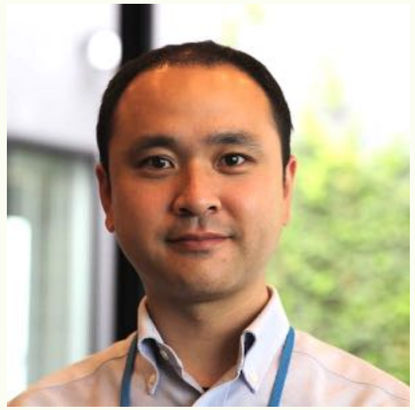
High-Performance Computing at NIES: Building a New Computing Infrastructure to Address Diverse Scientific Needs

Hisashi Yashiro (National Institute for Environmental Studies, Tsukuba, Japan)

NEC User Group Meeting (day 3), Osaka U., 2025/5/15

About me



Hisashi YASHIRO, Ph.D

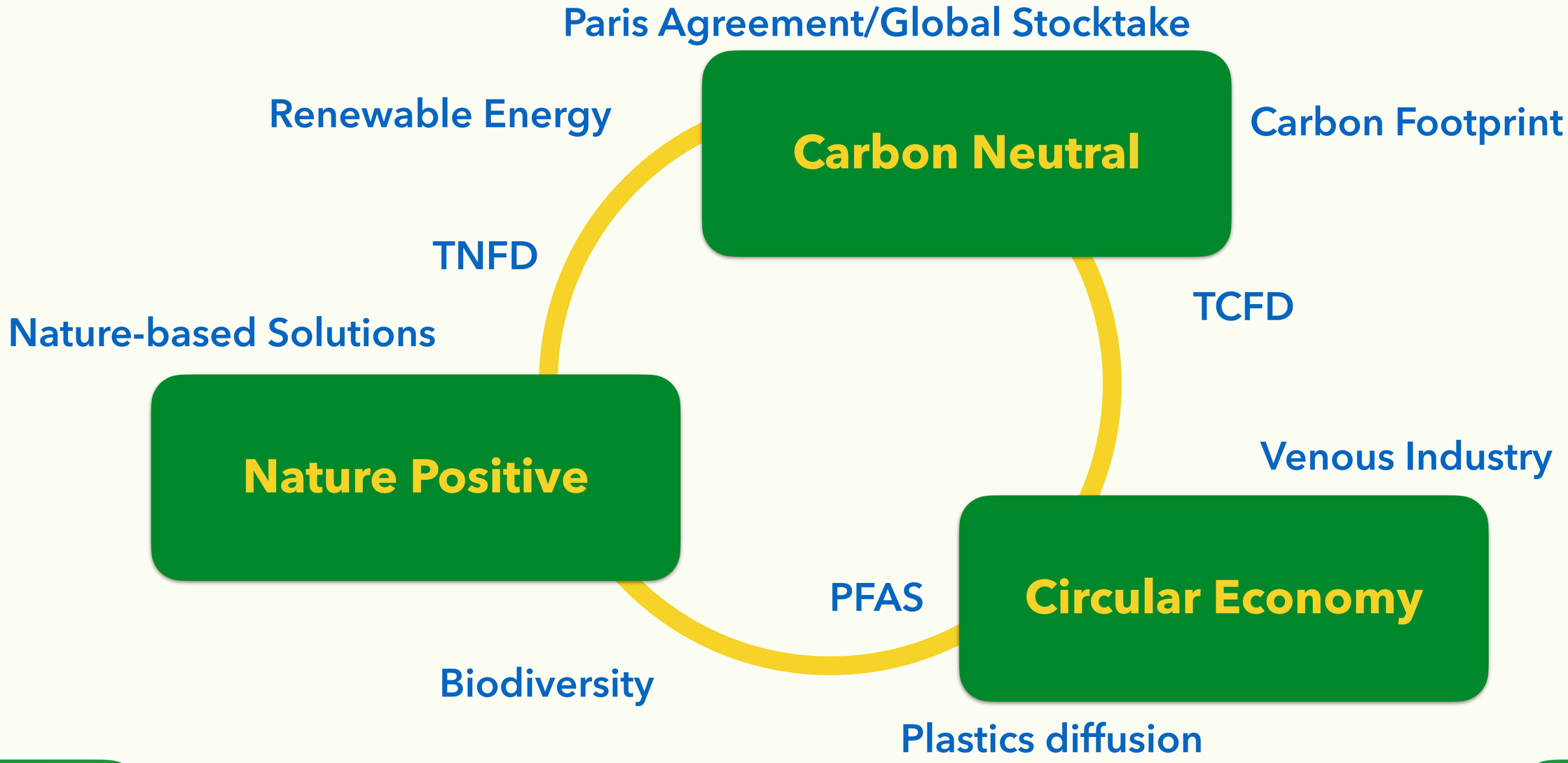
- Senior researcher, National Institute for Environmental Studies, Tsukuba, Japan

- **Education: Tohoku University, Japan**
  - Observational study of greenhouse gases (GHGs) and GHG-related gases
- **Works**
  - Japan Agency for Marine-Earth Science and Technology (**JAMSTEC**, Yokohama, 2008-2011)
    - Research & study for atmospheric short-lived gases by using **global chemical climate model**
  - RIKEN Center for Computational Science (**R-CCS**, Kobe, 2011-2019)
    - R&D of next-generation **high-performance weather/climate model**
    - Japanese flagship supercomputer (**Fugaku**) project
  - National Institute for Environmental Studies (**NIES**, Tsukuba, 2019-)
    - Management and development of the ground system for a **new GHG observation satellite** (GOSAT-GW)
    - Manager of Research Information Office: IT services for researchers

National Institute for Environmental Studies (NIES)

- Established in 1974

National Institute for Environmental Studies (NIES)



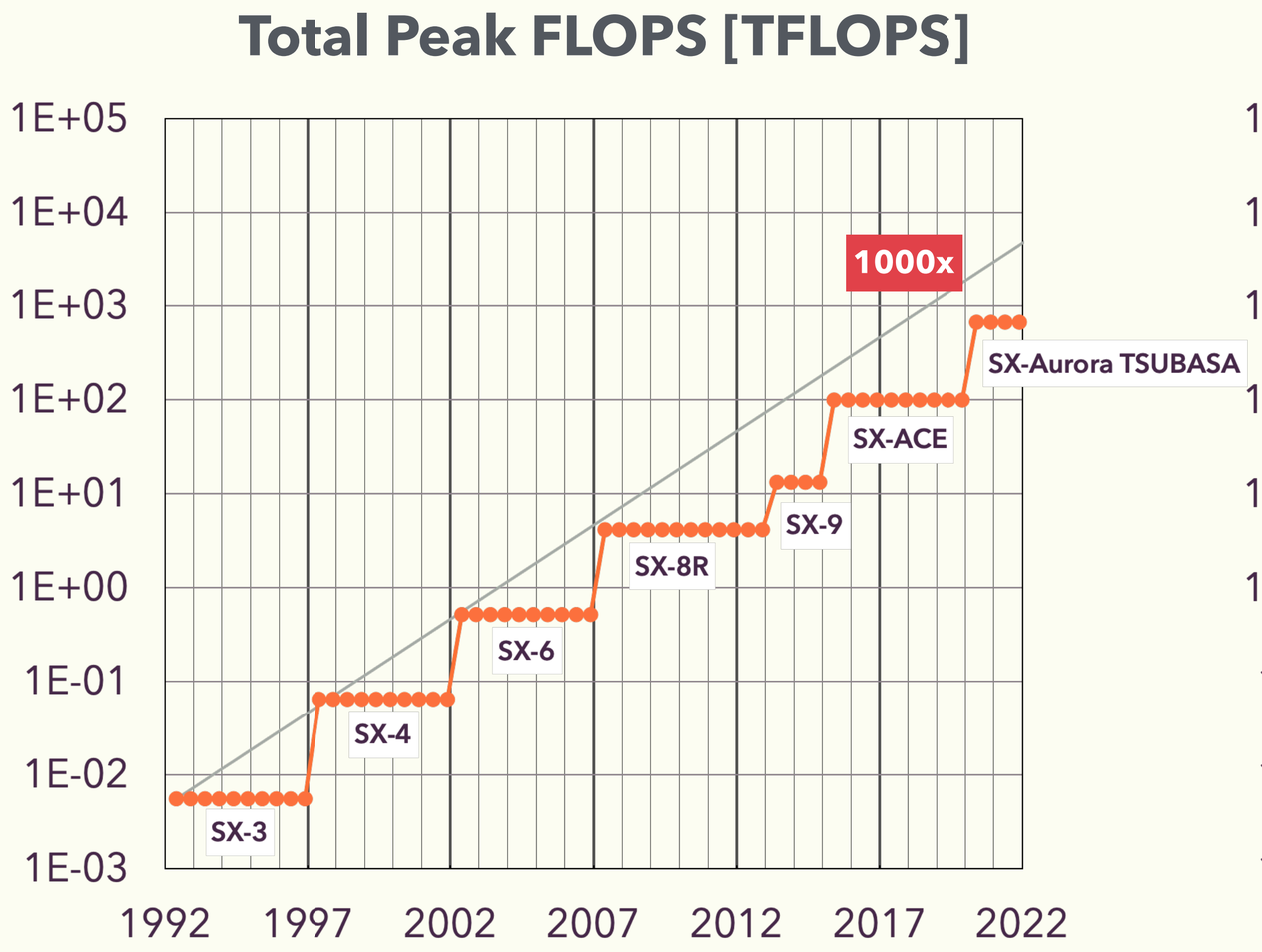
Supercomputer system in NIES

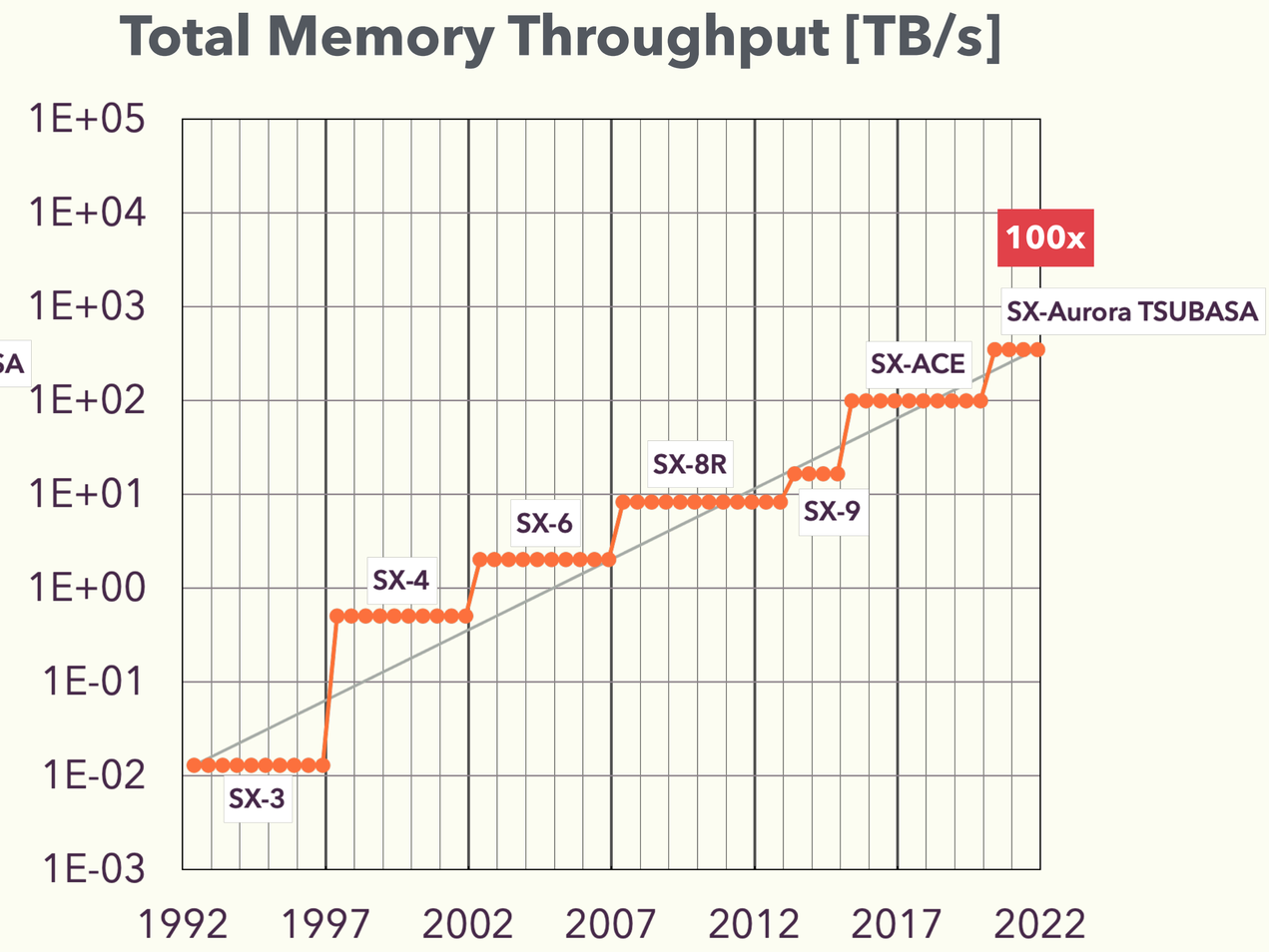
NEC SX Aurora TSUBASA A511-64

	スーパーコンピュータの機種	型式	導入年度	処理速度	メモリ転送速度	計算ノード数	稼働期間
第1号機	NEC SX-3	type 14	1991	5.5GFLOPS※	12.8GB/s	1	1992.2~1997.2
第2号機	NEC SX-4	type 32	1996	64GFLOPS	512GB/s	1	1997.2~2002.2
第3号機	NEC SX-6	type 64M8	2001	512GFLOPS	2.0TB/s	8	2002.2~2007.3
第4号機	NEC SX-8R	type 128M16	2006	4.1TFLOPS	8.2TB/s	16	2007.3~2013.6
第5号機	NEC SX-9	type A(ECO)	2013	13.1TFLOPS	16.4TB/s	8	2013.6~2015.3
第6号機	NEC SX-ACE		2015	98.3TFLOPS	98.3TB/s	384	2015.6~2019.11
第7号機	NEC SX-Aurora TSUBASA	type A511-64	2019	622.8TFLOPS	345.6TB/s	256(VE)	2020.3~2026.2 (予定)

※コンピュータの処理速度をあらわす単位の一つで、1秒間に実行できる浮動小数点数演算の回数。

Performance trends of NIES supercomputer





7th generation of the NIES supercomputer (2019-)

623TFLOPS

ベクトル処理用計算機
NEC SX-Aurora TSUBASA

ホスト名：scv01～scv32
OS：CentOS 7

- 総理論演算性能(VE)
  622.8TFLOPS
- 総主記憶容量(VE)
  12TiB
- 総メモリバンド幅（VE）
  345.6TB/s

256 VE

86TFLOPS

スカラ処理用計算機
HPE Apollo 2000

ホスト名：scs01～scs28
OS：Red Hat Enterprise Linux 7

- 総理論演算性能
  86.0TFLOPS
- CPUコア数
  1120コア
- 総主記憶容量
  5.25TiB

7式（28ノード）

所内NW

高速ネットワーク
（InfiniBand EDR）

コンピュータシステム接続用
ネットワーク（Ethernet）

大容量ファイルシステム

22PByte

フロントエンドサーバ
HPE ProLiant DL360 Gen10

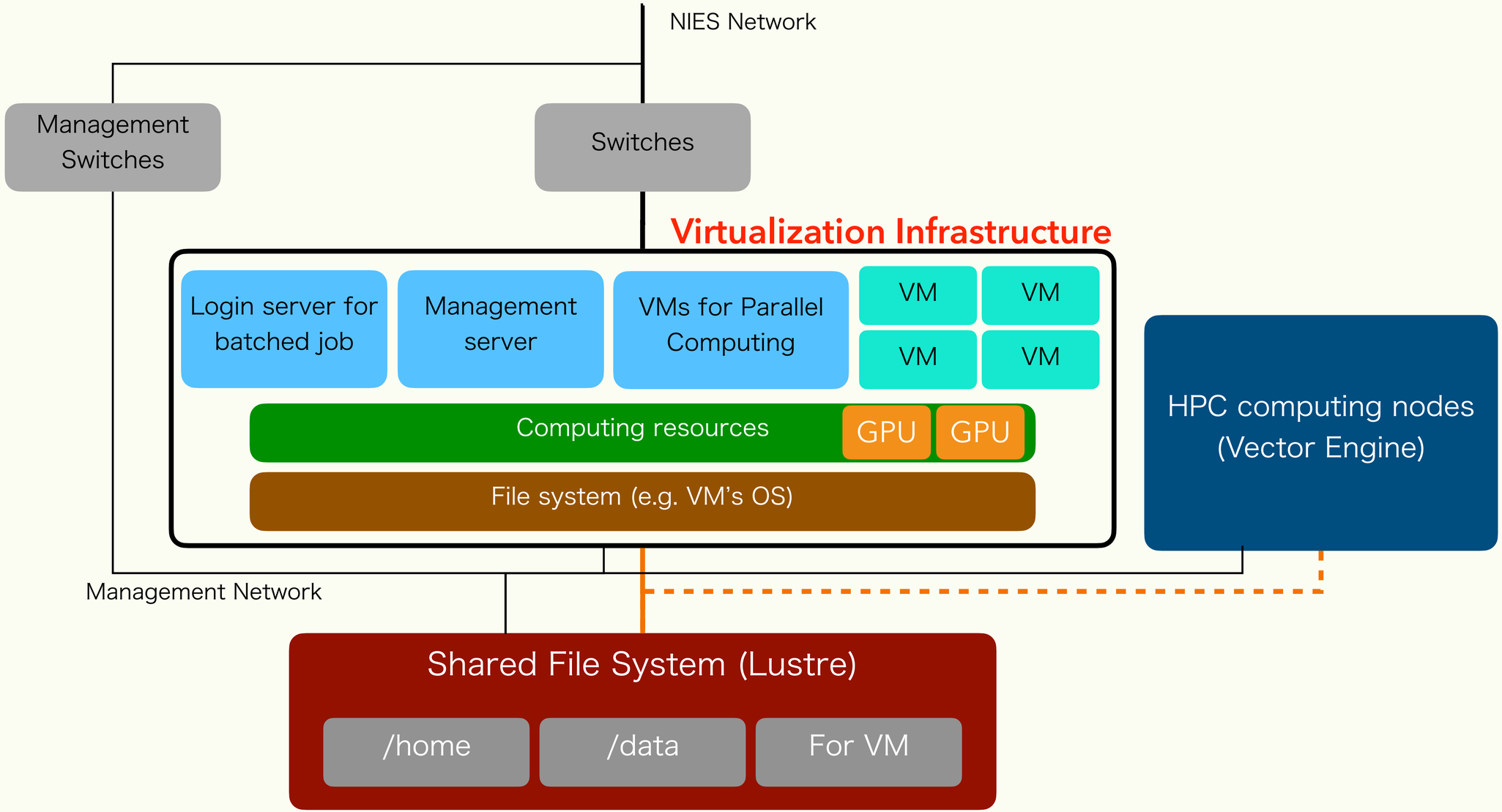
ベクトル用 (2ノード)
ホスト名：scfrv01, scfrv02

スカラ用 (2ノード)
ホスト名：scfrs01, scfrs02

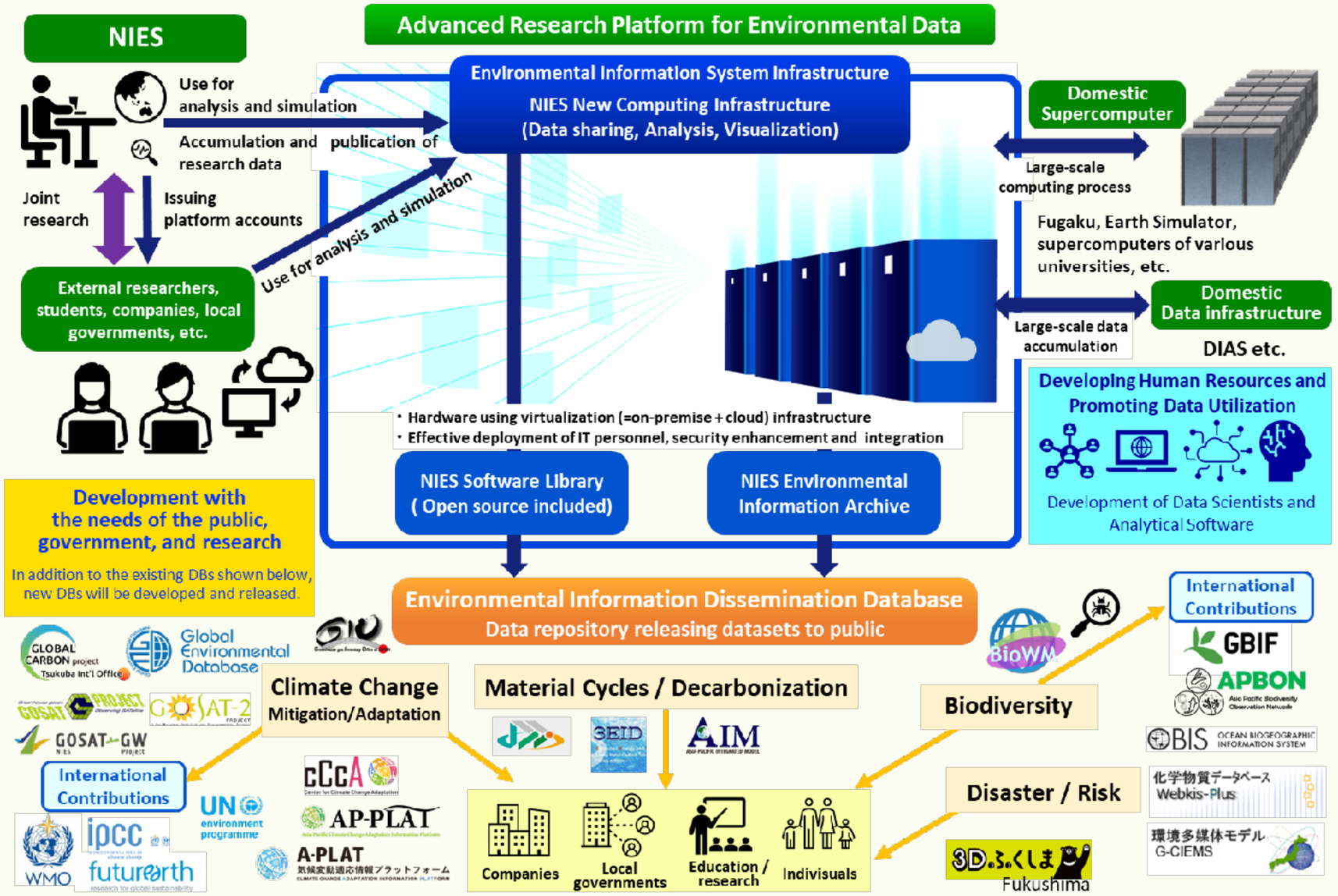
OS：Red Hat Enterprise Linux 7
ノードあたりのCPUコア数：40
ノードあたりのメモリ容量：192GiB

~40 active users (vector)
~50 active users (scalar)

8th generation of the NIES supercomputer (2026-)



NIES Environmental Research Hub (ERHu)



NIES Environmental Research Hub (ERHu)

Information System Infrastructure

- Collect increasingly large-scale environmental data efficiently, and store/manage them securely.
- Hardware commonality (virtualized computing infrastructure, hybrid on-premise + Cloud).

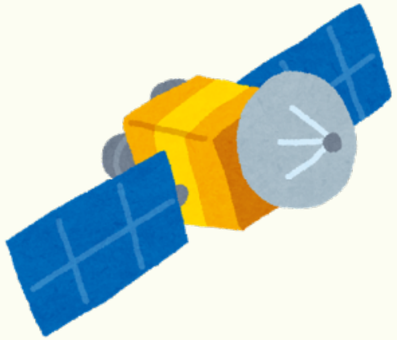
Dissemination Database

- Provide environmental data to public in easy-to-use formats to promote utilization of environmental data.
- Hub function of environmental data repositories in Japan and networking internationally.

Advanced Research Platform

- Connect environmental research communities in industry, government, and academia via data.
- Large-scale computation and analysis infrastructure to support cutting-edge research methods, including big data and AI.

Use case 1: GHG analysis & forecast system “NIES-DE”



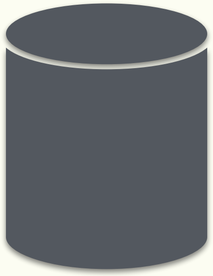
Observation

AI

NIES-DE

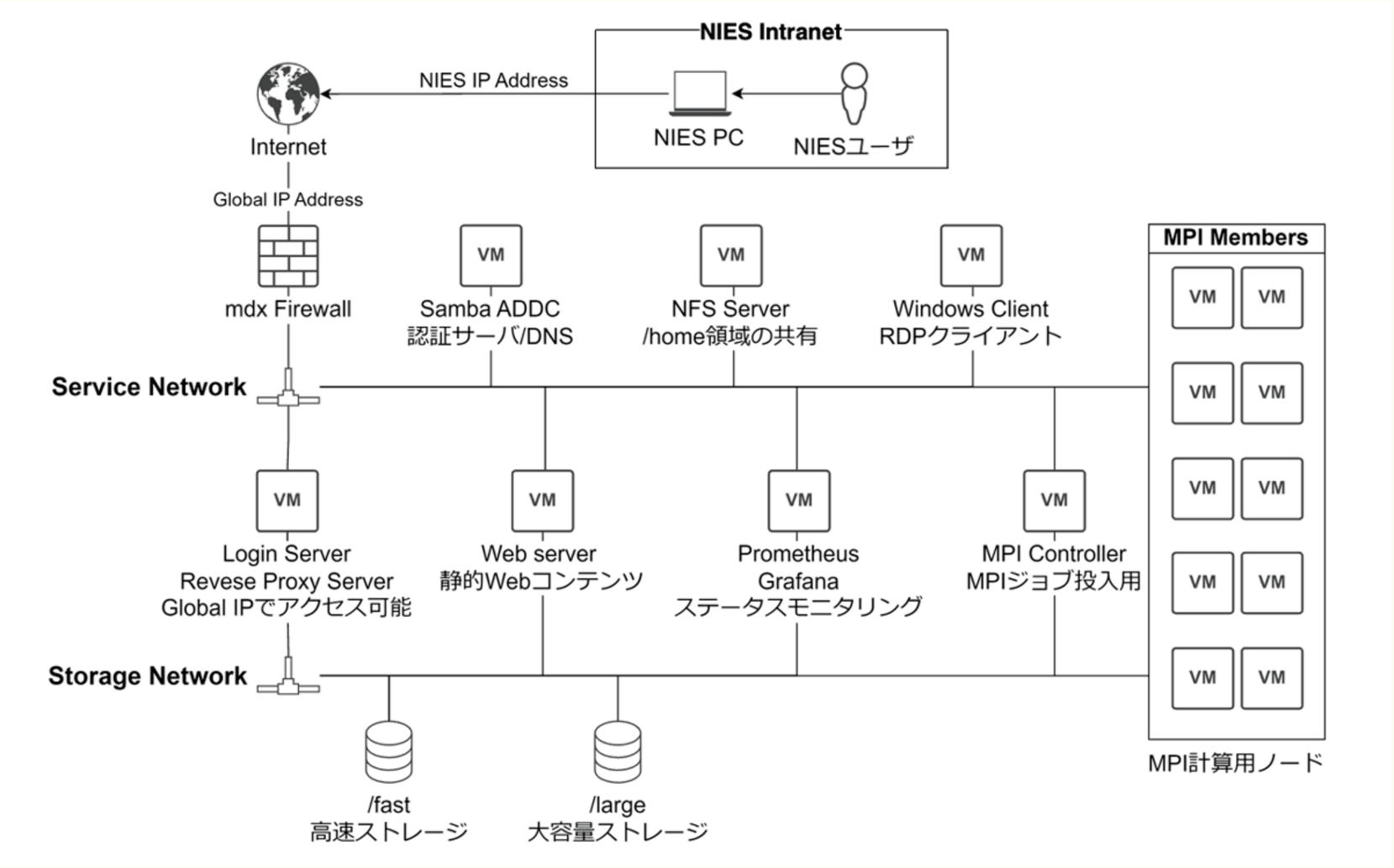
Simulation

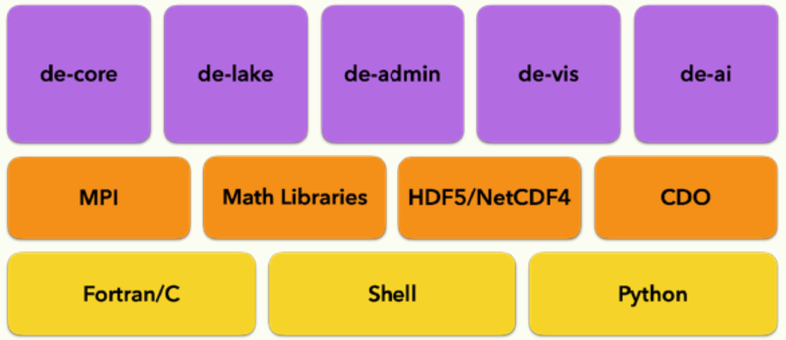
Visualized Info



Analysis result database

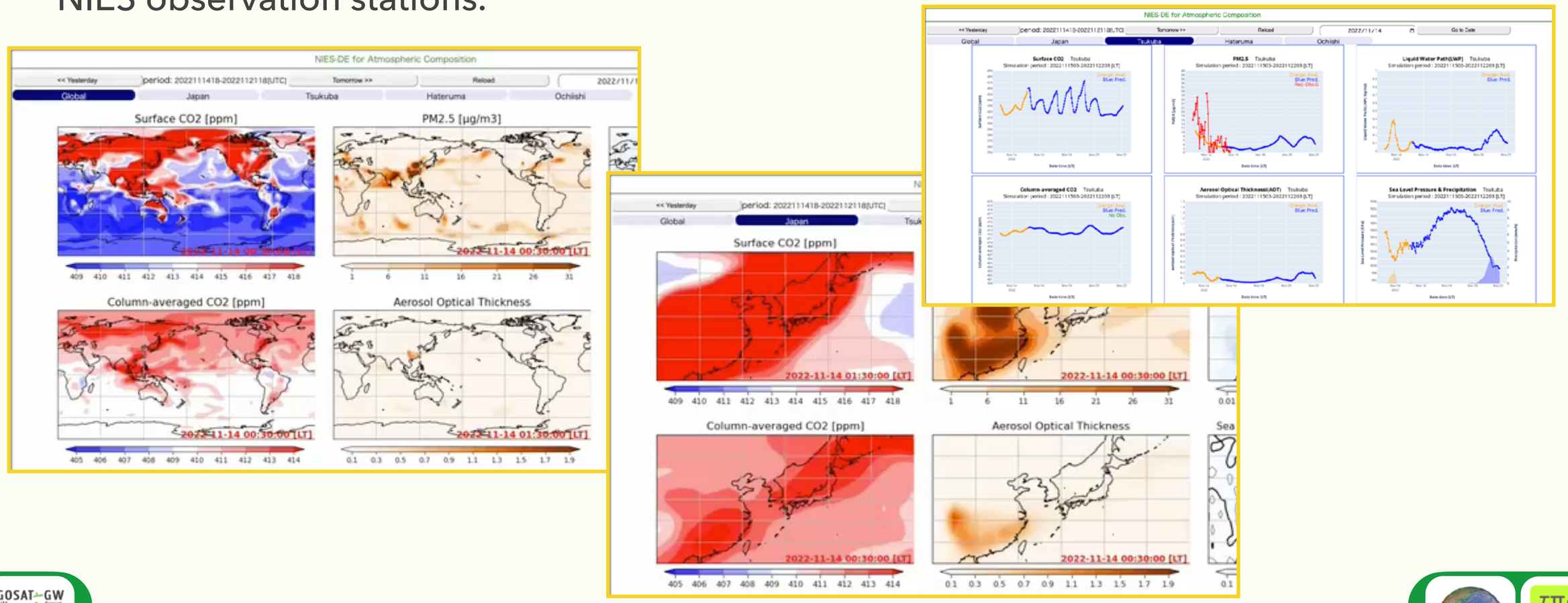
Use case 1: GHG analysis & forecast system “NIES-DE”



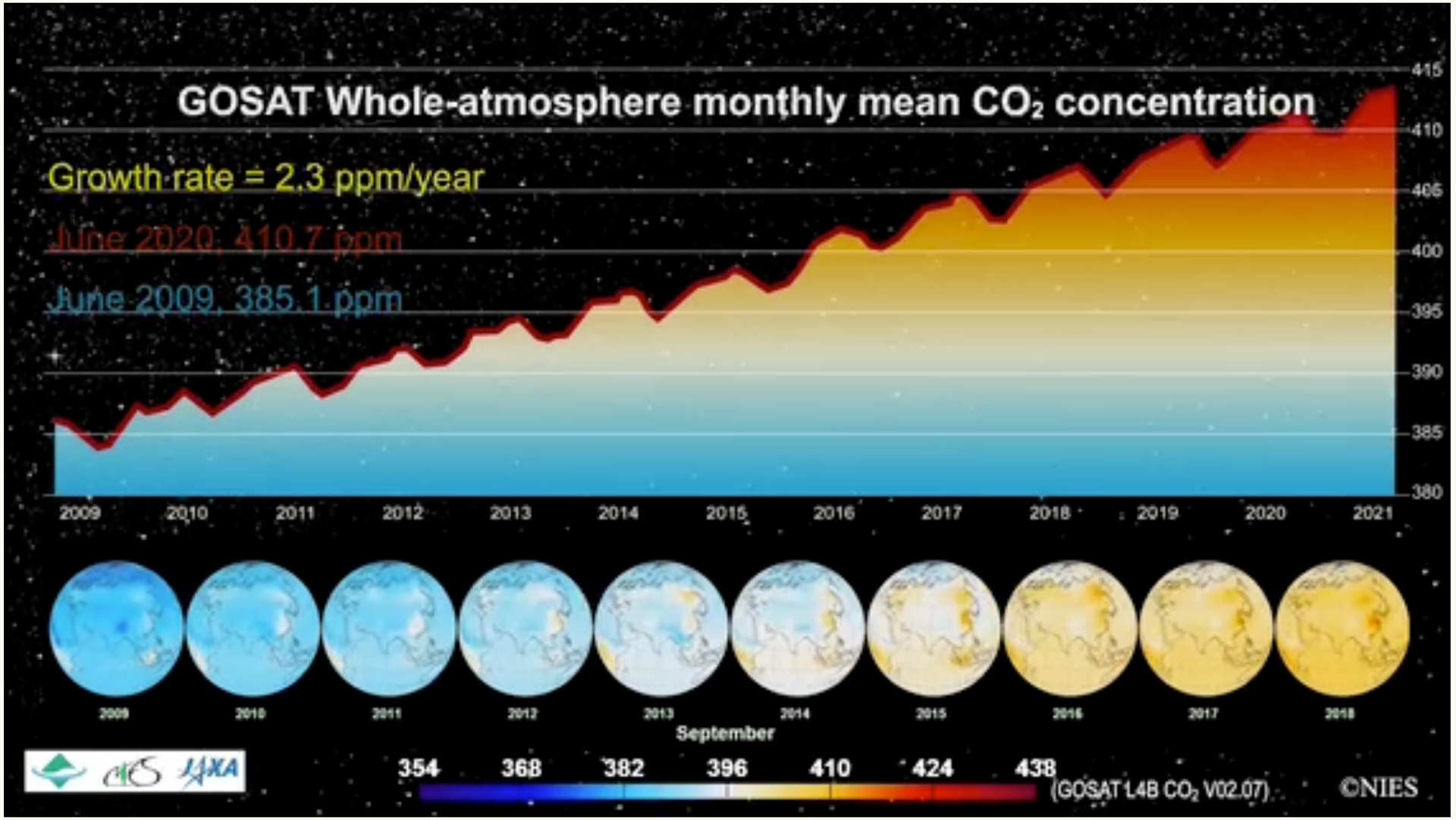


Use case 1: GHG analysis & forecast system “NIES-DE”

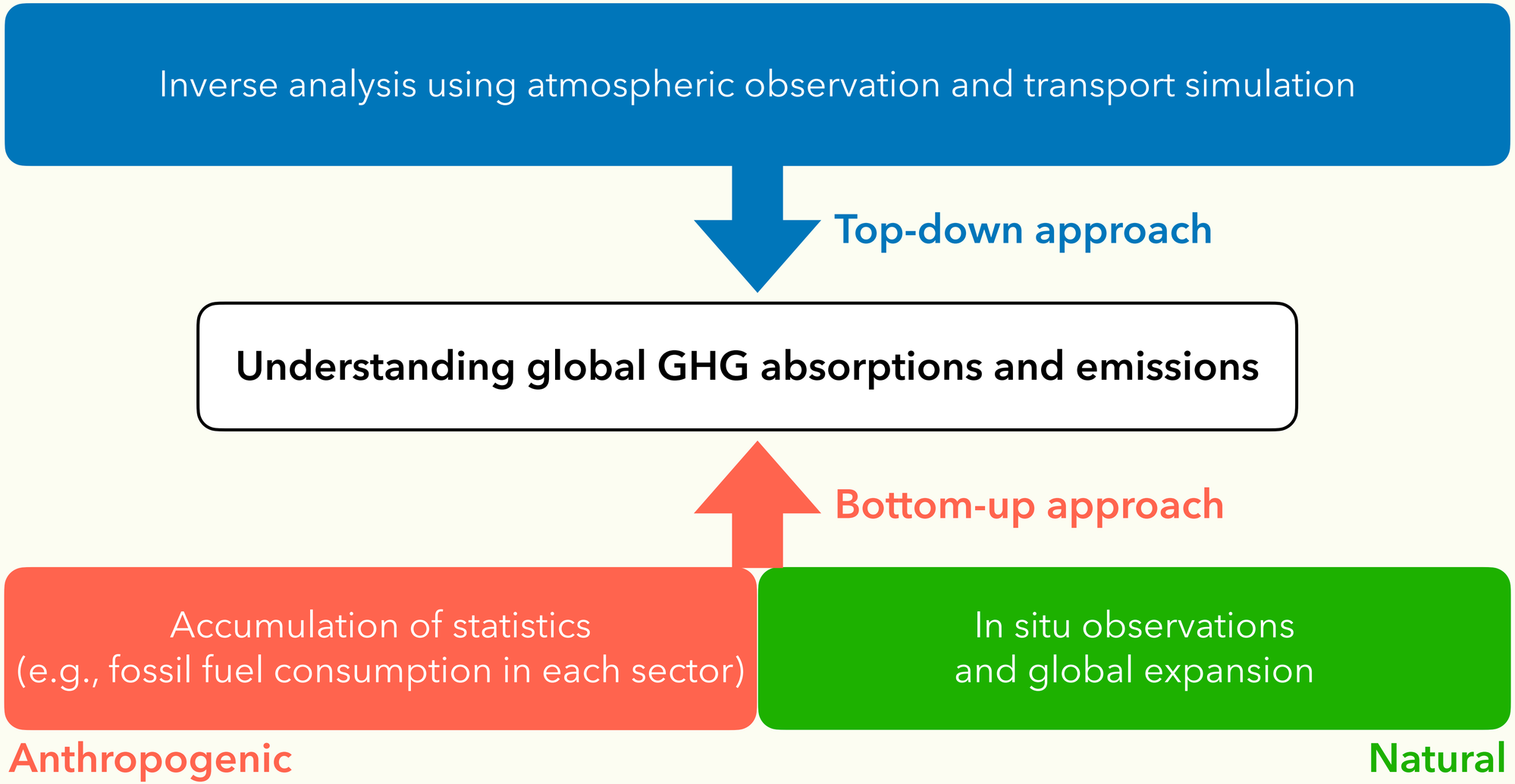
- Analysis results are compared to the global observation
- Prediction results are compared to the near-realtime observations, such as the data from NIES observation stations.



Carbon neutral: Atmospheric CO_2 is increasing

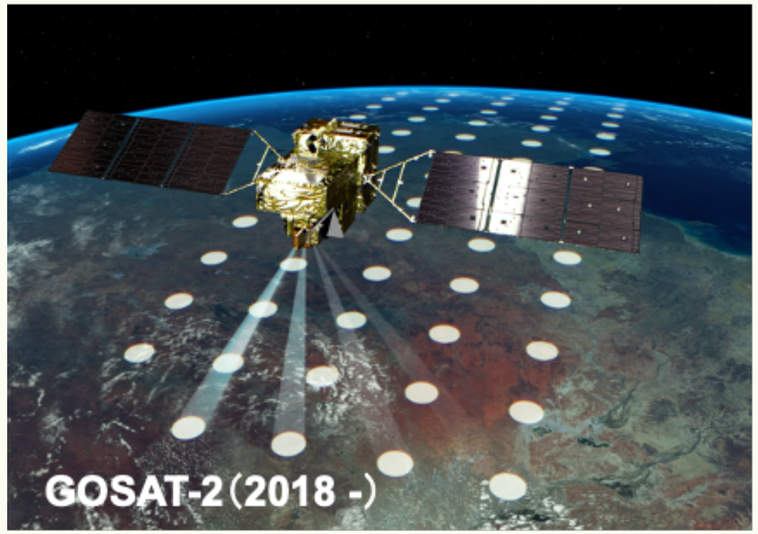


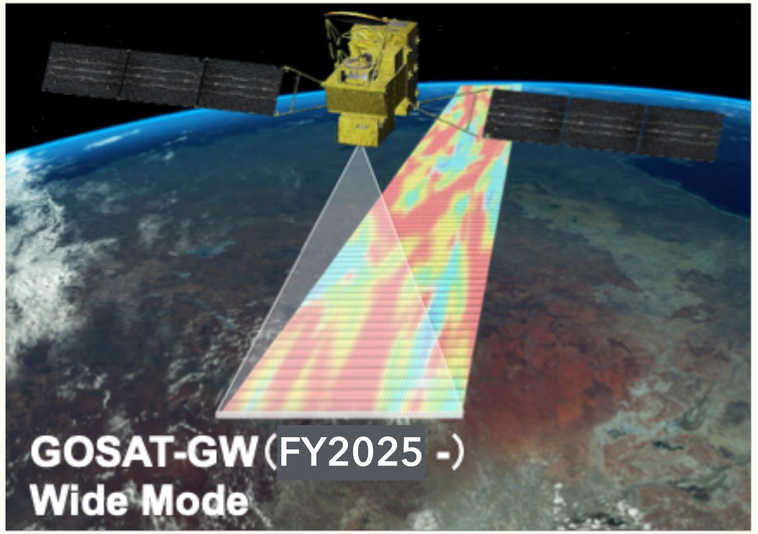
Two estimation technique: top-down and bottom-up



CO_2 observations from the space

GOSAT-series: Japanese GHG observation satellites





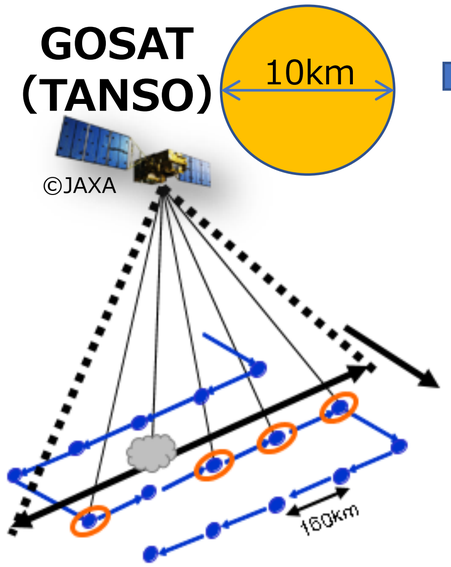
Planned launch date: June 24, 2025!

- Advantages of the satellite monitoring
  - No borders
  - Covering the area where the ground station cannot be build

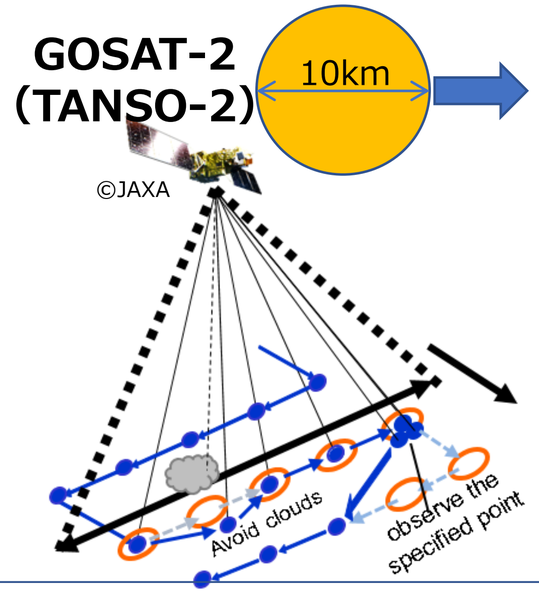
From GOSAT, GOSAT-2 to GOSAT-GW

GHG sensor	TANSO-FTS	TANSO-FTS-2	**TANSO-3**
satellite	GOSAT	GOSAT-2	**GOSAT-GW**
method	FTS	FTS	**grating**
Observation gas	CO2, CH4	CO2, CH4, CO	**CO2, CH4, NO2**
Others		Function to automatically avoid clouds and observe	**Wide mode, Focus mode*1**

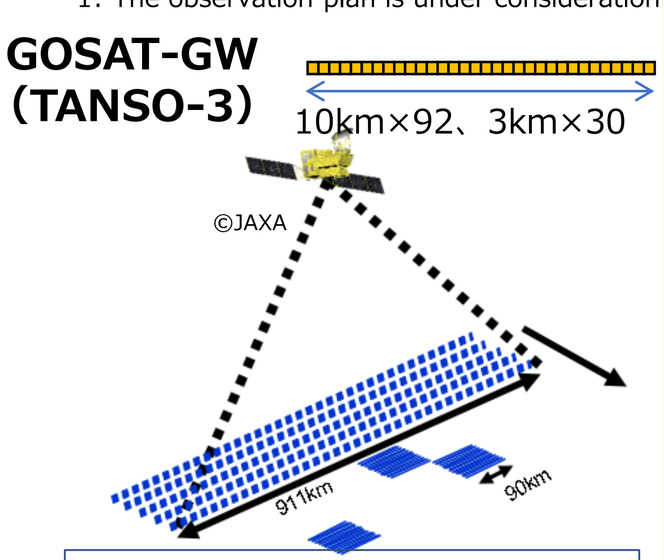
*1: The observation plan is under consideration



Observing one element with a FOV Φ10km intervals grid width 160 km. If there are clouds in the FOV ,the GHG concentrations cannot be calculated.

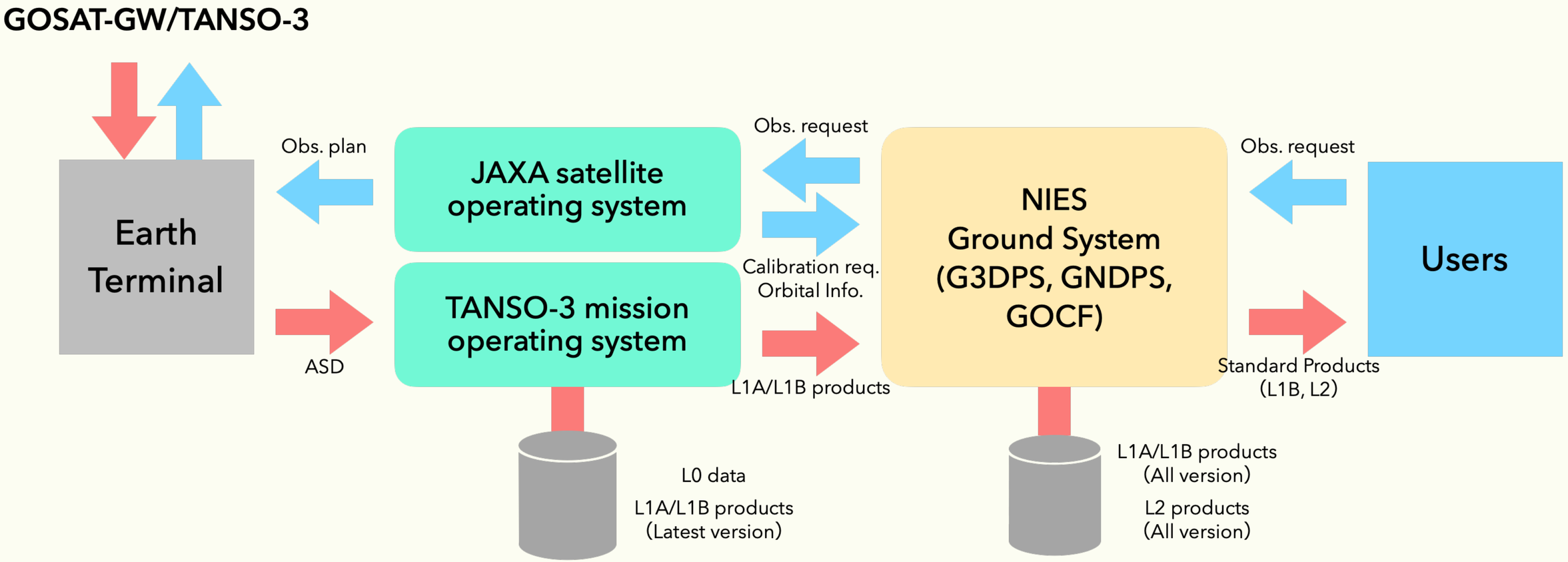


It is possible to observe the specified point with one element with FOV Φ10km.The sensor can detect clouds by itself and automatically avoid them.



It is possible to observe the entire globe with a spatial resolution of 10 km in the wide mode, or the specified range (90 km width) with a spatial resolution of 3 km in the focus mode.

Data flow of GOSAT-GW/TANSO-3 observation

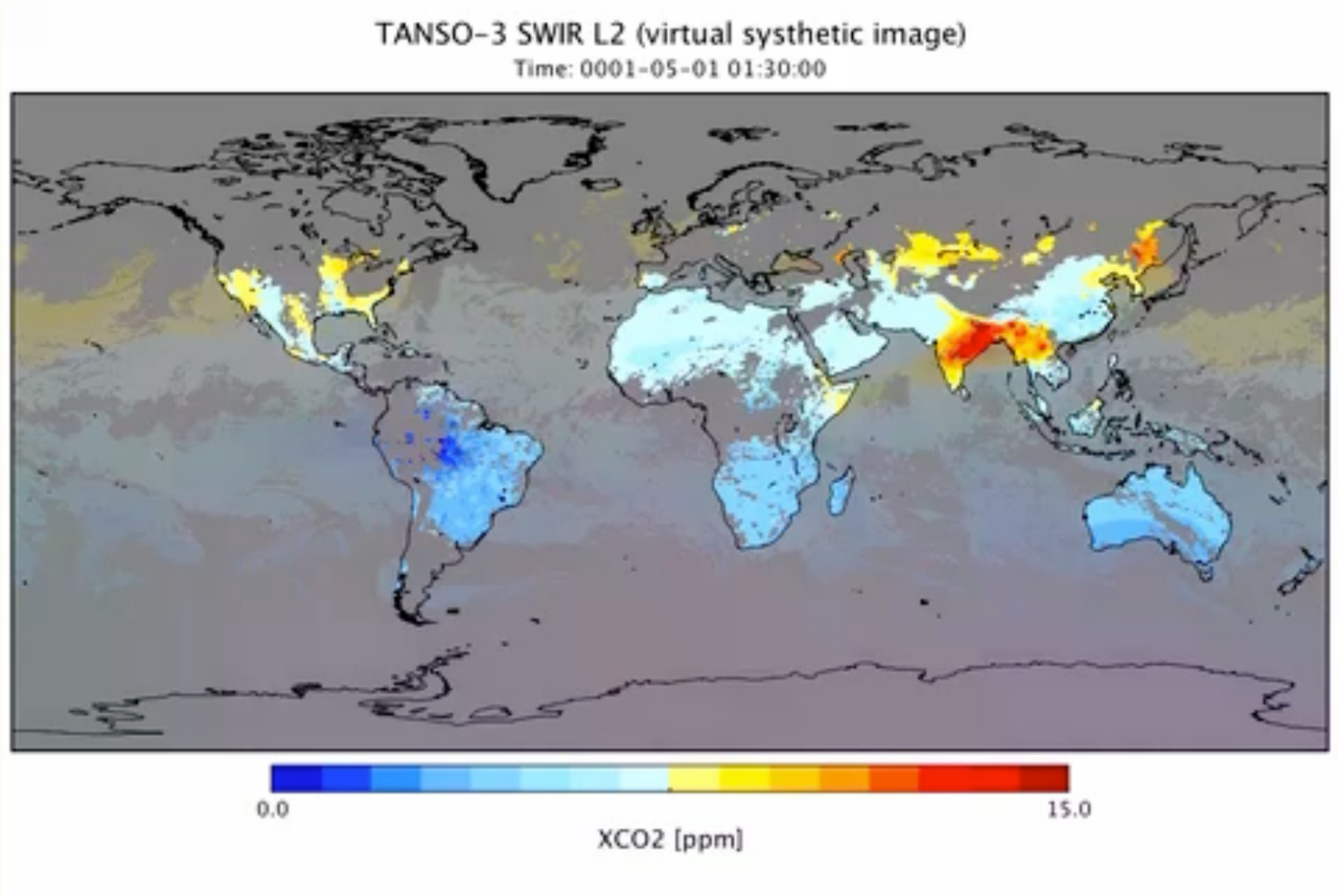


GOCF: Computing power for production & research

GOCF
GOSAT operational and research Computing Facility

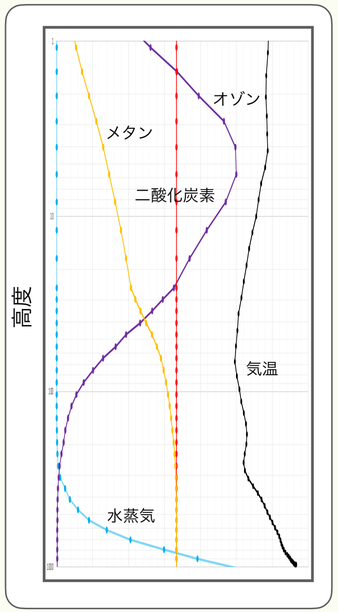
- 200TFLOPS, CPU-Only (Intel Sapphire Rapids), Infiniband HDR, 1PB SSD Lustre

Located on the campus of Tsukuba U.

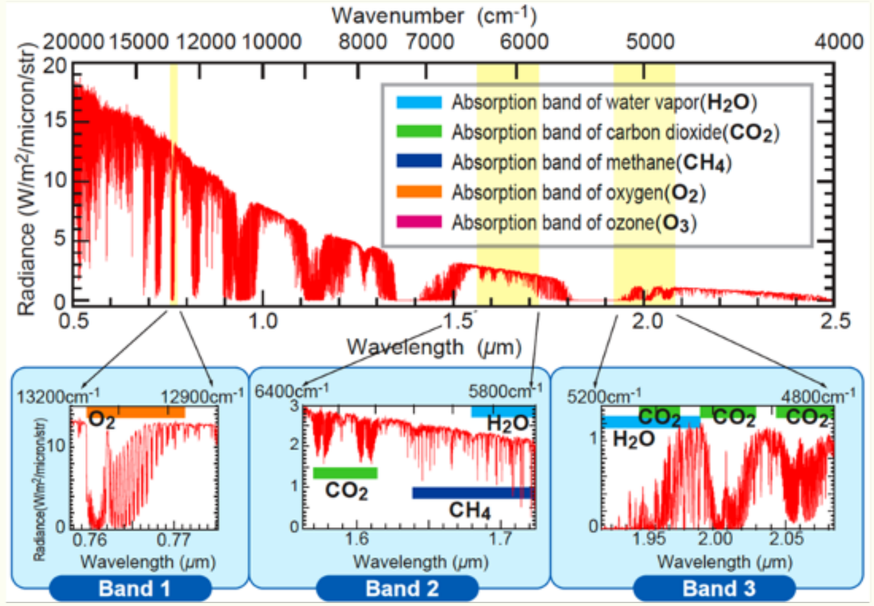


AI integration in satellite data processing

- Inverse estimation of GHG concentrations without using physical models
  : Research collaboration among NIES, NEC, and EURECOM(France)
  - Emulates the retrieval process (radiative transfer model + inverse analysis)
  - Pegasus (Tsukuba U.) is used for machine learning



Estimated GHG concentration



Observed spectral data by GOSAT

Thanks for listening!