Stability Characteristics of the Mesopause Region above the Andes

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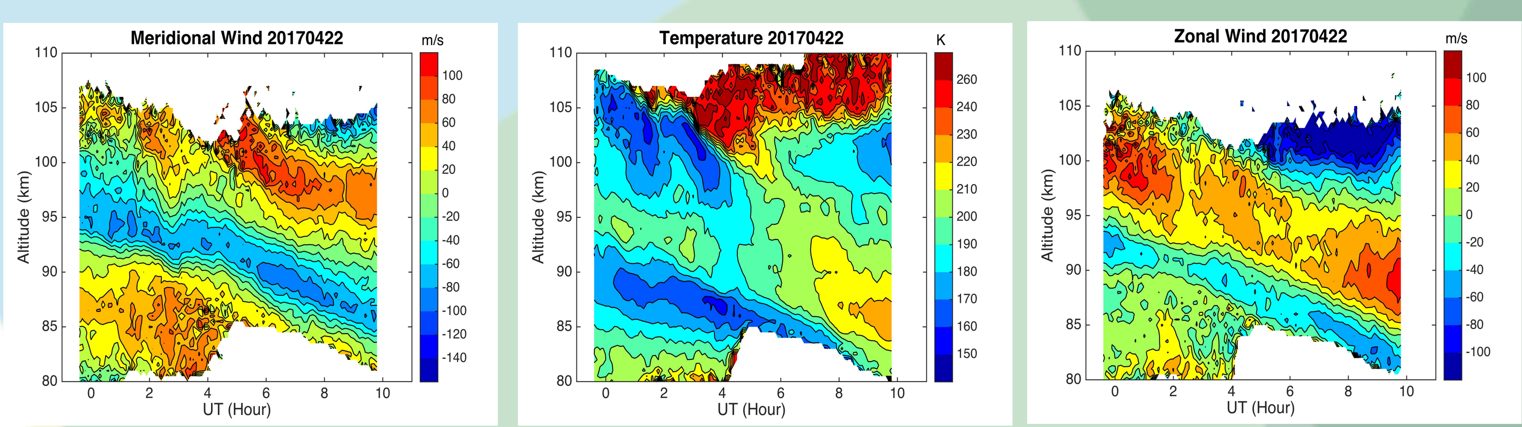
Abstract: We report a detailed analysis of the stability parameters based on high-resolution temperature and horizontal wind measurements obtained with a Na Lidar at Andes Lidar Observatory. We also examined the effects on stability parameters from waves or perturbations with different frequencies. The overall probabilities of convective and dynamical instabilities are 3.6% and 10.4%, respectively. The relationships among seasonal variations of stability parameters, mean wind and temperature, and their variances are also presented.

Data

Andes Lidar Observatory, Cerro Pachón, Chile (30.3S, 70.7W) (2014-2019), 1300 hours Na lidar wind and temperature data. The resolution is 0.1hour and 500m.

The total observation nights for ALO are listed in the table below. Horizontal wind and temperature are used to calculate stability parameters. Such high-resolution-data provided confidence to compare the magnitudes of PCI and PDI. And effect of perturbations with different frequency on the instability parameters can be studied.



data	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
T & W	31	25	25	35	12	6	10	4	7	10	24	13
U & V	26	25	25	35	12	6	10	0	0	10	24	13

Stability parameters

$$N^2 = \frac{g}{T}\left(\frac{g}{C_p} + \frac{dT}{dz}\right) \qquad S = \sqrt{(du/dz)^2 + (dv/dz)^2} \qquad Ri = N^2/S^2$$

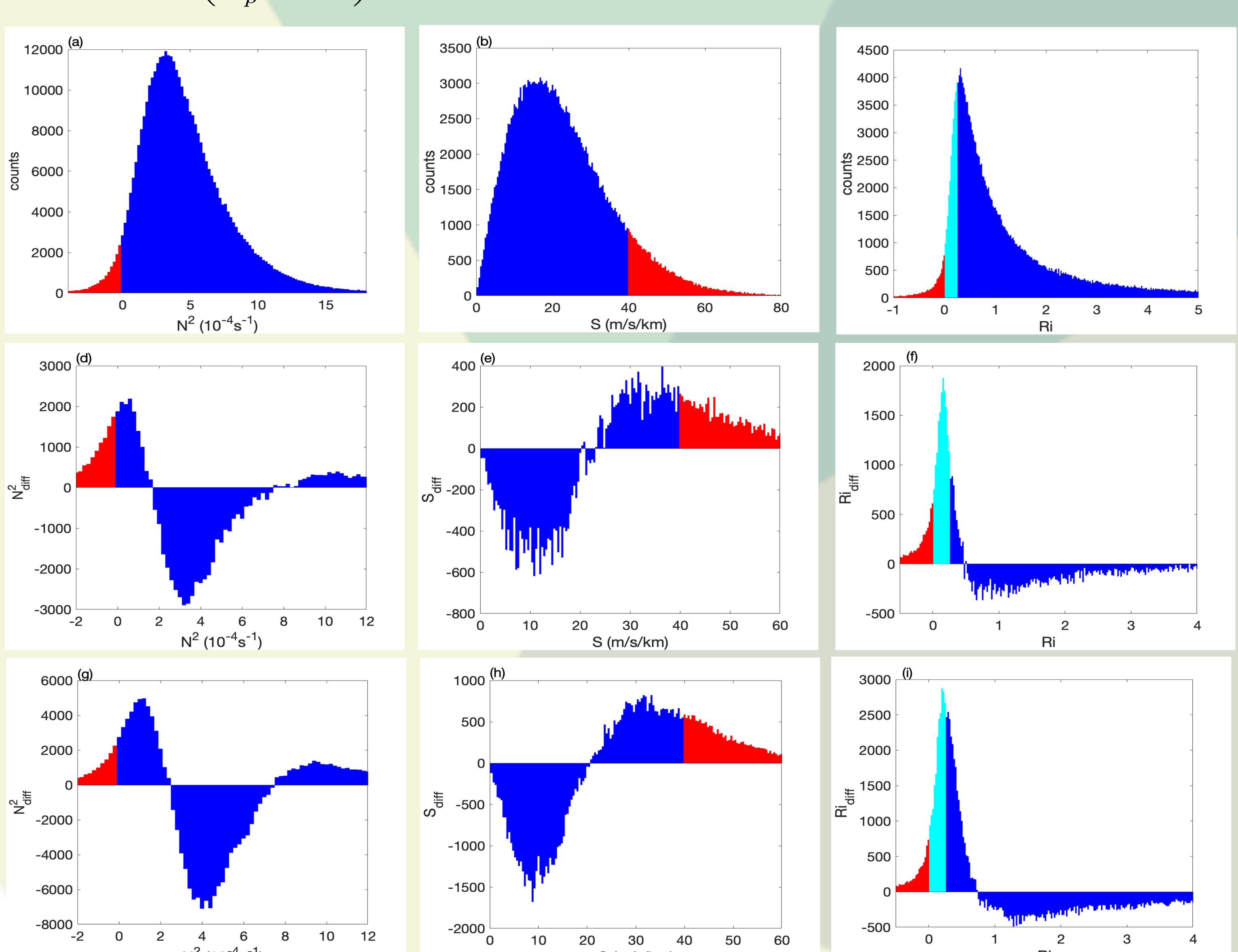


Fig1. Histograms of N^2 , S and Ri from all measurements between 85-100 km at ALO. Red in N^2 indicates convective instability (N^2<0). Red in S indicates large shear (S>40 m/s/km). Light blue indicates dynamic instability (0<Ri<0.25). 2nd raw, difference from HF GWs. 3rd raw, difference from HF+MF GWs.

Probabilities

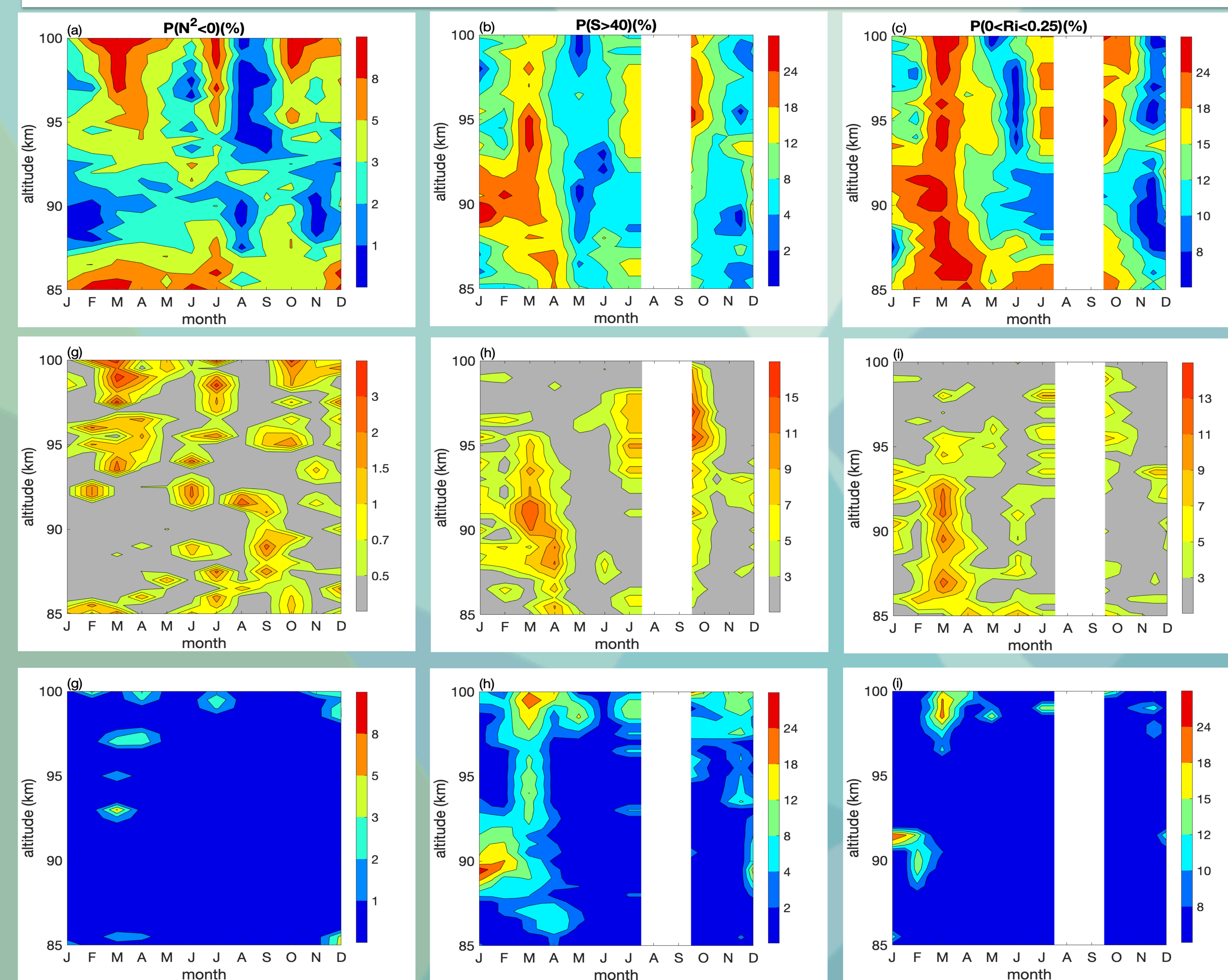


Fig2. Height-month contours of probabilities and contributions on probabilities from different waves. Top raw, 0.1 hour resolution data results. 2nd raw, MF contributions. Last raw, 6-hour-smoothed data results. HF and HF+MF contributions are similar to MF contributions will larger magnitudes.

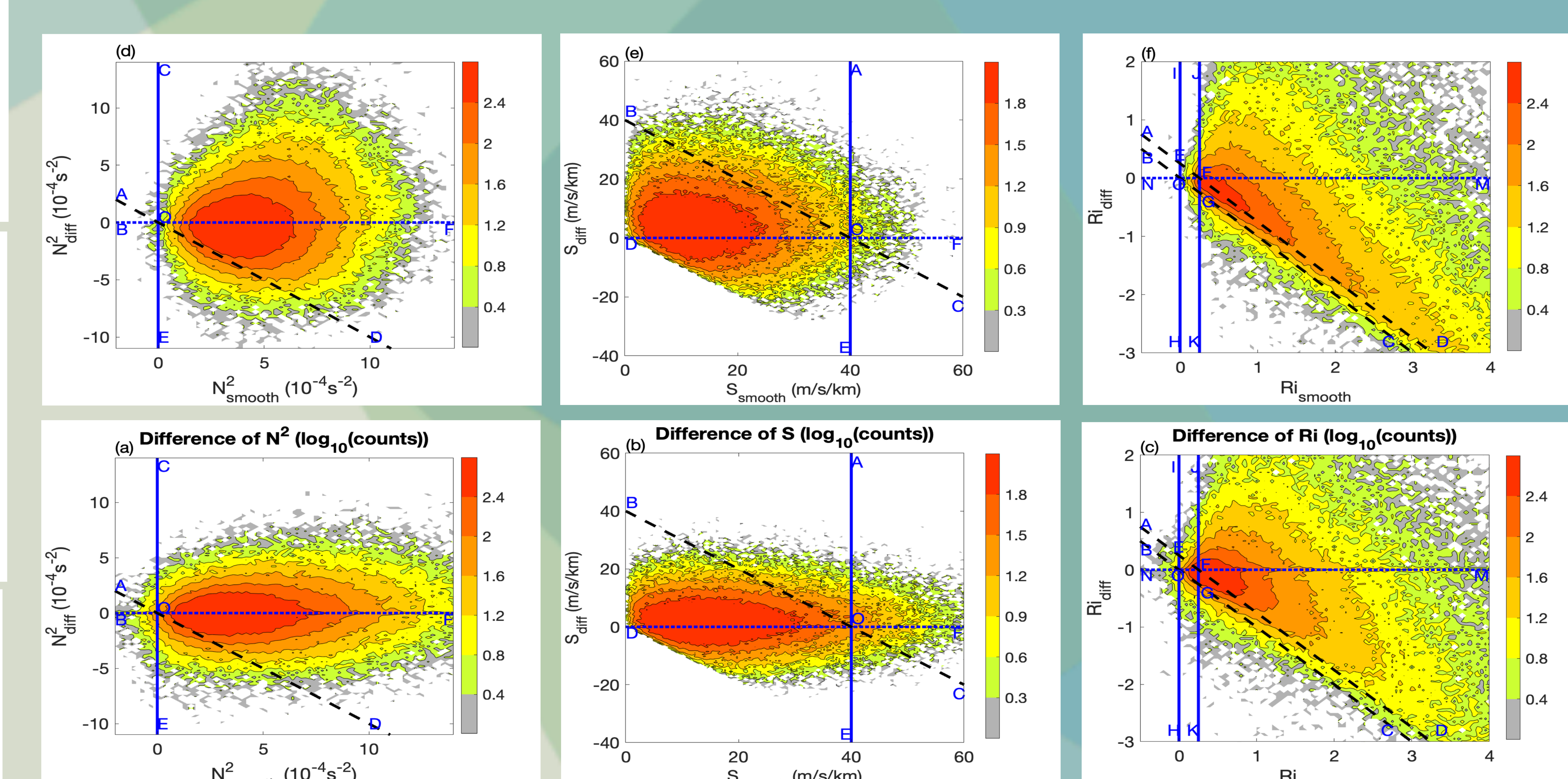


Fig3. Effect from different waves.

variable	Probability (%)	MF contribution	HF contribution
P(N^2<0)	3.6	13.8%	83.3%
P(S>40)	11.3	41.6%	40.7%
P(0<Ri<0.25)	10.4	51.9%	31.7%

Variances

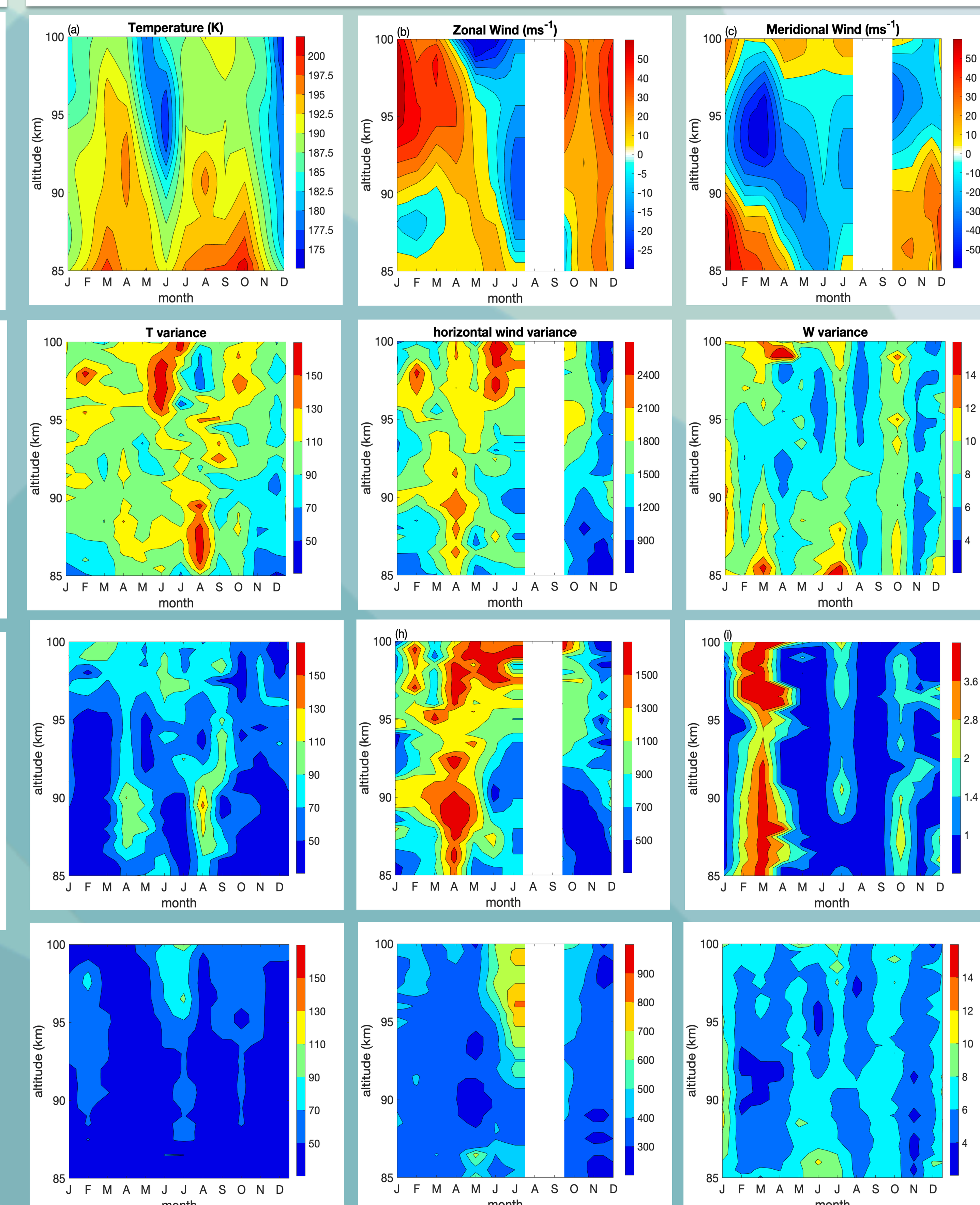


Fig3. Mean and variances of T,U,V. Red color in 1st raw 2nd and 3rd plots stands for zonal or meridional winds from west or from south, blue color stands for winds from east or from north. 2nd raw, variance of high resolution data. 3rd raw, 6 hour smoothed data. 4th raw, MF+HF perturbations.

Discussions

1, Lidar can provide such simultaneously high-resolution data for both wind and temperature.
2, HF and MF GWs increase the probabilities of dynamical instabilities when the horizontal wind variance in LF back ground has large shear.
3, Seasonal variation in the PDI with minimum occurrence on winter and maximum in summer. However, PCI seems generally small all year.
4, HF GWs have contribution on PCI and MF GWs have contribution on PDI.
5, Seasonal variation of PLW and PDI are not directly related to horizontal wind variance.

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