

PHYSIOGRAPHY SENSITIVITY TESTING OVER IRELAND

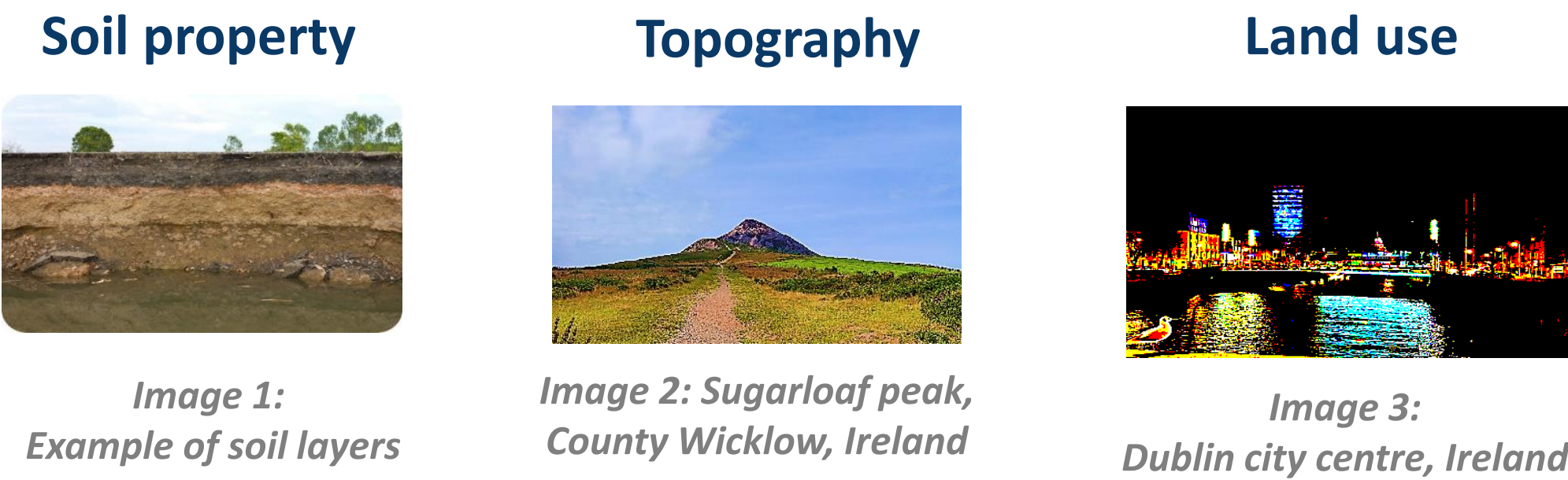
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1. Introduction: Background and Motivation

a. What is physiography?

- No clear definition:** Another name for geomorphology, physical geography (Collins Dictionary)
- My definition:** Any natural or anthropogenic feature affecting the Earth's surface



b. Numerical weather prediction model at Met Éireann

- Met Éireann currently runs the HARMONIE-AROME configuration of the shared ALADIN-HIRLAM NWP system
- Operational configuration cycle 40h1 (cycle 43 used for testing)
- 1000 × 900 grid points
- 2.5 km horizontal resolution
- 65 vertical layers
- Surface modelling: SURFEX
- SURFEX requires accurate topographic, land use and soil property maps as input

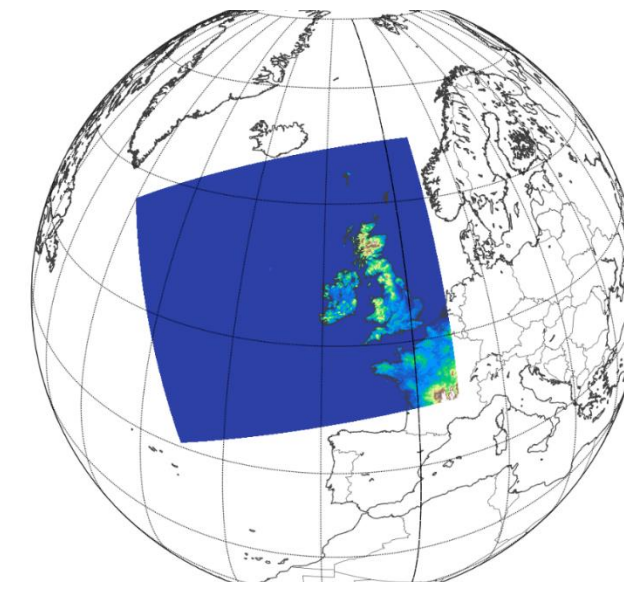


Figure 1: Irish HARMONIE-AROME operational domain [1]

c. Why perform sensitivity tests over Ireland?

- Some HARMONIE-AROME performance issues are attributed to surface processes and physiography issues [2].
- The use of an improved physiography database over Ireland improved significantly their wind forecast [3].
- A first case study using different land cover and soil maps (including SOILGRID-blend) presented during EMS 2019 showed encouraging results [4].

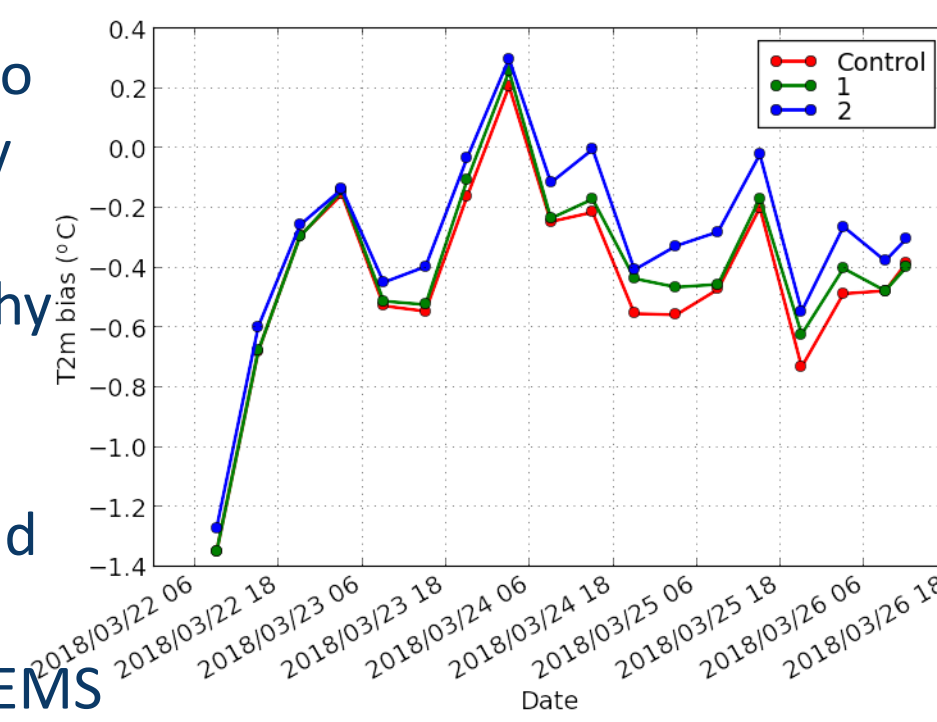


Figure 2: 2 m temperature (T2m) bias timeline for 28 stations over Ireland from [4]

2. Methods

a. HARMONIE-AROME experimental set-up

- HARMONIE-AROME cycle 43 is used in each experiment
- Same topography
- The experiment uses different land use and soil property data (see table)
- Run over the month of June 2018

Experiment	Soil property	Land use
REF	FAO	ECOCLIMAP v2.5
1	SOILGRIDS	ECOCLIMAP v2.5
2	SOILGRIDS-BLEND	ECOCLIMAP v2.5
3	SOILGRIDS	ECOCLIMAP-SG [5]

Table 1: Table describing land use and soil property datasets used for each experiment
SOILGRIDS-Blend= SOILGRIDS blended with a local dataset [4]

b. June 2018 drought

- June 2018 2-3°C warmer than the 1981-2010 average
- About 50 mm less precipitation than 1981-2010 average
- Soil moisture deficit about two times larger than the 1981-2010 average (not shown)

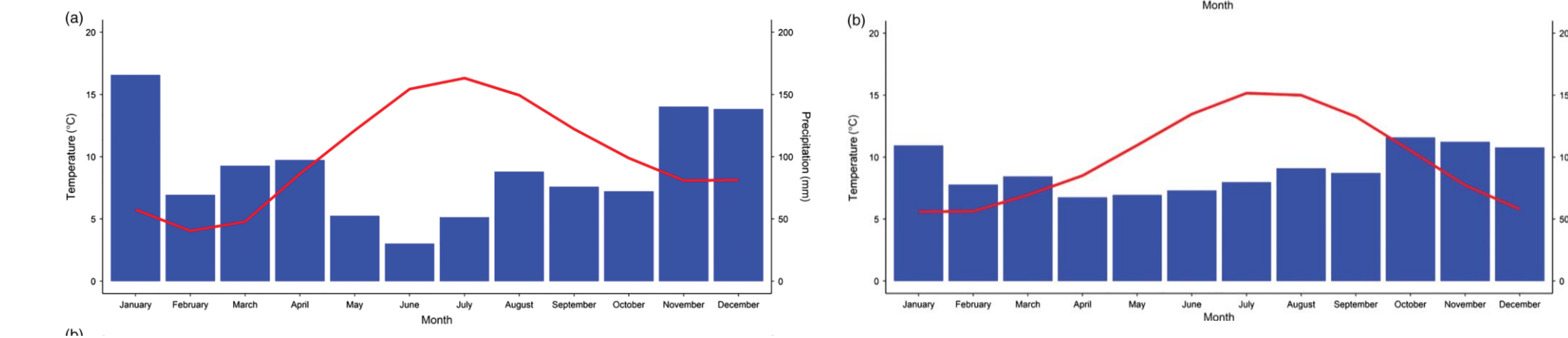


Figure 3: Thermo-pluviometric diagram for Ireland for (a) 2018 and (b) the reference period 1981-2010. The blue bars represent the monthly amount of precipitation, and the red line shows the average monthly trend from [6]

3. Soil Maps Comparison

a. Sand fraction

- FAO data are coarse and differ a lot from SOILGRIDS and SOILGRIDS-BLEND
- FAO has the largest sand fraction in counties Kerry, Galway and Donegal
- The local dataset is really similar to SOILGRIDS therefore SOILGRIDS should be used instead of FAO.

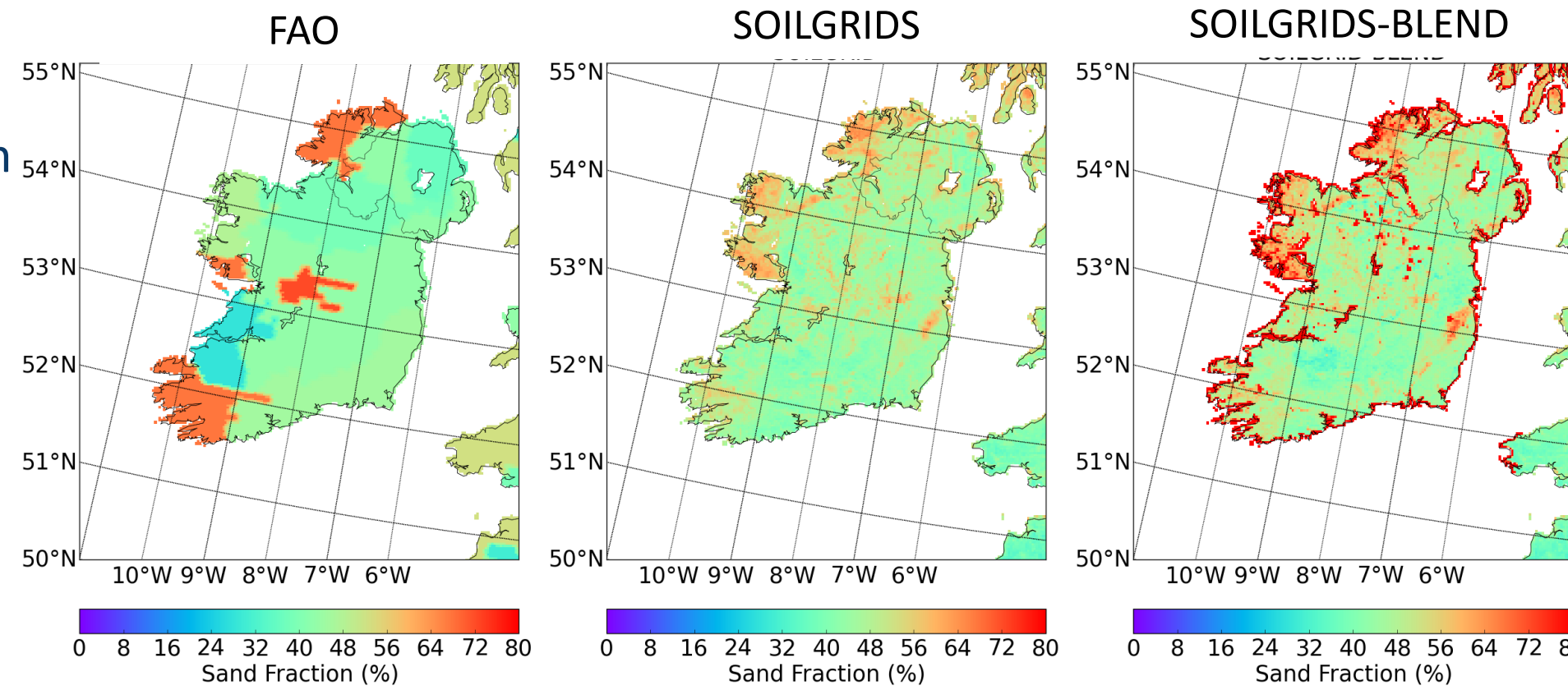


Figure 4: Sand fraction over Ireland for FAO (left), SOILGRIDS (middle) and SOILGRIDS-BLEND (right)

b. Soil moisture compared to the soil state for evapotranspiration

- On Figure 5 & 8 browns represent the soil moisture residue when Soil Moisture (SM) < Wilting Point (WP), yellows represent the evaporation efficiency when WP < SM < Field Capacity (FC), blues represent the field capacity excess when FC < SM < saturation. [7]
- For REF, EXP1, EXP2, the green yellow indicated WP < SM < Field Capacity, thus changing soil map does not have great impact on the SM for the evapotranspiration process.

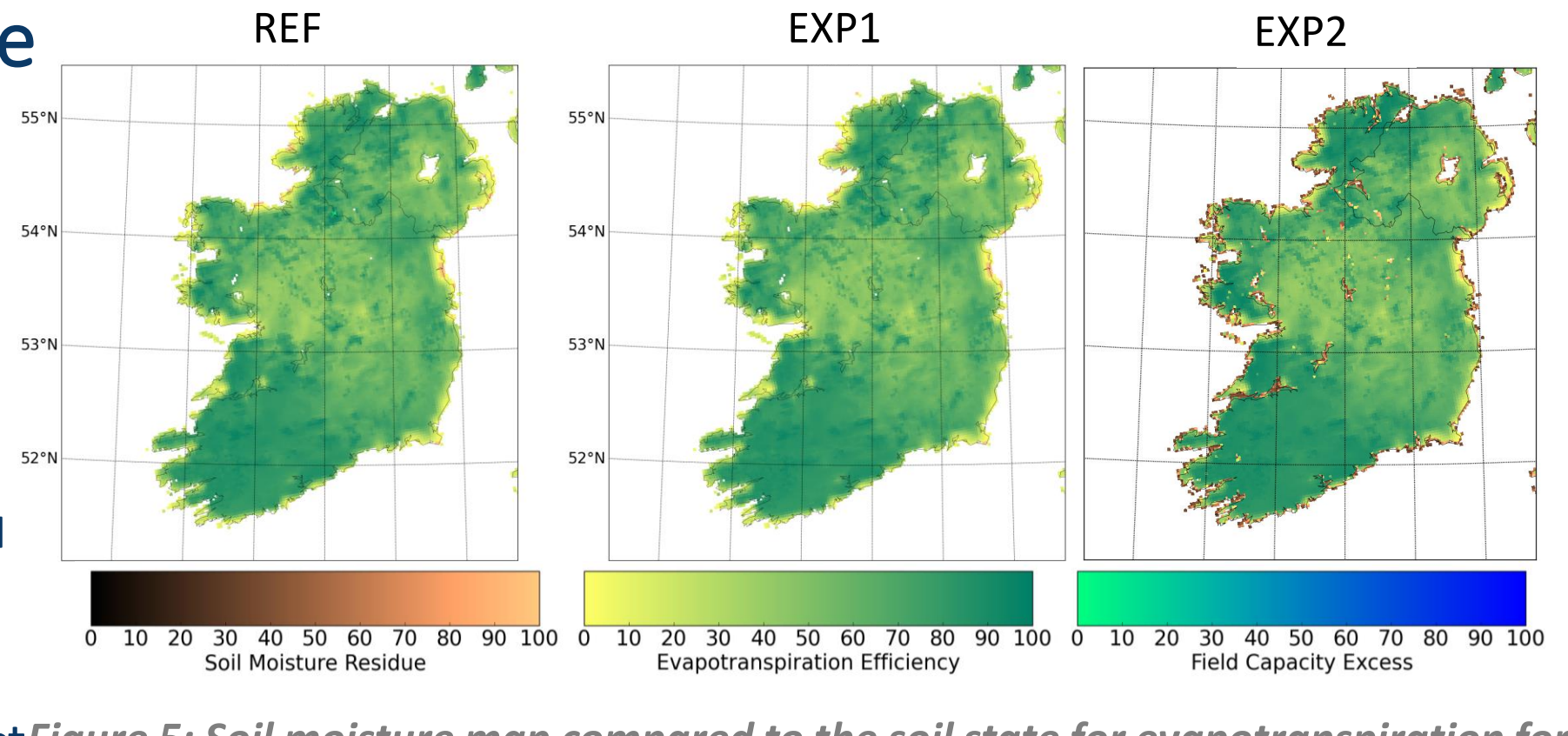


Figure 5: Soil moisture map compared to the soil state for evapotranspiration for REF (left), EXP1 (middle) and EXP2 (right). [7]

4. Land-Use Maps Comparison

a. Characteristics

- A direct comparison is impossible as there has been considerable change in cover types definition.
- ECOCLIMAP-SG shows the growing extent of Ireland's cities with corresponding reductions in the green/nature regions.
- ECOCLIMAP-SG identifies more water bodies and has an improved land-sea mask.

Land-use	ECOCLIMAP v2.5	ECOCLIMAP -SG
Resolution	1 km	300 m
Number of Cover	573	33
LAI	MODIS and SPOT-VGT 1999-2005	SPOT-VGT 1999-2016 downscaled [5]

Table 2: Table land-use map characteristics

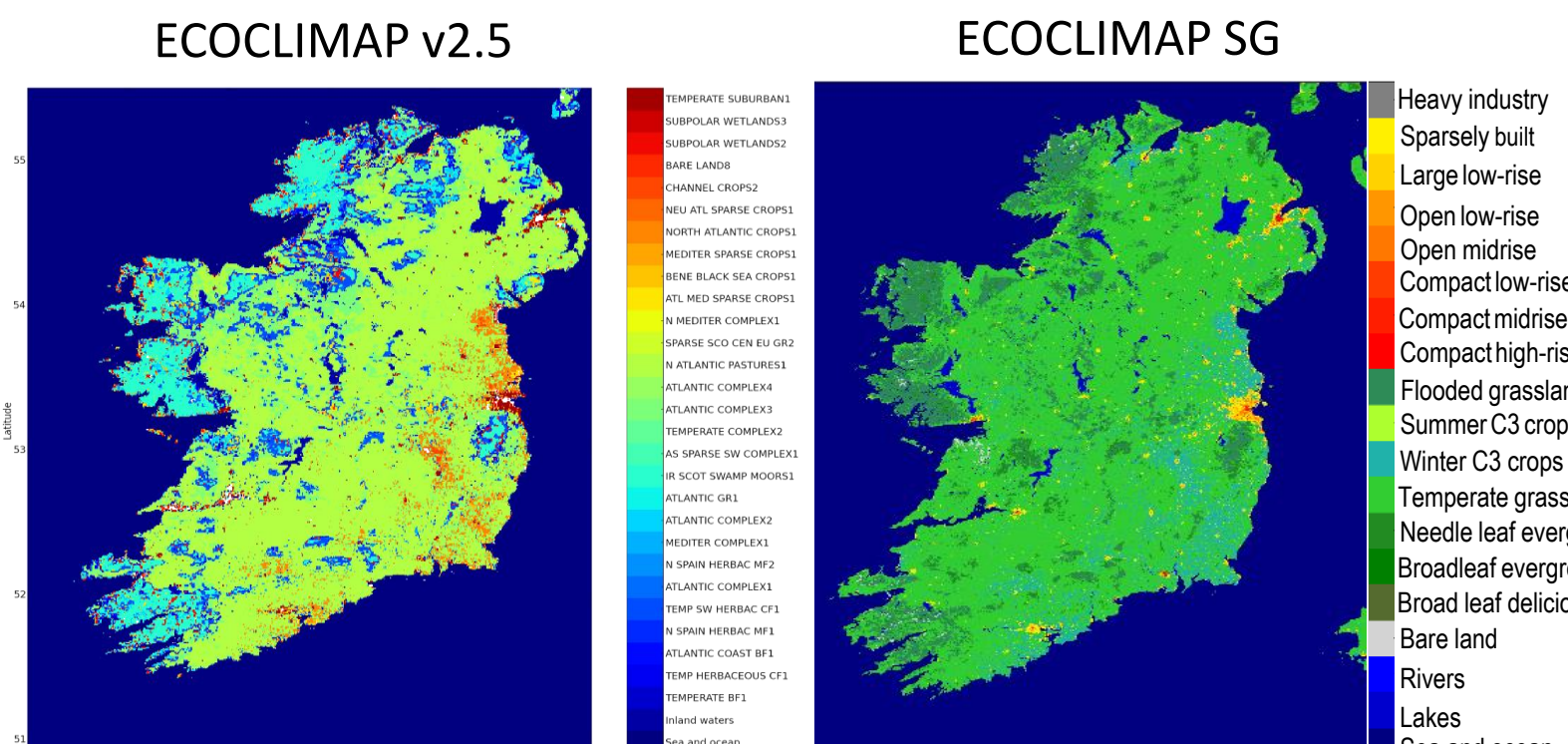


Figure 6: Land-use map of Ireland ECOCLIMAP v2.5 (left) ECOCLIMAP-SG (right)

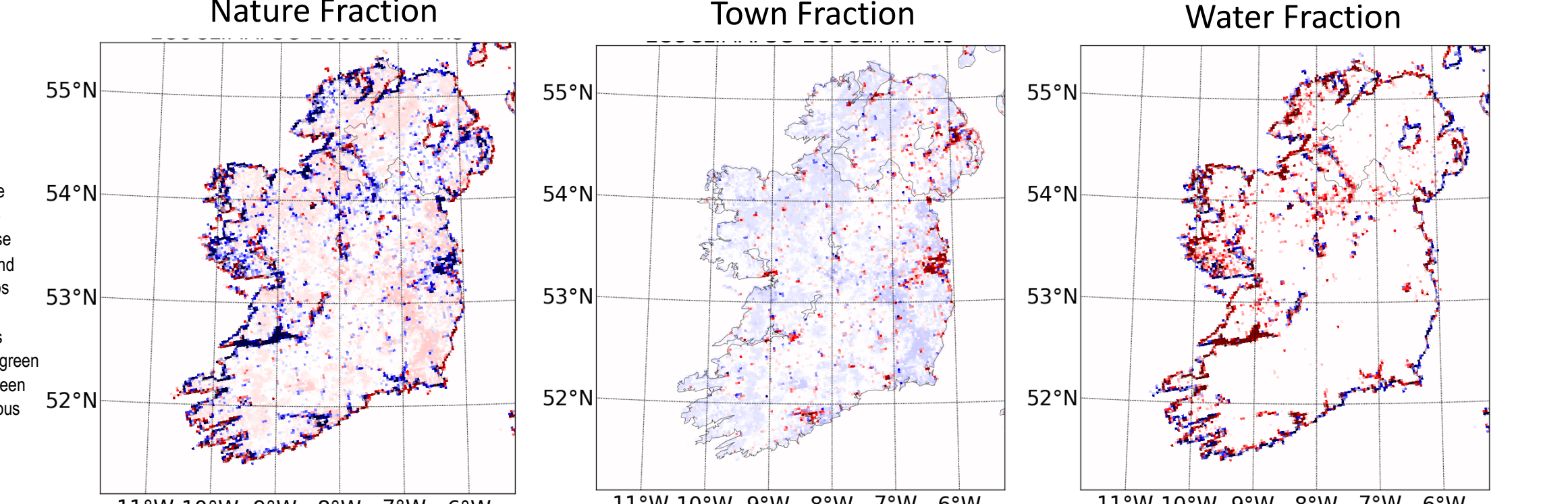


Figure 7: Cover fraction difference ECOCLIMAP-SG - ECOCLIMAP v2.5 for nature (left), town (middle), and Water (right)

b. Soil moisture compared to the soil state for evapotranspiration

- ECOCLIMAP-SG results in mostly higher humidity, leading to a field capacity excess as shown by the blue area on figure 8.

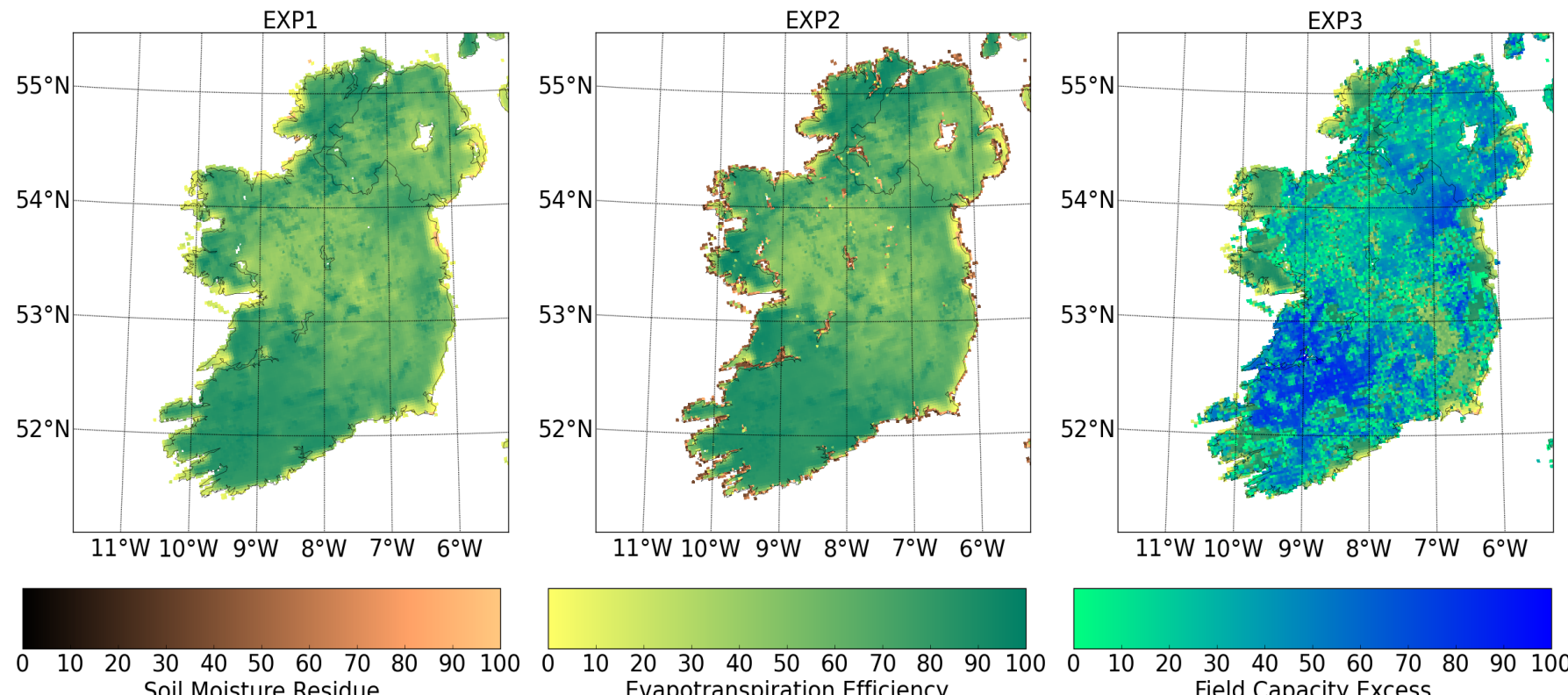


Figure 8: Same as figure 5 with EXP1 (left), EXP2 (middle) and EXP3 (right).

c. Leaf area index June 2018

- In general LAI is smaller in ECOCLIMAP-SG using SPOT-VGT 1999-2016 by up to 20% though there are areas of increase in the southwest, northwest, and east.

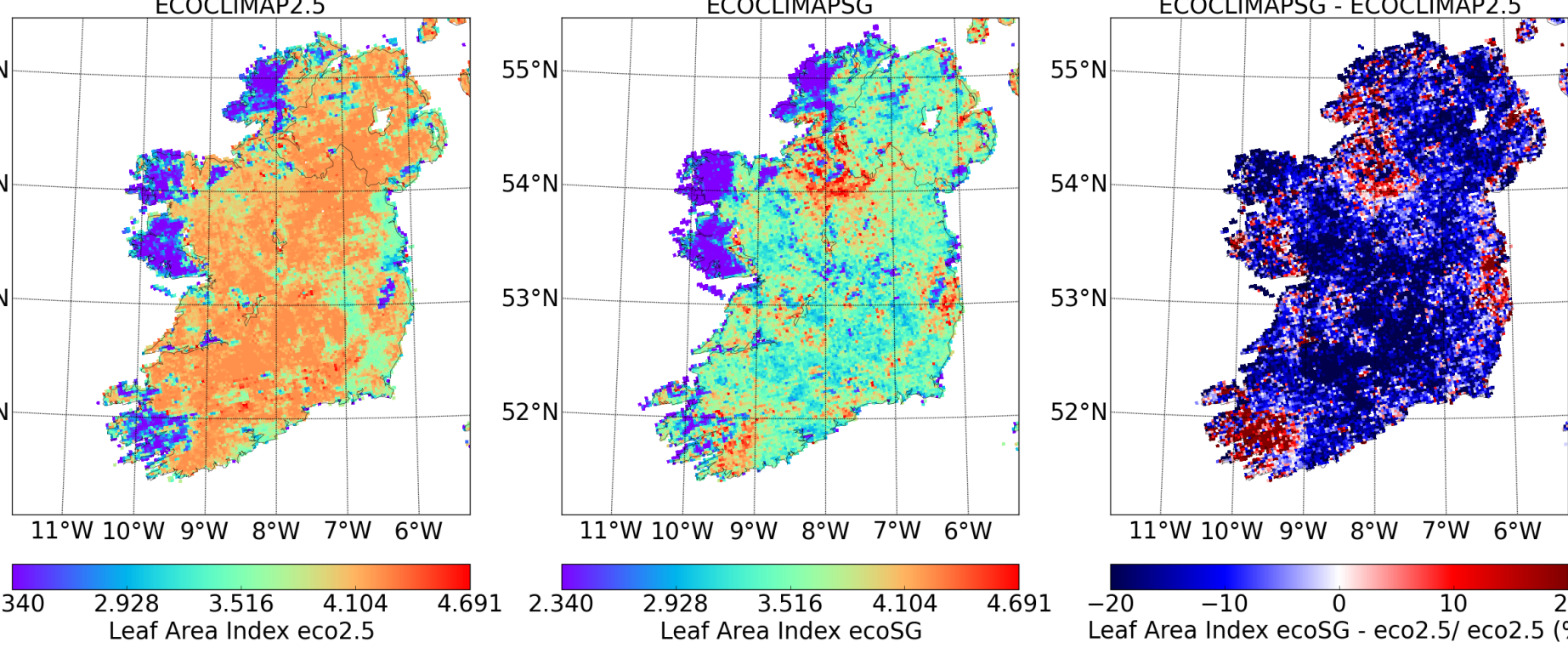


Figure 9: Leaf Area Index map over Ireland for ECOCLIMAPv2.5, ECOCLIMAP-SG and the % difference between ECOCLIMAP-SG and ECOCLIMAPv2.5

d. Leaf area index annual cycle

- Multiyear climatologies are similar
- Year 2018 is significantly different
- Multi-year LAI annual cycle is not appropriate for representing the LAI cycle during a drought.

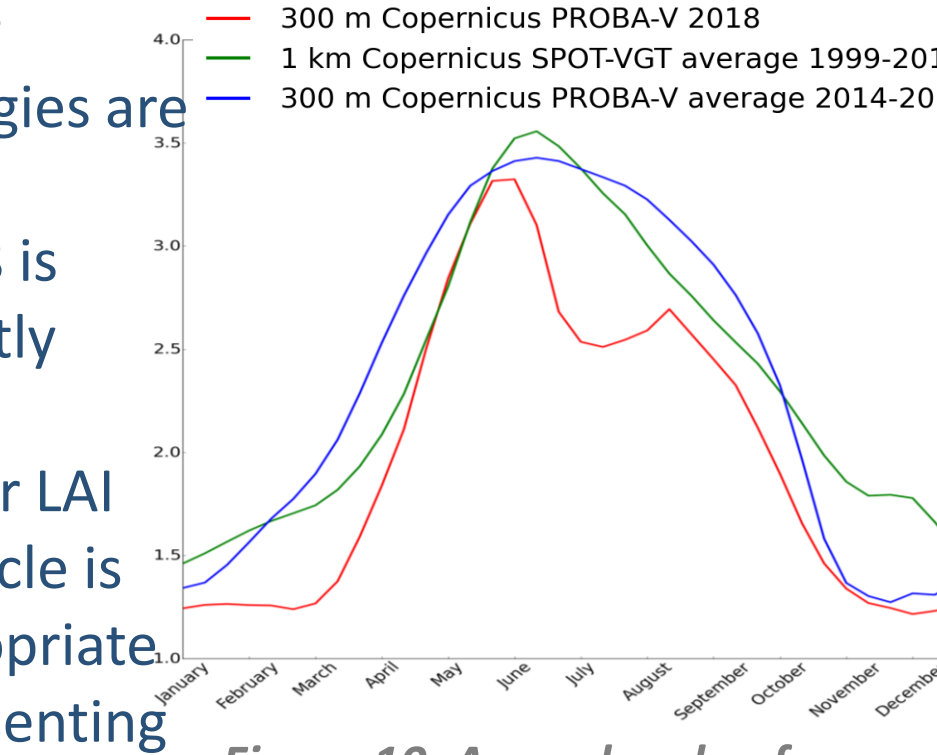


Figure 10: Annual cycle of mean LAI over Ireland

5. June 2018 Forecast Verification Scores

a. 2 m Temperature

- HARMONIE-AROME has a small cold bias of around 0.2°C for June 2018
- This cold bias is of around 0.5 for other periods (not shown)

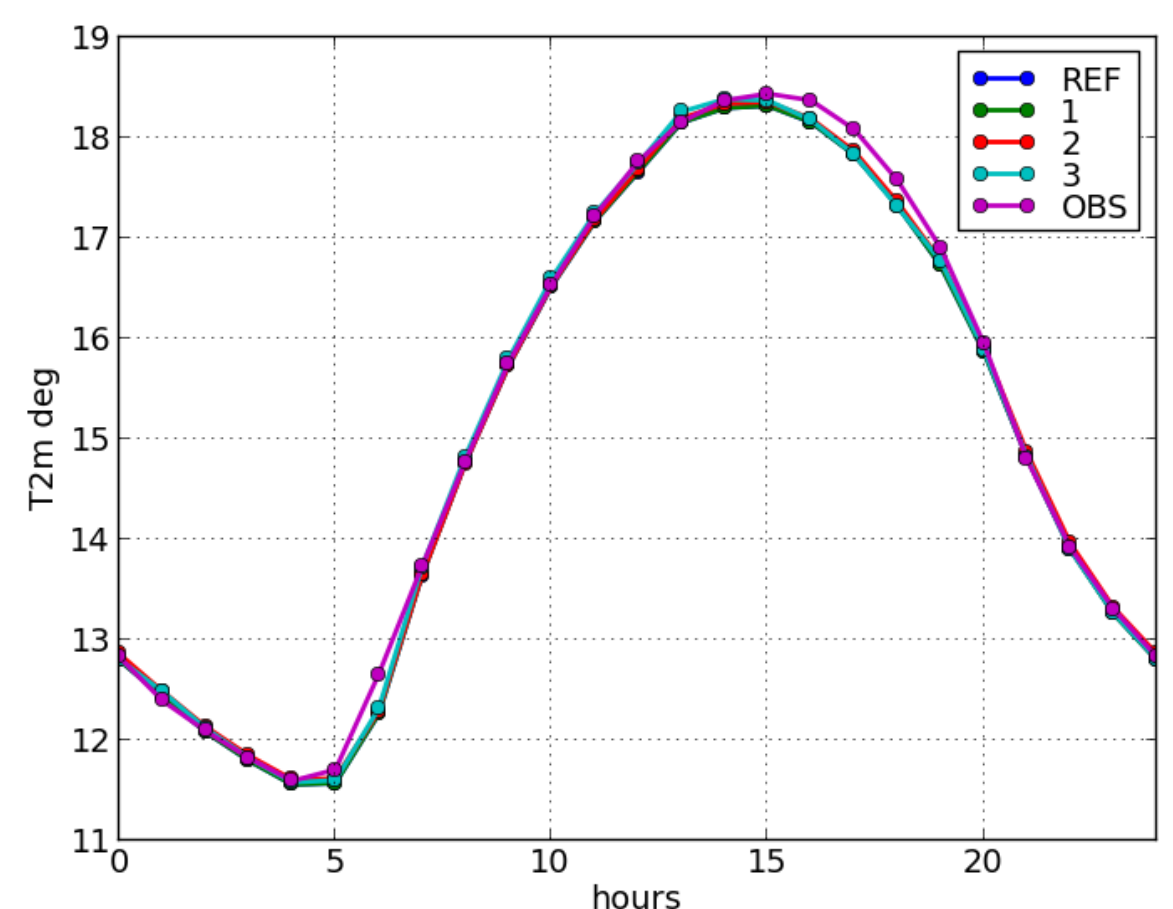


Figure 11: Mean diurnal cycle in T2m for 28 stations over Ireland REF (blue), EXP1 (green), EXP2 (red), EXP3 (cyan), observations (purple)

b. 2 m Relative humidity

- HARMONIE-AROME has a diurnal cycle in the biases too dry at night, too moist by day and slightly worse in the case of ECOCLIMAP-SG

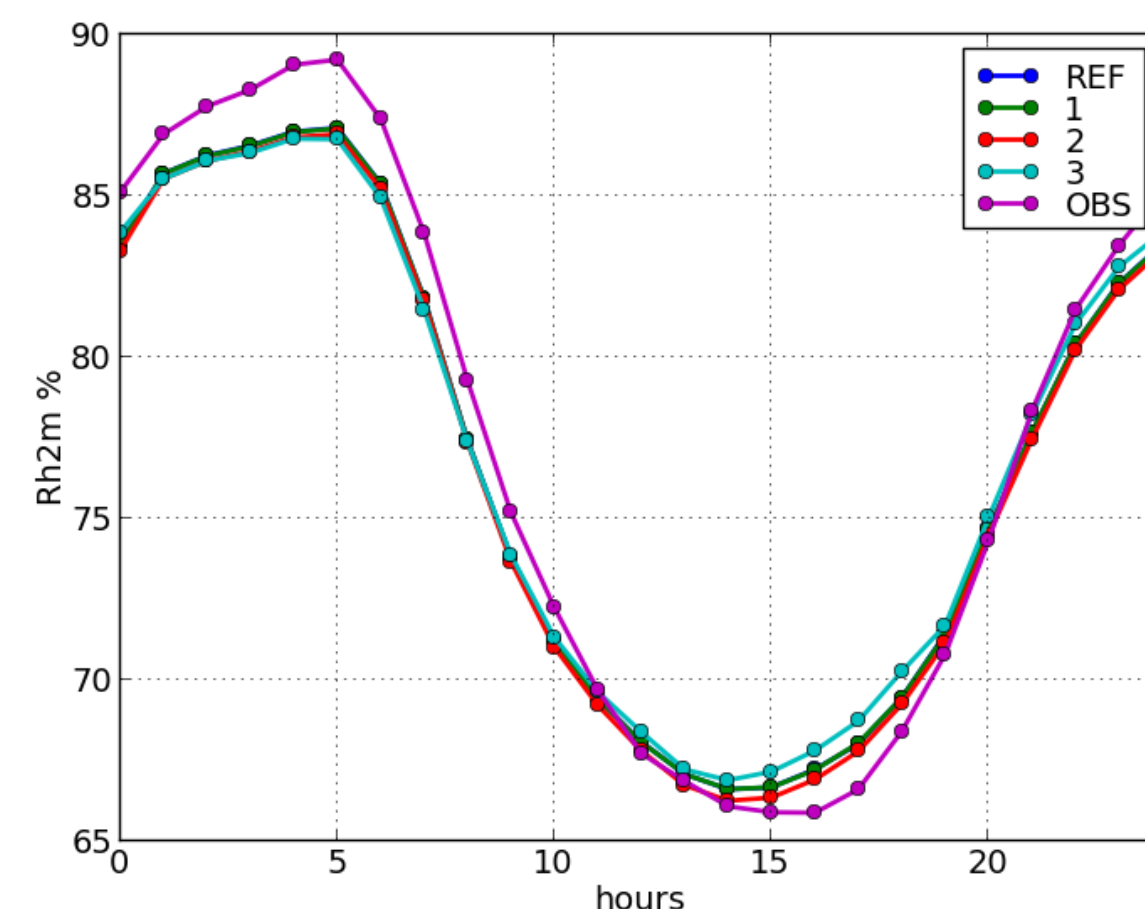


Figure 12: Mean diurnal cycle of 2 m relative humidity for 28 stations over Ireland REF (blue), EXP1 (green), EXP2 (red), EXP3 (cyan), observations (purple)

c. 10 m Horizontal wind

- HARMONIE-AROME winds are too strong, particularly where ECOCLIMAP-SG is used.
- Further testing by Gleeson et al. (2020) using gas changes have shown an improvement in the wind forecast (not shown)

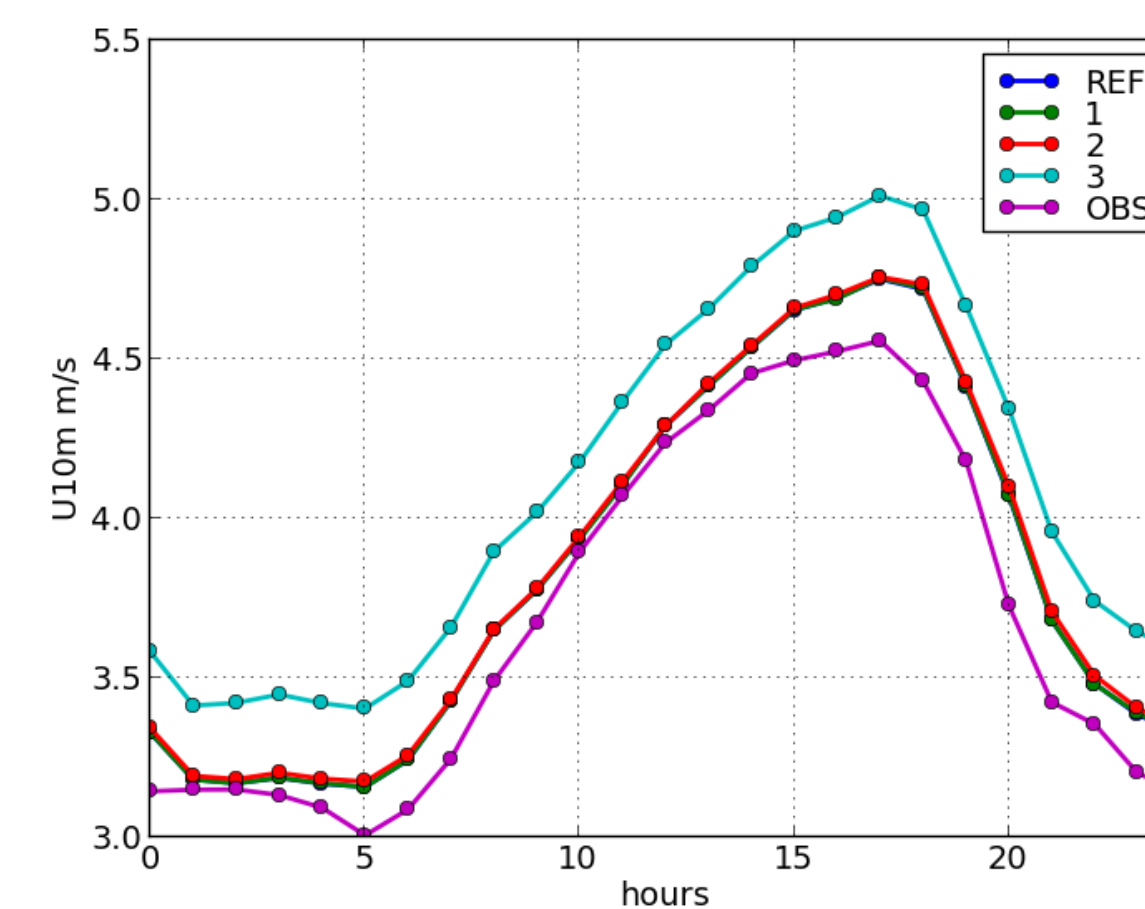


Figure 13: Mean diurnal cycle of 10 m horizontal wind for 28 stations over Ireland REF (blue), EXP1 (green), EXP2 (red), EXP3 (cyan), observations (purple)

6. Conclusions, Implications and Outlook:

a. Conclusions

- SOILGRID and SOILGRID-Blend are similar and significantly different to the lower resolution FAO. Therefore SOILGRID can be considered of better quality.
- SOILGRID-Blend provides additional local information and should be used in validation runs
- Water, urban and nature fractions in the ECOCLIMAP-SG land cover dataset are much more realistic than in ECOCLIMAP2.5plus.
- The LAI climatologies used in HARMONIE-AROME are not sufficient for years that vary greatly from normal.

b. Outlook:

- Analysis of the Lucas Topsoil are currently underway [8]
- Investigation into the production of a new land-use map using AI are currently underway (Eoin Walsh, University of Limerick)
- Offline experiments to investigate the influence of LAI
- Test of the orographic friction scheme OROTUR

5. References:

[1] Operational NWP In Met Éireann
[2] Bengtsson, L., et al. (2017).
[3] Petersen, G. N., et al. (2017). Using the best available physiography to improve weather forecasts.
[4] Bessardon G., et al. (2019) Using the best available physiography to improve weather forecasts for Ireland
[5] https://opensource.umr-cnrm.fr/projects/ecoclimap-sg/wiki
[6] Falzoi, S., et al. (2019). Analysis of the severe drought in Ireland in 2018.
[7] https://www.ecmwf.int/en/forecasts/charts/catalogue/data_w_soil_moisture
[8] LUCAS (Land Use/Cover Area frame statistical Survey) http://esdac.jrc.ec.europa.eu/content/lucas-2009-topsoil-