Laboratory for Atmospheric and Space Physics
University of Colorado **Boulder**

ATOC

PBL analysis by Combining Raman and Doppler Lidar Measurements

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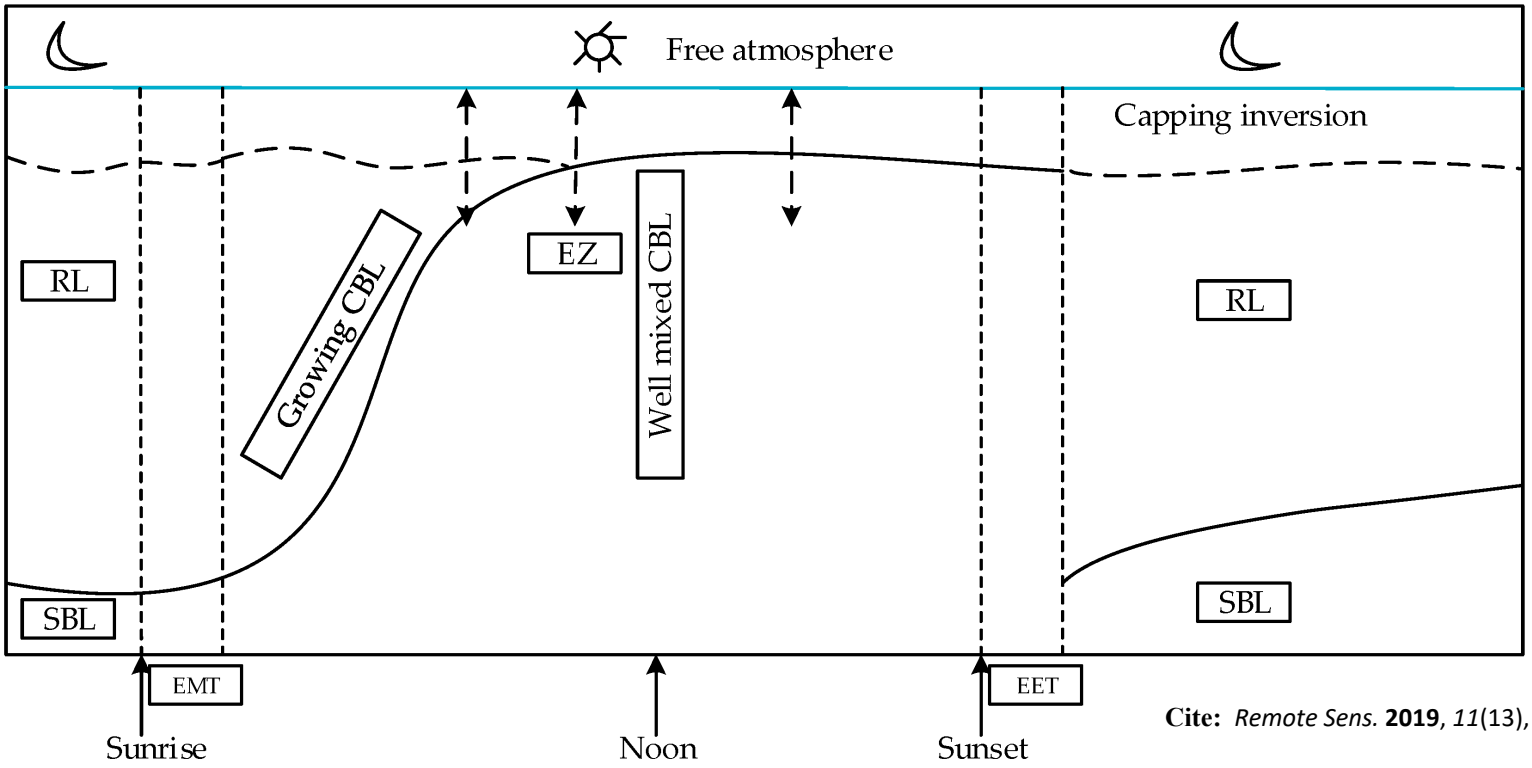
1. Introduction



Cite: *Remote Sens.* **2019**, *11*(13), 1590;

1. **Daytime** ML developments are closely **coupled with nighttime** PBL properties. It is necessary to know **both** PBL and ML properties to Characterize PBL evolution and impact.

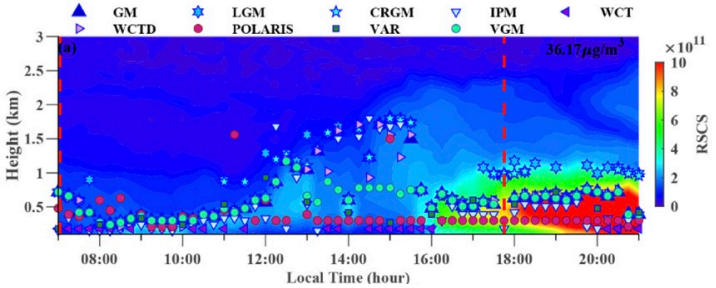
2. **PBLH** and **MLH** are the critical parameters for PBL/ML development and vertical vapor transport.

MLH: the height from the ground to mixing layer top

PBLH: the height from the ground to the base of capping inversion

Issues and approach:

1. Aerosol vertical structures over the land are **challenging** to provide an accurate **PBLH** all the time

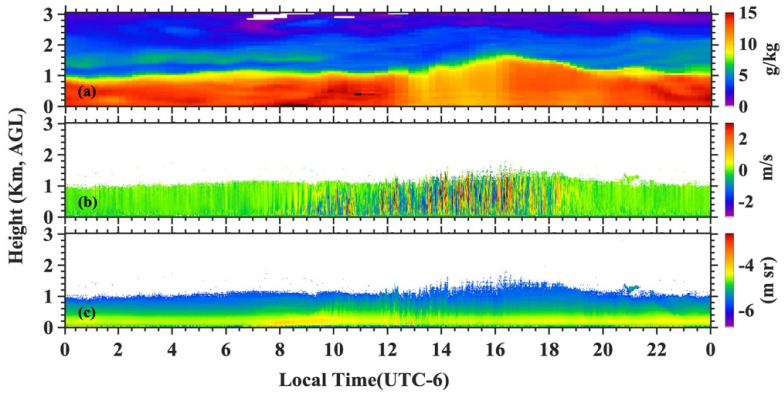


Evolution of the Lidar RSCS signal at 1064 nm and different symbols mark the PBLHs retrieved from the nine algorithms on Feb. 11, 2017. **Cite:** Atmospheric Research 253 (2021) 105483.

2. The **vertical wind variance** is used to determine **MLH, but still has challenging:**

1) diurnal and seasonal turbulence variations
2) the effect of gravity waves
3) the choice of signal noise ratio
4) the different eddy size

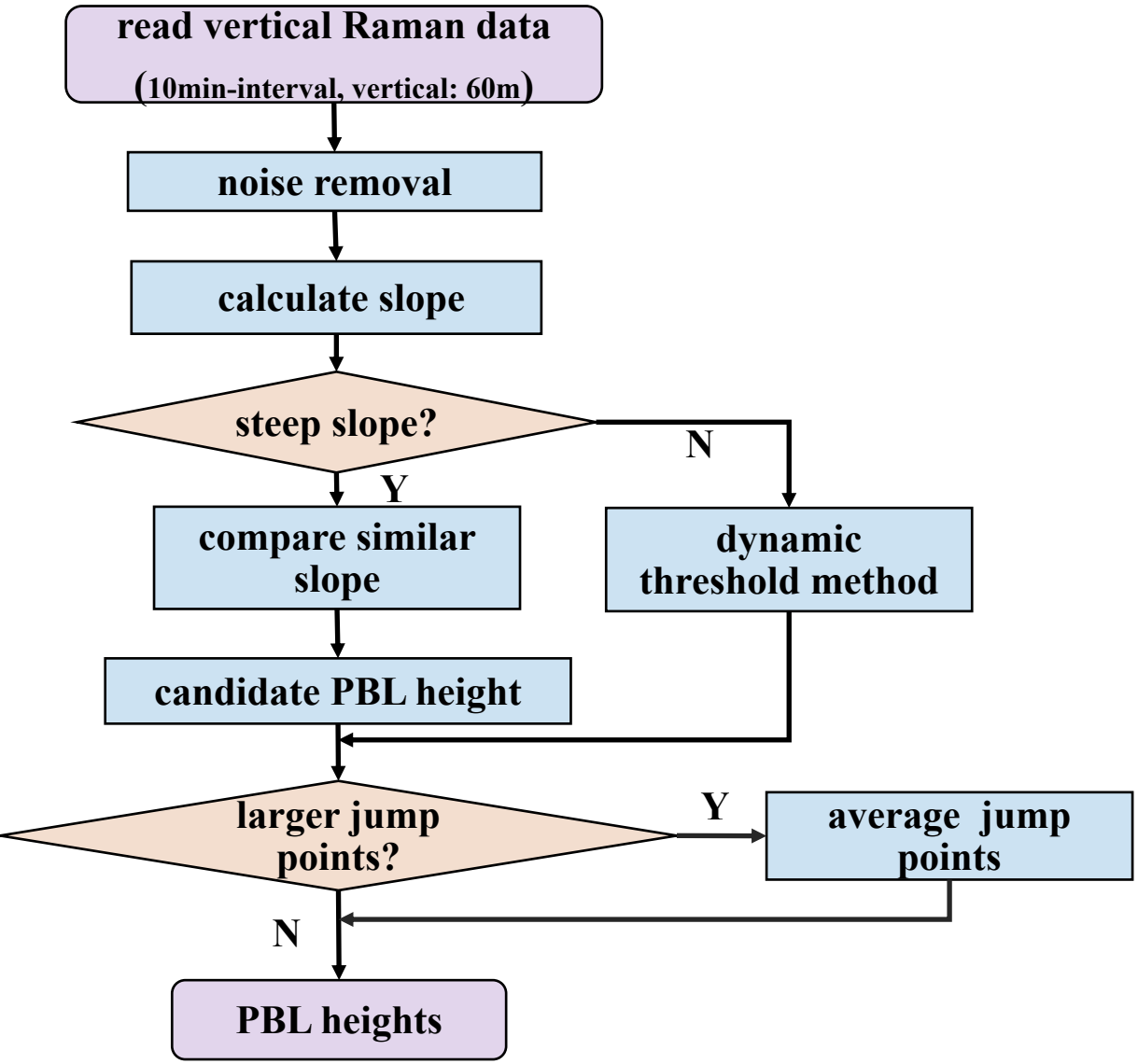
Need improve



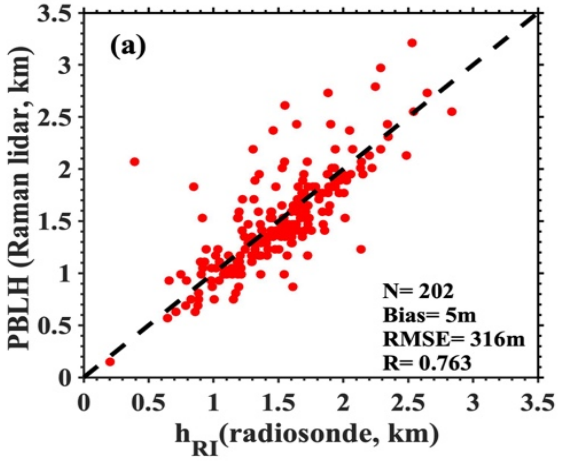
1. The change of **water vapor** between ground and capping inversion is very slow and can be used to get PBLH

2. The vertical wind will be analyzed by **wavelet method**. Then we further optimize the MLH algorithm to eliminate the influence of gravity waves and different eddy size.

3.PBLH:



Flowchart of the algorithm to determine PBLH



The PBLH results obtained by WV compare with sounding data

3.PBLH:

Three key points of the algorithm

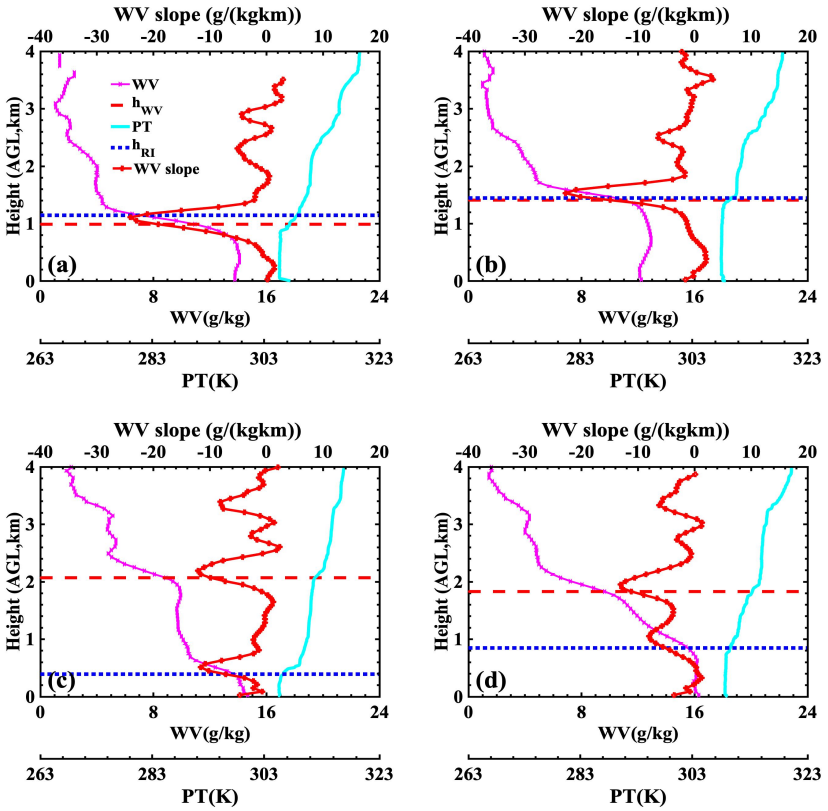
1. Slope: 300m data to calculate slope

If slope<-10g/(kg*km)
steep slope
else
soft slope
end

2. Slope method(steep slope**):**

1) Find the two local minimum value of the slopes as the candidate PBLHs.

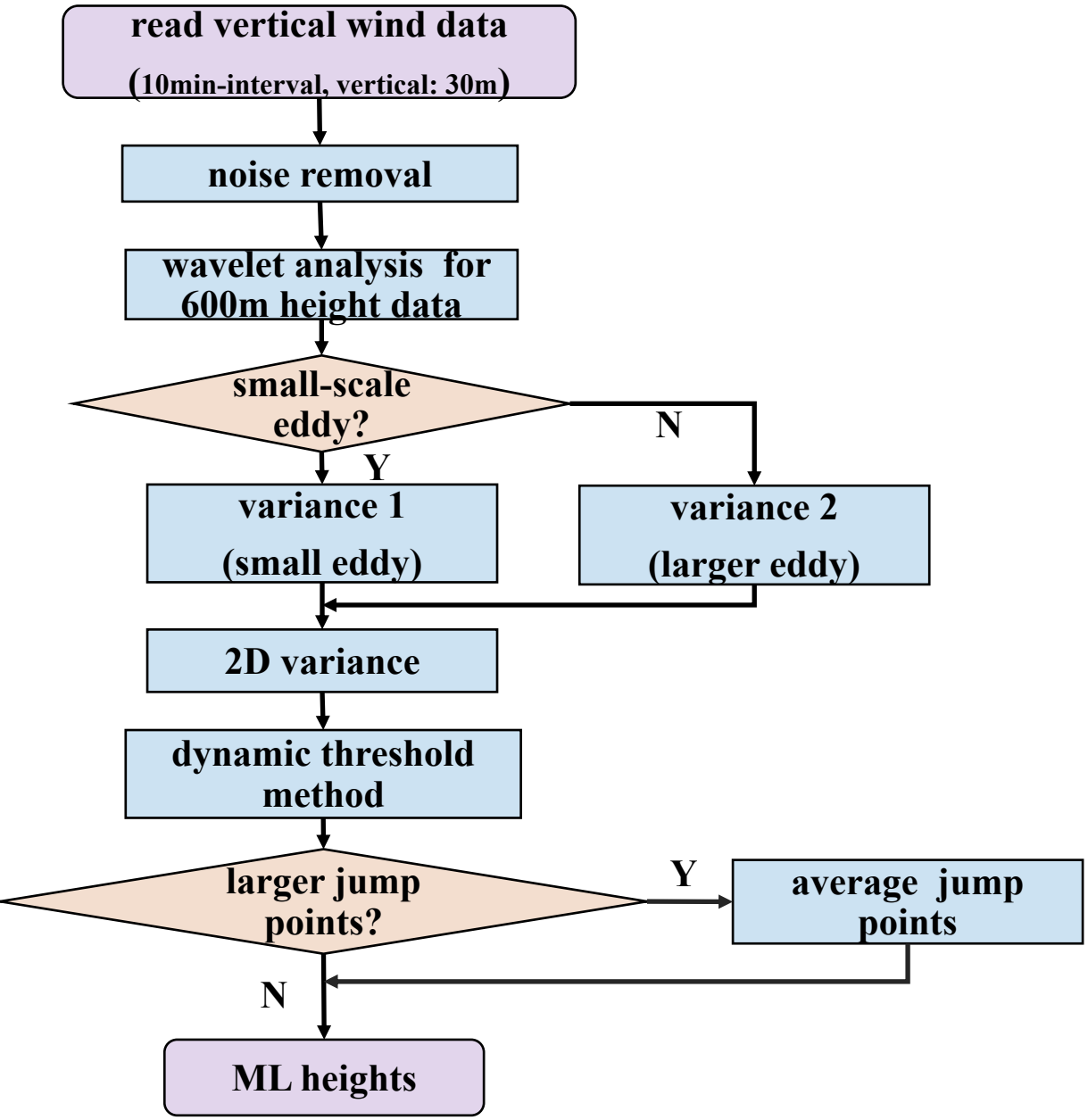
2)Compare the minimum two slope values **avoid jump** when there is horizontal movement of different air masses



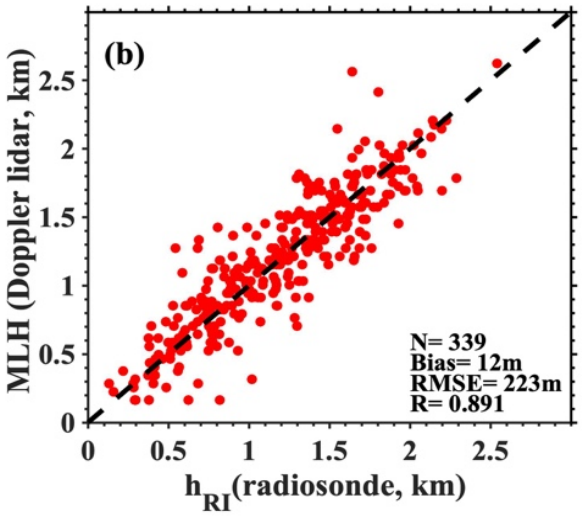
3. Dynamic threshold method(soft slope**):**

Dynamic threshold: upper limit WVMR of the 95% confidence interval of all the minimum slope heights for a whole day.

4.MLH:



Flowchart of the algorithm to determine PBLH



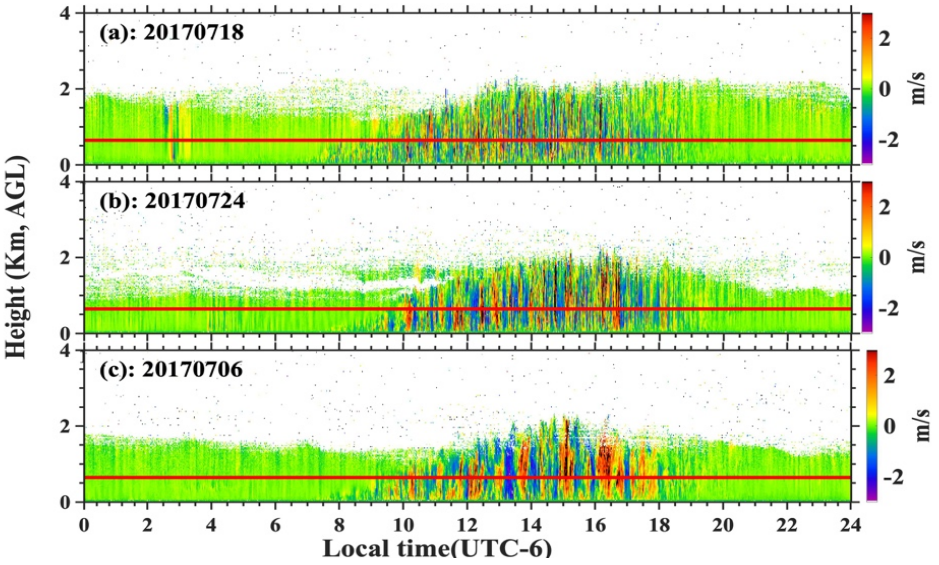
The MLH results obtained by Doppler data compare with sounding data

Two key points of the algorithm

1.Eddy size:

The spectral densities of different eddy sizes are different. The eddy size can be identified by the comparison of energy integral:

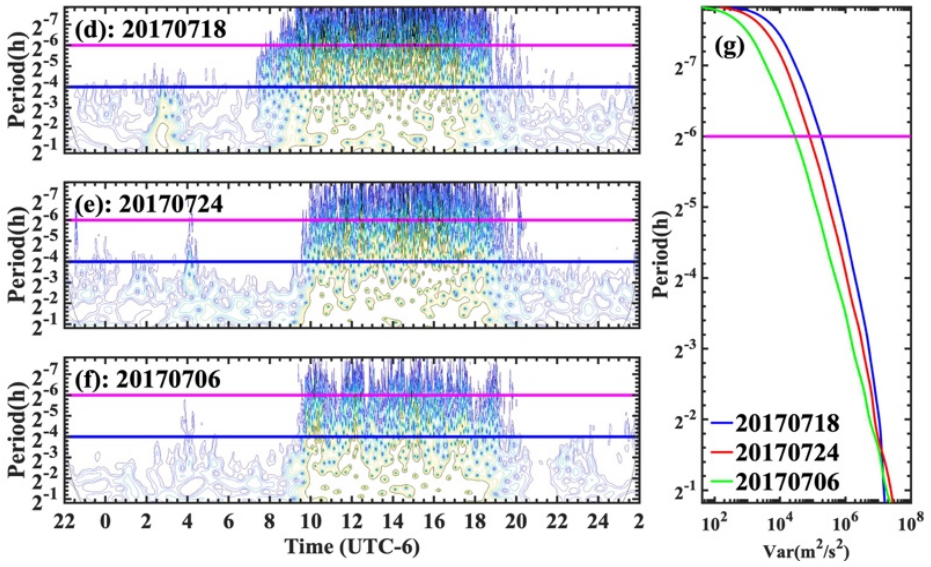
If $E_{0\sim2^{-6}}<10^3$: larger eddy day
elseif $E_{0\sim2^{-6}}>4*10^4$: small eddy day
else
    if $E_{0\sim2^{-6}}/E_{0\sim2^{-1}}<0.0055$: larger eddy day
    else : small eddy day
    end
end



2. **Gravity waves:**

The energy density's distributions of Gravity waves and turbulence are different:

$0\sim2^{-6}$: Turbulence
$2^{-6}\sim 2^{-4}$: Turbulence+ Gravity waves
$>2^{-4}$: Turbulence+ Gravity waves + Other

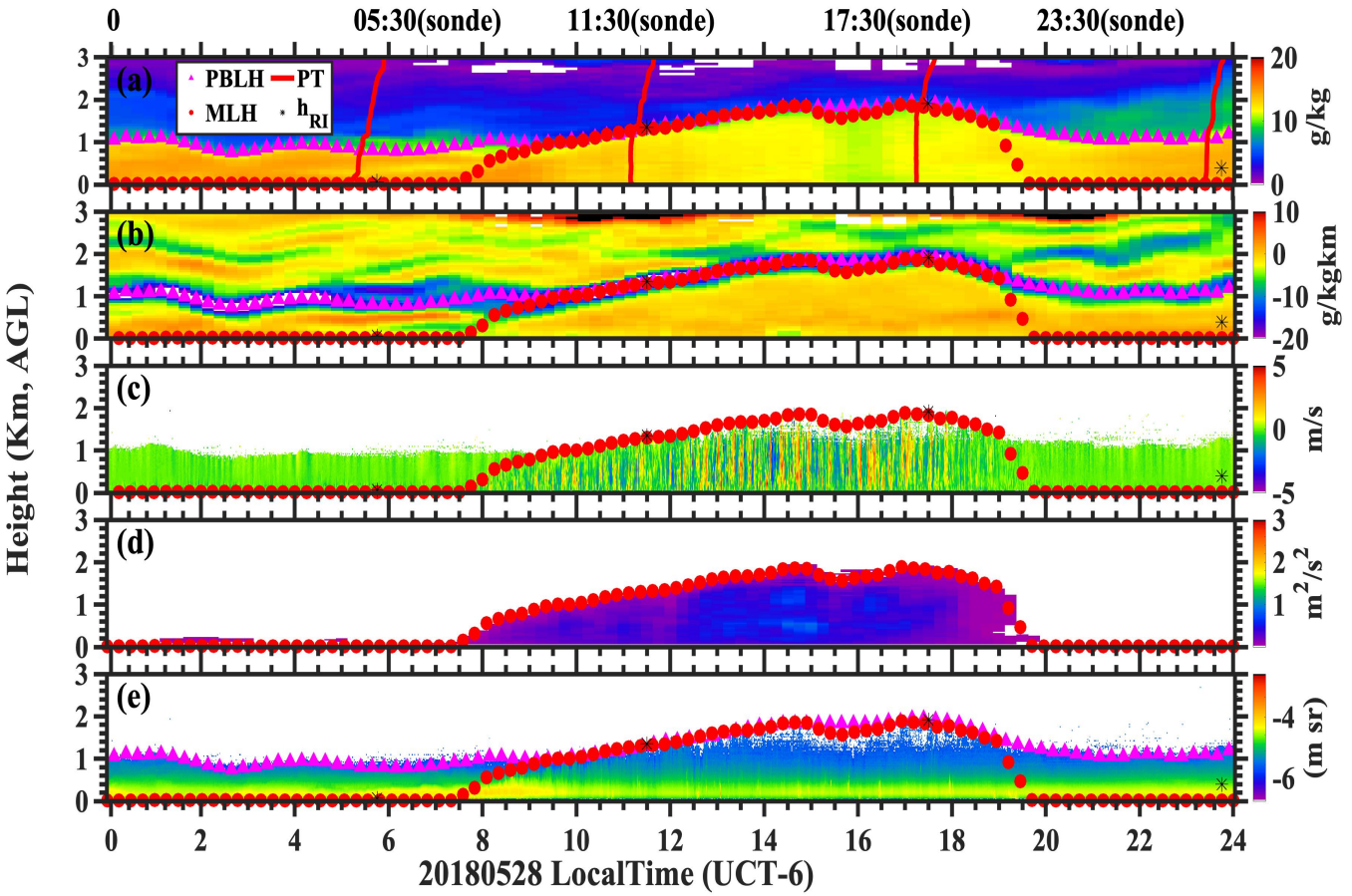


5.Results:

5.1 One case of sunny day

1. The MLH starts to rise after sun rise; then, at about 10:00, the MLH reaches the PBLH.

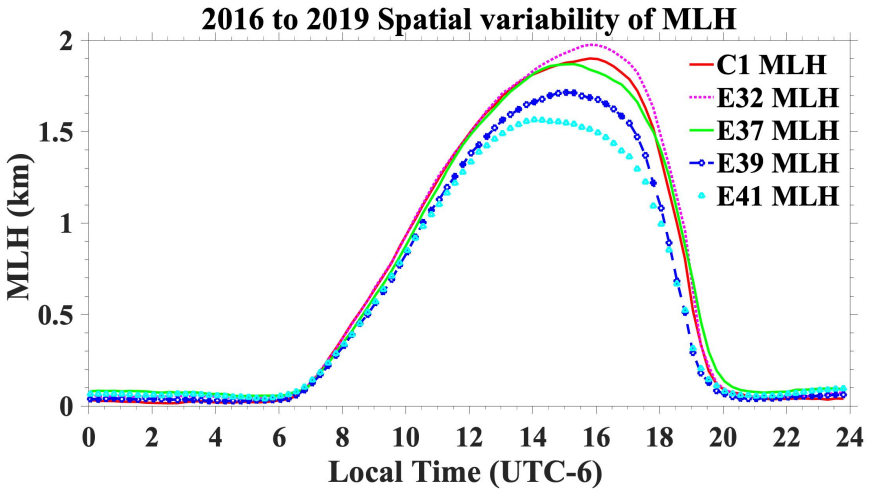
2. The MLH will quickly dissipate after sunset (about 19:00), but PBLH slowly damps down and fluctuates.



3. The MLH and PBLH are highly consistent with the bulk Richard method's height (RI=0.25) and consistent with the height of the potential temperature's inflection point. Moreover, the evolution PBLH is very consistent with the evolution of aerosol.

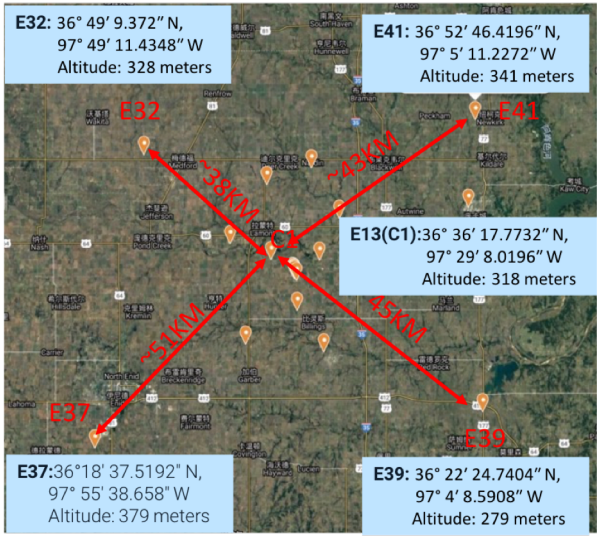
5.2 Spatial variability of ML development

Five Doppler lidar measurements offer a unique opportunity to explore the spatial variability of ML development.



compares the mean diurnal cycles of ML heights at the five sites. There are a few distinct differences

1) the maximum and minimum peak ML heights differ by more than 500 m.
2) the ML morning development (before the noon local time) clearly separates into two groups with the two eastern sites (E39 and E41) developing slower than the other three sites.



Provide possible guidance to improve model PBL parameterizations

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Thank you !

Thanks for Listening

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