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Réunion Mexico, Nantes le 22/11/2012

Can we robustly reach goals fixed on simple indicators ?

Study Sites and Goals

Determine the consequences of various management measures, either direct or indirect, on flatfish populations and activities in the Eastern Channel.

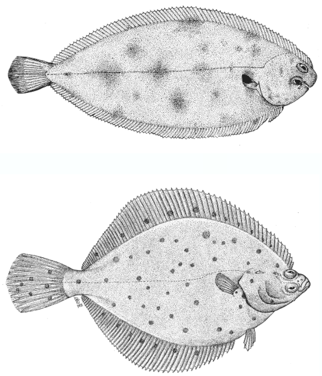
England

- Effort reduction
- Gears restrictions
- Temporary closures

- MPAs
- Wind farms
- Sediment dredging

VIID

- Min size
- TAC



France

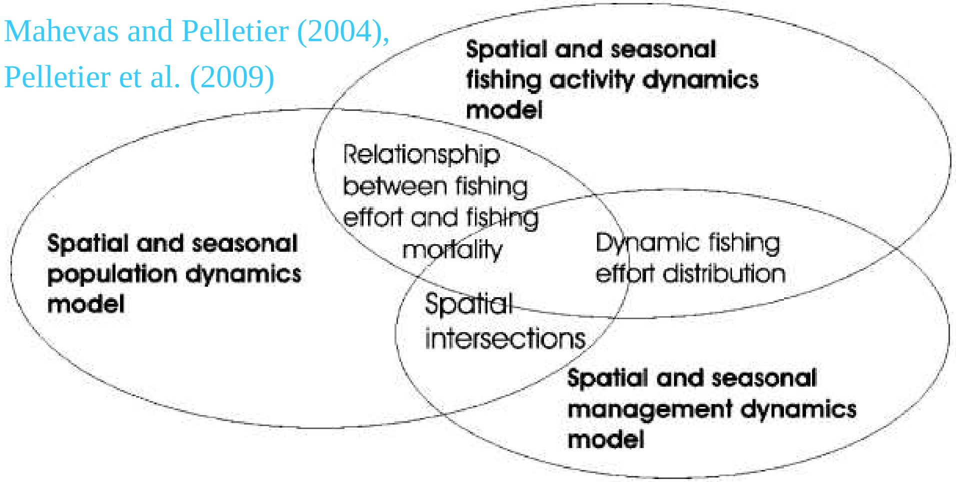
Achieve a greater robustness to uncertainties on the ecosystem's state

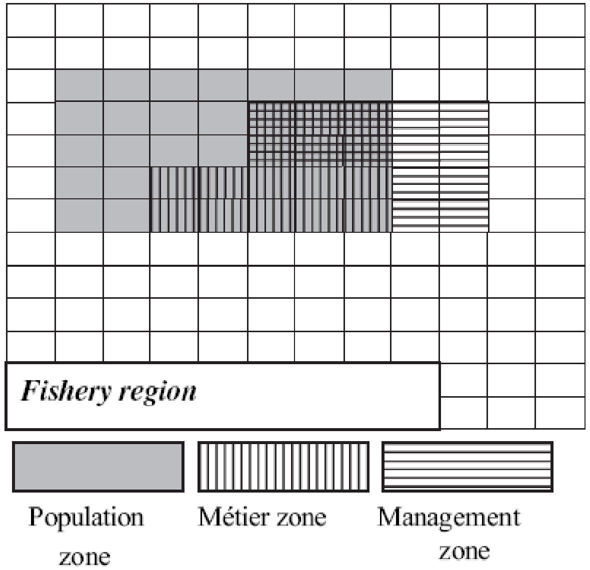
ISIS-fish model of the area by Marchal et al., 2011

The ISIS-Fish model

Superimposition of 3 sub-models that interact in time and space.

Mahevas and Pelletier (2004), Pelletier et al. (2009)



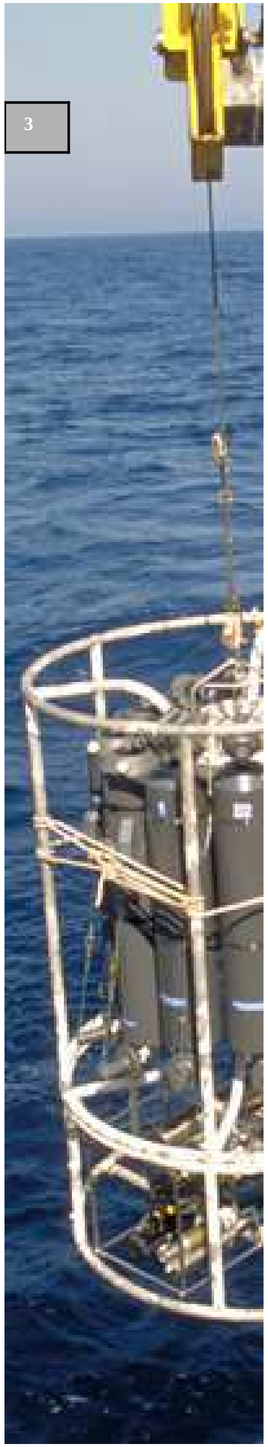


A complex model :

- No analytical solution
- Possible overparameterization
- High number of uncertain input variables

→ How to deal with uncertainties ?

http://www.isis-fish.org/



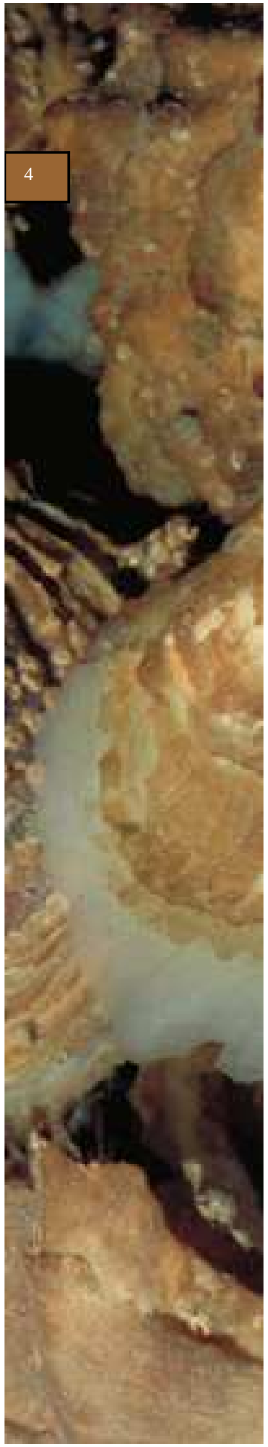
Decision Theory

	Probability	η_1	η_2	$\cdots$	η_n
Probability	**Nature** / **Manager**	F_1	F_2	$\cdots$	F_n
ξ_1	$\mathfrak{D}_1 = d(x)_1$				
ξ_2	$\mathfrak{D}_2$		$K_{1:l}^{2,2}(F_2, \mathfrak{D}_2), \rho_{1:l}^{2,2}$		
$\vdots$	$\vdots$		$\vdots$	$\cdots$	$\vdots$
ξ_m	$\mathfrak{D}_m$				$K_{1:p}^{n,m}(F_2, \mathfrak{D}_2), \rho_{1:p}^{n,m}$

Table 1: Usual application of Decision Theory (mixed strategies and Bayesian framework)

Nature / **Manager**	F_1	F_2	$\cdots$	F_n
$\mathfrak{D}_1 = d(x)_1$				
$\mathfrak{D}_2$		$K(F_2, \mathfrak{D}_2)$		
$\vdots$		$\vdots$	$\cdots$	$\vdots$
$\mathfrak{D}_m$				$K(F_n, \mathfrak{D}_m)$

Table 2: Decision theory with no a-priori information (pure strategies)



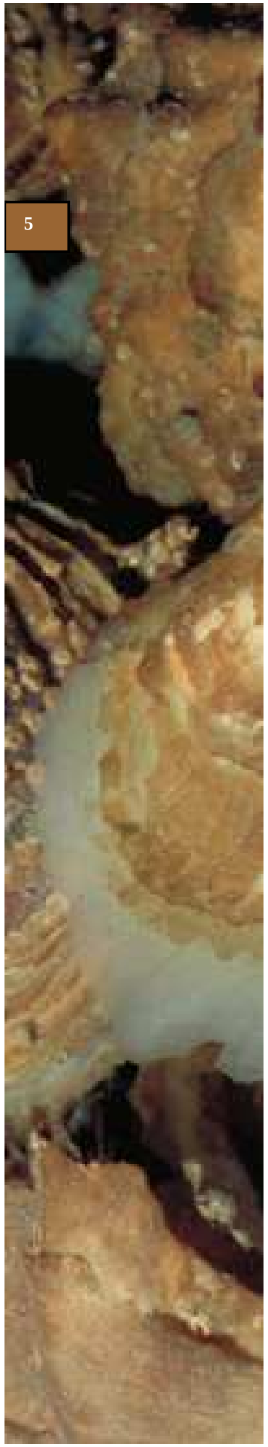
Info-Gap

Input variables that cannot be impacted by management measures (u)

	Uncertainty Model
Decision scenario	System Model + Performance Criterion

Input variables that can be impacted by management measures (q)

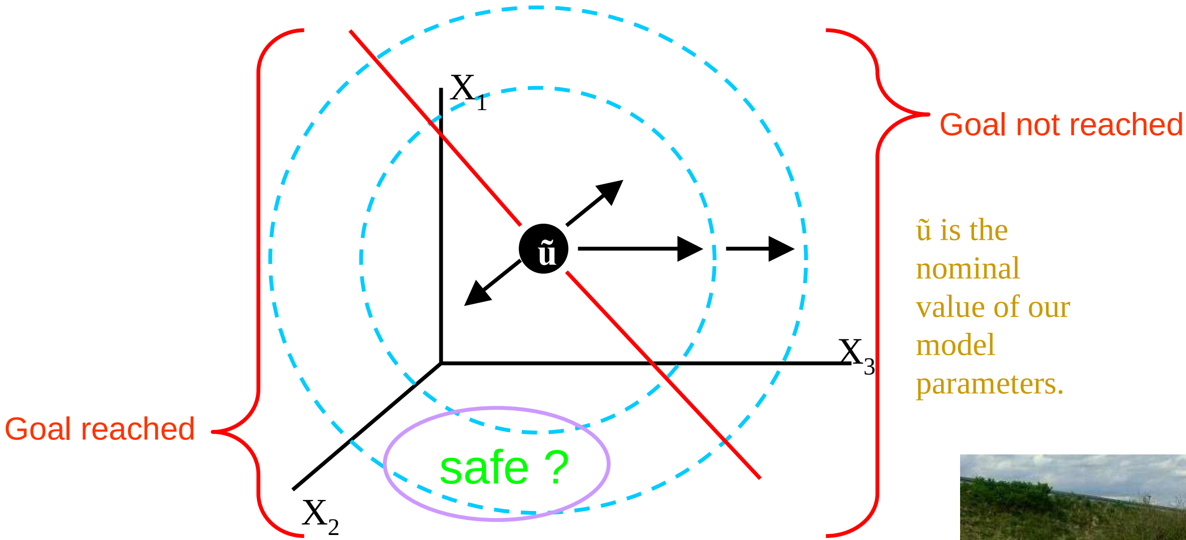
Model output variables (R(q,u)) associated to given thresholds (r_c)



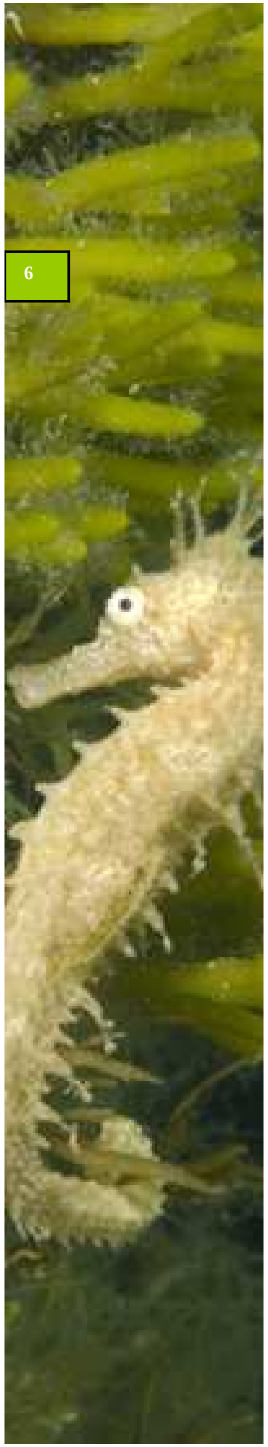
Info-Gap

The robustness function ($\hat{\alpha}(q, r_c)$) is the greatest horizon of uncertainty a that can be tolerated while being sure that the reward function did not cross r_c:

$$\hat{\alpha}(q, u, r_c) = max \left\{ \alpha : \left(min_{r \in U(\alpha, \tilde{r})} R(q, u) \right) \geq r_c \right\}$$

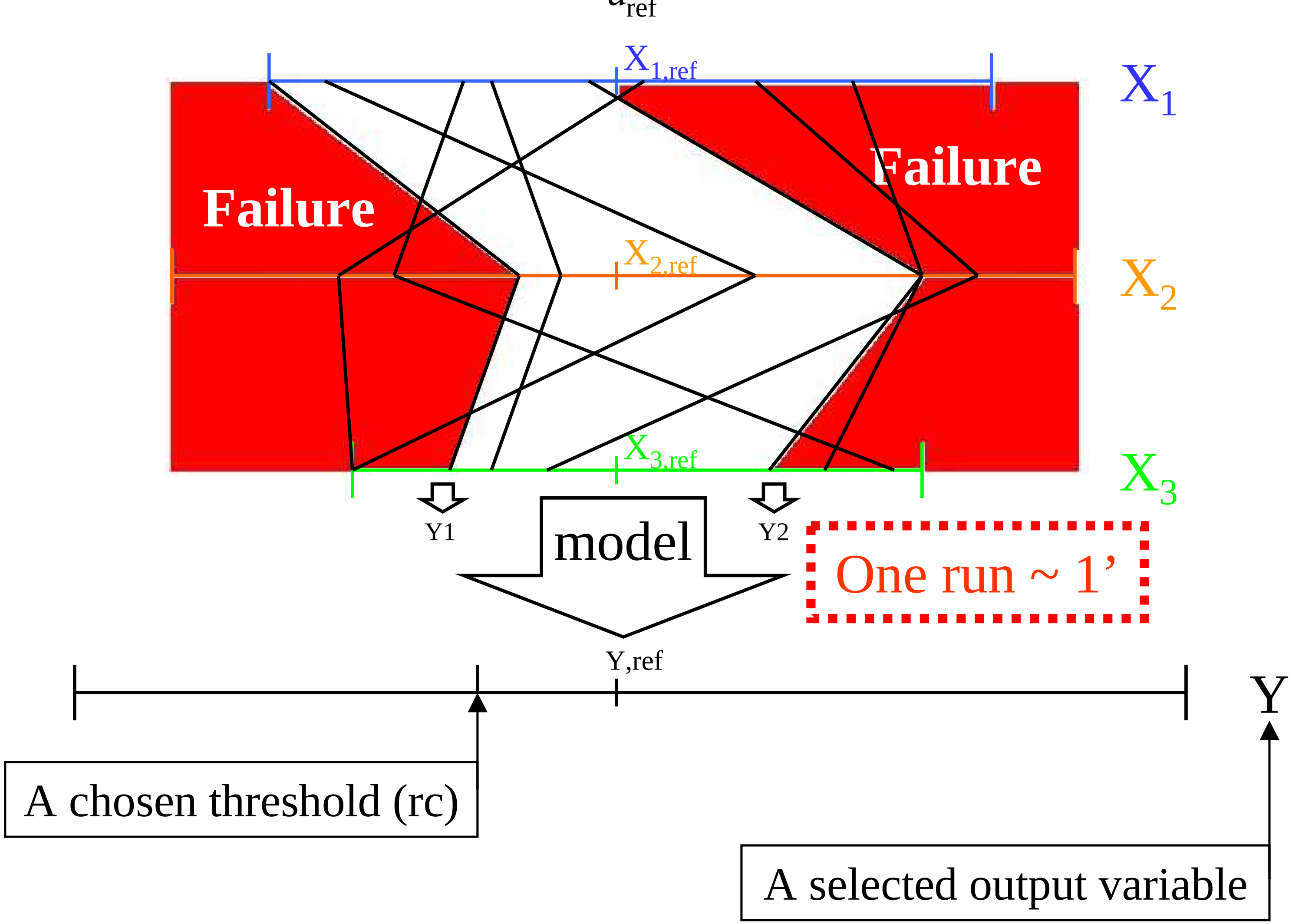


ũ is the nominal value of our model parameters.



Looking for the gap…

Example with N= 3



Reducing the number of runs

1: Identification of important parameters

→ Parameters not impacting the output variable are removed

2: Optimisation of the exploration techniques

→ The input space has to be explored as uniformly and thoroughly as possible in as few simulations as possible.

3: Reduction of domains of variation

→ It is not needed to explore parameter values that cannot occur in this ecosystem.

The need for sensitivity analysis

Sensitivity analysis has two main assets:

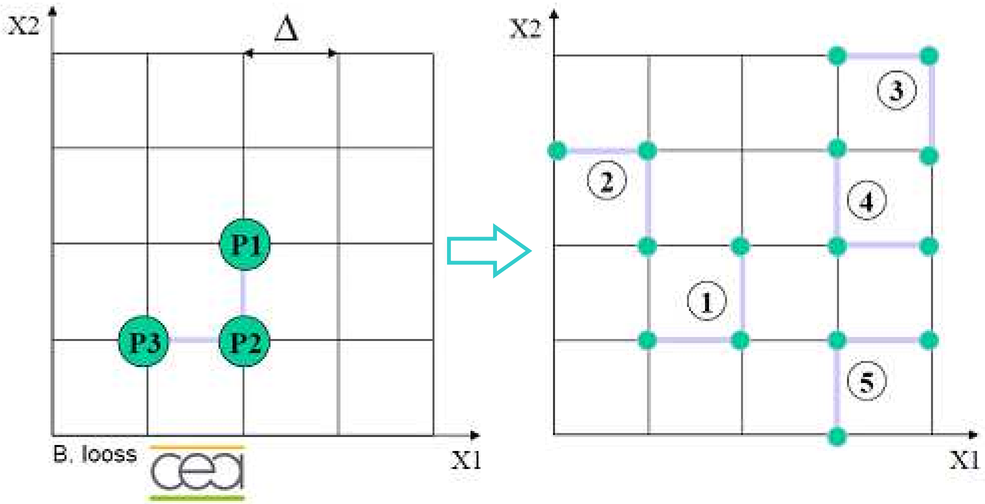
- It is associated with powerful tools to explore spaces (Saltelli et al. 1999, 2000 and 2004)

- It provides efficient statistical methods to evaluate the variation of the outputs conditional on the inputs.

→ Which method should we use ?

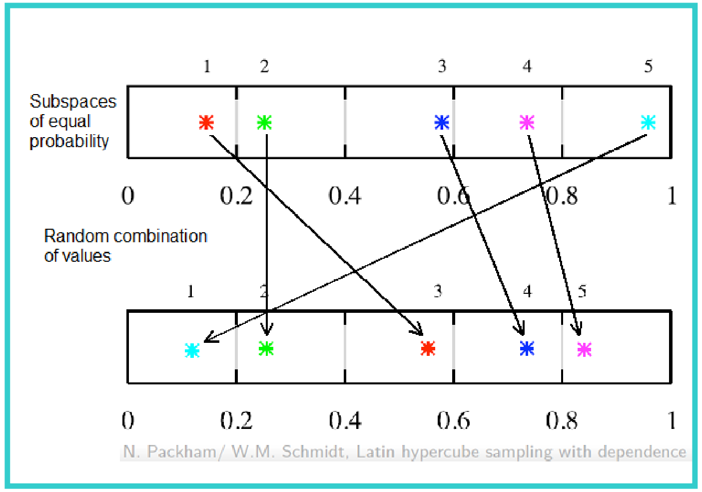
Which Method should we use ?

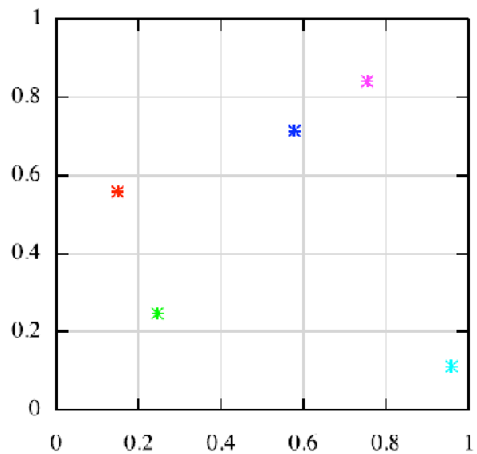
Morris

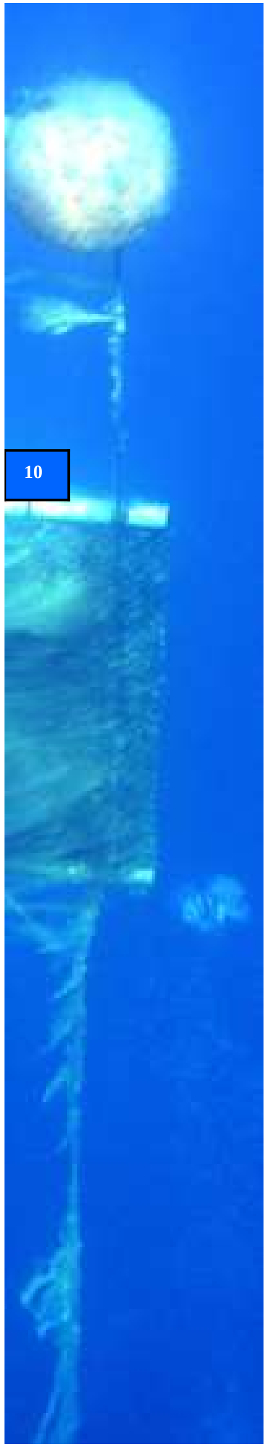


VS

LHS







Applying LHS to our model

77 input parameters:

Category	Nb of parameters
Gears	15
Metiers	15
Fish Biology	41
Management	6

Parameter	Abbreviation
Catchability	Q
Mean Weight	MW
Maturity Ogive	MO
Recruitment	RE
Natural Death Rate	NDR
Growth Rate	K
Asymptotic Length	Linf
Time at the Origin	T0
Price	P
Reproduction Rate	RR
Selectivity Beam Trawl	SBT
Selectivity Net	SN
Selectivity Other Gears	SO
Target Factor Beaming	TFB
Target Factor Netting	TFN
Target Factor Other Metiers	TFO
ICES subarea 7D	7D
ICES subarea 7E	7E
Total Allowable Catch	TAC
Minimum Landing Size	MinSize

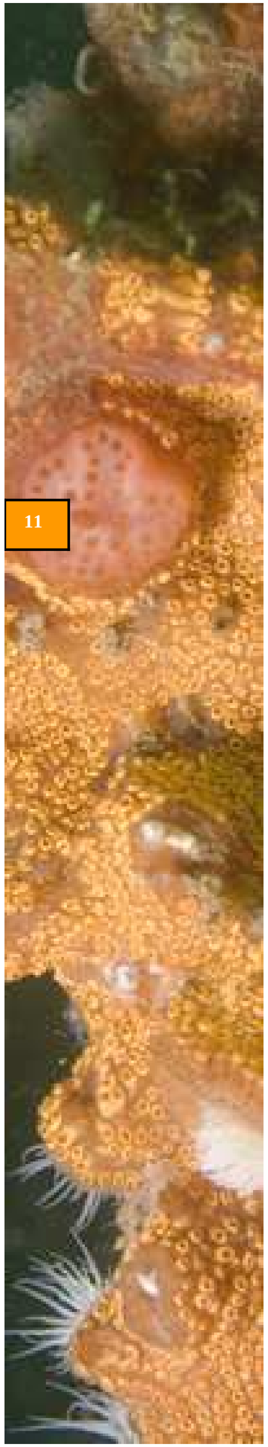
Table 3: Parameter Names and Abbreviations

5000 simulations

16 output variables:

- 4 types: Biomass, Spawning Biomass, Fishing Mortality, Catch
- 4 populations: Sole7D, Plaice7D, Sole7E, Plaice7E

Sensitivity analysis results



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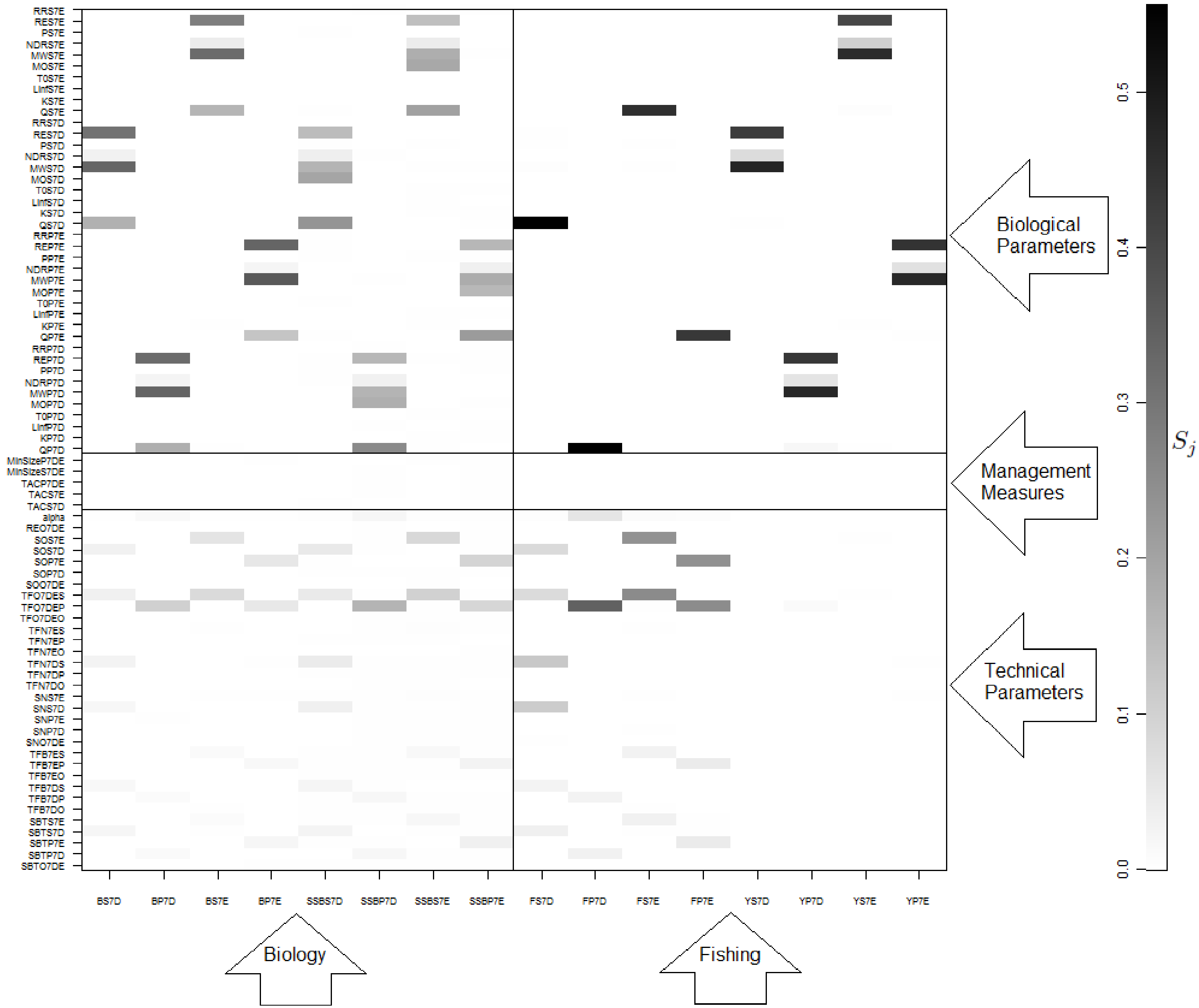


Sensitivity analysis results

Biomass				Spawning Biomass				Fishing Mortality				Catch			
Recruitment Mean Weight Catchability Target Factor Other Metiers Natural Death Rate				Catchability Maturity Ogive Mean Weight Recruitment Natural Death Rate Target Factor Other Metiers				Catchability Target Factor Other Metiers				Mean Weight Recruitment Natural Death Rate			
S7D	P7D	S7E	P7E	S7D	P7D	S7E	P7E	S7D	P7D	S7E	P7E	S7D	P7D	S7E	P7E
SO	alpha			SO	alpha			SO	alpha	SO	SO				
SN				SN				SN							
TFB				TFB		TFB	TFB	TFB		TFB	TFB				
SBT				TFN				TFN							
				SBT		SBT	SBT		SBT	SBT	SBT				

Table 4: Input parameters most impacting output variables, sorted from the most impacting to the less impacting

We keep 25 parameters for the info-gap analysis:

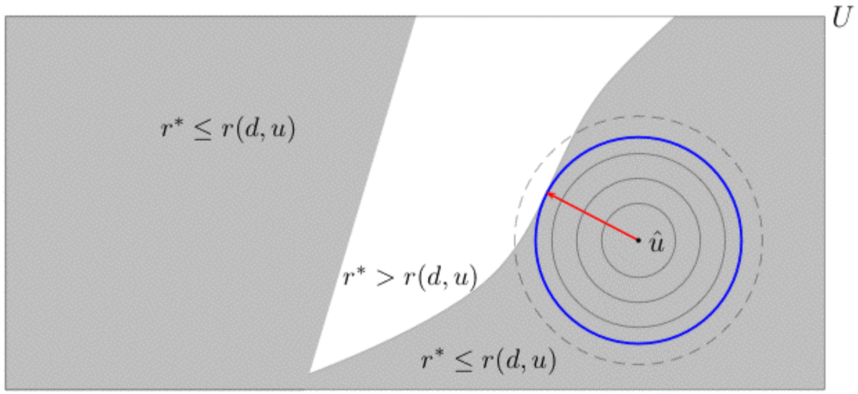
Parameter	Occurences	Parameter	Occurences
Target factor	2	Mean Weight	4
TAC	3	Natural Death Rate	4
Catchability	4	Recruitment	4
Maturity	4	**Total**	**25**

Criticisms of the info-gap method

It is not new, but based on:

- Maximin (or Minimax) theories
- Game theory
- Stability radius theories

It is inherently local, and therefore not fit for cases of severe (true) uncertainty



http://info-gap.moshe-online.com/mobile_maximin_theorem.html

Sniedovich 2010, 2011, 2012

Info-gap (Ben-Haim, 2001, 2006)

Minimax (Wald 1939, 1945, 1950; Hurwicz 1950, 1951a,b; Savage, 1951; Sniedovich 2010, 2011)

Game Theory (Von Neumann & Morgenstern, 1944)

The proposed approach

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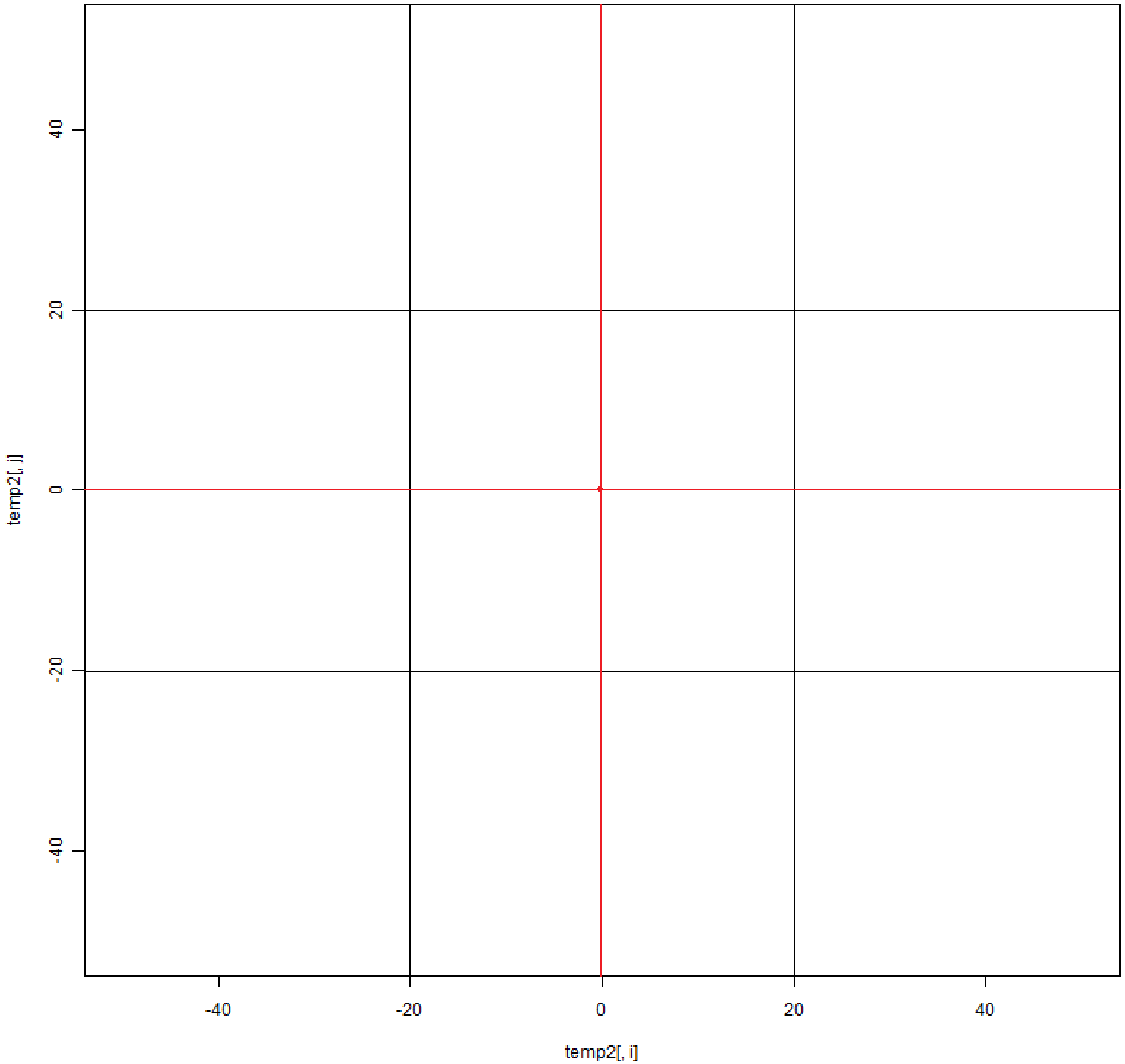
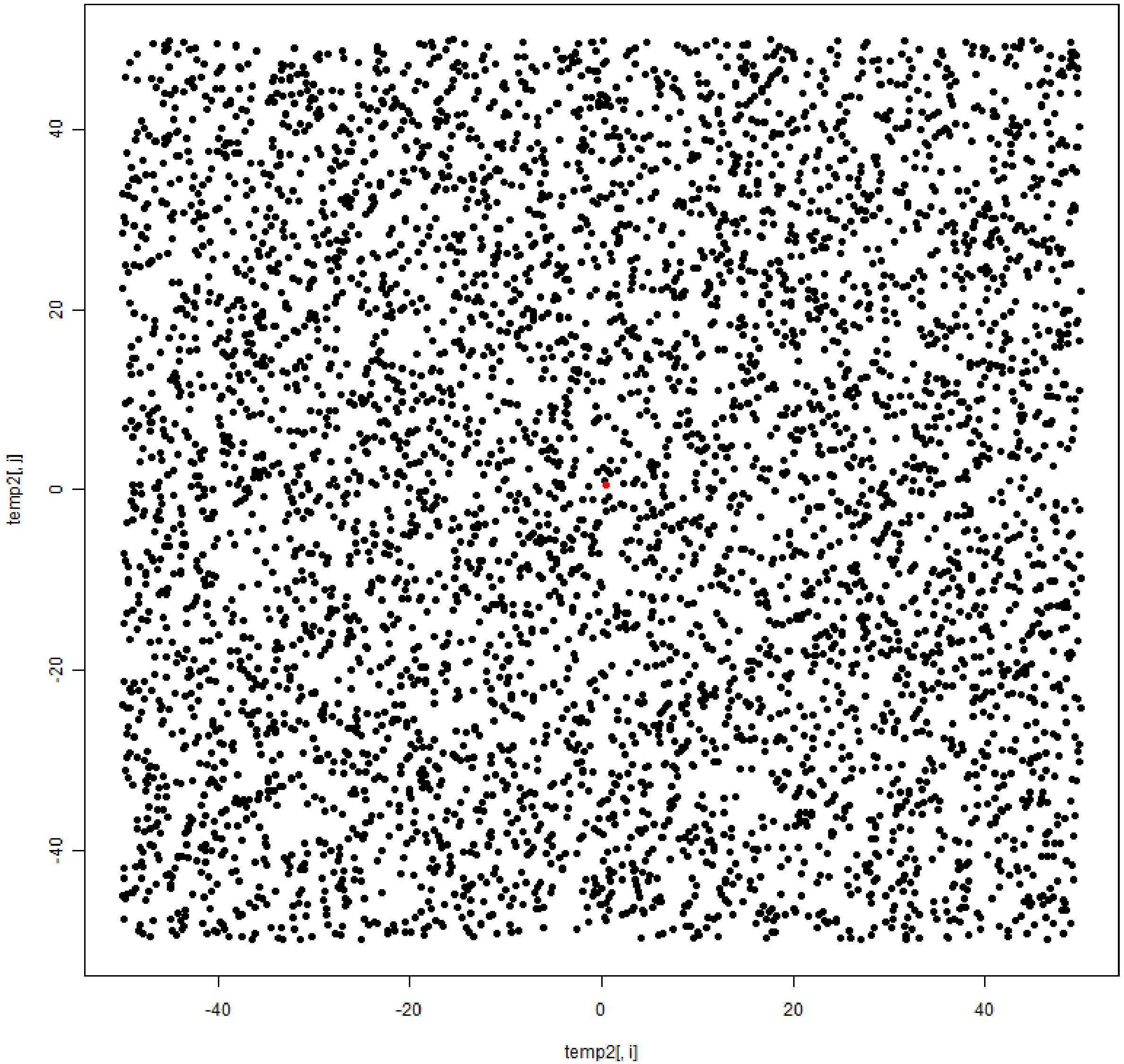
The proposed approach



The proposed approach



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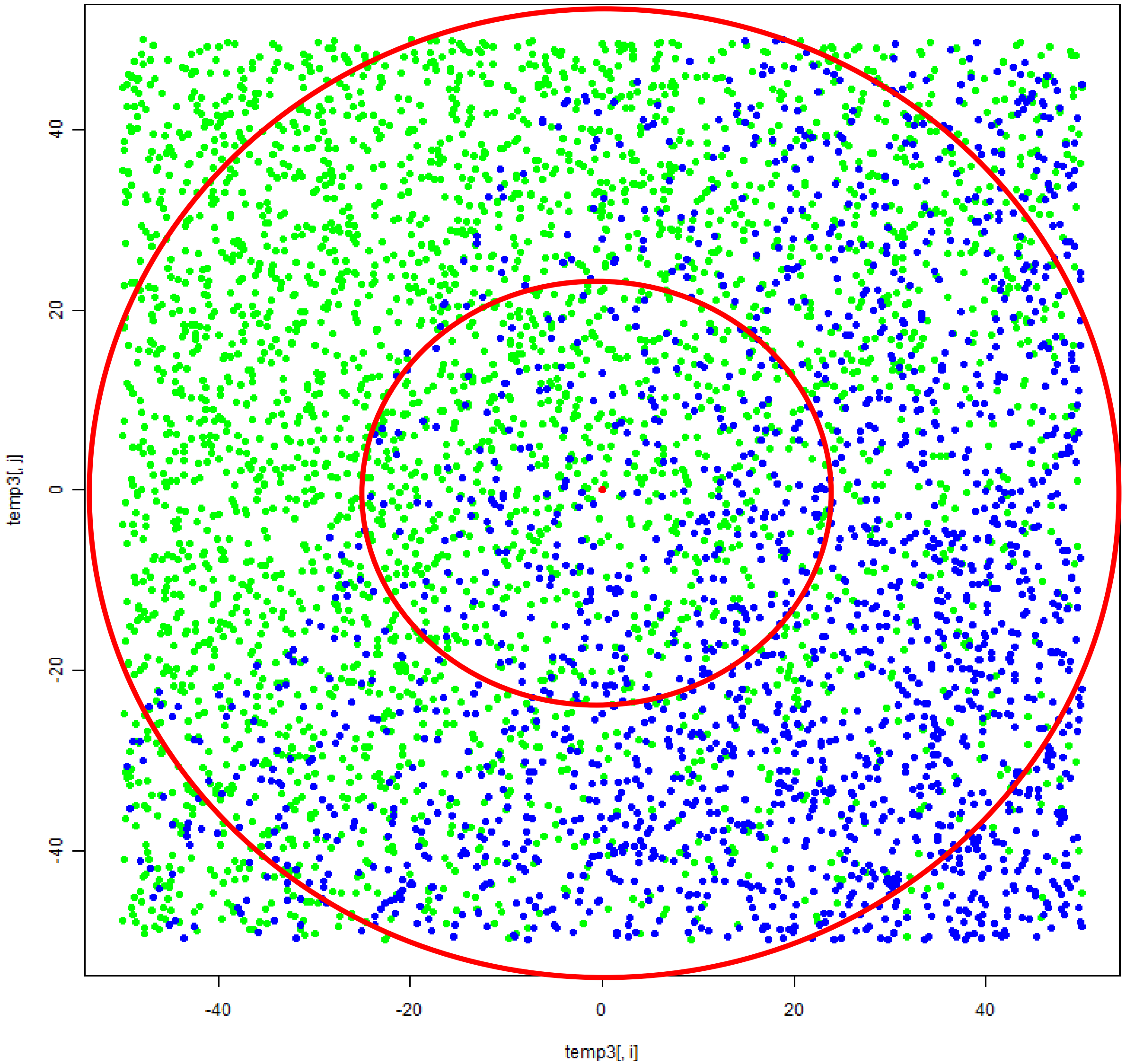
The proposed approach



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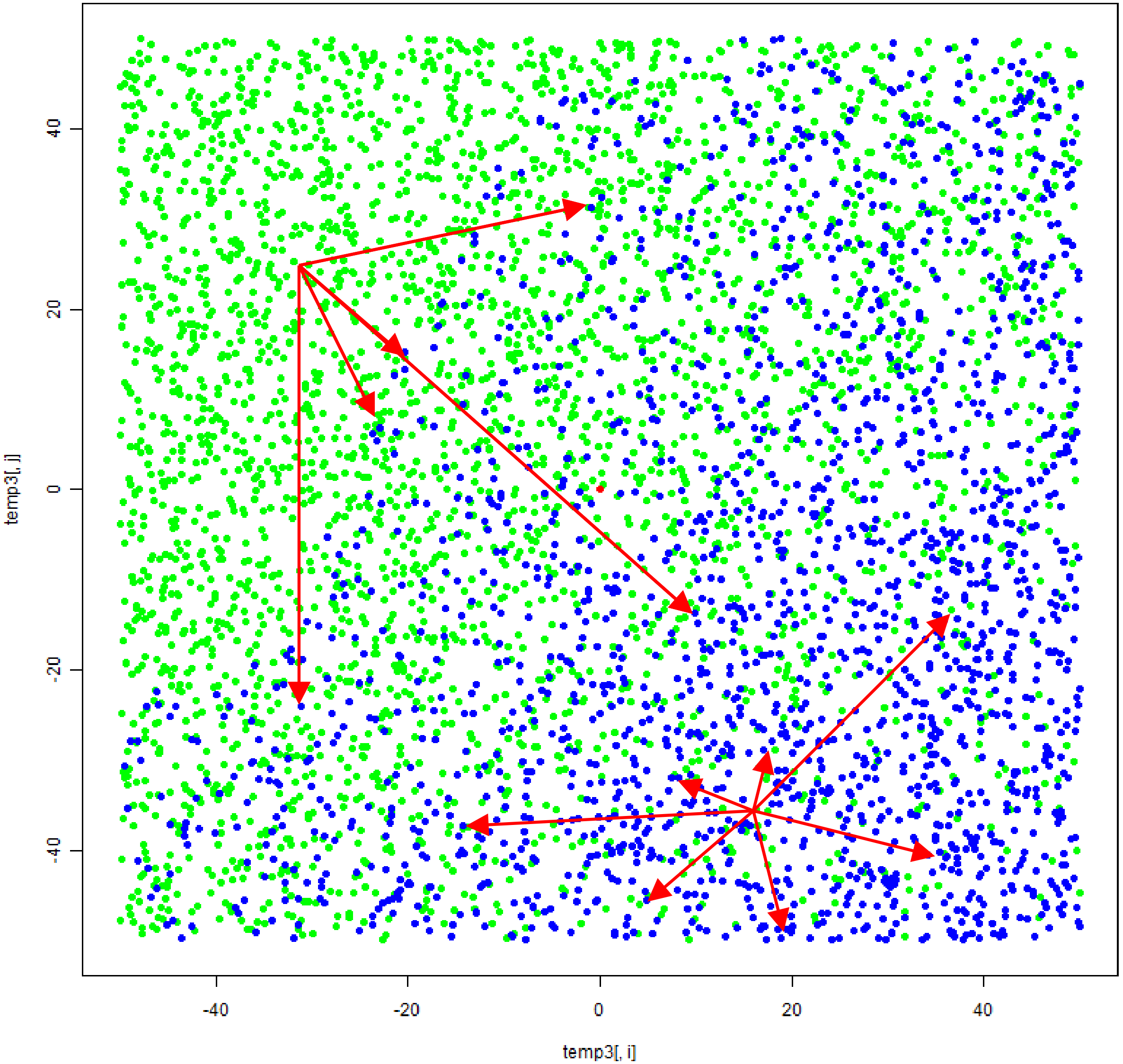

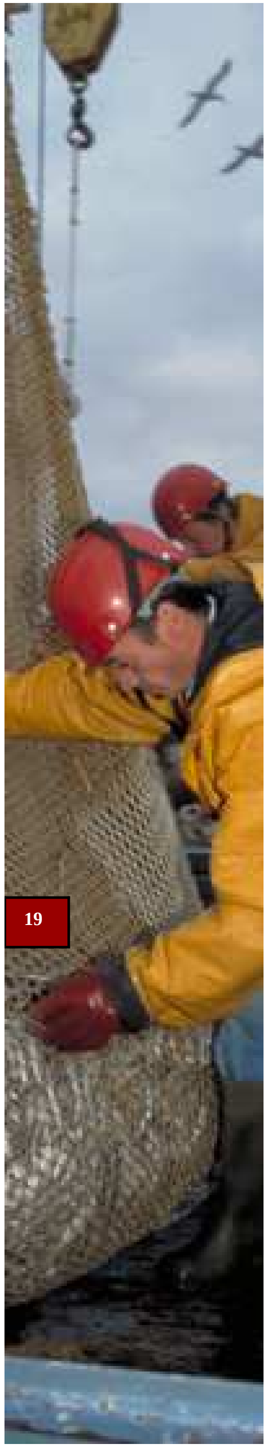

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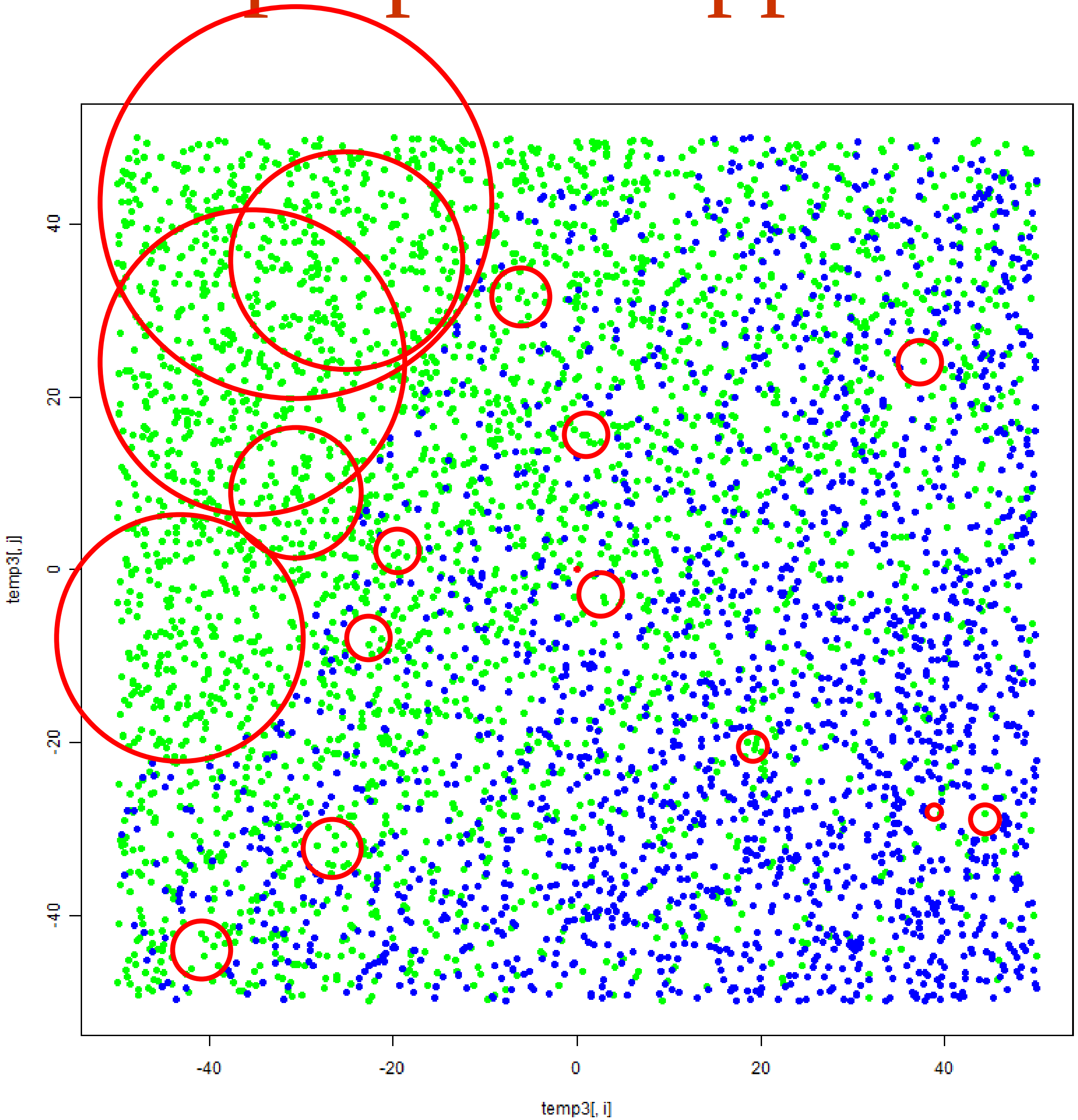
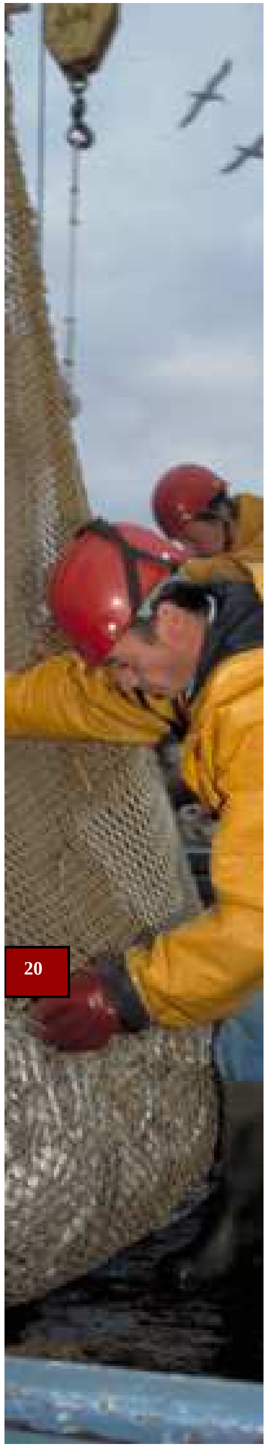
The proposed approach





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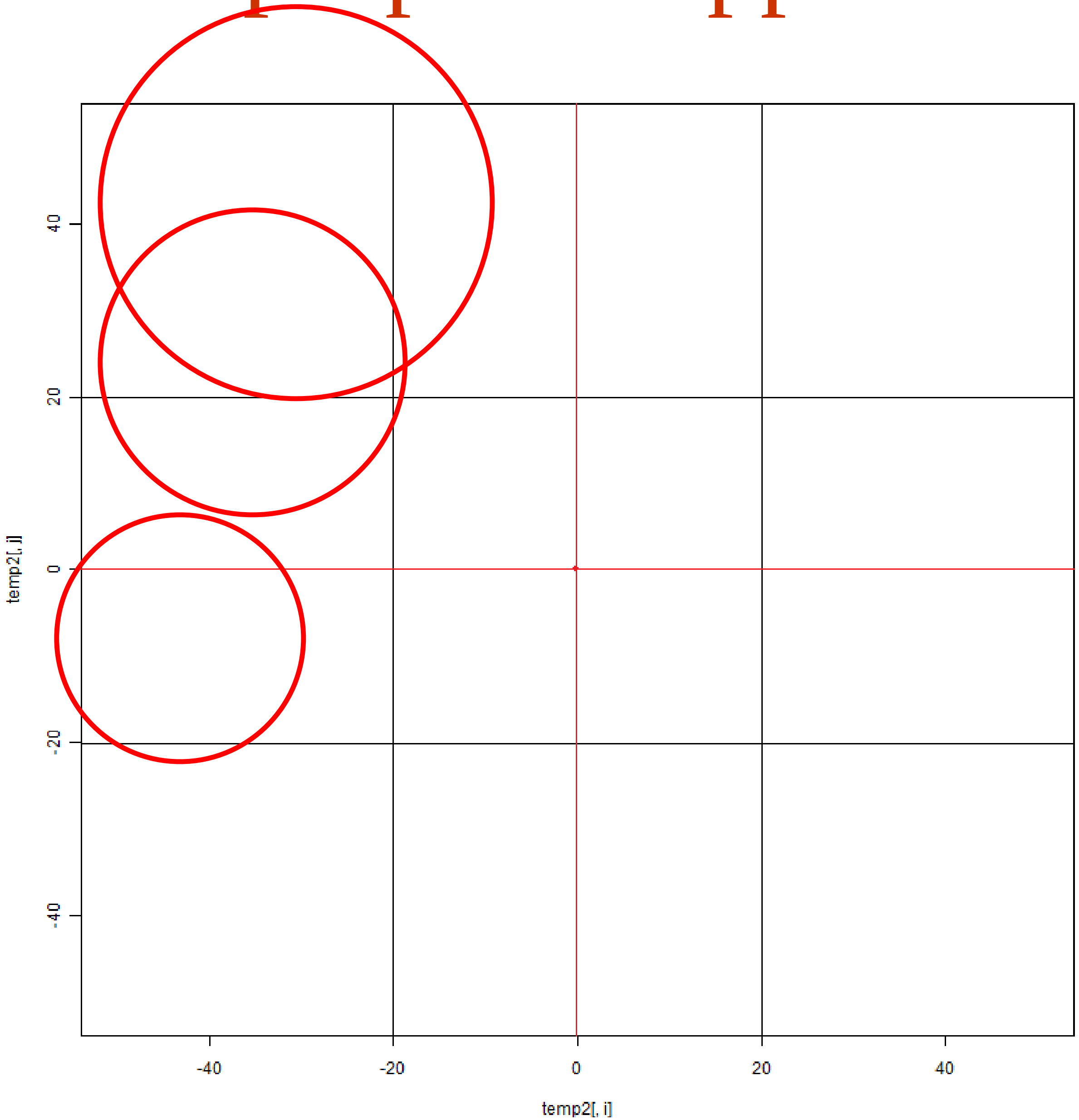

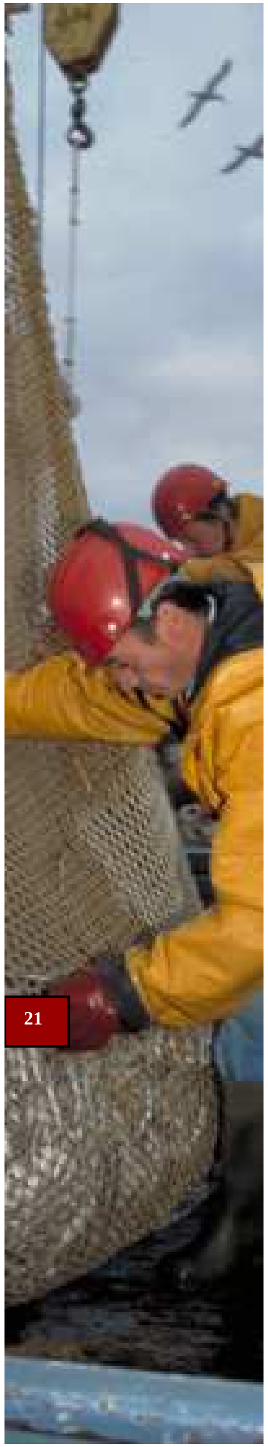

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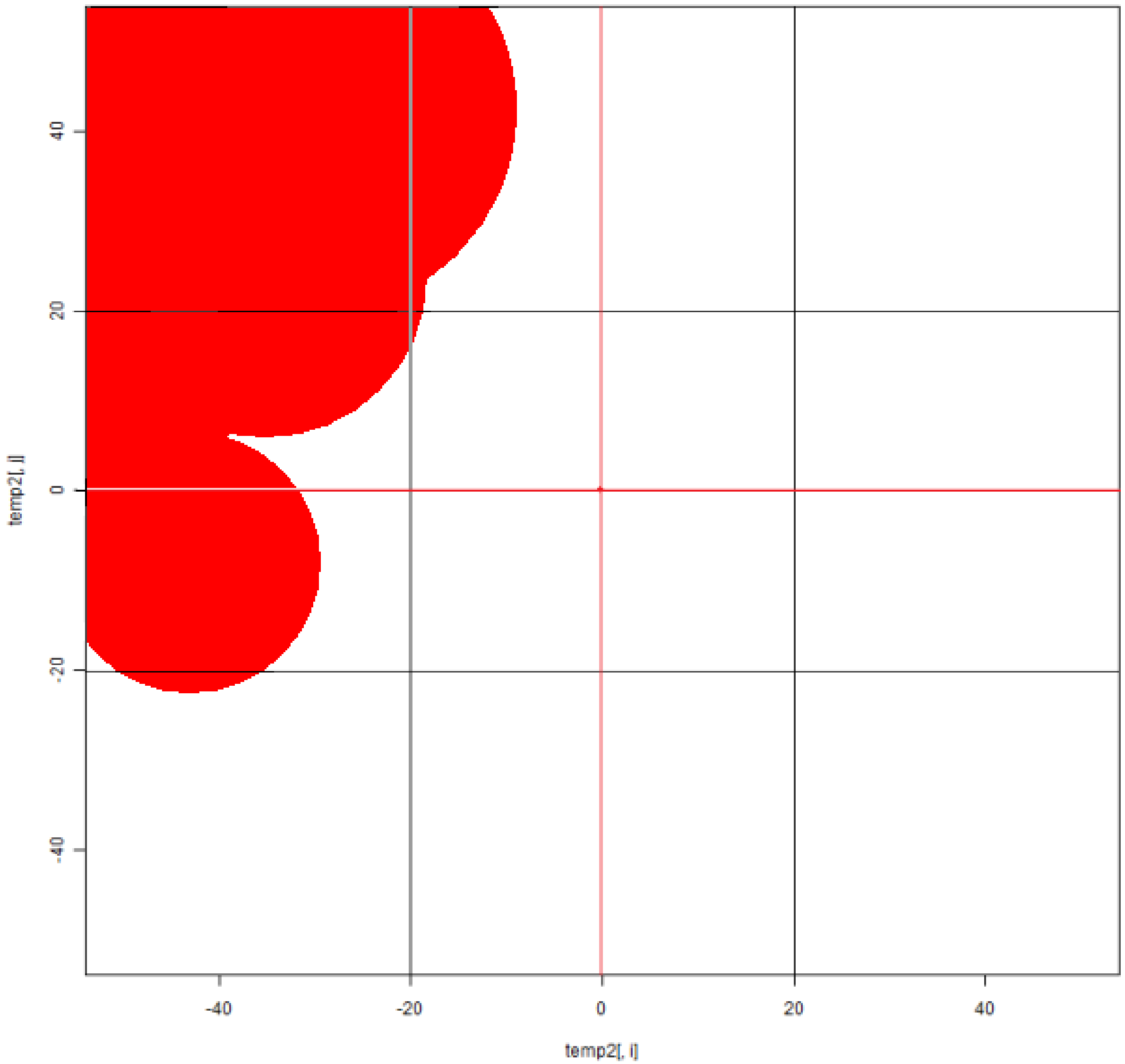

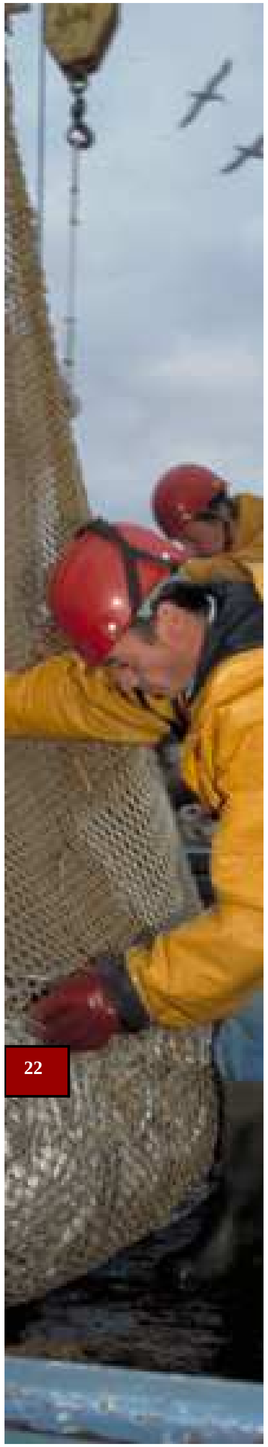

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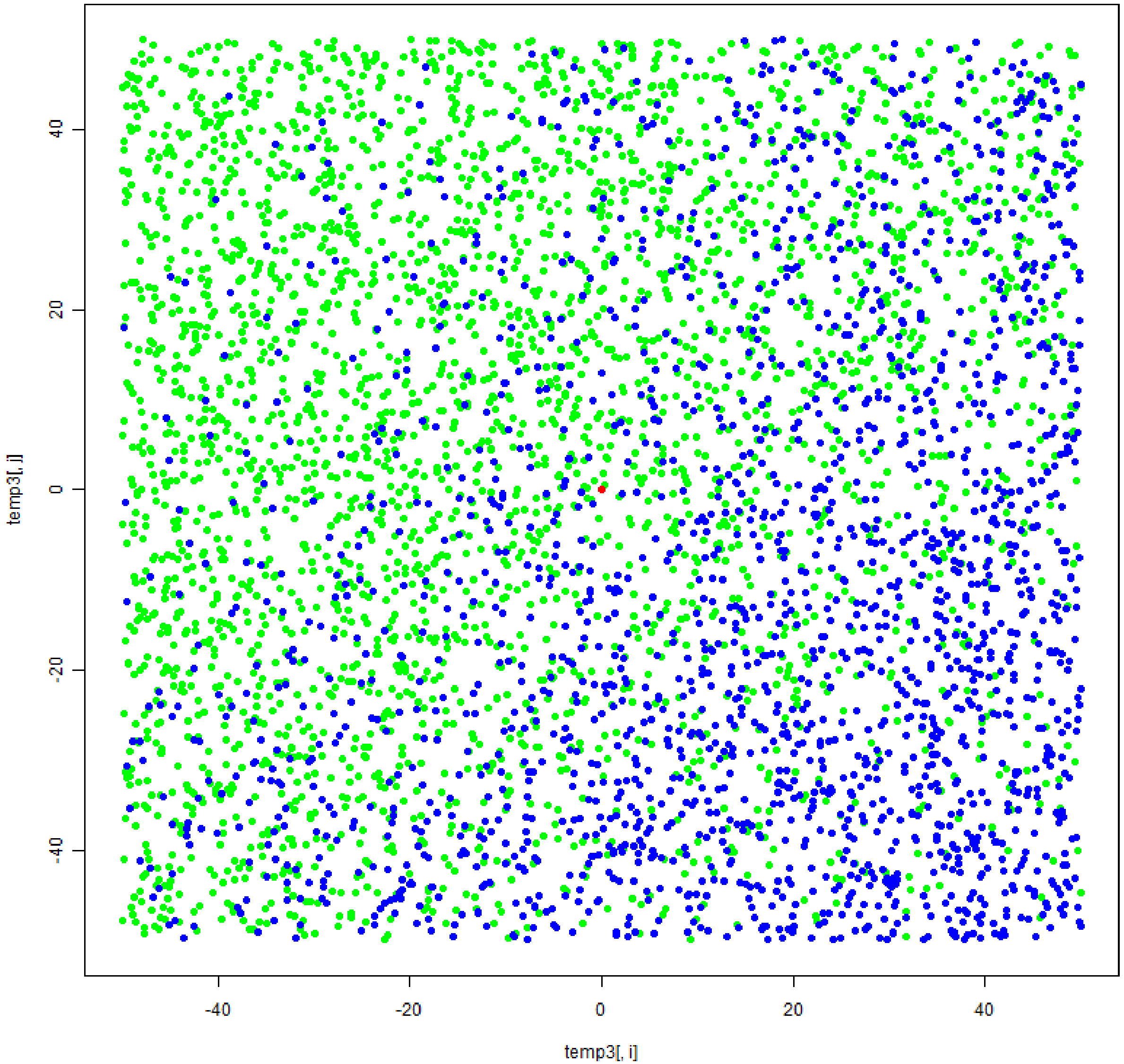
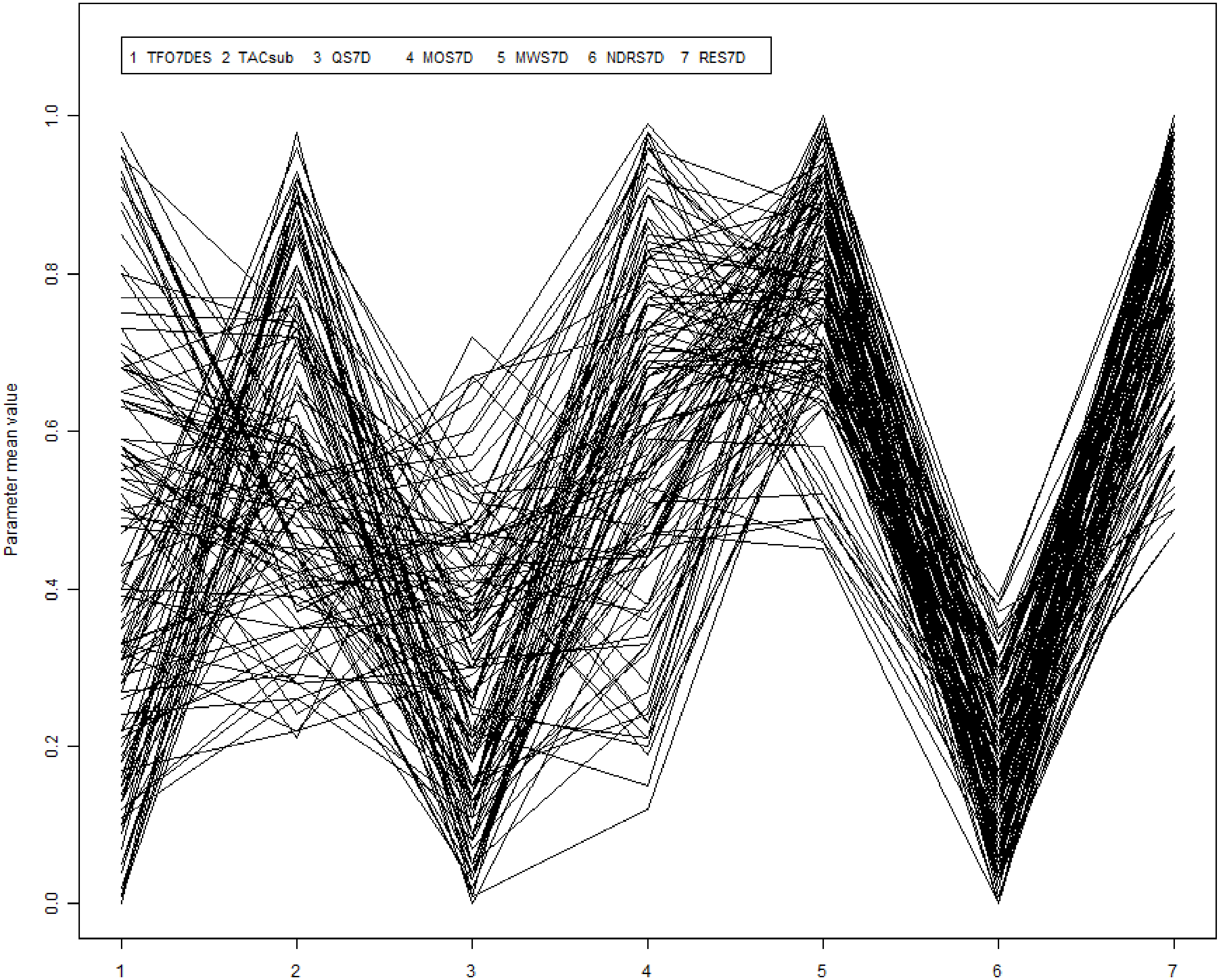
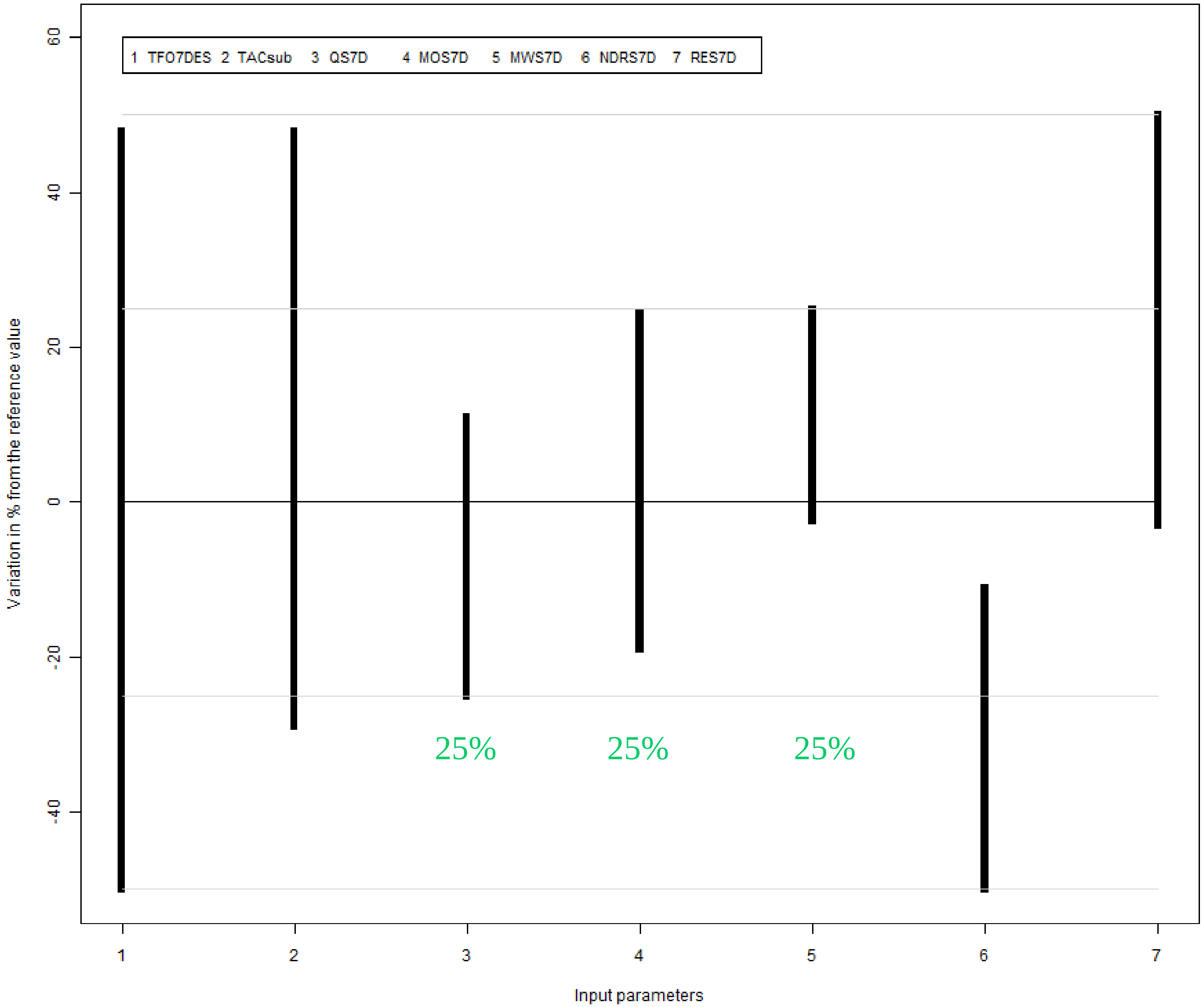


Info-gap + ISIS-Fish



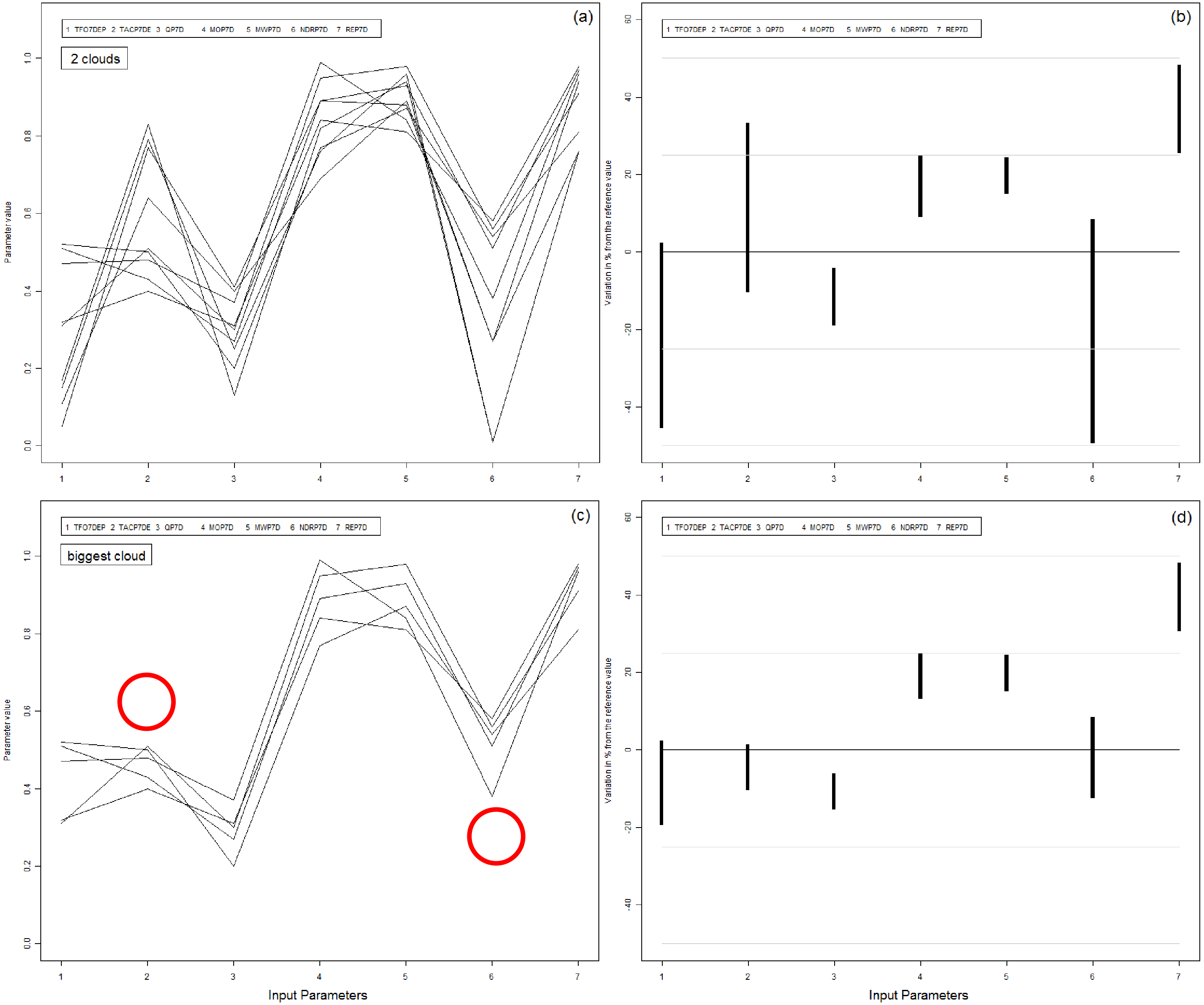
40 points cloud, criterion: SSBS7D>8000t

Info-gap + ISIS-Fish



40 points cloud, criterion: SSBS7D>8000t

Info-gap + ISIS-Fish



4 and 5 points clouds, criterion: SSBP7D>7000t

Conclusion

Sensitivity analysis had a major role to play in the reduction of the number of simulations to be performed in our approach.

Lack of impact of management measures, strongly environmentally-driven ecosystem → Need to test other management measures.

The weight of the « Other Metiers » groups calls for improvements in our model.

Some uncertainty can remain at the boundaries of the subspaces identified as « safe » (number of points per cloud).

Need to test the method on other cases, with a higher influence of management to determine its usefulness.

Conclusion

Taking into account our current knowledge of the ecosystem’s state, goals defined by the ICES for the 4 populations cannnot be reached.

We used the most standard indicators set up for fisheries management.

It is rather straightforward how input parameters influence values of the output variables.

But it is much harder to determine which input parameter values are desirable, relative to fixed goals in the indicators values.

Can we deal with more complex indicators ?

Thanks for your attention !