Oct 16, 2018 @ SUPER DARN work shop (Nagoya Univ.)

Plan for coordinated observation of Noctilucent clouds in Mid-latitude region. (中緯度帯における夜光雲観測計画)

NLC photo taken by Mr. M. Shisa on 21st Jun, 2015 from Otaru Hokkaido

Hidehiko Suzuki（Meiji Univ）, MTI-NLC science team

Introduction

PMC : Polar Mesospheric Cloud

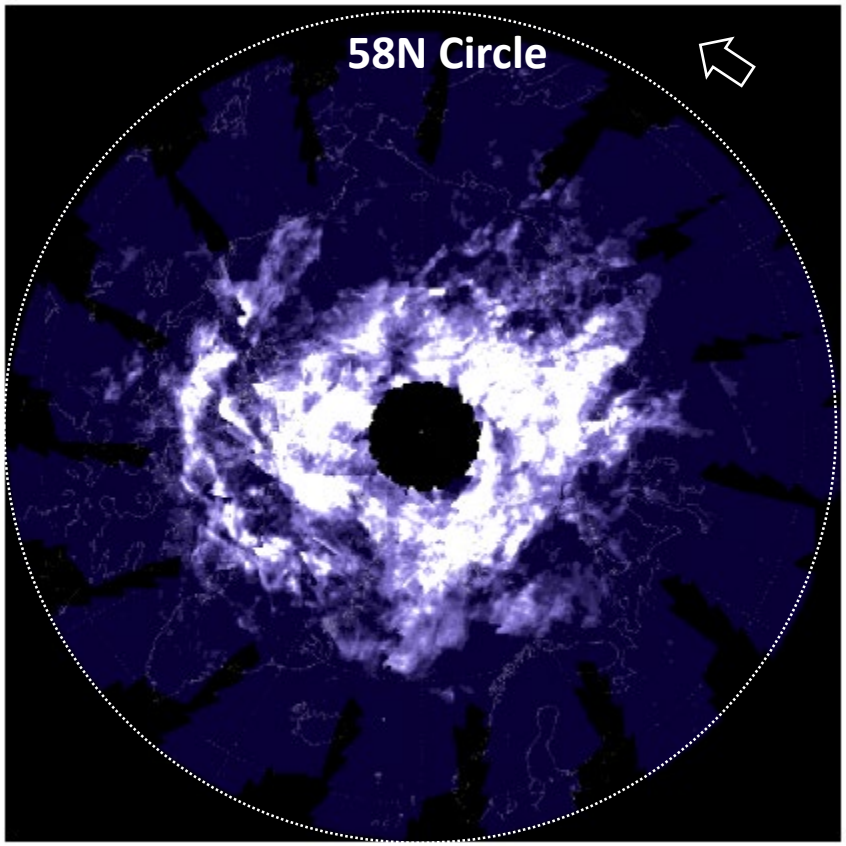


Fig. 6. CIPS daily mean image showing coverage for a full day of CIPS images on July 17, 2007. FOV overlap from one orbit to the next occurs at ~70°N. The lowest latitude in the plot is 58°N.

PMC distribution over arctic region captured by CIPS instrument (@265nm) onboard NASA's AIM satellite in 2007.

Aeronomy of the Ice in Mesosphere / Cloud Imaging and Particle Size instrument.)

PMC is the most highest cloud in the Earth which appears in a mesopause region (80-90km) during summer season in both polar regions.

Extremely low temperature (<140K) in the summer mesopause region makes water vapor condensated.

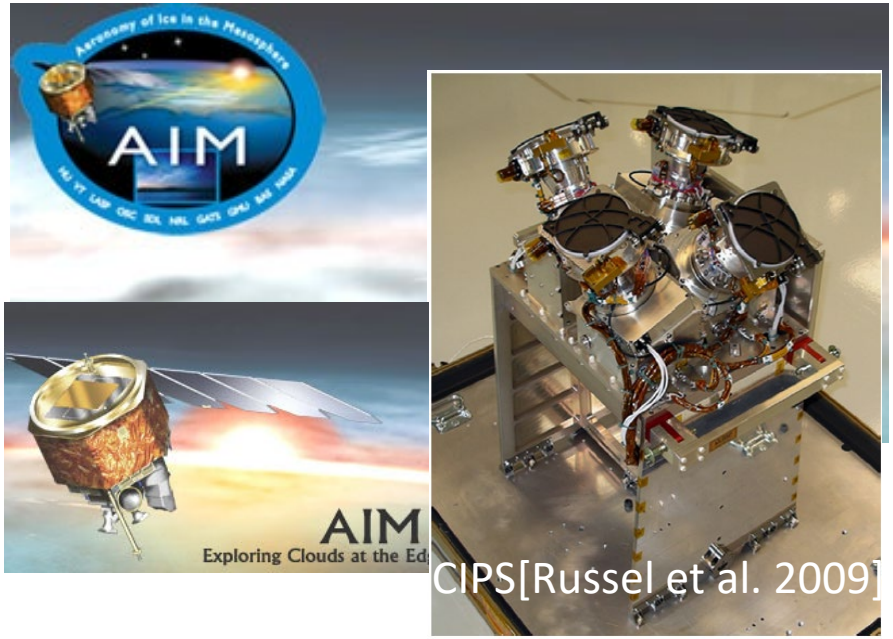
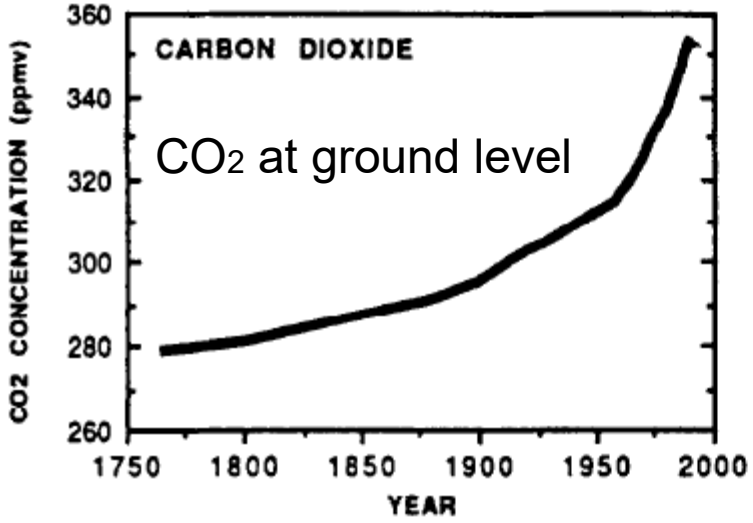
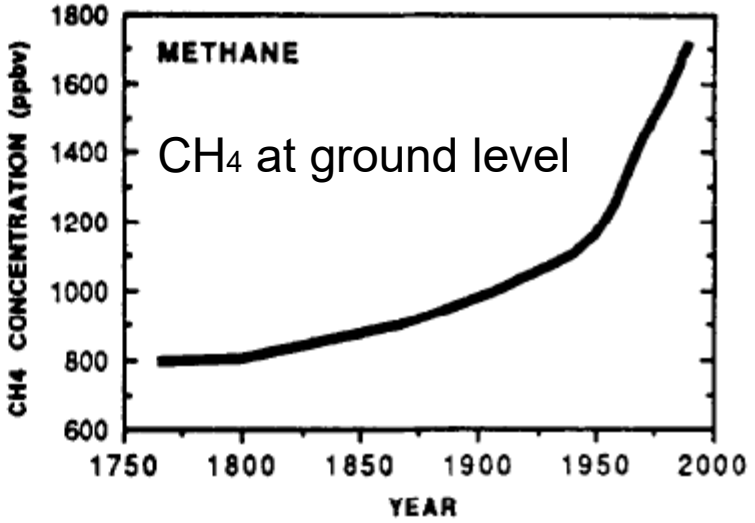


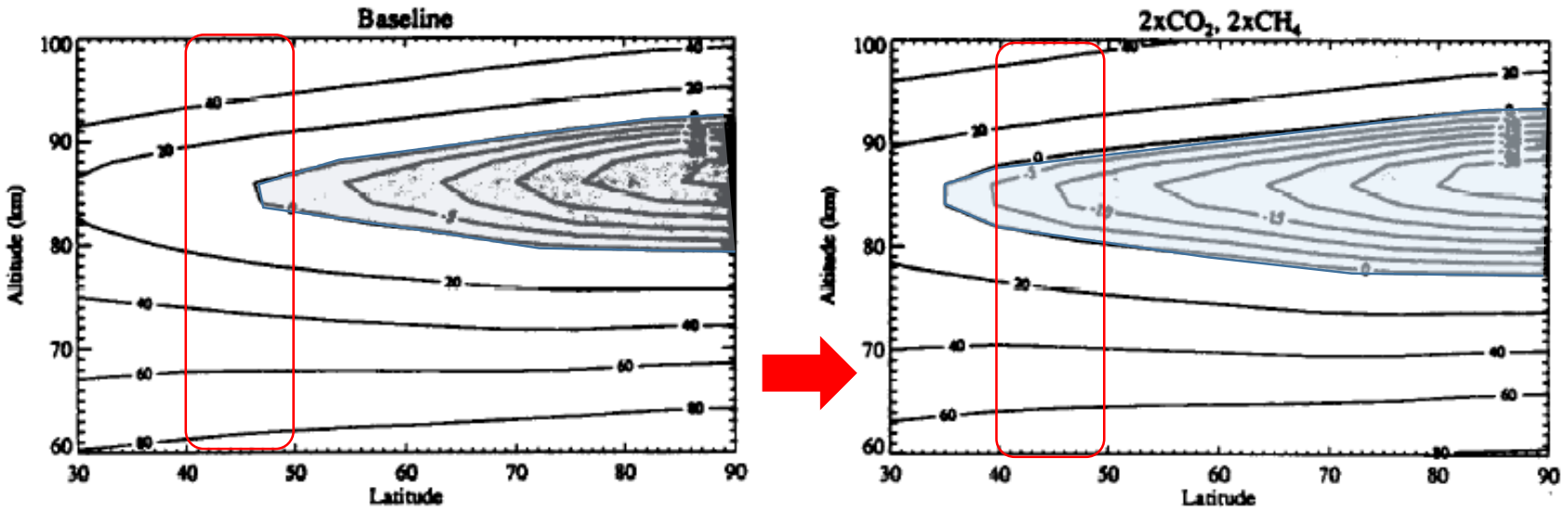
Fig. 4. CIPS Instrument.

Introduction

Model prediction of an expansion of PMC zone due to increase of greenhouse gasses.







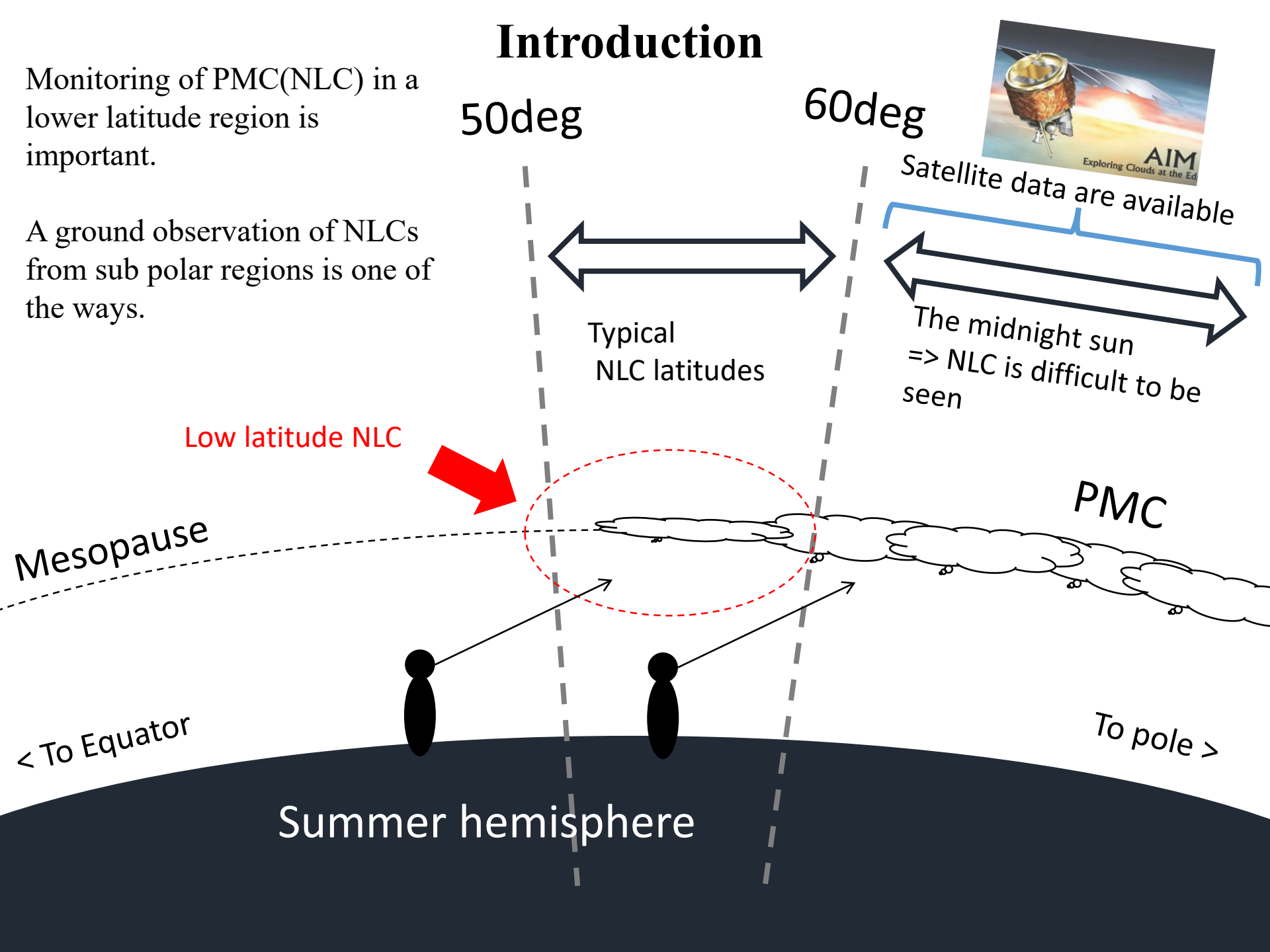
CO2 & CH4 x 2

Thomas, 1996

Introduction

Monitoring of PMC(NLC) in a lower latitude region is important.

A ground observation of NLCs from sub polar regions is one of the ways.



First imaging of an NLC in Japan on Jun 21, 2015 !

紋別山山頂から撮影した夜光雲。水平線の上に青白く光り、神秘的な美しさを見せる＝21日午前2時15分（北大低温科学研究所提供）

水平線に神秘の光

北大低温研「夜光雲」国内初観測

【紋別】北大低温科学研究所（札幌）は29日、地球上で最も高い高度に発生する雲と言われる「夜光雲（やこううん）」＝社会面のことば＝の撮影に成功したことを明らかにした。紋別市内の紋別山（334メートル）山頂のカメラがその姿をとらえた。国内での夜光雲観測は初めて。

夜光雲は、上空の高度10キロ程度までにできる普通の雲とは異なり、高度約80キロに現れる特殊な雲。夏の日の出前や日没後に、わずかな氷の結晶に太陽の光が当たって輝いて見える。

北大低温研はオホーツク海の流氷や雲の動きを、同山山頂のカメラで15分おきに撮影。藤吉康志特任教授（雲科学）が撮影画像を確

北欧やカナダなどで観測されている。藤吉特任教授は「なぜ北海道で見えたのかは分からないが、神秘的で興奮した。当時の気象条件などの研究を進めたい」と話している。

夜光雲　通常の　よりはるかに高　気の層に発生す　関（WMO）が　彩には含まれな　没後の暗い夜空　光って見えるこ

とから、その名称が付いた。細かい筋状の雲が波打つような形が特徴。地上の雲が遮り、観測できない場合も多いとされる。1885年（明治18年）にイギリスで初めて発見され、日本では研究機関などによる正式な観測報告がなかった。

夜明け前 白く輝く

夜明け前や日没後に筋状の雲が白く輝く「夜光雲」が21日未明に北海道陸別町など道内4カ所で観測された

国内で初めて観測された夜光雲＝北海道陸別町で21日午前2時24分、西谷望・名古屋大准教授撮影

と、名古屋大や北海道大などの研究グループが30日発表した。雲の高さは通常、地上から十数キロ以内だが、氷の結晶でできた夜光雲は80～90キロの高度にあるため、地平線の下にある太陽の光を受けて反射する。国内での観測は初めてという。

夜光雲は北極や南極付近にできることが多いが、近年はフランスなどの中緯度地域でも出現している。二酸化炭素などの温室効果ガスが増えると、熱が地表近くにとどまって上空の大気が冷え、高度80～90キロで氷の粒ができやすくなるとみられている。名古屋大太陽地球環境研究所の西谷望准教授（超高層物理学）は「世界規模で環境変動が起きている可能性を示す現象だ」と話す。【伊藤奈々恵】

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Japanese newspaper and other medias widely reported this unusual phenomena.

Selected photos of the NLC taken from multiple sites in Hokkaido in the early morning on June 21, 2015.

(a) Nayoro 02:26:07 LST

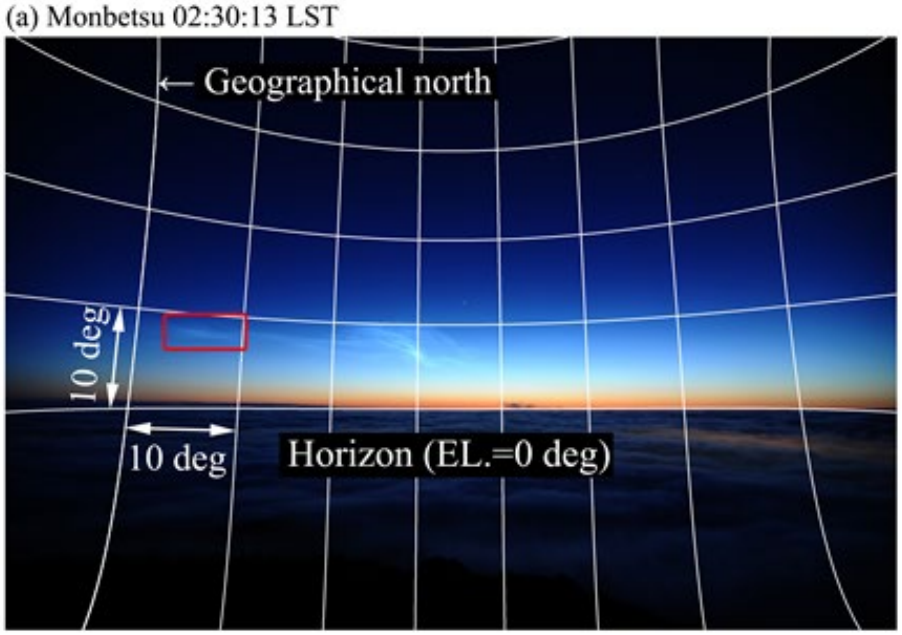
(b) Moshiri 02:15:55 LST

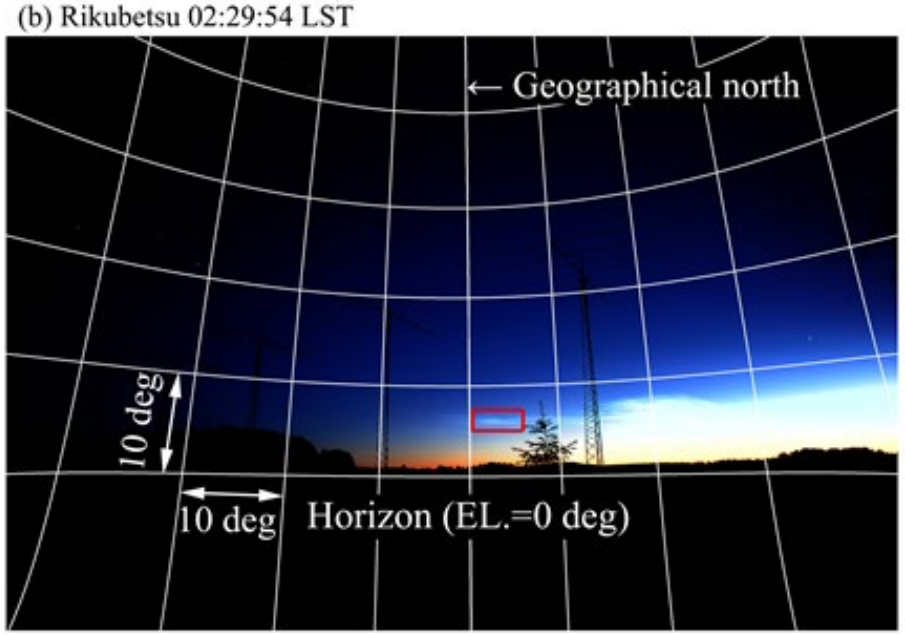
(c) Monbetsu 02:30:13 LST

(d) Rikubetsu 02:24:54 LST

(e) Otaru 02:27:?? LST

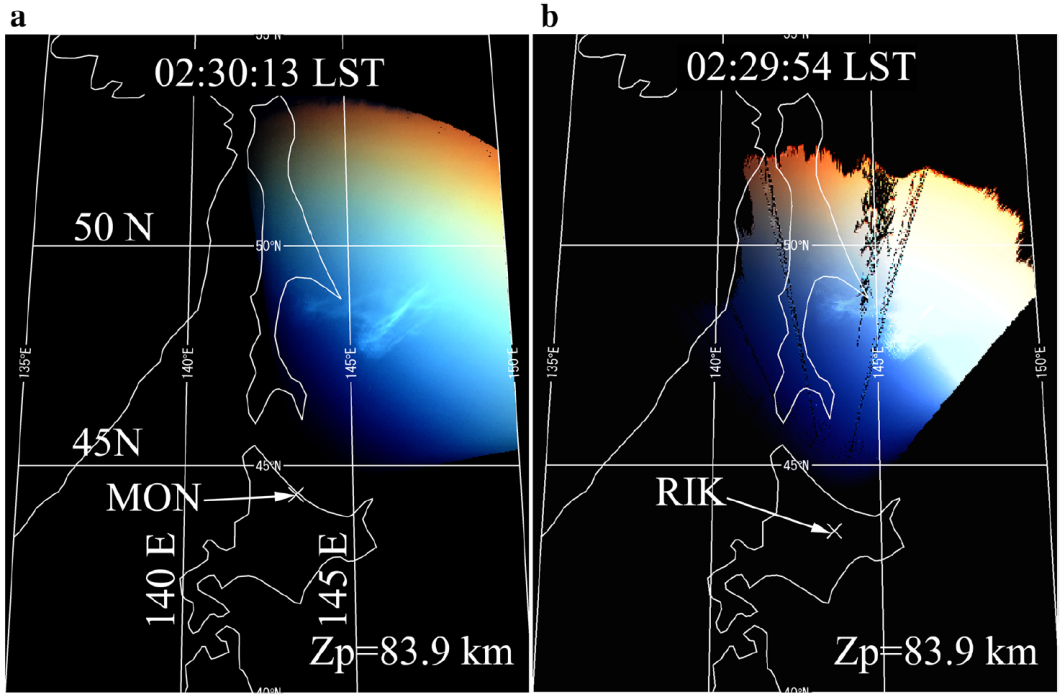
Nearly simultaneous imaging from 6 locations in Hokkaido were successfully carried out. [Suzuki+, EPS, 2016]



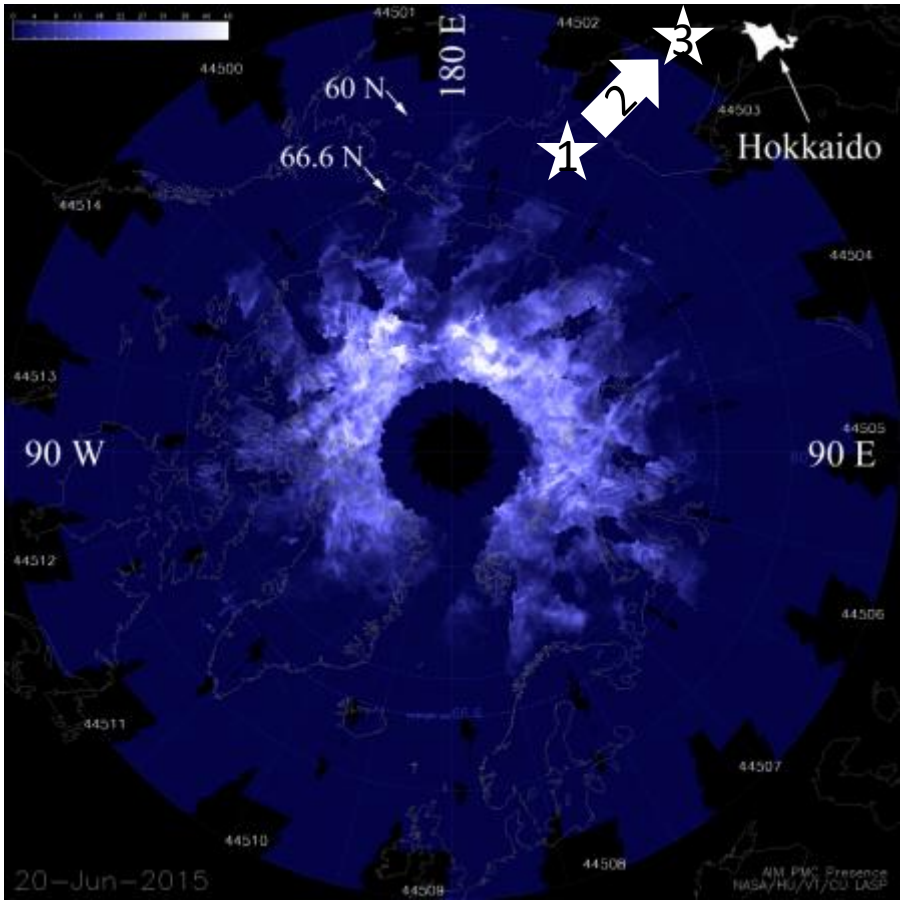


Identification of known stars to determine distortion of optics and horizontal coordinates (Azimuth and Elevation angles) corresponding to each pixel is conducted.

By assuming NLC altitude as 85 km, the images are projected to a geographical coordinate.



Introduction : Why the NLC had not been previously sighted in Hokkaido ?



Composed albedo map of PMC observed by AIM/CIPS on June 20 UTC.
(Data from http://lasp.colorado.edu/aim/browse-images.php)

Horizontal wind data by MF radar support 'Transport scenario' for the event.

1. Generated in high latitude region (i.e. colder region)
2. Transported by continuous southward wind.
3. Sighted as an NLC from Hokkaido.

Question.

Atmospheric conditions (temperature and an amplitude of a tidal component) at upper mesosphere were **not extreme** in 2015.

Why the NLC had not been previously sighted in Hokkaido ?

Why 2015 is the first time for NLC detection in Japan ??

Introduction : Why the NLC had not been previously sighted in Hokkaido ?

One of possibilities is simply the bad weather conditions during the NLC season.
Actually, MSE (PMSE) have been frequently observed by the VHF radar at Wakkanai (Ogawa et al., 2011).

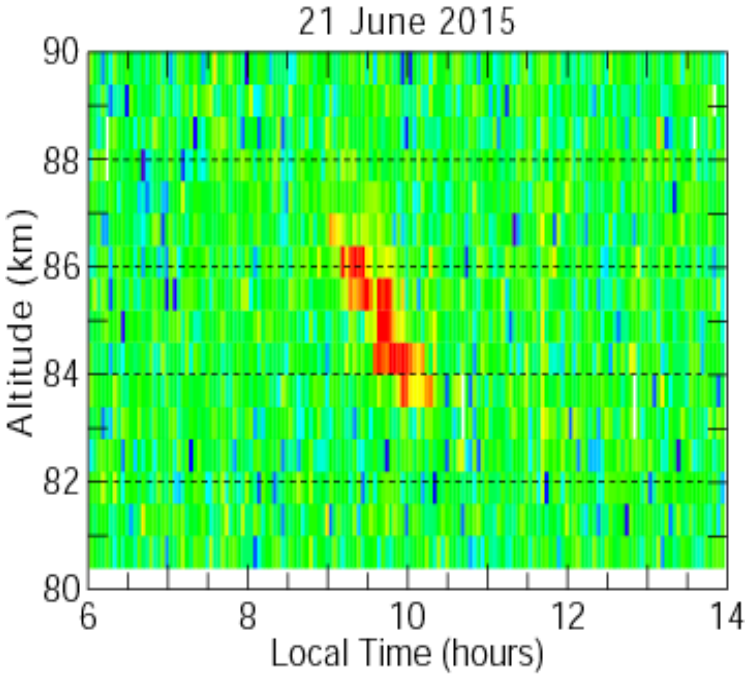
Number of MSE events between June 2009 and September 2015 were

65 events.

According to database by Japan Meteorological Agency (www.jma.go.jp/),

Only 10.8% (3.1%) of morning (night) twilight times were clear (amounts of clouds = 0) on the days of MSE events in Wakkanai.

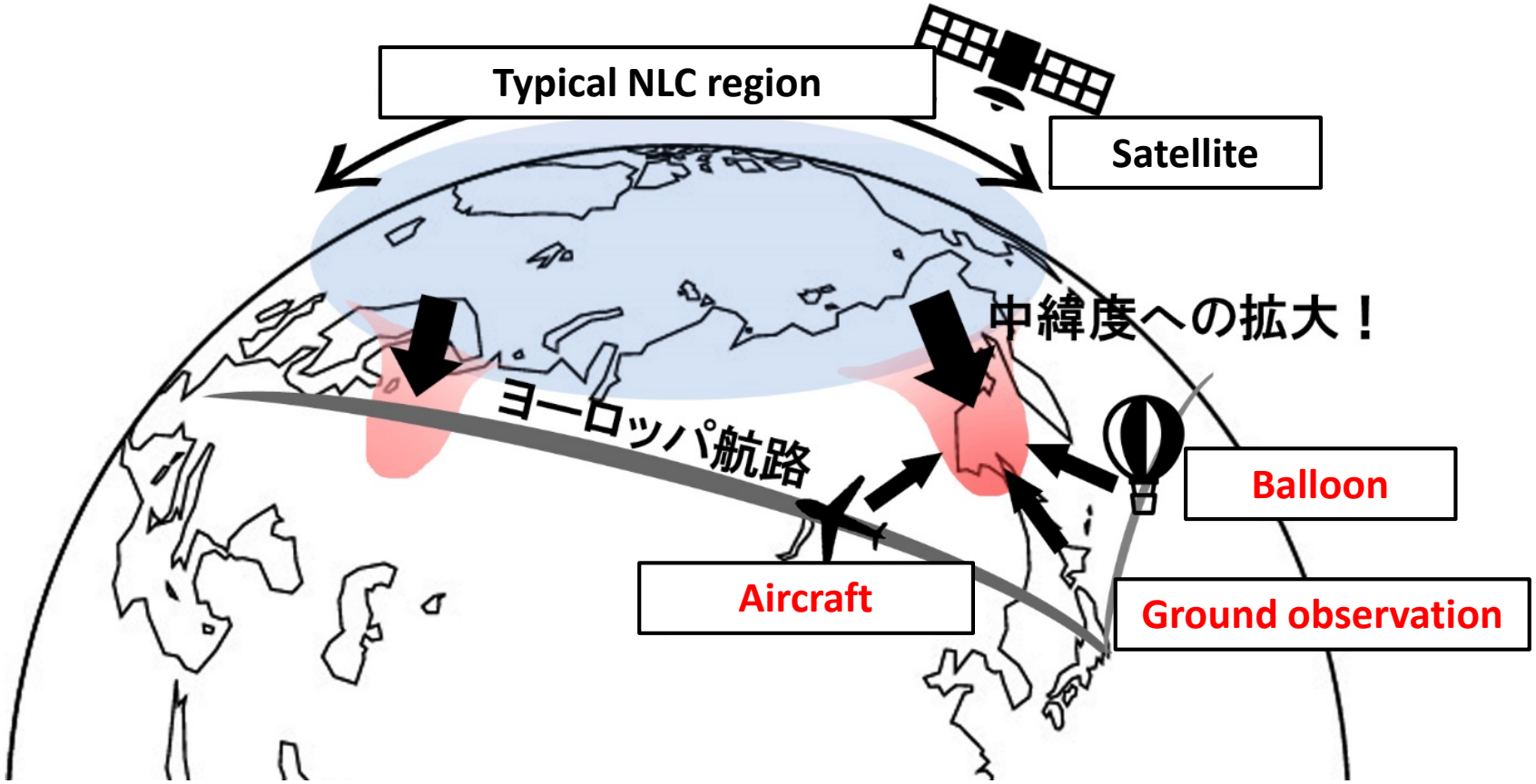
This fact cannot rule out the possibility of bad weather as an explanation of why the NLCs had not been captured in Hokkaido before this event.



Example of MSE echo observed by VHF radar at Wakkanai. (Case on the NLC event day Jun 21, 2015)

Plan for coordinated observation of Noctilucent clouds in Mid-latitude region.

Observation from platform over lower clouds would be effective to achieve continuous monitoring of the mid-latitude NLC.



Method 1 : Observation from an aircraft.

Imaging from a cockpit of aircrafts connecting Japan and Europe (and North America) is one of the effective ways.

Beautiful NLC pictures taken from a cockpit of an aircraft are introduced in the published book by K. Kokubun (2012, ISBN-13: 978-4486018384).

Observation plan has been already under discussion with Japanese airline company.

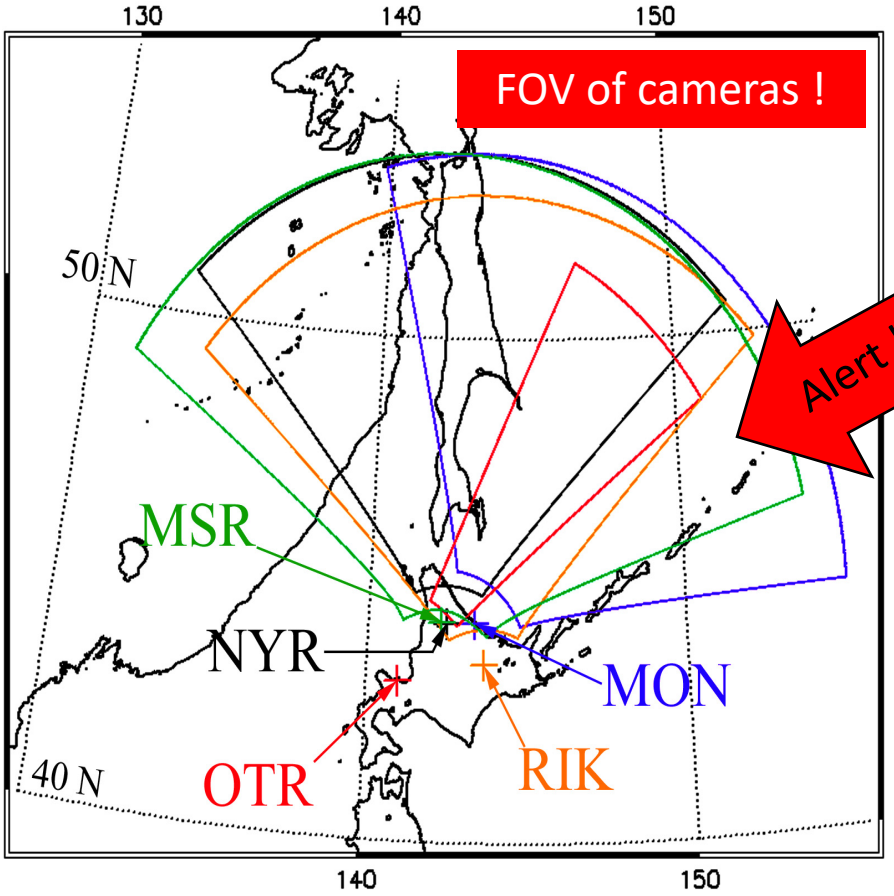
Method 2 : Observation from a balloon.

Balloon observation is another way which is not interrupted by lower clouds.

Swedish team (PI: Dr. Peter Dalin) has successfully imaged NLC picture from a small balloon above Moscow on July, 2018.

Swedish team will provide us a technical knowhow of the balloon observation.
New communication technology using LoRa band will be used to monitor the trajectory of the balloon. The scheme is now under test by Kochi technical college team.

Method 3 : Observation with improved ground system cooperated with satellites.



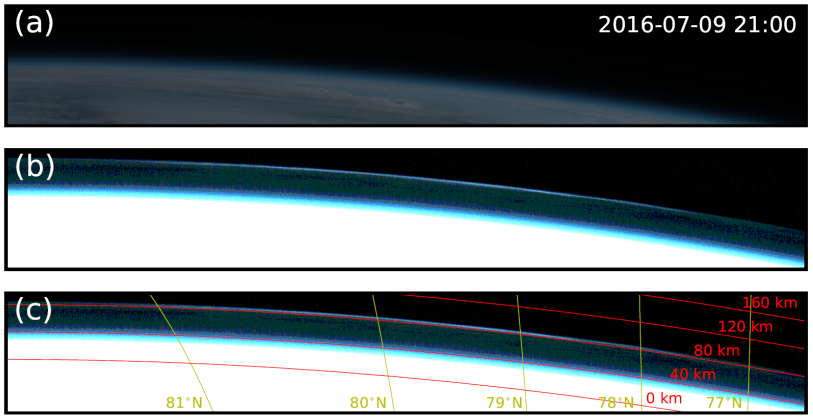


Figure 1. (a) An original true-color image (composites of the 3 visible bands) around northern high latitudes at 21:00 UT on 9 July 2016. (b) Same as Figure 1a, but the color scale is 50 times enhanced. (c) Same as Figure 1b, but latitudes and heights of the tangential points are overlaid.

Himawari-8 is capable for NLC detection.
[Tsuda, AMT discussion paper, 2018]

Equatorward expansion of NLC region is detected by HIMAWARI-8.

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Alert to ground observers !

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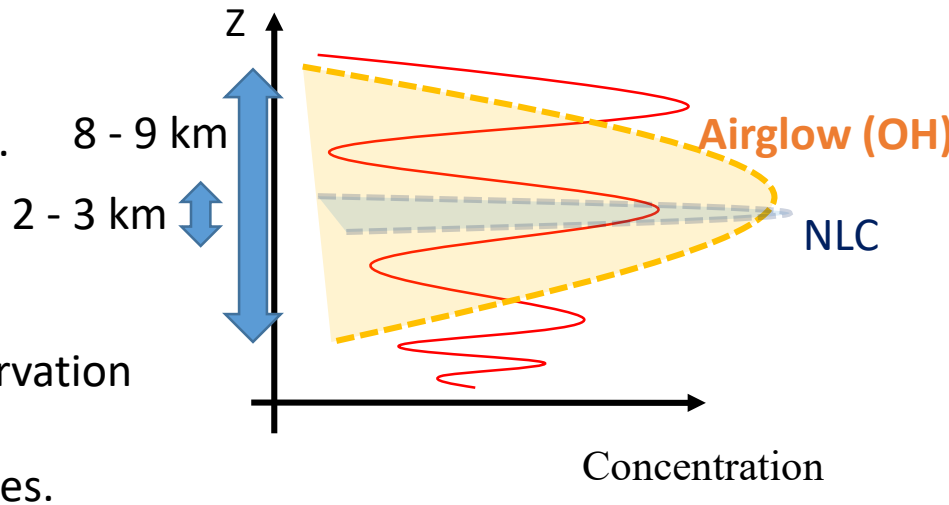
Network cameras start observation with high temporal resolution.

Noctilucent cloud as a tracer of local dynamics in mesopause region

V.S. Airglow imaging method

1. More sensitive to small scale structures.

Typical thickness of the NLC layer is 2-3 km which is smaller than that of OH layer (8-9 km).



2. High temporal and spatial resolutions

NLC is brighter than airglow.
This allows shorter exposure time for NLC observation than airglow observation.
NLC : ~ 1 sec , Airglow : 10 sec – Several minutes.
Also Imaging sensor with small pitch can detect NLC.

3. Needs small instruments

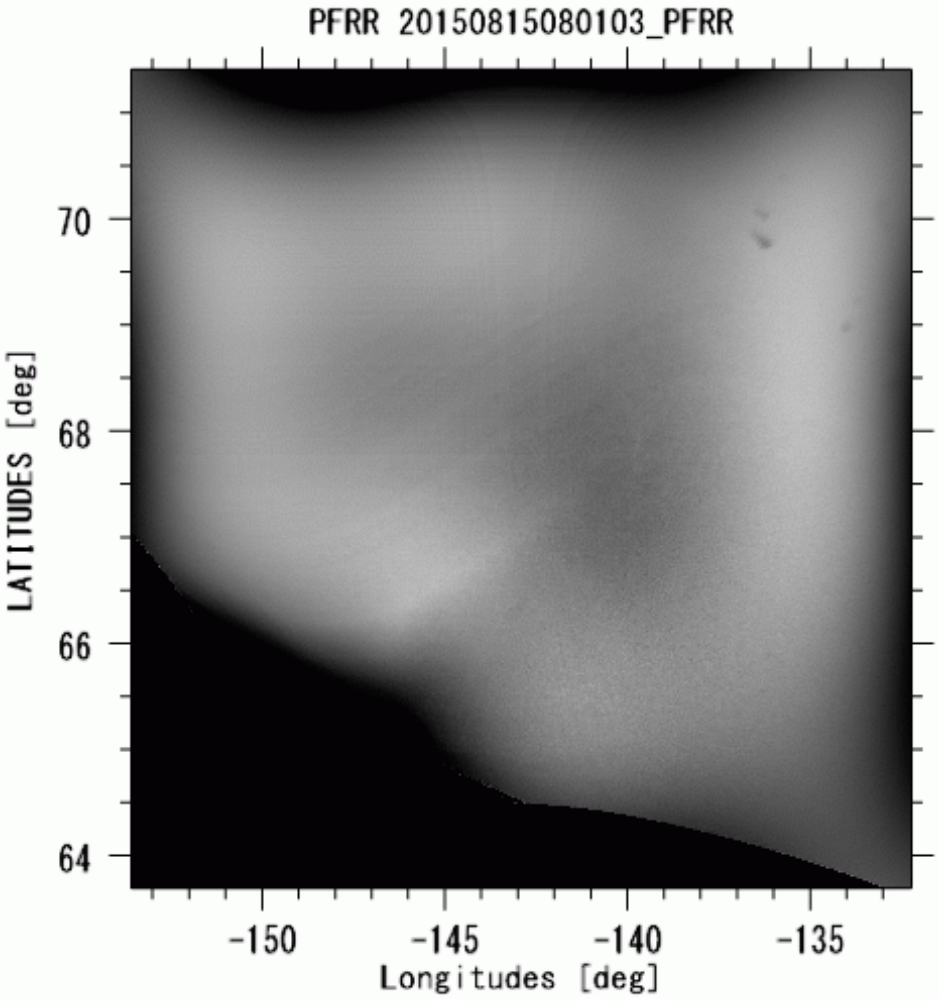
Ordinal digital cameras is sufficient to image NLC structure.

The camera installed in a all-sky dome.

4. Observable location and time are limited.

NLCs are observable only during the summer season In polar mesopause region. Also, an observation is limited during twilight time.

Further expectations for simultaneous observation of NLC and (P)MSE.



Sequential FFT filtered images between 08:01:03 and 12:59:05 (2 min interval)
Suzuki and Sakaguchi, AM45, 2018

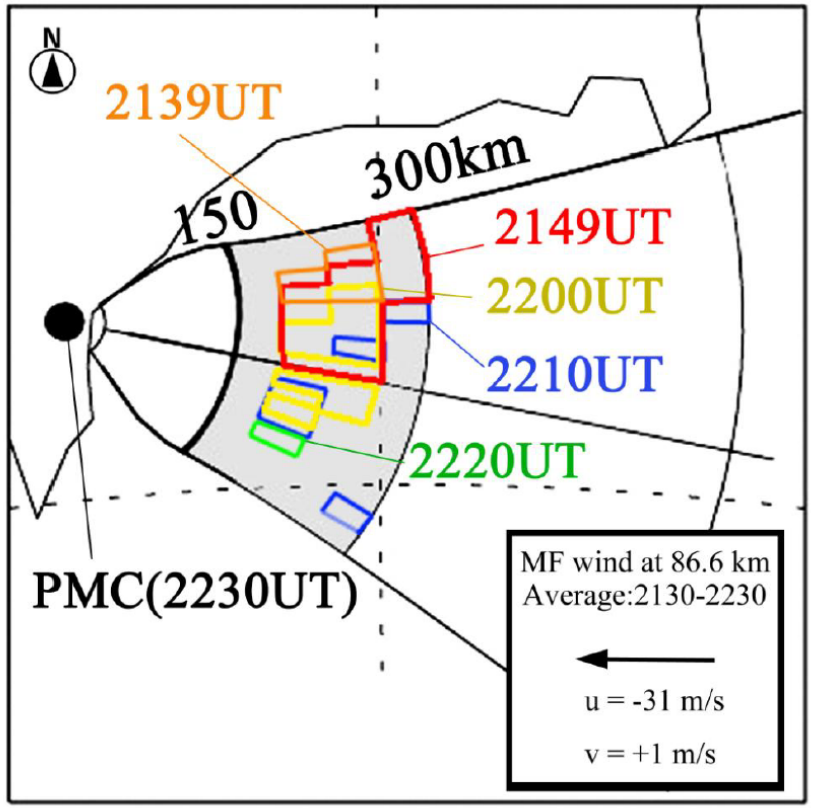


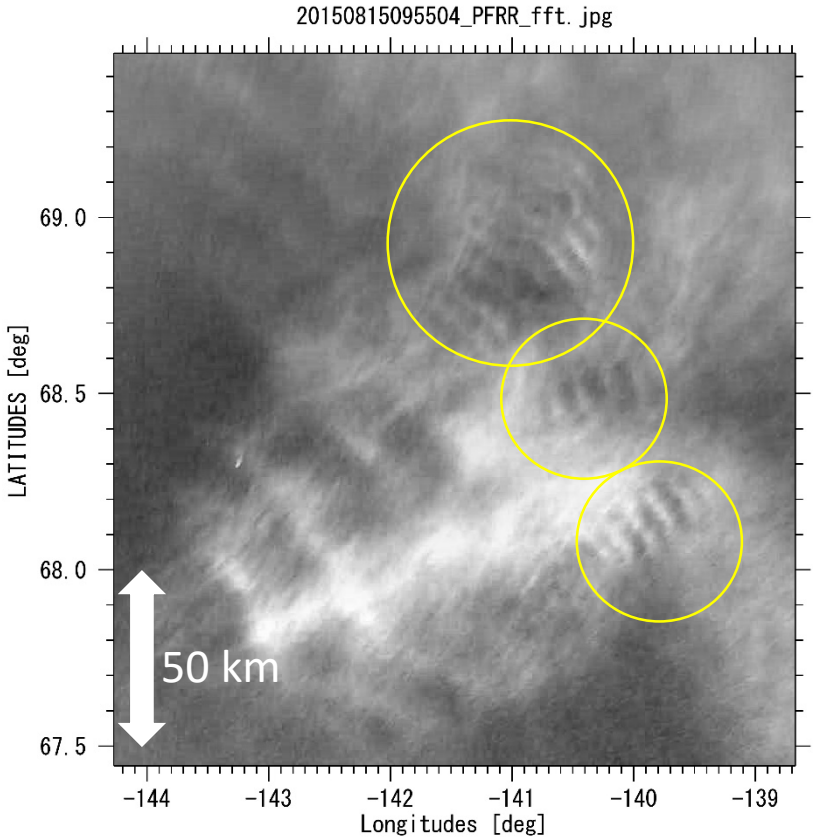
Fig. 8. Spatiotemporal variation of the strong echo region (> 20 dB) for the ground range between 150 and 300 km. The wind vector at the PMC altitude (86.6 km) scaled by the distance of wind advection for one hour is also shown.

Spatio temporal variation of PMSE Echo region observed by Syowa HF radar during ~1 hour.

Result : Structure likely to be related with instabilities (Spatial distribution)

Type 1

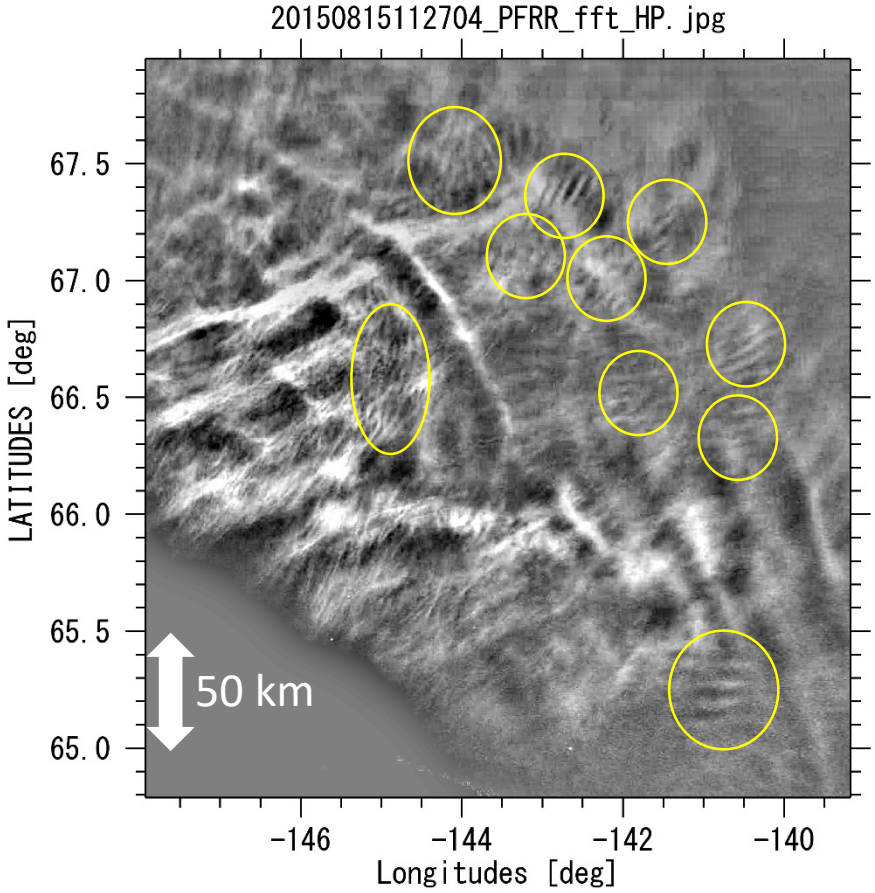
Phase lines are nearly parallel with QM



Three instability regions exist within 100 km x 100 km area at 9:55:04.

Type 2

Phase lines are perpendicular with QM



Eight instability regions exist within 200 km x 200 km area.
Each cell is confined in area smaller than 30km x 30km.

Summary

- NLC is considered to be an one of possible tracer of global warming. In particular, NLC occurrence in Mid-latitude is one of the important factors to use NLC as a proxy of the global change.

- Coordinated observation of Mid-NLC by using an aircraft, a compact balloon and ground-based imaging system is suggested.

- Fine NLC images obtained by these observations would be powerful tool to investigate the dynamical relationship between NLC(PMC) and (P)MSEs.