Polar Lows over the Sea of Japan during the cold season

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Jan. 31, 2012
(website of Kochi Univ.)
Polar lows (PLs)

- meso-α-scale (200~1000km) cyclones that develop over the high/mid-latitude oceans.
- various cloud patterns (spiral-shape, comma-shape, etc.)
- development within cold air outbreaks.

Feb. 27, 1987
(website of Dundee)

Jan. 30, 2011
(website of STARS)

Oct. 19, 2010
(website of STARS)
Diverse climate in Japan

Records
Temperature (max): 41°C
Temperature (min): -41°C
Precipitation: 852mm/day

walls of snow
sea ice
mangrove
Diverse cyclones around Japan

Synoptic scale (> ~2000km)

- Typhoon
- Extratropical cyclone

Meso-α scale (<~ 2000 km)

- Polar Low
- Baiu-front Depression

courtesy of Dr. Tochimoto
An energy source for a typhoon is condensational heating within cumulus convection over the warm ocean.
Extratropical cyclones

An energy source for an extratropical cyclone is horizontal temperature gradient at mid-latitudes

Ogura (Ippan Kisho-gaku)

Distribution of explosive cyclones
(Lim & Simmonds, 2002)
A PL is not a top priority in Japan.

Even so, we have 3 motivations for studying PLs.
1. PLs develop frequently over the Sea of Japan.
PLs over the Sea of Japan

Frequent PL formation and many case studies
Social influences of PLs around Japan

- Heavy snowfall
- A 6000-ton ship disaster (Feb. 1981)
- A train disaster (Dec. 1986)
- Six tornadoes in a PL (Jan. 1987)

A train disaster (top) and a weather map (left) on Dec. 28, 1986
(事故の鉄道史)
2. PLs over the Sea of Japan are unique.
Areas of PL formation

Sea Ice Concentration (red) on Feb. 1 2015 (U.S. Naval Research Laboratory)
Winter weather over the Sea of Japan

Winter monsoon (northwesterly)

Asia  Japan Sea  Japan

Northwesterly Monsoon  Polar Low Formation

Satellite imagery: Kochi University
Satellite observation around Japan

By virtue of the relatively low latitudes, we can use:

- Visible light imagery even during the winter.
- Frequent observation by geostationary satellites.

Visible light imagery of a polar low over the Sea of Japan on Feb. 15, 2016.

Himawari-8
Jul. 2015 -

Every 2.5 minutes!
Climatology of PLs over the Sea of Japan

Using a tracking algorithm, we are compiling a PL database. The climatology of PLs over the Sea of Japan is important for understanding of global climatology and interregional comparison.

PL tracks for 36 seasons
- genesis
- mature (maximum intensity)

cf. Yanase et al. (2016, J. Clim.)
collaboration with a Norwegian group
3. PLs are hybrid cyclones that use multiple energy sources.
Within cold air outbreaks, PLs use multiple energy sources:

- condensational heating in cumulus convection
  - similar mechanism to typhoons (spiral-shape)
- temperature gradient from cold upstream to warm downstream
  - similar mechanism to extratropical cyclones (comma-shape)
- other processes (upper-tropospheric trough, shear, orography)

Idealized numerical experiment on PLs (Yanase and Niino 2007)
Hybrid cyclones in the real atmosphere

The hybrid mechanism works in various cyclones.

- Extratropical transition of tropical cyclones
- Explosive development of extratropical cyclones
- Subtropical cyclones
- Baiu-frontal cyclones

subtropical cyclone
Sep. 24, 2013 (digital typhoon)

Baiu-frontal cyclone
May 30, 2016 (JMA)
Summary

Even though a PL is not a top priority in Japan, we have high motivations for studying PLs.

1. PLs frequently develop over the Sea of Japan, and have social influences around Japan.

2. PLs over the Sea of Japan are unique: low latitude, little sea ice, East Asian winter monsoon ➔ The climatology of PLs over the Sea of Japan is important for inter-regional comparison and global climatology.

3. PLs are hybrid cyclones that use multiple energy sources including condensational heating and temperature gradient. The hybrid mechanism is important for comprehensive understanding of various types of cyclones.

Collaborations with Norwegian meteorologists are necessary.
Cyclones & Environmental field climatology for autumn 1982-2011

Locations of Developing cyclones
Tropical cyclones
Extratropical cyclones
Hybrid cyclones

Sea Surface Temperature
Idealized experiment of PLs

Yanase and Niino (2007)

Yellow frames indicate PL’s development stages

Various cloud patterns