GAMS

Model deployment in GAMS

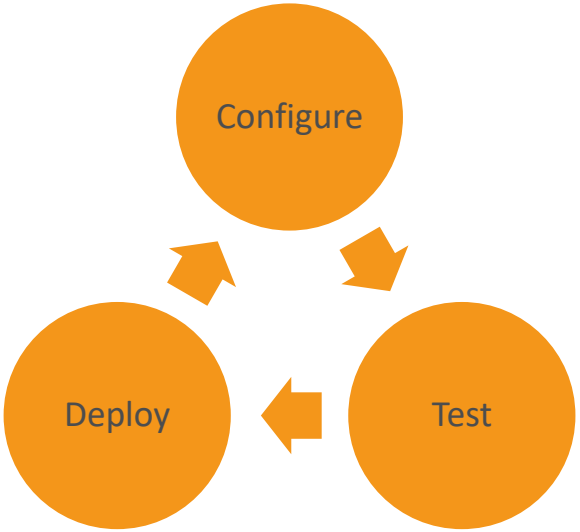
GAMS MIRO – An interactive web interface

Motivation

Separation of Tasks:

- Modeling work
  - → AMLs are powerful tools for developing solver-independent optimization models
  - → GAMS for modeling and optimization
- Intuitive deployment and visualization are becoming increasingly important
  - → End-users of optimization software are very often not modeling experts
  - → Need for easy-to-use tool to visualize data and compare results

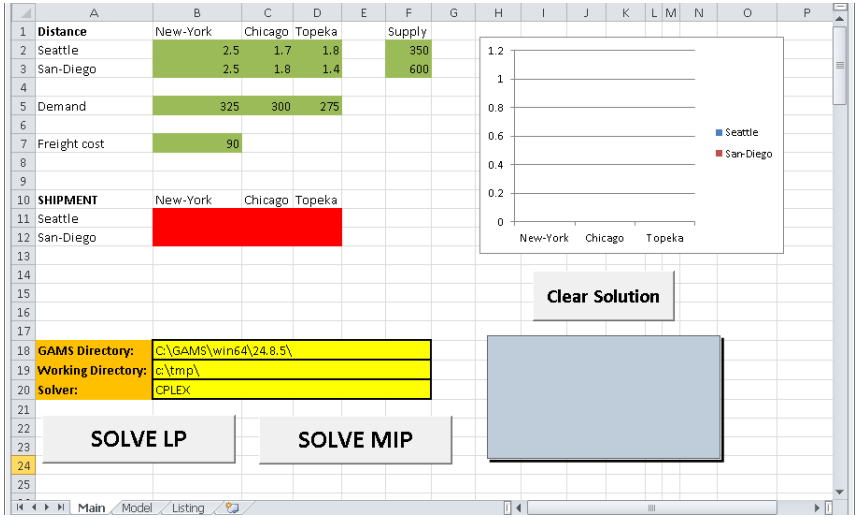
→ Current deployment possibilities are not satisfactory for everyone



Deployment of GAMS models
current possibilities

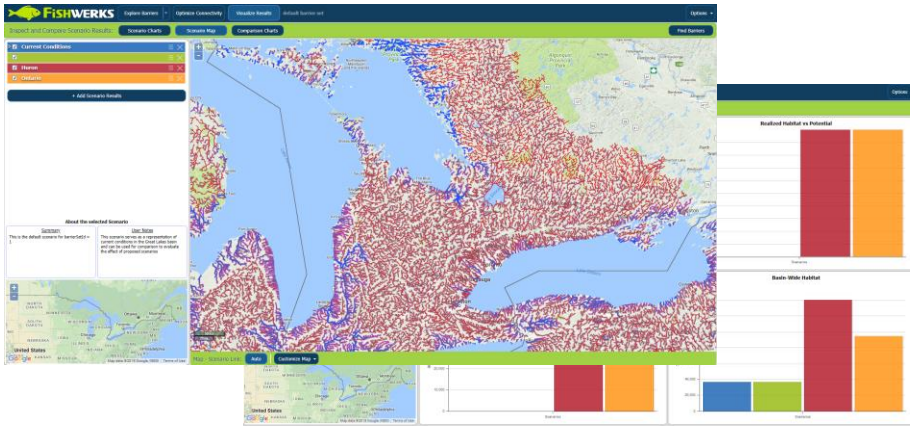
Expert level APIs

- GDX, OPT, GAMSX, GMO, …
- High performance and flexibility
- Automatically generated imperative APIs for several languages (C, C++, C#, Delphi, Java, Python, VBA, …)



Object Oriented APIs

- GAMS comes with several OO APIs (Python, Java, C++, C#, …) to develop applications



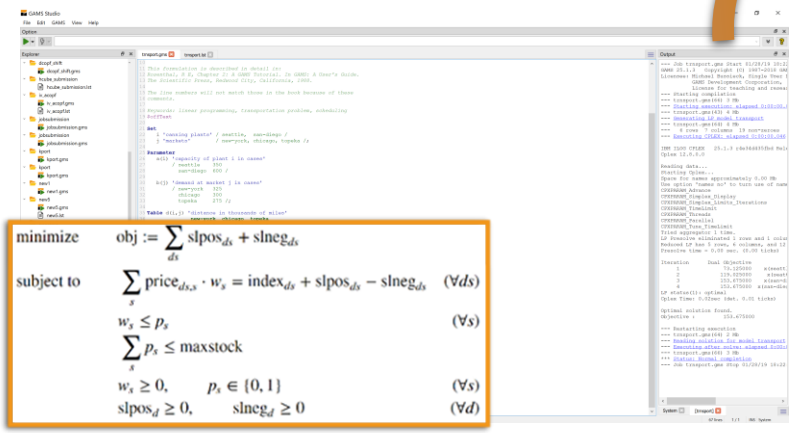
→ Programming required to build your applications

GAMS MIRO

Model Interface with Rapid Orchestration

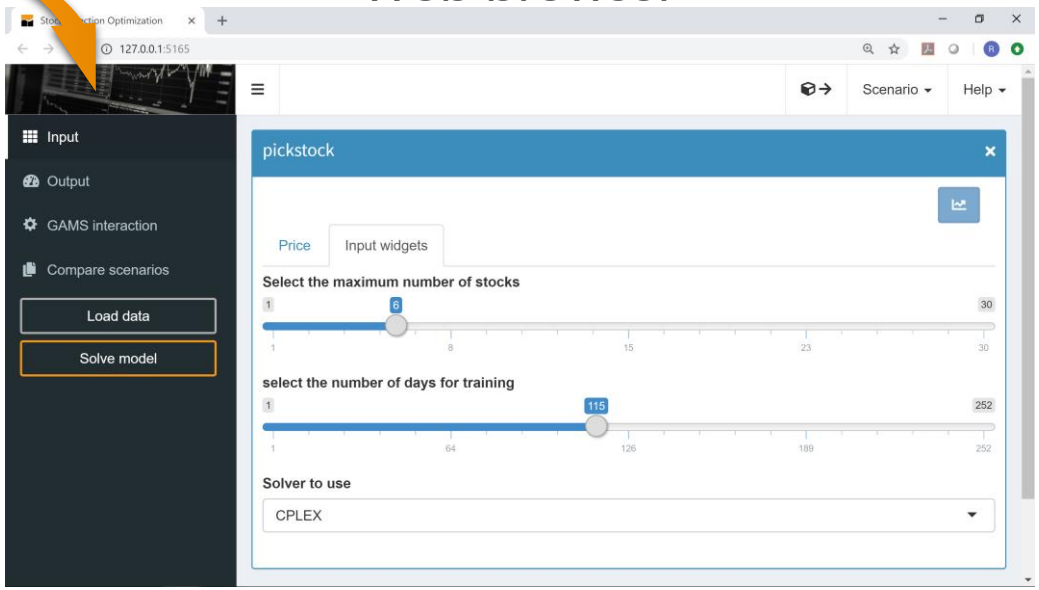
Click to deploy

Develop GAMS model



$$\begin{aligned}
\text{minimize} \quad & \text{obj} := \sum_{ds} \text{slpos}_{ds} + \text{slneg}_{ds} \\
\text{subject to} \quad & \sum_{s} \text{price}_{ds,s} \cdot w_s = \text{index}_{ds} + \text{slpos}_{ds} - \text{slneg}_{ds} \quad (\forall ds) \\
& w_s \le p_s \quad (\forall s) \\
& \sum_{s} p_s \le \text{maxstock} \\
& w_s \ge 0, \qquad p_s \in \{0,1\} \quad (\forall s) \\
& \text{slpos}_d \ge 0, \qquad \text{slneg}_d \ge 0 \quad (\forall d)
\end{aligned}$$

Web browser

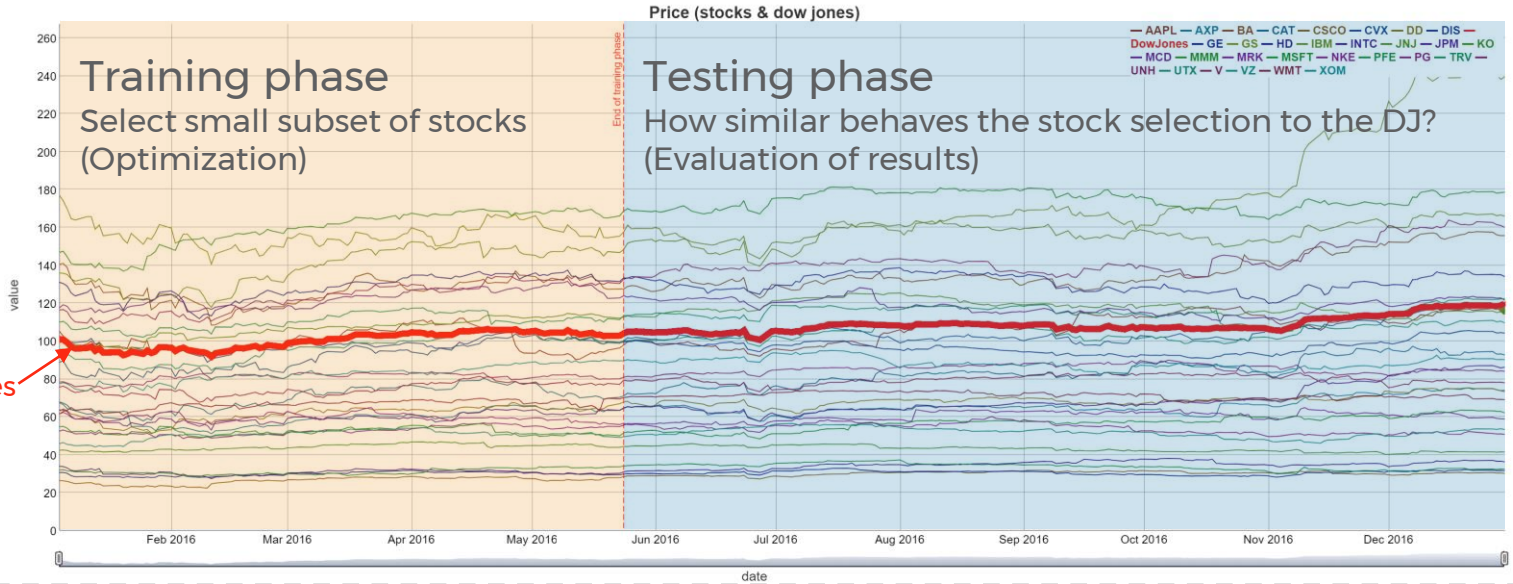


- ✓ Web interface for GAMS models
- ✓ Usage via web browser
- ✓ GAMS as a black box
- ✓ Focus on automated deployment
- ✓ Configuration instead of programming

Example

Model: Pickstock

Model: *Pickstock*



- **Data**: Performance of all shares of the Dow Jones index over a period of 1 year
- **Goal**: Find a small selection of stocks that follows the Dow Jones as good as possible
- **Optimization model**: Select a subset (≤ `maxstock`) of Dow Jones stocks, along with weights, so that this portfolio behaves similarly to the overall index (in the training phase)

$$\text{minimize} \quad \text{obj} := \sum_{ds} \text{slpos}_{ds} + \text{slneg}_{ds}$$

$$\text{subject to} \quad \sum_{s} \text{price}_{ds,s} \cdot w_s = \text{index}_{ds} + \text{slpos}_{ds} - \text{slneg}_{ds} \qquad (\forall ds)$$

$$w_s \le p_s \qquad (\forall s)$$

$$\sum_{s} p_s \le \text{maxstock}$$

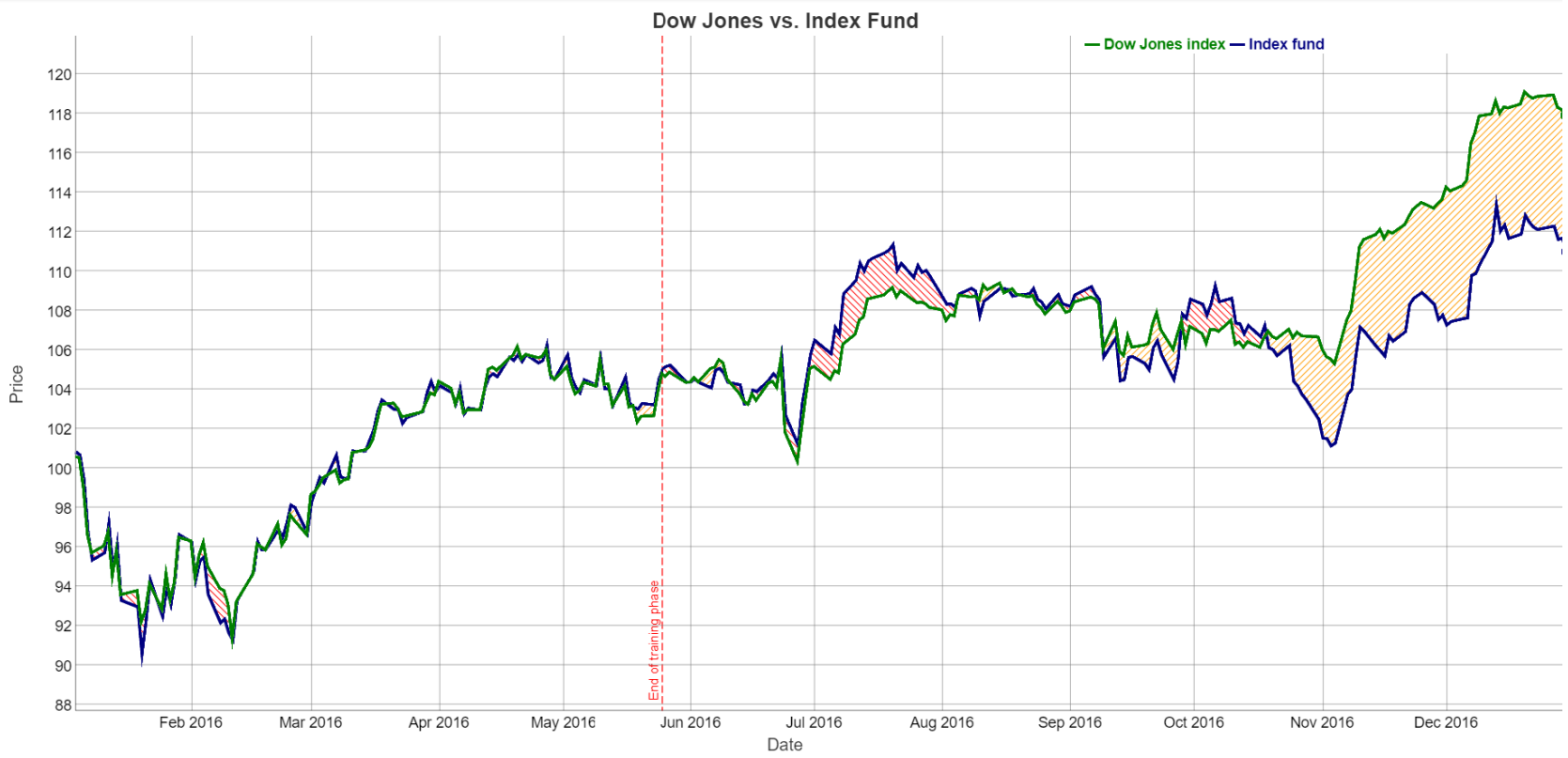
$$w_s \ge 0, \qquad p_s \in \{0,1\} \qquad (\forall s)$$

$$\text{slpos}_d \ge 0, \qquad \text{slneg}_d \ge 0 \qquad (\forall d)$$

Model: *Pickstock*

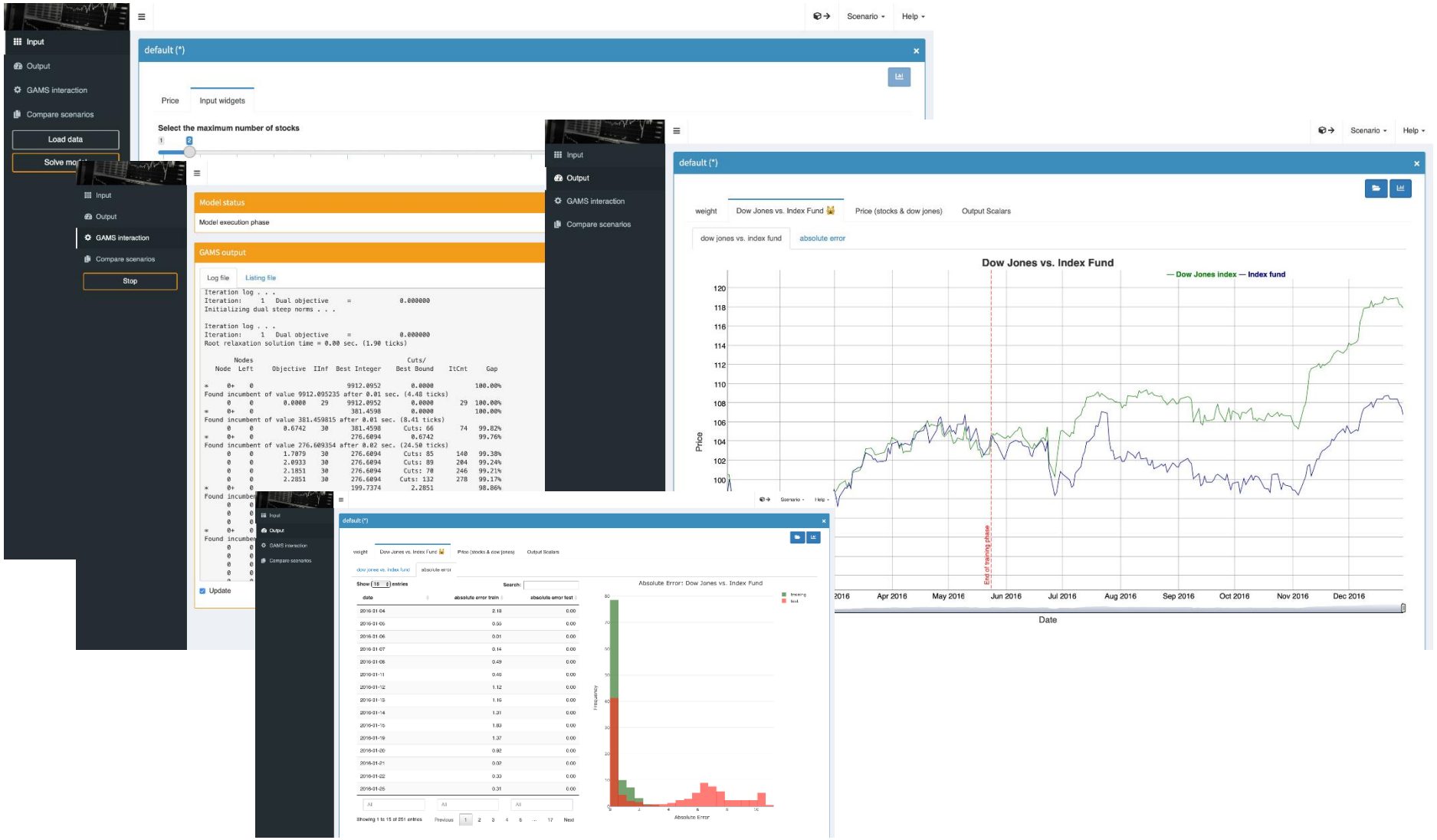
$$\text{minimize} \qquad \text{obj} := \sum_{ds} \text{slpos}_{ds} + \text{slneg}_{ds}$$

Model: *Pickstock*

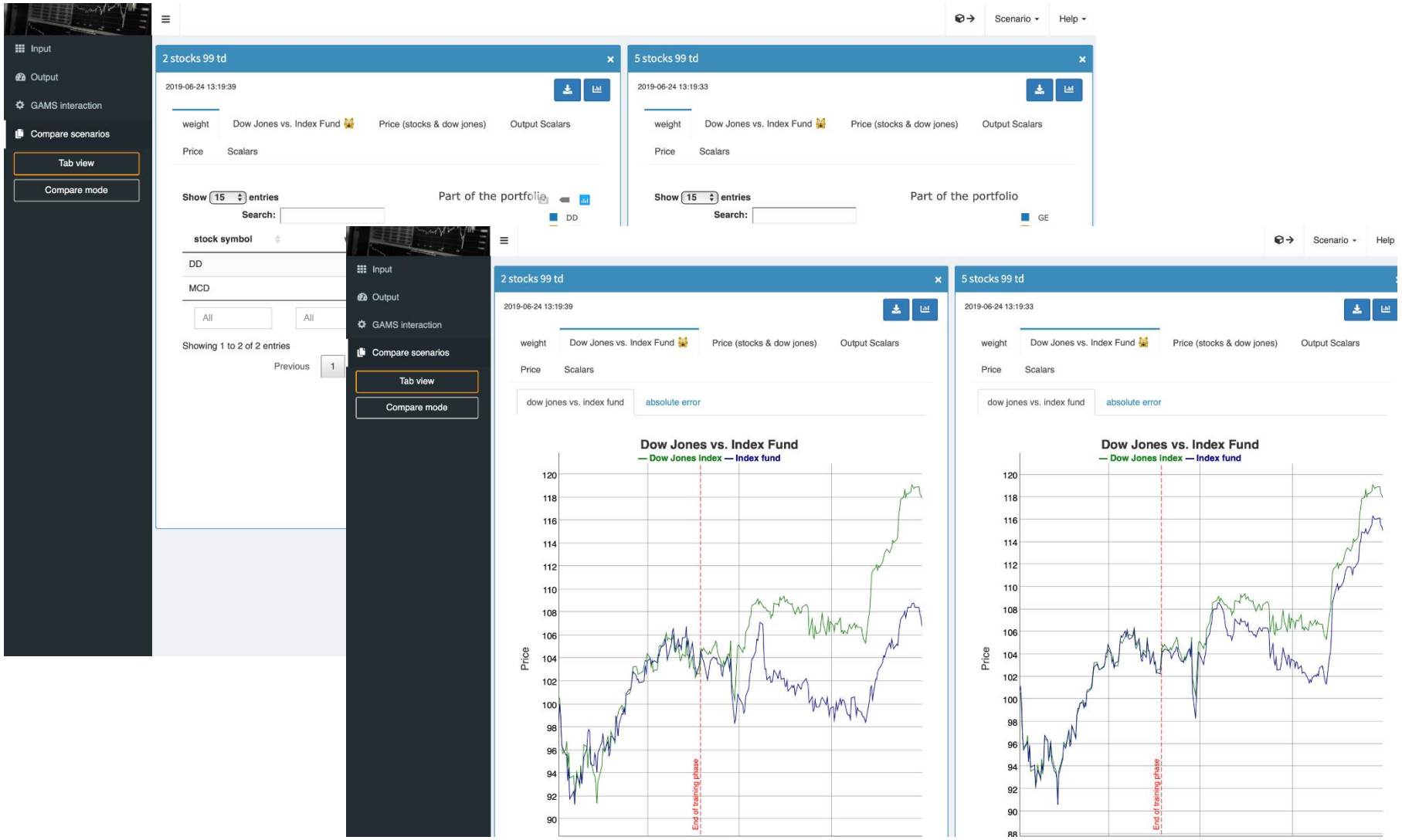


$$\text{minimize} \qquad \text{obj} := \sum_{ds} \text{slpos}_{ds} + \text{slneg}_{ds}$$

Run the model



Compare scenarios



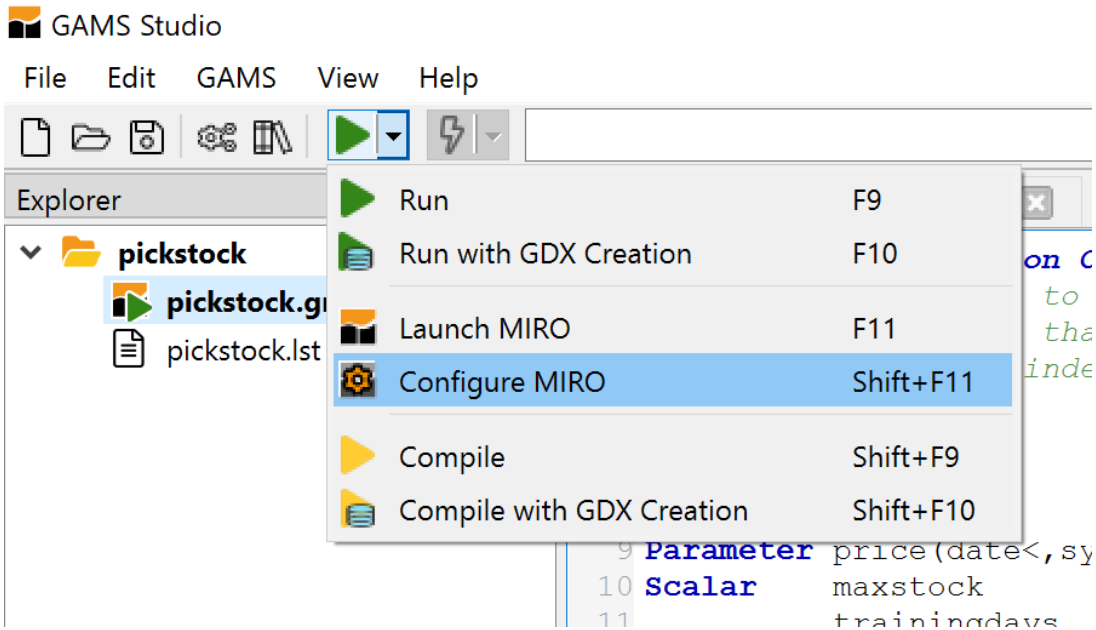
How-to

Deployment of a GAMS model with GAMS MIRO

Basic Setup – Model Annotations

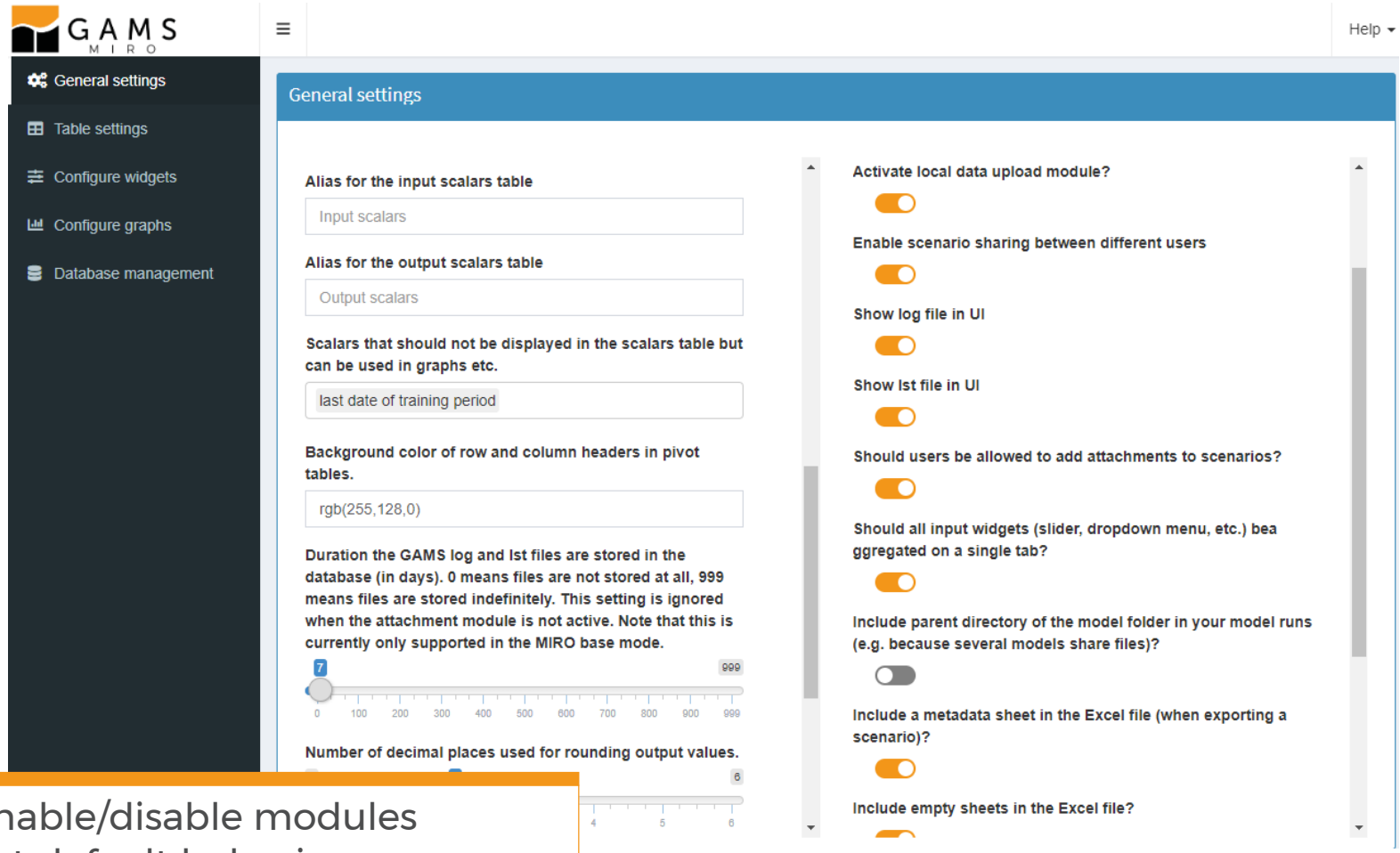
```
 6 Set         date                      'date'
 7             symbol                    'stock symbol';
 8 $onExternalInput
 9 Parameter   price(date<,symbol<)      'Price';
10 Scalar      maxstock                  'maximum number of stocks to select'  /  2 /
11             trainingdays              'number of days for training'         / 99 /;
12 $offExternalInput

80 $onExternalOutput
81 Scalar error_train                    'Absolute error in entire training phase'
82        error_test                     'Absolute error in entire testing phase'
83        error_ratio                    'Ratio between error test and error train'
84 Parameter
85        stock_weight(symbol)           'weight'
86        dowVSindex(date,fHdr)          'dow jones vs. index fund [MIRO:table]'
87        abserror(date,errHdr)          'absolute error [MIRO:table]'
88 Singleton Set
89 firstDayTraining(date)    'first date of training period'
90 lastDayTraining(date)     'last date of training period' ;
91 $offExternalOutput
```

MIRO configuration mode



The MIRO configuration mode

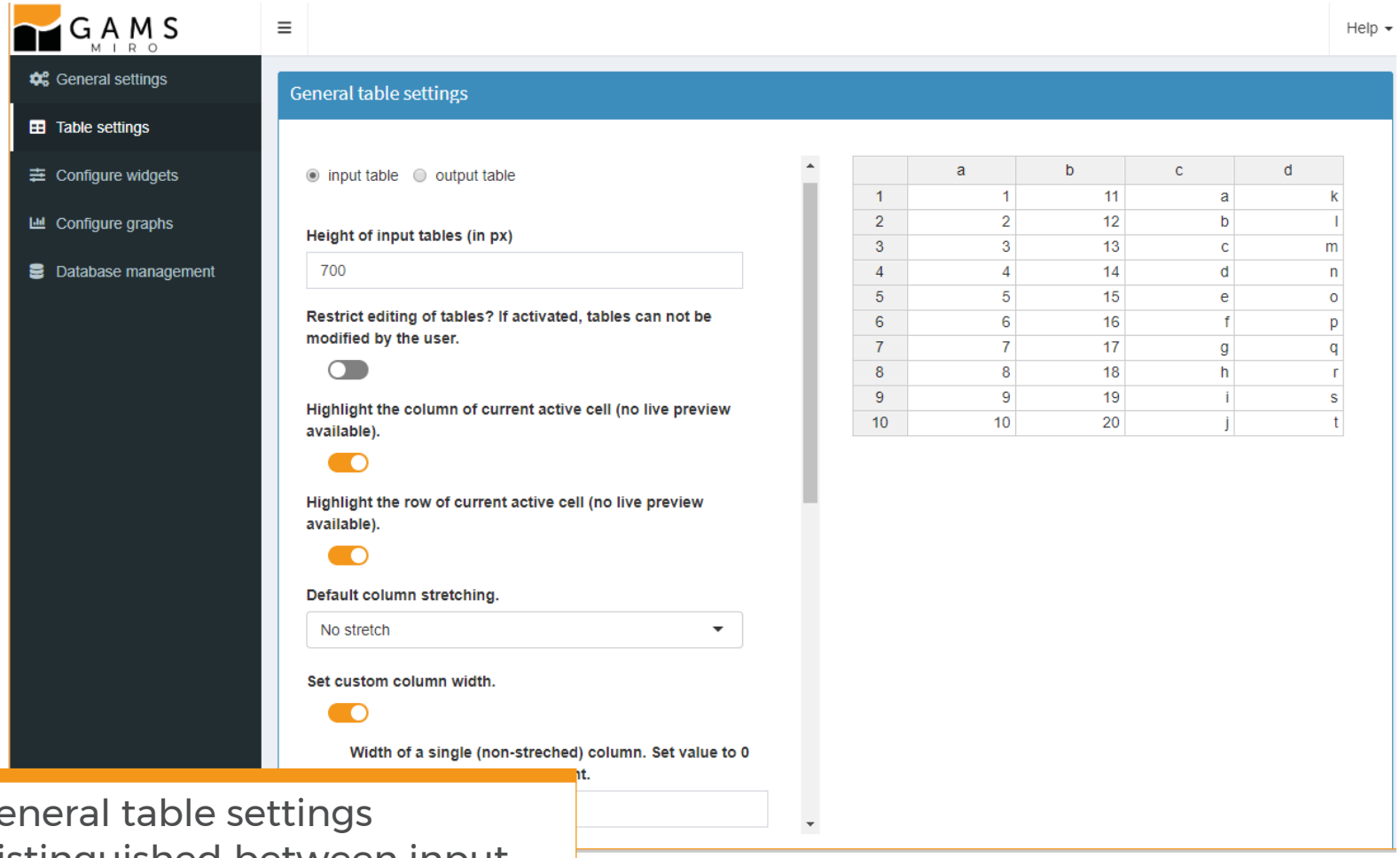
General settings



- ✓ Enable/disable modules
- ✓ Set default behavior
- ✓ Color scheme
- ✓ etc.

The MIRO configuration mode

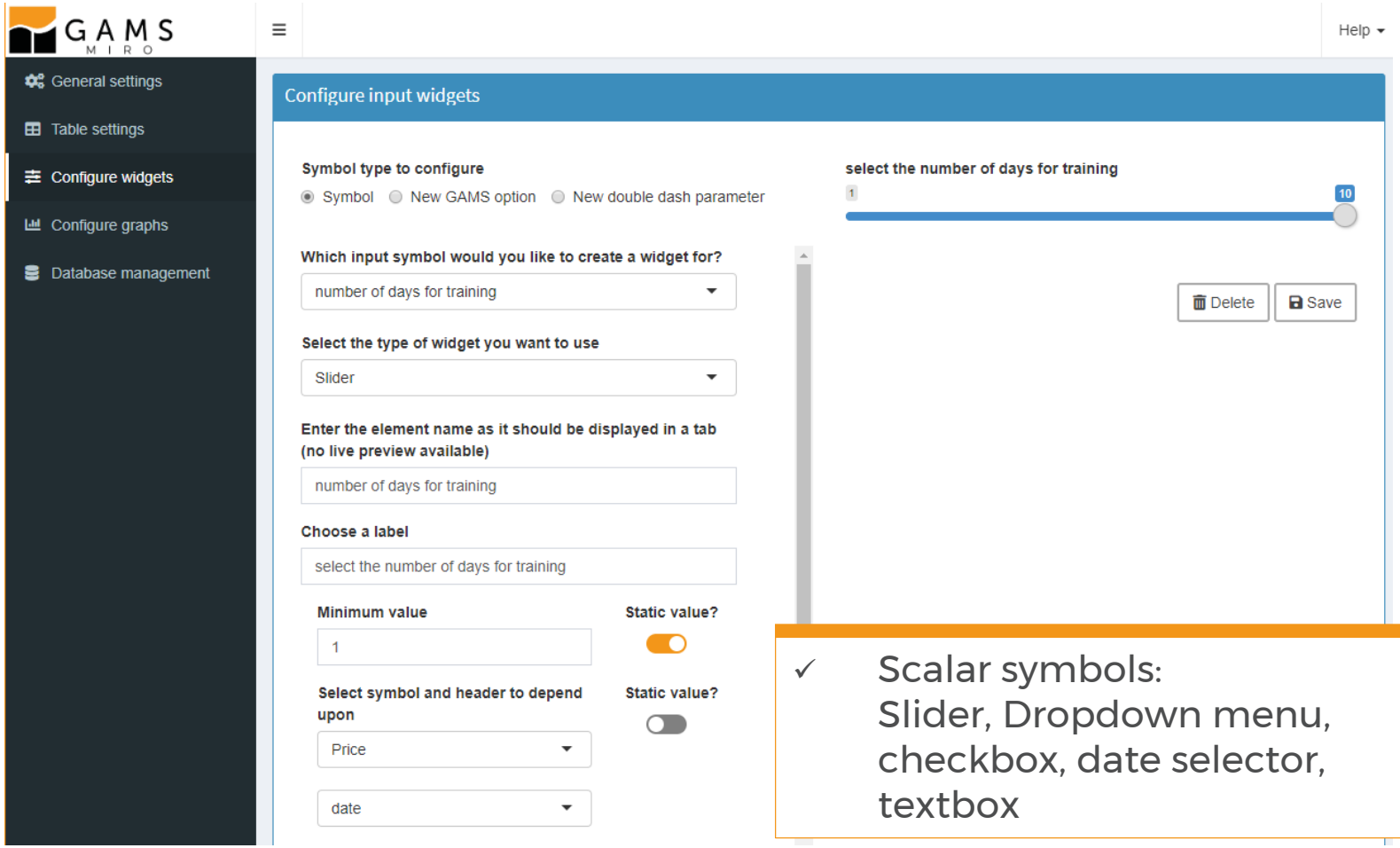
Table settings



- ✓ General table settings
- ✓ Distinguished between input and output tables

The MIRO configuration mode

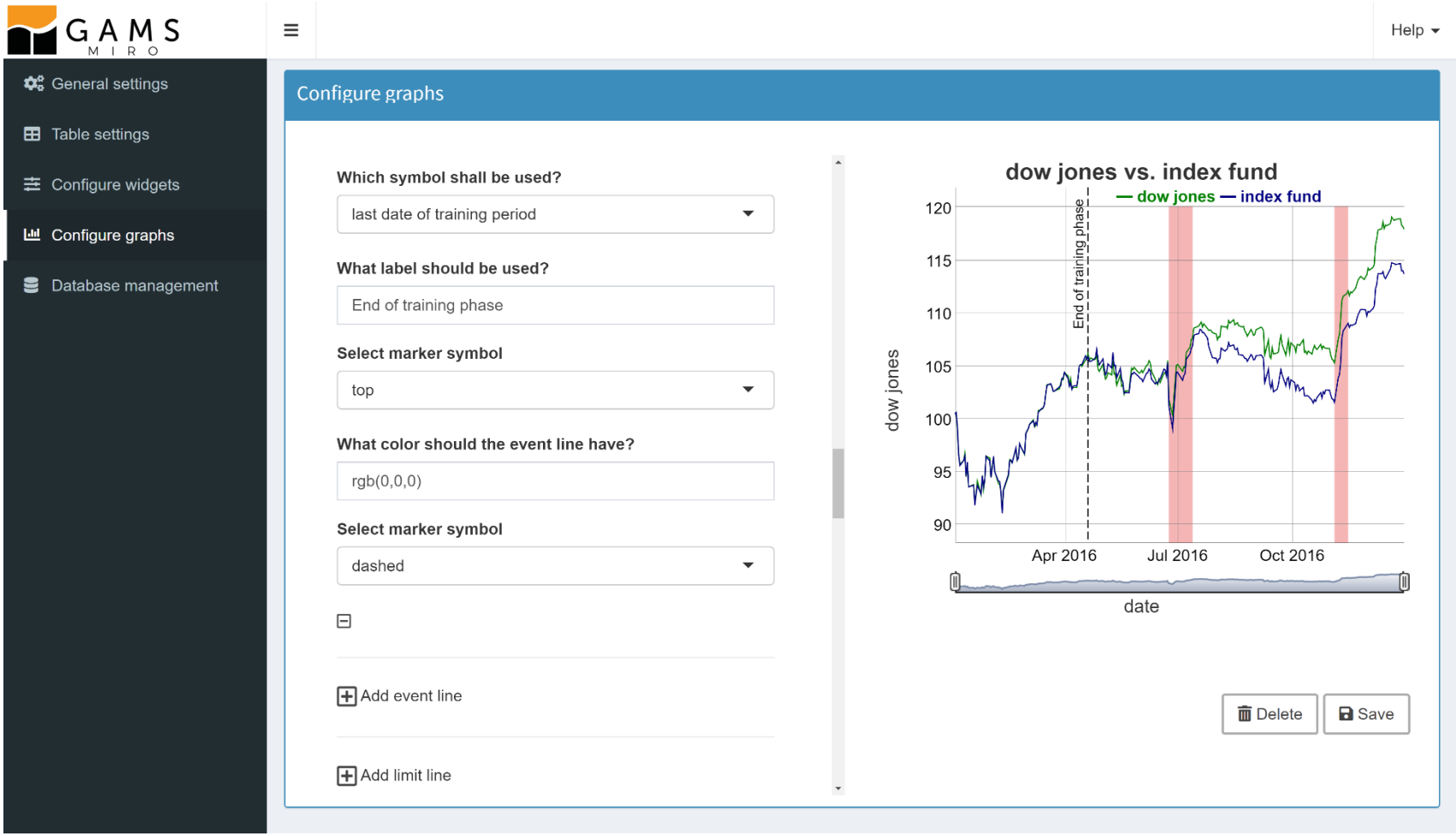
Widgets configuration



✓ Scalar symbols:
Slider, Dropdown menu, checkbox, date selector, textbox

The MIRO configuration mode

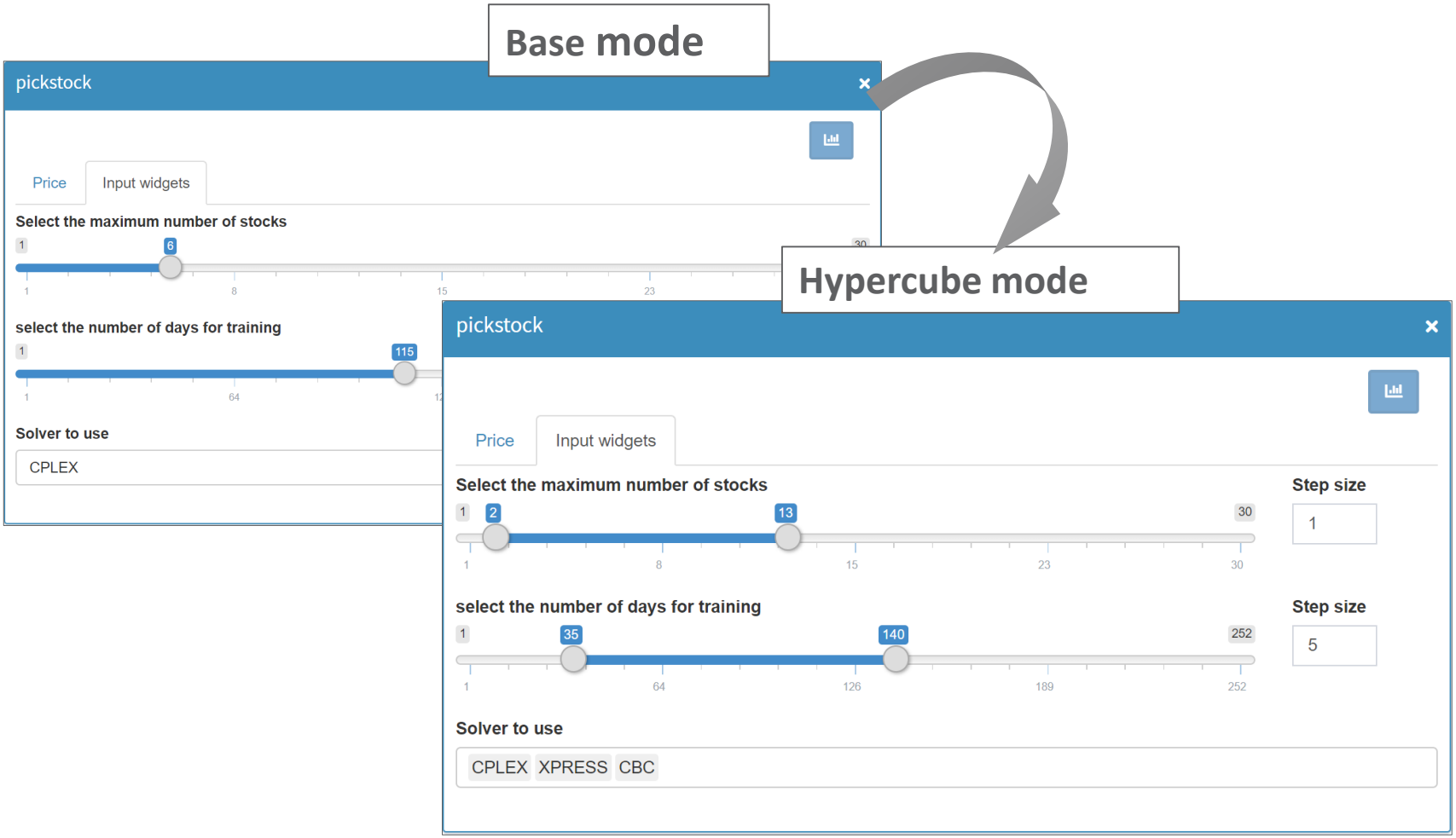
Graphics configuration



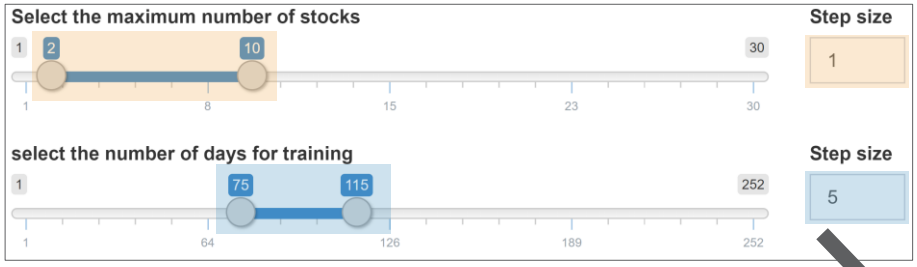
Scenario runs

The GAMS MIRO Hypercube mode

Hypercube mode
scenario generation



Hypercube mode
scenario generation



+1

+5

	2	3	4	5	6	7	8	9	10
75	1	2	3	4	5	6	7	8	9
80	10	11		13	14	15	16	17	18
85	19	20					25	26	27
90	28	2						5	36
95	37							4	45
100	46							53	54
105	55	56	57					62	63
110	64	65	66	67	68	69		71	72
115	73	74	75	76	77	78	79	80	81

Number of scenarios
=
Cartesian product of scalar input combinations

Hypercube mode
Analysis

- ✓ Perform analyses related to KPIs and/or other indicators
- ✓ Export scenario data for external analyses

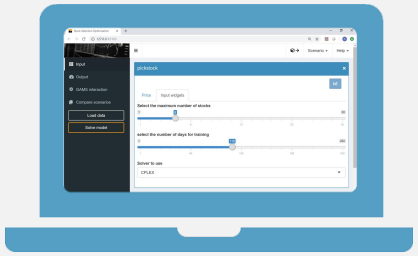
Job execution

MIRO Server

MIRO – job execution

MIRO Desktop

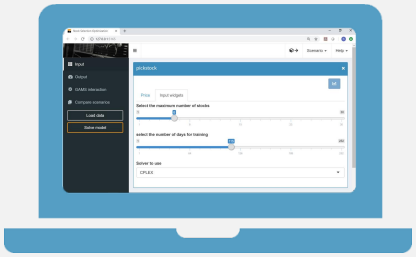
Everything local



- GAMS installed
- MIRO installed
- Synchronous execution of GAMS jobs

MIRO Server (I)

Local MIRO application
Remote GAMS execution



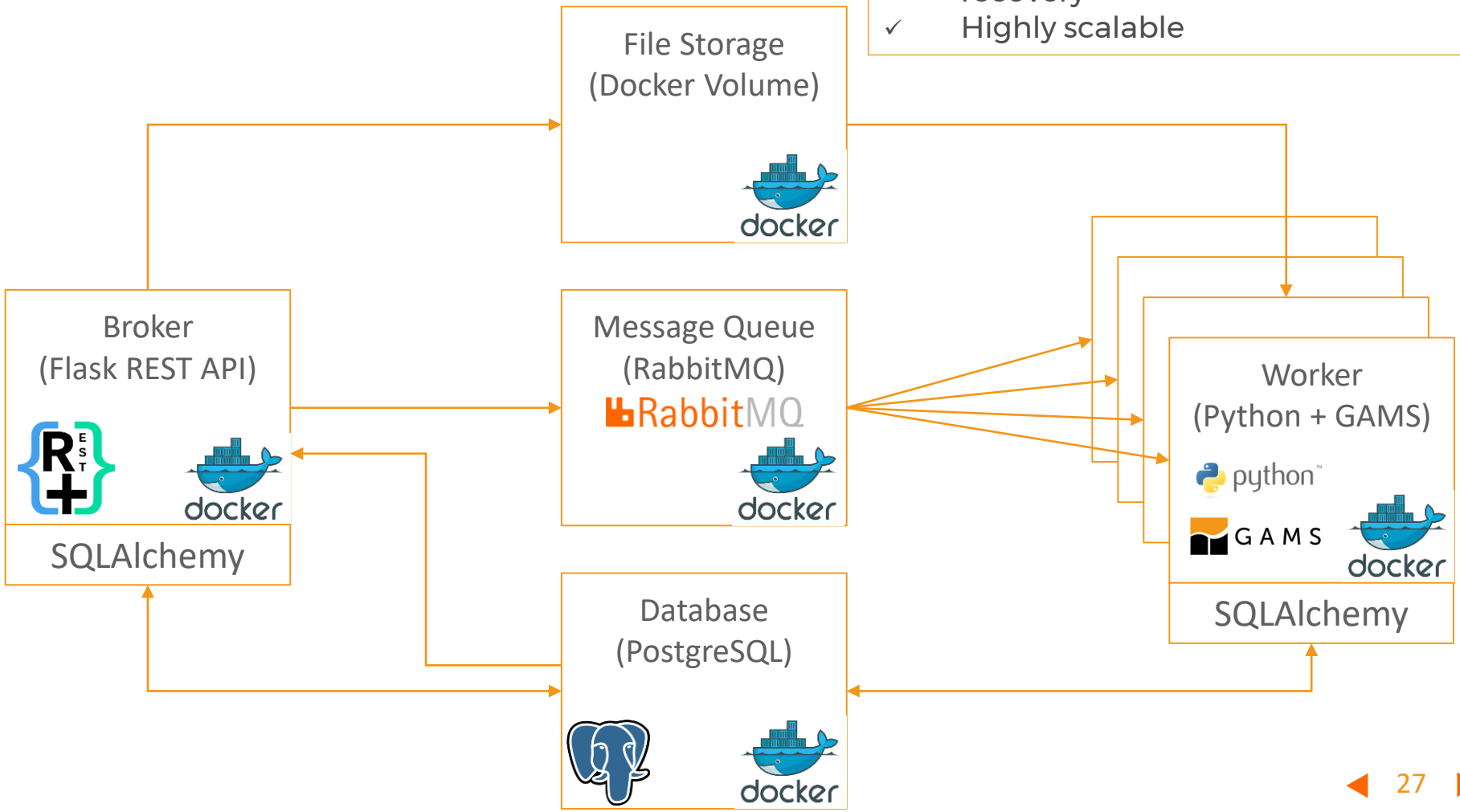
GAMS job execution

MIRO Server (II)

Everything on a server

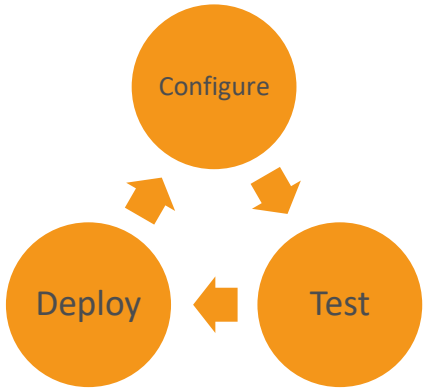
Remote job execution

- ✓ REST API for job requests
- ✓ Microservices instead of monolithic approach
- ✓ Automated failure detection and recovery
- ✓ Highly scalable



Summary

Summary

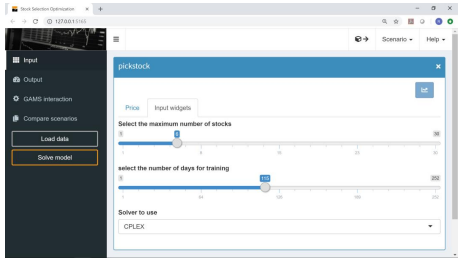


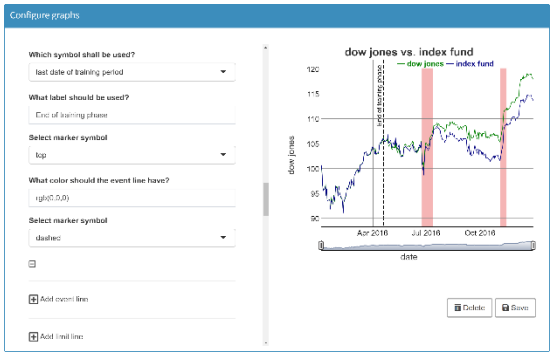
- Separation of tasks:
  - Modeling work
  - Model deployment

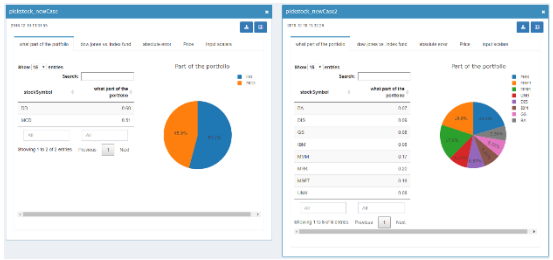
  → In OR projects often over several iterations

  → model deployment should not take much time (at least during these iterations)

- End-users are very often not modeling experts
- Quick & automated deployment of GAMS models
- Data visualization with charts / graphics
- Easy to configure
- Desktop and server version







GAMS

For more information visit:

www.gams.com/miro

Meet us at the GAMS booth!