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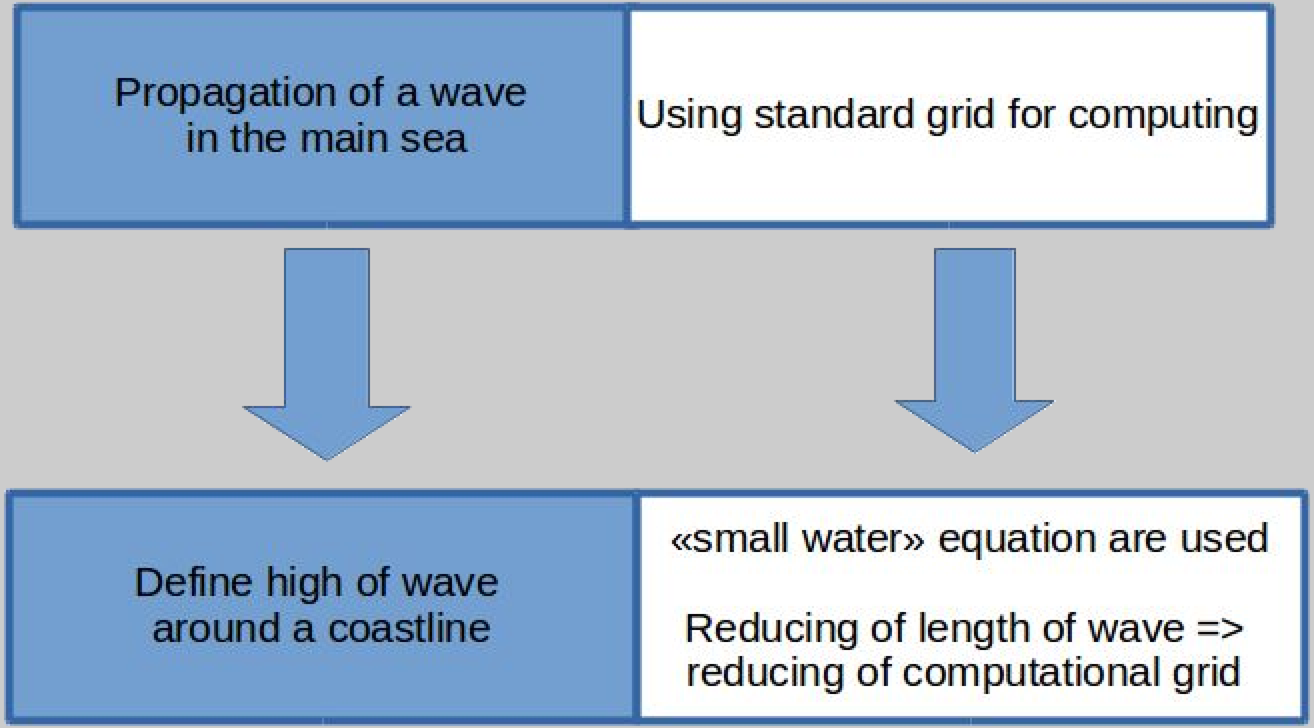
Processing of multidimensional data in distributed systems for solving the task of tsunami waves modeling

GRID’ 2016

Introduction

There are 2 stages of waves propagation and 2 computer modeling methods.



Propagation of a wave in the main sea

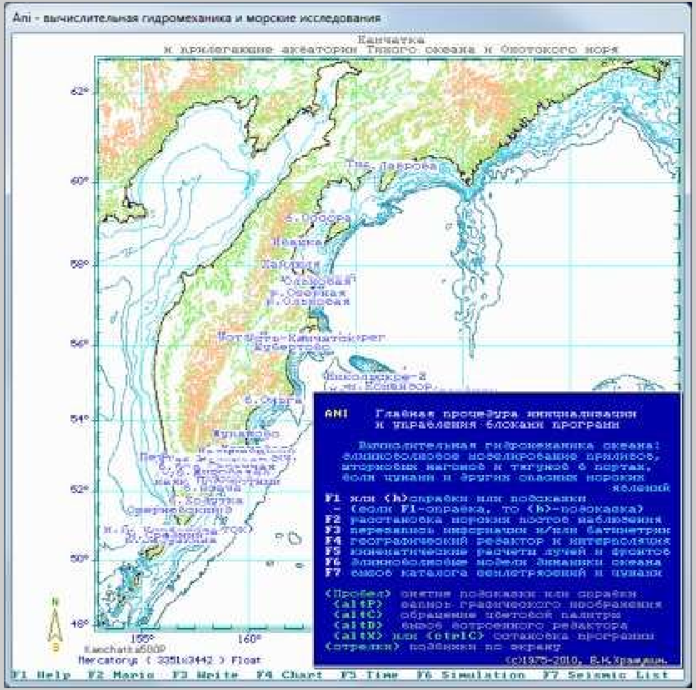
Using standard grid for computing

Define high of wave around a coastline

«small water» equation are used

Reducing of length of wave => reducing of computational grid

Existing solution



Ani - вычислительная гидромеханика и морские исследования
Камчатка
и прилегающие акватории Тихого океана и Охотского моря
62°
60°
58°
56°
54°
52°
50°
48°
155°
160°
N
Kamchatka500P
Mercator (3351x3442) Float
F1 Help
F2 Mario
F3 Write
F4 Chart
F5 Time
F6 Simulation
F7 Seismic List

```
ANI   Главная процедура инициализации
      и управления блоками программ

   Вычислительная гидромеханика океана:
  длинноволновое моделирование приливов,
  штормовых нагонов и тягунов в портах,
  волн цунами и других опасных морских
                                 явлений
F1 или (h)справки или подсказки
 - (если F1-справка, то (h)-подсказка)
F2 расстановка морских постов наблюдения
F3 перезапись информации и/или батиметрии
F4 географический редактор и интерполяция
F5 кинематические расчеты лучей и фронтов
F6 длинноволновые модели динамики океана
F7 выбор каталога землетрясений и цунами

<Пробел> снятие подсказки или справки
 (altP)  запись графического изображения
 (altC)  обращение цветовой палитры
 (altD)  вывод встроенного редактора
 (altX) или (ctrlC) остановка программы
(стрелки) движения по экрану
                  (c)1975-2010, В.Н.Храмушин.
```

- Works only for one node
- Bathymetry was full downloaded in RAM
- Only for Windows

Храмушин В. Н. Прямые вычислительные эксперименты для моделирования цунами, штормовых нагонов, экстремальных течений и приливного режима в открытом океане и вблизи побережья (г/р № 2010615848).

Our task

To develop tools for operative processing grid re-interpolation indicated area from bathymetry files for solve modeling tsunami tasks.

System requirements:

1. NetCDF files must have processing
2. Work with 14 gb files in operative memory
3. Selection of given section on the map for further operations (coordinates and required accuracy given by user)

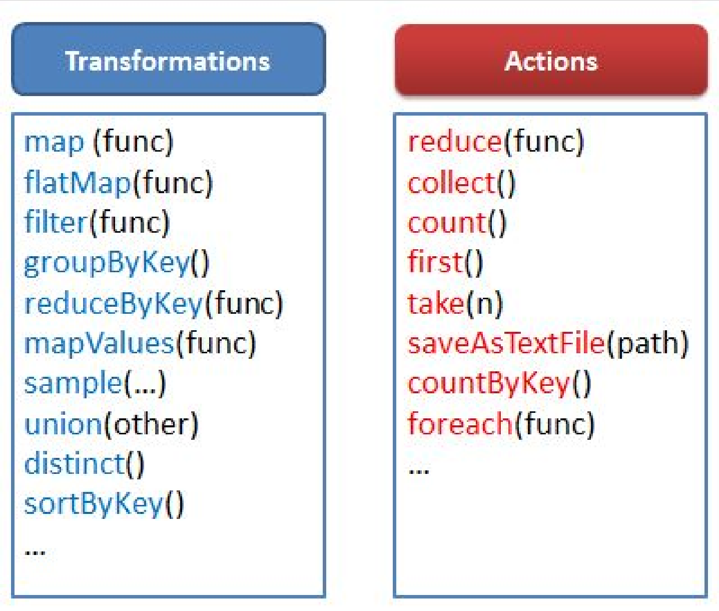
Why distributed computing?

- ✓ High speed
- ✓ Availability for big data processing
- ✓ Reliability and fault-tolerance

Our choice it is framework Apache Spark

Apache Spark implements that structure as RDD.

RDD - resilient distributed dataset for speed big data processing in operating memory.

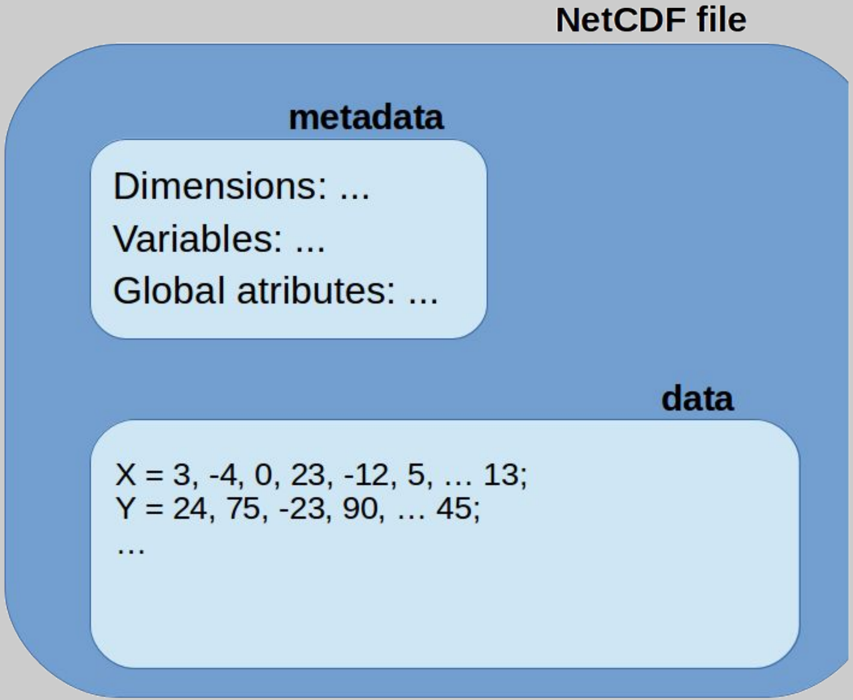


Transformations	Actions
map (func)	reduce(func)
flatMap(func)	collect()
filter(func)	count()
groupByKey()	first()
reduceByKey(func)	take(n)
mapValues(func)	saveAsTextFile(path)
sample(...)	countByKey()
union(other)	foreach(func)
distinct()	...
sortByKey()	
...	

Some problems...

- ✓ Spark is designed for streaming and non-structure data processing

- ✓ NetCDF format use metadata and multidimensional arrays and require random access to file



NetCDF file

metadata

Dimensions: ...
Variables: ...
Global atributes: ...

data

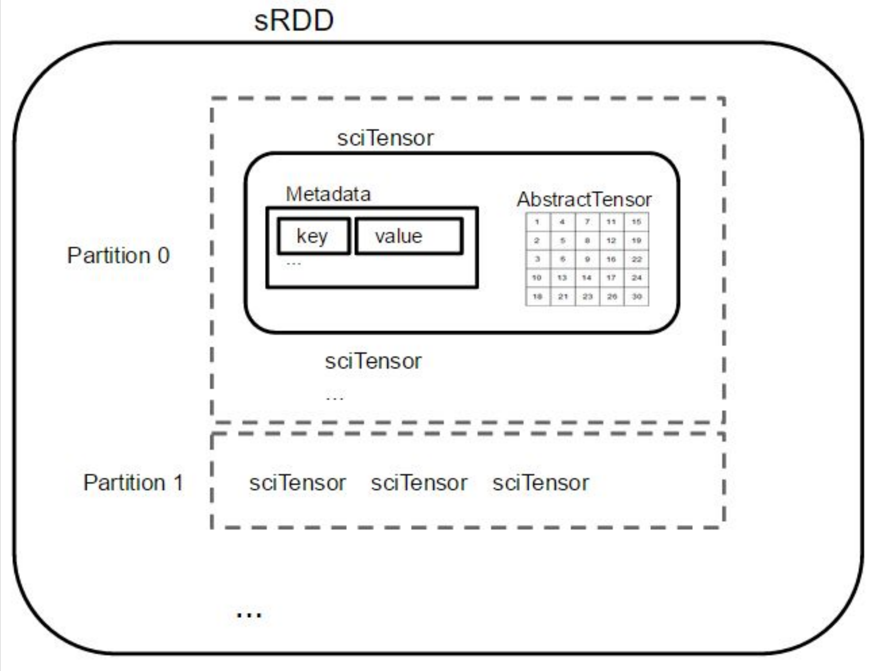
X = 3, -4, 0, 23, -12, 5, … 13;
Y = 24, 75, -23, 90, … 45;
…

One of solutions

At the moment there are several solutions for processing data in NetCDF format on big-data systems (Hadoop and Spark). For Spark it is SciSpark library.

SciSpark - project supported by Apache Foundation and NASA Laboratory, that works with NetCDF files used linear algebra libraries (Breeze and ND4J).

sRDD - distributed dataset, oriented on the scientific data processing, in particular NetCDF.



1	4	7	11	15
2	5	8	12	19
3	6	9	16	22
10	13	14	17	24
18	21	23	26	30

Advantages and disadvantages

- 😊 First available solution for processing geodata in Spark
- 😊 Support metadata and multidimensional arrays

- 😟 No official documentation: mans, tutorials, etc.
- 😟 Raw state of the product

Data

Data for processing: file with Earth’s topography

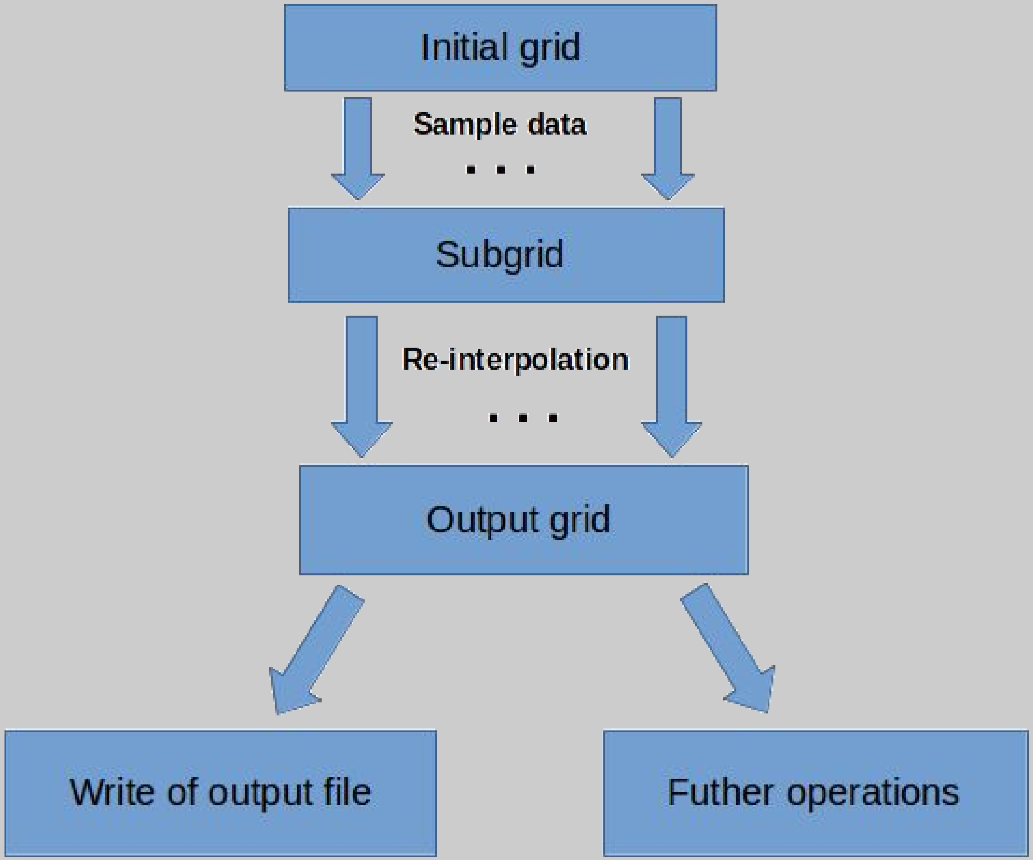
Source: ftp://topex.ucsd.edu/pub/srtm15_plus/

Data Size: 14 Gb

Step of the grid: 15 seconds

Data origin: the data given by processing of result altimetry survey from satellites CryoSat-2, Jason-1 and etc.

Block-scheme of the program



Initial grid

Sample data

. . .

Subgrid

Re-interpolation

. . .

Output grid

Write of output file

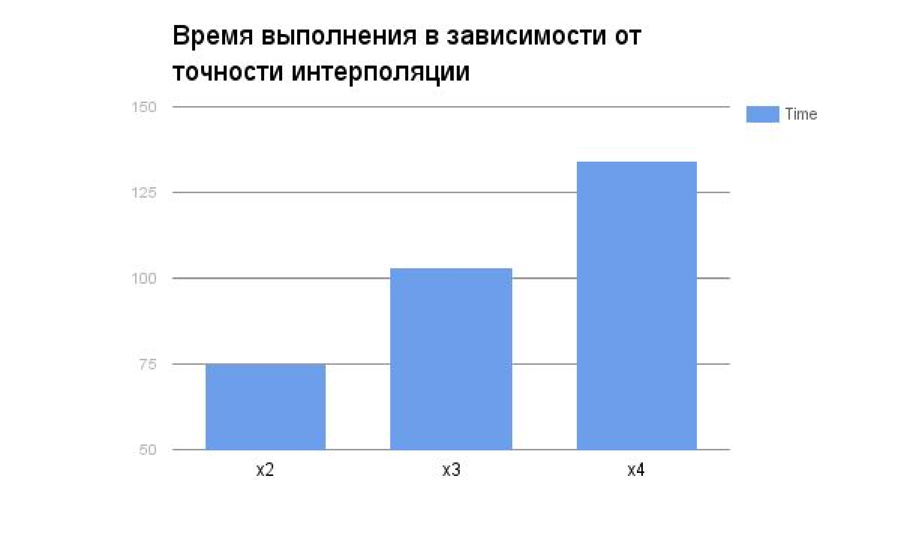
Futher operations

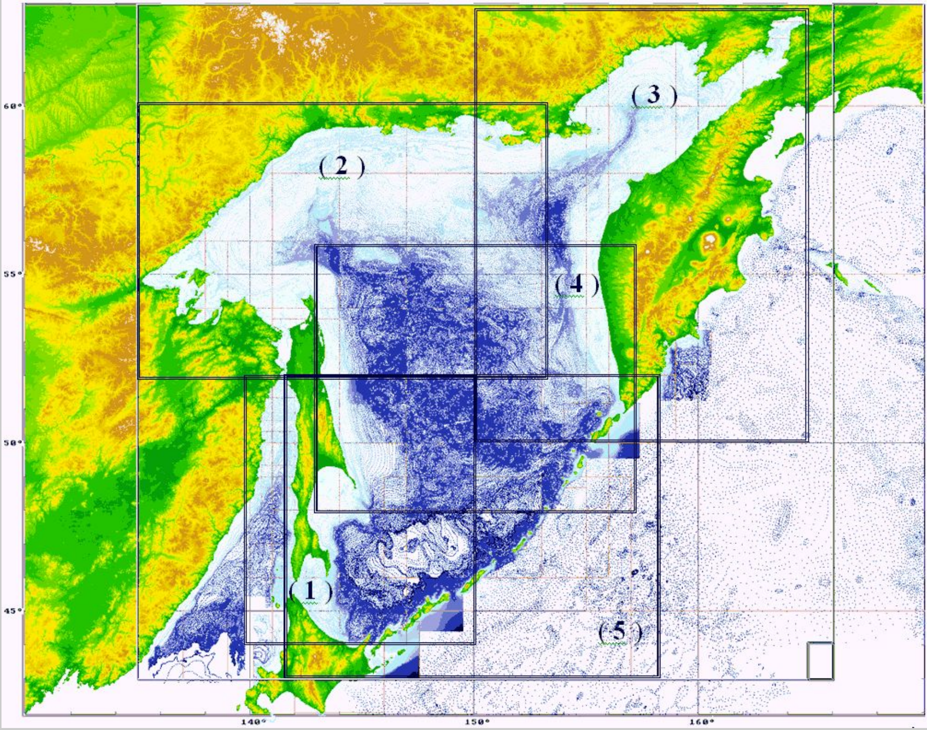
Cluster configuration

CPU	Intel Xeon E5440, 2,83GHz
RAM	4Gb
HDD	ST3250310NS, 7200
Number of nodes	12
Number of cores per node	8
Software	Spark 1.6.0 + GlusterFS 3.6.3

Results

1 file ~50Mb. Grid 30x15 degrees. (7200x3600). Sample for interpolation 10x10 degrees.





Thank you for your attention!
Questions?