PPS Cloud Products

Summary of recent development and validation efforts + outlook

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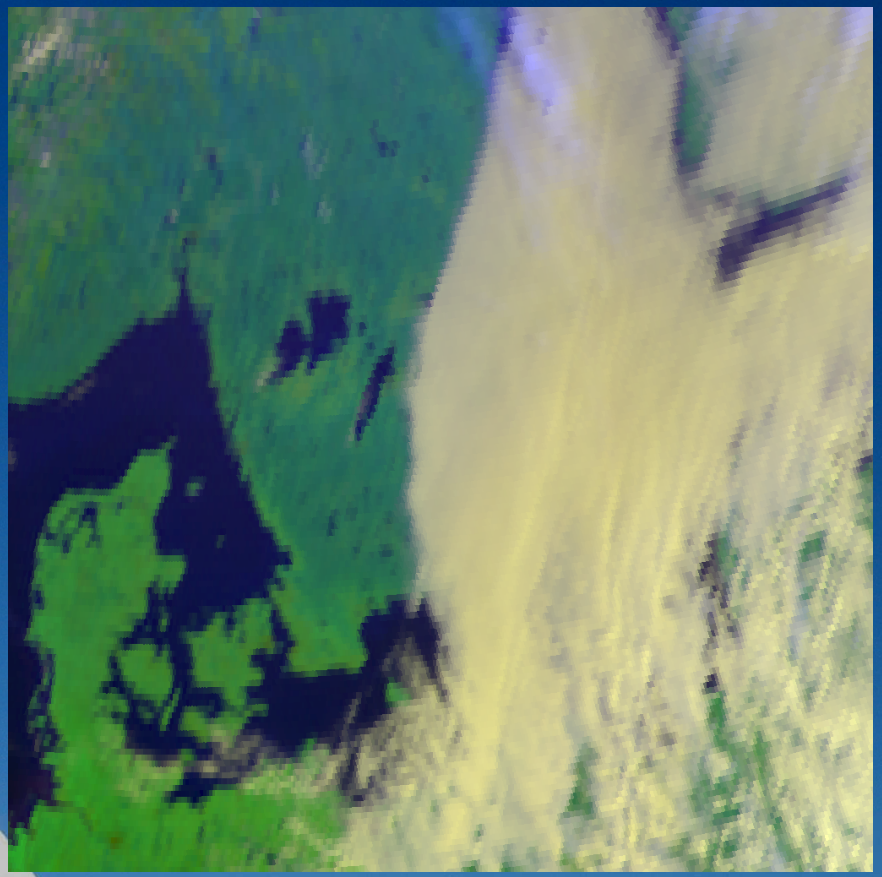
SMHI, #: University of Wisconsin

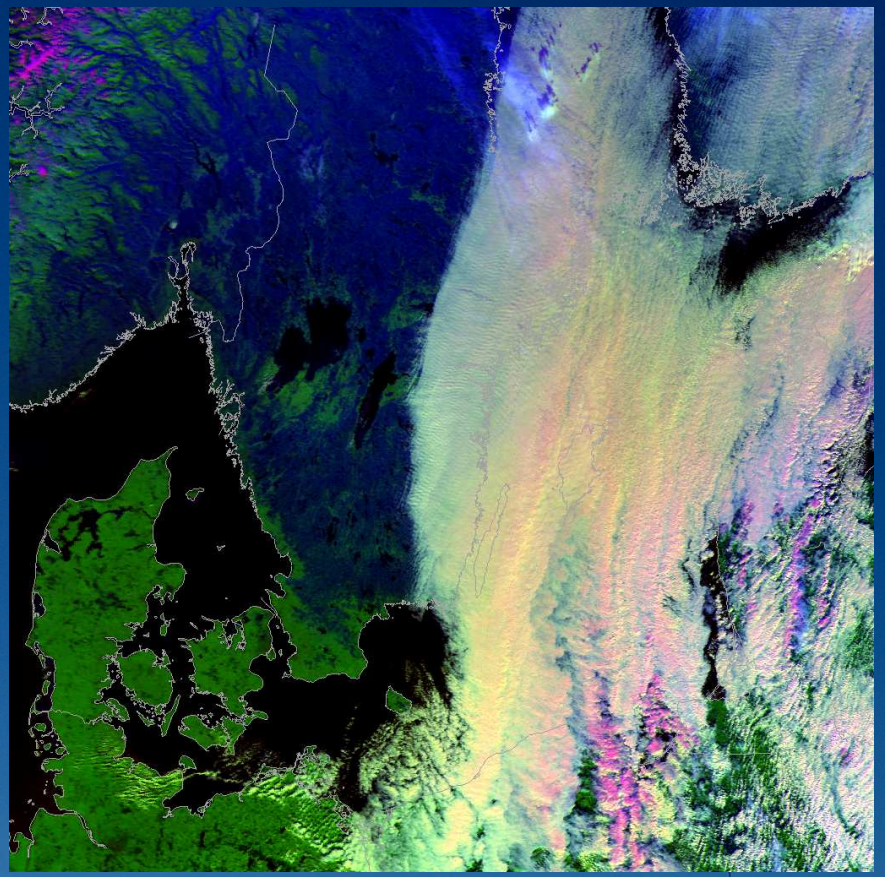
- Introduction
- Summary of recent validation results
  - PGE01&02 – Cloud Mask & Type
  - PGE03 - CTTH
  - PGE04 - Precipitating Clouds
- Ongoing validation activities – Cloud Mask
- Planned updates for 2.x

SEVIRI RGB ch 1,2,9



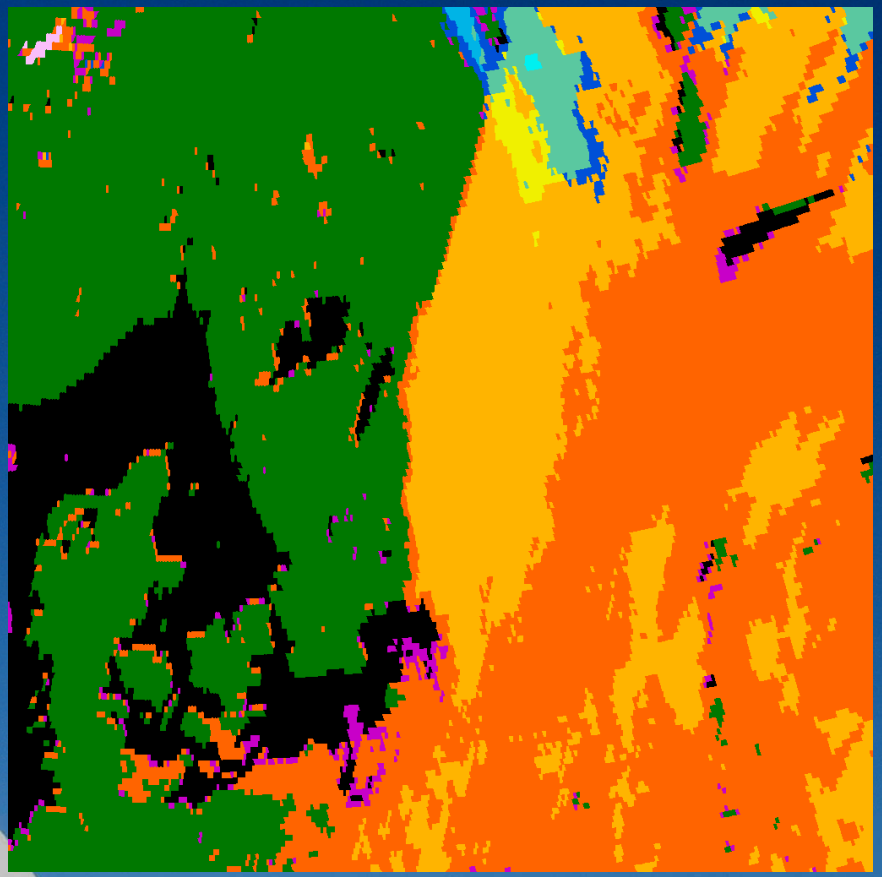
Met08 2005-10-16 09:45 UTC

AVHRR RGB ch 1,3A,4



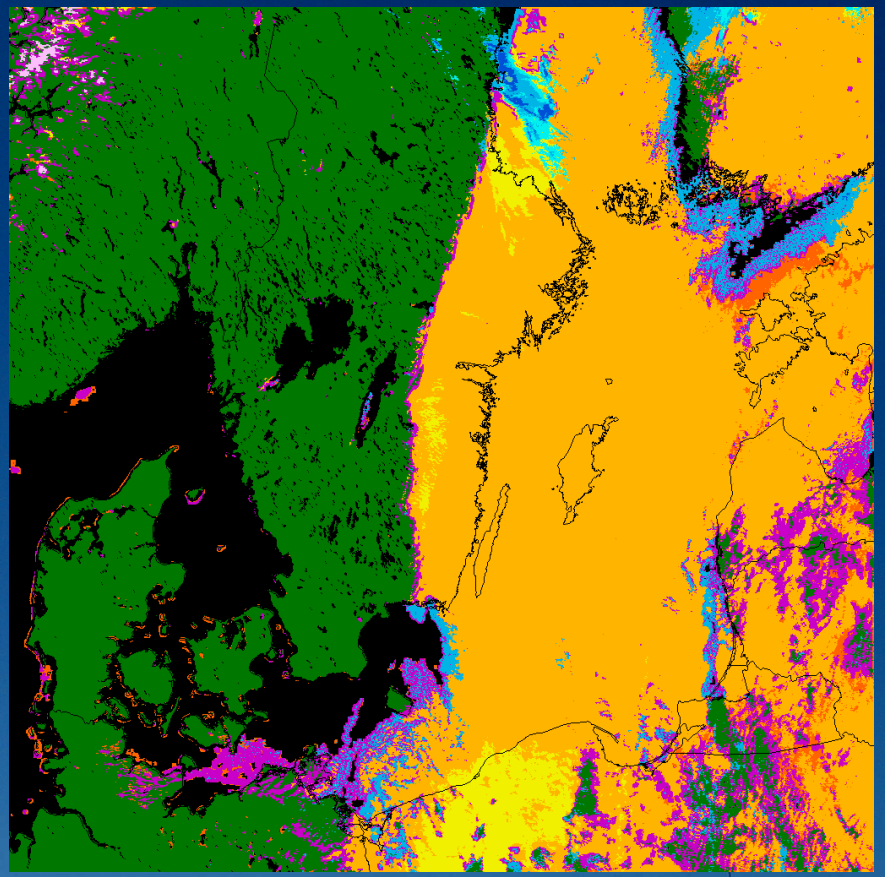
NOAA 17 #17209 2005-10-16 09:36 UTC

SEVIRI Cloud Type



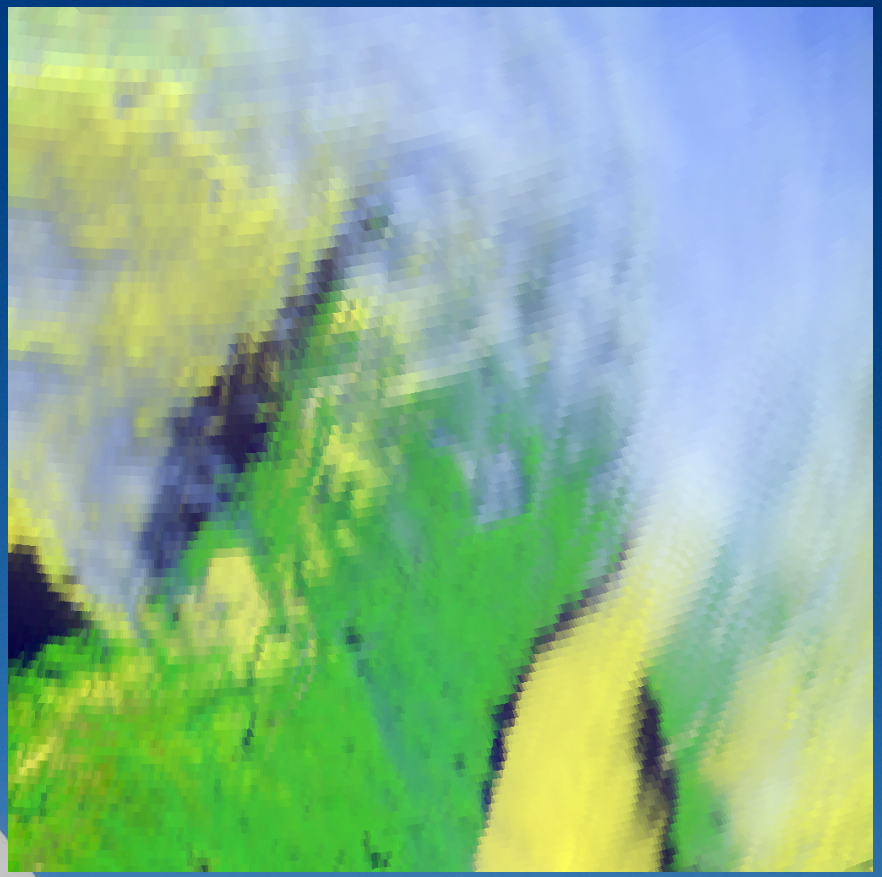
Met08 2005-10-16 09:45 UTC

AVHRR Cloud Type



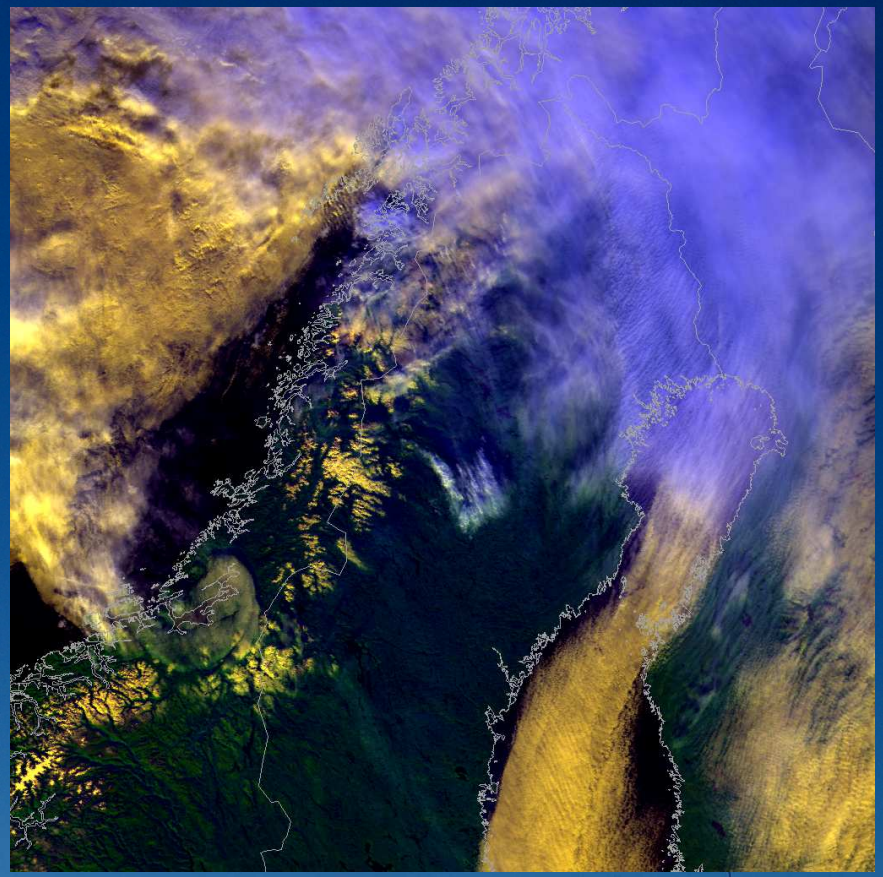
NOAA 17 #17209 2005-10-16 09:36 UTC

SEVIRI RGB ch 1,2,9



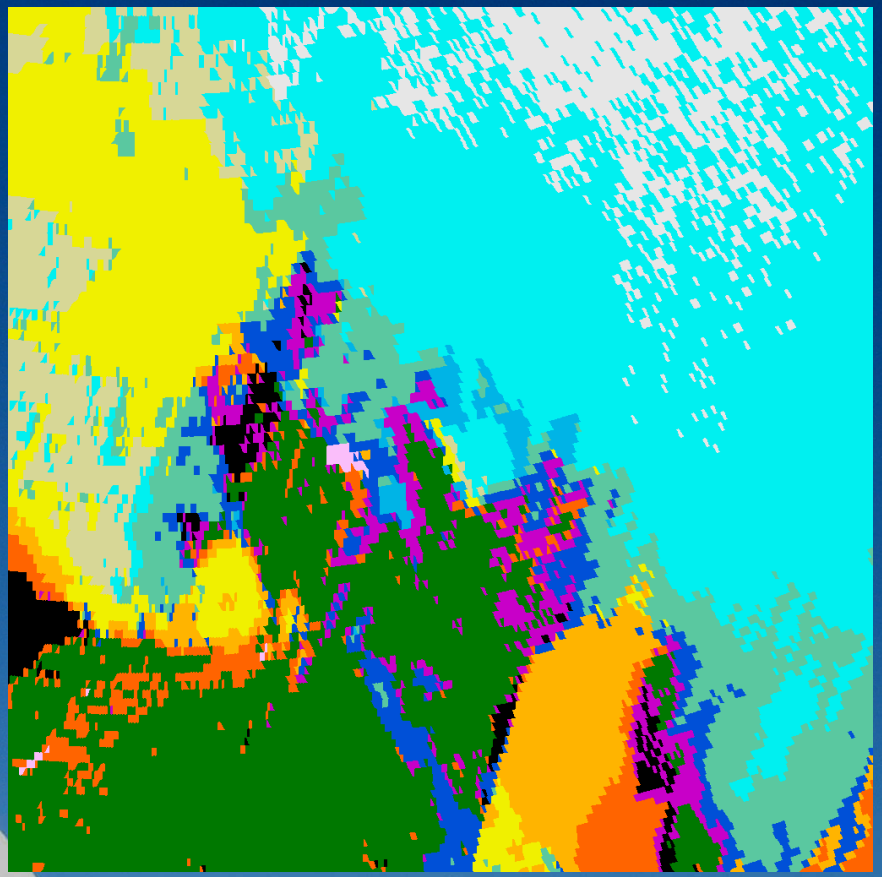
Met08 2005-10-16 11:30 UTC

AVHRR RGB ch 1,2,4



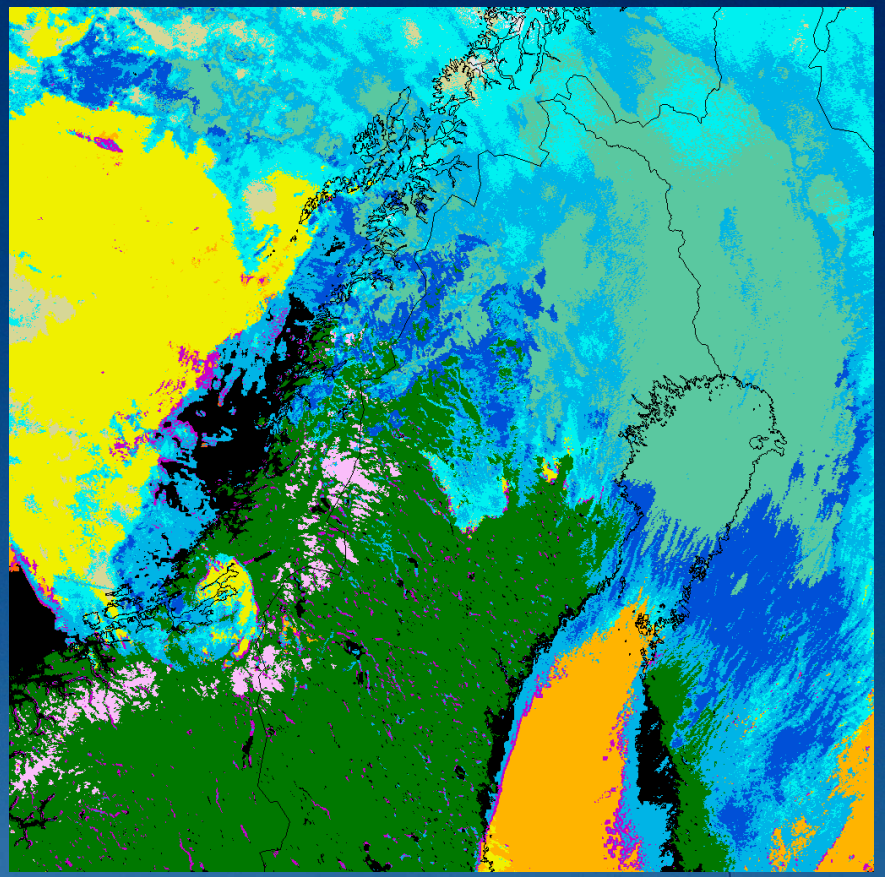
NOAA 18 #2102 2005-10-16 11:31 UTC

SEVIRI Cloud Type



Met08 2005-10-16 11:30 UTC

AVHRR Cloud Type



NOAA 18 #2102 2005-10-16 11:31 UTC

Timeline:

- PPS **v0.2.0** August 2002 - First release to β-users
- PPS **v0.3.3** August 2003 – β-release to review
- PPS **v1.0** June 2004 – First official release
- PPS **v1.1** June 2005 – 1 year of validation
- PPS **v1.1-patch3** September 2005 – N18 patch
- PPS **v2.0** July 2006
- PPS **v2.1** February 2007

Summary of code updates – PPS 1.0 – PPS 1.1-patch3:

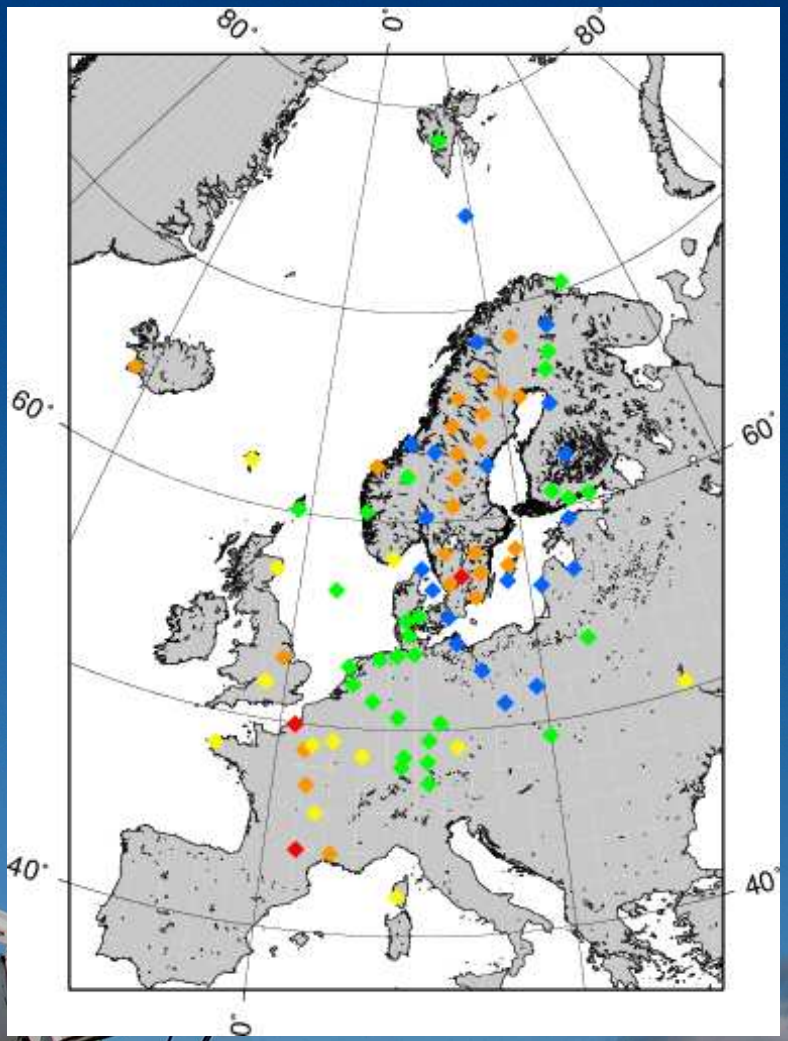
- NWP library improvements and bug corrections
- Cloud Mask desert adaptations
- Updates to PGE04 including MHS adaptations
- Szlib support
- Support for hl-hdf debug-message parsing
- Removing memory leaks - PGE03 & 04 + common library
- Adaptations to Intel Fortran version 8.0 (ifort) on Linux
- New facility to check if compilation was successful
- Added support for automatic html page generation
- Compatibility with Python 2.3
- Various minor bug-fixes

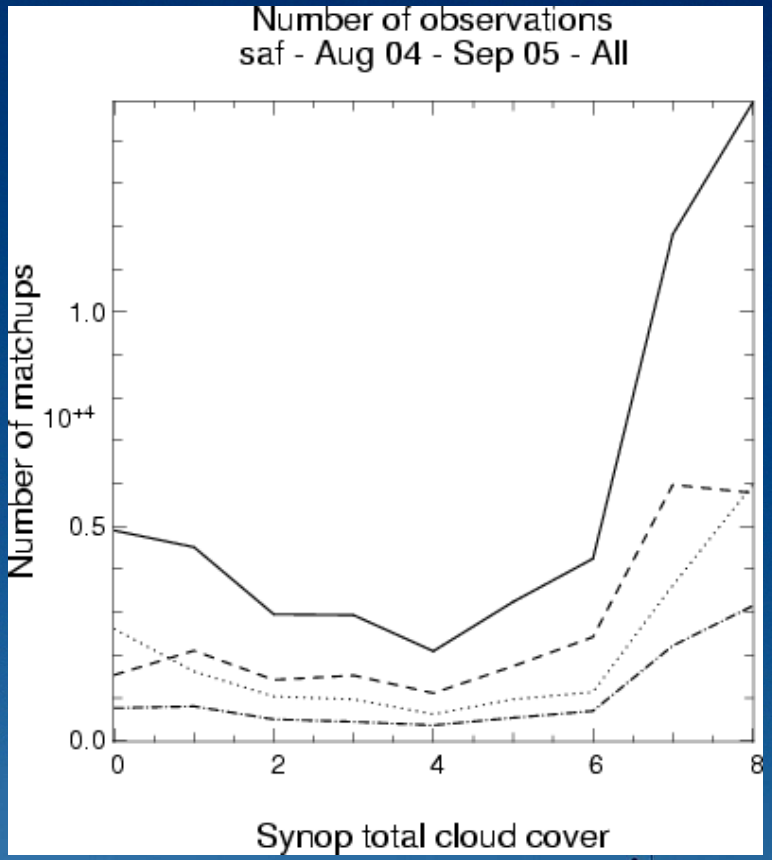
See list of SPRs/SMRs at the NWCSAF Help Desk

Synop based matchup database – MSMS
New version running since July 2004

Number of matchups:

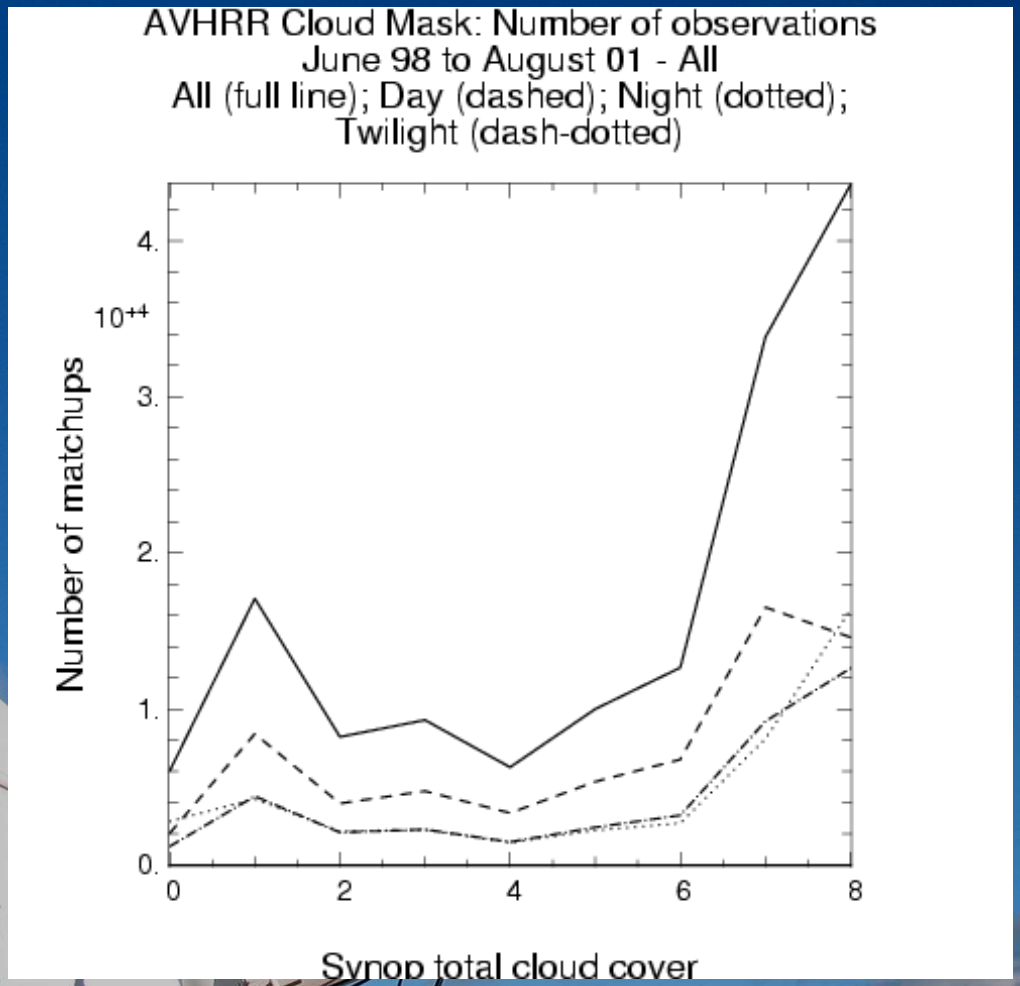
- < 200
- 200-400
- 400-600
- 600-800
- > 800

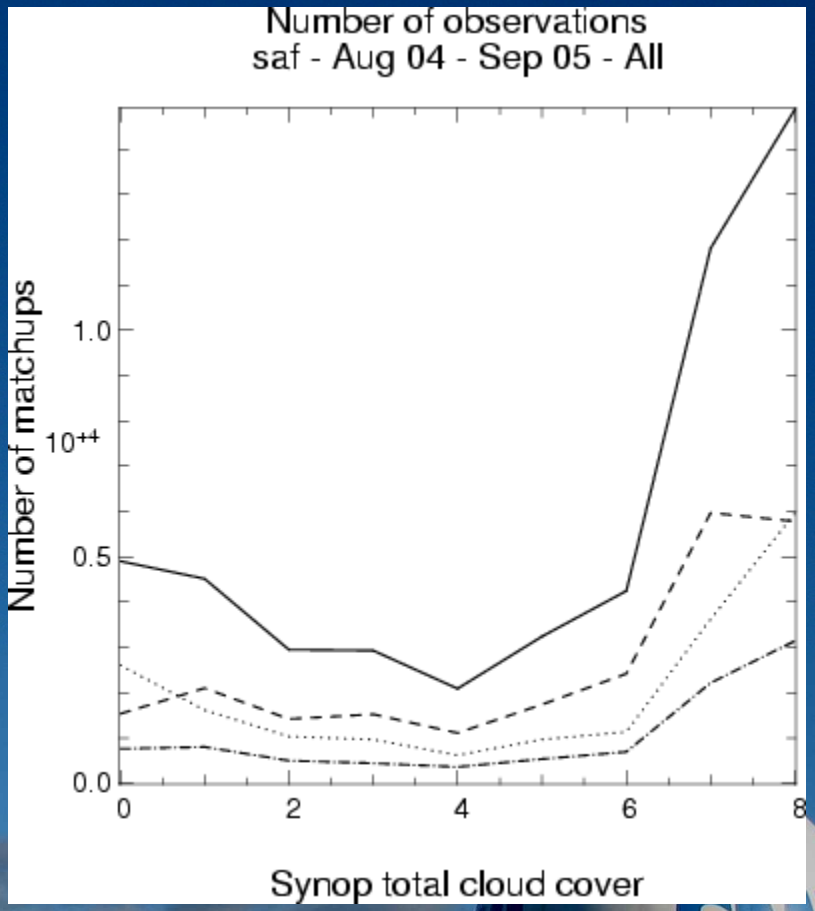




All: full line
Night: dotted
Day: dashed
Twilight: dash-dotted

Old versus new MSMS database



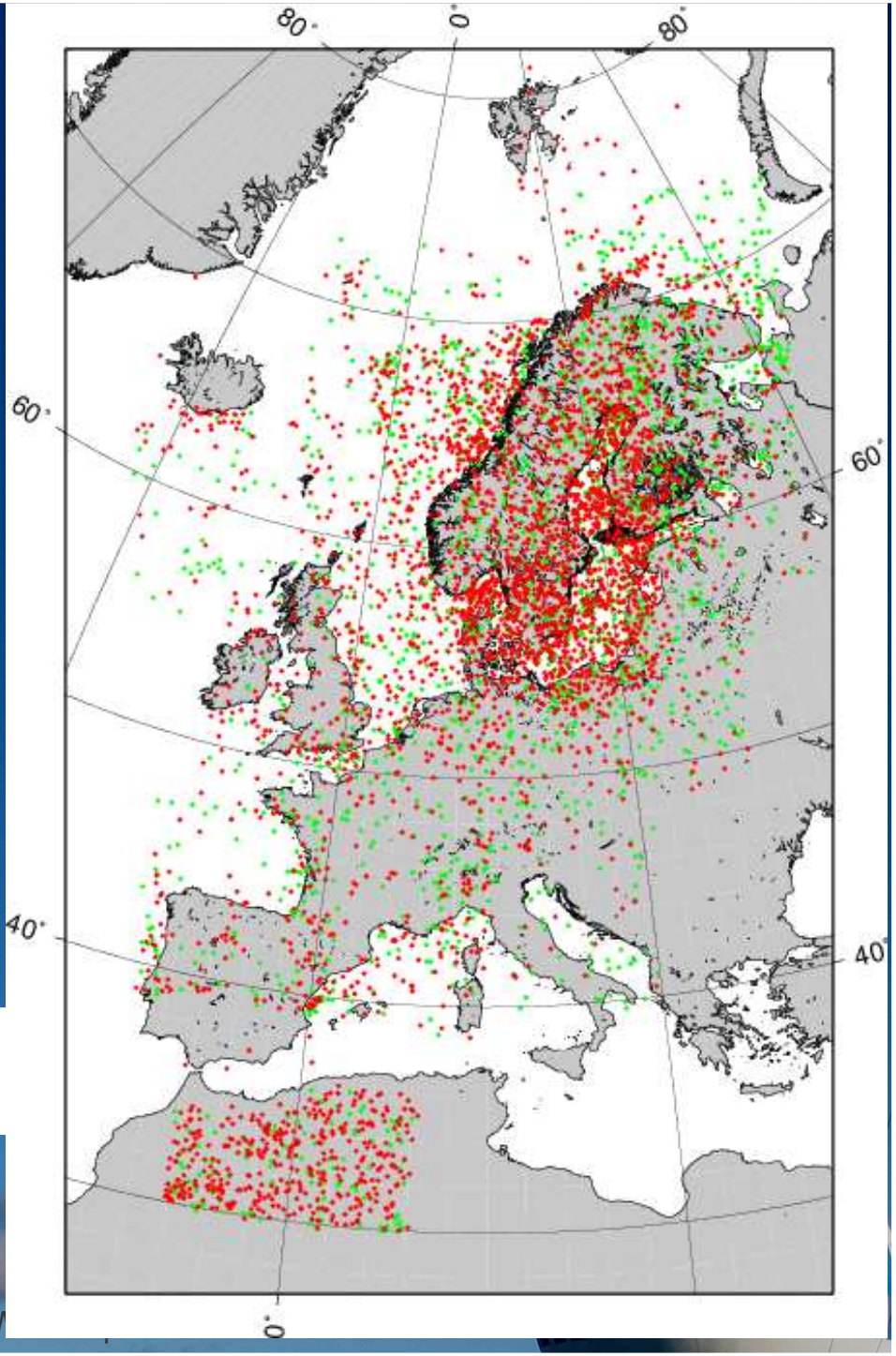


Interactive Training & Validation Database

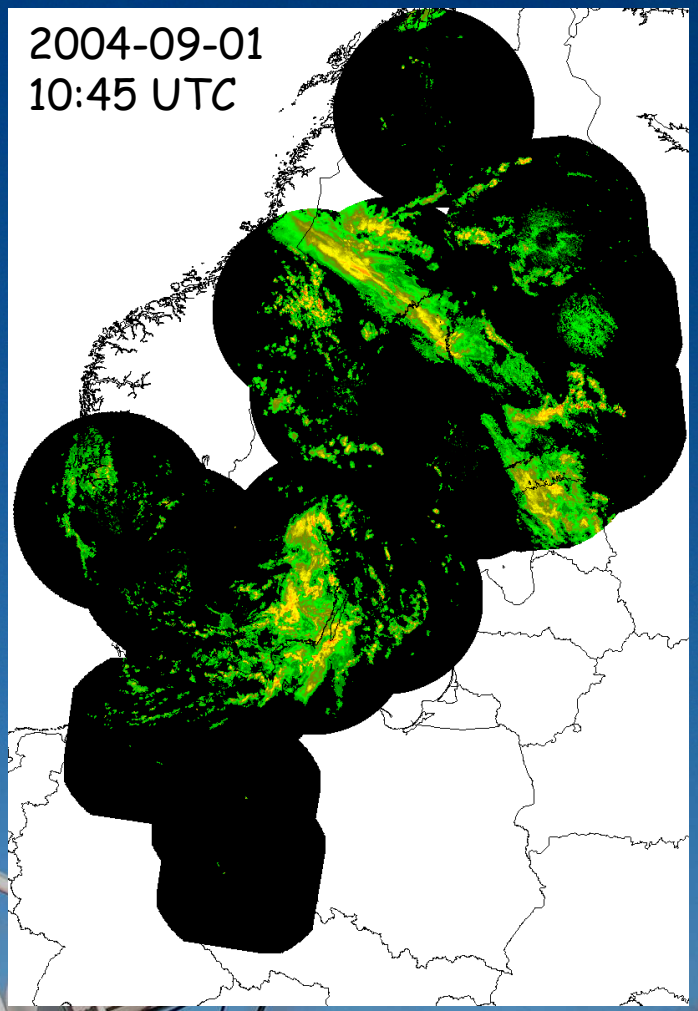
Totally 5544 targets as of 2004

Green: Channel 3A

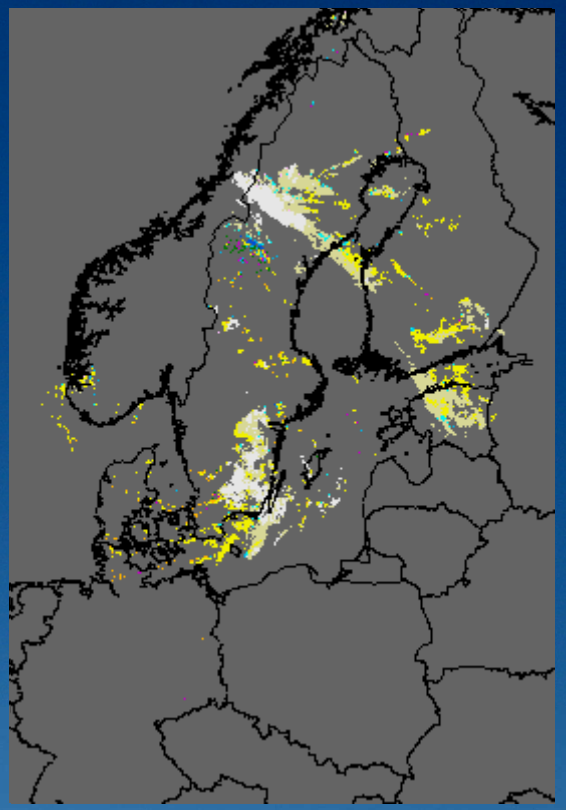
Red: Channel 3B



Nordrad Weather Radar composite – collocated in time with AVHRR data: **3234 NOAA overpasses July'04 to Sep'05**



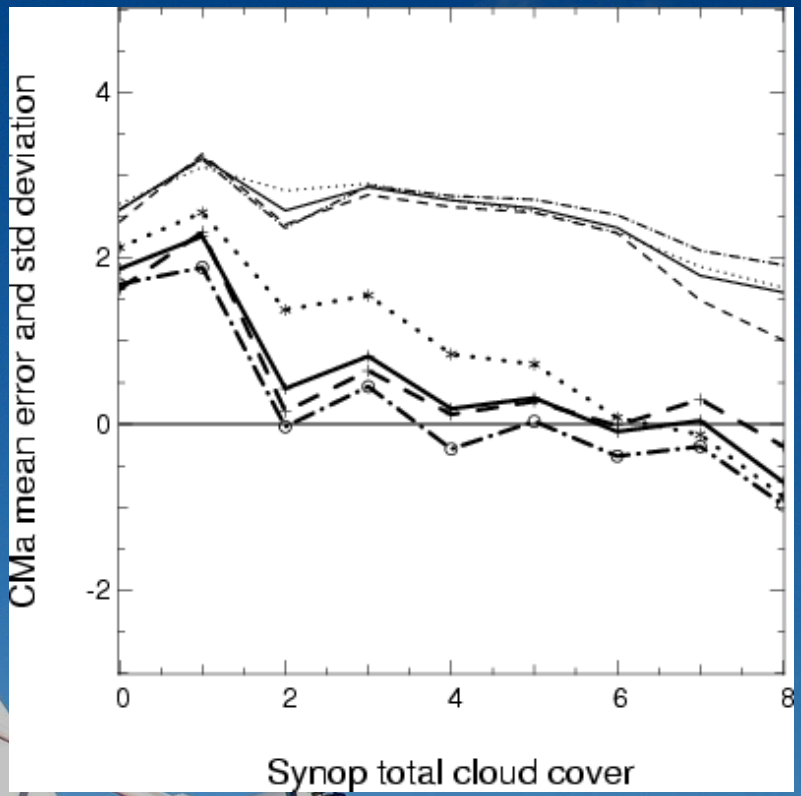
Noaa17 2004-09-01 10:39 UTC



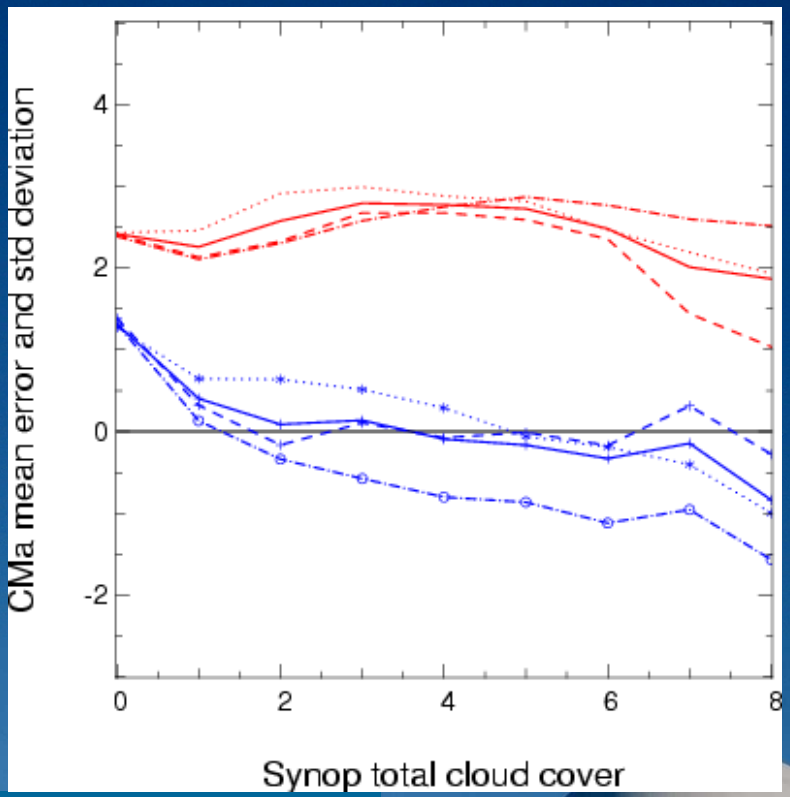
Cloud Type data corresponding to reflectivities greater than 10 dBZ

Cloud Mask – Mean error and stdv as compared to Synop

Pre pps 1.0: 34 Months from July 1998 to August 2001



PPS 1.1: August 2004 to September 2005



All: full line Night: dotted
Day: dashed Twilight: dash-dotted

Synop based validation scores:

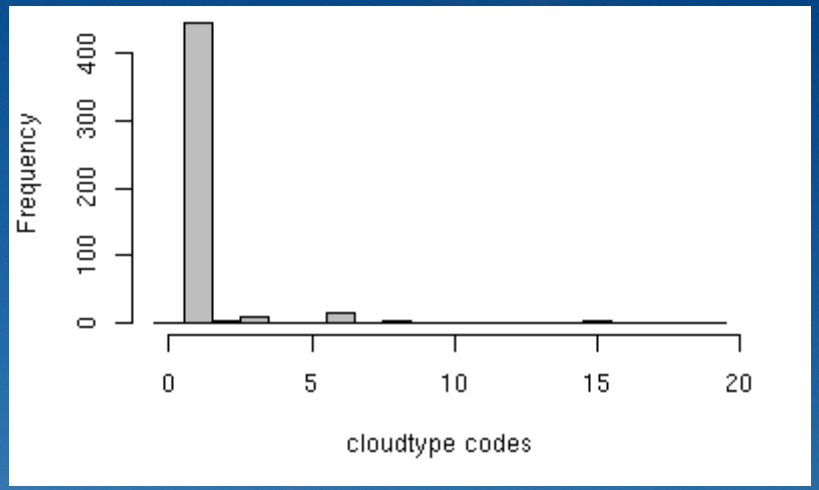
	MA	Hit rate	Bias (%)	Pod cloudy	Far cloudy	Pod clear	Far clear	N
All	1.51	0.904	-1.2	0.946	0.082	0.809	0.130	51566
Day	1.33	0.941	1.9	0.961	0.040	0.882	0.115	23591
Night	1.57	0.889	-0.7	0.922	0.090	0.826	0.153	18524
Twilight	1.84	0.845	-9.7	0.955	0.171	0.650	0.109	9451

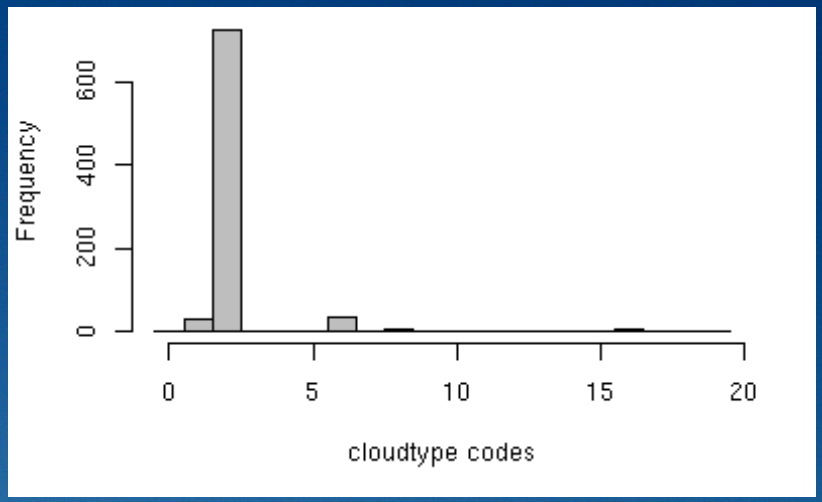
Validation using interactive target database:

	Algorithm result				
Manual classification	**Sea**	**Snow**	**Cloud**	**Land**	**N**
Sunglint	28.7	0.0	69.3	2.0	13962
Sea	90.5	0.2	6.0	3.3	72044
Snow	6.2	55.8	18.4	19.6	34724
Cloud	2.8	1.7	91.6	4.7	385656
Land	1.0	3.1	4.4	91.5	46052

Interactive training target database:

Cloudfree



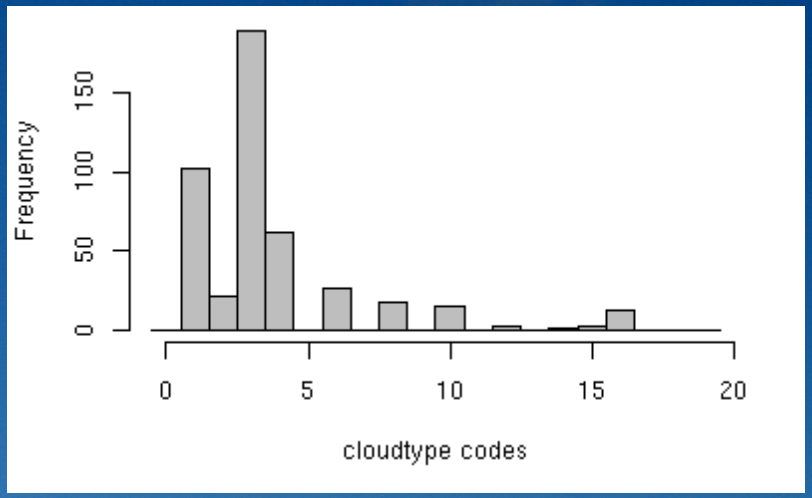


Cloud free land: 479 targets

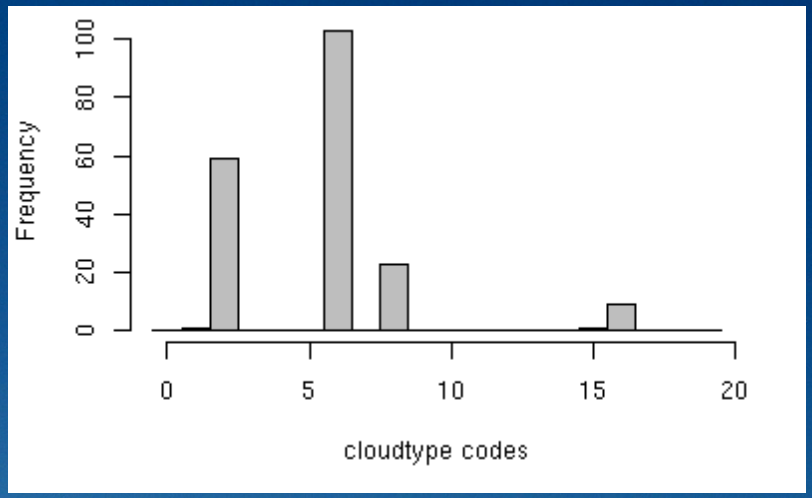
Cloud free sea: 799 targets

Interactive training target database:

Cloudfree – Snow/Sea ice and Sunglint



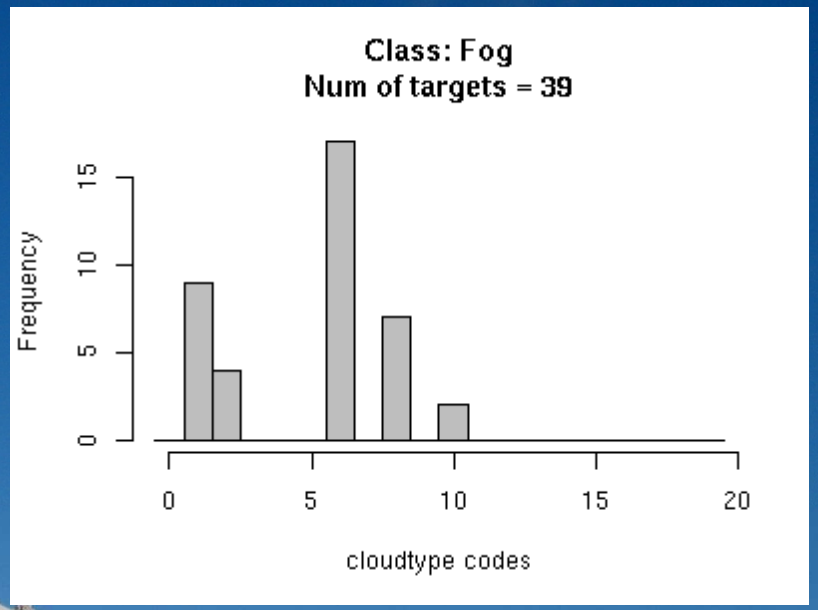
Cloud free with snow/sea ice cover: 454 targets

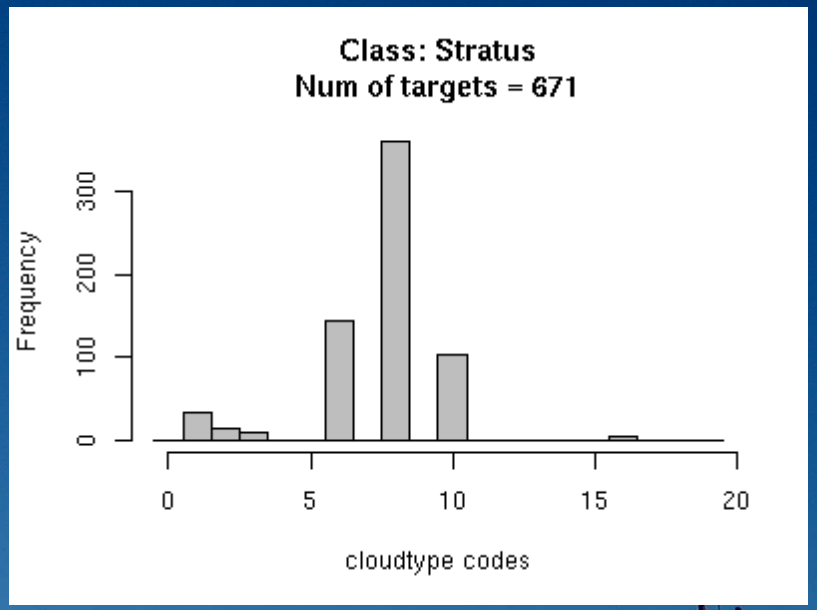


Cloud free with sunglint: 196 targets

Interactive training target database:

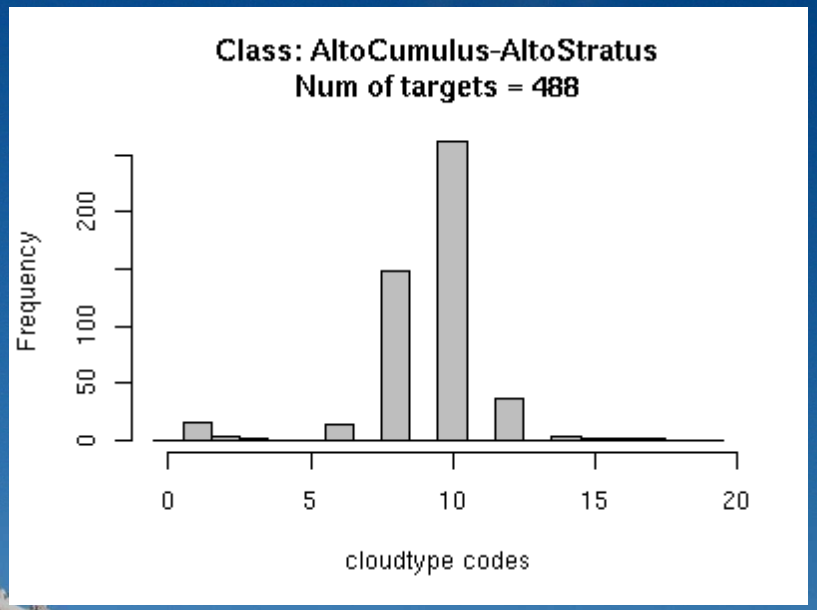
Fog and Stratus

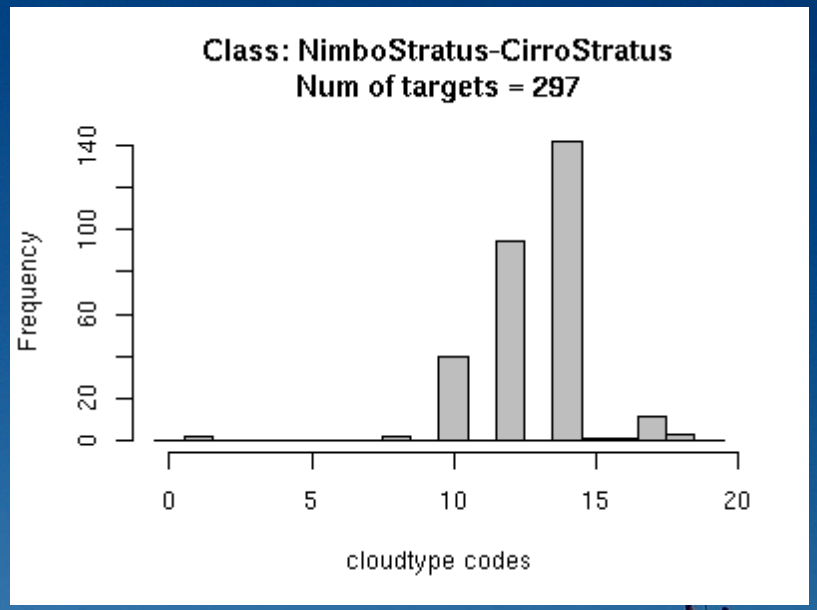




Interactive training target database:

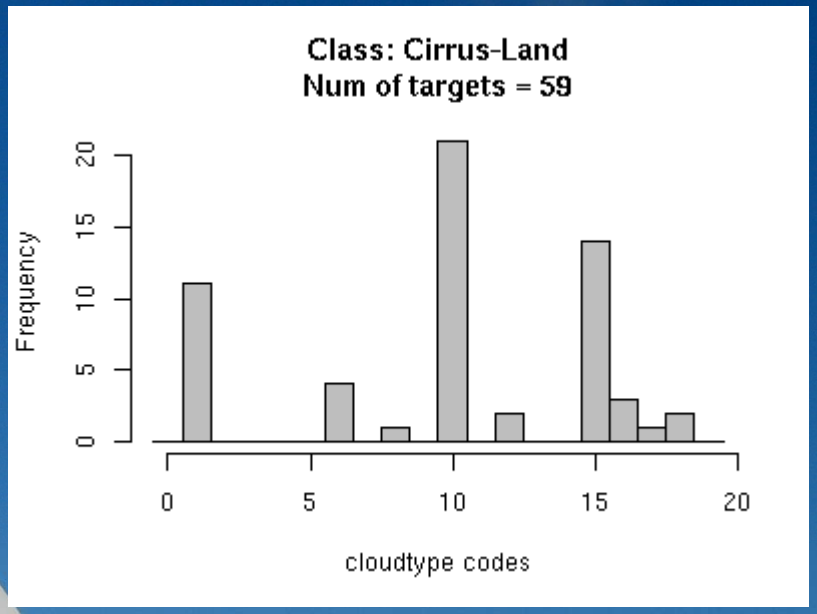
Mid and High level clouds

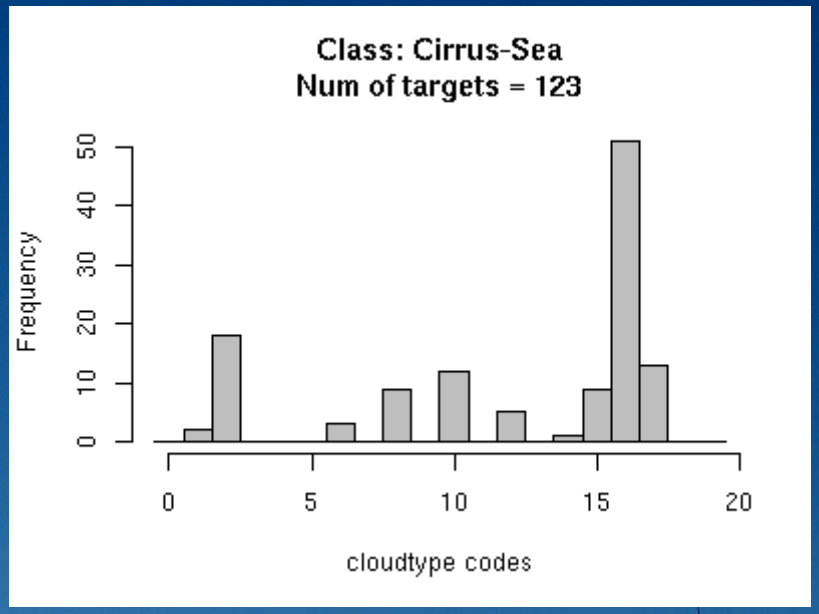




Interactive training target database:

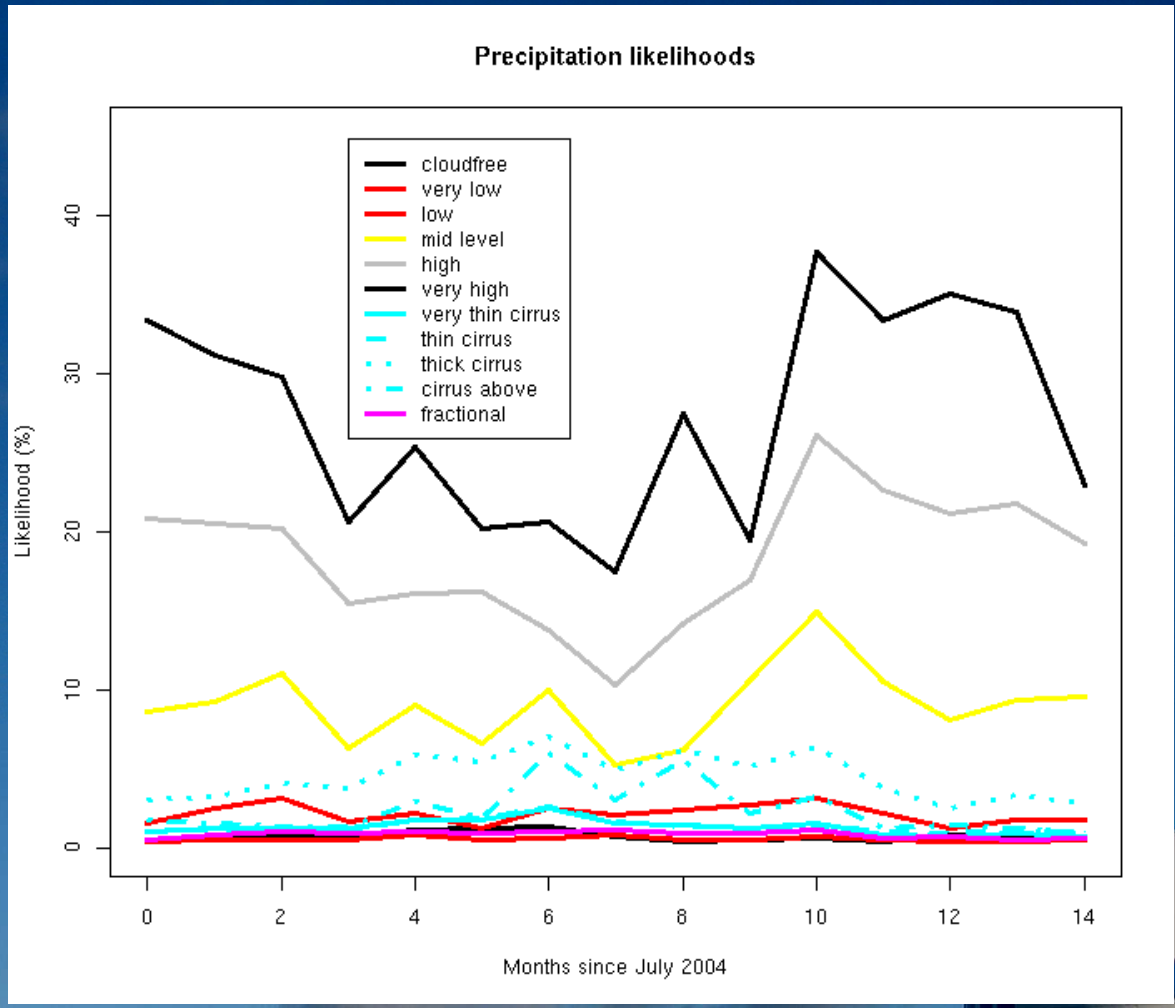
Cirrus clouds





Which Cloud Types are likely to precipitate according to Weather Radar? – *A sanity check*

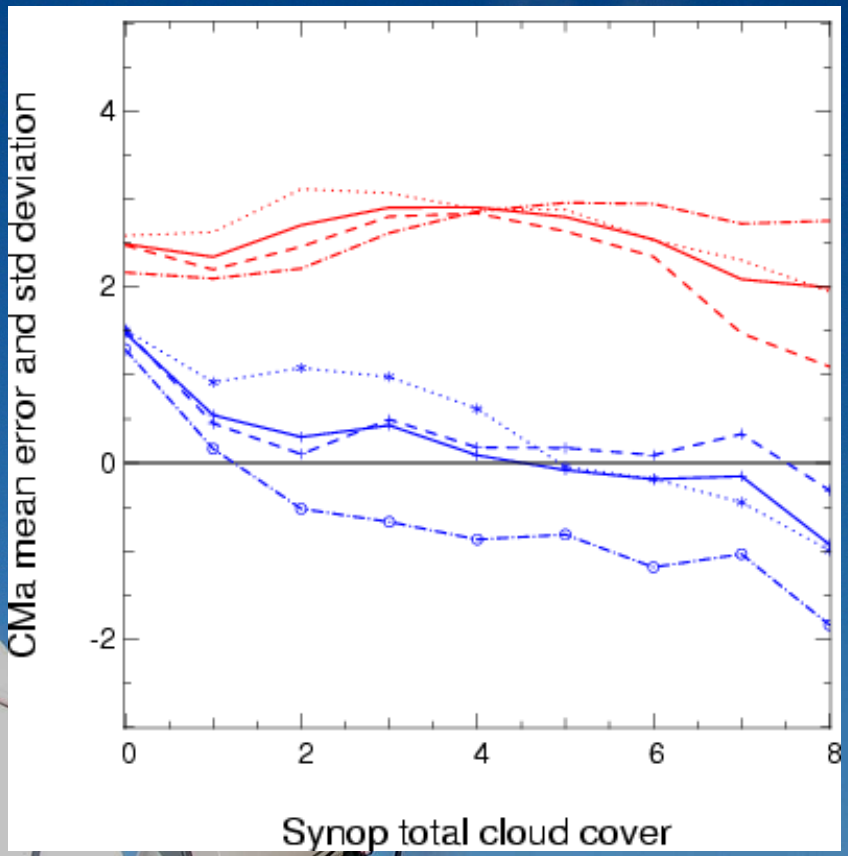
Precipitation likelihoods in %: July 2004 – September 2005



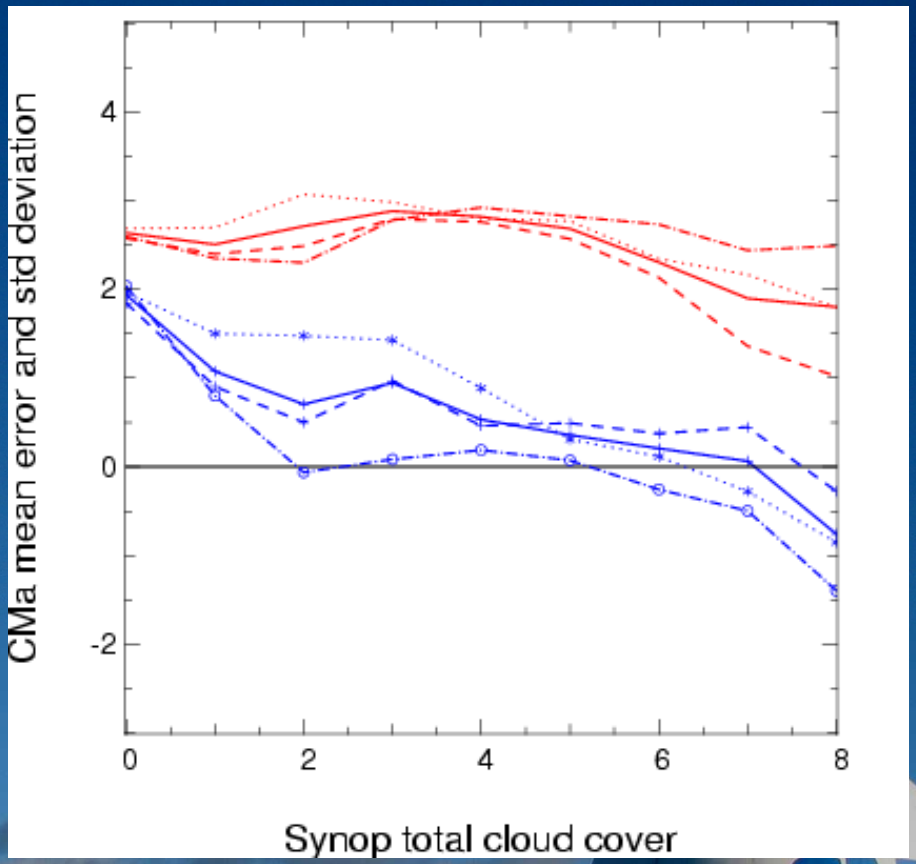
Effects of narrowing the coastal zone at SMHI

December '04, March '05, June '05, September '05

Default coast: ~20 km



Narrow coast: ~6-8 km

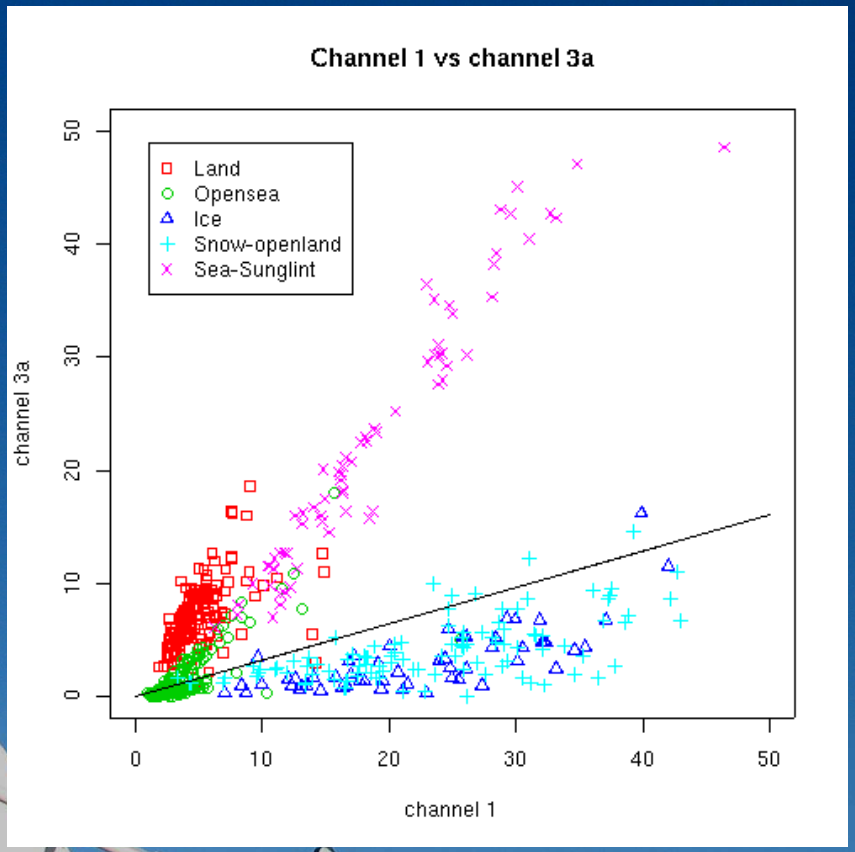


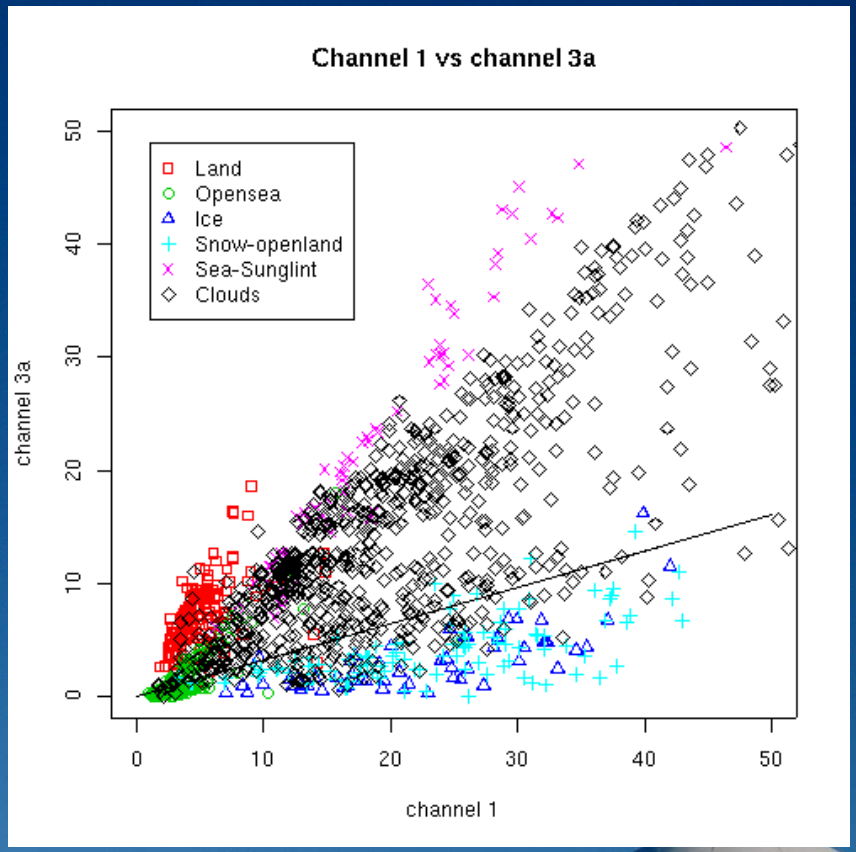
Effects of narrowing the coastal zone at SMHI

December '04, March '05, June '05, September '05

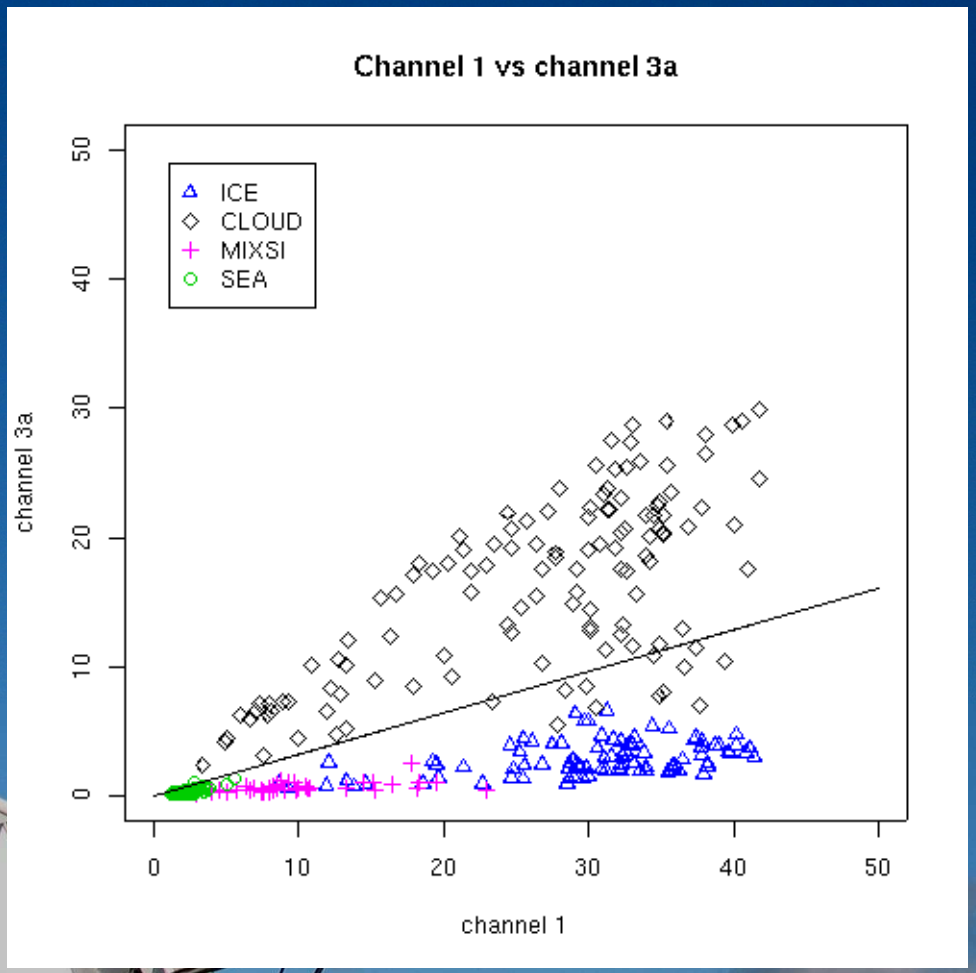
	Ma	Hit rate	Bias (%)	POD cloudy	FAR cloudy	POD clear	FAR clear	N
Default coast	1.58	0.891	-0.2	0.935	0.092	0.796	0.150	16369
Narrow coast	1.57	0.896	3.8	0.924	0.068	0.825	0.193	16369

1.6μm discrepancy: Some clouds look like snow/ice





Occasional problems mis-classifying clouds as cloud free snow/ice using channel 3A



Met.no matchup database: 350 targets collected during spring 2003

Courtesy: Vibeke Thynes & Steinar Eastwood, met.no

Cloudy targets with a NIR/VIS snow signal: Ch3A/Ch1 < 0.32

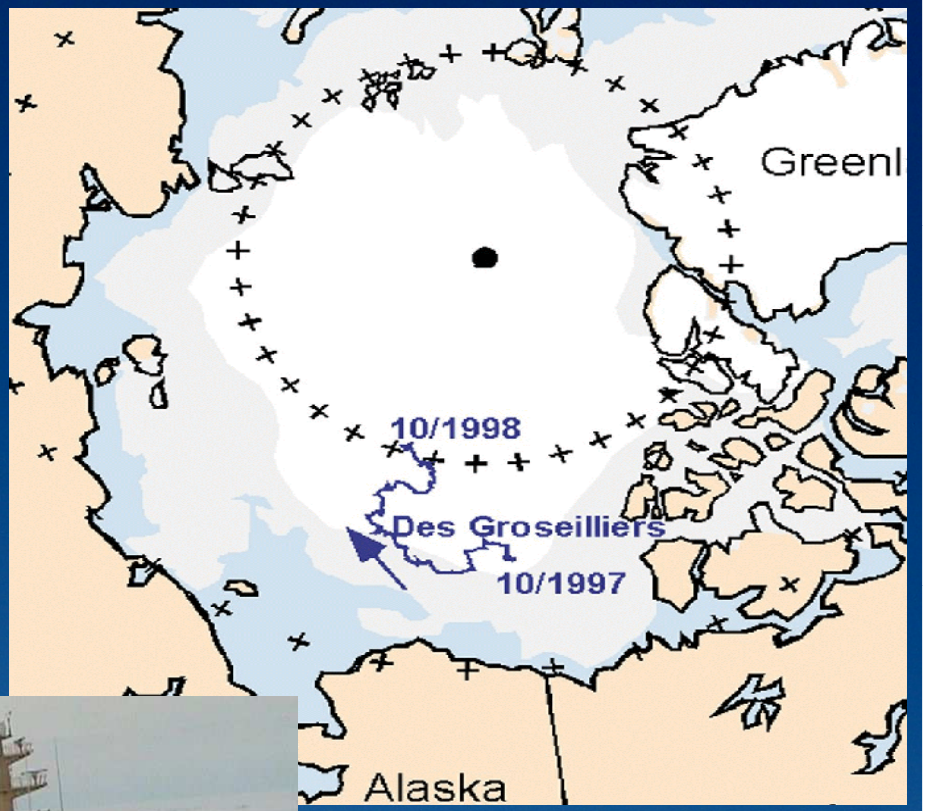
Out of 3258 (628 cloudy) targets **50 cloudy** targets had a Ch3a/Ch1 < 0.32:

- 3 Ac (PPS ok)
- 5 Cb (PPS ok)
- 2 Extensive Cb (PPS ok)
- 3 Ns (PPS ok)
- 1 StSc (PPS ok: Partly cloudy)
- 1 Broken Sc-Land (PPS ok: Partly cloudy)
- 2 Ci-AcAs (PPS ok)
- 5 Ci-StSc (PPS ok)
- 10 Ci-ice (PPS: only 1 cloudy)
- 7 Ci-sea (PPS: 1 cloudy + 1 partly cloudy)
- 13 Ci-snow (PPS: 2 cloudfree + 3 partly cloudy)

Arctic validation study using SHEBA data

SHEBA: October 1997 – October 1998

Based on an icebreaker, frozen into the ice pack North of Prudhoe Bay, drifting W & N across the Beaufort & Chukchi Seas (2800 km total w/a 770 km net displacement)



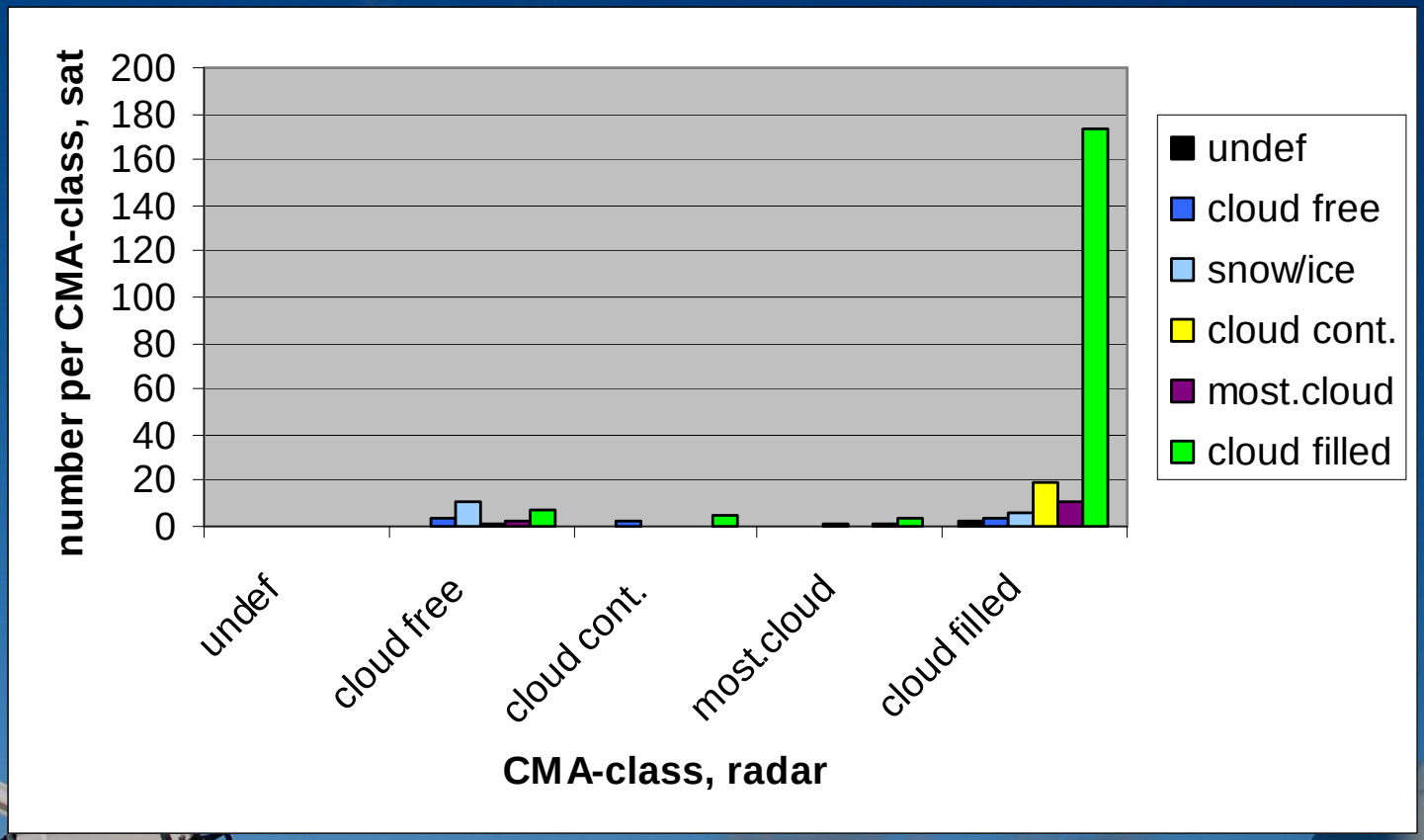
Courtesey Janet Intrieri, NOAA/ETL

Arctic validation study using SHEBA data

- N12 & N14 LAC data
- Summer of 1998 (no winter cases selected due to too high noise levels in NOAA data)
- Overall validation of PPS (using ECMWF forecast data) against combined Lidar & Cloud Radar product
- A very cloudy dataset (>90% mean cloud cover)!
- Identifying problematic cases (mainly where PPS mistakes cloudfree for cloudy)

Arctic validation study using SHEBA data

Summary results:



Arctic validation study using SHEBA data

Summary results:

	N	Sat: cloud free + snow	sat: partly + mostly + cloudy
Rad: cloud free	26	0.58	0.42
Rad: partly + mostly + cloudy	229	0.06	0.93

Summary Cloud Mask results:

- An overall small but insignificant (according to Synop) negative bias
  - But: Over detection over sea and under detection over land!!!
- A clear negative bias (-9.7%) and worst performance during twilight.
- Best skill over central Europe. Quality degrades towards the Nordic and Arctic conditions.
- Best performance over sea, and worst over coasts.
- Performs the best during day.
- On average a 1.5 octa overestimation of completely cloud-free situations (0 octa) and around 1 octa underestimation of overcast (8/8) situations.
- Partly cloudy skies: 1 octa underestimation at twilight and small overestimation at night.
- Significant improvements over desert sands (northern Africa). But still frequently mis-classifying cloud-free land as low or mid level clouds.

Summary Cloud Type results:

- Consistency check successful: The *very low* and *low* opaque clouds, the *fractional* clouds and the *very thin* and *thin cirrus* clouds are not likely to precipitate.
- Broken cloudiness may be taken for *very low* and *low* opaque clouds as well as *very thin* and *thick cirrus.*
- Opaque mid to high level clouds (which may precipitate) may be mistaken for the categories *thick cirrus* and *cirrus above low/mid level clouds* .
- Significant overlap between the *fractional* cloud class and the categories *very thin* and *thick cirrus.* Sub-pixel water clouds are often mis-classified as cirrus.
- Significant overlap between *mid level* clouds and *cirrus above low/mid level* clouds.

PGE03 validation

- Lidar & Cloud Radar datasets
- Finnish Weather radar dataset

Conclusions from CTTH-Lidar inter-comparisons:

- A general much higher sensitivity of the Lidar for thin cirrus clouds. The AVHRR retrieval is unable to see many of the thinnest cirrus clouds detected by the Lidar. This makes comparison difficult.
- General underestimation of the height of semi transparent cirrus.
- The underestimation of the cirrus height occurs often when a fractional/broken cloud field is present as well.
- However, for single layer cloud fields the height retrieved by the satellite seems to be the correct one.
- A very limited dataset show very good agreement between the Lidar and the CTTH for low fractional/broken clouds: The semi transparent correction seems to work well in case of fractional clouds.

Conclusions from the early validation effort of the CMSAF using cloud radar and sounding data during the CLIWA-NET campaigns CNN-2, BBC-1 and BBC-2:

- Good agreement for low-level clouds.
- Rather poor agreement for high-level clouds.
- Significant underestimation of the height in cases of multi layered clouds with semi-transparent cirrus and broken water clouds present.

Conclusions from inter-comparisons with weather radar data are:

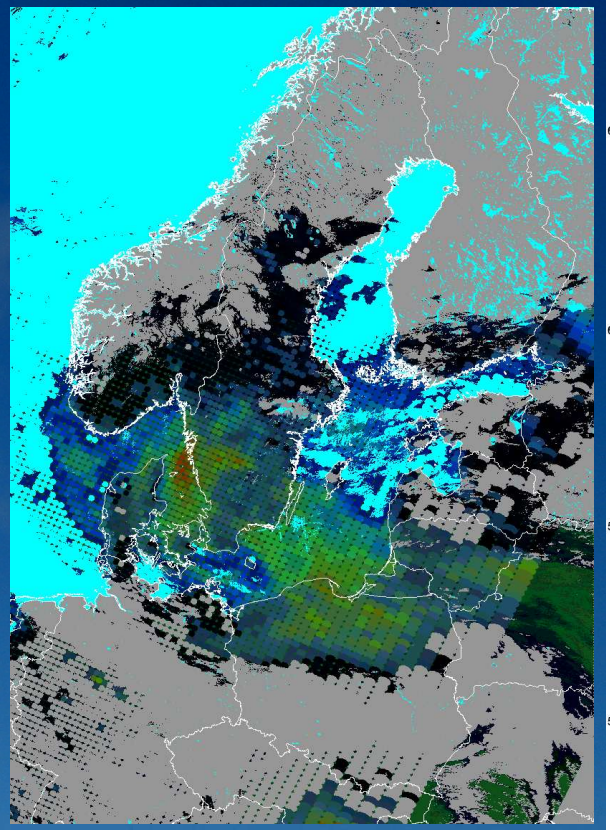
- General good agreement for mid and high level opaque clouds: Mean Absolute Deviation was ~600 m (satellite overestimation against radar) and the Inter Quartile Range 900 m and 800 m respectively.
- Good agreement on broken water clouds.
- Results on thin cirrus show huge spread from case to case. Some agreement with weather radar was found though.
- The weather radar is not sensitive enough to reliably detect thin cirrus clouds.

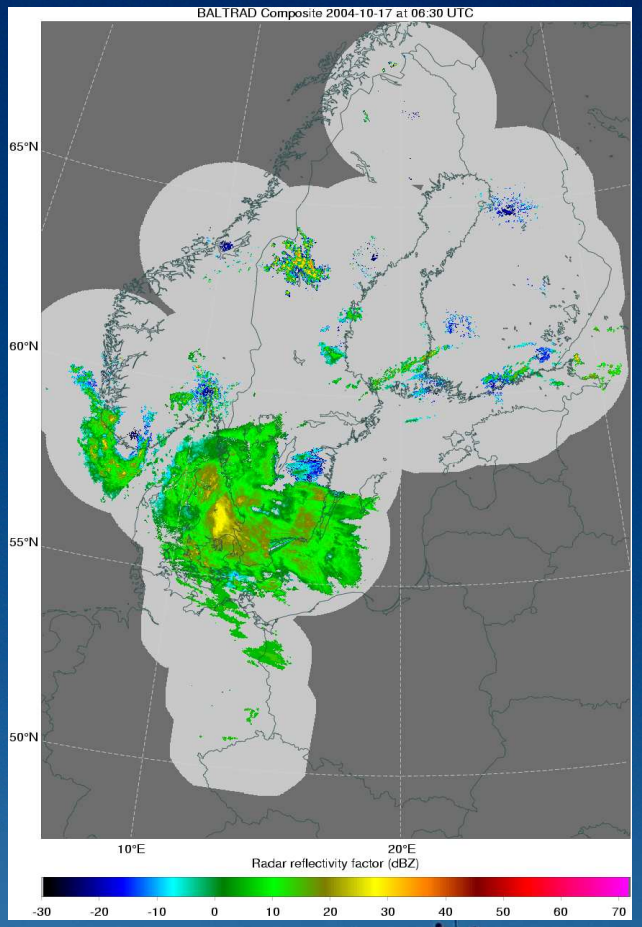
PGE04 validation

- Validation against BALTRAD radar data
- The "winter" problem
- Scores
- Summary
- Adaptations for MHS

Validation dataset:

- Validation against colocated BALTRAD radar data (no gauge correction)
- Jul 2004 – Feb 2005
- Orbit numbers ending on "0"
- Every 100th pixel





AMSU performance in winter:

- AMSU values are only considered in a fraction of cases in winter time for all NOAA satellites
- looking at processing flags and the AMSU B flags in the AMSU file it becomes apparent that whole swaths fail the internal quality check which maps AMSU-A and AMSU-B 89GHz data on each other. If the difference exceeds 5K (2.5stdev according to tuning dataset) the estimate for the FOV gets rejected.
- Possible reasons:
  - AAPP (version not adequate?)
  - Possibly QC needs to be relaxed in winter

Scores and contingency tables:

AVHRR

Threshold 20% NOAA17	Satellite, <0.1mm/h	Satellite 0.1-0.5mm/h	Satellite 0.5-5mm/h	Satellite >5mm/h	Total number in radar class
Radar <0.1mm/h	**82.3%**	**3.9%**	**13.7%**	**0.1%**	**248588**
Radar 0.1-0.5mm/h	**34.2%**	**8.0%**	**57.5%**	**0.3%**	**12200**
Radar 0.5-5mm/h	**26.8%**	**6.7%**	**65.9%**	**0.6%**	**5363**
Radar >5mm/h	**24.5%**	**5.5%**	**67.9%**	**2.1%**	**259**

AVHRR/ AMSU

Threshold 20% NOAA15&16	Satellite, <0.1mm/h	Satellite 0.1-0.5mm/h	Satellite 0.5-5mm/h	Satellite >5mm/h	Total number in radar class
Radar <0.1mm/h	**86.7%**	**7.7%**	**5.2%**	**0.4%**	**556718**
Radar 0.1-0.5mm/h	**42.4%**	**29.8%**	**24.6%**	**3.2%**	**22860**
Radar 0.5-5mm/h	**32.6%**	**29.7%**	**29.2%**	**8.5%**	**9451**
Radar >5mm/h	**35.8%**	**23.1%**	**27.2%**	**13.9%**	**432**

Scores and contingency tables:

NOAA17 Threshold **20%**	Satellite rain	Satellite no rain
Radar rain	**4.56%**	**2.13%**
Radar no rain	**16.47%**	**76.84%**

NOAA17 Threshold **30%**	Satellite rain	Satellite no rain
Radar rain	**3.61%**	**3.08%**
Radar no rain	**9.46%**	**83.85%**

NOAA16 Threshold **20%**	Satellite rain	Satellite no rain
Radar rain	**3.31%**	**2.41%**
Radar no rain	**12.00%**	**82.28%**

NOAA16 Threshold **30%**	Satellite rain	Satellite no rain
Radar rain	**3.03%**	**2.69%**
Radar no rain	**9.53%**	**84.75%**

Scores and contingency tables:

•20%	NOAA17	NOAA16
•POD	0.71	0.58
•FAR	0.81	0.78
•PODF	0.23	0.13
•HK	0.49	0.45
•Bias	3.86	2.67
•ACC	0.77	0.86

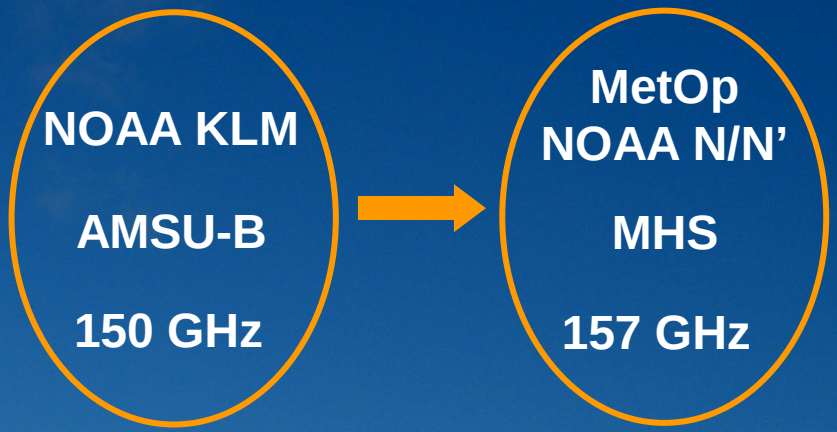
•30%	NOAA17	NOAA16
•POD	0.68	0.53
•FAR	0.78	0.76
•PODF	0.18	0.10
•HK	0.50	0.43
•Bias	3.14	2.20
•ACC	0.81	0.88

Summary PC results:

- AMSU algorithm misses more precipitation events, but can deliniate intensity better than IR algorithm
- For rain/norain discrimination similar overall performance of AVHRR night algorithm and combined AVHRR/AMSU algorithm, probability of detection better in AVHRR but also a higher probability of false detection. Detection thresholds 20% or 30% recommended.
- Area of precipitation generally overestimated (bias score)
- As compared to MSG, better description of frontal precipitation when AMSU is used
- Retrieval for opaque clouds out-performs retrieval for thick cirrus types.
- AMSU data failed internal quality check quite often during 2004/2005 winter season:
  - Expected to have been solved for PPS 1.1 (AAPP upgrade + relaxed internal quality check)
- Validation planned with gauge adjusted data, better scores (better FAR) and better fit to intensity classes to be expected

Adaptations for MHS

Slight shift of channel 2 from AMSU-B to MHS!



Adaptations for MHS

- Predict channel 2 correction term from MHS channels 1 & 5
- Add correction to 157 GHz Tb

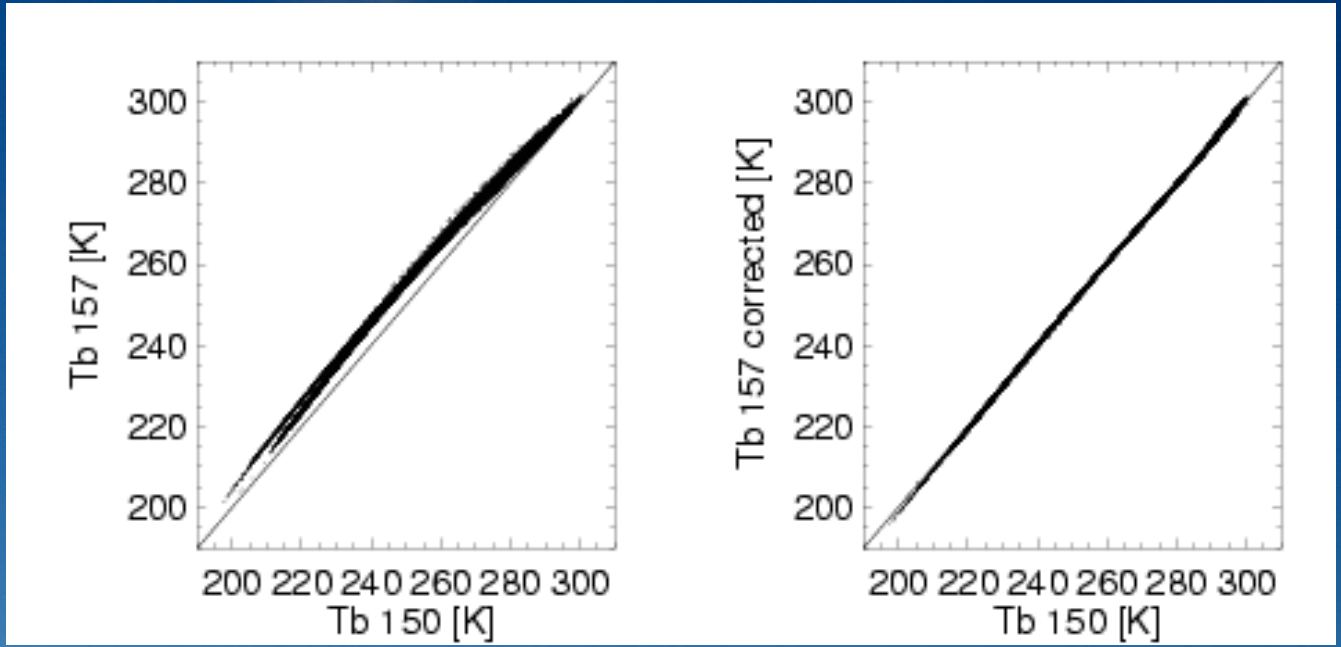
$$Corr = a_0 + a_1 * T_{89} + a_2 * T_{183+7} + a_3 * \frac{T_{89}}{\cos(\theta)}$$

a_0 = -0.4060 a_1 = -0.1152

a_2 = -0.1046 a_3 = -0.0016

Adaptations for MHS

Simulated 157 GHz versus 150 GHz brightness temperatures without (left panel) and with (right panel) correction towards 150 GHz

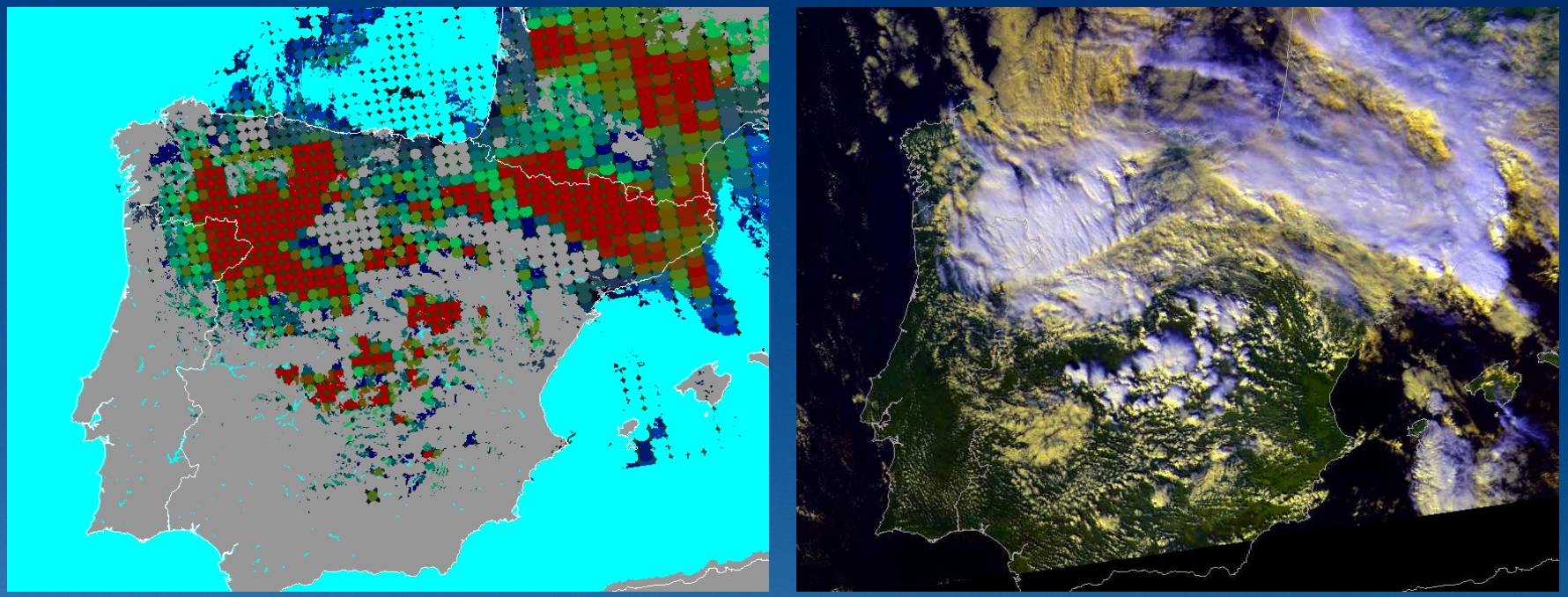


Adaptations for MHS

Still to be done:

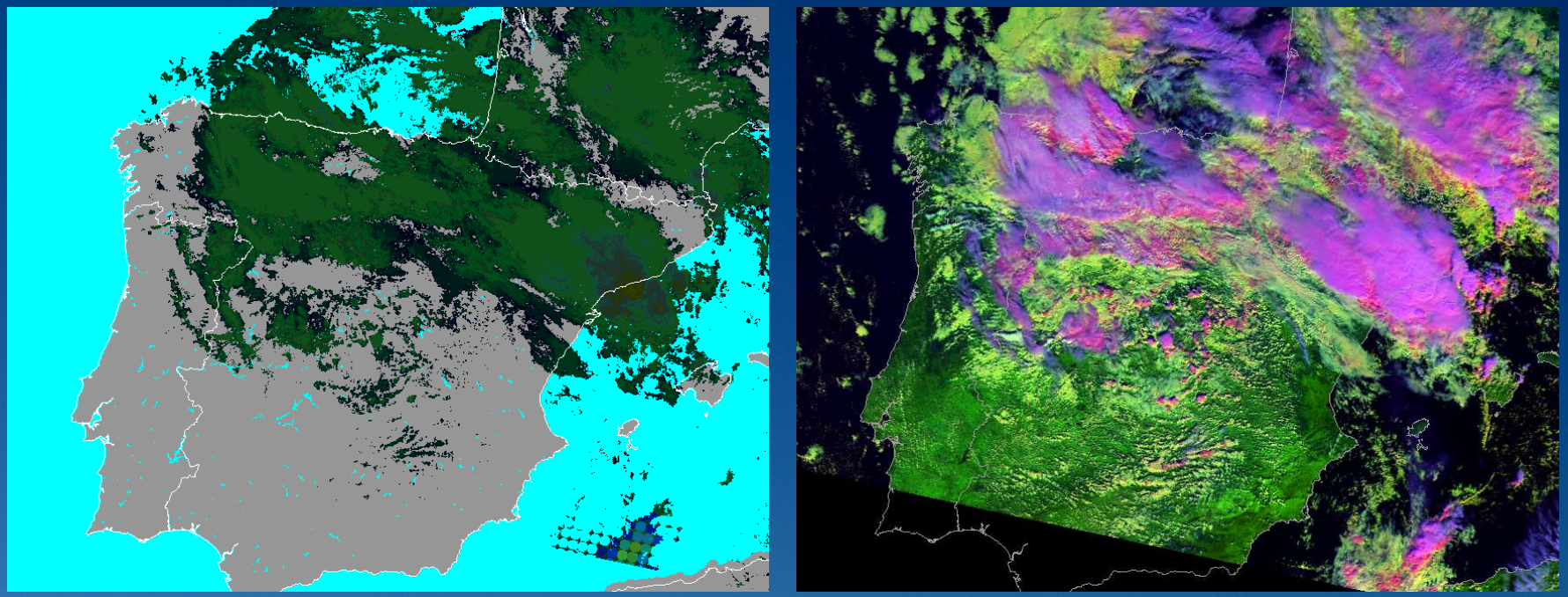
- Tuning on real MHS data planned for June 2006 (PPS 2.x)

PC product over Spain: AVHRR/MHS



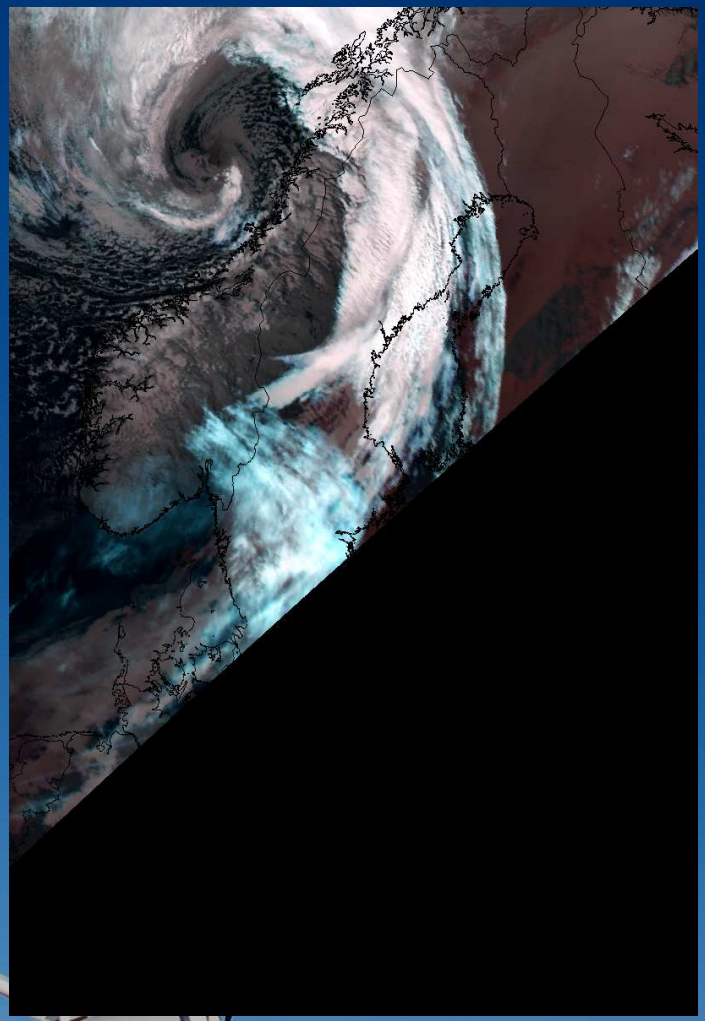
NOAA 18 #2061 13/10-2005 13:45 UTC

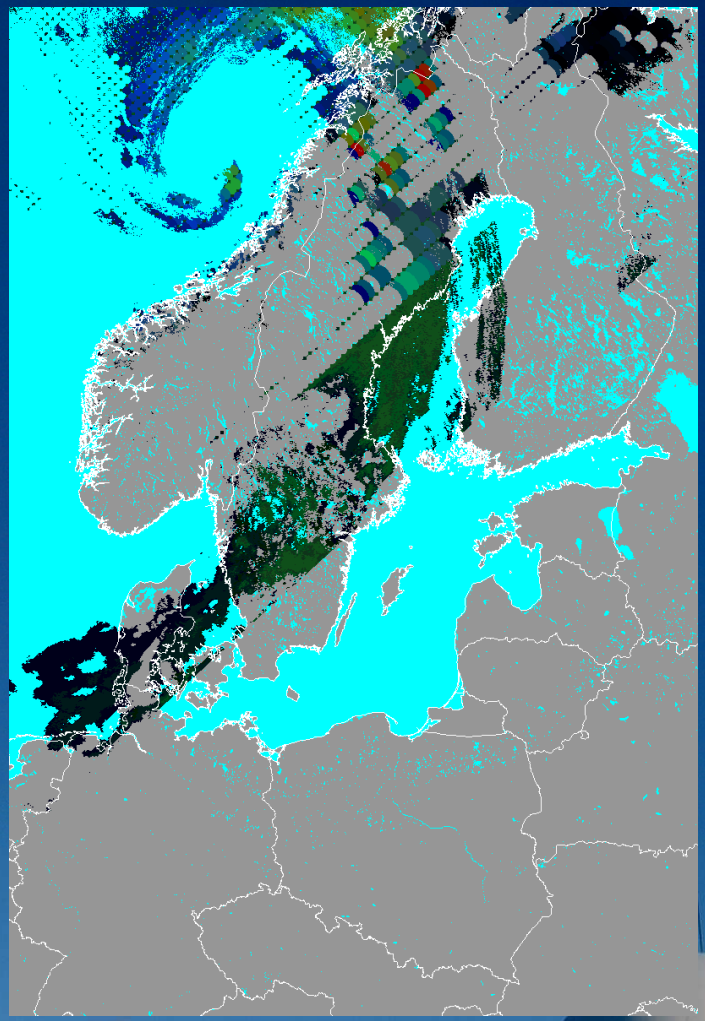
PC product over Spain: AVHRR



NOAA 17 #17167 13/10-2005 10:45 UTC

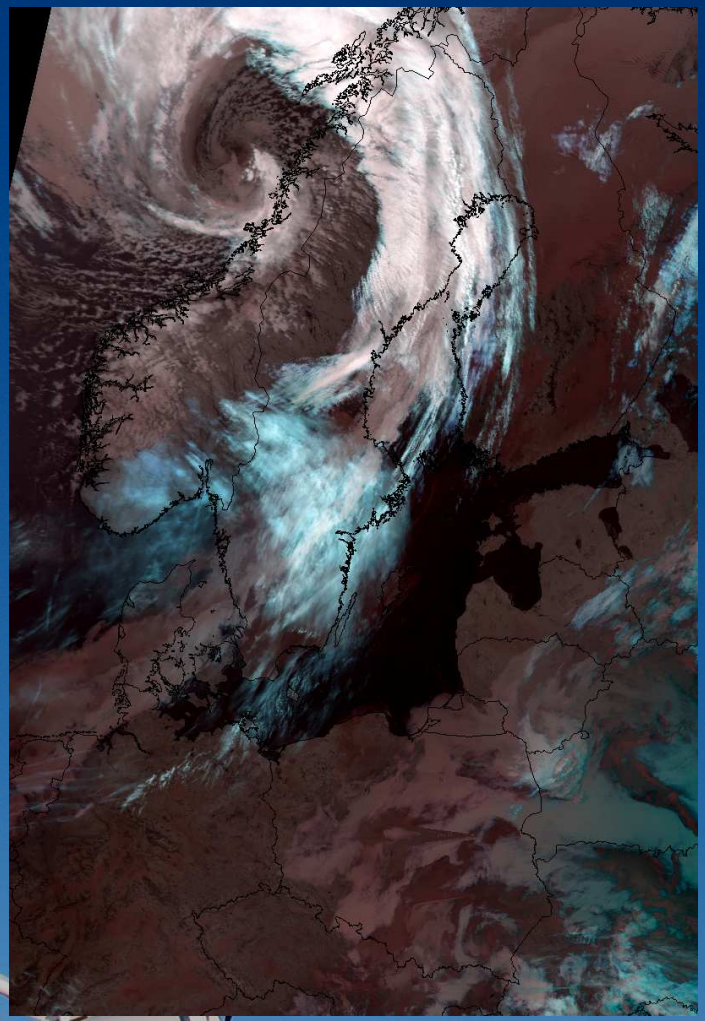
PC product over Northern Europe: AVHRR/MHS

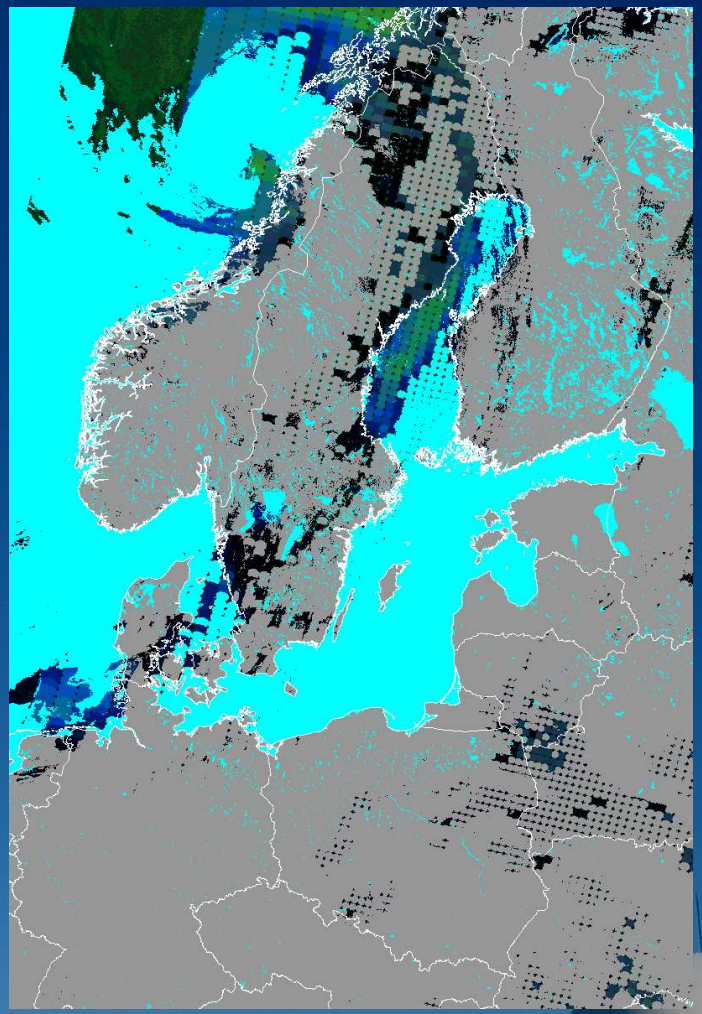




NOAA 18 #2069 14/10-2005 03:37 UTC

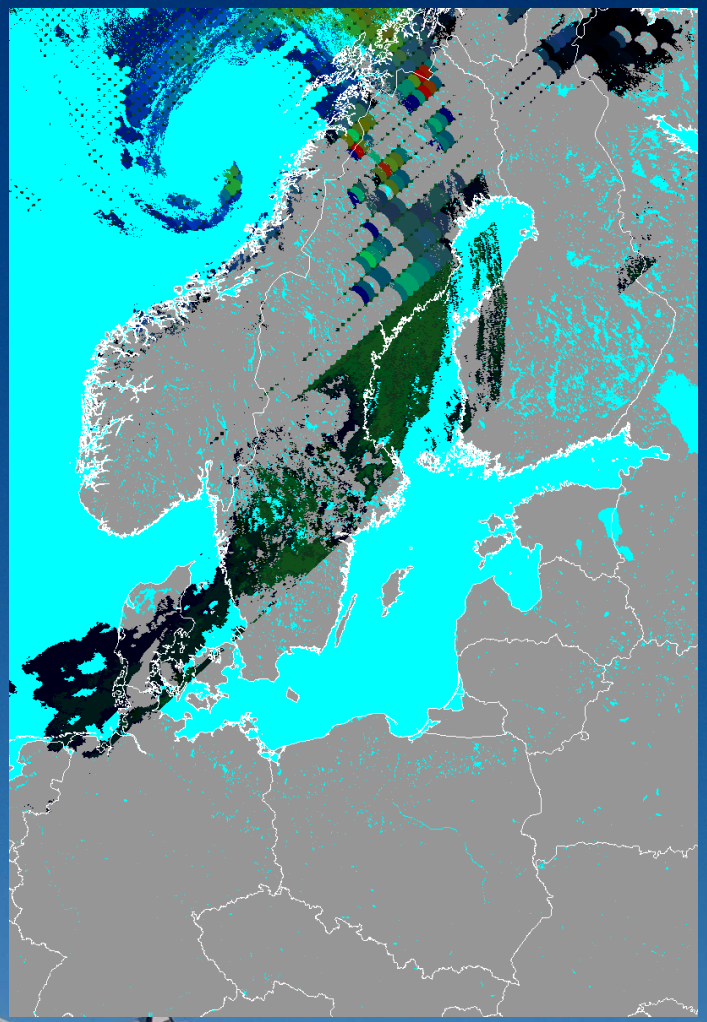
PC product over Northern Europe: AVHRR/AMSU





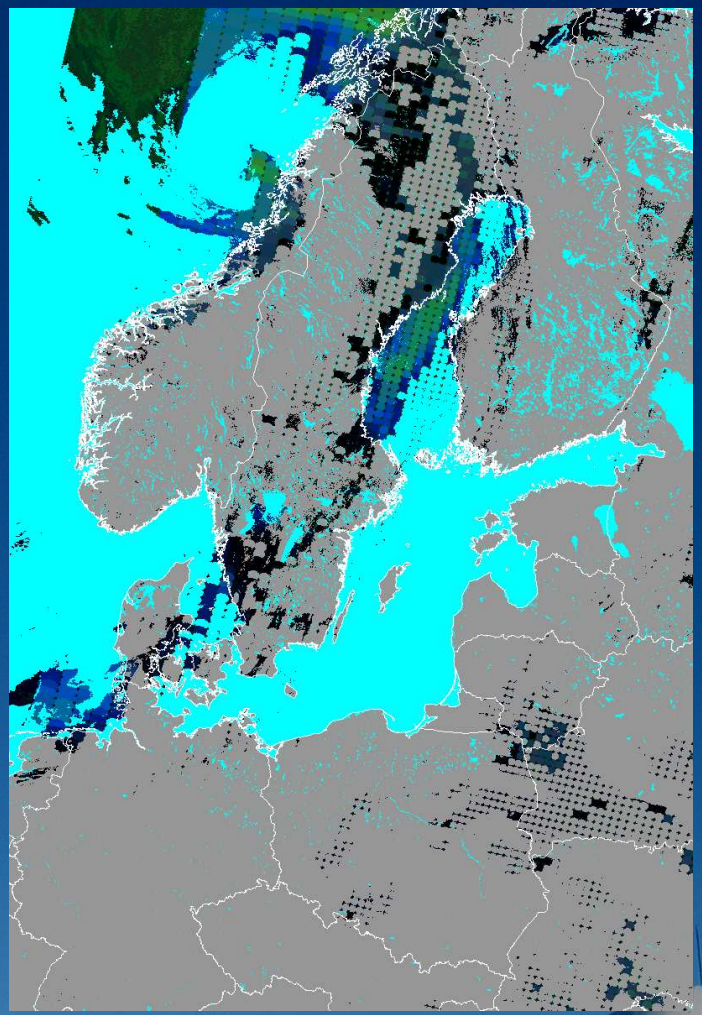
NOAA 15 #38570 14/10-2005 05:08 UTC

AVHRR/MHS



NOAA 18 - 03:37 UTC

AVHRR/AMSU



NOAA 15 - 05:08 UTC

Ongoing validation activities

Cloud Mask

Ongoing validation efforts – focusing on the arctic:

- OSISAF Global SST project: Intercomparison with MAIA.
- Continuation of the MSMS database: Synop validation
- Interactive training over the Arctic using locally received HRPT data from Kangerllusuaq, Greenland (Data made available from DMI): ~163 Gb of summer data (~4 months with N15, N16, and N17 from May 2005 till August 2005)
- Nighttime target collection around Barrow, Alaska
- Daytime MODIS/AVHRR target collection
- AVHRR/GLAS match-up data

The polar night – a true headache!

Not possible to rely on subjective nephanalysis alone!

Collocate with other "ground" truth data

- Cloud radar and lidar from ground: ARM site NSA, Barrow, Alaska
- Lidar from space: GLAS
- NOAA LAC data
- MODIS – EOS-archive

The Atmospheric Radiation Measurement (ARM) Program site at the North Slope of Alaska (NSA) - Barrow

Heavy instrumentation - continous measurements

Millimiter-Wavelength Cloud Radar - MMCR

Micropulse lidar - MPL

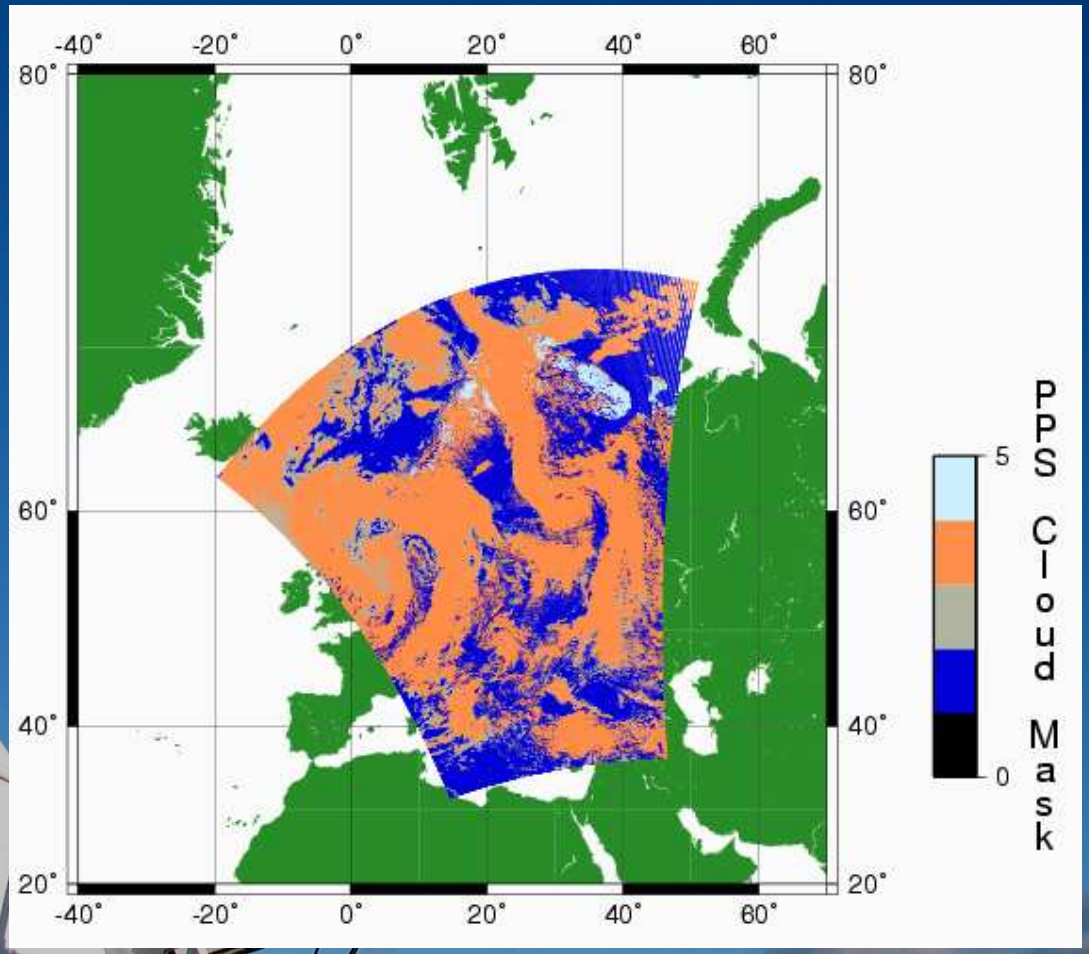
Nighttime target collection around Barrow, Alaska

- N15 & N16 LAC data from December 2001 till February 2002
- Using Lidar/Cloud Radar ground truth to guide in the collection of targets around Barrow: Open water, Land, Sea-Ice
- ~300 (30-40 %) targets collected so far (end of sep-05)

Planned updates for 2.x

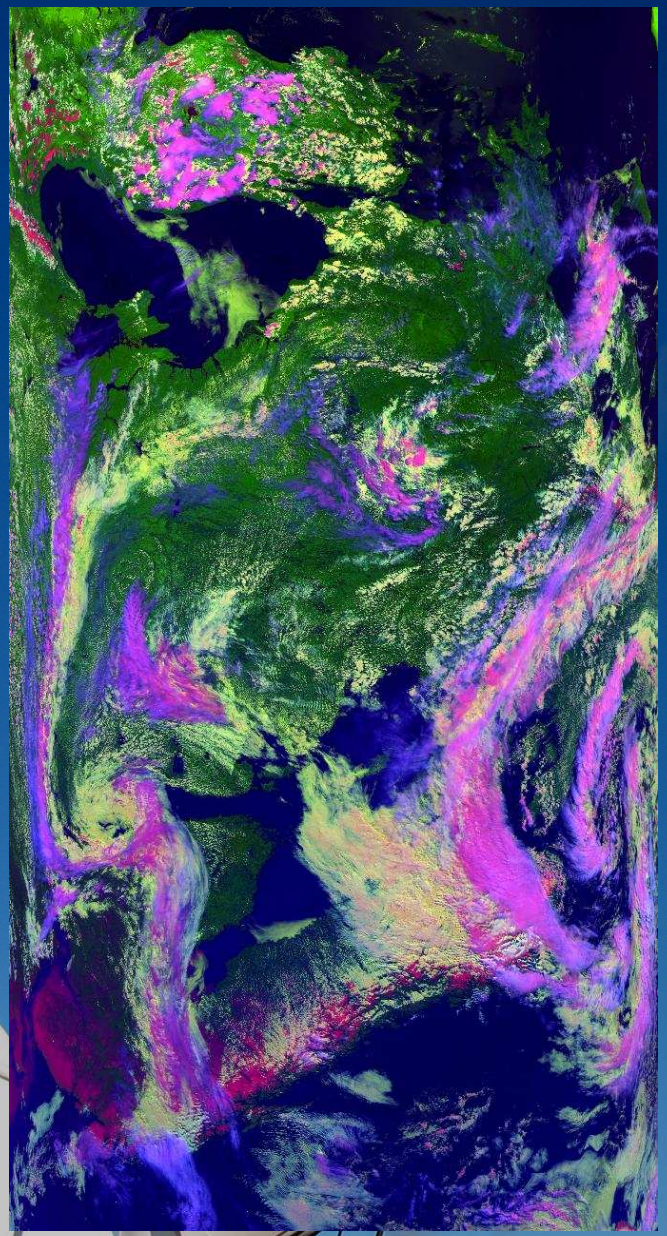
- Satellite projection
- Extending the area of interest = Global
- Tuning of PGE04 with real MHS data

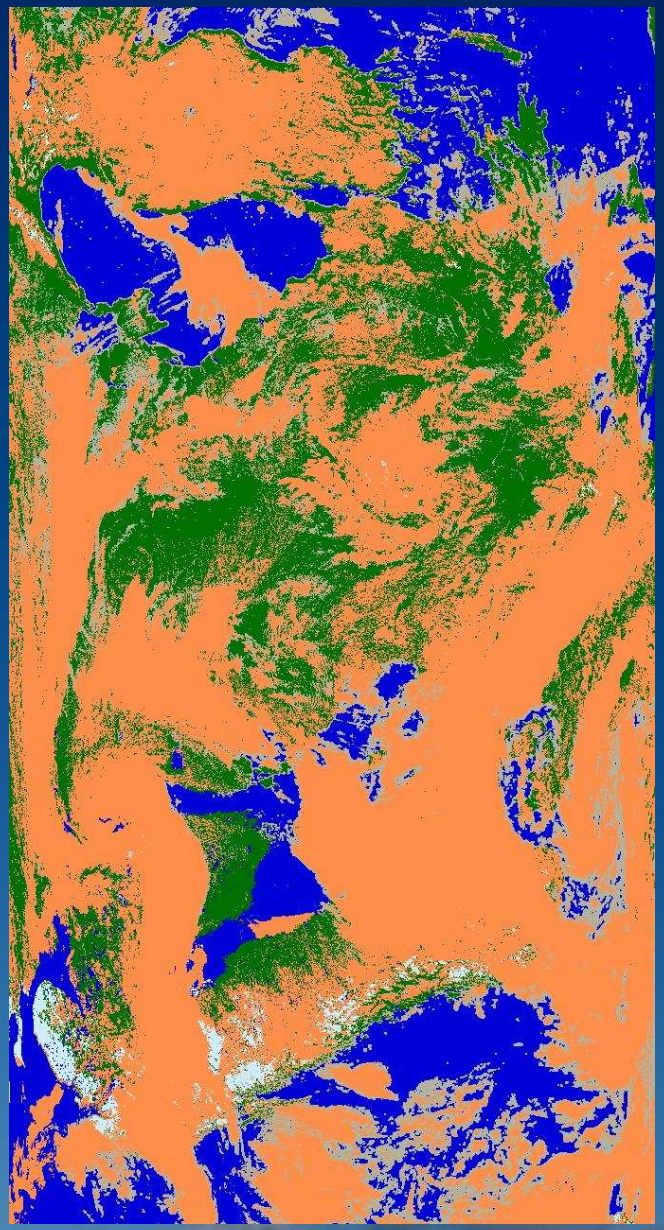
From map projections to Satellite projection



Cloud Mask on full overpass as received at Norrköping

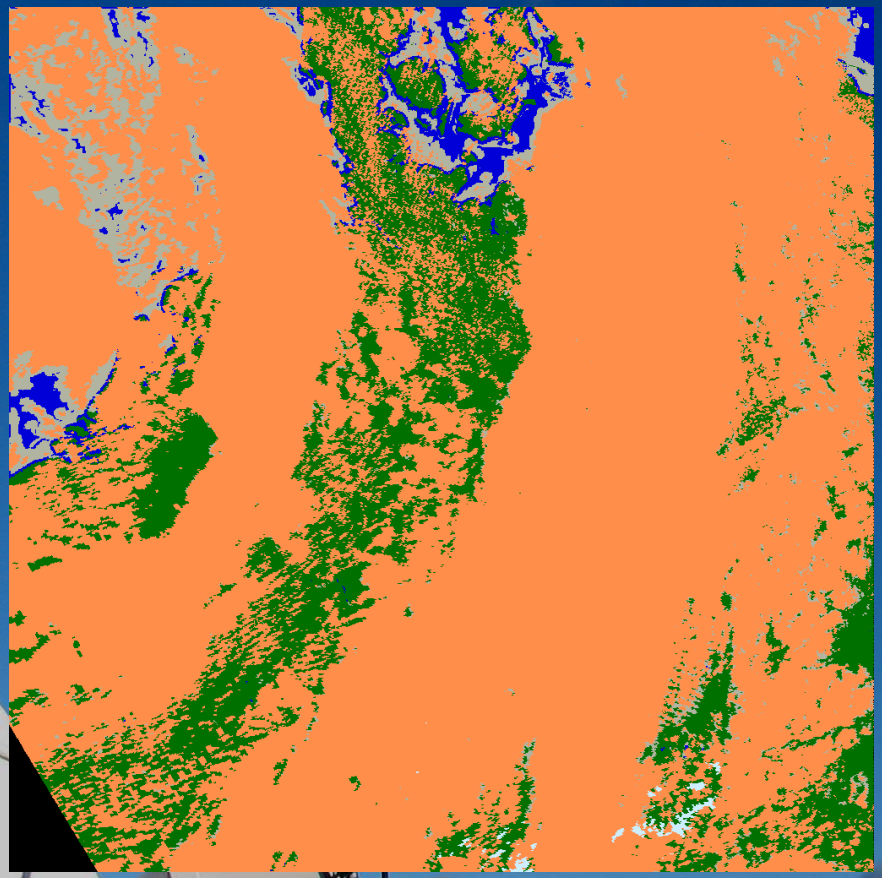
NOAA 16 #8252 April 29 2002 11:29 UTC



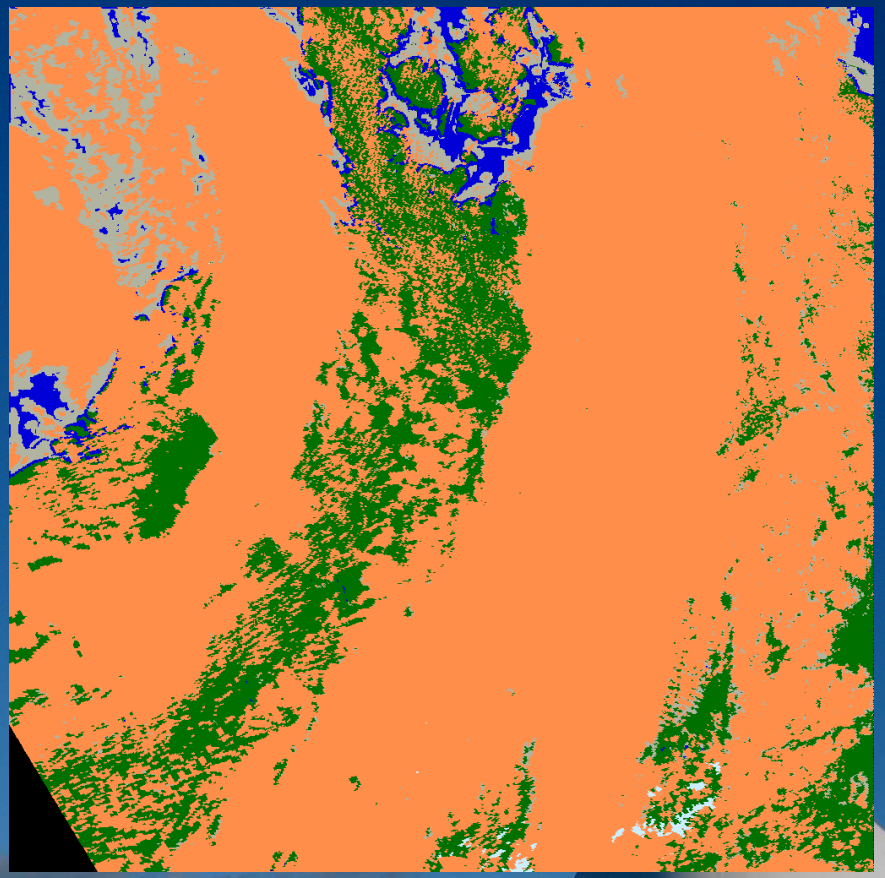


NOAA 16 #8252
April 29 2002
11:29 UTC

PPS 1.1 Cloud Mask on area "germ"

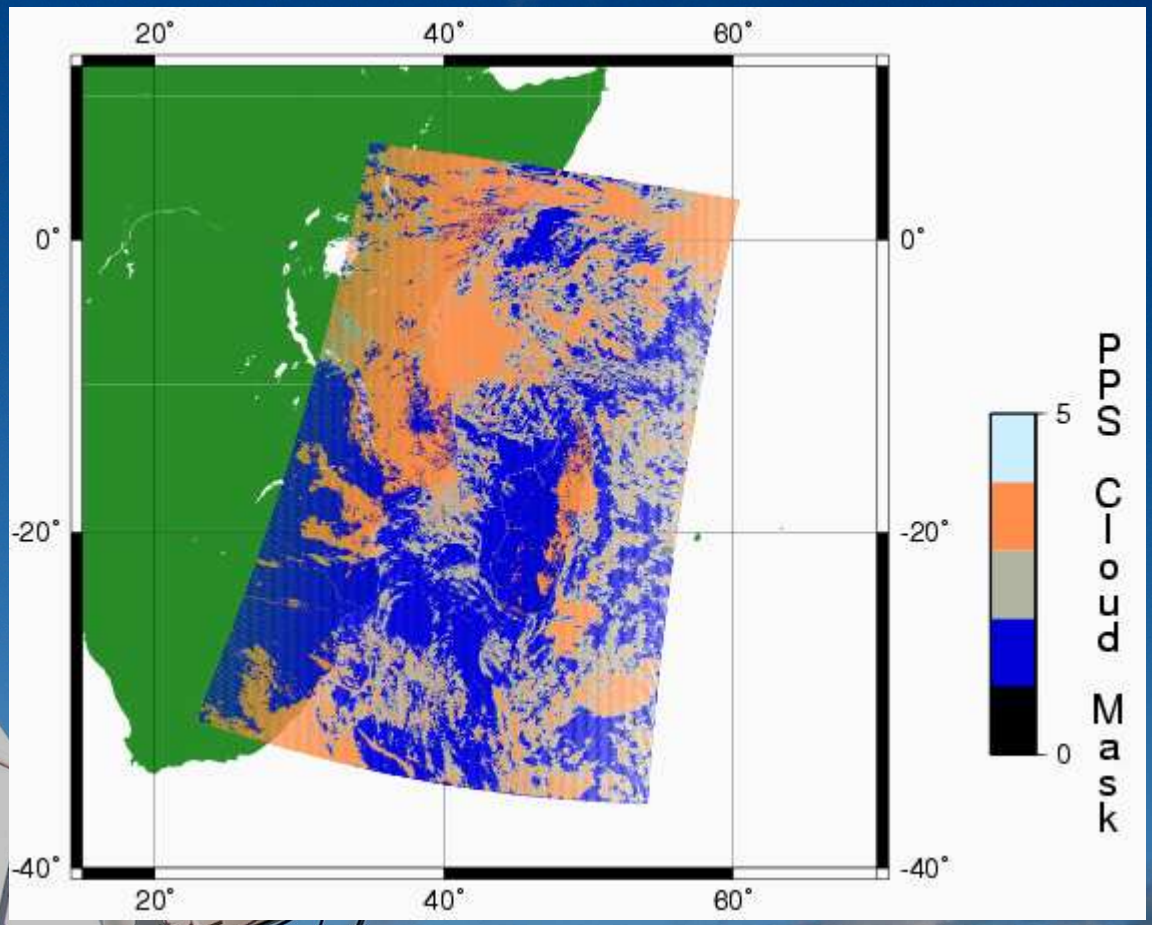


PPS 2.x Cloud Mask warped to map-projection

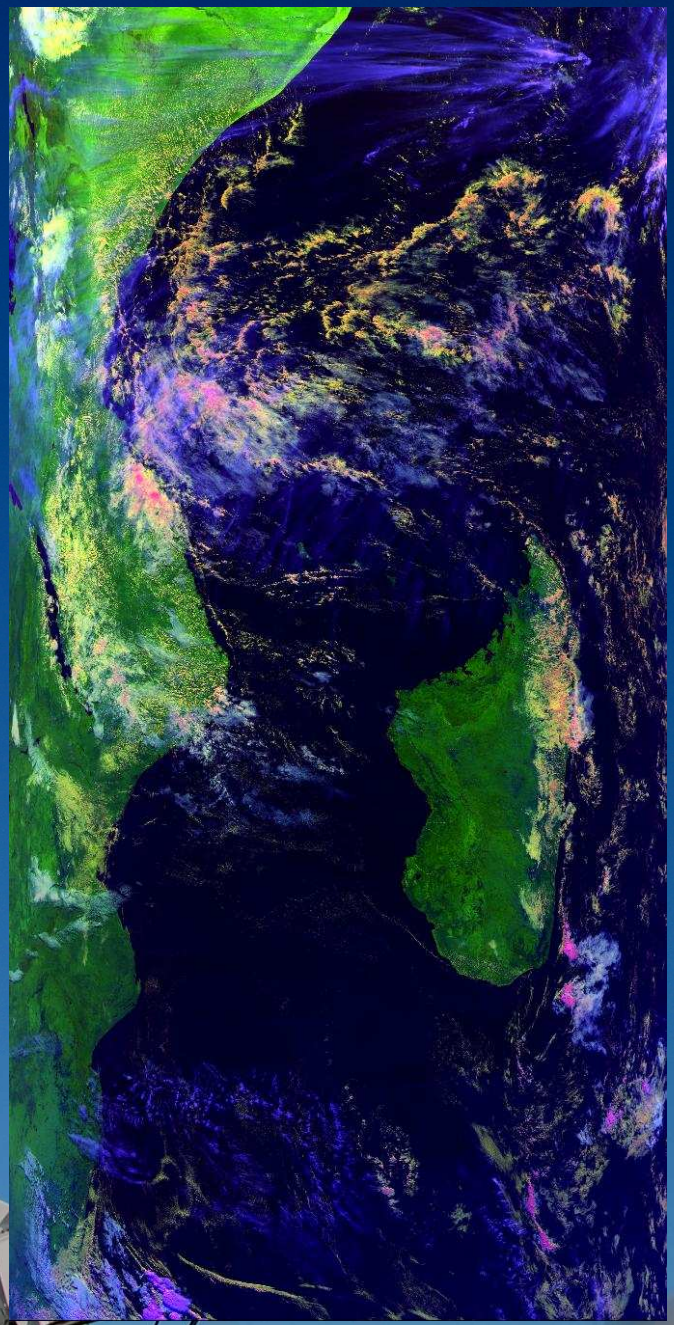


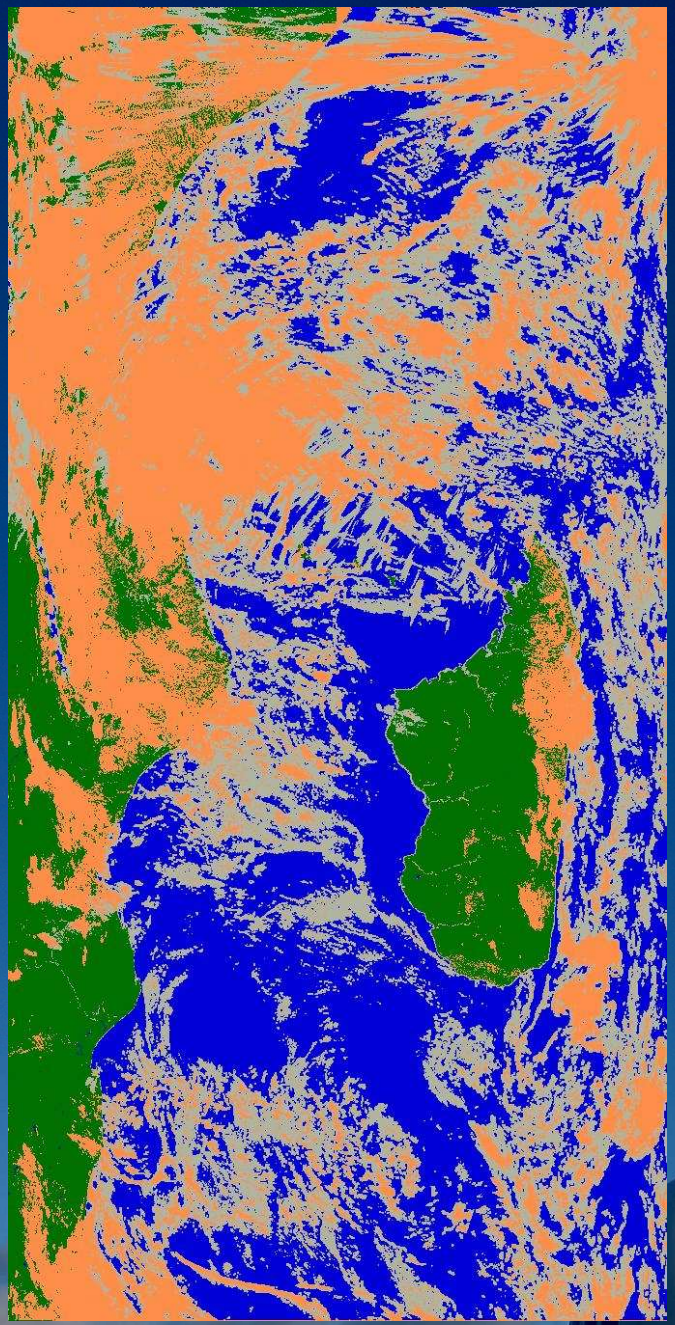
NOAA 16 #8252 April 29 2002 11:29 UTC

Extending the area of interest: Global



NOAA 17 #15628 June 27 2005 07:16 UTC






Thank you!
SMH