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East Asia Regional CO_2 Concentrations Observed by GOSAT - Spatial and Seasonal Variations

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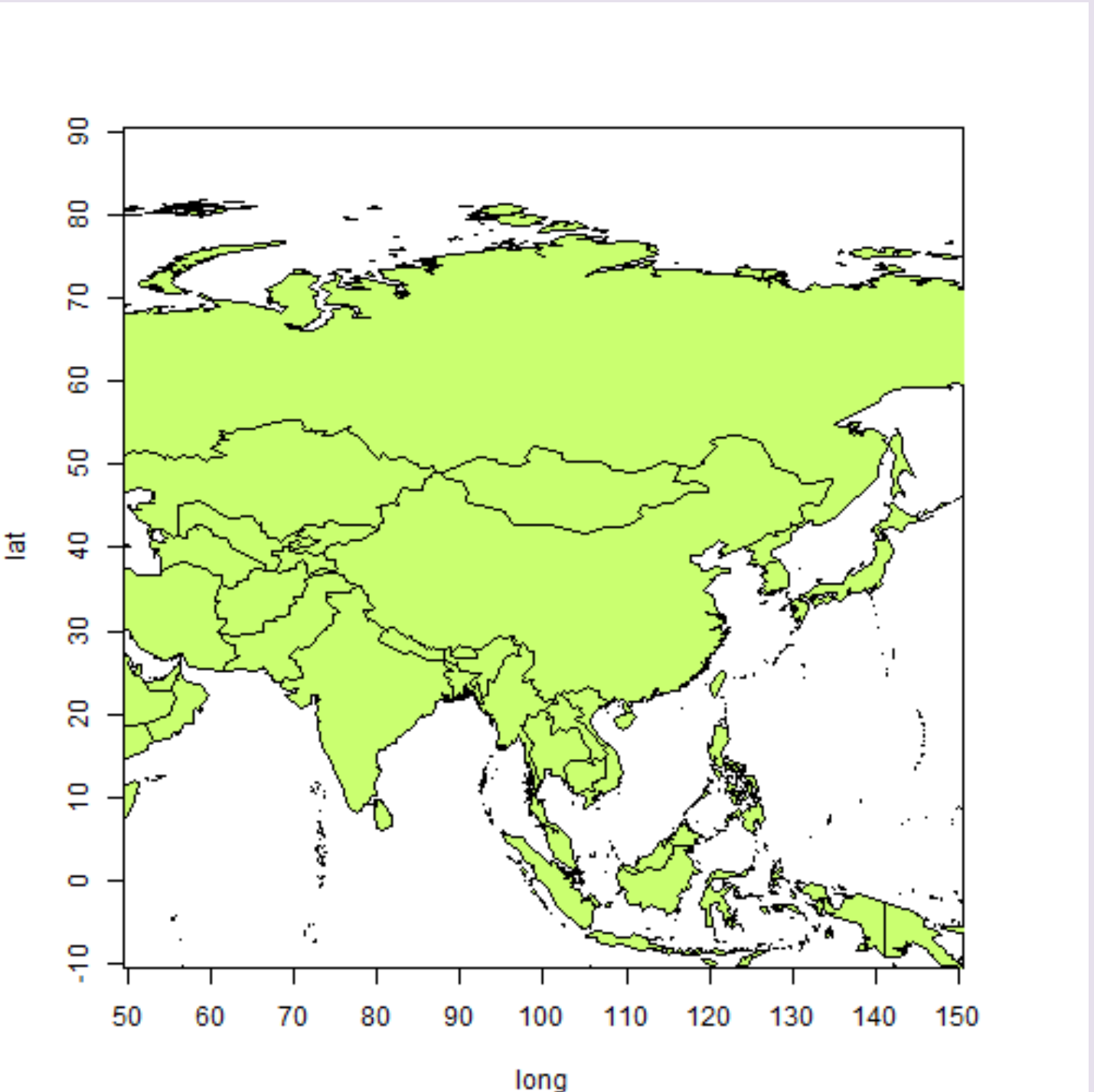
Introduction

- CO2 concentration estimated by GOSAT FTS (XCO2) were collected for the period of 2009 – 2015.
- We focus on analyzing the spatial and seasonal variations of CO2 concentrations in East Asia Region (Longitude E50 – E150, Latitude N90 – S10).

Study Area

- East Asia
  - China
  - Japan
  - Korean Peninsula
  - Mongolia
  - Taiwan
- Period of data collection: 2009 - 2016

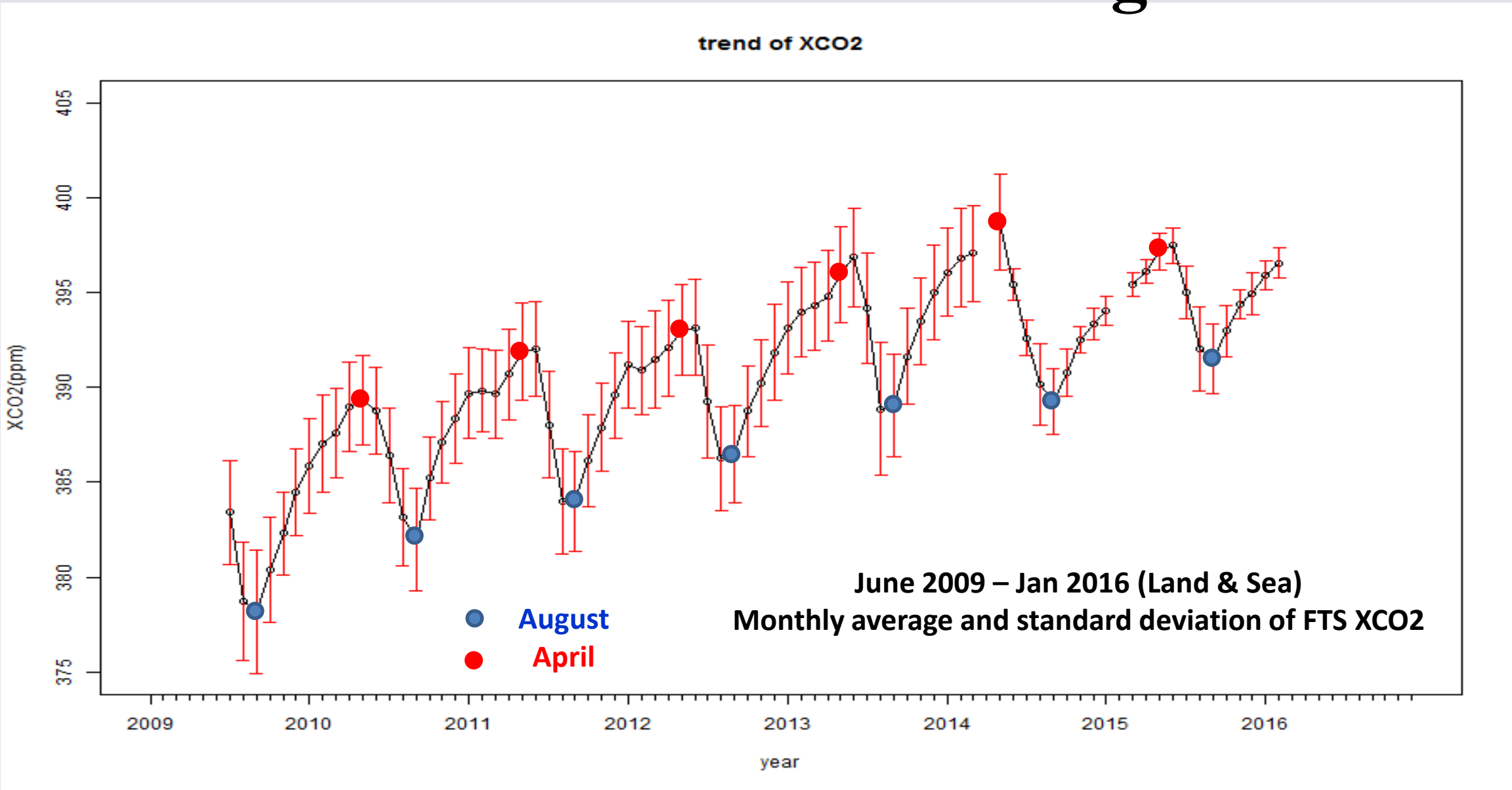


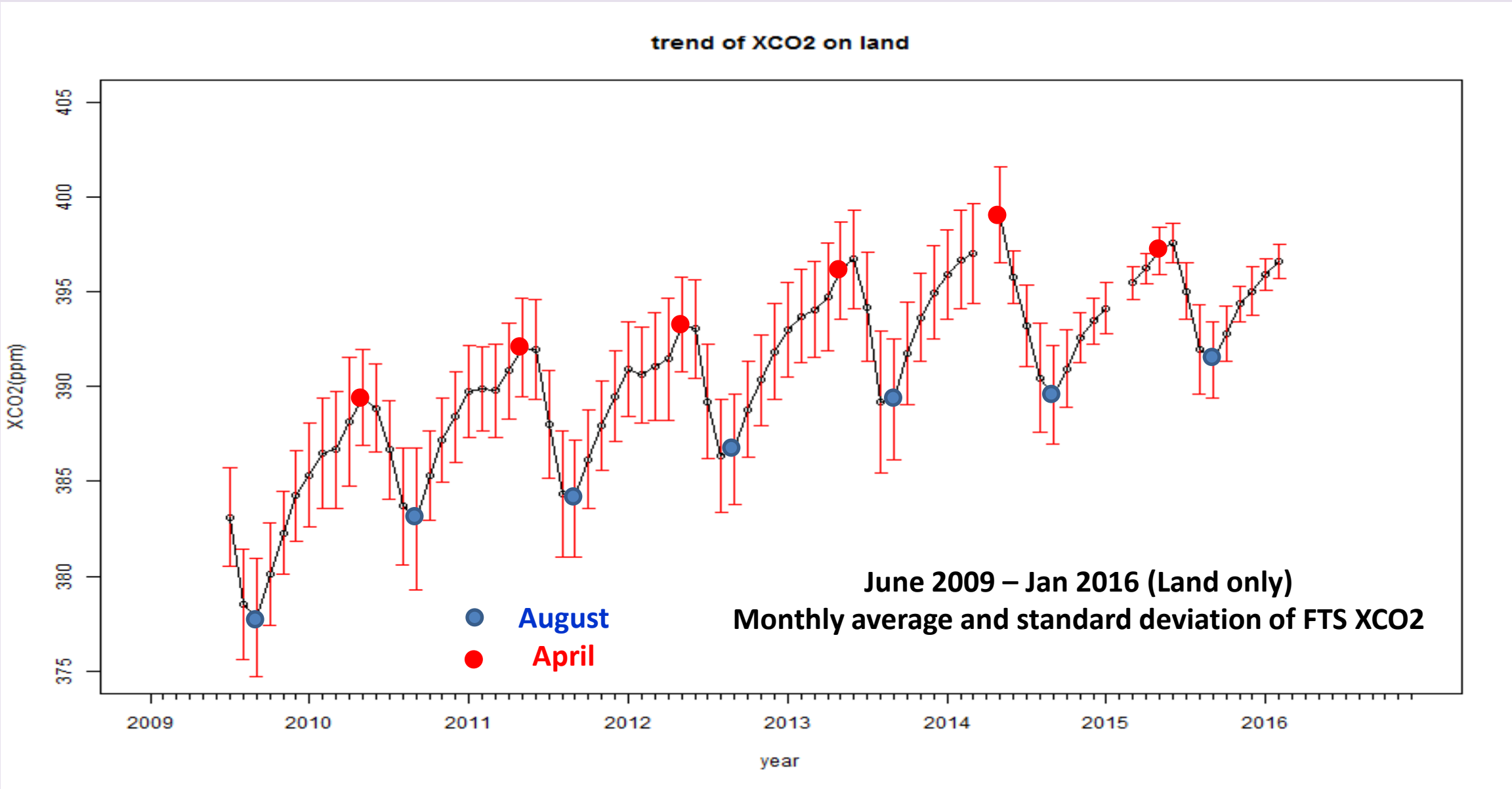
- Spatial resolution of the FTS CO_2 concentration (XCO_2) is 1.5 km by 1.5 km.
- Grid cells of 1°×1° were used in this study. A total of 10201 cells in the study area. (GCO_2: Grid average CO_2 concentration)

FTS XCO2 data availability

Time period	Cells with data	Percentage	Avg # of measurements per cell	Avg CO2 concentration (ppm)	Stdev of CO2 concentration (ppm)	Time period	Cells with data	Percentage	Avg # of measurements per cell	Avg CO2 concentration (ppm)	Stdev of CO2 concentration (ppm)
2009_6,7,8	821	8.05	5	383.3	1	2011_12,1,2	769	7.54	5.6	388.9	1.4
2009_9,10,11	1426	13.98	4.1	381.8	1.7	2012_3,4,5	299	2.93	5.1	392.3	0.9
2009_12,1,2	1211	11.87	4.5	384.5	1.3	2012_6,7,8	556	5.45	3.4	393	0.8
2010_3,4,5	545	5.34	4.2	388.7	1	2012_9,10,11	559	5.48	4.5	387.9	1.5
2010_6,7,8	851	8.34	3.4	389.2	0.7	2012_12,1,2	838	8.21	5	392.2	1.4
2010_9,10,11	984	9.65	3.4	384.5	1.2	2013_3,4,5	331	3.24	5.2	395.2	1
2010_12,1,2	791	7.75	5.9	387.7	1.3	2013_6,7,8	754	7.39	3.6	396	0.8
2011_3,4,5	373	3.66	5.6	390.5	1	2013_9,10,11	653	6.4	4.1	391	1.6
2011_6,7,8	741	7.26	3.7	391.6	0.9	2013_12,1,2	729	7.15	4.5	394.4	1.1
2011_9,10,11	581	5.7	3.8	385.7	1.3	2014_3,4,5	538	5.27	3.3	398.7	0.6

Trend and Seasonal Variation of XCO2 in the East Asia Region




trend of XCO2 on land
XCO2(ppm)
375
380
385
390
395
400
405
2009
2010
2011
2012
2013
2014
2015
2016
year
August
April
June 2009 – Jan 2016 (Land only)
Monthly average and standard deviation of FTS XCO2

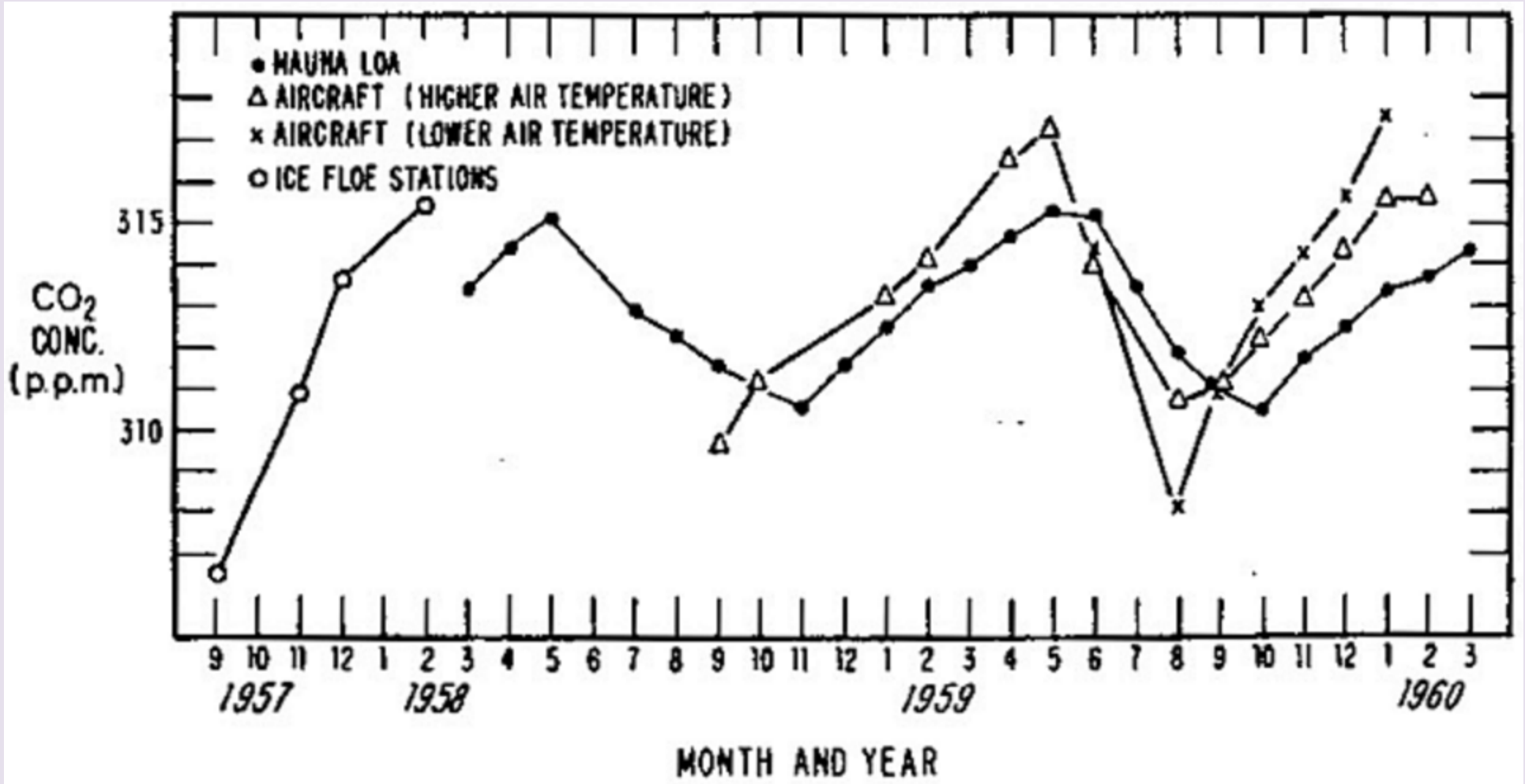
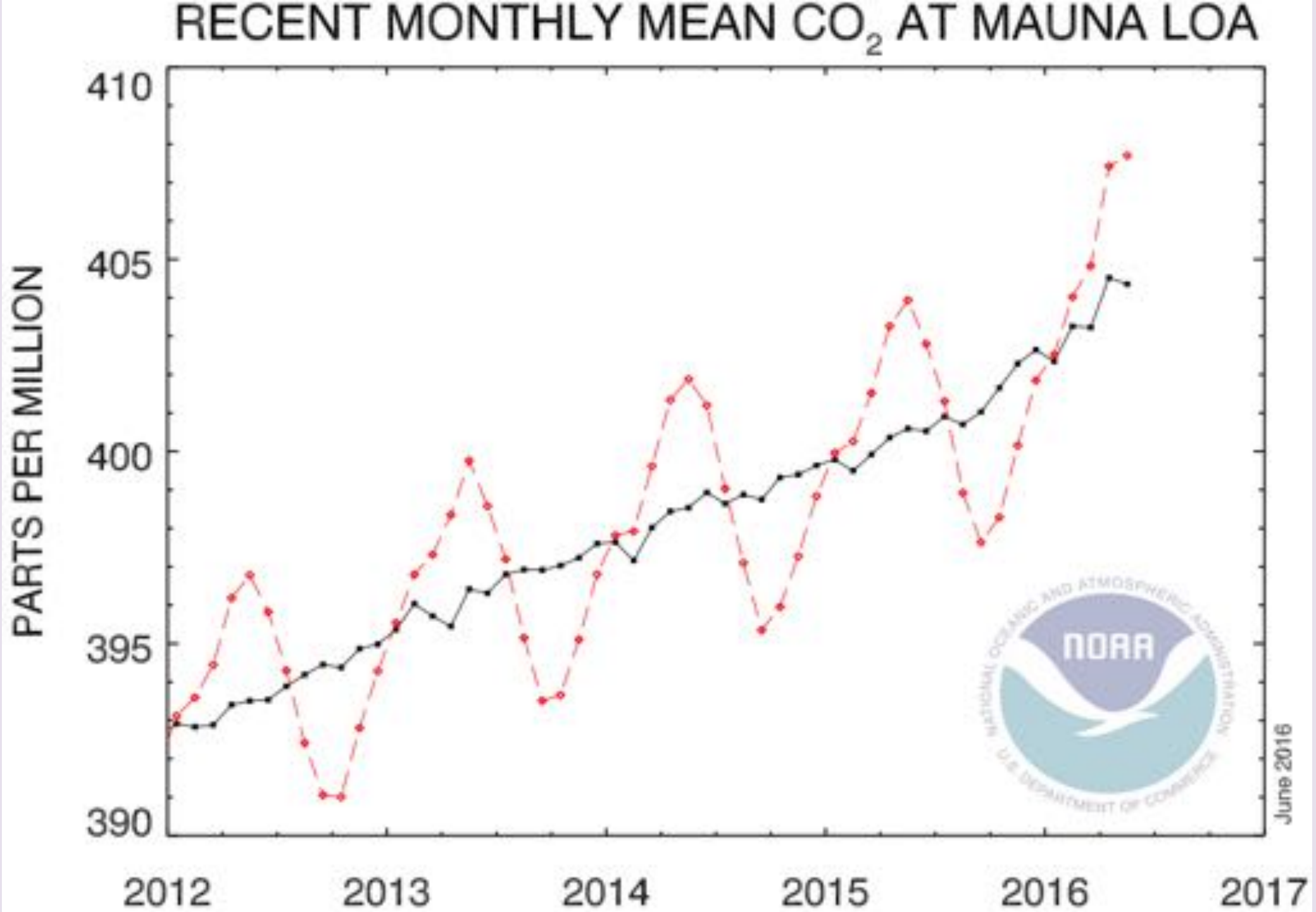
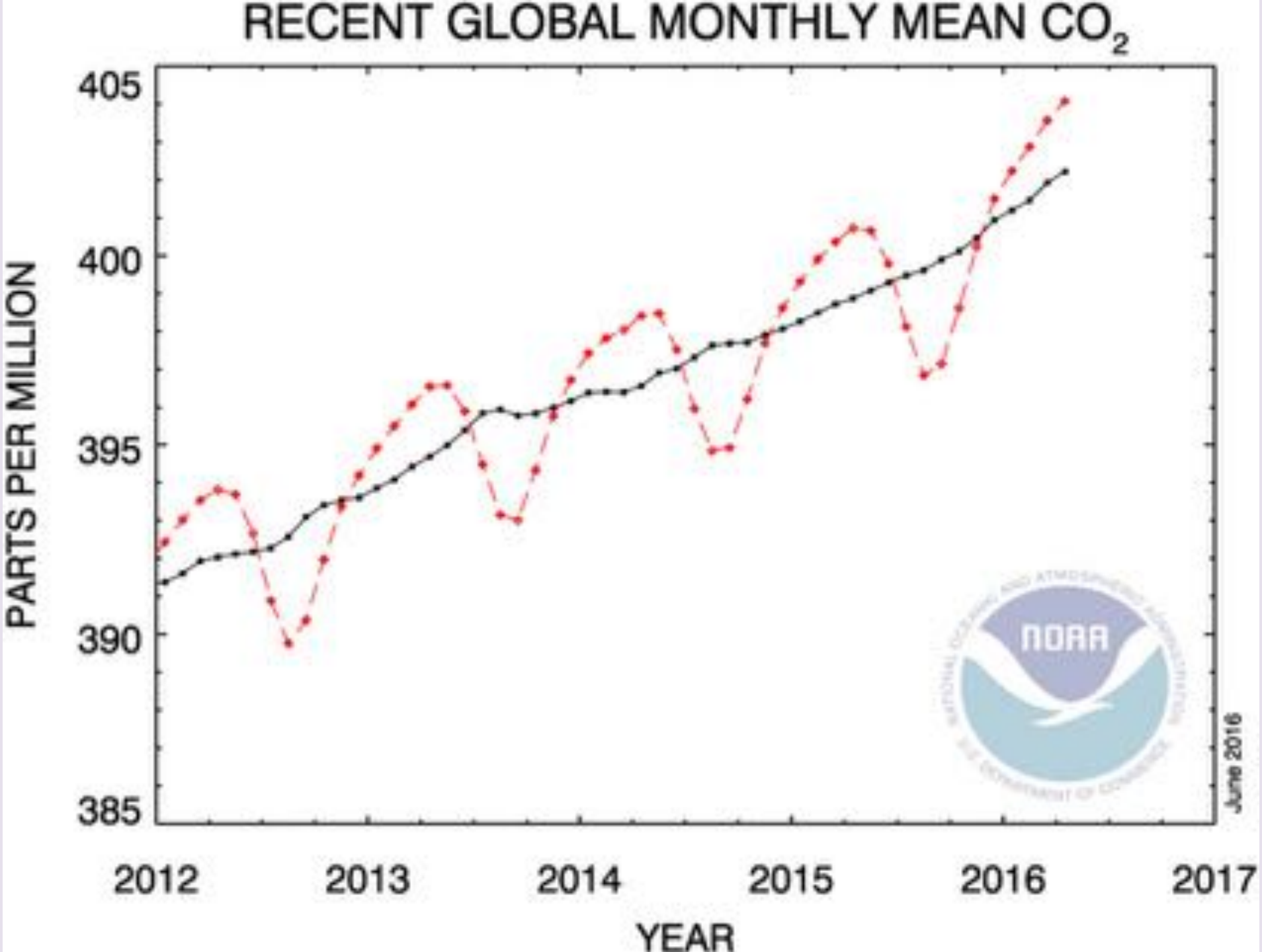


Fig. 1. Variation in concentration of atmospheric carbon dioxide in the Northern Hemisphere.

Tellus XII (1960), 2

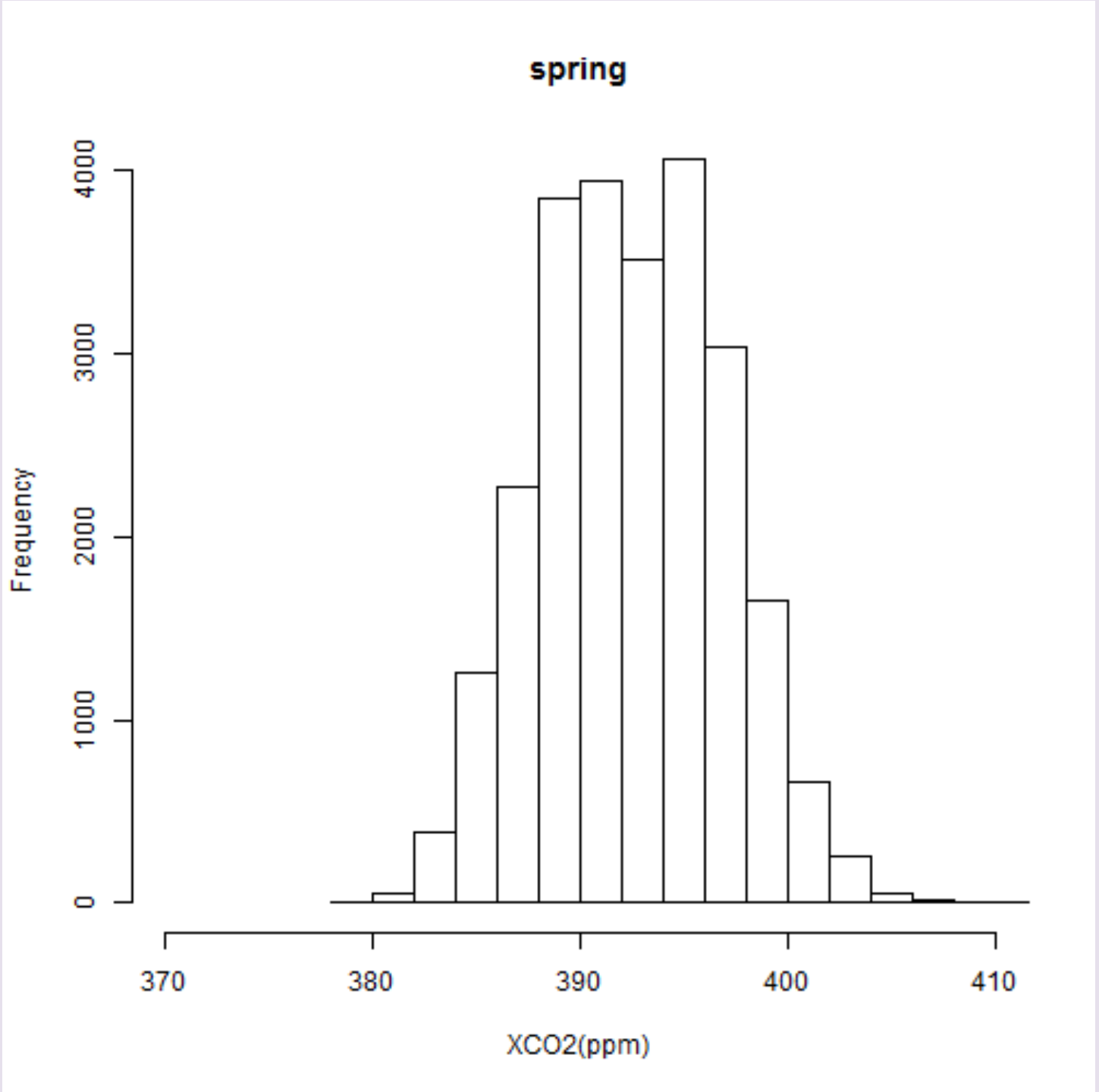

RECENT MONTHLY MEAN CO_2 AT MAUNA LOA
PARTS PER MILLION
410
405
400
395
390
2012
2013
2014
2015
2016
2017
NOAA
June 2016

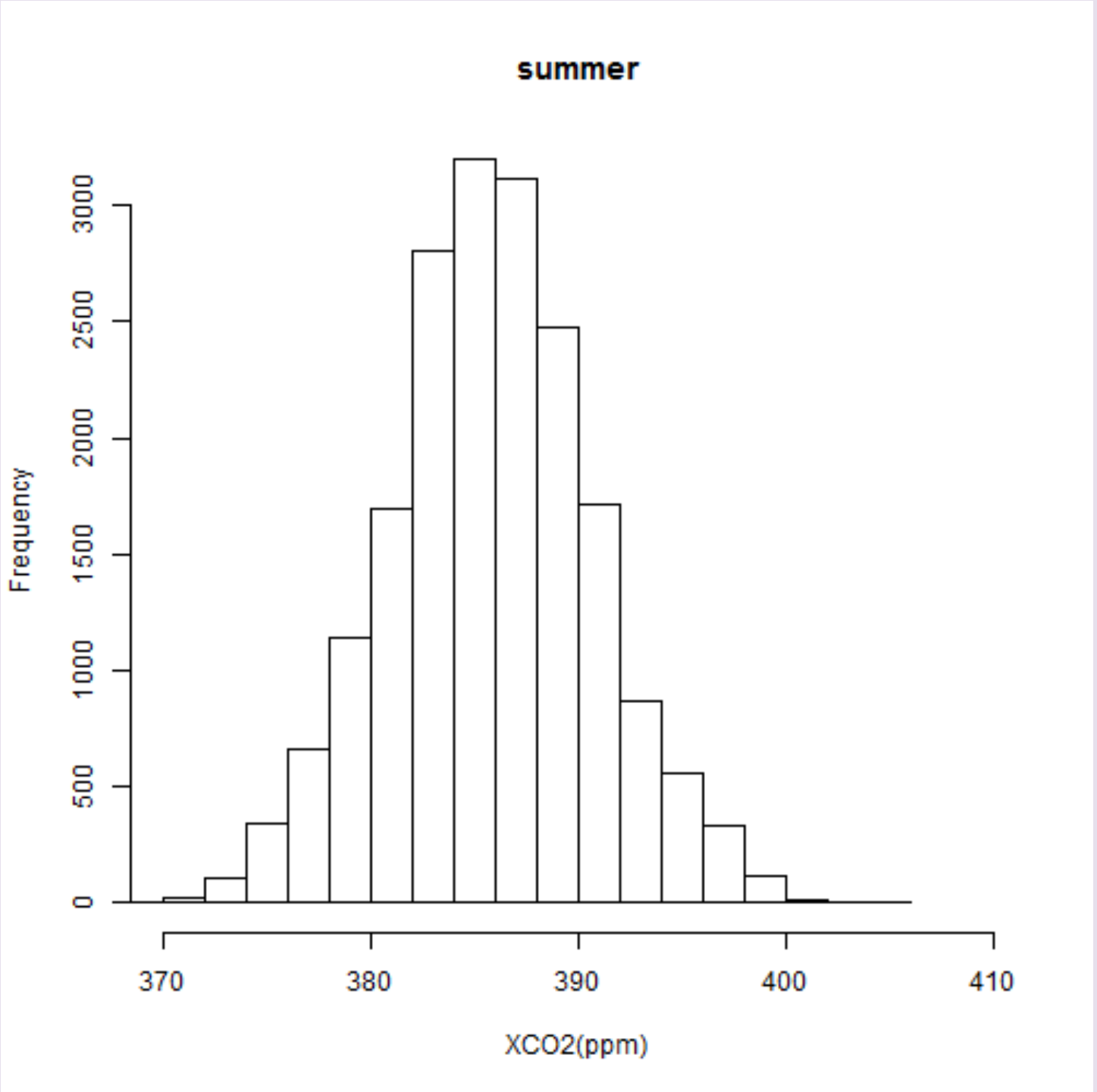

RECENT GLOBAL MONTHLY MEAN CO_2
405
400
395
390
385
PARTS PER MILLION
2012
2013
2014
2015
2016
2017
YEAR
NOAA
June 2016

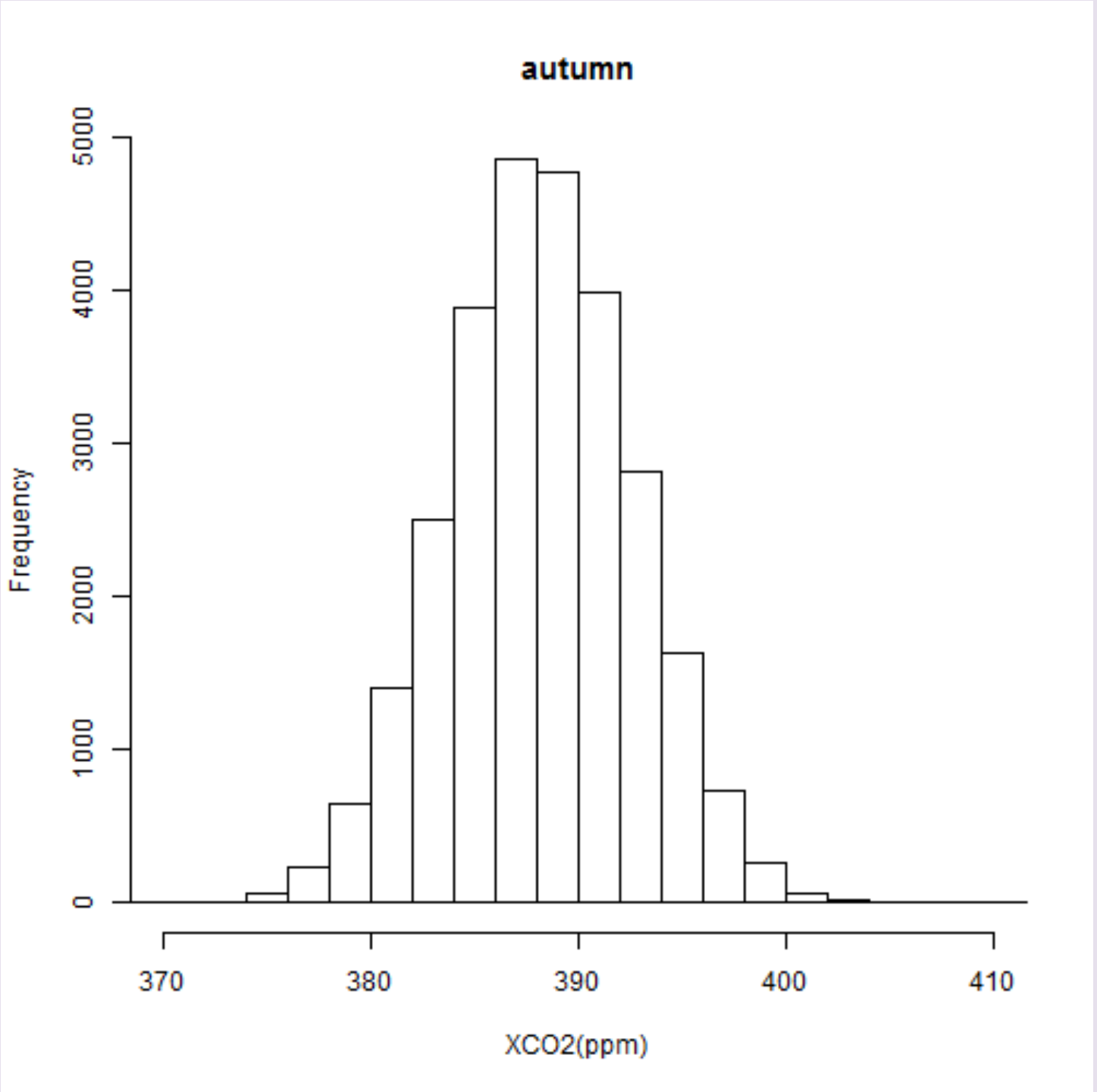
Seasonal Variation of FTS XCO2

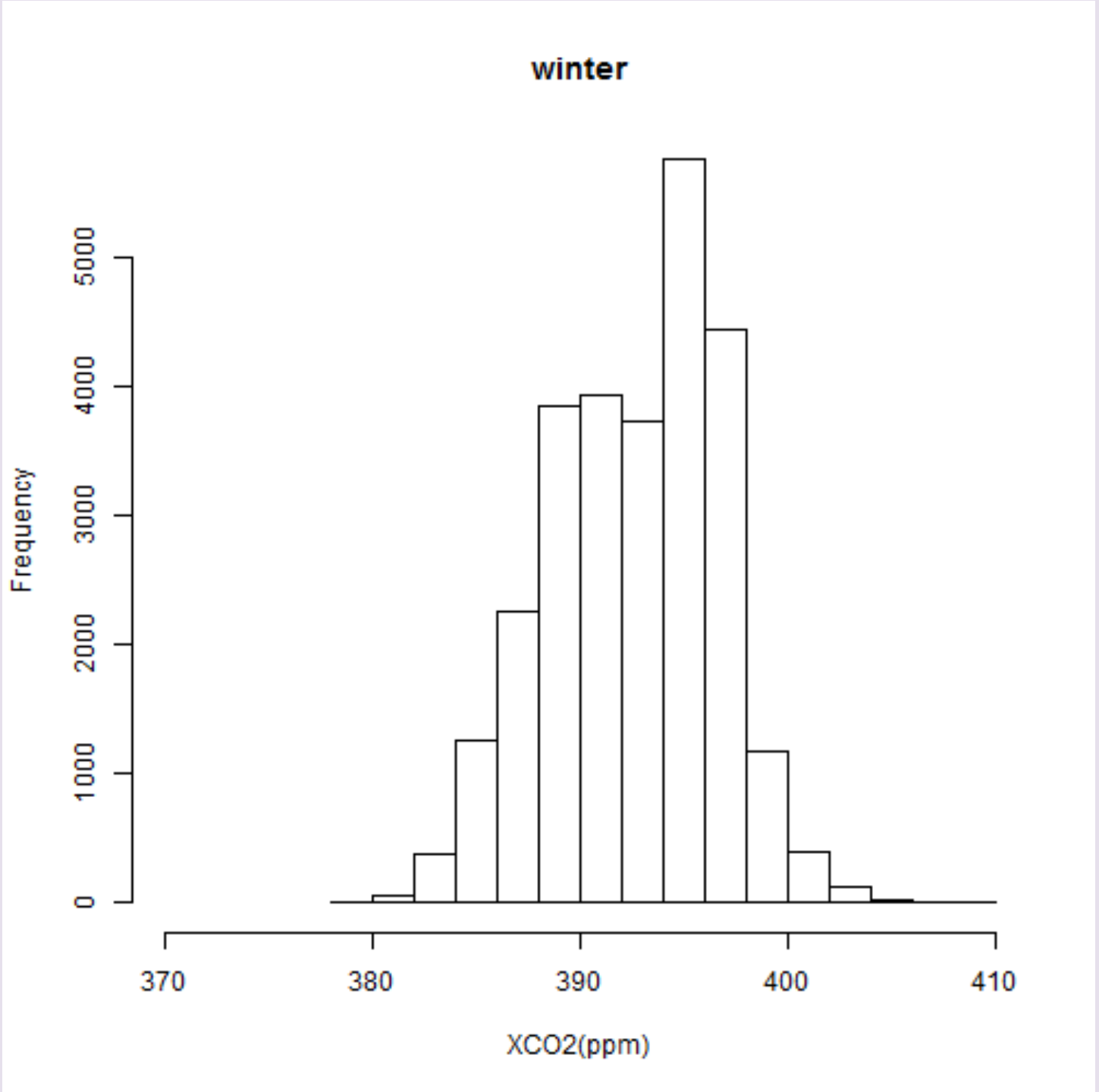
season	mean	sd
spring	392.4977	4.360145
summer	385.8039	4.903655
autumn	388.1570	4.458877
winter	392.6235	4.055581

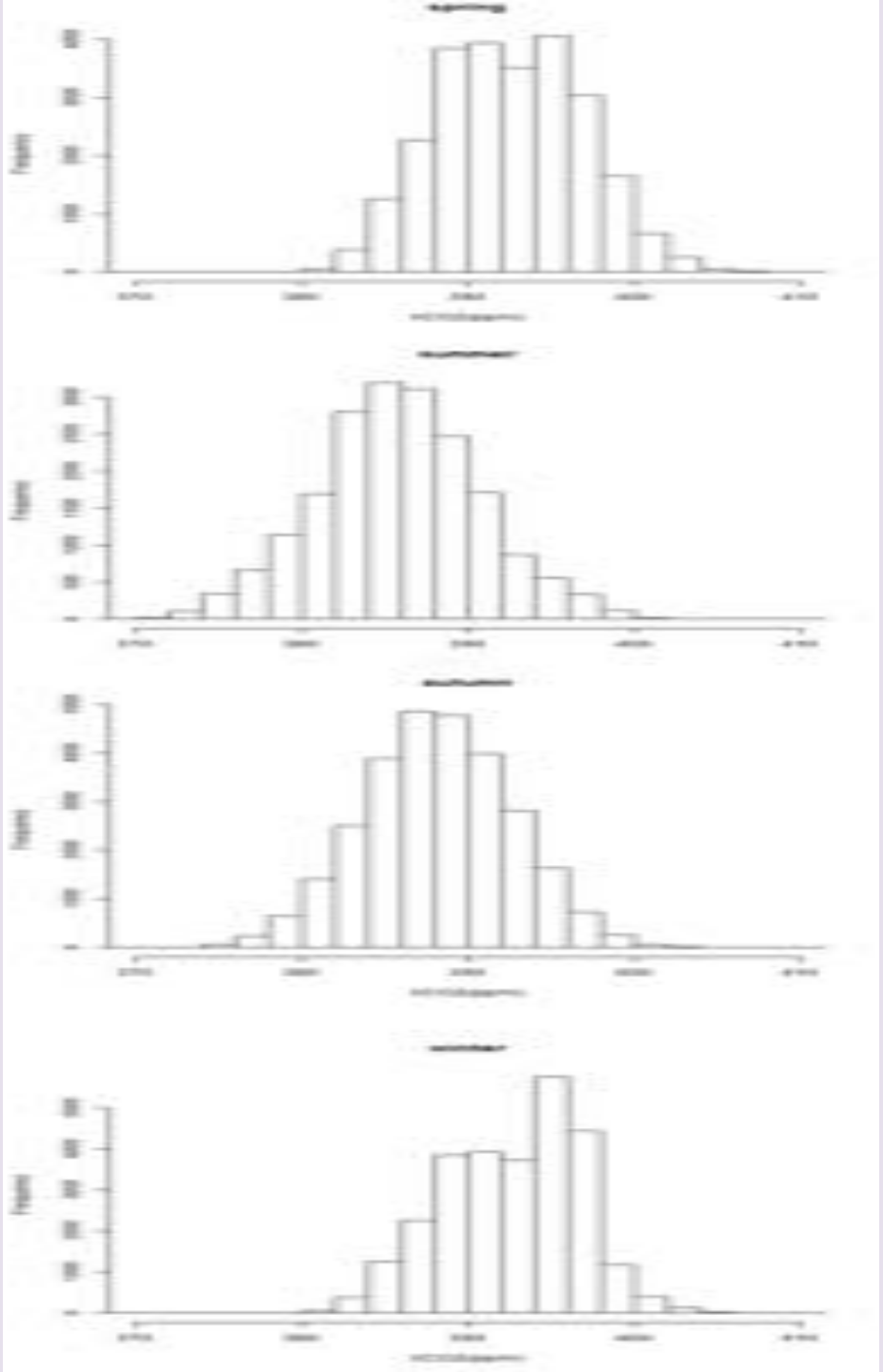
Spring: March – May
Summer: June – August
Autumn: September – November
Winter: December - February


spring
Frequency
0
1000
2000
3000
4000
370
380
390
400
410
XCO2(ppm)

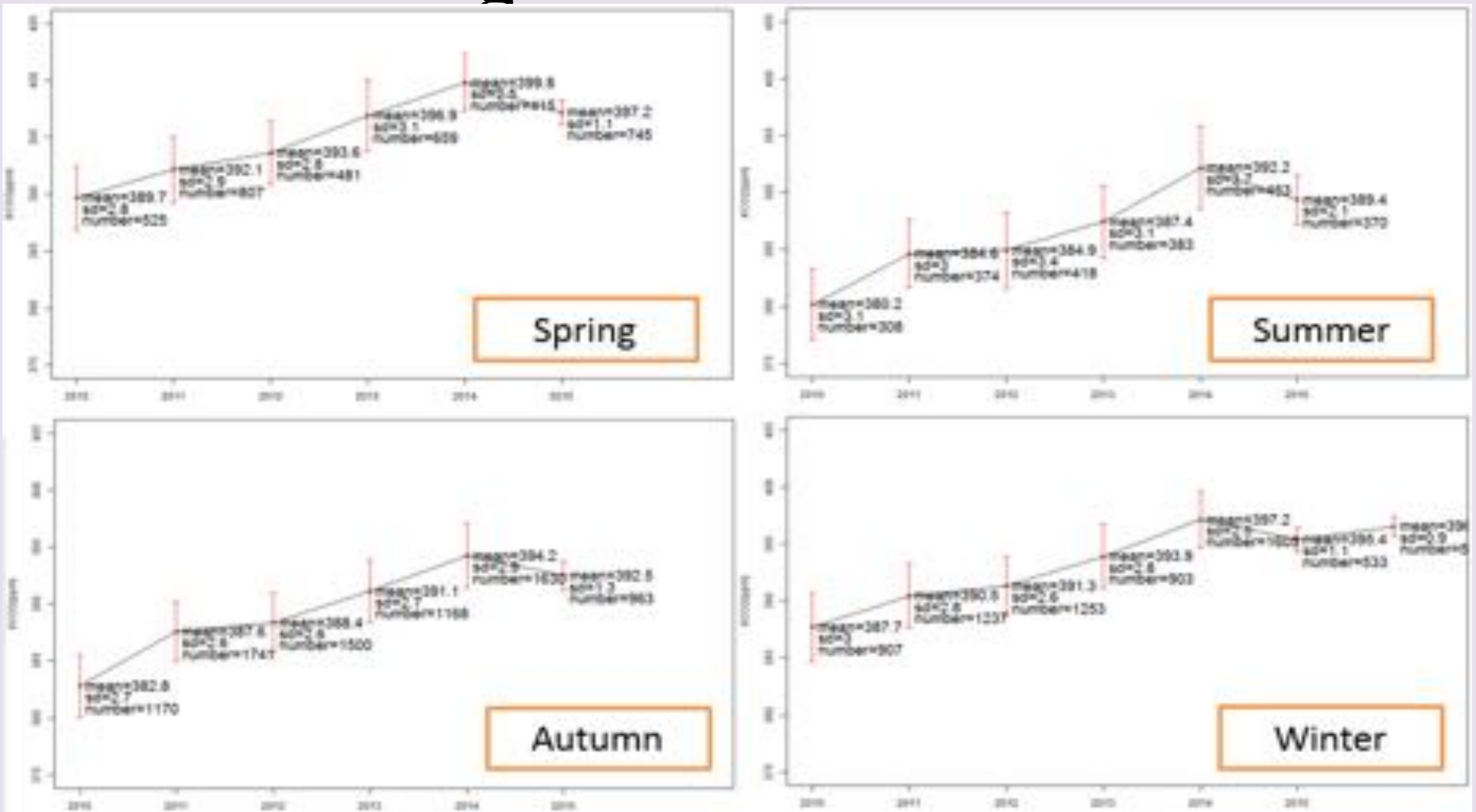

summer
Frequency
0
500
1000
1500
2000
2500
3000
370
380
390
400
410
XCO2(ppm)


autumn
Frequency
0
1000
2000
3000
4000
5000
370
380
390
400
410
XCO2(ppm)


winter
Frequency
0
1000
2000
3000
4000
5000
370
380
390
400
410
XCO2(ppm)



Increasing trend of seasonal XCO2



- These latitudinal differences in fluctuation are the result of photosynthetic activity by plants. As plants begin to photosynthesize in the spring and summer, they consume CO_2 from the atmosphere and eventually use it as a carbon source for growth and reproduction. This causes the decrease in CO_2 levels that begins every year in May. Once winter arrives, plants save energy by decreasing photosynthesis. Without photosynthesis, the dominant process is the exhalation of CO_2 by the total ecosystem, including bacteria, plants, and animals.

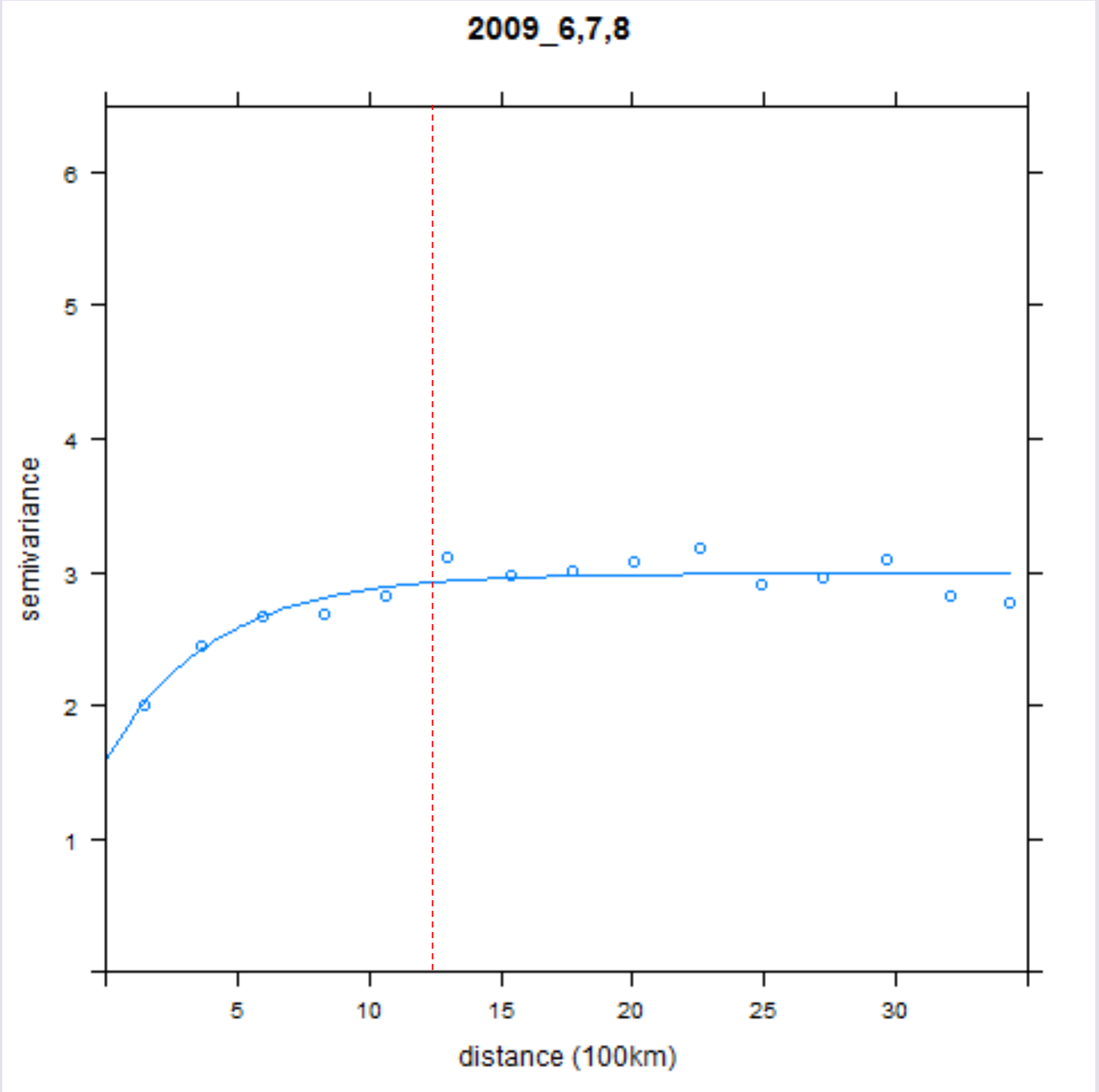
WHY ARE SEASONAL CO2 FLUCTUATIONS STRONGEST AT NORTHERN LATITUDES? (The Keeling Curve, SCRIPPS Institution of Oceanography, UCSD)

Modeling Spatial Variability of XCO2

- Spatial variability modeling (semivariogram)
- Spatial interpolation (Kriging method)
- Preliminary results and analyses

Semivariogram Modeling of XCO2

- Seasonal semivariograms
  - Ranges are approximately 12°.
  - Sills (variance of XCO2) mostly vary in a range from 2.5 to 5 ppm.
    - Semivariograms of the Dec - Feb and March - May periods have higher sills than the June - August and September - November periods.


2009_6,7,8
semivariance
distance (100km)
1
2
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25
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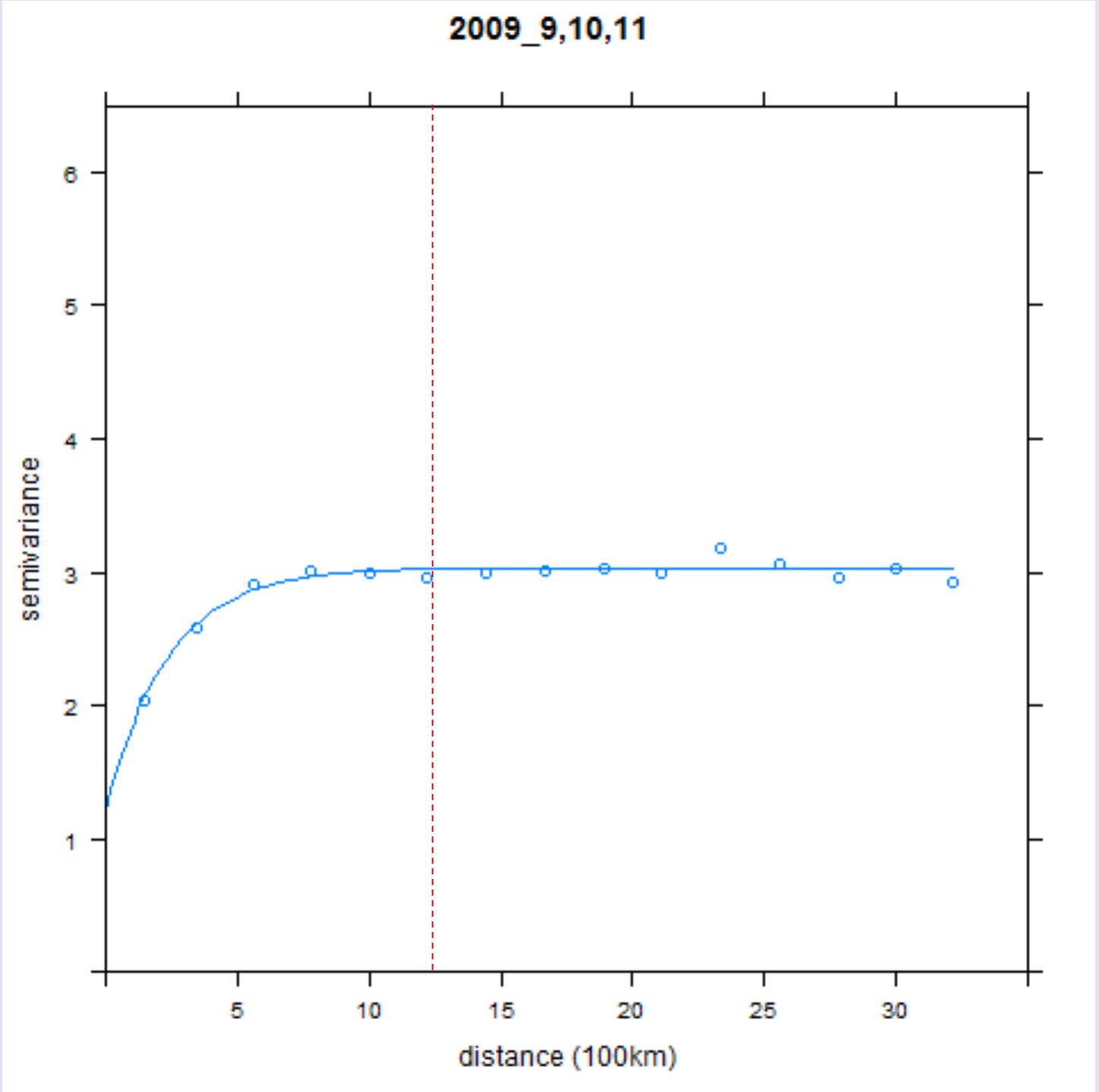
2009_9,10,11
semivariance
distance (100km)
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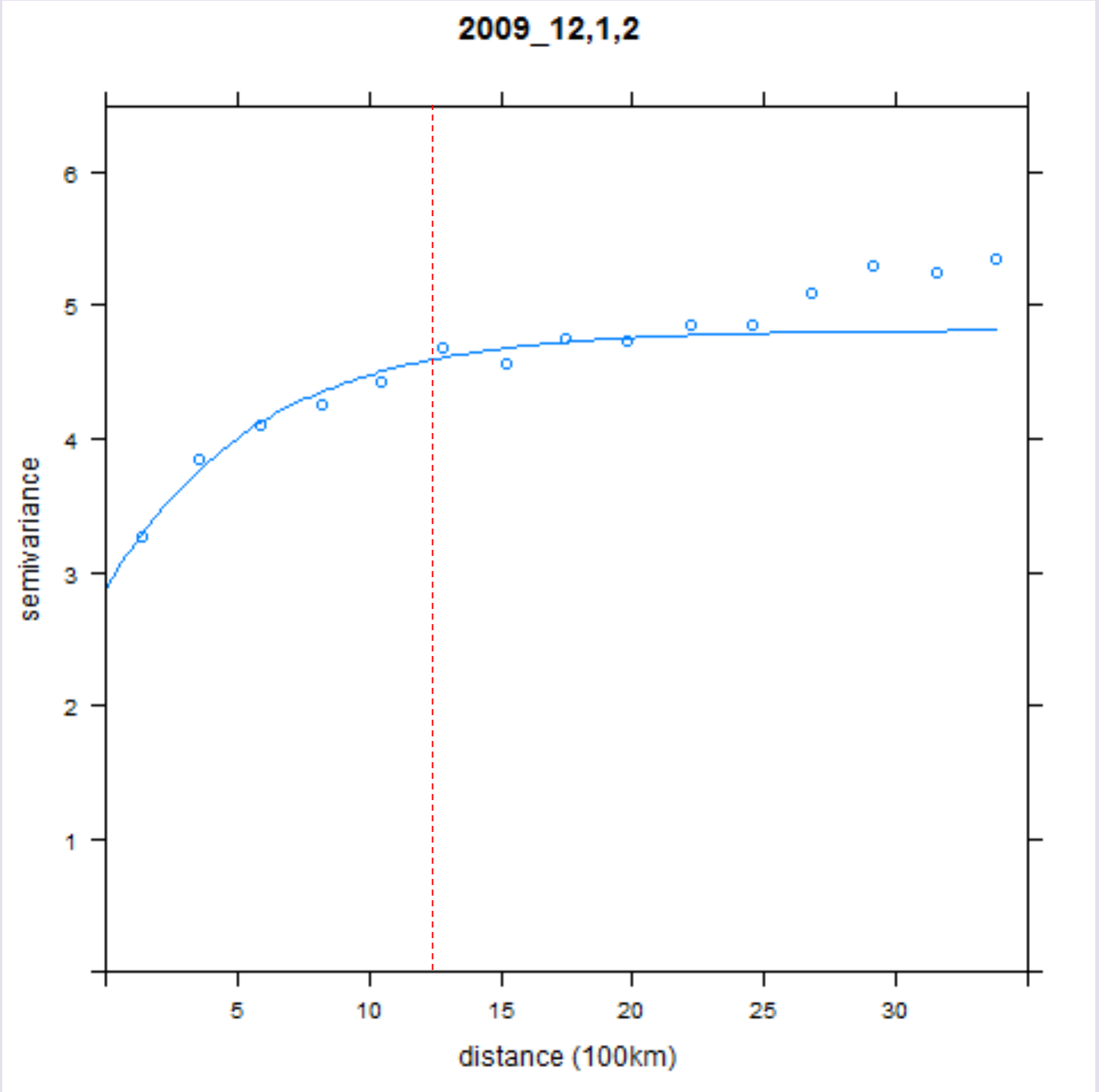
2009_12,1,2
semivariance
distance (100km)
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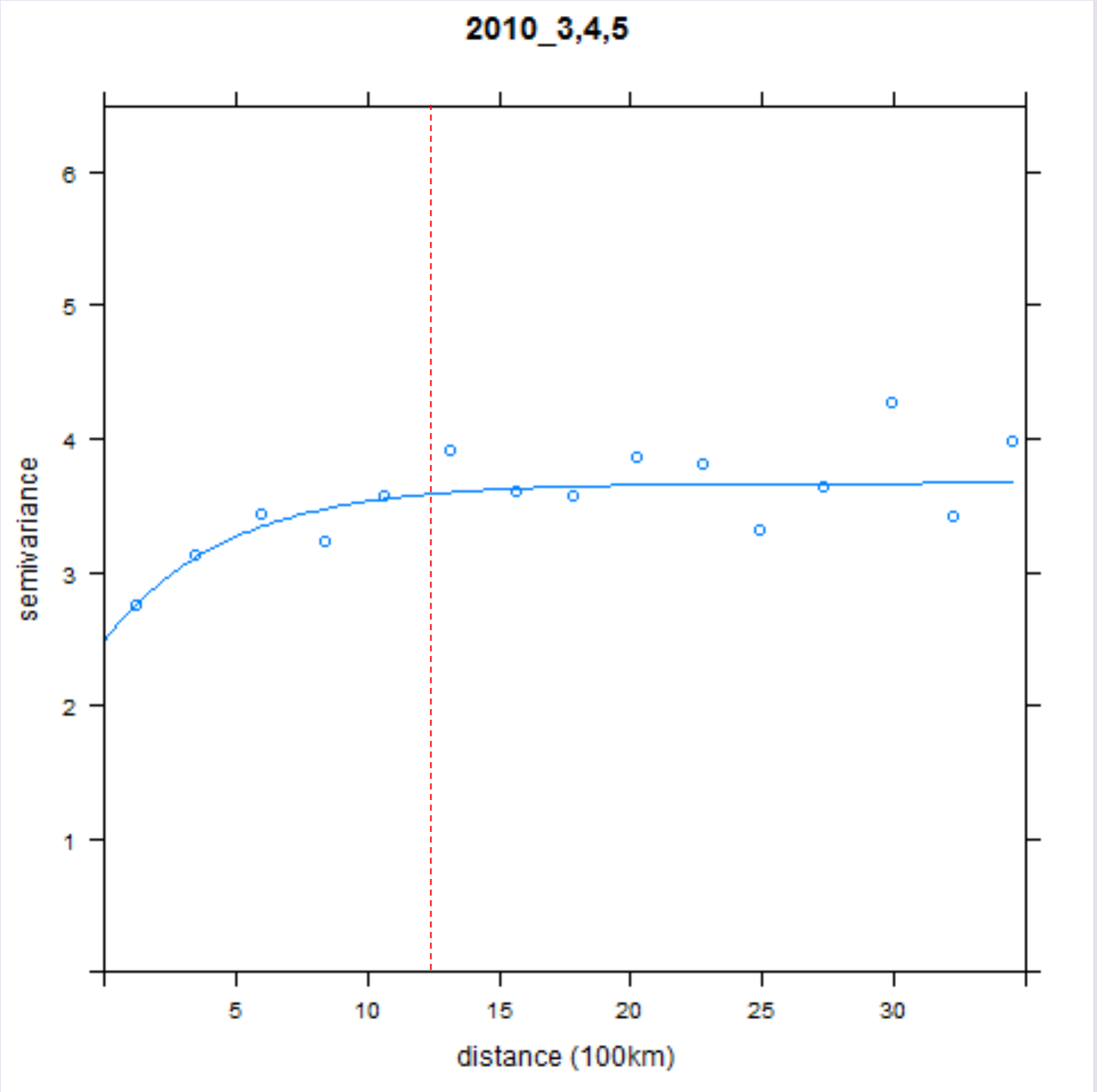
2010_3,4,5
semivariance
distance (100km)
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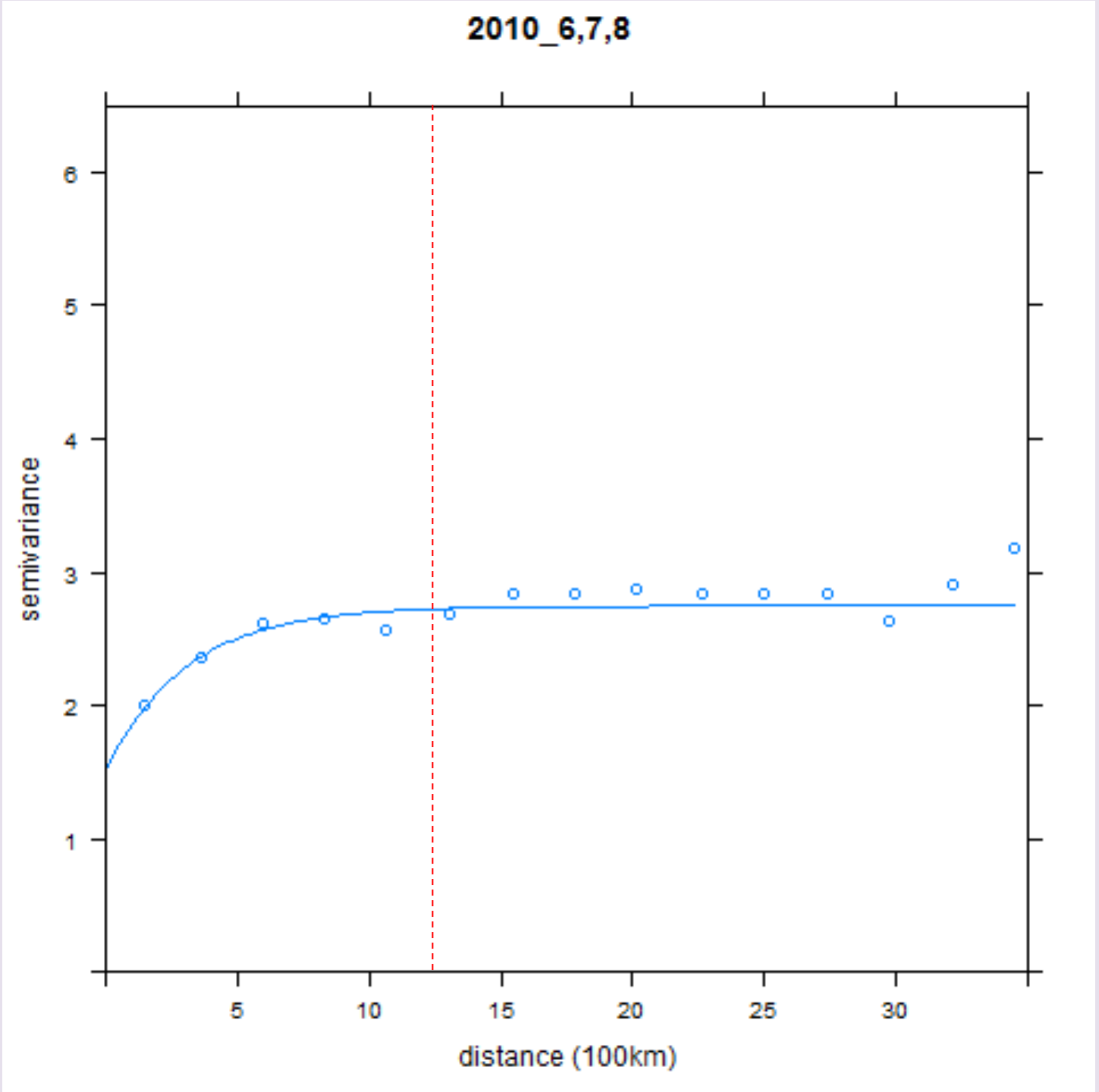
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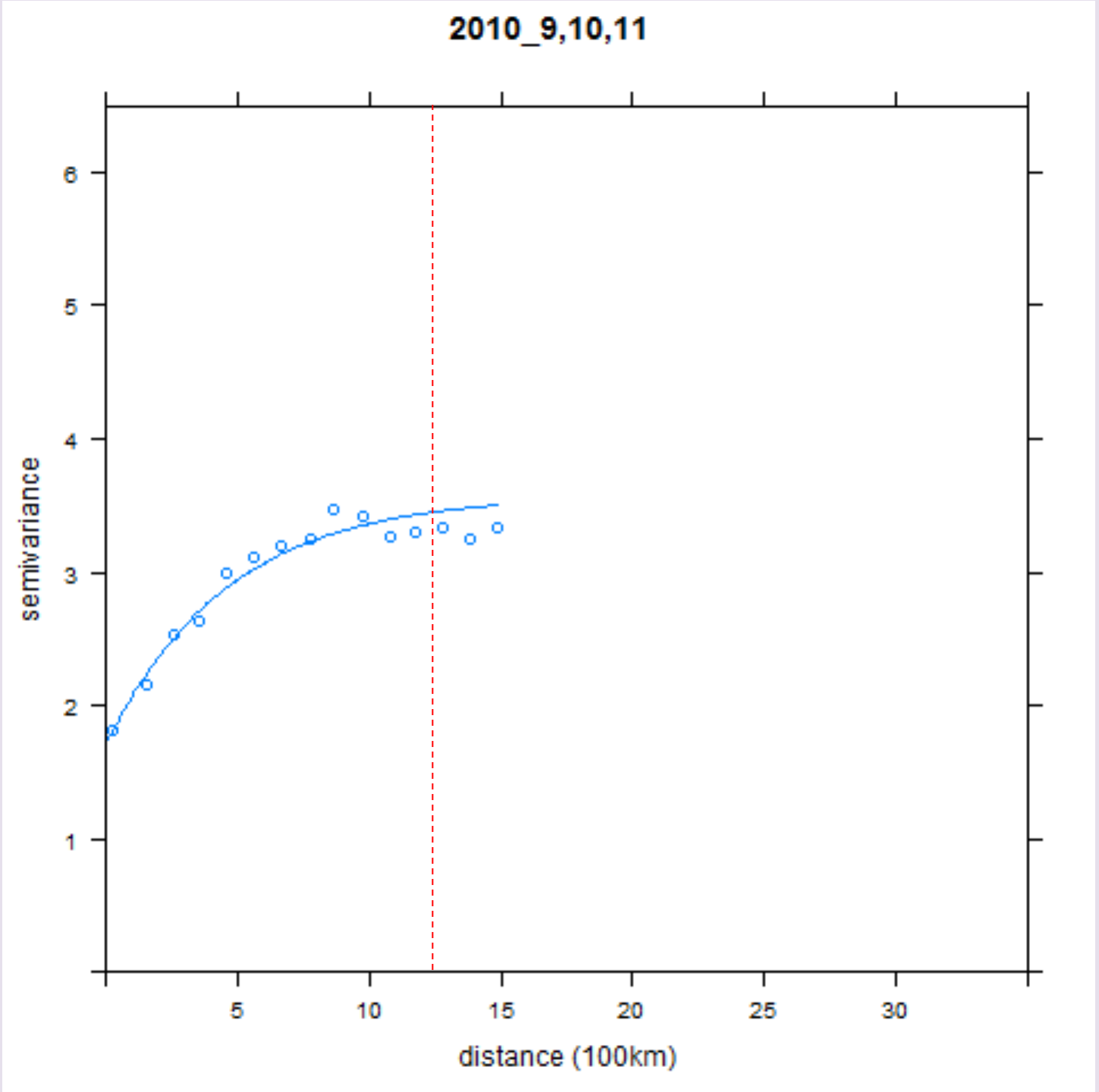
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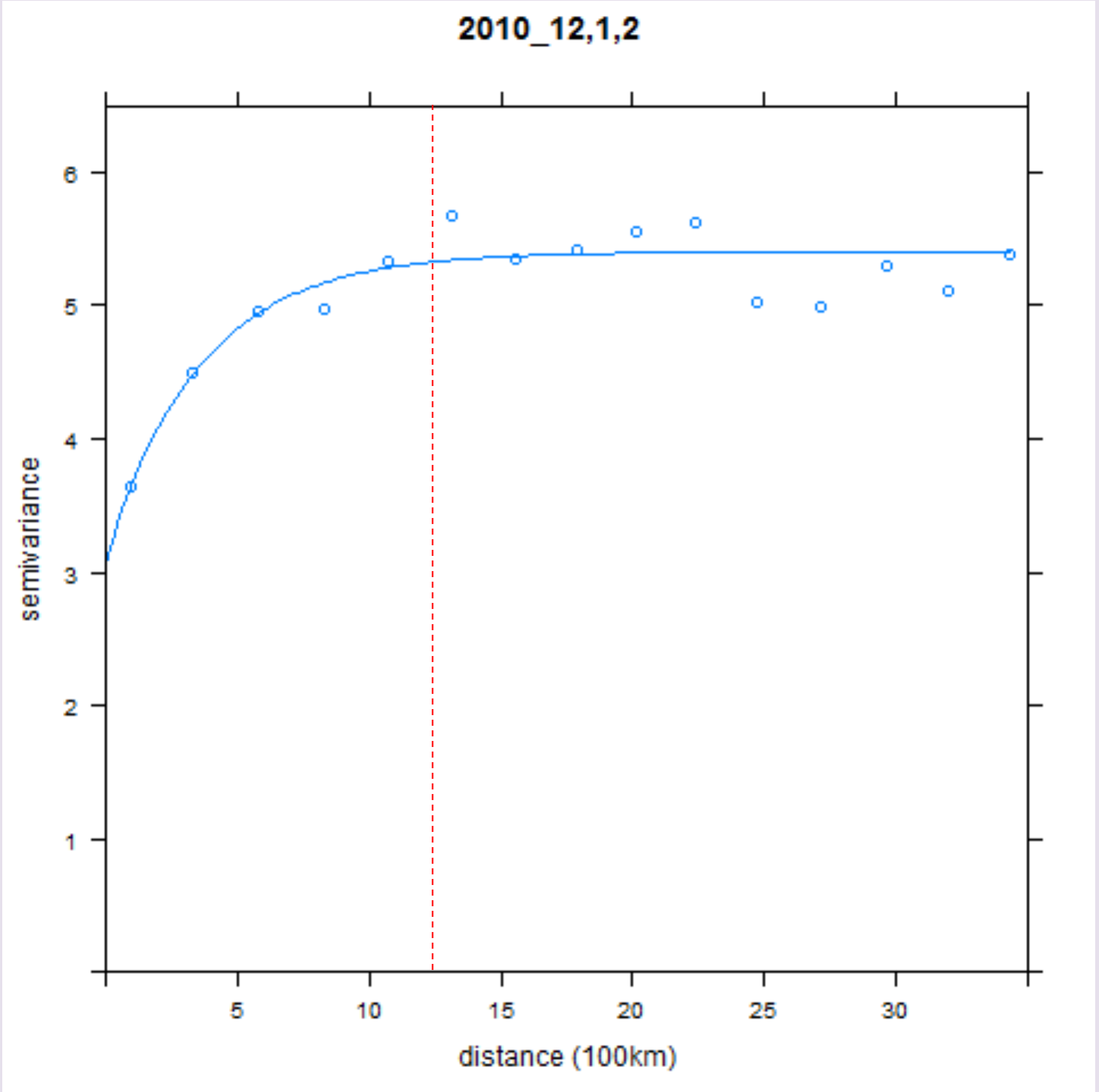
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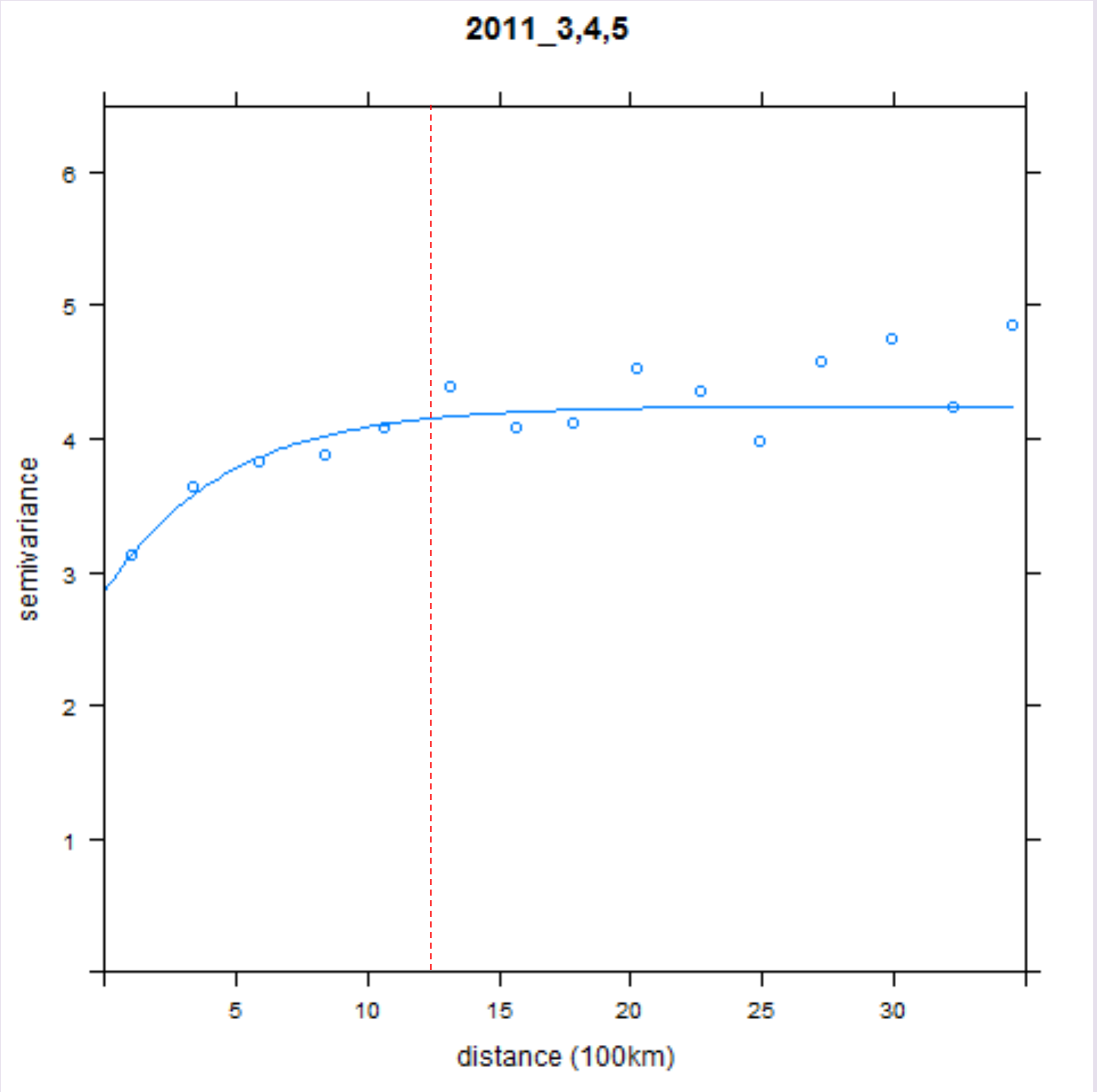
2011_3,4,5
semivariance
distance (100km)
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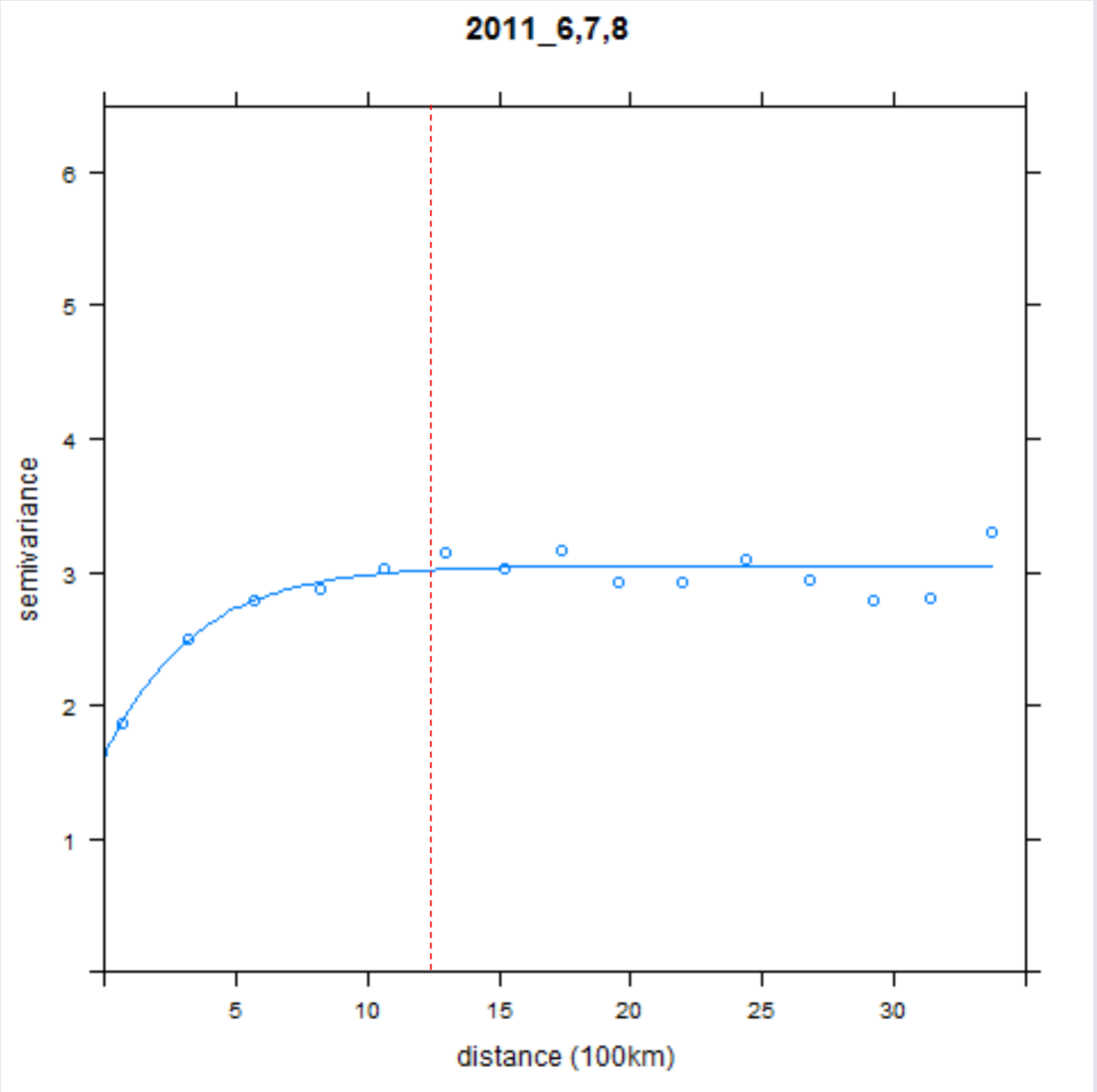
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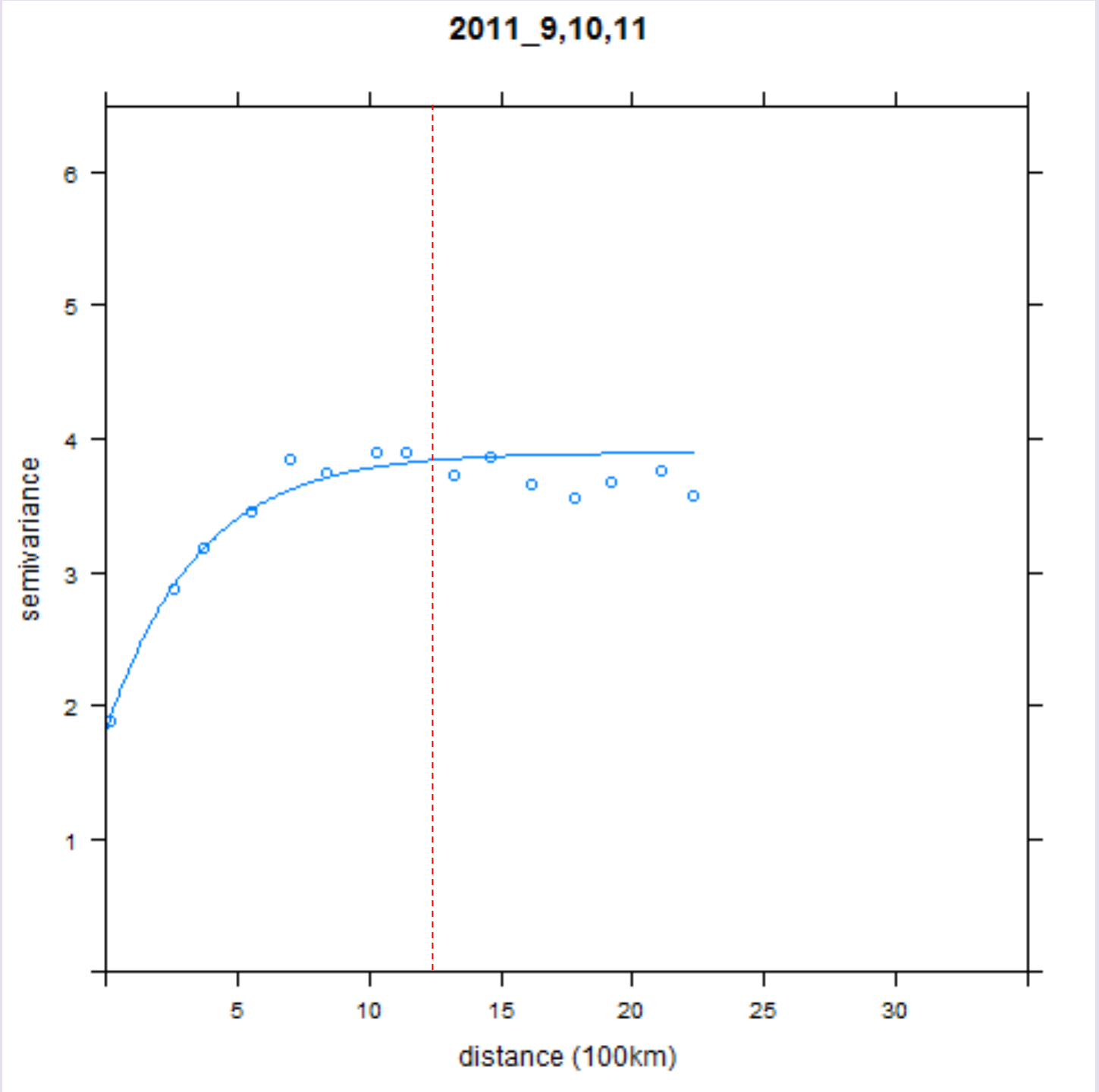
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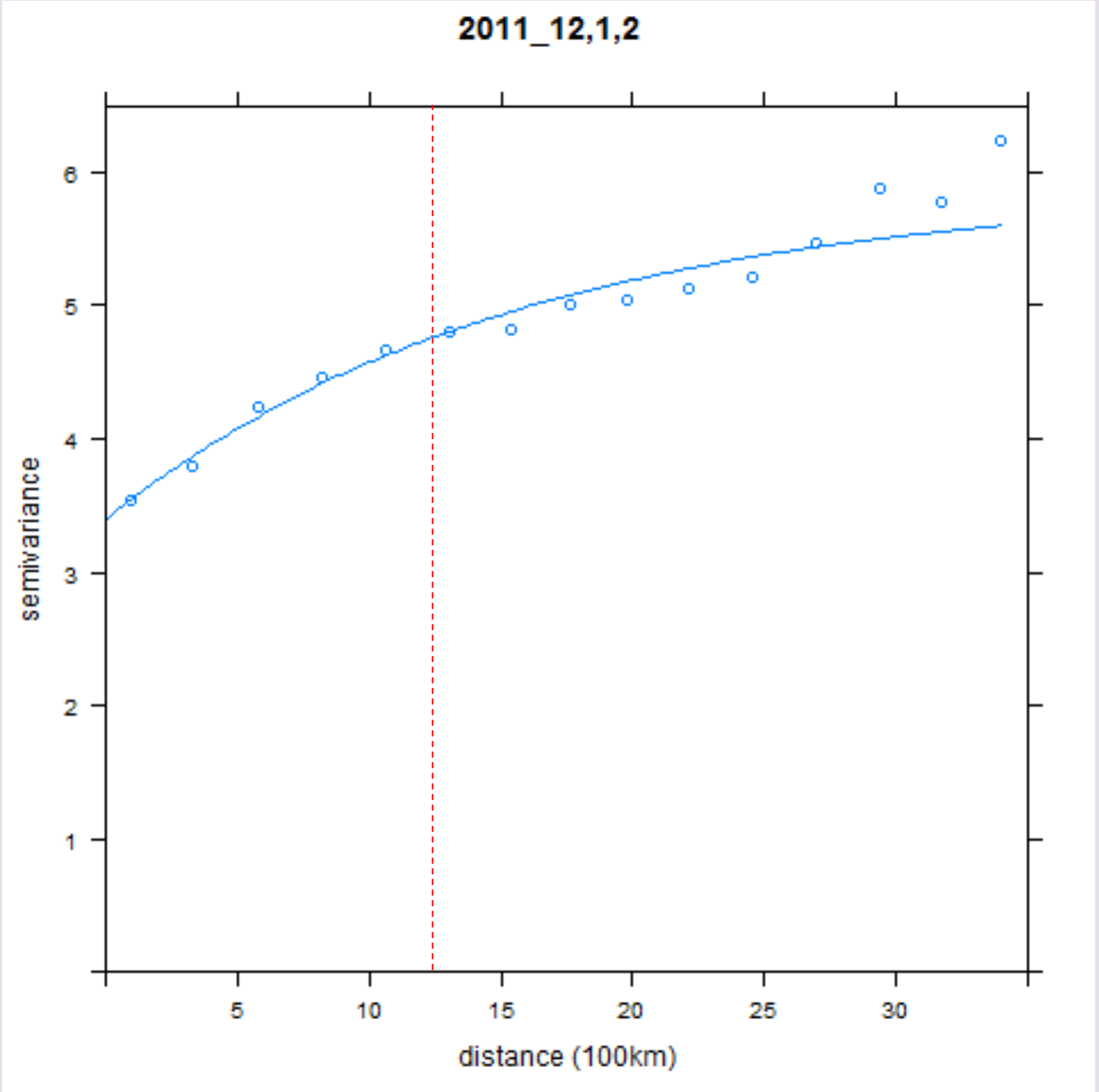
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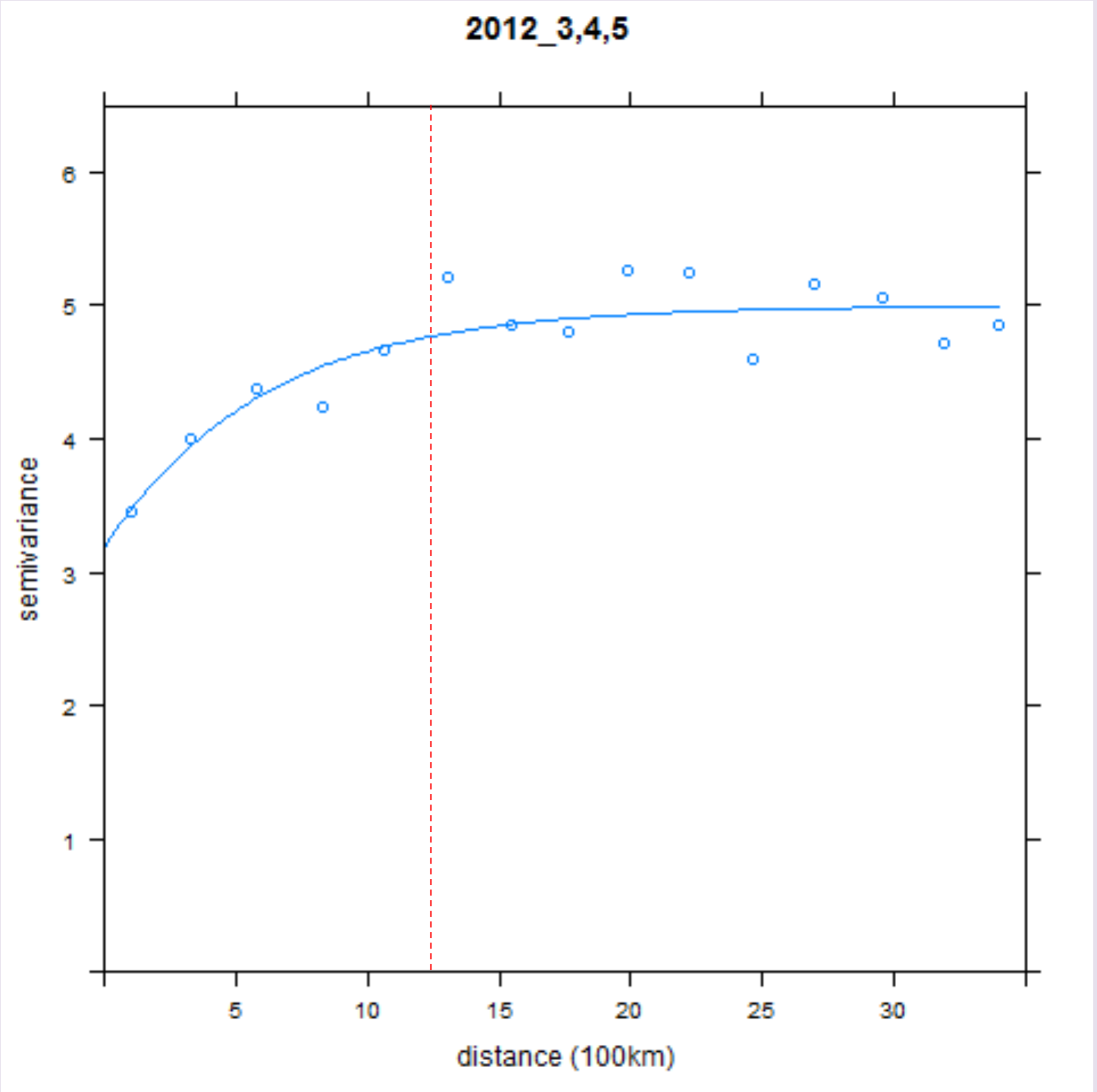
2012_3,4,5
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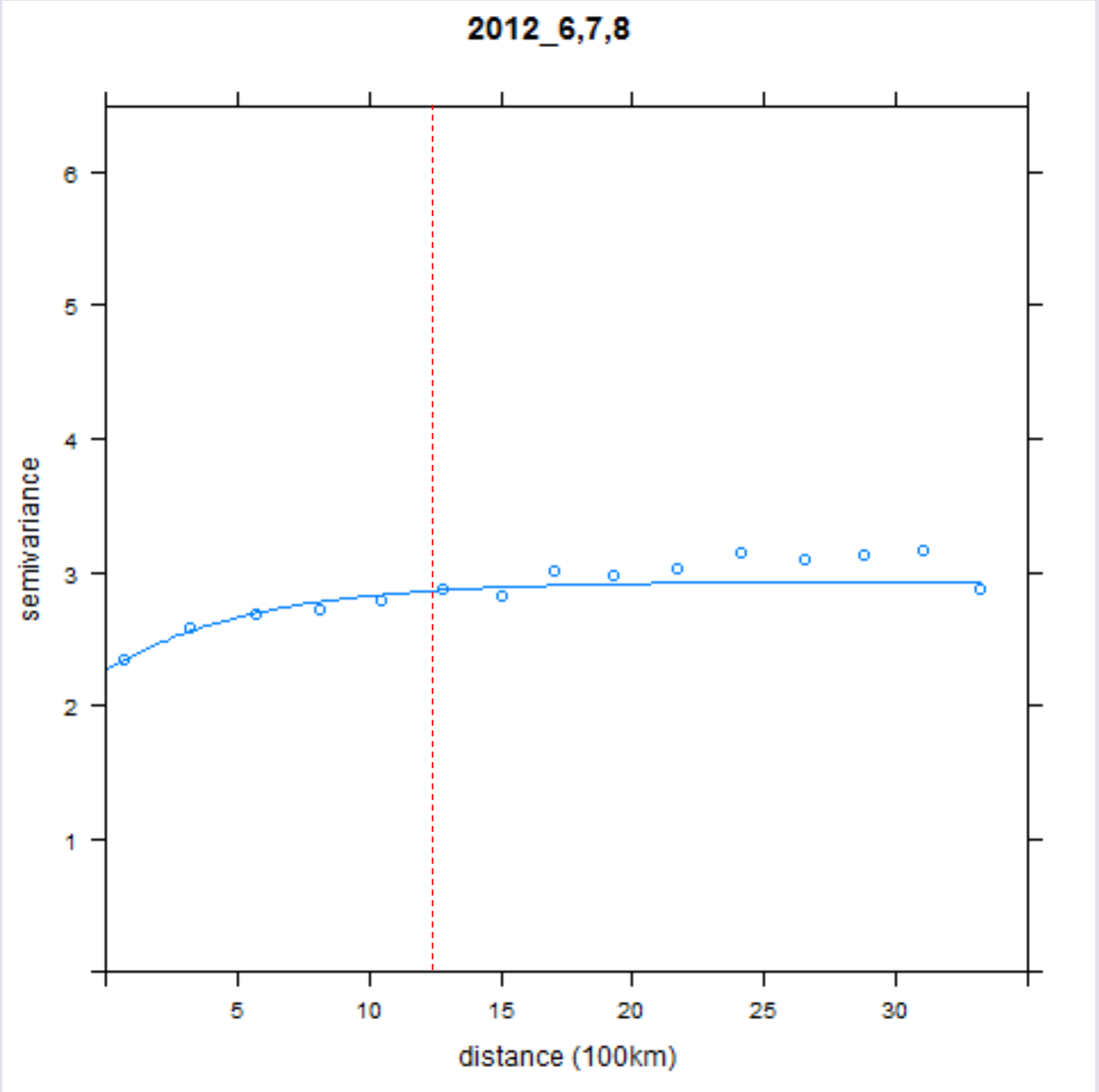
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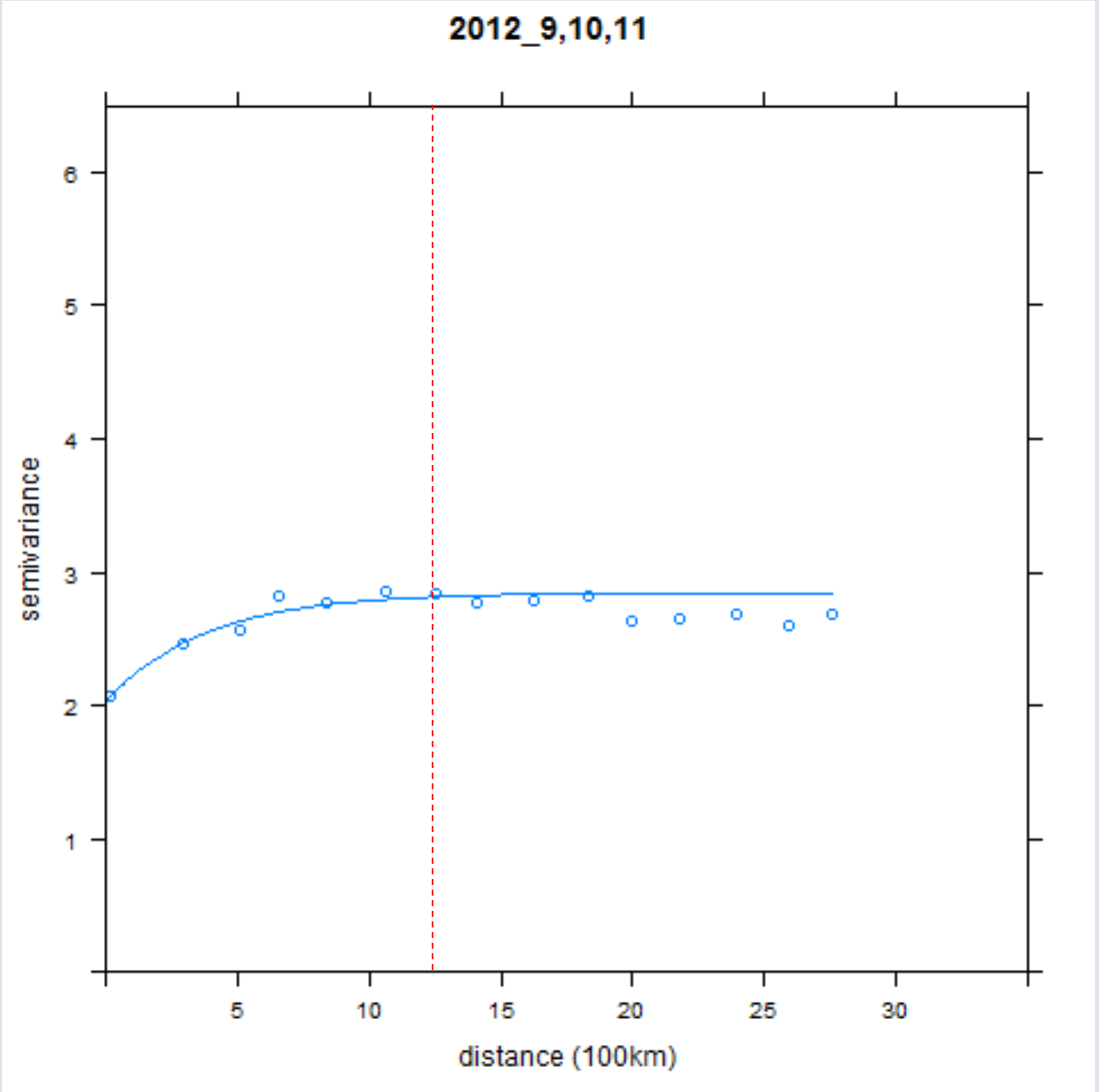
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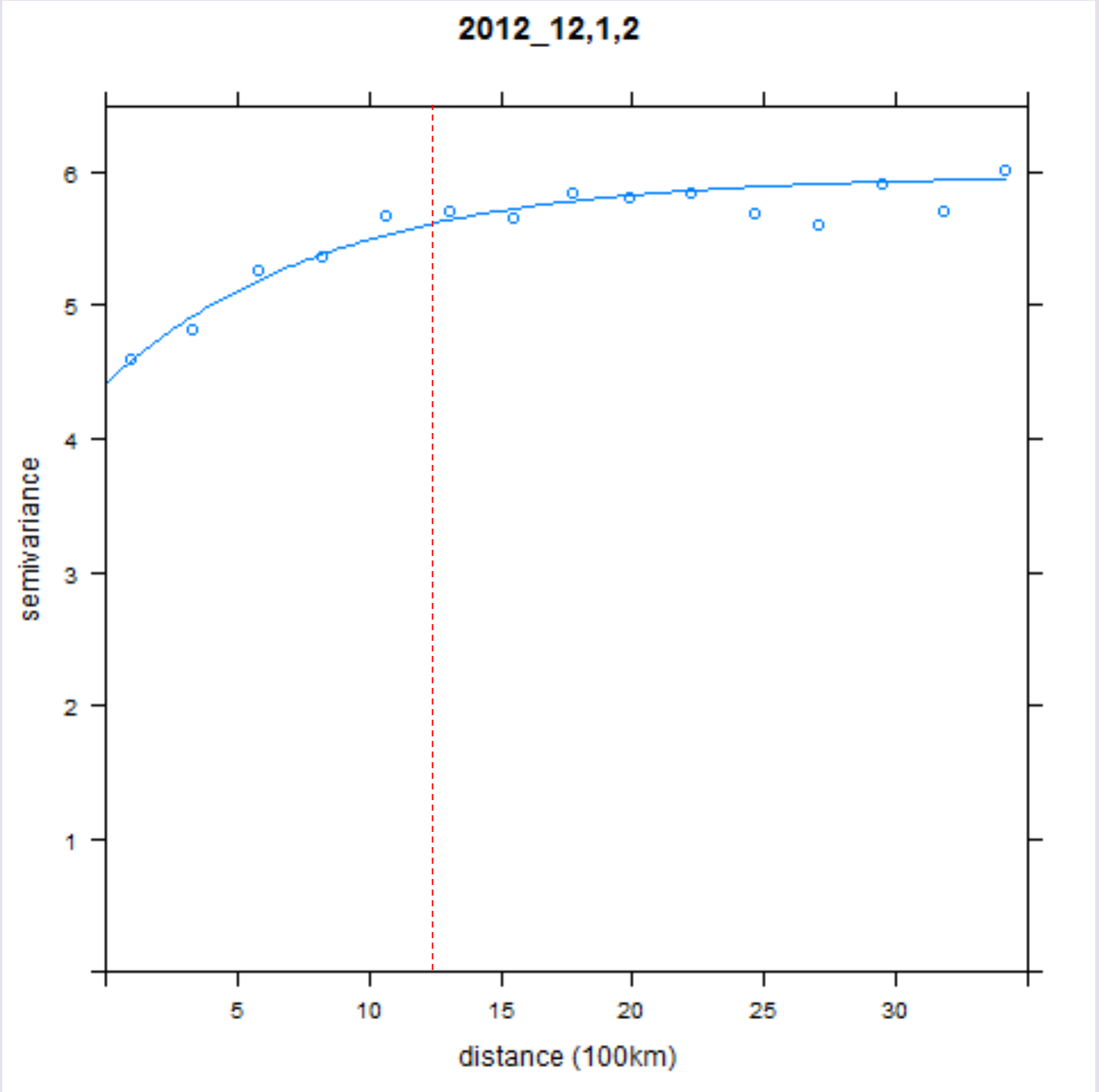
2012_12,1,2
semivariance
distance (100km)
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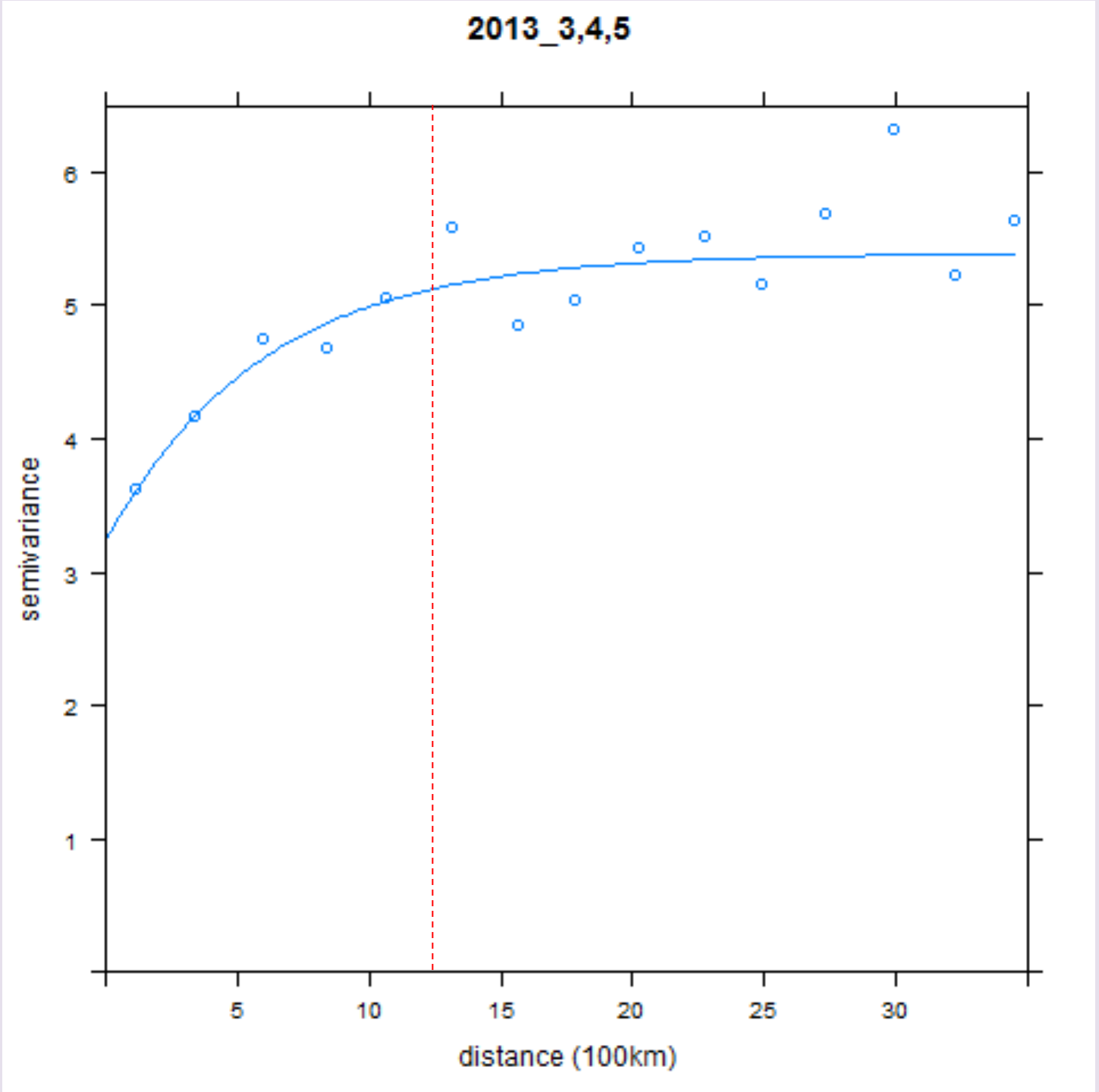
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semivariance
distance (100km)
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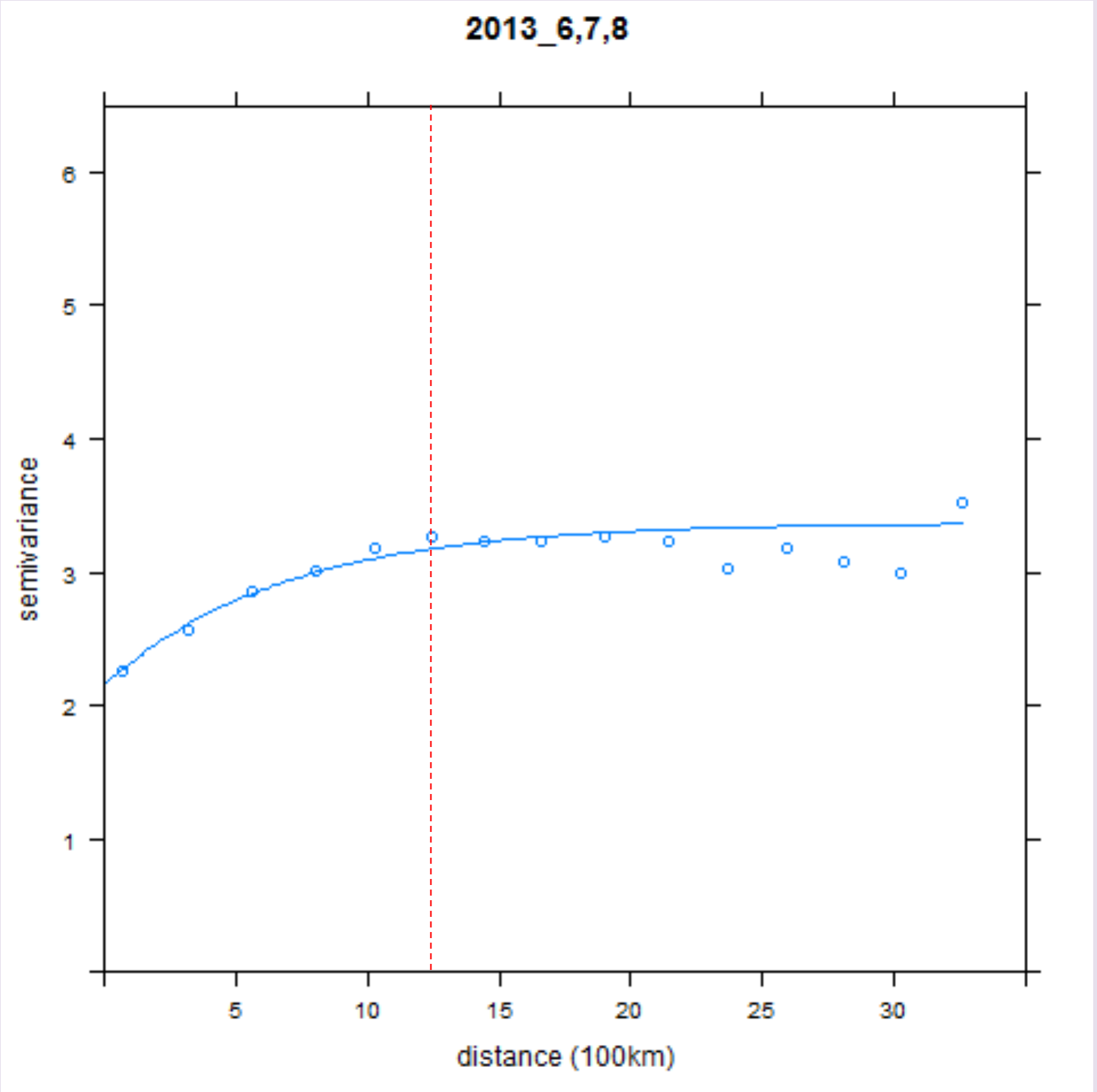
2013_6,7,8
semivariance
distance (100km)
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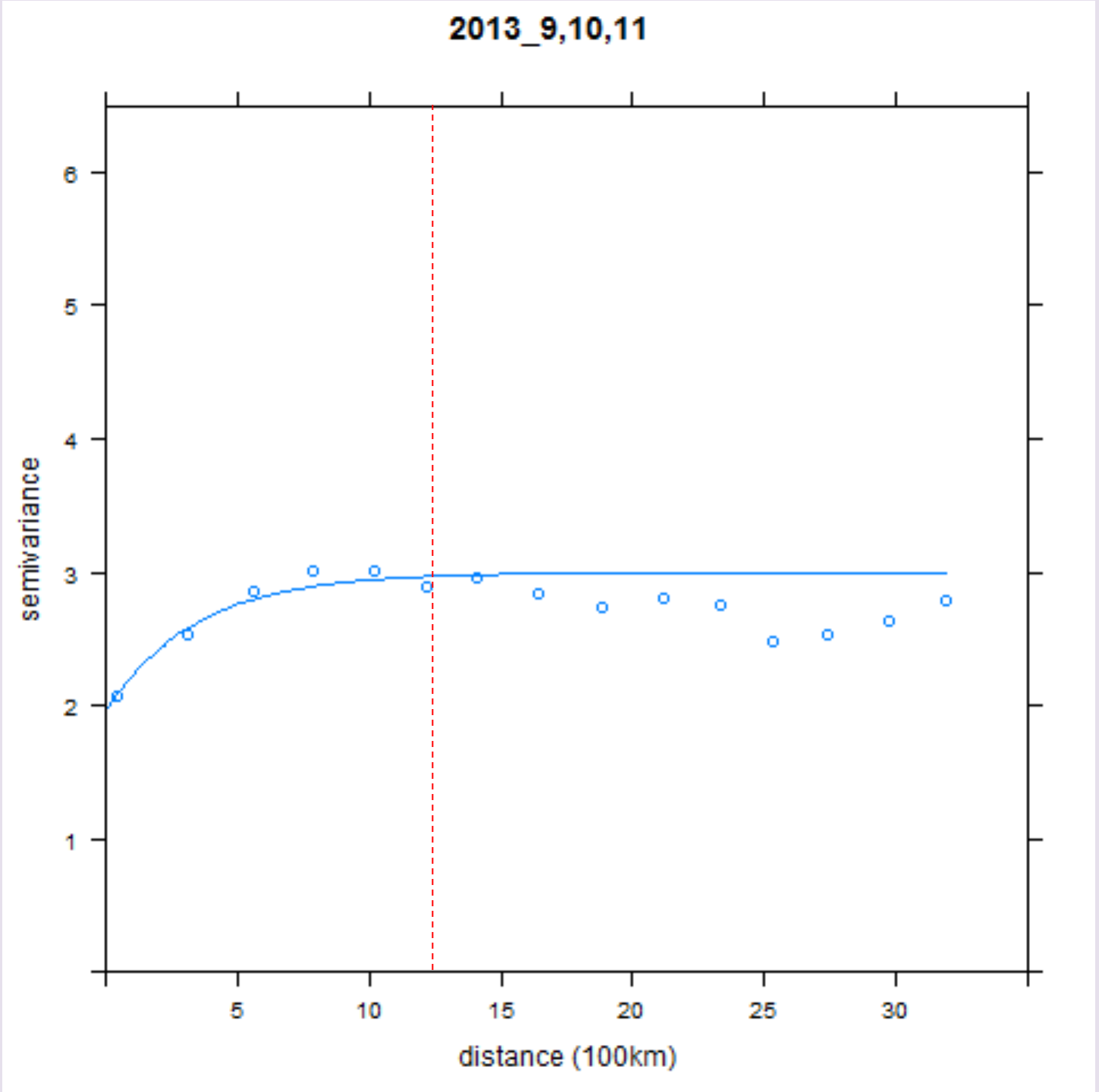
2013_9,10,11
semivariance
distance (100km)
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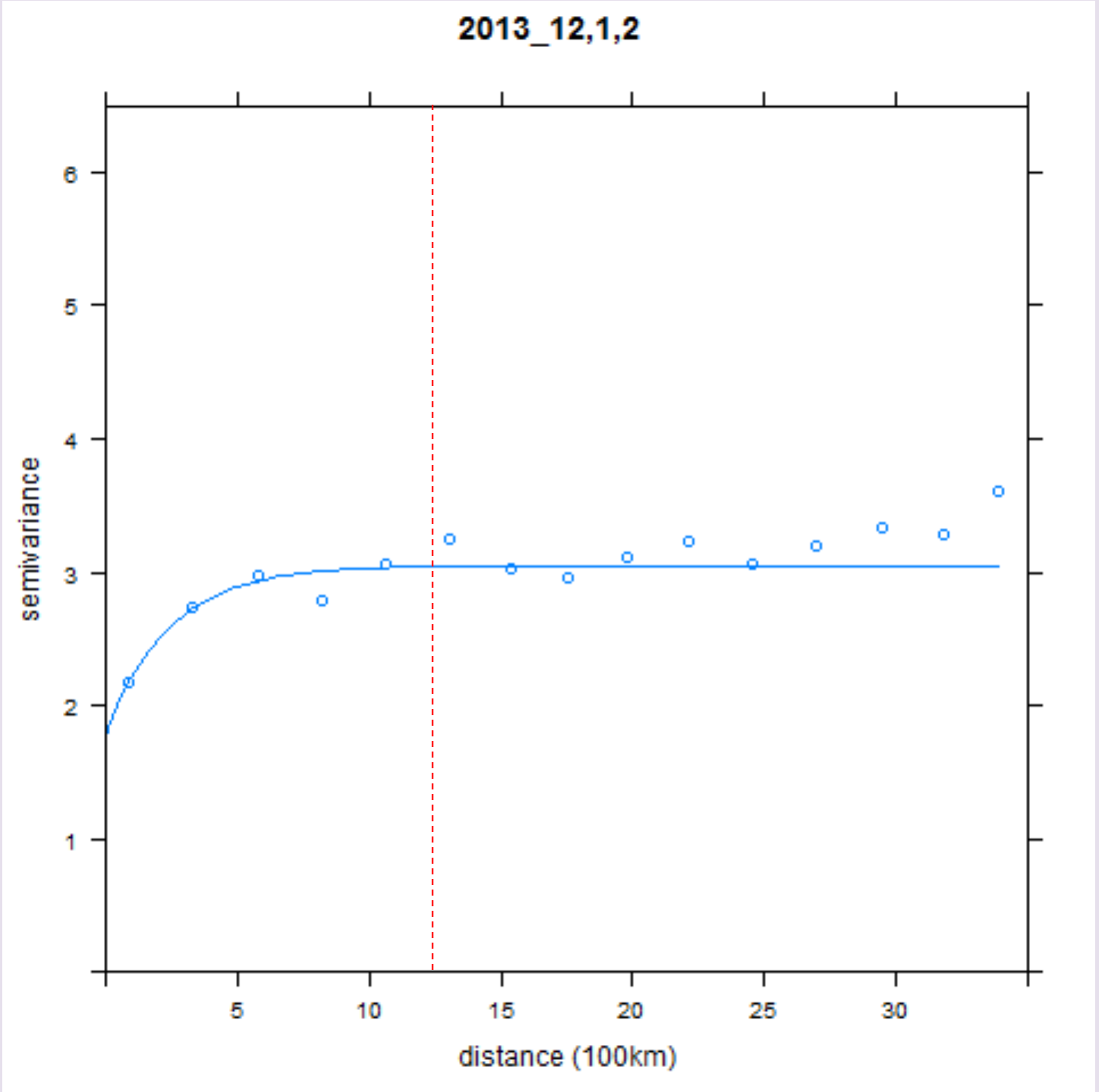
2013_12,1,2
semivariance
distance (100km)
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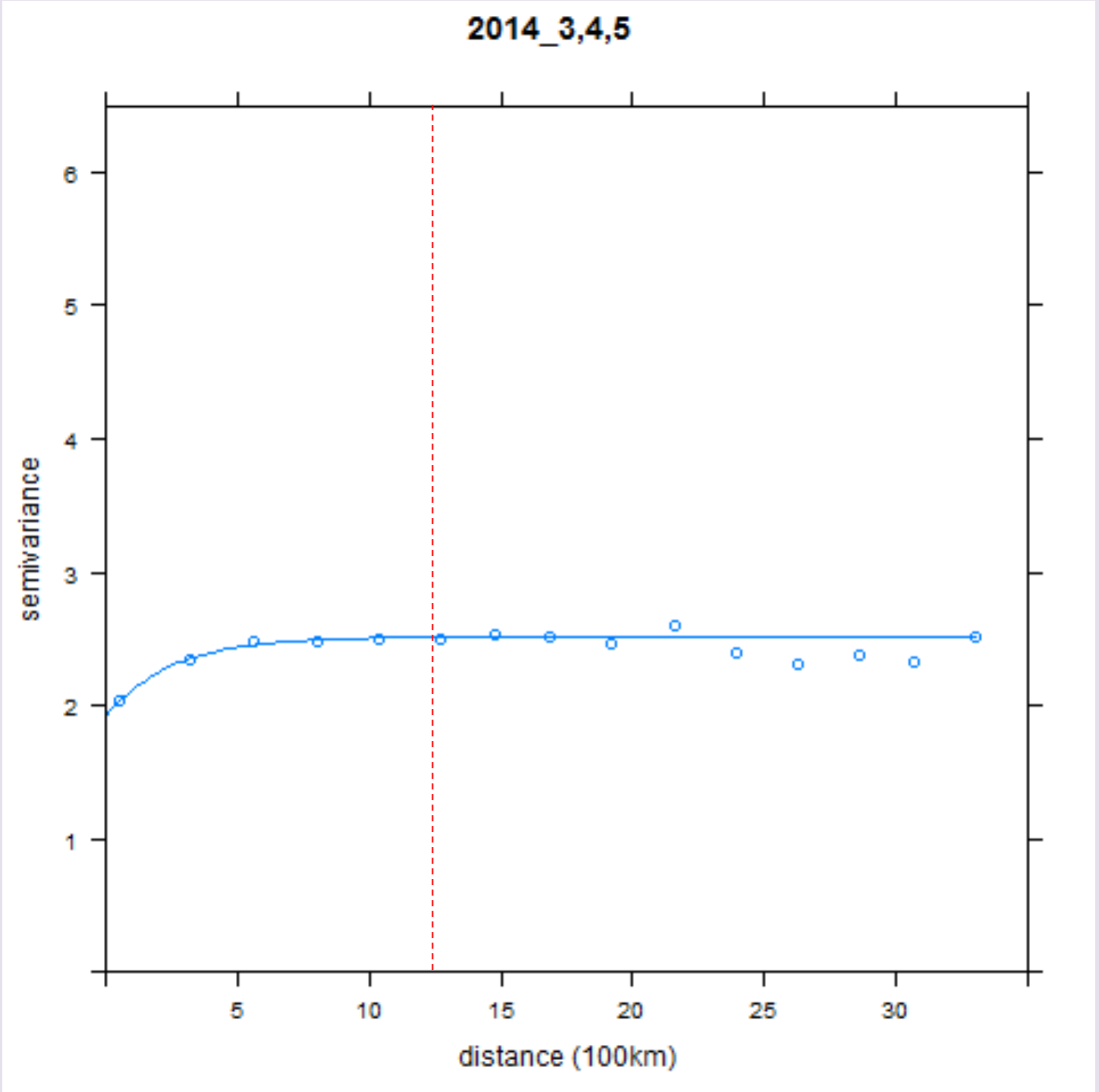
2014_3,4,5
semivariance
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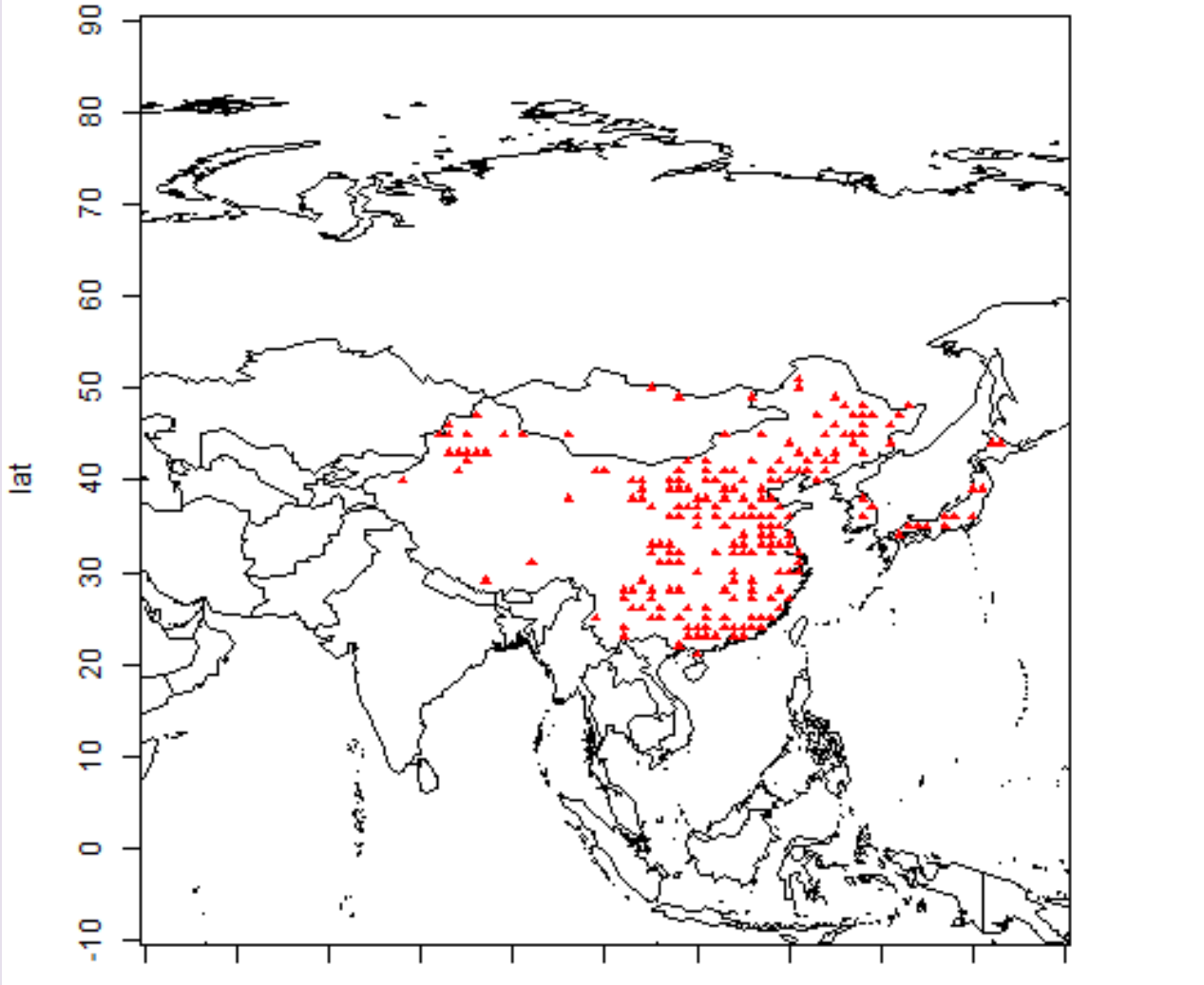
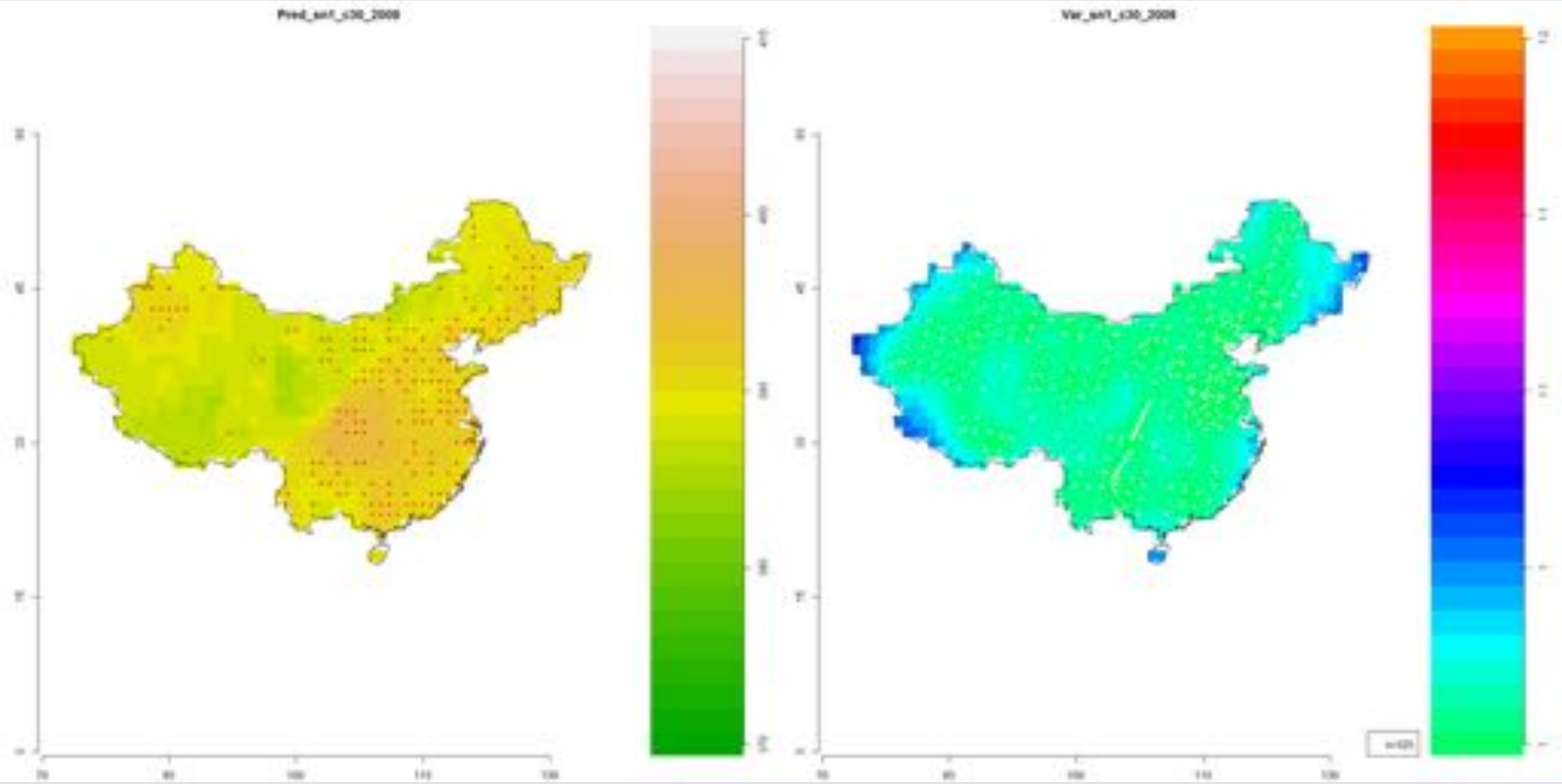
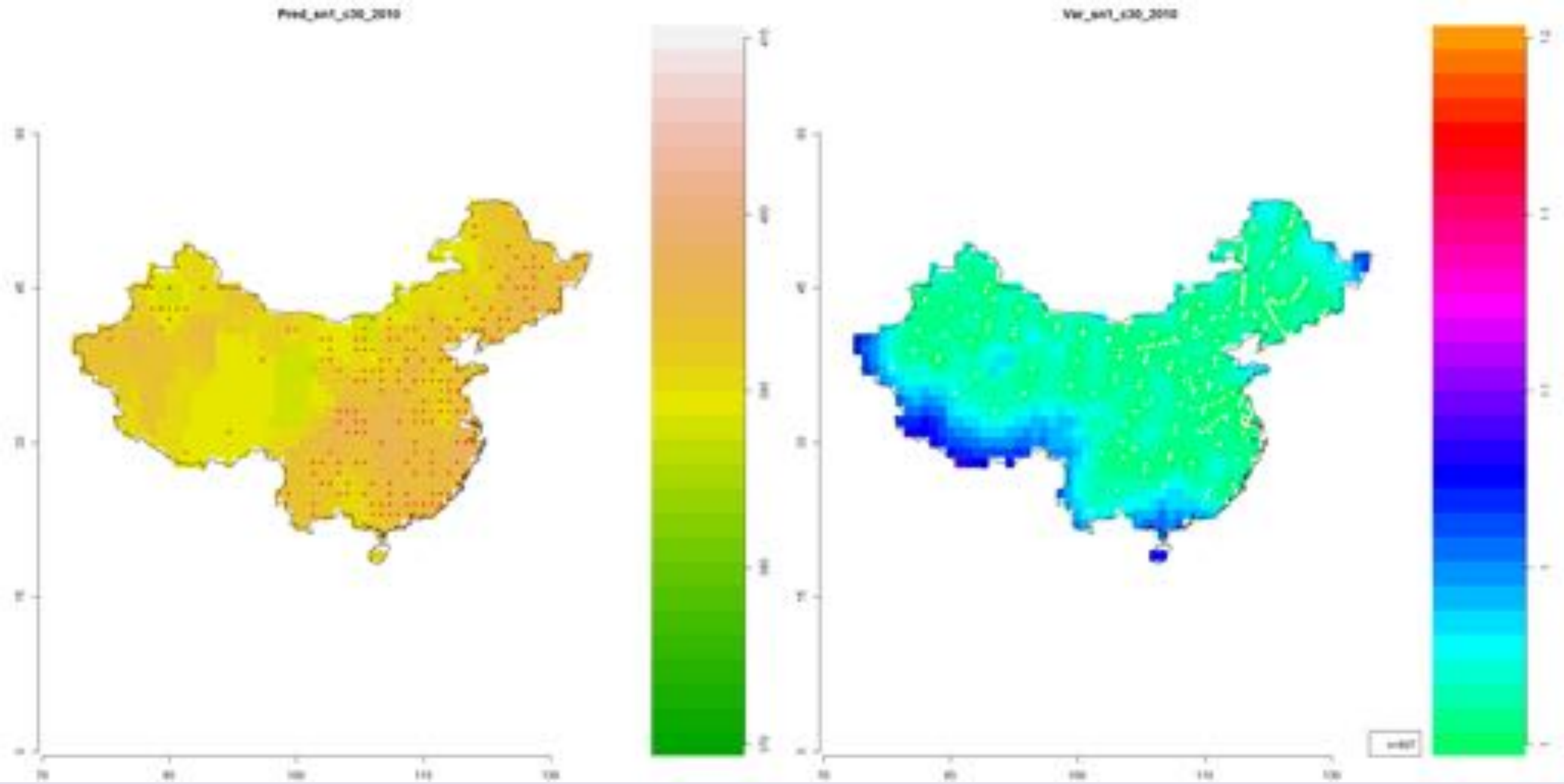
distance (100km)

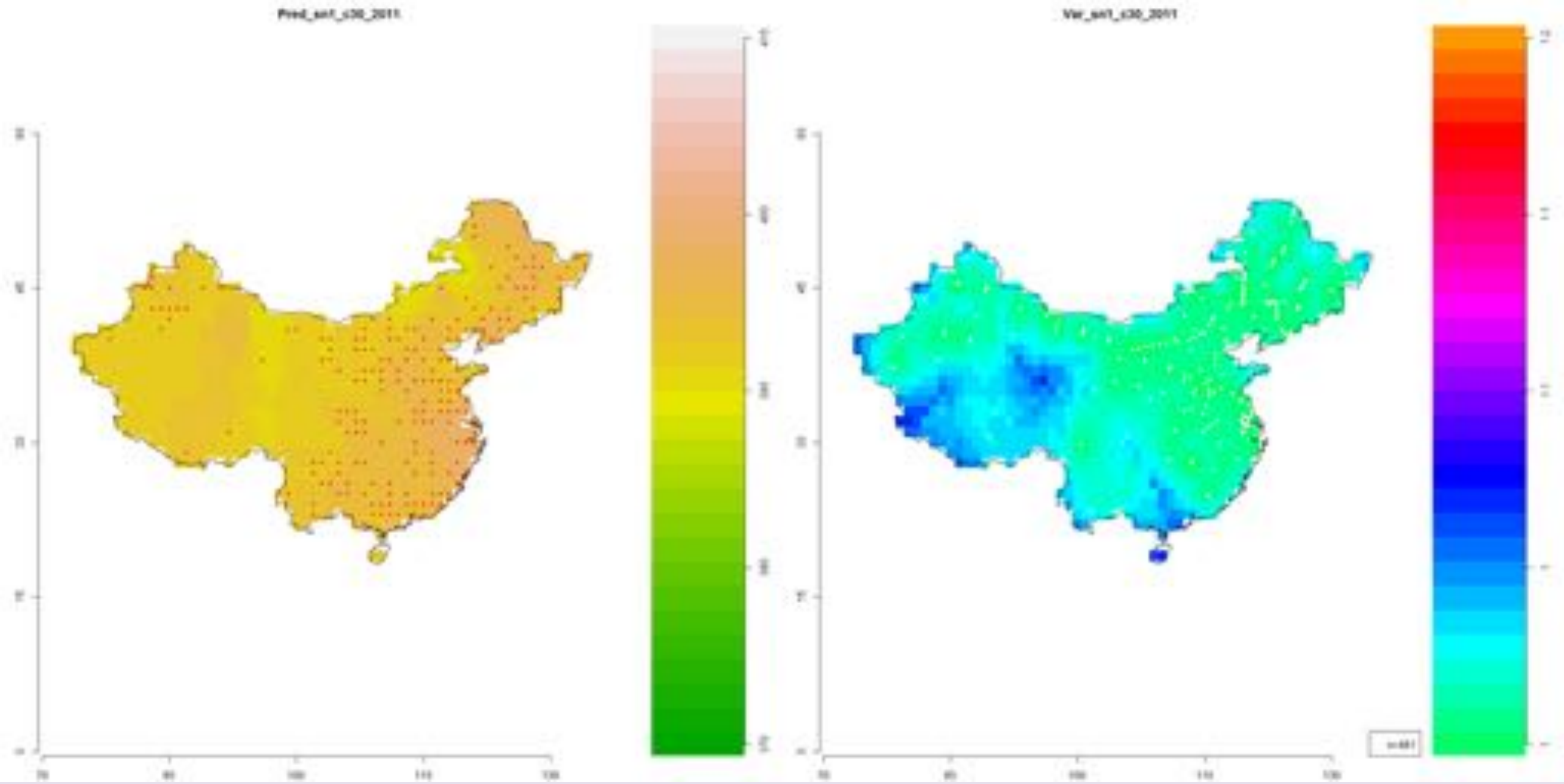
Spatial distribution of XCO2 estimates and kriging variance

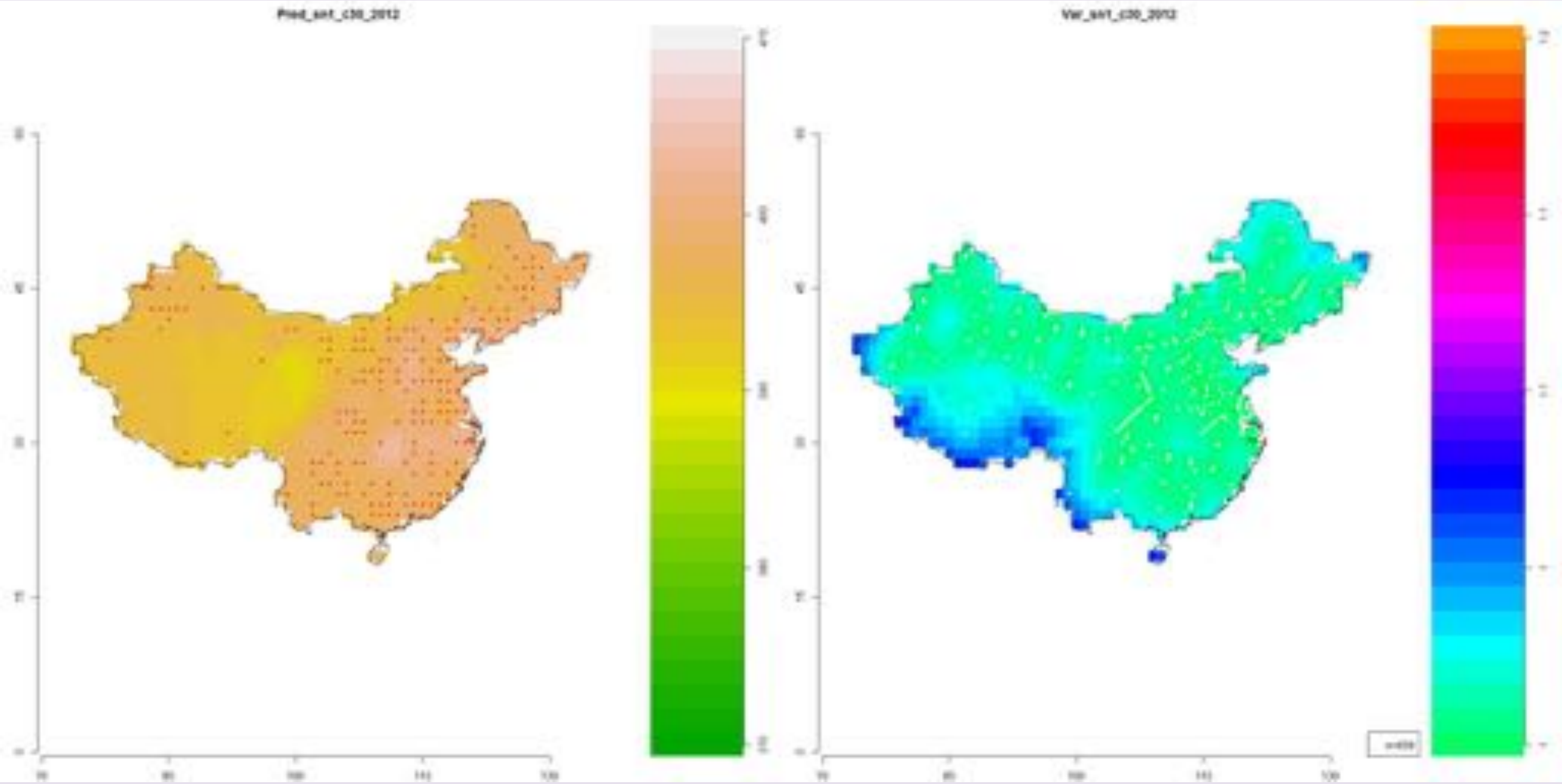
Night-time image of the Suomi NPP satellite

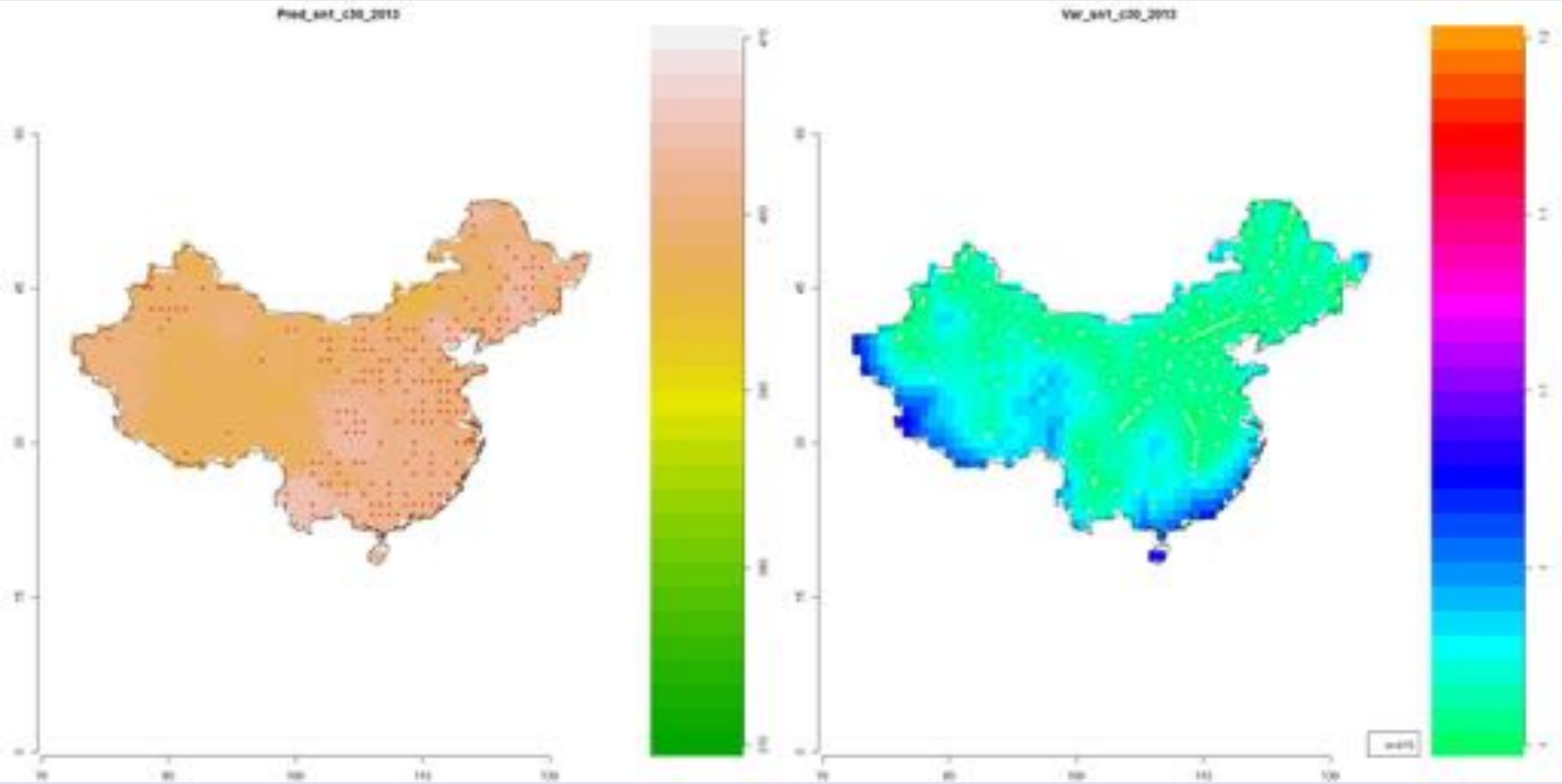


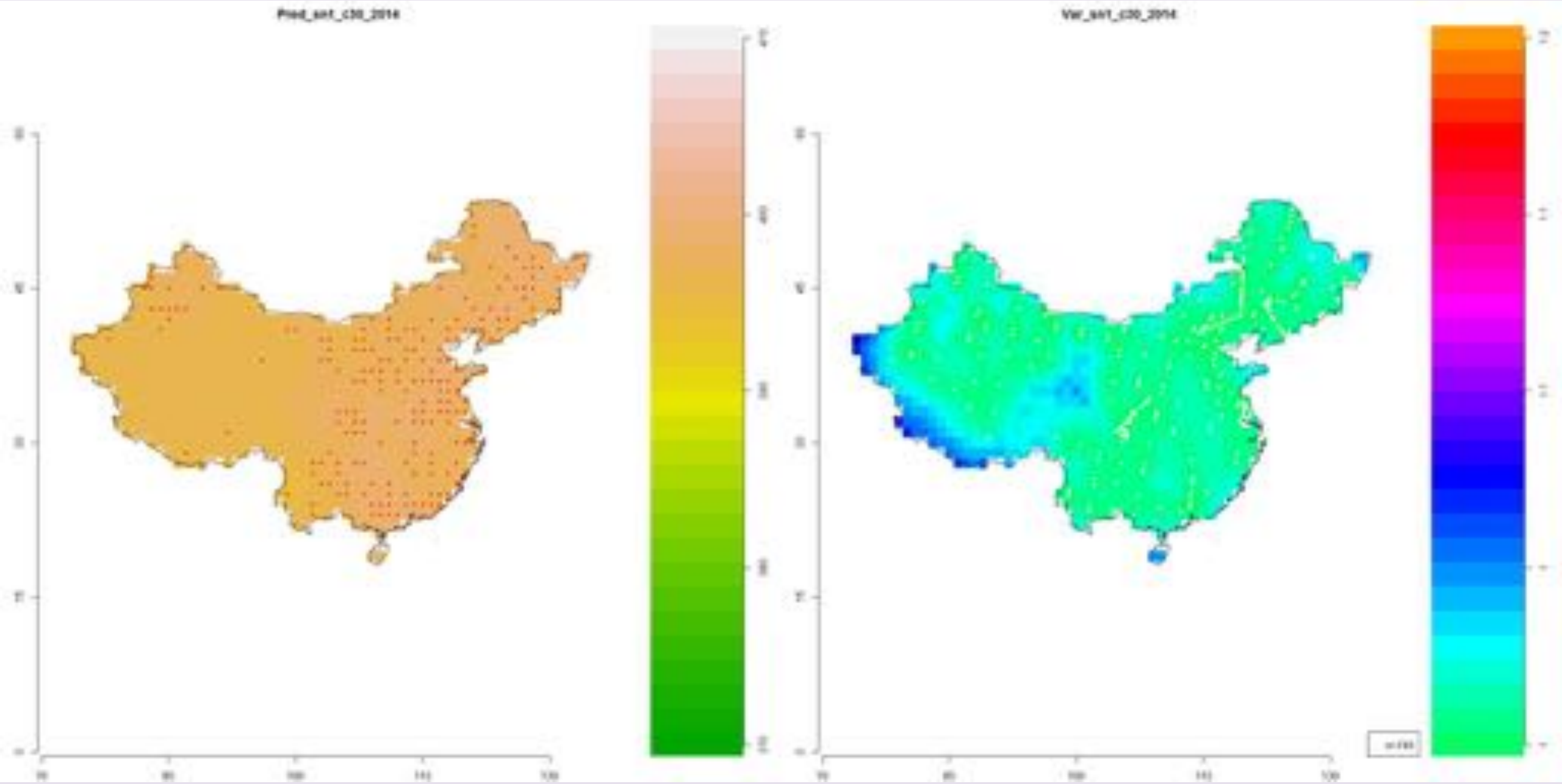


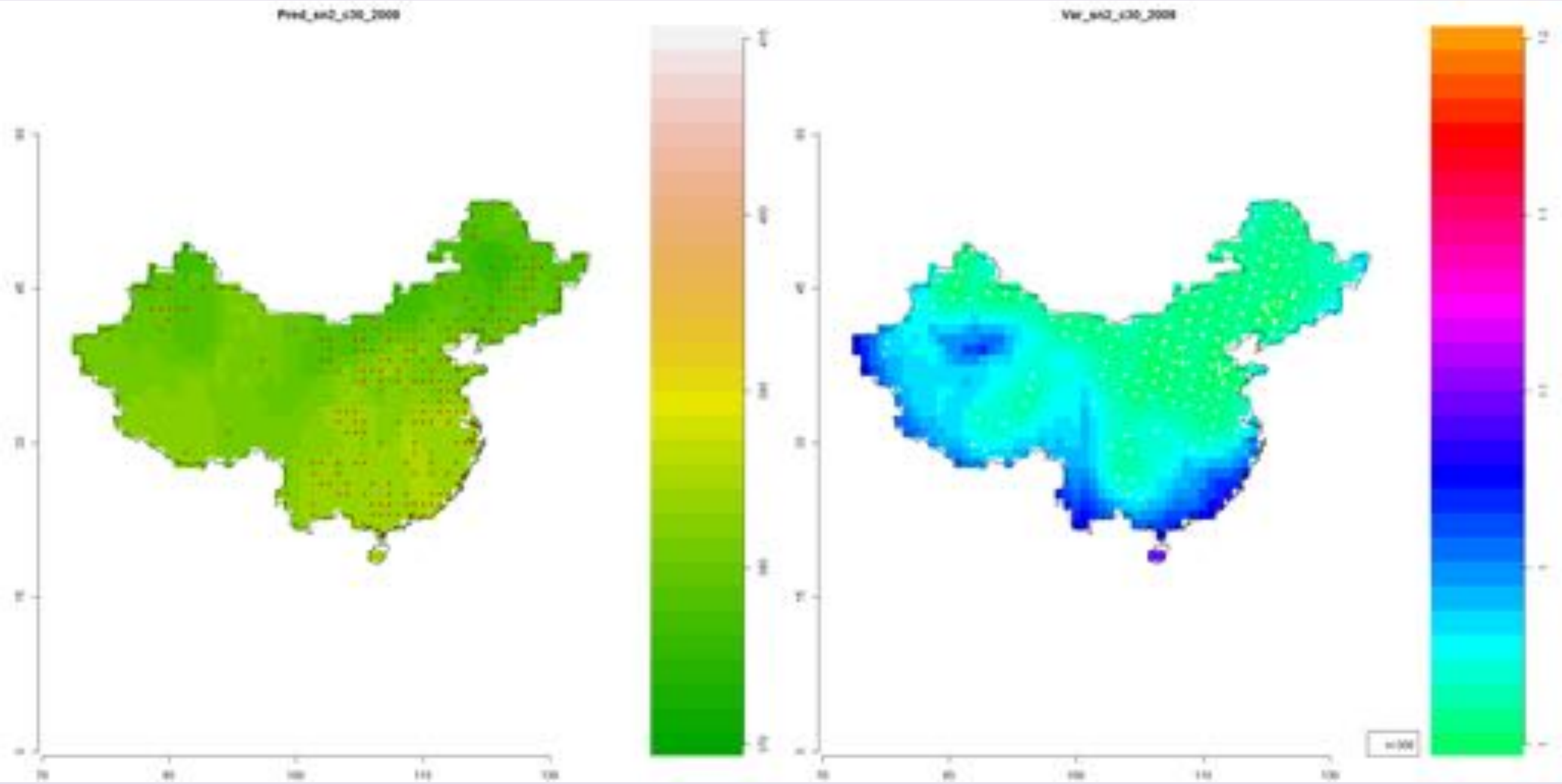


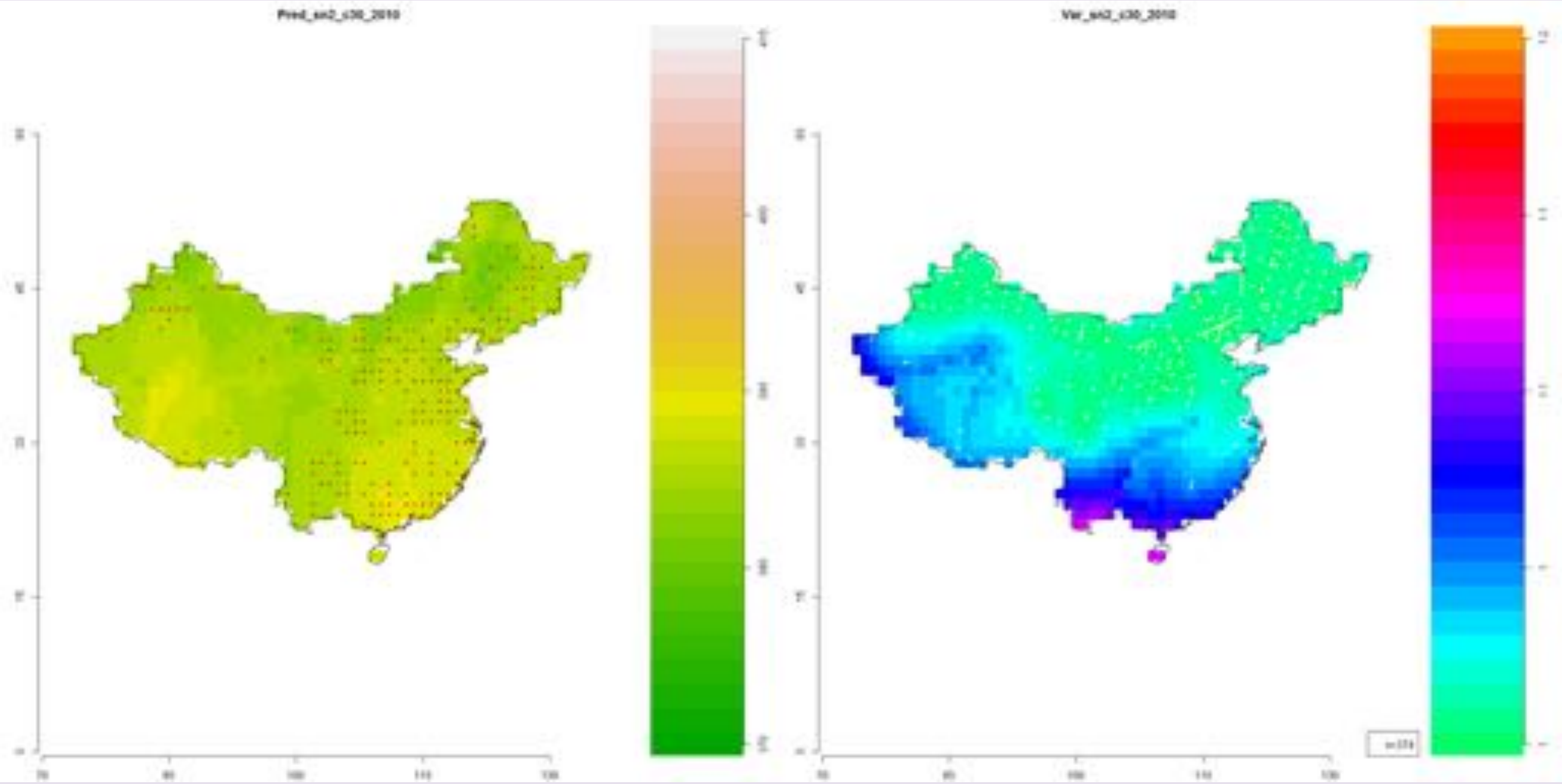


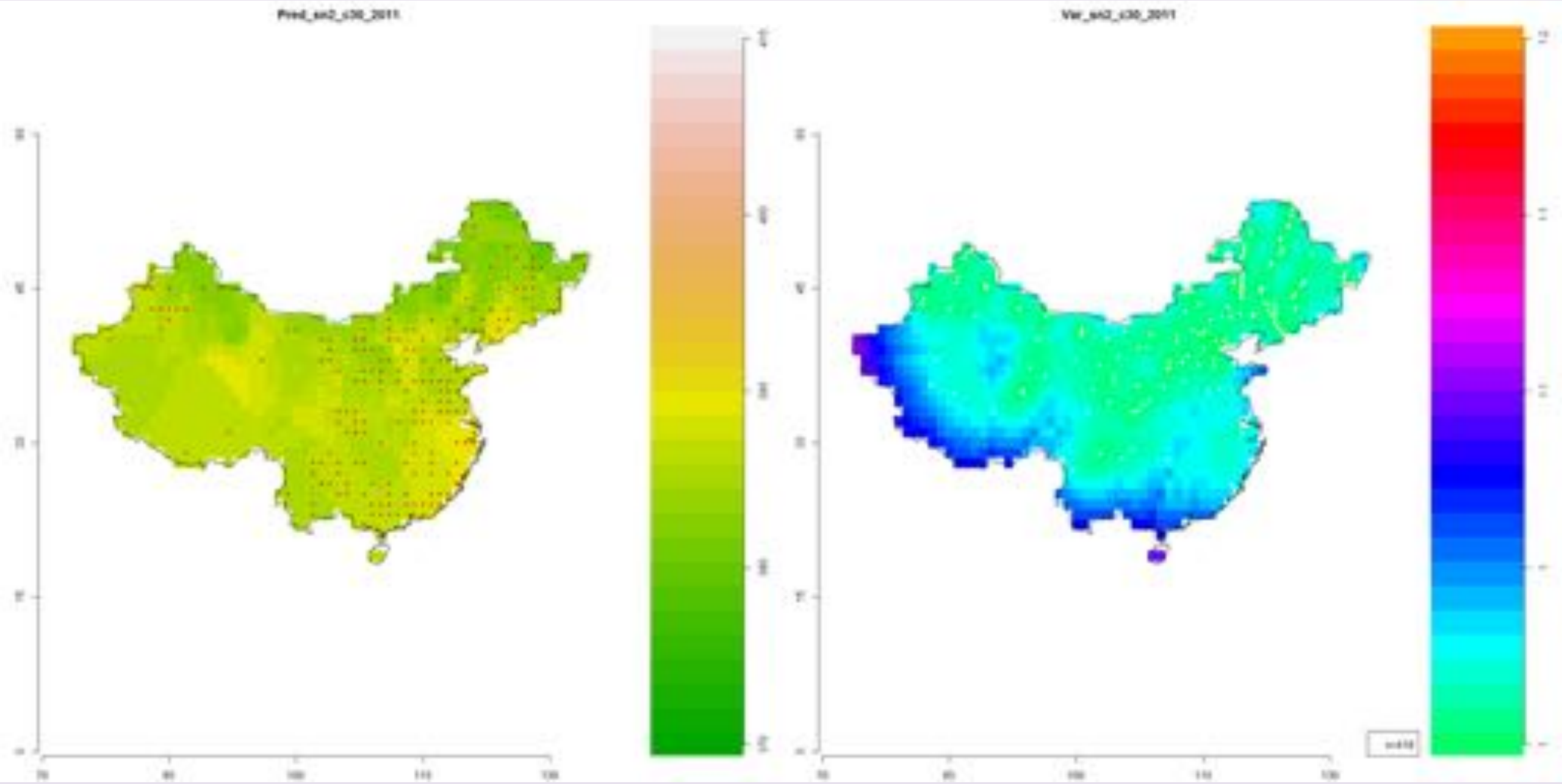



Pred_ant_c30_2013
Var_ant_c30_2013





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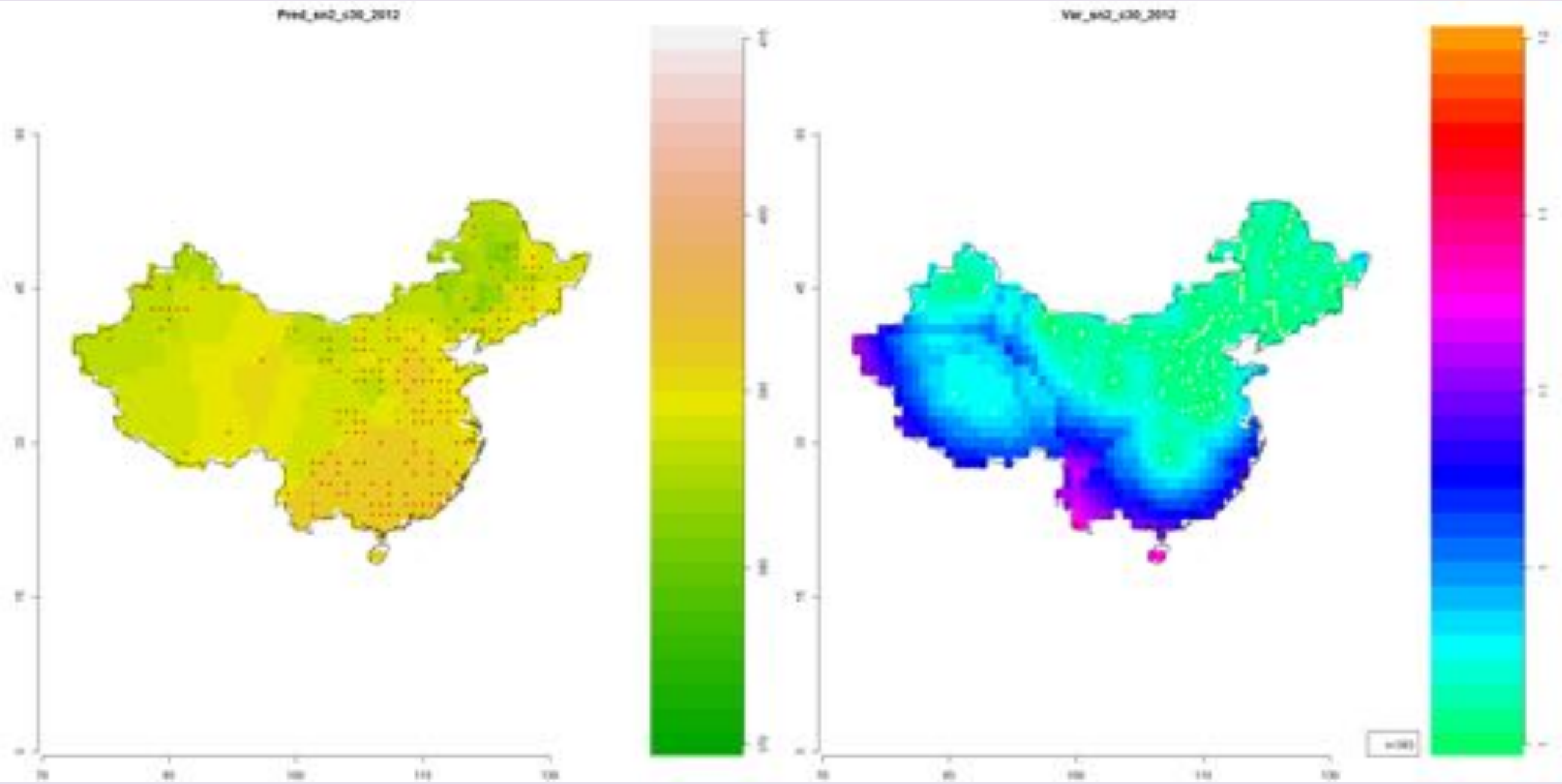
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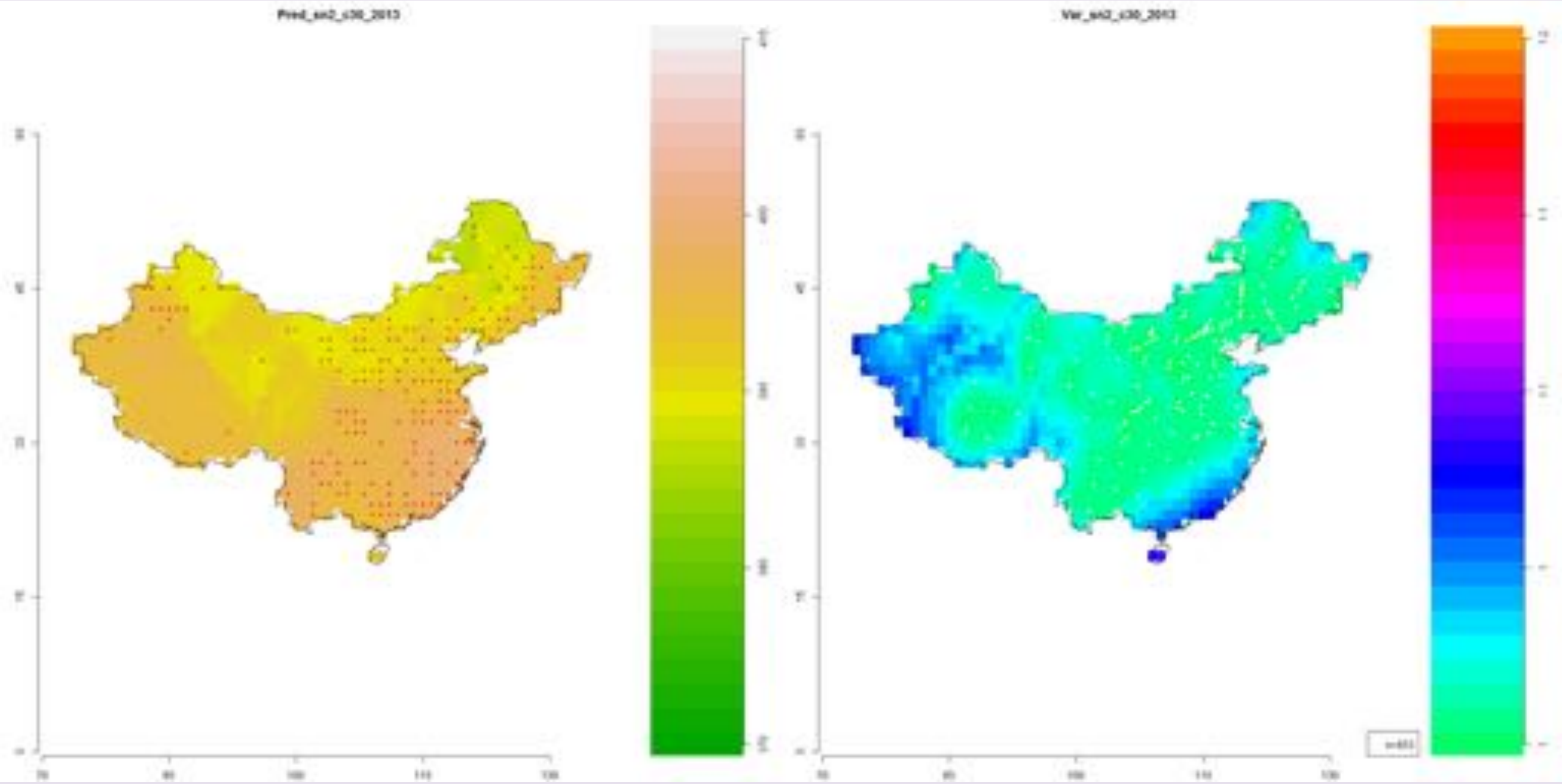

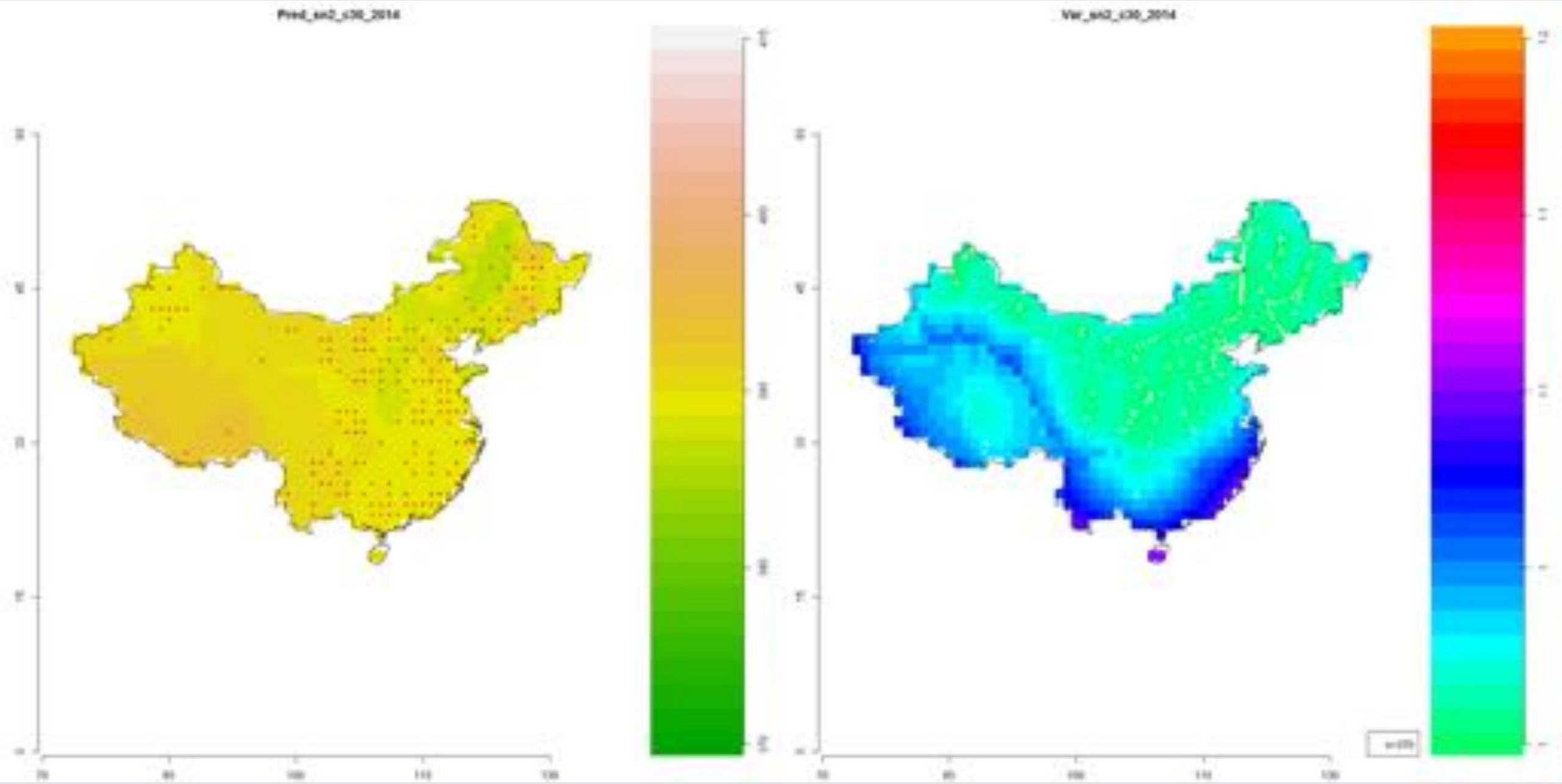

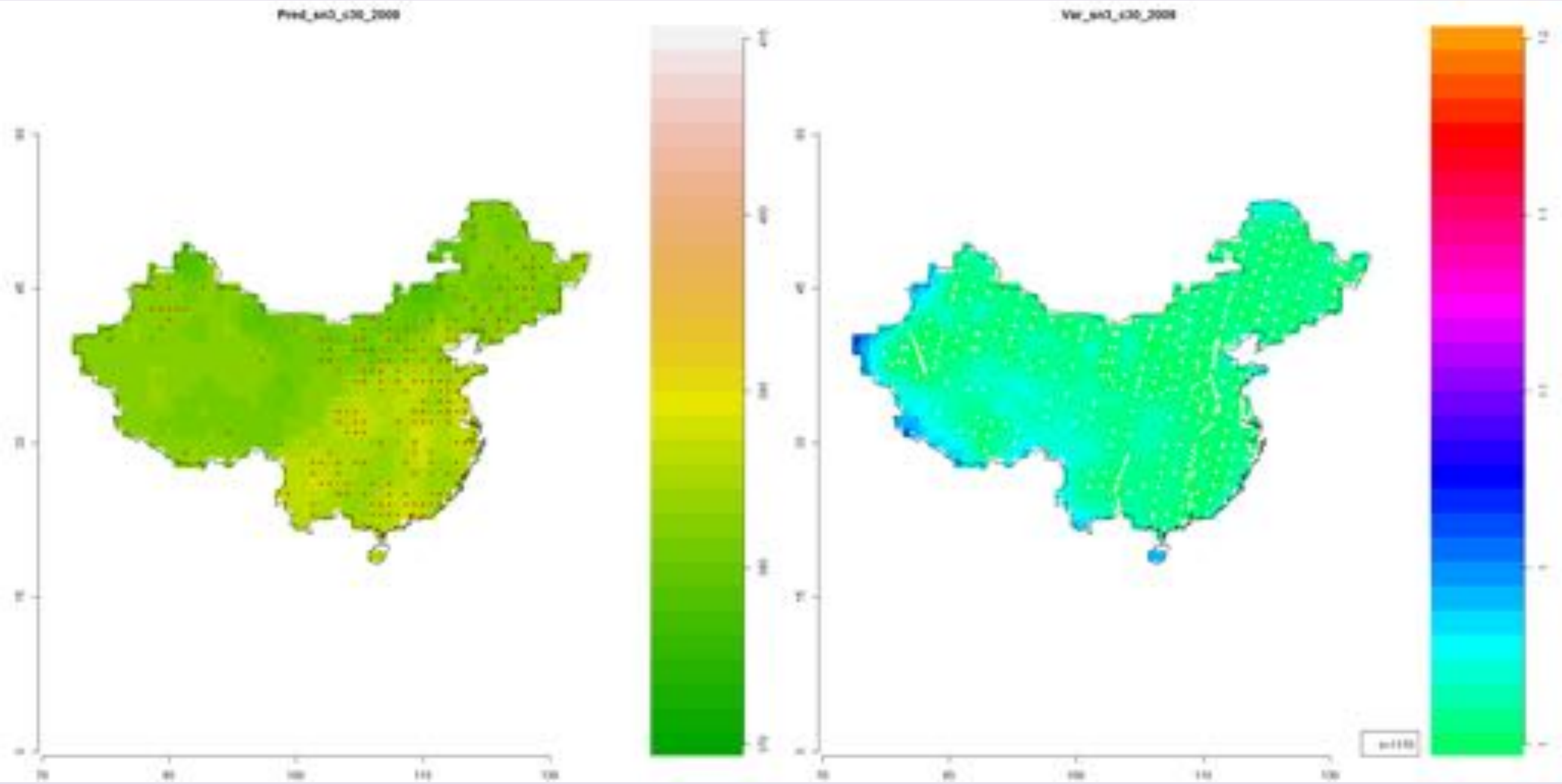
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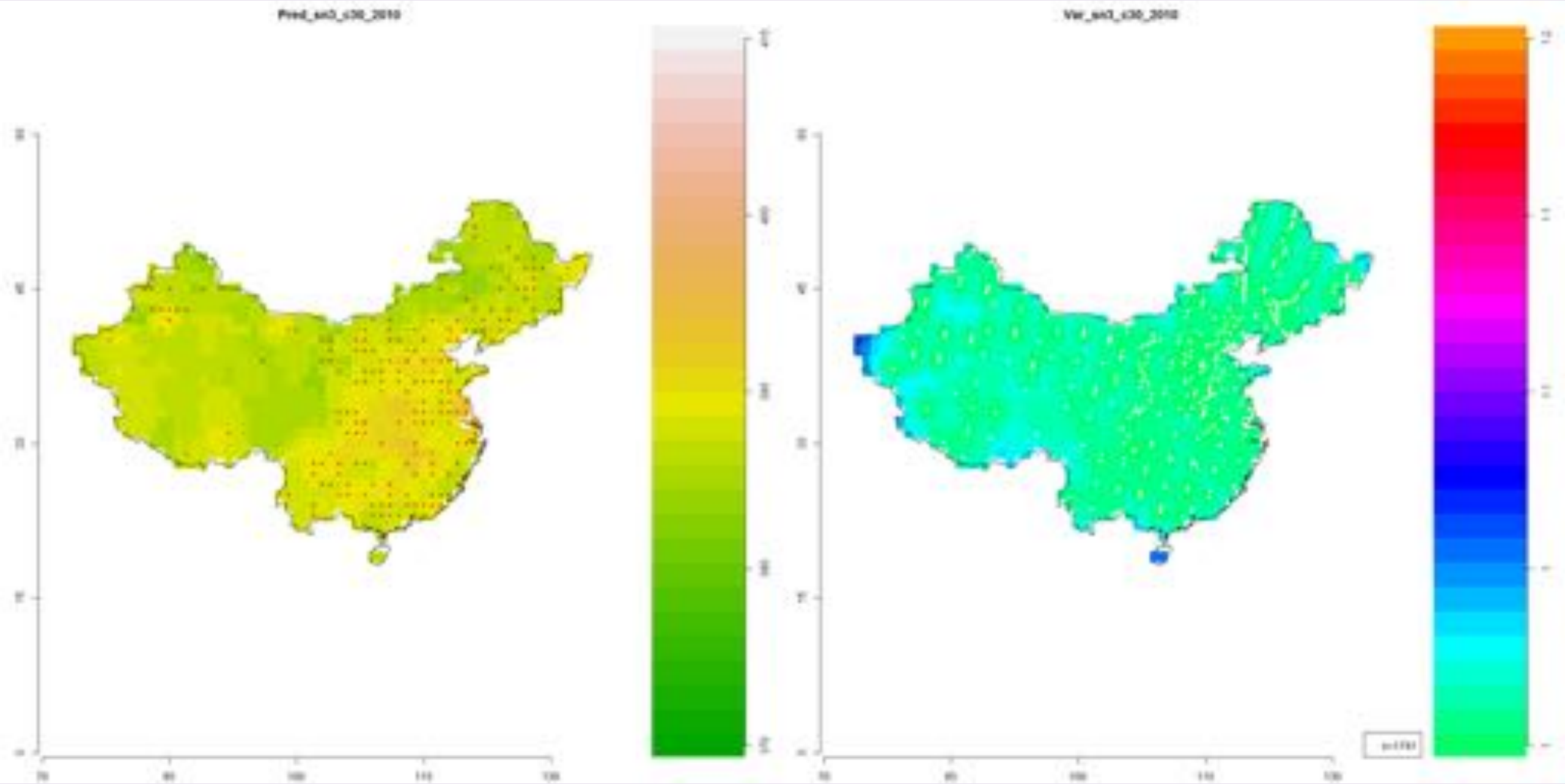
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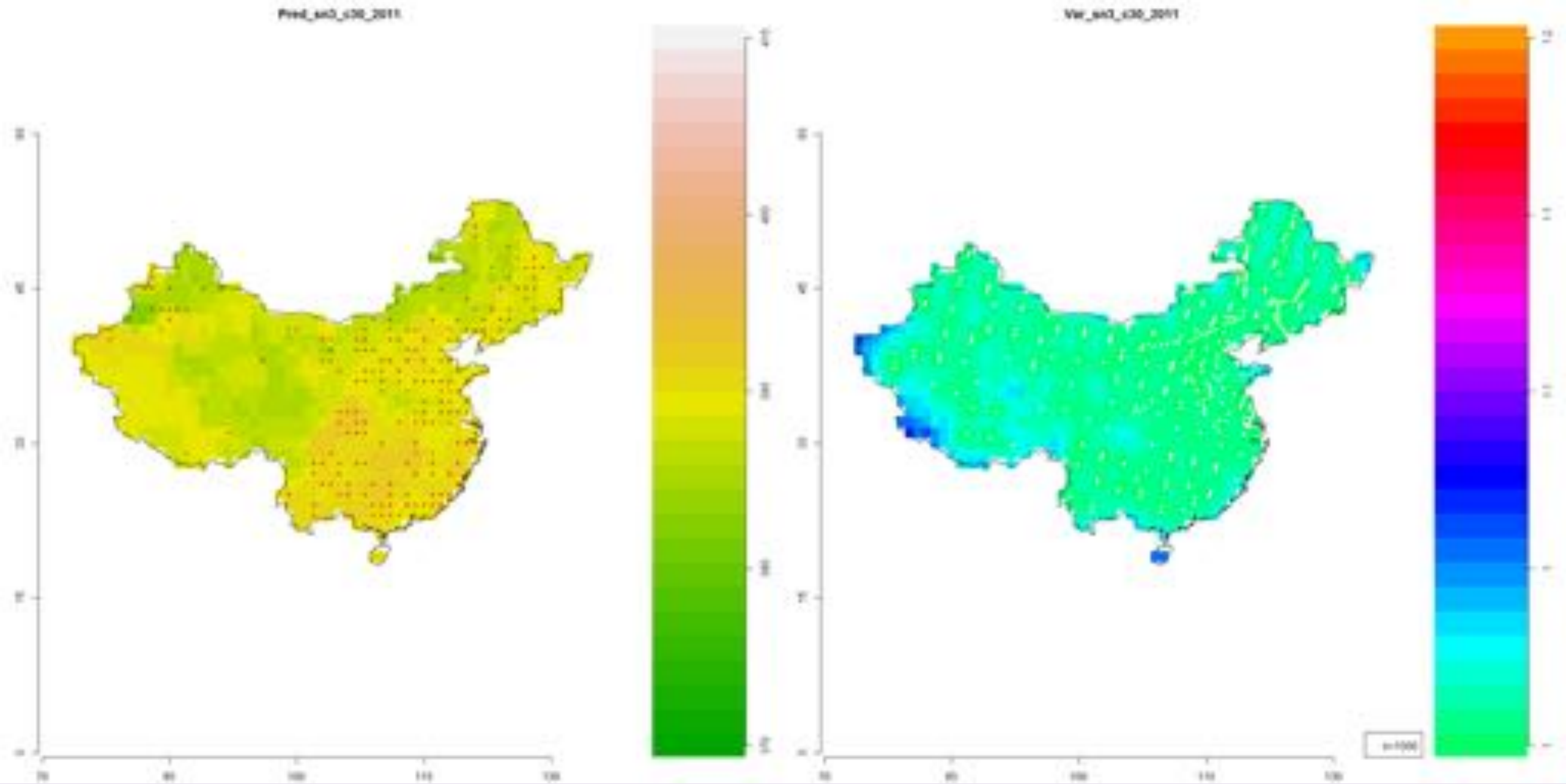
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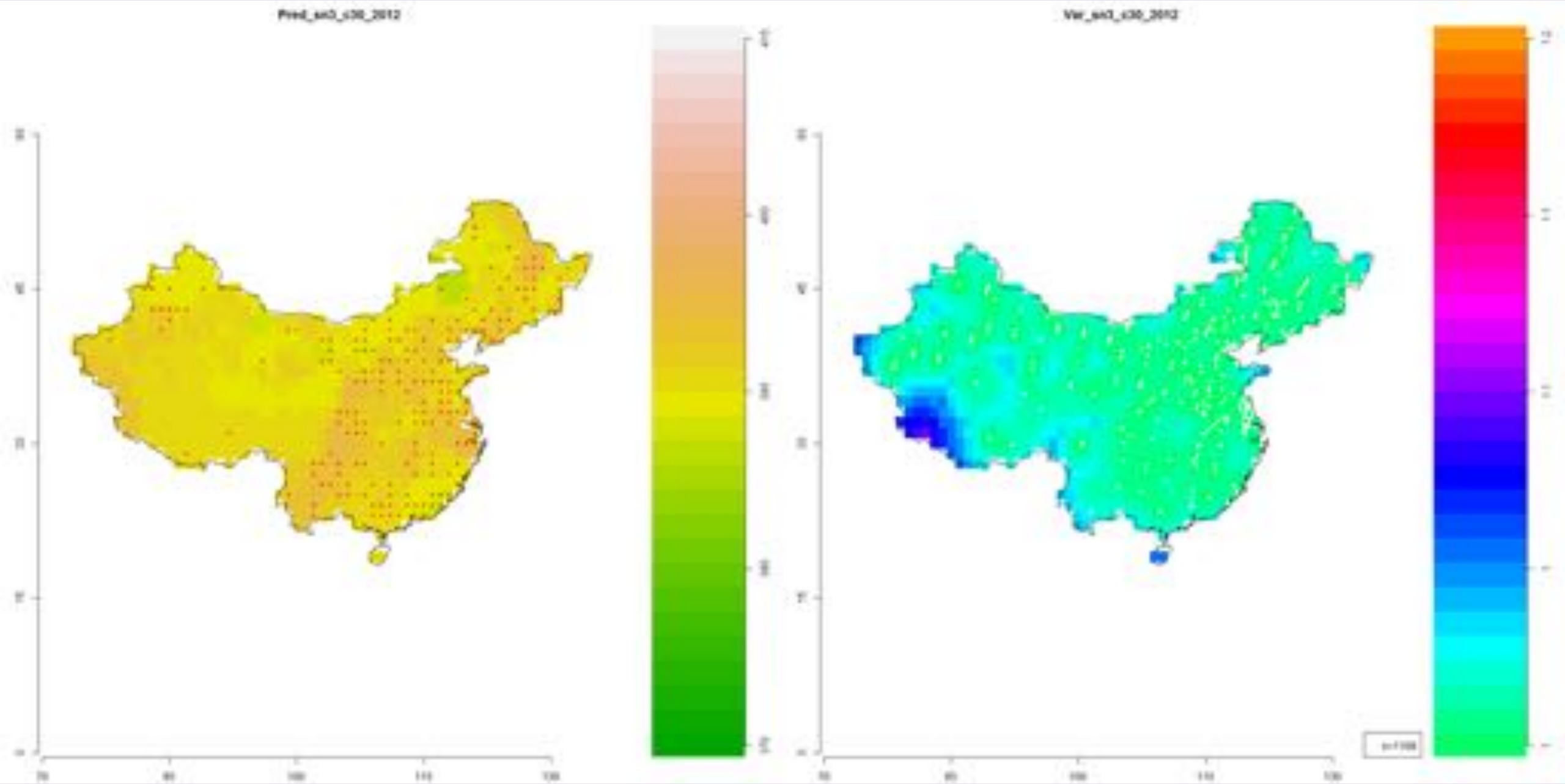
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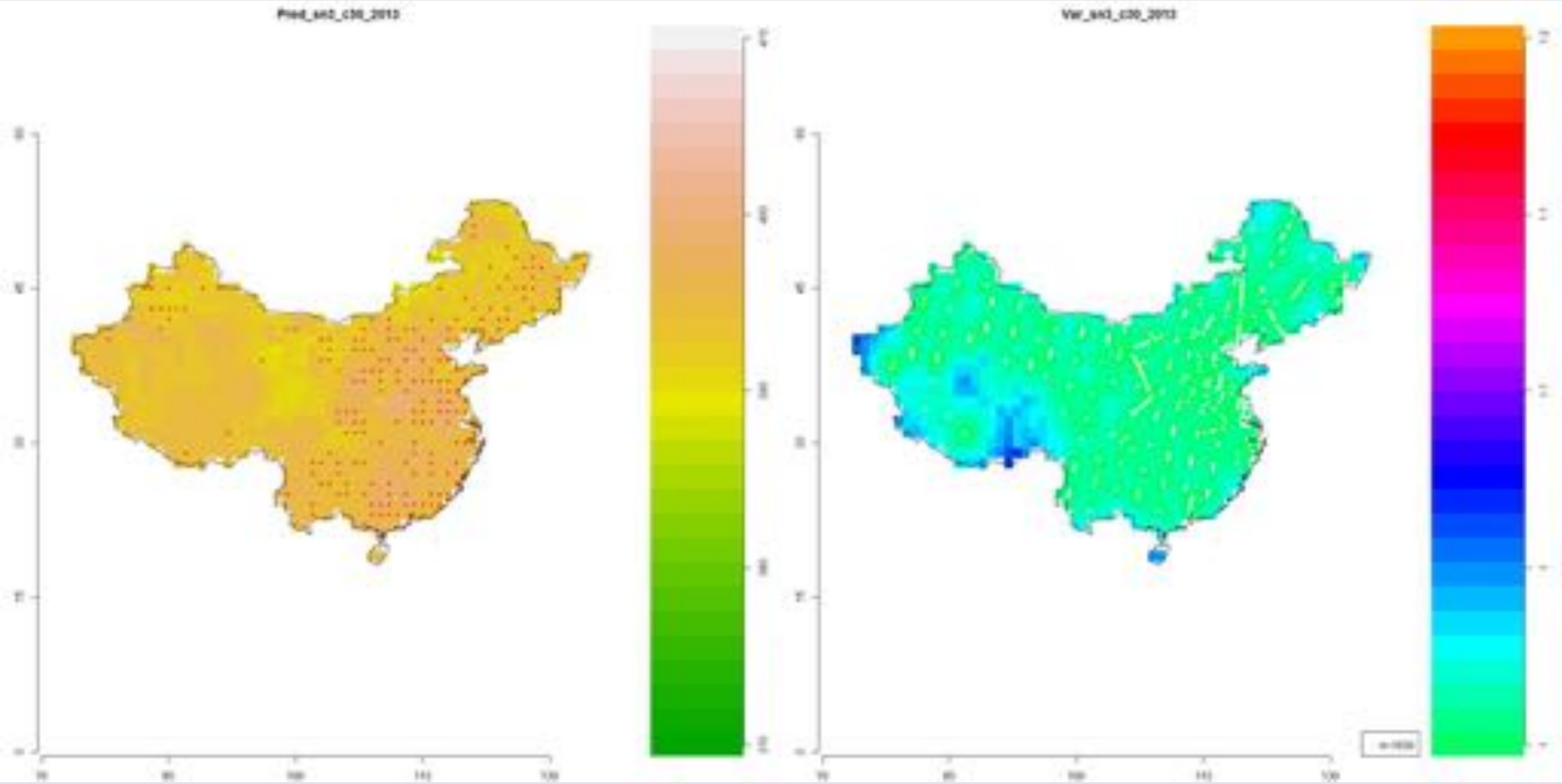

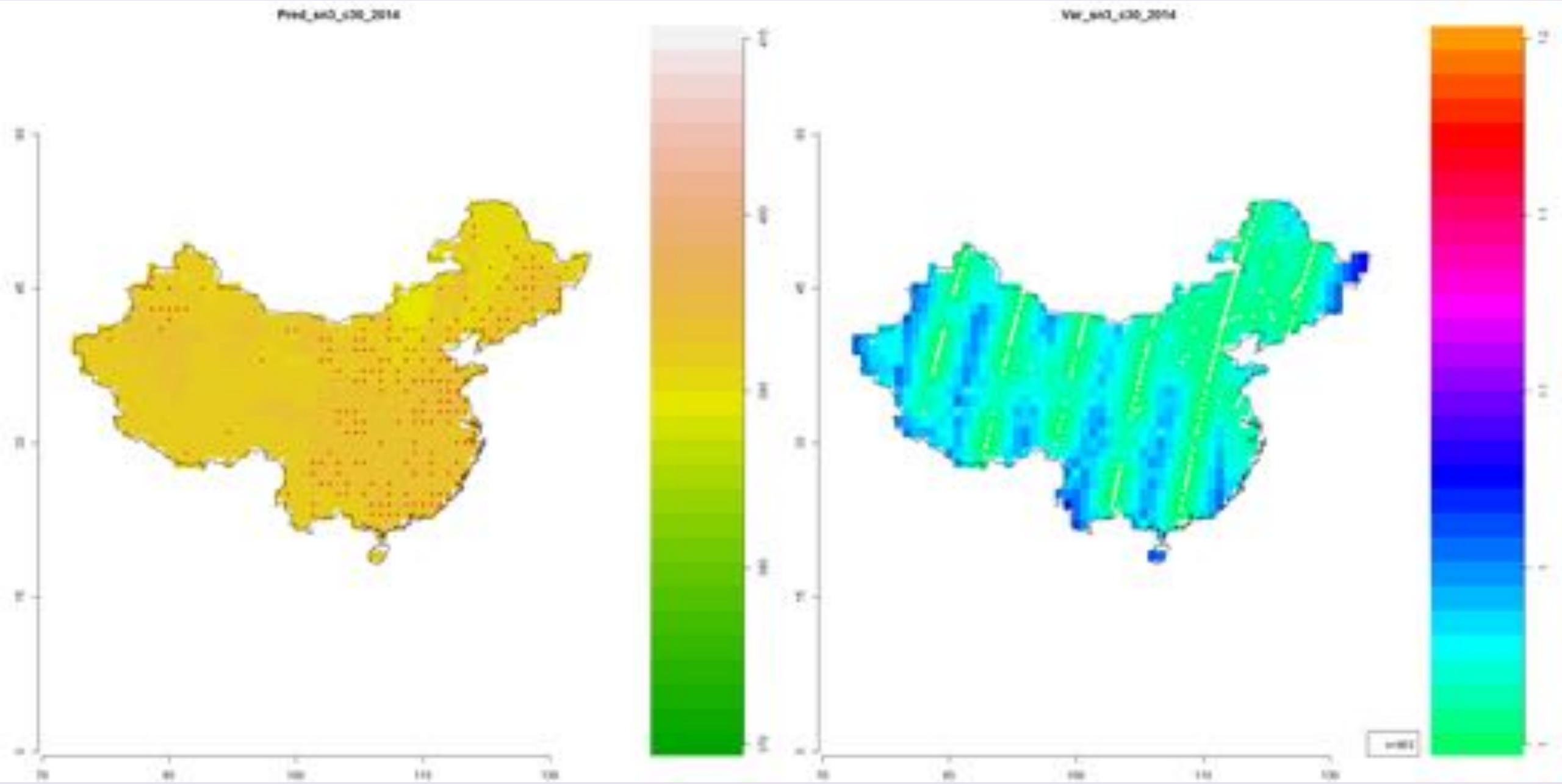

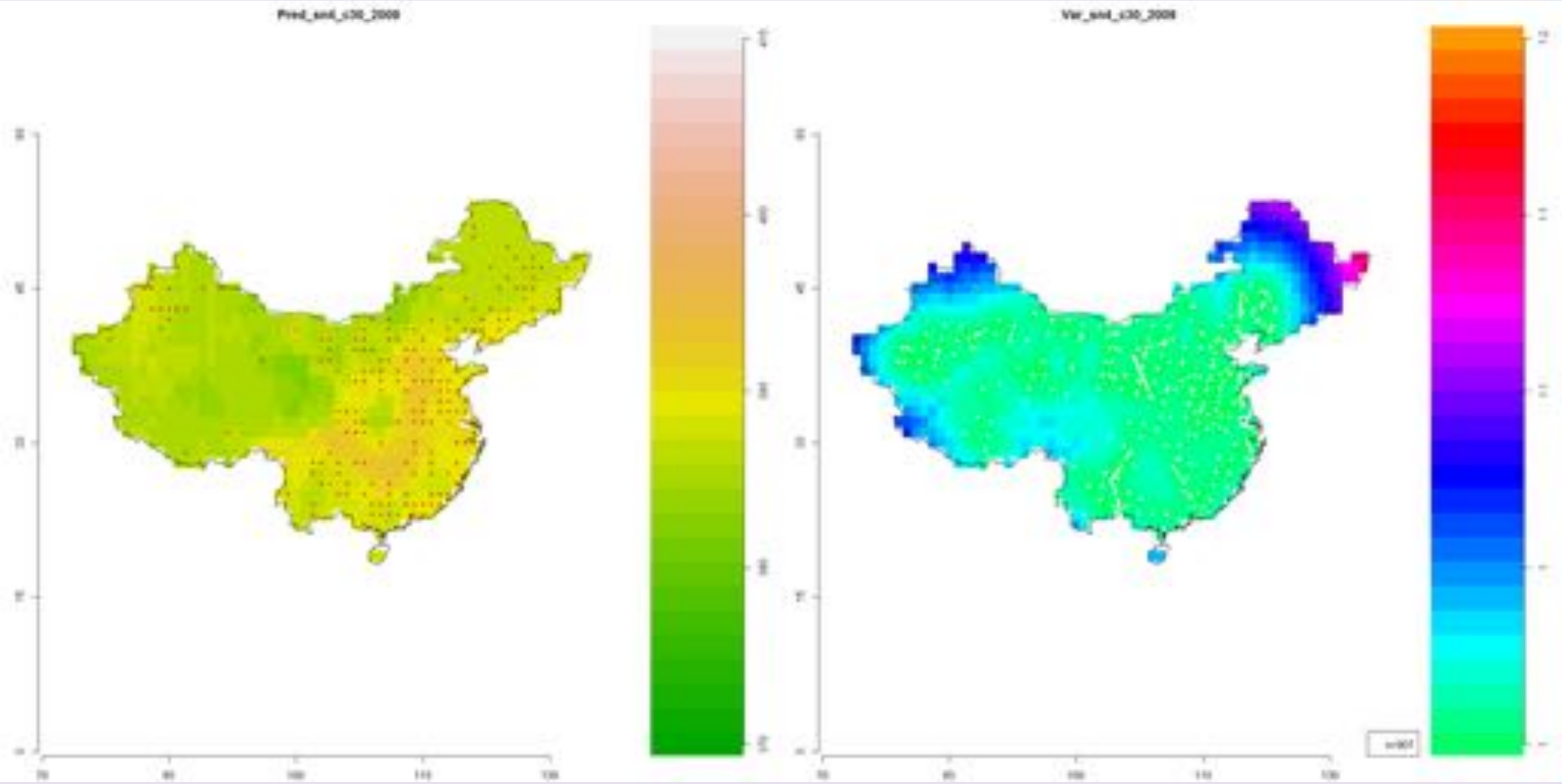
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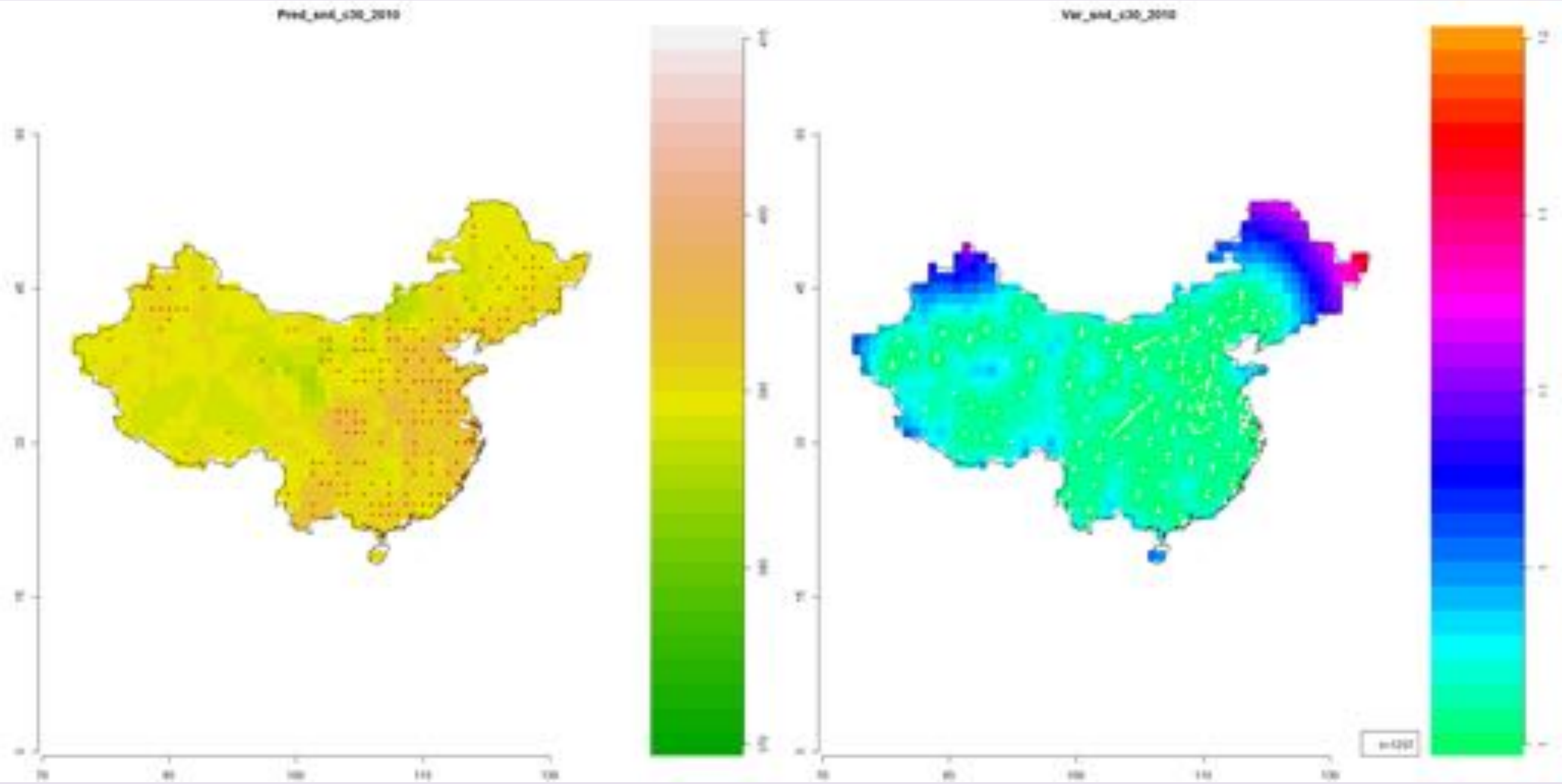
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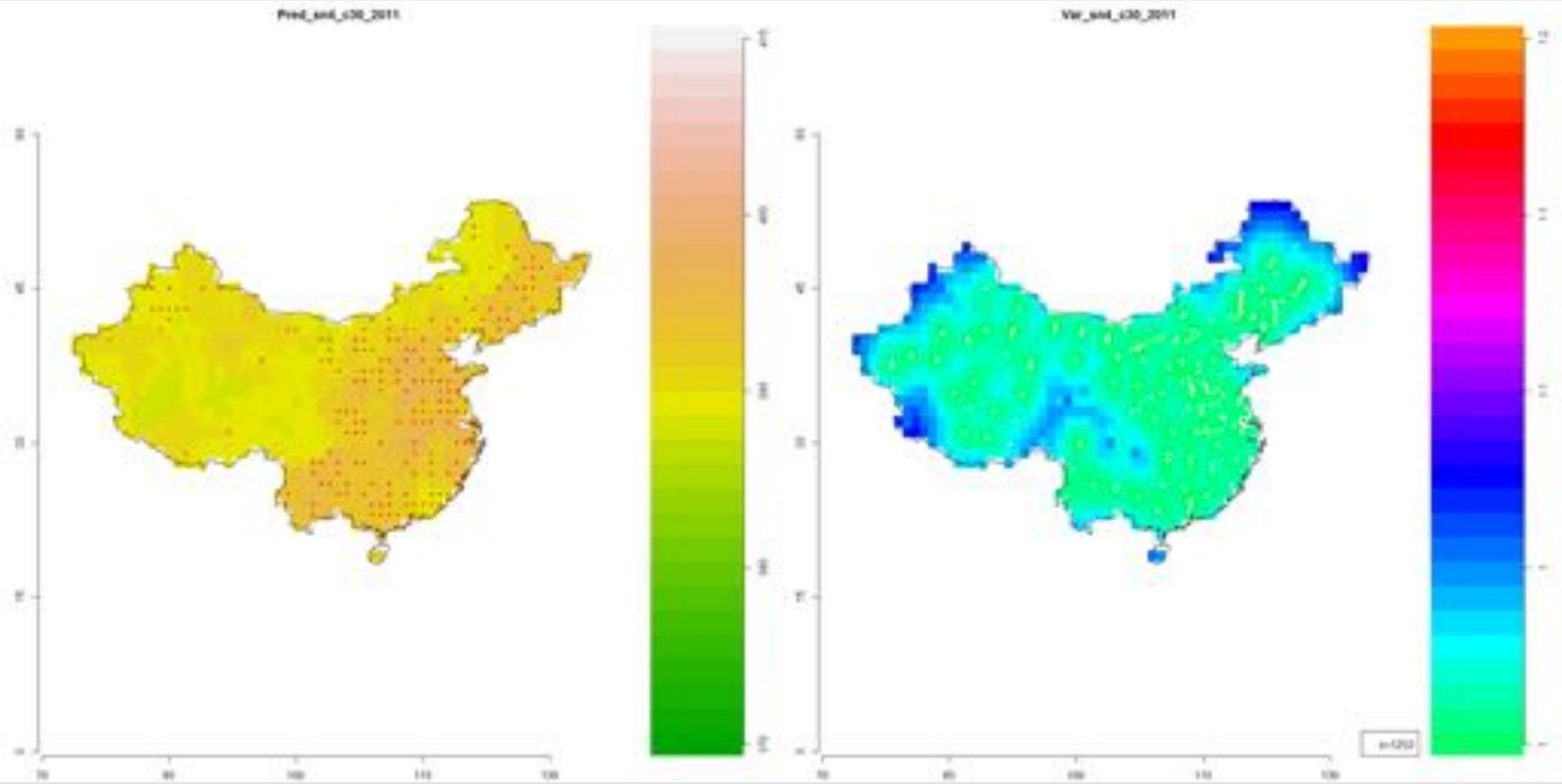
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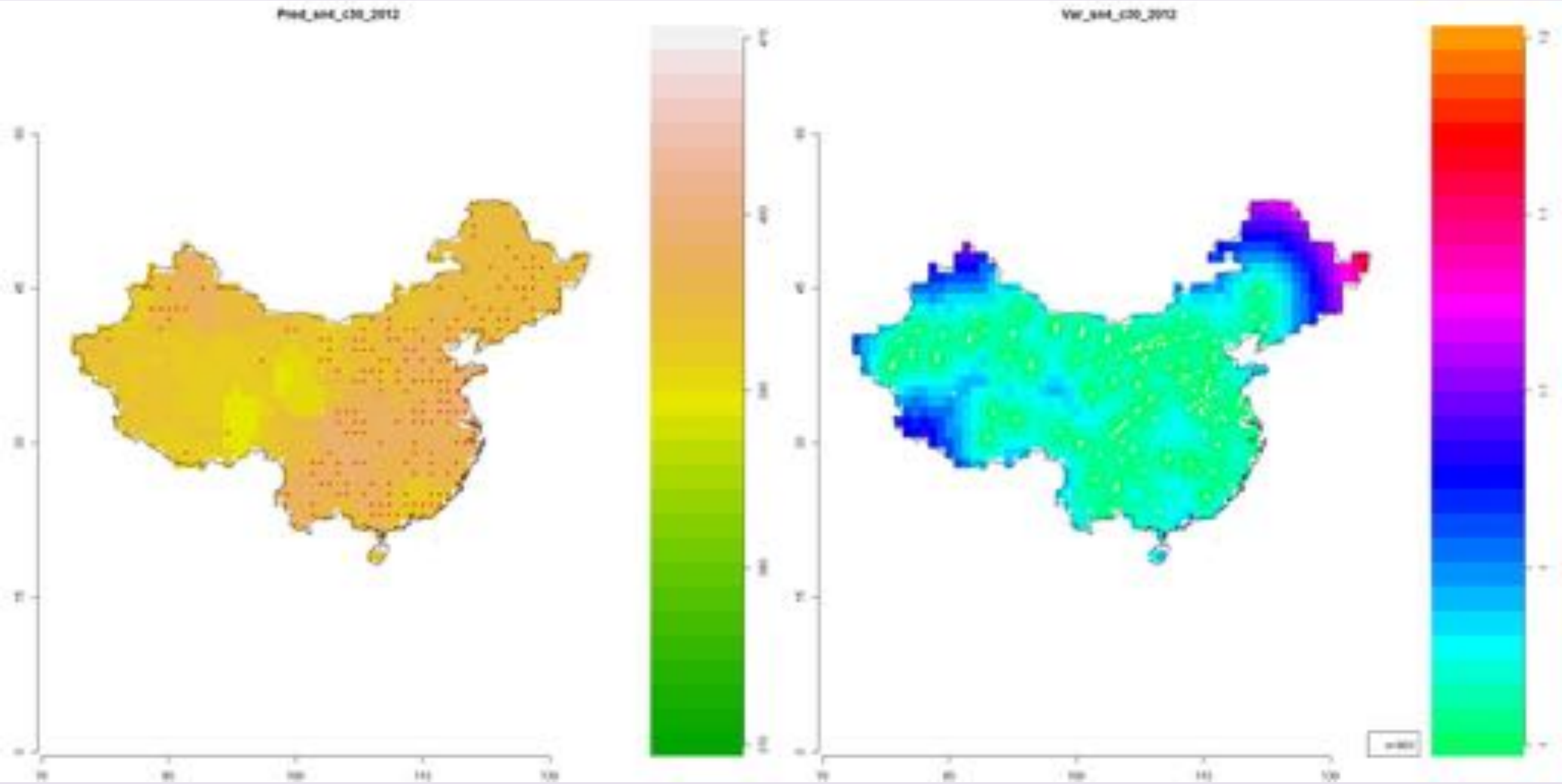

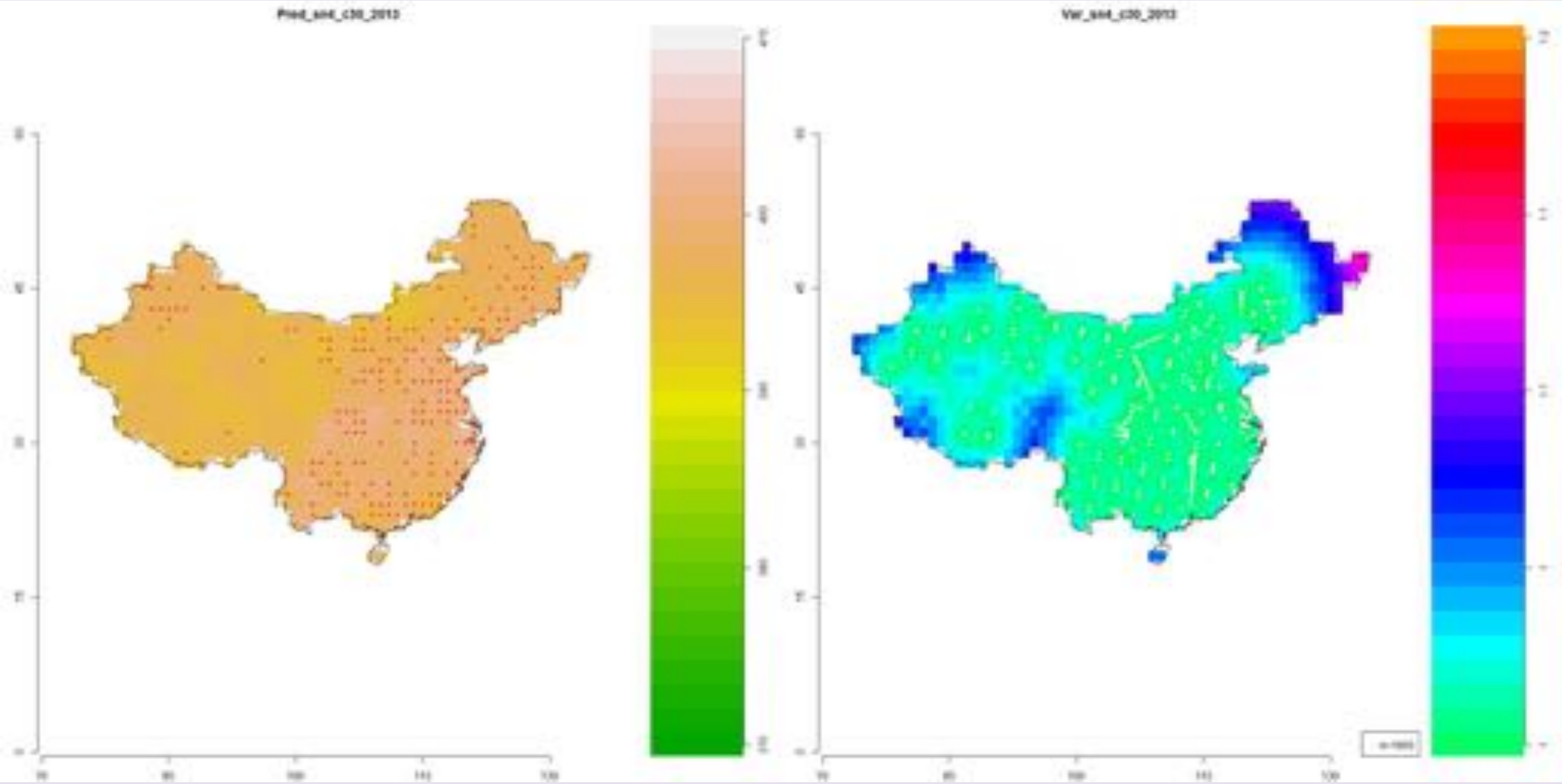

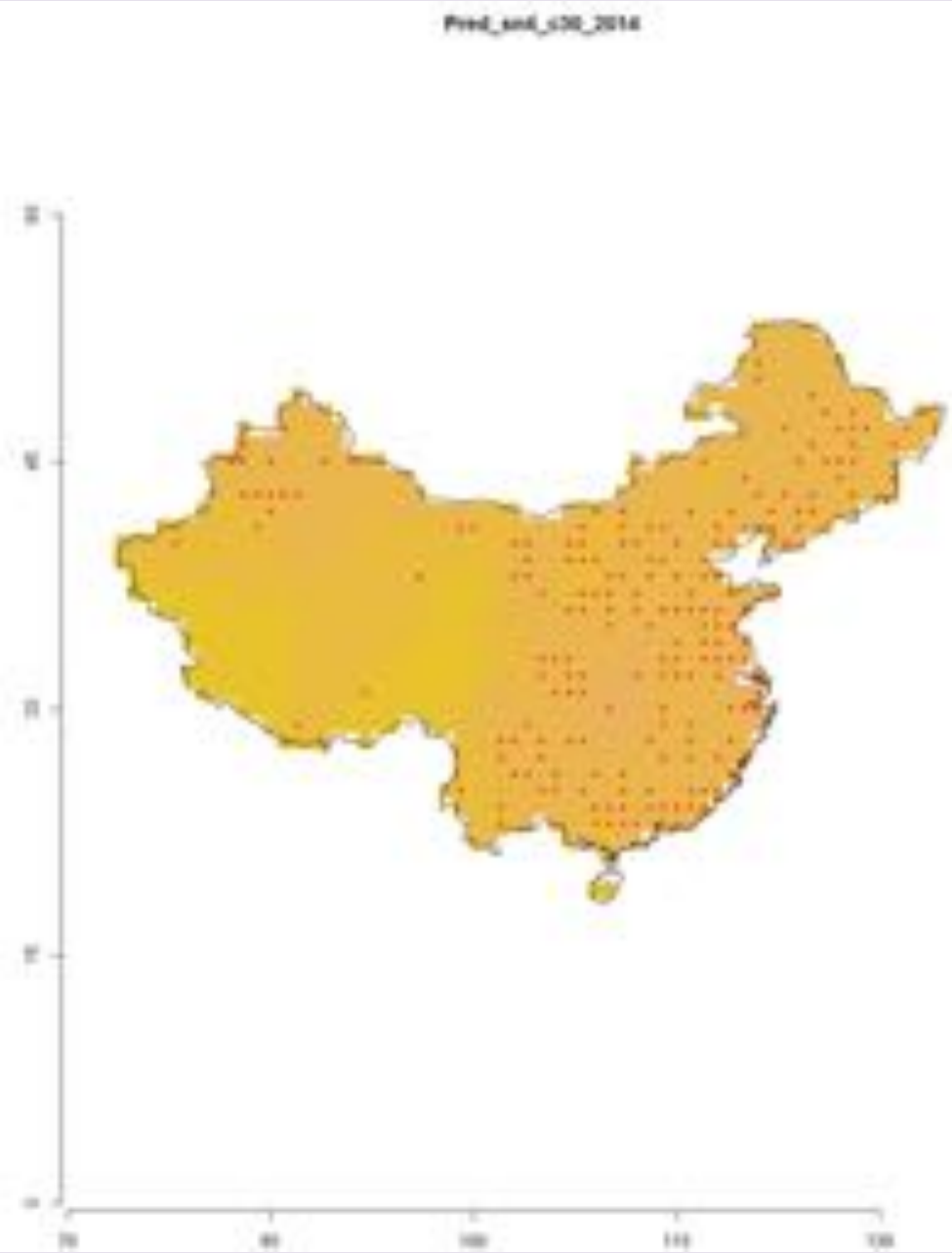

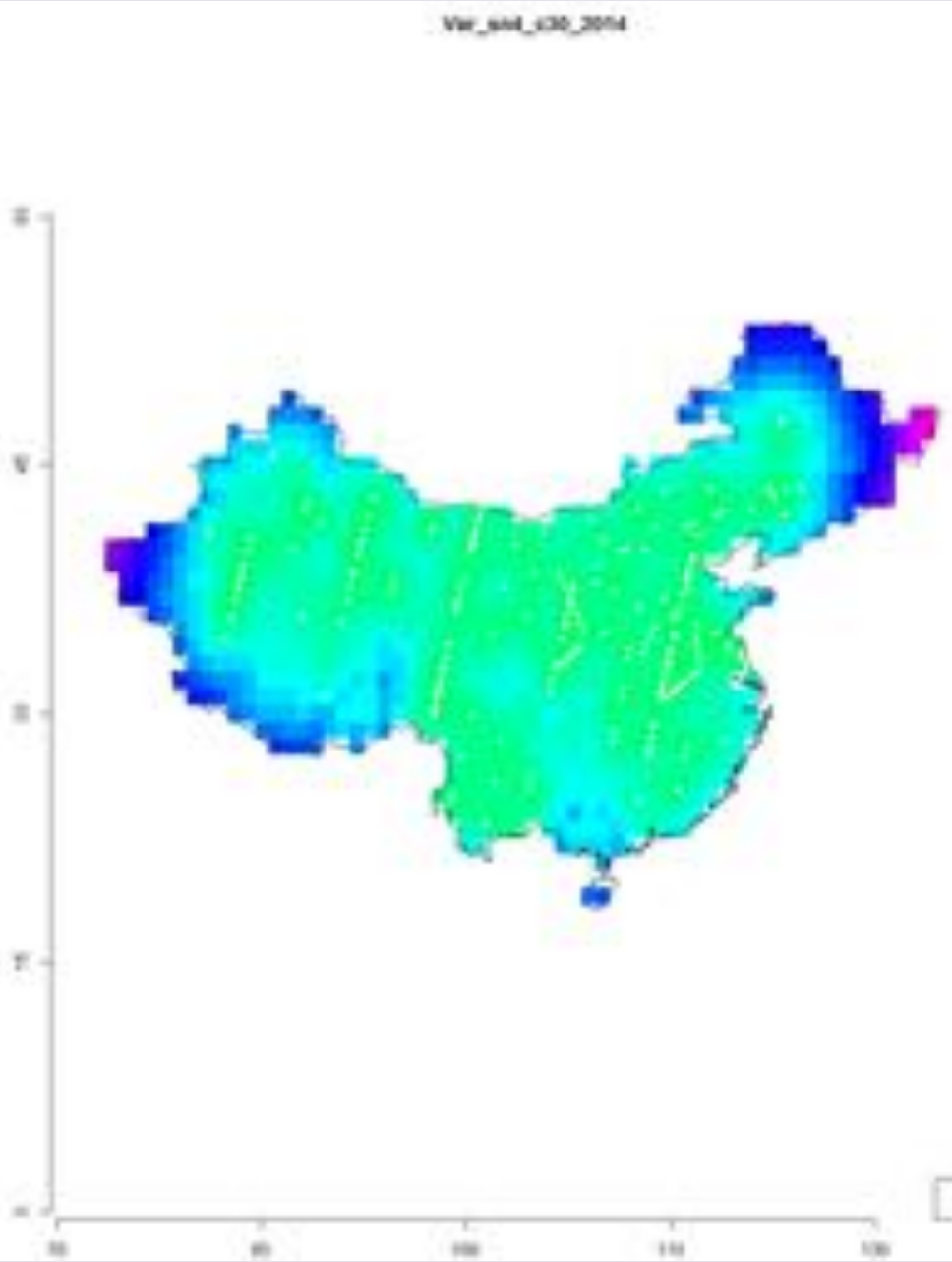

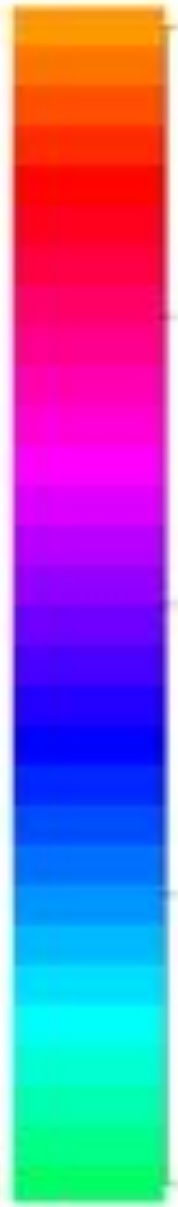

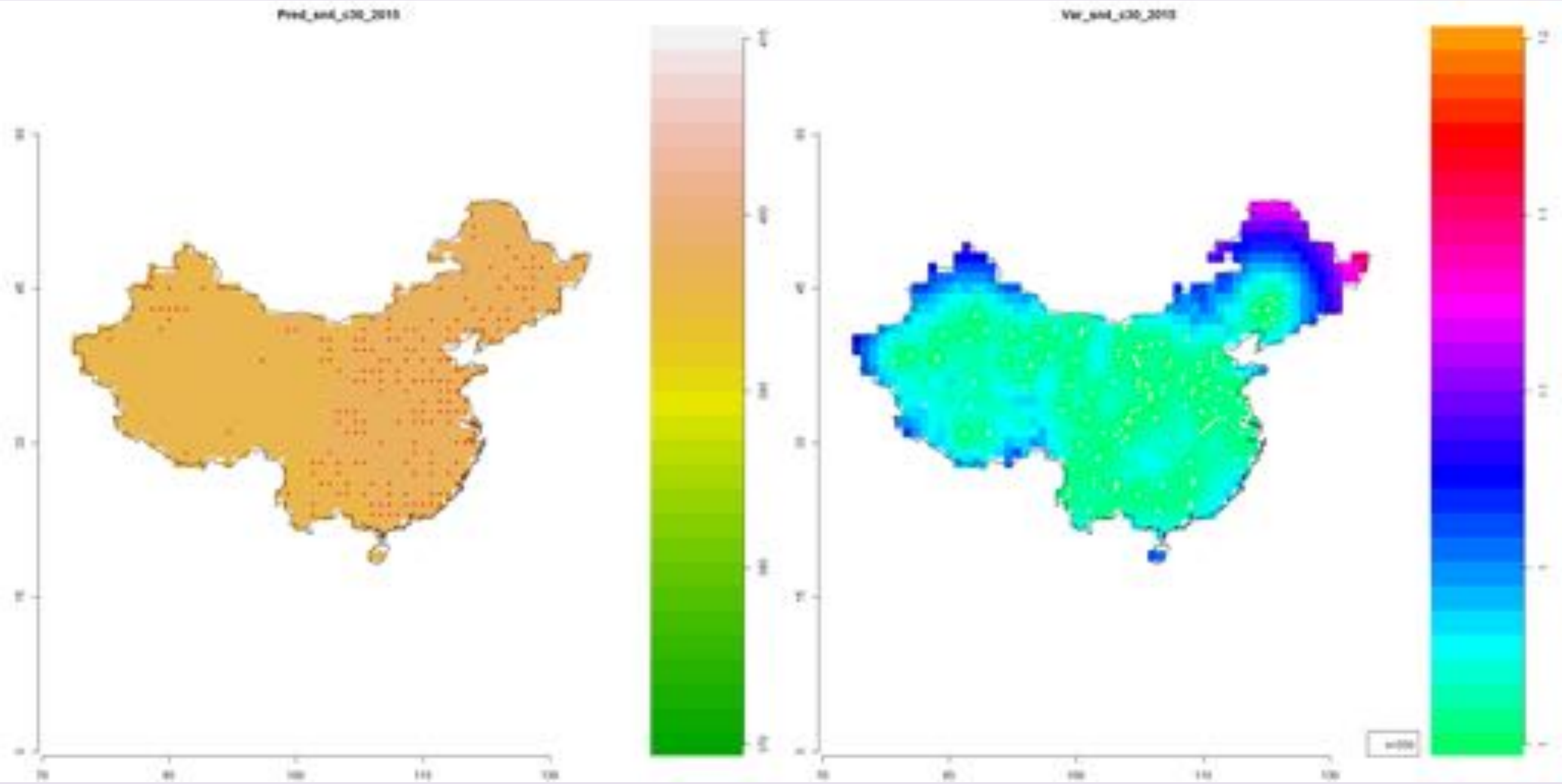

Conclusions

- XCO2 shows an increasing trend since 2009.
- XCO2 are highest in spring (April or May) and lowest in summer (July or August).
- Influence range of XCO2 is approximately 1200 km.
- Areas of higher XCO2 in China are roughly consistent with areas of higher population densities.

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