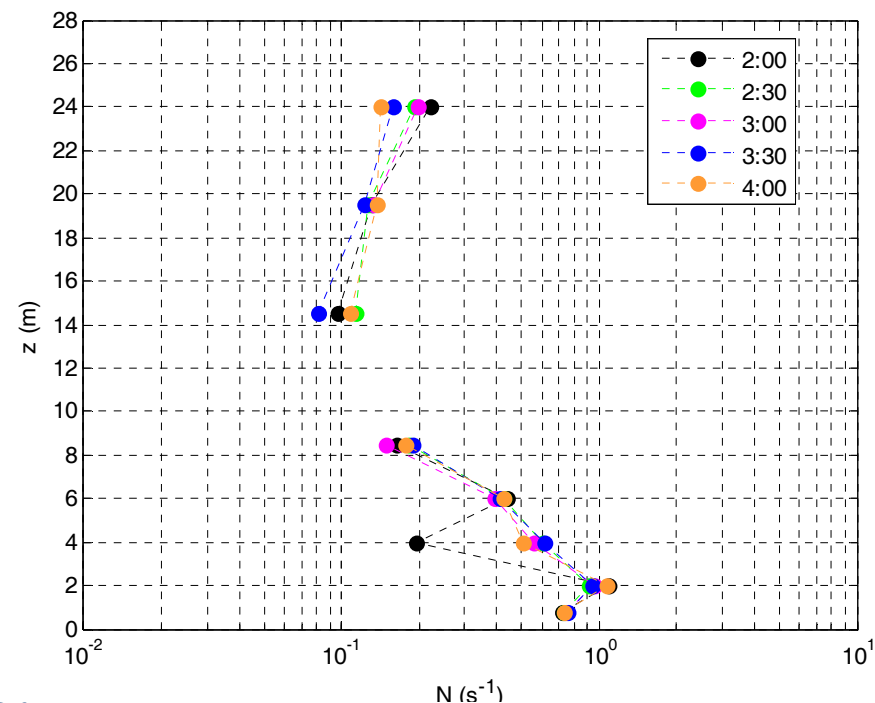




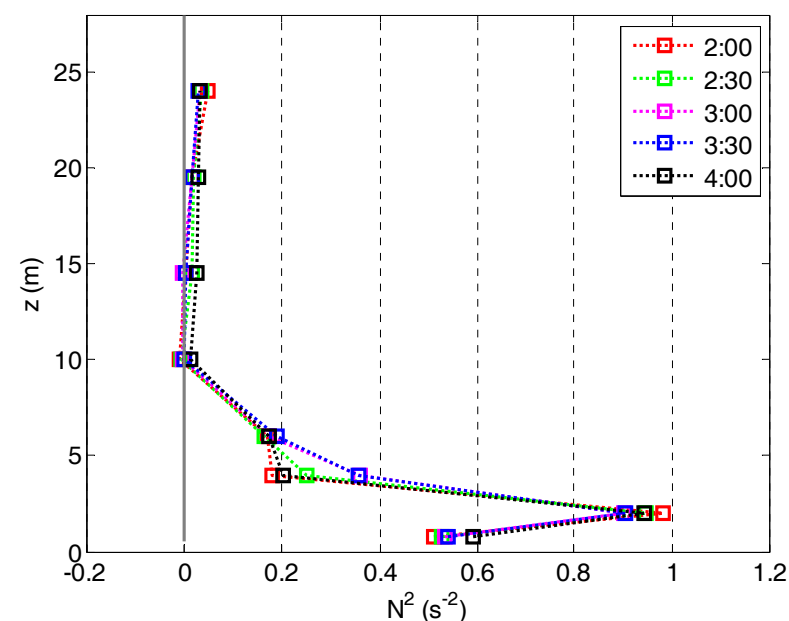
# Temperature and wind speed timeseries (5 min avg)

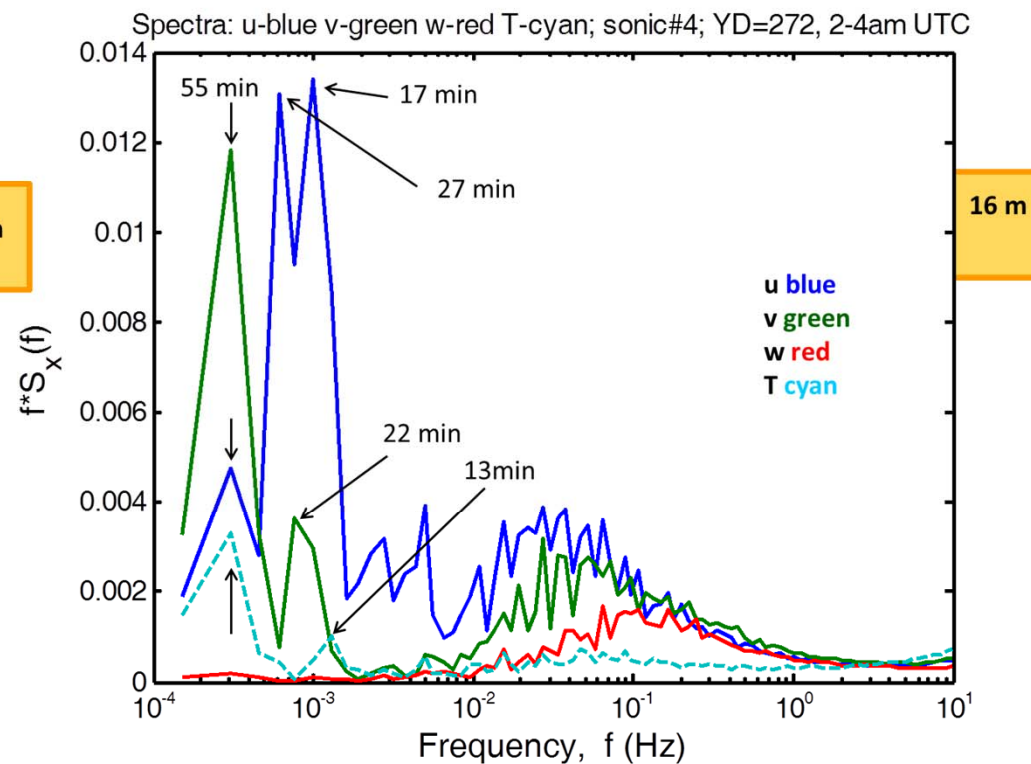
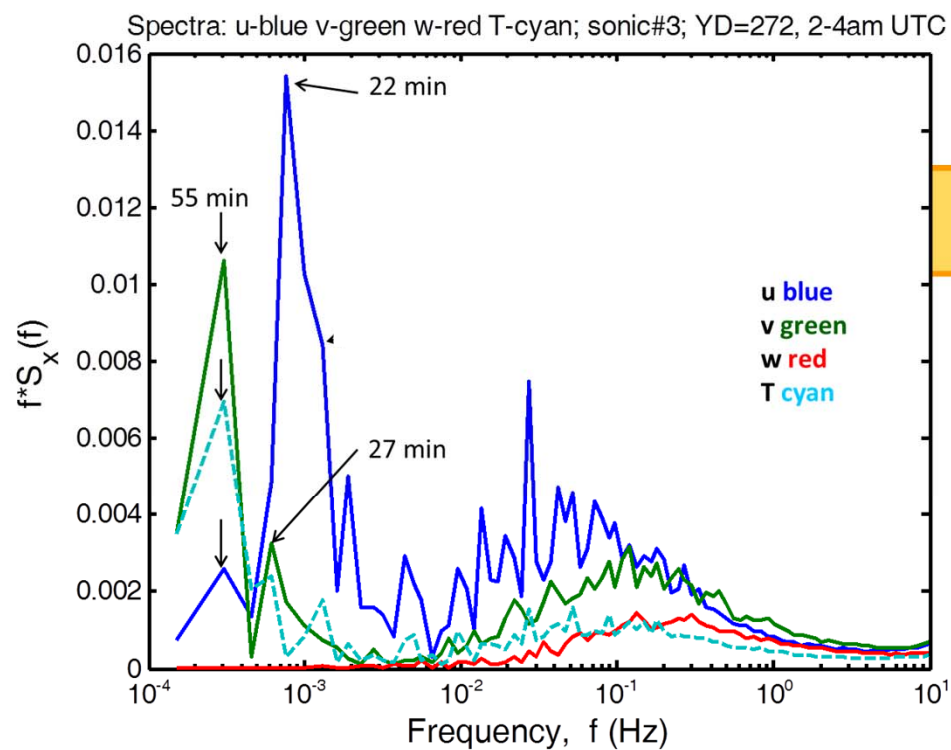
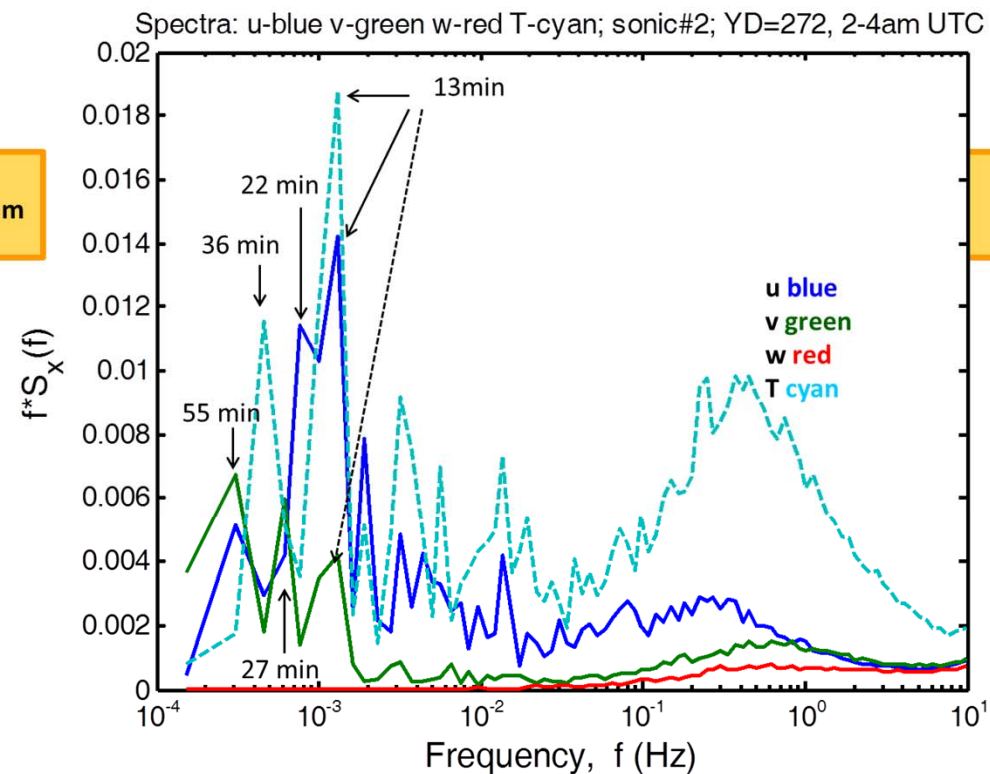
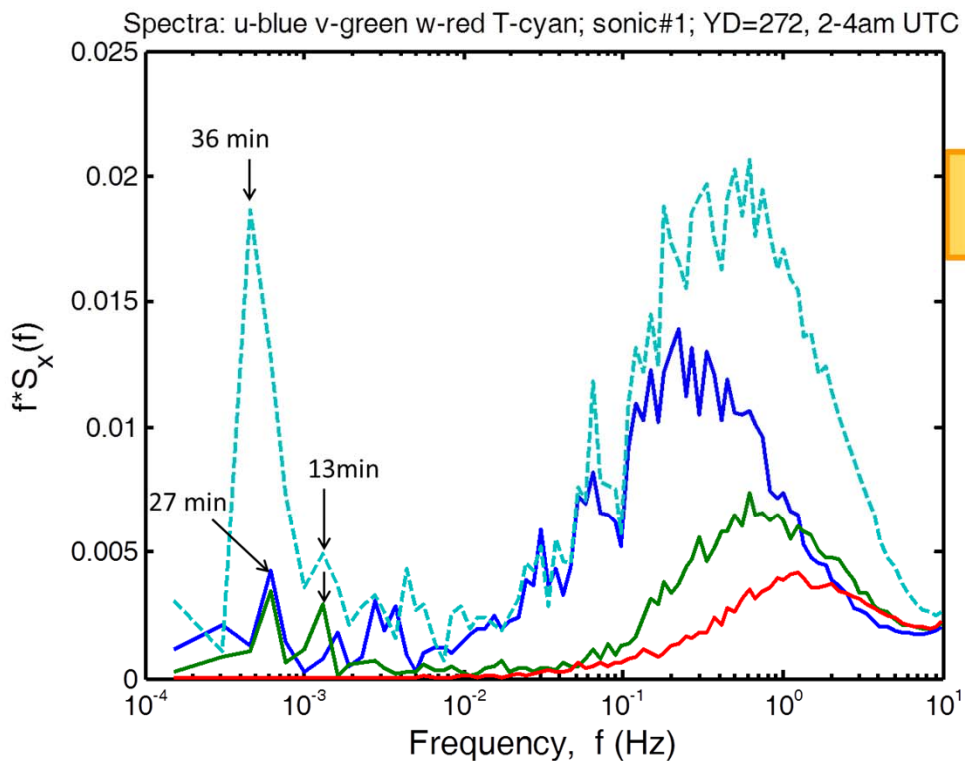


# Brunt-Väisälä Frequency profiles

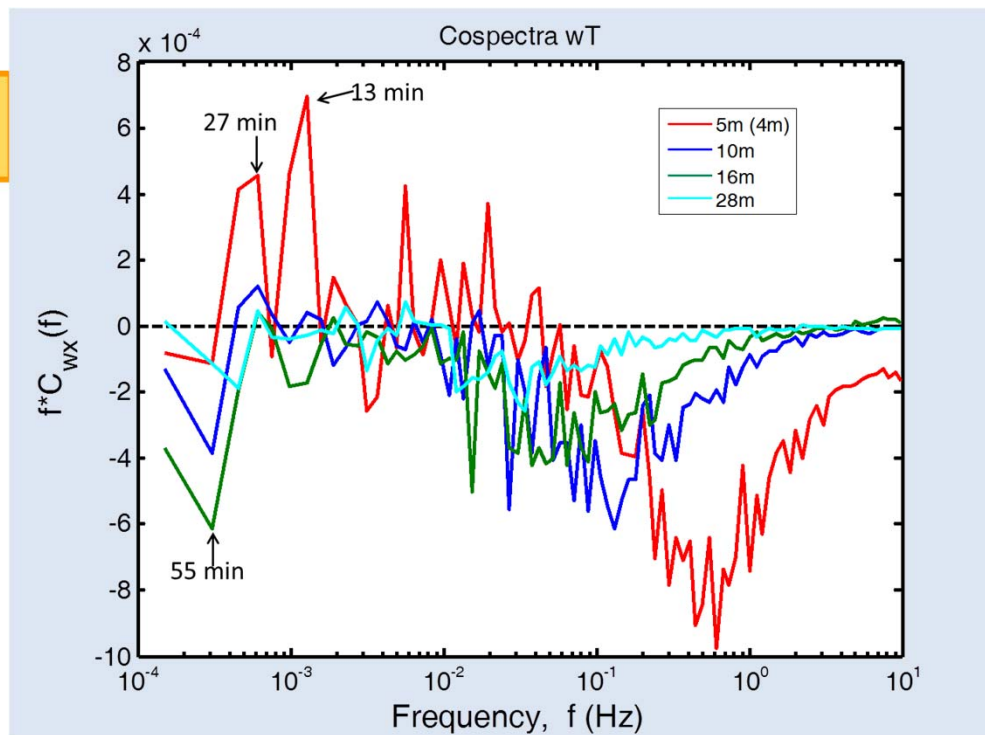
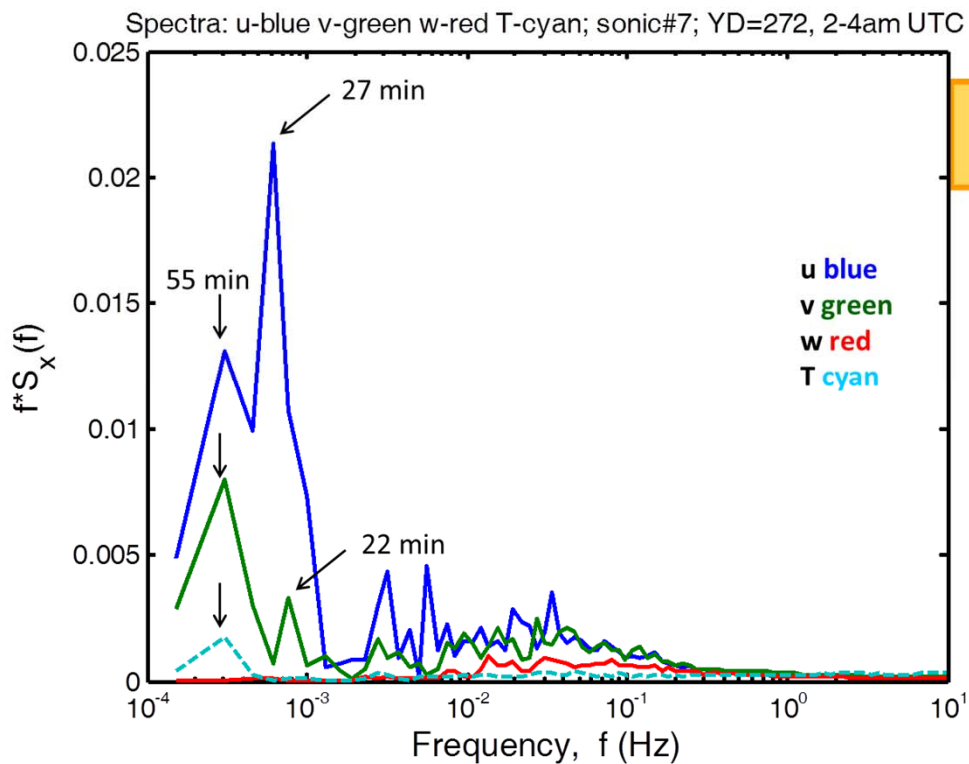
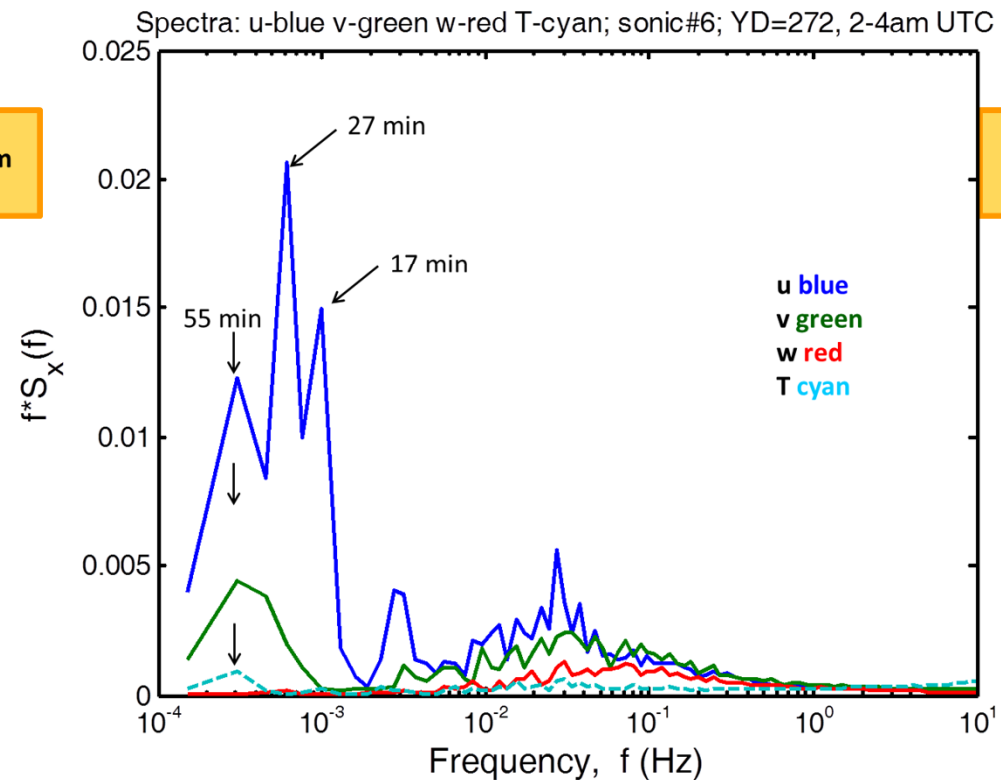
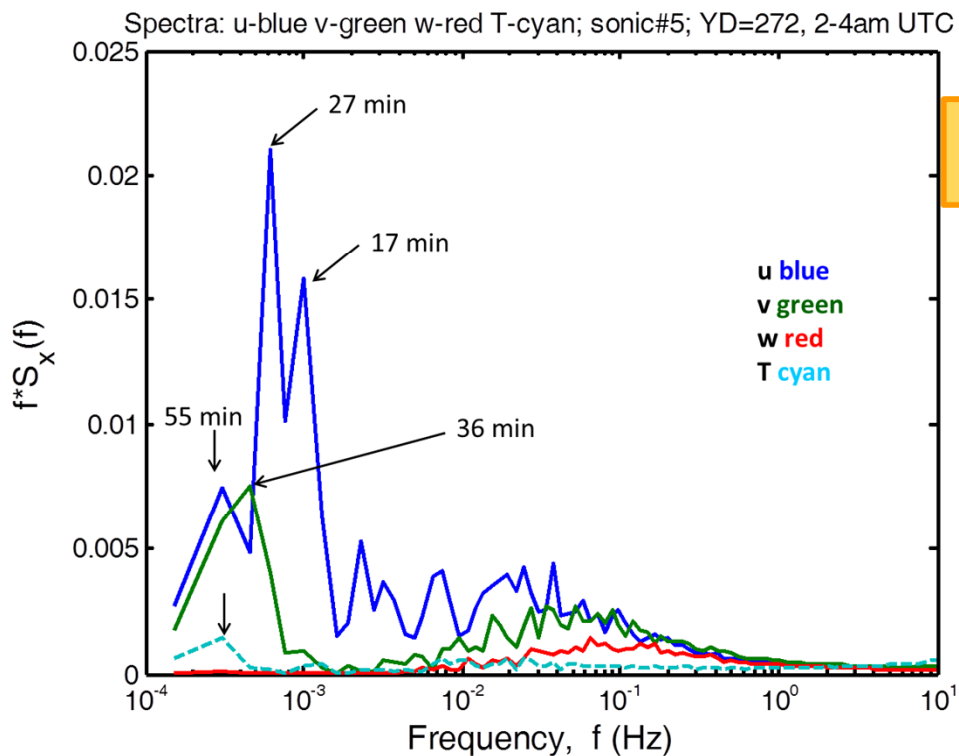


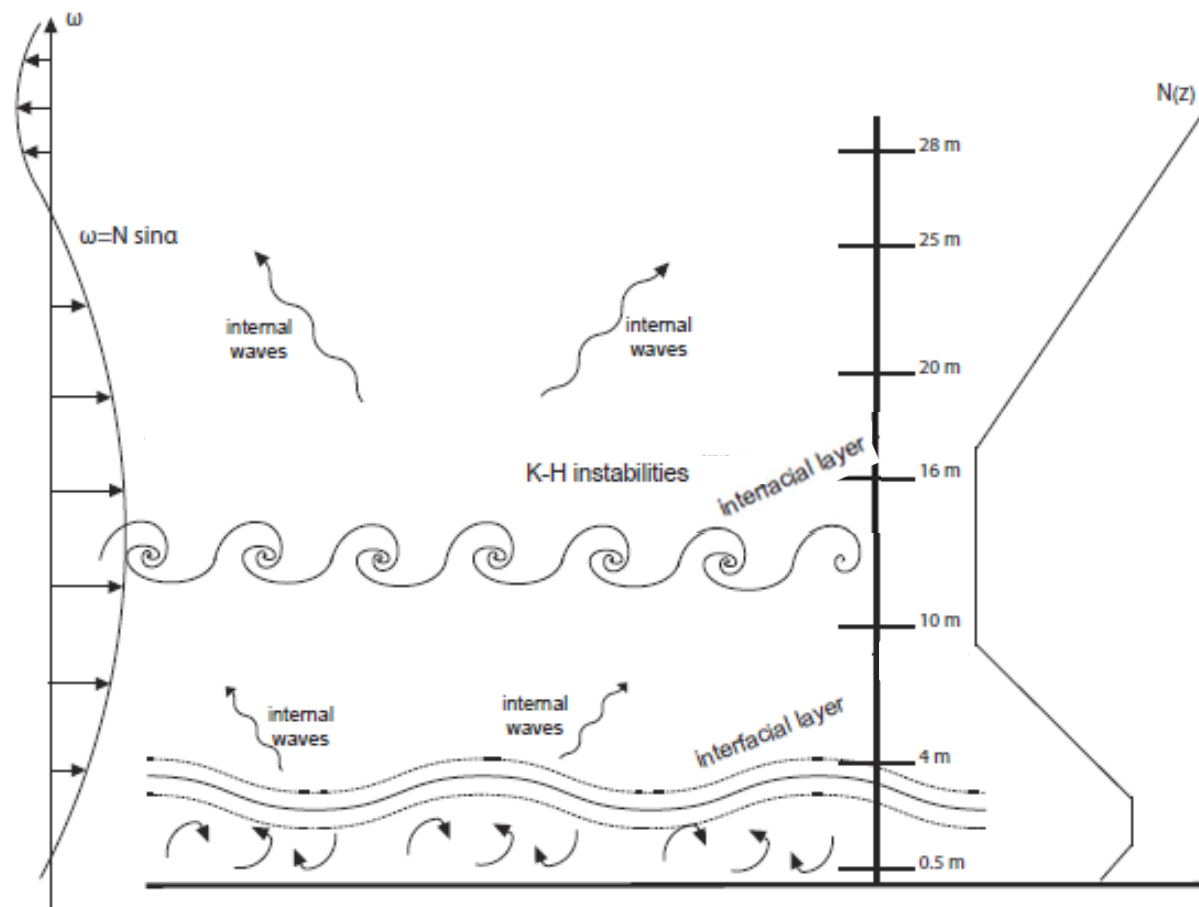
# ES2 tower



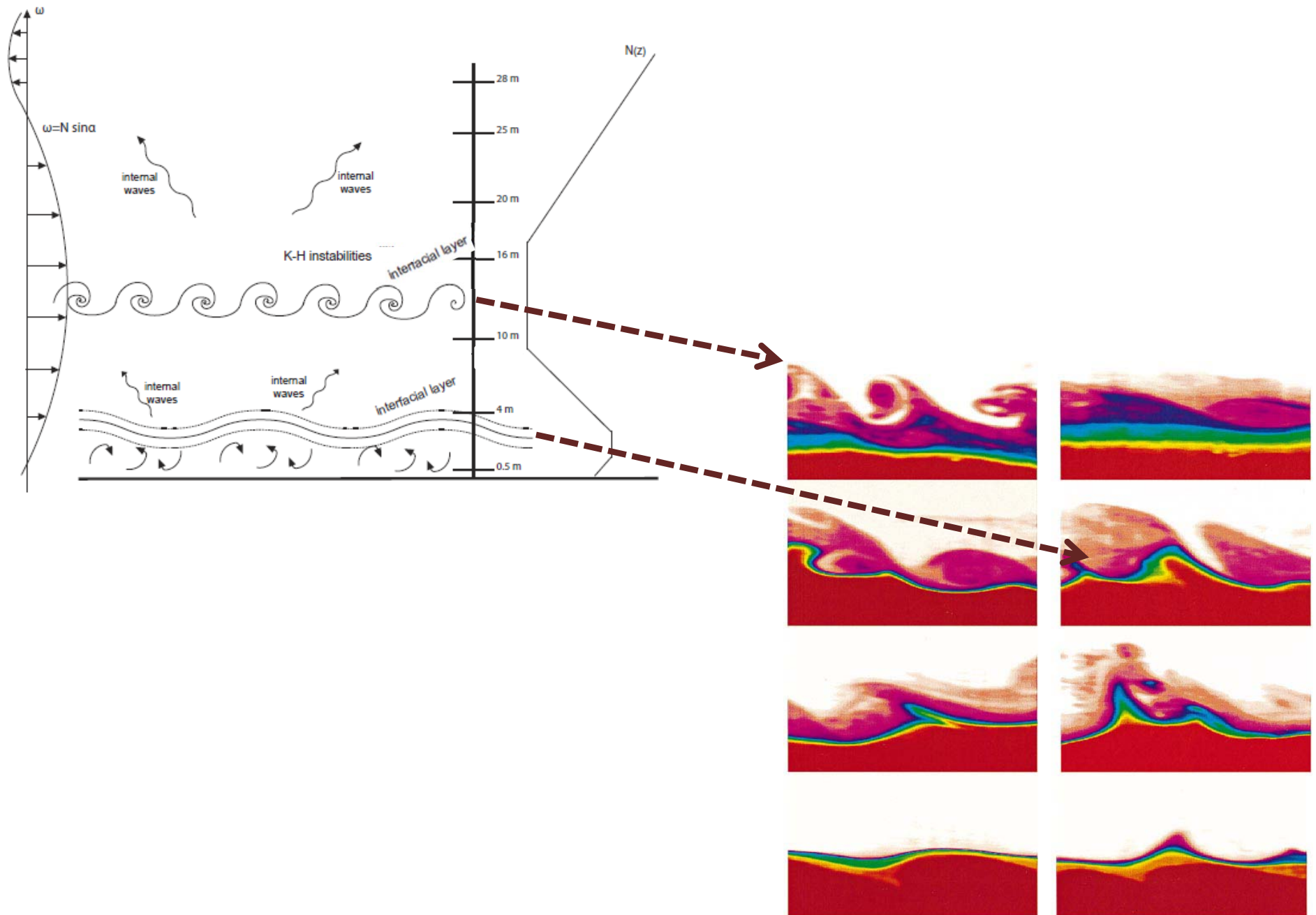




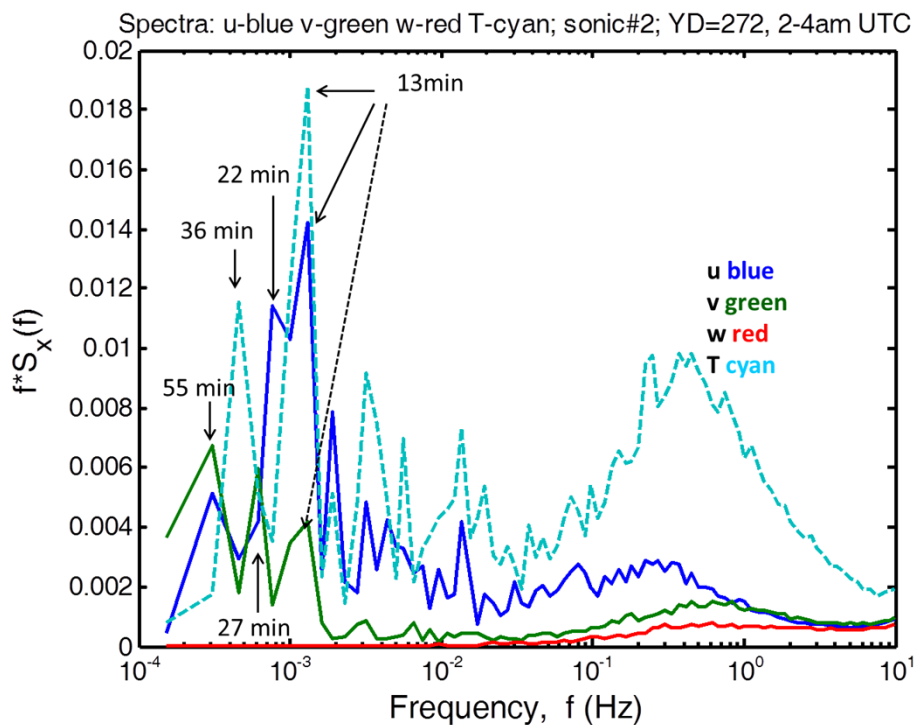
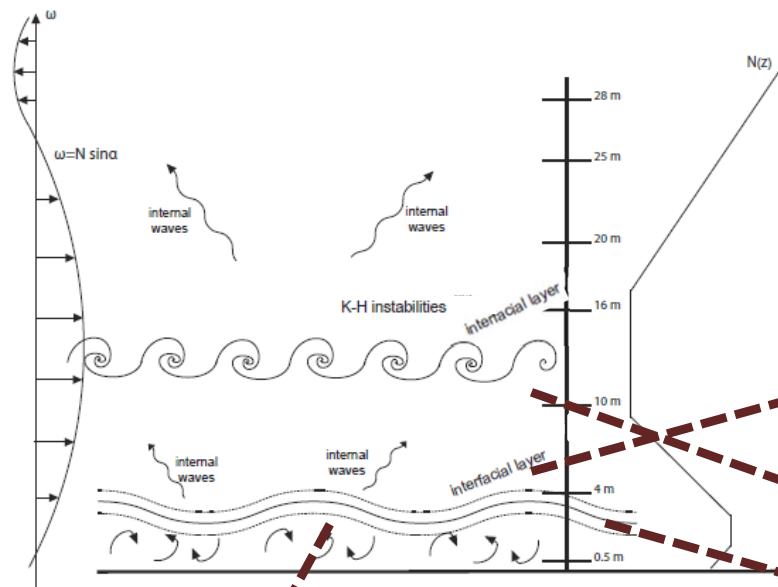




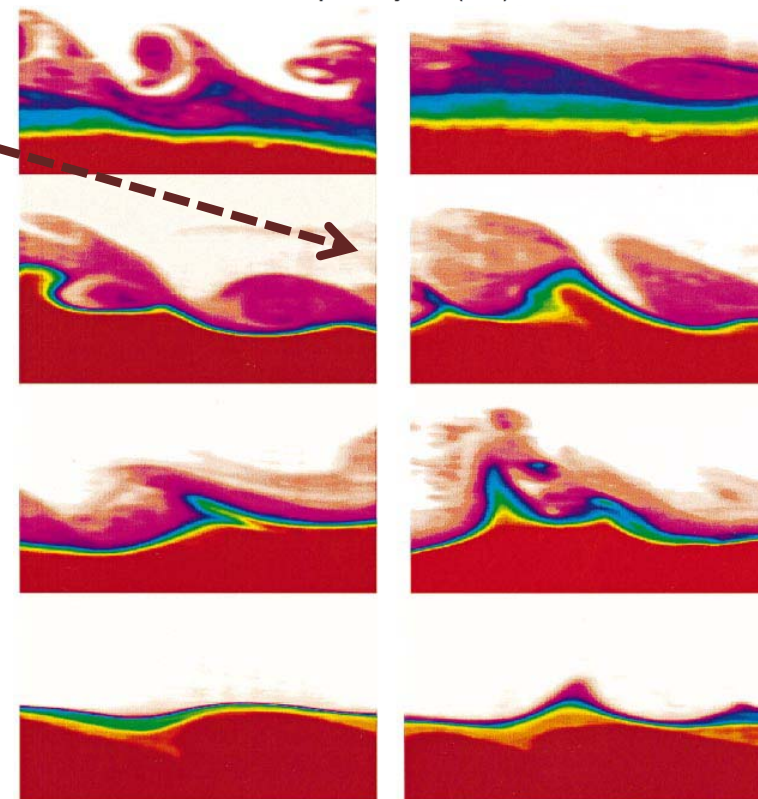
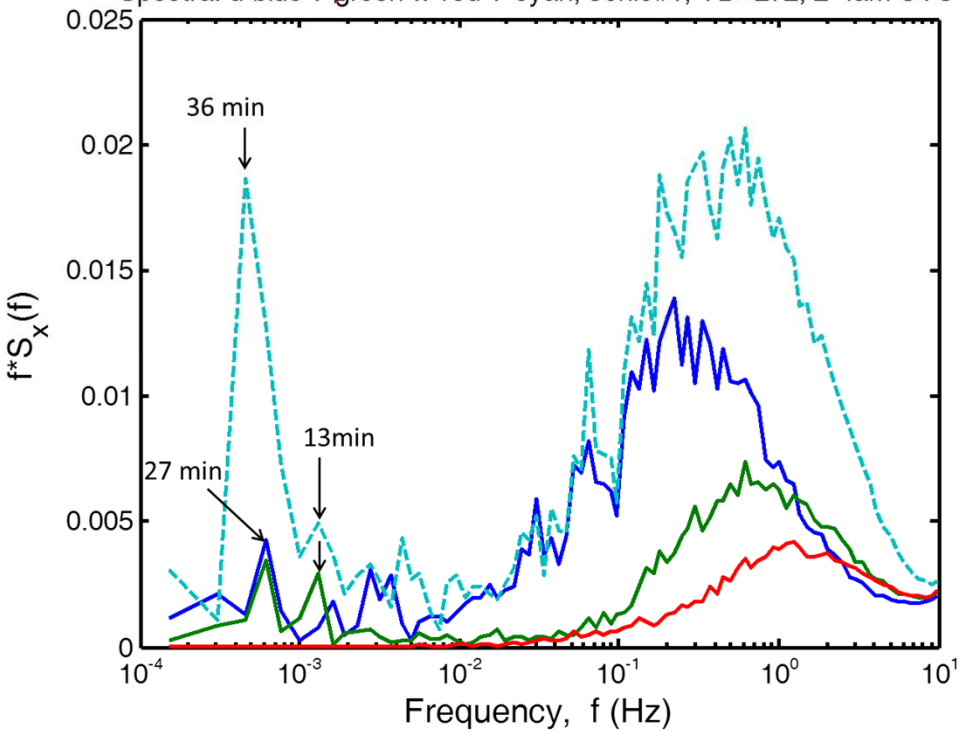




Strang and Fernando (2001)

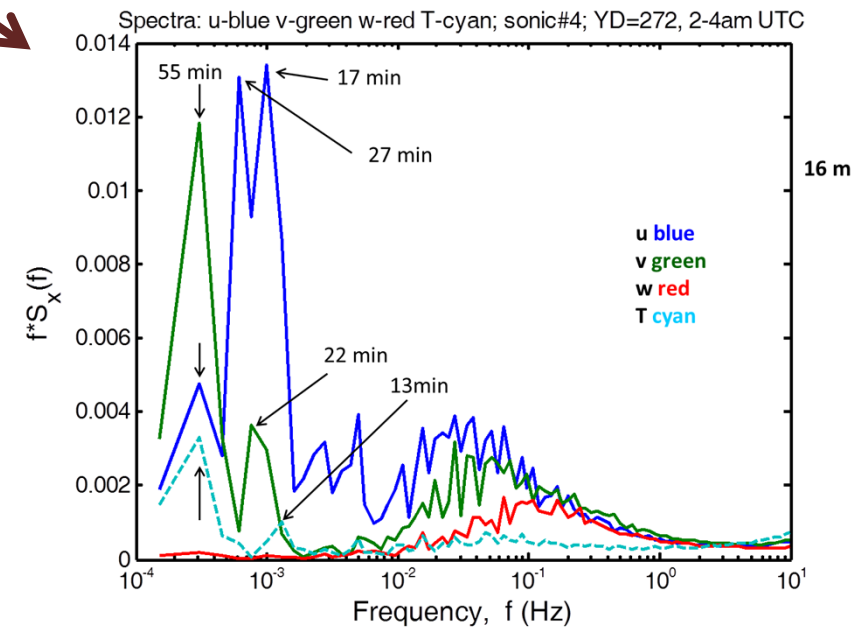
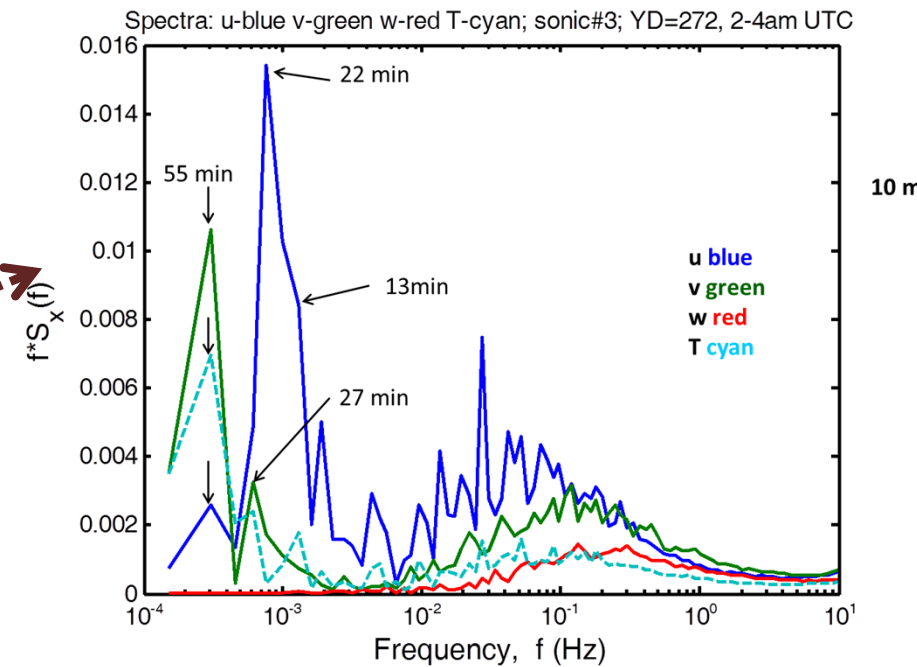
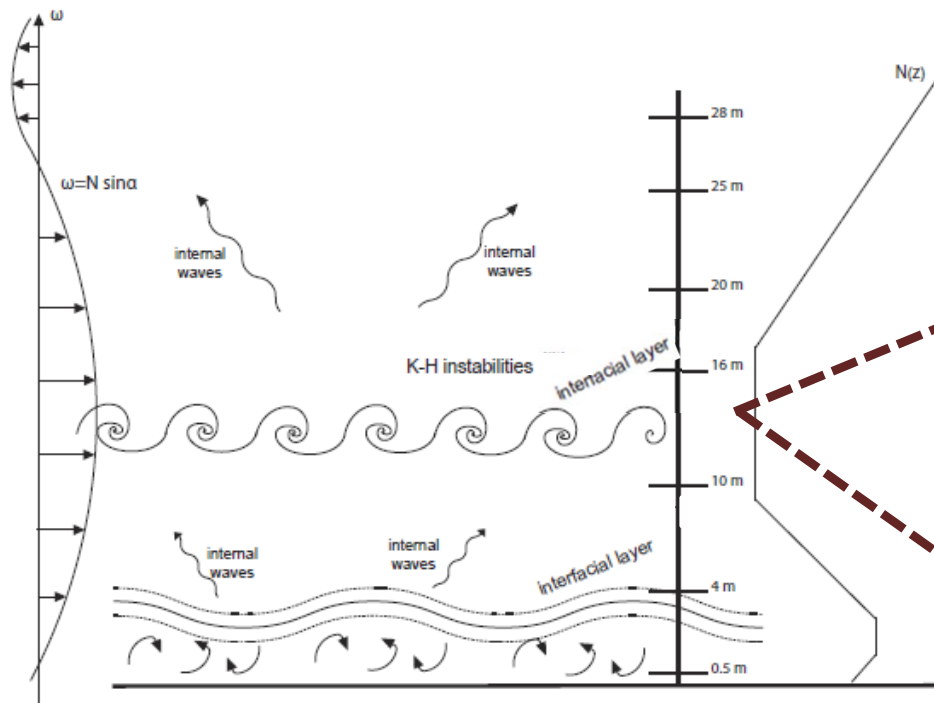


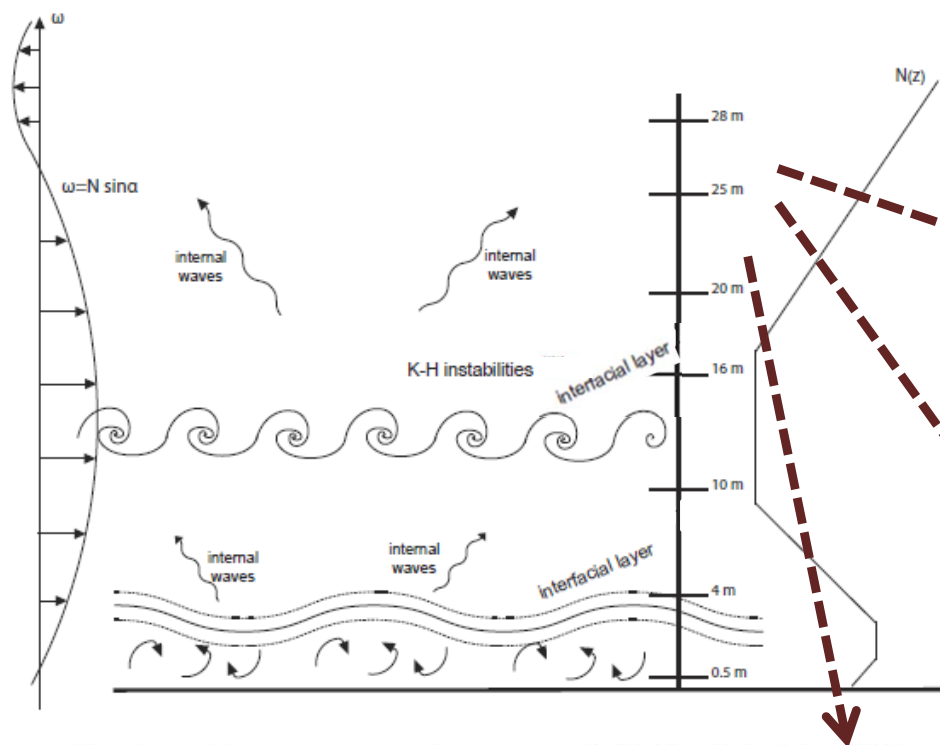
Spectra: u-blue v-green w-red T-cyan; sonic#1; YD=272, 2-4am UTC



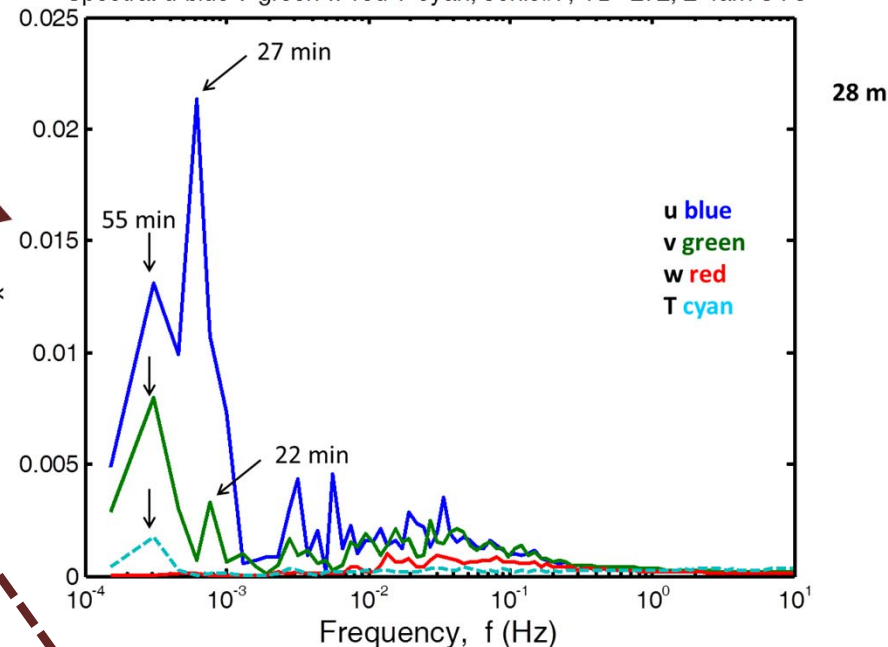
Strang and Fernando (2001)



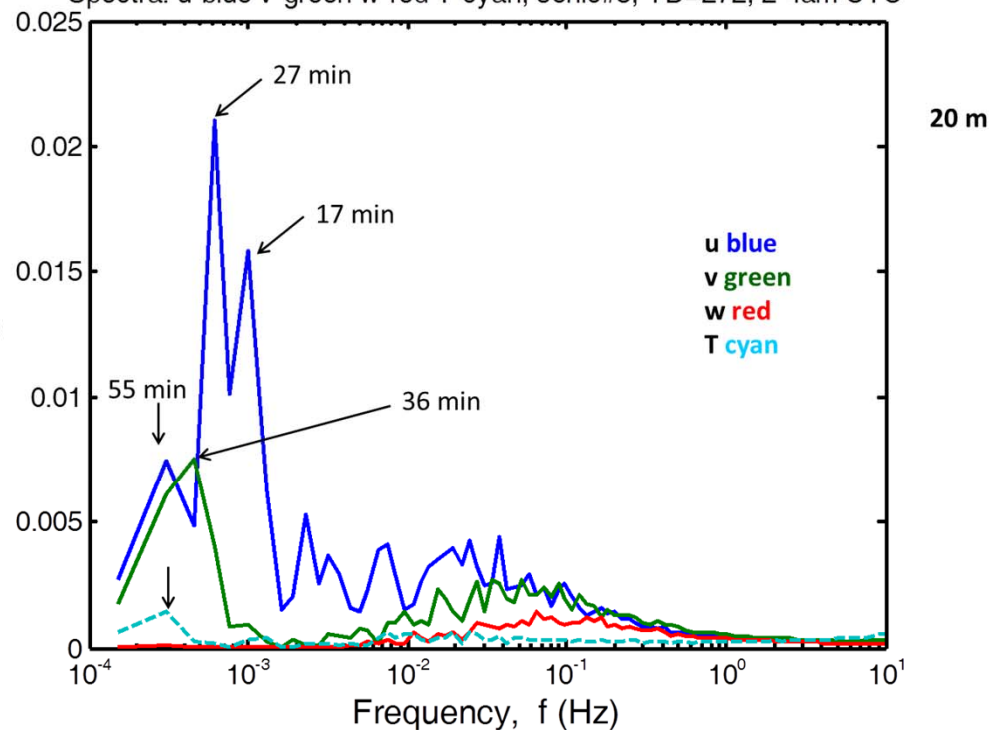




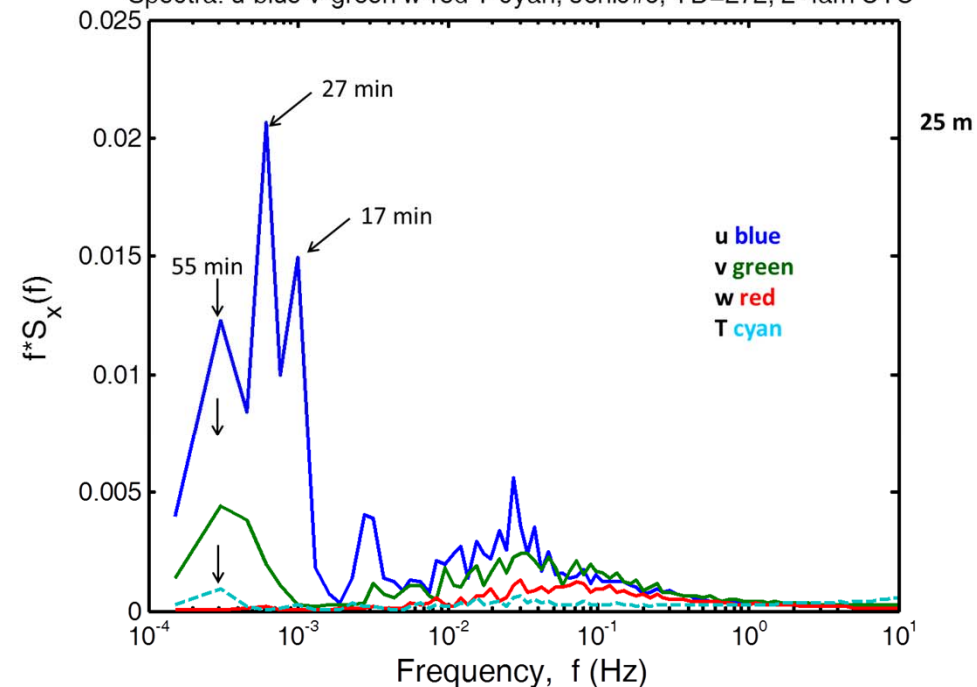
Spectra: u-blue v-green w-red T-cyan; sonic#7; YD=272, 2-4am UTC



Spectra: u-blue v-green w-red T-cyan; sonic#5; YD=272, 2-4am UTC



Spectra: u-blue v-green w-red T-cyan; sonic#6; YD=272, 2-4am UTC





## CONCLUSIONS & OUTLOOK

- Several occurrences of slope flows during quiescent periods
- Strong interaction between slope flows and the circulation in the valley
- Due to these multi-scale flow interactions, slope flows appear to be intermittent and disturbed with tendency to decay through the night
- Slope flow develops rapidly after sunset and usually persists for 2-3 hours. This is also the period where the flow structure resembles a “pure” katabatic flow.
- Presence of oscillations were documented in the katabatic flow and associated to a multi-layer structure of the flow. Future work will be devoted to further understanding the dynamics of these wave motions

A photograph of five horses in a desert landscape. In the foreground, five horses are standing on a dirt path. From left to right: a dark horse, a dark horse, a dark horse, a brown horse, and a brown horse with a white blaze. The background features a vast, flat desert floor with sparse vegetation, leading up to a range of rugged, rocky mountains under a bright blue sky with scattered white clouds.

**THANK YOU!**

*QUESTIONS?*