Numerical Simulation of Tropical and Arctic Cyclones Using Cloud Resolving Global Model NICAM Installed at CCS, University of Tsukuba, Japan

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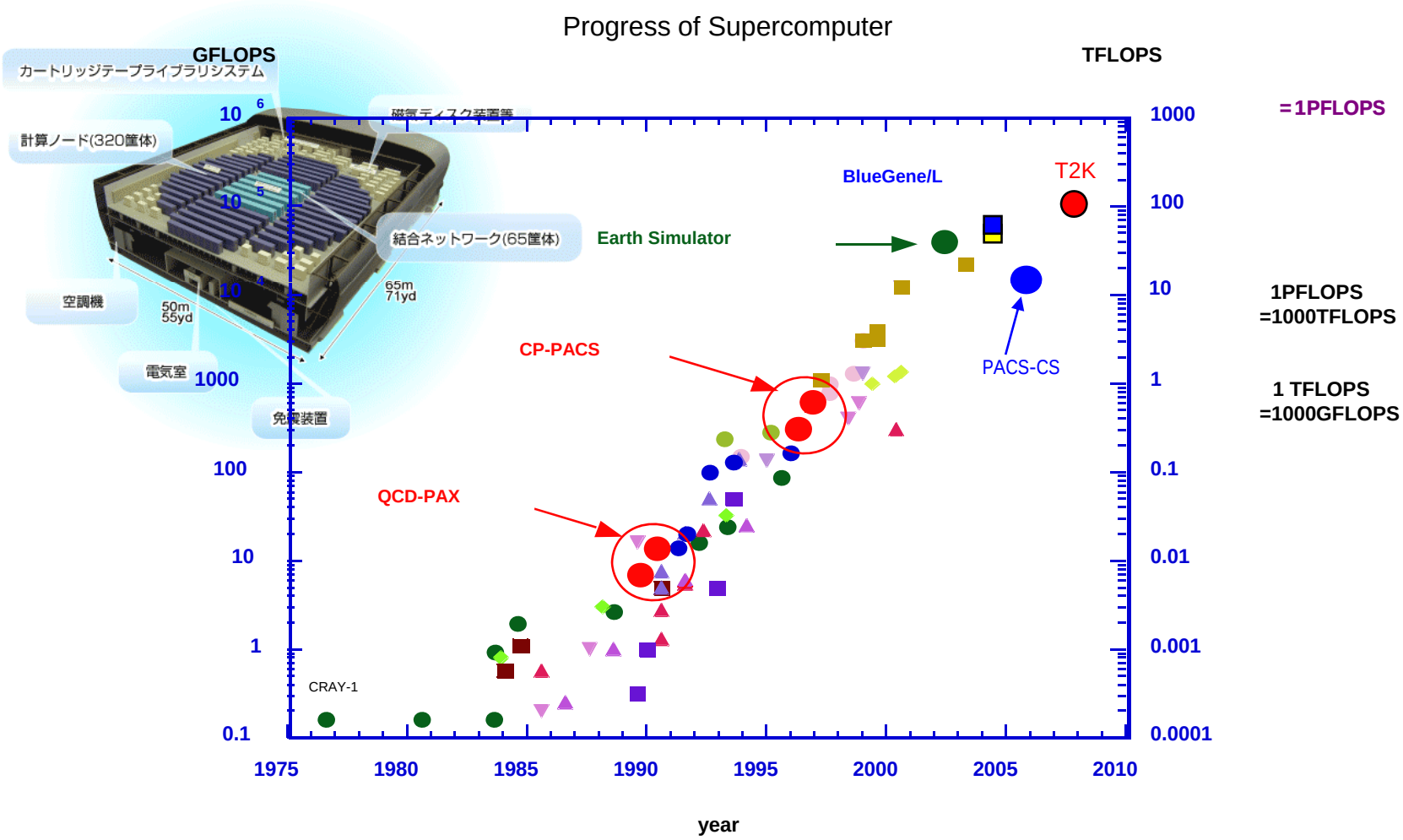
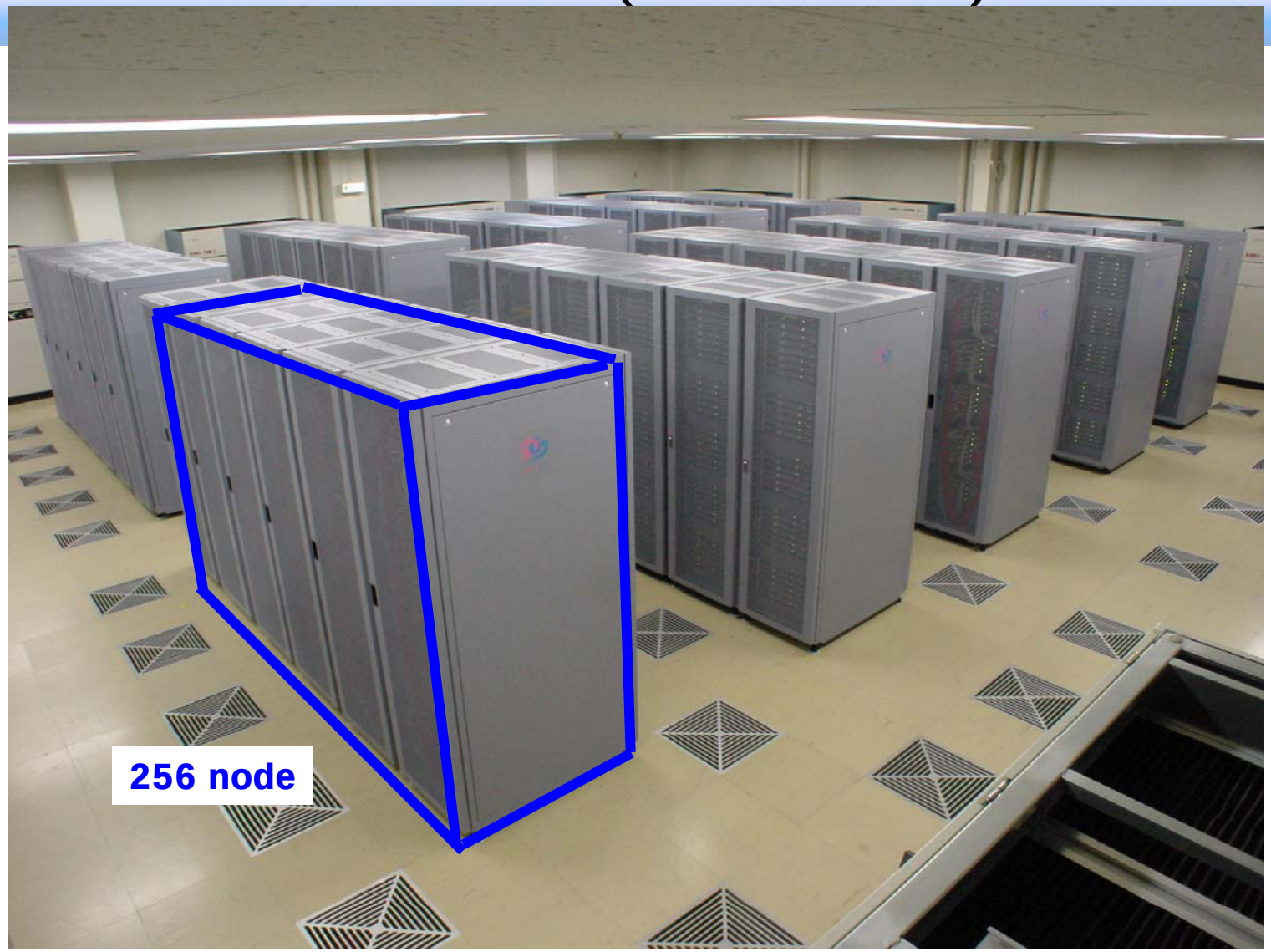
Advancement of HPC



PACS-CS (2560 node)



T2K-Tsukuba System

Installed at Secondary Computer Building
of Center for Computational Sciences, University of Tsukuba
#20 in TOP500 (June 2008 list)

Cluster part and File Server part

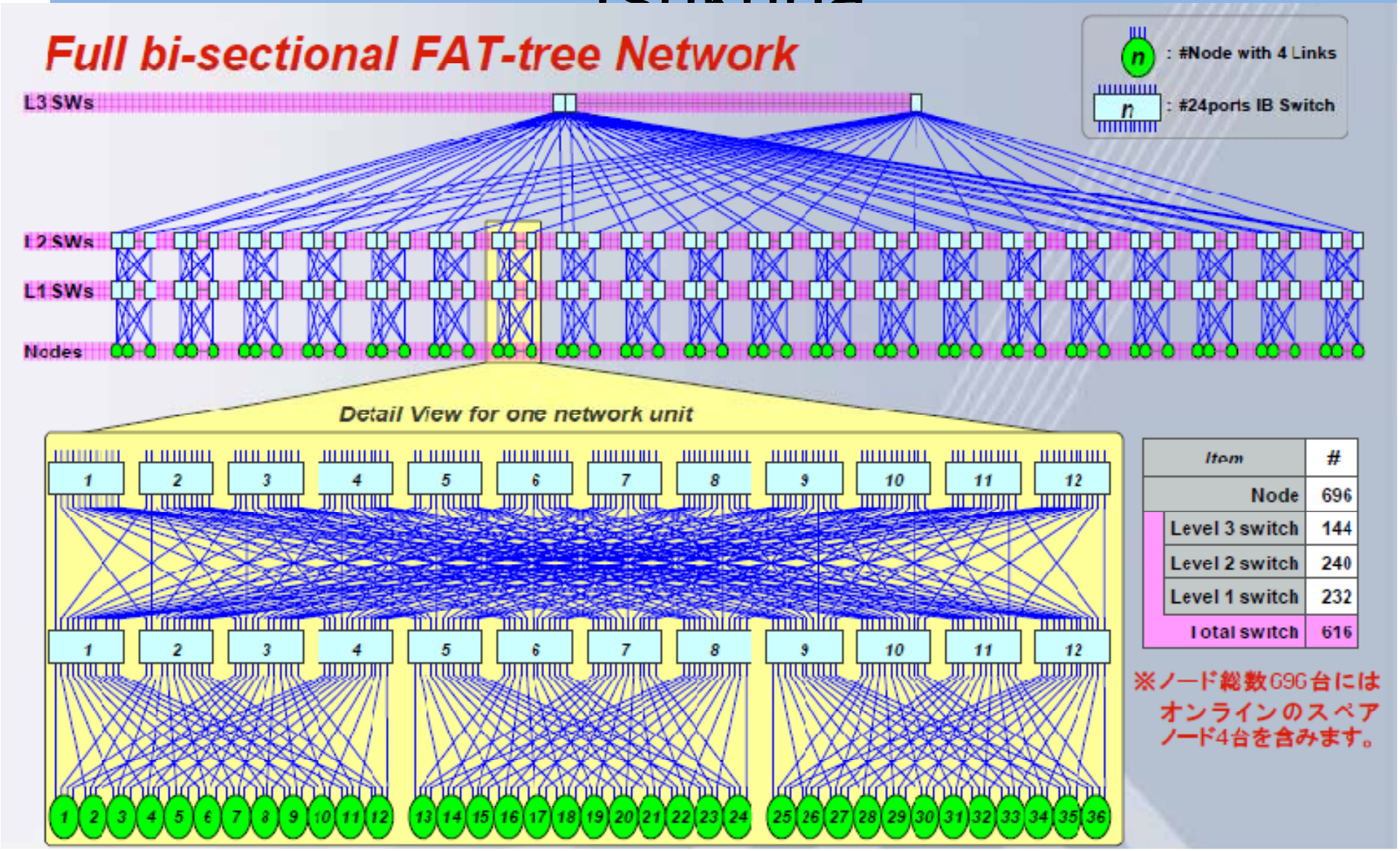
Computation Nodes (70 racks)

648 node (quad-core x 4socket / node)
Opteron “Barcelona” B8000 CPU
2.3GHz x 4-inst./clock x 4core x 4socket
= 147.2 GFLOPS / node
= 95.3 TFLOPS / system
20.7 TB memory / system

800 TB (physical 1PB) RAID-6
Luster cluster file system
Infiniband x 2
Meta-data servers and File servers are all duplicated tandem
⇒ high fault tolerance

File Sever (Disk Drive, 5 racks)

Interconnection network of T2K-Tsukuba



Item	#
Node	696
Level 3 switch	144
Level 2 switch	240
Level 1 switch	232
Total switch	616

※ノード総数696台にはオンラインのスペアノード4台を含みます。

What is T2K-Tsukuba ?

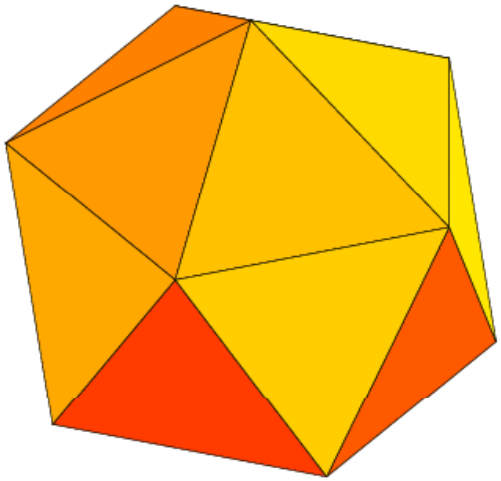
- A supercomputer in University of Tsukuba under operation by Center for Computational Sciences
- “T2K” represents the alliance of three national universities in Japan: Tsukuba, Tokyo and Kyoto, for supercomputer research, design, procurement and operation
- A very large scale PC cluster with 10,368 cores and 95TFLOPS of peak performance
- Each computation node consists of quad-socket AMD Opteron (Barcelona) with quad-core (totally 16 cores / node)
- Interconnection network with full-bisection bandwidth Fat-Tree with quad-rail of Infiniband ConnectX
- Operation duration: June 2008 – May 2013

NICAM AGCM

Original Icosahedron

Glevel-0

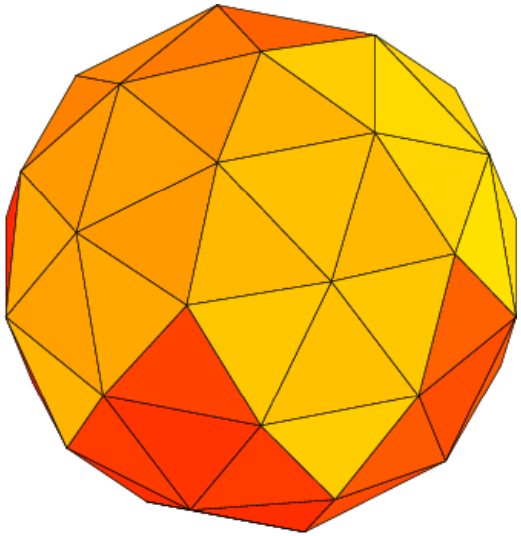
(by Satoh and Tomita)



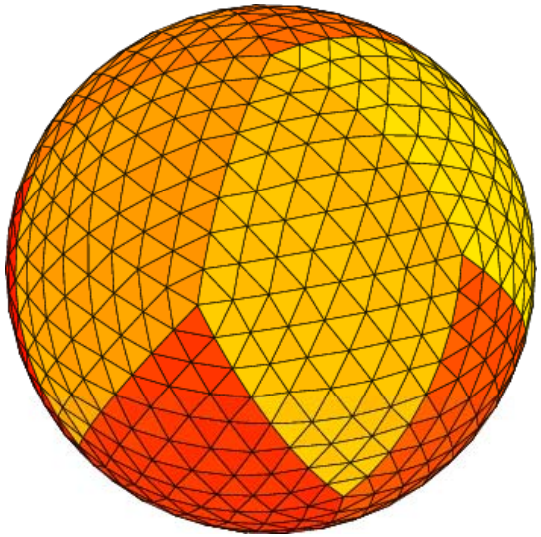
Glevel and resolution

Glevel-5: Δx=250km
Glevel-6: Δx=120km
Glevel-7: Δx= 60km
Glevel-8: Δx= 28km
Glevel-9: Δx= 14km
Glevel-10: Δx= 7km
Glevel-11: Δx=3.5km

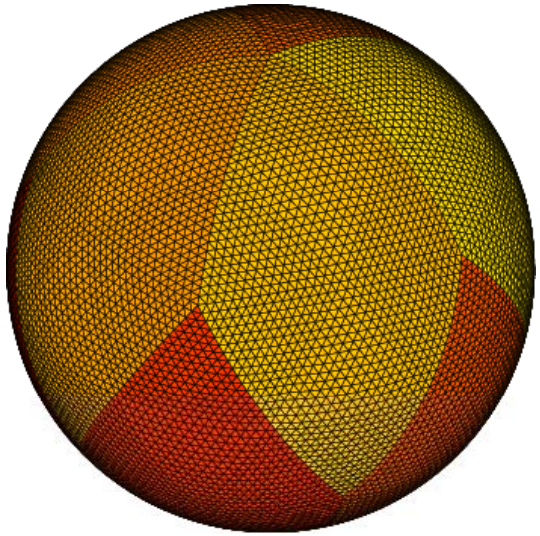
Glevel-1



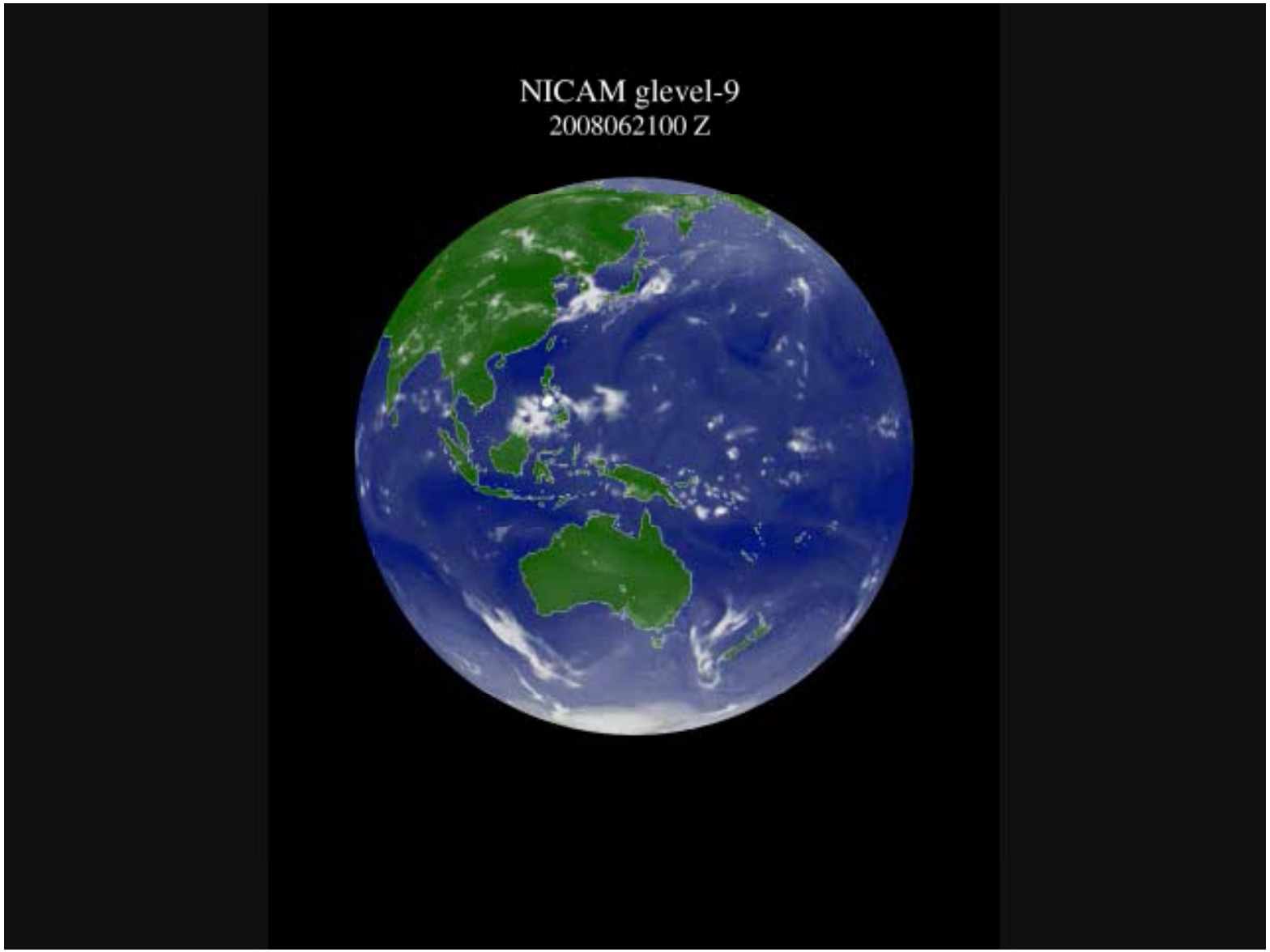
Glevel-3



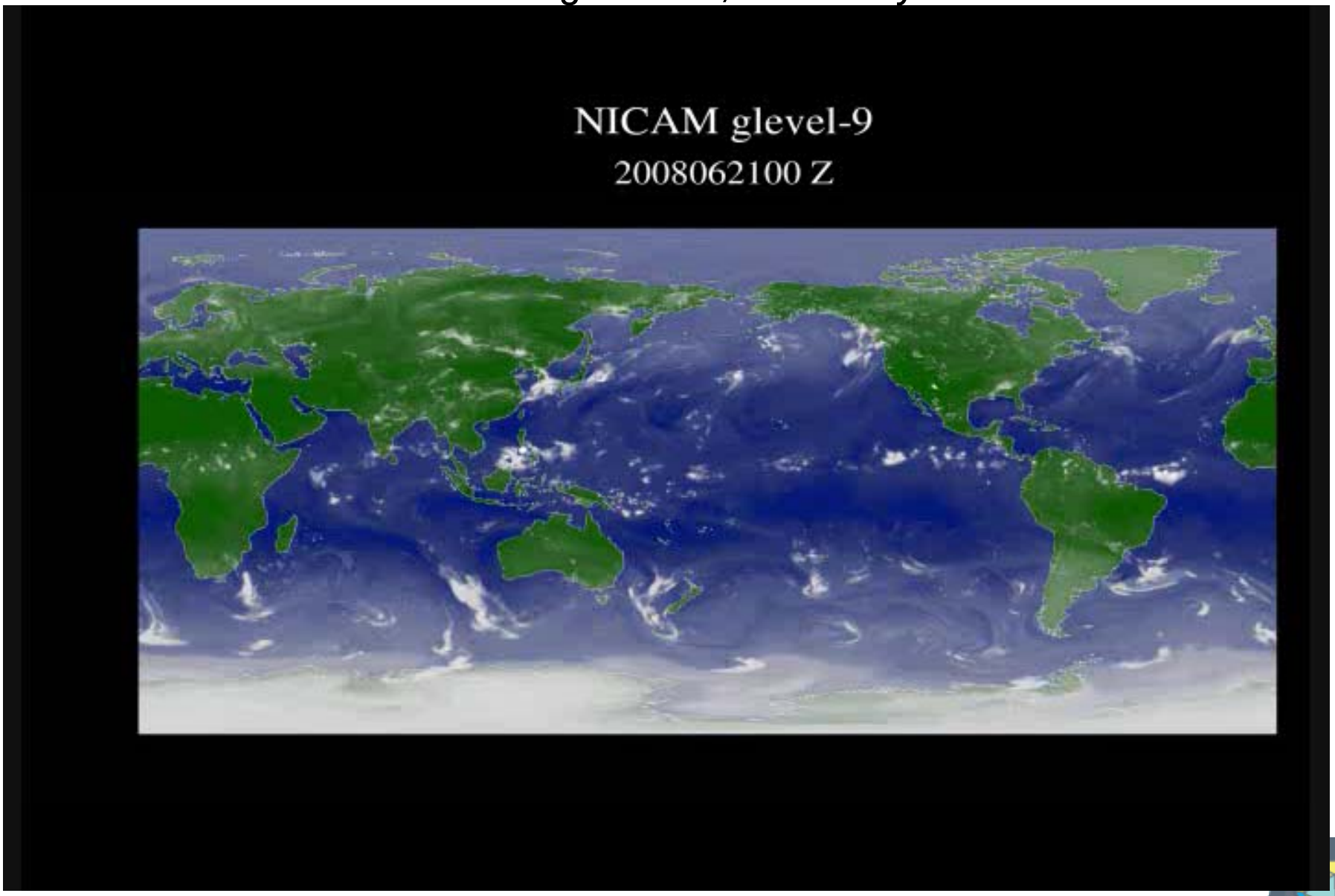
Glevel-5



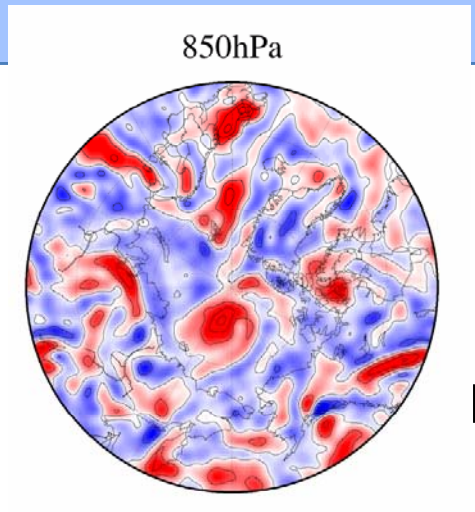
NICAM running at CCS, University of Tsukuba



NICAM running at CCS, University of Tsukuba

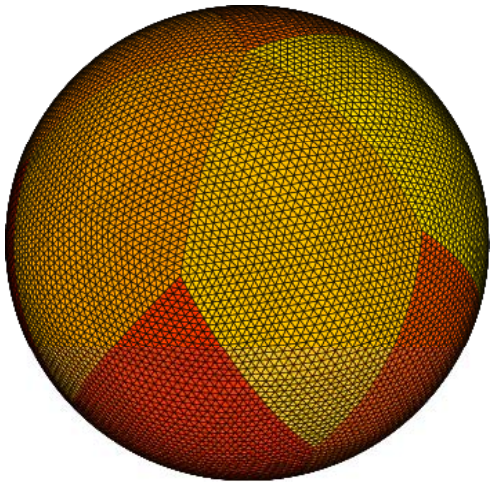


NICAM running at CCS



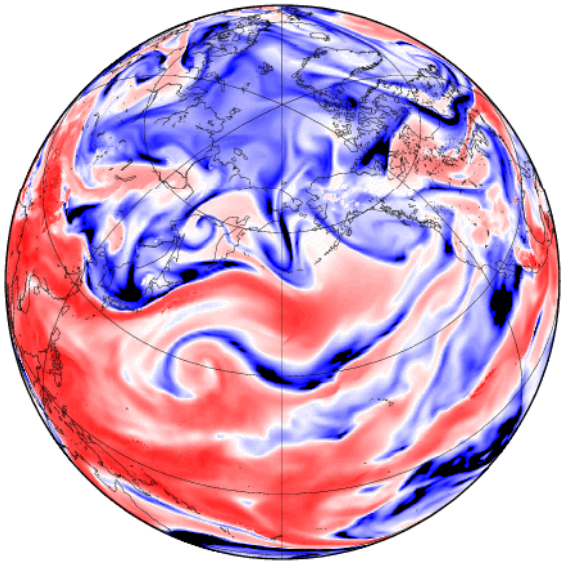
Arctic Cyclone

Glevel-5: Δx = 224 km
Glevel-6: Δx = 112 km
Glevel-7: Δx = 56 km
Glevel-8: Δx = 28 km
Glevel-9: Δx = 14 km
Glevel-10: Δx = 7 km
Glevel-11: Δx = 3.5 km



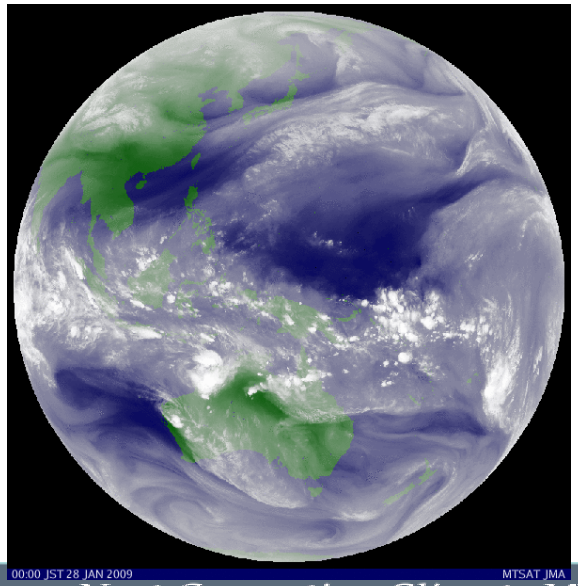
500 hPa S. Humidity

NICAM 2004060100Z+0HR



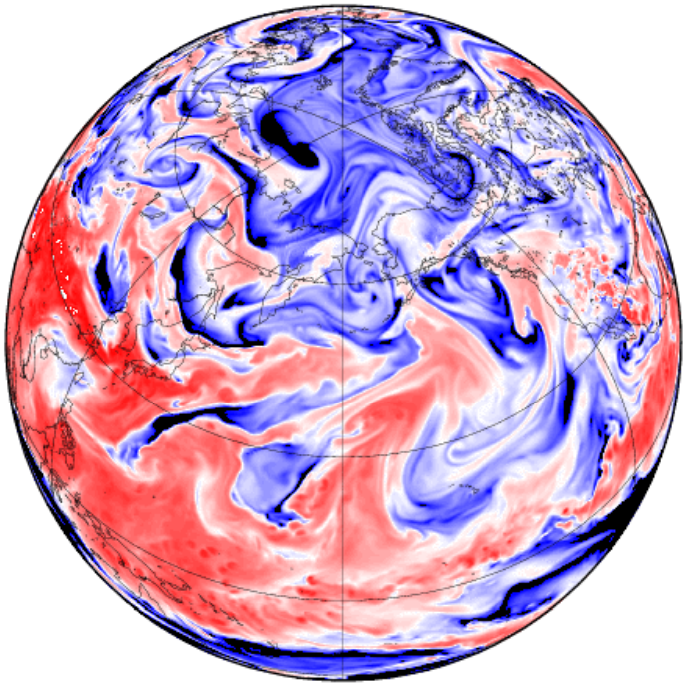
NICAM
7km

GMS



500 hPa S. Humidity

NICAM 2008062100Z+0HR

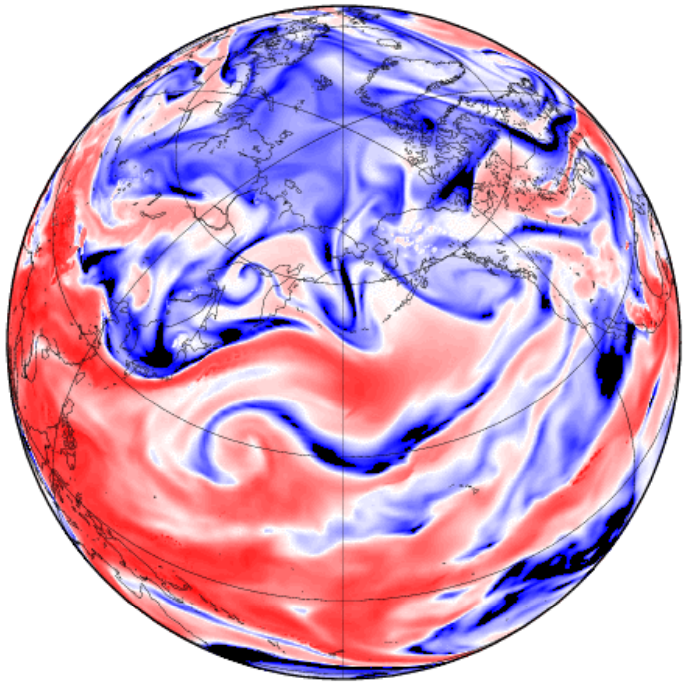


Glevel=9, 14km

GMT 2009 Jan 30 22:26:44 CCS g9r4n256

500 hPa S. Humidity

NICAM 2004060100Z+0HR

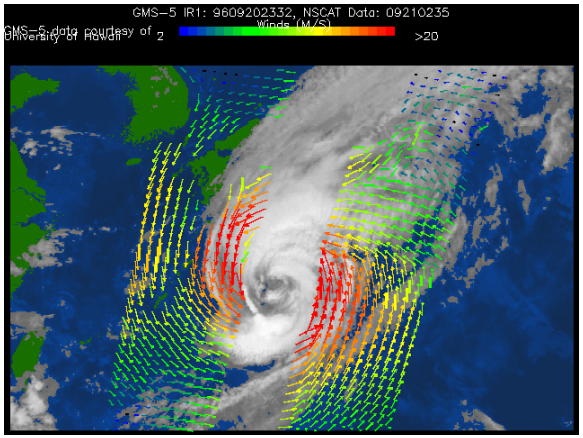


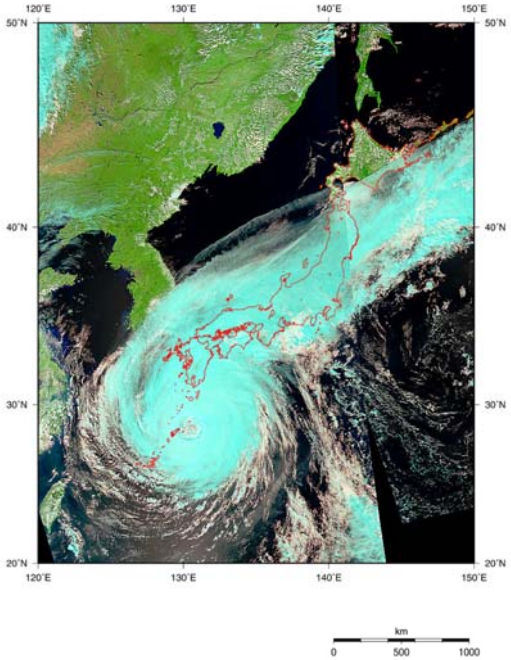
Glevel=10, 7km

GMT 2009 Feb 4 11:21:23 CCS g10r4n256

Tropical Cyclone

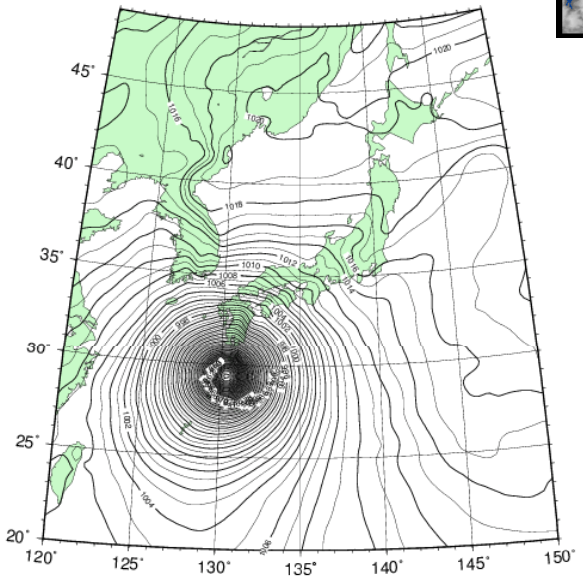
- Life cycle of Typhoon





Sea-level Pressure (hPa)

2005090512 + 00 hr (JMA/GPV/RSM)

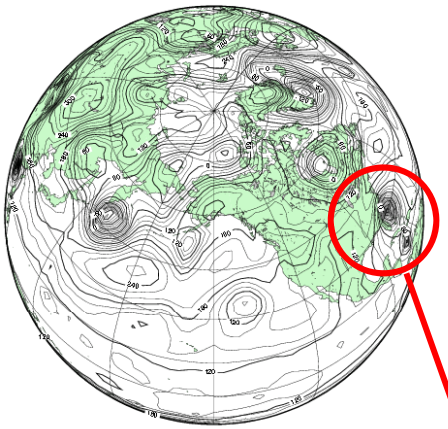


Tropical cyclone

NICAM 28km model 21 day integration starting from June 21, (PACS-CS 256PE)

1000 hPa Height

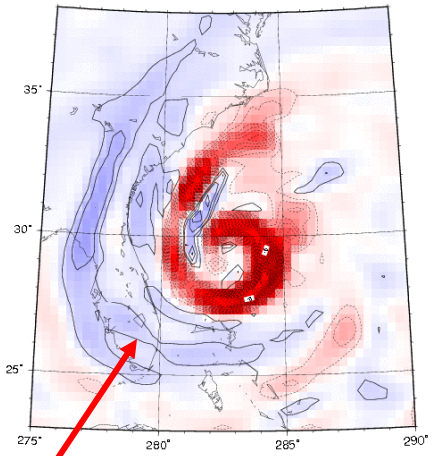
NICAM 2008070500Z+78HR



Global

500 hPa Omega

NICAM 2008070500Z+78HR

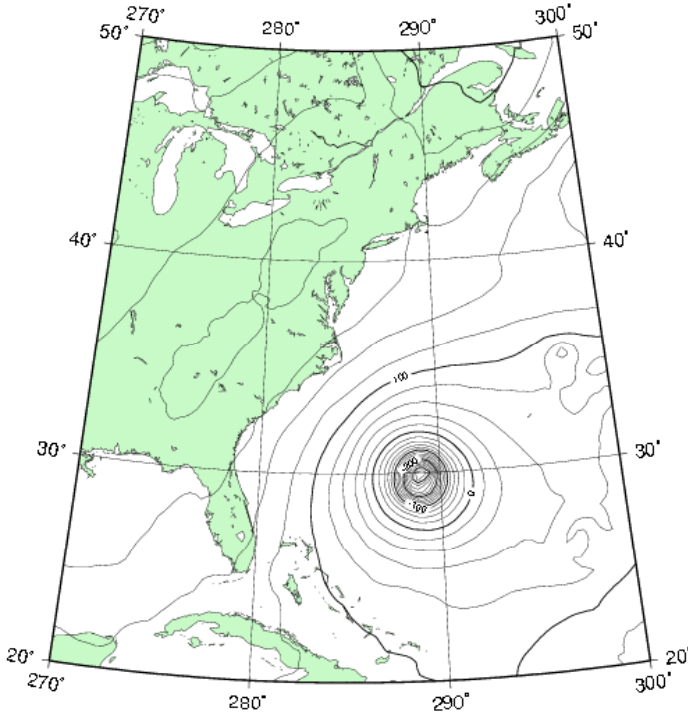


Omega

1000 hPa Height

NICAM 2008070500Z+0HR

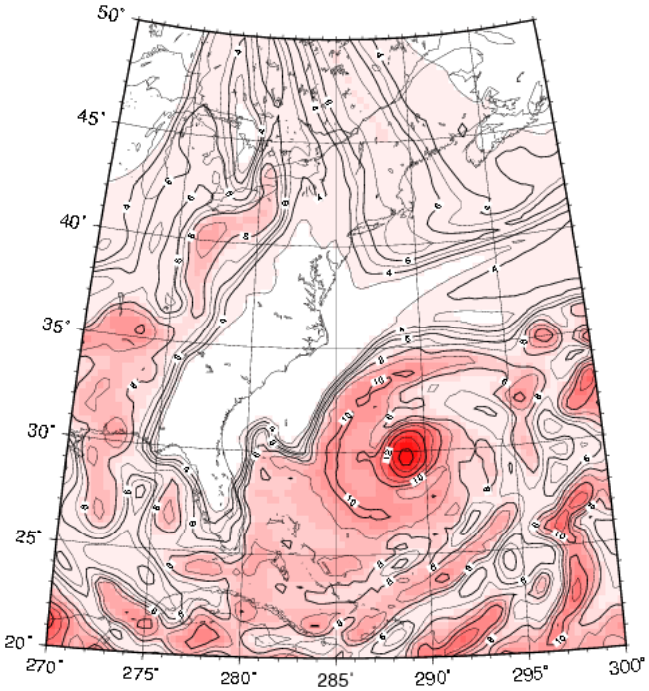
SLP



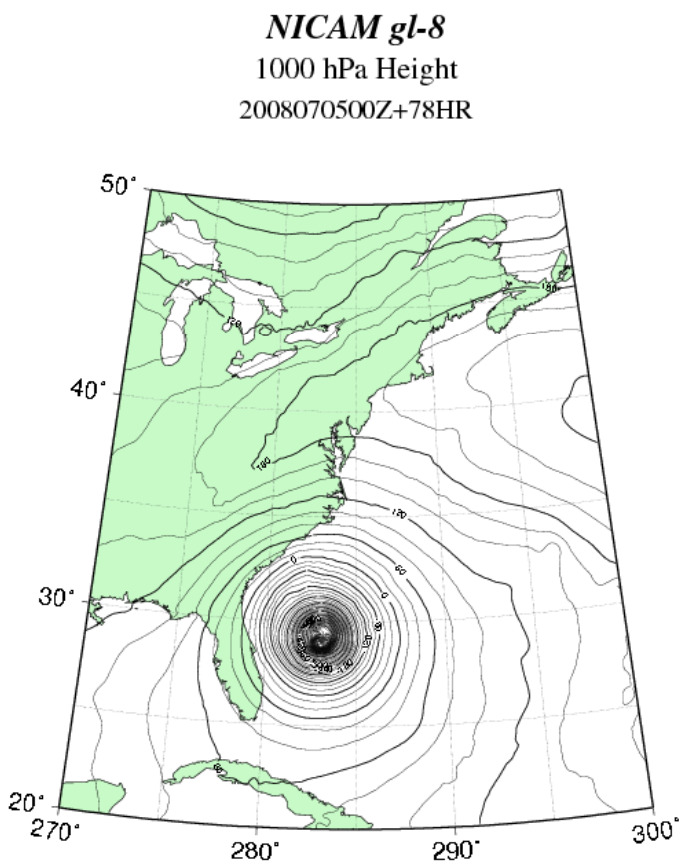
850 hPa S. Humidity

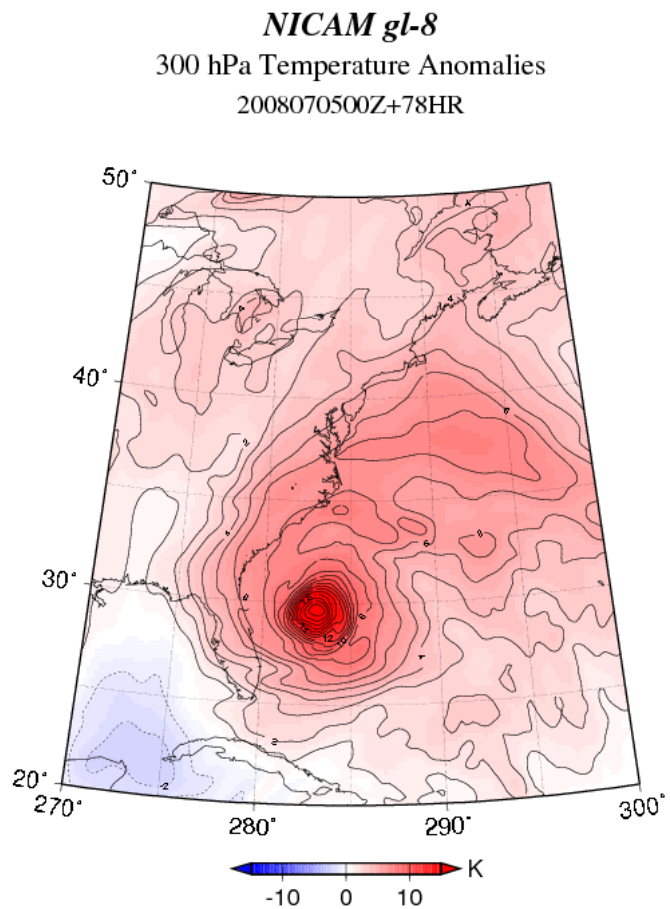
NICAM 2008070500Z+0HR

Humidity



Hurricane in NICAM

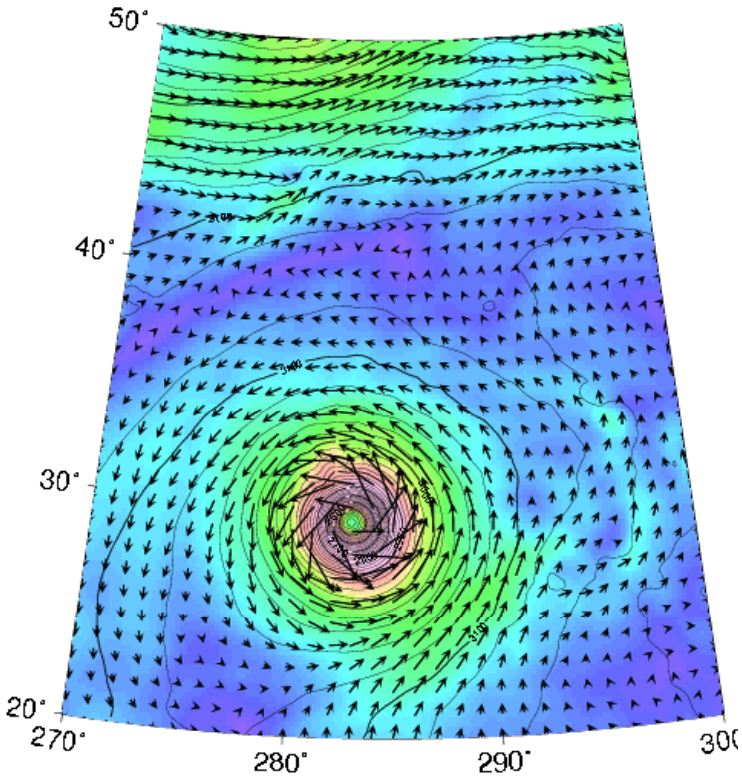




NICAM gl-8

Height (m) and Wind (m/s) at 700 hPa

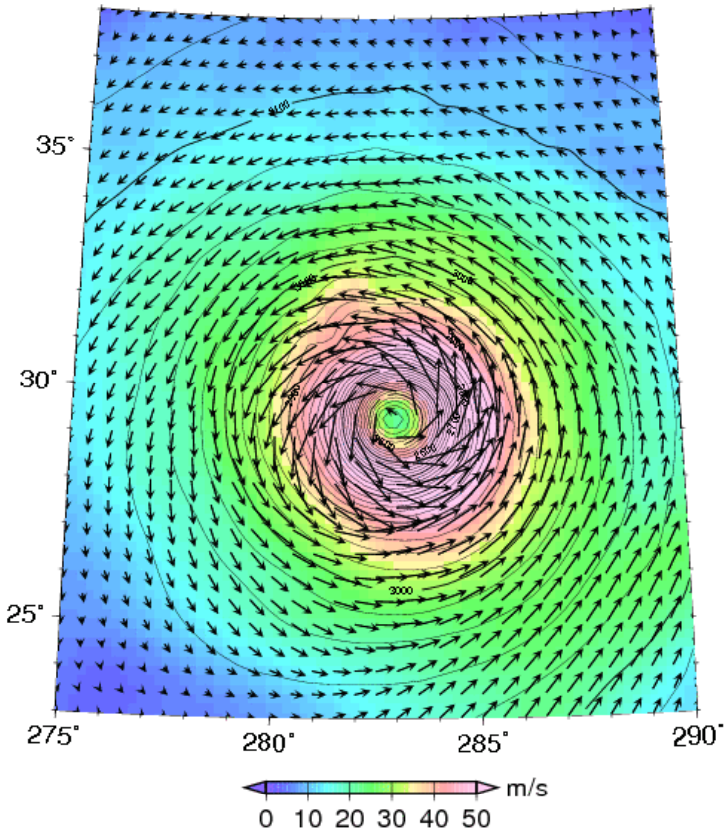
2008070500Z+78HR



NICAM gl-8

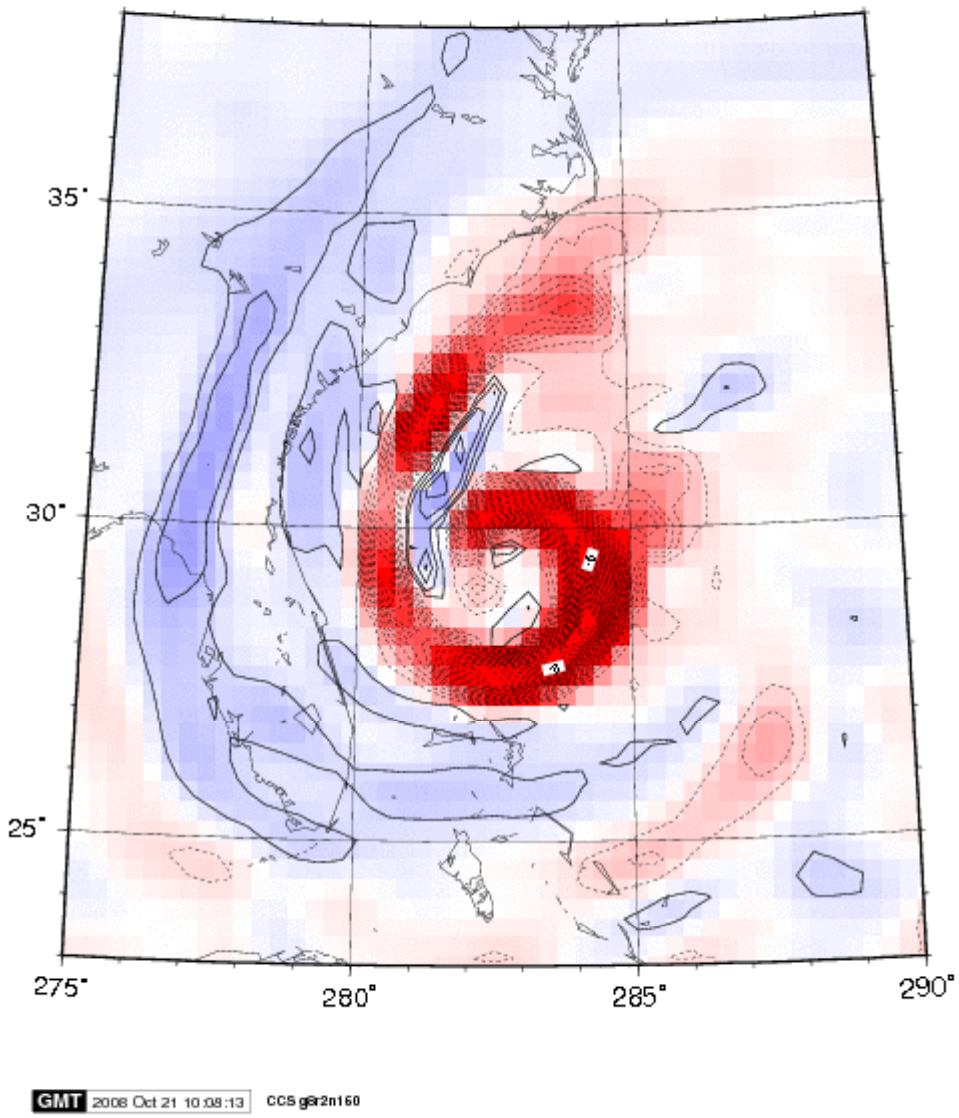
Height (m) and Wind (m/s) at 700 hPa

2008070500Z+78HR



500 hPa Omega

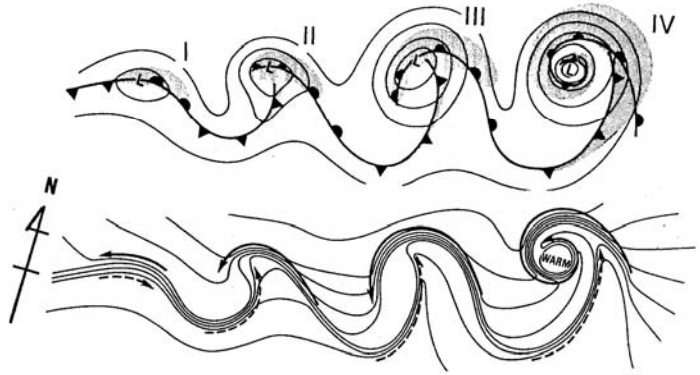
NICAM 2008070500Z+78HR

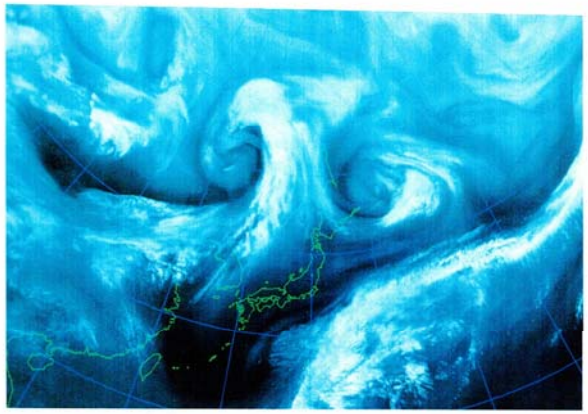


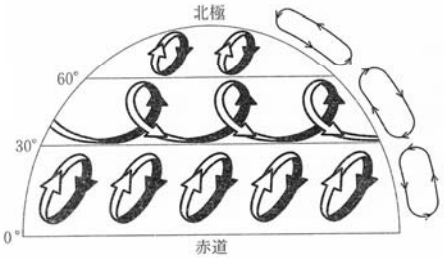
ate Model

Extra-tropical Cyclones

- Life cycle
- Warm and cold fronts







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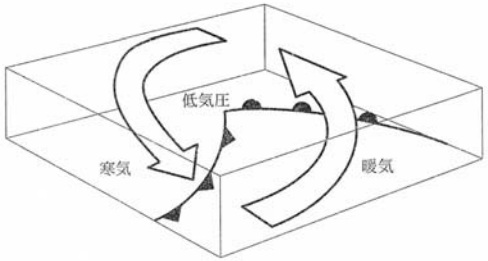
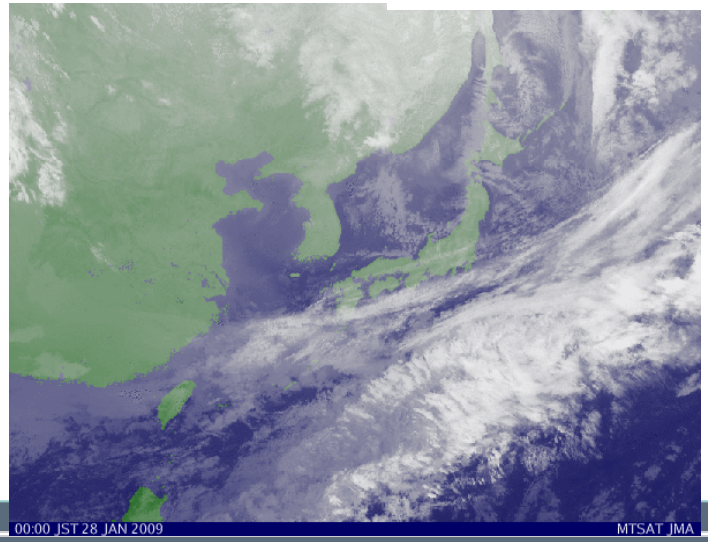
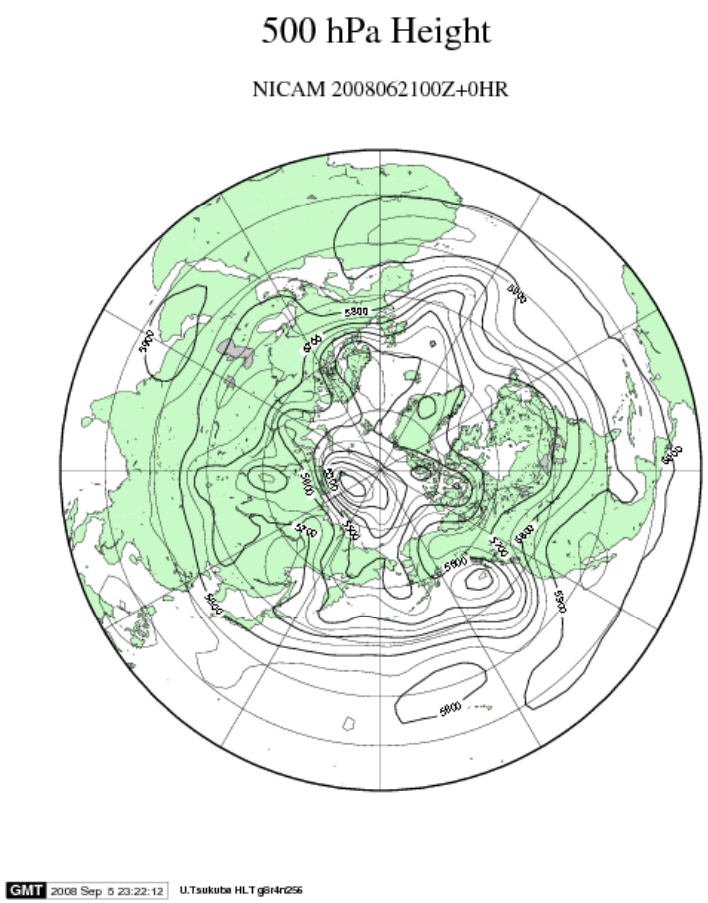
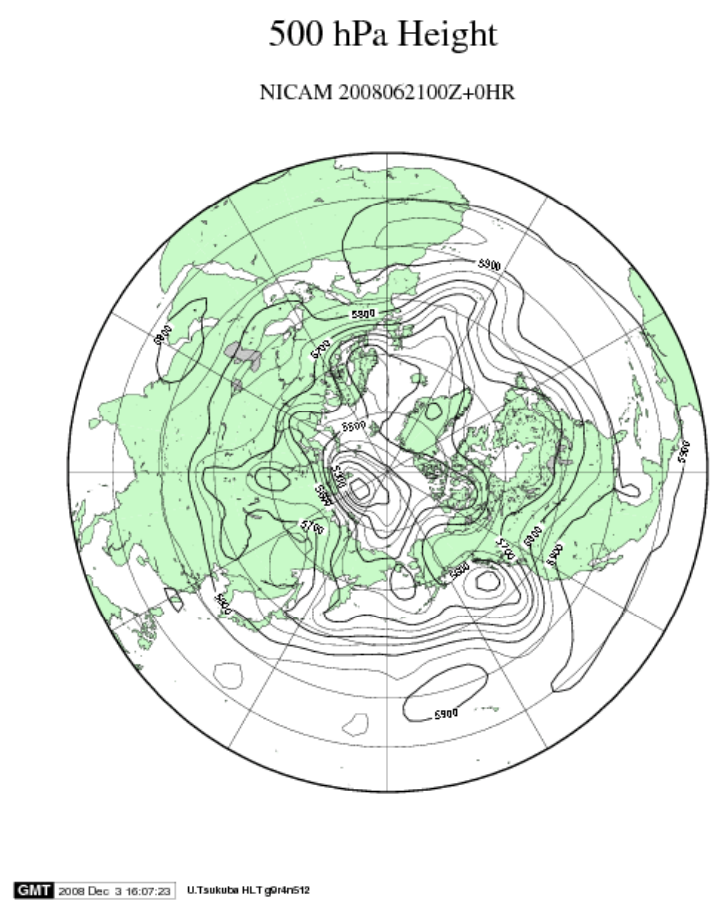




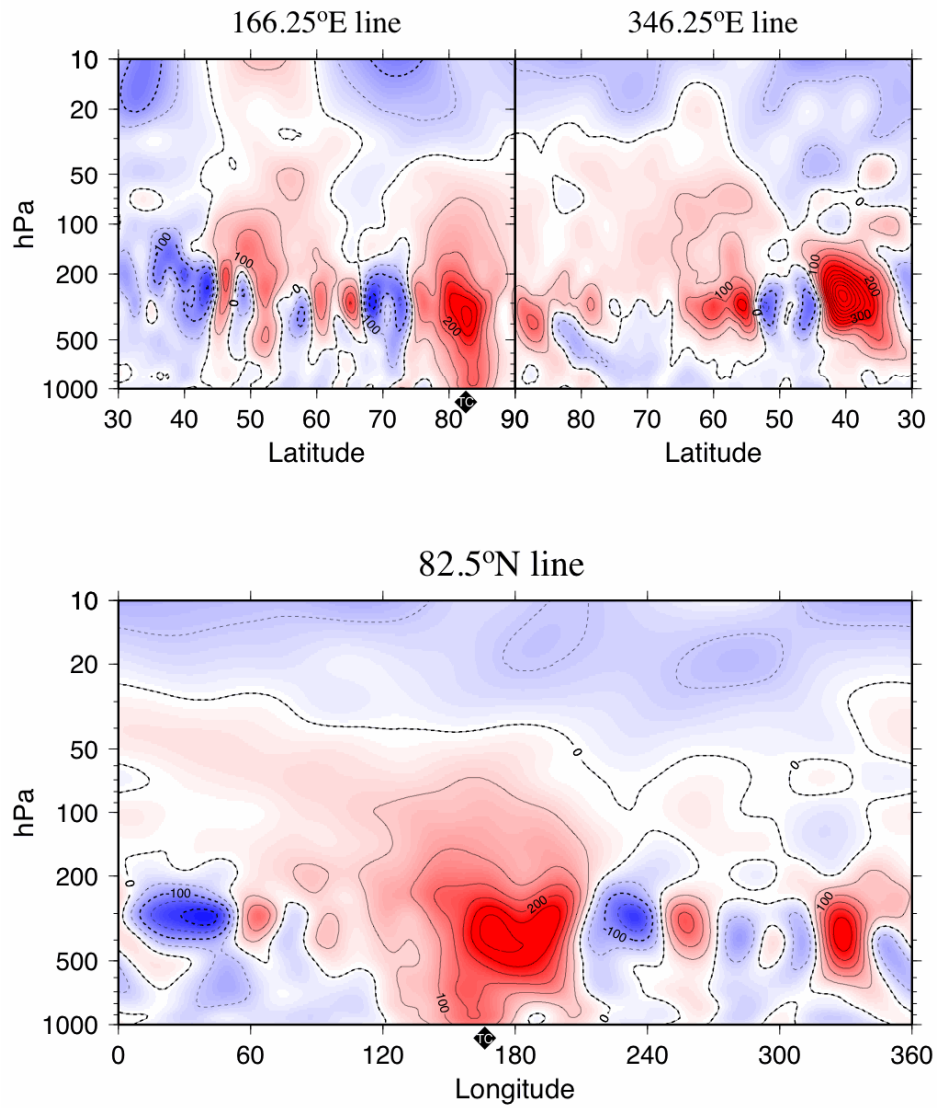
Arctic Cyclones SLP

10 day integration starting
From June 21, 2008
NICAM gl8 and gl9 rl02-n512





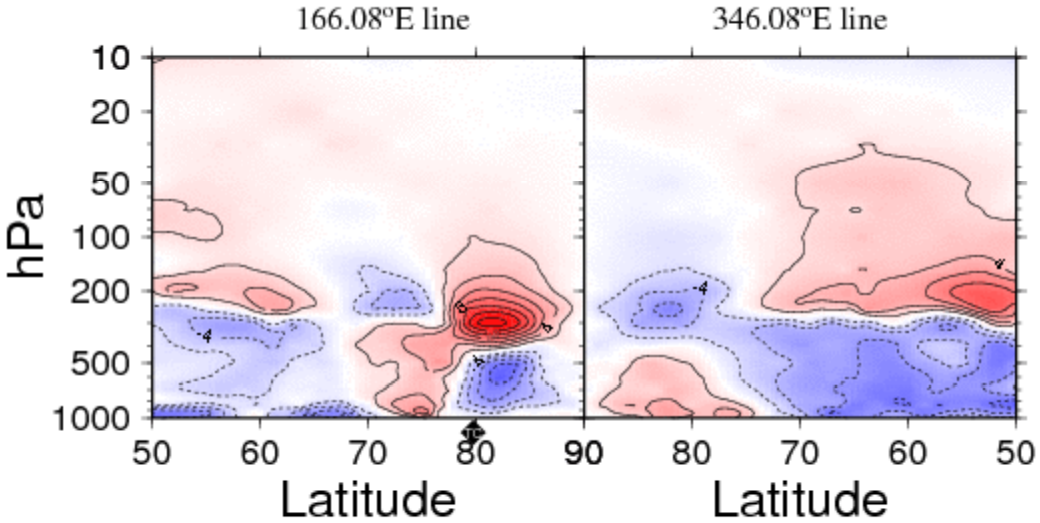
Relative Vorticity
2008062218Z
Target Cyclone 82.5ºN/166.25ºE

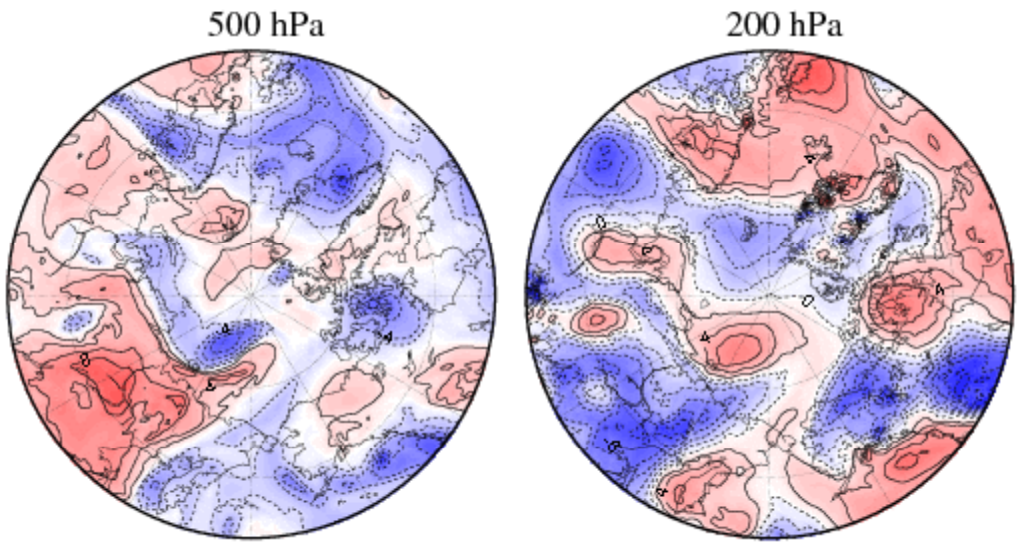


NICAM gl-8

Temperature Anomalies

2008062100Z+24HR

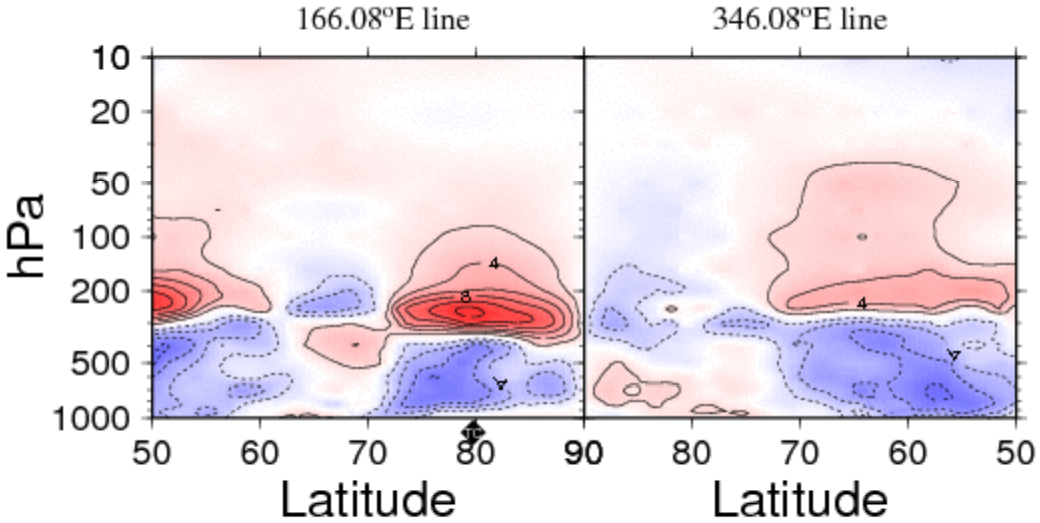


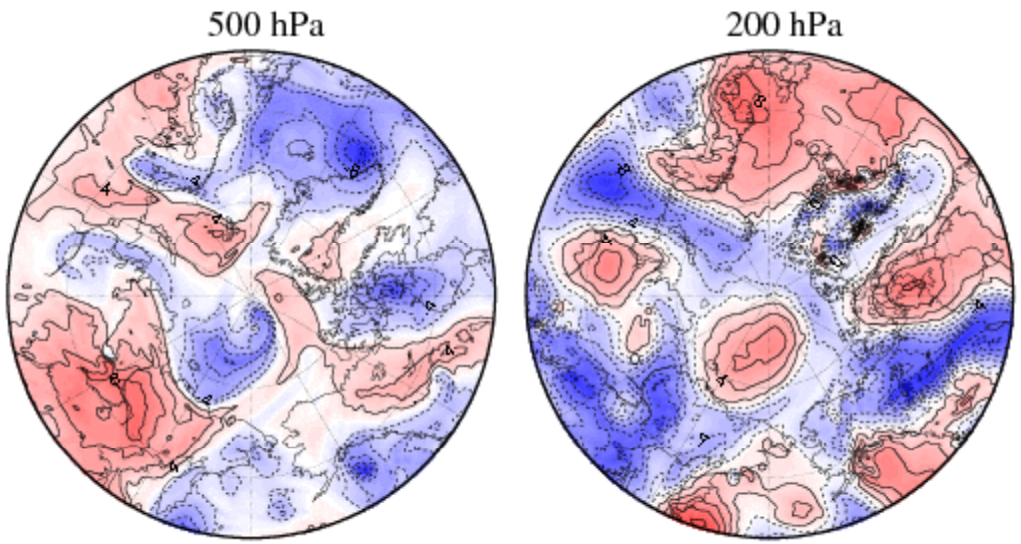


NICAM gl-8

Temperature Anomalies

2008062100Z+48HR





Summary

- Tropical cyclone
  - Dynamical Instability with vertical heat transport
  - Warm core in mid-troposphere by latent heat
- Extra-tropical cyclone
  - Dynamical Instability with meridional heat transport
- Arctic cyclone
  - Vorticity transfer from the polar cortex
  - Warm core in lower stratosphere by subsidence
- NICAM runs at CCS
  - ES vector machine is 8 times faster than T2K