Supporting Global Air Quality Management Needs with a Flexible Data Fusion Tool for Estimation and Forecasting in Google Earth Engine

Carl Malings
Morgan State University & GESTAR-II cooperative agreement
NASA Global Modeling and Assimilation Office

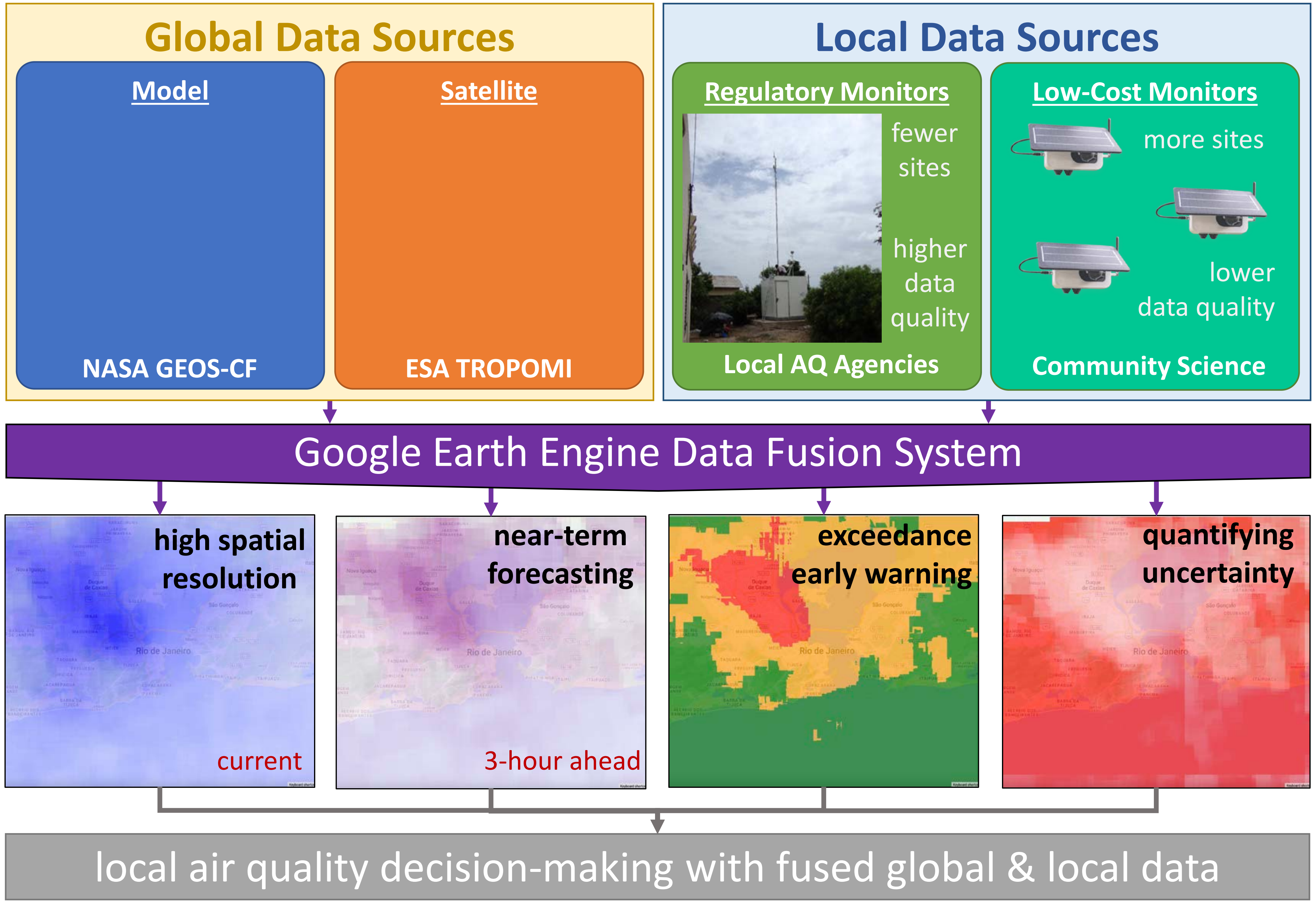
PROJECT TEAM
PI: K. Emma Knowland (MSU/GESTAR-II, GMAO)
Science-PIs: Carl Malings (MSU/GESTAR-II, GMAO), Nathan R. Pavlovic with Alan Chan, Justin Coughlin, and Daniel King (Sonoma Technology)
Co-Is: Christoph Keller (MSU/GESTAR-II, GMAO), Stephen Cohn (GMAO)
National/Global End-Users: United Nations Environment Programme (UNEP) & US Environmental Protection Agency (EPA)
Local End-Users: Ministry of Environment and Sustainable Development, Dakar, Senegal Instituto Pereira Passos, City Municipal Government, Rio de Janeiro, Brazil
Collaborators: Sean Khan (UNEP), John White (US EPA), Dan Westervelt (LDEO), Sean Wihera (Clarity Movement Co.), Randall Martin (WUSTL)

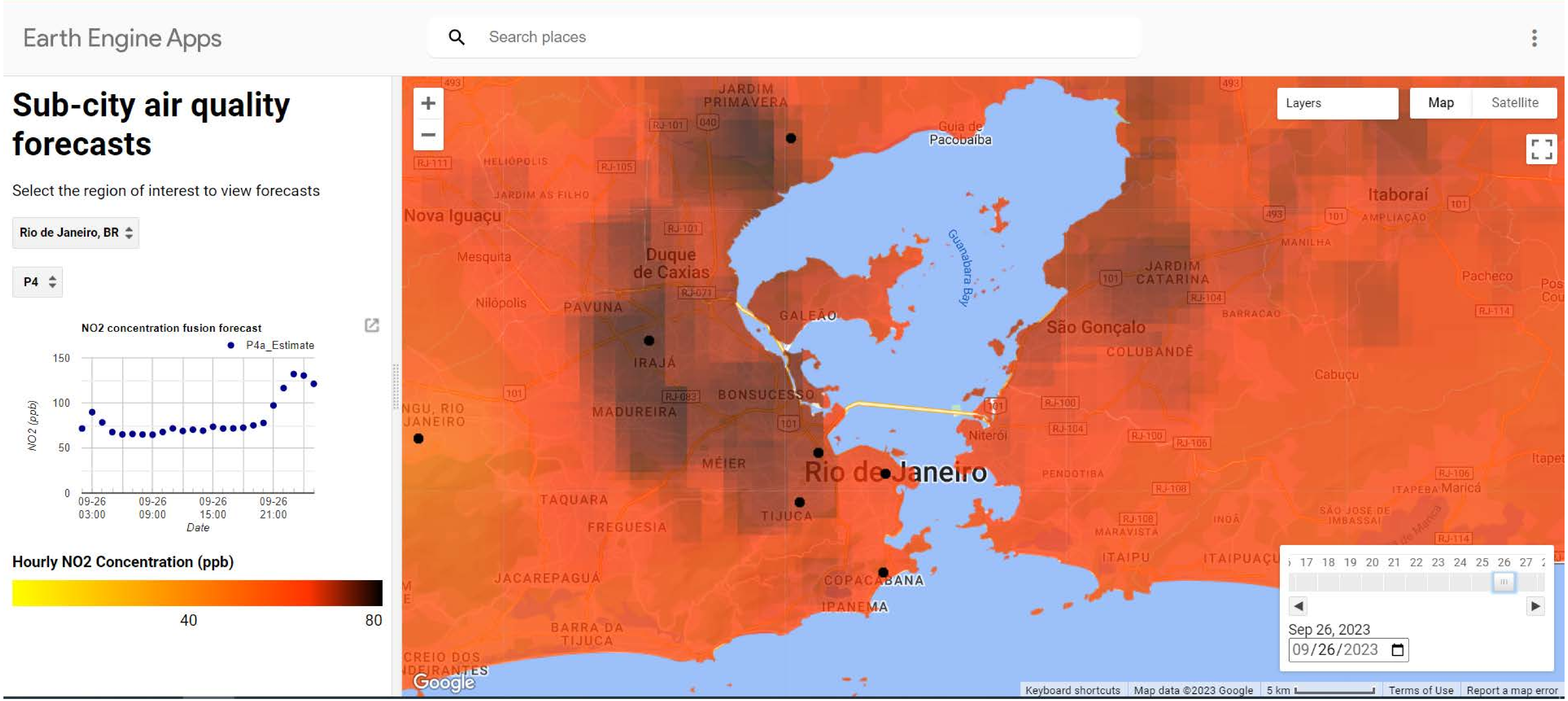
…integrate diverse **global** and **local** air quality data sources…

…using the cloud computing platform of **Google Earth Engine**…

…to provide synthesized **estimates** and **forecasts** of air quality at a **local scale** but with a **global scope**…

…freely accessible by air quality managers worldwide, facilitating their **decision-making** processes.




Earth Engine Apps
Search places
Sub-city air quality forecasts
Select the region of interest to view forecasts
Rio de Janeiro, BR
P4
NO2 concentration fusion forecast
P4a_Estimate
150
100
50
0
NO2 (ppb)
09-26 03:00
09-26 09:00
09-26 15:00
09-26 21:00
Date
Hourly NO2 Concentration (ppb)
40
80
Layers
Map
Satellite
JARDIM PRIMAVERA
Guia de Pacobaíba
Guanabara Bay
Nova Iguaçu
Mesquita
Duque de Caxias
Nilópolis
PAVUNA
GALEÃO
Itaboraí
JARDIM CATARINA
São Gonçalo
COLUBANDÊ
IRAJÁ
BONSUCESSO
MADUREIRA
Niterói
Rio de Janeiro
MÉIER
TIJUCA
TAQUARA
FREGUESIA
JACAREPAGUÁ
COPACABANA
IPANEMA
BARRA DA TIJUCA
Pacheco
Cabuçu
Maricá
ITAIPU
17 18 19 20 21 22 23 24 25 26 27
Sep 26, 2023
09/26/2023
Google
Keyboard shortcuts
Map data ©2023 Google
5 km
Terms of Use
Report a map error

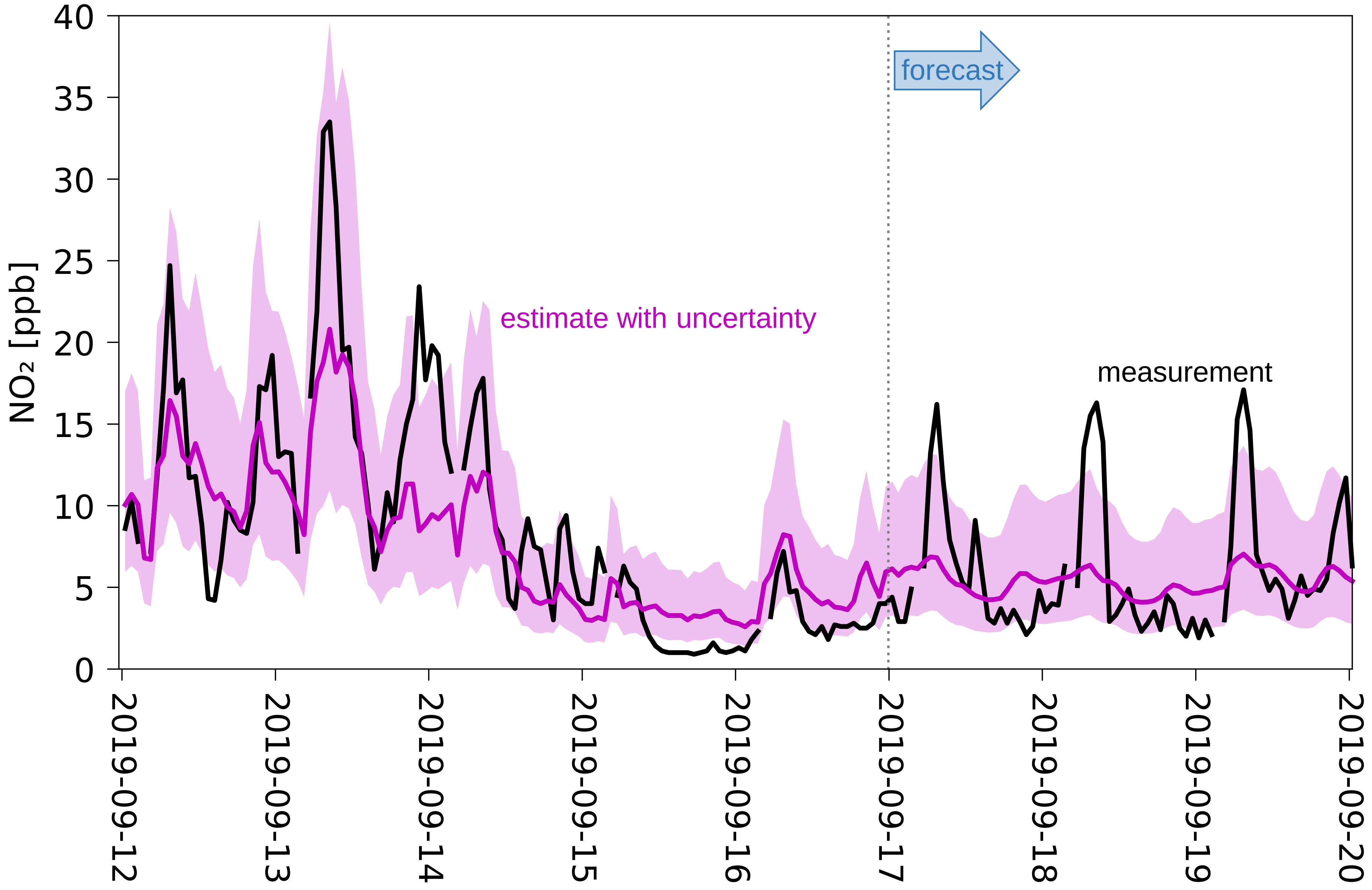
Provide a prior estimate of the relative confidence in a forecast

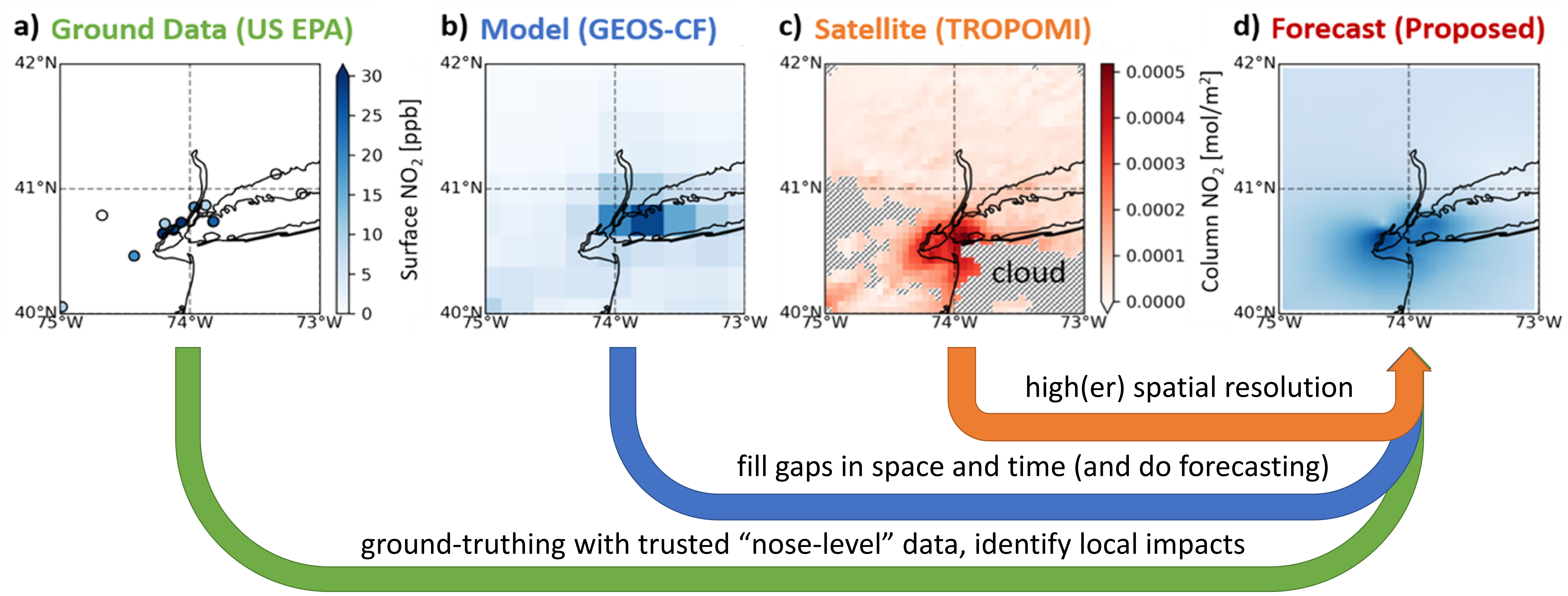
Convey probabilities of specific events, e.g., exceedance of standards

Identify a range of likely outcomes

Quantify the impacts of different data sources in reducing uncertainties

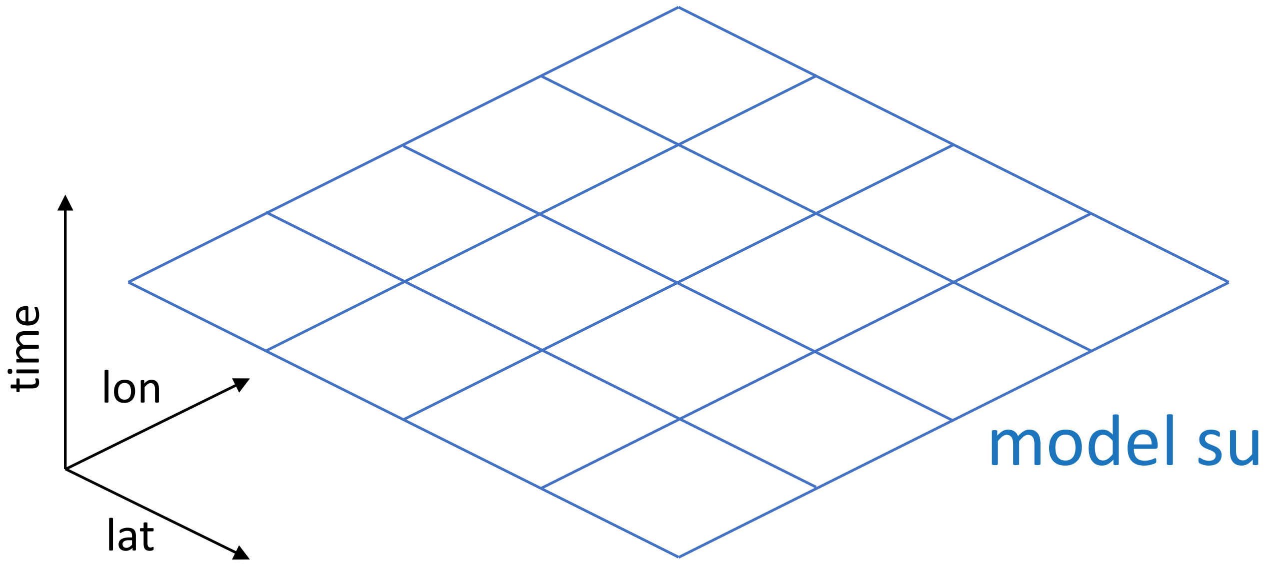
Identify the potential to reduce uncertainties through additional data collection





Source: Malings et al. (2021), "Sub-City Scale Hourly Air Quality Forecasting by Combining Models, Satellite Observations, and Ground Measurements" *Earth & Space Science.* [DOI: 10.1029/2021EA001743](https://doi.org/10.1029/2021EA001743)

Phase	Estimate
1	forecast model (GEOS-CF)



model surface concentration $M(x,t)$

Phase	Estimate
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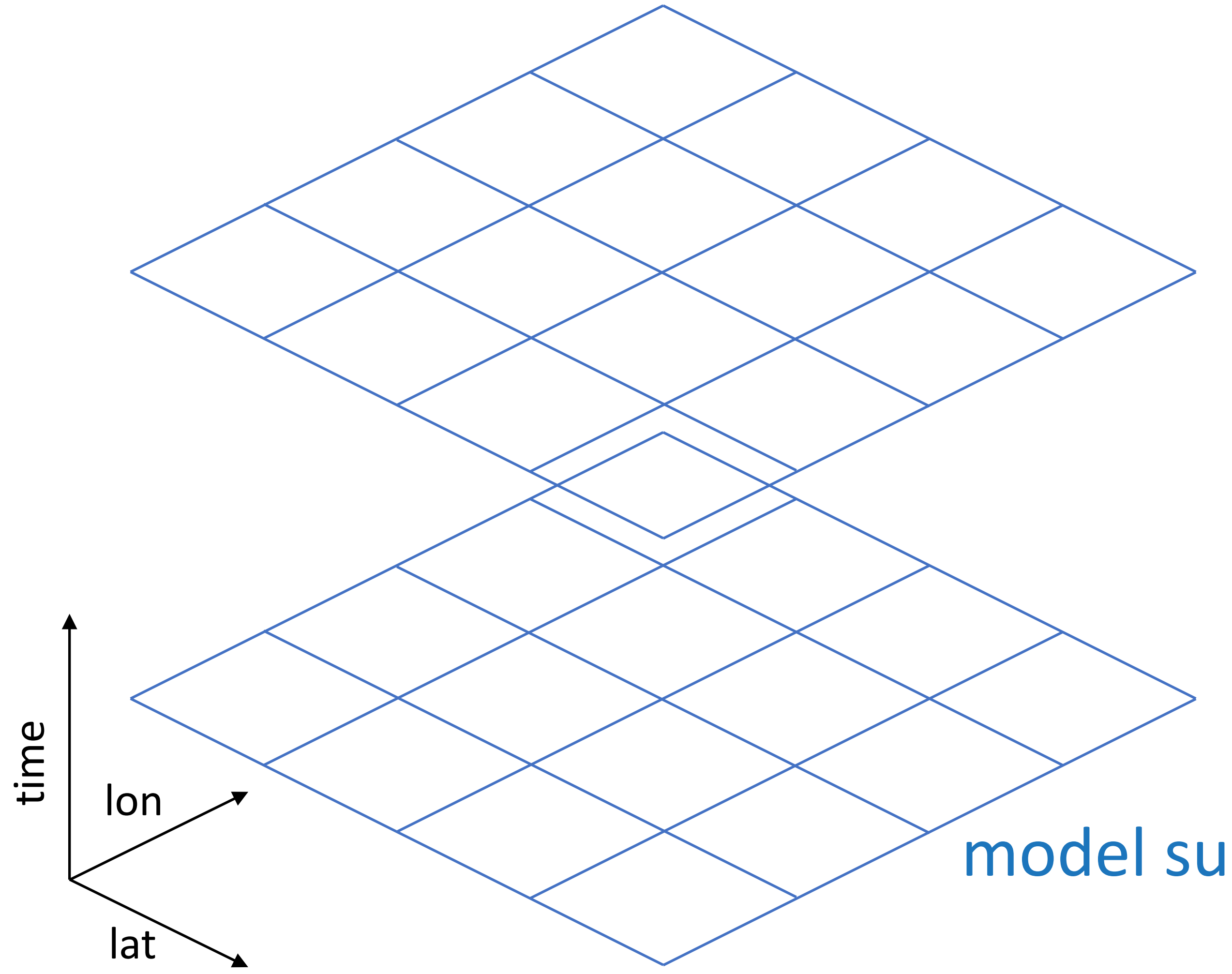

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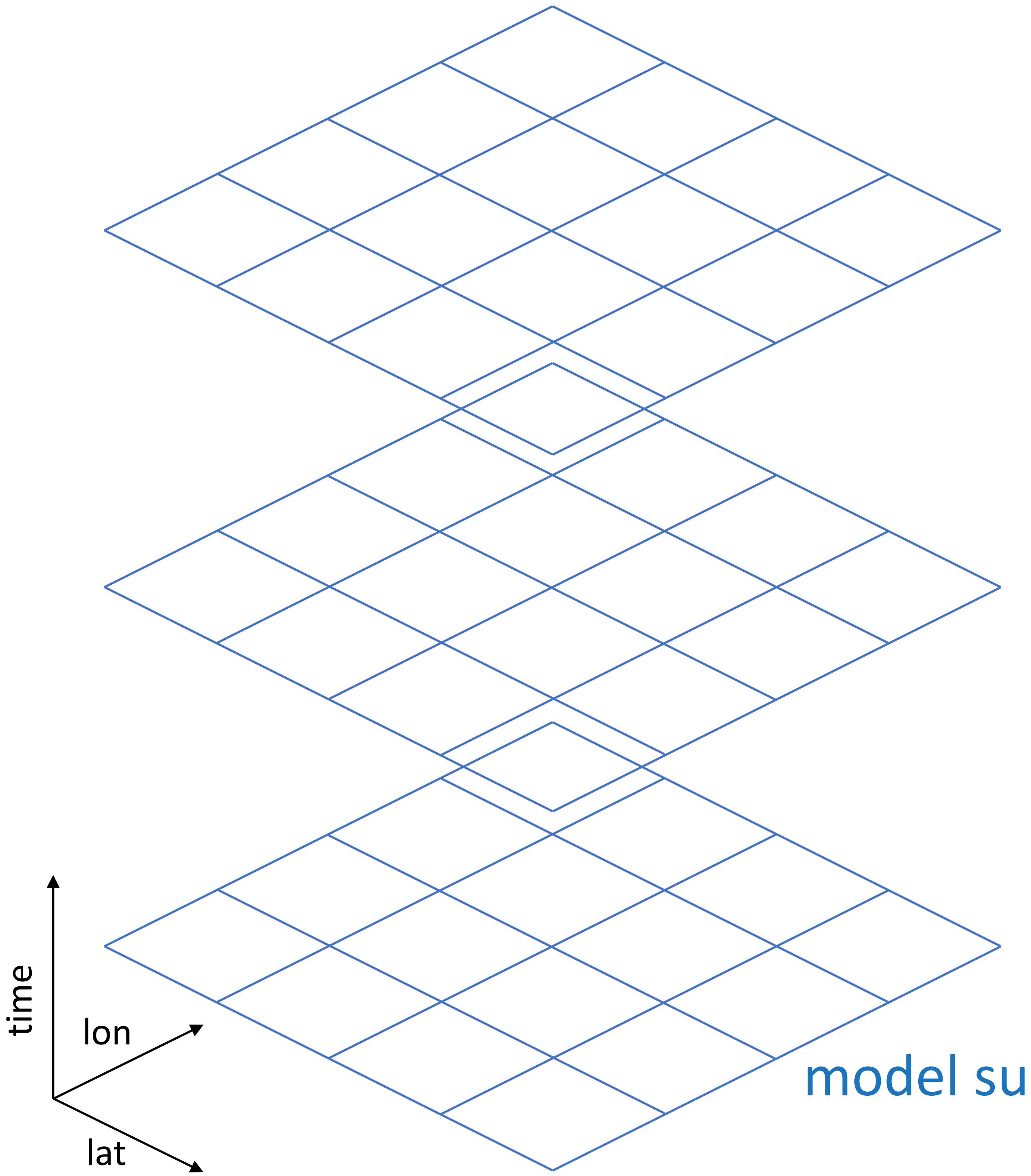
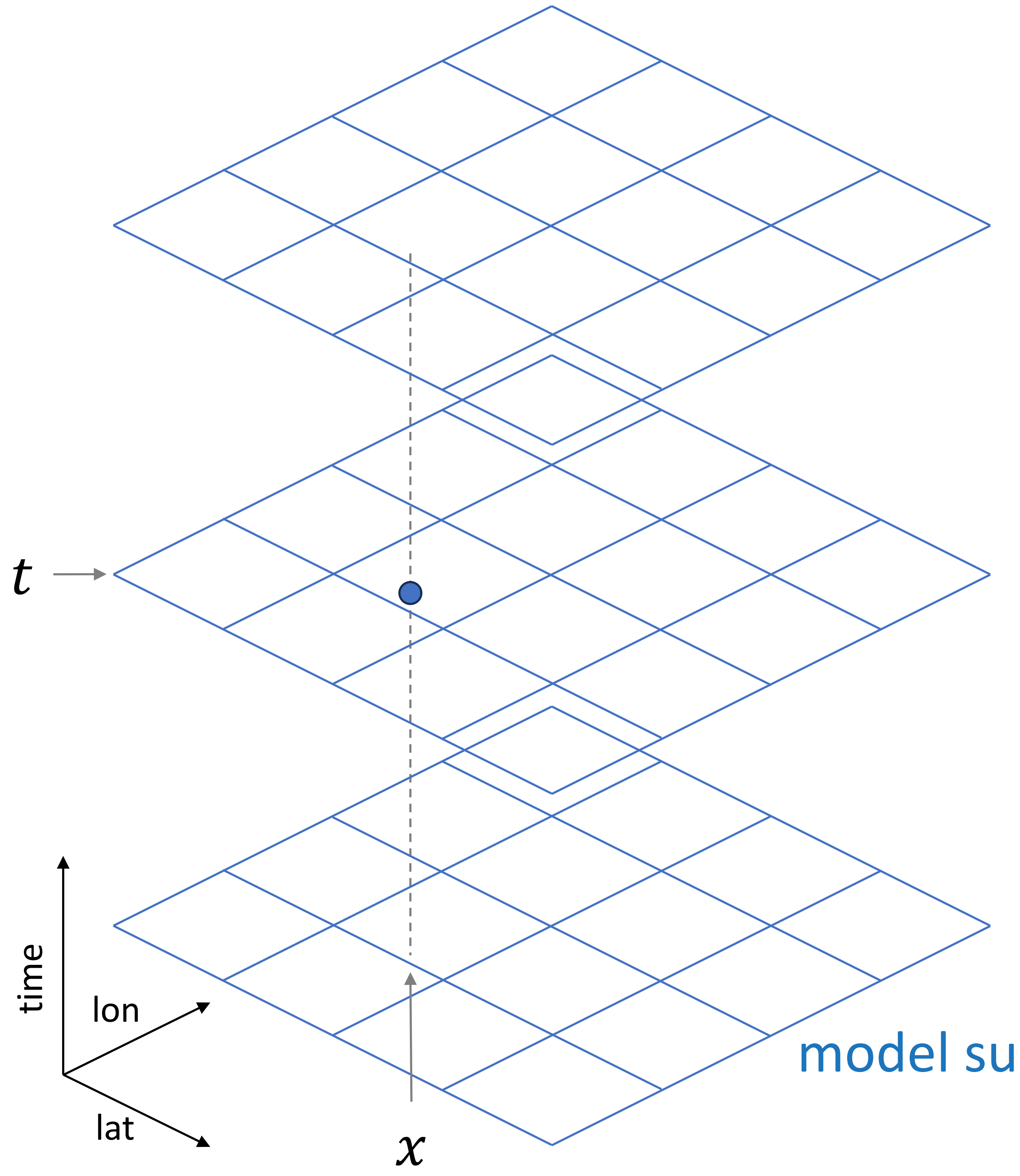


model surface concentration $M(x,t)$

Phase	Estimate	Uncertainty
1	forecast model (GEOS-CF)	cell-to-cell variability of model



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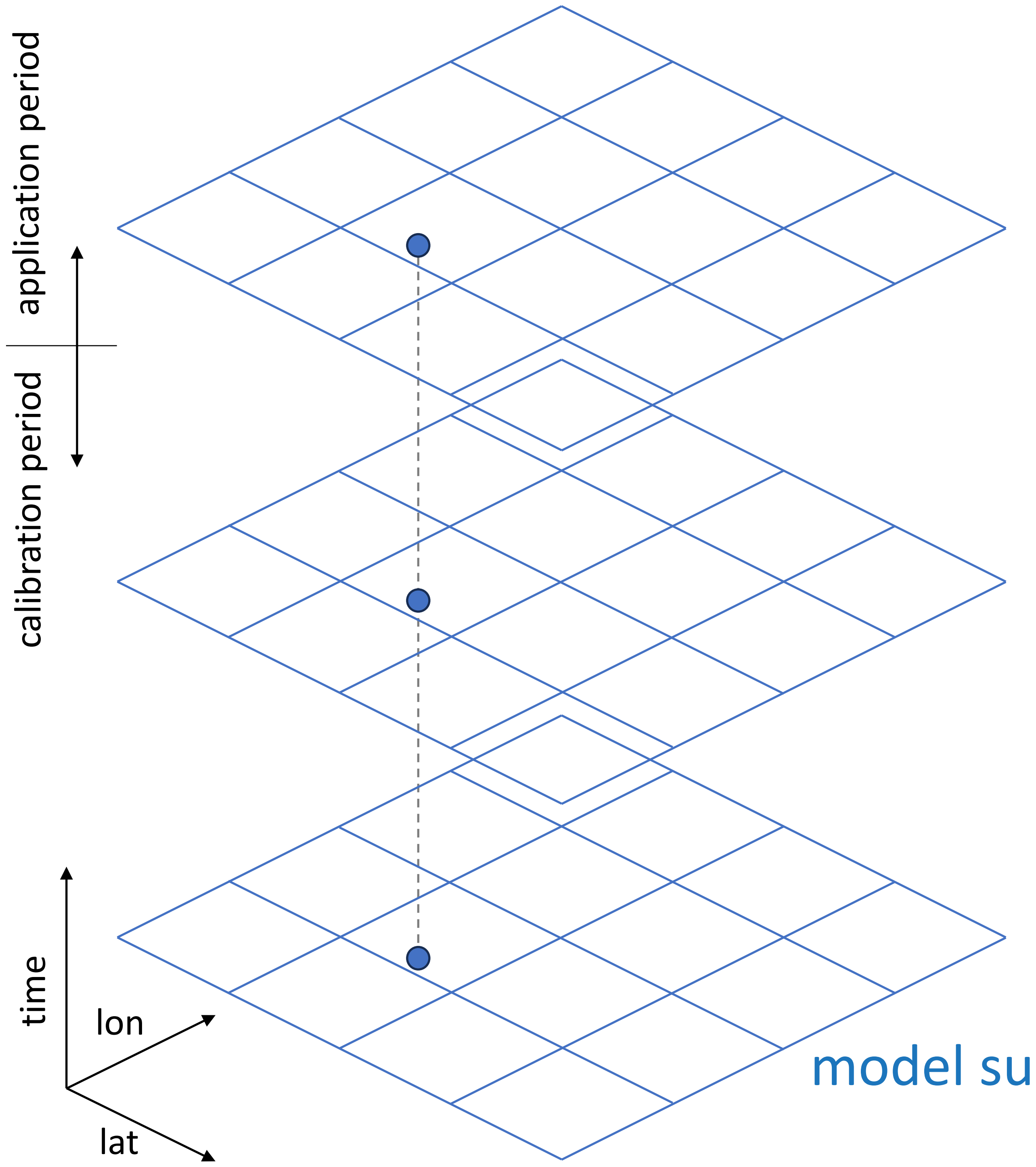
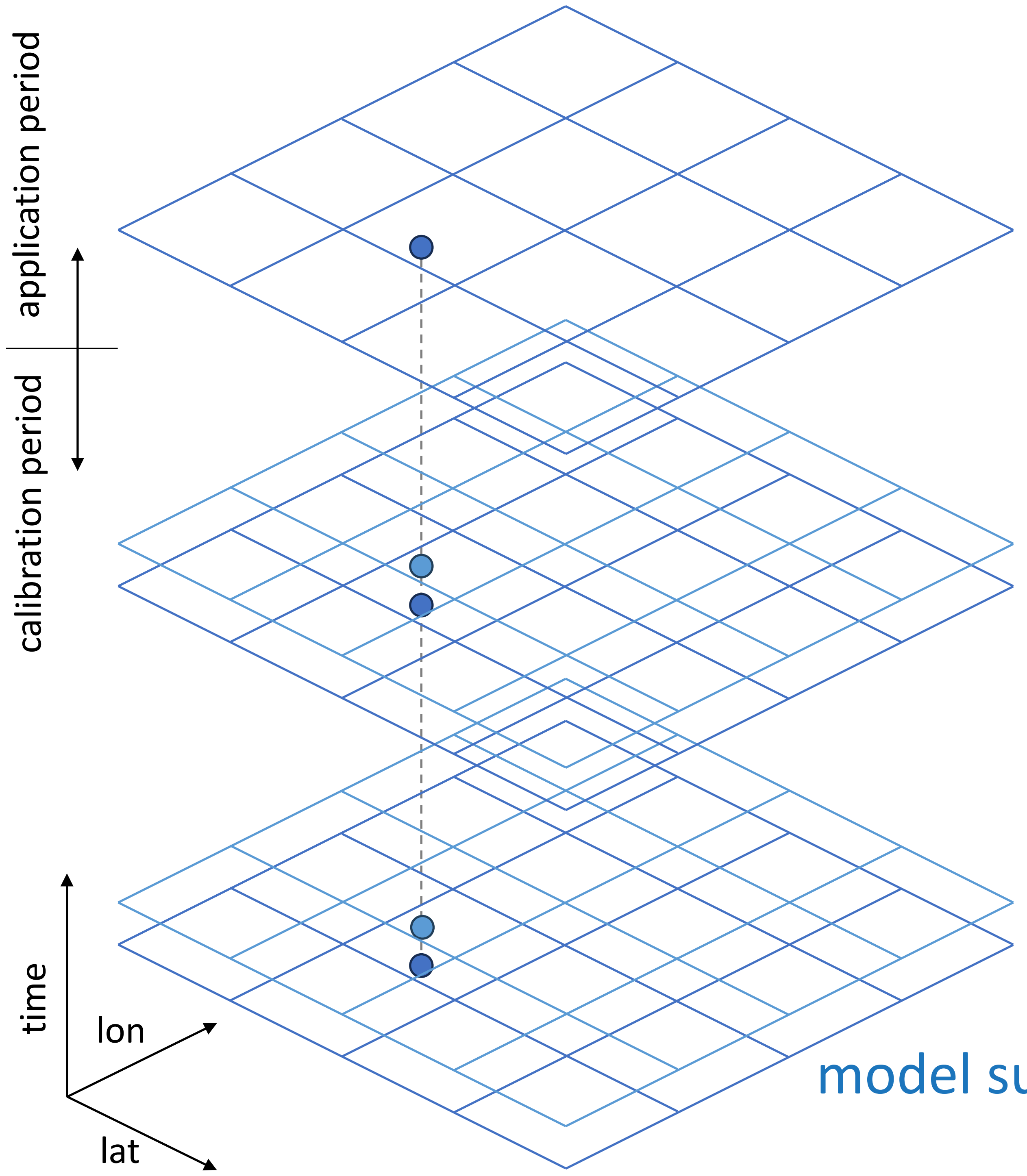


Phase	Estimate	Uncertainty
1	forecast model (GEOS-CF)	cell-to-cell variability of model
2	satellite (TROPOMI) informs sub-model-grid variability	satellite-to-model and surface-to-column ratios vary over time

model surface concentration $M(x,t)$



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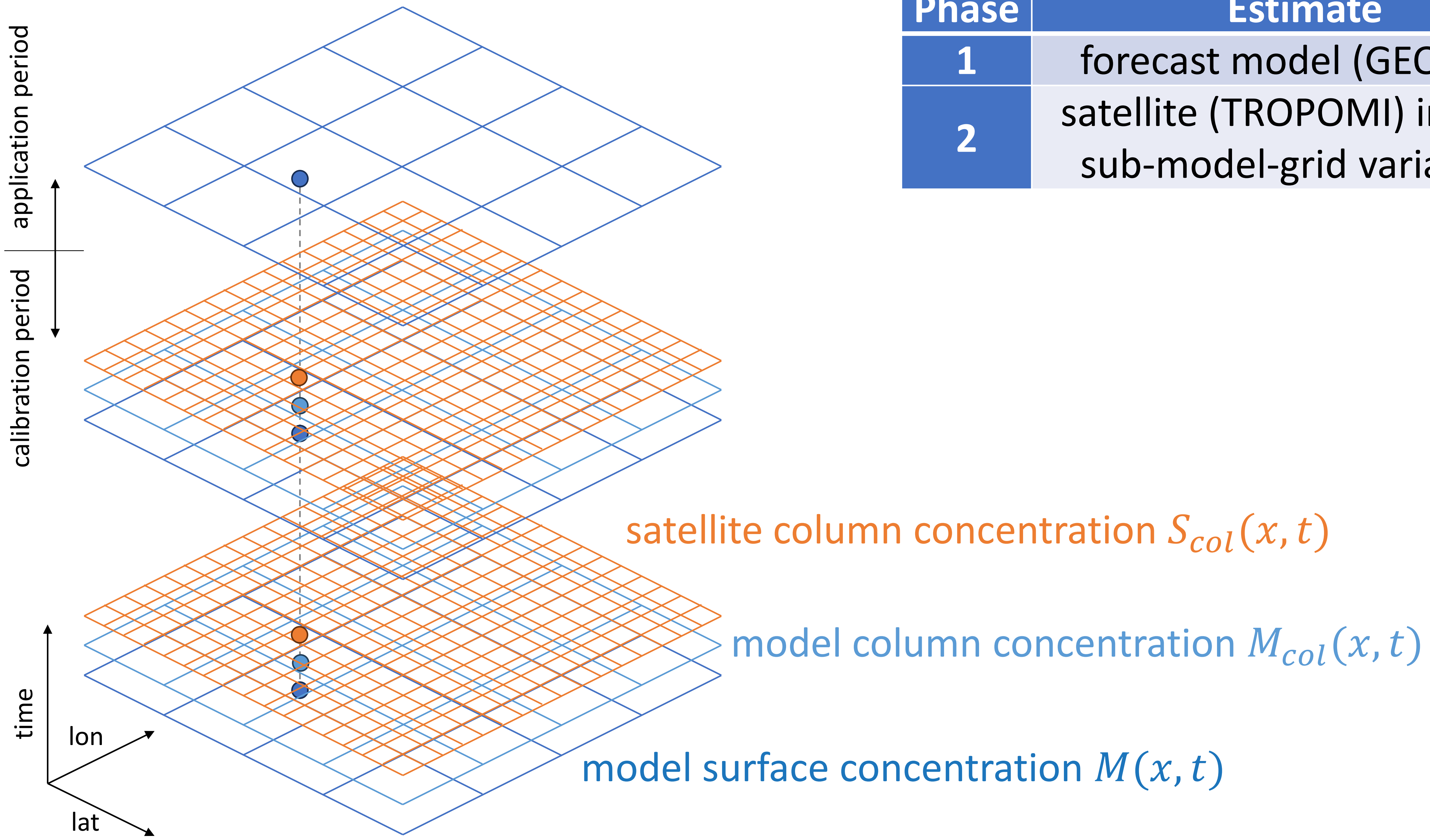
model column concentration $M_{col}(x,t)$

model surface concentration $M(x,t)$



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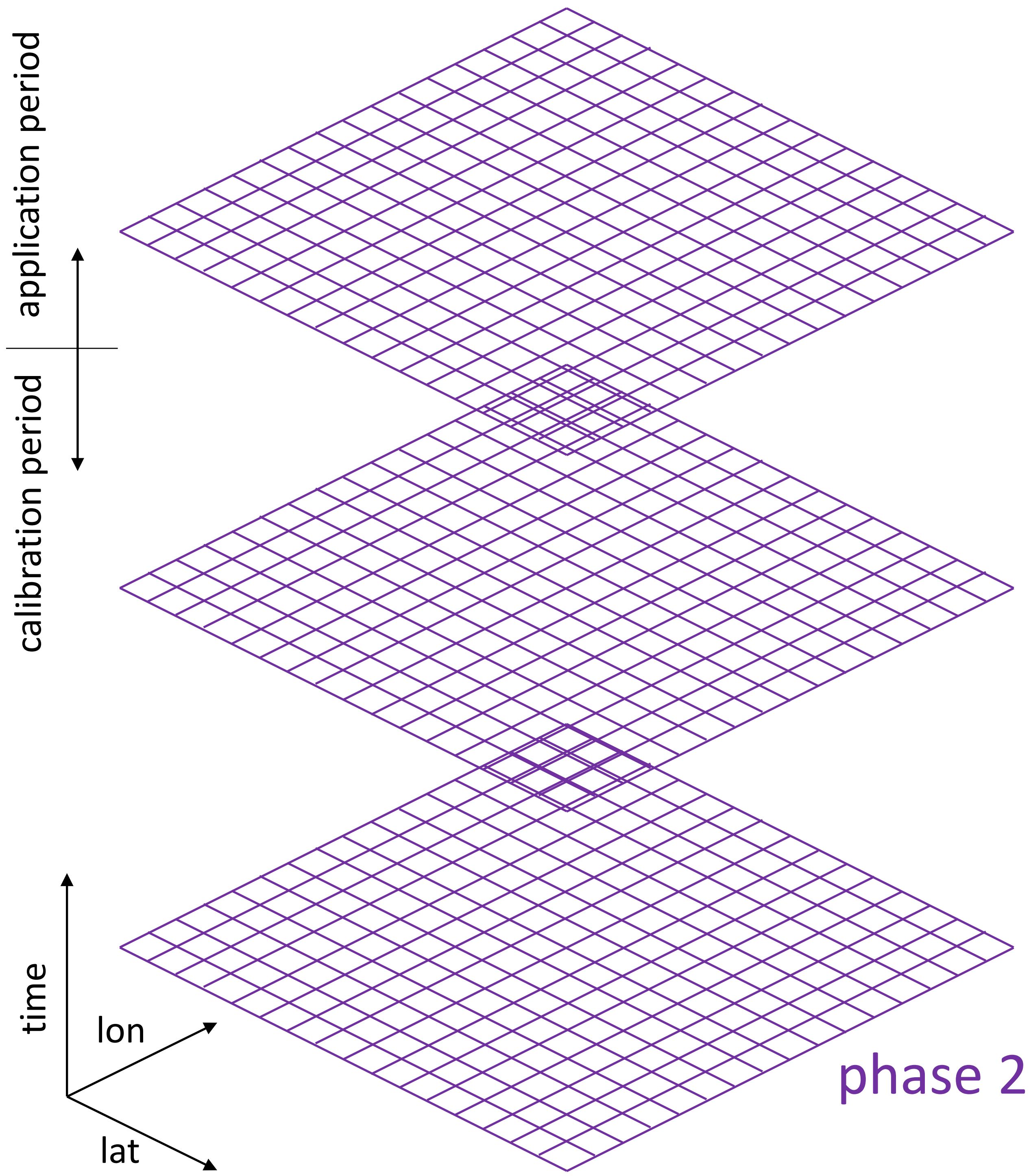

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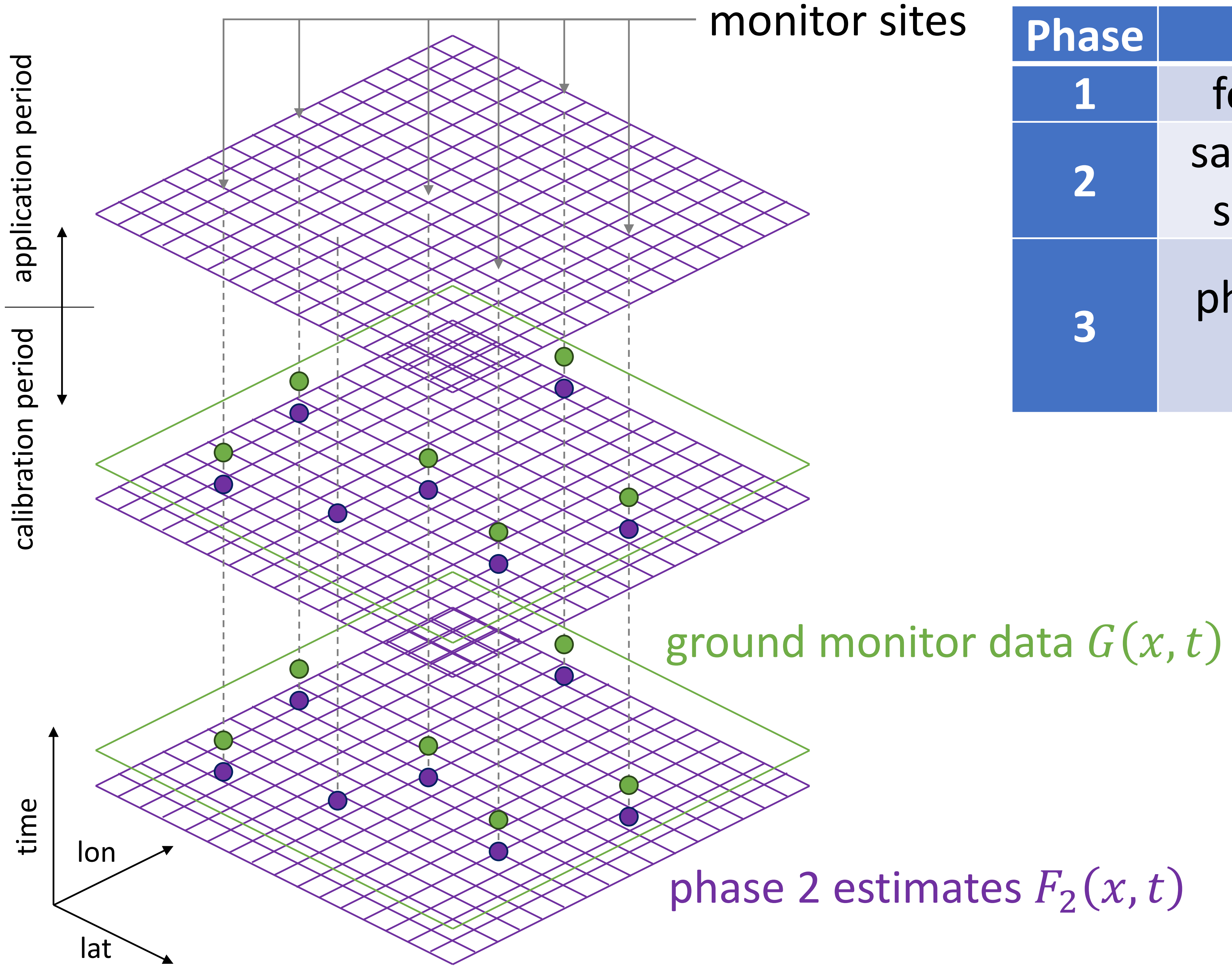
3	phase 2 corrected to match surface monitor data	uncertain regression parameters between phase 2 output and surface monitor data

phase 2 estimates $F_2(x, t)$



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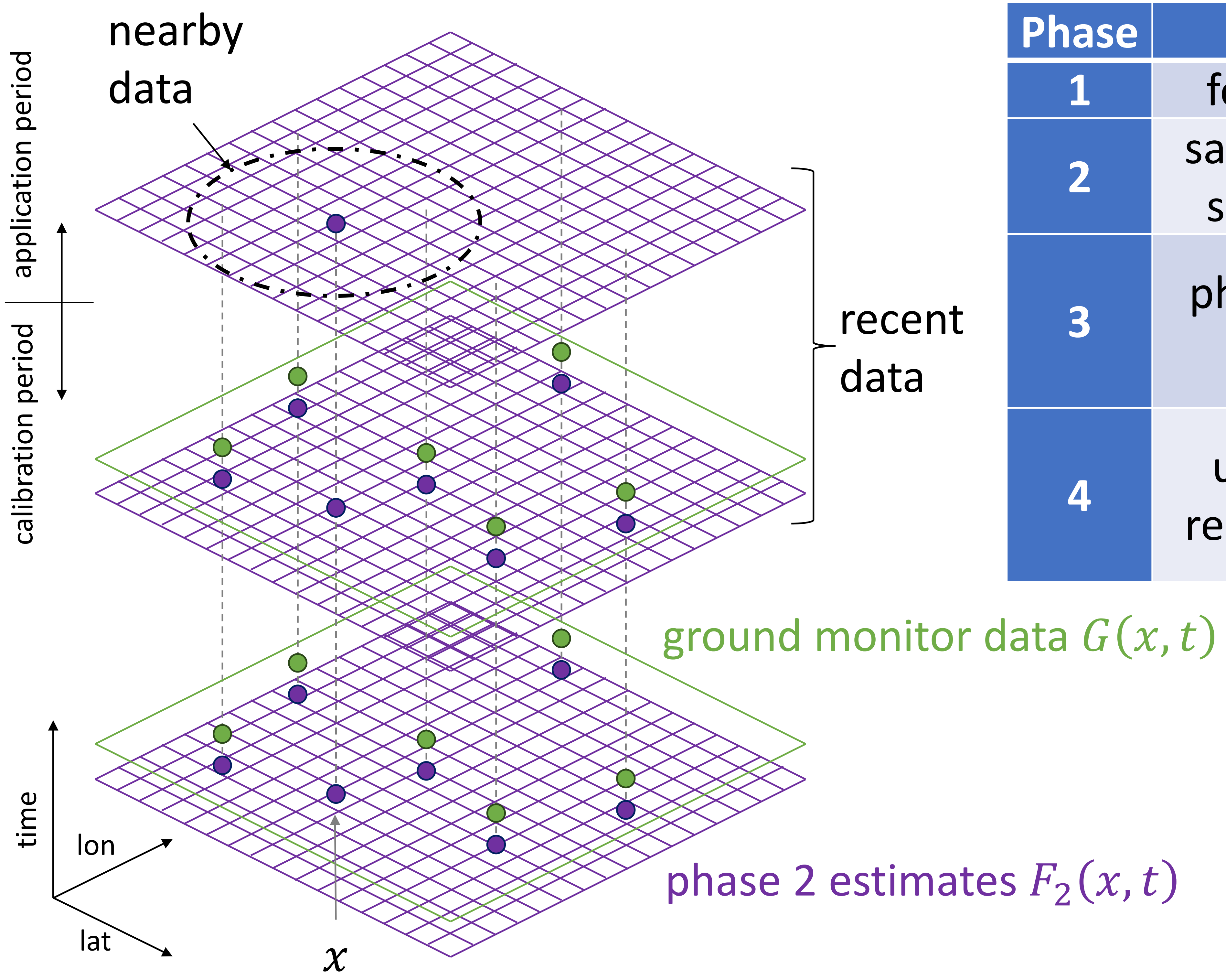

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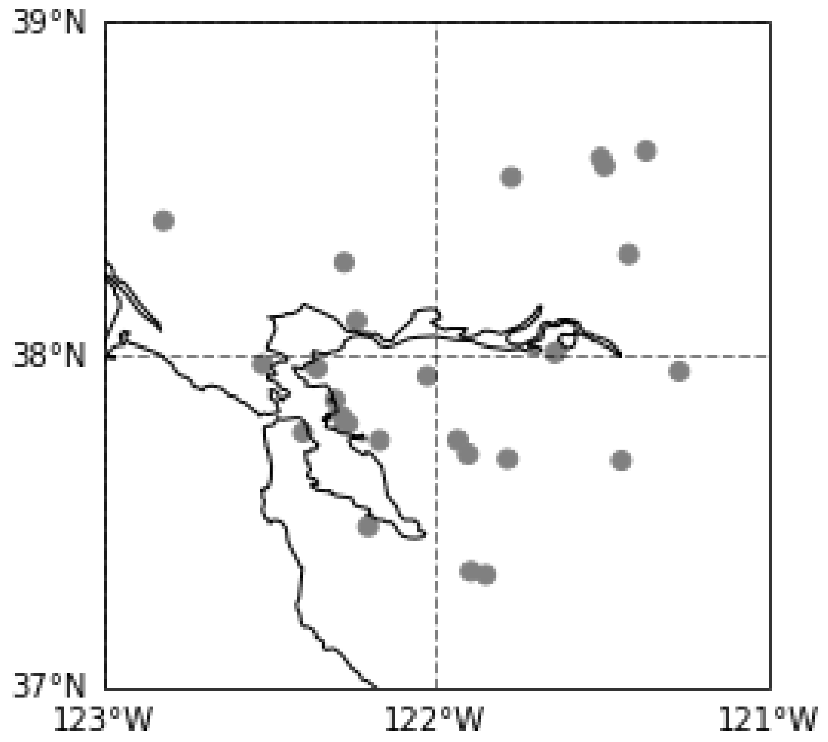
3	phase 2 corrected to match surface monitor data	uncertain regression parameters between phase 2 output and surface monitor data
4	update phase 3 based on recent surface monitor data	uncertainty reduction via updating with nearby & recent data (kriging)

Case Study Details
San Francisco
September 2019
Surface NO_2
Lognormal distribution
Cross-validation test
25 ground monitors

Ground Sites



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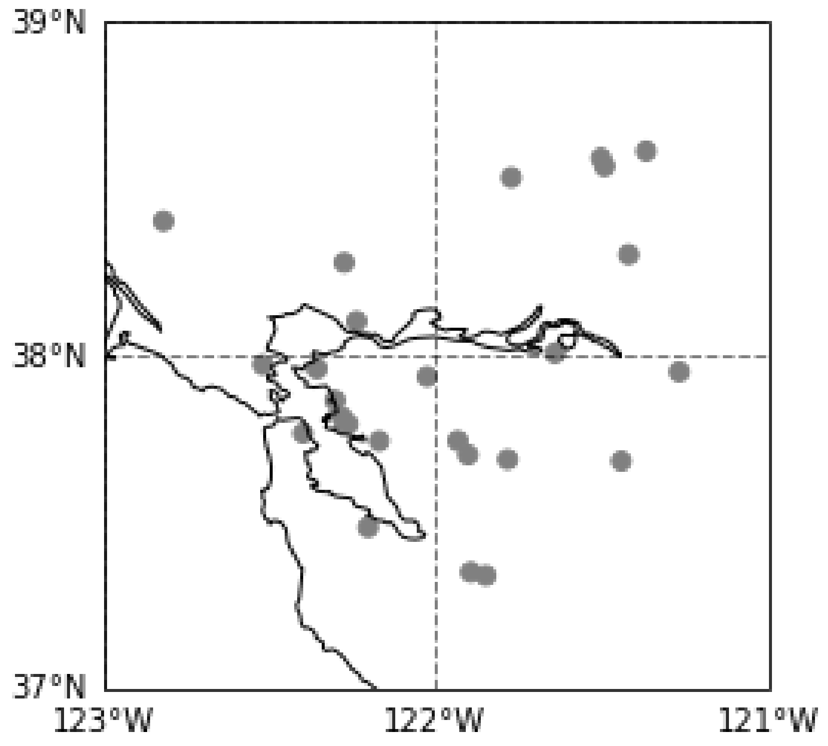

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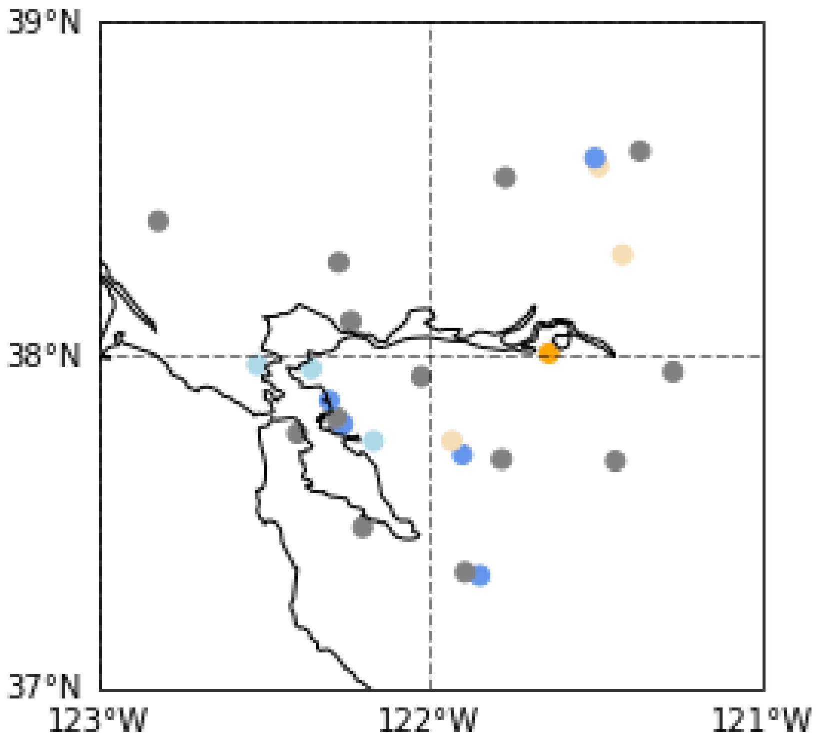

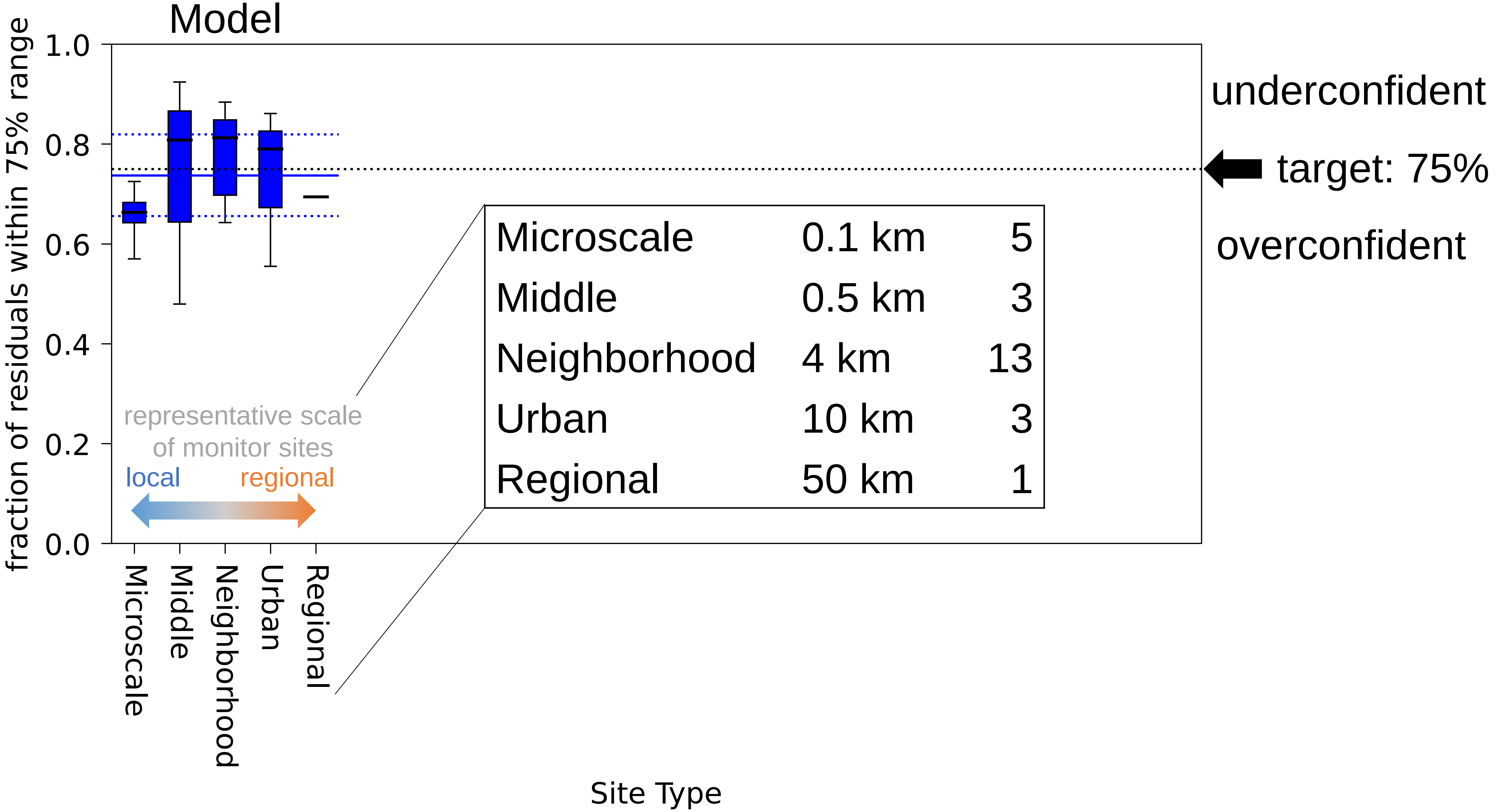

Microscale	0.1 km	5
Middle	0.5 km	3
Neighborhood	4 km	13
Urban	10 km	3
Regional	50 km	1

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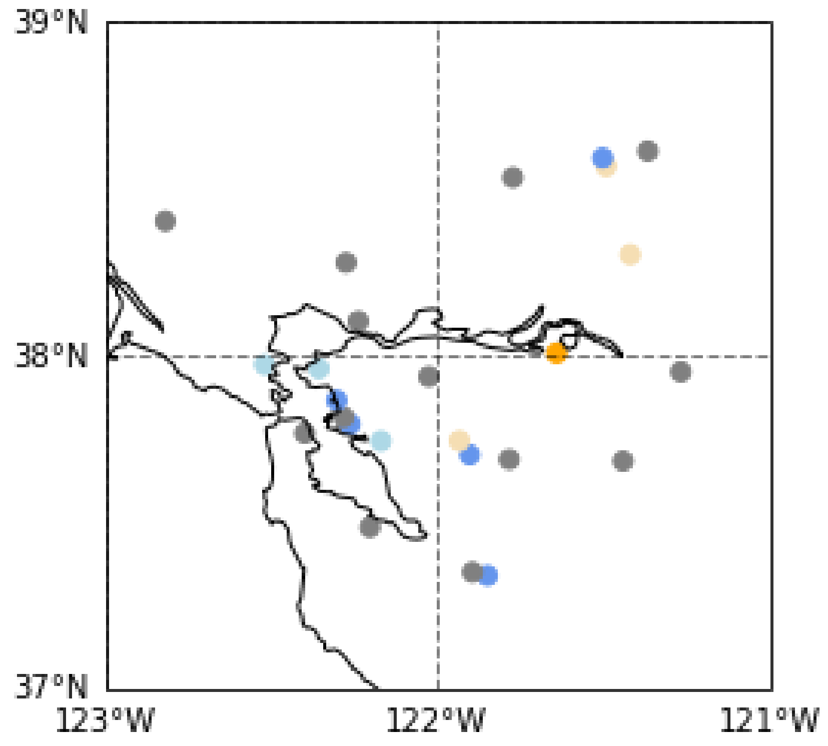

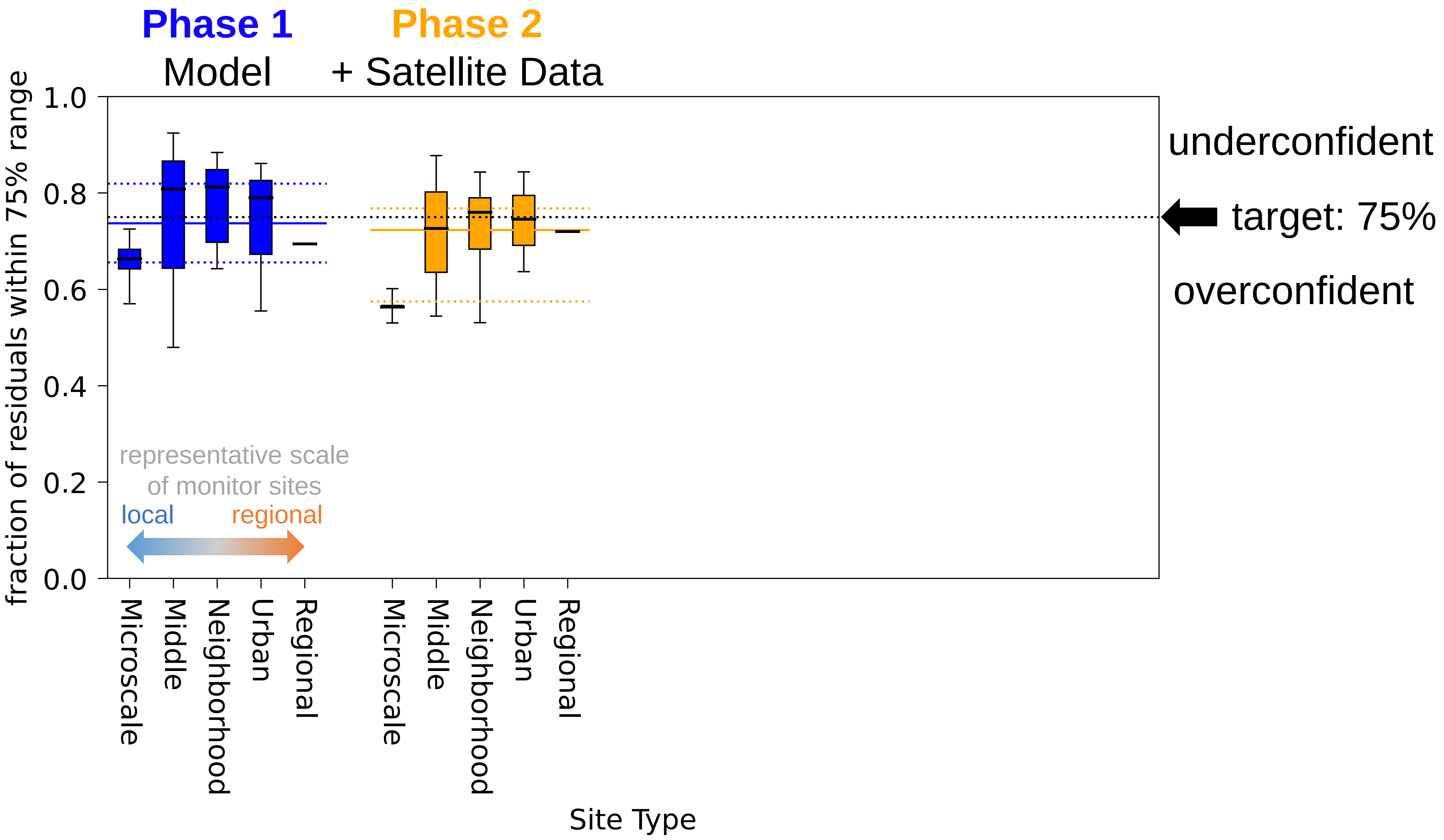

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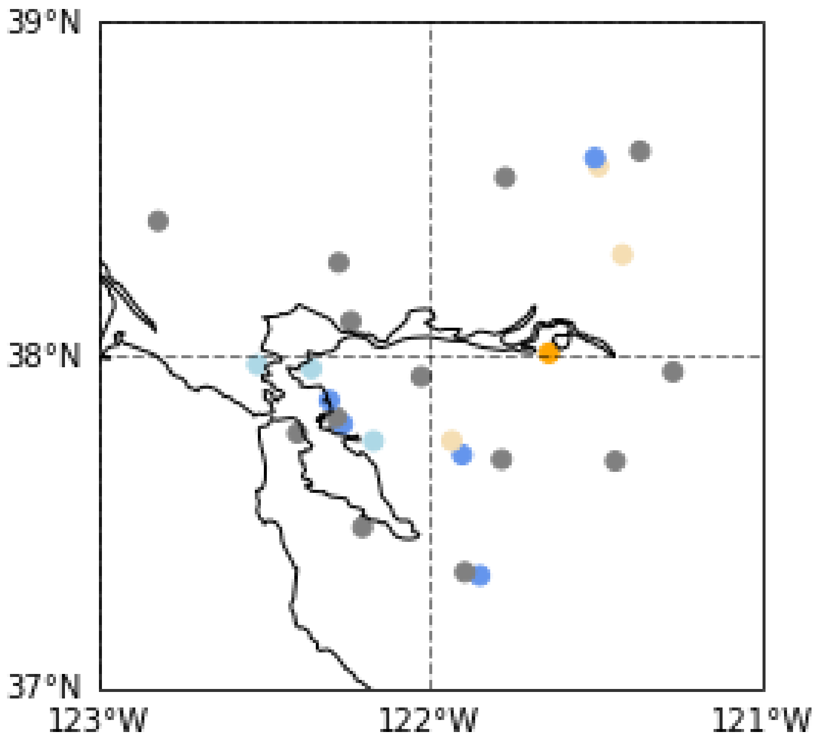

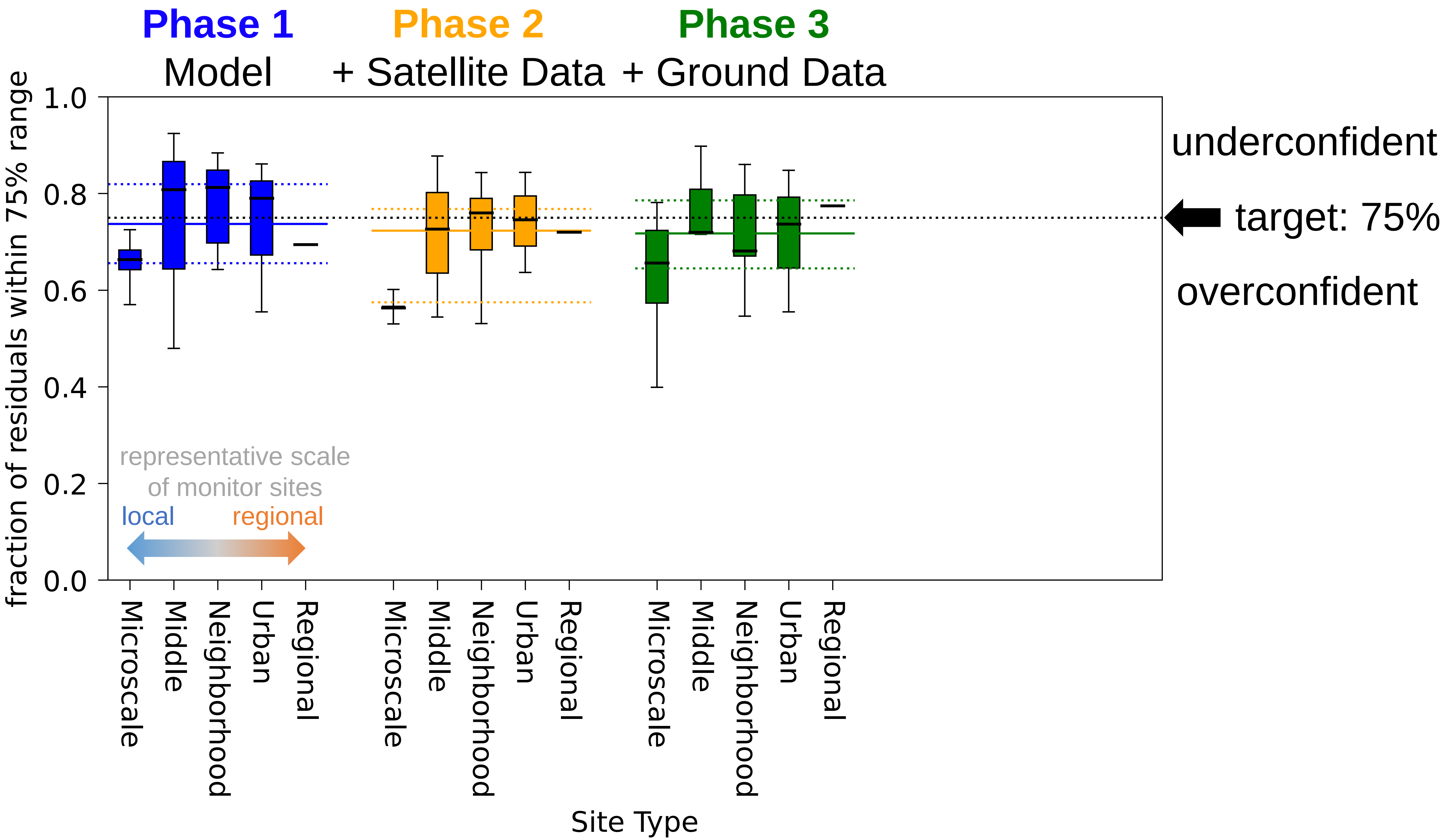

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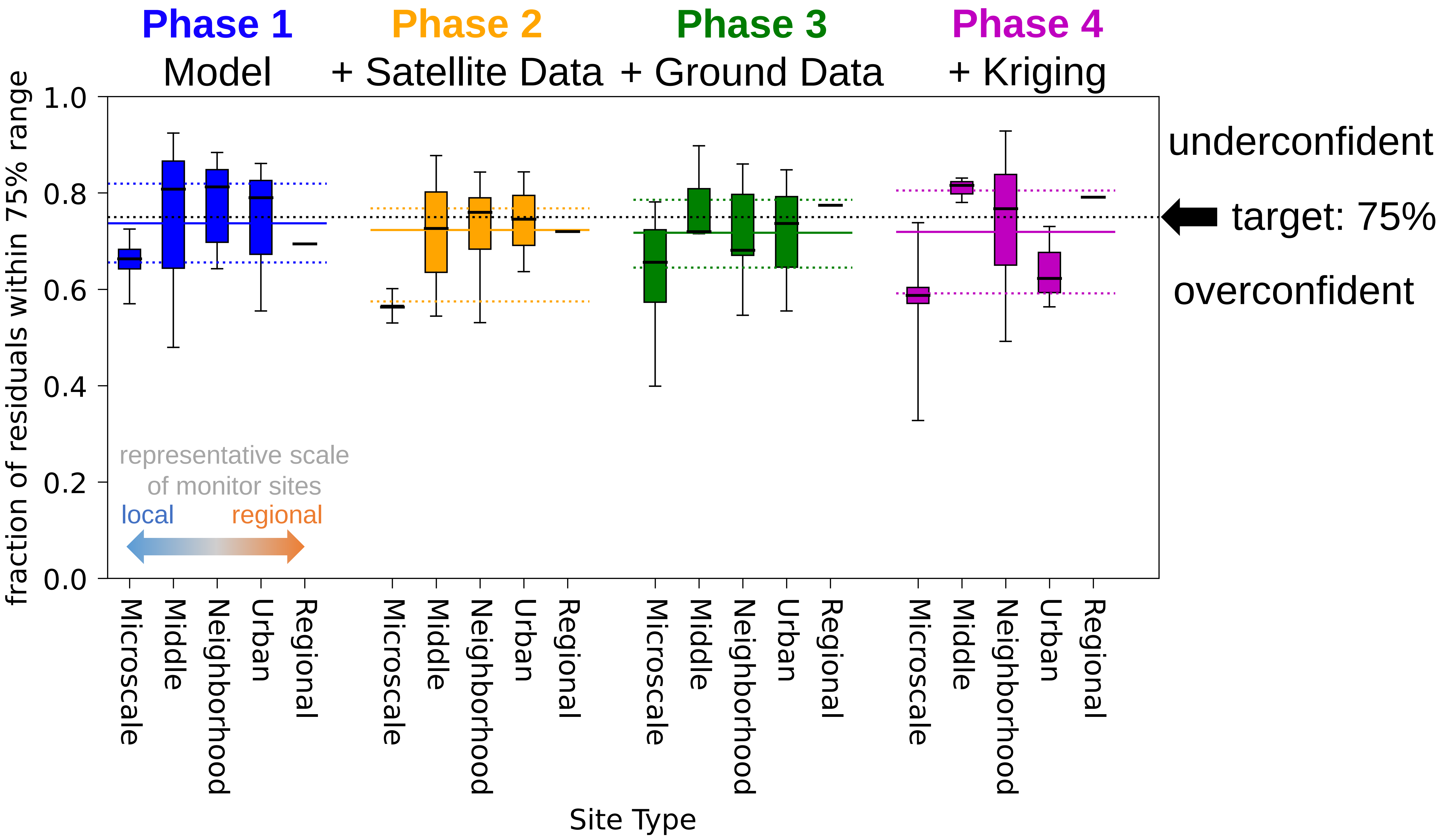

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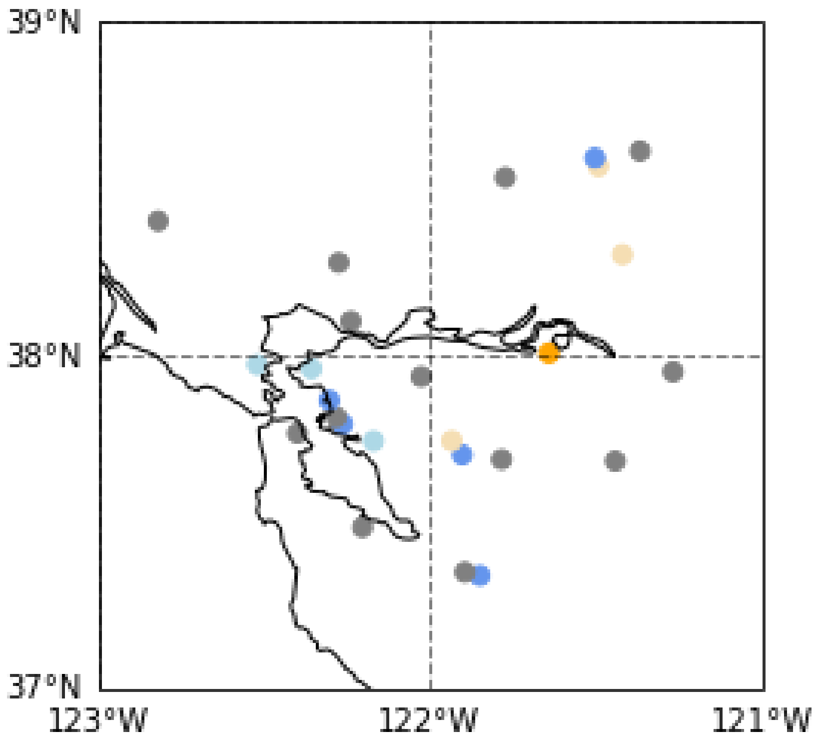

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GESTAR II Cooperative Agreement

Partner

Thank you!

Questions?

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This research is supported by the GESTAR II Cooperative Agreement with NASA Goddard Space Flight Center. For more information about GESTAR II, scan the QR code provided.