AVHRR Polar Winds Derivation at EUMETSAT: Current Status and Future Developments

Gregory Dew

EUMETSAT

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BACKGROUND (1)

- METOP-A polar orbiting satellite launched October 2006
- EUMETSAT (EPS) METOP mission series is the European contribution to a joint European-US satellite system, the Initial Joint Polar Satellite System (IJPS)
- Advanced Very High Resolution Radiometer (AVHRR/3) - provides global imagery twice a day at 1km (nadir) resolution
  - visible (0.63, 0.86 µm), near IR (1.6 µm) (day)
  - IR (3.7 (night), 10.8, 12.0 µm)
- Applications in meteorology and oceanography
- Provides inputs for other METOP instrument processor (ATOVS and IASI) activities

BACKGROUND (2)

- EPS End User Requirement to derive polar winds using AVHRR
- AVHRR Winds part of the original EUMETSAT EURD and planned Day-2 activities; agreed by delegations
- IJPS agreement foresees that both NOAA and EUMETSAT derive and provide polar wind data to users
- NOAA generate polar winds data from METOP AVHRR
- EUMETSAT commenced Day-2 preparation activities
- AVHRR Winds IR 10.8 µm channel

SUMMARY OF ACTIVITIES (1)

- EUMETSAT provided with copy of CIMSS AVHRR Polar Winds code
- Use to reproduce NOAA test cases and run other input data and support the operational development of the AVHRR Winds Product Processor
- A parallel implementation in operations (there are a number of key differences in the proposed wind generation approach compared to NOAA)
  - prototyping of AVHRR winds processing
  - product implementation in the EUMETSAT EPS Ground Segment
  - winds generated from CIMSS code as reference
  - fine tuning of EUMETSAT winds processor
  - external validation

SUMMARY OF ACTIVITIES (2)

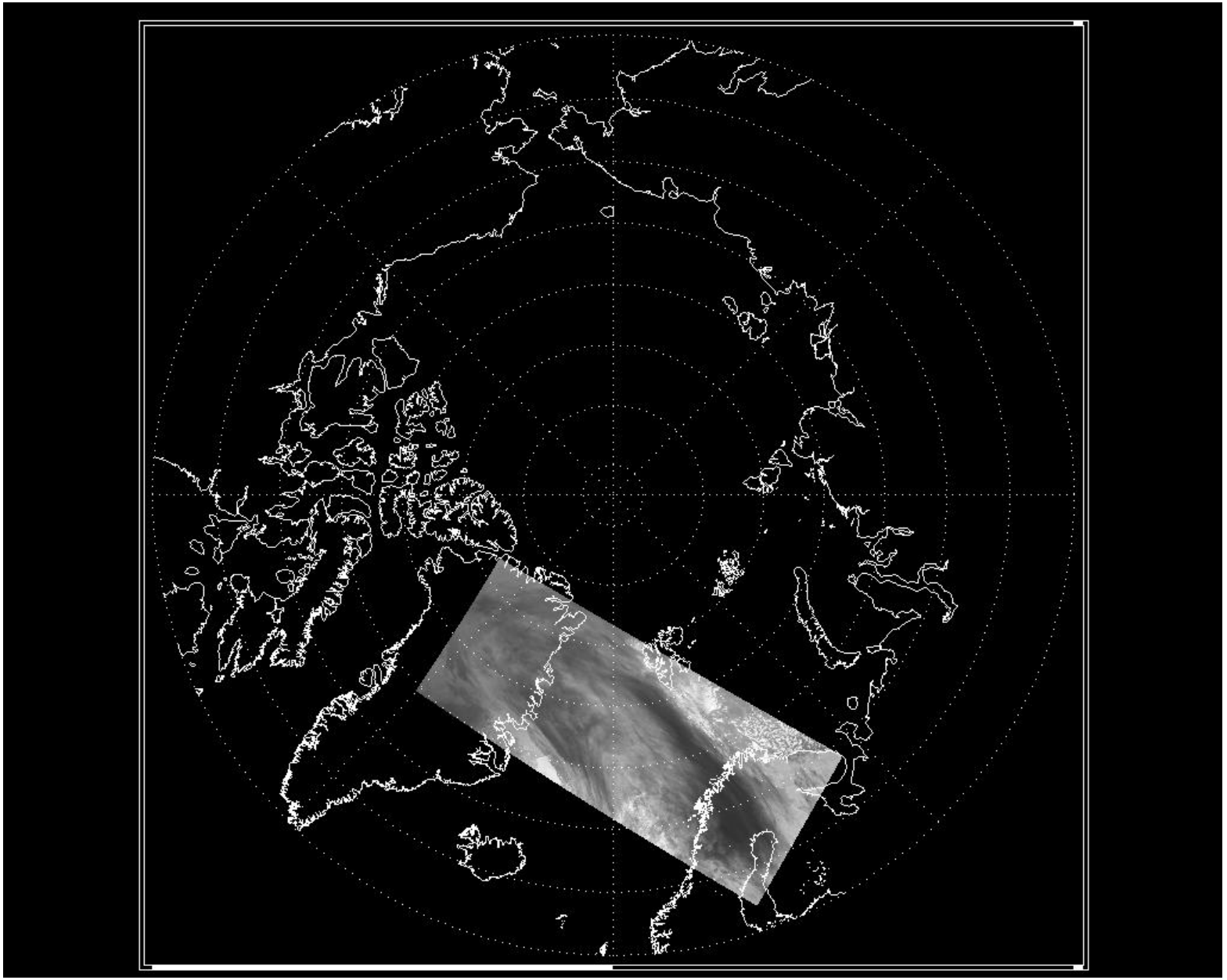
- Team structure
- Prototyping 2007/2008
- EUMETSAT Product Processing Facility (PPF) development environment activities – started 2008
- Run initial versions in EPS EUMETSAT Ground Segment – summer 2008
- Fine tuning and iterative versions
- Product Validation
- Make the AVHRR Polar Winds operational as a Day-2 product, target date end of 2008

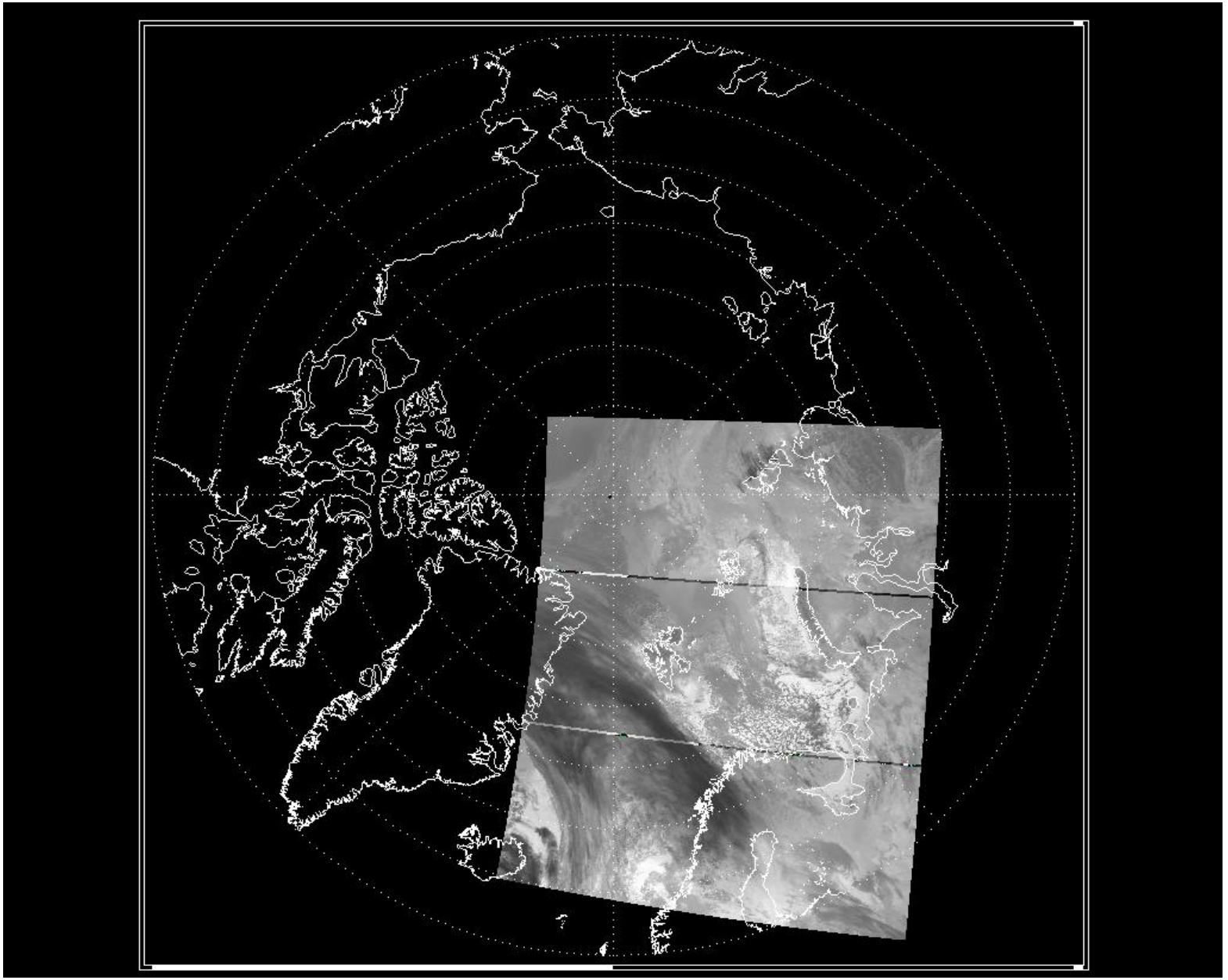
AVHRR WINDS INPUT DATA

- Svalbard – complete orbit's worth of data is dumped
- EUM Level 1b AVHRR data
  - pixel radiances
  - navigation information
  - cloud information
- Available as a series of Product Dissemination Units (PDUs)
- PDU – near real-time dissemination – length of 3 minutes
- Approximately 33/34 PDUs per orbit
- Complete orbit's worth of Level 1b data is processed within the time span of the next orbit (pipeline approach)

WINDS DERIVATION

- Rolling buffer of nearly 3 orbits worth (about 100 PDUs) of level 1b data stored in the on-line ground segment
- For each (target) PDU which covers polar region – produce a corresponding winds PDU
- Estimate up to 12 wind PDUs for each orbit
- Processed in near-real time within the duration of an orbit
- Only use 2 orbits to produce the winds for each PDU
- For each target PDU – find the 3 search PDUs in the previous orbit which overlap the target PDU
- Reverse track the selected targets from the target PDU to the search PDUs





TARGET SELECTION

- Each PDU : 1080 lines and 2048 pixels per line
- Targets selected at designated locations, eg grid points separated by 80 pixels; or position of localised maximum contrast within expanded search (optimisation) areas
- Use of cloud information from EUM Level 1b product
  - information available as a series of flags (eg ‘cloudy’, ‘clear’, ‘test failed’),
  - output from a number of threshold tests using different individual and combination channels
  - main aim of AVHRR cloud detection algorithm to select cloud free areas
  - pixels will be biased towards being detected as ‘cloudy’
  - investigate how best to optimise individual test results

DATA MAPPING

- Target tracking requires that both target and search areas have the same geographical representation
- One option is to re-project both target and search PDUs onto a common stereographic projection, centred at either North or South Pole
- Re-projection of data implies a loss of information
- AVHRR wind product is a Level 2 Product
- Level 2 – derived geophysical parameters at same resolution and location as those of the Level 1 data
- To better satisfy Level 2 definition, re-project search PDU data only, map directly onto the target PDU

TARGET TRACKING (1)

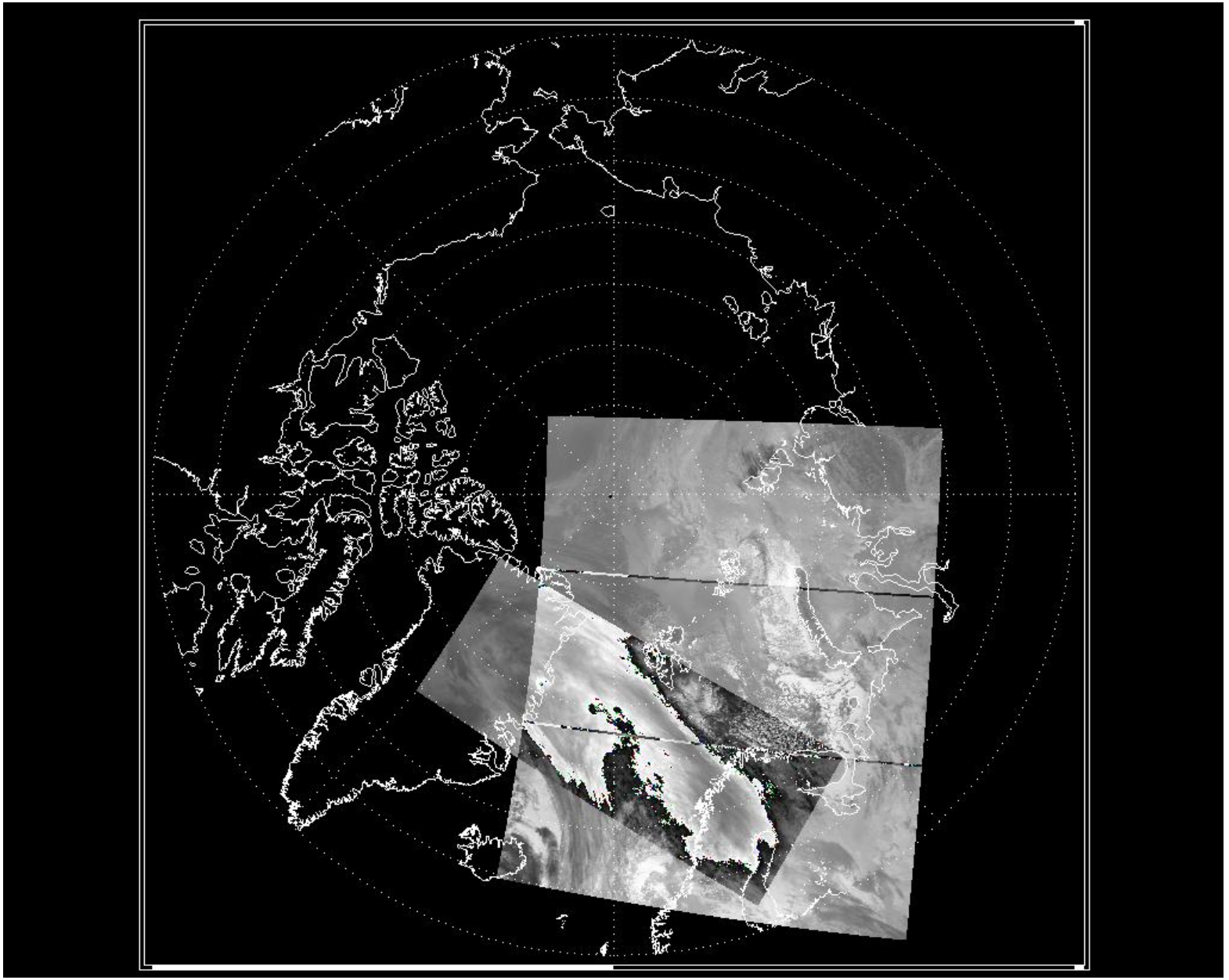
- As for geostationary wind production, choose appropriate search area and find the best target match using cross-correlation
- Consideration of target and search area sizes
- Repeat cycle time ~ 100 minutes
- Tracer may not be passive
- Contour/contrast features potentially change significantly
- Search area sizes much larger compared to eg the MSG search areas

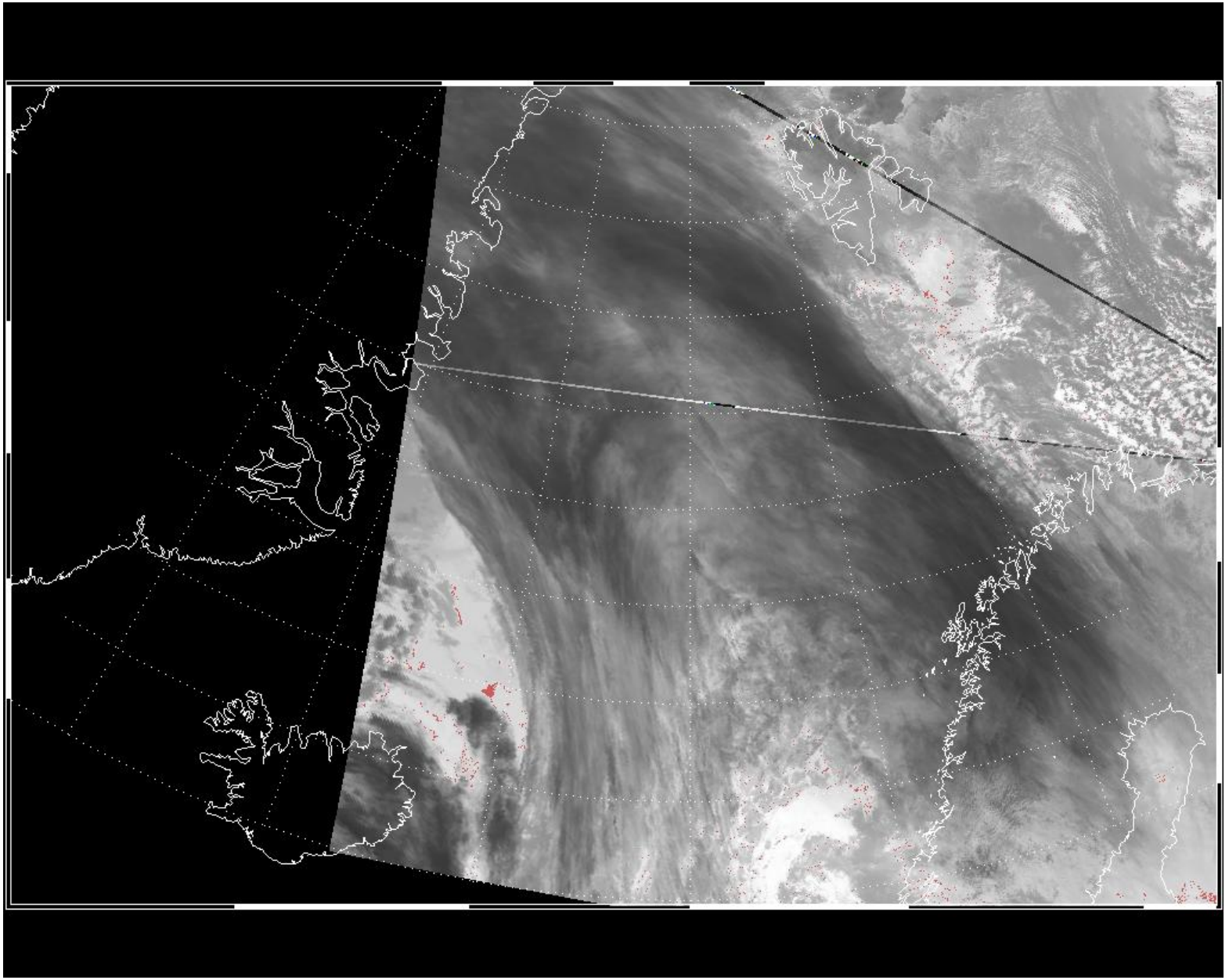
TARGET TRACKING (2)

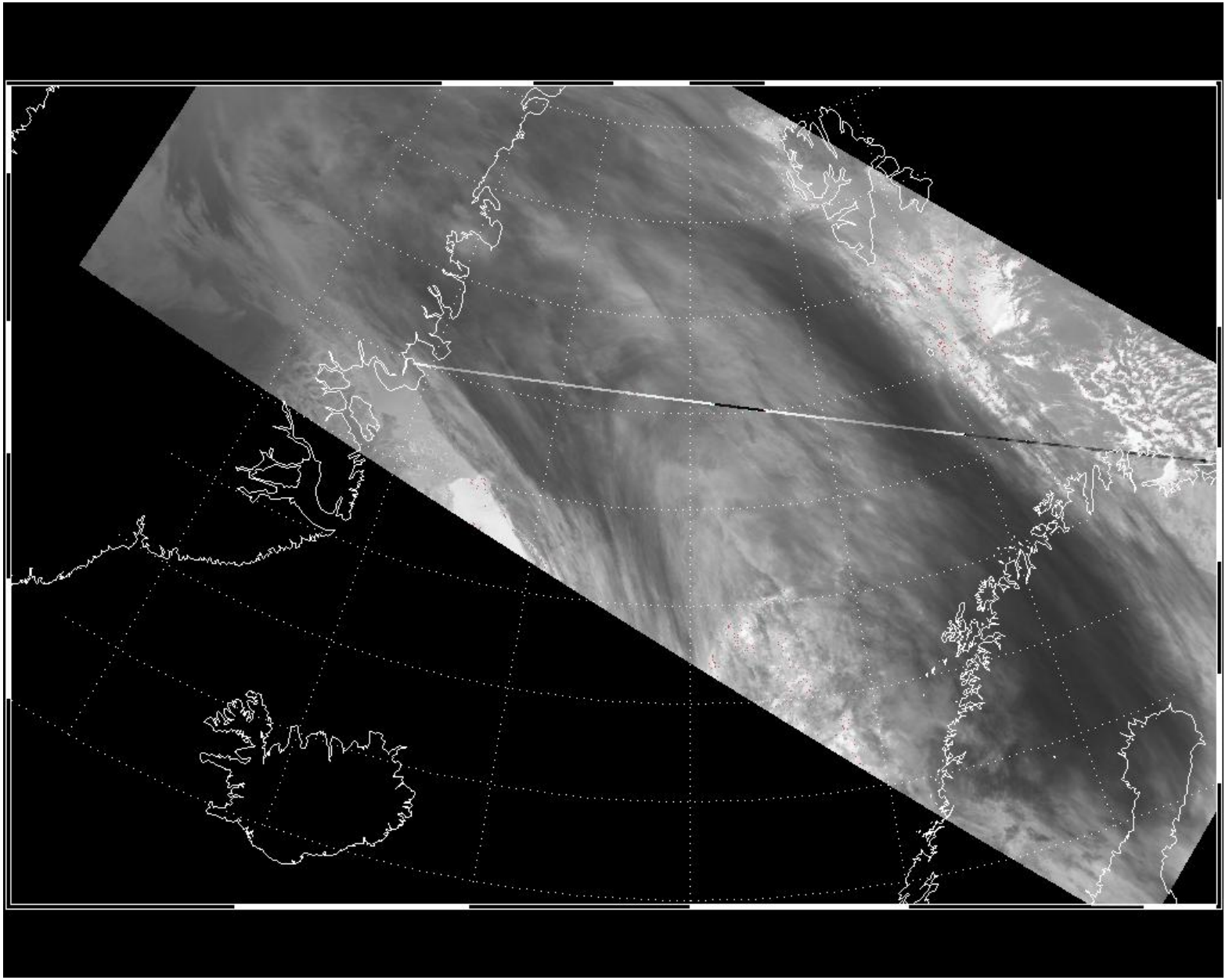
- Target area sizes need to typically larger than 100 x 100 pixels – easier to track a larger feature than a smaller contrast feature which may change significantly in 100 minutes
- Consider standard cross-correlation matching technique
- Could also consider Euclidean Distance
- Are there other more appropriate tracking techniques which concentrate on tracking a “centre of mass” feature rather than the edge ?

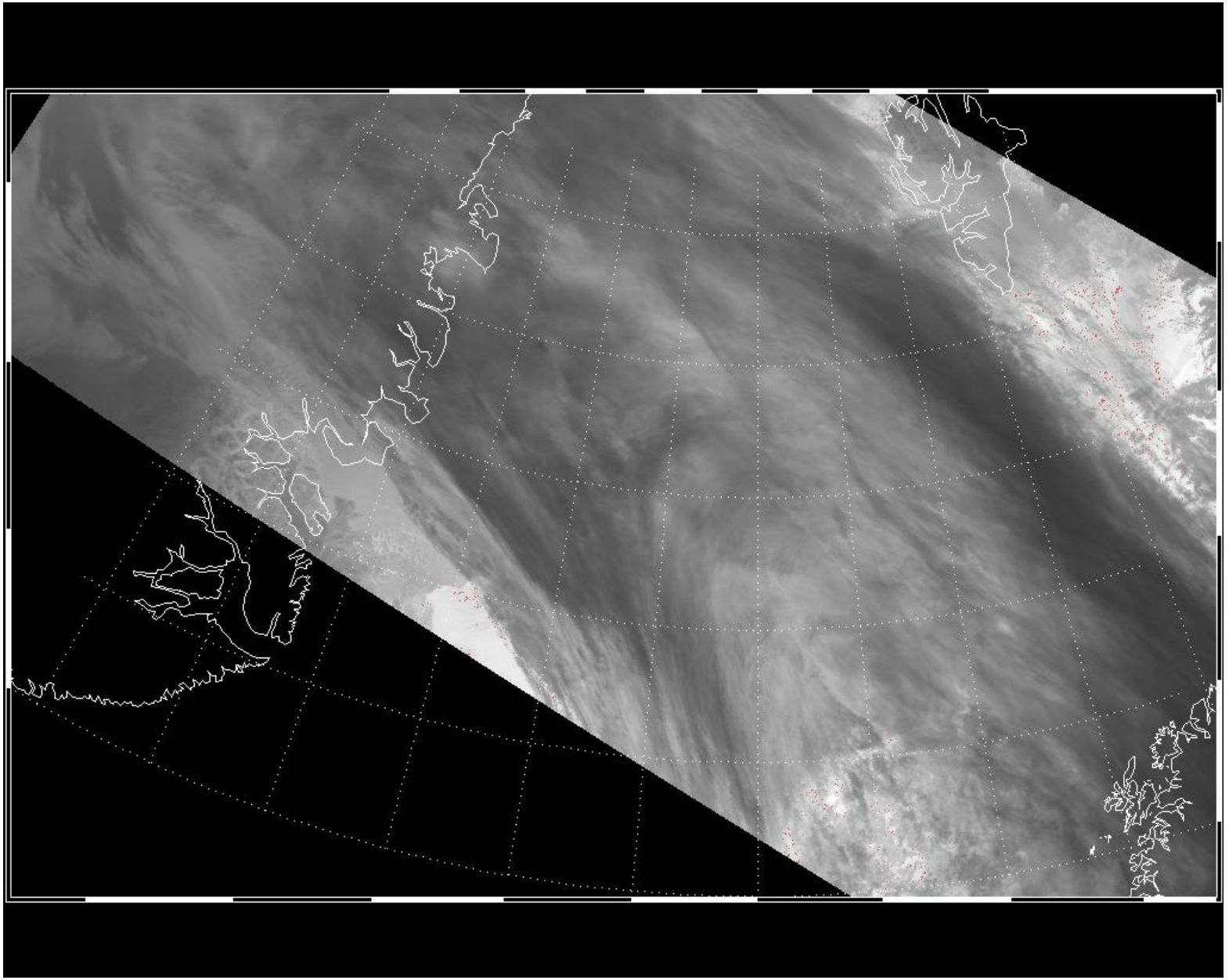
EXAMPLE

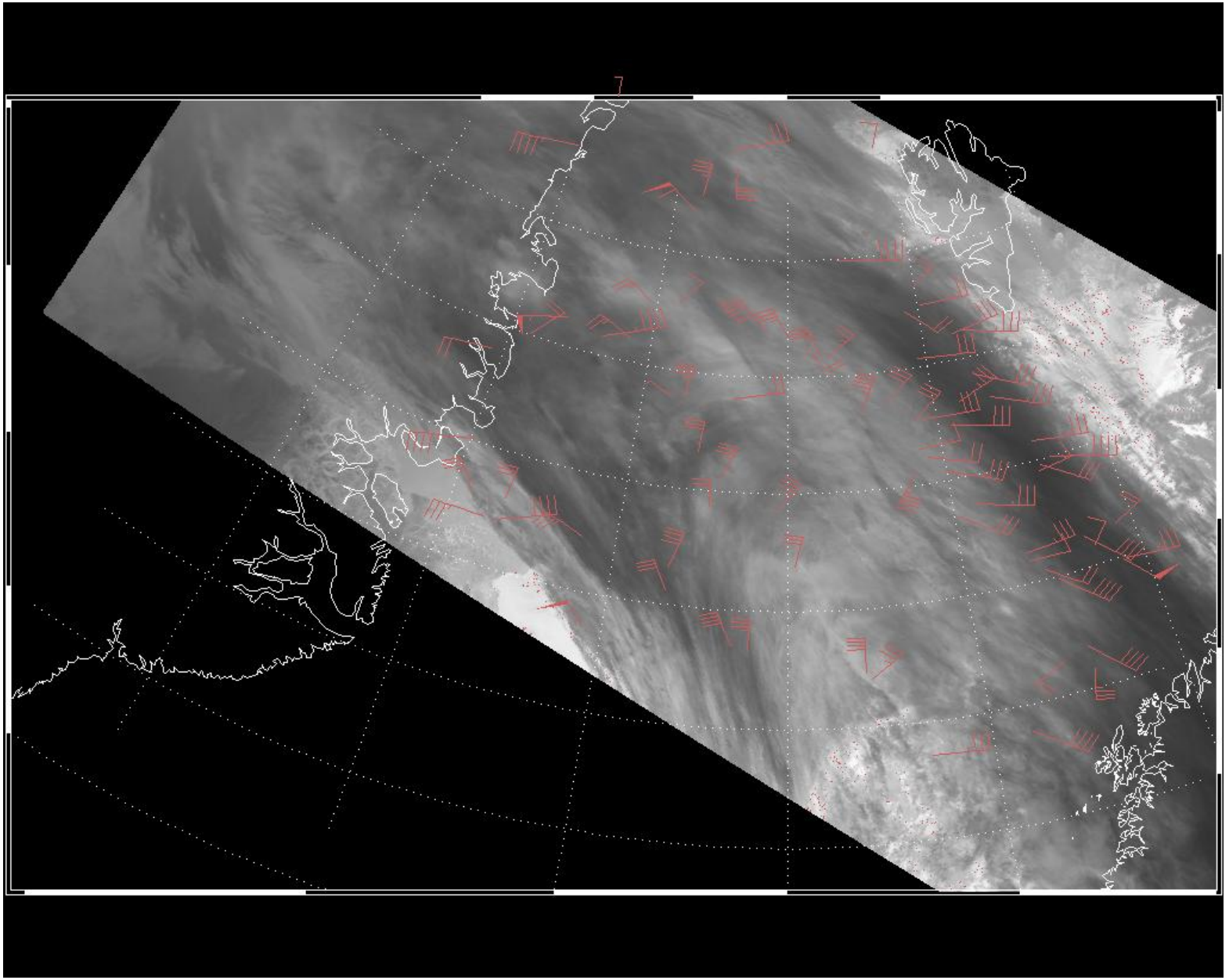
- AVHRR Level 1b target PDU , 20 February 2008, 11:25z-11:28z
- AVHRR Level 1b search PDUs, 9.40z – 9.49z
- PDU size: 1080 x 2048 pixels
- Target Area: 2 cases – 80 x 80 pixels
  140 x 140 pixels
- Search Area: 300 x 300 pixels
- Targets selected at grid positions 80 pixels apart

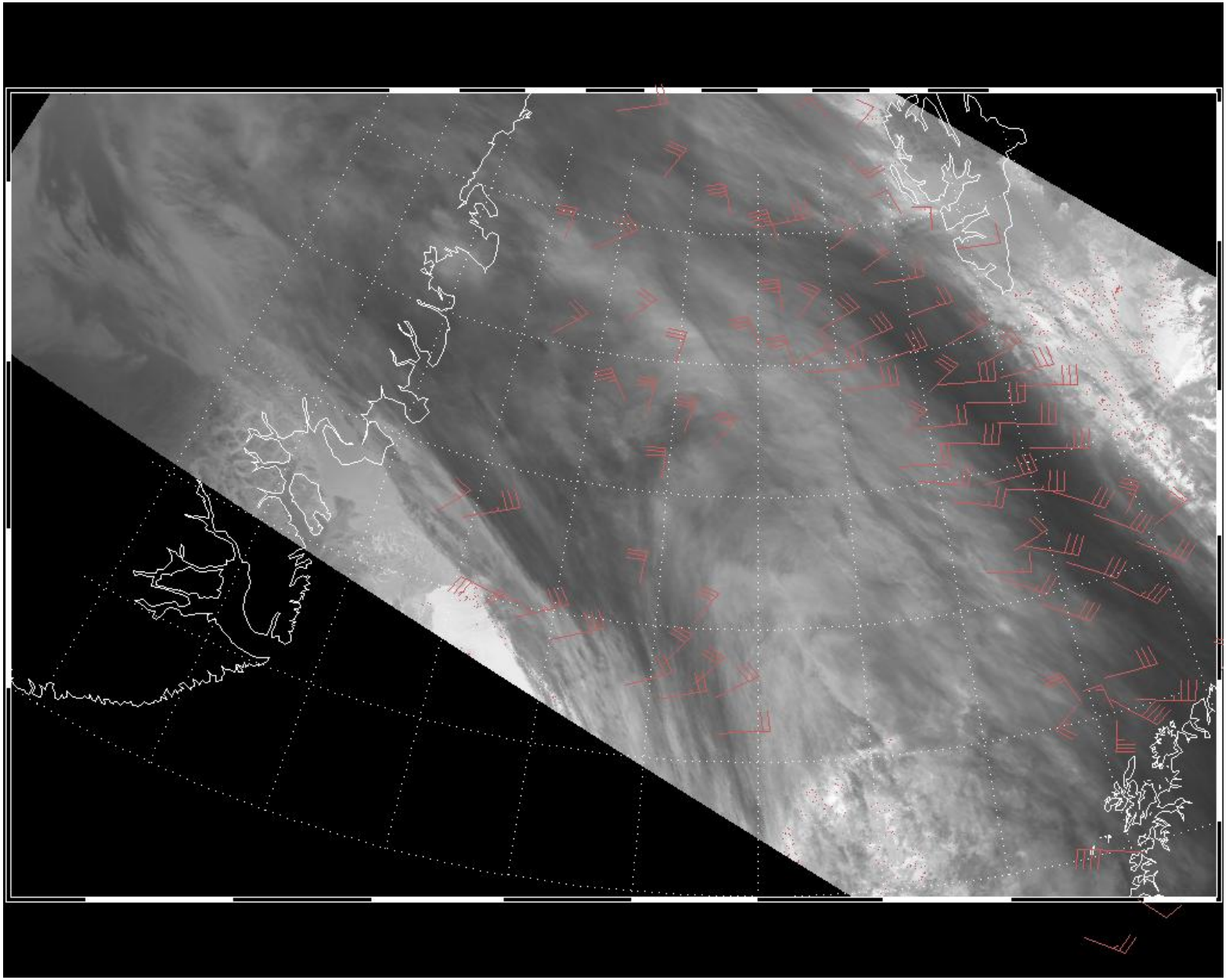












TIMING ISSUES

- Cross-correlation computationally intensive
- Spatial domain computation time for 140 x 140 target , search 300 x 300 typically about 300 times that compared to an MSG 24 x 24, search 80 x 80 target
- Use of the cross-correlation in the FFT domain will significantly reduce the run time
- Especially using the Mixed-Radix FFT, eg only use a data set of size 300 x 300 vs 512 x 512 for Radix-2 FFT
- Run-times typically less than 1% of spatial domain for these target sizes

HEIGHT ASSIGNMENT

- Basic IR window method – work well for opaque clouds
  - select a certain percentage of coldest pixels
  - use dynamic clustering method to select a suitable scene
- Use forecast temperature profiles
- Allow for temperature inversion
- Use of Recursive Filter Function (RFF) – a function used for Automatic Quality Control which provides a recursive filter analysis of the derived wind field using background forecast data and adjusts the height assignment of the wind to provide a best fit
- Use of other METOP instrument data

PARALLAX

- Apparent position displacement of a feature above the ground that results from non-nadir viewing angles
- Shift in terms of distance and direction of wind over the geoid
- Important consideration for winds generated from successive orbits as the viewing geometry changes from orbit to orbit

QUALITY CONTROL

- Use forecast wind profiles
- Spatial Consistency checks
- Temporal consistency more difficult as just a single component of wind
- Forward correlate the target from the search orbit to the target orbit
  - new position compared to original target location provides an indication of quality
- Calculate height assignment for the target position in both orbits

OTHER INSTRUMENT DATA

- IASI (Infra-red Atmospheric Sounding Interferometer) instrument on board METOP-A
- IASI produces cloud top height information
- AVHRR data is already used to support geo-location of IASI products
- Co-registration information available
- IASI resolution 12 km nadir
- Quality test – compare brightness temperatures as an indication of usefulness of the cloud top height

- METOP-B planned to be launched in 2011
- Potential to combine images from 2 satellites to provide better quality winds

VALIDATION

- Compare CIMSS code generated winds and the EUM PPF winds
- Limited use of radiosonde co-locations in the polar regions
- NWP assimilation experiments to assess impact on forecast models

THE NEXT 2 YEARS

- Currently, we are at the very early stage of the EUMETSAT AVHRR polar winds production
- Goal of EUMETSAT is to provide the best quality AVHRR polar wind product, investigating the techniques summarised in this talk and the techniques well established in the CIMMS polar wind production software
- The AVHRR polar winds will become an operational Day-2 product earliest end 2008
- Over the next two years aim will be to fine tune and investigate the techniques previously discussed