# Unraveling the mystery of DeepMind's rainfall nowcasting: A step-by-step tutorial for hydrologists


**Presentors**

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Stay tuned with the update of our reproduction of DGMR on Github!

Check out our abstract!


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## DGMR: Deep Generative Models of Radar proposed by DeepMind

In 2021, DeepMind proposed a deep-learning-based model, ***Deep Generative Models of Radar***, that achieved a great success in the field of **short-term rainfall nowcasting** (Ravuri et al., 2021).

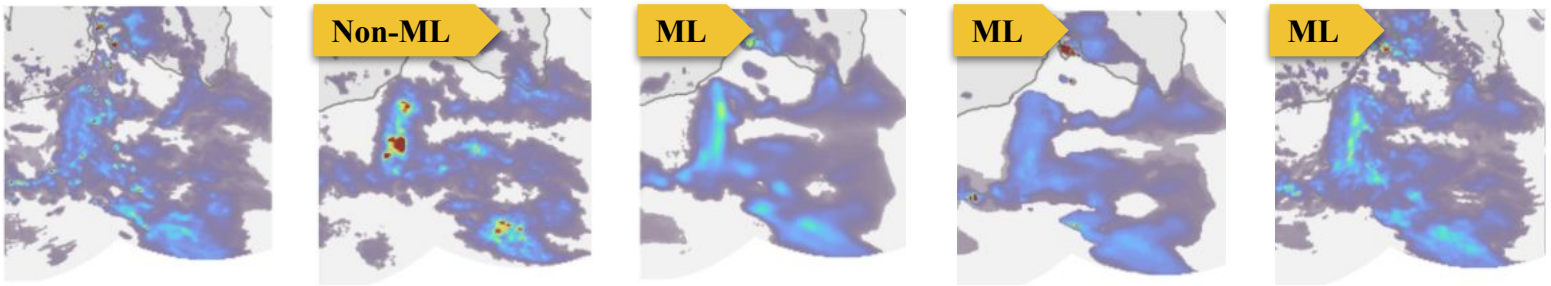



Figure. Case study of performance on a challenging precipitation event starting on = 24 June 2019 at 16:15 UK, showing convective cells over eastern Scotland (Ravuri et al., 2021).

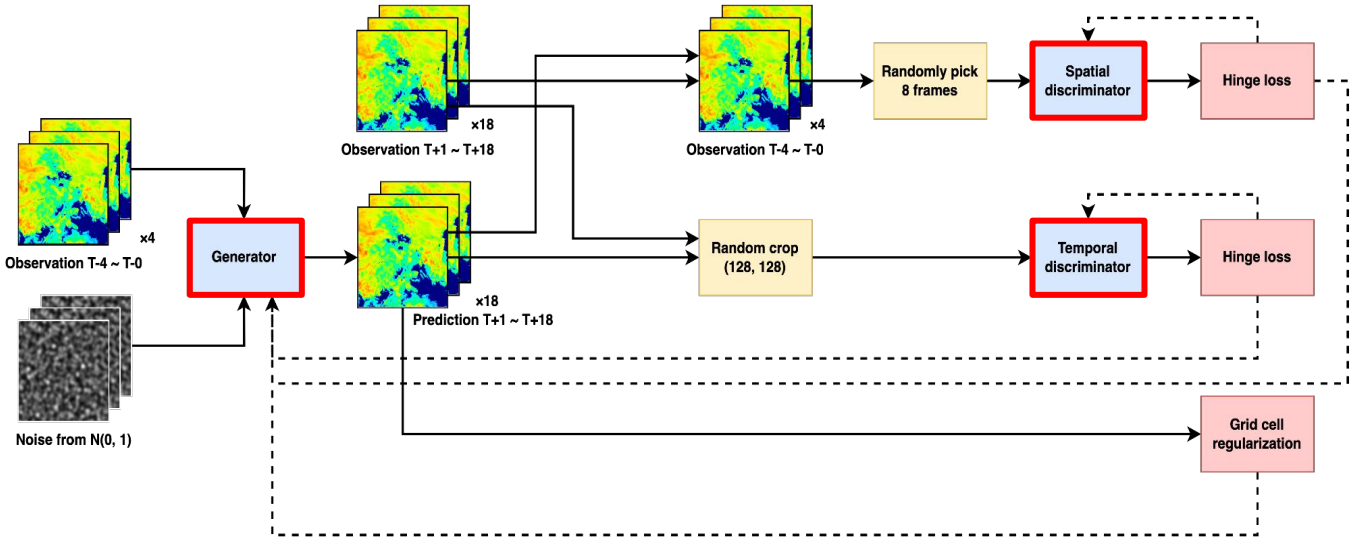
Check out DGMR's article!

## DGMR: A rainfall nowcasting model trained with the GAN technique

DGMR includes three main models, which are trained simultaneously via an adversarial process.

These models are:

- **A Generator** that produces rainfall nowcasts.
- **Two Discriminators** that discriminate if the generated nowcasts are 'similar enough' to the ground truth in terms of their spatial and temporal features, respectively.

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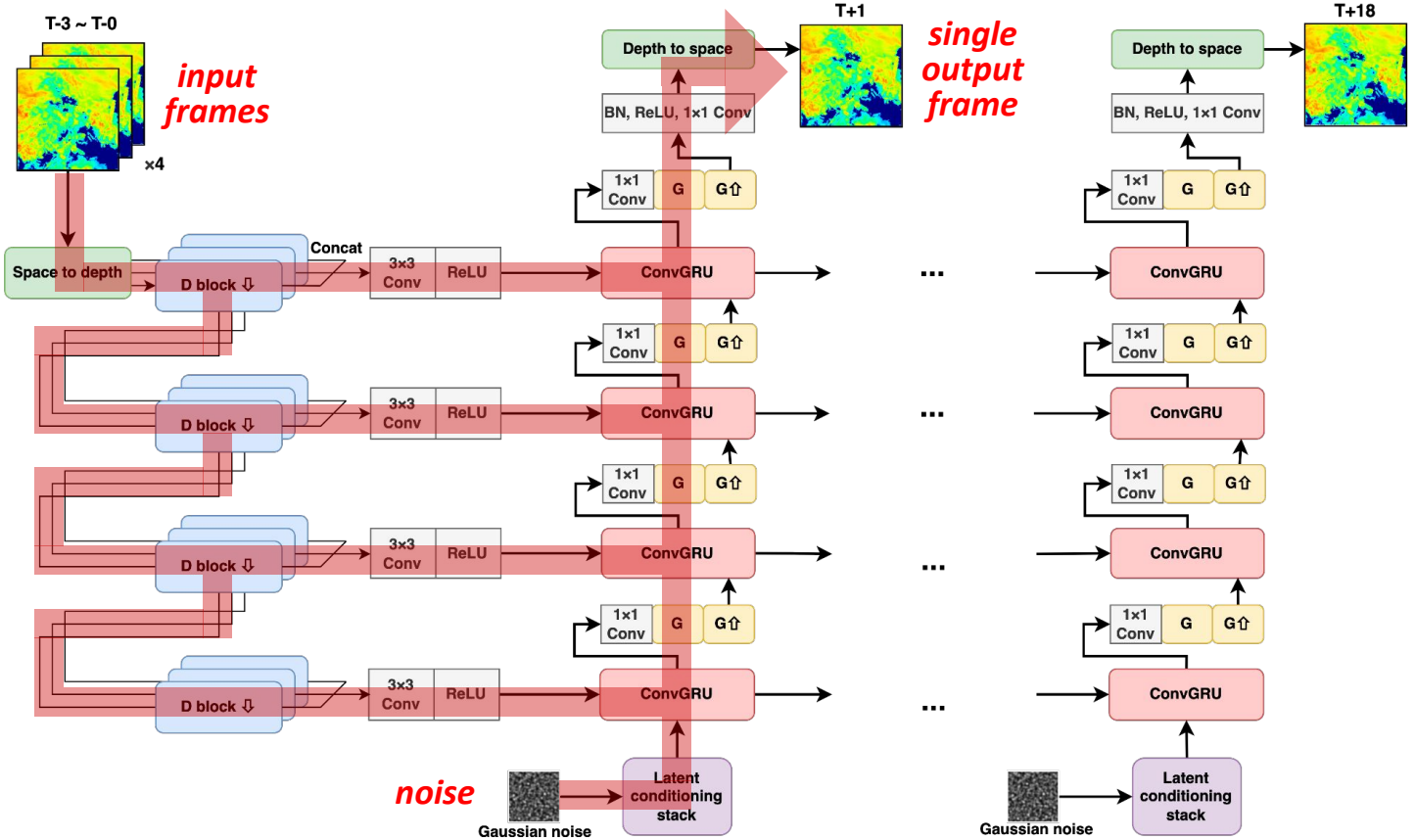
## Overview of the DGMR generator

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## DGMR: Key techniques leading to better nowcasts

Through reproducing the DGMR, we identify the following four key techniques that make DGMR better than other AI-based models:

- **Space to Depth (S2D)**
  - A downsampling method.
  - Reduce image size with S2D, rather than pooling, can better preserving spatial details.
- **Hierachical feature extractor**
  - A feature extraction framework.
  - Extract image features across a wide range of spatial scales.
- **ConvGRU along downsampling axis**
  - A feature extraction framework.
  - Establish relationship across multi-scale spatial and temporal features.
- **Generative Adversarial Network (GAN)**
  - A model training framework.
  - Reduce smoothness between spatial details.

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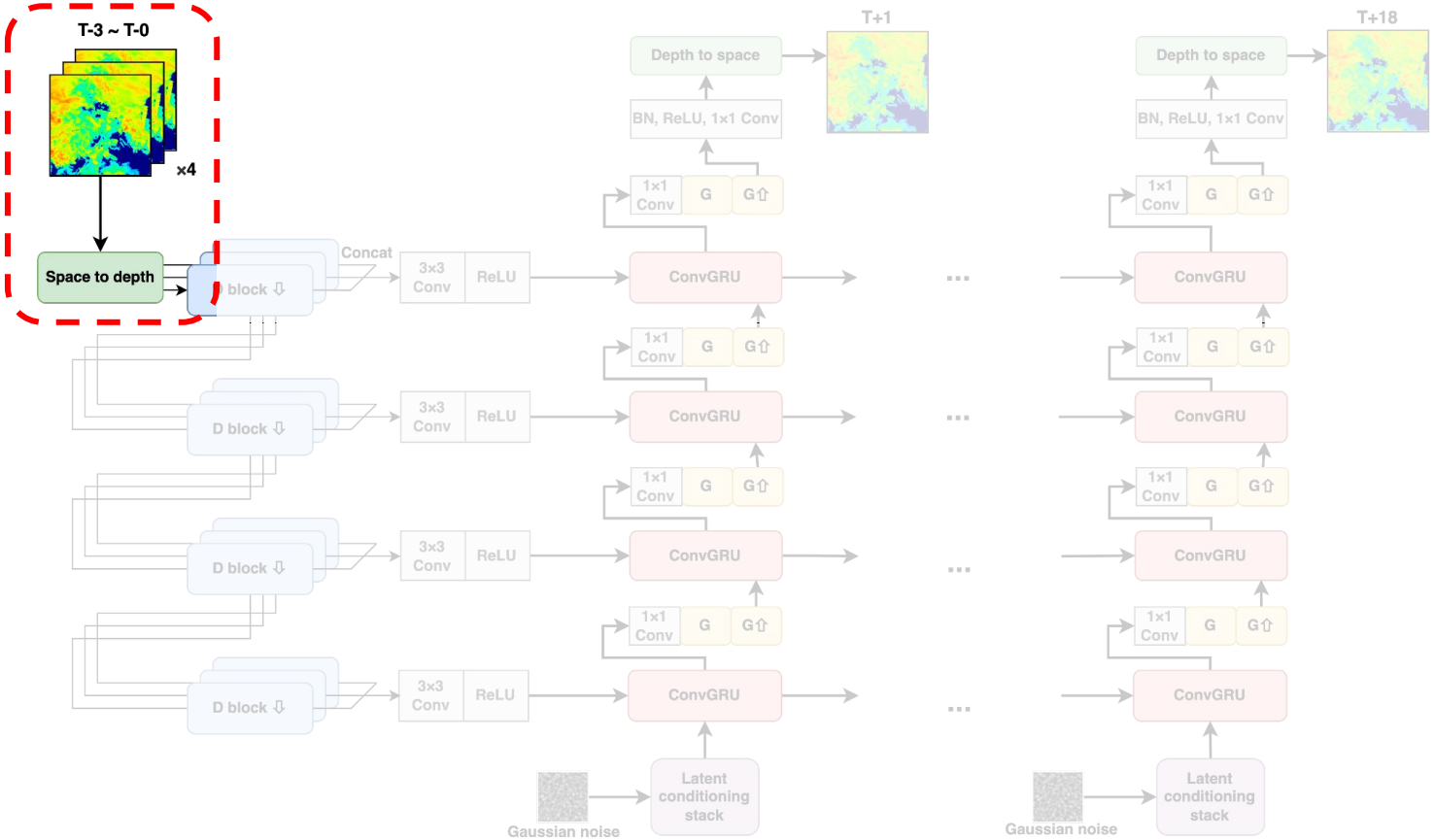
## DGMR: Space to depth (S2D)

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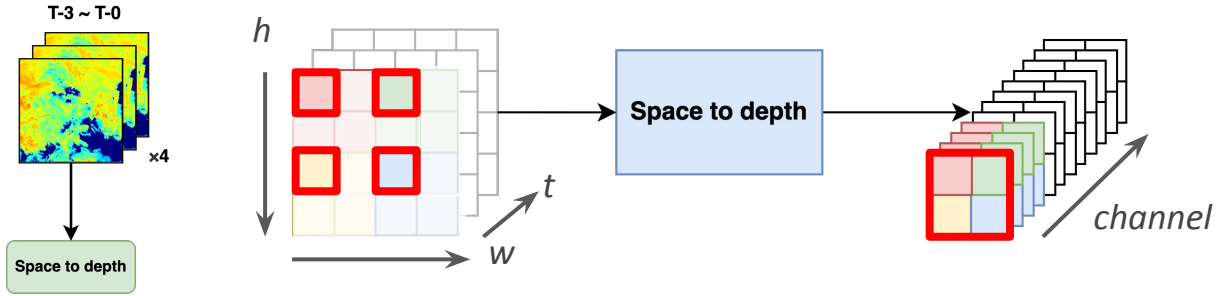
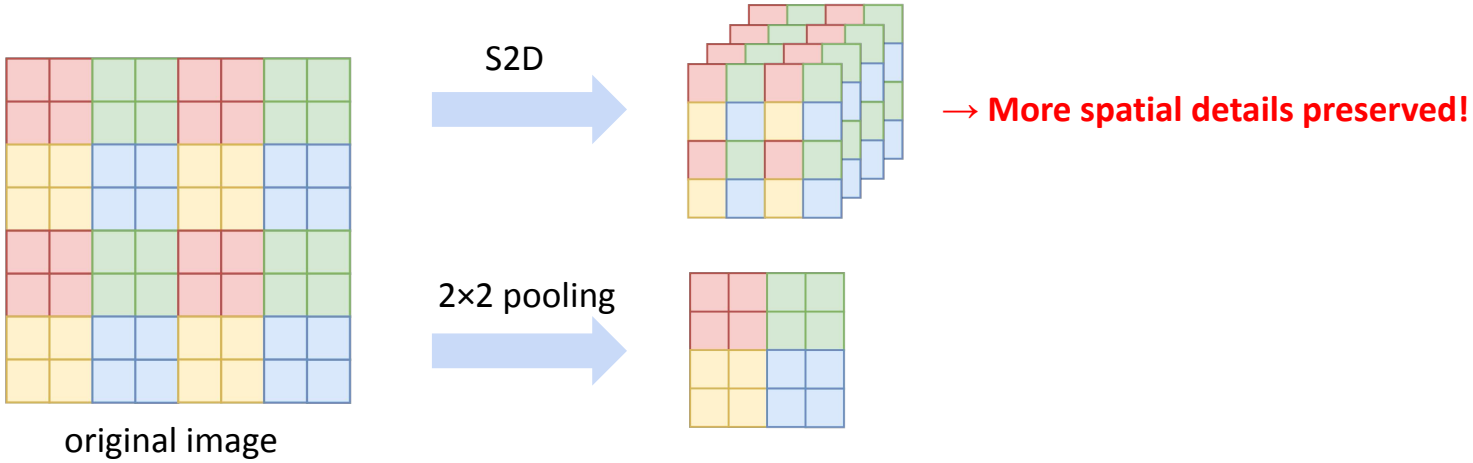
## (1) Space to depth: Reduce image size while preserving spatial details

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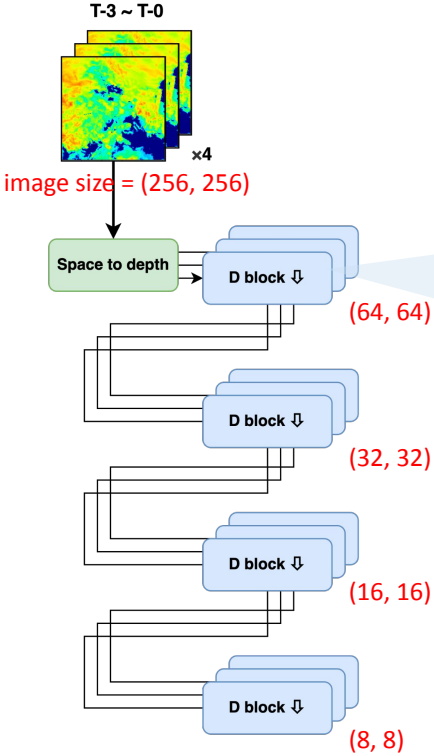
## (2) Hierachical feature extractor: Extract features across a wide range of spatial scales




Operations a single D block contains:

(1) **1×1 convolution**
(2) **3×3 convolution**
} operates in parallel

(3) **space to depth** (after convolutions)

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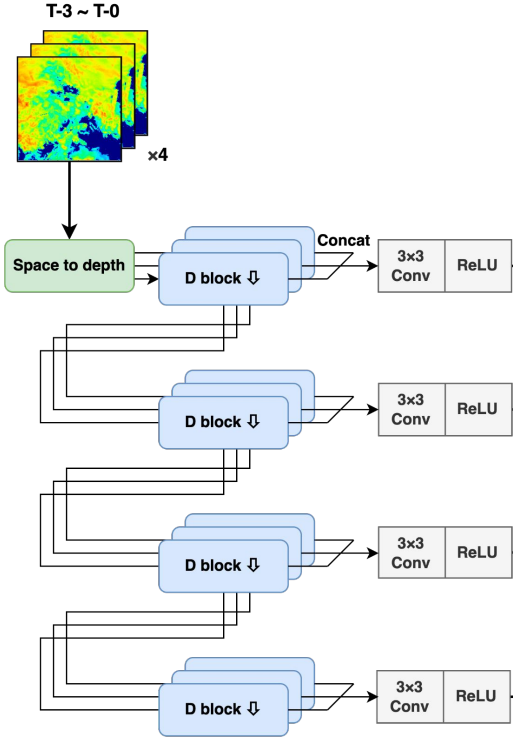
## (2) Hierachical feature extractor: Extract features across a wide range of spatial scales




**Extracted features' spatial extent**

original image size = *256km × 256km*, resolution = *1km × 1km*

***≦ 14km × 14km***

***≦ 34km × 34km***

***≦ 86km × 86km***

***≦ 226km × 226km***

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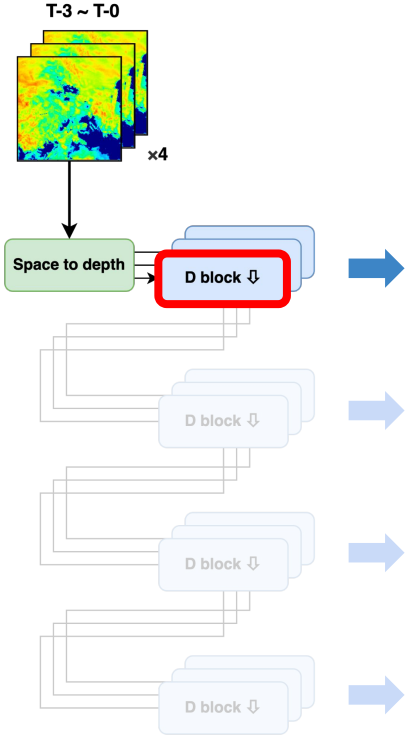
## (2) Hierachical feature extractor: Extract features across a wide range of spatial scales

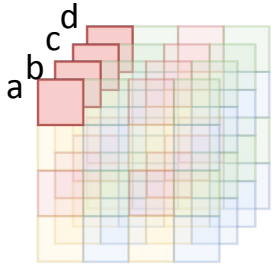



**Extracted features' spatial extent**

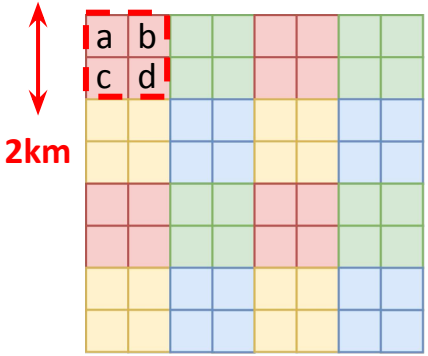
original image size = *256km × 256km*, resolution = *1km × 1km*

**1×1 convolution** **3×3 convolution**

***≦ 2km × 2km***




images
(after 1 space to depth)




original rainfall image
(resolution: 1km)

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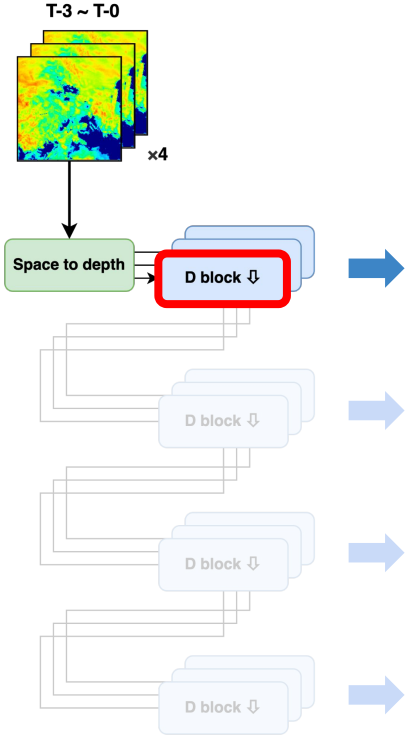
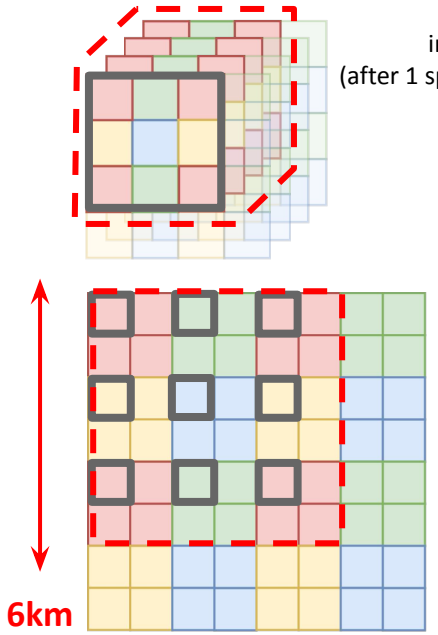
## (2) Hierachical feature extractor: Extract features across a wide range of spatial scales




**Extracted features' spatial extent**

original image size = *256km × 256km*, resolution = *1km × 1km*

| 1×1 convolution | 3×3 convolution |
|---|---|
| ≦ *2km × 2km* | ≦ ***6km × 6km*** |

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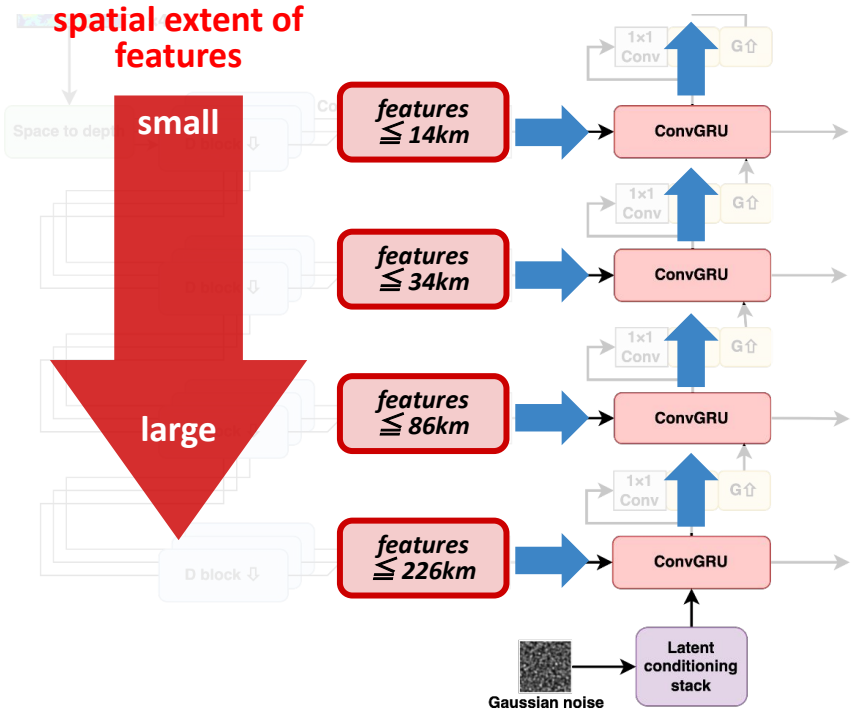
## (3) ConvGRU: Establish spatial and temporal relationship between features at different scales.

**ConvGRU** (Gated Recurrent Unit) is a gating mechanism that **decided whether the inputs make a long term or short term impact or little impact on the output** .




**Features in larger spatial extent are able to effect features in smaller spatial extent.**

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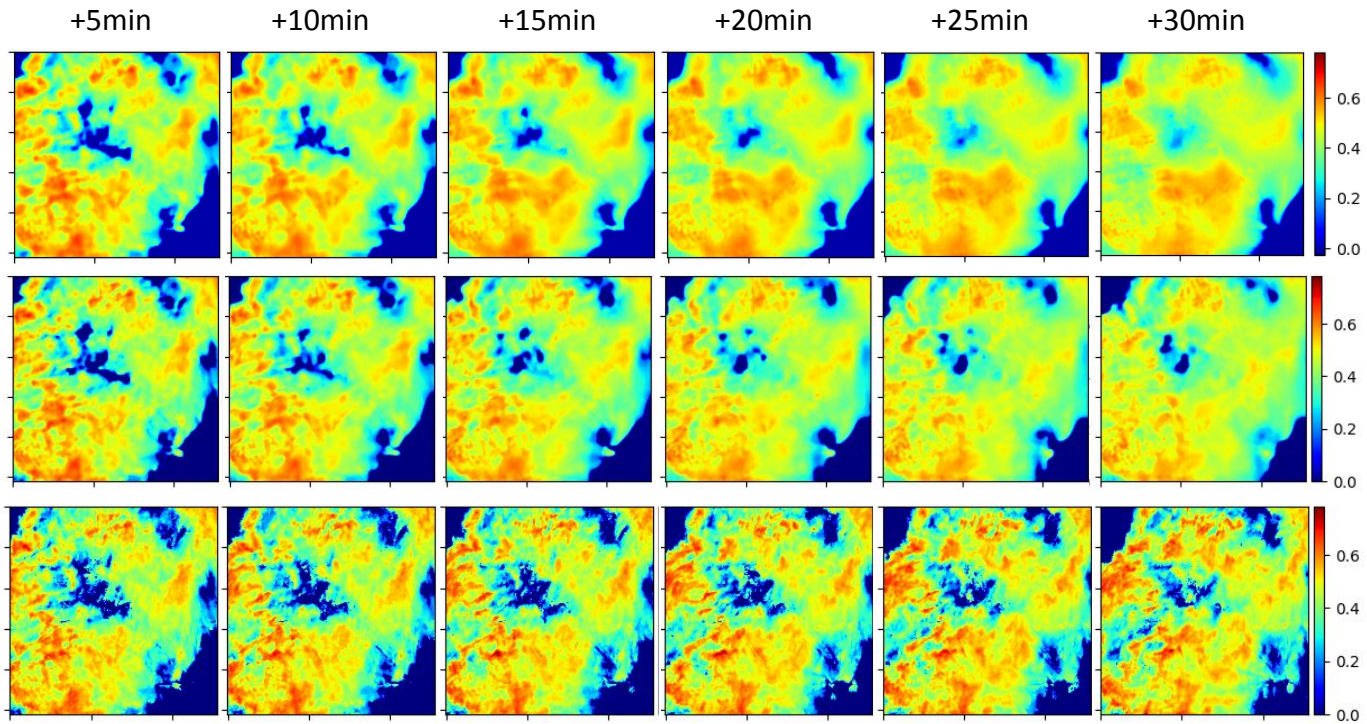
## (4) GAN: Reduce smoothness of spatial details

More details can be perserved in the fields with GAN.

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**A more detailed explanation can be found in our full tutorial!**

Tutorial Outline

- **Deep Learning 101: How does DL work?**
- **What is Convolution?**
  - How does it work on a 2-dimensional images?
- **What is Space to Depth?**
  - How does it work?
  - Space to Depth + Convolution
  - Hierachical feature extractor
- **What is GRU (Gated Recurrent Units)?**
  - How does GRU work?
  - The role of ConvGRU in DGMR
- **What is GAN?**
  - GAN framework in a nutshell
  - The benefit of using GAN

Article of DGMR

Our abstract

**Full tutorial on YouTube!**

Our reproduction of DGMR on Github
(weights are yet to update)


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