Probabilistic Seasonal Climate Forecasting

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Problem

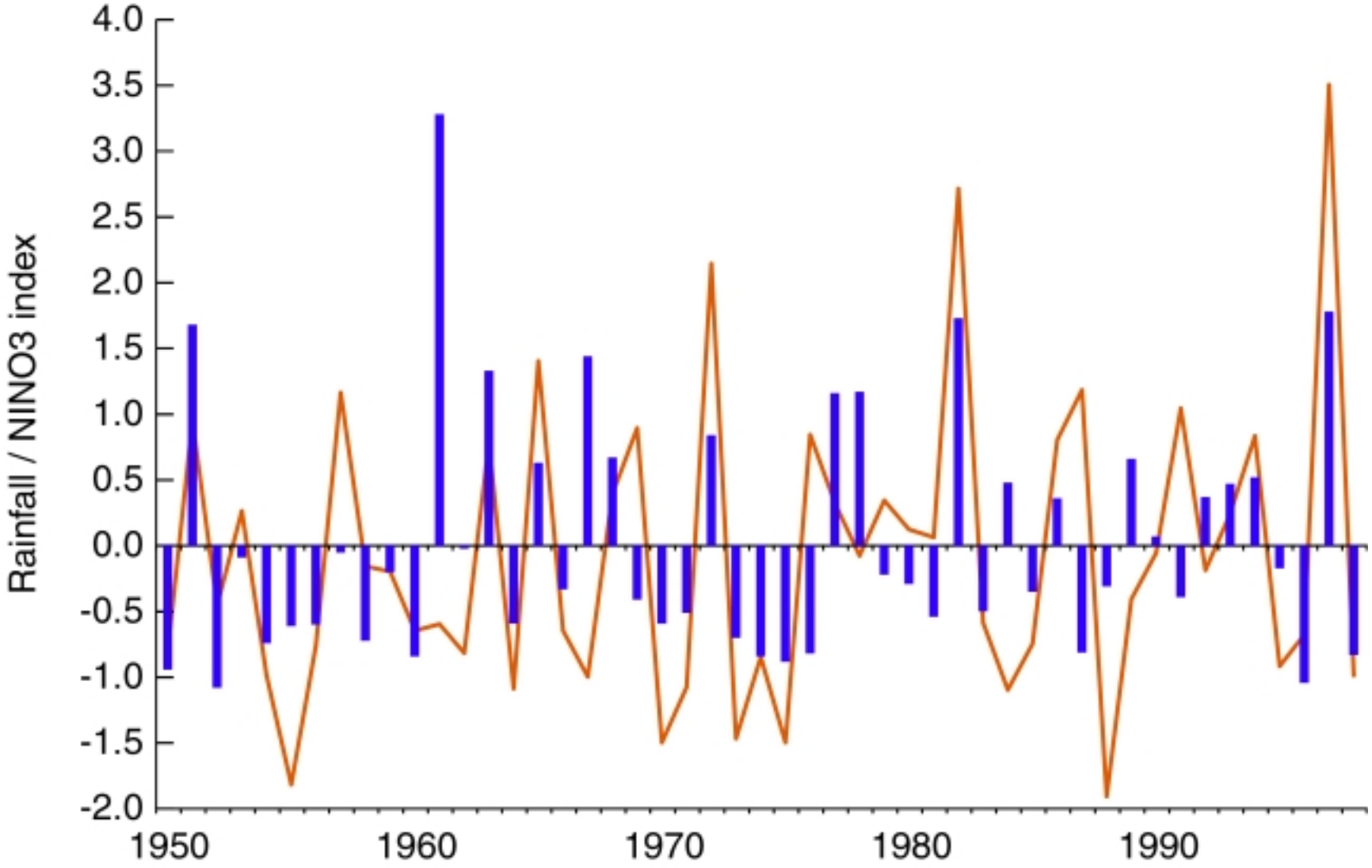
- Inherent uncertainty in medium to long-range forecasts because of:

  - Uncertainty in initial conditions.
  - Imperfect models.

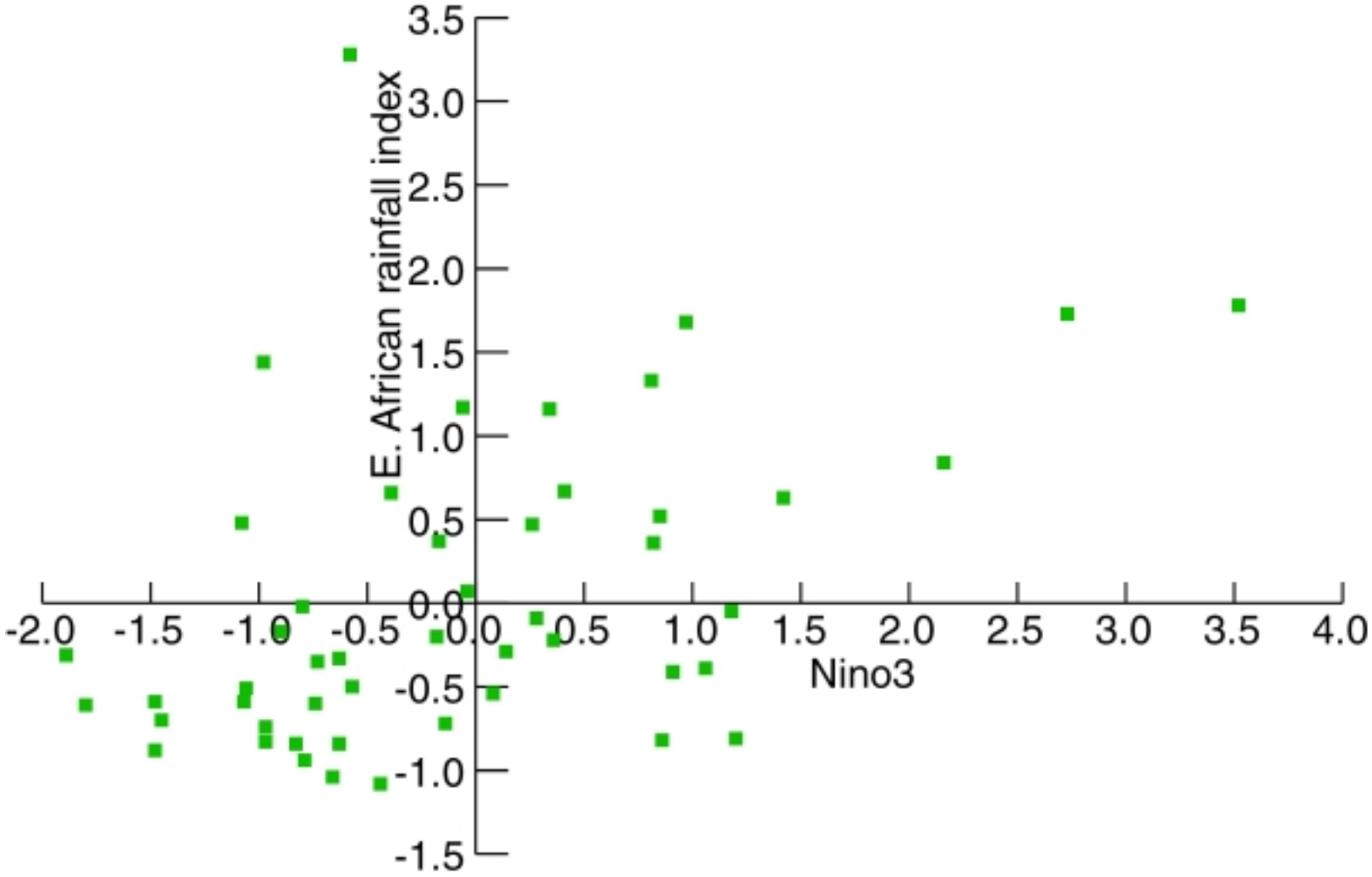
Solutions

- Define:
  - forecast probabilities / forecast uncertainty.
- Estimating forecast uncertainty:
  - statistical methods;
  - produce more than one forecast.
- An ensemble of forecasts, is a set of individual forecasts that verify at the same time.

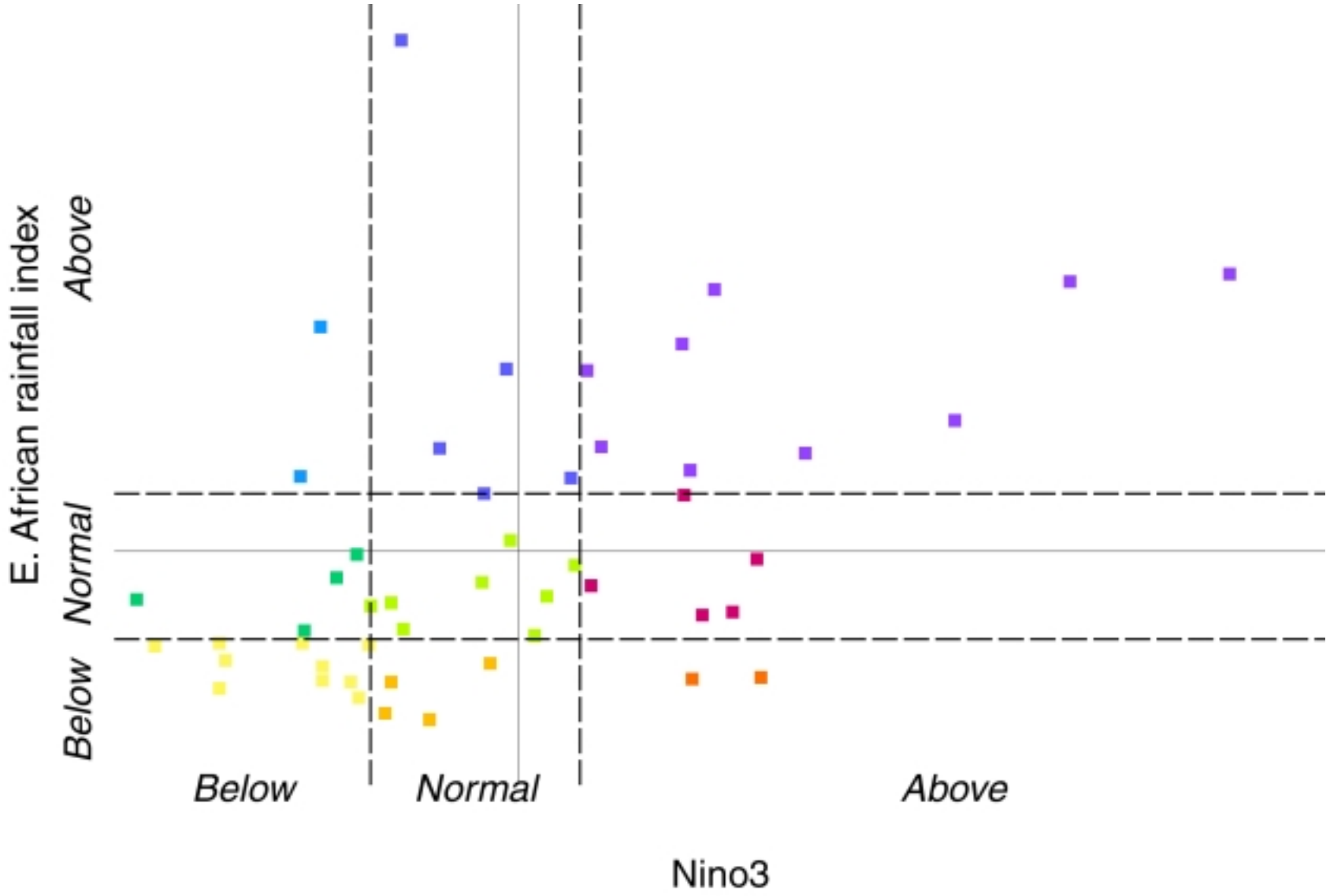
The data


Rainfall / NINO3 index
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
1950
1960
1970
1980
1990

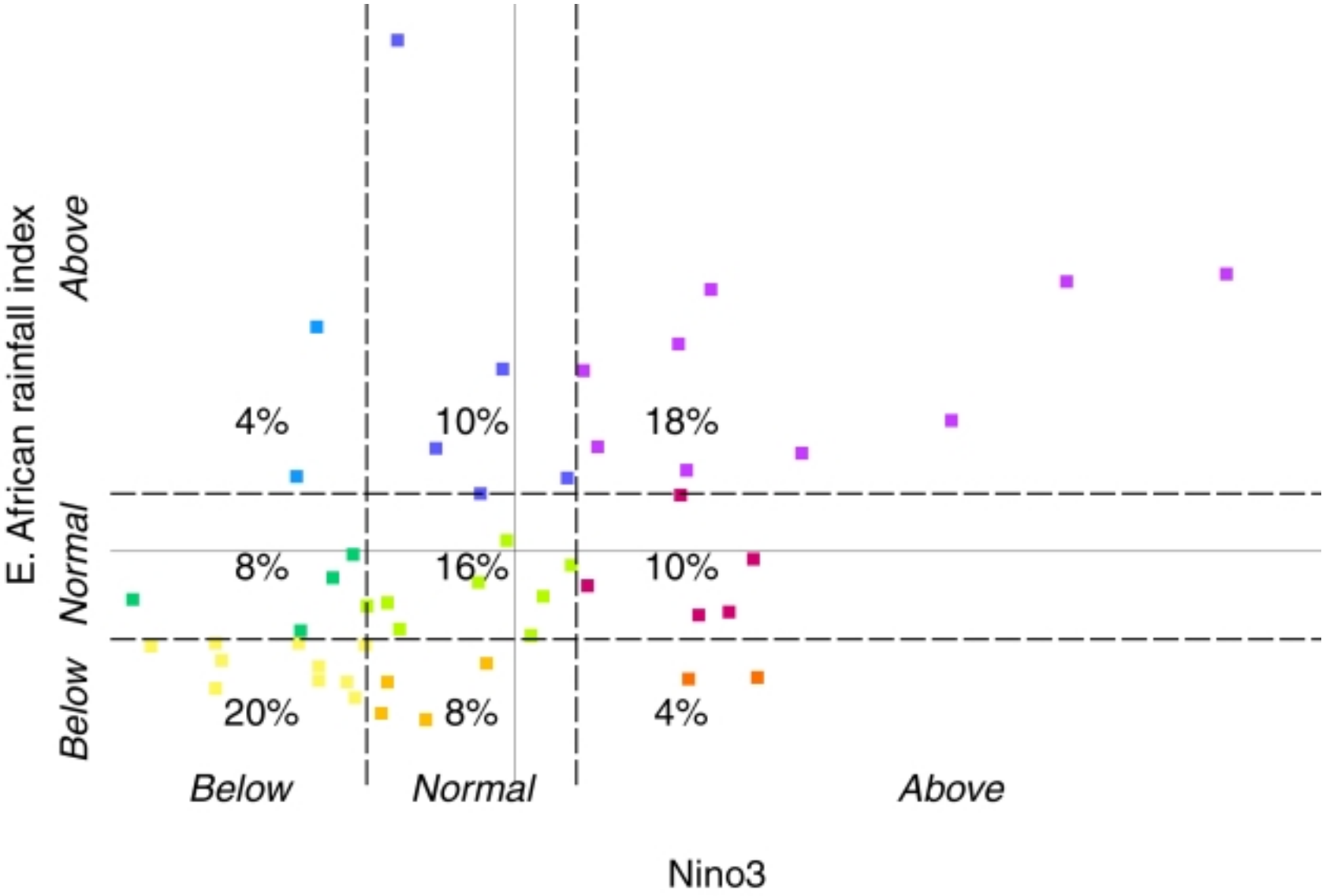
The data


E. African rainfall index
Nino3
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
-1.5
-1.0
-0.5
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0

Contingency tables



Contingency tables



Statistical probabilistic forecasts

Contingency table.

RAINFALL	NINO3		
	Below	Normal	Above
Above	2 of 16	5 of 17	9 of 16
Normal	4 of 16	8 of 17	5 of 16
Below	10 of 16	4 of 17	2 of 16

Statistical probabilistic forecasts

Contingency table.

	NINO3		
RAINFALL	**Below**	**Normal**	**Above**
Above	13%	30%	**57%**
Normal	25%	48%	**32%**
Below	64%	24%	**13%**

But we do not know what the NINO3 index will be.

Statistical probabilistic forecasts

ENSO forecast: 20% below; 30% above; 50% above.

	NIÑO3		
RAINFALL	**Below**	**Normal**	**Above**
Above	13%	30%	**57%**
Normal	25%	48%	**32%**
Below	64%	24%	**13%**

Rainfall forecast: 25% below; 35% normal; 40% above.

Contingency tables

Problems and assumptions:

Allows for only one predictor.

Tends to be “unreliable”, especially given small samples.

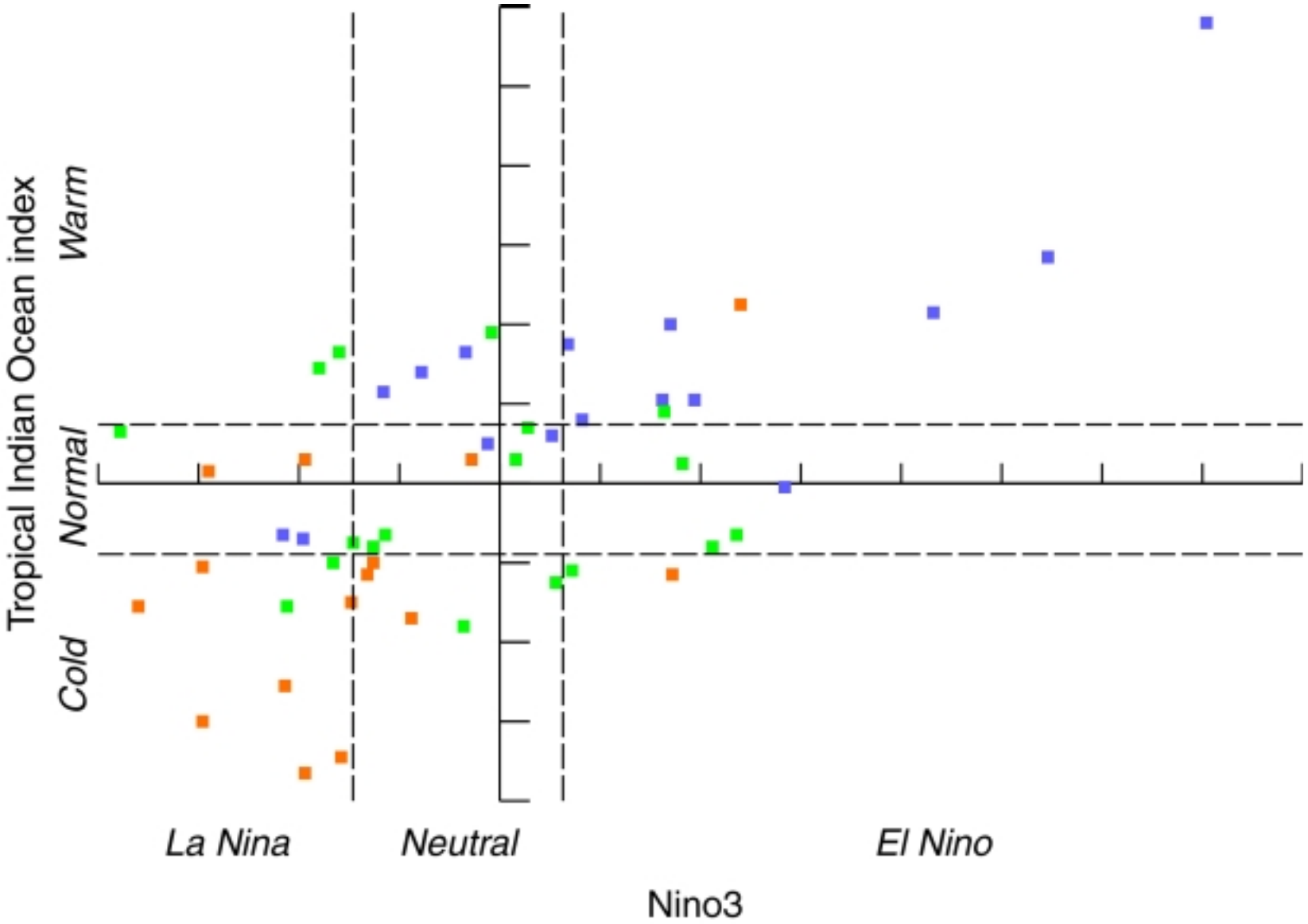
The data are assumed to be independent (no trends or long-term persistence).

Contingency tables

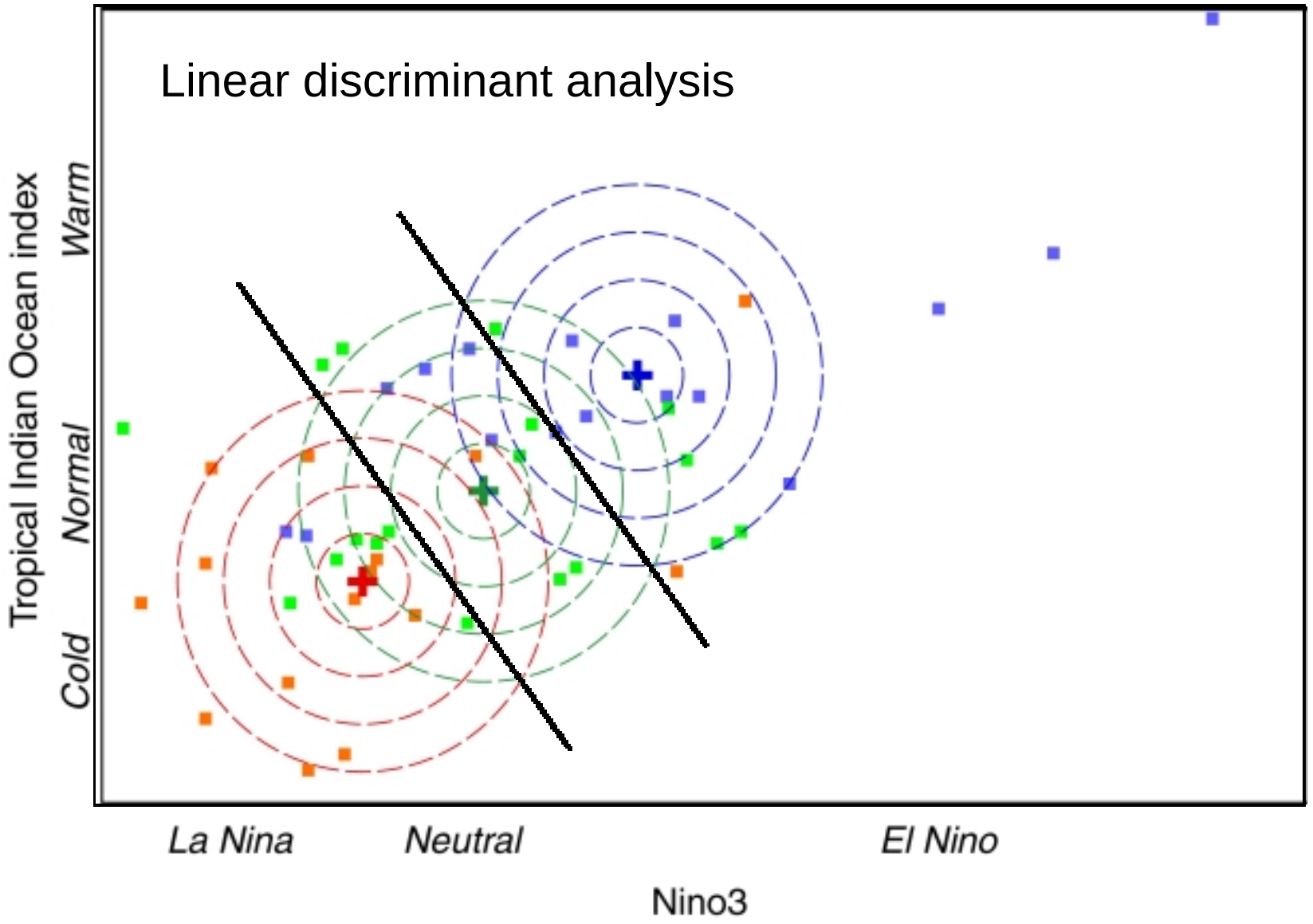
Advantages:

Simple to calculate.
Easy to understand.
Few assumptions.

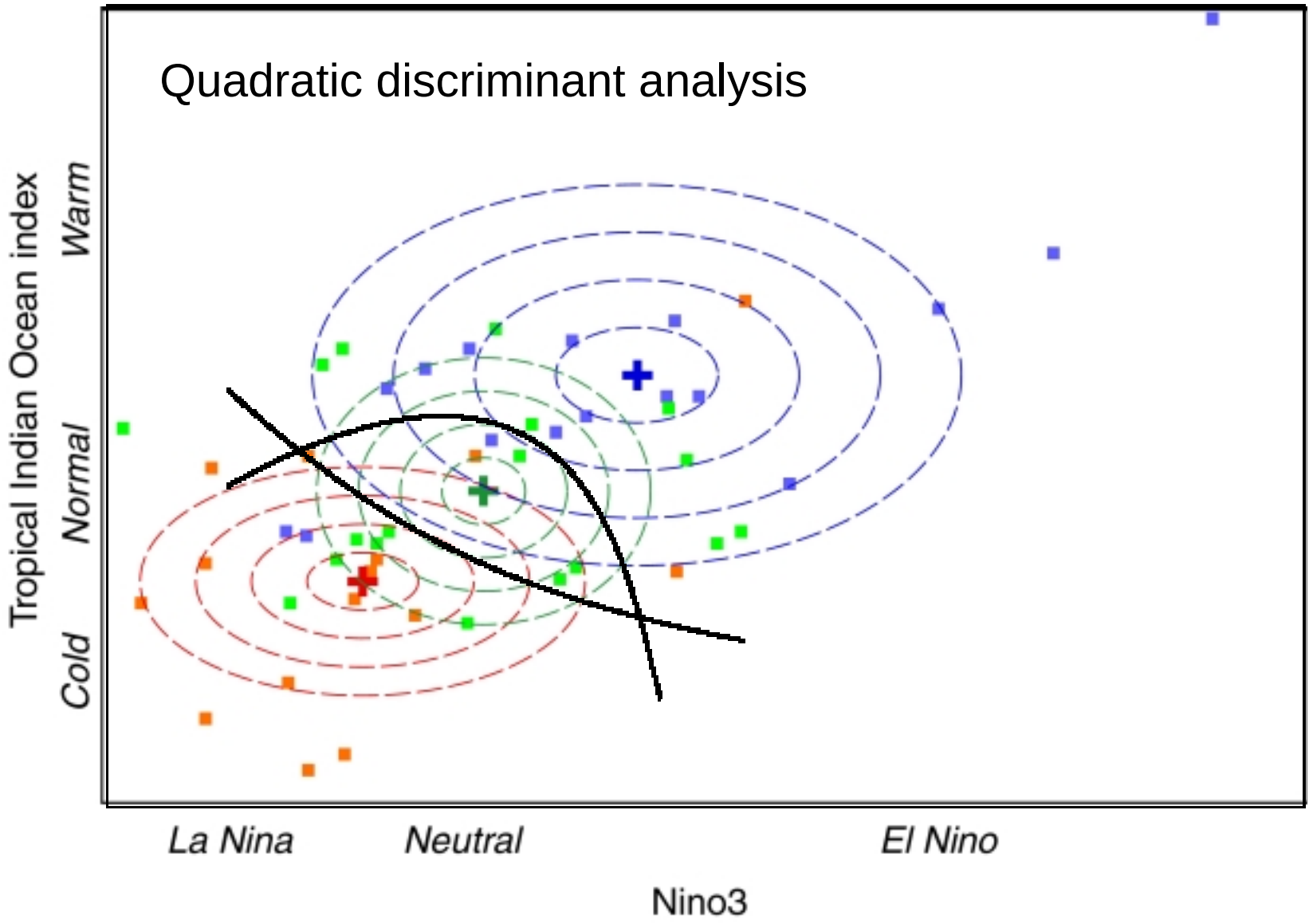
Discriminant analysis



Discriminant analysis

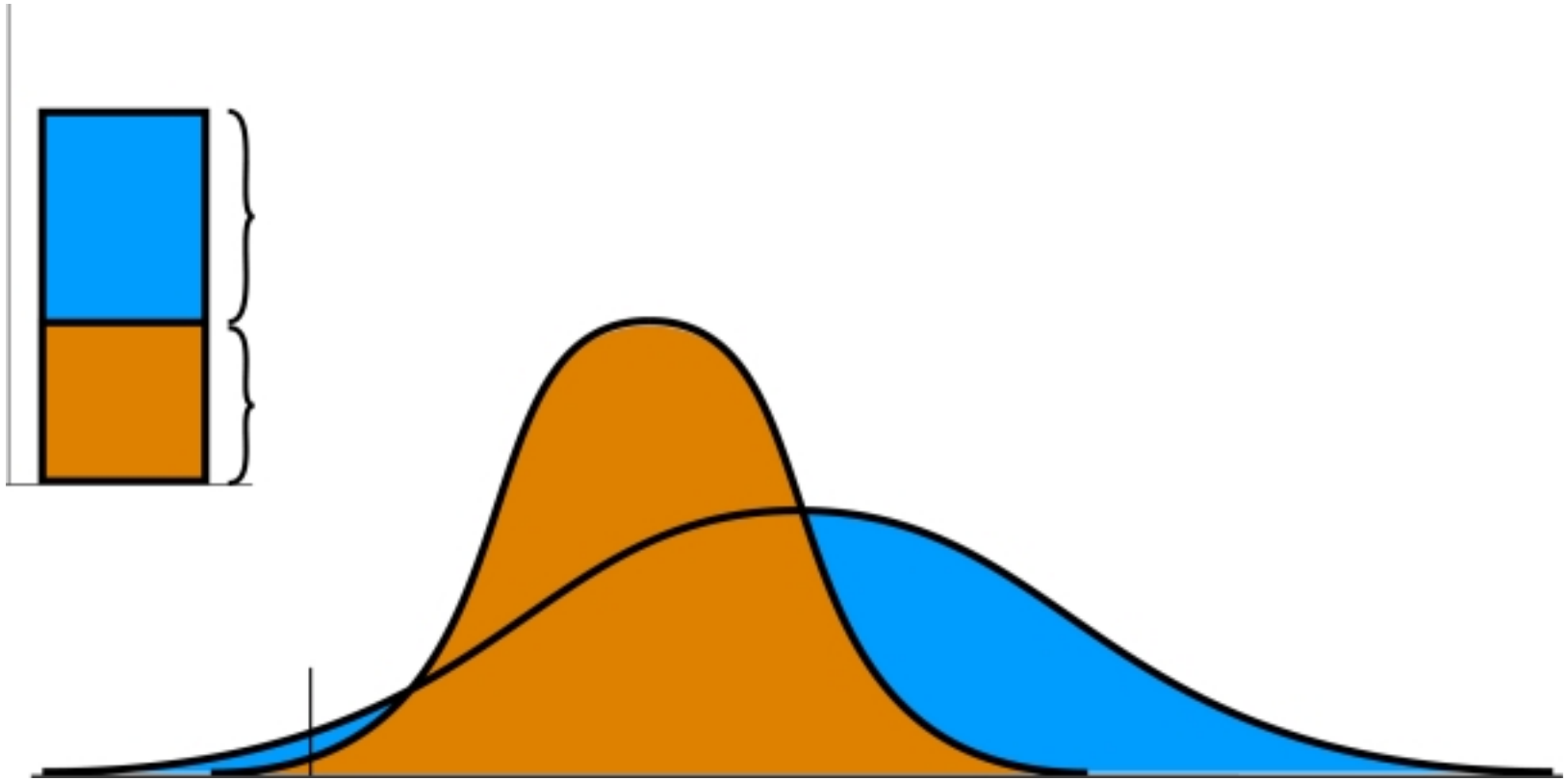


Discriminant analysis



Discriminant analysis

Quadratic discriminant analysis



Discriminant analysis

Appropriate tests:

Are the category means different?

ANOVA

Do the variances differ?

A very complicated likelihood ratio test, producing a statistic that is approximately distributed as χ^2.

Discriminant analysis

Problems and assumptions:

Requires reasonably large samples because of large number of parameters:

$$n > 3 \times \text{number of predictors} \times \text{number of categories}$$

Distributional assumptions about predictors.

Assumption of equal variance a problem with linear DA, but quadratic DA can give strange results.

(In most cases it is best to use linear DA).

Probabilities can be “unreliable”.

Discriminant analysis

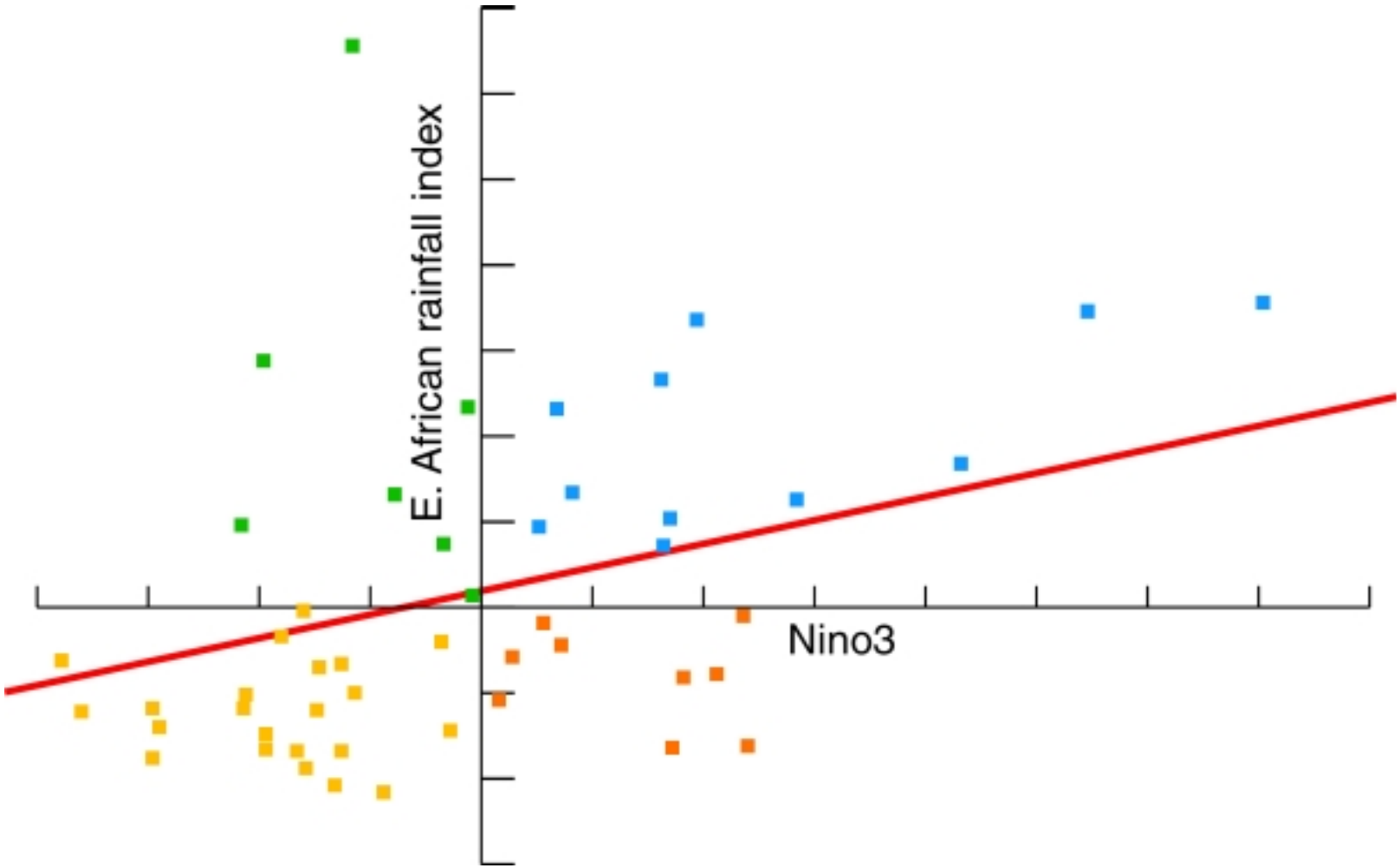
Advantages:

No distributional assumptions about the predictand.

No simple linear relationship assumed even with linear DA (groups are categorical nor ordinal).

Probabilistic.

Regression



From regression to probabilistic forecasts

Contingency table.

	PREDICTED RAINFALL		
RAINFALL	**Below**	**Normal**	**Above**
Above	**0% (0)**	**19% (6)**	**77% (10)**
Normal	**0% (0)**	**47% (15)**	**15% (2)**
Below	**100% (4)**	**34% (11)**	**7% (1)**

Using prediction intervals