

Data-efficient Deep Learning for Earth Observation

Deep Learning Recap

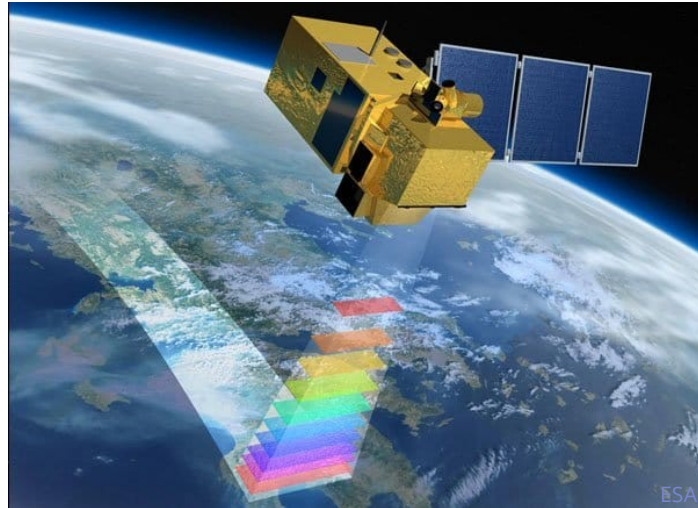
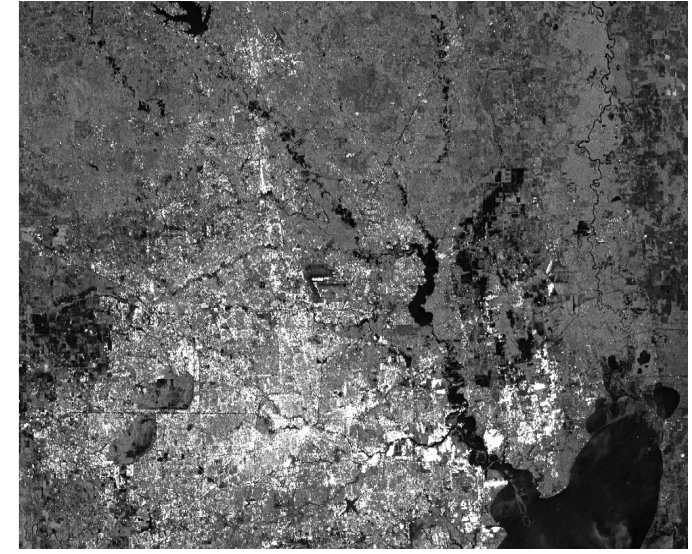
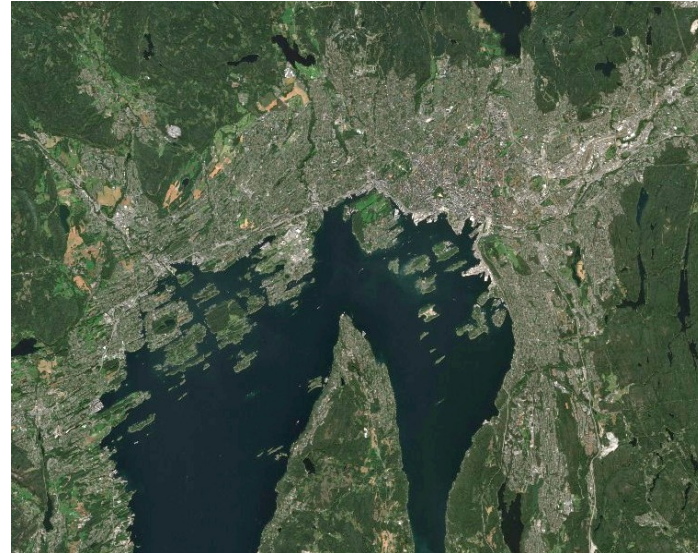
Michael Mommert



Deep Learning for Earth observation

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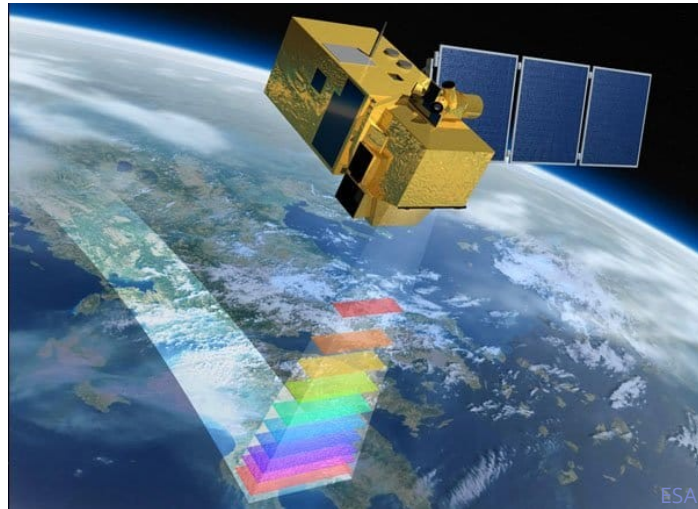
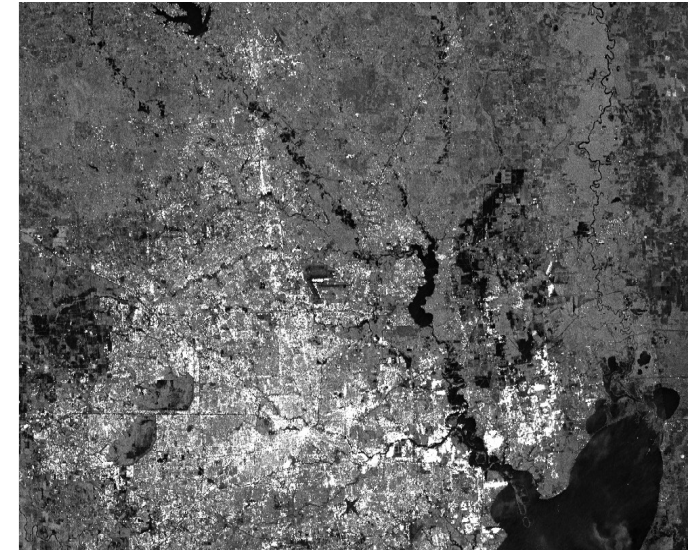
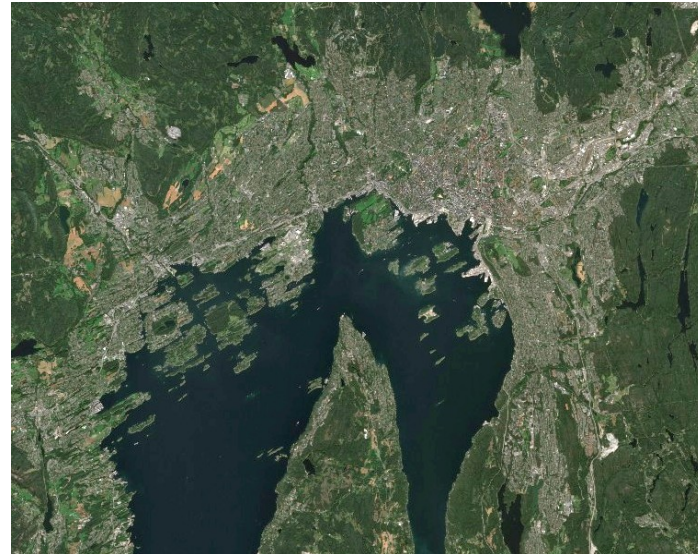
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How can we analyze these vast amounts
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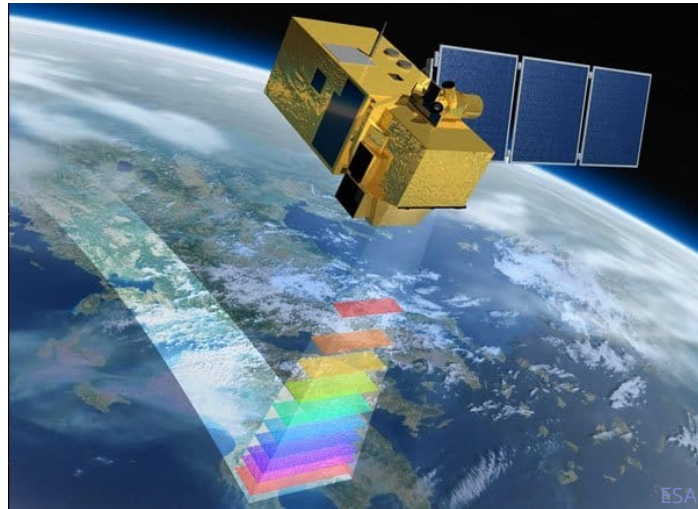
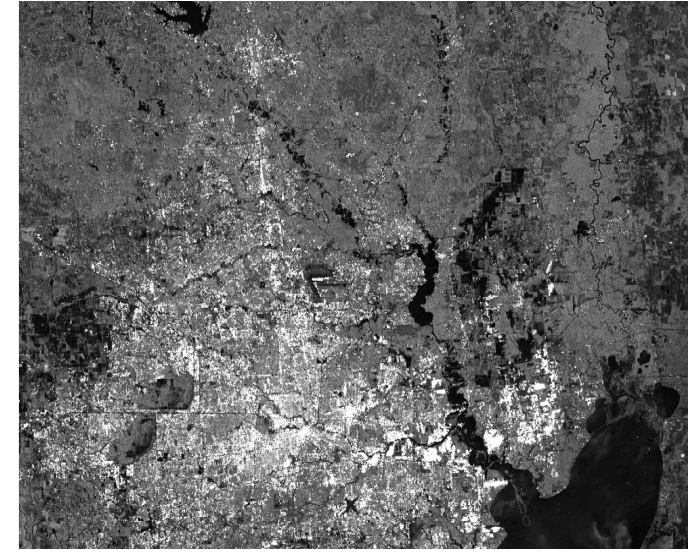
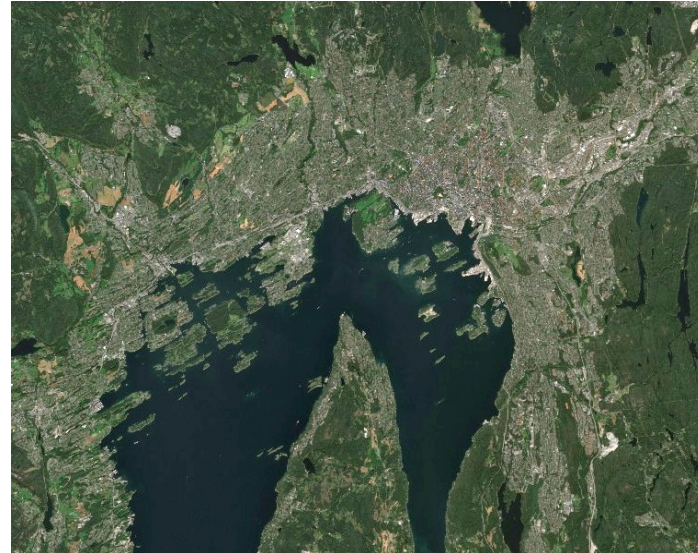


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Deep Learning offers the **scalability** to
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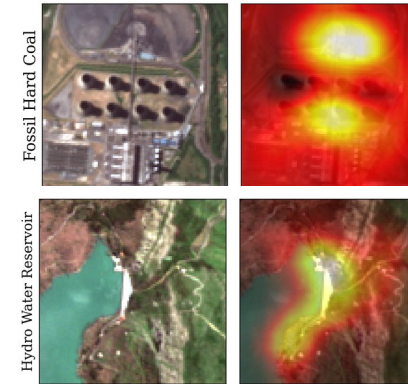
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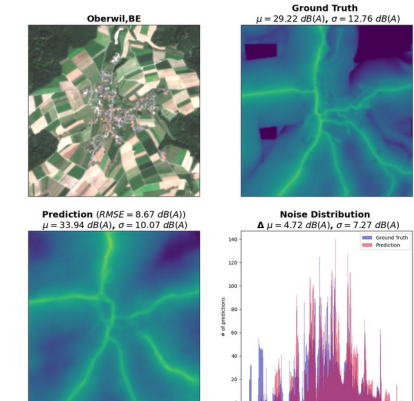
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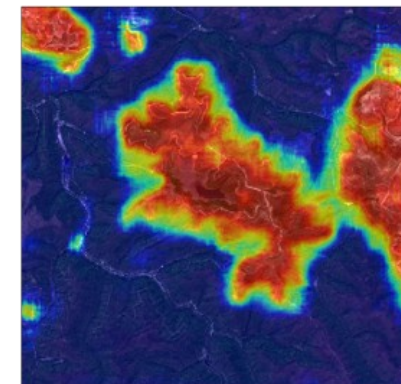
Deep Learning also offers the **flexibility** to
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Classification



Regression



Segmentation



**Object
Detection**

Deep Learning for Earth observation

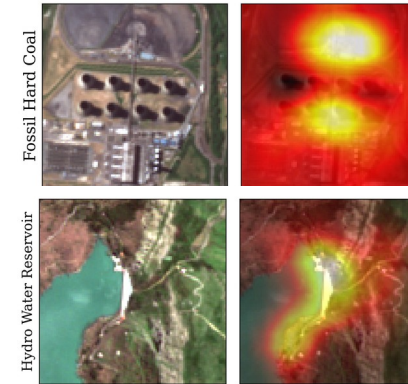
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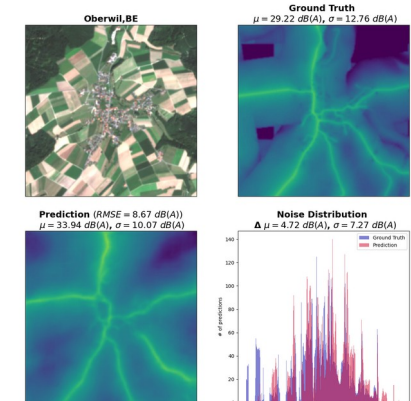
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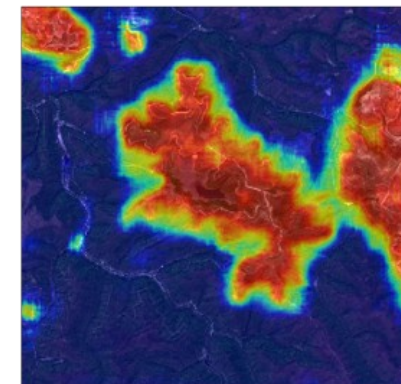
How does it work?



Classification



Regression

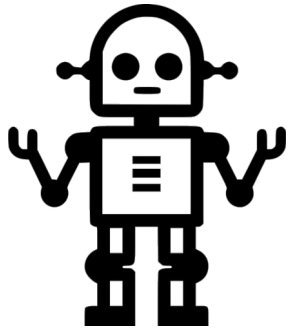


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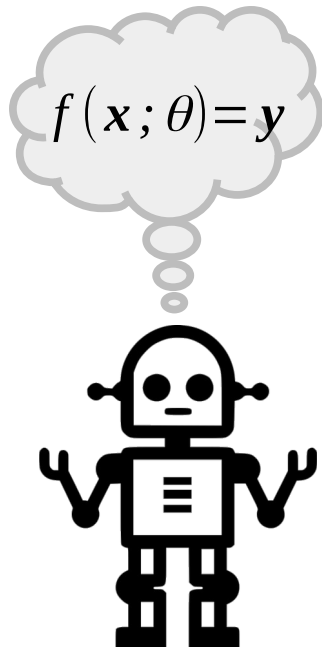


**Object
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Supervised learning with Neural Networks



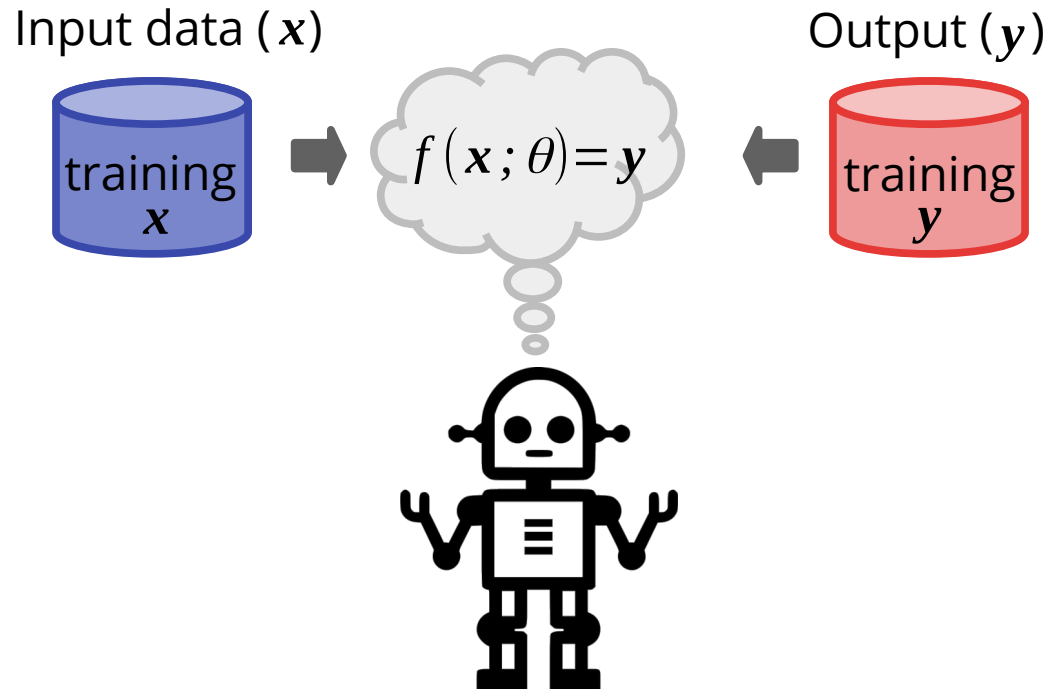
Supervised learning with Neural Networks



A machine learns a task from **annotated examples**.

Mathematically, it learns a function, f , that maps input data, \mathbf{x} , to the output, \mathbf{y} .

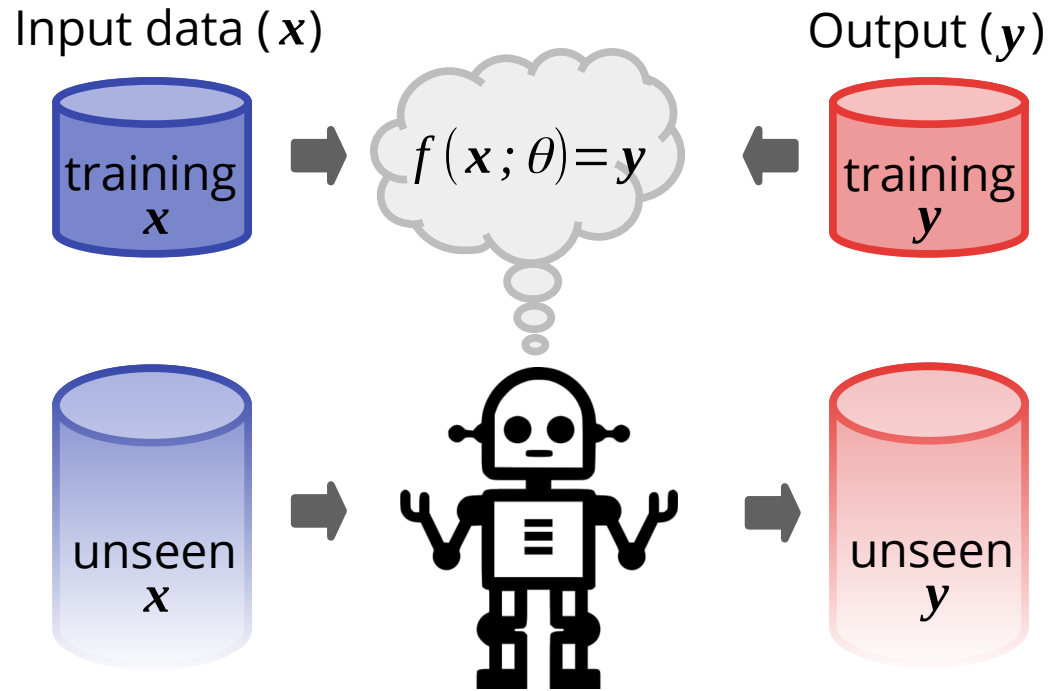
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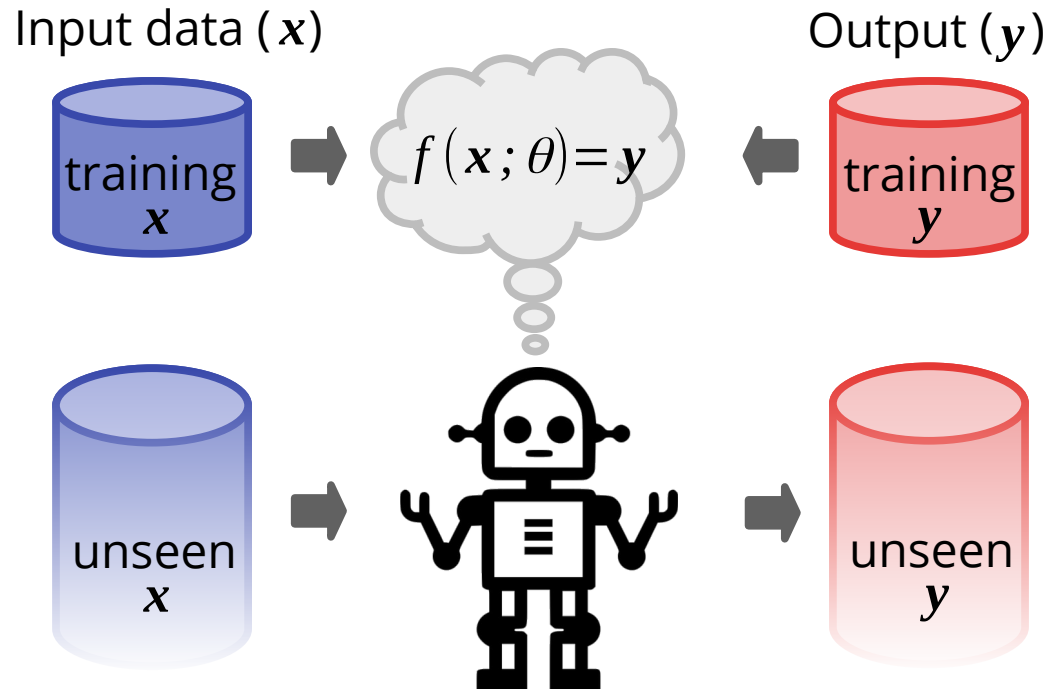
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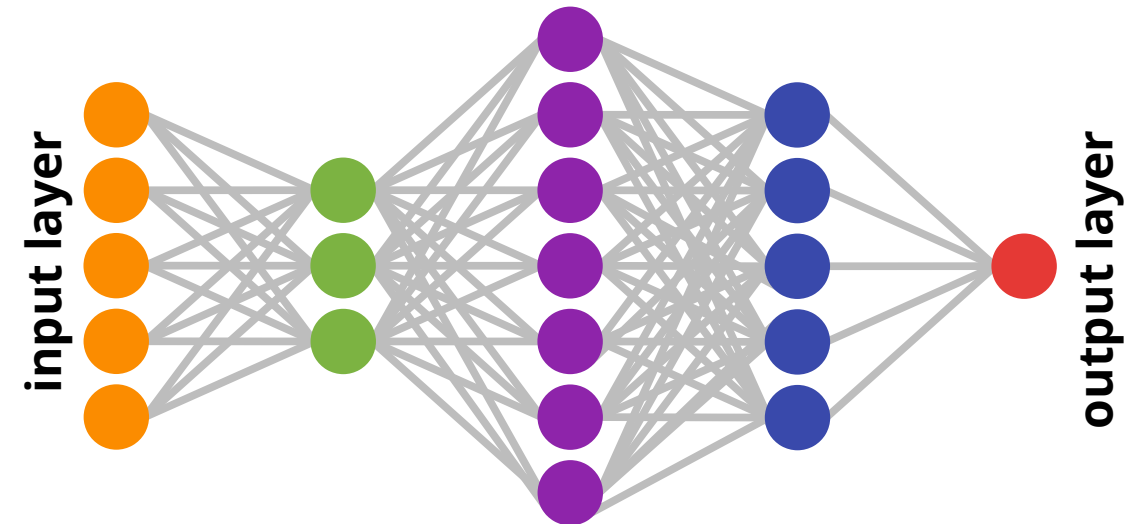
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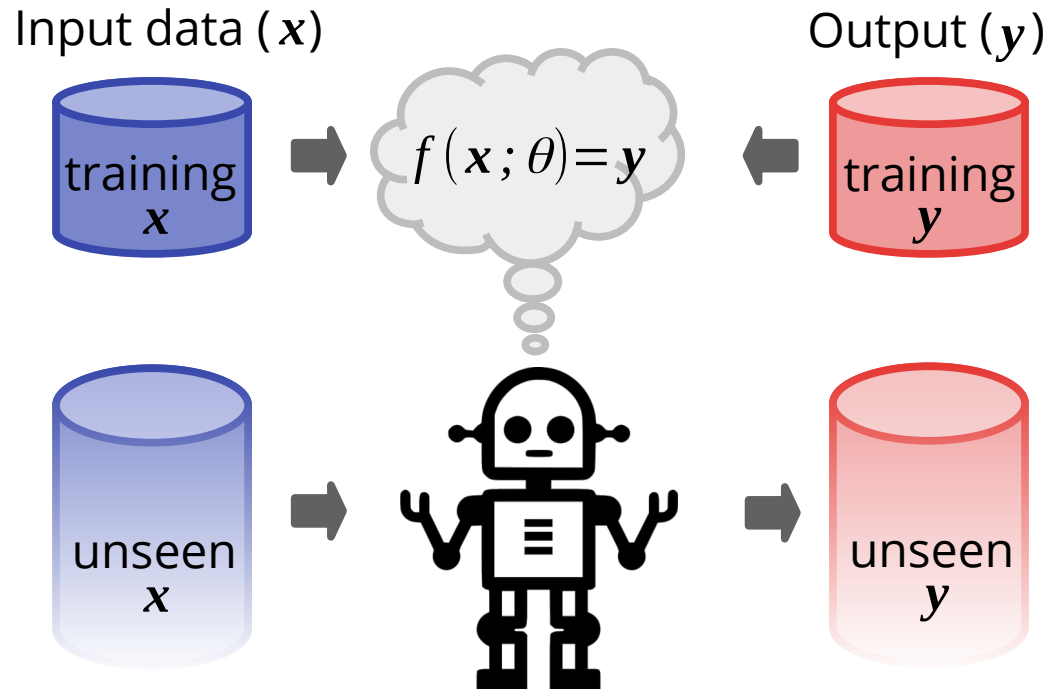
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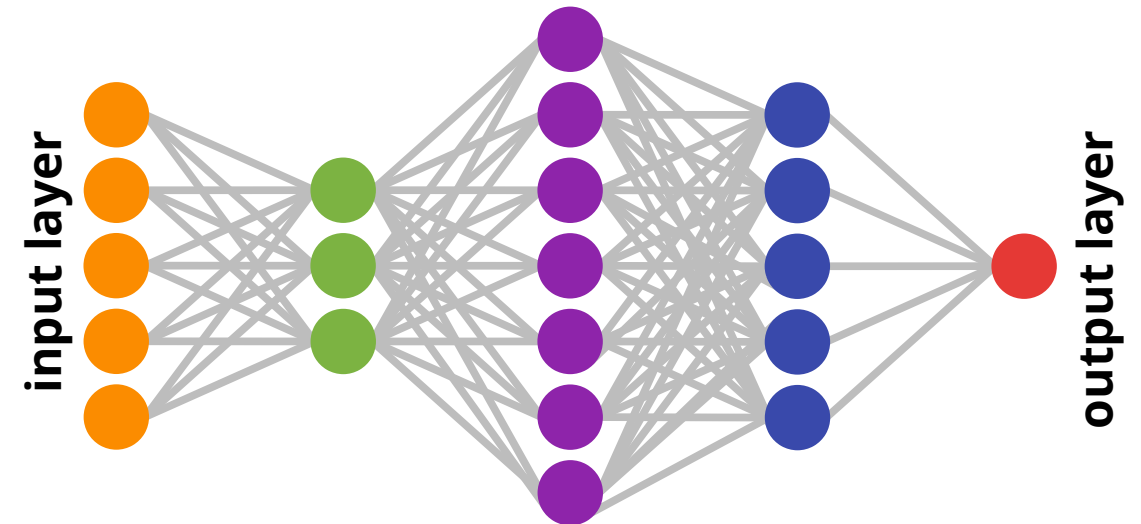
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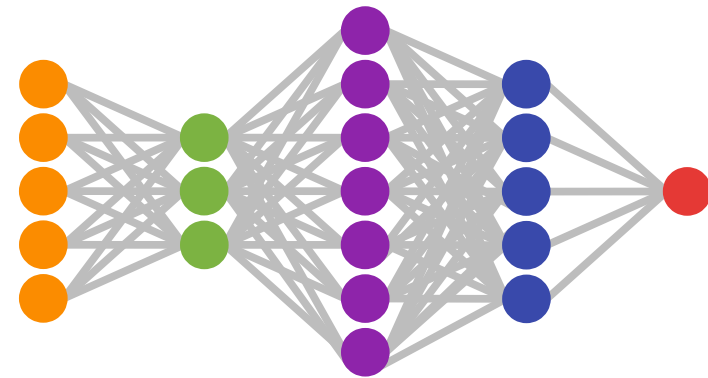
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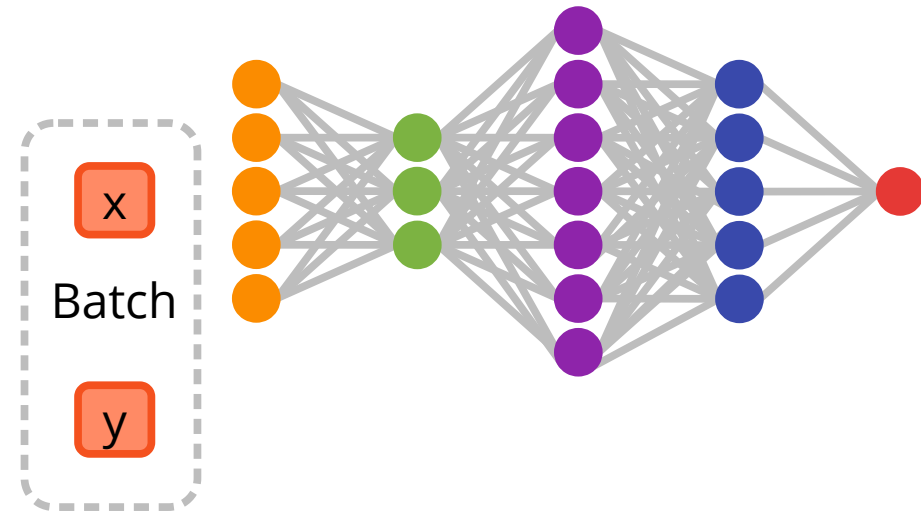
How does the model learn?

Neural network training pipeline



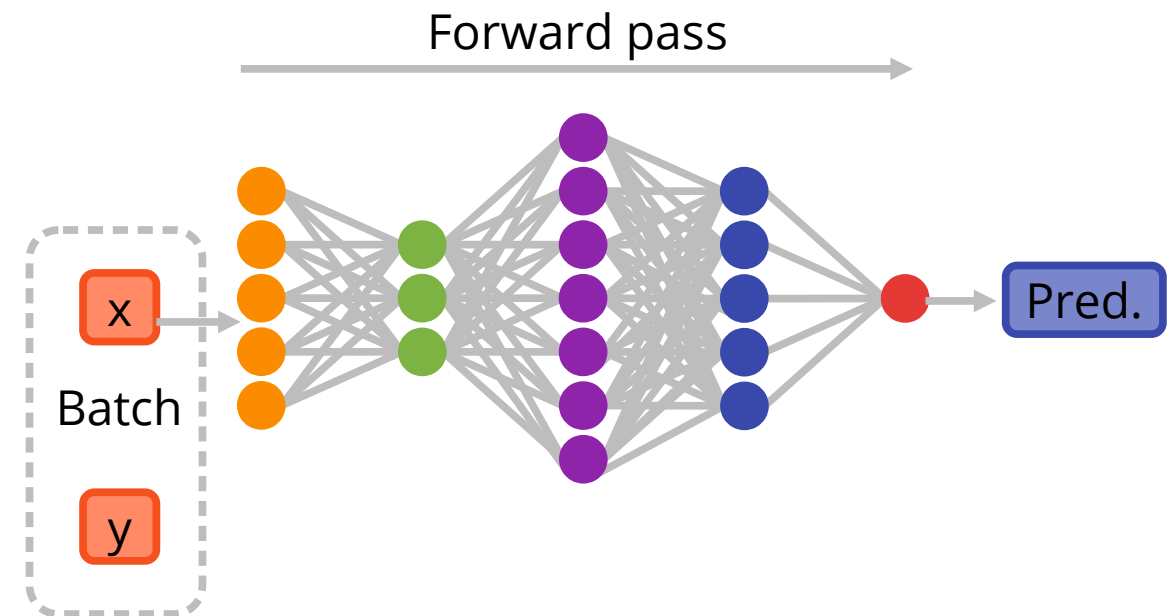
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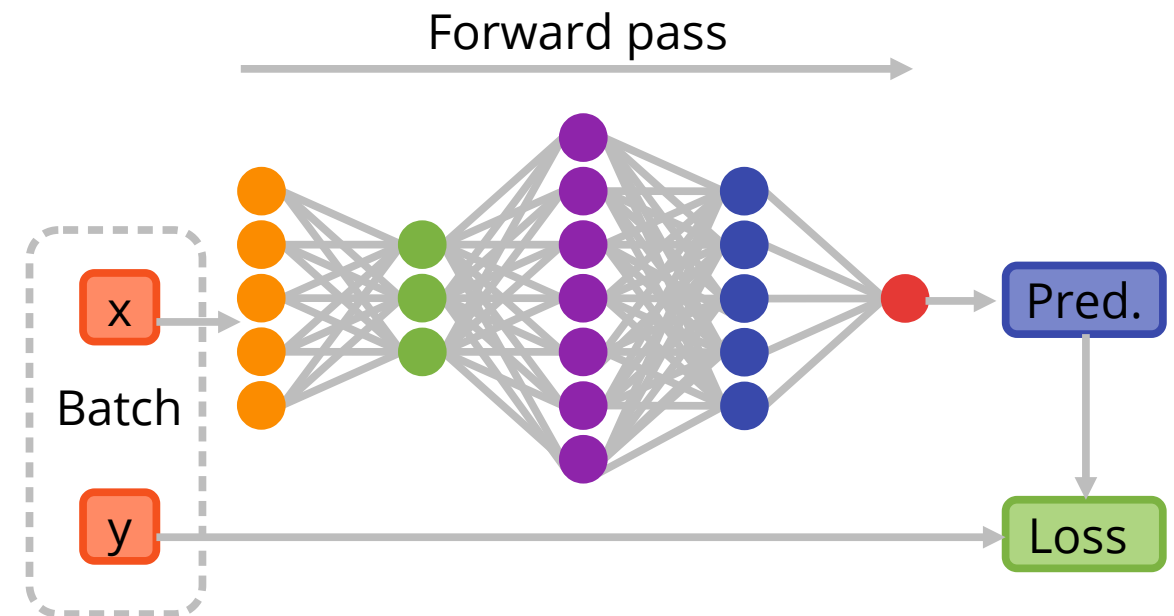
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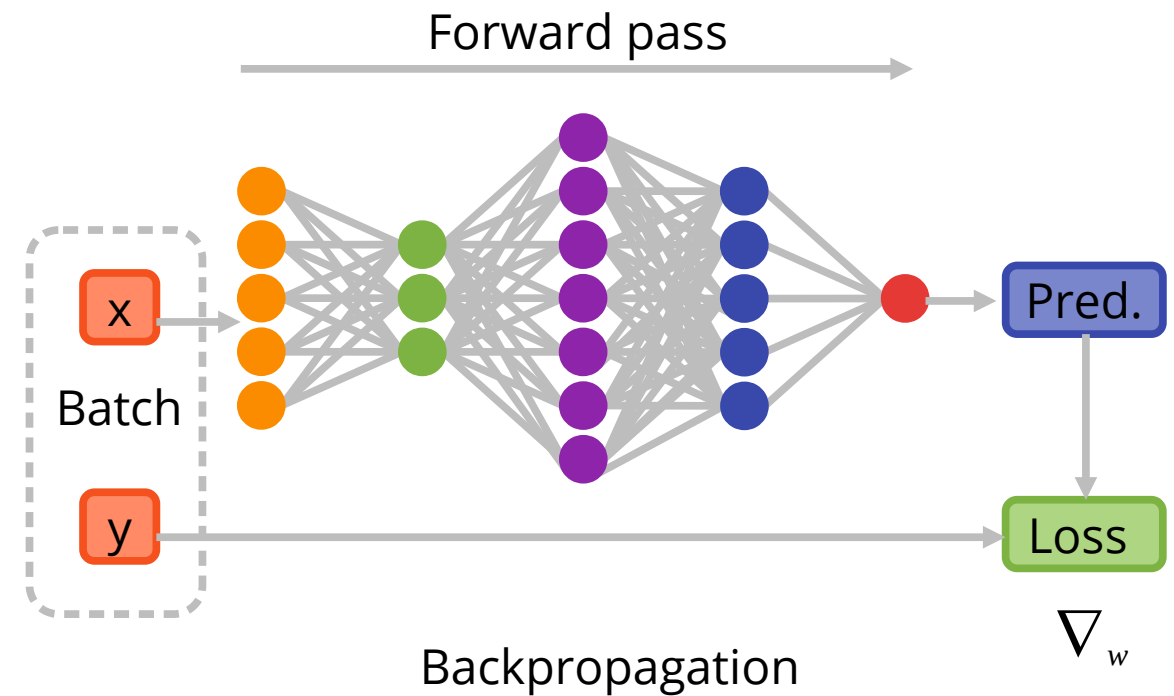
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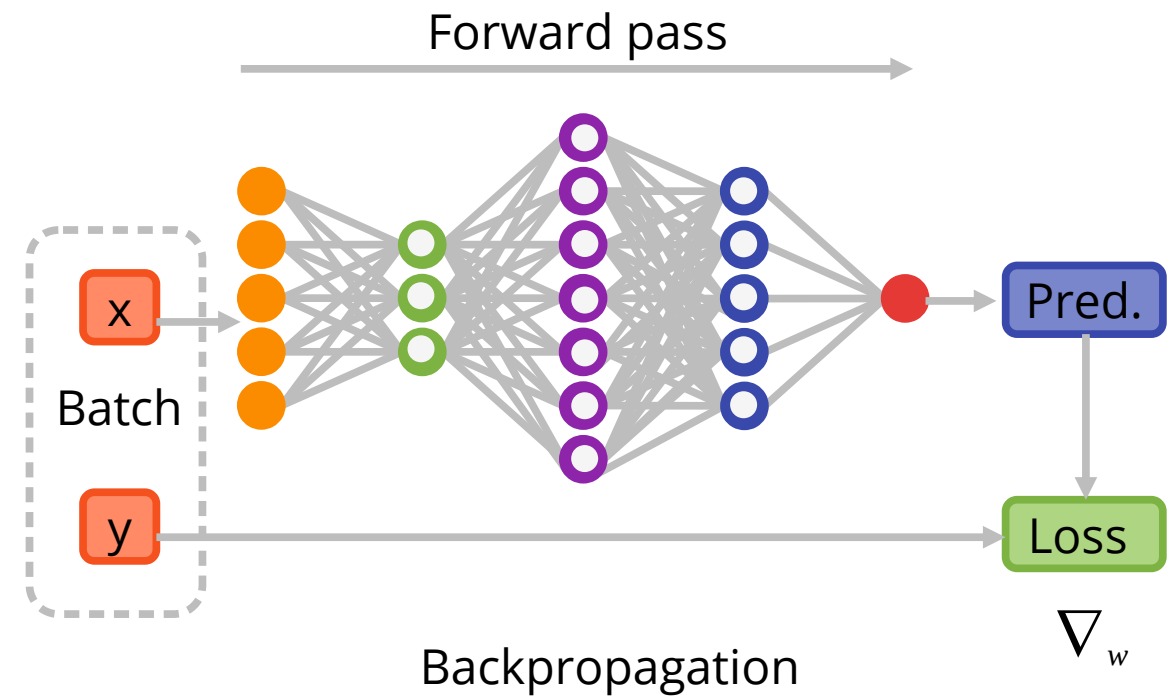
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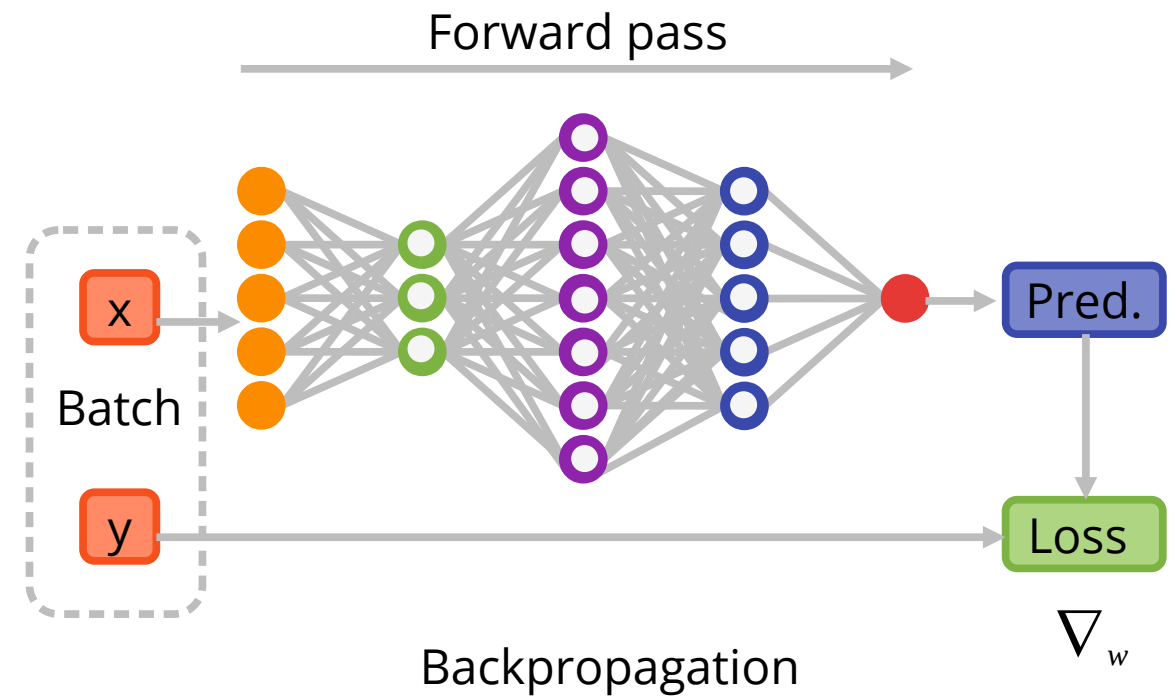
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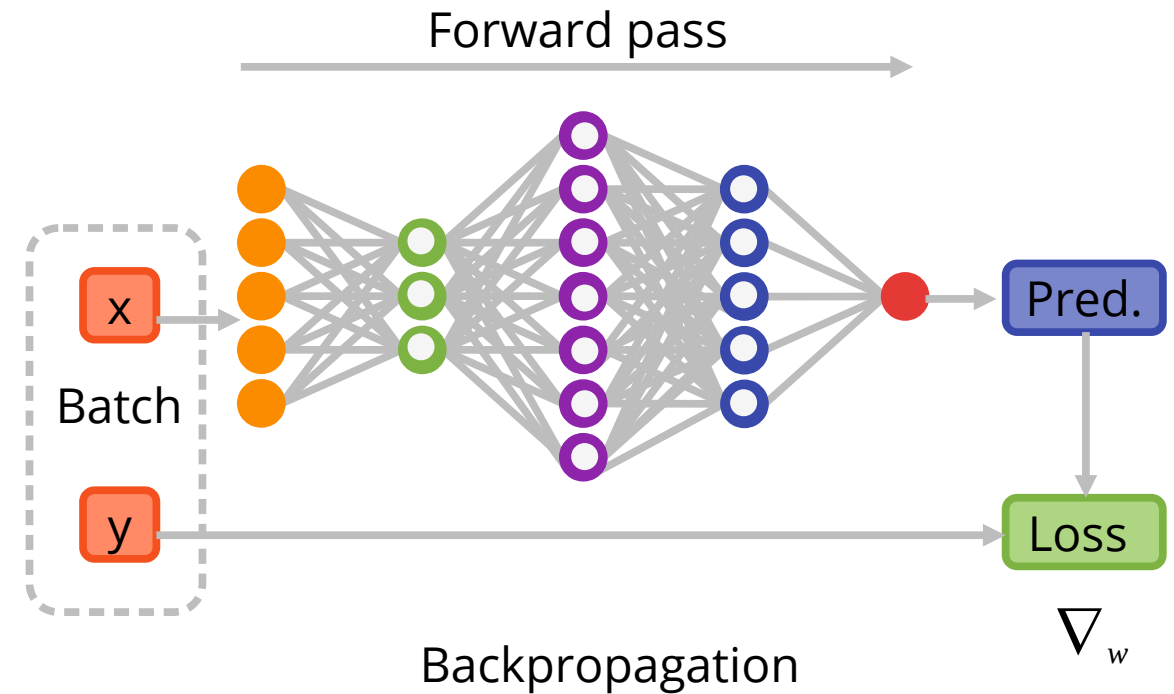
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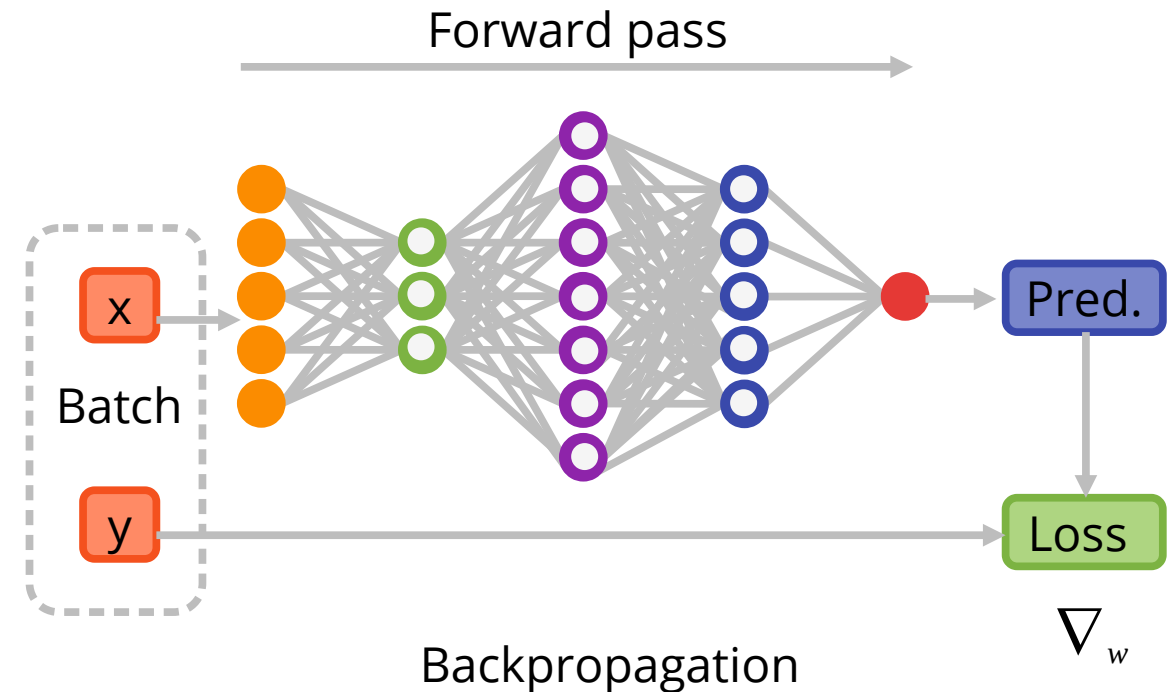
1 epoch



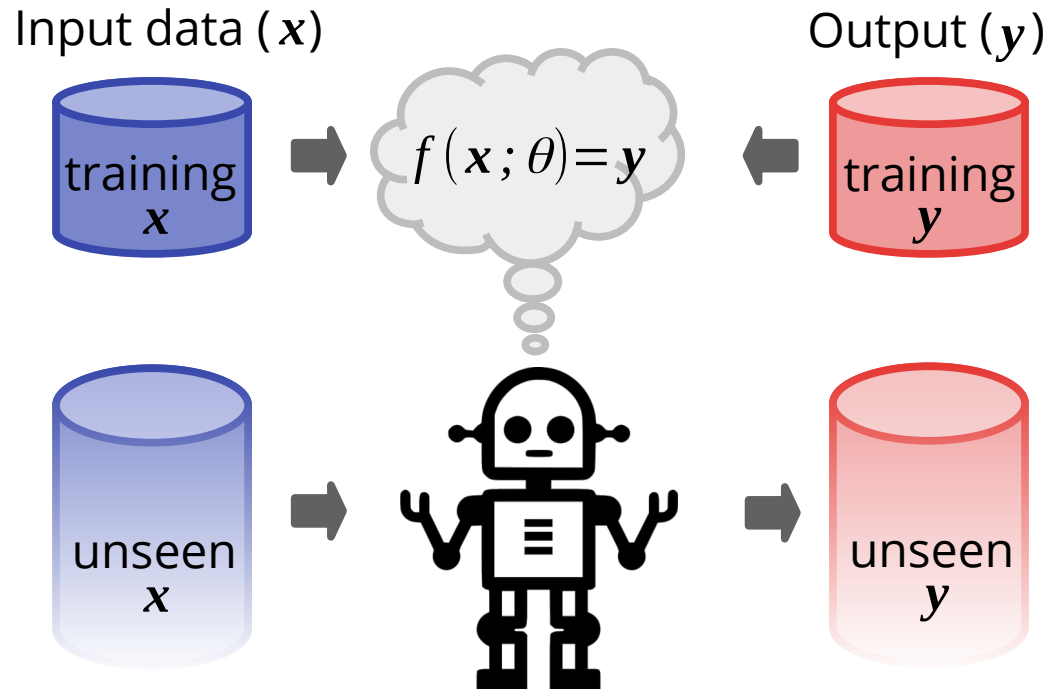
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 - Stop before overfitting sets in

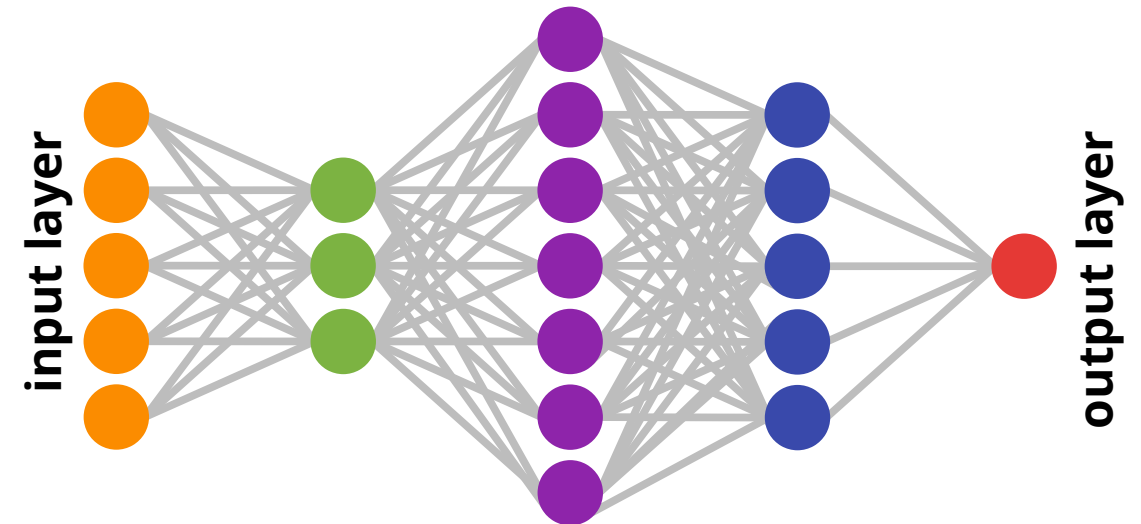


Supervised learning with Neural Networks



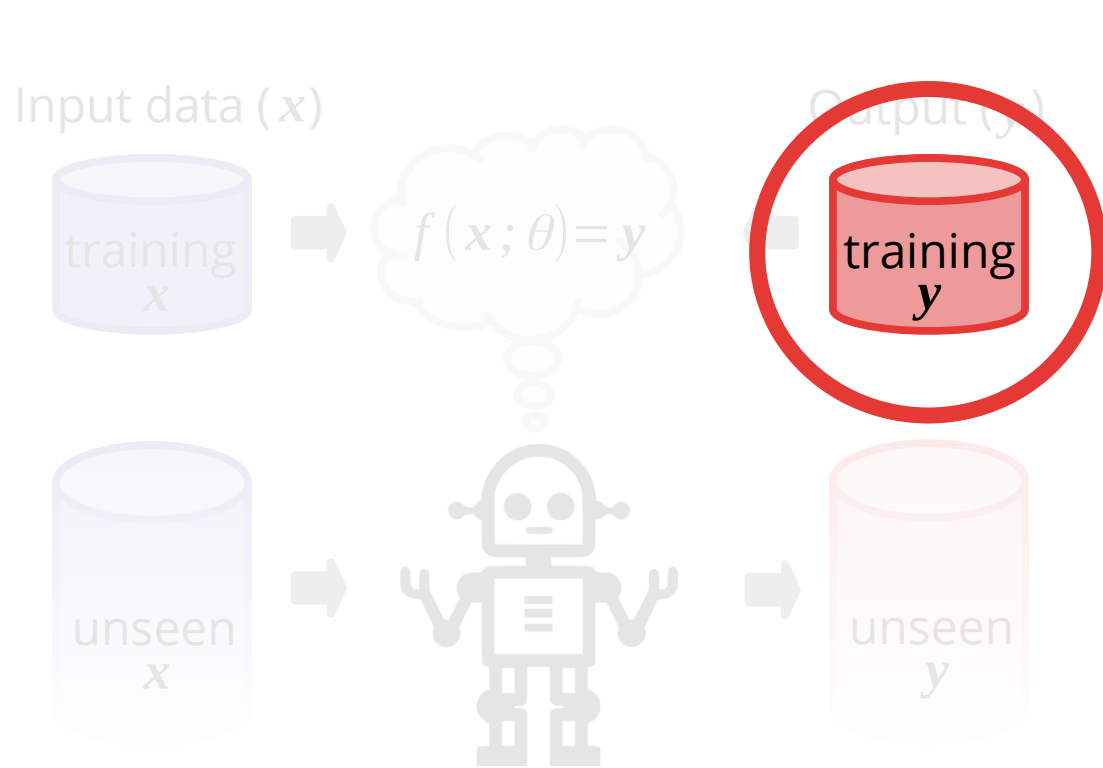
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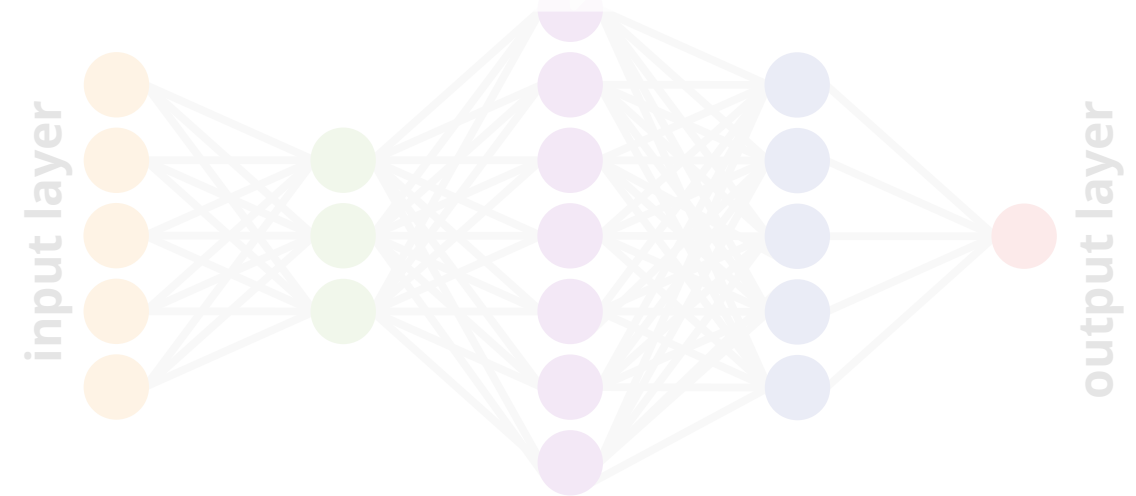
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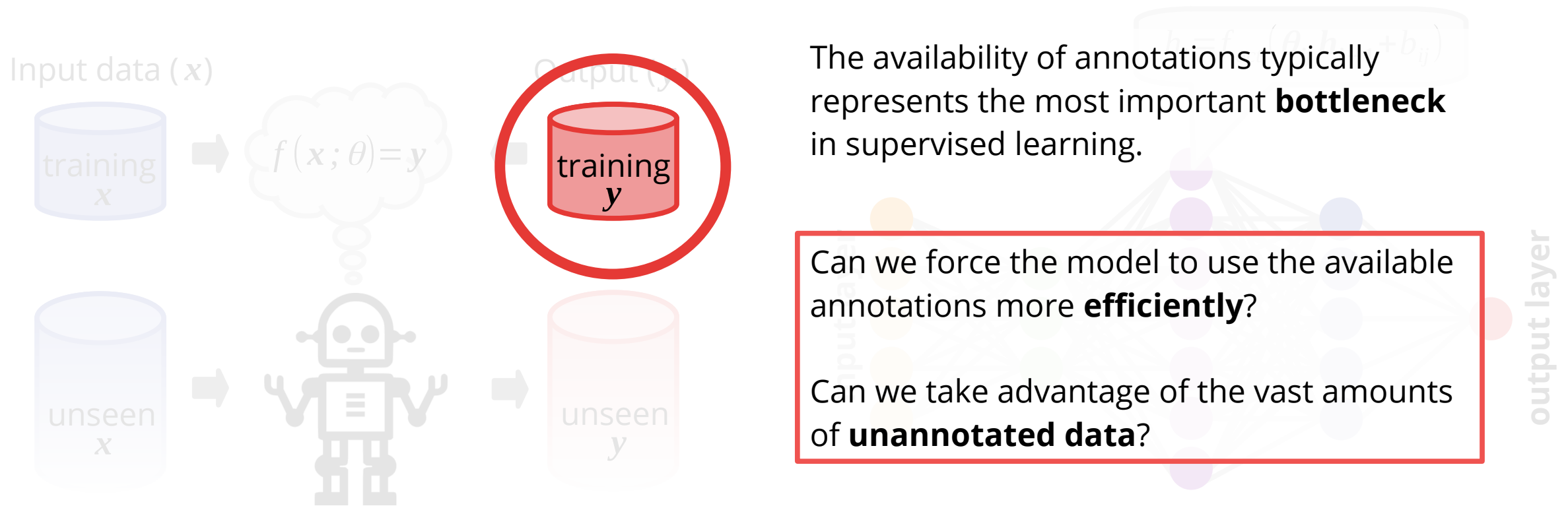
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The availability of annotations typically represents the most important **bottleneck** in supervised learning.



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Supervised learning with Neural Networks



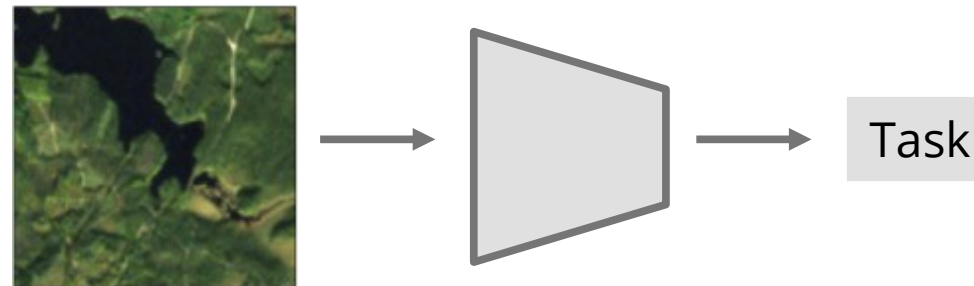
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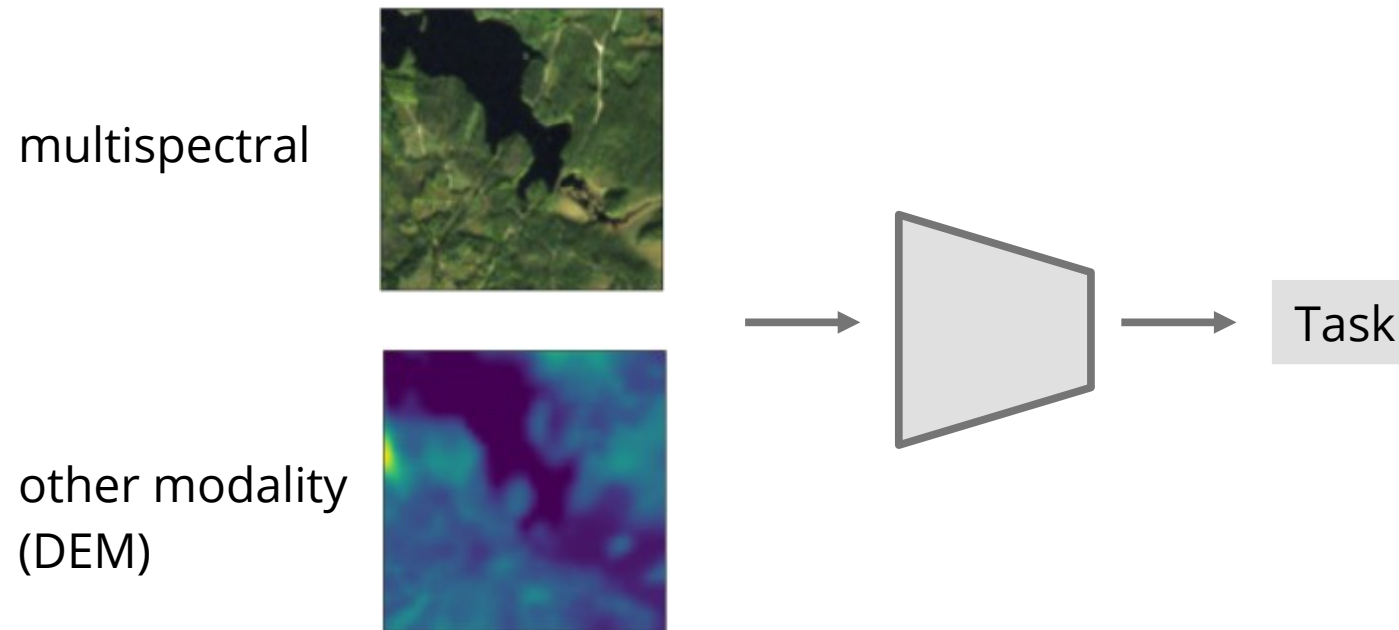
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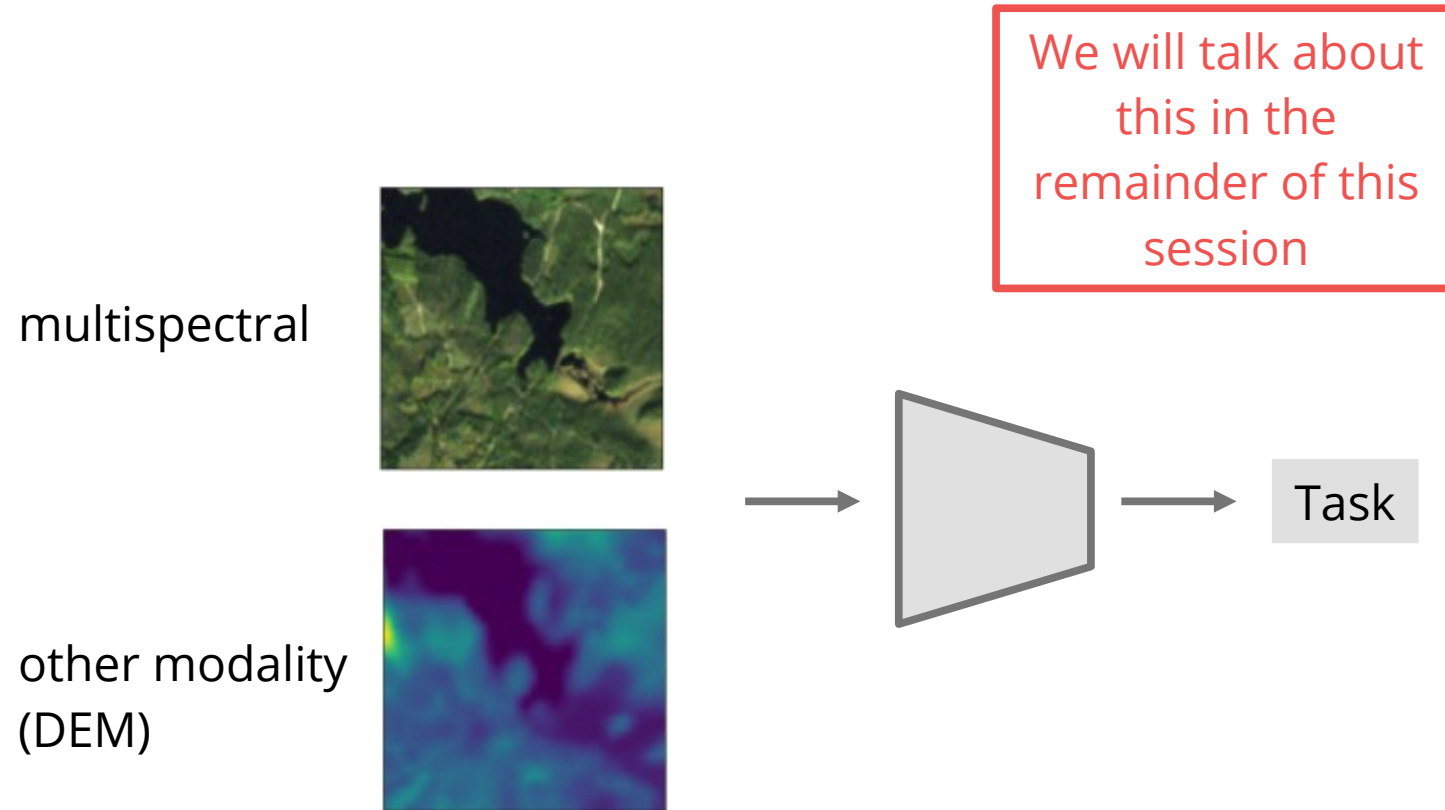
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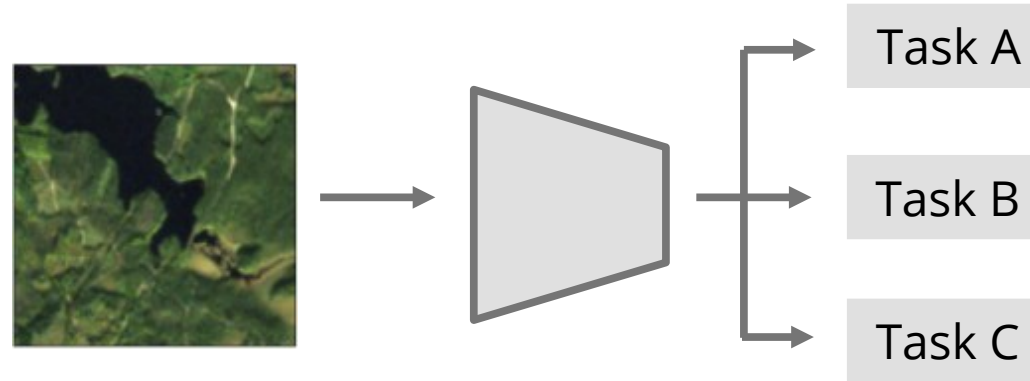
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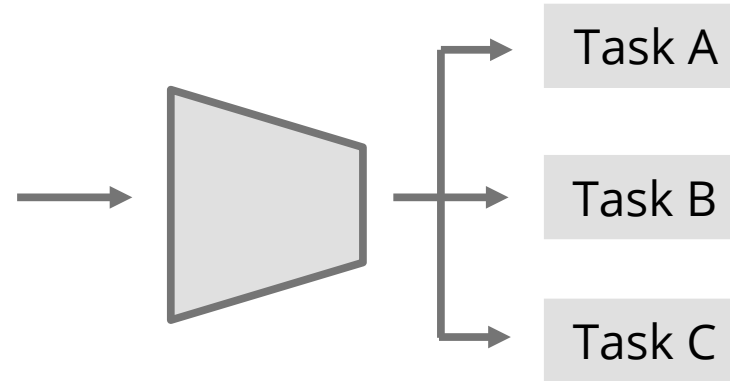
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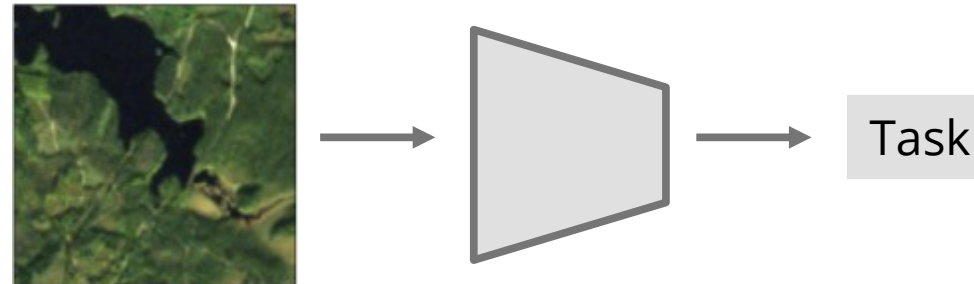
Joëlle will talk
about this in the
next session



How can we use annotated data more efficiently?

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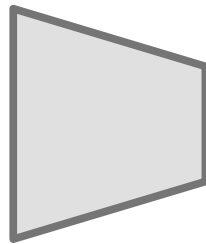
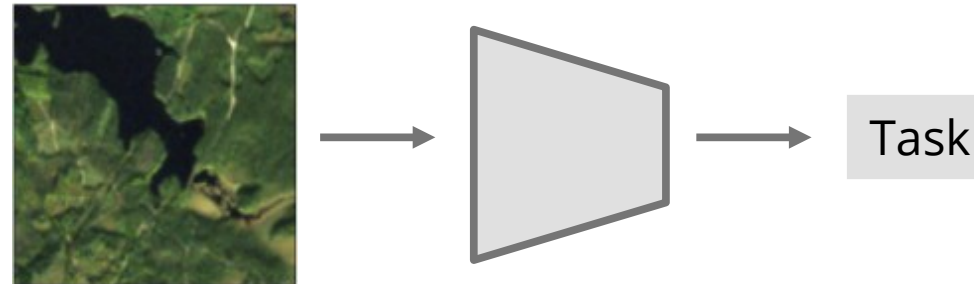
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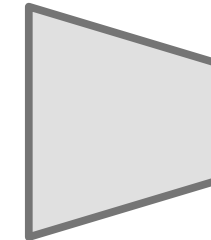
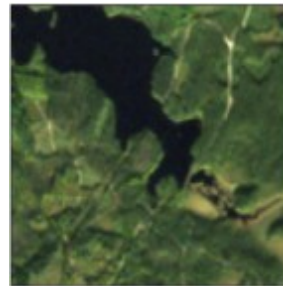
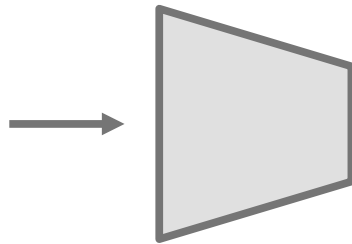


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other dataset

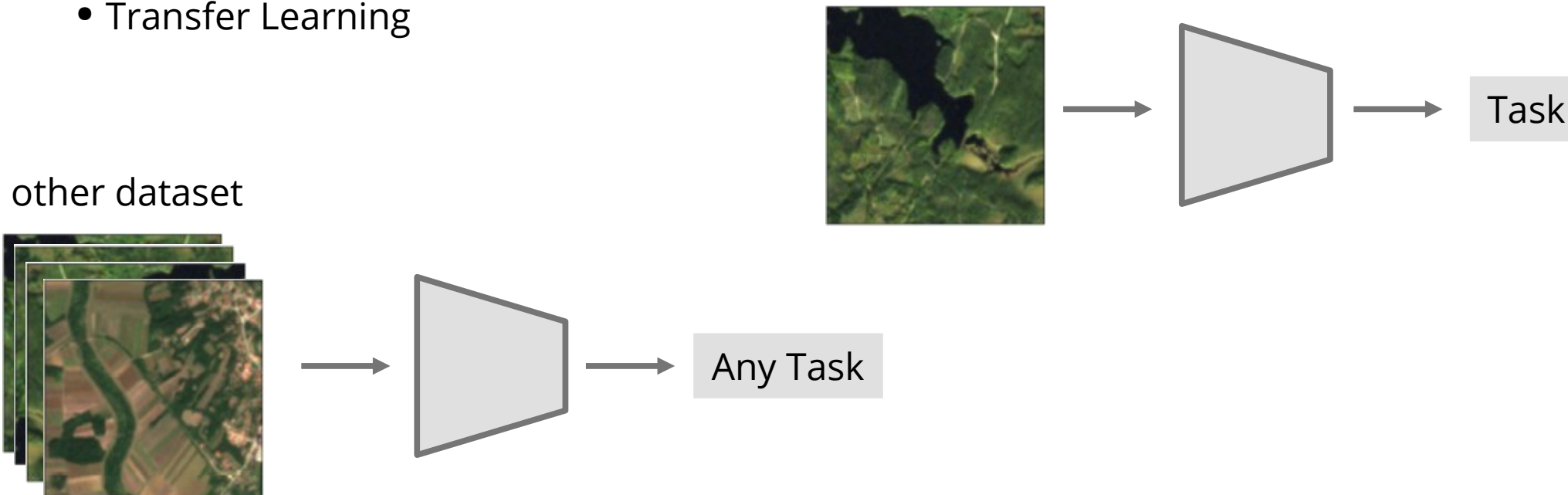


Task

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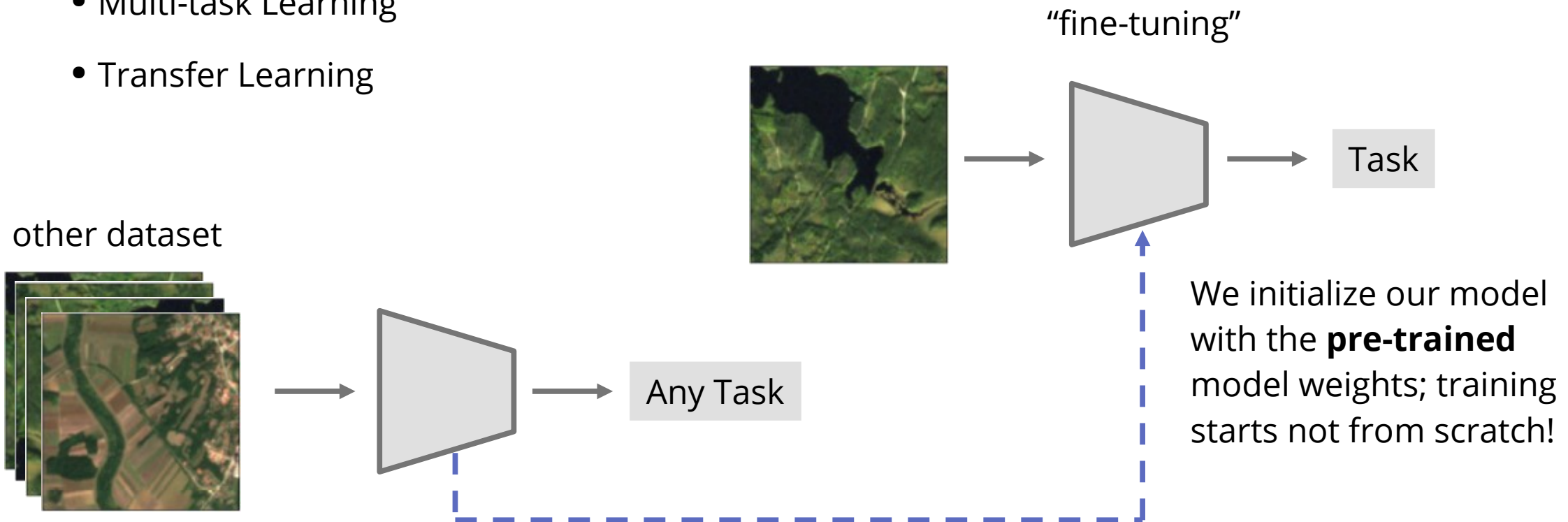
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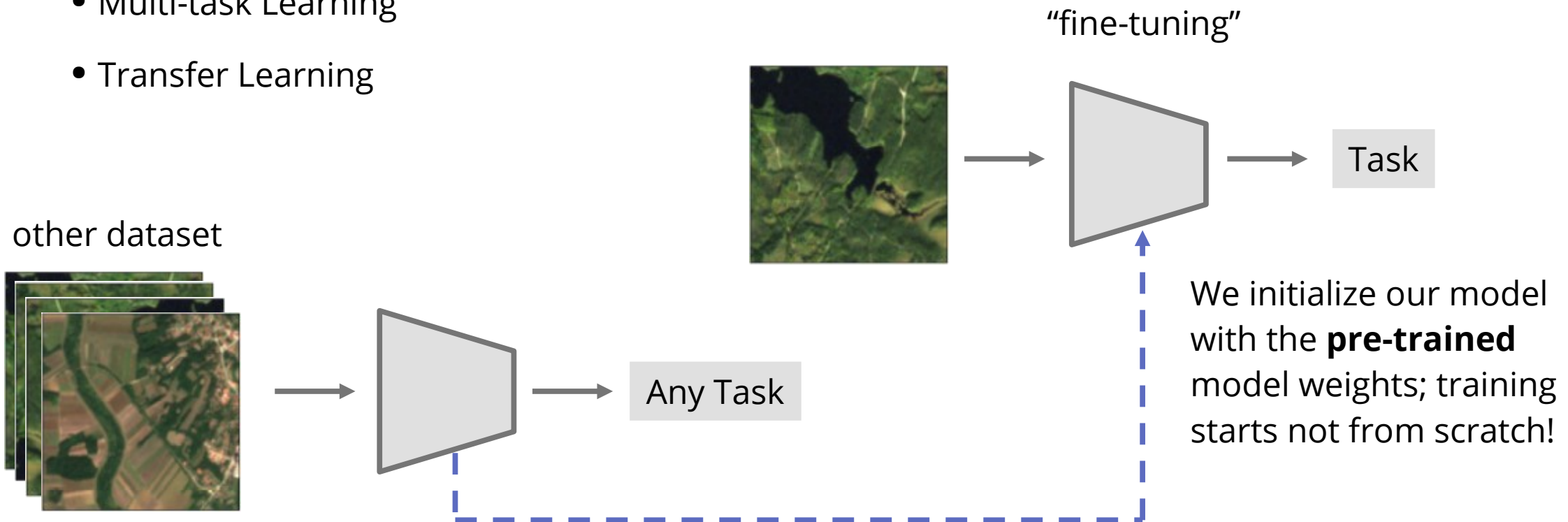
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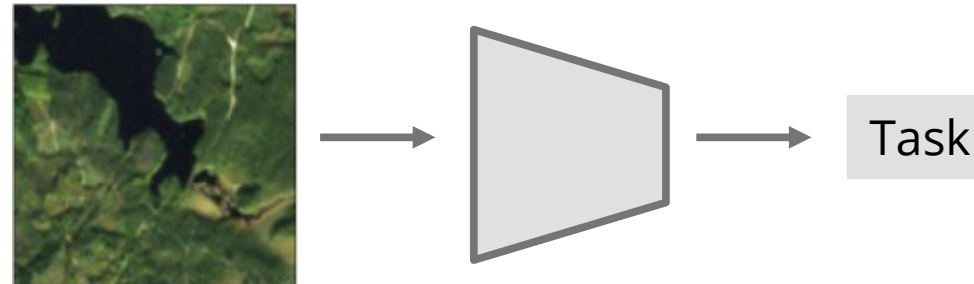
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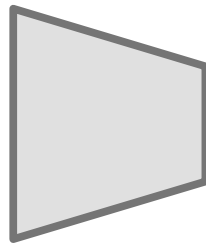
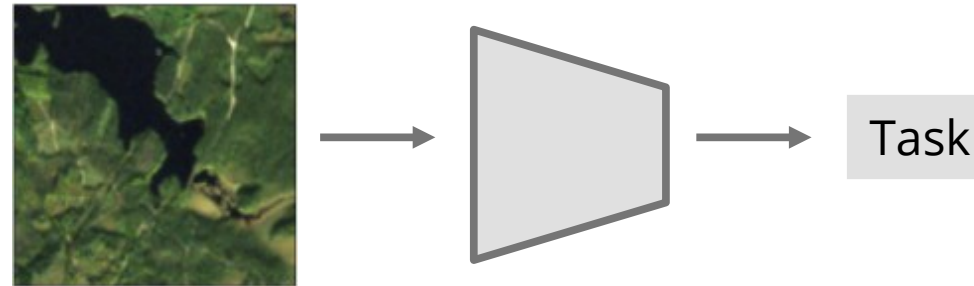
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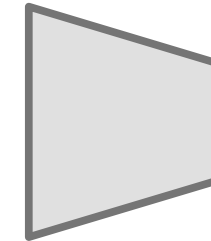
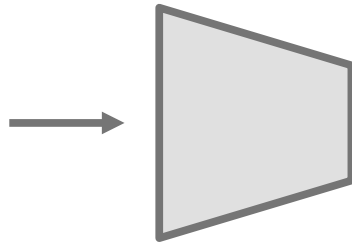
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other dataset

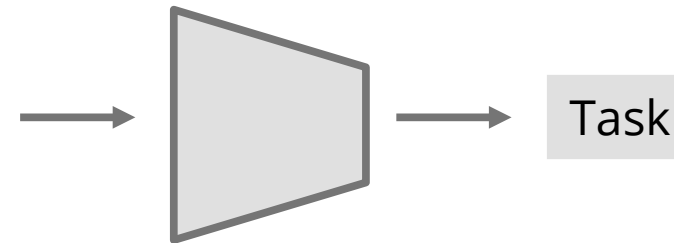
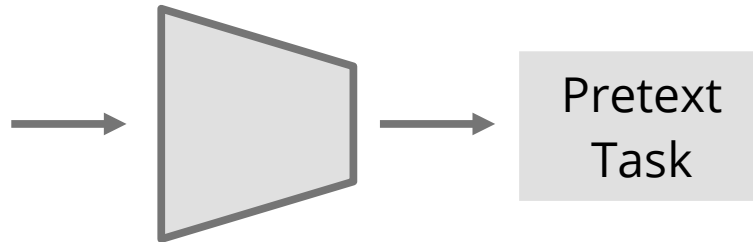


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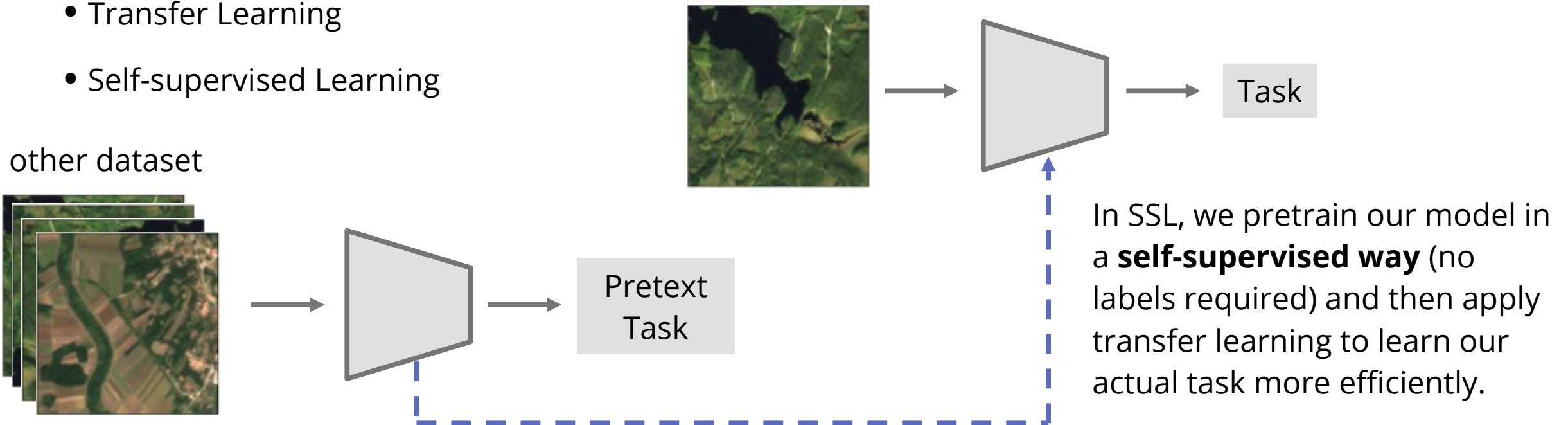
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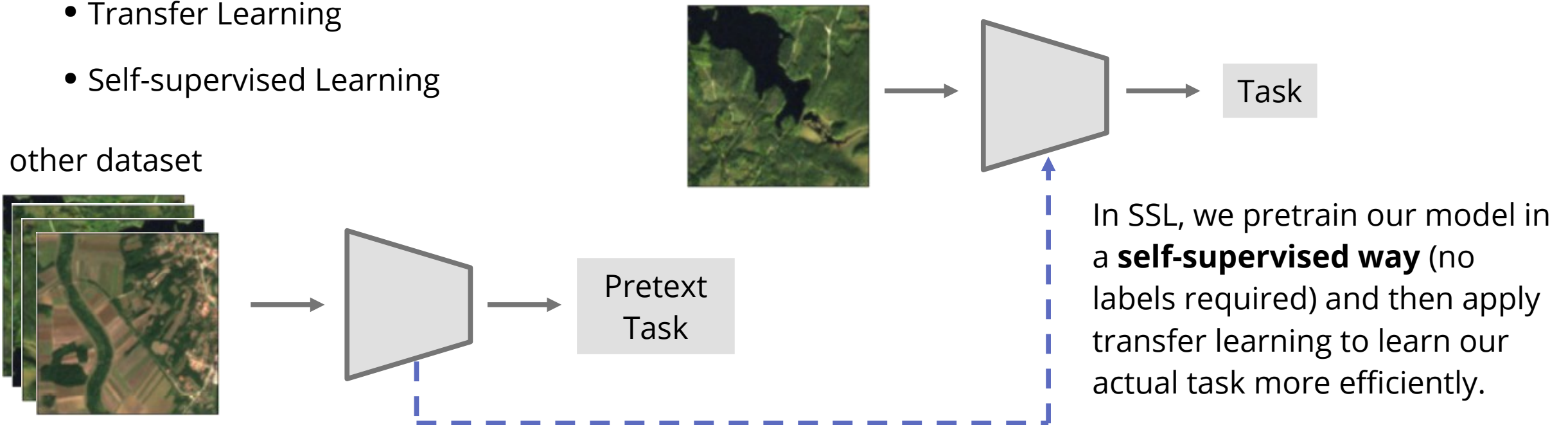
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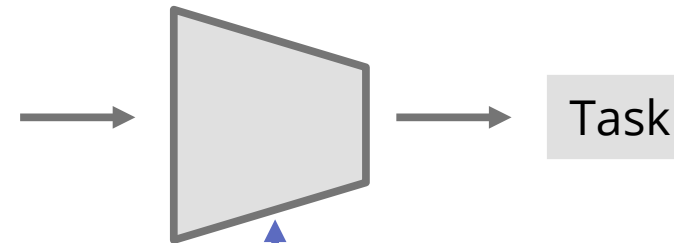
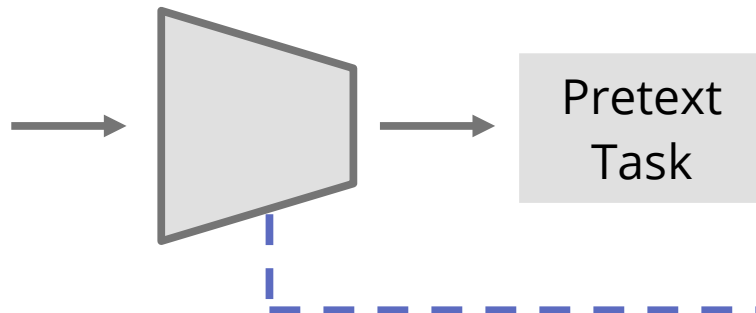


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Damian and Linus
will talk about this
later

other dataset



In SSL, we pretrain our model in a **self-supervised way** (no labels required) and then apply transfer learning to learn our actual task more efficiently.

Data-efficient Deep Learning for Earth Observation

Data Fusion

Michael Mommert



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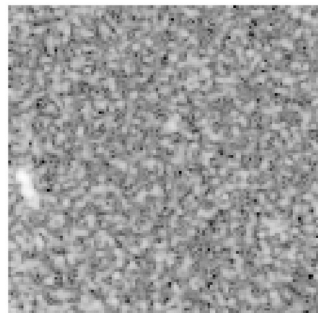
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(e.g., Sentinel-2,
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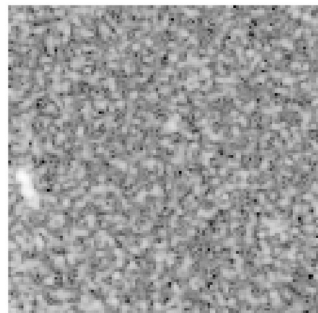
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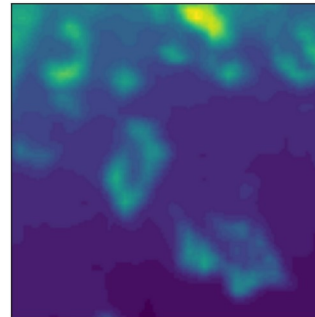
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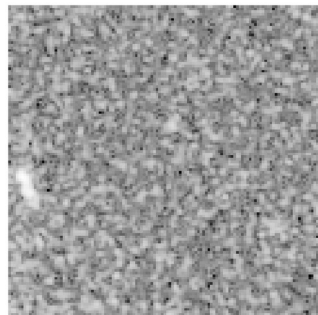
DEM
(e.g., Copernicus DEM)

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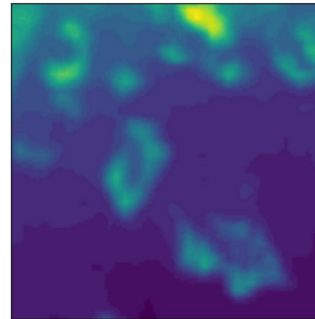
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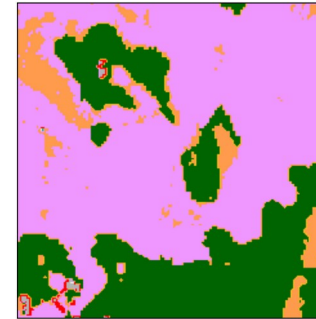
Multispectral
(e.g., Sentinel-2,
Landsat)



SAR
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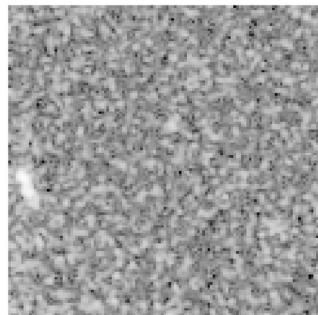
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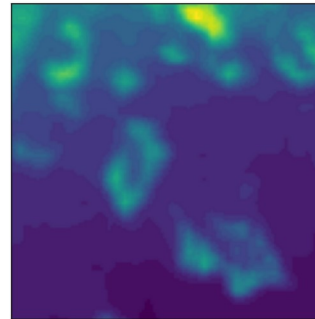
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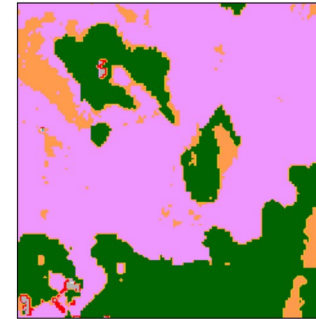
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Meta Data
(e.g., weather data,
observation
circumstances)

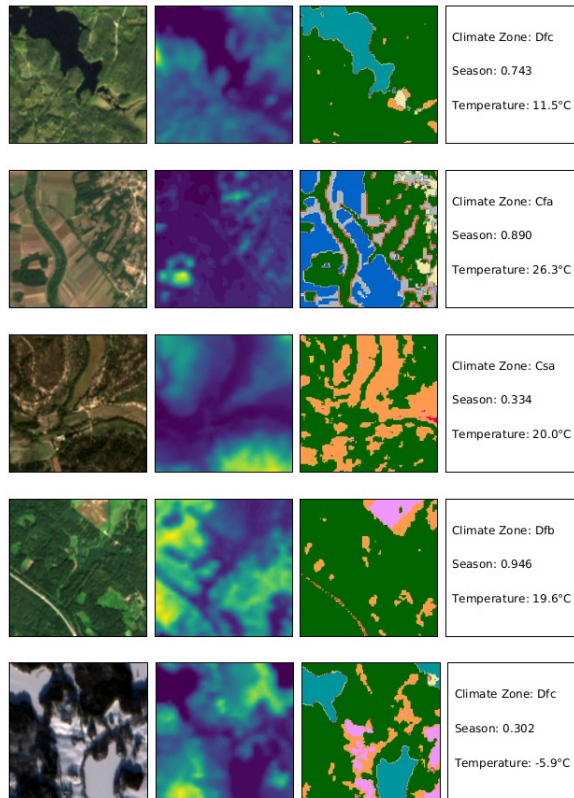
ben-ge: a truly multimodel dataset for EO

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To explore the use of multimodal for Data Fusion (and other methods), we will use a specifically designed dataset:

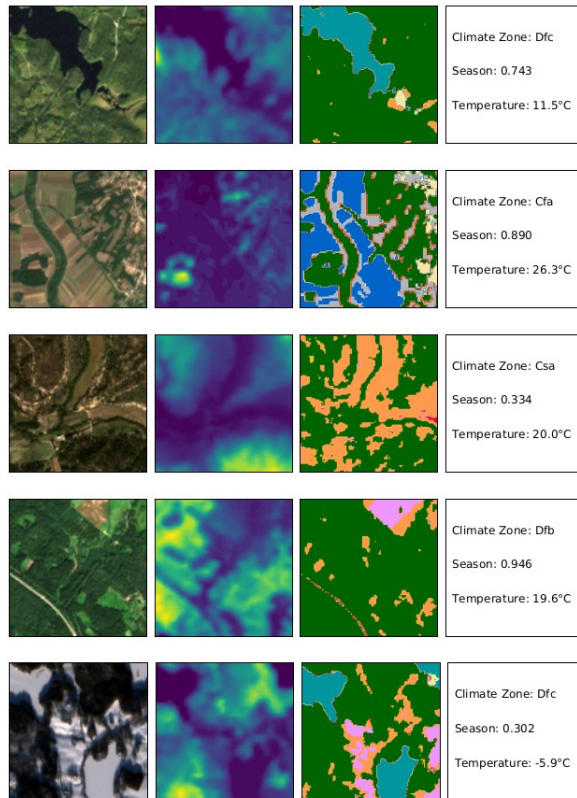
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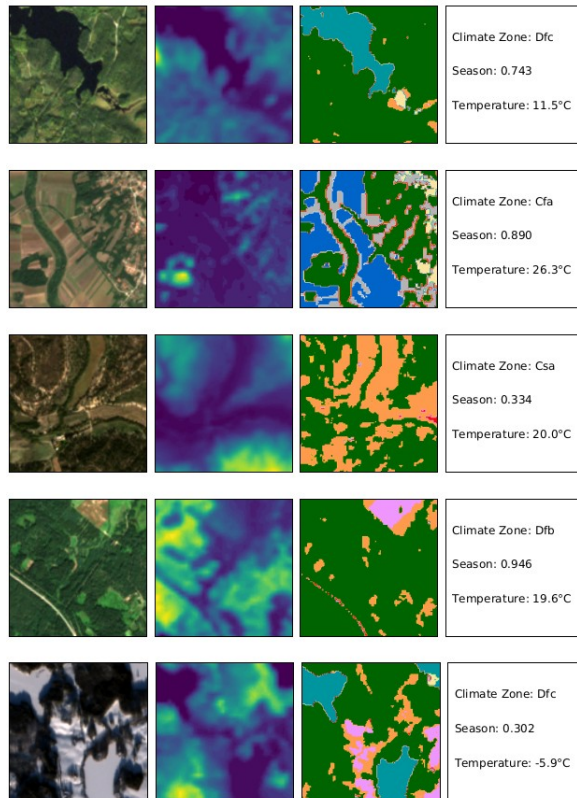
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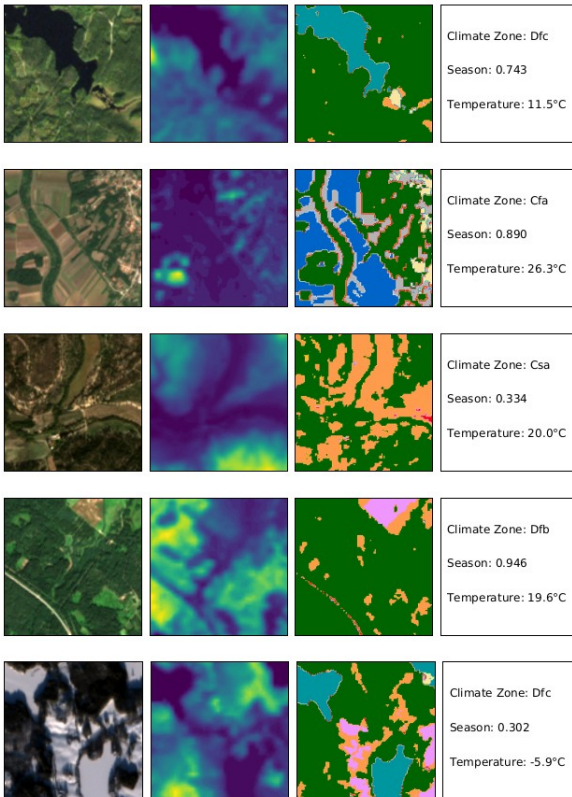


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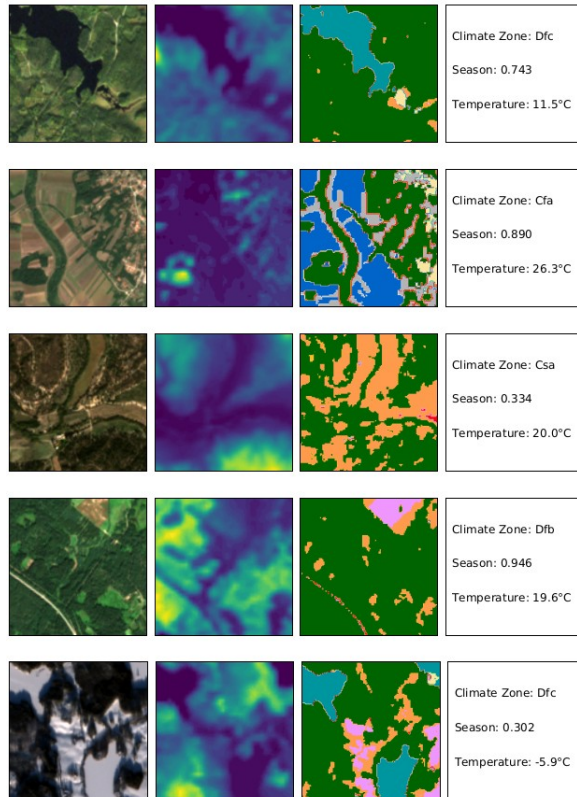
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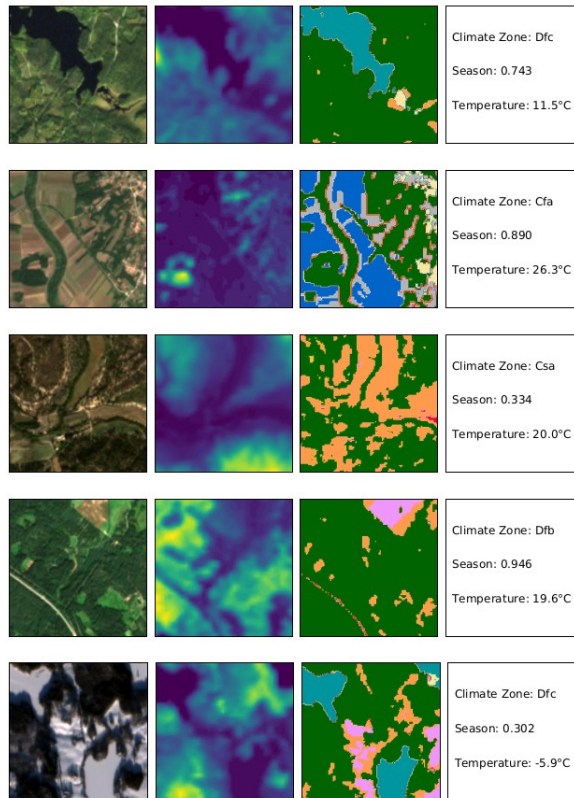
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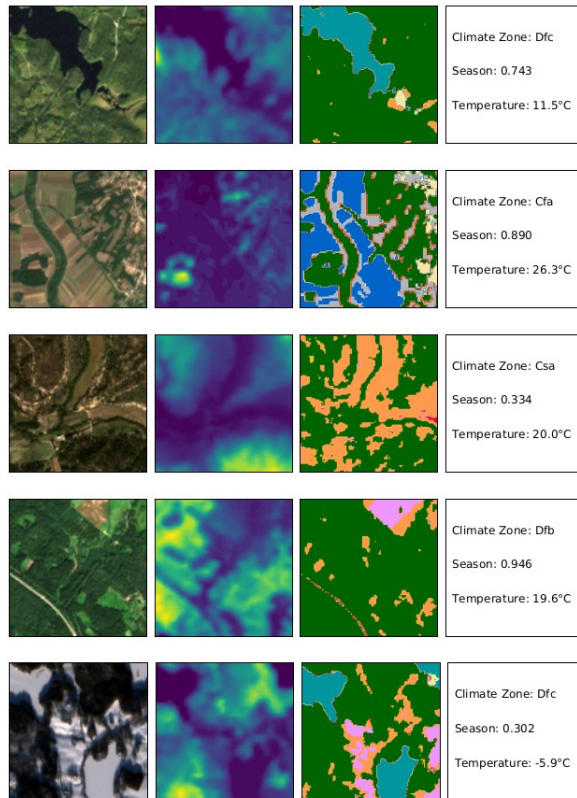
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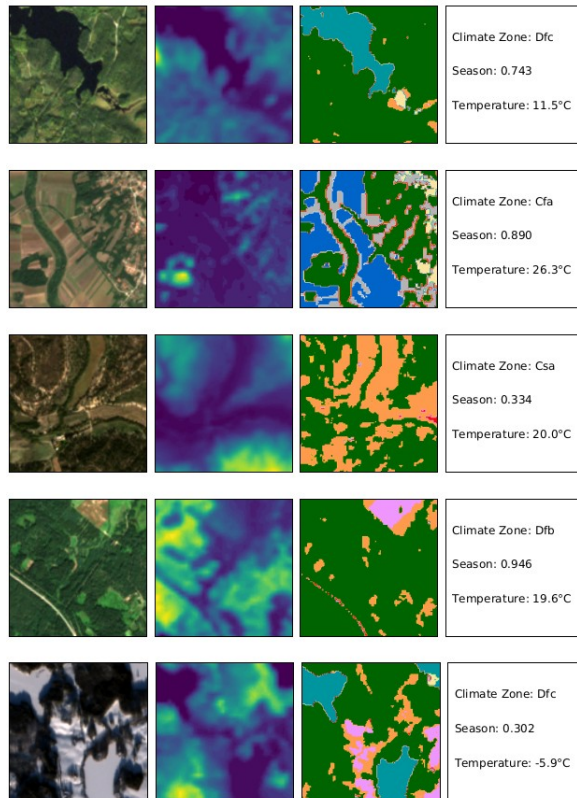
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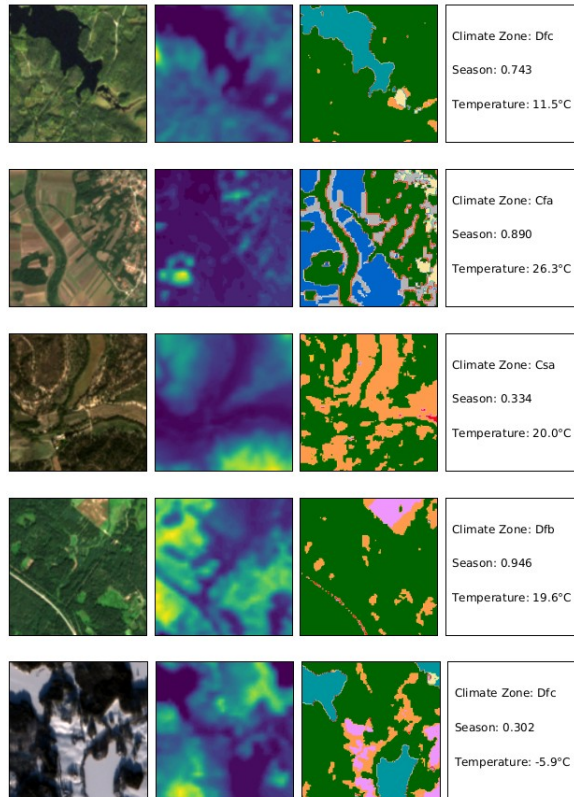
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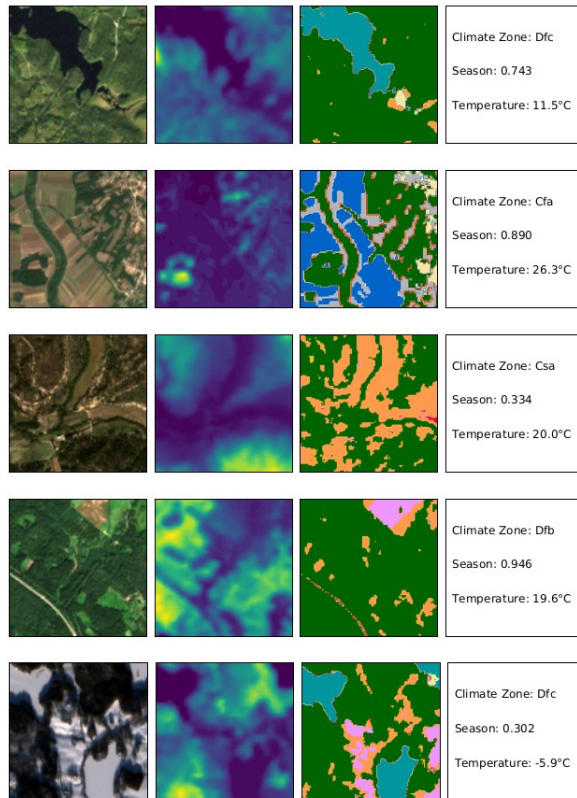
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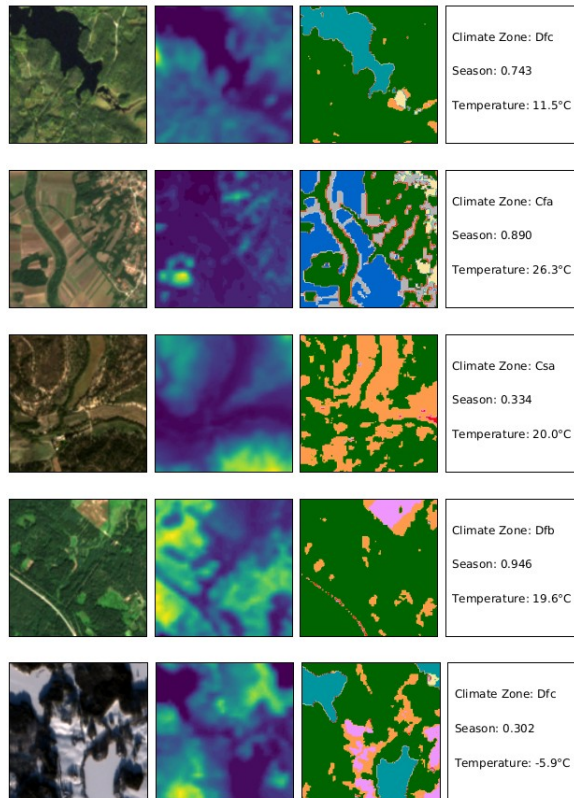
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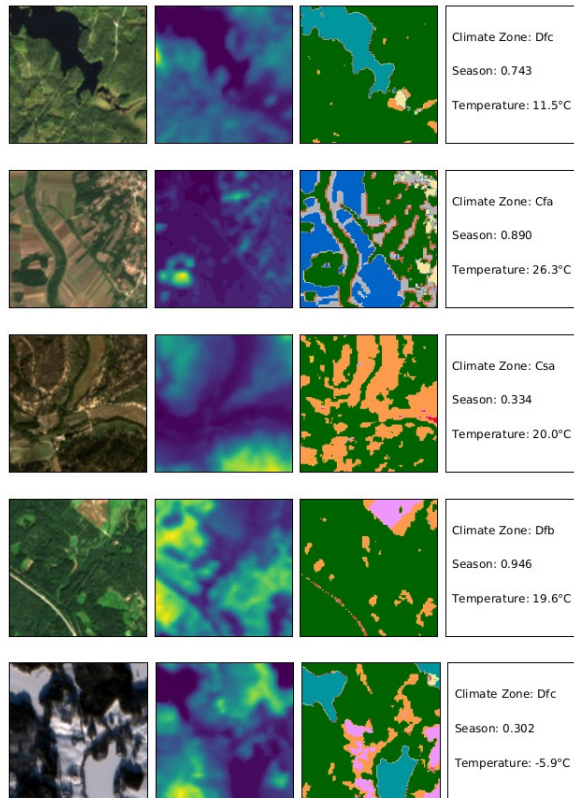
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Come and see our ben-ge presentation: WE2.R10.3, Wed, 10:39-10:51, Rm 101

ben-ge: a truly multimodel dataset for EO

What data modalities are available in ben-ge?

ben-ge: a truly multimodel dataset for EO

What data modalities are available in ben-ge?



Sentinel-2
Multispectral

12 bands
Level-2A

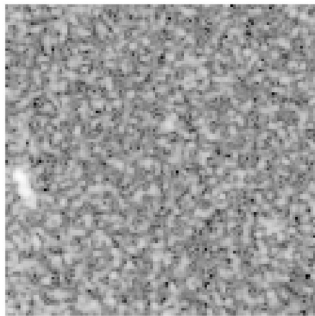
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Sentinel-1
SAR

2 bands

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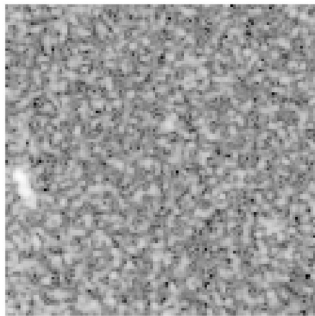
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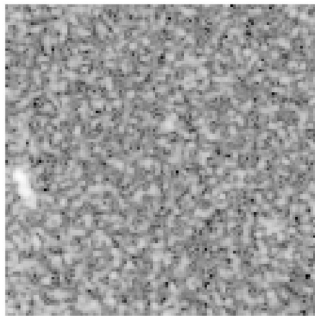
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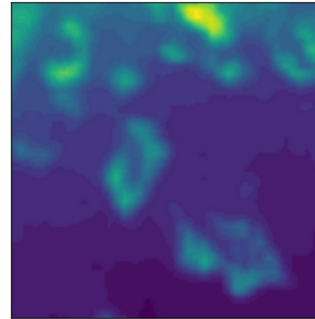
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Copernicus
DEM
(GLO-30,
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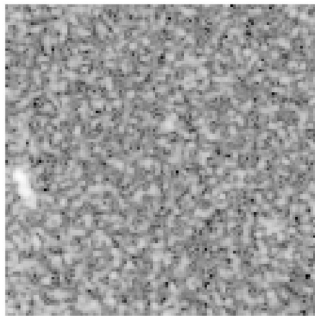
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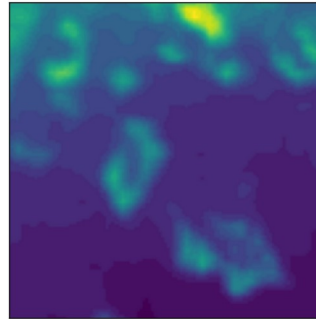
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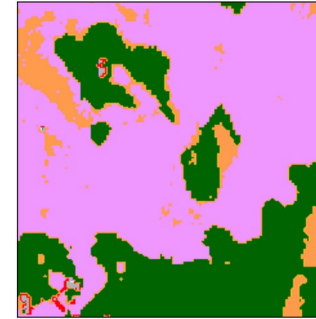


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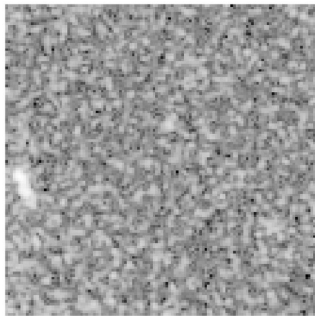
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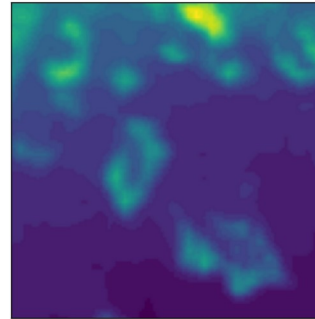
Sentinel-2
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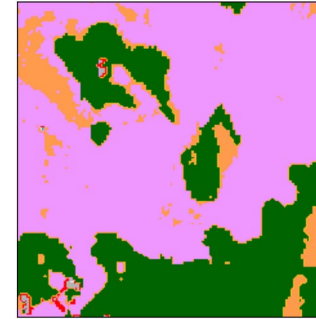


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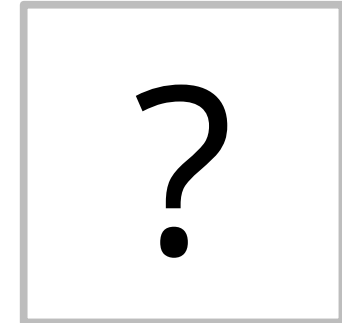


Copernicus
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Meta Data

ERA-5 weather
Climate zones
Seasonality

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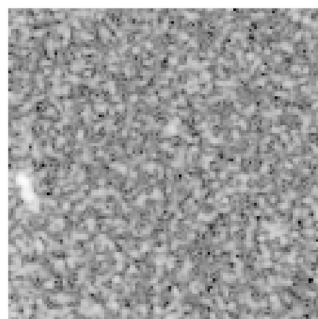
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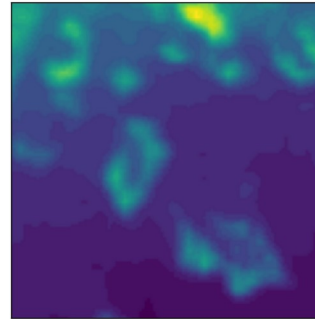
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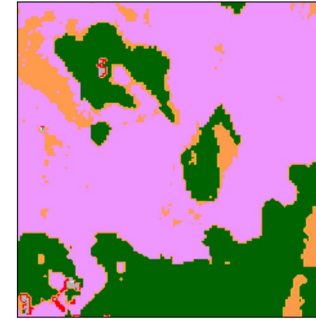


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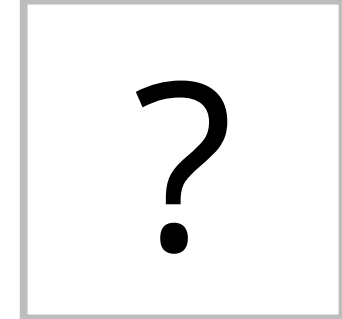


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10m resolution

Data Fusion for Deep Learning

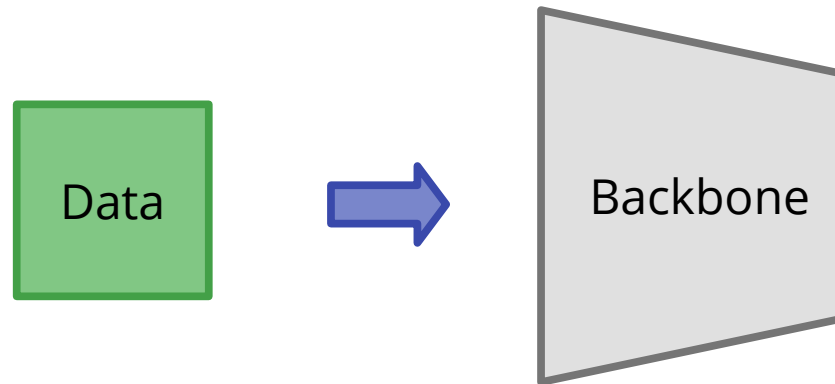
How can we leverage Data Fusion in Deep Learning?

Default supervised learning setup



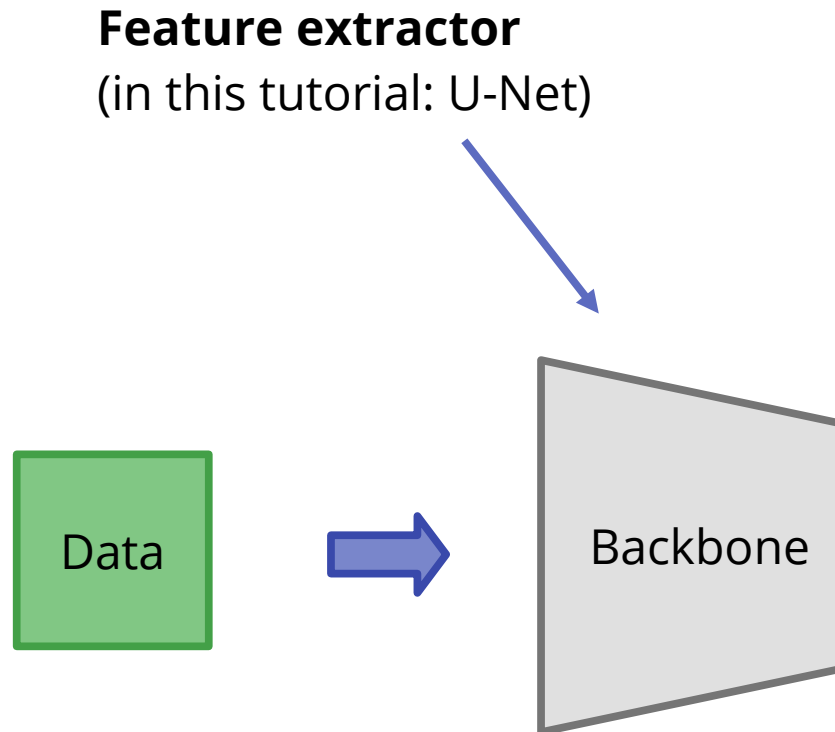
“Default supervised learning setup”

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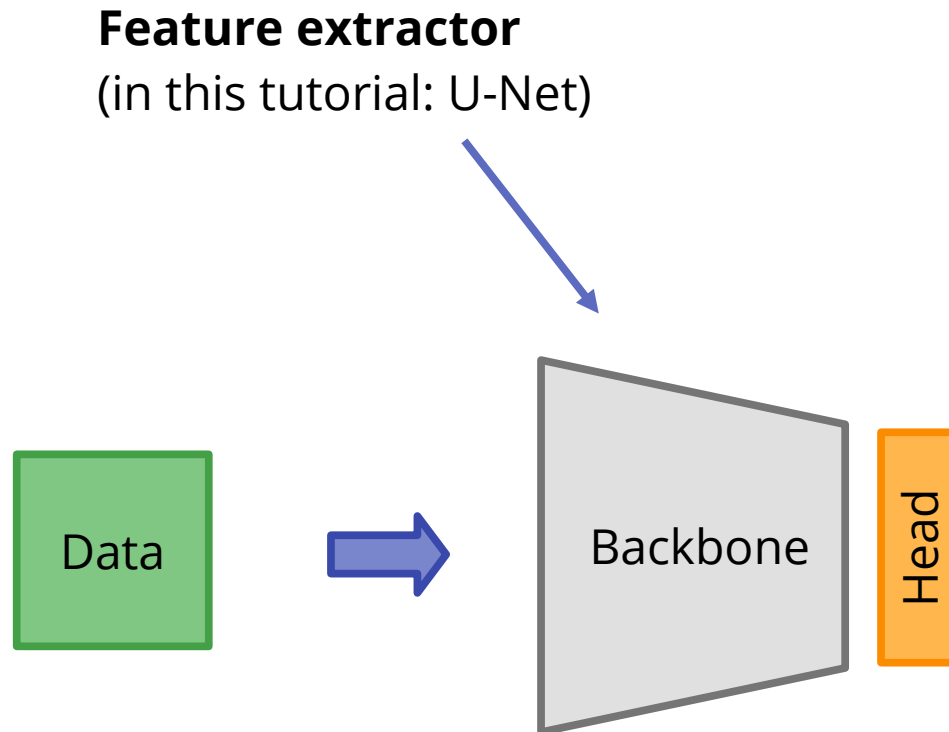
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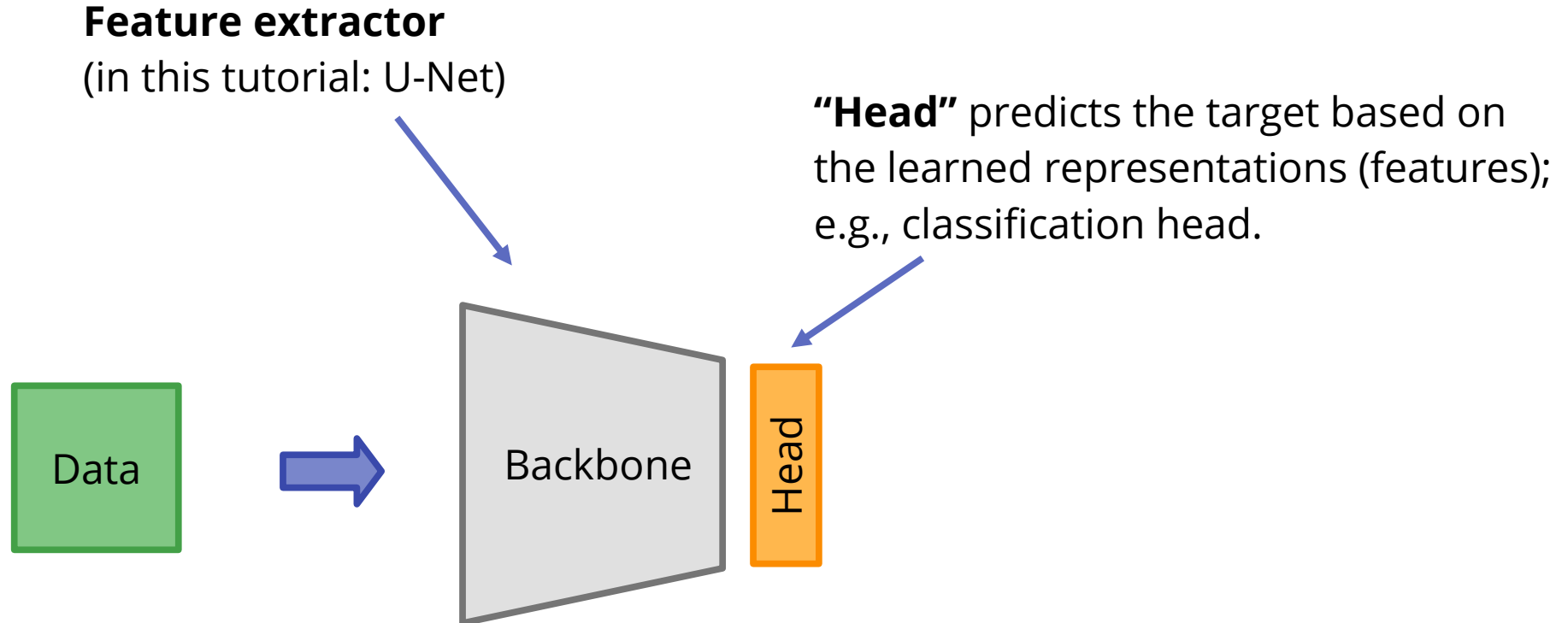
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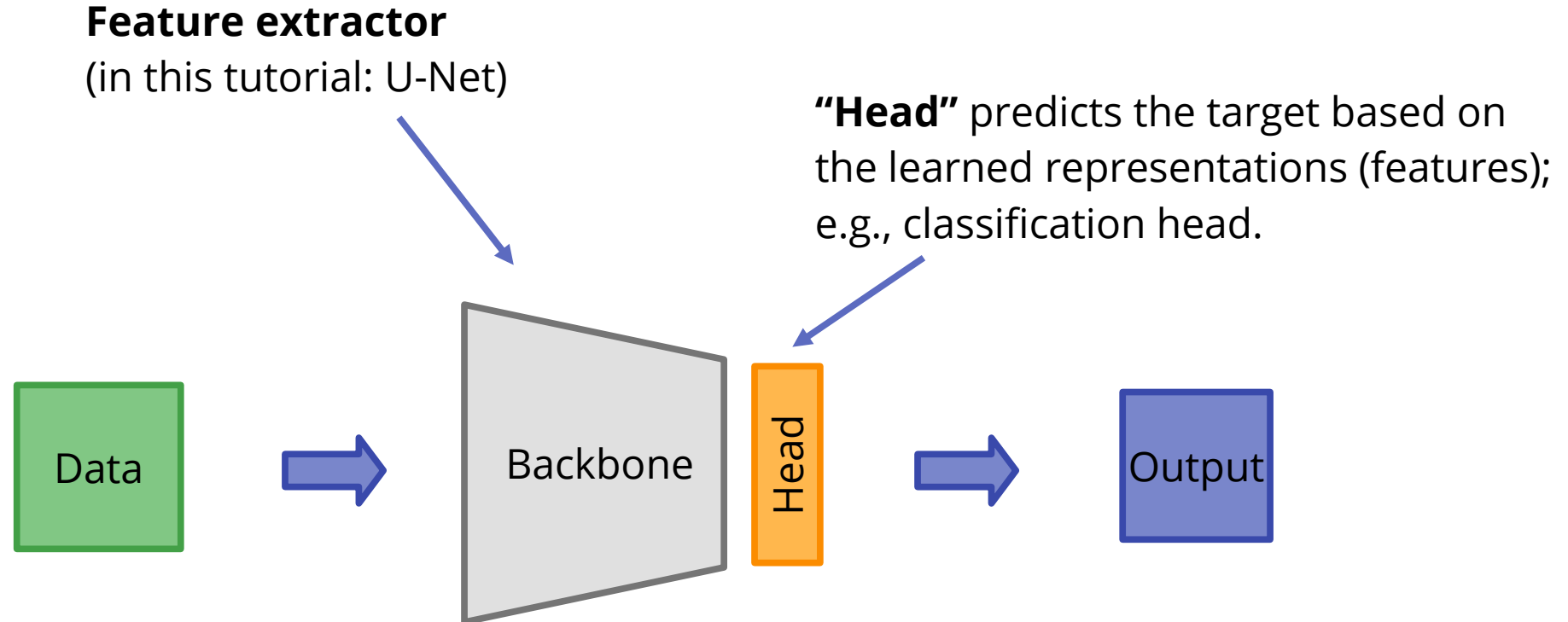
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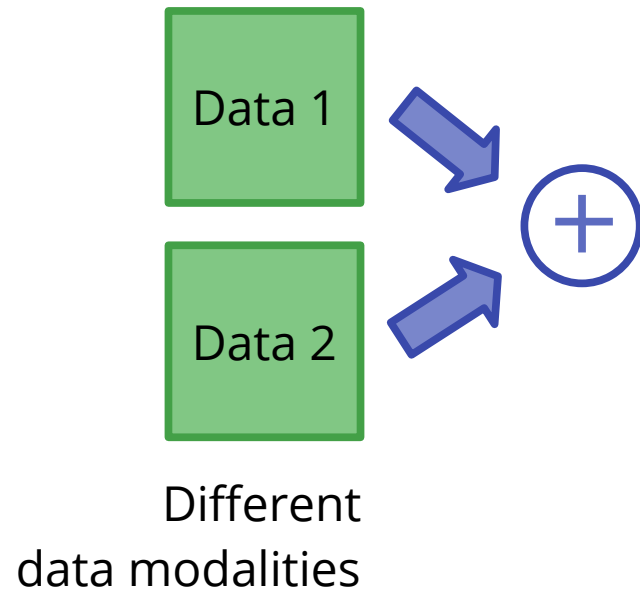
Data 1

Data 2

Different
data modalities

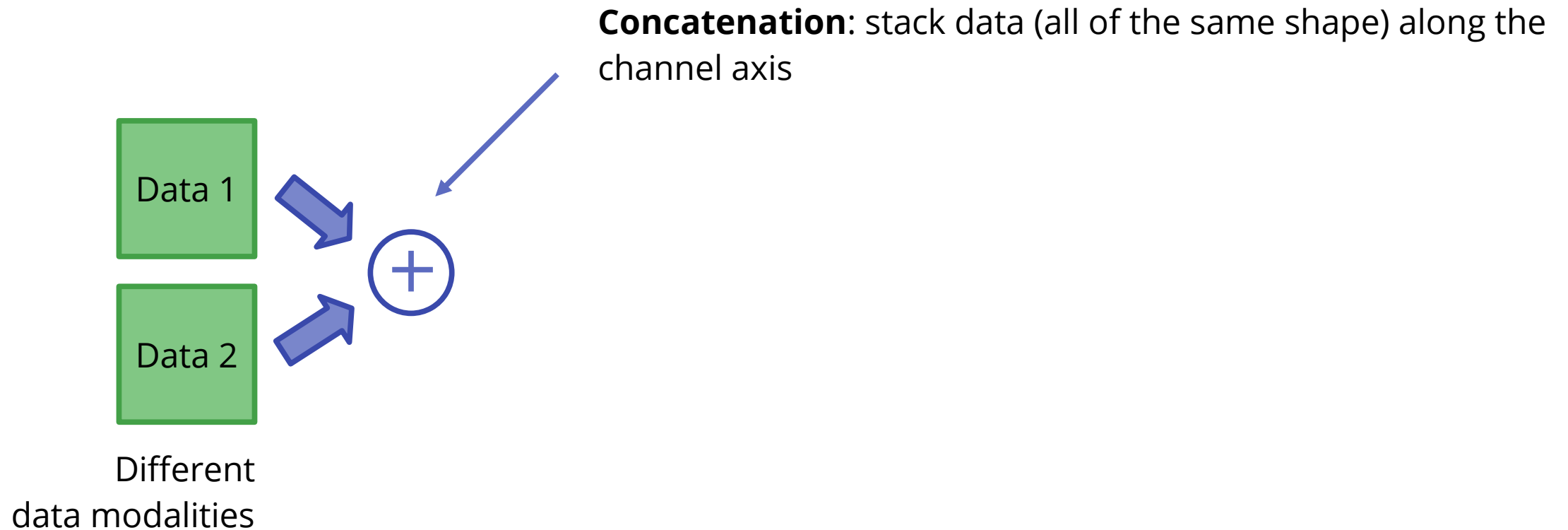
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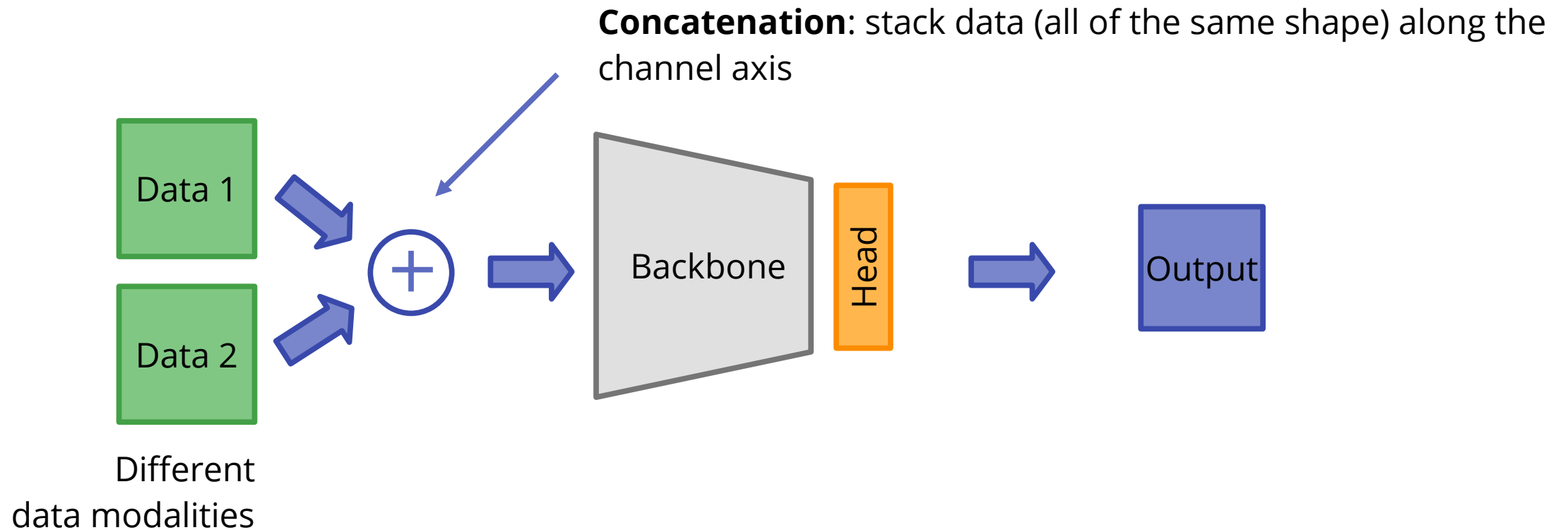
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Early Fusion: Different Data Shapes

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Early Fusion is simple if the data modalities to be combined have the same shape (e.g., map-like features with the same extent).

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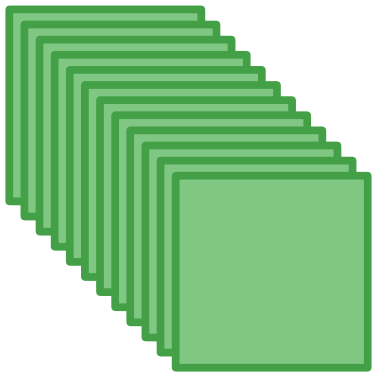
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But: how to combine Sentinel-2 data (12 channels x 120 px x 120 px) with patch-global seasonality (scalar value in the range [0, 1]) data?

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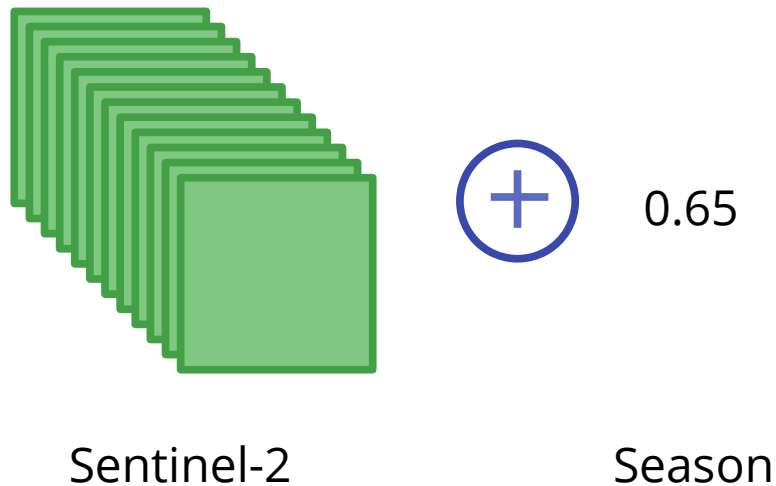


Sentinel-2

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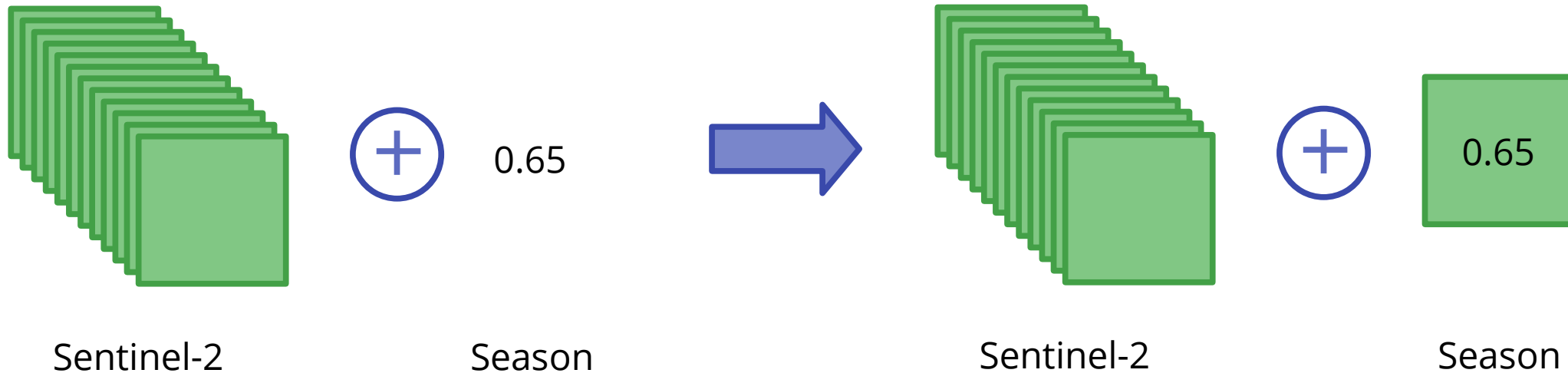
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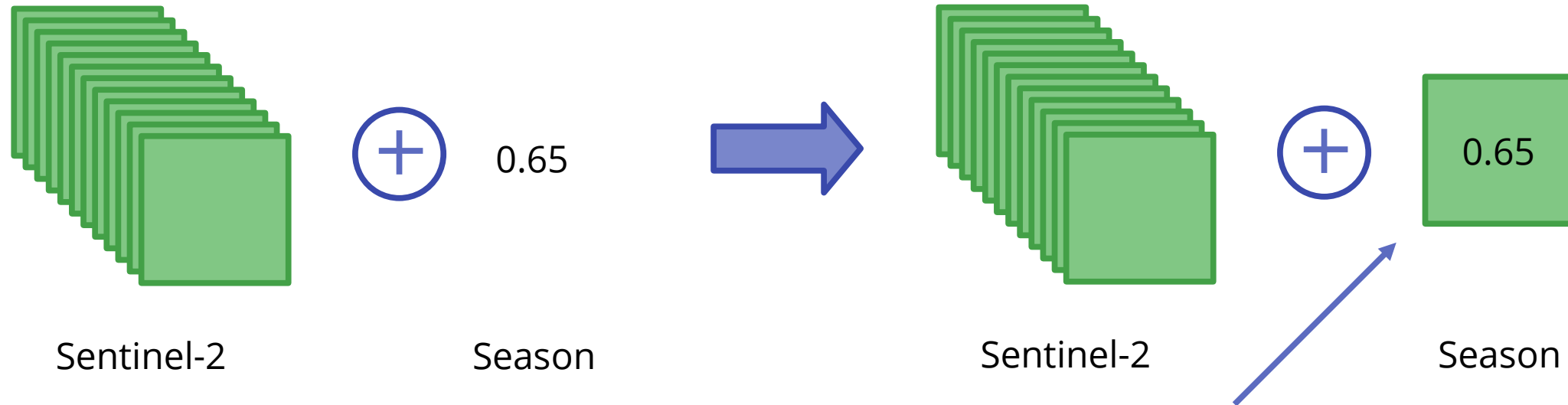
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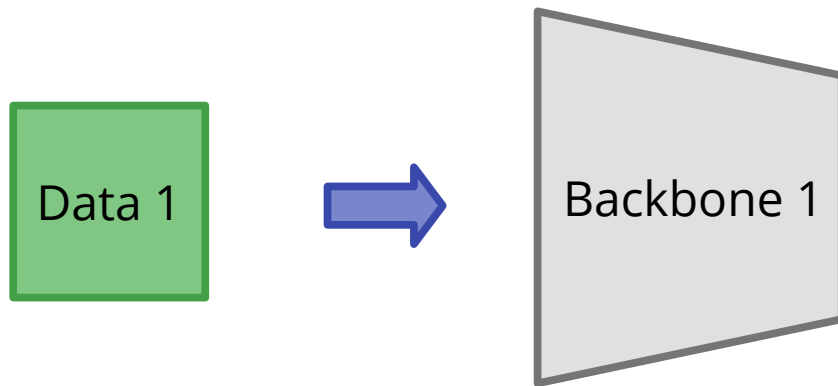
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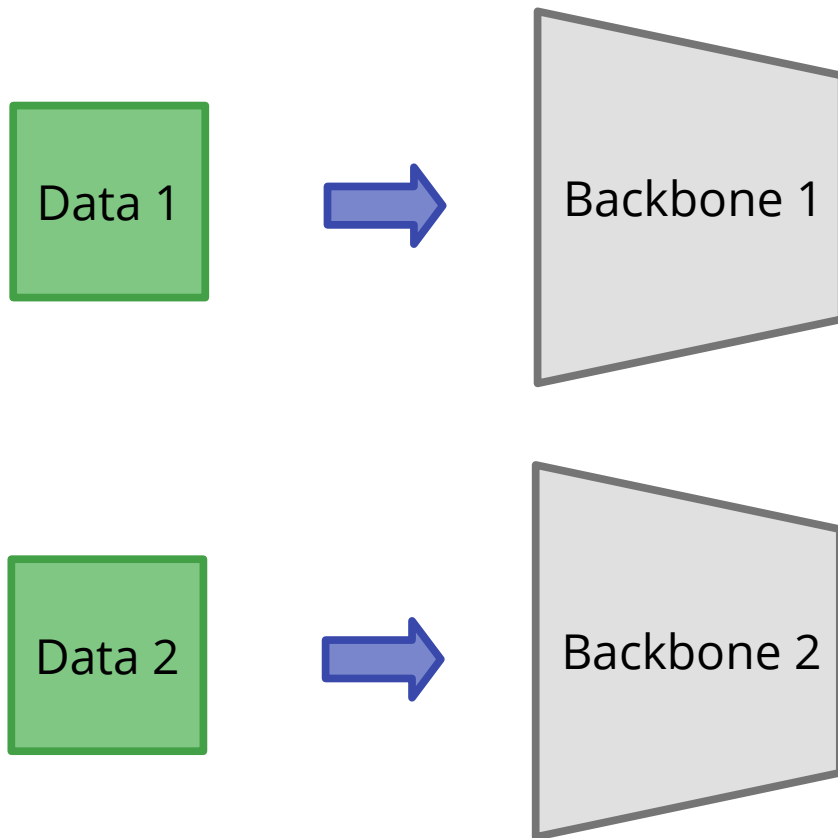
Blow-up patch: same height and width as Sentinel-2; each “pixel” equals the global value (0.65)

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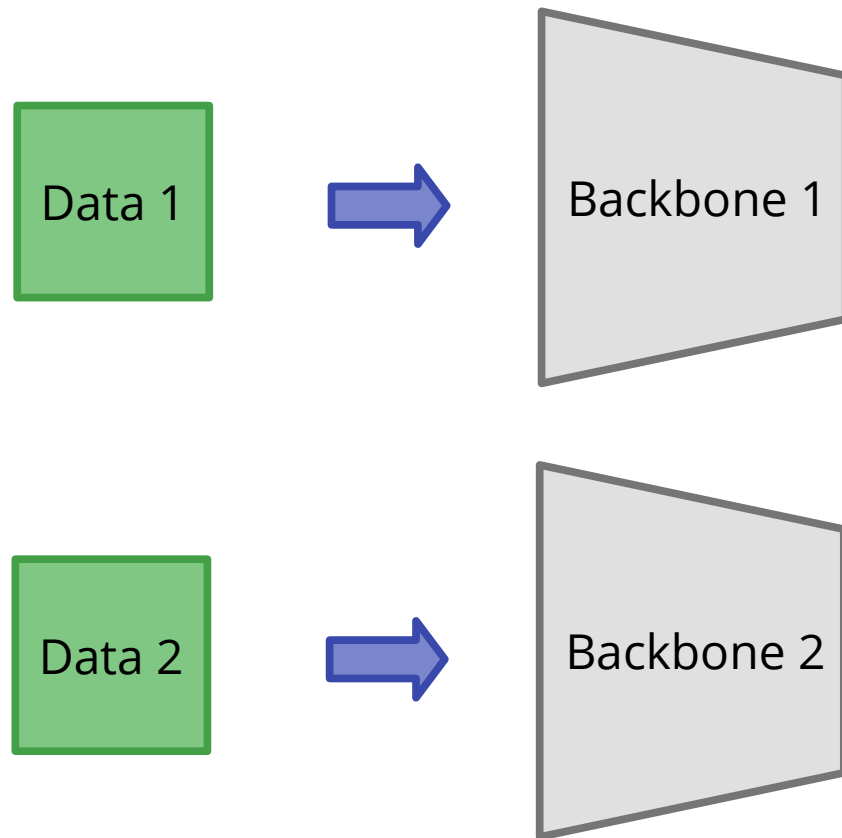


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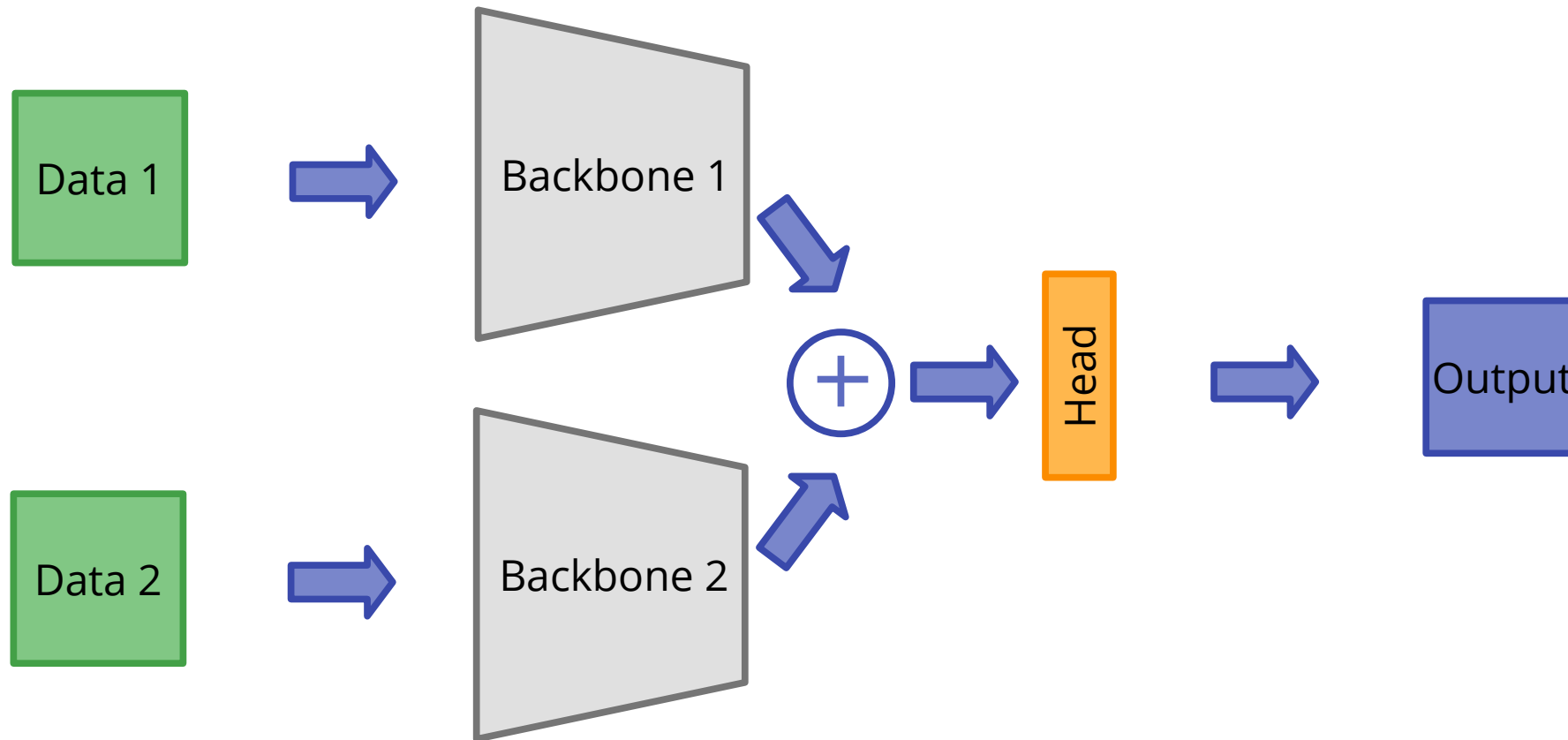
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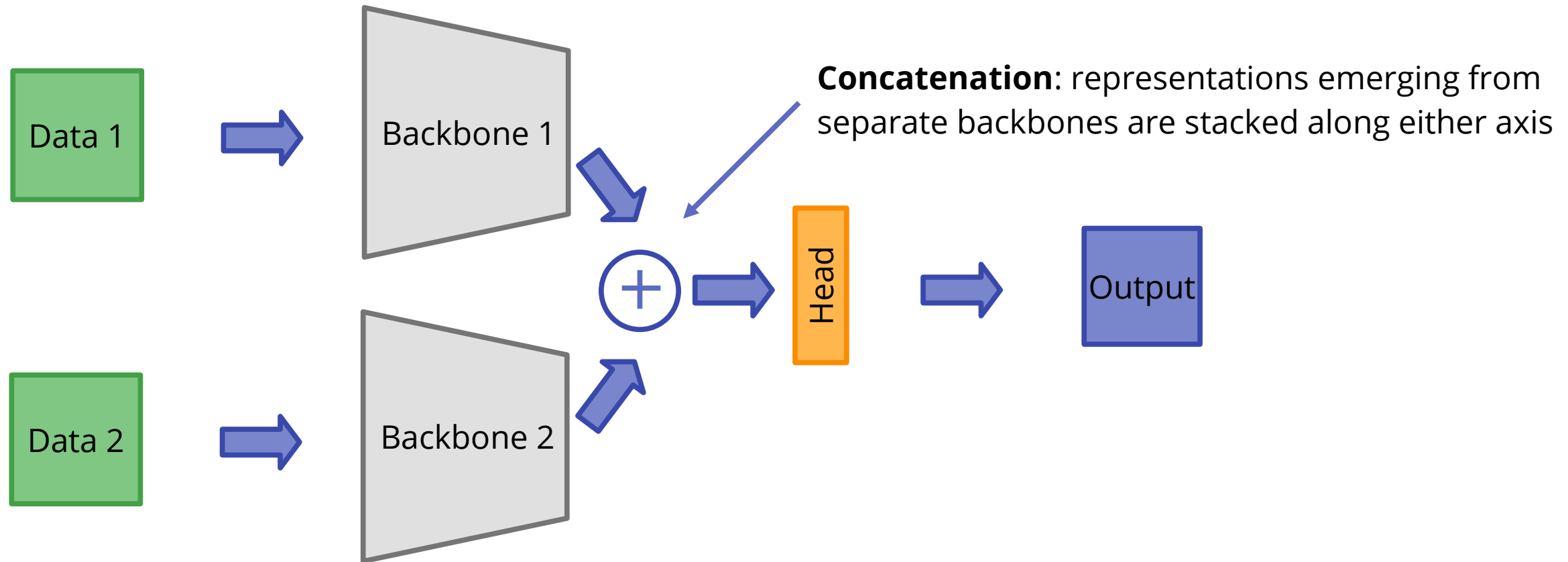
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Let's get our hands dirty

We will now implement a few Data Fusion methods in our [first Notebook](#).

Specifically, we will implement the following:

- Supervised baseline model (Sentinel-2)
- Early Fusion (Sentinel1 and Sentinel-2)
- Early Fusion with blow-up patches (Sentinel-1, Sentinel-2 and Season)
- Late Fusion (Sentinel-1 and Sentinel-2)