TIGGE, an International Data Archive and Access System

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Topic Outline

- TIGGE Archive Centers and Data Providers
- Data Format
- Status Snap Shot
- Technical Challenges
- User Interface
- Analysis Tools
- Brief Status and Contrast with Partner Centers
- Future Plans

International Foundation

- WMO World Weather Research Programme THORPEX
  - *THe Observing system Research and Predictability Experiment*
  - *Weather research leading to an integrated Global Interactive Forecast System*
    - Integrated across multiple international NWP Centers
  - *THORPEX Interactive Global Grand Ensemble Archive supports research*

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Why Three International Archive Centers?

- Security and mutual back up at distributed mirrored sites
- Centralization creates a focus data service point for users
  - *Easy for users*
- Use existent proven data handling capability at experienced centers
- Allow most NWP centers to focus on providing data, not additional user service burden
- Note: Future TIGGE system is envisioned to be fully distributed - Phase II
  - *NWP centers could provide their own data service*

TIGGE Archive Centers and Data Providers

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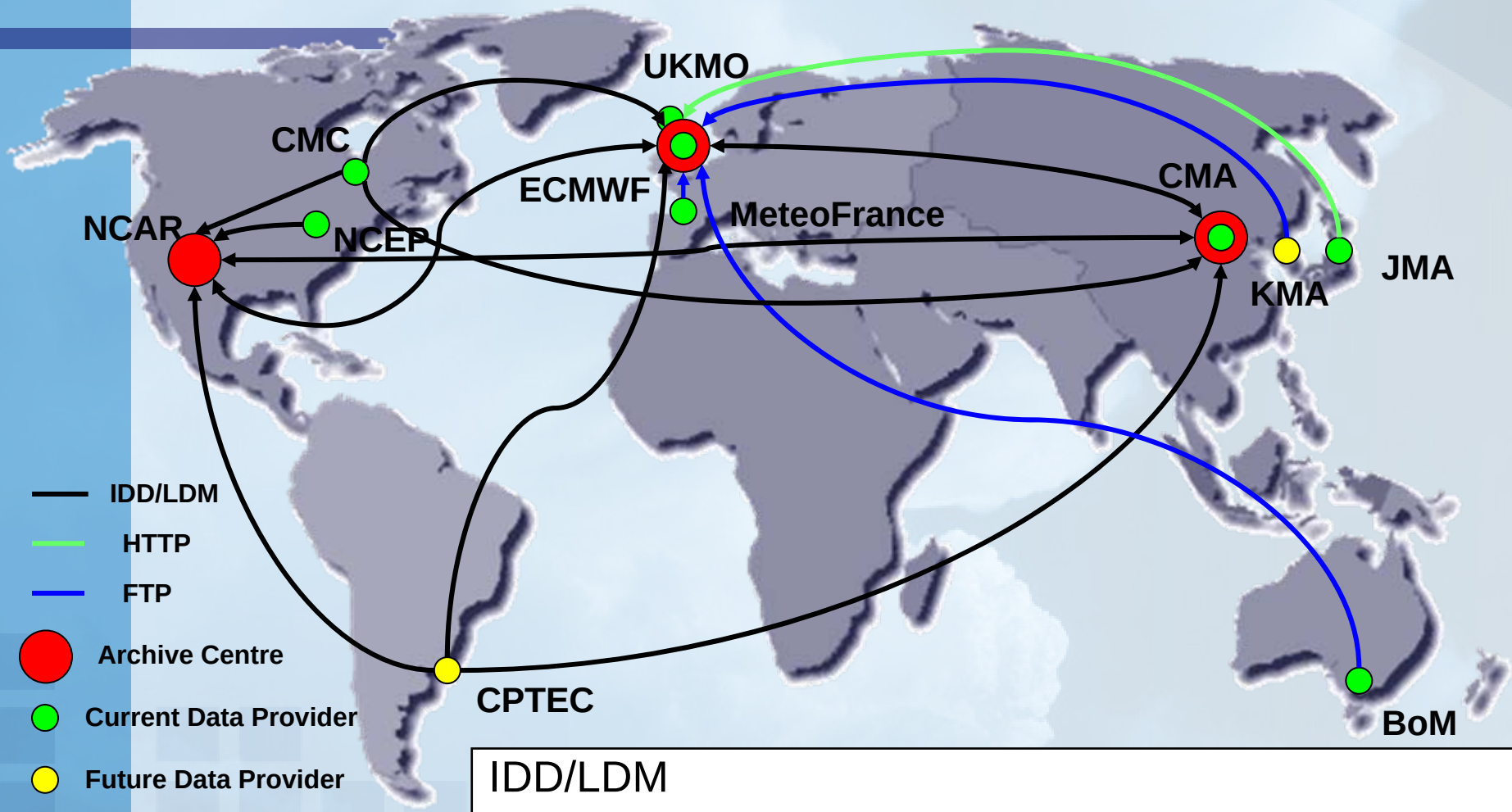

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IDD/LDM

Internet Data Distribution / Local Data Manager

Commodity internet application to send and receive data

Standardized TIGGE Data Format

- Enables systematic data management
  - *GRIB2 file format*
  - *Consistent parameter encoding across all data providers.*
  - *Field compliancy - standard parameters, units, and pressure levels*
- Enables convenient multi-center multi-model comparison
- Outstanding challenges - anomalies between centers
  - *Native horizontal resolution*
  - *Number of ensemble members*
  - *Number of forecast initialization times (1x, 2x, 4x daily)*
  - *Forecast length*
  - *Number of fields provided*
  - *Internal file compression (e.g. jpg) was not specified*

Summary of Current Data Providers

Center	Conforming Parameters	Ens. Members	Model Res.	Fcst Length	Fcsts/ Day	GB/ Day	Fields/ Day	Files/ Day
ECMWF (ecmf)	70/73	51	N200 (Reduced Gaussian)	10 day	2	115	289,734	328
ECMWF (ecmf)	70/73	51	N128 (Reduced Gaussian)	10-15 day	2	24	138,978	160
UKMO (egrr)	70/73	24	1.25 x 0.83 Deg	15 day	2	21	175,680	488
JMA (rjtd)	61/73	51	1.25 x 1.25 Deg	9 day	1	7	113,192	74
NCEP (kwbc)	59/73	21	1.00 x 1.00 Deg	16 day	4	10	316,596	1040
CMA (babj)	60/73	15	0.56 x 0.56 Deg	10 day	2	28	72,510	82
CMC (cwao)	56/73	21	1.00 x 1.00 Deg	16 day	2	8	163,674	260
BOM (ammc)	55/73	33	1.50 x 1.50 Deg	10 day	2	8	147,972	164
MF (lfpw)	62/73	11	1.50 x 1.50 Deg	2.5 day	1	.15	7,558	33
Total					18	221	1,425,894	2,629

Status Snap Shot

Parameter	ECMWF	UKMO	JMA	NCEP	CMA	BoM	MF	CMC
10 meter U-velocity	x	x	x	x	x	X	x	x
10 meter V-velocity	x	x	x	x	x	X	x	x
Convective available potential energy	x			x			x	
Convective inhibition				x				
Land-sea mask	x	x	x	x	x	x	x	
Mean sea level pressure	x	x	x	x	x	x	x	x
Orography	x	x	x	x	x	x	x	x
Skin Temperature	x	x	x	x			x	x
Snow Depth Water Equivalent	x	x	x	x	x		x	x
Snow Fall Water Equivalent	x	x			x	x	x	
Soil moisture	x	x	x					
Soil temperature	x	x				x	x	x
Sunshine duration	x				x		x	x
Surface air dew point temp	x	x	x	x	x		x	x

Technical Challenges

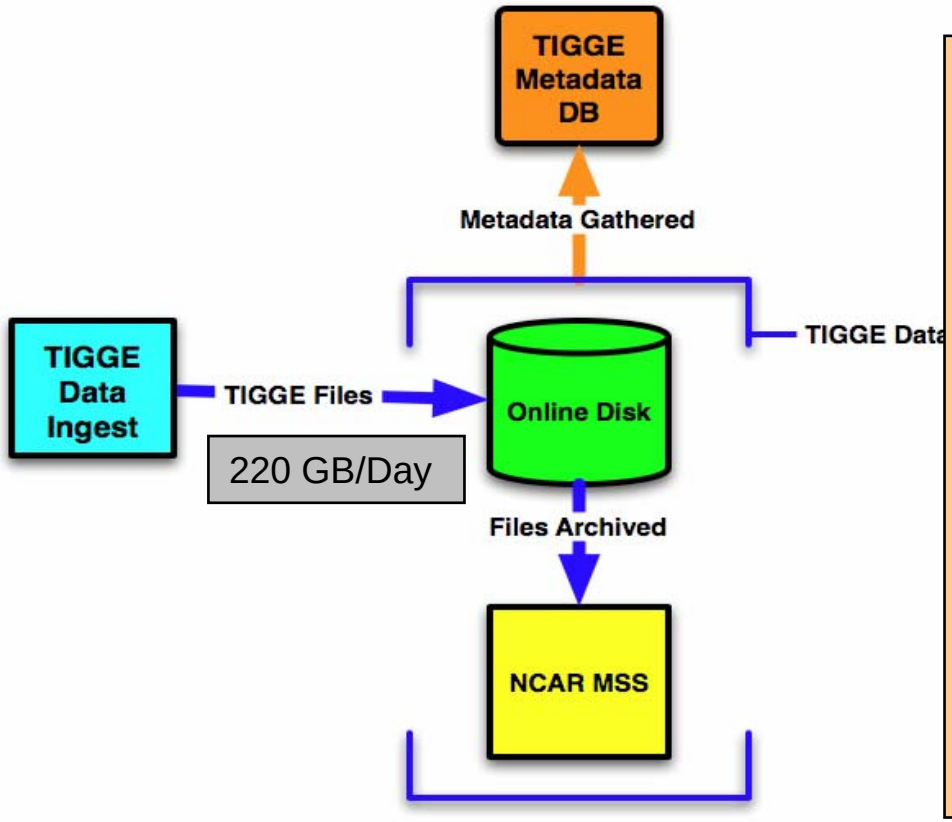
- Building a research file structure
  - *Receive over 1.4 million GRIB2 messages per day*
  - *NCAR doesn't have operational services so we handle TIGGE with methods common in science research - i.e in files*
    - Quite different from ECMWF
    - Create files based on Center, initialization date/time, forecast step, and level type
  - *Outcome - we manage over 2600 files per day*
    - Satisfactory approach with acceptable impact on the NCAR MSS

Technical Challenges

- Building a research file structure
  - *4 files per model timestep (if available)*
    - Single Level
    - Pressure Level
    - Potential Vorticity Level
    - Isentropic Level
  - *Each file includes all parameters and ensemble members for the specified level type and forecast time.*

Technical Challenges

Coordinated Online and MSS data



TIGGE Metadata DB Functions

Currency of all TIGGE data

- Location of all online files
- Location of all MSS files
- Pointers to all online GRIB records within files
- Constantly updated
- Drives display and access at the user interface
  - More discussion later

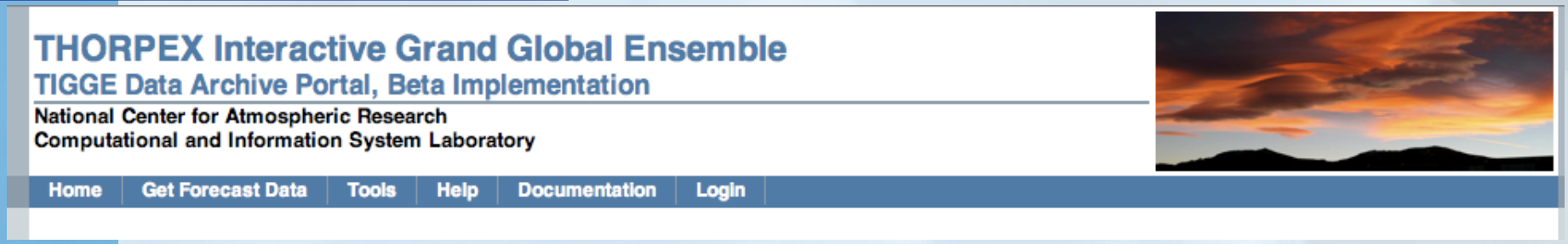
User Interface/Portal

Address: http://tigge.ucar.edu

Main Features

- *Registration and Login*
- *Get Data*
- *User Tools*
- *Documentation*
- *Technical and Community Supported Help*

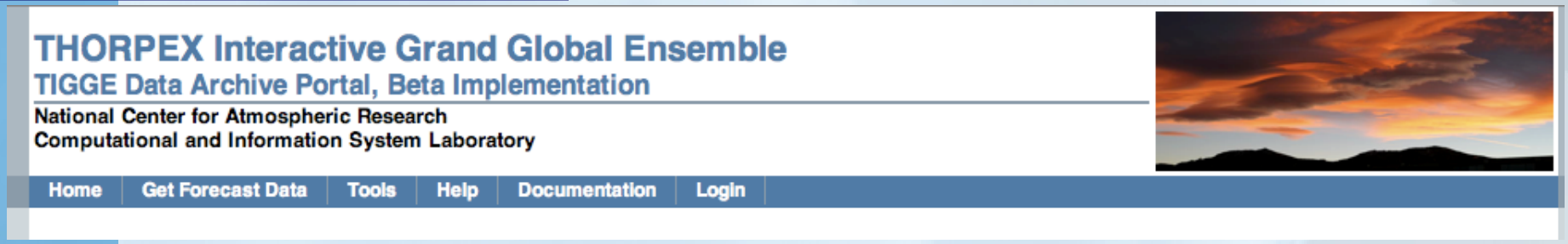
User Interface



Registration and Login

- *Required per international agreement*
  - Users electronically accept conditions for usage
  - Primarily, for education and research
  - 48-hour delay, except by special permission granted by IPO
- *We capture metrics for*
  - Name, email, organization name, organization type (univ., gov.,), and country
  - Who , what, when files were downloaded

User Interface



Get Forecast Data

- Two Selection Interfaces
  - *File Granularity*
    - Developed First
  - *Parameter Granularity*
    - Added Summer 2007

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Dates

Center

File Type

Forecast Time

Forecast Duration

Data Request Selection

Start and End Dates

Start Date	End Date
2007-07-31	2007-08-01

Select Centers

China Meteorological Administration	European Center for Medium-Range Weather Forecasts	United Kingdom Met Office	National Centers for Environmental Prediction (USA)	Japan Meteorological Agency
☑ BABJ	☑ ECMF	☑ EGRR	☑ KWBC	☑ RJTD

Select Level Type

Center	Single Level Parameters (includes surface)	Pressure Level Parameters	Potential Vorticity Level Parameters	Potential Temperature Level Parameters	
BABJ	☐	☐			All Clr
ECMF	☐	☐	☐	☐	All Clr
EGRR	☐	☐	☐	☐	All Clr
KWBC	☐	☐	☐		All Clr
RJTD	☐	☐			All Clr

Select Initial Forecast Time

Center	00z	06z	12z	18z	
BABJ	☐		☐		All Clr
ECMF	☐		☐		All Clr
EGRR	☐		☐		All Clr
KWBC	☐	☐	☐	☐	All Clr
RJTD			☐		All Clr

Select Forecast Times

Center	1 (0-24)	2 (24-48)	3 (48-72)	4 (72-96)	5 (96-120)	6 (120-144)	7 (144-168)	8 (168-192)	9 (192-216)	10 (216-240)	11 (240-264)	12 (264-288)	13 (288-312)	14 (312-336)	15 (336-360)	16 (360-384)	
BABJ	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐							All Clr
ECMF	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐		All Clr
EGRR	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐		All Clr
KWBC	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	All Clr
RJTD	☐	☐	☐	☐	☐	☐	☐	☐	☐								All Clr

Next

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Get Forecast Data

Two User Interfaces

NCAR online file archive

- Selection options
  - Center(s)
  - Date
  - File type (sl, pl, etc)
  - Initialization time
  - Forecast length

Real Time

User customized files

- Selection options
  - **Same as for files, plus**
  - Parameter
  - Regridding
  - Spatial subsets
  - Formats, GRIB2 netCDF

Delayed Mode

Download Options

- Point and click using browser, one file at a time
- Script to run on local machine
  - User and password encrypted '**wget**' commands
  - background process to access all files

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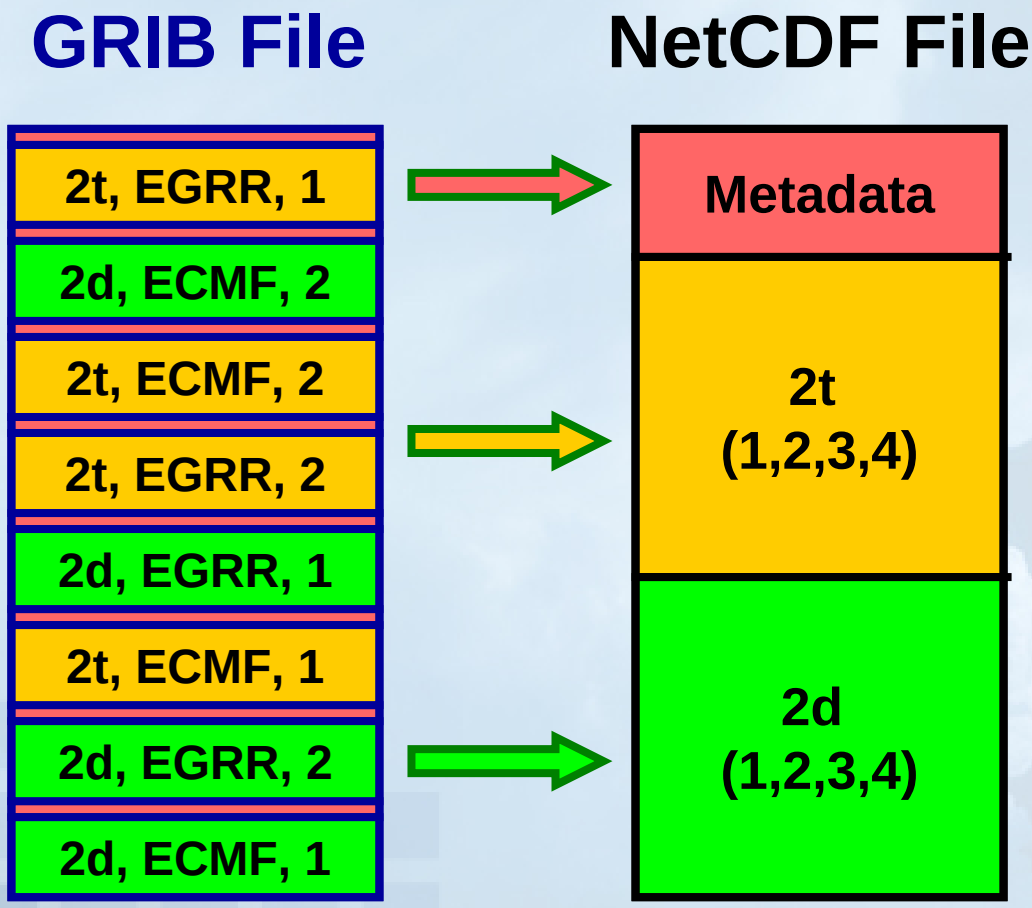
Data handling challenges and solutions

- Fast field extraction from a large GRIB archive
  - *Use a dynamic DB the holds address information for individual fields*
- Deriving user specified horizontal grids when no two native grids are the same
  - *Brute force, use specialized software and sufficient background computing (Spherepak and EMOS)*
- Inform users about delayed mode processing
  - *Have online queue so users can check status of their request*
- Minimize user repetitive interface input
  - *Archive user requests and seed online forms during subsequent visits (to be implemented)*
  - *Submit request as a subscription service (tbi)*

Tools

- Challenges
  - *New format, WMO GRIB2*
  - *Additional dimension, 5th, "ensemble member id"*
- Collection of tools with growing maturity
  - *Contributors*
    - NCAR
    - ECMWF
    - NOAA
    - Unidata
- Forthcoming
  - *NCAR and ECMWF staff are collaborating (ECMWF Consultancy) to develop a GRIB2 to NetCDF conversion tool*
    - Broad application, TIGGE and others
    - Initial development will leverage the ECMWF GRIB API
    - Complimentary to NCAR/NCL GRIB2 ingest capability

Tools: GRIB to NetCDF conversion



Gather metadata and message locations

Create NetCDF file structure

Populate NetCDF parameter arrays

(1,2,3,4) represents ensemble member id (Realization)

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Tools: GRIB to NetCDF conversion

- NetCDF File format
  - *Based on available CF conventions*
  - *File organization built according to Doblas-Reyes (ENSEMBLES project) proposed NetCDF file structure*
  - *Provides grid/ensemble specific metadata for each member*
    - Data Provider
    - Forecast type (perturbed, control, deterministic)
  - *Allows for multiple combinations of initialization times and forecast periods within one file.*
    - Consistent across all data providers.
  - *All data on same Lat/Lon GRID.*

- Designed to work with GRIB-1 or GRIB-2 data using ECMWF GRIB-API functionality.

Tools: GRIB to NetCDF conversion

- NetCDF Parameter structure (5 dimensions):
  - *Time (Time id)*
  - *Realization (Ensemble member id)*
  - *Level*
  - *Latitude*
  - *Longitude*

- “Coordinate” variables are use to describe:
  - *Time*
    - Allows for multiple initialization times and forecast periods to be contained within one file
  - *Realization*
    - Provides metadata associated with each ensemble grid.

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Tools: GRIB to NetCDF conversion

- Coordinate variables
  - *Provide ensemble member metadata*
    - Institution
    - Forecast Type

2d (1,2,3,4)

Realization	**1**	**2**	**3**	**4**
Institution	**ECMF**	**ECMF**	**EGRR**	**EGRR**
Forecast Type	**cf**	**pf**	**cf**	**pf**

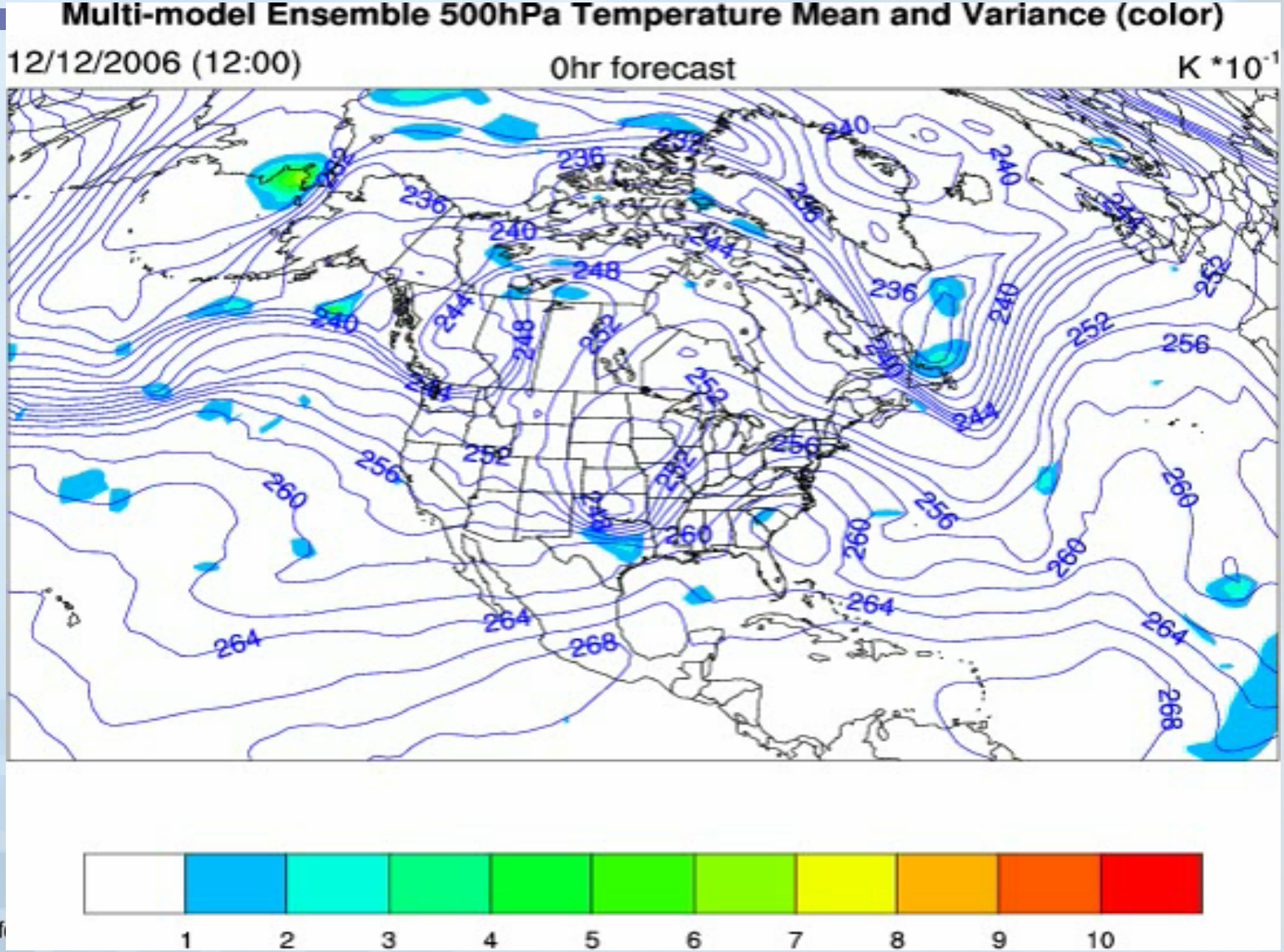
Tools: GRIB to NetCDF conversion

- Coordinate variables
  - *Provide time description*
    - Initialization time
    - Forecast Hour

2d (1,2,3)

Time	**1**	**2**	**3**
Initialization	**2007101212**	**2007101300**	**2007101300**
Forecast Hour	**24**	**12**	**18**

Tools, example; NCAR NCL



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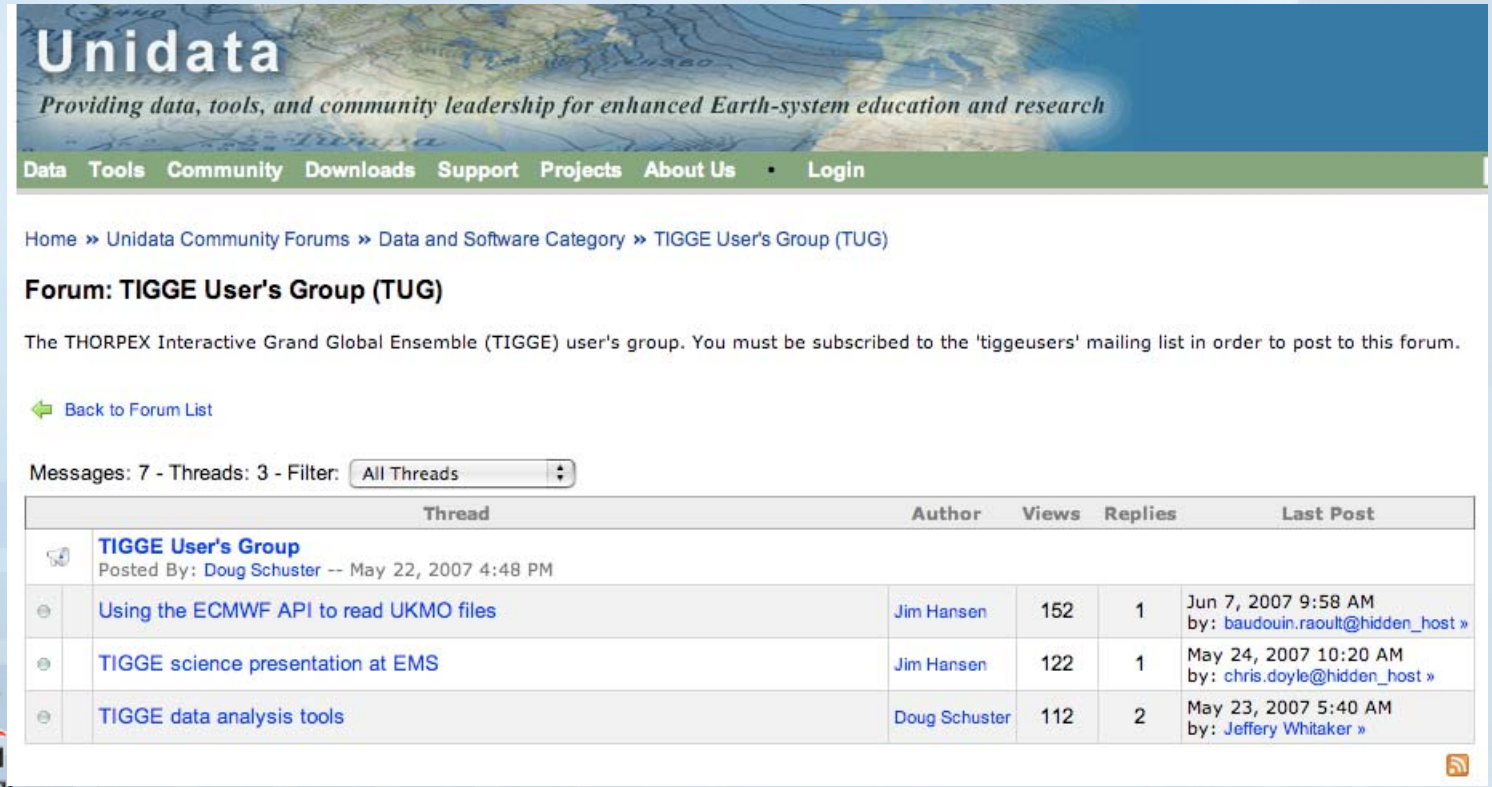
User Help

Two modes

- Technical assistance directly from TIGGE staff at NCAR via email
  - *Could originate from the portal*
- Open community website forum, including subscription email
  - *Enrollees can post questions, give answers, and share ideas and experiences*
  - *Provided by Unidata*



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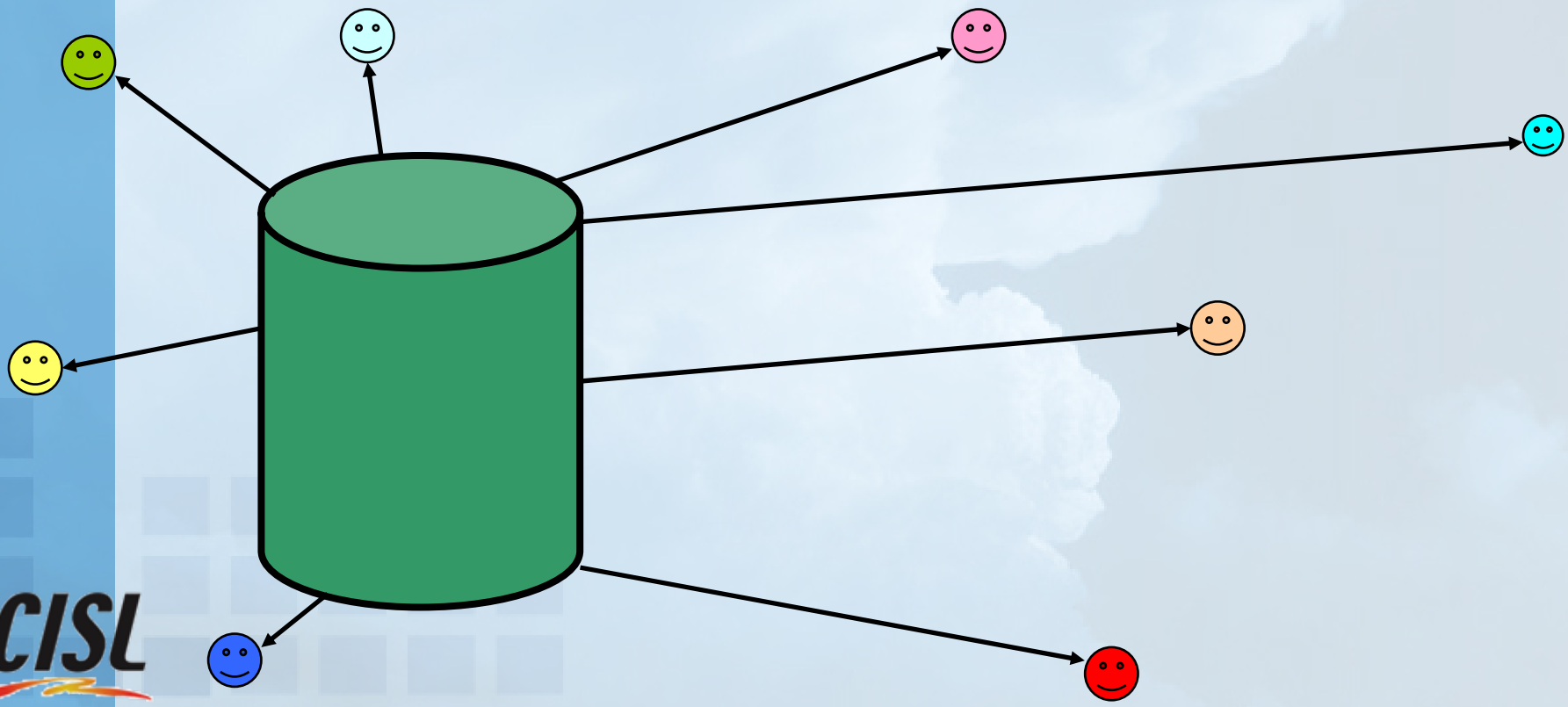
NCAR TIGGE archive usage

- 1.0 TB, 65 K file, downloaded (11/11/07)
- 61 Unique data users



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Comparisons with partners; ECMWF

- NCAR and ECMWF have fully mirrored archives
- ECMWF uses a storage and access model based on individual fields (MARS)
  - *Quite different than NCAR files based system*
- ECMWF and NCAR have interfaces with the **same** look and feel
- ECMWF is a data provider and an archive center
  - *Has 160+ GB/day data produced locally (EC and UKMO)*
  - *Does significant data processing to prepare TIGGE fields from operational output*
  - *Assists UKMO, JMA, BoM, KMA, and MeteoFrance in building the TIGGE archive*

Comparisons with partners; CMA

- Uses file-based system to save all data at present
  - *Plan to deploy MARS in the near future*
- Designing a portal similar to NCAR and ECMWF
  - *Same look and feel*
  - *Same access options and development plan*
- Data provider and an archive center
  - *Receives data via IDD/LDM, same data as ECMWF and NCAR*
  - *Provide TIGGE data to support internal research program*
- Future plan at CMA
  - *Integrate data access portal interface with MARS*
  - *Enhance portal and open for wide data distribution*

Future at NCAR

- Complete advanced subsetting features
  - *Spatial, grid interpolation, and user selected output format (GRIB2 and NetCDF)*
- Add new contributors into the archive
  - *All have committed to doing so in 2007*
- Continue data analysis tool development
- Develop web service protocols for uniform direct access at distributed centers
  - *Termed as Phase II in TIGGE documentation*
  - *Could enable data provider host their data directly*
- Automated user access to long-term TIGGE holdings from the NCAR MSS

TIGGE Portals

Portals

- http://tigge.ucar.edu
- http://tigge.ecmwf.int
- http://tigge-portal.ecmwf.int

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Comparisons with partners; ECMWF

- Website/Portal (http://tigge.ecmwf.int)
- Primary Information
  - *Meeting Reports and Documentation*
  - *Technical information for Data Providers*
  - *Downloadable scripts to implement TIGGE IDD/LDM protocol*
  - *Detailed description of agreed GRIB 2 encoding*
- ECMWF Archive Status
  - *Monitoring plots showing each parameter from each Data Provider, use for quality assurance (e.g. correct units):*
  - *History web page: record of events, such as addition of new fields or missing cycles*

    (http://tigge.ecmwf.int/tigge/d/tigge_history/)

Summary Lessons

- Formal agreements on formats and variables are essential
  - *Small loop holes, anomalies, are problematic*
- Work sharing ethics between skilled partners allows rapid progress - TIGGE Archive partners are excellent
- Pushing the technical and experience limits forces leading edge developments, preparation for the future

Comparisons with partners; ECMWF

- Data Retrieval Interface
  - *User Registration*
  - *Access to **all** available data, including data off-line (on tape)*
    - Integrated with MARS
  - *Smallest accessible item: one 2D field*
  - *Subset by space, time, variable, level, etc.*
  - *Interpolation capabilities (re-gridding)*

Comparisons with partners; ECMWF

- Usage:
  - *45 registered users*
  - *2.5 TB extracted from the archive*
  - *After interpolation, 353 GB delivered to users*

- Future
  - *Add new data providers*
  - *Offer netCDF format output*
  - *Enable web service access*

Agreement Process

- Chronology of major workshops and outcomes
  - *First Workshop on TIGGE, March 2005, Reading UK*
  - *TIGGE - Archive Working Group, September 2005, Reading UK*
  - *2nd GIFS-TIGGE Working Group, March 2006, Reading UK*
  - *3rd GIFS-TIGGE Working Group, December 2006, Landshut Germany*
  - *4th GIFS-TIGGE Working Group, March 2007, Beijing China*
    - Establish data policy and requirements
    - Get agreement to participate from 10 NWP centers
    - Target support for IPY and Beijing Olympics '08
- Archive relevance
  - *Standardized data products, formats, distribution policy*

TIGGE Objectives

- Enhance collaboration on ensemble prediction, internationally and between operational centers and universities
- Develop new methods to combine ensembles from different sources and to correct for systematic errors (e.g. biases, etc)
- Achieve a deeper understanding forecast errors contributed by the observation, and initial and model uncertainties
- Enable evolution towards an operational “Global Interactive Forecast System”.

From Philippe Bougeault, ECMWF

Technical Challenges

- Why use IDD/LDM?
  - *Advantages*
    - **Application coordinates data transfer between sending and receiving queues - very automated**
    - **Queue size and TCP/IP packet size are configurable to optimize transfer rate and success**
    - **Developed and supported by Unidata, a UCAR program**
    - **Used in many other real-time data transport scenarios, e.g. education, field projects, US National Weather Service**
    - **Easy to coordinate multi-center exchanges, *one can feed many, CPTEC***
  - *Disadvantages*
    - **Somewhat complex to configure and tune**
    - **Monitoring software must be developed to assure archive completeness**
      - **Verify receipt against a manifest list, request data resend**

Technical Challenges

- Alternate Approach
  - *Use on 'old reliable' HTTP/FTP*
    - Exclusively a two-way exchange
    - Must arrange agreements and processes independently at both ends
    - Not complex
    - Works best for small to moderate data volume, e.g. JMA, KMA, BoM, MeteoFrance feeds to ECMWF