AP1 EVALUATING POSSIBLE BENEFITS OF SPATIAL INFORMATION FROM ASCAT DATA IN BEST MEMBERS SELECTION

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10.03.2026
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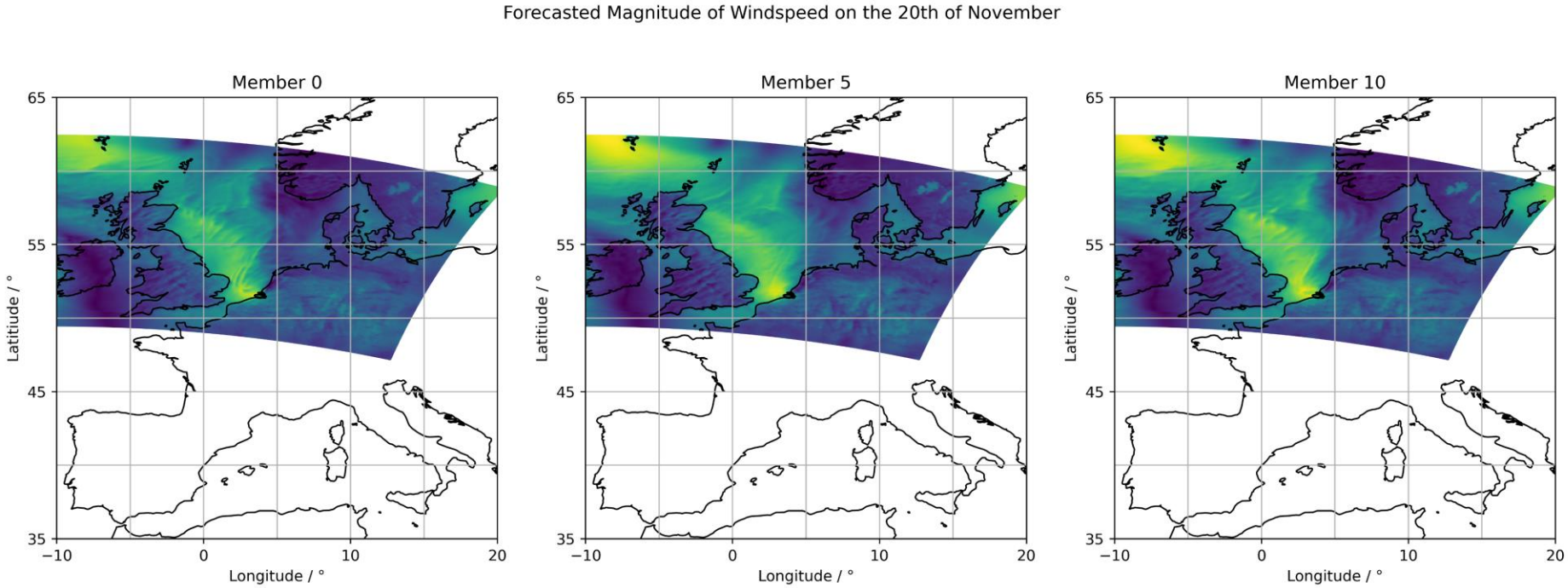
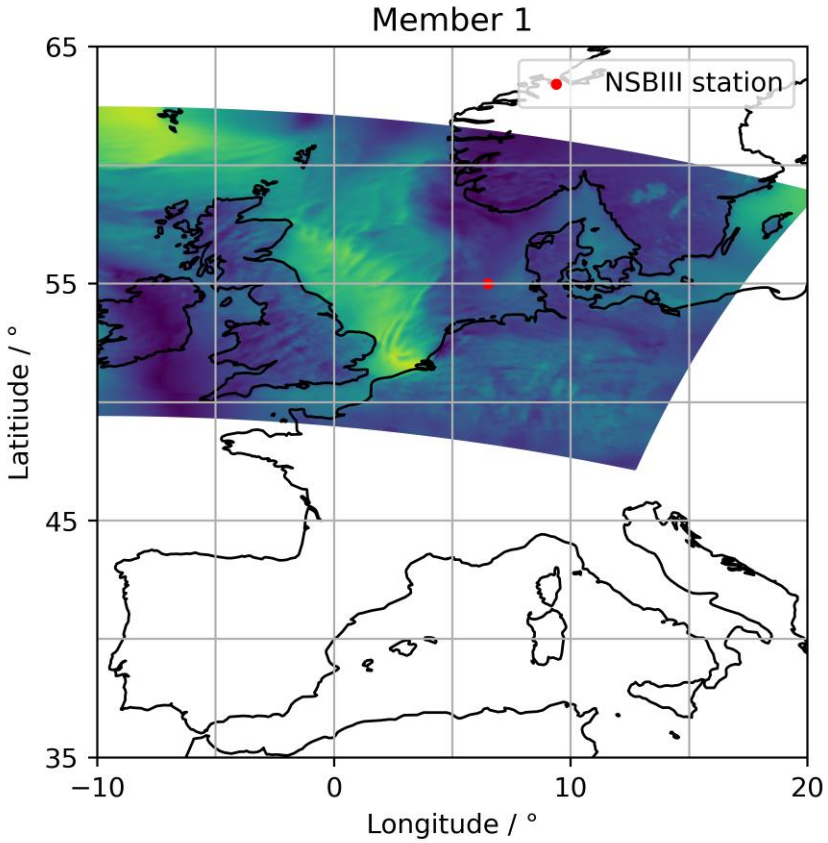
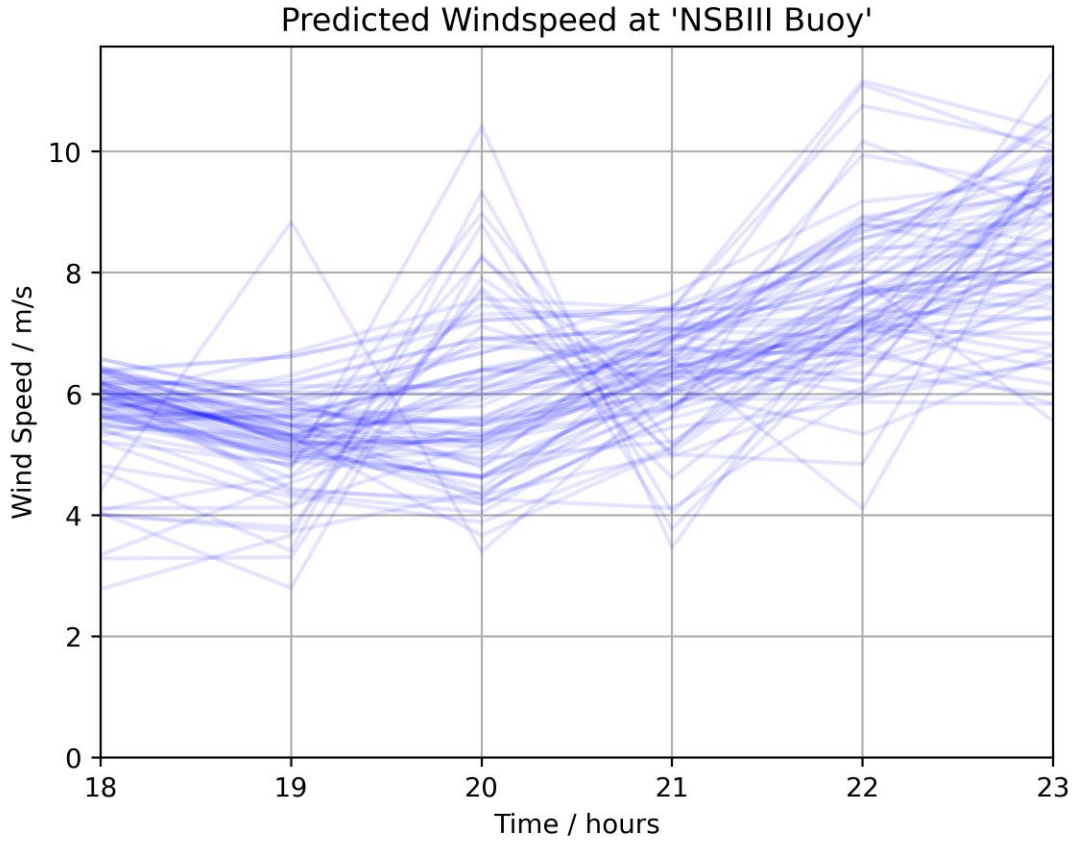
Ensemble Forecasts

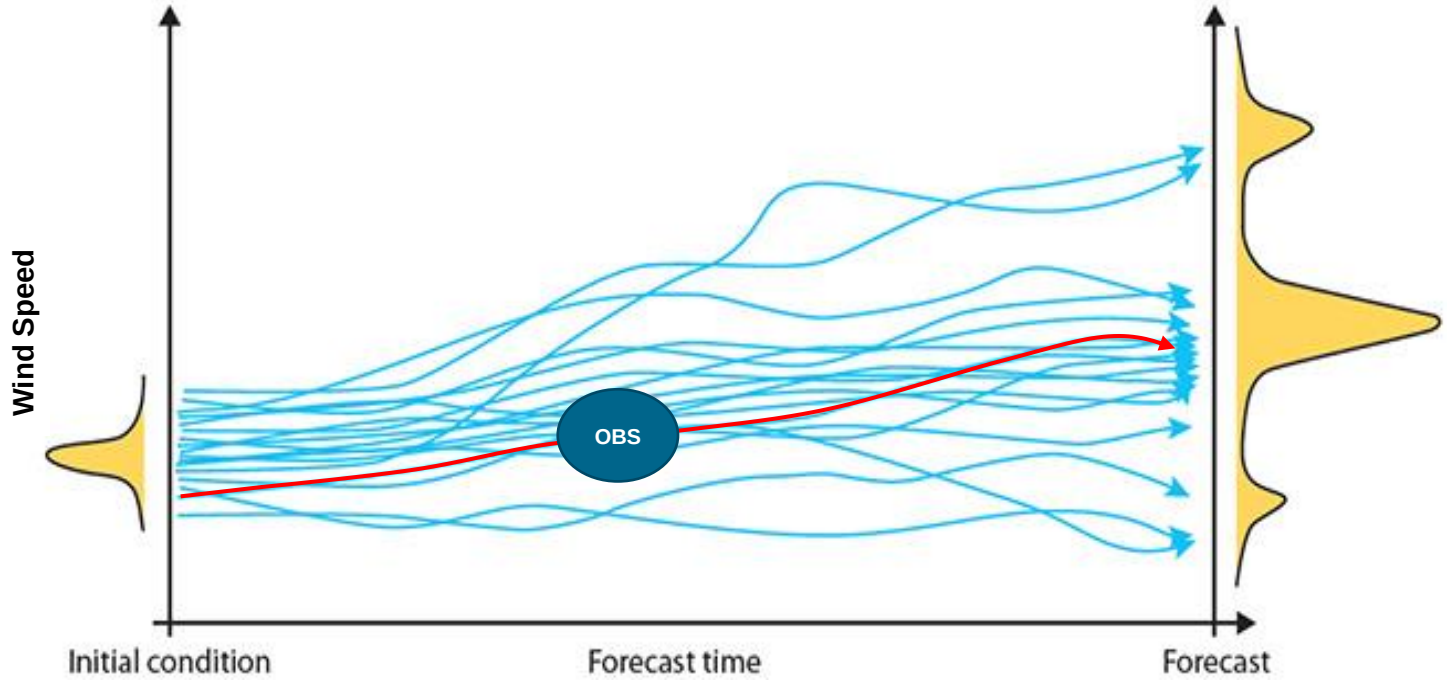


Ensemble Forecasts



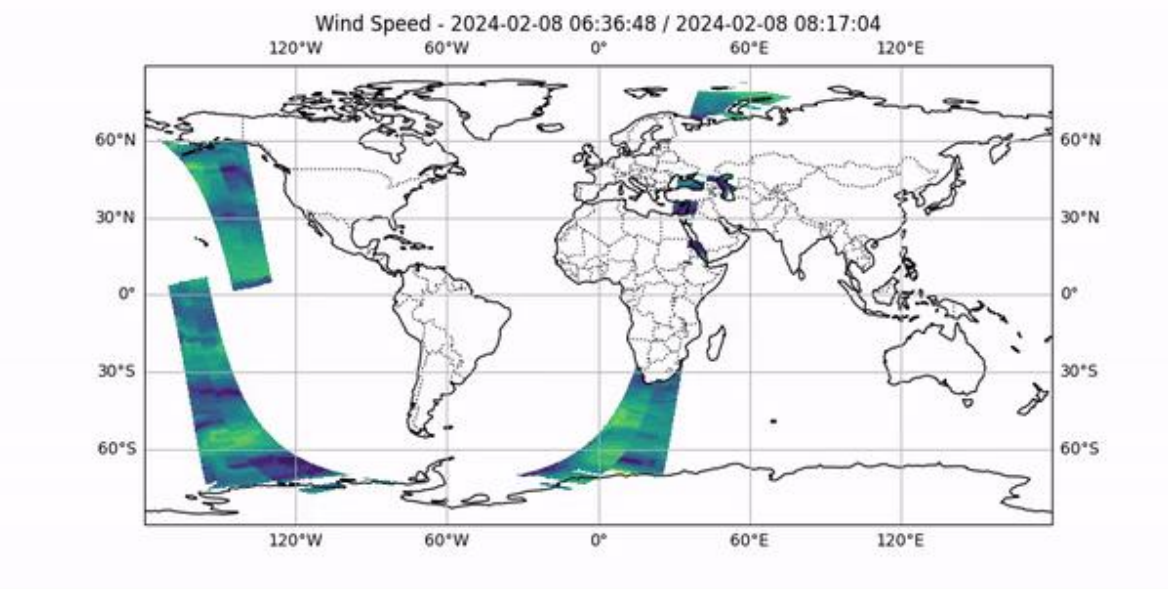


Best Member Selection



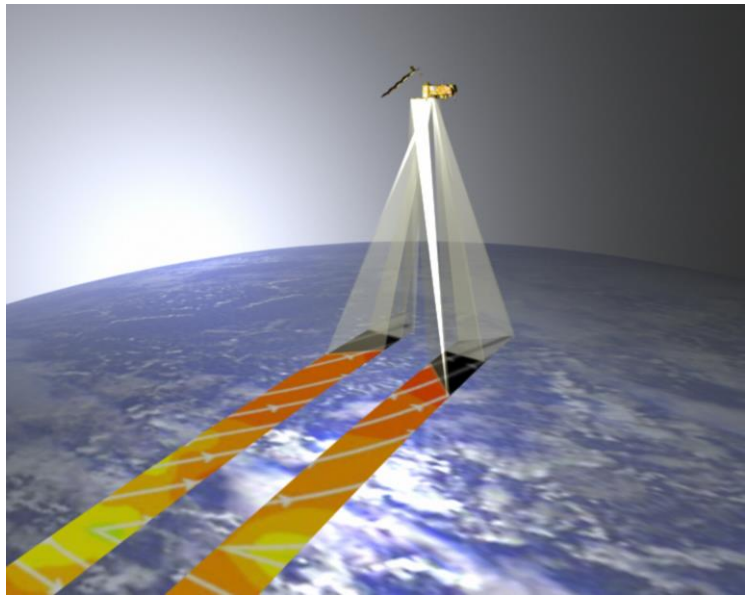
- Choose member closest to observation
- Member should provide best forecast for further future as well

Best Member Selection using ASCAT



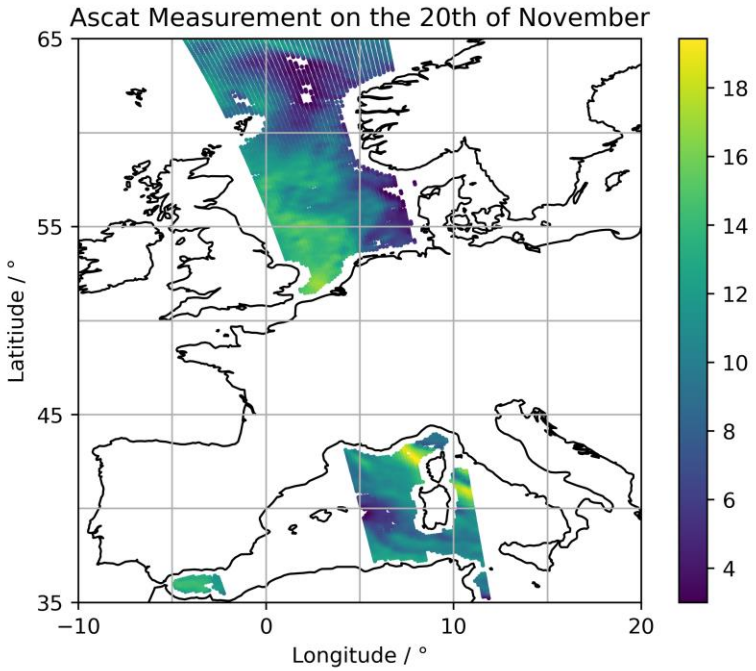
- Two satellites in polar orbits
- Pass over Europe at 8:30 a.m./p.m. (UTC)
- Surface level wind measurement over the ocean
- Uses radar scattering on waves formed by wind

MetOP satellite with ASCAT device

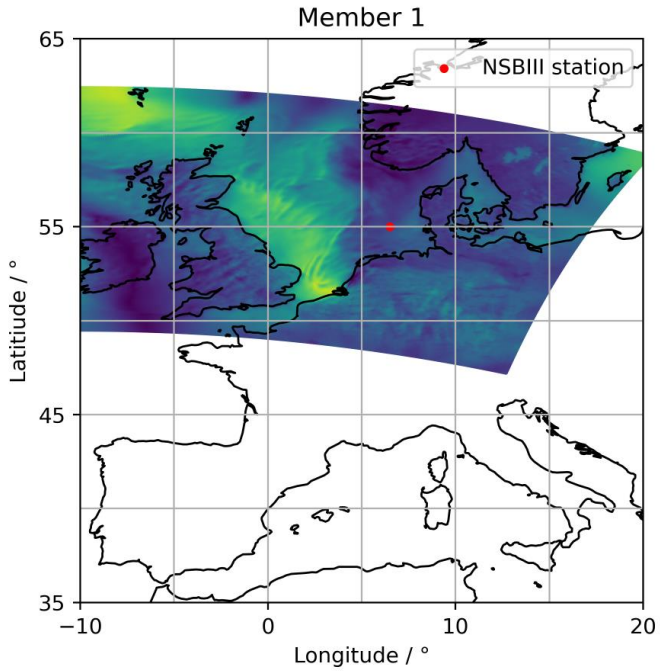


Source: ESA

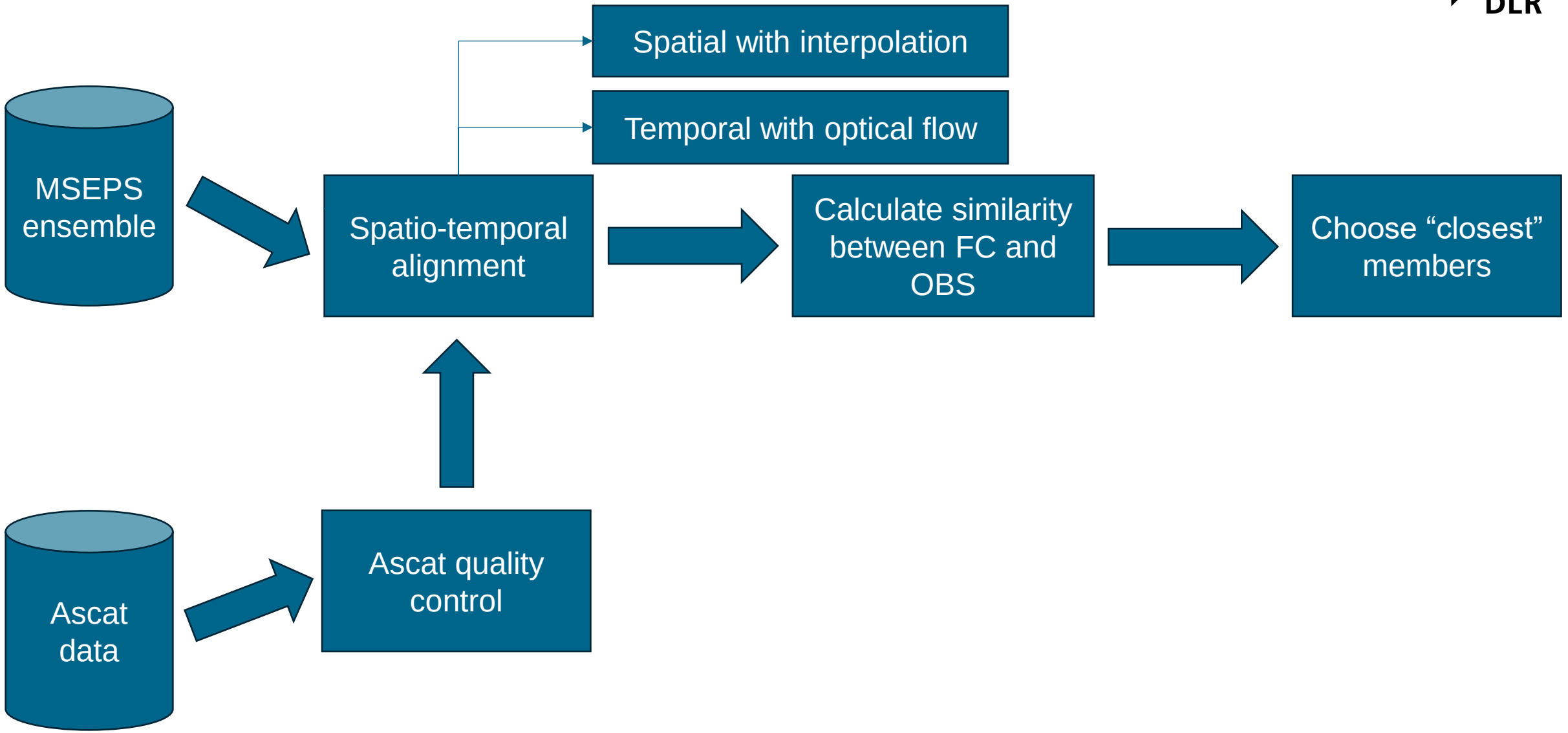
Best Member Selection using ASCAT



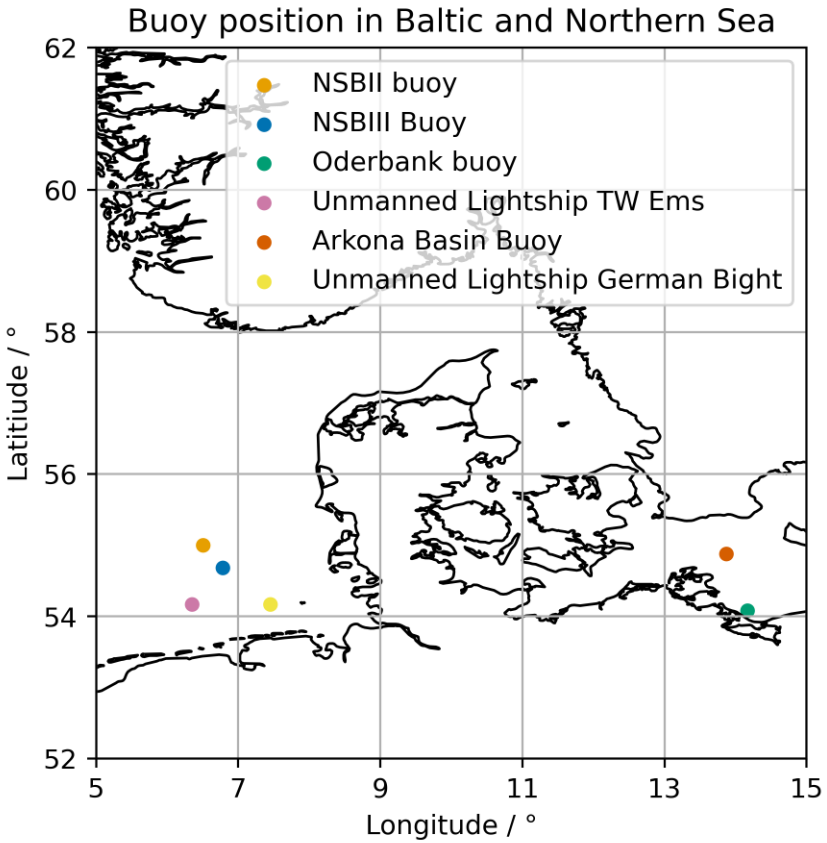
Compare and select



Workflow for Best Member Selection



Evaluation using buoy data



Source: BSH

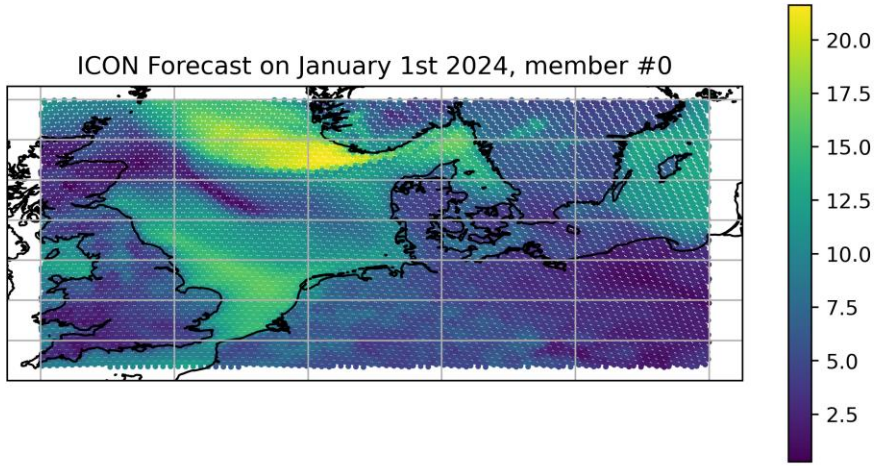
- Given our supposed best member, how well does it actually perform?
- Interpolate Member onto 6 (maximum) buoy positions and compare it to their measurements
- Score is also the **Mean Absolute Error**

Progress Update

- Use ICON (EU EPS) and ECMWF (EPS) forecasts with 48h lead times
- Improved optical flow algorithm for temporal alignment
- Limited area visible to ASCAT Best Member Selection
- Rewrote Workflow
- Analyzed results in the north sea to find out, what influences ASCAT driven best member selection to work well (in comparison to selection with buoy)

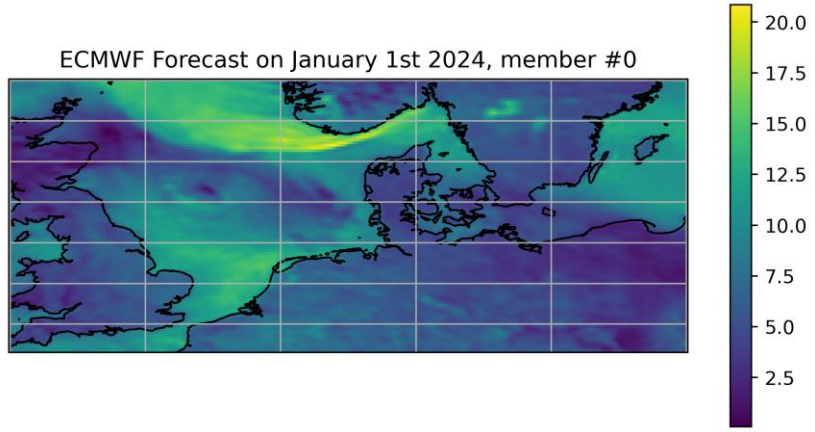
ICON and ECMWF forecasts

ICON



40 members
48h maximum lead time

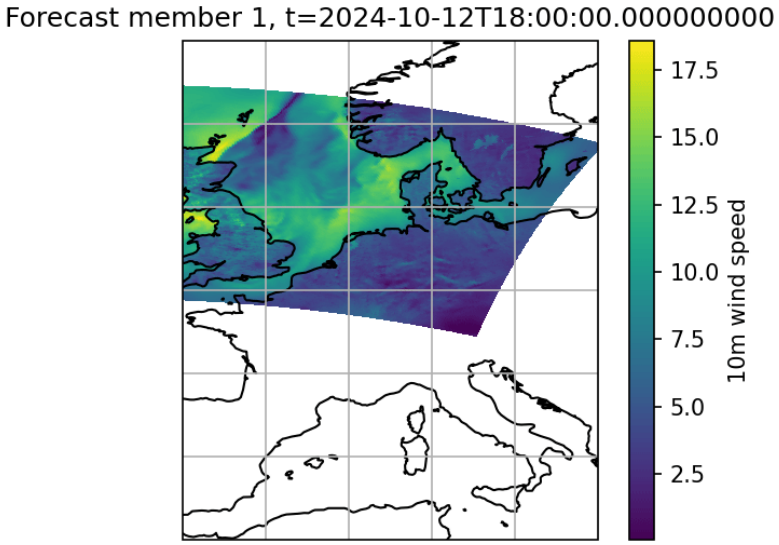
ECWMF



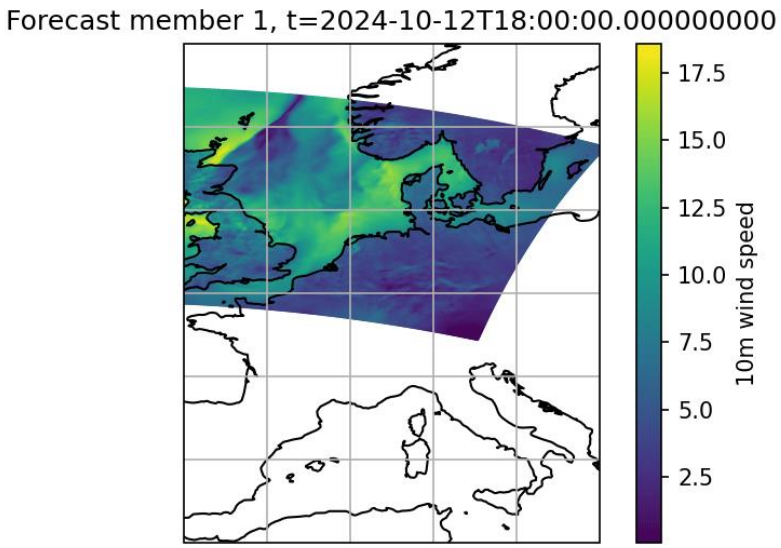
50 members
48h maximum lead time

Improved optical flow

Before



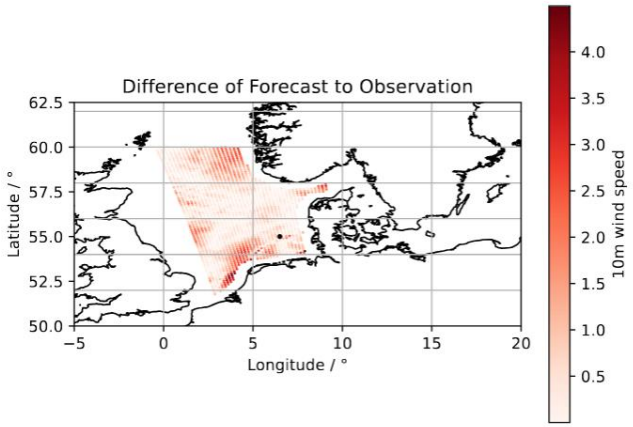
After



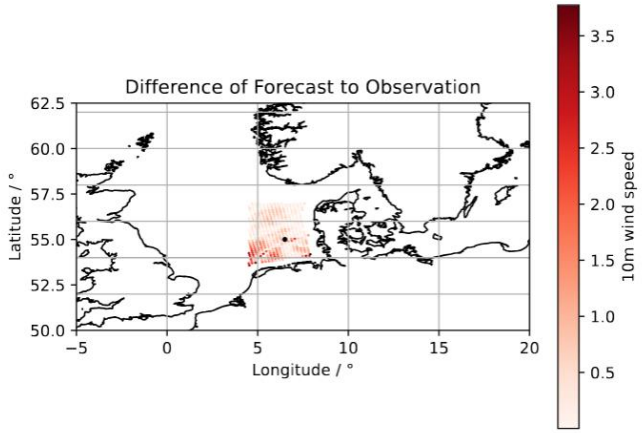
- Old algorithm calculated very small movement vectors
- Changed from polynomial based algorithm to variational algorithm that optimizes a cost function (DualTVL)
- Reduced artifacts, but slightly longer calculation time (~60s for 50 members)

Impact of high gradient features on overall score

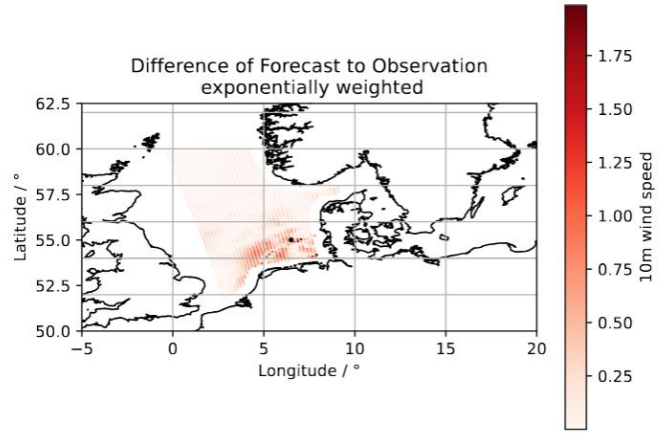
Full ASCAT measurement



ASCAT limited to 4°x4° window

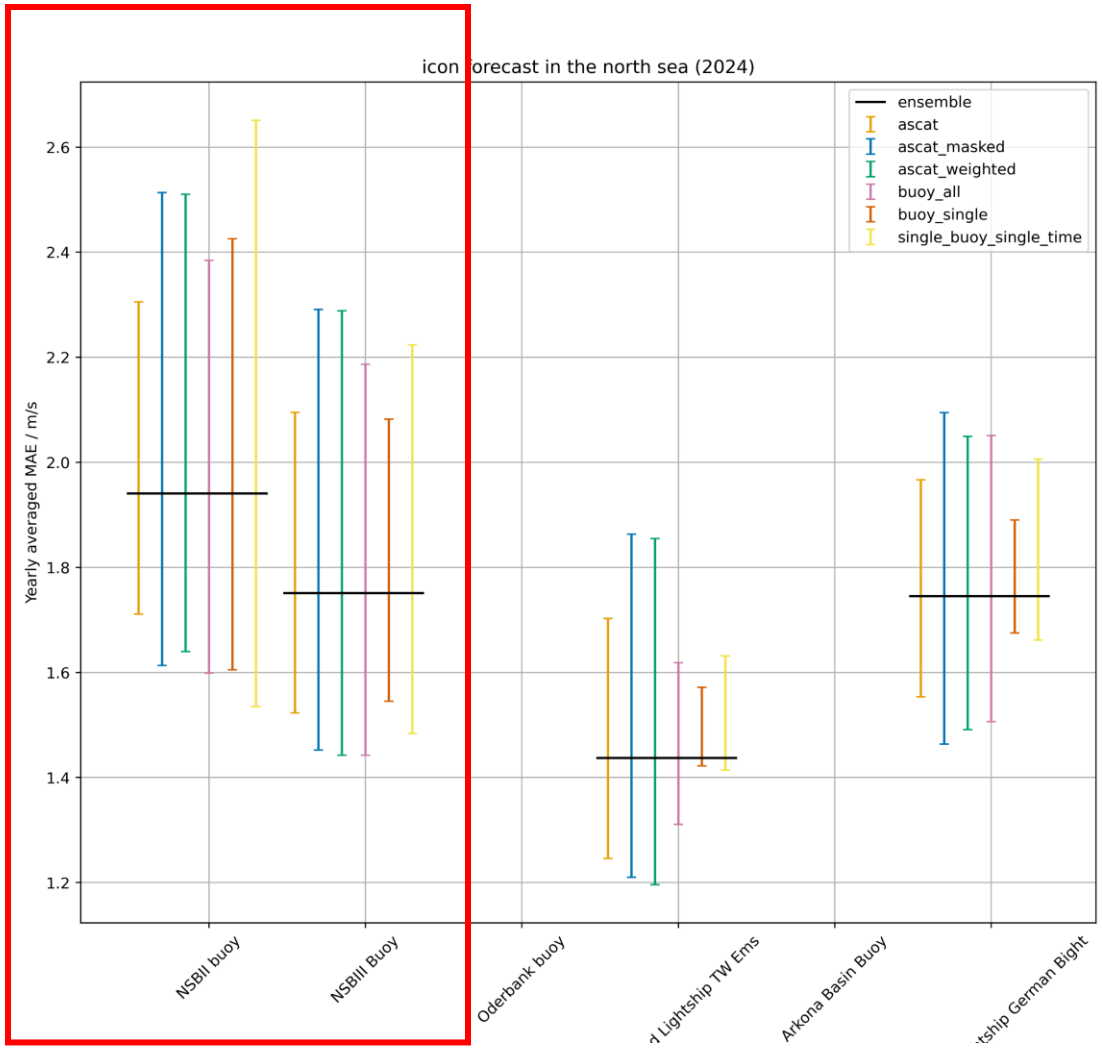


Differences weighed



- Limited the spatial information to a smaller area
  - By using a smaller window
  - By exponentially weighing the absolute differences ($\sim e^{-\frac{x}{\lambda}}$), where x is distance from buoy and λ a constant (150 km)
- Reduces impact of further away areas while keeping spatial information of direct surroundings of point of interest

Performance of different BMS methods for ICON forecast

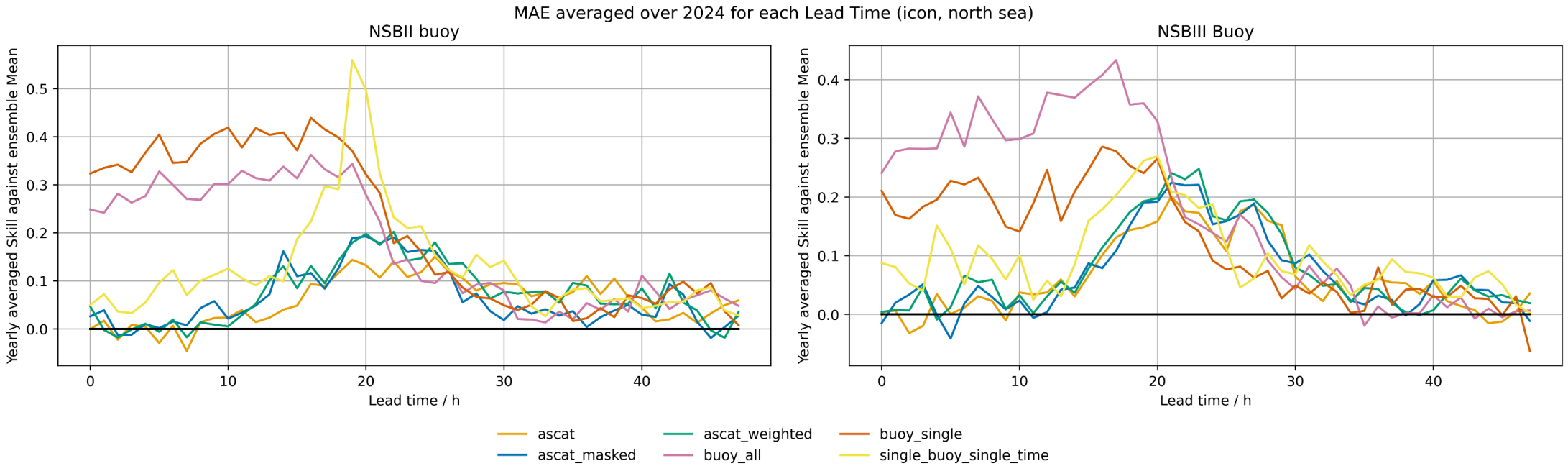


- These are not errors!
- **Black** line is **Ensemble Mean MAE**
- **Lower** marker is **Best Member MAE**
- **Upper** marker is **Worst Member MAE**

- with masking (cutout or weighing), ASCAT BMS performs as well as Buoy BMS

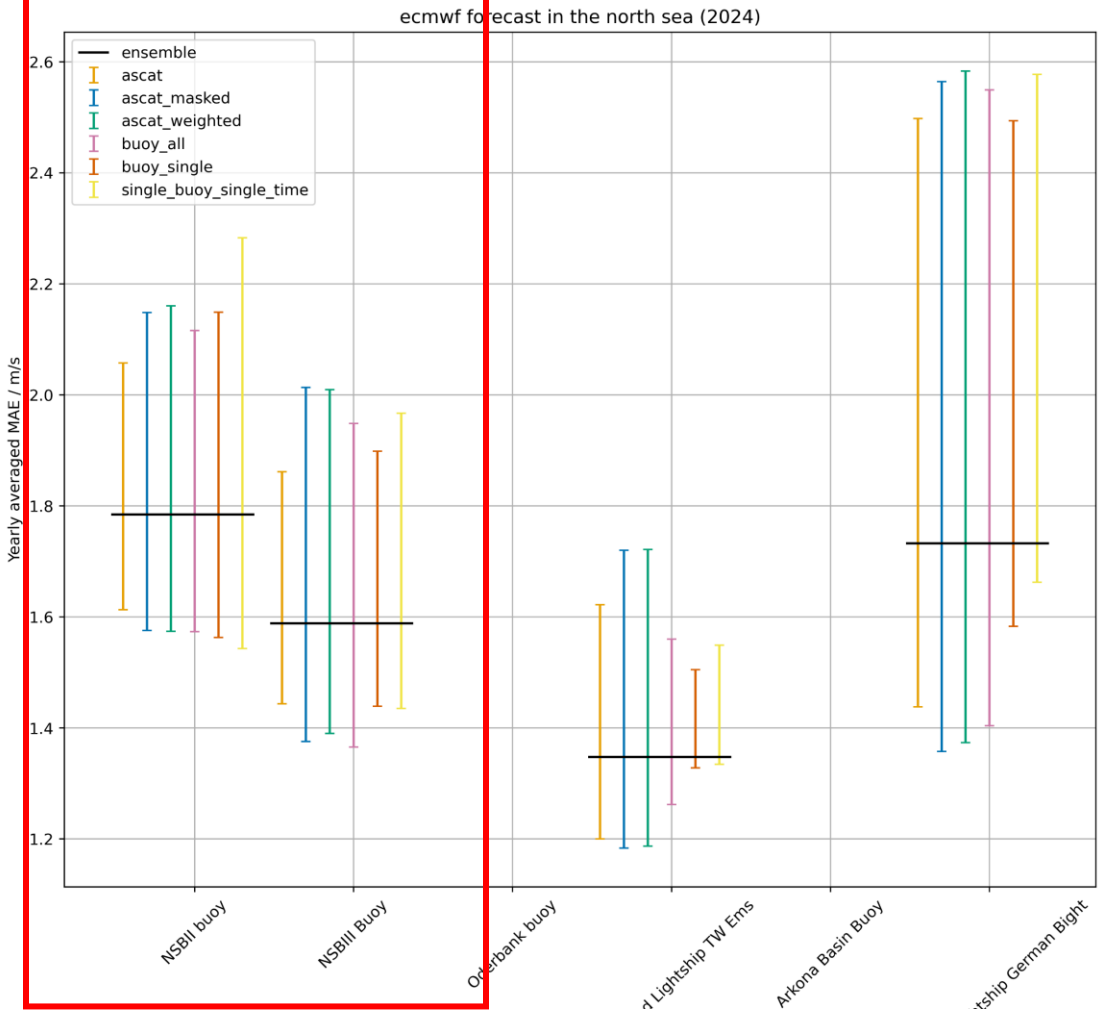
Performance of different BMS methods for ICON forecast

Skill Score: $(1 - (MAE_{ASCAT\ BMS} / MAE_{Ensemble\ Mean})$



- Each time step is averaged for that time over the year of 2024
- ASCAT observation happens at 20h lead time
- Afterwards, there is a 5-7h period where Best Members perform better than ensemble mean (on average)
- Buoy BMS (that sees history) also performs well before ASCAT observation (orange and pink line)

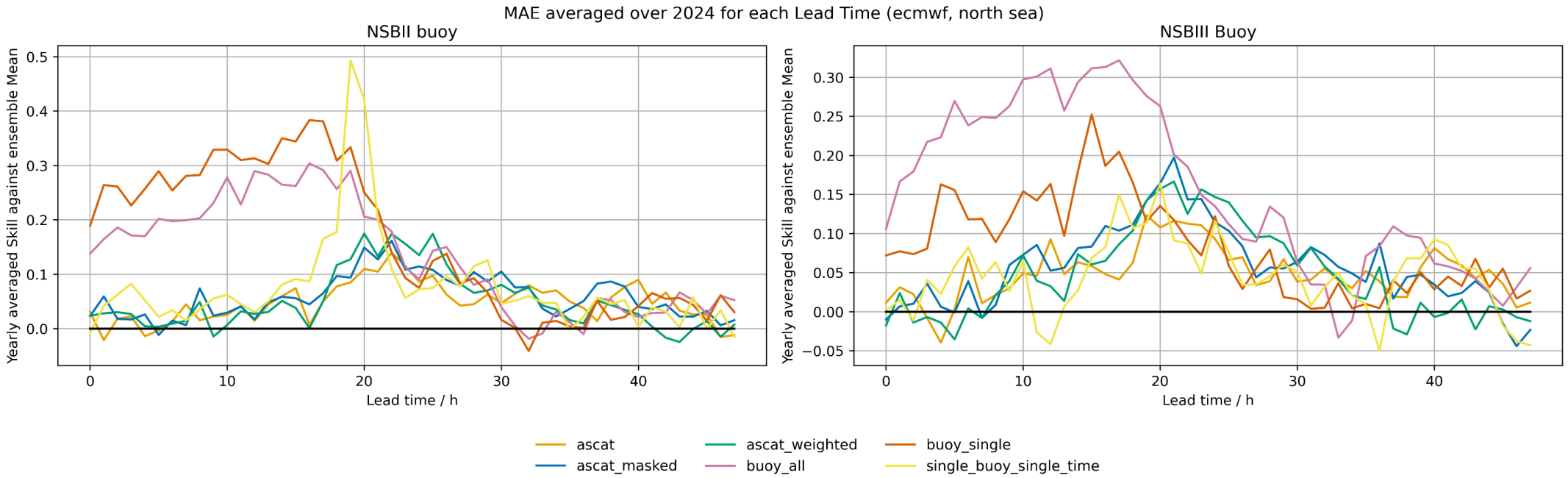
Performance of different BMS methods for ECMWF forecast



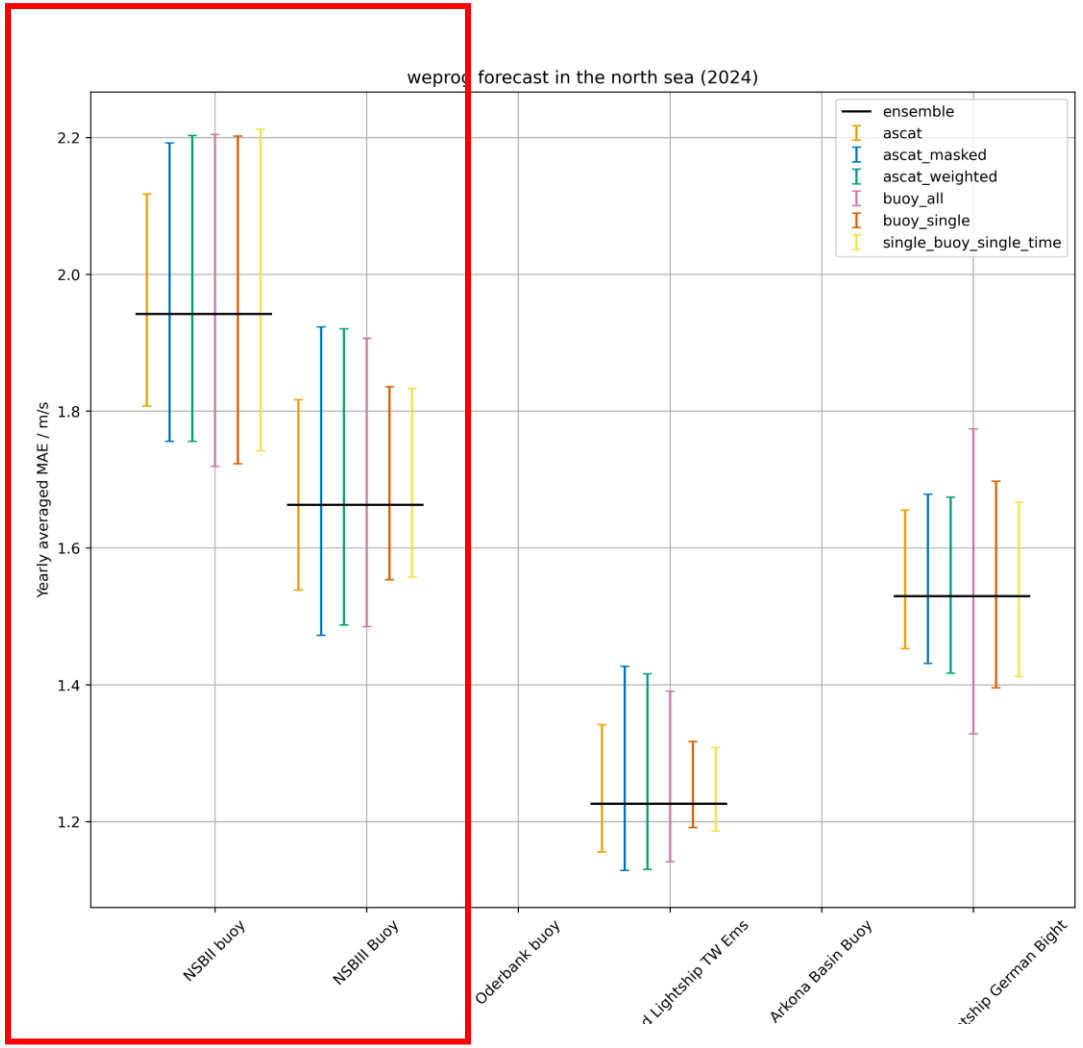
- Similar to ICON
- Ensemble MAE is slightly lower (0.2 m/s)

Performance of different BMS methods for ECMWF forecast

Skill Score: $(1 - (MAE_{ASCAT\ BMS} / MAE_{Ensemble\ Mean})$



Performance of different BMS methods for WEPROG forecast



- Slightly better ensemble MAE than ICON
- Lower spread of (best and worst) members

Finding a score to determine when to use ASCAT over buoy

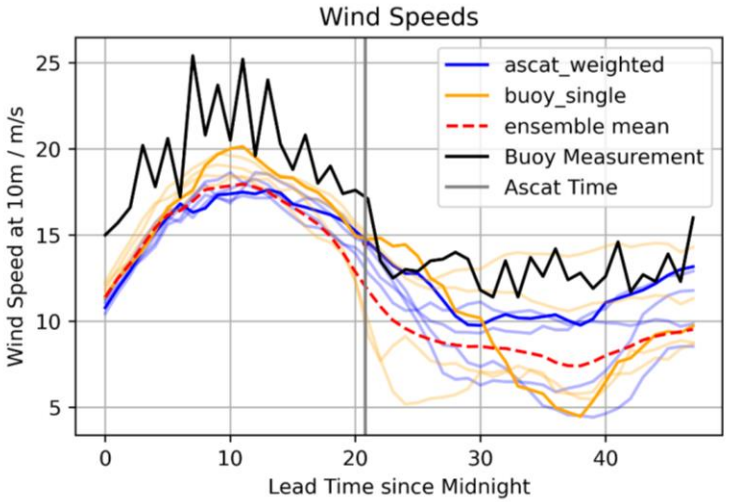
- After forecast period has passed, we can evaluate performance with buoy data
- Use a combined score
  - ($\boldsymbol{MAE_{Buoy\ BMS} - MAE_{ASCAT\ BMS}}$): difference of MAEs of members selected by buoys and ASCAT; **is large if ASCAT performs better than buoys** (evaluated for 5 hours after the ASCAT measurement)
  - (**1 –** ($\boldsymbol{MAE_{ASCAT\ BMS}/MAE_{Ensemble\ Mean}}$)): Skill score of best ASCAT selected member compared to Ensemble Mean; **is large if ASCAT performs better than ensemble mean**
  - Look at events where BMS leads to improvement and ASCAT works better than buoy

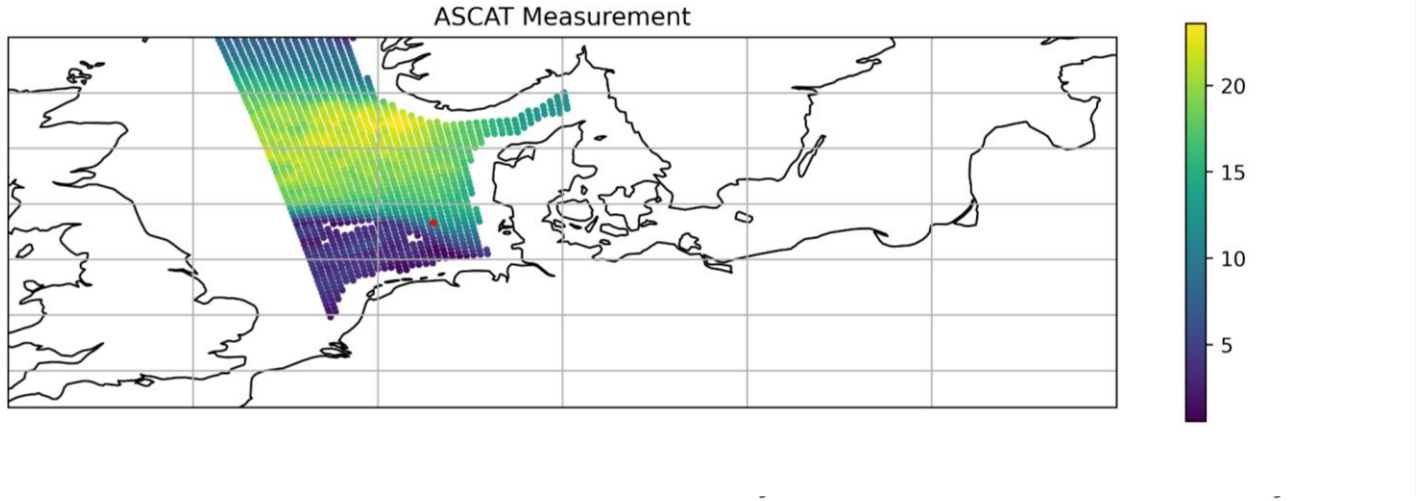
- Cannot calculate this score “at runtime”
- Find a different score that correlates with this one

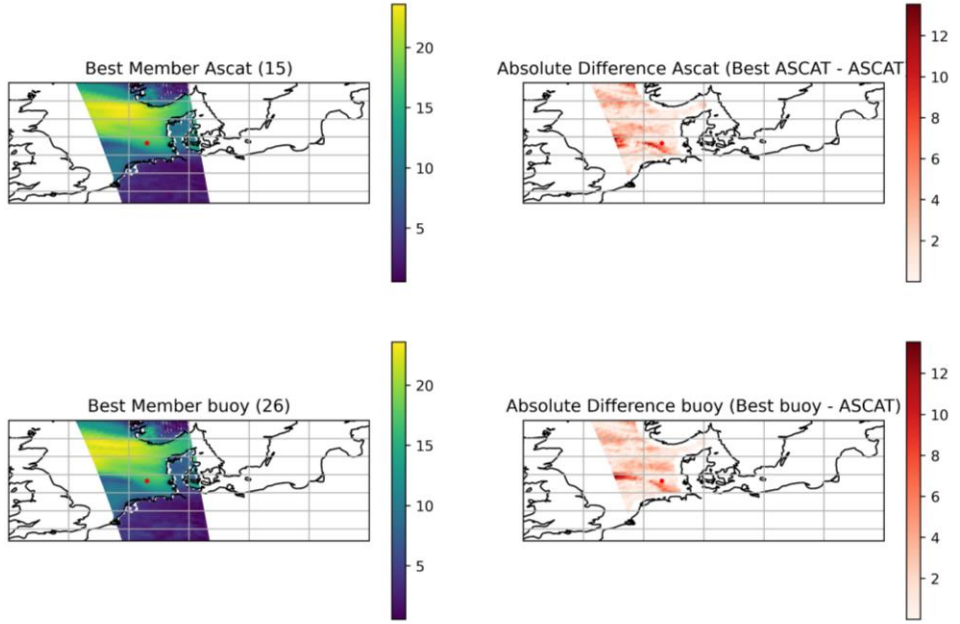
Investigating events, where ASCAT performs better than selection with buoy

- Usual involvement of spatial features in the wind field
- Also works on days with more homogenous wind
- “historic information” for buoy selection does not seem to matter
  - May actually be a disadvantage, as prior good performance does not guarantee good performance in the future

Investigating events, where ASCAT performs better than selection with buoy

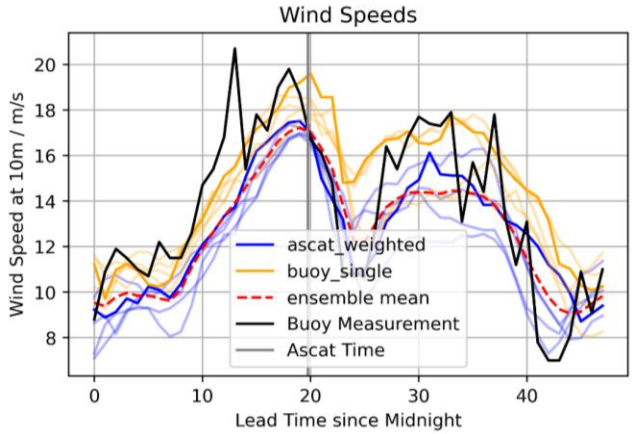


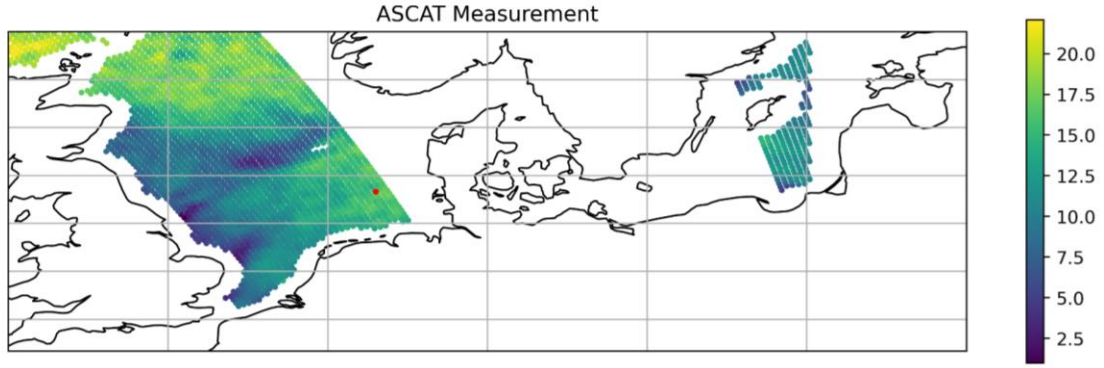


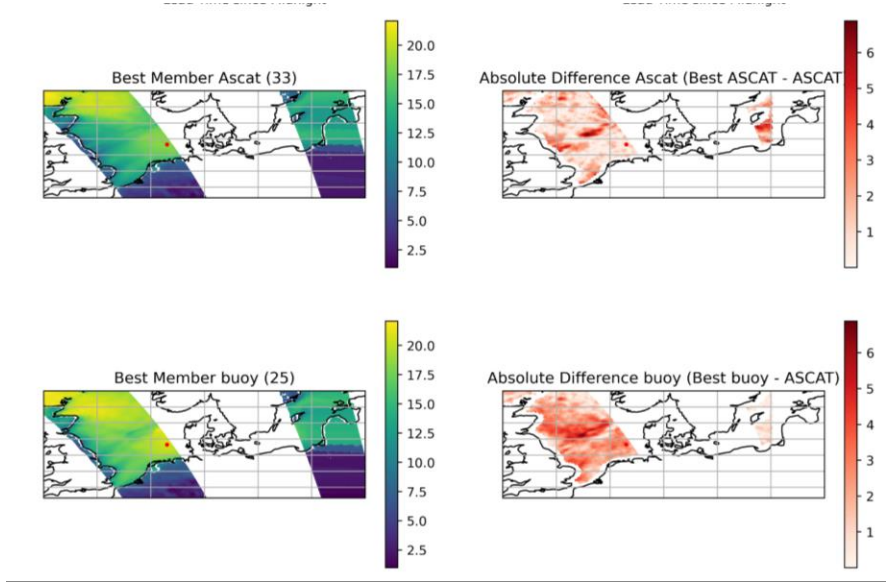


- Timing of windfront predicted
- Also predicted windspeed better than mean
- MAE map again shows influence of spatial feature

Investigating events, where ASCAT performs better than selection with buoy



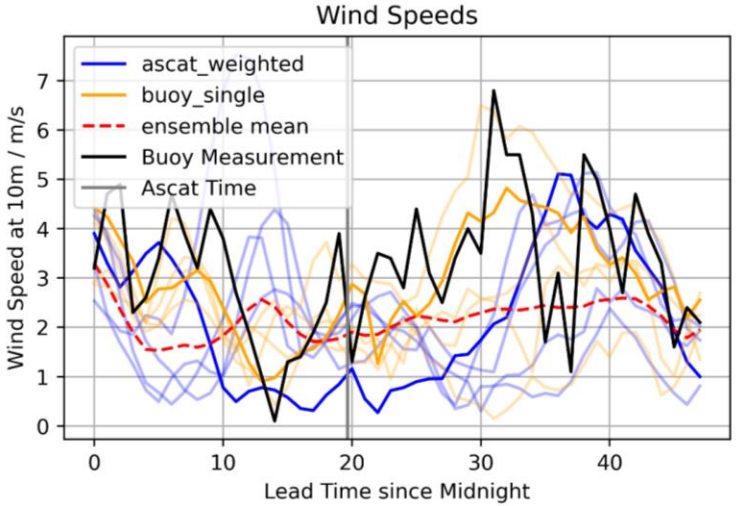


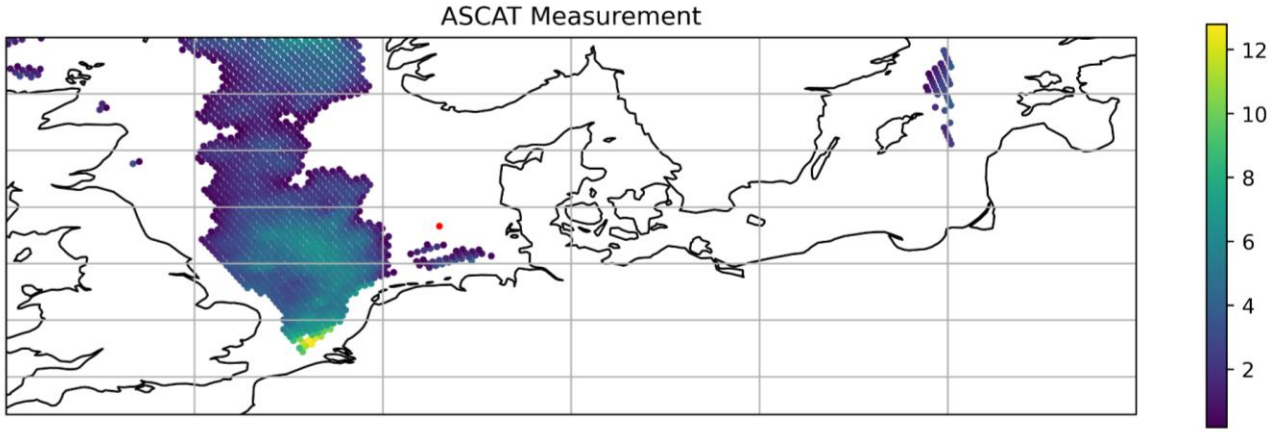


- Also works without obvious spatial features
- ASCAT selects event, where windspeed is correct in the surrounding area, ensuring good forecast over next few hours
- Buoy only selects member, that fits at observation time, no guarantee for future performance

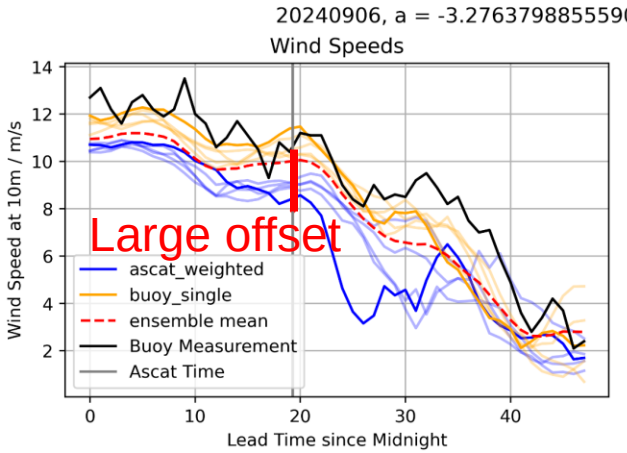
Investigating events, where ASCAT performs worse than selection with buoy

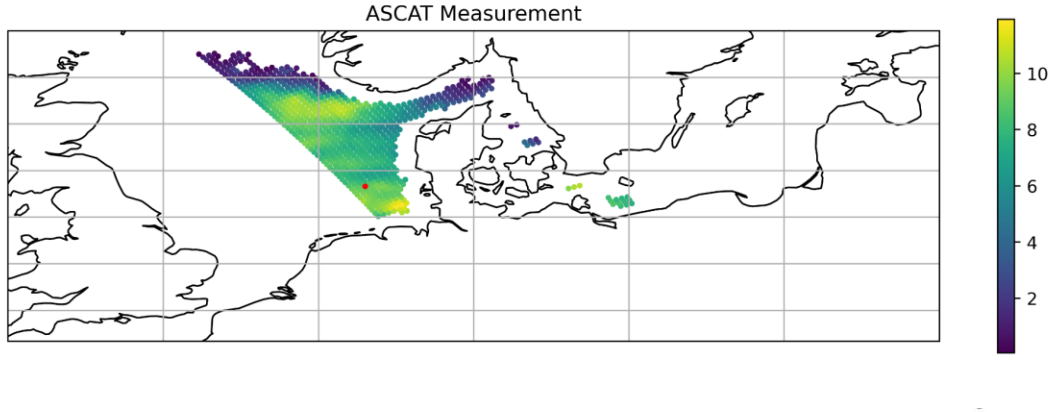
- For a lot of events, the buoy was not actually in the ASCAT scan
- Quality control flags large regions due to low wind speed and/or e.g. storms

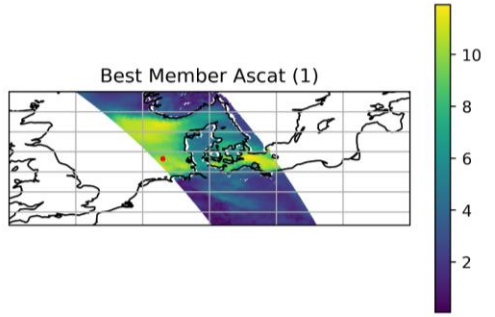


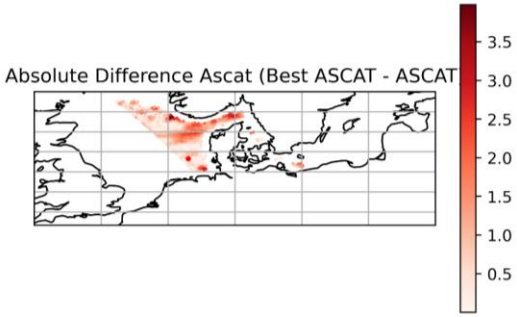


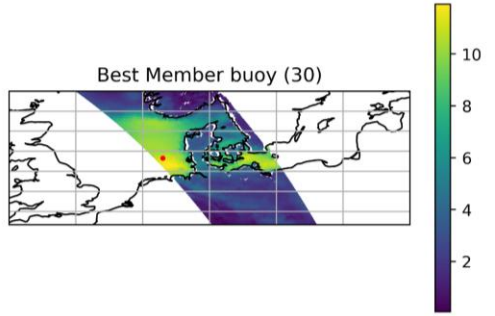
Investigating events, where ASCAT performs worse than selection with buoy

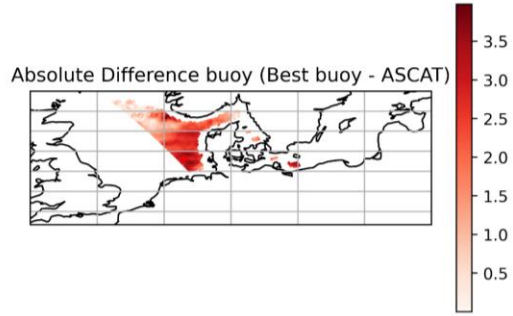










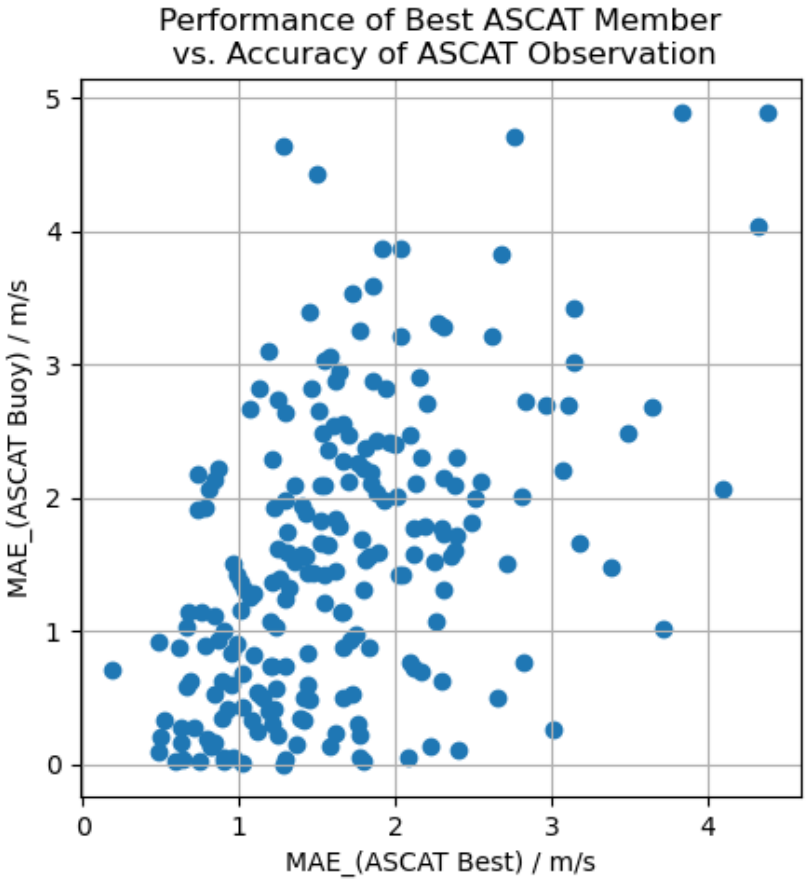


- ASCAT sometimes measures windspeed wrong
  - ASCAT map is offset by a few m/s compared to forecast
  - Especially bad if buoy is currently experiencing rising/falling windspeed

Finding a score that predicts if ASCAT will work better than selection with buoy

- Use gradient (its magnitude) of the windfield as score
  - Magnitude is related to average windspeed
  - Difficult to find a threshold, as spatial features are not only in high wind speed regions

- Difference of **ASCAT Windspeed and Buoy Windspeed** (during scan) to judge if ASCAT measured wrong
  - Correlation between **Best Member MAE** (over five hours after ASCAT observation) and this difference
  - Correlation coefficient of 0.48



Summary

- Using optimized optical flow and better ASCAT scan selection, ASCAT BMS performs about as good as BMS with buoys on buoys in the north sea

- ASCAT BMS works across different Forecasts (WEPROG, ECMWF ICON)
  - Improvement for about 5 hours after Scan

- ASCAT BMS suffers from relatively high measurement errors of wind speed (~2 m/s)
  - The measurement error correlates with ASCAT performance

Outlook

- Use a neural network to select the members
  - Replaces MAE as metric
  - Generate probabilistic forecasts
- Also possibly judge when to use/trust a Scan and when not

- Make use of Chinese and Indian Satellites (Oceansat3, HY-2B, HY-2C)
  - More scans spread over the entire day

- We are also placing a lot of trust in (two!) buoys for verification
  - Not sufficient
  - Try to get more data for verification
  - Possibly do verification in Ireland using data from wind parks