2 High / Low Resolution

Discussing the geographical location of the computing power that contributed to the IPCC's fifth assessment report on behalf of Russia is just one way to begin the conversation about the resolution of simulations and their subsequent governability. The climate model, operated by the Marchuk Institute of Numerical Mathematics, is now in its fifth generation[1] and alongside more than one hundred other models, run by around 45 institutions and organizations worldwide, carried out the calculations to simulate the potential versions of the future climate. Part of the Russian Academy of Sciences' dispersed Moscow campus network, the Marchuk Institute is dedicated to "solving both fundamental and applied problems of interdisciplinary character", with atmospheric and oceanic physics, and mathematical immunology being its top priorities. Unlike the extravagant design of the Academy's headquarters on the banks of the Moscow river, the Marchuk Institute is a modest building in the Gagarin district, south of the city centre. The computational facilities that store the programming basis for the model are hosted within a cluster of regular office rooms, so visually familiar to anyone who has dealt with the routine academic bureaucracy in Russia.

Located in its capital, the model generates simulations of the global climate and is the only one participating in the Coupled Model Intercomparison Project, which calibrates various climate projections for IPCC assessment reports, on behalf of Russia. Its geographical proximity to the locus of, at least notional, decision-making activity is well fitting if it is to be operationalized as a tool of direct governance in the future.[2] This process of instrumentalizing the climate models can be envisioned not only in relation to state and municipal authorities, but the presiding bodies of most oil and gas companies, whose headquarters are usually legally registered in Moscow, which is where they file taxes as well. Installing regulation mechanisms right into the space between the simulations of the climate and those practices that are largely responsible for its transformation can be especially generative since those companies usually happen to own the resources and technologies necessary for high resolution sensing and simulation of the

1 It differs from the previous one in improved vertical resolution of the upper stratosphere and the lower mesosphere, and a two times higher horizontal resolution for its ocean simulations. www.researchgate.net/publication/312472371_Simulation_of_the_present-day_climate_with_the_climate_model_INMCM5

2 The question whether the geographical proximity will really be that generative still stands if the next generations of governance are to move towards algorithm-based, automated regulation. If governance takes place in the geographically dispersed infrastructure of the "cloud", the notion of "proximity", and other traditional markers of space, will either lose their relevance or will come to signify something radically different.

environmental processes, in the first place. Albeit, the application of those resources is usually limited to the things that have potential value or carry potential financial risks, in ways that are directly obvious.

Foregrounding the feedback loops between the sensing technologies, the simulations that they co-author, and the phenomena that is being sensed, the question of resolution emerges as one of the protagonists in the assessment of the roles that models will play in the future. Its importance is relevant not only as it relates to both collection of data *and* its visualization, but also to the quality of predictions informed by those simulations and how they are actualized. The models that are at the foundation of the IPCC's fifth report project five characteristic variations of the greenhouse gas concentration in the atmosphere, informed by potential technological and social changes. The five scenarios are generalized, assume even distribution of both climate action and its effects around the globe, and present the socio-economic processes which in reality are intertwined as categorically distinct. This indicates the blind spots in climate predictions which feed into the problems with governability of the processes they model, as well as points to the grey zone they occupy in relation to politics and sovereignty.

The questions of high and low resolution, and the visibility or, rather, "readability" of the reality as it is mediated through the sensing technologies, have been treated extensively in the past, particularly, the questions of what it means politically when certain things fall through the cracks of low-resolution sensing. Notoriously, Forensic Architecture has brought that to the forefront of their practice, questioning whose agency is negated when certain things are purposefully and accidentally made "unreadable", as well as proposing strategies to counteract those incidents, that is how to add granularity where there are gaps and omissions, or in other words, how to increase the resolution of "imaging" for political purposes.

In this report, the issue of resolution is understood broader. The political aspect of it is, of course, important, but it can be better positioned as assessing the connections between resolution and the recursive process of sensing-simulation-governance. Responding to the question of operability for the models that the sensing technologies feed into, the concept of resolution embodies the challenge of how to operationalize the simulation so that it becomes governance. The argument is then posed that if you need sharper tools for managing the process of climate change, you need sharper resolution.

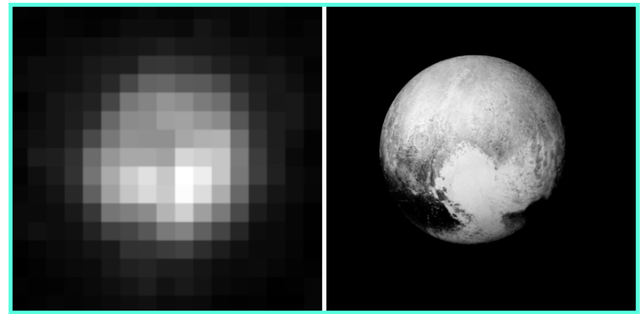
The high resolution is usually associated with either, specifically, the quality of photographic imagery or, more generally, the abundance of data—as in the more pixels are contained within a square centimeter of the photograph or the screen, the better the quality is. The latter, more abstract interpretation comes through, for example, in the Forensic Architecture's practice, where if the "top-down" resolution from "above" is not good enough, proposed counteraction is to collect as much data from the "bottom-up." For instance, collecting and synchronizing all the smartphone videos in the area to produce the accurate recreation of an event becomes a way through which the "resolution" of its representation is increased.[3] In this assessment, however, analysis of the concept of resolution is paralleled with another task of expanding the concept of an image, due to the foregrounding of the sensing and modeling infrastructure that reads, projects and represents data in ways other than photographic.

Nevertheless, if one is to take away the image part, the association of high resolution with abundance remains. It appears in the tracking of oil tankers in the sea, where it is not so much the quantity of data that is being collected, but rather the abundance of angles from which the tankers are "seen", i.e. the multiplicity of sensing *registers*. The geolocation tracking is paired with satellite remote sensing, the chemical samples of the cargo, the financial records, such as customs and trading databases, which register what the tanker is carrying, its status as empty or loaded, its political allegiances, and so on. The argument is usually posed that if you take one register out of the equation, what you will get is a representation with less specificity, and so lower resolution. If you only rely on geolocation tracking, you will see an oil tanker moving through the sea, but as a black-box with unknown "insides", unknown status and unknown intentions.[4] The *more* registers the sensing is performed through, all zooming in on the same phenomena from different angles, the higher the resolution will be.

That becomes problematized by the methodologies of climate and weather modeling, since the contemporary weather forecasting methods are believed to be more accurate when they rely solely on the data included in satellite imaging, rather than registering and modeling of the interactions between the physicochemical processes "on the ground"—the "traditional" way.[5] That is where the question of *precision* comes into play. Instead of thinking of high resolution as an abundance and variety of data that is collected, and the complexity of the ways in which it is represented, the question of finetuning and justification appears as "the appropriate means for

3 www.forensic-architecture.org/investigation/the-bombing-of-rafah
4 "To Evade Sanctions on Iran, Ships Vanish in Plain Sight," www.nytimes.com/2019/07/02/world/middleeast/china-oil-iran-sanctions.html
5 This idea came out of the lecture given by Abelardo Gil-Fournier on the Terraforming programme at Strelka Institute, which took place in the winter of 2020.

the appropriate ends" formula. Thinking of resolution as a level of precision with which the capture of data is finetuned to produce the simulations that are able to govern what is being captured, in a way that will bring the desirable ends in predictable ways. And so high resolution can be seen as the precision with which the simulations can be made operational.



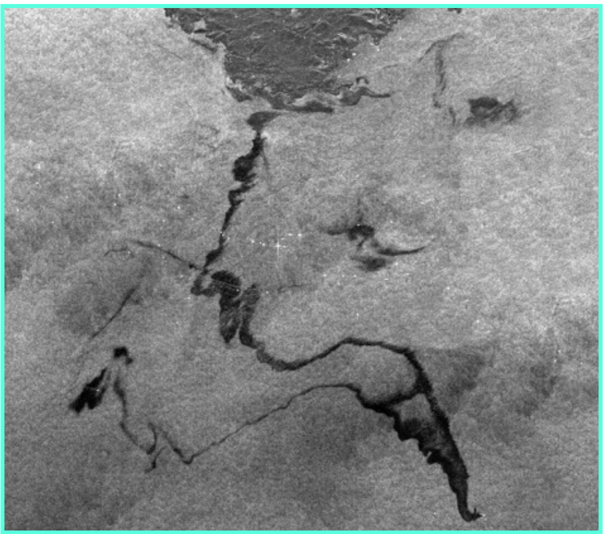
The image of Pluto on the left was taken from Earth by the Hubble Space Telescope in 1994, the one on the right was captured by the New Horizons spacecraft on the day of the flyby in 2015. Credits: NASA/ESA/A. Stern and M. Buie (left image); NASA/JHUAPL/SWRI (right image).

In the context of this assessment, the resolution of the infrastructure for sensing and simulation culminates in the process of climate modeling itself. In the literal sense, the standard average resolution of the global climate models used by the IPCC for its fifth report is 100 x 100 km2 cells, within the grid that the biosphere is divided into along longitude and latitude of the globe. The horizontal model grids also extend vertically up through the atmosphere, where it is broken up into layers that can be as thin as 11 km, and down trough the ocean. The simulation is then calculated in 30 min steps as the temporal resolution of climate projections.[6] In the IPCC context, the spatial cell is a representation of balance—what is the biggest quantity of data you can feed into the model before it overwhelms the computational capacity that would be needed to calculate all possible interactions within that data set. That points towards the purposefulness or justification of the precision that is applied within the space between sensing and modeling.

Returning to the potential of recursive functionality of the models, the question then becomes whether the logic of precision can be extended into the space between modeling and governance to operationalize the former

6 www.carbonbrief.org/qa-how-do-climate-models-work

and to make it high-res. When the notion of governance is brought forward, the context of climate resolution is revealed as already a contested terrain. For instance, the *sovereignty* of certain territories that are politically substantial is seen as diminished or even denied when they become completely "invisible" within the dominant frameworks of climate modeling, that is when they disappear into a black box of the spatial cell.[7] The expanded understanding of resolution can provide a more functional understanding why in some cases improving precision will be directly linked to the increase in the quantity of data and its representations, while in others it will be the opposite. That, in turn, leads to the question of optics. Whose point of view is used to evaluate the quality of resolution, since understanding how precise the process of simulating and governing is in achieving the "necessary" effects will change based on what those desirable effects are.



Examples for oil slicks visible in SAR, ASAR (Advanced Synthetic Aperture Radar images.

Analyzing the recursive relationship between sensing and governance, in turn, points to the relationship between sensing and sovereignty within the recursive feedback loops between the simulation of an ecological phenomenon and the claims of jurisdiction over it—whether a territory, commodity, or even a metabolic process. A study from 2013 describes how the scanning of

7 ibid

the surface of the Black sea with remote sensing technologies—specifically, synthetic aperture radar—revealed the disproportionate amount of oil spills of shipping origins within the Russian sector of the sea or on its borders.[8] Resulting from the general issue with jurisdiction in Russia, the problem draws attention to how those oil spills, if seen from the imagined radar view, perform as contrast dye used in X-ray exams. They visually highlight where the Russian territory ends in the allegedly borderless terrain of the sea, like the coloring book outlines on its surface, all due to questions of jurisdiction, governance and accountability. This example relates to another one Benjamin Bratton details in The Stack where both Pakistan and India put ice cap sensors in the Himalayan glaciers which, being dynamic phenomena, move around over the course of the winter. Occasionally the Pakistan's sensors will wind up on the Indian side of the border and vice versa, and so both countries will claim the territory where their sensors end up.

These examples lead to a suggestion that time might be the most unpredictable variable in the relationship between sensing, simulation and governance, which highlights the urgency of the detailed analysis of the recursive models already in operation, so that they can be instrumentalized in the present with more deliberation and precision. What happens in 100, 200, 300 years, when the Arctic melts and the sea level rises, and those oil borders in the Black sea spill into other countries? Will Russia accept the accountability and jurisdiction over the task of cleaning up those dumps because that will lead to an expansion of its territory? Or is it that by then, there won't be any nation states at all to care about the territorial disputes? Will you have new forms of recognized sovereignty, like the sensing and simulation apparatus itself structured as a kaleidoscope of autographic images, in other words, the models as images that act back upon themselves? This brings back the framework of scenario planning, particularly, the read-write media element of it, seen as the projective models of the future which become normative as they act back on the reality of the present, similar to how financial models operate in the present.

8 www.tandfonline.com/doi/abs/10.1080/01431161.2014.926416?scroll=top&needAccess=true&journalCode=tres20