Steffen M. Olsen

Narrative of the Briefing

- The European Arctic context

Tipping points, extreme events and uncertainty: How can studying the Arctic help us predict future European climate beyond the mean?

Web-conference, 14 October 2020

Narrative of the Briefing

The European and Arctic context

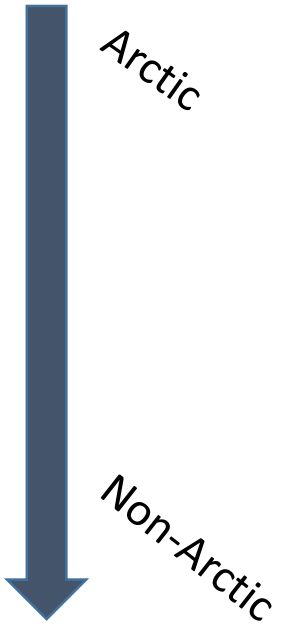
- Concepts, building blocks and the relevance of projects
  - Dr. Steffen M. Olsen, Blue-Action/DMI

Scientific panel of experts

- Risks and impacts of abrupt changes in the North Atlantic
  - Dr. Didier Swingedouw, University of Bordeaux
- The ocean is key to climate prediction in the North Atlantic – Arctic region
  - Dr. Helene R. Langehaug, NERSC
- Climate and mortality in Europe: Is early adaptation improving human health?
  - Dr. Joan Ballester, ISGlobal

Feedback Session

- Nuno Lopes
  - Head of the Innovation, Climate and Energy Division, City Council of Almada
- Mininnguaq Kleist
  - Head of Greenland Representation / Minister Counsellor, Greenland Representation to the EU



The European and Arctic context

Climate change and its polar amplification is dramatically transforming the Arctic region

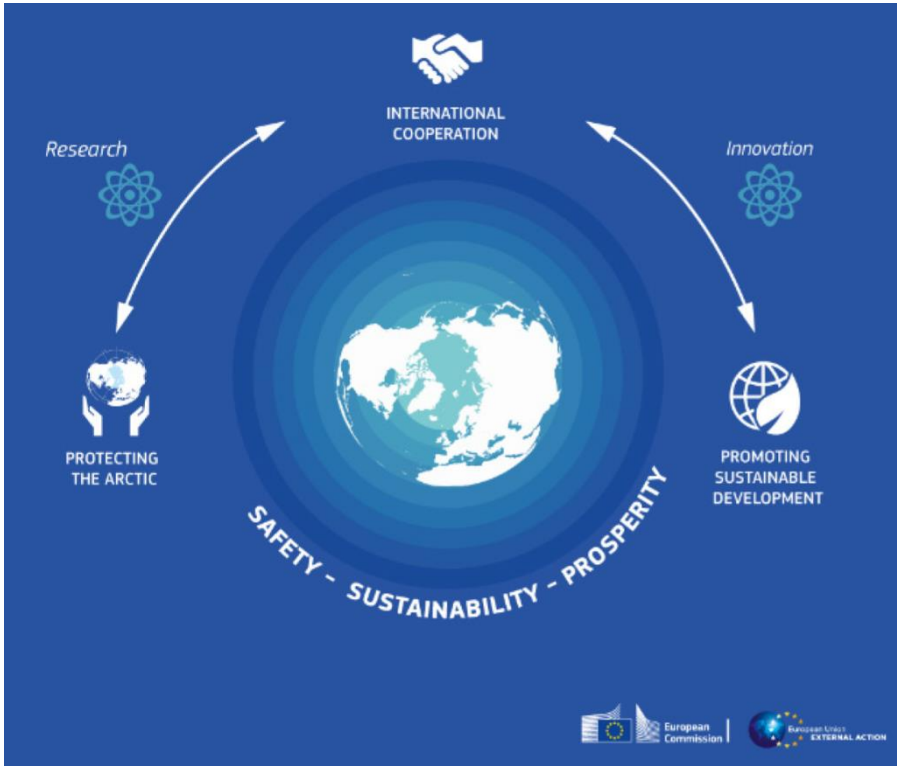
- Increased environmental pressure
- Increasing its geopolitical importance
- Offering new strategic and economic opportunities

EU Ambition: To build low tension and peaceful cooperation

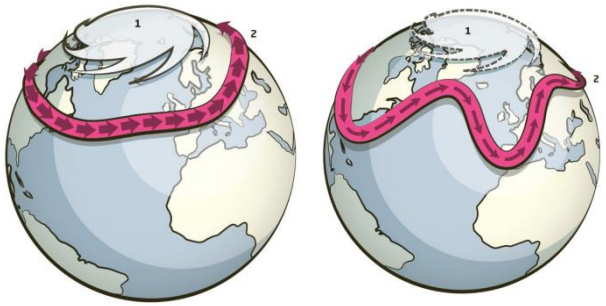
The European and Arctic context

One of the major contributions of the EU to the Arctic is through its investment in **technology** and **science/research** which support the EU Arctic Policy along its main areas of focus:

- **Climate Change and Safeguarding the Arctic Environment**
- Sustainable Development in and around the Arctic and
- International Cooperation on Arctic Issues



“What happens in the Arctic, does not stay in the Arctic” *(Vidar Helgesen 2017)*



- Melting ice sheets cause sea level rise elsewhere
- Polar warming and retreating sea ice cause changes in weather patterns
- Polar climate system is likely associated with tipping points.

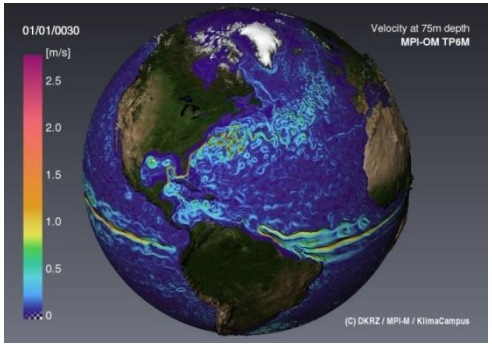
Climate change will continue to create significant stress in Europe in spite of the mitigation efforts.

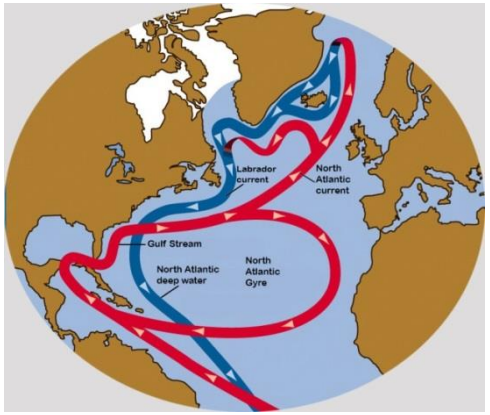
Strengthening the efforts on climate-proofing, resilience building, prevention and preparedness

- Climate predictions and projections
- Climate Services

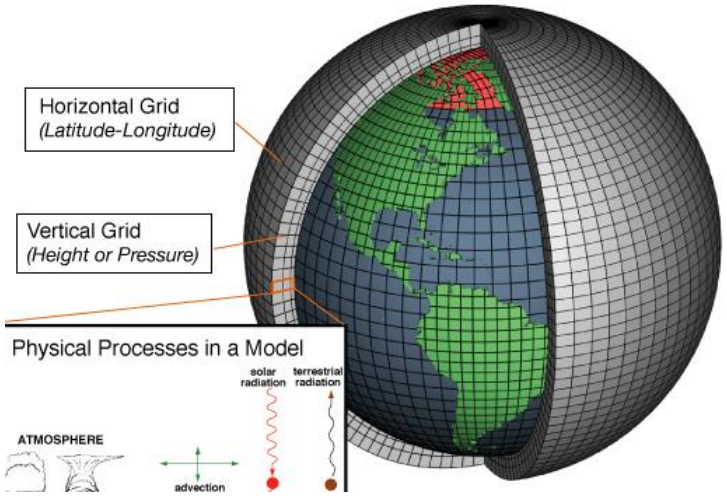
Predictions and projections - societal relevance

Days to a week • Accurate weather forecasts	• Operations • Safety
Long range and sub-seasonal • Weather outlook	• Natural hazards preparedness
Seasonal-to-interannual • Shifts in the likelihood of weather regimes	• Resource management • New transportation patterns (e.g., Arctic shipping routes)
Decadal • Climate variability and change • Tipping points	• Long-term resource management • Infrastructure investments • Natural hazard mitigation and adaptation
Centennial • Climate projections, tipping points	• Safe operation space • Political decisions, sustainable pathways





Building blocks of predictions



Computer Models

Advanced simulations of the Earth System run on supercomputers

Observations

Satellite, buoys, moorings, gliders, hydrography, etc.

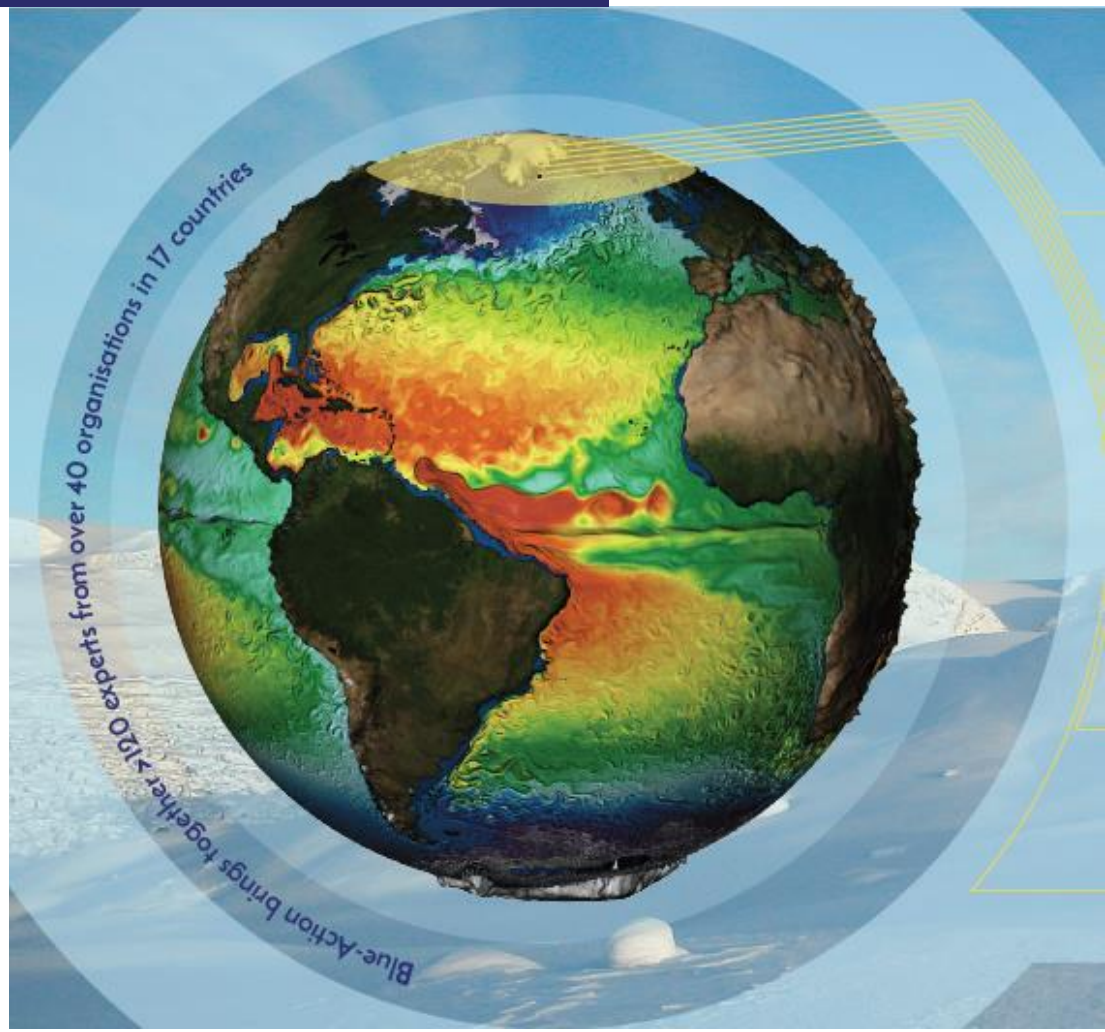
Initial Conditions

Advanced techniques to incorporate current weather / climate state into the models, i.e., a data assimilation system

BLUE ACTION

- Understanding the impact of a changing Arctic on Northern Hemisphere Weather and Climate

- Apply new modelling techniques to cutting-edge climate services co-designed with organisations and industries that rely on accurate weather and climate forecasting.



Key messages

- Climate adaptation requires not only planning for gradual changes over time, but also preparing for high impact consequences such as abrupt climate shifts and extreme weather events.
- Understanding climate change in the Arctic is key to help us predict high impact consequences and develop early-warning systems.
- To improve these predictive skills, long-term sustained observational North Atlantic and Arctic networks are required.
- Greater integration between researchers and end-users are needed to develop meaningful climate services and action plans

Didier Swingedouw

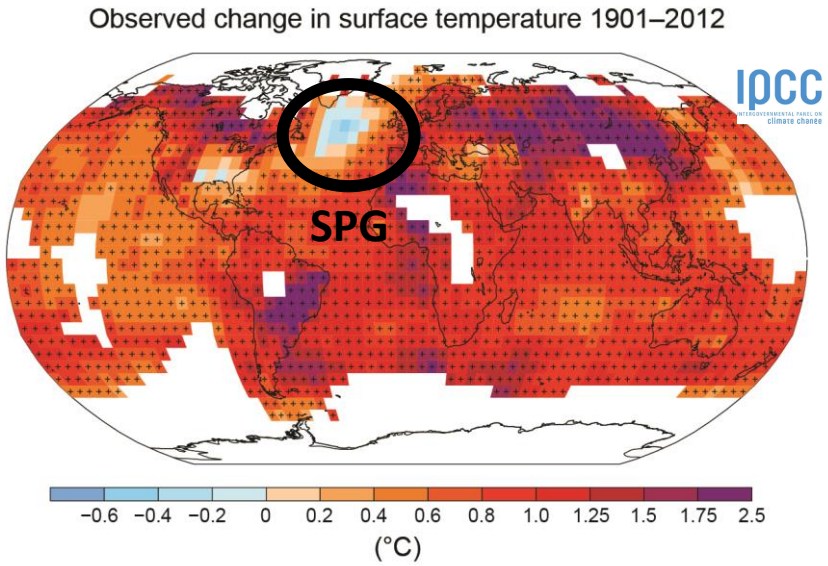
Risks and impacts of abrupt changes in the North Atlantic

Tipping points, extreme events and uncertainty: How can studying the Arctic help us predict future European climate beyond the mean?

Web-conference, 14 October 2020

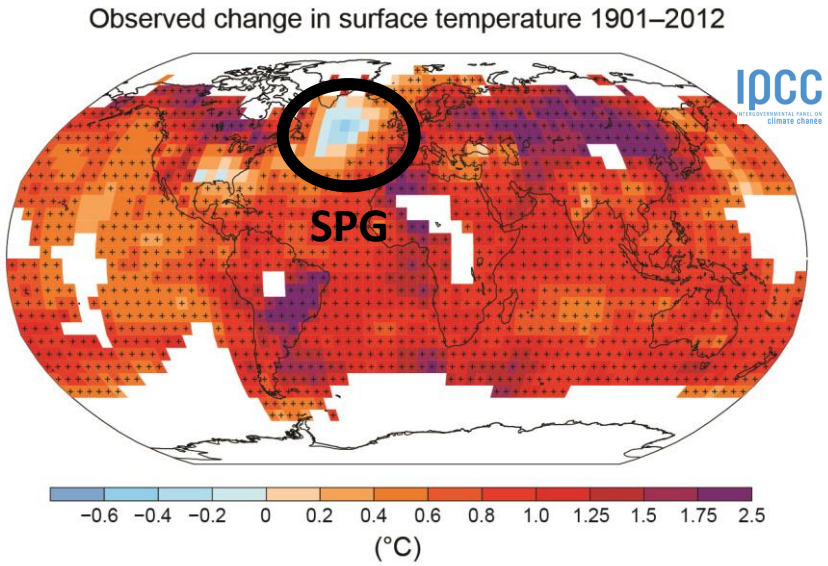
Where are we now?

- There is an observed **cooling and freshening of the subpolar gyre** (SPG) over the last century
- This might be a fingerprint of an on-going **weakening of the Atlantic ocean circulation**

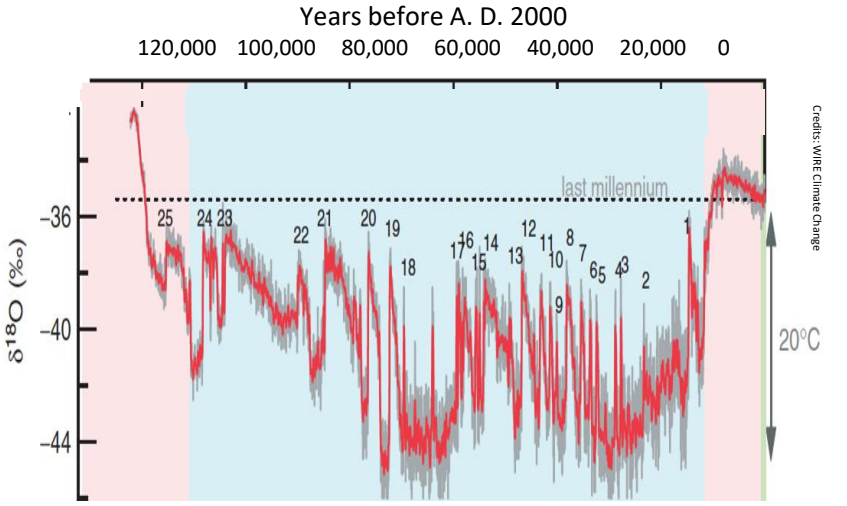


Where are we now?

- There is an observed **cooling and freshening of the subpolar gyre** (SPG) over the last century
- This might be a fingerprint of an on-going **weakening of the Atlantic ocean circulation**
- Lessons from the past both in glacial and interglacial periods highlight that **abrupt changes/instabilities/tipping points are possible**



Ice core reconstructions

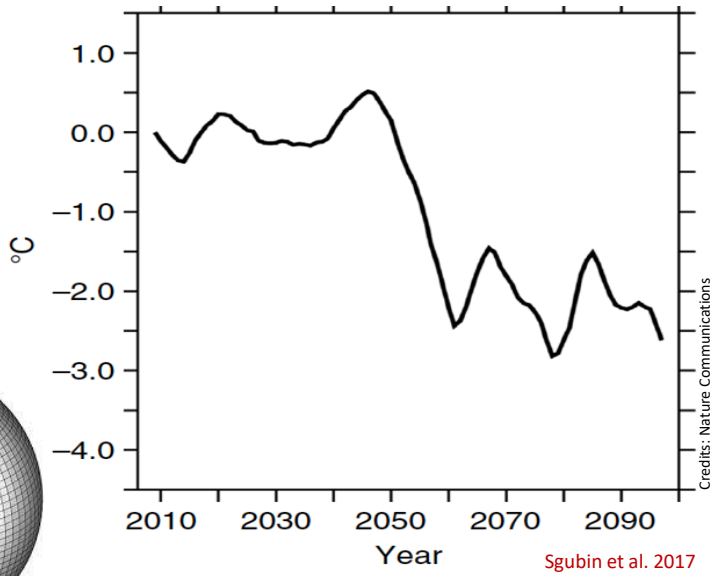


Masson-Delmotte et al. 2012

Possibility of Abrupt Changes in the North Atlantic in climate models

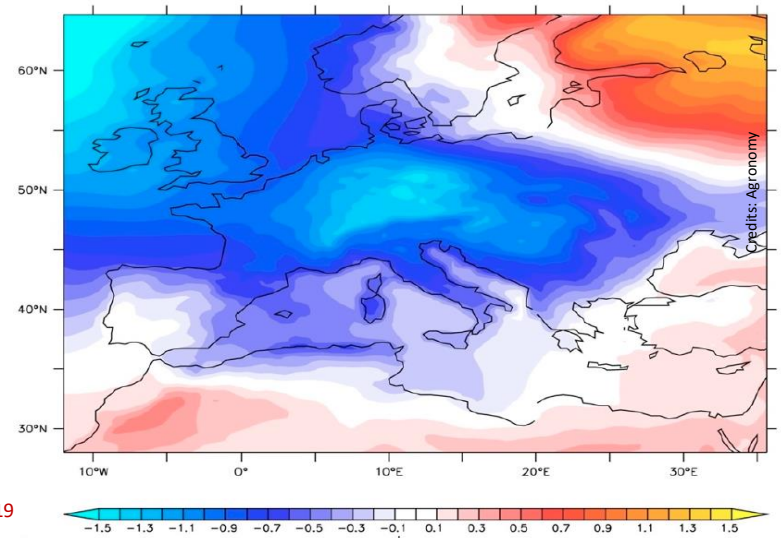
- Some models do show abrupt (<10 years) cooling in the subpolar gyre (SPG)
- The risk for such changes can be estimated between about 20 to 45%

Changes of surface temperature in the subpolar gyre in a model projection



Sgubin et al. 2017

Difference of temperature after and before the shift



Sgubin et al. 2019

- The impact of the decade after the abrupt change, as compared to the former one, can be huge over Europe
- This might put some adaptation measures in agriculture at risk (e.g. viticulture) on a decadal time scale

Large-scale impact of substantial changes in Atlantic circulation

Physical system

- Droughts
- Temperature trend
- Sea level rise
- Cyclones frequency
- Sea ice and snow
- Precipitation and flooding
- Storminess

Biological system

- Vegetation
- Oxygenation
- Marine ecosystems
- Oceanic carbon and acidification
- Wetland methane

Human and managed systems

- Agriculture and food production
- Migration pressure due to degradation in livelihoods

Direction of the change

- Increase
- Decrease

Confidence in process understanding

- High
- Medium
- Low

IPCC INTERGOVERNMENTAL PANEL ON climate change

Fig. 6.10 from IPCC SROCC report, 2019

Large-scale impact of substantial changes in Atlantic circulation

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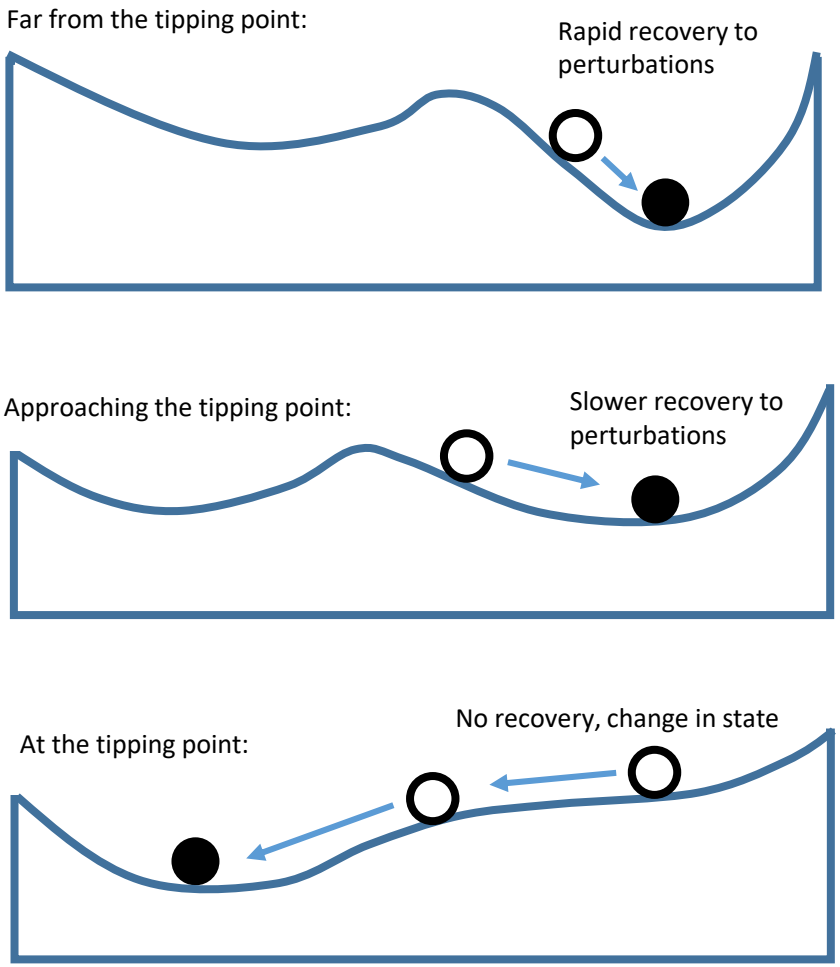
IPCC INTERGOVERNMENTAL PANEL ON climate change

Fig. 6.10 from IPCC SROCC report, 2019

How to have early warnings of such a change?

- Theory from dynamical system teaches us that approaching a tipping point, the climate variability tends to increase
- Recent results (Michel et al. sub.), reconstructing the circulation over the last millennium, indicate that we can see such a change in variability and therefore are approaching a tipping point

Change of temporal variability when approaching the tipping point



Adapted from: Lenton 2011

How to have early warnings of such a change?

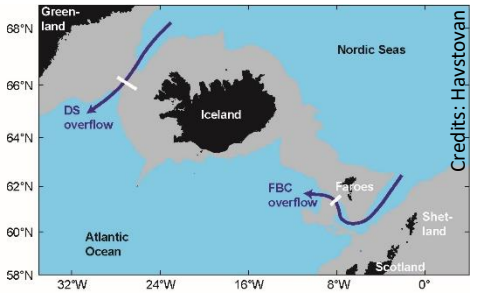
- According to CMIP5 models, we might also be not far from a tipping point in the **stratification of the water column**, a useful early warning for abrupt subpolar gyre changes (Swingedouw et al. 2020)

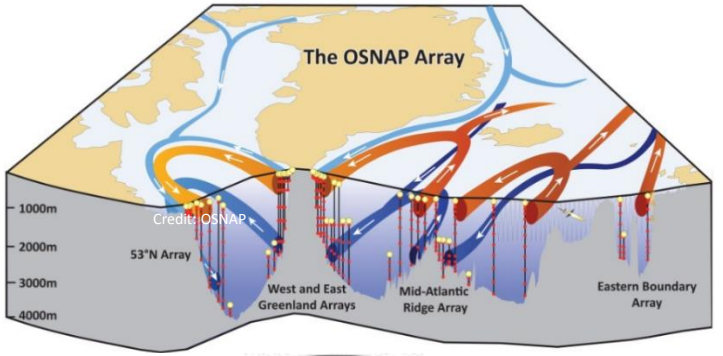
- **Decadal prediction systems** with initialized ocean state including observations might be the most up-to-date tool to predict the risk for such a shift in the coming decades

- Its is necessary to start thinking of **adaptation plans** to be prepared to a potential associated crisis (e.g. COVID)

=> To include in “Destination Earth” EU programme?

Overflow measurements





What are the research gaps?

- **Observation systems** are needed for an efficient early warning system
  - Continue on-going *in situ* arrays and monitoring systems
  - Include more oceanic observations below 2000m
- **Decadal prediction systems** still need further development to:
  - Diminish their offset to observations
  - Avoid drift when launched from observed ocean
  - Better predict the recent cooling in the subpolar gyre since 2015
- Need for **reconstructions of the last few thousands of years** to have better insights on “natural variability” and the approach of a tipping point
- Assessment of the impact of **such low probability - high impact scenario** in **adaptation plans** are poorly accounted for up to now.

Key take-home messages

- Possibility of Abrupt Changes in the North-Atlantic/Arctic in IPCC-type climate models
- They have global impacts (Atlantic marine life, Sahelian precipitations, European heat waves, storms, agriculture, Asian monsoon shift…)
- Decadal prediction systems need to be further developed to have early warnings of such potential abrupt changes

Helene R. Langehaug

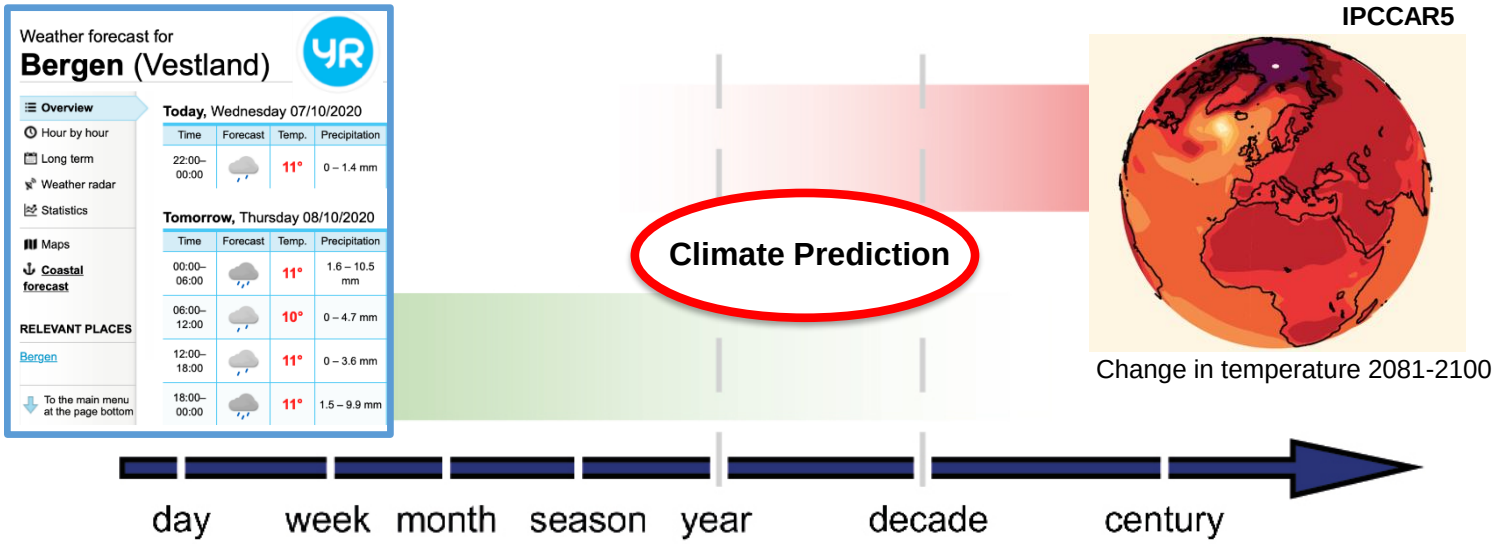
The ocean is key to climate prediction in the North Atlantic – Arctic region

Tipping points, extreme events and uncertainty: How can studying the Arctic help us predict future European climate beyond the mean?

Web-conference, 14 October 2020

What is climate prediction and why is it important?

*We are focusing on **near-term** climate changes*

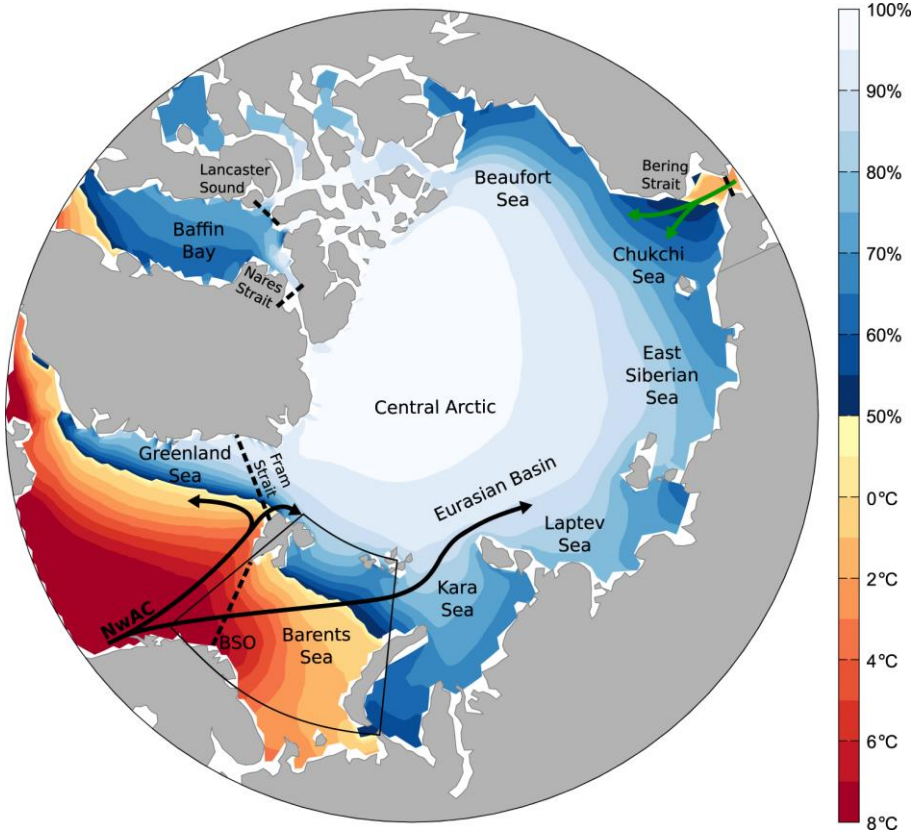


***Climate predictions to climate services**:*
providing specific and relevant information for businesses, communities and policy-makers on evolving future conditions

Meehl et al. 2009

Challenging to predict climate changes in the Arctic region several years ahead

- Challenging for climate models to predict the Arctic climate on decadal time scales
- Observations suggest that there is potential to predict on these time scales. WHY?



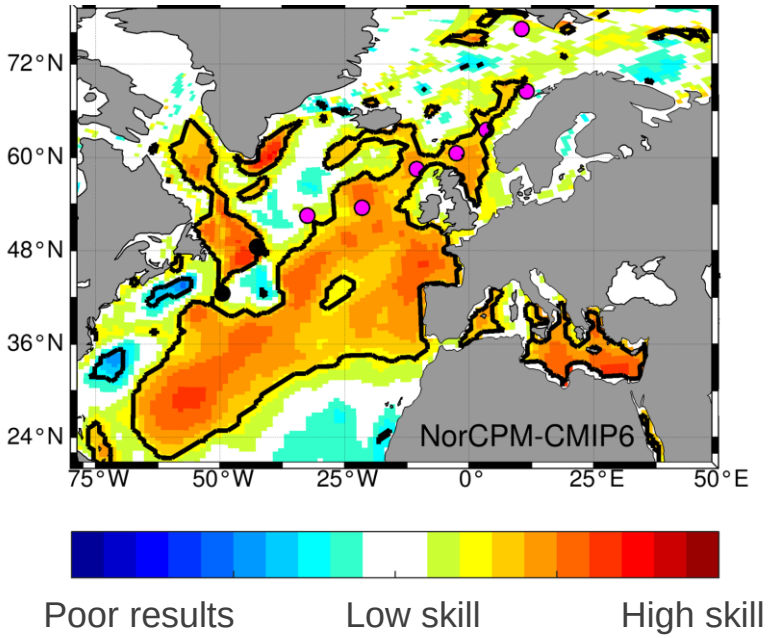
Circulation of warm and saline water from the south gives rise to predictability

Blue-Action studies: Årthun et al. 2017, 2019; Dai et al., 2020

Much more successful in predicting climate changes in the North Atlantic Ocean

- Changes in the large-scale ocean circulation is a source of predictability several years ahead
- Yet challenging for climate models to predict the pathway to the Arctic on decadal time scales

Prediction of winter Sea Surface Temperature 3 years ahead

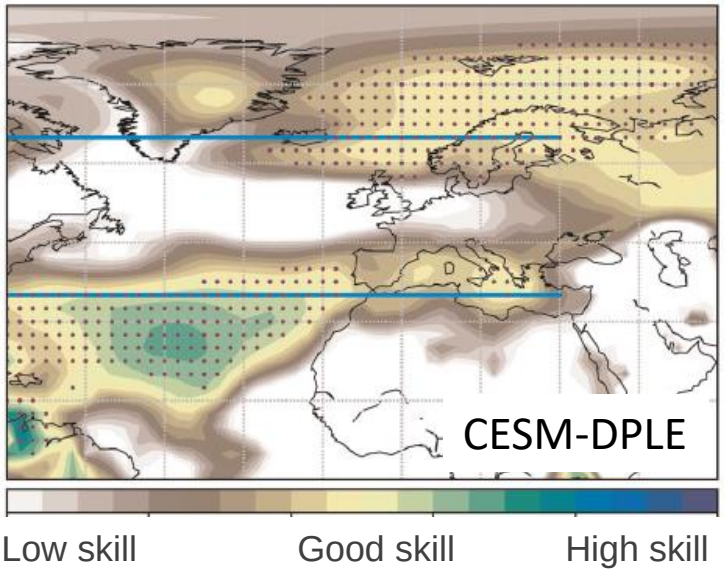


Blue-Action studies: Yeager, 2020; Langehaug et al., ongoing

Promising results also for the North Atlantic atmosphere

- Prediction of atmospheric circulation regimes is possible thanks to many model simulations and ocean predictability
- With better understanding of where predictability comes from, climate predictions are improving

Prediction of winter atmospheric sea level pressure several years ahead



”North Atlantic climate is far more predictable than models imply”

EUCP
European Climate Prediction system

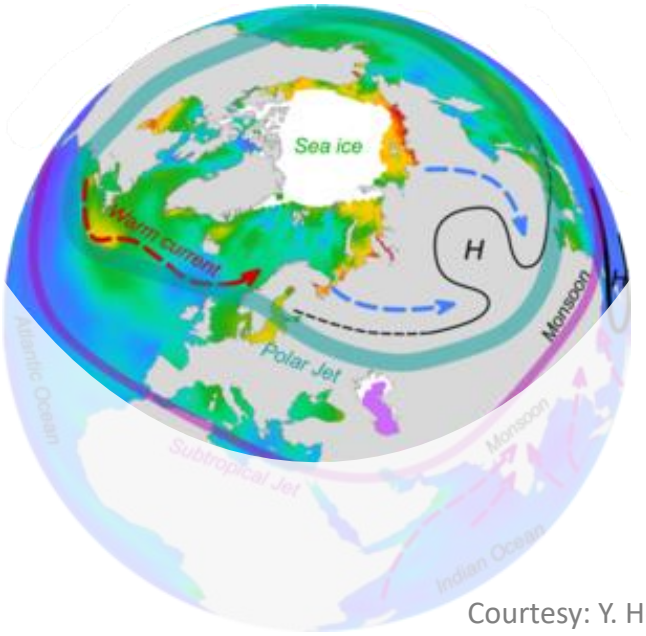
Blue-Action studies: Årthun et al., 2018; Athanasiadis et al., 2020; Smith et al., 2020

Understand how the Arctic is linked with the Northern Hemisphere and Europe

- The Arctic climate has far reaching influence beyond the Arctic region
  → **Tele-connections**

- To separate the influence of the Arctic sea ice on mid-latitude climate **requires a large amount of models with many simulations**

How is Arctic sea ice influencing temperatures at mid-latitudes?



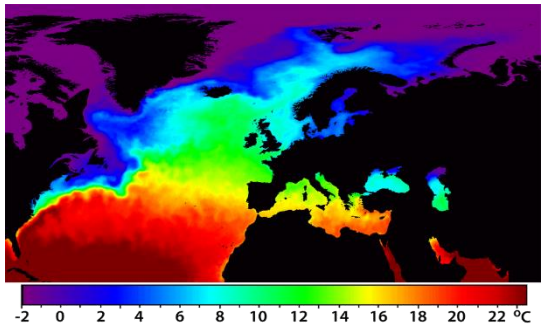
Courtesy: Y. He @ NERSC

Teleconnections needs to be more investigated

Blue-Action studies: Liang et al., 2020; Lü et al., 2020

Understand how the Arctic is linked with the Northern Hemisphere and Europe

Ice-cold Arctic



Warm subtropics

Source: NOC from Met Office OSTIA data

Large north-south temperature difference powers the jet stream

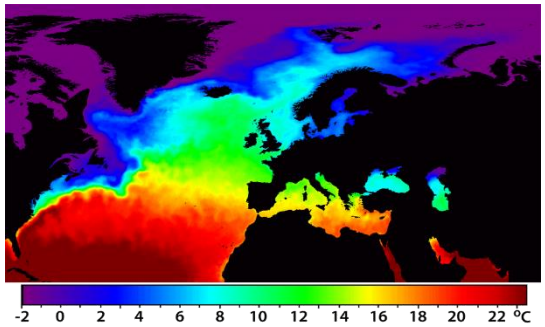
www.reklim.de

***Warmer Arctic** has been linked with meandering in the jet stream*

*More likely persistent weather patterns leading to **extreme events***

Understand how the Arctic is linked with the Northern Hemisphere and Europe

Ice-cold Arctic

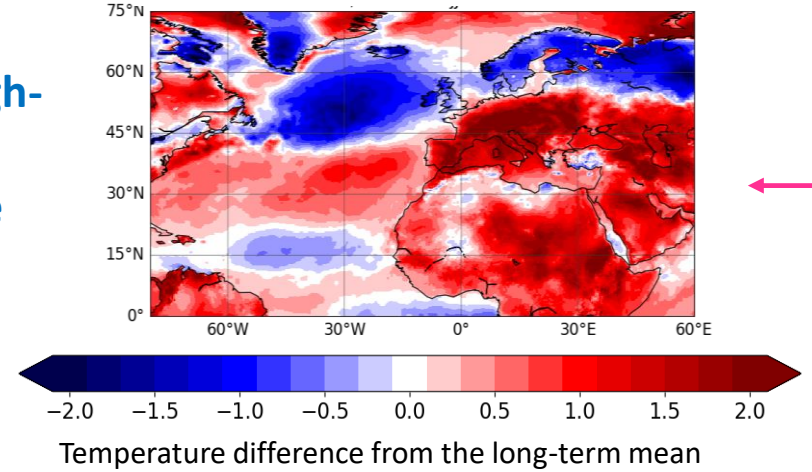


Source: NOC from Met Office OSTIA data

Warm subtropics

Better predictions of high-latitudes can improve predictions for Europe

Example of European extreme event



More likely persistent weather patterns leading to ***extreme events***

Blue-Action studies: Mecking et al., 2019; Oltmanns et al., 2020

Key take-home messages

- Much success is achieved in using **climate models** to predict the ocean several years ahead in the North Atlantic → need to build and further enhance prediction skill in the Arctic region (higher resolution)

- To build good climate predictions it is vital to have **observations** reflecting key processes in the Arctic → expand observational network and ways to use observations in climate models

- Greater awareness among stakeholders of the potential benefits of **climate services** is required to further accelerate the field of climate prediction

The ocean is key to climate prediction in the North Atlantic – Arctic region

Joan Ballester

Climate and Mortality in Europe: is Early Adaptation Improving Human Health?

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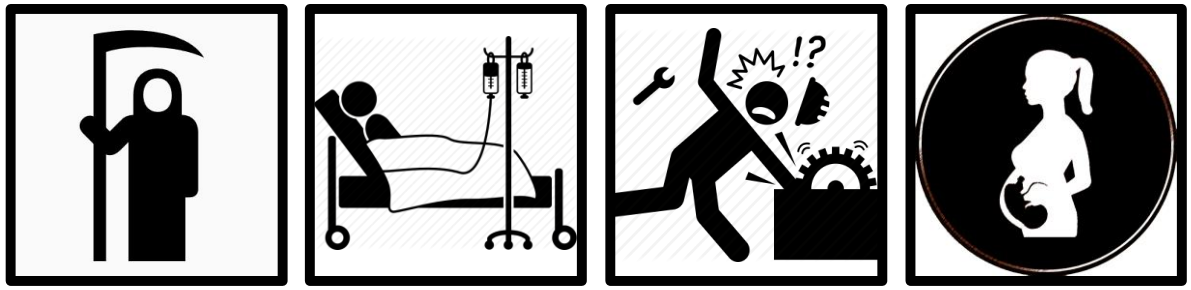
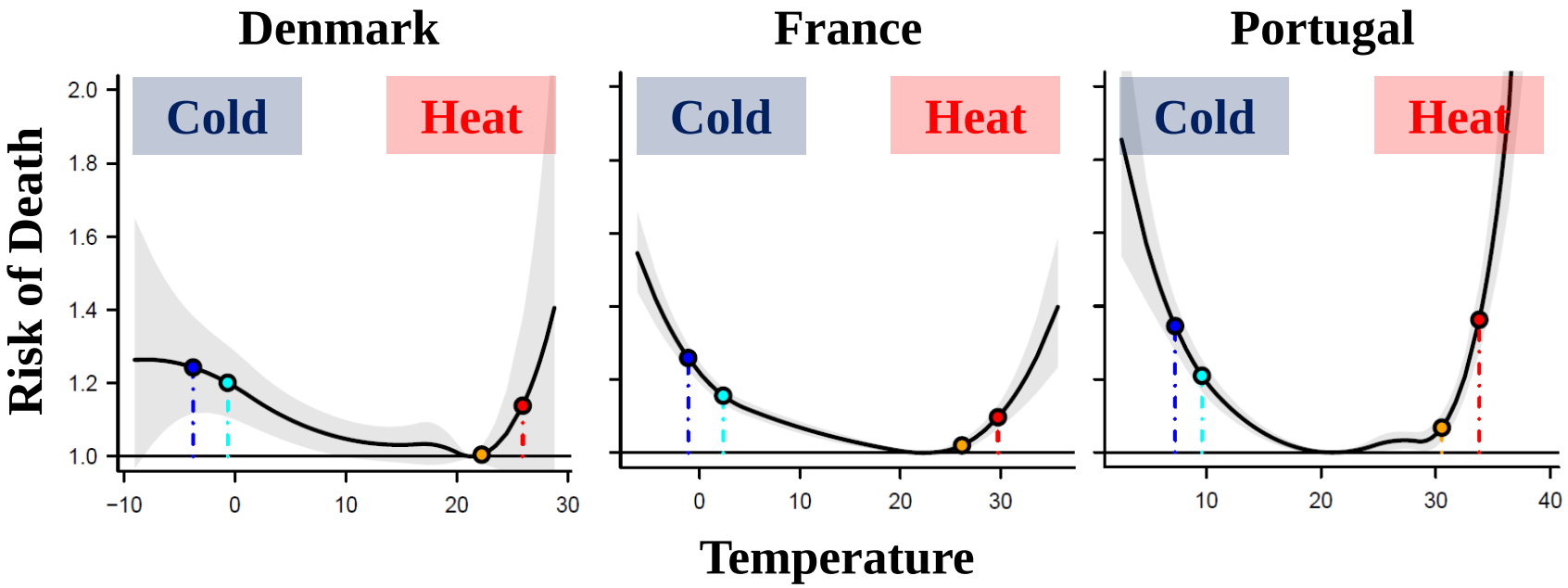
Temperature Impacts on Human Health

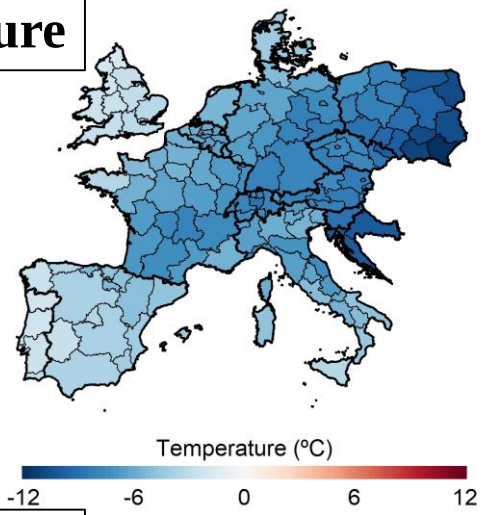
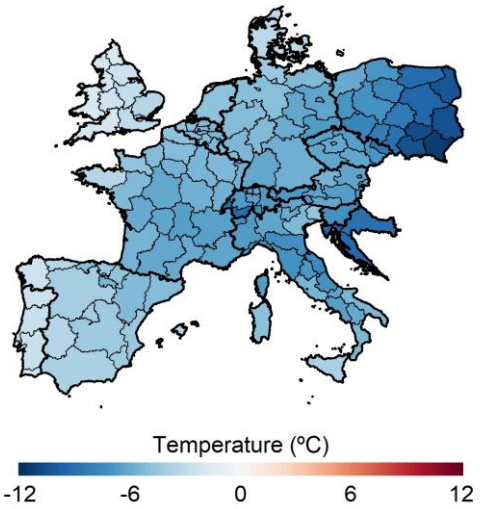
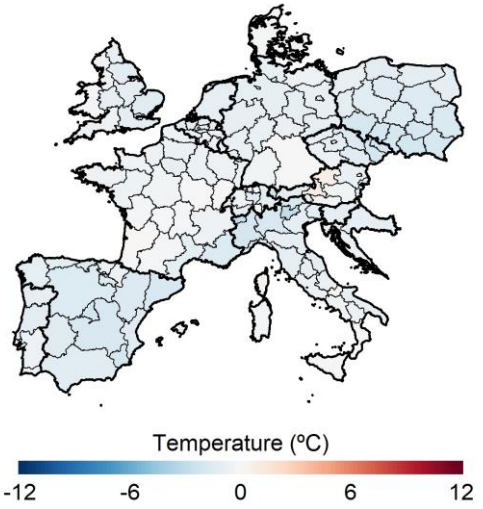
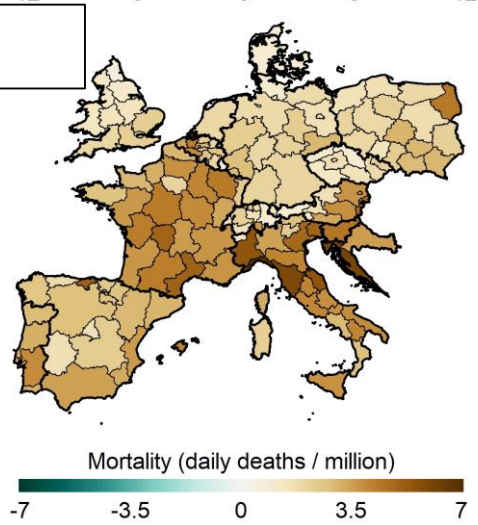
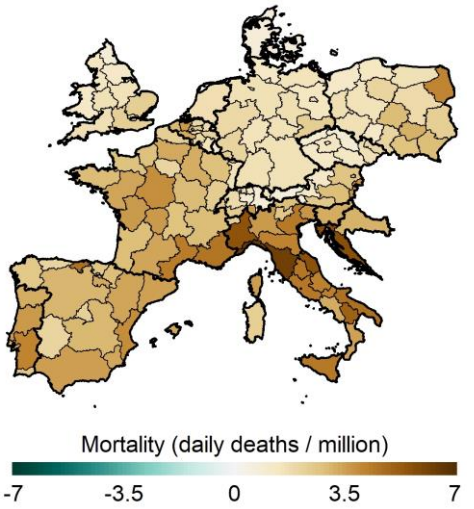
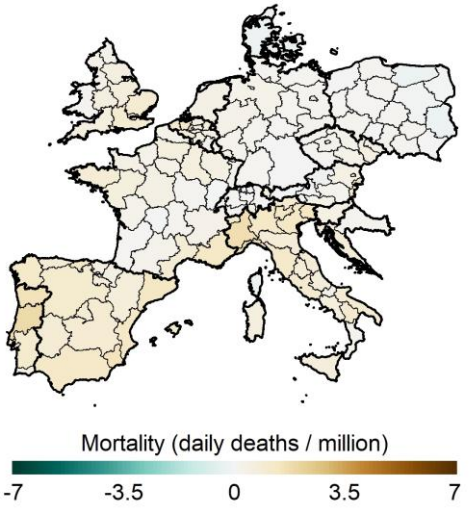




Blue-Action: Achebak et al. (2018, 2019, 2020), Ballester et al. (2011, 2016, 2019)

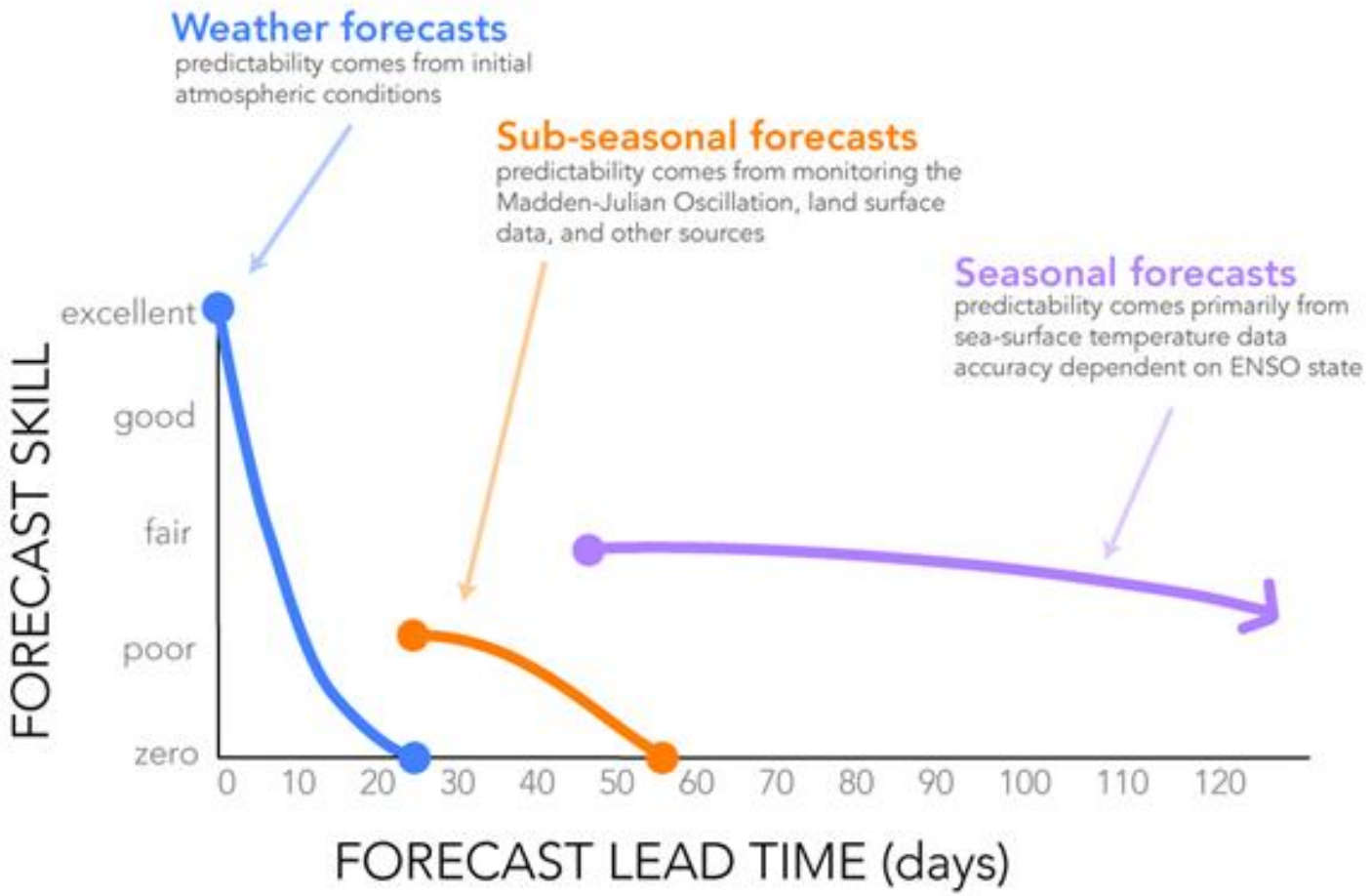
Is Health Predictable?

BLUE ACTION

	Observation	7-day Forecast	15-day Forecast
Temperature			
Mortality			

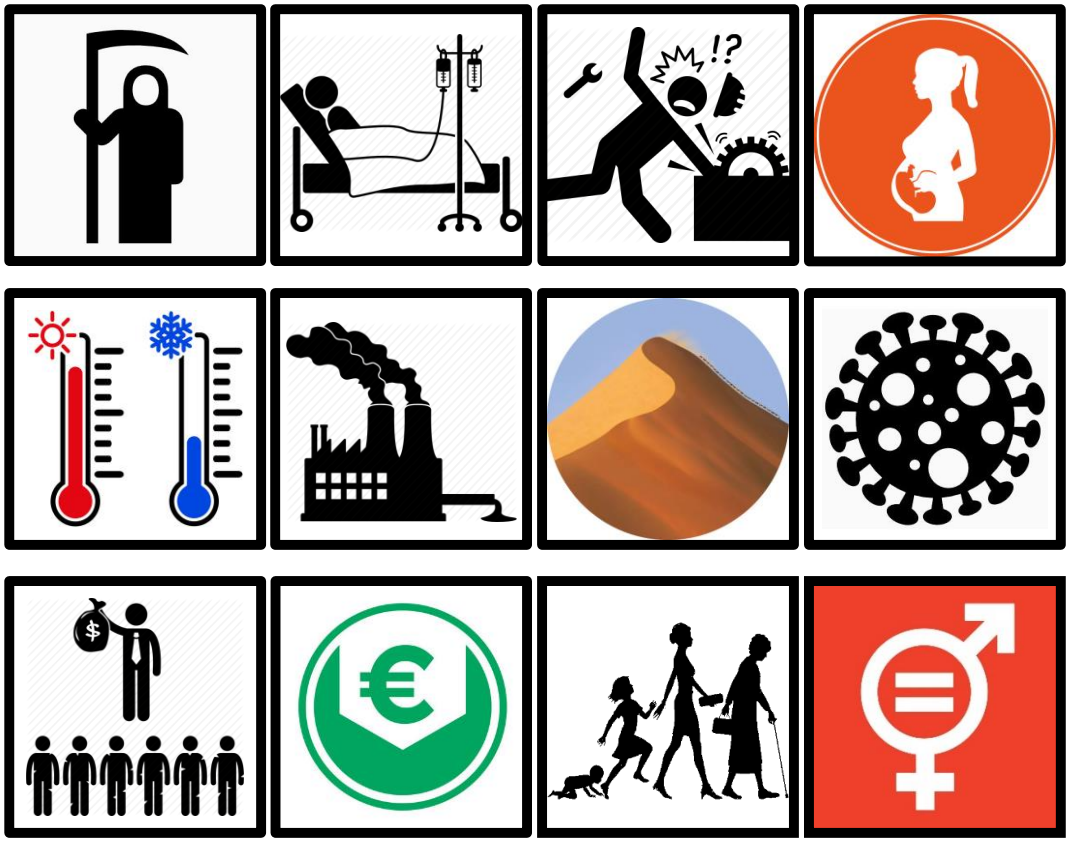
Analyses:
Blue-Action

What is the Real Predictability Limit?



Source: IRI

Next: Environment and Socioeconomy



Health Outcomes

=

Environmental Exposures

+

Socioeconomic Inequalities

Source: EARLY-ADAPT.eu

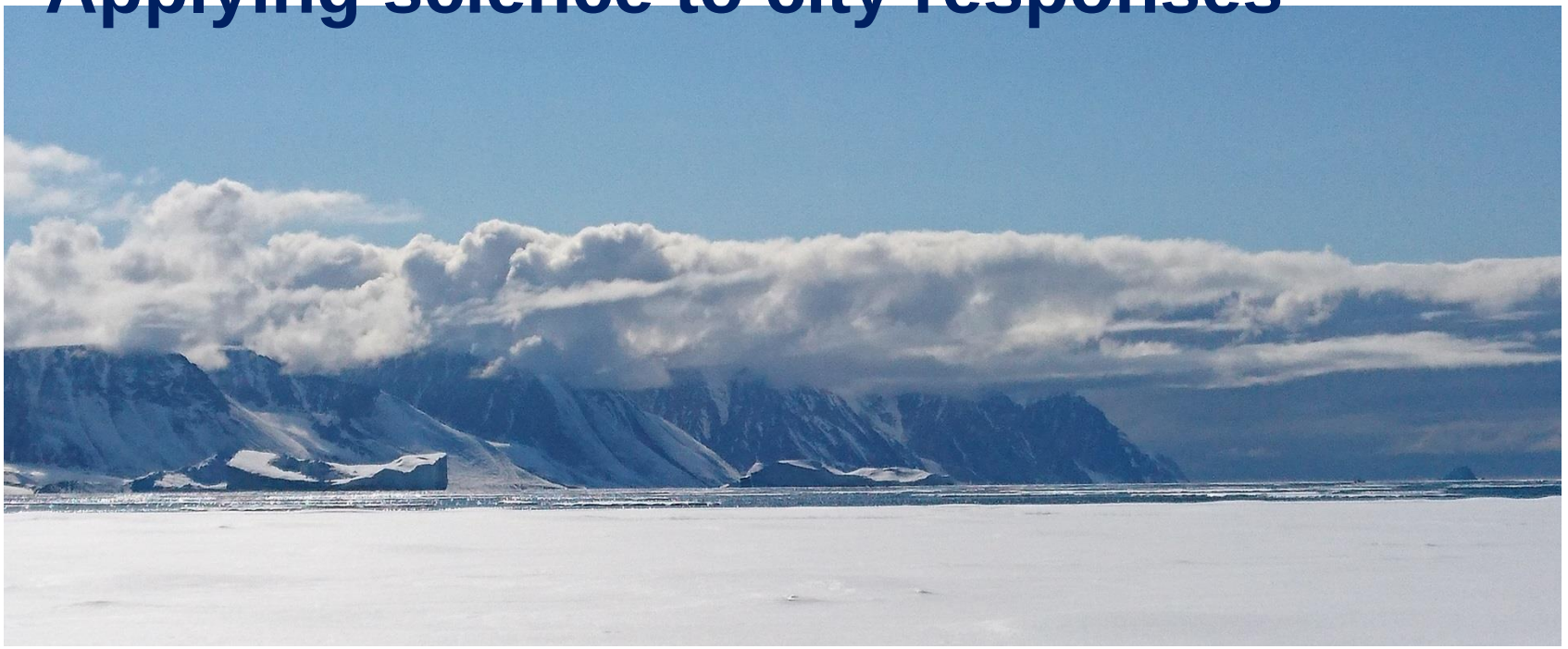
Key Take-Home Messages

- Health is Predictable
- Improvements in Climate Forecasting will lead to Improvements in Health Forecasting
- Health Early Warnings Need to Include Environmental and Socioeconomic Data
- They Can Reduce Inequalities in the Adaptation to Climate Change

Nuno Lopes, Sara Dionísio, Catarina Freitas

City Council of Almada

Almada's Local Adaptation Strategy: Applying science to city responses



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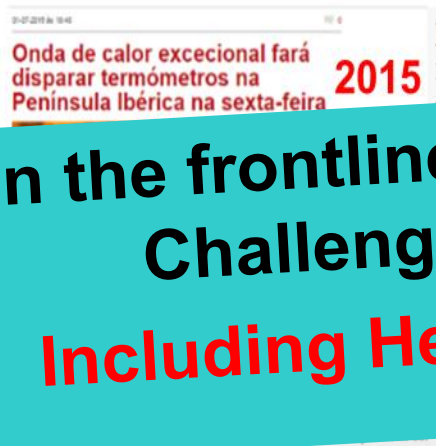
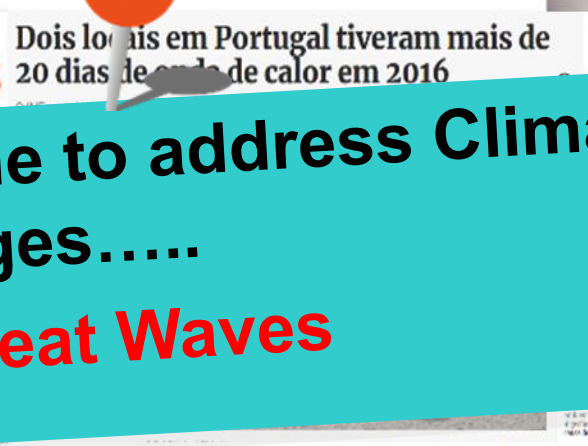
Almada

- Located in **Portugal**, in the **Lisbon Metropolitan Area**
- Area ~ 70 km^2
- Medium size city
- 175 000 inhabitants
- Atlantic beach front (13km)
- 35 km waterfront
- **Several climate hazards and vulnerabilities** (...)

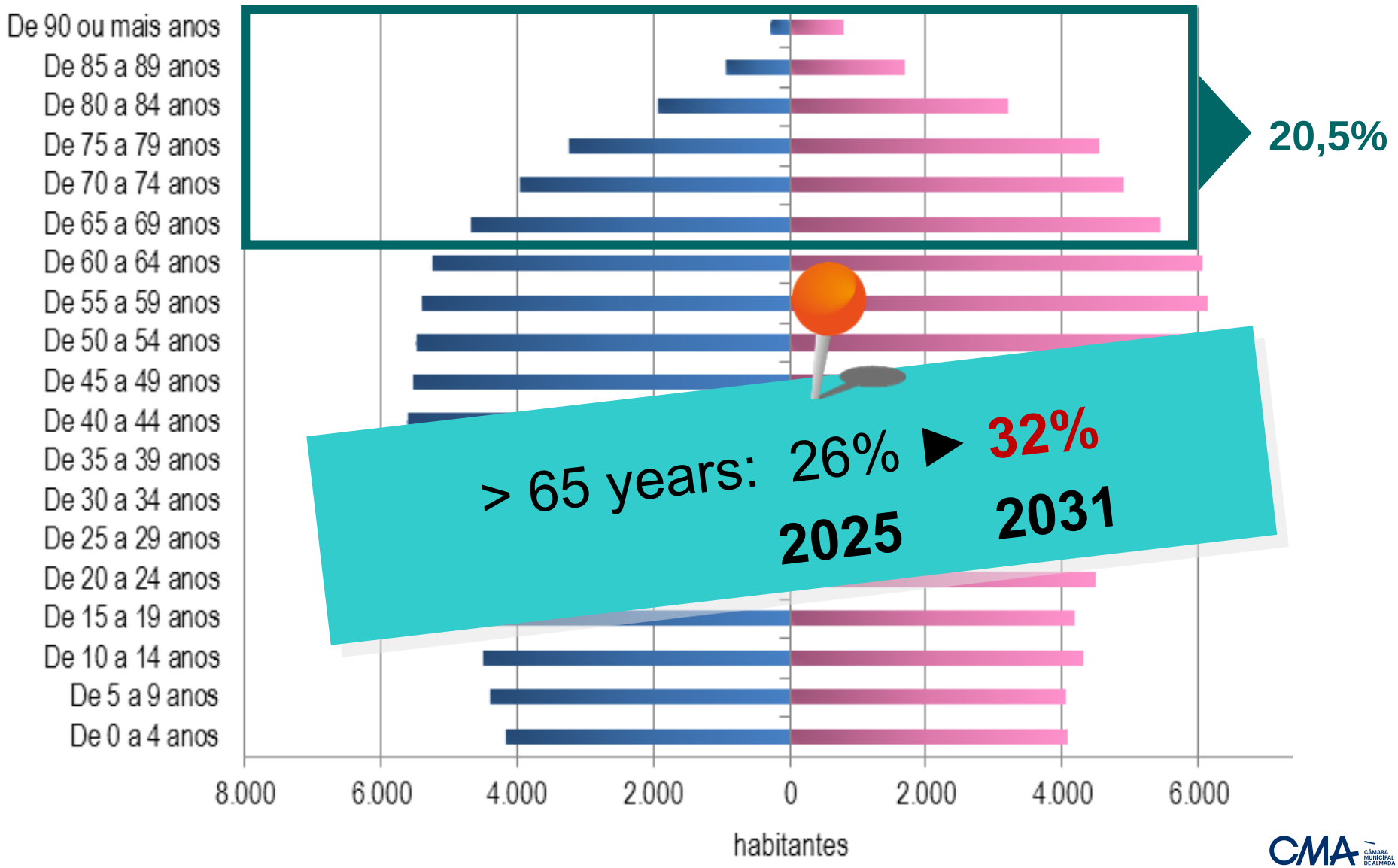




Cities are in the frontline to address Climate Challenges…..

Including Heat Waves

Almada's Demographic data | 2011



Almada: Local Strategy for Climate Change

BLUE ACTION

↳ **Mitigation** Agenda

↓ energy consumption and GHGs emissions (energy efficiency, renewables, smart mobility) ... **Low carbon city**

↳ **Adaptation Agenda**

Allowing the resilience of our natural, social and economic systems, providing our communities a healthy and safe environment to live and work.

Covenant of Mayors

WORLD MAYORS SUMMIT ON CLIMATE • MEXICO CITY 21 • NOV • 2010

dac durban adaptation charter

MAYORS ADAPT THE COVENANT OF MAYORS INITIATIVE ON ADAPTATION TO CLIMATE CHANGE

COMPACT of MAYORS

CMA CÂMARA MUNICIPAL DE ALMADA

Almada's Local Adaptation Agenda

- Downscaling Climate Evolution Scenarios
- Monitoring climate change impacts (floods, landslides, heat waves, oceanic overwashes)
- **Vulnerability assessment (coast, riverfront, ecosystems, urban water cycle, urban services), existing and amplified…**
- **Heat waves and Urban Heat Island Effect**
- Design Risk Maps
- Definition of adaptation goals and measures
- Integrating adaptation goals and measures in land use planning: Urban Plans and Master Plan of Almada (currently under revision)

Almada's Local Adaptation Agenda

≠ Sectors ▶ Multiple Challenges

- Human Health 
- Biodiversity 
- Coastal Ecosystems 
- Water resources 
- Heat Waves/UHIE 
- Agriculture and Food Security 
- Security 
- Social and Economic Activities 
- Tourism and Leisure 
- Urban Water Services 

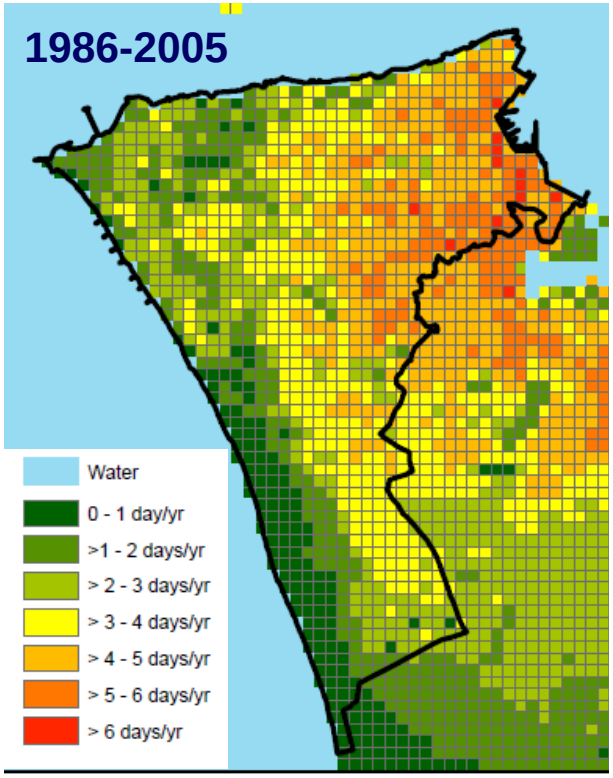
Modelling Heat Waves

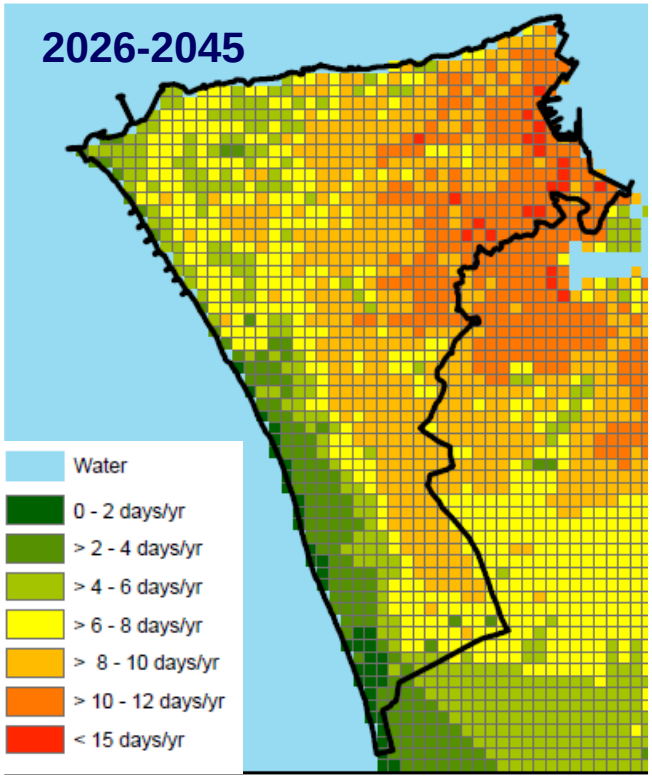
The average number of heatwave days per year might increase from 5-6 to up 30-40 days

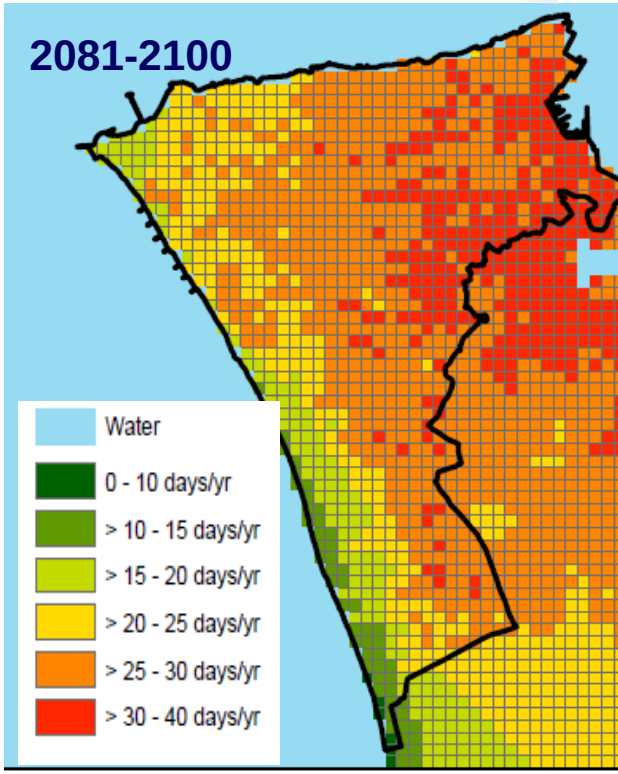
Heat waves in Almada

(nº of days per year)

The research leading to these results has received funding from the European Union 7th Framework Programme (FP7 2007-2013), under grant agreement n.308299
NACLIM www.naclim.eu

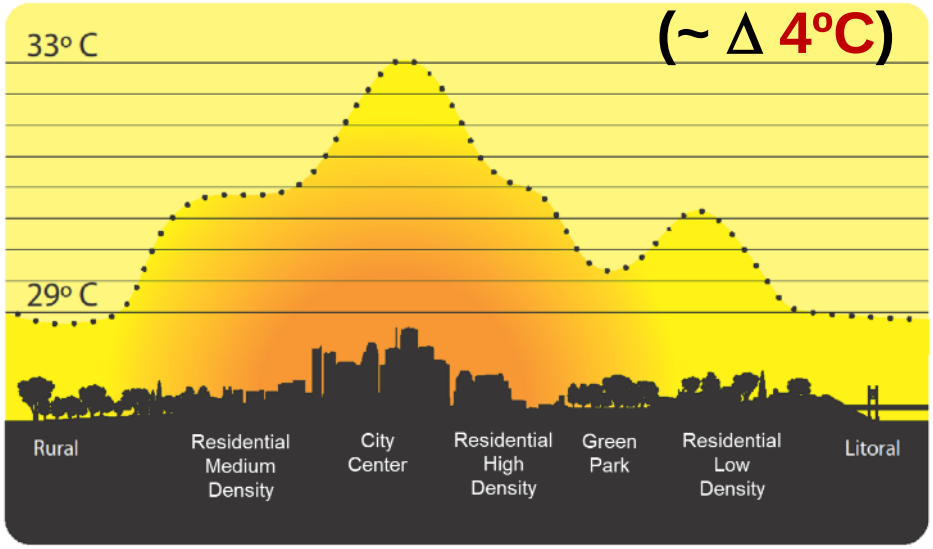






Evaluating UHIE and Heat Stress

- **Urban Heat Island Effect (UHIE)**
- **Evaluate heat stress of people (daytime) in public space =>** radiation, moisture and ventilation need to be taken into account



- **Indicator : Mean Radiant Temperature (MRT) (www.utci.org)**

Physiological Comfort Index: expresses the influence of surface temperatures on occupant's comfort of a particular location

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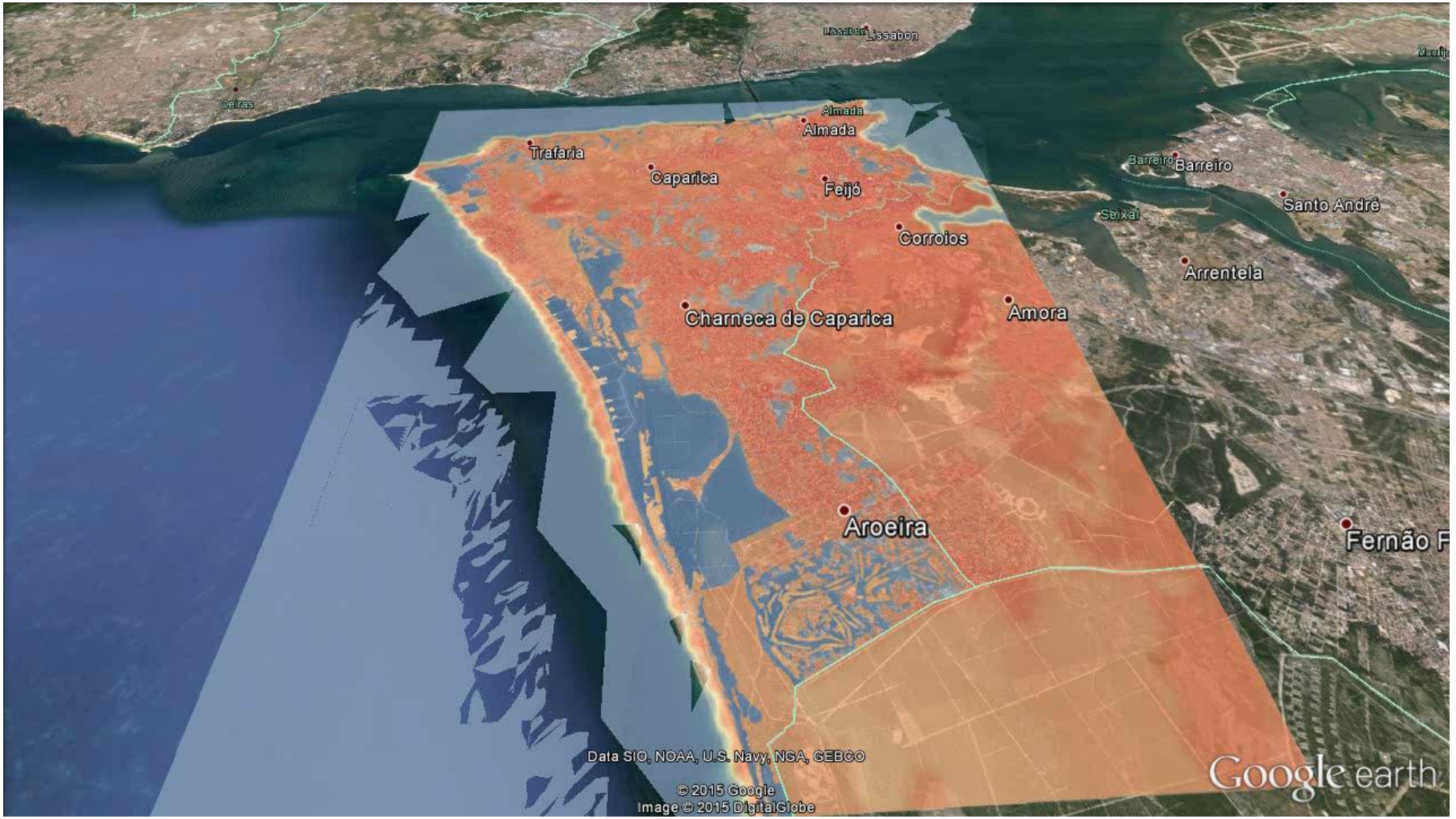
Modelling Mean Radiant Temperature



MRT<40°C: no heat stress | MRT 40-60°C: heat stress | MRT>60°C: high heat stress

Modelling Mean Radiant Temperature

Modelling measures to improve microclimatic regulation in areas with high MRT

↳ **White roofs + Green roofs + Planting trees**

The research leading to these results has received funding from the European Union 7th Framework Programme (FP7 2007-2013), under grant agreement n.308299
NACLIM www.naclim.eu

↳ **The area with high heat stress level is reduced by more than 50% in outdoor spaces. Positive effects also on indoor temperatures**




Modelling Temperature-Related Mortality Risk

Objective:

↳ **Study the impact of heat waves on the population, namely the increase of heat-related mortality.**

Inputs:

↳ **Study period**: 2000-2015 (16 years)

↳ **Temperature data**: Daily mean temperature

↳ **Mortality data**: Daily counts of all-cause mortality (28.450 deaths)

Almada's Outcomes:

↳ **Defining measures for land use planning, following a multi-dimension and multi-level approach**

↳ **Improving the adaptive capacity and resilience of the municipality, especially in areas with relevant exposure (ex: elderly, children)**

Modelling Temperature-Related Mortality Risk

↳ Impact of heat waves on the population: Mortality

In Almada, during the studied period, 219 people died due to extreme heat, of which 190 in the 5 to 6 hottest days

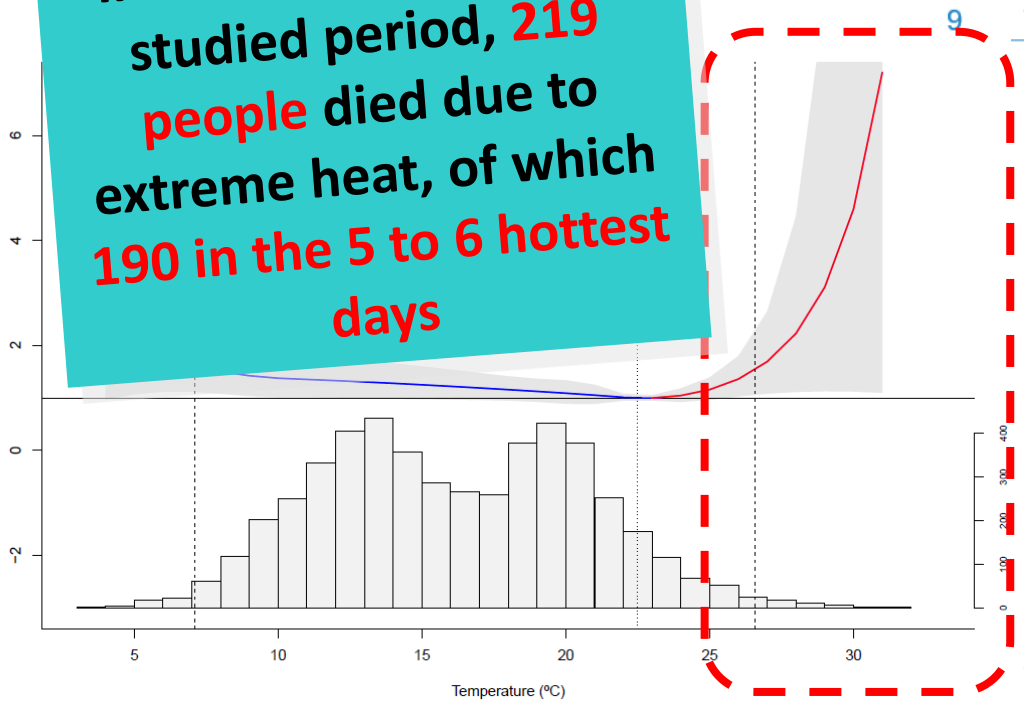


TABLE 3: Attributable measures (fraction and number)

	Attributable Fraction (%)			Attributable Number		
		Confidence Interval (95%)			Confidence Interval (95%)	
	AF	Low	High	AN	Low	High
Global	19.03	1.07	32.58	5,413	428	9,217
Heat	0.77	0.03	1.32	219	-6	370
Cold	18.25	-0.3	32.63	5,194	29	9,286
Components						
Extreme heat	0.67	0.09	0.99	190	50	282
Moderate heat	0.12	-0.24	0.42	34	-64	123
Moderate cold	16.95	-0.98	31.11	4,821	-490	8,615
Extreme cold	1.31	0.43	1.95	372	130	546

Heat: temperatures above the minimum mortality temperature

Cold: temperatures below the minimum mortality temperature

Extreme heat/cold: temperatures below the 2.5th and above the 97.5th percentiles

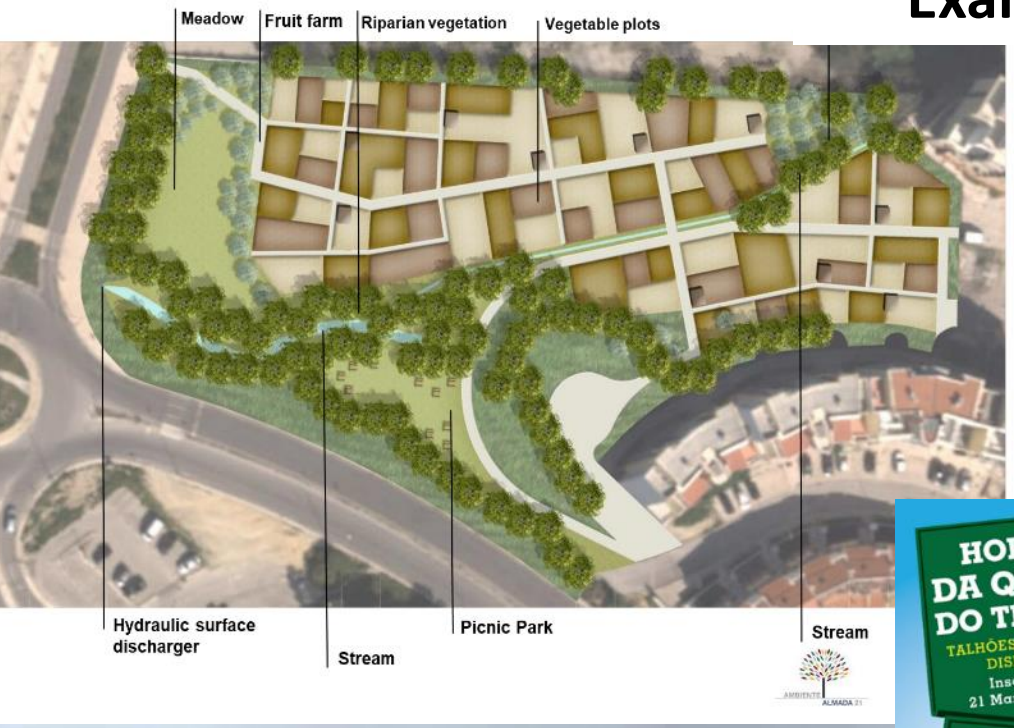
Local Action: Multi-level Approach

- Projects like Blue-Action can be an <u>important scientific support of the work done by Cities to address Climate Challenges</u>
- Facing this new challenges, Almada developed a **multi-dimension, integrated and <u>multi-level</u> approach**:
  - "Boosting" resilience by adopting **Ecosystem Based Planning** in land use plans, using **Nature Based Solutions**
  - Defining **adaptive measures in projects**
  - Including **heat-health prevention in the Municipal Emergency Plan**
  - Raising **awareness about heat waves and their impacts** (especially children)

Local Action: Define and Integrate Microclimatic Regulation Measures in Municipal Action

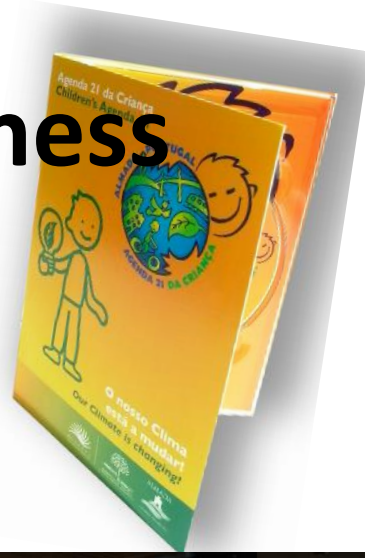
Plans/Projects /Regulations	Microclimatic Regulation Measures (examples)
Green/Blue Infrastructure + Local Biodiversity Plan	▪ Delimitation of the **Green** and **Blue** infrastructure and identification of ecological services provided by ecosystems ▪ **Ecosystem-based multifunctional adaptation** projects that joint in one area municipal gardens, retention basins and the recovery of water lines ▪ "Boosting" of **urban green corridors**
Almada's Water and Drainage Master Plan	▪ **Reduction of urban seal surfaces** and use of permeable floors ▪ **Promotion of rain retention** in soils with vegetation and / or by forwarding water to areas of infiltration or temporary storage
Almada's Urban Regulation (art. 63º)	▪ Improve the **natural cooling of buildings** ▪ Climate proof buildings ▪ Use of **green roofs and green façades** to promote climate regulation and biodiversity in urban areas
Interventions in public spaces at the street level	▪ **Nature based solutions applied to multifunctional adaptation projects** that combine different ecosystems services (green and blue infrastructure) creating green spaces with multiple benefits for the population

Example GI +BI multifuntional project



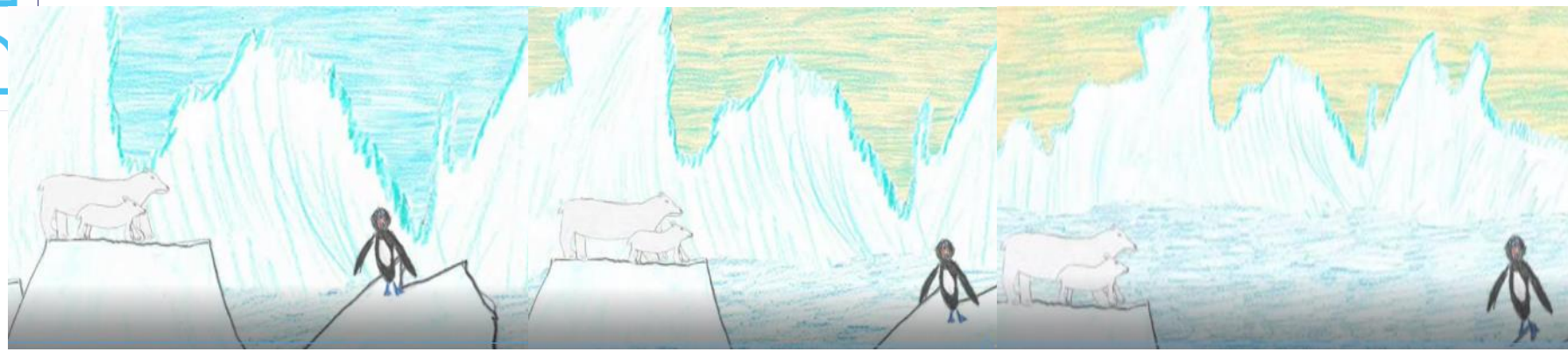
Examples of Microclimatic Regulation Measures

Local Action: Improving awareness



Working in Children's Agenda 21 framework

- Establish, in a perceptible way for children, **relations between local sustainable options, the protection of the planet and climate change**
- Each school participating in the **project produces proposals and outputs done by the children**



Local Action: Sharing Results

- Blue Action **results improved the in-house knowledge and supported an application of Almada to the EEA Grants**, together with other 17 municipalities of the Lisbon Metropolitan Area
- The project **"CLIMA.AML"** will evaluate for 30 months, the evolution of temperature and relative humidity in different seasons, in urban areas with contrasting characteristics of green and grey cover and model some microclimate regulation measures.

Key messages

- **<u>Cities are in the frontline to address Climate Challenges</u>**
- It is hard to keep the *momentum* in **managing local problems with a global knowledge; EU projects like Blue Action are important on zooming in to city level.**
- It is important for Cities to rely on robust **("translated") scientific data to knowledge, to apply to practical solutions.** (R&D)
- **Specific budget for end users like Cities** is essential to test measures in pilot projects and **applying science to city measures.**
- **Ecosystem Based Planning is a multi-dimension and multi-level approach to improve Climate Resilience and an effective and flexible way to build/protect natural and urban areas.**
- **Nature Based Solutions are investments aligned with the European Green Deal Objectives and the European Biodiversity Strategy, so cities should be a target for new financial instruments.**

BLUE ACTION

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