

短波長赤外(1.0-1.6 μm)におけるオーロラ・大気光の分光観測:
昭和基地における観測データ公開の実例

西山尚典 (国立極地研究所)

Introduction

Spectroscopy of aurora and airglow

- ▶ 超高層大気分光学的研究 - 組成の同定、エネルギーや物質の輸送・収支
 - ▶ オーロラ：宇宙空間から流入する粒子エネルギーに対する大気応答（高度100-300 km）
 - ▶ 大気光：放射や熱・大気波動に駆動される化学過程による発光（高度 80-100 km）
- ▶ 1867年にÅngströmがオーロラスペクトルの取得
 - ▶ 以降も可視域（~800 nm）での観測が主流
 - ▶ 70-80年代に短波長赤外 (SWIR, 1.0-1.6 μm)での調査があるものの、それ以降、基礎的な分光学データの更新は行われていない。

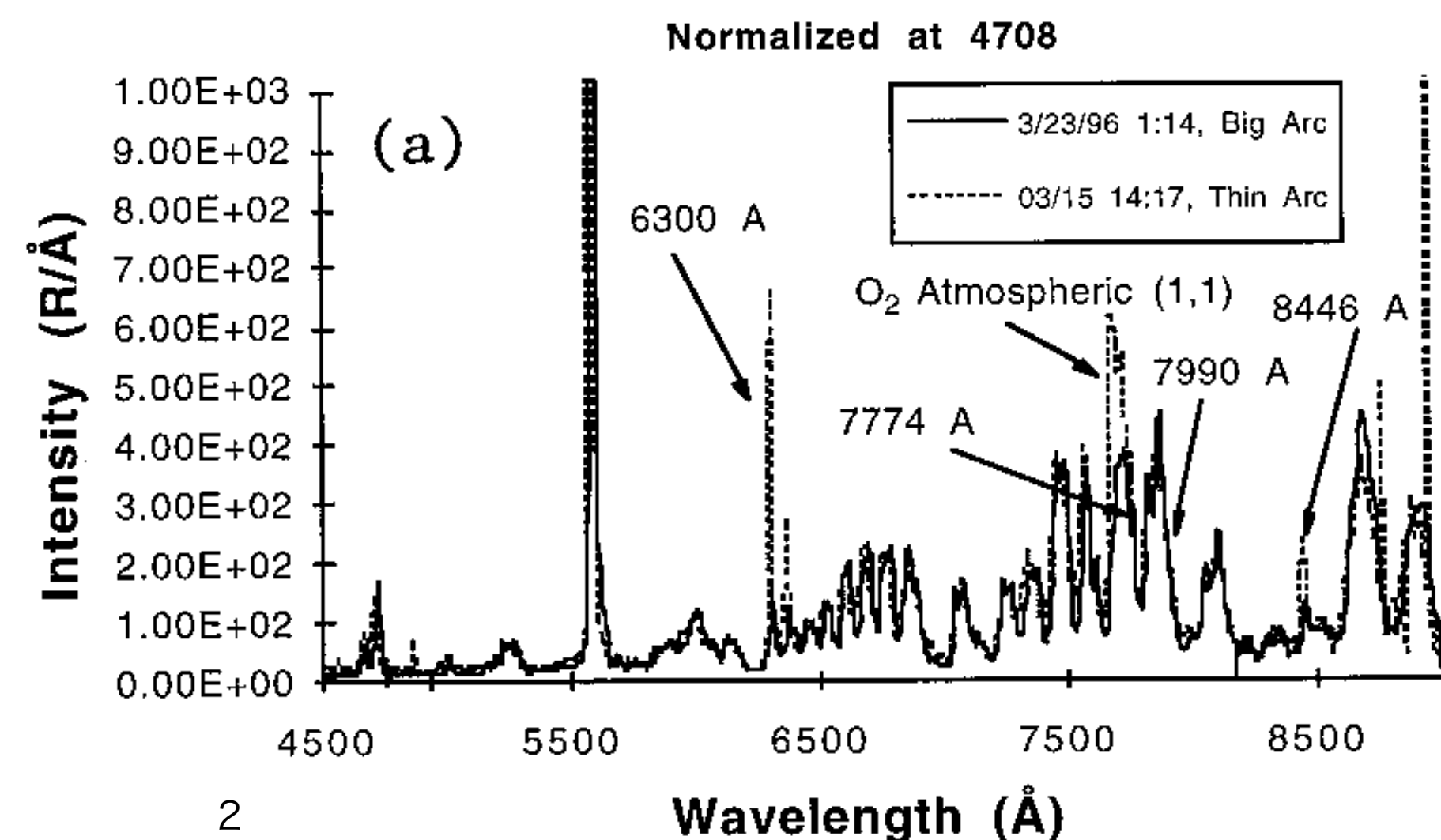
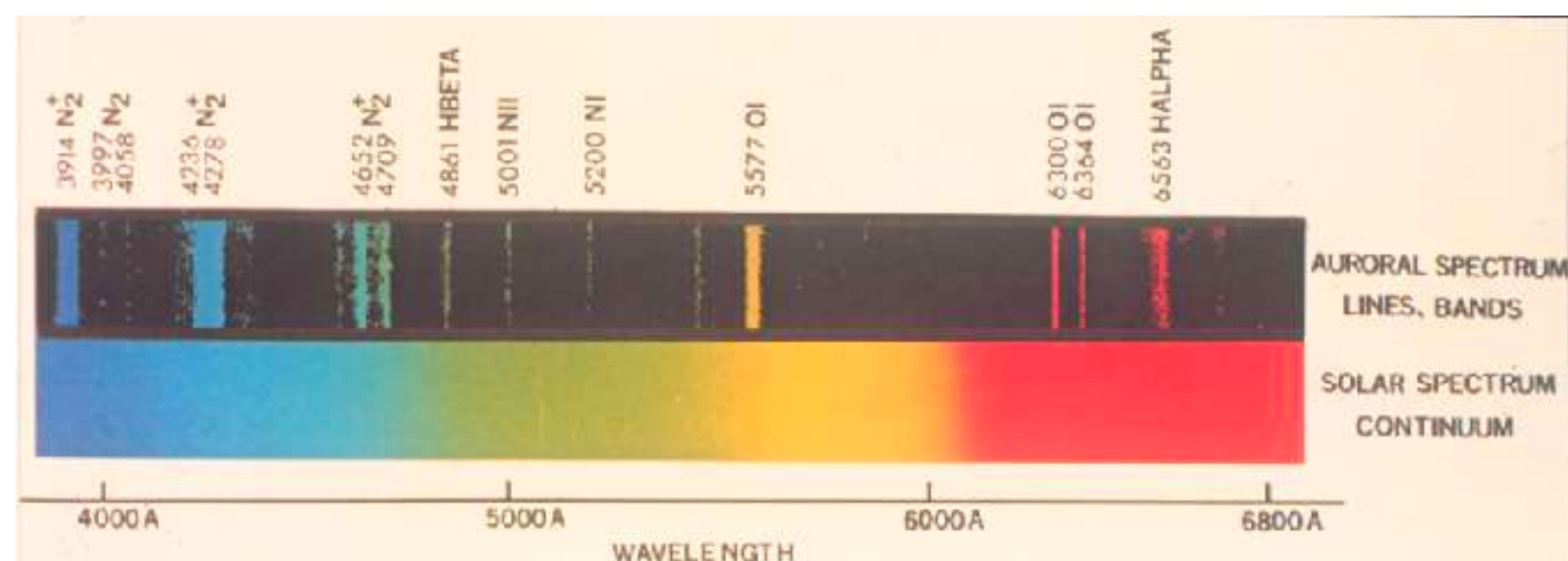
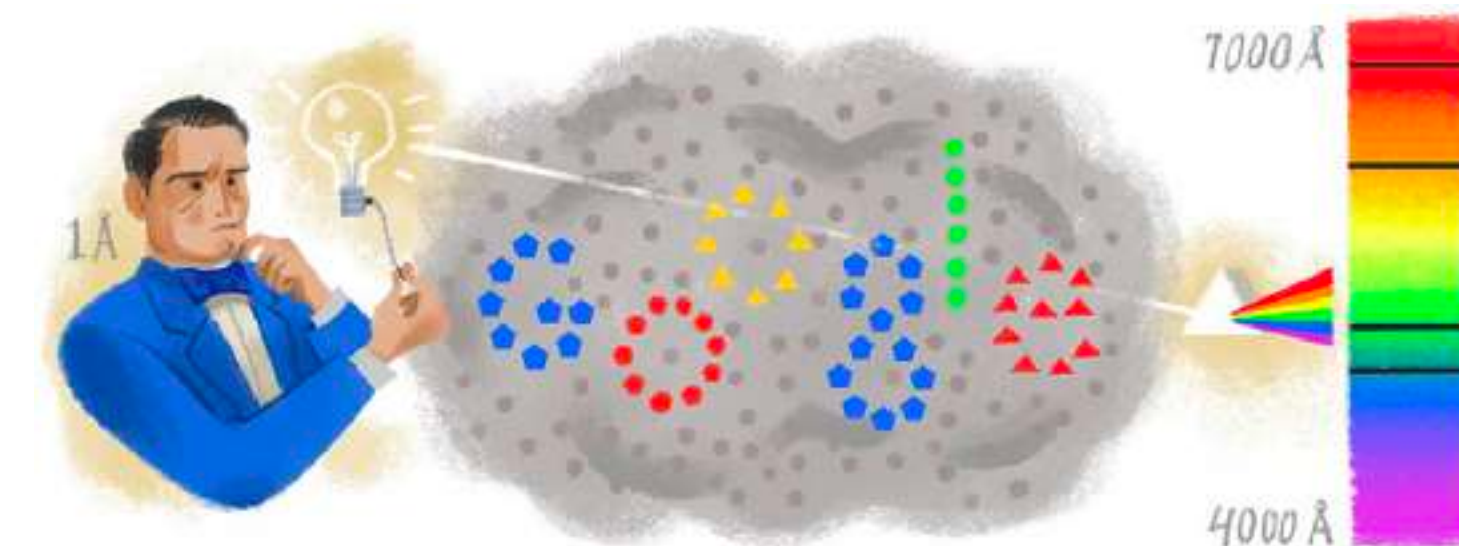
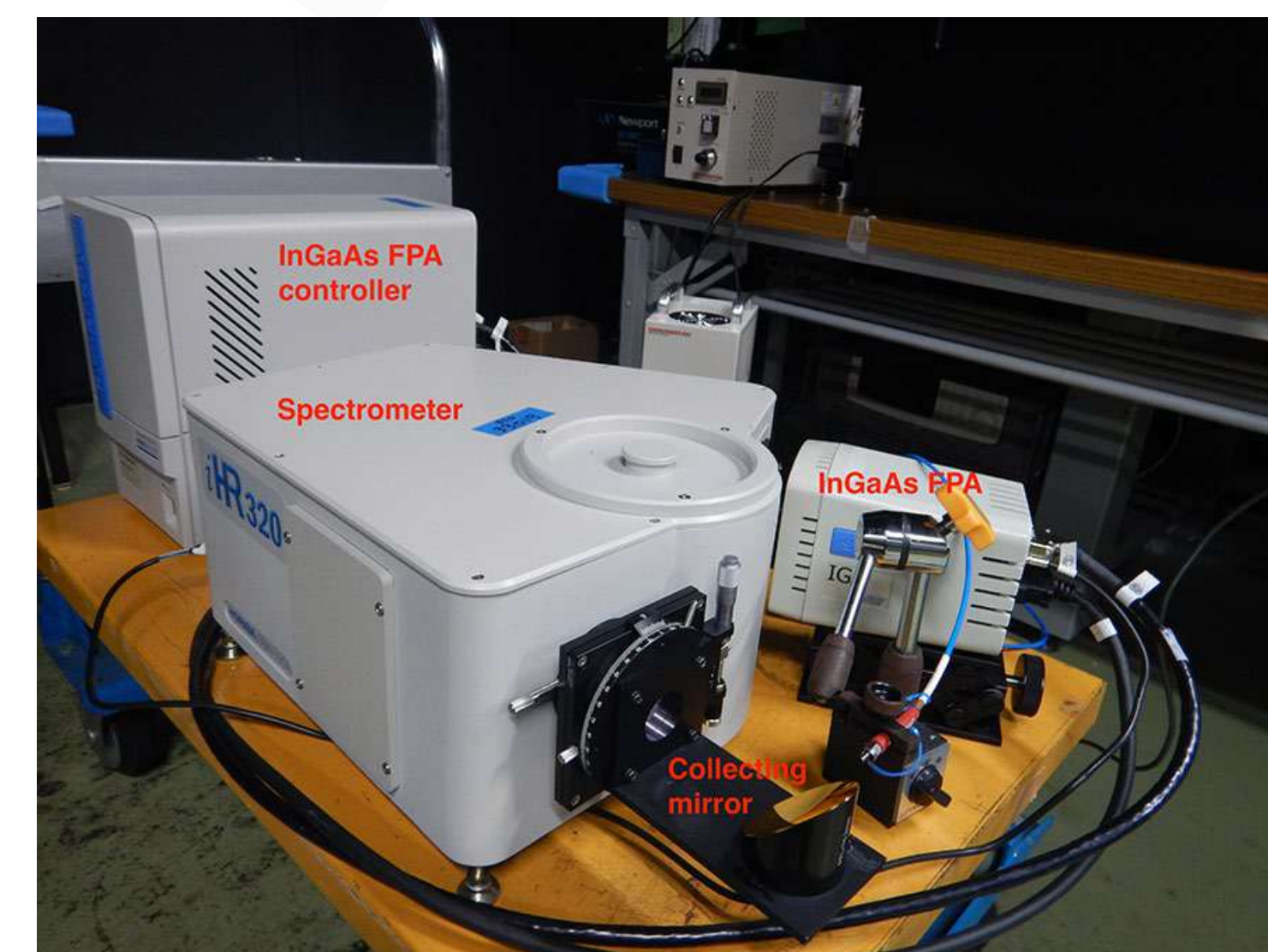
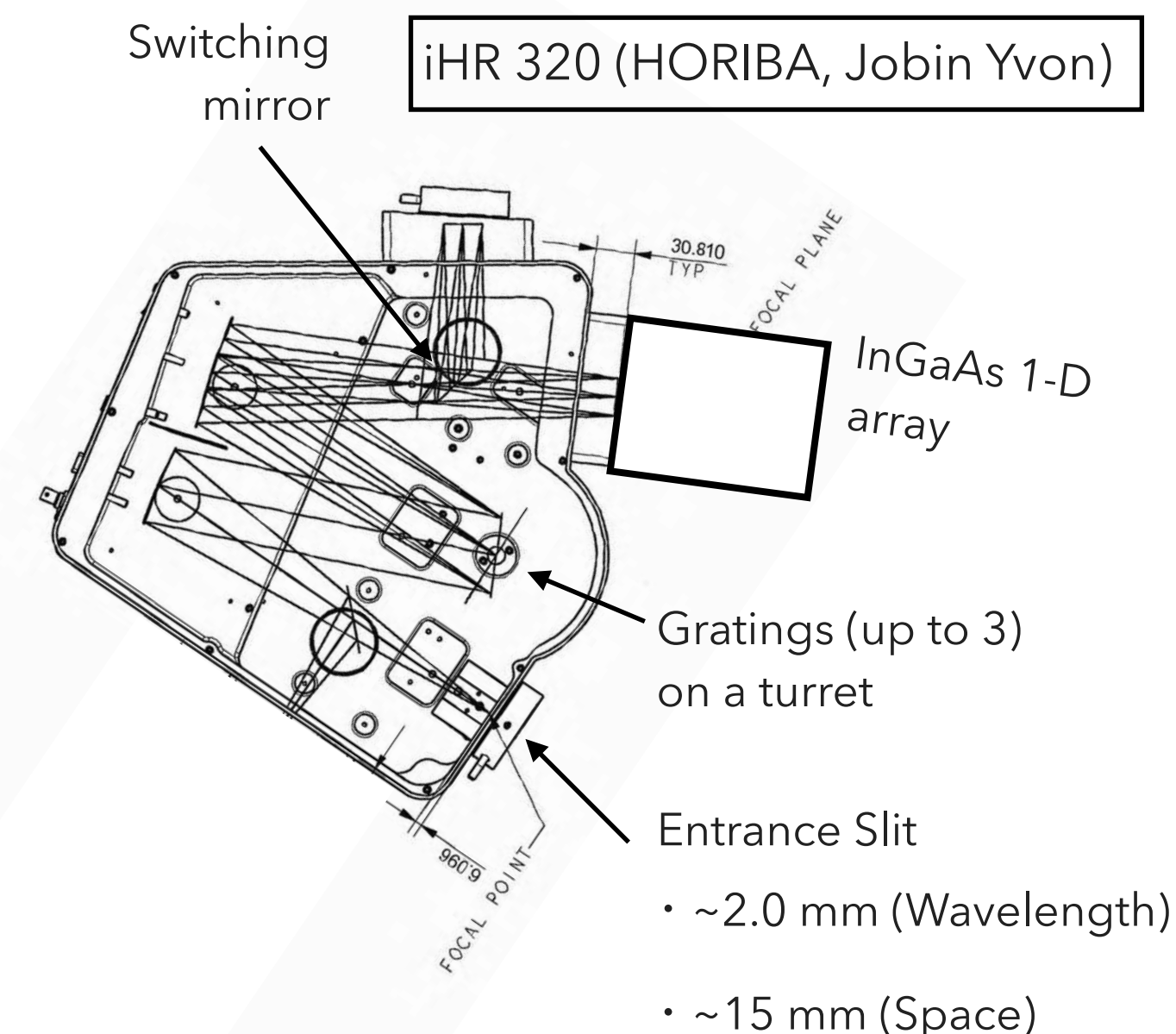


Fig. Auroral spectra in a wavelength range from 4500 to 9000 Å
[Swenson et al., 1998]

Introduction

NIRAS: Near InfraRed Aurora and airglow Spectrograph

- ▶ 2000年以降：検出器（InGaAs）の性能向上と大気光観測での利用
- ▶ JARE59の重点観測としてNIRASの導入（科研費ベース）
 - ▶ 科学目的：
 - ▶ オーロラスペクトル情報のアップデート
 - ▶ オーロラと大気光の相互比較・分離
 - ▶ 大気光を用いた中間圏界面の温度モニタ
 - ▶ Czerny-Turner型の分光器（HORIBA, iHR 320）と検出器にInGaAs 1-D FPAを用いた分光計
- ▶ 観測実施概要
 - ▶ 昭和基地とスウェーデン・キルナの2地点
 - ▶ 1.5 μm におけるスペクトル取得を中心に運用（全観測の80%）



Syowa Station, Antarctic

Location: 69.0°S, 39.6°E (Magnetic latitude: 66.9°S)
 Period: March 7–November 2, 2018 (austral winter)
 # of observations: 235 nights (168 nights, a 600-lpmm grating for OH (3,1) band)

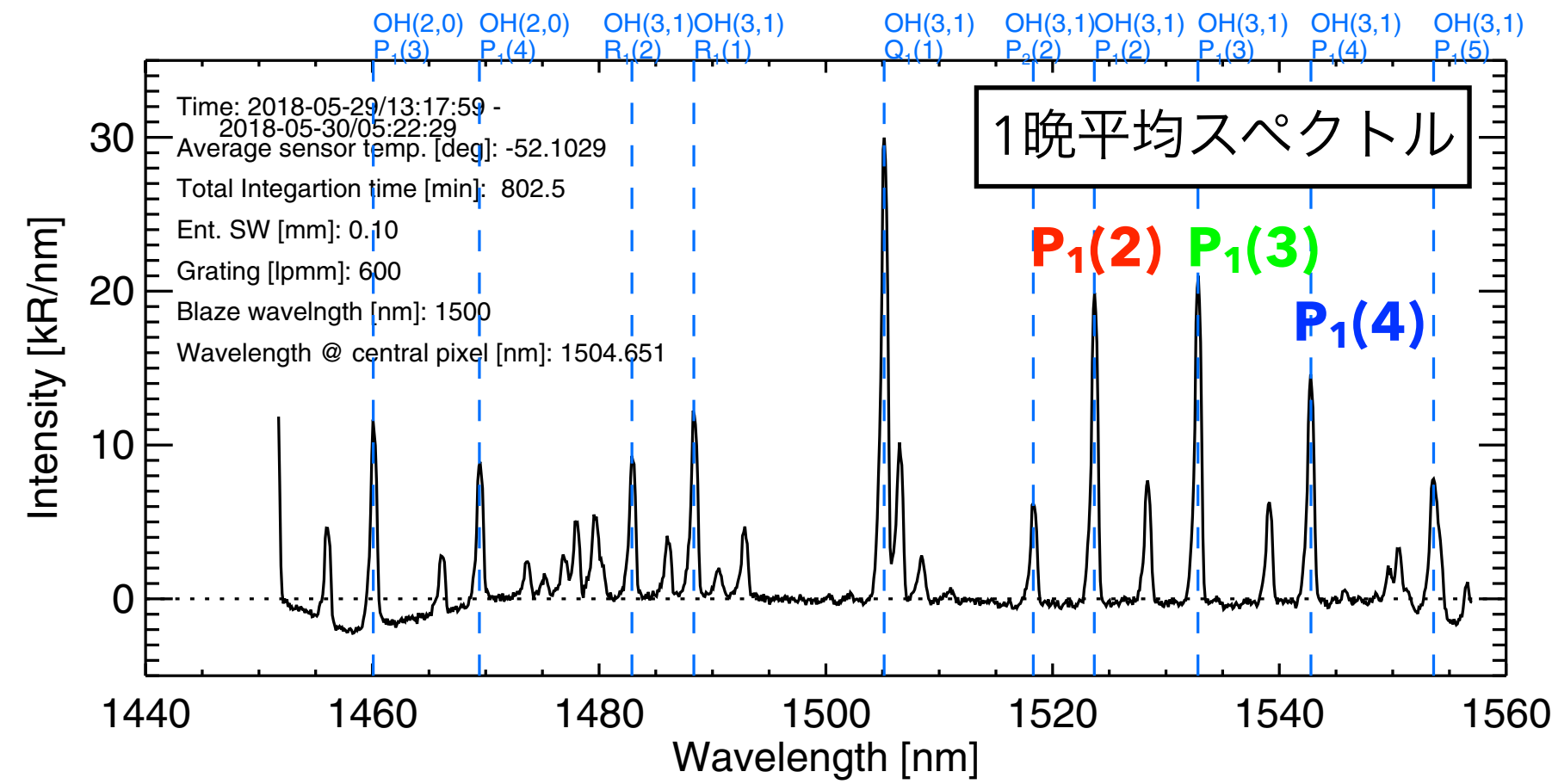
IRF, Sweden

Location: 67.8°N, 20.4°E (Magnetic latitude: 65.2°N)
 Period: August 28, 2019–January 10, 2020
 # of observations: 133 nights (127 nights, a 600-lpmm grating for OH (3,1) band)

Introduction

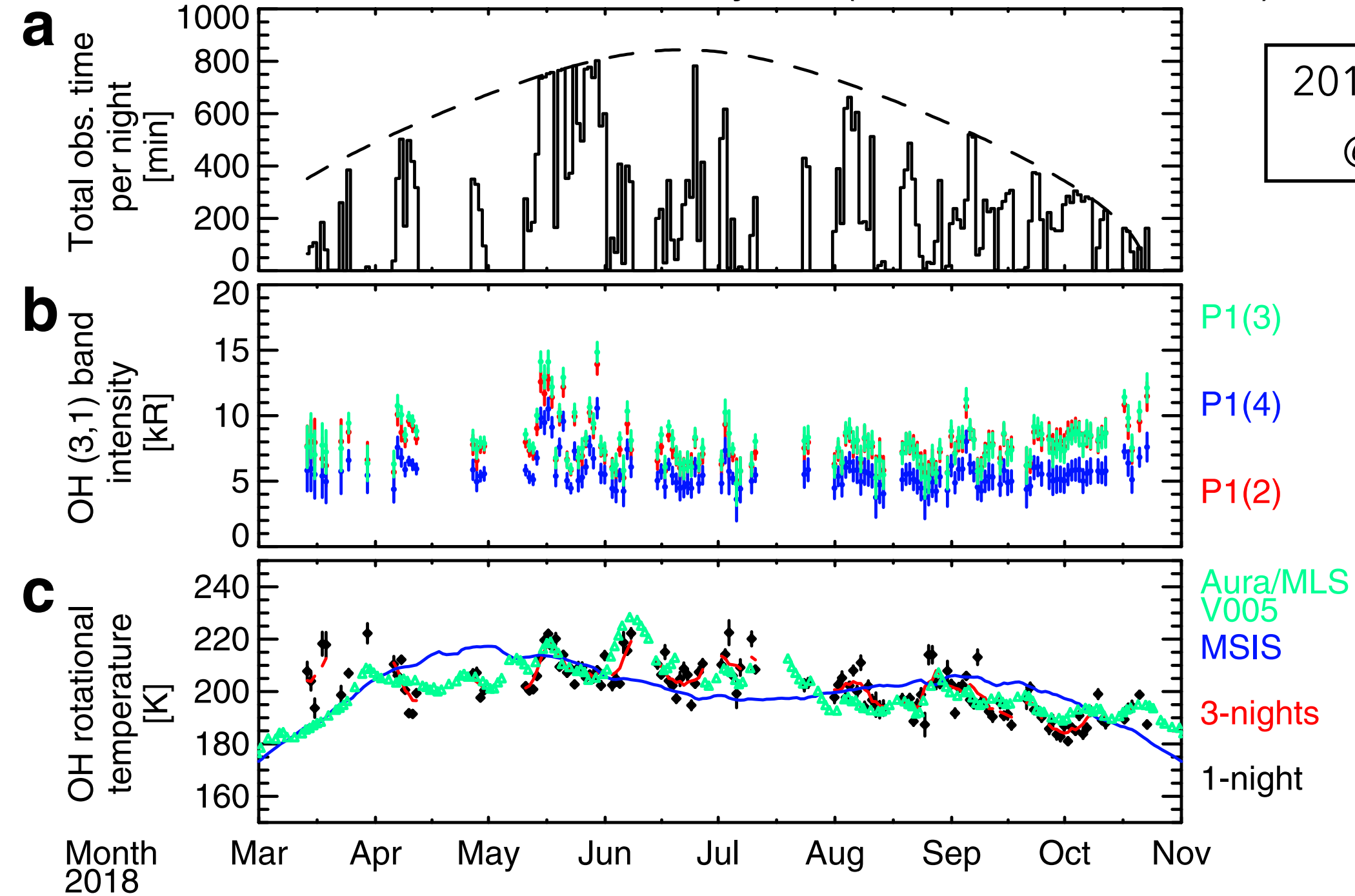
NIRAS results

▶ OH大気光 3-1 bandの観測例



a 2018-05-29

NIRAS Observation 2018 @ Syowa (Lat. -69.0°, Lon. 39.6°)



2018年季節変動
@昭和基地

▶ オーロラスペクトルの高時間分解能観測とOH大気光との比較 (Nishiyama et al., 2021)

Nishiyama et al. *Earth, Planets and Space* (2021) 73:30
<https://doi.org/10.1186/s40623-021-01360-0>

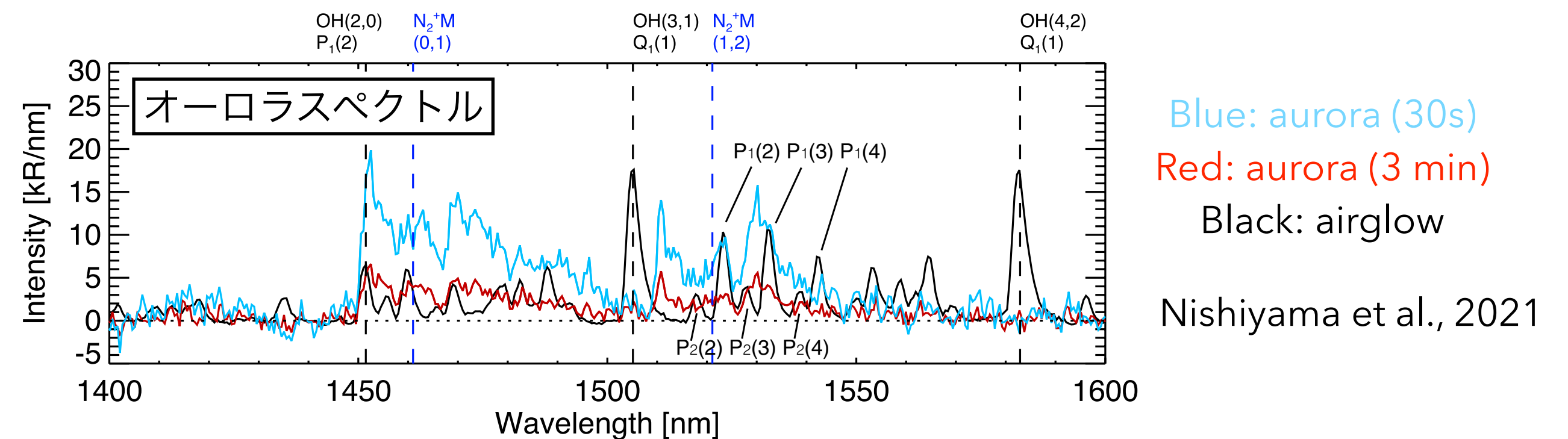
Earth, Planets and Space

FULL PAPER

Open Access

Temporal evolutions of N_2^+ Meinel (1,2) band near $1.5 \mu\text{m}$ associated with aurora breakup and their effects on mesopause temperature estimations from OH Meinel (3,1) band

Takanori Nishiyama^{1,2*}, Makoto Taguchi³, Hidehiko Suzuki⁴, Peter Dalin⁵, Yasunobu Ogawa^{1,2,6}, Urban Brändström⁵ and Takeshi Sakanoi⁷



a 2018-05-06

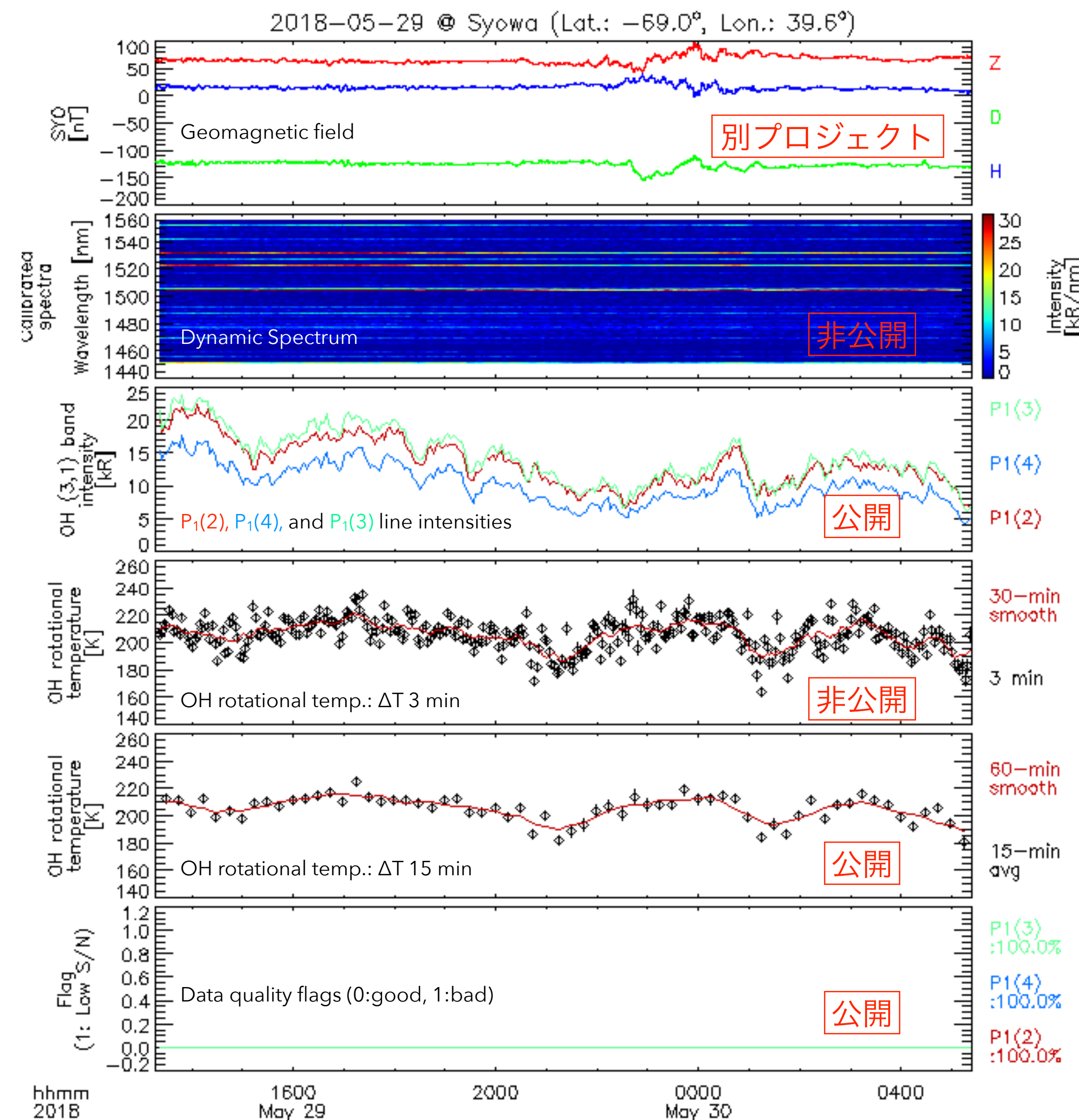
Blue: aurora (30s)
Red: aurora (3 min)
Black: airglow
Nishiyama et al., 2021

About Data

Data information

- ▶ 公開データ：1.5 μm帯の大気光スペクトル, version 5.1
- ▶ 物理量（時系列 1次元）
 - ▶ Level-2：OH 3-1 band P₁(2), P₁(3), P₁(4) 強度、3分値
 - ▶ Level-3：中間圏温度（フラグ付き）、15分値
- ▶ データ形式：netCDF
- ▶ 容量：1ファイル最大で 8 kB, 3 kB
- ▶ DOI：[10.17592/002.2021030390](https://doi.org/10.17592/002.2021030390)
- ▶ Landing Page：https://scidbase.nipr.ac.jp/modules/metadata/index.php?content_id=390&ml_lang=en

Science Field	
Space and Upper Atmospheric Sciences => Observations by the Japanese Antarctic Research Expedition	
Project => Space and Upper Atmospheric Sciences	
View GCMD Formatted XML	
Overview	
Title	Near InfraRed Aurora and airglow Spectrograph (NIRAS) @ Syowa
Sub-Title	Aurora and airglow spectroscopic observations
Data Summary	Aurora and airglow spectral data in netCDF - Level-2, P ₁ (2), P ₁ (4), and P ₁ (3) line intensities in OH (3,1) band - Level-3, OH rotational temperature More detail of the contents can be found in netCDF data as attributes



About Data

Data header

```
(base) nishiyama@Takanori-MacBook-Pro 05 % ncdump -h NIRAS_OH_3-1_syo_20180529_v5.1.nc
```

```
netcdf NIRAS_OH_3-1_syo_20180529_v5.1 {
dimensions:
  time = 321 ;
```

Level-2 : 大気光発光強度

```
variables:
```

```
double time(time) ;
  time:units = "Seconds since 1970-01-01/00:00:00" ;
  time:long_name = "Time of measurement" ;
float p12(time) ;
  p12:units = "kR, kilo-Rayleigh" ;
  p12:long_name = "OH (3,1) P1(2) line intensity" ;
float p14(time) ;
  p14:units = "kR, kilo-Rayleigh" ;
  p14:long_name = "OH (3,1) P1(4) line intensity" ;
float p13(time) ;
  p13:units = "kR, kilo-Rayleigh" ;
  p13:long_name = "OH (3,1) P1(3) line intensity" ;
```

```
// global attributes:
```

```
:project = "NIRAS, Near InfraRed Aurora and airglow Spectrogr" ;
:title = "OH (3,1) band P1(2), P1(4), and P1(3) line intensit" ;
:processing_level = "Level 2, calibrated intentensity" ;
:institution = "National Institute of Polar Research, Japan" ;
:location = "Syowa Station, Antarctica" ;
:longitude = "39.6 E" ;
:latitude = "69.0 S" ;
:creator_name = "Takanori Nishiyama" ;
:creator_email = "nishiyama.takanori@nipr.ac.jp" ;
:license = "Public" ;
:comment = "Please contact the data provider for information" ;
:version = "v5.1" ;
:history = "Wed Mar 10 05:54:43 2021" ;
```

```
(base) nishiyama@Takanori-MacBook-Pro 05 % ncdump -h NIRAS_OH_rot_temp_syo_20180529_v5.1.nc
```

```
netcdf NIRAS_OH_rot_temp_syo_20180529_v5.1 {
dimensions:
  time = 64 ;
```

```
variables:
```

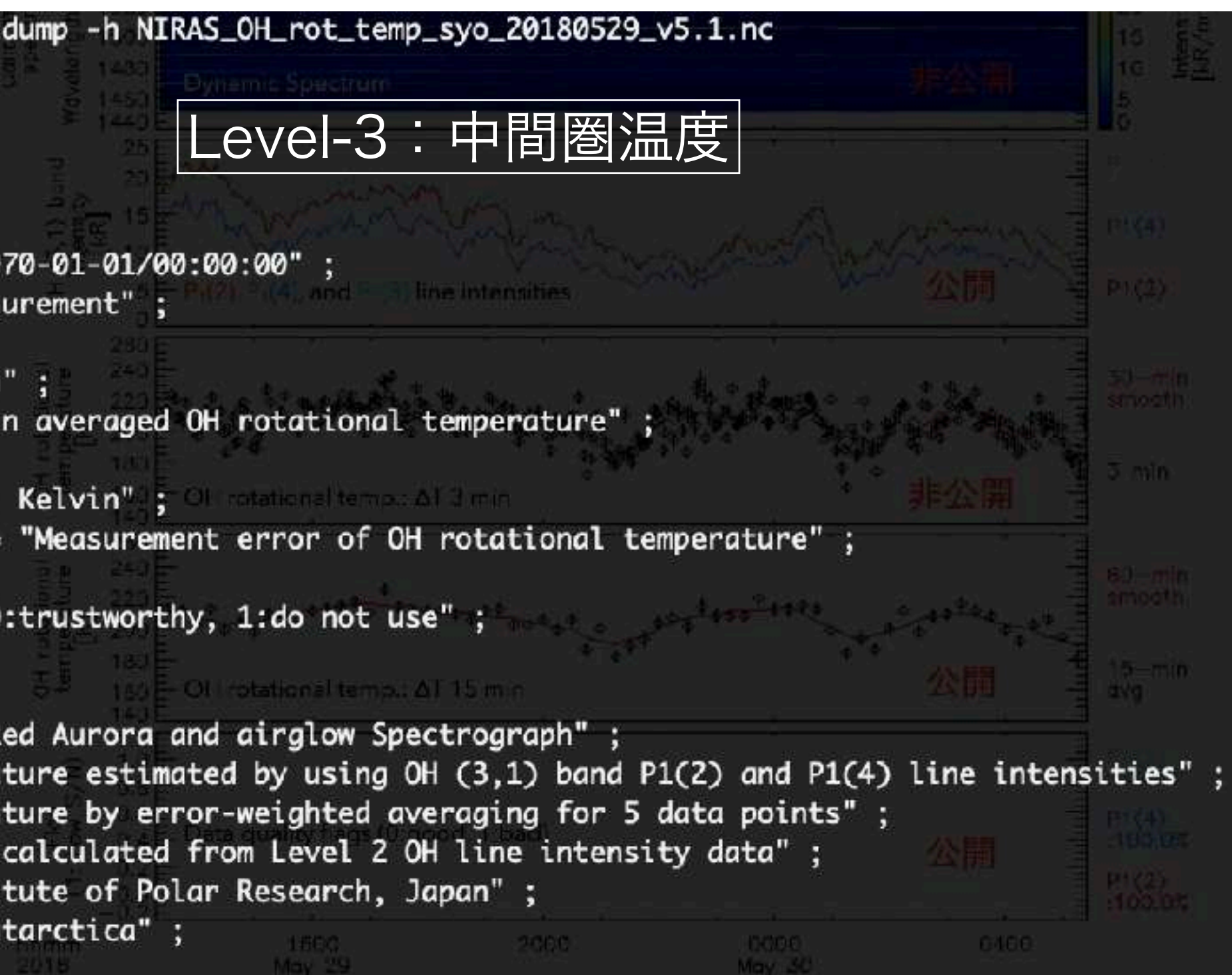
```
double time(time) ;
  time:units = "Seconds since 1970-01-01/00:00:00" ;
  time:long_name = "Time of measurement" ;
float temperature(time) ;
  temperature:units = "K, Kelvin" ;
  temperature:long_name = "15-min averaged OH rotational temperature" ;
float temperature\ error(time) ;
  temperature\ error:units = "K, Kelvin" ;
  temperature\ error:long_name = "Measurement error of OH rotational temperature" ;
short flag(time) ;
  flag:long_name = "Data flag; 0:trustworthy, 1:do not use" ;
```

Level-3 : 中間圏温度

```
// global attributes:
```

```
:project = "NIRAS, Near InfraRed Aurora and airglow Spectrograph" ;
:title = "OH rotaional temperature estimated by using OH (3,1) band P1(2) and P1(4) line intensities" ;
:discription = "15-min temperature by error-weighted averaging for 5 data points" ;
:processing_level = "Level 3, calculated from Level 2 OH line intensity data" ;
:institution = "National Institute of Polar Research, Japan" ;
:location = "Syowa Station, Antarctica" ;
:longitude = "39.6 E" ;
:latitude = "69.0 S" ;
:creator_name = "Takanori Nishiyama" ;
:creator_email = "nishiyama.takanori@nipr.ac.jp" ;
:license = "Public" ;
:comment = "Please contact the data provider for information on how to properly use the data." ;
:version = "v5.1" ;
:history = "Wed Mar 10 05:54:43 2021" ;
```

```
}
```



About Data

Publication status

- ▶ Numerical data :
 - ▶ 1.5 μm における大気光スペクトルデータは公開済み
 - ▶ <http://polaris.nipr.ac.jp/~niras/index.html#!data.md>
 - ▶ オーロラおよび他の波長の大気光スペクトル：リクエストベースの提供
 - ▶ キルナで取得したデータに関しても公開準備中
 - ▶ IUGONETと協力して、IDL用のデータロードプロシージャの提供予定
- ▶ Quick look plot :
 - ▶ 1晩平均スペクトル・時系列プロットを同ページで閲覧可能

2018.05

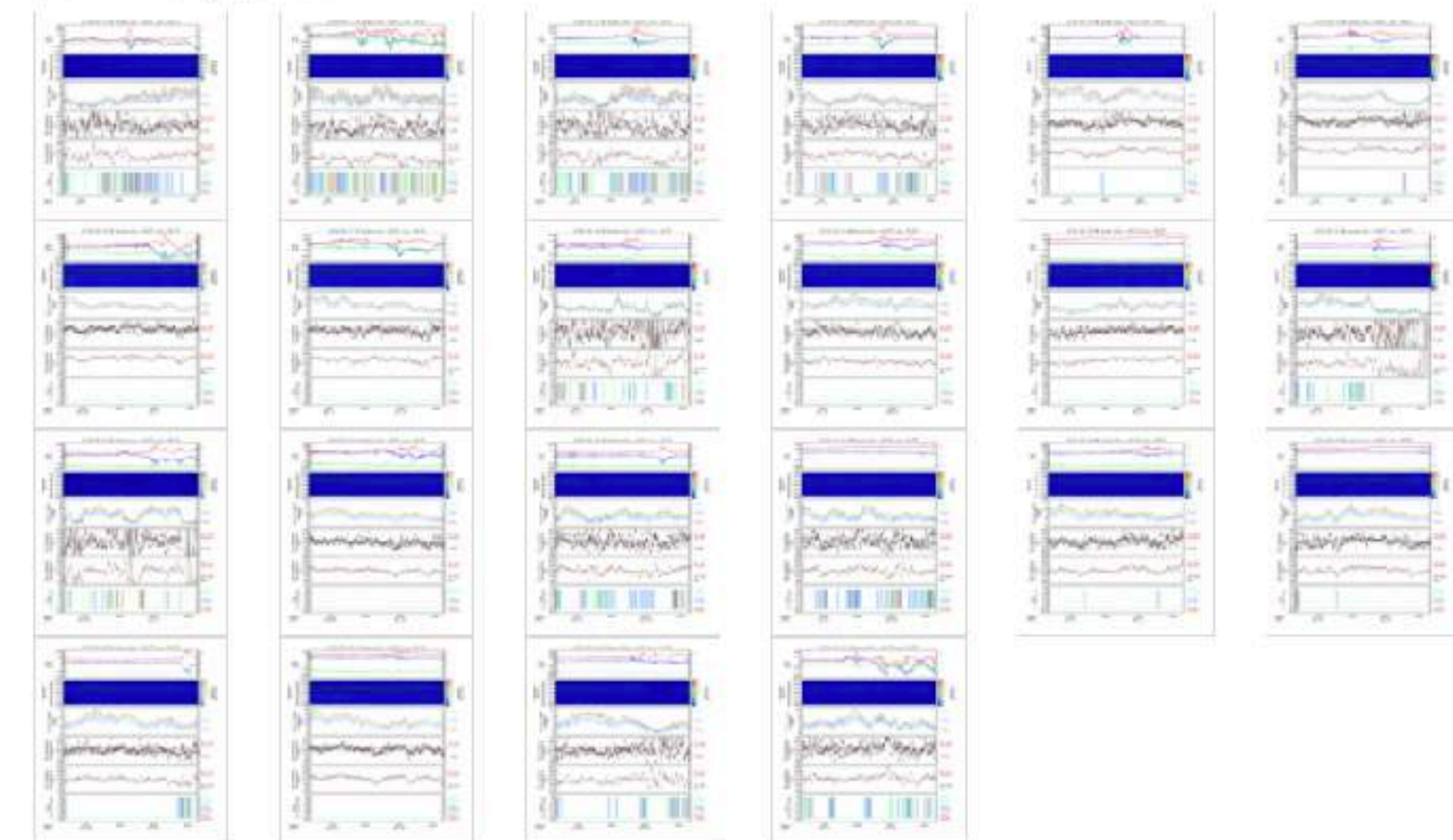
[Available data list](#)
[Quick Look](#)

Available data list

Date	P1(2), P1(4), and P1(3) line intensities in OH 3-1	OH rotational temperature
20180510	NIRAS_OH_3-1_20180510.nc	NIRAS_OH_rot_temp_20180510.nc
20180511	NIRAS_OH_3-1_20180511.nc	NIRAS_OH_rot_temp_20180511.nc
20180512	NIRAS_OH_3-1_20180512.nc	NIRAS_OH_rot_temp_20180512.nc
20180513	NIRAS_OH_3-1_20180513.nc	NIRAS_OH_rot_temp_20180513.nc
20180514	NIRAS_OH_3-1_20180514.nc	NIRAS_OH_rot_temp_20180514.nc
20180515	NIRAS_OH_3-1_20180515.nc	NIRAS_OH_rot_temp_20180515.nc
20180516	NIRAS_OH_3-1_20180516.nc	NIRAS_OH_rot_temp_20180516.nc
20180517	NIRAS_OH_3-1_20180517.nc	NIRAS_OH_rot_temp_20180517.nc
20180518	NIRAS_OH_3-1_20180518.nc	NIRAS_OH_rot_temp_20180518.nc
20180519	NIRAS_OH_3-1_20180519.nc	NIRAS_OH_rot_temp_20180519.nc
20180520	NIRAS_OH_3-1_20180520.nc	NIRAS_OH_rot_temp_20180520.nc

Quick Look

Summary plots



Conclusion

And future works

- ▶ 超高層大気の研究において分光スペクトルは基本的なデータ
 - ▶ 近年, SWIR波長領域における観測の充実化
 - ▶ JAREおよびスウェーデンでの共同研究によるNIRASの観測実施
- ▶ データ公開状況
 - ▶ OH 3-1 bandの大気光スペクトルデータを公開
 - ▶ それ以外のデータはリクエストベースでの提供
 - ▶ データの実態
 - ▶ netCDF, 1ファイル 数 kB程度, 特定の波長での発光強度および温度 (フラグ付き)
 - ▶ DOI取得済み, プロジェクトHPでデータおよびQLプロット公開中
- ▶ Future work
 - ▶ 2次元 (時間・波長) スペクトルデータの公開 (ただし1.5 μm 付近のデータのみ)
 - ▶ IUGONETと連携したデータロードプロシージャの提供
 - ▶ スウェーデンにおける観測データの公開・NIRAS後継機のデータの整備準備