  

A systematic assessment of water vapor products from satellite and reanalysis in the Arctic

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Content

- Arctic Amplification and and water vapour
- ACLOUD overview
- ACLOUD instrumentation
- Atmospheric rivers during ACLOUD
- IWV from instantaneous to
  → daily
  → monthly

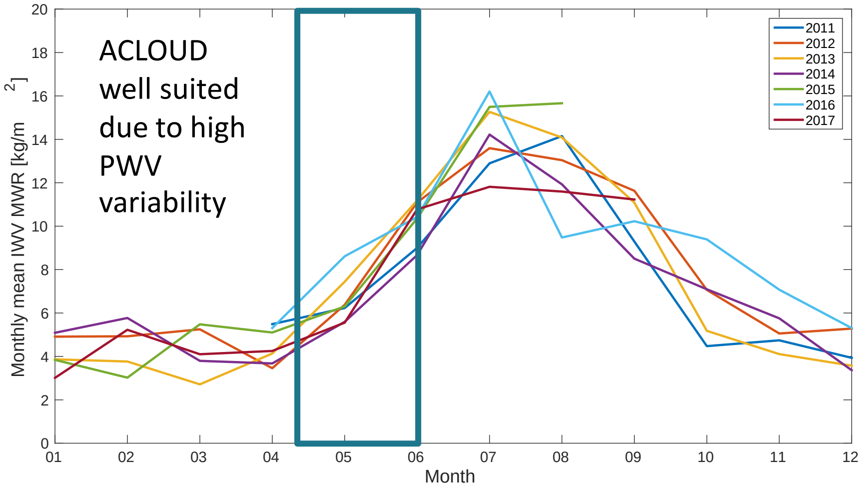
Ultimate Goal: Trend derivation

Arctic Amplification and water vapor WV

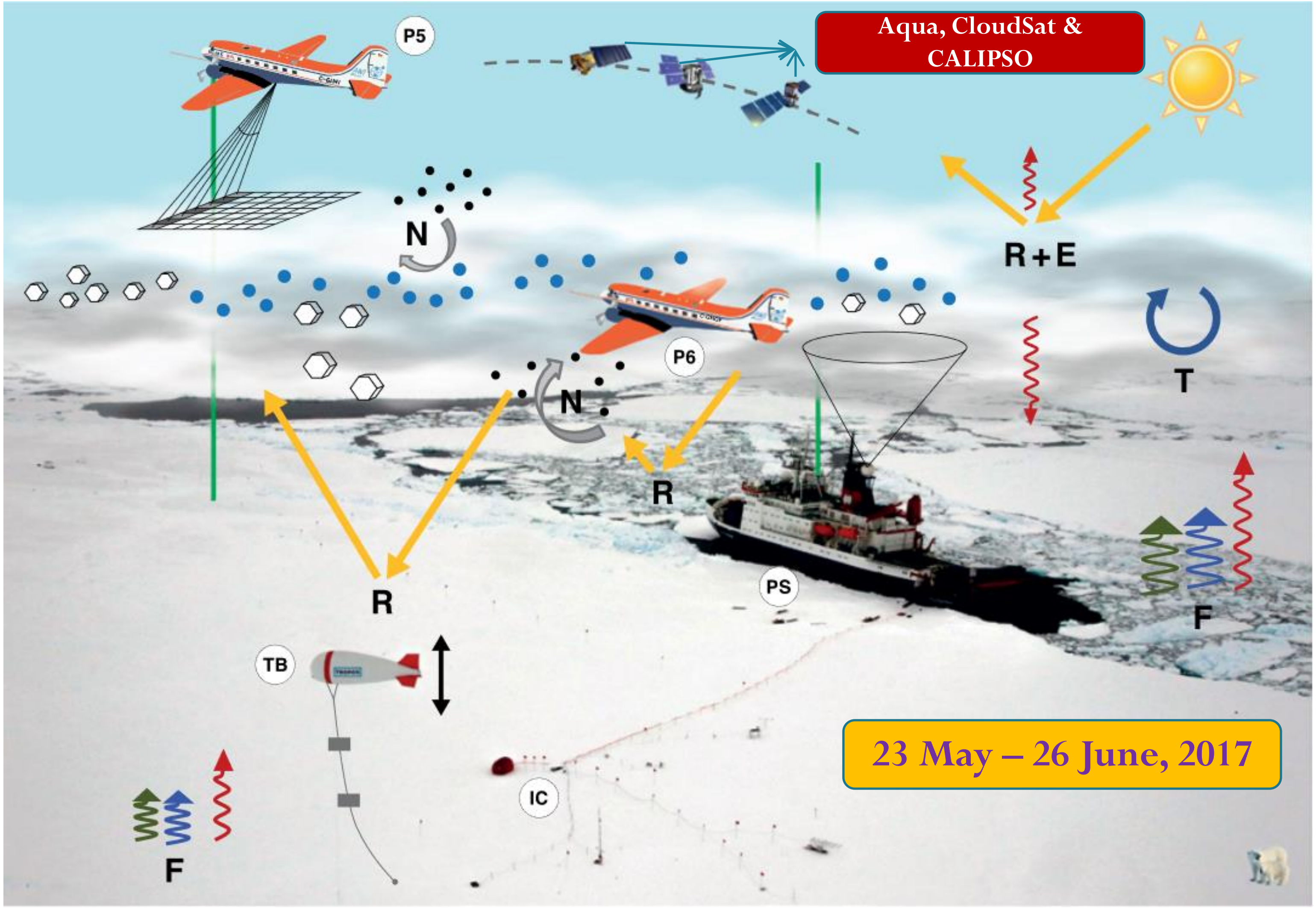
- water vapor-radiation feedback is important in the Arctic (Francis et al., 2009; Serreze and Barry, 2011).
- WV increase is expected due to increased evaporation over ocean regions becoming ice-free and enhanced moisture transport from lower latitudes into the Arctic
- Rinke et al. (in discussion) investigate IWV trend using global reanalysis: In may & june
  - central Arctic (> 80 N): no significant trend and no agreement between reanalysis
  - north Atlantic: positive trend but large differenc in magnitude between different reanalysis

Overall question:

- How trustworthy are reanalyis?
- Are satellite products good enough to evaluate reanalyis?
- Do reanalysis and satellite data sets capture water vapor and its variability in the Arctic?



ACLOUD - Arctic Cloud Observations Using airborne measurements during polar Day



Collocated Measurements

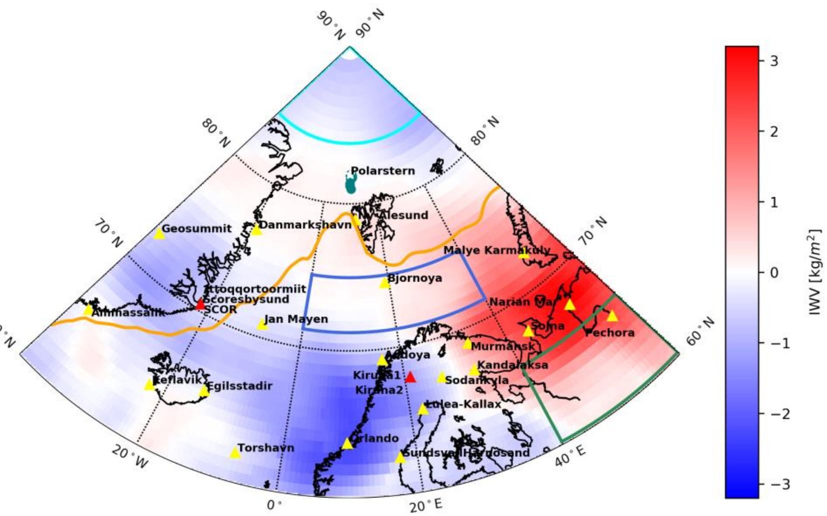
ACLOUD overview

- Ice floe camp: 5 and 14 June 2017
- Polar 5 and Polar 6 – 19 flights both (165 f light hours in total), of which 16 were coordinated flights between the two aircrafts)
  - 10 coordinated aircraft f lights above the R/V Polarstern, while
  - 13 occurred over the Ny-Ålesund site, and
  - 6 were carried out underneath the CloudSat/Cloud–Aerosol Lidar and Infrared Pathfinder Satellite Observations (CALIPSO)

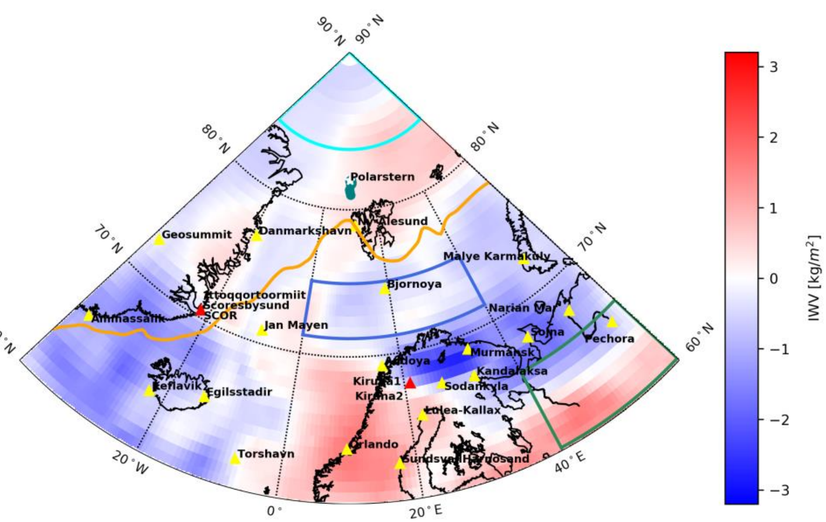
ACLOUD – WV region of interest

ERA-I

May, 2017



June, 2017



Region of investigation

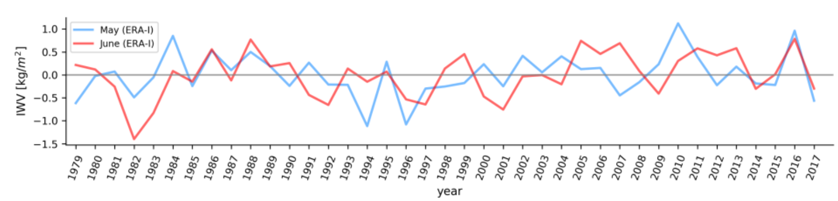
40°W-60°E, 60°N-90°N

- devided into subregions:
  - Central Artic Ocean

    84° N – 90° N & 40° W – 60° E
  - Ice free region

    72° N – 76° N & 0°- 40° E
  - North Eastern Europe

    60° N - 66° N & 40° W - 60° E
- Sea ice edge > 15 %



ACLOUD –WV assesment data sets

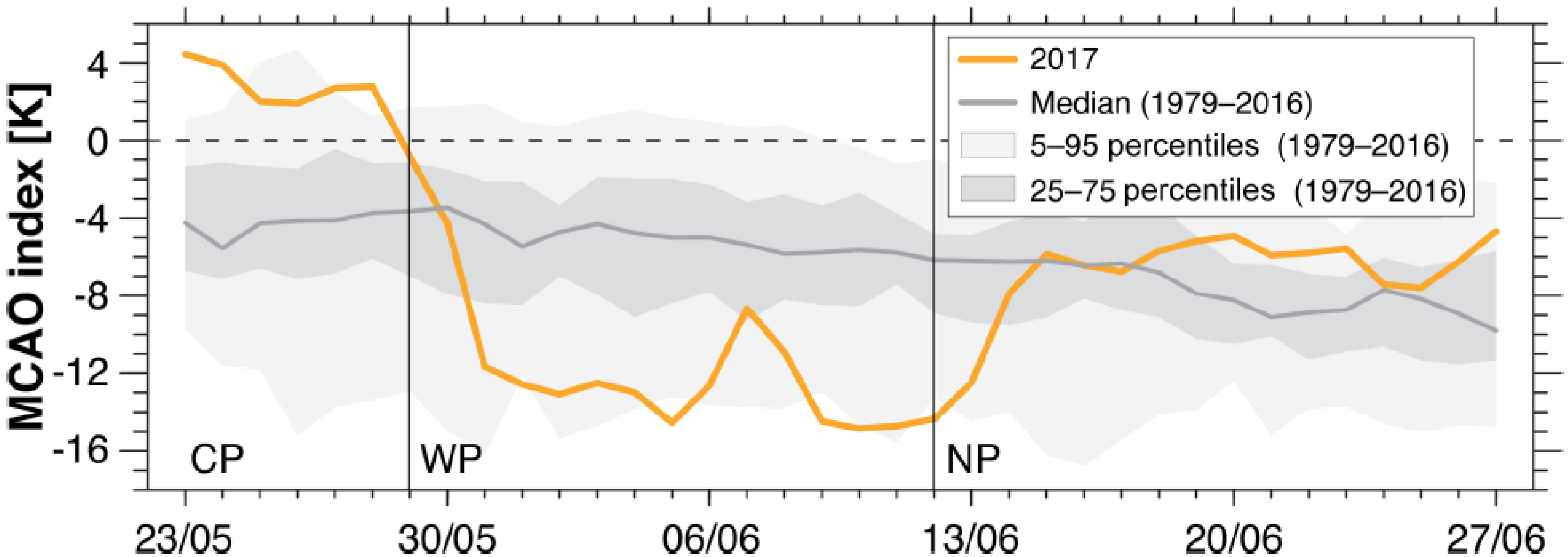
- IGRA radiosonde (Durre et al., 2018): **20** stations and ice camp
- Microwave Radiometer (MWR): Ny-Alesund and ice breaker research vessel Polarstern (dates)
- GNSS data: GFZ stations (Ny-Alesund, Kiruna, Kely, Scoresbysund)
- Satellite orbital data:
  - AMSR-2 (OEM Scarlat et al., 2018),
  - GOME (S. Noel et al.,)
  - IASI l2 v6 (EUMETSAT),
  - MIRS (NOAA CLASS),
  - MODIS (monthly l3) and

Daily and monthly means resampled to 0.75 deg grid

- Reanalyses:
  - CFSR
  - ERA-I,
  - JRA-55,
  - MERRA-2

Daily, spatially resampled to 0.75 deg grid

ACLOUD - Synoptic overview



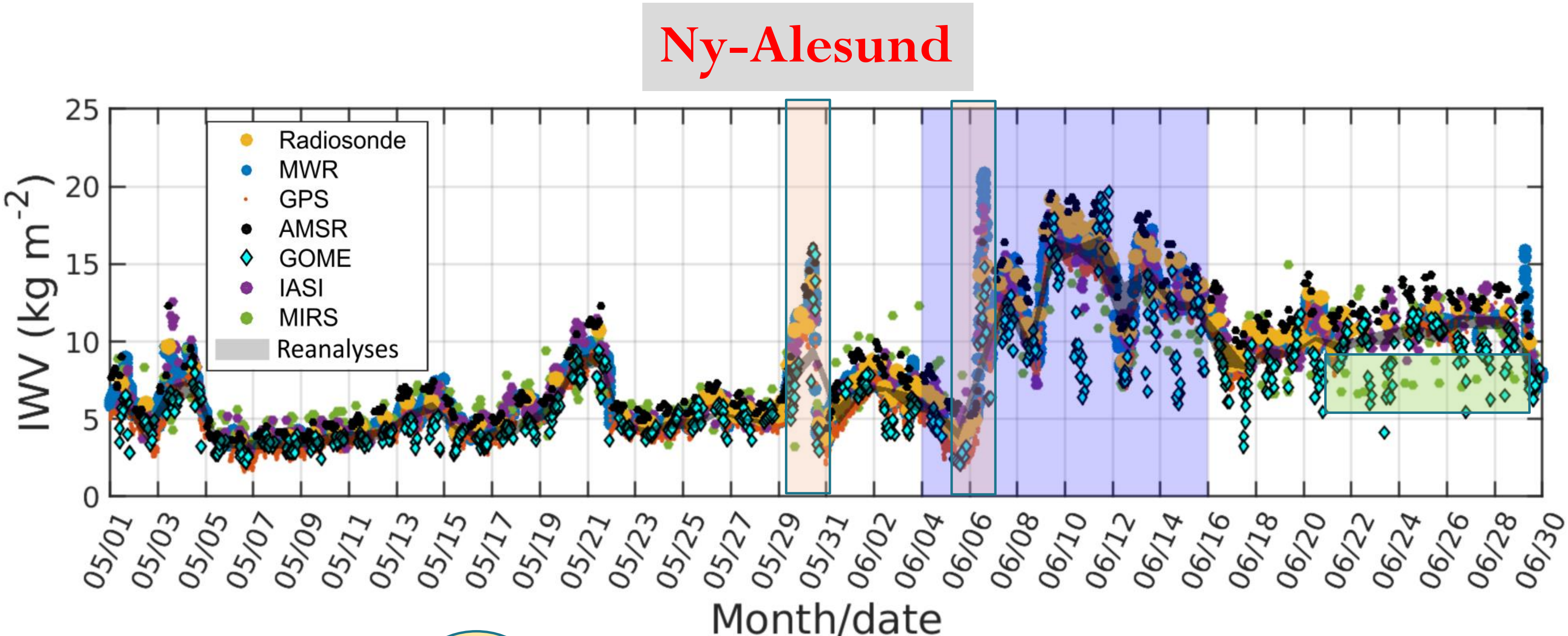
Cold Air Outbreak
23–29 May

Warm Air Intrusion
30 May–12 June

North Westerly Flow
13–26 June

E. M. Knudsen et al., 2018

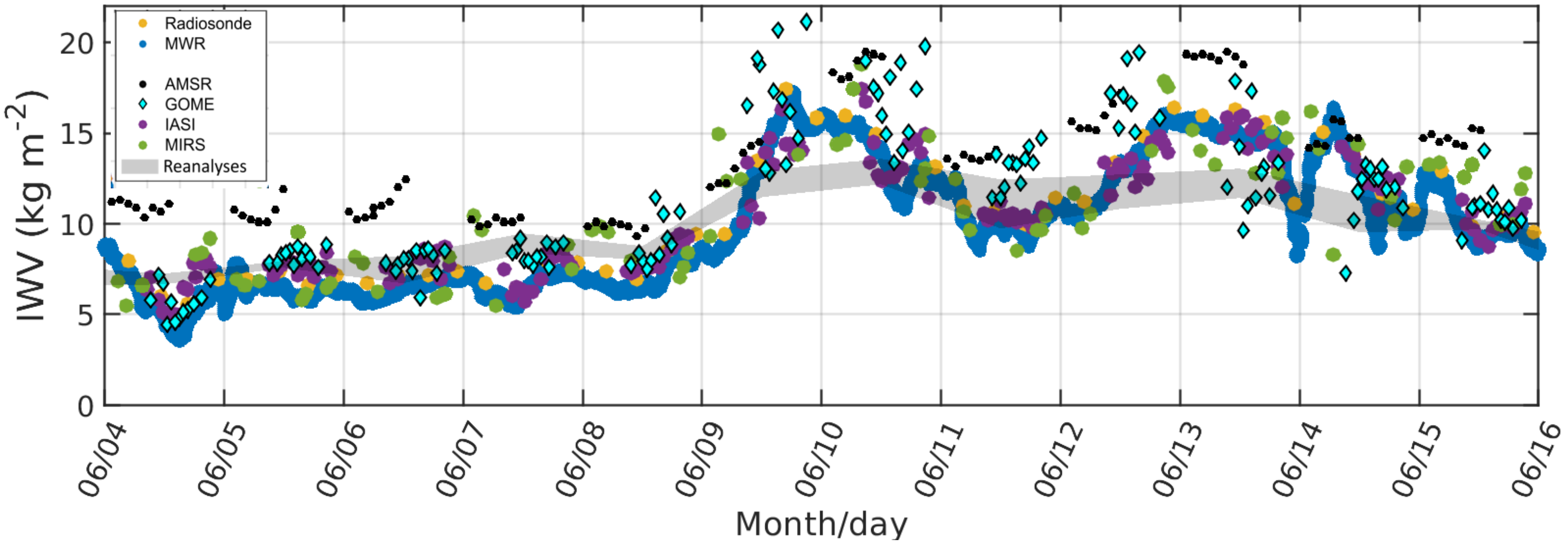
IWV – instruments intercomparison



- Data in range of 50km around Ny-Alesund station (78.91°N 11.93°E)
- Atmospheric river on 30th of May and 6th of June
- Daily means can't capture WV intrusions
- Notable MIRS differences at end of the period from SSM/I F17 & F18
- AMSR differences due to water vapor absorption model

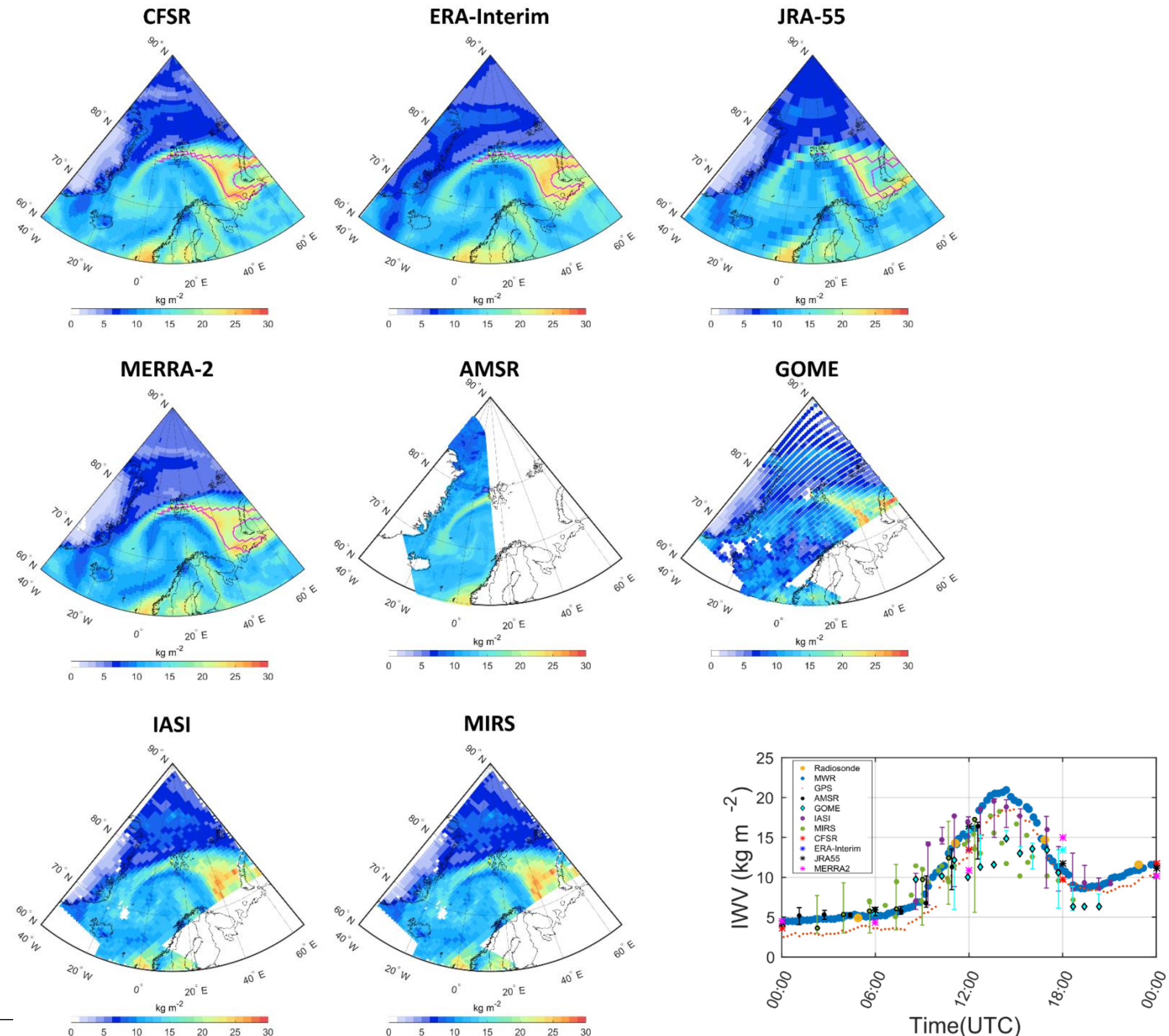
IWV – instruments intercomparison

Polarstern

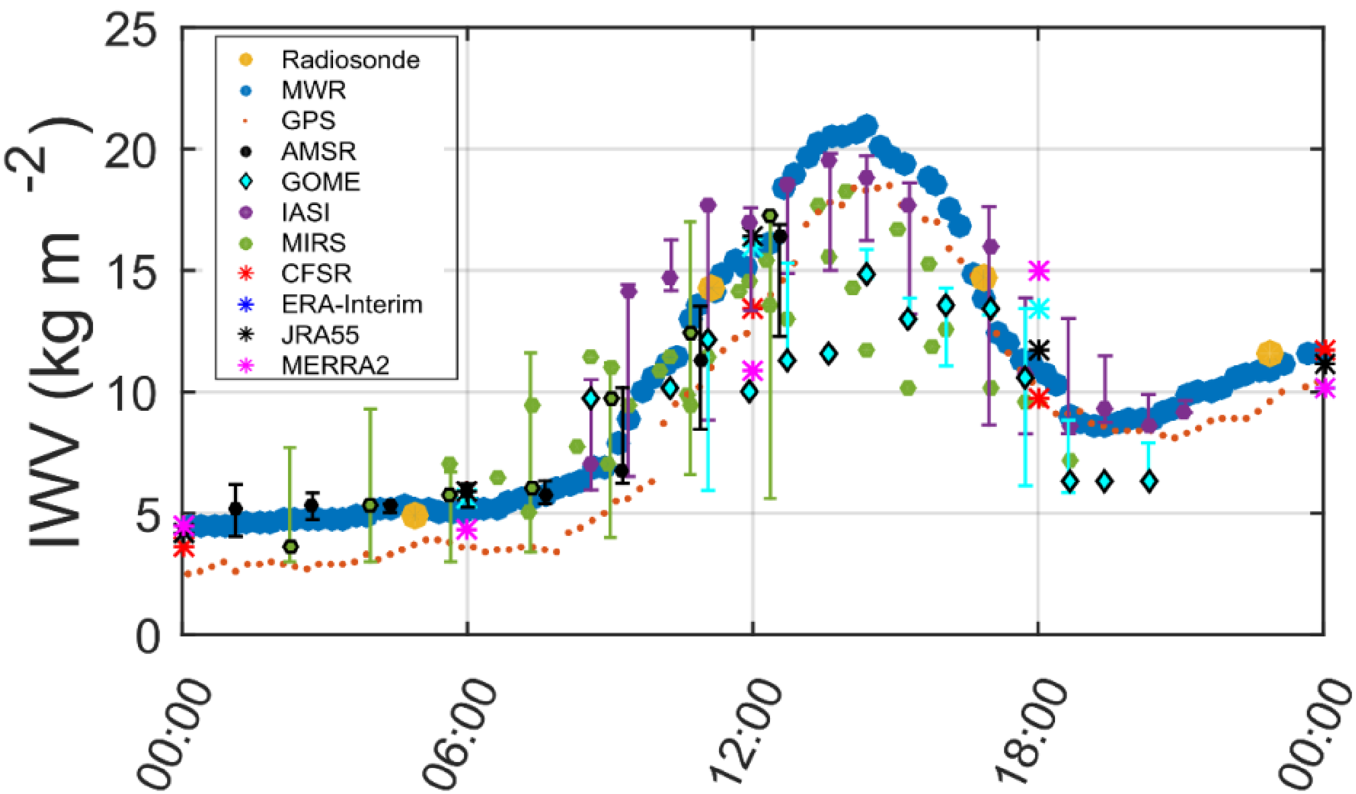


- Only MWR can capture high IWV variability
- Excellent MWR and RS agreement
- AMSR IWV retrieval offset due to water vapor absorption model

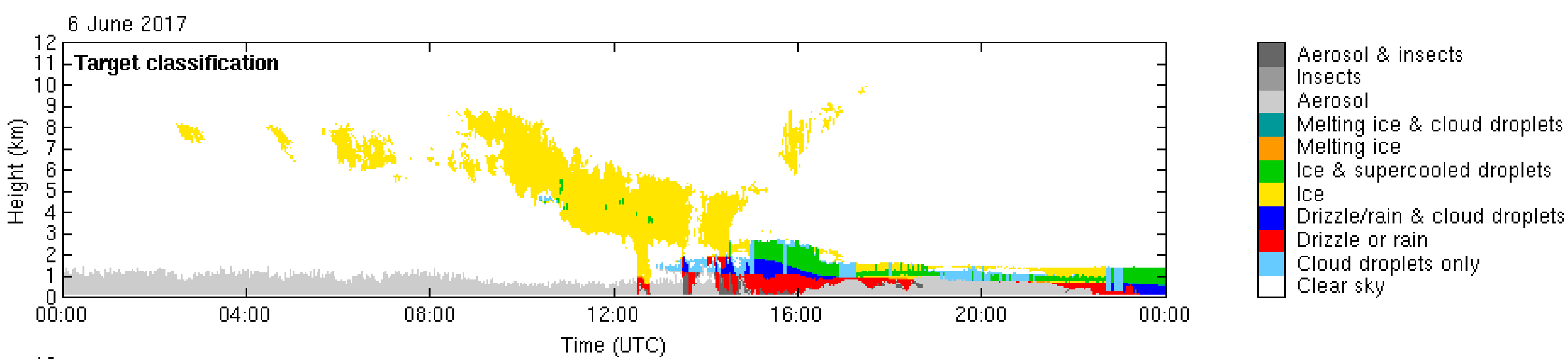
Atmospheric river on 6th of June, 12 UTC



Atmospheric river on 6th of June, Ny Alesund

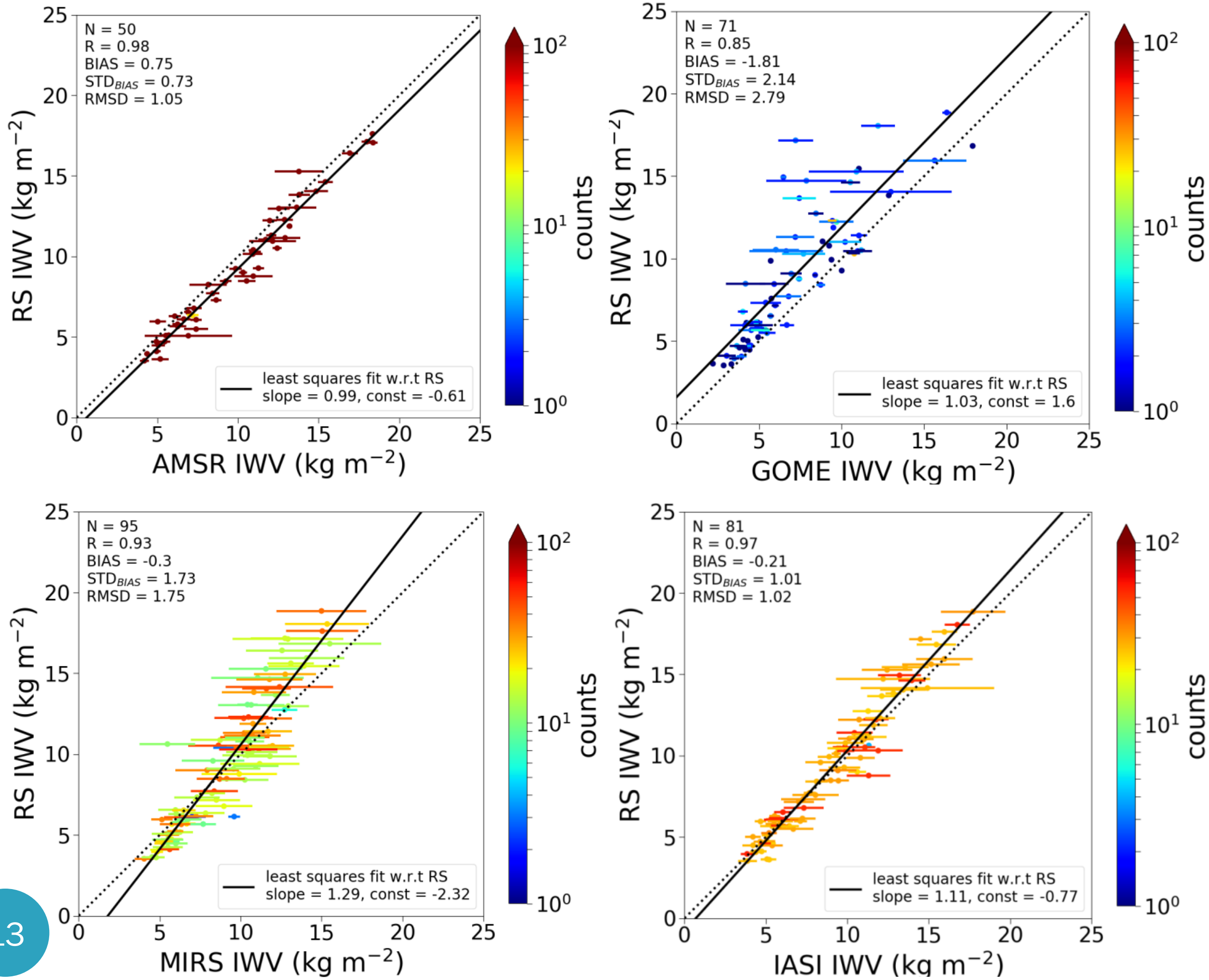


- All pixels < 50 km
- Retrieval difficulties due to liquid clouds starting 13:00
- IASI performance best (NWP influence)



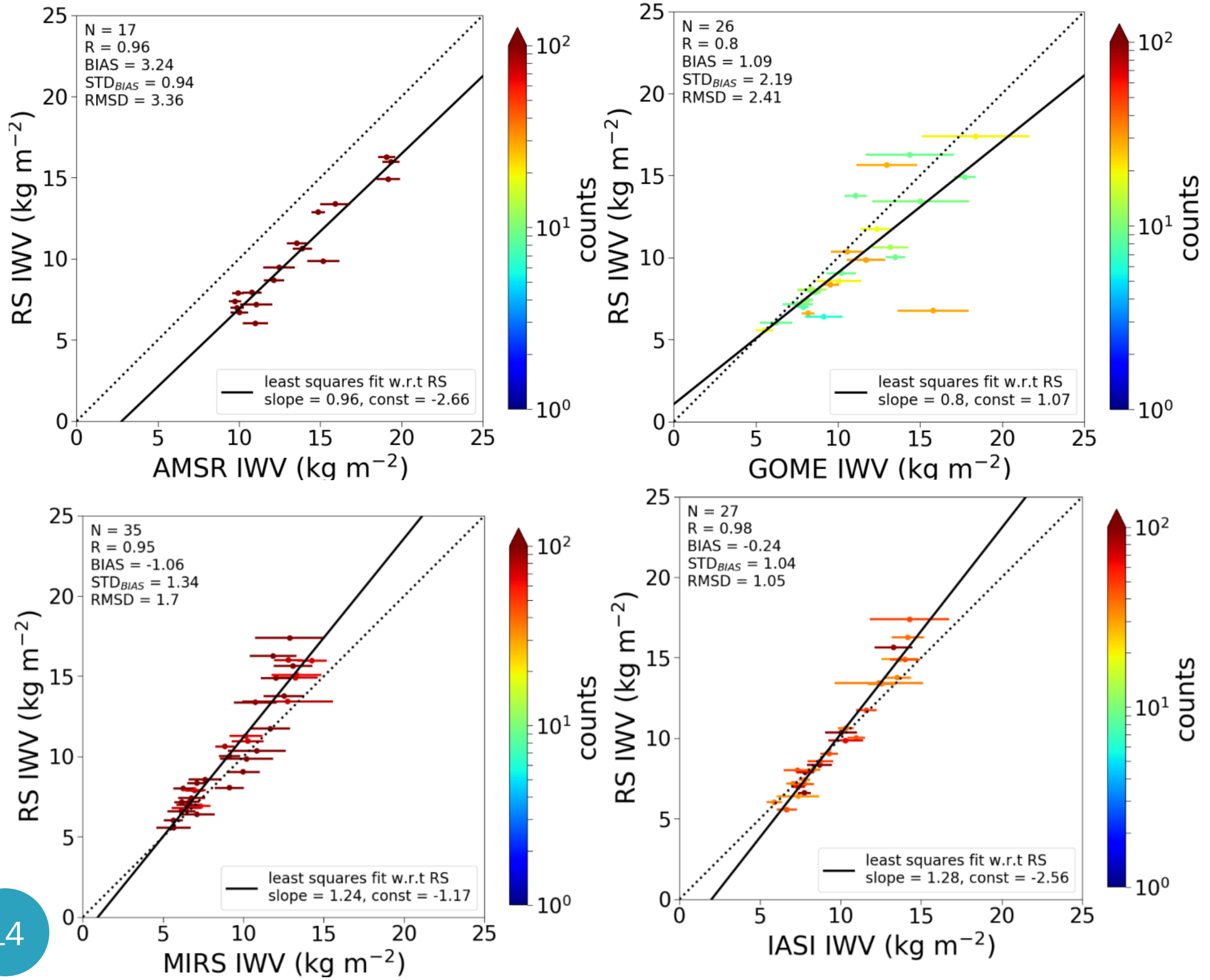
Satellites in comparison to RS (AR day)

Ny-Alesund



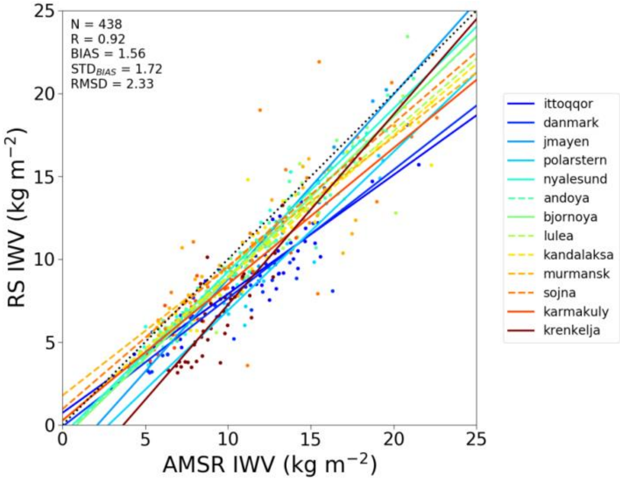
Satellites in comparison to RS (AR day)

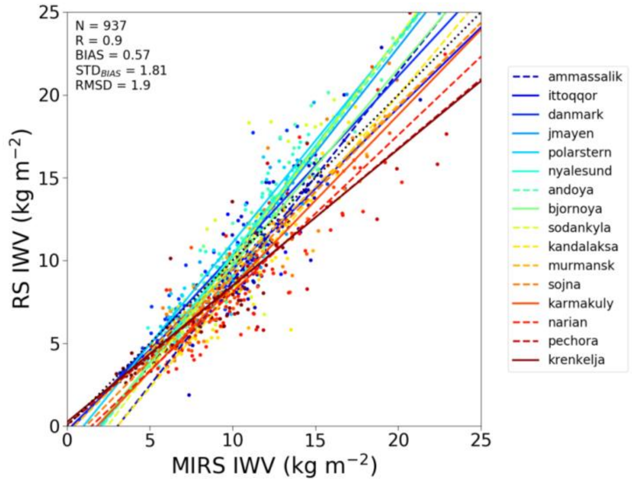
Polarstern

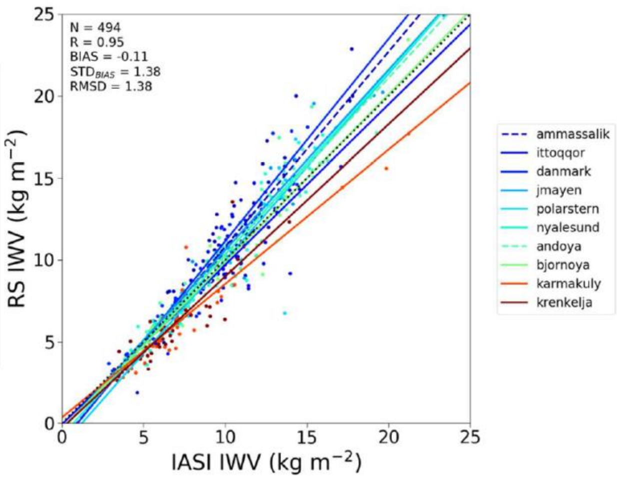


All RS stations compared satellites

Only water area







	#	bias	std	rmse	R
AMSR	438	1.6	1.7	2.3	0.92
IASI	602	-0.1	1.3	1.3	0.95
MIRS	937	0.6	1.8	1.9	0.90
GOME-2	452	-0.7	2.5	2.5	0.79

Summary individual intercomparison

- High-latitude reference measurements (RS, GNSS, MWR) during the highly variable ACLOUD period provide unique opportunity to assess the quality of reanalyses and satellite IWV products

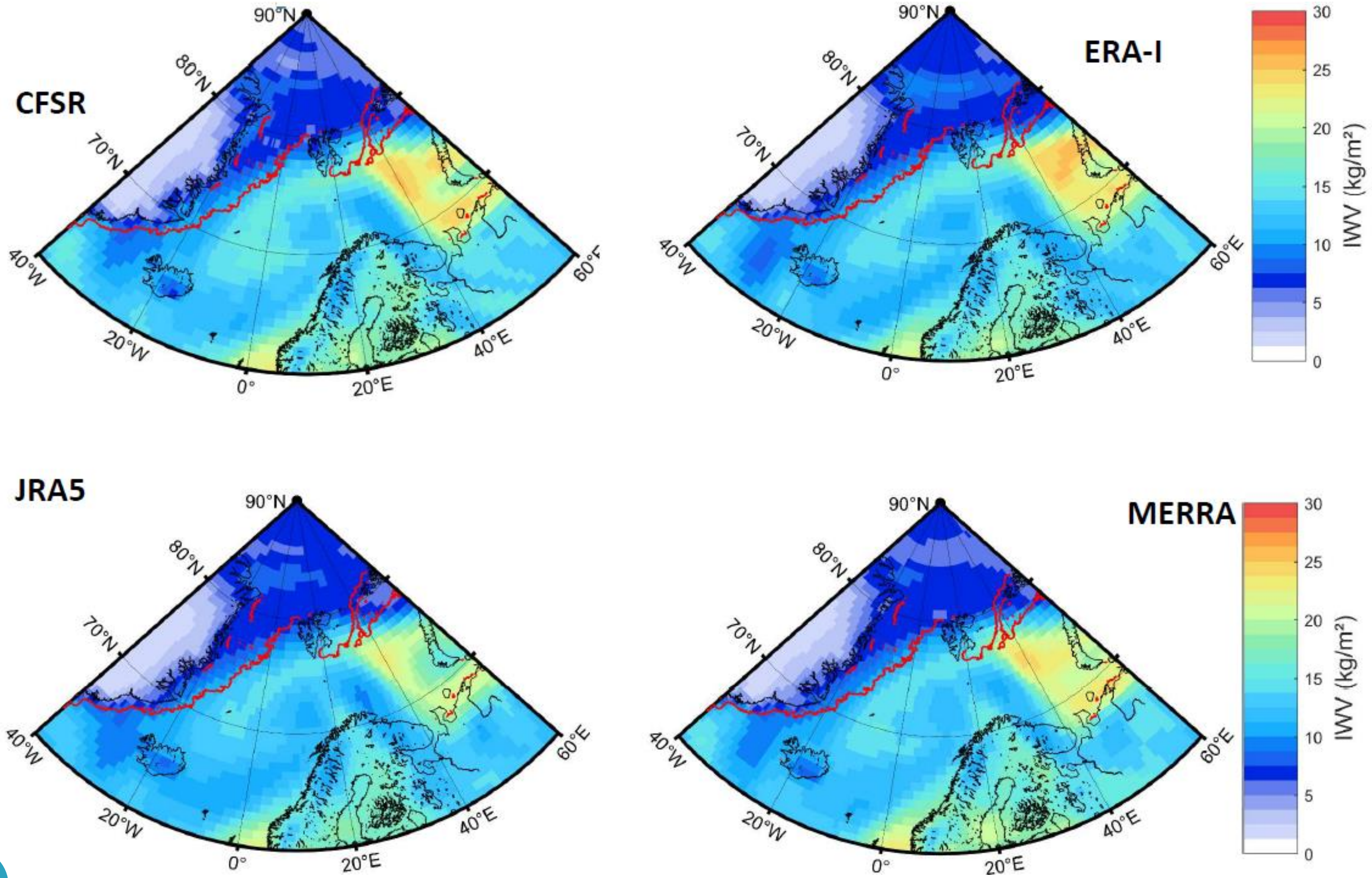
- Excellent agreement of radiosondes and microwave radiometer (RMS 0.6 mm)
  → MWR which has highest temporal resolution can be used to characterize variabilty on all scales

- Though GNSS behaves slightly worse (RMS = 1.1 mm to MWR) can be used as reference at other GNSS stations

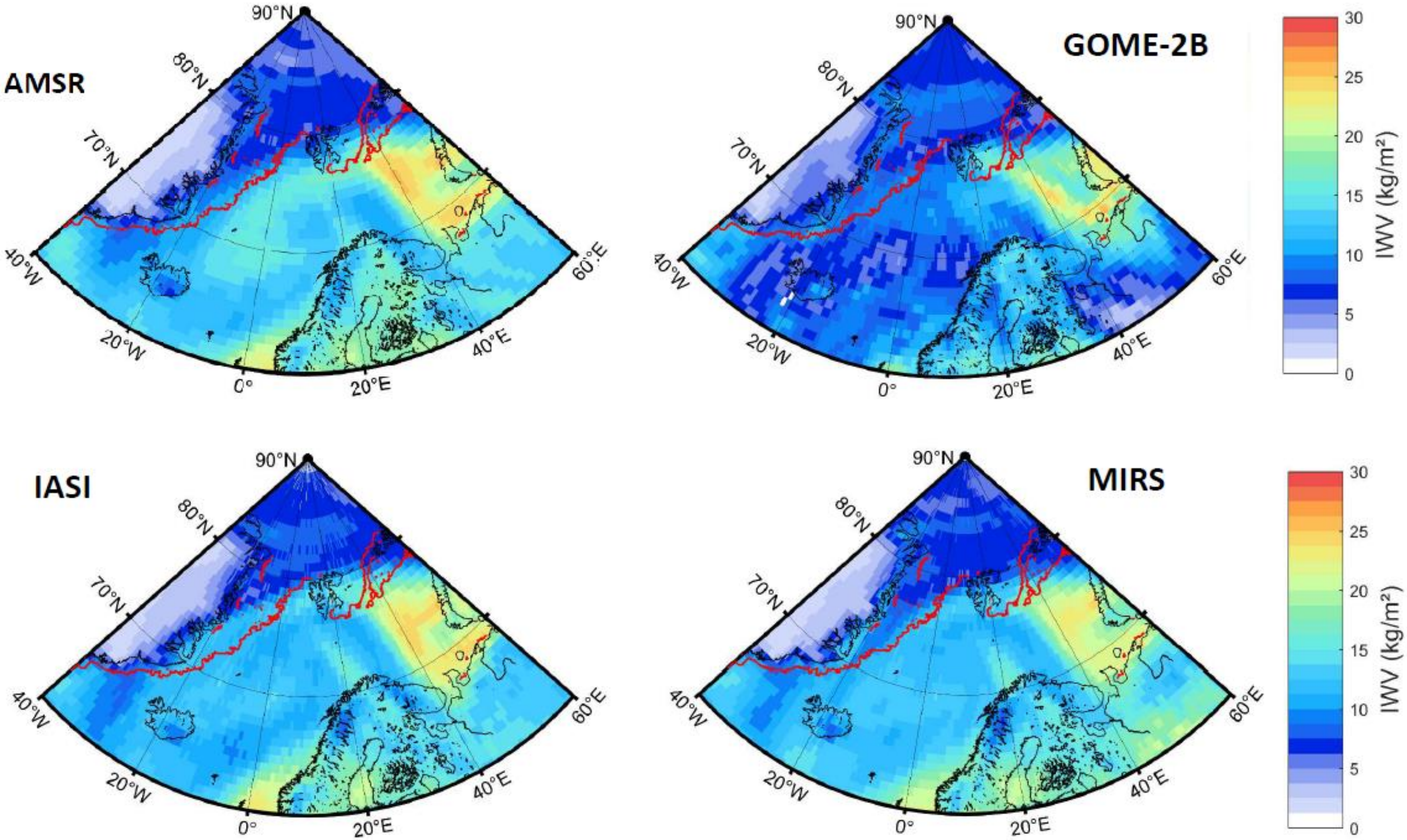
- Satellite data availability of MIRS and IASI is highest – need to avoid pixels with elevation

- MIRS and IASI underestimate IWV at the high IWV end

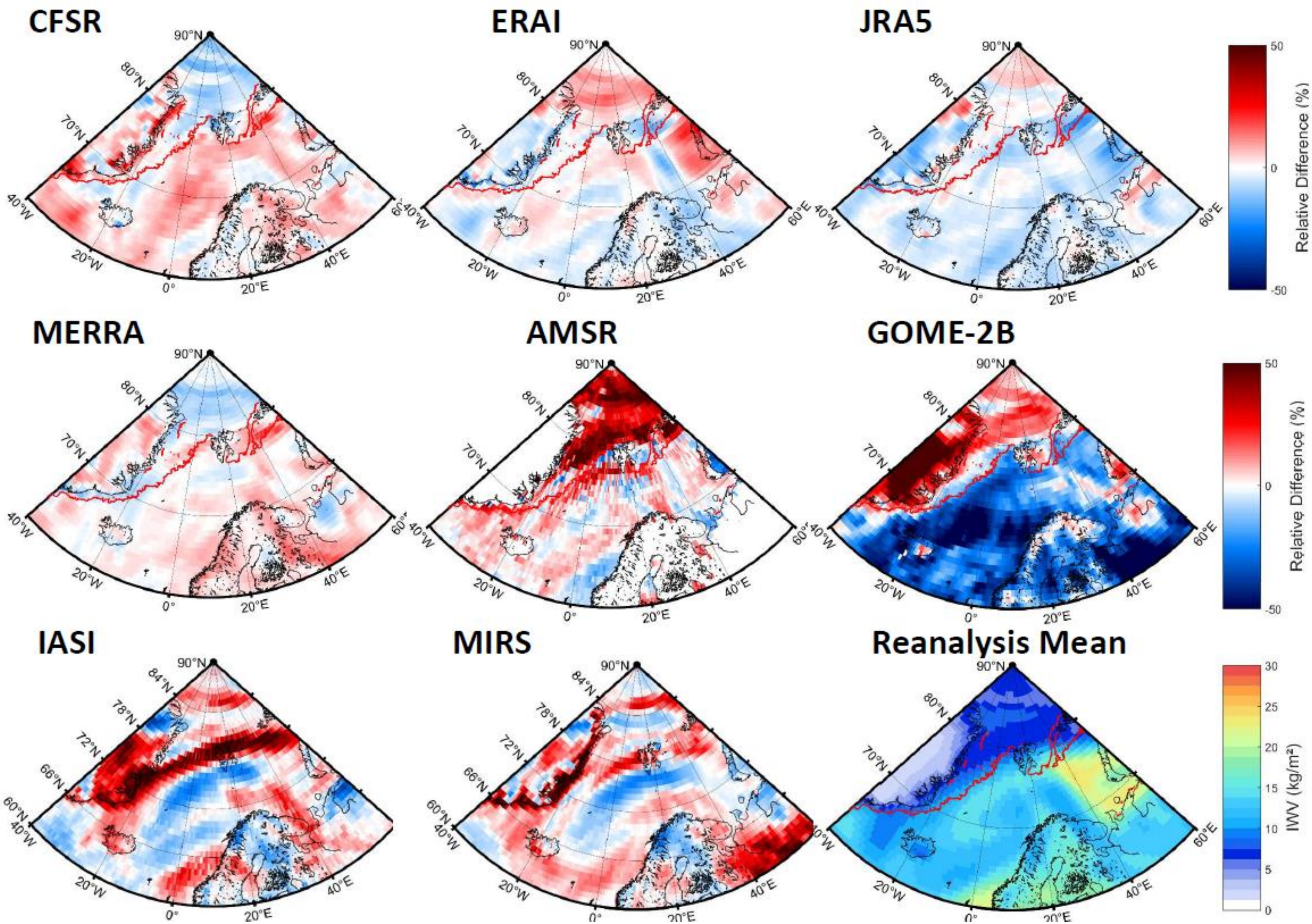
Daily means - reanalyses



Daily means - satellites

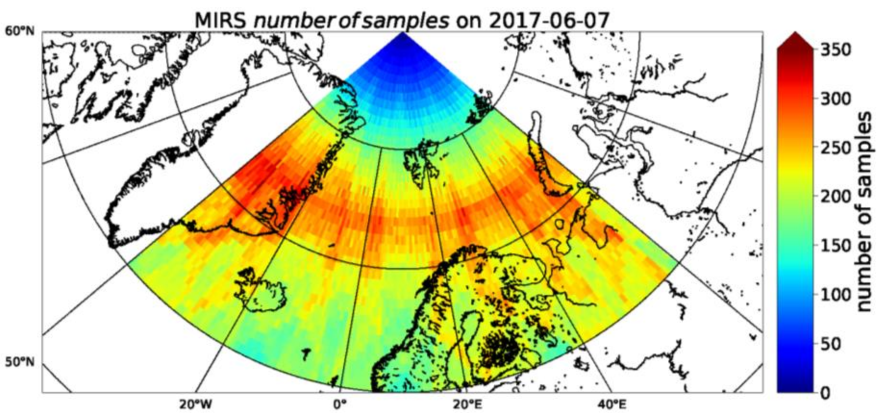


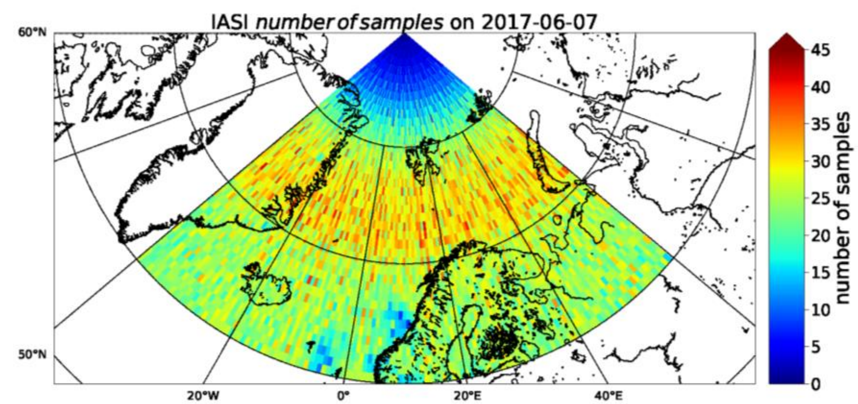
Daily means rel. diff. In respect to reas mean

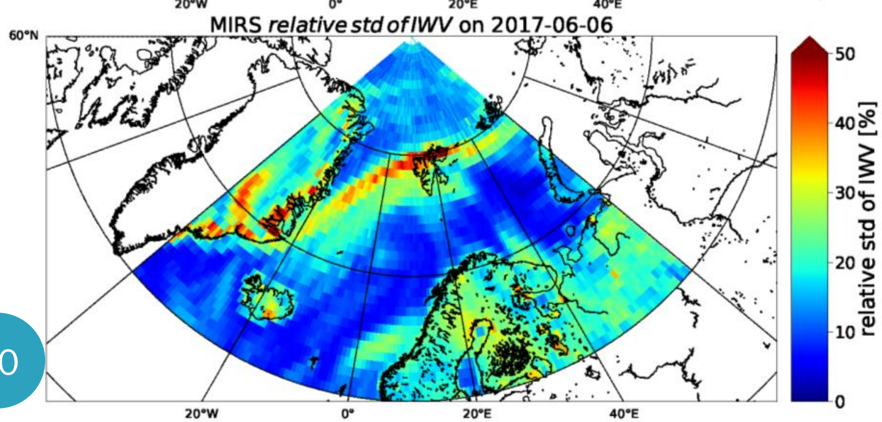


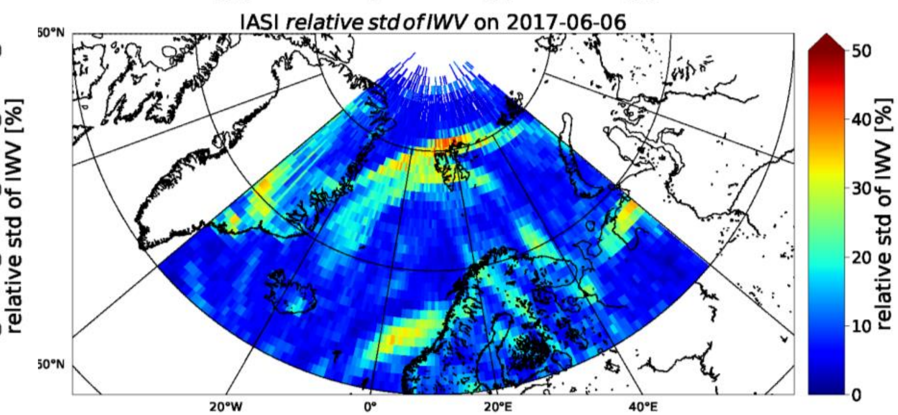
Atmospheric river on 6th of June

- Atmospheric river produces pronounced spatio-temporal variablity
- Differneces between reanayses are in order of ± 15%
- Satellie estimates can differ by more than 30 % from reanalyses mean
- Over ocean AMSR has similar spatial patterns as ERA-I (a-priori)
- Part of the differences can be explained sampling since IASI and MIRS with they good covergae detect relative standard devaiation of more than 30 %

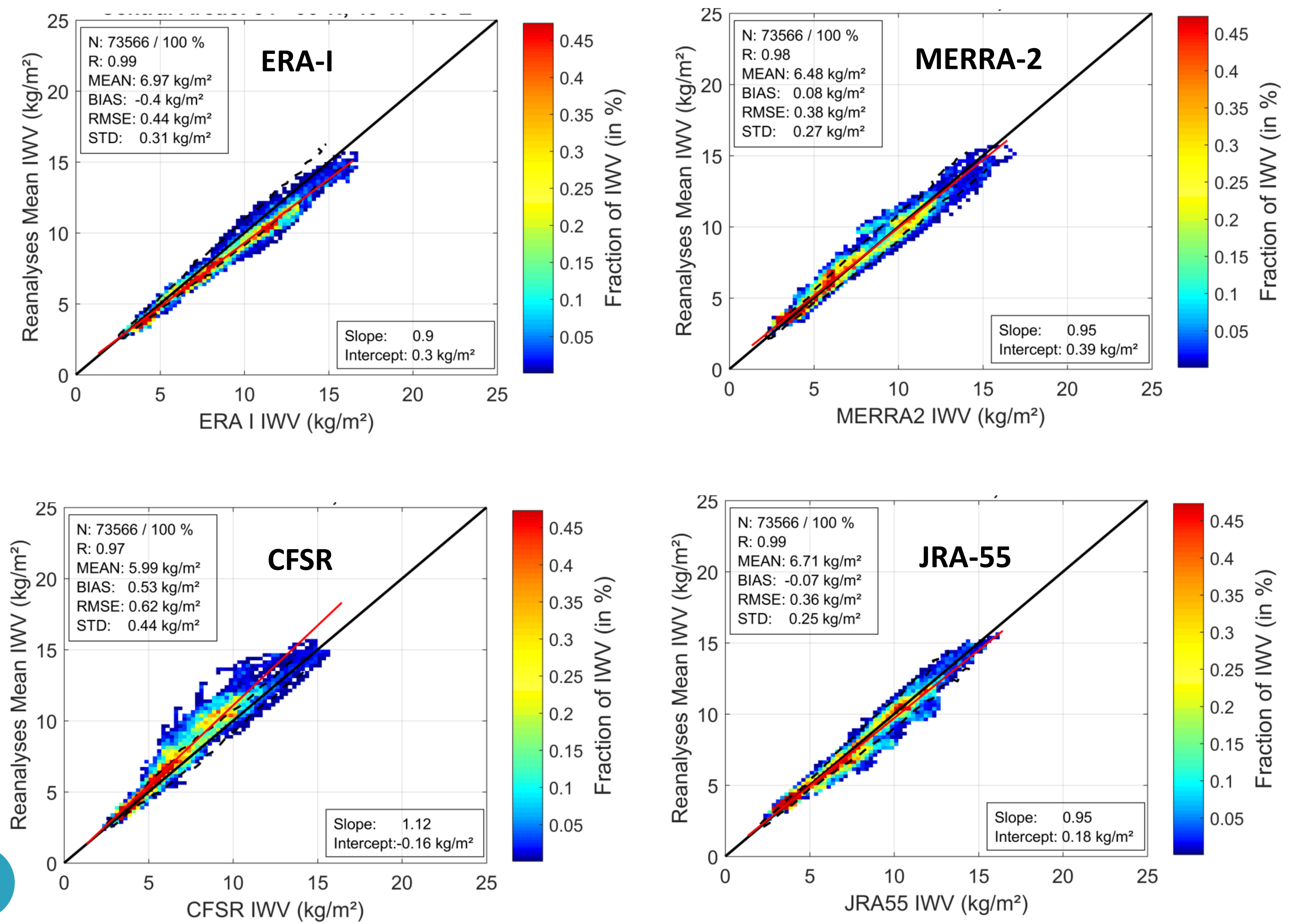




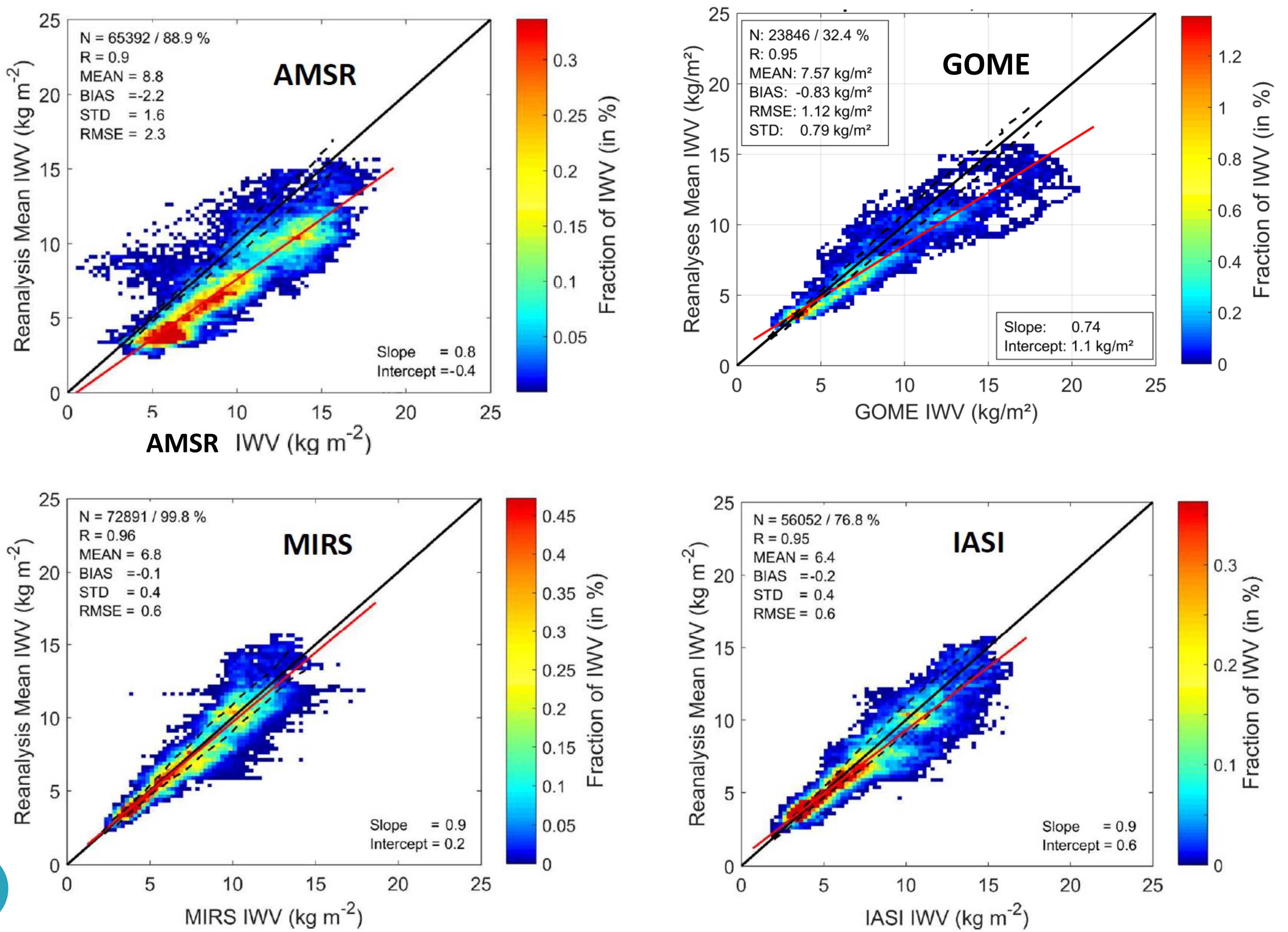




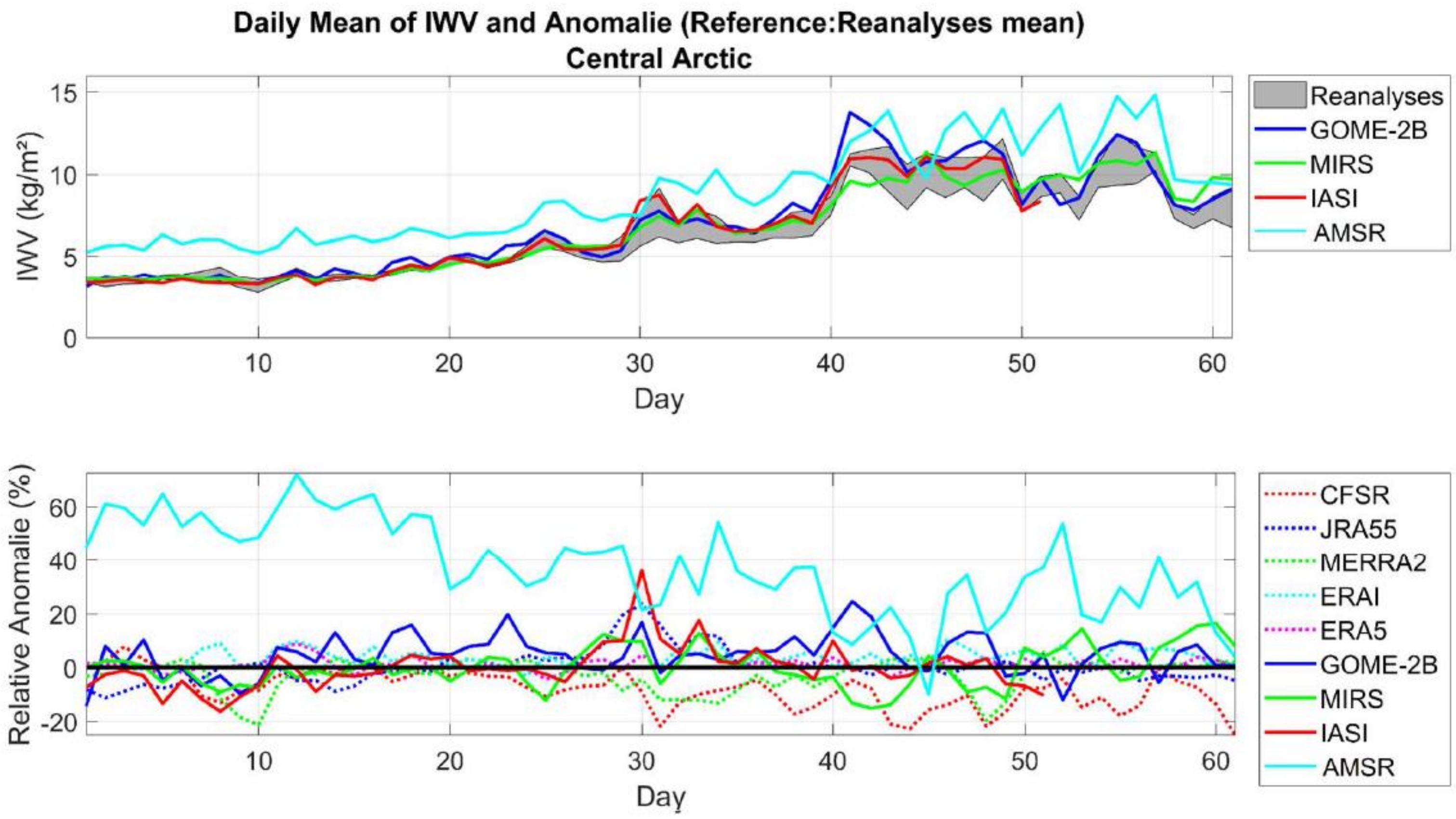
Joint distributions – 40°W – 60°E and 84°N-90°N



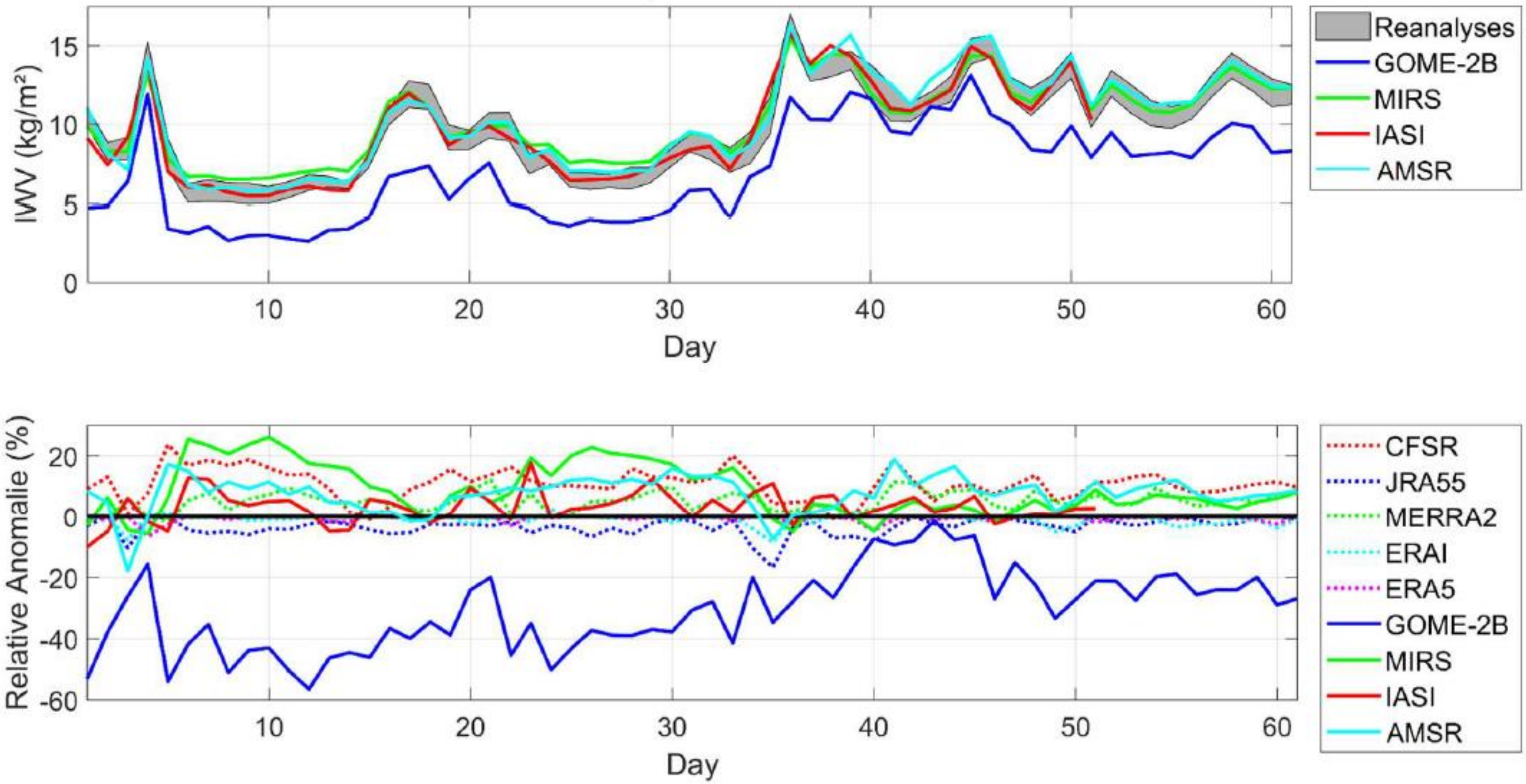
Joint distributions – 40°W – 60°E and 84°N-90°N



Time series for Central Arctic



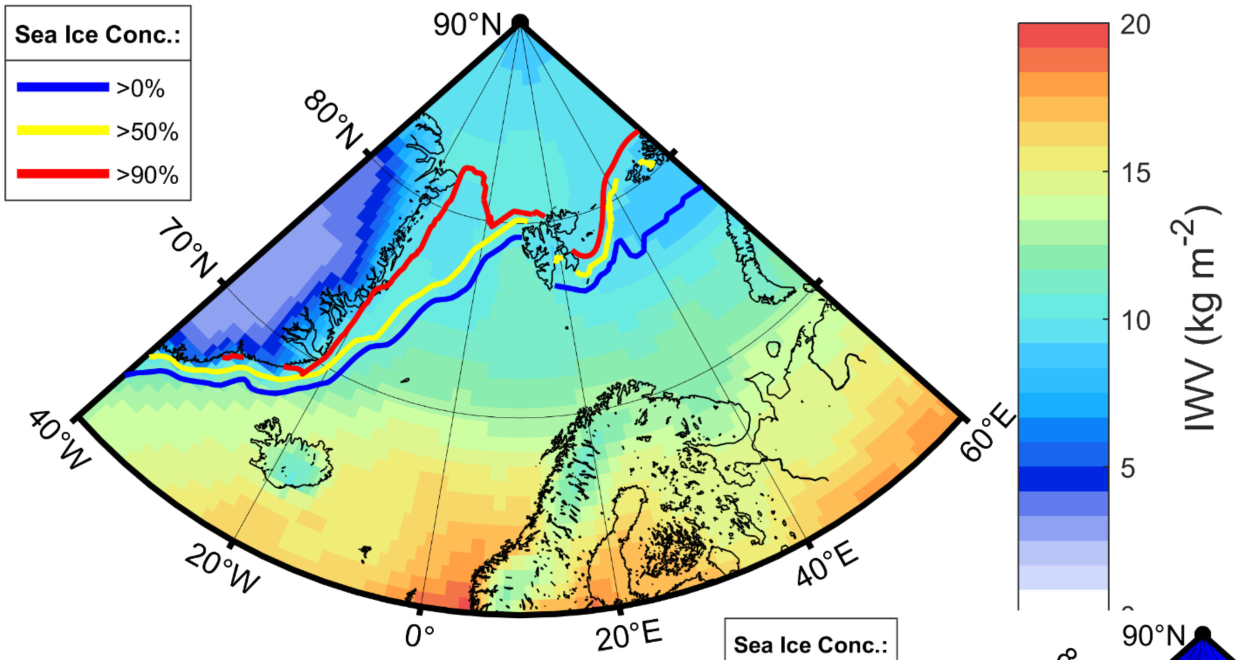
Time series for open ocean



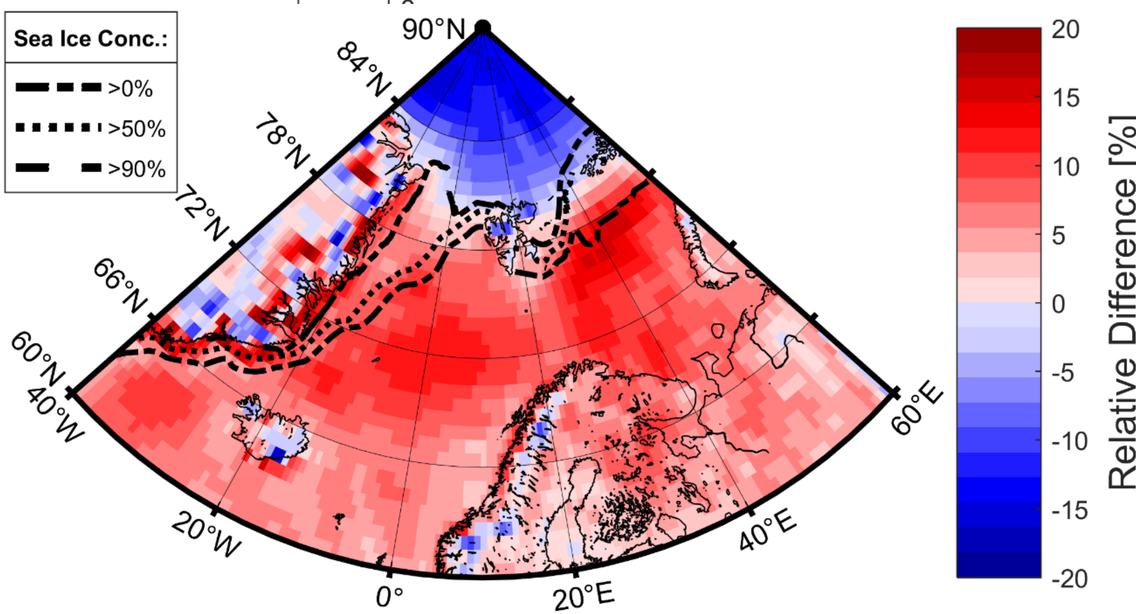
Summary daily means

- Diurnal standard deviation at times can be 50%
  → importance of sampling
- MIRS and IASI have very frequent sampling
- Magnitude of IASI and MIRS show similiar deviations from reanalysis mean than individual reanalysis
- CFSR (dry) and ERA-I (moist) differ strongly over sea ice

Monthly means - CFSR



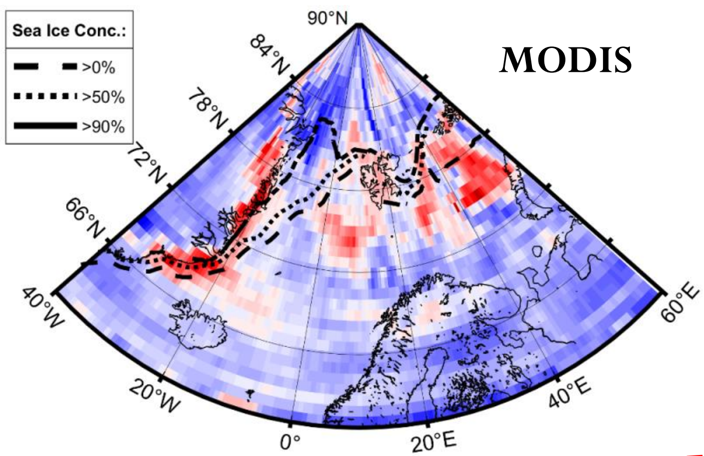
Reanalysis show deviations of +/- 20%

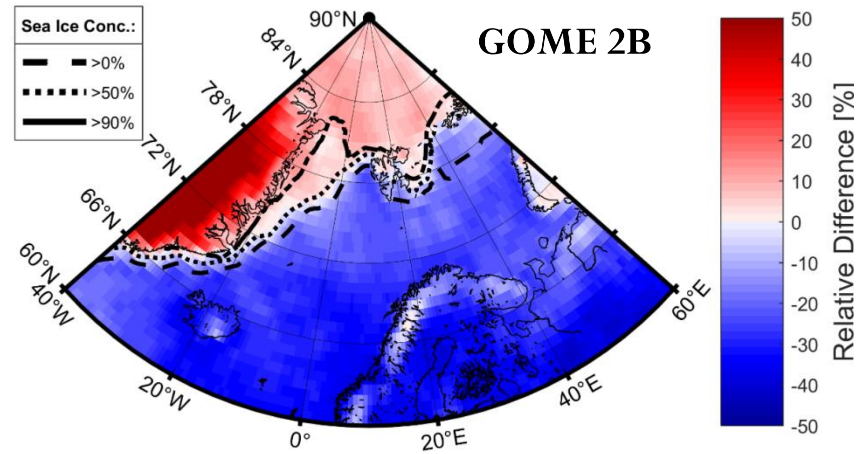


Difference in respect to reanalysis mean

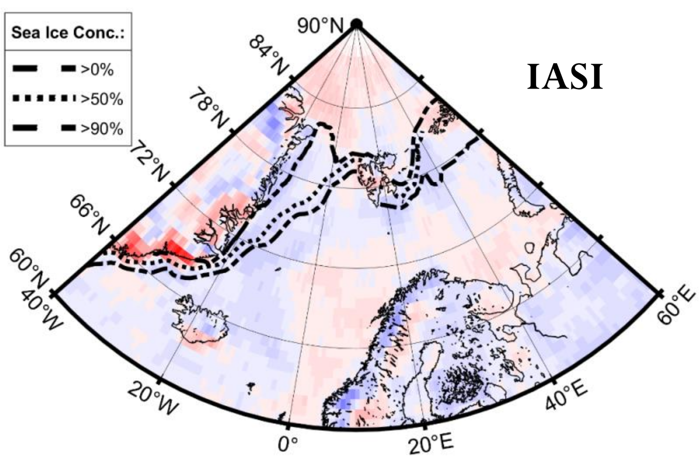
Monthly means

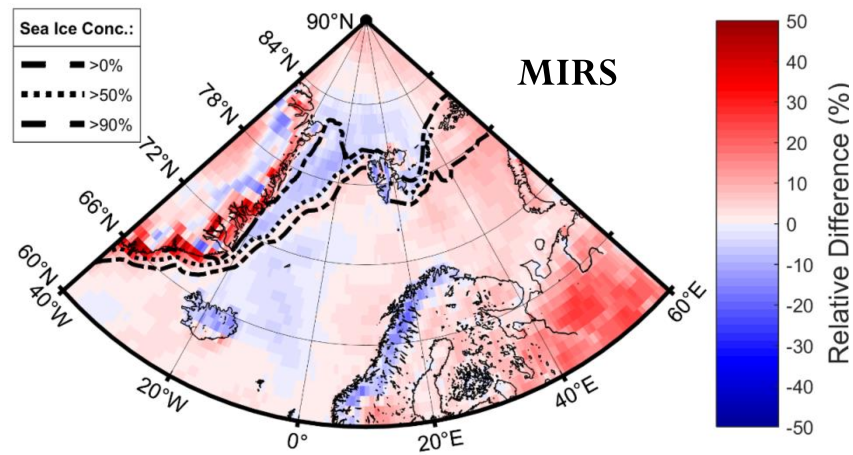
Satellites show deviations of +/- 40%





Preliminary

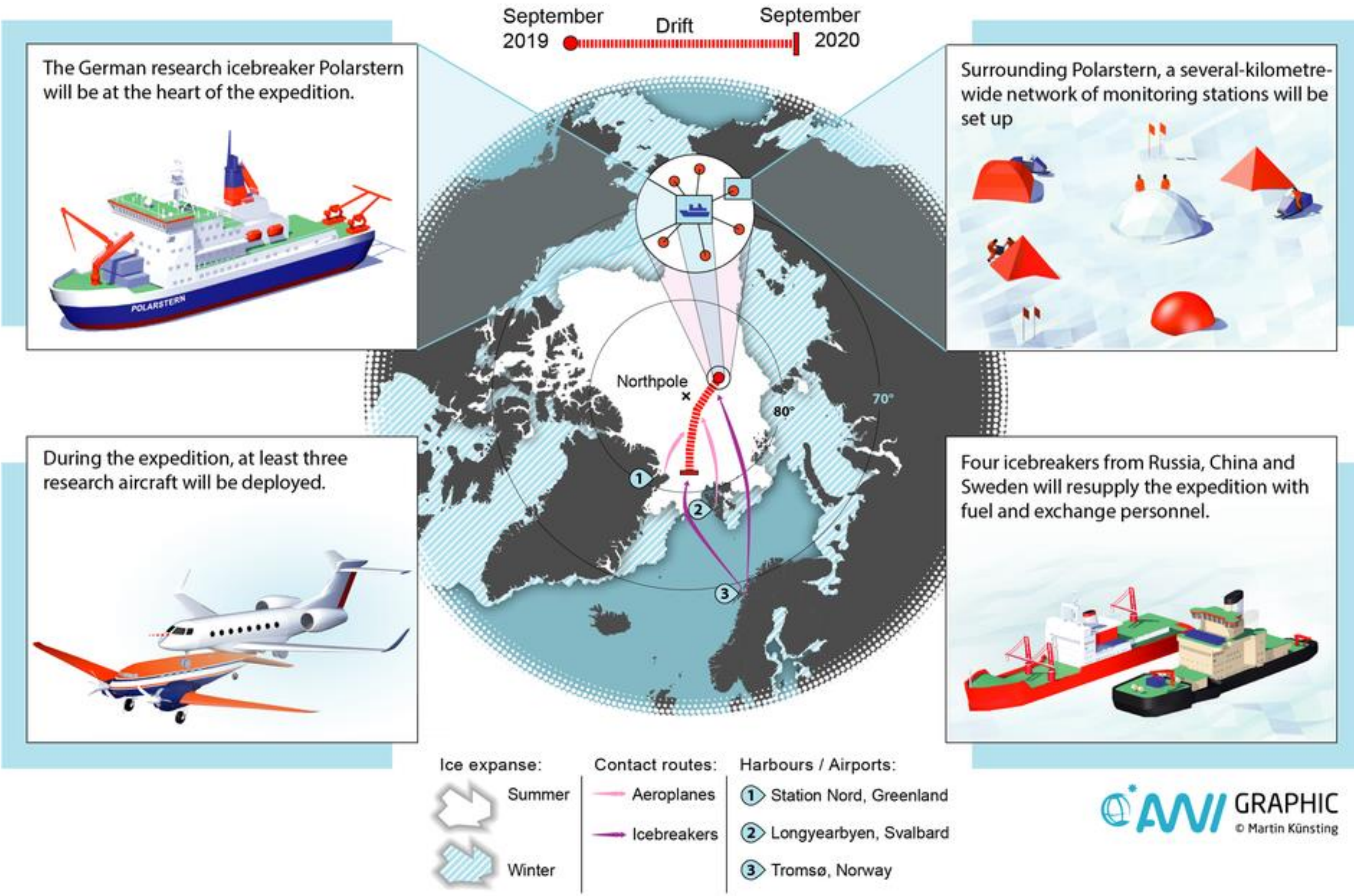




Summary

- Arctic water vapor challenging due to
  - complex surface conditions and frequent cloudiness
  - high variabity on all scales up to 30 % on daily scale
- IASI and MIRS provide robust averages due to incorporation of microwave frequencies (clouds) and high number of samples for climatology
- Strong differences over Siberia between MIRS and IASI?
- Modis have too few data for monthly means

- Strongly over sea ice (central Arctic)
  → MOSAiC cruise with Polarstern equpped with ground-based MWR and GRUAN radiosondes


September 2019
Drift
September 2020
The German research icebreaker Polarstern will be at the heart of the expedition.
POLARSTERN
Surrounding Polarstern, a several-kilometre-wide network of monitoring stations will be set up
Northpole
80°
70°
During the expedition, at least three research aircraft will be deployed.
Four icebreakers from Russia, China and Sweden will resupply the expedition with fuel and exchange personnel.
Ice expanse:
Summer
Winter
Contact routes:
Aeroplanes
Icebreakers
Harbours / Airports:
1 Station Nord, Greenland
2 Longyearbyen, Svalbard
3 Tromsø, Norway
AWI GRAPHIC
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