

Gfdnavi, web-based data and knowledge server software for geophysical fluid sciences



S. Nishizawa (Kobe Univ.), **T. Horinouchi** (Hokkaido Univ.),
C. Watanabe, A. Tomobayashi, S. Otsuka, **Y. Isamoto**,
T. Koshiro, Y.-Y. Hayashi, and GFD Dennou Club

black: Geophysical scientists / blue: Database scientist

Introduction of GFD Dennou Club

What's GFD Dennou Club

- A grass-root activity
 - scientists and students in fields mainly of Geophysical Fluid Dynamics (GFD)
 - Geophysical fluid: atmosphere, ocean, mantle, etc.
 - Inter-University
- Founded in 1988
 - by Y.-Y. Hayashi, M. Shiotani, S. Yoden, and S. Sakai



Purposes

- To promote
 1. activities for **caching up developments** of computer and information science and technology and introducing those into education and research of our fields.
 2. **accumulation of knowledge** on our and related fields, and digitize them onto Internet servers, and share them among not only ourselves but also others.
 3. **developing software tools** which can be provided to our activities of education and research, and accumulation of knowledge.

Main activities

- Server management
 - <http://www.gfd-dennou.org/>
- Seminar organization
- Software development
 - Data analysis and visualization tool development (DAVIS)
 - DCL (graphic library), Dennou Ruby project
 - Numerical simulation models
 - I/O libraries, hierarchical set of models
- Knowledge archive
 - Theoretical documents
 - Tech notes
 - Multimedia of seminars and lectures
 - Digital archive of Laboratory experiments on GFD
- Data archive
 - Satellite and objective analysis data

Gfdnavi

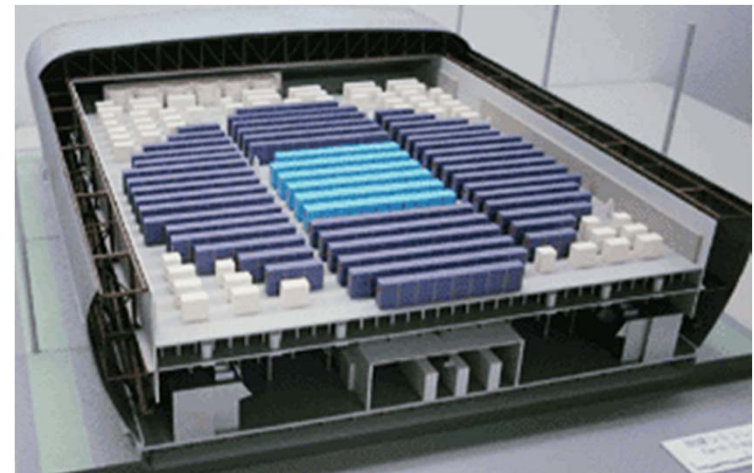
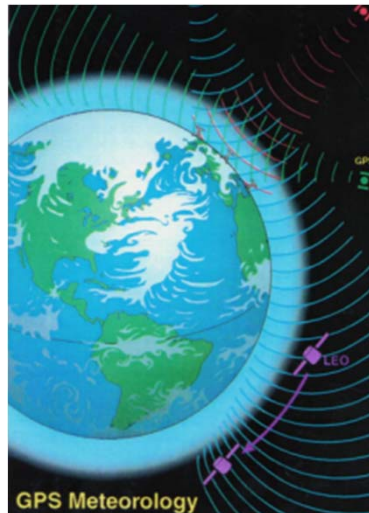
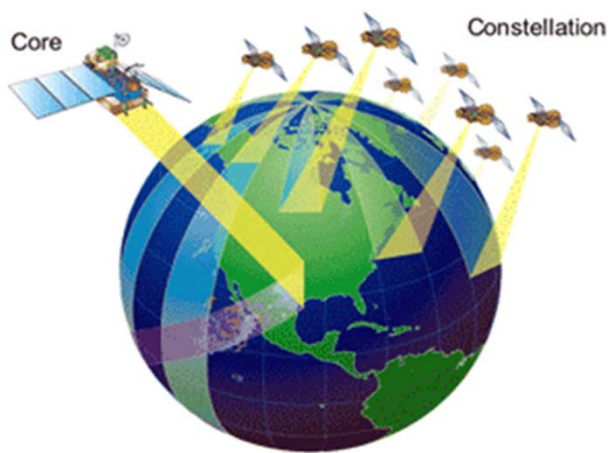
What is Gfdnavi

- = **G**eophysical **f**luid **d**ata **n**avigator
- A suite of software to construct **Web-based** database of geophysical fluid data
- Functionality:
 - Data Search
 - Numerical analysis and visualization
 - Documentation of analysis results
- Available (open source):
<http://www.gfd-dennou.org/library/davis/gfdnavi/>

Background

Data we use

- **Observational data** (satellite, station etc) / **Simulation data** (climate prediction etc) / other numerical data (assimilation data, idealized data etc)
- **Mostly in a few self-descriptive binary formats** such as NetCDF, GRIB, HDF-EOS (but not always)



Data publication

- Many organizations/research groups provide data through web
 - They provide data files
 - Optionally visualization etc
 - in many cases custom-made (for each project / organization)

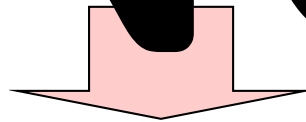
Problems of current web-based data servers

- Limited visualization / analysis capability
 - Only quick-looks. Need to DL data
 - Service are not available to local data
- Support of non-georeferencing data is weak

Is visualization the goal?

- While working: memos
- To collaborators: reports / internal documents / discussion
- To others (scientists, society) reports, papers

NO



Outputs are documents
(not just pieces of images)

Introducing Gfdnavi

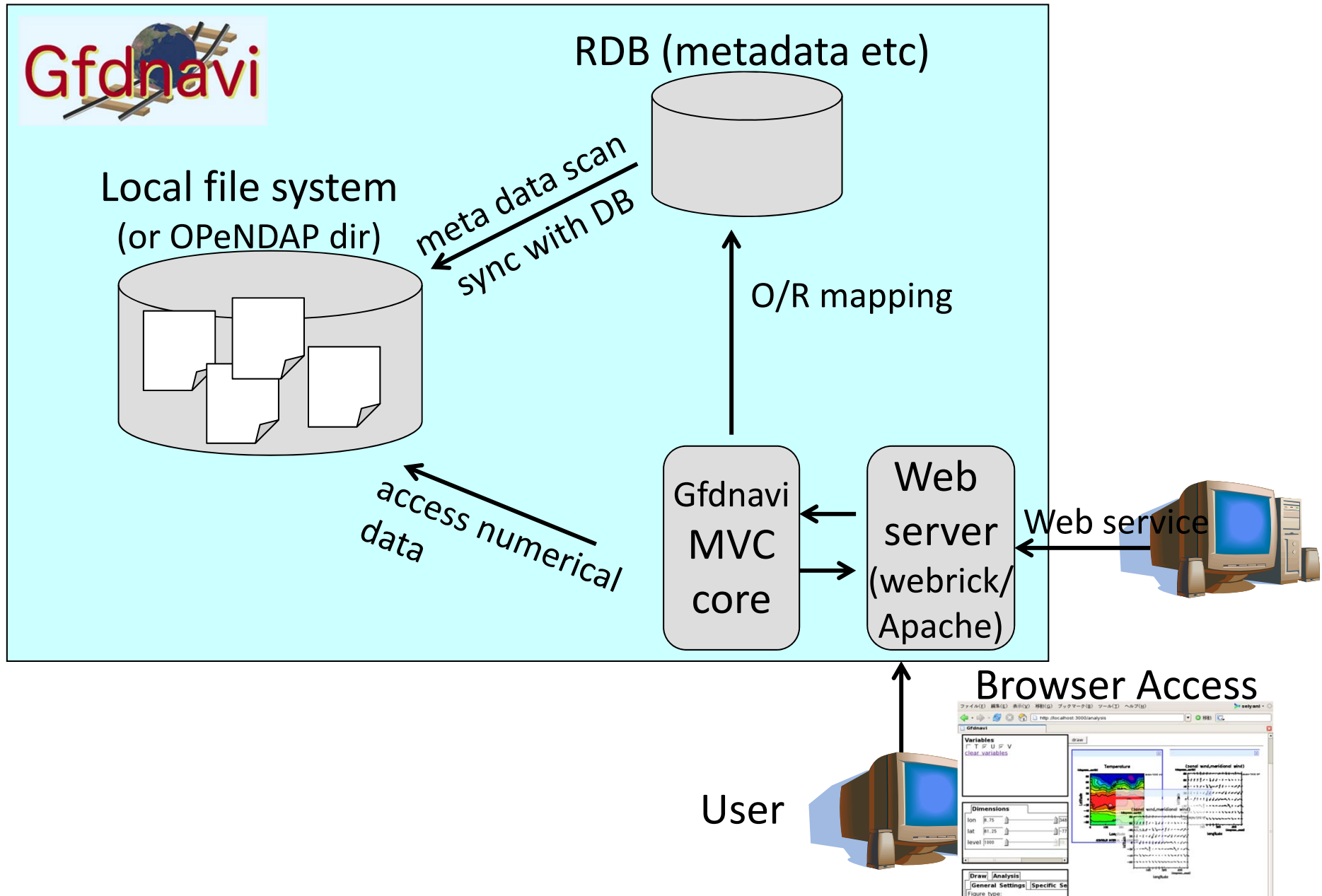
Basic requirement

- Support both browser **GUI** & **programmability** for users
 - **Beyond initial quick-look**
 - GUI: good to start up / good for novices – interdisciplinary collaboration
 - Programming : infinite degrees of freedom / good to repeat
- Support a wide range of use cases from **public data services**, group use, to **personal desktop use**
 - Should be easy to install, start up, and manage
- Support documenting & archiving **knowledge** obtained through data analysis

Two fundamental libraries used to build Gfdnavi

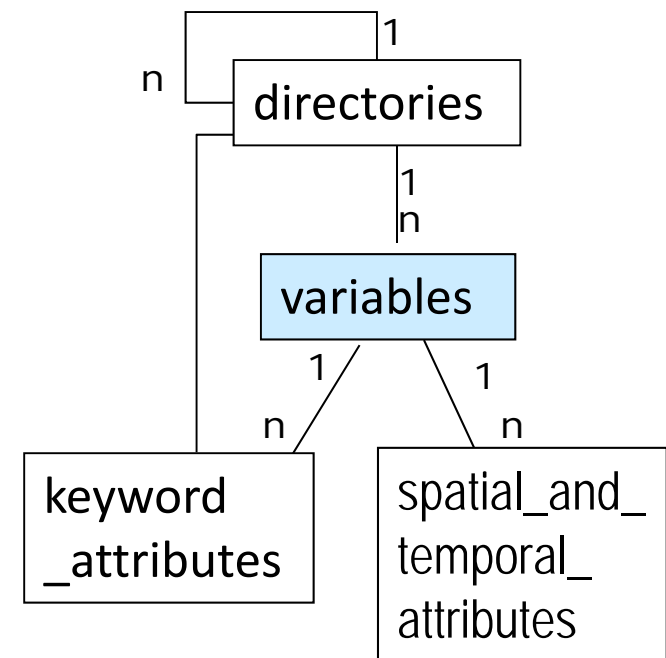
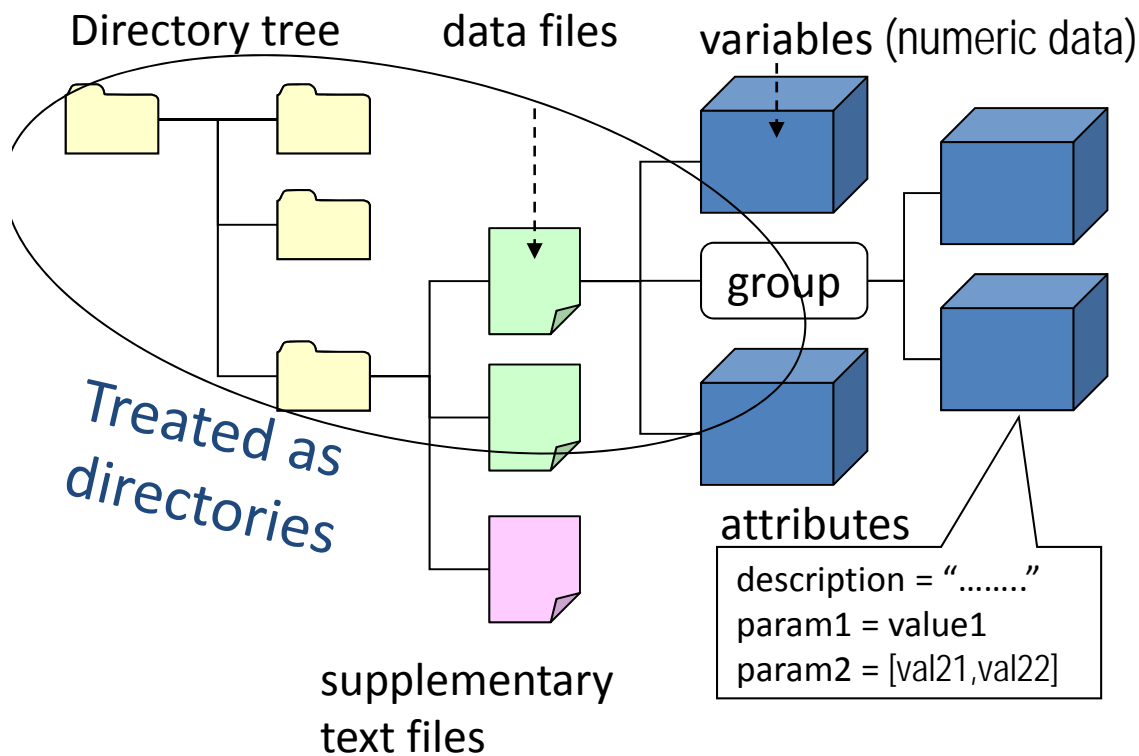
- **GPhys** – a Ruby library to analyze and visualize geophysical fluid data *(by Horinouchi etc since 2003; GFD Dennou Club)*
 - For consolidated access to data in files (NetCDF, GRIB, GrADS, NuSDAS, HDF5-EOS etc) or on runtime memory
 - **A community infrastructure for data analysis – Key to unite all forms of data access**
 - **Used by increasing number of scientists**
- **Ruby on Rails** – Web application development framework
 - Written in/for Ruby → We can use GPhys directly
 - Equips its products with web server → Easy to deploy

Structure of Gfdnavi



Metadata DB

- **Attributes** (extracted from data files or supplied by additional text files)
- **Directory tree structure**



Data search

- Case1: you know which dataset you want to analyze/visualize
 - Browsing directory tree with MS-Explore like view

Select from directory tree:

[clear tree](#)

[/samples/reanalysis/ncp](#)

	name	title	size	la	
<input type="checkbox"/>	Anal/Viz Details	T.jan.nc	26K	200	
<input type="checkbox"/>	Anal/Viz Details	T.jan.zonal_mean.nc	1.7K	200	
<input type="checkbox"/>	Anal/Viz Details	UV.jan.nc	ncep climatology	13K	200
<input type="checkbox"/>	Show Details	T.jan.100hPa.png	16K	200	

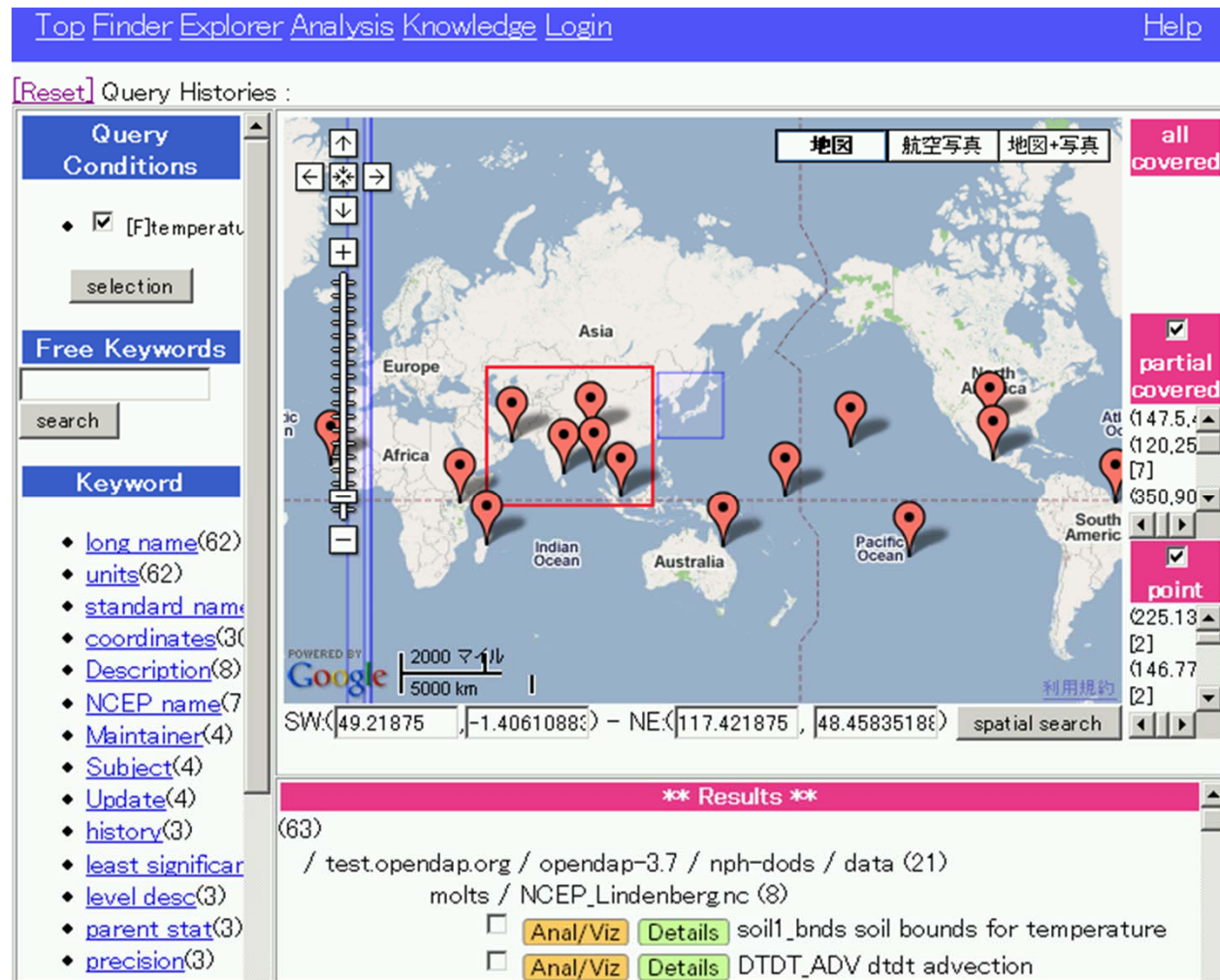
[Analyze/Visualize checked items](#) [Show checked items](#)

[open node tree](#) [Download this file](#)

T.jan.nc [plain file] /samples/reanalysis/ncp/T.jan.nc

T.jan.nc

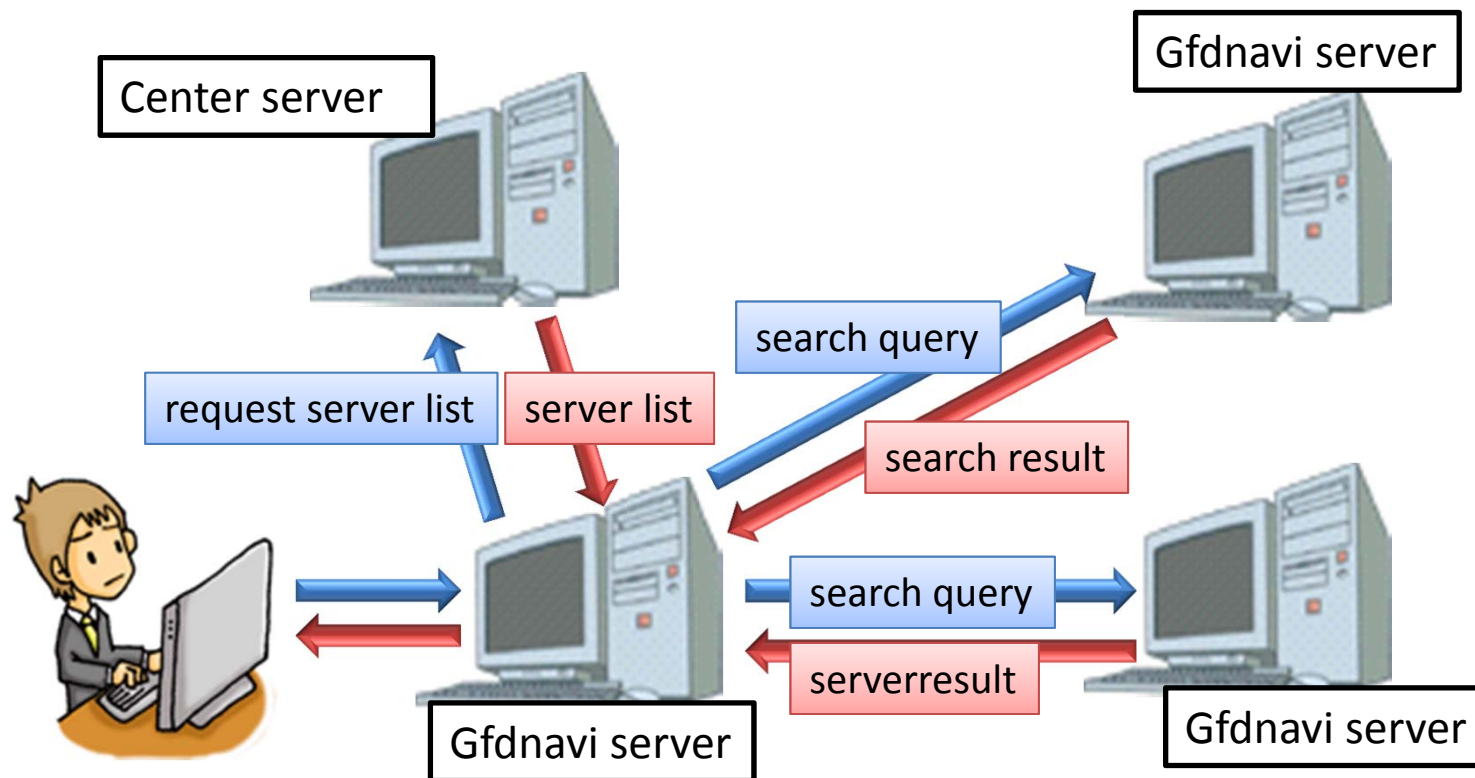
- Case2: you did not know a specific dataset
 - Faceted search
 - free text, geo-space and time, attributes



Cross search

- search data in multiple data servers across networks
 - (multiple kinds of datasets could be found)
 - data: observations, numerical simulations, etc
 - servers: personal, group's, public

- Hybrid peer-to-peer (P2P)
 - a central server having a server list
 - send search request to each peer



Support programmability

- usefulness in all stages of scientific studies
 - GUI: **trial-and-error stages** (e.g. quick-look)
 - programming: **later stages** (e.g. repetition)

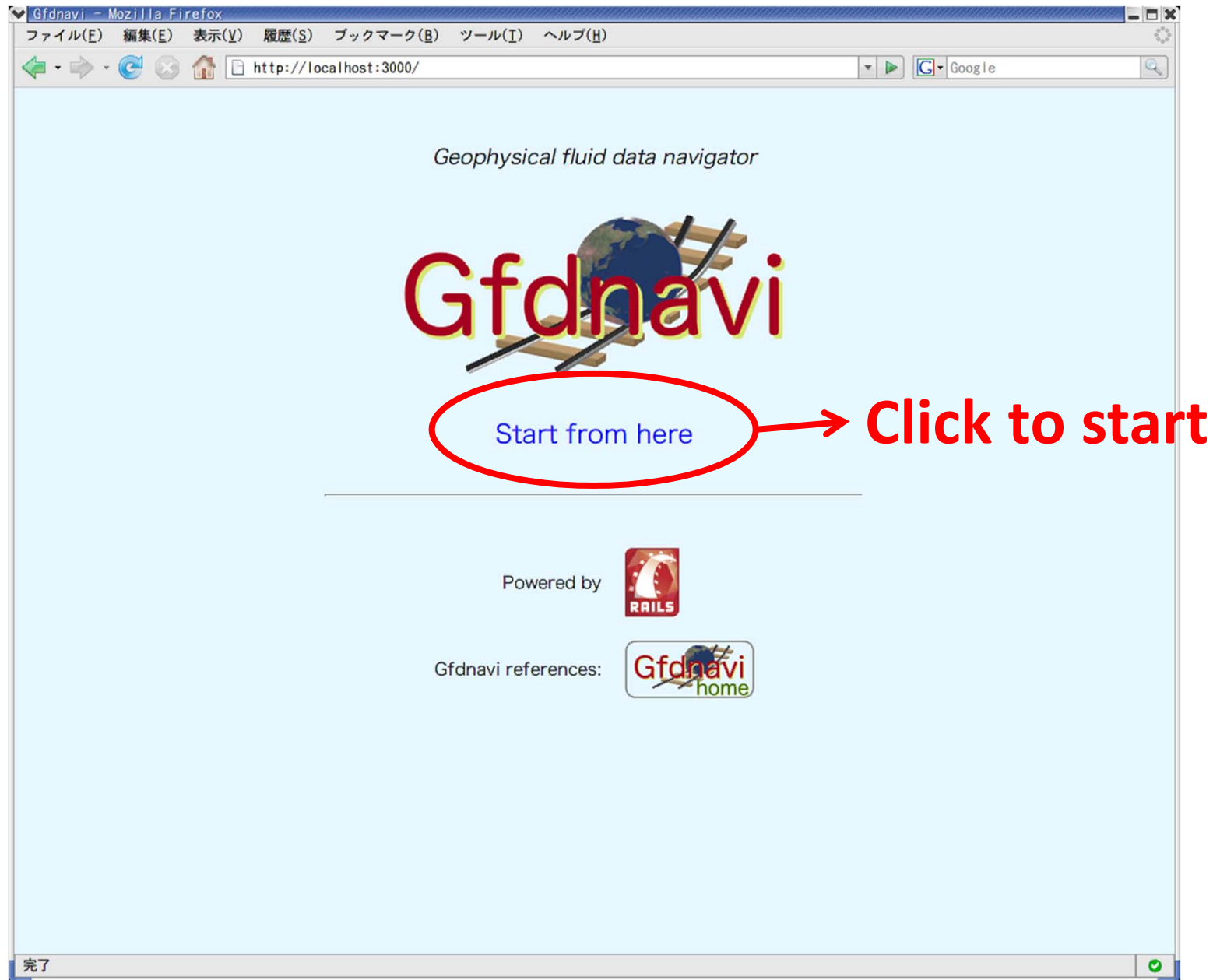
- multiple ways of programmability
 1. downloading a **minimum subset of data** and **scripts**
 - reproduce visualization produced by GUI operations
 2. registering scripts
 - own methods become available with GUI
 3. web services and their client library
 - The library APIs are similar with that of GPhys, so user can analyze/visualize data on **server-side** with similar manor as **local-side** data analysis/visualization

Linking a document with data and analysis/visualization methods

- Enable redrawing plots in documents
 - One can confirm and extend it (falsifiability)
- Applications
 - interactive publication / science collaboration / educational material (incl. interdisciplinary collaboration)

User Interface

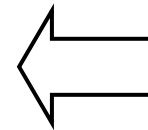
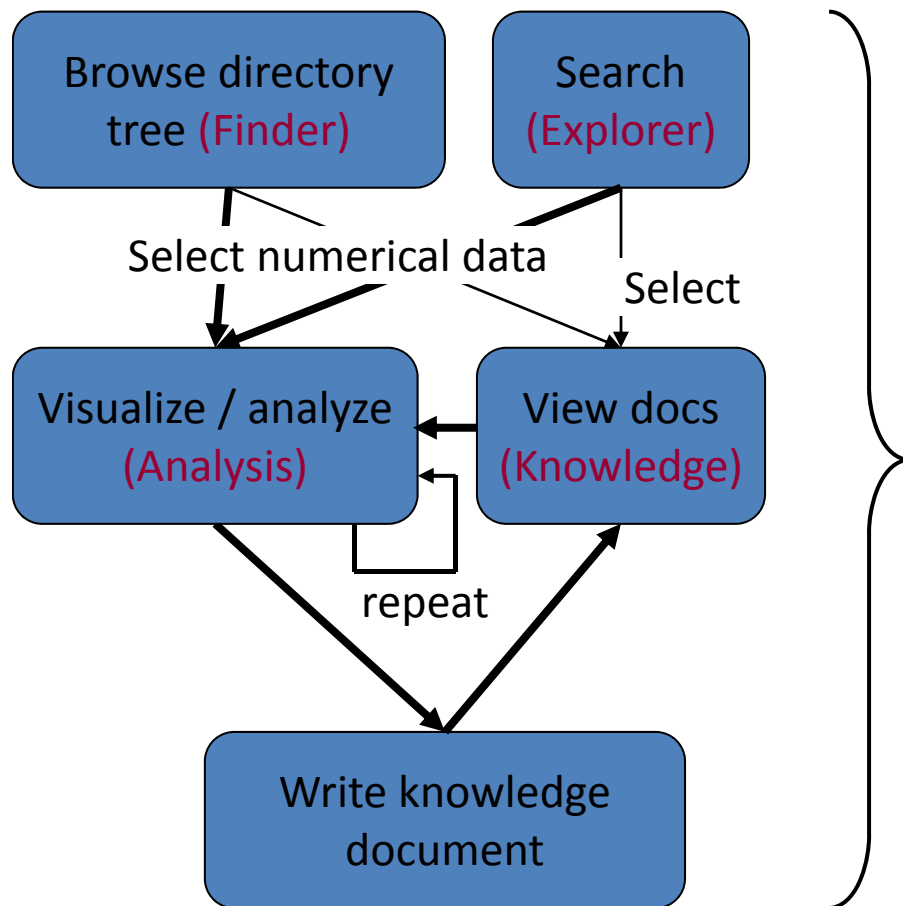
Home : Independent simple html → replaceable



Functionality

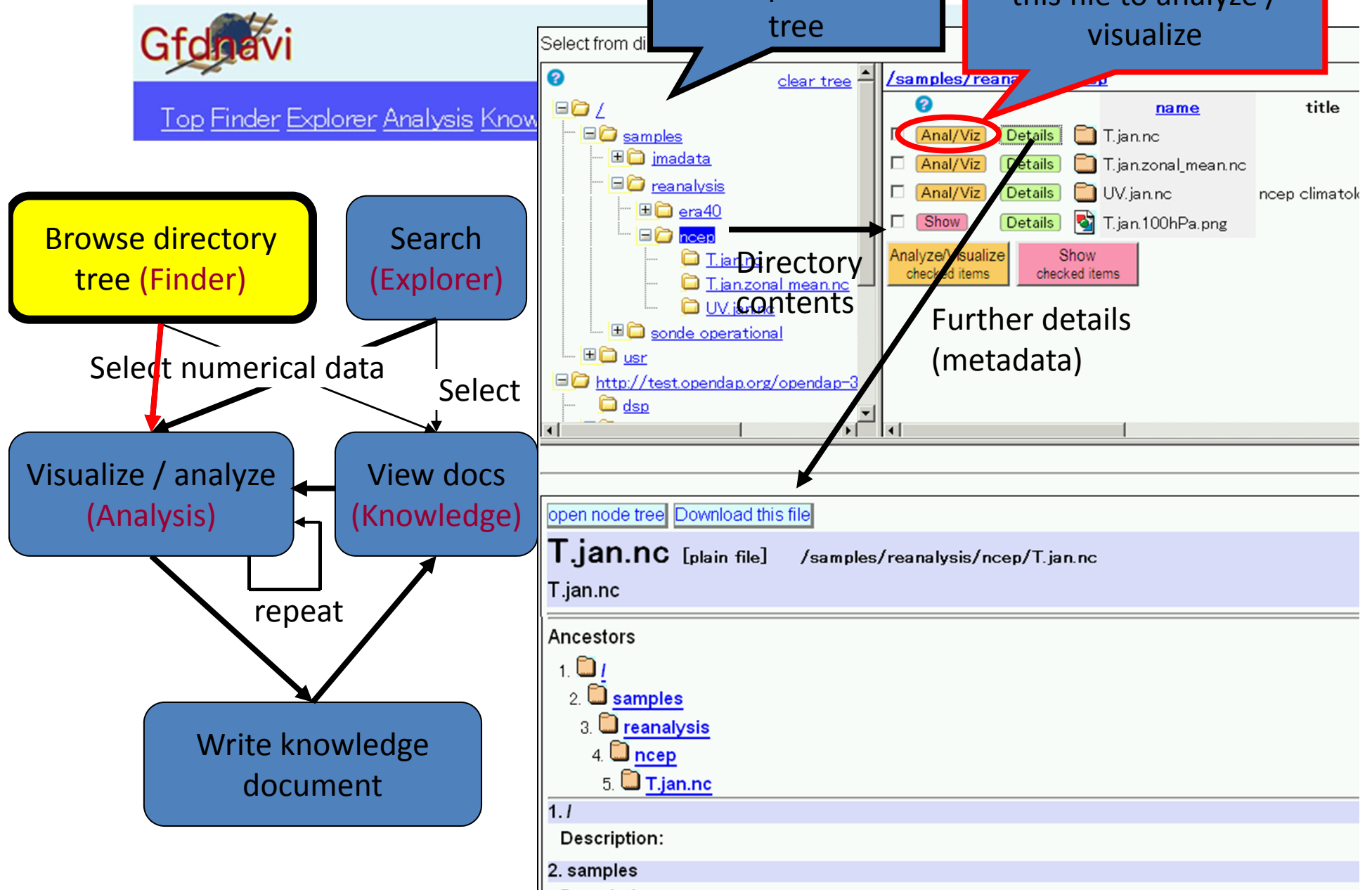


Browser UI Header

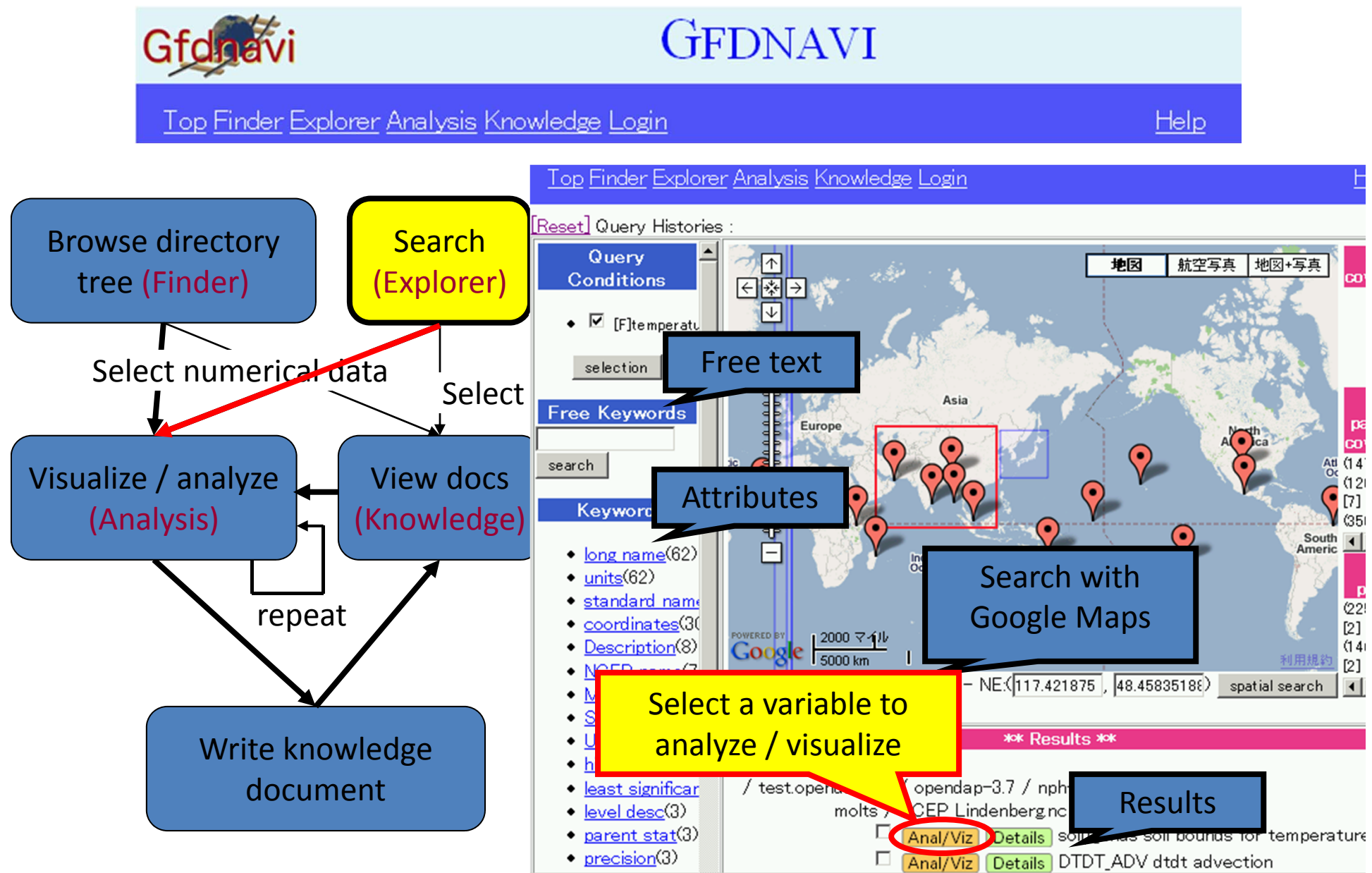


Typical work flow
to use Gfdnavi's
browser UI

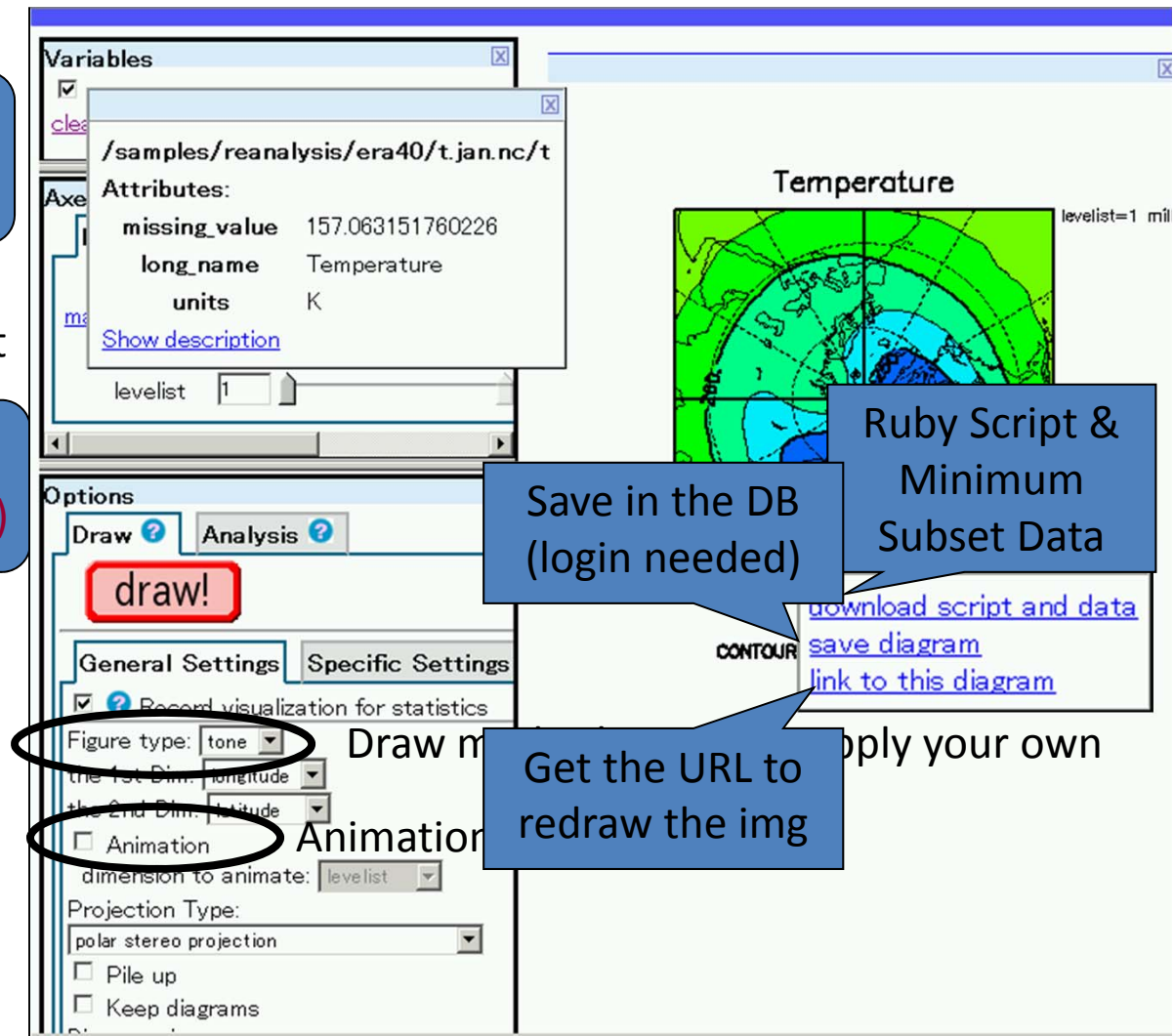
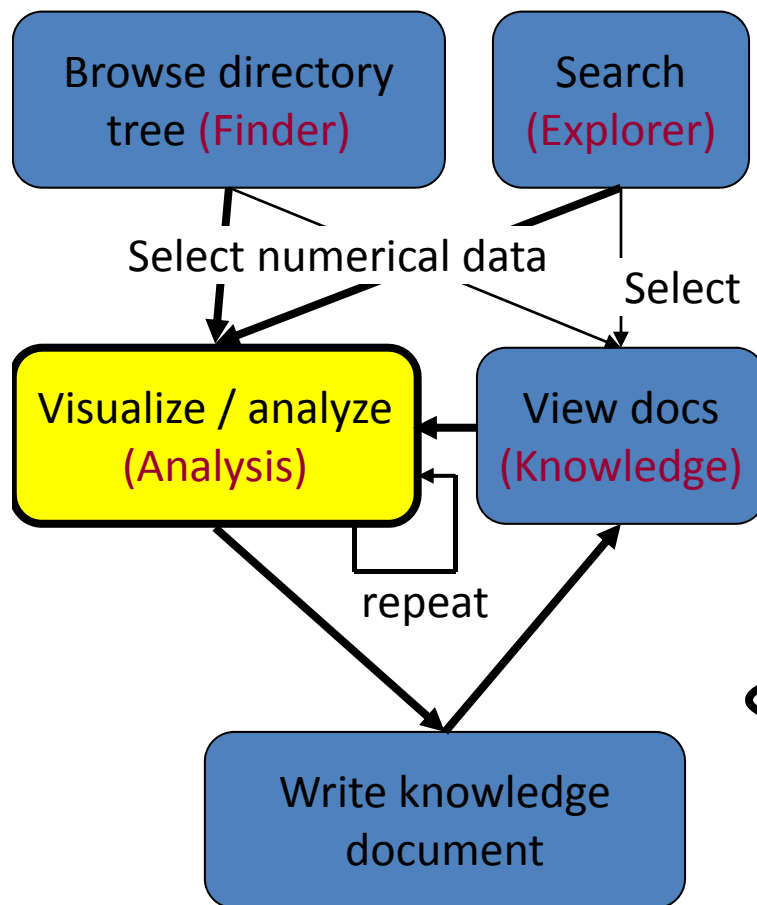
Functionality



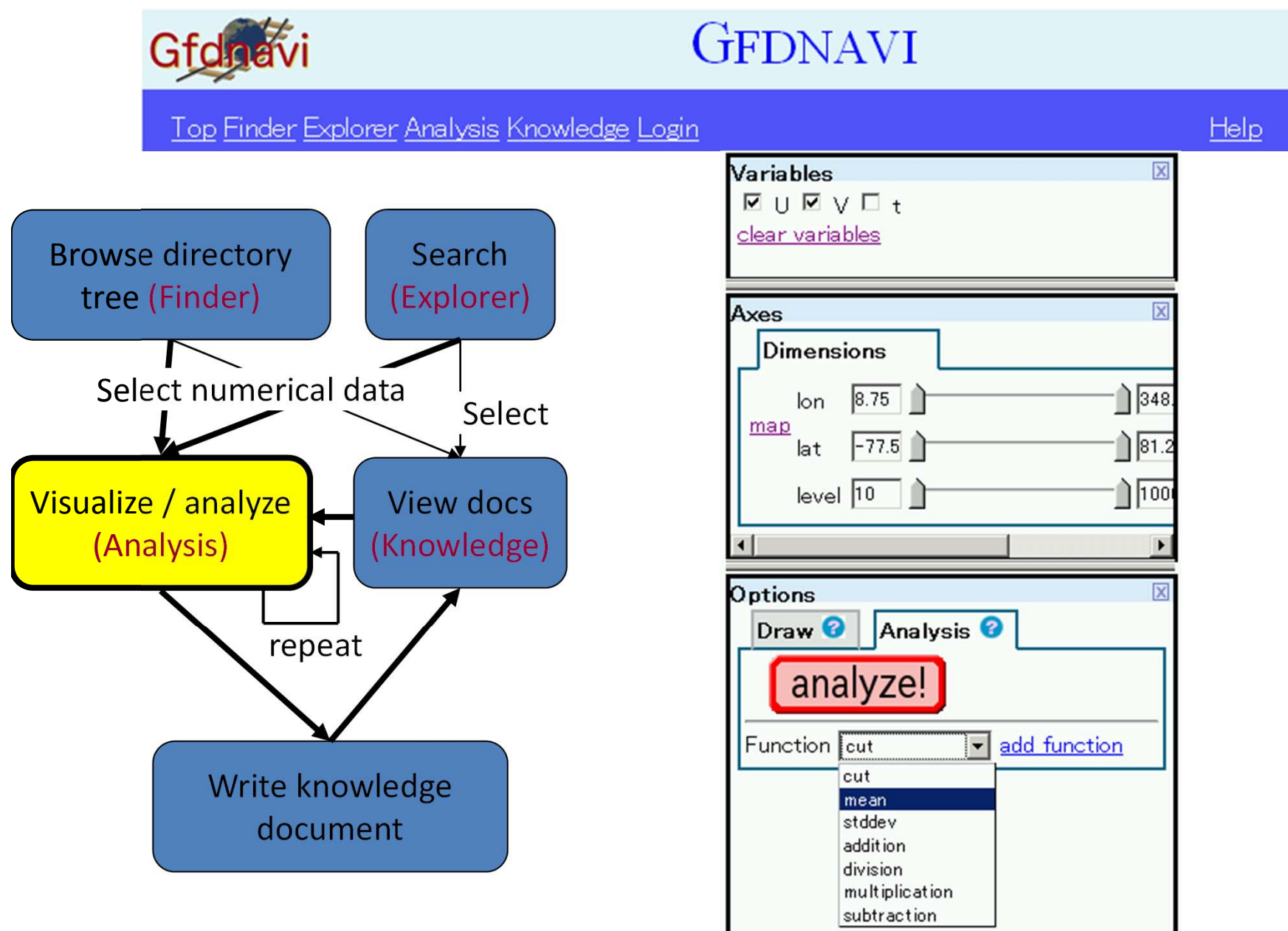
Functionality



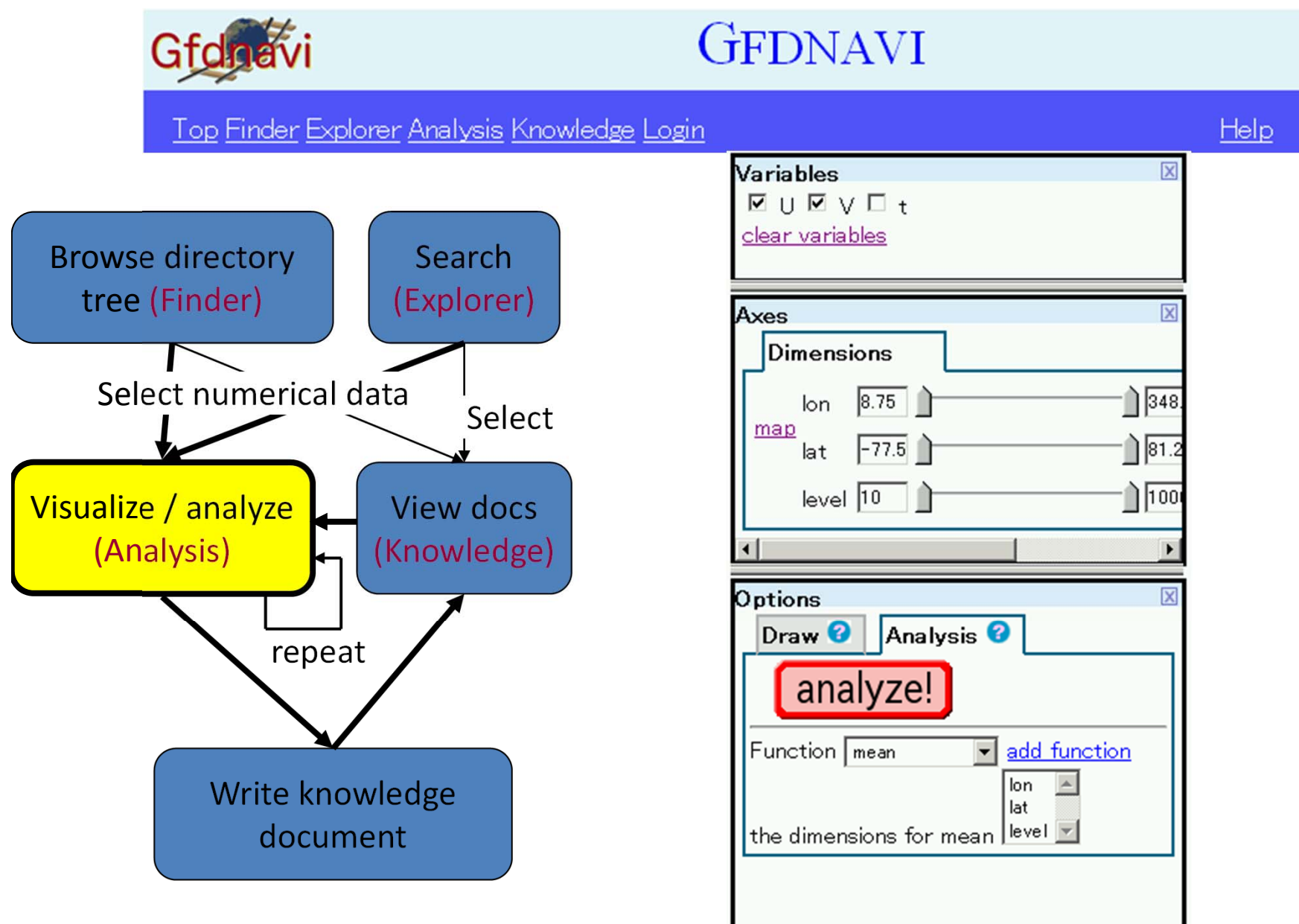
Functionality



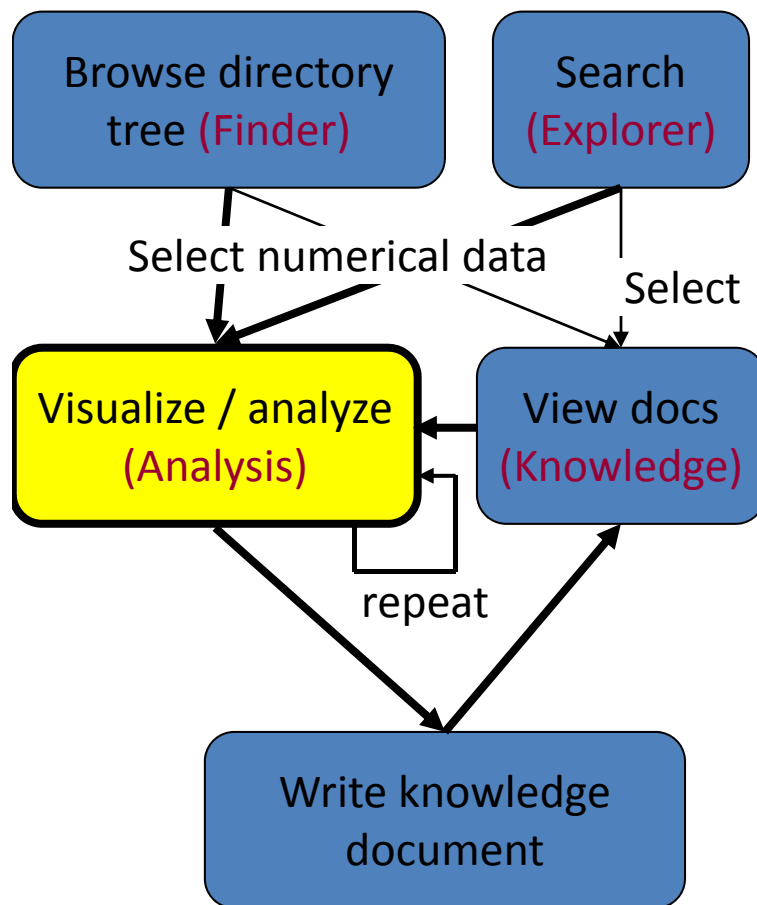
Functionality



Functionality

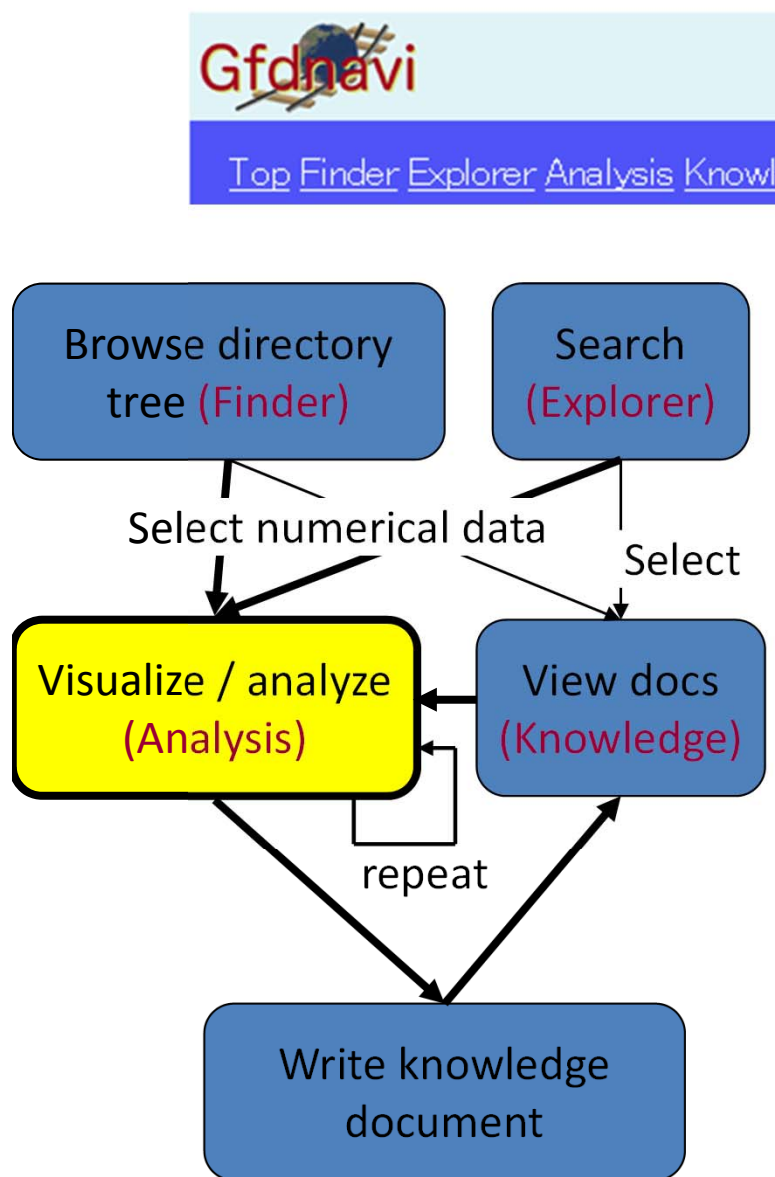


Functionality



A screenshot of the login form in the GFDNAVI application. The form is titled 'Please login' and includes input fields for 'Login:' and 'Password:'. Below the fields are 'login' and 'signup' buttons. The navigation bar at the top of the form shows links: 'Top', 'Finder', 'Explorer', and 'Analysis'.

Functionality



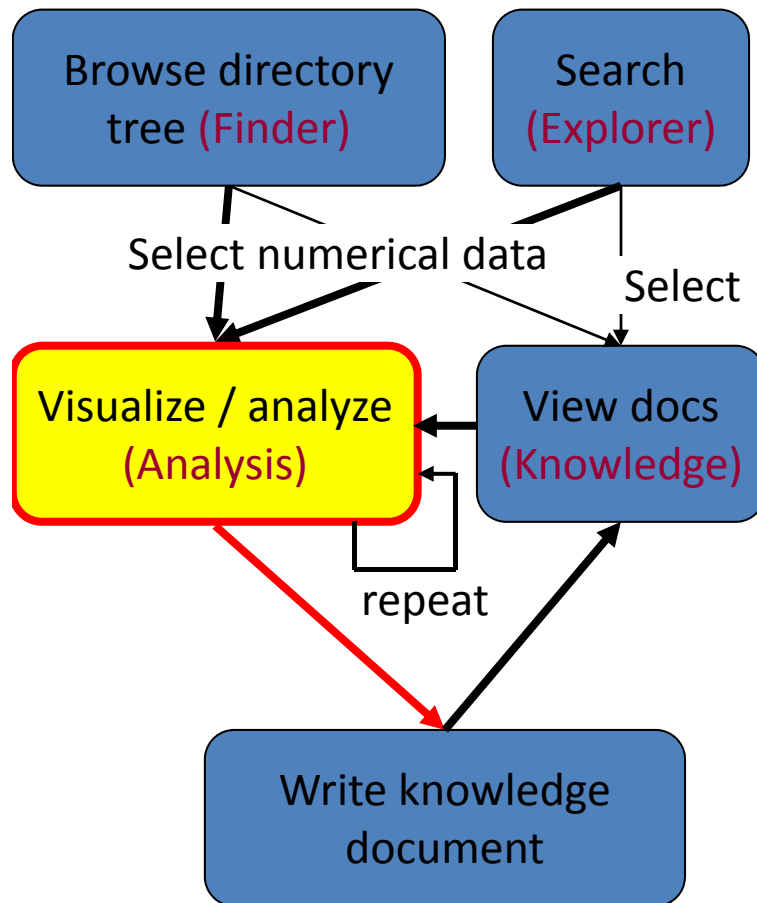
Create Function

Function

name	spectrum
save directory	/usr/root/functions
description	<div> FFT ^2 along a specified dimension</div>
group	<div>only me --groups-- create_group</div>
number of input variables	1
number of arguments	1
script	<div>{arg0, gphys0} [gphys0.fft(arg0).abs ** 2] }</div>
number of output variables	1

Function Arguments

Functionality



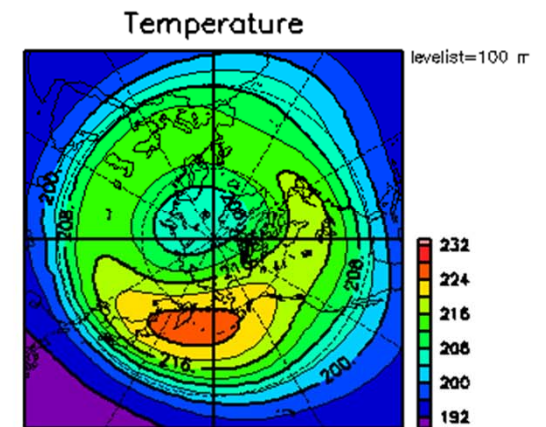
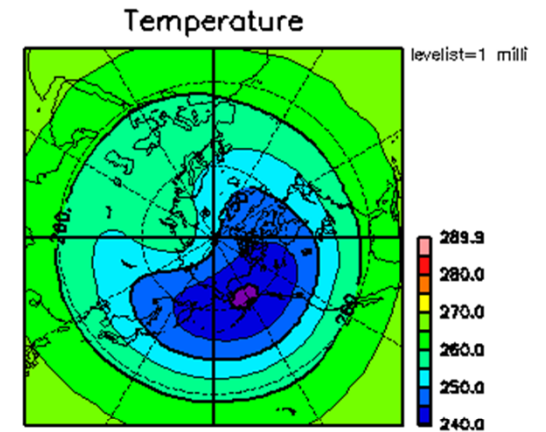
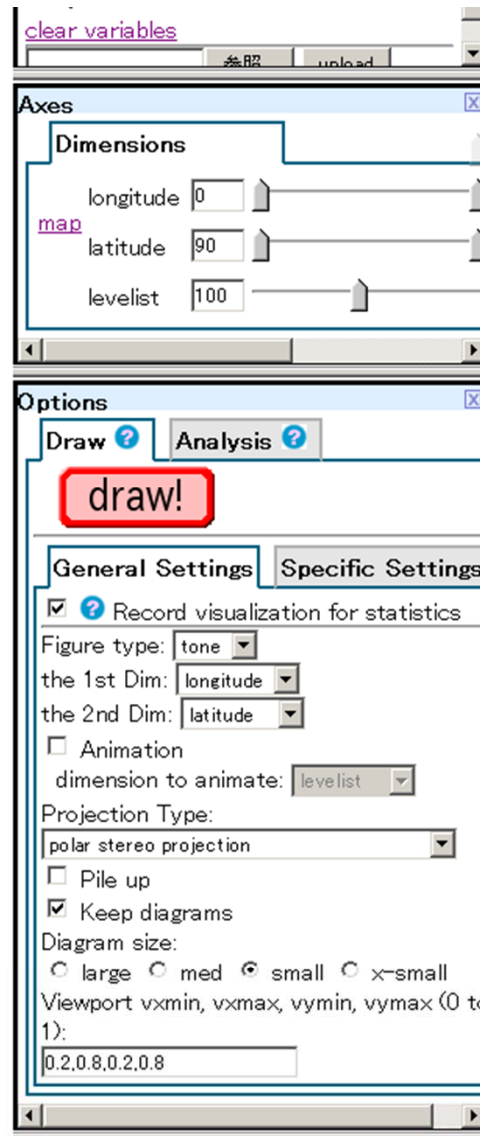
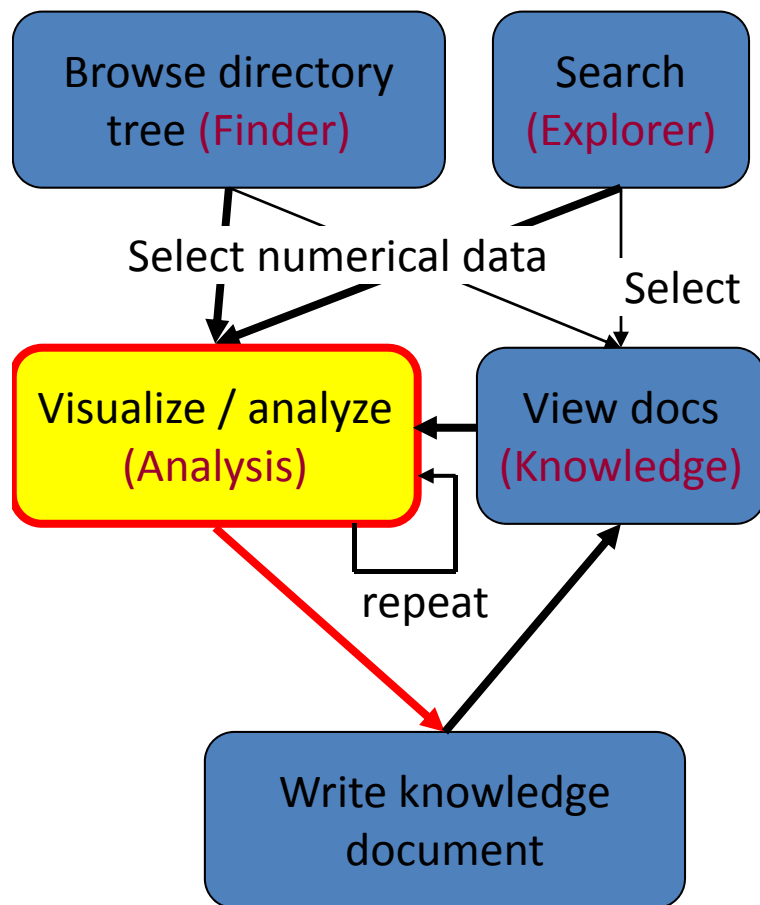
The screenshot shows the GFDNAVI web interface. At the top is the 'Gfdnavi' logo and a navigation bar with links: 'Top', 'Finder', 'Explorer', 'Analysis', 'Knowledge', 'User', 'Logout', and 'Help'. Below the navigation bar are three main panels:

- Variables:** A list of variables with a checkbox for 't' and a 'clear variables' link.
- Axes:** A section for setting dimensions with input fields for 'longitude' (0), 'latitude' (90), and 'levelist' (1). There is a 'map' link.
- Options:** A section with tabs for 'Draw' and 'Analysis'. The 'Draw' tab is active, showing a 'draw!' button. Below it are 'General Settings' and 'Specific Settings'. In 'General Settings', there is a checkbox for 'Record visualization for statistics' (checked), a 'Figure type' dropdown set to 'tone', and dropdowns for 'the 1st Dim' (longitude) and 'the 2nd Dim' (latitude). In 'Specific Settings', there is a checkbox for 'Keep diagrams' (checked and circled in red), a 'Projection Type' dropdown set to 'polar stereo projection', and a 'Diagram size' section with radio buttons for 'large', 'med', 'small' (selected), and 'x-small'. At the bottom, there is a 'Viewport' section with input fields for 'vxmin', 'vxmax', 'vymin', and 'vymax'.

To the right of the interface is a visualization titled 'Temperature'. It shows a polar projection map of the Arctic region with a color scale ranging from 240.0 to 289.9. The map is labeled 'levelist=1 milli' and 'CONTOUR INTERVAL = 5.000E+00'. Below the map is a button that says 'Create a Knowledge Document with this/these Image(s)'.



Top Finder Explorer Analysis Know



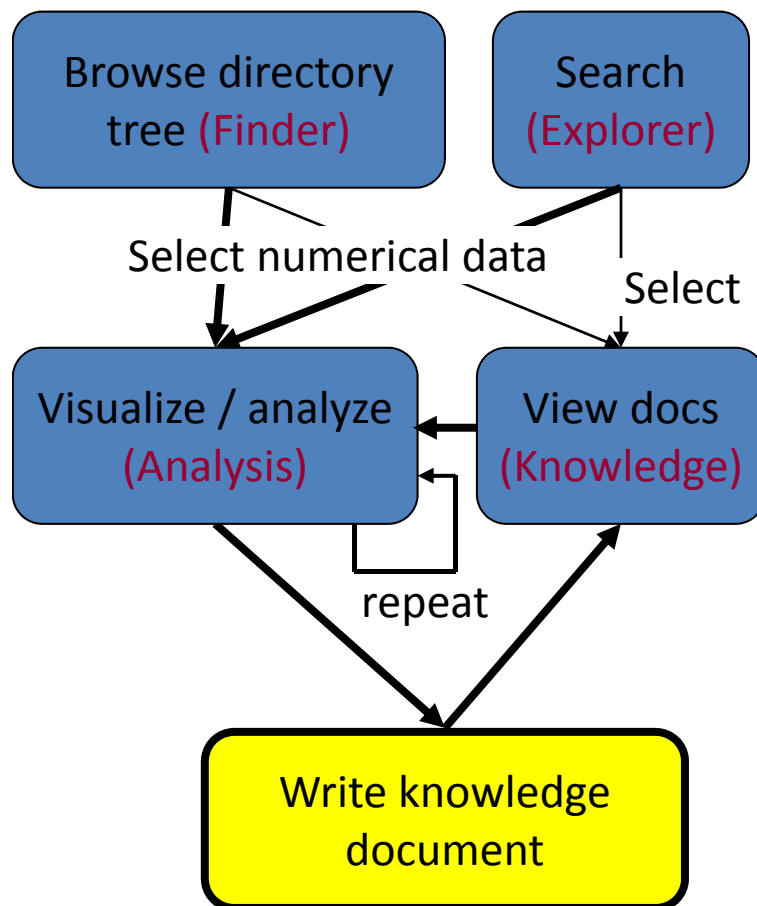
Create a Knowledge Document
with this/these Image(s)

People who chose the variables saw the following diagrams

F Save Images and Create a New Knowledge



[Top](#) [Finder](#) [Explorer](#) [Analysis](#) [Knowledge](#)



Title:

Author:

Textbody:

((Figure 1>>)) shows the climatological temperature at 1 hPa using the ECMWF Reanalysis (ERA40) in the northern hemisphere. It shows that the climatological polar vortex is shifted to the Pacific side.

((Figure 2>>)) shows is the same as Fig.1 but for 100 hPa. It shows that the westerly jet is strong in the Pacific storm track.

Path:

ex)

visible to: ☒ everyone

Choose a default layout :

size of figure: height %

input the number of figures in a row

Figure 1

Caption:

File Name:



[view this image in the original size](#)

Figure 2

Caption:

File Name:



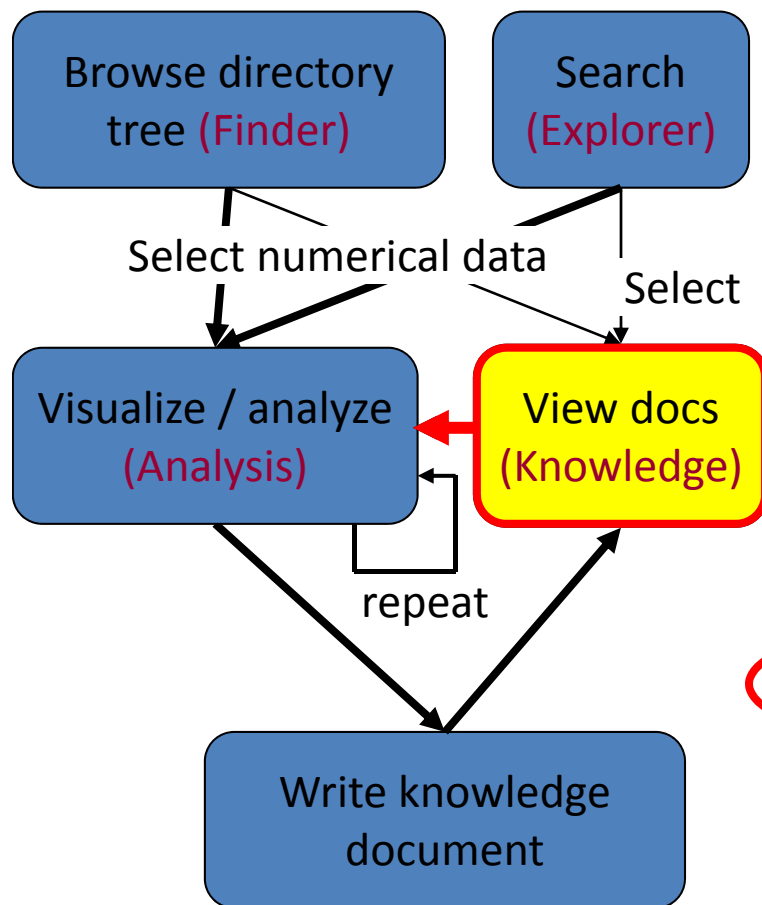
[view this image in the original size](#)

[More Figure](#)

Create



[Top](#) [Finder](#) [Explorer](#) [Analysis](#) [Knowl](#)



Gfdnavi

GFDNAVI

[Top](#) [Finder](#) [Explorer](#) [Analysis](#) [Knowledge](#) [User](#) [Logout](#)

[Help](#)

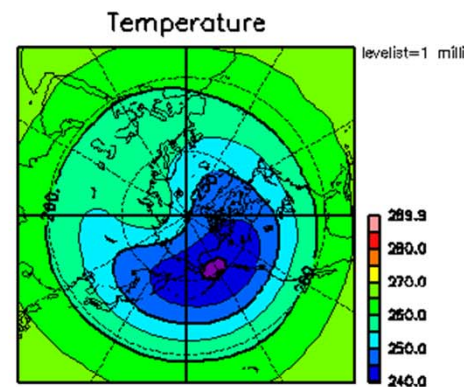
Layout : size of figure: height %
input the number of figures in a row

ECMWF Reanalysis January Climatology

Author: T Horinouchi

[Figure 1](#) shows the climatological temperature at 1 hPa using the ECMWF Reanalysis (ERA40) in the northern hemisphere. It shows that the climatological polar vortex is shifted to the Pacific side.

[Figure 2](#) shows is the same as Fig1 but for 100 hPa. It shows that the westerly jet is strong in the Pacific storm track



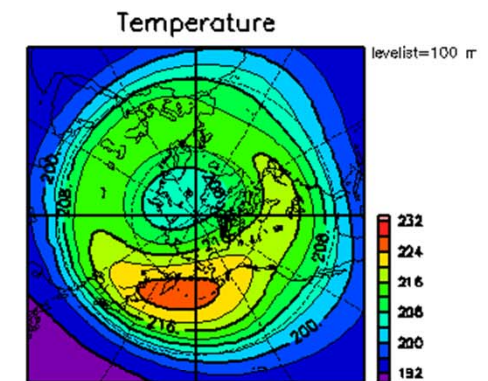
CONTOUR INTERVAL = 5.000E+00

[<redraw this image>](#) [<Get the URL>](#)

Fig. 1. ERA Jan T at 1 hPa

Path: /usr/root/knowledge/tmp/eraT.knlge

[Edit](#) | [Back to List](#)



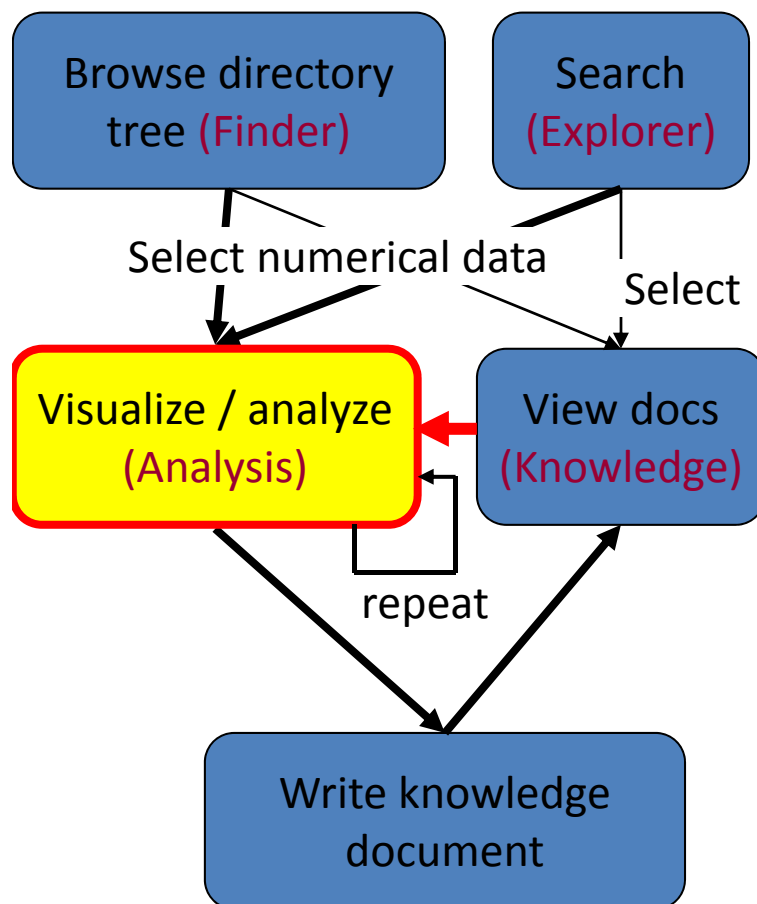
CONTOUR INTERVAL = 4.000E+00

[<redraw this image>](#) [<Get the URL>](#)

Fig. 2. ERA Jan T at 100 hPa

There are no comment on this document.

[Back to List](#)



Variables

☒ t
[clear variables](#)

Axes

Dimensions

longitude 0
[map](#)
latitude 90
levelist 1

Options

Draw ? Analysis ?

draw!

General Settings

Specific Settings

☒ Record visualization for statistics
Figure type: tone
the 1st Dim: longitude
the 2nd Dim: latitude
☐ Animation
dimension to animate: levelist
Projection Type:
polar stereo projection
☐ Pile up
☐ Keep diagrams
Diagram size:
☐ large ☐ med ☒ small ☐ x-small
Viewport vxmin, vxmax, vymin, vymax (0 to 1):
0.2,0.8,0.2,0.8

Results will show the variables with the follow

Listing Knowledge Documents

New Knowledge

Previous 1 2 Next

[Temperature data from era40](#) by root last update: Sun Sep 14 13:02:18 [show full t](#)

about figure. temperature data. levelist 1, so height is about 48km.

path: /usr/root/knowledge/temperature_data_from_era40.knlge [Edit](#) [Delete](#)

[Typhoon Information](#) by root last update: Sun Sep 14 12:54:21

A typhoon occurred at east of philippine A typhoon 5 occurred on July 2005. The figure means amount of

path: /usr/root/knowledge/typhoon4.knlge [Edit](#) [Delete](#)

[Typhoon Information](#) by root last update: Sun Sep 14 12:23:16 [show full t](#)

A typhoon occurred at east of philippine A typhoon 5 occurred on July 2005. The figure means amount of

path: /usr/root/knowledge/typhoon3.knlge [Edit](#) [Delete](#)

[台風情報](#) by root last update: Mon Sep 08 01:55:36 [show full text here](#) [display comme](#)

台風発生 2005年7月、台風5号が発生しました。図は2005年7月16日の、1時間当たりの降雨量を表してい

path: /usr/root/knowledge/typhoon.knlge [Edit](#) [Delete](#)

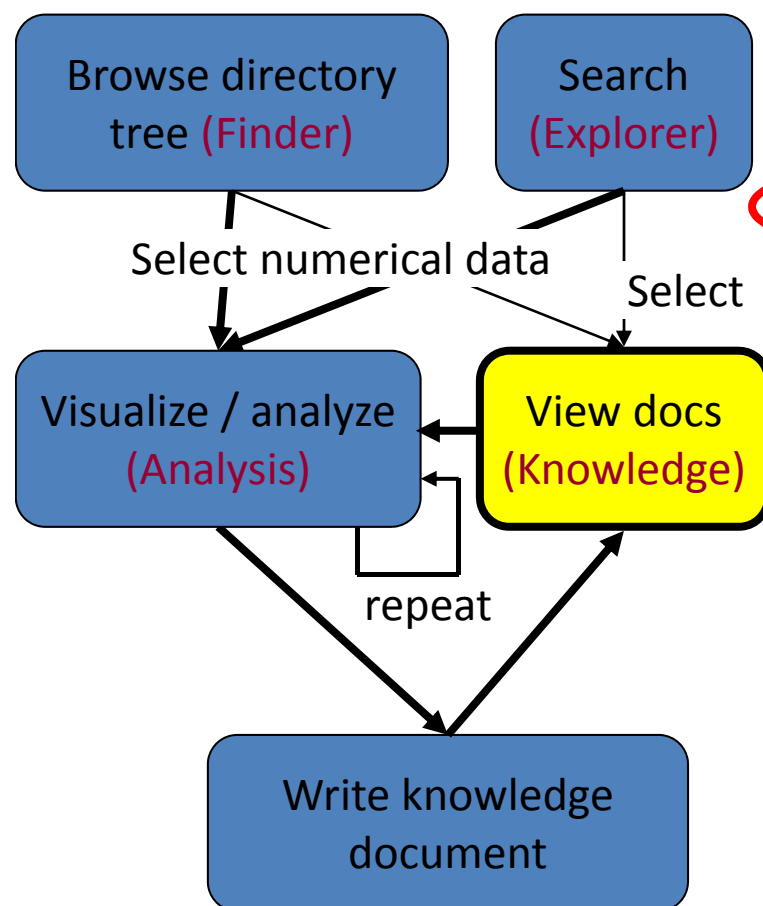
[複数の絵を描画する方法](#) by root last update: Sat Aug 23 21:46:15

はじめに この文書では、多くの図が入った知見文書を作成するために、複数の絵を描く方法について解説
に関してはKnowledge 機能の使い方/samples/how_to_knowledge.knlgeをご覧ください。...

path: /samples/how_to_draw_multiple_images.knlge [Edit](#) [Delete](#)

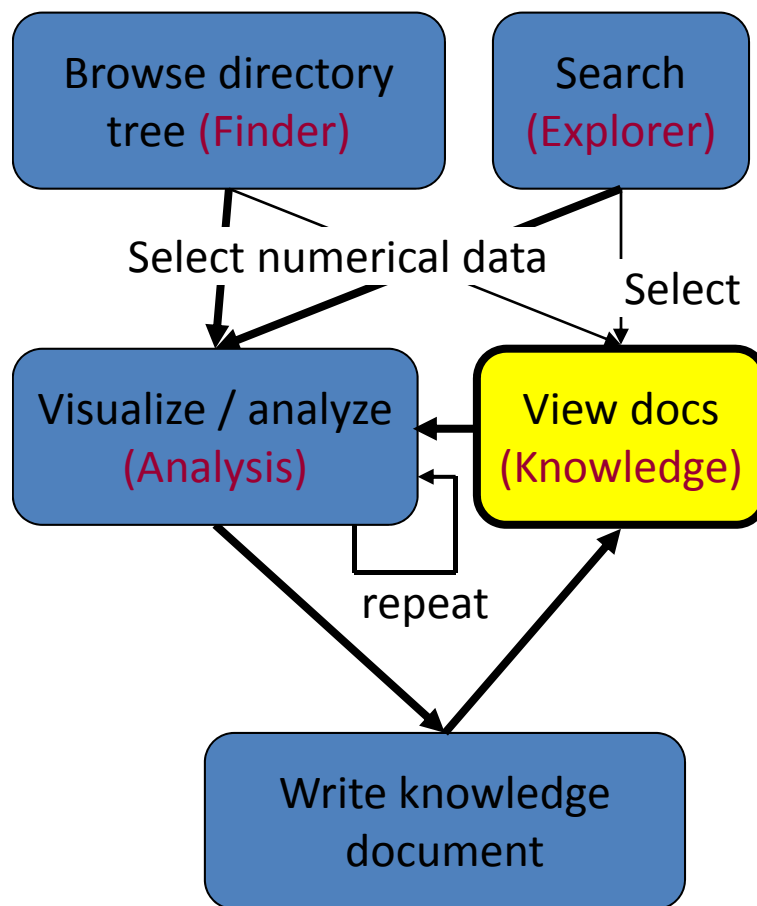
Previous 1 2 Next

New Knowledge





[Top](#) [Finder](#) [Explorer](#) [Analysis](#) [Know](#)



Typhoon Information

Author: Akinori

A typhoon occurred at east of philippine

A typhoon 5 occurred on July 2005.

The figure means amount of rainfall per hour at July 16, 2005. We can see a typhoon east of philippine.

Forecast of Course of typhoon

According to the forecast of Japan Meteorological Agency, typhoon 5 will change direction of movement near Taiwan. The sea around Okinawa is warmed by the intense heat of days, so it seems that the typhoon will move further. There is a possibility of coming off from the expectation and landing on West Japan. Please note the future.

Rainfall rate (mm/hr)

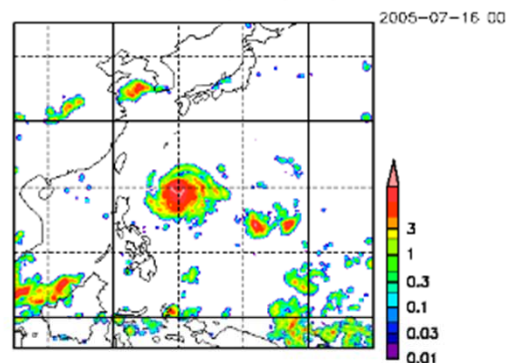


Fig. 1. Rainfall

Path: /usr/root/knowledge/typhoon3.knlge

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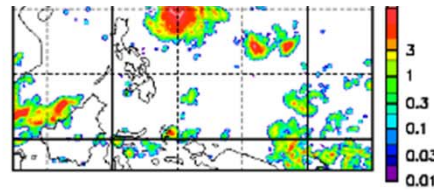
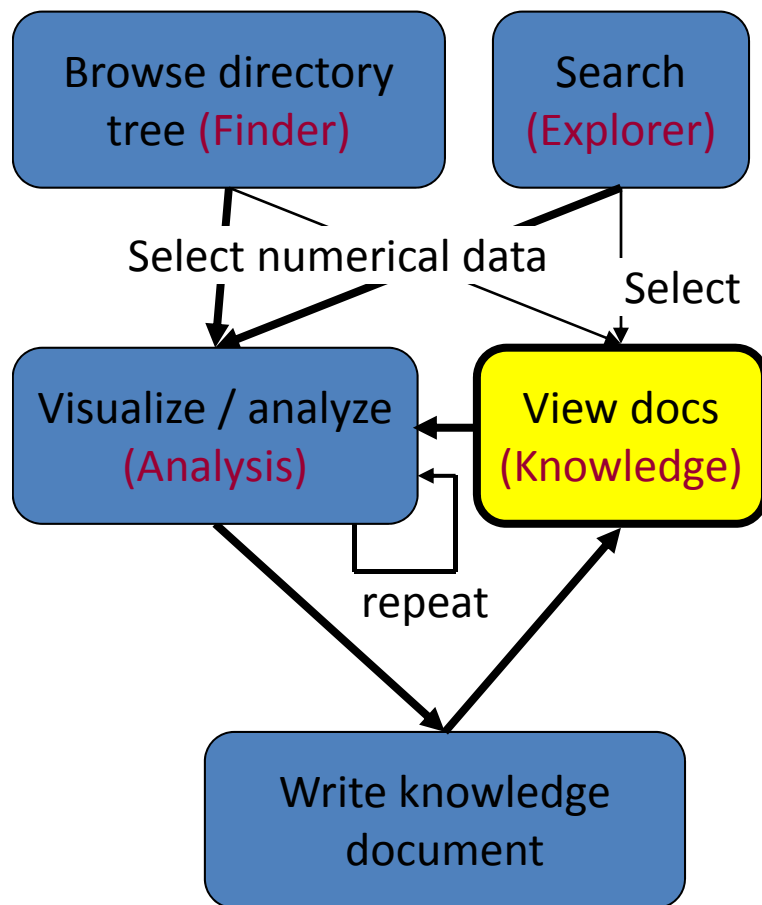


Fig. 1. Rainfall

Path: /usr/root/knowledge/typhoon4.knlge

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Add a Comment on this document.

Title:

Author:

Textbody:

Choose a default layout :

size of figure: %

input the number of figures in a row

Figure 1

Caption:

delete

Figure Path:

.png

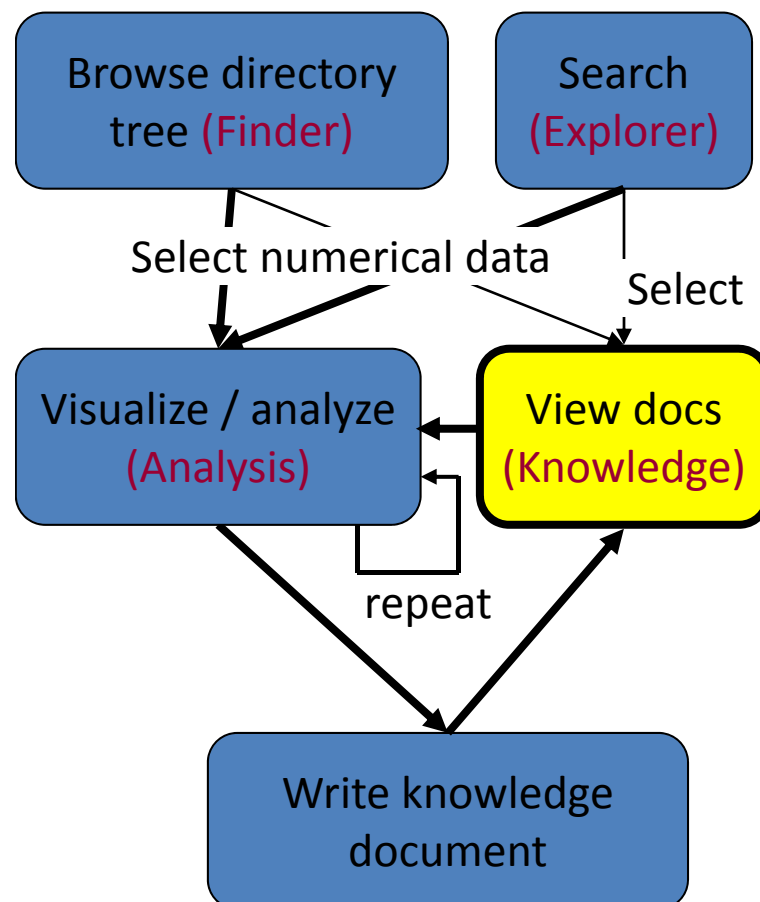
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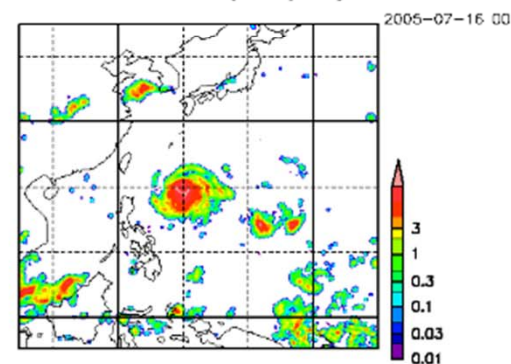


Fig. 1. Rainfall

Path: /usr/root/knowledge/typhoon3.knlge

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1 comment exists.

[Show Summary of Comments](#) [Hide Comments](#) [Show full text of Comments](#)

[Re\[1\]:Typhoon Information](#) author: Akinori Tomobayashi by root last update: Sun Sep

After all, typhoon 5 went for Taiwan and landed China.

[Write a Comment on this document.](#)

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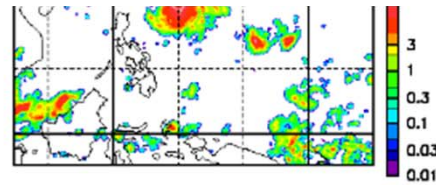
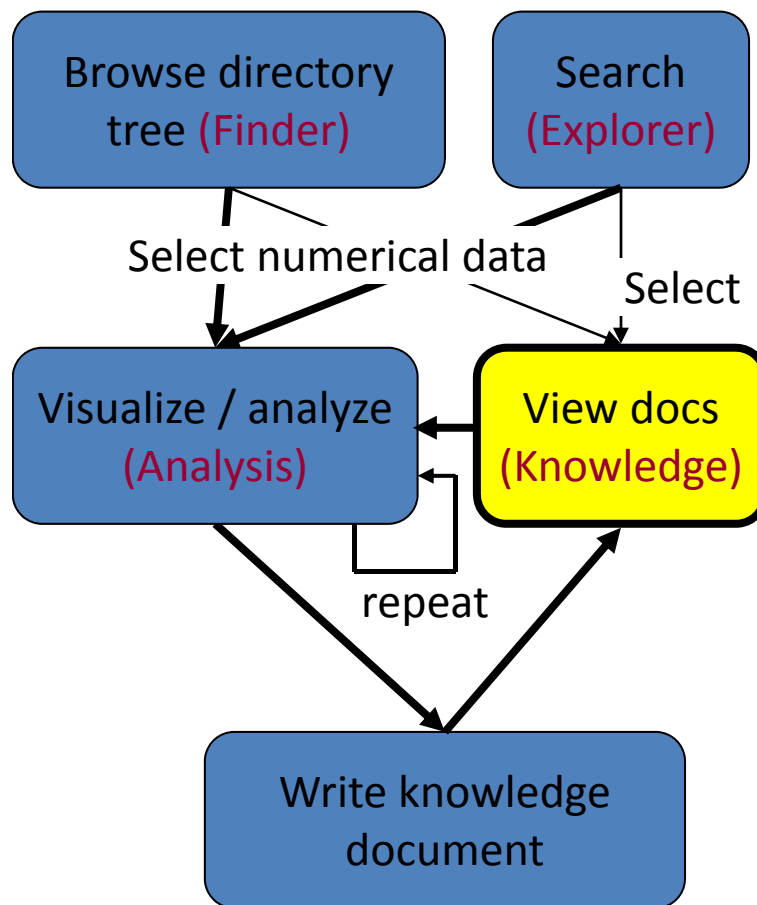


Fig. 1. Rainfall

Path: /usr/root/knowledge/typhoon3.knlge

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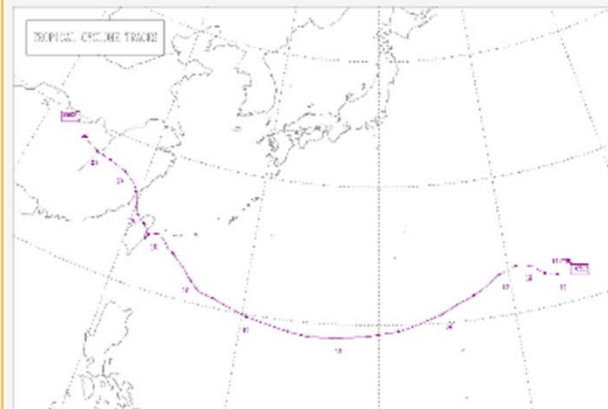


Fig. 1. course of typhoon 5 in 2005.

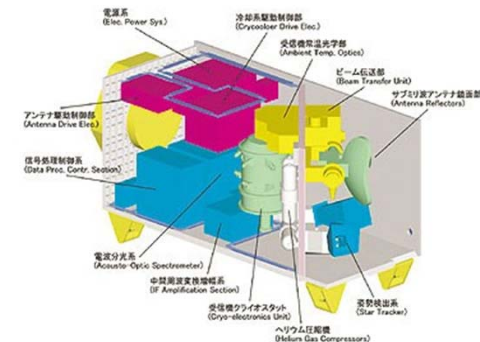
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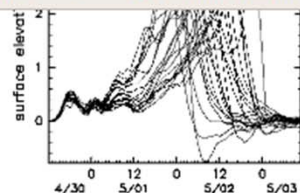
Application Examples

- **JEM/SMILES** data server (JAXA):
 - Satellite obs for ozone etc: Science team (incl. restricted access) + General data service



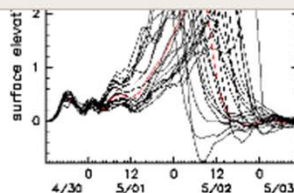
- International collaboration project to improve **weather forecast in Asia**

The screenshot shows the homepage of a website titled "International Research for Prevention and Mitigation of Meteorological Disasters in Southeast Asia". The header includes the text "MEXT Special Coordination Funds for Promoting Science and Technology for FY 2007 - 2009" and "Asia S&T Strategic Cooperation Program". On the left, there is a map of Southeast Asia with orange and red markers, and a navigation menu with links: "Home", "Motivations", and "Major Research". On the right, there is a red logo and the text "振興調整費" (Vibrant Adjustment Fee). The main content area has a large "Home" button and a paragraph of text starting with "This is the Home Page of International Research for Prevention and Mitigation of Meteorological Disasters in Southeast Asia".



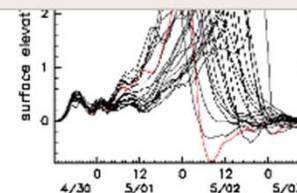
[<Redraw this image>](#) [<Get the URL>](#)

Fig.1. Time series of surface elevation at Irrawaddy point (95.07 degE, 16.10 degN) for 21 members.



[<Redraw this image>](#) [<Get the URL>](#)

Fig.2. Same as Fig. 1, but the control run is highlighted.



[<Redraw this image>](#) [<Get the URL>](#)

Fig.3. Same as Fig. 1, but the member 1 (which shows the highest surface elevation) is highlighted.

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6. Decision support tools for ensemble numerical weather prediction: I. Basic diagrams

6.1 1D line plot

Data

[/Nargis/NHM/POM/h.nc](#) (lon, lat, t, member)

Settings

- Axes
 - h_member(t)
 - lon = 95.07 degE
 - lat = 16.10 degN
 - (X) t = [0 h, ..., 71 h]
 - (Ens) member = 0, ..., 20
- General Settings
 - Draw method
 - ensemble_1D
- Specific settings
 - style: lines

This diagram is called "**Plume diagram**".

Result

Time series of surface elevation at Irrawaddy point (95.07 degE, 16.10 degN) for 21 members [Fig. 1](#). Some members show storm surge of more than 3 m in height.

Advanced usage

Sample knowledge document:
Visualization of "ensemble
forecast"

Summary

- We have developed Gfdnavi: software to build data and knowledge servers
 - Wide coverage from desktop use to public data service (by having custom web server)
 - Programmability (on browser & by web service)
 - Network capability (cross search)
 - Documentation of analysis results (dynamically reproducible/extendible) (→ memos / reports / PR / Blog for scientific collaboration)

Thank you