



OpenSense

Deltares



FINNISH METEOROLOGICAL INSTITUTE



# OpenSense Training School

## *OS-based nowcasting with pysteps*

Introduction to the nowcasting training session

Training instructors:

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# Outline

- When and why to use nowcasting
- Introduction to nowcasting with pysteps
- Nowcasting with OS data
- Setup of this training session

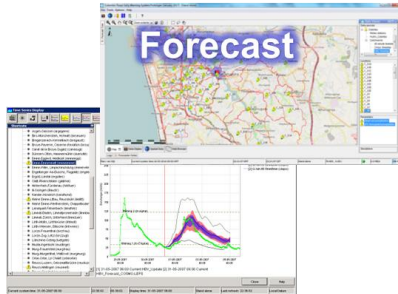
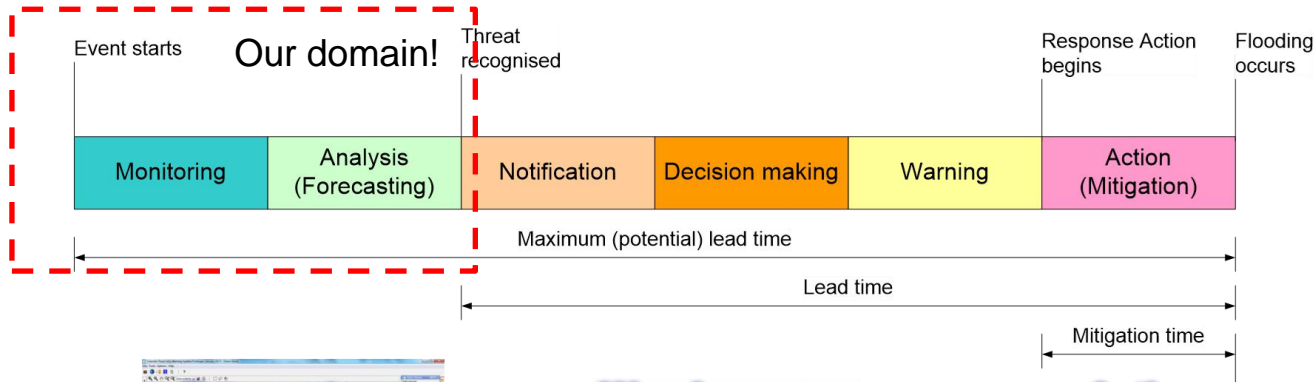
**Goal of this training session:** To give a “hands-on” experience of using pysteps with conventional radar and OS data

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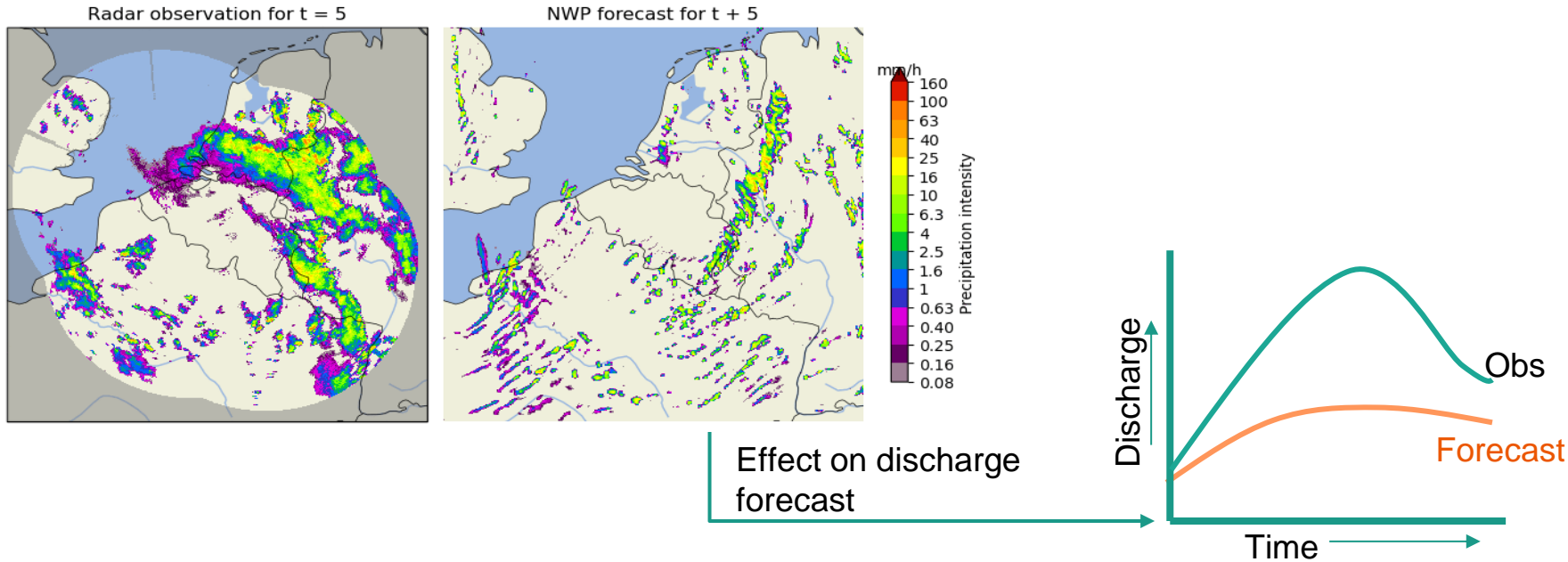
# When and why to use nowcasting



# Forecasts, warning and action



# For short lead times Numerical Weather Prediction models are generally not sufficient

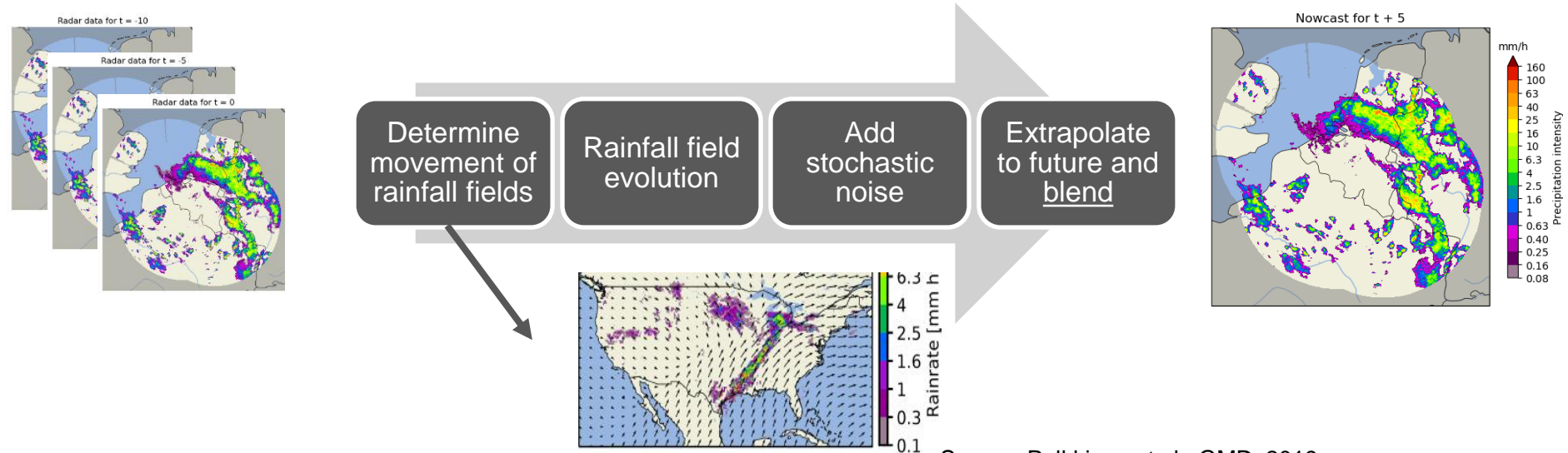


# Nowcasting as a fast alternative for the short lead times

Statistical extrapolation

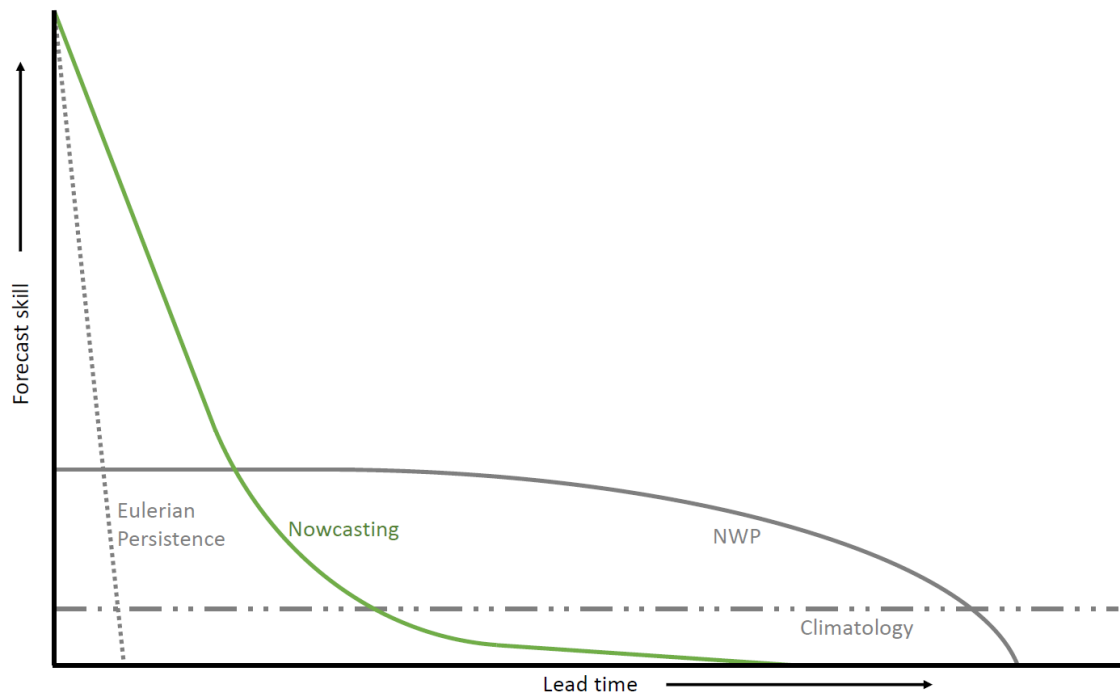
Fast!

But no physics involved..



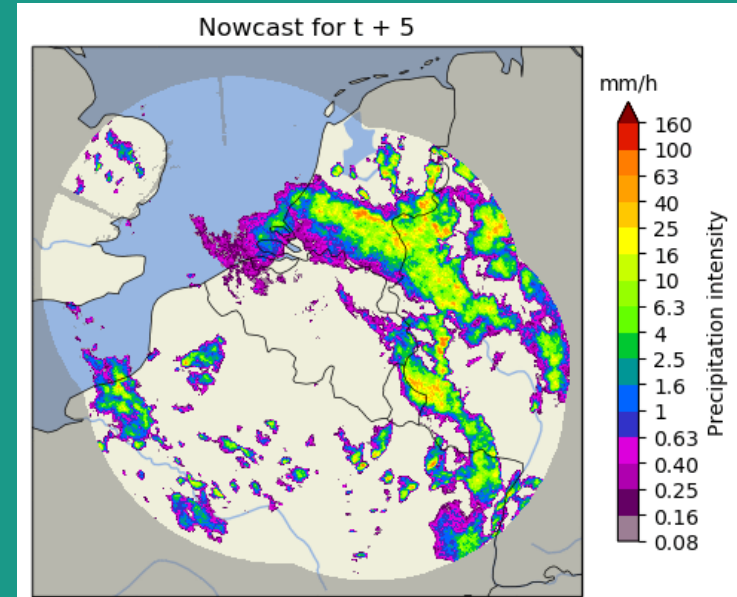
Source: Pulkkinen et al., GMD, 2019

# The skill of nowcasting



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# Introduction to nowcasting with pysteps

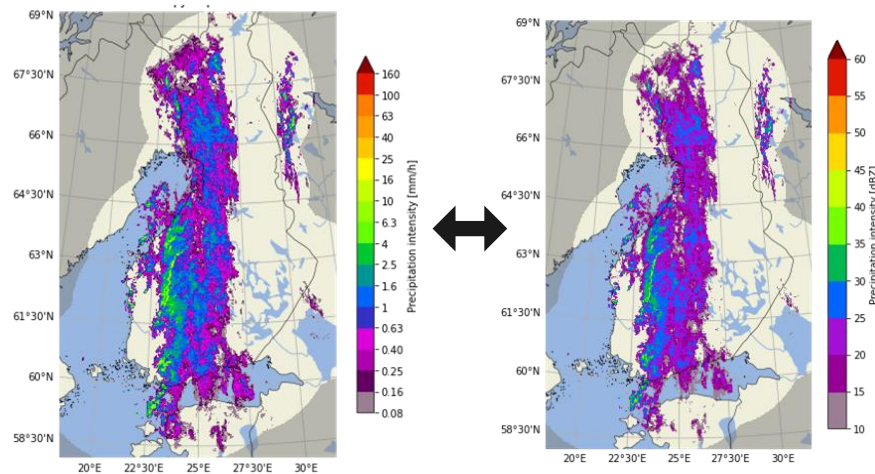




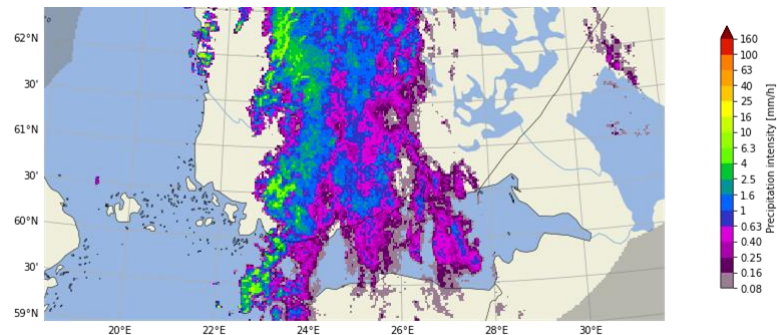
## Input data

- pysteps uses gridded data as the main input data source
  - Often this consists of radar rainfall data.
- Reading input data from various sources has been implemented in the **io.importers** module
- To implement your own importers, you can use cookiecutter:  
[https://pysteps.readthedocs.io/en/stable/developer\\_guide/importer\\_plugins.html](https://pysteps.readthedocs.io/en/stable/developer_guide/importer_plugins.html) or simply wrap it in an xarray reader.
- The **utils** module contains different methods for converting, transforming, clipping and upsampling the input data
  - Helps you, but also the motion fields and noise generation in pysteps!

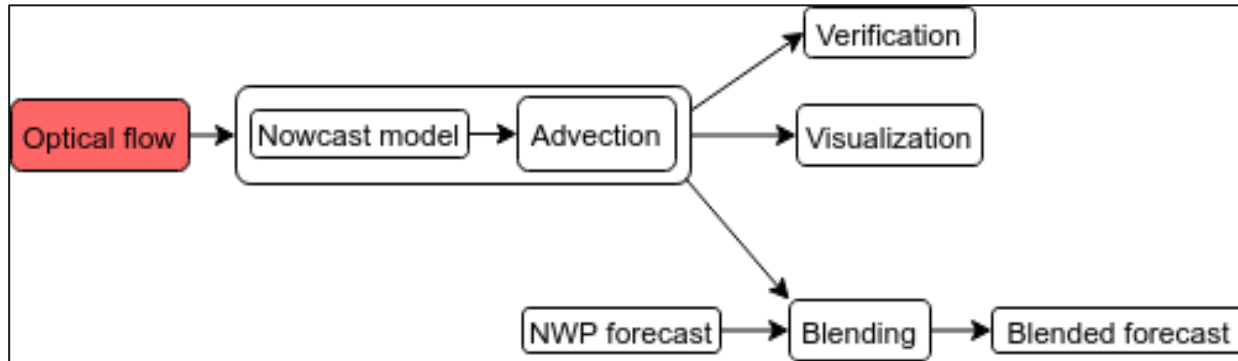
## Transformations and conversions between units

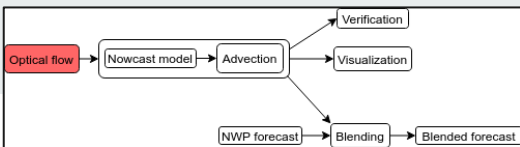


## Clipping



## A typical workflow when using pysteps

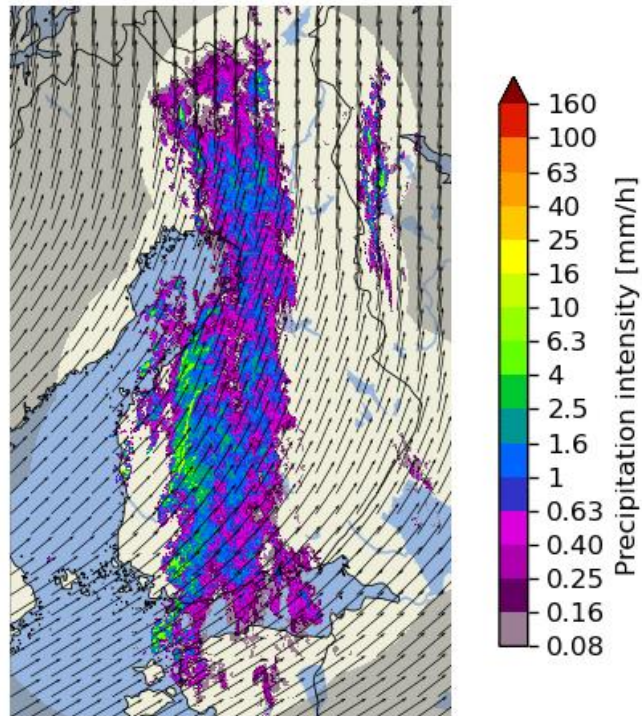


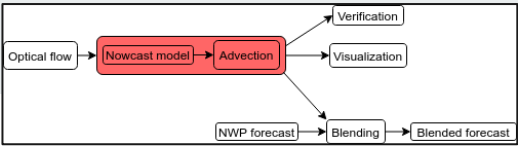


## Optical Flow and Extrapolation

- Advection (optical flow & extrapolation) is the key component of all pysteps nowcasting methods
- All methods are based on the “Lagrangian persistence” nowcast shown on the right
- Three different types of optical flow methods have been implemented in the **motion** module:
  - feature tracking: Lucas-Kanade
  - variational: VET and Proesmans
  - spectral: DARTS
- For advection, pysteps implements the backward semi-Lagrangian scheme in the **extrapolation** module

2016-09-28 15:50:00 + 5 min

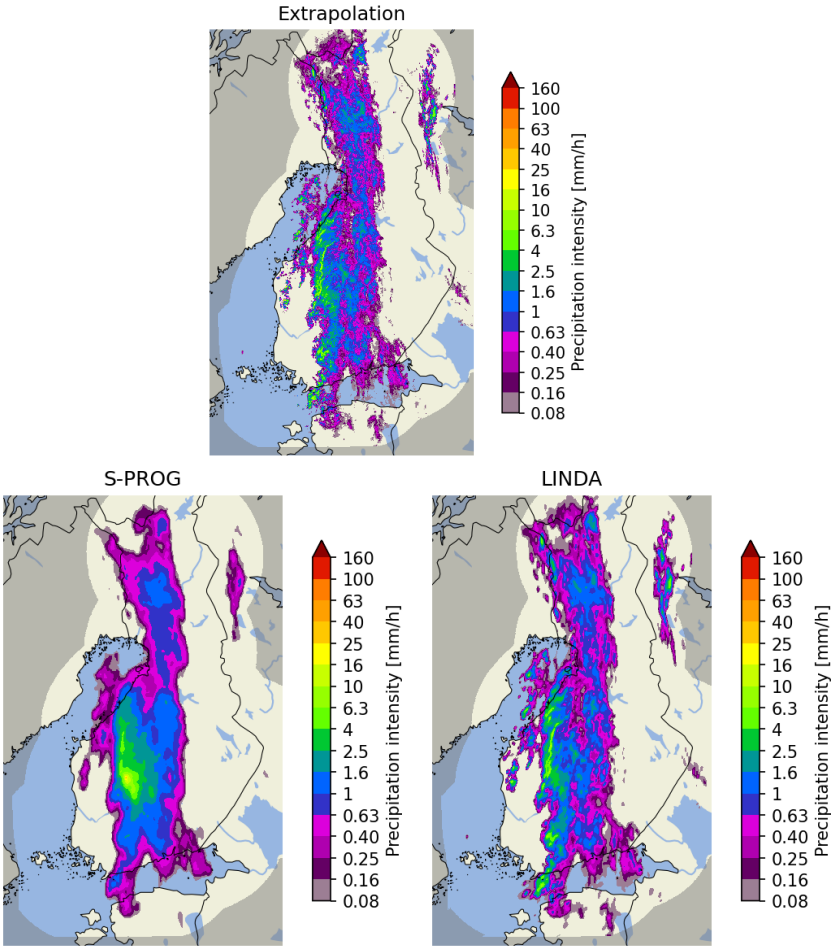




# Deterministic Nowcasts

The main methods implemented in the **nowcasts** module:

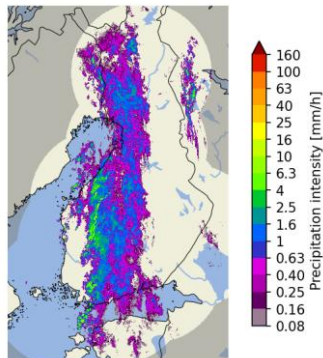
Method	Pros	Cons	Typical computation time
<b>Extrapolation</b>	very fast	no prediction of growth or decay of precipitation	< 10 seconds
<b>S-PROG</b>	<ul style="list-style-type: none"> <li>for low-intensity precipitation (&lt; 1-2 mm/h) has generally the best skill</li> <li>choose for stratiform events</li> </ul>	inability to preserve the spatial structure of rainfall fields, and particularly convective cells	< 20 seconds
<b>LINDA-D</b>	<ul style="list-style-type: none"> <li>the most accurate method for intense precipitation (&gt; 1-2 mm/h)</li> <li>choose for convective events</li> </ul>	slow to compute	might take several minutes



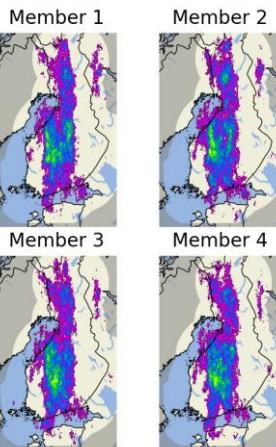
## Ensemble Nowcasts

- The main ensemble methods implemented in the **nowcasts** module are STEPS and LINDA-P
- They model two sources of uncertainty: advection field estimation and Lagrangian growth and decay
- The basic rule for choosing the method:
  - stratiform events: STEPS
  - convective events: LINDA-P
- LINDA-P generally produces more realistic ensemble members
- Computation times for the 4-member ensembles shown on the right:
  - STEPS: ~20 seconds
  - LINDA-P: ~5 minutes

Observations at 2016-09-28 15:50 UTC

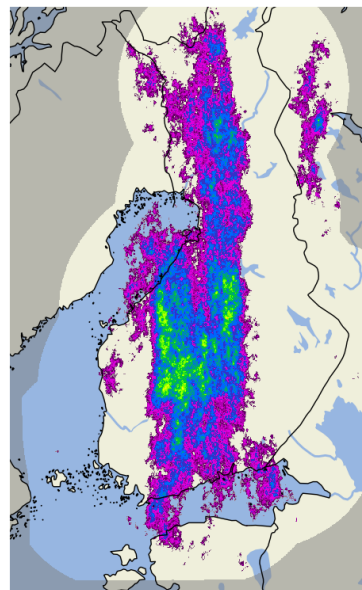


Nowcast ensemble

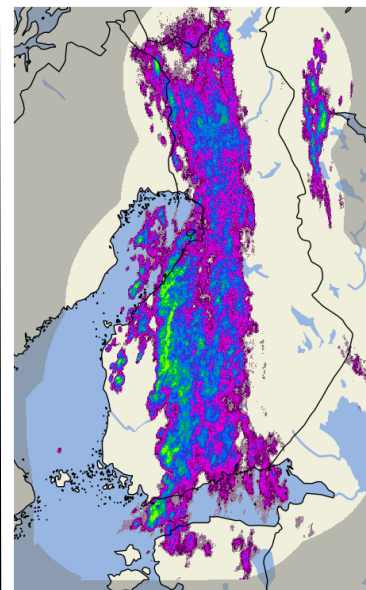


First ensemble members

STEPS

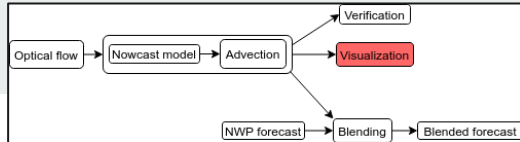


LINDA-P





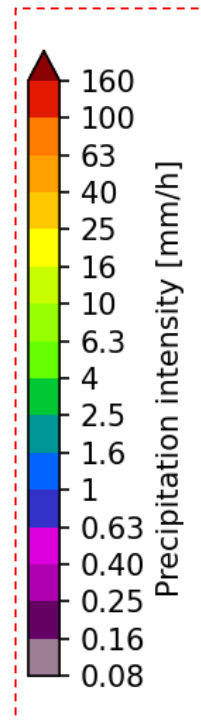
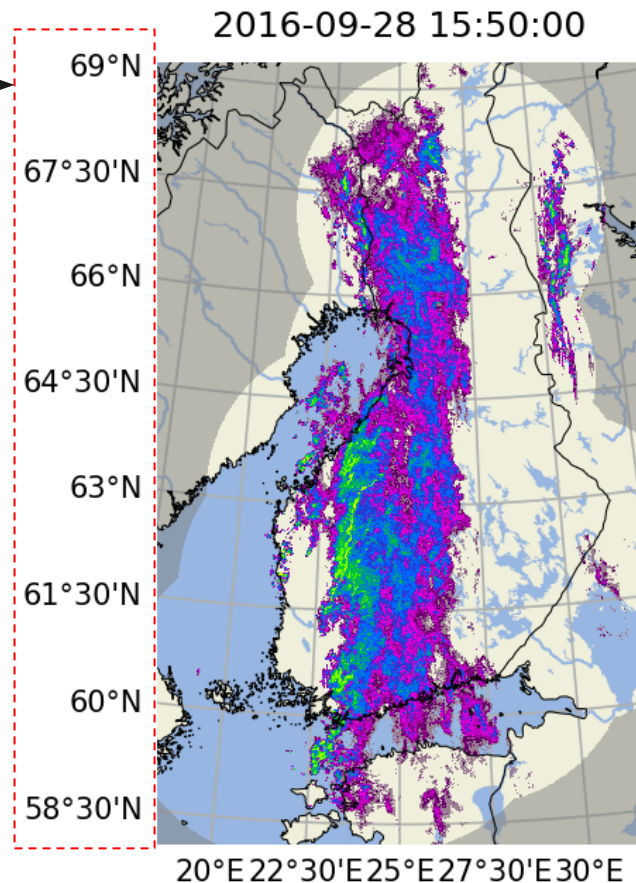
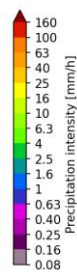
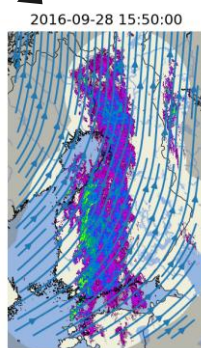
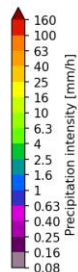
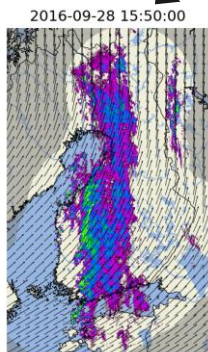
Colorbars with several pre-configured scales and for different data units

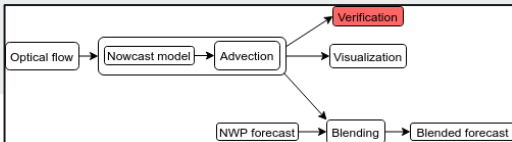


Longitude-latitude lines with labels

## Visualization tools

- Extensive set of visualization tools has been implemented in the **visualization** module
- Support for multiple layers: basemap, precipitation and motion field:
  - plotting of basemaps by using cartopy
  - quivers and streamlines for advection fields





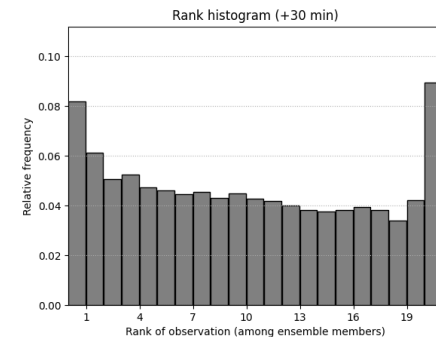
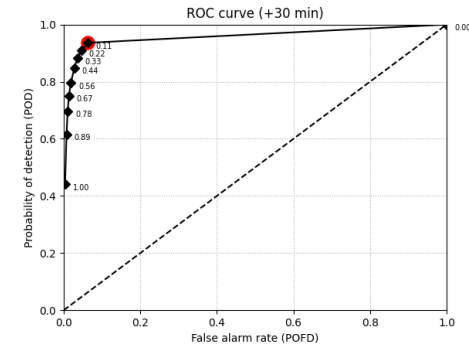
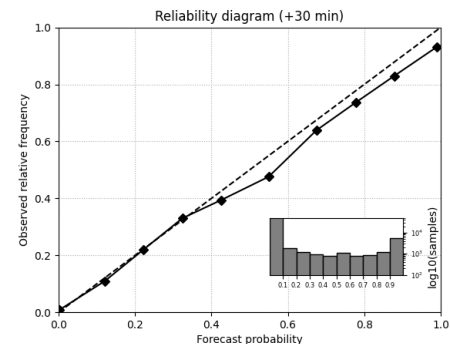
## Verification tools & metrics

- A large number of verification utilities and metrics have been implemented in the **verification** module
- Functionality
  - creation of verification objects and aggregation from multiple nowcasts
  - plotting of verification results

### Metrics

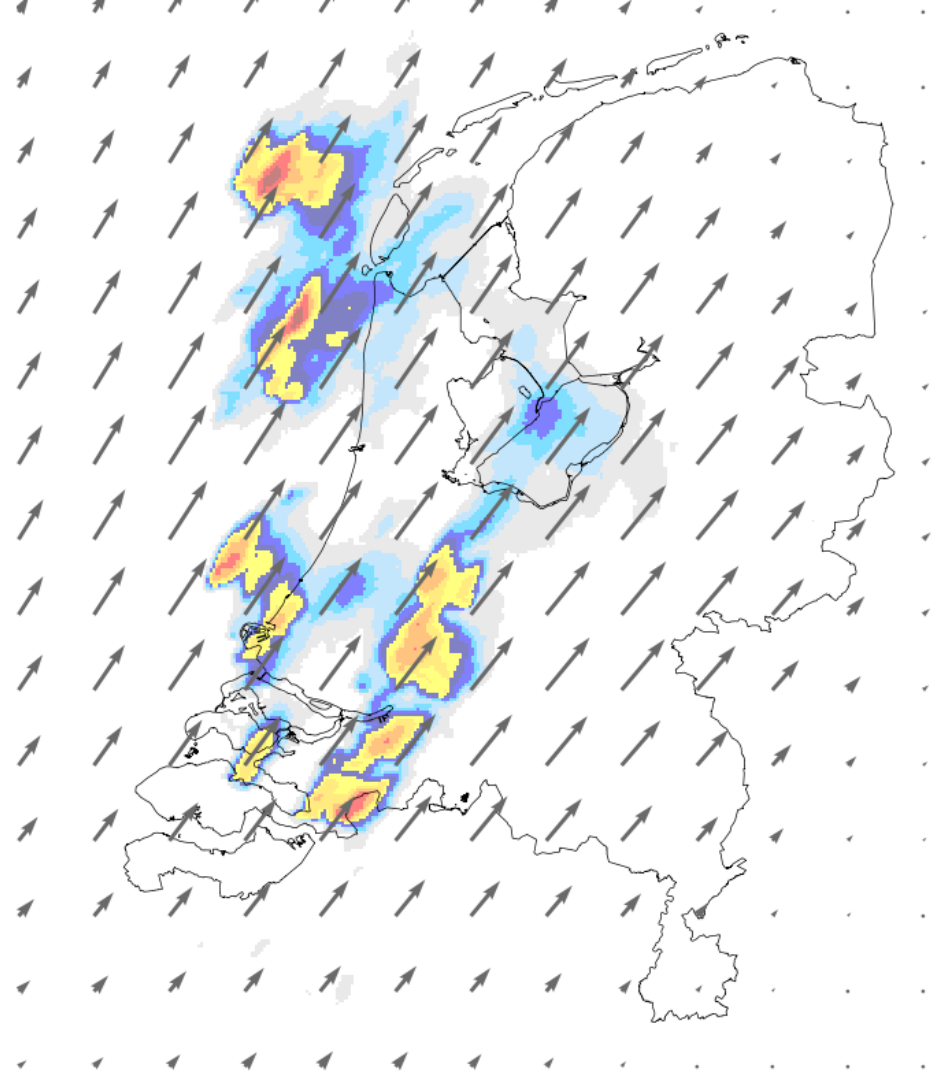
- Deterministic
  - categorical: CSI, ETS, POD, FAR
  - continuous: MAE, ME
  - scale/intensity-based metrics: FSS, intensity-scale
  - radially averaged power spectral density (RAPSD)
- Probabilistic
  - CRPS
  - reliability diagram
- Ensemble
  - spread
  - rank histogram

Examples of verification plots for 30-minute STEPS nowcasts



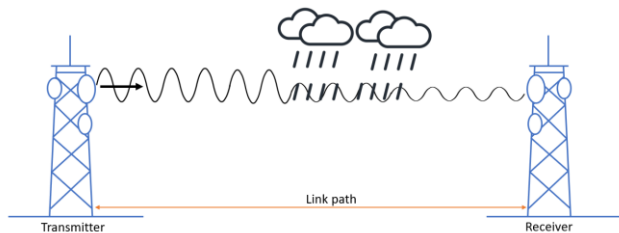
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# Nowcasting with OS data



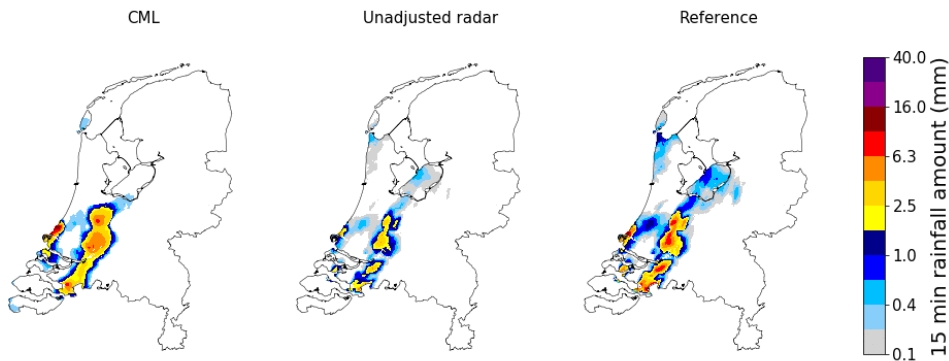


# Rainfall nowcasting with alternative sensors

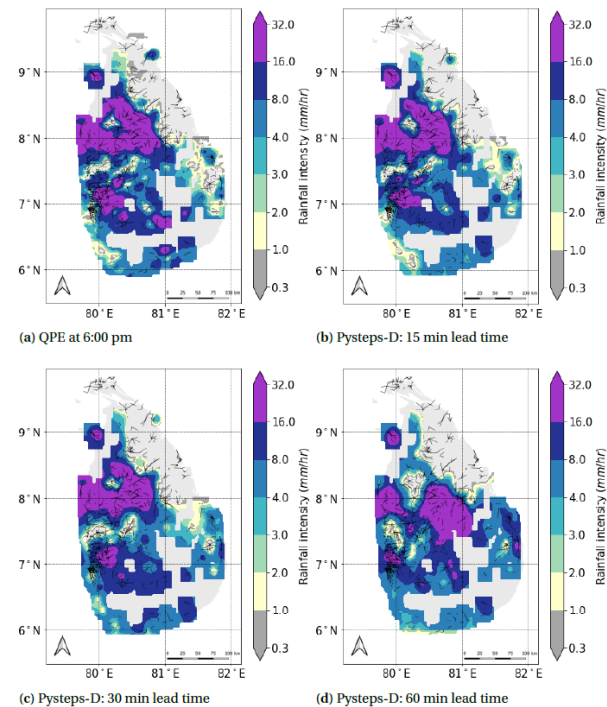


Schoenmaker, 2022

2011-09-10 20:00 UTC + 0 min.



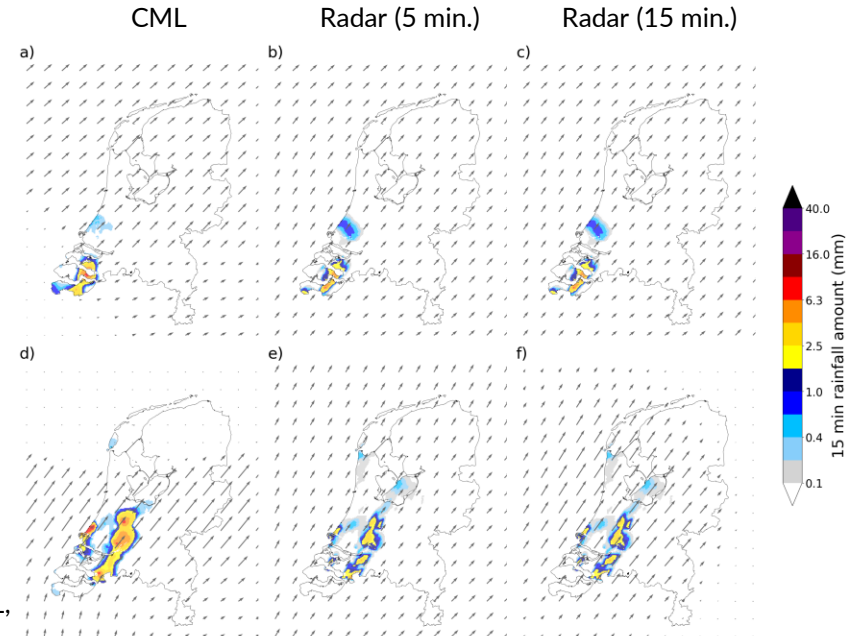
Imhoff et al., GRL, 2020



Schoenmaker, 2022 and current work of Bas Walraven (TU Delft)

## Challenges when nowcasting with OS data

- Advection field derivation
- Data consistency
- Can you think of other possible issues when using OS data for nowcasting?
- Request to you: have a close look at the differences in the optical flow fields, processing steps and resulting nowcasts between the various OS products that you are testing today.



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# Setup of this training session



## Hands-on experience through four exercises


### Exercises:


1. Check pysteps installation and download example data
2. Read, visualize and process input data with pysteps
3. Optical flow and extrapolation
  - a) Optional: Advection correction of the gridded rainfall fields for accumulation.
4. Creating your first nowcasts with the OS datasets
  - a) Optional: Creating a probabilistic (ensemble) nowcast with the same datasets





## Setup of the training material


Nowcasting-session folder

 [exercises]

 [notebooks]

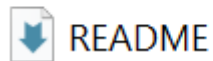
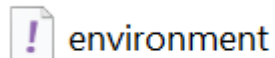
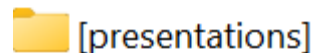
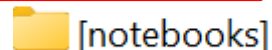
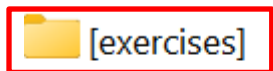
 [presentations]

 environment

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## Setup of the training material

Nowcasting-session folder

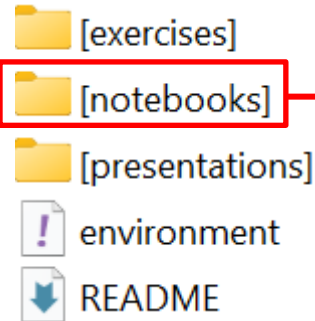


This folder contains the  
description of each exercise







	exercise_01_local_conda_setup	md
	exercise_02_input_data	md
	exercise_03_optical_flow_and_extrapolation	md
	exercise_03a_advection_interpolation	md
	exercise_04_deterministic_nowcasting	md
	exercise_04a_probabilistic_nowcasting	md

## Setup of the training material

Nowcasting-session folder




This folder contains the notebooks in which you can work on the exercises and the notebooks with the solutions


	block_01_local_conda_setup	ipynb
	block_02_input_data	ipynb
	block_03_optical_flow_and_extrapolation	ipynb
	block_03a_advection_interpolation	ipynb
	block_04_deterministic_nowcasts	ipynb
	block_04a_probabilistic_nowcasts	ipynb





## Setup of the training material


Nowcasting-session folder


 [exercises]

 [notebooks]

 [presentations]

 environment

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Finally, all presentations of this session can be found in this folder



**Time to try it out yourself!**

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