

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

Part I: Rationales, stand-alone features, and supporting knowledge documentation linked to data



Takeshi Horinouchi (Hokkaido U),

Seiya Nishizawa (Kobe U),

C. Watanabe, A. Tomobayashi, S. Otsuka, T. Koshiro,

Y.-Y. Hayashi, and GFD Dennou Club

black: Geophysical scientists / blue: Database scientist

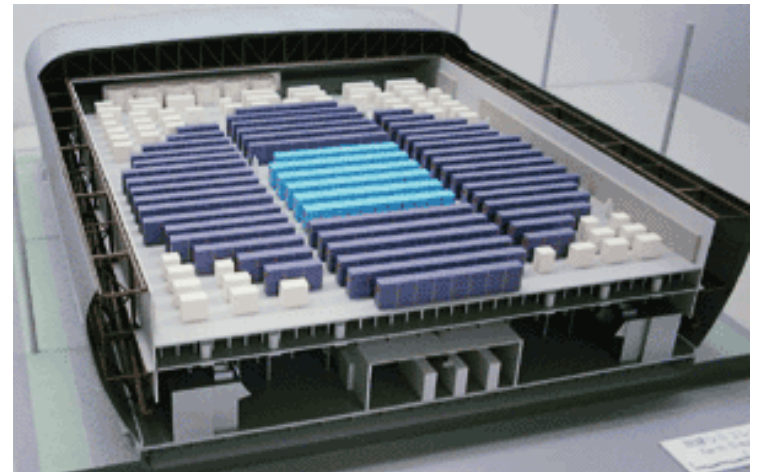
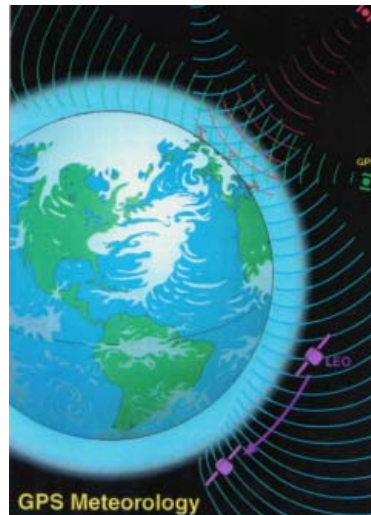
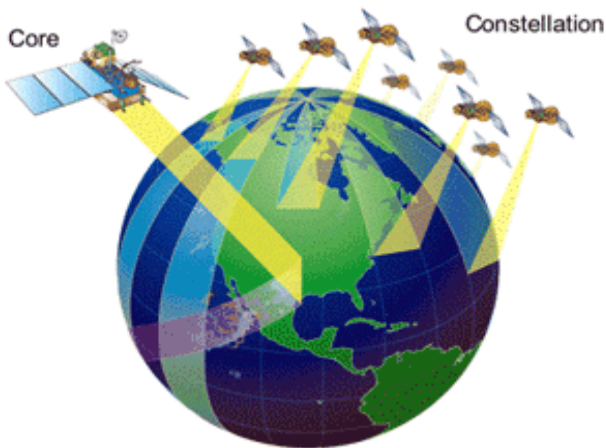
What is Gfdnavi

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

Introduction

Data we use

- Observational data (satellite, station etc etc) / Simulation data (climate prediction etc 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)



Many organizations/research groups provide data through web

- They provide data files
- Optionally visualization etc: in many cases custom-made (for each project / organization)

Related work

Live Access Server (LAS)



Live Access Server

- Software to build web server for georeferencing geophysical data
- Data browsing, search and visualization
- Web-page structure: Highly configurable

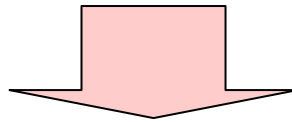
A screenshot of the Live Access Server (LAS) web interface. The top banner features the AVISO logo on the left, the text 'LIVE ACCESS SERVER' in the center, and a search box on the right with the placeholder text 'Search dataset/variable:' and a 'Go' button. Below the banner, there are two tabs: 'single data set' and 'compare two'. The main content area is titled 'Datasets' and contains a search bar with the instruction 'Click on a dataset to continue or an **i** for information about a dataset.' and a 'Help' link. Below the search bar, there are four links: 'NRT - Near-real time Data', 'DT - Delayed time Data', 'Select by geographic area', and 'Select by variable'. On the left side, there are links for 'Variables' and 'Constraints'.

Problem 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

Visualization is not the goal

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



Outputs are documents
(not just pieces of images)

Introducing Gfdnavi

Basic requirement

- Support both browser GUI & programability 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 desktop data management
 - Should be easy to install, start up, and manage
- Support documenting & archiving knowledge obtained through data analysis

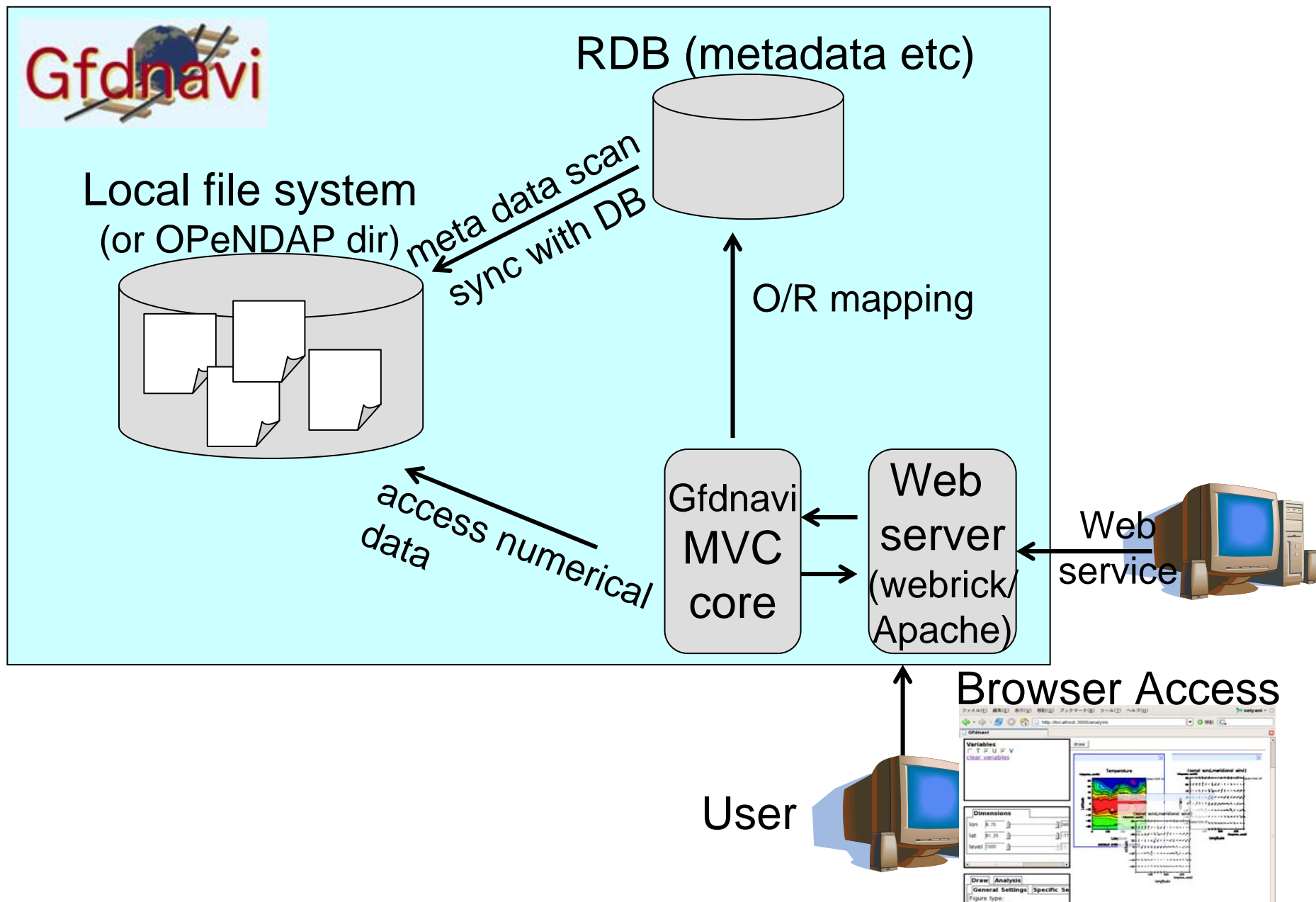
Two fundamental libraries used to build Gfdnavi (*open-source*)

- **GPhys** – a Ruby library to analyze and visualize geophysical fluid data (*by Horinouchi etc since 2003*)
 - 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

Support programability in multiple ways

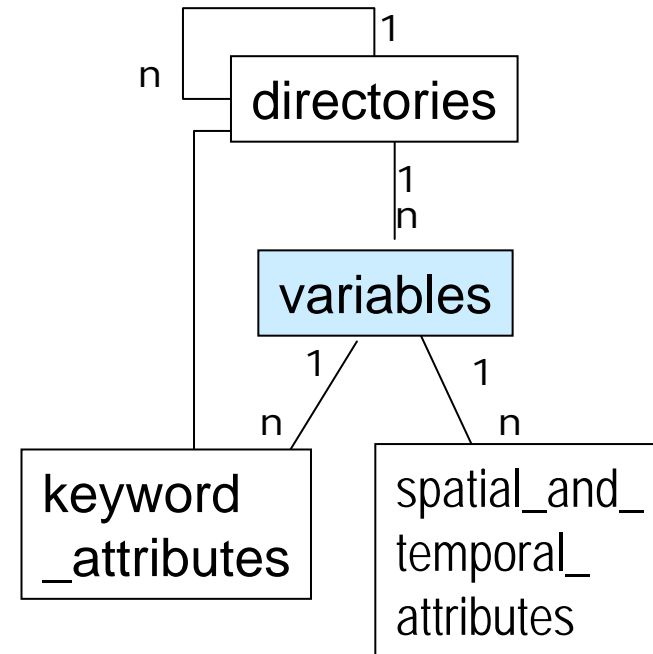
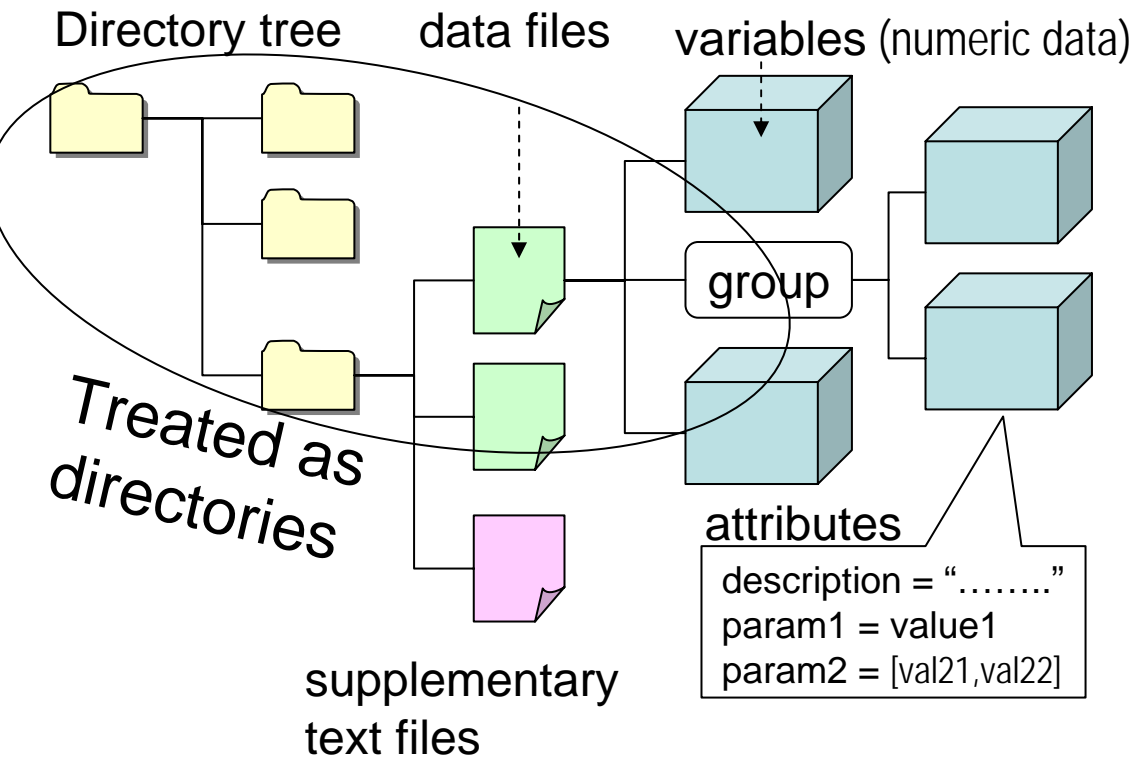
- Web services – **Part II (next talk)**
- Browser access
 - Download Ruby code and data subset to reproduce visualization
 - Upload Ruby script (for qualified users)

Structure of Gfdnavi



Metadata DB

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



User Interface

Home : Independent simple html → replaceable










GFDNAVI

[Top](#) [Finder](#) [Explorer](#) [Analysis](#) [Knowledge](#) [Login](#)[Help](#)[Search \(Explorer\)](#) [Search \(old version\)](#)

Select from directory tree:

 [clear tree](#)

- localhost
 -   /
- localhost
 -   <http://test.opendap.org/opendap-3.7/>

Functionality



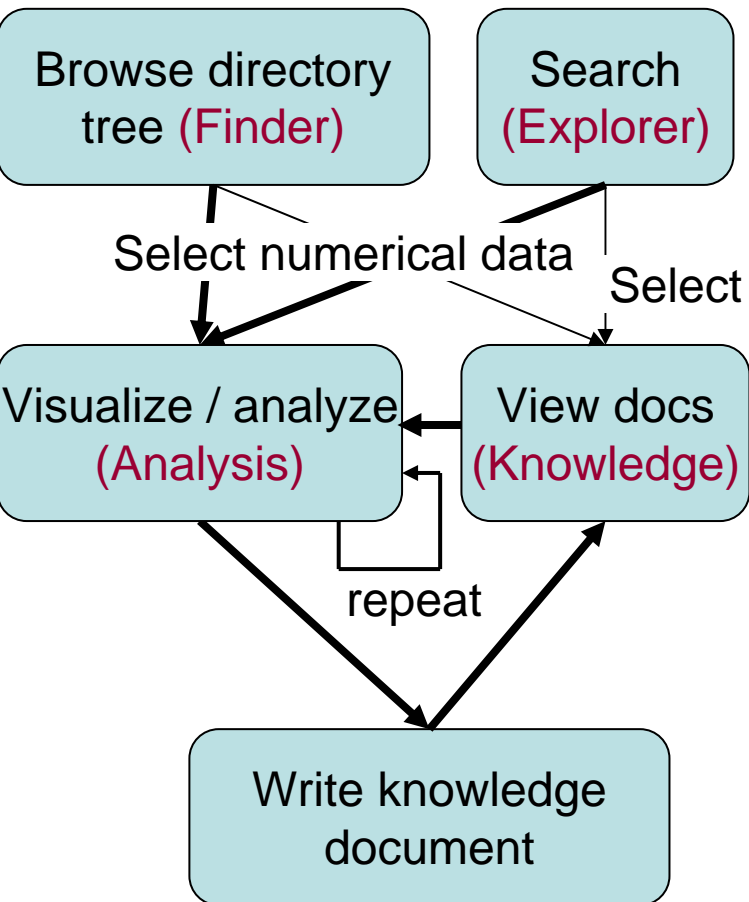
GFDNAVI

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

[Help](#)



Browser UI Header

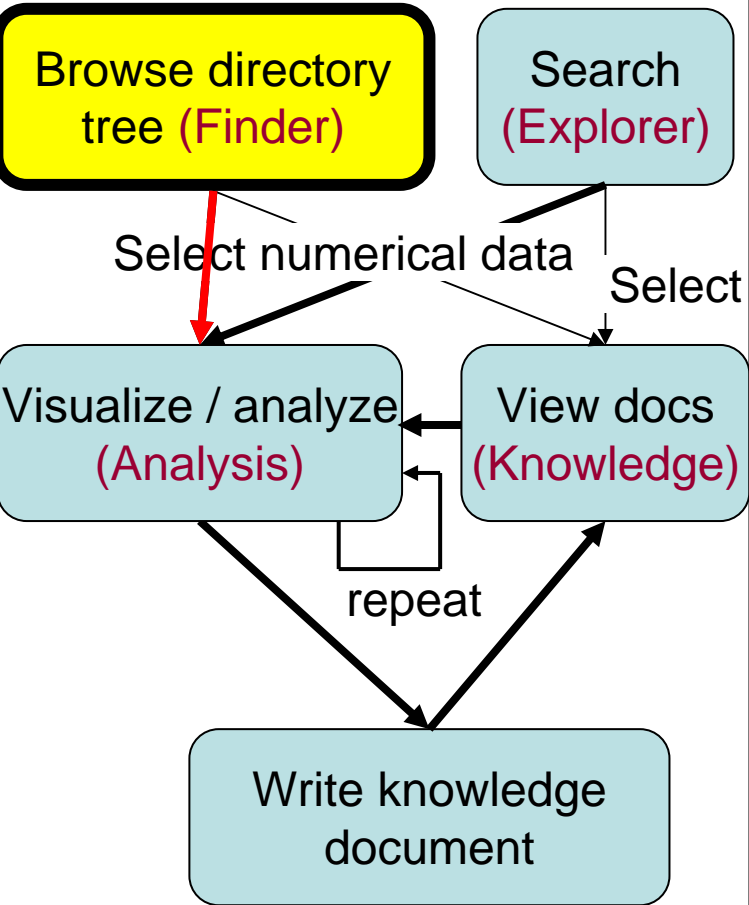


Typical work flow
to use Gfdnavi's
browser UI

Functionality



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



MS Explorer-like tree

Select variables in this file to analyze / visualize

Directory contents

Further details (metadata)

	name	title
<input type="checkbox"/>	Anal/Viz	T.jan.nc
<input type="checkbox"/>	Anal/Viz	T.jan.zonal_mean.nc
<input type="checkbox"/>	Anal/Viz	UV.jan.nc
<input type="checkbox"/>	Anal/Viz	ncep climatol
<input type="checkbox"/>	Show	T.jan.100hPa.png

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

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

T.jan.nc

Ancestors

1. /
2. [samples](#)
3. [reanalysis](#)
4. [ncep](#)
5. [T.jan.nc](#)

1. /

Description:

2. samples

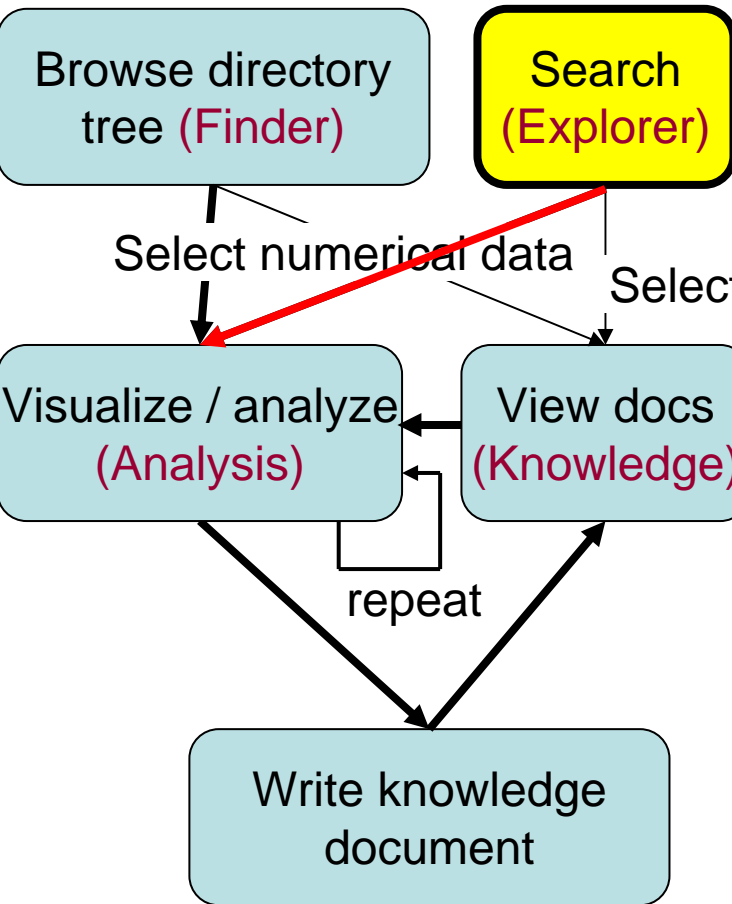
Functionality



GFDNAVI

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

[Help](#)



The screenshot shows the GFDNAVI web interface. At the top, there is a navigation bar with links: [Top](#), [Finder](#), [Explorer](#), [Analysis](#), [Knowledge](#), [Login](#), and [Help](#). Below the navigation bar, there is a search area with a 'Query Conditions' section containing a checked checkbox for '[F]temperatu' and a 'Free Keywords' section. A 'Free text' callout points to the search input field. Below the search area, there is a 'Keyword' section with a list of variables:

- long_name(62)
- units(62)
- standard_name
- coordinates(30)
- Description(8)
- NOEP
- least significant
- level_desc(3)
- parent_stat(3)
- precision(3)

An 'Attributes' callout points to this list. A 'Search with Google Maps' callout points to a map showing a world view with several red location pins. A yellow callout points to the 'Anal/Viz' button in the results table, with the text 'Select a variable to analyze / visualize'. The results table shows columns for 'Anal/Viz' and 'Details'. A 'Results' callout points to the table header. The bottom of the page shows a 'powered by Google' logo and a scale bar.

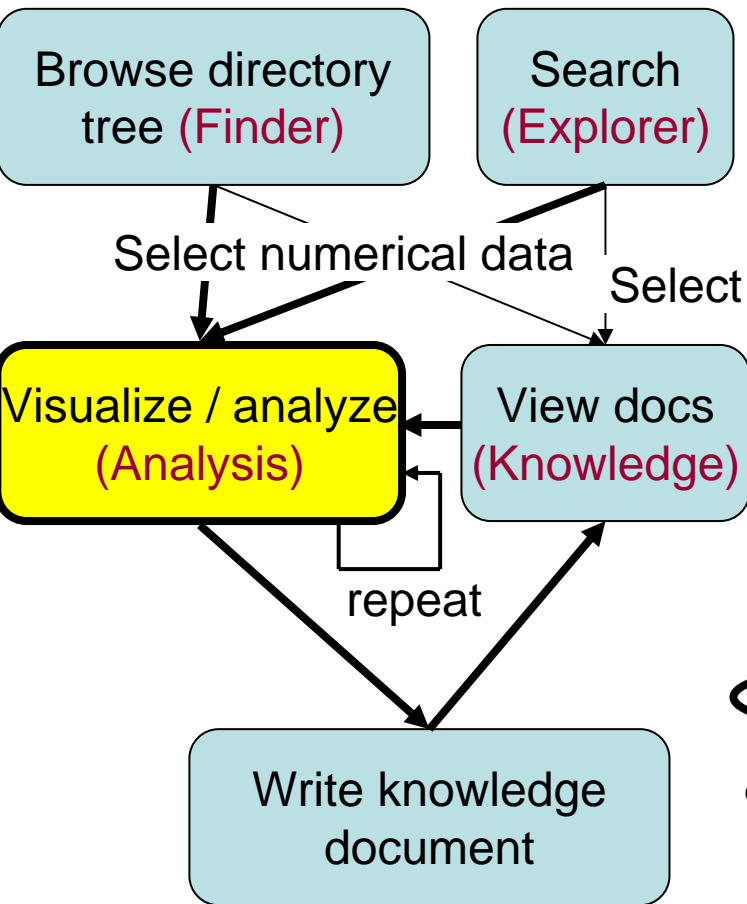
Functionality



GFDNAVI

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

[Help](#)



The screenshot shows the GFDNAVI web interface. A 'Variables' window displays the path `/samples/reanalysis/era40/t.jan.nc/t` and attributes: `missing_value: 157.063151760226`, `long_name: Temperature`, and `units: K`. A 'Temperature' contour plot is visible. The 'Options' window has a red 'draw!' button circled in red. Below it, 'Figure type: tone' and 'Animation' are circled in black. A 'Ruby Script & Minimum Subset Data' window contains links: [download script and data](#), [save diagram](#), and [link to this diagram](#). Other annotations include 'Save in the DB (login needed)', 'Get the URL to redraw the img', and 'supply your own'.

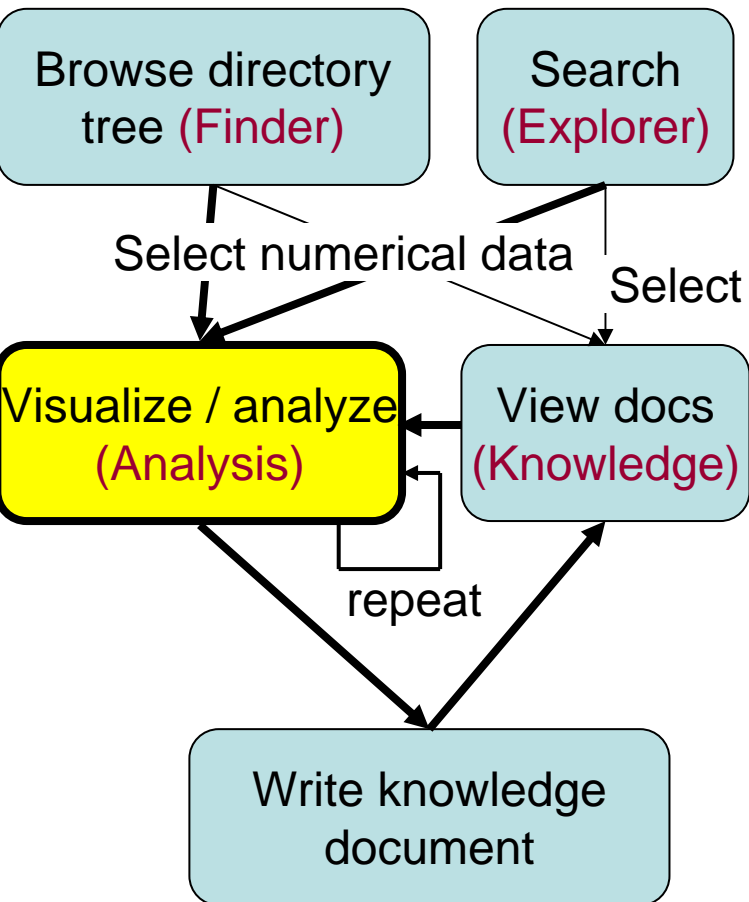
Functionality



GFDNAVI

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

[Help](#)



Variables

U V t

[clear variables](#)

Axes

Dimensions

lon	8.75	348.0
lat	-77.5	81.2
level	10	100

[map](#)

Options

Draw ? Analysis ?

analyze!

Function: cut [add function](#)

- cut
- mean
- stddev
- addition
- division
- multiplication
- subtraction

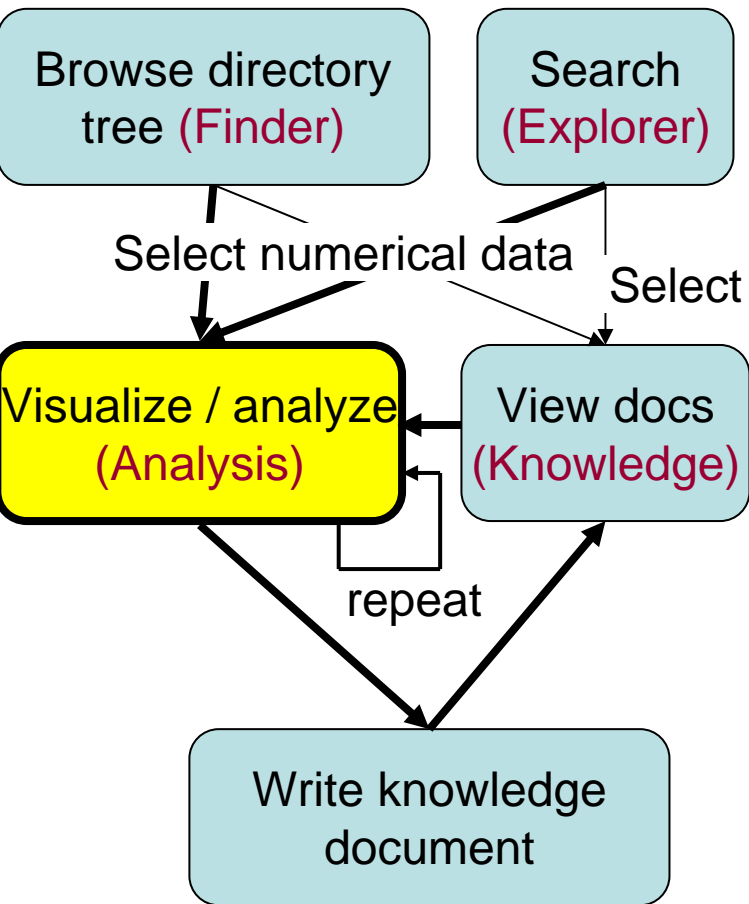
Functionality



GFDNAVI

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

[Help](#)



The screenshot shows the GFDNAVI interface with three main panels:

- Variables:** Contains checkboxes for 'U', 'V', and 't'. 'U' and 'V' are checked. A 'clear variables' link is present below.
- Axes:** Contains a 'Dimensions' section with three rows of sliders:
 - lon: 8.75 (left) to 348. (right)
 - lat: -77.5 (left) to 81.2 (right)
 - level: 10 (left) to 100 (right)A 'map' link is located to the left of the 'lat' slider.
- Options:** Contains two tabs: 'Draw' and 'Analysis'. The 'Analysis' tab is active, and a red box highlights the text 'analyze!'. Below this, there is a 'Function' dropdown menu set to 'mean' and an 'add function' link. To the right, there are three vertical sliders for 'lon', 'lat', and 'level'. Below these sliders, the text 'the dimensions for mean' is displayed.

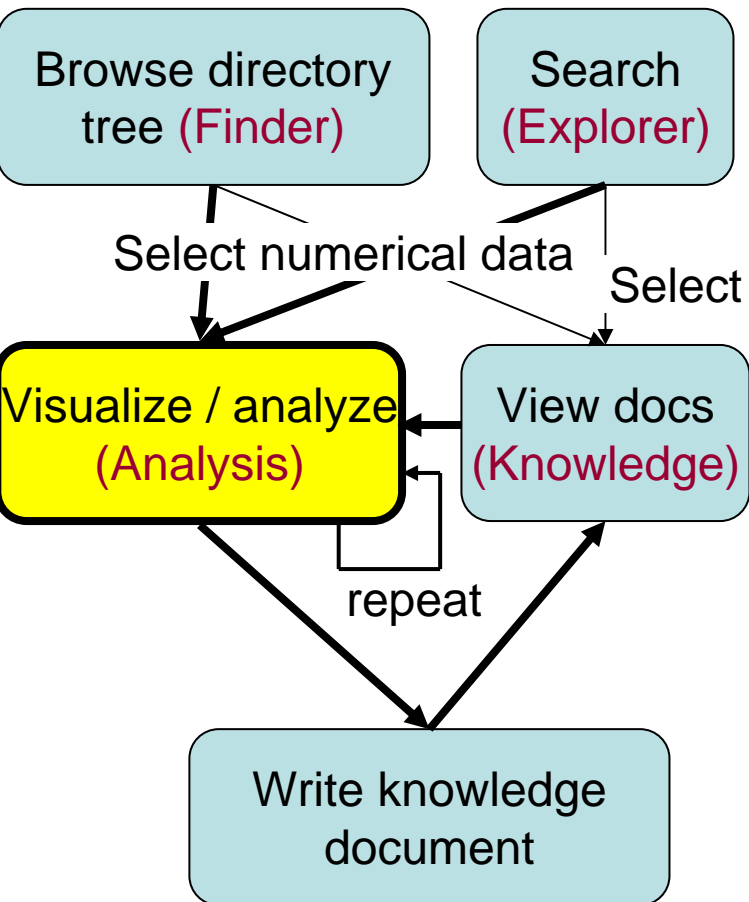
Functionality



GFDNAVI

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

[Help](#)

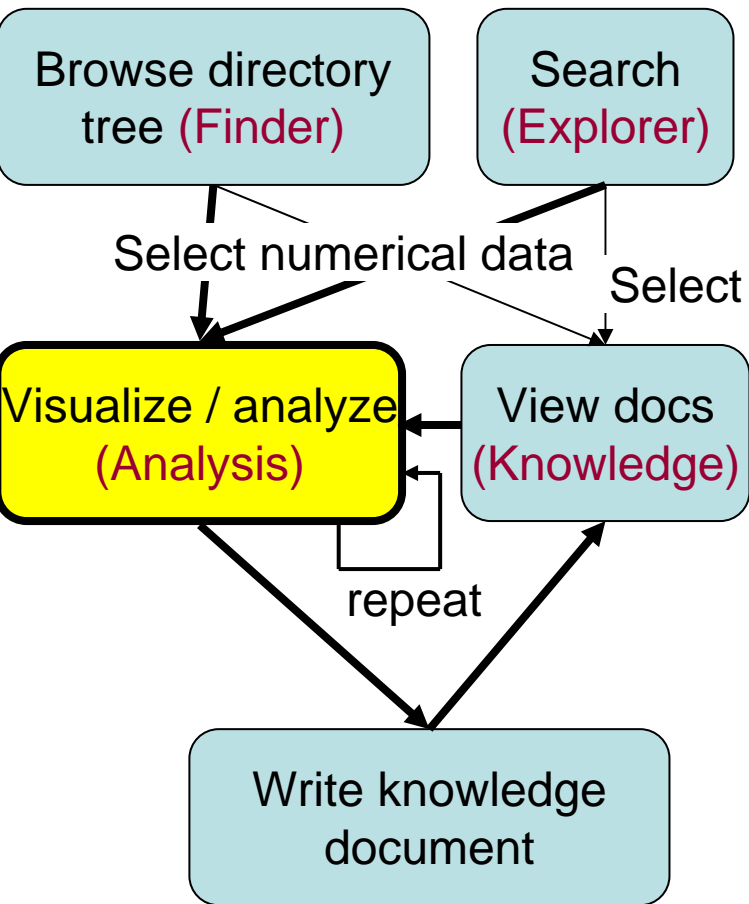


The screenshot shows the login page of GFDNAVI. At the top, there is a navigation bar with links: [Top](#), [Finder](#), [Explorer](#), [Analysis](#). Below the navigation bar, the text 'Please login' is displayed. There are two input fields: 'Login:' and 'Password:'. Below the input fields, there are two buttons: 'login' and 'signup'.

Functionality



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



Create Function

Function

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

Function Arguments

Functionality



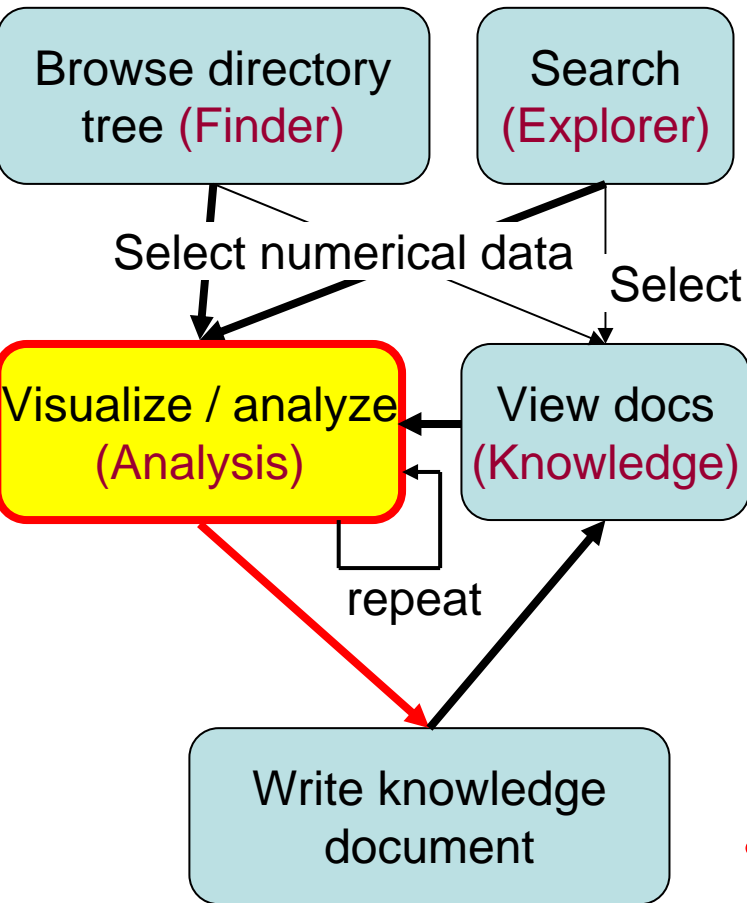
[Top](#) [Finder](#) [Explorer](#) [Analysis](#) [Know](#)



GFDNAVI

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

[Help](#)



Variables

t

[clear variables](#)

upload

Axes

Dimensions

longitude 0

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

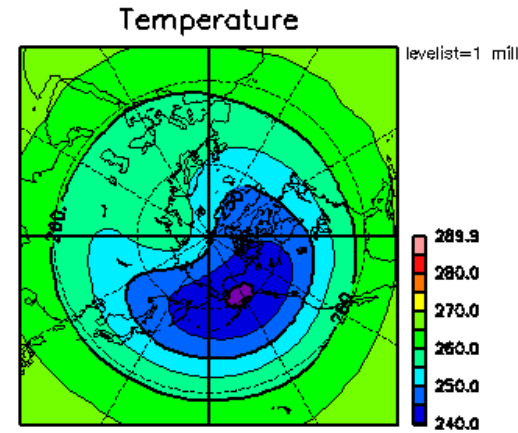
Projection Type: polar stereo projection

Pile up

Keep diagrams

Diagram size: small

Viewport vxmin, vxmax, ymin, ymax (0 to 1):

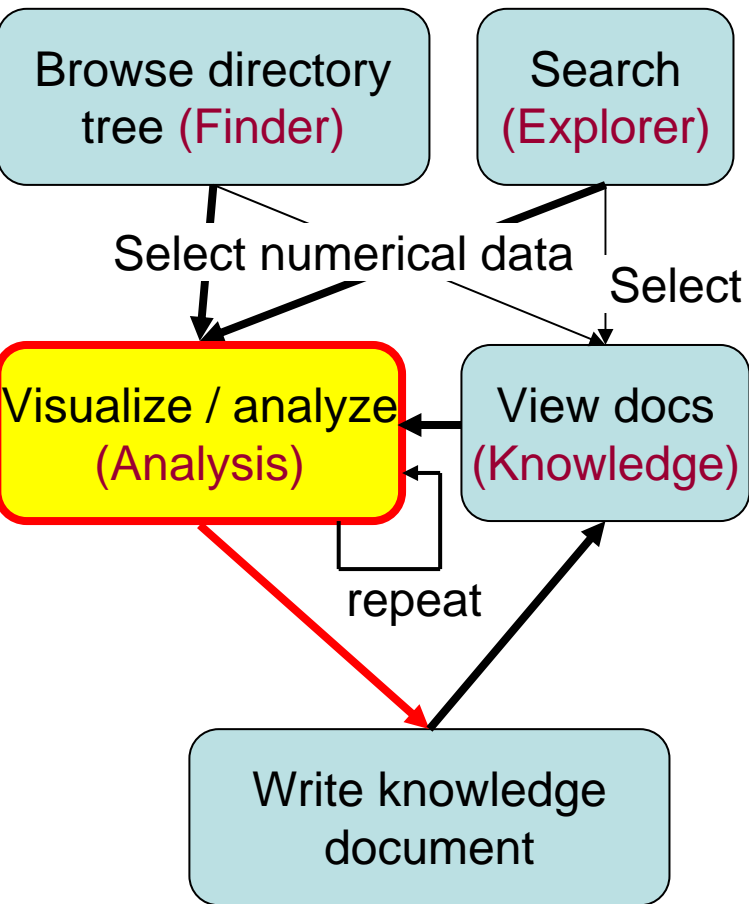


CONTOUR INTERVAL = 5.000E+00

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



Top Finder Explorer Analysis Know



F

clear_variables

upload

Axes

Dimensions

longitude 0

latitude 90

levelist 100

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

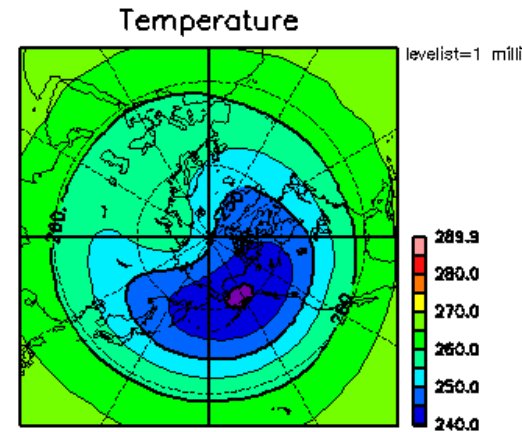
Projection Type: polar stereo projection

Pile up

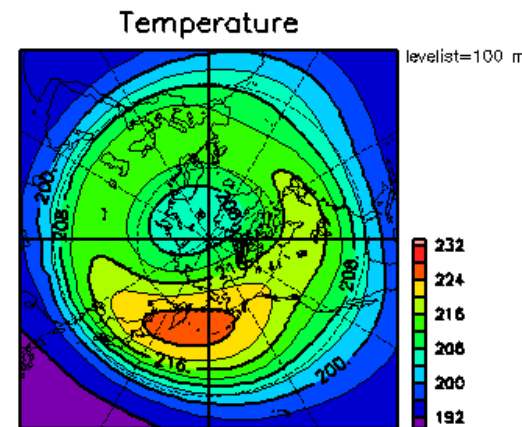
Keep diagrams

Diagram size: large med small x-small

Viewport vxmin, vxmax, vymin, vymax (0 to 1): 0.2,0.8,0.2,0.8



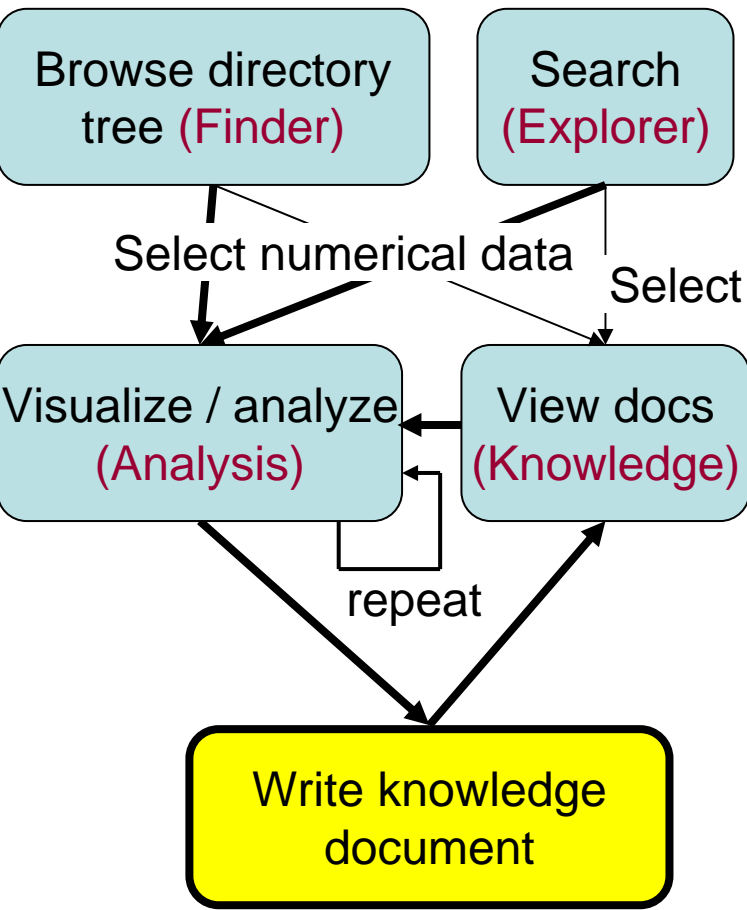
CONTOUR INTERVAL = 5.000E+00



CONTOUR INTERVAL = 4.000E+00

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

Full Save Images and Create a New 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: /usr/root/knowledge/tmp/eraT.knlge
e\ /usr/root/knowledge/folder1/folder2/writing.knlge


visible to: everyone

Choose a default layout : size of figure: %

input the number of figures in a row

Figure 1

Caption:

Temperature

File Name:

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

Figure 2

Caption:

Temperature

File Name:

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

[More Figure](#)

Layout : size of figure: %

input the number of figures in a row

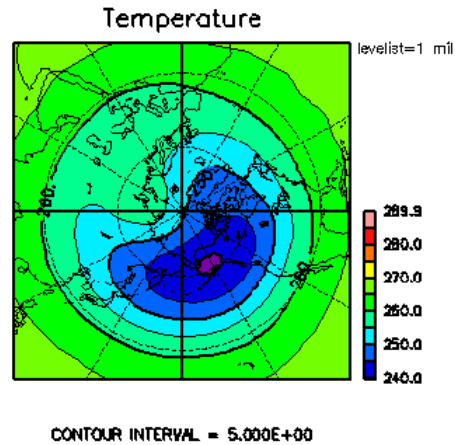
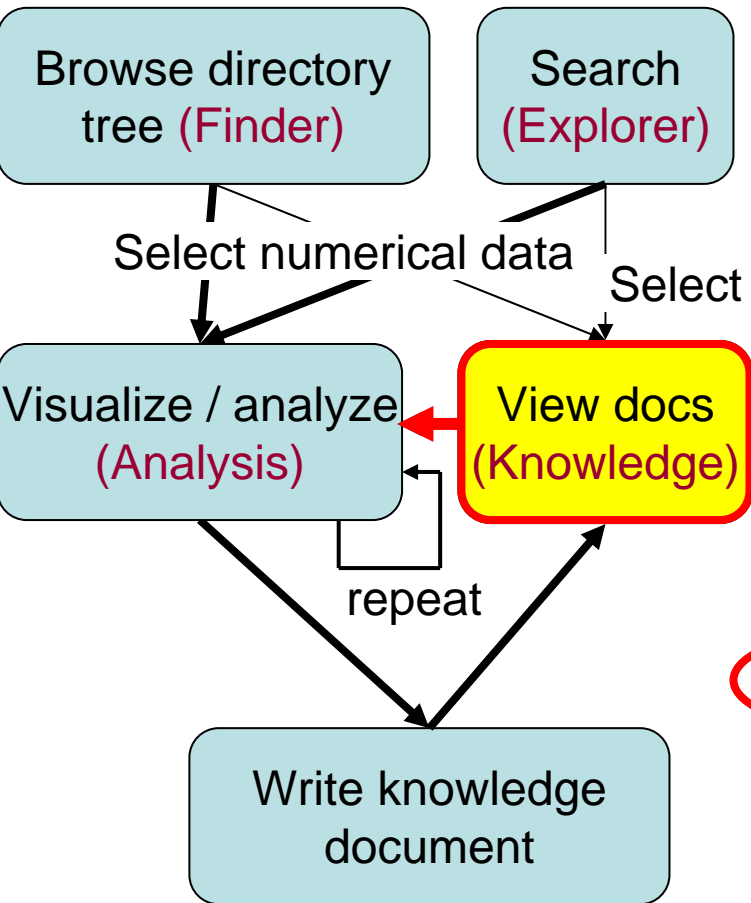


ECMWF Reanalysis January Climatology

Author: T Horinouchi

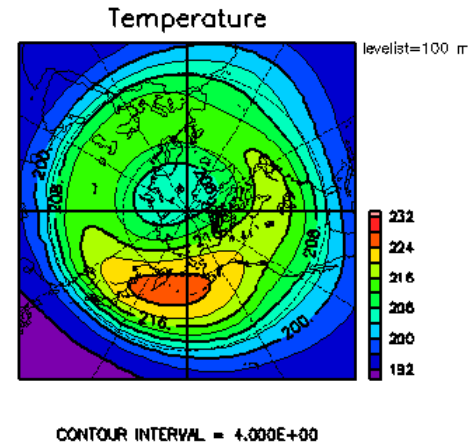
[Figure 1](#) shows the climatological temperature at 1 hPa using the ECMWF Reanalysis (ERA40) in the northern hemisphere. It shows that the climatological polar vortex is shifted to the Pacific side.

[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.



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

Fig. 1. ERA Jan T at 1 hPa



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

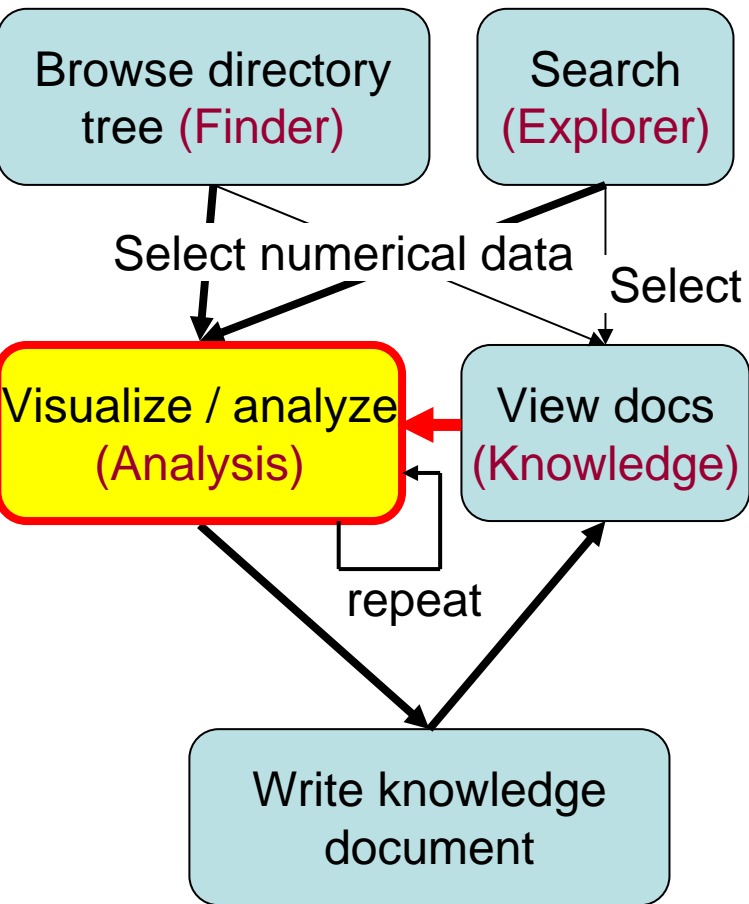
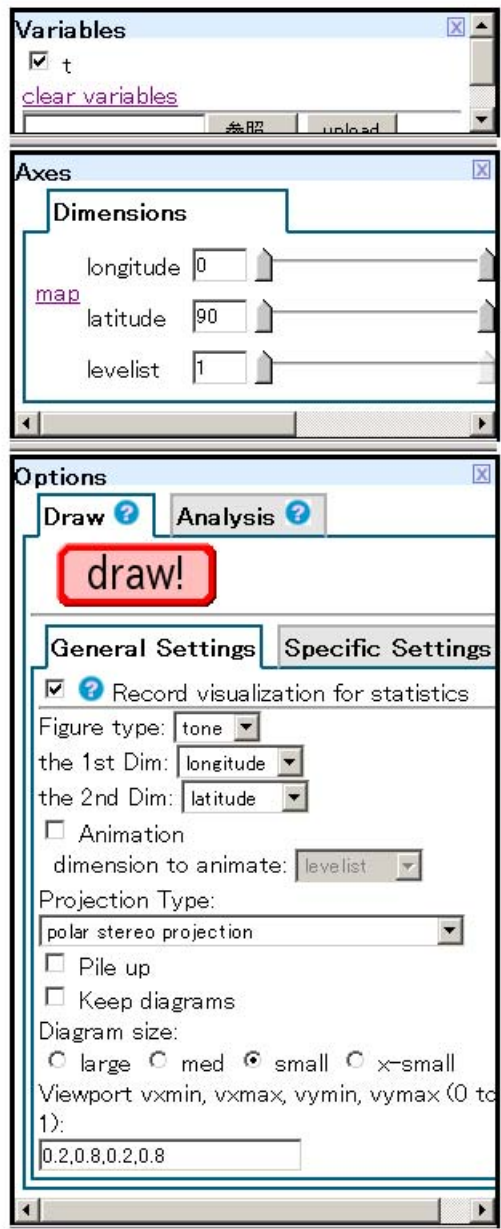
Fig. 2. ERA Jan T at 100 hPa

Path: /usr/root/knowledge/tmp/era.T.knlge

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

There are no comment on this document.

[Back to List](#)



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](#)
 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 [show full](#)
 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](#)

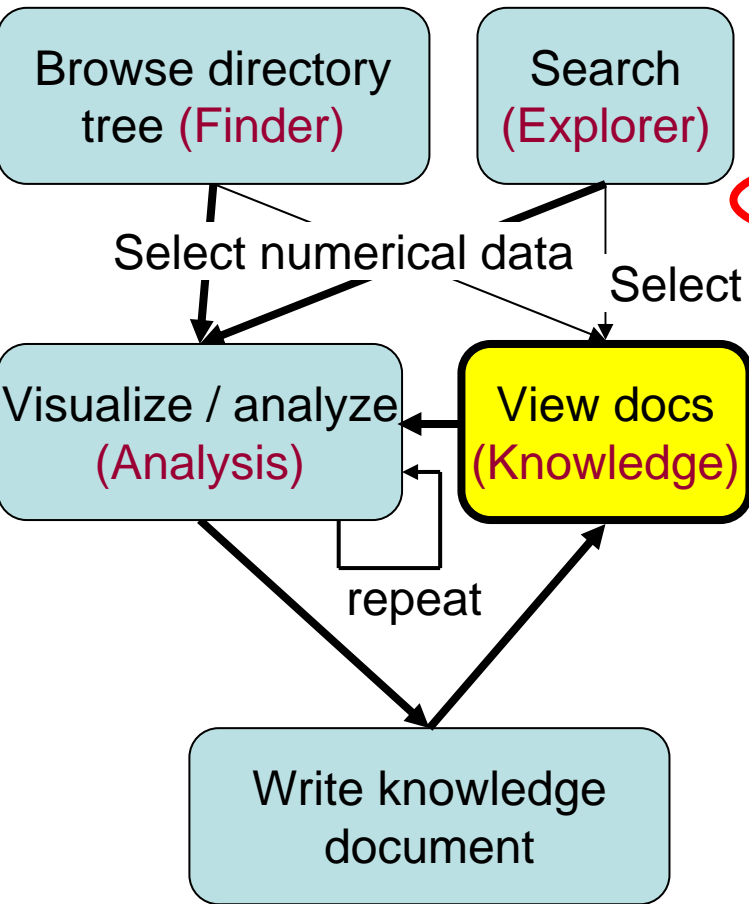
[Typhoon Information](#) by root last update: Sun Sep 14 12:23:16 [show full](#)
 A typhoon occurred at east of philippine A typhoon 5 occurred on July 2005. The figure means amount of
 path: /usr/root/knowledge/typhoon3.knlge [Edit](#) [Delete](#)

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

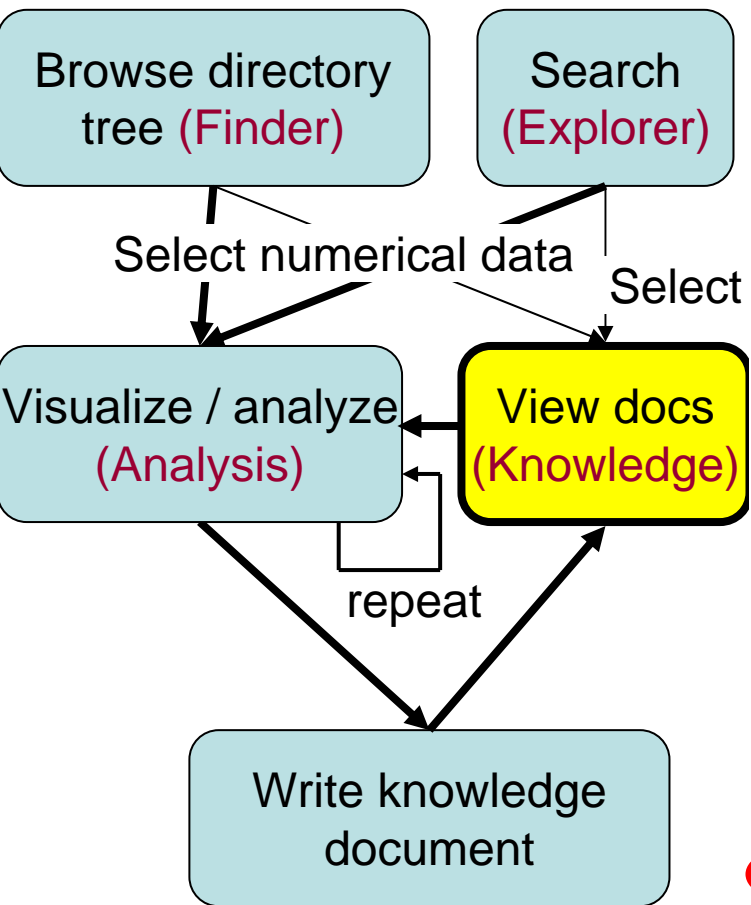
Previous **1** 2 Next

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 possibility of coming off from the expectation and landing on West Japan. Please note this in the future.

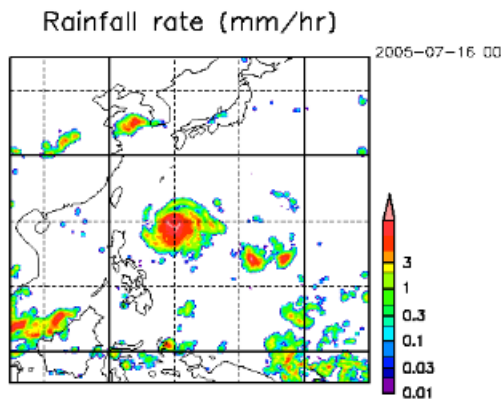


Fig. 1. Rainfall

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

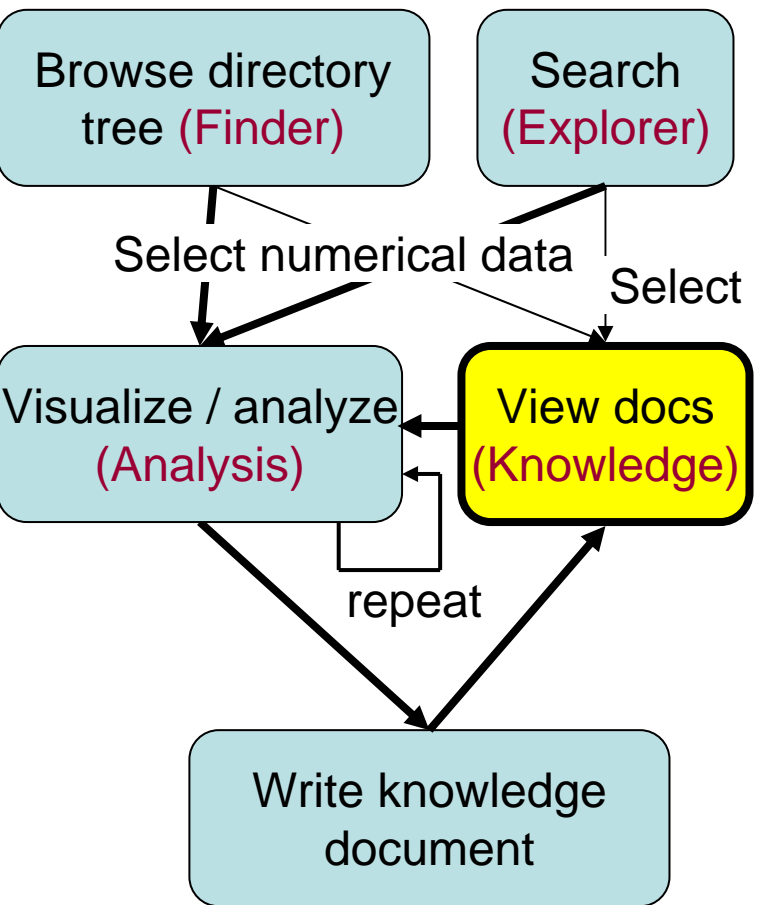
[Edit](#) | [Back to List](#)

There are no comment on this document.

[Back to List](#)



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



F

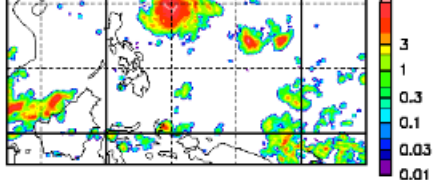


Fig. 1. Rainfall

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

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

[There are no comment on this document.](#)

[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

F 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 possibility of coming off from the expectation and landing on West Japan. Please note this in the future.

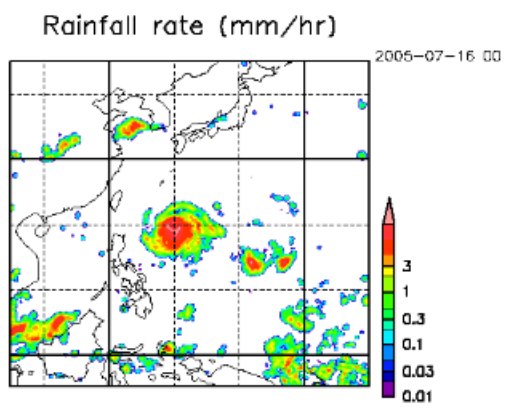
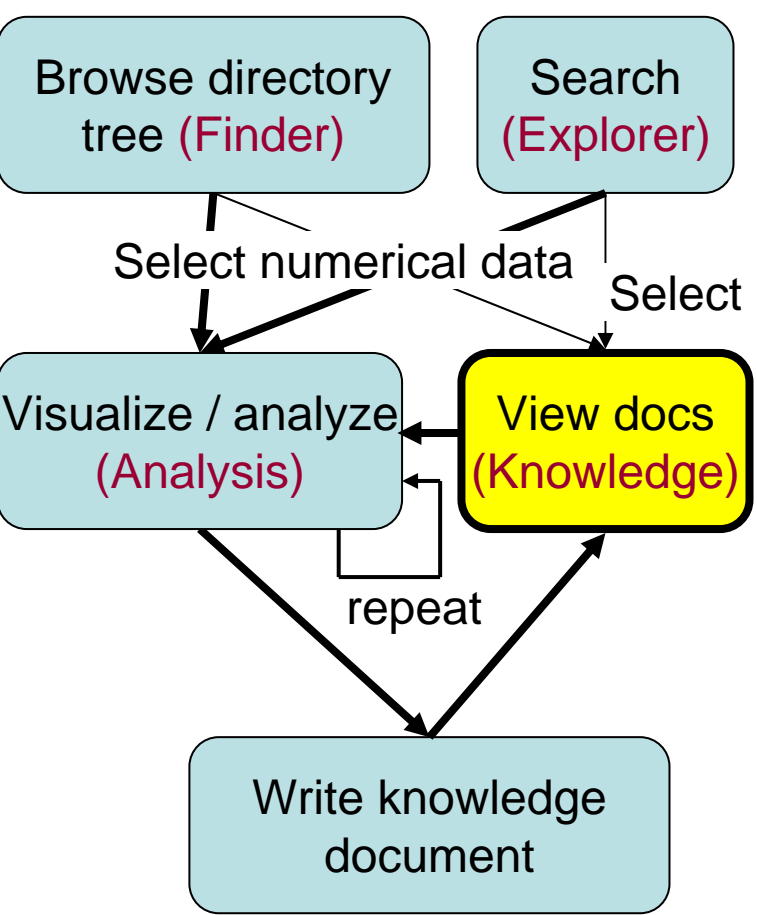
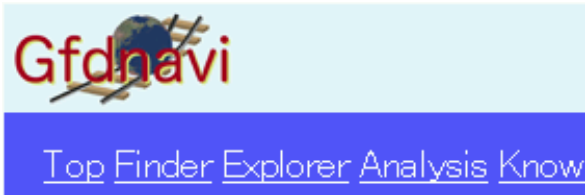


Fig. 1. Rainfall

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

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

1 comment exists.

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

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

[Back to List](#)

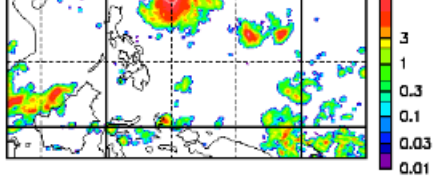


Fig. 1. Rainfall

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

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

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.

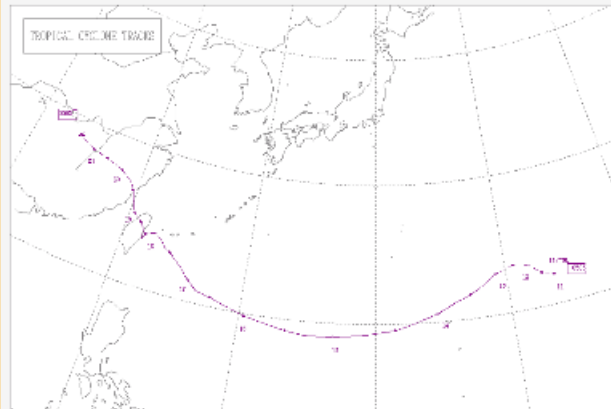
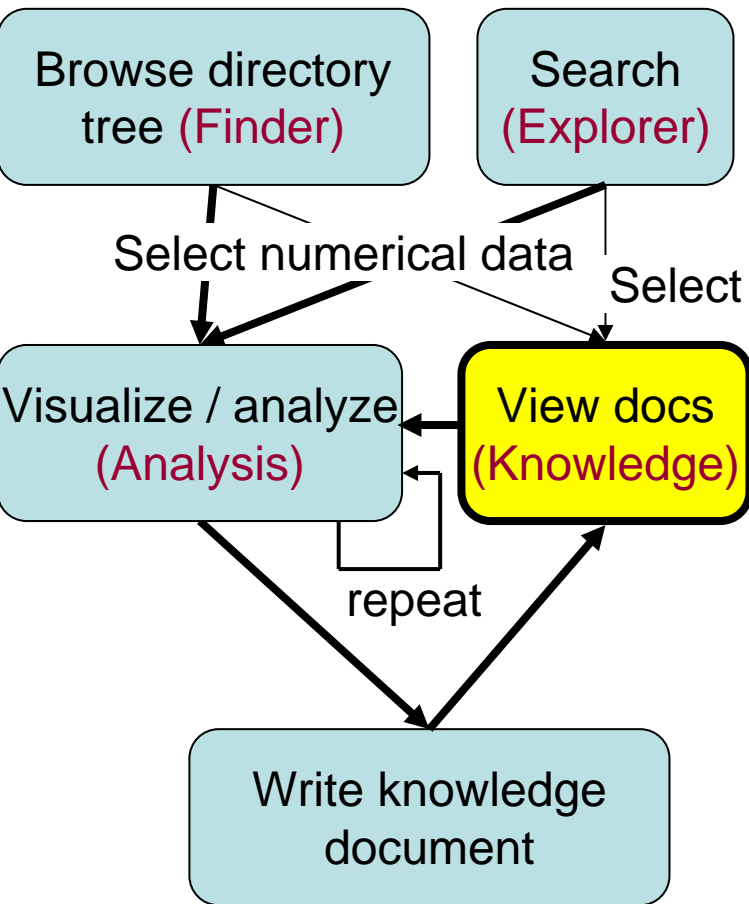


Fig. 1. course of typhoon 5 in 2005.

Path: /usr/root/knowledge/typhoon3_comment_1.knlge

Write a Coment on this document.

[Back to List](#)

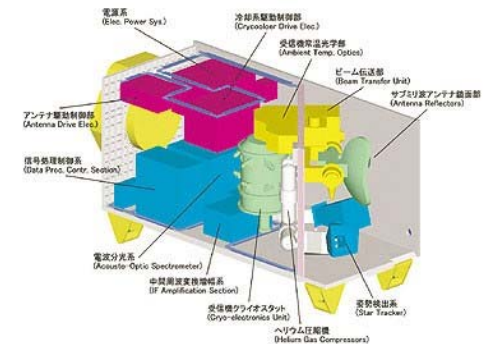


By linking a document with data and visualization/analysis methods

- One can confirm and extend it
 - falsifiability
- Annotate data with the document
 - scientific metadata
- Applications
 - interactive publication / science collaboration / educational material (incl. interdisciplinary collaboration)

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**

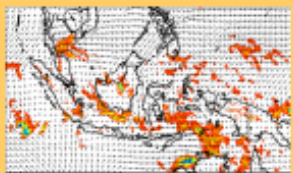
International Research for Prevention and Mitigation of Meteorological Disasters in Southeast Asia

MEXT Special Coordination Funds for Promoting Science and Technology for FY 2007 - 2009

Asia S&T Strategic Cooperation Program



振興調整費



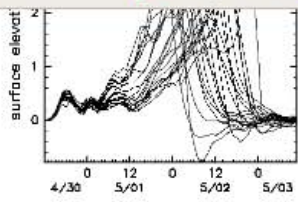
[Home](#)

[Motivations](#)

[Major Research](#)

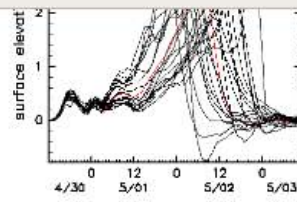
■ Home

This is the Home Page of International Research for Prevention and Mitigation of Meteorological



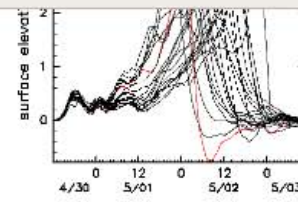
[<Redraw this image>](#) [<Get the URL>](#)

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.

[Previous](#) [Next](#)

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

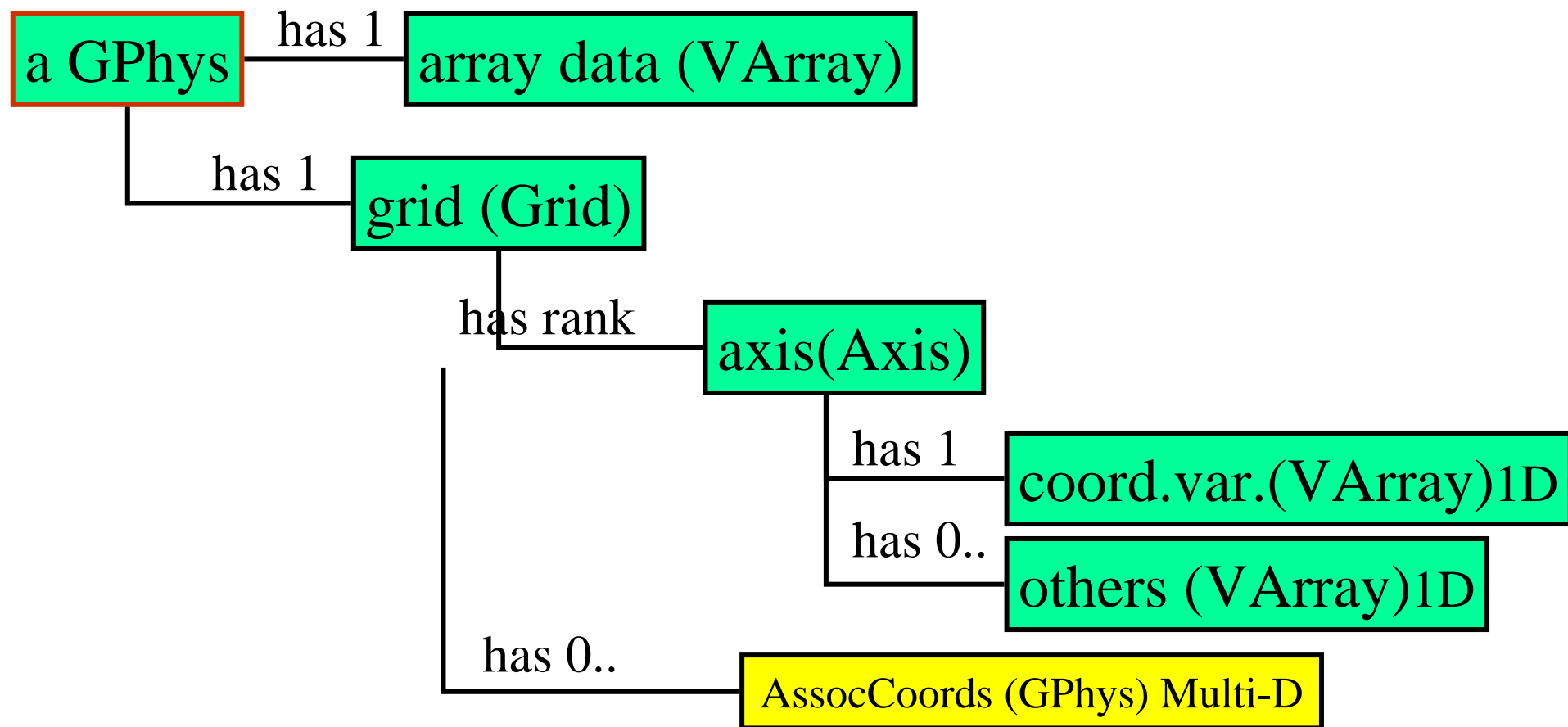
- We have developed Gfdnavi: software to build data and knowledge servers
 - Wide coverage from desktop use to public data service (by having custom web server)
 - Programmability (on browser & by web service)
 - Documentation of analysis results (dynamically reproducible/extendible) (→ memos / reports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

Next talk by Seiya Nishizawa:

- ✓ More on programability
- ✓ Web services
- ✓ Network of Gfdnavi

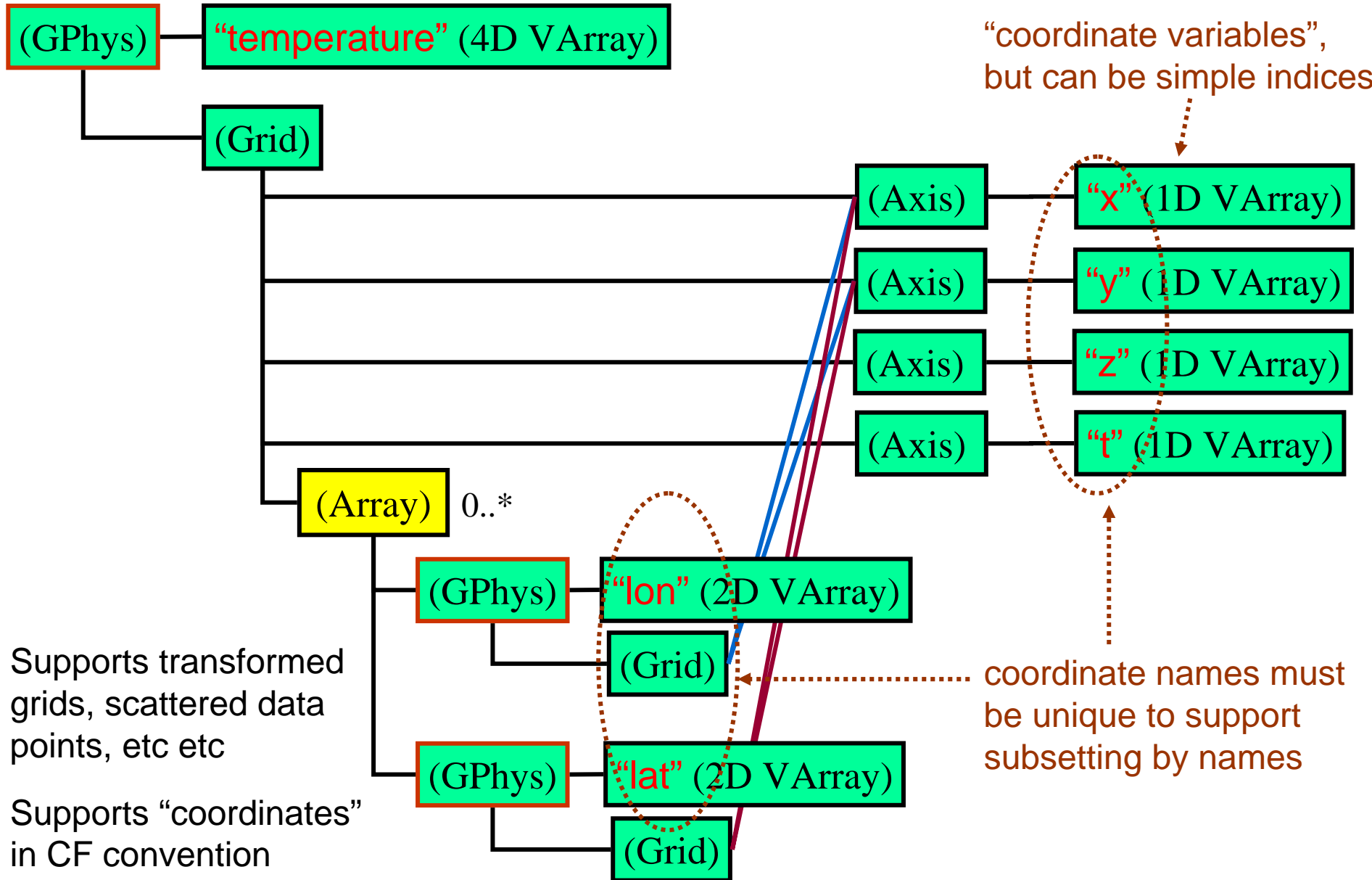
fin

GPhys (Gridded Physical quantity)



VArray (Virtual Array) – Abstracts Data Storage
(Can be in file(s) or multi-D Array on memory; can also be a subset or aggregation of (an)other VArray(s))

Example of GPhys's associated coordinates





What is Ruby on Rails

<http://www.rubyonrails.org/>

Agile Web
Development
with Rails



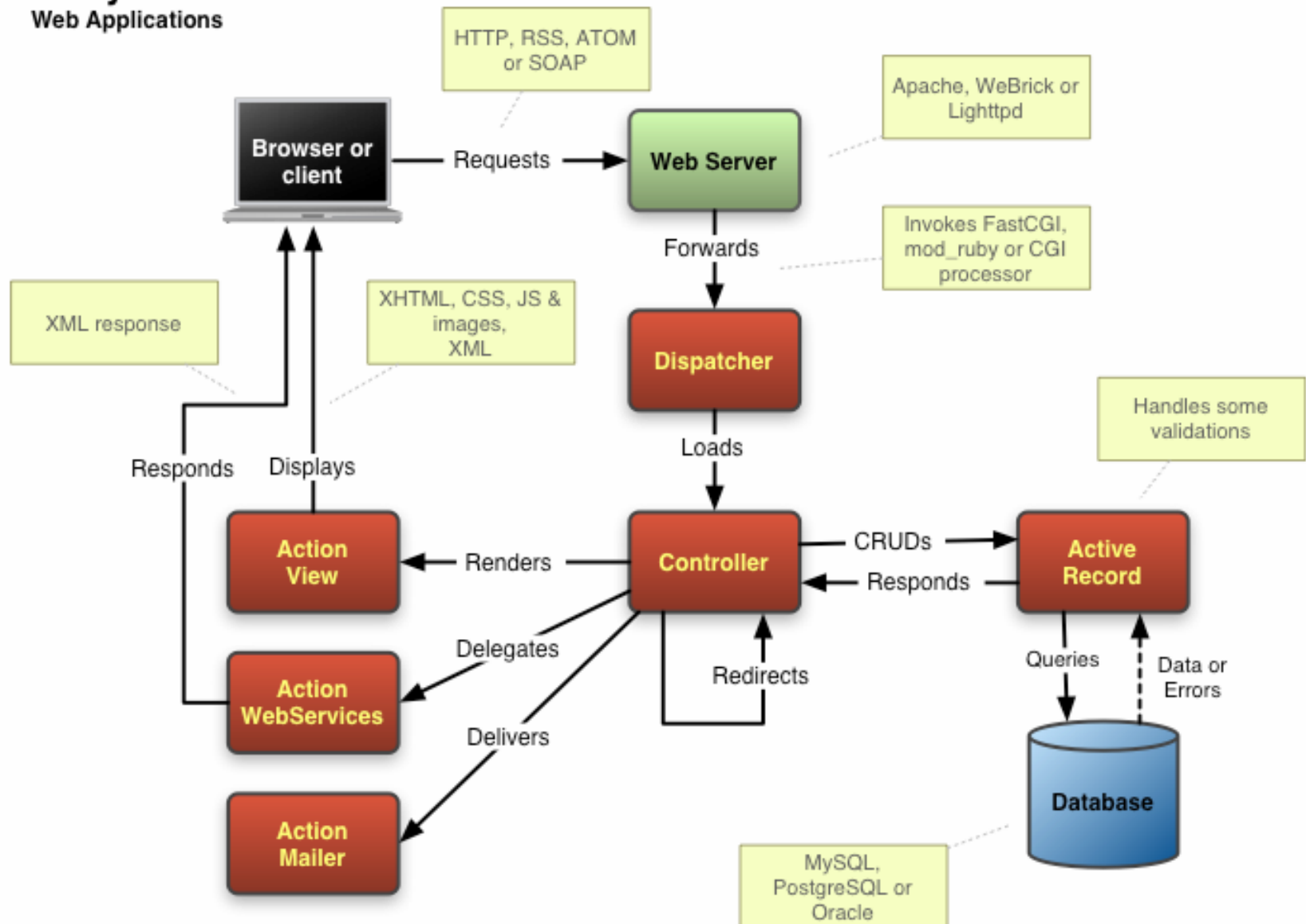
- Web development framework in Ruby
- With RDBMS (Mysql, Postgres, SQL Server, SQLite etc)
- Strong prototyping (e.g. Model-View-Controller (MVC) structure)
- Comprehensive library (covering Ajax and Web service)
- Ruby-embedded html
 - suitable to use our Ruby library
- Has a private web server (Webrick); also runs on Apache, lighttpd etc
 - One can personally run a web server anywhere with arbitrary port

From “Understanding Rails MVC”:

<http://wiki.rubyonrails.org/rails/pages/UnderstandingRailsMVC>

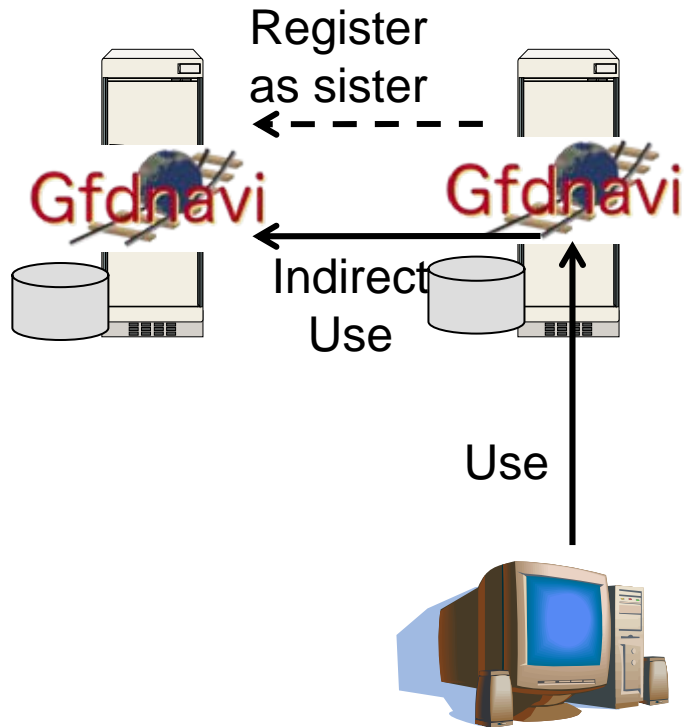
Ruby on Rails

Web Applications

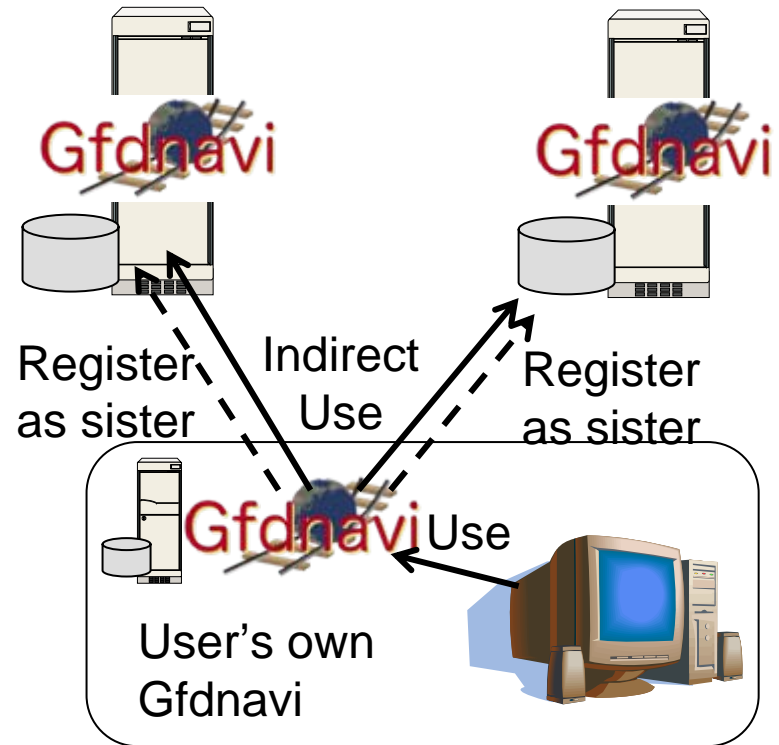


Sister-server method

(a) Basic case: available in LAS.
User can't choose peers

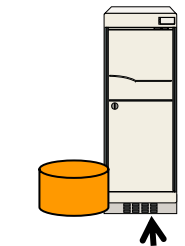


(b) Gfdnavi: one can register any peer by running a Gfdnavi

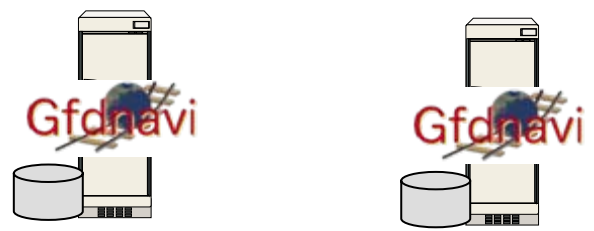


P2P with directory server

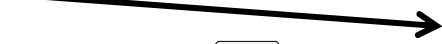
Directory Server



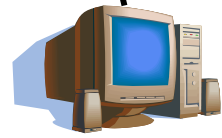
Query Server List



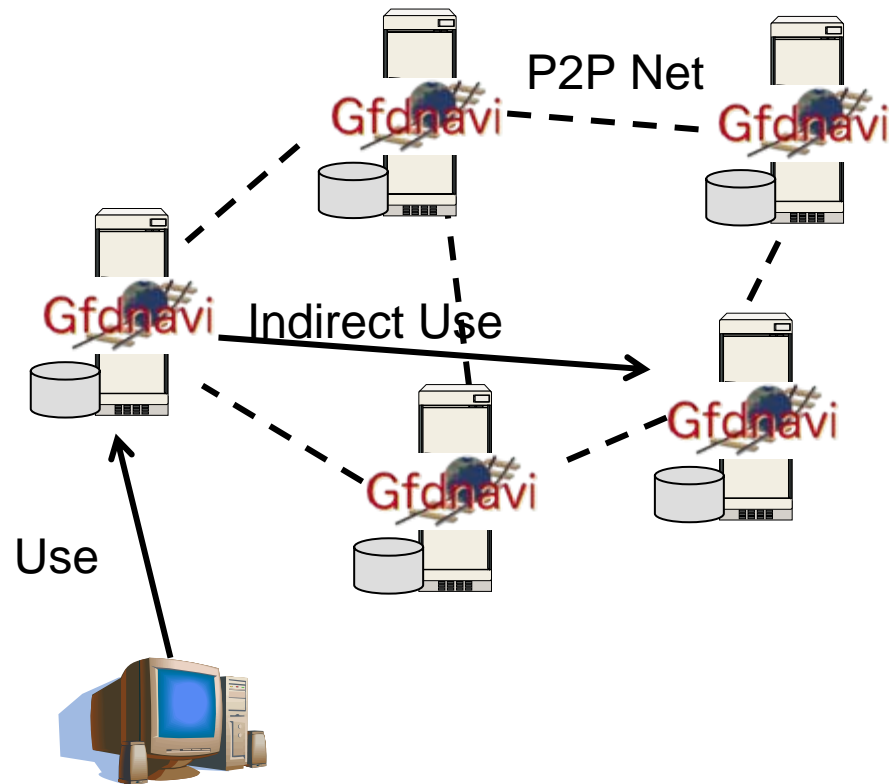
Indirect Use



Direct Use



Overlay network by P2P



Currently tested by C. Watanabe by using
Overlay Weaver (Java-based p2p library)
and Rails' Action Web Service

- Decentralized p2p with distributed hash tables (DHT)