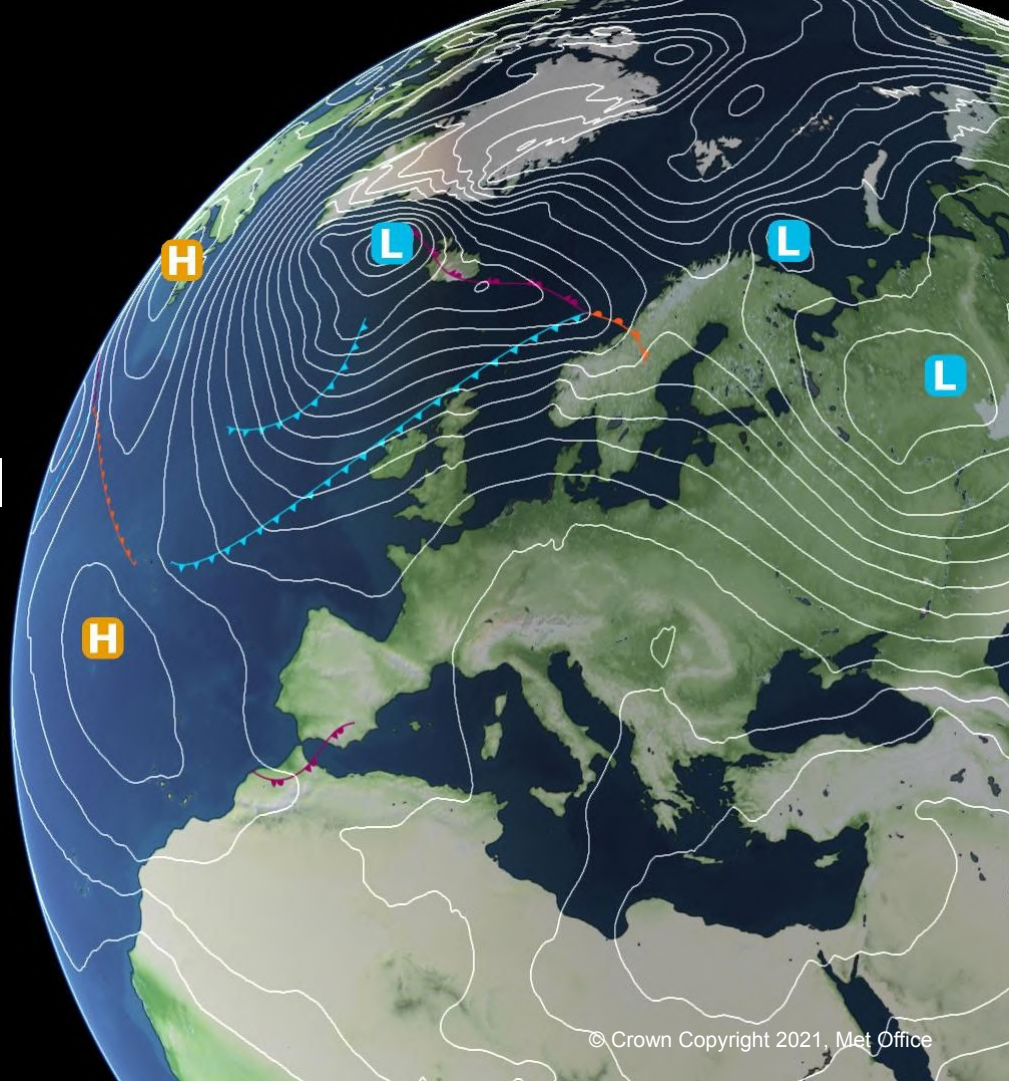
SOFOG3D – UK Met Office update on deterministic model comparison with observations

Jenna Thornton, Paul Field, Jeremy Price, Anne McCabe, Steve Derbyshire, Adrian Lock, Bernie Claxton

7th June 2022



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Outline

(1) Overview of model setup and methodology

(2) Categorized list of case studies

- focusing in this presentation mainly on radiation fog cases
- but we do also have stratus fog cases and null cases

(3) Sensitivity tests

- Output from different model configurations
- Effect of changing setup parameters

(4) VERA output – a different visibility scheme

(5) Conclusions and Further work

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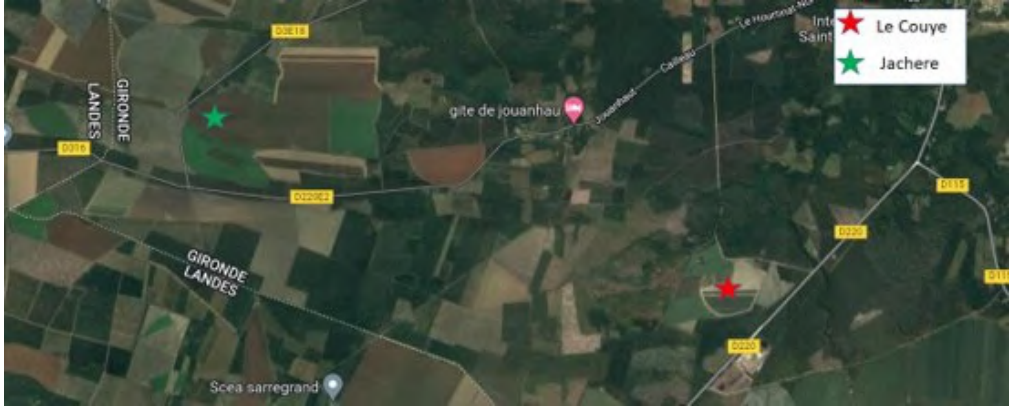
Methodology
comparisons and tests



- We use measurements primarily from **Le Couye**
  - Plus some comparisons with the nearby (slightly more open) **Jachere** site
- We categorize periods as: radiation fog/no fog/stratus fog
- We evaluate the standard model against these measurements for visibility and other relevant parameters
- We test sensitivity to various existing model options, including cloud, aerosol and surface options
- We also compare with a new stochastic diagnostic visibility scheme (VERA)

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- UM deterministic model ran initially @ 100m, 300m, and 1.5km resolutions
- Previous presentation discussed these runs UKMO model vs obs 20210330
- **Only results from 1.5km horizontal resolution shown in this presentation**

- Vertical grid: standard 70 model levels
  - Level 1 corresponds to 5m
  - Additional diagnostic outputs at 1.5m: visibility, temperature, RH

- Run (for selected dates) from 1200UTC on day x until 2300UTC on x+1

Overview of model setup

Categorization of different types of events

Observed stratus fog events

- 5th to 6th January 2020
- 8th to 9th February 2020
- 7th to 8th March 2020

Null case (no observed fog)

- 11th to 12th January 2020

Observed radiation fog events

- 28th to 29th October 2019
- 29th to 30th October 2019
- 31st October to 1st November 2019
- 5th to 6th December 2019
- 4th to 5th January 2020
- 8th to 9th January 2020

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Sensitivity test one – using different model configurations

1. Current operational configuration
2. Same as 1 but using a **bimodal-cloud scheme**
3. Same as 2 but using a **double-moment microphysics scheme (CASIM)**
4. Same as 3 but changing the **aerosol climatology (aerosol more interactive)**

Links to further info given on final slide

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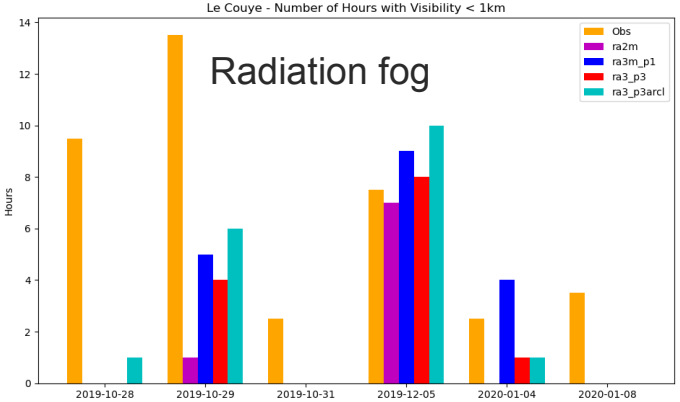
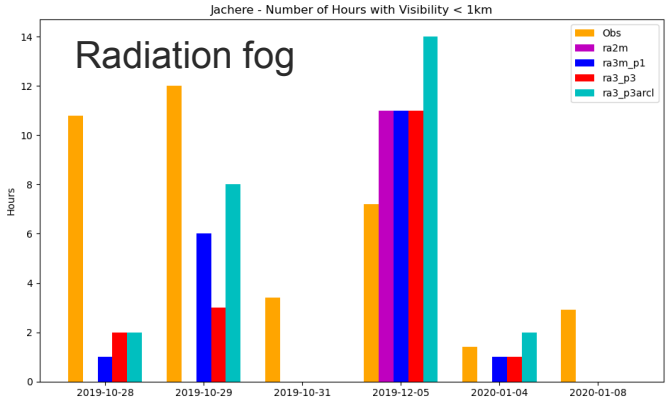
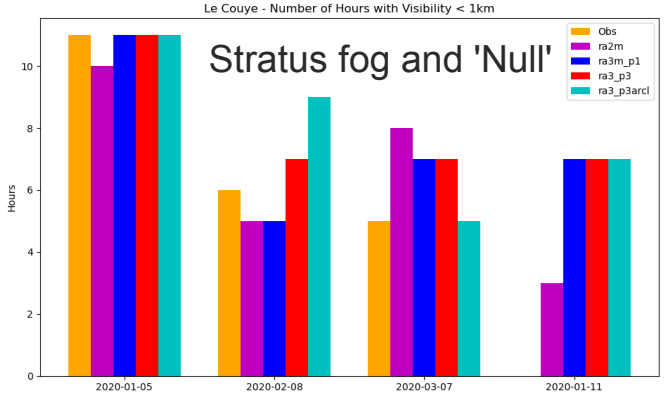
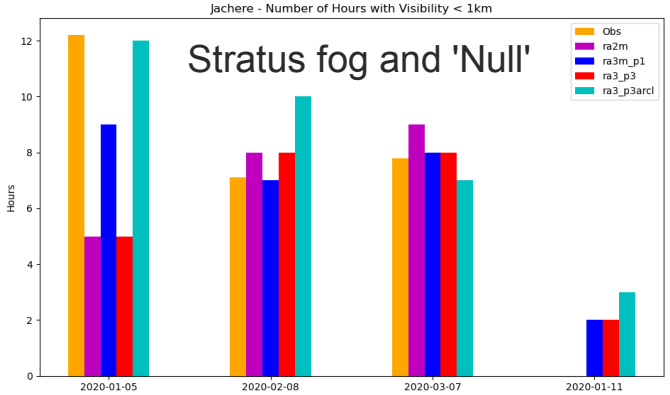
Operational
With bi-modal cloud scheme
With CASIM microphysics & bi-modal cloud scheme
With CASIM microphysics & bi-modal cloud scheme & aerosol climatology







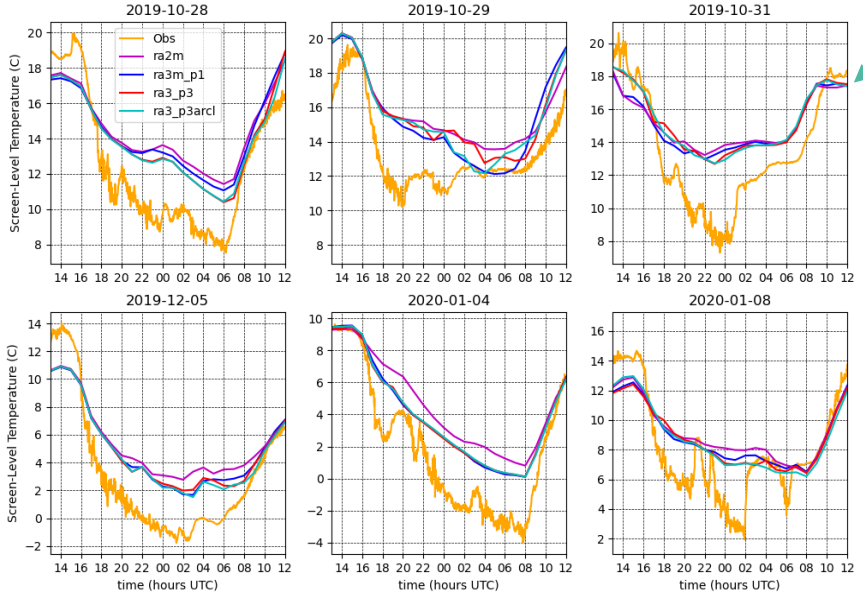


- More fog when bi-modal cloud scheme and CASIM are used
- Stratus fog better predicted than radiation fog
- Fog formed during 'null' case

Output from different model configurations

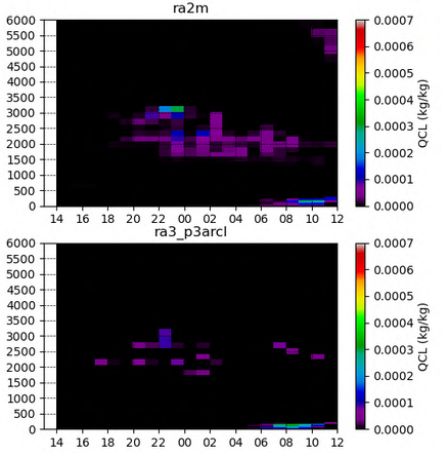
Radiation fog

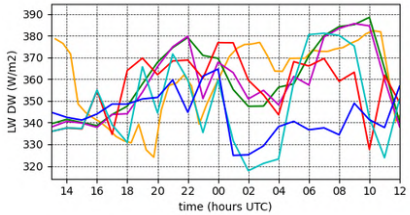
Le Couye



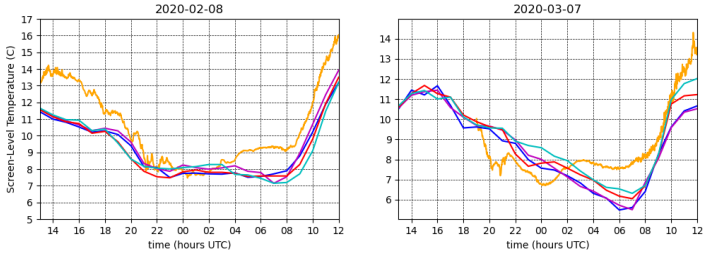
Screen-level temperatures drop lower when CASIM and bi-modal cloud schemes are used, probably due to **less cloud**.

2019-10-29





Stratus fog



Screen temperatures generally too high during radiation fog cases...

.. but not necessarily in Stratus fog

Output from different model configurations

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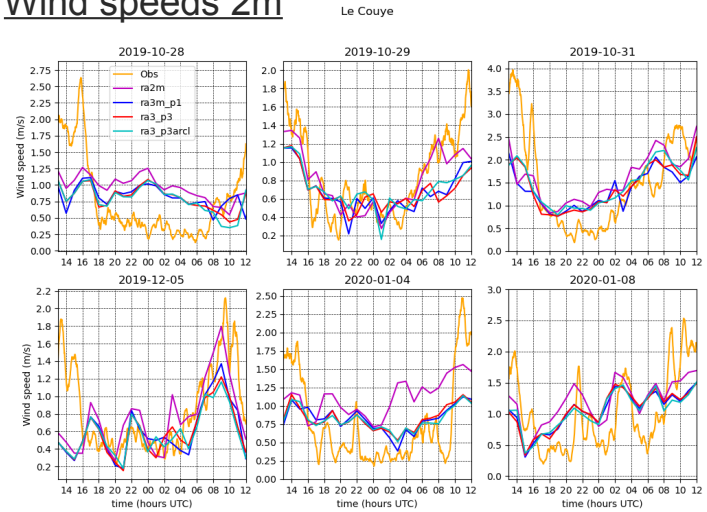
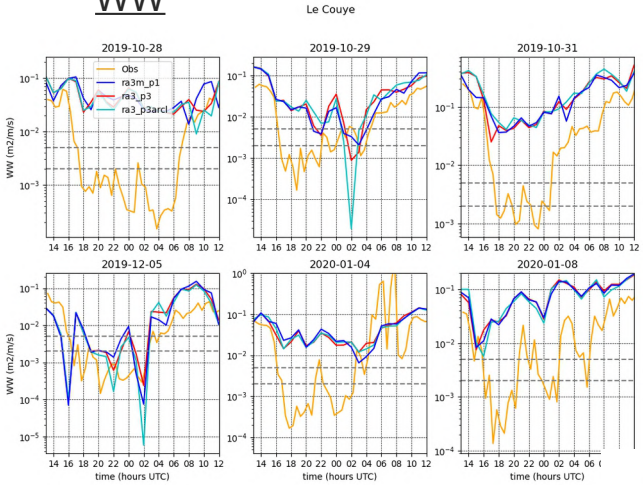
Wind speeds 2m

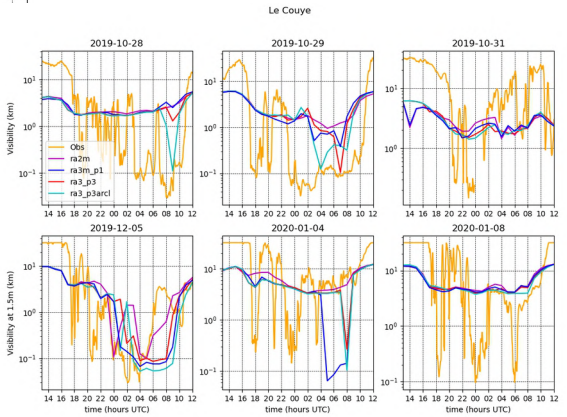


WW



Additionally... wind speed and WW generally too high

Visibility



Model wind speed and WW closest to observations on 2019-10-29 and 2019-12-05 – fog also predicted for these dates

Output from different model configurations

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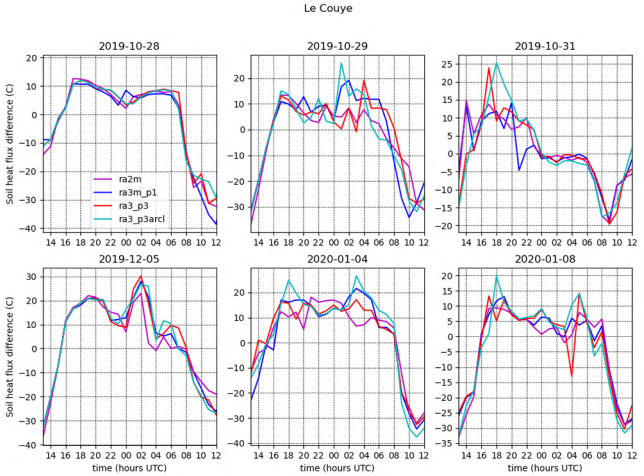
Sensitivity test two – changing set-up parameters

Aim: Reduce skin and near-surface temperatures

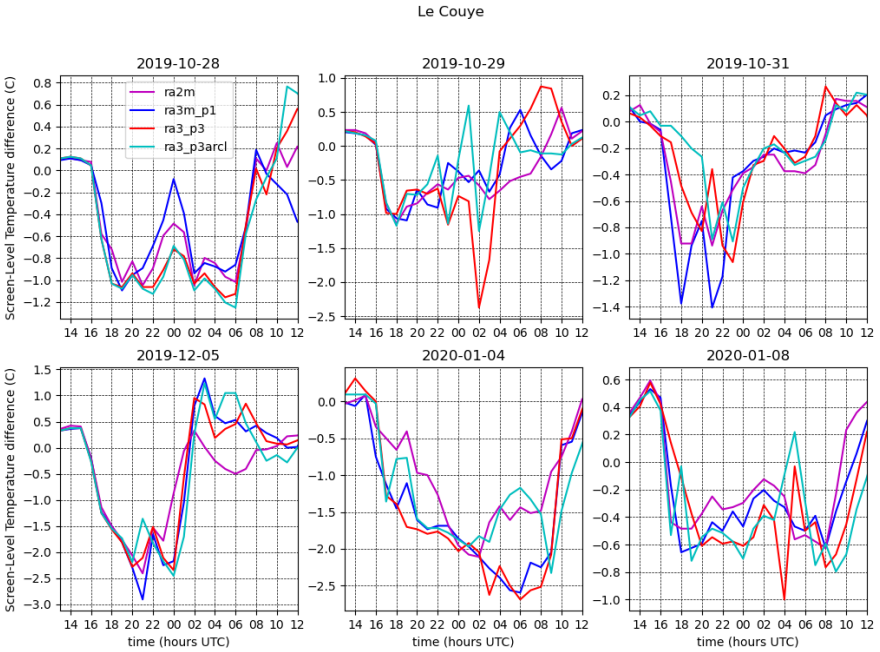
How: Effectively modifying bare soil fraction to limit turbulent exchange between atmosphere and surface

Result of change in set-up – Le Couye

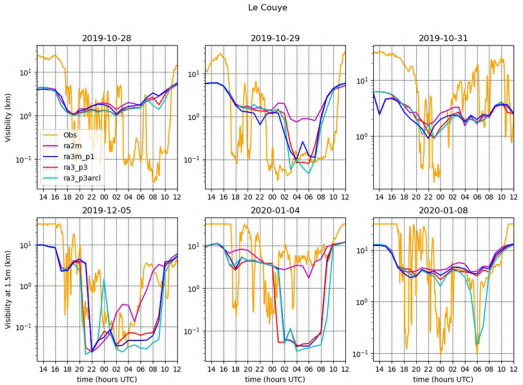
(1) Soil heat flux – less from soil to surface



(2) Temp reductions



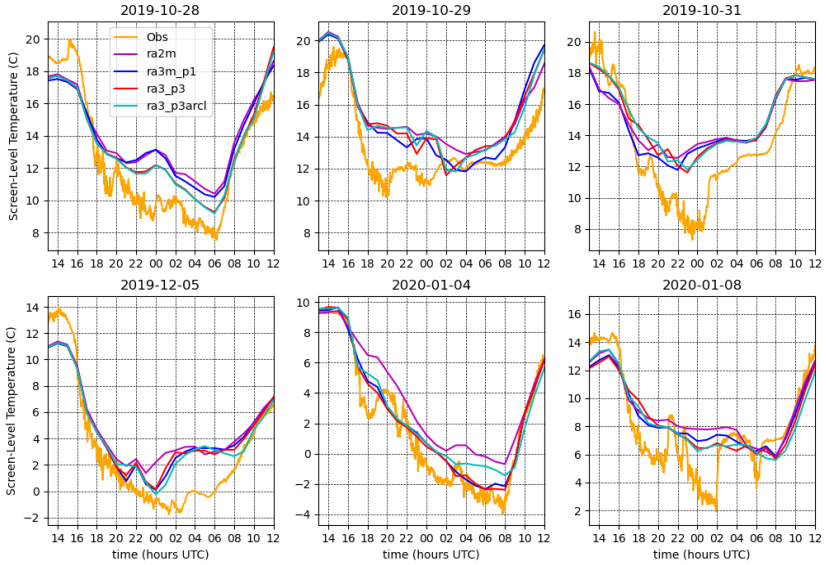
(3) More fog formed



Effect of changing setup parameters

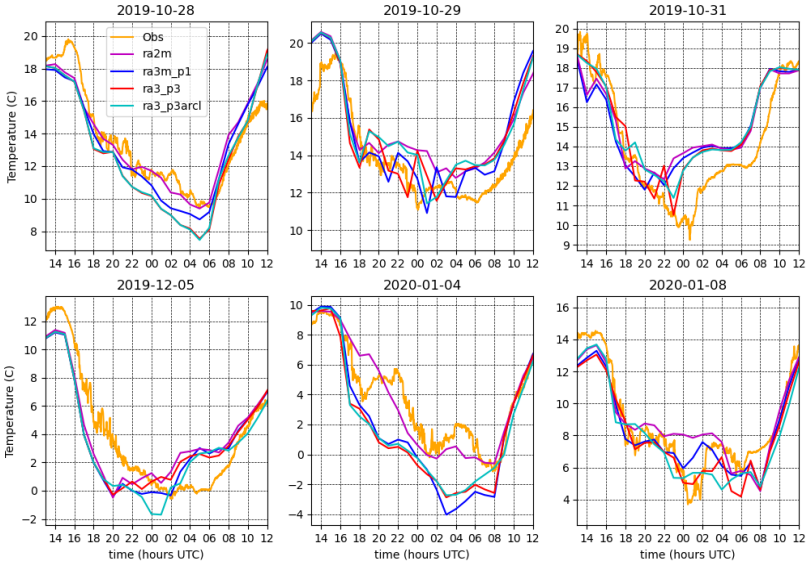
But model temperatures still generally too high at Le Couye

Le Couye – after change in set-up



However temperatures more comparable at Jachere – Jachere temperature reductions up to double those at Le Couye

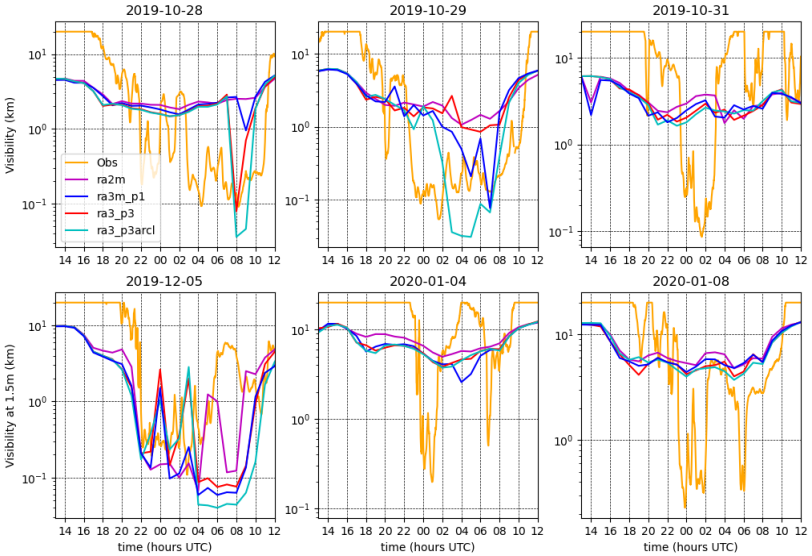
Jachere – after change in set-up



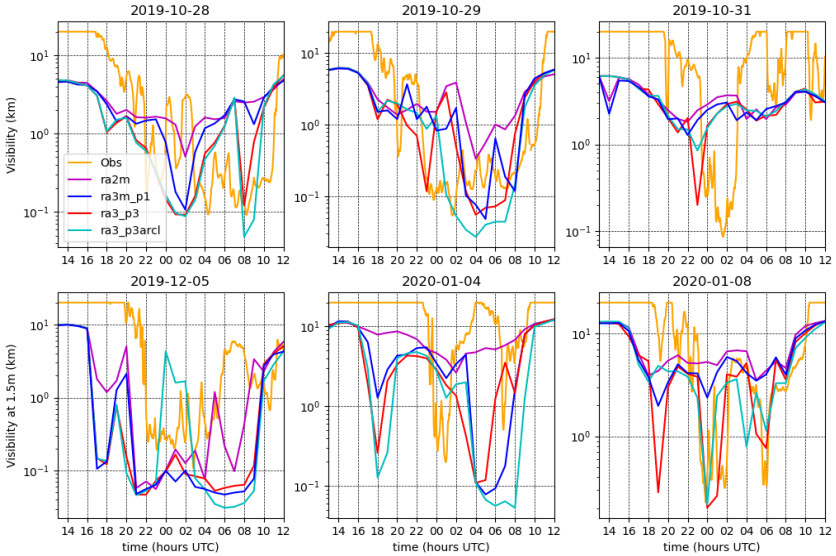
Warmer at Le Couye – due to model averaging over the grid box whereas obs are local?

.... with reduction in screen-level temperature, model now formed fog during each radiation fog case at Jachere

Jachere – before change in set-up



Jachere – after change in set-up



Effect of changing setup parameters

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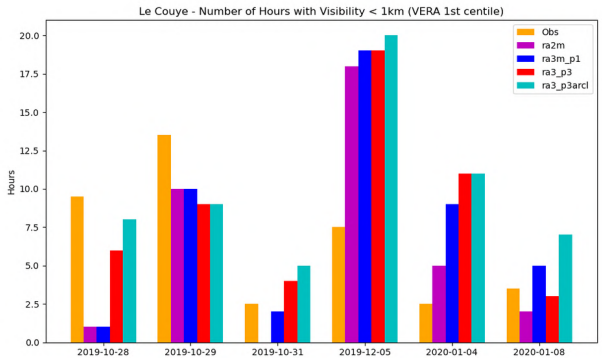
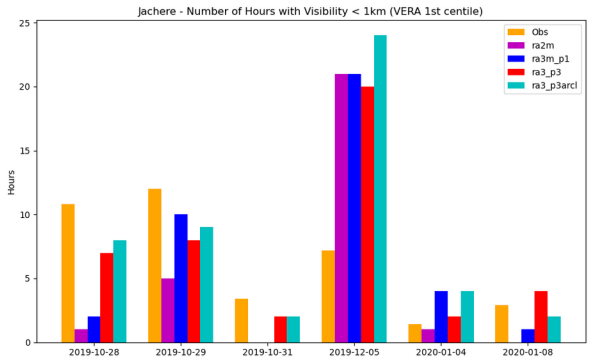
Very briefly.... VERA is a new visibility scheme (B Claxton)

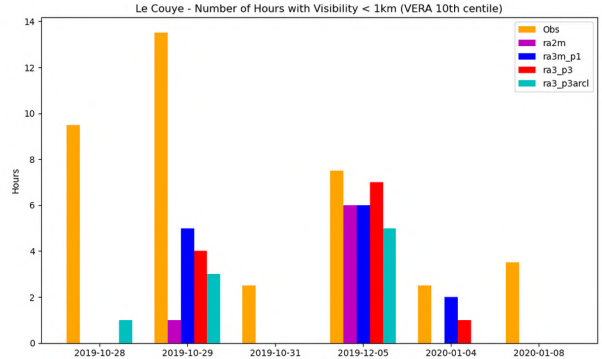
- VERA uses polydisperse aerosol particles (lognormal size distribution and triangular hygroscopy distribution)
- Synthetic noise added to VERA to generate a set of possible visibilities…
- Outputs: probabilities of vis below specific thresholds, and centiles of these.

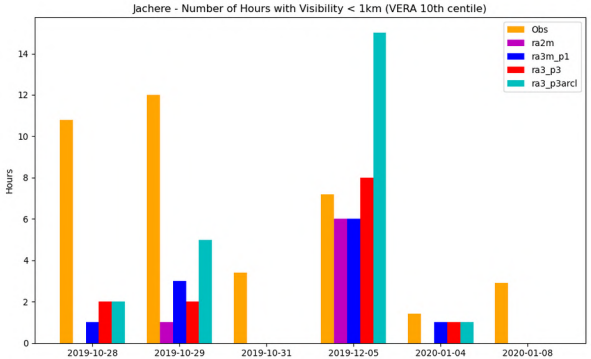
Lowest 1% of visibility outputs





Lowest 10% of visibility outputs





VERA output – a different visibility scheme

Conclusions from these comparisons

- Met Office UM has been run using more sophisticated visibility, cloud, and microphysics schemes as tests
- Standard model (control) tends to under-predict radiation fog events – but when a bi-modal cloud scheme and/or a double-moment microphysics scheme (CASIM) are implemented:
  - Fog is more willing to form
  - Skin and near-surface temperatures can drop lower
  - Low/mid level cloud (higher than 200m) is less persistent
- Model doesn't cool enough in the late afternoon/early evening before an observed radiation fog event
  - Forcing a cooler surface T leads to enhanced fog formation
  - Even after this forcing, the surface temperature is still too high in the model output during evenings that were followed by observed radiation fog events at Le Couye
- Model vertical velocity variance WW looks too high (certainly at Le Couye)

Future work

- Further investigation into temperature bias based on tile temperatures rather than grid-box values.
- Investigate alternative ways to reduce skin and near-surface temperature
- More detailed look at the Stratus fog cases

Acknowledgement: Merci beaucoup to all who have been involved in the collection and provision of data at the Jachere site!

Any Questions?

Links to further information:

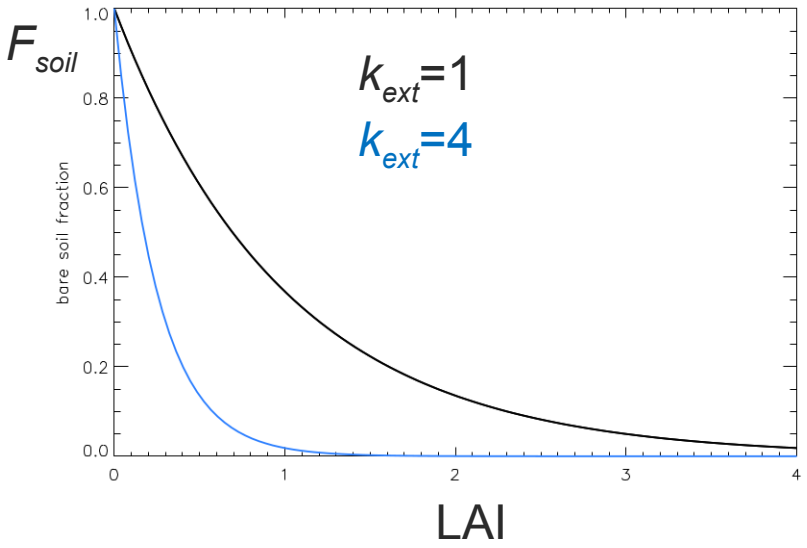
- Bi-modal cloud scheme I
- Bi-modal cloud scheme II
- VERA paper in progress – for VERA info contact bernie.claxton@metoffice.gov.uk

jenna.thornton@metoffice.gov.uk

Sensitivity test modifying bare soil fraction

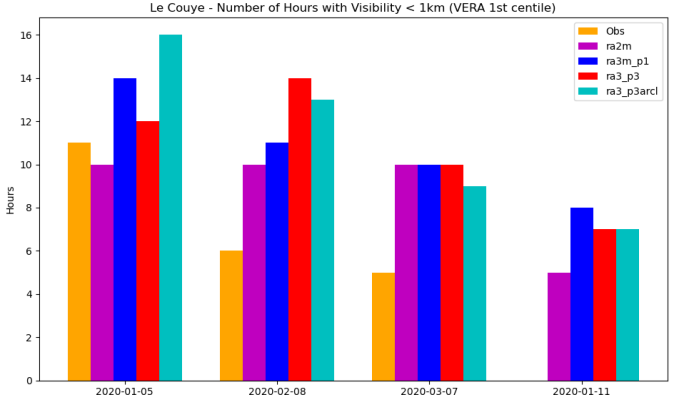
- The fraction bare soil exposed to the atmosphere on vegetated tiles is related to the LAI as:

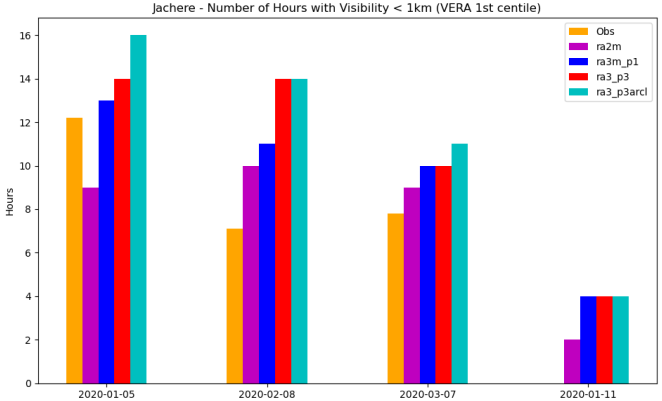
- Here we increase k_{ext} from 1 to 4(?)
- Reducing F_{soil} weakens the thermal coupling between the soil and atmosphere

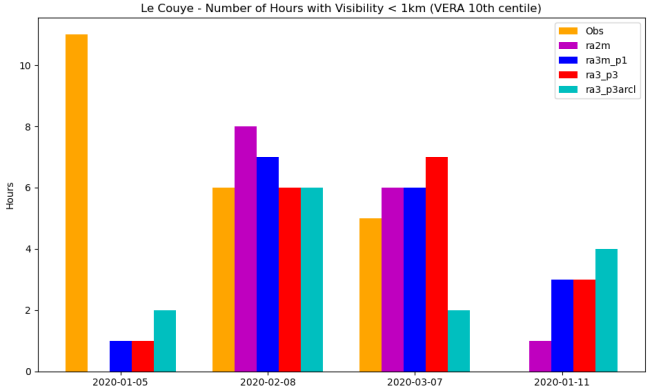


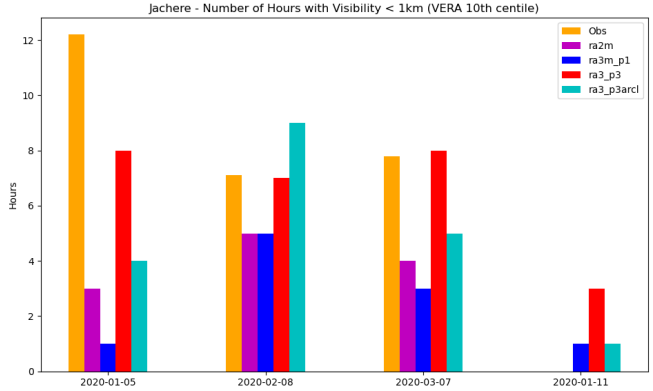
Appendix – additional plots

VERA – Stratus and 'null'



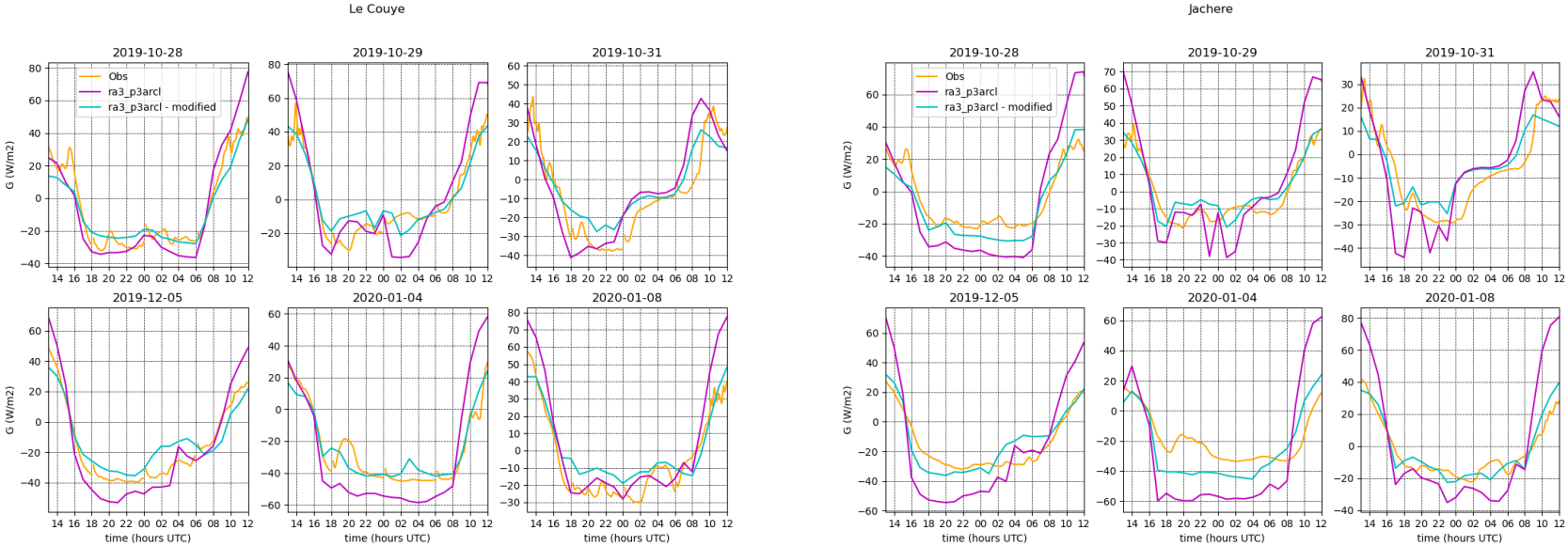






Appendix – additional plots

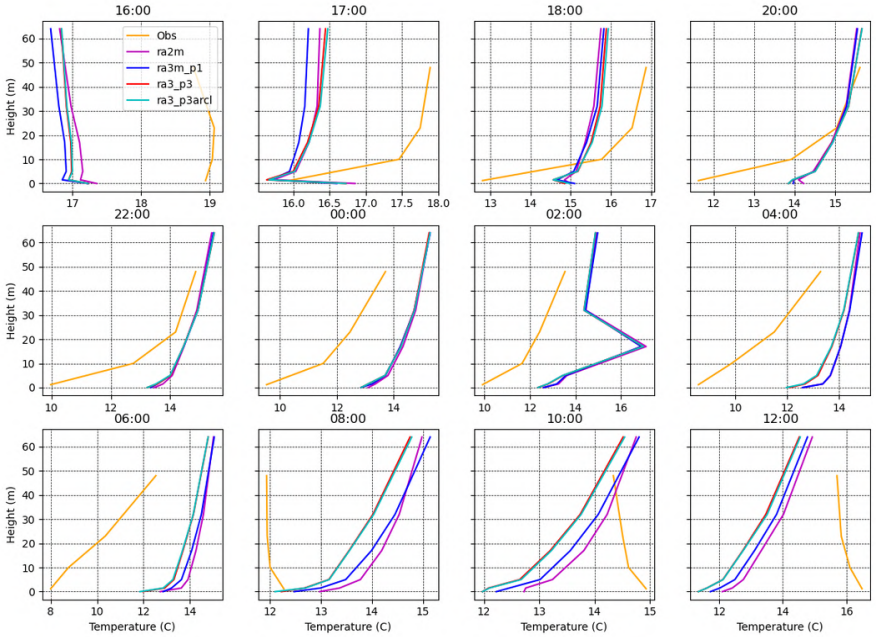
Soil Heat Flux – ra3_p3arcl and obs only – before and after change of set-up parameter



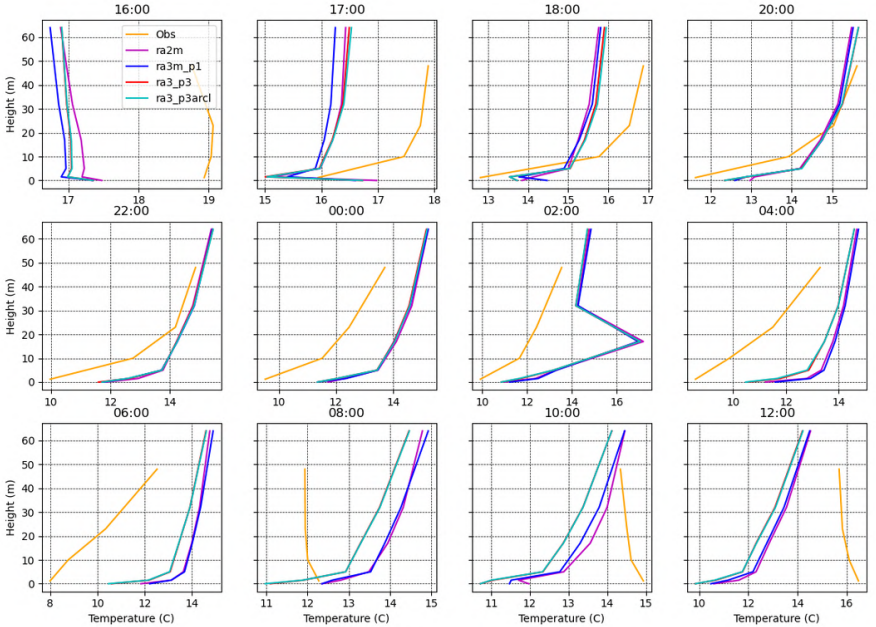
Appendix – additional plots

Temperature Profiles – 28th to 29th October 2019 radiation fog case

Le Couye – before change in set-up



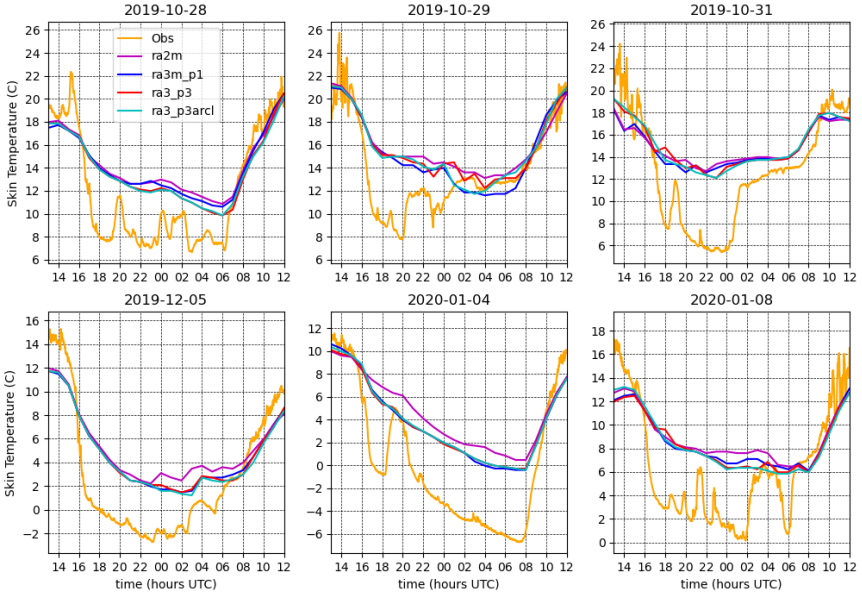
Le Couye – after change in set-up



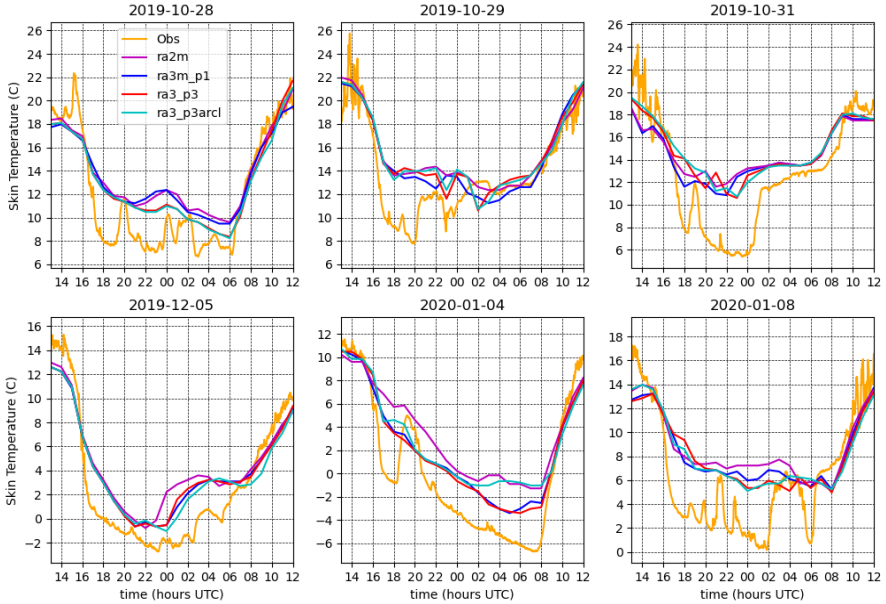
Appendix – additional plots

Skin temperatures – Radiation fog cases

Le Couye – before change in set-up



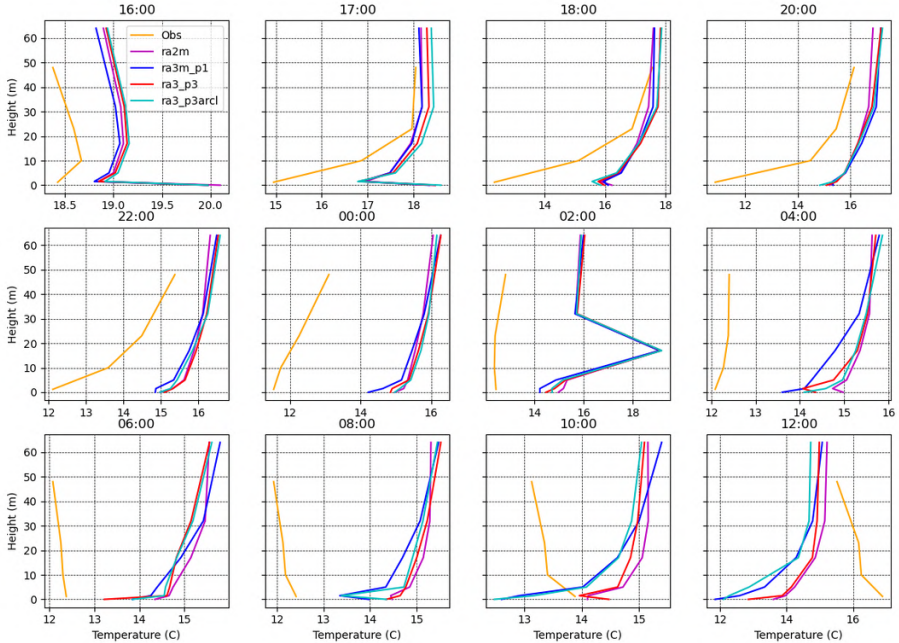
Le Couye – after change in set-up



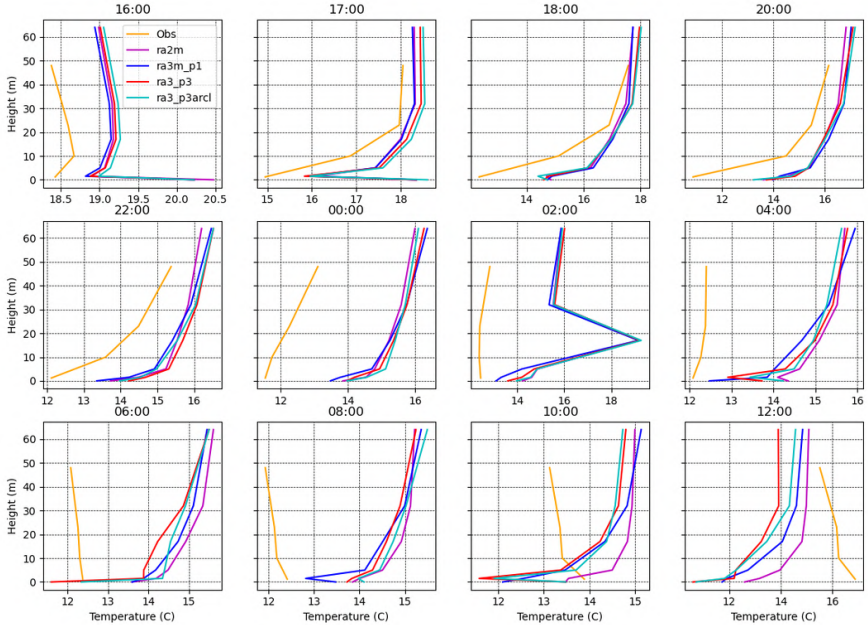
Appendix – additional plots

Temperature Profiles – 29th to 30th October 2019 radiation fog case

Le Couye – before change in set-up



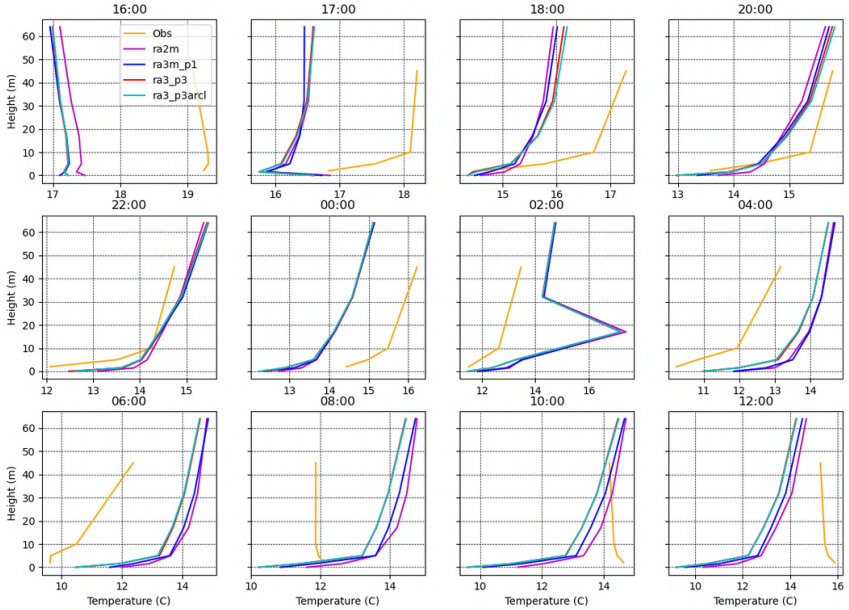
Le Couye – after change in set-up



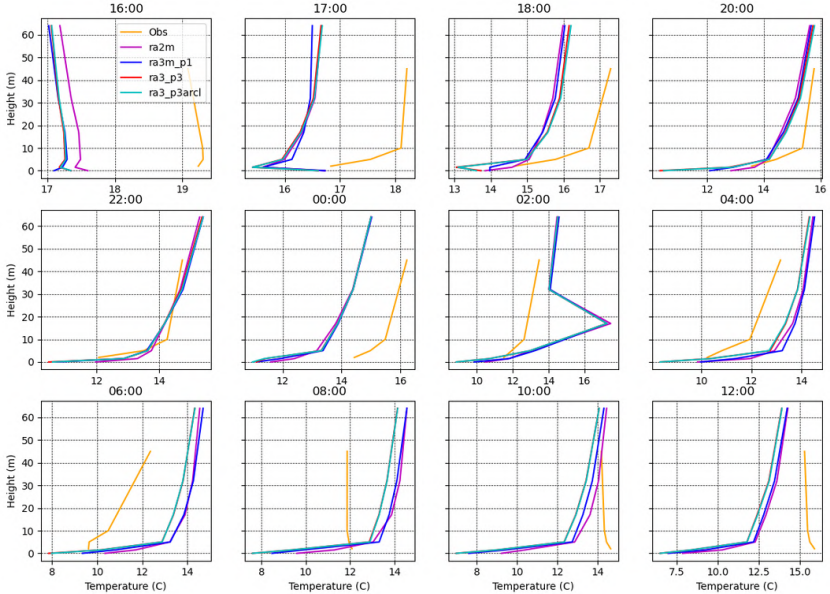
Appendix – additional plots

Temperature Profiles – 28th to 29th 2019 October radiation fog case

Jachere –before change in set-up



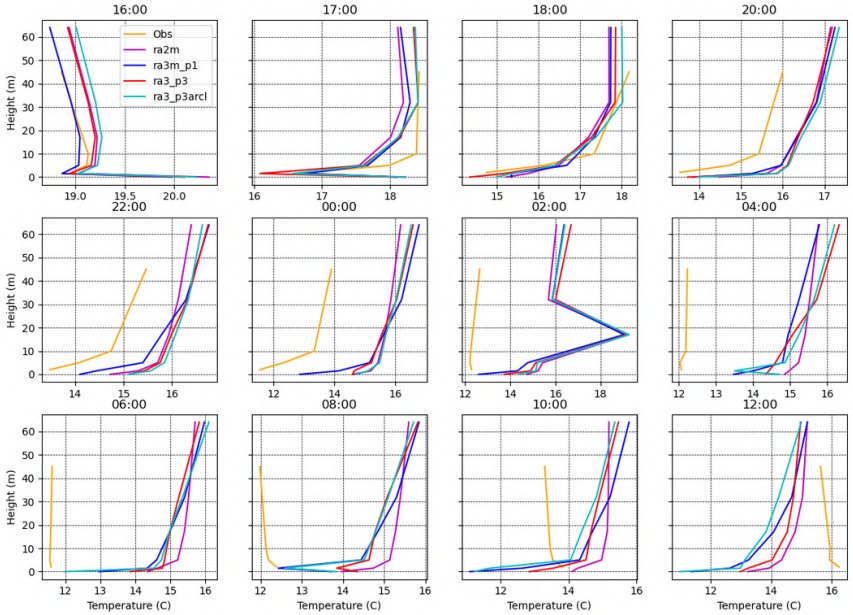
Jachere – after change in set-up



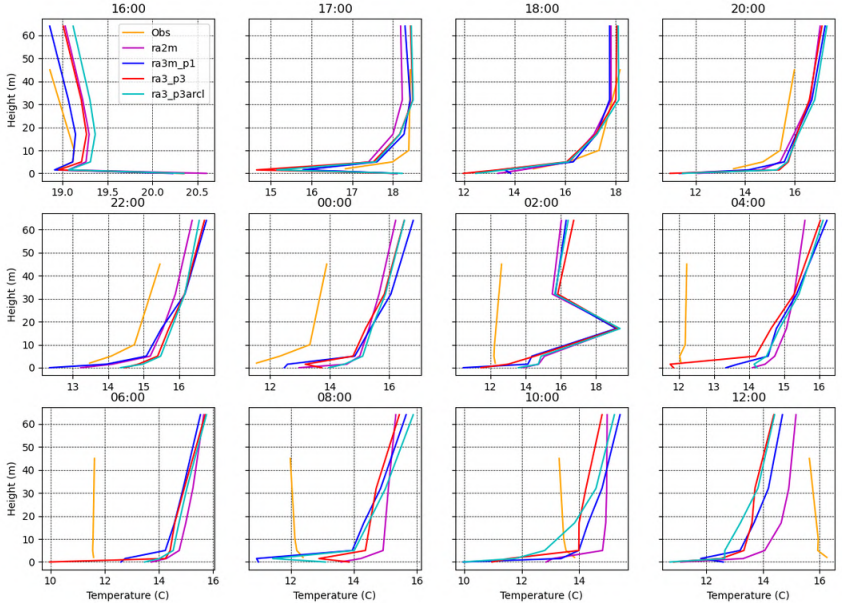
Appendix – additional plots

Temperature Profiles – 29th to 30th October 2019 radiation fog case

Jachere – before change in set-up



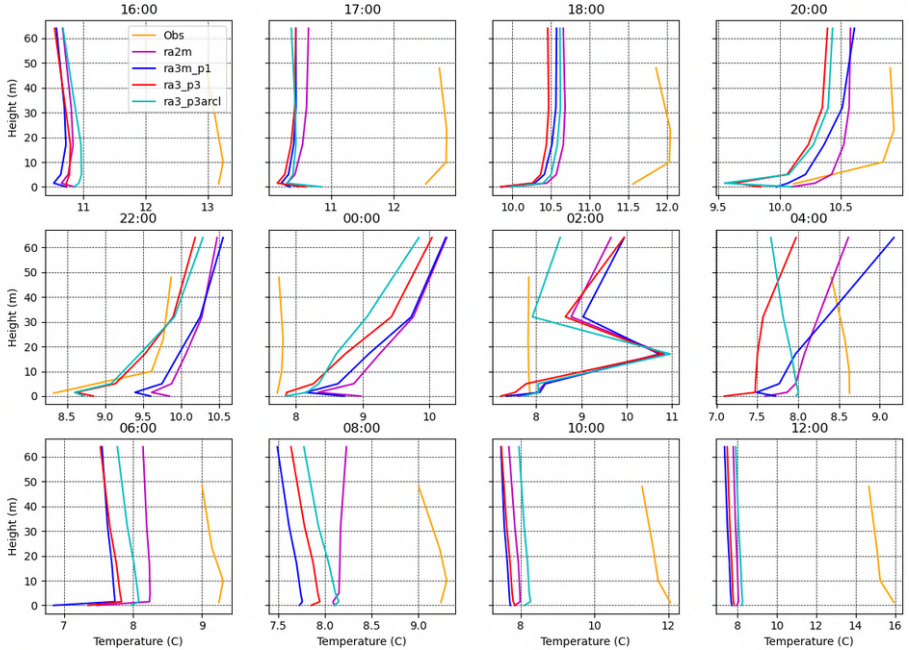
Jachere – after change in set-up



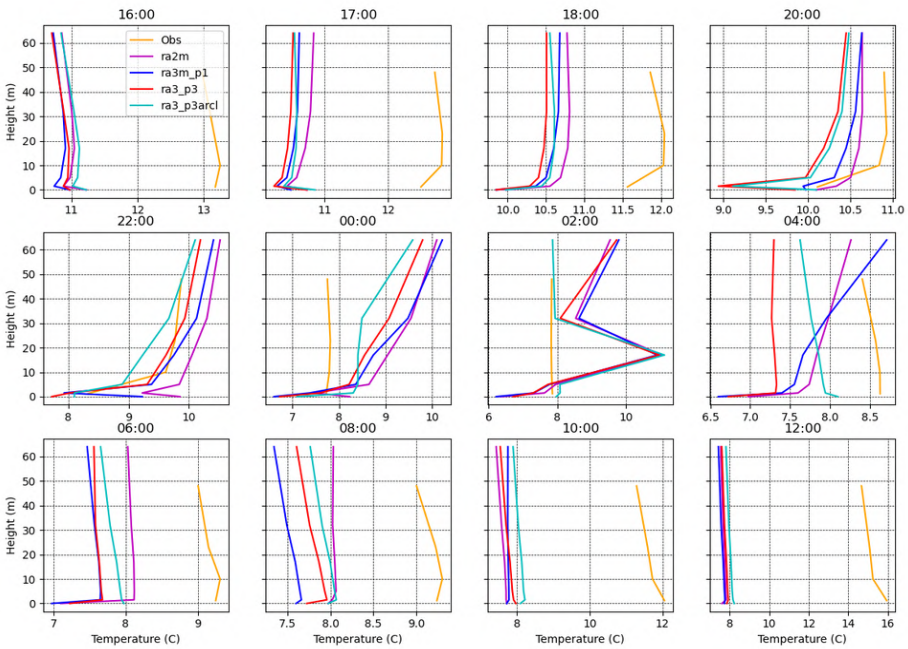
Appendix – additional plots

Temperature Profiles – 8th to 9th February 2020 stratus fog case

Le Couye – before change in set-up



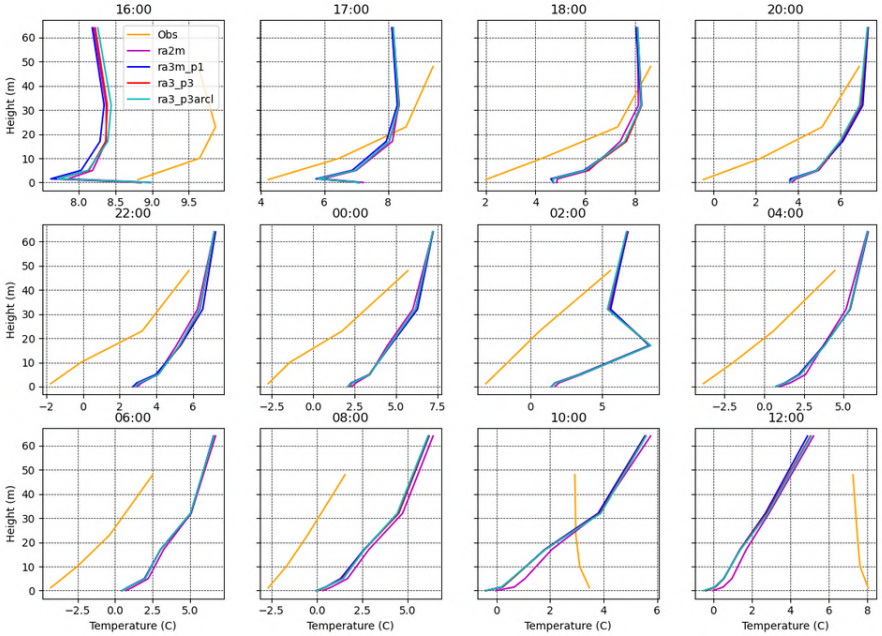
Le Couye – after change in set-up



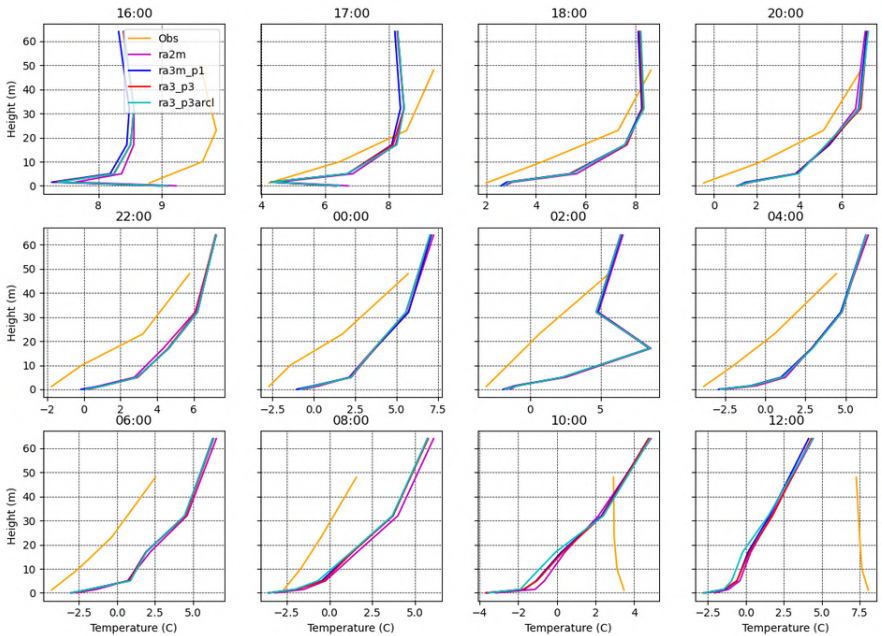
Appendix – additional plots

Temperature Profiles – 11th to 12th January 2020 null case

Jachere – before change in set-up



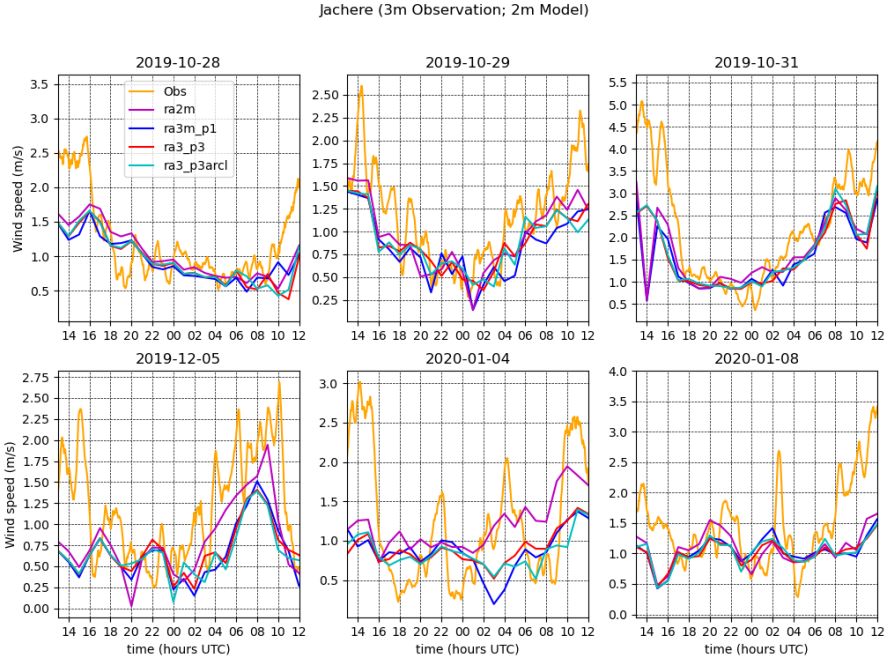
Jachere – after change in set-up



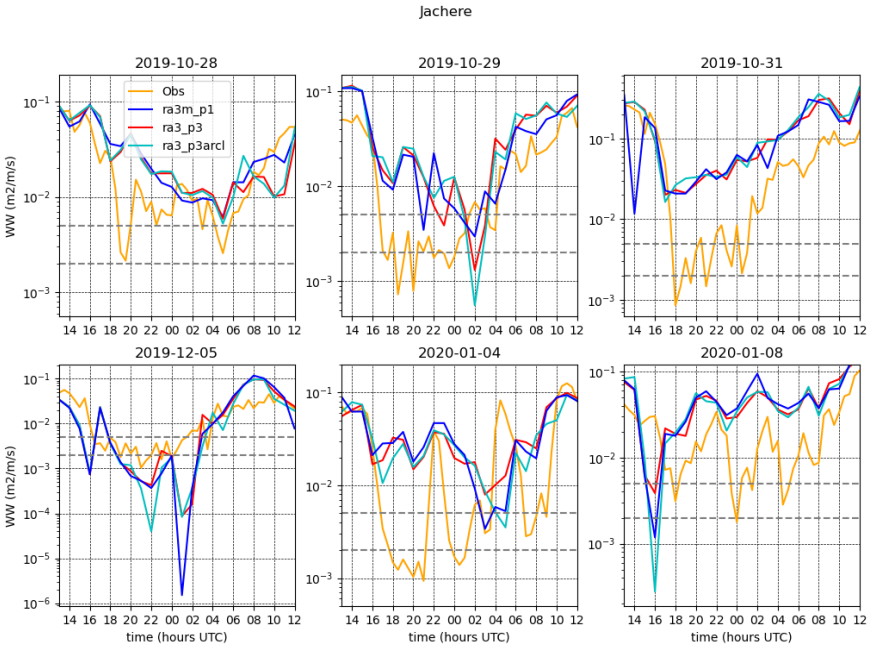
Appendix – additional plots

Wind Speed and Vertical Velocity Variance

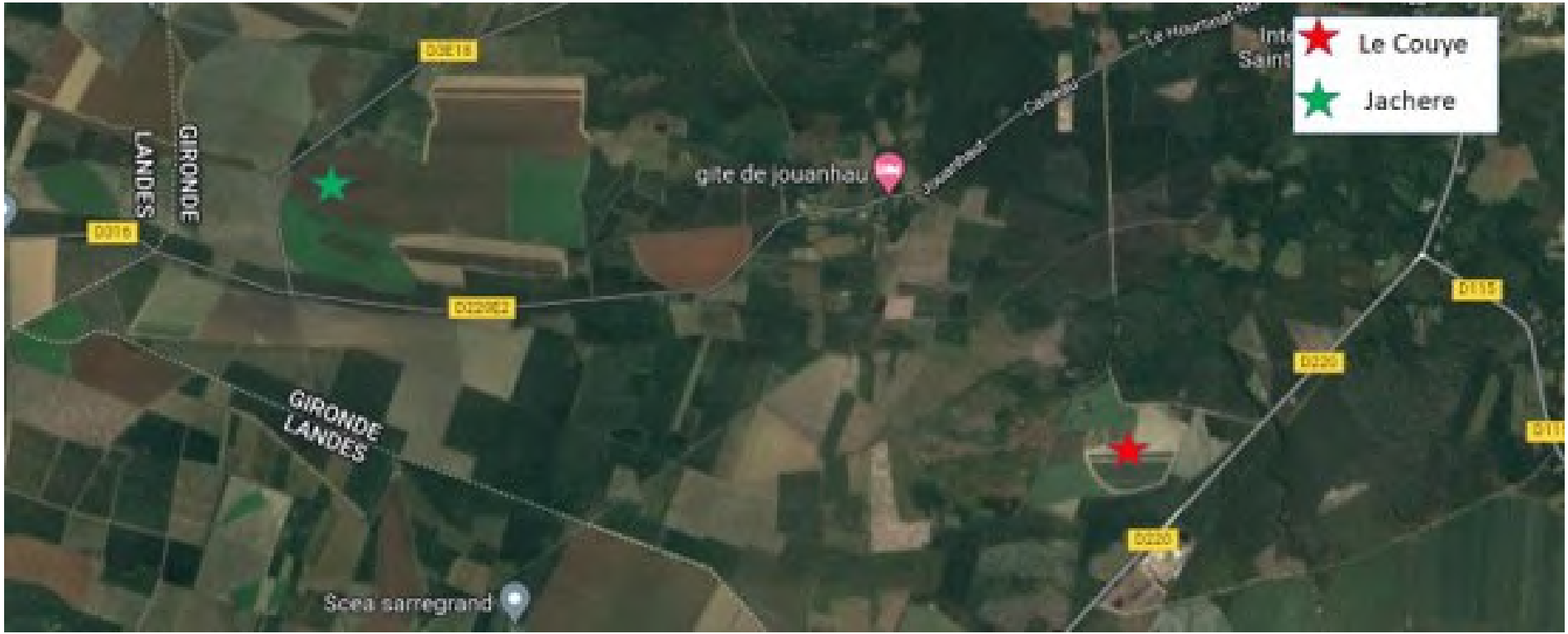
Jachere – after change in set-up



Jachere – after change in set-up



Appendix – additional plots



Appendix – additional plots