Conditions for Stratocumulus Clouds at the Azores

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What large-scale conditions lead to stratocumulus clouds at the Azores?

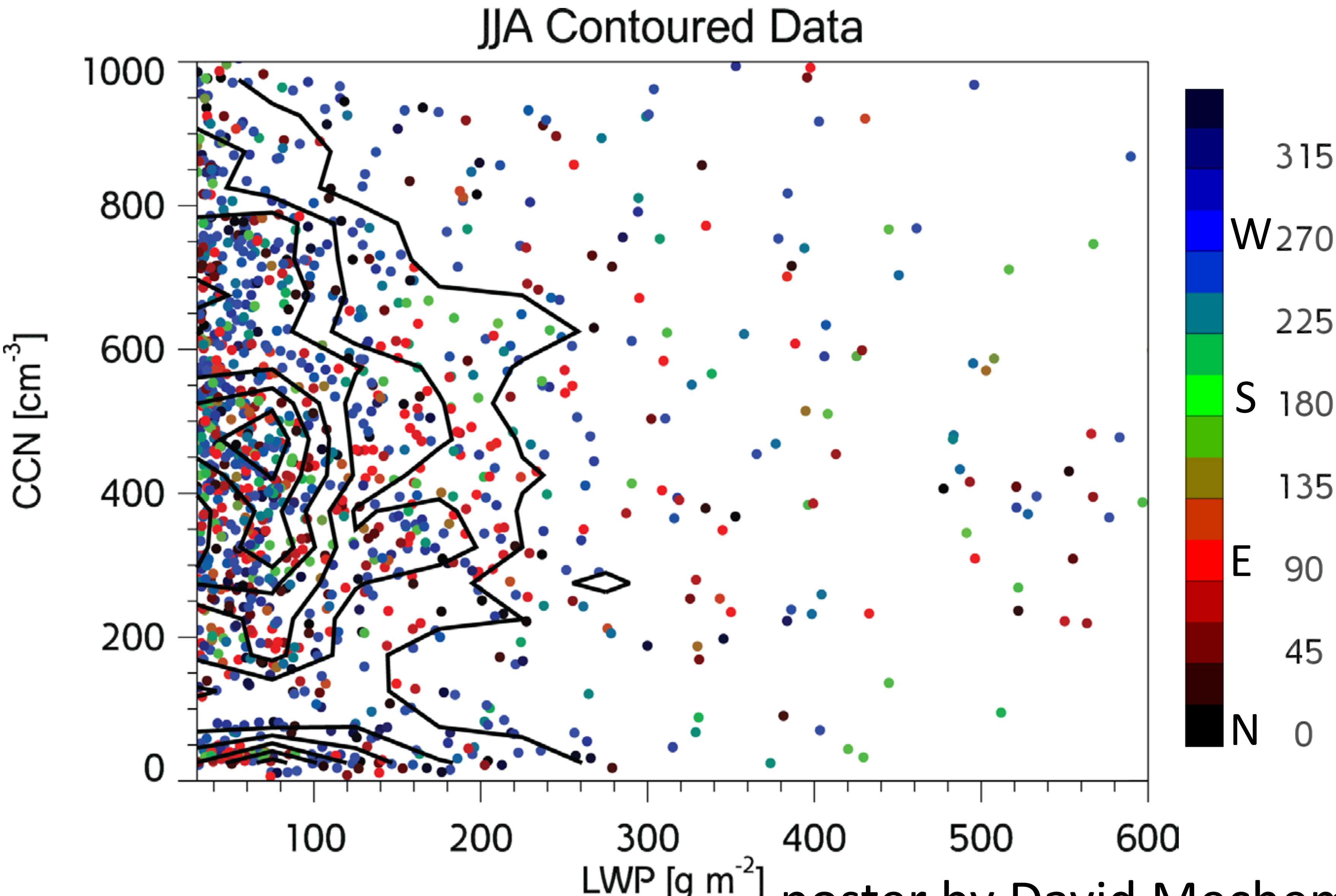
- Thermodynamic effects
  - stability
  - inversion strength
- Dynamical forcing
  - large scale ascent/descent
- Microphysical effects
  - cloud condensation nuclei population
  - cloud-precipitation interaction

CCN effect on cloud lifecycle

- separate microphysical and meteorological effects
- Azores AMF observations
- a simple macrophysical model

  of the LWP, N_c phase space
- Large eddy simulation

Azores, summer



poster by David Mechem

Simple macrophysical model

<u>equations:</u>

$d(LWP)/dt \quad = -P \quad + C$

$d(N_c)/dt \quad = -\alpha P \quad + G$

$P \quad = \beta * LWP/N_c$

<u>parameters:</u>

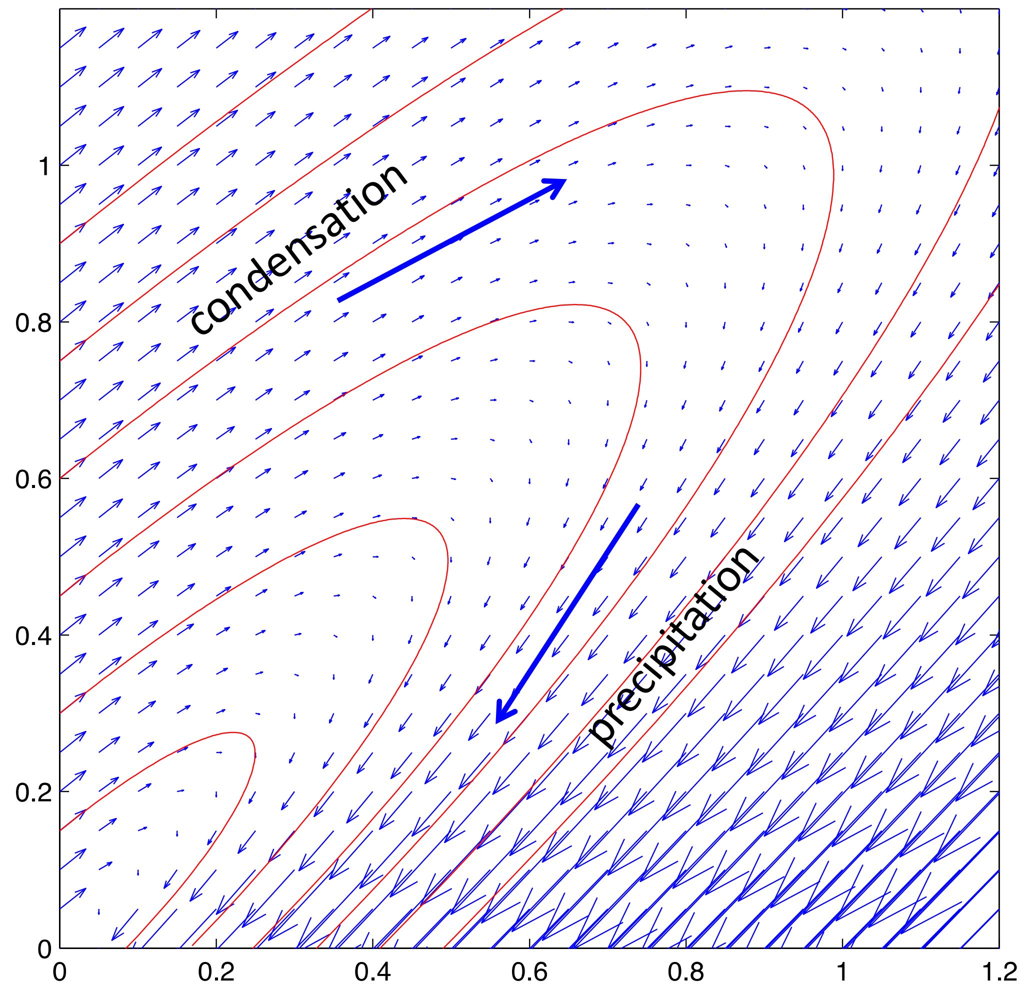
precip. efficiency β

scouring coefft. α

<u>forcings:</u>

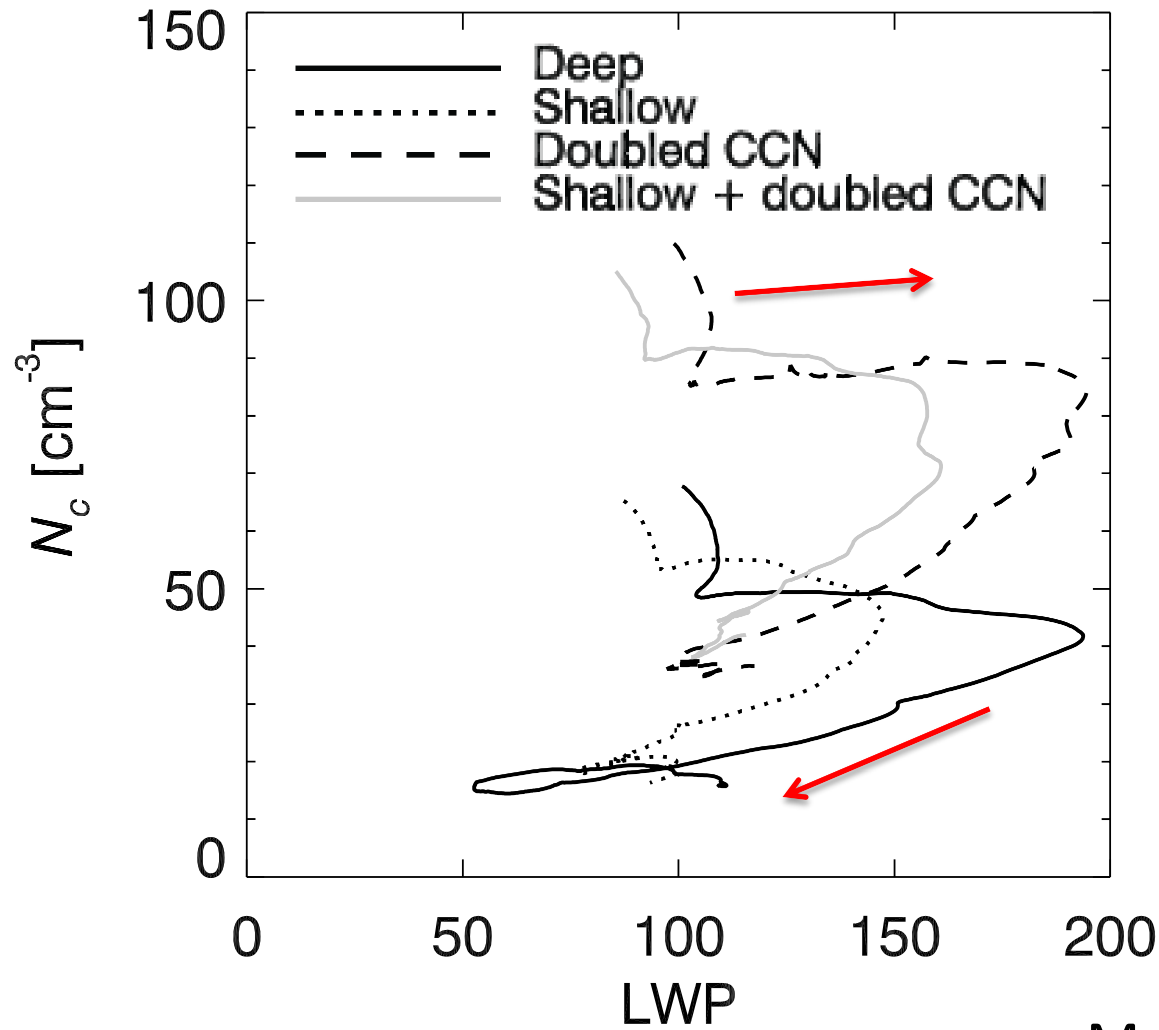
condensation C

N_c source G



N_c initial condition affects cloud lifetime by choosing which trajectory a cloud follows.

Large eddy simulations of VOCALS stratocumulus qualitatively agree



Mechem et al. 2012

Conditions at Graciosa, Azores

May-September 2009 and 2010

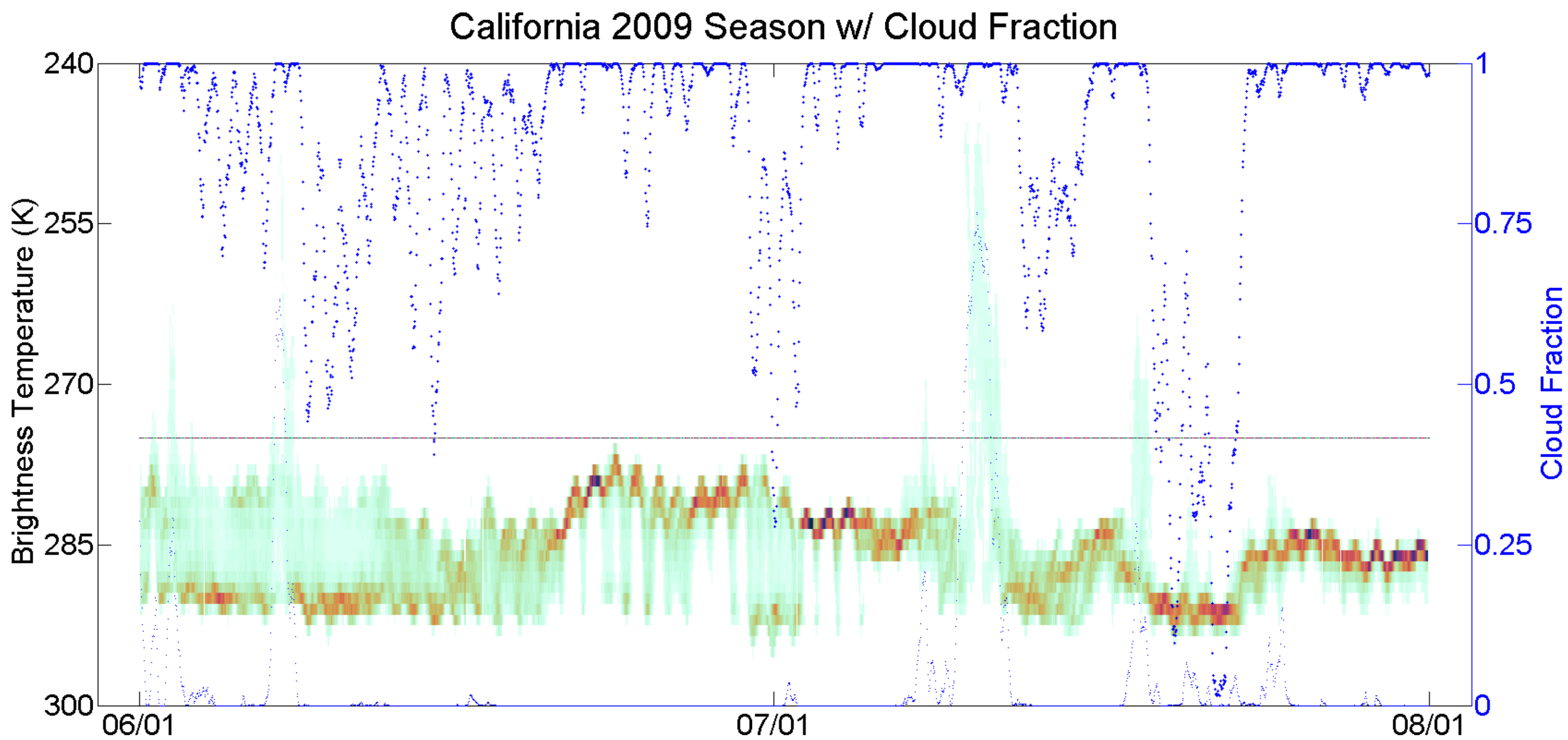
Cloud fraction time series

Composite thermodynamic soundings

- Lower tropospheric stability LTS=$\theta_{700}-\theta_{1000}$ (e.g. Klein and Hartmann 1993)
- Estimated inversion strength (EIS)
- environmental subsidence w_{800}

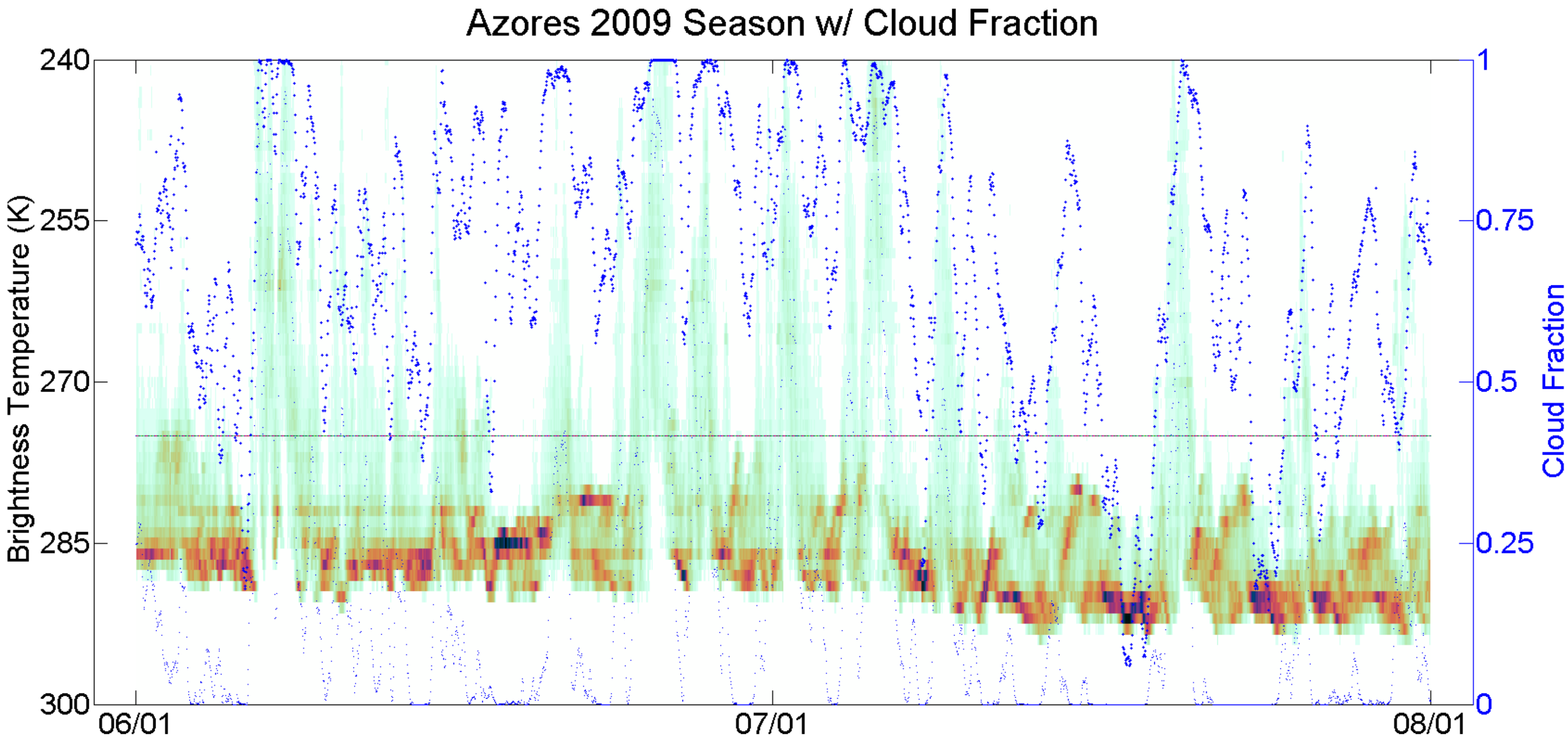
ECMWF interim

Cloud fraction from geostationary satellite IR

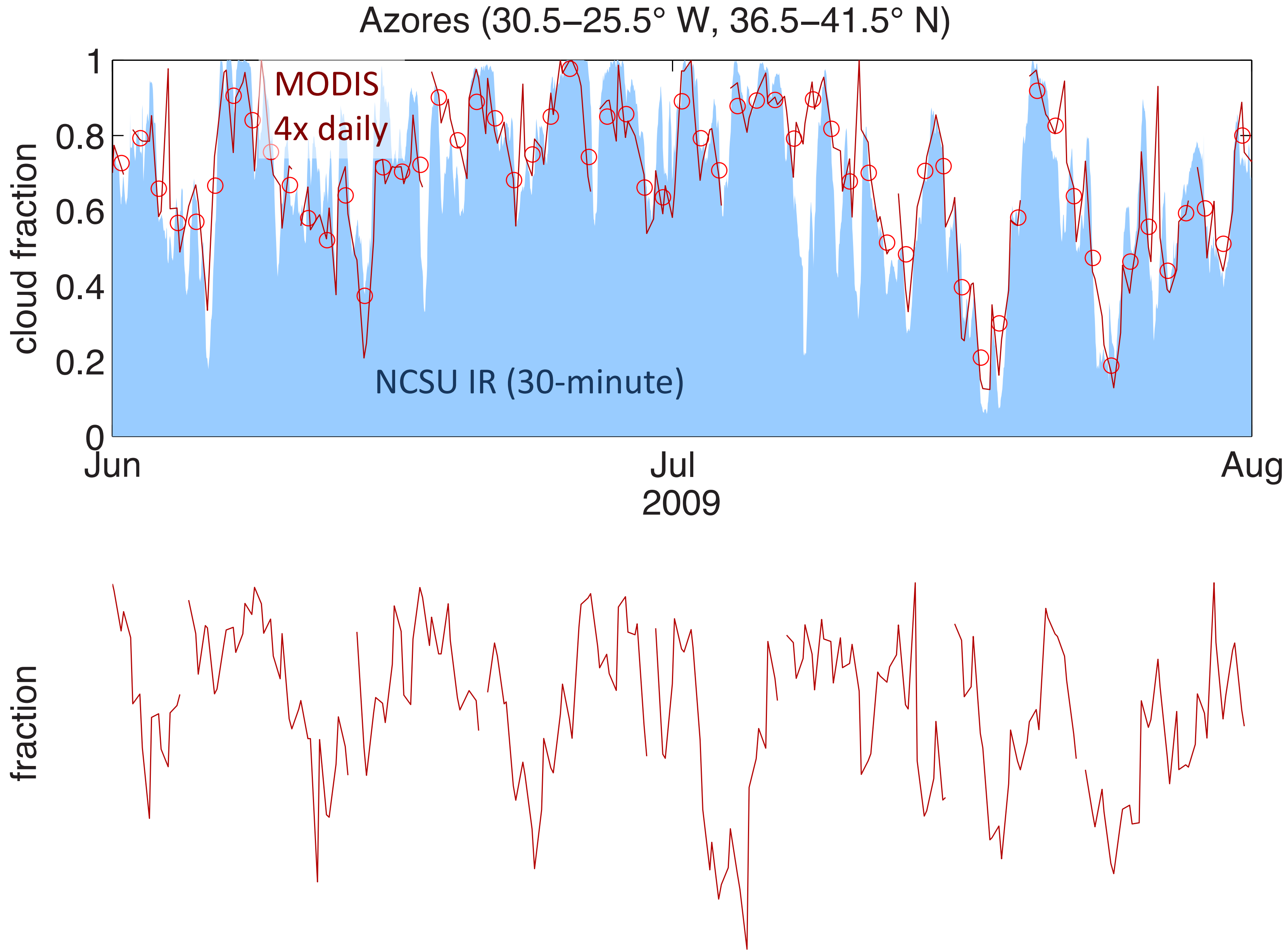


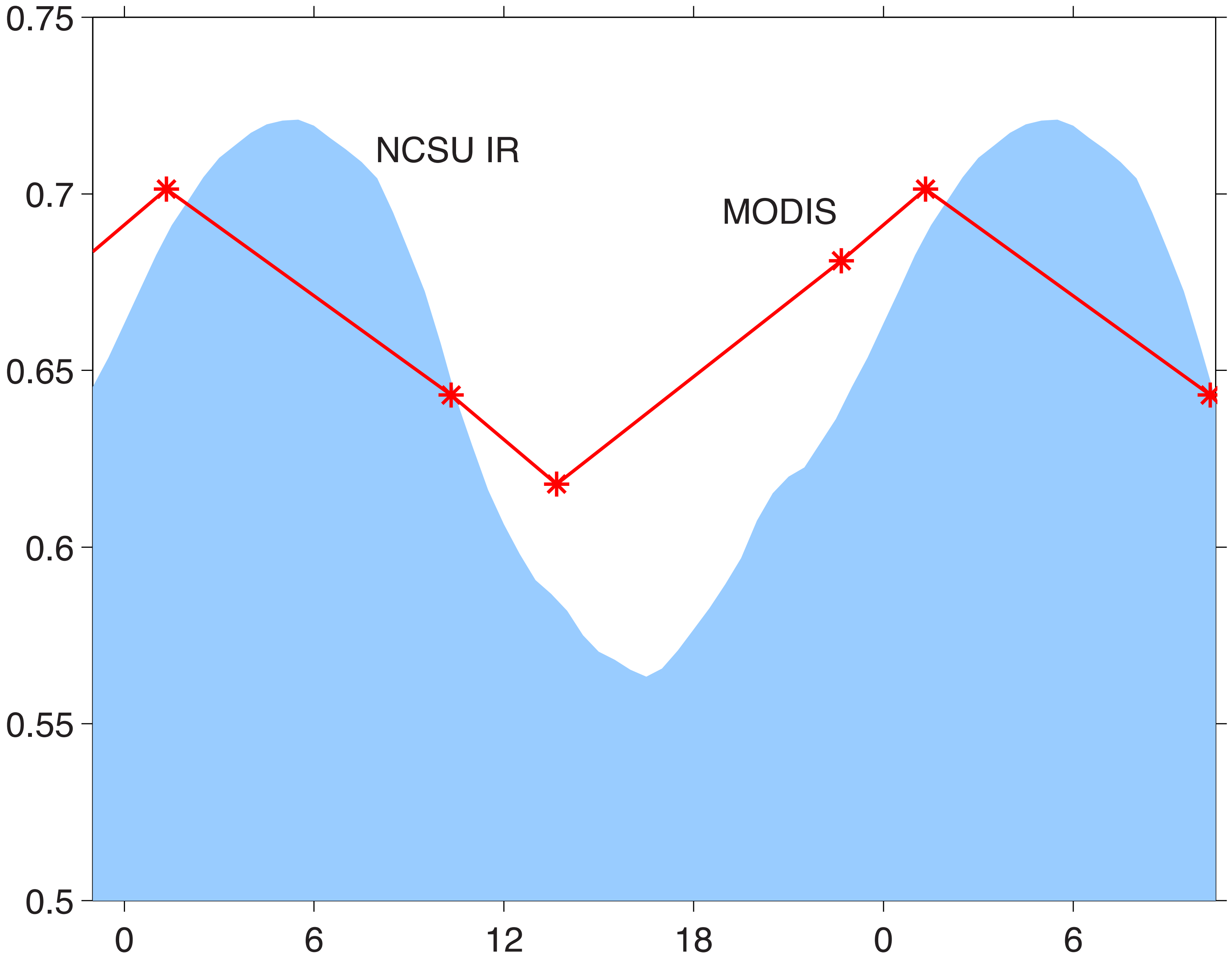
see Sandra Yuter’s poster

Azores



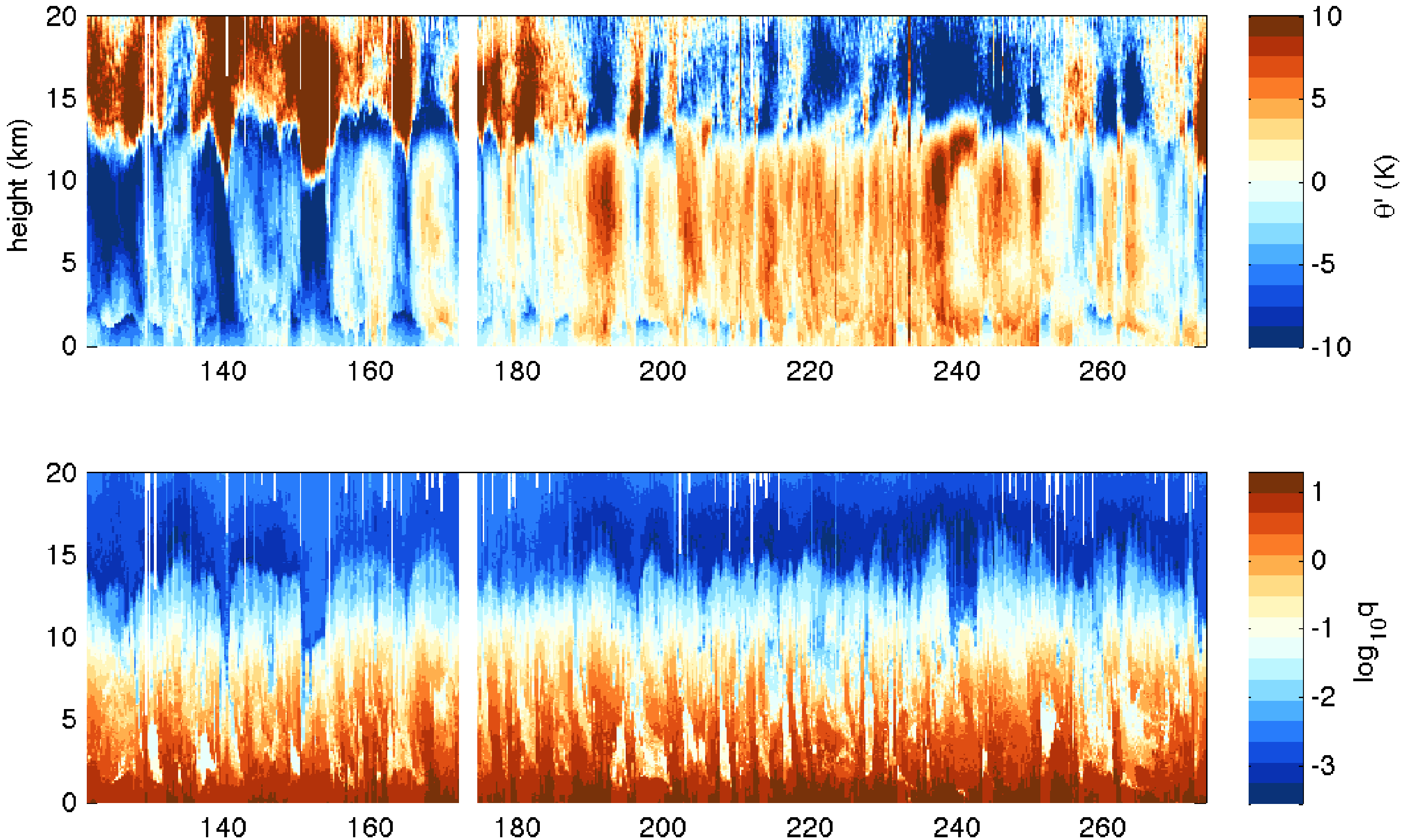
see Sandra Yuter's poster


Azores (30.5–25.5° W, 36.5–41.5° N)
MODIS
4x daily
NCSU IR (30-minute)
cloud fraction
0
0.2
0.4
0.6
0.8
1
Jun
Jul
Aug
2009
fraction



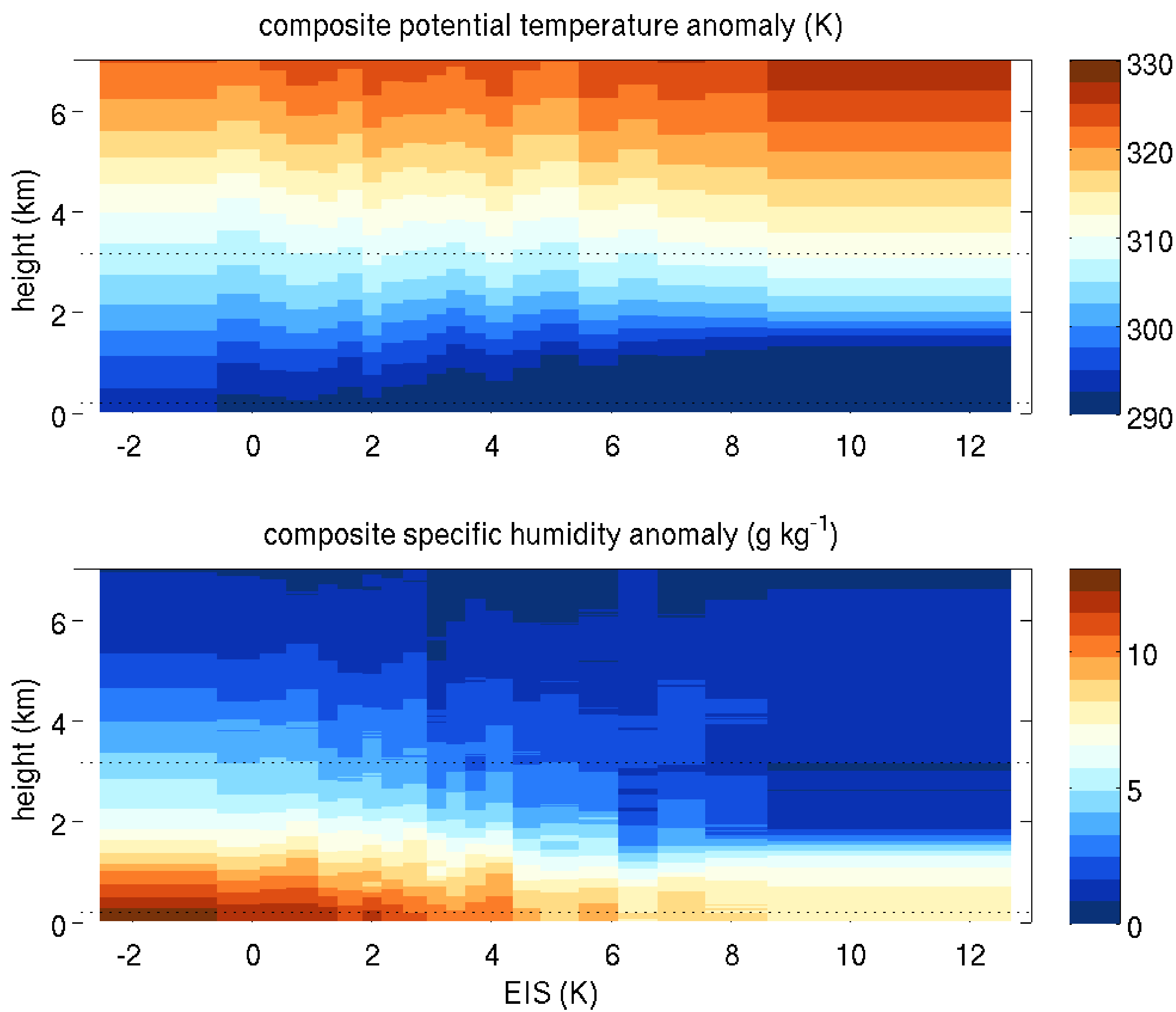
0.75
0.7
0.65
0.6
0.55
0.5
NCSU IR
MODIS
0
6
12
18
0
6

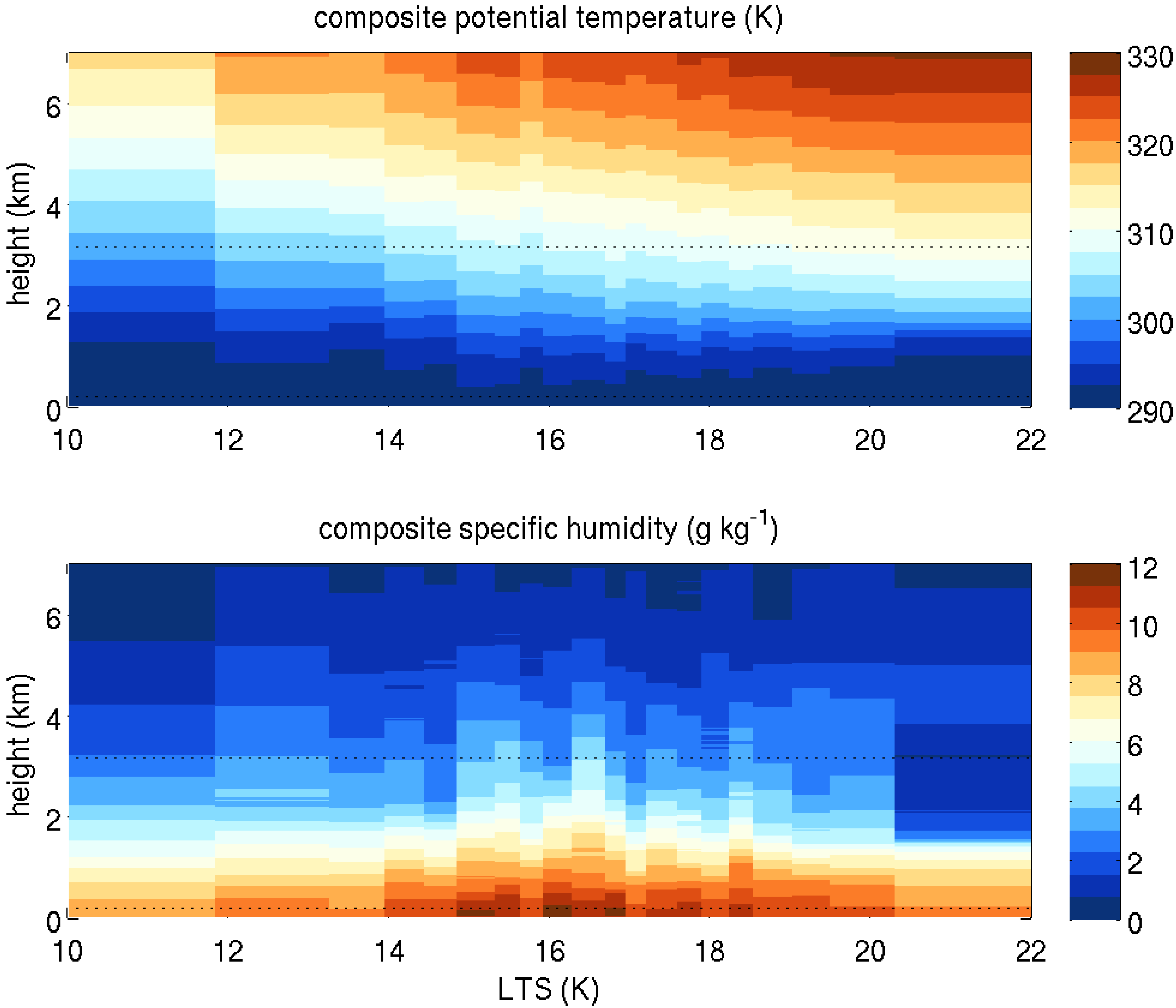
Graciosa, Azores soundings May-September 2009

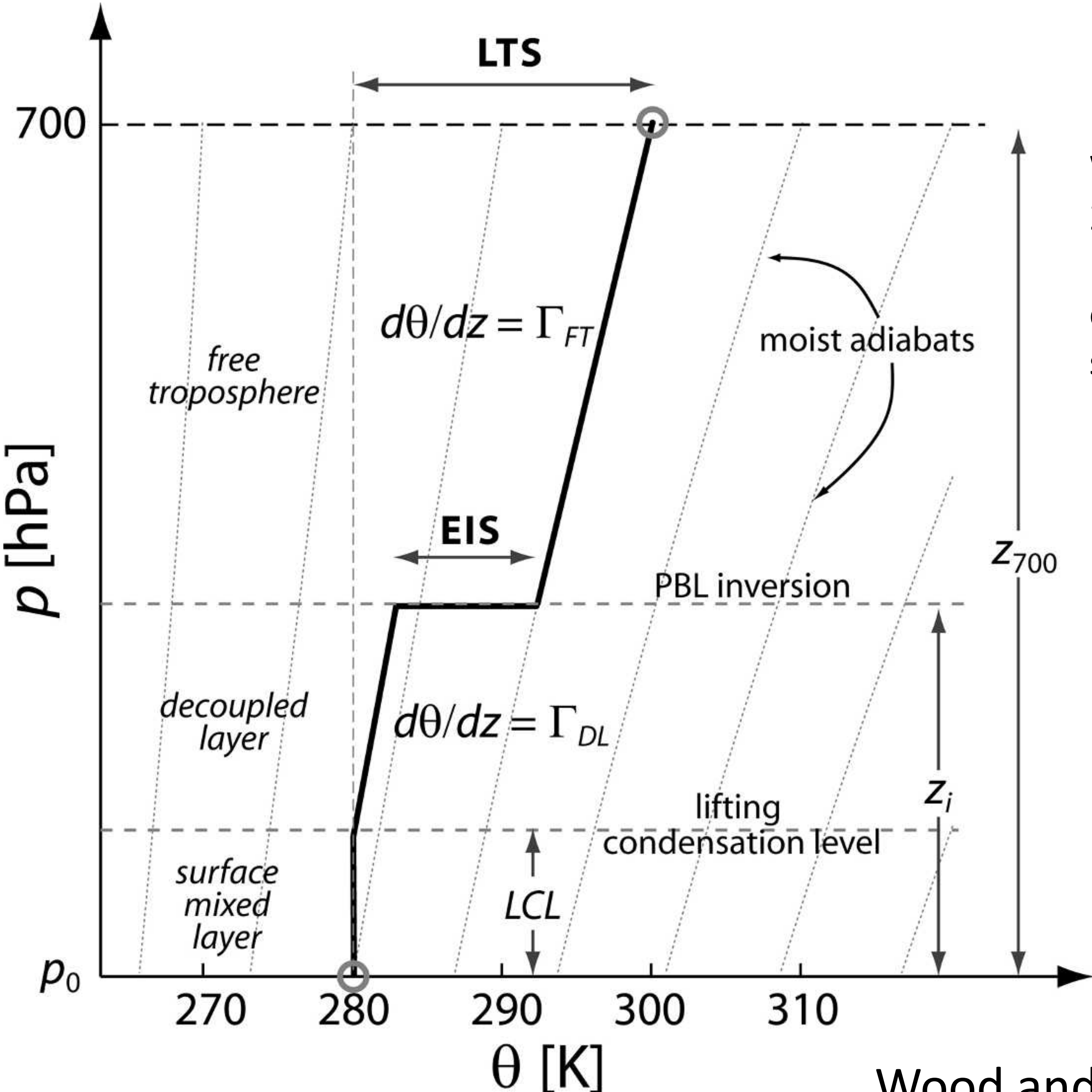


seasonal, synoptic, and diurnal variability

How will we formulate cases to study processes?


composite potential temperature anomaly (K)
height (km)
6
4
2
0
-2
0
2
4
6
8
10
12
330
320
310
300
290
composite specific humidity anomaly (g kg-1)
height (km)
6
4
2
0
-2
0
2
4
6
8
10
12
EIS (K)
10
5
0

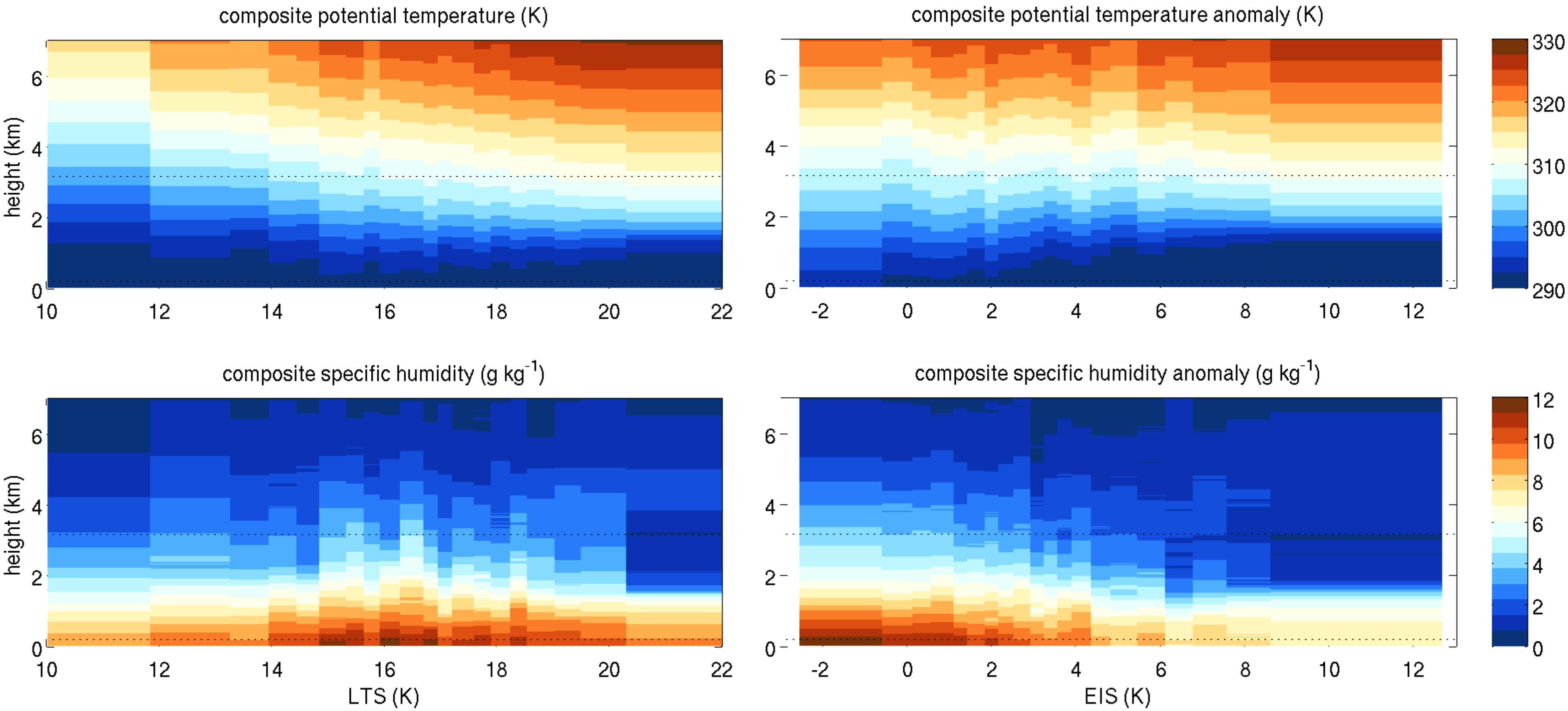

composite potential temperature (K)
height (km)
0
2
4
6
10
12
14
16
18
20
22
290
300
310
320
330
composite specific humidity (g kg-1)
height (km)
0
2
4
6
10
12
14
16
18
20
22
LTS (K)
0
2
4
6
8
10
12



Wood and Bretherton 2006:

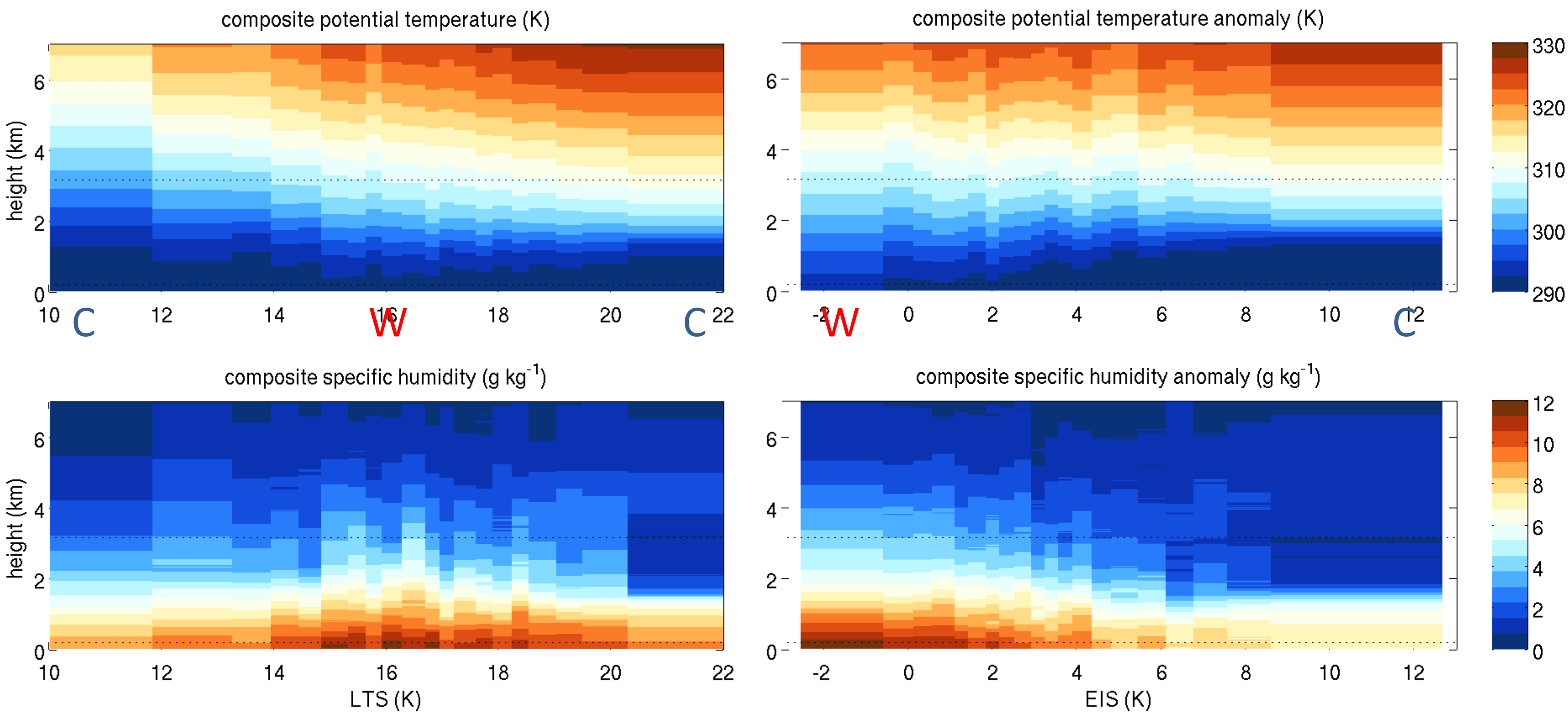
estimated inversion strength
EIS = LTS–moist adiabatic stability

Wood and Bretherton 2006


composite potential temperature (K)
composite potential temperature anomaly (K)
composite specific humidity (g kg-1)
composite specific humidity anomaly (g kg-1)
height (km)
height (km)
LTS (K)
EIS (K)
0 2 4 6
10 12 14 16 18 20 22
-2 0 2 4 6 8 10 12
290 300 310 320 330
0 2 4 6 8 10 12

LTS

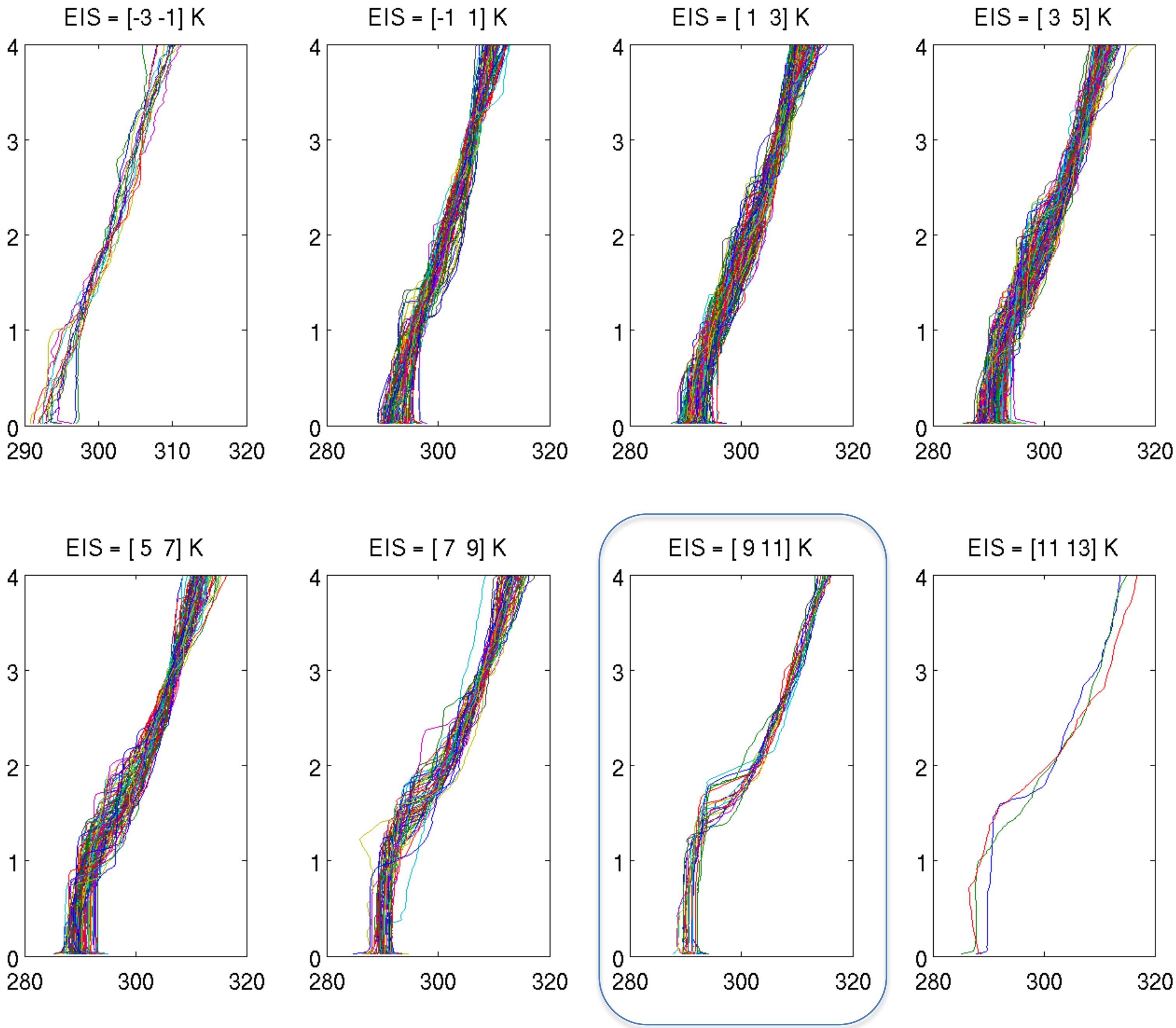
EIS



composite potential temperature (K)
composite potential temperature anomaly (K)
composite specific humidity (g kg^{-1})
composite specific humidity anomaly (g kg^{-1})
height (km)
height (km)
C
W
C
W
C
LTS (K)
EIS (K)
330
320
310
300
290
12
10
8
6
4
2
0

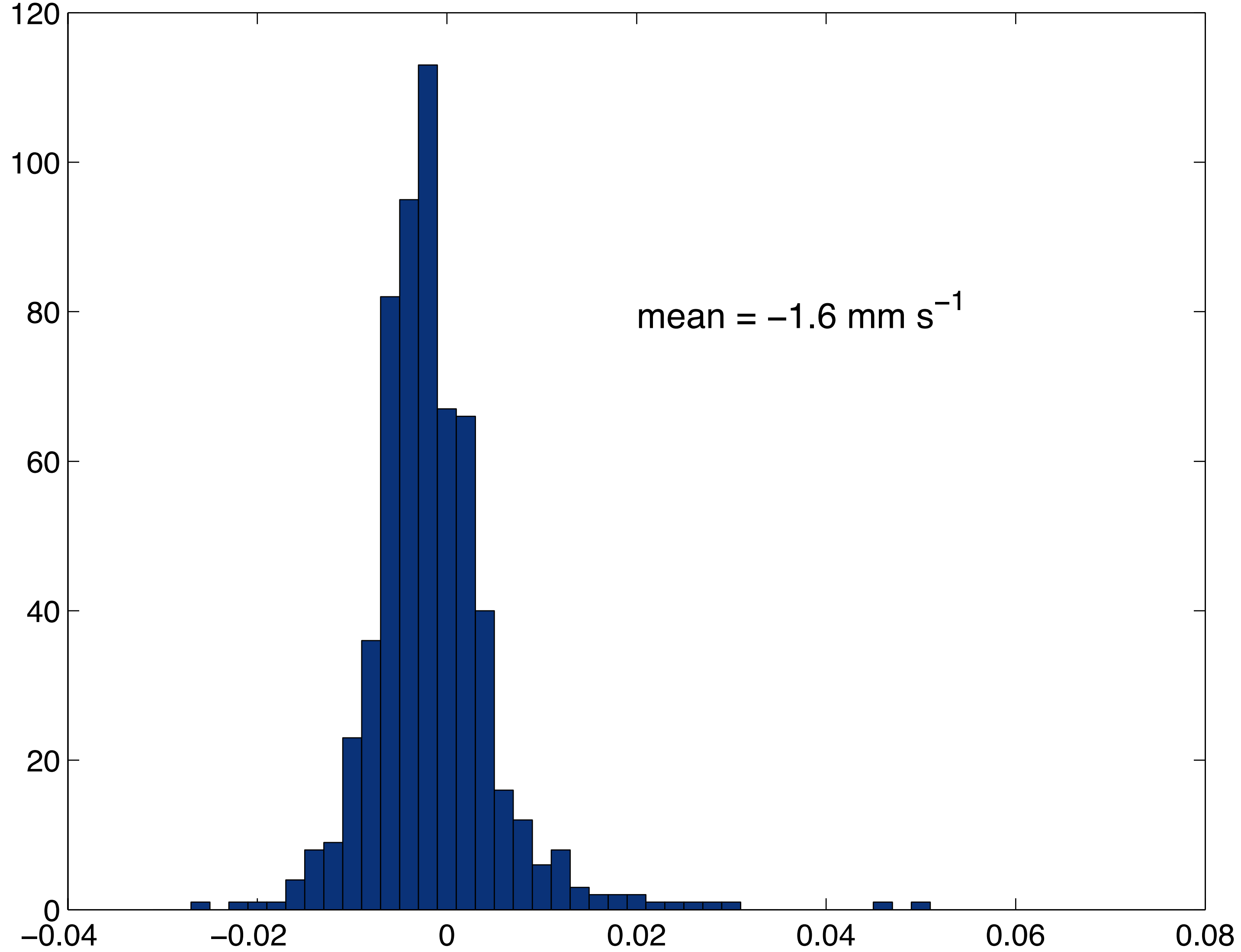
LTS

EIS

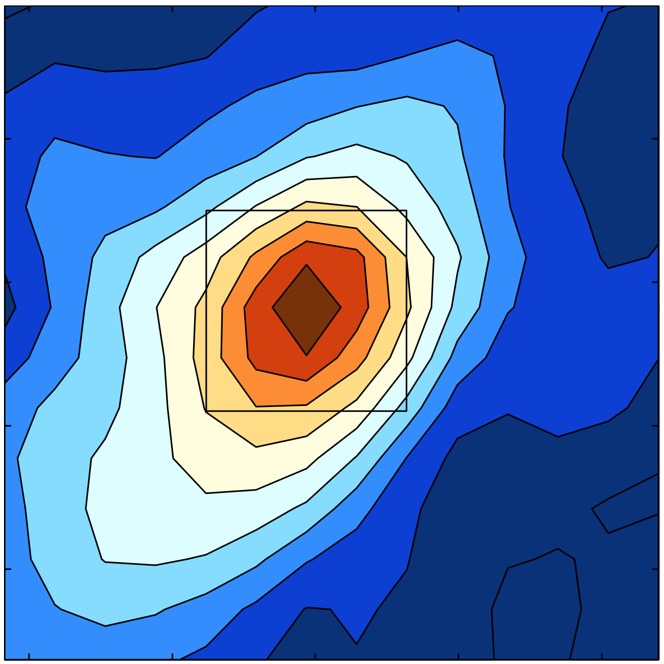


EIS = [-3 -1] K
EIS = [-1 1] K
EIS = [1 3] K
EIS = [3 5] K
EIS = [5 7] K
EIS = [7 9] K
EIS = [9 11] K
EIS = [11 13] K
0
1
2
3
4
290
300
310
320
280

considerable w_{800} variability



scale of *w* variability



ag autocorrelation

days

consistent with
synoptic waves

decorrelated in
<6 hours

Summer 2009, 2010 correlation summary

	cloud	EIS	w
cloud		-0.13	0.27
EIS	-0.13		-0.24
w	0.27	-0.24	

summary

- EIS/LTS *not* a good predictor of sub-seasonal cloud variability
- Cloud fraction related to **upward** vertical velocity w_{800}

next steps:

- Model stratocumulus cloud dynamics in near-LES cases
- Compare to radar observations
- Test simple models