



# Rayleigh/Raman lidar observations of gravity wave activity

## in the middle atmosphere over Syowa Station (69°S, 40°E), Antarctic.

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# NIPR

### 1. Background

- High latitude (~60°S) is a hot spot of gravity wave (GW) activity.
- Detailed Potential energy of GWs ( $E_p$ ) profiles are useful, but radiosondes (e.g., Pfenninger et al. [1999]; Yoshiaki and Sato [2000]) and Rayleigh lidars (e.g., Yamashita et al. [2009]; Alexander et al. [2011]) have limited height range (Rayleigh lidar: 30-70 km, Radiosonde:-30 km).
- We used improved Rayleigh/Raman lidar to estimate  $E_p$  profiles between 15 and 70 km at Syowa (69°S, 40°E).

### 2. Rayleigh/Raman(RR) lidar observation

Location	Syowa Station (69°S, 40°E)
Laser	Nd:YAG (355 nm, 6W)
Telescope	Nasmyth-Cassegrain (Diameter:82 cm)
Resolution*	Height : 900 m / Temporal : 1hour

Height Range 15-70 km (cf., Rayleigh lidar:30-70 km)

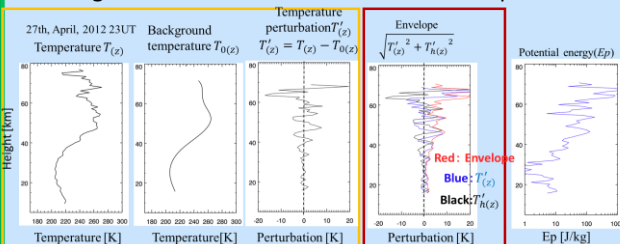
\*Original resolution : height resolution 15m / temporal resolution 1 min.

#### Number of nights of data available

Month Year	Number of nights of data available										total
	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.		
2011	0	0	0	6	1	12	12	12	9	52	
2012	3	4	9	10	13	7	7	17	10	80	
2013	0	7	12	11	10	13	5	10	7	75	
total	3	11	21	27	24	32	24	39	26	207	

### 3. How to calculate potential energy of GWs

Potential energy of GWs ( $E_p$ ) was estimated with vertical wavelength between 1.8 and 16 km from the temperature.



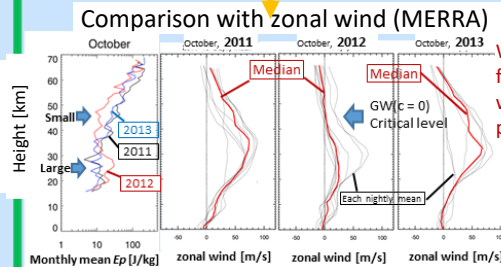
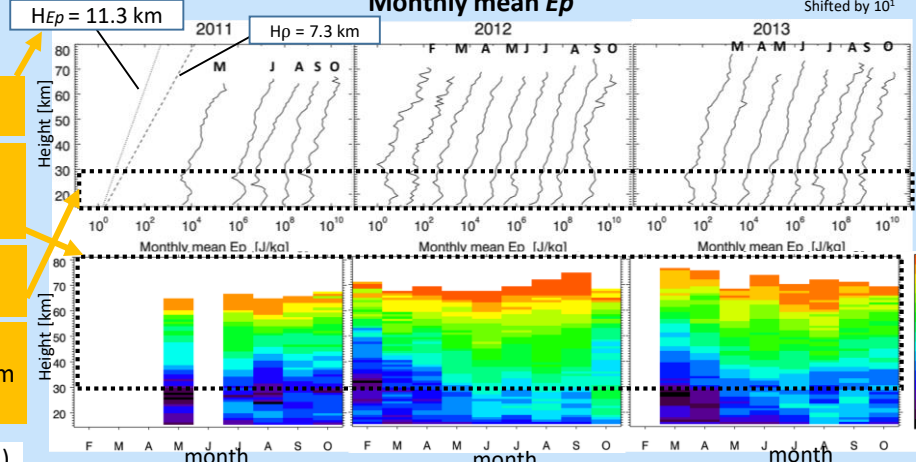
Same method as Duck et al. [2001]

Envelope estimated using Hilbert transform

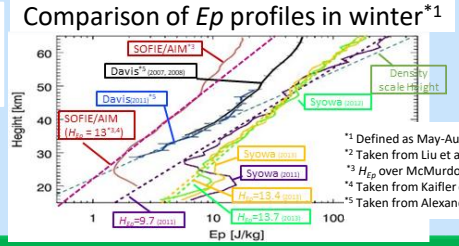
### 4. Result & Discussion

#### Features of $E_p$ over Syowa

- Above 30 km,  $E_p$  increases with a mean scale height of 11.3 km.
- Above 30 km,  $E_p$  is larger in winter than in spring & fall (e.g., Alexander et al. [2011]).
- $E_p$  locally maximizes around 20 km and minimizes around 25 km.
- $E_p$  in Oct. 2012 is smaller and larger than these in the other years at 35-60 km and at 20-35 km, respectively.



Weak zonal wind filtered GWs with small zonal phase speed.

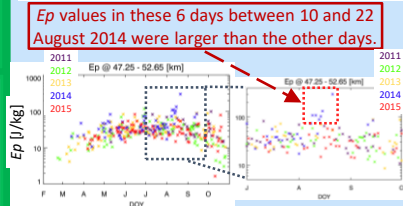


$H_{ep}$  over Syowa between 30 and 40 km was larger than those over Davis (69°S, 78°E), and vice versa above 40 km.

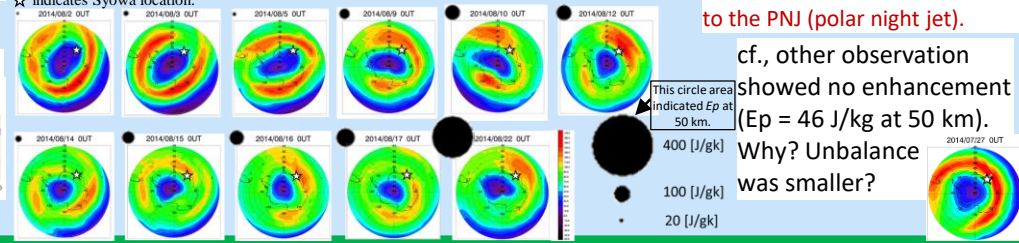
### 5. Additional analysis

We also estimated  $E_p$  in 2014-15, and the  $E_p$  significantly enhanced in Aug. 2014.

#### Day-to-day variation of $E_p$ at 50 km



#### Comparison between $E_p$ values at 50 km and zonal wind at ~40 km



The enhancement could be due to the PNJ (polar night jet).

cf., other observation showed no enhancement ( $E_p = 46$  J/kg at 50 km). Why? Unbalance was smaller?

### 6. Summary

- Potential energy of gravity waves ( $E_p$ ) over Syowa (69°S, 40°E) was extracted from the temperature observed by the RRLidar.
  - $E_p$  increased with a mean scale height of 11.3 km above 30 km, and significant enhancement (~200%) was found at 20 km.
  - In spring, descent of  $u \sim 0$  m/s altitude modulated  $E_p$  profile around 35 km.
  - A scale height of  $E_p$  at Syowa between 30 and 40 km was larger than that at Davis (1500km distance), and vice versa above 40 km.
- The results shown here are to be published by Kogure et al., JGR 2017 (in revision).
- The  $E_p$  over Syowa in Aug. 2014 was significantly enhanced, This coincided with approach of strong PNJ to Syowa. How is the mechanism? 1. emission of GWs from PNJ? or 2. favored propagation within the positive shear?