

Gael Forget
MIT, Jan. 8th 2016



Introduction to ocean
data-model analysis

Class overview

- I. observations
- II. gridded products
- III. numerical models
- IV. completion of activities

Gael Forget
MIT, Jan. 8th 2016



Introduction to ocean
data-model analysis

structure of each session

1. review (1/4h)
2. introductory slides (1/2h)
3. activity period (3/4h)

Gael Forget
MIT, Jan. 8th 2016



Introduction to ocean
data-model analysis

Links

- IAP course material: http://mitgcm.org/viewvc/MITgcm/MITgcm_contrib/gael/comm/course-idma2016/
- ECCO v4 overview paper: <http://www.geosci-model-dev.net/8/3071/2015/gmd-8-3071-2015.html>
- ECCO v4 user guide: http://mitgcm.org/viewvc/*checkout*/MITgcm/MITgcm_contrib/gael/verification/eccov4.pdf
- MITgcm user guide : http://mitgcm.org/public/r2_manual/latest/online_documents/manual.pdf
- Paper reprints: <http://www.gaelforget.net/publications/>

Gael Forget
MIT, Jan. 8th 2016



Introduction to ocean
data-model analysis

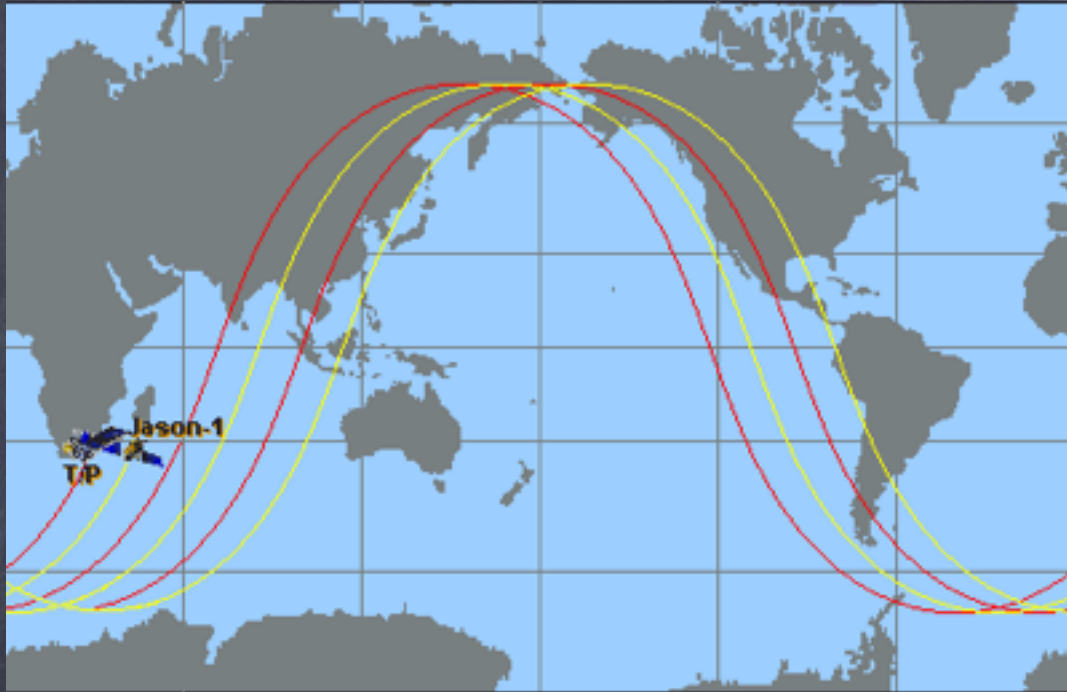
session I : observations

1. data collection
2. observational statistics
3. MITprof data sets
4. *activity period*

what do I like 'pure' observations for?

1. observational statistics
2. testing models
3. basis for estimation

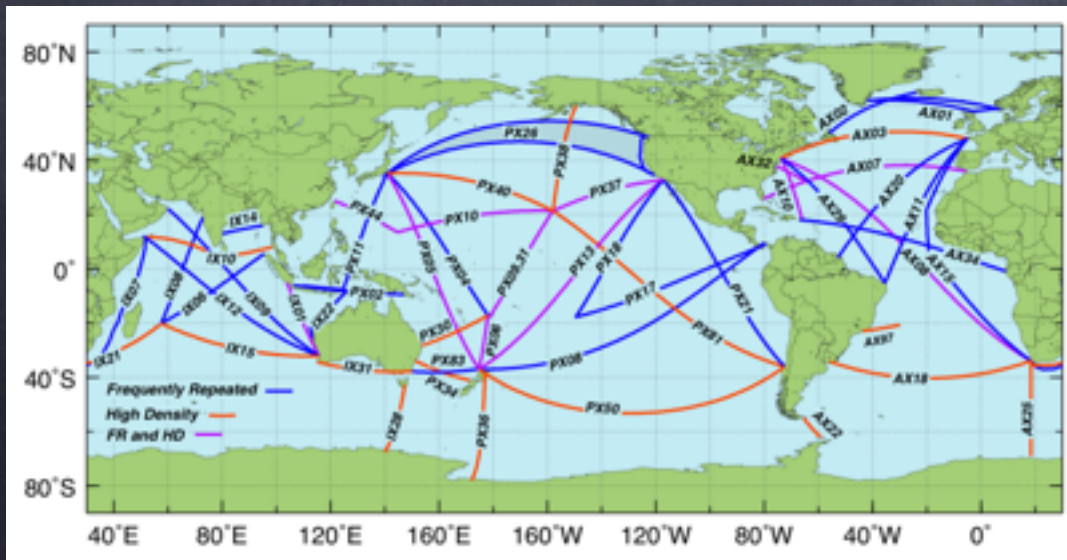
(1) data collection



remote sensing



WOCE repeat



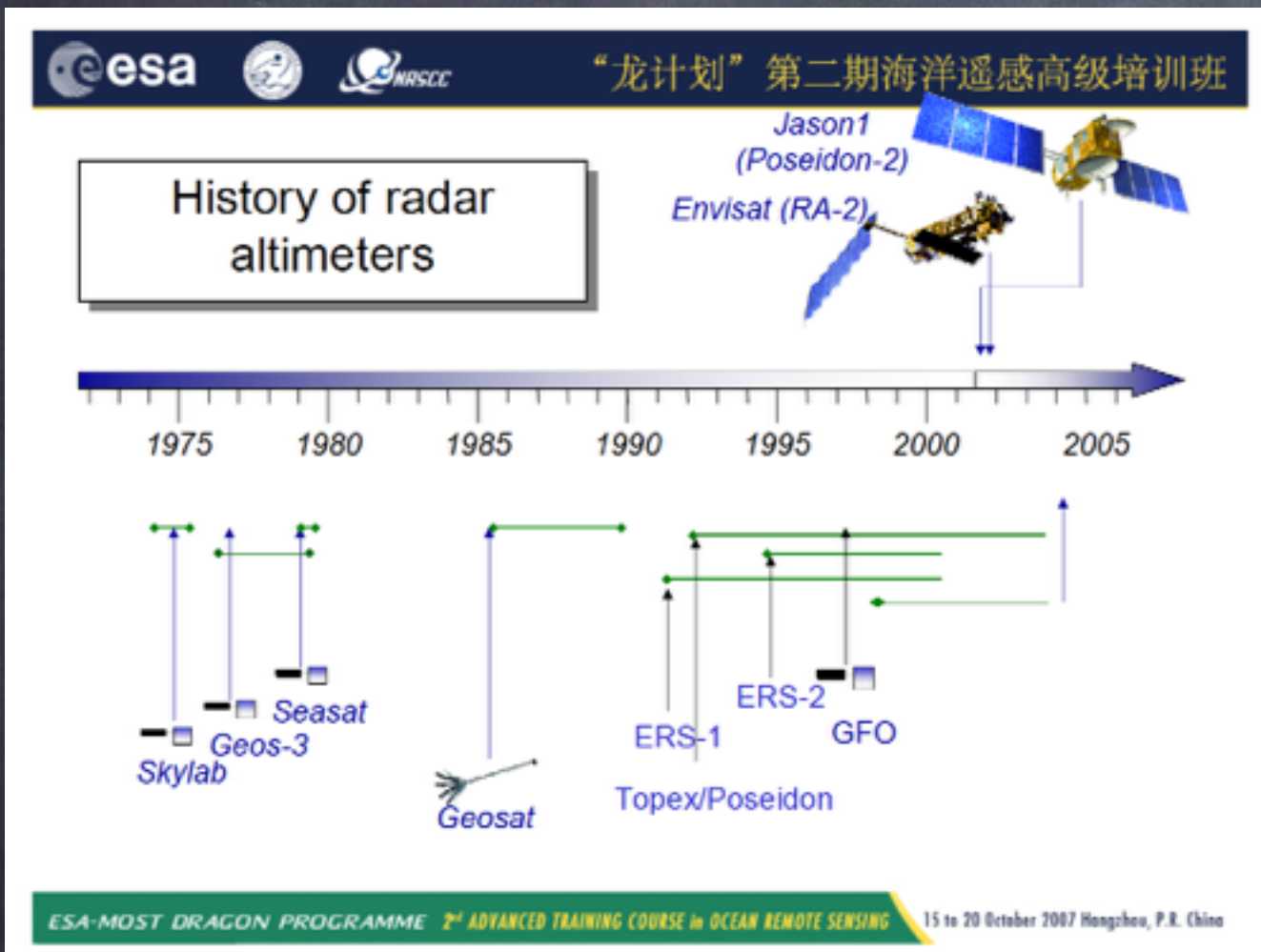
XBT repeat



Argo

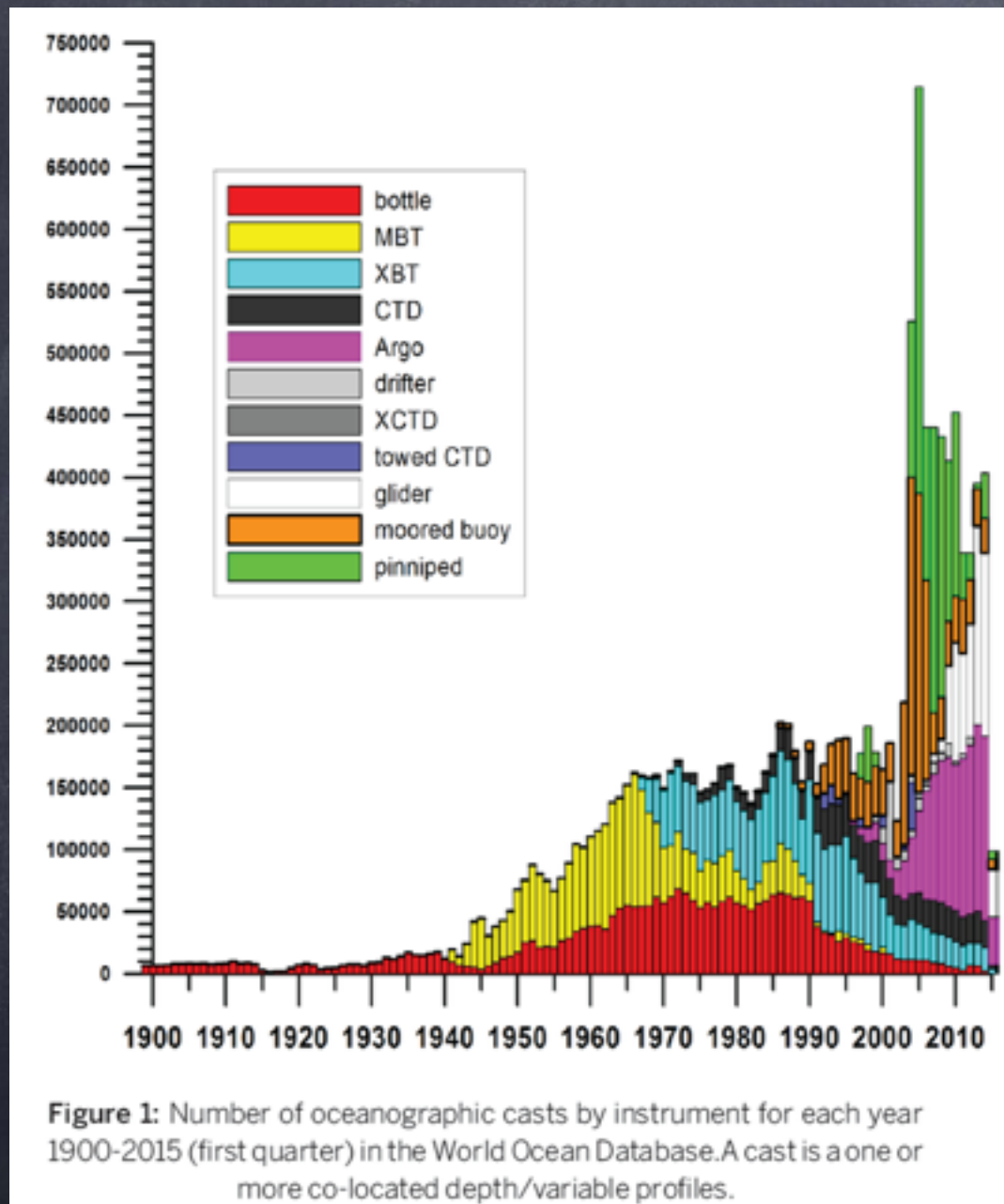
(1) data collection

- ocean variables that satellites do observe:
- surface temperature
 - sea ice cover
 - sea level anomaly
 - surface wind stress
 - ocean mass anomaly
 - surface color
 - surface salinity
 - ...

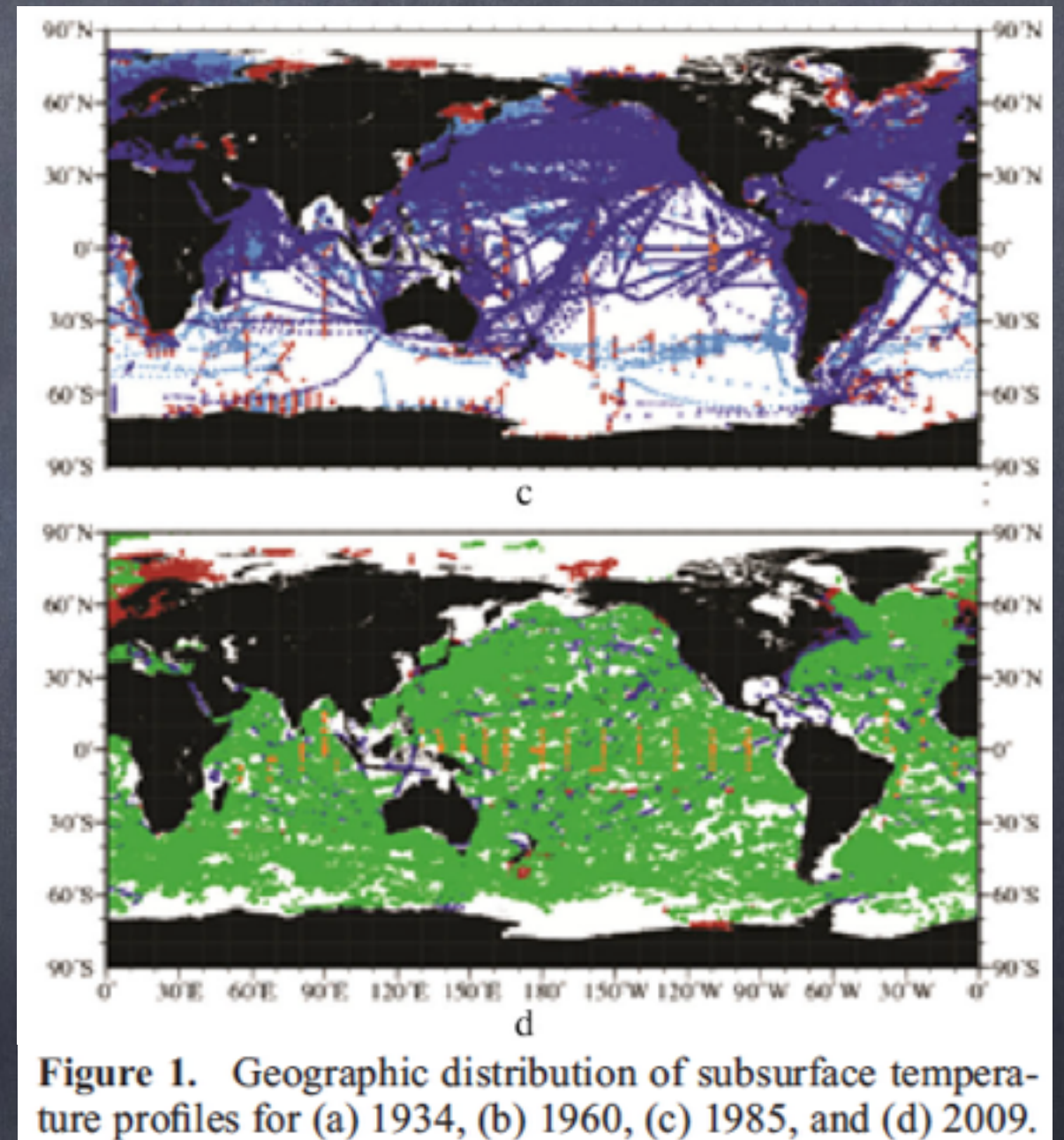


(ESA source)

(1) data collection

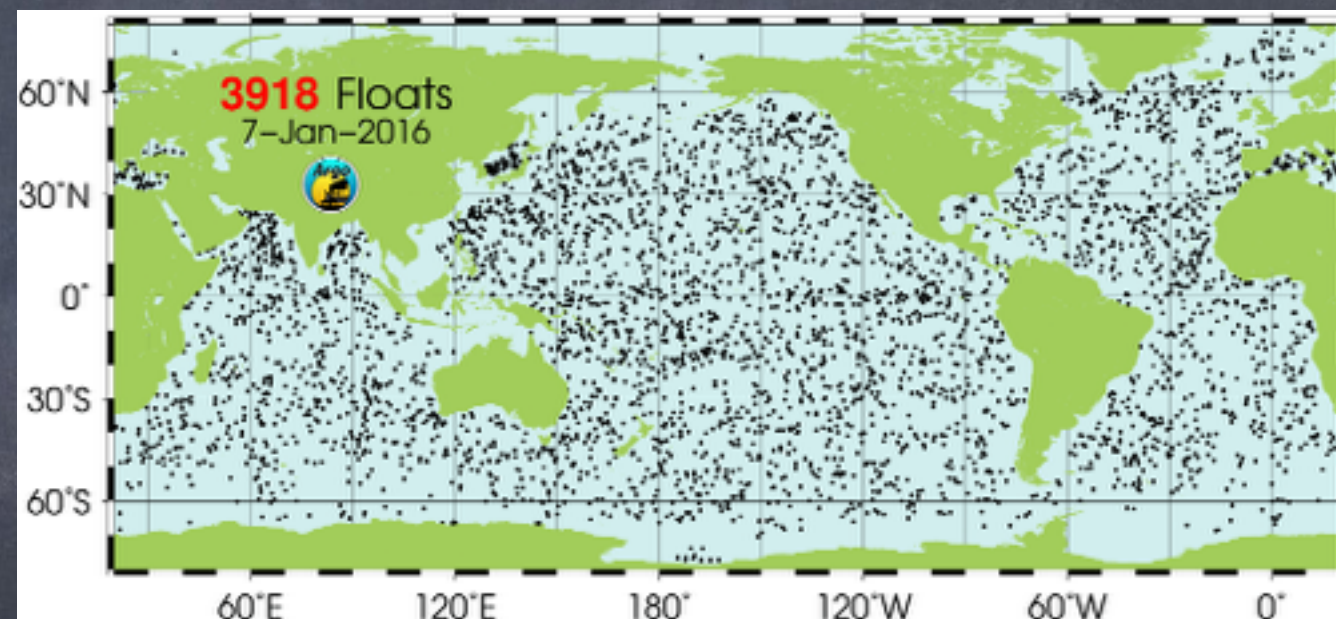
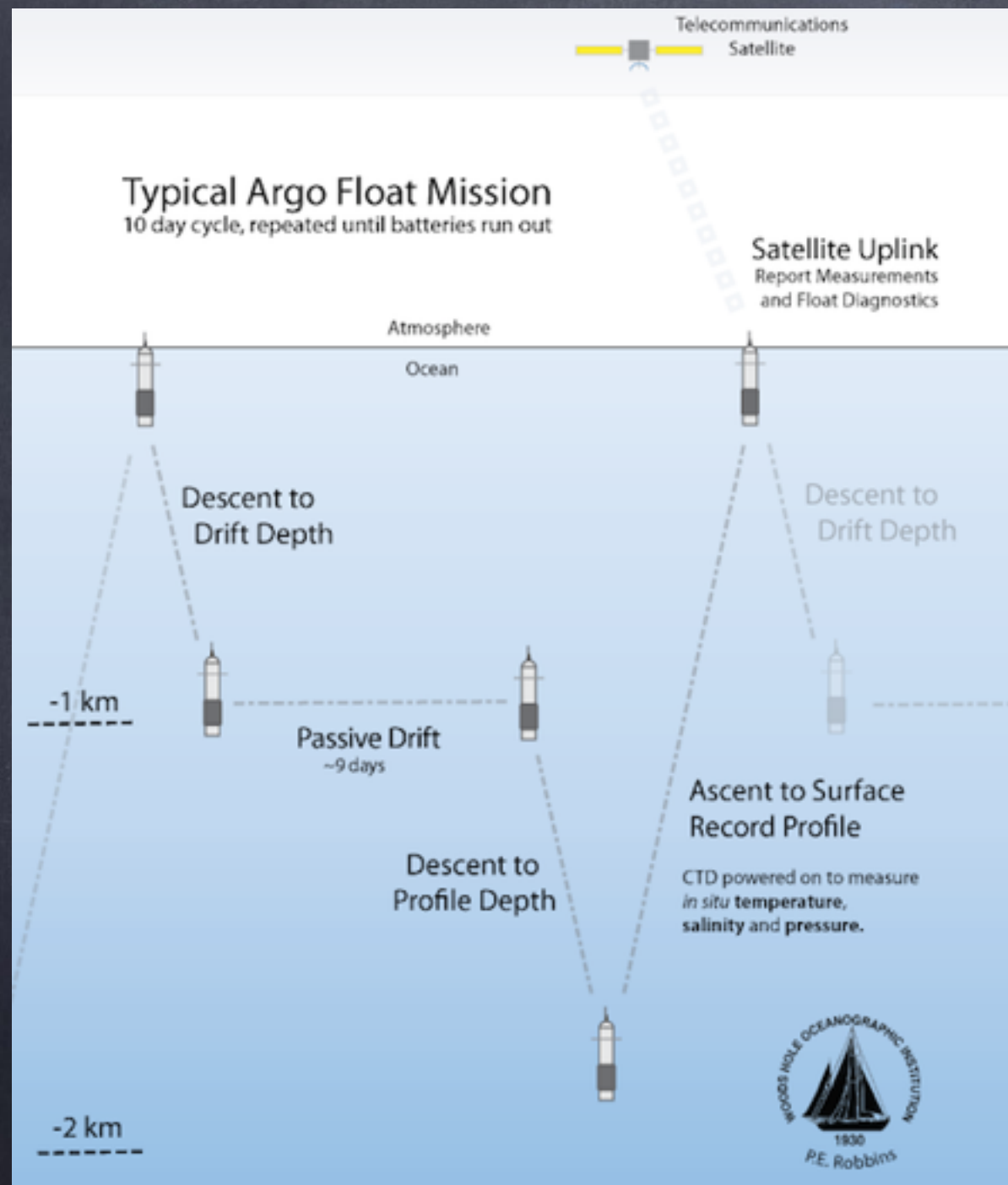


(Domingues et al. 2015)



(Abraham et al. 2013)

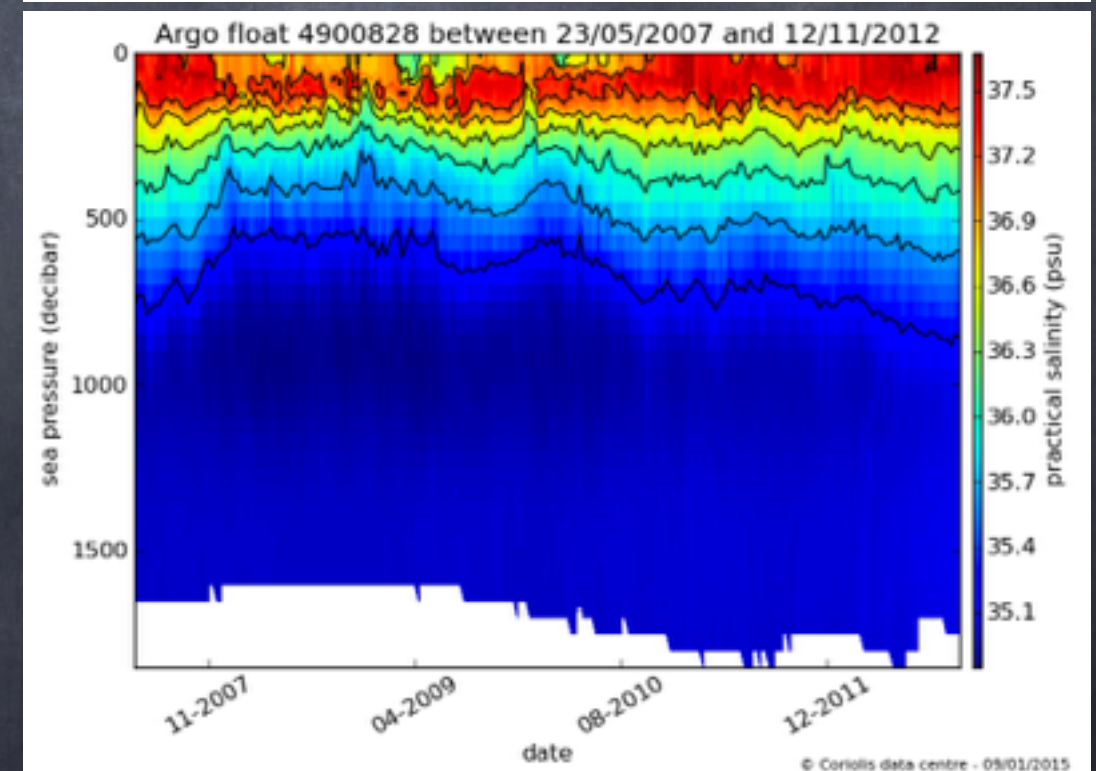
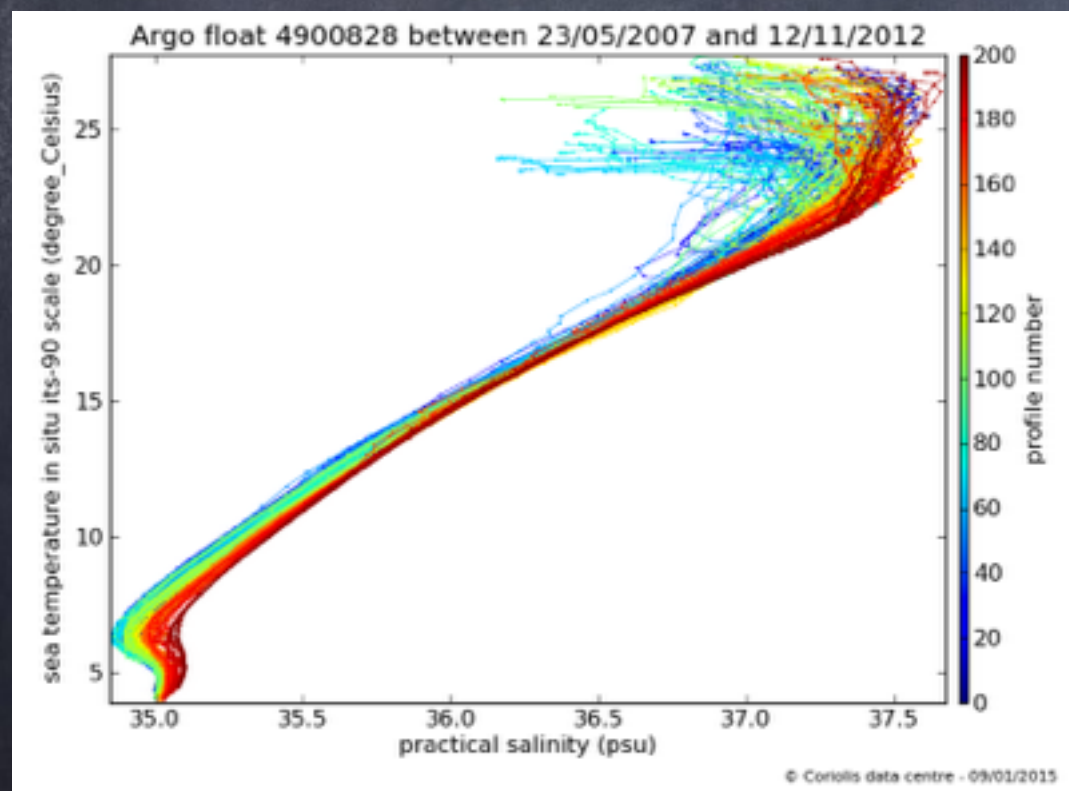
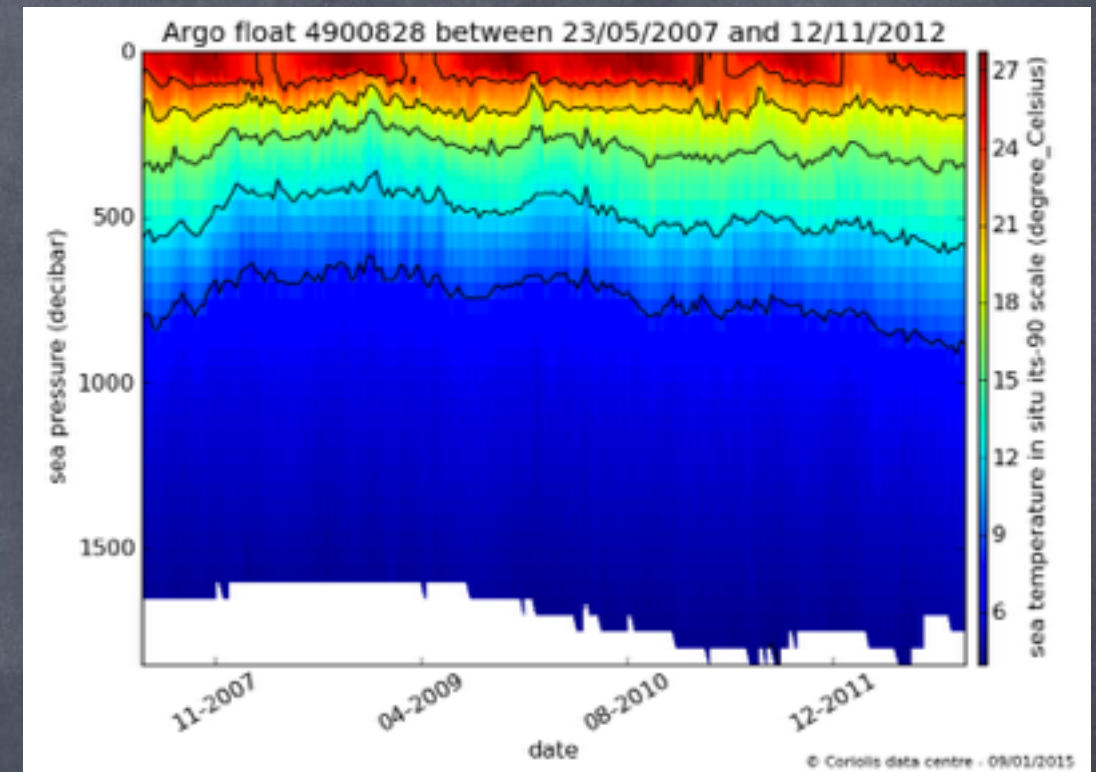
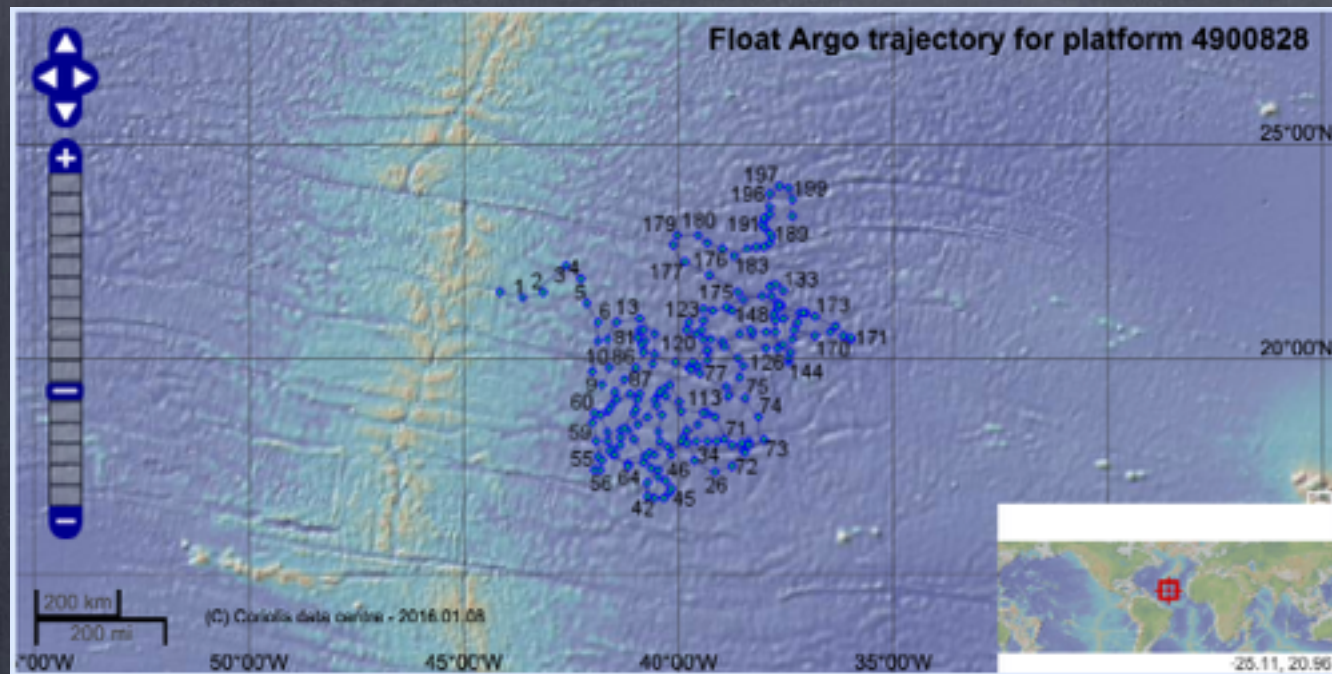
(1) data collection



(<http://argo.whoi.edu/>)

(<http://www.argo.ucsd.edu/>)

(1) data collection



(<http://www.argodatamgt.org> > Access to data >> Description of all floats)

(2) observational statistics

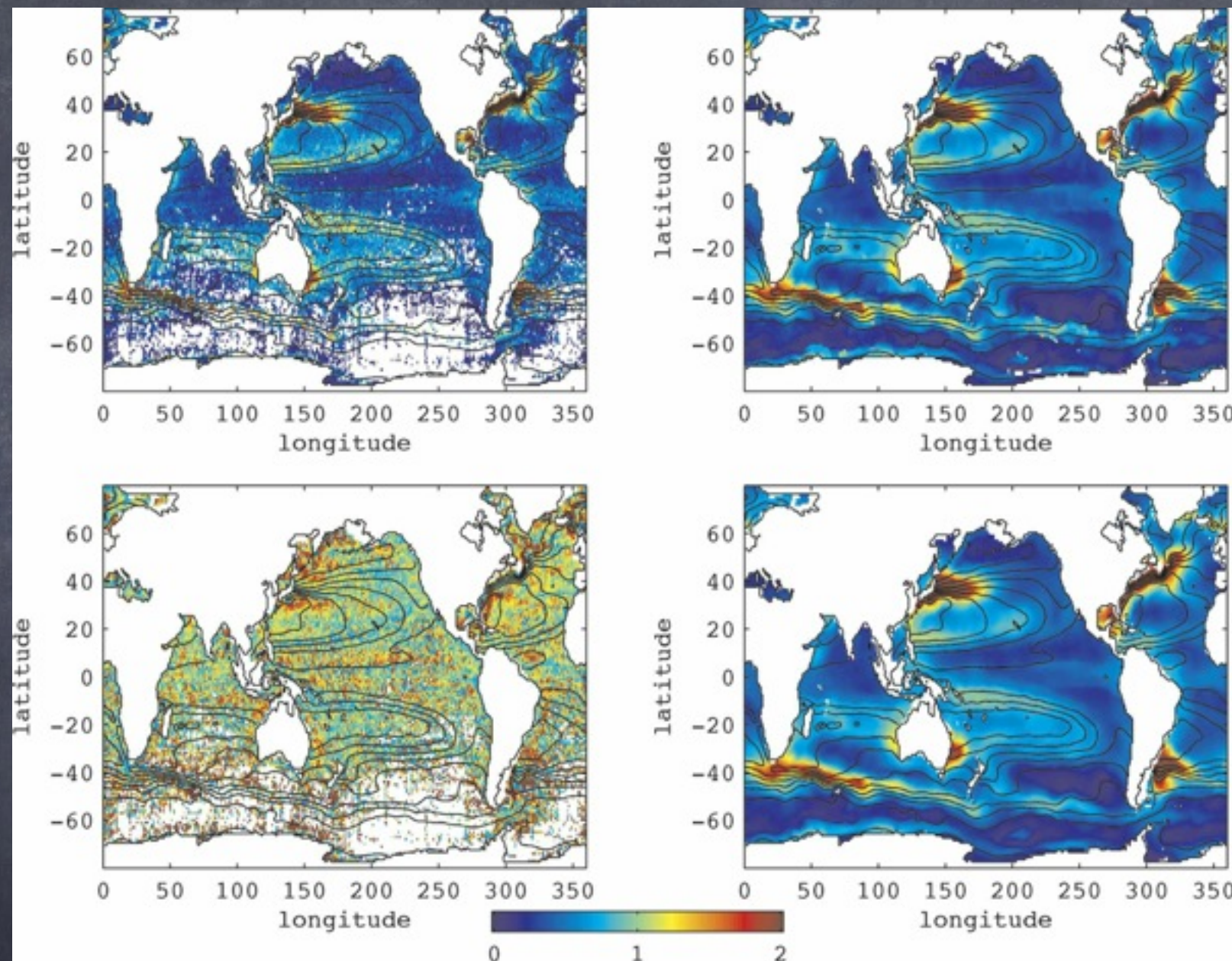


FIG. 3. Illustration of the methodology (see text) for T at 300 m: (top left) pointwise, (top right) mapped, and (bottom right) estimated standard deviations of T ($^{\circ}\text{C}$); and (bottom left) the ratio of the mapped to the pointwise standard deviations. Superimposed contours: annual mean climatological T ($\bar{T}$) from Stephens et al. (2002) with an interval of 2°C .

(Forget and Wunsch 2007)

(2) observational statistics

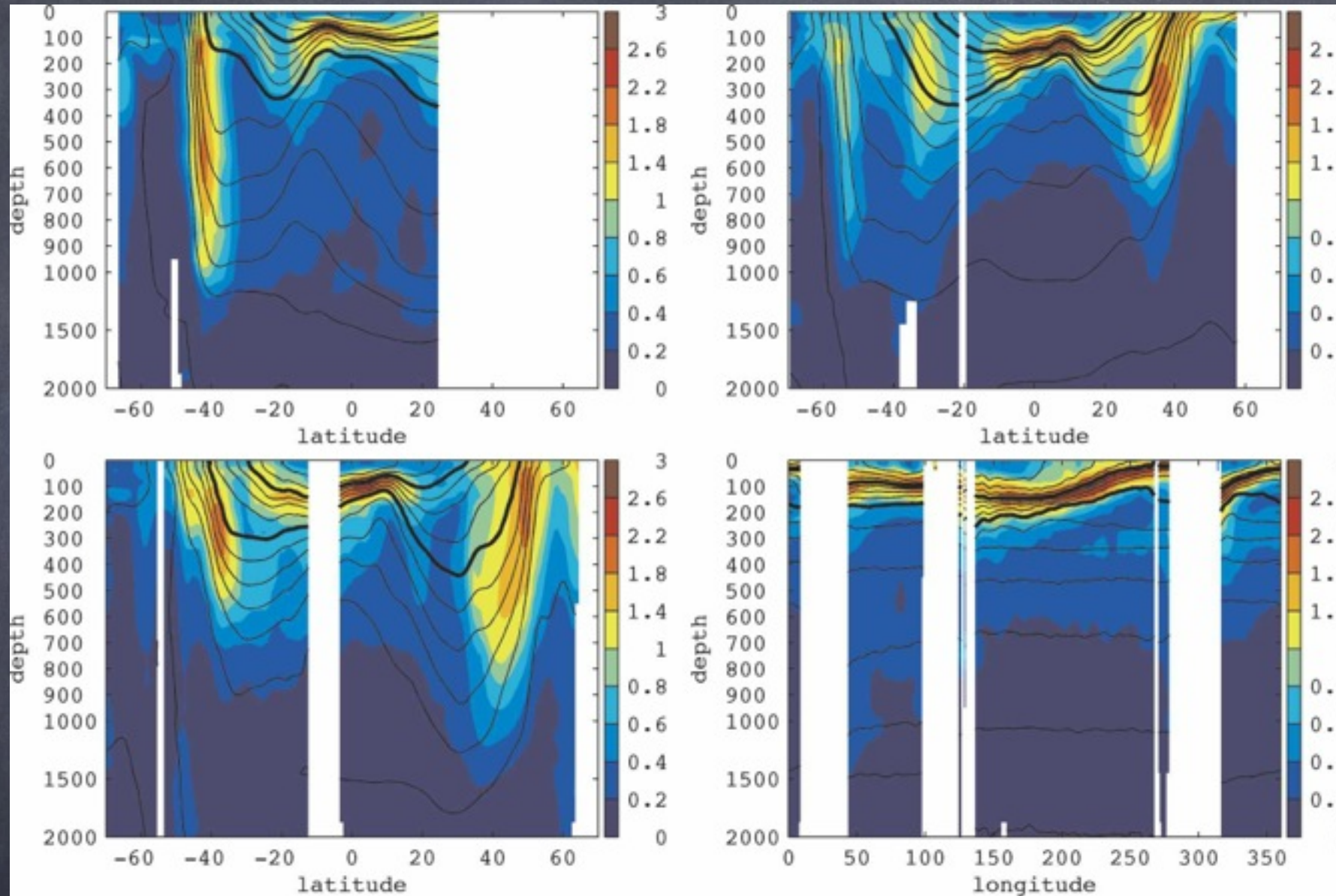
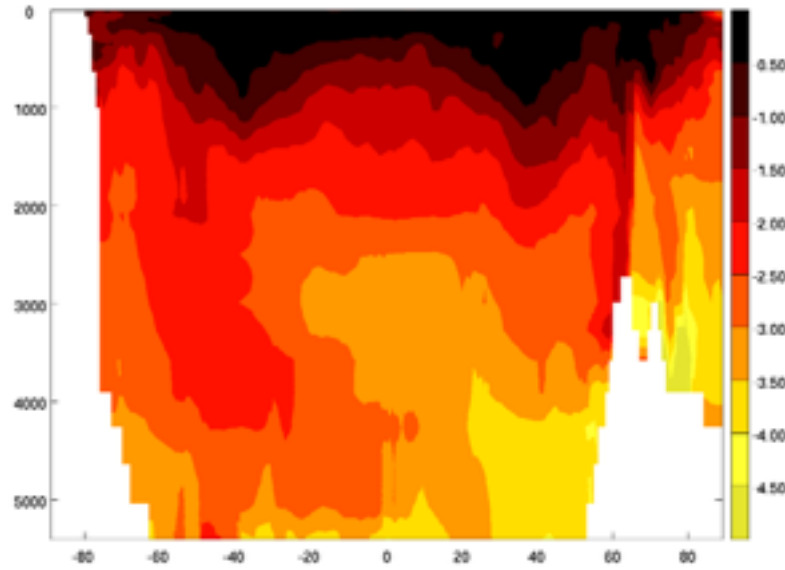


FIG. 5. Estimated standard deviation of T (σ_T ; °C; colors) in (top left) the Indian Ocean at 64.5°E, (top right) the Pacific Ocean at 164.5°E, (bottom left) the Atlantic Ocean at 322.5°E, and (bottom right) along the equator at 0.5°S. Superimposed contours: $\bar{T}$, with an interval of 2°C. Thick contours denote the $\bar{T} = 14^\circ\text{C}$ and $\bar{T} = 22^\circ\text{C}$ isotherms.

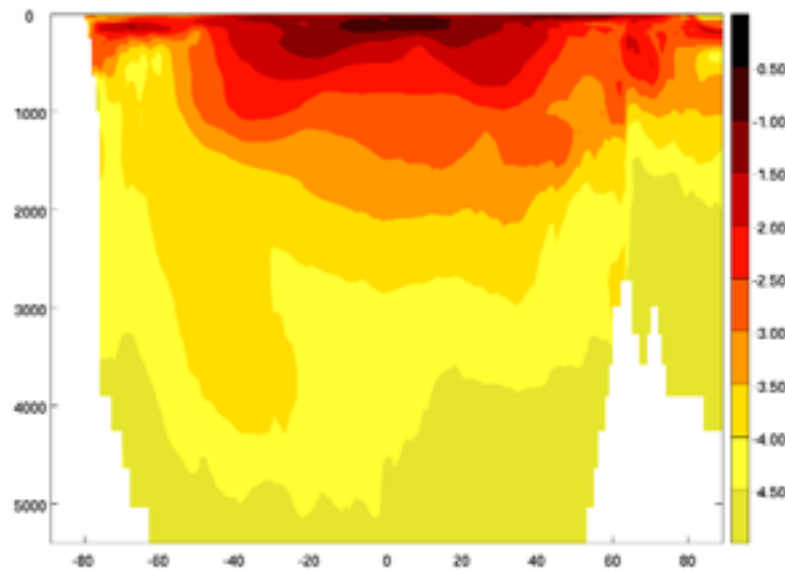
(Forget and Wunsch 2007)

(2) observational statistics

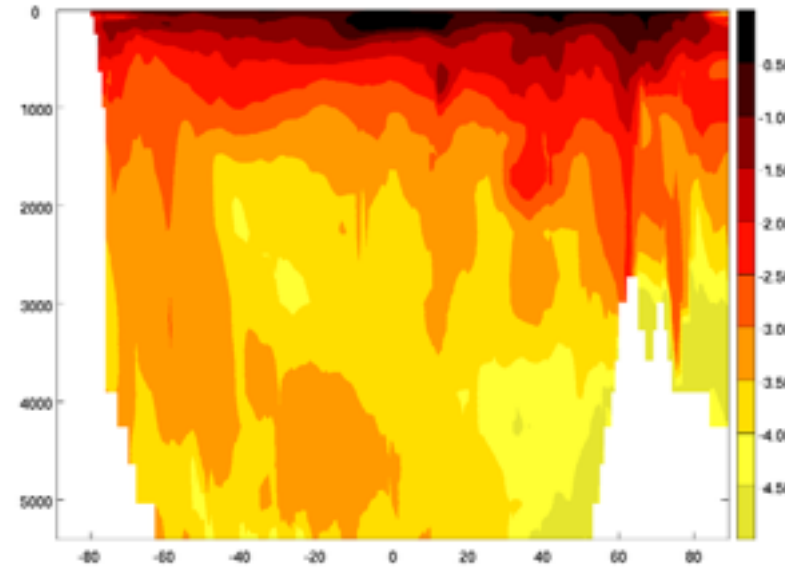
Observed



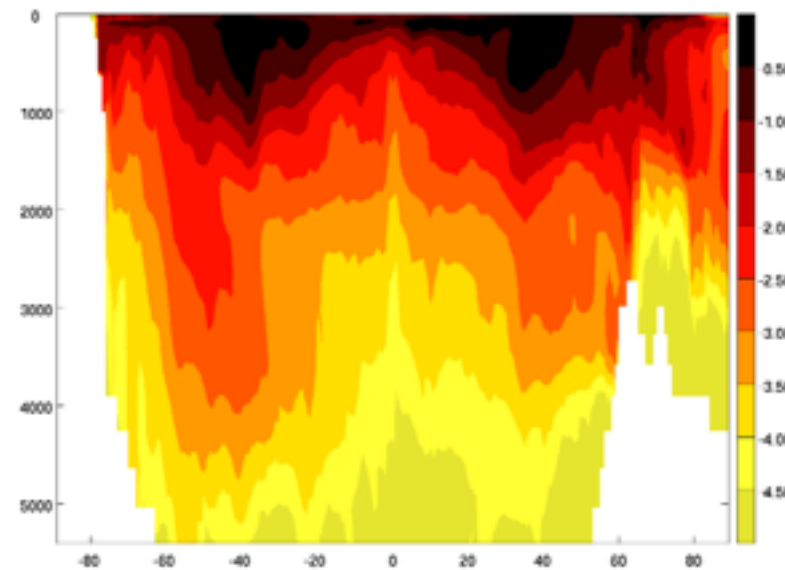
Internal waves
(Munk 1981)



Large-scale
Forced
responses
(ECCO)



Meso-scale
eddies
(MODEL)



(2) observational statistics

(Worthington 1981)

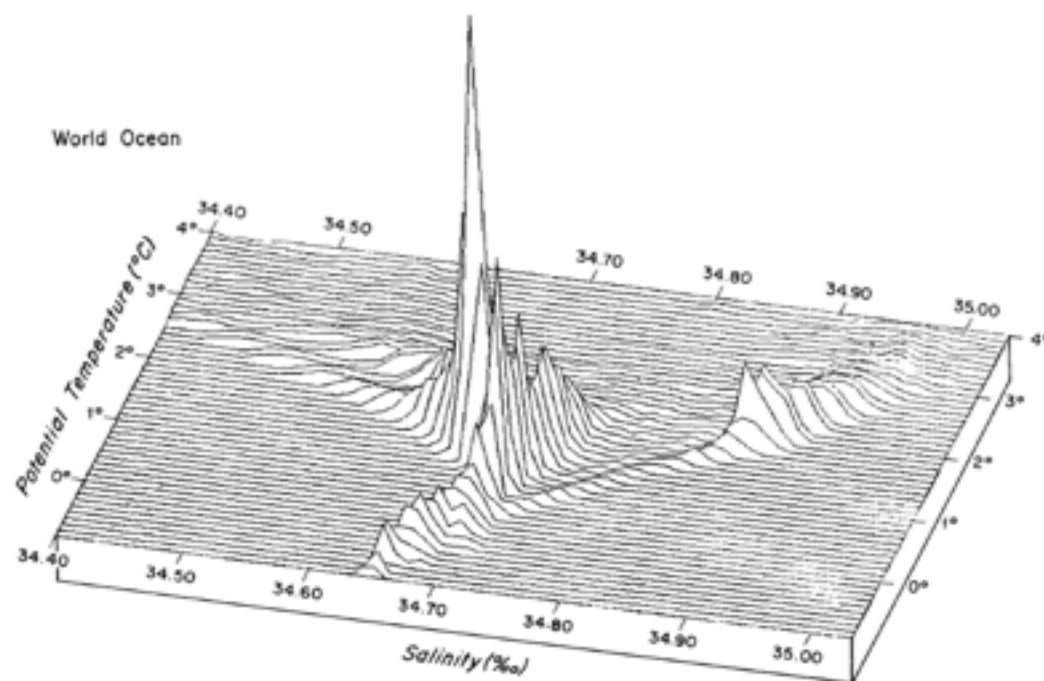
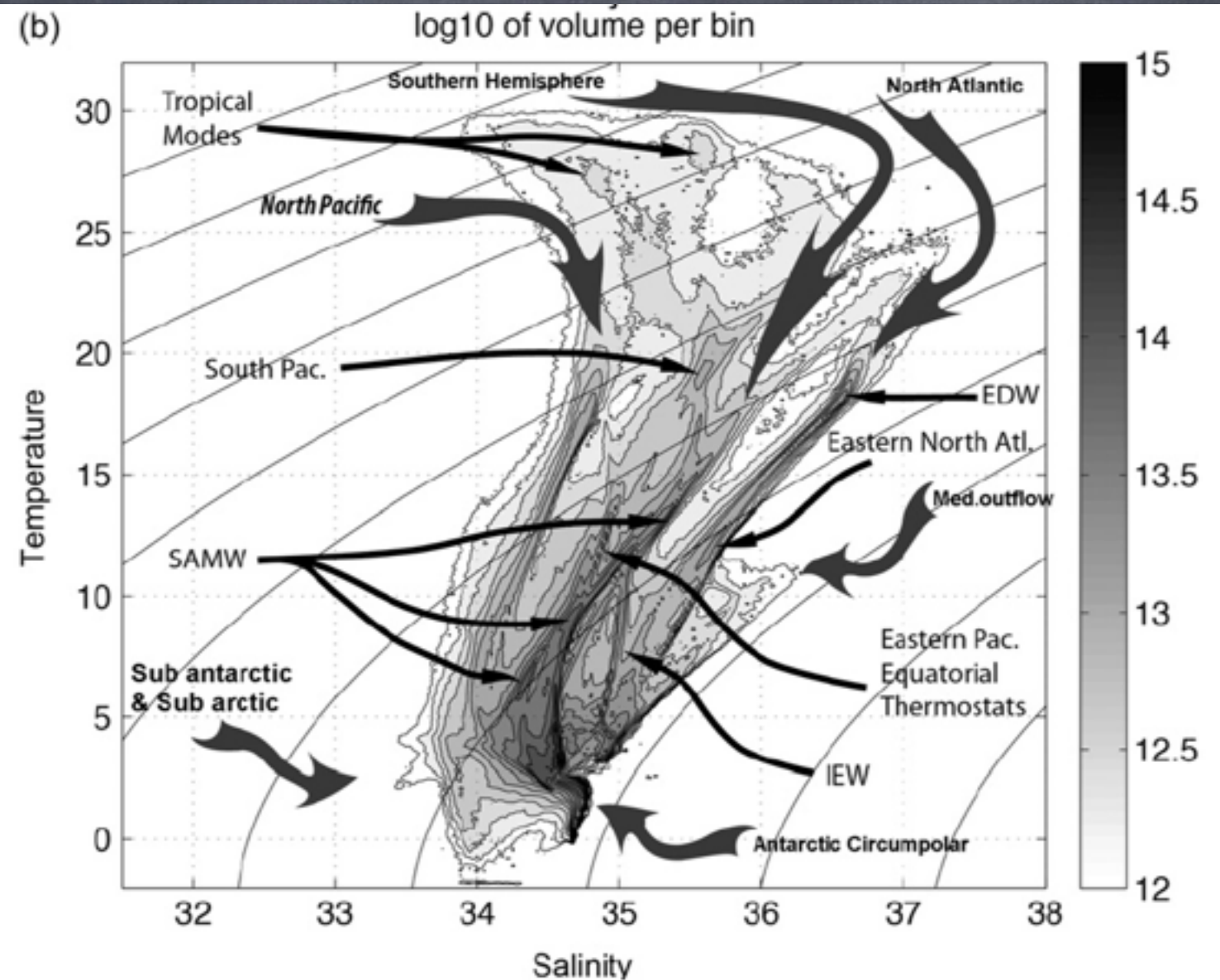
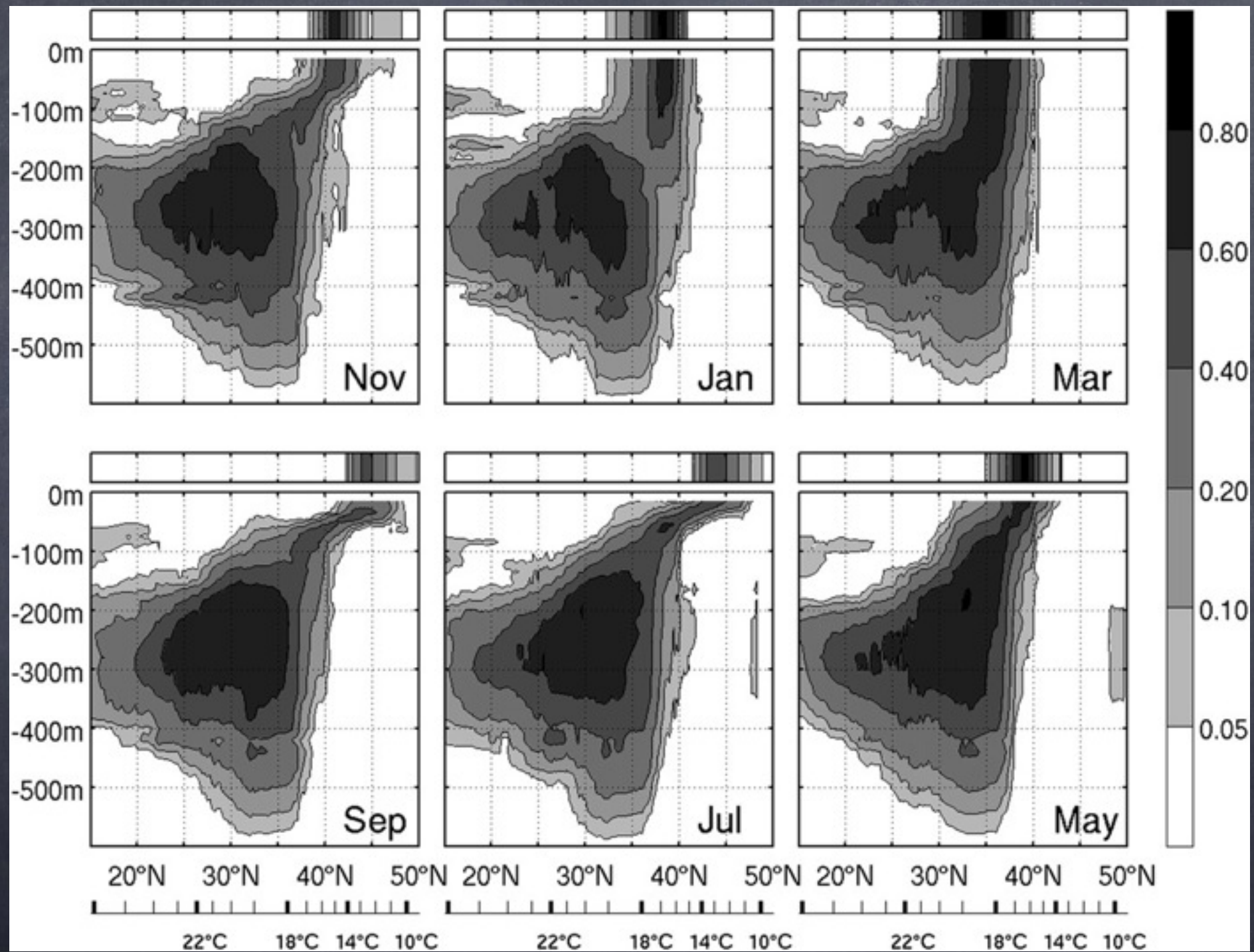


Figure 2.2 Simulated three-dimensional T-S diagram of the water masses of the world ocean. Apparent elevation is proportional to volume. Elevation of highest peak corresponds to $26.0 \times 10^6 \text{ km}^3$ per bivariate class $0.1^\circ\text{C} \times 0.01\text{‰}$.



(Speer and Forget 2013)

(2) observational statistics



(Forget et al. 2011)

(3) MITprof data sets

MITprof format Design:

- standardized data collections
- simple file format and usage
- complemented data sets

key MITprof features:

- standard depth level (prof_depth)
- weight profiles ($1/\sigma^2$ or 0 if 'bad data')
- model or climatology profiles (e.g. ECCO v4)

(3) MITprof data sets

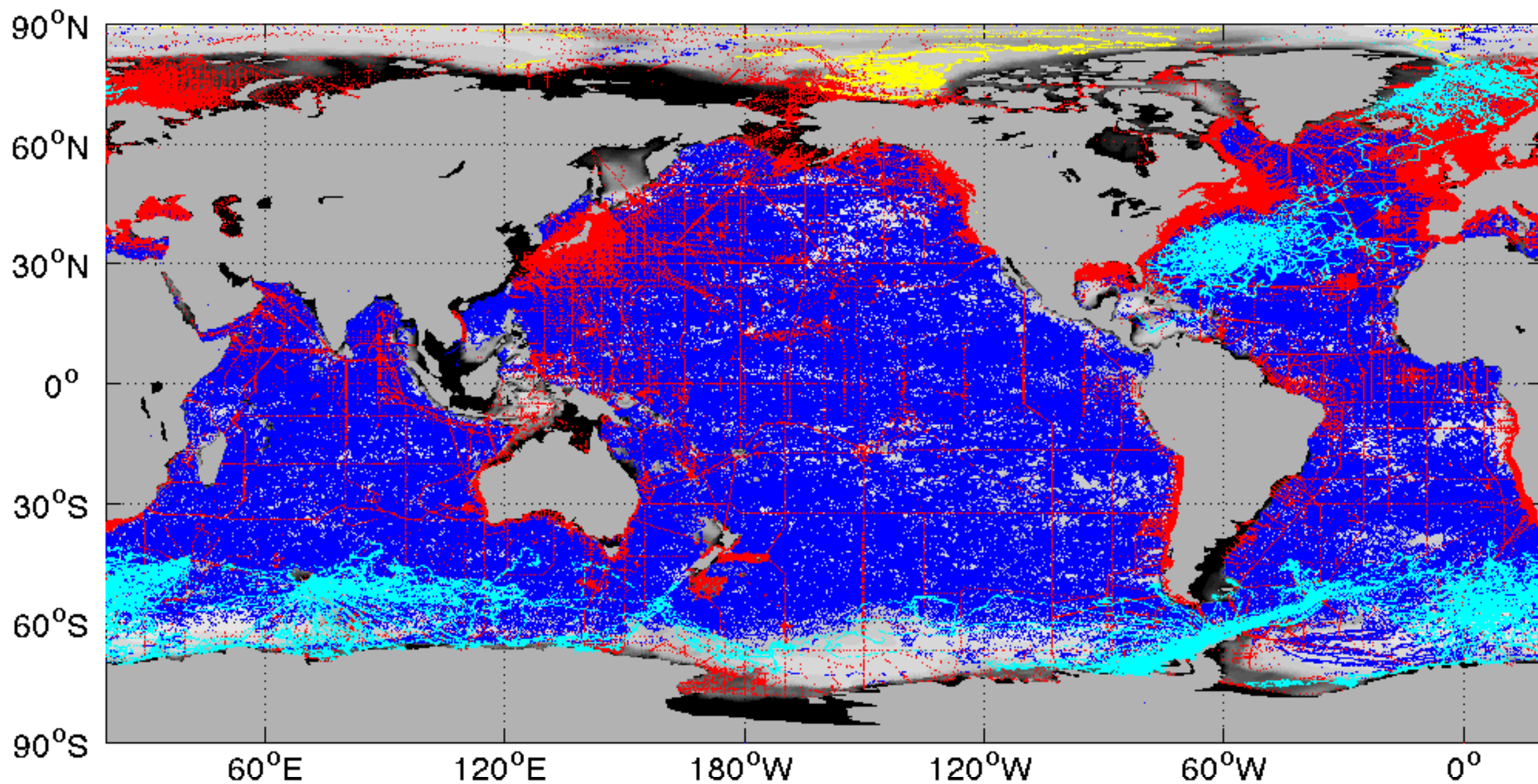


Figure F2. Standardized in situ profile data available in MITprof format from [Argo](#), [WOD CTD](#), [climode](#), [ITP](#), [seals](#) over 1992-2011. These are the in situ data that, along with WOD XBT data, are used in ECCO v4 release 1.

(3) MITprof data sets

Table 13: Netcdf file header illustrating the MITprof format used in MITgcm/pkg/profiles.

```
netcdf argo_feb2013_2008_to_2010 {
```

```
...
```

```
double prof_T(iPROF, iDEPTH) ;  
    prof_T:long_name = "potential temperature" ;  
    prof_T:units = "degree C" ;
```

```
double prof_Tweight(iPROF, iDEPTH) ;  
    prof_Tweight:long_name = "least-square weight" ;  
    prof_Tweight:units = "(degree C)-2" ;
```

```
double prof_Testim(iPROF, iDEPTH) ;  
    prof_Testim:long_name = "pot. temp. estimate" ;  
    prof_Testim:units = "degree C" ;
```

```
...
```

```
double prof_depth(iDEPTH) ;  
double prof_YYYYMMDD(iPROF) ;  
double prof_HHMMSS(iPROF) ;  
double prof_lon(iPROF) ;  
double prof_lat(iPROF) ;  
char prof_descr(iPROF, 1TXT) ;  
    prof_descr:long_name = "i
```

```
...
```

```
}
```

observed profiles

weight profiles

estimated profiles

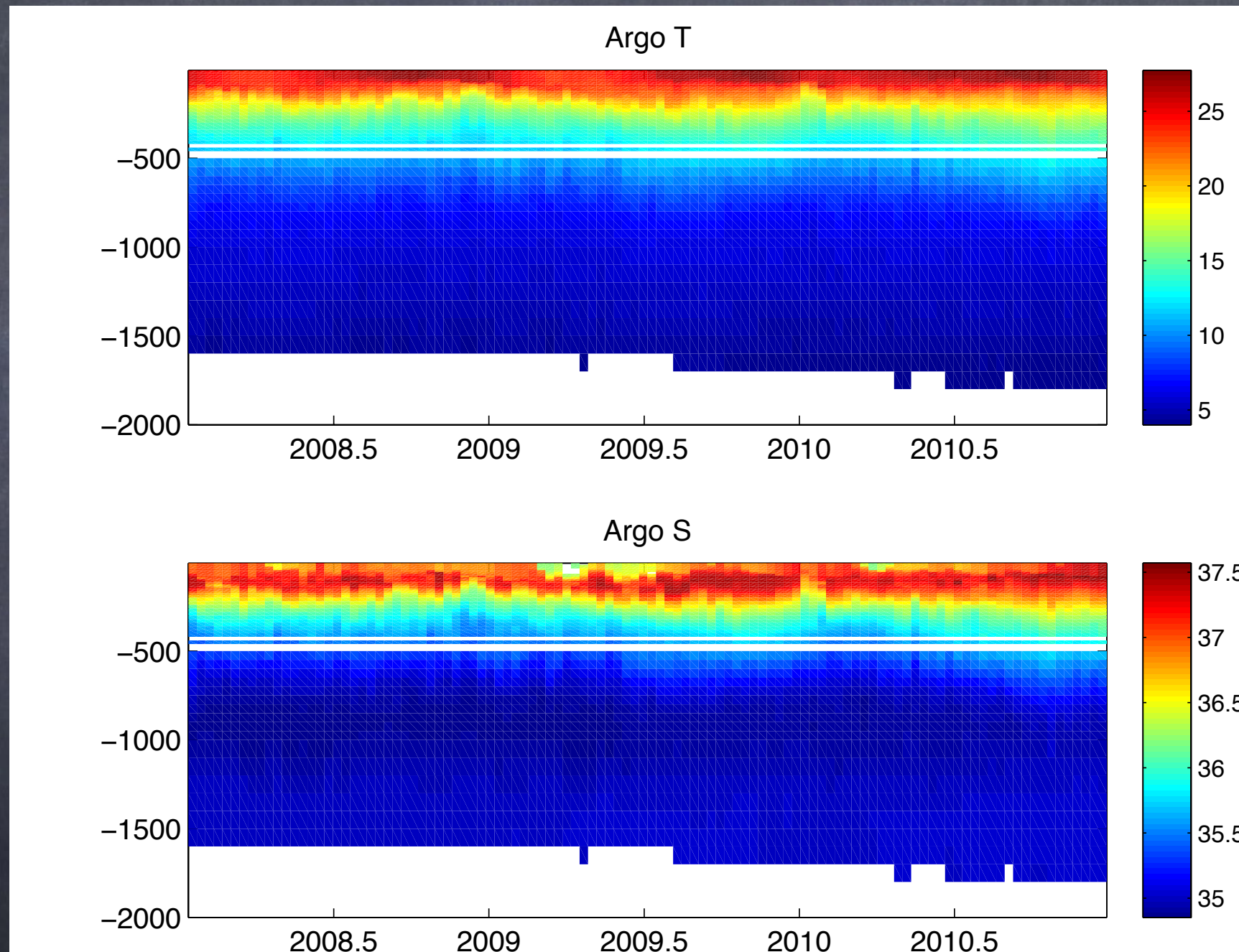
standard depth levels

location & date

identifier

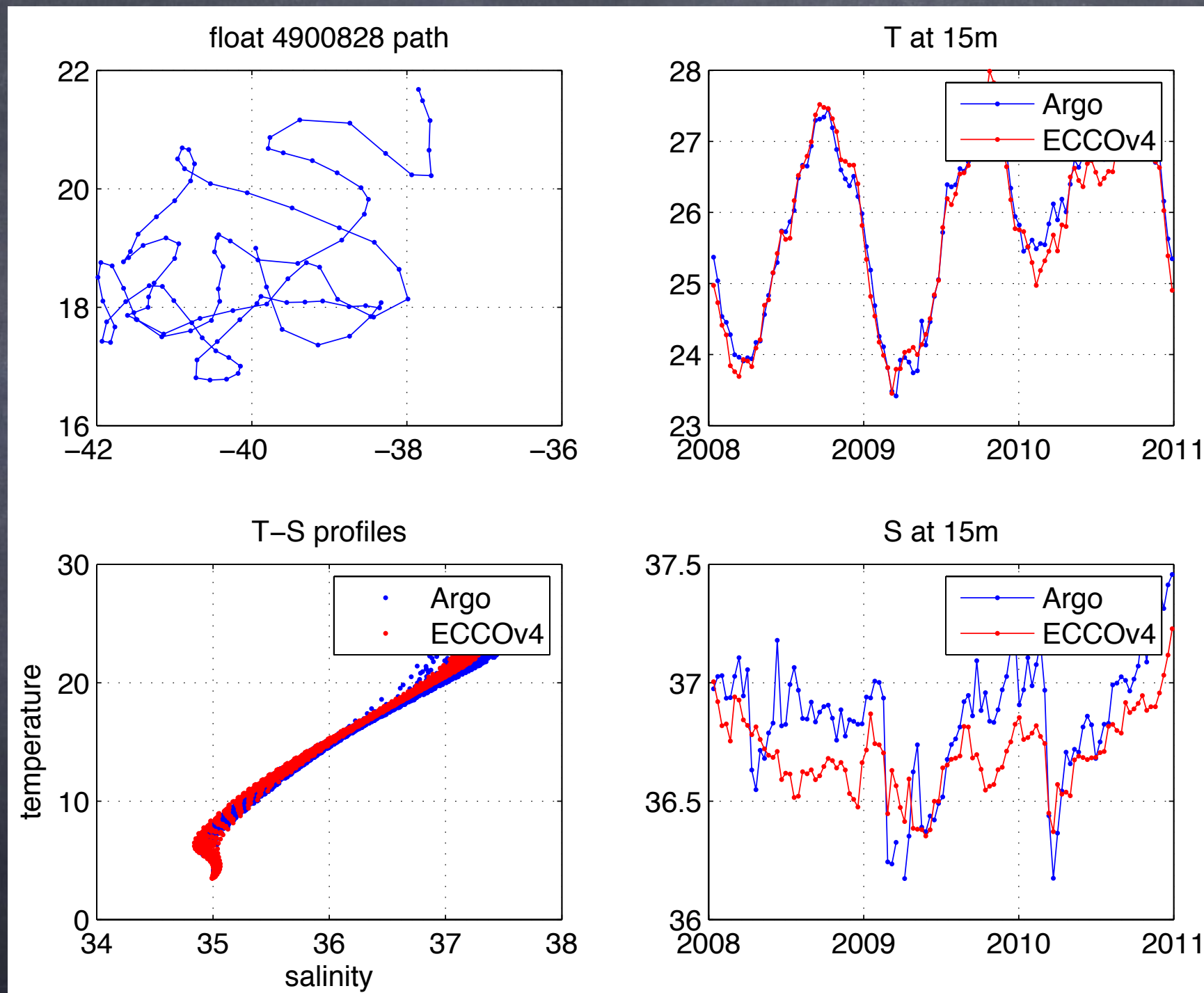
(Forget et al. 2015)

(3) MITprof data sets



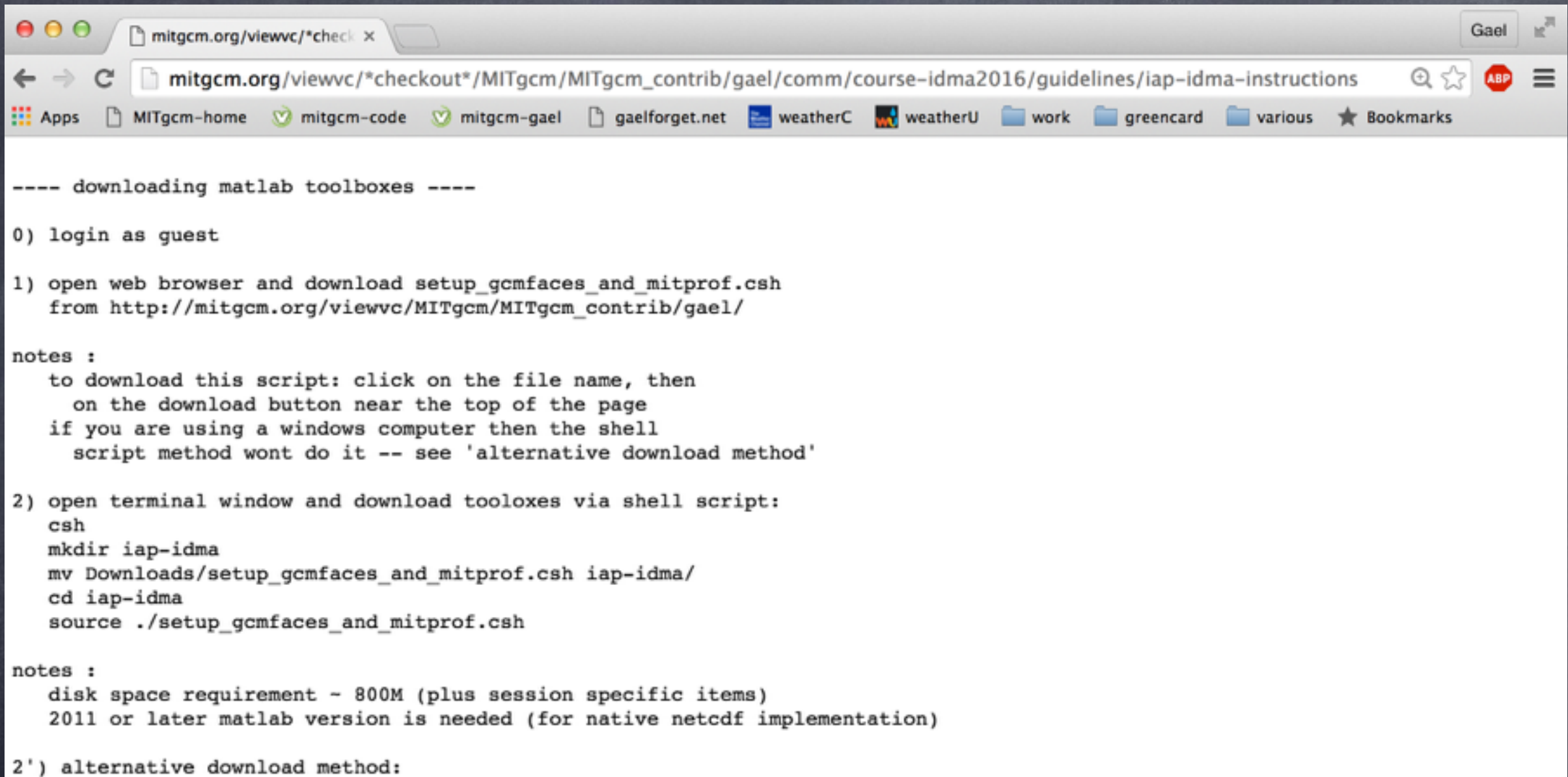
float # 4900828 (MITprof version)

(3) MITprof data sets



float # 4900828 (MITprof version)

(4) activity period



The screenshot shows a web browser window with the address bar displaying the URL: `mitgcm.org/viewvc/*checkout*/MITgcm/MITgcm_contrib/gael/comm/course-idma2016/guidelines/iap-idma-instructions`. The browser's bookmark bar is visible, showing various folders and links. The main content area of the browser displays a text-based instruction page. The text is as follows:

```
---- downloading matlab toolboxes ----

0) login as guest

1) open web browser and download setup_gcmfaces_and_mitprof.csh
   from http://mitgcm.org/viewvc/MITgcm/MITgcm_contrib/gael/

notes :
  to download this script: click on the file name, then
  on the download button near the top of the page
  if you are using a windows computer then the shell
  script method wont do it -- see 'alternative download method'

2) open terminal window and download toolboxes via shell script:
   csh
   mkdir iap-idma
   mv Downloads/setup_gcmfaces_and_mitprof.csh iap-idma/
   cd iap-idma
   source ./setup_gcmfaces_and_mitprof.csh

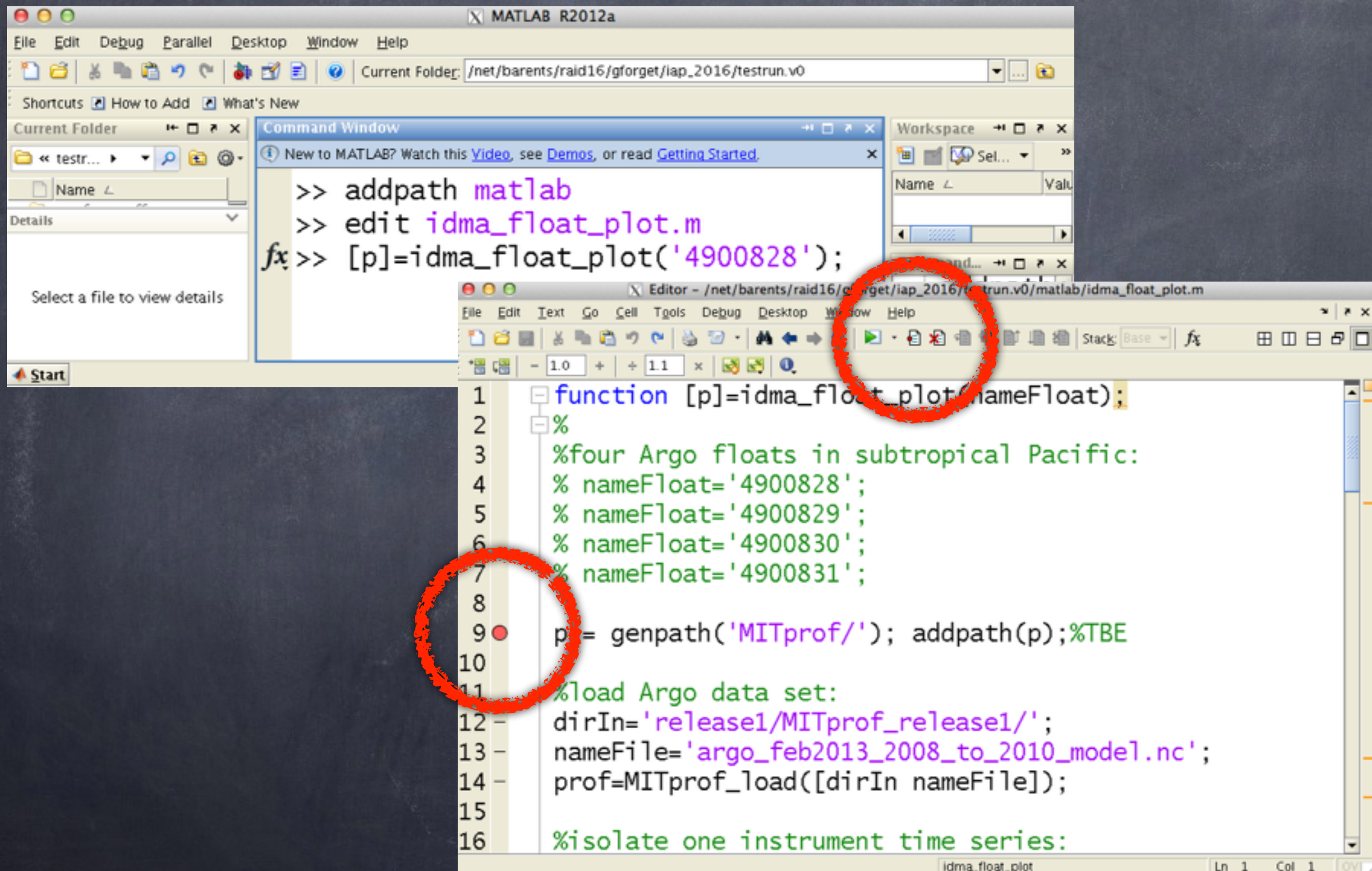
notes :
  disk space requirement - 800M (plus session specific items)
  2011 or later matlab version is needed (for native netcdf implementation)

2') alternative download method:
```

To get started: follow instructions @

http://mitgcm.org/viewvc/*checkout*/MITgcm/MITgcm_contrib/gael/comm/course-idma2016/guidelines/iap-idma-instructions

(4) activity period



The image shows the MATLAB R2012a interface. The Command Window displays the following commands:

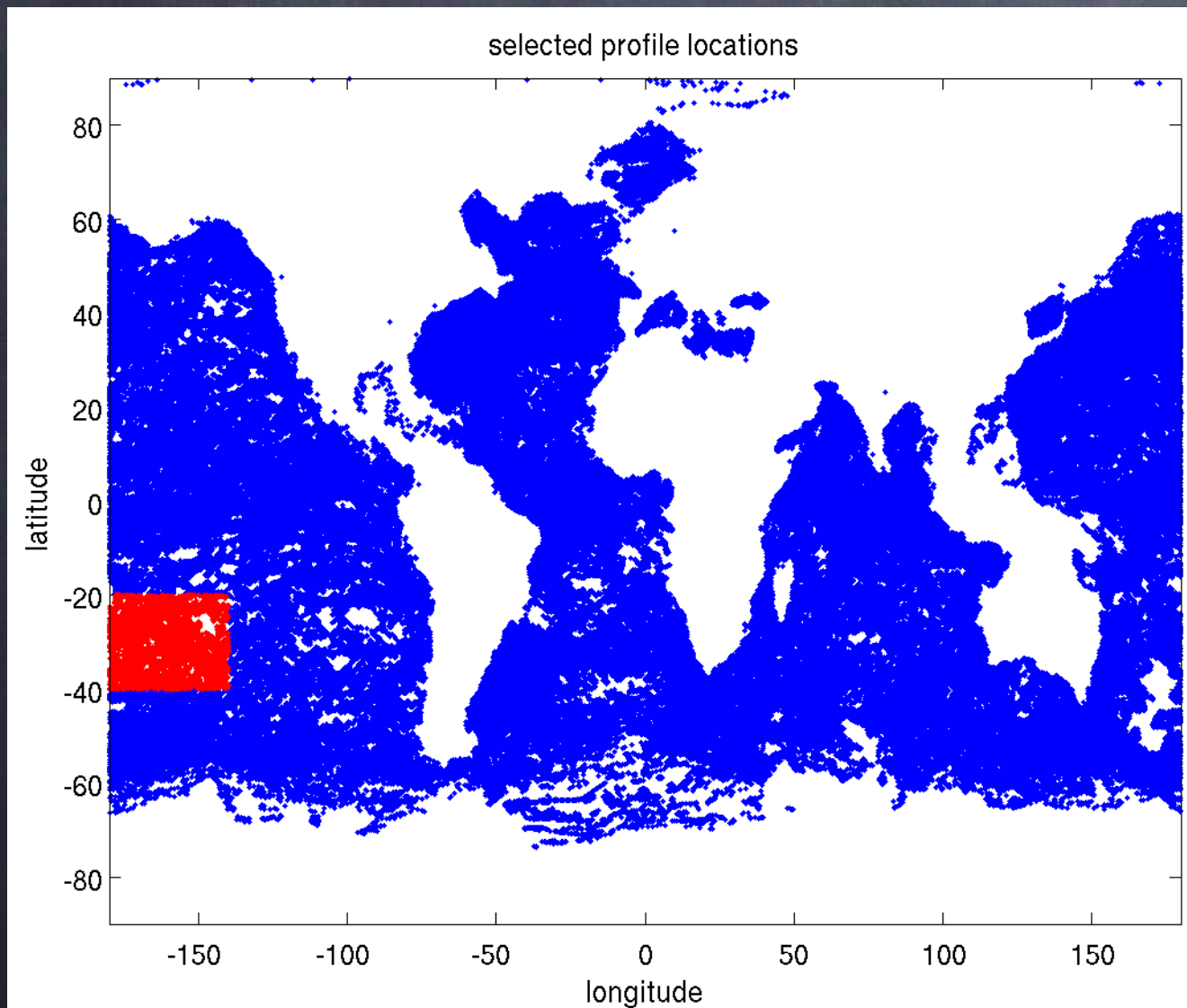
```
>> addpath matlab
>> edit idma_float_plot.m
fx>> [p]=idma_float_plot('4900828');
```

The Editor window shows the file `idma_float_plot.m` with the following code:

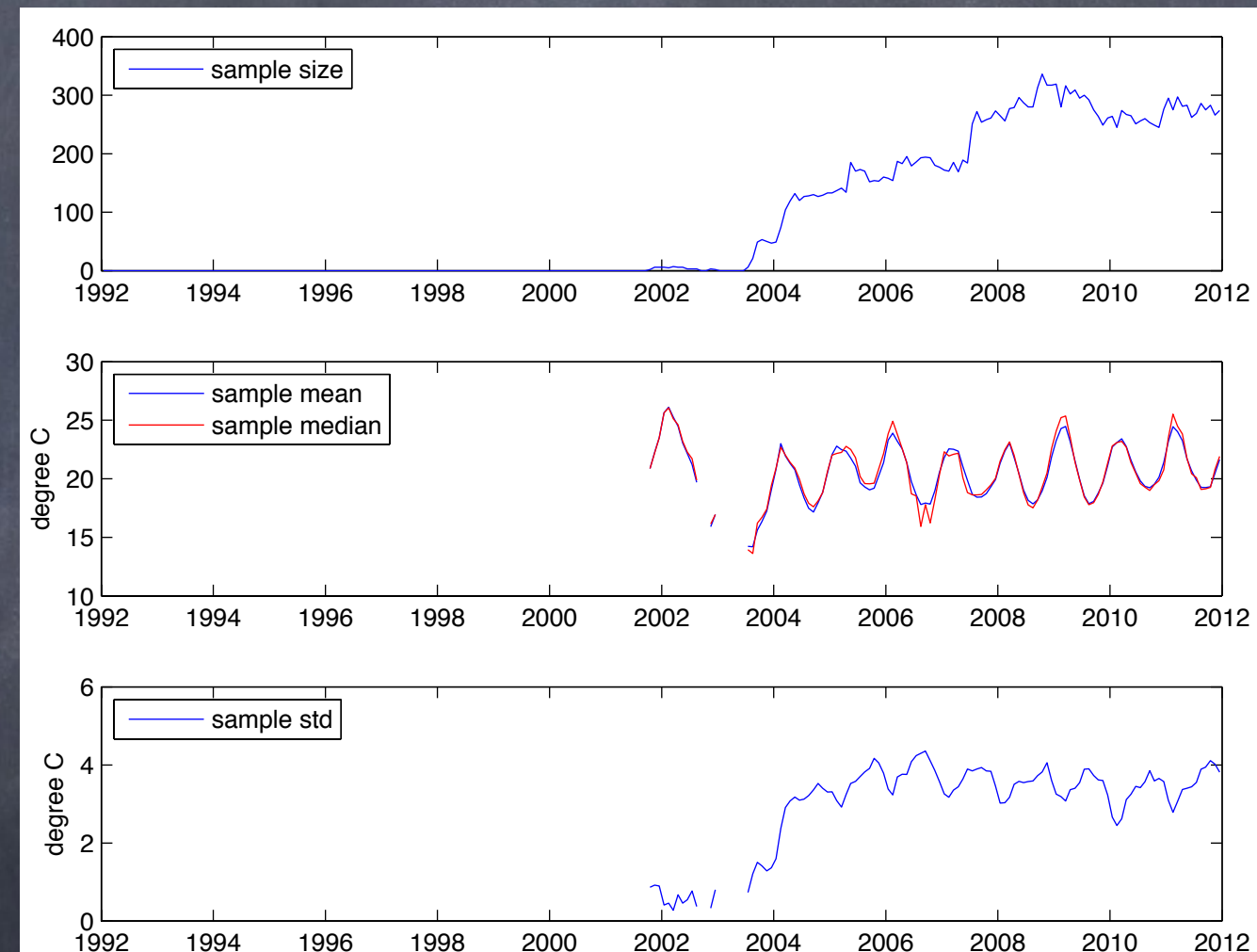
```
1 function [p]=idma_float_plot(nameFloat);
2 %
3 %four Argo floats in subtropical Pacific:
4 % nameFloat='4900828';
5 % nameFloat='4900829';
6 % nameFloat='4900830';
7 % nameFloat='4900831';
8
9 p = genpath('MITprof/'); addpath(p);%TBE
10
11 %load Argo data set:
12 dirIn='release1/MITprof_release1/';
13 nameFile='argo_feb2013_2008_to_2010_model.nc';
14 prof=MITprof_load([dirIn nameFile]);
15
16 %isolate one instrument time series:
```

Red circles highlight the Run button in the Command Window toolbar and the line number 9 in the Editor window.

(4) activity period

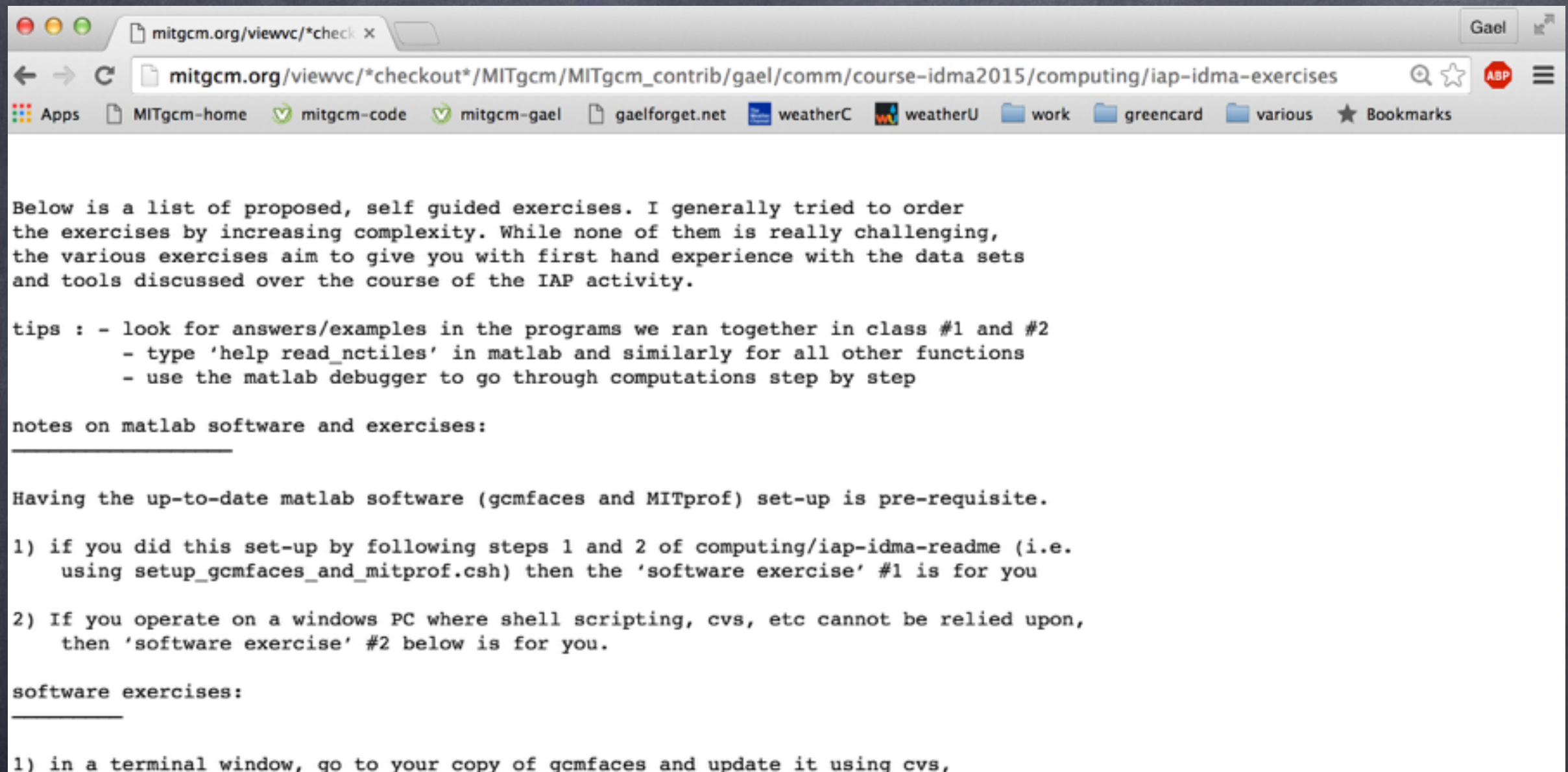


(idma_box_subset.m)



(idma_box_mean.m)

(4) activity period



Below is a list of proposed, self guided exercises. I generally tried to order the exercises by increasing complexity. While none of them is really challenging, the various exercises aim to give you with first hand experience with the data sets and tools discussed over the course of the IAP activity.

tips : - look for answers/examples in the programs we ran together in class #1 and #2
- type 'help read_nctiles' in matlab and similarly for all other functions
- use the matlab debugger to go through computations step by step

notes on matlab software and exercises:

Having the up-to-date matlab software (gcmfaces and MITprof) set-up is pre-requisite.

- 1) if you did this set-up by following steps 1 and 2 of computing/iap-idma-readme (i.e. using setup_gcmfaces_and_mitprof.csh) then the 'software exercise' #1 is for you
- 2) If you operate on a windows PC where shell scripting, cvs, etc cannot be relied upon, then 'software exercise' #2 below is for you.

software exercises:

- 1) in a terminal window, go to your copy of gcmfaces and update it using cvs,

Suggested exercise subjects are @

http://mitgcm.org/viewvc/*checkout*/MITgcm/MITgcm_contrib/gael/comm/course-idma2016/guidelines/iap-idma-exercises