Retrieval of Surface Properties Based on Microwave Emissivity Spectra

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1 **Overview of Retrieval System Approach**

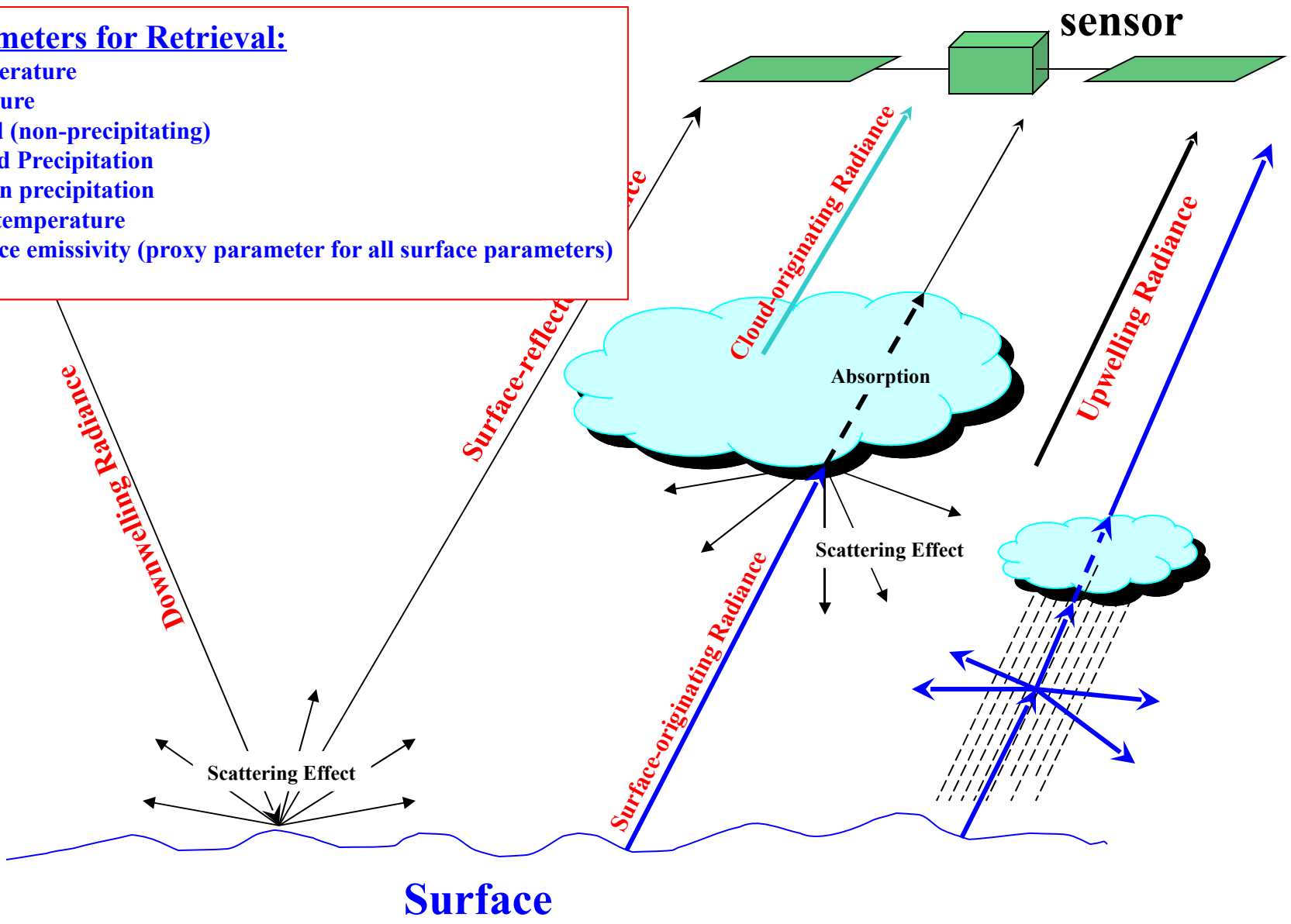
2 Emissivity Assessment

3 Emissivity-Based Products Assessment

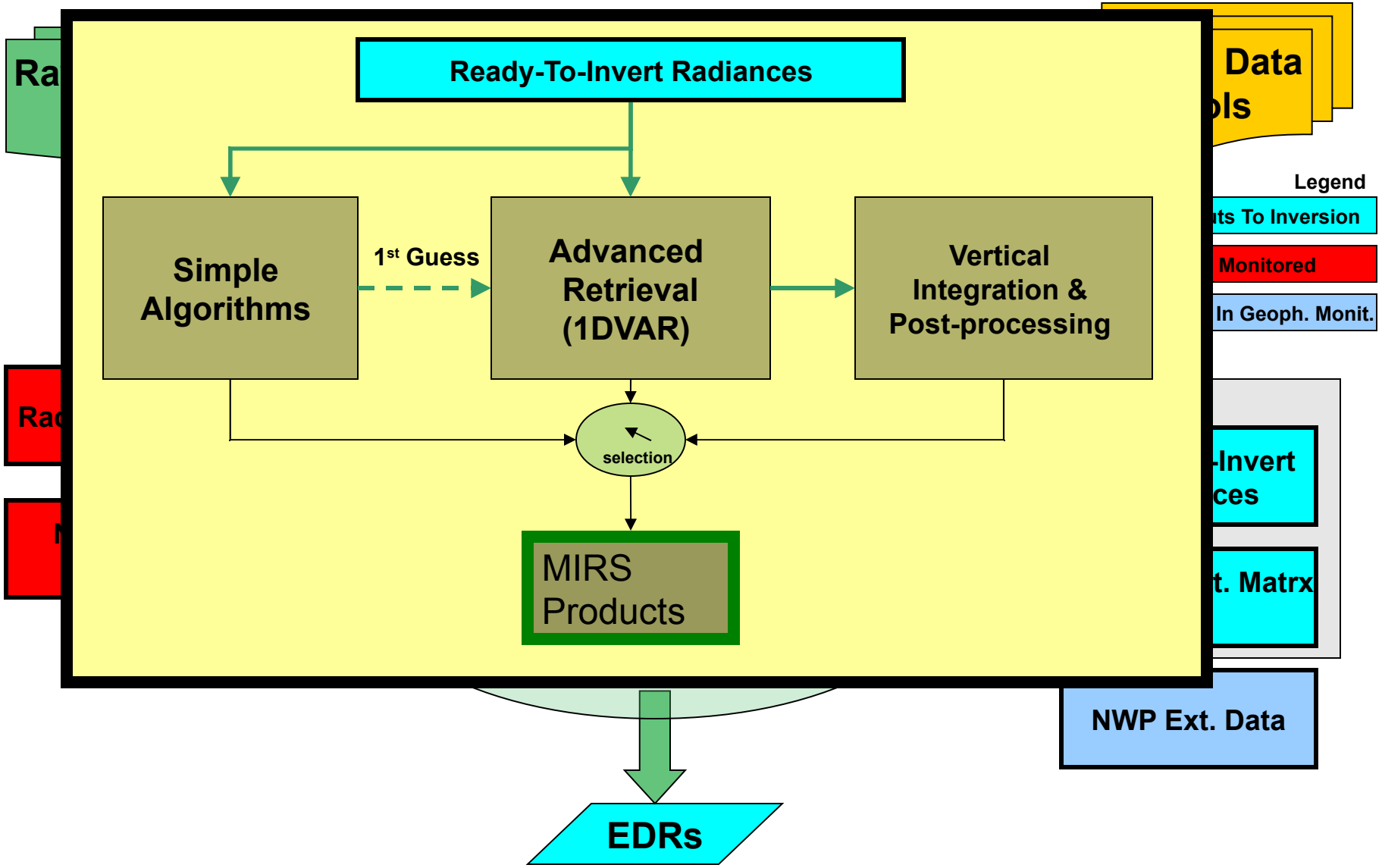
4 Other Applications & Summary

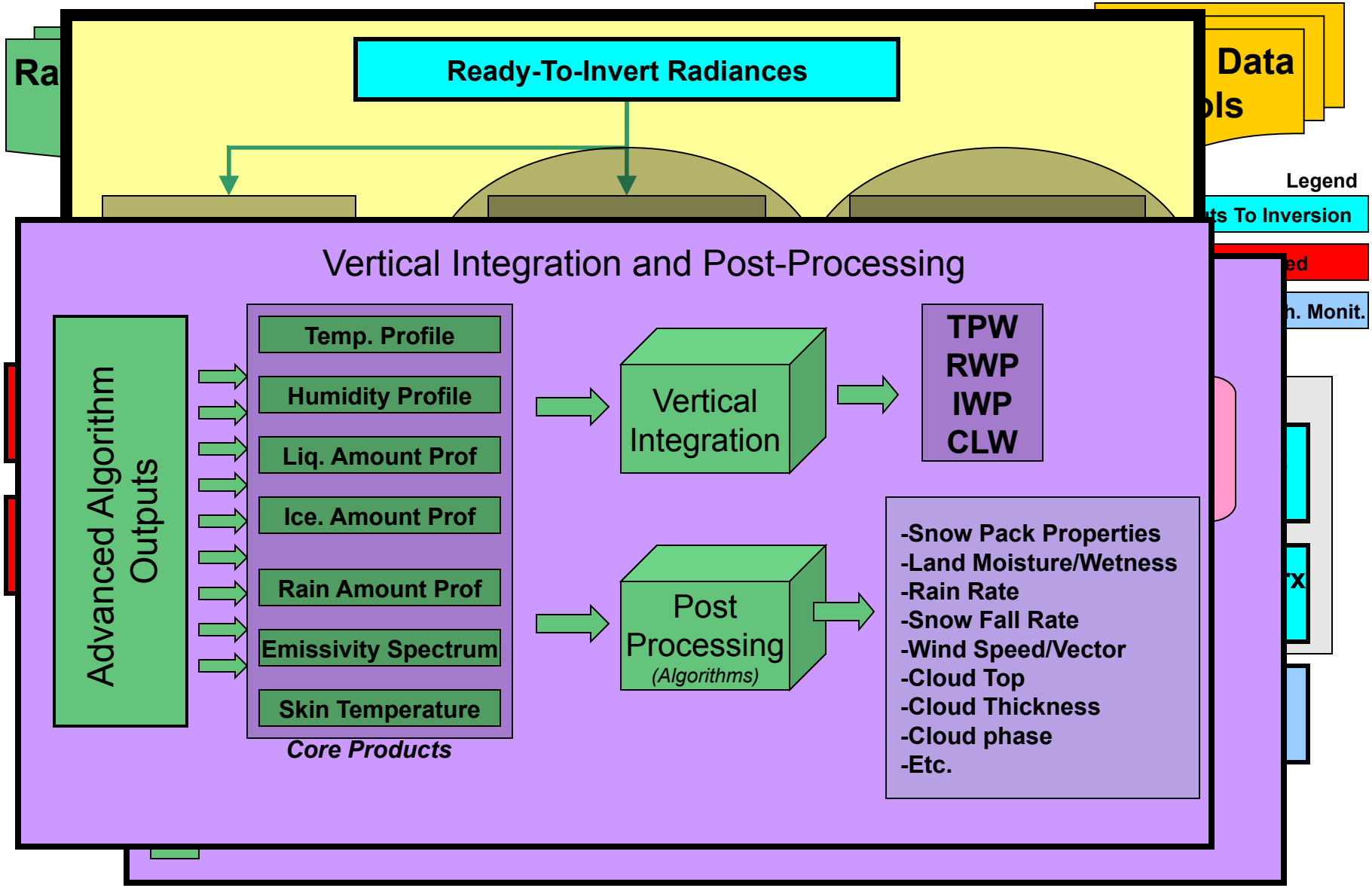
Parameters for Retrieval:

- Temperature
- Moisture
- Cloud (non-precipitating)
- Liquid Precipitation
- Frozen precipitation
- Skin temperature
- Surface emissivity (proxy parameter for all surface parameters)



- Emissivity is simply added to the state vector to be retrieved in the Bayesian Algorithm
- Allows point-to-point variation of emissivity
- Allows distinguishing Tskin signal from emissivity
- Allows distinguishing atmospheric and cloud signals from emissivity
- It is constrained by:
  - Background covariance (spectral constraints)
  - Physical constraints (CRTM)
  - Fitting the radiances
- The Algorithm used is called the Microwave Integrated Retrieval System (MiRS)
- We will show results for N18 AMSU/MHS but MiRS is applied to N19, Metop-A, DMSP F16 SSMIS and AMSR-E


Ready-To-Invert Radiances
Simple Algorithms
1st Guess
Advanced Retrieval (1DVAR)
Vertical Integration & Post-processing
selection
MIRS Products
EDRs
Legend
Monitored
In Geoph. Monit.
NWP Ext. Data


Ready-To-Invert Radiances
Data
Legend
Vertical Integration and Post-Processing
Advanced Algorithm Outputs
Temp. Profile
Humidity Profile
Liq. Amount Prof
Ice. Amount Prof
Rain Amount Prof
Emissivity Spectrum
Skin Temperature
Core Products
Vertical Integration
TPW
RWP
IWP
CLW
Post Processing
(Algorithms)
-Snow Pack Properties
-Land Moisture/Wetness
-Rain Rate
-Snow Fall Rate
-Wind Speed/Vector
-Cloud Top
-Cloud Thickness
-Cloud phase
-Etc.

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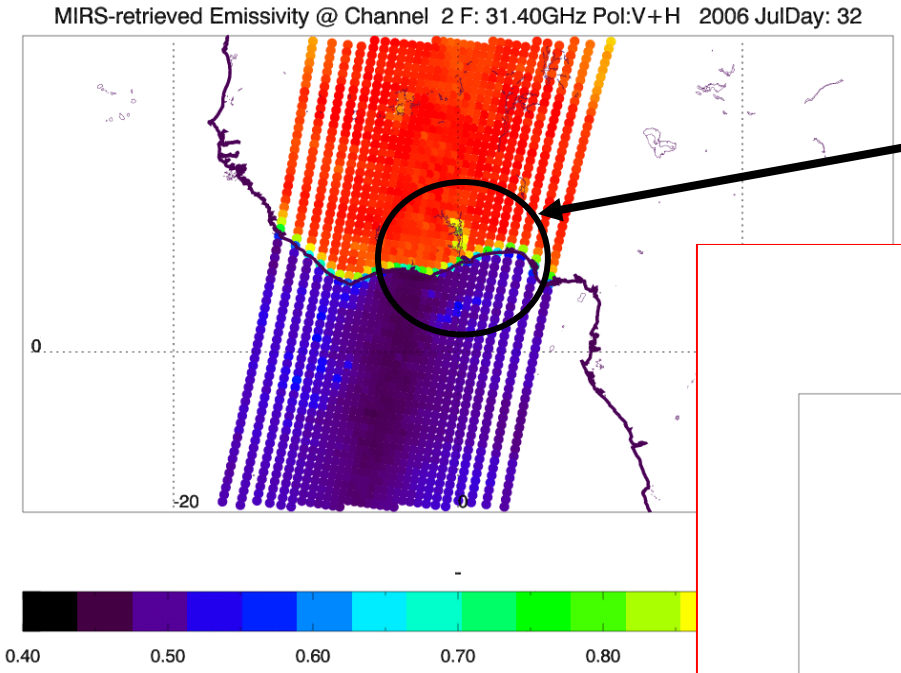
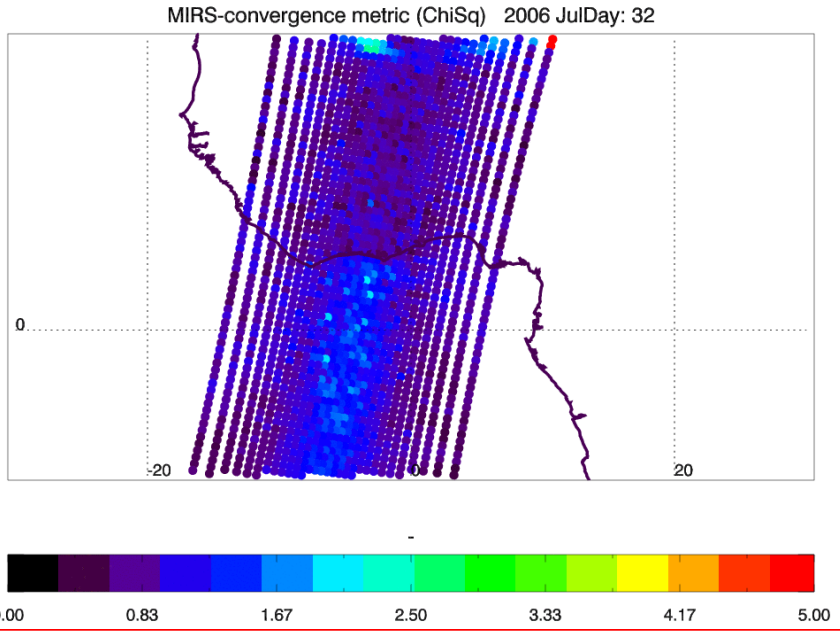
Emissivity is lower over ocean and higher over land.

It is intermediate for coasts and rivers.

Convergence is achieved in all cases

River/Coast signature





- Simplified RT equation:

$$T_B = \varepsilon \cdot T_s \cdot \Gamma + T^{\uparrow} + T^{\downarrow} \cdot (\cdot - \varepsilon) \cdot \Gamma$$

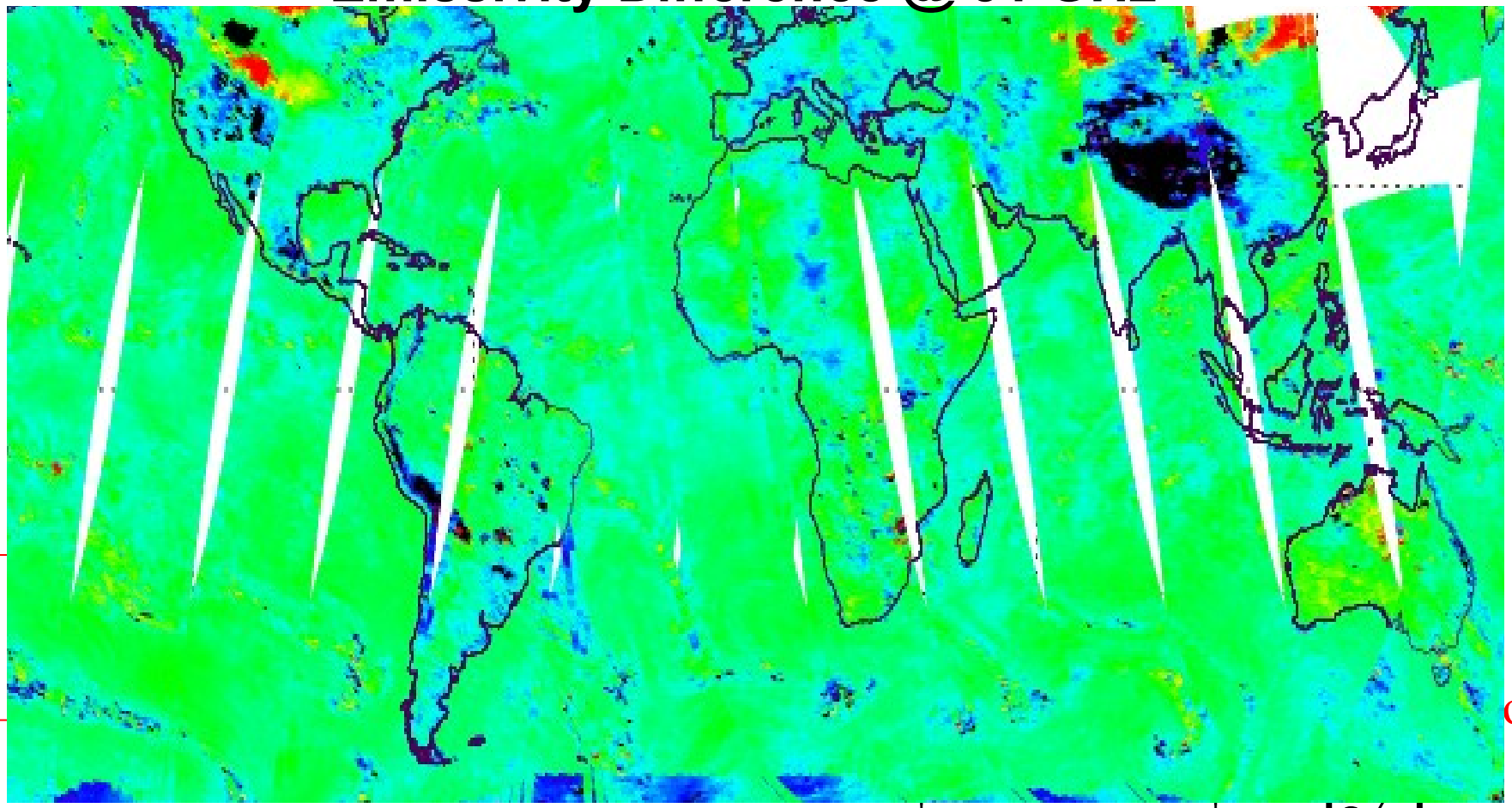
- Therefore:

$$\varepsilon = \frac{\left(\frac{\left(T_B - T^{\uparrow} \right)}{\Gamma} - T^{\downarrow} \right)}{\left(T_s - T^{\downarrow} \right)}$$

Four conditions (to be valid):

1. $\Gamma \neq$ ˇ (not usable for opaque channels)
2. $T_s \neq T^{\downarrow}$ (Could be unstable)
3. Assumes surface specular (for RT validity)
4. Assumes clear sky (no cloud, no rain, no ice)

Emissivity Difference @ 31 GHz



ons:

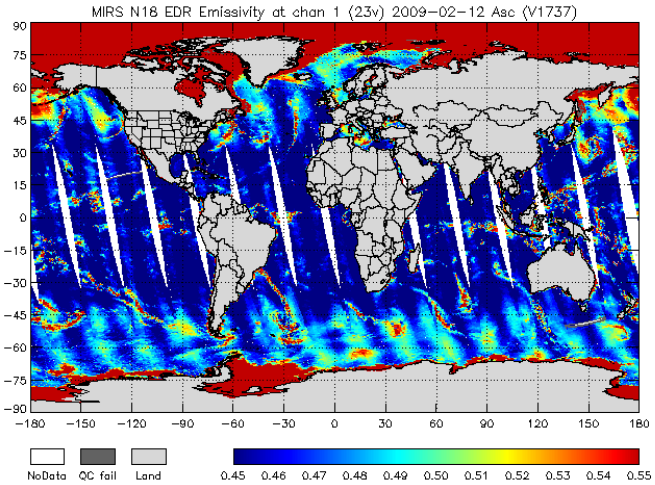
$\varepsilon =$

's

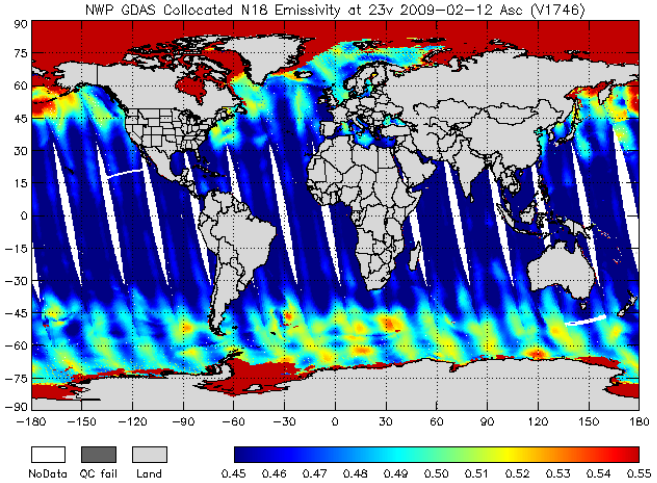
$\Gamma \neq 0$

-0.15 -0.10 -0.05 0.00 0.05 0.10 0.15

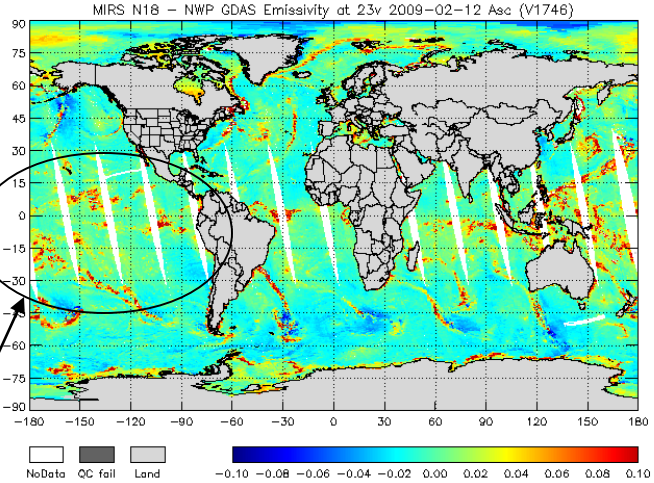
MiRS/N18



Ocean:Emissivity model
Sea Ice: Analytical using GDAS



Difference (Varia.-Analy.)



High Differences when precip

23.8 GHz	Std Dev	Bias
Sea	0.03	0.003
Ice	0.02	0.001

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2. Emissivity Assessment
3. **Emissivity-Based Products Assessment**
4. Other Applications & Summary

We search for the closest spectrum from a pre-computed catalog to determine the surface parameters that correspond to the retrieved spectrum

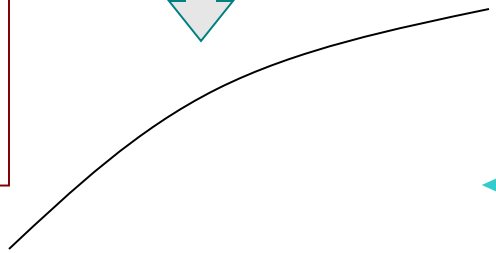
1DVAR

Core products Including Emissivity spectrum

Look-Up

Emissivity Catalogs:

1) Emiss=f(SIC, age)
2) Emiss=f(SWE, size)
3) Emiss=f(wind, angle, Ts)



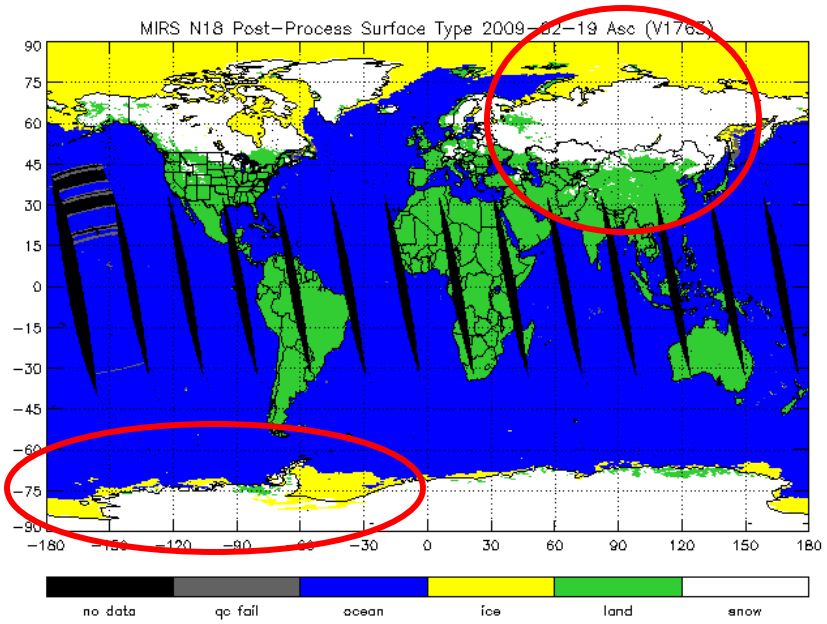
Emissivity-Based Products:

(1) Snow Cover, (2) Snow Water Equivalent, (3) Sea Ice Concentration

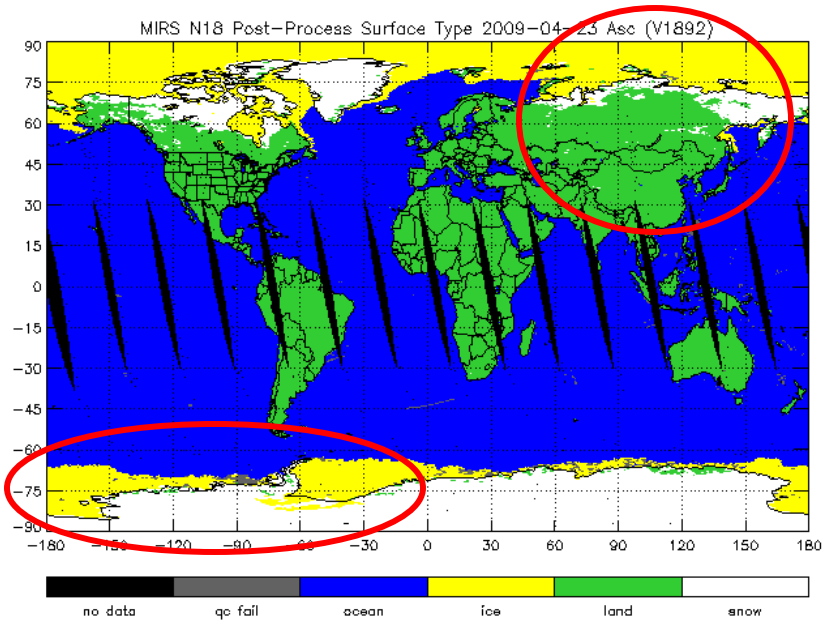
By-products:

(1) Snow grain size, (2) Sea Ice age

Winter



Spring



Retreat of snow in Northern hemisphere &
Extension of sea-ice in Southern hemisphere

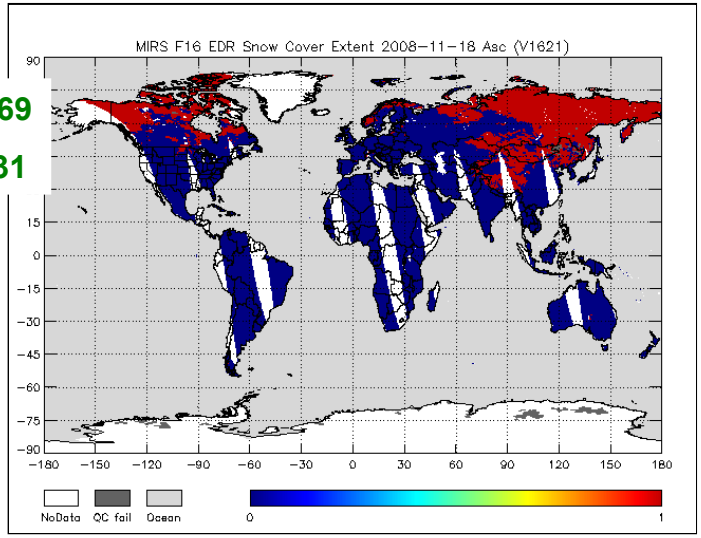
F16 MIRS

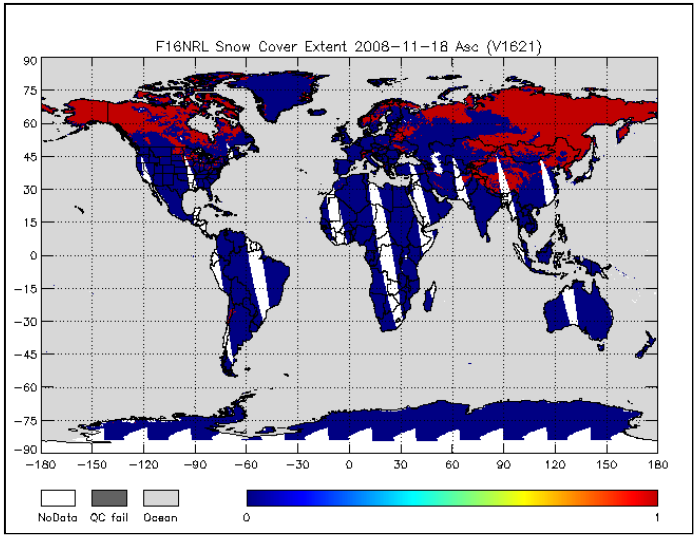
2008-11-18

F16 NRL

POD=0.769

FAR=0.031



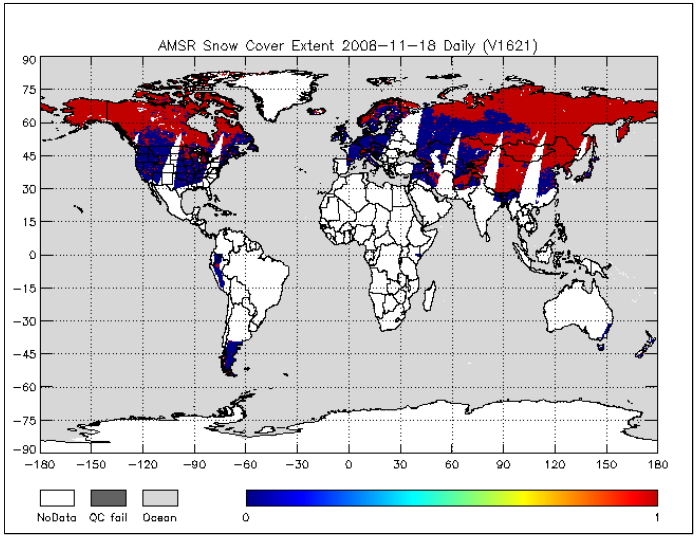


HSS=0.599

POD=0.755

FAR=0.065

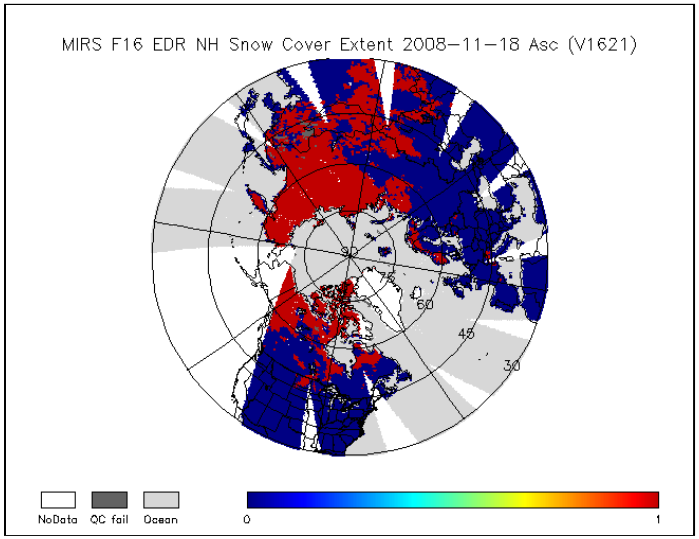
AMSRE

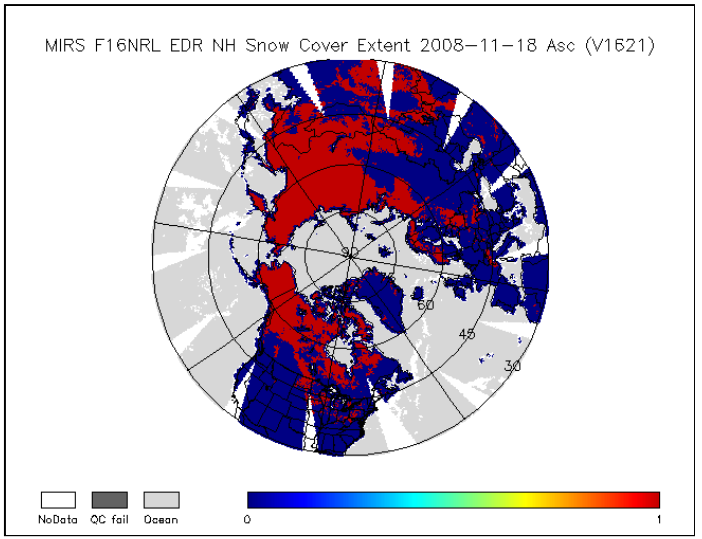


- ***MIRS SCE comparable to NRL and AMSRE over N. and E. Asia, Scandinavia, N. Canada***
- ***MIRS SCE underestimated w/r to AMSRE over C. Asia, C. Canada, U.S.***
- ***AMSRE greater than MIRS and NRL over C. Asia***

2008-11-18

F16 MIRS

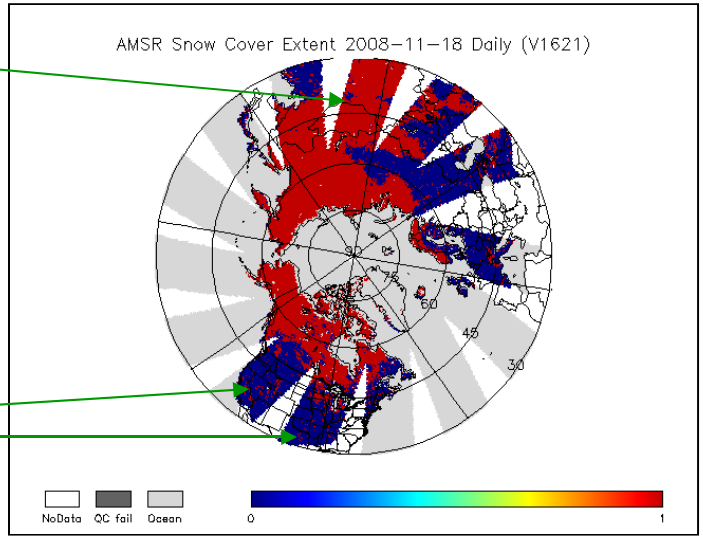




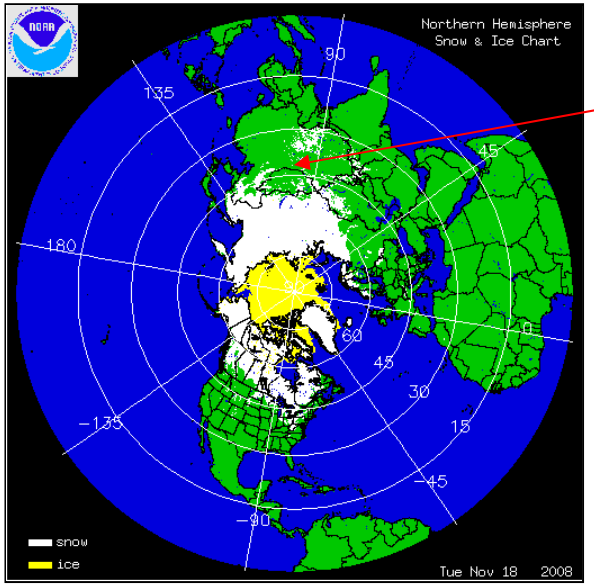
F16 NRL

Extensive snow cover

AMSRE



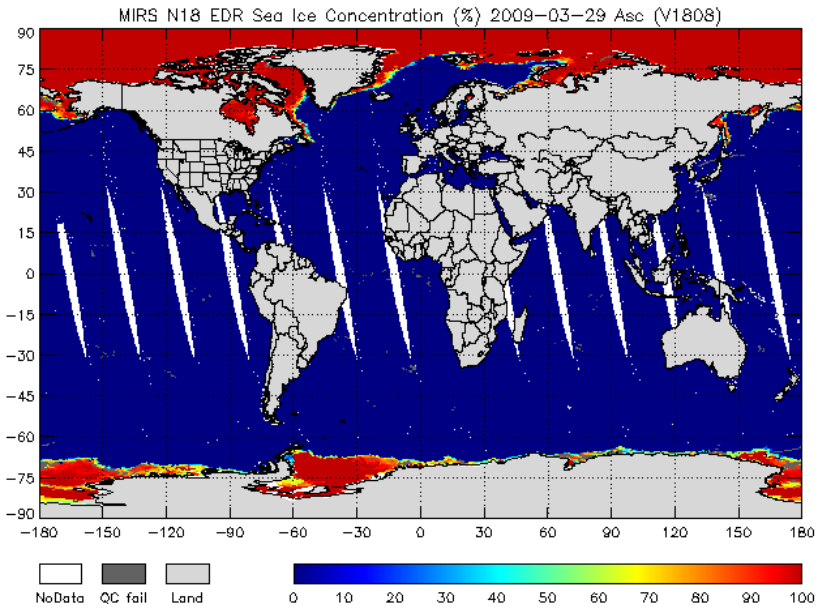
False alarms



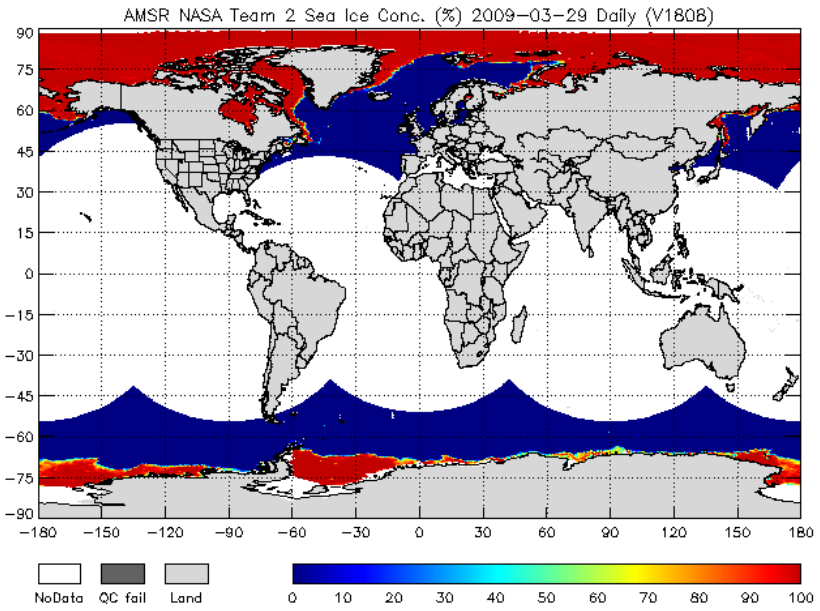
Less Extensive snow cover

IMS

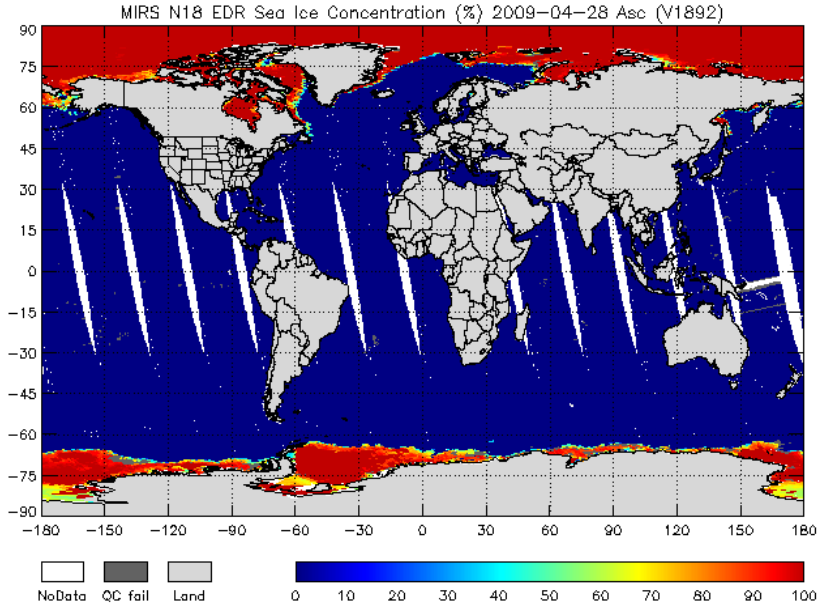
MiRS

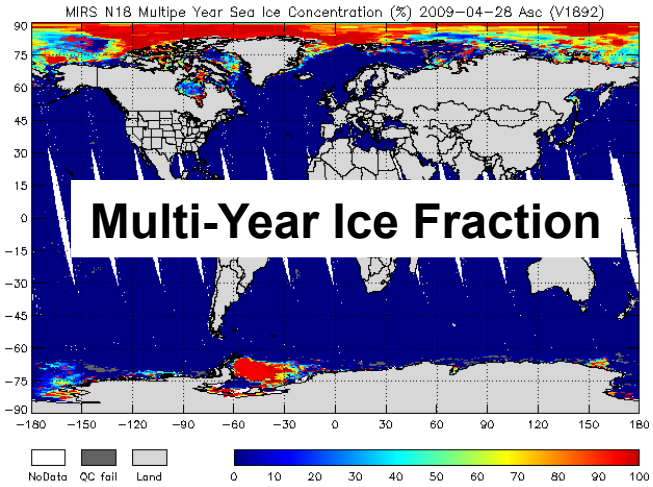


AMSR (NASA-T2 Algorithm)

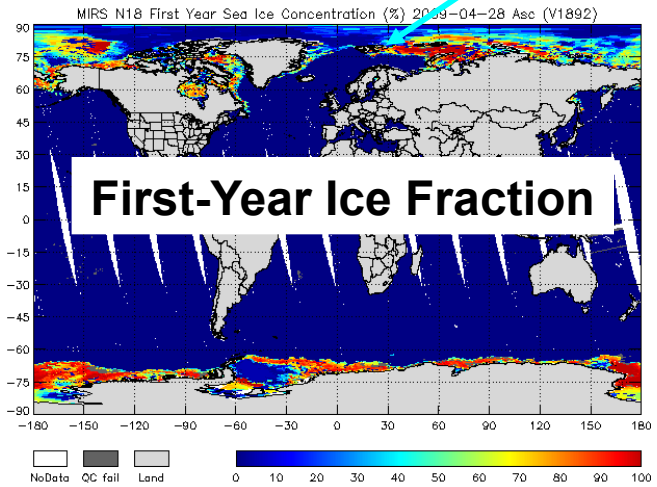


Total Ice Fraction





First-Year type confined to edges of sea ice



Sea Ice Type (Multi-Year or First-Year), part of the emissivity catalog, is a by-product of the Sea-Ice Concentration retrieval (from emissivity).

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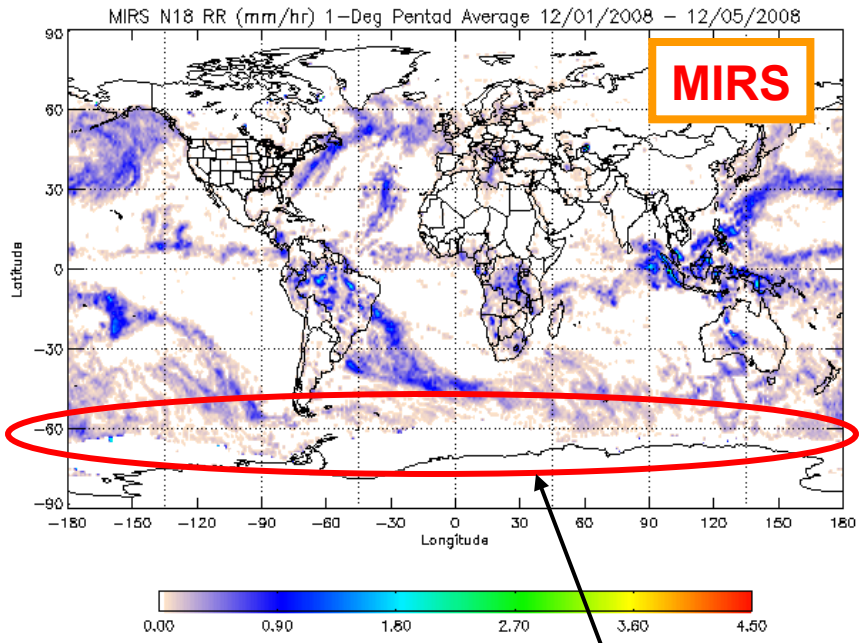
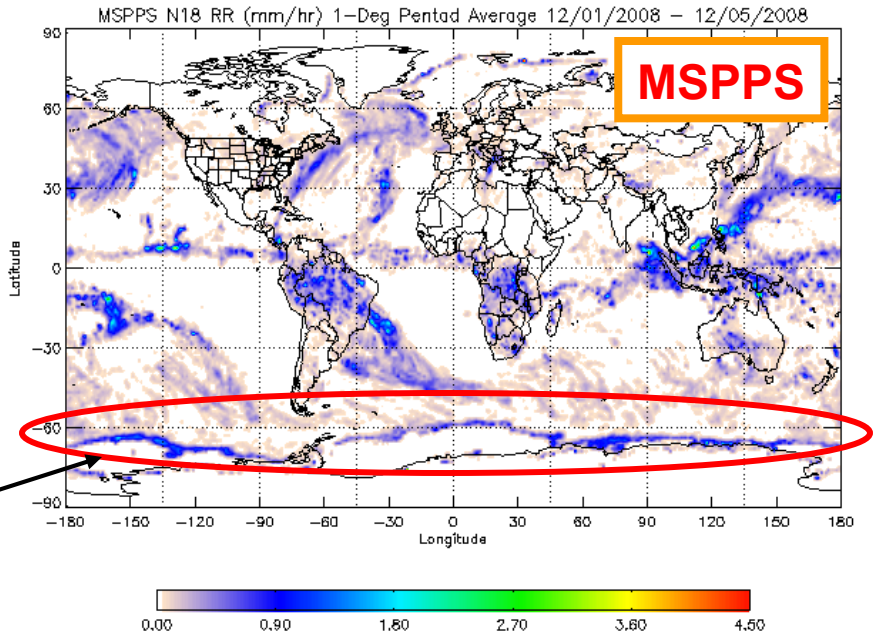
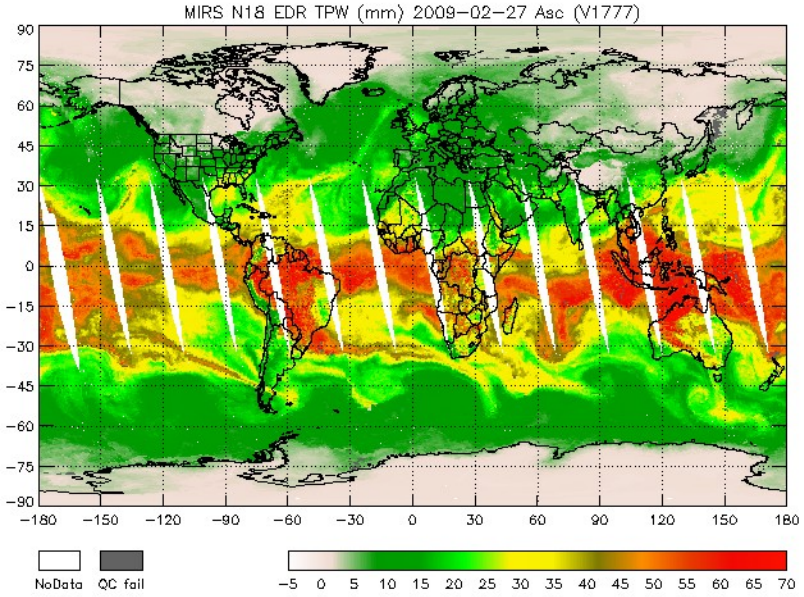
- Besides the more accurate retrieval of surface parameters from emissivity (instead of TBs), the inclusion of the emissivity in the retrieval allowed us to:
  - Retrieve Precipitation over land more accurately
  - Extend spatial coverage of standard parameters
  - Retrieve more accurately lower layers of temperature and moisture (with surface-sensitive channels)

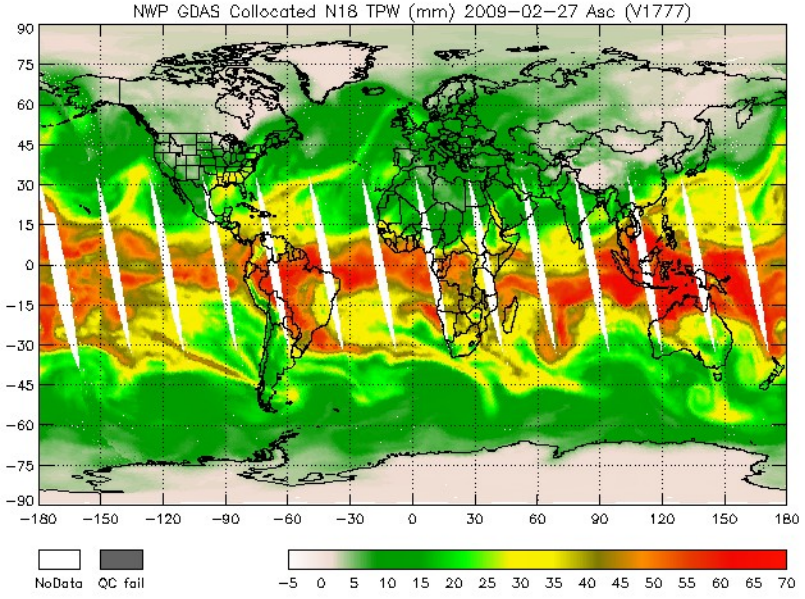
Pentad composites of MiRS (left) and MSPPS (right) Rainfall Rate.





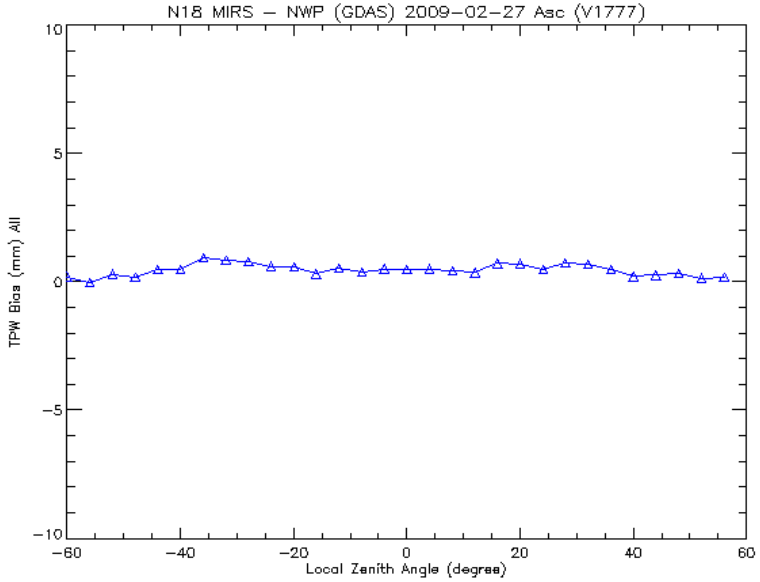
Improvement over the sea ice edges (significant reductions in false alarms).
Due to accounting for emissivity in retrieval process





Smooth transition over coasts

Very similar features to GDAS



- Emissivity has been implemented in the retrieval system to account for surface-sensitivity of channels
- Qualitative assessment of the emissivity behaviors demonstrates the product is of good quality
- Variational emissivity perfs: Bias and std devs depend on channel & surface type (less than 1% bias and 2-3% std dev wrt analy. estimat.)
- Emissivity-based surface products have been generated: Surface Type, SCE, SWE and SIC. Upcoming: WS+SM
- Accounting for emissivity in retrieval, allows to TPW extension over land, snow, ice and coast.
- Accounting for emissivity in retrieval allowed improvement of the rainfall rate performances as well.
- **Emissivity could be viewed as a radiometric signal, free from atmospheric, cloud and Tskin signatures.**