Boundary layer, cloud, and aerosol variability in the southeast Pacific coastal marine stratocumulus during VOCALS-REx

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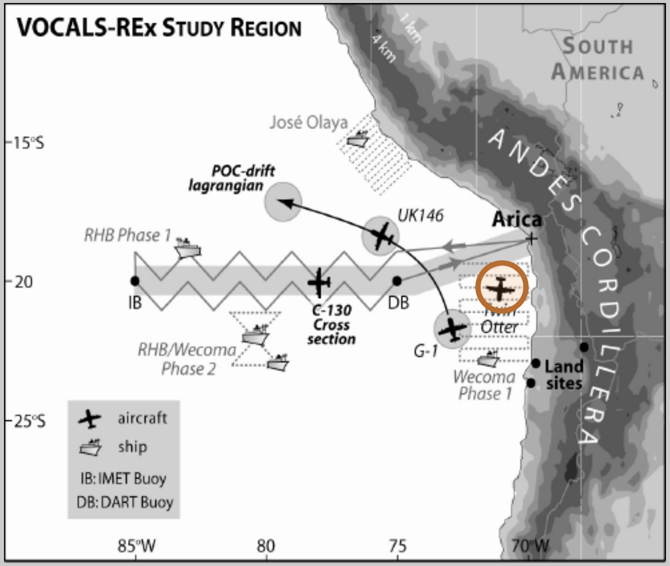
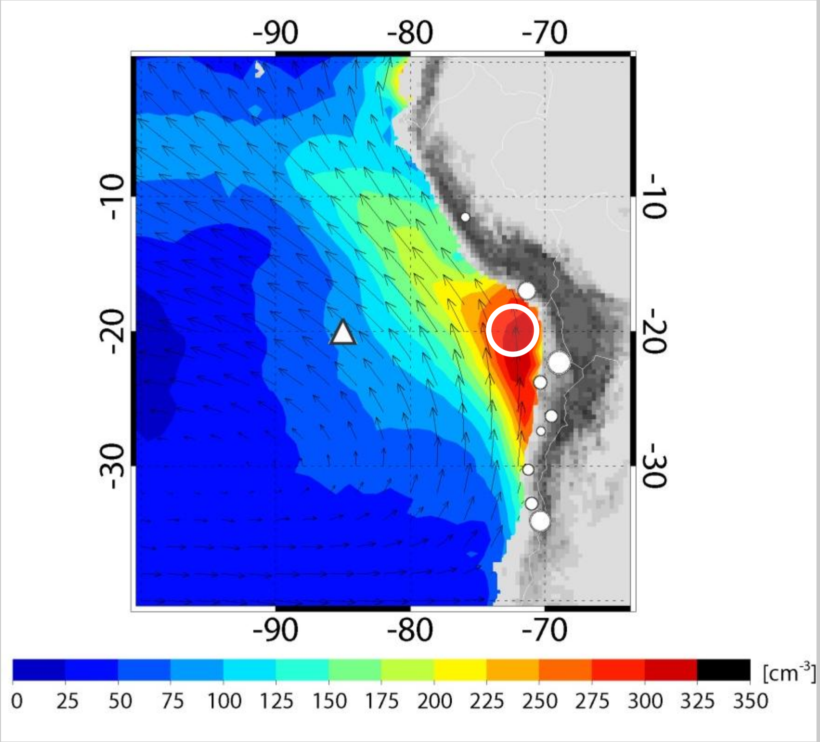
03/21/2011

Point Alpha (20ºS; 72ºW)





VOCALS--Hypothesis 1a: Aerosol-Cloud-Drizzle Interactions

From VOCALS Program Summary

Scientific objectives:

- Characterize variations of the coastal BL, clouds, and aerosols
- The first-hand evidence of cloud-aerosol-turbulence interactions in the coastal marine Sc

CIRPAS Twin Otter Instrumentation

Instrument	Observations/Purpose
Standard met	**Winds, temp, dewpoint, cloud liquid water, sfc temp**
Turbulence Probes	**High speed wind, temp, and moisture (Djamal Khelif)**
94 GHz Doppler FMCW radar	Cloud properties; in-cloud turbulence
CPCs	**Ultrafine aerosols**
PCASP	**Aerosols 0.1-3 µm**
CAS	**Clouds 2-40 µm**
CIP	**Drizzle 25-1500 µm**
CCN-200	**CCN (fast-2-point; slow-6 points)**
Phased Doppler Interferometer	**Cloud-drizzle 2-150 µm (Patrick Chuang)**
Photo-Acoustic Soot Spectrometer	Bulk soot absorption
SP2-Black Carbon; DMT	BC mass and ratio to total particles;

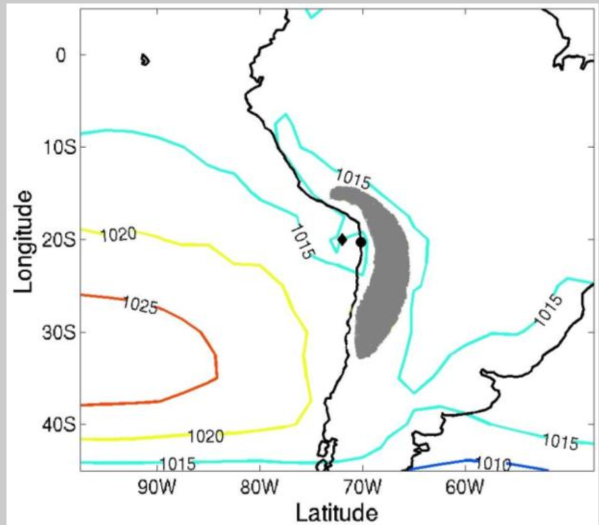
Date

10/16	**10/18**	**10/19**	**10/21**	**10/22**
10/24	**10/26**	**10/27**	10/29	10/30
11/01	11/02	11/04	11/08	**11/09**
11/10	**11/12**	11/13		

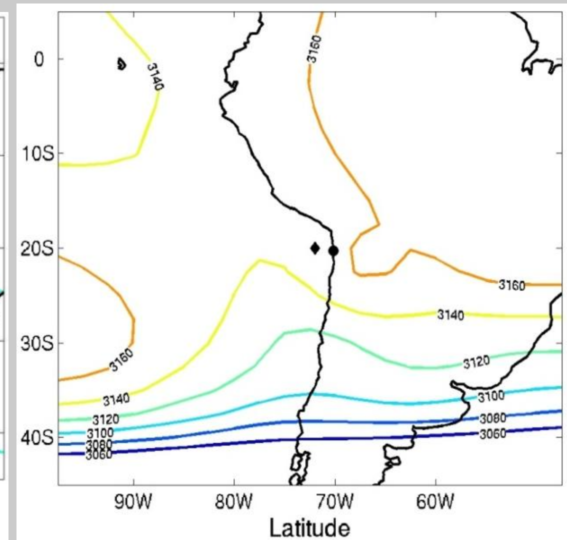
Synoptic Conditions

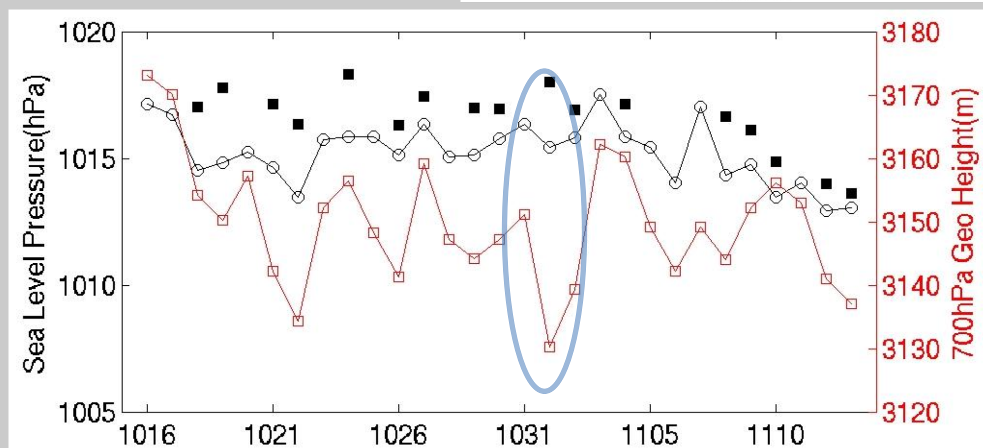
- Subtropical high, a low-level trough, and a mid-latitude trough
- ~ Oct. 29 – Nov. 4 an intense mid-latitude disturbance. (Rahn and Garreaud, 2010; Toniazzo et al., 2011)

SLP



700-hPa

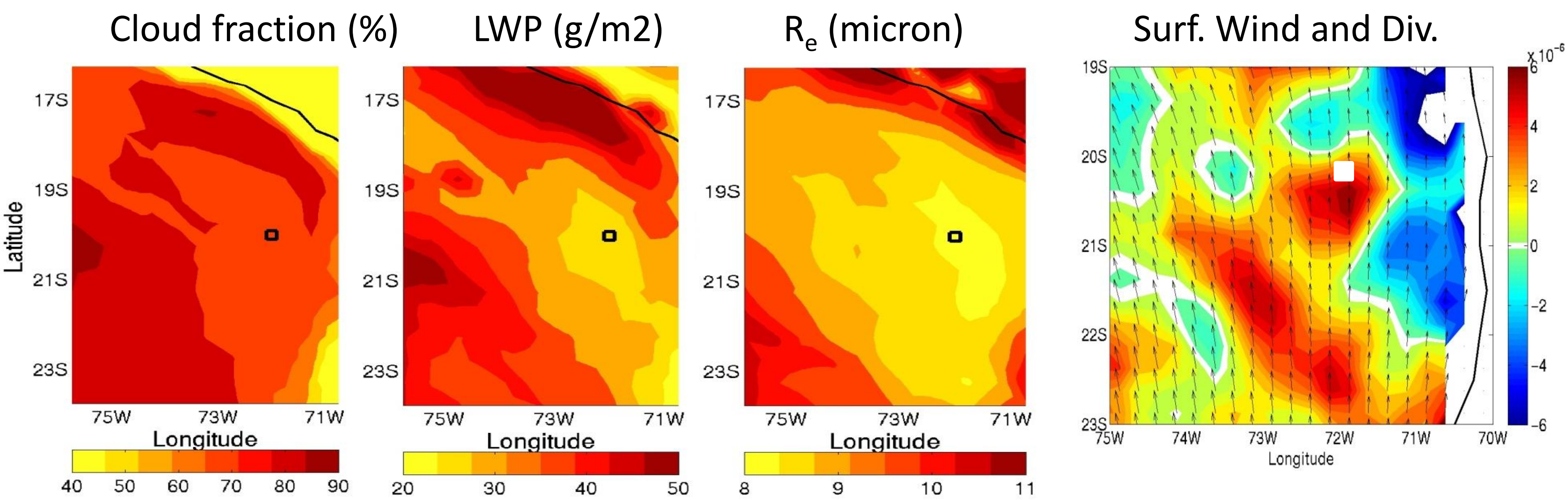




Point Alpha

NCEP/NCAR Reanalysis

Composite Fields from Satellite Observations

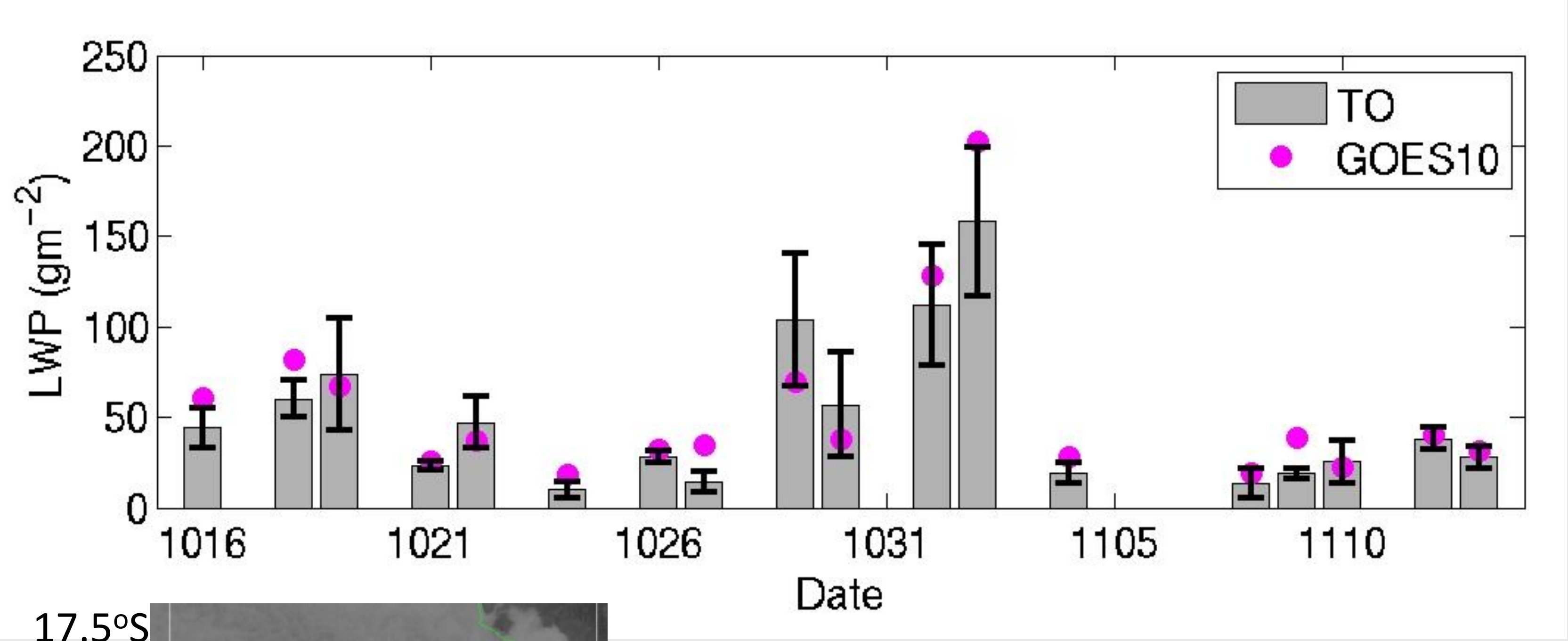


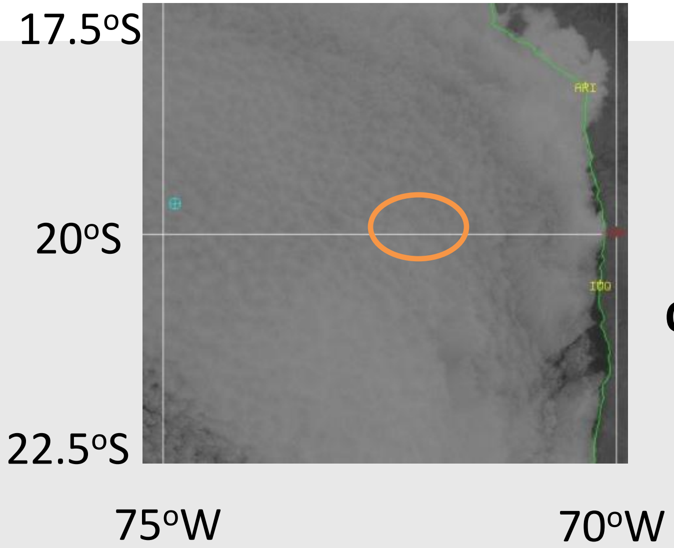
GOES-10 from Minnis and Ayers

QuikSCAT

- Generally solid cloud
- Relatively low LWP and R_e → thin and polluted cloud
- QuikSCAT surf. wind: 4.1±1.5 ms^{-1} , 175^o (Southerly wind)
- Average Div: ~ $3X10^{-6}$ s^{-1}

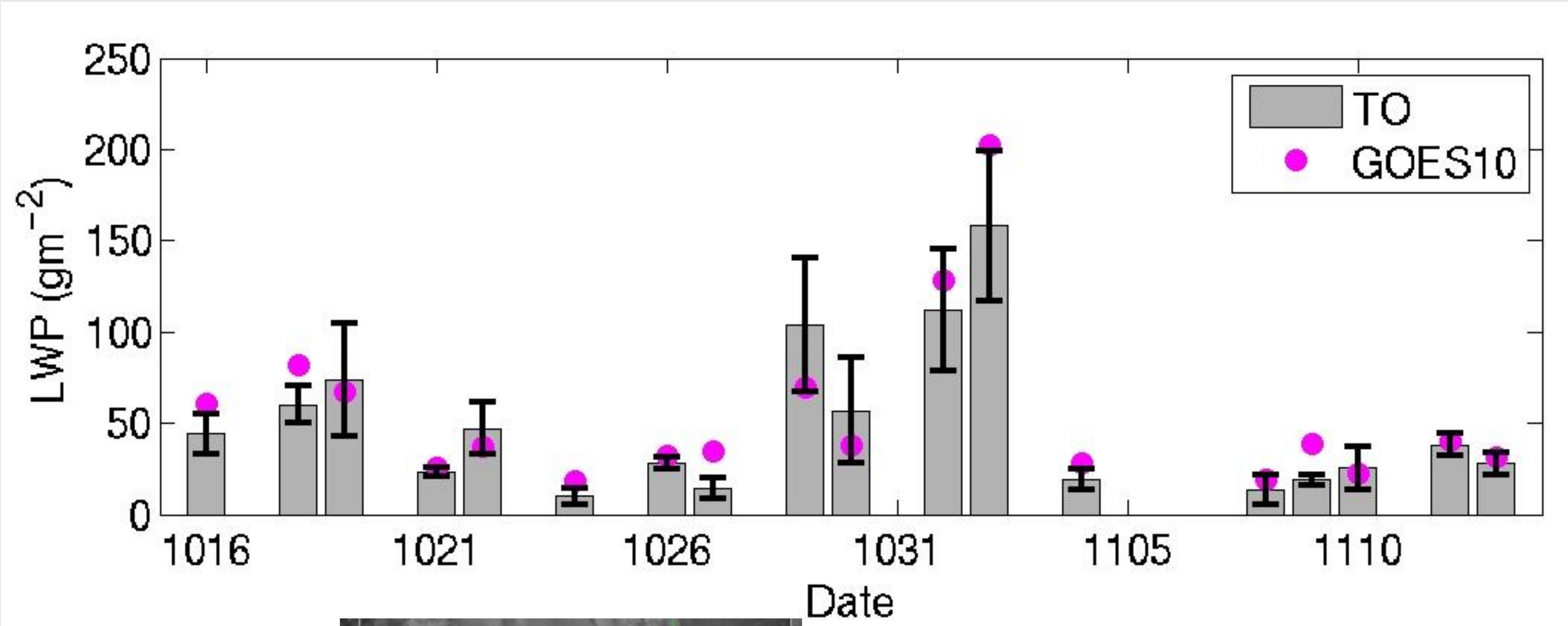
Cloud Liquid Water Path





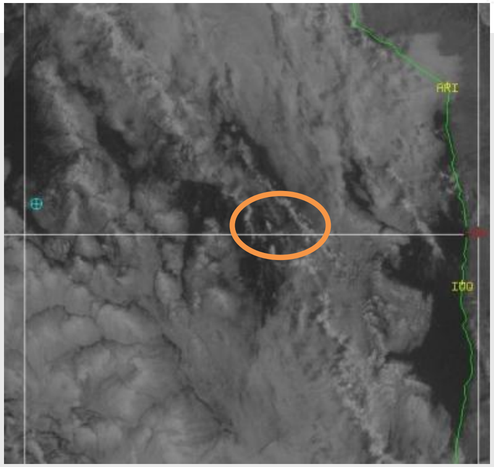
Oct. 19 GOES10 Ch1

Cloud Liquid Water Path



17.5°S

20°S



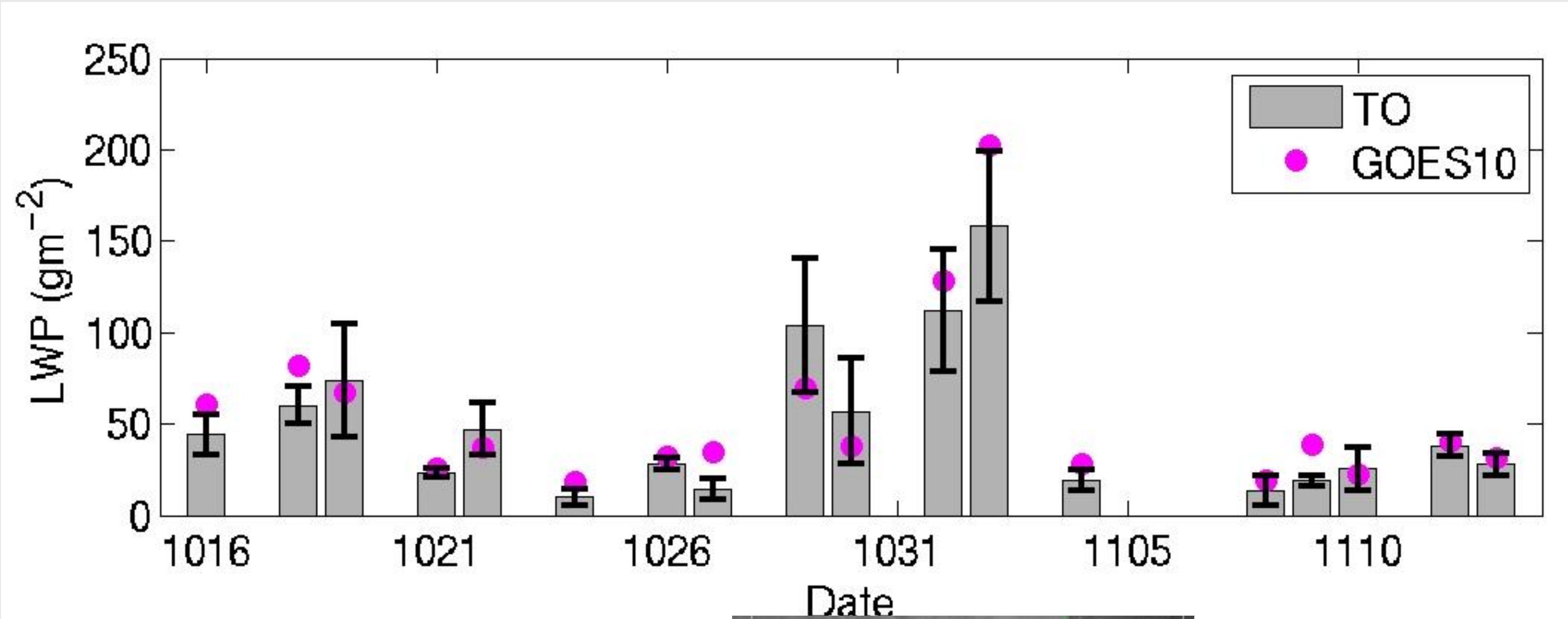
Oct. 24

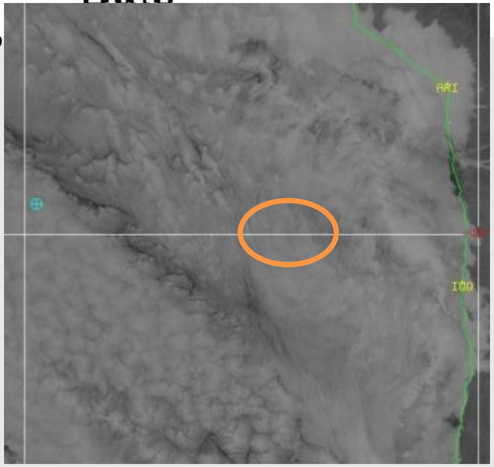
22.5°S

75°W

70°W

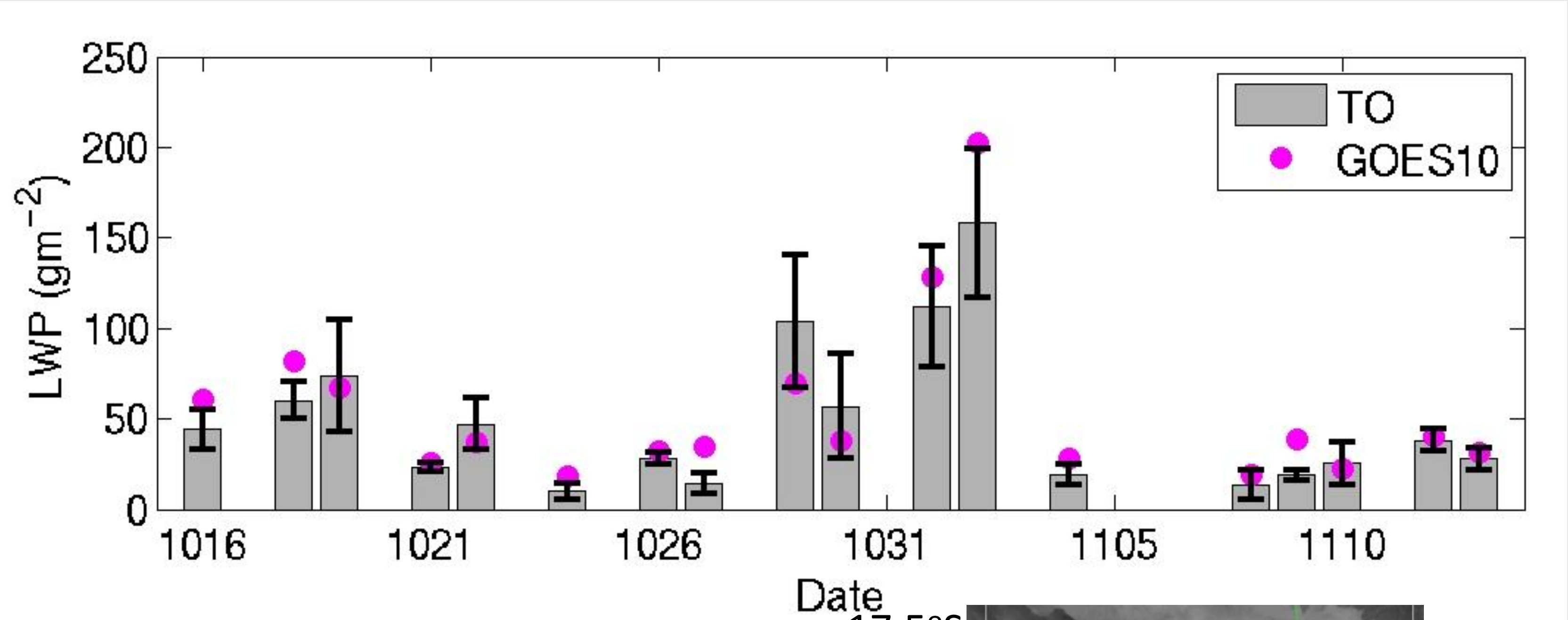
Cloud Liquid Water Path

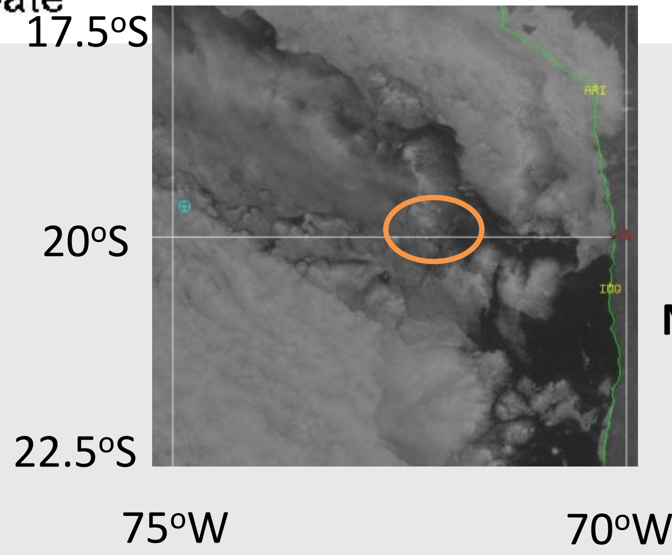




Nov. 1

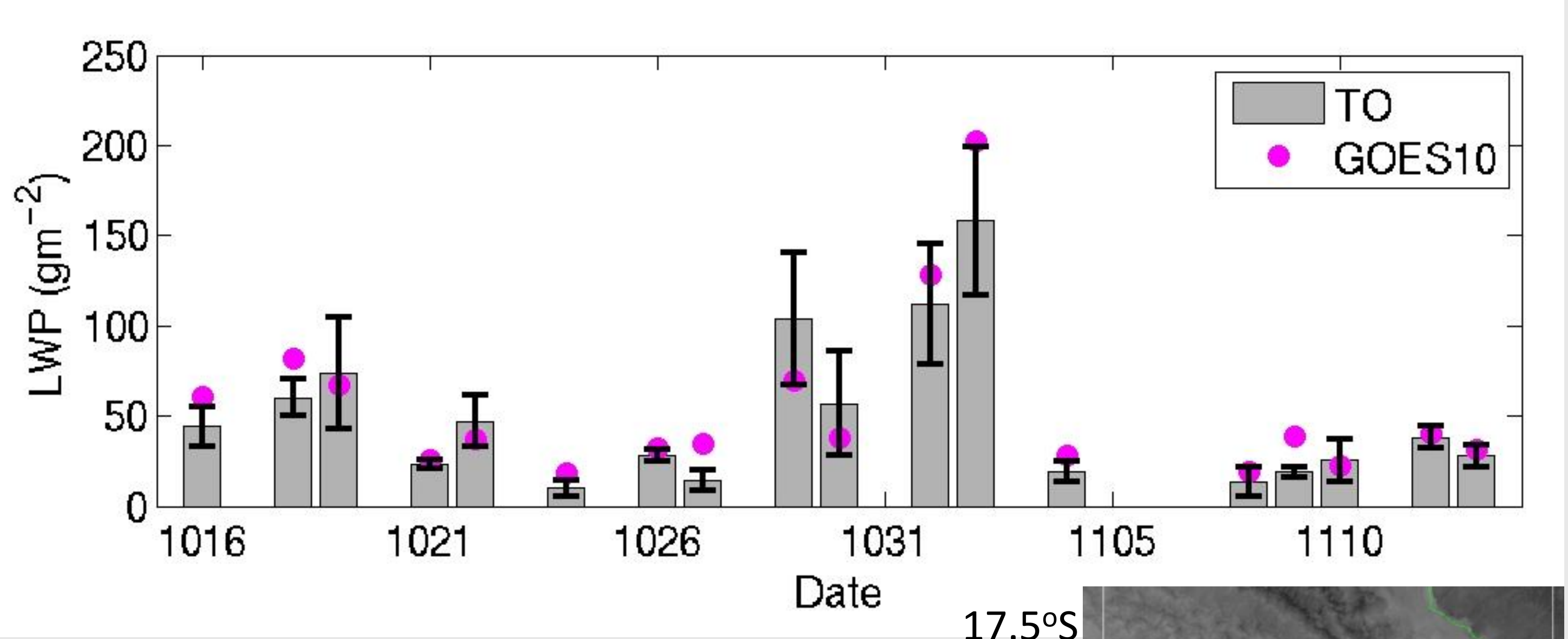
Cloud Liquid Water Path





Nov. 8

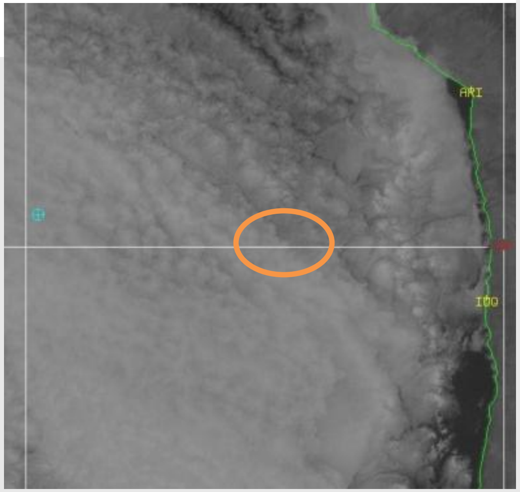
Cloud Liquid Water Path



17.5°S

20°S

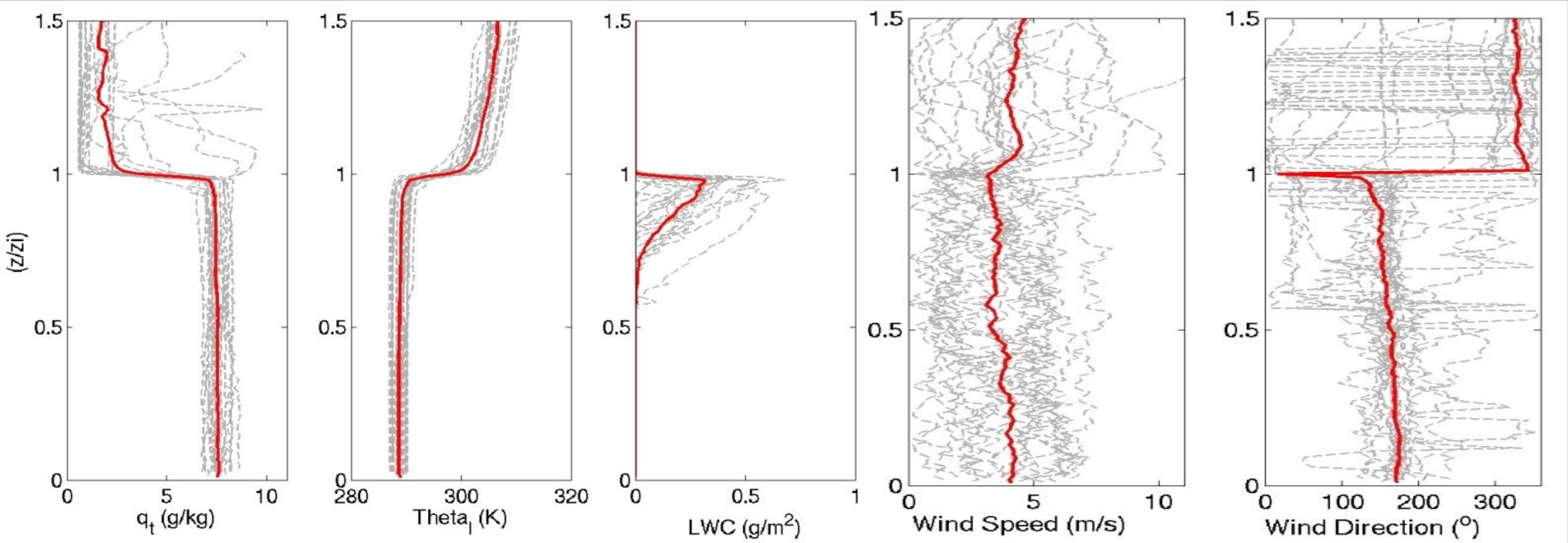
Nov. 12



22.5°S

75°W 70°W

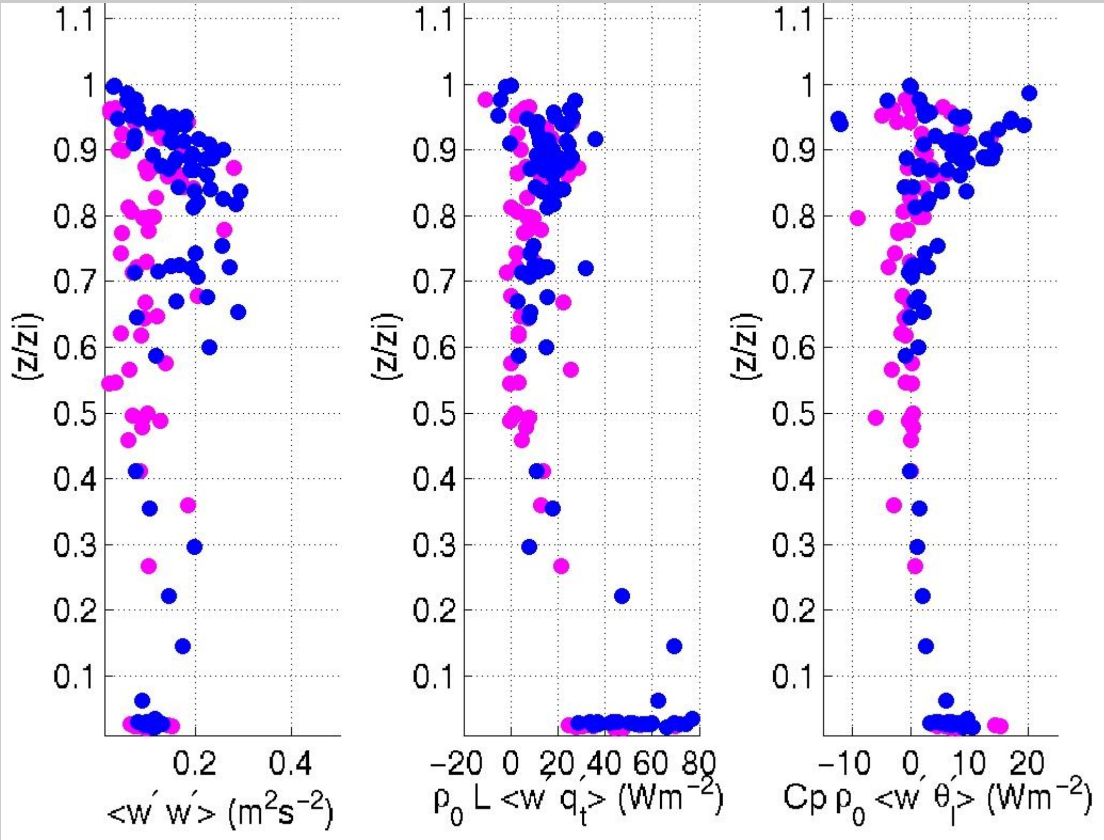
Boundary Layer Structure



- Well mixed BL with strong inversion
- Relatively low wind speed with strong veritical wind shear
- Some complications involving wind shear within the BL, moist layers above, strong decoupled BL with cumulus below

Turbulence structure

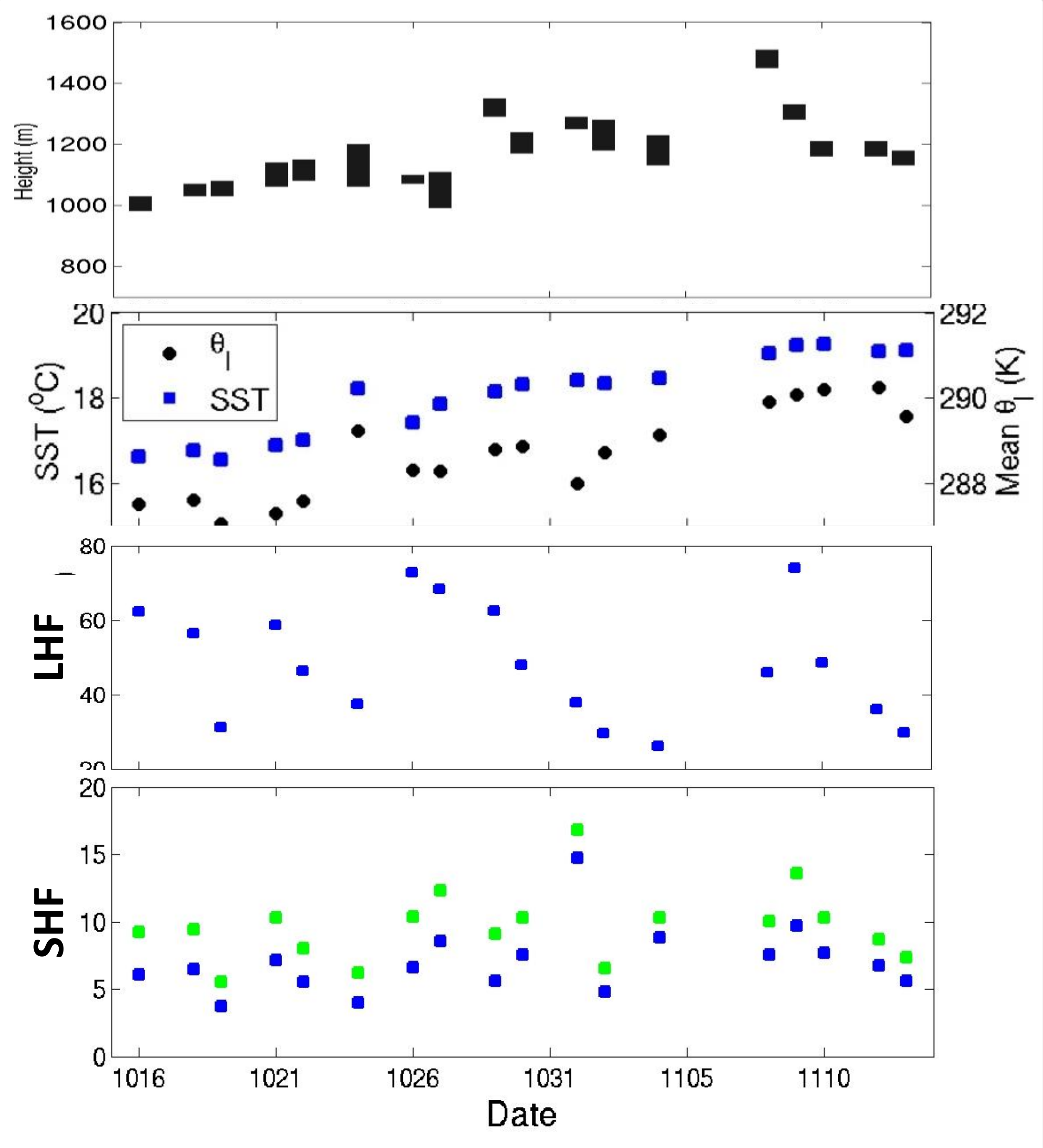
- Relatively weak turbulence in the BL
- Entrainment rates (average of 1.5±0.6 mms^{-1})
- Cloud top radiative cooling



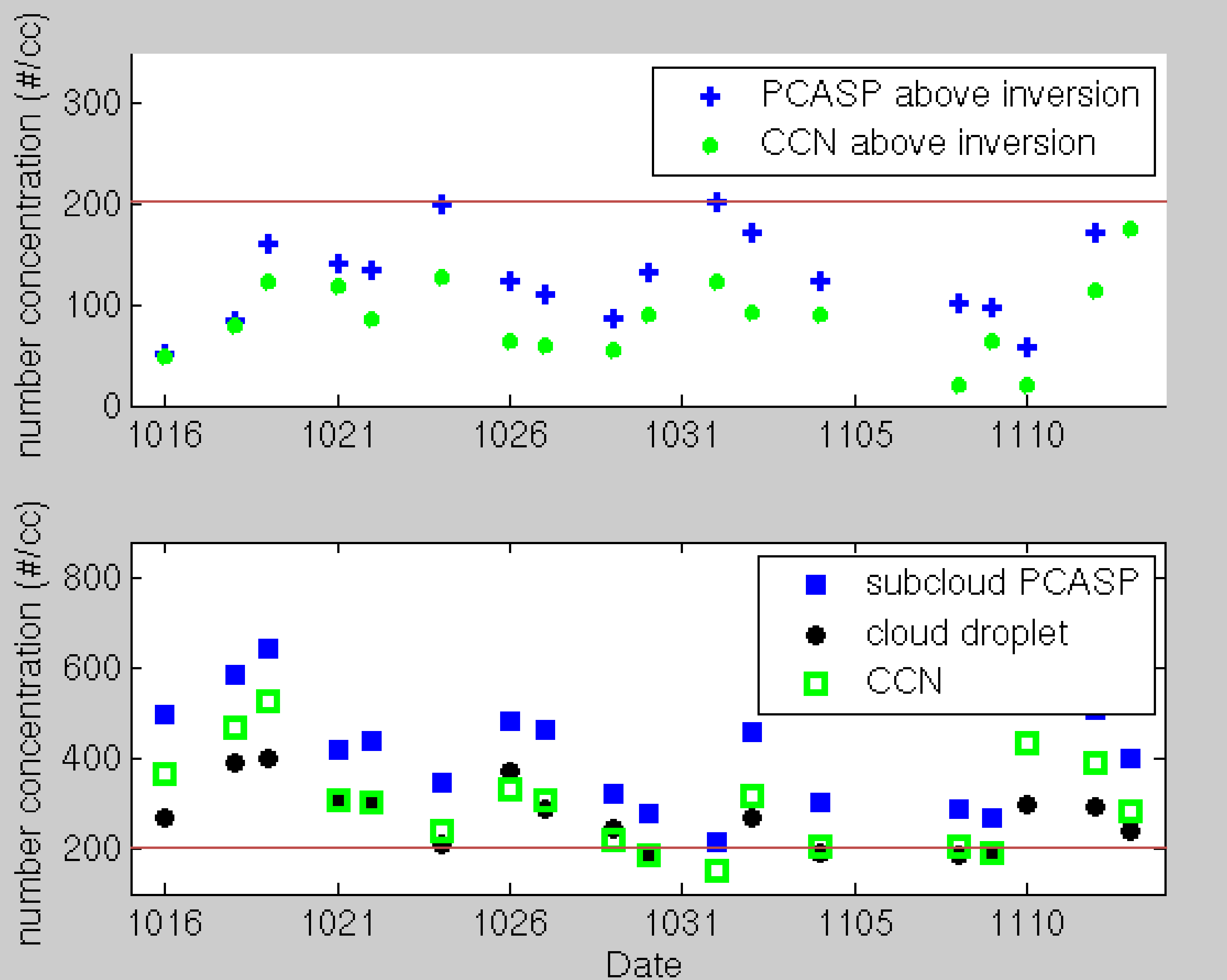
Vertical vel. variance total water flux heat flux

BL Variations

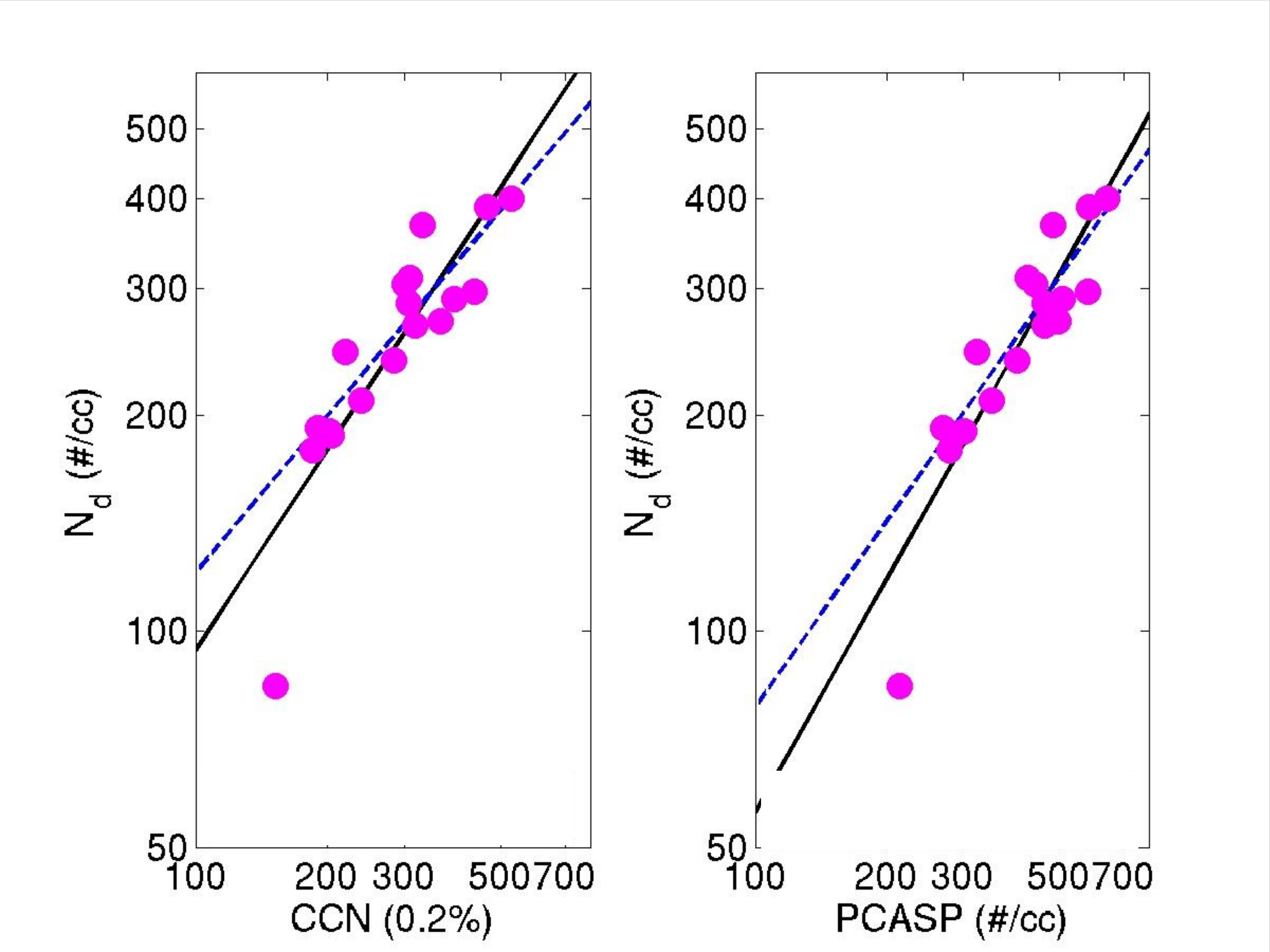
- Inversion height varied between 1000 and 1500 m
- SST gradually increased
- the 30-m fluxes



Aerosol and Cloud Properties



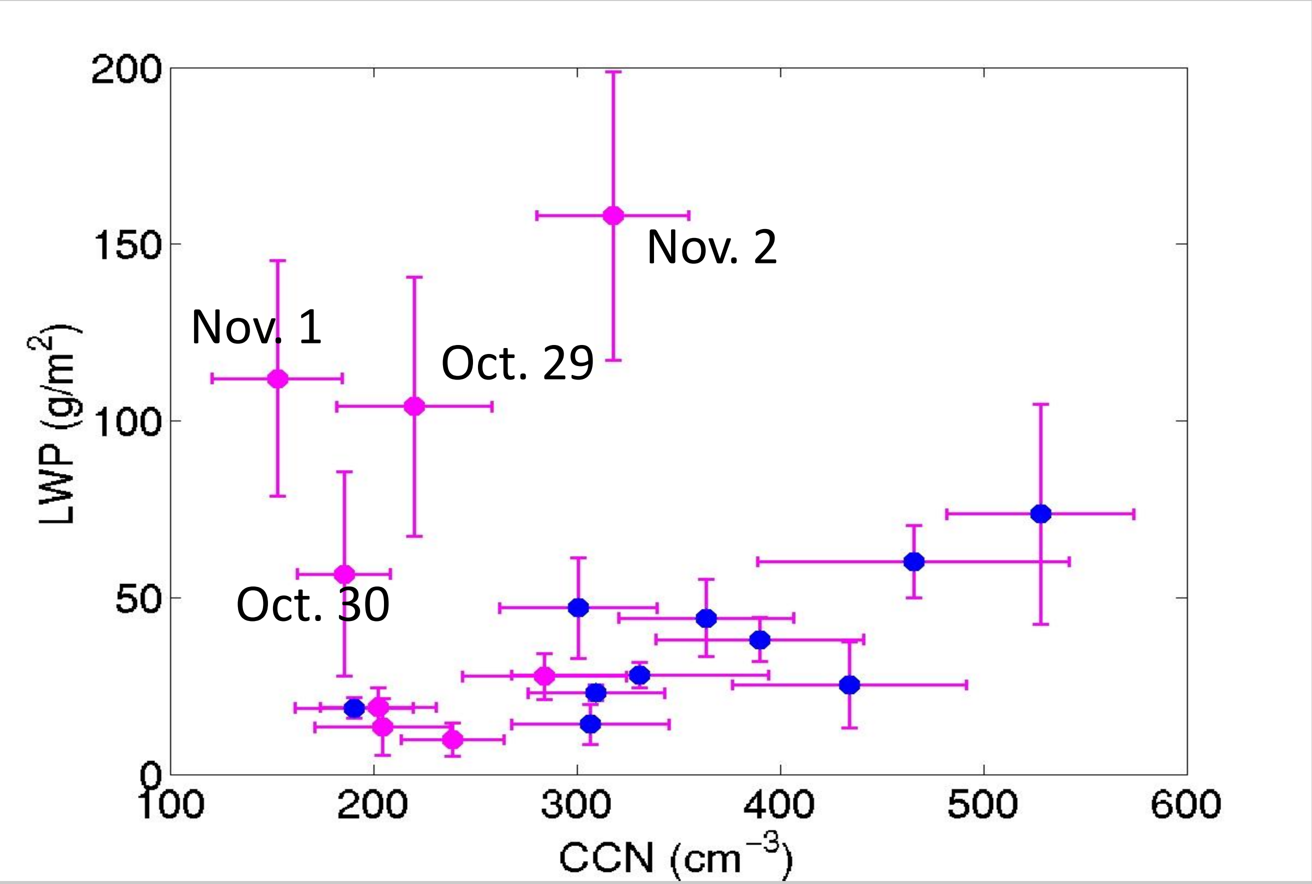
Aerosol Indirect Effect



$$\frac{dlnN_d}{dlnCCN} = 0.92, 0.72$$

$$\frac{dlnN_d}{dlnN_a} = 1.07, 0.86$$

LWP and Sub-cloud CCN



(Zheng et al. GRL 2010)

Conclusions

- Typical non-drizzling, well-mixed stratocumulus topped BL on days when synoptic and meso-scale influences are small
- Aerosol variability driven by boundary layer flow and processes.
- Entrainment rates and turbulence were weaker than that in the BL over the open ocean west of Point Alpha and the BL off the coast of the NE Pacific *(Bretherton et al. 2010; Stevens et al. 2005)*.
- During the typical well-mixed BL days, the LWP increased with the CCN concentrations *(Zheng et al. GRL 2010)*
- On the other hand, meteorological factors and the decoupling processes can have large influences on the cloud LWP variations