Coast.SENSE

towards an integrated coastal intelligence solution

AI for metropolitan scale urban climate: an approach for predicting sub-kilometric near-surface air temperature

Numerical Weather Prediction in Portugal 2021: Surface-Atmosphere Interactions

11-12 November 2021

CoLAB +ATLANTIC

+ AGENDA

- Motivation
- Coast.SENSE Concept
- +ATLANTIC Machine Learning Downscaling Model
  - Data and Methodology
  - Results
- Next Steps

+ MOTIVATION

In the context of the societal challenges

CLIMATE CHANGE

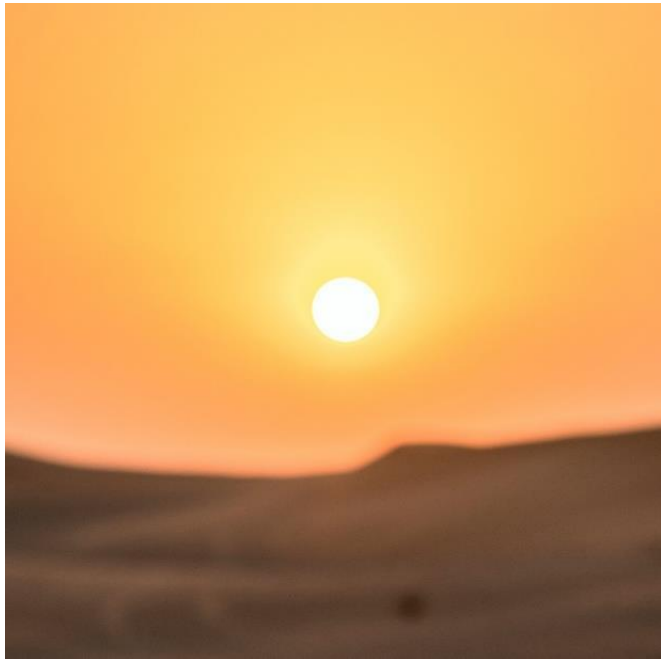


Photo by Leonid Danilov from Pexels

EXTREME EVENTS

Photo by Leonid Danilov from Pexels

PLANETARY HEALTH

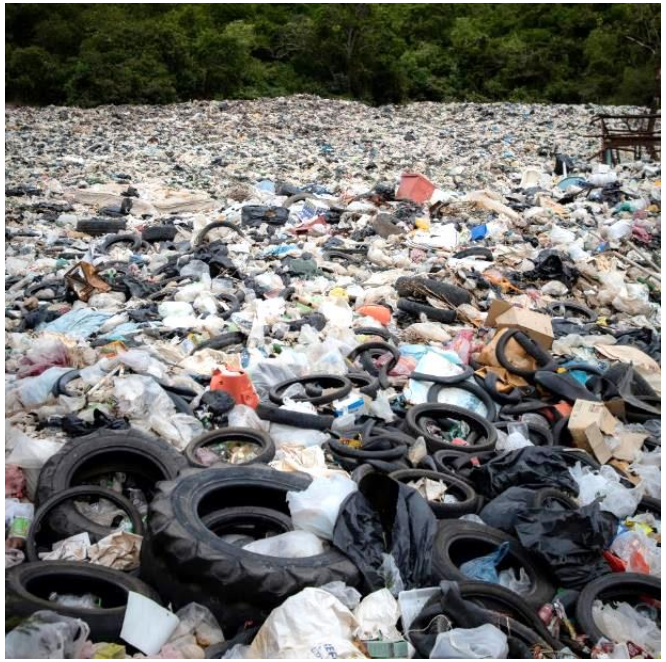


Photo by Leonid Danilov from Pexels

Out of sight, out of mind?

Photo by Aleksandar Pasaric from Pexels

Out of sight, out of mind?

$792 trillion losses

by 2100 (if business as usual)*

Photo by Aleksandar Pasaric from Pexels

*Source: Wei et al. (2020) Self-preservation strategy for approaching global warming targets in the post-Paris Agreement era, *nature communications*, 11, 1624(2020)

Yes,
in our backyard!

*Source: Wei et al. (2020) Self-preservation strategy for approaching global warming targets in the post-Paris Agreement era, *nature communications*, 11, 1624(2020)

Photo by **Kelly Lácy** from **Pexels**

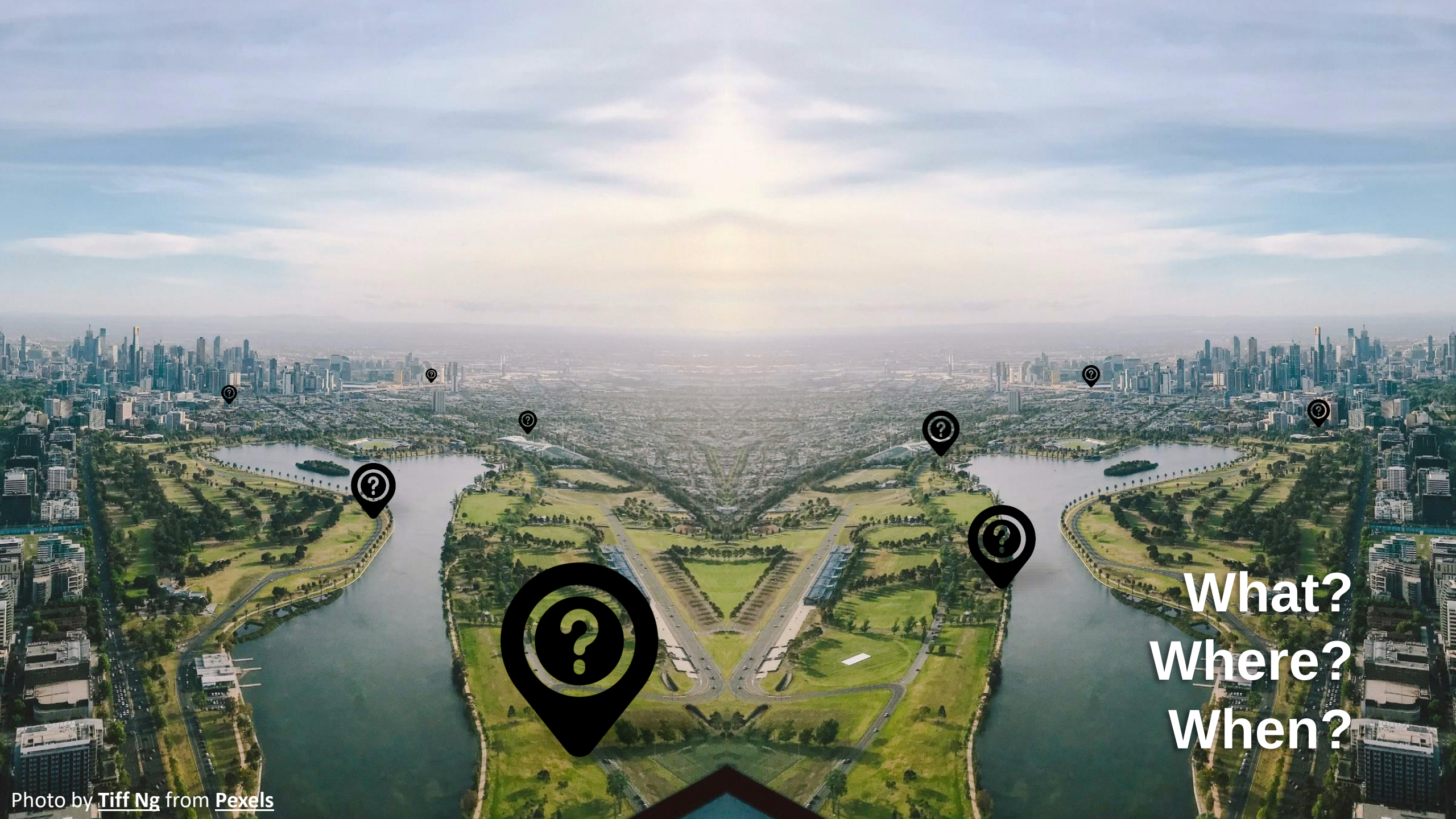


Photo by Tiff Ng from Pexels

+ **Coast.SENSE** Concept

Towards an integrated coastal intelligence solution

Coast.SENSE aims to deliver **multidisciplinary** environmental data (Earth Systems approach) rendered into user friendly **local impact assessment** information.

- Real-time, Short-term Forecast, Long-term Scenarios
- Accuracy Assessment
- High Spatio-temporal Resolution (sub-km, hourly)

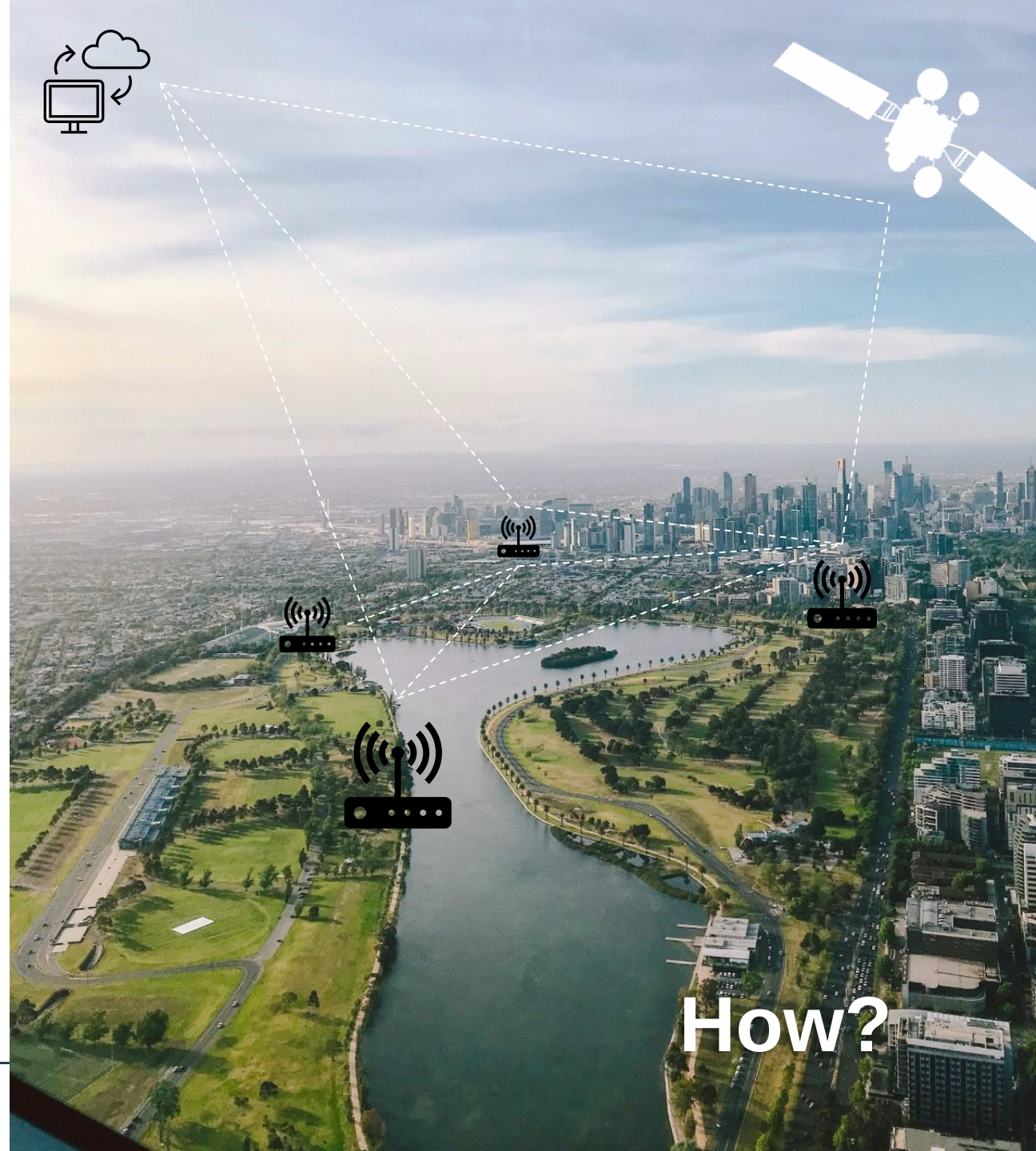
- Remote Sensing Imagery Processing
- Citizen Science Workflows
- Machine Learning/Artificial Intelligence
- Deterministic Numerical Models

Coast.SEA

- Overtopping
- Water quality
- Sedimentation

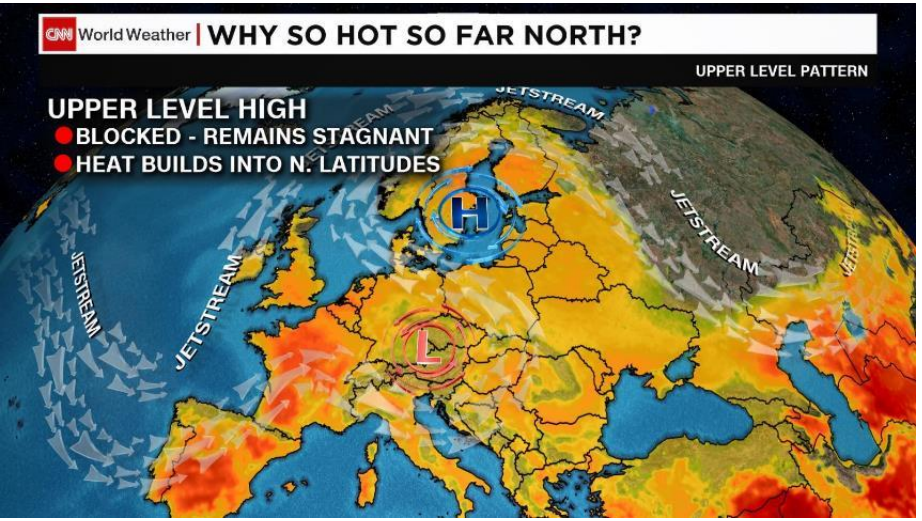
Coast.AIR

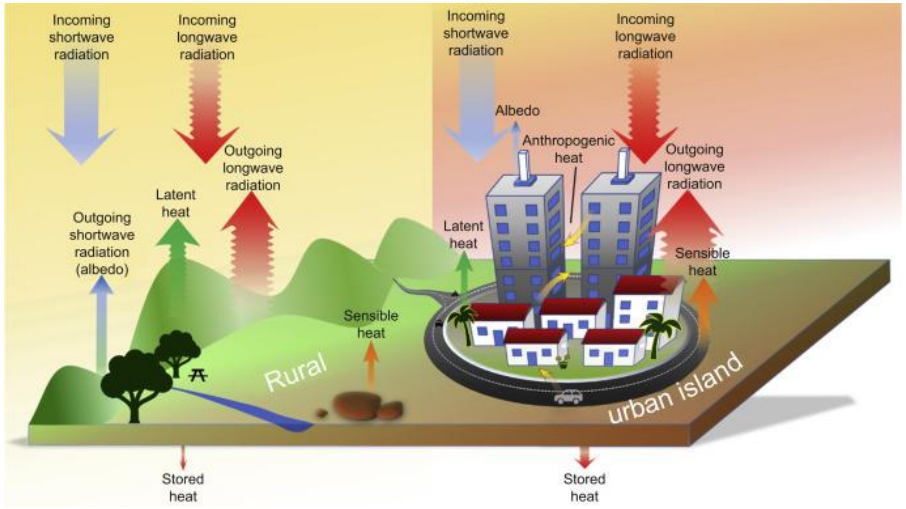
- Air quality
- Air Temperature/Heatwave Exposure
- CO_2 fluxes



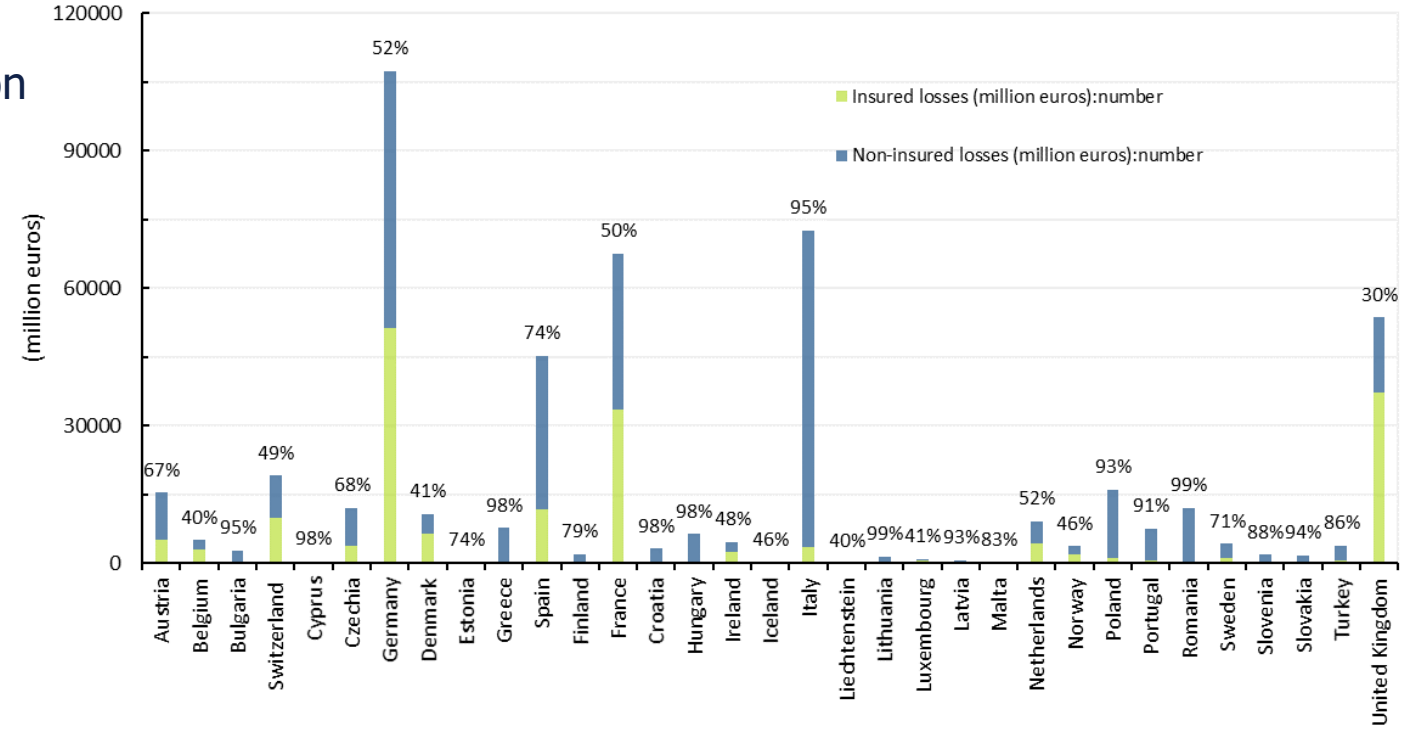
+ Coast.SENSE Concept

Towards an integrated coastal intelligence solution





Impacts of extreme weather and climate related events in the EEA member countries and the UK (1980-2019) [1]



New official data in Europe exposes heatwaves as still the 'silent killer' of the elderly

« Go to news archive

European summer heatwaves the most lethal disaster of 2019, says international research group

News and Press Release • **Source:** Red Cross Red Crescent Climate Centre • **Posted:** 5 May 2020 • **Originally published:** 5 May 2020

View original

[1] Data sources: NatCatSERVICE (Dataset URL is not available) provided by **Munich Re**

+ Machine Learning Application

Air Temperature/Heatwave Exposure Module

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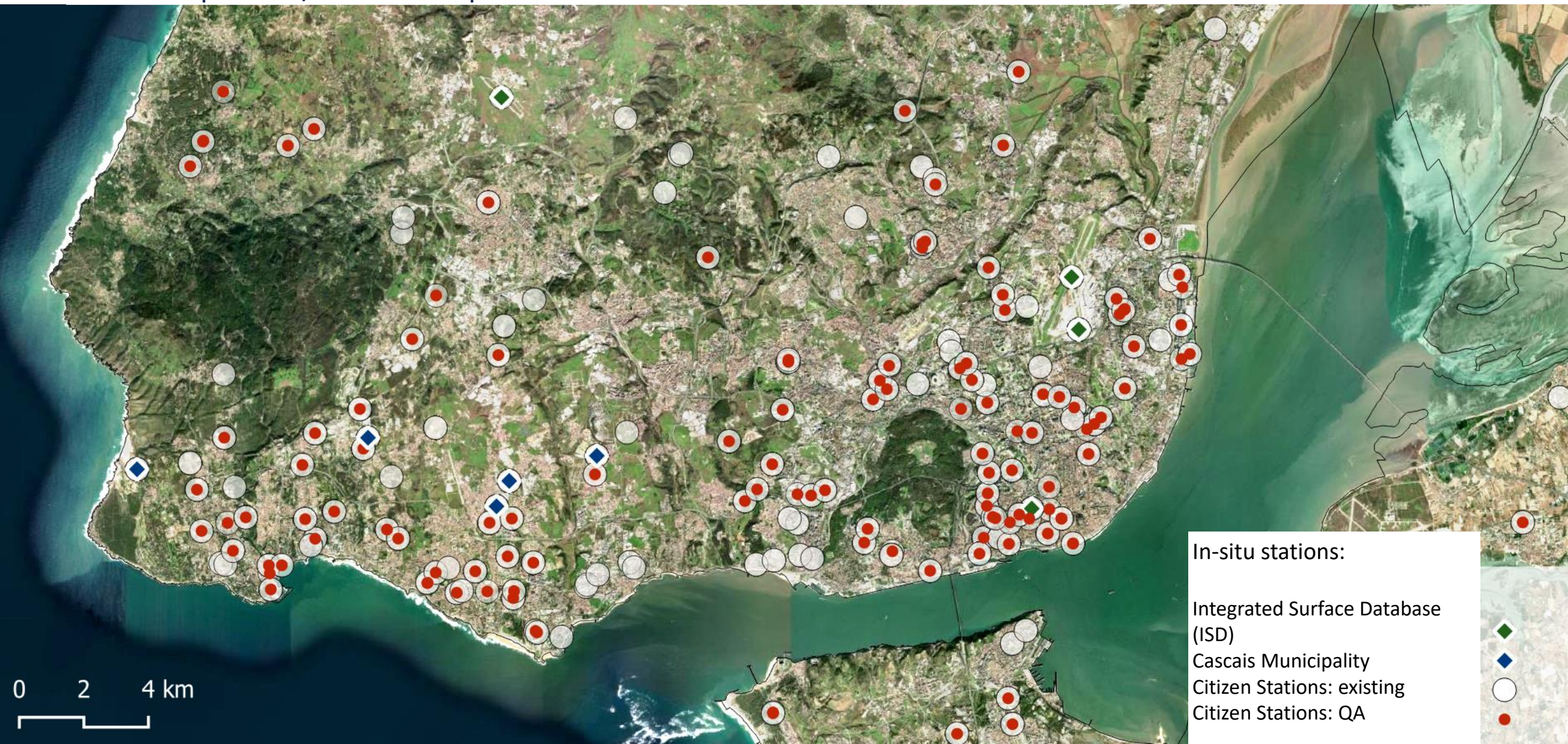
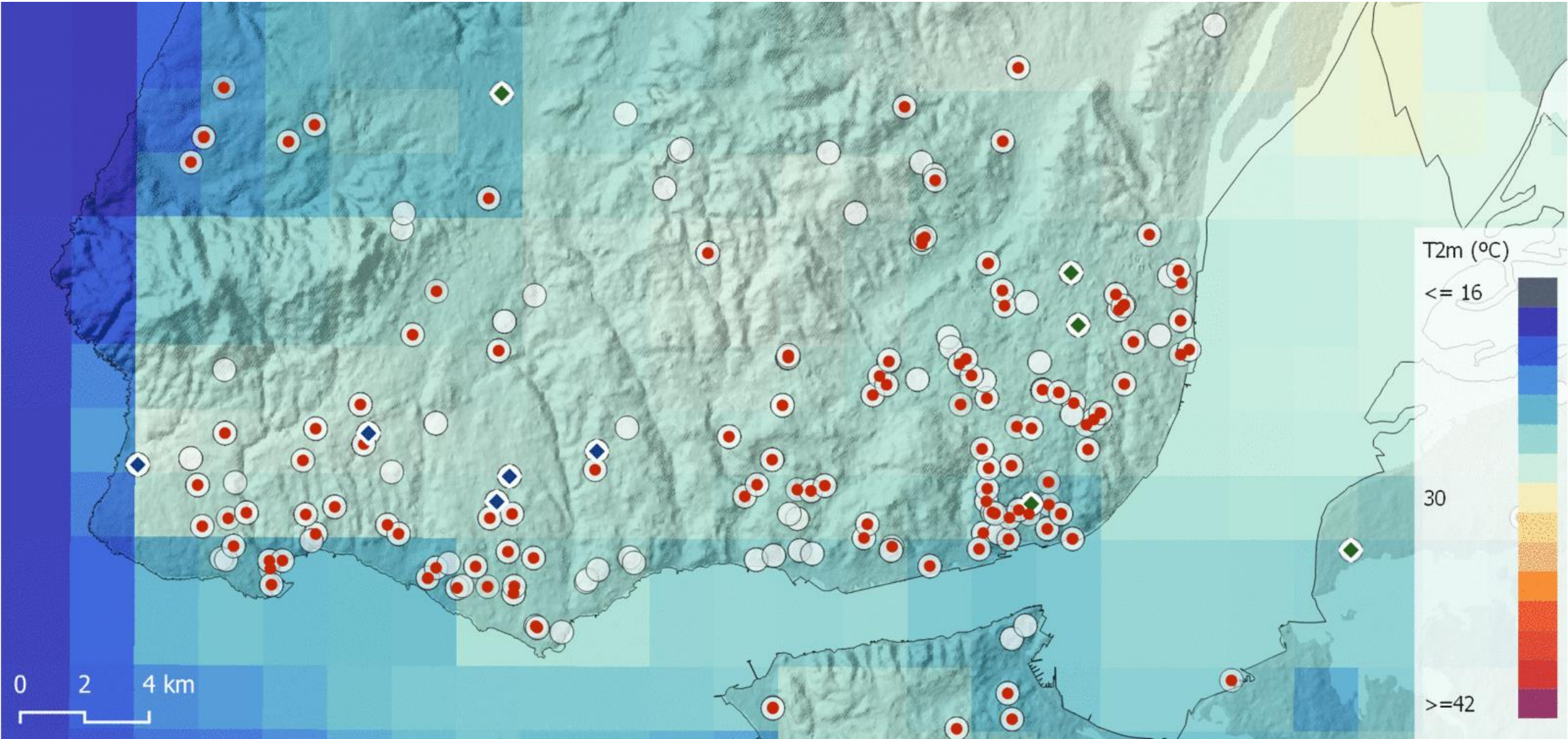


+ Machine Learning Application

Air Temperature/Heatwave Exposure Module



+ Machine Learning Application

Air Temperature/Heatwave Exposure Module – Data and Methodology

Equation:	$T_{t,x} = R_{t,x} + L_{t,x} + U_{t,x}$
Where:	$T_{t,x}$ near-surface air temperature, in time t and place x $R_{t,x}$ is the regional weather contribution $L_{t,x}$ is the natural landscape contribution $U_{t,x}$ is the urban/artificial land cover contribution

(Lowry, 1977).

+ Machine Learning Application

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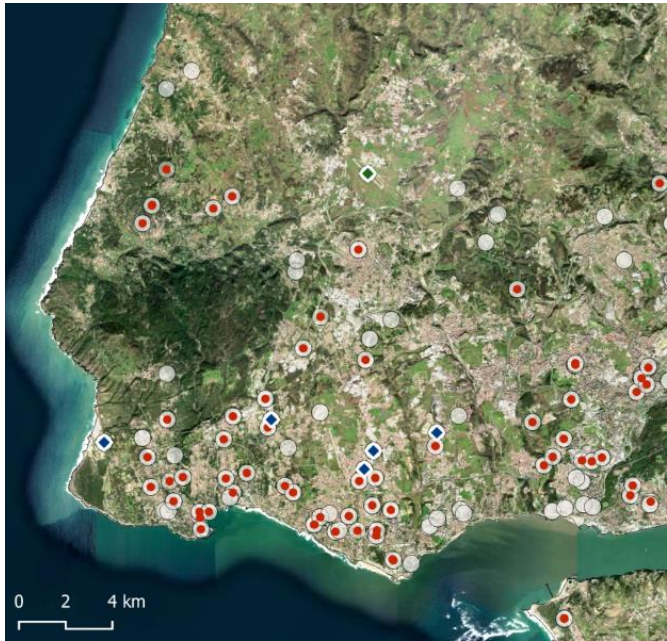
Response Variable = In-situ observations, after quality control, i.e., Netatmo + NCDC + Municipal Networks (e.g., Cascais, Lisbon)

T2m obs



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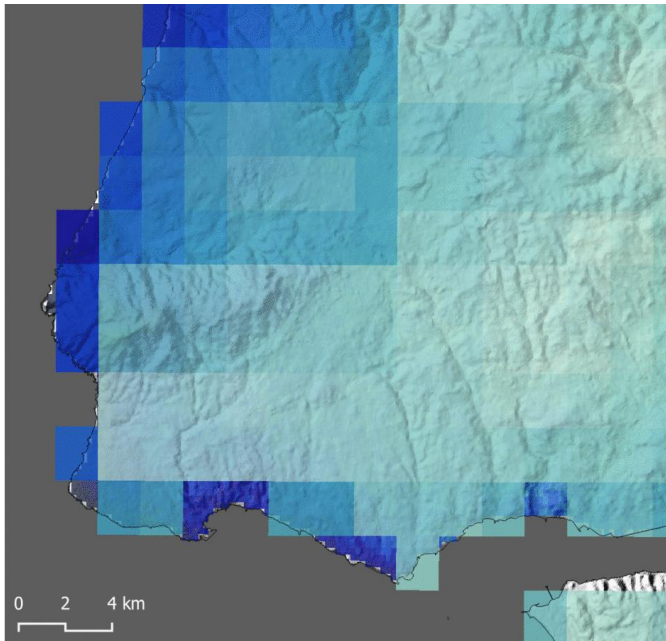
T2m obs

Regional Weather Contribution = AROME (T2m, Ws, Wdir, MSLP, RH)

90% T2m



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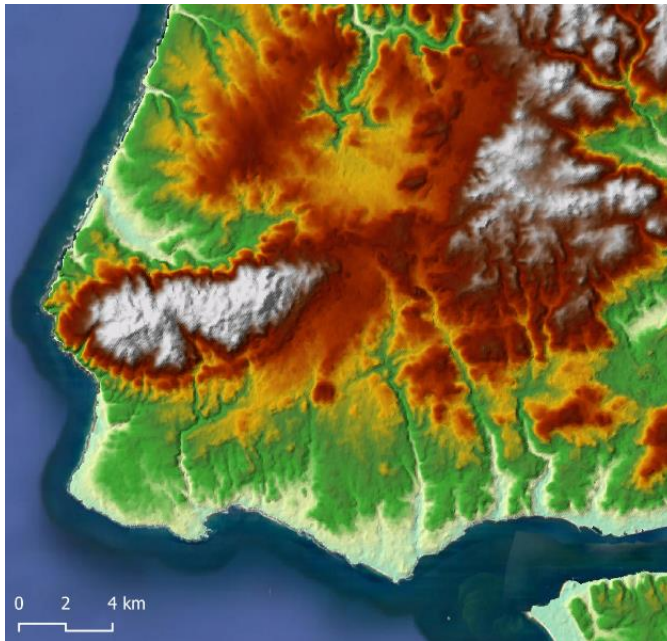

+ Machine Learning Application

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Response Variable = In-situ observations, after quality control, i.e., Netatmo + NCDC + Municipal Networks (e.g., Cascais, Lisboa) — **T2m obs**

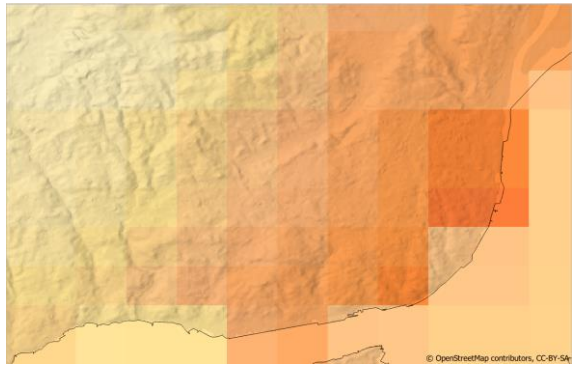
Regional Weather Contribution = AROME (T2m, Ws, Wdir, MSLP, RH) — **90% T2m**

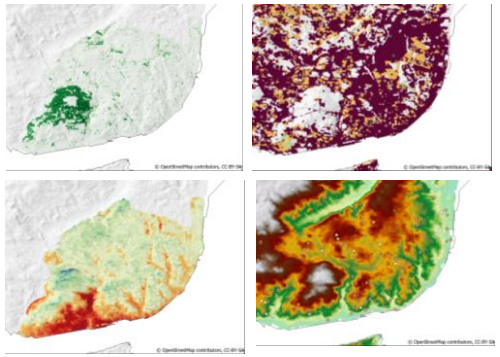
Natural Landscape Contribution = Latitude, Longitude, Altitude, Topographic Exposure to prevailing winds (regarding AROMEs Wdir) and coastal breezes

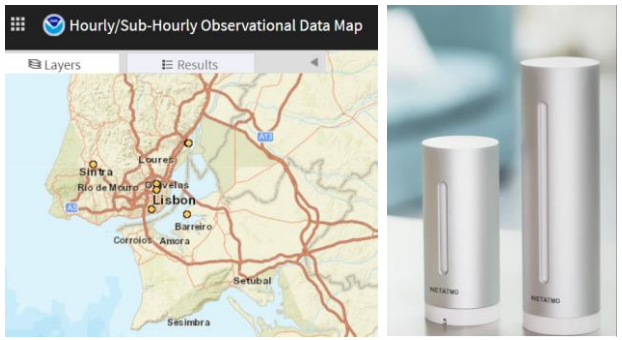
Urban/Artificial Land Cover Contribution = Imperviousness %, Bowen-ratio %, Tree coverage % — **10% T2m**

+ Machine Learning Application

Air Temperature/Heatwave Exposure Module







Input Information

AROME (NetCDF)

Grid w/ t-fixed var 250x250m (csv)

Netatmo (csv)

WMO (csv)

CDO pre-processing (merge first 12 timesteps of each daily model run)

Resample and correct coastal pixels

Sample AROME time-series to each grid point (csv)

Train RF and NN (csv)

Train LMM (csv)

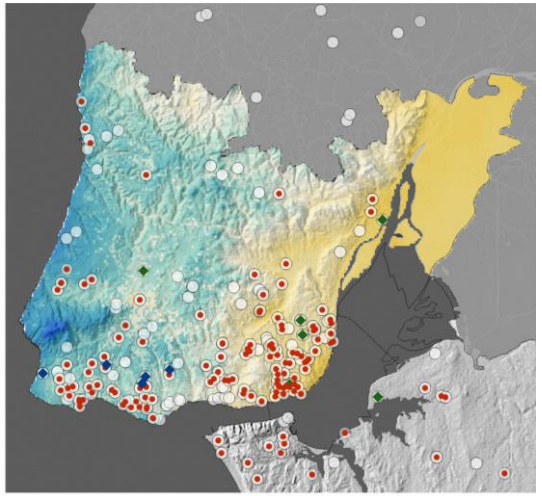
Data wrangling, to merge (csv)

Output Information

Make time-step average between the two (csv)

pyQGIS (sample Netatmo/WMO)

Errors (csv)

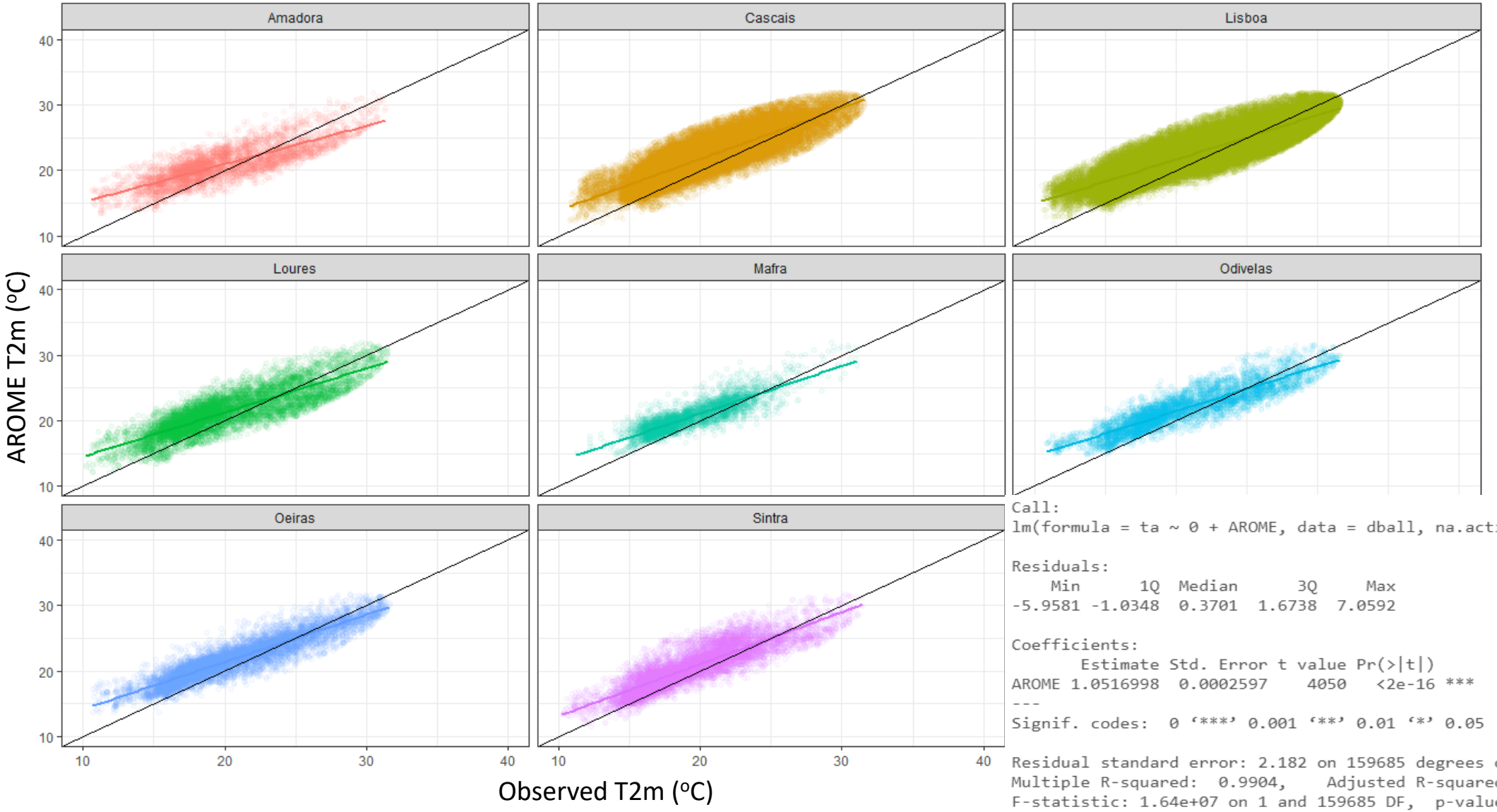


Predictions in Regular Grid

+ Machine Learning Application

Air Temperature/Heatwave Exposure Module – AROME Model

AROME T2m forecast versus Observed Air Temperature (citizen's in situ stations)

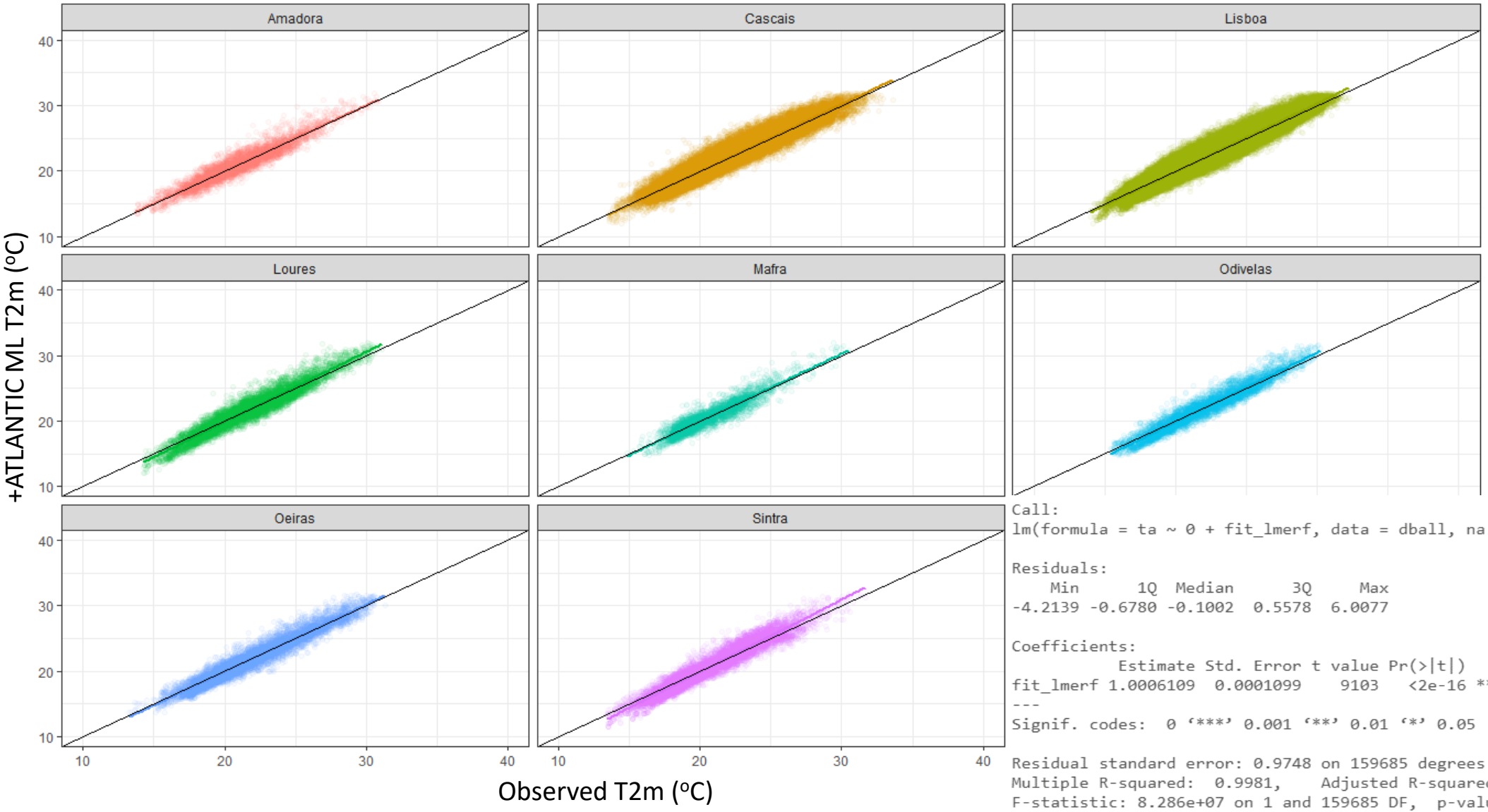



```
Call:
lm(formula = ta ~ 0 + AROME, data = dball, na.action = na.omit)

Residuals:
    Min      1Q  Median      3Q     Max
-5.9581 -1.0348  0.3701  1.6738  7.0592

Coefficients:
       Estimate Std. Error t value Pr(>|t|)
AROME 1.0516998  0.0002597    4050   <2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 2.182 on 159685 degrees of freedom
Multiple R-squared:  0.9904,    Adjusted R-squared:  0.9904
F-statistic: 1.64e+07 on 1 and 159685 DF,  p-value: < 2.2e-16
```

+ Machine Learning Application

Air Temperature/Heatwave Exposure Module - +ATLANTIC ML Model

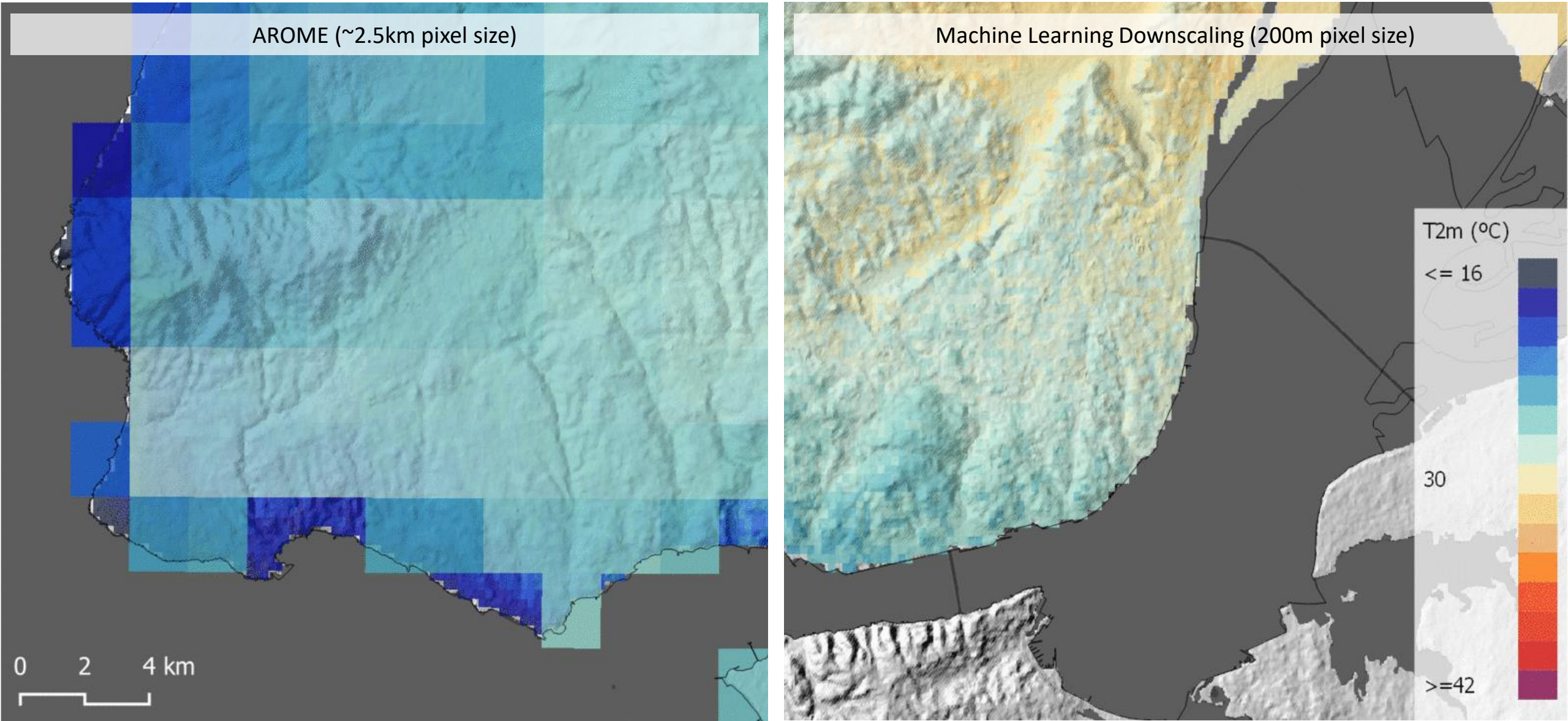
+ATLANTIC ML downscaling model versus Observed Air Temperature (citizen's in situ stations)




```
Call:
lm(formula = ta ~ 0 + fit_lmerf, data = dball, na.action = na.omit)

Residuals:
    Min      1Q  Median      3Q     Max
-4.2139 -0.6780 -0.1002  0.5578  6.0077

Coefficients:
           Estimate Std. Error t value Pr(>|t|)
fit_lmerf 1.0006109  0.0001099    9103   <2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.9748 on 159685 degrees of freedom
Multiple R-squared:  0.9981,    Adjusted R-squared:  0.9981
F-statistic: 8.286e+07 on 1 and 159685 DF,  p-value: < 2.2e-16
```

+ Machine Learning Application

Air Temperature/Heatwave Exposure Module – AROME *verus* +ATLANTIC Model



Example in Lisbon, during a heatwave day 17th of July 2020, at 6p.m.

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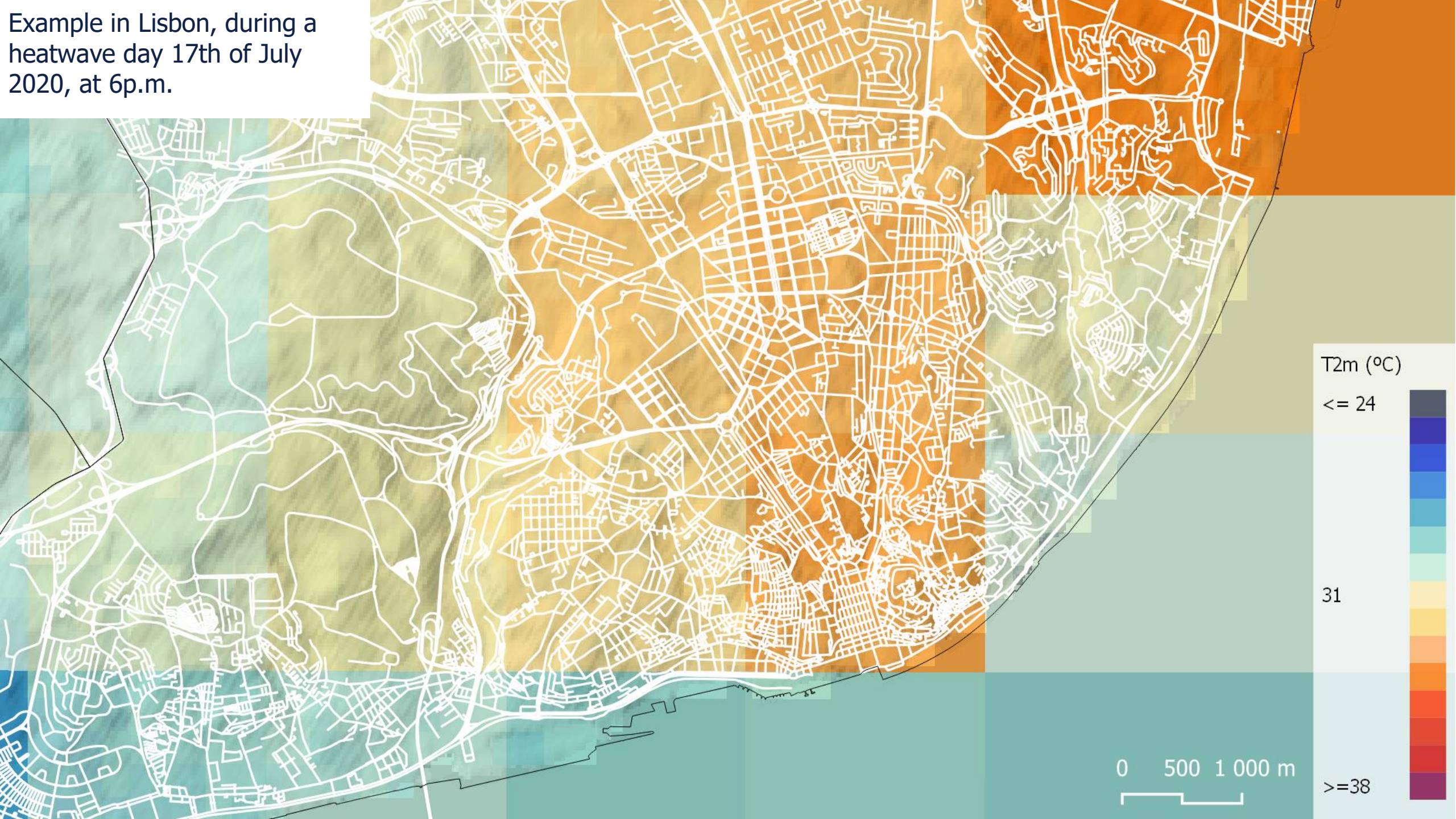
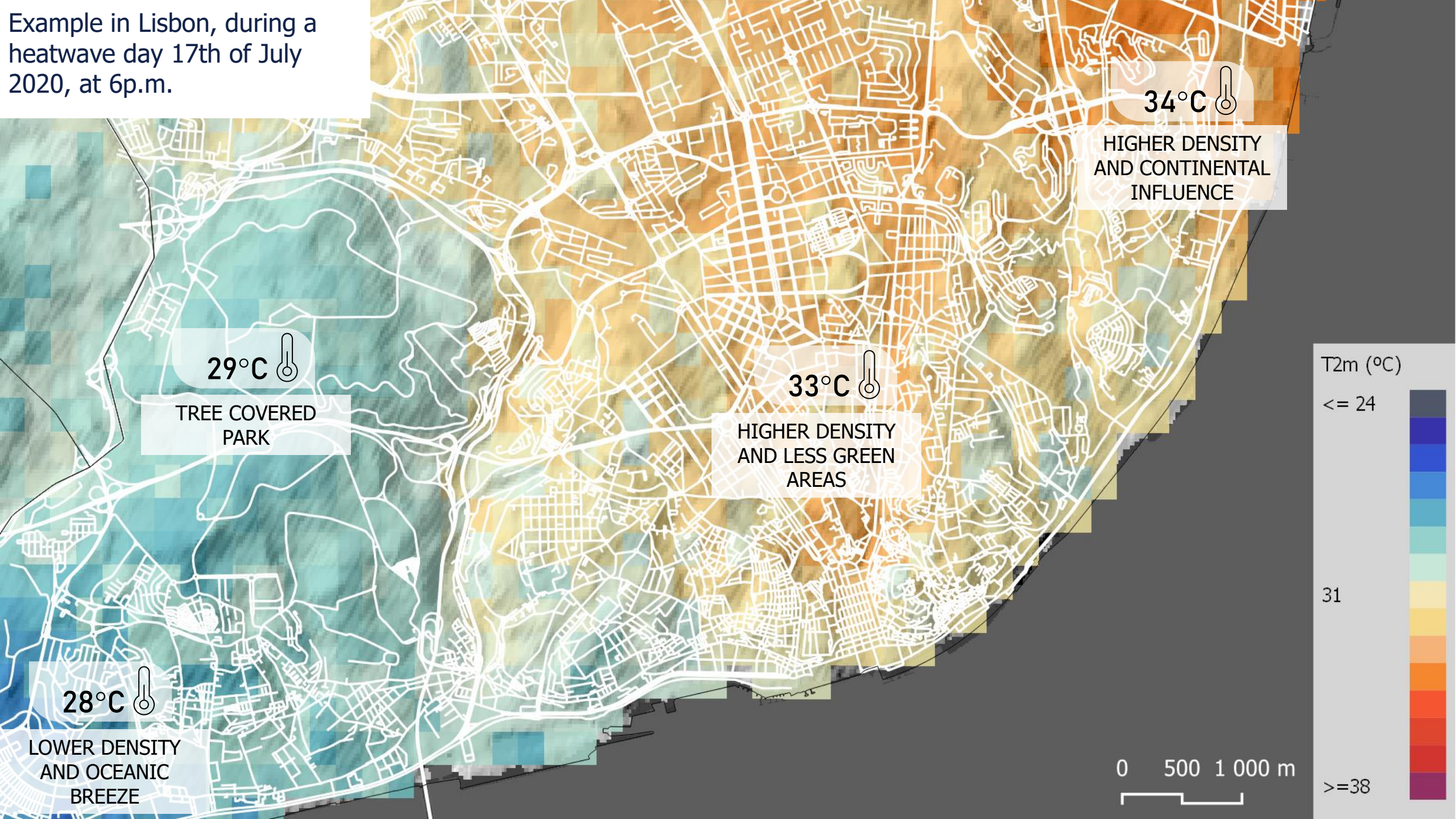
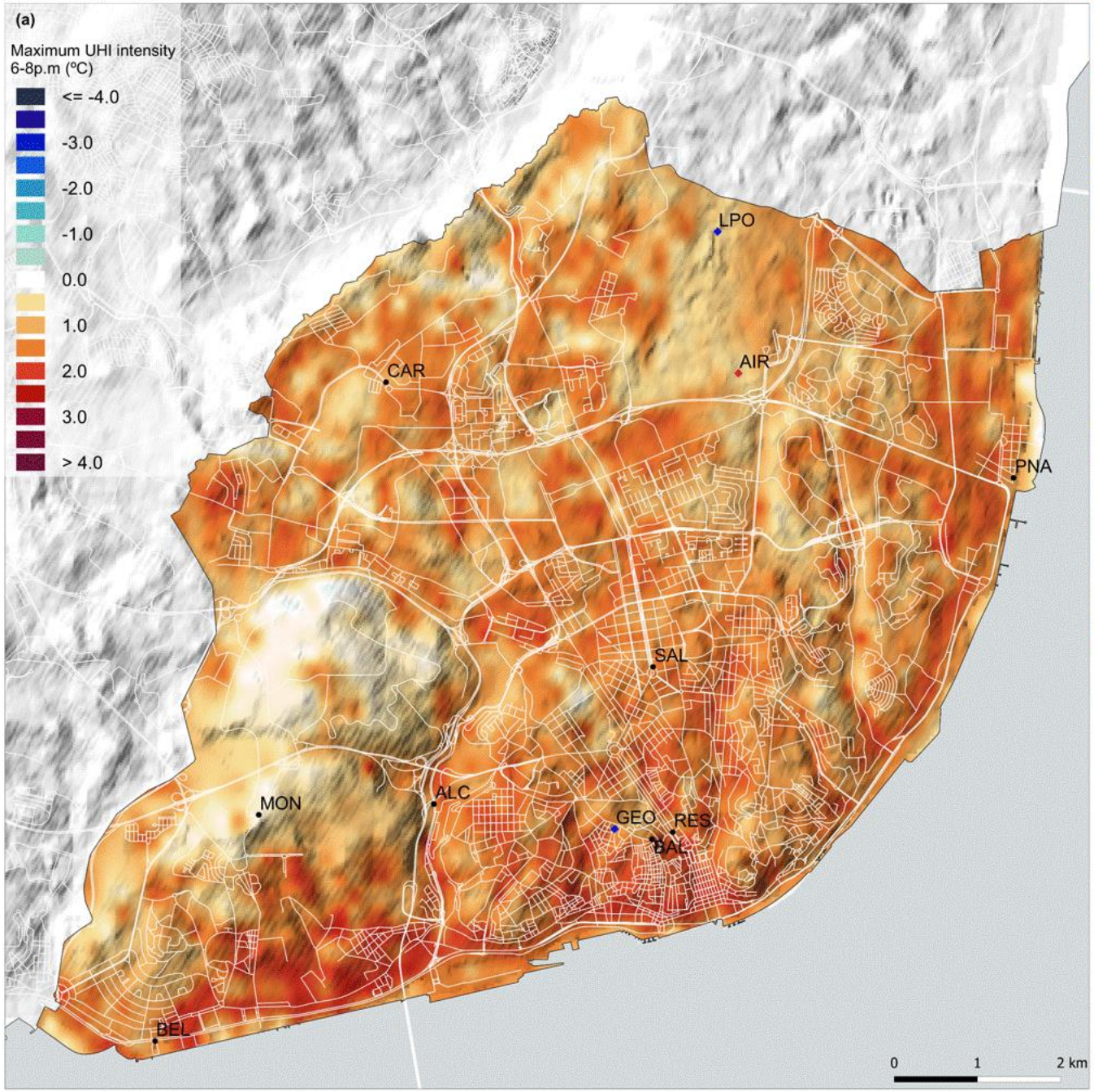



Example in Lisbon, during a heatwave day 17th of July 2020, at 6p.m.
34°C
HIGHER DENSITY AND CONTINENTAL INFLUENCE
29°C
TREE COVERED PARK
33°C
HIGHER DENSITY AND LESS GREEN AREAS
28°C
LOWER DENSITY AND OCEANIC BREEZE
T2m (°C)
<= 24
31
>=38
0 500 1 000 m

UTS daily cyle, Stage 5: Late Afternoon Peak UHI intensity
(from 6 to 8p.m.)



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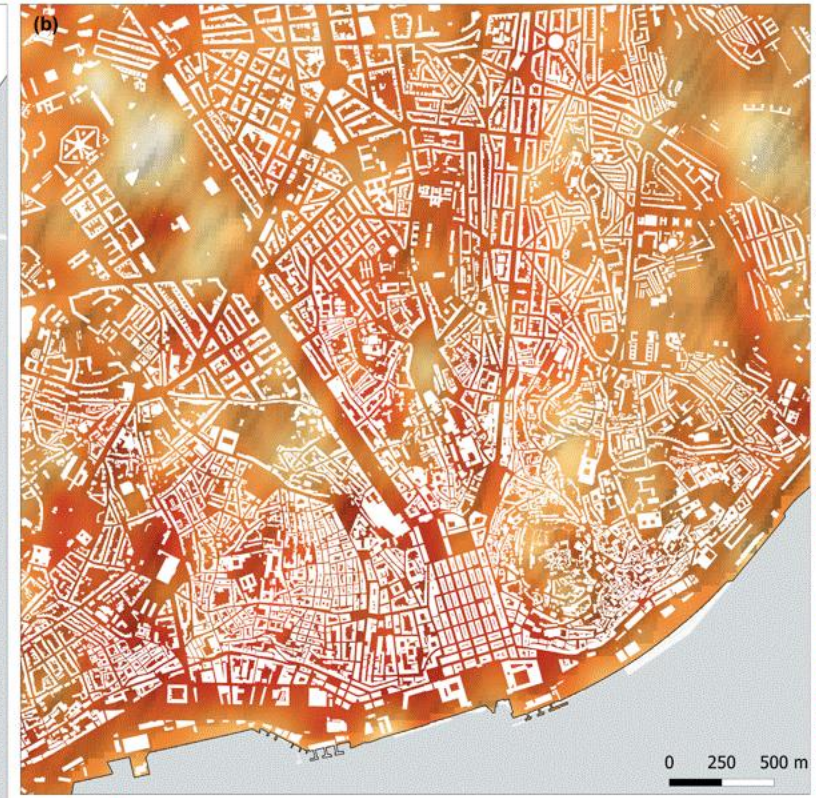
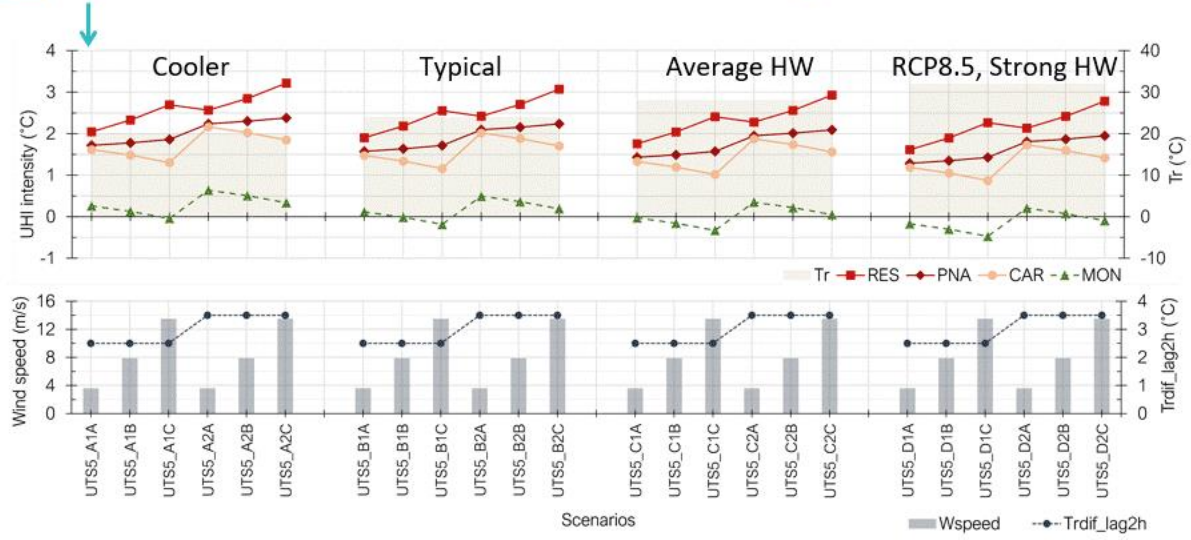


Scenarios: Late Afternoon Peak UHI intensity, per regional weather model inputs

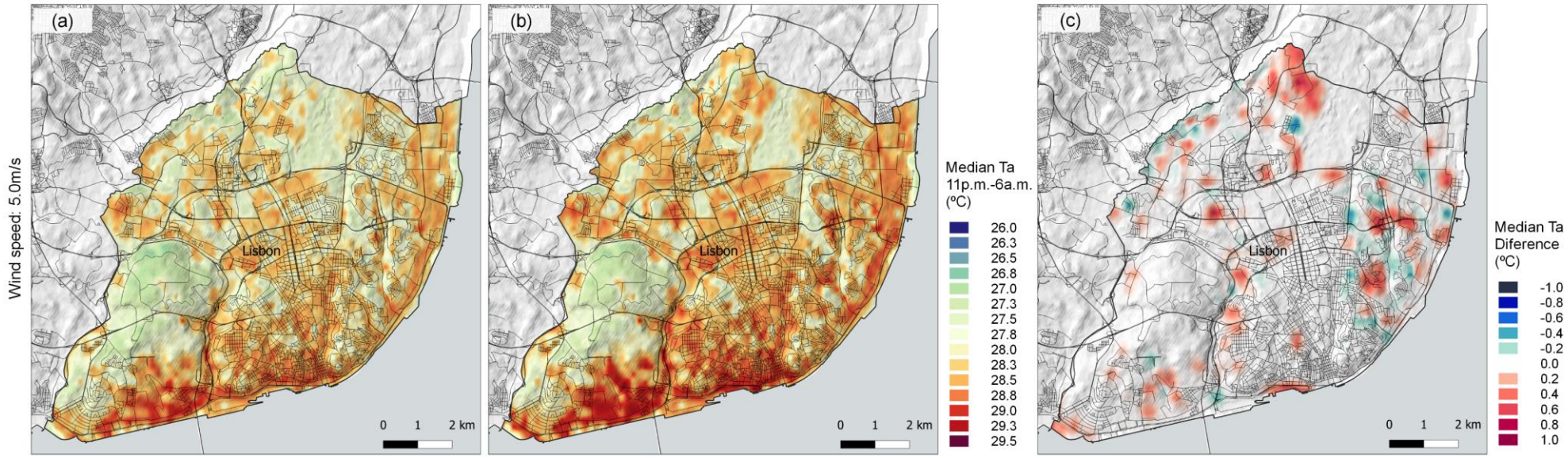


UTS daily cyle, Stage 1: Nocturnal Stable UHI intensity - Scenarios
(from 11p.m. to 6a.m.)

RCP8.5, 1981-2100, Current Urban Development Scenario
(Tr: 28ºC, Trdif_lag2h: 1.2ºC)

RCP8.5, 1981-2100, Urban Densification Scenario
(Tr: 28ºC, Trdif_lag2h: 1.2ºC)

RCP8.5, 1981-2100, Ta Diference between Current Urban Development and Densification Scenario



UTS daily cyle, Stage 5: Late Afternoon Peak UHI intensity
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RCP8.5, 1981-2100, Current Urban Development Scenario
(Tr: 32ºC, Trdif_lag2h: 3.5ºC)

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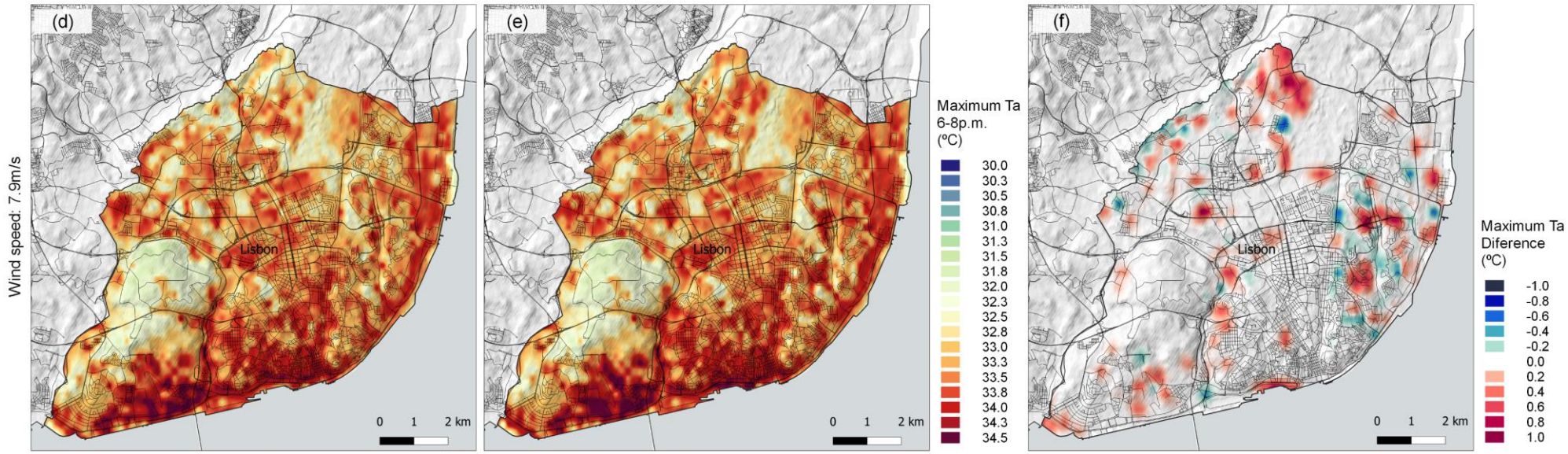

+ Coast.SENSE

Towards an integrated coastal intelligence solution

Going Forward

- Assessing Ecosystems Services and Health
  - Habitats' vulnerability to extreme heat and wildfires
  - Vegetation as an urban acclimatization tool
- Evaluate the role of the Atlantic proximity
  - Land and sea breezes
  - Atmosphere and ocean interactions
- Investigate Climate Change Trends and Scenarios
  - Historical changes in the atmospheric, coastal and biological domains
  - Scenarios of climate changed induced impacts

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- Sedimentation

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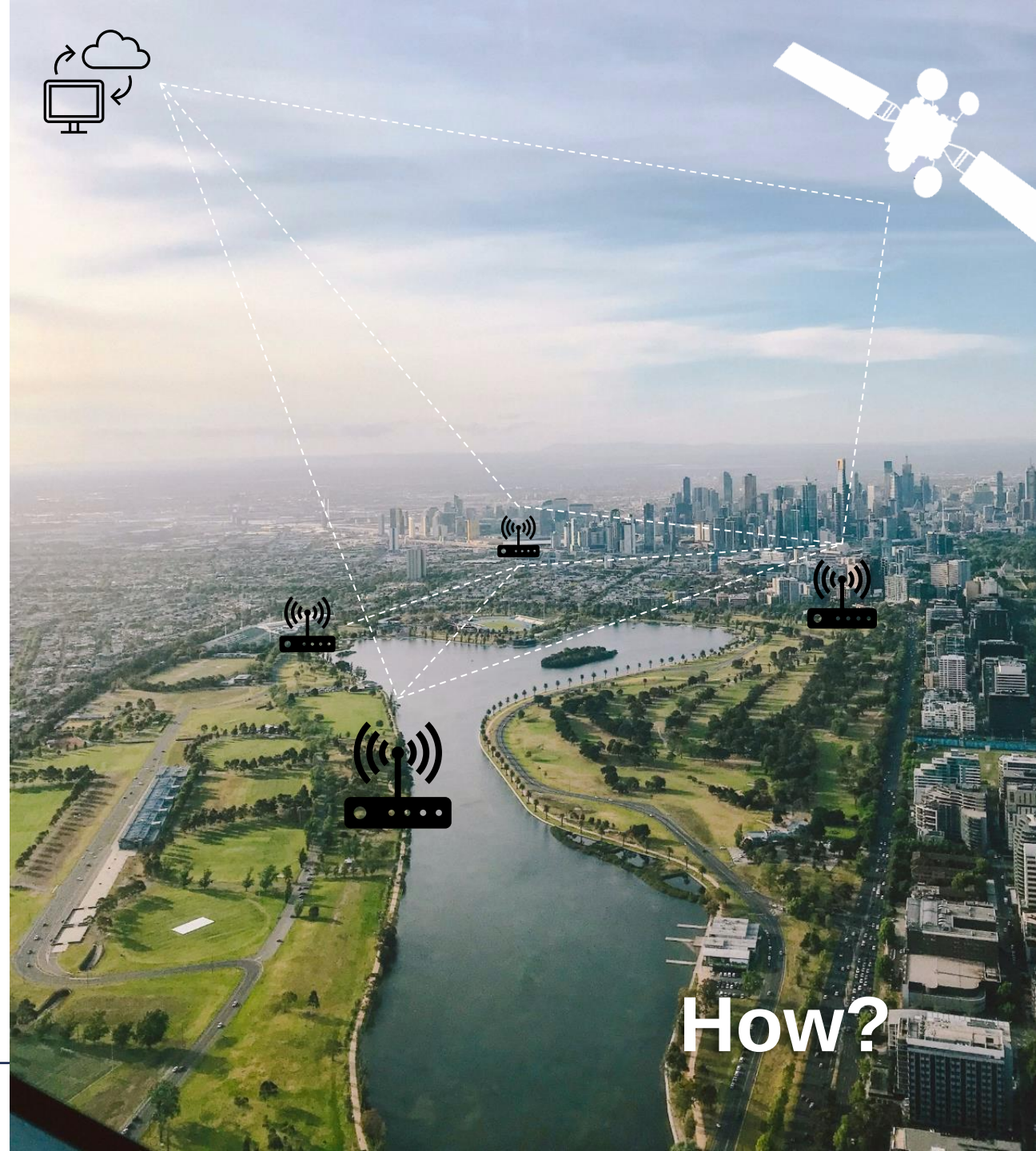

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