SEEK: Science Environment for Ecological Knowledge

Experiences in Integration of the 'R' System into Kepler

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http://seek.ecoinformatics.org
http://www.kepler-project.org

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What is 'R' ?

"R is a language and environment for statistical computing and graphics. It is a GNU project which is similar to the S language and environment which was developed at Bell Laboratories (formerly AT&T, now Lucent Technologies) by John Chambers and colleagues. R can be considered as a different implementation of S. There are some important differences, but much code written for S runs unaltered under R."

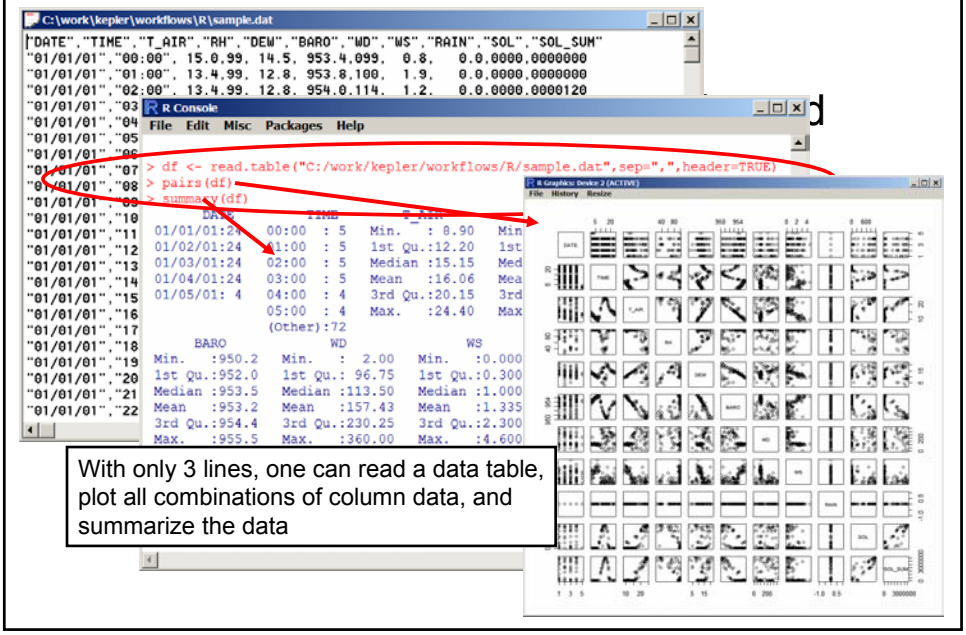
"R provides a wide variety of statistical (linear and nonlinear modelling, classical statistical tests, time-series analysis, classification, clustering, ...) and graphical techniques, and is highly extensible. The S language is often the vehicle of choice for research in statistical methodology, and R provides an Open Source route to participation in that activity."

From the R Project Web page - http://www.r-project.org/

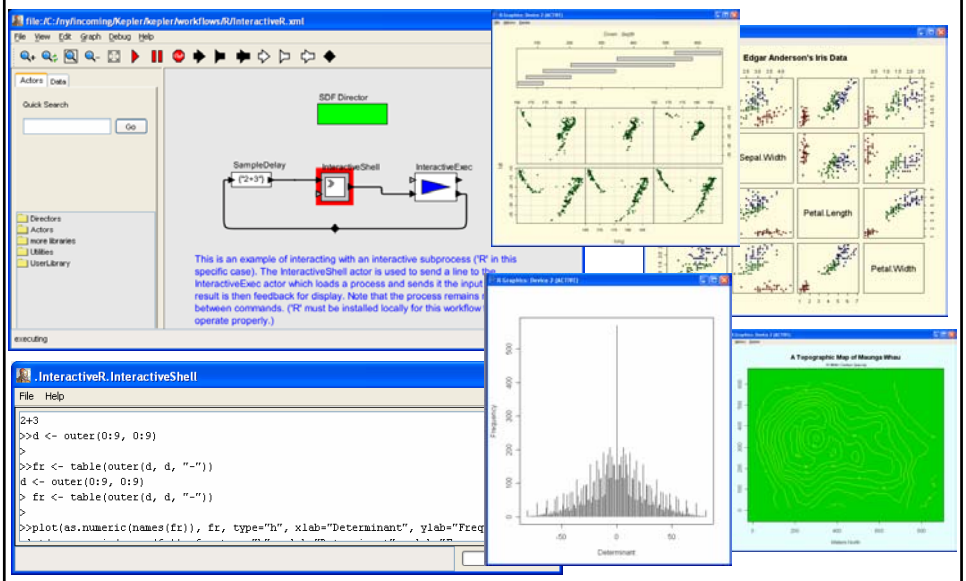
Ptolemy/Kepler and R

- R language has many similarities to the PTII/Kepler expression language
- R language emphasizes operations on vectors, matrices, and tables (in R, 'data frames') rather than scalars. (This eliminates many explicit looping statements)
- Many detailed statistical operations and data manipulation routines already exist in R
- R has ability to create sophisticated graphic displays
- Being able to call R routines from Kepler would greatly simplify many workflows

R Example



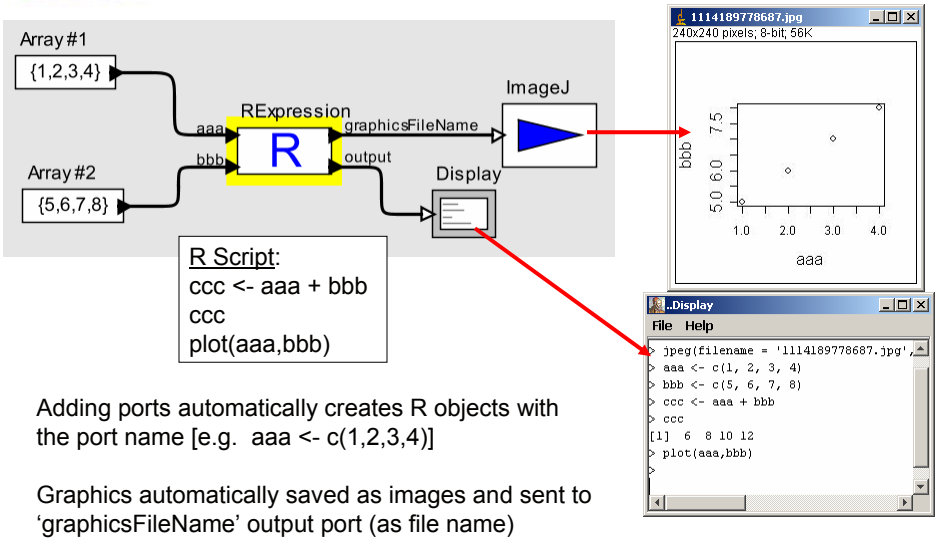
Interactive R in Kepler



Efforts to R in Kepler

- First Effort --- Interactive R actor
  - No real advantage over existing R console
- Use of Command Line Actor
  - Problems: R initialization
  - How to get data in/out ? (files)
  - How to display graphics ? (files)
- RExpression actor
  - Use concepts from Kepler/PT Expression language/actor
- Using RServer

RExpression Actor

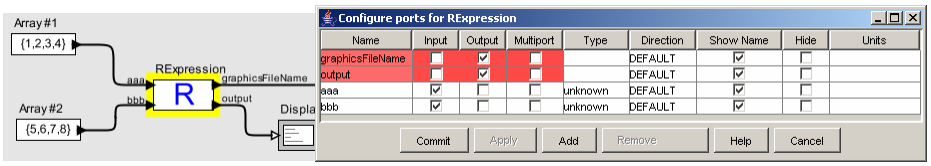


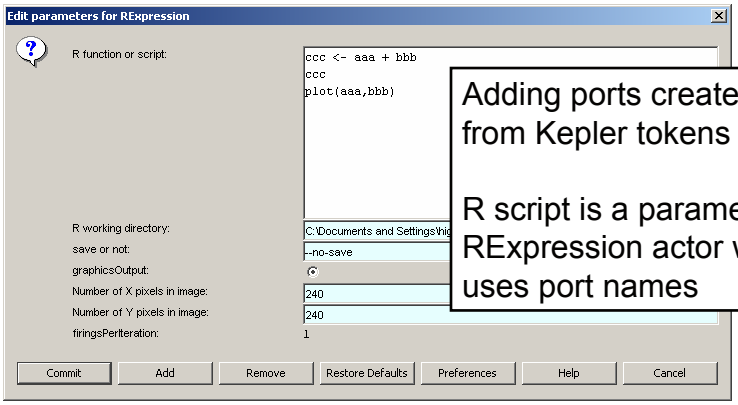
Adding ports automatically creates R objects with the port name [e.g. aaa <- c(1,2,3,4)]

Graphics automatically saved as images and sent to 'graphicsFileName' output port (as file name)

R text output automatically sent to 'output' port

RExpression – Ports & Parameters





Adding ports creates R objects from Kepler tokens

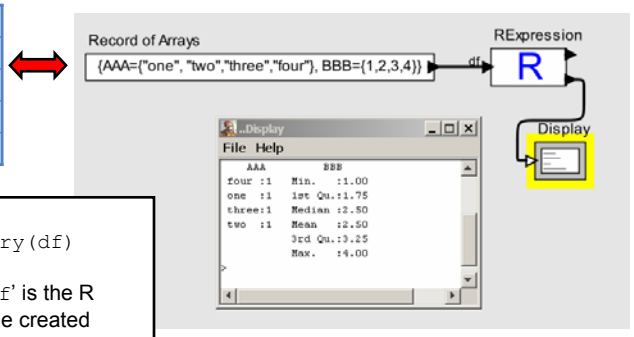
R script is a parameter of the RExpression actor which uses port names

Array Records and Data Frames

Tables are represented as ‘Data Frame’ objects in ‘R’

A Ptolemy ‘Record of Arrays’ can also represent a table

AAA	BBB
one	1
two	2
three	3
four	4



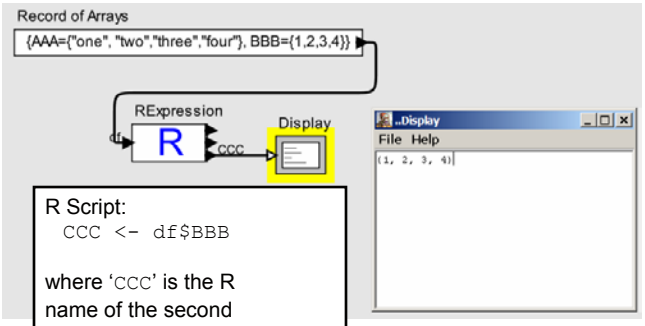
R Script:

```
summary(df)
```

where ‘df’ is the R dataframe created automatically when a record of arrays is passed to an input port

RExpression Output Ports

R vectors can also be assigned to output ports

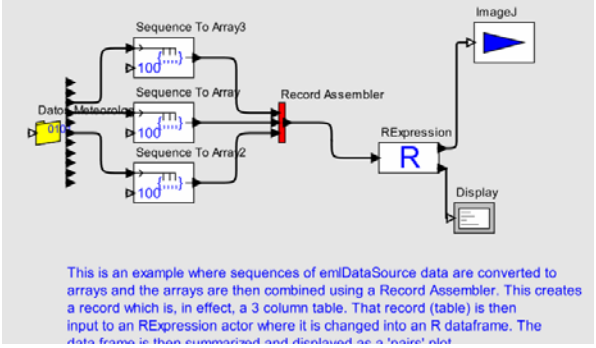


R Script:

```
CCC <- df$BBB
```

where ‘CCC’ is the R name of the second column of the dataframe

EML DataSource Sequence Inputs

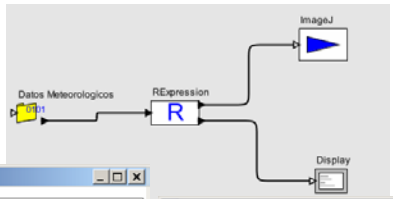


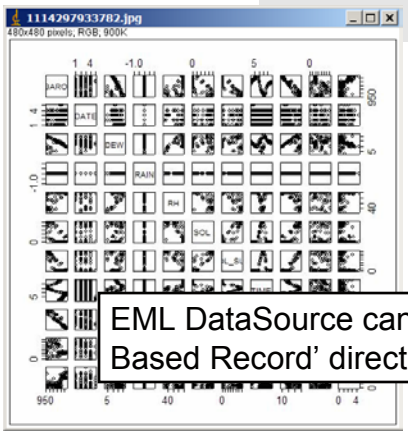
EML DataSource actor provides table data from SEEK Ecogrid

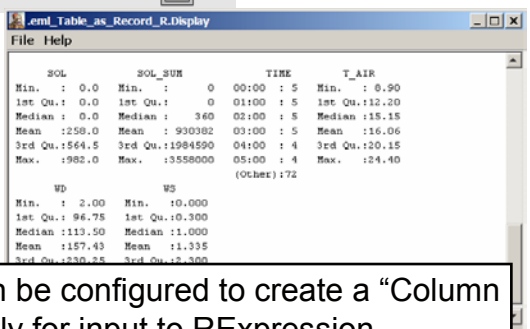
Column data from table can be supplied in various ways

Sequences of tokens from EML DataSource can be converted to arrays and then to a Record for input to RExpression

EML DataSource as Column Record

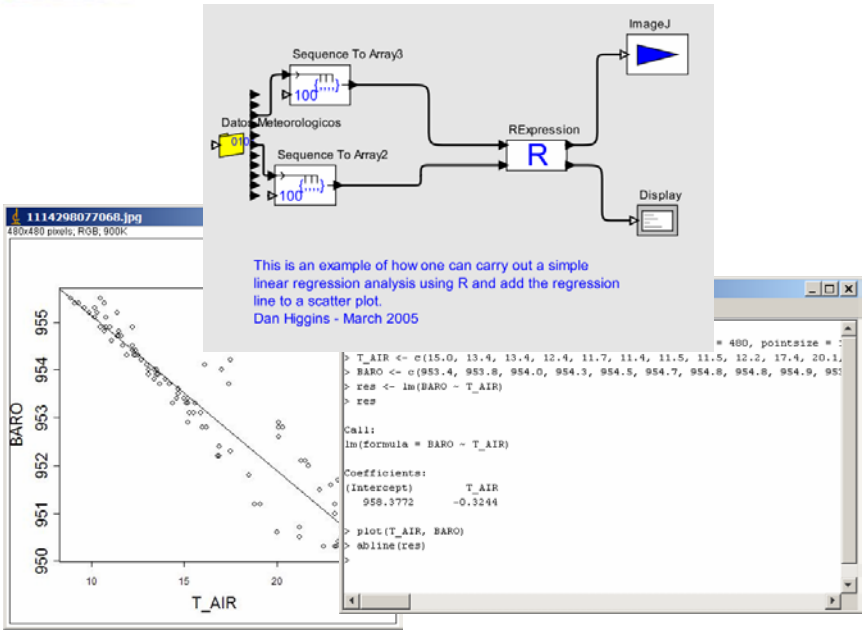




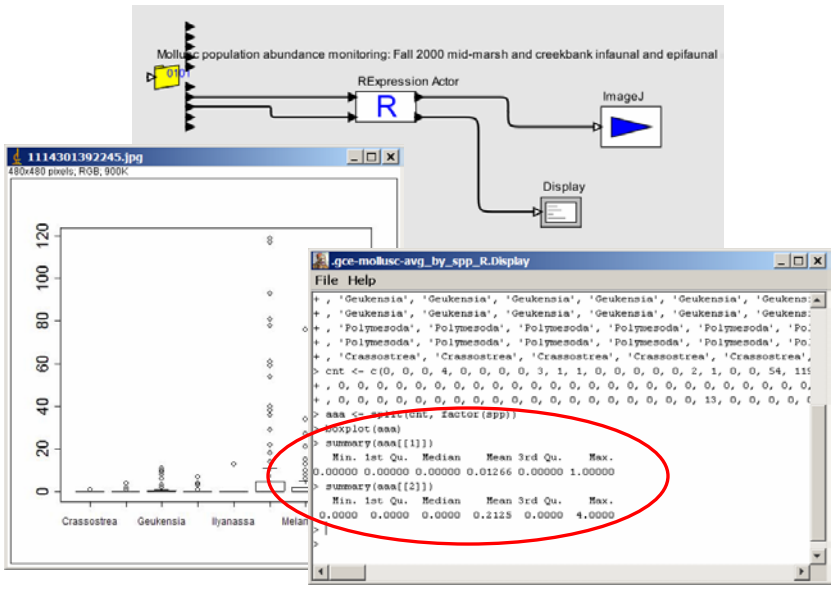


EML DataSource can be configured to create a “Column Based Record’ directly for input to RExpression

R Regression Analysis Example



R Summarize Table By Species



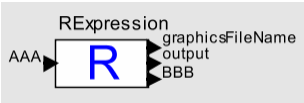
RExpression Implementation - 1

1.Input Ports

Kepler tokens are converted to R string expressions
e.g. If port AAA has token {1,2,3} it is converted to the R expression '`AAA <- c(1,2,3)`'
Automatically handles strings, numbers, arrays, and records with arrays of the same length

2. R Command Line Process

R is started as a Java subprocess with text streams attached to standard in, out, and error

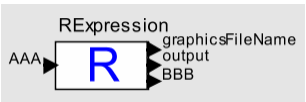


RExpression Implementation - 2

3. Input Block of R Commands

A set of R commands are sent to the input stream of the R subprocess

Initialization	Create graphics device (jpeg file); Create input port objects
User Script	Whatever is in user's script BBB <- 2 * AAA
Finalization	R commands for output ports (e.g. BBB)

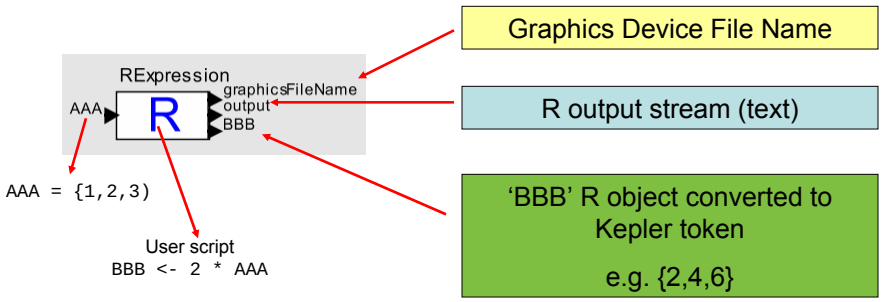


RExpression Implementation - 3

4. Execute R

Send input block to R subprocess and get output

5. Put R results on appropriate output ports



RServe

"Rserve is a TCP/IP server which allows other programs to use facilities of **R** without the need to initialize **R** or link against **R** library."

Client-side implementations are available for C/C++ and Java.

------Java code example ----

```
Rconnection c = new Rconnection();
double d[]=c.eval("rnorm(10)").asDoubleArray();
-------------------------------------
```

Use of RServe would avoid each actor 're-starting' R and allow remote execution of R scripts

RServe --- http://stats.math.uni-augsburg.de/Rserve/

Summary

An RExpression actor that operates similarly to the existing Expression actor looks like a good way of integrating R into Kepler

Using R in Kepler provides powerful extensions to the Ptolemy expression language that allows operations on complex structures (e.g. tables)

Existing implementation is inefficient in some ways and incomplete, but is relatively easy to use and does not require detailed knowledge of R for simple operations