A journey from climate information to decision-making: a tale of two worlds?

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A tale of two worlds?

Introduction

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Introduction

Source: https://www.gfcs-climate.org/about-gfcs/

2009-2012

The Global Framework for Climate Services

"To enable better **management** of the **risks** of **climate variability** and **change** and adaptation to climate change, through the development and incorporation of science-based climate information and prediction into **planning**, **policy** and **practice** on the global, regional and national scale."

Source: https://www.gfcs-climate.org/about-

Five Pillars

(I) Monitoring and Observations

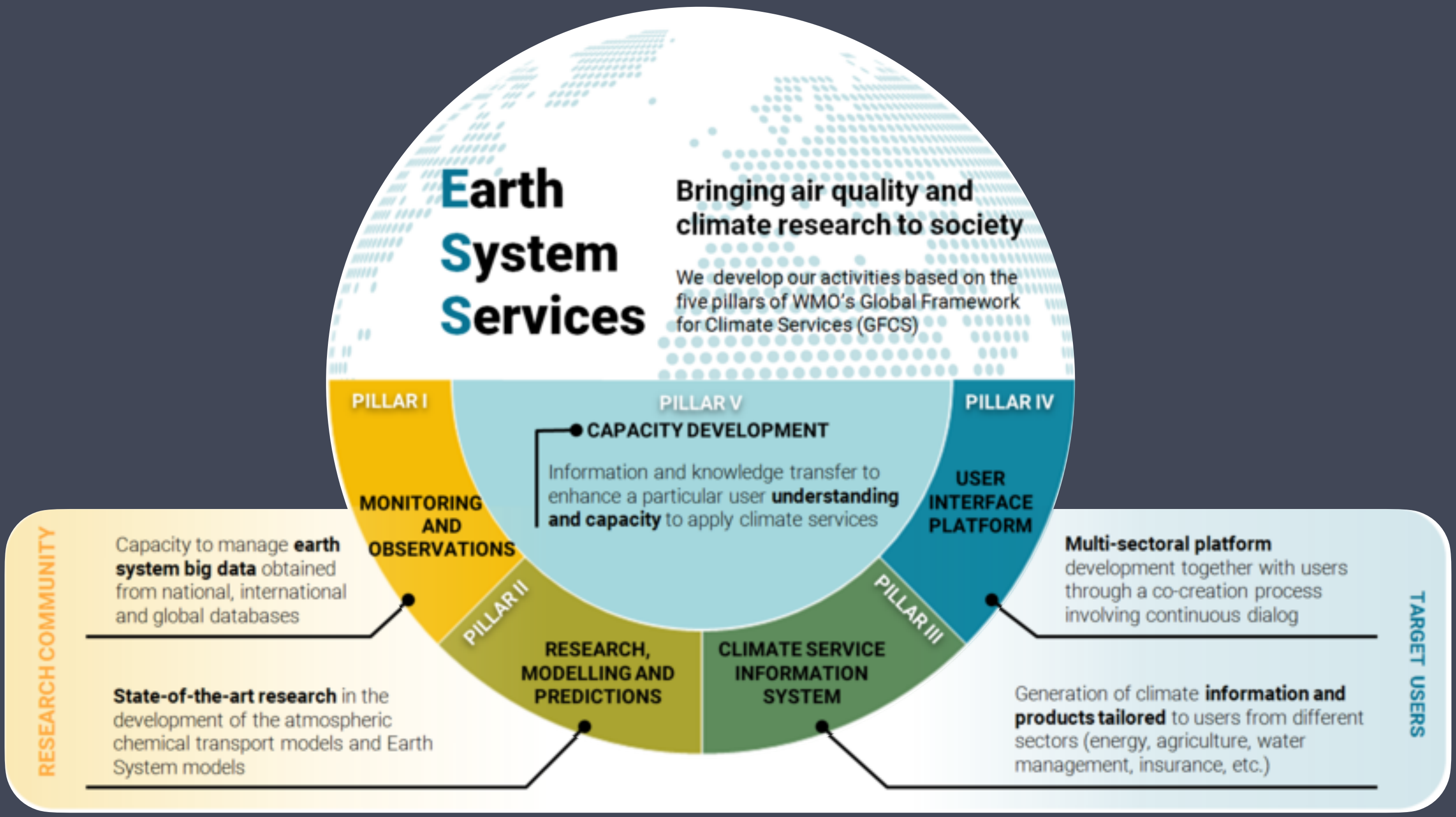
(II) Research Modelling and Prediction

(III) Climate Service Information System

(IV) User interface Platform

(V) Capacity Development

Earth System Services



A tale of two worlds?

First round

A tale of two worlds?

First round

(2) Water Resource Manager:

"We cannot afford public water restrictions"

Risk aversion: High
Public Institution

(1) Grape-vine grower:

"Open to new stratregies to optimise profits & expenses. I have 5ha for testing (out of 20ha)"

Risk aversion: Moderate
Farmer

(3) Weather Derivatives trader:

"We have to take advantage of the predictions to maximise profit. We can hedge with other products."

Risk aversion: Low
Business

A tale of two worlds?

First round

We are at the **end** of **February**. Our region is a **semi-arid** extra-tropical area with **hot** and **dry** summers. The **rainy** season is **spring**. Each one of our users has to take a **context-specific** decision based on the March-April-May rain by the 1st of **June**. This decision, if taken in **advance**, could be **advantageous** (but also **detrimental**, depending on the final spring-rain outcome).

March	April	May	June

A tale of two worlds?

First round

In this **first round** we only need that you discuss three **items**:

- What kind of **predictions** would you **choose** to look at? **Deterministic** or **probabilistic**? Why?
- What do you understand by ‘**risk aversion**’ in decision-making?
- What is a ‘**risk**’?

March	April	May	June

A tale of two worlds?

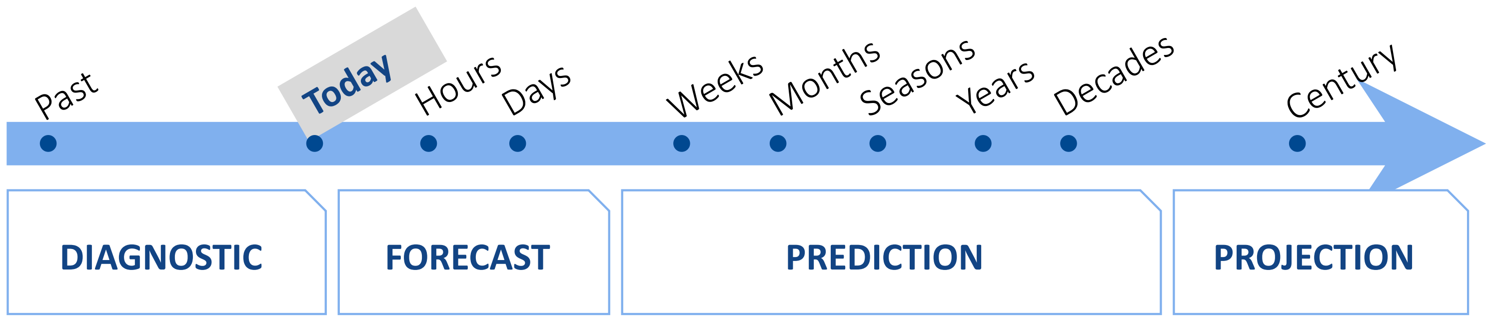
First round

What kind of **forecast** would you look at? **Deterministic** or **probabilistic**?

A tale of two worlds?

First round

Seasonal forecasts



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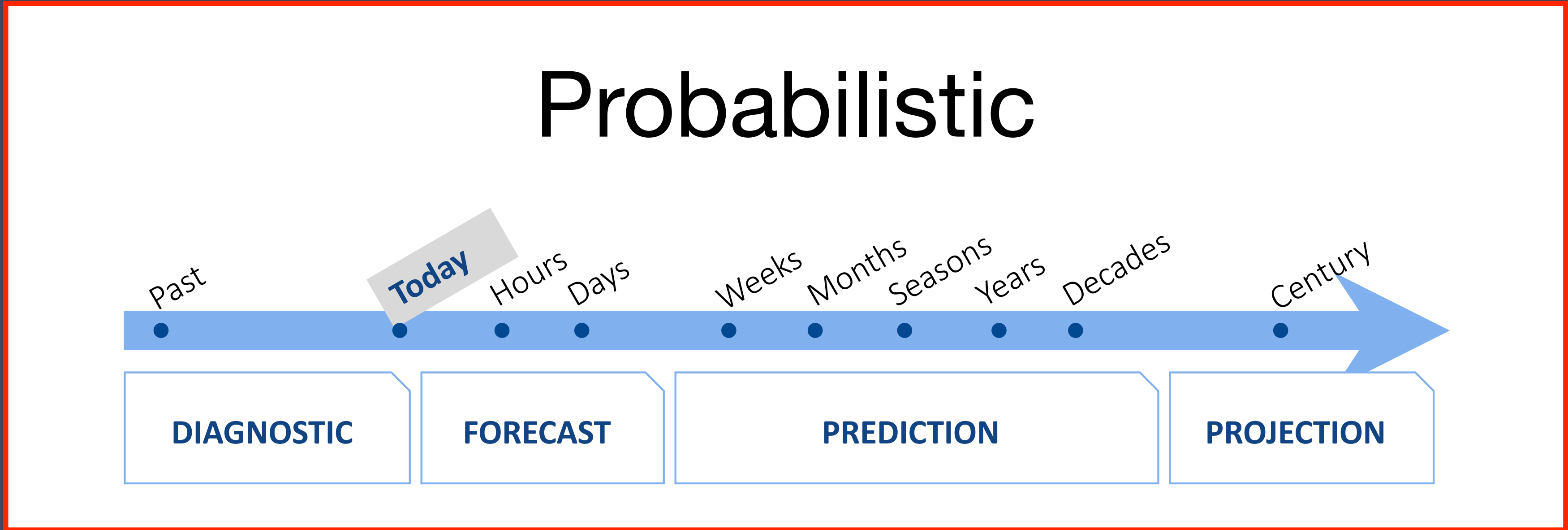
First round



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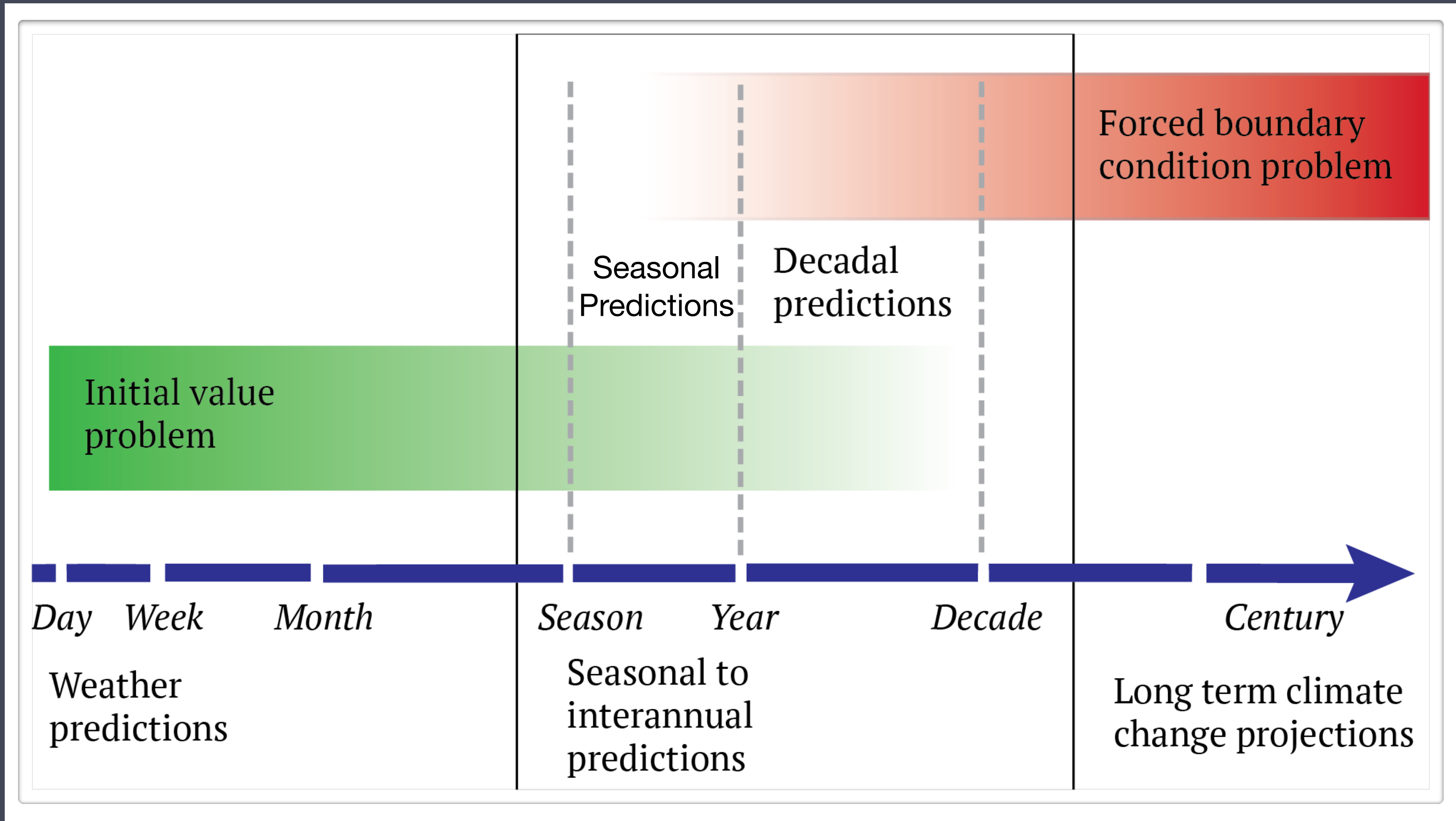

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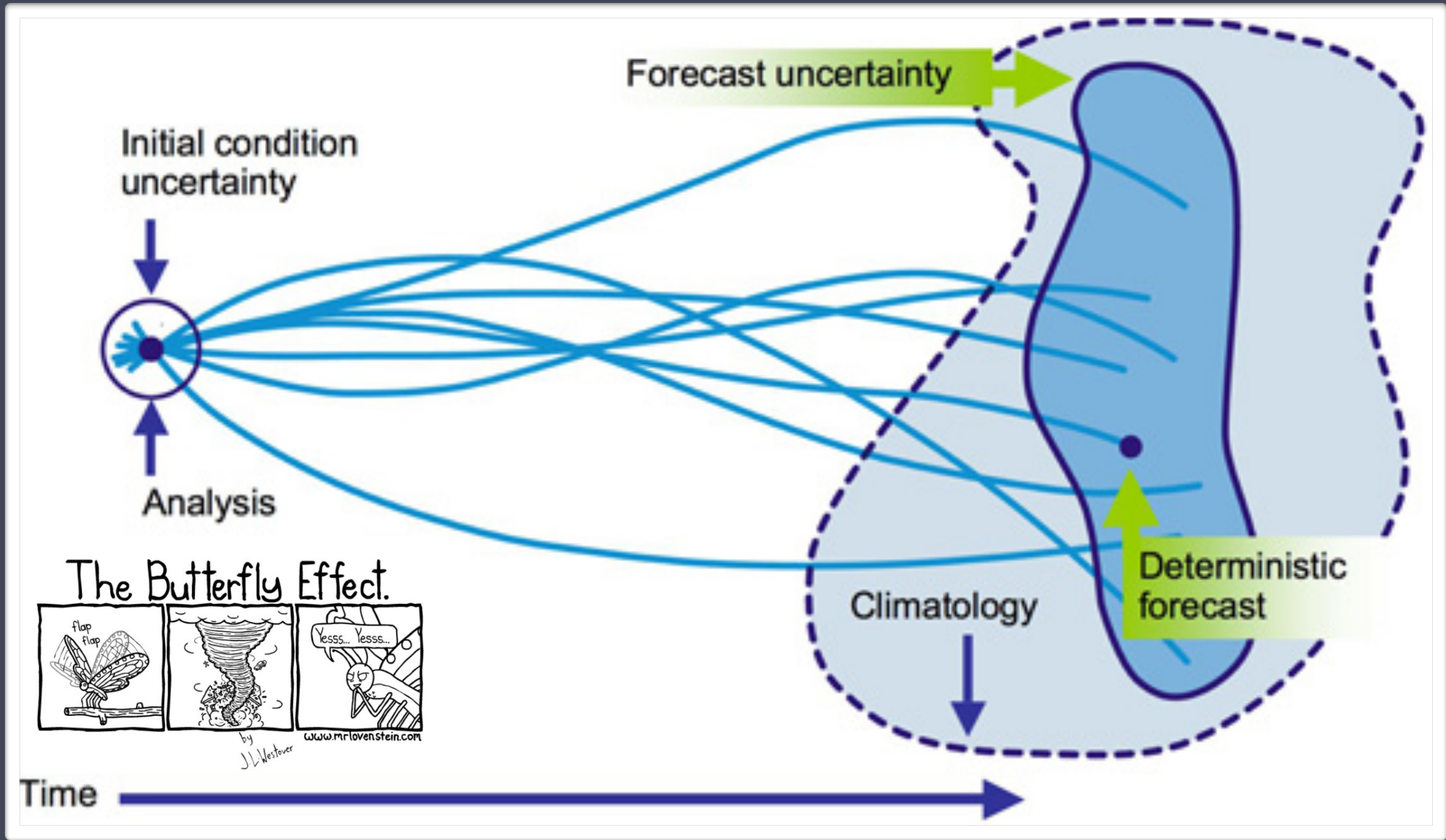
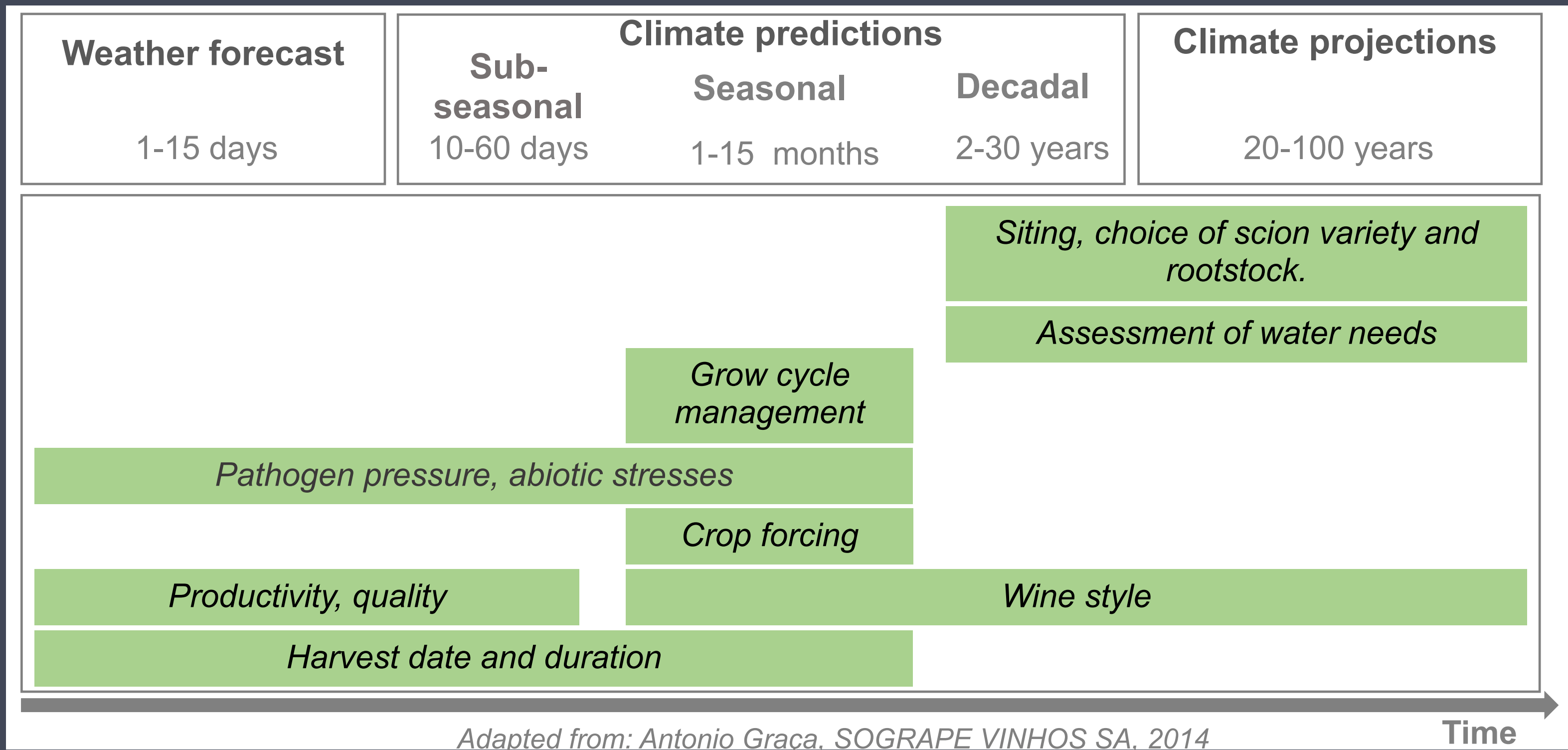


A tale of two worlds?

First round

Example for the farmer



Adapted from: Antonio Graça, SOGRAPE VINHOS SA, 2014

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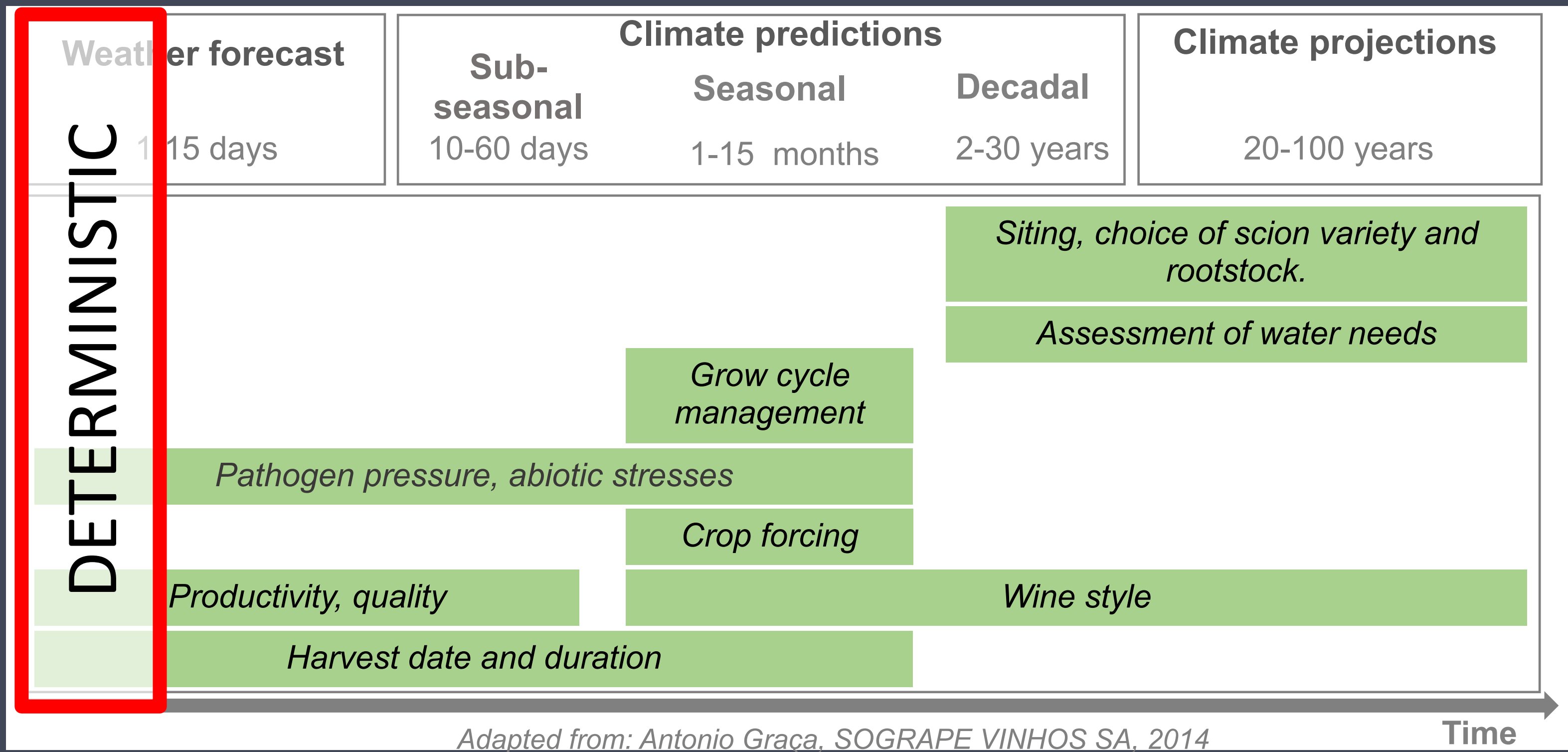
First round



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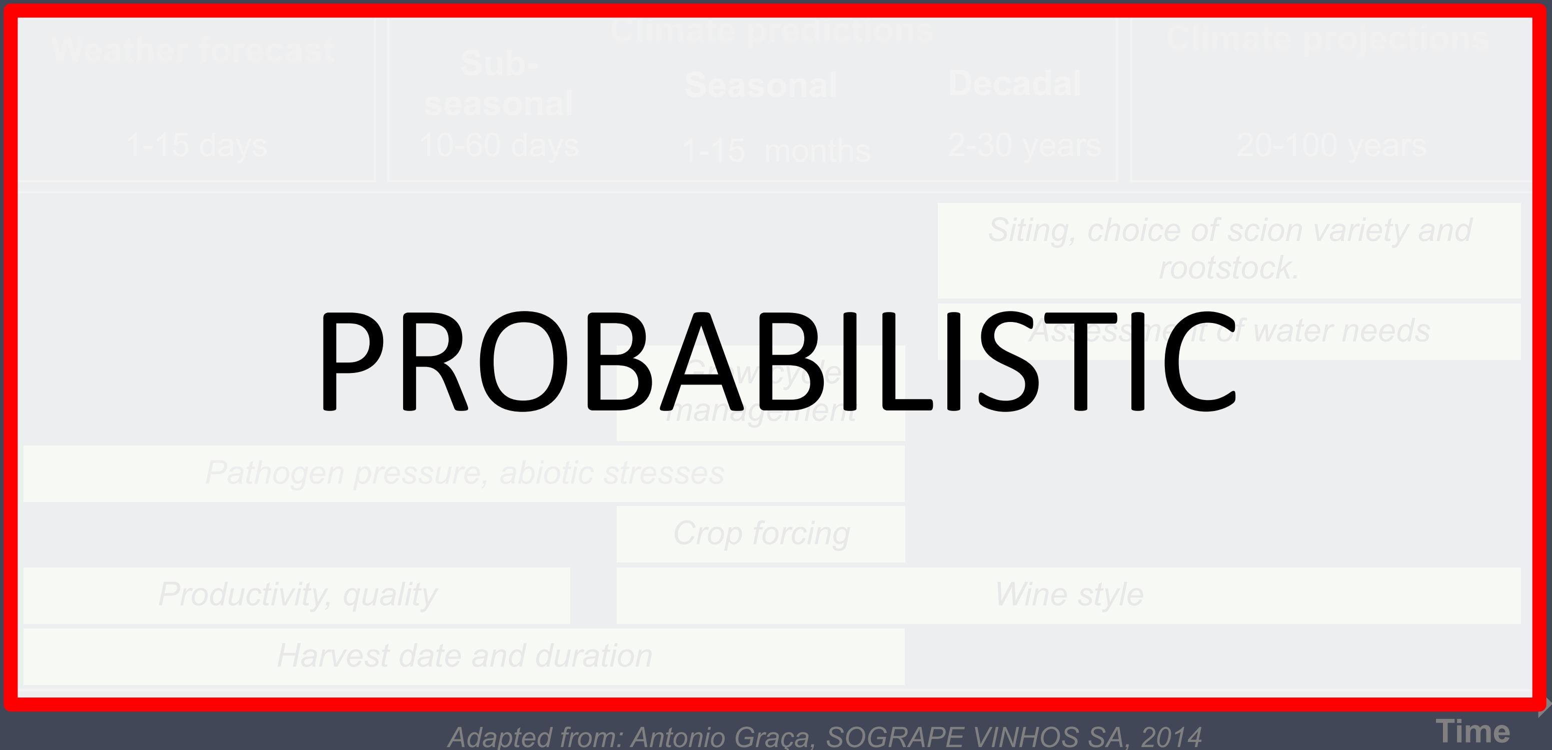

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What do we understad by
‘**risk aversion**’ in decision-making?

When facing a **decision**, risk aversion is a **preference** for the option that maximises **certainty** and **minimises negative** outcomes (even if there are other options with higher potential gains).

What is a ‘**risk**’ in a decision-making context?

Although the exact language depends on the **framework**, in general the ‘risk’ equation for any **event** can be defined as:

Risk = Likelihood x Consequences

The ‘**likelihood**’ of any event can be determined through predictions, whereas the ‘**consequences**’ are an information that can vary on a decision-case basis.

Risk = Likelihood x Consequences

A tale of two worlds?

Second round

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Second round

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March	April	May	June

At the **beginning** of each **month**, each user will be told about the **probability** of having a **dry** spring. Then, the user will decide to either: ‘**wait and see**’ or ‘**insure**’. Consequently, in this second round we will give you three more **information** items:

- The **probability** to have a **dry** spring (it is a **negative** outcome for each of the users).
- The **cost** of **insuring** against a **dry** spring (in views of the **June deadline**).
- The **losses** that would **incur** if there is **no insurance** and a dry spring happens.

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Second round

In this **second round** we will repeat the process for two or three years, and see what is the final remaining budget for **each** of the **groups**. After that, we will **discuss**:

- What **drove** your **decision-making**? Which were the most important **factors** that you **considered**?

March	April	May	June

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Second round

100000 Tokens (initial budget for insuring / support losses)	1st March		1st April		1st May	
	Insurance Cost	Losses	Insurance Cost	Losses	Insurance Cost	Losses
Water Resource Manager	16000	25000	18500	25000	20000	25000
Grape-vine grower	7500	15000	9000	15000	10500	15000
Weather Derivatives Trader	2000	5000	3000	5000	4500	5000

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Second round

Did you find any **systematic** approach to try to **maximise** the **outcomes**?

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Second round

We have the **cost/loss** model approach (i.e. Richardson D.S., 2000):

$$p > \frac{C}{L}$$

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Second round

Consider the situation where we do not have **any** forecast **information.** We have two **systematic** options. The **first** one is to **always** take de ‘**protective**’ action. The mean expense per time step in that case would be:

$$E_{always} = C$$

Conversely, the **second option** would be to **never** take any **protective** action. In that cases, we would incur in **losses** each time the event **happens**. Consequently:

$$E_{never} = \frac{n}{N}L = p_{clim}L$$

The **optimal** systematic strategy in that **situation** would be to take the **action** if:

$$E_{always} < E_{never}$$

And, **consequently**:

$$C < p_{clim} L \rightarrow \frac{C}{L} < p_{clim}$$

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Second round

50000 Tokens (initial budget for insuring / support losses)	1st March	1st April	1st May
	C/L	C/L	C/L
Water Resource Manager	64 %	72 %	80 %
Grape-vine grower	50 %	60 %	70 %
Weather Derivatives Trader	40 %	60 %	90 %

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Third round

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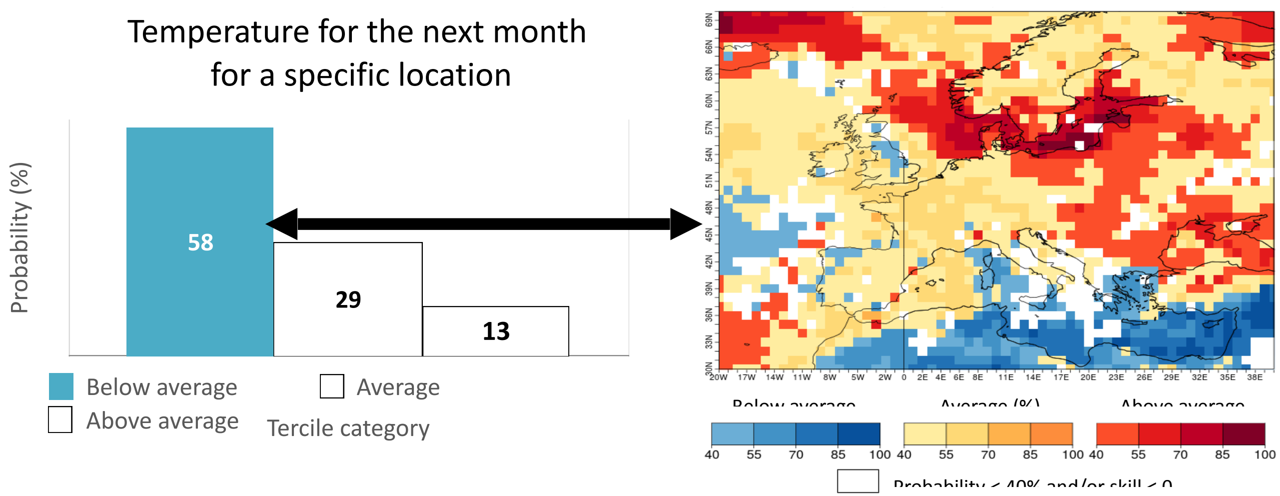
March	April	May	June

In this **third** and final **round**, we will introduce **tercile** forecasts (more complete information), so we will have **three** different scenarios for spring rain: above normal, normal and below normal. This time our focus will be on making the decision at the **beginning** of **March**.

Prediction of temperature for April 2019.



A tale of two worlds?

Third round

This time we will focus only in the ‘farmer’ **user**. He will have to choose from **three** different **decisions** which, at the same time, will have 9 **different** possible outcome **scenarios** (depending on the coincidence or not of the prediction and observation). And he wants to ‘**maximise**’ its **outcome**.

The question that we want to answer here will be: according to the farmer’s context, at what **probability threshold** does they have to **make** a **decision**?

Grape-vine grower

Decision Scenario 1	Payoff
A3	4880
A2	-1200
A1	-1200

Decision Scenario 2	Payoff
N3	0
N2	0
N1	0

Decision Scenario 3	Payoff
B3	-5800
B2	-3200
B1	3200

Prediction	Observation	Category
A	3	Above Normal
N	2	Normal
B	1	Below Normal

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Third round

We can analyse, within each decision **scenario**, which are the **relationships** between hits, errors and expected outcome. A question to answer: what is the minimum **percentage** of **hits** we need to have a **positive** outcome in that **scenario**? (Vigo et al. in rev. Climate Services)

Counts	Decision Scenario 1	Payoff
D1	A3	4880
D2	A2	-1200
D3	A1	-1200

Prediction	Observation	Category
A	3	Above Normal
N	2	Normal
B	1	Below Normal

$$D_1 x + D_2 y + D_3 z \geq 0 \rightarrow D_1 \geq -\frac{D_2 y + D_3 z}{x}$$

$$D_1 + D_2 + D_3 = 100$$

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Third round

If we go for the minimum: $D_1x + D_2y + D_3z = 0 \rightarrow D_1 = -\frac{D_2y + D_3z}{x}$

In this category $\rightarrow y = z \rightarrow D_1 = -\frac{y}{x} \cdot (D_2 + D_3)$

$$D_1 = -\frac{-1200}{4880} \cdot (D_2 + D_3) \simeq 0.245 \cdot (100 - D_1)$$

$$D_2 + D_3 = 100 - D_1$$

$$D_1 = \frac{25}{1.25} = 20\,\% \rightarrow D_1 \geq 20\,\%$$

This number is **lower** than what we would obtain with **climatology**!! (33%)

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Third round

Decision Scenario 2	Payoff
N3	0
N2	0
N1	0

Prediction	Observation	Category
A	3	Above Normal
N	2	Normal
B	1	Below Normal

$$D_1 x + D_2 y + D_3 z \geq 0 \rightarrow D_1 \geq -\frac{D_2 y + D_3 z}{x}$$

$$D_1 + D_2 + D_3 = 100$$

This is the BaU scenario $x = y = z = 0 \rightarrow$ no profits / losses expected in comparison to what is already applied.

A tale of two worlds?

Third round

Decision Scenario 3	Payoff
B3	-5800
B2	-3200
B1	3200

Prediction	Observation	Category
A	3	Above Normal
N	2	Normal
B	1	Below Normal

$$D_1 x + D_2 y + D_3 z \geq 0 \rightarrow D_3 \geq -\frac{D_1 x + D_2 y}{z}$$

$$D_1 + D_2 + D_3 = 100$$

Here we have two equations with 3 variables, so we will have a 'free' variable. Let's try to set a range of possible / likely values.

What is the minimum percentage of hits we need to have a positive outcome in scenario 3?

$$D_1 x + D_2 y + D_3 z \geq 0 \rightarrow D_3 \geq -\frac{D_1 x + D_2 y}{z}$$

If we go for the minimum: $$D_1 x + D_2 y + D_3 z = 0 \rightarrow D_3 = -\frac{D_1 x + D_2 y}{z} \rightarrow \boxed{D_3 = 1.81\, D_1 + D_2}$$

First situation $D_1 = 0$ **(Best scenario)**

$$D_3 = D_2 \qquad \boxed{D_3 = \frac{100}{2} = 50\,\%}$$

Second situation $D_2 = 0$ **(Worst scenario)**

$$D_1 = \frac{D_3}{1.81} \qquad \boxed{D_3 + \frac{D_3}{1.81} = 100 \rightarrow D_3 = \frac{1.81}{2.81} \cdot 100 \simeq 64.4\,\%}$$

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Third round

In a real **working** scenario, nor D_1 or D_2 will be 0. Although both cumulated D_1 & D_2 are equiprobable, their relative impact is not, $\frac{x}{y} = 1.81$, and so the **weighted** mean of both **impact** scenarios gives us a more **realistic** view to what is the **probable** minimum D_3 needed to attain value for the user:

$$D_3 \geq \frac{1.81 \cdot 64 + 50}{2.81} = 59\,\%$$

Are we **missing** something? (In the second and third round discussions)

We are **assuming** that the forecast **probability** (computed from the ensemble) is **equivalent** to the observed **climatic** probability, p_{clim}

Can we do this?

… only if the forecast is **perfectly reliable**. That is, that the forecast probabilities match the **observed probabilities** (and this includes p_{clim}).

That is to say, if the event happens 60% of the time in our time-series, when the forecast system gives us a probability of 60%, this means that for every 10 times the model gave a 60% probability, 6 times the event actually happened.

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Or maybe three…

The models have uncertainties!

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Risk = **Likelihood** x Consequences

The models have uncertainties!

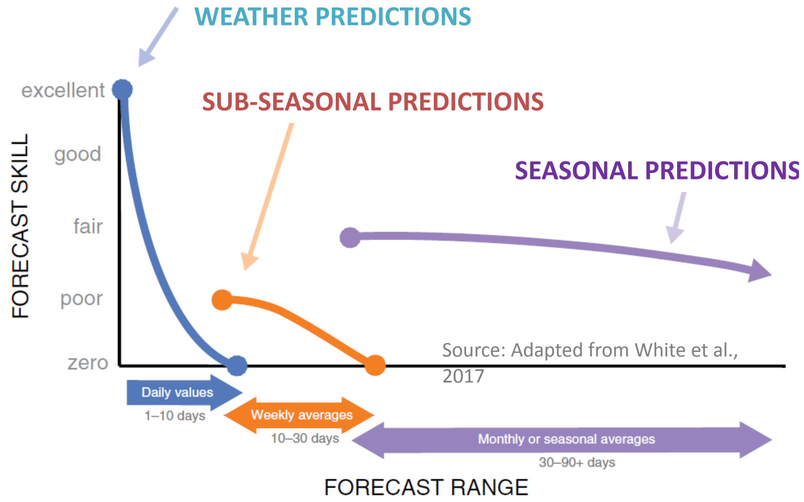
The ‘**trust**’ on the likelihood of an event is highly dependent on the **quality** of the forecast.

A tale of two worlds?

Or maybe three…

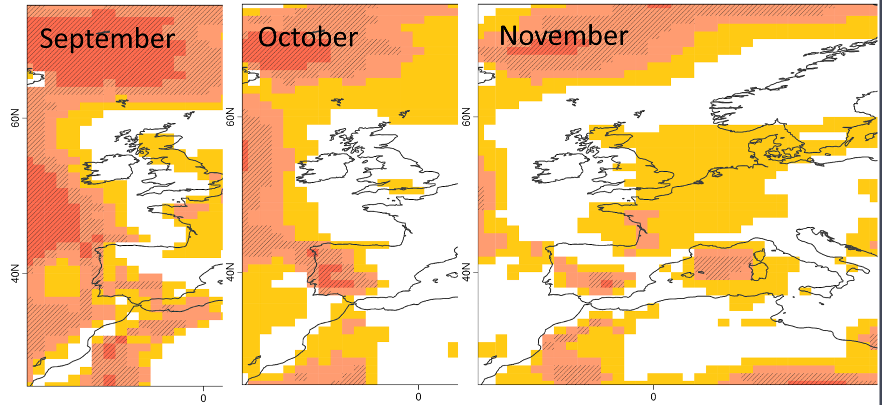
The quality (or skill) of climate predictions varies with:

TEMPORAL HORIZON | **REGION** | **MONTH/SEASON**



Source: Adapted from White et al., 2017

Correlation for temperature predictions from August start date



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Or maybe three…

Science

We can give you predictions months ahead.

End-Users: 

Wow!

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Or maybe three…

Science

We can give you predictions months ahead.

End-Users: 

Weather forecast skill!!

A tale of two worlds?

Or maybe three…

Science

Actually, the skill is much lower.
But, statistically, it can still be valuable.

End-Users:

How much lower?

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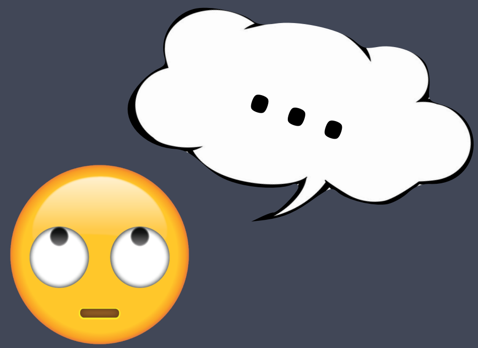
Or maybe three…

It means seasonal predictions are not that **specific** and might be **wrong** many times. In the long run, however, they could still be **worthy**, depending on the decision.

End-Users:



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End-Users:

Skill vs. Value

This **gap** between end-users and scientific providers involves the concepts of **quality** and **value**.

- A forecast is of **high quality** if it successfully predicts the conditions observed according to some objective criterion.

- A forecast has **value** if it helps the user to obtain some kind of benefit from the decisions it has to make.

Given a prediction, the optimal strategy changes depending on the user, specific context and decision-making

Predicted Probabilities

Above Average	
Normal	
Below Average	

Range of skill values

Skill ≦ 0 worse than past observations

Skill > 0 better than past observations

Skill = 1 perfect forecast

When to make a decision?

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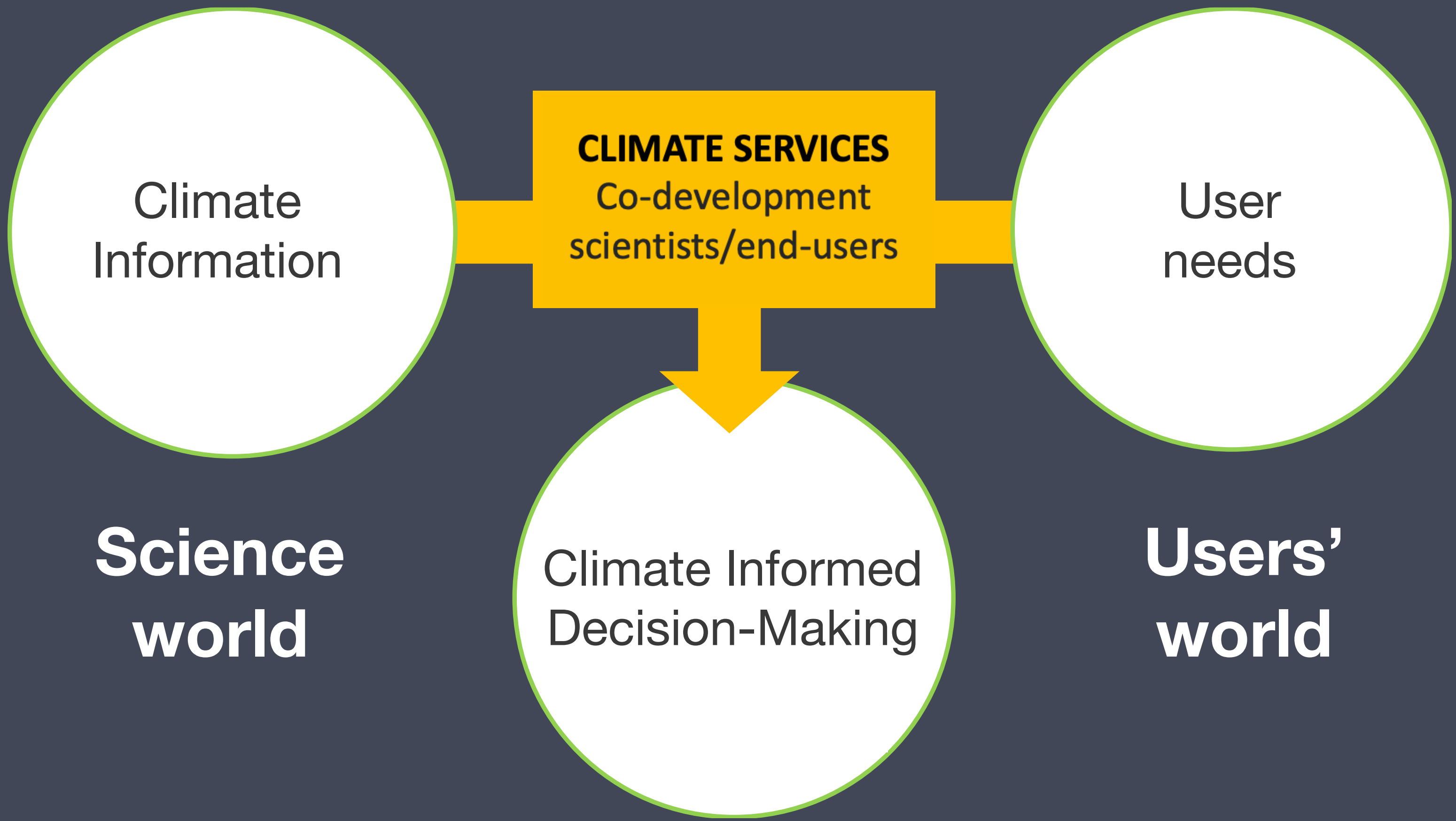

Take Home Messages

- Any **decision-making** considers the **relationship** between the **likelihood** of an event and its **consequences**.

Likelihood x Consequences

- Need to **balance** the request for **confidence** from the users (for effective decision-making), with the intrinsic **uncertainty** of the **predictions** (that it is unavoidable at climate prediction time-scales).

Take Home Messages

- There are different **strategies** to **maximise** the **performance** of the **predictions** (bias correction, downscaling, multi-model, impact-based indicators…). However, they are **highly specific**, so to reach a sufficient level of '**performance**' (so as to be value-effective), **co-production** and **communication** play a big **role** (to identify the critical features for the user).

- **Adaptation** and **facilitation** of decision-making can only be **achieved** if the product provided answers the **particular needs** of the user, and so the specific **tailoring** and **co-development** has to be performed at its '**production** scale **level**’.

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THANK YOU!

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