Global Precipitation Mission
An opportunity for Ocean surface Remote sensing ?

Elements for discussion & Focus on Sea-Ice

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- Context
- GPM
- Analysis
- Conclusions

Context

2 CNES Missions with Ocean applications are planned

- SWOT (CNES/JPL, 2020 ?)
  - Ka-Band KaRin

- CFOSAT (CNES/China National Space Administration-CNSA, 2018 ?)
  - Ku-Band SWIM (Surface Waves Investigation and Monitoring), a wave scatterometer supplied by CNES, with inc. angle [0-10°]
  - Ku-Band SCAT (wind SCAT terometer), a wind-field scatterometer supplied by CNSA

→ Ku and Ka-Band measurements from CNES missions will be available soon over ocean at low incidence angles, where not much as been done yet

GPM (JPL/JAXA) mission for precipitation has 2 radars in Ka and Ku Band operating at low incidence angles

Context

Ifremer is involved in the preparation of these 2 missions (for the ocean component) to :

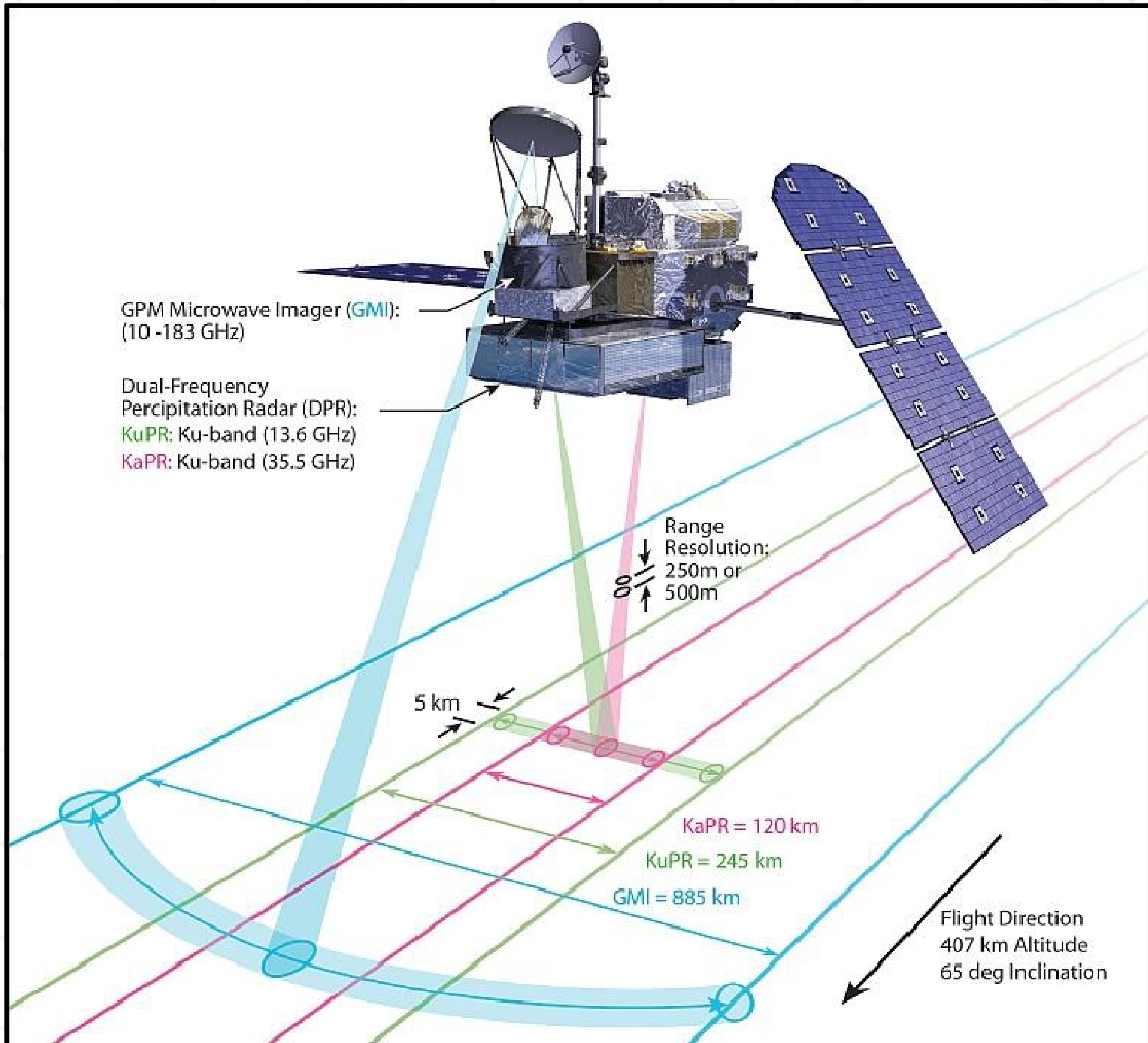
- Improve our understanding of electromagnetic and oceanic waves (sea-ice) interactions at low incidence angles
- Develop ocean products
- Anticipate Science Applications
- Prepare the Cal/Val phase (for CFOSAT)

➡ GPM may be a good opportunity to get a flavor of what could be done at low incidence angles in Ku and Ka-Band

Exploitation of multi-incidence concept to derive properties of the statistics of the sea surface slope, and other natural media (eg sea ice ?)

The GPM Mission

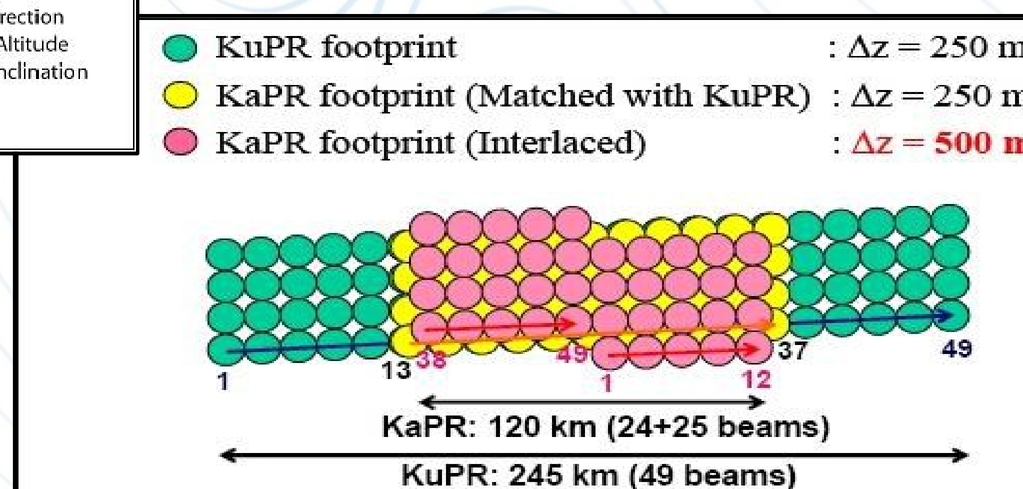
The GPM Mission: Instrument & Acquisition pattern



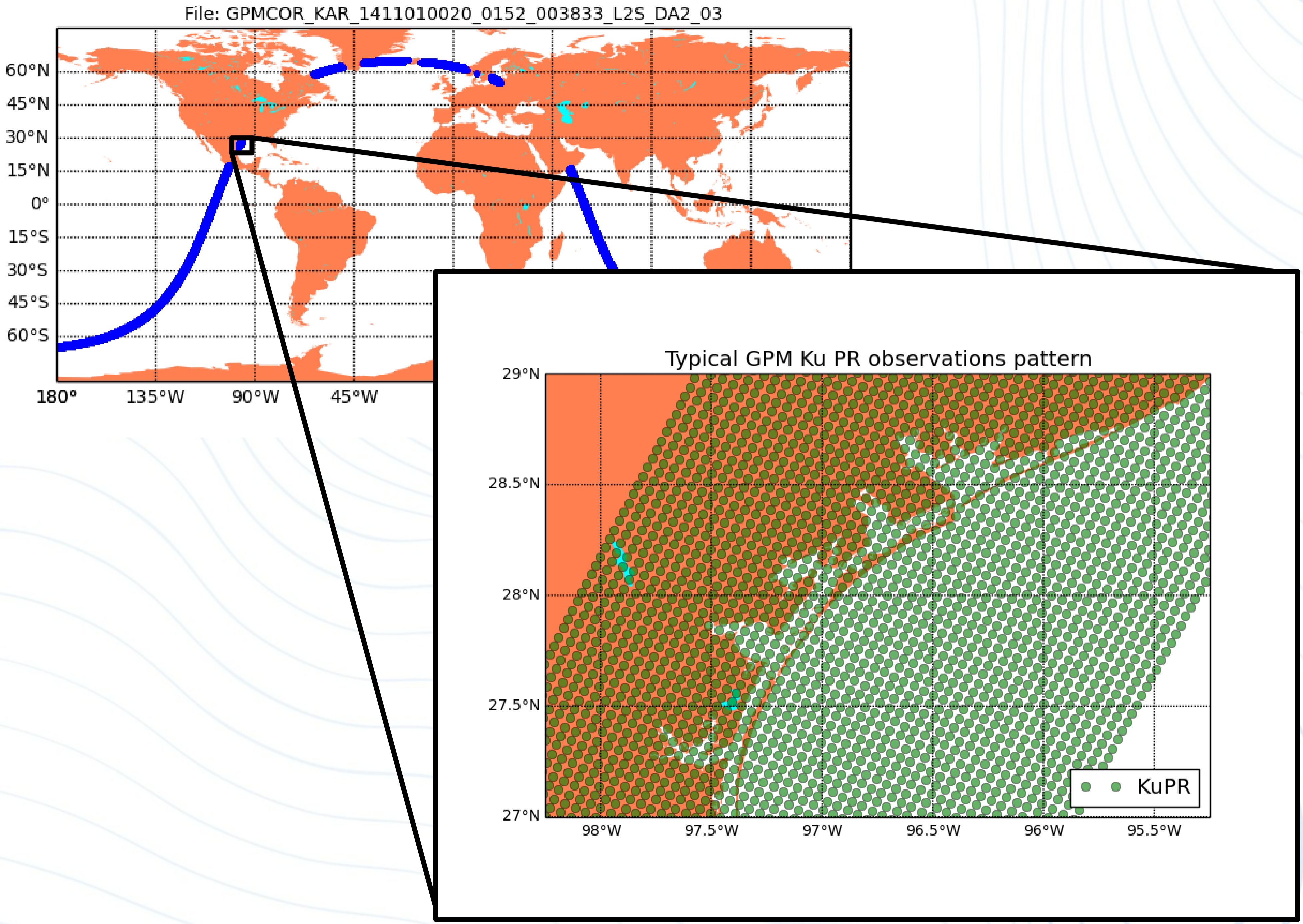
Quasi-simultaneaous observations are available from both KaPR and KuPR in the quasi-specular domain :

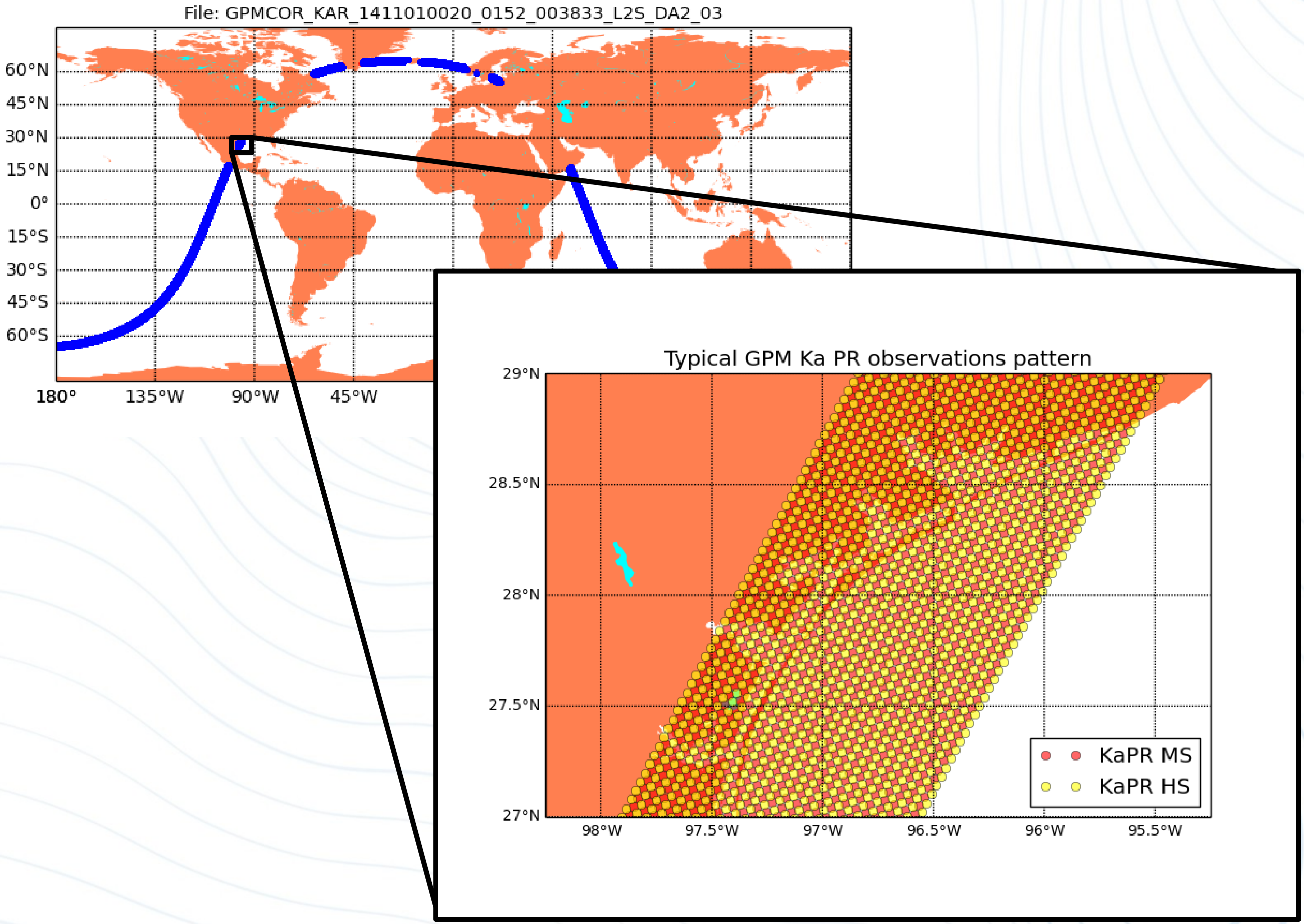
inc ϵ [-18,18] Ku PR

inc ϵ [-9, 9] Ka PR

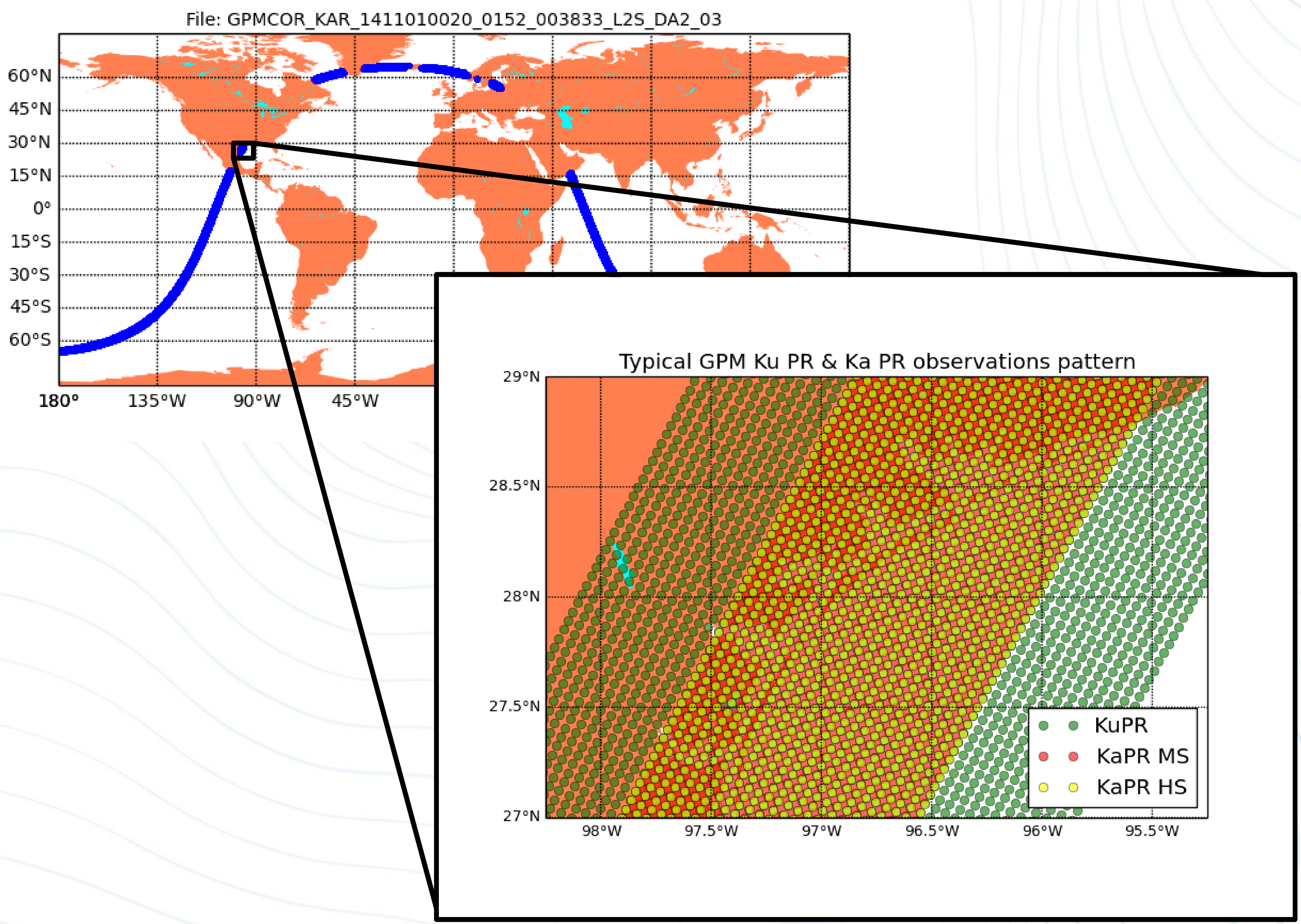


The GPM Mission: Instrument & Acquisition pattern





File: GPMCOR_KAR_1411010020_0152_003833_L2S_DA2_03
60°N
45°N
30°N
15°N
0°
15°S
30°S
45°S
60°S
180°
135°W
90°W
45°W
Typical GPM Ka PR observations pattern
29°N
28.5°N
28°N
27.5°N
27°N
98°W
97.5°W
97°W
96.5°W
96°W
95.5°W
KaPR MS
KaPR HS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60°N
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29°N
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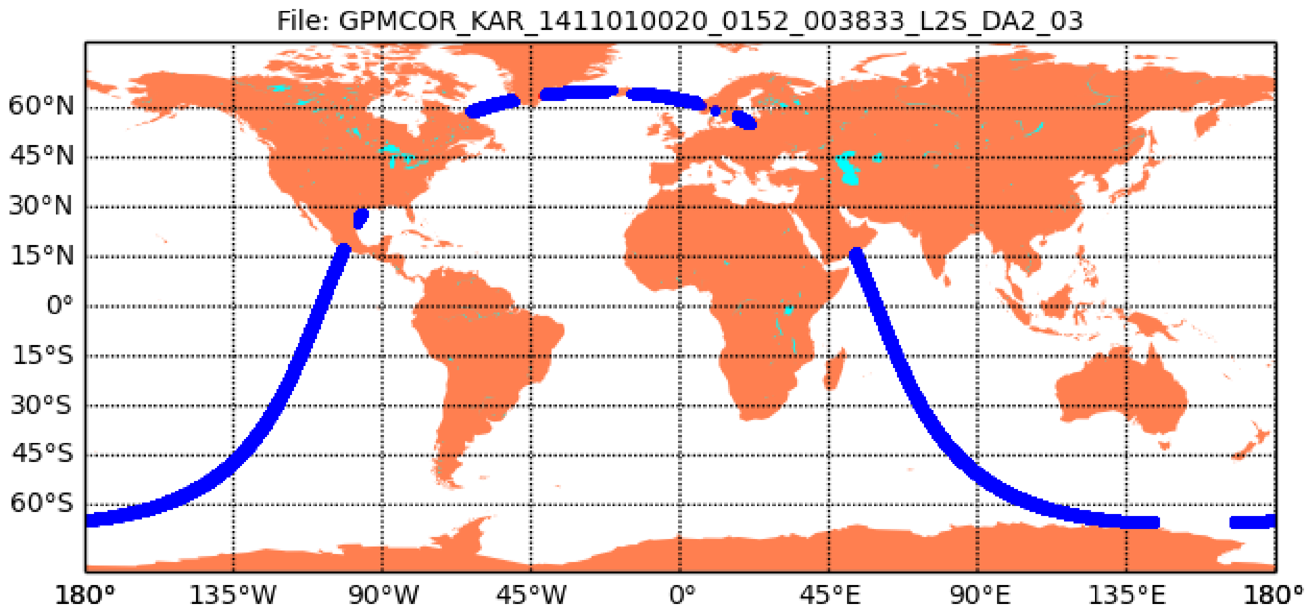
27°N
98°W
97.5°W
97°W
96.5°W
96°W
95.5°W
KuPR
KaPR MS
KaPR HS

The GPM Mission: Coverage (benefits with respect to TRMM)



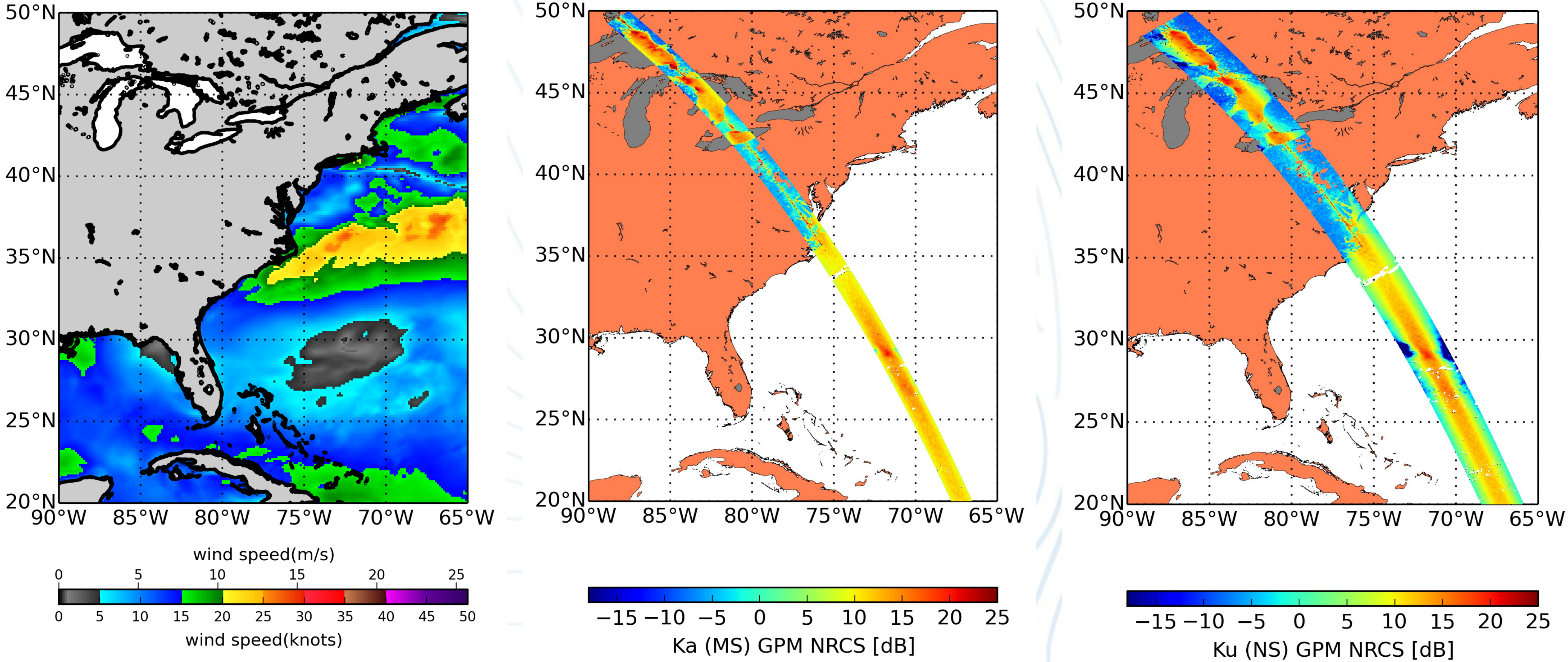
- Orbit has changed since TRMM.
- Latitudes larger than 30°N and 30°S are now observed by DPR. Acquisitions up to 66° north and south are now available.

- More chances to get extreme situations such as extra-tropical storms in high latitudes, with high winds and severe sea state.
- Area with strong ocean surface current such as Gulf Stream, Kuroshio or Agulhas current will be better covered.

- Opportunities to get sea ice, iceberg signature in Ka and Ku band at near nadir.
- Acquisitions over Great lakes
- Co-existence with RapidSCAT (Ku-band @inc 49& 56°) & Sentinel-1 A (C-band @inc [18-47°]

Analysis

Analysis

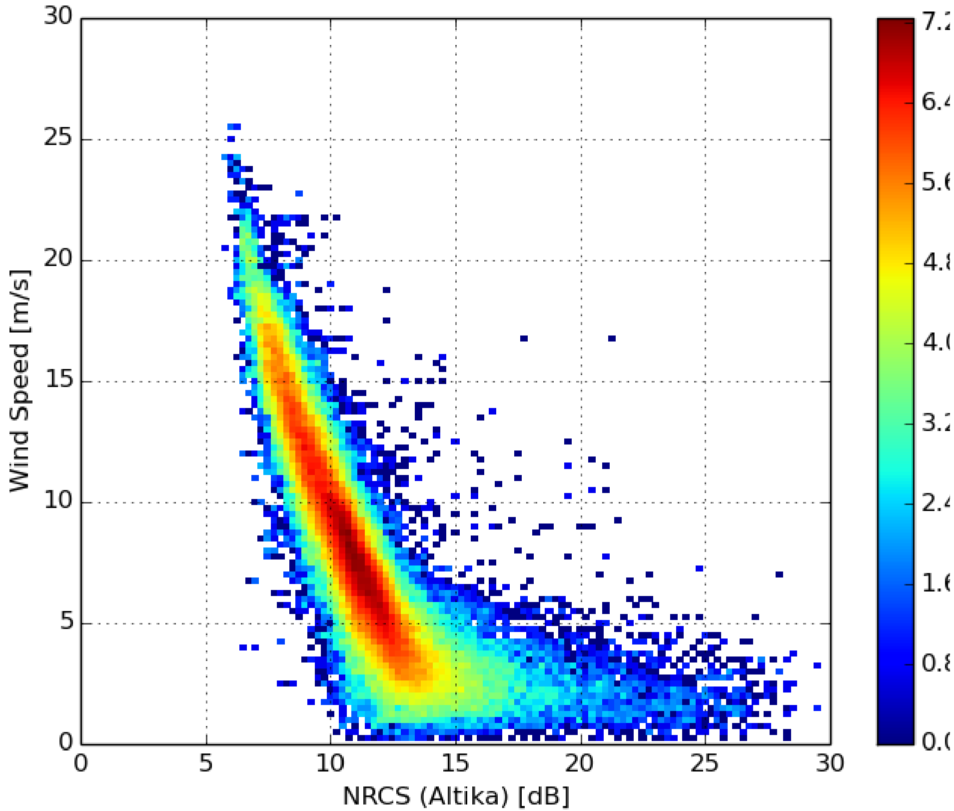


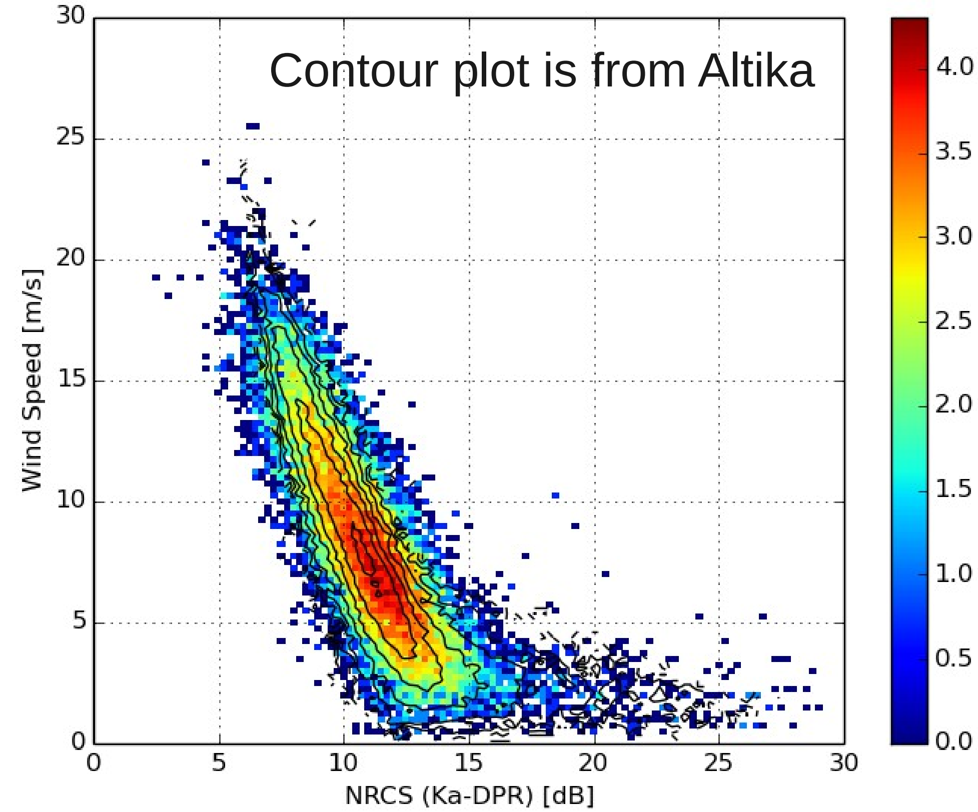
Exemple of acquisition in Ka (MS) and Ku (NS) Band with GPM over land, lake and Ocean

- Acquisitions over land can certainly help to prepare hydrology applications
- Consistency between NRCS acquired over ocean and ECMWF Winds

Massive triple co-locations with Altika, WaveWatch 3 have been done to

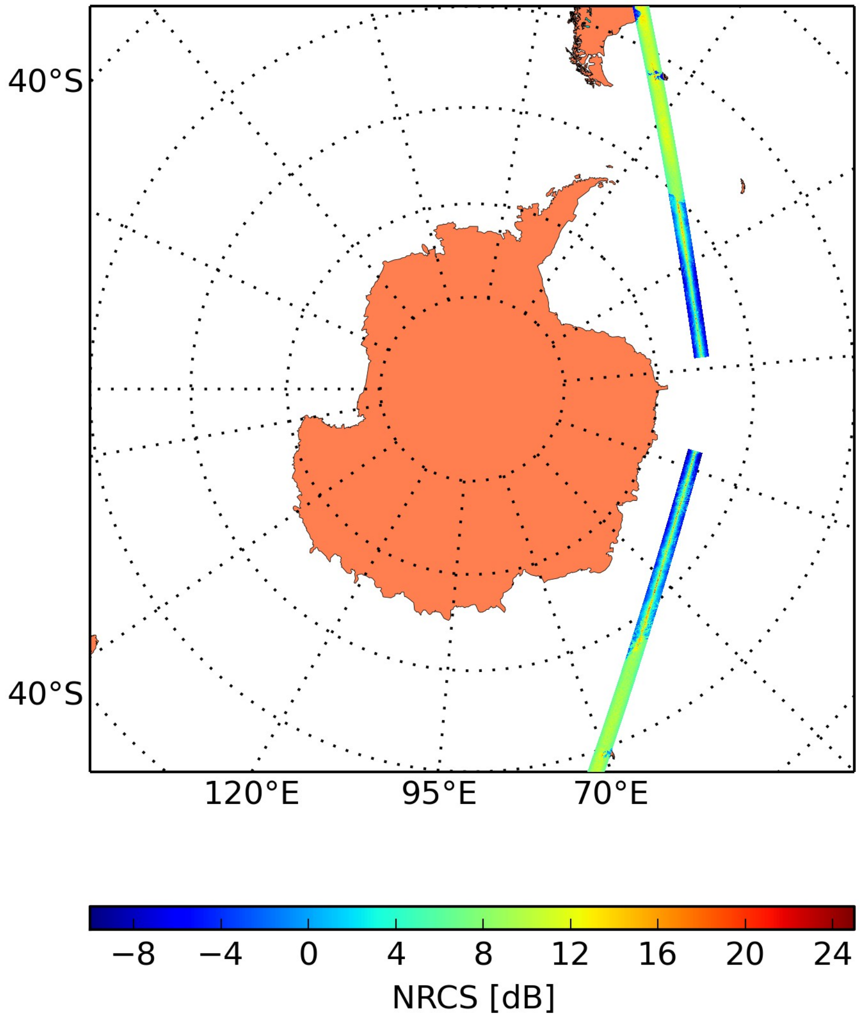
- Compare the calibration betwee the two Ka-Band radar at nadir
- Check the dynamic of the signal

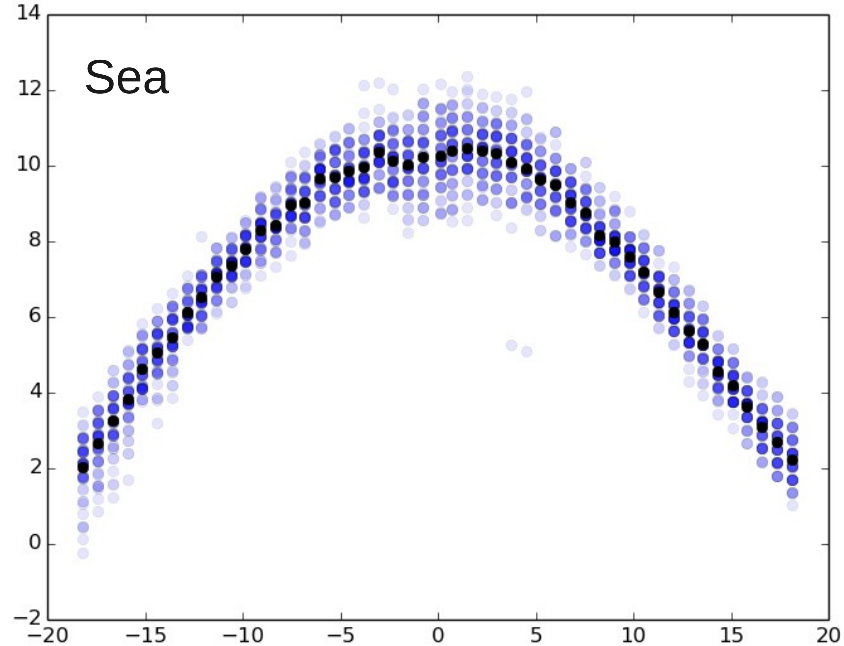


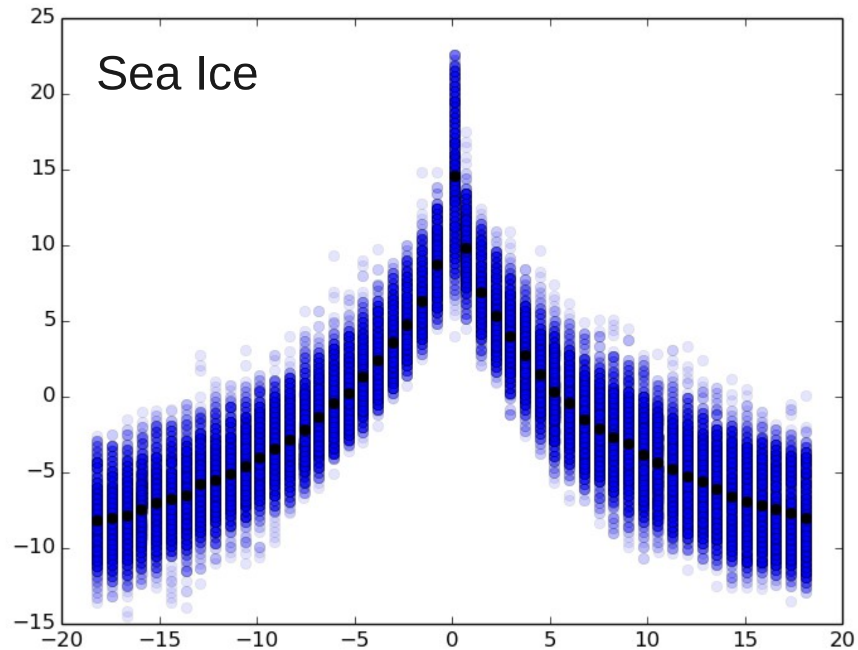


NRCS variations of Ka-DPR at nadir are very consistent with Altika
Bias is around 0.1 dB

Exemple of Acquisition over Sea Ice

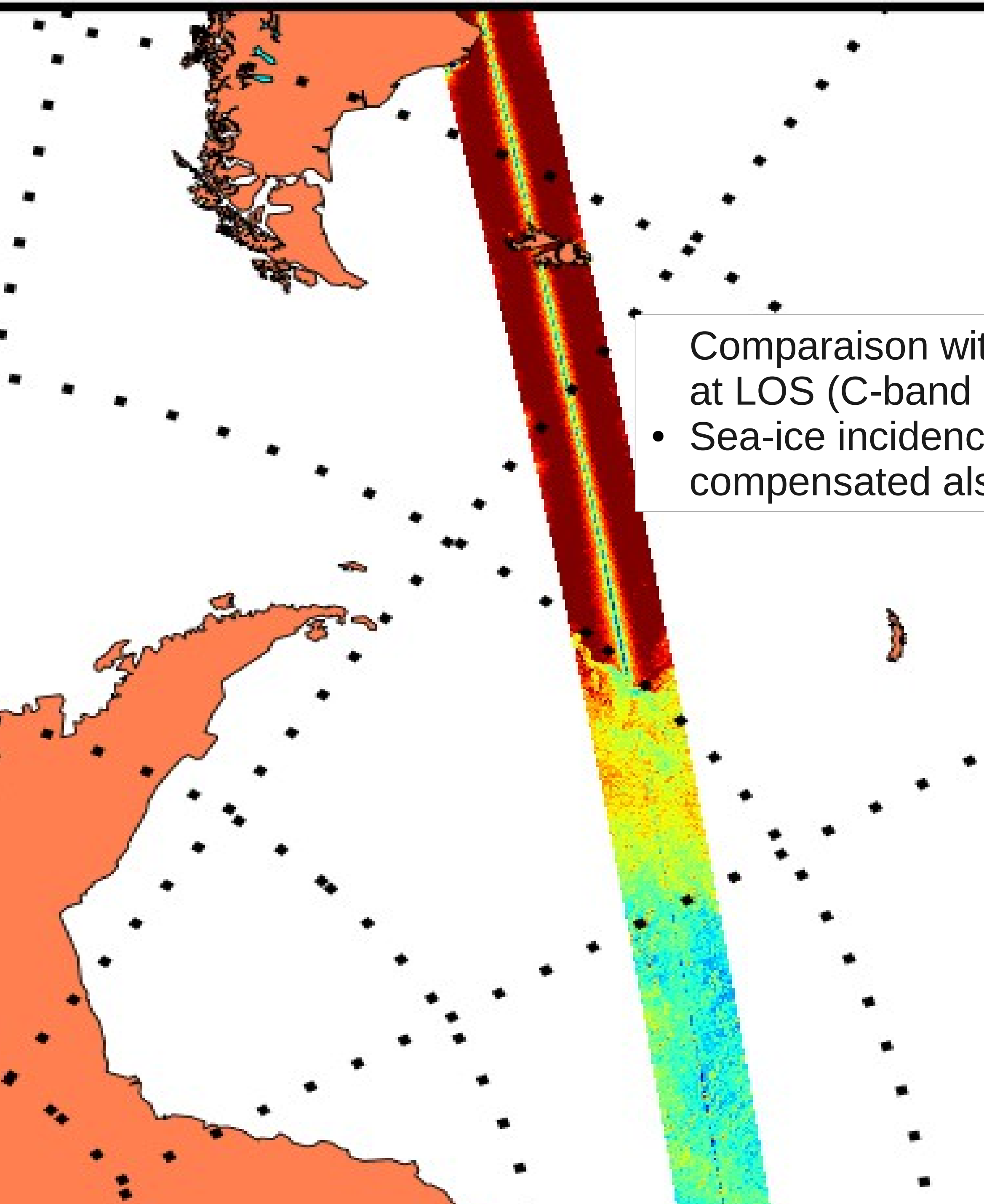


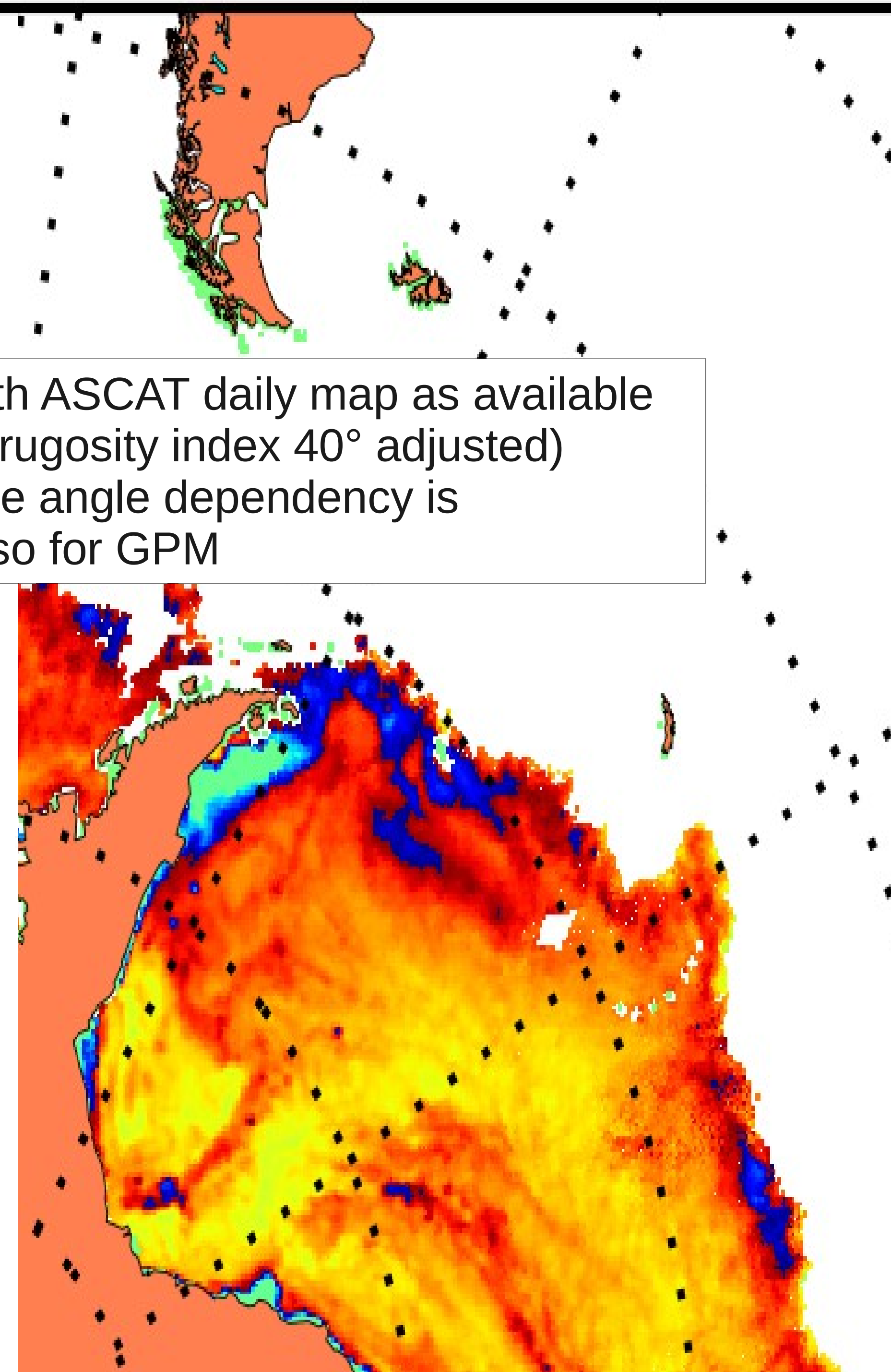




NRCS fall-off over sea ice is faster than over seas

→ Strong specular contribution for sea ice. Less Roughness than over seas

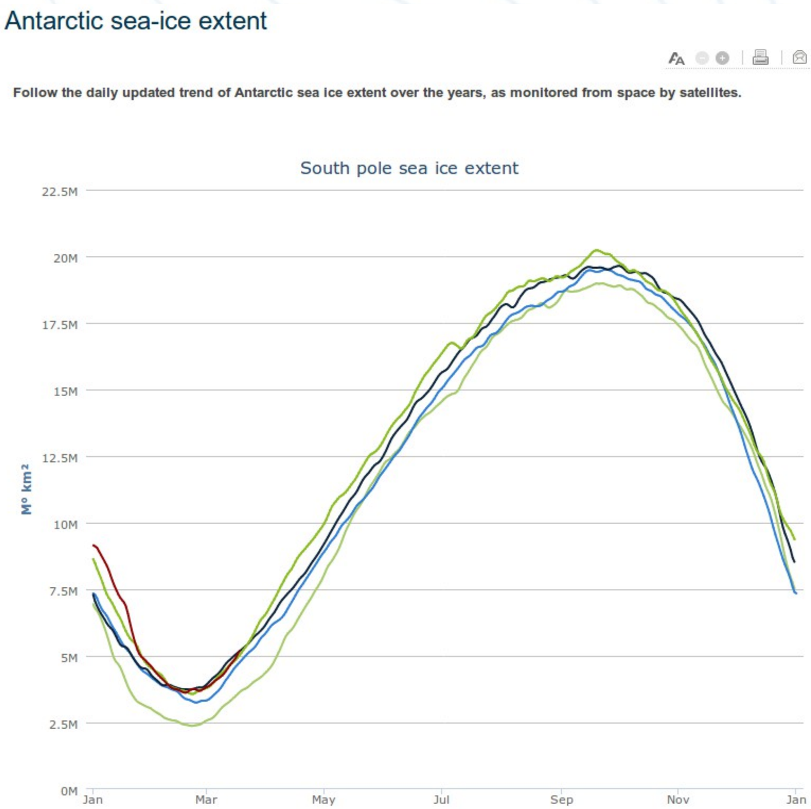




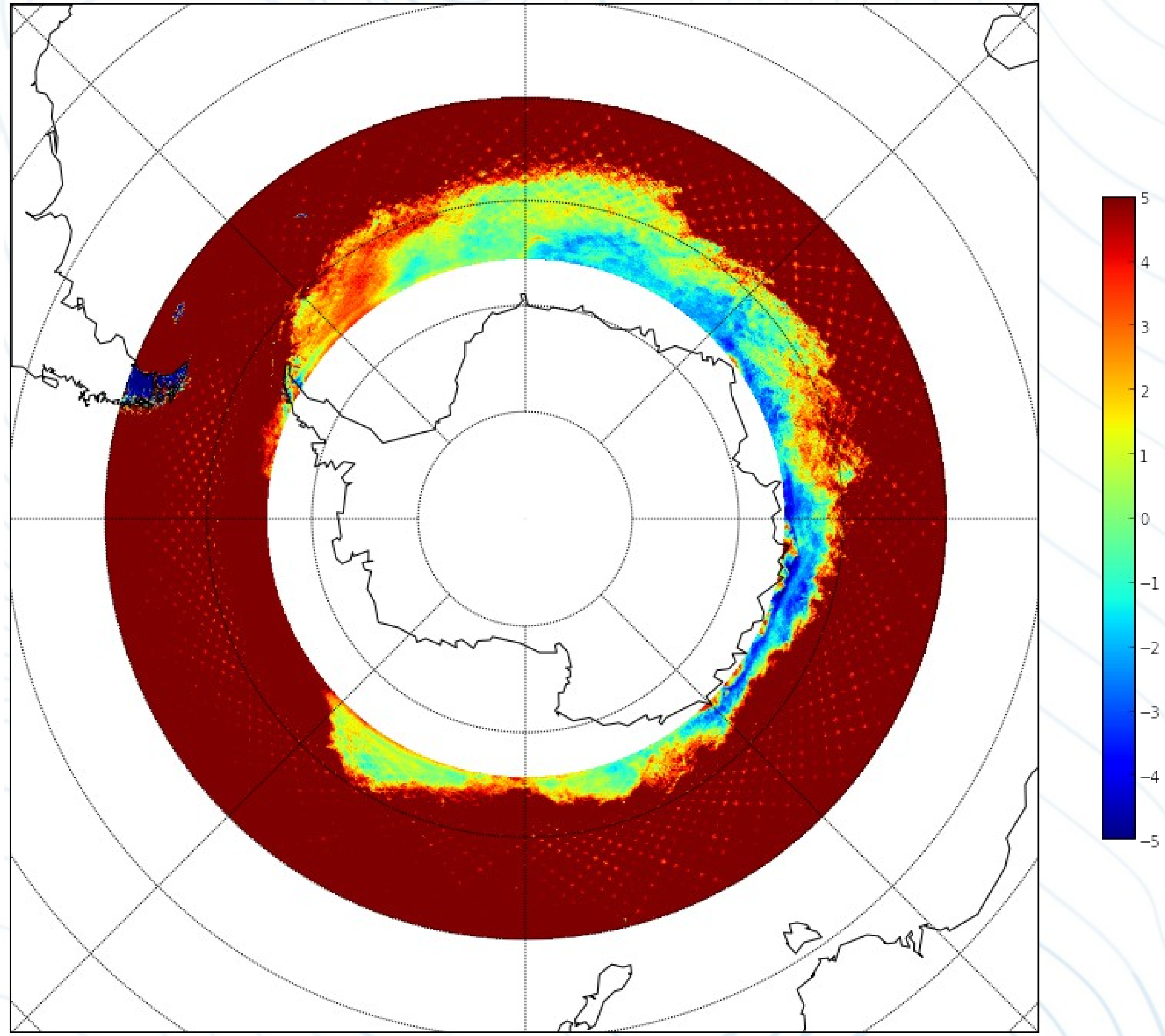
Comparaison with ASCAT daily map as available at LOS (C-band rugosity index 40° adjusted)

- Sea-ice incidence angle dependency is compensated also for GPM

Analysis



Monthly map of averaged NRCS as obtained in Ku-Band after detrend for September 2014

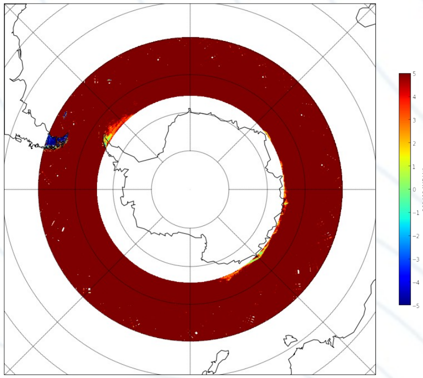


Both sea ice-extent and NRCS spatial variability are observed in Ku and Ka-Band (not shown) at low incidence angles

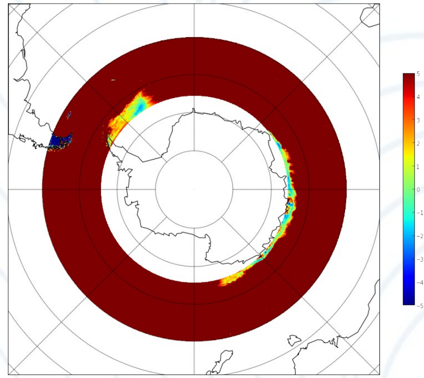
Proxy for sea ice concentration product ? Ice type...

Ifremer

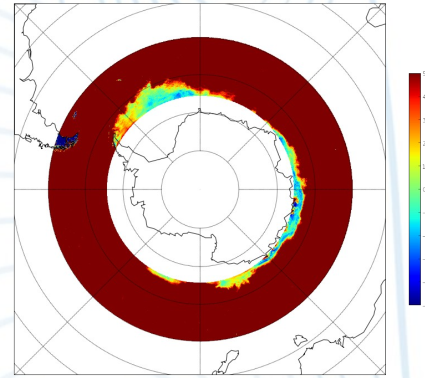
Sea ice extent evolution and Ku-band NRCS variability



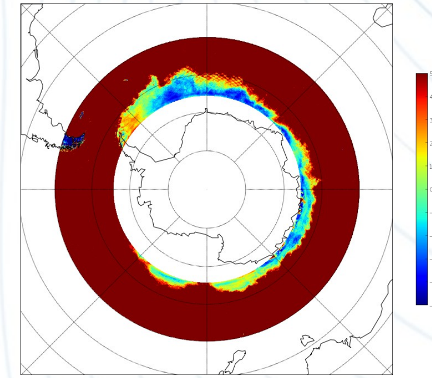
2014/03



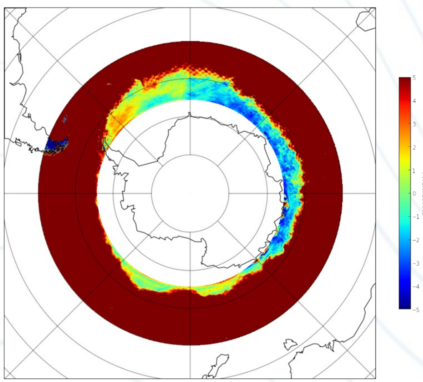
2014/04



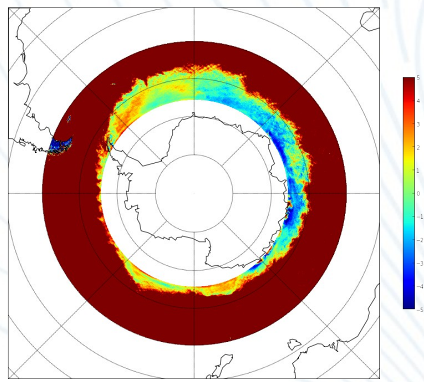
2014/05



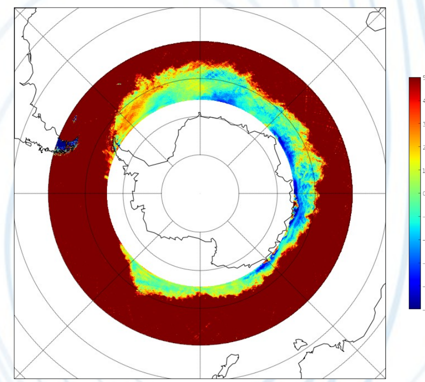
2014/06



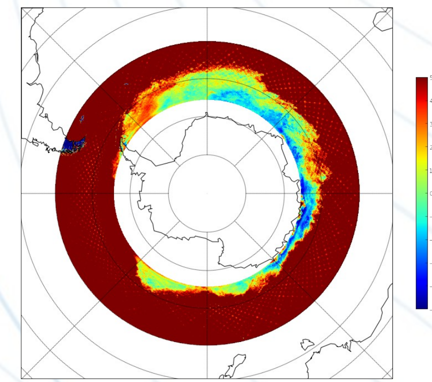
2014/07



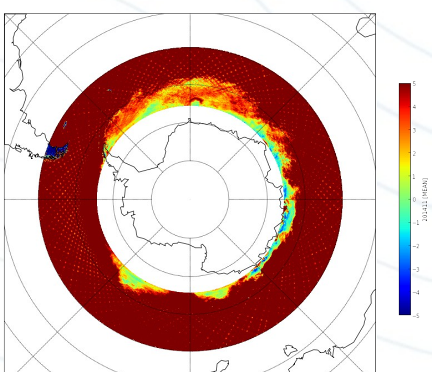
2014/08



2014/09



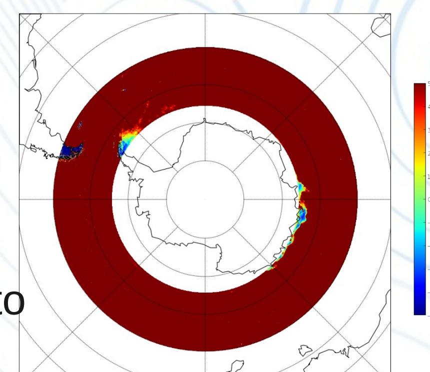
2014/10



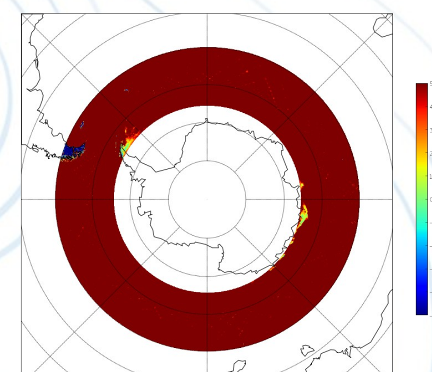
2014/11

Ku-Band Band maps along the year

Sea ice extent evolution and NRCS variability in space and time can be monitored with respect to time

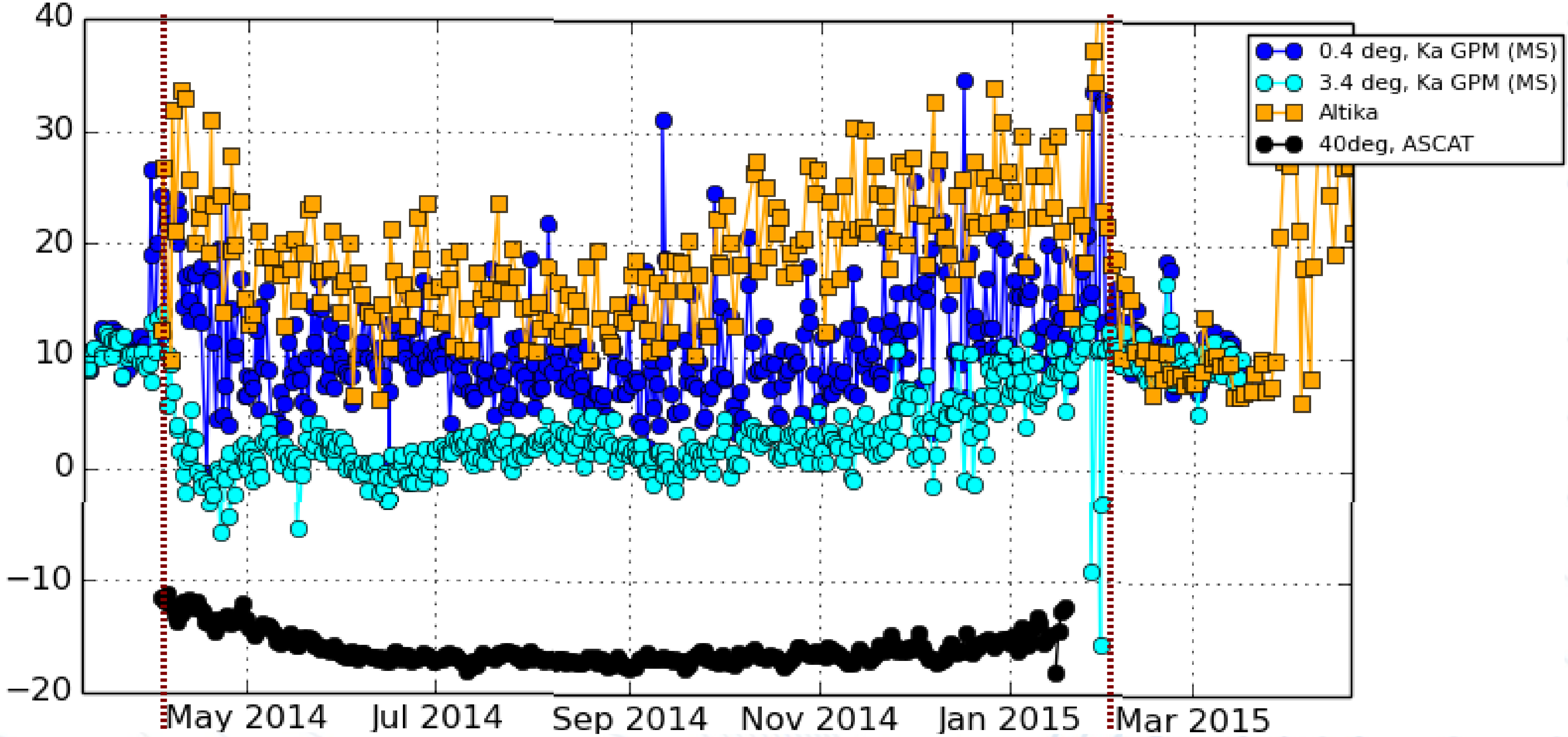


2015/01



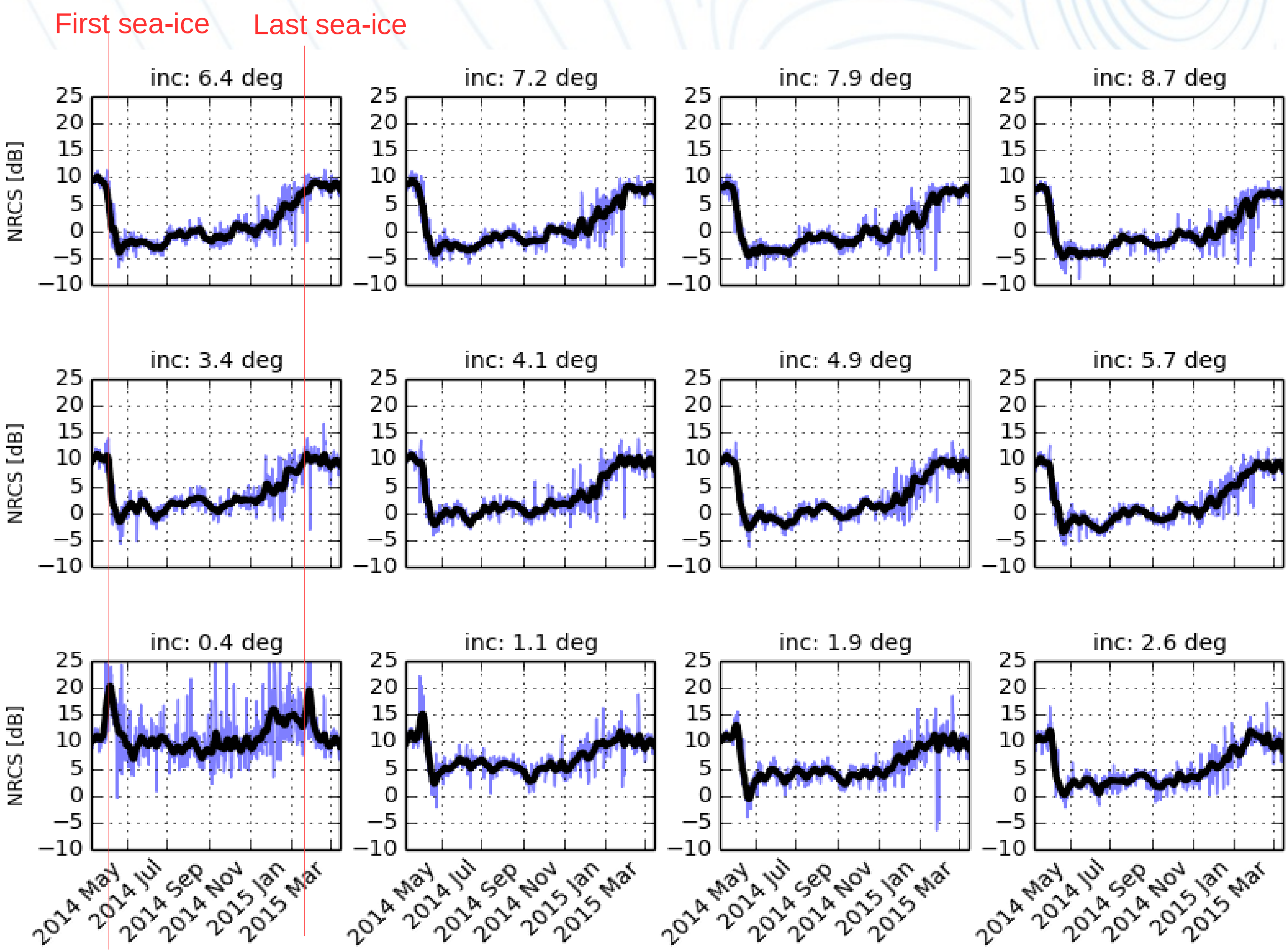
2015/02

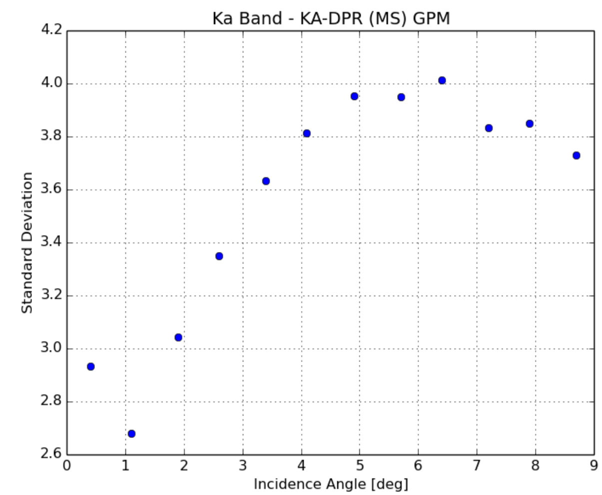
NRCS variation as a function of time for Ka-Band and ASCAT



Information from a unique geographical location all along a year
- high sensibility at nadir with Altika
- larger variability at near-nadir with Ka GPM than eq. 40° ASCAT

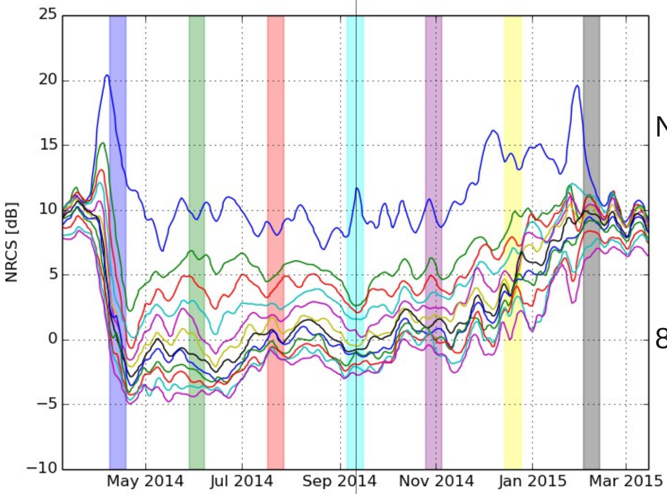
NRCS variation as a function of time for Ka-Band





- When sea ice starts to appear : high specular contribution (increase of backscattering from nadir to 2.6°, decrease for larger incidence)
- Slight increase of backscattering from May to November during freeze-up, but more significant increase during thawing period
- Sensitivity to ice modifications (NRCS seasonal trend) increases from nadir to 5 degrees

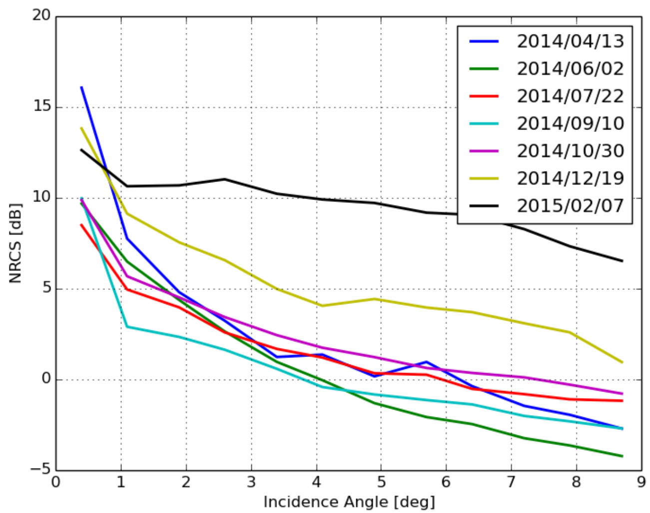
Fall-off variation as a function of time for Ka-Band



Nadir

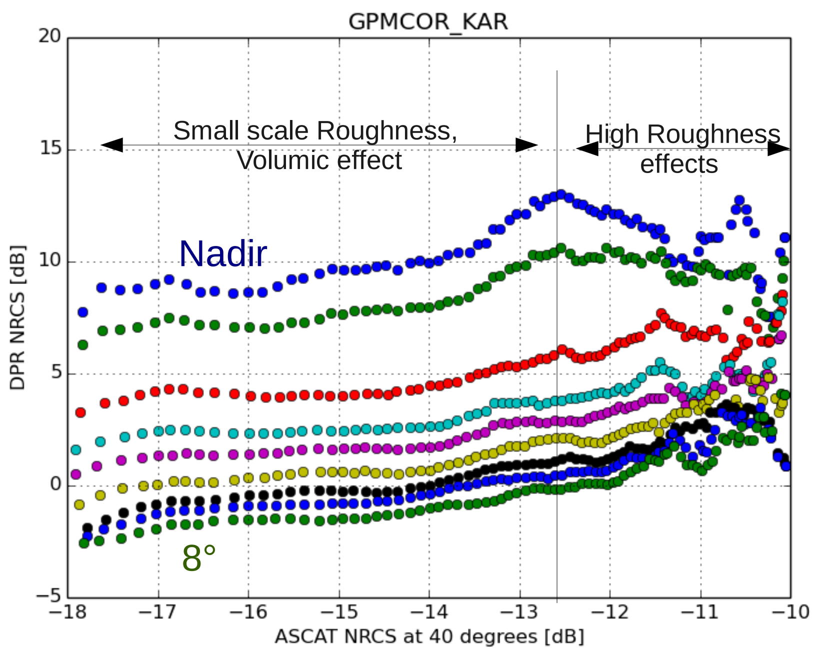
8,7°

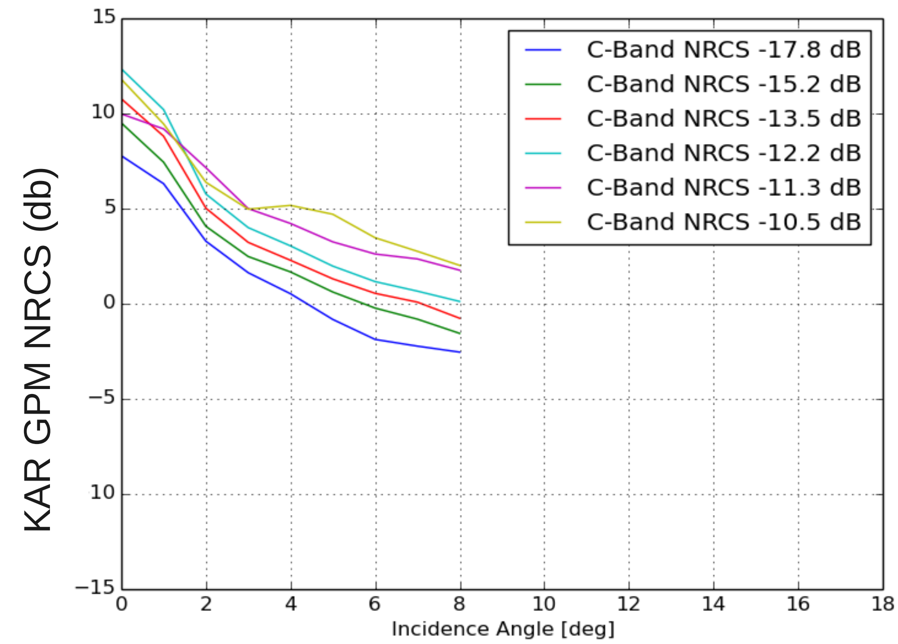
Maximum sea ice extent



- At the beginning when sea ice starts to appear, the fall-off is very rapid. Sea ice can be assumed dry and flat. Electromagnetic waves and surface interactions are specular (blue line).
- During the period when the sea-ice extent increases, the specular contribution has decreased and the fall-off has no significant changes (green, red & cyan lines).
- After September, melting period starts
  - Just after September (cyan, magenta, yellow), the slope of the fall-off does not seem to change much. Only the level. It suggests a non incidence angle-dependent phenomena.
  - Then, just before total melting, the slopes is changing. It suggest apparition of roughness with steep slopes and wavelength larger than Bragg waves .

Analysis





- Positive correlation between KaPr and $NRCS_{ascat}$ (40°) when $NRCS_{ascat}$ (40°) <-12.5dB
  - NRCS also increases at near-nadir.
  - No changes are observed in the fall-off (see blue, green and red on Right panel)

→ It suggest an increase of the fraction of small scales roughness effect
Or/And isotropic volumique scattering contribution from snow

- Negative correlation between nadir and 1° Ka GPM with $NRCS_{ascat}$ (40°) when $NRCS_{ascat}$ (40°) >12.5dB
  - Changes are observed in the fall-off

→ It suggests apparition of roughness with steep slopes and wavelength larger than Bragg waves.

- Strong potential in the analysis of GPM PR at Ku and Ka-band in the perspective of the upcoming SWOT and CFOSAT mission

- May benefit not only to open water characterization (waves and wind), but only sea ice, and even terrestrial applications

- Angular signature of sea ice largely differs from sea surface, enabling the potential generation of sea ice concentration products

- First analysis jointly with ASCAT roughness data and temporal trends :
    - Signature over sea ice at nadir and near-nadir at Ka band (and Ku?) is complex
        - Annual variability larger than 40° C-band data
        - Exploitation of multi-angular concept is quite new to altimetry, but may already provides a preliminary understanding on backscattering mechanisms
            - small-scale roughness modification or change of isotropic volume backscattering from overlying media (snow) VERSUS multi-scale rugosity with large slopes involved

    - To be further understood with adequate EM modelling (IEM + radiatif transfert considering not only sea ice, but also overlying snow layer)