Spatially adaptive modelling:
mapping distribution and behaviour

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Spatially adaptive modelling

- Modelling baseline characteristics & change
  - **Abundance**: Monitoring numbers in the (local) population, in the survey area (or sub-areas).
  - **Distribution**: Looking for changes in distribution across time, including before/during/after interventions.
  - **Behaviour**: Identifying areas where animals exhibit important behaviours (e.g. feeding).
- Spatially adaptive & distance-related considerations
  - **Detecting local change in often large areas:** e.g. locating depressions in/around sites of interest.
  - **Complex topography:** e.g. Preventing `leakage' over land forms, e.g. hotspots in numbers/behaviours `spilling over' islands

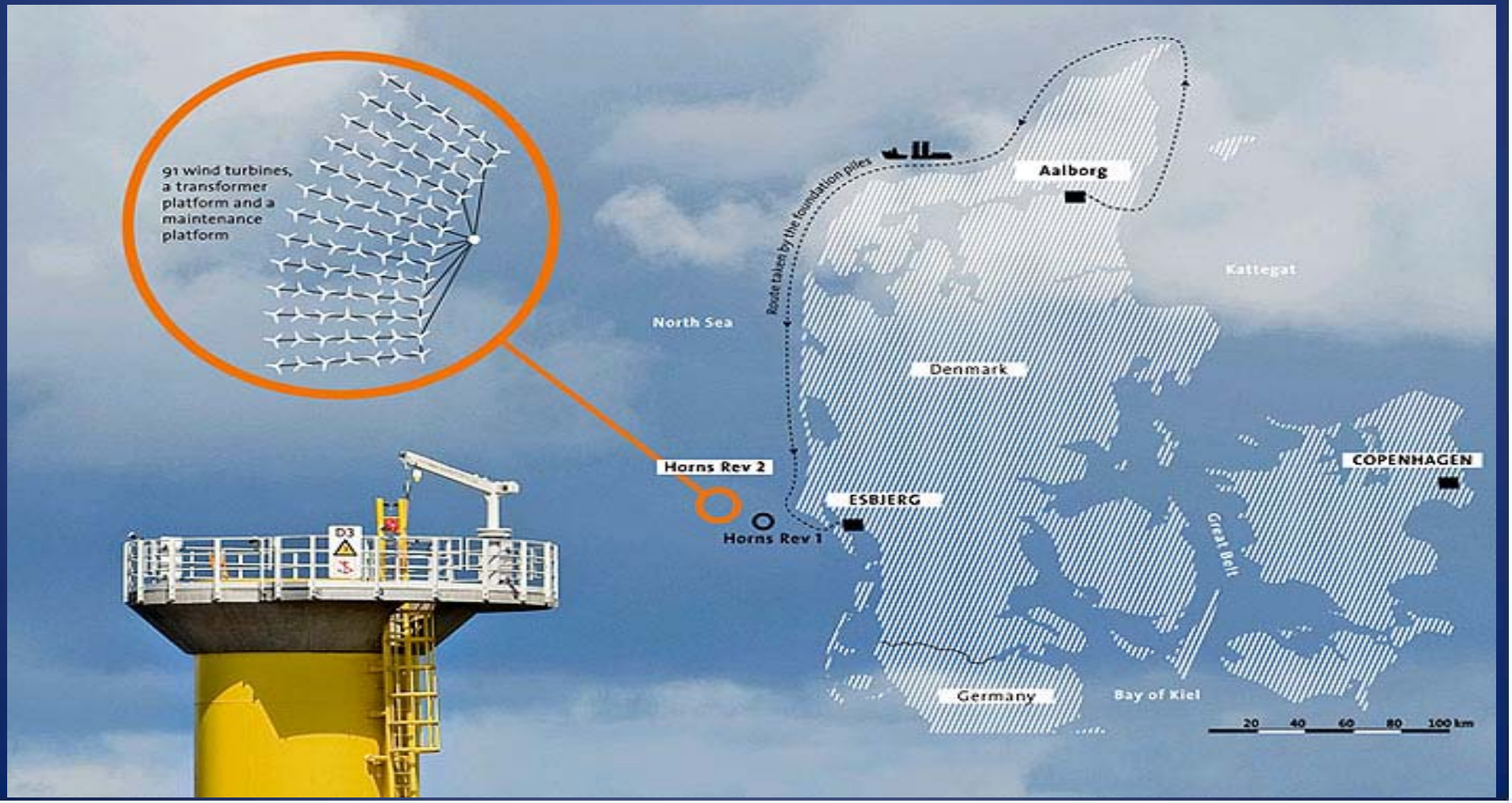
Spatially adaptive modelling

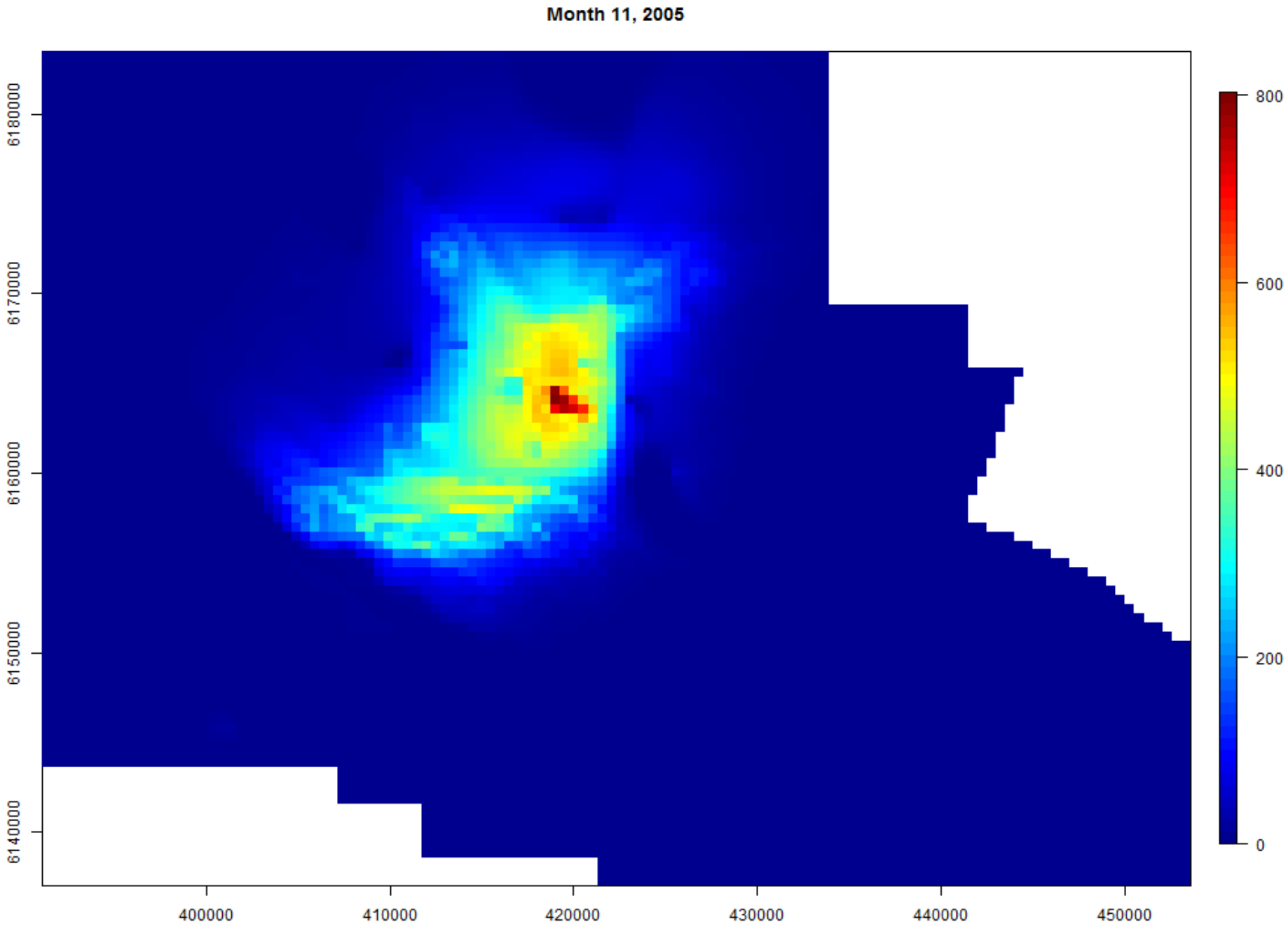
- Considering uncertainty: separating impacts from natural change.
  - Complex Region Spatial Smoother (CReSS[1]) coupled with Generalized Estimating Equation (GEEs)
  - The MRSea package in R[2].
- Methods in action:
  - Abundance and distribution (birds)
  - Feeding behaviour (killer whales)
- Combining behaviour and abundance maps to help us understand the extent of any impacts.

1: (2014) Journal of Computational and Graphical statistics, Volume 23, Issue 2.
2: http://creem2.st-andrews.ac.uk/software/

Mapping abundance and distribution:

Horns Rev off-shore wind farms

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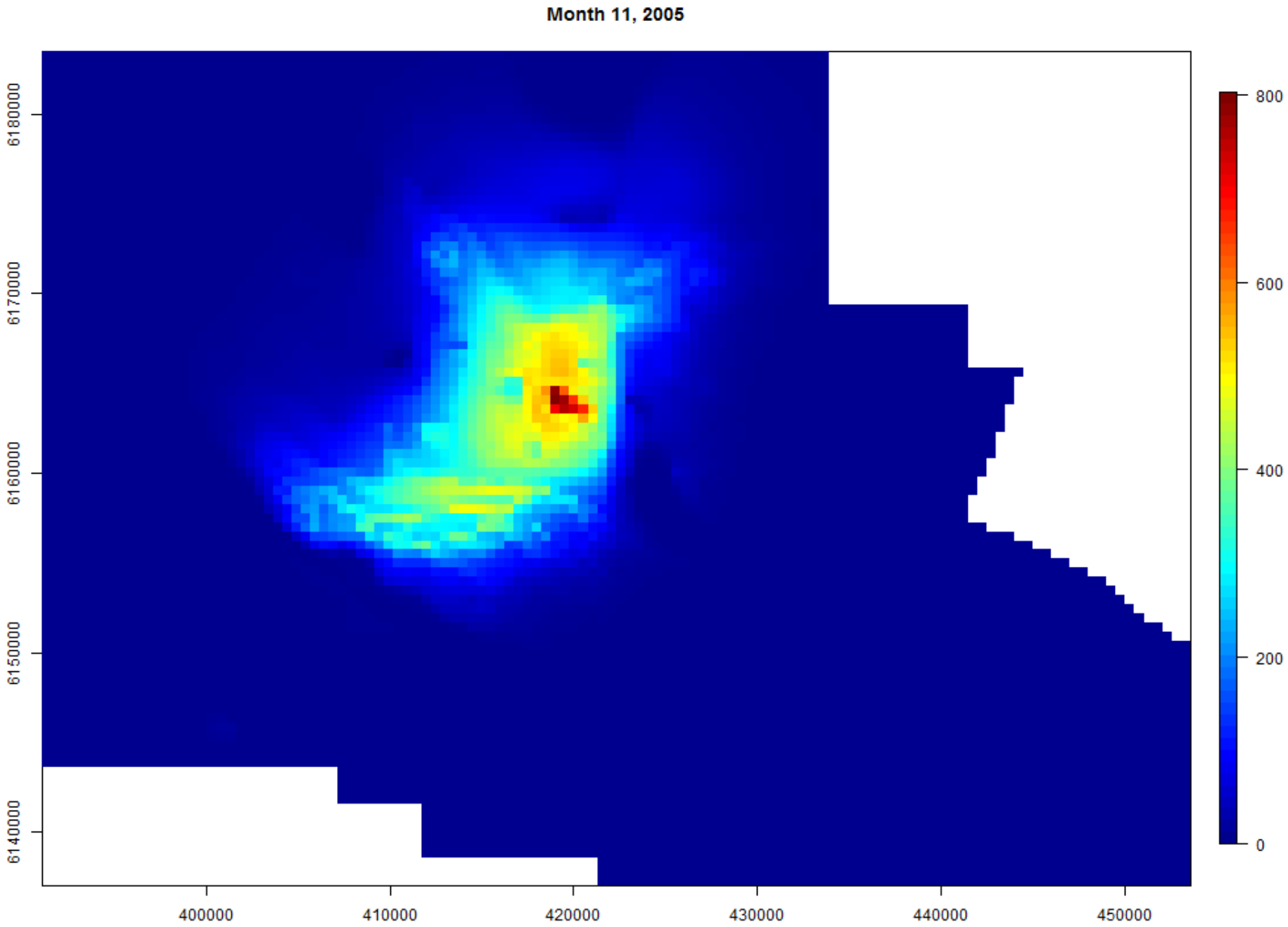
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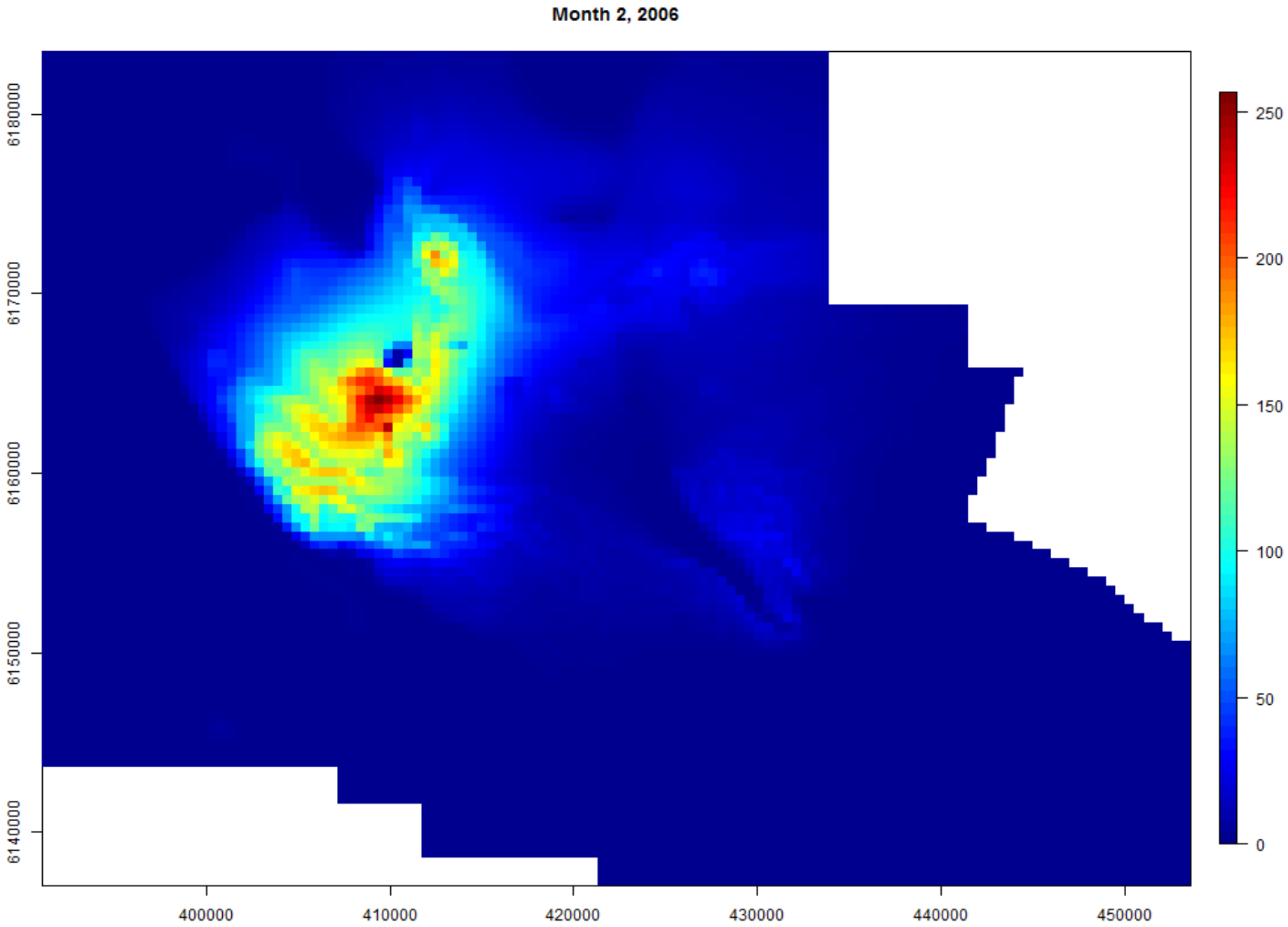
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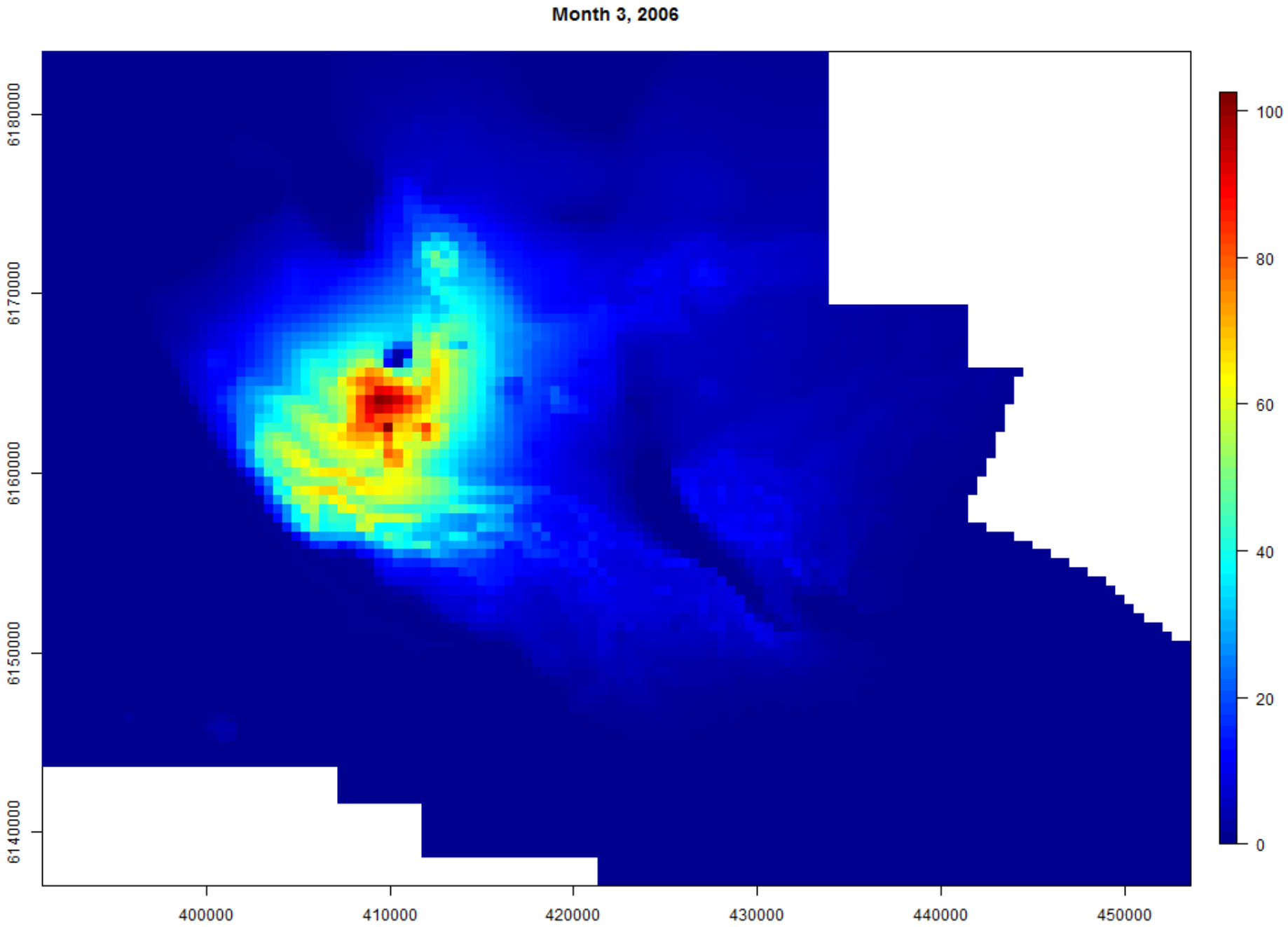
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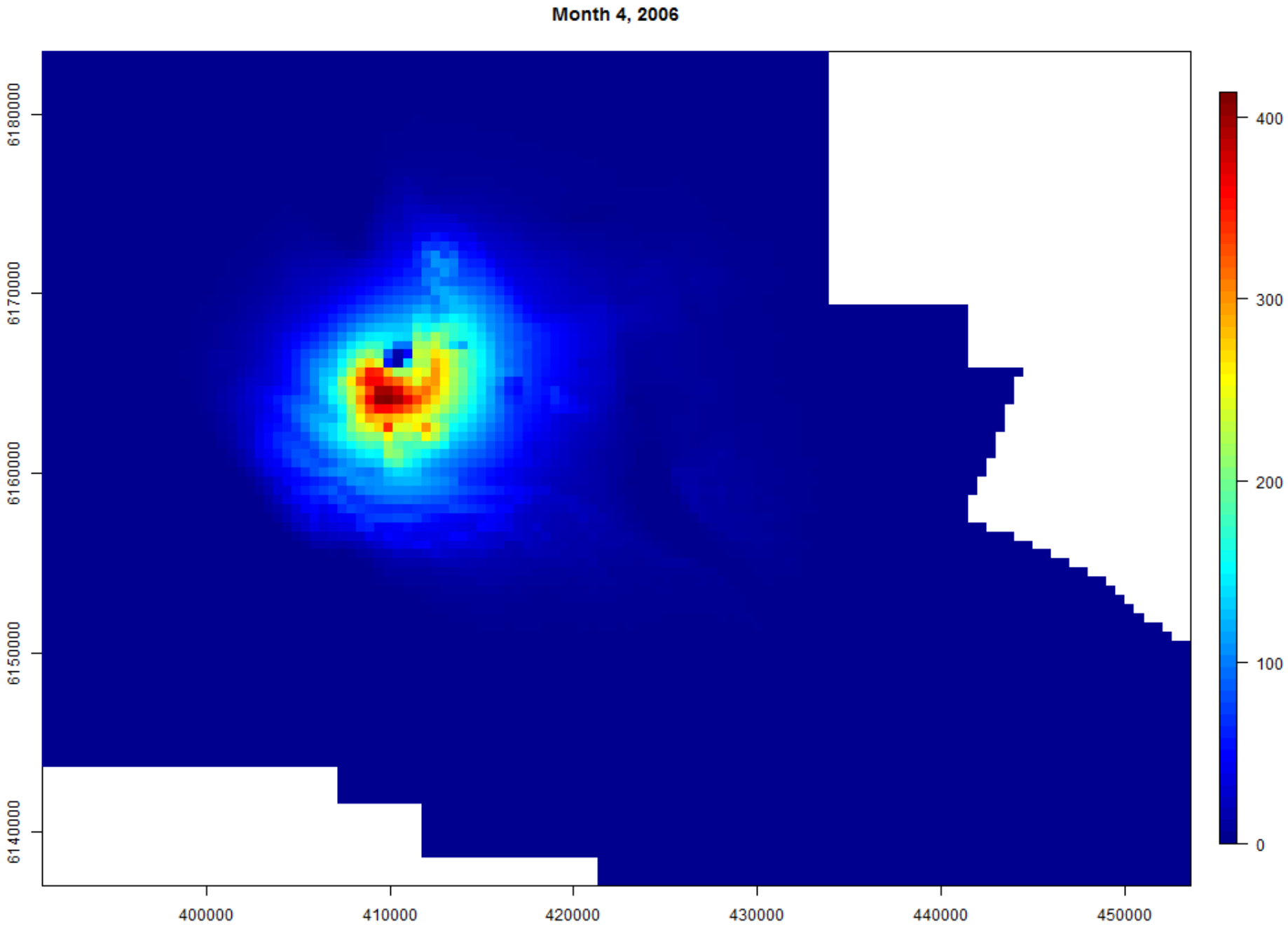
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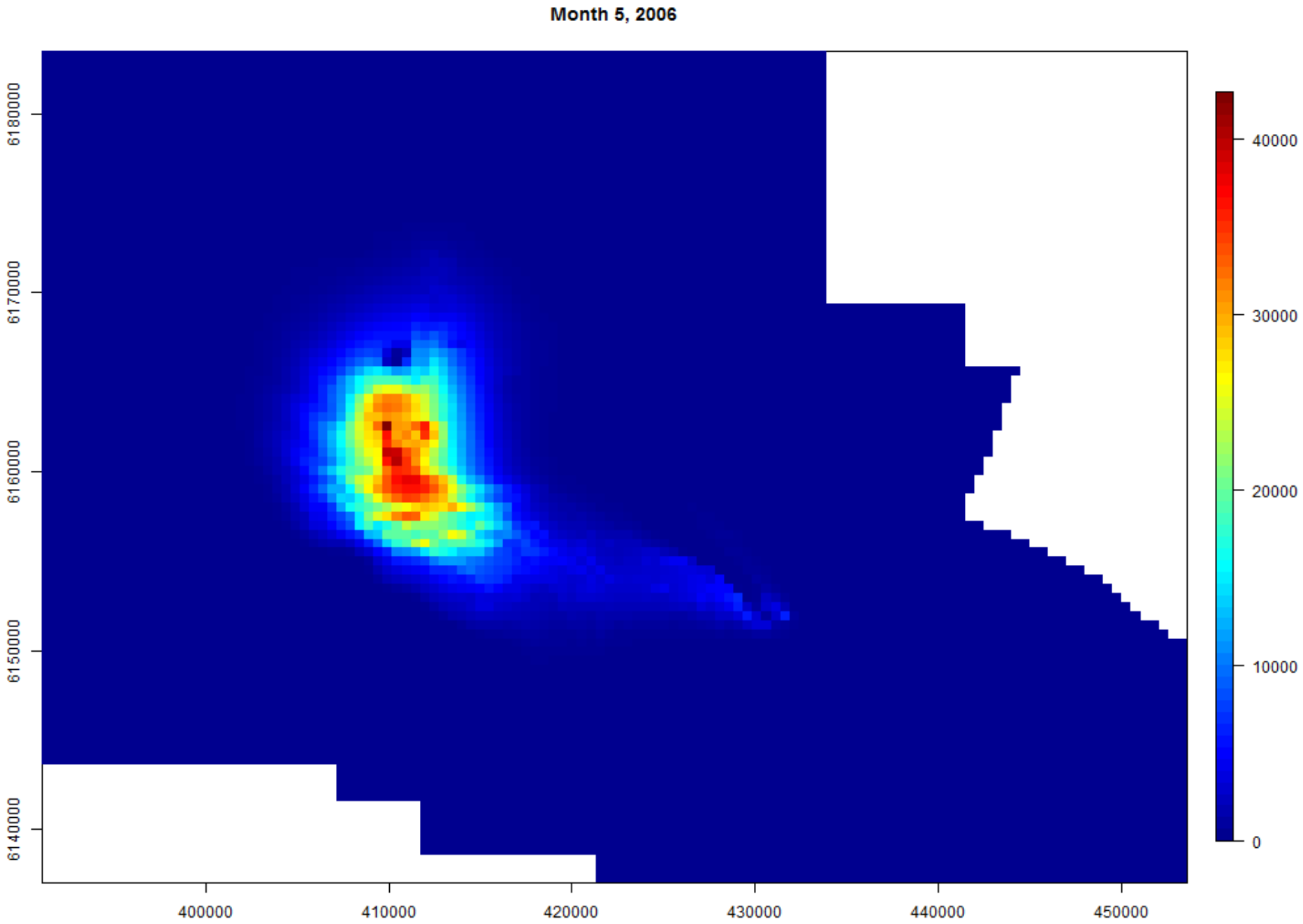
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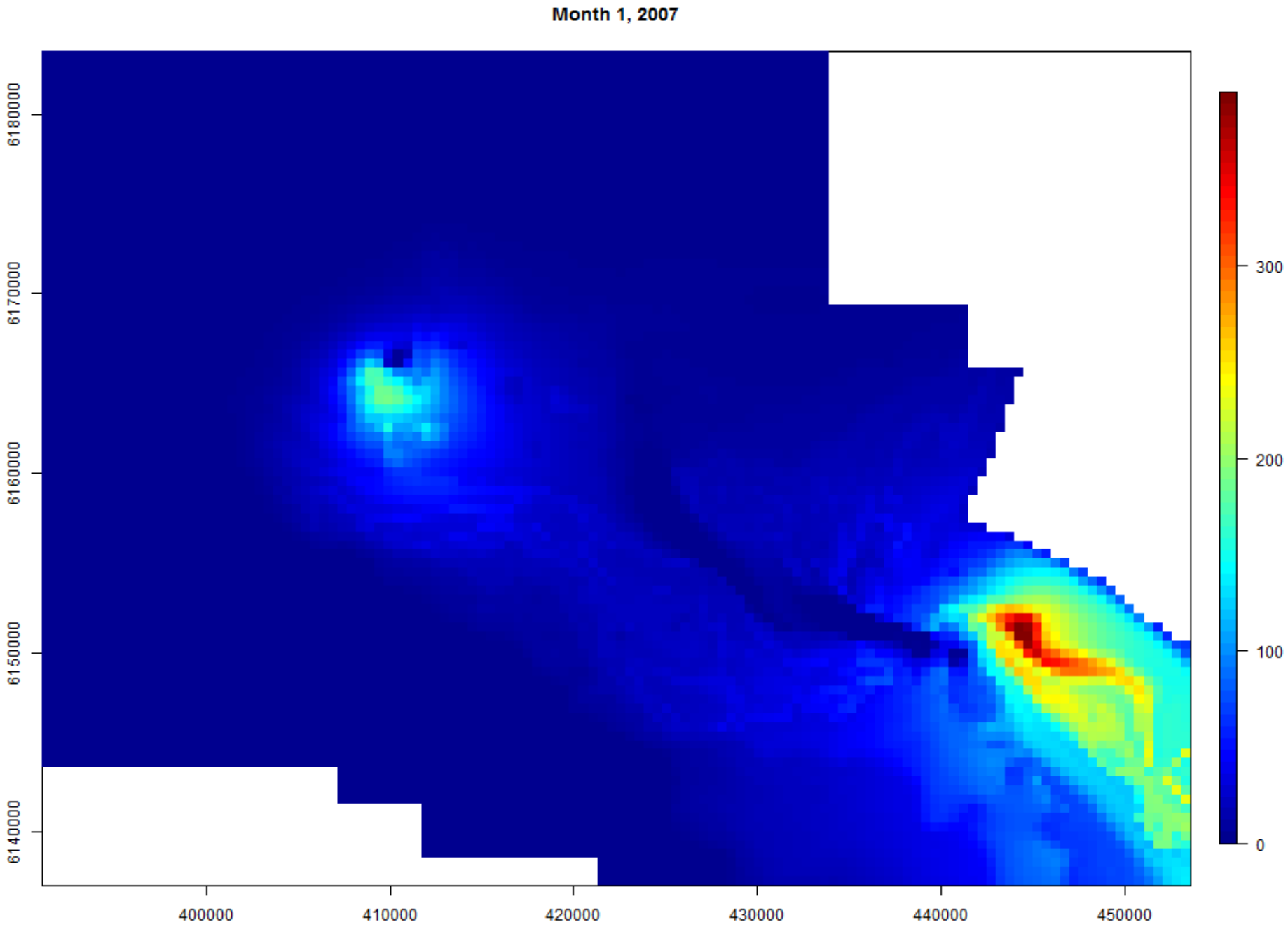
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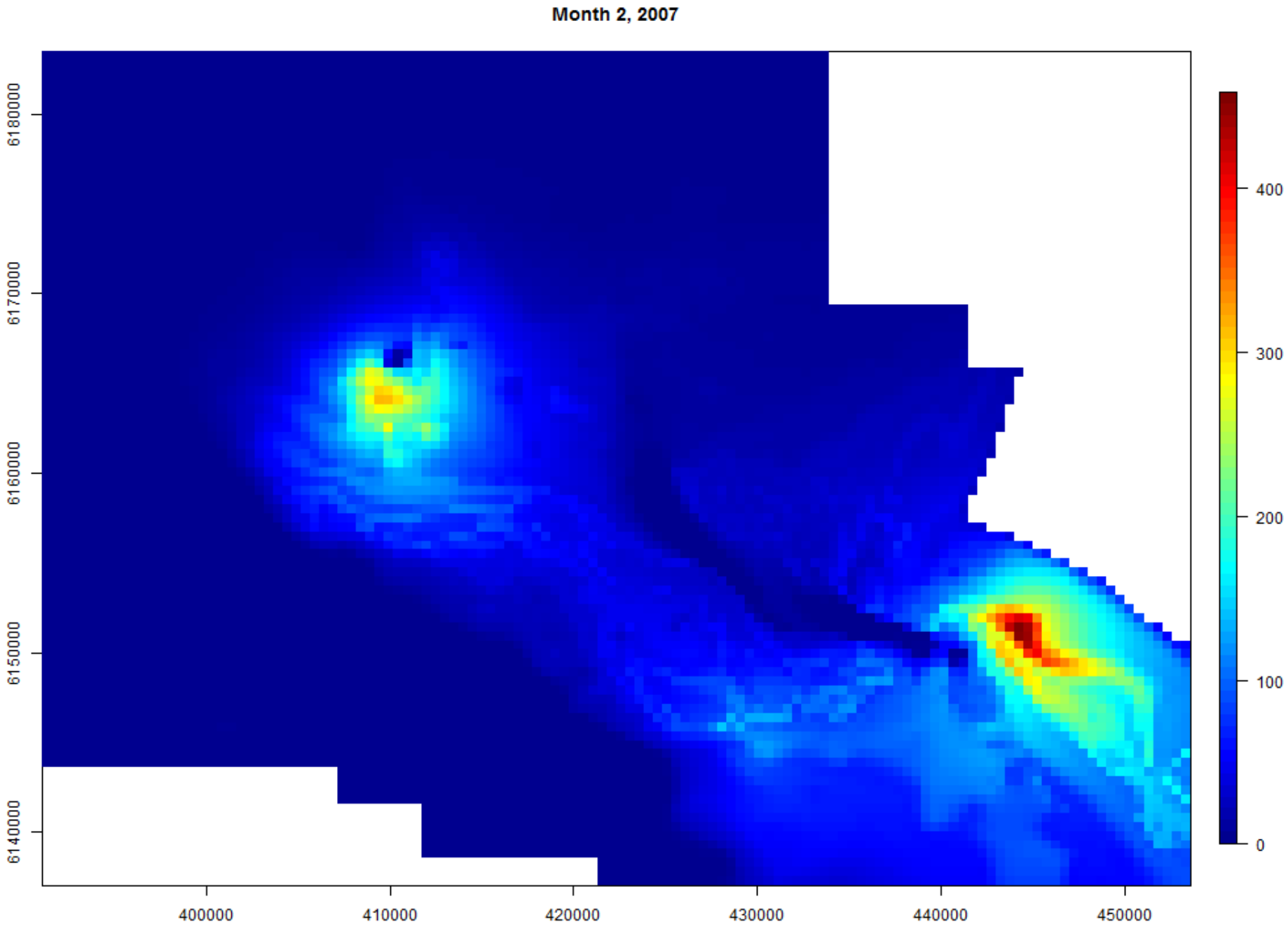
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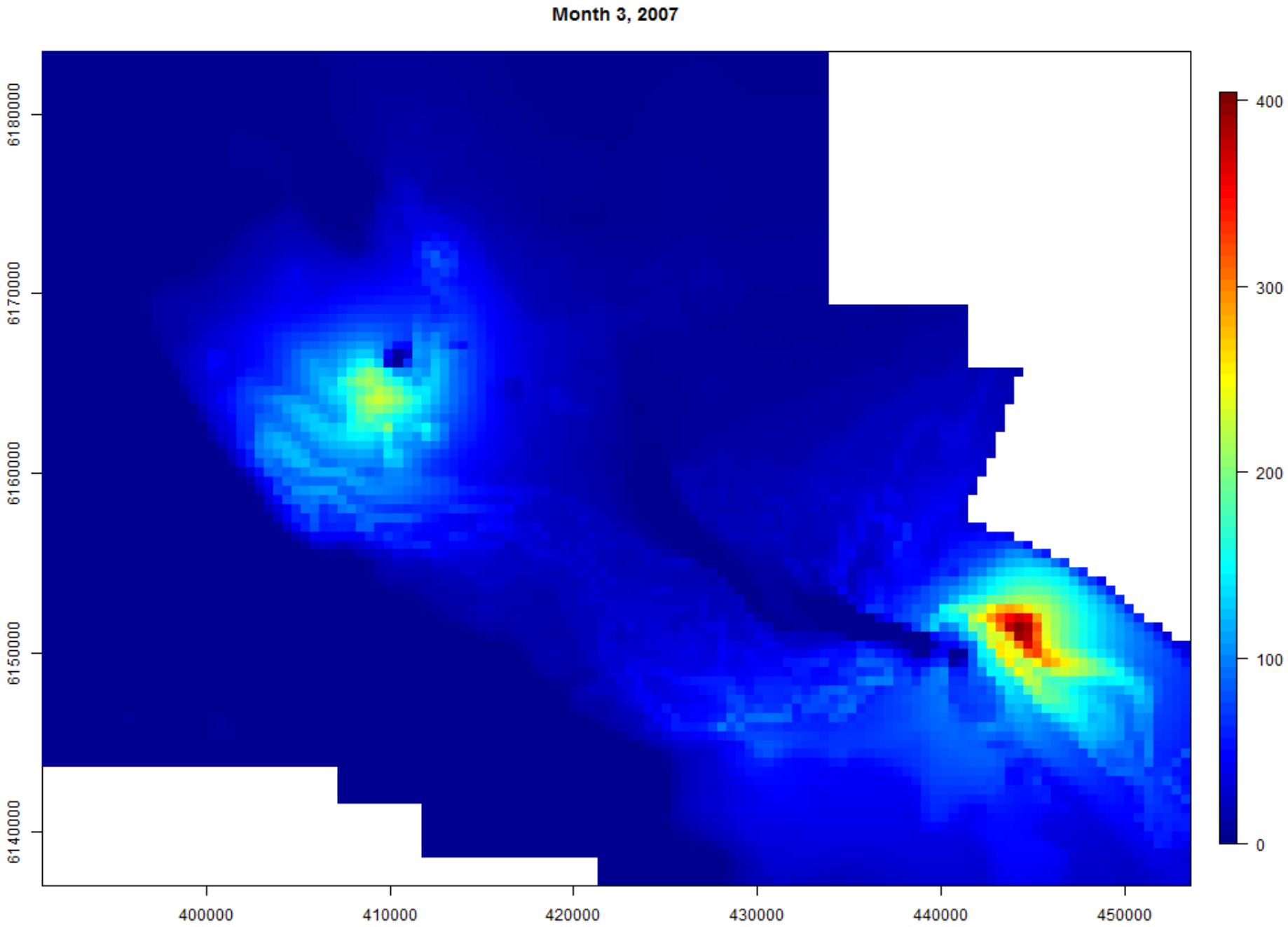
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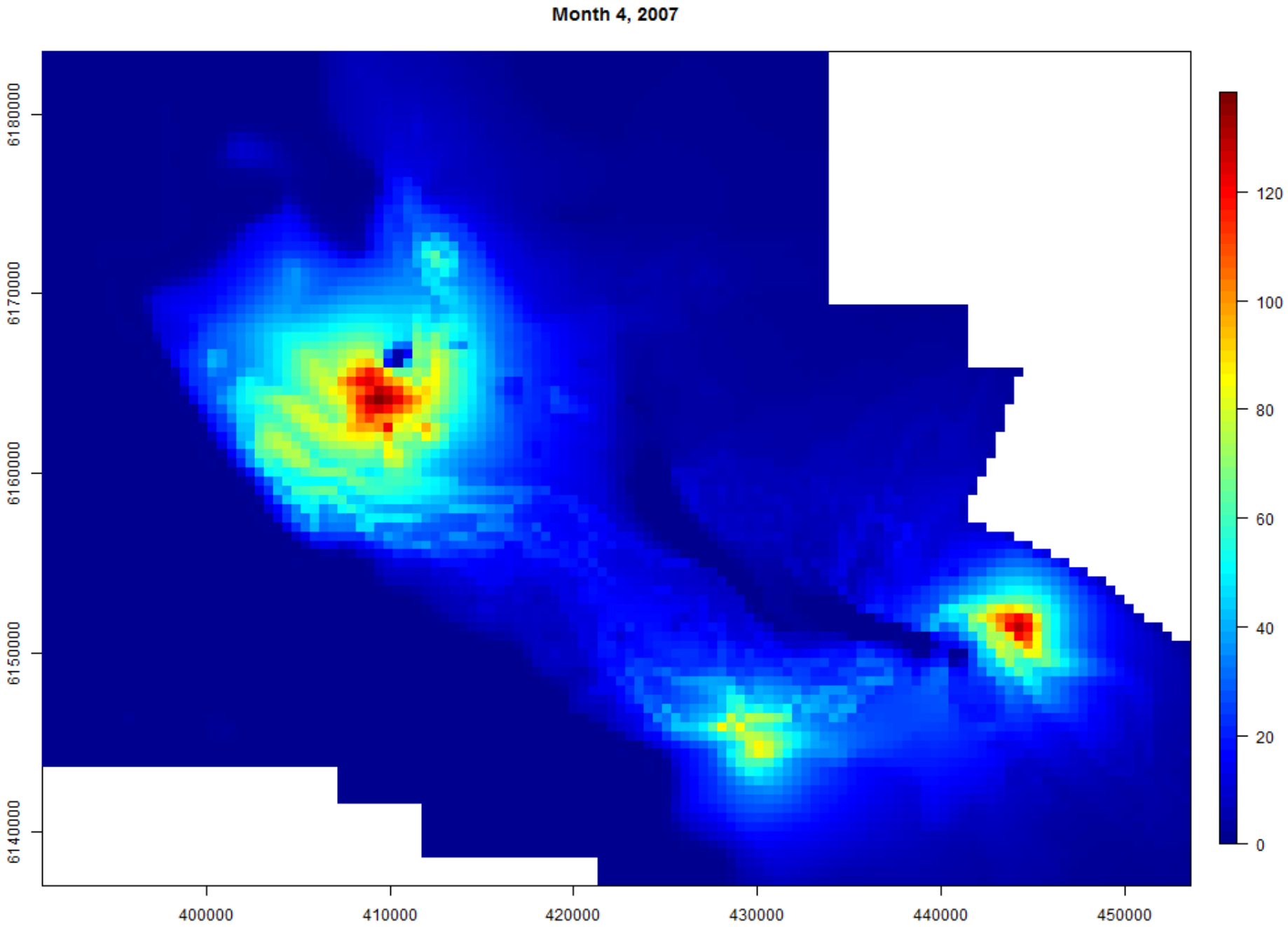
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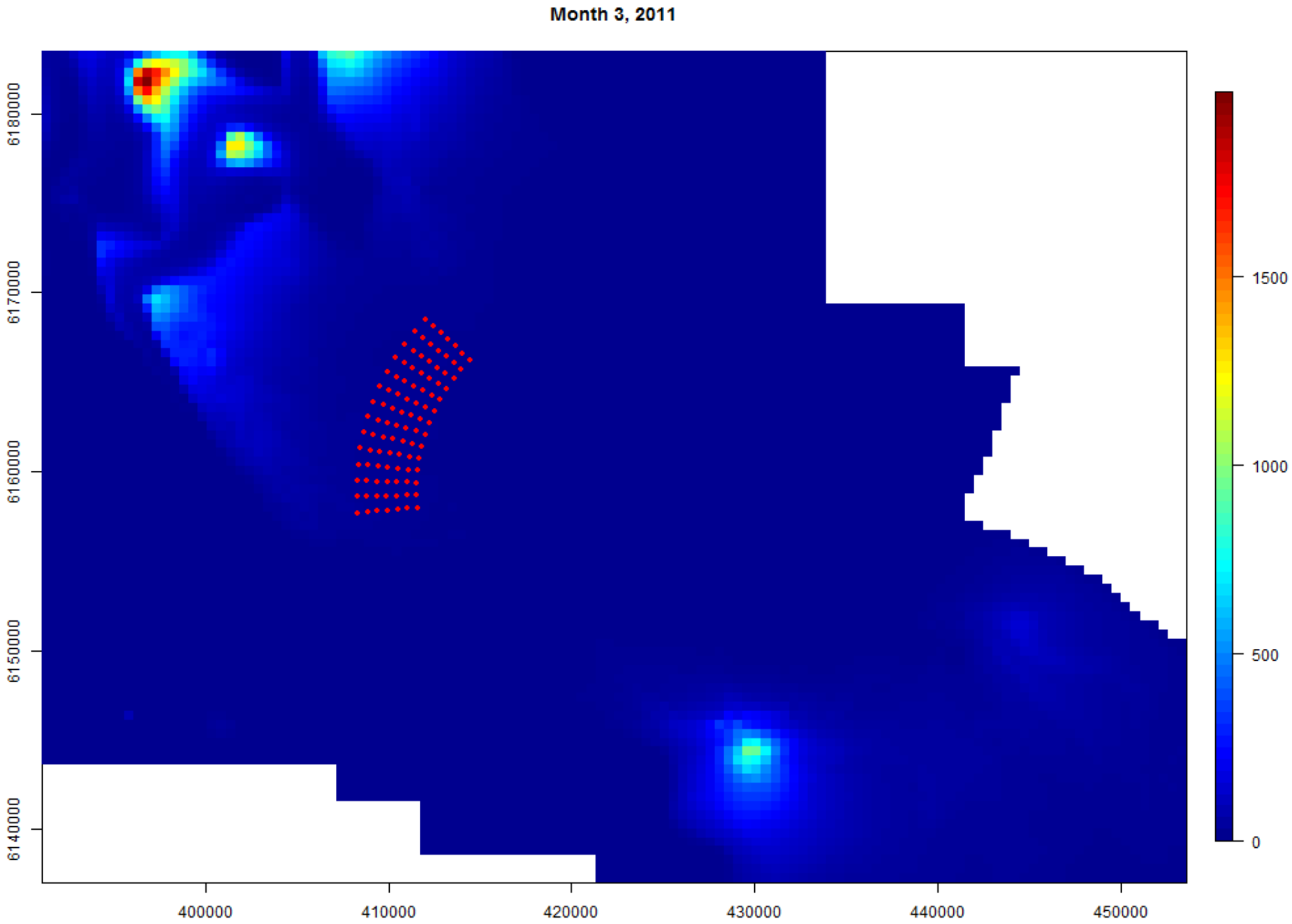
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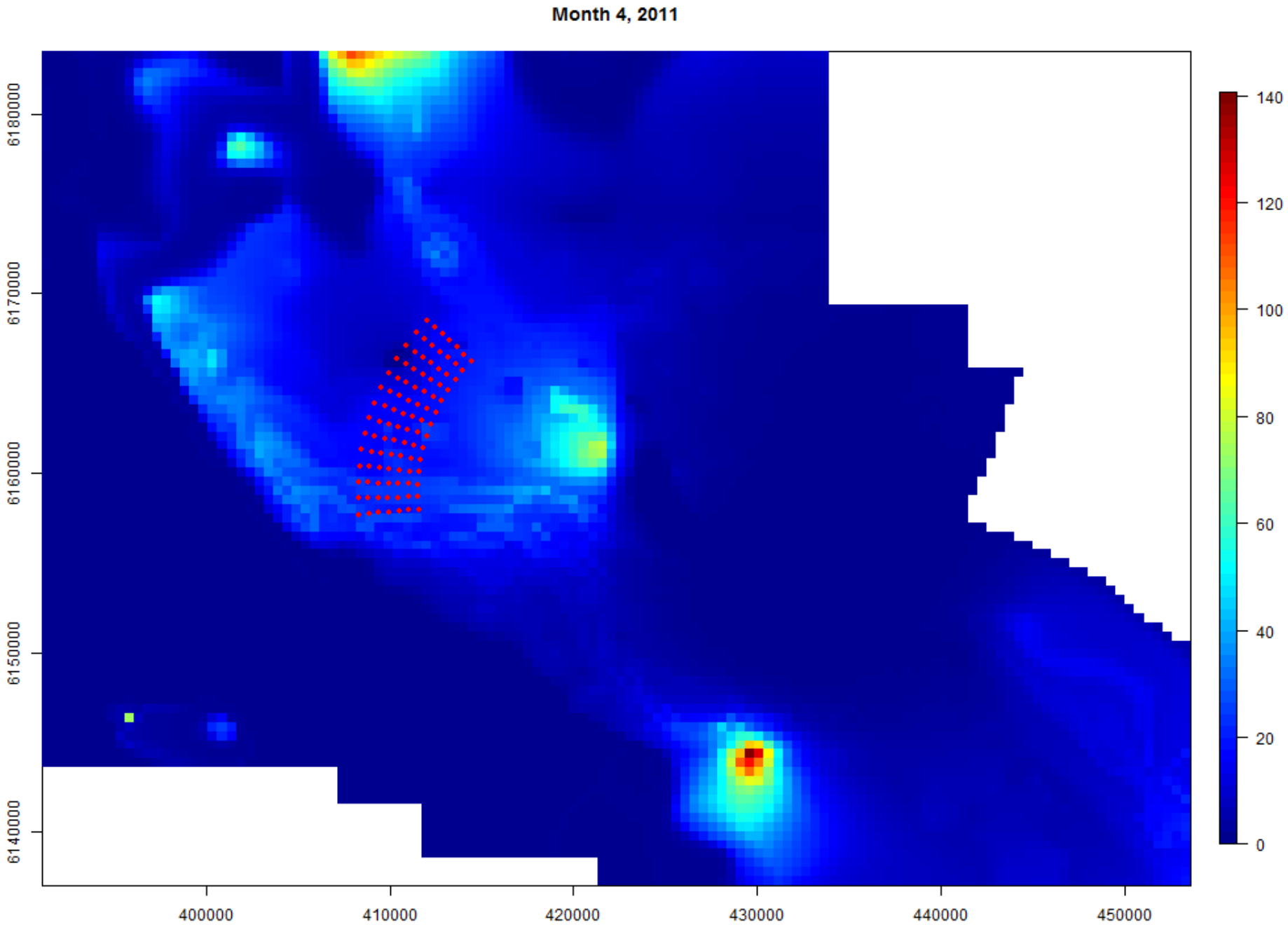
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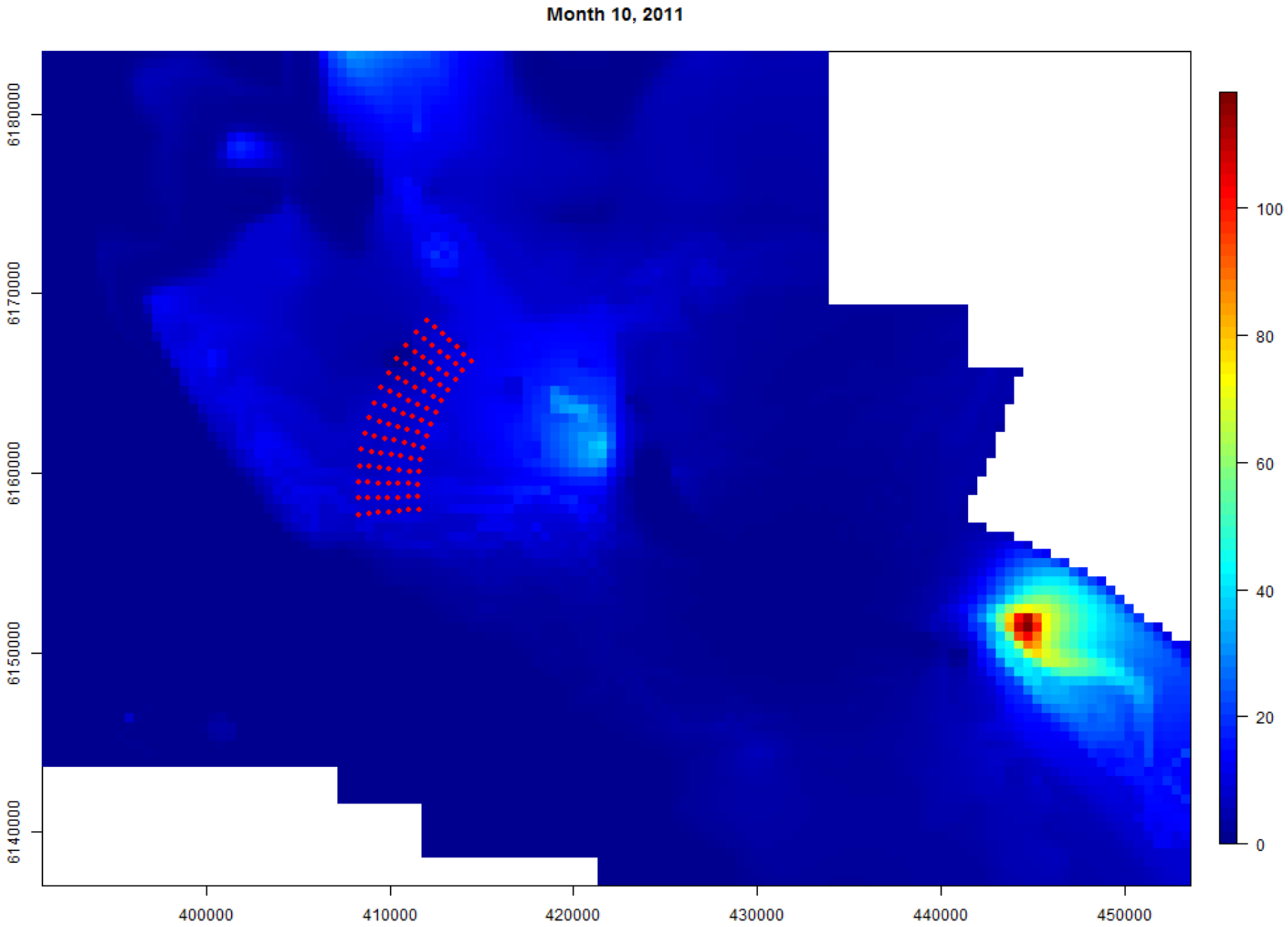
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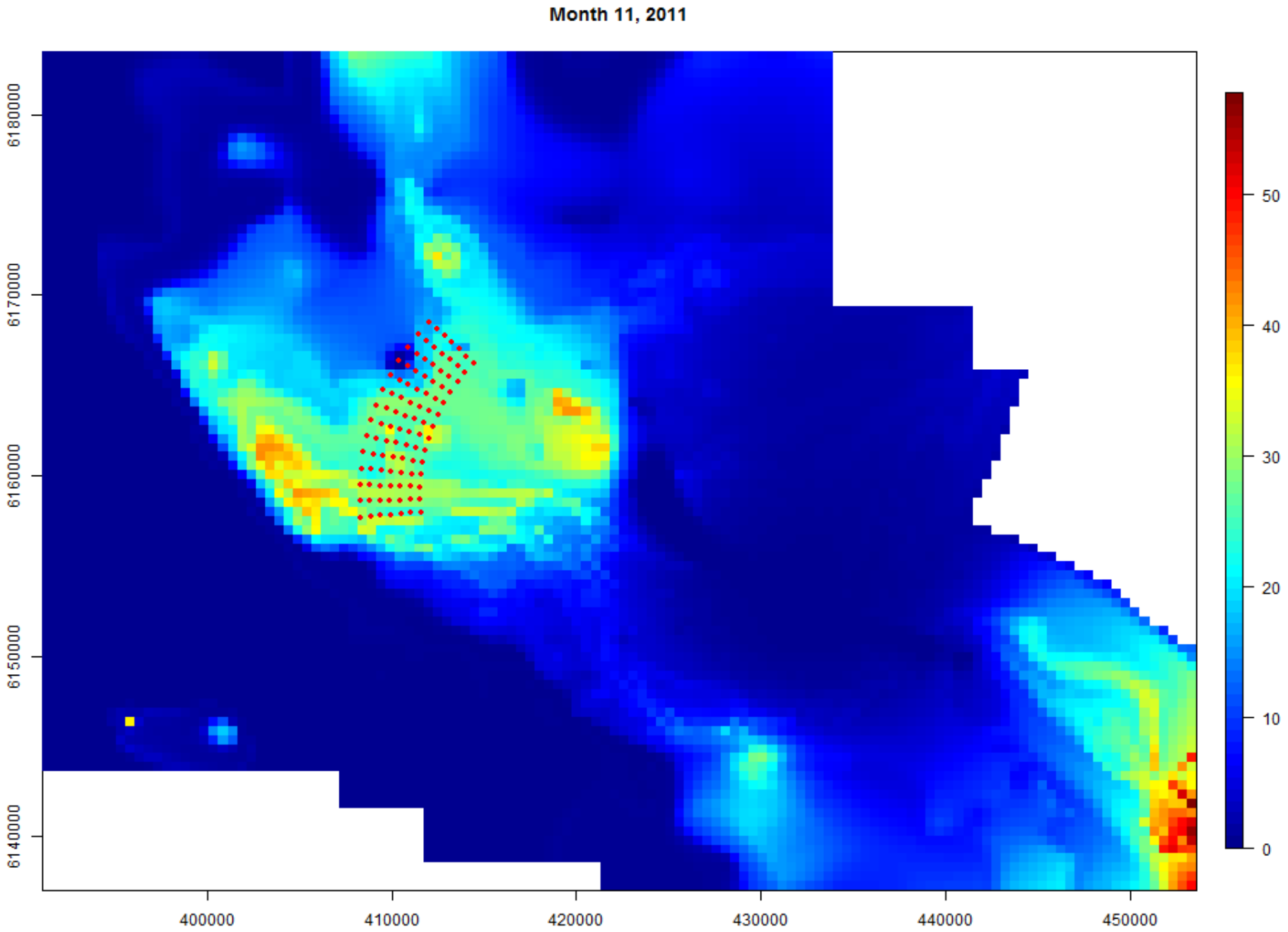
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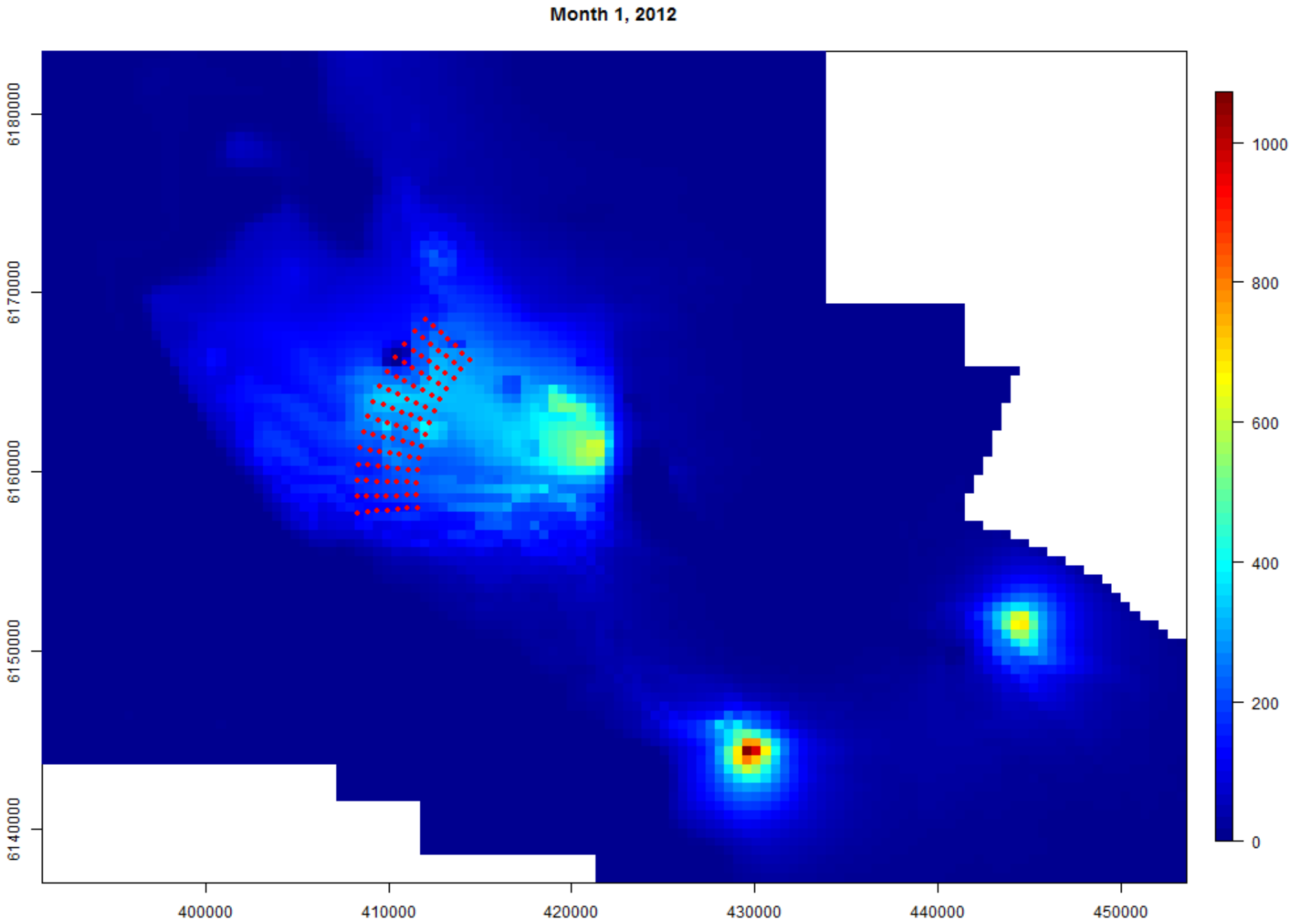
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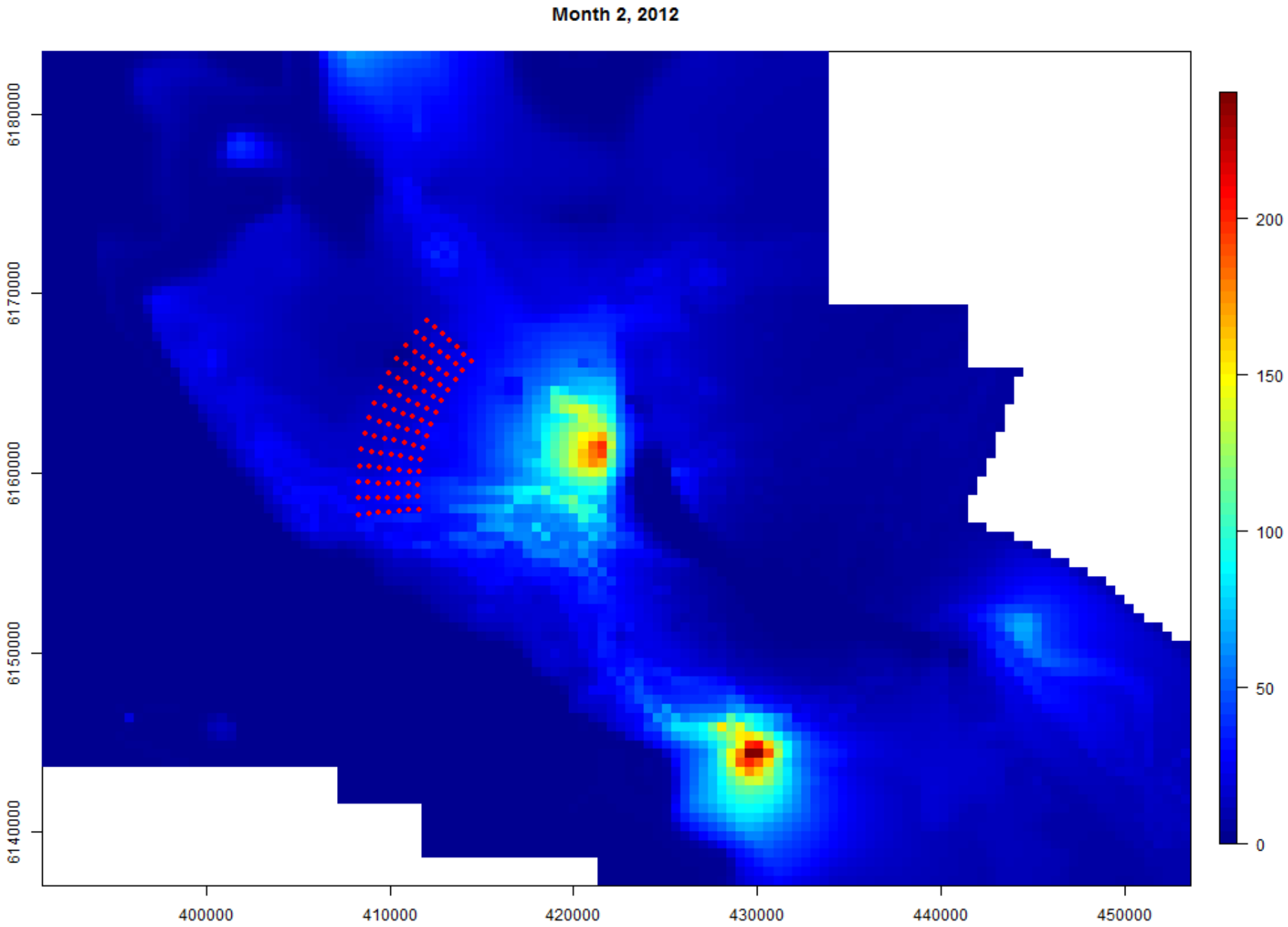
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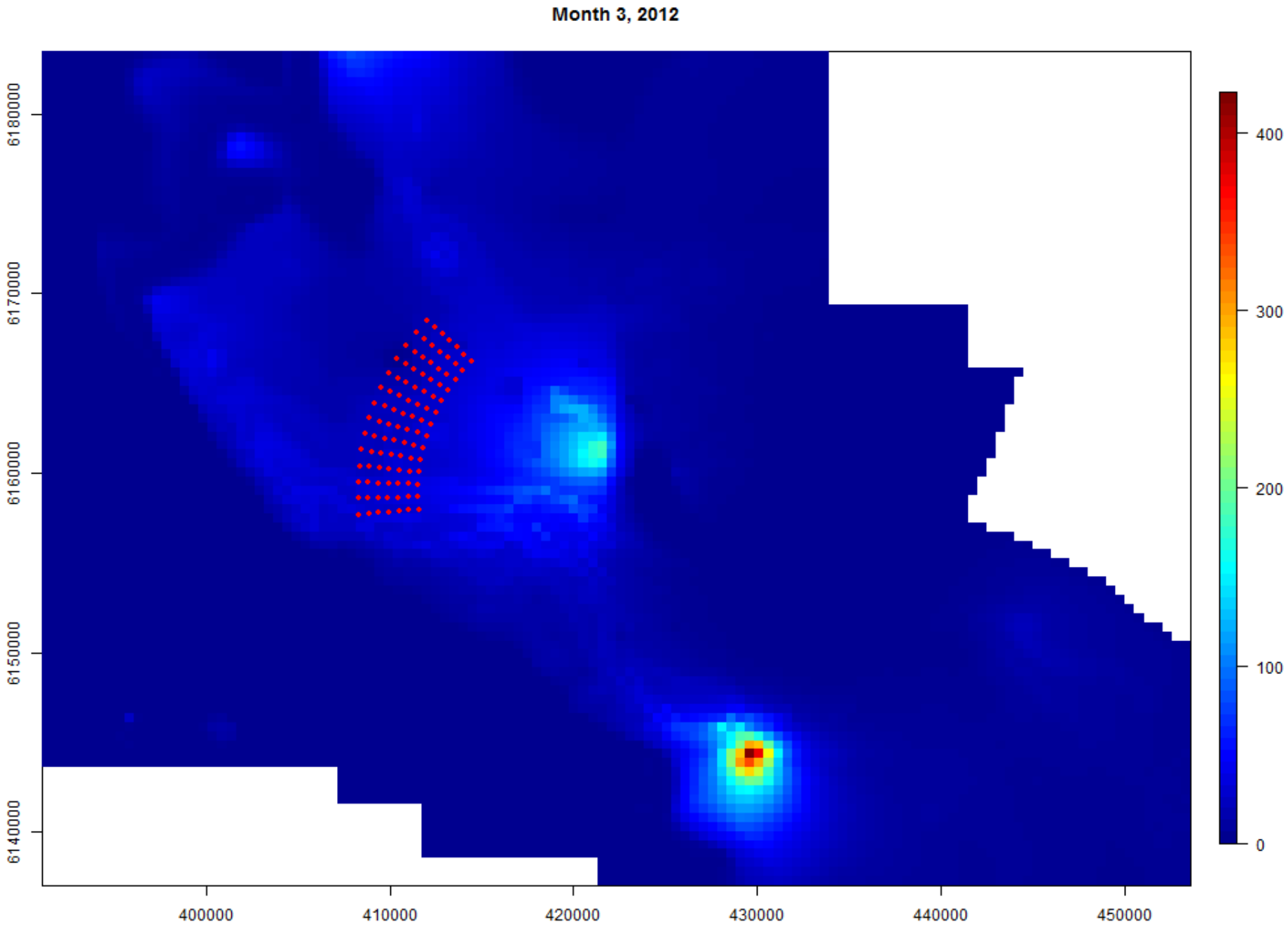
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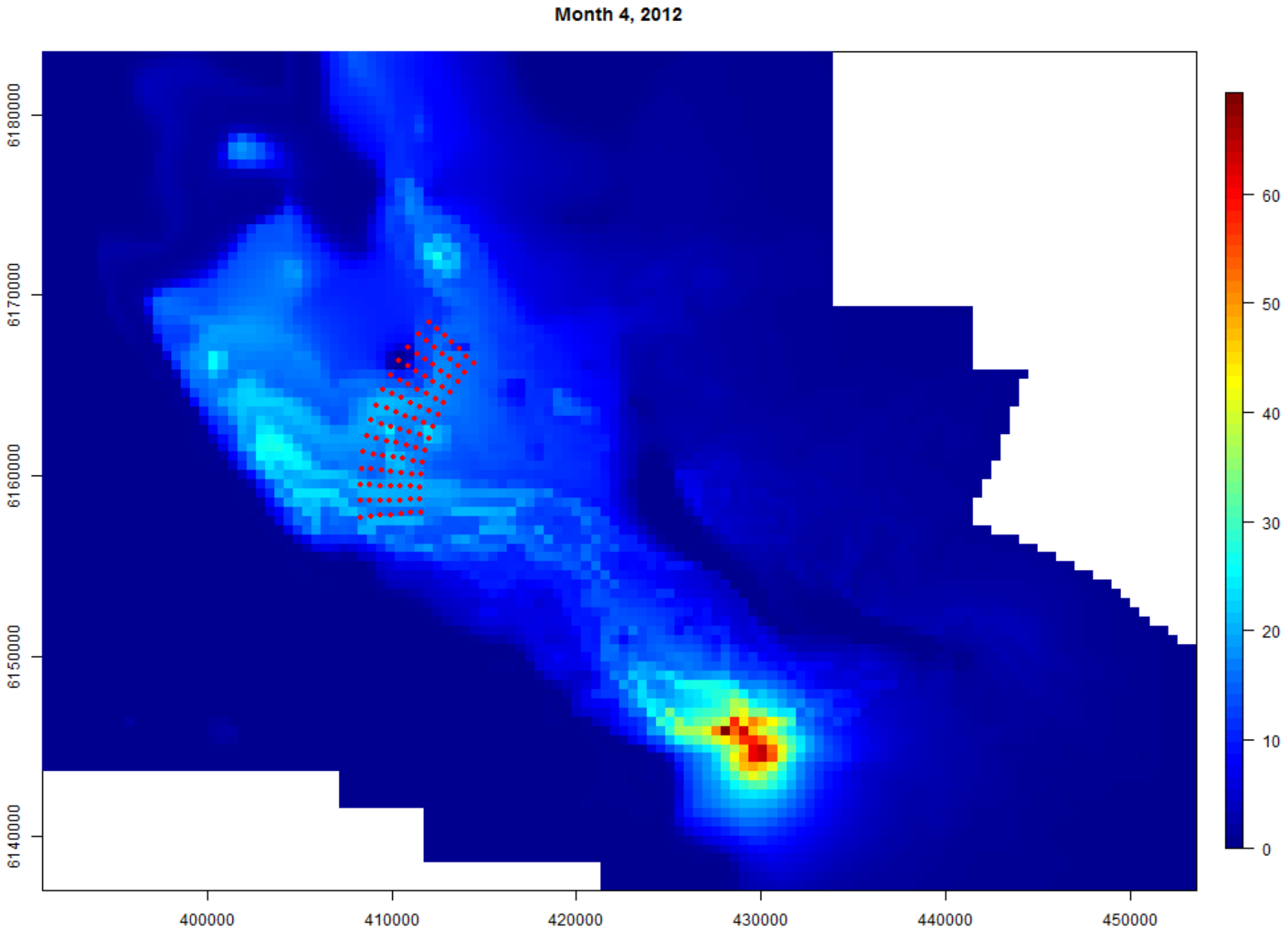
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Red throated diver species

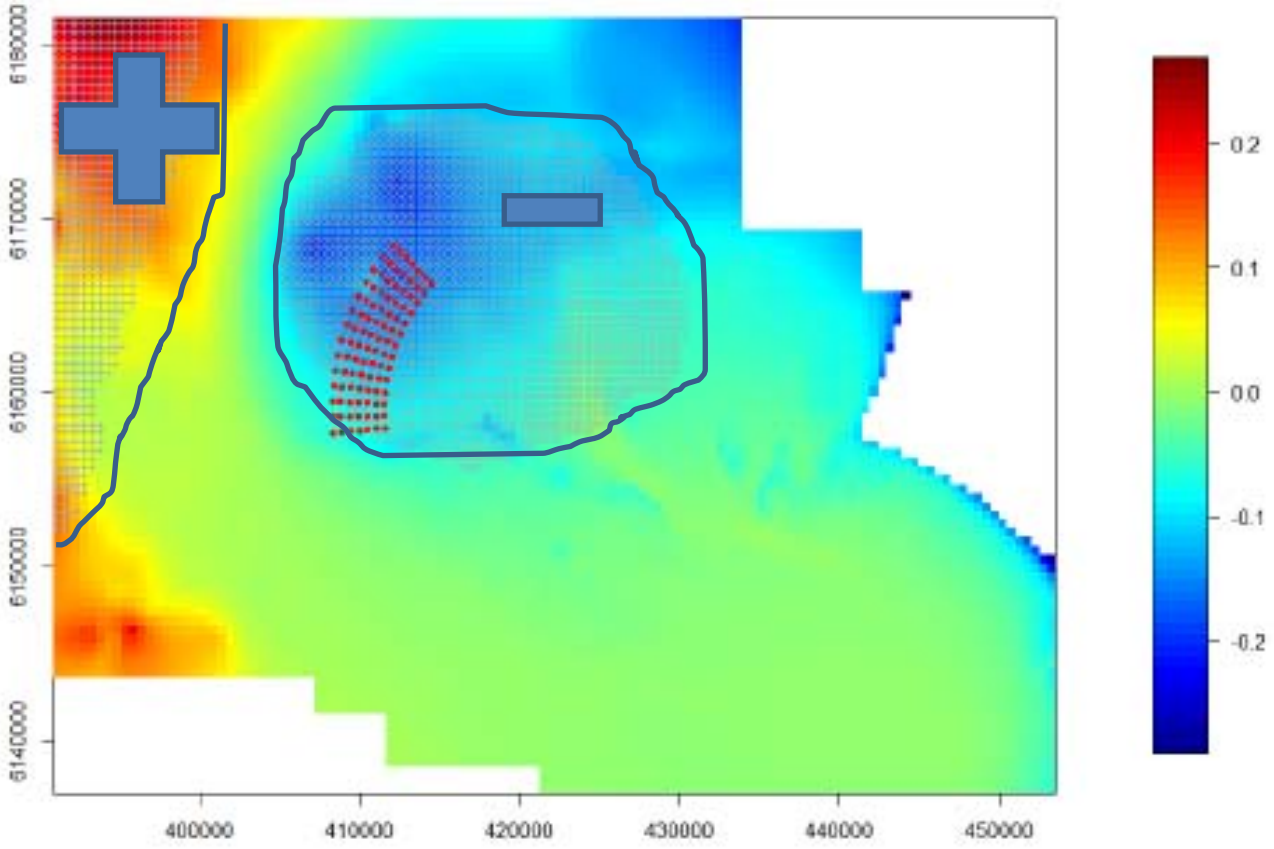
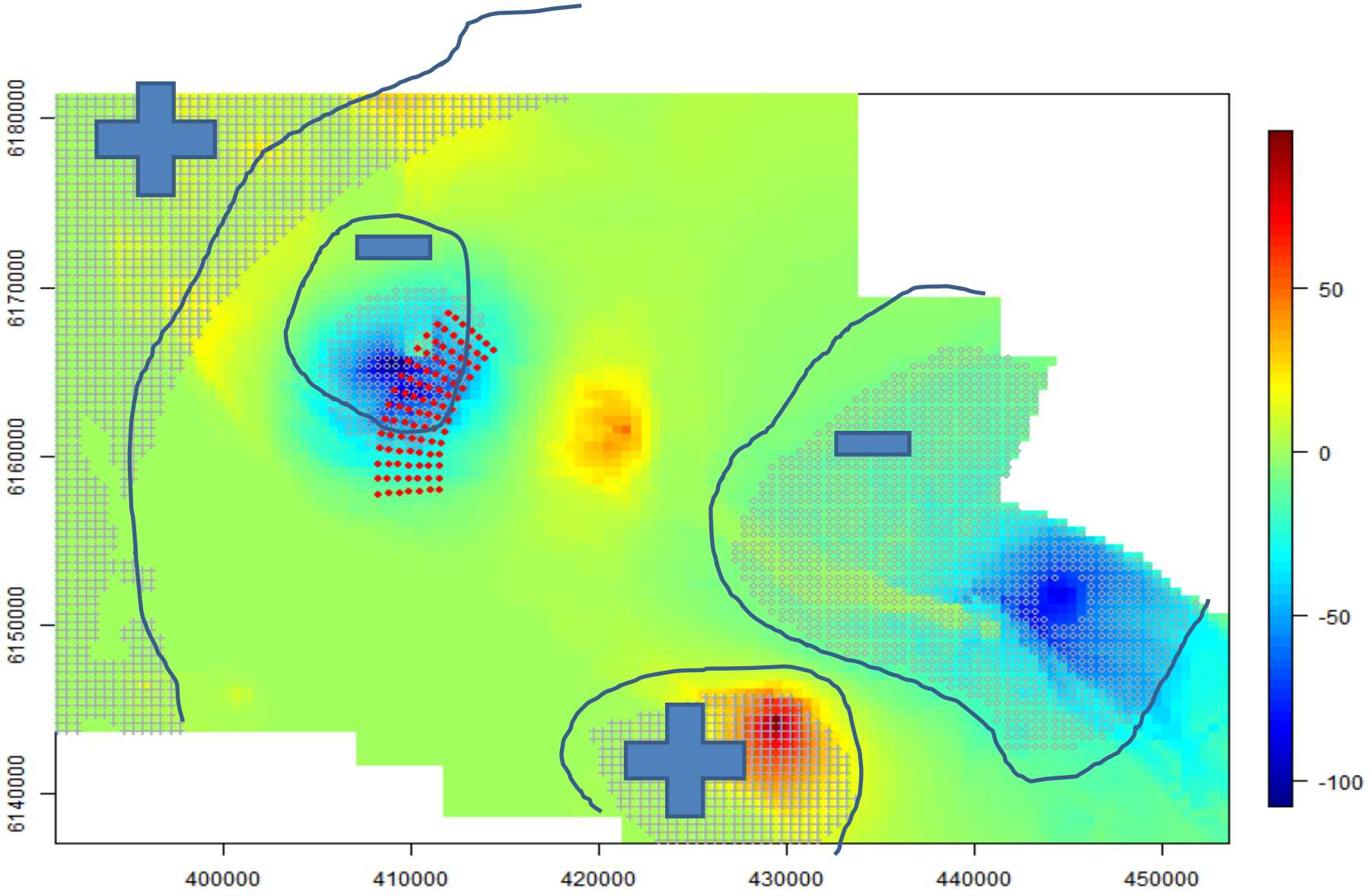


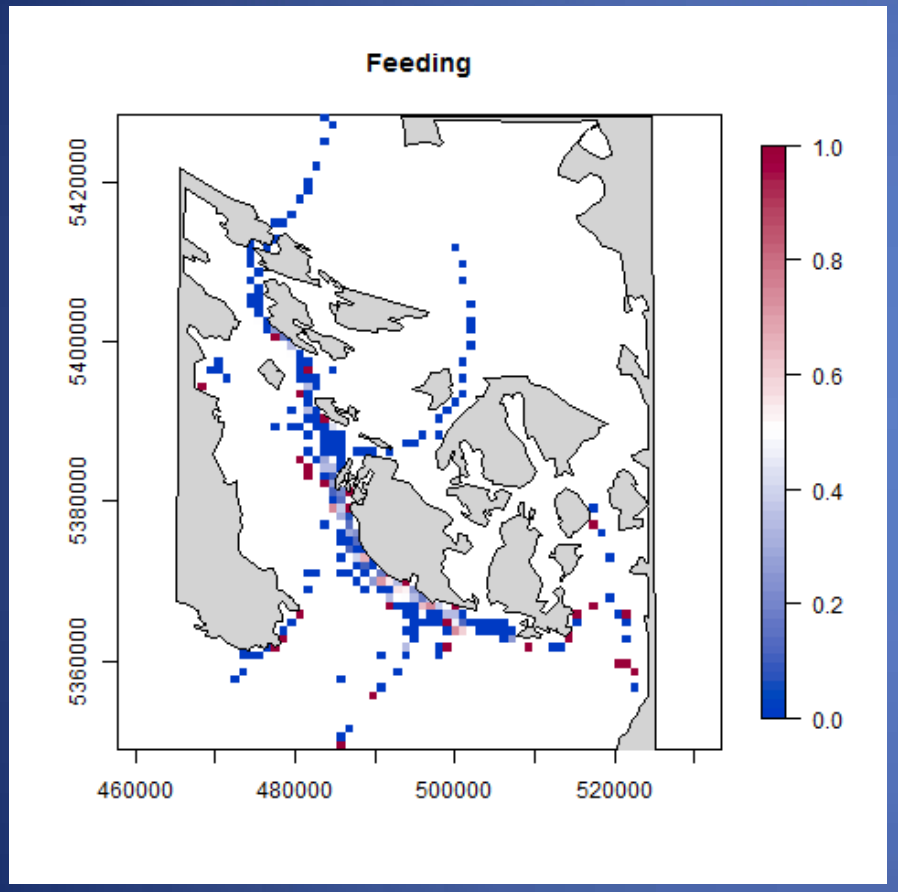
Figure 20: Estimated pre-post impact difference in animal numbers per 0.25km^2 in each grid cell averaged over the survey period with markers for cells which show statistically significant differences; the + signs represent increases while the 0's indicate decreases.

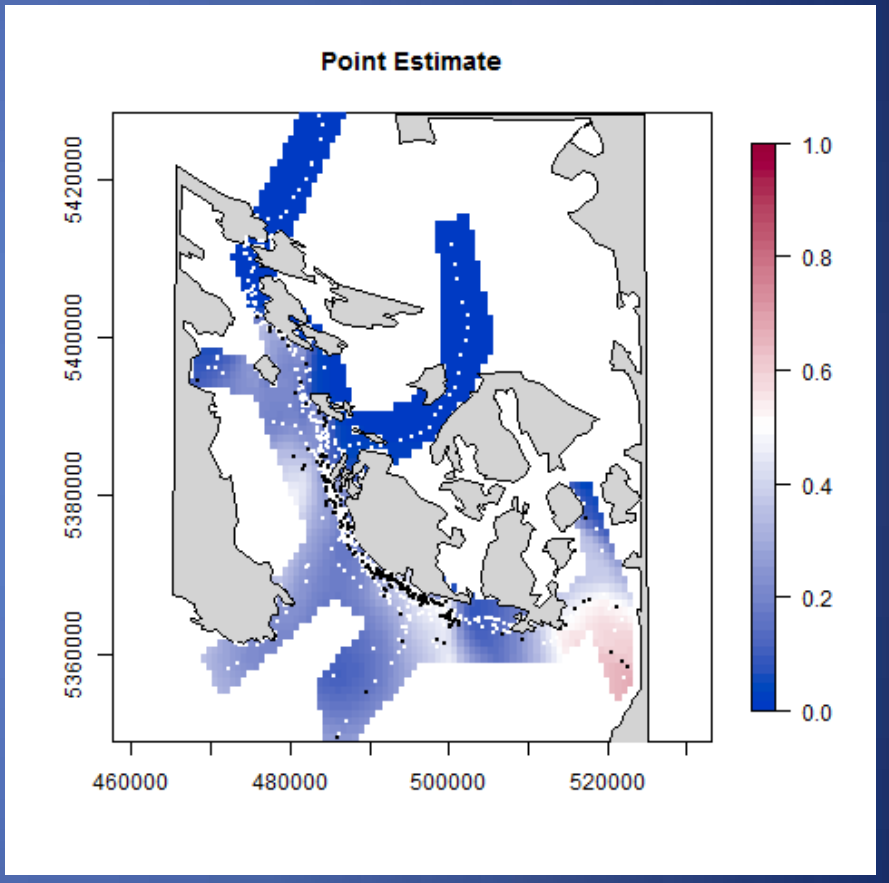
Common Scoters



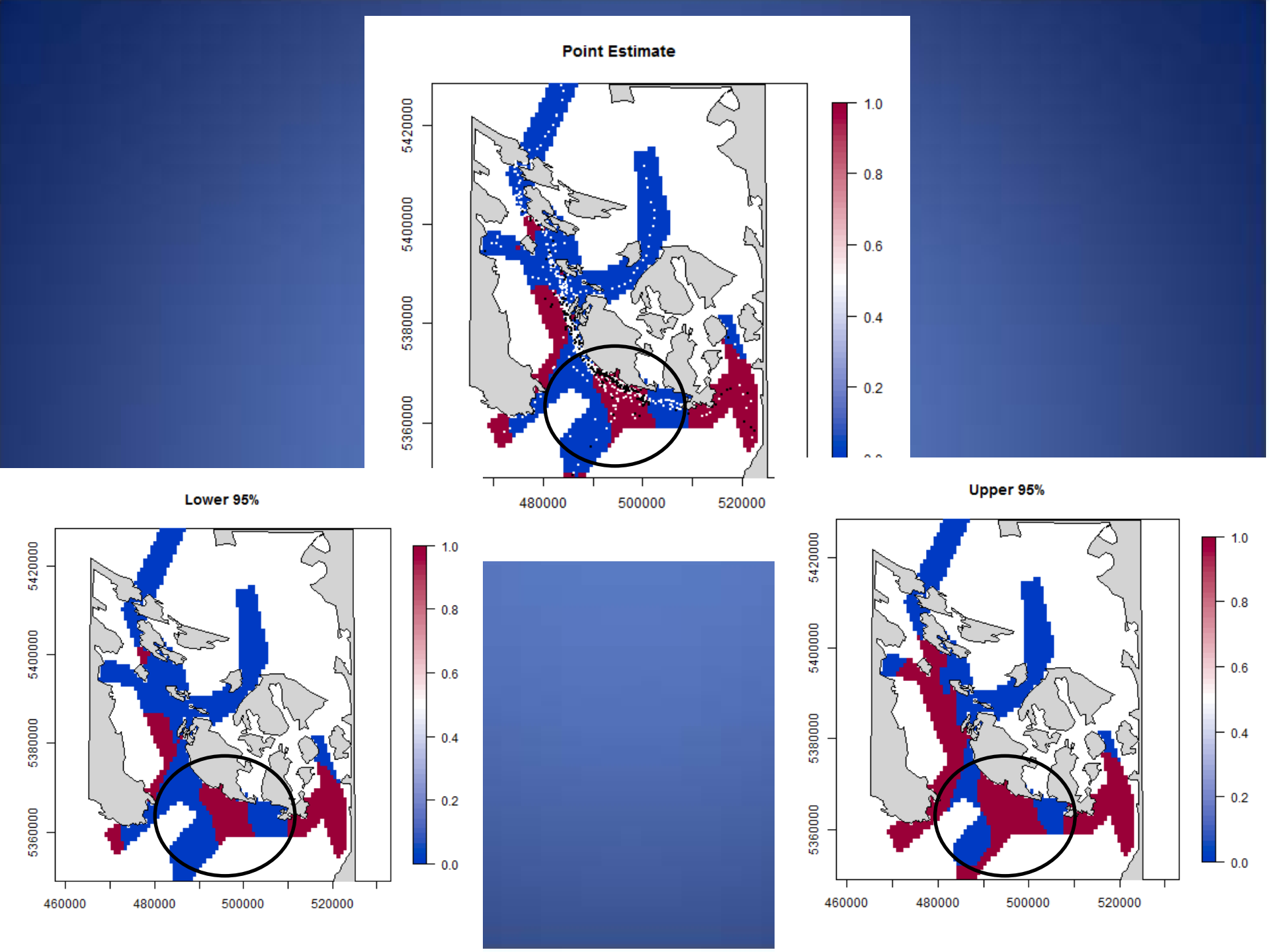
Mapping feeding behaviour using CReSS & GEEs

(2015) Journal of Agricultural, Biological and Ecological Statistics, Accepted.





Modelling the probability of feeding using feeding/not feeding response. The data has 4 behavioural states but only feeding was of interest; multinomial models are also possible here.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Using behaviour maps to delineate zones

- Areas above a certain threshold can be determined as `feeding' using the point estimates alone *or*
- Areas that persist, given the uncertainty, might dictate feeding zones (e.g. breaking the threshold at lower confidence limits).

Quantifying meaningful impacts

- Opportunities:
  - Insights could be gained by combining maps of abundance/distribution and behaviour.
    - Knowing where animals are, and what they are likely to be *doing* when they are there.
    - Considering changes in distribution & behaviour and how this might impact the population.
  - Working towards the quantification of real impacts for the population.
    - We can attempt to `cost' movement away from loafing areas relative to redistribution away from feeding areas.

Quantifying meaningful impacts

- Barriers:
  - Data availability
  - Methodological issues for nominal categorical repeated measures data (e.g. generalized logit models) using off-the-shelf software:
    - The GLIMMIX procedure in SAS
    - The *multgee* package in R (2014)